REMEDIAL ACTION PLAN (RAP)
RENEWAL PERMIT APPLICATION FOR
CORRECTIVE ACTION MANAGEMENT UNIT (CAMU)
HENDERSON, NEVADA

Submitted to:

Nevada Division of Environmental Protection
901 South Stewart Street – 4th Floor
Carson City, Nevada 89701
(775) 687-4670

Prepared for

Basic Remediation Company
875 West Warm Springs Road
Henderson, Nevada 89015
(702) 567-0400

Prepared by

Geosyntec Consultants, Inc.
10875 Rancho Bernardo Road, Suite 200
San Diego, California 92127
(858) 674-6559

May 2013

Basic Remediation
COMPANY

To:

Mr. Mike Leigh, Supervisor
Nevada Division of Environmental Protection
901 South Stewart Street – 4th Floor
Carson City, Nevada 89701

Ref: Application for Renewal of the BRC CAMU

Dear Mr. Leigh

BRC hereby submits the attached renewal application for the BRC CAMU located in Henderson, NV. The current permit, which was issued on September 24, 2007, expires on September 24, 2012. We are submitting this renewal application for a new 5-year term.

The BRC CAMU was/is planned to be constructed in Phases, per the original NDEP-approved design. The CAMU consists of Phases I, II, IIIA, IIIB, IV, and V. All but Phase V have already been constructed with waste placement and closure completed for Phases I, II, IIIA, IIIB, and IV. Closure documents for these Phases was submitted to the NDEP and approved. As such, ongoing activities for these Phases consist of inspection and maintenance. Partial waste placement has occurred in Phase V. It is anticipated that additional waste placement, due to remediation activities at BRC, will occur in Phase V between now and roughly early-2013, followed by capping and closure of Phase V at that time. Shortly after completion of the closure of Phase V, BRC will submit a final closure document to NDEP for Phase V for approval. When approved, the entire CAMU construction will be complete. Thus, for the first many months of the next renewal term of the RAP, it is anticipated that construction/waste placement/closure activities will take place in Phase V, much like activities that occurred for the previous Phases during the current term of the RAP. For the balance of the term of the next renewal period of the RAP, the entire, closed CAMU will be in inspection/maintenance.

Related activities also completed to date include capping the contiguous, the majority of the existing BMI North and all of the existing BMI South landfills, with approval by the NDEP.

Since the next term of the RAP will consist of activities that are similar to the current term (i.e., due to remaining construction and closure of Phase V)), we have retained construction and closure related documents in this application, updating only as needed to reflect current conditions. We have kept the format of this application consistent with the prior application for ease of review, including prior Attachment numbering. When relevant we have revised existing Attachments and/or provided new Attachments.

Specifically, with regards to final design drawings, for ease of reference and in order to avoid a substantial effort associated with reissuance of drawings that have already previously been approved by the NDEP, instead of separating out the design documents just for Phase V, we have provided the entire set of final design documents in this application.

With regards to groundwater monitoring please note that we are currently in negotiations with the NDEP Bureau of Corrective Actions (BCA) with regards to the Long Term Groundwater Monitoring Plan for the CAMU. We have a placeholder Attachment for this Plan (Attachment Y) which will be submitted once discussions with the BCA are completed.

With regards to future land use on the final cover of the CAMU, as the NDEP is aware, a solar collection field is planned for installation. This system will be installed and maintained by a party other than BRC, subject to a land lease agreement with BRC. The land lease between BRC and the parties will include all applicable conditions of the RAP. Whomever the solar operator may be, they will separately obtain the necessary approvals and permits to install and operate the solar field (including such permits as may be necessary from the NDEP), BRC's CAMU design engineer Geosyntec will review any proposed design to ensure it is in conformance with the CAMU cover design (Attachment AA). Attachment AA provides guidance to any solar field design for the installation and operation of a Solar field. Attachment AB provides a placeholder in which the details of the solar field design documents are located. Currently, this includes documents which have been submitted to the NDEP for review.

It is BRC's understanding, based on conversations with the NDEP, that there is no special format for this application and no forms, etc. as such. As noted above, we have updated the application materials as needed, based on relevance going forward.

Finally, we request that the NDEP issue the revised RAP, deleting conditions in the current version that are no longer appropriate for the next term.

Should you have any questions, please call me at 702.567.0400.

Mr. Lee C. Farris, P.E.
Vice-President

cc: Mr. Michael Friend, NDEP
Mr. Greg Lovato, NDEP
Dr. Ranajit Sahu
distribution list

I hereby certify that I am responsible for the services described in this document and for the preparation of this document. The services described in this document have been provided in a manner consistent with the current standards of the profession and to the best of my knowledge comply with all applicable federal, state and local statutes, regulations and ordinances. I hereby certify that all laboratory analytical data was generated by a laboratory certified by the NDEP for each constituent and media presented herein.

12/17/13

Dr. Ranajit Sahu, C.E.M. (No. EM-1699, Exp. 10/07/2015) Date

BRC Project Manager

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision according to a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Mr. Mark Paris

President and CEO, BRC

TABLE OF CONTENTS

i. Cover Letter
iii. Signatures and Certification (270.105)
v. Table of Contents
vii. Definitions
viii. Acronyms

1.0 Introduction.....1
2.0 Background.....4
3.0 Overview.....4
4.0 Required information.....6
5.0 References.....9

LIST OF TABLES

Table 1 Application contents cross-referenced to required regulatory information

Attachments:

A Drawing (USGS/County Map)
B Drawing (Scaled Drawing)
C Waste Analysis Plan
D Security Plan
E Inspection Plan and Schedules
F Personnel Training Plan
G Accident Prevention, Contingency, and Emergency Response Plan
H Emergency Coordinator
I Location Standards and Siting Requirements
J CAMU (Landfill) Design – conceptual
K CAMU (Landfill) Design – final
L CAMU (Landfill) Construction Plan
M CAMU (Landfill) Operation Plan
N CAMU (Landfill) Monitoring Plan
O CAMU (Landfill) Closure and Post-Closure Plan
P CAMU (Landfill) Final Cover Design

Q	Closure and Post-Closure Cost Estimates
R	Financial Assurance
S	Sudden and Non-sudden Insurance Documentation
T	Report and Recordkeeping Plan
U	Compliance with applicable Federal Laws
V	Additional Information Required by NDEP
V.1	Record of Decision issued by NDEP selecting the remedy alternative that calls for the construction of a CAMU for the permanent disposition of remediation waste at a location adjacent to the existing (closed) BMI Landfills.
V.2	Letter issued by NDEP confirming that the construction and location of the proposed CAMU at the selected sites near the existing BMI Landfills and above the slit trenches is consistent with the approved Corrective Action Plan.
W	Copy of Existing (Current) RAP
X	Copy of NDEP Approval Letters for Closure of Phases I, II, IIIA, IIIB, and IV and for a portion of the BMI North (North Mesa) and all of the BMI South (South Mesa) Landfills
Y	Long Term Groundwater Monitoring Plan
Z	Final Leachate Monitoring Plan
AA	Geosyntec Letter Regarding Invenergy Design
AB	Future Solar Partner Design Documents [Reserved]
AC	Responses to Interim CAMU Design Review

Definitions

Owner – Basic Remediation Company (BRC)

Design Engineer – Geosyntec Consultants

Regulatory Agency – Nevada Department of Environmental Protection (NDEP)

ACRONYMS AND ABBREVIATIONS

F	Degrees Fahrenheit
AST	Above-ground Storage Tank
ASTM	American Society for Testing Materials
AOC3	Agreement and Order on Consent
ASO	Apparent Size Opening
BEC	Basic Environmental Company
bgs	below ground surface
BMI	Basic Management Incorporated
BMIC	Black Mountain Industrial Center
BMP	Best Management Practice
BRC	Basic Remediation Company
CAMU	Corrective Action Management Unit
CAP	Corrective Action Plan
CCHD	Clark County Health District
CCL	Compacted Clay Liner
CEM	Certified Environmental Manager
CFR	Code of Federal Regulations
cm/sec	centimeters per second
CPE	Chlorinated polyethylene
CQA	Construction Quality Assurance
CRZ	Contaminant Reduction Zone
CSPE	Chlorosulfonated polyethylene
DBS&A	Daniel B. Stevens & Associates
ERM	Environmental Resources Management
FAA	Federal Aviation Administration
FEMA	Federal Emergency Management Agency
FSSOP	Field Sampling and Standard Operating Proceedures
ft/d	feet per day
ft^2	square feet
ft^3	cubic feet
GAC	Granular activated carbon
GCL	Geosynthetic clay liner
Geosyntec	Geosyntec Consultants, Inc.
GP	Poorly Graded Gravel
GM	Silty Gravel
G&M	Geraghty & Miller
HAZWOPER	Hazardous Waste Operations and Emergency Response
HDPE	High density polyethylene

HELP	Hydrologic Evaluation of Landfill Performance
HASP	Health and Safety Plan
HSP	Health and Safety Plan
HWIR	Hazardous Waste Identification Rule
lb/in	pounds per inch
LCS	Leachate collection system
LDR	Land Disposal Restrictions
LDPE	Low density polyethylene
LLDPE	Linear low density polyethylene
mg/L	Milligrams per liter
MSW	Municipal solid waste
mph	miles per hour
MSL	Mean Sea Level
MTR	Minimal Treatment Requirements
M_W	Magnitude Moment
MWH	MWH Americas, Inc.
NAC	Nevada Administrative Code
NDEP	Nevada Division of Environmental Protection
NPDES	National Pollution Discharge Elimination System
NPV	Net Present Value
NOAA	National Oceanic and Atmospheric Administration
OSHA	Occupational Safety and Health Administration
PAMP	Perimeter Air Monitoring Program
Parsons	Parsons Engineering Group
PCBs	Polychlorinated biphenyls
PCE	Tetrachloroethylene
PGPVs	Preliminary Groundwater Protection Values
PHGA	Peak Horizontal Ground Acceleration
PPE	Personal Protective Equipment
PRGs	Preliminary Remediation Goals
psf	pounds per square foot
psi	pounds per square inch
PVC	Polyvinyl chloride
Qa	Quaternary Alluvium
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RAP	Remedial Action Plan
RAS	Remedial Alternatives Study
RCRA	Resource Conservation Recovery Act
ROI	Radius of influence
RWMS	Remedial Waste Management System

SASW	Spectral-analysis of Surface Waves
SCBA	Self Contained Breathing Apparatus
SDR	Standard Dimension Ratio
SHSO	Site Health and Safety Officer
SRAPI	Supplemental RAP Information
scfm	Standard cubic feet per minute
SM	Silty Sand
SP	Poorly Graded Sand
SRC	Site Related Chemicals
SVE	Soil vapor extraction
SVOC	Semi-Volatile Organic Chemicals
SW	Well-graded Sand
TCE	Trichloroethylene
TCLP	Toxicity Characteristic Leaching Procedure
TIMET	Titanium Metals Corporation
TMCf	Tertiary Muddy Creek Formation
USCS	United Soil Classification System
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UTS	Universal Treatment Standards
UV	Ultraviolet
VOCs	Volatile organic compounds

1.0 INTRODUCTION

Basic Remediation Company (BRC) has prepared and submits this application for the renewal of the current Remedial Action Plan (RAP) permit (Attachment W) to construct and operate a Remediation Waste Management System (RWMS) in Clark County, Nevada. A previous version of this document was submitted to the Nevada Division of Environmental Protection (NDEP) in March 2007 by BRC's design engineer Geosyntec Consultants. This document includes the application and supporting documentation for a proposed Corrective Action Management Unit (CAMU), hereafter referred to as the BRC CAMU. This permit application is being submitted to the NDEP, Carson City, Nevada.

This application provides the information needed to obtain a RAP as specified in 40 CFR 270, Subpart H. In this context, a RAP is defined as a special form of RCRA permit that authorizes the disposal of remediation waste at a remediation waste management site. This type of permit was developed as part of the Hazardous Waste Identification Rule for Contaminated Media, or "HWIR-media rule" (63 FR 65874). As stated in the United States Environmental Protection Agency (USEPA) Environmental Fact Sheet on the Final HWIR-Media Rule (EPA530-F-98-029), this rule is designed to eliminate existing regulatory disincentives to remediation, make site cleanup faster and easier, and, thus, provide increased protection to human health and the environment.

As described in the previous application, the proposed disposal facility will continue to only receive remediation waste. The proposed unit is conservatively designed to meet the regulatory requirements for a CAMU, as referred to in 40 CFR 264.552.

As noted in the prior application, the purpose of the BRC CAMU is to provide a permitted disposal facility at the NDEP-approved location (per the Record of Decision dated 2 November 2001) for wastes generated during the voluntary cleanup of certain areas of the BMI Common Areas (the "Site"), as specifically contemplated by the "Nevada Division of Environmental Protection Settlement Agreement and Order on Consent: BMI Common Areas, Phase 3" (the "AOC3") dated February 15, 2006, and as defined in the Corrective Action Plan (CAP) (BRC, 2006). Portions of the Site have been impacted during the legal disposal of various materials, including industrial wastes and cooling waters. The NDEP provides oversight of the voluntary cleanup activities. As a result of the NDEP's review of the "Remedial Alternatives Study (RAS) for the BMI Common Areas" (ERM, 1999), and subsequent discussion with BRC, the location

stated in remedial alternative 4B was approved as the preferred location of waste materials generated from the voluntary cleanup of the Site. The actual text of the NDEP's comment is provided below for reference.

> "Per discussions with Basic Remediation Company (Robin Bain) on August 5, 1999, the Division assumes this alternative (4B in the RAS) has been modified to locate soils within the confines of BMI property immediately surrounding the current BMI Landfill. Based on currently available information, co-location of impacted soils with the BMI Landfill is the current preference of the Division for soil disposal."

The BRC CAMU was/is planned to be constructed in Phases, per the original NDEP-approved design. The CAMU consists of Phases I, II, IIIA, IIIB, IV, and V. All but Phase V have already been constructed with waste placement and closure completed for Phases I, II, IIIA, IIIB, and IV. The following Construction Quality Assurance (CQA) Reports for these Phases were submitted to NDEP and approved:

- Phase I Construction Quality Assurance Report, Basic Remediation Company, Corrective Action Management Unit, Henderson, Nevada prepared by Geosyntec Consultants, Inc. dated September 2008. (Phase I Liner CQA Report)
- Phase II Construction Quality Assurance Report, Basic Remediation Company, Corrective Action Management Unit, Henderson, Nevada prepared by Geosyntec Consultants, Inc. dated December 2008. (Phase II Liner CQA Report)
- Phase IIIA Construction Quality Assurance Report, Basic Remediation Company, Corrective Action Management Unit, Henderson, Nevada prepared by Geosyntec Consultants, Inc. dated March 2009. (Phase IIIA Liner CQA Report)
- Phase IIIB Construction Quality Assurance Report, Basic Remediation Company, Corrective Action Management Unit, Henderson, Nevada prepared by Geosyntec Consultants, Inc. dated May 2009. (Phase IIIB Liner CQA Report)
- Phase IV Construction Quality Assurance Report, Basic Remediation Company, Corrective Action Management Unit, Henderson, Nevada prepared by Geosyntec Consultants, Inc. dated July 2009. (Phase IV Liner CQA Report)
- Phase V Construction Quality Assurance Report, Basic Remediation Company, Corrective Action Management Unit, Henderson, Nevada prepared by Geosyntec Consultants, Inc. dated September 2009. (Phase V Liner CQA Report)

The following Closure documents for these Phases were submitted to the NDEP and approved:

- CAMU Partial Final Closure Construction Quality Assurance Report, Phases IIIA & Portion of Phase II, Basic Remediation Company, Corrective Action Management Unit, Henderson, Nevada prepared by Geosyntec Consultants, Inc. dated April 2010. (Closure I CQA Report)
- CAMU Partial Final Closure Construction Quality Assurance Report, Phases I, IIIB, IV, & Portions of Phases II and V, Basic Remediation Company, Corrective Action Management Unit, Henderson, Nevada prepared by Geosyntec Consultants, Inc. dated May 2010. (Closure II CQA Report)

As such, ongoing activities for these Phases consist of inspection and maintenance.

Partial waste placement has occurred in Phase V. It is anticipated that additional waste placement, due to remediation activities at BRC, will occur in Phase V between now and roughly early-2013, followed by capping and closure of Phase V at that time. Shortly after completion of the closure of Phase V, BRC will submit the Phase V final closure document to NDEP for approval. When approved, the entire CAMU construction will be complete. Thus, for the first many months of the next renewal term of the RAP, it is anticipated that construction/waste placement/closure activities will take place in Phase V, much like activities that occurred for the previous Phases during the current term of the RAP. For the balance of the term of the next renewal period of the RAP, the entire, closed CAMU will be in inspection/maintenance.

Since the next term of the RAP will consist of activities that are similar to the current term (i.e., due to remaining construction and closure of Phase V)), we have retained construction and closure related documents in this application, updated as needed to reflect current conditions. We have kept the format of this application consistent with the prior application for ease of review, including prior Attachment numbering. When relevant we have revised existing Attachments and/or provided new Attachments.

Specifically, with regards to final design drawings, for ease of reference and in order to avoid a substantial effort associated with reissuance of drawings that have already previously been approved by the NDEP, instead of separating out the design documents just for Phase V, we have provided the entire set of final design documents in this application.

With regards to groundwater monitoring please note that we are currently in negotiations with the NDEP Bureau of Corrective Actions (BCA) with regards to the Long Term Groundwater Monitoring Plan for the CAMU. We have a placeholder Attachment for this Plan (Attachment Y) which will be submitted once discussions with the BCA are completed.

With regards to future land use on the final cover of the CAMU, as the NDEP is aware, a solar collection field is planned for installation. This system will be installed and maintained by a party other than BRC, subject to a land lease agreement with BRC. The land lease between BRC and the parties will include all applicable conditions of the RAP. Whomever the solar operator may be, they will separately obtain the necessary approvals and permits to install and operate the solar field (including such permits as may be necessary from the NDEP), BRC's CAMU design engineer Geosyntec will review any proposed design to ensure it is in conformance with the CAMU cover design (Attachment AA). Attachment AA provides guidance to any solar field design for the installation and operation of a Solar field. Attachment AB provides a placeholder in which the details of the solar field design documents are located. Currently, this includes documents which have been submitted to the NDEP for review.

It is BRC's understanding, based on conversations with the NDEP, that there is no special format for this application and no forms, etc. as such. As noted above, we have updated the application materials as needed, based on relevance going forward.

Finally, we request that the NDEP issue the revised RAP, deleting conditions in the current version that are no longer appropriate for the next term.

2.0 BACKGROUND

The BRC CAMU is located within Sections 11 and 12 of Township 22 South, Range 62 East, approximately 10,000 feet west-northwest of the intersection of Lake Mead Drive and Boulder Highway and approximately 3,500 feet west-southwest of intersection of Warm Springs Road and Boulder Highway (Attachment A). The site is approximately 13 miles south of the City of Las Vegas. The BRC CAMU is located within the boundaries of the BMI Common Areas and is bordered on the north, east, and south by the BMI Industrial Complex. The BMI Industrial Complex consists of four operational plants west of Boulder Highway and north of Lake Mead Drive.

The BRC CAMU, which is approximately 55 acres, is located within a 113-acre area northwest of the active plant area of the BMI Complex (Attachment B). The separate, distinct, and existing BMI Landfills (BMI North and BMI South)occupy approximately 66 acres of this area and was initially used as effluent disposal ponds for the Basic Magnesium, Inc. magnesium refinery since its inception. Following shut-down of the refinery in November 1944, the two western-most ponds were converted to a solid waste disposal area which became known as the BMI Landfill. Use of this Landfill continued by successor operations until its closure in February 1980. As part of the current RAP, BRC has completed the closure and capping of Phases I, II, IIIA, IIIB, IV, and a portion of Phase V of the CAMU, and the entire BMI south Landfill a portion of the BMI North Landfill (Attachment X).

Immediately to the south of the BMI North Landfill, a series of slit trenches were excavated during the 1950s through 1970s. A range of refuse and industrial wastes were placed into these slit trenches, the use of which was discontinued prior to 1980. Under NDEP oversight, these wastes have been removed and placed within the CAMU in Phases II, IIIB, and IV as part of the construction of these Phases under the terms of the current RAP.

3.0 OVERVIEW

Since Phase V of the CAMU and a portion of the BMI North Landfill have not been closed, we have retained this section consistent with the previous version of this application.

This permit application addresses the requirements for a RAP, as specified in 40 CFR 270. Table 1 of this permit application includes introductory material and

citations of where each regulatory requirement is addressed in this application package. Attachment I contains site location information. Attachment R provides documentation of financial assurance.

Plans relating to Waste Characterization, Monitoring Programs, and Post-Closure are presented in Attachments C, N, and O respectively. The final design documents for the BRC CAMU are provided in Attachment K. Attachment C also includes a general discussion of the waste material to be disposed of in the remaining portions of the CAMU Phase V as well as provides summary tables of analytical data for these waste source areas.

A geotechnical evaluation of the site is presented in Section 8 of the SRAPI. The geotechnical study encompasses the proposed landfill (Borings B1 through B-12 and B-102) and Basic Environmental Company (BEC) property immediately to the west and northwest of the proposed landfill. In addition, boring logs for recent slit trench investigation work are presented in Section 8 of the SRAPI.

Attachment O includes discussion of the BRC CAMU Closure Plan with conceptual design parameters for the final cover along with supporting infiltration modeling information and conceptual design of the Final Cover System.

It should be noted that a solar collection field is planned for installation on top of the cover. This system will be installed and maintained by a party other than BRC, subject to a land lease agreement with BRC. The land lease between BRC and the parties will include all applicable conditions of the RAP. Whomever the solar operator may be, they will separately obtain the necessary approvals and permits to install and operate the solar field (including such permits as may be necessary from the NDEP), BRC's CAMU design engineer Geosyntec will review any proposed design to ensure it is in conformance with the CAMU cover design (Attachment AA). Attachment AA provides guidance to any solar field design for the installation and operation of a Solar field. Attachment AB provides a placeholder in which the details of the solar field design documents are located. Currently, this includes documents which have been submitted to the NDEP for review.

4.0 REQUIRED INFORMATION

This section outlines the information required for a RAP application, as specified in 63 FR 65942 and 40 CFR 270.110. For those requirements that call for detailed explanation or the use of drawings, reference is provided to the appropriate section or drawing within this document. Table 1 is provided as an outline of applicable regulatory requirements, with references to pertinent sections of this RAP application.

The following is a list of the RAP application questions and associated responses:

(a) The name, address, and USEPA identification number of the remediation waste management site;

BRC CAMU, Clark County, 22S/62E/11 and 12; EPA ID# NVR000082255

(b) The name, address, and telephone number of the owner and operator;

Basic Remediation Company, 875 West Warm Springs Road, Henderson, Nevada; Phone: 702-567-0400

(c) The latitude and longitude of the site;

Latitude: 36D 02M 56.23S N (36.048953 decimal degrees)
Longitude: 115D 00M 47.51S W (-115.013197 decimal degrees)

(d) The United States Geological Survey (USGS), or county map, showing the location of the remediation waste management site;

The BRC CAMU site is located on the USGS Las Vegas SE, Nevada, Clark County quadrangle map. The site location is shown on Attachment A.

(e) A scaled drawing of the remediation waste management site showing:
1. The remediation waste management site boundaries;
2. Any significant physical structures; and
3. The boundary of all areas on-site where remediation waste is to be treated, stored, or disposed.

A scaled drawing showing all the required information is provided as Attachment B.

(f) A specification of the remediation waste to be treated, stored or disposed of at the facility or remediation waste management site. This must include information on:

1. Constituent concentrations and other properties of the remediation wastes that may affect how such materials should be treated and/or otherwise managed;

   Properties and constituent concentrations of the waste materials placed or to be placed in the BRC CAMU are provided in Attachment C of this document, entitled "Waste Analysis Plan".

2. An estimate of the quantity of these wastes; and

   As noted in Attachment C, the estimated quantity of waste material is approximately 3.7 million cubic yards. However, based on post-excavation confirmation sampling and removal of wastes from the remediation areas, the final quantity of waste materials will likely be around 4.1 million cubic yards.

3. A description of the processes you will use to treat, store, or dispose of this waste, including technologies, handling systems, design and operating parameters you will use to treat hazardous remediation wastes before disposing of them according to the Land Disposal Restrictions (LDR) standards of part 268 of this chapter, as applicable.

   The process to be used in handling and disposal of the waste is outlined in Attachments C through P of this RAP permit application.

(g) Enough information to demonstrate that operations that follow the provisions in your RAP application will ensure compliance with applicable requirements of parts 264, 266, and 268 of this chapter;

Table 1 is provided as an outline of the applicable regulatory requirements, with references to pertinent sections of this RAP application, which demonstrate compliance.

(h) Such information as may be necessary to enable the Regional Administrator to carry out his duties under other Federal laws, as is required for traditional RCRA permits under 270.14(b)(20);

This RAP permit application is intended to provide sufficient information to enable the Regional Administrator to carry out his/her duties under other Federal Law, as is required for traditional RCRA permits under 270.14(b)(20).

(i) Any other information the Director decides is necessary for demonstrating compliance with this subpart or for determining any additional RAP conditions that are necessary to protect human health and the environment.

This RAP permit application is intended to provide sufficient information regarding siting, design, and operation to determine compliance with RAP conditions that are necessary to protect human health and the environment.

5.0 REFERENCES

BRC, 2006, "Corrective Action Plan (CAP) for the Basic Remediation Company (BRC) Common Areas Remediation Project," Henderson, Nevada, September

ERM, 1999, "Preliminary Draft Remedial Action Alternatives Study BMI Common Areas, Clark County, Nevada," Prepared for Henderson Industrial Steering Committee. April, 30.

ERM, March 2000, "Remedial Alternatives Study for Soils and Sediments in the Upper and Lower Ponds at the BMI Complex."

Geosyntec, 2006, "Revised Draft Remedial Action Plan (RAP) Permit Application for Corrective Action Management Unit (CAMU), Henderson, Nevada," March.

Geosyntec, 2007, "Revised Draft Remedial Action Plan (RAP) Permit Application for Corrective Action Management Unit (CAMU), Henderson, Nevada," March.

"Record of Decision, Remediation of Soils and Sediments in the Upper and Lower Ponds at the BMI Complex, Henderson, Nevada, Bureau of Correction Actions," Nevada Division of Environmental Protection, November 02, 2001.

Tables

Table 1
Regulatory Requirements
BRC CAMU
Henderson, Nevada

Reference				Description/Comments	Location
270.105				Owner and operator signature and certification	Cover Letter
270.11					
a				name, address, EPA ID # of site	Page 5
b				Name, address, and telephone number of the owner and operator	Page 5
c				The latitude and longitude of the site	Page 5
d				USGS or county map showing the location of the RWMS	Attachment A
e				Scaled Drawing	Attachment B
		1		Remediation waste management site boundaries	Attachment B
		2		Significant physical structures	Attachment B
		3		Boundary of all area where remediation waste is to be disposed	Attachment B
f				Specification of the hazardous remediation waste to be treated, stored, or disposed of at the facility or RWMS	Waste Analysis Plan (Attachment C)
		1		Constituent concentrations and other properties relevant to how materials should be treated or otherwise managed	Waste Analysis Plan (Attachment C)
		2		Estimate of the quantity of these wastes	Waste Analysis Plan (Attachment C)
		3		Description of the process (if any) used to treat material before disposing according to applicable LDR standards of part 268	Waste Analysis Plan (Attachment C)
g				Information to demonstrate that operations that follow the provisions in the RAP application will ensure compliance with the applicable requirements of parts 264, 266, and 268	See sublistings below
	264 Subpart A			Subpart A of 264 excuses this site from the requirements of Subpart B, C, and D of 264. The site will comply with the requiremetns of 264.1(j) instead	
	264.1(j)(1)			Obtain EPA ID number	Page 5
	264.1(j)(2)			Obtain detailed chemical and physical analysis of wastes to be managed at the site	Waste Analysis Plan (Attachment C)
	264.1(j)(3)			Prevent inadvertent or deliberate access to site by unauthorized people or livestock	Security Plan (Attachment D)
	264.1(j)(4)			Inspect site for malfunctions, deterioration, etc. that may cause or lead to release of hazardous waste constituents to the environment, etc.	Inspection Plan (Attachment E)
	264.1(j)(5)			Provide personnel training on how to perform duties and respond effectively to emergencies	Personnel Training Plan (Attachment F)
	264.1(j)(6)			Take precautions to prevent accidental ignition or reaction of ignitable or reactive waste, and mixing of incompatible waste	Accident Prevention, Contingency, and Emergency Response Plan (Attachment G)
	264.1(j)(7)			Floodplain documentation	Figure I-1 (Attachment I)
	264.1(j)(8)			No placement of waste in salt dome or underground mine or cave	Not Applicable

Table 1
Regulatory Requirements
BRC CAMU
Henderson, Nevada

	264.1(j)(9)	Develop and maintain a construction quality assurance program for CAMU landfills	Landfill Design, Construction, and Operation Plan (Attachment L)
	264.1(j)(10)	Develop and maintain procedures to prevent accidents and a contingency and emergency plan to control accidents that occur	Accident Prevention, Contingency, and Emergency Response Plan (Attachment G)
	264.1(j)(11)	Emergency coordinator/designee	Accident Prevention, Contingency, and Emergency Response Plan (Attachment G)
	264.1(j)(12)	Develop, maintain, and implemnet a plan to meet the requirements in paragraphs (j)(2) through (j)(6) and (j)(9) through (j)(10) of 264.1	See respective plans
	264.1(j)(13)	Maintain records documenting compliance with paragraphs (j)(1) through (j)(12) of 264.1	Recordkeeping and Reporting Plan (Attachment T)
	264 Subpart B	Not Applicable	
	264 Subpart C	Not Applicable	
	264 Subpart D	Not Applicable	
	264 Subpart E	Recordkeeping and Reporting	Recordkeeping and Reporting Plan (Attachment T)
	264 Subpart F	Releases from Soild Waste Management Units	
	264 Subpart G	Closure and Post Closure	Closure and Post Closure Plan (Attachment O)
	264 Subpart H	Financial Requirements	Financial Assurance Plan (Attachment R)
	264 Subpart I - M	Not Applicable	
	264 Subpart N	Landfills	Landfill Design, Construction, and Operation Plan (Attachment J, L, M)
	264.301(a)	Not Applicable	
	264.301(b)	Not Applicable	
	264.301(c)	See 264.301(d) instead	
	264.301(d)	Alternative design and operating practices	Landfill Design, Construction, and Operation Plan (Attachment J, L, M)
	264.301(e)	Double liner waiver	Landfill Design, Construction, and Operation Plan (Attachment J, L, M)
	264.301(f)	Not Applicable	

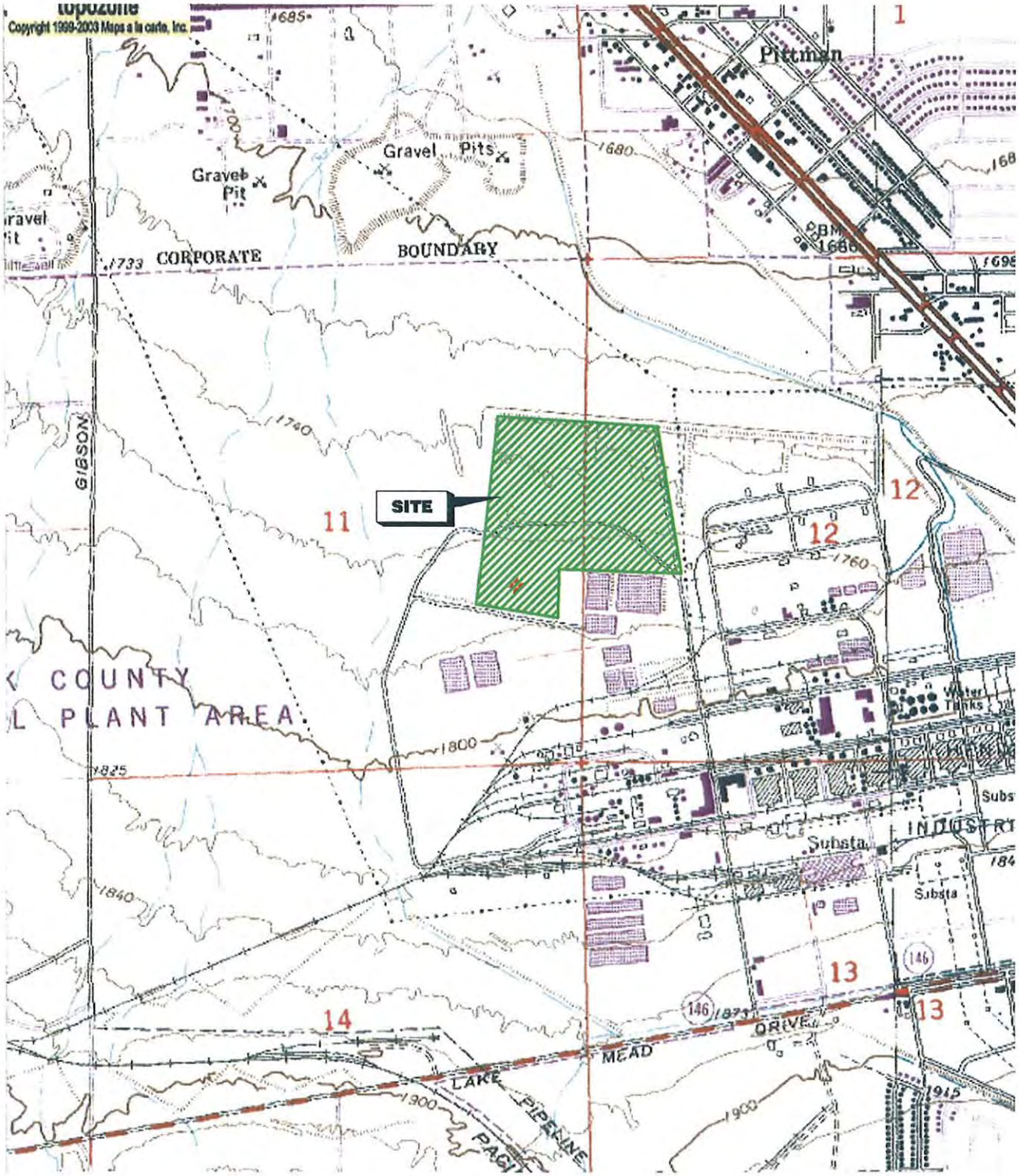
Table 1
Regulatory Requirements
BRC CAMU
Henderson, Nevada

	264.301(g)			Run-on control system	Landfill Design, Construction, and Operation Plan (Attachment J, L, M)
	264.301(h)			Run-off control system	Landfill Design, Construction, and Operation Plan (Attachment J, L, M)
	264.301(i)			Collection and holding facilities for run-on and run-off control systems	Landfill Design, Construction, and Operation Plan (Attachment J, L, M)
	264.301(j)			Wind Dispersal/dust control	Operation Plan (Attachment M)
	264.301(k)				
	264.301(l)			Not Applicable	
	O-R				
	S			Special Provisions for Cleanup	
	264.552(a)			CAMU-eligibility of waste/contiguousness of property/prohibition of liquids	
	264.552(b)			Not Applicable	
	264.552(c)			NDEP will address in RAP permit	
	264.552(d)			Sufficient information to enable NDEP to designate a CAMU	
		1		Origin of waste and how it was subsequently managed (including a description of the timing and circumstances surrounding the disposal and/or release)	Waste Analysis Plan (Attachment C)
		2		Whether the waste was listed or identified as hazardous at the time of disposal and/or release	Waste Analysis Plan (Attachment C)
		3		Whether the disposal and/or release of the waste occurred before or after the land disposal requirements of part 268 were in effect	Waste Analysis Plan (Attachment C)
	264.552(e)				
		1		Aerial configuration of CAMU	Attachment B
		2		Specification of CAMU-eligible wastes	Waste Analysis Plan (Attachment C)
		3		Minimum design requirements	Landfill Design (Attachment J)
		4		Minimum treatment requirements	Waste Analysis Plan (Attachment C)
			i	Principal hazardous constituents (PHCs)	Waste Analysis Plan (Attachment C)
			ii	PHCs vs. Universal Treatment Standards	Waste Analysis Plan (Attachment C)
			iii	Demonstration/acknowledgement of PHCs subject to UTS	Waste Analysis Plan (Attachment C)
			iv	Treatment Standards for wastes placed in CAMU	Waste Analysis Plan (Attachment C)

Table 1
Regulatory Requirements
BRC CAMU
Henderson, Nevada

			v	Adjusted standards	Waste Analysis Plan (Attachment C)
			vi	Treatment Timeline/location	Waste Analysis Plan (Attachment C)
			vii	CAMU Closure	Closure and Post Closure Plan (Attachment O)
		5		Requirements for groundwater monitoring and corrective action	Monitoring Plan (Attachment N)
		6		Closure and Post Closure Requirements	
			i	Design elements and procedures to minimize need for further maintenance and to control or eliminate escape of hazardous constituents (including leachate) to the ground, air, surface, and/or groundwater	Landfill Design, Construction, and Operation Plan (Attachment J, L, M)
			ii	Requirements for excavation, removal, treatment, or containment of waste. Requirement and procedures for removal and decontamination of equipment, devices, and structures used in material management activities (include surveying, excavation, transportation, and placement of waste material).	Operating Plan; Closure and Post-Closure Plan (Attachments M, O)
			iii	Specific Requirements based on CAMU characteristics, volumes, characteristics of waste, potential for release	WAP, Closure and Post-Closure Plan (Attachment C, O)
			iv	Cap Requirements	
			v	Post-Closure Requirements	Closure and Post Closure Plan (Attachment O)
	264.552(f)			Not Applicable	
	264.552(g)			Not Applicable	
	264.552(h)			Will be addressed by NDEP in RAP Permit	
	264.552(i)			Will be addressed by NDEP in RAP Permit	
	264.552(j)			Not Applicable	
	264.552(k)			Will be addressed by NDEP in RAP Permit	
	T-EE			Not Applicable	
	266			Not Applicable	
	268.5			LDR treatment Standards [see 264.442(e)(4)]	Waste Analysis Plan (Attachment C)
	268.5			Alternative LDR treatment standards for contaminated soil	Waste Analysis Plan (Attachment C)
h				Information to enable Administration to carry out duties under other Federal laws as required under 270.14(b)(20)	Attachment U
i				Other information the Director decides is necessary for compliance with 270 Subpart H or determining any additional RAP conditions that are necessary to protect human health and the environment	Attachment V

Attachment A
Drawing 1
USGS/County Map



NOT TO SCALE

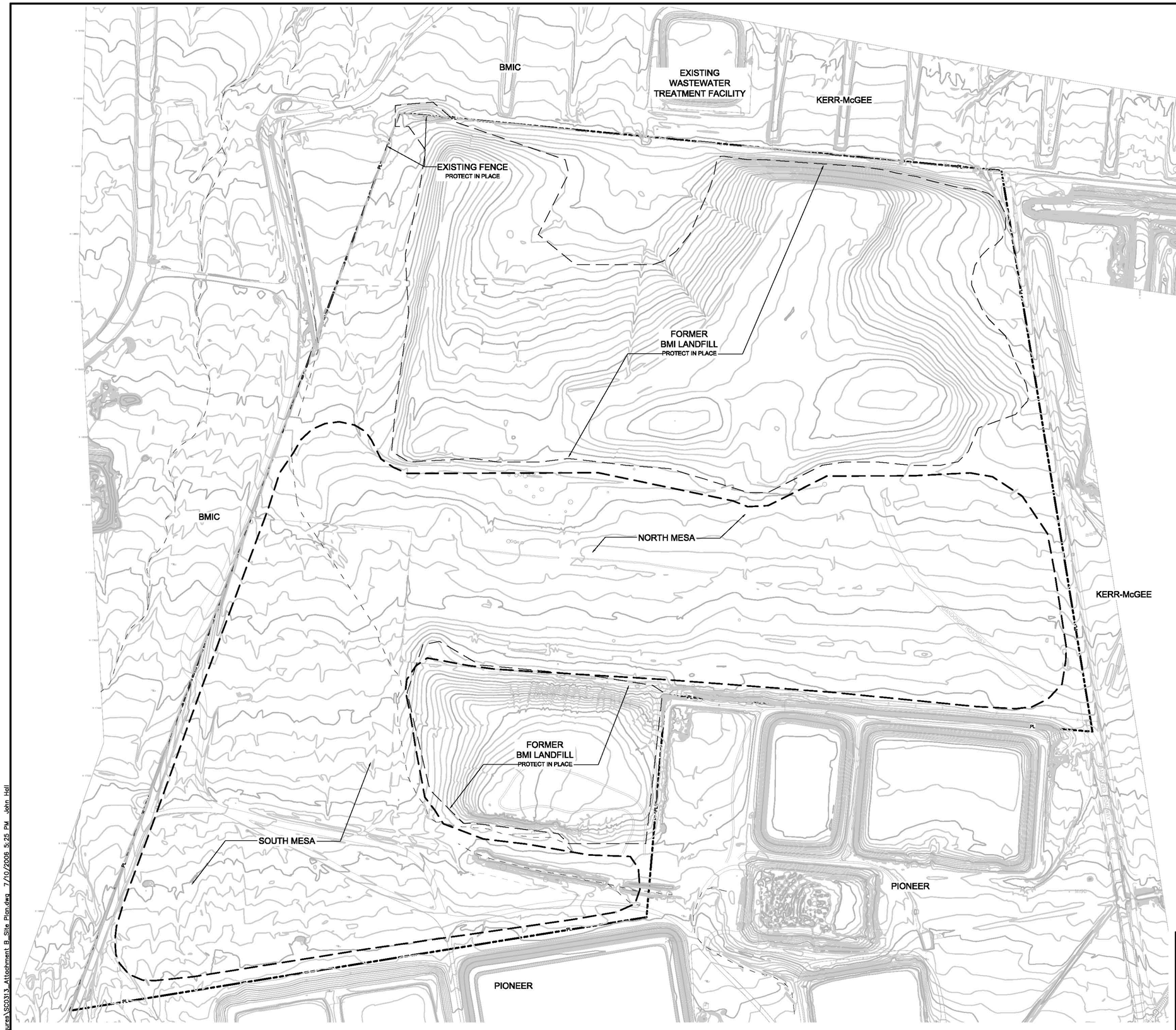
GEOSYNTEC CONSULTANTS

USGS LAS VEGAS SE QUADRANGLE
BRC CAMU
HENDERSON, CALIFORNIA

FIGURE NO.	ATTACHMENT A
PROJECT NO.	SC0313
DATE:	NOVEMBER 2006

P:\PRJ\SDCadd\CADD\SC0313\BRC\figures\SC0313_Attachment A_Site Location.dwg 7/10/2006 5:25 PM John Hall

Attachment B
Drawing 2
Scaled Drawing



LEGEND

- PL — BRC LANDFILL SITE BOUNDARY
- EXISTING LIMITS OF FORMER BMI LANDFILL
- EXISTING SURFACE WATER FLOW PATH
- EXISTING MINOR ELEVATION CONTOUR
- EXISTING MAJOR ELEVATION CONTOUR
- PROPOSED LIMIT OF WASTE

N

100 50 0 100 200

SCALE IN FEET

GEOSYNTEC CONSULTANTS
10875 RANCHO BERNARDO ROAD, SUITE 200
SAN DIEGO, CALIFORNIA 92127
TELEPHONE: (858) 674-6559

PROJECT: BRC CAMU
HENDERSON/CLARK COUNTY NEVADA

TITLE: ATTACHMENT B

MARK	DATE	REVISION	BY	APPROVED

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

SIGNATURE

DATE

SEAL

DATE:	NOVEMBER 2006	SCALE:	AS SHOWN
DESIGN BY:	G.T.C.	JOB NO.:	SC0313
DRAWN BY:	J.R.H.	FILE NO:	
CHECKED BY:	G.T.C.	DOCUMENT NO:	
REVIEWED BY:	G.T.C.	DRAWING NO:	
APPROVED BY:	G.T.C.		

P:\PRJ\SDCadd\CADD\SC0313\BRC\figures\SC0313_Attachment B_Site Plan.dwg 7/10/2006 5:25 PM John Hall

Attachment C
Waste Analysis Plan

Attachment C
Waste Analysis Plan
Basic Remediation Company (BRC)
Corrective Action Management Unit (CAMU)
Henderson, Nevada

(No Changes Have Been Made to This Attachment)

Table of Contents

1.0 Introduction.....C-1
2.0 Investigative History.....C-1
3.0 Results.....C-4
4.0 References.....C-5

List of Tables

Table C-1 Site-Related Chemicals - Universal Treatment Standards
Table C-2 Waste Characterization Composite Sampling
Table C-3 Waste Characterization Sampling Summary Table
Table C-4 Comparison of Detected Chemical Concentrations with UTS Levels
Table C-5 Estimated Waste Volumes, By Location

List of Figures

Figure C-1 Waste Areas and Depths
Figure C-2 Waste Characterization Sample Locations
Figure C-3A Individual Composite Sample Locations (East)
Figure C-3B Individual Composite Sample Locations (West)
Figure C-3C Individual Composite Sample Locations (North)
Figure C-4 Waste Areas and Waste Volumes

1.0 INTRODUCTION

The Basic Remediation Company (BRC) site-related chemicals (SRC) list, as approved by the Nevada Division of Environmental Protection (NDEP), currently includes a wide range of analytes, including many chemicals with universal treatment standards (UTS), as defined in Code of Federal Regulations (CFR) Title 40, Chapter 268.48 (40 CFR 268.48). The UTS list, with those constituents on the BRC SRC list identified, is shown in Table C-1. All areas where wastes are present or may be present based on visual evidence and an understanding of the Conceptual Site Model (CSM), along with measured or anticipated waste depths, are shown on Figure C-1. Although additional remediation may be required in areas not shown in order to meet project risk goals, wastes are not present in discernable quantities in other areas; therefore, sampling in areas not shown as containing wastes in Figure C-1 would not provide a realistic representation of waste composition (i.e., any samples collected will be unavoidably diluted with non-waste soils, thus rendering them unrepresentative of waste materials). Although sporadic waste sampling efforts have been conducted in the past within the BMI Common Areas, the recent Waste Sampling and Analysis effort in 2006 was a systematic attempt to characterize the wastes present in the Common Areas. This recent round of sampling also utilized the final SRC list for the BMI Common Areas, thereby providing the largest number of analytes for analysis. Thus, this most recent sampling provides the most complete characterization of the wastes and is summarized in this Attachment. It should be noted, however, that since these waste sampling results reflect the condition of the wastes as they are present in the source areas, there is likely to be some unavoidable commingling of wastes and non-waste materials during removal actions leading to dilution – thus, the characteristics of the wastes prior to placement in the CAMU may therefore be somewhat different. In this respect the results presented and discussed in this Attachment are conservative.

2.0 INVESTIGATIVE HISTORY

The 2006 waste characterization investigation, pursuant to an approved workplan by NDEP, focused on areas within the BMI Common Areas (Eastside) where wastes are located. Each of the samples collected from these areas was a composite grab sample in order to provide a representative concentration of the wastes present. Details of this compositing approach are shown in Table C-2 and Figure C-2, and Figures C-3A through C-3C.

The methodology for the solid matrix samples and waste water sample were in accordance with the project Field Sampling and Standard Operating Procedures (FSSOP; BRC and MWH 2006a) for surface and subsurface soil sample collection, including pre-field activities. The project Health and Safety Plan (HSP; BRC and MWH 2005) and Quality Assurance Project Plan (QAPP; BRC and MWH 2006b) prepared for the BMI

Common Areas were also used for this work. All work was completed under the direction of a State of Nevada Certified Environmental Manager (CEM).

The vast majority of the wastes present are soils and sediments; however, for completeness BRC also sampled the only wastewater present – namely in the TIMET Pond SW-12. This pond and the other TIMET ponds are no longer in service and the free water contained therein are evaporating. The primary purpose of the sampling effort was to (a) complete characterization of the remedial wastes in order to address certain regulatory requirements pertaining to their anticipated excavation and placement into the proposed CAMU; and (b) to assist with continued development of the BMI Common Areas (Eastside) CSM.

Waste characterization was performed to determine whether excavated materials comply with minimum treatment requirements (MTRs) prior to placement into a land disposal unit. As such the Waste Sampling and Analysis Plan (BRC, 2006) that was prepared and approved by the NDEP, with incorporated comments, complied with and was intended to support regulations at 40 CFR 270.110(f); 40 CFR 264(1)(j)(2); 40 CFR 264.552(d); 40 CFR 264.552(e)(2)&(4); and 40 CFR 268.49 (U.S. Environmental Protection Agency [USEPA] 2005).

Samples were collected from the following areas:

- Alpha ditch: composite samples were collected from three locations along the length of the alpha ditch. Each of the three sample locations consisted of composite samples from three equidistant locations (50 feet apart) and from two depths each.

- Beta ditch: composite samples were collected from three locations along the length of the beta ditch. Each of the three sample locations consisted of composite samples from three equidistant locations (50 feet apart) and from three depths each.

- IRM soil holding ponds: a single composite sample was collected from each of the IRM holding ponds – these are seven of the Upper Ponds. Each IRM holding pond sample consisted of composite samples from two locations within the holding pond and from two depths each. Since these ponds are capped for dust mitigation purposes, the upper sampling interval was below the cap.

- Mohawk area: a single composite sample was collected which consisted of samples from ponds PUE-01, PUE-02, PUF-01, and PUF-02 collected from surface soils.

- No-build area: three composite samples were collected which consisted of samples from ponds within the no-build area footprint. Each no-build area sample consisted of composite samples from four to five ponds each (as discussed in Table C-2) collected from surface soils.

- Sunset North area: a single composite sample was collected which consisted of samples from ponds west of the no-build area (as discussed in Table C-2) collected from surface soils. These ponds have undergone previous IRM activities.

- Spray Wheel: two composite samples were collected which consisted of samples from ponds with sediments within the Spray Wheel area. Each Spray Wheel sample consisted of composite samples from three to four ponds (as discussed in Table C-2) collected from two depths each.

- TIMET abandoned test pit: a single composite sample was collected which consisted of two samples from within the test pit footprint and from two depths each.

- Former Espey Construction site: a single composite sample was collected which consisted of two samples from within the construction site footprint and from two depths each.

- Other TIMET debris areas: a single composite sample was collected which consisted of samples from four areas identified as debris or storage areas (other than TIMET ponds, test pit or Espey Construction site). The other debris composite sample consisted of one sample from each of the four locations and from two depths each.

- TIMET berms: four composite samples were collected from berms between each of the TIMET ponds. Each sample consisted of composite samples from three locations from two depths each. Although the berms have not received any TIMET wastes, they were constructed via grading of historic BMI ponds located in this area.

- TIMET OPW ponds: two composite samples were collected which consisted of samples from each OPW pond. Each OPW pond sample consisted of composite samples from six to eight ponds each collected from two depths each. Only two samples were collected since the nature of the OPW wastes deposited in these ponds is uniform. A separate sample was collected from OPW Pond #12 since TIMET used this pond for disposal of lime bottoms. A single composite sample was collected consisting of samples from two locations within this pond and from two depths each.

- TIMET ponds: a single composite sample was collected from each of the 16 TIMET ponds. Each TIMET pond sample consisted of two composite samples from within the pond collected from two depths each. In addition, a wastewater sample was collected from Pond SW-12.

- Upper ponds: composite samples were collected, which consisted of samples from each of first seven upper pond rows from ponds with sediment (one composite sample per row). Each upper pond sample consisted of composite samples from four to six ponds each (as discussed in Table C-2) collected from two depths each.

Field sampling was conducted from July 26 through August 9, 2006. Through this effort, 53 soil samples and one sediment sample were collected for analyses, which were composited from 300 individual sample locations. A separate Data Validation

Summary Report (Dataset #39) was prepared and submitted to NDEP (BRC and MWH 2006c). This report was approved by the NDEP in November 2006. This report contains an electronic version of the waste characterization sampling database. Table C-3 summarizes the results of this investigation.

Table C-5 shows the estimated impacted soil volumes associated with the various waste areas. Figure C-4 shows the waste area locations.

3.0 RESULTS

A summary of the results of the waste sampling and analysis is provided in Table C-4. This table presents the minimum and maximum detected concentrations for each of the SRCs with a listed UTS, as defined in 40 CFR 268.48. The chemical-specific UTS times 10 and the chemicals that have been detected in concentrations that exceed 10 times their UTS are also indicated in Table C-4. Those chemicals with maximum concentrations that exceed 10 times their UTS are also compared to: 1) a potential carcinogenic direct risk from ingestion or inhalation at the site at or above 10^{-3}, and 2) a non-carcinogenic direct risk from ingestion or inhalation at the site an order of magnitude or greater over their reference dose. As discussed by USEPA (2002), hazard quotients are used as a measure of unacceptable exposure to constituents that produce toxic endpoints other than cancer.

USEPA Region 9 preliminary remediation goals (PRGs) tables provide exposure pathway-specific risk-based comparison values (USEPA 2004). These tables provide values for both carcinogenic and non-carcinogenic risks. If a particular chemical has both carcinogenic and non-carcinogenic toxicity criteria, these tables provide values for both these endpoints. Therefore, USEPA Region 9 residential PRGs for both carcinogenic and non-carcinogenic risks for the combined ingestion and inhalation exposure pathways were used in this analysis. Because PRGs for carcinogens are based on a cancer risk level of 10^{-6}, the values in the PRG tables were multiplied by 1,000 to obtain a 10^{-3} risk level. PRGs for non-carcinogens, which are based on a hazard quotient of 1, were multiplied by 10. These adjusted PRG values are shown in Table C-4 for those chemicals that exceeded 10 times their UTS. These chemicals were 2,4'-DDE, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, beta-BHC, 1,2,3,4,6,7,8-HpCDD, 1,2,3,4,6,7,8-HpCDF, 1,2,3,4,7,8,9-HpCDF, OCDD, and OCDF. Because PRG values were not available for 2,4'-DDE, values for 4,4'-DDE were used as a surrogate. PRG values for each of the dioxin congeners were obtained by multiplying the PRG for 2,3,7,8-TCDD by each congener's respective toxicity equivalency factor (TEF). All of the chemicals are considered carcinogens and have PRGs for carcinogenic risks. 4,4'-DDT and beta-BHC also have PRGs for non-carcinogenic risks. As indicated in Table C-4, none of these chemicals equal or exceed either a potential carcinogenic direct risk from ingestion or inhalation of 10^{-3}, nor a non-carcinogenic direct risk from ingestion or inhalation an order

of magnitude or greater over their reference dose. Therefore, all of the waste materials in the Eastside meet the UTS/MTR requirements.

4.0 REFERENCES

Basic Remediation Company (BRC). 2006. Sampling and Analysis Plan for Waste Characterization, BMI Common Areas (Eastside), Clark County, Nevada. June 29.

Basic Remediation Company (BRC) and MWH. 2005. BRC Health and Safety Plan, BMI Common Areas, Clark County, Nevada. October.

Basic Remediation Company (BRC) and MWH. 2006a. BRC Field Sampling and Standard Operating Procedures, BMI Common Areas, Clark County, Nevada. May.

Basic Remediation Company (BRC) and MWH. 2006b. BRC Quality Assurance Project Plan, BMI Common Areas, Clark County, Nevada. April.

Basic Remediation Company (BRC) and MWH. 2006c. Data Validation Summary Report, 2006 Waste Characterization Investigation (Dataset 39), BMI Common Areas (Eastside), Clark County, Nevada. October.

U.S. Environmental Protection Agency (USEPA). 2002. Amendments to the Corrective Action Management Unit Rule; Final Rule. Federal Register, Vol. 67, No. 14. January 22.

U.S. Environmental Protection Agency (USEPA). 2004. Preliminary Remediation Goals (PRGs), Region 9. Website: www.epa.gov/region09/waste/sfund/prg/index.html.

U.S. Environmental Protection Agency (USEPA). 2005. Code of Federal Regulations (CFR) Title 40.

TABLE C-1
SITE-RELATED CHEMICALS - UNIVERSAL TREATMENT STANDARDS
(Page 1 of 11)

Parameter of Interest	Analytical Method	Compound List	CAS Number	Universal Treatment Standard		
				Wastewater	Nonwastewater	
				mg/L	mg/kg	mg/L TCLP
Ions	EPA 300.0	Bromide	24959-67-9	NA	NA	NA
		Bromine	7726-95-6	NA	NA	NA
		Chlorate	14866-68-3	NA	NA	NA
		Chloride	16887-00-6	NA	NA	NA
		Chlorine (soluble)	7782-50-5	NA	NA	NA
		Chlorite	14998-27-7	NA	NA	NA
		Fluoride	16984-48-8	35	NA	NA
		Nitrate (as N)	14797-55-8	NA	NA	NA
		Nitrite (as N)	14797-65-0	NA	NA	NA
		Orthophosphate	14265-44-2	NA	NA	NA
		Sulfate	14808-79-8	NA	NA	NA
	EPA 377.1	Sulfite	14265-45-3	NA	NA	NA
	EPA 314.0	Perchlorate	14797-73-0	NA	NA	NA
Dissolved Gases	RSK 175	Ethane	74-84-0	NA	NA	NA
		Ethylene	74-85-1	NA	NA	NA
		Methane	74-82-8	NA	NA	NA
Chlorinated Compounds	EPA 551.1	Chloral	75-87-6	NA	NA	NA
		Dichloroacetaldehyde	79-02-7	NA	NA	NA
Polychlorinated Dibenzodioxins/ Dibenzofurans	EPA 8290	1,2,3,4,6,7,8,9-Octachlorodibenzofuran	39001-02-0	0.000063	0.005	NA
		1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin	3268-87-9	0.000063	0.005	NA
		1,2,3,4,6,7,8-Heptachlorodibenzofuran	67562-39-4	0.000035	0.0025	NA
		1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	35822-46-9	0.000035	0.0025	NA
		1,2,3,4,7,8,9-Heptachlorodibenzofuran	55673-89-7	0.000035	0.0025	NA
		1,2,3,4,7,8-Hexachlorodibenzofuran	70648-26-9	NA	NA	NA
		1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	39227-28-6	NA	NA	NA
		1,2,3,6,7,8-Hexachlorodibenzofuran	57117-44-9	NA	NA	NA
		1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	57653-85-7	NA	NA	NA
		1,2,3,7,8,9-Hexachlorodibenzofuran	72918-21-9	NA	NA	NA
		1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	19408-74-3	NA	NA	NA
		1,2,3,7,8-Pentachlorodibenzofuran	57117-41-6	NA	NA	NA
		1,2,3,7,8-Pentachlorodibenzo-p-dioxin	40321-76-4	NA	NA	NA
		2,3,4,6,7,8-Hexachlorodibenzofuran	60851-34-5	NA	NA	NA
		2,3,4,7,8-Pentachlorodibenzofuran	57117-31-4	NA	NA	NA
		2,3,7,8-Tetrachlorodibenzofuran	51207-31-9	NA	NA	NA
		2,3,7,8-Tetrachlororodibenzo-p-dioxin	1746-01-6	NA	NA	NA
Asbestos	Elutriator/TEM	Asbestos	1332-21-4	NA	NA	NA
General Chemistry Parameters	EPA 350.2	Ammonia (as N)	7664-41-7	NA	NA	NA
	EPA 9010/9014	Cyanide (Total)	57-12-5	1.2	590	NA
	EPA 345.1	Iodine	7553-56-2	NA	NA	NA
	EPA 9045C	pH in soil	pH	NA	NA	NA

TABLE C-1
SITE-RELATED CHEMICALS - UNIVERSAL TREATMENT STANDARDS
(Page 2 of 11)

Parameter of Interest	Analytical Method	Compound List	CAS Number	Universal Treatment Standard		
				Wastewater	Nonwastewater	
				mg/L	mg/kg	mg/L TCLP
General Chemistry Parameters	EPA 9040B	pH in water	pH	NA	NA	NA
	EPA 376.1/376.2	Sulfide	18496-25-8	14	NA	NA
	Mod. EPA 415.1	Total inorganic carbon	7440-44-0	NA	NA	NA
	EPA 351.2	Total Kjeldahl nitrogen (TKN)	TKN	NA	NA	NA
	EPA 415.1	Total organic carbon (TOC)	7440-44-0	NA	NA	NA
Metals	EPA 6020/6010B	Aluminum	7429-90-5	NA	NA	NA
		Antimony	7440-36-0	1.9	NA	1.15
		Arsenic	7440-38-2	1.4	NA	5
		Barium	7440-39-3	1.2	NA	21
		Beryllium	7440-41-7	0.82	NA	1.22
		Boron	7440-42-8	NA	NA	NA
		Cadmium	7440-43-9	0.69	NA	0.11
		Calcium	7440-70-2	NA	NA	NA
		Chromium	7440-47-3	2.77	NA	0.6
		Cobalt	7440-48-4	NA	NA	NA
		Copper	7440-50-8	NA	NA	NA
		Iron	7439-89-6	NA	NA	NA
		Lead	7439-92-1	0.69	NA	0.75
		Lithium	1313-13-9	NA	NA	NA
		Magnesium	7439-95-4	NA	NA	NA
		Manganese	7439-96-5	NA	NA	NA
		Molybdenum	7439-98-7	NA	NA	NA
		Nickel	7440-02-0	3.98	NA	11
		Niobium	7440-03-1	NA	NA	NA
		Palladium	7440-05-3	NA	NA	NA
		Phosphorus	7723-14-0	NA	NA	NA
		Platinum	7440-06-4	NA	NA	NA
		Potassium	7440-09-7	NA	NA	NA
		Selenium	7782-49-2	0.82	NA	5.7
		Silicon	7440-21-3	NA	NA	NA
		Silver	7440-22-4	0.43	NA	0.14
		Sodium	7440-23-5	NA	NA	NA
		Strontium	7440-24-6	NA	NA	NA
		Sulfur	7704-34-9	NA	NA	NA
		Thallium	7440-28-0	1.4	NA	0.2
		Tin	7440-31-5	NA	NA	NA
		Titanium	7440-32-6	NA	NA	NA
		Tungsten	7440-33-7	NA	NA	NA
		Uranium	7440-61-1	NA	NA	NA
		Vanadium	7440-62-2	4.3	NA	1.6

TABLE C-1
SITE-RELATED CHEMICALS - UNIVERSAL TREATMENT STANDARDS
(Page 3 of 11)

Parameter of Interest	Analytical Method	Compound List	CAS Number	Universal Treatment Standard		
				Wastewater	Nonwastewater	
				mg/L	mg/kg	mg/L TCLP
Metals		Zinc	7440-66-6	2.61	NA	4.3
		Zirconium	7440-67-7	NA	NA	NA
	EPA 7196A	Chromium (VI)	18540-29-9	NA	NA	NA
	EPA 7470/7471A	Mercury	7439-97-6	0.15	NA	0.025
Organophosphorous Pesticides	EPA 8141A	Azinphos-ethyl	264-27-19	NA	NA	NA
		Azinphos-methyl	86-50-0	NA	NA	NA
		Carbophenothion	786-19-6	NA	NA	NA
		Chlorpyrifos	2921-88-2	NA	NA	NA
		Coumaphos	56-72-4	NA	NA	NA
		Demeton-O	298-03-3	NA	NA	NA
		Demeton-S	126-75-0	NA	NA	NA
		Diazinon	333-41-5	NA	NA	NA
		Dichlorvos	62-73-7	NA	NA	NA
		Dimethoate	60-51-5	NA	NA	NA
		Disulfoton	298-04-4	0.017	6.2	NA
		EPN	2104-64-5	NA	NA	NA
		Ethoprop	13194-48-4	NA	NA	NA
		Ethyl parathion	56-38-2	0.014	4.6	NA
		Fampphur	52-85-7	0.017	15	NA
		Fenthion	55-38-9	NA	NA	NA
		Malathion	121-75-5	NA	NA	NA
		Methyl carbophenothion	953-17-3	NA	NA	NA
		Methyl parathion	298-00-0	0.014	4.6	NA
		Mevinphos	7786-34-7	NA	NA	NA
		Naled	300-76-5	NA	NA	NA
		O,O,O-Triethyl phosphorothioate (TEPP)	297-97-2	NA	NA	NA
		Phorate	298-02-2	0.021	4.6	NA
		Phosmet	732-11-6	NA	NA	NA
		Ronnel	299-84-3	NA	NA	NA
		Stirophos (Tetrachlorovinphos)	22248-79-9	NA	NA	NA
		Sulfotep	3689-24-5	NA	NA	NA
Chlorinated Herbicides	EPA 8151A	2,4,5-T	93-76-5	0.72	7.9	NA
		2,4,5-TP (Silvex)	93-72-1	0.72	7.9	NA
		2,4-D	94-75-7	0.72	10	NA
		2,4-DB	94-82-6	NA	NA	NA
		Dalapon	75-99-0	NA	NA	NA
		Dicamba	1918-00-9	NA	NA	NA

TABLE C-1
SITE-RELATED CHEMICALS - UNIVERSAL TREATMENT STANDARDS
(Page 4 of 11)

Parameter of Interest	Analytical Method	Compound List	CAS Number	Universal Treatment Standard		
				Wastewater	Nonwastewater	
				mg/L	mg/kg	mg/L TCLP
Chlorinated Herbicides	EPA 8151A	Dichloroprop	120-36-5	NA	NA	NA
		Dinoseb	88-85-7	0.066	2.5	NA
		MCPA	94-74-6	NA	NA	NA
		MCPP	93-65-2	NA	NA	NA
Organic Acids	HPLC	4-Chlorobenzene sulfonic acid	98-66-8	NA	NA	NA
		Benzenesulfonic acid	98-11-3	NA	NA	NA
		O,O-Diethylphosphorodithioic acid	298-06-6	NA	NA	NA
		O,O-Dimethylphosphorodithioic acid	756-80-9	NA	NA	NA
Nonhalogenated Organics	EPA 8015B	Ethylene glycol	107-21-1	NA	NA	NA
		Ethylene glycol monobutyl ether	111-76-2	NA	NA	NA
		Methanol	67-56-1	5.6	NA	0.75
		Propylene glycol	57-55-6	NA	NA	NA
Organochlorine Pesticides	EPA 8081A	2,4-DDD	53-19-0	0.023	0.087	NA
		2,4-DDE	3424-82-6	0.031	0.087	NA
		4,4-DDD	72-54-8	0.023	0.087	NA
		4,4-DDE	72-55-9	0.031	0.087	NA
		4,4-DDT	50-29-3	0.0039	0.087	NA
		Aldrin	309-00-2	0.021	0.066	NA
		alpha-BHC	319-84-6	0.00014	0.066	NA
		alpha-Chlordane	5103-71-9	0.0033	0.26	NA
		beta-BHC	319-85-7	0.00014	0.066	NA
		Chlordane	57-74-9	NA	NA	NA
		delta-BHC	319-86-8	0.023	0.066	NA
		Dieldrin	60-57-1	0.017	0.13	NA
		Endosulfan I	959-98-8	0.023	0.066	NA
		Endosulfan II	33213-65-9	0.029	0.13	NA
		Endosulfan sulfate	1031-07-8	0.029	0.13	NA
		Endrin	72-20-8	0.0028	0.13	NA
		Endrin aldehyde	7421-93-4	0.025	0.13	NA
		Endrin ketone	53494-70-5	NA	NA	NA
		gamma-BHC (Lindane)	58-89-9	0.0017	0.066	NA
		gamma-Chlordane	5103-74-2	0.0033	0.26	NA
		Heptachlor	76-44-8	0.0012	0.066	NA
		Heptachlor epoxide	1024-57-3	0.016	0.066	NA
		Methoxychlor	72-43-5	0.25	0.18	NA
		Toxaphene	8001-35-2	0.0095	2.6	NA

TABLE C-1
SITE-RELATED CHEMICALS - UNIVERSAL TREATMENT STANDARDS

Parameter of Interest	Analytical Method	Compound List	CAS Number	Universal Treatment Standard		
				Wastewater mg/L	Nonwastewater mg/kg	Nonwastewater mg/L TCLP
Polychlorinated Biphenyls (PCBs)	**EPA 8082**	Aroclor 1016	12674-11-2	0.1	10	NA
		Aroclor 1221	11104-28-2			NA
		Aroclor 1232	11141-16-5			NA
		Aroclor 1242	53469-21-9			NA
		Aroclor 1248	12672-29-6			NA
		Aroclor 1254	11097-69-1			NA
		Aroclor 1260	11096-82-5			NA
		PCB-77	32598-13-3			NA
		PCB-81	70362-50-4			NA
		PCB-105	32598-14-4			NA
		PCB-114	74472-37-0			NA
		PCB-118	31508-00-6			NA
		PCB-123	65510-44-3			NA
		PCB-126	57465-28-8			NA
		PCB-156	38380-08-4			NA
		PCB-157	69782-90-7			NA
		PCB-167	52663-72-6			NA
		PCB-169	32774-16-6			NA
		PCB-189	39635-31-9			NA
Polynuclear Aromatic Hydrocarbons	**EPA 8310**	Acenaphthene	83-32-9	NA	NA	NA
		Acenaphthylene	208-96-8	NA	NA	NA
		Anthracene	120-12-7	NA	NA	NA
		Benzo(a)anthracene	56-55-3	NA	NA	NA
		Benzo(a)pyrene	50-32-8	NA	NA	NA
		Benzo(b)fluoranthene	205-99-2	NA	NA	NA
		Benzo(g,h,i)perylene	191-24-2	NA	NA	NA
		Benzo(k)fluoranthene	207-08-9	NA	NA	NA
		Chrysene	218-01-9	NA	NA	NA
		Dibenzo(a,h)anthracene	53-70-3	NA	NA	NA
		Indeno(1,2,3-cd)pyrene	193-39-5	NA	NA	NA
		Phenanthrene	85-01-8	NA	NA	NA
		Pyrene	129-00-0	NA	NA	NA
Radionuclides	**EPA 900.0 or EPA 9310**	Gross alpha	G_Alpha	NA	NA	NA
		Gross beta	G_Beta	NA	NA	NA
	EPA 901.1/ HASL GA-01-R	Actinium-228	14331-83-0	NA	NA	NA
		Bismuth-212	14913-49-6	NA	NA	NA
		Bismuth-214	14733-03-0	NA	NA	NA
		Cobalt-57	13981-50-5	NA	NA	NA
		Cobalt-60	10198-40-0	NA	NA	NA

TABLE C-1
SITE-RELATED CHEMICALS - UNIVERSAL TREATMENT STANDARDS

Parameter of Interest	Analytical Method	Compound List	CAS Number	Universal Treatment Standard		
				Wastewater	Nonwastewater	
				mg/L	mg/kg	mg/L TCLP
Radionuclides	EPA 901.1/ HASL GA-01-R	Lead-210	14255-04-0	NA	NA	NA
		Lead-211	015816-77-0	NA	NA	NA
		Lead-212	15092-94-1	NA	NA	NA
		Lead-214	15067-28-4	NA	NA	NA
		Potassium-40	13966-00-2	NA	NA	NA
		Thallium-208	14913-50-9	NA	NA	NA
		Thorium-227	15623-47-9	NA	NA	NA
		Thorium-234	15065-10-8	NA	NA	NA
	HASL A-01-R	Thorium-232	7440-29-1	NA	NA	NA
		Thorium-228	14274-82-9	NA	NA	NA
		Thorium-230	14269-63-7	NA	NA	NA
		Uranium-233/234	13966-29-5	NA	NA	NA
		Uranium 235/236	15117-96-1	NA	NA	NA
		Uranium-238	7440-61-1	NA	NA	NA
	EPA 903.0 / 903.1	Radium-226	13982-63-3	NA	NA	NA
	EPA 904.0	Radium-228	15262-20-1	NA	NA	NA
	Quantitate from Parent or Daughter Radionuclide	Actinium-227 (from Th-227)	14952-40-0	NA	NA	NA
		Bismuth-210 (from Pb-210)	14331-79-4	NA	NA	NA
		Bismuth-211 (from Pb-211)	15229-37-5	NA	NA	NA
		Polonium-210 (from Pb-210)	13981-52-7	NA	NA	NA
		Polonium-212 (from Bi-212)	13981-52-7	NA	NA	NA
		Polonium-214 (from Bi-214)	15735-67-8	NA	NA	NA
		Polonium-216 (from Pb-212)	15756-58-8	NA	NA	NA
		Polonium-218 (from Pb-214)	15422-74-9	NA	NA	NA
		Protactinium-231 (from U-235)	14331-85-2	NA	NA	NA
		Protactinium-234 (from Th-234)	15100-28-4	NA	NA	NA
		Radium-223 (from Th-227)	15623-45-7	NA	NA	NA
		Radium-224 (from Pb-212)	13233-32-4	NA	NA	NA
		Thallium-207 (from Pb-211)	14133-67-6	NA	NA	NA
		Thorium-231 (from U-235)	14932-40-2	NA	NA	NA
Radon	FLUX	Radon-220	22481-48-7	NA	NA	NA
		Radon-222	14859-67-7	NA	NA	NA
Aldehydes	EPA 8315A	Acetaldehyde	75-07-0	NA	NA	NA
		Chloroacetaldehyde	107-20-0	NA	NA	NA
		Dichloroacetaldehyde	79-02-7	NA	NA	NA
		Formaldehyde	50-00-0	NA	NA	NA
		Trichloroacetaldehyde	75-87-6	NA	NA	NA

TABLE C-1
SITE-RELATED CHEMICALS - UNIVERSAL TREATMENT STANDARDS

Parameter of Interest	Analytical Method	Compound List	CAS Number	Universal Treatment Standard		
				Wastewater	Nonwastewater	
				mg/L	mg/kg	mg/L TCLP
Semivolatile Organic Compounds	EPA 8270C	1,2,4,5-Tetrachlorobenzene	95-94-3	0.055	14	NA
		1,2-Diphenylhydrazine	122-66-7	0.087	NA	NA
		1,4-Dioxane	123-91-1	12	170	NA
		2,2'/4,4'-Dichlorobenzil	3457-46-3	NA	NA	NA
		2,4,5-Trichlorophenol	95-95-4	0.18	7.4	NA
		2,4,6-Trichlorophenol	88-06-2	0.035	7.4	NA
		2,4-Dichlorophenol	120-83-2	0.044	14	NA
		2,4-Dimethylphenol	105-67-9	0.036	14	NA
		2,4-Dinitrophenol	51-28-5	0.12	160	NA
		2,4-Dinitrotoluene	121-14-2	0.32	140	NA
		2,6-Dinitrotoluene	606-20-2	0.55	28	NA
		2-Chloronaphthalene	91-58-7	0.055	5.6	NA
		2-Chlorophenol	95-57-8	0.044	5.7	NA
		2-Methylnaphthalene	91-57-6	NA	NA	NA
		2-Nitroaniline	88-74-4	0.27	14	NA
		2-Nitrophenol	88-75-5	0.028	13	NA
		3,3-Dichlorobenzidine	91-94-1	NA	NA	NA
		3-Nitroaniline	99-09-2	NA	NA	NA
		4,4'-Dichlorobenzil	3457-46-3	NA	NA	NA
		4-Bromophenyl phenyl ether	101-55-3	0.055	15	NA
		4-Chloro-3-methylphenol	59-50-7	0.018	14	NA
		4-Chlorophenyl phenyl ether	7005-72-3	NA	NA	NA
		4-Chlorothioanisole	123-09-1	NA	NA	NA
		4-Chlorothiophenol	106-54-7	NA	NA	NA
		4-Nitroaniline	100-01-6	0.028	28	NA
		4-Nitrophenol	100-02-7	0.12	29	NA
		Acenaphthene	83-32-9	0.059	3.4	NA
		Acenaphthylene	208-96-8	0.059	3.4	NA
		Acetophenone	98-86-2	0.01	9.7	NA
		Aniline	62-53-3	0.81	14	NA
		Anthracene	120-12-7	0.059	3.4	NA
		Azobenzene	103-33-3	NA	NA	NA
		Benzo(a)anthracene	56-55-3	0.059	3.4	NA
		Benzo(a)pyrene	50-32-8	0.061	3.4	NA
		Benzo(b)fluoranthene	205-99-2	0.11	6.8	NA
		Benzo(g,h,i)perylene	191-24-2	0.0055	1.8	NA
		Benzo(k)fluoranthene	207-08-9	0.11	6.8	NA
		Benzoic acid	65-85-0	NA	NA	NA
		Benzyl alcohol	100-51-6	NA	NA	NA

TABLE C-1
SITE-RELATED CHEMICALS - UNIVERSAL TREATMENT STANDARDS
(Page 8 of 11)

Parameter of Interest	Analytical Method	Compound List	CAS Number	Universal Treatment Standard		
				Wastewater	Nonwastewater	
				mg/L	mg/kg	mg/L TCLP
Semivolatile Organic Compounds	EPA 8270C	bis(2-Chloroethoxy)methane	111-91-1	0.036	7.2	NA
		bis(2-Chloroethyl) ether	111-44-4	0.033	6	NA
		bis(2-Chloroisopropyl) ether	108-60-1	0.055	7.2	NA
		bis(2-Ethylhexyl) phthalate	117-81-7	NA	NA	NA
		bis(Chloromethyl) ether	542-88-1	NA	NA	NA
		bis(p-Chlorophenyl) sulfone	80-07-9	NA	NA	NA
		bis(p-Chlorophenyl)disulfide	1142-19-4	NA	NA	NA
		Butylbenzyl phthalate	85-68-7	0.017	28	NA
		Carbazole	86-74-8	NA	NA	NA
		Chrysene	218-01-9	0.059	3.4	NA
		Dibenzo(a,h)anthracene	53-70-3	0.055	8.2	NA
		Dibenzofuran	132-64-9	NA	NA	NA
		Dichloromethyl ether	542-88-1	NA	NA	NA
		Diethyl phthalate	84-66-2	0.2	28	NA
		Dimethyl phthalate	131-11-3	0.047	28	NA
		Di-n-butyl phthalate	84-74-2	0.057	28	NA
		Di-n-octyl phthalate	117-84-0	0.017	28	NA
		Diphenyl disulfide	882-33-7	NA	NA	NA
		Diphenyl sulfide	139-66-2	NA	NA	NA
		Diphenyl sulfone	127-63-9	NA	NA	NA
		Fluoranthene	206-44-0	0.068	3.4	NA
		Fluorene	86-73-7	0.059	3.4	NA
		Hexachlorobenzene	118-74-1	0.055	10	NA
		Hexachlorobutadiene	87-68-3	0.055	5.6	NA
		Hexachlorocyclopentadiene	77-47-4	0.057	2.4	NA
		Hexachloroethane	67-72-1	0.055	30	NA
		Hydroxymethyl phthalimide	118-29-6	NA	NA	NA
		Indeno(1,2,3-cd)pyrene	193-39-5	0.0055	3.4	NA
		Isophorone	78-59-1	NA	NA	NA
		m,p-Cresol	106-44-5	0.77	5.6	NA
		Naphthalene	91-20-3	0.059	5.6	NA
		Nitrobenzene	98-95-3	0.068	14	NA
		N-nitrosodi-n-propylamine	621-64-7	0.4	14	NA
		N-nitrosodiphenylamine	86-30-6	0.92	13	NA
		o-Cresol	95-48-7	0.11	5.6	NA
		Octachlorostyrene	29082-74-4	NA	NA	NA
		p-Chloroaniline (4-Chloroaniline)	106-47-8	0.46	16	NA
		p-Chlorobenzenethiol	106-54-7	NA	NA	NA
		Pentachlorobenzene	608-93-5	0.055	10	NA
		Pentachlorophenol	87-86-5	0.089	7.4	NA

TABLE C-1
SITE-RELATED CHEMICALS - UNIVERSAL TREATMENT STANDARDS
(Page 9 of 11)

Parameter of Interest	Analytical Method	Compound List	CAS Number	Universal Treatment Standard		
				Wastewater	Nonwastewater	
				mg/L	mg/kg	mg/L TCLP
Semivolatile Organic Compounds	EPA 8270C	Phenanthrene	85-01-8	0.059	5.6	NA
		Phenol	108-95-2	0.039	6.2	NA
		Phthalic acid	88-99-3	0.055	28	NA
		Pyrene	129-00-0	0.067	8.2	NA
		Pyridine	110-86-1	0.014	16	NA
		Thiophenol	108-98-5	NA	NA	NA
		Tentatively Identified Compounds (TICs)		NA	NA	NA
Volatile Organic Compounds	EPA 8260B	1,1,1,2-Tetrachloroethane	630-20-6	0.057	6	NA
		1,1,1-Trichloroethane	71-55-6	0.054	6	NA
		1,1,2,2-Tetrachloroethane	79-34-5	0.057	6	NA
		1,1,2-Trichloroethane	79-00-5	0.054	6	NA
		1,1-Dichloroethane	75-34-3	0.059	6	NA
		1,1-Dichloroethene	75-35-4	0.025	6	NA
		1,1-Dichloropropene	563-58-6	NA	NA	NA
		1,2,3-Trichlorobenzene	87-61-6	NA	NA	NA
		1,2,3-Trichloropropane	96-18-4	0.85	30	NA
		1,2,4-Trichlorobenzene	120-82-1	0.055	19	NA
		1,2,4-Trimethylbenzene	95-63-6	NA	NA	NA
		1,2-Dichlorobenzene	95-50-1	0.088	6	NA
		1,2-Dichloroethane	107-06-2	0.21	6	NA
		1,2-Dichloroethene	540-59-0	NA	NA	NA
		1,2-Dichloropropane	78-87-5	0.85	18	NA
		1,3,5-Trichlorobenzene	108-70-3	NA	NA	NA
		1,3,5-Trimethylbenzene	108-67-8	NA	NA	NA
		1,3-Dichlorobenzene	541-73-1	0.036	6	NA
		1,3-Dichloropropene	542-75-6	NA	NA	NA
		1,3-Dichloropropane	142-28-9	NA	NA	NA
		1,4-Dichlorobenzene	106-46-7	0.09	6	NA
		2,2-Dichloropropane	594-20-7	NA	NA	NA
		2,2-Dimethylpentane	590-35-2	NA	NA	NA
		2,2,3-Trimethylbutane	464-06-2	NA	NA	NA
		2,3-Dimethylpentane	565-59-3	NA	NA	NA
		2,4-Dimethylpentane	108-08-7	NA	NA	NA
		2-Chlorotoluene	95-49-8	NA	NA	NA
		2-Hexanone	591-78-6	NA	NA	NA
		2-Methylhexane	591-76-4	NA	NA	NA
		2-Nitropropane	79-46-9	NA	NA	NA
		3,3-Dimethylpentane	562-49-2	NA	NA	NA
		3-Ethylpentane	617-78-7	NA	NA	NA
		3-Methylhexane	589-34-4	NA	NA	NA

TABLE C-1
SITE-RELATED CHEMICALS - UNIVERSAL TREATMENT STANDARDS
(Page 10 of 11)

Parameter of Interest	Analytical Method	Compound List	CAS Number	Universal Treatment Standard		
				Wastewater	Nonwastewater	
				mg/L	mg/kg	mg/L TCLP
Volatile Organic Compounds	EPA 8260B	4-Chlorobenzene	108-90-7	NA	NA	NA
		4-Chlorotoluene	106-43-4	NA	NA	NA
		4-Methyl-2-pentanone (MIBK)	108-10-1	0.14	33	NA
		Acetone	67-64-1	0.28	160	NA
		Acetonitrile	75-05-8	5.6	38	NA
		Benzene	71-43-2	0.14	10	NA
		Bromobenzene	108-86-1	NA	NA	NA
		Bromodichloromethane	75-27-4	0.11	15	NA
		Bromoform	75-25-2	0.63	15	NA
		Bromomethane	74-83-9	NA	NA	NA
		Carbon disulfide	75-15-0	3.8	NA	4.8
		Carbon tetrachloride	56-23-5	0.057	6	NA
		Chlorobenzene	108-90-7	0.057	6	NA
		Chlorobromomethane	74-97-5	NA	NA	NA
		Chlorodibromomethane	124-48-1	0.057	15	NA
		Chloroethane	75-00-3	0.27	6	NA
		Chloroform	67-66-3	0.046	6	NA
		Chloromethane	74-87-3	0.19	30	NA
		cis-1,2-Dichloroethene	156-59-2	NA	NA	NA
		cis-1,3-Dichloropropene	10061-01-5	0.036	18	NA
		Cymene (Isopropyltoluene)	99-87-6	NA	NA	NA
		Dibromochloroethane	73506-94-2	NA	NA	NA
		Dibromochloromethane	124-48-1	NA	NA	NA
		Dibromochloropropane	96-12-8	0.11	15	NA
		Dibromomethane	74-95-3	0.11	15	NA
		Dichloromethane (Methylene chloride)	75-09-2	0.089	30	NA
		Dimethyldisulfide	624-92-0	NA	NA	NA
		Ethanol	64-17-5	NA	NA	NA
		Ethylbenzene	100-41-4	0.057	10	NA
		Freon-11 (Trichlorofluoromethane)	75-69-4	0.02	30	NA
		Freon-113 (1,1,2-Trifluoro-1,2,2-trichloroethane)	76-13-1	0.057	30	NA
		Freon-12 (Dichlorodifluoromethane)	75-71-8	0.23	7.2	NA
		Heptane	142-82-5	NA	NA	NA
		Isoheptane	31394-54-4	NA	NA	NA
		Isopropylbenzene	98-82-8	NA	NA	NA
		m,p-Xylene	mp-XYL	NA	NA	NA
		Methyl ethyl ketone (2-Butanone)	78-93-3	0.28	36	NA
		Methyl iodide	74-88-4	0.19	65	NA
		MTBE (Methyl tert-butyl ether)	1634-04-4	NA	NA	NA
		n-Butyl benzene	104-51-8	NA	NA	NA

TABLE C-1
SITE-RELATED CHEMICALS - UNIVERSAL TREATMENT STANDARDS
(Page 11 of 11)

Parameter of Interest	Analytical Method	Compound List	CAS Number	Universal Treatment Standard		
				Wastewater	Nonwastewater	
				mg/L	mg/kg	mg/L TCLP
Volatile Organic Compounds	EPA 8260B	n-Propylbenzene	103-65-1	NA	NA	NA
		Nonanal	124-19-6	NA	NA	NA
		o-Xylene	95-47-6	NA	NA	NA
		sec-Butylbenzene	135-98-8	NA	NA	NA
		Styrene	100-42-5	NA	NA	NA
		tert-Butyl benzene	98-06-6	NA	NA	NA
		Tetrachloroethene	127-18-4	0.056	6	NA
		Toluene	108-88-3	0.08	10	NA
		trans-1,2-Dichloroethene	156-60-5	0.054	30	NA
		trans-1,3-Dichloropropene	10061-02-6	0.036	18	NA
		Trichloroethene	79-01-6	0.054	6	NA
		Vinyl acetate	108-05-4	NA	NA	NA
		Vinyl chloride	75-01-4	0.27	6	NA
		Xylenes (total)	1330-20-7	0.32	30	NA
		Tentatively Identified Compounds (TICs)		NA	NA	NA
Water Quality Parameters	EPA 120.1	Conductivity	COND	NA	NA	NA
	EPA 130.2	Hardness, total	Hardness	NA	NA	NA
	EPA 160.1	Total dissolved solids	TDS	NA	NA	NA
	EPA 160.2	Total suspended solids	TSS	NA	NA	NA
Water Quality Parameters (continued)	EPA 310.1	Alkalinity, Total (as $CACO_3$)	ALK	NA	NA	NA
		Bicarbonate alkalinity	71-52-3	NA	NA	NA
		Carbonate alkalinity	3812-32-6	NA	NA	NA
		Hydroxide alkalinity	OH-ALK	NA	NA	NA
Flashpoint	EPA 1010	Flammables	NA	NA	NA	NA
Total Petroleum Hydrocarbons	EPA 8015	Diesel	64742-46-7	NA	NA	NA
		Gasoline	8006-61-9	NA	NA	NA
		Grease	68153-81-1	NA	NA	NA
		Mineral Spirits	NA	NA	NA	NA
White Phosphorus	EPA 7580M	White phosphorus	12185-10-3	NA	NA	NA
Methyl Mercury	EPA 1630	Methyl mercury	22967-92-6	NA	NA	NA

Shaded chemicals are those with Universal Treatment Standards.
NA = not applicable; a UTS has not been established for this chemical/medium/analysis.

TABLE C-2
WASTE CHARACTERIZATION COMPOSITE SAMPLING
(Page 1 of 2)

Area / Sample ID	Spatial Composite	Depth Composite
Alpha Ditch		
WC-AD01*	composite of 3 (-50, 0, 50 feet) samples collected from along ditch	composite of samples collected from 0 and 2 feet bgs
WC-AD02	composite of 3 (-50, 0, 50 feet) samples collected from along ditch	composite of samples collected from 0 and 2 feet bgs
WC-AD03	composite of 3 (-50, 0, 50 feet) samples collected from along ditch	composite of samples collected from 0 and 2 feet bgs
Beta Ditch		
WC-BD01	composite of 3 (-50, 0, 50 feet) samples collected from along ditch	composite of samples collected from 0 , 6, and 11 feet bgs
WC-BD02	composite of 3 (-50, 0, 50 feet) samples collected from along ditch	composite of samples collected from 0, 4, and 8 feet bgs
WC-BD03	composite of 3 (-50, 0, 50 feet) samples collected from along ditch	composite of samples collected from 0, 4, and 8 feet bgs
IRM Soil Holding Areas		
WC-IM01	composite of 2 samples collected from IRM soil holding area in pond PUA-04	composite of samples collected from 2 and 4 feet bgs
WC-IM02	composite of 2 samples collected from IRM soil holding area in pond PUB-04	composite of samples collected from 2 and 4 feet bgs
WC-IM03	composite of 2 samples collected from IRM soil holding area in pond PUB-05	composite of samples collected from 2 and 4 feet bgs
WC-IM04	composite of 2 samples collected from IRM soil holding area in pond PUB-10	composite of samples collected from 2 and 4 feet bgs
WC-IM05	composite of 2 samples collected from IRM soil holding area in pond PUC-03	composite of samples collected from 2 and 4 feet bgs
WC-IM06	composite of 2 samples collected from IRM soil holding area in pond PUC-04	composite of samples collected from 2 and 4 feet bgs
WC-IM07	composite of 2 samples collected from IRM soil holding area in pond PUD-03	composite of samples collected from 2 and 4 feet bgs
Mohawk Area		
WC-MH01	composite of one sample each from ponds PUE-01, PUE-02, PUF-01, and PUF-02	composite of samples collected from 0 feet bgs
No-Build Area		
WC-NB01	composite of one sample each from ponds PLH-01, PLI-01, PLI-02, PLJ-01, and PLJ-02	composite of samples collected from 0 feet bgs
WC-NB02	composite of one sample each from ponds PLH-02, PLH-03, PLH-04, and PLI-03	composite of samples collected from 0 feet bgs
WC-NB03	composite of one sample each from ponds PLG-02 through PLG-05	composite of samples collected from 0 feet bgs
Sunset North Area		
WC-SN01	composite of one sample each from ponds PLD-10, PLE-08, PLE-09, PLF-05 through PLF-08, and PLG-06	composite of samples collected from 0 feet bgs
Spray Wheel		
WC-SW01	composite of one sample each from ponds PUE-08, PUE-09, PUF-08, and PUF-09	composite of samples collected from 0 and 2 feet bgs
WC-SW02	composite of one sample each from ponds PUF-07, PUG-08, and PUH-07	composite of samples collected from 0 and 2 feet bgs
Former Espey Construction Site		
WC-TE01	composite of two samples from footprint of former Espey Construction site	composite of samples collected from 0 and 2 feet bgs
Other TIMET Debris Areas		
WC-TD01	composite of one sample each from footprint of three other TIMET debris areas	composite of samples collected from 0 and 2 feet bgs
TIMET Abandoned Test Pit		
WC-TA01	composite of two samples from footprint of TIMET Abandoned Test Pit	composite of samples collected from 0 and 3 feet bgs

TABLE C-2
WASTE CHARACTERIZATION COMPOSITE SAMPLING
(Page 2 of 2)

Area / Sample ID	Spatial Composite	Depth Composite
TIMET Berms		
WC-TB01	composite of 3 equispaced samples from western berms between TIMET ponds	composite of samples collected from 0 and 2 feet bgs
WC-TB02	composite of 3 equispaced samples from central west berms between TIMET ponds	composite of samples collected from 0 and 2 feet bgs
WC-TB03	composite of 3 equispaced samples from central east berms between TIMET ponds	composite of samples collected from 0 and 2 feet bgs
WC-TB04	composite of 3 equispaced samples from eastern berms between TIMET ponds	composite of samples collected from 0 and 2 feet bgs
TIMET OPW Ponds		
WC-TW01	composite of one sample each from ponds OPW-6 through OPW-11	composite of samples collected from 0 and 3 feet bgs
WC-TW02	composite of one sample each from ponds OPW-13 through OPW-20	composite of samples collected from 0 and 3 feet bgs
WC-TW03	composite of two samples from pond OPW-12	composite of samples collected from 0 and 3 feet bgs
TIMET Ponds		
WC-TP01	composite of 2 samples from pond SC-1	composite of samples collected from 0 and 5 feet bgs
WC-TP02	composite of 2 samples from pond SW-2	composite of samples collected from 0 and 2 feet bgs
WC-TP03	composite of 2 samples from pond SW-3	composite of samples collected from 0 and 2 feet bgs
WC-TP04	composite of 2 samples from pond SW-4	composite of samples collected from 0 and 5 feet bgs
WC-TP05	composite of 2 samples from pond SW-5	composite of samples collected from 0 and 2 feet bgs
WC-TP06	composite of 2 samples from pond SW-6	composite of samples collected from 0 and 2 feet bgs
WC-TP07	composite of 2 samples from pond SW-7	composite of samples collected from 0 and 5 feet bgs
WC-TP08	composite of 2 samples from pond SW-8	composite of samples collected from 0 and 5 feet bgs
WC-TP09	composite of 2 samples from pond SW-9	composite of samples collected from 0 and 2 feet bgs
WC-TP10	composite of 2 samples from pond SW-10	composite of samples collected from 0 and 2 feet bgs
WC-TP11	composite of 2 samples from pond SW-11	composite of samples collected from 0 and 2 feet bgs
WC-TP12	composite of 2 samples from pond SW-12*	composite of samples collected from 0 and 2 feet bgs
WC-TP13	composite of 2 samples from pond HP-2	composite of samples collected from 0 and 2 feet bgs
WC-TP14	composite of 2 samples from pond HP-3	composite of samples collected from 0 and 2 feet bgs
WC-TP15	composite of 2 samples from pond HP-4	composite of samples collected from 0 and 2 feet bgs
WC-TP16	composite of 2 samples from pond HP-5	composite of samples collected from 0 and 2 feet bgs
Upper Ponds		
WC-UP01	composite of one sample each from ponds PUA-05 through PUA-10	composite of samples collected from 0 and 2 feet bgs
WC-UP02	composite of one sample each from ponds PUB-06 through PUB-09	composite of samples collected from 0 and 2 feet bgs
WC-UP03	composite of one sample each from ponds PUC-05 through PUC-08	composite of samples collected from 0 and 2 feet bgs
WC-UP04	composite of one sample each from ponds PUD-04 through PUD-09	composite of samples collected from 0 and 2 feet bgs
WC-UP05	composite of one sample each from ponds PUE-03 through PUE-07	composite of samples collected from 0 and 2 feet bgs
WC-UP06	composite of one sample each from ponds PUF-03 through PUF-06	composite of samples collected from 0 and 2 feet bgs
WC-UP07	composite of one sample each from ponds PUG-04 through PUG-07	composite of samples collected from 0 and 2 feet bgs

Note: Wastewater sample collected from TIMET Pond SW-12.

*Indicates BMI Siphon sample location.

Table C-3
Waste Characterization Sampling Summary Table
(Page 1 of 8)

	Sample	1,1,1-Trichloroethane	1,2,3,4,6,7,8-HpCDD	1,2,3,4,6,7,8-HpCDF	1,2,3,4,7,8,9-HpCDF	1,2,4,5-Tetrachlorobenzene	1,2,4-Trichlorobenzene	1,2-Dichlorobenzene	1,2-Dichloroethane	1,2-Dichloropropane	1,3-Dichlorobenzene	1,4-Dichlorobenzene	2,4,6-Trichlorophenol	2,4-D	2,4'-DDD	2,4'-DDE	4,4'-DDD	4,4'-DDE	4,4'-DDT	Acenaphthene	Acenaphthylene	Acetone
Nonwastewater (mg/kg)	UTS x 10	60	0.025	0.025	0.025	140	190	60	60	180	60	60	74		0.87	0.87	0.87	0.87	0.87	34	34	1600
	WC-AD01		0.000034	0.0002	0.000078											0.01 J+		0.029 J+	0.02 J+			
	WC-AD02		0.0000098	0.000064	0.000031											0.0024		0.0069	0.0057			
	WC-AD03		0.0000099	0.000061	0.000023											0.0035		0.0097	0.0062			
	WC-BD01		0.00072	0.002	0.00088	0.068	0.0034	0.0012				0.0017			0.38 J	15 J		16 J	4 J			
	WC-BD02		0.00011	0.0011	0.00053										0.0023 J+	0.056 J		0.035 J+	0.011 J+			
	WC-BD03			0.000025	0.000011											0.0019		0.0025				
	WC-IM01		0.00022	0.0016	0.0011	0.04						0.00046			0.67 J	3.8 J	1.6	9.2 J	3.4			
	WC-IM02		0.0003	0.0037	0.003	0.049						0.00045			0.54 J	3	0.93	6.5 J	2.6			
	WC-IM03		0.00019	0.002	0.0015	0.039	0.0051	0.0029				0.0035			0.25 J	2.5 J-	0.52 J-	4.2 J	1.8 J-			
	WC-IM04	0.001	0.068 J+	0.42 J	0.16 J+	0.073	0.0029	0.0032			0.00047	0.0038	0.087		0.27	11 J		6.3 J	1.9			
	WC-IM05		0.00024	0.00028	0.00011											0.46 J		0.38 J	0.11			
	WC-IM06		0.0003	0.00083	0.00054	0.26	0.0048	0.003				0.0032			0.82 J	4.1 J	1.3	8.8 J	7 J			
	WC-IM07		0.00037	0.00067	0.0003											2.9		2.6	0.66 J			
	WC-MH01	0.0027	0.0019	0.0026	0.00057											0.33 J		0.43 J	0.043 J			0.016 J+
	WC-NB01	0.00065	0.0000054	0.000052	0.000024													0.0032 J				0.0098 J+
	WC-NB02		0.000038	0.00043	0.00014										0.0031 J	0.012	0.01 J	0.04 J	0.0032 J			0.01 J+
	WC-NB03	0.0015	0.000014	0.00014	0.000053										0.0023	0.0077	0.0039	0.033	0.0065			0.017 J-
	WC-SN01		0.0000085 J-	0.000045 J-	0.000039 J-										0.0037 J	0.024	0.0052 J	0.09 J	0.021			0.0097 J-
	WC-SW01		0.0036	0.039	0.018											0.56		0.12				
	WC-SW02		0.0012	0.0036	0.0011	0.066	0.0011	0.001				0.0012			0.37	14		7.9	3.8			
	WC-TA01		0.000021	0.00026	0.000069											0.0049 J+		0.008 J+	0.0044 J+			
	WC-TB01		0.000011	0.000082	0.000042											0.0061 J		0.0046	0.003			
	WC-TB02			0.000028	0.000013											0.0021						
	WC-TB03		0.000094	0.00075	0.00038											0.49		0.21				
	WC-TB04		0.0024	0.023	0.011											0.88		0.32	0.094			
	WC-TD01		0.000009	0.000086	0.00003											0.0034		0.0046	0.0036			
	WC-TE01		0.000012	0.00014	0.000047													0.0028				
	WC-TP01		0.000031	0.0051	0.00074				0.0051 J+	0.0061 J+												0.57 J
	WC-TP02		0.00016	0.0022	0.0007																	
	WC-TP03		0.000012	0.00042	0.000097																	
	WC-TP04		0.000036	0.0014	0.00033																	0.61 J
	WC-TP05		0.0000082	0.00041	0.000096																	
	WC-TP06		0.0000084	0.00038	0.000072																	
	WC-TP07			0.00082	0.00019																	0.22 J+
	WC-TP08		0.000057	0.0033	0.00083				0.0086 J+													0.83 J
	WC-TP09			0.00029	0.000075				0.0013	0.00083		0.00081 J-										0.097
	WC-TP10			0.0002	0.000059																	0.34 J+
	WC-TP11		0.0000052	0.000092	0.000023																	
	WC-TP12		0.0012	0.011	0.0039											0.006 J		0.006 J+				0.011 J+
	WC-TP13			0.00092	0.00012											0.0032 J+						0.31 J+
	WC-TP14		0.00018	0.011	0.0011																	0.097 J+
	WC-TP15			0.000023	0.0000058														0.01			3.8 J
	WC-TP16		0.000071	0.0012	0.00026											0.011 J+		0.0073 J+	0.0046 J+			1.5 J
	WC-TW01		0.000057	0.0013	0.00038										0.0029 J	0.006 J+			0.0036 J			0.024 J-
	WC-TW02		0.000044	0.0014	0.00035										0.0056 J+	0.0089 J		0.019 J+	0.003 J	0.53	0.38	0.075 J-
	WC-TW03		0.000016	0.00061	0.00013											0.0024 J+		0.0031 J+				
	WC-UP01		0.0037	0.032	0.013			0.00084 J-							0.41 J	5 B	0.35 J	6.3	0.18 J			0.012 J+
	WC-UP02		0.0022	0.01	0.0037	0.057		0.00057				0.0013			0.38	15		6.9	1.9			
	WC-UP03		0.0055	0.0073	0.0025			0.00075				0.0012				16		12	2.3			
	WC-UP04	0.00061	0.0035	0.0024	0.00064			0.00054							0.33 J	9.7 B	0.13 J	8.3	2.4			
	WC-UP05	0.00054	0.0001	0.00027	0.000089			0.00088 J-								7.7	0.05 J	5.4	0.48 J			0.0058 J+
	WC-UP-06		0.0015	0.00091	0.00021			0.00033								10		8.5	0.77 J			0.017 J+
	WC-UP07	0.00057	0.0045	0.00076	0.00024											9.2 B		6.7	2.8			0.0061 J+
Wastewater (mg/L)	UTS x 10													100								
	SW-12TP													0.024								

Table shows detects only.

Table C-3
Waste Characterization Sampling Summary Table
(Page 2 of 8)

	Sample	1,1,1-Trichloroethane	1,2,3,4,6,7,8-HpCDD	1,2,3,4,6,7,8-HpCDF	1,2,3,4,7,8,9-HpCDF	1,2,4,5-Tetrachlorobenzene	1,2,4-Trichlorobenzene	1,2-Dichlorobenzene	1,2-Dichloroethane	1,2-Dichloropropane	1,3-Dichlorobenzene	1,4-Dichlorobenzene	2,4,6-Trichlorophenol	2,4-D	2,4'-DDD	2,4'-DDE	4,4'-DDD	4,4'-DDE	4,4'-DDT	Acenaphthene	Acenaphthylene	Acetone
TCLP (mg/L)	UTS x 10																					
	WC-AD01																					
	WC-AD02																					
	WC-AD03																					
	WC-BD01																					
	WC-BD02																					
	WC-BD03																					
	WC-IM01																					
	WC-IM02																					
	WC-IM03																					
	WC-IM04																					
	WC-IM05																					
	WC-IM06																					
	WC-IM07																					
	WC-MH01																					
	WC-NB01																					
	WC-NB02																					
	WC-NB03																					
	WC-SN01																					
	WC-SW01																					
	WC-SW02																					
	WC-TA01																					
	WC-TB01																					
	WC-TB02																					
	WC-TB03																					
	WC-TB04																					
	WC-TD01																					
	WC-TE01																					
	WC-TP01																					
	WC-TP02																					
	WC-TP03																					
	WC-TP04																					
	WC-TP05																					
	WC-TP06																					
	WC-TP07																					
	WC-TP08																					
	WC-TP09																					
	WC-TP10																					
	WC-TP11																					
	WC-TP12																					
	WC-TP13																					
	WC-TP14																					
	WC-TP15																					
	WC-TP16																					
	WC-TW01																					
	WC-TW02																					
	WC-TW03																					
	WC-UP01																					
	WC-UP02																					
	WC-UP03																					
	WC-UP04																					
	WC-UP05																					
	WC-UP-06																					
	WC-UP07																					

Table shows detects only.

Table C-3
Waste Characterization Sampling Summary Table
(Page 3 of 8)

	Sample	Acetonitrile	Acetophenone	Aldrin	alpha-BHC	Anthracene	Arsenic	Barium	Benzene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(ghi)perylene	Benzo(k)fluoranthene	Beryllium	beta-BHC	Bromodichloromethane	Bromoform	Carbon tetrachloride	Chlorobenzene	Chlorodibromomethane	Chloroethane
Nonwastewater	UTS x 10	380	97	0.66	0.66	34			100	34	34	68	18	68		0.66	150	150	60	60	150	60
(mg/kg)	WC-AD01									0.035						0.0021 J+						
	WC-AD02																					
	WC-AD03																					
	WC-BD01									0.05												
	WC-BD02															0.0057 J						
	WC-BD03																					
	WC-IM01																					
	WC-IM02				0.4					0.037						0.19						
	WC-IM03																					
	WC-IM04									0.072						1.1				0.0017		
	WC-IM05																					
	WC-IM06				0.6					0.047						0.25						
	WC-IM07															0.033 J						
	WC-MH01															0.003 J			0.0044			
	WC-NB01															0.012						
	WC-NB02															0.022						
	WC-NB03															0.0084			0.0024			
	WC-SN01															0.0054						
	WC-SW01															0.042						
	WC-SW02									0.049												
	WC-TA01															0.0057 J+						
	WC-TB01															0.0092						
	WC-TB02															0.0027						
	WC-TB03															0.017						
	WC-TB04															0.093						
	WC-TD01															0.0041						
	WC-TE01															0.0068						
	WC-TP01	0.073 J							0.0017 J+							0.0058 J+	0.22 J+	0.13 J	0.095 J+		0.2 J	
	WC-TP02																0.052	0.14	0.015		0.069	
	WC-TP03																0.049	0.063	0.014		0.041	
	WC-TP04	0.15 J														0.0047 J+	0.032 J+	0.012 J	0.045 J+		0.033 J	0.02 J+
	WC-TP05																		0.013 J+			
	WC-TP06																0.034		0.031			
	WC-TP07	0.11 J															0.0063 J+		0.011 J+			
	WC-TP08																					0.04 J+
	WC-TP09	0.066 J															0.032		0.011		0.0099 J-	
	WC-TP10	0.03 J															0.0021 J+				0.0012 J+	
	WC-TP11																					
	WC-TP12															0.015 J+	0.011	0.012			0.011	
	WC-TP13	0.035 J															0.0038	0.002				
	WC-TP14															0.0052 J+						
	WC-TP15																					
	WC-TP16	0.078 J																				
	WC-TW01															0.02 J						
	WC-TW02		0.068		0.0034 J+	2.8				5.8	4.1	4.3	2.1	3.8		0.016 J+						
	WC-TW03																					
	WC-UP01			0.004 J												0.065 J						
	WC-UP02									0.052												
	WC-UP03									0.043												
	WC-UP04									0.036						0.065 J						
	WC-UP05															0.022 J						
	WC-UP-06				0.0033 J											0.026 J-						
	WC-UP07				0.0037 J											0.033 J						
Wastewater	UTS x 10						14	12							8.2			150			150	
(mg/L)	SW-12TP						0.0263 J-	3.36 J							0.0076 BJ			0.0019			0.0021	

Table shows detects only.

Table C-3
Waste Characterization Sampling Summary Table
(Page 4 of 8)

	Sample	Acetonitrile	Acetophenone	Aldrin	alpha-BHC	Anthracene	Arsenic	Barium	Benzene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(ghi)perylene	Benzo(k)fluoranthene	Beryllium	beta-BHC	Bromodichloromethane	Bromoform	Carbon tetrachloride	Chlorobenzene	Chlorodibromomethane	Chloroethane
TCLP (mg/L)	UTS x 10						50	210							12.2							
	WC-AD01							0.526														
	WC-AD02							0.605														
	WC-AD03							0.656														
	WC-BD01							1							0.0125 B							
	WC-BD02							1.64														
	WC-BD03							0.639														
	WC-IM01							0.685														
	WC-IM02							0.633														
	WC-IM03							0.476														
	WC-IM04							0.262							0.0125 B							
	WC-IM05							0.95														
	WC-IM06							0.853														
	WC-IM07							0.704														
	WC-MH01							2.59							0.0125 B							
	WC-NB01						0.178	0.137							0.0125 B							
	WC-NB02						0.259	0.167							0.0125 B							
	WC-NB03						0.128	0.275							0.0125 B							
	WC-SN01							0.432							0.0125 B							
	WC-SW01							0.177														
	WC-SW02							0.227														
	WC-TA01							0.278							0.0125 B							
	WC-TB01							0.433							0.0125 B							
	WC-TB02							0.788							0.0125 B							
	WC-TB03							1.27							0.0125 B							
	WC-TB04							0.851							0.0125 B							
	WC-TD01							0.71														
	WC-TE01							0.723														
	WC-TP01							0.113							0.0125 B							
	WC-TP02							0.0178							0.0125 B							
	WC-TP03							0.082							0.0125 B							
	WC-TP04							0.246							0.0125 B							
	WC-TP05							0.0537														
	WC-TP06							0.209														
	WC-TP07							0.823							0.0125 B							
	WC-TP08							0.671							0.0125 B							
	WC-TP09							0.42							0.0125 B							
	WC-TP10							0.799							0.0125 B							
	WC-TP11							0.306							0.0125 B							
	WC-TP12							0.134							0.0125 B							
	WC-TP13							0.0919														
	WC-TP14														0.0125 B							
	WC-TP15							0.165							0.0125 B							
	WC-TP16							0.0934							0.0125 B							
	WC-TW01							0.152							0.0125 B							
	WC-TW02							0.149							0.0125 B							
	WC-TW03							0.378														
	WC-UP01							0.221														
	WC-UP02							0.411														
	WC-UP03							0.388														
	WC-UP04							0.631														
	WC-UP05							0.948							0.0125 B							
	WC-UP-06							0.552														
	WC-UP07							0.499														

Table shows detects only.

Table C-3
Waste Characterization Sampling Summary Table
(Page 5 of 8)

	Sample	Chloroform	Chloromethane	Chromium	Chrysene	Cyanide, Total	delta-BHC	Dibenz(a,h)anthracene	Dieldrin	Di-n-butyl phthalate	Di-n-octyl phthalate	Endosulfan I	Endosulfan II	Endrin aldehyde	Fluoranthene	Fluorene	Fluoride	gamma-BHC (Lindane)	gamma-Chlordane	Hexachlorobenzene	Hexachlorobutadiene	Indeno(1,2,3-cd)pyrene
Nonwastewater	UTS x 10	60	300		34	5900	0.66	82	1.3	280	280	0.66	1.3	1.3	34	34		0.66	160	100	56	34
(mg/kg)	WC-AD01				0.035										0.065				0.0022 J+			
	WC-AD02																					
	WC-AD03																					
	WC-BD01				0.14				0.28 J						0.18					1.1		
	WC-BD02																		0.0024 J	0.16		
	WC-BD03																					
	WC-IM01																			1.2		
	WC-IM02				0.037															1.5		
	WC-IM03																			1		
	WC-IM04				0.2	0.66									0.32					19 J		0.044
	WC-IM05												0.019 J							0.052		
	WC-IM06				0.049										0.071			0.39		1.2		
	WC-IM07												0.049 J							0.47		
	WC-MH01									0.036		0.0031 J										
	WC-NB01																					
	WC-NB02						0.0074							0.0021 J								
	WC-NB03																					
	WC-SN01													0.002 J								
	WC-SW01					0.36														0.54		
	WC-SW02				0.096	0.87							0.46 J		0.11					0.66		
	WC-TA01										1.6											
	WC-TB01														0.036							
	WC-TB02																					
	WC-TB03																			0.16		
	WC-TB04																			4.5		
	WC-TD01				0.036																	
	WC-TE01																					
	WC-TP01	4.8 J	0.0059 J+																	1.2		
	WC-TP02	0.62																		0.066		
	WC-TP03	0.46																		0.088		
	WC-TP04	5.2 J	0.029 J+																	2.3		
	WC-TP05	2.3 J																		0.3		
	WC-TP06	0.83																		0.38		
	WC-TP07	1.4 J	0.015 J+			3.8														1.9		
	WC-TP08	0.033 J+	0.036 J+																	4.1		
	WC-TP09	0.9 J																		0.63		
	WC-TP10	0.15 J+				2.7														0.21		
	WC-TP11	0.037				1.8														0.12		
	WC-TP12	0.0072	0.0064																	0.41		
	WC-TP13	0.035				12.7														0.45		
	WC-TP14	0.0014																		1.5		
	WC-TP15	0.1				2.1																
	WC-TP16	0.016	0.0038			0.95																
	WC-TW01	0.016																		10	0.076	
	WC-TW02	0.0027 J-			5.3	0.29		0.94				0.018 J+		0.0043 J	16 J	1.3				12 J	0.074	2.2
	WC-TW03																			0.087		
	WC-UP01	0.00021			0.061							0.0084 J			0.07				0.0089 J	1.1		
	WC-UP02				0.11	0.87							0.25 J		0.2					1.8		
	WC-UP03				0.14	1.7							0.41 J		0.19					1.1		
	WC-UP04				0.13	0.68						0.019 J			0.17					1.1		
	WC-UP05				0.091							0.045 J			0.2					0.56		
	WC-UP-06				0.089	0.55						0.054 J			0.13					0.35		
	WC-UP07	0.00027			0.1	0.42						0.096 J			0.14					0.37		
Wastewater	UTS x 10	0.46	1.9	27.7		12											350					
(mg/L)	SW-12TP	0.0093	0.0016	0.29 J-		0.0152											41.4 J					

Table shows detects only.

Table C-3
Waste Characterization Sampling Summary Table
(Page 6 of 8)

	Sample	Chloroform	Chloromethane	Chromium	Chrysene	Cyanide, Total	delta-BHC	Dibenz(a,h)anthracene	Dieldrin	Di-n-butyl phthalate	Di-n-octyl phthalate	Endosulfan I	Endosulfan II	Endrin aldehyde	Fluoranthene	Fluorene	Fluoride	gamma-BHC (Lindane)	gamma-Chlordane	Hexachlorobenzene	Hexachlorobutadiene	Indeno(1,2,3-cd)pyrene
TCLP (mg/L)	UTS x 10			6																		
	WC-AD01			0.019																		
	WC-AD02																					
	WC-AD03																					
	WC-BD01			0.0381																		
	WC-BD02			0.0213																		
	WC-BD03																					
	WC-IM01			0.0105																		
	WC-IM02			0.0291																		
	WC-IM03																					
	WC-IM04			0.107																		
	WC-IM05			0.0254																		
	WC-IM06			0.107																		
	WC-IM07			0.0207																		
	WC-MH01			0.145																		
	WC-NB01																					
	WC-NB02																					
	WC-NB03																					
	WC-SN01																					
	WC-SW01			0.11																		
	WC-SW02			0.198																		
	WC-TA01																					
	WC-TB01																					
	WC-TB02																					
	WC-TB03																					
	WC-TB04			0.0614																		
	WC-TD01																					
	WC-TE01																					
	WC-TP01			2.94																		
	WC-TP02			0.181																		
	WC-TP03			0.0083																		
	WC-TP04																					
	WC-TP05			0.0334																		
	WC-TP06			0.0128																		
	WC-TP07			0.0881																		
	WC-TP08			0.0842																		
	WC-TP09			0.189																		
	WC-TP10			0.0807																		
	WC-TP11			0.0648																		
	WC-TP12			0.136																		
	WC-TP13			0.0129																		
	WC-TP14			0.0183																		
	WC-TP15			0.0139																		
	WC-TP16			0.0254																		
	WC-TW01			0.0653																		
	WC-TW02			0.0373																		
	WC-TW03																					
	WC-UP01			0.115																		
	WC-UP02			0.246																		
	WC-UP03			0.756																		
	WC-UP04			0.251																		
	WC-UP05			0.727																		
	WC-UP-06			0.773																		
	WC-UP07			1.01																		

Table shows detects only.

Table C-3
Waste Characterization Sampling Summary Table
(Page 7 of 8)

	Sample	Lead	Mercury	Methoxychlor	Methyl ethyl ketone	Methylene chloride	Naphthalene	Nickel	OCDD	OCDF	Pentachlorobenzene	Perchlorate	Phenanthrene	Phthalic acid	Pyrene	Tetrachloroethylene	Thallium	Toluene	Trichloroethene	Vanadium	Xylenes (total)	Zinc
Nonwastewater	UTS x 10			1.8	360	300	56		0.05	0.05	100	(blank)	56	280	82	60		100	60		300	
(mg/kg)	WC-AD01					0.006 B			0.00017	0.0014			0.064		0.061							
	WC-AD02					0.0059 B			0.000032	0.00029												
	WC-AD03					0.0058 B			0.000049	0.00033												
	WC-BD01					0.0081 B			0.016	0.014	0.15		0.19		0.074				0.0069			
	WC-BD02			0.011 J					0.000089	0.0034									0.00059			
	WC-BD03								0.0000068	0.0002												
	WC-IM01					0.0068 B			0.00034	0.0051	1.4											
	WC-IM02					0.0055 B			0.00063	0.017	1.5											
	WC-IM03					0.0054 B			0.00036	0.0097	0.96											
	WC-IM04					0.014 B			0.077 J+	1.7 J	2.1		0.24		0.14			0.0053 B	0.016			
	WC-IM05					0.0052 B			0.00045	0.0033												
	WC-IM06					0.0052 B			0.00058	0.0055	1.2											
	WC-IM07			0.31 J		0.0054 B			0.0012	0.0026	0.2											
	WC-MH01				0.003	0.0076			0.0031	0.041								0.0017	0.0066			
	WC-NB01				0.0032					0.000072									0.0018			
	WC-NB02				0.0031				0.000053	0.00077												
	WC-NB03				0.0023	0.0095 B			0.000017	0.00026						0.0022		0.0051 B				
	WC-SN01					0.0052 B			0.0000087 J-	0.000077 J-												
	WC-SW01					0.0084 BJ			0.0037	0.14				0.082								
	WC-SW02					0.012 BJ			0.0051	0.033	0.24		0.1		0.062							
	WC-TA01			0.034 J		0.0091 BJ			0.000063	0.0038				0.13 J+								
	WC-TB01								0.000042	0.00033												
	WC-TB02								0.0000058	0.00011												
	WC-TB03			0.036 J					0.00015	0.0081									0.00074			
	WC-TB04								0.0019	0.087	0.59								0.0017			
	WC-TD01					0.0087 BJ			0.000026	0.00028				0.084								
	WC-TE01					0.0088 BJ			0.000023	0.00046												
	WC-TP01				0.059 J+				0.00068	0.083	0.058					0.0066 J		0.0082 J			0.007 J	
	WC-TP02					0.073 B			0.00032	0.037												
	WC-TP03					0.051 B			0.000097	0.02						0.0025						
	WC-TP04								0.0005	0.052	0.17					0.0035 J						
	WC-TP05			0.012 J+		0.065 BJ			0.00021	0.035												
	WC-TP06					0.058 B			0.00019	0.029												
	WC-TP07				0.037 J+	0.0065 J+			0.00029	0.018	0.098								0.001 J+			
	WC-TP08				0.12 J+				0.0016	0.1	0.2					0.014 J						
	WC-TP09				0.011	0.017 B			0.00012	0.029						0.0042 J-		0.0086 BJ				
	WC-TP10				0.014 J+				0.0001	0.025						0.0022 J+						
	WC-TP11			0.022 J+					0.00005	0.0053												
	WC-TP12								0.0011	0.042	0.055											
	WC-TP13				0.011				0.0001	0.033		2.81										
	WC-TP14				0.019				0.0052	0.16		0.274										
	WC-TP15					0.036 B			0.0000083	0.00015		1.69										
	WC-TP16				0.016				0.00014	0.01		1.87										
	WC-TW01					0.017 BJ			0.00076	0.047	0.26		0.058									
	WC-TW02				0.0096 J-	0.015 BJ	2.1		0.00056	0.063	0.26		18 J		10 J							
	WC-TW03								0.000076	0.018												
	WC-UP01			0.49 J					0.0071	0.15 J+	0.052		0.054		0.05	0.00039						
	WC-UP02					0.008 BJ			0.0076	0.052	0.28		0.13		0.083							
	WC-UP03					0.012 BJ			0.017 J+	0.15 J+	0.078		0.099		0.078				0.0018			
	WC-UP04					0.003			0.011	0.045 J+	0.15		0.12		0.081				0.0045			
	WC-UP05				0.002				0.00018	0.0013	0.079		0.1		0.1				0.0025			
	WC-UP-06								0.0025	0.014	0.097		0.12		0.059				0.00072			
	WC-UP07								0.0064	0.0099	0.18		0.11		0.051			0.0011	0.0039			
Wastewater	UTS x 10	6.9	1.5			0.89		39.8		0.00063							14			43		26.1
(mg/L)	SW-12TP	0.341 J-	0.0034			0.003		1.69 J		0.000089							0.2 BJ			0.717 J		4.66

Table shows detects only.

Table C-3
Waste Characterization Sampling Summary Table
(Page 8 of 8)

	Sample	Lead	Mercury	Methoxychlor	Methyl ethyl ketone	Methylene chloride	Naphthalene	Nickel	OCDD	OCDF	Pentachlorobenzene	Perchlorate	Phenanthrene	Phthalic acid	Pyrene	Tetrachloroethylene	Thallium	Toluene	Trichloroethene	Vanadium	Xylenes (total)	Zinc
TCLP	UTS x 10	7.5	0.25					110												16		43
(mg/L)	WC-AD01							0.0331												0.152		0.0246
	WC-AD02																			0.0334		
	WC-AD03	0.122																		0.021		
	WC-BD01																			0.223		
	WC-BD02																			0.125 B		
	WC-BD03																			0.125 B		
	WC-IM01																			0.234		
	WC-IM02																			0.133		
	WC-IM03																			0.112		
	WC-IM04																			0.367		0.0243
	WC-IM05							0.0447												0.44		
	WC-IM06							0.0595												0.6		
	WC-IM07							0.0365												0.054		
	WC-MH01							0.0879												0.22		0.101
	WC-NB01																			0.07		
	WC-NB02																			0.0604		
	WC-NB03																			0.0234		
	WC-SN01																					
	WC-SW01							0.191												0.259		0.0784
	WC-SW02							0.142												0.414		
	WC-TA01							0.13												0.186		
	WC-TB01	0.229																		0.18		
	WC-TB02																			0.125 B		
	WC-TB03																			0.22		
	WC-TB04																			0.152		
	WC-TD01																			0.0574		0.0368
	WC-TE01																					
	WC-TP01							0.944												0.0612		0.0761 B
	WC-TP02																			1.94		
	WC-TP03							0.179												0.148		
	WC-TP04							1.53												0.43		0.05 B
	WC-TP05																			0.199		
	WC-TP06							1.43												0.107		0.116
	WC-TP07							2												0.148		0.108
	WC-TP08							5.76												0.112		0.295
	WC-TP09	0.0817	0.00063					2.36												0.128		0.224
	WC-TP10	0.0834						3.08												0.0445		0.239
	WC-TP11							2.23												0.037		0.103
	WC-TP12							0.37												0.0386		0.131
	WC-TP13							0.131														
	WC-TP14							0.0194												0.117		
	WC-TP15							0.202														0.0538
	WC-TP16							0.135														
	WC-TW01																			0.948		
	WC-TW02																			0.335		
	WC-TW03																			0.125 B		
	WC-UP01							0.326												0.289		0.0555
	WC-UP02							0.0478												0.415		0.069
	WC-UP03							0.0396												0.78		
	WC-UP04							0.045												0.472		
	WC-UP05							0.0619												0.308		0.0285
	WC-UP-06							0.0893												0.418		0.0307
	WC-UP07							0.05												0.35		

Table shows detects only.

TABLE C-4
COMPARISON OF DETECTED CHEMICAL CONCENTRATIONS WITH UTS LEVELS
(Page 1 of 7)

Category	Analytical Method	Site-Related Chemical	CAS No.	Minimum Detect	Maximum Detect	UTS x 10	Maximum > UTSx10?	Carcinogen?	10^{-3} Cancer PRG[1]	Risk > 10^{-3}?	Non-Cancer PRG × $10^{(2)}$	Risk > PRG × 10 ?
Nonwastewater (mg/kg)	E314.0	Perchlorate	14797-73-0	0.274	2.81	--	--	--	--	--	--	--
	E335.4	Cyanide, Total	57-12-5	0.29	12.7	5900	NO	--	--	--	--	--
	SW8081	2,4'-DDD	53-19-0	0.0023	0.82	0.87	NO	--	--	--	--	--
		2,4'-DDE	3424-82-6	0.0018	16	0.87	YES	YES	1883	NO	--	--
		4,4'-DDD	72-54-8	0.0039	1.6	0.87	YES	YES	2668	NO	--	--
		4,4'-DDE	72-55-9	0.0025	16	0.87	YES	YES	1883	NO	--	--
		4,4'-DDT	50-29-3	0.003	7	0.87	YES	YES	1883	NO	391	NO
		Aldrin	309-00-2	0.004	0.004	0.66	NO	--	--	--	--	--
		alpha-BHC	319-84-6	0.0033	0.6	0.66	NO	--	--	--	--	--
		alpha-Chlordane	5103-71-9	< 0.00012	< 0.015	160	NO	--	--	--	--	--
		beta-BHC	319-85-7	0.002	1.1	0.66	YES	YES	356	NO	156	NO
		delta-BHC	319-86-8	0.0074	0.0074	0.66	NO	--	--	--	--	--
		Dieldrin	60-57-1	0.28	0.28	1.3	NO	--	--	--	--	--
		Endosulfan I	959-98-8	0.0031	0.11	0.66	NO	--	--	--	--	--
		Endosulfan II	33213-65-9	0.019	0.46	1.3	NO	--	--	--	--	--
		Endosulfan sulfate	1031-07-8	< 0.00023	< 0.029	1.3	NO	--	--	--	--	--
		Endrin	72-20-8	< 0.0002	< 0.024	1.3	NO	--	--	--	--	--
		Endrin aldehyde	7421-93-4	0.002	0.0043	1.3	NO	--	--	--	--	--
		gamma-BHC (Lindane)	58-89-9	0.39	0.39	0.66	NO	--	--	--	--	--
		gamma-Chlordane	5103-74-2	0.0022	0.0089	160	NO	--	--	--	--	--
		Heptachlor	76-44-8	< 0.0001	< 0.012	0.66	NO	--	--	--	--	--
		Heptachlor epoxide	1024-57-3	< 0.00014	< 0.017	0.66	NO	--	--	--	--	--
		Methoxychlor	72-43-5	0.011	0.49	1.8	NO	--	--	--	--	--
		Toxaphene	8001-35-2	< 0.0066	< 6.8	26	NO	--	--	--	--	--
	SW8082	PCBs (total)	1336-36-3	< 0.0093	< 0.47	100	NO	--	--	--	--	--
	SW8141	Disulfoton	298-04-4	< 0.0078	< 0.025	62	NO	--	--	--	--	--
		Famphur	52-85-7	< 0.0032	< 0.01	150	NO	--	--	--	--	--
		Methyl parathion	298-00-0	< 0.0064	< 0.02	46	NO	--	--	--	--	--
		Parathion	56-38-2	< 0.0053	< 0.017	46	NO	--	--	--	--	--
		Phorate	298-02-2	< 0.0057	< 0.018	46	NO	--	--	--	--	--
	SW8151	2,4,5-T	93-76-5	< 0.005	< 0.016	79	NO	--	--	--	--	--
		2,4,5-TP (Silvex)	93-72-1	< 0.0033	< 0.01	79	NO	--	--	--	--	--
Nonwastewater (mg/kg)		2,4-D	94-75-7	< 0.029	< 0.094	100	NO	--	--	--	--	--
		Dinoseb	88-85-7	< 0.006	< 0.019	25	NO	--	--	--	--	--
	SW8260	1,1,1,2-Tetrachloroethane	630-20-6	< 0.00023	< 0.055	60	NO	--	--	--	--	--
		1,1,1-Trichloroethane	71-55-6	0.00054	0.0027	60	NO	--	--	--	--	--
		1,1,2,2-Tetrachloroethane	79-34-5	< 0.00014	< 0.019	60	NO	--	--	--	--	--
		1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	< 0.00054	< 0.061	300	NO	--	--	--	--	--
		1,1,2-Trichloroethane	79-00-5	< 0.00028	< 0.077	60	NO	--	--	--	--	--
		1,1-Dichloroethane	75-34-3	< 0.00096	< 0.1	60	NO	--	--	--	--	--
		1,1-Dichloroethene	75-35-4	< 0.00055	< 0.083	60	NO	--	--	--	--	--
		1,2,3-Trichloropropane	96-18-4	< 0.00056	< 0.16	300	NO	--	--	--	--	--
		1,2,4-Trichlorobenzene	120-82-1	0.0011	0.0051	190	NO	--	--	--	--	--
		1,2-Dibromo-3-chloropropane	96-12-8	< 0.0009	< 0.1	150	NO	--	--	--	--	--
		1,2-Dichlorobenzene	95-50-1	0.00033	0.0032	60	NO	--	--	--	--	--
		1,2-Dichloroethane	107-06-2	0.0013	0.0086	60	NO	--	--	--	--	--
		1,2-Dichloropropane	78-87-5	0.00083	0.0061	180	NO	--	--	--	--	--
		1,3-Dichlorobenzene	541-73-1	0.00047	0.00047	60	NO	--	--	--	--	--
		1,4-Dichlorobenzene	106-46-7	0.00045	0.0038	60	NO	--	--	--	--	--
		Acetone	67-64-1	0.0058	3.8	1600	NO	--	--	--	--	--

TABLE C-4
COMPARISON OF DETECTED CHEMICAL CONCENTRATIONS WITH UTS LEVELS
(Page 2 of 7)

Category	Analytical Method	Site-Related Chemical	CAS No.	Minimum Detect	Maximum Detect	UTS x 10	Maximum > UTSx10?	Carcinogen?	10^{-3} Cancer PRG[1]	Risk > 10^{-3}?	Non-Cancer PRG × 10[2]	Risk > PRG × 10 ?
Nonwastewater (mg/kg)		Acetonitrile	75-05-8	0.03	0.15	380	NO	--	--	--	--	--
		Benzene	71-43-2	0.0017	0.0017	100	NO	--	--	--	--	--
		Bromodichloromethane	75-27-4	0.0021	0.22	150	NO	--	--	--	--	--
		Bromoform	75-25-2	0.002	0.14	150	NO	--	--	--	--	--
		Bromomethane	74-83-9	< 0.00031	< 0.088	150	NO	--	--	--	--	--
		Carbon tetrachloride	56-23-5	0.0024	0.095	60	NO	--	--	--	--	--
		Chlorobenzene	108-90-7	0.0017	0.0017	60	NO	--	--	--	--	--
		Chlorodibromomethane	124-48-1	0.0012	0.2	150	NO	--	--	--	--	--
		Chloroethane	75-00-3	0.02	0.04	60	NO	--	--	--	--	--
		Chloroform	67-66-3	0.00021	5.2	60	NO	--	--	--	--	--
		Chloromethane	74-87-3	0.0038	0.036	300	NO	--	--	--	--	--
		cis-1,3-Dichloropropene	10061-01-5	< 0.00073	< 0.019	180	NO	--	--	--	--	--
		Dibromomethane	74-95-3	< 0.00035	< 0.055	150	NO	--	--	--	--	--
		Dichlorodifluoromethane	75-71-8	< 0.00038	< 0.098	72	NO	--	--	--	--	--
		Ethylbenzene	100-41-4	< 0.00019	< 0.069	100	NO	--	--	--	--	--
		Iodomethane	74-88-4	< 0.00026	< 0.13	650	NO	--	--	--	--	--
		Methyl ethyl ketone	78-93-3	0.002	0.12	360	NO	--	--	--	--	--
		Methyl isobutyl ketone	108-10-1	< 0.0016	< 0.07	330	NO	--	--	--	--	--
		Methylene chloride	75-09-2	0.003	0.073	300	NO	--	--	--	--	--
		Tetrachloroethylene	127-18-4	0.00039	0.014	60	NO	--	--	--	--	--
		Toluene	108-88-3	0.0011	0.0086	100	NO	--	--	--	--	--
		trans-1,2-Dichloroethene	156-60-5	< 0.00022	< 0.12	300	NO	--	--	--	--	--
		trans-1,3-Dichloropropylene	10061-02-6	< 0.0002	< 0.12	180	NO	--	--	--	--	--
		Trichloroethene	79-01-6	0.00059	0.016	60	NO	--	--	--	--	--
		Trichlorofluoromethane	75-69-4	< 0.00051	< 0.067	300	NO	--	--	--	--	--
		Vinyl chloride	75-01-4	< 0.00024	< 0.19	60	NO	--	--	--	--	--
		Xylenes (total)	1330-20-7	0.007	0.007	300	NO	--	--	--	--	--
	SW8270	1,2,4,5-Tetrachlorobenzene	95-94-3	0.039	0.26	140	NO	--	--	--	--	--
		1,4-Dioxane	123-91-1	< 0.034	< 0.11	1700	NO	--	--	--	--	--
		2,4,5-Trichlorophenol	95-95-4	< 0.034	< 0.11	74	NO	--	--	--	--	--
		2,4,6-Trichlorophenol	88-06-2	0.087	0.087	74	NO	--	--	--	--	--
		2,4-Dichlorophenol	120-83-2	< 0.034	< 0.11	140	NO	--	--	--	--	--
		2,4-Dimethylphenol	105-67-9	< 0.034	< 0.11	140	NO	--	--	--	--	--
		2,4-Dinitrophenol	51-28-5	< 0.33	< 1.1	1600	NO	--	--	--	--	--
		2,4-Dinitrotoluene	121-14-2	< 0.034	< 0.11	1400	NO	--	--	--	--	--
		2,6-Dinitrotoluene	606-20-2	< 0.034	< 0.11	280	NO	--	--	--	--	--
		2-Chloronaphthalene	91-58-7	< 0.034	< 0.11	56	NO	--	--	--	--	--
		2-Chlorophenol	95-57-8	< 0.034	< 0.11	57	NO	--	--	--	--	--
		2-Methylphenol	95-48-7	< 0.034	< 0.38	56	NO	--	--	--	--	--
		2-Nitroaniline	88-74-4	< 0.034	< 0.11	140	NO	--	--	--	--	--
		2-Nitrophenol	88-75-5	< 0.034	< 0.11	130	NO	--	--	--	--	--
		4-Bromophenyl phenyl ether	101-55-3	< 0.034	< 0.11	150	NO	--	--	--	--	--
		4-Chloro-3-methylphenol	59-50-7	< 0.034	< 0.11	140	NO	--	--	--	--	--
		4-Chloroaniline	106-47-8	< 0.034	< 0.11	160	NO	--	--	--	--	--
		4-Nitroaniline	100-01-6	< 0.33	< 1.1	280	NO	--	--	--	--	--
		4-Nitrophenol	100-02-7	< 0.33	< 1.1	290	NO	--	--	--	--	--
		Acenaphthene	83-32-9	0.53	0.53	34	NO	--	--	--	--	--
		Acenaphthylene	208-96-8	0.38	0.38	34	NO	--	--	--	--	--
		Acetophenone	98-86-2	0.068	0.068	97	NO	--	--	--	--	--
		Aniline	62-53-3	< 0.034	< 0.11	140	NO	--	--	--	--	--

TABLE C-4
COMPARISON OF DETECTED CHEMICAL CONCENTRATIONS WITH UTS LEVELS
(Page 3 of 7)

Category	Analytical Method	Site-Related Chemical	CAS No.	Minimum Detect	Maximum Detect	UTS x 10	Maximum > UTSx10?	Carcinogen?	10^{-3} Cancer PRG[1]	Risk > 10^{-3}?	Non-Cancer PRG × $10^{(2)}$	Risk > PRG × 10 ?
Nonwastewater (mg/kg)		Anthracene	120-12-7	2.8	2.8	34	NO	--	--	--	--	--
		Benzo(a)anthracene	56-55-3	0.035	5.8	34	NO	--	--	--	--	--
		Benzo(a)pyrene	50-32-8	4.1	4.1	34	NO	--	--	--	--	--
		Benzo(b)fluoranthene	205-99-2	4.3	4.3	68	NO	--	--	--	--	--
		Benzo(ghi)perylene	191-24-2	2.1	2.1	18	NO	--	--	--	--	--
		Benzo(k)fluoranthene	207-08-9	3.8	3.8	68	NO	--	--	--	--	--
		bis(2-Chloroethoxy)methane	111-91-1	< 0.034	< 0.11	72	NO	--	--	--	--	--
		bis(2-Chloroethyl) ether	111-44-4	< 0.034	< 0.11	60	NO	--	--	--	--	--
		bis(2-Chloroisopropyl) ether	108-60-1	< 0.034	< 0.11	72	NO	--	--	--	--	--
		Butyl benzyl phthalate	85-68-7	< 0.034	< 0.11	280	NO	--	--	--	--	--
		Chrysene	218-01-9	0.035	5.3	34	NO	--	--	--	--	--
		Dibenz(a,h)anthracene	53-70-3	0.94	0.94	82	NO	--	--	--	--	--
		Diethyl phthalate	84-66-2	< 0.034	< 0.11	280	NO	--	--	--	--	--
		Dimethyl phthalate	131-11-3	< 0.034	< 0.11	280	NO	--	--	--	--	--
		Di-n-butyl phthalate	84-74-2	0.036	0.036	280	NO	--	--	--	--	--
		Di-n-octyl phthalate	117-84-0	1.6	1.6	280	NO	--	--	--	--	--
		Fluoranthene	206-44-0	0.036	16	34	NO	--	--	--	--	--
		Fluorene	86-73-7	1.3	1.3	34	NO	--	--	--	--	--
		Hexachlorobenzene	118-74-1	0.052	20	100	NO	--	--	--	--	--
		Hexachlorobutadiene	87-68-3	0.074	0.076	56	NO	--	--	--	--	--
		Hexachlorocyclopentadiene	77-47-4	< 0.33	< 1.1	24	NO	--	--	--	--	--
		Hexachloroethane	67-72-1	< 0.034	< 0.11	300	NO	--	--	--	--	--
		Indeno(1,2,3-cd)pyrene	193-39-5	0.044	2.2	34	NO	--	--	--	--	--
		Naphthalene	91-20-3	2.1	2.1	56	NO	--	--	--	--	--
		Nitrobenzene	98-95-3	< 0.034	< 0.11	140	NO	--	--	--	--	--
		N-Nitrosodi-n-propylamine	621-64-7	< 0.034	< 0.11	140	NO	--	--	--	--	--
		N-Nitrosodiphenylamine	86-30-6	< 0.034	< 0.11	130	NO	--	--	--	--	--
		Pentachlorobenzene	608-93-5	0.052	2.1	100	NO	--	--	--	--	--
		Pentachlorophenol	87-86-5	< 0.33	< 1.1	74	NO	--	--	--	--	--
		Phenanthrene	85-01-8	0.054	18	56	NO	--	--	--	--	--
		Phenol	108-95-2	< 0.034	< 0.11	62	NO	--	--	--	--	--
		Phthalic acid	88-99-3	0.082	0.13	280	NO	--	--	--	--	--
		Pyrene	129-00-0	0.05	10	82	NO	--	--	--	--	--
		Pyridine	110-86-1	< 0.034	< 0.41	160	NO	--	--	--	--	--
	SW8290	1,2,3,4,6,7,8-HpCDD	35822-46-9	0.0000052	0.068	0.025	YES	YES	0.43	NO	--	--
		1,2,3,4,6,7,8-HpCDF	67562-39-4	0.000023	0.42	0.025	YES	YES	0.43	NO	--	--
		1,2,3,4,7,8,9-HpCDF	55673-89-7	0.0000058	0.16	0.025	YES	YES	0.43	NO	--	--
		OCDD	OCDD	0.0000058	0.077	0.05	YES	YES	43	NO	--	--
		OCDF	OCDF	0.000072	1.7	0.05	YES	YES	43	NO	--	--
Wastewater (mg/L)	E300	Fluoride	16984-48-8	41.4	41.4	350	NO	--	--	--	--	--
	E335.4	Cyanide, Total	57-12-5	0.0152	0.0152	12	NO	--	--	--	--	--
	E376.1	Total Sulfide	18496-25-8	< 0.31	< 0.31	140	NO	--	--	--	--	--
	SW6010	Antimony	7440-36-0	< 0.002604	< 0.002604	19	NO	--	--	--	--	--
		Arsenic	7440-38-2	0.0263	0.0263	14	NO	--	--	--	--	--
		Barium	7440-39-3	3.36	3.36	12	NO	--	--	--	--	--
		Beryllium	7440-41-7	0.0076	0.0076	8.2	NO	--	--	--	--	--
		Cadmium	7440-43-9	< 0.0005	< 0.0005	6.9	NO	--	--	--	--	--
		Chromium	7440-47-3	0.29	0.29	27.7	NO	--	--	--	--	--
		Lead	7439-92-1	0.341	0.341	6.9	NO	--	--	--	--	--
		Nickel	7440-02-0	1.69	1.69	39.8	NO	--	--	--	--	--

TABLE C-4
COMPARISON OF DETECTED CHEMICAL CONCENTRATIONS WITH UTS LEVELS
(Page 4 of 7)

Category	Analytical Method	Site-Related Chemical	CAS No.	Minimum Detect	Maximum Detect	UTS x 10	Maximum > UTSx10?	Carcinogen?	10^{-3} Cancer PRG[1]	Risk > 10^{-3}?	Non-Cancer PRG × $10^{(2)}$	Risk > PRG × 10 ?
Wastewater (mg/L)		Selenium	7782-49-2	< 0.003222	< 0.003222	8.2	NO	--	--	--	--	--
		Silver	7440-22-4	< 0.05209	< 0.05209	4.3	NO	--	--	--	--	--
		Thallium	7440-28-0	0.2	0.2	14	NO	--	--	--	--	--
		Vanadium	7440-62-2	0.717	0.717	43	NO	--	--	--	--	--
		Zinc	7440-66-6	4.66	4.66	26.1	NO	--	--	--	--	--
	SW7470	Mercury	7439-97-6	0.0034	0.0034	1.5	NO	--	--	--	--	--
	SW8015	Methanol	67-56-1	< 0.81	< 0.81	56	NO	--	--	--	--	--
	SW8081	2,4'-DDD	53-19-0	< 0.0000056	< 0.0000056	0.23	NO	--	--	--	--	--
		2,4'-DDE	3424-82-6	< 0.000013	< 0.000013	0.31	NO	--	--	--	--	--
		4,4'-DDD	72-54-8	< 0.000004	< 0.000004	0.23	NO	--	--	--	--	--
		4,4'-DDE	72-55-9	< 0.0000082	< 0.0000082	0.31	NO	--	--	--	--	--
		4,4'-DDT	50-29-3	< 0.000032	< 0.000032	0.039	NO	--	--	--	--	--
		Aldrin	309-00-2	< 0.0000052	< 0.0000052	0.21	NO	--	--	--	--	--
		alpha-BHC	319-84-6	< 0.000018	< 0.000018	0.0014	NO	--	--	--	--	--
		alpha-Chlordane	5103-71-9	< 0.0000065	< 0.0000065	0.033	NO	--	--	--	--	--
		beta-BHC	319-85-7	< 0.0000072	< 0.0000072	0.0014	NO	--	--	--	--	--
		delta-BHC	319-86-8	< 0.0000034	< 0.0000034	0.23	NO	--	--	--	--	--
		Dieldrin	60-57-1	< 0.000011	< 0.000011	0.17	NO	--	--	--	--	--
		Endosulfan I	959-98-8	< 0.0000061	< 0.0000061	0.23	NO	--	--	--	--	--
		Endosulfan II	33213-65-9	< 0.0000035	< 0.0000035	0.29	NO	--	--	--	--	--
		Endosulfan sulfate	1031-07-8	< 0.000017	< 0.000017	0.29	NO	--	--	--	--	--
		Endrin	72-20-8	< 0.0000079	< 0.0000079	0.028	NO	--	--	--	--	--
		Endrin aldehyde	7421-93-4	< 0.0000048	< 0.0000048	0.25	NO	--	--	--	--	--
		gamma-BHC (Lindane)	58-89-9	< 0.0000067	< 0.0000067	0.017	NO	--	--	--	--	--
		gamma-Chlordane	5103-74-2	< 0.000013	< 0.000013	0.033	NO	--	--	--	--	--
		Heptachlor	76-44-8	< 0.0000036	< 0.0000036	0.012	NO	--	--	--	--	--
		Heptachlor epoxide	1024-57-3	< 0.0000048	< 0.0000048	0.16	NO	--	--	--	--	--
		Methoxychlor	72-43-5	< 0.0000081	< 0.0000081	2.5	NO	--	--	--	--	--
		Toxaphene	8001-35-2	< 0.00022	< 0.00022	0.095	NO	--	--	--	--	--
	SW8082	PCBs (total)	1336-36-3	< 0.00057	< 0.00057	1	NO	--	--	--	--	--
	SW8141	Disulfoton	298-04-4	< 0.00014	< 0.00014	0.17	NO	--	--	--	--	--
		Famphur	52-85-7	< 0.00018	< 0.00018	0.17	NO	--	--	--	--	--
		Methyl parathion	298-00-0	< 0.001	< 0.001	0.14	NO	--	--	--	--	--
		Parathion	56-38-2	< 0.00029	< 0.00029	0.14	NO	--	--	--	--	--
		Phorate	298-02-2	< 0.000072	< 0.000072	0.21	NO	--	--	--	--	--
	SW8151	2,4,5-T	93-76-5	< 0.00017	< 0.00017	7.2	NO	--	--	--	--	--
		2,4,5-TP (Silvex)	93-72-1	< 0.00015	< 0.00015	7.2	NO	--	--	--	--	--
		2,4-D	94-75-7	0.024	0.024	7.2	NO	--	--	--	--	--
		Dinoseb	88-85-7	< 0.0006	< 0.0006	0.66	NO	--	--	--	--	--
	SW8260	1,1,1,2-Tetrachloroethane	630-20-6	< 0.00022	< 0.00022	0.57	NO	--	--	--	--	--
		1,1,1-Trichloroethane	71-55-6	< 0.00015	< 0.00015	0.54	NO	--	--	--	--	--
		1,1,2,2-Tetrachloroethane	79-34-5	< 0.00014	< 0.00014	0.57	NO	--	--	--	--	--
		1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	< 0.00054	< 0.00054	0.57	NO	--	--	--	--	--
		1,1,2-Trichloroethane	79-00-5	< 0.00028	< 0.00028	0.54	NO	--	--	--	--	--
		1,1-Dichloroethane	75-34-3	< 0.00095	< 0.00095	0.59	NO	--	--	--	--	--
		1,1-Dichloroethene	75-35-4	< 0.00055	< 0.00055	0.25	NO	--	--	--	--	--
		1,2,3-Trichloropropane	96-18-4	< 0.00056	< 0.00056	8.5	NO	--	--	--	--	--
		1,2,4-Trichlorobenzene	120-82-1	< 0.00073	< 0.00073	0.55	NO	--	--	--	--	--
		1,2-Dibromo-3-chloropropane	96-12-8	< 0.00089	< 0.00089	1.1	NO	--	--	--	--	--
		1,2-Dichlorobenzene	95-50-1	< 0.00015	< 0.00015	0.88	NO	--	--	--	--	--

TABLE C-4
COMPARISON OF DETECTED CHEMICAL CONCENTRATIONS WITH UTS LEVELS
(Page 5 of 7)

Category	Analytical Method	Site-Related Chemical	CAS No.	Minimum Detect	Maximum Detect	UTS x 10	Maximum > UTSx10?	Carcinogen?	10^{-3} Cancer PRG[1]	Risk > 10^{-3}?	Non-Cancer PRG × $10^{(2)}$	Risk > PRG × 10 ?
Wastewater (mg/L)		1,2-Dichloroethane	107-06-2	< 0.00044	< 0.00044	2.1	NO	--	--	--	--	--
		1,2-Dichloropropane	78-87-5	< 0.00037	< 0.00037	8.5	NO	--	--	--	--	--
		1,3-Dichlorobenzene	541-73-1	< 0.00013	< 0.00013	0.36	NO	--	--	--	--	--
		1,4-Dichlorobenzene	106-46-7	< 0.00011	< 0.00011	0.9	NO	--	--	--	--	--
		Acetone	67-64-1	< 0.0038	< 0.0038	2.8	NO	--	--	--	--	--
		Acetonitrile	75-05-8	< 0.002	< 0.002	56	NO	--	--	--	--	--
		Benzene	71-43-2	< 0.00017	< 0.00017	1.4	NO	--	--	--	--	--
		Bromodichloromethane	75-27-4	< 0.00033	< 0.00033	3.5	NO	--	--	--	--	--
		Bromoform	75-25-2	0.0019	0.0019	6.3	NO	--	--	--	--	--
		Bromomethane	74-83-9	< 0.00031	< 0.00031	1.1	NO	--	--	--	--	--
		Carbon disulfide	75-15-0	< 0.00055	< 0.00055	38	NO	--	--	--	--	--
		Carbon tetrachloride	56-23-5	< 0.0009	< 0.0009	0.57	NO	--	--	--	--	--
		Chlorobenzene	108-90-7	< 0.00012	< 0.00012	0.57	NO	--	--	--	--	--
		Chlorodibromomethane	124-48-1	0.0021	0.0021	0.57	NO	--	--	--	--	--
		Chloroethane	75-00-3	< 0.00035	< 0.00035	2.7	NO	--	--	--	--	--
		Chloroform	67-66-3	0.0093	0.0093	0.46	NO	--	--	--	--	--
		Chloromethane	74-87-3	0.0016	0.0016	1.9	NO	--	--	--	--	--
		cis-1,3-Dichloropropene	10061-01-5	< 0.00073	< 0.00073	0.36	NO	--	--	--	--	--
		Dibromomethane	74-95-3	< 0.00035	< 0.00035	1.1	NO	--	--	--	--	--
		Dichlorodifluoromethane	75-71-8	< 0.00037	< 0.00037	2.3	NO	--	--	--	--	--
		Ethylbenzene	100-41-4	< 0.00019	< 0.00019	0.57	NO	--	--	--	--	--
		Iodomethane	74-88-4	< 0.00026	< 0.00026	1.9	NO	--	--	--	--	--
		Methyl ethyl ketone	78-93-3	< 0.0014	< 0.0014	2.8	NO	--	--	--	--	--
		Methyl isobutyl ketone	108-10-1	< 0.0016	< 0.0016	1.4	NO	--	--	--	--	--
		Methylene chloride	75-09-2	0.003	0.003	0.89	NO	--	--	--	--	--
		Tetrachloroethylene	127-18-4	< 0.00027	< 0.00027	0.56	NO	--	--	--	--	--
		Toluene	108-88-3	< 0.00013	< 0.00013	0.8	NO	--	--	--	--	--
		trans-1,2-Dichloroethene	156-60-5	< 0.00022	< 0.00022	0.54	NO	--	--	--	--	--
		trans-1,3-Dichloropropylene	10061-02-6	< 0.0002	< 0.0002	0.36	NO	--	--	--	--	--
		Trichloroethene	79-01-6	< 0.00036	< 0.00036	0.54	NO	--	--	--	--	--
		Trichlorofluoromethane	75-69-4	< 0.0005	< 0.0005	0.2	NO	--	--	--	--	--
		Vinyl chloride	75-01-4	< 0.00024	< 0.00024	2.7	NO	--	--	--	--	--
		Xylenes (total)	1330-20-7	< 0.00086	< 0.00086	3.2	NO	--	--	--	--	--
	SW8270	1,2,4,5-Tetrachlorobenzene	95-94-3	< 0.001	< 0.001	0.55	NO	--	--	--	--	--
		1,2-Diphenylhydrazine (as Azobenzene	122-66-7	< 0.001	< 0.001	0.87	NO	--	--	--	--	--
		1,4-Dioxane	123-91-1	< 0.002	< 0.002	120	NO	--	--	--	--	--
		2,4,5-Trichlorophenol	95-95-4	< 0.002	< 0.002	1.8	NO	--	--	--	--	--
		2,4,6-Trichlorophenol	88-06-2	< 0.002	< 0.002	0.35	NO	--	--	--	--	--
		2,4-Dichlorophenol	120-83-2	< 0.001	< 0.001	0.44	NO	--	--	--	--	--
		2,4-Dimethylphenol	105-67-9	< 0.001	< 0.001	0.36	NO	--	--	--	--	--
		2,4-Dinitrophenol	51-28-5	< 0.01	< 0.01	1.2	NO	--	--	--	--	--
		2,4-Dinitrotoluene	121-14-2	< 0.0011	< 0.0011	3.2	NO	--	--	--	--	--
		2,6-Dinitrotoluene	606-20-2	< 0.0011	< 0.0011	5.5	NO	--	--	--	--	--
		2-Chloronaphthalene	91-58-7	< 0.001	< 0.001	0.55	NO	--	--	--	--	--
		2-Chlorophenol	95-57-8	< 0.001	< 0.001	0.44	NO	--	--	--	--	--
		2-Methylphenol	95-48-7	< 0.002	< 0.002	1.1	NO	--	--	--	--	--
		2-Nitroaniline	88-74-4	< 0.002	< 0.002	2.7	NO	--	--	--	--	--
		2-Nitrophenol	88-75-5	< 0.001	< 0.001	0.28	NO	--	--	--	--	--
		4-Bromophenyl phenyl ether	101-55-3	< 0.001	< 0.001	0.55	NO	--	--	--	--	--
		4-Chloro-3-methylphenol	59-50-7	< 0.001	< 0.001	0.18	NO	--	--	--	--	--

TABLE C-4
COMPARISON OF DETECTED CHEMICAL CONCENTRATIONS WITH UTS LEVELS
(Page 6 of 7)

Category	Analytical Method	Site-Related Chemical	CAS No.	Minimum Detect	Maximum Detect	UTS x 10	Maximum > UTSx10?	Carcinogen?	10^{-3} Cancer PRG[1]	Risk > 10^{-3}?	Non-Cancer PRG × $10^{(2)}$	Risk > PRG × 10 ?
Wastewater (mg/L)		4-Chloroaniline	106-47-8	< 0.001	< 0.001	4.6	NO	--	--	--	--	--
		4-Nitroaniline	100-01-6	< 0.0013	< 0.0013	0.28	NO	--	--	--	--	--
		4-Nitrophenol	100-02-7	< 0.005	< 0.005	1.2	NO	--	--	--	--	--
		Acenaphthene	83-32-9	< 0.001	< 0.001	0.59	NO	--	--	--	--	--
		Acenaphthylene	208-96-8	< 0.001	< 0.001	0.59	NO	--	--	--	--	--
		Acetophenone	98-86-2	< 0.001	< 0.001	0.1	NO	--	--	--	--	--
		Aniline	62-53-3	< 0.001	< 0.001	8.1	NO	--	--	--	--	--
		Anthracene	120-12-7	< 0.0011	< 0.0011	0.59	NO	--	--	--	--	--
		Benzo(a)anthracene	56-55-3	< 0.001	< 0.001	0.59	NO	--	--	--	--	--
		Benzo(a)pyrene	50-32-8	< 0.001	< 0.001	0.61	NO	--	--	--	--	--
		Benzo(b)fluoranthene	205-99-2	< 0.001	< 0.001	1.1	NO	--	--	--	--	--
		Benzo(ghi)perylene	191-24-2	< 0.001	< 0.001	0.055	NO	--	--	--	--	--
		Benzo(k)fluoranthene	207-08-9	< 0.001	< 0.001	1.1	NO	--	--	--	--	--
		bis(2-Chloroethoxy)methane	111-91-1	< 0.001	< 0.001	0.36	NO	--	--	--	--	--
		bis(2-Chloroethyl) ether	111-44-4	< 0.001	< 0.001	0.33	NO	--	--	--	--	--
		bis(2-Chloroisopropyl) ether	108-60-1	< 0.001	< 0.001	0.55	NO	--	--	--	--	--
		Butyl benzyl phthalate	85-68-7	< 0.001	< 0.001	0.17	NO	--	--	--	--	--
		Chrysene	218-01-9	< 0.001	< 0.001	0.59	NO	--	--	--	--	--
		Dibenz(a,h)anthracene	53-70-3	< 0.001	< 0.001	0.55	NO	--	--	--	--	--
		Diethyl phthalate	84-66-2	< 0.001	< 0.001	2	NO	--	--	--	--	--
		Dimethyl phthalate	131-11-3	< 0.001	< 0.001	0.47	NO	--	--	--	--	--
		Di-n-butyl phthalate	84-74-2	< 0.001	< 0.001	0.57	NO	--	--	--	--	--
		Di-n-octyl phthalate	117-84-0	< 0.005	< 0.005	0.17	NO	--	--	--	--	--
		Fluoranthene	206-44-0	< 0.001	< 0.001	0.68	NO	--	--	--	--	--
		Fluorene	86-73-7	< 0.001	< 0.001	0.59	NO	--	--	--	--	--
		Hexachlorobenzene	118-74-1	< 0.001	< 0.001	0.55	NO	--	--	--	--	--
		Hexachlorobutadiene	87-68-3	< 0.001	< 0.001	0.55	NO	--	--	--	--	--
		Hexachlorocyclopentadiene	77-47-4	< 0.0025	< 0.0025	0.57	NO	--	--	--	--	--
		Hexachloroethane	67-72-1	< 0.001	< 0.001	0.55	NO	--	--	--	--	--
		Indeno(1,2,3-cd)pyrene	193-39-5	< 0.001	< 0.001	0.055	NO	--	--	--	--	--
		Naphthalene	91-20-3	< 0.001	< 0.001	0.59	NO	--	--	--	--	--
		Nitrobenzene	98-95-3	< 0.001	< 0.001	0.68	NO	--	--	--	--	--
		N-Nitrosodi-n-propylamine	621-64-7	< 0.001	< 0.001	4	NO	--	--	--	--	--
		N-Nitrosodiphenylamine	86-30-6	< 0.001	< 0.001	9.2	NO	--	--	--	--	--
		Pentachlorobenzene	608-93-5	< 0.0027	< 0.0027	0.55	NO	--	--	--	--	--
		Pentachlorophenol	87-86-5	< 0.002	< 0.002	0.89	NO	--	--	--	--	--
		Phenanthrene	85-01-8	< 0.001	< 0.001	0.59	NO	--	--	--	--	--
		Phenol	108-95-2	< 0.004	< 0.004	0.39	NO	--	--	--	--	--
		Phthalic acid	88-99-3	< 0.4	< 0.4	0.55	NO	--	--	--	--	--
		Pyrene	129-00-0	< 0.001	< 0.001	0.67	NO	--	--	--	--	--
		Pyridine	110-86-1	< 0.005	< 0.005	0.14	NO	--	--	--	--	--
	SW8290	1,2,3,4,6,7,8-HpCDD	35822-46-9	< 0.0000049	< 0.0000049	0.00035	NO	--	--	--	--	--
		1,2,3,4,6,7,8-HpCDF	67562-39-4	< 0.000017	< 0.000017	0.00035	NO	--	--	--	--	--
		1,2,3,4,7,8,9-HpCDF	55673-89-7	< 0.0000031	< 0.0000031	0.00035	NO	--	--	--	--	--
		OCDD	OCDD	< 0.000013	< 0.000013	0.00063	NO	--	--	--	--	--
		OCDF	OCDF	0.000089	0.000089	0.00063	NO	--	--	--	--	--
TCLP (mg/L)	SW6010	Antimony	7440-36-0	< 0.1121	< 0.5605	11.5	NO	--	--	--	--	--
		Arsenic	7440-38-2	0.128	0.259	50	NO	--	--	--	--	--
		Barium	7440-39-3	0.0178	2.59	210	NO	--	--	--	--	--
		Beryllium	7440-41-7	0.0125	0.0125	12.2	NO	--	--	--	--	--

TABLE C-4
COMPARISON OF DETECTED CHEMICAL CONCENTRATIONS WITH UTS LEVELS
(Page 7 of 7)

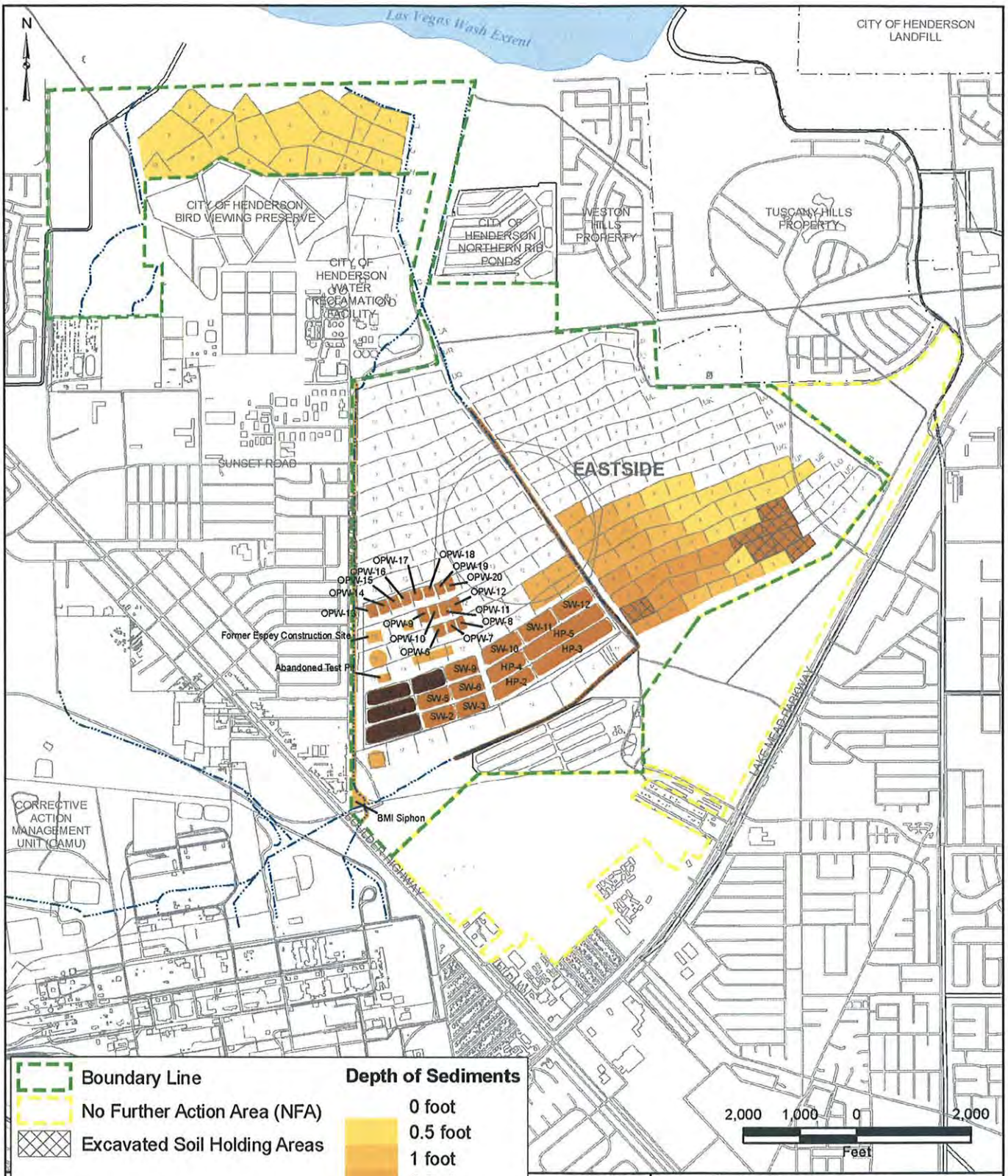
Category	Analytical Method	Site-Related Chemical	CAS No.	Minimum Detect	Maximum Detect	UTS x 10	Maximum > UTSx10?	Carcinogen?	10^{-3} Cancer PRG[1]	Risk > 10^{-3}?	Non-Cancer PRG × 10[2]	Risk > PRG × 10 ?
TCLP (mg/L)		Cadmium	7440-43-9	< 0.00569	< 0.00569	1.1	NO	--	--	--	--	--
		Chromium	7440-47-3	0.0083	2.94	6	NO	--	--	--	--	--
		Lead	7439-92-1	0.0817	0.229	7.5	NO	--	--	--	--	--
		Nickel	7440-02-0	0.0194	5.76	110	NO	--	--	--	--	--
		Selenium	7782-49-2	< 0.1038	< 0.104	57	NO	--	--	--	--	--
		Silver	7440-22-4	< 0.01302	< 0.01302	1.4	NO	--	--	--	--	--
		Thallium	7440-28-0	< 0.125	< 0.125	2	NO	--	--	--	--	--
		Vanadium	7440-62-2	0.021	1.94	16	NO	--	--	--	--	--
		Zinc	7440-66-6	0.0243	0.295	43	NO	--	--	--	--	--
	SW7470	Mercury	7439-97-6	0.00063	0.00063	0.25	NO	--	--	--	--	--
	SW8015	Methanol	67-56-1	< 0.54	< 0.54	7.5	NO	--	--	--	--	--
	SW8260	Carbon disulfide	75-15-0	< 0.012	< 0.012	48	NO	--	--	--	--	--

(1) USEPA Region 9 residential soil PRG based on cancer risk and ingestion and inhalation exposure pathways times 1,000.
(2) USEPA Region 9 residential soil PRG based on non-cancer risk and ingestion and inhalation exposure pathways times 10.

Table C-5
Estimated Waste Volumes, By Location
BRC CAMU
Henderson, NV

Area / Sample ID	Spatial Composite	Area (Sq. Yds.)	Depth (Ft.) (Average)	Volume (Cubic Yds.)
Alpha Ditch				
WC-AD01	Includes WC-AD02 and WC-AD03	70,199	1.0	23,397
Beta Ditch				
WC-BD01	Includes WC-BD02 and WC-BD03	79,453	4.0	105,927
IRM Soil Holding Areas				
WC-IM01	From IRM soil holding area in pond PUA-04	10,880	4.0	14,506
WC-IM02	From IRM soil holding area in pond PUB-04	14,230	4.0	18,971
WC-IM03	From IRM soil holding area in pond PUB-05	14,985	4.1	20,602
WC-IM04	From IRM soil holding area in pond PUB-10	14,202	6.4	30,375
WC-IM05	From IRM soil holding area in pond PUC-03	13,029	4.0	17,371
WC-IM06	From IRM soil holding area in pond PUC-04	12,596	4.6	19,504
WC-IM07	From IRM soil holding area in pond PUD-03	13,908	4.0	18,542
Mohawk Area				
WC-MH01	From ponds PUE-01, PUE-02, PUF-01, and PUF-02	63,412	0	0
No-Build Area				
WC-NB01	From ponds PLH-01, PLI-01, PLI-02, PLJ-01, and PLJ-02	87,058	0	0
WC-NB02	From ponds PLH-02, PLH-03, PLH-04, and PLI-03	117,264	0	0
WC-NB03	From ponds PLG-02 through PLG-05	96,184	0	0
Sunset North Area				
WC-SN01	From ponds PLD-10, PLE-08, PLE-09, PLF-05 through PLF-08, and PLG-06	191,676	0.5	31,943
Spray Wheel				
WC-SW01	From ponds PUE-08, PUE-09, PUF-08, and PUF-09	48,927	2.0	32,614
WC-SW02	From ponds PUF-07, PUG-08, and PUH-07	45,260	2.0	30,170
Former Espey Construction Site				
WC-TE01	From footprint of former Espey Construction site	6,216	2.0	4,146
Other TIMET Debris Areas				
WC-TD01	From footprint of three other TIMET debris areas	34,776	2.0	23,196
TIMET Abandoned Test Pit				
WC-TA01	From footprint of TIMET Abandoned Test Pit	3,887	3.0	3,887
TIMET Berms				
WC-TB01	From western berms between TIMET ponds	NE	NE	NE
WC-TB02	From central west berms between TIMET ponds	NE	NE	NE
WC-TB03	From central east berms between TIMET ponds	NE	NE	NE
WC-TB04	From eastern berms between TIMET ponds	NE	NE	NE
TIMET OPW Ponds				
WC-TW01	From ponds OPW-6 through OPW-11	32,960	4.5	49,436
WC-TW02	From ponds OPW-13 through OPW-20	41,382	4.5	62,067
WC-TW03	From pond OPW-12	5,421	4.5	8,130
TIMET Ponds				
WC-TP01	From pond SC-1	41,624	18.5	256,656
WC-TP02	From pond SW-2	18,682	4.5	28,021
WC-TP03	From pond SW-3	19,312	4.5	28,965
WC-TP04	From pond SW-4	23,958	18.5	147,726
WC-TP05	From pond SW-5	18,828	4.5	28,239
WC-TP06	From pond SW-6	19,650	4.5	29,473
WC-TP07	From pond SW-7	23,377	18.5	144,145
WC-TP08	From pond SW-8	19,650	22.5	147,363
WC-TP09	From pond SW-9	20,667	4.5	30,997
WC-TP10	From pond SW-10	25,507	5.5	46,758
WC-TP11	From pond SW-11	23,861	5.5	43,741
WC-TP12	From pond SW-12	25,265	5.5	46,314
WC-TP13	From pond HP-2	24,974	4.5	37,458
WC-TP14	From pond HP-3	49,320	4.5	73,972
WC-TP15	From pond HP-4	22,845	4.5	34,264
WC-TP16	From pond HP-5	49,513	4.5	74,262
Upper Ponds				
WC-UP01	From ponds PUA-05 through PUA-10	67,102	0.6	12,920
WC-UP02	From ponds PUB-06 through PUB-09	54,615	2.0	37,565
WC-UP03	From ponds PUC-05 through PUC-08	66,385	2.6	56,782
WC-UP04	From ponds PUD-04 through PUD-09	83,035	0.3	28,245
WC-UP05	From ponds PUE-03 through PUE-07	94,070	0.9	25,589
WC-UP06	From ponds PUF-03 through PUF-06	66,474	0.1	9,788
WC-UP07	From ponds PUG-04 through PUG-07	65,344	0.7	15,004
			Total:	**1,899,028**

NE = No Estimate. No waste expected to be excavated



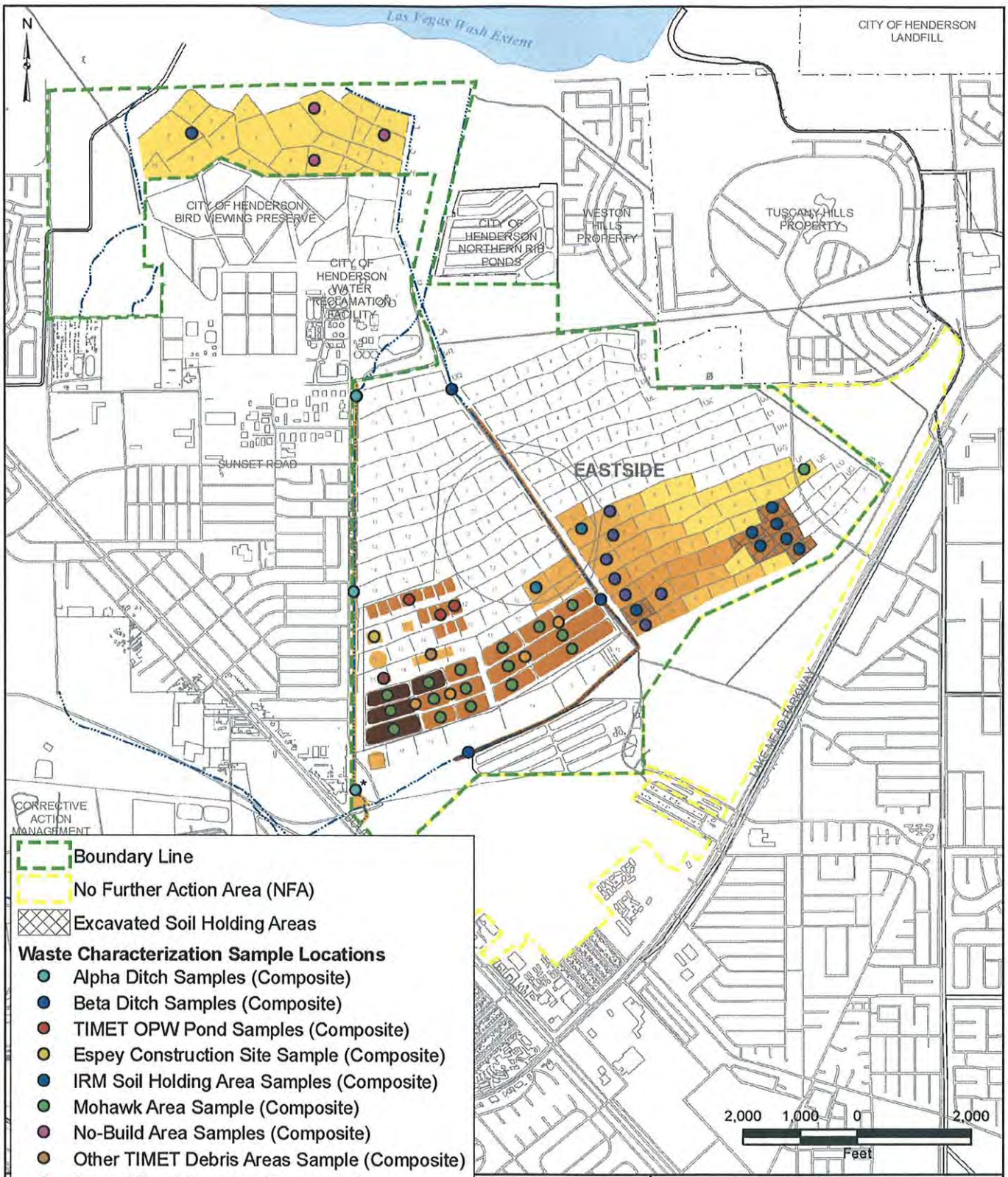
BMI Common Areas
Clark County, Nevada

FIGURE C-1

WASTE AREAS AND DEPTHS

Basic Remediation COMPANY

Prepared by:	Date	JOB No 1881425
MWH MKJ	10/26/06	FILE GIS/BRC/RAP_WASTE/FIGURE_C1.MXD



Boundary Line

No Further Action Area (NFA)

Excavated Soil Holding Areas

Waste Characterization Sample Locations

- Alpha Ditch Samples (Composite)
- Beta Ditch Samples (Composite)
- TIMET OPW Pond Samples (Composite)
- Espey Construction Site Sample (Composite)
- IRM Soil Holding Area Samples (Composite)
- Mohawk Area Sample (Composite)
- No-Build Area Samples (Composite)
- Other TIMET Debris Areas Sample (Composite)
- Spray Wheel Samples (Composite)
- Sunset North Area Sample (Composite)
- TIMET Berm Samples (Composite)
- TIMET Pond Samples (Composite)
- TIMET Abandoned Test Pit Sample (Composite)
- Upper Pond Samples (Composite)

Note: See Table C-2 for description of sample collection. See Figure C-1 for identification of sediment depths. See Figures C-3A through C-3C for individual composite sample locations.
* Indicates BMI Siphon sample location.

BMI Common Areas
Clark County, Nevada

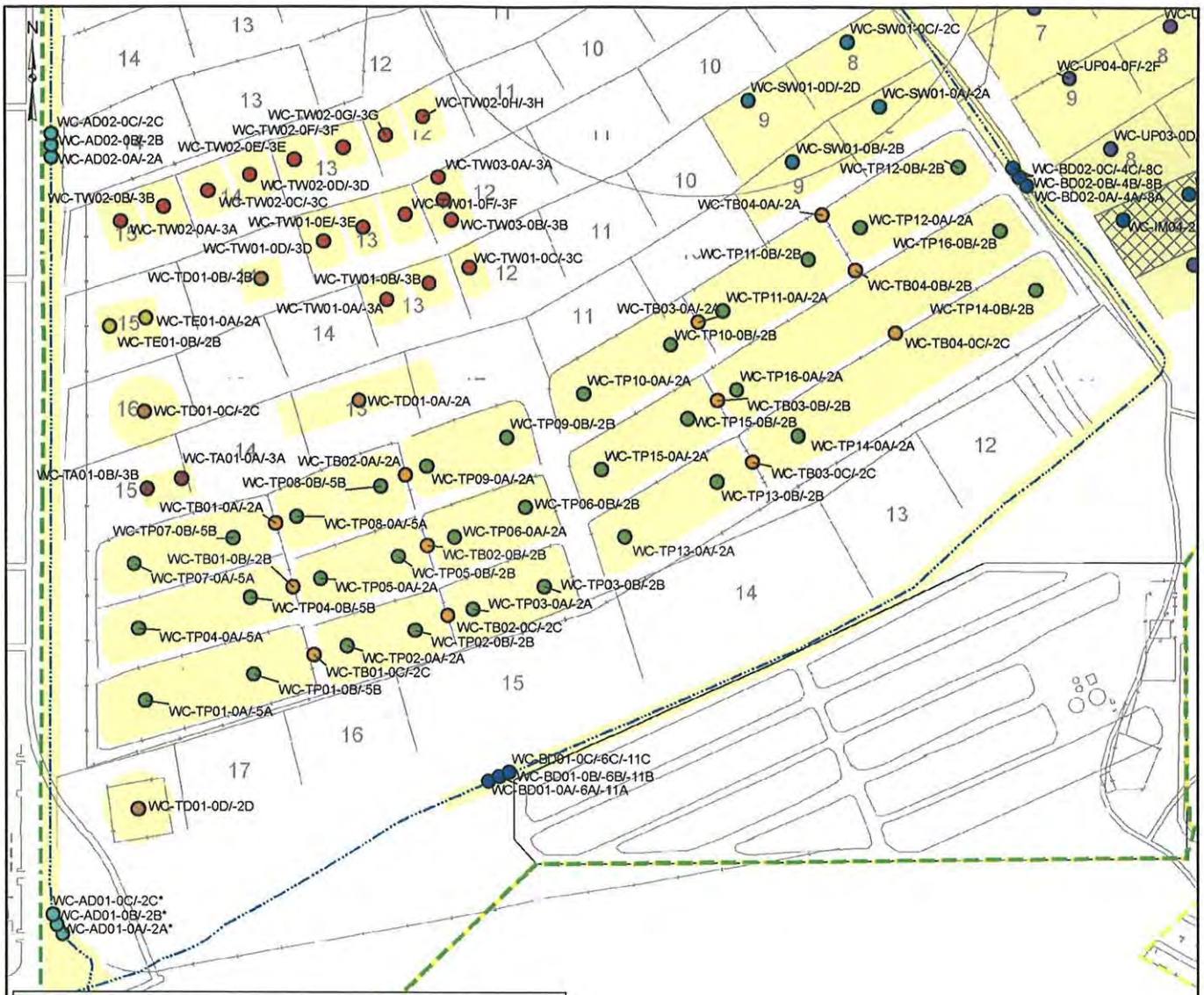
FIGURE C-2

WASTE CHARACTERIZATION SAMPLE LOCATIONS

Basic Remediation COMPANY

Prepared by: MWH MKJ Date 10/26/06

JOB No 1881425
FILE GIS/BRC/RAP_WASTE/FIGURE_C2.MXD



Boundary Line

No Further Action Area (NFA)

Excavated Soil Holding Areas

Individual Composite Sample Locations

- Alpha Ditch Samples (Composite)
- Beta Ditch Samples (Composite)
- TIMET OPW Pond Samples (Composite)
- Espey Construction Site Sample (Composite)
- IRM Soil Holding Area Samples (Composite)
- Mohawk Area Sample (Composite)
- No-Build Area Samples (Composite)
- Other TIMET Debris Areas Sample (Composite)
- Spray Wheel Samples (Composite)
- Sunset North Area Sample (Composite)
- TIMET Berm Samples (Composite)
- TIMET Pond Samples (Composite)
- TIMET Abandoned Test Pit Sample (Composite)
- Upper Pond Samples (Composite)

Note: Composite sample locations are approximate. Sample depths are indicated on the sample labels.
* Indicates BMI Siphon sample location.

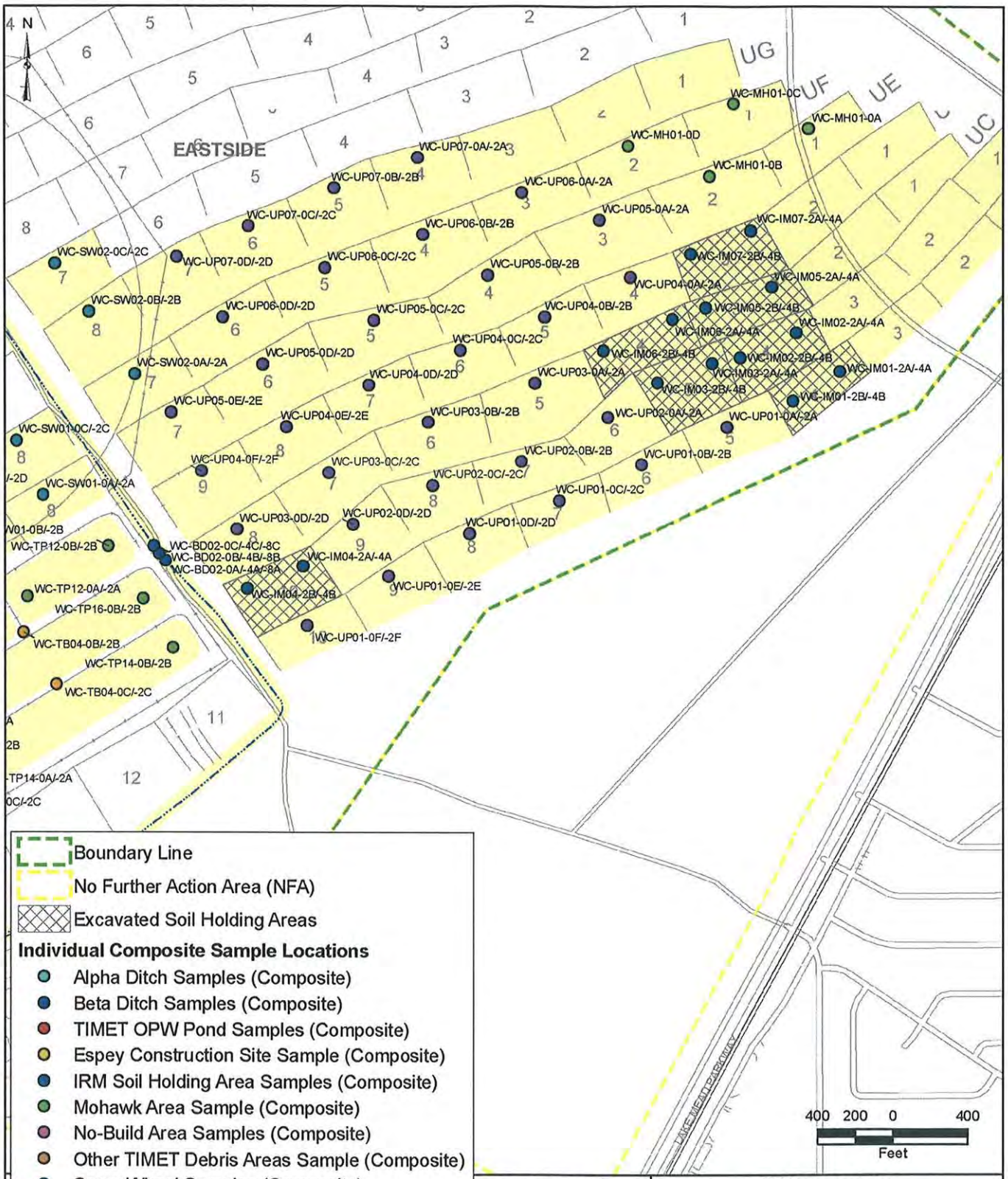
BMI Common Areas
Clark County, Nevada

FIGURE C-3A

INDIVIDUAL COMPOSITE SAMPLING LOCATIONS (WEST)

Basic Remediation COMPANY

Prepared by	Date	JOB No. 1881425
MWH MKJ	10/26/06	FILE GIS/BRC/RAP_WASTE/FIGURE_C3.MXD



Boundary Line

No Further Action Area (NFA)

Excavated Soil Holding Areas

Individual Composite Sample Locations

- Alpha Ditch Samples (Composite)
- Beta Ditch Samples (Composite)
- TIMET OPW Pond Samples (Composite)
- Espey Construction Site Sample (Composite)
- IRM Soil Holding Area Samples (Composite)
- Mohawk Area Sample (Composite)
- No-Build Area Samples (Composite)
- Other TIMET Debris Areas Sample (Composite)
- Spray Wheel Samples (Composite)
- Sunset North Area Sample (Composite)
- TIMET Berm Samples (Composite)
- TIMET Pond Samples (Composite)
- TIMET Abandoned Test Pit Sample (Composite)
- Upper Pond Samples (Composite)

Note: Composite sample locations are approximate. Sample depths are indicated on the sample labels.

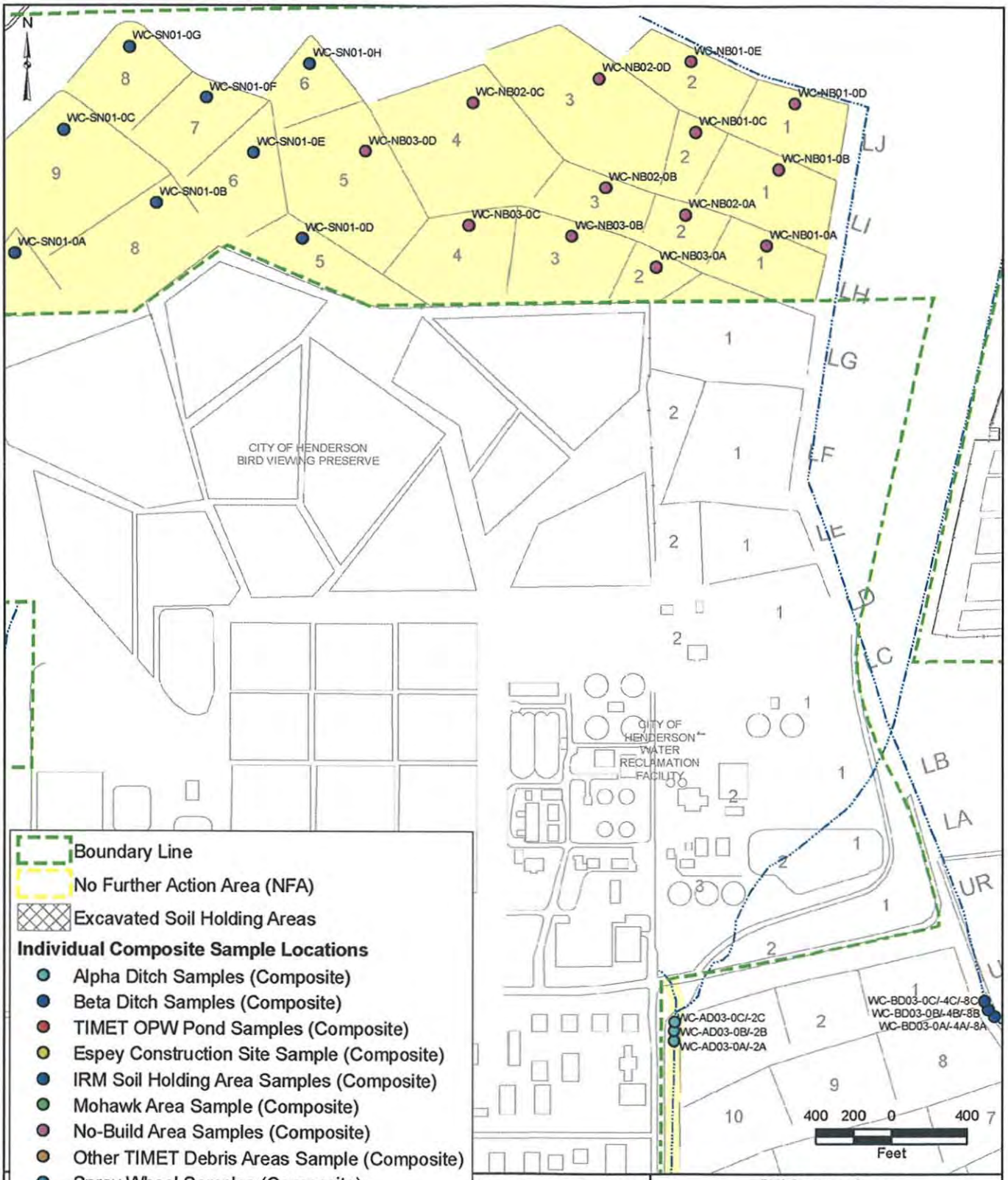
BMI Common Areas
Clark County, Nevada

FIGURE C-3B

INDIVIDUAL COMPOSITE SAMPLING LOCATIONS (EAST)

Basic Remediation COMPANY

Prepared by:	Date	JOB No 1881425
MWH MKJ	10/26/06	FILE: GIS/BRC/RAP_WASTE/FIGURE_C3.MXD



Boundary Line

No Further Action Area (NFA)

Excavated Soil Holding Areas

Individual Composite Sample Locations

- Alpha Ditch Samples (Composite)
- Beta Ditch Samples (Composite)
- TIMET OPW Pond Samples (Composite)
- Espey Construction Site Sample (Composite)
- IRM Soil Holding Area Samples (Composite)
- Mohawk Area Sample (Composite)
- No-Build Area Samples (Composite)
- Other TIMET Debris Areas Sample (Composite)
- Spray Wheel Samples (Composite)
- Sunset North Area Sample (Composite)
- TIMET Berm Samples (Composite)
- TIMET Pond Samples (Composite)
- TIMET Abandoned Test Pit Sample (Composite)
- Upper Pond Samples (Composite)

Note: Composite sample locations are approximate. Sample depths are indicated on the sample labels.

BMI Common Areas
Clark County, Nevada

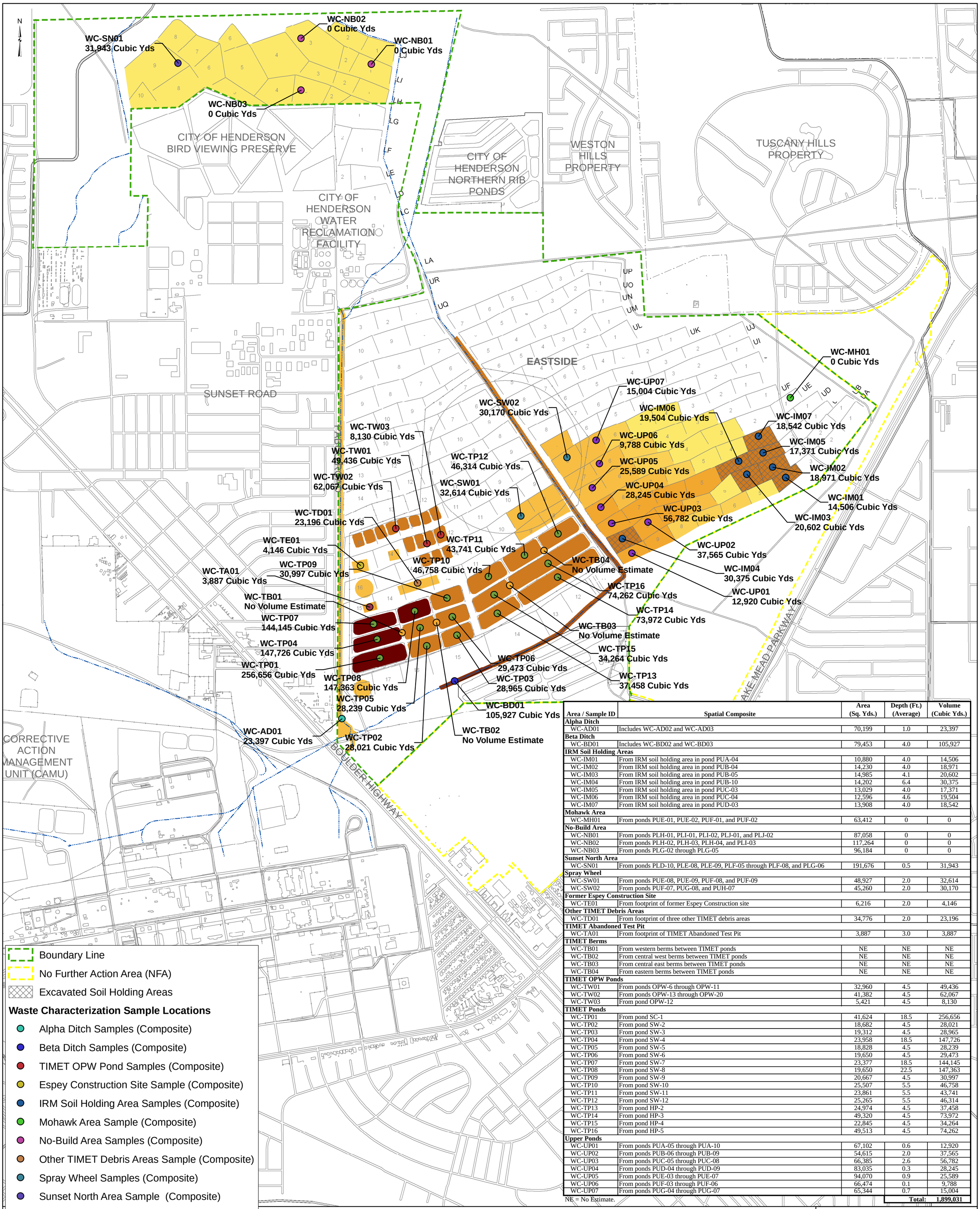
FIGURE C-3C

INDIVIDUAL COMPOSITE SAMPLING LOCATIONS (NORTH)

Basic Remediation COMPANY

Prepared by: MWH MKJ Date 10/26/06

JOB No 1881425
FILE GIS/BRC/RAP_WASTE/FIGURE_C3.MXD



Area / Sample ID	Spatial Composite	Area (Sq. Yds.)	Depth (Ft.) (Average)	Volume (Cubic Yds.)
Alpha Ditch				
WC-AD01	Includes WC-AD02 and WC-AD03	70,199	1.0	23,397
Beta Ditch				
WC-BD01	Includes WC-BD02 and WC-BD03	79,453	4.0	105,927
IRM Soil Holding Areas				
WC-IM01	From IRM soil holding area in pond PUA-04	10,880	4.0	14,506
WC-IM02	From IRM soil holding area in pond PUB-04	14,230	4.0	18,971
WC-IM03	From IRM soil holding area in pond PUB-05	14,985	4.1	20,602
WC-IM04	From IRM soil holding area in pond PUB-10	14,202	6.4	30,375
WC-IM05	From IRM soil holding area in pond PUC-03	13,029	4.0	17,371
WC-IM06	From IRM soil holding area in pond PUC-04	12,596	4.6	19,504
WC-IM07	From IRM soil holding area in pond PUD-03	13,908	4.0	18,542
Mohawk Area				
WC-MH01	From ponds PUE-01, PUE-02, PUF-01, and PUF-02	63,412	0	0
No-Build Area				
WC-NB01	From ponds PLH-01, PLI-01, PLI-02, PLJ-01, and PLJ-02	87,058	0	0
WC-NB02	From ponds PLH-02, PLH-03, PLH-04, and PLI-03	117,264	0	0
WC-NB03	From ponds PLG-02 through PLG-05	96,184	0	0
Sunset North Area				
WC-SN01	From ponds PLD-10, PLE-08, PLE-09, PLF-05 through PLF-08, and PLG-06	191,676	0.5	31,943
Spray Wheel				
WC-SW01	From ponds PUE-08, PUE-09, PUF-08, and PUF-09	48,927	2.0	32,614
WC-SW02	From ponds PUF-07, PUG-08, and PUH-07	45,260	2.0	30,170
Former Espey Construction Site				
WC-TE01	From footprint of former Espey Construction site	6,216	2.0	4,146
Other TIMET Debris Areas				
WC-TD01	From footprint of three other TIMET debris areas	34,776	2.0	23,196
TIMET Abandoned Test Pit				
WC-TA01	From footprint of TIMET Abandoned Test Pit	3,887	3.0	3,887
TIMET Berms				
WC-TB01	From western berms between TIMET ponds	NE	NE	NE
WC-TB02	From central west berms between TIMET ponds	NE	NE	NE
WC-TB03	From central east berms between TIMET ponds	NE	NE	NE
WC-TB04	From eastern berms between TIMET ponds	NE	NE	NE
TIMET OPW Ponds				
WC-TW01	From ponds OPW-6 through OPW-11	32,960	4.5	49,436
WC-TW02	From ponds OPW-13 through OPW-20	41,382	4.5	62,067
WC-TW03	From pond OPW-12	5,421	4.5	8,130
TIMET Ponds				
WC-TP01	From pond SC-1	41,624	18.5	256,656
WC-TP02	From pond SW-2	18,682	4.5	28,021
WC-TP03	From pond SW-3	19,312	4.5	28,965
WC-TP04	From pond SW-4	23,958	18.5	147,726
WC-TP05	From pond SW-5	18,828	4.5	28,239
WC-TP06	From pond SW-6	19,650	4.5	29,473
WC-TP07	From pond SW-7	23,377	18.5	144,145
WC-TP08	From pond SW-8	19,650	22.5	147,363
WC-TP09	From pond SW-9	20,667	4.5	30,997
WC-TP10	From pond SW-10	25,507	5.5	46,758
WC-TP11	From pond SW-11	23,861	5.5	43,741
WC-TP12	From pond SW-12	25,265	5.5	46,314
WC-TP13	From pond HP-2	24,974	4.5	37,458
WC-TP14	From pond HP-3	49,320	4.5	73,972
WC-TP15	From pond HP-4	22,845	4.5	34,264
WC-TP16	From pond HP-5	49,513	4.5	74,262
Upper Ponds				
WC-UP01	From ponds PUA-05 through PUA-10	67,102	0.6	12,920
WC-UP02	From ponds PUB-06 through PUB-09	54,615	2.0	37,565
WC-UP03	From ponds PUC-05 through PUC-08	66,385	2.6	56,782
WC-UP04	From ponds PUD-04 through PUD-09	83,035	0.3	28,245
WC-UP05	From ponds PUE-03 through PUE-07	94,070	0.9	25,589
WC-UP06	From ponds PUF-03 through PUF-06	66,474	0.1	9,788
WC-UP07	From ponds PUG-04 through PUG-07	65,344	0.7	15,004
NE = No Estimate.			**Total:**	**1,899,031**

BMI Common Areas
Clark County, Nevada

FIGURE _

ESTIMATED WASTE VOLUMES

Basic Remediation COMPANY

Prepared by: MWH MKJ Date 02/28/07

JOB No. 1881657
FILE: GIS/BRC/RAP_WASTE/FIGURE_.MXD

Attachment D
Security Plan

Attachment D
Security Plan
Basic Remediation Company (BRC)
Corrective Action Management Unit (CAMU)
Henderson, Nevada

Table of Contents

1.0 Introduction D-1
2.0 Personnel D-1
3.0 Site Control D-1
3.1 Fencing and Gates D-1
3.2 Access D-2
3.3 Signs D-2
3.4 Lighting D-3
4.0 Communication D-3

1.0 INTRODUCTION

This Security Plan describes the procedures and barriers that will be used to prevent persons who are unaware of the danger from entering the Remedial Waste Management System (RWMS). In addition, this plan also includes measures to minimize the possibility of unauthorized entry by persons or livestock onto the active portion of the RWMS.

2.0 PERSONNEL-ACTIVE OPERATIONS

One or two full-time employees, not including contractor employees, will be onsite during construction operations. The following is a list of assigned personnel and their responsibilities:

- BRC – BRC will be on site for a portion of the time the site is open for waste disposal to oversee site operations. BRC will be responsible for keys and/or combinations to the site gates.
- Equipment Operators – The primary responsibility of these (two) positions is the normal construction and operational duties associated with the landfill operations, including spotting vehicles, spreading and compaction of waste material, landfill attendant duties, and installation of earthen cover. Equipment operators will report to BRC.
- Laborers – Typical duties will include site and roadway construction, maintenance, and cleanup, as determined by BRC. In addition, a minimum of one employee will be assigned the job of daily policing the site perimeter, providing directions to disposal locations, monitoring received waste and collecting management data. Laborers will report to BRC.

3.0 SITE CONTROL

3.1 <u>Fencing and Gates</u>

Primary site access will be gained through the entry gate located off Warm Springs Road on the west side of the property. The entry gate will be equipped with a lockable mechanism to prevent unauthorized entry and/or uncontrolled waste deposition when the site is closed. The gates will remain locked except during periods of continuous ingress/egress (i.e., during transport of materials to the BRC CAMU). Access to the site at points other than the entry gate will be discouraged by maintenance of site perimeter fencing during site operations. The Fence Plan is shown on Figure J-12 in Section 1 of the Supplemental RAP Information (SRAPI).

BRC will implement a monitoring program to identify and repair breaches in the perimeter fence line within a reasonable time frame. This program continues after final remediation completion.

3.2 Access

Access to the site will be controlled by site fencing during non-working hours and site personnel during working hours. In addition, artificial barriers will be used to protect public health, safety, and the environment. During specified working hours, waste materials approved for acceptance will be directed to the active landfill working face.

Additional site controls will be employed to control traffic flow, including pedestrian traffic, within the Site during remediation. These site controls are necessary to control remediation workers, vendors and subcontractors, and Site visitors. Site visitors will not be allowed to access the exclusion zone unless approved and escorted by authorized BRC representatives. Visitors will be allowed access if they provide proof of current Title 29 CFR.1910.120, they "sign in" as authorized visitors, and they attend a required Health and Safety tailgate briefing.

3.3 Signs

Bilingual Signs will be posted that clearly indicate the following:

- The owner and operator of the site;
- The hours of operation;
- Materials accepted or excluded; and
- The site is private property and is not open to the public for public disposal of any waste materials whatsoever.

At the main entrance gate off Warm Springs Road an easily visible sign will be posted indicating the facility name, and other pertinent information as required. The sign will include the name of the site operator, the operator's telephone number, and hours of operation. It will be noted on the signage that the BRC CAMU is a private operation.

Instructional signs will be placed at this site entrance addressing prescribed safety measures on the site and include instructions regarding prohibition of smoking within the disposal areas and mandating that all instruction from site personnel be obeyed.

Interior site haul roads will be appropriately signed so as to direct each load to its designated disposal area. Typical directional and information signs will be posted at the site. Location of signage may be changed from time-to-time to facilitate operations. In

addition, authorized personnel may be utilized to direct traffic at the active working face of the landfill operation.

Signs stating "Danger—Unauthorized Personnel Keep Out" will be posted at each entrance to the active portion of the facility, and at other locations, in sufficient numbers to be seen from any approach to the active portion of the site.

"No Trespassing" signs will be posted at each site entrance. Additional signs and/or measures may be required to protect personnel and public health and safety. All signs will be legible from a distance of at least 25 feet.

3.4 Lighting

Lighting will be provided at the main entrance to illuminate the gate and signs. During night time construction, temporary lighting will be used within areas of the site where work is being performed.

4.0 COMMUNICATION

Breaches in security will be reported to the BRC for immediate repair and correction.

On-site communication will be through mobile phones.

Attachment E
Inspection Plan and Schedules

Attachment E
Inspection Plan and Schedules
Basic Remediation Company (BRC)
Corrective Action Management Unit (CAMU)
Henderson, Nevada

Table of Contents

1.0 Introduction E-1
1.1 Personnel E-1
2.0 Operational Inspections E-2
2.1 Health and Safety E-2
2.2 Air Monitoring E-2
2.3 Hauling/Transport E-2
2.4 Surface Water E-3
2.5 Leachate E-3
2.6 Gates and Fences E-3
2.7 Liner and Cover Systems E-3
2.8 Equipment E-4
2.9 Best Management Practices E-4
3.0 Recordkeeping E-4

Appendices

Appendix A – Inspection Checklists

1.0 INTRODUCTION

This Inspection Plan includes the items, areas, units, and equipment that will be inspected during the construction and operation of the BRC CAMU to identify malfunctions, deterioration, operator errors, and discharges that may be causing, or may lead to, a release of waste constituents to the environment or a threat to human health. Inspections performed during the post-closure care period are discussed in Attachment O. This plan includes checklists, schedules, and qualifications of personnel charged to perform inspections. A separate Construction Quality Assurance (CQA) Plan for the construction of the base liner system is included in Supplemental RAP Information (SRAPI), Section 3 and a separate CQA Plan for the construction of the final cover system is included in SRAPI, Section 6.

BRC will inspect monitoring equipment, safety and emergency equipment, security devices, and operating and structural equipment (such as dikes and sump pumps) that are important to preventing, detecting, or responding to environmental or human health hazards. Inspection checklists will be kept on site and will identify the types of problems (e.g., malfunctions or deterioration) which are to be looked for during the inspection (e.g., inoperative sump pump, leaking fitting, erosion, etc.). Inspection checklists are included as Appendix A.

1.1 Personnel

To develop and maintain the overall BRC CAMU in conformance with the inspection standards outlined in this document, BRC employees and/or contractors will be assignedto site inspections. Other employees or contractors will be assigned, as needed, for support activities.

The following is a list of assigned personnel with a brief outline of their qualifications:

- BRC–BRC will maintain an office near the site. This individual will be directly responsible for all site-related inspection activities. The BRC shall assign inspection duties, ensure all activities are performed on schedule, and maintain records in accordance with this plan and the Reports and Recordkeeping Plan (Attachment T). This individual will report to the Project Manager.

- Equipment Operators – Employees serving in this capacity will possess experience and training in the fields of heavy equipment operation and earth movement and construction activities. The primary inspection responsibilities of

these positions include equipment and additional inspections as directed by the BRC. Equipment operators will report to the BRC.

- Laborer – Typical duties will include site and roadway construction, maintenance, and cleanup, as determined by BRC. One employee will be assigned the job of daily policing the site perimeter and regulation of site access, providing directions to disposal locations, monitoring received waste and collecting management data.

BRC is committed to placing and maintaining individuals with the overall training, experience, capabilities, and/or other qualifications in the above noted positions as necessary to operate and develop the site in such a manner as to meet or exceed applicable requirements and regulations. Additional equipment and personnel will be provided as required to accomplish overall site maintenance and operation standards, which equal or exceed all applicable State and local rules and regulations pertaining to site safety measures and the overall general protection of the area's environment.

2.0 OPERATIONAL INSPECTIONS

2.1 Health and Safety

Health and Safety inspections will be performed as outlined in the Accident Prevention, Contingency, and Emergency Response Plan (Attachment G). These inspections will be carried out by BRC or his/her designee. The Health and Safety inspections include verifying PPE and communication devices are in good, working condition, inspection of safe work practices, and verifying personnel has received proper health and safety training. If conditions are found to be unsafe through inspections, the Project Manager will halt work and address problems. Examples of unsafe conditions are: Personal Protective Equipment (PPE) or radio/communication malfunction, severe weather, and/or fire.

2.2 Air Monitoring

Given the small amount of additional waste to be placed in the CAMU, BRC does not plan to conduct any air monitoring. Of course, all dust suppression actions will continue to be implemented.

2.3 Hauling/Transport

Haul routes will be inspected on a daily basis by BRC or their designee during hauling operations. Condition of the haul routes will be evaluated daily to determine if repairs are required. Repairs will be made when rutting, drainage, or other issues impact the transport of the waste materials.

Hauling/transport equipment will be kept in good working order and will have covers over the load. Standard construction entrance features (rumble strips and large aggregate aprons) will be used to remove soil from vehicle wheels departing the BRC CAMU site. Sweeper and vacuum trucks will be used daily to maintain haul routes. Further details are found in the CAP.

2.4 Surface Water

BRC or his/her designee will be responsible for inspecting the storm water collection system after precipitation events (i.e. post storm) exceeding 1/4 inch in a 24 hour period and will evaluate erosion, sedimentation, and other damage, if any. In addition, the post storm inspection will be performed to evaluate the potential for surface water infiltration into the BRC CAMU. Surface water conveyance features will be inspected quarterly during the dry season and weekly during the wet season for sediment and debris accumulation. Collection and holding facilities will be inspected for sediment build-up and debris after precipitation events (i.e. post storm) exceeding 1/4 inch in a 24 hour period to maintain conveyance and design capacity.

Accumulated surface water, which has not entered the waste containing areas of the BRC CAMU, will be removed as soon as practical. An operational pump and appurtenant equipment will be maintained on-site during the entirety of the project (and not just during typically wet periods of the year) to be used in surface water removal. Accumulated surface water, which has contacted the waste material, will be treated as leachate and handled accordingly.

2.5 Leachate

Leachate monitoring will be conducted in accordance with the Final Leachate Monitoring Plan (Attachment Z). BRC

Leachate will be handled for proper disposal in accordance with BRC CAMU Operation Plan (Attachment M).

2.6 Gates and Fences

The BRC or designee will inspect the fences and gates routinely to ensure all are in proper working order. In addition, the security guard will note any missing or damaged signs around the property as well as evidence of unauthorized access. Damages will be recorded and repairs performed immediately to minimize unauthorized site access.

2.7 Liner and Cover Systems

During construction and installation, liners and cover systems will be inspected regularly for uniformity, damage, and imperfections (e.g., holes, cracks, thin spots, or foreign materials) as outlined in the construction quality assurance plans for the base liner system and final cover system. Details of liner and cover construction quality assurance are provided in the Construction Plan (Attachment L) and Closure and Post-Closure Plan (Attachment O), respectively. The liner system will be inspected weekly during waste placement activities to verify the system remains undamaged. If damage occurs, work activities in the area of the damage will halt while damage is repaired.

2.8 Equipment

During construction activities, all equipment in operation will be inspected daily by the equipment operator. BRC will also inspect and track on-site equipment to ensure that it is in good working order. Inspections will be performed by equipment operators to ensure equipment is in good working order. Equipment which is not in good working order will not be used until repaired or replaced.

2.9 Best Management Practices

Best management practices (BMPs) will be inspected weekly and after storm events to verify they are in good, working condition. If inspections indicate BMPs are damaged, they will be replaced.

3.0 RECORDKEEPING

BRC or their designee will record inspections in an inspection log. These records will be kept in accordance with the records retention requirements of the AOC3. At a minimum, these records will include the date and time of the inspection, the name of the inspector, a notation of the observations made, and the date and nature of any repairs or other remedial actions. Inspection checklists are included as Appendix A.

Appendix A
Inspection Checklists

Basic Remediation Company
Corrective Action Management Unit (CAMU)

Log of Operations

Yearly Cover Sheet

This log cover sheet shall be completed at the beginning of each license year and should be kept on file at the beginning of the daily log file for that year. Attach amendments to this form as necessary.

Annual Log for Year: _____ License #: _____ Phone #: _____

Name of Facility: _____

Mailing Address: _____

(Street) (City) (State) (Zip)

Location of Facility _____

(Street) (City) (State) (Zip)

Owner of Facility: _____ Licensee Name: _____

Name of Site Manager: _____

Method of Measuring Amount of Incoming Materials:

_____ Scales _____ Visual Estimate _____ Capacity of Hauling Vehicle

Types & Number of Equipment on Site:

_____ Dozers _____ Graders _____ Pan/Scraper

_____ Compactor _____ Sweepers _____ Water Trucks

Other: _____

_____

_____

Daily Inspection Checklist
BRC CAMU
Henderson, NV

Date: _____

Name: _____ Title: _____

Weather: _____

	Time:	YES	NO	
Health & Safety:	_____	☐	☐	Site map posted
		☐	☐	Buddy system implemented
		☐	☐	Work zones identified
		☐	☐	Site access controlled
		☐	☐	Visitors escorted
		☐	☐	On/off site communication in working order
		☐	☐	Air monitoring equipment is working order
		☐	☐	Air monitoring records recorded in field logbook
		☐	☐	Air monitoring calibration records recorded in field logbook
		☐	☐	Standard operating procedures implemented
		☐	☐	Housekeeping at decontamination zone is appropriate
		☐	☐	Decontamination procedures implemented
		☐	☐	Emergency response equipment in working order
		☐	☐	Route to hospital is posted
		☐	☐	Hazards incurred. If yes: _____
Haul Roads:	_____	☐	☐	Waste Debris on Roadways
				if yes: _____
Surface Water:	_____	☐	☐	Surface Water Present
				if yes, where and disposal method: _____
Waste Placement:	_____	☐	☐	Liner/cover free from damage and imperfections
				if no: _____
		☐	☐	Placement in accordance with Project Drawings and schedule
				if no: _____

Daily Inspection Checklist
BRC CAMU
Henderson, NV

☐ ☐ Fill Stable

if no: _____

Security: _____

☐ ☐ Fences and gates in good condition

if no: _____

☐ ☐ Signs of unauthorized access

if yes: _____

☐ ☐ Notification signs present and in good condition

if no: _____

☐ ☐ Improper Salvaging

if yes: _____

Equipment: _____

☐ ☐ Air Monitoring equipment in good, working condition

if no: _____

☐ ☐ Scales in good, working condition:

if no: _____

Daily Inspection Checklist
BRC CAMU
Henderson, NV

	# in Operation:	of:	
Load-out Operation			Dozer
			Waterpull
			P/W Scraper
			Excavator
			Off-Road Dump Truck
			Lube Truck
			Water Stand Tank
Boulder Highway Operation			Sweeper
			Loader
			Light Plant
			Traffic Read Board
			Vacuum Truck
Haul Route Operation			Blade
			Waterpull
			Water Stand Tank
			Light Plan
Disposal Equipment			Dozer
			Waterpull
			P/W Scraper
			Off-Road Dump Truck
			Lube Truck
			Water Stand Tank
			Compactor
	Other:		_____
			_____
			_____

Work shall be postponed until correct

Needs to be addressed

Weekly Inspection Checklist

BRC CAMU
Henderson, NV

Week of: _____

Name: _____ Title: _____

Leachate Collection:

Amount of Leachate Collected: _____ Gallons (Weekly)
_____ Gallons (Daily)

Action Level Reached? ☐ Yes ☐ No

Disposal Method: ☐ Dust Control
☐ Off-Site
☐ N/A

	YES	NO	
Health and Safety			
	☐	☐	Pre-entry brief meetings are current
	☐	☐	Tailgate meetings are current
	☐	☐	Primary and Secondary containers are properly labeled
	☐	☐	Material safety data sheets are available
	☐	☐	PPE storage is neat and organized
Haul Roads:			
	☐	☐	Erosion of road
			if yes: _____
			_____
	☐	☐	Rumble strips/aggregate aprons in good condition
			if no: _____
			_____
Run-off Collection:			
	☐	☐	Cracks in conveyance channels
			if yes: _____
			_____
	☐	☐	Water present in conveyance channels
			if yes: _____
			_____
	☐	☐	Evidence of flooding
			if yes: _____
			_____

Weekly Inspection Checklist

BRC CAMU
Henderson, NV

Run-on Collection:

☐ ☐ Water Present

if yes: _____

_____

☐ ☐ Pumps in good, working condition

if no: _____

_____

CAMU Surface:

☐ ☐ Evidence of erosion

Type:

☐ Wind

☐ Water

if yes: _____

_____

☐ ☐ Cracks in surface

if yes: _____

_____

BMPs:

☐ ☐ Dormant areas outside of silt fence seeded/mulched

if no: _____

_____

☐ ☐ Seed and mulch blown away

if yes: _____

_____

☐ ☐ Silt fences/wind screens in good, working condition

if no: _____

_____

☐ Needs to be addressed

Monthly Inspection Checklist
BRC CAMU
Henderson, NV

Month of: _____

Name: _____ Title: _____

	YES	NO	
Health and Safety			
	☐	☐	Training/medical surveillance/respiratory protection records are current
	☐	☐	Chemical inventory is up to date
Repairs			
	☐	☐	Previous month's failed inspections addressed
			if no: _____
Leachate:			
	☐	☐	Leachate Pump in good, working order
Haul Roads:			
	☐	☐	Ruts/Cracks in road
			if yes: _____
	☐	☐	Rumble Strips/Aggregate Aprons in good condition
			if no: _____

☐ Needs to be addressed

Post-Storm Inspection Checklist

BRC CAMU
Henderson, NV

Date: _____

Name: _____

Storm Duration: _____

Total Precipitation Amount: _____ (inches)

Leachate Collection:

Amount of Leachage Collected: _____ Gallons

Action Level Reached? ☐ Yes ☐ No

Disposal Method: ☐ Dust Control
☐ Off-Site
☐ N/A

	YES	NO	
Haul Roads:	☐	☐	Pooled Water
			if yes: _____
Run-off Collection:	☐	☐	Evidence of flooding
			if yes: _____
	☐	☐	Water Samples Collected
			if no: _____
Run-on Collection:	☐	☐	Water Present
			if yes: _____
	☐	☐	Water Samples Collected
			if no: _____
CAMU Surface:	☐	☐	Evidence of erosion
			if yes: _____

Post-Storm Inspection Checklist

BRC CAMU

Henderson, NV

☐ ☐ Water present

if yes: _____

_____

☐ ☐ Cracks/rills in surface

if yes: _____

_____

Best Management Practices:

☐ ☐ BMPs in good condition

if no: _____

_____

Off-site Disposal:

☐ ☐ Evidence of off-site disposal

if yes, corrective actions implemented: _____

_____

_____

☐ Needs to be addressed

Quarterly Inspection Checklist

BRC CAMU
Henderson, NV

Date: _____ Quarter: _____

Name: _____ Title: _____

Health and Safety:	YES	NO	
	☐	☐	New Employees if yes, names/titles: _____
	☐	☐	New employees have received H&S training if no, when will it be scheduled: _____
	☐	☐	HASP needs updating if yes: _____
	☐	☐	Health and Safety Inspection logs maintained if no: _____
	☐	☐	Accident, Contingency, and Emergency Response Plan on site if no: _____
	☐	☐	Accidents/Emergencies within last 3 months if yes, what was done to prevent future occurance: _____

Quarterly Inspection Checklist
BRC CAMU
Henderson, NV

Water Quality:

☐ ☐ Analytical results maintained for surface water monitoring

if no: _____

_____

☐ ☐ Analytical results maintained for groundwater monitoring

if no: _____

_____

☐ Needs to be addressed

Attachment F
Personnel Training Plan

Attachment F
Personnel Training Plan
Basic Remediation Company (BRC)
Corrective Action Management Unit (CAMU)
Henderson, Nevada

Table of Contents

1.0 Introduction F-1
1.1 Personnel F-1
2.0 Training F-1
2.1 Field Supervisor Training F-3
2.2 Equipment Operator and General Employee Training F-3
2.3 Post-Closure Personnel Training F-4
3.0 Recordkeeping F-4

Appendices

Appendix A – Training Course Descriptions

Appendix B – Site Specific Training Lesson Plans and Exams

Appendix C – Organizational Flowchart

1.0 INTRODUCTION

This Personnel Training Plan describes the personnel and classroom or on-the-job training workers and other site personnel receive on how to perform their duties in a way that ensures the BRC CAMU complies with the conditions of this RAP and how to respond effectively to emergencies.

1.1 Personnel

To develop and maintain the overall BRC CAMU in conformance with the design and operational standards outlined in this document, three to four employees or contractors will be assigned, as required, to site operations. Other employees or contractors will be assigned, as needed, for support activities.

The following is a list of on-site personnel with a brief outline of their qualifications:

- BRC CAMU Construction Manager –BRC or their designee will be on site at least 50 percent (50%) of the time the site is open for waste disposal to oversee site operations. BRC will be responsible for keys to the site gates.
- Equipment Operators – The primary responsibility of these (two) positions is the normal construction and operational duties associated with the landfill operations, including spotting vehicles, spreading and compaction of waste material, landfill attendant duties, and installation of earthen cover. Equipment operators will report to BRC.
- Laborers – Typical duties will include site and roadway construction, maintenance, and cleanup, as determined by BRC. In addition, a minimum of one employee will be assigned the job of daily policing the site perimeter, providing directions to disposal locations, monitoring received waste and collecting management data. Laborers will report to BRC.

2.0 TRAINING

BRC is committed to placing and maintaining individuals with such overall training, experience, capabilities, and/or other qualifications in the above noted positions as necessary to operate and develop the site in such a manner as to meet or exceed applicable requirements and regulations. Additional equipment and personnel will be provided as required to accomplish overall site maintenance and operation standards, which equal or exceed all applicable State and local rules and regulations pertaining to site safety measures, and the overall general protection of the area's environment.

Non-office site personnel will receive 40-hr Occupational Safety and Health Administration (OSHA) Hazardous Waste Operations and Emergency Response Standards (HAZWOPER) training, which will be provided by certified trainers. Personnel will renew this training annually with the 8-hr refresher course. Employees using a Nuclear Density Gauge will be required to have completed the 8-hour Nuclear Density Safety Course, which will be provided by a certified trainer (e.g. Troxler Electronics, etc.). Prior to beginning work at the CAMU site, employees, contractors, and subcontractor personnel are required to submit all applicable training certificates to BRC to be maintained and stored in accordance with the Report and Record Keeping Plan (Attachment T). The task supervisor will be responsible for providing BRC with records of training. The following table lists the training required for specific work tasks and personnel working at the CAMU site. Select course descriptions are provided in Appendix A.

Work Task	**Training**	**Personnel Required to be Trained**	**Documentation Required**
All work at the CAMU site	40 hour OSHA HAZWOPER	All on-site personnel	Certificate from certified training meeting 29 CFR 1910
All work at the CAMU site	8 hour OSHA refresher	All on-site personnel	Certificate from certified training meeting 29 CFR 1910
All work at the CAMU site	8 hour OSHA Supervisor Training	On-site supervisors	Certificate from certified training meeting 29 CFR 1910
All work at the CAMU site	Respirator Fit Test	All on-site personnel	Certificate from certified trainer 29 CFR 1910
All work at the CAMU site	Red Cross First Aid and CPR	On-site supervisors	Certificate from Red Cross
Liner system – geomembrane installation	Manufacturer training on seaming geomembrane	Geomembrane installation technicians	Approval letter from geomembrane manufacturer
Liner system – geosynthetic material installation	Qualifications and experience installing similar materials	Geosynthetic material installation technicians	Qualifications and resumes of personnel responsible for installing geosynthetic materials
Soil/waste moisture / density testing	8 hour Nuclear Density Safety Training	CQA monitor testing fill and waste moisture / density	Certificate from certified trainer
Landfill operations management	SWANA Manager of Landfill Operations Training	Landfill manager	Certificate from certified SWANA trainer

HDPE pipe joining	Manufacturer Butt-Fusion Training	HDPE pipe joining technicians	Certificate from certified trainer

Additional site specific training will be conducted and recorded by task supervisors related to their work tasks. Site specific training is discussed in Section 2.2.

2.1 Construction Manager Training

In addition to OSHA 40-hr HAZWOPER Training, BRC will receive the OSHA 8-hr HAZWOPER Supervisor course. BRC or their designee will be responsible for providing a health and safety training for site personnel to become familiar BRC CAMU-specific procedures. BRC or their designee will keep records on names and dates of those who attended and passed training.

BRC or their designee will also be responsible for conducting pre-entry brief meetings and tailgate safety meetings. He/she will verify monitoring equipment and personal protective equipment is operational and will be responsible for verifying monitoring equipment has been calibrated. BRC will also be responsible for weekly inspections.

2.2 Equipment Operator and Laborer Training

In addition to OSHA 40-hr HAZWOPER training, employees shall receive BRC CAMU-specific training covering:

- Procedures for using, inspecting, repairing, and replacing facility emergency and monitoring equipment: Personnel receive instruction in the use of emergency and monitoring equipment described in the Attachment G. Personnel will be trained to inspect all facility emergency and monitoring equipment to mitigate the effects of equipment failure in the Inspection Plan. In addition, personnel will be trained in the use of emergency equipment in their job areas (e.g. fire extinguishers, respirators, etc.);
- Key parameters for equipment automatic shut-off: Plant and equipment operators will receive on-the-job training for automatic shut down of equipment in their work areas;
- Communications or alarm systems: Facility employees will be instructed as to the location and use of all telephones, intercoms, sirens, alarms, and two-way radios;
- Responses to fires or explosions: Personnel will receive fire prevention training and fire response;
- Response to spills: Personnel will receive instruction in spill and release prevention and response ; and
- Shutdowns of operations: Personnel will receive instruction in shutdown procedures during BRC CAMU operation. Personnel with operational

responsibilities are instructed in procedures for planned and unplanned shutdowns during on-the-job training.

Training sessions will be held quarterly to review new health and safety hazards and provide new employees with training. The employees will be familiar with contingency plans to deal with accidents, injuries, fires, explosions, or natural disasters as outlined in Attachment G, Accident Prevention, Contingency, and Emergency Response Plan.

2.3 Post-Closure Personnel Training

Post-closure care personnel will have received adequate training in their specific job duties. This includes OSHA 24-hour health-and-safety training as well as pertinent training in BRC CAMU maintenance procedures. In addition, staff will be trained on emergency procedures and contacts as well as hazards they may encounter at the BRC CAMU. This post-closure staff will consist of a facility manager and various staff workers as needed. The name, address, and telephone number of the facility manager will be provided to the NDEP during the closure process.

3.0 RECORDKEEPING

The BRC will maintain the following documents and records for each hazardous waste management related position at the facility:

- The job title for each position
- The name of the employee filling each position
- A written job description including requisite skill, education, or other qualifications
- Duties of employees assigned
- Description of training
- Records documenting completion of training

BRC will maintain records at their onsite facilities. All records will be kept in accordance with the record retention requirements of the AOC3.

Appendix A
Training Course Descriptions

HAZWOPER 40 Hour Course

OSHACAMPUS.com™
powered by 360training

Course Description

This course covers broad issues pertaining to the hazard recognition at work sites. OSHA has developed the HAZWOPER program to protect the workers working at hazardous sites and devised extensive regulations to ensure their safety and health. This course, while identifying different types of hazards, also suggests possible precautions and protective measures to reduce or eliminate hazards at the work place. It is specifically designed for workers who are involved in clean-up operations, voluntary clean-up operations, emergency response operations, and storage, disposal, or treatment of hazardous substances or uncontrolled hazardous waste sites. Topics include: protection against hazardous chemicals, elimination of hazardous chemicals, safety of workers and the environment, and OSHA regulations. This course covers topics included in 29 CFR 1910.120.

Regulatory

This course meets the in class training requirements of the 1910.120 standard. An additional 8 hours of hands on training is required to meet the training requirements of the standard.

Seat Time

This course has been approved for 40 hours.

Course Pre-Requisite

There are no pre-requisite requirements for this course. Upon successful completion of this course, you will be able to print your certificate.

Testing:

Quizzes: Lesson quizzes require no mastery. Quizzes at the end of each module require a passing grade to proceed to the next module. Final Exam: Final Exam must be passed with a 70% to pass the course. The final exam can be taken three times if necessary.

Topics Covered

- Regulation Overview
- Site Characterization
- Toxicology
- Hazard Recognition
- Hazard & Safety Analysis
- Hazardous Chemical Awareness
- Radiological Hazards
- Respiratory Protection
- Personal Protective Equipment
- Site Control
- Decontamination
- Medical Surveillance
- Air Monitoring
- Confined Space Entry
- Emergency Procedures
- Material Sampling

HAZWOPER 8 Hour Annual Refresher Course

OSHACAMPUS.com™
powered by 360training

Course Description

This course meets the requirements in OSHA 29 CFR 1910.120 for 8 hours of annual refresher training for workers at hazardous waste sites. This course is designed for general site workers who remove hazardous waste or who are exposed or potentially exposed to hazardous substances or health hazards. Topics include HAZWOPER regulations, safety and health plans, hazardous chemicals, safety hazards, air monitoring, medical surveillance, site control, decontamination, personal protective equipment, and respiratory equipment. This course covers the topics in OSHA 29 CFR 1910.120

Learning Objectives

- Read and understand OSHA regulations and requirements
- Use Site Characterization to identify hazards found in the workplace and steps to be taken to minimize hazards
- Understand the principles of toxicology and how they relate to various types of chemical exposures
- Develop a Medical Surveillance Program and understand its purpose
- Identify the uses for Personal Protective Equipment (PPE) and how to choose the correct PPE for a situation
- Understand the principles of decontamination as well as levels of decontamination and decontamination methods
- Have a better understanding of potentially hazardous situations involving corrosives, solvents, oxidizers, and reactive chemicals
- Understand the various considerations in an emergency and the importance of training and actions to personal safety and the safety of others

Topics Covered

- Regulation Overview
- Hazard Recognition
- Site Characterization, Analysis, and Control
- Toxicology
- Medical Surveillance
- Safe Work Practices and PPE
- Decontamination
- Chemical Awareness
- Emergency Procedures

Regulatory

Please refer to the state/regulatory requirement in the course catalog page.

Seat Time

This course has been approved for 8 hours

Course Pre-Requisite

Must have taken the 24 or 40 hour HAZWOPER course

Testing

Quizzes: All quizzes must be passed with a 100% to proceed to the next lesson. Final Exam: Final exam must be passed with a 70% to pass the next course. The final exam can be taken three times if necessary.

Contact us at: safety@360training.com or call 1.888.318.3497

360training™

American Red Cross

Standard First Aid with CPR/AED - Adult

American Red Cross First Aid with CPR/AED - Adult, trains participants to recognized ad care for life-threatening respiratory or cardiac emergencies in adults and provides the knowledge and skills needed to care for injury or sudden illness until professional medical help arrives. Training complements adult learning styles with hands-on practice and real-life scenarios while take-away materials serve as excellent refresher tools after training is complete. This comprehensive course meets training guidelines for first aid programs established by the Occupational Safety and Health Administration.

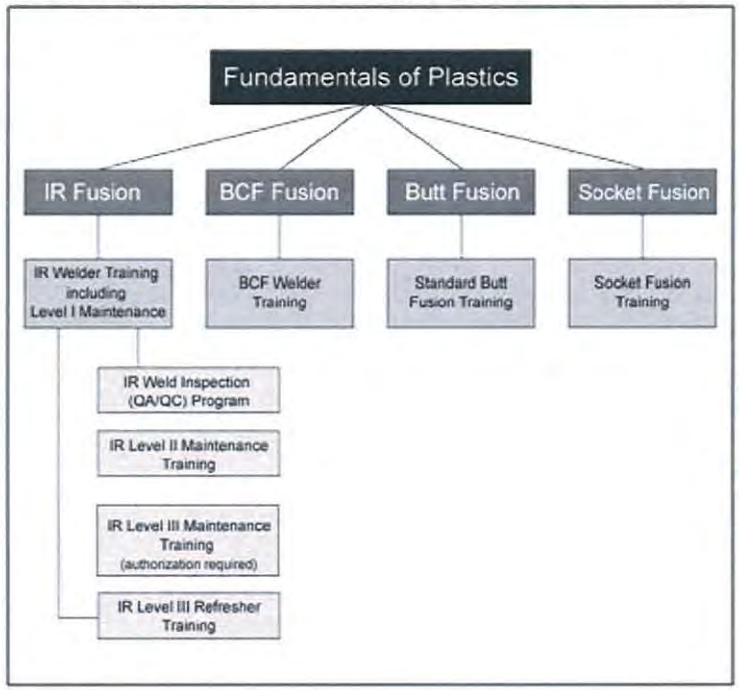
Topics covered include:

- Recognizing and respond to an emergency.
- How to care for a person who is choking.
- Checking an unconscious person for life-threatening and nonlife-threatening conditions.
- Recognizing and caring for a person who is not breathing.
- How to care for a heart attack and how to give CPR.
- Using and AED and identifying precautions when using and AED.
- Identifying the signs and symptoms of sudden illness, including stroke, diabetic emergency, poisoning and allergic reactions and care for them.
- Controlling bleeding.
- Recognizing and caring for heat- and cold-related emergencies.

© Copyright 2006 The American National Red Cross. All Rights Reserved.

Fusion Machine Training Programs

Experience shows that improper installation, rather than faulty products, is the primary reason for system failures, delays, and cost overruns. Georg Fischer believes that the installation of our products is as important as the quality of the products we manufacture. In keeping with this belief, Georg Fischer offers several training courses.



Socket Fusion Training

Standard Butt Fusion Training

Infrared Welding
- IR Level I Welder Training
- IR Level II Maintenance Training
- IR Level III Maintenance Training
- IR Level III Refresher Training
- IR Weld Inspection Program (WIP)

BCF Welder Training

Course Description

Socket Fusion Training	Standard Butt Fusion Training (Conventional or CNC)
This four-hour course covers all aspects of hand-held and machine Socket Fusion Technology. Trainees will demonstrate their ability to perform socket fusion joining.	This four-hour course covers all aspects of Standard Butt Fusion Technology. Trainees will demonstrate

Upon successful completion and testing, the trainee will receive a Certificate of Completion and an Installer's Badge which may be worn on the job site.	their ability to prepare pipe, face pipe, heat and join piping.
IR Level I Welder Training This course covers fundamental training absolutely necessary for proper operation of the infrared (IR Plus) fusion machines. Topics: • Plastic pipe fundamentals • Infrared butt fusion • General information • Design/function/operation of the IR Plus fusion machines • Weld bead inspection • Basic machine maintenance Duration/Value: • 1 day/$250.00 per person Register now	**IR Level II Maintenance Training** Completion of this 16-hour (2 day) class allows the trainee to maintain external parts of the machine. Prerequisite: • All attendees must have completed the Georg Fischer IR Level I Welder Certification Program and Weld Inspection Program Topics: • Technical concepts of the machine • Machine inspections • Functional check • Maintenance procedures Level II • Alignment and adjustments • Weld evaluation • Documentation Duration/Value: • 2 days/$500.00 per person Register now
IR Level III Maintenance Training **(Authorization Required)** Completion of this 32-hour (4 day) class allows the trainee to maintain external and internal parts of the machine. This course is conducted at the Georg Fischer Tustin facility only. Prerequisite: • All attendees must have completed the Georg Fischer IR Level II Maintenance Training Topics: • Technical concepts of the machine • Machine inspections • Functional check • Maintenance procedures Level III • Alignment and adjustments • Weld Inspection Program • Documentation Duration/Value: • 4 days/$1,500.00 per person Register now	**IR Level III Refresher Training** **(Authorization Required)** This course is a refresher for Level III personnel and includes current updates for the IR 63, IR 225, and IR Plus machines. This course must be taken 1 year after the initial Level III course and then every two years after that. This course is condcuted at the Georg Fischer Tustin facility only. Prerequisite: • All attendees must have completed the Georg Fischer IR Welder Certification and IR Level II and Level III Maintenance Training. Duration/Value: • 2 days/$500.00 per person Register now
IR Weld Inspection Program (WIP) Upon completion of this eight-hour (1 day) class, the QU inspector will have a good basis to perform on-site visual IR weld evaluation. Topics: • Weld background • Terminology • Bead characteristics • Restmelt evaluation • Flow charts and checklist Duration/Value:	**BCF Welder Training** This four-hour course covers all aspects of using the BCF Flow Fusion Technology. Trainee will prepare pipe samples, insert and remove bladders, generate welds, and perform hot cleaning of the heater heads. Upon successful completion and testing, the trainee will receive a Certificate of Completion and an Installer's Badge which may be worn on the job site. Prerequisite: • All attendees must have completed the Georg Fischer IR Level I Welder Training

- 1 day/$250.00 per person

Print

George Fischer Inc, 2882 Dow Avenue, Tustin, CA 92780-7258 USA,
Phone (714) 731-8800, Toll Free (800) 854-4090, Fax (714) 731-6201

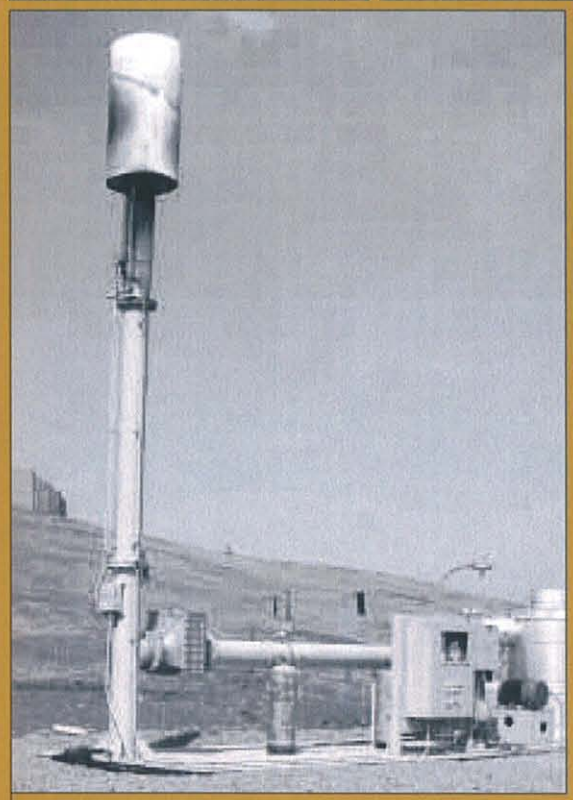
Using this site means you accept its terms of use | disclaimer
Copyright © 2004 GF Piping Systems. All rights reserved.

2007 TRAINING COURSE CATALOG

SWANA®

SOLID WASTE ASSOCIATION of North America

THE LEADING PROFESSIONAL ASSOCIATION IN THE SOLID WASTE FIELD



I AM SWANA

"Many people overlook the hard work and dedication necessary to perform a public service like solid waste management. SWANA's training courses make it possible for these men and women to operate at the highest level of performance with a sense of pride and achievement."

Bill Tobin | Director of Field Operations
Waste Authority of Montgomery County

Message from SWANA's President

INTRODUCTORY LETTER FROM TOM PARKER

Dear Colleague,

Thank you for choosing SWANA as the provider of all your training and professional development needs. For over 40 years, SWANA has thrived at the forefront of all training and education for municipal solid waste needs. This effort results from our first-and-foremost commitment to you, our members, but also to the field of solid waste.

The 2007 catalog contains training opportunities for you and all your staff. Whether you need training for professional development, for SWANA certification, or to maintain a current certification, SWANA offers specific education to fit your needs. This year SWANA Training takes place as several great locations beginning in Tampa, Fla., and closing out the year at WASTECON 2007 in Reno, Nev.

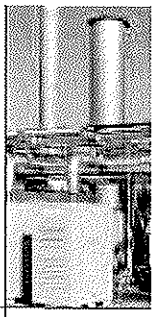
SWANA gives you what you need to stay ahead of them game with our new list of course offerings. We have updated the Manager of Landfill Operations Course (MOLO) and our ever-growing line of distance learning opportunities. With our increased offerings of E-Courses and E-Sessions, you can train individually at your desk or with your whole staff in a conference room to get the most out of your money! As with all SWANA events, in person and online, you will interact with and learn from some of the best and the brightest in the industry.

Thank you for your continued support of SWANA, and our mission to advance the practice of economically and environmentally sound management of municipal solid waste. I look forward to learning from you online or at one of our live events.

Sincerely,

Tom Parker, P.E
CDM, New Mexico
SWANA President

P.S. Receive the mark of professionalism in the solid waste industry with SWANA certification. SWANA offers eight different Certifications including the industry's only Bioreactor Landfill Certification. In this competitive landscape, it is integral to have an integrated MSW management background to efficiently manage your facility.



2007 Training Catalog Directory

SWANA's Solution for Available Courses

About the SWANA Training Catalog 4

Getting SWANA Certified 5

SWANA[DL] (Distance Learning) 6-7

SWANA E-Training Calendar of Events 8

Landfill and Landfill Gas Courses 10-14

Collection and Transfer Courses 16-17

SWANA Registration Form 18-19

Recycling, Waste Reduction and Composting Courses 20-21

Special Waste Courses 22-23

Planning, Management and Communication Courses 24-25

SWANA Recertification Information (Already SWANA Certified?) 26

CEU Chart for All SWANA Courses 27

CEU Chart for SWANA[DL] (Distance Learning) 28

About SWANA Training Centers 29-30

SWANA 2007 Events 31-33

Training On Demand 34

Classroom Training | Chapter Partnering Events | E-Courses | E-Sessions | E-Studies | On-Site Training | Home Study Course | Training On-Demand

About the SWANA Training Catalog

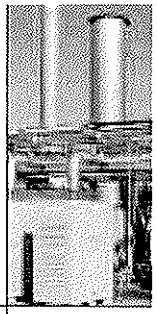
Congratulations on choosing SWANA for your professional development, training and certification!

For those of you who are new to SWANA: Welcome. To our over 7,700 loyal members, thank you for your continued support of SWANA's Technical Programs, and welcome to our new catalog format. Our new look has been designed to showcase SWANA's commitment to providing the best-in-class educational products to the entire solid waste industry. Today, SWANA continues that pledge with more educational products than ever before.

We hope the new format will make it easier for you to find just what you are looking for by using the following symbols to indicate the format of each product. Additional information including full course descriptions, is available on **www.SWANA.org** under "Educate".

- **SWANA Classroom Training:** Held at SWANA events throughout the year.
- **SWANA Chapter Partnering Events:** SWANA Chapters host additional SWANA training courses throughout North America.
- **E-Courses:** Traditional courses and brand new offerings that can be accessed from the convenience of your office. E-Courses are conducted through SWANA's web conferencing and teleconferencing system.
- **E-Sessions:** The best of SWANA's technical sessions brought to you each month through Web conferencing. These 75-minute sessions give you and your staff an opportunity to learn from the experts in this extended session. A different topic is covered every month.
- **E-Studies:** These self-paced, self-study options give you the training and the CEUs you need. All it takes is an internet browser.
- **On-Site Training:** Full training packages that you deliver to your staff at your own site and at your own pace.
- **Home Study Courses:** Written materials on important solid waste topics. Looking for CEUs – just pass the test that comes with the course and you'll qualify.
- **SWANA Training On Demand:** Do you have a group that needs to be trained and the next event isn't soon enough or your budget can't afford the cost? Let our best-in-class training come to you! Any of our courses can be customized to your needs. For quotes, contact **learn@SWANA.org**.

We love to hear about the training and educational products that you need. You can always reach us with your ideas, comments and feedback at **learn@SWANA.org**.



Getting SWANA Certified Easy As 1, 2, 3!

SWANA'S PREMIER TRAINING COURSES

1. CHOOSE YOUR DISCIPLINE(S).

The Solid Waste Association of North America offers eight (8) certifications in the following solid waste disciplines:

- Landfill Management (MOLO)
- Bioreactor Landfill*
- Collections Systems
- Composting Programs
- Construction & Demolition Materials (C&D)
- Principles of MSW Management
- Recycling Systems
- Transfer Station Systems

* The Bioreactor Landfill certification requires candidates to hold a current SWANA Landfill management certification.

2. CHOOSE YOUR CERTIFICATION LEVEL.

Most SWANA Certifications offer at least two (2) eligibility levels, with an additional Inspector level offered to Landfill and Construction & Demolition SWANA Certification holders:

- **Technical Associate:** This level is ideal for professionals new to the industry and involved in the planning, design, implementation, operation or promotion of the MSW field. This would also include consultants, planners, vendors and regulators, etc. A minimum of a High School Degree or GED Required.
- **Manager:** This professional must meet all of the requirements of the Technical Associate level plus a minimum of five (5) years** experience in Municipal Solid Waste Management. Also required are at least two (2) years experience in a management/supervisory position*** in the discipline for which you are applying.

** 4-year degree in a related field may be substituted for up to 2 years of MSW experience
*** directly responsible for daily operations; compliance with design and permit conditions, utilization of field equipment and services, personnel needs, utilization and retention.

- **Inspector:** Unique to Landfill and Construction & Demolition certification holders, this professional must meet all of the requirements of the Technical Associate level as well as the ability to issue official citations for violations which require action/impose penalties. This professional must also be an active inspector with at least 2 years experience.

3. PASS THE SWANA CERTIFICATION EXAM FOR YOUR DISCIPLINE.

SWANA certification exams are offered at all SWANA and SWANA Chapter training events, even if the preparatory class is not being offered. You may only sit for one exam per testing session. You are not required to attend the preparatory training courses to become certified; however, it does reinforce your knowledge in a particular discipline. A passing score of 70% or above is needed to become SWANA certified. You will be allotted three (3) hours to complete your exam. All exams are proctored.

You may use calculators, preferably one capable of handling up to seven digits. Landfill Certification candidates may use MOLO scales for maps. The exam is a "closed book" exam so you may not bring manuals, worksheet or notes to the testing site. Before leaving the testing site, you will be asked to complete the SWANA Certification Application. Exam results will be mailed to the certification candidates within 60 days of the test date.

If you have any questions about becoming SWANA Certified, please contact us at **cert@SWANA.org**.

SWANA[DL] (Distance Learning)

SWANA CEUs are available for most SWANA Courses

Can't get away from work? Enjoy the industry's top training from the comfort of your home or office with SWANA[DL] (Distance Learning). With these courses, get the training you need in a format you want. SWANA[DL] allows you to train from your home or office, with your computer, or with home study manuals. Also by attending these courses, Certified Professionals can earn SWANA Continuing Education Units (CEUs). With SWANA[DL], training has never been easier!

E-COURSES

Learn, Earn and Return with these new online courses! You'll learn about a wide range of solid waste topics. Every course is taught by SWANA faculty. All you need is an internet connection and separate phone line and you're ready to learn. Each session lasts up to two hours, making SWANA training more convenient than ever! For a schedule of upcoming E-Courses, visit **www.SWANAstore.com** and click on E-Courses.

E-SESSIONS

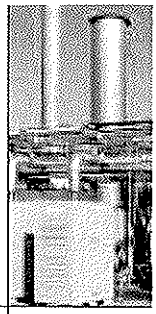
With these 75-minute presentations you can attend SWANA technical sessions all year long, from any location! These sessions bring you the latest on today's hot topics on the first three Wednesdays of the month. Each month focuses on a different area of MSW to keep you informed on all the current trends in solid waste. For a schedule of upcoming E-Session topics visit **www.SWANAstore.com** and click on E-Sessions.

E-STUDIES

Train your way with these self-paced online courses. These courses are completely online and are always a click away. The course also moves with you, so you spend your time on the areas that you need. Many of our courses also allow more than one user to train per account, with our new subscription-based pricing plan. Training has never been more flexible than it is with these courses!

Courses include:

- Landfill Operations
- Composting Operations
- Transfer Station Health and Safety
- Waste Screening
- Landfill Health and Safety
- Landfill Gas Primer
- Establishing An Electronics Recycling Program
- Integrated Solid Waste Management



SWANA DL
(Distance Learning)

SWANA'S PREMIER TRAINING COURSES

HOME STUDY COURSES ✉

Not quite ready for the world of online learning but still need convenient training? Well then look no further than SWANA Home Study Courses. Each course includes a manual that you review at your own pace. Once you're comfortable with the information, complete the enclosed exam. Score a 90% or better and you'll receive credit for the course. The manual also serves as a good reference once you've completed the course.

Courses include:

- Managing Landfill Gas at MSW Landfills
- Waste Screening at MSW Management Facilities
- Groundwater Monitoring, Sampling, Analysis & Construction
- Leachate Generation, Collection & Treatment at MSW Landfills
- Construction Waste and Demolition Debris Materials Manual

ON-SITE COURSES

Act as a trainer for your staff with these courses. Each course contains 8-10 hours of training, made up of smaller modules. This allows the courses to be tailor-made for your company.

Courses include:

- Training for Sanitary Landfill Operations Personnel
- Training for Collection Operations Personnel
- Waste Screening at MSW Management Facilities
- Health and Safety for MSW Landfill Training
- Health and Safety for MRF Personnel
- Health and Safety for Collection Personnel
- Health and Safety for Transfer Station Personnel

TRAIN YOUR WHOLE STAFF WITH SWANA E-TRAINING AND SAVE BIG!

When signing up for an E-Course or E-Sessions you register for one computer. By hooking up a projector and speaker phone, you could present E-Training to your whole staff for the cost of one registration, saving you big on training!

SWANA CEUs will only be allocated for registered individuals.

SWANA E-Training Calendar of Events

SWANA's E-Training allows you to receive the industry's best training from the comfort of your home or office. The Web seminars are the perfect way for busy professionals to stay current on the latest trends in the industry. These courses are always being updated in a continuing effort to bring you fresh, new training. The listing below is just a taste of what's to come. Keep an eye on **www.SWANAstore.com** for all the latest developments in SWANA's E-Training.

Have you attended a local training or technical session that you think all solid waste professionals could benefit from? Let us know! SWANA is always looking for ways to promote training that today's solid waste professionals can use. E-mail **learn@SWANA.org** with any topics or suggestions, as well as at which event the training was presented.

UPCOMING E-COURSES

Course subjects and times subject to change. Visit ***www.SWANAstore.com*** *for updated course listings.*

See page 28 for E-Course CEU information.

Fall 2006 Landfill Fire

Fall 2006 Erosion Control

Fall/Winter 2007 Electronics Recycling

Winter 2007 Landfill Operations

Winter 2007 Collections Operation

Winter 2007 Bioreactor Basics

Have a course developed that you want to share online? Email ***learn@SWANA.org*** *to find out how!*

UPCOMING E-SESSIONS *Tentative Schedule*

Topics subject to change. Visit ***www.SWANAstore.com*** *and click on E-Sessions for the latest information.*

Get 1 SWANA CEU for each E-Session (Registration required)

October 2006: Bioreactor Landfills

November 2006: Overcoming Challenges in Transfer Station Design and Operation

December 2006: Multi-Family and Institutional Recycling Programs

January 2007: Life Cycle of a Landfill – Strategies for Permitting, Designing, Operating and Closing

February 2007: Waste-to-Energy and Waste Conversion

March 2007: Special Waste Management

April 2007: Construction and Demolition Debris Management

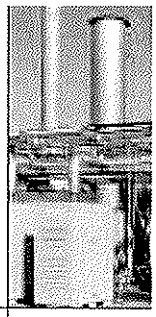
May 2007: Landfill Gas Control and Utilization

June 2007: Organics Management and Composting

July 2007: Boosting Recycling Rates: New and Innovative Programs

August 2007: Planning & Management

September 2007: Legislative and Regulatory Developments Impacting Solid Waste Management



SWANA Technical Divisions

SWANA's Member Training Courses

Join one of SWANA's Technical Divisions and shape the future of solid waste management.

The Benefits include

- Access to cutting-edge information
  - TECHnews—electronic newsletter with the latest news in your specific field
  - SWANA's online eLibrary and Members Only section including the Division subscriber list
- Unmatched networking opportunities
  - Participate in an exchange of ideas with more than 2,700 Division Members
  - Receive a contact list of all Technical Division Subscribers
  - Make valuable contacts at conferences
  - Post and respond to questions through an electronic Technical Division Members list serve
- Shape the future of SWANA
  - Help develop programs for symposia
  - Guide technical policies and advocacy initiatives
  - Produce real change on industry issues
- Special discounts
  - $25 registration discount to your Division's annual symposium
  - Special discounts on publications, conference proceedings and training, and online educational sessions and events

For more information, visit **www.SWANA.org** or call **1-800-GO-SWANA (467-9262)**

Classroom Training · Chapter Partnering Events · E-Courses · E-Sessions · E-Studies · On-Site Training · Home Study Course · Training On-Demand

Landfill and Landfill Gas Courses

For SWANA CEU information, see pages 27-28.

MANAGER OF LANDFILL OPERATIONS (MOLO)

3-Day Certification Prep Course

Updated for 2007

Updated for 2007 for MOLO and Landfill Operations courses.

Updated for 2007, this prep course for the Landfill Certification contains all the latest landfill techniques and technologies to keep you ahead of the competition. Learn to efficiently run your landfill, as well as gain knowledge on planning, operating and closing a landfill. Discuss issues surrounding regulatory standards, compliance with design requirements, and an introduction to state-of-the-art bioreactor landfill technologies. Upon completion of the course you will gain a better understanding of landfill economics, leachate and landfill gas management, and comprehend the importance of safety and contingency counter measures.

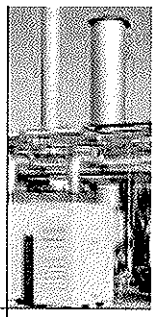
Need some help preparing for the MOLO, try these:

MOLO: JUST THE MATH E-COURSE

Planning to take the MOLO exam, but need to brush up on the math? With this live web course you can prepare for the math that is covered on the MOLO exam from your home or office. All you need is an internet connection and separate phone line and you're ready to learn the math. Taught by MOLO faculty, this course covers such calculations as elevation, area, slope, and volume. And because the course is only two hours long, you can learn and return to work. **MOLO: Just the Math does not allocate CEUs toward SWANA recertification.**

LANDFILL OPERATIONS

Need a boost to get ready for the MOLO or just need a refresher before taking the SWANA Landfill Certification Exam? Then get online with this new E-Study Course. Learn about such topics as Waste Decomposition, Geology and Hydrology, Landfill Design and Construction, General Operations, and Regulations from your computer. The course has also been enhanced with up-to-date photographs, audio, interactive exercises, related online links, and video to make learning more enjoyable.



Landfill and Landfill Gas Courses

SWANA's PREMIER TRAINING COURSES

THE WORLD'S ONLY BIOREACTOR LANDFILL CERTIFICATION PROGRAM

Technology is changing and bioreactor landfills are emerging. Now it is your turn to learn what bioreactors can do for you. Get career-enhancing certification by taking this prep course for the Bioreactor Landfill Certification exam. Examine the unique characteristics of a bioreactor landfill in comparison with dry tomb landfills in this brand new course. Explore the methods of introducing air and water into landfill cells, while at the same time discovering how this cutting-edge technology can increase landfill gas activity.

Special Publication: *Manager of Bioreactor Landfill Operations Body Of Knowledge*

The SWANA Manager of Bioreactor Landfill Operations Body Of Knowledge (BOK) is a compendium of the basic knowledge an individual must know to accomplish the work of a Manager of Bioreactor Landfill Operations. This BOK includes both proven traditional practices and the innovative, advanced practices of managing a bioreactor landfill, as well as empirical, esthetical, ethical and tacit knowledge. The Manager of Bioreactor Landfill Operations BOK is the basis of the SWANA Bioreactor Landfill course and certification exam.

The BOK consists of eight comprehensive knowledge statements covering the knowledge and abilities a manager of bioreactor landfills should have in the areas of construction, operation and monitoring of bioreactor landfills. You can use the BOK to prepare for the SWANA certification exam or as a tool for your operations.

Go to **www.SWANAstore.com** to order.

MANAGER OF BIOREACTOR LANDFILL OPERATIONS

2-Day Certification Prep Course

Mark your calendars for SWANA's

30th Annual **Landfill Gas Symposium**

March 4 – 8, 2007 at the Hyatt Regency Monterey

Join top professionals in the solid waste field for the 30th anniversary of the world's premier forum on landfill gas utilization and technology!

The special 30th Anniversary of SWANA's Landfill Gas Symposium will include:

- Hall of Flame induction revealed
- Plenty of technical sessions
- A tabletop trade show
- Several great receptions
- and a whole lot more!

SWANA

Enjoy Monterey, California's great beaches, lively aquarium and over 20 world-class public golf courses, while networking with other professionals.

See you in Monterey!

Classroom Training · Chapter Partnering Events · E-Courses · E-Sessions · E-Studies · On-Site Training · Home Study Course · Training On-Demand

Landfill and Landfill Gas Courses

For SWANA CEU information, see pages 27-28.

LANDFILL OPERATIONAL ISSUES

2-Day Course/ 1-Day Workshop

This course is perfect for anyone interested in learning more about improving the daily operations at their landfill site. You will experience in-depth discussions that will help you solve everyday issues surrounding landfill operations and be able to understand successful landfill management practices, including equipment selection. Turn your landfill into a money maker by learning how to control cost, maximize your site's airspace, and determine if your landfill is really efficient. Upon completion of the course, you can earn valuable SWANA Continuing Education Units (CEUs). Furthermore, with your registration you will receive the book *The Handbook of Landfill Operations,* by Neal Bolton, P.E.

HEALTH AND SAFETY FOR MSW LANDFILL OPERATIONS PERSONNEL

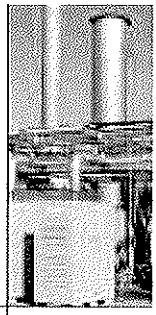
1-Day Course

Discover new horizons by enhancing your landfill health and safety program! This course prepares you to easily and intelligently identify and circumvent landfill health and safety issues. Not only will you learn exactly what elements constitute a proper loss control program, but you will understand the importance of establishing an effective program and overview OSHA and federal regulations. At the end of this course, participants will be able to recognize an unsafe practice and know how to handle it. Not only will you earn valuable SWANA Continuing Education Units (CEUs), but you will also gain imperative knowledge on how to keep your landfill safe.

LANDFILL GAS BASICS

1-Day Course

Don't waste landfill gas! Learn to "Control, Manage and Capture" it! These are the key concepts to successfully understanding landfill gas basics. Through exercises and case studies, SWANA instructors will help you grasp these three ideas in this introductory course. You will gain vital insight about gas regulations and become familiar with system design, construction and monitoring. In addition, you will be provided with information and guidance in order to understand the importance of landfill gas utilization. Anyone working with a landfill gas system will benefit from this course.



Landfill and Landfill Gas Courses

SWANA's Solid Waste Training Courses

LANDFILL GAS SYSTEM OPERATION

2-Day Course and 1-Day Workshop

Go "beyond basics" with this interactive workshop exploring the daily challenges associated with operations and maintenance of LFG systems. Share knowledge with your colleagues and learn new approaches for capturing, controlling, and managing landfill gas. This interactive session will be moderated by a SWANA faculty member, and is a great way to actively increase your knowledge of landfill gas systems.

TRAINING FOR SANITARY LANDFILL OPERATIONS PERSONNEL

1-Day Course

Through interactive classroom exercises, discussions and case studies, you will overview landfill operations and how they relate to one another in order to learn how to be more effective on the job. Instructors with in-depth experience in landfill operations will help you gain a better understanding of the fundamentals of groundwater movement, accident analysis and recognize the factors that contribute to leachate production. In addition, receive top of the line training on how sanitary landfills work as components of integrated solid waste management systems.

LANDFILL GAS PRIMER

Gain vital insight about gas regulations and become familiar with system design, construction and monitoring. In addition, you will be provided with information and guidance in order to understand the importance of landfill gas utilization. Anyone working with a landfill gas system will benefit from this course. As with all online E-Study Courses, you determine the pace and schedule of the course.

ECTC PRESENTS CONTROLLING EROSION & STORM WATER RUNOFF ON LANDFILL CAPS

Finish your landfill off with style with this new E-Course. In a partnership with the Erosion Control Technology Council (ECTC), SWANA is proud to present this new E-Course to help landfill owners create more presentable landfill caps through the use of Rolled Erosion Control Products (RECPs). Presented by a member of ECTC, this course will cover such topics as NPDES Regulations, an overview of RECPs, as well as the installation, design, and selection of RECPs.

Landfill and Landfill Gas Courses

For SWANA CEU information, see pages 27-28.

CONSTRUCTION WASTE & DEMOLITION DEBRIS RECYCLING... A PRIMER

An educational tool for communities and private sector interests, this document focuses on the planning issues and implementation opportunities associated with the recycling of construction waste and demolition debris. Lessons covered include regulatory climate, generation data, materials, market opportunities, and management systems to name a few. Keep the manual for future reference, so you'll always have this valuable information at your fingertips.

MANAGING LANDFILL GAS AT MUNICIPAL SOLID WASTE LANDFILLS

This course is perfect for those seeking guidance on the complex issue of landfill gas management. This course covers such topics as MSW landfill emission generation, composition, migrations and extraction components, as well as regulatory codes pertaining to RCRA and the Clean Air Act. As with all Home Study Courses, keep the manual for future reference!

LITTER MANAGEMENT AT MSW LANDFILLS

Are you blown away by the cost of litter at your landfill? Let SWANA help you clean up your act with Litter Management at MSW Landfills. Learn about the impact of litter and the importance of a good litter management program, as well as the sources and causes of litter. Learn about litter control techniques from one of the industry's top professionals from the comfort of your home or office.

LEACHATE GENERATION, COLLECTION AND TREATMENT AT MSW LANDFILLS

Learn about the common constituents that make up groundwater and biological treatment. Also get an understanding of the regulatory scope of RCRA Subtitle D in regards to groundwater monitoring, and become familiar with leachate recirculation methods. Keep the manual for future reference, so you'll always have this valuable information at your fingertips.

GROUNDWATER MONITORING, SAMPLING, ANALYSIS AND WELL CONSTRUCTION

This course provides MSW professionals with an understanding of monitoring groundwater within the scope of RCRA Subtitle D. Topics include design and construction of wells, monitoring programs, and corrective actions. As with all Home Study Courses, keep the manual for future reference!

SAVE THE DATE

www.wastecon.org

Join the High Rollers!

WASTECON 2007

OCTOBER 16-18, 2007

Reno, NV

The Premier Show for Solid Waste Professionals

hosted by the **Solid Waste Association of North America**

Collection and Transfer Courses

For SWANA CEU information, see pages 27-28.

MANAGING TRANSFER STATION SYSTEMS

3-Day Certification Prep Course

Be a lean mean, transfer operations machine! As a prep course for the Transfer Systems Certification exam, anyone who is or would like to become a transfer station manager or consulting engineer will be provided with fundamental information on ways to effectively plan, design, and operate MSW transfer stations. Receive cutting edge training on how to run a MSW transfer station in the most successful way by experiencing a hands-on tour, a field exercise at a local transfer station facility and classroom taught exercises. In addition, learn about design objectives including capacity, selection of appropriate technology, structure considerations and site planning.

MANAGING MUNICIPAL SOLID WASTE COLLECTION SYSTEMS

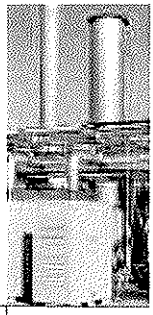
3-Day Certification Prep Course

Be able to handle waste with haste through this prep course for the Collection Systems Certification exam. Receive instruction in all the areas tested on the exam, such as an understanding of the logistics of planning, managing and operating solid waste and recyclables collection services. This course consists of presentations, classroom exercises and case studies that will enable you to navigate and chart routes more effectively. You will examine waste characteristics, service types, equipment, routing and system design. Furthermore, learn up-to-date practices for handling various materials, including residential MSW, traditional recyclables, yard wastes, bulky items and commercial wastes.

TRAINING FOR COLLECTION OPERATIONS PERSONNEL

1-Day Course

Save time and money on every route, every day! Individuals who are responsible for the collection of solid waste and recyclables from household and commercial establishments on a day-to-day basis can increase their knowledge of collection strategies. Be provided with what every collection operations personnel should know through interactive classroom exercises, discussions and case studies. Time is money, and this course will help you to acquire a higher understanding of routing in order to be cost-efficient. Furthermore, learn how to define a preventative maintenance program, go over the importance of effective sanitation practices, and obtain insight on important health and safety issues.



Collection and Transfer Courses

SWANA'S PREMIER TRAINING COURSES

Why "waste" an opportunity to improve your safety performance? At SWANA, we recognize the importance of minimizing risk and developing an effective safety program for transfer station personnel. During this course, you will get an overview of OSHA and federal regulations. Also, you will discuss musculo-skeletal disorders and how to prevent ergonomic injuries. Upon completion, you will understand why it is essential to establish a transfer station health and safety program as well as learn to recognize unsafe practices of others. Earn valuable SWANA CEUs for a range of Certification Disciplines by participating in this extremely important course!

HEALTH AND SAFETY FOR TRANSFER STATION PERSONNEL

1-Day Course

Does it pain you to see the unsafe work habits of your collection personnel? Well let SWANA help you reduce those pains with our Health and Safety for Collections Personnel Course. This kit comes with everything a supervisor or manager needs to train their employees on proper techniques and precautions to reduce workplace injuries. Other topics covered in this course include loss control, and health and safety issues, as well as regulatory issues.

HEALTH AND SAFETY FOR COLLECTION PERSONNEL

1-Day Course

SWANA'S Heading Up The Strip...

SWANA's Spring Training Center

April 23 - 26, 2007 | Bally's Las Vegas | (800)-634-3434

You Can Bet On:

Landfill Operations/LFG Workshop Combo

New MOLO Course - Updated for 2007

FEMA Debris Management Course - Only Time Offered for 2007 by SWANA National!

7 Different SWANA CEU Earning Courses

- Manager of Landfill Operations (MOLO), April 23-25
- Managing MSW Collections Systems, April 23-25
- Managing MSW Transfer Systems, April 23-25
- Principles of MSW Management, April 23-25
- FEMA: Debris Management, April 23-25
- Landfill Operations, April 23-24
- Landfill Gas Operations Workshop, April 25
- Testing Center (All certification exams), April 26 7:00 am (only)

ACT NOW!

For more information or to register, visit www.SWANAstore.com

Classroom Training · Chapter Partnering Events · E-Courses · E-Sessions · E-Studies · On-Site Training · Home Study Course · Training On-Demand

Appendix B
Site Specific Training
Lesson Plan and Exam

Pre-Entry Briefing

Objective: The objective of this pre-entry briefing is to introduce visitors and first-day employees to the safety controls of the BRC CAMU. Attendees should understand where active portions of the site are, where emergency response equipment is located, site hazards (chemical, physical, biological), and general safety rules of the BRC CAMU.

Active Areas
Indicate on map:

- haul routes
- waste excavation (exclusion, contamination reduction, support zones, as appropriate)
- waste placement (exclusion, contamination reduction, support zones, as appropriate)

Emergency Response:

Contact Name

Phone number(s)

Hospital Location

Location of emergency equipment (fire extinguishers, alarms)

Meeting location(s)

First Aid steps: Check-Call-Care

Personal Protection Equipment

Hardhat – at all times

Steel Toe Boots – at all times

Eye protection – at all times

Hearing Protection – where applicable

Tyvek – where applicable

Gloves – where applicable

Respirator – where applicable

Basic Site Safety:

1. Keep your mind on your work at all times. No horseplay on the job. Injury or termination or both can be the result.

2. Personal safety equipment must be worn as prescribed for each job, such as: safety glasses for eye protection, hard hats at all times, gloves when handling materials, and safety shoes..

3. Watch where you are walking. Don't run.

4. Seat belts are required at all times when driving/operating.

5. The use of illegal drugs or alcohol or being under the influence of the same on the project shall be cause for your immediate termination. Inform your supervisor if taking strong prescription drugs that warn against driving or using machinery.

6. Do not distract the attention of fellow workers. Do no engage in any act that would endanger another employee.

7. Sanitation facilities are provided for your use. Defacing or damaging these facilities is forbidden.

8. Never move an injured person unless it is absolutely necessary. Further injury may result. Keep the injured as comfortable as possible and utilize job site first-aid equipment until an ambulance arrives.

9. Know where firefighting equipment is located and be trained on how to use it.

10. Nobody but operator shall be allowed to ride on equipment unless proper seating is provided.

11. Do not use power tools and equipment until you have been properly instructed in the safe work methods and become authorized to use them.

12. Do not enter an area that is barricaded or otherwise blocked from entry.

13. If you must work around trucks or heavy equipment, make sure operators can always see you and know that you are there. Barricades are required for cranes.

14. Never oil, lubricate, or fuel equipment while it is running or in motion. Do not perform these operations on equipment in areas not specifically designated for these operations.

15. Before servicing, repairing, or adjusting any powered tool or piece of equipment, disconnect it, lock out the source of power, and tag it out.

16. Barricade danger areas. Guard rails or perimeter cables may be required.

17. Trenches over five feet deep must be shored or sloped as required. Keep out of trenches or cuts that have not been properly shored or sloped. Excavated or other material shall not be stored nearer than two feet from the edge of the excavation. Excavations less than 5 ft may also require cave in protection.

18. Use the "four and one" rule when using a ladder. One foot of base for every four feet of height.

19. Know what emergency procedures have been established for your job site. (location of first aid kit, fire extinguisher locations, evacuation plan, etc.)

Hazard Analysis

Physical
Heat Stress
Excavation
Hand/Foot Injury
Heavy Equipment
Noise
Portable Power/Hand Tool
Slip/Trip/Fall

Chemical
Inhalation
Skin absorption
Fire
Reactivity

Biological
Insect/Vermin/Snake Bites

Exam

The pre-entry briefing exam will be taken at the conclusion of the meeting. A passing rate of 75% is required for access to the site. Incorrect answers will be explained and topics covered again.

Pre-entry Briefing Exam

Name:_____
I have read and understand the BRC CAMU Health and Safety Plan Yes No
Date:_____

Position:_____

1. What are the three emergency first aid steps?

   A. Stop-Look-Listen
   B. Call-Check-Care
   C. Check-Call-Care
   D. None of the Above

2. You are working near an excavator, what PPE do you need?

   A. Hardhat, boots, eye protection, hearing protection
   B. Boots, hardhat
   C. Hardhat, hearing protection
   D. None of the above

3. When excavating, at what depth is shoring required?

   A. 3 feet
   B. 1 foot
   C. 5 feet
   D. 2 feet

4. You are not 24-hour or 40-hour HAZWOPER certified, how close can you be to the excavation or waste placement activities?

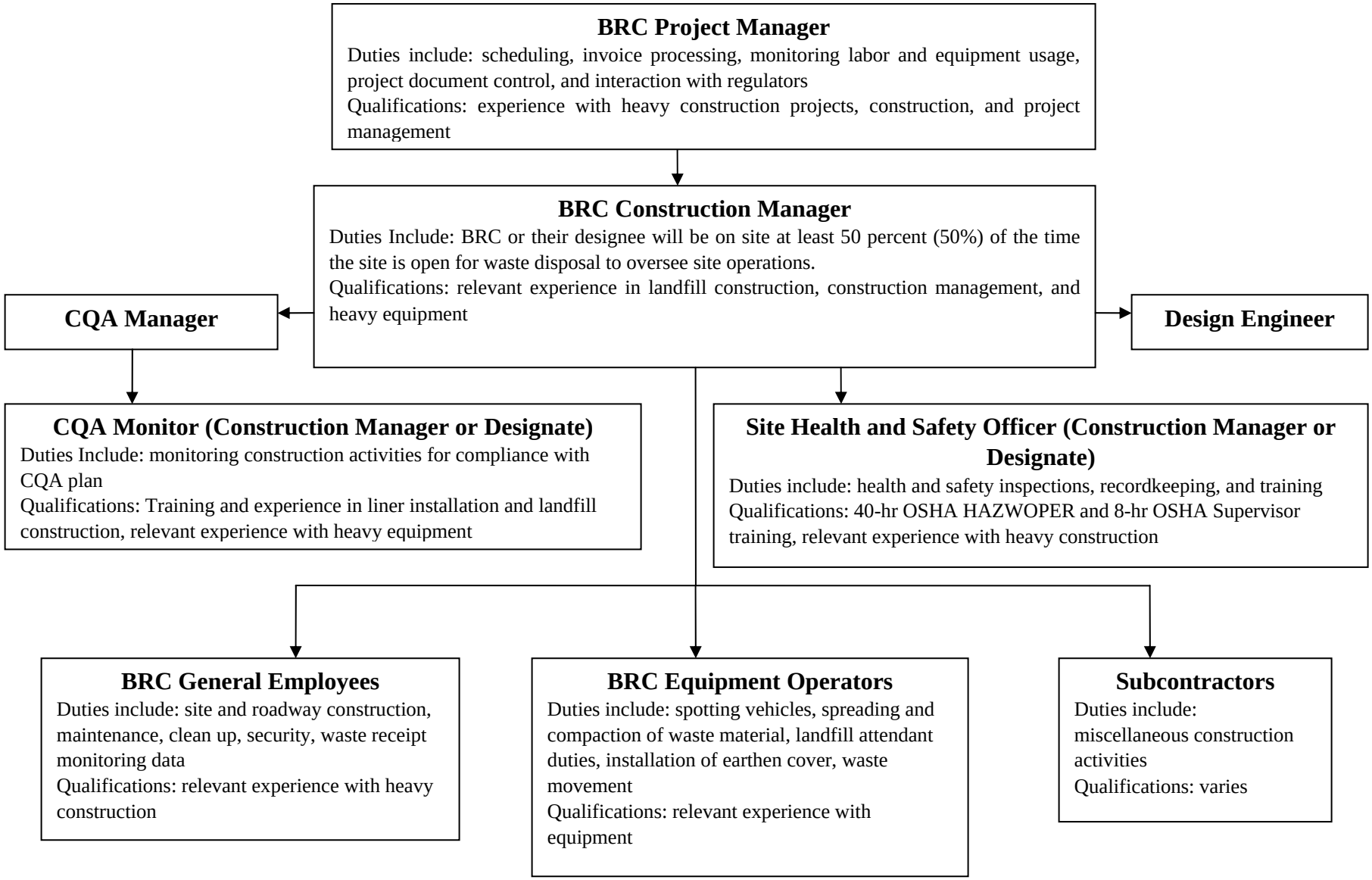
   A. Exclusion Zone
   B. Contamination Reduction Zone
   C. Support Zone
   D. None of the Above

5. What's the first step in an emergency?

   A. Call BRC
   B. Go to a safe location
   C. Go Home
   D. None of the above

Number Incorrect:_____ Pass / Fail Trainer's Name:_____

Appendix C
Organizational Flowchart


BRC Project Manager
Duties include: scheduling, invoice processing, monitoring labor and equipment usage, project document control, and interaction with regulators
Qualifications: experience with heavy construction projects, construction, and project management
BRC Construction Manager
Duties Include: BRC or their designee will be on site at least 50 percent (50%) of the time the site is open for waste disposal to oversee site operations.
Qualifications: relevant experience in landfill construction, construction management, and heavy equipment
CQA Manager
Design Engineer
CQA Monitor (Construction Manager or Designate)
Duties Include: monitoring construction activities for compliance with CQA plan
Qualifications: Training and experience in liner installation and landfill construction, relevant experience with heavy equipment
Site Health and Safety Officer (Construction Manager or Designate)
Duties include: health and safety inspections, recordkeeping, and training
Qualifications: 40-hr OSHA HAZWOPER and 8-hr OSHA Supervisor training, relevant experience with heavy construction
BRC General Employees
Duties include: site and roadway construction, maintenance, clean up, security, waste receipt monitoring data
Qualifications: relevant experience with heavy construction
BRC Equipment Operators
Duties include: spotting vehicles, spreading and compaction of waste material, landfill attendant duties, installation of earthen cover, waste movement
Qualifications: relevant experience with equipment
Subcontractors
Duties include: miscellaneous construction activities
Qualifications: varies

Attachment G
Accident Prevention, Contingency, and Emergency Response Plan

Attachment G
Accident Prevention, Contingency, and Emergency Response Plan
Basic Remediation Company (BRC)
Corrective Action Management Unit (CAMU)
Henderson, Nevada

Table of Contents

1.0 Introduction G-1
1.1 Contaminants G-1
2.0 Prevention G-1
2.1 Health and Safety Plan G-1
2.2 Arrangements with Local Authorities G-2
2.3 Personal Protective Equipment (PPE) G-2
2.4 Exposure Assessment and Air Monitoring G-2
2.5 Activity Hazard Analysis G-2
2.6 Personnel Training G-2
2.7 Site Map G-3
2.7.1 Work Zones G-3
2.8 Site Access G-3
2.9 Visitors G-3
2.10 Communications G-4
2.11 Safe Work Practices G-4
2.12 Inspections G-5
2.13 Decontamination G-5
3.0 Contingency and Emergency Response Plan G-5
3.1 Fire Control G-5
3.2 Shut Down Procedures G-5
3.3 Hazardous or Toxic Materials Release G-6

3.4 Emergency Procedures G-6
3.5 Reporting G-7

List of Figures

Figure G-1 – Hospital Location

List of Tables

Table G-1 – Emergency Contacts

Appendix

A – Copies of Letters Sent to Police, Fire, and Hospital Emergency Contacts

1.0 INTRODUCTION

This Accident Prevention, Contingency, and Emergency Response Plan describes the precautions taken to prevent accidental ignition or reaction of ignitable or reactive wastes, and precautions taken to prevent interaction of incompatible wastes. This plan also includes other procedures to minimize the possibility of, and hazards from, a fire, explosion, or unplanned sudden or non-sudden release of hazardous waste constituent to air, soil, or surface water. These procedures also address the proper design, construction, maintenance, and operating practices designed to reduce the potential for injury or other threats to human health or the environment.

1.1 Contaminants

Extensive testing of the waste material determined the majority of wastes to be non-hazardous. The following is a list of general contaminants found in the waste material to be placed in the CAMU:

- VOCs
- SVOCs
- PCBs
- Metals
- Pesticides

The waste materials are not incompatible, reactive, or ignitable. Additional waste characterization detail can be found in Attachment C, Waste Analysis Plan.

2.0 PREVENTION

2.1 Health and Safety Plan

The BRC CAMU will have an active Health and Safety program for workers at the BRC CAMU. Either the current BRC Health and Safety Plan (HASP) or a similar plan developed by the pertinent contractor will be used, periodically updated, and kept on site. A safety meeting will be held at least quarterly to review safety procedures and issues, or whenever operations change. Daily safety tailgate meetings will address health and safety issues of the day. Employees working at the BRC CAMU will attend. Personal safety equipment such as eye protection, steel-toed boots and hard hats will be required of all BRC CAMU non-office personnel. In case of personal injury, the field office will be notified immediately by two-way radio or cellular telephone and, if necessary, an ambulance summoned from the local hospital, St. Rose de Lima

approximately 1 ¼ miles from the BRC CAMU (Figure G-1), or the local (City of Henderson or Clark County) Fire Department.

2.2 Arrangements with Local Authorities

Prior to operation, BRC will contact the Henderson Police and Fire Departments and the Clark County Sheriff and Fire Departments and their emergency response teams to make arrangements to familiarize them with the BRC CAMU. BRC will provide details of the BRC CAMU including layout, properties of wastes handled and associated hazards, normal operating areas, entrances, and possible evacuation routes. In addition, BRC will contact the St. Rose de Lima Hospital with the types of injuries or illnesses that could potentially occur at the BRC CAMU.

2.3 Personal Protective Equipment (PPE)

Level D PPE will be required at all times at the Site. Level D equipment required includes long pants, gloves, steel-toe boots, hard hats, safety glasses, and hearing protection (when appropriate).

2.4 Exposure Assessment and Air Monitoring

Given the small amount of additional to be placed in the Phase V of the CAMU, dust monitoring, similar to what was conducted during the bulk of the CAMU waste placement, is not cost-effective and will not be implemented. Based on prior air monitoring results, use of dust control measures should not create any off-site dust migration above relevant regulatory thresholds.

2.5 Activity Hazard Analysis

The chemical, physical, and biological hazards are discussed in detail in the Site HASP for each activity performed on-site.

2.6 Personnel Training

Employees assisting in construction activities within the exclusion zone will have Occupational Safety and Health Administration (OSHA) 40-hr Hazardous Waste Operations and Emergency Response Standards (HAZWOPER) certification. In addition, BRC and/or their designee will have 8-hr OSHA Site Supervisor training. The

CAMU Construction Manager will be required to provide health and safety "tail gate" meetings for new workers and visitors. Employees are responsible for knowing the site chemical, biological, and physical hazards as well as how to prevent accidental release of wastes.

2.7 Site Map

A site map will be maintained on site. The site map will be regularly updated to show the exclusion zone, decontamination zone, and support zone as they change throughout BRC CAMU construction. The site map shall be posted in the work area and will include the following information:

- General Wind Direction
- Evacuation Routes
- Refuge Locations
- Route to St. Rose de Lima Hospital and First Aid Medical Assistance (may be provided on separate map)
- Boundaries of Exclusion Zone (as described below)
- Boundaries of Contamination Reduction Zone (as described below)
- Boundaries of Support Zone (as described below)

Changes will be made to the site map by the SHSO, as needed, based on site conditions.

2.7.1 Work Zones

Three work zones will be established for each task. The Exclusion Zone is defined as the area on-site where contamination is suspected and tasks are to be performed. The Contamination Reduction Zone (CRZ) is defined as the area where equipment and workers are to be decontaminated. The Support Zone is defined as the command area and also serves as a storage area for supplies. The exact location and extent of the work zones will be modified as necessary.

2.8 Site Access

Access to the site will be controlled using a sign-in/sign-out log.

2.9 Visitors

Visitors to the site will be continually escorted in order to assure their safety since they may be unfamiliar with the site. Visitors will not be allowed past the Support Zone unless they read, understand, sign, and meet the requirements outlined in the Site HASP.

2.10 Communications

On-site communications will be conducted through the use of the following:

- Verbal
- Two-way radio
- Horn
- Mobile telephone
- Siren
- Hand signals

Off-site communications will be conducted through the use of mobile telephones.

2.11 Safe Work Practices

General Safe Work Practices that will be implemented during work activities at this site are:

- Minimization of contact with waste materials.
- Smoking, eating, or drinking after entering the work zone and before decontamination will not be allowed. Employees who are suspected of being under the influence of illegal drugs or alcohol will be removed from the site. Workers taking prescribed medication that may cause drowsiness will not be permitted to operate heavy equipment, and will be prohibited from performing tasks where Level C, B, or A PPE is required.
- Good housekeeping will be practiced.
- Use of contact lenses on-site will not be allowed when dictated by working conditions.
- The following conditions will be observed when operating a motor vehicle.
  - Wearing of seat belts is mandatory
  - During periods of rain, fog, or other adverse weather conditions, the use of headlights is mandatory
  - A backup warning system or use of vehicle horn is mandatory when

the vehicle is engaged in a backward motion
  - All posted traffic signs and directions from flagmen will be observed
  - Equipment and/or samples transported in vehicles will be secured from movement
- In an unknown situation, the worst conditions will always be assumed.
- Conflicting situations may arise concerning safety requirements and working conditions and will be addressed and resolved rapidly by BRC to relieve any motivations or pressures to circumvent established safety policies.
- Breaches of specified safety protocol will not be allowed.

2.12 Inspections

BRC will conduct weekly health and safety inspections. The inspections will be documented using the Inspection checklist included with Attachment E. The Weekly Health & Safety Inspection Checklist will be kept on file at the project site.

2.13 Decontamination

PPE will be decontaminated as per 29 CFR §1910.120(k). The decontamination procedures, equipment and decontamination solution required for each task will be included in the Site Health and Safety Plan. In an emergency, the primary concern is to prevent the loss of life or severe injury to site personnel. If immediate medical treatment is required to save a life, decontamination will be delayed until the victim is stabilized. If decontamination can be performed without interfering with essential life-saving measures or first aid, or if worker has been contaminated with an extremely toxic or corrosive material that could cause severe injury or loss of life, decontamination will be performed in coordination with or prior to initial medical treatment at the scene.

3.0 CONTINGENCY AND EMERGENCY RESPONSE PLAN

3.1 Fire Control

Fire extinguishers will be on hand to put out small fires near the working area, in the remote possibility they may occur. In the event of a significant fire emergency, the Henderson Fire Department will be notified immediately and the emergency will be reported.

3.2 Shut Down Procedures

In the event the BRC CAMU needs to be shut down, a detailed procedure list will be available at the site in the contingency plan. Step-by-step procedures will be detailed, including maps showing pertinent locations of systems.

3.3 Hazardous or Toxic Materials Release

A Hazardous Materials Emergency Plan will be prepared. It will mainly focus on those chemicals and materials associated with vehicle fueling and maintenance. Because the waste material being disposed of in the BRC CAMU is from a known source area, the likelihood of hazardous or toxic material release resulting from the waste materials is minimal.

3.4 Emergency Procedures

The following steps will be followed when there is an emergency:

1. BRC, or alternate, will be immediately notified. BRC assumes control of the emergency response.
2. As necessary, off-site emergency responders (e.g., fire department, hospital, police department, etc.) will be notified as to the nature and location of the emergency on site. Please see Table G-1 for contact information.
3. If applicable, BRC evacuates the site. Site workers will move to their respective refuge stations using the evacuation routes provided on the Site Map.
4. BRC CAMU Construction Manager will assess possible hazards to human health or the environment resulting from the emergency and shall contact the appropriate authorities for the Henderson, Nevada area or the National Response Center (toll free: (800) 424-8802). The report will include:
    a. Name and telephone number of the reporter;
    b. Name and address of the BRC CAMU;
    c. Time and type of incident;
    d. Name and quantity of material(s) involved, to the extent known;
    e. The extent of injuries, if any; and
    f. The possible hazards to human health, or the environment, outside the facility.

5. For small fires, flames will be extinguished using the fire extinguisher. Large fires will be handled by the fire department.
6. In an unknown situation or if responding to toxic gas emergencies, appropriate PPE, including SCBAs, will be donned.
7. If chemicals are accidentally spilled or splashed into eyes or on skin, safety eyewash and/or shower will be used.
8. Before continuing site operations, after an emergency involving toxic gas, BRC will don a SCBA and utilize appropriate air monitoring equipment to verify that the site is safe.
9. An injured worker shall be decontaminated appropriately.
10. If a worker is injured, first aid will be administered by workers certified in first aid.

3.5 Reporting

BRC will note in the operating record the time, date, and details of any incident that requires implementing this plan. The report will be submitted to the NDEP and include:

a. Name, address, and telephone number of the owner or operator;
b. Name, address, and telephone number of the facility;
c. Date, time, and type of incident;
d. Name and quantity of material(s) involved;
e. The extent of injuries, if any;
f. An assessment of actual or potential hazards to human health or the environment, where applicable; and
g. The estimated quantity and disposition of recovered material that resulted from the incident.

Incident reports will be kept as part of the operational records and maintained by BRC for at least 3 years and otherwise in accordance with the records retention provision of the AOC3.

FIGURE G-1
HOSPITAL LOCATION

TABLE G-1
EMERGENCY RESPONSE CONTACTS

Name	***Telephone Numbers***		***Date of Pre-Emergency Notification***
	Office	***Cell***	
Fire Department – Henderson Fire Dept.	911 (702) 267-2222		February 20, 2007
Hospital – St. Rose Dominican-Rose de Lima Campus 102 E. Lake Mead Parkway Henderson, NV 89015 (702)616-5000	(702) 564-2622		February 20, 2007
Police Department – Henderson Police Dept	911 (702) 267-4550		February 20, 2007
Construction Manager – Basic Remediation – Lee Farris	(702) 567-0400	(702) 523-2920	TBD*
Nevada DEP*			TBD*
Other			

* To be completed before site activities are initiated.

Copy of letter sent is provided in Appendix A to this Attachment

Appendix A

Copies of Letters Sent to Police, Fire, and Hospital Emergency Contacts

Basic Remediation
COMPANY

February 20, 2007

Mr. Val Baciarelli
President
St. Rose Dominican Hospital-Rose de Lima
102 East Lake Mead Parkway
Henderson, Nevada 89015

Dear Mr. Baciarelli,

As you may know, work will soon commence on the clean-up and restoration of the 2200 acre tract owned by our affiliate, the LandWell Company, that is bounded on the south by Lake Mead Parkway, on the west by Boulder Highway, and on the north by the Las Vegas Wash. This clean-up and restoration is being conducted under the jurisdiction and supervision of the Nevada Division of Environmental Protection, with significant input from the City of Henderson and Clark County. As part of this project, we have developed Accident Prevention, Contingency, and Emergency Response Plans. These plans provide for fire, police, and medical responses, if needed. We have designated the St. Rose Dominican Hospital as primary responder in the event of injury. While we do not expect problems to arise that would require a response by the Hospital's emergency room, we want to be prepared for such a contingency. If you would like a more detailed briefing in person on details of the clean-up and restoration project, I would be happy to provide this. I can be contacted at 702-567-0400 and at sahuron@earthlink.net.

Sincerely,

Ron Sahu, Ph.D., CEM
Project Manager

875 West Warm Springs, Henderson, Nevada 89015 • Phone 702.567.0400 • Fax 702.567.0473

Basic Remediation
COMPANY

February 20, 2007

Mr. Richard D. Perkins
Chief of Police
Henderson Police Department
223 Lead Street
Henderson, Nevada 89015

Dear Chief Perkins,

As you may know, work will soon commence on the clean-up and restoration of the 2200 acre tract owned by our affiliate, the LandWell Company, that is bounded on the south by Lake Mead Parkway, on the west by Boulder Highway, and on the north by the Las Vegas Wash. This clean-up and restoration is being conducted under the jurisdiction and supervision of the Nevada Division of Environmental Protection, with significant input from the City of Henderson and Clark County. As part of this project, we have developed Accident Prevention, Contingency, and Emergency Response Plans. These plans provide for fire, police, and medical responses, if needed. We have designated the Henderson Police Department as primary responder in the event of theft or assault. While we do not expect problems to arise that would require a response by the Police Department, we want to be prepared for such a contingency. If you would like a more detailed briefing in person on details of the clean-up and restoration project, I would be happy to provide this. I can be contacted at 702-567-0400 and at sahuron@earthlink.net.

Sincerely,

Ron Sahu, Ph.D., CEM
Project Manager

875 West Warm Springs, Henderson, Nevada 89015 • Phone 702.567.0400 • Fax 702.567.0473

Basic Remediation
COMPANY

February 20, 2007

Mr. Douglas Stevens
Deputy Fire Chief
Henderson Fire Department
City Hall
240 Water Street
PO Box 95050
Henderson, Nevada 89009-5050

Dear Chief Stevens,

As you may know, work will soon commence on the clean-up and restoration of the 2200 acre tract owned by our affiliate, the LandWell Company, that is bounded on the south by Lake Mead Parkway, on the west by Boulder Highway, and on the north by the Las Vegas Wash. This clean-up and restoration is being conducted under the jurisdiction and supervision of the Nevada Division of Environmental Protection, with significant input from the City of Henderson and Clark County. As part of this project, we have developed Accident Prevention, Contingency, and Emergency Response Plans. These plans provide for fire, police, and medical responses, if needed. We have designated the Henderson Fire Department as primary responder in the event of fire. While we do not expect problems to arise that would require a response by the Fire Department, we want to be prepared for such a contingency. If you would like a more detailed briefing in person on details of the clean-up and restoration project, I would be happy to provide this. I can be contacted at 702-567-0400 and at sahuron@earthlink.net.

Sincerely,

Ron Sahu, Ph.D., CEM
Project Manager

875 West Warm Springs, Henderson, Nevada 89015 • Phone 702.567.0400 • Fax 702.567.0473

Attachment H
Emergency Coordinator

Attachment H
Emergency Coordinator
Basic Remediation Company (BRC)
Corrective Action Management Unit (CAMU)
Henderson, Nevada

1.0 Introduction H-1
1.1 Emergency Coordinator H-1
1.2 Back Up H-1

1.0 INTRODUCTION

The BRC CAMU emergency coordinator is completely familiar with the site operation and Accident Prevention, Contingency, and Emergency Response Plan. In addition, the emergency coordinator must be familiar with all activities at the facility, the location and characteristics of waste handled, the location of all records within the facility, and the layout. The emergency coordinator is responsible for directing the emergency procedures outlined in Attachment G. He or she shall have successfully completed all training and is responsible for the training records of all personnel outlined in Attachment G. The contact information for two additional individuals is also provided who can also fulfill this role. At least one individual shall be within 30 minutes of the BRC CAMU until closure.

1.1 Emergency Coordinator

Name: Lee Farris – Basic Remediation
Address: 875 W Warm Springs Road
Cell Phone: (702) 523-2920
Home Phone: (702) 914-6740

1.2 Back Up

Name: Mark Paris
Address: 875 W Warm Springs Road
Henderson, NV 89011
Office Phone: (702) 567-0400

Attachment I
Location Standards and Siting Requirements

Attachment I
Location Standards and Siting Requirements
Basic Remediation Company (BRC)
Corrective Action Management Unit (CAMU)
Henderson, Nevada

(No Changes Have Been Made to this Attachment)

Table of Contents

1.0 Introduction I-1
2.0 Geologic Conditions I-1
2.1 Geology I-1
2.2 Hydrogeology I-2
3.0 Climate I-3
4.0 Location Restrictions I-3
4.1 Flood Plains I-3
4.2 Fault Areas I-4
4.3 Seismic Impact Zones I-4
4.4 Unstable Areas I-4
5.0 References I-5

List of Figures

Figure I-1 FEMA Flood Insurance Map

Figure I-2 USGS SE Folio Geologic Map- Las Vegas Area

1.0 INTRODUCTION

This attachment describes the geological, hydrogeological, and climatic conditions at the BRC CAMU. In addition, location standards and siting requirements for the proposed BRC CAMU are discussed.

2.0 GEOLOGIC CONDITIONS

This section summarizes the geological conditions present at the BRC CAMU site. The Draft Conceptual Site Model (CSM) for the Common Areas prepared by Daniel B. Stevens & Associates (DBS&A, 2006) provides greater detail about the geological and hydrogeological conditions at the site.

2.1 Geology

Regional Geology in Southern Nevada is the Basin and Range Province morphology of the Western Cordillera of North America. In this region, Cenozoic tectonic extension has resulted it a system of fault-bounded mountains separated by sediment-filled valleys. The basins consist of down-dropped blocks of crust while the ranges are upthrust slabs with a regional tilt to the east. The typical arrangement in the Basin and Range system is a valley bounded on each side by a normal fault running parallel to the range (DBS&A, 2006).

The BRC CAMU site is located in the Las Vegas Valley, a northwest-southeast trending basin within the Basin and Range Province. The predominate range influencing the BRC CAMU site conditions is the McCullough Mountains bounding the valley to the south (DBS&A, 2006).

Valley fill in the vicinity of the BRC CAMU site consists of Tertiary Muddy Creek Formation (TMCf) and overlying Quaternary Alluvium (Qa) associated with alluvial fan deposits shed from the McCullough Range Mountains. The Qa is the present-day land surface at the CAMU as well as in most of the Henderson area and has an average thickness of 50 to 60 feet. The Qa is predominantly sands and gravels classified as poorly graded gravels (GP), silty gravels (GM), well-graded sands (SW), poorly graded sands (SP), and silty sands (SM) in accordance with the Common Unified Soil Classification System (USCS) (DBS&A, 2006).

Beneath the BRC CAMU site, the boundary between the Qa and TMCf is an unconformity that represents a period of time when the TMCf strata was likely exposed to weathering and erosion. Erosion by streams originating in the McCullough Mountains cut into the TMCf resulting in paleochannels that were later filled by Qa. Two

paleochannels have been inferred in the vicinity of the CAMU site: one paleochannel from the south-central area to the northwest corner and a second paleochannel from the northeast corner of the CAMU site trending almost due north (DBS&A, 2006).

Beneath the Qa is lies the TMCf consisting of predominantly fine-grained sandy silts and clayey silts. Layers with increasing sand content are encountered. With the increasing distance east and north from the McCullough Range, the proportion of coarse-grained sediments in the upper portion of the TMCf appears to decrease. The total thickness of the TMCf is unknown with measurements varying from 2,158 feet to 3,050 (DBS&A, 2006).

2.2 Hydrogeology

Groundwater flow beneath the BRC CAMU site is generally to the north, northeast. Groundwater ranges from approximately 1725 ft Mean Sea Level (MSL) to 1695 ft MSL from the southern to northern areas of the BRC CAMU (Figure C7). The groundwater flow is approximately parallel to the slope of the land surface. The average gradient of the water table ranges from about 0.02 to 0.04 ft/ft with a hydraulic conductivity typically ranging from a few inches to up to 33 feet per day (ft/d). The Qa is unsaturated towards the east, with saturation first noted in the uppermost TMCf, near the contact between the Qa and the TMCf. The groundwater treatment system located on the eastern property adjacent to the CAMU is thought to have dewatered the Qa (DBS&A, 2006).

Groundwater quality in the Qa is poor. General water quality analysis performed on a groundwater sample collected from Kerr-McGee monitoring well M-10, which is installed upgradient of the BMI Complex, reported relatively high concentrations of total dissolved solids (2,680 mg/L), chloride (732 mg/L), and sulfate (857 mg/L) (ERM-West Inc., 1996).

Beneath the Qa, within the TMCf, groundwater exists generally under confined conditions in saturated coarser-grained lenses. Water in wells screened in the upper portion of the TMCf rose under the confining pressure to elevations within the Qa indicating an upward flux gradient from the TMCf into the overlying alluvium. The hydraulic conductivity in the TMCf was approximately 12 ft/d (DBS&A, 2006).

Recharge to the Qa due to precipitation is generally considered to be negligible but has increased in recent years due to increasing irrigation infiltration, sewage treatment plant effluent, and from the removal of phreatophytic vegetation near the washes (Geraghty & Miller, 1993). Natural discharge from the Qa is primarily due to springs, direct evaporation, and evapotranspiration, with little or no water discharging to the Las Vegas Wash (Geraghty & Miller, 1993, after USBR, 1982).

3.0 CLIMATE

The Las Vegas Valley is one of the driest and warmest areas in the nation. The climate consists of hot summers, and cool winters. Summer temperatures above 105° Fahrenheit (F) and winter temperatures below freezing are common. The average daily minimum and maximum temperatures during winter months are about 35º and 60º F. During summer nights, minimum temperatures average 70º to 75º F. The frost-free period averages about 241 days per year (Geraghty & Miller, 1993, after USBR, 1982).

The Las Vegas Valley is characterized by low annual rainfall, approximately 4.5 inches per year, that fall during two rainy seasons. During the winter, the rainfall is generally low-intensity and falls over a wide area. In the spring and fall, local thunderstorms subject the area to high-intensity rains of short duration, which can cause high-runoff conditions. Maximum rainfall within a 24-hour period for a 25-year storm is approximately 2.3 inches (NOAA Atlas 2, undated) in the site area.

Evaporation is high in the Las Vegas Valley, influenced by high temperatures, high winds, and low humidity (average 20%). Pan evaporation data form the period of 1985 through 1988 range from approximately 2.5 inches/month to more than 17 inches/month (ERM-West, Inc., 1996, after Law Engineering, 1993). The months with the highest evaporation (May through September) correspond to the times of high-intensity rainfall, which indicates that rainfall does not contribute significantly to the recharge of groundwater in this area (ERM-West, 1996). Measurements of evaporation at Boulder City and Lake Mead indicate an annual loss of about 6.5 feet of water, three-fourths of which occurs during the six warmer months. The evapotranspiration within Las Vegas Wash is expected to be significantly higher due to high consumptive use by cattails, warmer temperatures, and lower humidity (Geraghty & Miller, 1993, after USBR, 1982).

Winds are typically out of the southwest or northwest and average nine miles per hour (mph). Gusts greater than 50 mph occur several times a year during the massage of major frontal systems. Topography influences the wind flow patterns.

4.0 LOCATION RESTRICTIONS

4.1 Flood Plains

The proposed BRC CAMU is located in an area determined to be outside the 100-year flood plain (Figure I-1) (FEMA, 2002).

4.2 Fault Areas

The proposed BRC CAMU is not located within 200 feet of a fault that has had displacement in Holocene time. Two north-trending fault scarps are located approximately ½ mile northwest and southwest of the proposed BRC CAMU (Figure I-2) (Converse Consultants, 1999). Displacement on both faults is recorded as pre-Holocene.

4.3 Seismic Impact Zones

The proposed BRC CAMU is located in a seismic impact zone (USGS, 1982). The site is located in an area with a 10 percent or greater probability that the maximum horizontal acceleration in lithified earth material will exceed 10 percent of the earth's gravitational pull in 250 years (USGS, 1982). The maximum horizontal acceleration depicted on the seismic hazard map with a 90 percent or greater probability that the acceleration will not be exceeded in 250 years is 14 percent of the earth's gravity. The peak horizontal ground acceleration recommended for the design of the project is 0.15g (Converse Consultants, 1999). A soil profile type of S_D per Table 16-J of the 1997 Uniform Building Code is recommended for the site.

Structures for containment, including liners, systems for the collection of leachate and systems for the control of surface water, will be designed to resist the maximum horizontal acceleration in lithified earth material for the site. Proof of meeting these design requirements will be placed in the operating records for the site and the solid waste management authority will be notified that the proof has been placed in the operating records.

4.4 Unstable Areas

Portions of the land on which the North Mesa will be constructed have been historically used for waste disposal – namely, the slit trenches. Wastes, consisting of various industrial wastes, construction and demolition debris, and office trash was disposed of in "slit trenches" that were excavated below grade. The Draft Conceptual Site Model prepared by DBS&A details the recent investigation of the "slit trenches" revealing the depth and extent of waste material (DBS&A, 2006). The waste was placed in the trenches without compaction effort and covered with previously excavated native material. There is also evidence that some waste may have been ignited and burned. As a result of the waste being placed without compaction, the "slit trenches" have experienced settlement over the years.

As noted above, the BRC CAMU is sited to overlay the slit trench area, and this overlay will in itself protect the slit trenches from erosion by wind and water. However, the potential for continued settlement of the "slit trenches" may cause instability of the

BRC CAMU liner system, if not addressed. Therefore, engineering measures will be incorporated into the structural design of the BRC CAMU to consolidate (compact) these materials prior to construction of the overlying BRC CAMU liner system. These measures are more particularly specified in Attachment J, CAMU Design- Conceptual.

In addition, it should be noted that BRC expects to excavate certain portions of the slit trenches, based on a Slit Trench Remedial Alternative Study (Slit Trench RAS), which is in preparation. The goal is to remove waste materials in "hot spot" areas within the slit trenches on a preventive basis and to meet regulatory requirements. Locations so excavated will be properly backfilled and consolidated prior to construction of the CAMU.

5.0 REFERENCES

Converse Consultants, 1999. Preliminary Geotechincal and Geologic Investigation, Industrial Non-Hazardous Disposal Facility, Basic Remediation Incorporated, Clark County, Nevada, October.

DBS&A, 2006 "Draft Conceptual Site Model for the Common Areas" prepared by Daniel B. Stevens and Associates, October.

ERM-West, 1996. Project Workplan – BMI Common Area, Environmental Conditions Investigation, Henderson, Nevada. February.

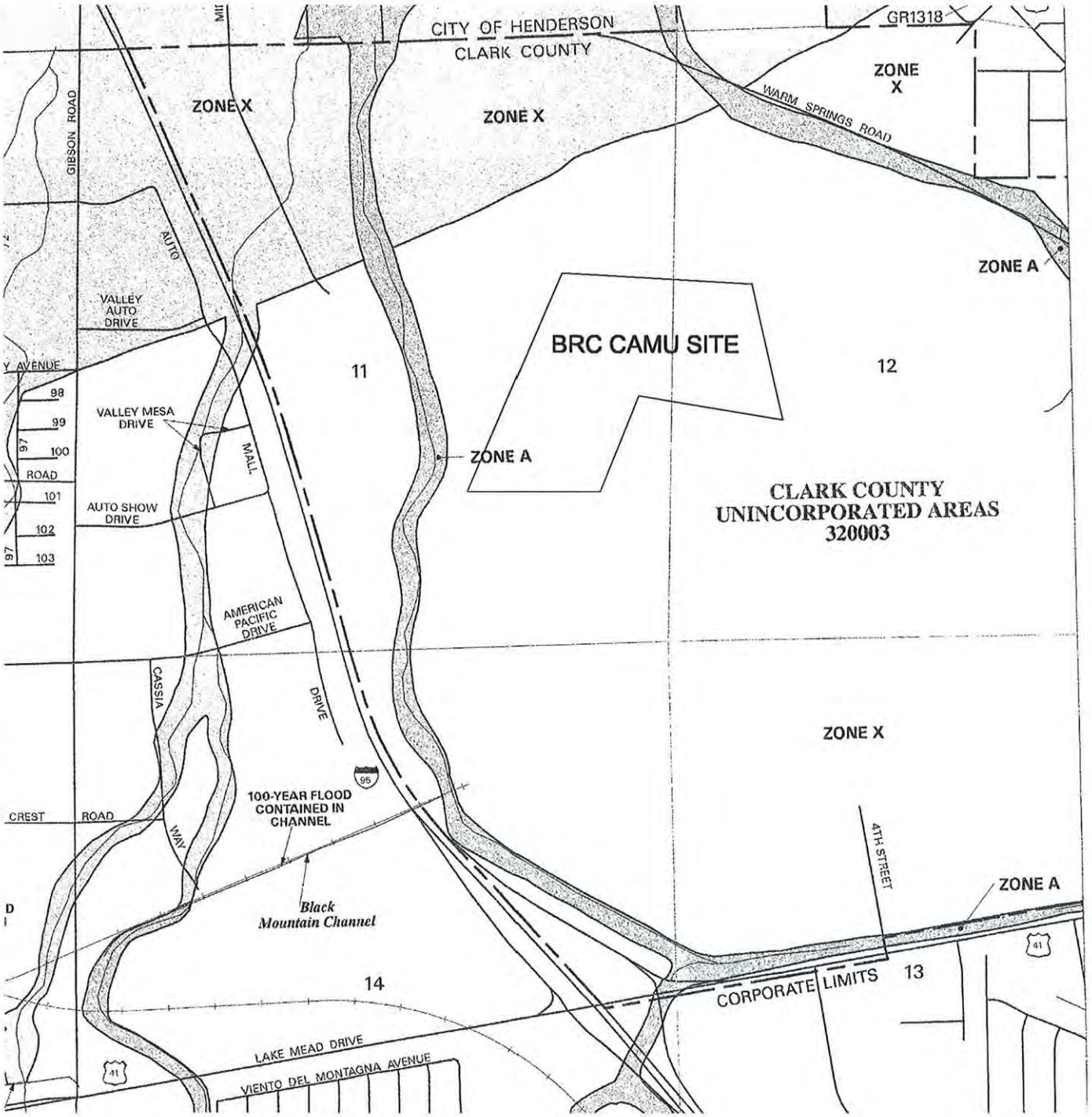
FEMA, 2002. Flood Insurance Rate Map No. 32003C2595E. Federal Emergency Management Agency. Revised September 27.

Geraghty & Miller, Inc., 1993. Phase I Environmental Conditions Assessment for BMI Complex – Clark County, Nevada, April.

Kerr-McGee, 1985, Phase II Groundwater Perchlorate Investigation, Henderson, Nevada Facility, July.

NOAA Atlas 2, Undated. "Precipitation Frequency Atlas of the Western United States," volume VII-Nevada, prepared by the national Weather Service and National Oceanic and Atmospheric Administration, United States Department of Commerce.

United States Geological Survey, 1982. Open File Report 82-1033, "Probabilistic Estimates of Maximum Acceleration and Velocity in Rock in the Contiguous United States."



LEGEND

100 YEAR FLOOD PLAIN

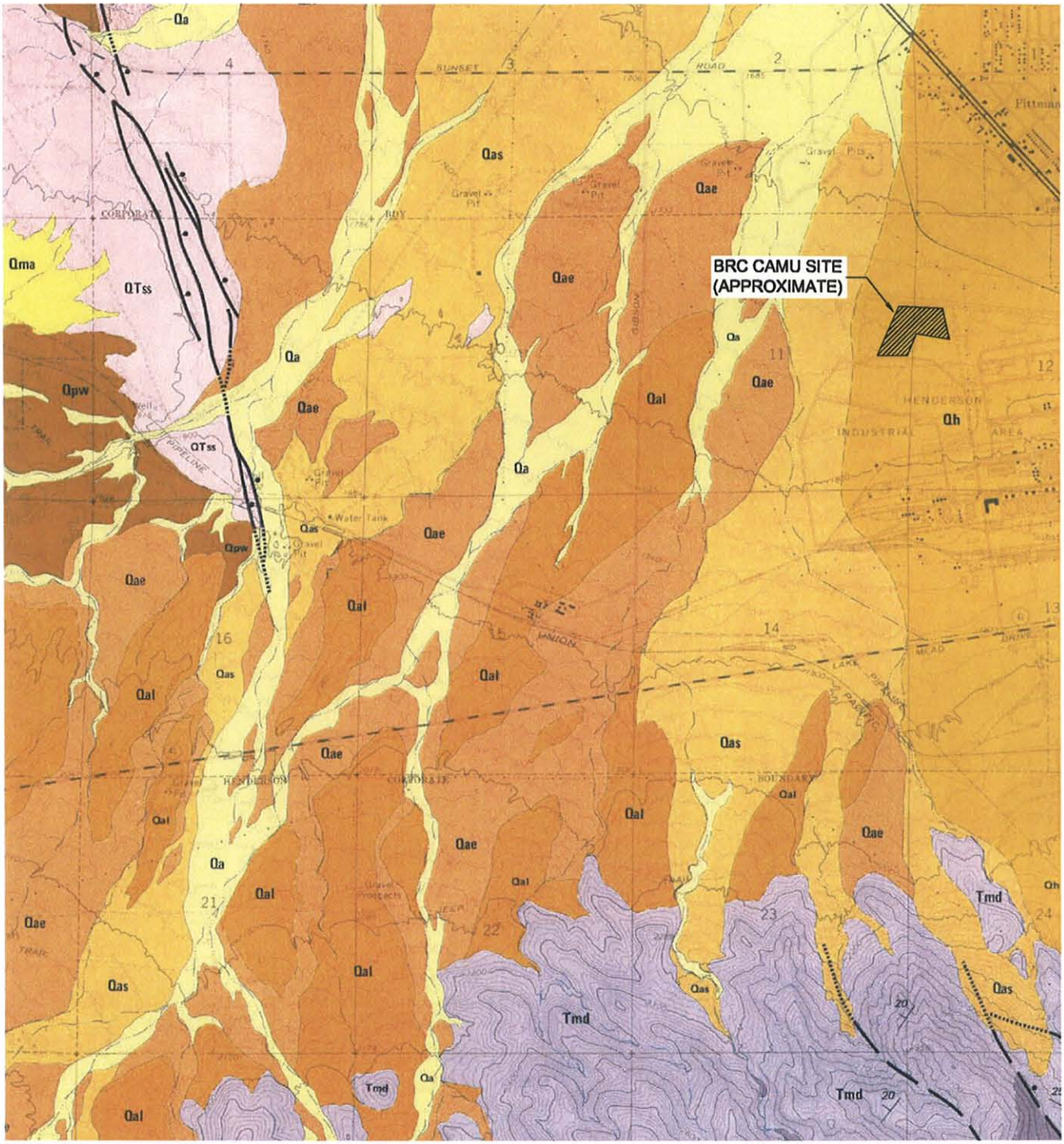
NOT TO SCALE

GEOSYNTEC CONSULTANTS

FEMA FLOOD INSURANCE MAP NO. 32003C2595 E
MAP REVISED SEPTEMBER 27, 2002
APPROXIMATE BRC CAMU LOCATION
BRC CAMU

FIGURE NO.	I-1
PROJECT NO.	SC0313
DATE:	NOVEMBER 2006

P:\PRJ\SDCadd\CADD\SC0313\BRC\figures\SC0313_Figure I-1_Insurance Map.dwg 7/10/2006 5:25 PM John Hall



Contact. Dashed where approximately located.

Fault. Dashed where approximately located; dotted where concealed. Ball on downthrown side.

15 **Bedding.**

NOT TO SCALE

GEOSYNTEC CONSULTANTS

USGS SE FOLIO GEOLOGIC MAP – LAS VEGAS AREA
BRC CAMU
HENDERSON, NEVADA

FIGURE NO.	I–2
PROJECT NO.	SC0313
DATE:	NOVEMBER 2006

P:\PRJ\SDCadd\CADD\SC0313\BRC\figures\SC0313_Figure I-2_Geological Map.dwg 7/10/2006 5:25 PM John Hall

Attachment J
CAMU (Landfill) Design – Conceptual

Attachment J
CAMU (Landfill) Design – Conceptual
Basic Remediation Company (BRC)
Corrective Action Management Unit (CAMU)
Henderson, Nevada

Table of Contents

1.0 Introduction J-1
1.1 Maps and Plans J-1
1.2 Anticipated Waste Material J-1
1.2.1 Predicted Leachate Generation J-2
2.0 Liner Design J-2
2.1 Liner and Leachate Collection System J-2
3.0 Summary of Engineering Analysis J-5
3.1 General J-5
3.2 Slope Stability Evaluation J-6
3.2.1 General J-6
3.2.2 Cut Slopes J-6
3.2.3 Final Waste Slopes J-6
3.3 Drainage Pipe Size Requirement J-7
3.4 Pipe Strength J-7
3.5 Veneer Stability J-7
3.6 Geotextile/Separation/Filtration Requirements J-7
3.7 Geotextile Cushion Protection J-8
3.8 Sump Capacity J-8
3.9 Comparison of Flow Through a CCL and CGL J-9
3.10 Tension Due to Wind Uplift J-9
3.11 Anchorage Capacity J-9
3.12 Geocomposite Equivalency Demonstration J-10
3.13 Consolidation Analysis J-10
4.0 References J-10

List of Tables

Table J-1 – Cushion Geotextile Requirements

List of Details

Detail J-1, Composite Liner Layout

Appendices

Appendix A – Groundwater Elevation Letter

CERTIFICATION PAGE

CONCEPTUAL DESIGN FOR THE CONSTRUCTION OF THE BASIC REMEDIATION COMPANY CORRECTIVE ACTION MANAGEMENT UNIT

HENDERSON, NEVADA

The Engineering material and data contained in this Conceptual Design Plan were prepared under the supervision and direction of the undersigned, whose seal as a registered Professional Engineer is affixed below.

The Engineering system in this conceptual design will prevent the migration of any hazardous constituents into the ground water or surface water at least as effectively as the liner and leachate collection and removal system specified in 40 CFR 264.301(c).

Ronald Johnson, P.E.
Nevada No. 12835

PROFESSIONAL ENGINEER - STATE OF NEVADA
RONALD S. JOHNSON
CIVIL
No. 12835

1.0 INTRODUCTION

This conceptual design is prepared in accordance with 40 CFR Parts 264, 266 and 268. The technical approaches discussed in this section are intended to outline the key conceptual design features and components of the proposed landfill. Upon regulatory review and approval, the conceptual design will be refined to provide detailed specifications to meet the design standards and performance criteria outlined in this permit.

1.1 Maps and Plans

A series of maps, plans and cross-sections referenced throughout this section is located in Section 1 of the Supplemental RAP Information (SRAPI). The design plans include the following:

- Figure J-1 – Title Sheet and Drawing List (includes general location map).
- Figure J-2 – Legend, Abbreviations, and General Notes;
- Figure J-3 – Overall Site Plan;
- Figure J-4 – Construction Sequence Plan;
- Figure J-5 – Surcharge Plan;
- Figure J-6 – Site Preparation Plan;
- Figure J-7 – Construction Grading Plan;
- Figure J-8 – Storm Drain Plan;
- Figure J-9 – Final Cover Grading Plan;
- Figure J-10 – Cross Sections
- Figure J-11 – Final Cover and Liner Details and Sections;
- Figure J-12 – Fence Plan.

1.2 Anticipated Waste Material

The source materials for the proposed BRC CAMU include approximately 3.7 million cubic yards of residual solids (i.e., sediments and associated soils) from the industrial ponds, ditches, and other source areas within the BMI Common Areas known as the Eastside Area, slit trenches, and western ditch within the BRC CAMU area. Extensive testing of the waste material has determined the majority of wastes to be non-hazardous. Volatile Organic Compounds (VOCs), Semi-volatile Organic Compounds (SVOCs), and Polychlorinated Biphenyls (PCBs) were detected sporadically, with VOCs and SVOCs throughout the site and PCBs in the Beta Ditch and first eight Upper Pond rows. Pesticides, metals, and cyanide were detected at low levels in the Beta Ditch and first eight Upper Pond rows. Asbestos was tested at measureable levels in the Beta Ditch and first eight Upper Pond rows. These wastes are not incompatible, reactive, or

ignitable. Additional waste characterization detail can be found in the Waste Analysis Plan (Attachment C). No wastes will be accepted from other sources.

Unlike typical landfills, both the source material and the proposed BRC CAMU will be under sole control of BRC. Consequently, there will be direct control over the types of waste materials placed at the BRC CAMU. Physical and chemical descriptions of the anticipated waste materials are presented in the Waste Analysis Plan (Attachment C).

1.2.1 Predicted Leachate Generation

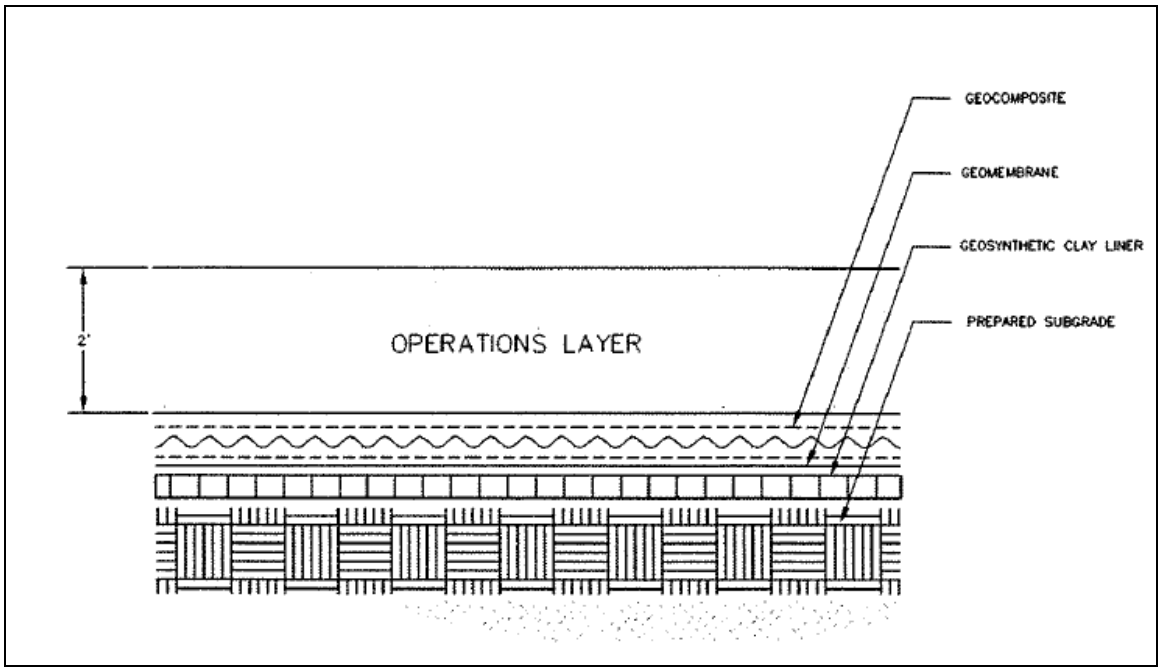
In the case of the proposed BRC CAMU, the mass of waste material will be compacted in place to form a hard-packed, monolithic "block," through which little or no saturated flow is expected to occur. Achieving the most favorable hydraulic conductivity in the compacted sediments depends on the degree of compaction, compaction method, type of soil, soil moisture content, and *in-situ* density. Wet waste sediments from the TIMET ponds will be mixed with dry solids, or otherwise dewatered, and then transported and placed to maintain a moisture content below that which is capable of generating leachate. The process will be designed such that waste sediments placed in the landfill meet the density and moisture content requirements that will in turn reduce leachate generation.

While waste material placed within the landfill will not be intrinsically capable of generating leachate, the ability for the landfill to produce leachate will be dependent on the quantity of the water allowed to infiltrate the interim and final cover materials and penetrate into the underlying waste materials. Therefore, final cover design and operational specifications for interim covers are important for the landfill system to provide for protection of the waters of the state. For this reason, the proposed interim and final cover are designed to reduce infiltration of water as described in Attachment O (Closure and Post-Closure Plan) and Attachment P (Final Cover Design).

2.0 LINER DESIGN

2.1 <u>Liner and Leachate Collection System</u>

A composite liner and leachate collection system is proposed as shown in cross-sections in Detail J-1 below. The composite liner will underlie the waste materials, providing a barrier to the underlying native soils and groundwater. Although leachate generation is not anticipated, this liner system is designed with a leachate collection system to reduce potential liquid accumulation at the base of the waste materials. Liner and leachate collection components will be constructed of materials having appropriate strength and chemical compatibility.



Detail J- 1, Composite Liner Layout

As shown in Detail J-1 above, the liner system is anticipated to consist of the following elements, or layers, from top to bottom: a geocomposite drainage layer, a geomembrane, and a geosynthetic clay liner (GCL). GCLs consist of a layer of bentonite-clay-backed geotextile. GCLs exhibit properties of low permeability soil liners, and have successfully substituted for the soil component in composite liner designs. Placement of a GCL under the geomembrane is commonly employed to increase effectiveness of the composite liner by limiting flow through potential flaws or pinholes in the geomembrane.

Geomembranes are relatively thin sheets of flexible polymeric materials that are manufactured and prefabricated at a factory and transported to the site. Because of their inherent impermeability, use of geomembranes in landfill construction is typically standard in the industry. Geomembranes are made of one or more polymers along with a variety of other ingredients such as carbon black, pigments, fillers, plasticizers, processing aids, crosslinking chemicals, anti-degradants, and biocides. The polymers used to manufacture geomembranes include a wide range of plastics differing in properties such as chemical resistance and basic composition. The polymeric materials may be categorized as follows:

- Thermoplastics such as polyvinyl chloride (PVC);

- Crystalline thermoplastics such as high density polyethylene (HDPE), low density polyethylene (LDPE), and linear low density polyethylene (LLDPE); and

- Thermoplastic elastomers such as chlorosulfonated polyethylene (CSPE).

The polymeric materials used most frequently as geomembranes are HDPE, PVC, and CSPE. Geomembrane thickness range from 20 to 120 mil (1 mil = 0.001 inch). The recommended minimum thickness for all geomembranes is 30 mil, with the exception of HDPE, which must be at least 60 mil. A 60-mil HDPE geomembrane is proposed for the BRC CAMU, which is widely recognized in the industry as a very chemically resistant, durable, long-lasting material.

Geocomposite is to be placed on the geomembrane to protect it from puncture by the overlying operations layer soil. The geocomposite is designed to allow leachate, if generated by the waste materials, to flow toward perforated HDPE collection piping and be collected at the pump-out locations. The base grade of the landfill is engineered to slope toward these leachate collection areas.

Components of the leachate collection system (LCS) will have sufficient strength to support overlying compressive stresses. Pipe strength calculations will include resistance to wall crushing, pipe deflection, and buckling pressure. Perforated drainage pipes have been shown to provide good long-term performance in LCSs (USEPA, 1993).

Geotextile filter is a component of the geocomposite that will reduce physical clogging of the drainage layer from the overlying fine-grained material.

The liner system is intended to work together with other design components to isolate the waste materials from the environment. The main objective of BRC CAMU design is to provide a design that protects waters of the state. Design components that are intended to accomplish this objective are as follows:

1. The final cover, or cap, of the landfill is designed to allow essentially no infiltration of water into the waste materials. The final cover is described in the CAMU (Landfill) Closure and Post Closure Plan (Attachment O). A solar field is contemplated to be installed and operated by a third party on top of the final cover. For additional details see Section 3.0 of the application.

2. The waste material will be processed and compacted to the degree necessary to reduce saturated flow within the interred materials. As discussed earlier, material from the TIMET ponds will be mixed with dry soils or dewatered, as necessary, prior to interment in the BRC CAMU. Together with a cap that reduces infiltration in an arid environment, the

resulting potential for contaminant mobilization and leachate generation is considered minimal.

3. In addition to the above precautions, the underlying liner system will be designed to collect leachate generated, thereby providing an additional factor of safety in reducing waste migration into the groundwater.

4. The base of the landfill will be at least 5 feet higher than first groundwater at the groundwater's highest elevation, providing a buffer between groundwater and the landfill (Appendix A).

Engineering design calculations and construction specifications for the base liner system and leachate collection system are presented with the Supplemental RAP Information (SRAPI), Sections 2 and 4, respectively. A summary is provided in the following section.

3.0 SUMMARY OF ENGINEERING ANALYSIS

3.1 General

This section summarizes the results of the conceptual design calculations performed for the base liner system at the BRC CAMU Landfill site. The following calculations were performed:

- Slope Stability Evaluation - Cut Slopes (Calculation Package A);
- Slope Stability Evaluation - Final Waste Slopes (Calculation Package B);
- Drainage Pipe Size Calculations (Calculation Package C);
- Pipe Strength Calculations (Calculation Package D);
- Veneer Stability Calculations (Calculation Package E);
- Geotextile Separation/Filtration Calculations (Calculation Package F);
- Geotextile Puncture Protection Calculations (Calculation Package G);
- Sump Capacity Calculations (Calculation Package H);
- Comparison of Flow Through the Prescriptive Composite Liner and a Proposed Alternative Composite Liner (Calculation Package I);
- Tension Due to Wind Uplift (Calculation Package J);
- Evaluation of Liner System Anchor Capacity (Calculation Package K);
- Drainage Geocomposite Equivalency Demonstration (Calculation Package L); and
- Consolidation Analyses (Calculation Packages M and N)

The base liner system calculations are based on the conceptual design grading plans shown on Figures J-7 and J-9 Additional calculations may have to be performed if there are changes to elevation and grade in the aforementioned design grading plans.

3.2 Slope Stability Evaluation

3.2.1 General

This section summarizes the analyses performed for the cut slopes and the final waste slopes. The analyses summarized herein are for static stability. Seismic site response, stability, and permanent deformation analyses are presented in Attachment O.

3.2.2 Cut Slopes

Slope stability was evaluated for the proposed cut slopes for the BRC CAMU. One cross-section was analyzed that represents the most critical case. Cut slopes with the highest height, weakest materials, and/or steepest slope are chosen for this analysis. The analyzed native soil cut slope has a height of approximately 44 ft and a base sloping at 3%. The proposed native soil cut slopes are at a slope angle of 2.1:1 (horizontal:vertical). The material properties selected and used in these analyses were based on a preliminary investigation by Converse Consultants, Inc. [Converse, 1999]. The calculations suggest that the most critical potential failure surface of the 2.1H:1V native soil cut slope possesses a factor of safety of approximately 1.5. Since the native soil cut slopes are considered interim, seismic evaluations were not conducted. Native soil cut slope stability calculations are presented in Section 2, Calculation Package A of the SRAPI.

3.2.3 Final Waste Slopes

The stability of the final waste slopes for the BRC CAMU was analyzed. Two cross-sections were analyzed that represent the most critical cases. Similar to cut slope analysis, waste slopes with the highest height, weakest materials, and/or steepest slope are chosen for this analysis. Originally, the analyzed final waste slope has a height of approximately 47 ft above surrounding grades at a slope angle of 3:1 (horizontal:vertical). Waste testing performed during waste placement as described in the Revised Waste Placement and Processing Plan was used to define waste material properties (Geosyntec, 2008). The calculations suggest that an apparent internal or interface friction angle of 11 degrees and 625 psf adhesion for any component of the composite liner system is the minimum allowable value provides a static factor of safety of 2.0. Furthermore, the calculations suggest that the yield acceleration for the final waste slopes is approximately 1.10 g (where “g” is the gravitational acceleration of 32.2 ft/s^2).

Design Change Notifications (DCNs) 47 and 48, issued during construction of the BRC CAMU, increased the height of the CAMU by an additional 34 ft, total. The additional waste was placed with 3H:1V slopes. The increased waste slopes were offset from the original 47 ft waste slopes by a minimum 10 ft wide bench. The material

properties selected and used in the analyses were based on the results of conformance testing performed during construction of the CAMU. The calculations suggest that the minimum interface friction angle of 11 degrees with 625 psf adhesion resulting from interface shear conformance testing for the composite liner system provides a static factor of safety of 2.0. The original and revised final waste slope stability calculations are presented in Section 2, Calculation Package B of the SRAPI.

3.3 Drainage Pipe Size Requirement

Drainage pipes will be placed on the base liner system to collect and transport potential leachate to the sump for removal. Analyses were performed to model leachate generation by using the Hydrologic Evaluation of Landfill Performance (HELP) model. The calculations suggest that a 4-inch diameter pipe with four 1/4-inch perforations spaced at 1-ft intervals will accommodate the flow predicted by HELP model analyses. Larger perforations are permitted if pipes are wrapped in filter geotextile to limit drainage rock intrusion. Drainage pipe size calculations are presented in Section 2, Calculation Package C of the SRAPI.

3.4 Pipe Strength

Based on drainage pipe size analyses, a 4-inch diameter drainage pipe will be used for leachate collection and transport. 12- and 18- inch diameter pipes will be used for the side slope riser for the vadose zone and leachate collection sumps, respectively. Based on the calculations performed for the 4-inch diameter drainage pipe and the 12- and 18-inch diameter side slope riser, the appropriate standard dimension ratio (SDR) is 13.5 or smaller. This calculation assumes the maximum height above the pipe of waste is 93 ft (South Mesa). Pipe strength calculations are presented in Section 2, Calculation Package D of the SRAPI.

3.5 Veneer Stability

The design criteria for the side slope liner system is to develop zero tension in the geosynthetics during installation of the operations layer on the side slopes. Potential causes of tension in the liner system include construction equipment loading and overburden stresses (e.g., operations layer materials). Based on the proposed grades and expected construction conditions, the calculations suggest that the side slope liner system will not be placed into tension provided a minimum dry interface friction angle of 18 degrees is maintained and the operations layer is staged in 10-ft high increments inclined at 2.5H:1V. Veneer stability calculations are presented in Section 2, Calculation Package E of the SRAPI.

3.6 Geotextile/Separation/Filtration Requirements

A separation/filtration geotextile will be placed between the operations layer and the drainage aggregate surrounding the leachate collection pipe and as a component of the geocomposite drainage layer. The purpose of the geotextile is to limit migration of fine material from the operations layer into the drainage aggregate and/or geonet component of the geocomposite. The calculations suggest that the separation/filtration geotextile overlying the drainage aggregate layer has an apparent opening size (AOS) greater than Sieve No. 70, a permittivity greater than 0.8 sec^{-1}, a minimum mass per unit area of 6 oz./yd^2, and sufficient mechanical properties. Geotextile separation/filtration calculations are presented in Section 2, Calculation Package F of the SRAPI.

3.7 Geotextile Cushion Protection

The geomembrane needs to be protected from puncture by particles from the prepared subgrade and operations material. Based upon the selection of using a geocomposite as the drainage layer in the leachate collection system, the geocomposite is selected such that the combined weight of the geocomposite geotextiles will act as an equivalent cushion. With respect to subgrade puncture, the geotextile components of the GCL will protect the geomembrane from the prepared subgrade. This calculation is based on a maximum overburden height of 93 feet. The analysis suggests that the following maximum particle sizes and geotextile mass per unit areas will be required:

Soil Component of Liner	Maximum Particle Size	Minimum Mass per Unit Area
Subgrade	0.75 inch	9 oz./yd^2 (GCL)
Angular Drainage Aggregate	1.00 inch	16 oz./yd^2

Table J -1- Cushion Geotextile requirements

Geotextile cushion protection calculations are presented in Section 2, Calculation Package G of the SRAPI.

3.8 Sump Capacity

The USEPA regulations limit the head over the liner system to less than 12 inches. Therefore, the available capacity to retain the peak daily runoff includes the sump and the volume of 12 inches of leachate in the geocomposite and operations layer extending away from the sump. The maximum, average daily runoff calculated from the HELP model analyses (see drainage pipe sizing calculation) is 231 ft^3. A sump will be located at four low points (Phases I, II, IIIB, and V). Each sump will be approximately 10 ft x 10 ft x 2 ft deep. The sump has a capacity of approximately 112 ft^3. The capacity of the drainage geocomposite/operations layer extending away from the sump (at a 12-inch head) is greater than 342 ft^3. The combined capacity of the sump and drainage

geocomposite/operations layer is 453 ft^3, which exceeds the maximum, average daily runoff noted above of 231 ft^3.

The capacity of the four sumps located throughout the site will be able to accommodate the anticipated peak daily flow (as evaluated from the HELP model – drainage pipe sizing calculation, Section 2, Calculation C of the SRAPI) and meet the EPA requirement of less than 12 inches of head over the liner. Sump and drainage aggregate capacity calculations are presented in Section 2, Calculation Package H of the SRAPI.

3.9 Comparison of Flow Through a CCL and GCL

The calculations suggest that the flow rate through the prescriptive composite liner system containing a compacted clay liner (CCL) is approximately 1.64 times greater than the flow rate through the alternative composite liner system containing a geosynthetic clay liner (GCL). The comparison calculations are presented in Section 2, Calculation Package I of the SRAPI.

3.10 Tension Due to Wind Uplift

The most critical scenario for wind uplift is after the 10-ft vertical height of operations material has been placed against the slope while the remainder of the geosynthetic liner is exposed on the upper portion of the slope. A UV-protective woven geotextile will be installed to overlie the exposed portions of geosynthetics on these cut slopes. The woven geotextile will be subjected to tension due to wind uplift.

Due to proximity of the site, the Las Vegas Airport wind speed data was used for this analysis. A design wind speed of 90 mph is used, which is the peak gust recorded since 1961. This is a conservative design wind speed since the likelihood of this wind speed occurring during the period of construction is very low. Assuming the design wind speed, the calculations suggest that the maximum tension the woven geotextile will experience is 82.8 lb/in. In order to resist the uplift forces from wind loads, the woven geotextile shall have a minimum ultimate wide width tensile strength of 110 lb/in. The tension due to wind uplift calculations is presented in Section 2, Calculation Package J of the SRAPI.

3.11 Anchorage Capacity

The geosynthetics' anchor must have the capacity to withstand potential pullout tension due to wind uplift from the UV-protective woven geotextile. The proposed anchor consists of a 2-ft wide and 2.5-ft deep trench filled with compacted soil. The anchor trench will be overlain by 1 ft of soil with a 3-ft runout length from the top of

slope. The capacity of the anchor trench is sufficient to withstand pullout tension from the woven geotextile. The anchorage capacity calculations are presented in Calculation Package K.

3.12 Geocomposite Equivalency Demonstration

A geocomposite layer will be used in lieu of a leachate collection gravel and separation/filtration geotextile. A geocomposite layer, consisting of two 8 oz/yd^2 nonwoven geotextiles bonded to either side of a geonet, is proposed. The top geotextile shall conform to the requirements presented in the geotextile separation/filter calculation package (Section 2, Calculation Package F in the SRAPI). The combined weight of the geotextiles will act as an equivalent cushion. The calculations suggest that a drainage composite will provide equivalent transmissivity to the aggregate drainage layer. The geocomposite equivalency demonstration calculations are presented in Section 2, Calculation Package L of the SRAPI.

3.13 Consolidation Analysis

Consolidation analyses were performed to evaluate the potential affect on the performance of the proposed liner system under increased loads related to the BRC CAMU. Borings and associated laboratory test results were used for locations beneath the South Mesa (higher loads due to thicker waste profile). Conservative analyses suggest that consolidation will not adversely impact the performance of the proposed liner or leachate collection systems. The consolidation analysis for the South Mesa is presented in Section 2, Calculation Package M of the SRAPI.

In addition, a consolidation analysis was performed to evaluate the effects of the consolidation settlement of waste in the “slit trenches” that will be overlain by the North Mesa disposal area. This evaluation was performed prior to the decision to remove the slit trench waste, place the waste in the CAMU, and backfill the excavations to original grade.

The consolidation analysis is presented in Section 2, Calculation Package N of the SRAPI.

4.0 REFERENCES

Converse Consultants, 1999. Preliminary Geotechnical and Geologic Investigation, Industrial Non-Hazardous Disposal Facility, Basic Remediation Incorporated, Clark County, Nevada, October.

Geosyntec, 2008. Revised Waste Processing and Placement plan, dated October 14, 2008.

USEPA 1993, “Solid Waste Disposal Facility Criteria, Technical Manual.” EPA530-R-93-017. Soild Waste and Emergency Response, November.

Appendix A

Groundwater Elevation Letter

Geosyntec consultants

10875 Rancho Bernardo Road, Suite 200
San Diego, California 92127
PH 858.674.6559
FAX 858.674.6586
www.geosyntec.com

6 April 2007

Ranajit Sahu, Ph.D.
Director of Environmental Services
Basic Remediation Company
875 West Warm Springs Road
Henderson, Nevada 89015

Subject: Groundwater Elevations
BRC CAMU
Henderson, Nevada

Dear Dr. Sahu:

In accordance with the Nevada Department of Environmental Protection (NDEP) draft Notice of Deficiency (NOD) dated 13 February 2007, Geosyntec has evaluated the groundwater elevation data associated with the Basic Remediation Company Correction Action Management Unit (CAMU) located in Henderson, Nevada. The proposed CAMU liner system, as illustrated on Drawing J-7, is designed to be a minimum of 5 feet above the groundwater elevation. The groundwater elevations presented on Drawing J-7 were obtained by Montgomery Watson Harza (MWH) in July 2005.

Based on the groundwater contours provided by MWH, the north mesa portion of the CAMU (i.e., the portion over the slit trenches) liner system is greater than approximately 40 feet above groundwater and the south mesa portion of the CAMU liner system (i.e., in the borrow pit area) greater than 5 feet above groundwater. Approximately 93% of the south mesa portion of the CAMU liner system area is more than 10 feet above the groundwater.

The CAMU liner system is designed to limit migration of liquids in the CAMU to the groundwater, which will also limit the migration of groundwater into the CAMU if groundwater were to rise above the base liner system elevation. Furthermore, if groundwater were to rise to an elevation above and migrate through the CAMU liner system, the liquid would be collected in the leachate collection and removal system and would then be removed from the landfill as outlined in the operations plan.

RAP_Att J GW Letter 20070406.doc

Based on this information, we do not anticipate that rising groundwater levels, if they occur, would adversely impact the performance of the liner system or CAMU.

Sincerely,

Ronald S. Johnson, P.E.
Associate Engineer

PROFESSIONAL ENGINEER-STATE OF NEVADA
RONALD S. JOHNSON
CIVIL
No. 12635

RAP_Att J GW Letter 20070406.doc

Attachment K
Final Design Drawings for the CAMU (Landfill)

Attachment K
Final Design Drawings for the CAMU (Landfill)
Basic Remediation Company (BRC)
Corrective Action Management Unit (CAMU)
Henderson, Nevada

Attachment L
CAMU (Landfill) Liner Construction Plan

Attachment L
CAMU (Landfill) Liner Construction Plan
Basic Remediation Company (BRC)
Corrective Action Management Unit (CAMU)
Henderson, Nevada

Table of Contents

1.0 Introduction L-1
2.0 Liner Construction Schedule and Sequence L-1
2.1 Site Preparation L-1
2.2 Liner Installation L-1
2.3 Leachate Collection and Removal System Installation L-2
3.0 Liner Construction Requirements L-2
3.1 General L-2
3.2 Slope Inclinations L-2
3.3 Drainage Pipe Size Requirement L-2
3.4 Equipment Loading L-3
3.5 Geotextile Requirements L-3
3.6 Geosynthetic Clay Liner (GCL) L-4
3.7 Leachate Collection Layer L-4
3.7.1 Geocomposite Requirements L-4
3.7.2 Geomembrane Requirements L-4
3.8 Prepared Subgrade Requirements L-4
4.0 Records and Recordkeeping L-5
4.1 General L-5
4.2 Daily Recordkeeping L-5
4.3 Construction Problems and Resolution Data Sheets L-6
4.4 Photographic Documentation L-6
4.5 Design Changes L-7
4.6 CQA Report L-7

1.0 INTRODUCTION

This BRC CAMU Construction Plan outlines the general construction requirements and schedule for the base liner systems. This plan addresses the construction materials, installation, and grading requirements for the BRC CAMU. The rationale for selecting the liner materials is described in the supporting calculations. A Base Liner System Construction Quality Assurance (CQA) plan, base liner system technical specifications, and conceptual drawings are included with the Supplemental RAP Information (SRAPI).

2.0 LINER CONSTRUCTION SCHEDULE AND SEQUENCE

Construction of the CAMU components will be phased so as to increase efficiency of waste disposal. One unit of the BRC CAMU will receive wastes while the base liner system is being constructed for the next unit. These different sections will be divided using storm water controls to reduce surface water, leachate, and waste interaction. The liners in adjacent units will be joined using the seaming techniques outlined in the Base Liner CQA and Technical Specifications (Sections 3 and 4 of the SRAPI, respectively). As lined areas are completed with waste placement, they will be closed and the final cover system will be constructed, as discussed in the CAMU (Landfill) Closure and Post-Closure Plan (Attachment O).

The general construction sequence of the CAMU, as shown on Figure J-4 of the Conceptual Drawings, Section 1, in the SRAPI, is outlined in the following sections.

2.1 Site Preparation

The site will be prepared by removing surface vegetation and portions of the fence currently on site. The temporary perimeter fence will be established and all support facilities brought on-site. At this time, the haul roads and storm water controls (ditches, culverts, silt fences, check dams, and basins) will be constructed. The slit trenches will be excavated, waste disposed of within the CAMU, and backfilled. The liner foundation will be graded in accordance with the Conceptual Drawings to prepare for liner installation. The grading requirements are summarized in Section 3 of this Attachment and in shown detail in Section 1 of the SRAPI.

2.2 Liner Installation

After the liner foundation grading, the leachate collection system and liner installation will begin. The flowlines, sumps, and berms for leachate conveyance and

storage will be constructed as shown on the Drawings at this time. Liner construction will begin with the installation of the geosynthetic clay liner (GCL), and geomembrane. Requirements for installation are summarized in Section 3 of this Attachment and in detail in the SRAPI.

2.3 Leachate Collection and Removal System Installation

The leachate collection and removal system will be installed next, with collection pipes, drainage aggregate, geotextile, and geocomposite. The geocomposite and filter geotextile will be overlain with 2 feet of soil acting as an operations layer. Requirements of the geocomposite and filter geotextile are summarized in Section 3 of this Attachment and in detail in the SRAPI.

3.0 LINER CONSTRUCTION REQUIREMENTS

3.1 General

This section describes the construction requirements for installation of the base liner system at the BRC CAMU. These construction requirements are necessary in order to ensure that the construction of the liner system is consistent with the design performance goals and assumptions.

3.2 Slope Inclinations

Native soil cut slopes shall be excavated no steeper than a slope inclination of 2.1H:1V. Waste soil slopes shall be placed no steeper than a slope inclination of 3H:1V.

3.3 Drainage Pipe Size Requirement

In accordance with the analyses performed, the drainage pipe shall be 4-inch diameter HDPE pipe with four 1/4-inch perforations per foot of pipe. Larger perforations are permitted if the pipe is wrapped in a geotextile fabric to prevent drainage rock intrusion. The side slope riser pipes shall be 12 – and 18-inch diameter HDPE solid-wall pipe for the vadose zone monitoring and leachate collection sumps, respectively. The standard dimension ratio (SDR) for the 4-inch diameter pipe and the 12- and 18-inch side slope risers shall be less than or equal to 13.5.

3.4 Equipment Loading

Equipment loads shall be limited to a maximum loading of 5 psi overlying a minimum of 1 ft of operations materials. In addition, roads for haul trucks shall be a minimum of 3 ft in thickness overlying the liner system.

3.5 Geotextile Requirements

Two geotextile components of the base liner system are utilized, a 6 oz/yd^2 separation/filtration geotextile and a 16 oz./yd^2 cushion geotextile. A UV protective geotextile will be used on the exposed liner system components on the side slopes. To ensure proper manufacturing and durability, the 6 oz/yd^2 separation/filter geotextile shall have the following properties:

Matrix	Nonwoven
Mass per Unit Area	≥ 6 oz/yd^2
Apparent Opening	≤Sieve No. 70
Permittivity	≥ 0.8 sec-1
Grab Strength	≥ 130 lb
Puncture Strength	≥ 40 lb
Ultraviolet strength retention	≥ 70%

The 16 oz/yd^2 cushion geotextile shall have the following properties:

Matrix	Nonwoven
Mass per Unit Area	≥ 16 oz/yd^2
Puncture Strength	≥ 155 lb
Grab Strength	≥ 350 lb
Ultraviolet strength retention	≥ 70%

The UV protective layer woven geotextile shall have the following properties:

Matrix	woven
Wide Width Tensile Strength	≥ 110 lb/in (ultimate strength)
Apparent Opening	≤ Sieve No. 40

3.6 Geosynthetic Clay Liner (GCL)

The GCL component of the base liner system shall have the following properties:

- Index flux > 1.0 x 10^{-8} ft^3/ft^2-sec;
- Minimum interface shear strength of 12 degrees;
- The GCL shall be dry during installation; and
- combined geotextile mass per unit area of 9 oz/yd^2.

3.7 Leachate Collection Layer

3.7.1 Geocomposite Requirements

In lieu of using drainage aggregate, a geocomposite will be used to collect potential leachate. The selected geocomposite shall have the following properties:

- Transmissivity > 3.05 x 10^{-5} ft^2/sec under a confining pressure of 12,000 psf and a hydraulic gradient of 0.10;
- an 8 oz/yd^2 non-woven geotextile bonded to each side of the geonet; and
- the top 8 oz./yd^2 non-woven geotextile shall have an AOS greater than Sieve No. 70, permittivity greater than 0.6 sec-1, and sufficient mechanical properties.

3.7.2 Geomembrane Requirements

The geomembrane shall be high-density polyethylene (HDPE), have a nominal thickness of 60 mil, and be textured on both sides.

3.8 Prepared Subgrade Requirements

The prepared subgrade shall have a maximum exposed particle diameter less than 3/4 inch.

4.0 RECORDS AND RECORDKEEPING

4.1 General

Liner and Leachate Collection System construction records will be kept in accordance with the CQA plan. The CQA Site Manager will document that all quality assurance requirements have been addressed and satisfied.

The CQA Site Manager will provide BRC with signed descriptive remarks, data sheets, and logs to verify that monitoring activities have been carried out. The CQA Site Manager will also maintain, at the job site, a complete file of Drawings and Technical Specifications, a CQA Plan, checklists, test procedures, daily logs, and other pertinent documents.

4.2 Daily Recordkeeping

Preparation of daily CQA documentation will consist of daily reports prepared by the CQA Site Manager which will include CQA monitoring logs, and testing data sheets. This information may be regularly submitted to and reviewed by BRC.

The CQA Site Manager will prepare daily reports that document the activities observed during each day of activity. The daily reports may include monitoring logs and testing data sheets. At a minimum, these logs and data sheets will include the following information:

- the date, project name, location, and other identification;
- a summary of the weather conditions;
- a summary of locations where construction is occurring;
- equipment and personnel on the project;
- a summary of meetings held and attendees;
- a description of materials used and references of results of testing and documentation;
- identification of deficient work and materials;
- results of re-testing corrected “deficient work;”
- an identifying sheet number for cross referencing and document control;
- descriptions and locations of construction inspected;
- type of construction and inspection performed;

- description of construction procedures and procedures used to evaluate construction;
- a summary of test data and results;
- calibrations or re-calibrations of test equipment and actions taken as a result of re-calibration;
- decisions made regarding acceptance of units of work and/or corrective actions to be taken in instances of substandard testing results;
- a discussion of agreements made between the interested parties which may affect the work; and
- signature of the respective CQA Site Manager.

4.3 Construction Problems and Resolution Data Sheets

Construction Problems and Resolution Data Sheets, to be submitted with the daily reports prepared by the CQA Site Manager, describing special construction situations will be cross-referenced with daily reports, specific observation logs, and testing data sheets and will include the following information, where available:

- an identifying sheet number for cross-referencing and document control;
- a detailed description of the situation or deficiency;
- the location and probable cause of the situation or deficiency;
- how and when the situation or deficiency was found or located;
- documentation of the response to the situation or deficiency;
- final results of responses;
- measures taken to prevent a similar situation from occurring in the future; and
- signature of the CQA Site Manager and a signature indicating concurrence by BRC.

BRC will be made aware of significant recurring nonconformance with the Drawings, Technical Specifications, or CQA Plan. The cause of the nonconformance will be determined and appropriate changes in procedures or specifications will be recommended. These changes will be submitted to the Engineer for approval. When this type of evaluation is made, the results will be documented and revision to procedures or specifications will be approved by the Contractor and Engineer.

4.4 Photographic Documentation

Photographs will be taken and documented in order to serve as a pictorial record of work progress, problems, and mitigation activities.

4.5 Design Changes

Design changes may be required during construction. In such cases, the CQA Site Manager will notify BRC. Design changes will be made with the written agreement of BRC and the Engineer and will take the form of an addendum to the Drawings and Technical Specifications. Design changes will be included in the CQA Reports.

4.6 CQA Report

At the completion of the Project, the CQA Consultant will submit to BRC the CQA report signed and sealed by a Professional Engineer licensed in the State of Nevada. The CQA report will acknowledge: (i) that the work has been performed in compliance with the Drawings and Technical Specifications; (ii) physical sampling and testing has been conducted at the appropriate frequencies; and (iii) that the summary document provides the necessary supporting information. At a minimum, this report will include:

- Manufacturers' quality control documentation;
- a summary report describing the CQA activities and indicating compliance with the Drawings and Technical Specifications which is signed and sealed by the CQA Officer;
- a summary of CQA/CQC testing, including failures, corrective measures, and retest results;
- contractor personnel resumes and qualifications;
- documentation that the geomembrane trial seams were performed in general accordance with the CQA Plan and *Technical Specifications*;
- documentation that field seams were non-destructively tested using a method in general accordance with the applicable test standards;
- documentation that nondestructive testing was monitored by the CQA Consultant, that the CQA Consultant informed the Geosynthetic Installer of any required repairs, and that the CQA Consultant inspected the seaming and patching operations for uniformity and completeness;
- records of sample locations, the name of the individual conducting the tests, and the results of tests;

- record drawings as provided by the Surveyor;
- documentation showing that piping was tested in general accordance with the Technical Specifications; and
- daily inspection reports.

The record drawings will include scale drawings depicting the location of the construction and details pertaining to the extent of construction (e.g., depths, plan dimensions, elevations, soil component thicknesses). Base maps required for development of the record drawings and the record drawings themselves will be prepared by a qualified Professional Land Surveyor registered in the State of Nevada. These documents will be reviewed by the CQA Consultant and included as part of the CQA Report, which will be kept with the project records in accordance with the records retention requirement of the AOC3.

Attachment M
CAMU (Landfill) Operation Plan

Attachment M
CAMU (Landfill) Operation Plan
Basic Remediation Company (BRC)
BRC Corrective Action Management Unit (CAMU)
Henderson, Nevada

Table of Contents

1.0 Introduction M-1
2.0 Facilities M-1
2.1 Equipment M-1
2.2 Operation Support M-2
2.3 Access, Traffic Control, and Roads M-2
2.4 Signs M-2
3.0 Operating Criteria M-3
3.1 Health and Safety M-3
3.2 Fire Prevention M-3
3.3 Control of Windblown Material M-4
3.4 Special Waste Disposal M-4
3.5 Control of Authorized and Unauthorized Waste M-4
3.6 Disposal of Liquids M-5
3.7 Control of Explosive Gas M-5
3.8 Disposal of Vegetation M-5
3.9 Compliance with State Implementation Plan M-5
3.10 Putrescible Wastes and Vector Control M-5
3.11 Nuisance Control M-6
3.12 Disposition, Compaction, and Coverage M-6
3.13 Miscellaneous Requirements for Operation M-6
3.14 Control of Erosion, Mud and Dust M-7
3.15 Run-on and Runoff Control Systems M-7
3.16 Leachate M-8
3.17 Decontamination M-9
4.0 Remediation M-9
4.1 Soil Excavation M-10

4.3 Soil Transportation to BRC CAMU M-10
4.4 Soil Placement M-11
5.0 Reporting and Recordkeeping.....M-11
5.1 General M-11
5.2 Interim Status Reports..... M-12
6.0 References.....M-13

1.0 INTRODUCTION

The purpose of this Operation Plan is to delineate the procedures and operating practices that will be implemented to ensure the safe and efficient excavation, loading, transportation, receipt, and placement of remediation wastes at the BRC CAMU. This Operation Plan summarizes operational procedures discussed in detail in the Corrective Action Plan (CAP) for the BRC Common Areas Remediation Project prepared by Dr. Ranajit Sahu, C.E.M. for BRC dated September 2006. This Operation Plan is intended to provide guidelines to the operator and managers of the BRC CAMU in conducting CAMU operations.

2.0 FACILITIES

2.1 Equipment

The proposed equipment at the BRC CAMU is listed in Table 3 of the CAP. The equipment will be adequate in type, capacity and number, and sufficiently maintained to permit the site operation to meet requirements of these standards. Periodically, the overall maintenance level of site equipment and the quality of site maintenance facilities will be evaluated. In addition, periodically the size and adequacy of the equipment to carry out operations, including the types and quantities of major landfill equipment such as bulldozers, scrapers, compactors, graders and water trucks will be evaluated by BRC.

Selection of type, size, quantity, and combination of machines required to move, dry, spread, and compact waste depend on the following factors:

- Amount and type of waste to be handled;
- Weather conditions;
- Compaction requirements;
- Site and soil conditions (topography, soil moisture, and difficulty of excavation); and
- Supplemental tasks such as maintaining roads, assisting in vehicle unloading, and moving other materials and equipment around the site.

In addition to the above, BRC is committed, through either purchase or lease, to provide other equipment to serve as replacements, backups, or supplements to existing operations, or for such special needs that may arise.

2.2 Operation Support

Suitable shelter and sanitary facilities will be provided for operating personnel and waste transport personnel. In addition, a storage area will be provided for BRC CAMU operators to store equipment.

2.3 Access, Traffic Control, and Roads

Site access will be gained through the entry gate located off Warm Springs Road on the west side of the property. Access will be controlled fencing during site operations in order to prevent unauthorized vehicular traffic and illegal dumping. Access will also be controlled by using artificial barriers to protect public health, safety, and the environment. The entry gate will be equipped with a lockable mechanism to prevent unauthorized entry and/or uncontrolled waste deposition when the site is closed. Access to the site at points other than the entry gate will be discouraged by maintenance of site perimeter fencing and full time security during site operations.

Temporary roads will be provided as necessary to the working face. All roads will be passable during inclement weather. The entire site will be enclosed with a continuous chain link fence. Figure F-1 through F-3 of the CAP show the locations of the proposed haul roads.

2.4 Signs

At the main entrance gate off Fourth Street a sign will be posted indicating the following:

- Facility name;
- The owner and operator of the site;
- The hours of operation; and
- Materials accepted or excluded.

It will be noted on the signage that the BRC CAMU is a private operation.

Instructional signs will be placed at this site entrance addressing prescribed safety measures on the site and include instructions regarding prohibition of smoking within the disposal areas and mandating that all instruction from site personnel be obeyed.

Interior site haul roads will be appropriately signed so as to direct each load to its designated disposal area. Typical directional and information signs will be posted at the site. Location of signage may be changed from time-to-time to facilitate operations.

In addition, authorized personnel may be utilized to direct traffic at the active working face of the landfill operation.

"No Trespassing" signs will be posted at 100-foot intervals along the site perimeter fencing. "Danger- Unauthorized Personnel Keep Out," will be posted at each entrance to the active portion of the BRC CAMU and additional locations as necessary. All signs will be posted in English and Spanish.

Additional signs and/or measures may be required to protect personnel and public health and safety.

3.0 OPERATING CRITERIA

This section presents operating criteria of the BRC CAMU and methodologies to be used to meet such criteria.

3.1 Health and Safety

All activities will be performed in accordance with a Health and Safety Plan(s) (HASP) developed for Site remediation activities by the contractor(s) selected for the project. These HASP(s) shall apply to the contractor's employees and subcontractors. The parameters and details that will be included in the HASP are described in the Accident Prevention, Contingency, and Emergency Response Plan. Briefly, the HASP shall include the following:

- Identification of chemical and physical hazards associated with the remediation activities;
- Minimum training requirements for site workers;
- Minimum Personal Protective Equipment (PPE) for site workers and visitors and criteria for upgrades;
- Air monitoring requirements for workers' breathing zone and site perimeter (for public protection);
- Emergency information, such as emergency telephone numbers and directions to the nearest hospital; and
- Administrative requirements, such as documentation of training, daily health and safety tailgate meetings, and documentation of air monitoring.

A sample Health and Safety Plan table of contents for the BRC CAMU and the Common Areas Remediation Project is included as Appendix D of the CAP.

3.2 Fire Prevention

Fire hazard at the BRC CAMU is expected to be minimal due to the type of material being landfilled. Explosive gases (e.g. methane) are not anticipated at the BRC CAMU because putrescible material will not be accepted at the BRC CAMU for disposal.

No open burning of wastes will be allowed at this site. Fire control protection will be provided by the utilization of on-site equipment such as a water truck, track type dozer and front-end loaders for wetting and smothering accidental fires. In addition, site-related operational vehicles will be equipped with fully functional fire extinguishers. Backup fire protection will be available from units of the Clark County Fire Department.

Site personnel will receive periodic on-the-job training in fire fighting practices conducted by BRC and/or other authorized representatives.

3.3 Control of Windblown Material

Scattering of papers, plastic, or other debris by the wind will not be an issue at the BRC CAMU as such types of wastes will not be accepted. However, minor amounts of paper waste were encountered during slit trench waste excavation and subsequent disposal in the BRC CAMU. BRC used litter fences and hand labor to control windblown waste materials.

Dust control measures will be implemented to limit the amounts of wind-blown dust. Dust control will be accomplished via moisture management and synthetic covers, as required. Operations will cease during periods of high winds, consistent with Clark County requirements as provided in the Dust Control Plan Application included in the CAP.

3.4 Special Waste Disposal

The projected mix of wastes to be received from the service area is a by-product of industrial process fluids allowed to settle in various evaporation ponds. The resulting residual soil is the solid waste requiring disposal. In addition, solid waste from the slit trench excavations will be placed in the BRC CAMU. No other special wastes are anticipated.

3.5 Control of Authorized and Unauthorized Waste

The source materials for the BRC CAMU include the residual solids (i.e., sediments and associated soils) from the industrial ponds, ditches, and related source areas, and slit trench waste from the BRC CAMU area. Municipal wastes will not be accepted from private individuals. Unlike typical landfills, both the source material and

the BRC CAMU will be under sole control of BRC. Consequently, there will be control over the types of waste materials accepted at the BRC CAMU.

3.6 Disposal of Liquids

Liquids will not be disposed of at the BRC CAMU.

3.7 Control of Explosive Gas

Due to the nature of material to be placed in the landfill, generation of methane or other explosive gases is not anticipated. Controls for explosive gas are not required.

3.8 Disposal of Vegetation

Vegetation, if any, will be removed from excavation areas and access routes. Soil attached to plant roots will be shaken loose and left on the ground surface in the pond in which the vegetation was present, to be collected with the other soils in that pond. The vegetation will be relocated and temporarily stockpiled within the Debris Storage Area, as discussed in the CAP, where it will be tested to determine whether chemicals within the site soils have bioaccumulated within the vegetative matter at levels that would cause it to be unsuitable for disposal at a municipal landfill. In the event that vegetation meets disposal requirements in municipal landfills, they will be so disposed. In the event that contaminate levels dictate that they should be disposed in hazardous waste landfills, they will so be disposed. Vegetation grubbed during excavation will not be disposed in the BRC CAMU unless approved by the Design Engineer.

3.9 Compliance with State Implementation Plan

BRC will ensure that the BRC CAMU does not violate applicable requirements developed by the state implementation plan, if any, approved or adopted by the Administrator of the USEPA, pursuant to Section 110 of the Federal Clean Air Act, as amended (42 U.S.C. § 7410), and the regulations adopted pursuant thereto. As noted earlier, dust mitigation will be ensured by adherence to the Dust Mitigation Plan Application, Appendix C of the CAP. In addition, there will be no open burning of solid wastes at the BRC CAMU.

3.10 Putrescible Wastes and Vector Control

Due to the nature of material to be placed in the BRC CAMU, putrescible wastes and vector control issues do not apply.

3.11 Nuisance Control

The operation and maintenance of the BRC CAMU will be in a manner which will not create odors, unsightliness or other nuisances. There will be no ponded and stored water at the site; thus this source of obnoxious odors and vector breeding is obviated.

As necessary, water or other dust palliatives such as magnesium chloride will be applied to the landfill and its roads to minimize nuisance dust consistent with the Dust Mitigation Plan.

3.12 Disposition, Compaction, and Coverage

Since the waste to be disposed will be soil and sediment a daily cover will not be required to control disease vectors, fires, odors, blowing litter and scavenging. Instead, if operations cease for prolonged periods of time, which is not expected, an intermediate cover will be applied on an as-needed basis. Moisture will be added periodically as needed to reduce dust and particulates.

Solid wastes will be spread and compacted in layers. Waste will be offloaded from the haul vehicles, and spread by a tracked dozer in lifts with a maximum thickness of eighteen inches. A landfill compactor or other suitable equipment will accomplish a sufficient number of passes over each lift in order to reduce voids and produce a compact mass.

The BRC CAMU will be operated to facilitate efficient placement of the waste material. At any given time, the compacted waste mass will be contoured to allow effective drainage in case of inclement (rainy) operations. Construction Sequence Plan, included in the Supplemental RAP Information, presents general steps of landfilling activities.

Horizontal and vertical control is necessary to ensure that the final grades and cell geometry are constructed as planned. The BRC CAMU will be filled to within two feet of the required final elevation. Elevation control for equipment operators at the landfill is achieved through the use of steel pipe grade poles installed in the fill area and marked with red rings against a yellow background at the fill level (two feet below the final grade). The ring elevations are surveyed with respect to a BRC CAMU surveyed benchmark, which will be a concrete monument.

3.13 Miscellaneous Requirements for Operation

Scavenging through waste at the working face of the BRC CAMU by citizens or non-employees of the landfill operations will be prohibited and is not expected.

The working face area will be inspected daily and lightweight debris will be returned to the fill area and covered.

Provisions will be established concerning recording all solid waste delivered to the site. Topographic surveys will be performed on a quarterly basis to double-check and further quantify the volume of materials placed within the BRC CAMU.

Damage to areas or components of the BRC CAMU that affect system performance in meeting engineering design objectives will be repaired within 60 days of discovery of the damage.

3.14 Control of Erosion, Mud and Dust

An adequate amount of water from storm water or municipal well sources will be available at all times for the control of dust and the compaction of cover material.

Adequate measures will be taken to minimize the creation of dust and minimize safety hazards due to obscured visibility. Roadways will be sprayed with water and/or magnesium chloride to reduce dust generation. Dust control measures are described in detail in the Dust Mitigation Plan Application which is provided as Appendix C of the CAP.

Primary interior roadways will be surfaced with compacted crushed stone or gravel materials, as necessary. Ramps and unloading areas at designated interior disposal areas will be graded for proper drainage with earth-moving and grading equipment.

During periods of wet weather, such surfacing and maintenance practices will be eliminated, or at least minimized to reduce the tracking of mud off-site. During wet periods, BRC or his/her designee will be responsible for a daily inspection of the main incoming road and will be responsible for the timely removal of any accumulated mud on that portion of the roadway within the immediate site vicinity. In addition, temporary shaker plates will be installed to minimize tracking of mud off site. Accumulated mud deposits remaining on interior haul road surfaces will be similarly removed as needed by light grading to control dust emissions resulting from normal traffic.

3.15 Run-on and Runoff Control Systems

BRC will provide a system to control run-on and runoff of surface water as outlined in the Technical Drainage Study for Eastside Landfill (ATKINS, 2006). The

goal of the run-on system is to collect and control the flow of surface waters entering the BRC CAMU boundaries.

Runoff from the active portion of the BRC CAMU will be managed so as to not cause a discharge of pollutants, silts, or a nonpoint source of pollution from the BRC CAMU into the waters of the state or waters of the United States, including wetlands. Surface water runoff throughout the active portion of the site will be managed to minimize contact of water with solid waste.

Rainfall within the BRC CAMU will be drained away from the active working face. Such drainage will be maintained by constructing each disposal area bottom, or floor, on a uniform grade, with the working face progressing in a downslope direction.

Water coming into contact with the active working face, and thus retained within the BRC CAMU, will be evaporated or may be used for such on-site activities as waste compaction and dust control within the BRC CAMU lined areas. Water not coming into contact with the active working face and collected in the downslope portions of designated water disposal areas may be utilized for such site-related operations as dust control, waste compaction, windblown dust minimization, construction and compaction of disposal area liners, and maintenance of access roadways.

All interim surface water runoff and post closure runoff from the site and surrounding areas will be managed through a series of permanent perimeter drainage channels (Figure J-8). Natural drainage patterns or discharge quantities associated with the site and surrounding areas will not be significantly altered. Runoff will be periodically sampled and tested for general compliance with Nevada National Pollution Discharge Elimination System (NPDES) permit standards.

3.16 Leachate

During waste placement activities, the leachate will be removed from the sumps using portable submersible pumps and will be used for dust control on waste materials placed within the lined limits of the BRC CAMU. Leachate levels will be monitored in accordance with the Final Leachate Monitoring Plan (Attachment Z).

3.17 Decontamination

The Contractor will inspect the equipment to confirm that the equipment arrives on the site in a clean state. If obvious indications of contamination are observed, the Contractor will refuse entrance of the equipment onto the site, or decontaminate the equipment before it is used subject to the approval of BRC. No personal vehicles, "lunch wagons" or other non-essential vehicles will be permitted within the area of active work where the potential to encounter waste may occur. Vehicular traffic will be kept to a minimum. To the extent practical, equipment will be stored when not in use in the location last used or the nearest safe location. Overnight staging in clean areas is not permitted unless the equipment is first decontaminated to prevent the potential for tracking contamination back and forth across the site.

The Contractor will operate the equipment in a manner that minimizes contact with waste, including minimizing the surface area contacting waste and minimizing the potential for spills, drips, splashes or sprays. Equipment, once decontaminated, will be stored in a designated clean area of the site, or preferably removed from the site as soon as practicable.

As described in the CAP, construction equipment decontamination is summarized as follows:

- Transport trucks will be driven across gravel track out aprons with scraping of mud and/or use of water spray to be performed at dedicated decontamination areas.
- Equipment heavily caked with soil and/or other material will be scraped off with a flat-bladed scraper. The scrapings will be placed in the soil staging area for disposal with the excavated soils.
- Equipment will be decontaminated using steam cleaning equipment prior to departure from the work site.

The dozer blades and tracks, and compactor wheels and drum will require decontamination only when removed from the surface of the waste. The frequency of decontamination will be a field decision based on the type of waste materials being encountered.

4.0 REMEDIATION

This section summarizes the excavation procedures, the methods for transporting soils to the BRC CAMU, and documentation which are discussed in detail in the CAP. The BRC CAMU has been sized to contain approximately 3.7 million cubic

yards of material. In the event that impacted soils volume is exceeded, those excess soils will be dispose of off-site, at a properly-licensed facility.

4.1 Soil Excavation

A BRC contractor will complete the excavations in accordance with the plans and specifications developed for this work, under the direction of the BRC. Soil excavation will be performed as described in the CAP. The contractor will use appropriate construction equipment to excavate, load, and transport the materials to the BRC CAMU.

BRC anticipates that 7,500 cubic yards of soil will be excavated, transported, and interred, on average, each day, with the actual volume dependent on equipment used, daily conditions, and hours of operation.

4.2 Soil Transportation to BRC CAMU

All transportation of the remaining small amounts of waste, to be interred in Phase V, will be completed during daylight hours. Hauling will take place using street legal trucks across public roadways.

Soils excavated from the Eastside area will be transported by truck to the BRC CAMU approximately 1.5 to 2 miles away as discussed in the CAP.

Trucks hauling waste materials from the Eastside Area will enter the BRC CAMU Area from the eastern site ingress/egress at 4th Street. Trucks will then travel along site access roads adjacent to the BRC CAMU lined landfill area and enter into the BRC CAMU lined landfill area at dedicated access points or ramps. Upon entering the BRC CAMU lined landfill area, the trucks will travel directly on the operations layer above the liner system or above previously placed waste materials. Each truck will be directed to a “working face” where the contents of the truck will be dumped. Trucks will then travel off of the lined landfill area, across “rumble strips” and track-out aprons summarized in Section 3.17 and described in greater detail in the CAP. Water spray will be performed at dedicated decontamination areas as needed to minimize tracking waste materials off of the landfill. Trucks will exit the BRC CAMU Area at 4th Street.

Spillage of soils from trucks during transportation will be minimized by not overloading the transport vehicles, by grading smooth haul roads, and by employing trucks with enclosed or covered cargo bays. Dust will be controlled by water in accordance with the Dust Control and Mitigation Plan Application in Appendix C of the CAP. Because the access routes will be wetted to suppress dust, some mud will be

generated, and it is likely that this mud would be transferred to truck tires and the vehicle body. When needed, prior to crossing Boulder Highway, the transport trucks will be decontaminated by scraping and/or water spray to avoid transfer of dirt to the pavement. In addition, after excavation/transport operation cease for a given day, the affected portion of Boulder Highway will be cleaned to remove soils from the roadway.

In the event of an accident resulting in release of the soils being transported, the truck driver will immediately contact BRC. BRC will immediately inspect the site of the accident and notify the local emergency management agencies. The potential for immediate threat to workers and people nearby will be evaluated, and BRC will instruct the remediation contractor to take appropriate corrective steps to rectify the problem. Any spilled material will be returned to the truck (or another truck, if the original truck is disabled) and transport to the BRC CAMU will be complete. If the spill occurred on a public roadway (i.e., Boulder Highway), the spilled material will be removed, and the road surface will be immediately vacuumed to remove remaining materials.

4.3 Soil Placement

The waste material at the working face will be spread by a bulldozer in a lift no greater than 18-inches in thickness and compacted using standard earthworks construction equipment. The compaction of the waste material will be confirmed through monitoring of placement and through proof rolling of the waste. The moisture content will be compared to the optimum moisture content result from previously performed moisture/density laboratory testing. Ideally, the in-situ moisture content will be less than the optimum moisture content, thereby minimizing the potential for liquids to “squeeze out” of the waste material upon placement of overlying materials that will increase the normal static pressure and thus the “squeezing” of the underlying waste material.

5.0 REPORTING AND RECORDKEEPING

5.1 General

BRC will prepare daily progress reports documenting all daily activities. Daily activity records include, but are not limited to, documentation that evidences the quantity of waste materials placed in the BRC CAMU and log in/out forms. In addition to this summary daily report, the contractor will also keep detailed field notes and daily logs. Daily photographic and video record will be kept by BRC documenting all remediation activities. Records and results of daily, weekly, and monthly inspections will be maintained and kept onsite consistent with requirements specified in the AOC3.

Records and results of waste analysis and waste determinations will be maintained and kept on site. In addition, all monitoring, testing or analytical data, and corrective action records resulting from BRC CAMU releases shall be maintained onsite consistent with requirements specified in the AOC3. Groundwater monitoring and clean up records will be maintained until closure of the BRC CAMU.

Summary reports of all incidents that require the use of the Contingency Plan will contain the details outlined in Attachment G, Accident Prevention, Contingency, and Emergency Response Plan. The incident reports will be maintained and kept onsite until closure of the BRC CAMU.

Additional items to be included with the operating records are: closure and post-closure cost estimates, plans for closure and post-closure, EPA identification number, detailed chemical and physical analysis of a representative waste sample, Quality Control (QC) and Quality Assurance (QA) documentation.

5.2 Interim Status Reports

During remediation activities at the Site, BRC will submit monthly status reports to the NDEP as stated in the CAP. The purpose of the monthly status reports will be to keep the NDEP informed of the progress of remedial activities at the Site. The reports will present a summary of the remediation progress during the previous month, including as appropriate:

- Significant milestones in CAMU construction;
- Pond and ditch locations where excavation has been completed (including graphical format);
- Pond and ditch locations where special control measures (except dust control, which is routine measure) were necessary and/or where excavation had to be prematurely terminated due to the presence of ground water or based on any of the other “stopping rules” discussed in Figure J; and
- Estimates of volumes of soil excavated and placed in the CAMU (monthly and cumulative). Other information (e.g., discovery of significant environmental conditions previously unidentified) will be provided in the monthly status reports as warranted. Interim status meetings will also be conducted by telephone to supplement these written reports.

Other information (e.g., discovery of significant environmental conditions previously unidentified) will be provided in the monthly status reports as warranted or

otherwise required by the AOC3. Interim status meetings will also be conducted by telephone to supplement these written reports.

6.0 REFERENCES

ATKINS, 2006. "Technical Drainage Study for Eastside Landfill," Henderson, Nevada, October.

Attachment N
CAMU (Landfill) Monitoring Plan

Attachment N
CAMU (Landfill) Monitoring Plan
Basic Remediation Company (BRC)
Corrective Action Management Unit (CAMU)
Henderson, Nevada

Table of Contents

1.0 Introduction N-1
2.0 Construction Monitoring N-1
2.1 Surface water N-1
2.2 Leachate N-1
2.3 Air Monitoring N-2
3.0 Post Closure N-2
3.1 General N-2
3.2 Final Cover N-2
3.3 Leachate N-3
3.4 Settlement N-3
3.5 Groundwater N-3
4.0 Reporting and Recordkeeping N-4
5.0 References N-4

1.0 INTRODUCTION

This BRC CAMU Monitoring Plan describes the procedures and activities that BRC will undertake to detect and subsequently characterize releases of wastes or hazardous constituents to groundwater that may occur from areas of the BRC CAMU during operation and after closure.

2.0 CONSTRUCTION MONITORING

2.1 Surface water

BRC will carefully maintain drainage to expedite storm water collection. A portable pump will be provided at the low end of the BRC CAMU to remove accumulated storm water. The operator will maintain access to this pump and maintain the pump in good working condition with a good supply of fuel and suction hoses in position for water removal at all appropriate times.

During operating hours, the operator will pump water from the working cell as quickly as possible whenever it accumulates. When heavy rainfalls occur during non-operating hours, standing water will be pumped out before normal operations resume.

Surface water exiting the site from the on-site storm water basin will periodically be sampled and tested for general compliance with Nevada surface water standards for the Las Vegas Wash. BRC will obtain necessary NPDES permits from the NDEP prior to discharge of such waters.

2.2 Leachate

The BRC CAMU will be managed to reduce the generation of leachate. However, leachate, if generated, will slowly accumulate in the leachate collection sumps designed as part of the BRC CAMU. The base grade of the BRC CAMU will be engineered so that leachate generated will accumulate at the designated leachate collection points. The operator will monitor the leachate level and remove and dispose of the leachate, as needed, consistent with the Final Leachate Monitoring Plan (Attachment Z). During active waste placement, leachate collected from the sumps will be used for dust control and waste material moisture conditioning purposes over the lined areas only.

In addition, pan lysimeters, or vadose zone monitoring sumps, will be installed beneath the sump areas of the BRC CAMU to monitor for possible leakage from the liner system at the locations of the lowest elevations in the liner system (sumps),

which is where leachate, if any, will accumulate. The vadose zone monitoring sumps will be monitored in accordance with the Final Leachate Monitoring Plan (Attachment Z).

2.3 Air Monitoring

Given the small amount of additional waste to be placed in the Phase V of the CAMU, dust monitoring, similar to what was conducted during the bulk of the CAMU waste placement, is not cost-effective and will not be implemented. Based on prior air monitoring results, use of dust control measures should not create any off-site dust migration above relevant regulatory thresholds.

3.0 POST CLOSURE

3.1 General

Formal periodic inspections will be performed using site walks. These site walks will be performed within one week of significant precipitation events (e.g., greater than ¼ inch of rain during a 24-hour period) that could potentially impact either the surface water drainage system or the BRC CAMU cover. At a minimum, a site-wide inspection will be performed at least quarterly.

The condition of the facility will be documented with field notes, maps, and photographs, as appropriate. Evidence of potential compromises in the cover will be recorded including eroded patches, animal burrows, subsidence, and cracks along the cover. Surface water drainage features will be inspected for the presence of debris, physical integrity, and evidence of conditions that are different from design assumptions.

3.2 Final Cover

Final cover performance will be evaluated through a monitoring program of the final cover and periodic groundwater monitoring. The basis for this strategy is the fact that the final cover will be the critical element to reduce moisture infiltration into the BRC CAMU. Therefore, it is proposed that monitoring efforts be focused on direct observation, measurement, and analysis of the performance of the final cover.

The final cover system shall be periodically monitored in order to evaluate the performance of the final cover. The final cover monitoring plan consists of:

- visual inspection of the final cover system performed on a semi-annual basis and after all major precipitation events; and

- if erosion has occurred, ascertain damage to the geosynthetics, if any, and repair as necessary in accordance with the Technical Specifications and CQA Plan.

The decorative rock cover will be visually inspected for signs of erosion. Areas of erosion will be repaired as needed.

A solar field is planned for installation on top of the final cover. Additional discussion is provided in Section 3.0 of the application.

3.3 Leachate

The leachate collection system will be monitored in accordance with the Final Leachate Monitoring Plan (Attachment Z).

Because the proposed BRC CAMU is located in an arid environment receiving approximately 4.5 inches of average rainfall annually, with high rates of evaporation and low infiltration rates, it is unlikely that significant amounts of precipitation will be introduced to the BRC CAMU leachate collection and removal system. These factors will limit the generation of leachate. Moreover, the waste material consists primarily of soil, which will be monitored for moisture content prior to placement into the landfill.

Pan lysimeters, or vadose zone monitoring sumps, will be installed beneath the sumps to monitor leaks within the collection system. Pan lysimeters will be monitored at the same time as the leachate sumps in accordance with the Final Leachate Monitoring Plan (Attachment Z).

3.4 Settlement

A topography survey using 1-foot contour intervals will be performed within 3 months after final closure of the CAMU to document baseline conditions in support of post-closure settlement evaluations. Although settlement is not expected to be a significant issue, this will provide a convenient mechanism to document the surface elevation. Excessive settlement can lead to depressions and ponding causing stress in the infiltration layer. When depressions are identified through the survey, they will immediately be filled with the appropriate cover material.

3.5 Groundwater

The groundwater at the site ranges from 30 to 60 feet bgs, as discussed in the Draft CAMU Area Conceptual Site Model (DBS&A, 2006). At a minimum, the BRC

CAMU base liner is approximately 5 feet above the groundwater. Constituent release to the groundwater from the BRC CAMU, post-closure, is considered unlikely for the following reasons:

- The BRC CAMU will not receive liquid waste or waste containing free liquids;
- Waste materials within the BRC CAMU are relatively immobile;
- The BRC CAMU will be designed and operated to reduce liquid, precipitation, and other run-on and run-off; and
- The BRC CAMU will have both a base liner system, with a leachate collection and removal system, and final cover system.

It should be noted that releases, if any, into the upper aquifer are difficult to monitor because of the impaired quality of the existing groundwater beneath the BRC CAMU. Most or all of the same constituents which will be present in the BRC CAMU are currently present in groundwater at the site. Constituents present in upgradient groundwater make differentiating potential releases from the BRC CAMU difficult or impossible. BRC has completed a set of four semi-annual baseline groundwater monitoring events. Based on this monitoring, a long term groundwater monitoring plan is in development. When approved, BRC will conduct long term groundwater monitoring in accordance with this plan. (see Attachment Y).

4.0 REPORTING AND RECORDKEEPING

Monitoring results will be maintained by BRC in accordance with the provisions of the AOC3 following closure of the CAMU. Monitoring results will be summarized and submitted to NDEP with the annual post-closure report of inspection and monitoring activities.

5.0 REFERENCES

DBS&A, 2006. Draft Conceptual Site Model of the Common Areas. Henderson, Nevada, October.

Attachment O
CAMU (Landfill) Closure and Post-Closure Plan

Attachment O
CAMU (Landfill) Closure and Post-Closure Plan
Basic Remediation Company (BRC)
Corrective Action Management Unit (CAMU)
Henderson, Nevada

Table of Contents

1.0 Introduction O-1
1.1 Notice of Intent to Close O-1
1.2 Construction Schedule and Sequence O-1
1.2.1 Final Waste Placement O-1
1.2.2 Infiltration Layer Construction O-2
1.2.3 Final Cover Construction O-2
2.0 Final Cover Components O-2
2.1 Infiltration Layer O-3
2.2 Protection Layer O-4
2.3 Surface Water Drainage System O-5
2.4 Performance Evaluation of the Final Cover O-5
3.0 Summary of Cover Analysis O-5
3.1 General O-5
3.2 Slope Stability Evaluation - Final Waste Slopes O-6
3.3 Comparison of Flow between a CCL and GCL O-6
3.4 Geocomposite and Pipe Size Calculations O-6
3.5 Veneer Stability O-7
3.6 Cover Liner Sloughing Stability O-7
3.7 Geotextile Filtration Requirements O-7
3.8 Geotextile Puncture Protection O-7
3.9 Pipe Strength Calculations O-8
3.10 Seismic Performance Evaluation O-8
3.10.1 General O-8
3.10.2 Seismic Hazard Evaluation O-8
3.10.3 Evaluation of Design Ground Motions O-9
3.10.4 Site Response Analyses O-9

3.10.5 Site-Specific Seismic Deformation Charts O-9
3.10.6 Deformation Analyses O-10
4.0 Cover Construction Requirements O-10
4.1 General O-10
4.2 Slope Stability Evaluation O-10
4.3 Geocomposite Requirements O-10
4.4 Drainage Pipe Requirements O-11
4.5 Final Cover Soil O-11
4.6 Equipment Loadings O-11
4.7 Geotextile Requirements O-11
4.8 Geosynthetic Clay Liner (GCL) O-12
4.9 Geomembrane Requirements O-12
4.10 Prepared Subgrade Requirements O-12
4.11 Final Cover Surface Treatment O-12
5.0 CAMU Post-Closure Plan O-12
5.1 Requirements After Closure O-13
5.2 Program for Postclosure O-13
5.3 Land Use O-13
5.4 Personnel O-14
5.5 Security O-14
5.6 Operation and Maintenance O-15
5.7 Post-Closure Inspections and Monitoring O-15
5.8 Reports and Recordkeeping O-15
6.0 References O-16

List of Details

Detail O-1 – Final Cover System

List of Tables

Table O-1 – Geotextile Puncture Protection

1.0 INTRODUCTION

This section of the permit application addresses the closure of the BRC CAMU, which will occur when disposal operations are complete. This Closure Plan addresses pertinent regulatory requirements, including a description of the final cover. It is anticipated that a final CAMU Closure Plan will be prepared approximately six months prior to closure. By that time, additional details regarding BRC CAMU volume will be available. For purposes of this permit application, the Closure Plan addresses activities that will occur when waste placement activities are complete.

Access to the BRC CAMU will be controlled during the closure phase using procedures employed during the operational phase (see Security Plan, Attachment D). Fugitive dust control measures will be maintained and traffic management procedures continued. Site aesthetics will continue to be an important element during this phase. Community outreach programs will be continued as part of the overall remediation effort (as discussed in the Community Involvement Plan) to address public concerns and issues associated with the BRC CAMU.

1.1 Notice of Intent to Close

At least 60 days before beginning the closure of the BRC CAMU, the NDEP will be notified in writing of the intent to close. BRC CAMU closure activities will begin no later than 30 days after the date on which the final receipt of wastes occurs.

All closure activities will be completed in accordance with this CAMU Closure Plan within 180 days after the beginning of the closure. An extension beyond this 180-day deadline may be requested if it is determined that additional time is needed and all actions are taken necessary to prevent threats to public health and safety and the environment.

A request for an extension to these deadlines will include a description of the measures needed to control access to the unclosed unit prior to closure or receipt of additional wastes. It would also include a description of activities to prevent threats to public health and safety and the environment from the open unit.

1.2 Construction Schedule and Sequence

1.2.1 Final Waste Placement

After receipt of the final waste, either construction of the final cover will begin or an interim cover will be placed. If the unit is going to be left without the final

cover for longer than 30 days, the interim cover layer will be placed and compacted on top of the final waste layer.

1.2.2 Infiltration Layer Construction

The infiltration layer will be placed beginning with the geosynthetic clay liner (GCL) above the interim cover. The geomembrane is placed above the GCL with the geocomposite placed last. Details of each layer are discussed in later sections.

1.2.3 Final Cover Construction

The soil materials for the final cover will be placed, compacted, and graded. The permanent storm drain facilities (gutters, ditches, culverts, headwalls, etc.) will be installed as the cover is being completed.

2.0 FINAL COVER COMPONENTS

The final cover is designed to minimize infiltration and erosion. A final cover that reduces infiltration is an essential component in the overall design strategy for the BRC CAMU. This, combined with adequate moisture control of the wastes prior to placement, should ensure that no leachate is formed.

Specific design objectives of the final cover system include:

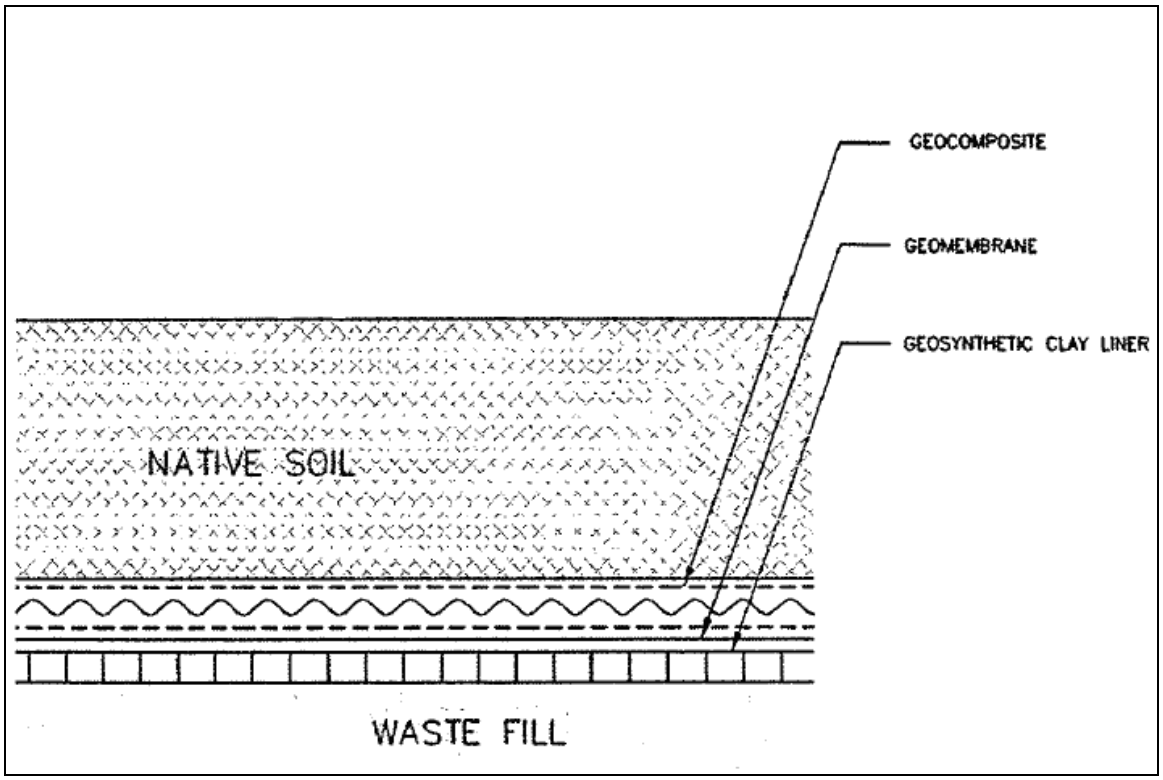
- Minimize infiltration of precipitation into the waste;
- Promote good surface drainage;
- Resist erosion by rain and wind;
- Protect human health and the environment;
- Improve aesthetics;
- Reduce long-term maintenance; and
- Be consistent with land use.

Several of these objectives are directly related to regulatory requirements while the others represent design considerations. BRC CAMU closure technology, design, and maintenance procedures continue to evolve, and it is possible that the cover design for the BRC CAMU may be refined prior to final closure to incorporate the latest design procedures. Modifications or enhancements to this proposed design would be submitted to the NDEP for approval prior to implementation.

Infiltration through the final cover will be minimized through:

- Design of adequate surface drainage and runoff with minimal erosion; and
- Design of composite barrier system (HDPE geomembrane over GCL) with an overlying drainage layer (geocomposite) to minimize hydrostatic head build-up on the geomembrane.

The final cover will consist of a separate infiltration and erosion layer. Engineering design calculations and construction specifications for the final cover system are presented within Sections 5, 6, and 7 of the Supplemental RAP Information (SRAPI). A cross section of the Final Cover System is shown in Detail O-1 below with an explanation of the components explained in the following sections.



Detail O- 1, Final Cover System

2.1 Infiltration Layer

40 CFR 264.310 specifies that the final cover be designed and constructed to have a permeability less than or equal to the permeability of any bottom liner system. Based on the proposed base liner system, construction of this type of cover will involve the use of a geomembrane and GCL composite liner system to serve as the infiltration layer as shown in Detail O-1 above.

The cover system will be designed to be physically stable to reduce failure, such as sliding between cover layers or within the waste.

Settlement is not expected to be a significant issue given the nature of the waste material and the manner of its placement (i.e. well compacted). Excessive settlement and subsidence at MSW landfills, caused by decomposition and consolidation of the wastes, can impair the integrity of the final cover system. Specifically, it can contribute to ponding of surface water on the cover and fracturing of the low-permeability layers of the cover. However, because the source materials for this BRC CAMU consist primarily of soil materials, the waste placement will be fairly homogeneous with little potential for significant differential settlement. Moreover, the soils will be compacted after placement.

The methods, procedures, and processes used to install the final cover system will be consistent with standard industry practices. Detailed design documents and construction specifications are included in Section 7 of the SRAPI. Included in the CQA plan is a description of quality control testing procedures for the construction materials and associated quality assurance procedures for construction activities. An independent registered professional engineer will be hired to observe closure activities and provide necessary certifications.

2.2 Protection Layer

Protection of the infiltration layer will be accomplished by the use of a 22-inch thick layer consisting of earthen material with 2-inch decorative rock layer. The source for erosion layer soils will be native, clean soil. It is expected to be from the vicinity of the BRC CAMU or from elsewhere in the BMI Common Areas. The earthen material used for the erosion layer will be free of debris, cobbles, rubbish, and roots. If the CAMU materials are used, then they will not be exposed to the atmosphere and will be covered with additional clean materials procured from outside the CAMU area.

The erosion layer will be designed to be geotechnically stable to reduce failure, such as sloughing of the soils overlying the geomembrane/GCL composite infiltration layer (Section 2, Calculation Package I in the SRAPI).

The surface of the erosion layer will have a minimum slope of 2 percent to facilitate run-off while reducing erosion. The side slopes will have a 3H:1V (Horizontal:Vertical) slope. The final grading plan is shown on Figure J-9 in the SRAPI.

2.3 Surface Water Drainage System

A surface water drainage system, designed by ATKINS, will be constructed to convey runoff around and away from waste disposal areas. Surface water will be conveyed around the BRC CAMU to two retention basins located at the northeast and northwest corners of the site. The water will be conveyed by concrete channels and pipes as shown on Figure J-8. The channel and pipe locations correspond to the locations of the access roads for the BRC CAMU. Surface water from the top deck will be conveyed to the conveyance channels via two rip-rap lined channels in the northeast and northwest corners. Drainage channels are designed along existing natural features to enhance surface runoff during high-precipitation events. Based on a 25-year storm event, the design will be sufficient to control erosion and maintain the stability of the slope (ATKINS, 2006).

2.4 Performance Evaluation of the Final Cover

The design of the final cover was evaluated using the Hydrologic Evaluation of Landfill Performance (HELP) model, which was developed by the U.S. Army Corps of Engineers for the USEPA and is widely used for evaluating the hydraulic performance of landfill cover systems (USEPA, 1993). The HELP model calculates daily, average, and worst-case estimates of water movement across, into, through, and out of landfills. The input parameters for the model include soil properties, precipitation and other climatological data, vegetation type, and landfill design information. Useful information provided by the HELP model includes surface run-off, duration, and quantity of water storage within the erosion layer, and net infiltration through the cover system. The information is used for performance evaluation of the geocomposite and drainage pipe sizing, as described in Section 3.4 below.

Site-specific input parameters were used in the HELP model and are documented in Section 5, Calculation Package A in the SRAPI. The results indicated that the net infiltration through the cover system would be 0.000002 in/year.

3.0 SUMMARY OF COVER ANALYSIS

3.1 General

This section summarizes the results of design analyses that were performed for the final cover at the BRC CAMU Landfill site. The following calculations were performed and are located in the respective Calculation Package found in Section 5 unless otherwise noted of the SRAPI:

- Slope Stability Evaluation - Final Waste Slopes (Section 2, Calculation Package B);
- Comparison of Flow between a compacted clay liner (CCL) and geosynthetic clay liner (GCL) (Section 2, Calculation Package I);
- Drainage Geocomposite and Pipe Size Calculations (Calculation Package A);
- Veneer Stability Calculations (Calculation Package B);
- Cover Soil Sloughing Stability Calculations (Calculation Package C);
- Geotextile Filtration Calculations (Calculation Package D);
- Geotextile Puncture Protection Calculations(Calculation Package E);
- Pipe Strength Calculations (Calculation Package F); and
- Seismic Performance Evaluation (Calculation Package G).

The final cover system calculations are based on the conceptual design grading plans shown on Figure J-9 in Section 1 of the SRAPI. Additional calculations and/or design modifications may have to be performed if there are changes to elevation and grade in the aforementioned design grading plans. Design modifications are described in the Closure CQA Reports.

3.2 Slope Stability Evaluation - Final Waste Slopes

Geosyntec analyzed the stability of the final waste slopes for the BRC CAMU as discussed in Attachment J. The slope stability analysis is included in Section 2, Calculation Package B of the SRAPI.

3.3 Comparison of Flow between a CCL and GCL

Geosyntec demonstrated that the flow rate through the prescriptive composite liner system (i.e. - CCL) is greater than the flow rate through the alternative composite liner system (i.e. - GCL), as discussed in Attachment J. The comparison of flow between a CCL and GCL is presented in the SRAPI, Section 2, Calculation Package I.

3.4 Geocomposite and Pipe Size Calculations

A geocomposite will be placed above the geomembrane to collect and drain surface water that has infiltrated through the cover soil. Drainage pipes will be placed in the final cover to collect water from the geocomposite and drain the water to the perimeter surface water collection channels. Analyses were performed to model infiltration using U.S. Environmental Protection Agency's (USEPA) Hydrologic Evaluation of Landfill Performance (HELP) model.

The head on the cover liner was evaluated to be less than 12-in. at the top deck area, and negligible (i.e., less than 1/10-inch) on the side slopes. Furthermore, the

calculations suggest that a 4-in diameter perforated corrugated polyethylene (CPE) pipe bedded in drainage aggregate will accommodate the maximum flow predicted by HELP model analyses. The 4-in. diameter perforated CPE pipe shall have a smooth interior wall to maximize pipe efficiency. Geocomposite and drainage pipe size calculations are presented in the SRAPI, Section 5, Calculation Package A.

3.5 Veneer Stability

The design criteria for the side slope liner system is to develop zero tension in the geosynthetics during installation of the final cover on the side slopes. Potential causes of tension in the liner system include construction equipment loading and overburden stresses (e.g., final cover materials). Based on the proposed grades and expected construction conditions, the calculations suggest that the side slope liner system will not be placed into tension provided a minimum interface friction angle of 20 degrees is maintained. Veneer stability calculations are presented in the SRAPI, Section 5, Calculation Package B.

3.6 Cover Liner Sloughing Stability

Based on the geocomposite and pipe size calculation results, no head buildup is expected above the side slope final cover system geosynthetic components. Calculations suggest that the minimum cover soil shear strength (interface with geocomposite or internal) of 27 degrees will meet the design factor of safety criteria of 1.5. the yield acceleration was found to be 0.15g ($g = 32.2$ ft/s^2). Cover liner sloughing calculations are presented in the SRAPI, Section 5, Calculation Package C.

3.7 Geotextile Filtration Requirements

A separation/filtration geotextile will be used in the following applications: (i) a component of the geocomposite for the final cover system, and (ii) separation/filtration between the cover soil and drainage aggregate. The purpose of the separation/filtration geotextile is to limit migration of fine material from the cover soil into the geocomposite and drainage aggregate, thereby reducing the transmissivity and hydraulic conductivity of the respective materials. The calculations suggest that the separation/filtration geotextile have an apparent opening size (AOS) greater than sieve No. 70, a permittivity greater than 0.5 sec^{-1}, and sufficient mechanical strength properties. Geotextile separation/filtration calculations are presented in the SRAPI, Section 5, Calculation Package D.

3.8 Geotextile Puncture Protection

The geocomposite and geosynthetic clay liner (GCL) will protect the geomembrane from puncture by particles from the prepared subgrade and cover soil. The geotextile components of the drainage geocomposite will protect the geomembrane from puncture by oversized particles in the cover soil. The geotextile components of the GCL will protect the geomembrane from puncture by particles from the prepared subgrade. For the design loading condition, Geosyntec conservatively assumed an H-20 haul truck tire loading which exhibits a very high force related to hauling equipment. The analysis suggests that the following maximum particle sizes and geotextile mass per unit areas will be required:

Soil Component of Liner	Maximum Particle Size	Minimum Mass per Unit Area
Prepared Subgrade	1.5-in.	9 oz./yd^2 (GCL)
Cover Soil	1-in.	6 oz./yd^2 (single-sided geocomposite)

Table O-1, Geotextile Puncture Protection

Geotextile puncture protection calculations are presented in the SRAPI, Section 5, Calculation Package E.

3.9 Pipe Strength Calculations

Based on drainage pipe size analyses, a 4-in. diameter perforated CPE pipe will be used to collect and transport surface water that has infiltrated through the final cover soil into the geocomposite on the top deck area of the landfill. Based on the calculations performed for the 4-in. diameter perforated CPE pipe, the pipe has adequate strength to withstand equipment (i.e., H-20 haul truck) and soil overburden loads. Pipe strength calculations are presented in the SRAPI, Section 5, Calculation Package F.

3.10 Seismic Performance Evaluation

3.10.1 General

Geosyntec performed an evaluation of the seismic performance of the BRC CAMU. The evaluation included a seismic hazard evaluation, site response analyses, development of site-specific deformation charts, and seismic deformation analyses for the final cover and base liner of the proposed BRC CAMU.

3.10.2 Seismic Hazard Evaluation

Geosyntec evaluated the seismic hazard at the site using the most recent United States Geological Survey (USGS) probabilistic seismic hazard maps (Frankel et al., 1996). For compliance with the State of Nevada regulations, Geosyntec considered motions with 2 percent probability of being exceeded in 50 years for use in design. The

USGS data was used to establish the design free-field peak horizontal ground acceleration (PHGA) and set limits on the target acceleration response spectrum for design ground motions. The 2 percent probability of exceedence in 50 years USGS map values indicate that the free-field bedrock PHGA at the site equals 0.34 g from USGS. Based on the deaggregated hazard for Las Vegas, this PHGA was assigned a representative moment magnitude (M_w) of 6.5. The seismic hazard evaluation is presented in the SRAPI, Section 5, Calculation Package G.

3.10.3 Evaluation of Design Ground Motions

A suite of acceleration time histories considered representative of the 2 percent in 50 year ground motions evaluated in the seismic hazard analysis was selected for use in the seismic response analyses. Geosyntec selected a suite of three time histories that enveloped the target response spectrum using the following methodology: (i) screen the database of acceleration time histories on the basis of earthquake magnitude to select a reduced set of accelerograms; and (ii) plot the acceleration response spectra of the candidate accelerograms against the target acceleration response spectrum and select the representative accelerograms for use in design analyses. Using the above methodology, Geosyntec selected three candidate accelerograms to represent design ground motions at the BRC CAMU site: (i) the Parkfield earthquake, M_w 6.3, (ii) the Superstition Mountain earthquake, M_w 6.5, and (iii) the Big Bear Lake earthquake, M_w 6.7. Evaluation of the design seismic ground motions are presented in the SRAPI, Section 5, Calculation Package G-1.

3.10.4 Site Response Analyses

One-dimensional site response analyses were performed for the BRC CAMU using the computer program SHAKE91 (Idriss et al., 1992). Analyses were performed for two conditions; (i) 30-ft of contaminated soil placed on the ground surface (i.e., the North Mesa), and (ii) 60-ft of contaminated soil placed 30-ft below grade (i.e., the South Mesa). Shear wave velocity and layer thickness data for the native soil was derived from spectral-analysis of surface waves (SASW) testing performed at the site by Dr. Barbara Luke at the University of Nevada at Las Vegas. Since the depth to bedrock is not known, the thickness to bedrock was varied to evaluate the effect of depth to bedrock on the results of the analysis. The calculated accelerations are all less than 0.50 g and generally decrease with increasing depth to bedrock. Site response analyses results are presented in the SRAPI, Section 5, Calculation Package G-2.

3.10.5 Site-Specific Seismic Deformation Charts

The site-specific deformation charts were developed using the computer program YSLIP_PM (Yan et al., 1996). YSLIP_PM is based upon the Newmark

(Newmark, 1965) method for seismic deformation analysis. YSLIP_PM uses the yield acceleration of the slope (e.g., liner system or final cover system) and the output of the seismic site response analysis to compute seismic deformations. The results indicate that the largest seismic displacement response is calculated by applying the Parkfield earthquake record. The site-specific seismic deformation charts are presented in the SRAPI, Section 5, Calculation Package G-3.

3.10.6 Deformation Analyses

Geosyntec evaluated the expected seismically-induced permanent deformations at the BRC CAMU. The calculations suggest that the calculated seismically-induced permanent deformations are less than 3-in. for the final cover and less than 6-in. for the base liner. These deformations are less than current generally accepted limits for the final cover and for the base liner. Therefore, the seismic performance of the waste containment system proposed for the BRC CAMU is considered to meet current design standards. The site-specific seismic deformation calculations are presented in the SRAPI, Section 5, Calculation Package G-4.

4.0 COVER CONSTRUCTION REQUIREMENTS

4.1 General

This section describes the construction requirements for installation of the final cover system at the BRC CAMU. These construction requirements are necessary in order to ensure that the construction of the final cover system is consistent with the design performance goals and assumptions.

Technical Specifications and a Construction Quality Assurance (CQA) plan have been prepared for the construction of the final cover system that incorporates the construction requirements presented in this section. Geosyntec's proposed CQA Plan and Technical Specifications related to the final cover system are presented in the SRAPI, Section 6 and 7, respectively.

4.2 Slope Stability Evaluation

Final cover and interim waste soil slopes shall be constructed no steeper than a slope inclination of 3:1 (horizontal:vertical).

4.3 Geocomposite Requirements

A geocomposite will be used to collect infiltration of surface water through the cover soil. The geocomposite shall have the following properties:

- transmissivity no less than 5 x 10^{-4} m^2/sec under a confining pressure of 2,000 psf and a hydraulic gradient of 0.10.
- an 6 oz/yd^2 nonwoven geotextile bonded to each side of the geonet for the side slopes (i.e., double-sided) and one 6 oz/yd^2 nonwoven geotextile bonded to the top side of the geonet for the top deck (i.e., single-sided); and
- the 6 oz/yd^2 nonwoven geotextile shall have sufficient permittivity and mechanical properties as summarized in Section 3.7.

4.4 Drainage Pipe Requirements

The drainage pipes used to collect water from the geocomposite shall be 4-in. diameter perforated CPE pipe with a smooth interior wall. The drainage pipes shall be backfilled with aggregate. The aggregate shall have a maximum particle size of 1-inch and a minimum hydraulic conductivity of 1 x 10^{-2} cm/sec.

4.5 Final Cover Soil

The cover soil shall be placed from the bottom-up, using equipment exerting a ground pressure no greater than 10 psi. Cover soil shall be compacted to minimum of 90 percent of the maximum dry density determined by ASTM D 1557 and the lower 12-inches will have a maximum particle size of 1-in. diameter. Surface water control and drainage shall be promoted.

4.6 Equipment Loadings

Equipment loads shall be limited to a maximum loading of 10 psi overlying a minimum of 1 ft of cover soil. In addition, roads for haul trucks shall be a minimum of 2 ft in thickness overlying the final cover system geosynthetic components.

4.7 Geotextile Requirements

A geocomposite consisting of either one or two geotextile components of the final cover liner system is proposed. The geotextiles will serve a dual purpose - separation/filtration and cushion protection. The geotextile shall have the following properties:

Matrix	Nonwoven
Mass per Unit Area	6 oz/yd^2
Apparent Opening	≤ Sieve No. 70
Permittivity	≥ 0.5 sec-1
Grab Strength	≥ 130 lb
Puncture Strength	≥ 40 lb
Mullen Burst	≥ 210 psi
Trapezoidal Tear	≥ 40 lb
Ultraviolet strength retention	≥ 70%

4.8 Geosynthetic Clay Liner (GCL)

The GCL component of the final cover system shall have the following properties:

- Index flux not greater than 1 x 10^{-8} m^3/m^2-sec;
- Minimum interface/internal shear strength of 20 degrees;
- The GCL shall be dry during installation; and
- combined geotextile mass per unit area of 9 oz./yd^2.

4.9 Geomembrane Requirements

The geomembrane shall be HDPE and have a nominal thickness of 60-mil. The geomembrane shall be double-sided textured on the side slopes and may be smooth on the top deck.

4.10 Prepared Subgrade Requirements

The prepared subgrade shall have a maximum exposed particle diameter less than 1.5-inch.

4.11 Final Cover Surface Treatment

The final cover will require surface treatment to reduce surface erosion due to rainfall or wind forces. There are a wide variety of possible surface treatments to reduce erosion. For example, cobbles or rip rap can be placed on the outer slope surfaces, aggregate base or crusher-run rock can be applied to flatter surfaces such as the top deck or roadways, and some areas can be treated chemically to bind the soil together. Side slopes typically require a different treatment than the top deck or roadways. The final selection of materials and treatment will be performed prior to commencing closure activities and will be consistent with the NDEP's guidelines for erosion mitigation.

5.0 CAMU POST-CLOSURE PLAN

This section of the permit application addresses post-closure activities for the BRC CAMU, which commence after final closure is completed and extends for a period of 30 years therefrom. This preliminary Post-Closure Plan provides a description of procedures that will be used to maintain the integrity of the final cover system. It is anticipated that the Post-Closure Plan will be updated prior to completing closure activities.

5.1 Requirements After Closure

After closure of the BRC CAMU, a notation on the landfill property deed, or any other instrument that is normally examined during a title search, will be recorded in Clark County. The notation on the deed, or other instrument, will in perpetuity notify any potential purchaser of the property that the land has been used as a landfill and that its use is restricted to uses that would not negatively affect the integrity of the landfill.

Permission may be requested in the future from Clark County to remove the notation from the deed, or other instrument, if all wastes are removed from the site. Any request would document that all wastes have been removed from the facility. Such documentation might include photographs, soil testing in the area where the wastes were deposited, and reports of waste removal activity.

5.2 Program for Postclosure

After closure of the BRC CAMU, a program for post-closure will be conducted as stipulated by the AOC3. This post-closure program will ensure that the integrity and effectiveness of the final cover will be maintained, including making repairs to the cover as necessary to correct the effects of settlement, subsidence, erosion or other events.

Following closure of the CAMU, certification will be submitted to the NDEP verifying closure. This will be signed by an independent Nevada registered professional engineer and will verify that the program was completed in accordance with the CAMU Closure Plan. The certification will be placed in the operating record. The certification will be based on knowledge of the Closure Plan, observations made during closure, and documentation of closure activities.

Post-closure use of the property will be managed to not disturb the integrity of the final cover, liner or other components of the BRC CAMU (e.g., surface water drainage network, infiltration monitoring system, etc.).

5.3 Land Use

The post-closure use of the BRC CAMU site is to install a solar field on top of the final cover, substantially covering the CAMU with the remainder maintained as open space containing a variety of native vegetation. Access to the site will continue to be restricted. Any solar field installed will be designed to be compatible with the design of the final cover. For additional discussion, please see Section 3.0 of the application. The final cover will not be compromised due to incompatible development. It is anticipated that this land use will be maintained beyond the 30-year required post-closure monitoring duration. However, no land use will be allowed that would compromise the integrity of the final cover system, the liner system, or other components of the containment or monitoring systems.

A precise, metes-and-bounds survey of the closed BRC CAMU will be conducted and the resulting map recorded with the clerk of Clark County. The recordation will include a notation that the property is a Corrective Action Management Unit and contains remediation waste.

5.4 Personnel

Post-closure care personnel will have received adequate training in their specific job duties. This includes applicable OSHA health-and-safety training as well as pertinent training in BRC CAMU maintenance procedures. This staff will consist of a facility manager and various staff workers as needed. The name, address, and telephone number of the facility manager will be provided to the NDEP during the closure process.

Specific duties of these staff will include:

- Limiting access to the site and providing security;
- Performance of routine operations and maintenance activities;
- Responding to public or community inquiries;
- Ensuring regulatory compliance and maintaining appropriate documentation;
- Managing and coordinating post-closure monitoring (i.e., the leachate collection system); and
- Maintenance of the vegetative cover, if necessary.

5.5 Security

The perimeter fencing will remain after closure of the BRC CAMU. Security personnel will not be required 24-hrs because the waste will not be exposed nor will access by the public or domestic livestock pose a health hazard. The perimeter fence will

be maintained to deter trespassing. The periodic site inspection walks to assess the cover system will include an evaluation of the perimeter fence.

5.6 Operation and Maintenance

Routine maintenance will be required to maintain the effectiveness of the various BRC CAMU sub-systems. This will include periodic maintenance, and repairs of the final cover, the surface water drainage system, the leachate collection system, and the vegetative cover.

Routine operations and maintenance activities will include frequent inspections of the BRC CAMU. Particular attention will be given to any conditions that could compromise the integrity of the final cover or the associated surface water drainage system or the soil moisture monitoring system. Normal erosion processes are expected to result in the need to periodically replace some cover material and to fill depressions caused by settlement. Extensive maintenance of the vegetative layer is not anticipated since it is being designed to be tolerant of the low rainfall and large temperature extremes in Las Vegas. Occasional fertilizing, if vegetated, may be needed, especially during the first few years after closure. Maintenance of the solar field to be installed on top of the final cover will be in accordance with the land lease between BRC and the third-party solar contractor, which will ensure proper protection of the cover.

5.7 Post-Closure Inspections and Monitoring

Post-closure monitoring will be performed as outlined in Attachment N, Landfill (CAMU) Monitoring Plan. In summary, the final cover, leachate, settlement, and groundwater monitoring will be performed, as needed, for a period of 30 years after closure of the BRC CAMU. Formal periodic inspections will be performed using site walks. These site walks will be performed within one week of significant precipitation events (e.g., greater than ¼ inch of rain during a 24-hour period) that could potentially impact either the surface water drainage system or the BRC CAMU cover. At a minimum, a site-wide inspection will be performed at least bi-annually.

At least annually, an internal audit will be performed to verify that all activities at the site have been performed in accordance with the provisions of this Post-Closure Plan. Inspection records will kept and maintained in a log book in order to clearly document any changes in physical conditions. Copies of the inspection report will be provided to the NDEP annually. Post-closure inspections will occur for at least 30 years after BRC CAMU closure.

Reports and Recordkeeping

The condition of the facility will be documented with field notes, maps, and photographs, as appropriate. Evidence of potential compromises in the cover will be recorded including eroded patches, patches of dead vegetation, extensive or significant animal burrows, subsidence, and cracks along the cover. Surface water drainage features will be inspected for the presence of debris, physical integrity, and evidence of conditions that exceeded design assumptions.

A copy of the plans for closure and post-closure will be maintained in the operating records of the site.

6.0 REFERENCES

Frankel, F., Mueller, C., Bernhard, T., Perkins, D., Leyendecker, Dickman, N., Hanson, S., and Hopper, M., 1996. "Interim National Hazard Maps: Documentation," *Draft Report*, U.S. Geological Survey, Denver, Colorado.

Idriss, I.M., Sun, J.I., 1992."Users Manual for SHAKE91, A Computer Program for Conducting Equivalent Liner Seismic Response Analysis of Horizontally Layered Soil Deposits," Center for geotechnical Modeling, Department of Civil and Environmental Engineering, University of California, Davis, California, November.

Newmark, N.M., 1965. "Effects of Earthquakes on Dams and Embankments," Geotechnique, Vol. 15, No. 2, pp. 139-160.

ATKINS, 2006. "Technical Drainage Study for Eastside Landfill," Henderson, Nevada, October.

USEPA, 1993. "Solid Waste Disposal Facility Criteria, Technical Manual." EPA530-R-93-017. Soild Waste and Emergency Response, November.

Yan, L., Matasovic, N., and Kavazanjian, E.,1996. "YSLIP_PM- User's Guide," Research Report, Geosyntec Consultants, Huntington Beach, California.

Attachment P
CAMU (Landfill) Final Cover Design

Attachment P
CAMU (Landfill) Final Cover Design
Basic Remediation Company (BRC)
Corrective Action Management Unit (CAMU)
Henderson, Nevada

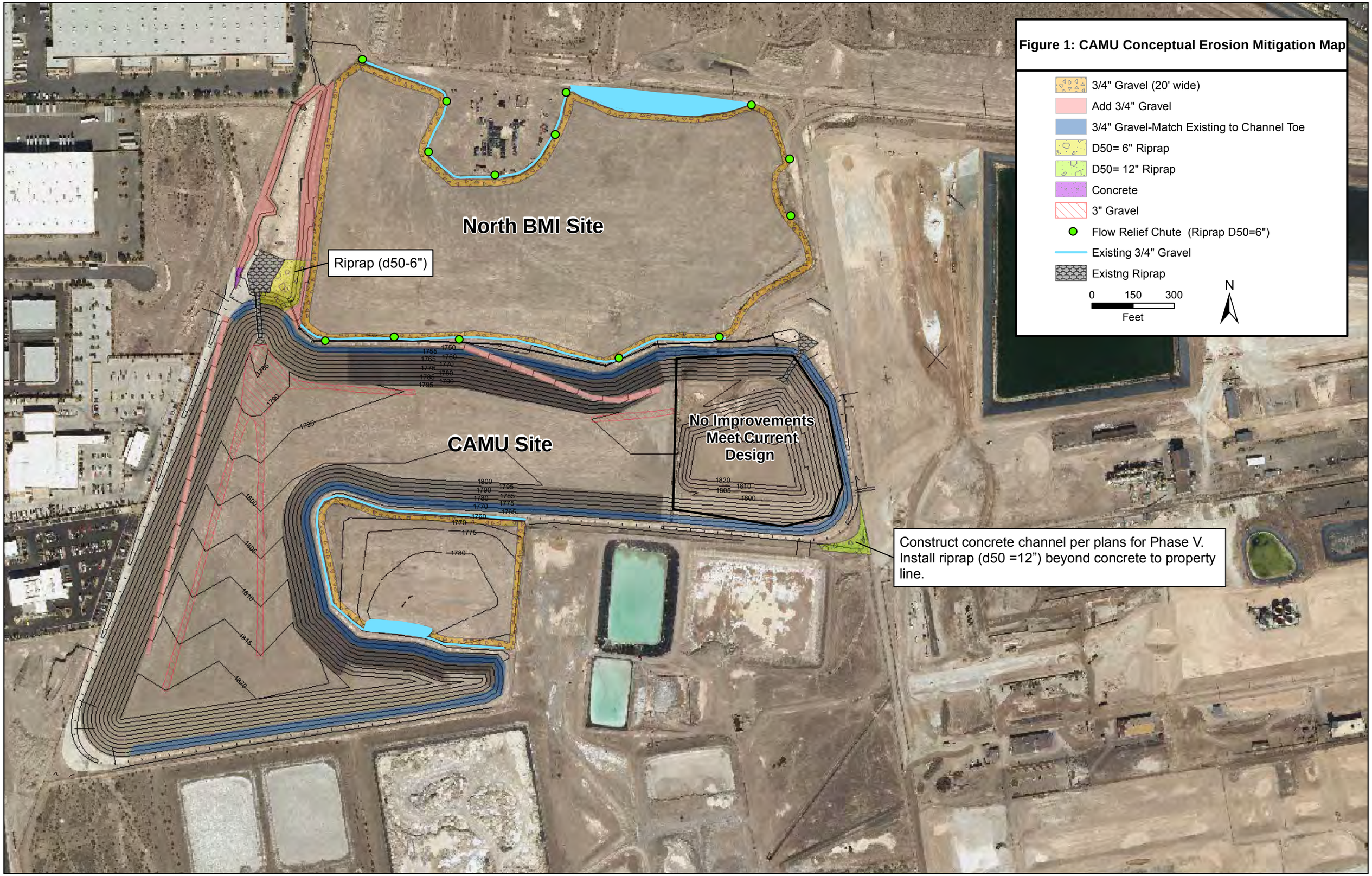


Figure 1: CAMU Conceptual Erosion Mitigation Map
3/4" Gravel (20' wide)
Add 3/4" Gravel
3/4" Gravel-Match Existing to Channel Toe
D50= 6" Riprap
D50= 12" Riprap
Concrete
3" Gravel
Flow Relief Chute (Riprap D50=6")
Existing 3/4" Gravel
Existng Riprap
0 150 300
Feet
N
North BMI Site
Riprap (d50-6")
CAMU Site
No Improvements Meet Current Design
Construct concrete channel per plans for Phase V. Install riprap (d50 =12") beyond concrete to property line.

Attachment Q
Closure and Post-Closure
Cost Estimates

Attachment Q
Closure and Post-Closure Cost Estimates
Basic Remediation Company (BRC)
Corrective Action Management Unit (CAMU)
Henderson, Nevada

Table of Contents

1.0.....Introduction Q-1
2.0.....Closure costs Q-1
3.0.....Post-Closure Costs Q-1

1.0 INTRODUCTION

The estimated and projected cost to close and post close the BRC CAMU is explained in this Attachment. These cost estimates summarized herein are for budgeting and planning purposes only.

The current closure and post closure cost estimates will remain on site during the operating life of the BRC CAMU.

2.0 CLOSURE COSTS

At this time, all Phases of the CAMU except for Phase V have been closed. Thus, no additional Closure costs are relevant for these prior Phases. In addition, BRC anticipates closing Phase V roughly by the end of 2014 and all anticipated Closure costs for Phase V are already budgeted for 2014. While it is not clear when the renewed RAP will be issued, it is likely to be within months of closure of Phase V. Therefore, BRC does not believe that any additional demonstration of Closure costs is relevant for this renewal. In other words, there is no financial risk that BRC will be unable to closure this last Phase V, when it has already demonstrated that it can close and has closed the previous Phases of the CAMU. Thus, BRC is not providing a separate Closure cost for this last Phase. BRC will of course, as a matter of ongoing project management, keep NDEP appraised as to all closure activities related to Phase V so that NDEP is aware of all such activities.

3.0 POST-CLOSURE COSTS

The post-closure cost estimate is based on the 30-year cost of annual inspection, monitoring, and maintenance at the BRC CAMU, including implementation of the NDEP-approved annual groundwater monitoring program, sump dewatering, off-site disposal of leachate, expected maintenance due to weather-related impacts to the CAMU cover, weed management and control, etc. Making reasonable assumptions for these costs, based on costs that have been incurred in the last several years for such activities, BRC expects that the 30-year post-closure cost will be roughly $3,323,000. Of course, BRC will update this estimate for the next RAP renewal after 5 years.

It should be noted that BRC has not included in this post-closure estimate, any additional NDEP management or regulatory fees. BRC is aware that NDEP is likely to propose regulations covering such fees. However, at this point in time, such developments are preliminary and there is therefore no firm basis to include NDEP management costs. Should this change, BRC will update this cost estimate accordingly.

Estimate of Geosyntec Post-Closure Costs
BRC CAMU
Henderson, Nevada

Geosyntec consultants

Item No.	Item	Unit	Unit Price	No. Units	Total	Comments
1	**Annual Groundwater Monitoring**	**YR**	**$ 80,000.00**	**1**	**$ 80,000.00**	
1A	*Field Collection and Analysis*	*LS*	*$ 45,000.00*	*1*	*$ 45,000.00*	Assume $15K for field collection; $30k for analysis
1B	*Report Preparation*	*LS*	*$ 30,000.00*	*1*	*$ 30,000.00*	Assume $12K for data validation; Assume $18k for Report
1C	*Project Management*	*LS*	*$ 5,000.00*	*1*	*$ 5,000.00*	Assume 2 hr/month
2	**Sump Pumping and Monitoring - 5 years**	**5 YR**	**$ 173,000.00**	**1**	**$ 173,000.00**	Truck owned by BRC; Onsite Disposal
2A	*Year 1*	*LS*	*$ 64,000.00*	*1*	*$ 64,000.00*	Pumping: 4 hours a day, 3 days a week, $50K; O&M: $12K & PM $2K/yr from Geo TO Request
2B	*Year 2*	*LS*	*$ 42,000.00*	*1*	*$ 42,000.00*	Pumping: 1 day per week, $33.5K; O&M $6.5K & PM $2K/yr from Geo TO Request
2C	*Year 3*	*LS*	*$ 26,000.00*	*1*	*$ 26,000.00*	Pumping: 1 day every other week, $17K; O&M: $7K & PM $2K/yr from Geo TO Request
2D	*Year 4*	*LS*	*$ 17,000.00*	*1*	*$ 17,000.00*	Pumping: 1 day per month, $10K; O&M: $7K & PM $2K/yr from Geo TO Request
2E	*Year 5*	*LS*	*$ 24,000.00*	*1*	*$ 24,000.00*	No pumping, only inspection and monitoring; O&M: $7.5K+$14K (sensor replacement) & PM $2K/yr from Geo TO Request
3	**Annual Storm Inspections and Repairs**	**YR**	**$ 25,000.00**	**1**	**$ 25,000.00**	
3A	*Inspections*	*LS*	*$ 5,000.00*	*1*	*$ 5,000.00*	4 inspections/yr, 8 hrs each; PM 6 hr/yr
3B	*Repairs*	*LS*	*$ 20,000.00*	*1*	*$ 20,000.00*	$20K, lump sum

***If off-site disposal of LCRS leachate is required, cost per gallon for Non-Haz transportation & disposal will be $0.85 per gallon**

Attachment R
Financial Assurance

Attachment R
Financial Assurance
Basic Remediation Company (BRC)
Corrective Action Management Unit (CAMU)
Henderson, Nevada

(No Changes Have Been Made to this Attachment)

The mechanism for financial assurance for the entire cleanup project, which includes post-closure costs associated with the CAMU itself, is discussed in the AOC3. Thus, no additional financial assurance guarantees are provided here.

Attachment S
Sudden and Non-sudden Insurance Documentation

Attachment S
Sudden and Non-sudden Insurance Documentation
Basic Remediation Company (BRC)
Corrective Action Management Unit (CAMU)
Henderson, Nevada

(No Changes Have Been Made to this Attachment)

Provisions for insurance including sudden and non-sudden insurance coverage for the entire cleanup project are discussed in the AOC3. Thus, no additional details for such coverage are provided here.

Attachment T
Report and Recordkeeping Plan

Attachment T
Report and Recordkeeping Plan
Basic Remediation Company (BRC)
Corrective Action Management Unit (CAMU)
Henderson, Nevada

Table of Contents

1.0 Introduction T-1
2.0 Operational Recordkeeping and Reports T-1
2.1 Training Records T-1
2.2 Operational Records T-1
2.2.1 Construction Quality Control and Quality Assurance T-2
2.3 Interim Status Reports T-3
2.4 Annual Reports T-3
2.5 Biennial Reports T-3
3.0 Post CAMU Closure Reporting and Recordkeeping T-3

1.0 INTRODUCTION

Records of all data, drawings and calculations concerning work proposed or completed at the BRC CAMU will be kept on permanent file in the BRC Data Repository, consistent with document retention requirements specified in the AOC3. In addition, records will be maintained at the BRC offices in conjunction with investigative work at the BRC CAMU. Included in the reports will be appendices with copies of data sheets, log books, and laboratory analysis results. All investigative results will be incorporated into the reports detailed in the following section.

Prior to any document destruction, NDEP will be provided an opportunity to acquire the documents in question.

2.0 OPERATIONAL RECORDKEEPING AND REPORTS

2.1 Training Records

BRC will maintain records of training received by onsite workers. These records will include copies of certificates received prior to BRC CAMU site activities and site specific training received. The training records will be stored onsite at the facilities maintained by BRC. Records will be maintained onsite for a period consistent with that specified in the AOC3.

2.2 Operational Records

The contractor will prepare daily progress reports documenting daily BRC CAMU activities. Daily activity records include, but are not limited to, documentation that evidences the quantity of waste materials placed in the BRC CAMU and log in/out forms. In addition to this summary daily report, the contractor will also keep detailed field notes and daily logs documenting:

- the date, project name, location, and other identification;
- a summary of the weather conditions;
- a summary of locations where construction is occurring;
- equipment and personnel on the project; and
- a summary of meetings held and attendees.

Daily photographic and video record will be kept by BRC documenting disposal activities. Records and results of inspections will be maintained and kept onsite for a period consistent with the AOC3.

Records and results of waste analysis and waste determinations will be maintained and kept on site. In addition, monitoring, testing or analytical data, and corrective action records resulting from BRC CAMU releases shall be maintained for three years. Groundwater monitoring and clean up records will be maintained until closure of the BRC CAMU.

Summary reports of all incidents that require the use of the Contingency Plan will contain the details outlined in Attachment G, Accident Prevention, Contingency, and Emergency Response Plan. The incident reports will be maintained and kept onsite until completion of the post-closure period for the BRC CAMU.

Additional items to be included with the operating records are: closure and post-closure cost estimates, plans for closure and post-closure, EPA identification number, detailed chemical and physical analysis of a representative waste sample, Quality Control (QC) and Quality Assurance (QA) documentation.

2.2.1 Construction Quality Control and Quality Assurance

The CQA Site Manager will prepare daily reports that document the activities observed during each day of activity as detailed in the CQA Plans for the Base Liner and Final Cover Systems (Sections 3 and 6 in the SRAPI, respectively). The daily reports may include monitoring logs and testing data sheets. At a minimum, these logs and data sheets will include the following information:

- a description of materials used and references of results of testing and documentation;
- identification of deficient work and materials;
- results of re-testing corrected “deficient work;”
- an identifying sheet number for cross referencing and document control;
- descriptions and locations of construction inspected;
- type of construction and inspection performed;
- description of construction procedures and procedures used to evaluate construction;
- a summary of test data and results;
- calibrations or re-calibrations of test equipment and actions taken as a result of re-calibration;
- decisions made regarding acceptance of units of work and/or corrective actions to be taken in instances of substandard testing results;
- a discussion of agreements made between the interested parties which may affect the work; and
- signature of the respective CQA Site Manager.

2.3 Interim Status Reports

During remediation activities at the Site, BRC will submit monthly status reports to the NDEP. The purpose of the monthly status reports will be to keep the NDEP informed of the progress of remediation activities at the Site. The reports will present a summary of the remediation progress during the previous month, including as appropriate, significant milestones in BRC CAMU construction, locations of completed pond and ditch excavation (including graphical format), and estimates of soil volumes excavated and placed in the BRC CAMU.

2.4 Annual Reports

BRC will submit an annual report of the solid wastes received at the site to the NDEP. This report will be submitted in a format mutually agreed to between BRC and NDEP. The report will consist of data reported in units of tons and cubic yards for waste materials received at the BRC CAMU.

The annual report will be submitted to NDEP and will include data compiled throughout the year. The total quantity of wastes deposited and the remaining capacity of the BRC CAMU in cubic yards will be incorporated. In addition, the leachate quality data will be compiled and the status of the leachate collection, including quantity of leachate collected on-site and disposed on a monthly basis, reported. Finally, any changes from the approved report, plans, and specifications, with justifications.

2.5 Biennial Reports

BRC will submit a biennial report by March 1 of each even year to the NDEP on EPA form 8700-13B. The report will summarize activities at the BRC CAMU for the previous two years. The report will contain: EPA identification number, BRC CAMU address, dates covered, description of wastes received, method of waste disposal, most recent closure and post-closure cost estimates, methods utilized to reduce waste volume, and any changes in waste volumes. This report will be signed by BRC.

3.0 POST CAMU CLOSURE REPORTING AND RECORDKEEPING

Maintenance inspection records will kept and maintained in a log book in order to clearly document any changes in physical conditions. Copies of the inspection report will be provided to the NDEP annually.

Results of monitoring will be kept and maintained onsite for a period of at least 30 years after closure. Copies of the monitoring will be provided to NDEP with the inspection report annually.

The condition of the facility will be documented with field notes, maps, and photographs, as appropriate. Evidence of potential compromises in the cover will be recorded including eroded patches, patches of dead vegetation, animal burrows, subsidence, and cracks along the cover. Surface water drainage features will be inspected for the presence of debris, physical integrity, and evidence of conditions that exceeded design assumptions.

Attachment U
Compliance with Applicable Federal Laws

Attachment U
Compliance with Applicable Federal Laws
Basic Remediation Company (BRC)
Corrective Action Management Unit (CAMU)
Henderson, Nevada

(No Changes Have Been Made to this Attachment)

Table of Contents

1.0 Introduction U-1
1.1 The Wild and Scenic Rivers Act U-1
1.2 The National Historic Preservation Act of 1966 ..... U-1
1.3 The Endangered Species Act U-2
1.4 The Coastal Zone Management Act U-2
1.5 The Fish and Wildlife Coordination Act U-3

1.0 INTRODUCTION

This attachment discusses how the BRC CAMU is in compliance with the following Federal Laws.

1.1 The Wild and Scenic Rivers Act

The Wild and Scenic Rivers Acts protects river areas and their immediate environments for the present and future generations. Rivers are eligible for protection if they display one or more of the following characteristics:

1. *Wild river areas* -- Those rivers or sections of rivers that are free of impoundments and generally inaccessible except by trail, with watersheds or shorelines essentially primitive and waters unpolluted. These represent vestiges of primitive America.

2. *Scenic river areas* -- Those rivers or sections of rivers that are free of impoundments, with shorelines or watersheds still largely primitive and shorelines largely undeveloped, but accessible in places by roads.

3. *Recreational river areas* -- Those rivers or sections of rivers that are readily accessible by road or railroad, that may have some development along their shorelines, and that may have undergone some impoundment or diversion in the past.

There are no rivers in the vicinity of the BRC CAMU site with the exception of the Las Vegas Wash which is approximately 2 miles north of the Site, and the Las Vegas Wash is not designated as a Wild and Scenic River.

1.2 The National Historic Preservation Act of 1966

The National Historic Preservation Act protects, rehabilitates, restores and reconstructs the districts, sites, buildings, structures, and objects significant in American history, architecture, archaeology, or culture.

There are no locations of historical significance at the BRC CAMU site. BRC contacted the Nevada Natural Heritage Program and requested a search of their database. No locations of historical significance were identified as a result of this search. A copy of the seach result is provided in Appendix A to this Attachment.

1.3 The Endangered Species Act

The city of Henderson, along with other cities within Clark County, submitted an application to the EPA for a permit to incidentally take desert tortoises (*gopherus agassizii*), pursuant to section 10(a)(1)(B) of the Endangered Species Act of 1973, as amended (Act), in association with various proposed public and private projects in Clark County, Nevada. The permit allows incidental take of desert tortoises for a period of 30 years, resulting from development on up to 113,900 acres of private lands within Clark County, Nevada. The permit application was received September 28, 1994, and was accompanied by the Clark County Desert Conservation Plan (CCDCP), which serves as the Applicant's habitat conservation plan and details their proposed measures to minimize, monitor, and mitigate the impacts of the proposed take on the desert tortoise.

To minimize the impacts of take, Henderson provides a free pick-up and collection service for desert tortoises encountered in harm's way within the city. These desert tortoises will be made available for beneficial uses such as translocation studies and programs, research, education, zoos, museums, or other programs approved by the Service and Nevada Division of Wildlife. Sick or injured desert tortoises will be humanely euthanized.

Henderson approves the issuance of land development permits for otherwise lawful public and private project proponents during the 30-year period in which the proposed Federal permit is in effect. Henderson imposes a fee of $550 per acre of habitat disturbance to fund the measures to minimize and mitigate the impacts of the proposed action on desert tortoises.

The BRC CAMU will be in compliance with the Endangered Species Act through a fee of $550 per acre submitted with the grading permit application. If a Desert Tortoise is encountered during construction, the City of Henderson will be contacted and the tortoise relocated.

The above discussion notwithstanding, BRC does not believe that there are any threatened and endangered species in the CAMU area. BRC requested that Nevada Natural Heritage conduct a search related to such species. The letter from Nevada Natural Heritage provided in Appendix A to the Attachment confirms that there are no at risk taxa in this area.

1.4 The Coastal Zone Management Act

The Coastal Zone Management Act seeks to manage and preserve the nation’s coastal resources, ensuring their protection for future generation.

The BRC CAMU site is not located near any coasts.

1.5 The Fish and Wildlife Coordination Act

The Act provides that whenever the waters or channel of a body of water are modified by a department or agency of the U.S., the department or agency first shall consult with the U.S. Fish and Wildlife Service and with the head of the agency exercising administration over the wildlife resources of the state where construction will occur, with a view to the conservation of wildlife resources. The Act provides that land, water and interests may be acquired by federal construction agencies for wildlife conservation and development. In addition, real property under jurisdiction or control of a federal agency and no longer required by that agency can be utilized for wildlife conservation by the state agency exercising administration over wildlife resources upon that property.

The BRC CAMU will not modify the waters or channel of a body of water.

Appendix A

Copy of Letter Received from Nevada Natural Heritage

Nevada Natural Heritage Program

Nevada Department of Conservation and Natural Resources
Richard H. Bryan Building
901 South Stewart Street, suite 5002 • Carson City, Nevada 89701-5245, U.S.A.
tel: (775) 684-2900 • internet: http://heritage.nv.gov

28 February 2007

Ranajit Sahu
Basic Remediation Company
875 W Warm Springs Rd.
Henderson, NV 89011

RE: Data request received 23 February 2007

Dear Mr. Sahu:

We are pleased to provide the information you requested on endangered, threatened, candidate, and/or At Risk plant and animal taxa recorded within or near the BRC Common Areas-CAMU Project area. We searched our database and maps for the following a 5 kilometer radius around including:

Township 22S Range 62E Sections 11 and 12

There are no at risk taxa recorded within the given area. However, habitat may be available for: the big free-tailed bat, *Nyctinomops macrotis*, a Nevada Bureau of Land Management (BLM) Sensitive Species; the spotted bat, *Euderma maculatum*, a Nevada BLM Special Status Species; the Arizona toad, *Bufo microscaphus*, a Nevada BLM Sensitive Species; the desert tortoise, *Gopherus agassizii*, a Federally Threatened Taxon; the chuckwalla, *Sauromalus ater*, a Nevada BLM Sensitive Species; and the banded Gila monster, *Heloderma suspectum cinctum*, a Nevada BLM Special Status Species. We do not have complete data on various raptors that may also occur in the area; for more information contact Ralph Phenix, Nevada Division of Wildlife at (775) 688-1565. Note that all cacti, yuccas, and Christmas trees are protected by Nevada state law (NRS 527.060-.120), including taxa not tracked by this office.

Please note that our data are dependent on the research and observations of many individuals and organizations, and in most cases are not the result of comprehensive or site-specific field surveys. Natural Heritage reports should never be regarded as final statements on the taxa or areas being considered, nor should they be substituted for on-site surveys required for environmental assessments.

Thank you for checking with our program. Please contact us for additional information or further assistance.

Sincerely,

Eric S. Miskow
Biologist III/Data Manager

Attachment V
Additional Information Required by NDEP

(ROD, CAP Consistency Letter)
Basic Remediation Company (BRC)
Corrective Action Management Unit (CAMU)
Henderson, Nevada

(No Changes Have Been Made to this Attachment)

Attachment W
Copy of Existing (Current) RAP

Basic Remediation Company (BRC)
Corrective Action Management Unit (CAMU)
Henderson, Nevada

REVISED
REMEDIAL ACTION PLAN (RAP)
PERMIT APPLICATION FOR
CORRECTIVE ACTION MANAGEMENT UNIT (CAMU)
HENDERSON, NEVADA

Submitted to:

Nevada Division of Environmental Protection
901 South Stewart Street – 4th Floor
Carson City, Nevada 89701
(775) 687-4670

Prepared for:

Basic Remediation Company
875 West Warm Springs Road
Henderson, Nevada 89015
(702) 567-0400

Prepared by:

GeoSyntec Consultants
10875 Rancho Bernardo Road, Ste. 200
San Diego, California 92127
(858) 674-6559

November 2006
Revised:
March 2007

Basic Remediation
COMPANY

14 November 2006

Mr. Jeff Denison
Nevada Department of Environmental Protection
901 South Stewart Street – 4th Floor
Carson City, Nevada 89701

Subject: Revised Remedial Action Plan Permit Application
Basic Remediation Company
Corrective Action Management Unit
Henderson, Nevada

Dear Mr. Denison:

Basic Remediation Company (BRC) is pleased to provide this Remedial Action Plan (RAP) Permit Application for the Corrective Action Management Unit (CAMU) located in Henderson, Nevada. The proposed BRC CAMU encompasses approximately 55 acres located within Sections 11 and 12 of Township 22 South, Range 62 East, in accordance with the Record of Decision (ROD) dated 2 November 2001.

This RAP is defined as a Resource Conservation Recovery Act (RCRA) permit that authorizes the disposal of remediation waste at a remediation waste management site. This permit application provides the information necessary to obtain a RAP as specified in 40 CFR 270, Subpart H. The proposed disposal unit is conservatively designed to meet the regulatory requirements for a CAMU, as referred to in 40 CFR 264.552.

As described in this application, the proposed disposal facility will be receiving remediation waste from the Basic Management, Inc., (BMI) Common Areas effluent ponds. Conceptual-level design, construction, and operations plans for the active and closed life of the facility are outlined in the enclosed Attachments. Additional details will be provided as part of a final design package. This application is for planning purposes only and is not intended to serve as a construction document.

If you have any questions or require additional information, please contact me at (702) 567 - 0465.

Sincerely,

Ranajit Sahu

Dr. Ranajit Sahu, C.E.M.
BRC Project Manager

875 West Warm Springs, Henderson, Nevada 89015 • Phone 702.567.0400 • Fax 702.567.0473

I hereby certify that I am responsible for the services described in this document and for the preparation of this document. The services described in this document have been provided in a manner consistent with the current standards of the profession and to the best of my knowledge comply with all applicable federal, state and local statutes, regulations and ordinances. I hereby certify that all laboratory analytical data were generated by a laboratory certified by the NDEP for each constituent and media presented herein.

April 6, 2007

Dr. Ranajit Sahu, C.E.M. (No. EM-1699, Exp. 10/07/2007) Date

BRC Project Manager

TABLE OF CONTENTS

i. Cover Letter
ii. Signatures and Certification (270.105)
iii. Table of Contents
iv. Definitions
v. Acronyms

1.0 Introduction 1
2.0 Background 3
3.0 Overview 4
4.0 Required information 5
5.0 References 8

LIST OF TABLES

Table 1 Application contents cross-referenced to required regulatory information

Attachments:

A Drawing (USGS/County Map)
B Drawing (Scaled Drawing)
C Waste Analysis Plan
D Security Plan
E Inspection Plan and Schedules
F Personnel Training Plan
G Accident Prevention, Contingency, and Emergency Response Plan
H Emergency Coordinator
I Location Standards and Siting Requirements
J CAMU (Landfill) Design – conceptual
K CAMU (Landfill) Design – final [reserved]
L CAMU (Landfill) Construction Plan
M CAMU (Landfill) Operation Plan
N CAMU (Landfill) Monitoring Plan
O CAMU (Landfill) Closure and Post-Closure Plan

P	CAMU (Landfill) Final Cover Design – [reserved]
Q	Closure and Post-Closure Cost Estimates
R	Financial Assurance
S	Sudden and Non-sudden Insurance Documentation
T	Report and Recordkeeping Plan
U	Compliance with applicable Federal Laws
V	Additional Information Required by NDEP
V.1	Record of Decision issued by NDEP selecting the remedy alternative that calls for the construction of a CAMU for the permanent disposition of remediation waste at a location adjacent to the existing (closed) BMI Landfills.
V.2	Letter issued by NDEP confirming that the construction and location of the proposed CAMU at the selected sites near the existing BMI Landfills and above the slit trenches is consistent with the approved Corrective Action Plan.

Definitions

Owner – Basic Remediation Company (BRC)

Design Engineer – GeoSyntec Consultants

Regulatory Agency – Nevada Department of Environmental Protection (NDEP)

ACRONYMS AND ABBREVIATIONS

^{o}F	Degrees Fahrenheit
AST	Above-ground Storage Tank
ASTM	American Society for Testing Materials
AOC3	Agreement and Order on Consent
ASO	Apparent Size Opening
BEC	Basic Environmental Company
bgs	below ground surface
BMI	Basic Management Incorporated
BMIC	Black Mountain Industrial Center
BMP	Best Management Practice
BRC	Basic Remediation Company
CAMU	Corrective Action Management Unit
CAP	Corrective Action Plan
CCHD	Clark County Health District
CCL	Compacted Clay Liner
CEM	Certified Environmental Manager
CFR	Code of Federal Regulations
cm/sec	centimeters per second
CPE	Chlorinated polyethylene
CQA	Construction Quality Assurance
CRZ	Contaminant Reduction Zone
CSPE	Chlorosulfonated polyethylene
DBS&A	Daniel B. Stevens & Associates
ERM	Environmental Resources Management
FAA	Federal Aviation Administration
FEMA	Federal Emergency Management Agency
FSSOP	Field Sampling and Standard Operating Proceedures
ft/d	feet per day
ft^2	square feet
ft^3	cubic feet
GAC	Granular activated carbon
GCL	Geosynthetic clay liner
GeoSyntec	GeoSyntec Consultants, Inc.
GP	Poorly Graded Gravel
GM	Silty Gravel
G&M	Geraghty & Miller
HAZWOPER	Hazardous Waste Operations and Emergency Response

HDPE	High density polyethylene
HELP	Hydrologic Evaluation of Landfill Performance
HASP	Health and Safety Plan
HSP	Health and Safety Plan
HWIR	Hazardous Waste Identification Rule
lb/in	pounds per inch
LCS	Leachate collection system
LDR	Land Disposal Restrictions
LDPE	Low density polyethylene
LLDPE	Linear low density polyethylene
mg/L	Milligrams per liter
MSW	Municipal solid waste
mph	miles per hour
MSL	Mean Sea Level
MTR	Minimal Treatment Requirements
M_W	Magnitude Moment
MWH	MWH Americas, Inc.
NAC	Nevada Administrative Code
NDEP	Nevada Division of Environmental Protection
NPDES	National Pollution Discharge Elimination System
NPV	Net Present Value
NOAA	National Oceanic and Atmospheric Administration
OSHA	Occupational Safety and Health Administration
PAMP	Perimeter Air Monitoring Program
Parsons	Parsons Engineering Group
PCBs	Polychlorinated biphenyls
PCE	Tetrachloroethylene
PGPVs	Preliminary Groundwater Protection Values
PHGA	Peak Horizontal Ground Acceleration
PPE	Personal Protective Equipment
PRGs	Preliminary Remediation Goals
psf	pounds per square foot
psi	pounds per square inch
PVC	Polyvinyl chloride
Qa	Quaternary Alluvium
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RAP	Remedial Action Plan
RAS	Remedial Alternatives Study
RCRA	Resource Conservation Recovery Act
ROI	Radius of influence

RWMS	Remedial Waste Management System
SASW	Spectral-analysis of Surface Waves
SCBA	Self Contained Breathing Apparatus
SDR	Standard Dimension Ratio
SHSO	Site Health and Safety Officer
SRAPI	Supplemental RAP Information
scfm	Standard cubic feet per minute
SM	Silty Sand
SP	Poorly Graded Sand
SRC	Site Related Chemicals
SVE	Soil vapor extraction
SVOC	Semi-Volatile Organic Chemicals
SW	Well-graded Sand
TCE	Trichloroethylene
TCLP	Toxicity Characteristic Leaching Procedure
TIMET	Titanium Metals Corporation
TMCf	Tertiary Muddy Creek Formation
USCS	United Soil Classification System
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UTS	Universal Treatment Standards
UV	Ultraviolet
VOCs	Volatile organic compounds

1.0 INTRODUCTION

On behalf of Basic Remediation Company (BRC), GeoSyntec Consultants has prepared this REVISED Remedial Action Plan (RAP) permit application to operate a Remediation Waste Management System (RWMS) in Clark County, Nevada. A previous version of this document was submitted to the Nevada Division of Environmental Protection (NDEP) in January 2000 by Parsons Engineering Science of Pasadena, CA (Parsons, 2000). The NDEP requested in 2005 that the RAP be refreshed, and a draft document was submitted in response in March 2006. Based on the NDEP's comments to the March 2006 draft, this REVISED RAP has been prepared and is herewith submitted. This document includes the application and supporting documentation for a proposed Corrective Action Management Unit (CAMU), hereafter referred to as the BRC CAMU. This permit application is being submitted to the NDEP, Carson City, Nevada.

This application provides the information needed to obtain a RAP as specified in 40 CFR 270, Subpart H. In this context, a RAP is defined as a special form of RCRA permit that authorizes the disposal of remediation waste at a remediation waste management site. This type of permit was developed as part of the Hazardous Waste Identification Rule for Contaminated Media, or "HWIR-media rule" (63 FR 65874). As stated in the United States Environmental Protection Agency (USEPA) Environmental Fact Sheet on the Final HWIR-Media Rule (EPA530-F-98-029), this rule is designed to eliminate existing regulatory disincentives to remediation, make site cleanup faster and easier, and, thus, provide increased protection to human health and the environment.

As described in this application, the proposed disposal facility will only be receiving remediation waste. The proposed unit is conservatively designed to meet the regulatory requirements for a CAMU, as referred to in 40 CFR 264.552. This document provides conceptual-level design. Additional details will be provided as part of a final design package. Final design will be developed concurrently with review of the permit application.

The purpose of the proposed BRC CAMU is to provide a permitted disposal facility at the NDEP-approved location (per the Record of Decision dated 2 November 2001) for wastes generated during the voluntary cleanup of certain areas of the BMI Common Areas (the "Site"), as specifically contemplated by the "Nevada Division of Environmental Protection Settlement Agreement and Order on Consent: BMI Common Areas, Phase 3" (the "AOC3") dated February 15, 2006, and as defined in the

Corrective Action Plan (CAP) (BRC, 2006). Portions of the Site have been impacted during the legal disposal of various materials, including industrial wastes and cooling waters. The NDEP provides oversight of the voluntary cleanup activities. As a result of the NDEP's review of the "Remedial Alternatives Study (RAS) for the BMI Common Areas" (ERM, 1999), and subsequent discussion with BRC, the location stated in remedial alternative 4B was approved as the preferred location of waste materials generated from the voluntary cleanup of the Site. The actual text of the NDEP's comment is provided below for reference.

> "Per discussions with Basic Remediation Company (Robin Bain) on August 5, 1999, the Division assumes this alternative (4B in the RAS) has been modified to locate soils within the confines of BMI property immediately surrounding the current BMI Landfill. Based on currently available information, co-location of impacted soils with the BMI Landfill is the current preference of the Division for soil disposal."

2.0 BACKGROUND

The proposed BRC CAMU is located within Sections 11 and 12 of Township 22 South, Range 62 East, approximately 10,000 feet west-northwest of the intersection of Lake Mead Drive and Boulder Highway and approximately 3,500 feet west-southwest of intersection of Warm Springs Road and Boulder Highway (Attachment A). The site is approximately 13 miles south of the City of Las Vegas. The proposed BRC CAMU is located within the boundaries of the BMI Common Areas and is bordered on the north, east, and south by the BMI Industrial Complex. The BMI Industrial Complex consists of four operational plants west of Boulder Highway and north of Lake Mead Drive.

The proposed BRC CAMU is located within a 113-acre area northwest of the active plant area of the BMI Complex (Attachment B). Approximately 55 acres, the footprint of the BRC CAMU consists of two contiguous landfill areas, known as the North Mesa and South Mesa (Attachment B). The separate, distinct, and existing BMI Landfill occupies approximately 66 acres of this area and was initially used as effluent disposal ponds for the Basic Magnesium, Inc. magnesium refinery since its inception. Following shut-down of the refinery in November 1944, the two western-most ponds were converted to a solid waste disposal area which became known as the BMI Landfill. Use of this Landfill continued by successor operations until its closure in February 1980.

Immediately to the south of the BMI Landfill, a series of slit trenches were excavated during the 1950s through 1970s. A range of refuse and industrial wastes were placed into these slit trenches, the use of which was discontinued prior to 1980.

3.0 OVERVIEW

This permit application addresses the requirements for a RAP, as specified in 40 CFR 270. Table 1 of this permit application includes introductory material and citations of where each regulatory requirement is addressed in this application package. Attachment I contains site location information. Attachment R provides documentation of financial assurance.

Plans relating to Waste Characterization, Monitoring Programs, and Post-Closure are presented in Attachments C, N, and O respectively. The conceptual design for the proposed BRC CAMU is discussed in Attachment J. Drawings are provided in Section 1 of the Supplement RAP Information (SRAPI). Attachment C also includes a general discussion of the waste material to be disposed of in the landfill as well as provides summary tables of analytical data for these waste source areas.

A geotechnical evaluation of the site is presented in Section 8 of the SRAPI. The geotechnical study encompasses the proposed landfill (Borings B1 through B-12 and B-102) and Basic Environmental Company (BEC) property immediately to the west and northwest of the proposed landfill. In addition, boring logs for recent slit trench investigation work are presented in Section 8 of the SRAPI.

Attachment O includes discussion of the BRC CAMU Closure Plan with conceptual design parameters for the final cover along with supporting infiltration modeling information and conceptual design of the Final Cover System.

4.0 REQUIRED INFORMATION

This section outlines the information required for a RAP application, as specified in 63 FR 65942 and 40 CFR 270.110. For those requirements that call for detailed explanation or the use of drawings, reference is provided to the appropriate section or drawing within this document. Table 1 is provided as an outline of applicable regulatory requirements, with references to pertinent sections of this RAP application.

The following is a list of the RAP application questions and associated responses:

(a) The name, address, and USEPA identification number of the remediation waste management site;

BRC CAMU, Clark County, 22S/62E/11 and 12; EPA ID# NVD074150798

(b) The name, address, and telephone number of the owner and operator;

Basic Remediation Company, 875 West Warm Springs Road, Henderson, Nevada; Phone: 702-567-0400

(c) The latitude and longitude of the site;

Latitude: 36D 02M 56.23S N (36.048953 decimal degrees)
Longitude: 115D 00M 47.51S W (-115.013197 decimal degrees)

(d) The United States Geological Survey (USGS), or county map, showing the location of the remediation waste management site;

The proposed BRC CAMU site is located on the USGS Las Vegas SE, Nevada, Clark County quadrangle map. The site location is shown on Attachment A.

(e) A scaled drawing of the remediation waste management site showing:
1. The remediation waste management site boundaries;
2. Any significant physical structures; and
3. The boundary of all areas on-site where remediation waste is to be treated, stored, or disposed.

A scaled drawing showing all the required information is provided as Attachment B.

(f) A specification of the remediation waste to be treated, stored or disposed of at the facility or remediation waste management site. This must include information on:

1. Constituent concentrations and other properties of the remediation wastes that may affect how such materials should be treated and/or otherwise managed;

   Properties and constituent concentrations of the waste materials proposed for placement in the BRC CAMU are provided in Attachment C of this document, entitled "Waste Analysis Plan".

2. An estimate of the quantity of these wastes; and

   As noted in Attachment C, the estimated quantity of waste material is approximately 3.5 million cubic yards.

3. A description of the processes you will use to treat, store, or dispose of this waste, including technologies, handling systems, design and operating parameters you will use to treat hazardous remediation wastes before disposing of them according to the Land Disposal Restrictions (LDR) standards of part 268 of this chapter, as applicable.

   The process to be used in handling and disposal of the waste is outlined in Attachments C through P of this RAP permit application.

(g) Enough information to demonstrate that operations that follow the provisions in your RAP application will ensure compliance with applicable requirements of parts 264, 266, and 268 of this chapter;

Table 1 is provided as an outline of the applicable regulatory requirements, with references to pertinent sections of this RAP application, which demonstrate compliance.

(h) Such information as may be necessary to enable the Regional Administrator to carry out his duties under other Federal laws, as is required for traditional RCRA permits under 270.14(b)(20);

This RAP permit application is intended to provide sufficient information to enable the Regional Administrator to carry out his/her duties under other Federal Law, as is required for traditional RCRA permits under 270.14(b)(20).

(i) Any other information the Director decides is necessary for demonstrating compliance with this subpart or for determining any additional RAP conditions that are necessary to protect human health and the environment.

This RAP permit application is intended to provide sufficient information regarding siting, design, and operation to determine compliance with RAP conditions that are necessary to protect human health and the environment.

5.0 REFERENCES

BRC, 2006, "Corrective Action Plan (CAP) for the Basic Remediation Company (BRC) Common Areas Remediation Project," Henderson, Nevada, September

ERM, 1999, "Preliminary Draft Remedial Action Alternatives Study BMI Common Areas, Clark County, Nevada," Prepared for Henderson Industrial Steering Committee. April, 30.

ERM, March 2000, "Remedial Alternatives Study for Soils and Sediments in the Upper and Lower Ponds at the BMI Complex."

GeoSyntec, 2006, "Revised Draft Remedial Action Plan (RAP) Permit Application for Corrective Action Management Unit (CAMU), Henderson, Nevada," March.

Parsons Engineering Science, January 2000, "Remedial Action Plan (RAP), Permit Application for Corrective Action Management Unit (CAMU), Henderson, Nevada."

"Record of Decision, Remediation of Soils and Sediments in the Upper and Lower Ponds at the BMI Complex, Henderson, Nevada, Bureau of Correction Actions," Nevada Division of Environmental Protection, November 02, 2001.

Tables

Table 1
Regulatory Requirements
BRC CAMU
Henderson, Nevada

Reference				Description/Comments	Location
270.105				Owner and operator signature and certification	Cover Letter
270.11					
a				name, address, EPA ID # of site	Page 5
b				Name, address, and telephone number of the owner and operator	Page 5
c				The latitude and longitude of the site	Page 5
d				USGS or county map showing the location of the RWMS	Attachment A
e				Scaled Drawing	Attachment B
		1		Remediation waste management site boundaries	Attachment B
		2		Significant physical structures	Attachment B
		3		Boundary of all area where remediation waste is to be disposed	Attachment B
f				Specification of the hazardous remediation waste to be treated, stored, or disposed of at the facility or RWMS	Waste Analysis Plan (Attachment C)
		1		Constituent concentrations and other properties relevant to how materials should be treated or otherwise managed	Waste Analysis Plan (Attachment C)
		2		Estimate of the quantity of these wastes	Waste Analysis Plan (Attachment C)
		3		Description of the process (if any) used to treat material before disposing according to applicable LDR standards of part 268	Waste Analysis Plan (Attachment C)
g				Information to demonstrate that operations that follow the provisions in the RAP application will ensure compliance with the applicable requirements of parts 264, 266, and 268	See sublistings below
	264 Subpart A			Subpart A of 264 excuses this site from the requirements of Subpart B, C, and D of 264. The site will comply with the requiremetns of 264.1(j) instead	
	264.1(j)(1)			Obtain EPA ID number	Page 5
	264.1(j)(2)			Obtain detailed chemical and physical analysis of wastes to be managed at the site	Waste Analysis Plan (Attachment C)
	264.1(j)(3)			Prevent inadvertent or deliberate access to site by unauthorized people or livestock	Security Plan (Attachment D)
	264.1(j)(4)			Inspect site for malfunctions, deterioration, etc. that may cause or lead to release of hazardous waste constituents to the environment, etc.	Inspection Plan (Attachment E)
	264.1(j)(5)			Provide personnel training on how to perform duties and respond effectively to emergencies	Personnel Training Plan (Attachment F)
	264.1(j)(6)			Take precautions to prevent accidental ignition or reaction of ignitable or reactive waste, and mixing of incompatible waste	Accident Prevention, Contingency, and Emergency Response Plan (Attachment G)
	264.1(j)(7)			Floodplain documentation	Figure I-1 (Attachment I)
	264.1(j)(8)			No placement of waste in salt dome or underground mine or cave	Not Applicable

Table 1
Regulatory Requirements
BRC CAMU
Henderson, Nevada

	264.1(j)(9)	Develop and maintain a construction quality assurance program for CAMU landfills	Landfill Design, Construction, and Operation Plan (Attachment L)
	264.1(j)(10)	Develop and maintain procedures to prevent accidents and a contingency and emergency plan to control accidents that occur	Accident Prevention, Contingency, and Emergency Response Plan (Attachment G)
	264.1(j)(11)	Emergency coordinator/designee	Accident Prevention, Contingency, and Emergency Response Plan (Attachment G)
	264.1(j)(12)	Develop, maintain, and implemnet a plan to meet the requirements in paragraphs (j)(2) through (j)(6) and (j)(9) through (j)(10) of 264.1	See respective plans
	264.1(j)(13)	Maintain records documenting compliance with paragraphs (j)(1) through (j)(12) of 264.1	Recordkeeping and Reporting Plan (Attachment T)
	264 Subpart B	Not Applicable	
	264 Subpart C	Not Applicable	
	264 Subpart D	Not Applicable	
	264 Subpart E	Recordkeeping and Reporting	Recordkeeping and Reporting Plan (Attachment T)
	264 Subpart F	Releases from Soild Waste Management Units	
	264 Subpart G	Closure and Post Closure	Closure and Post Closure Plan (Attachment O)
	264 Subpart H	Financial Requirements	Financial Assurance Plan (Attachment R)
	264 Subpart I - M	Not Applicable	
	264 Subpart N	Landfills	Landfill Design, Construction, and Operation Plan (Attachment J, L, M)
	264.301(a)	Not Applicable	
	264.301(b)	Not Applicable	
	264.301(c)	See 264.301(d) instead	
	264.301(d)	Alternative design and operating practices	Landfill Design, Construction, and Operation Plan (Attachment J, L, M)
	264.301(e)	Double liner waiver	Landfill Design, Construction, and Operation Plan (Attachment J, L, M)
	264.301(f)	Not Applicable	

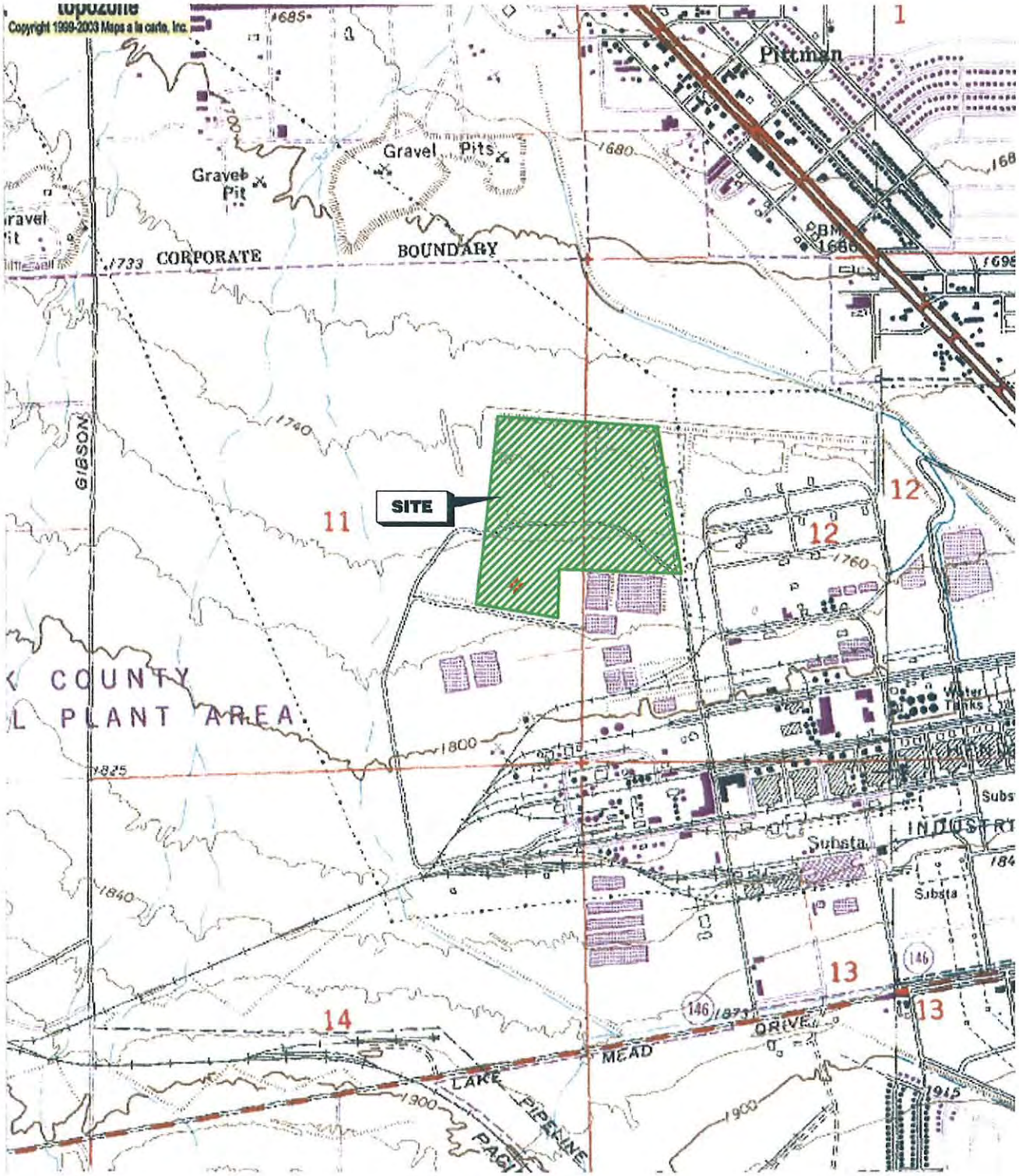
Table 1
Regulatory Requirements
BRC CAMU
Henderson, Nevada

	264.301(g)			Run-on control system	Landfill Design, Construction, and Operation Plan (Attachment J, L, M)
	264.301(h)			Run-off control system	Landfill Design, Construction, and Operation Plan (Attachment J, L, M)
	264.301(i)			Collection and holding facilities for run-on and run-off control systems	Landfill Design, Construction, and Operation Plan (Attachment J, L, M)
	264.301(j)			Wind Dispersal/dust control	Operation Plan (Attachment M)
	264.301(k)				
	264.301(l)			Not Applicable	
	O-R				
	S			Special Provisions for Cleanup	
	264.552(a)			CAMU-eligibility of waste/contiguousness of property/prohibition of liquids	
	264.552(b)			Not Applicable	
	264.552(c)			NDEP will address in RAP permit	
	264.552(d)			Sufficient information to enable NDEP to designate a CAMU	
		1		Origin of waste and how it was subsequently managed (including a description of the timing and circumstances surrounding the disposal and/or release)	Waste Analysis Plan (Attachment C)
		2		Whether the waste was listed or identified as hazardous at the time of disposal and/or release	Waste Analysis Plan (Attachment C)
		3		Whether the disposal and/or release of the waste occurred before or after the land disposal requirements of part 268 were in effect	Waste Analysis Plan (Attachment C)
	264.552(e)				
		1		Aerial configuration of CAMU	Attachment B
		2		Specification of CAMU-eligible wastes	Waste Analysis Plan (Attachment C)
		3		Minimum design requirements	Landfill Design (Attachment J)
		4		Minimum treatment requirements	Waste Analysis Plan (Attachment C)
			i	Principal hazardous constituents (PHCs)	Waste Analysis Plan (Attachment C)
			ii	PHCs vs. Universal Treatment Standards	Waste Analysis Plan (Attachment C)
			iii	Demonstration/acknowledgement of PHCs subject to UTS	Waste Analysis Plan (Attachment C)
			iv	Treatment Standards for wastes placed in CAMU	Waste Analysis Plan (Attachment C)

Table 1
Regulatory Requirements
BRC CAMU
Henderson, Nevada

			v	Adjusted standards	Waste Analysis Plan (Attachment C)
			vi	Treatment Timeline/location	Waste Analysis Plan (Attachment C)
			vii	CAMU Closure	Closure and Post Closure Plan (Attachment O)
		5		Requirements for groundwater monitoring and corrective action	Monitoring Plan (Attachment N)
		6		Closure and Post Closure Requirements	
			i	Design elements and procedures to minimize need for further maintenance and to control or eliminate escape of hazardous constituents (including leachate) to the ground, air, surface, and/or groundwater	Landfill Design, Construction, and Operation Plan (Attachment J, L, M)
			ii	Requirements for excavation, removal, treatment, or containment of waste. Requirement and procedures for removal and decontamination of equipment, devices, and structures used in material management activities (include surveying, excavation, transportation, and placement of waste material).	Operating Plan; Closure and Post-Closure Plan (Attachments M, O)
			iii	Specific Requirements based on CAMU characteristics, volumes, characteristics of waste, potential for release	WAP, Closure and Post-Closure Plan (Attachment C, O)
			iv	Cap Requirements	
			v	Post-Closure Requirements	Closure and Post Closure Plan (Attachment O)
	264.552(f)			Not Applicable	
	264.552(g)			Not Applicable	
	264.552(h)			Will be addressed by NDEP in RAP Permit	
	264.552(i)			Will be addressed by NDEP in RAP Permit	
	264.552(j)			Not Applicable	
	264.552(k)			Will be addressed by NDEP in RAP Permit	
	T-EE			Not Applicable	
	266			Not Applicable	
	268.5			LDR treatment Standards [see 264.442(e)(4)]	Waste Analysis Plan (Attachment C)
	268.5			Alternative LDR treatment standards for contaminated soil	Waste Analysis Plan (Attachment C)
h				Information to enable Administration to carry out duties under other Federal laws as required under 270.14(b)(20)	Attachment U
i				Other information the Director decides is necessary for compliance with 270 Subpart H or determining any additional RAP conditions that are necessary to protect human health and the environment	Attachment V

Attachment A
Drawing 1
USGS/County Map



NOT TO SCALE

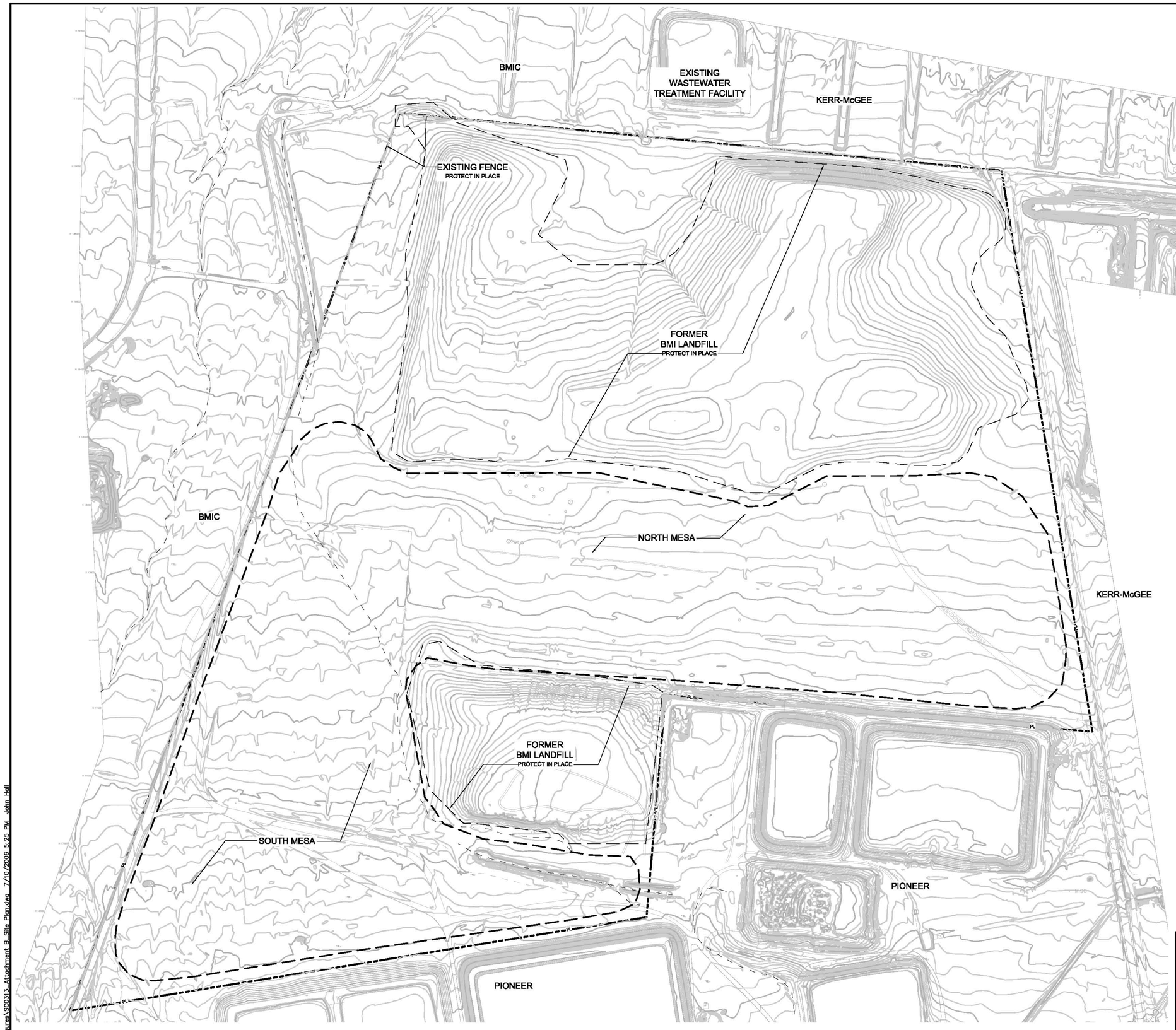
GEOSYNTEC CONSULTANTS

USGS LAS VEGAS SE QUADRANGLE
BRC CAMU
HENDERSON, CALIFORNIA

FIGURE NO.	ATTACHMENT A
PROJECT NO.	SC0313
DATE:	NOVEMBER 2006

P:\PRJ\SDCadd\CADD\SC0313\BRC\figures\SC0313_Attachment A_Site Location.dwg 7/10/2006 5:25 PM John Hall

Attachment B
Drawing 2
Scaled Drawing



LEGEND

- PL — BRC LANDFILL SITE BOUNDARY
- EXISTING LIMITS OF FORMER BMI LANDFILL
- EXISTING SURFACE WATER FLOW PATH
- EXISTING MINOR ELEVATION CONTOUR
- EXISTING MAJOR ELEVATION CONTOUR
- PROPOSED LIMIT OF WASTE

N

100 50 0 100 200

SCALE IN FEET

GEOSYNTEC CONSULTANTS
10875 RANCHO BERNARDO ROAD, SUITE 200
SAN DIEGO, CALIFORNIA 92127
TELEPHONE: (858) 674-6559

PROJECT: BRC CAMU
HENDERSON/CLARK COUNTY NEVADA

TITLE: ATTACHMENT B

MARK	DATE	REVISION	BY	APPROVED

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

SIGNATURE

DATE

SEAL

DATE:	NOVEMBER 2006	SCALE:	AS SHOWN
DESIGN BY:	G.T.C.	JOB NO.:	SC0313
DRAWN BY:	J.R.H.	FILE NO:	
CHECKED BY:	G.T.C.	DOCUMENT NO:	
REVIEWED BY:	G.T.C.	DRAWING NO:	
APPROVED BY:	G.T.C.		

P:\PRJ\SDCadd\CADD\SC0313\BRC\figures\SC0313_Attachment B_Site Plan.dwg 7/10/2006 5:25 PM John Hall

Attachment C
Waste Analysis Plan

Attachment C
Waste Analysis Plan
Basic Remediation Company (BRC)
Corrective Action Management Unit (CAMU)
Henderson, Nevada

Table of Contents

1.0 Introduction C-1
2.0 Investigative History C-1
3.0 Results C-4
4.0 References C-5

List of Tables

Table C-1 Site-Related Chemicals - Universal Treatment Standards
Table C-2 Waste Characterization Composite Sampling
Table C-3 Waste Characterization Sampling Summary Table
Table C-4 Comparison of Detected Chemical Concentrations with UTS Levels
Table C-5 Estimated Waste Volumes, By Location

List of Figures

Figure C-1 Waste Areas and Depths
Figure C-2 Waste Characterization Sample Locations
Figure C-3A Individual Composite Sample Locations (East)
Figure C-3B Individual Composite Sample Locations (West)
Figure C-3C Individual Composite Sample Locations (North)
Figure C-4 Waste Areas and Waste Volumes

1.0 INTRODUCTION

The Basic Remediation Company (BRC) site-related chemicals (SRC) list, as approved by the Nevada Division of Environmental Protection (NDEP), currently includes a wide range of analytes, including many chemicals with universal treatment standards (UTS), as defined in Code of Federal Regulations (CFR) Title 40, Chapter 268.48 (40 CFR 268.48). The UTS list, with those constituents on the BRC SRC list identified, is shown in Table C-1. All areas where wastes are present or may be present based on visual evidence and an understanding of the Conceptual Site Model (CSM), along with measured or anticipated waste depths, are shown on Figure C-1. Although additional remediation may be required in areas not shown in order to meet project risk goals, wastes are not present in discernable quantities in other areas; therefore, sampling in areas not shown as containing wastes in Figure C-1 would not provide a realistic representation of waste composition (i.e., any samples collected will be unavoidably diluted with non-waste soils, thus rendering them unrepresentative of waste materials). Although sporadic waste sampling efforts have been conducted in the past within the BMI Common Areas, the recent Waste Sampling and Analysis effort in 2006 was a systematic attempt to characterize the wastes present in the Common Areas. This recent round of sampling also utilized the final SRC list for the BMI Common Areas, thereby providing the largest number of analytes for analysis. Thus, this most recent sampling provides the most complete characterization of the wastes and is summarized in this Attachment. It should be noted, however, that since these waste sampling results reflect the condition of the wastes as they are present in the source areas, there is likely to be some unavoidable commingling of wastes and non-waste materials during removal actions leading to dilution – thus, the characteristics of the wastes prior to placement in the CAMU may therefore be somewhat different. In this respect the results presented and discussed in this Attachment are conservative.

2.0 INVESTIGATIVE HISTORY

The 2006 waste characterization investigation, pursuant to an approved workplan by NDEP, focused on areas within the BMI Common Areas (Eastside) where wastes are located. Each of the samples collected from these areas was a composite grab sample in order to provide a representative concentration of the wastes present. Details of this compositing approach are shown in Table C-2 and Figure C-2, and Figures C-3A through C-3C.

The methodology for the solid matrix samples and waste water sample were in accordance with the project Field Sampling and Standard Operating Procedures (FSSOP; BRC and MWH 2006a) for surface and subsurface soil sample collection, including pre-field activities. The project Health and Safety Plan (HSP; BRC and MWH 2005) and Quality Assurance Project Plan (QAPP; BRC and MWH 2006b) prepared for the BMI

Common Areas were also used for this work. All work was completed under the direction of a State of Nevada Certified Environmental Manager (CEM).

The vast majority of the wastes present are soils and sediments; however, for completeness BRC also sampled the only wastewater present – namely in the TIMET Pond SW-12. This pond and the other TIMET ponds are no longer in service and the free water contained therein are evaporating. The primary purpose of the sampling effort was to (a) complete characterization of the remedial wastes in order to address certain regulatory requirements pertaining to their anticipated excavation and placement into the proposed CAMU; and (b) to assist with continued development of the BMI Common Areas (Eastside) CSM.

Waste characterization was performed to determine whether excavated materials comply with minimum treatment requirements (MTRs) prior to placement into a land disposal unit. As such the Waste Sampling and Analysis Plan (BRC, 2006) that was prepared and approved by the NDEP, with incorporated comments, complied with and was intended to support regulations at 40 CFR 270.110(f); 40 CFR 264(1)(j)(2); 40 CFR 264.552(d); 40 CFR 264.552(e)(2)&(4); and 40 CFR 268.49 (U.S. Environmental Protection Agency [USEPA] 2005).

Samples were collected from the following areas:

- Alpha ditch: composite samples were collected from three locations along the length of the alpha ditch. Each of the three sample locations consisted of composite samples from three equidistant locations (50 feet apart) and from two depths each.

- Beta ditch: composite samples were collected from three locations along the length of the beta ditch. Each of the three sample locations consisted of composite samples from three equidistant locations (50 feet apart) and from three depths each.

- IRM soil holding ponds: a single composite sample was collected from each of the IRM holding ponds – these are seven of the Upper Ponds. Each IRM holding pond sample consisted of composite samples from two locations within the holding pond and from two depths each. Since these ponds are capped for dust mitigation purposes, the upper sampling interval was below the cap.

- Mohawk area: a single composite sample was collected which consisted of samples from ponds PUE-01, PUE-02, PUF-01, and PUF-02 collected from surface soils.

- No-build area: three composite samples were collected which consisted of samples from ponds within the no-build area footprint. Each no-build area sample consisted of composite samples from four to five ponds each (as discussed in Table C-2) collected from surface soils.

- Sunset North area: a single composite sample was collected which consisted of samples from ponds west of the no-build area (as discussed in Table C-2) collected from surface soils. These ponds have undergone previous IRM activities.

- Spray Wheel: two composite samples were collected which consisted of samples from ponds with sediments within the Spray Wheel area. Each Spray Wheel sample consisted of composite samples from three to four ponds (as discussed in Table C-2) collected from two depths each.

- TIMET abandoned test pit: a single composite sample was collected which consisted of two samples from within the test pit footprint and from two depths each.

- Former Espey Construction site: a single composite sample was collected which consisted of two samples from within the construction site footprint and from two depths each.

- Other TIMET debris areas: a single composite sample was collected which consisted of samples from four areas identified as debris or storage areas (other than TIMET ponds, test pit or Espey Construction site). The other debris composite sample consisted of one sample from each of the four locations and from two depths each.

- TIMET berms: four composite samples were collected from berms between each of the TIMET ponds. Each sample consisted of composite samples from three locations from two depths each. Although the berms have not received any TIMET wastes, they were constructed via grading of historic BMI ponds located in this area.

- TIMET OPW ponds: two composite samples were collected which consisted of samples from each OPW pond. Each OPW pond sample consisted of composite samples from six to eight ponds each collected from two depths each. Only two samples were collected since the nature of the OPW wastes deposited in these ponds is uniform. A separate sample was collected from OPW Pond #12 since TIMET used this pond for disposal of lime bottoms. A single composite sample was collected consisting of samples from two locations within this pond and from two depths each.

- TIMET ponds: a single composite sample was collected from each of the 16 TIMET ponds. Each TIMET pond sample consisted of two composite samples from within the pond collected from two depths each. In addition, a wastewater sample was collected from Pond SW-12.

- Upper ponds: composite samples were collected, which consisted of samples from each of first seven upper pond rows from ponds with sediment (one composite sample per row). Each upper pond sample consisted of composite samples from four to six ponds each (as discussed in Table C-2) collected from two depths each.

Field sampling was conducted from July 26 through August 9, 2006. Through this effort, 53 soil samples and one sediment sample were collected for analyses, which were composited from 300 individual sample locations. A separate Data Validation

Summary Report (Dataset #39) was prepared and submitted to NDEP (BRC and MWH 2006c). This report was approved by the NDEP in November 2006. This report contains an electronic version of the waste characterization sampling database. Table C-3 summarizes the results of this investigation.

Table C-5 shows the estimated impacted soil volumes associated with the various waste areas. Figure C-4 shows the waste area locations.

3.0 RESULTS

A summary of the results of the waste sampling and analysis is provided in Table C-4. This table presents the minimum and maximum detected concentrations for each of the SRCs with a listed UTS, as defined in 40 CFR 268.48. The chemical-specific UTS times 10 and the chemicals that have been detected in concentrations that exceed 10 times their UTS are also indicated in Table C-4. Those chemicals with maximum concentrations that exceed 10 times their UTS are also compared to: 1) a potential carcinogenic direct risk from ingestion or inhalation at the site at or above 10^{-3}, and 2) a non-carcinogenic direct risk from ingestion or inhalation at the site an order of magnitude or greater over their reference dose. As discussed by USEPA (2002), hazard quotients are used as a measure of unacceptable exposure to constituents that produce toxic endpoints other than cancer.

USEPA Region 9 preliminary remediation goals (PRGs) tables provide exposure pathway-specific risk-based comparison values (USEPA 2004). These tables provide values for both carcinogenic and non-carcinogenic risks. If a particular chemical has both carcinogenic and non-carcinogenic toxicity criteria, these tables provide values for both these endpoints. Therefore, USEPA Region 9 residential PRGs for both carcinogenic and non-carcinogenic risks for the combined ingestion and inhalation exposure pathways were used in this analysis. Because PRGs for carcinogens are based on a cancer risk level of 10^{-6}, the values in the PRG tables were multiplied by 1,000 to obtain a 10^{-3} risk level. PRGs for non-carcinogens, which are based on a hazard quotient of 1, were multiplied by 10. These adjusted PRG values are shown in Table C-4 for those chemicals that exceeded 10 times their UTS. These chemicals were 2,4'-DDE, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, beta-BHC, 1,2,3,4,6,7,8-HpCDD, 1,2,3,4,6,7,8-HpCDF, 1,2,3,4,7,8,9-HpCDF, OCDD, and OCDF. Because PRG values were not available for 2,4'-DDE, values for 4,4'-DDE were used as a surrogate. PRG values for each of the dioxin congeners were obtained by multiplying the PRG for 2,3,7,8-TCDD by each congener's respective toxicity equivalency factor (TEF). All of the chemicals are considered carcinogens and have PRGs for carcinogenic risks. 4,4'-DDT and beta-BHC also have PRGs for non-carcinogenic risks. As indicated in Table C-4, none of these chemicals equal or exceed either a potential carcinogenic direct risk from ingestion or inhalation of 10^{-3}, nor a non-carcinogenic direct risk from ingestion or inhalation an order

of magnitude or greater over their reference dose. Therefore, all of the waste materials in the Eastside meet the UTS/MTR requirements.

4.0 REFERENCES

Basic Remediation Company (BRC). 2006. Sampling and Analysis Plan for Waste Characterization, BMI Common Areas (Eastside), Clark County, Nevada. June 29.

Basic Remediation Company (BRC) and MWH. 2005. BRC Health and Safety Plan, BMI Common Areas, Clark County, Nevada. October.

Basic Remediation Company (BRC) and MWH. 2006a. BRC Field Sampling and Standard Operating Procedures, BMI Common Areas, Clark County, Nevada. May.

Basic Remediation Company (BRC) and MWH. 2006b. BRC Quality Assurance Project Plan, BMI Common Areas, Clark County, Nevada. April.

Basic Remediation Company (BRC) and MWH. 2006c. Data Validation Summary Report, 2006 Waste Characterization Investigation (Dataset 39), BMI Common Areas (Eastside), Clark County, Nevada. October.

U.S. Environmental Protection Agency (USEPA). 2002. Amendments to the Corrective Action Management Unit Rule; Final Rule. Federal Register, Vol. 67, No. 14. January 22.

U.S. Environmental Protection Agency (USEPA). 2004. Preliminary Remediation Goals (PRGs), Region 9. Website: www.epa.gov/region09/waste/sfund/prg/index.html.

U.S. Environmental Protection Agency (USEPA). 2005. Code of Federal Regulations (CFR) Title 40.

TABLE C-1
SITE-RELATED CHEMICALS - UNIVERSAL TREATMENT STANDARDS
(Page 1 of 11)

Parameter of Interest	Analytical Method	Compound List	CAS Number	Universal Treatment Standard		
				Wastewater	Nonwastewater	
				mg/L	mg/kg	mg/L TCLP
Ions	EPA 300.0	Bromide	24959-67-9	NA	NA	NA
		Bromine	7726-95-6	NA	NA	NA
		Chlorate	14866-68-3	NA	NA	NA
		Chloride	16887-00-6	NA	NA	NA
		Chlorine (soluble)	7782-50-5	NA	NA	NA
		Chlorite	14998-27-7	NA	NA	NA
		Fluoride	16984-48-8	35	NA	NA
		Nitrate (as N)	14797-55-8	NA	NA	NA
		Nitrite (as N)	14797-65-0	NA	NA	NA
		Orthophosphate	14265-44-2	NA	NA	NA
		Sulfate	14808-79-8	NA	NA	NA
	EPA 377.1	Sulfite	14265-45-3	NA	NA	NA
	EPA 314.0	Perchlorate	14797-73-0	NA	NA	NA
Dissolved Gases	RSK 175	Ethane	74-84-0	NA	NA	NA
		Ethylene	74-85-1	NA	NA	NA
		Methane	74-82-8	NA	NA	NA
Chlorinated Compounds	EPA 551.1	Chloral	75-87-6	NA	NA	NA
		Dichloroacetaldehyde	79-02-7	NA	NA	NA
Polychlorinated Dibenzodioxins/ Dibenzofurans	EPA 8290	1,2,3,4,6,7,8,9-Octachlorodibenzofuran	39001-02-0	0.000063	0.005	NA
		1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin	3268-87-9	0.000063	0.005	NA
		1,2,3,4,6,7,8-Heptachlorodibenzofuran	67562-39-4	0.000035	0.0025	NA
		1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	35822-46-9	0.000035	0.0025	NA
		1,2,3,4,7,8,9-Heptachlorodibenzofuran	55673-89-7	0.000035	0.0025	NA
		1,2,3,4,7,8-Hexachlorodibenzofuran	70648-26-9	NA	NA	NA
		1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	39227-28-6	NA	NA	NA
		1,2,3,6,7,8-Hexachlorodibenzofuran	57117-44-9	NA	NA	NA
		1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	57653-85-7	NA	NA	NA
		1,2,3,7,8,9-Hexachlorodibenzofuran	72918-21-9	NA	NA	NA
		1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	19408-74-3	NA	NA	NA
		1,2,3,7,8-Pentachlorodibenzofuran	57117-41-6	NA	NA	NA
		1,2,3,7,8-Pentachlorodibenzo-p-dioxin	40321-76-4	NA	NA	NA
		2,3,4,6,7,8-Hexachlorodibenzofuran	60851-34-5	NA	NA	NA
		2,3,4,7,8-Pentachlorodibenzofuran	57117-31-4	NA	NA	NA
		2,3,7,8-Tetrachlorodibenzofuran	51207-31-9	NA	NA	NA
		2,3,7,8-Tetrachlororodibenzo-p-dioxin	1746-01-6	NA	NA	NA
Asbestos	Elutriator/TEM	Asbestos	1332-21-4	NA	NA	NA
General Chemistry Parameters	EPA 350.2	Ammonia (as N)	7664-41-7	NA	NA	NA
	EPA 9010/9014	Cyanide (Total)	57-12-5	1.2	590	NA
	EPA 345.1	Iodine	7553-56-2	NA	NA	NA
	EPA 9045C	pH in soil	pH	NA	NA	NA

TABLE C-1
SITE-RELATED CHEMICALS - UNIVERSAL TREATMENT STANDARDS
(Page 2 of 11)

Parameter of Interest	Analytical Method	Compound List	CAS Number	Universal Treatment Standard		
				Wastewater	Nonwastewater	
				mg/L	mg/kg	mg/L TCLP
General Chemistry Parameters	EPA 9040B	pH in water	pH	NA	NA	NA
	EPA 376.1/376.2	Sulfide	18496-25-8	14	NA	NA
	Mod. EPA 415.1	Total inorganic carbon	7440-44-0	NA	NA	NA
	EPA 351.2	Total Kjeldahl nitrogen (TKN)	TKN	NA	NA	NA
	EPA 415.1	Total organic carbon (TOC)	7440-44-0	NA	NA	NA
Metals	EPA 6020/6010B	Aluminum	7429-90-5	NA	NA	NA
		Antimony	7440-36-0	1.9	NA	1.15
		Arsenic	7440-38-2	1.4	NA	5
		Barium	7440-39-3	1.2	NA	21
		Beryllium	7440-41-7	0.82	NA	1.22
		Boron	7440-42-8	NA	NA	NA
		Cadmium	7440-43-9	0.69	NA	0.11
		Calcium	7440-70-2	NA	NA	NA
		Chromium	7440-47-3	2.77	NA	0.6
		Cobalt	7440-48-4	NA	NA	NA
		Copper	7440-50-8	NA	NA	NA
		Iron	7439-89-6	NA	NA	NA
		Lead	7439-92-1	0.69	NA	0.75
		Lithium	1313-13-9	NA	NA	NA
		Magnesium	7439-95-4	NA	NA	NA
		Manganese	7439-96-5	NA	NA	NA
		Molybdenum	7439-98-7	NA	NA	NA
		Nickel	7440-02-0	3.98	NA	11
		Niobium	7440-03-1	NA	NA	NA
		Palladium	7440-05-3	NA	NA	NA
		Phosphorus	7723-14-0	NA	NA	NA
		Platinum	7440-06-4	NA	NA	NA
		Potassium	7440-09-7	NA	NA	NA
		Selenium	7782-49-2	0.82	NA	5.7
		Silicon	7440-21-3	NA	NA	NA
		Silver	7440-22-4	0.43	NA	0.14
		Sodium	7440-23-5	NA	NA	NA
		Strontium	7440-24-6	NA	NA	NA
		Sulfur	7704-34-9	NA	NA	NA
		Thallium	7440-28-0	1.4	NA	0.2
		Tin	7440-31-5	NA	NA	NA
		Titanium	7440-32-6	NA	NA	NA
		Tungsten	7440-33-7	NA	NA	NA
		Uranium	7440-61-1	NA	NA	NA
		Vanadium	7440-62-2	4.3	NA	1.6

TABLE C-1
SITE-RELATED CHEMICALS - UNIVERSAL TREATMENT STANDARDS
(Page 3 of 11)

Parameter of Interest	Analytical Method	Compound List	CAS Number	Universal Treatment Standard		
				Wastewater	Nonwastewater	
				mg/L	mg/kg	mg/L TCLP
Metals		Zinc	7440-66-6	2.61	NA	4.3
		Zirconium	7440-67-7	NA	NA	NA
	EPA 7196A	Chromium (VI)	18540-29-9	NA	NA	NA
	EPA 7470/7471A	Mercury	7439-97-6	0.15	NA	0.025
Organophosphorous Pesticides	EPA 8141A	Azinphos-ethyl	264-27-19	NA	NA	NA
		Azinphos-methyl	86-50-0	NA	NA	NA
		Carbophenothion	786-19-6	NA	NA	NA
		Chlorpyrifos	2921-88-2	NA	NA	NA
		Coumaphos	56-72-4	NA	NA	NA
		Demeton-O	298-03-3	NA	NA	NA
		Demeton-S	126-75-0	NA	NA	NA
		Diazinon	333-41-5	NA	NA	NA
		Dichlorvos	62-73-7	NA	NA	NA
		Dimethoate	60-51-5	NA	NA	NA
		Disulfoton	298-04-4	0.017	6.2	NA
		EPN	2104-64-5	NA	NA	NA
		Ethoprop	13194-48-4	NA	NA	NA
		Ethyl parathion	56-38-2	0.014	4.6	NA
		Fampphur	52-85-7	0.017	15	NA
		Fenthion	55-38-9	NA	NA	NA
		Malathion	121-75-5	NA	NA	NA
		Methyl carbophenothion	953-17-3	NA	NA	NA
		Methyl parathion	298-00-0	0.014	4.6	NA
		Mevinphos	7786-34-7	NA	NA	NA
		Naled	300-76-5	NA	NA	NA
		O,O,O-Triethyl phosphorothioate (TEPP)	297-97-2	NA	NA	NA
		Phorate	298-02-2	0.021	4.6	NA
		Phosmet	732-11-6	NA	NA	NA
		Ronnel	299-84-3	NA	NA	NA
		Stirophos (Tetrachlorovinphos)	22248-79-9	NA	NA	NA
		Sulfotep	3689-24-5	NA	NA	NA
Chlorinated Herbicides	EPA 8151A	2,4,5-T	93-76-5	0.72	7.9	NA
		2,4,5-TP (Silvex)	93-72-1	0.72	7.9	NA
		2,4-D	94-75-7	0.72	10	NA
		2,4-DB	94-82-6	NA	NA	NA
		Dalapon	75-99-0	NA	NA	NA
		Dicamba	1918-00-9	NA	NA	NA

TABLE C-1
SITE-RELATED CHEMICALS - UNIVERSAL TREATMENT STANDARDS
(Page 4 of 11)

Parameter of Interest	Analytical Method	Compound List	CAS Number	Universal Treatment Standard		
				Wastewater	Nonwastewater	
				mg/L	mg/kg	mg/L TCLP
Chlorinated Herbicides	EPA 8151A	Dichloroprop	120-36-5	NA	NA	NA
		Dinoseb	88-85-7	0.066	2.5	NA
		MCPA	94-74-6	NA	NA	NA
		MCPP	93-65-2	NA	NA	NA
Organic Acids	HPLC	4-Chlorobenzene sulfonic acid	98-66-8	NA	NA	NA
		Benzenesulfonic acid	98-11-3	NA	NA	NA
		O,O-Diethylphosphorodithioic acid	298-06-6	NA	NA	NA
		O,O-Dimethylphosphorodithioic acid	756-80-9	NA	NA	NA
Nonhalogenated Organics	EPA 8015B	Ethylene glycol	107-21-1	NA	NA	NA
		Ethylene glycol monobutyl ether	111-76-2	NA	NA	NA
		Methanol	67-56-1	5.6	NA	0.75
		Propylene glycol	57-55-6	NA	NA	NA
Organochlorine Pesticides	EPA 8081A	2,4-DDD	53-19-0	0.023	0.087	NA
		2,4-DDE	3424-82-6	0.031	0.087	NA
		4,4-DDD	72-54-8	0.023	0.087	NA
		4,4-DDE	72-55-9	0.031	0.087	NA
		4,4-DDT	50-29-3	0.0039	0.087	NA
		Aldrin	309-00-2	0.021	0.066	NA
		alpha-BHC	319-84-6	0.00014	0.066	NA
		alpha-Chlordane	5103-71-9	0.0033	0.26	NA
		beta-BHC	319-85-7	0.00014	0.066	NA
		Chlordane	57-74-9	NA	NA	NA
		delta-BHC	319-86-8	0.023	0.066	NA
		Dieldrin	60-57-1	0.017	0.13	NA
		Endosulfan I	959-98-8	0.023	0.066	NA
		Endosulfan II	33213-65-9	0.029	0.13	NA
		Endosulfan sulfate	1031-07-8	0.029	0.13	NA
		Endrin	72-20-8	0.0028	0.13	NA
		Endrin aldehyde	7421-93-4	0.025	0.13	NA
		Endrin ketone	53494-70-5	NA	NA	NA
		gamma-BHC (Lindane)	58-89-9	0.0017	0.066	NA
		gamma-Chlordane	5103-74-2	0.0033	0.26	NA
		Heptachlor	76-44-8	0.0012	0.066	NA
		Heptachlor epoxide	1024-57-3	0.016	0.066	NA
		Methoxychlor	72-43-5	0.25	0.18	NA
		Toxaphene	8001-35-2	0.0095	2.6	NA

TABLE C-1
SITE-RELATED CHEMICALS - UNIVERSAL TREATMENT STANDARDS

Parameter of Interest	Analytical Method	Compound List	CAS Number	Universal Treatment Standard		
				Wastewater mg/L	Nonwastewater mg/kg	Nonwastewater mg/L TCLP
Polychlorinated Biphenyls (PCBs)	**EPA 8082**	Aroclor 1016	12674-11-2	0.1	10	NA
		Aroclor 1221	11104-28-2			NA
		Aroclor 1232	11141-16-5			NA
		Aroclor 1242	53469-21-9			NA
		Aroclor 1248	12672-29-6			NA
		Aroclor 1254	11097-69-1			NA
		Aroclor 1260	11096-82-5			NA
		PCB-77	32598-13-3			NA
		PCB-81	70362-50-4			NA
		PCB-105	32598-14-4			NA
		PCB-114	74472-37-0			NA
		PCB-118	31508-00-6			NA
		PCB-123	65510-44-3			NA
		PCB-126	57465-28-8			NA
		PCB-156	38380-08-4			NA
		PCB-157	69782-90-7			NA
		PCB-167	52663-72-6			NA
		PCB-169	32774-16-6			NA
		PCB-189	39635-31-9			NA
Polynuclear Aromatic Hydrocarbons	**EPA 8310**	Acenaphthene	83-32-9	NA	NA	NA
		Acenaphthylene	208-96-8	NA	NA	NA
		Anthracene	120-12-7	NA	NA	NA
		Benzo(a)anthracene	56-55-3	NA	NA	NA
		Benzo(a)pyrene	50-32-8	NA	NA	NA
		Benzo(b)fluoranthene	205-99-2	NA	NA	NA
		Benzo(g,h,i)perylene	191-24-2	NA	NA	NA
		Benzo(k)fluoranthene	207-08-9	NA	NA	NA
		Chrysene	218-01-9	NA	NA	NA
		Dibenzo(a,h)anthracene	53-70-3	NA	NA	NA
		Indeno(1,2,3-cd)pyrene	193-39-5	NA	NA	NA
		Phenanthrene	85-01-8	NA	NA	NA
		Pyrene	129-00-0	NA	NA	NA
Radionuclides	**EPA 900.0 or EPA 9310**	Gross alpha	G_Alpha	NA	NA	NA
		Gross beta	G_Beta	NA	NA	NA
	EPA 901.1/ HASL GA-01-R	Actinium-228	14331-83-0	NA	NA	NA
		Bismuth-212	14913-49-6	NA	NA	NA
		Bismuth-214	14733-03-0	NA	NA	NA
		Cobalt-57	13981-50-5	NA	NA	NA
		Cobalt-60	10198-40-0	NA	NA	NA

TABLE C-1
SITE-RELATED CHEMICALS - UNIVERSAL TREATMENT STANDARDS

Parameter of Interest	Analytical Method	Compound List	CAS Number	Universal Treatment Standard		
				Wastewater	Nonwastewater	
				mg/L	mg/kg	mg/L TCLP
Radionuclides	EPA 901.1/ HASL GA-01-R	Lead-210	14255-04-0	NA	NA	NA
		Lead-211	015816-77-0	NA	NA	NA
		Lead-212	15092-94-1	NA	NA	NA
		Lead-214	15067-28-4	NA	NA	NA
		Potassium-40	13966-00-2	NA	NA	NA
		Thallium-208	14913-50-9	NA	NA	NA
		Thorium-227	15623-47-9	NA	NA	NA
		Thorium-234	15065-10-8	NA	NA	NA
	HASL A-01-R	Thorium-232	7440-29-1	NA	NA	NA
		Thorium-228	14274-82-9	NA	NA	NA
		Thorium-230	14269-63-7	NA	NA	NA
		Uranium-233/234	13966-29-5	NA	NA	NA
		Uranium 235/236	15117-96-1	NA	NA	NA
		Uranium-238	7440-61-1	NA	NA	NA
	EPA 903.0 / 903.1	Radium-226	13982-63-3	NA	NA	NA
	EPA 904.0	Radium-228	15262-20-1	NA	NA	NA
	Quantitate from Parent or Daughter Radionuclide	Actinium-227 (from Th-227)	14952-40-0	NA	NA	NA
		Bismuth-210 (from Pb-210)	14331-79-4	NA	NA	NA
		Bismuth-211 (from Pb-211)	15229-37-5	NA	NA	NA
		Polonium-210 (from Pb-210)	13981-52-7	NA	NA	NA
		Polonium-212 (from Bi-212)	13981-52-7	NA	NA	NA
		Polonium-214 (from Bi-214)	15735-67-8	NA	NA	NA
		Polonium-216 (from Pb-212)	15756-58-8	NA	NA	NA
		Polonium-218 (from Pb-214)	15422-74-9	NA	NA	NA
		Protactinium-231 (from U-235)	14331-85-2	NA	NA	NA
		Protactinium-234 (from Th-234)	15100-28-4	NA	NA	NA
		Radium-223 (from Th-227)	15623-45-7	NA	NA	NA
		Radium-224 (from Pb-212)	13233-32-4	NA	NA	NA
		Thallium-207 (from Pb-211)	14133-67-6	NA	NA	NA
		Thorium-231 (from U-235)	14932-40-2	NA	NA	NA
Radon	FLUX	Radon-220	22481-48-7	NA	NA	NA
		Radon-222	14859-67-7	NA	NA	NA
Aldehydes	EPA 8315A	Acetaldehyde	75-07-0	NA	NA	NA
		Chloroacetaldehyde	107-20-0	NA	NA	NA
		Dichloroacetaldehyde	79-02-7	NA	NA	NA
		Formaldehyde	50-00-0	NA	NA	NA
		Trichloroacetaldehyde	75-87-6	NA	NA	NA

TABLE C-1
SITE-RELATED CHEMICALS - UNIVERSAL TREATMENT STANDARDS

Parameter of Interest	Analytical Method	Compound List	CAS Number	Universal Treatment Standard		
				Wastewater	Nonwastewater	
				mg/L	mg/kg	mg/L TCLP
Semivolatile Organic Compounds	EPA 8270C	1,2,4,5-Tetrachlorobenzene	95-94-3	0.055	14	NA
		1,2-Diphenylhydrazine	122-66-7	0.087	NA	NA
		1,4-Dioxane	123-91-1	12	170	NA
		2,2'/4,4'-Dichlorobenzil	3457-46-3	NA	NA	NA
		2,4,5-Trichlorophenol	95-95-4	0.18	7.4	NA
		2,4,6-Trichlorophenol	88-06-2	0.035	7.4	NA
		2,4-Dichlorophenol	120-83-2	0.044	14	NA
		2,4-Dimethylphenol	105-67-9	0.036	14	NA
		2,4-Dinitrophenol	51-28-5	0.12	160	NA
		2,4-Dinitrotoluene	121-14-2	0.32	140	NA
		2,6-Dinitrotoluene	606-20-2	0.55	28	NA
		2-Chloronaphthalene	91-58-7	0.055	5.6	NA
		2-Chlorophenol	95-57-8	0.044	5.7	NA
		2-Methylnaphthalene	91-57-6	NA	NA	NA
		2-Nitroaniline	88-74-4	0.27	14	NA
		2-Nitrophenol	88-75-5	0.028	13	NA
		3,3-Dichlorobenzidine	91-94-1	NA	NA	NA
		3-Nitroaniline	99-09-2	NA	NA	NA
		4,4'-Dichlorobenzil	3457-46-3	NA	NA	NA
		4-Bromophenyl phenyl ether	101-55-3	0.055	15	NA
		4-Chloro-3-methylphenol	59-50-7	0.018	14	NA
		4-Chlorophenyl phenyl ether	7005-72-3	NA	NA	NA
		4-Chlorothioanisole	123-09-1	NA	NA	NA
		4-Chlorothiophenol	106-54-7	NA	NA	NA
		4-Nitroaniline	100-01-6	0.028	28	NA
		4-Nitrophenol	100-02-7	0.12	29	NA
		Acenaphthene	83-32-9	0.059	3.4	NA
		Acenaphthylene	208-96-8	0.059	3.4	NA
		Acetophenone	98-86-2	0.01	9.7	NA
		Aniline	62-53-3	0.81	14	NA
		Anthracene	120-12-7	0.059	3.4	NA
		Azobenzene	103-33-3	NA	NA	NA
		Benzo(a)anthracene	56-55-3	0.059	3.4	NA
		Benzo(a)pyrene	50-32-8	0.061	3.4	NA
		Benzo(b)fluoranthene	205-99-2	0.11	6.8	NA
		Benzo(g,h,i)perylene	191-24-2	0.0055	1.8	NA
		Benzo(k)fluoranthene	207-08-9	0.11	6.8	NA
		Benzoic acid	65-85-0	NA	NA	NA
		Benzyl alcohol	100-51-6	NA	NA	NA

TABLE C-1
SITE-RELATED CHEMICALS - UNIVERSAL TREATMENT STANDARDS
(Page 8 of 11)

Parameter of Interest	Analytical Method	Compound List	CAS Number	Universal Treatment Standard		
				Wastewater	Nonwastewater	
				mg/L	mg/kg	mg/L TCLP
Semivolatile Organic Compounds	EPA 8270C	bis(2-Chloroethoxy)methane	111-91-1	0.036	7.2	NA
		bis(2-Chloroethyl) ether	111-44-4	0.033	6	NA
		bis(2-Chloroisopropyl) ether	108-60-1	0.055	7.2	NA
		bis(2-Ethylhexyl) phthalate	117-81-7	NA	NA	NA
		bis(Chloromethyl) ether	542-88-1	NA	NA	NA
		bis(p-Chlorophenyl) sulfone	80-07-9	NA	NA	NA
		bis(p-Chlorophenyl)disulfide	1142-19-4	NA	NA	NA
		Butylbenzyl phthalate	85-68-7	0.017	28	NA
		Carbazole	86-74-8	NA	NA	NA
		Chrysene	218-01-9	0.059	3.4	NA
		Dibenzo(a,h)anthracene	53-70-3	0.055	8.2	NA
		Dibenzofuran	132-64-9	NA	NA	NA
		Dichloromethyl ether	542-88-1	NA	NA	NA
		Diethyl phthalate	84-66-2	0.2	28	NA
		Dimethyl phthalate	131-11-3	0.047	28	NA
		Di-n-butyl phthalate	84-74-2	0.057	28	NA
		Di-n-octyl phthalate	117-84-0	0.017	28	NA
		Diphenyl disulfide	882-33-7	NA	NA	NA
		Diphenyl sulfide	139-66-2	NA	NA	NA
		Diphenyl sulfone	127-63-9	NA	NA	NA
		Fluoranthene	206-44-0	0.068	3.4	NA
		Fluorene	86-73-7	0.059	3.4	NA
		Hexachlorobenzene	118-74-1	0.055	10	NA
		Hexachlorobutadiene	87-68-3	0.055	5.6	NA
		Hexachlorocyclopentadiene	77-47-4	0.057	2.4	NA
		Hexachloroethane	67-72-1	0.055	30	NA
		Hydroxymethyl phthalimide	118-29-6	NA	NA	NA
		Indeno(1,2,3-cd)pyrene	193-39-5	0.0055	3.4	NA
		Isophorone	78-59-1	NA	NA	NA
		m,p-Cresol	106-44-5	0.77	5.6	NA
		Naphthalene	91-20-3	0.059	5.6	NA
		Nitrobenzene	98-95-3	0.068	14	NA
		N-nitrosodi-n-propylamine	621-64-7	0.4	14	NA
		N-nitrosodiphenylamine	86-30-6	0.92	13	NA
		o-Cresol	95-48-7	0.11	5.6	NA
		Octachlorostyrene	29082-74-4	NA	NA	NA
		p-Chloroaniline (4-Chloroaniline)	106-47-8	0.46	16	NA
		p-Chlorobenzenethiol	106-54-7	NA	NA	NA
		Pentachlorobenzene	608-93-5	0.055	10	NA
		Pentachlorophenol	87-86-5	0.089	7.4	NA

TABLE C-1
SITE-RELATED CHEMICALS - UNIVERSAL TREATMENT STANDARDS
(Page 9 of 11)

Parameter of Interest	Analytical Method	Compound List	CAS Number	Universal Treatment Standard		
				Wastewater	Nonwastewater	
				mg/L	mg/kg	mg/L TCLP
Semivolatile Organic Compounds	EPA 8270C	Phenanthrene	85-01-8	0.059	5.6	NA
		Phenol	108-95-2	0.039	6.2	NA
		Phthalic acid	88-99-3	0.055	28	NA
		Pyrene	129-00-0	0.067	8.2	NA
		Pyridine	110-86-1	0.014	16	NA
		Thiophenol	108-98-5	NA	NA	NA
		Tentatively Identified Compounds (TICs)		NA	NA	NA
Volatile Organic Compounds	EPA 8260B	1,1,1,2-Tetrachloroethane	630-20-6	0.057	6	NA
		1,1,1-Trichloroethane	71-55-6	0.054	6	NA
		1,1,2,2-Tetrachloroethane	79-34-5	0.057	6	NA
		1,1,2-Trichloroethane	79-00-5	0.054	6	NA
		1,1-Dichloroethane	75-34-3	0.059	6	NA
		1,1-Dichloroethene	75-35-4	0.025	6	NA
		1,1-Dichloropropene	563-58-6	NA	NA	NA
		1,2,3-Trichlorobenzene	87-61-6	NA	NA	NA
		1,2,3-Trichloropropane	96-18-4	0.85	30	NA
		1,2,4-Trichlorobenzene	120-82-1	0.055	19	NA
		1,2,4-Trimethylbenzene	95-63-6	NA	NA	NA
		1,2-Dichlorobenzene	95-50-1	0.088	6	NA
		1,2-Dichloroethane	107-06-2	0.21	6	NA
		1,2-Dichloroethene	540-59-0	NA	NA	NA
		1,2-Dichloropropane	78-87-5	0.85	18	NA
		1,3,5-Trichlorobenzene	108-70-3	NA	NA	NA
		1,3,5-Trimethylbenzene	108-67-8	NA	NA	NA
		1,3-Dichlorobenzene	541-73-1	0.036	6	NA
		1,3-Dichloropropene	542-75-6	NA	NA	NA
		1,3-Dichloropropane	142-28-9	NA	NA	NA
		1,4-Dichlorobenzene	106-46-7	0.09	6	NA
		2,2-Dichloropropane	594-20-7	NA	NA	NA
		2,2-Dimethylpentane	590-35-2	NA	NA	NA
		2,2,3-Trimethylbutane	464-06-2	NA	NA	NA
		2,3-Dimethylpentane	565-59-3	NA	NA	NA
		2,4-Dimethylpentane	108-08-7	NA	NA	NA
		2-Chlorotoluene	95-49-8	NA	NA	NA
		2-Hexanone	591-78-6	NA	NA	NA
		2-Methylhexane	591-76-4	NA	NA	NA
		2-Nitropropane	79-46-9	NA	NA	NA
		3,3-Dimethylpentane	562-49-2	NA	NA	NA
		3-Ethylpentane	617-78-7	NA	NA	NA
		3-Methylhexane	589-34-4	NA	NA	NA

TABLE C-1
SITE-RELATED CHEMICALS - UNIVERSAL TREATMENT STANDARDS
(Page 10 of 11)

Parameter of Interest	Analytical Method	Compound List	CAS Number	Universal Treatment Standard		
				Wastewater	Nonwastewater	
				mg/L	mg/kg	mg/L TCLP
Volatile Organic Compounds	EPA 8260B	4-Chlorobenzene	108-90-7	NA	NA	NA
		4-Chlorotoluene	106-43-4	NA	NA	NA
		4-Methyl-2-pentanone (MIBK)	108-10-1	0.14	33	NA
		Acetone	67-64-1	0.28	160	NA
		Acetonitrile	75-05-8	5.6	38	NA
		Benzene	71-43-2	0.14	10	NA
		Bromobenzene	108-86-1	NA	NA	NA
		Bromodichloromethane	75-27-4	0.11	15	NA
		Bromoform	75-25-2	0.63	15	NA
		Bromomethane	74-83-9	NA	NA	NA
		Carbon disulfide	75-15-0	3.8	NA	4.8
		Carbon tetrachloride	56-23-5	0.057	6	NA
		Chlorobenzene	108-90-7	0.057	6	NA
		Chlorobromomethane	74-97-5	NA	NA	NA
		Chlorodibromomethane	124-48-1	0.057	15	NA
		Chloroethane	75-00-3	0.27	6	NA
		Chloroform	67-66-3	0.046	6	NA
		Chloromethane	74-87-3	0.19	30	NA
		cis-1,2-Dichloroethene	156-59-2	NA	NA	NA
		cis-1,3-Dichloropropene	10061-01-5	0.036	18	NA
		Cymene (Isopropyltoluene)	99-87-6	NA	NA	NA
		Dibromochloroethane	73506-94-2	NA	NA	NA
		Dibromochloromethane	124-48-1	NA	NA	NA
		Dibromochloropropane	96-12-8	0.11	15	NA
		Dibromomethane	74-95-3	0.11	15	NA
		Dichloromethane (Methylene chloride)	75-09-2	0.089	30	NA
		Dimethyldisulfide	624-92-0	NA	NA	NA
		Ethanol	64-17-5	NA	NA	NA
		Ethylbenzene	100-41-4	0.057	10	NA
		Freon-11 (Trichlorofluoromethane)	75-69-4	0.02	30	NA
		Freon-113 (1,1,2-Trifluoro-1,2,2-trichloroethane)	76-13-1	0.057	30	NA
		Freon-12 (Dichlorodifluoromethane)	75-71-8	0.23	7.2	NA
		Heptane	142-82-5	NA	NA	NA
		Isoheptane	31394-54-4	NA	NA	NA
		Isopropylbenzene	98-82-8	NA	NA	NA
		m,p-Xylene	mp-XYL	NA	NA	NA
		Methyl ethyl ketone (2-Butanone)	78-93-3	0.28	36	NA
		Methyl iodide	74-88-4	0.19	65	NA
		MTBE (Methyl tert-butyl ether)	1634-04-4	NA	NA	NA
		n-Butyl benzene	104-51-8	NA	NA	NA

TABLE C-1
SITE-RELATED CHEMICALS - UNIVERSAL TREATMENT STANDARDS
(Page 11 of 11)

Parameter of Interest	Analytical Method	Compound List	CAS Number	Universal Treatment Standard		
				Wastewater	Nonwastewater	
				mg/L	mg/kg	mg/L TCLP
Volatile Organic Compounds	EPA 8260B	n-Propylbenzene	103-65-1	NA	NA	NA
		Nonanal	124-19-6	NA	NA	NA
		o-Xylene	95-47-6	NA	NA	NA
		sec-Butylbenzene	135-98-8	NA	NA	NA
		Styrene	100-42-5	NA	NA	NA
		tert-Butyl benzene	98-06-6	NA	NA	NA
		Tetrachloroethene	127-18-4	0.056	6	NA
		Toluene	108-88-3	0.08	10	NA
		trans-1,2-Dichloroethene	156-60-5	0.054	30	NA
		trans-1,3-Dichloropropene	10061-02-6	0.036	18	NA
		Trichloroethene	79-01-6	0.054	6	NA
		Vinyl acetate	108-05-4	NA	NA	NA
		Vinyl chloride	75-01-4	0.27	6	NA
		Xylenes (total)	1330-20-7	0.32	30	NA
		Tentatively Identified Compounds (TICs)		NA	NA	NA
Water Quality Parameters	EPA 120.1	Conductivity	COND	NA	NA	NA
	EPA 130.2	Hardness, total	Hardness	NA	NA	NA
	EPA 160.1	Total dissolved solids	TDS	NA	NA	NA
	EPA 160.2	Total suspended solids	TSS	NA	NA	NA
Water Quality Parameters (continued)	EPA 310.1	Alkalinity, Total (as $CACO_3$)	ALK	NA	NA	NA
		Bicarbonate alkalinity	71-52-3	NA	NA	NA
		Carbonate alkalinity	3812-32-6	NA	NA	NA
		Hydroxide alkalinity	OH-ALK	NA	NA	NA
Flashpoint	EPA 1010	Flammables	NA	NA	NA	NA
Total Petroleum Hydrocarbons	EPA 8015	Diesel	64742-46-7	NA	NA	NA
		Gasoline	8006-61-9	NA	NA	NA
		Grease	68153-81-1	NA	NA	NA
		Mineral Spirits	NA	NA	NA	NA
White Phosphorus	EPA 7580M	White phosphorus	12185-10-3	NA	NA	NA
Methyl Mercury	EPA 1630	Methyl mercury	22967-92-6	NA	NA	NA

Shaded chemicals are those with Universal Treatment Standards.
NA = not applicable; a UTS has not been established for this chemical/medium/analysis.

TABLE C-2
WASTE CHARACTERIZATION COMPOSITE SAMPLING
(Page 1 of 2)

Area / Sample ID	Spatial Composite	Depth Composite
Alpha Ditch		
WC-AD01*	composite of 3 (-50, 0, 50 feet) samples collected from along ditch	composite of samples collected from 0 and 2 feet bgs
WC-AD02	composite of 3 (-50, 0, 50 feet) samples collected from along ditch	composite of samples collected from 0 and 2 feet bgs
WC-AD03	composite of 3 (-50, 0, 50 feet) samples collected from along ditch	composite of samples collected from 0 and 2 feet bgs
Beta Ditch		
WC-BD01	composite of 3 (-50, 0, 50 feet) samples collected from along ditch	composite of samples collected from 0 , 6, and 11 feet bgs
WC-BD02	composite of 3 (-50, 0, 50 feet) samples collected from along ditch	composite of samples collected from 0, 4, and 8 feet bgs
WC-BD03	composite of 3 (-50, 0, 50 feet) samples collected from along ditch	composite of samples collected from 0, 4, and 8 feet bgs
IRM Soil Holding Areas		
WC-IM01	composite of 2 samples collected from IRM soil holding area in pond PUA-04	composite of samples collected from 2 and 4 feet bgs
WC-IM02	composite of 2 samples collected from IRM soil holding area in pond PUB-04	composite of samples collected from 2 and 4 feet bgs
WC-IM03	composite of 2 samples collected from IRM soil holding area in pond PUB-05	composite of samples collected from 2 and 4 feet bgs
WC-IM04	composite of 2 samples collected from IRM soil holding area in pond PUB-10	composite of samples collected from 2 and 4 feet bgs
WC-IM05	composite of 2 samples collected from IRM soil holding area in pond PUC-03	composite of samples collected from 2 and 4 feet bgs
WC-IM06	composite of 2 samples collected from IRM soil holding area in pond PUC-04	composite of samples collected from 2 and 4 feet bgs
WC-IM07	composite of 2 samples collected from IRM soil holding area in pond PUD-03	composite of samples collected from 2 and 4 feet bgs
Mohawk Area		
WC-MH01	composite of one sample each from ponds PUE-01, PUE-02, PUF-01, and PUF-02	composite of samples collected from 0 feet bgs
No-Build Area		
WC-NB01	composite of one sample each from ponds PLH-01, PLI-01, PLI-02, PLJ-01, and PLJ-02	composite of samples collected from 0 feet bgs
WC-NB02	composite of one sample each from ponds PLH-02, PLH-03, PLH-04, and PLI-03	composite of samples collected from 0 feet bgs
WC-NB03	composite of one sample each from ponds PLG-02 through PLG-05	composite of samples collected from 0 feet bgs
Sunset North Area		
WC-SN01	composite of one sample each from ponds PLD-10, PLE-08, PLE-09, PLF-05 through PLF-08, and PLG-06	composite of samples collected from 0 feet bgs
Spray Wheel		
WC-SW01	composite of one sample each from ponds PUE-08, PUE-09, PUF-08, and PUF-09	composite of samples collected from 0 and 2 feet bgs
WC-SW02	composite of one sample each from ponds PUF-07, PUG-08, and PUH-07	composite of samples collected from 0 and 2 feet bgs
Former Espey Construction Site		
WC-TE01	composite of two samples from footprint of former Espey Construction site	composite of samples collected from 0 and 2 feet bgs
Other TIMET Debris Areas		
WC-TD01	composite of one sample each from footprint of three other TIMET debris areas	composite of samples collected from 0 and 2 feet bgs
TIMET Abandoned Test Pit		
WC-TA01	composite of two samples from footprint of TIMET Abandoned Test Pit	composite of samples collected from 0 and 3 feet bgs

TABLE C-2
WASTE CHARACTERIZATION COMPOSITE SAMPLING
(Page 2 of 2)

Area / Sample ID	Spatial Composite	Depth Composite
TIMET Berms		
WC-TB01	composite of 3 equispaced samples from western berms between TIMET ponds	composite of samples collected from 0 and 2 feet bgs
WC-TB02	composite of 3 equispaced samples from central west berms between TIMET ponds	composite of samples collected from 0 and 2 feet bgs
WC-TB03	composite of 3 equispaced samples from central east berms between TIMET ponds	composite of samples collected from 0 and 2 feet bgs
WC-TB04	composite of 3 equispaced samples from eastern berms between TIMET ponds	composite of samples collected from 0 and 2 feet bgs
TIMET OPW Ponds		
WC-TW01	composite of one sample each from ponds OPW-6 through OPW-11	composite of samples collected from 0 and 3 feet bgs
WC-TW02	composite of one sample each from ponds OPW-13 through OPW-20	composite of samples collected from 0 and 3 feet bgs
WC-TW03	composite of two samples from pond OPW-12	composite of samples collected from 0 and 3 feet bgs
TIMET Ponds		
WC-TP01	composite of 2 samples from pond SC-1	composite of samples collected from 0 and 5 feet bgs
WC-TP02	composite of 2 samples from pond SW-2	composite of samples collected from 0 and 2 feet bgs
WC-TP03	composite of 2 samples from pond SW-3	composite of samples collected from 0 and 2 feet bgs
WC-TP04	composite of 2 samples from pond SW-4	composite of samples collected from 0 and 5 feet bgs
WC-TP05	composite of 2 samples from pond SW-5	composite of samples collected from 0 and 2 feet bgs
WC-TP06	composite of 2 samples from pond SW-6	composite of samples collected from 0 and 2 feet bgs
WC-TP07	composite of 2 samples from pond SW-7	composite of samples collected from 0 and 5 feet bgs
WC-TP08	composite of 2 samples from pond SW-8	composite of samples collected from 0 and 5 feet bgs
WC-TP09	composite of 2 samples from pond SW-9	composite of samples collected from 0 and 2 feet bgs
WC-TP10	composite of 2 samples from pond SW-10	composite of samples collected from 0 and 2 feet bgs
WC-TP11	composite of 2 samples from pond SW-11	composite of samples collected from 0 and 2 feet bgs
WC-TP12	composite of 2 samples from pond SW-12*	composite of samples collected from 0 and 2 feet bgs
WC-TP13	composite of 2 samples from pond HP-2	composite of samples collected from 0 and 2 feet bgs
WC-TP14	composite of 2 samples from pond HP-3	composite of samples collected from 0 and 2 feet bgs
WC-TP15	composite of 2 samples from pond HP-4	composite of samples collected from 0 and 2 feet bgs
WC-TP16	composite of 2 samples from pond HP-5	composite of samples collected from 0 and 2 feet bgs
Upper Ponds		
WC-UP01	composite of one sample each from ponds PUA-05 through PUA-10	composite of samples collected from 0 and 2 feet bgs
WC-UP02	composite of one sample each from ponds PUB-06 through PUB-09	composite of samples collected from 0 and 2 feet bgs
WC-UP03	composite of one sample each from ponds PUC-05 through PUC-08	composite of samples collected from 0 and 2 feet bgs
WC-UP04	composite of one sample each from ponds PUD-04 through PUD-09	composite of samples collected from 0 and 2 feet bgs
WC-UP05	composite of one sample each from ponds PUE-03 through PUE-07	composite of samples collected from 0 and 2 feet bgs
WC-UP06	composite of one sample each from ponds PUF-03 through PUF-06	composite of samples collected from 0 and 2 feet bgs
WC-UP07	composite of one sample each from ponds PUG-04 through PUG-07	composite of samples collected from 0 and 2 feet bgs

Note: Wastewater sample collected from TIMET Pond SW-12.

*Indicates BMI Siphon sample location.

Table C-3
Waste Characterization Sampling Summary Table
(Page 1 of 8)

	Sample	1,1,1-Trichloroethane	1,2,3,4,6,7,8-HpCDD	1,2,3,4,6,7,8-HpCDF	1,2,3,4,7,8,9-HpCDF	1,2,4,5-Tetrachlorobenzene	1,2,4-Trichlorobenzene	1,2-Dichlorobenzene	1,2-Dichloroethane	1,2-Dichloropropane	1,3-Dichlorobenzene	1,4-Dichlorobenzene	2,4,6-Trichlorophenol	2,4-D	2,4'-DDD	2,4'-DDE	4,4'-DDD	4,4'-DDE	4,4'-DDT	Acenaphthene	Acenaphthylene	Acetone
Nonwastewater (mg/kg)	UTS x 10	60	0.025	0.025	0.025	140	190	60	60	180	60	60	74		0.87	0.87	0.87	0.87	0.87	34	34	1600
	WC-AD01		0.000034	0.0002	0.000078											0.01 J+		0.029 J+	0.02 J+			
	WC-AD02		0.0000098	0.000064	0.000031											0.0024		0.0069	0.0057			
	WC-AD03		0.0000099	0.000061	0.000023											0.0035		0.0097	0.0062			
	WC-BD01		0.00072	0.002	0.00088	0.068	0.0034	0.0012				0.0017			0.38 J	15 J		16 J	4 J			
	WC-BD02		0.00011	0.0011	0.00053										0.0023 J+	0.056 J		0.035 J+	0.011 J+			
	WC-BD03			0.000025	0.000011											0.0019		0.0025				
	WC-IM01		0.00022	0.0016	0.0011	0.04						0.00046			0.67 J	3.8 J	1.6	9.2 J	3.4			
	WC-IM02		0.0003	0.0037	0.003	0.049						0.00045			0.54 J	3	0.93	6.5 J	2.6			
	WC-IM03		0.00019	0.002	0.0015	0.039	0.0051	0.0029				0.0035			0.25 J	2.5 J-	0.52 J-	4.2 J	1.8 J-			
	WC-IM04	0.001	0.068 J+	0.42 J	0.16 J+	0.073	0.0029	0.0032			0.00047	0.0038	0.087		0.27	11 J		6.3 J	1.9			
	WC-IM05		0.00024	0.00028	0.00011											0.46 J		0.38 J	0.11			
	WC-IM06		0.0003	0.00083	0.00054	0.26	0.0048	0.003				0.0032			0.82 J	4.1 J	1.3	8.8 J	7 J			
	WC-IM07		0.00037	0.00067	0.0003											2.9		2.6	0.66 J			
	WC-MH01	0.0027	0.0019	0.0026	0.00057											0.33 J		0.43 J	0.043 J			0.016 J+
	WC-NB01	0.00065	0.0000054	0.000052	0.000024													0.0032 J				0.0098 J+
	WC-NB02		0.000038	0.00043	0.00014										0.0031 J	0.012	0.01 J	0.04 J	0.0032 J			0.01 J+
	WC-NB03	0.0015	0.000014	0.00014	0.000053										0.0023	0.0077	0.0039	0.033	0.0065			0.017 J-
	WC-SN01		0.0000085 J-	0.000045 J-	0.000039 J-										0.0037 J	0.024	0.0052 J	0.09 J	0.021			0.0097 J-
	WC-SW01		0.0036	0.039	0.018											0.56		0.12				
	WC-SW02		0.0012	0.0036	0.0011	0.066	0.0011	0.001				0.0012			0.37	14		7.9	3.8			
	WC-TA01		0.000021	0.00026	0.000069											0.0049 J+		0.008 J+	0.0044 J+			
	WC-TB01		0.000011	0.000082	0.000042											0.0061 J		0.0046	0.003			
	WC-TB02			0.000028	0.000013											0.0021						
	WC-TB03		0.000094	0.00075	0.00038											0.49		0.21				
	WC-TB04		0.0024	0.023	0.011											0.88		0.32	0.094			
	WC-TD01		0.000009	0.000086	0.00003											0.0034		0.0046	0.0036			
	WC-TE01		0.000012	0.00014	0.000047													0.0028				
	WC-TP01		0.000031	0.0051	0.00074				0.0051 J+	0.0061 J+												0.57 J
	WC-TP02		0.00016	0.0022	0.0007																	
	WC-TP03		0.000012	0.00042	0.000097																	
	WC-TP04		0.000036	0.0014	0.00033																	0.61 J
	WC-TP05		0.0000082	0.00041	0.000096																	
	WC-TP06		0.0000084	0.00038	0.000072																	
	WC-TP07			0.00082	0.00019																	0.22 J+
	WC-TP08		0.000057	0.0033	0.00083				0.0086 J+													0.83 J
	WC-TP09			0.00029	0.000075				0.0013	0.00083		0.00081 J-										0.097
	WC-TP10			0.0002	0.000059																	0.34 J+
	WC-TP11		0.0000052	0.000092	0.000023																	
	WC-TP12		0.0012	0.011	0.0039											0.006 J		0.006 J+				0.011 J+
	WC-TP13			0.00092	0.00012											0.0032 J+						0.31 J+
	WC-TP14		0.00018	0.011	0.0011																	0.097 J+
	WC-TP15			0.000023	0.0000058														0.01			3.8 J
	WC-TP16		0.000071	0.0012	0.00026											0.011 J+		0.0073 J+	0.0046 J+			1.5 J
	WC-TW01		0.000057	0.0013	0.00038										0.0029 J	0.006 J+			0.0036 J			0.024 J-
	WC-TW02		0.000044	0.0014	0.00035										0.0056 J+	0.0089 J		0.019 J+	0.003 J	0.53	0.38	0.075 J-
	WC-TW03		0.000016	0.00061	0.00013											0.0024 J+		0.0031 J+				
	WC-UP01		0.0037	0.032	0.013			0.00084 J-							0.41 J	5 B	0.35 J	6.3	0.18 J			0.012 J+
	WC-UP02		0.0022	0.01	0.0037	0.057		0.00057				0.0013			0.38	15		6.9	1.9			
	WC-UP03		0.0055	0.0073	0.0025			0.00075				0.0012				16		12	2.3			
	WC-UP04	0.00061	0.0035	0.0024	0.00064			0.00054							0.33 J	9.7 B	0.13 J	8.3	2.4			
	WC-UP05	0.00054	0.0001	0.00027	0.000089			0.00088 J-								7.7	0.05 J	5.4	0.48 J			0.0058 J+
	WC-UP-06		0.0015	0.00091	0.00021			0.00033								10		8.5	0.77 J			0.017 J+
	WC-UP07	0.00057	0.0045	0.00076	0.00024											9.2 B		6.7	2.8			0.0061 J+
Wastewater (mg/L)	UTS x 10													100								
	SW-12TP													0.024								

Table shows detects only.

Table C-3
Waste Characterization Sampling Summary Table
(Page 2 of 8)

	Sample	1,1,1-Trichloroethane	1,2,3,4,6,7,8-HpCDD	1,2,3,4,6,7,8-HpCDF	1,2,3,4,7,8,9-HpCDF	1,2,4,5-Tetrachlorobenzene	1,2,4-Trichlorobenzene	1,2-Dichlorobenzene	1,2-Dichloroethane	1,2-Dichloropropane	1,3-Dichlorobenzene	1,4-Dichlorobenzene	2,4,6-Trichlorophenol	2,4-D	2,4'-DDD	2,4'-DDE	4,4'-DDD	4,4'-DDE	4,4'-DDT	Acenaphthene	Acenaphthylene	Acetone
TCLP (mg/L)	UTS x 10																					
	WC-AD01																					
	WC-AD02																					
	WC-AD03																					
	WC-BD01																					
	WC-BD02																					
	WC-BD03																					
	WC-IM01																					
	WC-IM02																					
	WC-IM03																					
	WC-IM04																					
	WC-IM05																					
	WC-IM06																					
	WC-IM07																					
	WC-MH01																					
	WC-NB01																					
	WC-NB02																					
	WC-NB03																					
	WC-SN01																					
	WC-SW01																					
	WC-SW02																					
	WC-TA01																					
	WC-TB01																					
	WC-TB02																					
	WC-TB03																					
	WC-TB04																					
	WC-TD01																					
	WC-TE01																					
	WC-TP01																					
	WC-TP02																					
	WC-TP03																					
	WC-TP04																					
	WC-TP05																					
	WC-TP06																					
	WC-TP07																					
	WC-TP08																					
	WC-TP09																					
	WC-TP10																					
	WC-TP11																					
	WC-TP12																					
	WC-TP13																					
	WC-TP14																					
	WC-TP15																					
	WC-TP16																					
	WC-TW01																					
	WC-TW02																					
	WC-TW03																					
	WC-UP01																					
	WC-UP02																					
	WC-UP03																					
	WC-UP04																					
	WC-UP05																					
	WC-UP-06																					
	WC-UP07																					

Table shows detects only.

Table C-3
Waste Characterization Sampling Summary Table
(Page 3 of 8)

	Sample	Acetonitrile	Acetophenone	Aldrin	alpha-BHC	Anthracene	Arsenic	Barium	Benzene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(ghi)perylene	Benzo(k)fluoranthene	Beryllium	beta-BHC	Bromodichloromethane	Bromoform	Carbon tetrachloride	Chlorobenzene	Chlorodibromomethane	Chloroethane
Nonwastewater	UTS x 10	380	97	0.66	0.66	34			100	34	34	68	18	68		0.66	150	150	60	60	150	60
(mg/kg)	WC-AD01									0.035						0.0021 J+						
	WC-AD02																					
	WC-AD03																					
	WC-BD01									0.05												
	WC-BD02															0.0057 J						
	WC-BD03																					
	WC-IM01																					
	WC-IM02				0.4					0.037						0.19						
	WC-IM03																					
	WC-IM04									0.072						1.1				0.0017		
	WC-IM05																					
	WC-IM06				0.6					0.047						0.25						
	WC-IM07															0.033 J						
	WC-MH01															0.003 J			0.0044			
	WC-NB01															0.012						
	WC-NB02															0.022						
	WC-NB03															0.0084			0.0024			
	WC-SN01															0.0054						
	WC-SW01															0.042						
	WC-SW02									0.049												
	WC-TA01															0.0057 J+						
	WC-TB01															0.0092						
	WC-TB02															0.0027						
	WC-TB03															0.017						
	WC-TB04															0.093						
	WC-TD01															0.0041						
	WC-TE01															0.0068						
	WC-TP01	0.073 J							0.0017 J+							0.0058 J+	0.22 J+	0.13 J	0.095 J+		0.2 J	
	WC-TP02																0.052	0.14	0.015		0.069	
	WC-TP03																0.049	0.063	0.014		0.041	
	WC-TP04	0.15 J														0.0047 J+	0.032 J+	0.012 J	0.045 J+		0.033 J	0.02 J+
	WC-TP05																		0.013 J+			
	WC-TP06																0.034		0.031			
	WC-TP07	0.11 J															0.0063 J+		0.011 J+			
	WC-TP08																					0.04 J+
	WC-TP09	0.066 J															0.032		0.011		0.0099 J-	
	WC-TP10	0.03 J															0.0021 J+				0.0012 J+	
	WC-TP11																					
	WC-TP12															0.015 J+	0.011	0.012			0.011	
	WC-TP13	0.035 J															0.0038	0.002				
	WC-TP14															0.0052 J+						
	WC-TP15																					
	WC-TP16	0.078 J																				
	WC-TW01															0.02 J						
	WC-TW02		0.068		0.0034 J+	2.8				5.8	4.1	4.3	2.1	3.8		0.016 J+						
	WC-TW03																					
	WC-UP01			0.004 J												0.065 J						
	WC-UP02									0.052												
	WC-UP03									0.043												
	WC-UP04									0.036						0.065 J						
	WC-UP05															0.022 J						
	WC-UP-06				0.0033 J											0.026 J-						
	WC-UP07				0.0037 J											0.033 J						
Wastewater	UTS x 10						14	12							8.2			150			150	
(mg/L)	SW-12TP						0.0263 J-	3.36 J							0.0076 BJ			0.0019			0.0021	

Table shows detects only.

Table C-3
Waste Characterization Sampling Summary Table
(Page 4 of 8)

	Sample	Acetonitrile	Acetophenone	Aldrin	alpha-BHC	Anthracene	Arsenic	Barium	Benzene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(ghi)perylene	Benzo(k)fluoranthene	Beryllium	beta-BHC	Bromodichloromethane	Bromoform	Carbon tetrachloride	Chlorobenzene	Chlorodibromomethane	Chloroethane
TCLP (mg/L)	UTS x 10						50	210							12.2							
	WC-AD01							0.526														
	WC-AD02							0.605														
	WC-AD03							0.656														
	WC-BD01							1							0.0125 B							
	WC-BD02							1.64														
	WC-BD03							0.639														
	WC-IM01							0.685														
	WC-IM02							0.633														
	WC-IM03							0.476														
	WC-IM04							0.262							0.0125 B							
	WC-IM05							0.95														
	WC-IM06							0.853														
	WC-IM07							0.704														
	WC-MH01							2.59							0.0125 B							
	WC-NB01						0.178	0.137							0.0125 B							
	WC-NB02						0.259	0.167							0.0125 B							
	WC-NB03						0.128	0.275							0.0125 B							
	WC-SN01							0.432							0.0125 B							
	WC-SW01							0.177														
	WC-SW02							0.227														
	WC-TA01							0.278							0.0125 B							
	WC-TB01							0.433							0.0125 B							
	WC-TB02							0.788							0.0125 B							
	WC-TB03							1.27							0.0125 B							
	WC-TB04							0.851							0.0125 B							
	WC-TD01							0.71														
	WC-TE01							0.723														
	WC-TP01							0.113							0.0125 B							
	WC-TP02							0.0178							0.0125 B							
	WC-TP03							0.082							0.0125 B							
	WC-TP04							0.246							0.0125 B							
	WC-TP05							0.0537														
	WC-TP06							0.209														
	WC-TP07							0.823							0.0125 B							
	WC-TP08							0.671							0.0125 B							
	WC-TP09							0.42							0.0125 B							
	WC-TP10							0.799							0.0125 B							
	WC-TP11							0.306							0.0125 B							
	WC-TP12							0.134							0.0125 B							
	WC-TP13							0.0919														
	WC-TP14														0.0125 B							
	WC-TP15							0.165							0.0125 B							
	WC-TP16							0.0934							0.0125 B							
	WC-TW01							0.152							0.0125 B							
	WC-TW02							0.149							0.0125 B							
	WC-TW03							0.378														
	WC-UP01							0.221														
	WC-UP02							0.411														
	WC-UP03							0.388														
	WC-UP04							0.631														
	WC-UP05							0.948							0.0125 B							
	WC-UP-06							0.552														
	WC-UP07							0.499														

Table shows detects only.

Table C-3
Waste Characterization Sampling Summary Table
(Page 5 of 8)

	Sample	Chloroform	Chloromethane	Chromium	Chrysene	Cyanide, Total	delta-BHC	Dibenz(a,h)anthracene	Dieldrin	Di-n-butyl phthalate	Di-n-octyl phthalate	Endosulfan I	Endosulfan II	Endrin aldehyde	Fluoranthene	Fluorene	Fluoride	gamma-BHC (Lindane)	gamma-Chlordane	Hexachlorobenzene	Hexachlorobutadiene	Indeno(1,2,3-cd)pyrene
Nonwastewater	UTS x 10	60	300		34	5900	0.66	82	1.3	280	280	0.66	1.3	1.3	34	34		0.66	160	100	56	34
(mg/kg)	WC-AD01				0.035										0.065				0.0022 J+			
	WC-AD02																					
	WC-AD03																					
	WC-BD01				0.14				0.28 J						0.18					1.1		
	WC-BD02																		0.0024 J	0.16		
	WC-BD03																					
	WC-IM01																			1.2		
	WC-IM02				0.037															1.5		
	WC-IM03																			1		
	WC-IM04				0.2	0.66									0.32					19 J		0.044
	WC-IM05												0.019 J							0.052		
	WC-IM06				0.049										0.071			0.39		1.2		
	WC-IM07												0.049 J							0.47		
	WC-MH01									0.036		0.0031 J										
	WC-NB01																					
	WC-NB02						0.0074							0.0021 J								
	WC-NB03																					
	WC-SN01													0.002 J								
	WC-SW01					0.36														0.54		
	WC-SW02				0.096	0.87							0.46 J		0.11					0.66		
	WC-TA01										1.6											
	WC-TB01														0.036							
	WC-TB02																					
	WC-TB03																			0.16		
	WC-TB04																			4.5		
	WC-TD01				0.036																	
	WC-TE01																					
	WC-TP01	4.8 J	0.0059 J+																	1.2		
	WC-TP02	0.62																		0.066		
	WC-TP03	0.46																		0.088		
	WC-TP04	5.2 J	0.029 J+																	2.3		
	WC-TP05	2.3 J																		0.3		
	WC-TP06	0.83																		0.38		
	WC-TP07	1.4 J	0.015 J+			3.8														1.9		
	WC-TP08	0.033 J+	0.036 J+																	4.1		
	WC-TP09	0.9 J																		0.63		
	WC-TP10	0.15 J+				2.7														0.21		
	WC-TP11	0.037				1.8														0.12		
	WC-TP12	0.0072	0.0064																	0.41		
	WC-TP13	0.035				12.7														0.45		
	WC-TP14	0.0014																		1.5		
	WC-TP15	0.1				2.1																
	WC-TP16	0.016	0.0038			0.95																
	WC-TW01	0.016																		10	0.076	
	WC-TW02	0.0027 J-			5.3	0.29		0.94				0.018 J+		0.0043 J	16 J	1.3				12 J	0.074	2.2
	WC-TW03																			0.087		
	WC-UP01	0.00021			0.061							0.0084 J			0.07				0.0089 J	1.1		
	WC-UP02				0.11	0.87							0.25 J		0.2					1.8		
	WC-UP03				0.14	1.7							0.41 J		0.19					1.1		
	WC-UP04				0.13	0.68						0.019 J			0.17					1.1		
	WC-UP05				0.091							0.045 J			0.2					0.56		
	WC-UP-06				0.089	0.55						0.054 J			0.13					0.35		
	WC-UP07	0.00027			0.1	0.42						0.096 J			0.14					0.37		
Wastewater	UTS x 10	0.46	1.9	27.7		12											350					
(mg/L)	SW-12TP	0.0093	0.0016	0.29 J-		0.0152											41.4 J					

Table shows detects only.

Table C-3
Waste Characterization Sampling Summary Table
(Page 6 of 8)

	Sample	Chloroform	Chloromethane	Chromium	Chrysene	Cyanide, Total	delta-BHC	Dibenz(a,h)anthracene	Dieldrin	Di-n-butyl phthalate	Di-n-octyl phthalate	Endosulfan I	Endosulfan II	Endrin aldehyde	Fluoranthene	Fluorene	Fluoride	gamma-BHC (Lindane)	gamma-Chlordane	Hexachlorobenzene	Hexachlorobutadiene	Indeno(1,2,3-cd)pyrene
TCLP (mg/L)	UTS x 10			6																		
	WC-AD01			0.019																		
	WC-AD02																					
	WC-AD03																					
	WC-BD01			0.0381																		
	WC-BD02			0.0213																		
	WC-BD03																					
	WC-IM01			0.0105																		
	WC-IM02			0.0291																		
	WC-IM03																					
	WC-IM04			0.107																		
	WC-IM05			0.0254																		
	WC-IM06			0.107																		
	WC-IM07			0.0207																		
	WC-MH01			0.145																		
	WC-NB01																					
	WC-NB02																					
	WC-NB03																					
	WC-SN01																					
	WC-SW01			0.11																		
	WC-SW02			0.198																		
	WC-TA01																					
	WC-TB01																					
	WC-TB02																					
	WC-TB03																					
	WC-TB04			0.0614																		
	WC-TD01																					
	WC-TE01																					
	WC-TP01			2.94																		
	WC-TP02			0.181																		
	WC-TP03			0.0083																		
	WC-TP04																					
	WC-TP05			0.0334																		
	WC-TP06			0.0128																		
	WC-TP07			0.0881																		
	WC-TP08			0.0842																		
	WC-TP09			0.189																		
	WC-TP10			0.0807																		
	WC-TP11			0.0648																		
	WC-TP12			0.136																		
	WC-TP13			0.0129																		
	WC-TP14			0.0183																		
	WC-TP15			0.0139																		
	WC-TP16			0.0254																		
	WC-TW01			0.0653																		
	WC-TW02			0.0373																		
	WC-TW03																					
	WC-UP01			0.115																		
	WC-UP02			0.246																		
	WC-UP03			0.756																		
	WC-UP04			0.251																		
	WC-UP05			0.727																		
	WC-UP-06			0.773																		
	WC-UP07			1.01																		

Table shows detects only.

Table C-3
Waste Characterization Sampling Summary Table
(Page 7 of 8)

	Sample	Lead	Mercury	Methoxychlor	Methyl ethyl ketone	Methylene chloride	Naphthalene	Nickel	OCDD	OCDF	Pentachlorobenzene	Perchlorate	Phenanthrene	Phthalic acid	Pyrene	Tetrachloroethylene	Thallium	Toluene	Trichloroethene	Vanadium	Xylenes (total)	Zinc
Nonwastewater	UTS x 10			1.8	360	300	56		0.05	0.05	100	(blank)	56	280	82	60		100	60		300	
(mg/kg)	WC-AD01					0.006 B			0.00017	0.0014			0.064		0.061							
	WC-AD02					0.0059 B			0.000032	0.00029												
	WC-AD03					0.0058 B			0.000049	0.00033												
	WC-BD01					0.0081 B			0.016	0.014	0.15		0.19		0.074				0.0069			
	WC-BD02			0.011 J					0.000089	0.0034									0.00059			
	WC-BD03								0.0000068	0.0002												
	WC-IM01					0.0068 B			0.00034	0.0051	1.4											
	WC-IM02					0.0055 B			0.00063	0.017	1.5											
	WC-IM03					0.0054 B			0.00036	0.0097	0.96											
	WC-IM04					0.014 B			0.077 J+	1.7 J	2.1		0.24		0.14			0.0053 B	0.016			
	WC-IM05					0.0052 B			0.00045	0.0033												
	WC-IM06					0.0052 B			0.00058	0.0055	1.2											
	WC-IM07			0.31 J		0.0054 B			0.0012	0.0026	0.2											
	WC-MH01				0.003	0.0076			0.0031	0.041								0.0017	0.0066			
	WC-NB01				0.0032					0.000072									0.0018			
	WC-NB02				0.0031				0.000053	0.00077												
	WC-NB03				0.0023	0.0095 B			0.000017	0.00026						0.0022		0.0051 B				
	WC-SN01					0.0052 B			0.0000087 J-	0.000077 J-												
	WC-SW01					0.0084 BJ			0.0037	0.14				0.082								
	WC-SW02					0.012 BJ			0.0051	0.033	0.24		0.1		0.062							
	WC-TA01			0.034 J		0.0091 BJ			0.000063	0.0038				0.13 J+								
	WC-TB01								0.000042	0.00033												
	WC-TB02								0.0000058	0.00011												
	WC-TB03			0.036 J					0.00015	0.0081									0.00074			
	WC-TB04								0.0019	0.087	0.59								0.0017			
	WC-TD01					0.0087 BJ			0.000026	0.00028				0.084								
	WC-TE01					0.0088 BJ			0.000023	0.00046												
	WC-TP01				0.059 J+				0.00068	0.083	0.058					0.0066 J		0.0082 J			0.007 J	
	WC-TP02					0.073 B			0.00032	0.037												
	WC-TP03					0.051 B			0.000097	0.02						0.0025						
	WC-TP04								0.0005	0.052	0.17					0.0035 J						
	WC-TP05			0.012 J+		0.065 BJ			0.00021	0.035												
	WC-TP06					0.058 B			0.00019	0.029												
	WC-TP07				0.037 J+	0.0065 J+			0.00029	0.018	0.098								0.001 J+			
	WC-TP08				0.12 J+				0.0016	0.1	0.2					0.014 J						
	WC-TP09				0.011	0.017 B			0.00012	0.029						0.0042 J-		0.0086 BJ				
	WC-TP10				0.014 J+				0.0001	0.025						0.0022 J+						
	WC-TP11			0.022 J+					0.00005	0.0053												
	WC-TP12								0.0011	0.042	0.055											
	WC-TP13				0.011				0.0001	0.033		2.81										
	WC-TP14				0.019				0.0052	0.16		0.274										
	WC-TP15					0.036 B			0.0000083	0.00015		1.69										
	WC-TP16				0.016				0.00014	0.01		1.87										
	WC-TW01					0.017 BJ			0.00076	0.047	0.26		0.058									
	WC-TW02				0.0096 J-	0.015 BJ	2.1		0.00056	0.063	0.26		18 J		10 J							
	WC-TW03								0.000076	0.018												
	WC-UP01			0.49 J					0.0071	0.15 J+	0.052		0.054		0.05	0.00039						
	WC-UP02					0.008 BJ			0.0076	0.052	0.28		0.13		0.083							
	WC-UP03					0.012 BJ			0.017 J+	0.15 J+	0.078		0.099		0.078				0.0018			
	WC-UP04					0.003			0.011	0.045 J+	0.15		0.12		0.081				0.0045			
	WC-UP05				0.002				0.00018	0.0013	0.079		0.1		0.1				0.0025			
	WC-UP-06								0.0025	0.014	0.097		0.12		0.059				0.00072			
	WC-UP07								0.0064	0.0099	0.18		0.11		0.051			0.0011	0.0039			
Wastewater	UTS x 10	6.9	1.5			0.89		39.8		0.00063							14			43		26.1
(mg/L)	SW-12TP	0.341 J-	0.0034			0.003		1.69 J		0.000089							0.2 BJ			0.717 J		4.66

Table shows detects only.

Table C-3
Waste Characterization Sampling Summary Table
(Page 8 of 8)

	Sample	Lead	Mercury	Methoxychlor	Methyl ethyl ketone	Methylene chloride	Naphthalene	Nickel	OCDD	OCDF	Pentachlorobenzene	Perchlorate	Phenanthrene	Phthalic acid	Pyrene	Tetrachloroethylene	Thallium	Toluene	Trichloroethene	Vanadium	Xylenes (total)	Zinc
TCLP	UTS x 10	7.5	0.25					110												16		43
(mg/L)	WC-AD01							0.0331												0.152		0.0246
	WC-AD02																			0.0334		
	WC-AD03	0.122																		0.021		
	WC-BD01																			0.223		
	WC-BD02																			0.125 B		
	WC-BD03																			0.125 B		
	WC-IM01																			0.234		
	WC-IM02																			0.133		
	WC-IM03																			0.112		
	WC-IM04																			0.367		0.0243
	WC-IM05							0.0447												0.44		
	WC-IM06							0.0595												0.6		
	WC-IM07							0.0365												0.054		
	WC-MH01							0.0879												0.22		0.101
	WC-NB01																			0.07		
	WC-NB02																			0.0604		
	WC-NB03																			0.0234		
	WC-SN01																					
	WC-SW01							0.191												0.259		0.0784
	WC-SW02							0.142												0.414		
	WC-TA01							0.13												0.186		
	WC-TB01	0.229																		0.18		
	WC-TB02																			0.125 B		
	WC-TB03																			0.22		
	WC-TB04																			0.152		
	WC-TD01																			0.0574		0.0368
	WC-TE01																					
	WC-TP01							0.944												0.0612		0.0761 B
	WC-TP02																			1.94		
	WC-TP03							0.179												0.148		
	WC-TP04							1.53												0.43		0.05 B
	WC-TP05																			0.199		
	WC-TP06							1.43												0.107		0.116
	WC-TP07							2												0.148		0.108
	WC-TP08							5.76												0.112		0.295
	WC-TP09	0.0817	0.00063					2.36												0.128		0.224
	WC-TP10	0.0834						3.08												0.0445		0.239
	WC-TP11							2.23												0.037		0.103
	WC-TP12							0.37												0.0386		0.131
	WC-TP13							0.131														
	WC-TP14							0.0194												0.117		
	WC-TP15							0.202														0.0538
	WC-TP16							0.135														
	WC-TW01																			0.948		
	WC-TW02																			0.335		
	WC-TW03																			0.125 B		
	WC-UP01							0.326												0.289		0.0555
	WC-UP02							0.0478												0.415		0.069
	WC-UP03							0.0396												0.78		
	WC-UP04							0.045												0.472		
	WC-UP05							0.0619												0.308		0.0285
	WC-UP-06							0.0893												0.418		0.0307
	WC-UP07							0.05												0.35		

Table shows detects only.

TABLE C-4
COMPARISON OF DETECTED CHEMICAL CONCENTRATIONS WITH UTS LEVELS
(Page 1 of 7)

Category	Analytical Method	Site-Related Chemical	CAS No.	Minimum Detect	Maximum Detect	UTS x 10	Maximum > UTSx10?	Carcinogen?	10^{-3} Cancer PRG[1]	Risk > 10^{-3}?	Non-Cancer PRG × $10^{(2)}$	Risk > PRG × 10 ?
Nonwastewater (mg/kg)	E314.0	Perchlorate	14797-73-0	0.274	2.81	--	--	--	--	--	--	--
	E335.4	Cyanide, Total	57-12-5	0.29	12.7	5900	NO	--	--	--	--	--
	SW8081	2,4'-DDD	53-19-0	0.0023	0.82	0.87	NO	--	--	--	--	--
		2,4'-DDE	3424-82-6	0.0018	16	0.87	YES	YES	1883	NO	--	--
		4,4'-DDD	72-54-8	0.0039	1.6	0.87	YES	YES	2668	NO	--	--
		4,4'-DDE	72-55-9	0.0025	16	0.87	YES	YES	1883	NO	--	--
		4,4'-DDT	50-29-3	0.003	7	0.87	YES	YES	1883	NO	391	NO
		Aldrin	309-00-2	0.004	0.004	0.66	NO	--	--	--	--	--
		alpha-BHC	319-84-6	0.0033	0.6	0.66	NO	--	--	--	--	--
		alpha-Chlordane	5103-71-9	< 0.00012	< 0.015	160	NO	--	--	--	--	--
		beta-BHC	319-85-7	0.002	1.1	0.66	YES	YES	356	NO	156	NO
		delta-BHC	319-86-8	0.0074	0.0074	0.66	NO	--	--	--	--	--
		Dieldrin	60-57-1	0.28	0.28	1.3	NO	--	--	--	--	--
		Endosulfan I	959-98-8	0.0031	0.11	0.66	NO	--	--	--	--	--
		Endosulfan II	33213-65-9	0.019	0.46	1.3	NO	--	--	--	--	--
		Endosulfan sulfate	1031-07-8	< 0.00023	< 0.029	1.3	NO	--	--	--	--	--
		Endrin	72-20-8	< 0.0002	< 0.024	1.3	NO	--	--	--	--	--
		Endrin aldehyde	7421-93-4	0.002	0.0043	1.3	NO	--	--	--	--	--
		gamma-BHC (Lindane)	58-89-9	0.39	0.39	0.66	NO	--	--	--	--	--
		gamma-Chlordane	5103-74-2	0.0022	0.0089	160	NO	--	--	--	--	--
		Heptachlor	76-44-8	< 0.0001	< 0.012	0.66	NO	--	--	--	--	--
		Heptachlor epoxide	1024-57-3	< 0.00014	< 0.017	0.66	NO	--	--	--	--	--
		Methoxychlor	72-43-5	0.011	0.49	1.8	NO	--	--	--	--	--
		Toxaphene	8001-35-2	< 0.0066	< 6.8	26	NO	--	--	--	--	--
	SW8082	PCBs (total)	1336-36-3	< 0.0093	< 0.47	100	NO	--	--	--	--	--
	SW8141	Disulfoton	298-04-4	< 0.0078	< 0.025	62	NO	--	--	--	--	--
		Famphur	52-85-7	< 0.0032	< 0.01	150	NO	--	--	--	--	--
		Methyl parathion	298-00-0	< 0.0064	< 0.02	46	NO	--	--	--	--	--
		Parathion	56-38-2	< 0.0053	< 0.017	46	NO	--	--	--	--	--
		Phorate	298-02-2	< 0.0057	< 0.018	46	NO	--	--	--	--	--
	SW8151	2,4,5-T	93-76-5	< 0.005	< 0.016	79	NO	--	--	--	--	--
		2,4,5-TP (Silvex)	93-72-1	< 0.0033	< 0.01	79	NO	--	--	--	--	--
Nonwastewater (mg/kg)		2,4-D	94-75-7	< 0.029	< 0.094	100	NO	--	--	--	--	--
		Dinoseb	88-85-7	< 0.006	< 0.019	25	NO	--	--	--	--	--
	SW8260	1,1,1,2-Tetrachloroethane	630-20-6	< 0.00023	< 0.055	60	NO	--	--	--	--	--
		1,1,1-Trichloroethane	71-55-6	0.00054	0.0027	60	NO	--	--	--	--	--
		1,1,2,2-Tetrachloroethane	79-34-5	< 0.00014	< 0.019	60	NO	--	--	--	--	--
		1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	< 0.00054	< 0.061	300	NO	--	--	--	--	--
		1,1,2-Trichloroethane	79-00-5	< 0.00028	< 0.077	60	NO	--	--	--	--	--
		1,1-Dichloroethane	75-34-3	< 0.00096	< 0.1	60	NO	--	--	--	--	--
		1,1-Dichloroethene	75-35-4	< 0.00055	< 0.083	60	NO	--	--	--	--	--
		1,2,3-Trichloropropane	96-18-4	< 0.00056	< 0.16	300	NO	--	--	--	--	--
		1,2,4-Trichlorobenzene	120-82-1	0.0011	0.0051	190	NO	--	--	--	--	--
		1,2-Dibromo-3-chloropropane	96-12-8	< 0.0009	< 0.1	150	NO	--	--	--	--	--
		1,2-Dichlorobenzene	95-50-1	0.00033	0.0032	60	NO	--	--	--	--	--
		1,2-Dichloroethane	107-06-2	0.0013	0.0086	60	NO	--	--	--	--	--
		1,2-Dichloropropane	78-87-5	0.00083	0.0061	180	NO	--	--	--	--	--
		1,3-Dichlorobenzene	541-73-1	0.00047	0.00047	60	NO	--	--	--	--	--
		1,4-Dichlorobenzene	106-46-7	0.00045	0.0038	60	NO	--	--	--	--	--
		Acetone	67-64-1	0.0058	3.8	1600	NO	--	--	--	--	--

TABLE C-4
COMPARISON OF DETECTED CHEMICAL CONCENTRATIONS WITH UTS LEVELS
(Page 2 of 7)

Category	Analytical Method	Site-Related Chemical	CAS No.	Minimum Detect	Maximum Detect	UTS x 10	Maximum > UTSx10?	Carcinogen?	10^{-3} Cancer PRG[1]	Risk > 10^{-3}?	Non-Cancer PRG × 10[2]	Risk > PRG × 10 ?
Nonwastewater (mg/kg)		Acetonitrile	75-05-8	0.03	0.15	380	NO	--	--	--	--	--
		Benzene	71-43-2	0.0017	0.0017	100	NO	--	--	--	--	--
		Bromodichloromethane	75-27-4	0.0021	0.22	150	NO	--	--	--	--	--
		Bromoform	75-25-2	0.002	0.14	150	NO	--	--	--	--	--
		Bromomethane	74-83-9	< 0.00031	< 0.088	150	NO	--	--	--	--	--
		Carbon tetrachloride	56-23-5	0.0024	0.095	60	NO	--	--	--	--	--
		Chlorobenzene	108-90-7	0.0017	0.0017	60	NO	--	--	--	--	--
		Chlorodibromomethane	124-48-1	0.0012	0.2	150	NO	--	--	--	--	--
		Chloroethane	75-00-3	0.02	0.04	60	NO	--	--	--	--	--
		Chloroform	67-66-3	0.00021	5.2	60	NO	--	--	--	--	--
		Chloromethane	74-87-3	0.0038	0.036	300	NO	--	--	--	--	--
		cis-1,3-Dichloropropene	10061-01-5	< 0.00073	< 0.019	180	NO	--	--	--	--	--
		Dibromomethane	74-95-3	< 0.00035	< 0.055	150	NO	--	--	--	--	--
		Dichlorodifluoromethane	75-71-8	< 0.00038	< 0.098	72	NO	--	--	--	--	--
		Ethylbenzene	100-41-4	< 0.00019	< 0.069	100	NO	--	--	--	--	--
		Iodomethane	74-88-4	< 0.00026	< 0.13	650	NO	--	--	--	--	--
		Methyl ethyl ketone	78-93-3	0.002	0.12	360	NO	--	--	--	--	--
		Methyl isobutyl ketone	108-10-1	< 0.0016	< 0.07	330	NO	--	--	--	--	--
		Methylene chloride	75-09-2	0.003	0.073	300	NO	--	--	--	--	--
		Tetrachloroethylene	127-18-4	0.00039	0.014	60	NO	--	--	--	--	--
		Toluene	108-88-3	0.0011	0.0086	100	NO	--	--	--	--	--
		trans-1,2-Dichloroethene	156-60-5	< 0.00022	< 0.12	300	NO	--	--	--	--	--
		trans-1,3-Dichloropropylene	10061-02-6	< 0.0002	< 0.12	180	NO	--	--	--	--	--
		Trichloroethene	79-01-6	0.00059	0.016	60	NO	--	--	--	--	--
		Trichlorofluoromethane	75-69-4	< 0.00051	< 0.067	300	NO	--	--	--	--	--
		Vinyl chloride	75-01-4	< 0.00024	< 0.19	60	NO	--	--	--	--	--
		Xylenes (total)	1330-20-7	0.007	0.007	300	NO	--	--	--	--	--
	SW8270	1,2,4,5-Tetrachlorobenzene	95-94-3	0.039	0.26	140	NO	--	--	--	--	--
		1,4-Dioxane	123-91-1	< 0.034	< 0.11	1700	NO	--	--	--	--	--
		2,4,5-Trichlorophenol	95-95-4	< 0.034	< 0.11	74	NO	--	--	--	--	--
		2,4,6-Trichlorophenol	88-06-2	0.087	0.087	74	NO	--	--	--	--	--
		2,4-Dichlorophenol	120-83-2	< 0.034	< 0.11	140	NO	--	--	--	--	--
		2,4-Dimethylphenol	105-67-9	< 0.034	< 0.11	140	NO	--	--	--	--	--
		2,4-Dinitrophenol	51-28-5	< 0.33	< 1.1	1600	NO	--	--	--	--	--
		2,4-Dinitrotoluene	121-14-2	< 0.034	< 0.11	1400	NO	--	--	--	--	--
		2,6-Dinitrotoluene	606-20-2	< 0.034	< 0.11	280	NO	--	--	--	--	--
		2-Chloronaphthalene	91-58-7	< 0.034	< 0.11	56	NO	--	--	--	--	--
		2-Chlorophenol	95-57-8	< 0.034	< 0.11	57	NO	--	--	--	--	--
		2-Methylphenol	95-48-7	< 0.034	< 0.38	56	NO	--	--	--	--	--
		2-Nitroaniline	88-74-4	< 0.034	< 0.11	140	NO	--	--	--	--	--
		2-Nitrophenol	88-75-5	< 0.034	< 0.11	130	NO	--	--	--	--	--
		4-Bromophenyl phenyl ether	101-55-3	< 0.034	< 0.11	150	NO	--	--	--	--	--
		4-Chloro-3-methylphenol	59-50-7	< 0.034	< 0.11	140	NO	--	--	--	--	--
		4-Chloroaniline	106-47-8	< 0.034	< 0.11	160	NO	--	--	--	--	--
		4-Nitroaniline	100-01-6	< 0.33	< 1.1	280	NO	--	--	--	--	--
		4-Nitrophenol	100-02-7	< 0.33	< 1.1	290	NO	--	--	--	--	--
		Acenaphthene	83-32-9	0.53	0.53	34	NO	--	--	--	--	--
		Acenaphthylene	208-96-8	0.38	0.38	34	NO	--	--	--	--	--
		Acetophenone	98-86-2	0.068	0.068	97	NO	--	--	--	--	--
		Aniline	62-53-3	< 0.034	< 0.11	140	NO	--	--	--	--	--

TABLE C-4
COMPARISON OF DETECTED CHEMICAL CONCENTRATIONS WITH UTS LEVELS
(Page 3 of 7)

Category	Analytical Method	Site-Related Chemical	CAS No.	Minimum Detect	Maximum Detect	UTS x 10	Maximum > UTSx10?	Carcinogen?	10^{-3} Cancer PRG[1]	Risk > 10^{-3}?	Non-Cancer PRG × $10^{(2)}$	Risk > PRG × 10 ?
Nonwastewater (mg/kg)		Anthracene	120-12-7	2.8	2.8	34	NO	--	--	--	--	--
		Benzo(a)anthracene	56-55-3	0.035	5.8	34	NO	--	--	--	--	--
		Benzo(a)pyrene	50-32-8	4.1	4.1	34	NO	--	--	--	--	--
		Benzo(b)fluoranthene	205-99-2	4.3	4.3	68	NO	--	--	--	--	--
		Benzo(ghi)perylene	191-24-2	2.1	2.1	18	NO	--	--	--	--	--
		Benzo(k)fluoranthene	207-08-9	3.8	3.8	68	NO	--	--	--	--	--
		bis(2-Chloroethoxy)methane	111-91-1	< 0.034	< 0.11	72	NO	--	--	--	--	--
		bis(2-Chloroethyl) ether	111-44-4	< 0.034	< 0.11	60	NO	--	--	--	--	--
		bis(2-Chloroisopropyl) ether	108-60-1	< 0.034	< 0.11	72	NO	--	--	--	--	--
		Butyl benzyl phthalate	85-68-7	< 0.034	< 0.11	280	NO	--	--	--	--	--
		Chrysene	218-01-9	0.035	5.3	34	NO	--	--	--	--	--
		Dibenz(a,h)anthracene	53-70-3	0.94	0.94	82	NO	--	--	--	--	--
		Diethyl phthalate	84-66-2	< 0.034	< 0.11	280	NO	--	--	--	--	--
		Dimethyl phthalate	131-11-3	< 0.034	< 0.11	280	NO	--	--	--	--	--
		Di-n-butyl phthalate	84-74-2	0.036	0.036	280	NO	--	--	--	--	--
		Di-n-octyl phthalate	117-84-0	1.6	1.6	280	NO	--	--	--	--	--
		Fluoranthene	206-44-0	0.036	16	34	NO	--	--	--	--	--
		Fluorene	86-73-7	1.3	1.3	34	NO	--	--	--	--	--
		Hexachlorobenzene	118-74-1	0.052	20	100	NO	--	--	--	--	--
		Hexachlorobutadiene	87-68-3	0.074	0.076	56	NO	--	--	--	--	--
		Hexachlorocyclopentadiene	77-47-4	< 0.33	< 1.1	24	NO	--	--	--	--	--
		Hexachloroethane	67-72-1	< 0.034	< 0.11	300	NO	--	--	--	--	--
		Indeno(1,2,3-cd)pyrene	193-39-5	0.044	2.2	34	NO	--	--	--	--	--
		Naphthalene	91-20-3	2.1	2.1	56	NO	--	--	--	--	--
		Nitrobenzene	98-95-3	< 0.034	< 0.11	140	NO	--	--	--	--	--
		N-Nitrosodi-n-propylamine	621-64-7	< 0.034	< 0.11	140	NO	--	--	--	--	--
		N-Nitrosodiphenylamine	86-30-6	< 0.034	< 0.11	130	NO	--	--	--	--	--
		Pentachlorobenzene	608-93-5	0.052	2.1	100	NO	--	--	--	--	--
		Pentachlorophenol	87-86-5	< 0.33	< 1.1	74	NO	--	--	--	--	--
		Phenanthrene	85-01-8	0.054	18	56	NO	--	--	--	--	--
		Phenol	108-95-2	< 0.034	< 0.11	62	NO	--	--	--	--	--
		Phthalic acid	88-99-3	0.082	0.13	280	NO	--	--	--	--	--
		Pyrene	129-00-0	0.05	10	82	NO	--	--	--	--	--
		Pyridine	110-86-1	< 0.034	< 0.41	160	NO	--	--	--	--	--
	SW8290	1,2,3,4,6,7,8-HpCDD	35822-46-9	0.0000052	0.068	0.025	YES	YES	0.43	NO	--	--
		1,2,3,4,6,7,8-HpCDF	67562-39-4	0.000023	0.42	0.025	YES	YES	0.43	NO	--	--
		1,2,3,4,7,8,9-HpCDF	55673-89-7	0.0000058	0.16	0.025	YES	YES	0.43	NO	--	--
		OCDD	OCDD	0.0000058	0.077	0.05	YES	YES	43	NO	--	--
		OCDF	OCDF	0.000072	1.7	0.05	YES	YES	43	NO	--	--
Wastewater (mg/L)	E300	Fluoride	16984-48-8	41.4	41.4	350	NO	--	--	--	--	--
	E335.4	Cyanide, Total	57-12-5	0.0152	0.0152	12	NO	--	--	--	--	--
	E376.1	Total Sulfide	18496-25-8	< 0.31	< 0.31	140	NO	--	--	--	--	--
	SW6010	Antimony	7440-36-0	< 0.002604	< 0.002604	19	NO	--	--	--	--	--
		Arsenic	7440-38-2	0.0263	0.0263	14	NO	--	--	--	--	--
		Barium	7440-39-3	3.36	3.36	12	NO	--	--	--	--	--
		Beryllium	7440-41-7	0.0076	0.0076	8.2	NO	--	--	--	--	--
		Cadmium	7440-43-9	< 0.0005	< 0.0005	6.9	NO	--	--	--	--	--
		Chromium	7440-47-3	0.29	0.29	27.7	NO	--	--	--	--	--
		Lead	7439-92-1	0.341	0.341	6.9	NO	--	--	--	--	--
		Nickel	7440-02-0	1.69	1.69	39.8	NO	--	--	--	--	--

TABLE C-4
COMPARISON OF DETECTED CHEMICAL CONCENTRATIONS WITH UTS LEVELS
(Page 4 of 7)

Category	Analytical Method	Site-Related Chemical	CAS No.	Minimum Detect	Maximum Detect	UTS x 10	Maximum > UTSx10?	Carcinogen?	10^{-3} Cancer PRG[1]	Risk > 10^{-3}?	Non-Cancer PRG × $10^{(2)}$	Risk > PRG × 10 ?
Wastewater (mg/L)		Selenium	7782-49-2	< 0.003222	< 0.003222	8.2	NO	--	--	--	--	--
		Silver	7440-22-4	< 0.05209	< 0.05209	4.3	NO	--	--	--	--	--
		Thallium	7440-28-0	0.2	0.2	14	NO	--	--	--	--	--
		Vanadium	7440-62-2	0.717	0.717	43	NO	--	--	--	--	--
		Zinc	7440-66-6	4.66	4.66	26.1	NO	--	--	--	--	--
	SW7470	Mercury	7439-97-6	0.0034	0.0034	1.5	NO	--	--	--	--	--
	SW8015	Methanol	67-56-1	< 0.81	< 0.81	56	NO	--	--	--	--	--
	SW8081	2,4'-DDD	53-19-0	< 0.0000056	< 0.0000056	0.23	NO	--	--	--	--	--
		2,4'-DDE	3424-82-6	< 0.000013	< 0.000013	0.31	NO	--	--	--	--	--
		4,4'-DDD	72-54-8	< 0.000004	< 0.000004	0.23	NO	--	--	--	--	--
		4,4'-DDE	72-55-9	< 0.0000082	< 0.0000082	0.31	NO	--	--	--	--	--
		4,4'-DDT	50-29-3	< 0.000032	< 0.000032	0.039	NO	--	--	--	--	--
		Aldrin	309-00-2	< 0.0000052	< 0.0000052	0.21	NO	--	--	--	--	--
		alpha-BHC	319-84-6	< 0.000018	< 0.000018	0.0014	NO	--	--	--	--	--
		alpha-Chlordane	5103-71-9	< 0.0000065	< 0.0000065	0.033	NO	--	--	--	--	--
		beta-BHC	319-85-7	< 0.0000072	< 0.0000072	0.0014	NO	--	--	--	--	--
		delta-BHC	319-86-8	< 0.0000034	< 0.0000034	0.23	NO	--	--	--	--	--
		Dieldrin	60-57-1	< 0.000011	< 0.000011	0.17	NO	--	--	--	--	--
		Endosulfan I	959-98-8	< 0.0000061	< 0.0000061	0.23	NO	--	--	--	--	--
		Endosulfan II	33213-65-9	< 0.0000035	< 0.0000035	0.29	NO	--	--	--	--	--
		Endosulfan sulfate	1031-07-8	< 0.000017	< 0.000017	0.29	NO	--	--	--	--	--
		Endrin	72-20-8	< 0.0000079	< 0.0000079	0.028	NO	--	--	--	--	--
		Endrin aldehyde	7421-93-4	< 0.0000048	< 0.0000048	0.25	NO	--	--	--	--	--
		gamma-BHC (Lindane)	58-89-9	< 0.0000067	< 0.0000067	0.017	NO	--	--	--	--	--
		gamma-Chlordane	5103-74-2	< 0.000013	< 0.000013	0.033	NO	--	--	--	--	--
		Heptachlor	76-44-8	< 0.0000036	< 0.0000036	0.012	NO	--	--	--	--	--
		Heptachlor epoxide	1024-57-3	< 0.0000048	< 0.0000048	0.16	NO	--	--	--	--	--
		Methoxychlor	72-43-5	< 0.0000081	< 0.0000081	2.5	NO	--	--	--	--	--
		Toxaphene	8001-35-2	< 0.00022	< 0.00022	0.095	NO	--	--	--	--	--
	SW8082	PCBs (total)	1336-36-3	< 0.00057	< 0.00057	1	NO	--	--	--	--	--
	SW8141	Disulfoton	298-04-4	< 0.00014	< 0.00014	0.17	NO	--	--	--	--	--
		Famphur	52-85-7	< 0.00018	< 0.00018	0.17	NO	--	--	--	--	--
		Methyl parathion	298-00-0	< 0.001	< 0.001	0.14	NO	--	--	--	--	--
		Parathion	56-38-2	< 0.00029	< 0.00029	0.14	NO	--	--	--	--	--
		Phorate	298-02-2	< 0.000072	< 0.000072	0.21	NO	--	--	--	--	--
	SW8151	2,4,5-T	93-76-5	< 0.00017	< 0.00017	7.2	NO	--	--	--	--	--
		2,4,5-TP (Silvex)	93-72-1	< 0.00015	< 0.00015	7.2	NO	--	--	--	--	--
		2,4-D	94-75-7	0.024	0.024	7.2	NO	--	--	--	--	--
		Dinoseb	88-85-7	< 0.0006	< 0.0006	0.66	NO	--	--	--	--	--
	SW8260	1,1,1,2-Tetrachloroethane	630-20-6	< 0.00022	< 0.00022	0.57	NO	--	--	--	--	--
		1,1,1-Trichloroethane	71-55-6	< 0.00015	< 0.00015	0.54	NO	--	--	--	--	--
		1,1,2,2-Tetrachloroethane	79-34-5	< 0.00014	< 0.00014	0.57	NO	--	--	--	--	--
		1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	< 0.00054	< 0.00054	0.57	NO	--	--	--	--	--
		1,1,2-Trichloroethane	79-00-5	< 0.00028	< 0.00028	0.54	NO	--	--	--	--	--
		1,1-Dichloroethane	75-34-3	< 0.00095	< 0.00095	0.59	NO	--	--	--	--	--
		1,1-Dichloroethene	75-35-4	< 0.00055	< 0.00055	0.25	NO	--	--	--	--	--
		1,2,3-Trichloropropane	96-18-4	< 0.00056	< 0.00056	8.5	NO	--	--	--	--	--
		1,2,4-Trichlorobenzene	120-82-1	< 0.00073	< 0.00073	0.55	NO	--	--	--	--	--
		1,2-Dibromo-3-chloropropane	96-12-8	< 0.00089	< 0.00089	1.1	NO	--	--	--	--	--
		1,2-Dichlorobenzene	95-50-1	< 0.00015	< 0.00015	0.88	NO	--	--	--	--	--

TABLE C-4
COMPARISON OF DETECTED CHEMICAL CONCENTRATIONS WITH UTS LEVELS
(Page 5 of 7)

Category	Analytical Method	Site-Related Chemical	CAS No.	Minimum Detect	Maximum Detect	UTS x 10	Maximum > UTSx10?	Carcinogen?	10^{-3} Cancer PRG[1]	Risk > 10^{-3}?	Non-Cancer PRG × $10^{(2)}$	Risk > PRG × 10 ?
Wastewater (mg/L)		1,2-Dichloroethane	107-06-2	< 0.00044	< 0.00044	2.1	NO	--	--	--	--	--
		1,2-Dichloropropane	78-87-5	< 0.00037	< 0.00037	8.5	NO	--	--	--	--	--
		1,3-Dichlorobenzene	541-73-1	< 0.00013	< 0.00013	0.36	NO	--	--	--	--	--
		1,4-Dichlorobenzene	106-46-7	< 0.00011	< 0.00011	0.9	NO	--	--	--	--	--
		Acetone	67-64-1	< 0.0038	< 0.0038	2.8	NO	--	--	--	--	--
		Acetonitrile	75-05-8	< 0.002	< 0.002	56	NO	--	--	--	--	--
		Benzene	71-43-2	< 0.00017	< 0.00017	1.4	NO	--	--	--	--	--
		Bromodichloromethane	75-27-4	< 0.00033	< 0.00033	3.5	NO	--	--	--	--	--
		Bromoform	75-25-2	0.0019	0.0019	6.3	NO	--	--	--	--	--
		Bromomethane	74-83-9	< 0.00031	< 0.00031	1.1	NO	--	--	--	--	--
		Carbon disulfide	75-15-0	< 0.00055	< 0.00055	38	NO	--	--	--	--	--
		Carbon tetrachloride	56-23-5	< 0.0009	< 0.0009	0.57	NO	--	--	--	--	--
		Chlorobenzene	108-90-7	< 0.00012	< 0.00012	0.57	NO	--	--	--	--	--
		Chlorodibromomethane	124-48-1	0.0021	0.0021	0.57	NO	--	--	--	--	--
		Chloroethane	75-00-3	< 0.00035	< 0.00035	2.7	NO	--	--	--	--	--
		Chloroform	67-66-3	0.0093	0.0093	0.46	NO	--	--	--	--	--
		Chloromethane	74-87-3	0.0016	0.0016	1.9	NO	--	--	--	--	--
		cis-1,3-Dichloropropene	10061-01-5	< 0.00073	< 0.00073	0.36	NO	--	--	--	--	--
		Dibromomethane	74-95-3	< 0.00035	< 0.00035	1.1	NO	--	--	--	--	--
		Dichlorodifluoromethane	75-71-8	< 0.00037	< 0.00037	2.3	NO	--	--	--	--	--
		Ethylbenzene	100-41-4	< 0.00019	< 0.00019	0.57	NO	--	--	--	--	--
		Iodomethane	74-88-4	< 0.00026	< 0.00026	1.9	NO	--	--	--	--	--
		Methyl ethyl ketone	78-93-3	< 0.0014	< 0.0014	2.8	NO	--	--	--	--	--
		Methyl isobutyl ketone	108-10-1	< 0.0016	< 0.0016	1.4	NO	--	--	--	--	--
		Methylene chloride	75-09-2	0.003	0.003	0.89	NO	--	--	--	--	--
		Tetrachloroethylene	127-18-4	< 0.00027	< 0.00027	0.56	NO	--	--	--	--	--
		Toluene	108-88-3	< 0.00013	< 0.00013	0.8	NO	--	--	--	--	--
		trans-1,2-Dichloroethene	156-60-5	< 0.00022	< 0.00022	0.54	NO	--	--	--	--	--
		trans-1,3-Dichloropropylene	10061-02-6	< 0.0002	< 0.0002	0.36	NO	--	--	--	--	--
		Trichloroethene	79-01-6	< 0.00036	< 0.00036	0.54	NO	--	--	--	--	--
		Trichlorofluoromethane	75-69-4	< 0.0005	< 0.0005	0.2	NO	--	--	--	--	--
		Vinyl chloride	75-01-4	< 0.00024	< 0.00024	2.7	NO	--	--	--	--	--
		Xylenes (total)	1330-20-7	< 0.00086	< 0.00086	3.2	NO	--	--	--	--	--
	SW8270	1,2,4,5-Tetrachlorobenzene	95-94-3	< 0.001	< 0.001	0.55	NO	--	--	--	--	--
		1,2-Diphenylhydrazine (as Azobenzene	122-66-7	< 0.001	< 0.001	0.87	NO	--	--	--	--	--
		1,4-Dioxane	123-91-1	< 0.002	< 0.002	120	NO	--	--	--	--	--
		2,4,5-Trichlorophenol	95-95-4	< 0.002	< 0.002	1.8	NO	--	--	--	--	--
		2,4,6-Trichlorophenol	88-06-2	< 0.002	< 0.002	0.35	NO	--	--	--	--	--
		2,4-Dichlorophenol	120-83-2	< 0.001	< 0.001	0.44	NO	--	--	--	--	--
		2,4-Dimethylphenol	105-67-9	< 0.001	< 0.001	0.36	NO	--	--	--	--	--
		2,4-Dinitrophenol	51-28-5	< 0.01	< 0.01	1.2	NO	--	--	--	--	--
		2,4-Dinitrotoluene	121-14-2	< 0.0011	< 0.0011	3.2	NO	--	--	--	--	--
		2,6-Dinitrotoluene	606-20-2	< 0.0011	< 0.0011	5.5	NO	--	--	--	--	--
		2-Chloronaphthalene	91-58-7	< 0.001	< 0.001	0.55	NO	--	--	--	--	--
		2-Chlorophenol	95-57-8	< 0.001	< 0.001	0.44	NO	--	--	--	--	--
		2-Methylphenol	95-48-7	< 0.002	< 0.002	1.1	NO	--	--	--	--	--
		2-Nitroaniline	88-74-4	< 0.002	< 0.002	2.7	NO	--	--	--	--	--
		2-Nitrophenol	88-75-5	< 0.001	< 0.001	0.28	NO	--	--	--	--	--
		4-Bromophenyl phenyl ether	101-55-3	< 0.001	< 0.001	0.55	NO	--	--	--	--	--
		4-Chloro-3-methylphenol	59-50-7	< 0.001	< 0.001	0.18	NO	--	--	--	--	--

TABLE C-4
COMPARISON OF DETECTED CHEMICAL CONCENTRATIONS WITH UTS LEVELS
(Page 6 of 7)

Category	Analytical Method	Site-Related Chemical	CAS No.	Minimum Detect	Maximum Detect	UTS x 10	Maximum > UTSx10?	Carcinogen?	10^{-3} Cancer PRG[1]	Risk > 10^{-3}?	Non-Cancer PRG × $10^{(2)}$	Risk > PRG × 10 ?
Wastewater (mg/L)		4-Chloroaniline	106-47-8	< 0.001	< 0.001	4.6	NO	--	--	--	--	--
		4-Nitroaniline	100-01-6	< 0.0013	< 0.0013	0.28	NO	--	--	--	--	--
		4-Nitrophenol	100-02-7	< 0.005	< 0.005	1.2	NO	--	--	--	--	--
		Acenaphthene	83-32-9	< 0.001	< 0.001	0.59	NO	--	--	--	--	--
		Acenaphthylene	208-96-8	< 0.001	< 0.001	0.59	NO	--	--	--	--	--
		Acetophenone	98-86-2	< 0.001	< 0.001	0.1	NO	--	--	--	--	--
		Aniline	62-53-3	< 0.001	< 0.001	8.1	NO	--	--	--	--	--
		Anthracene	120-12-7	< 0.0011	< 0.0011	0.59	NO	--	--	--	--	--
		Benzo(a)anthracene	56-55-3	< 0.001	< 0.001	0.59	NO	--	--	--	--	--
		Benzo(a)pyrene	50-32-8	< 0.001	< 0.001	0.61	NO	--	--	--	--	--
		Benzo(b)fluoranthene	205-99-2	< 0.001	< 0.001	1.1	NO	--	--	--	--	--
		Benzo(ghi)perylene	191-24-2	< 0.001	< 0.001	0.055	NO	--	--	--	--	--
		Benzo(k)fluoranthene	207-08-9	< 0.001	< 0.001	1.1	NO	--	--	--	--	--
		bis(2-Chloroethoxy)methane	111-91-1	< 0.001	< 0.001	0.36	NO	--	--	--	--	--
		bis(2-Chloroethyl) ether	111-44-4	< 0.001	< 0.001	0.33	NO	--	--	--	--	--
		bis(2-Chloroisopropyl) ether	108-60-1	< 0.001	< 0.001	0.55	NO	--	--	--	--	--
		Butyl benzyl phthalate	85-68-7	< 0.001	< 0.001	0.17	NO	--	--	--	--	--
		Chrysene	218-01-9	< 0.001	< 0.001	0.59	NO	--	--	--	--	--
		Dibenz(a,h)anthracene	53-70-3	< 0.001	< 0.001	0.55	NO	--	--	--	--	--
		Diethyl phthalate	84-66-2	< 0.001	< 0.001	2	NO	--	--	--	--	--
		Dimethyl phthalate	131-11-3	< 0.001	< 0.001	0.47	NO	--	--	--	--	--
		Di-n-butyl phthalate	84-74-2	< 0.001	< 0.001	0.57	NO	--	--	--	--	--
		Di-n-octyl phthalate	117-84-0	< 0.005	< 0.005	0.17	NO	--	--	--	--	--
		Fluoranthene	206-44-0	< 0.001	< 0.001	0.68	NO	--	--	--	--	--
		Fluorene	86-73-7	< 0.001	< 0.001	0.59	NO	--	--	--	--	--
		Hexachlorobenzene	118-74-1	< 0.001	< 0.001	0.55	NO	--	--	--	--	--
		Hexachlorobutadiene	87-68-3	< 0.001	< 0.001	0.55	NO	--	--	--	--	--
		Hexachlorocyclopentadiene	77-47-4	< 0.0025	< 0.0025	0.57	NO	--	--	--	--	--
		Hexachloroethane	67-72-1	< 0.001	< 0.001	0.55	NO	--	--	--	--	--
		Indeno(1,2,3-cd)pyrene	193-39-5	< 0.001	< 0.001	0.055	NO	--	--	--	--	--
		Naphthalene	91-20-3	< 0.001	< 0.001	0.59	NO	--	--	--	--	--
		Nitrobenzene	98-95-3	< 0.001	< 0.001	0.68	NO	--	--	--	--	--
		N-Nitrosodi-n-propylamine	621-64-7	< 0.001	< 0.001	4	NO	--	--	--	--	--
		N-Nitrosodiphenylamine	86-30-6	< 0.001	< 0.001	9.2	NO	--	--	--	--	--
		Pentachlorobenzene	608-93-5	< 0.0027	< 0.0027	0.55	NO	--	--	--	--	--
		Pentachlorophenol	87-86-5	< 0.002	< 0.002	0.89	NO	--	--	--	--	--
		Phenanthrene	85-01-8	< 0.001	< 0.001	0.59	NO	--	--	--	--	--
		Phenol	108-95-2	< 0.004	< 0.004	0.39	NO	--	--	--	--	--
		Phthalic acid	88-99-3	< 0.4	< 0.4	0.55	NO	--	--	--	--	--
		Pyrene	129-00-0	< 0.001	< 0.001	0.67	NO	--	--	--	--	--
		Pyridine	110-86-1	< 0.005	< 0.005	0.14	NO	--	--	--	--	--
	SW8290	1,2,3,4,6,7,8-HpCDD	35822-46-9	< 0.0000049	< 0.0000049	0.00035	NO	--	--	--	--	--
		1,2,3,4,6,7,8-HpCDF	67562-39-4	< 0.000017	< 0.000017	0.00035	NO	--	--	--	--	--
		1,2,3,4,7,8,9-HpCDF	55673-89-7	< 0.0000031	< 0.0000031	0.00035	NO	--	--	--	--	--
		OCDD	OCDD	< 0.000013	< 0.000013	0.00063	NO	--	--	--	--	--
		OCDF	OCDF	0.000089	0.000089	0.00063	NO	--	--	--	--	--
TCLP (mg/L)	SW6010	Antimony	7440-36-0	< 0.1121	< 0.5605	11.5	NO	--	--	--	--	--
		Arsenic	7440-38-2	0.128	0.259	50	NO	--	--	--	--	--
		Barium	7440-39-3	0.0178	2.59	210	NO	--	--	--	--	--
		Beryllium	7440-41-7	0.0125	0.0125	12.2	NO	--	--	--	--	--

TABLE C-4
COMPARISON OF DETECTED CHEMICAL CONCENTRATIONS WITH UTS LEVELS
(Page 7 of 7)

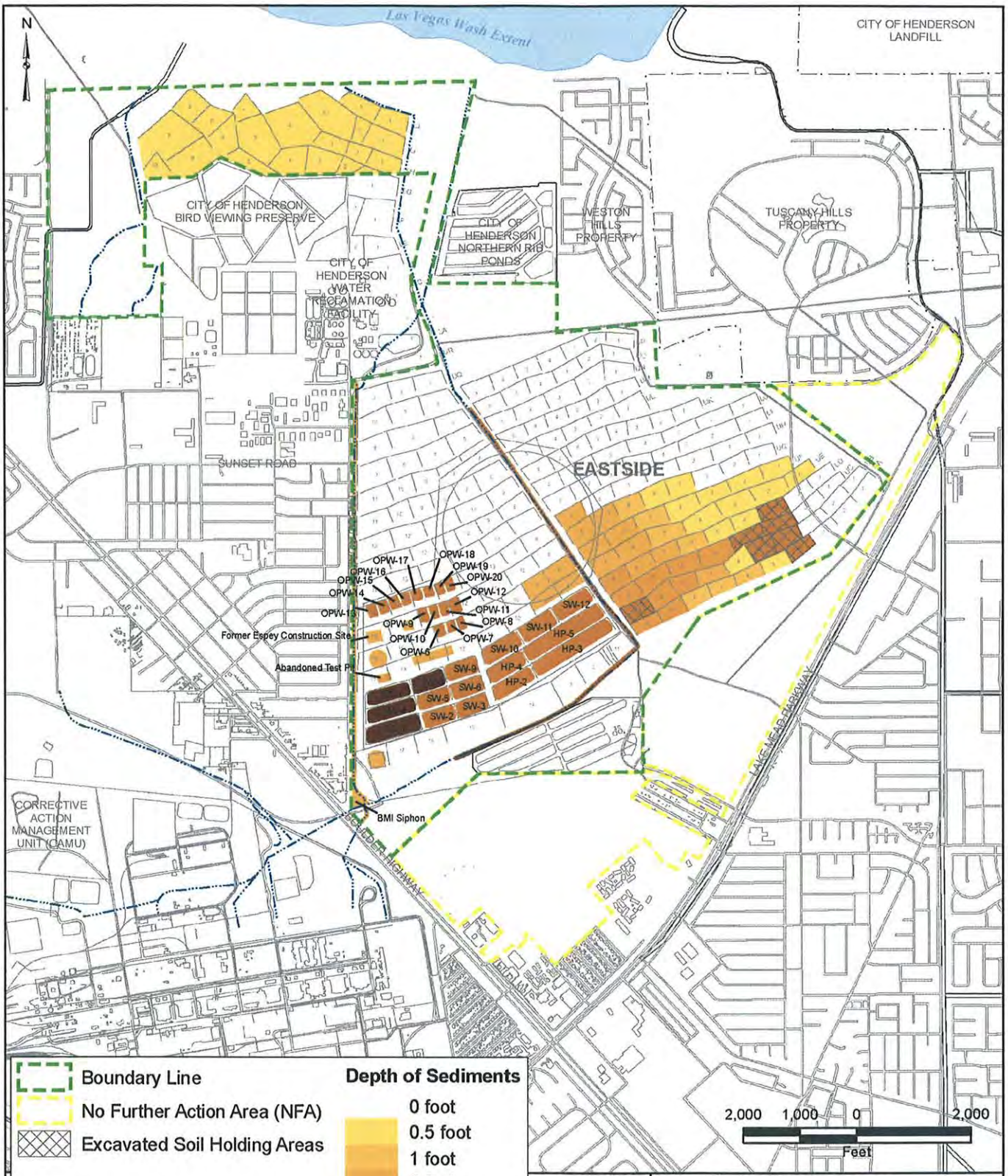
Category	Analytical Method	Site-Related Chemical	CAS No.	Minimum Detect	Maximum Detect	UTS x 10	Maximum > UTSx10?	Carcinogen?	10^{-3} Cancer PRG[1]	Risk > 10^{-3}?	Non-Cancer PRG × 10[2]	Risk > PRG × 10 ?
TCLP (mg/L)		Cadmium	7440-43-9	< 0.00569	< 0.00569	1.1	NO	--	--	--	--	--
		Chromium	7440-47-3	0.0083	2.94	6	NO	--	--	--	--	--
		Lead	7439-92-1	0.0817	0.229	7.5	NO	--	--	--	--	--
		Nickel	7440-02-0	0.0194	5.76	110	NO	--	--	--	--	--
		Selenium	7782-49-2	< 0.1038	< 0.104	57	NO	--	--	--	--	--
		Silver	7440-22-4	< 0.01302	< 0.01302	1.4	NO	--	--	--	--	--
		Thallium	7440-28-0	< 0.125	< 0.125	2	NO	--	--	--	--	--
		Vanadium	7440-62-2	0.021	1.94	16	NO	--	--	--	--	--
		Zinc	7440-66-6	0.0243	0.295	43	NO	--	--	--	--	--
	SW7470	Mercury	7439-97-6	0.00063	0.00063	0.25	NO	--	--	--	--	--
	SW8015	Methanol	67-56-1	< 0.54	< 0.54	7.5	NO	--	--	--	--	--
	SW8260	Carbon disulfide	75-15-0	< 0.012	< 0.012	48	NO	--	--	--	--	--

(1) USEPA Region 9 residential soil PRG based on cancer risk and ingestion and inhalation exposure pathways times 1,000.
(2) USEPA Region 9 residential soil PRG based on non-cancer risk and ingestion and inhalation exposure pathways times 10.

Table C-5
Estimated Waste Volumes, By Location
BRC CAMU
Henderson, NV

Area / Sample ID	Spatial Composite	Area (Sq. Yds.)	Depth (Ft.) (Average)	Volume (Cubic Yds.)
Alpha Ditch				
WC-AD01	Includes WC-AD02 and WC-AD03	70,199	1.0	23,397
Beta Ditch				
WC-BD01	Includes WC-BD02 and WC-BD03	79,453	4.0	105,927
IRM Soil Holding Areas				
WC-IM01	From IRM soil holding area in pond PUA-04	10,880	4.0	14,506
WC-IM02	From IRM soil holding area in pond PUB-04	14,230	4.0	18,971
WC-IM03	From IRM soil holding area in pond PUB-05	14,985	4.1	20,602
WC-IM04	From IRM soil holding area in pond PUB-10	14,202	6.4	30,375
WC-IM05	From IRM soil holding area in pond PUC-03	13,029	4.0	17,371
WC-IM06	From IRM soil holding area in pond PUC-04	12,596	4.6	19,504
WC-IM07	From IRM soil holding area in pond PUD-03	13,908	4.0	18,542
Mohawk Area				
WC-MH01	From ponds PUE-01, PUE-02, PUF-01, and PUF-02	63,412	0	0
No-Build Area				
WC-NB01	From ponds PLH-01, PLI-01, PLI-02, PLJ-01, and PLJ-02	87,058	0	0
WC-NB02	From ponds PLH-02, PLH-03, PLH-04, and PLI-03	117,264	0	0
WC-NB03	From ponds PLG-02 through PLG-05	96,184	0	0
Sunset North Area				
WC-SN01	From ponds PLD-10, PLE-08, PLE-09, PLF-05 through PLF-08, and PLG-06	191,676	0.5	31,943
Spray Wheel				
WC-SW01	From ponds PUE-08, PUE-09, PUF-08, and PUF-09	48,927	2.0	32,614
WC-SW02	From ponds PUF-07, PUG-08, and PUH-07	45,260	2.0	30,170
Former Espey Construction Site				
WC-TE01	From footprint of former Espey Construction site	6,216	2.0	4,146
Other TIMET Debris Areas				
WC-TD01	From footprint of three other TIMET debris areas	34,776	2.0	23,196
TIMET Abandoned Test Pit				
WC-TA01	From footprint of TIMET Abandoned Test Pit	3,887	3.0	3,887
TIMET Berms				
WC-TB01	From western berms between TIMET ponds	NE	NE	NE
WC-TB02	From central west berms between TIMET ponds	NE	NE	NE
WC-TB03	From central east berms between TIMET ponds	NE	NE	NE
WC-TB04	From eastern berms between TIMET ponds	NE	NE	NE
TIMET OPW Ponds				
WC-TW01	From ponds OPW-6 through OPW-11	32,960	4.5	49,436
WC-TW02	From ponds OPW-13 through OPW-20	41,382	4.5	62,067
WC-TW03	From pond OPW-12	5,421	4.5	8,130
TIMET Ponds				
WC-TP01	From pond SC-1	41,624	18.5	256,656
WC-TP02	From pond SW-2	18,682	4.5	28,021
WC-TP03	From pond SW-3	19,312	4.5	28,965
WC-TP04	From pond SW-4	23,958	18.5	147,726
WC-TP05	From pond SW-5	18,828	4.5	28,239
WC-TP06	From pond SW-6	19,650	4.5	29,473
WC-TP07	From pond SW-7	23,377	18.5	144,145
WC-TP08	From pond SW-8	19,650	22.5	147,363
WC-TP09	From pond SW-9	20,667	4.5	30,997
WC-TP10	From pond SW-10	25,507	5.5	46,758
WC-TP11	From pond SW-11	23,861	5.5	43,741
WC-TP12	From pond SW-12	25,265	5.5	46,314
WC-TP13	From pond HP-2	24,974	4.5	37,458
WC-TP14	From pond HP-3	49,320	4.5	73,972
WC-TP15	From pond HP-4	22,845	4.5	34,264
WC-TP16	From pond HP-5	49,513	4.5	74,262
Upper Ponds				
WC-UP01	From ponds PUA-05 through PUA-10	67,102	0.6	12,920
WC-UP02	From ponds PUB-06 through PUB-09	54,615	2.0	37,565
WC-UP03	From ponds PUC-05 through PUC-08	66,385	2.6	56,782
WC-UP04	From ponds PUD-04 through PUD-09	83,035	0.3	28,245
WC-UP05	From ponds PUE-03 through PUE-07	94,070	0.9	25,589
WC-UP06	From ponds PUF-03 through PUF-06	66,474	0.1	9,788
WC-UP07	From ponds PUG-04 through PUG-07	65,344	0.7	15,004
			Total:	**1,899,028**

NE = No Estimate. No waste expected to be excavated



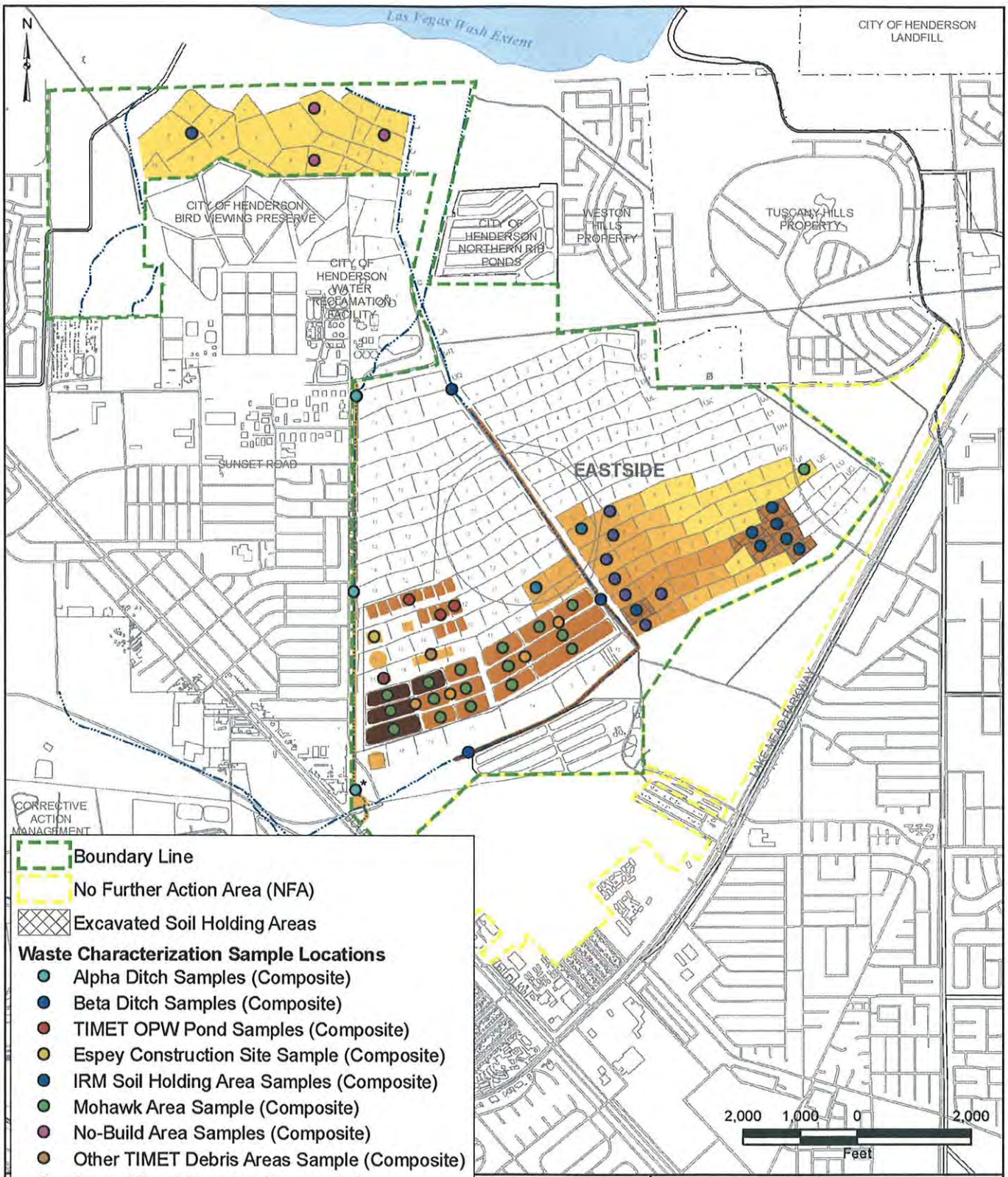
BMI Common Areas
Clark County, Nevada

FIGURE C-1

WASTE AREAS AND DEPTHS

Basic Remediation COMPANY

Prepared by:	Date	JOB No 1881425
MWH MKJ	10/26/06	FILE GIS/BRC/RAP_WASTE/FIGURE_C1.MXD



Boundary Line

No Further Action Area (NFA)

Excavated Soil Holding Areas

Waste Characterization Sample Locations

- Alpha Ditch Samples (Composite)
- Beta Ditch Samples (Composite)
- TIMET OPW Pond Samples (Composite)
- Espey Construction Site Sample (Composite)
- IRM Soil Holding Area Samples (Composite)
- Mohawk Area Sample (Composite)
- No-Build Area Samples (Composite)
- Other TIMET Debris Areas Sample (Composite)
- Spray Wheel Samples (Composite)
- Sunset North Area Sample (Composite)
- TIMET Berm Samples (Composite)
- TIMET Pond Samples (Composite)
- TIMET Abandoned Test Pit Sample (Composite)
- Upper Pond Samples (Composite)

Note: See Table C-2 for description of sample collection. See Figure C-1 for identification of sediment depths. See Figures C-3A through C-3C for individual composite sample locations.
* Indicates BMI Siphon sample location.

BMI Common Areas
Clark County, Nevada

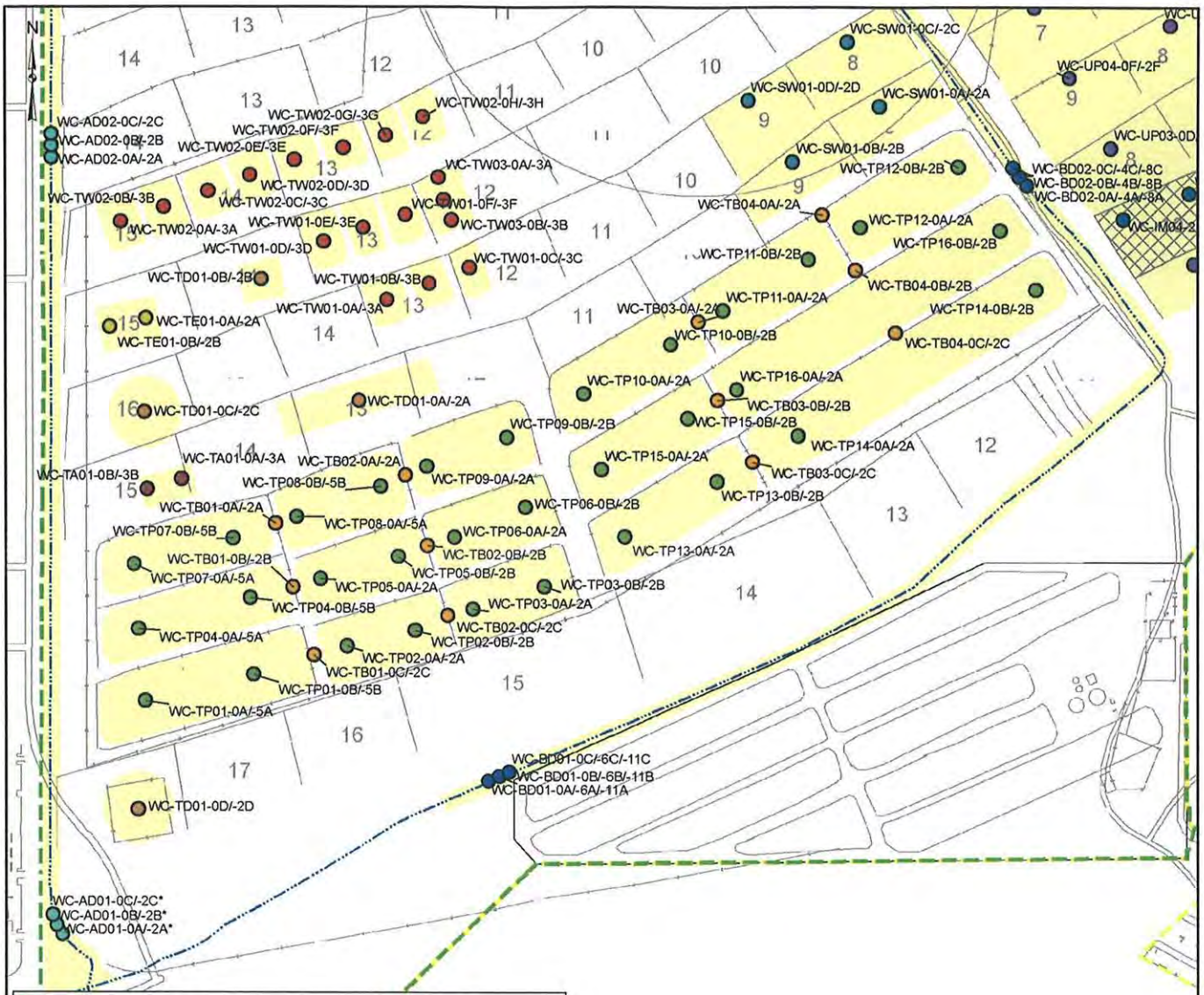
FIGURE C-2

WASTE CHARACTERIZATION SAMPLE LOCATIONS

Basic Remediation COMPANY

Prepared by: MWH MKJ Date 10/26/06

JOB No 1881425
FILE GIS/BRC/RAP_WASTE/FIGURE_C2.MXD



Boundary Line

No Further Action Area (NFA)

Excavated Soil Holding Areas

Individual Composite Sample Locations

- Alpha Ditch Samples (Composite)
- Beta Ditch Samples (Composite)
- TIMET OPW Pond Samples (Composite)
- Espey Construction Site Sample (Composite)
- IRM Soil Holding Area Samples (Composite)
- Mohawk Area Sample (Composite)
- No-Build Area Samples (Composite)
- Other TIMET Debris Areas Sample (Composite)
- Spray Wheel Samples (Composite)
- Sunset North Area Sample (Composite)
- TIMET Berm Samples (Composite)
- TIMET Pond Samples (Composite)
- TIMET Abandoned Test Pit Sample (Composite)
- Upper Pond Samples (Composite)

Note: Composite sample locations are approximate. Sample depths are indicated on the sample labels.
* Indicates BMI Siphon sample location.

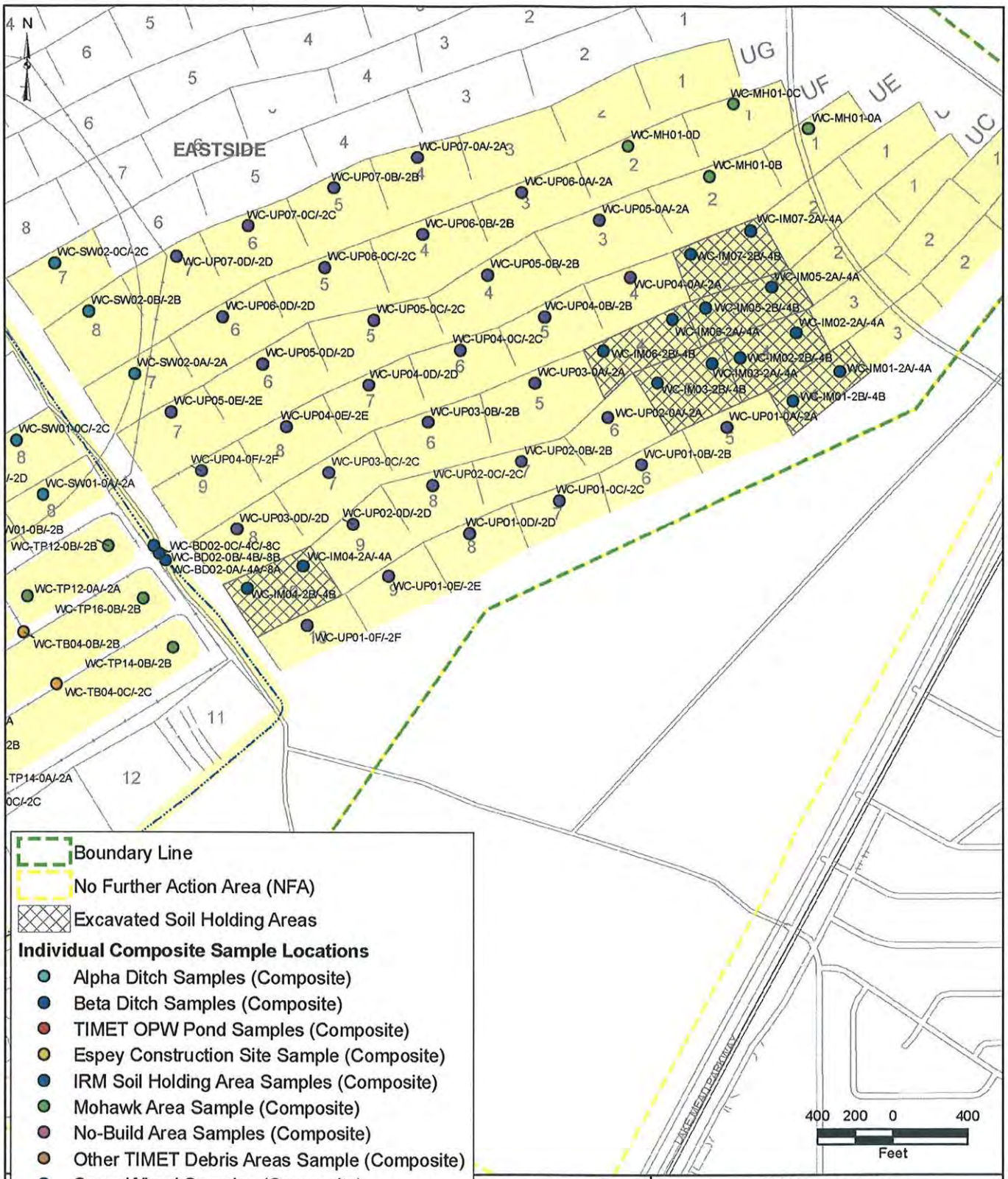
BMI Common Areas
Clark County, Nevada

FIGURE C-3A

INDIVIDUAL COMPOSITE SAMPLING LOCATIONS (WEST)

Basic Remediation COMPANY

Prepared by	Date	JOB No. 1881425
MWH MKJ	10/26/06	FILE GIS/BRC/RAP_WASTE/FIGURE_C3.MXD



Boundary Line

No Further Action Area (NFA)

Excavated Soil Holding Areas

Individual Composite Sample Locations

- Alpha Ditch Samples (Composite)
- Beta Ditch Samples (Composite)
- TIMET OPW Pond Samples (Composite)
- Espey Construction Site Sample (Composite)
- IRM Soil Holding Area Samples (Composite)
- Mohawk Area Sample (Composite)
- No-Build Area Samples (Composite)
- Other TIMET Debris Areas Sample (Composite)
- Spray Wheel Samples (Composite)
- Sunset North Area Sample (Composite)
- TIMET Berm Samples (Composite)
- TIMET Pond Samples (Composite)
- TIMET Abandoned Test Pit Sample (Composite)
- Upper Pond Samples (Composite)

Note: Composite sample locations are approximate. Sample depths are indicated on the sample labels.

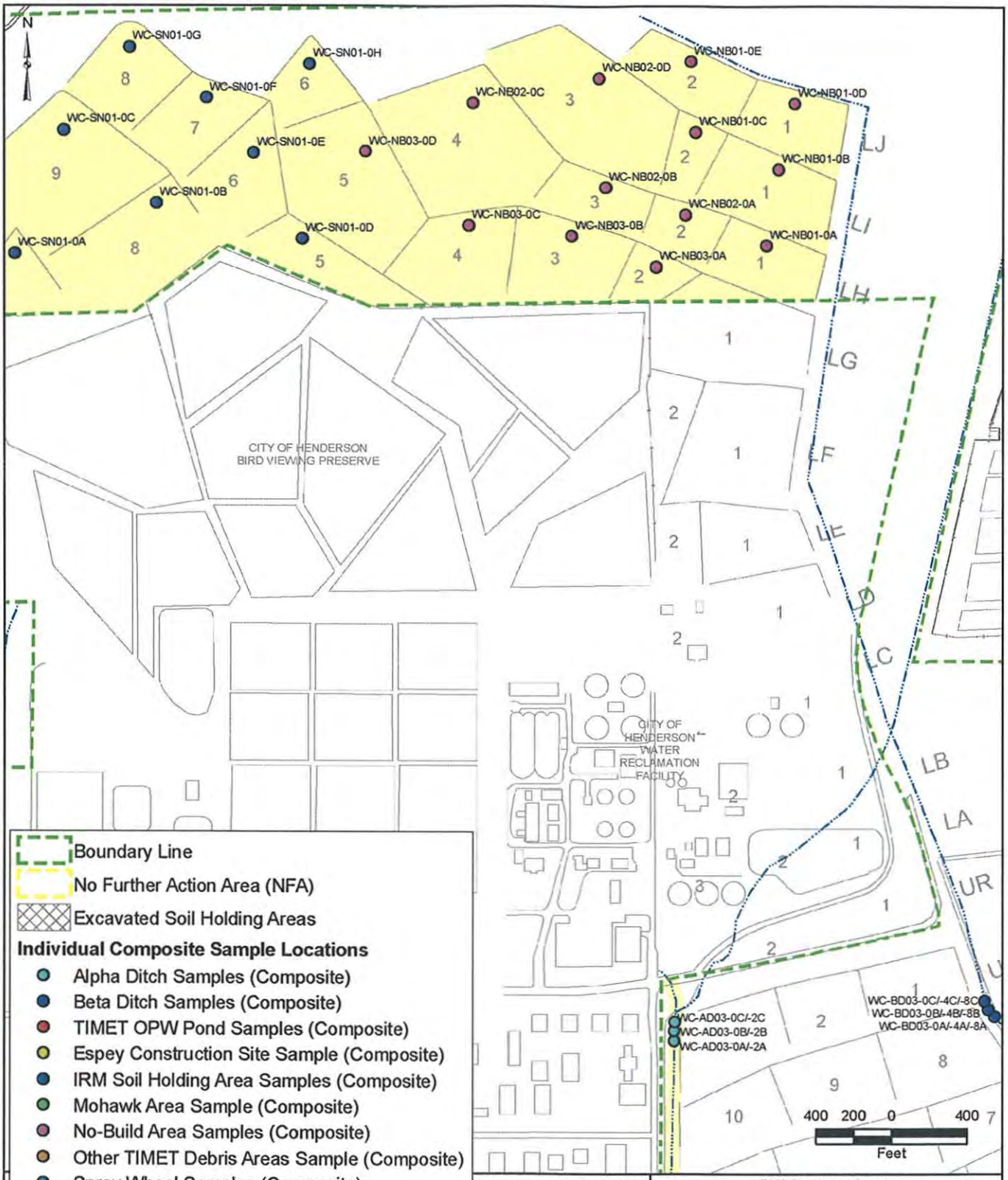
BMI Common Areas
Clark County, Nevada

FIGURE C-3B

INDIVIDUAL COMPOSITE SAMPLING LOCATIONS (EAST)

Basic Remediation COMPANY

Prepared by:	Date	JOB No 1881425
MWH MKJ	10/26/06	FILE: GIS/BRC/RAP_WASTE/FIGURE_C3.MXD



Boundary Line

No Further Action Area (NFA)

Excavated Soil Holding Areas

Individual Composite Sample Locations

- Alpha Ditch Samples (Composite)
- Beta Ditch Samples (Composite)
- TIMET OPW Pond Samples (Composite)
- Espey Construction Site Sample (Composite)
- IRM Soil Holding Area Samples (Composite)
- Mohawk Area Sample (Composite)
- No-Build Area Samples (Composite)
- Other TIMET Debris Areas Sample (Composite)
- Spray Wheel Samples (Composite)
- Sunset North Area Sample (Composite)
- TIMET Berm Samples (Composite)
- TIMET Pond Samples (Composite)
- TIMET Abandoned Test Pit Sample (Composite)
- Upper Pond Samples (Composite)

Note: Composite sample locations are approximate. Sample depths are indicated on the sample labels.

BMI Common Areas
Clark County, Nevada

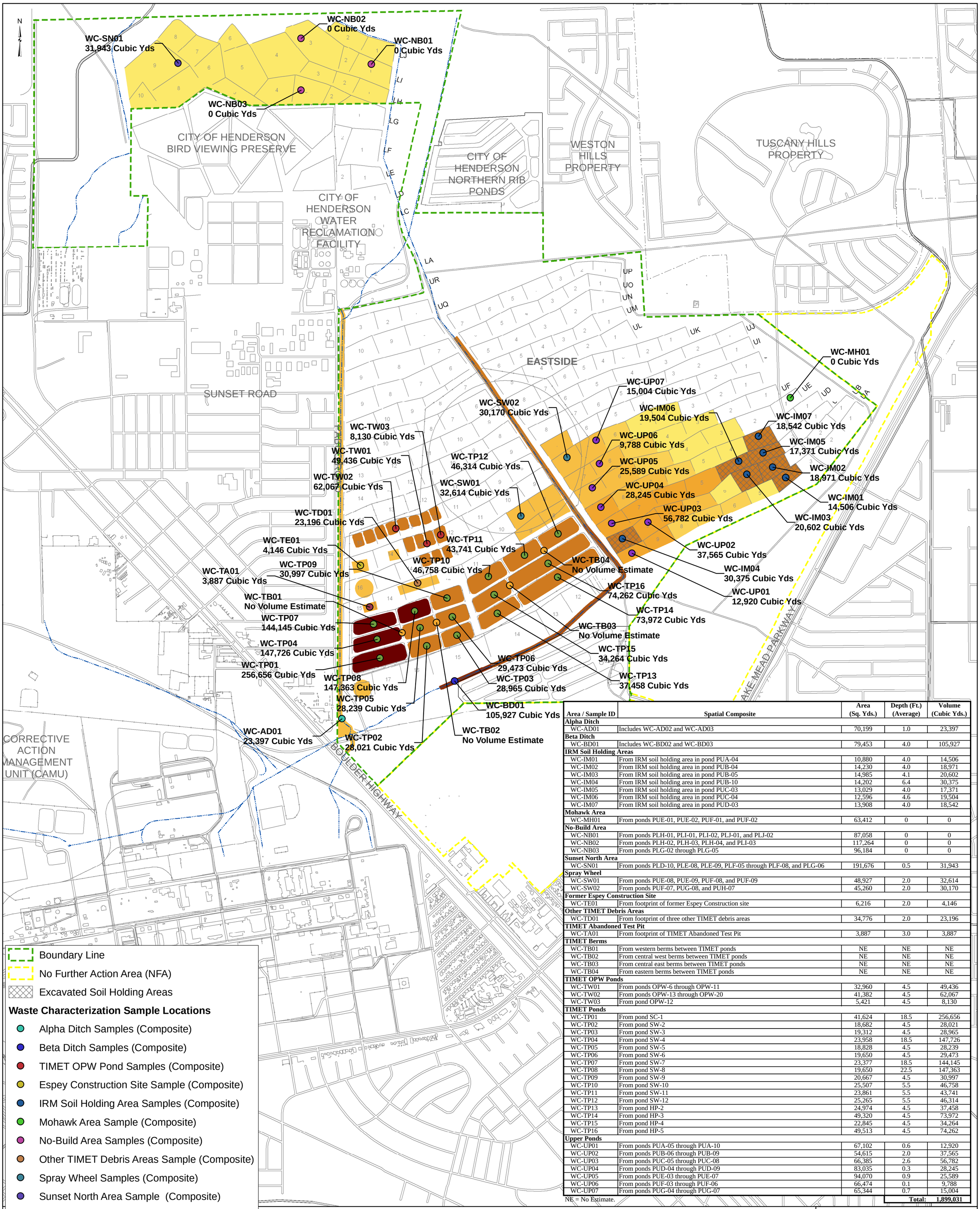
FIGURE C-3C

INDIVIDUAL COMPOSITE SAMPLING LOCATIONS (NORTH)

Basic Remediation COMPANY

Prepared by: MWH MKJ Date 10/26/06

JOB No 1881425
FILE GIS/BRC/RAP_WASTE/FIGURE_C3.MXD



Area / Sample ID	Spatial Composite	Area (Sq. Yds.)	Depth (Ft.) (Average)	Volume (Cubic Yds.)
Alpha Ditch				
WC-AD01	Includes WC-AD02 and WC-AD03	70,199	1.0	23,397
Beta Ditch				
WC-BD01	Includes WC-BD02 and WC-BD03	79,453	4.0	105,927
IRM Soil Holding Areas				
WC-IM01	From IRM soil holding area in pond PUA-04	10,880	4.0	14,506
WC-IM02	From IRM soil holding area in pond PUB-04	14,230	4.0	18,971
WC-IM03	From IRM soil holding area in pond PUB-05	14,985	4.1	20,602
WC-IM04	From IRM soil holding area in pond PUB-10	14,202	6.4	30,375
WC-IM05	From IRM soil holding area in pond PUC-03	13,029	4.0	17,371
WC-IM06	From IRM soil holding area in pond PUC-04	12,596	4.6	19,504
WC-IM07	From IRM soil holding area in pond PUD-03	13,908	4.0	18,542
Mohawk Area				
WC-MH01	From ponds PUE-01, PUE-02, PUF-01, and PUF-02	63,412	0	0
No-Build Area				
WC-NB01	From ponds PLH-01, PLI-01, PLI-02, PLJ-01, and PLJ-02	87,058	0	0
WC-NB02	From ponds PLH-02, PLH-03, PLH-04, and PLI-03	117,264	0	0
WC-NB03	From ponds PLG-02 through PLG-05	96,184	0	0
Sunset North Area				
WC-SN01	From ponds PLD-10, PLE-08, PLE-09, PLF-05 through PLF-08, and PLG-06	191,676	0.5	31,943
Spray Wheel				
WC-SW01	From ponds PUE-08, PUE-09, PUF-08, and PUF-09	48,927	2.0	32,614
WC-SW02	From ponds PUF-07, PUG-08, and PUH-07	45,260	2.0	30,170
Former Espey Construction Site				
WC-TE01	From footprint of former Espey Construction site	6,216	2.0	4,146
Other TIMET Debris Areas				
WC-TD01	From footprint of three other TIMET debris areas	34,776	2.0	23,196
TIMET Abandoned Test Pit				
WC-TA01	From footprint of TIMET Abandoned Test Pit	3,887	3.0	3,887
TIMET Berms				
WC-TB01	From western berms between TIMET ponds	NE	NE	NE
WC-TB02	From central west berms between TIMET ponds	NE	NE	NE
WC-TB03	From central east berms between TIMET ponds	NE	NE	NE
WC-TB04	From eastern berms between TIMET ponds	NE	NE	NE
TIMET OPW Ponds				
WC-TW01	From ponds OPW-6 through OPW-11	32,960	4.5	49,436
WC-TW02	From ponds OPW-13 through OPW-20	41,382	4.5	62,067
WC-TW03	From pond OPW-12	5,421	4.5	8,130
TIMET Ponds				
WC-TP01	From pond SC-1	41,624	18.5	256,656
WC-TP02	From pond SW-2	18,682	4.5	28,021
WC-TP03	From pond SW-3	19,312	4.5	28,965
WC-TP04	From pond SW-4	23,958	18.5	147,726
WC-TP05	From pond SW-5	18,828	4.5	28,239
WC-TP06	From pond SW-6	19,650	4.5	29,473
WC-TP07	From pond SW-7	23,377	18.5	144,145
WC-TP08	From pond SW-8	19,650	22.5	147,363
WC-TP09	From pond SW-9	20,667	4.5	30,997
WC-TP10	From pond SW-10	25,507	5.5	46,758
WC-TP11	From pond SW-11	23,861	5.5	43,741
WC-TP12	From pond SW-12	25,265	5.5	46,314
WC-TP13	From pond HP-2	24,974	4.5	37,458
WC-TP14	From pond HP-3	49,320	4.5	73,972
WC-TP15	From pond HP-4	22,845	4.5	34,264
WC-TP16	From pond HP-5	49,513	4.5	74,262
Upper Ponds				
WC-UP01	From ponds PUA-05 through PUA-10	67,102	0.6	12,920
WC-UP02	From ponds PUB-06 through PUB-09	54,615	2.0	37,565
WC-UP03	From ponds PUC-05 through PUC-08	66,385	2.6	56,782
WC-UP04	From ponds PUD-04 through PUD-09	83,035	0.3	28,245
WC-UP05	From ponds PUE-03 through PUE-07	94,070	0.9	25,589
WC-UP06	From ponds PUF-03 through PUF-06	66,474	0.1	9,788
WC-UP07	From ponds PUG-04 through PUG-07	65,344	0.7	15,004
NE = No Estimate.			**Total:**	**1,899,031**

BMI Common Areas
Clark County, Nevada

FIGURE _

ESTIMATED WASTE VOLUMES

Basic Remediation COMPANY

Prepared by: MWH MKJ Date 02/28/07

JOB No. 1881657
FILE: GIS/BRC/RAP_WASTE/FIGURE_.MXD

Attachment D
Security Plan

Attachment D
Security Plan
Basic Remediation Company (BRC)
Corrective Action Management Unit (CAMU)
Henderson, Nevada

Table of Contents

1.0 Introduction D-1
2.0 Personnel D-1
3.0 Site Control D-2
3.1 Fencing and Gates D-2
3.2 Access D-2
3.3 Signs D-2
3.4 Lighting D-3
4.0 Communication D-3

1.0 INTRODUCTION

This Security Plan describes the procedures and barriers that will be used to prevent persons who are unaware of the danger from entering the Remedial Waste Management System (RWMS). In addition, this plan also includes measures to minimize the possibility of unauthorized entry by persons or livestock onto the active portion of the RWMS.

2.0 PERSONNEL

Six to eight full-time employees, not including contractor employees, will be onsite during construction operations. In addition, at least one person will be present 24 hours a day, 7 days a week during the length of the remediation project. The following is a list of assigned personnel and their responsibilities:

- BRC CAMU Construction Manager –The Construction Manager will be on site at least 50 percent (50%) of the time the site is open for waste disposal to oversee site operations. The Construction Manager will be responsible for keys to the site gates.
- Equipment Operators – The primary responsibility of these (two) positions is the normal construction and operational duties associated with the landfill operations, including spotting vehicles, spreading and compaction of waste material, landfill attendant duties, and installation of earthen cover. Equipment operators will report to the BRC CAMU Construction Manager.
- Laborers – Typical duties will include site and roadway construction, maintenance, and cleanup, as determined by the BRC CAMU Construction Manager. In addition, a minimum of one employee will be assigned the job of daily policing the site perimeter, providing directions to disposal locations, monitoring received waste and collecting management data. Laborers will report to the BRC CAMU Construction Manager.
- Security Guards – Full-time security guards, on-site during non-working hours or using remote video equipment, will be responsible for site access, daily monitoring of the condition of the perimeter fence, and communicating problems to the BRC CAMU Construction Manager. During working hours, a Laborer will be responsible for site access, daily monitoring of the condition of the perimeter fence, and communicating problems to the BRC CAMU Construction Manager.

3.0 SITE CONTROL

3.1 Fencing and Gates

Primary site access will be gained through the entry gate located off Fourth Street on the east side of the property. The entry gate will be equipped with a lockable mechanism to prevent unauthorized entry and/or uncontrolled waste deposition when the site is closed. The gates will remain locked except during periods of continuous ingress/egress (i.e., during transport of materials to the BRC CAMU). Access to the site at points other than the entry gate will be discouraged by maintenance of site perimeter fencing and full time security during site operations. The Fence Plan is shown on Figure J-12 in Section 1 of the Supplemental RAP Information (SRAPI).

BRC will implement a monitoring program to identify and repair breaches in the perimeter fence line. This program includes new fence installation as part of remediation activities and continues after final remediation completion.

3.2 Access

Access to the site will be controlled by a security guard during non-working hours and site personnel during working hours. In addition, artificial barriers will be used to protect public health, safety, and the environment. The BRC CAMU entrance or gate attendant's office, located beyond the entry gate, will serve as the checkpoint to facilitate access and traffic control. Loads will be inspected at this point by assigned site personnel. During specified working hours, waste materials approved for acceptance will be directed to the active landfill working face.

Additional site controls will be employed to control traffic flow, including pedestrian traffic, within the Site during remediation. These site controls are necessary to control remediation workers, vendors and subcontractors, and Site visitors. Site visitors will not be allowed to access the exclusion zone. Visitors will be allowed access if they provide proof of current Title 29 CFR.1910.120, they "sign in" as authorized visitors, and they attend a required Health and Safety tailgate briefing.

3.3 Signs

Bilingual Signs will be posted that clearly indicate the following:

- The owner and operator of the site;
- The hours of operation;
- Materials accepted or excluded; and

- The site is private property and is not open to the public for public disposal of any waste materials whatsoever.

At the main entrance gate off Fourth Street an easily visible sign will be posted indicating the facility name, and other pertinent information as required. The sign will include the name of the site operator, the operator's telephone number, and hours of operation. It will be noted on the signage that the BRC CAMU is a private operation.

Instructional signs will be placed at this site entrance addressing prescribed safety measures on the site and include instructions regarding prohibition of smoking within the disposal areas and mandating that all instruction from site personnel be obeyed.

Interior site haul roads will be appropriately signed so as to direct each load to its designated disposal area. Typical directional and information signs will be posted at the site. Location of signage may be changed from time-to-time to facilitate operations. In addition, authorized personnel may be utilized to direct traffic at the active working face of the landfill operation.

Signs stating "Danger—Unauthorized Personnel Keep Out" will be posted at each entrance to the active portion of the facility, and at other locations, in sufficient numbers to be seen from any approach to the active portion of the site.

"No Trespassing" signs will be posted at 100-foot intervals along the site perimeter fencing. Additional signs and/or measures may be required to protect personnel and public health and safety. All signs will be legible from a distance of at least 25 feet.

3.4 Lighting

Lighting will be provided at the main entrance to illuminate the gate and signs. During night time construction, temporary lighting will be used within areas of the site where work is being performed.

4.0 COMMUNICATION

Security guards will have mobile phones for communicating with the Construction Manager and local police and fire services personnel, as necessary. Breaches in security will be reported to the Construction Manager for immediate repair and correction.

On-site communication will be through two-way radios or mobile phones. Operators will use radio or mobile phone technology to communicate with security personnel to report emergencies, injuries, etc.

Attachment E
Inspection Plan and Schedules

Attachment E
Inspection Plan and Schedules
Basic Remediation Company (BRC)
Corrective Action Management Unit (CAMU)
Henderson, Nevada

Table of Contents

1.0 Introduction E-1
1.1 Personnel E-1
2.0 Operational Inspections E-2
2.1 Health and Safety E-2
2.2 Air Monitoring E-2
2.3 Hauling/Transport E-3
2.4 Surface Water E-3
2.5 Leachate E-3
2.6 Gates and Fences E-4
2.7 Liner and Cover Systems E-4
2.8 Equipment E-4
2.9 Best Management Practices E-4
3.0 Recordkeeping E-5

Appendices

Appendix A – Inspection Checklists

1.0 INTRODUCTION

This Inspection Plan includes the items, areas, units, and equipment that will be inspected during the construction and operation of the BRC CAMU to identify malfunctions, deterioration, operator errors, and discharges that may be causing, or may lead to, a release of waste constituents to the environment or a threat to human health. Inspections performed during the post-closure care period are discussed in Attachment O. This plan includes checklists, schedules, and qualifications of personnel charged to perform inspections. A separate Construction Quality Assurance (CQA) Plan for the construction of the base liner system is included in Supplemental RAP Information (SRAPI), Section 3 and a separate CQA Plan for the construction of the final cover system is included in SRAPI, Section 6.

BRC will inspect monitoring equipment, safety and emergency equipment, security devices, and operating and structural equipment (such as dikes and sump pumps) that are important to preventing, detecting, or responding to environmental or human health hazards. Inspection checklists will be kept on site and will identify the types of problems (e.g., malfunctions or deterioration) which are to be looked for during the inspection (e.g., inoperative sump pump, leaking fitting, erosion, etc.). Inspection checklists are included as Appendix A.

1.1 Personnel

To develop and maintain the overall BRC CAMU in conformance with the inspection standards outlined in this document, four to five employees or contractors will be assigned, as required, to site inspections. Other employees or contractors will be assigned, as needed, for support activities.

The following is a list of assigned personnel with a brief outline of their qualifications:

- BRC Construction Manager – A BRC Construction Manager will maintain an operational/maintenance office onsite. This individual will be directly responsible for all site-related inspection activities. The BRC Construction Manager shall assign inspection duties, ensure all activities are performed on schedule, and maintain records in accordance with this plan and the Reports and Recordkeeping Plan (Attachment T). This individual will report to the Project Manager.

- Equipment Operators – Employees (two) serving in this capacity will possess experience and training in the fields of heavy equipment operation and earth movement and construction activities. The primary inspection responsibilities of

these positions include equipment and additional inspections as directed by the BRC Construction Manager. Equipment operators will report to the BRC Construction Manager.

- Laborer – Typical duties will include site and roadway construction, maintenance, and cleanup, as determined by the BRC CAMU Construction Manager. One employee will be assigned the job of daily policing the site perimeter and regulation of site access, providing directions to disposal locations, monitoring received waste and collecting management data. One employee will be assigned to air monitoring.

BRC is committed to placing and maintaining individuals with the overall training, experience, capabilities, and/or other qualifications in the above noted positions as necessary to operate and develop the site in such a manner as to meet or exceed applicable requirements and regulations. Additional equipment and personnel will be provided as required to accomplish overall site maintenance and operation standards, which equal or exceed all applicable State and local rules and regulations pertaining to site safety measures and the overall general protection of the area's environment.

2.0 OPERATIONAL INSPECTIONS

2.1 Health and Safety

Health and Safety inspections will be performed as outlined in the Accident Prevention, Contingency, and Emergency Response Plan (Attachment G). These inspections will be carried out by the BRC CAMU Construction Manager or his/her designee. The Health and Safety inspections include verifying PPE and communication devices are in good, working condition, inspection of safe work practices, and verifying personnel has received proper health and safety training. If conditions are found to be unsafe through inspections, the Project Manager will halt work and address problems. Examples of unsafe conditions are: Personal Protective Equipment (PPE) or radio/communication malfunction, severe weather, and/or fire.

2.2 Air Monitoring

Inspections associated with off-site dust transport are covered in detail in Appendix B, Perimeter Air Monitoring Program (PAMP), of the Corrective Action Plan (CAP). During waste placement within the BRC CAMU, air monitoring and sampling will be performed continuously, with a MIE® DATA RAM sampler that is calibrated prior to sampling each day. General site, breathing zone, and perimeter air monitoring will be conducted during construction operations. Personal air monitoring will be conducted if breathing zone or work zone monitoring results indicates that exposures

over the action level may have occurred. All sampling results will be included in the Corrective Action Completion Report to be submitted to NDEP following BRC CAMU closure. If the airborne concentrations exceed the action levels as prescribed in Section 4.0 of the PAMP, the BRC Project Manager will immediately stop work and modify dust control measures.

2.3 Hauling/Transport

Haul routes will be inspected on a daily basis by the BRC CAMU Construction Manager during hauling operations. Condition of the haul routes will be evaluated daily to determine if repairs are required. Repairs will be made when rutting, drainage, or other issues impact the transport of the waste materials.

Hauling/transport equipment will be kept in good working order and will have covers over the load. Standard construction entrance features (rumble strips and large aggregate aprons) will be used to remove soil from vehicle wheels departing the BRC CAMU site. Sweeper and vacuum trucks will be used daily to maintain haul routes. Further details are found in the CAP.

2.4 Surface Water

The BRC CAMU Construction Manager or his/her designee will be responsible for inspecting the storm water collection system after precipitation events (i.e. post storm) exceeding ½ inch in a 24 hour period and will evaluate erosion, sedimentation, and other damage, if any. In addition, the post storm inspection will be performed to evaluate the potential for surface water infiltration into the BRC CAMU. Surface water conveyance features will be inspected quarterly during the dry season and weekly during the wet season for sediment and debris accumulation. Collection and holding facilities will be inspected for sediment build-up and debris after precipitation events (i.e. post storm) exceeding ½ inch in a 24 hour period to maintain conveyance and design capacity.

Accumulated surface water, which has not entered the waste containing areas of the BRC CAMU, will be removed as soon as practical. An operational pump and appurtenant equipment will be maintained on-site during the entirety of the project (and not just during typically wet periods of the year) to be used in surface water removal. Accumulated surface water, which has contacted the waste material, will be treated as leachate and handled accordingly.

2.5 Leachate

Prior to completion of the final cover system, the BRC CAMU Construction Manager or his/her designee will be responsible for monitoring leachate levels in sumps

each week. If the leachate level exceeds 2-feet, the sump will be drained of leachate and used for dust control overlying lined areas of the BRC CAMU that have not been capped, in accordance with the BRC CAMU Operation Plan (Attachment M).

After completion of the final cover system, the leachate levels will be monitored on a quarterly basis for a period of two years and annually thereafter, see Attachment O (Closure and Post-Closure Plan). Leachate will be taken off-site for proper disposal in accordance with BRC CAMU Operation Plan (Attachment M).

2.6 Gates and Fences

The 24-hr site security guards will inspect the fences and gates daily to ensure all are in proper working order. In addition, the security guard will note any missing or damaged signs around the property as well as evidence of unauthorized access. Damages will be recorded and repairs performed immediately to minimize unauthorized site access.

2.7 Liner and Cover Systems

During construction and installation, liners and cover systems will be inspected regularly for uniformity, damage, and imperfections (e.g., holes, cracks, thin spots, or foreign materials) as outlined in the construction quality assurance plans for the base liner system and final cover system. Details of liner and cover construction quality assurance are provided in the Construction Plan (Attachment L) and Closure and Post-Closure Plan (Attachment O), respectively. The liner system will be inspected weekly during waste placement activities to verify the system remains undamaged. If damage occurs, work activities in the area of the damage will halt while damage is repaired.

2.8 Equipment

During construction activities, all equipment in operation will be inspected daily by the equipment operator. BRC will also inspect and track on-site equipment to ensure that it is in good working order. Inspections will be performed by equipment operators to ensure equipment is in good working order. Equipment which is not in good working order will not be used until repaired or replaced.

2.9 Best Management Practices

Best management practices (BMPs) will be inspected weekly and after storm events to verify they are in good, working condition. If inspections indicate BMPs are damaged, they will be replaced.

3.0 RECORDKEEPING

The BRC CAMU Construction Manager will record inspections in an inspection log. These records will be kept in accordance with the records retention requirements of the AOC3. At a minimum, these records will include the date and time of the inspection, the name of the inspector, a notation of the observations made, and the date and nature of any repairs or other remedial actions. Inspection checklists are included as Appendix A.

Appendix A
Inspection Checklists

Basic Remediation Company
Corrective Action Management Unit (CAMU)

Log of Operations

Yearly Cover Sheet

This log cover sheet shall be completed at the beginning of each license year and should be kept on file at the beginning of the daily log file for that year. Attach amendments to this form as necessary.

Annual Log for Year: _____ License #: _____ Phone #: _____

Name of Facility: _____

Mailing Address: _____

(Street) (City) (State) (Zip)

Location of Facility _____

(Street) (City) (State) (Zip)

Owner of Facility: _____ Licensee Name: _____

Name of Site Manager: _____

Method of Measuring Amount of Incoming Materials:

_____ Scales _____ Visual Estimate _____ Capacity of Hauling Vehicle

Types & Number of Equipment on Site:

_____ Dozers _____ Graders _____ Pan/Scraper

_____ Compactor _____ Sweepers _____ Water Trucks

Other: _____

_____

_____

Daily Inspection Checklist
BRC CAMU
Henderson, NV

Date: _____

Name: _____ Title: _____

Weather: _____

	Time:	YES	NO	
Health & Safety:	_____	☐	☐	Site map posted
		☐	☐	Buddy system implemented
		☐	☐	Work zones identified
		☐	☐	Site access controlled
		☐	☐	Visitors escorted
		☐	☐	On/off site communication in working order
		☐	☐	Air monitoring equipment is working order
		☐	☐	Air monitoring records recorded in field logbook
		☐	☐	Air monitoring calibration records recorded in field logbook
		☐	☐	Standard operating procedures implemented
		☐	☐	Housekeeping at decontamination zone is appropriate
		☐	☐	Decontamination procedures implemented
		☐	☐	Emergency response equipment in working order
		☐	☐	Route to hospital is posted
		☐	☐	Hazards incurred. If yes: _____
Haul Roads:	_____	☐	☐	Waste Debris on Roadways
				if yes: _____
Surface Water:	_____	☐	☐	Surface Water Present
				if yes, where and disposal method: _____
Waste Placement:	_____	☐	☐	Liner/cover free from damage and imperfections
				if no: _____
		☐	☐	Placement in accordance with Project Drawings and schedule
				if no: _____

Daily Inspection Checklist
BRC CAMU
Henderson, NV

☐ ☐ Fill Stable

if no: _____

Security: _____

☐ ☐ Fences and gates in good condition

if no: _____

☐ ☐ Signs of unauthorized access

if yes: _____

☐ ☐ Notification signs present and in good condition

if no: _____

☐ ☐ Improper Salvaging

if yes: _____

Equipment: _____

☐ ☐ Air Monitoring equipment in good, working condition

if no: _____

☐ ☐ Scales in good, working condition:

if no: _____

Daily Inspection Checklist
BRC CAMU
Henderson, NV

	# in Operation:	of:	
Load-out Operation			Dozer
			Waterpull
			P/W Scraper
			Excavator
			Off-Road Dump Truck
			Lube Truck
			Water Stand Tank
Boulder Highway Operation			Sweeper
			Loader
			Light Plant
			Traffic Read Board
			Vacuum Truck
Haul Route Operation			Blade
			Waterpull
			Water Stand Tank
			Light Plan
Disposal Equipment			Dozer
			Waterpull
			P/W Scraper
			Off-Road Dump Truck
			Lube Truck
			Water Stand Tank
			Compactor
	Other:		_____
			_____
			_____

Work shall be postponed until correct

Needs to be addressed

Weekly Inspection Checklist

BRC CAMU
Henderson, NV

Week of: _____

Name: _____ Title: _____

Leachate Collection:

Amount of Leachate Collected: _____ Gallons (Weekly)
_____ Gallons (Daily)

Action Level Reached? ☐ Yes ☐ No

Disposal Method: ☐ Dust Control
☐ Off-Site
☐ N/A

	YES	NO	
Health and Safety			
	☐	☐	Pre-entry brief meetings are current
	☐	☐	Tailgate meetings are current
	☐	☐	Primary and Secondary containers are properly labeled
	☐	☐	Material safety data sheets are available
	☐	☐	PPE storage is neat and organized
Haul Roads:			
	☐	☐	Erosion of road
			if yes: _____
			_____
	☐	☐	Rumble strips/aggregate aprons in good condition
			if no: _____
			_____
Run-off Collection:			
	☐	☐	Cracks in conveyance channels
			if yes: _____
			_____
	☐	☐	Water present in conveyance channels
			if yes: _____
			_____
	☐	☐	Evidence of flooding
			if yes: _____
			_____

Weekly Inspection Checklist

BRC CAMU
Henderson, NV

Run-on Collection:

☐ ☐ Water Present

if yes: _____

_____

☐ ☐ Pumps in good, working condition

if no: _____

_____

CAMU Surface:

☐ ☐ Evidence of erosion

Type:

☐ Wind

☐ Water

if yes: _____

_____

☐ ☐ Cracks in surface

if yes: _____

_____

BMPs:

☐ ☐ Dormant areas outside of silt fence seeded/mulched

if no: _____

_____

☐ ☐ Seed and mulch blown away

if yes: _____

_____

☐ ☐ Silt fences/wind screens in good, working condition

if no: _____

_____

☐ Needs to be addressed

Monthly Inspection Checklist
BRC CAMU
Henderson, NV

Month of: _____

Name: _____ Title: _____

	YES	NO	
Health and Safety			
	☐	☐	Training/medical surveillance/respiratory protection records are current
	☐	☐	Chemical inventory is up to date
Repairs			
	☐	☐	Previous month's failed inspections addressed
			if no: _____
Leachate:			
	☐	☐	Leachate Pump in good, working order
Haul Roads:			
	☐	☐	Ruts/Cracks in road
			if yes: _____
	☐	☐	Rumble Strips/Aggregate Aprons in good condition
			if no: _____

☐ Needs to be addressed

Post-Storm Inspection Checklist

BRC CAMU
Henderson, NV

Date: _____

Name: _____

Storm Duration: _____

Total Precipitation Amount: _____ (inches)

Leachate Collection:

Amount of Leachage Collected: _____ Gallons

Action Level Reached? ☐ Yes ☐ No

Disposal Method: ☐ Dust Control
☐ Off-Site
☐ N/A

	YES	NO	
Haul Roads:	☐	☐	Pooled Water
			if yes: _____
Run-off Collection:	☐	☐	Evidence of flooding
			if yes: _____
	☐	☐	Water Samples Collected
			if no: _____
Run-on Collection:	☐	☐	Water Present
			if yes: _____
	☐	☐	Water Samples Collected
			if no: _____
CAMU Surface:	☐	☐	Evidence of erosion
			if yes: _____

Post-Storm Inspection Checklist

BRC CAMU

Henderson, NV

☐ ☐ Water present

if yes: _____

_____

☐ ☐ Cracks/rills in surface

if yes: _____

_____

Best Management Practices:

☐ ☐ BMPs in good condition

if no: _____

_____

Off-site Disposal:

☐ ☐ Evidence of off-site disposal

if yes, corrective actions implemented: _____

_____

_____

☐ Needs to be addressed

Quarterly Inspection Checklist

BRC CAMU
Henderson, NV

Date: _____ Quarter: _____

Name: _____ Title: _____

Health and Safety:	YES	NO	
	☐	☐	New Employees if yes, names/titles: _____
	☐	☐	New employees have received H&S training if no, when will it be scheduled: _____
	☐	☐	HASP needs updating if yes: _____
	☐	☐	Health and Safety Inspection logs maintained if no: _____
	☐	☐	Accident, Contingency, and Emergency Response Plan on site if no: _____
	☐	☐	Accidents/Emergencies within last 3 months if yes, what was done to prevent future occurance: _____

Quarterly Inspection Checklist
BRC CAMU
Henderson, NV

Water Quality:

☐ ☐ Analytical results maintained for surface water monitoring

if no: _____

_____

☐ ☐ Analytical results maintained for groundwater monitoring

if no: _____

_____

☐ Needs to be addressed

Attachment F
Personnel Training Plan

Attachment F
Personnel Training Plan
Basic Remediation Company (BRC)
Corrective Action Management Unit (CAMU)
Henderson, Nevada

Table of Contents

1.0 Introduction F-1
1.1 Personnel F-1
2.0 Training F-2
2.1 Field Supervisor Training F-3
2.2 Equipment Operator and General Employee Training F-3
2.3 Post-Closure Personnel Training F-4
3.0 Recordkeeping F-4

Appendices

Appendix A – Training Course Descriptions

Appendix B – Site Specific Training Lesson Plans and Exams

Appendix C – Organizational Flowchart

1.0 INTRODUCTION

This Personnel Training Plan describes the personnel and classroom or on-the-job training workers and other site personnel receive on how to perform their duties in a way that ensures the BRC CAMU complies with the conditions of this RAP and how to respond effectively to emergencies.

1.1 Personnel

To develop and maintain the overall BRC CAMU in conformance with the design and operational standards outlined in this document, three to four employees or contractors will be assigned, as required, to site operations. Other employees or contractors will be assigned, as needed, for support activities.

The following is a list of on-site personnel with a brief outline of their qualifications:

- BRC CAMU Construction Manager –The Construction Manager will be on site at least 50 percent (50%) of the time the site is open for waste disposal to oversee site operations. The Construction Manager will be responsible for keys to the site gates.
- Equipment Operators – The primary responsibility of these (two) positions is the normal construction and operational duties associated with the landfill operations, including spotting vehicles, spreading and compaction of waste material, landfill attendant duties, and installation of earthen cover. Equipment operators will report to the BRC CAMU Construction Manager.
- Laborers – Typical duties will include site and roadway construction, maintenance, and cleanup, as determined by the BRC CAMU Construction Manager. In addition, a minimum of one employee will be assigned the job of daily policing the site perimeter, providing directions to disposal locations, monitoring received waste and collecting management data. Laborers will report to the BRC CAMU Construction Manager.
- Security Guards – Full-time security guards, on-site during non-working hours or using remote video equipment, will be responsible for site access, daily monitoring of the condition of the perimeter fence, and communicating problems to the BRC CAMU Construction Manager. During working hours, a Laborer will be responsible for site access, daily monitoring of the condition of the perimeter fence, and communicating problems to the BRC CAMU Construction Manager.

2.0 TRAINING

BRC is committed to placing and maintaining individuals with such overall training, experience, capabilities, and/or other qualifications in the above noted positions as necessary to operate and develop the site in such a manner as to meet or exceed applicable requirements and regulations. Additional equipment and personnel will be provided as required to accomplish overall site maintenance and operation standards, which equal or exceed all applicable State and local rules and regulations pertaining to site safety measures, and the overall general protection of the area's environment.

Non-office site personnel will receive 40-hr Occupational Safety and Health Administration (OSHA) Hazardous Waste Operations and Emergency Response Standards (HAZWOPER) training, which will be provided by certified trainers. Personnel will renew this training annually with the 8-hr refresher course. Employees using a Nuclear Density Gauge will be required to have completed the 8-hour Nuclear Density Safety Course, which will be provided by a certified trainer (e.g. Troxler Electronics, etc.). Prior to beginning work at the CAMU site, employees, contractors, and subcontractor personnel are required to submit all applicable training certificates to BRC to be maintained and stored in accordance with the Report and Record Keeping Plan (Attachment T). The task supervisor will be responsible for providing the Construction Manager with records of training. The following table lists the training required for specific work tasks and personnel working at the CAMU site. Select course descriptions are provided in Appendix A.

Work Task	Training	Personnel Required to be Trained	Documentation Required
All work at the CAMU site	40 hour OSHA HAZWOPER	All on-site personnel	Certificate from certified training meeting 29 CFR 1910
All work at the CAMU site	8 hour OSHA refresher	All on-site personnel	Certificate from certified training meeting 29 CFR 1910
All work at the CAMU site	8 hour OSHA Supervisor Training	On-site supervisors	Certificate from certified training meeting
All work at the CAMU site	Respirator Fit Test	All on-site personnel	Certificate from certified trainer
All work at the CAMU site	Red Cross First Aid and CPR	On-site supervisors	Certificate from Red Cross
Liner system – geomembrane installation	Manufacturer training on seaming geomembrane	Geomembrane installation technicians	Approval letter from geomembrane manufacturer
Liner system –	Qualifications and	Geosynthetic material	Qualifications and

geosynthetic material installation	experience installing similar materials	installation technicians	resumes of personnel responsible for installing geosynthetic materials
Soil/waste moisture / density testing	8 hour Nuclear Density Safety Training	CQA monitor testing fill and waste moisture / density	Certificate from certified trainer
Landfill operations management	SWANA Manager of Landfill Operations Training	Landfill manager	Certificate from certified SWANA trainer
HDPE pipe joining	Manufacturer Butt-Fusion Training	HDPE pipe joining technicians	Certificate from certified trainer

Additional site specific training will be conducted and recorded by task supervisors related to their work tasks. Site specific training is discussed in Section 2.2.

2.1 Construction Manager Training

In addition to OSHA 40-hr HAZWOPER Training, the Construction Manager will receive the OSHA 8-hr HAZWOPER Supervisor course. The Construction Manager will be responsible for providing a health and safety training for site personnel to become familiar BRC CAMU-specific procedures. The BRC CAMU Construction Manager will keep records on names and dates of those who attended and passed training.

The Construction Manager will also be responsible for conducting pre-entry brief meetings and tailgate safety meetings. He/she will verify monitoring equipment and personal protective equipment is operational and will be responsible for verifying monitoring equipment has been calibrated. The Construction Manager will also be responsible for weekly inspections.

2.2 Equipment Operator and Laborer Training

In addition to OSHA 40-hr HAZWOPER training, employees shall receive BRC CAMU-specific training covering:

- Procedures for using, inspecting, repairing, and replacing facility emergency and monitoring equipment: Personnel receive instruction in the use of emergency and monitoring equipment described in the Attachment G. Personnel will be trained to inspect all facility emergency and monitoring equipment to mitigate the effects of equipment failure in the Inspection Plan. In addition, personnel will be trained in the use of emergency equipment in their job areas (e.g. fire extinguishers, respirators, etc.);

- Key parameters for equipment automatic shut-off: Plant and equipment operators will receive on-the-job training for automatic shut down of equipment in their work areas;
- Communications or alarm systems: Facility employees will be instructed as to the location and use of all telephones, intercoms, sirens, alarms, and two-way radios;
- Responses to fires or explosions: Personnel will receive fire prevention training and fire response;
- Response to spills: Personnel will receive instruction in spill and release prevention and response ; and
- Shutdowns of operations: Personnel will receive instruction in shutdown procedures during BRC CAMU operation. Personnel with operational responsibilities are instructed in procedures for planned and unplanned shutdowns during on-the-job training.

Training sessions will be held quarterly to review new health and safety hazards and provide new employees with training. The employees will be familiar with contingency plans to deal with accidents, injuries, fires, explosions, or natural disasters as outlined in Attachment G, Accident Prevention, Contingency, and Emergency Response Plan.

2.3 Post-Closure Personnel Training

Post-closure care personnel will have received adequate training in their specific job duties. This includes OSHA 24-hour health-and-safety training as well as pertinent training in BRC CAMU maintenance procedures. In addition, staff will be trained on emergency procedures and contacts as well as hazards they may encounter at the BRC CAMU. This post-closure staff will consist of a facility manager and various staff workers as needed. The name, address, and telephone number of the facility manager will be provided to the NDEP during the closure process.

3.0 RECORDKEEPING

The BRC will maintain the following documents and records for each hazardous waste management related position at the facility:

- The job title for each position
- The name of the employee filling each position
- A written job description including requisite skill, education, or other qualifications
- Duties of employees assigned
- Description of training
- Records documenting completion of training

The Construction Manager will maintain records at their onsite facilities. All records will be kept in accordance with the record retention requirements of the AOC3.

Appendix A
Training Course Descriptions

HAZWOPER 40 Hour Course

OSHACAMPUS.com™
powered by 360training

Course Description

This course covers broad issues pertaining to the hazard recognition at work sites. OSHA has developed the HAZWOPER program to protect the workers working at hazardous sites and devised extensive regulations to ensure their safety and health. This course, while identifying different types of hazards, also suggests possible precautions and protective measures to reduce or eliminate hazards at the work place. It is specifically designed for workers who are involved in clean-up operations, voluntary clean-up operations, emergency response operations, and storage, disposal, or treatment of hazardous substances or uncontrolled hazardous waste sites. Topics include: protection against hazardous chemicals, elimination of hazardous chemicals, safety of workers and the environment, and OSHA regulations. This course covers topics included in 29 CFR 1910.120.

Regulatory

This course meets the in class training requirements of the 1910.120 standard. An additional 8 hours of hands on training is required to meet the training requirements of the standard.

Seat Time

This course has been approved for 40 hours.

Course Pre-Requisite

There are no pre-requisite requirements for this course. Upon successful completion of this course, you will be able to print your certificate.

Testing:

Quizzes: Lesson quizzes require no mastery. Quizzes at the end of each module require a passing grade to proceed to the next module. Final Exam: Final Exam must be passed with a 70% to pass the course. The final exam can be taken three times if necessary.

Topics Covered

- Regulation Overview
- Site Characterization
- Toxicology
- Hazard Recognition
- Hazard & Safety Analysis
- Hazardous Chemical Awareness
- Radiological Hazards
- Respiratory Protection
- Personal Protective Equipment
- Site Control
- Decontamination
- Medical Surveillance
- Air Monitoring
- Confined Space Entry
- Emergency Procedures
- Material Sampling

HAZWOPER 8 Hour Annual Refresher Course

OSHACAMPUS.com™
powered by 360training

Course Description

This course meets the requirements in OSHA 29 CFR 1910.120 for 8 hours of annual refresher training for workers at hazardous waste sites. This course is designed for general site workers who remove hazardous waste or who are exposed or potentially exposed to hazardous substances or health hazards. Topics include HAZWOPER regulations, safety and health plans, hazardous chemicals, safety hazards, air monitoring, medical surveillance, site control, decontamination, personal protective equipment, and respiratory equipment. This course covers the topics in OSHA 29 CFR 1910.120

Learning Objectives

- Read and understand OSHA regulations and requirements
- Use Site Characterization to identify hazards found in the workplace and steps to be taken to minimize hazards
- Understand the principles of toxicology and how they relate to various types of chemical exposures
- Develop a Medical Surveillance Program and understand its purpose
- Identify the uses for Personal Protective Equipment (PPE) and how to choose the correct PPE for a situation
- Understand the principles of decontamination as well as levels of decontamination and decontamination methods
- Have a better understanding of potentially hazardous situations involving corrosives, solvents, oxidizers, and reactive chemicals
- Understand the various considerations in an emergency and the importance of training and actions to personal safety and the safety of others

Topics Covered

- Regulation Overview
- Hazard Recognition
- Site Characterization, Analysis, and Control
- Toxicology
- Medical Surveillance
- Safe Work Practices and PPE
- Decontamination
- Chemical Awareness
- Emergency Procedures

Regulatory

Please refer to the state/regulatory requirement in the course catalog page.

Seat Time

This course has been approved for 8 hours

Course Pre-Requisite

Must have taken the 24 or 40 hour HAZWOPER course

Testing

Quizzes: All quizzes must be passed with a 100% to proceed to the next lesson. Final Exam: Final exam must be passed with a 70% to pass the next course. The final exam can be taken three times if necessary.

Contact us at: safety@360training.com or call 1.888.318.3497

360training™

American Red Cross

Standard First Aid with CPR/AED - Adult

American Red Cross First Aid with CPR/AED - Adult, trains participants to recognized ad care for life-threatening respiratory or cardiac emergencies in adults and provides the knowledge and skills needed to care for injury or sudden illness until professional medical help arrives. Training complements adult learning styles with hands-on practice and real-life scenarios while take-away materials serve as excellent refresher tools after training is complete. This comprehensive course meets training guidelines for first aid programs established by the Occupational Safety and Health Administration.

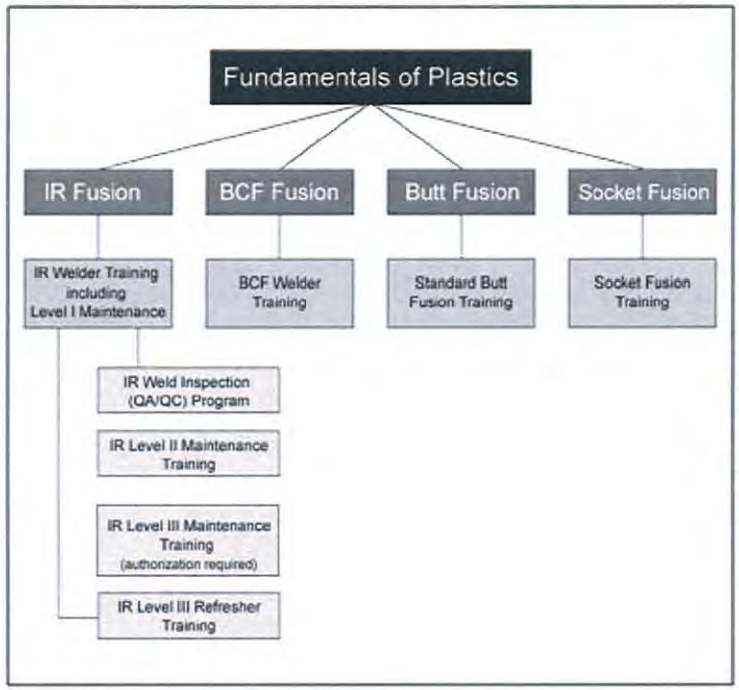
Topics covered include:

- Recognizing and respond to an emergency.
- How to care for a person who is choking.
- Checking an unconscious person for life-threatening and nonlife-threatening conditions.
- Recognizing and caring for a person who is not breathing.
- How to care for a heart attack and how to give CPR.
- Using and AED and identifying precautions when using and AED.
- Identifying the signs and symptoms of sudden illness, including stroke, diabetic emergency, poisoning and allergic reactions and care for them.
- Controlling bleeding.
- Recognizing and caring for heat- and cold-related emergencies.

© Copyright 2006 The American National Red Cross. All Rights Reserved.

Fusion Machine Training Programs

Experience shows that improper installation, rather than faulty products, is the primary reason for system failures, delays, and cost overruns. Georg Fischer believes that the installation of our products is as important as the quality of the products we manufacture. In keeping with this belief, Georg Fischer offers several training courses.



Socket Fusion Training

Standard Butt Fusion Training

Infrared Welding
- IR Level I Welder Training
- IR Level II Maintenance Training
- IR Level III Maintenance Training
- IR Level III Refresher Training
- IR Weld Inspection Program (WIP)

BCF Welder Training

Course Description

Socket Fusion Training	Standard Butt Fusion Training (Conventional or CNC)
This four-hour course covers all aspects of hand-held and machine Socket Fusion Technology. Trainees will demonstrate their ability to perform socket fusion joining.	This four-hour course covers all aspects of Standard Butt Fusion Technology. Trainees will demonstrate

Upon successful completion and testing, the trainee will receive a Certificate of Completion and an Installer's Badge which may be worn on the job site.	their ability to prepare pipe, face pipe, heat and join piping.
IR Level I Welder Training This course covers fundamental training absolutely necessary for proper operation of the infrared (IR Plus) fusion machines. Topics: • Plastic pipe fundamentals • Infrared butt fusion • General information • Design/function/operation of the IR Plus fusion machines • Weld bead inspection • Basic machine maintenance Duration/Value: • 1 day/$250.00 per person Register now	**IR Level II Maintenance Training** Completion of this 16-hour (2 day) class allows the trainee to maintain external parts of the machine. Prerequisite: • All attendees must have completed the Georg Fischer IR Level I Welder Certification Program and Weld Inspection Program Topics: • Technical concepts of the machine • Machine inspections • Functional check • Maintenance procedures Level II • Alignment and adjustments • Weld evaluation • Documentation Duration/Value: • 2 days/$500.00 per person Register now
IR Level III Maintenance Training **(Authorization Required)** Completion of this 32-hour (4 day) class allows the trainee to maintain external and internal parts of the machine. This course is conducted at the Georg Fischer Tustin facility only. Prerequisite: • All attendees must have completed the Georg Fischer IR Level II Maintenance Training Topics: • Technical concepts of the machine • Machine inspections • Functional check • Maintenance procedures Level III • Alignment and adjustments • Weld Inspection Program • Documentation Duration/Value: • 4 days/$1,500.00 per person Register now	**IR Level III Refresher Training** **(Authorization Required)** This course is a refresher for Level III personnel and includes current updates for the IR 63, IR 225, and IR Plus machines. This course must be taken 1 year after the initial Level III course and then every two years after that. This course is condcuted at the Georg Fischer Tustin facility only. Prerequisite: • All attendees must have completed the Georg Fischer IR Welder Certification and IR Level II and Level III Maintenance Training. Duration/Value: • 2 days/$500.00 per person Register now
IR Weld Inspection Program (WIP) Upon completion of this eight-hour (1 day) class, the QU inspector will have a good basis to perform on-site visual IR weld evaluation. Topics: • Weld background • Terminology • Bead characteristics • Restmelt evaluation • Flow charts and checklist Duration/Value:	**BCF Welder Training** This four-hour course covers all aspects of using the BCF Flow Fusion Technology. Trainee will prepare pipe samples, insert and remove bladders, generate welds, and perform hot cleaning of the heater heads. Upon successful completion and testing, the trainee will receive a Certificate of Completion and an Installer's Badge which may be worn on the job site. Prerequisite: • All attendees must have completed the Georg Fischer IR Level I Welder Training

- 1 day/$250.00 per person

Print

George Fischer Inc, 2882 Dow Avenue, Tustin, CA 92780-7258 USA,
Phone (714) 731-8800, Toll Free (800) 854-4090, Fax (714) 731-6201

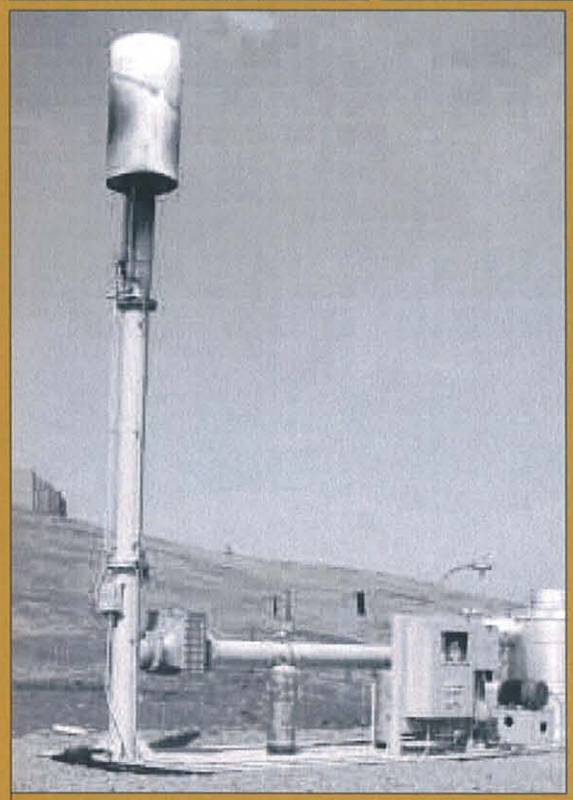
Using this site means you accept its terms of use | disclaimer
Copyright © 2004 GF Piping Systems. All rights reserved.

2007 TRAINING COURSE CATALOG

SWANA®

SOLID WASTE ASSOCIATION of North America

THE LEADING PROFESSIONAL ASSOCIATION IN THE SOLID WASTE FIELD



I AM SWANA

"Many people overlook the hard work and dedication necessary to perform a public service like solid waste management. SWANA's training courses make it possible for these men and women to operate at the highest level of performance with a sense of pride and achievement."

Bill Tobin | Director of Field Operations
Waste Authority of Montgomery County

Message from SWANA's President

INTRODUCTORY LETTER FROM TOM PARKER

Dear Colleague,

Thank you for choosing SWANA as the provider of all your training and professional development needs. For over 40 years, SWANA has thrived at the forefront of all training and education for municipal solid waste needs. This effort results from our first-and-foremost commitment to you, our members, but also to the field of solid waste.

The 2007 catalog contains training opportunities for you and all your staff. Whether you need training for professional development, for SWANA certification, or to maintain a current certification, SWANA offers specific education to fit your needs. This year SWANA Training takes place as several great locations beginning in Tampa, Fla., and closing out the year at WASTECON 2007 in Reno, Nev.

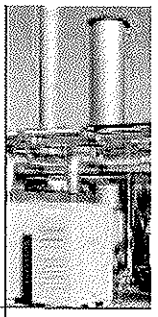
SWANA gives you what you need to stay ahead of them game with our new list of course offerings. We have updated the Manager of Landfill Operations Course (MOLO) and our ever-growing line of distance learning opportunities. With our increased offerings of E-Courses and E-Sessions, you can train individually at your desk or with your whole staff in a conference room to get the most out of your money! As with all SWANA events, in person and online, you will interact with and learn from some of the best and the brightest in the industry.

Thank you for your continued support of SWANA, and our mission to advance the practice of economically and environmentally sound management of municipal solid waste. I look forward to learning from you online or at one of our live events.

Sincerely,

Tom Parker, P.E
CDM, New Mexico
SWANA President

P.S. Receive the mark of professionalism in the solid waste industry with SWANA certification. SWANA offers eight different Certifications including the industry's only Bioreactor Landfill Certification. In this competitive landscape, it is integral to have an integrated MSW management background to efficiently manage your facility.



2007 Training Catalog Directory

SWANA's Solution for Available Courses

About the SWANA Training Catalog 4

Getting SWANA Certified 5

SWANA[DL] (Distance Learning) 6-7

SWANA E-Training Calendar of Events 8

Landfill and Landfill Gas Courses 10-14

Collection and Transfer Courses 16-17

SWANA Registration Form 18-19

Recycling, Waste Reduction and Composting Courses 20-21

Special Waste Courses 22-23

Planning, Management and Communication Courses 24-25

SWANA Recertification Information (Already SWANA Certified?) 26

CEU Chart for All SWANA Courses 27

CEU Chart for SWANA[DL] (Distance Learning) 28

About SWANA Training Centers 29-30

SWANA 2007 Events 31-33

Training On Demand 34

Classroom Training | Chapter Partnering Events | E-Courses | E-Sessions | E-Studies | On-Site Training | Home Study Course | Training On-Demand

About the SWANA Training Catalog

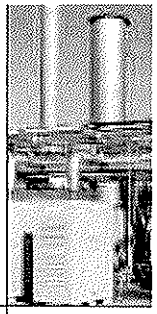
Congratulations on choosing SWANA for your professional development, training and certification!

For those of you who are new to SWANA: Welcome. To our over 7,700 loyal members, thank you for your continued support of SWANA's Technical Programs, and welcome to our new catalog format. Our new look has been designed to showcase SWANA's commitment to providing the best-in-class educational products to the entire solid waste industry. Today, SWANA continues that pledge with more educational products than ever before.

We hope the new format will make it easier for you to find just what you are looking for by using the following symbols to indicate the format of each product. Additional information including full course descriptions, is available on **www.SWANA.org** under "Educate".

- **SWANA Classroom Training:** Held at SWANA events throughout the year.
- **SWANA Chapter Partnering Events:** SWANA Chapters host additional SWANA training courses throughout North America.
- **E-Courses:** Traditional courses and brand new offerings that can be accessed from the convenience of your office. E-Courses are conducted through SWANA's web conferencing and teleconferencing system.
- **E-Sessions:** The best of SWANA's technical sessions brought to you each month through Web conferencing. These 75-minute sessions give you and your staff an opportunity to learn from the experts in this extended session. A different topic is covered every month.
- **E-Studies:** These self-paced, self-study options give you the training and the CEUs you need. All it takes is an internet browser.
- **On-Site Training:** Full training packages that you deliver to your staff at your own site and at your own pace.
- **Home Study Courses:** Written materials on important solid waste topics. Looking for CEUs – just pass the test that comes with the course and you'll qualify.
- **SWANA Training On Demand:** Do you have a group that needs to be trained and the next event isn't soon enough or your budget can't afford the cost? Let our best-in-class training come to you! Any of our courses can be customized to your needs. For quotes, contact **learn@SWANA.org**.

We love to hear about the training and educational products that you need. You can always reach us with your ideas, comments and feedback at **learn@SWANA.org**.



Getting SWANA Certified Easy As 1, 2, 3!

SWANA'S PREMIER TRAINING COURSES

1. CHOOSE YOUR DISCIPLINE(S).

The Solid Waste Association of North America offers eight (8) certifications in the following solid waste disciplines:

- Landfill Management (MOLO)
- Bioreactor Landfill*
- Collections Systems
- Composting Programs
- Construction & Demolition Materials (C&D)
- Principles of MSW Management
- Recycling Systems
- Transfer Station Systems

* The Bioreactor Landfill certification requires candidates to hold a current SWANA Landfill management certification.

2. CHOOSE YOUR CERTIFICATION LEVEL.

Most SWANA Certifications offer at least two (2) eligibility levels, with an additional Inspector level offered to Landfill and Construction & Demolition SWANA Certification holders:

- **Technical Associate:** This level is ideal for professionals new to the industry and involved in the planning, design, implementation, operation or promotion of the MSW field. This would also include consultants, planners, vendors and regulators, etc. A minimum of a High School Degree or GED Required.
- **Manager:** This professional must meet all of the requirements of the Technical Associate level plus a minimum of five (5) years** experience in Municipal Solid Waste Management. Also required are at least two (2) years experience in a management/supervisory position*** in the discipline for which you are applying.

** 4-year degree in a related field may be substituted for up to 2 years of MSW experience
*** directly responsible for daily operations; compliance with design and permit conditions, utilization of field equipment and services, personnel needs, utilization and retention.

- **Inspector:** Unique to Landfill and Construction & Demolition certification holders, this professional must meet all of the requirements of the Technical Associate level as well as the ability to issue official citations for violations which require action/impose penalties. This professional must also be an active inspector with at least 2 years experience.

3. PASS THE SWANA CERTIFICATION EXAM FOR YOUR DISCIPLINE.

SWANA certification exams are offered at all SWANA and SWANA Chapter training events, even if the preparatory class is not being offered. You may only sit for one exam per testing session. You are not required to attend the preparatory training courses to become certified; however, it does reinforce your knowledge in a particular discipline. A passing score of 70% or above is needed to become SWANA certified. You will be allotted three (3) hours to complete your exam. All exams are proctored.

You may use calculators, preferably one capable of handling up to seven digits. Landfill Certification candidates may use MOLO scales for maps. The exam is a "closed book" exam so you may not bring manuals, worksheet or notes to the testing site. Before leaving the testing site, you will be asked to complete the SWANA Certification Application. Exam results will be mailed to the certification candidates within 60 days of the test date.

If you have any questions about becoming SWANA Certified, please contact us at **cert@SWANA.org**.

SWANA[DL] (Distance Learning)

SWANA CEUs are available for most SWANA Courses

Can't get away from work? Enjoy the industry's top training from the comfort of your home or office with SWANA[DL] (Distance Learning). With these courses, get the training you need in a format you want. SWANA[DL] allows you to train from your home or office, with your computer, or with home study manuals. Also by attending these courses, Certified Professionals can earn SWANA Continuing Education Units (CEUs). With SWANA[DL], training has never been easier!

E-COURSES

Learn, Earn and Return with these new online courses! You'll learn about a wide range of solid waste topics. Every course is taught by SWANA faculty. All you need is an internet connection and separate phone line and you're ready to learn. Each session lasts up to two hours, making SWANA training more convenient than ever! For a schedule of upcoming E-Courses, visit **www.SWANAstore.com** and click on E-Courses.

E-SESSIONS

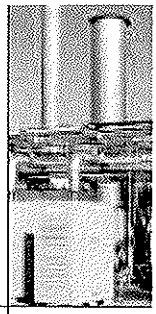
With these 75-minute presentations you can attend SWANA technical sessions all year long, from any location! These sessions bring you the latest on today's hot topics on the first three Wednesdays of the month. Each month focuses on a different area of MSW to keep you informed on all the current trends in solid waste. For a schedule of upcoming E-Session topics visit **www.SWANAstore.com** and click on E-Sessions.

E-STUDIES

Train your way with these self-paced online courses. These courses are completely online and are always a click away. The course also moves with you, so you spend your time on the areas that you need. Many of our courses also allow more than one user to train per account, with our new subscription-based pricing plan. Training has never been more flexible than it is with these courses!

Courses include:

- Landfill Operations
- Composting Operations
- Transfer Station Health and Safety
- Waste Screening
- Landfill Health and Safety
- Landfill Gas Primer
- Establishing An Electronics Recycling Program
- Integrated Solid Waste Management



SWANA DL
(Distance Learning)

SWANA'S PREMIER TRAINING COURSES

HOME STUDY COURSES ✉

Not quite ready for the world of online learning but still need convenient training? Well then look no further than SWANA Home Study Courses. Each course includes a manual that you review at your own pace. Once you're comfortable with the information, complete the enclosed exam. Score a 90% or better and you'll receive credit for the course. The manual also serves as a good reference once you've completed the course.

Courses include:

- Managing Landfill Gas at MSW Landfills
- Waste Screening at MSW Management Facilities
- Groundwater Monitoring, Sampling, Analysis & Construction
- Leachate Generation, Collection & Treatment at MSW Landfills
- Construction Waste and Demolition Debris Materials Manual

ON-SITE COURSES

Act as a trainer for your staff with these courses. Each course contains 8-10 hours of training, made up of smaller modules. This allows the courses to be tailor-made for your company.

Courses include:

- Training for Sanitary Landfill Operations Personnel
- Training for Collection Operations Personnel
- Waste Screening at MSW Management Facilities
- Health and Safety for MSW Landfill Training
- Health and Safety for MRF Personnel
- Health and Safety for Collection Personnel
- Health and Safety for Transfer Station Personnel

TRAIN YOUR WHOLE STAFF WITH SWANA E-TRAINING AND SAVE BIG!

When signing up for an E-Course or E-Sessions you register for one computer. By hooking up a projector and speaker phone, you could present E-Training to your whole staff for the cost of one registration, saving you big on training!

SWANA CEUs will only be allocated for registered individuals.

SWANA E-Training Calendar of Events

SWANA's E-Training allows you to receive the industry's best training from the comfort of your home or office. The Web seminars are the perfect way for busy professionals to stay current on the latest trends in the industry. These courses are always being updated in a continuing effort to bring you fresh, new training. The listing below is just a taste of what's to come. Keep an eye on **www.SWANAstore.com** for all the latest developments in SWANA's E-Training.

Have you attended a local training or technical session that you think all solid waste professionals could benefit from? Let us know! SWANA is always looking for ways to promote training that today's solid waste professionals can use. E-mail **learn@SWANA.org** with any topics or suggestions, as well as at which event the training was presented.

UPCOMING E-COURSES

Course subjects and times subject to change. Visit ***www.SWANAstore.com*** *for updated course listings.*

See page 28 for E-Course CEU information.

Fall 2006 Landfill Fire

Fall 2006 Erosion Control

Fall/Winter 2007 Electronics Recycling

Winter 2007 Landfill Operations

Winter 2007 Collections Operation

Winter 2007 Bioreactor Basics

Have a course developed that you want to share online? Email ***learn@SWANA.org*** *to find out how!*

UPCOMING E-SESSIONS *Tentative Schedule*

Topics subject to change. Visit ***www.SWANAstore.com*** *and click on E-Sessions for the latest information.*

Get 1 SWANA CEU for each E-Session (Registration required)

October 2006: Bioreactor Landfills

November 2006: Overcoming Challenges in Transfer Station Design and Operation

December 2006: Multi-Family and Institutional Recycling Programs

January 2007: Life Cycle of a Landfill – Strategies for Permitting, Designing, Operating and Closing

February 2007: Waste-to-Energy and Waste Conversion

March 2007: Special Waste Management

April 2007: Construction and Demolition Debris Management

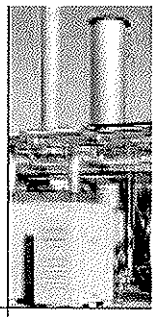
May 2007: Landfill Gas Control and Utilization

June 2007: Organics Management and Composting

July 2007: Boosting Recycling Rates: New and Innovative Programs

August 2007: Planning & Management

September 2007: Legislative and Regulatory Developments Impacting Solid Waste Management



SWANA Technical Divisions

SWANA's Member Training Courses

Join one of SWANA's Technical Divisions and shape the future of solid waste management.

The Benefits include

- Access to cutting-edge information
  - TECHnews—electronic newsletter with the latest news in your specific field
  - SWANA's online eLibrary and Members Only section including the Division subscriber list
- Unmatched networking opportunities
  - Participate in an exchange of ideas with more than 2,700 Division Members
  - Receive a contact list of all Technical Division Subscribers
  - Make valuable contacts at conferences
  - Post and respond to questions through an electronic Technical Division Members list serve
- Shape the future of SWANA
  - Help develop programs for symposia
  - Guide technical policies and advocacy initiatives
  - Produce real change on industry issues
- Special discounts
  - $25 registration discount to your Division's annual symposium
  - Special discounts on publications, conference proceedings and training, and online educational sessions and events

For more information, visit **www.SWANA.org** or call **1-800-GO-SWANA (467-9262)**

Classroom Training · Chapter Partnering Events · E-Courses · E-Sessions · E-Studies · On-Site Training · Home Study Course · Training On-Demand

Landfill and Landfill Gas Courses

For SWANA CEU information, see pages 27-28.

MANAGER OF LANDFILL OPERATIONS (MOLO)

3-Day Certification Prep Course

Updated for 2007

Updated for 2007 for MOLO and Landfill Operations courses.

Updated for 2007, this prep course for the Landfill Certification contains all the latest landfill techniques and technologies to keep you ahead of the competition. Learn to efficiently run your landfill, as well as gain knowledge on planning, operating and closing a landfill. Discuss issues surrounding regulatory standards, compliance with design requirements, and an introduction to state-of-the-art bioreactor landfill technologies. Upon completion of the course you will gain a better understanding of landfill economics, leachate and landfill gas management, and comprehend the importance of safety and contingency counter measures.

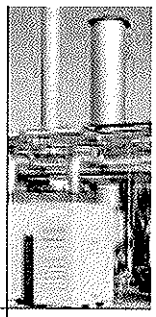
Need some help preparing for the MOLO, try these:

MOLO: JUST THE MATH E-COURSE

Planning to take the MOLO exam, but need to brush up on the math? With this live web course you can prepare for the math that is covered on the MOLO exam from your home or office. All you need is an internet connection and separate phone line and you're ready to learn the math. Taught by MOLO faculty, this course covers such calculations as elevation, area, slope, and volume. And because the course is only two hours long, you can learn and return to work. **MOLO: Just the Math does not allocate CEUs toward SWANA recertification.**

LANDFILL OPERATIONS

Need a boost to get ready for the MOLO or just need a refresher before taking the SWANA Landfill Certification Exam? Then get online with this new E-Study Course. Learn about such topics as Waste Decomposition, Geology and Hydrology, Landfill Design and Construction, General Operations, and Regulations from your computer. The course has also been enhanced with up-to-date photographs, audio, interactive exercises, related online links, and video to make learning more enjoyable.



Landfill and Landfill Gas Courses

SWANA's PREMIER TRAINING COURSES

THE WORLD'S ONLY BIOREACTOR LANDFILL CERTIFICATION PROGRAM

Technology is changing and bioreactor landfills are emerging. Now it is your turn to learn what bioreactors can do for you. Get career-enhancing certification by taking this prep course for the Bioreactor Landfill Certification exam. Examine the unique characteristics of a bioreactor landfill in comparison with dry tomb landfills in this brand new course. Explore the methods of introducing air and water into landfill cells, while at the same time discovering how this cutting-edge technology can increase landfill gas activity.

Special Publication: *Manager of Bioreactor Landfill Operations Body Of Knowledge*

The SWANA Manager of Bioreactor Landfill Operations Body Of Knowledge (BOK) is a compendium of the basic knowledge an individual must know to accomplish the work of a Manager of Bioreactor Landfill Operations. This BOK includes both proven traditional practices and the innovative, advanced practices of managing a bioreactor landfill, as well as empirical, esthetical, ethical and tacit knowledge. The Manager of Bioreactor Landfill Operations BOK is the basis of the SWANA Bioreactor Landfill course and certification exam.

The BOK consists of eight comprehensive knowledge statements covering the knowledge and abilities a manager of bioreactor landfills should have in the areas of construction, operation and monitoring of bioreactor landfills. You can use the BOK to prepare for the SWANA certification exam or as a tool for your operations.

Go to **www.SWANAstore.com** to order.

MANAGER OF BIOREACTOR LANDFILL OPERATIONS

2-Day Certification Prep Course

Mark your calendars for SWANA's

30th Annual **Landfill Gas Symposium**

March 4 – 8, 2007 at the Hyatt Regency Monterey

Join top professionals in the solid waste field for the 30th anniversary of the world's premier forum on landfill gas utilization and technology!

The special 30th Anniversary of SWANA's Landfill Gas Symposium will include:

- Hall of Flame induction revealed
- Plenty of technical sessions
- A tabletop trade show
- Several great receptions
- and a whole lot more!

SWANA

Enjoy Monterey, California's great beaches, lively aquarium and over 20 world-class public golf courses, while networking with other professionals.

See you in Monterey!

Classroom Training · Chapter Partnering Events · E-Courses · E-Sessions · E-Studies · On-Site Training · Home Study Course · Training On-Demand

Landfill and Landfill Gas Courses

For SWANA CEU information, see pages 27-28.

LANDFILL OPERATIONAL ISSUES

2-Day Course/ 1-Day Workshop

This course is perfect for anyone interested in learning more about improving the daily operations at their landfill site. You will experience in-depth discussions that will help you solve everyday issues surrounding landfill operations and be able to understand successful landfill management practices, including equipment selection. Turn your landfill into a money maker by learning how to control cost, maximize your site's airspace, and determine if your landfill is really efficient. Upon completion of the course, you can earn valuable SWANA Continuing Education Units (CEUs). Furthermore, with your registration you will receive the book *The Handbook of Landfill Operations,* by Neal Bolton, P.E.

HEALTH AND SAFETY FOR MSW LANDFILL OPERATIONS PERSONNEL

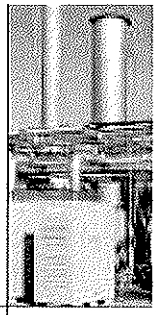
1-Day Course

Discover new horizons by enhancing your landfill health and safety program! This course prepares you to easily and intelligently identify and circumvent landfill health and safety issues. Not only will you learn exactly what elements constitute a proper loss control program, but you will understand the importance of establishing an effective program and overview OSHA and federal regulations. At the end of this course, participants will be able to recognize an unsafe practice and know how to handle it. Not only will you earn valuable SWANA Continuing Education Units (CEUs), but you will also gain imperative knowledge on how to keep your landfill safe.

LANDFILL GAS BASICS

1-Day Course

Don't waste landfill gas! Learn to "Control, Manage and Capture" it! These are the key concepts to successfully understanding landfill gas basics. Through exercises and case studies, SWANA instructors will help you grasp these three ideas in this introductory course. You will gain vital insight about gas regulations and become familiar with system design, construction and monitoring. In addition, you will be provided with information and guidance in order to understand the importance of landfill gas utilization. Anyone working with a landfill gas system will benefit from this course.



Landfill and Landfill Gas Courses

SWANA's Solid Waste Training Courses

LANDFILL GAS SYSTEM OPERATION

2-Day Course and 1-Day Workshop

Go "beyond basics" with this interactive workshop exploring the daily challenges associated with operations and maintenance of LFG systems. Share knowledge with your colleagues and learn new approaches for capturing, controlling, and managing landfill gas. This interactive session will be moderated by a SWANA faculty member, and is a great way to actively increase your knowledge of landfill gas systems.

TRAINING FOR SANITARY LANDFILL OPERATIONS PERSONNEL

1-Day Course

Through interactive classroom exercises, discussions and case studies, you will overview landfill operations and how they relate to one another in order to learn how to be more effective on the job. Instructors with in-depth experience in landfill operations will help you gain a better understanding of the fundamentals of groundwater movement, accident analysis and recognize the factors that contribute to leachate production. In addition, receive top of the line training on how sanitary landfills work as components of integrated solid waste management systems.

LANDFILL GAS PRIMER

Gain vital insight about gas regulations and become familiar with system design, construction and monitoring. In addition, you will be provided with information and guidance in order to understand the importance of landfill gas utilization. Anyone working with a landfill gas system will benefit from this course. As with all online E-Study Courses, you determine the pace and schedule of the course.

ECTC PRESENTS CONTROLLING EROSION & STORM WATER RUNOFF ON LANDFILL CAPS

Finish your landfill off with style with this new E-Course. In a partnership with the Erosion Control Technology Council (ECTC), SWANA is proud to present this new E-Course to help landfill owners create more presentable landfill caps through the use of Rolled Erosion Control Products (RECPs). Presented by a member of ECTC, this course will cover such topics as NPDES Regulations, an overview of RECPs, as well as the installation, design, and selection of RECPs.

Landfill and Landfill Gas Courses

For SWANA CEU information, see pages 27-28.

CONSTRUCTION WASTE & DEMOLITION DEBRIS RECYCLING... A PRIMER

An educational tool for communities and private sector interests, this document focuses on the planning issues and implementation opportunities associated with the recycling of construction waste and demolition debris. Lessons covered include regulatory climate, generation data, materials, market opportunities, and management systems to name a few. Keep the manual for future reference, so you'll always have this valuable information at your fingertips.

MANAGING LANDFILL GAS AT MUNICIPAL SOLID WASTE LANDFILLS

This course is perfect for those seeking guidance on the complex issue of landfill gas management. This course covers such topics as MSW landfill emission generation, composition, migrations and extraction components, as well as regulatory codes pertaining to RCRA and the Clean Air Act. As with all Home Study Courses, keep the manual for future reference!

LITTER MANAGEMENT AT MSW LANDFILLS

Are you blown away by the cost of litter at your landfill? Let SWANA help you clean up your act with Litter Management at MSW Landfills. Learn about the impact of litter and the importance of a good litter management program, as well as the sources and causes of litter. Learn about litter control techniques from one of the industry's top professionals from the comfort of your home or office.

LEACHATE GENERATION, COLLECTION AND TREATMENT AT MSW LANDFILLS

Learn about the common constituents that make up groundwater and biological treatment. Also get an understanding of the regulatory scope of RCRA Subtitle D in regards to groundwater monitoring, and become familiar with leachate recirculation methods. Keep the manual for future reference, so you'll always have this valuable information at your fingertips.

GROUNDWATER MONITORING, SAMPLING, ANALYSIS AND WELL CONSTRUCTION

This course provides MSW professionals with an understanding of monitoring groundwater within the scope of RCRA Subtitle D. Topics include design and construction of wells, monitoring programs, and corrective actions. As with all Home Study Courses, keep the manual for future reference!

SAVE THE DATE

www.wastecon.org

Join the High Rollers!

WASTECON 2007

OCTOBER 16-18, 2007

Reno, NV

The Premier Show for Solid Waste Professionals

hosted by the **Solid Waste Association of North America**

Collection and Transfer Courses

For SWANA CEU information, see pages 27-28.

MANAGING TRANSFER STATION SYSTEMS

3-Day Certification Prep Course

Be a lean mean, transfer operations machine! As a prep course for the Transfer Systems Certification exam, anyone who is or would like to become a transfer station manager or consulting engineer will be provided with fundamental information on ways to effectively plan, design, and operate MSW transfer stations. Receive cutting edge training on how to run a MSW transfer station in the most successful way by experiencing a hands-on tour, a field exercise at a local transfer station facility and classroom taught exercises. In addition, learn about design objectives including capacity, selection of appropriate technology, structure considerations and site planning.

MANAGING MUNICIPAL SOLID WASTE COLLECTION SYSTEMS

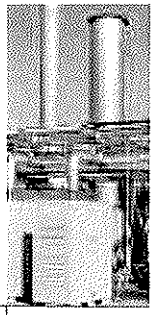
3-Day Certification Prep Course

Be able to handle waste with haste through this prep course for the Collection Systems Certification exam. Receive instruction in all the areas tested on the exam, such as an understanding of the logistics of planning, managing and operating solid waste and recyclables collection services. This course consists of presentations, classroom exercises and case studies that will enable you to navigate and chart routes more effectively. You will examine waste characteristics, service types, equipment, routing and system design. Furthermore, learn up-to-date practices for handling various materials, including residential MSW, traditional recyclables, yard wastes, bulky items and commercial wastes.

TRAINING FOR COLLECTION OPERATIONS PERSONNEL

1-Day Course

Save time and money on every route, every day! Individuals who are responsible for the collection of solid waste and recyclables from household and commercial establishments on a day-to-day basis can increase their knowledge of collection strategies. Be provided with what every collection operations personnel should know through interactive classroom exercises, discussions and case studies. Time is money, and this course will help you to acquire a higher understanding of routing in order to be cost-efficient. Furthermore, learn how to define a preventative maintenance program, go over the importance of effective sanitation practices, and obtain insight on important health and safety issues.



Collection and Transfer Courses

SWANA'S PREMIER TRAINING COURSES

Why "waste" an opportunity to improve your safety performance? At SWANA, we recognize the importance of minimizing risk and developing an effective safety program for transfer station personnel. During this course, you will get an overview of OSHA and federal regulations. Also, you will discuss musculo-skeletal disorders and how to prevent ergonomic injuries. Upon completion, you will understand why it is essential to establish a transfer station health and safety program as well as learn to recognize unsafe practices of others. Earn valuable SWANA CEUs for a range of Certification Disciplines by participating in this extremely important course!

HEALTH AND SAFETY FOR TRANSFER STATION PERSONNEL

1-Day Course

Does it pain you to see the unsafe work habits of your collection personnel? Well let SWANA help you reduce those pains with our Health and Safety for Collections Personnel Course. This kit comes with everything a supervisor or manager needs to train their employees on proper techniques and precautions to reduce workplace injuries. Other topics covered in this course include loss control, and health and safety issues, as well as regulatory issues.

HEALTH AND SAFETY FOR COLLECTION PERSONNEL

1-Day Course

SWANA'S Heading Up The Strip...

SWANA's Spring Training Center

April 23 - 26, 2007 | Bally's Las Vegas | (800)-634-3434

You Can Bet On:

Landfill Operations/LFG Workshop Combo

New MOLO Course - Updated for 2007

FEMA Debris Management Course - Only Time Offered for 2007 by SWANA National!

7 Different SWANA CEU Earning Courses

- Manager of Landfill Operations (MOLO), April 23-25
- Managing MSW Collections Systems, April 23-25
- Managing MSW Transfer Systems, April 23-25
- Principles of MSW Management, April 23-25
- FEMA: Debris Management, April 23-25
- Landfill Operations, April 23-24
- Landfill Gas Operations Workshop, April 25
- Testing Center (All certification exams), April 26 7:00 am (only)

ACT NOW!

For more information or to register, visit www.SWANAstore.com

Classroom Training · Chapter Partnering Events · E-Courses · E-Sessions · E-Studies · On-Site Training · Home Study Course · Training On-Demand

Appendix B
Site Specific Training
Lesson Plan and Exam

Pre-Entry Briefing

Objective: The objective of this pre-entry briefing is to introduce visitors and first-day employees to the safety controls of the BRC CAMU. Attendees should understand where active portions of the site are, where emergency response equipment is located, site hazards (chemical, physical, biological), and general safety rules of the BRC CAMU.

Active Areas
Indicate on map:

- haul routes
- waste excavation (exclusion, contamination reduction, support zones, as appropriate)
- waste placement (exclusion, contamination reduction, support zones, as appropriate)

Emergency Response:

Contact Name

Phone number(s)

Hospital Location

Location of emergency equipment (fire extinguishers, alarms)

Meeting location(s)

First Aid steps: Check-Call-Care

Personal Protection Equipment

Hardhat – at all times

Steel Toe Boots – at all times

Eye protection – at all times

Hearing Protection – where applicable

Tyvek – where applicable

Gloves – where applicable

Respirator – where applicable

Basic Site Safety:

1. Keep your mind on your work at all times. No horseplay on the job. Injury or termination or both can be the result.

2. Personal safety equipment must be worn as prescribed for each job, such as: safety glasses for eye protection, hard hats at all times, gloves when handling materials, and safety shoes..

3. Watch where you are walking. Don't run.

4. Seat belts are required at all times when driving/operating.

5. The use of illegal drugs or alcohol or being under the influence of the same on the project shall be cause for your immediate termination. Inform your supervisor if taking strong prescription drugs that warn against driving or using machinery.

6. Do not distract the attention of fellow workers. Do no engage in any act that would endanger another employee.

7. Sanitation facilities are provided for your use. Defacing or damaging these facilities is forbidden.

8. Never move an injured person unless it is absolutely necessary. Further injury may result. Keep the injured as comfortable as possible and utilize job site first-aid equipment until an ambulance arrives.

9. Know where firefighting equipment is located and be trained on how to use it.

10. Nobody but operator shall be allowed to ride on equipment unless proper seating is provided.

11. Do not use power tools and equipment until you have been properly instructed in the safe work methods and become authorized to use them.

12. Do not enter an area that is barricaded or otherwise blocked from entry.

13. If you must work around trucks or heavy equipment, make sure operators can always see you and know that you are there. Barricades are required for cranes.

14. Never oil, lubricate, or fuel equipment while it is running or in motion. Do not perform these operations on equipment in areas not specifically designated for these operations.

15. Before servicing, repairing, or adjusting any powered tool or piece of equipment, disconnect it, lock out the source of power, and tag it out.

16. Barricade danger areas. Guard rails or perimeter cables may be required.

17. Trenches over five feet deep must be shored or sloped as required. Keep out of trenches or cuts that have not been properly shored or sloped. Excavated or other material shall not be stored nearer than two feet from the edge of the excavation. Excavations less than 5 ft may also require cave in protection.

18. Use the "four and one" rule when using a ladder. One foot of base for every four feet of height.

19. Know what emergency procedures have been established for your job site. (location of first aid kit, fire extinguisher locations, evacuation plan, etc.)

Hazard Analysis

Physical
Heat Stress
Excavation
Hand/Foot Injury
Heavy Equipment
Noise
Portable Power/Hand Tool
Slip/Trip/Fall

Chemical
Inhalation
Skin absorption
Fire
Reactivity

Biological
Insect/Vermin/Snake Bites

Exam

The pre-entry briefing exam will be taken at the conclusion of the meeting. A passing rate of 75% is required for access to the site. Incorrect answers will be explained and topics covered again.

Pre-entry Briefing Exam

Name:_____

I have read and understand the BRC CAMU Health and Safety Plan Yes No

Date:_____

Position:_____

1. What are the three emergency first aid steps?

   A. Stop-Look-Listen
   B. Call-Check-Care
   C. Check-Call-Care
   D. None of the Above

2. You are working near an excavator, what PPE do you need?

   A. Hardhat, boots, eye protection, hearing protection
   B. Boots, hardhat
   C. Hardhat, hearing protection
   D. None of the above

3. When excavating, at what depth is shoring required?

   A. 3 feet
   B. 1 foot
   C. 5 feet
   D. 2 feet

4. You are not 24-hour or 40-hour HAZWOPER certified, how close can you be to the excavation or waste placement activities?

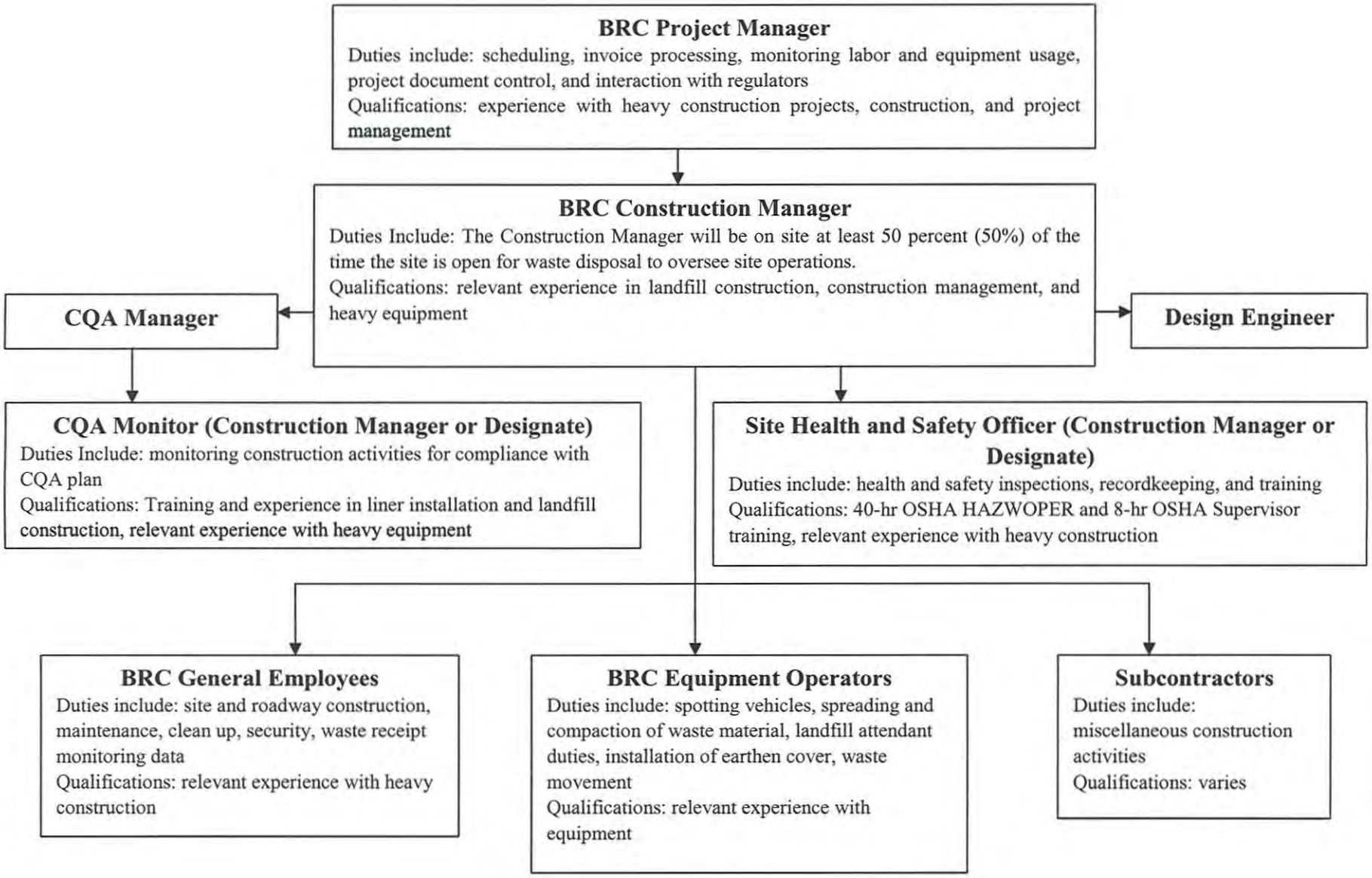
   A. Exclusion Zone
   B. Contamination Reduction Zone
   C. Support Zone
   D. None of the Above

5. What's the first step in an emergency?

   A. Call the Construction Manager
   B. Go to a safe location
   C. Go Home
   D. None of the above

Number Incorrect:_____ Pass / Fail Trainer's Name:_____

Appendix C
Organizational Flowchart


BRC Project Manager
Duties include: scheduling, invoice processing, monitoring labor and equipment usage, project document control, and interaction with regulators
Qualifications: experience with heavy construction projects, construction, and project management
BRC Construction Manager
Duties Include: The Construction Manager will be on site at least 50 percent (50%) of the time the site is open for waste disposal to oversee site operations.
Qualifications: relevant experience in landfill construction, construction management, and heavy equipment
CQA Manager
Design Engineer
CQA Monitor (Construction Manager or Designate)
Duties Include: monitoring construction activities for compliance with CQA plan
Qualifications: Training and experience in liner installation and landfill construction, relevant experience with heavy equipment
Site Health and Safety Officer (Construction Manager or Designate)
Duties include: health and safety inspections, recordkeeping, and training
Qualifications: 40-hr OSHA HAZWOPER and 8-hr OSHA Supervisor training, relevant experience with heavy construction
BRC General Employees
Duties include: site and roadway construction, maintenance, clean up, security, waste receipt monitoring data
Qualifications: relevant experience with heavy construction
BRC Equipment Operators
Duties include: spotting vehicles, spreading and compaction of waste material, landfill attendant duties, installation of earthen cover, waste movement
Qualifications: relevant experience with equipment
Subcontractors
Duties include: miscellaneous construction activities
Qualifications: varies

Attachment G
Accident Prevention, Contingency, and Emergency Response Plan

Attachment G
Accident Prevention, Contingency, and Emergency Response Plan
Basic Remediation Company (BRC)
Corrective Action Management Unit (CAMU)
Henderson, Nevada

Table of Contents

1.0 Introduction G-1

1.1 Contaminants G-1

2.0 Prevention G-1

2.1 Health and Safety Plan G-1

2.2 Arrangements with Local Authorities G-2

2.3 Personal Protective Equipment (PPE) G-2

2.4 Exposure Assessment and Air Monitoring G-2

2.5 Activity Hazard Analysis G-3

2.6 Personnel Training G-3

2.7 Site Map G-3

2.7.1 Work Zones G-4

2.8 Site Access G-4

2.9 Visitors G-4

2.10 Communications G-4

2.11 Safe Work Practices G-4

2.12 Inspections G-5

2.13 Decontamination G-5

3.0 Contingency and Emergency Response Plan G-6

3.1 Fire Control G-6

3.2 Shut Down Procedures G-6

3.3 Hazardous or Toxic Materials Release G-6
3.4 Emergency Procedures G-6
3.5 Reporting G-7

List of Figures

Figure G-1 – Hospital Location

List of Tables

Table G-1 – Emergency Contacts

Appendix

A – Copies of Letters Sent to Police, Fire, and Hospital Emergency Contacts

1.0 INTRODUCTION

This Accident Prevention, Contingency, and Emergency Response Plan describes the precautions taken to prevent accidental ignition or reaction of ignitable or reactive wastes, and precautions taken to prevent interaction of incompatible wastes. This plan also includes other procedures to minimize the possibility of, and hazards from, a fire, explosion, or unplanned sudden or non-sudden release of hazardous waste constituent to air, soil, or surface water. These procedures also address the proper design, construction, maintenance, and operating practices designed to reduce the potential for injury or other threats to human health or the environment.

1.1 Contaminants

Extensive testing of the waste material determined the majority of wastes to be non-hazardous. The following is a list of general contaminants found in the waste material to be placed in the CAMU:

- VOCs
- SVOCs
- PCBs
- Metals
- Pesticides

The waste materials are not incompatible, reactive, or ignitable. Additional waste characterization detail can be found in Attachment C, Waste Analysis Plan.

2.0 PREVENTION

2.1 Health and Safety Plan

The BRC CAMU will have an active Health and Safety program for workers at the BRC CAMU. Either the current BRC Health and Safety Plan (HASP) or a similar plan developed by the pertinent contractor will be used, periodically updated, and kept on site. A safety meeting will be held at least quarterly to review safety procedures and issues, or whenever operations change. Daily safety tailgate meetings will address health and safety issues of the day. Employees working at the BRC CAMU will attend. Personal safety equipment such as eye protection, steel-toed boots and hard hats will be required of all BRC CAMU non-office personnel. In case of personal injury, the field office will be notified immediately by two-way radio or cellular telephone and, if necessary, an ambulance summoned from the local hospital, St. Rose de Lima

approximately 1 ¼ miles from the BRC CAMU (Figure G-1), or the local (City of Henderson or Clark County) Fire Department.

2.2 Arrangements with Local Authorities

Prior to operation, the BRC CAMU Construction Manager will contact the Henderson Police and Fire Departments and the Clark County Sheriff and Fire Departments and their emergency response teams to make arrangements to familiarize them with the BRC CAMU. The BRC CAMU Construction Manager will provide details of the BRC CAMU including layout, properties of wastes handled and associated hazards, normal operating areas, entrances, and possible evacuation routes. In addition, the BRC CAMU Construction Manager will contact the St. Rose de Lima Hospital with the types of injuries or illnesses that could potentially occur at the BRC CAMU.

2.3 Personal Protective Equipment (PPE)

Level D PPE will be required at all times at the Site. Level D equipment required includes long pants, gloves, steel-toe boots, hard hats, safety glasses, and hearing protection (when appropriate).

2.4 Exposure Assessment and Air Monitoring

Dust monitoring will be conducted during the construction activities. The objectives are to monitor working conditions and to assess potential fugitive dust migration at the Site perimeter. MIE® DATA RAM air particulate monitors, or similar, will be set up at four dust monitoring stations during field activities to record total levels of dust. Air monitoring stations will be positioned with one station located upwind at the Site perimeter, two stations downwind at the Site perimeter, and one station in the workers' breathing zone. In addition, GilAir 5® air sampling pumps, or similar, will be placed at each dust monitoring station, with filter cassettes changed daily. Filter cassettes will be sent to a laboratory for analysis.

Frequency of air monitoring readings will be adjusted on site accordingly, with the consent of the Site Health and Safety Officer (SHSO and Project Manager). Equipment will be calibrated before work begins each day and at the end of the day. Air monitoring readings and calibration records will be documented in the Field Logbook.

2.5 Activity Hazard Analysis

The chemical, physical, and biological hazards are discussed in detail in the Site HASP for each activity performed on-site.

2.6 Personnel Training

Employees assisting in construction activities within the exclusion zone will have Occupational Safety and Health Administration (OSHA) 40-hr Hazardous Waste Operations and Emergency Response Standards (HAZWOPER) certification. In addition, the BRC CAMU Construction Manager will have 8-hr OSHA Site Supervisor training. The CAMU Construction Manager will be required to provide health and safety "tail gate" meetings for new workers and visitors. Employees are responsible for knowing the site chemical, biological, and physical hazards as well as how to prevent accidental release of wastes.

2.7 Site Map

A site map will be maintained on site. The site map will be regularly updated to show the exclusion zone, decontamination zone, and support zone as they change throughout BRC CAMU construction. The site map shall be posted in the work area and will include the following information:

- General Wind Direction
- Evacuation Routes
- Refuge Locations
- Route to St. Rose de Lima Hospital and First Aid Medical Assistance (may be provided on separate map)
- Boundaries of Exclusion Zone (as described below)
- Boundaries of Contamination Reduction Zone (as described below)
- Boundaries of Support Zone (as described below)

Changes will be made to the site map by the SHSO, as needed, based on site conditions.

2.7.1 Work Zones

Three work zones will be established for each task. The Exclusion Zone is defined as the area on-site where contamination is suspected and tasks are to be performed. The Contamination Reduction Zone (CRZ) is defined as the area where equipment and workers are to be decontaminated. The Support Zone is defined as the command area and also serves as a storage area for supplies. The exact location and extent of the work zones will be modified as necessary.

2.8 Site Access

Access to the site will be controlled using a sign-in/sign-out log.

2.9 Visitors

Visitors to the site will be continually escorted in order to assure their safety since they may be unfamiliar with the site. Visitors will not be allowed past the Support Zone unless they read, understand, sign, and meet the requirements outlined in the Site HASP.

2.10 Communications

On-site communications will be conducted through the use of the following:

- Verbal
- Two-way radio
- Horn
- Mobile telephone
- Siren
- Hand signals

Off-site communications will be conducted through the use of mobile telephones.

2.11 Safe Work Practices

General Safe Work Practices that will be implemented during work activities at this site are:

- Minimization of contact with waste materials.

- Smoking, eating, or drinking after entering the work zone and before decontamination will not be allowed. Employees who are suspected of being under the influence of illegal drugs or alcohol will be removed from the site. Workers taking prescribed medication that may cause drowsiness will not be permitted to operate heavy equipment, and will be prohibited from performing tasks where Level C, B, or A PPE is required.
- Good housekeeping will be practiced.
- Use of contact lenses on-site will not be allowed when dictated by working conditions.
- The following conditions will be observed when operating a motor vehicle.
  - Wearing of seat belts is mandatory
  - During periods of rain, fog, or other adverse weather conditions, the use of headlights is mandatory
  - A backup warning system or use of vehicle horn is mandatory when the vehicle is engaged in a backward motion
  - All posted traffic signs and directions from flagmen will be observed
  - Equipment and/or samples transported in vehicles will be secured from movement
- In an unknown situation, the worst conditions will always be assumed.
- Conflicting situations may arise concerning safety requirements and working conditions and will be addressed and resolved rapidly by the BRC CAMU Construction Manager to relieve any motivations or pressures to circumvent established safety policies.
- Breaches of specified safety protocol will not be allowed.

2.12 Inspections

The BRC CAMU Construction Manager will conduct weekly health and safety inspections. The inspections will be documented using the Inspection checklist included with Attachment E. The Weekly Health & Safety Inspection Checklist will be kept on file at the project site.

2.13 Decontamination

PPE will be decontaminated as per 29 CFR §1910.120(k). The decontamination procedures, equipment and decontamination solution required for each task will be included in the Site Health and Safety Plan. In an emergency, the primary concern is to prevent the loss of life or severe injury to site personnel. If immediate medical

treatment is required to save a life, decontamination will be delayed until the victim is stabilized. If decontamination can be performed without interfering with essential life-saving measures or first aid, or if worker has been contaminated with an extremely toxic or corrosive material that could cause severe injury or loss of life, decontamination will be performed in coordination with or prior to initial medical treatment at the scene.

3.0 CONTINGENCY AND EMERGENCY RESPONSE PLAN

3.1 Fire Control

Fire extinguishers will be on hand to put out small fires near the working area, in the remote possibility they may occur. In the event of a significant fire emergency, the Henderson Fire Department will be notified immediately and the emergency will be reported.

3.2 Shut Down Procedures

In the event the BRC CAMU needs to be shut down, a detailed procedure list will be available at the site in the contingency plan. Step-by-step procedures will be detailed, including maps showing pertinent locations of systems.

3.3 Hazardous or Toxic Materials Release

A Hazardous Materials Emergency Plan will be prepared. It will mainly focus on those chemicals and materials associated with vehicle fueling and maintenance. Because the waste material being disposed of in the BRC CAMU is from a known source area, the likelihood of hazardous or toxic material release resulting from the waste materials is minimal.

3.4 Emergency Procedures

The following steps will be followed when there is an emergency:

1. The BRC CAMU Construction Manager, or alternate, will be immediately notified. The BRC CAMU Construction Manager assumes control of the emergency response.
2. As necessary, off-site emergency responders (e.g., fire department, hospital, police department, etc.) will be notified as to the nature and

location of the emergency on site. Please see Table G-1 for contact information.

3. If applicable, the BRC CAMU Construction Manager evacuates the site. Site workers will move to their respective refuge stations using the evacuation routes provided on the Site Map.
4. BRC CAMU Construction Manager will assess possible hazards to human health or the environment resulting from the emergency and shall contact the appropriate authorities for the Henderson, Nevada area or the National Response Center (toll free: (800) 424-8802). The report will include:
    a. Name and telephone number of the reporter;
    b. Name and address of the BRC CAMU;
    c. Time and type of incident;
    d. Name and quantity of material(s) involved, to the extent known;
    e. The extent of injuries, if any; and
    f. The possible hazards to human health, or the environment, outside the facility.
5. For small fires, flames will be extinguished using the fire extinguisher. Large fires will be handled by the fire department.
6. In an unknown situation or if responding to toxic gas emergencies, appropriate PPE, including SCBAs, will be donned.
7. If chemicals are accidentally spilled or splashed into eyes or on skin, safety eyewash and/or shower will be used.
8. Before continuing site operations, after an emergency involving toxic gas, the BRC CAMU Construction Manager will don a SCBA and utilize appropriate air monitoring equipment to verify that the site is safe.
9. An injured worker shall be decontaminated appropriately.
10. If a worker is injured, first aid will be administered by workers certified in first aid.

3.5 Reporting

The BRC CAMU Construction Manager will note in the operating record the time, date, and details of any incident that requires implementing this plan. The report will be submitted to the NDEP and include:

a. Name, address, and telephone number of the owner or operator;
b. Name, address, and telephone number of the facility;
c. Date, time, and type of incident;

d. Name and quantity of material(s) involved;
e. The extent of injuries, if any;
f. An assessment of actual or potential hazards to human health or the environment, where applicable; and
g. The estimated quantity and disposition of recovered material that resulted from the incident.

Incident reports will be kept as part of the operational records and maintained by BRC for at least 3 years and otherwise in accordance with the records retention provision of the AOC3.

FIGURE G-1
HOSPITAL LOCATION

TABLE G-1
EMERGENCY RESPONSE CONTACTS

Name	*Telephone Numbers*		*Date of Pre-Emergency Notification*
	Office	*Home*	
Fire Department – Henderson Fire Dept.	911 (702) 267-2222		February 20, 2007
Hospital – St. Rose Dominican-Rose de Lima Campus 102 E. Lake Mead Parkway Henderson, NV 89015 (702)616-5000	(702) 616-5000		February 20, 2007
Police Department – Henderson Police Dept	911 (702) 267-4550		February 20, 2007
Construction Manager – Weston Solutions*			TBD*
Nevada DEP*			TBD*
Other			

* To be completed before site activities are initiated.

Copy of letter sent is provided in Appendix A to this Attachment

Appendix A

Copies of Letters Sent to Police, Fire, and Hospital Emergency Contacts

Basic Remediation
COMPANY

February 20, 2007

Mr. Val Baciarelli
President
St. Rose Dominican Hospital-Rose de Lima
102 East Lake Mead Parkway
Henderson, Nevada 89015

Dear Mr. Baciarelli,

As you may know, work will soon commence on the clean-up and restoration of the 2200 acre tract owned by our affiliate, the LandWell Company, that is bounded on the south by Lake Mead Parkway, on the west by Boulder Highway, and on the north by the Las Vegas Wash. This clean-up and restoration is being conducted under the jurisdiction and supervision of the Nevada Division of Environmental Protection, with significant input from the City of Henderson and Clark County. As part of this project, we have developed Accident Prevention, Contingency, and Emergency Response Plans. These plans provide for fire, police, and medical responses, if needed. We have designated the St. Rose Dominican Hospital as primary responder in the event of injury. While we do not expect problems to arise that would require a response by the Hospital's emergency room, we want to be prepared for such a contingency. If you would like a more detailed briefing in person on details of the clean-up and restoration project, I would be happy to provide this. I can be contacted at 702-567-0400 and at sahuron@earthlink.net.

Sincerely,

Ron Sahu, Ph.D., CEM
Project Manager

875 West Warm Springs, Henderson, Nevada 89015 • Phone 702.567.0400 • Fax 702.567.0473

Basic Remediation
COMPANY

February 20, 2007

Mr. Richard D. Perkins
Chief of Police
Henderson Police Department
223 Lead Street
Henderson, Nevada 89015

Dear Chief Perkins,

As you may know, work will soon commence on the clean-up and restoration of the 2200 acre tract owned by our affiliate, the LandWell Company, that is bounded on the south by Lake Mead Parkway, on the west by Boulder Highway, and on the north by the Las Vegas Wash. This clean-up and restoration is being conducted under the jurisdiction and supervision of the Nevada Division of Environmental Protection, with significant input from the City of Henderson and Clark County. As part of this project, we have developed Accident Prevention, Contingency, and Emergency Response Plans. These plans provide for fire, police, and medical responses, if needed. We have designated the Henderson Police Department as primary responder in the event of theft or assault. While we do not expect problems to arise that would require a response by the Police Department, we want to be prepared for such a contingency. If you would like a more detailed briefing in person on details of the clean-up and restoration project, I would be happy to provide this. I can be contacted at 702-567-0400 and at sahuron@earthlink.net.

Sincerely,

Ron Sahu, Ph.D., CEM
Project Manager

875 West Warm Springs, Henderson, Nevada 89015 • Phone 702.567.0400 • Fax 702.567.0473

Basic Remediation
COMPANY

February 20, 2007

Mr. Douglas Stevens
Deputy Fire Chief
Henderson Fire Department
City Hall
240 Water Street
PO Box 95050
Henderson, Nevada 89009-5050

Dear Chief Stevens,

As you may know, work will soon commence on the clean-up and restoration of the 2200 acre tract owned by our affiliate, the LandWell Company, that is bounded on the south by Lake Mead Parkway, on the west by Boulder Highway, and on the north by the Las Vegas Wash. This clean-up and restoration is being conducted under the jurisdiction and supervision of the Nevada Division of Environmental Protection, with significant input from the City of Henderson and Clark County. As part of this project, we have developed Accident Prevention, Contingency, and Emergency Response Plans. These plans provide for fire, police, and medical responses, if needed. We have designated the Henderson Fire Department as primary responder in the event of fire. While we do not expect problems to arise that would require a response by the Fire Department, we want to be prepared for such a contingency. If you would like a more detailed briefing in person on details of the clean-up and restoration project, I would be happy to provide this. I can be contacted at 702-567-0400 and at sahuron@earthlink.net.

Sincerely,

Ron Sahu, Ph.D., CEM
Project Manager

875 West Warm Springs, Henderson, Nevada 89015 • Phone 702.567.0400 • Fax 702.567.0473

Attachment H
Emergency Coordinator

Attachment H
Emergency Coordinator
Basic Remediation Company (BRC)
Corrective Action Management Unit (CAMU)
Henderson, Nevada

1.0 Introduction H-1
1.1 Emergency Coordinator H-1
1.2 Back Up H-1

1.0 INTRODUCTION

The BRC CAMU emergency coordinator is completely familiar with the site operation and Accident Prevention, Contingency, and Emergency Response Plan. In addition, the emergency coordinator must be familiar with all activities at the facility, the location and characteristics of waste handled, the location of all records within the facility, and the layout. The emergency coordinator is responsible for directing the emergency procedures outlined in Attachment G. He or she shall have successfully completed all training and is responsible for the training records of all personnel outlined in Attachment G. The contact information for two additional individuals is also provided who can also fulfill this role. At least one individual shall be within 30 minutes of the BRC CAMU until closure.

3.6 Emergency Coordinator

Name:	Construction Manager – Weston Solutions
Address:	
Cell Phone:	Will be provided prior to commencement of operations
Home Phone:	Will be provided prior to commencement of operations

3.7 Back Up

Name:	Lee Farris, P.E. (or designee)
Address:	875 W Warm Springs Road Henderson, NV 89011
Office Phone:	(702) 567-0400

Attachment I
Location Standards and Siting Requirement

Attachment I
Location Standards and Siting Requirements
Basic Remediation Company (BRC)
Corrective Action Management Unit (CAMU)
Henderson, Nevada

Table of Contents

1.0 Introduction I-1
2.0 Geologic Conditions I-1
2.1 Geology I-1
2.2 Hydrogeology I-2
3.0 Climate I-3
4.0 Location Restrictions I-3
4.1 Flood Plains I-3
4.2 Fault Areas I-4
4.3 Seismic Impact Zones I-4
4.4 Unstable Areas I-4
5.0 References I-5

List of Figures

Figure I-1 FEMA Flood Insurance Map

Figure I-2 USGS SE Folio Geologic Map- Las Vegas Area

1.0 INTRODUCTION

This attachment describes the geological, hydrogeological, and climatic conditions at the BRC CAMU. In addition, location standards and siting requirements for the proposed BRC CAMU are discussed.

2.0 GEOLOGIC CONDITIONS

This section summarizes the geological conditions present at the BRC CAMU site. The Draft Conceptual Site Model (CSM) for the Common Areas prepared by Daniel B. Stevens & Associates (DBS&A, 2006) provides greater detail about the geological and hydrogeological conditions at the site.

2.1 Geology

Regional Geology in Southern Nevada is the Basin and Range Province morphology of the Western Cordillera of North America. In this region, Cenozoic tectonic extension has resulted it a system of fault-bounded mountains separated by sediment-filled valleys. The basins consist of down-dropped blocks of crust while the ranges are upthrust slabs with a regional tilt to the east. The typical arrangement in the Basin and Range system is a valley bounded on each side by a normal fault running parallel to the range (DBS&A, 2006).

The BRC CAMU site is located in the Las Vegas Valley, a northwest-southeast trending basin within the Basin and Range Province. The predominate range influencing the BRC CAMU site conditions is the McCullough Mountains bounding the valley to the south (DBS&A, 2006).

Valley fill in the vicinity of the BRC CAMU site consists of Tertiary Muddy Creek Formation (TMCf) and overlying Quaternary Alluvium (Qa) associated with alluvial fan deposits shed from the McCullough Range Mountains. The Qa is the present-day land surface at the CAMU as well as in most of the Henderson area and has an average thickness of 50 to 60 feet. The Qa is predominantly sands and gravels classified as poorly graded gravels (GP), silty gravels (GM), well-graded sands (SW), poorly graded sands (SP), and silty sands (SM) in accordance with the Common Unified Soil Classification System (USCS) (DBS&A, 2006).

Beneath the BRC CAMU site, the boundary between the Qa and TMCf is an unconformity that represents a period of time when the TMCf strata was likely exposed to weathering and erosion. Erosion by streams originating in the McCullough Mountains cut into the TMCf resulting in paleochannels that were later filled by Qa. Two paleochannels have been inferred in the vicinity of the CAMU site: one paleochannel

from the south-central area to the northwest corner and a second paleochannel from the northeast corner of the CAMU site trending almost due north (DBS&A, 2006).

Beneath the Qa is lies the TMCf consisting of predominantly fine-grained sandy silts and clayey silts. Layers with increasing sand content are encountered. With the increasing distance east and north from the McCullough Range, the proportion of coarse-grained sediments in the upper portion of the TMCf appears to decrease. The total thickness of the TMCf is unknown with measurements varying from 2,158 feet to 3,050 (DBS&A, 2006).

2.2 Hydrogeology

Groundwater flow beneath the BRC CAMU site is generally to the north, northeast. Groundwater ranges from approximately 1725 ft Mean Sea Level (MSL) to 1695 ft MSL from the southern to northern areas of the BRC CAMU (Figure C7). The groundwater flow is approximately parallel to the slope of the land surface. The average gradient of the water table ranges from about 0.02 to 0.04 ft/ft with a hydraulic conductivity typically ranging from a few inches to up to 33 feet per day (ft/d). The Qa is unsaturated towards the east, with saturation first noted in the uppermost TMCf, near the contact between the Qa and the TMCf. The groundwater treatment system located on the eastern property adjacent to the CAMU is thought to have dewatered the Qa (DBS&A, 2006).

Groundwater quality in the Qa is poor. General water quality analysis performed on a groundwater sample collected from Kerr-McGee monitoring well M-10, which is installed upgradient of the BMI Complex, reported relatively high concentrations of total dissolved solids (2,680 mg/L), chloride (732 mg/L), and sulfate (857 mg/L) (ERM-West Inc., 1996).

Beneath the Qa, within the TMCf, groundwater exists generally under confined conditions in saturated coarser-grained lenses. Water in wells screened in the upper portion of the TMCf rose under the confining pressure to elevations within the Qa indicating an upward flux gradient from the TMCf into the overlying alluvium. The hydraulic conductivity in the TMCf was approximately 12 ft/d (DBS&A, 2006).

Recharge to the Qa due to precipitation is generally considered to be negligible but has increased in recent years due to increasing irrigation infiltration, sewage treatment plant effluent, and from the removal of phreatophytic vegetation near the washes (Geraghty & Miller, 1993). Natural discharge from the Qa is primarily due to springs, direct evaporation, and evapotranspiration, with little or no water discharging to the Las Vegas Wash (Geraghty & Miller, 1993, after USBR, 1982).

3.0 CLIMATE

The Las Vegas Valley is one of the driest and warmest areas in the nation. The climate consists of hot summers, and cool winters. Summer temperatures above 105° Fahrenheit (F) and winter temperatures below freezing are common. The average daily minimum and maximum temperatures during winter months are about 35° and 60° F. During summer nights, minimum temperatures average 70° to 75° F. The frost-free period averages about 241 days per year (Geraghty & Miller, 1993, after USBR, 1982).

The Las Vegas Valley is characterized by low annual rainfall, approximately 4.5 inches per year, that fall during two rainy seasons. During the winter, the rainfall is generally low-intensity and falls over a wide area. In the spring and fall, local thunderstorms subject the area to high-intensity rains of short duration, which can cause high-runoff conditions. Maximum rainfall within a 24-hour period for a 25-year storm is approximately 2.3 inches (NOAA Atlas 2, undated) in the site area.

Evaporation is high in the Las Vegas Valley, influenced by high temperatures, high winds, and low humidity (average 20%). Pan evaporation data form the period of 1985 through 1988 range from approximately 2.5 inches/month to more than 17 inches/month (ERM-West, Inc., 1996, after Law Engineering, 1993). The months with the highest evaporation (May through September) correspond to the times of high-intensity rainfall, which indicates that rainfall does not contribute significantly to the recharge of groundwater in this area (ERM-West, 1996). Measurements of evaporation at Boulder City and Lake Mead indicate an annual loss of about 6.5 feet of water, three-fourths of which occurs during the six warmer months. The evapotranspiration within Las Vegas Wash is expected to be significantly higher due to high consumptive use by cattails, warmer temperatures, and lower humidity (Geraghty & Miller, 1993, after USBR, 1982).

Winds are typically out of the southwest or northwest and average nine miles per hour (mph). Gusts greater than 50 mph occur several times a year during the massage of major frontal systems. Topography influences the wind flow patterns.

4.0 LOCATION RESTRICTIONS

4.1 Flood Plains

The proposed BRC CAMU is located in an area determined to be outside the 100-year flood plain (Figure I-1) (FEMA, 2002).

4.2 Fault Areas

The proposed BRC CAMU is not located within 200 feet of a fault that has had displacement in Holocene time. Two north-trending fault scarps are located approximately ½ mile northwest and southwest of the proposed BRC CAMU (Figure I-2) (Converse Consultants, 1999). Displacement on both faults is recorded as pre-Holocene.

4.3 Seismic Impact Zones

The proposed BRC CAMU is located in a seismic impact zone (USGS, 1982). The site is located in an area with a 10 percent or greater probability that the maximum horizontal acceleration in lithified earth material will exceed 10 percent of the earth's gravitational pull in 250 years (USGS, 1982). The maximum horizontal acceleration depicted on the seismic hazard map with a 90 percent or greater probability that the acceleration will not be exceeded in 250 years is 14 percent of the earth's gravity. The peak horizontal ground acceleration recommended for the design of the project is 0.15g (Converse Consultants, 1999). A soil profile type of S_D per Table 16-J of the 1997 Uniform Building Code is recommended for the site.

Structures for containment, including liners, systems for the collection of leachate and systems for the control of surface water, will be designed to resist the maximum horizontal acceleration in lithified earth material for the site. Proof of meeting these design requirements will be placed in the operating records for the site and the solid waste management authority will be notified that the proof has been placed in the operating records.

4.4 Unstable Areas

Portions of the land on which the North Mesa will be constructed have been historically used for waste disposal – namely, the slit trenches. Wastes, consisting of various industrial wastes, construction and demolition debris, and office trash was disposed of in "slit trenches" that were excavated below grade. The Draft Conceptual Site Model prepared by DBS&A details the recent investigation of the "slit trenches" revealing the depth and extent of waste material (DBS&A, 2006). The waste was placed in the trenches without compaction effort and covered with previously excavated native material. There is also evidence that some waste may have been ignited and burned. As a result of the waste being placed without compaction, the "slit trenches" have experienced settlement over the years.

As noted above, the BRC CAMU is sited to overlay the slit trench area, and this overlay will in itself protect the slit trenches from erosion by wind and water. However, the potential for continued settlement of the "slit trenches" may cause instability of the

BRC CAMU liner system, if not addressed. Therefore, engineering measures will be incorporated into the structural design of the BRC CAMU to consolidate (compact) these materials prior to construction of the overlying BRC CAMU liner system. These measures are more particularly specified in Attachment J, CAMU Design- Conceptual.

In addition, it should be noted that BRC expects to excavate certain portions of the slit trenches, based on a Slit Trench Remedial Alternative Study (Slit Trench RAS), which is in preparation. The goal is to remove waste materials in "hot spot" areas within the slit trenches on a preventive basis and to meet regulatory requirements. Locations so excavated will be properly backfilled and consolidated prior to construction of the CAMU.

5.0 REFERENCES

Converse Consultants, 1999. Preliminary Geotechincal and Geologic Investigation, Industrial Non-Hazardous Disposal Facility, Basic Remediation Incorporated, Clark County, Nevada, October.

DBS&A, 2006 "Draft Conceptual Site Model for the Common Areas" prepared by Daniel B. Stevens and Associates, October.

ERM-West, 1996. Project Workplan – BMI Common Area, Environmental Conditions Investigation, Henderson, Nevada. February.

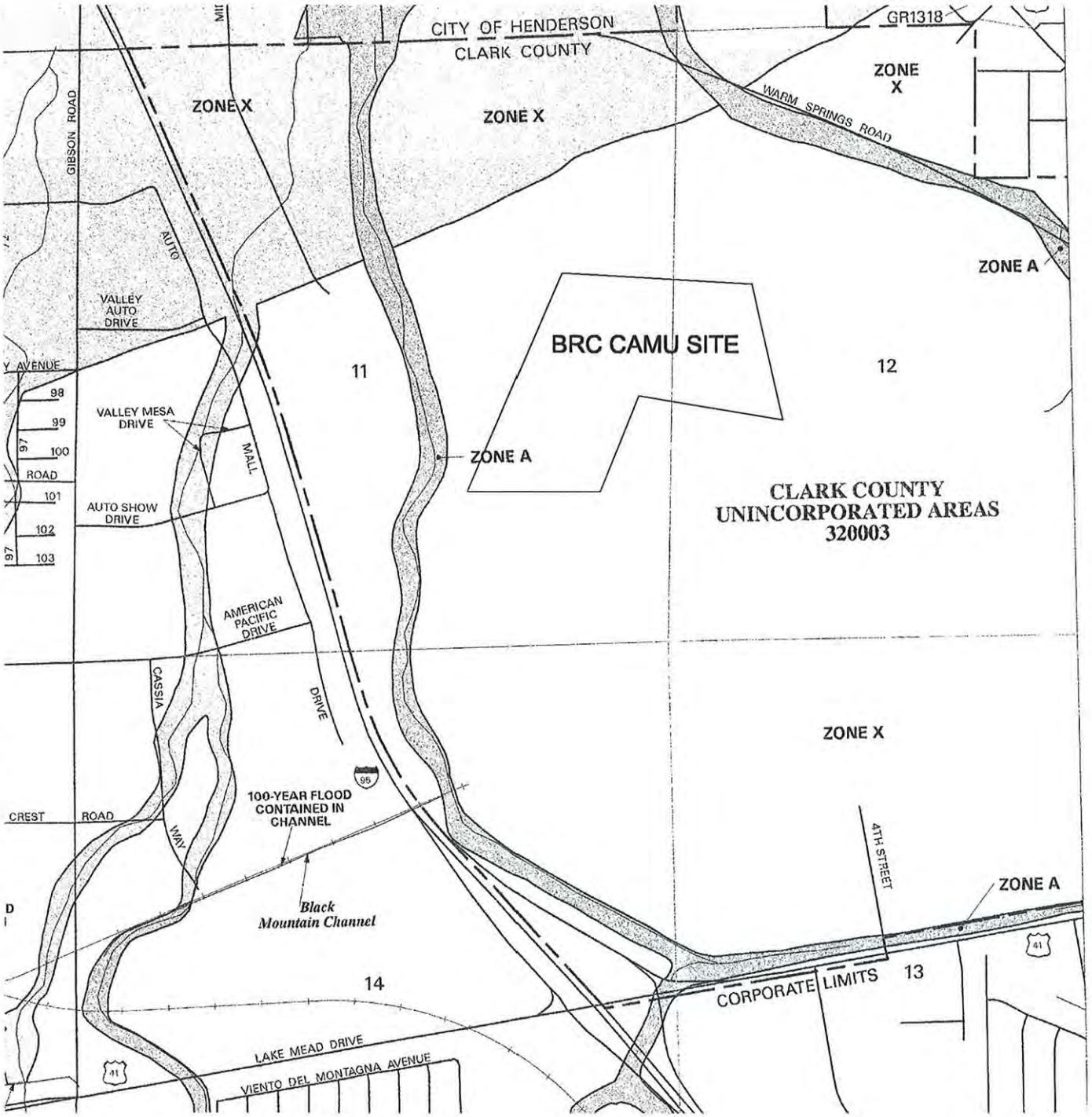
FEMA, 2002. Flood Insurance Rate Map No. 32003C2595E. Federal Emergency Management Agency. Revised September 27.

Geraghty & Miller, Inc., 1993. Phase I Environmental Conditions Assessment for BMI Complex – Clark County, Nevada, April.

Kerr-McGee, 1985, Phase II Groundwater Perchlorate Investigation, Henderson, Nevada Facility, July.

NOAA Atlas 2, Undated. "Precipitation Frequency Atlas of the Western United States," volume VII-Nevada, prepared by the national Weather Service and National Oceanic and Atmospheric Administration, United States Department of Commerce.

United States Geological Survey, 1982. Open File Report 82-1033, "Probabilistic Estimates of Maximum Acceleration and Velocity in Rock in the Contiguous United States."



LEGEND

100 YEAR FLOOD PLAIN

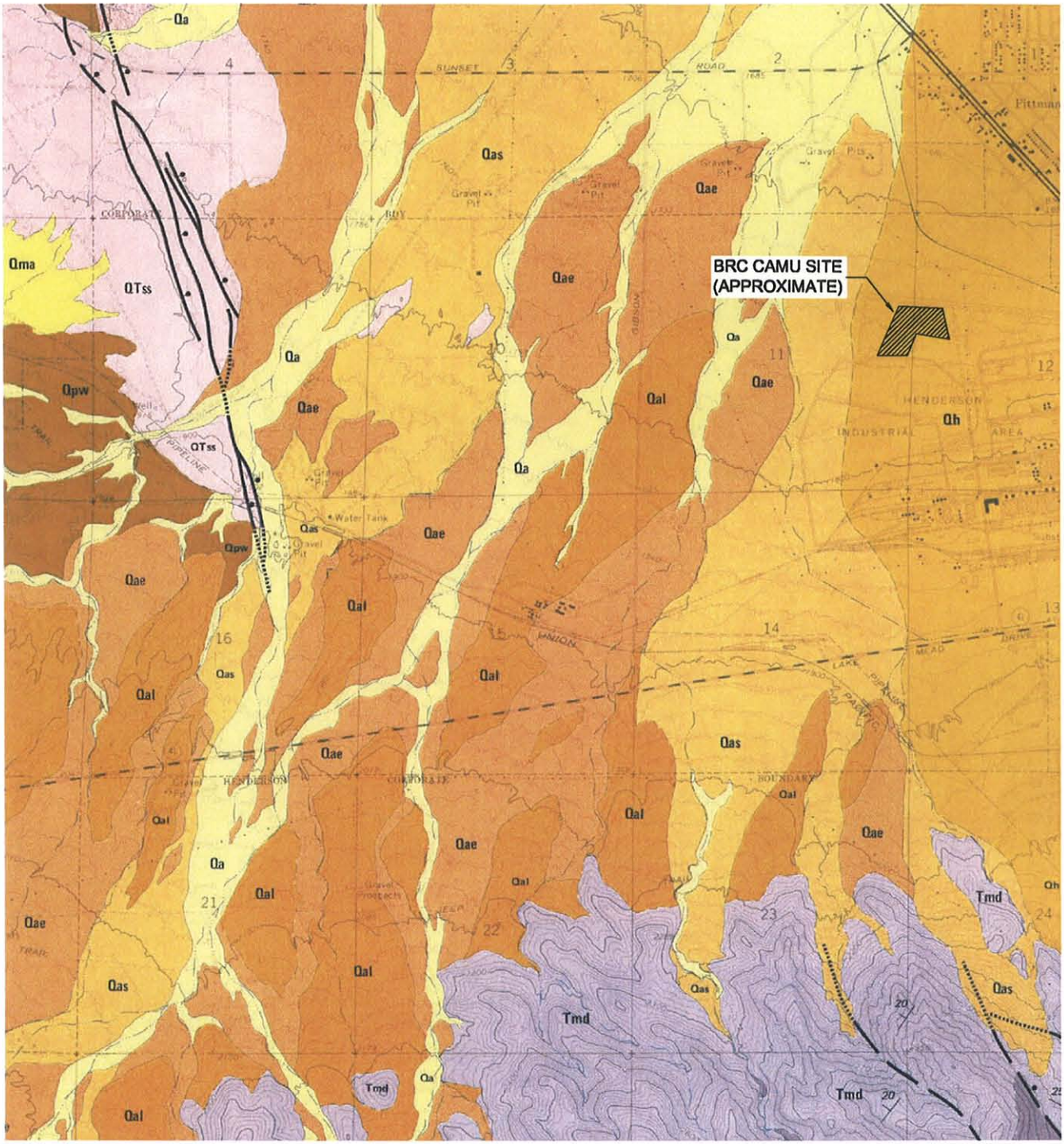
NOT TO SCALE

GEOSYNTEC CONSULTANTS

FEMA FLOOD INSURANCE MAP NO. 32003C2595 E
MAP REVISED SEPTEMBER 27, 2002
APPROXIMATE BRC CAMU LOCATION
BRC CAMU

FIGURE NO.	I-1
PROJECT NO.	SC0313
DATE:	NOVEMBER 2006

P:\PRJ\SDCadd\CADD\SC0313\BRC\figures\SC0313_Figure I-1_Insurance Map.dwg 7/10/2006 5:25 PM John Hall



Contact. Dashed where approximately located.

Fault. Dashed where approximately located; dotted where concealed. Ball on downthrown side.

15 **Bedding.**

NOT TO SCALE

GEOSYNTEC CONSULTANTS

USGS SE FOLIO GEOLOGIC MAP – LAS VEGAS AREA
BRC CAMU
HENDERSON, NEVADA

FIGURE NO.	I–2
PROJECT NO.	SC0313
DATE:	NOVEMBER 2006

P:\PRJ\SDCadd\CADD\SC0313\BRC\figures\SC0313_Figure I-2_Geological Map.dwg 7/10/2006 5:25 PM John Hall

Attachment J
CAMU (Landfill) Design – Conceptual

Attachment J
CAMU (Landfill) Design – Conceptual
Basic Remediation Company (BRC)
Corrective Action Management Unit (CAMU)
Henderson, Nevada

Table of Contents

1.0 Introduction J-1
1.1 Maps and Plans J-1
1.2 Anticipated Waste Material J-1
1.2.1 Predicted Leachate Generation J-2
2.0 Liner Design J-2
2.1 Liner and Leachate Collection System J-2
3.0 Summary of Engineering Analysis J-5
3.1 General J-5
3.2 Slope Stability Evaluation J-6
3.2.1 General J-6
3.2.2 Cut Slopes J-6
3.2.3 Final Waste Slopes J-6
3.3 Drainage Pipe Size Requirement J-6
3.4 Pipe Strength J-7
3.5 Veneer Stability J-7
3.6 Geotextile/Separation/Filtration Requirements J-7
3.7 Geotextile Cushion Protection J-8
3.8 Sump Capacity J-8
3.9 Comparison of Flow Through a CCL and CGL J-9
3.10 Tension Due to Wind Uplift J-9
3.11 Anchorage Capacity J-9
3.12 Geocomposite Equivalency Demonstration J-9
3.13 Consolidation Analysis J-10
4.0 References J-11

List of Tables

Table J-1 – Cushion Geotextile Requirements

List of Details

Detail J-1, Composite Liner Layout

Appendices

Appendix A – Groundwater Elevation Letter

CERTIFICATION PAGE

CONCEPTUAL DESIGN FOR THE CONSTRUCTION OF THE BASIC REMEDIATION COMPANY CORRECTIVE ACTION MANAGEMENT UNIT

HENDERSON, NEVADA

The Engineering material and data contained in this Conceptual Design Plan were prepared under the supervision and direction of the undersigned, whose seal as a registered Professional Engineer is affixed below.

The Engineering system in this conceptual design will prevent the migration of any hazardous constituents into the ground water or surface water at least as effectively as the liner and leachate collection and removal system specified in 40 CFR 264.301(c).

Ronald Johnson, P.E.
Nevada No. 12835

PROFESSIONAL ENGINEER - STATE OF NEVADA
RONALD S. JOHNSON
CIVIL
No. 12835

1.0 INTRODUCTION

This conceptual design is prepared in accordance with 40 CFR Parts 264, 266 and 268. The technical approaches discussed in this section are intended to outline the key conceptual design features and components of the proposed landfill. Upon regulatory review and approval, the conceptual design will be refined to provide detailed specifications to meet the design standards and performance criteria outlined in this permit.

1.1 Maps and Plans

A series of maps, plans and cross-sections referenced throughout this section is located in Section 1 of the Supplemental RAP Information (SRAPI). The design plans include the following:

- Figure J-1 – Title Sheet and Drawing List (includes general location map).
- Figure J-2 – Legend, Abbreviations, and General Notes;
- Figure J-3 – Overall Site Plan;
- Figure J-4 – Construction Sequence Plan;
- Figure J-5 – Surcharge Plan;
- Figure J-6 – Site Preparation Plan;
- Figure J-7 – Construction Grading Plan;
- Figure J-8 – Storm Drain Plan;
- Figure J-9 – Final Cover Grading Plan;
- Figure J-10 – Cross Sections
- Figure J-11 – Final Cover and Liner Details and Sections;
- Figure J-12 – Fence Plan.

1.2 Anticipated Waste Material

The source materials for the proposed BRC CAMU include approximately 3.5 million cubic yards of residual solids (i.e., sediments and associated soils) from the industrial ponds, ditches, and other sources areas within the BMI Common Areas known as the Eastside Area. Extensive testing of the waste material has determined the majority of wastes to be non-hazardous. Volatile Organic Compounds (VOCs), Semi-volatile Organic Compounds (SVOCs), and Polychlorinated Biphenyls (PCBs) were detected sporadically, with VOCs and SVOCs throughout the site and PCBs in the Beta Ditch and first eight Upper Pond rows. Pesticides, metals, and cyanide were detected at low levels in the Beta Ditch and first eight Upper Pond rows. Asbestos was tested at measureable levels in the Beta Ditch and first eight Upper Pond rows. These wastes are not incompatible, reactive, or ignitable. Additional waste characterization detail can be found

in the Waste Analysis Plan (Attachment C). No wastes will be accepted from other sources.

Unlike typical landfills, both the source material and the proposed BRC CAMU will be under sole control of BRC. Consequently, there will be direct control over the types of waste materials placed at the BRC CAMU. Physical and chemical descriptions of the anticipated waste materials are presented in the Waste Analysis Plan (Attachment C).

1.2.1 Predicted Leachate Generation

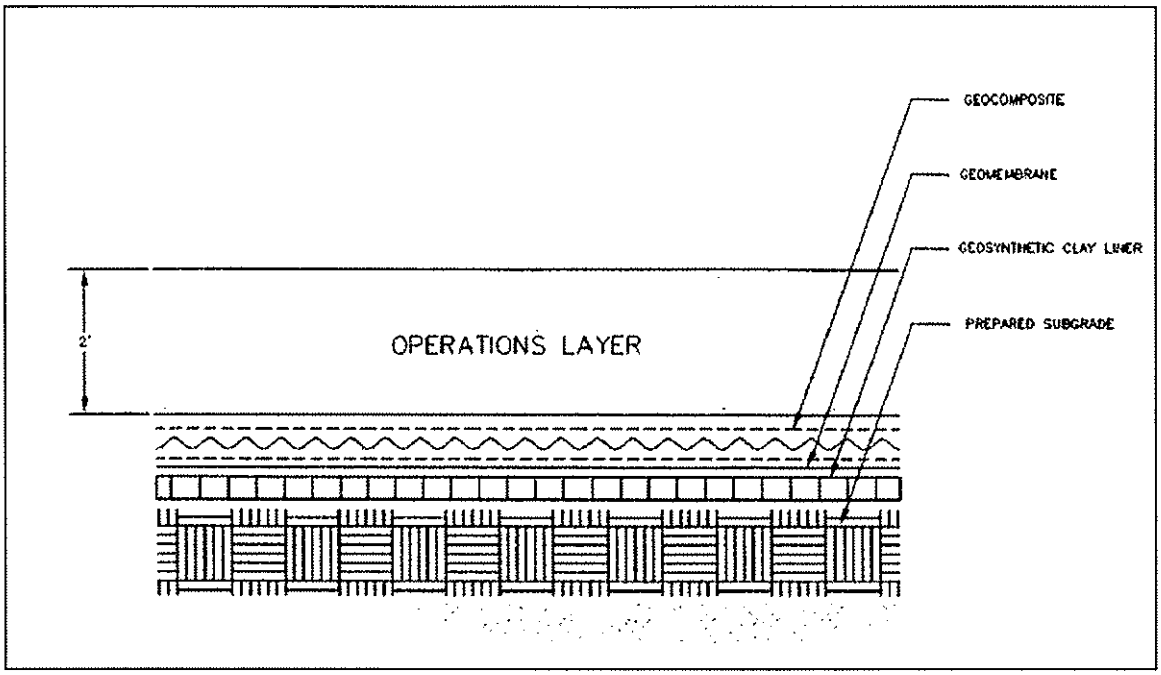
In the case of the proposed BRC CAMU, the mass of waste material will be compacted in place to form a hard-packed, monolithic "block," through which little or no saturated flow is expected to occur. Achieving the most favorable hydraulic conductivity in the compacted sediments depends on the degree of compaction, compaction method, type of soil, soil moisture content, and *in-situ* density. Wet waste sediments from the TIMET ponds will be mixed with dry solids, or otherwise dewatered, and then transported and placed to maintain a moisture content below that which is capable of generating leachate. The process will be designed such that waste sediments placed in the landfill meet the density and moisture content requirements that will in turn reduce leachate generation.

While waste material placed within the landfill will not be intrinsically capable of generating leachate, the ability for the landfill to produce leachate will be dependent on the quantity of the water allowed to infiltrate the interim and final cover materials and penetrate into the underlying waste materials. Therefore, final cover design and operational specifications for interim covers are important for the landfill system to provide for protection of the waters of the state. For this reason, the proposed interim and final cover are designed to reduce infiltration of water as described in Attachment O (Closure and Post-Closure Plan) and Attachment P (Final Cover Design).

2.0 LINER DESIGN

2.1 <u>Liner and Leachate Collection System</u>

A composite liner and leachate collection system is proposed as shown in cross-sections in Detail J-1 below. The composite liner will underlie the waste materials, providing a barrier to the underlying native soils and groundwater. Although leachate generation is not anticipated, this liner system is designed with a leachate collection system to reduce potential liquid accumulation at the base of the waste materials. Liner and leachate collection components will be constructed of materials having appropriate strength and chemical compatibility.



Detail J- 1, Composite Liner Layout

As shown in Detail J-1 above, the liner system is anticipated to consist of the following elements, or layers, from top to bottom: a geocomposite drainage layer, a geomembrane, and a geosynthetic clay liner (GCL). GCLs consist of a layer of bentonite-clay-backed geotextile. GCLs exhibit properties of low permeability soil liners, and have successfully substituted for the soil component in composite liner designs. Placement of a GCL under the geomembrane is commonly employed to increase effectiveness of the composite liner by limiting flow through potential flaws or pinholes in the geomembrane.

Geomembranes are relatively thin sheets of flexible polymeric materials that are manufactured and prefabricated at a factory and transported to the site. Because of their inherent impermeability, use of geomembranes in landfill construction is typically standard in the industry. Geomembranes are made of one or more polymers along with a variety of other ingredients such as carbon black, pigments, fillers, plasticizers, processing aids, crosslinking chemicals, anti-degradants, and biocides. The polymers used to manufacture geomembranes include a wide range of plastics differing in properties such as chemical resistance and basic composition. The polymeric materials may be categorized as follows:

- Thermoplastics such as polyvinyl chloride (PVC);

- Crystalline thermoplastics such as high density polyethylene (HDPE), low density polyethylene (LDPE), and linear low density polyethylene (LLDPE); and

- Thermoplastic elastomers such as chlorosulfonated polyethylene (CSPE).

The polymeric materials used most frequently as geomembranes are HDPE, PVC, and CSPE. Geomembrane thickness range from 20 to 120 mil (1 mil = 0.001 inch). The recommended minimum thickness for all geomembranes is 30 mil, with the exception of HDPE, which must be at least 60 mil. A 60-mil HDPE geomembrane is proposed for the BRC CAMU, which is widely recognized in the industry as a very chemically resistant, durable, long-lasting material.

Geocomposite is to be placed on the geomembrane to protect it from puncture by the overlying operations layer soil. The geocomposite is designed to allow leachate, if generated by the waste materials, to flow toward perforated HDPE collection piping and be collected at the pump-out locations. The base grade of the landfill is engineered to slope toward these leachate collection areas.

Components of the leachate collection system (LCS) will have sufficient strength to support overlying compressive stresses. Pipe strength calculations will include resistance to wall crushing, pipe deflection, and buckling pressure. Perforated drainage pipes have been shown to provide good long-term performance in LCSs (USEPA, 1993).

Geotextile filter is a component of the geocomposite that will reduce physical clogging of the drainage layer from the overlying fine-grained material.

The liner system is intended to work together with other design components to isolate the waste materials from the environment. The main objective of BRC CAMU design is to provide a design that protects waters of the state. Design components that are intended to accomplish this objective are as follows:

1. The final cover, or cap, of the landfill is designed to allow essentially no infiltration of water into the waste materials. The final cover is described in the CAMU (Landfill) Closure and Post Closure Plan (Attachment O).

2. The waste material will be compacted to the degree necessary to reduce saturated flow within the interred materials. As discussed earlier, material from the TIMET ponds will be mixed with dry soils or dewatered, as necessary, prior to interment in the BRC CAMU. Together with a cap that reduces infiltration in an arid environment, the resulting potential for contaminant mobilization and leachate generation is considered minimal.

3. In addition to the above precautions, the underlying liner system will be designed to collect leachate generated, thereby providing an additional factor of safety in reducing waste migration into the groundwater.

4. The base of the landfill will be at least 5 feet higher than first groundwater at the groundwater's highest elevation, providing a buffer between groundwater and the landfill (Section 9 of the Supplemental Rap Information [SRAPI]).

Engineering design calculations and construction specifications for the base liner system and leachate collection system are presented with the Supplemental RAP Information (SRAPI), Sections 2 and 4, respectively. A summary is provided in the following section.

3.0 SUMMARY OF ENGINEERING ANALYSIS

3.1 General

This section summarizes the results of the conceptual design calculations performed for the base liner system at the BRC CAMU Landfill site. The following calculations were performed:

- Slope Stability Evaluation - Cut Slopes (Calculation Package A);
- Slope Stability Evaluation - Final Waste Slopes (Calculation Package B);
- Drainage Pipe Size Calculations (Calculation Package C);
- Pipe Strength Calculations (Calculation Package D);
- Veneer Stability Calculations (Calculation Package E);
- Geotextile Separation/Filtration Calculations (Calculation Package F);
- Geotextile Puncture Protection Calculations (Calculation Package G);
- Sump Capacity Calculations (Calculation Package H);
- Comparison of Flow Through the Prescriptive Composite Liner and a Proposed Alternative Composite Liner (Calculation Package I);
- Tension Due to Wind Uplift (Calculation Package J);
- Evaluation of Liner System Anchor Capacity (Calculation Package K);
- Drainage Geocomposite Equivalency Demonstration (Calculation Package L); and
- Consolidation Analyses (Calculation Packages M and N)

The base liner system calculations are based on the conceptual design grading plans shown on Figures J-7 and J-9 Additional calculations may have to be performed if there are changes to elevation and grade in the aforementioned design grading plans.

3.2 Slope Stability Evaluation

3.2.1 General

This section summarizes the analyses performed for the cut slopes and the final waste slopes. The analyses summarized herein are for static stability. Seismic site response, stability, and permanent deformation analyses are presented in Attachment O.

3.2.2 Cut Slopes

Slope stability was evaluated for the proposed cut slopes for the BRC CAMU. One cross-section was analyzed that represents the most critical case. Cut slopes with the highest height, weakest materials, and/or steepest slope are chosen for this analysis. The analyzed native soil cut slope has a height of approximately 44 ft and a base sloping at 3%. The proposed native soil cut slopes are at a slope angle of 2.1:1 (horizontal:vertical). The material properties selected and used in these analyses were based on a preliminary investigation by Converse Consultants, Inc. [Converse, 1999]. The calculations suggest that the most critical potential failure surface of the 2.1H:1V native soil cut slope possesses a factor of safety of approximately 1.5. Since the native soil cut slopes are considered interim, seismic evaluations were not conducted. Native soil cut slope stability calculations are presented in Section 2, Calculation Package A of the SRAPI.

3.2.3 Final Waste Slopes

The stability of the final waste slopes for the BRC CAMU was analyzed. Two cross-sections were analyzed that represent the most critical cases. Similar to cut slope analysis, waste slopes with the highest height, weakest materials, and/or steepest slope are chosen for this analysis. The analyzed final waste slope has a height of approximately 47 ft above surrounding grades at a slope angle of 3:1 (horizontal:vertical). The material properties selected and used in these analyses were based on a preliminary investigation by Converse Consultants, Inc. [Converse, 1999]. The calculations suggest that an apparent internal or interface friction angle of 12 degrees for any component of the composite liner system is the minimum allowable value provides a static factor of safety of 1.6. Furthermore, the calculations suggest that the yield acceleration for the final waste slopes is approximately 1.10 g (where "g" is the gravitational acceleration of 32.2 ft/s^2). Final waste slope stability calculations are presented in Section 2, Calculation Package B of the SRAPI.

3.3 Drainage Pipe Size Requirement

Drainage pipes will be placed on the base liner system to collect and transport potential leachate to the sump for removal. Analyses were performed to model leachate

generation by using the Hydrologic Evaluation of Landfill Performance (HELP) model. The calculations suggest that a 4-inch diameter pipe with four 1/4-inch perforations spaced at 1-ft intervals will accommodate the flow predicted by HELP model analyses. Drainage pipe size calculations are presented in Section 2, Calculation Package C of the SRAPI.

3.4 Pipe Strength

Based on drainage pipe size analyses, a 4-inch diameter drainage pipe will be used for leachate collection and transport. An 18- inch diameter pipe will be used for the side slope riser. Based on the calculations performed for the 4-inch diameter drainage pipe and the 18-inch diameter side slope riser, the appropriate standard dimension ratio (SDR) is 13.5 or smaller. This calculation assumes the maximum height above the pipe of waste is 93 ft (South Mesa). Pipe strength calculations are presented in Section 2, Calculation Package D of the SRAPI.

3.5 Veneer Stability

The design criteria for the side slope liner system is to develop zero tension in the geosynthetics during installation of the operations layer on the side slopes. Potential causes of tension in the liner system include construction equipment loading and overburden stresses (e.g., operations layer materials). Based on the proposed grades and expected construction conditions, the calculations suggest that the side slope liner system will not be placed into tension provided a minimum dry interface friction angle of 18 degrees is maintained and the operations layer is staged in 10-ft high increments inclined at 2.5H:1V. Veneer stability calculations are presented in Section 2, Calculation Package E of the SRAPI.

3.6 Geotextile/Separation/Filtration Requirements

A separation/filtration geotextile will be placed between the operations layer and the drainage aggregate surrounding the leachate collection pipe and as a component of the geocomposite drainage layer. The purpose of the geotextile is to limit migration of fine material from the operations layer into the drainage aggregate and/or geonet component of the geocomposite. The calculations suggest that the separation/filtration geotextile overlying the drainage aggregate layer has an apparent opening size (AOS) less than Sieve No. 70, a permittivity greater than 0.8 sec^{-1}, a minimum mass per unit area of 6 $oz./yd^2$, and sufficient mechanical properties. Geotextile separation/filtration calculations are presented in Section 2, Calculation Package F of the SRAPI.

3.7 Geotextile Cushion Protection

The geomembrane needs to be protected from puncture by particles from the prepared subgrade and operations material. Based upon the selection of using a geocomposite as the drainage layer in the leachate collection system, the geocomposite is selected such that the combined weight of the geocomposite geotextiles will act as an equivalent cushion. With respect to subgrade puncture, the geotextile components of the GCL will protect the geomembrane from the prepared subgrade. This calculation is based on a maximum overburden height of 93 feet. The analysis suggests that the following maximum particle sizes and geotextile mass per unit areas will be required:

Soil Component of Liner	Maximum Particle Size	Minimum Mass per Unit Area
Subgrade	0.75 inch	9 oz./yd^2 (GCL)
Angular Drainage Aggregate	1.00 inch	16 oz./yd^2

Table J -1- Cushion Geotextile requirements

Geotextile cushion protection calculations are presented in Section 2, Calculation Package G of the SRAPI.

3.8 Sump Capacity

The USEPA regulations limit the head over the liner system to less than 12 inches. Therefore, the available capacity to retain the peak daily runoff includes the sump and the volume of 12 inches of leachate in the geocomposite and operations layer extending away from the sump. The maximum, average daily runoff calculated from the HELP model analyses (see drainage pipe sizing calculation) is 231 ft^3. A sump will be located at three low points (two in both the South Mesa and one in the North Mesa). Each sump will be approximately 10 ft x 10 ft x 2 ft deep. The sump has a capacity of approximately 112 ft^3. The capacity of the drainage geocomposite/operations layer extending away from the sump (at a 12-inch head) is greater than 342 ft^3. The combined capacity of the sump and drainage geocomposite/operations layer is 453 ft^3, which exceeds the maximum, average daily runoff noted above of 231 ft^3.

The capacity of the three sumps located throughout the site will be able to accommodate the anticipated peak daily flow (as evaluated from the HELP model – drainage pipe sizing calculation, Section 2, Calculation C of the SRAPI) and meet the EPA requirement of less than 12 inches of head over the liner. Sump and drainage aggregate capacity calculations are presented in Section 2, Calculation Package H of the SRAPI.

3.9 Comparison of Flow Through a CCL and GCL

The calculations suggest that the flow rate through the prescriptive composite liner system containing a compacted clay liner (CCL) is approximately 1.64 times greater than the flow rate through the alternative composite liner system containing a geosynthetic clay liner (GCL). The comparison calculations are presented in Section 2, Calculation Package I of the SRAPI.

3.10 Tension Due to Wind Uplift

The most critical scenario for wind uplift is after the 10-ft vertical height of operations material has been placed against the slope while the remainder of the geosynthetic liner is exposed on the upper portion of the slope. A UV-protective woven geotextile will be installed to overlie the exposed portions of geosynthetics on these cut slopes. The woven geotextile will be subjected to tension due to wind uplift.

Due to proximity of the site, the Las Vegas Airport wind speed data was used for this analysis. A design wind speed of 90 mph is used, which is the peak gust recorded since 1961. This is a conservative design wind speed since the likelihood of this wind speed occurring during the period of construction is very low. Assuming the design wind speed, the calculations suggest that the maximum tension the woven geotextile will experience is 82.8 lb/in. In order to resist the uplift forces from wind loads, the woven geotextile shall have a minimum ultimate wide width tensile strength of 110 lb/in. The tension due to wind uplift calculations is presented in Section 2, Calculation Package J of the SRAPI.

3.11 Anchorage Capacity

The geosynthetics' anchor must have the capacity to withstand potential pullout tension due to wind uplift from the UV-protective woven geotextile. The proposed anchor consists of a 2-ft wide and 2.5-ft deep trench filled with compacted soil. The anchor trench will be overlain by 1 ft of soil with a 3-ft runout length from the top of slope. The capacity of the anchor trench is sufficient to withstand pullout tension from the woven geotextile. The anchorage capacity calculations are presented in Calculation Package K.

3.12 Geocomposite Equivalency Demonstration

A geocomposite layer will be used in lieu of a leachate collection gravel and separation/filtration geotextile. A geocomposite layer, consisting of two 8 oz/yd^2 nonwoven geotextiles bonded to either side of a geonet, is proposed. The top geotextile shall conform to the requirements presented in the geotextile separation/filter calculation

package (Section 2, Calculation Package F in the SRAPI). The combined weight of the geotextiles will act as an equivalent cushion. The calculations suggest that a drainage composite will provide equivalent transmissivity to the aggregate drainage layer. The geocomposite equivalency demonstration calculations are presented in Section 2, Calculation Package L of the SRAPI.

3.13 Consolidation Analysis

Consolidation analyses were performed to evaluate the potential affect on the performance of the proposed liner system under increased loads related to the BRC CAMU. Borings and associated laboratory test results were used for locations beneath the South Mesa (higher loads due to thicker waste profile). Conservative analyses suggest that consolidation will not adversely impact the performance of the proposed liner or leachate collection systems. The consolidation analysis for the South Mesa is presented in Section 2, Calculation Package M of the SRAPI.

In addition, a consolidation analysis was performed to evaluate the effects of the consolidation settlement of waste in the "slit trenches" that will be overlain by the North Mesa disposal area. Since limited information is available regarding the consolidation characteristics of the waste materials contained in the "slit trenches", interpretation was required and the analyses were approached on a conservative basis. The calculations suggest that settlement of waste in the unconsolidated "slit trenches" is likely to cause unacceptable strain in the liner system. As a result, the North Mesa will be pre-loaded with surcharge fill, prior to construction of the overlying liner system, to heights of approximately 36 ft.

Surcharge fill will be monitored using settlement plates to assess the settlement progress and to ascertain the point at which the surcharge is removed and the liner system construction can begin. Since the waste materials contained in the "slit trenches" are primarily inert industrial wastes, long-term settlement due to biodegradation is minimal. Therefore, the time to achieve slit trench consolidation is anticipated to be very short. Settlement will be deemed complete once the difference between any two subsequent settlement plate readings is no more than 5%, or no greater than 0.05 ft change in one week's time.

The calculations suggest that after pre-loading, the strain on the liner system due to differential settlement is within tolerable amounts. In addition, the proposed grading plan can accommodate the calculated post-surcharge differential settlement without significant effects on drainage. The consolidation analysis is presented in Section 2, Calculation Package N of the SRAPI.

4.0 REFERENCES

Converse Consultants, 1999. Preliminary Geotechnical and Geologic Investigation, Industrial Non-Hazardous Disposal Facility, Basic Remediation Incorporated, Clark County, Nevada, October.

USEPA 1993, "Solid Waste Disposal Facility Criteria, Technical Manual." EPA530-R-93-017. Soild Waste and Emergency Response, November.

Appendix A

Groundwater Elevation Letter

Geosyntec consultants

10875 Rancho Bernardo Road, Suite 200
San Diego, California 92127
PH 858.674.6559
FAX 858.674.6586
www.geosyntec.com

6 April 2007

Ranajit Sahu, Ph.D.
Director of Environmental Services
Basic Remediation Company
875 West Warm Springs Road
Henderson, Nevada 89015

Subject: Groundwater Elevations
BRC CAMU
Henderson, Nevada

Dear Dr. Sahu:

In accordance with the Nevada Department of Environmental Protection (NDEP) draft Notice of Deficiency (NOD) dated 13 February 2007, Geosyntec has evaluated the groundwater elevation data associated with the Basic Remediation Company Correction Action Management Unit (CAMU) located in Henderson, Nevada. The proposed CAMU liner system, as illustrated on Drawing J-7, is designed to be a minimum of 5 feet above the groundwater elevation. The groundwater elevations presented on Drawing J-7 were obtained by Montgomery Watson Harza (MWH) in July 2005.

Based on the groundwater contours provided by MWH, the north mesa portion of the CAMU (i.e., the portion over the slit trenches) liner system is greater than approximately 40 feet above groundwater and the south mesa portion of the CAMU liner system (i.e., in the borrow pit area) greater than 5 feet above groundwater. Approximately 93% of the south mesa portion of the CAMU liner system area is more than 10 feet above the groundwater.

The CAMU liner system is designed to limit migration of liquids in the CAMU to the groundwater, which will also limit the migration of groundwater into the CAMU if groundwater were to rise above the base liner system elevation. Furthermore, if groundwater were to rise to an elevation above and migrate through the CAMU liner system, the liquid would be collected in the leachate collection and removal system and would then be removed from the landfill as outlined in the operations plan.

RAP_Att J GW Letter 20070406.doc

Based on this information, we do not anticipate that rising groundwater levels, if they occur, would adversely impact the performance of the liner system or CAMU.

Sincerely,

Ronald S. Johnson, P.E.
Associate Engineer

PROFESSIONAL ENGINEER-STATE OF NEVADA
RONALD S. JOHNSON
CIVIL
No. 12635

RAP_Att J GW Letter 20070406.doc

Attachment K
CAMU (Landfill) Design – Final [Reserved]

Attachment L
CAMU (Landfill) Construction Plan

Attachment L
CAMU (Landfill) Liner Construction Plan
Basic Remediation Company (BRC)
Corrective Action Management Unit (CAMU)
Henderson, Nevada

Table of Contents

1.0 Introduction L-1
2.0 Liner Construction Schedule and Sequence L-1
2.1 Site Preparation L-1
2.2 Liner Installation L-2
2.3 Leachate Collection and Removal System Installation L-2
3.0 Liner Construction Requirements L-2
3.1 General L-2
3.2 Slope Inclinations L-2
3.3 Drainage Pipe Size Requirement L-2
3.4 Equipment Loading L-3
3.5 Geotextile Requirements L-3
3.6 Geosynthetic Clay Liner (GCL) L-4
3.7 Leachate Collection Layer L-4
3.7.1 Geocomposite Requirements L-4
3.7.2 Geomembrane Requirements L-4
3.8 Prepared Subgrade Requirements L-4
4.0 Records and Recordkeeping L-5
4.1 General L-5
4.2 Daily Recordkeeping L-5
4.3 Construction Problems and Resolution Data Sheets L-6

4.4 Photographic Documentation L-7
4.5 Design Changes L-7
4.6 CQA Report L-7

1.0 INTRODUCTION

This BRC CAMU Construction Plan outlines the general construction requirements and schedule for the base liner systems. This plan addresses the construction materials, installation, and grading requirements for the BRC CAMU. The rationale for selecting the liner materials is described in the supporting calculations. A Base Liner System Construction Quality Assurance (CQA) plan, base liner system technical specifications, and conceptual drawings are included with the Supplemental RAP Information (SRAPI).

2.0 LINER CONSTRUCTION SCHEDULE AND SEQUENCE

Construction of the CAMU components will be phased so as to increase efficiency of waste disposal. One unit of the BRC CAMU will receive wastes while the base liner system is being constructed for the next unit. These different sections will be divided using storm water controls to reduce surface water, leachate, and waste interaction. The liners in adjacent units will be joined using the seaming techniques outlined in the Base Liner CQA and Technical Specifications (Sections 3 and 4 of the SRAPI, respectively). As lined areas are completed with waste placement, they will be closed and the final cover system will be constructed, as discussed in the CAMU (Landfill) Closure and Post-Closure Plan (Attachment O).

The general construction sequence of the CAMU, as shown on Figure J-4 of the Conceptual Drawings, Section 1, in the SRAPI, is outlined in the following sections.

2.1 Site Preparation

The site will be prepared by removing surface vegetation and portions of the fence currently on site. The temporary perimeter fence will be established and all support facilities brought on-site. At this time, the haul roads and storm water controls (ditches, culverts, silt fences, check dams, and basins) will be constructed. Hot spot excavation of specific areas of the slit trenches will be performed. Surcharge will be constructed, monitored, and removed over the slit trenches in the North Mesa, as shown on Figure J-5 of the Conceptual Drawings. The liner foundation will be graded in accordance with the Conceptual Drawings to prepare for liner installation. The grading requirements are summarized in Section 3 of this Attachment and in shown detail in Section 1 of the SRAPI.

2.2 Liner Installation

After the liner foundation grading, the leachate collection system and liner installation will begin. The flowlines, sumps, and berms for leachate conveyance and storage will be constructed as shown on the Drawings at this time. Liner construction will begin with the installation of the geosynthetic clay liner (GCL), and geomembrane. Requirements for installation are summarized in Section 3 of this Attachment and in detail in the SRAPI.

2.3 Leachate Collection and Removal System Installation

The leachate collection and removal system will be installed next, with collection pipes, drainage aggregate, geotextile, and geocomposite. The geocomposite and filter geotextile will be overlain with 2 feet of soil acting as an operations layer. Requirements of the geocomposite and filter geotextile are summarized in Section 3 of this Attachment and in detail in the SRAPI.

3.0 LINER CONSTRUCTION REQUIREMENTS

3.1 General

This section describes the construction requirements for installation of the base liner system at the BRC CAMU. These construction requirements are necessary in order to ensure that the construction of the liner system is consistent with the design performance goals and assumptions.

3.2 Slope Inclinations

Native soil cut slopes shall be excavated no steeper than a slope inclination of 2.1H:1V. Waste soil slopes shall be placed no steeper than a slope inclination of 3H:1V.

3.3 Drainage Pipe Size Requirement

In accordance with the analyses performed, the drainage pipe shall be 4-inch diameter HDPE pipe with four 1/4-inch perforations per foot of pipe. The side slope riser shall be 18-inch diameter HDPE solid-wall pipe. The standard dimension ratio (SDR) for the 4-inch diameter pipe and the 18-inch side slope riser shall be less than or equal to 13.5.

3.4 Equipment Loading

Equipment loads shall be limited to a maximum loading of 5 psi overlying a minimum of 1 ft of operations materials. In addition, roads for haul trucks shall be a minimum of 3 ft in thickness overlying the liner system.

3.5 Geotextile Requirements

Two geotextile components of the base liner system are utilized, a 6 oz/yd^2 separation/filtration geotextile and a 16 oz./yd^2 cushion geotextile. A UV protective geotextile will be used on the exposed liner system components on the side slopes. To ensure proper manufacturing and durability, the 6 oz/yd^2 separation/filter geotextile shall have the following properties:

Matrix	Nonwoven
Mass per Unit Area	$\geq$ 6 oz/yd^2
Apparent Opening	$\leq$Sieve No. 70
Permittivity	$\geq$ 0.8 sec-1
Grab Strength	$\geq$ 130 lb
Puncture Strength	$\geq$ 40 lb
Ultraviolet strength retention	$\geq$ 70%

The 16 oz/yd^2 cushion geotextile shall have the following properties:

Matrix	Nonwoven
Mass per Unit Area	$\geq$ 16 oz/yd^2
Puncture Strength	$\geq$ 155 lb
Grab Strength	$\geq$ 350 lb
Ultraviolet strength retention	$\geq$ 70%

The UV protective layer woven geotextile shall have the following properties:

Matrix	woven
Wide Width Tensile Strength	$\geq$ 110 lb/in (ultimate strength)
Apparent Opening	$\leq$ Sieve No. 40

3.6 Geosynthetic Clay Liner (GCL)

The GCL component of the base liner system shall have the following properties:

- Index flux > 1.0×10^{-8} ft^3/ft^2-sec;
- Minimum interface shear strength of 12 degrees;
- The GCL shall be dry during installation; and
- combined geotextile mass per unit area of 9 oz/yd^2.

3.7 Leachate Collection Layer

3.7.1 Geocomposite Requirements

In lieu of using drainage aggregate, a geocomposite will be used to collect potential leachate. The selected geocomposite shall have the following properties:

- Transmissivity > 3.05×10^{-5} ft^2/sec under a confining pressure of 12,000 psf and a hydraulic gradient of 0.10;
- an 8 oz/yd^2 non-woven geotextile bonded to each side of the geonet; and
- the top 8 $oz./yd^2$ non-woven geotextile shall have an AOS greater than Sieve No. 70, permittivity greater than 0.6 sec-1, and sufficient mechanical properties.

3.7.2 Geomembrane Requirements

The geomembrane shall be high-density polyethylene (HDPE), have a nominal thickness of 60 mil, and be textured on both sides.

3.8 Prepared Subgrade Requirements

The prepared subgrade shall have a maximum exposed particle diameter less than 3/4 inch.

4.0 RECORDS AND RECORDKEEPING

4.1 General

Liner and Leachate Collection System construction records will be kept in accordance with the CQA plan. The CQA Site Manager will document that all quality assurance requirements have been addressed and satisfied.

The CQA Site Manager will provide the Construction Manager with signed descriptive remarks, data sheets, and logs to verify that monitoring activities have been carried out. The CQA Site Manager will also maintain, at the job site, a complete file of Drawings and Technical Specifications, a CQA Plan, checklists, test procedures, daily logs, and other pertinent documents.

4.2 Daily Recordkeeping

Preparation of daily CQA documentation will consist of daily reports prepared by the CQA Site Manager which will include CQA monitoring logs, and testing data sheets. This information may be regularly submitted to and reviewed by the Construction Manager.

The CQA Site Manager will prepare daily reports that document the activities observed during each day of activity. The daily reports may include monitoring logs and testing data sheets. At a minimum, these logs and data sheets will include the following information:

- the date, project name, location, and other identification;
- a summary of the weather conditions;
- a summary of locations where construction is occurring;
- equipment and personnel on the project;
- a summary of meetings held and attendees;
- a description of materials used and references of results of testing and documentation;
- identification of deficient work and materials;
- results of re-testing corrected "deficient work;"
- an identifying sheet number for cross referencing and document control;
- descriptions and locations of construction inspected;
- type of construction and inspection performed;

- description of construction procedures and procedures used to evaluate construction;
- a summary of test data and results;
- calibrations or re-calibrations of test equipment and actions taken as a result of re-calibration;
- decisions made regarding acceptance of units of work and/or corrective actions to be taken in instances of substandard testing results;
- a discussion of agreements made between the interested parties which may affect the work; and
- signature of the respective CQA Site Manager.

4.3 Construction Problems and Resolution Data Sheets

Construction Problems and Resolution Data Sheets, to be submitted with the daily reports prepared by the CQA Site Manager, describing special construction situations will be cross-referenced with daily reports, specific observation logs, and testing data sheets and will include the following information, where available:

- an identifying sheet number for cross-referencing and document control;
- a detailed description of the situation or deficiency;
- the location and probable cause of the situation or deficiency;
- how and when the situation or deficiency was found or located;
- documentation of the response to the situation or deficiency;
- final results of responses;
- measures taken to prevent a similar situation from occurring in the future; and
- signature of the CQA Site Manager and a signature indicating concurrence by the Construction Manager.

The Construction Manager will be made aware of significant recurring nonconformance with the Drawings, Technical Specifications, or CQA Plan. The cause of the nonconformance will be determined and appropriate changes in procedures or specifications will be recommended. These changes will be submitted to the Engineer for approval. When this type of evaluation is made, the results will be documented and revision to procedures or specifications will be approved by the Contractor and Engineer.

4.4 Photographic Documentation

Photographs will be taken and documented in order to serve as a pictorial record of work progress, problems, and mitigation activities.

4.5 Design Changes

Design changes may be required during construction. In such cases, the CQA Site Manager will notify the Construction Manager. Design changes will be made with the written agreement of the Construction Manager and the Engineer and will take the form of an addendum to the Drawings and Technical Specifications.

4.6 CQA Report

At the completion of the Project, the CQA Consultant will submit to the Construction Manager the CQA report signed and sealed by a Professional Engineer licensed in the State of Nevada. The CQA report will acknowledge: (i) that the work has been performed in compliance with the Drawings and Technical Specifications; (ii) physical sampling and testing has been conducted at the appropriate frequencies; and (iii) that the summary document provides the necessary supporting information. At a minimum, this report will include:

- Manufacturers' quality control documentation;
- a summary report describing the CQA activities and indicating compliance with the Drawings and Technical Specifications which is signed and sealed by the CQA Officer;
- a summary of CQA/CQC testing, including failures, corrective measures, and retest results;
- contractor personnel resumes and qualifications;
- documentation that the geomembrane trial seams were performed in general accordance with the CQA Plan and *Technical Specifications*;
- documentation that field seams were non-destructively tested using a method in general accordance with the applicable test standards;
- documentation that nondestructive testing was monitored by the CQA Consultant, that the CQA Consultant informed the Geosynthetic Installer of any required repairs, and that the CQA Consultant inspected the seaming and patching operations for uniformity and completeness;
- records of sample locations, the name of the individual conducting the tests, and the results of tests;

- record drawings as provided by the Surveyor;
- documentation showing that piping was tested in general accordance with the Technical Specifications; and
- daily inspection reports.

The record drawings will include scale drawings depicting the location of the construction and details pertaining to the extent of construction (e.g., depths, plan dimensions, elevations, soil component thicknesses). Base maps required for development of the record drawings and the record drawings themselves will be prepared by a qualified Professional Land Surveyor registered in the State of Nevada. These documents will be reviewed by the CQA Consultant and included as part of the CQA Report, which will be kept with the project records in accordance with the records retention requirement of the AOC3.

Attachment M
CAMU (Landfill) Operation Plan

Attachment M
CAMU (Landfill) Operation Plan
Basic Remediation Company (BRC)
BRC Corrective Action Management Unit (CAMU)
Henderson, Nevada

Table of Contents

1.0 Introduction M-1
2.0 Facilities M-1
2.1 Equipment M-1
2.2 Operation Support M-2
2.3 Access, Traffic Control, and Roads M-2
2.4 Signs M-2
3.0 Operating Criteria M-3
3.1 Health and Safety M-3
3.2 Fire Prevention M-4
3.3 Control of Windblown Material M-4
3.4 Special Waste Disposal M-4
3.5 Control of Authorized and Unauthorized Waste M-5
3.6 Disposal of Liquids M-5
3.7 Control of Explosive Gas M-5
3.8 Disposal of Vegetation M-5
3.9 Compliance with State Implementation Plan M-5
3.10 Putrescible Wastes and Vector Control M-6
3.11 Nuisance Control M-6
3.12 Disposition, Compaction, and Coverage M-6
3.13 Miscellaneous Requirements for Operation M-7
3.14 Control of Erosion, Mud and Dust M-7
3.15 Run-on and Runoff Control Systems M-8
3.16 Leachate M-8
3.17 Decontamination M-9
4.0 Remediation M-9

4.1 Soil Excavation M-10
4.2 Dewatering Procedures for TIMET Ponds M-10
4.3 Soil Transportation to BRC CAMU M-10
4.4 Soil Placement M-11
5.0 Reporting and Recordkeeping M-12
5.1 General M-12
5.2 Interim Status Reports M-13
6.0 References M-13

1.0 INTRODUCTION

The purpose of this Operation Plan is to delineate the procedures and operating practices that will be implemented to ensure the safe and efficient excavation, loading, transportation, receipt, and placement of remediation wastes at the BRC CAMU. This Operation Plan summarizes operational procedures discussed in detail in the Corrective Action Plan (CAP) for the BRC Common Areas Remediation Project prepared by Dr. Ranajit Sahu, C.E.M. for BRC dated September 2006. This Operation Plan is intended to provide guidelines to the operator and managers of the BRC CAMU in conducting CAMU operations.

2.0 FACILITIES

2.1 Equipment

The proposed equipment at the BRC CAMU is listed in Table 3 of the CAP. The equipment will be adequate in type, capacity and number, and sufficiently maintained to permit the site operation to meet requirements of these standards. Periodically, the overall maintenance level of site equipment and the quality of site maintenance facilities will be evaluated. In addition, periodically the size and adequacy of the equipment to carry out operations, including the types and quantities of major landfill equipment such as bulldozers, scrapers, compactors, graders and water trucks will be evaluated by the BRC CAMU Construction Manager.

Selection of type, size, quantity, and combination of machines required to move, dry, spread, and compact waste depend on the following factors:

- Amount and type of waste to be handled;
- Weather conditions;
- Compaction requirements;
- Site and soil conditions (topography, soil moisture, and difficulty of excavation); and
- Supplemental tasks such as maintaining roads, assisting in vehicle unloading, and moving other materials and equipment around the site.

In addition to the above, BRC is committed, through either purchase or lease, to provide other equipment to serve as replacements, backups, or supplements to existing operations, or for such special needs that may arise.

2.2 Operation Support

Suitable shelter and sanitary facilities will be provided for operating personnel and waste transport personnel. In addition, a storage area will be provided for BRC CAMU operators to store equipment.

2.3 Access, Traffic Control, and Roads

Site access will be gained through the entry gate located off Fourth Street on the east side of the property. Access will be controlled through full time security (24 hours a day, 365 days per year) during site operations in order to prevent unauthorized vehicular traffic and illegal dumping. In addition to full-time security, access will be controlled by using artificial barriers to protect public health, safety, and the environment. The entry gate will be equipped with a lockable mechanism to prevent unauthorized entry and/or uncontrolled waste deposition when the site is closed. Access to the site at points other than the entry gate will be discouraged by maintenance of site perimeter fencing and full time security during site operations.

The BRC CAMU entrance or gate attendant's office, located beyond the entry gate, will serve as the checkpoint to facilitate access and traffic control. The office will be manned continuously. Loads will be inspected at this point by assigned site personnel. Subsequent to this inspection, loads will be directed to the appropriate BRC CAMU disposal areas.

Temporary roads will be provided as necessary to the working face. All roads will be passable during inclement weather. The entire site will be enclosed with a continuous chain link fence. Figure F-1 through F-3 of the CAP show the locations of the proposed haul roads.

2.4 Signs

At the main entrance gate off Fourth Street a sign will be posted indicating the following:

- Facility name;
- The owner and operator of the site;
- The hours of operation; and
- Materials accepted or excluded.

It will be noted on the signage that the BRC CAMU is a private operation.

Instructional signs will be placed at this site entrance addressing prescribed safety measures on the site and include instructions regarding prohibition of smoking within the disposal areas and mandating that all instruction from site personnel be obeyed.

Interior site haul roads will be appropriately signed so as to direct each load to its designated disposal area. Typical directional and information signs will be posted at the site. Location of signage may be changed from time-to-time to facilitate operations. In addition, authorized personnel may be utilized to direct traffic at the active working face of the landfill operation.

"No Trespassing" signs will be posted at 100-foot intervals along the site perimeter fencing. "Danger- Unauthorized Personnel Keep Out," will be posted at each entrance to the active portion of the BRC CAMU and additional locations as necessary. All signs will be posted in English and Spanish.

Additional signs and/or measures may be required to protect personnel and public health and safety.

3.0 OPERATING CRITERIA

This section presents operating criteria of the BRC CAMU and methodologies to be used to meet such criteria.

3.1 Health and Safety

All activities will be performed in accordance with a Health and Safety Plan(s) (HASP) developed for Site remediation activities by the contractor(s) selected for the project. These HASP(s) shall apply to the contractor's employees and subcontractors. The parameters and details that will be included in the HASP are described in the Accident Prevention, Contingency, and Emergency Response Plan. Briefly, the HASP shall include the following:

- Identification of chemical and physical hazards associated with the remediation activities;
- Minimum training requirements for site workers;
- Minimum Personal Protective Equipment (PPE) for site workers and visitors and criteria for upgrades;
- Air monitoring requirements for workers' breathing zone and site perimeter (for public protection);
- Emergency information, such as emergency telephone numbers and directions to the nearest hospital; and

- Administrative requirements, such as documentation of training, daily health and safety tailgate meetings, and documentation of air monitoring.

A sample Health and Safety Plan table of contents for the BRC CAMU and the Common Areas Remediation Project is included as Appendix D of the CAP.

3.2 Fire Prevention

Fire hazard at the BRC CAMU is expected to be minimal due to the type of material being landfilled. Explosive gases (e.g. methane) are not anticipated at the BRC CAMU because putrescible material will not be accepted at the BRC CAMU for disposal.

No open burning of wastes will be allowed at this site. Fire control protection will be provided by the utilization of on-site equipment such as a water truck, track type dozer and front-end loaders for wetting and smothering accidental fires. In addition, site-related operational vehicles will be equipped with fully functional fire extinguishers. Backup fire protection will be available from units of the Clark County Fire Department.

Site personnel will receive periodic on-the-job training in fire fighting practices conducted by the BRC CAMU Construction Manager and/or other authorized representatives.

3.3 Control of Windblown Material

Scattering of papers, plastic, or other debris by the wind will not be an issue at the BRC CAMU as such types of wastes will not be accepted. Dust control measures will be implemented to limit the amounts of wind-blown dust. Dust control will be accomplished via moisture management and synthetic covers, as required. Operations will cease during periods of high winds, consistent with Clark County requirements as provided in the Dust Control Plan Application included in the CAP.

3.4 Special Waste Disposal

The projected mix of wastes to be received from the service area is a by-product of industrial process fluids allowed to settle in various evaporation ponds. The resulting residual soil is the solid waste requiring disposal. No other special wastes are anticipated.

3.5 Control of Authorized and Unauthorized Waste

The source materials for the BRC CAMU include the residual solids (i.e., sediments and associated soils) from the industrial ponds, ditches, and related source areas. Municipal wastes will not be accepted from private individuals. Unlike typical landfills, both the source material and the BRC CAMU will be under sole control of BRC. Consequently, there will be control over the types of waste materials accepted at the BRC CAMU.

3.6 Disposal of Liquids

Liquids will not be disposed of at the BRC CAMU.

3.7 Control of Explosive Gas

Due to the nature of material to be placed in the landfill, generation of methane or other explosive gases is not anticipated. Controls for explosive gas are not required.

3.8 Disposal of Vegetation

Vegetation, if any, will be removed from excavation areas and access routes. Soil attached to plant roots will be shaken loose and left on the ground surface in the pond in which the vegetation was present, to be collected with the other soils in that pond. The vegetation will be relocated and temporarily stockpiled within the Debris Storage Area, as discussed in the CAP, where it will be tested to determine whether chemicals within the site soils have bioaccumulated within the vegetative matter at levels that would cause it to be unsuitable for disposal at a municipal landfill. In the event that vegetation meets disposal requirements in municipal landfills, they will be so disposed. In the event that contaminate levels dictate that they should be disposed in hazardous waste landfills, they will so be disposed. Vegetation grubbed during excavation will not be disposed in the BRC CAMU.

3.9 Compliance with State Implementation Plan

BRC will ensure that the BRC CAMU does not violate applicable requirements developed by the state implementation plan, if any, approved or adopted by the Administrator of the USEPA, pursuant to Section 110 of the Federal Clean Air Act, as amended (42 U.S.C. § 7410), and the regulations adopted pursuant thereto. As noted earlier, dust mitigation will be ensured by adherence to the Dust Mitigation Plan Application, Appendix C of the CAP. In addition, there will be no open burning of solid wastes at the BRC CAMU.

3.10 Putrescible Wastes and Vector Control

Due to the nature of material to be placed in the BRC CAMU, putrescible wastes and vector control issues do not apply.

3.11 Nuisance Control

The operation and maintenance of the BRC CAMU will be in a manner which will not create odors, unsightliness or other nuisances. There will be no ponded and stored water at the site; thus this source of obnoxious odors and vector breeding is obviated.

As necessary, water or other dust palliatives such as magnesium chloride will be applied to the landfill and its roads to minimize nuisance dust consistent with the Dust Mitigation Plan.

3.12 Disposition, Compaction, and Coverage

Since the waste to be disposed will be soil and sediment a daily cover will not be required to control disease vectors, fires, odors, blowing litter and scavenging. Instead, if operations cease for prolonged periods of time, which is not expected, an intermediate cover will be applied on an as-needed basis. Moisture will be added periodically as needed to reduce dust and particulates.

Solid wastes will be spread and compacted in layers. Waste will be offloaded from the haul vehicles, and spread by a tracked dozer in lifts with a maximum thickness of two feet. A landfill compactor or other suitable equipment will accomplish a sufficient number of passes over each lift in order to reduce voids and produce a compact mass.

The BRC CAMU will be operated to facilitate efficient placement of the waste material. At any given time, the compacted waste mass will be contoured to allow effective drainage in case of inclement (rainy) operations. Construction Sequence Plan, included in the Supplemental RAP Information, presents general steps of landfilling activities.

Horizontal and vertical control is necessary to ensure that the final grades and cell geometry are constructed as planned. The BRC CAMU will be filled to within two feet of the required final elevation. Elevation control for equipment operators at the landfill is achieved through the use of steel pipe grade poles installed in the fill area and marked with red rings against a yellow background at the fill level (two feet below the

final grade). The ring elevations are surveyed with respect to a BRC CAMU surveyed benchmark, which will be a concrete monument.

3.13 Miscellaneous Requirements for Operation

Scavenging through waste at the working face of the BRC CAMU by citizens or non-employees of the landfill operations will be prohibited and is not expected.

The working face area will be inspected daily and lightweight debris will be returned to the fill area and covered.

Provisions will be established concerning weighing and recording all solid waste delivered to the site. Specifically, a scale will be employed to weigh incoming hauling vehicles. The tare weight of each vehicle will be checked on a daily basis to establish the quantities of waste being placed in the BRC CAMU. In addition, topographic surveys will be performed on a quarterly basis to double-check and further quantify the volume of materials placed within the BRC CAMU.

3.14 Control of Erosion, Mud and Dust

An adequate amount of water from storm water or municipal well sources will be available at all times for the control of dust and the compaction of cover material.

Adequate measures will be taken to minimize the creation of dust and minimize safety hazards due to obscured visibility. Roadways will be sprayed with water and/or magnesium chloride to reduce dust generation. Dust control measures are described in detail in the Dust Mitigation Plan Application which is provided as Appendix C of the CAP.

Primary interior roadways will be surfaced with compacted crushed stone or gravel materials, as necessary. Ramps and unloading areas at designated interior disposal areas will be graded for proper drainage with earth-moving and grading equipment.

During periods of wet weather, such surfacing and maintenance practices will be eliminated, or at least minimized to reduce the tracking of mud off-site. During wet periods, the BRC CAMU Construction Manager or his/her designee will be responsible for a daily inspection of the main incoming road and will be responsible for the timely removal of any accumulated mud on that portion of the roadway within the immediate site vicinity. In addition, temporary shaker plates will be installed to minimize tracking of mud off site. Accumulated mud deposits remaining on interior haul road surfaces will be similarly removed as needed by light grading to control dust emissions resulting from normal traffic.

3.15 Run-on and Runoff Control Systems

BRC will provide a system to control run-on and runoff of surface water as outlined in the Technical Drainage Study for Eastside Landfill (PBS&J, 2006). The goal of the run-on system is to collect and control the flow of surface waters entering the BRC CAMU boundaries.

Runoff from the active portion of the BRC CAMU will be managed so as to not cause a discharge of pollutants, silts, or a nonpoint source of pollution from the BRC CAMU into the waters of the state or waters of the United States, including wetlands. Surface water runoff throughout the active portion of the site will be managed to minimize contact of water with solid waste.

Rainfall within the BRC CAMU will be drained away from the active working face. Such drainage will be maintained by constructing each disposal area bottom, or floor, on a uniform grade, with the working face progressing in a downslope direction.

Water coming into contact with the active working face, and thus retained within the BRC CAMU, will be evaporated or may be used for such on-site activities as waste compaction and dust control within the BRC CAMU lined areas. Water not coming into contact with the active working face and collected in the downslope portions of designated water disposal areas may be utilized for such site-related operations as dust control, waste compaction, windblown dust minimization, construction and compaction of disposal area liners, and maintenance of access roadways.

All interim surface water runoff and post closure runoff from the site and surrounding areas will be managed through a series of permanent perimeter drainage channels (Figure J-8). Natural drainage patterns or discharge quantities associated with the site and surrounding areas will not be significantly altered. Runoff will be periodically sampled and tested for general compliance with Nevada National Pollution Discharge Elimination System (NPDES) permit standards.

3.16 Leachate

During waste placement activities, the leachate will be removed from the sumps using portable submersible pumps and will be used for dust control on waste materials placed within the lined limits of the BRC CAMU. Leachate levels will be inspected weekly and after storm events.

3.17 Decontamination

The Contractor will inspect the equipment to confirm that the equipment arrives on the site in a clean state. If obvious indications of contamination are observed, the Contractor will refuse entrance of the equipment onto the site, or decontaminate the equipment before it is used subject to the approval of the Construction Manager. No personal vehicles, "lunch wagons" or other non-essential vehicles will be permitted within the area of active work where the potential to encounter waste may occur. Vehicular traffic will be kept to a minimum. To the extent practical, equipment will be stored when not in use in the location last used or the nearest safe location. Overnight staging in clean areas is not permitted unless the equipment is first decontaminated to prevent the potential for tracking contamination back and forth across the site.

The Contractor will operate the equipment in a manner that minimizes contact with waste, including minimizing the surface area contacting waste and minimizing the potential for spills, drips, splashes or sprays. Equipment, once decontaminated, will be stored in a designated clean area of the site, or preferably removed from the site as soon as practicable.

As described in the CAP, construction equipment decontamination is summarized as follows:

- Transport trucks will be driven across gravel track out aprons with scraping of mud and/or use of water spray to be performed at dedicated decontamination areas.
- Equipment heavily caked with soil and/or other material will be scraped off with a flat-bladed scraper. The scrapings will be placed in the soil staging area for disposal with the excavated soils.
- Equipment will be decontaminated using steam cleaning equipment prior to departure from the work site.

The dozer blades and tracks, and compactor wheels and drum will require decontamination only when removed from the surface of the waste. The frequency of decontamination will be a field decision based on the type of waste materials being encountered.

4.0 REMEDIATION

This section summarizes the excavation procedures, the methods for transporting soils to the BRC CAMU, and documentation which are discussed in detail in the CAP. The BRC CAMU has been sized to contain approximately 3.5 million cubic yards of material, which is significantly in excess of the volume of material calculated to

be disposed. However, in the event that impacted soils exceeding even this maximum BRC CAMU volume are generated, those excess soils will be dispose of off-site, at a properly-licensed facility.

4.1 Soil Excavation

A BRC contractor will complete the excavations in accordance with the plans and specifications developed for this work, under the direction of the BRC Construction Manager. Soil excavation will be performed as described in the CAP. The contractor will use appropriate construction equipment to excavate, load, and transport the materials to the BRC CAMU.

BRC anticipates that 7,500 cubic yards of soil will be excavated, transported, and interred, on average, each day, with the actual volume dependent on equipment used, daily conditions, and hours of operation.

4.2 Dewatering Procedures for TIMET Ponds

Currently, some of the TIMET Ponds contain material with moisture content higher than ideal, or comparably, higher than the excavated soils after dust suppression. Dewatering of these materials is necessary to decrease the moisture content to levels which will reduce the potential for leachate generation. BRC has conducted pilot testing for options to dewater the TIMET Ponds. Based on these studies, BRC may dewater the material in the ponds if needed using a combination of 1) air drying, and 2) draining of liquid through geotextile bag filters. However, BRC expects that moisture will be managed by mixing pond solids with other dry materials destined for the BRC CAMU.

4.3 Soil Transportation to BRC CAMU

To minimize effects on Boulder Highway traffic, remediation will occur during two distinct phases: during daylight hours, work will be restricted to the Eastside Area proper; during evening hours, the contaminated soils excavated during the day from the Eastside Area will be transported across Boulder Highway via the haulage road and then interred into the BRC CAMU.

Soils excavated from the Eastside area will be transported by truck to the BRC CAMU approximately 1.5 to 2 miles away as discussed in the CAP. While the soils to be transported are not hazardous waste, the haulers will possess a valid hazardous waste hauler license and will be certified to handle hazardous waste.

Trucks hauling waste materials from the Eastside Area will enter the BRC CAMU Area from the eastern site ingress/egress at 4th Street. Trucks will then travel

along site access roads adjacent to the BRC CAMU lined landfill area and enter into the BRC CAMU lined landfill area at dedicated access points or ramps. Upon entering the BRC CAMU lined landfill area, the trucks will travel directly on the operations layer above the liner system or above previously placed waste materials. Each truck will be directed to a "working face" where the contents of the truck will be dumped. Trucks will then travel off of the lined landfill area, across "rumble strips" and track-out aprons summarized in Section 3.17 and described in greater detail in the CAP. Water spray will be performed at dedicated decontamination areas as needed to minimize tracking waste materials off of the landfill. Trucks will exit the BRC CAMU Area at 4th Street.

Spillage of soils from trucks during transportation will be minimized by not overloading the transport vehicles, by grading smooth haul roads, and by employing trucks with enclosed or covered cargo bays. Dust will be controlled by water in accordance with the Dust Control and Mitigation Plan Application in Appendix C of the CAP. Because the access routes will be wetted to suppress dust, some mud will be generated, and it is likely that this mud would be transferred to truck tires and the vehicle body. When needed, prior to crossing Boulder Highway, the transport trucks will be decontaminated by scraping and/or water spray to avoid transfer of dirt to the pavement. In addition, after excavation/transport operation cease for a given day, the affected portion of Boulder Highway will be cleaned to remove soils from the roadway.

In the event of an accident resulting in release of the soils being transported, the truck driver will immediately contact the Construction Manager. The Construction Manager will immediately inspect the site of the accident and notify the local emergency management agencies. The potential for immediate threat to workers and people nearby will be evaluated, and the Construction Manager will instruct the remediation contractor to take appropriate corrective steps to rectify the problem. Any spilled material will be returned to the truck (or another truck, if the original truck is disabled) and transport to the BRC CAMU will be complete. If the spill occurred on a public roadway (i.e., Boulder Highway), the spilled material will be removed, and the road surface will be immediately vacuumed to remove remaining materials.

4.4 Soil Placement

The waste material at the working face will be spread by a bulldozer in a lift no greater than two feet in thickness and compacted using standard earthworks construction equipment. The compacted waste material will be tested using a nuclear moisture/density gauge to determine the estimated in-situ moisture content and density of the waste material. The moisture content will be compared to the optimum moisture content result from previously performed moisture/density laboratory testing. Ideally, the in-situ moisture content will be less than the optimum moisture content, thereby minimizing the potential for liquids to "squeeze out" of the waste material upon

placement of overlying materials that will increase the normal static pressure and thus the "squeezing" of the underlying waste material.

Periodically, undisturbed samples of the in situ waste materials will be collected using thin wall samplers (Shelby Tubes) and will be subjected to laboratory one-dimensional consolidation testing. The specifics of the consolidation testing are described in the CAP. If the results of testing indicate that the moisture content of the waste materials is too high, the material will be spread in a thin lift (e.g., 6-inches thick) to allow for evaporation of excess moisture or mixed with drier waste materials to achieve the desired moisture content.

5.0 REPORTING AND RECORDKEEPING

5.1 General

BRC will prepare daily progress reports documenting all daily activities. Daily activity records include, but are not limited to, documentation that evidences the quantity of waste materials placed in the BRC CAMU, truck weigh tickets, and log in/out forms. In addition to this summary daily report, the contractor will also keep detailed field notes and daily logs. Daily photographic and video record will be kept by BRC documenting all remediation activities. Records and results of daily, weekly, and monthly inspections will be maintained and kept onsite consistent with requirements specified in the AOC3.

Records and results of waste analysis and waste determinations will be maintained and kept on site. In addition, all monitoring, testing or analytical data, and corrective action records resulting from BRC CAMU releases shall be maintained onsite consistent with requirements specified in the AOC3. Groundwater monitoring and clean up records will be maintained until closure of the BRC CAMU.

Summary reports of all incidents that require the use of the Contingency Plan will contain the details outlined in Attachment G, Accident Prevention, Contingency, and Emergency Response Plan. The incident reports will be maintained and kept onsite until closure of the BRC CAMU.

Additional items to be included with the operating records are: closure and post-closure cost estimates, plans for closure and post-closure, EPA identification number, detailed chemical and physical analysis of a representative waste sample, Quality Control (QC) and Quality Assurance (QA) documentation.

5.2 Interim Status Reports

During remediation activities at the Site, BRC will submit monthly status reports to the NDEP as stated in the CAP. The purpose of the monthly status reports will be to keep the NDEP informed of the progress of remedial activities at the Site. The reports will present a summary of the remediation progress during the previous month, including as appropriate:

- Significant milestones in CAMU construction;
- Pond and ditch locations where excavation has been completed (including graphical format);
- Pond and ditch locations where special control measures (except dust control, which is routine measure) were necessary and/or where excavation had to be prematurely terminated due to the presence of ground water or based on any of the other "stopping rules" discussed in Figure J; and
- Estimates of volumes of soil excavated and placed in the CAMU (monthly and cumulative). Other information (e.g., discovery of significant environmental conditions previously unidentified) will be provided in the monthly status reports as warranted. Interim status meetings will also be conducted by telephone to supplement these written reports.

Other information (e.g., discovery of significant environmental conditions previously unidentified) will be provided in the monthly status reports as warranted or otherwise required by the AOC3. Interim status meetings will also be conducted by telephone to supplement these written reports.

6.0 REFERENCES

PBS&J, 2006. "Technical Drainage Study for Eastside Landfill," Henderson, Nevada, October.

Attachment N
CAMU (Landfill) Monitoring Plan

Attachment N
CAMU (Landfill) Monitoring Plan
Basic Remediation Company (BRC)
Corrective Action Management Unit (CAMU)
Henderson, Nevada

Table of Contents

1.0 Introduction N-1
2.0 Construction Monitoring N-1
2.1 Surface water N-1
2.2 Leachate N-1
2.3 Air Monitoring N-2
3.0 Post Closure N-2
3.1 General N-2
3.2 Final Cover N-2
3.3 Leachate N-3
3.4 Settlement N-4
3.5 Groundwater N-4
4.0 Reporting and Recordkeeping N-5
5.0 References N-5

1.0 INTRODUCTION

This BRC CAMU Monitoring Plan describes the procedures and activities that BRC will undertake to detect and subsequently characterize releases of wastes or hazardous constituents to groundwater that may occur from areas of the BRC CAMU during operation and after closure.

2.0 CONSTRUCTION MONITORING

2.1 Surface water

BRC will carefully maintain drainage to expedite storm water collection. A portable pump will be provided at the low end of the BRC CAMU to remove accumulated storm water. The operator will maintain access to this pump and maintain the pump in good working condition with a good supply of fuel and suction hoses in position for water removal at all appropriate times.

During operating hours, the operator will pump water from the working cell as quickly as possible whenever it accumulates. When heavy rainfalls occur during non-operating hours, standing water will be pumped out before normal operations resume.

Surface water exiting the site from the on-site storm water basin will periodically be sampled and tested for general compliance with Nevada surface water standards for the Las Vegas Wash. BRC will obtain necessary NPDES permits from the NDEP prior to discharge of such waters.

2.2 Leachate

The BRC CAMU will be managed to reduce the generation of leachate. However, leachate, if generated, will slowly accumulate in the leachate collection sumps designed as part of the BRC CAMU. The base grade of the BRC CAMU will be engineered so that leachate generated will accumulate at the designated leachate collection points. The operator will monitor the leachate level and remove and dispose of the leachate, as needed, consistent with proper waste disposal practices. During active waste placement, leachate collected from the sumps will be used for dust control and waste material moisture conditioning purposes over the lined areas only.

As stated in the Inspection Plan (Attachment E), leachate sumps will be monitored weekly and after storm events to confirm proper functioning of the leachate collection and removal system. The amount of leachate will be recorded and the average daily flow rate (gallons per acre per day) will be calculated.

In addition, pan lysimeters will be installed beneath the sump areas of the BRC CAMU to monitor for possible leakage from the liner system at the locations of the lowest elevations in the liner system (sumps), which is where leachate, if any, will accumulate.

2.3 Air Monitoring

Dust control measures and air monitoring will be implemented during the project to comply with the air quality regulations administered and enforced by the Clark County Department of Air Quality and Environmental Management. Air monitoring and sampling will be performed continuously during the project to assess the potential exposure of the general public. Air monitoring stations will be established daily at each soil management zone in the Eastside Area and at the BRC CAMU to measure upwind and downwind fugitive dust emissions as discussed in the CAP. Meteorological conditions will be monitored during the work to assist in determining the proper location of the monitoring stations. Air monitoring for respirable particulates will be performed using a direct-read instrument such as a DataRAM dust monitor. Additional details on air monitoring during the project are in Appendix B, Perimeter Air Monitoring Plan (PAMP) of the CAP.

3.0 POST CLOSURE

3.1 General

Formal periodic inspections will be performed using site walks. These site walks will be performed within one week of significant precipitation events (e.g., greater than ½ inch of rain during a 24-hour period) that could potentially impact either the surface water drainage system or the BRC CAMU cover. At a minimum, a site-wide inspection will be performed at least quarterly.

The condition of the facility will be documented with field notes, maps, and photographs, as appropriate. Evidence of potential compromises in the cover will be recorded including eroded patches, patches of dead vegetation, animal burrows, subsidence, and cracks along the cover. Surface water drainage features will be inspected for the presence of debris, physical integrity, and evidence of conditions that are different from design assumptions.

3.2 Final Cover

Final cover performance will be evaluated through a monitoring program of the final cover and periodic groundwater monitoring. The basis for this strategy is the

fact that the final cover will be the critical element to reduce moisture infiltration into the BRC CAMU. Therefore, it is proposed that monitoring efforts be focused on direct observation, measurement, and analysis of the performance of the final cover.

The final cover system shall be periodically monitored in order to evaluate the performance of the final cover. The final cover monitoring plan consists of:

- visual inspection of the final cover system performed on a semi-annual basis and after all major precipitation events; and
- if erosion has occurred, ascertain damage to the geosynthetics, if any, and repair as necessary in accordance with the Technical Specifications and CQA Plan.

The vegetation on the cover system will be visually inspected for signs of systemic or localized stress. Recommendations will be made regarding the need for nutrient enhancements or other measures to maintain the viability of the vegetative cover, such as the use of pesticides and/or fertilizer.

3.3 Leachate

The leachate collection system will be inspected quarterly and its levels recorded. If the liquid level in the sump stays below the pump operating level for two consecutive quarters, the amount of liquid in the sumps must be recorded at least semi-annually. If the liquid level in the sump stays below the pump operating level for two consecutive periods, the amount of liquids in the sumps must be recorded at least annually. If at any time during the CAMU post-closure care period the pump operating level is exceeded at units on semi-annual or annual recording schedules, BRC will return to quarterly recording of amounts of liquids removed from each sump until the liquid level again stays below the pump operating level for two consecutive quarters.

If leachate is measurable above the pump operating level, the liquid will be removed from the sump, sampled, and analyzed in an off-site laboratory for compounds detected in the waste materials (Waste Analysis Plan, Attachment C), and properly disposed off-site. If compounds not already found in the upgradient groundwater at the site are detected, groundwater monitoring will be performed, on an annual basis, to monitor for the specific constituent(s) detected in the leachate.

Because the proposed BRC CAMU is located in an arid environment receiving approximately 4.5 inches of average rainfall annually, with high rates of evaporation and low infiltration rates, it is unlikely that significant amounts of precipitation will be introduced to the BRC CAMU leachate collection and removal system. These factors will limit the generation of leachate. Moreover, the waste material

consists primarily of soil, which will be monitored for moisture content prior to placement into the landfill.

Pan lysimeters will be installed beneath the sumps to monitor leaks within the collection system. Pan lysimeters will be monitored at the same time as the leachate sumps.

3.4 Settlement

A topography survey using 1-foot contour intervals will be performed within 3 months after final closure of the CAMU to document baseline conditions in support of post-closure settlement evaluations. Although settlement is not expected to be a significant issue, this will provide a convenient mechanism to document the surface elevation. Excessive settlement can lead to depressions and ponding causing stress in the infiltration layer. When depressions are identified through the survey, they will immediately be filled with the appropriate cover material.

3.5 Groundwater

The groundwater at the site ranges from 30 to 60 feet bgs, as discussed in the Draft CAMU Area Conceptual Site Model (DBS&A, 2006). At a minimum, the BRC CAMU base liner is approximately 5 feet above the groundwater. Constituent release to the groundwater from the BRC CAMU, post-closure, is considered unlikely for the following reasons:

- The BRC CAMU will not receive liquid waste or waste containing free liquids;
- Waste materials within the BRC CAMU are relatively immobile;
- The BRC CAMU will be designed and operated to reduce liquid, precipitation, and other run-on and run-off; and
- The BRC CAMU will have both a base liner system, with a leachate collection and removal system, and final cover system.

It should be noted that releases, if any, into the upper aquifer are difficult to monitor because of the nature of the existing groundwater beneath the BRC CAMU. Most or all of the same constituents which will be present in the BRC CAMU are currently present in groundwater at the site. Constituents present in upgradient groundwater make differentiating potential releases from the BRC CAMU difficult or impossible. Nonetheless, groundwater monitoring will be conducted annually through completion of post-closure activities. The list of analytes for such groundwater monitoring will be established based on discussions with the NDEP and will include constituents present in leachate (if any) in the leachate collection and removal system.

Groundwater monitoring will be conducted for a period of at least 30 years from the date of substantial completion of the final closure construction. Analytical results will be compared with historical results and with upgradient and downgradient groundwater results to monitor for anomalies indicating a release from the BRC CAMU.

4.0 REPORTING AND RECORDKEEPING

Monitoring results will be maintained by BRC in accordance with the provisions of the AOC3 following closure of the CAMU. Monitoring results will be summarized and submitted to NDEP with the annual post-closure report of inspection and monitoring activities.

5.0 REFERENCES

DBS&A, 2006. Draft Conceptual Site Model of the Common Areas. Henderson, Nevada, October.

Attachment O
CAMU (Landfill) Closure and Post-Closure Plan

Attachment O
CAMU (Landfill) Closure and Post-Closure Plan
Basic Remediation Company (BRC)
Corrective Action Management Unit (CAMU)
Henderson, Nevada

Table of Contents

1.0 Introduction O-1
1.1 Notice of Intent to Close O-1
1.2 Construction Schedule and Sequence O-1
1.2.1 Final Waste Placement O-1
1.2.2 Infiltration Layer Construction O-2
1.2.3 Final Cover Construction O-2
2.0 Final Cover Components O-2
2.1 Infiltration Layer O-3
2.2 Protection Layer O-4
2.3 Surface Water Drainage System O-5
2.4 Performance Evaluation of the Final Cover O-5
3.0 Summary of Cover Analysis O-5
3.1 General O-5
3.2 Slope Stability Evaluation - Final Waste Slopes O-6
3.3 Comparison of Flow between a CCL and GCL O-6
3.4 Geocomposite and Pipe Size Calculations O-6
3.5 Veneer Stability O-7
3.6 Cover Liner Sloughing Stability O-7
3.7 Geotextile Filtration Requirements O-7
3.8 Geotextile Puncture Protection O-8
3.9 Pipe Strength Calculations O-8
3.10 Seismic Performance Evaluation O-8
3.10.1 General O-8
3.10.2 Seismic Hazard Evaluation O-9
3.10.3 Evaluation of Design Ground Motions O-9
3.10.4 Site Response Analyses O-9
3.10.5 Site-Specific Seismic Deformation Charts O-10

3.10.6 Deformation Analyses O-10
4.0 Cover Construction Requirements O-10
4.1 General O-10
4.2 Slope Stability Evaluation O-11
4.3 Geocomposite Requirements O-11
4.4 Drainage Pipe Requirements O-11
4.5 Final Cover Soil O-11
4.6 Equipment Loadings O-11
4.7 Geotextile Requirements O-12
4.8 Geosynthetic Clay Liner (GCL) O-12
4.9 Geomembrane Requirements O-12
4.10 Prepared Subgrade Requirements O-12
4.11 Final Cover Surface Treatment O-12
5.0 CAMU Post-Closure Plan O-13
5.1 Requirements After Closure O-13
5.2 Program for Postclosure O-13
5.3 Land Use O-14
5.4 Personnel O-14
5.5 Security O-15
5.6 Operation and Maintenance O-15
5.7 Post-Closure Inspections and Monitoring O-15
5.8 Reports and Recordkeeping O-16
6.0 References O-16

List of Details

Detail O-1 – Final Cover System

List of Tables

Table O-1 – Geotextile Puncture Protection

1.0 INTRODUCTION

This section of the permit application addresses the closure of the BRC CAMU, which will occur when disposal operations are complete. This Closure Plan addresses pertinent regulatory requirements, including a description of the final cover. It is anticipated that a final CAMU Closure Plan will be prepared approximately six months prior to closure. By that time, additional details regarding BRC CAMU volume will be available. For purposes of this permit application, the Closure Plan addresses activities that will occur when waste placement activities are complete.

Access to the BRC CAMU will be controlled during the closure phase using procedures employed during the operational phase (see Security Plan, Attachment D). Fugitive dust control measures will be maintained and traffic management procedures continued. Site aesthetics will continue to be an important element during this phase. Community outreach programs will be continued as part of the overall remediation effort (as discussed in the Community Involvement Plan) to address public concerns and issues associated with the BRC CAMU.

1.1 Notice of Intent to Close

At least 60 days before beginning the closure of the BRC CAMU, the NDEP will be notified in writing of the intent to close. BRC CAMU closure activities will begin no later than 30 days after the date on which the final receipt of wastes occurs.

All closure activities will be completed in accordance with this CAMU Closure Plan within 180 days after the beginning of the closure. An extension beyond this 180-day deadline may be requested if it is determined that additional time is needed and all actions are taken necessary to prevent threats to public health and safety and the environment.

A request for an extension to these deadlines will include a description of the measures needed to control access to the unclosed unit prior to closure or receipt of additional wastes. It would also include a description of activities to prevent threats to public health and safety and the environment from the open unit.

1.2 Construction Schedule and Sequence

1.2.1 Final Waste Placement

After receipt of the final waste, either construction of the final cover will begin or an interim cover will be placed. If the unit is going to be left without the final

cover for longer than 30 days, the interim cover layer will be placed and compacted on top of the final waste layer.

1.2.2 Infiltration Layer Construction

Prior to final cover construction, the interim cover layer, if installed, will be removed. The infiltration layer will be placed beginning with the geosynthetic clay liner (GCL). The geomembrane is placed above the GCL with the geocomposite placed last. Details of each layer are discussed in later sections.

1.2.3 Final Cover Construction

The soil materials for the final cover will be placed, compacted, and graded. The permanent storm drain facilities (gutters, ditches, culverts, headwalls, etc.) will be installed as the cover is being completed.

2.0 FINAL COVER COMPONENTS

The final cover is designed to minimize infiltration and erosion. A final cover that reduces infiltration is an essential component in the overall design strategy for the BRC CAMU. This, combined with adequate moisture control of the wastes prior to placement, should ensure that no leachate is formed.

Specific design objectives of the final cover system include:

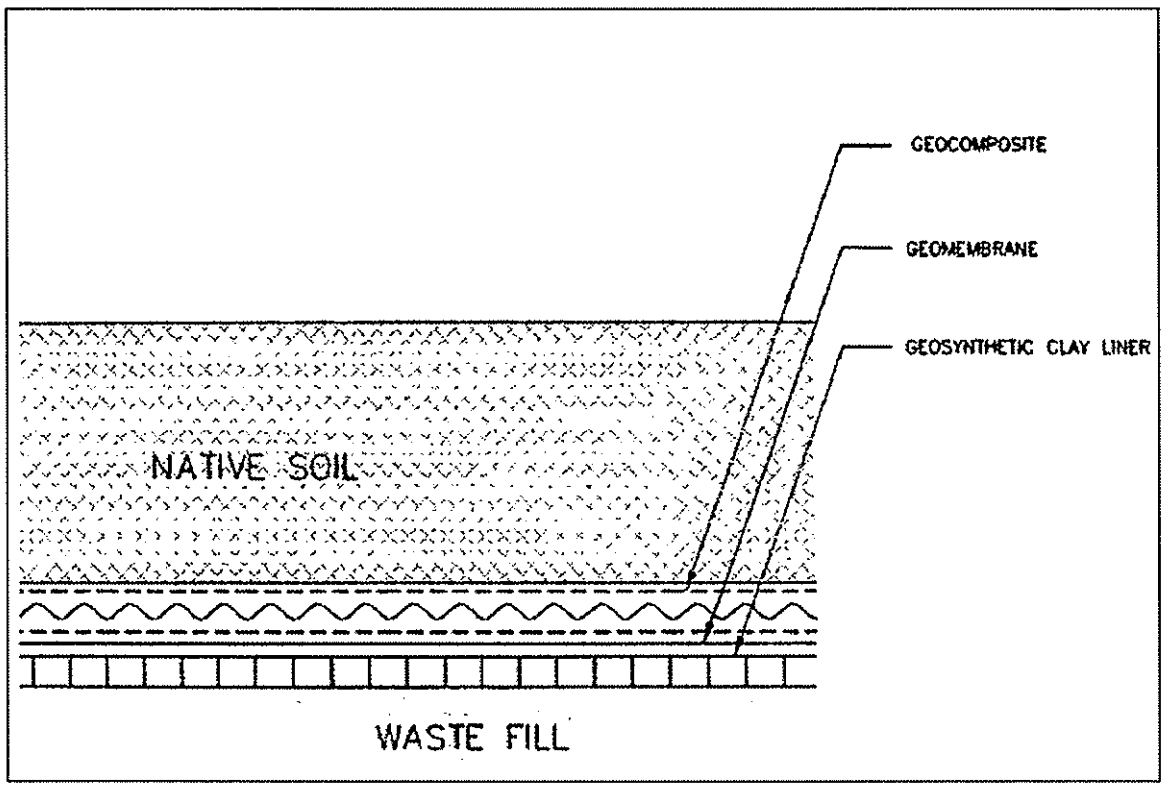
- Minimize infiltration of precipitation into the waste;
- Promote good surface drainage;
- Resist erosion by rain and wind;
- Protect human health and the environment;
- Improve aesthetics;
- Reduce long-term maintenance; and
- Be consistent with land use.

Several of these objectives are directly related to regulatory requirements while the others represent design considerations. BRC CAMU closure technology, design, and maintenance procedures continue to evolve, and it is possible that the cover design for the BRC CAMU may be refined prior to final closure to incorporate the latest design procedures. Modifications or enhancements to this proposed design would be submitted to the NDEP for approval prior to implementation.

Infiltration through the final cover will be minimized through:

- Design of adequate surface drainage and runoff with minimal erosion;
- Transpiration of water by native plants in the root zone, if present; and
- Design of composite barrier system (HDPE geomembrane over GCL) with an overlying drainage layer (geocomposite) to minimize hydrostatic head build-up on the geomembrane.

The final cover will consist of a separate infiltration and erosion layer. Engineering design calculations and construction specifications for the final cover system are presented within Sections 5, 6, and 7 of the Supplemental RAP Information (SRAPI). A cross section of the Final Cover System is shown in Detail O-1 below with an explanation of the components explained in the following sections.



Detail O- 1, Final Cover System

2.1 Infiltration Layer

40 CFR 264.310 specifies that the final cover be designed and constructed to have a permeability less than or equal to the permeability of any bottom liner system. Based on the proposed base liner system, construction of this type of cover will involve the use of a geomembrane and GCL composite liner system to serve as the infiltration layer as shown in Detail O-1 above.

The cover system will be designed to be physically stable to reduce failure, such as sliding between cover layers or within the waste.

Settlement is not expected to be a significant issue given the nature of the waste material and the manner of its placement (i.e. well compacted). Excessive settlement and subsidence at MSW landfills, caused by decomposition and consolidation of the wastes, can impair the integrity of the final cover system. Specifically, it can contribute to ponding of surface water on the cover and fracturing of the low-permeability layers of the cover. However, because the source materials for this BRC CAMU consist primarily of soil materials, the waste placement will be fairly homogeneous with little potential for significant differential settlement. Moreover, the soils will be compacted after placement.

The methods, procedures, and processes used to install the final cover system will be consistent with standard industry practices. Detailed design documents and construction specifications are included in Section 7 of the SRAPI. Included in the CQA plan is a description of quality control testing procedures for the construction materials and associated quality assurance procedures for construction activities. An independent registered professional engineer will be hired to observe closure activities and provide necessary certifications.

2.2 Protection Layer

Protection of the infiltration layer will be accomplished by the use of a 24-inch thick layer consisting of earthen material or an aggregate material (base course). The source for erosion layer soils will be native, clean soil. It is expected to be from the vicinity of the BRC CAMU or from elsewhere in the BMI Common Areas. The earthen material used for the erosion layer will be free of debris, cobbles, rubbish, and roots. If the CAMU materials are used, then they will not be exposed to the atmosphere and will be covered with additional clean materials procured from outside the CAMU area.

The erosion layer will be designed to be geotechnically stable to reduce failure, such as sloughing of the soils overlying the geomembrane/GCL composite infiltration layer (Section 2, Calculation Package I in the SRAPI).

The surface of the erosion layer will have a minimum slope of 2 percent to facilitate run-off while reducing erosion. The side slopes will have a 3H:1V (Horizontal:Vertical) slope. The final grading plan is shown on Figure J-9 in the SRAPI.

2.3 Surface Water Drainage System

A surface water drainage system, designed by PBS&J, will be constructed to convey runoff around and away from waste disposal areas. Surface water will be conveyed around the BRC CAMU to two retention basins located at the northeast and northwest corners of the site. The water will be conveyed by concrete channels and pipes as shown on Figure J-8. The channel and pipe locations correspond to the locations of the access roads for the BRC CAMU. Surface water from the top deck will be conveyed to the conveyance channels via two rip-rap lined channels in the northeast and northwest corners. Drainage channels are designed along existing natural features to enhance surface runoff during high-precipitation events. Based on a 25-year storm event, the design will be sufficient to control erosion and maintain the stability of the slope (PBS&J, 2006).

2.4 Performance Evaluation of the Final Cover

The design of the final cover was evaluated using the Hydrologic Evaluation of Landfill Performance (HELP) model, which was developed by the U.S. Army Corps of Engineers for the USEPA and is widely used for evaluating the hydraulic performance of landfill cover systems (USEPA, 1993). The HELP model calculates daily, average, and worst-case estimates of water movement across, into, through, and out of landfills. The input parameters for the model include soil properties, precipitation and other climatological data, vegetation type, and landfill design information. Useful information provided by the HELP model includes surface run-off, duration, and quantity of water storage within the erosion layer, and net infiltration through the cover system. The information is used for performance evaluation of the geocomposite and drainage pipe sizing, as described in Section 3.4 below.

Site-specific input parameters were used in the HELP model and are documented in Section 5, Calculation Package A in the SRAPI. The results indicated that the net infiltration through the cover system would be 0.000002 in/year.

3.0 SUMMARY OF COVER ANALYSIS

3.1 General

This section summarizes the results of design analyses that were performed for the final cover at the BRC CAMU Landfill site. The following calculations were performed and are located in the respective Calculation Package found in Section 5 unless otherwise noted of the SRAPI:

- Slope Stability Evaluation - Final Waste Slopes (Section 2, Calculation Package B);
- Comparison of Flow between a compacted clay liner (CCL) and geosynthetic clay liner (GCL) (Section 2, Calculation Package I);
- Drainage Geocomposite and Pipe Size Calculations (Calculation Package A);
- Veneer Stability Calculations (Calculation Package B);
- Cover Soil Sloughing Stability Calculations (Calculation Package C);
- Geotextile Filtration Calculations (Calculation Package D);
- Geotextile Puncture Protection Calculations(Calculation Package E);
- Pipe Strength Calculations (Calculation Package F); and
- Seismic Performance Evaluation (Calculation Package G).

The final cover system calculations are based on the conceptual design grading plans shown on Figure J-9 in Section 1 of the SRAPI. Additional calculations and/or design modifications may have to be performed if there are changes to elevation and grade in the aforementioned design grading plans.

3.2 Slope Stability Evaluation - Final Waste Slopes

GeoSyntec analyzed the stability of the final waste slopes for the BRC CAMU as discussed in Attachment J. The slope stability analysis is included in Section 2, Calculation Package B of the SRAPI.

3.3 Comparison of Flow between a CCL and GCL

GeoSyntec demonstrated that the flow rate through the prescriptive composite liner system (i.e. - CCL) is greater than the flow rate through the alternative composite liner system (i.e. - GCL), as discussed in Attachment J. The comparison of flow between a CCL and GCL is presented in the SRAPI, Section 2, Calculation Package I.

3.4 Geocomposite and Pipe Size Calculations

A geocomposite will be placed above the geomembrane to collect and drain surface water that has infiltrated through the cover soil. Drainage pipes will be placed in the final cover to collect water from the geocomposite and drain the water to the perimeter surface water collection channels. Analyses were performed to model infiltration using U.S. Environmental Protection Agency's (USEPA) Hydrologic Evaluation of Landfill Performance (HELP) model. For the calculations presented in this section, it is assumed that irrigation of the final cover will occur in the future. Irrigation rates were estimated based on conversations with Mesquite Country Club and Canyon South Golf Course in Palm Springs, California. GeoSyntec assumed that these operating

golf courses would represent future irrigation rates in the similar climate of Henderson, Nevada. Based on these conversations, the irrigation rates used for the HELP analyses were assumed to be approximately 0.11-in. per day in the winter, fall, and spring, and 0.24-in. per day in the summer. In addition, GeoSyntec assumed a 3-in rainfall event occurred at the end of the simulation year.

Based on these irrigation rates, the head on the cover liner was evaluated to be less than 12-in. at the top deck area, and negligible (i.e., less than 1/10-inch) on the side slopes. Furthermore, the calculations suggest that a 6-in diameter perforated corrugated polyethylene (CPE) pipe bedded in drainage aggregate will accommodate the maximum flow predicted by HELP model analyses. The 6-in. diameter perforated CPE pipe shall have a smooth interior wall to maximize pipe efficiency. Geocomposite and drainage pipe size calculations are presented in the SRAPI, Section 5, Calculation Package A.

3.5 Veneer Stability

The design criteria for the side slope liner system is to develop zero tension in the geosynthetics during installation of the final cover on the side slopes. Potential causes of tension in the liner system include construction equipment loading and overburden stresses (e.g., final cover materials). Based on the proposed grades and expected construction conditions, the calculations suggest that the side slope liner system will not be placed into tension provided a minimum interface friction angle of 20 degrees is maintained. Veneer stability calculations are presented in the SRAPI, Section 5, Calculation Package B.

3.6 Cover Liner Sloughing Stability

Based on the geocomposite and pipe size calculation results, no head buildup is expected above the side slope final cover system geosynthetic components. Calculations suggest that the minimum cover soil shear strength (interface with geocomposite or internal) of 27 degrees will meet the design factor of safety criteria of 1.5. the yield acceleration was found to be 0.15g ($g = 32.2$ ft/s^2). Cover liner sloughing calculations are presented in the SRAPI, Section 5, Calculation Package C.

3.7 Geotextile Filtration Requirements

A separation/filtration geotextile will be used in the following applications: (i) a component of the geocomposite for the final cover system, and (ii) separation/filtration between the cover soil and drainage aggregate. The purpose of the separation/filtration geotextile is to limit migration of fine material from the cover soil into the geocomposite and drainage aggregate, thereby reducing the transmissivity and hydraulic conductivity of the respective materials. The calculations suggest that the

separation/filtration geotextile have an apparent opening size (AOS) less than sieve No. 70, a permittivity greater than 0.5 sec^{-1}, and sufficient mechanical strength properties. Geotextile separation/filtration calculations are presented in the SRAPI, Section 5, Calculation Package D.

3.8 Geotextile Puncture Protection

The geocomposite and geosynthetic clay liner (GCL) will protect the geomembrane from puncture by particles from the prepared subgrade and cover soil. The geotextile components of the drainage geocomposite will protect the geomembrane from puncture by oversized particles in the cover soil. The geotextile components of the GCL will protect the geomembrane from puncture by particles from the prepared subgrade. For the design loading condition, GeoSyntec conservatively assumed an H-20 haul truck tire loading which exhibits a very high force related to hauling equipment. The analysis suggests that the following maximum particle sizes and geotextile mass per unit areas will be required:

Soil Component of Liner	Maximum Particle Size	Minimum Mass per Unit Area
Prepared Subgrade	1.5-in.	9 oz./yd^2 (GCL)
Cover Soil	1-in.	6 oz./yd^2 (single-sided geocomposite)

Table O-1, Geotextile Puncture Protection

Geotextile puncture protection calculations are presented in the SRAPI, Section 5, Calculation Package E.

3.9 Pipe Strength Calculations

Based on drainage pipe size analyses, a 6-in. diameter perforated CPE pipe will be used to collect and transport surface water that has infiltrated through the final cover soil into the geocomposite on the top deck area of the landfill. Based on the calculations performed for the 6-in. diameter perforated CPE pipe, the pipe has adequate strength to withstand equipment (i.e., H-20 haul truck) and soil overburden loads. Pipe strength calculations are presented in the SRAPI, Section 5, Calculation Package F.

3.10 Seismic Performance Evaluation

3.10.1 General

GeoSyntec performed an evaluation of the seismic performance of the BRC CAMU. The evaluation included a seismic hazard evaluation, site response analyses, development of site-specific deformation charts, and seismic deformation analyses for the final cover and base liner of the proposed BRC CAMU.

3.10.2 Seismic Hazard Evaluation

GeoSyntec evaluated the seismic hazard at the site using the most recent United States Geological Survey (USGS) probabilistic seismic hazard maps (Frankel et al., 1996). For compliance with the State of Nevada regulations, GeoSyntec considered motions with 2 percent probability of being exceeded in 50 years for use in design. The USGS data was used to establish the design free-field peak horizontal ground acceleration (PHGA) and set limits on the target acceleration response spectrum for design ground motions. The 2 percent probability of exceedence in 50 years USGS map values indicate that the free-field bedrock PHGA at the site equals 0.34 g from USGS. Based on the deaggregated hazard for Las Vegas, this PHGA was assigned a representative moment magnitude (M_w) of 6.5. The seismic hazard evaluation is presented in the SRAPI, Section 5, Calculation Package G.

3.10.3 Evaluation of Design Ground Motions

A suite of acceleration time histories considered representative of the 2 percent in 50 year ground motions evaluated in the seismic hazard analysis was selected for use in the seismic response analyses. GeoSyntec selected a suite of three time histories that enveloped the target response spectrum using the following methodology: (i) screen the database of acceleration time histories on the basis of earthquake magnitude to select a reduced set of accelerograms; and (ii) plot the acceleration response spectra of the candidate accelerograms against the target acceleration response spectrum and select the representative accelerograms for use in design analyses. Using the above methodology, GeoSyntec selected three candidate accelerograms to represent design ground motions at the BRC CAMU site: (i) the Parkfield earthquake, M_w 6.3, (ii) the Superstition Mountain earthquake, M_w 6.5, and (iii) the Big Bear Lake earthquake, M_w 6.7. Evaluation of the design seismic ground motions are presented in the SRAPI, Section 5, Calculation Package G-1.

3.10.4 Site Response Analyses

One-dimensional site response analyses were performed for the BRC CAMU using the computer program SHAKE91 (Idriss et al., 1992). Analyses were performed for two conditions; (i) 30-ft of contaminated soil placed on the ground surface (i.e., the North Mesa), and (ii) 60-ft of contaminated soil placed 30-ft below grade (i.e., the South Mesa). Shear wave velocity and layer thickness data for the native soil was derived from spectral-analysis of surface waves (SASW) testing performed at the site by Dr. Barbara Luke at the University of Nevada at Las Vegas. Since the depth to bedrock is not known, the thickness to bedrock was varied to evaluate the effect of depth to bedrock on the results of the analysis. The calculated accelerations are all less than 0.50 g and generally

decrease with increasing depth to bedrock. Site response analyses results are presented in the SRAPI, Section 5, Calculation Package G-2.

3.10.5 Site-Specific Seismic Deformation Charts

The site-specific deformation charts were developed using the computer program YSLIP_PM (Yan et al., 1996). YSLIP_PM is based upon the Newmark (Newmark, 1965) method for seismic deformation analysis. YSLIP_PM uses the yield acceleration of the slope (e.g., liner system or final cover system) and the output of the seismic site response analysis to compute seismic deformations. The results indicate that the largest seismic displacement response is calculated by applying the Parkfield earthquake record. The site-specific seismic deformation charts are presented in the SRAPI, Section 5, Calculation Package G-3.

3.10.6 Deformation Analyses

GeoSyntec evaluated the expected seismically-induced permanent deformations at the BRC CAMU. The calculations suggest that the calculated seismically-induced permanent deformations are less than 3-in. for the final cover and less than 6-in. for the base liner. These deformations are less than current generally accepted limits for the final cover and for the base liner. Therefore, the seismic performance of the waste containment system proposed for the BRC CAMU is considered to meet current design standards. The site-specific seismic deformation calculations are presented in the SRAPI, Section 5, Calculation Package G-4.

4.0 COVER CONSTRUCTION REQUIREMENTS

4.1 General

This section describes the construction requirements for installation of the final cover system at the BRC CAMU. These construction requirements are necessary in order to ensure that the construction of the final cover system is consistent with the design performance goals and assumptions.

Technical Specifications and a Construction Quality Assurance (CQA) plan have been prepared for the construction of the final cover system that incorporates the construction requirements presented in this section. GeoSyntec's proposed CQA Plan and Technical Specifications related to the final cover system are presented in the SRAPI, Section 6 and 7, respectively.

4.2 Slope Stability Evaluation

Final cover and interim waste soil slopes shall be constructed no steeper than a slope inclination of 3:1 (horizontal:vertical).

4.3 Geocomposite Requirements

A geocomposite will be used to collect infiltration of surface water through the cover soil. The geocomposite shall have the following properties:

- transmissivity no less than 1×10^{-3} under a confining pressure of 2,000 psf and a hydraulic gradient of 0.10.
- an 6 oz/yd^2 nonwoven geotextile bonded to each side of the geonet for the side slopes (i.e., double-sided) and one 6 oz/yd^2 nonwoven geotextile bonded to the top side of the geonet for the top deck (i.e., single-sided); and
- the 6 oz/yd^2 nonwoven geotextile shall have sufficient permittivity and mechanical properties as summarized in Section 3.7.

4.4 Drainage Pipe Requirements

The drainage pipes used to collect water from the geocomposite shall be 6-in. diameter perforated CPE pipe with a smooth interior wall. The drainage pipes shall be backfilled with aggregate. The aggregate shall have a maximum particle size of 1-inch and a minimum hydraulic conductivity of 1×10^{-2} cm/sec.

4.5 Final Cover Soil

The cover soil shall be placed from the bottom-up, using equipment exerting a ground pressure no greater than 10 psi. Cover soil shall be compacted to minimum of 90 percent of the maximum dry density determined by ASTM D 1557 and have a maximum particle size of 1-in. diameter. Surface water control and drainage shall be promoted.

4.6 Equipment Loadings

Equipment loads shall be limited to a maximum loading of 10 psi overlying a minimum of 1 ft of cover soil. In addition, roads for haul trucks shall be a minimum of 2 ft in thickness overlying the final cover system geosynthetic components.

4.7 Geotextile Requirements

A geocomposite consisting of either one or two geotextile components of the final cover liner system is proposed. The geotextiles will serve a dual purpose - separation/filtration and cushion protection. The geotextile shall have the following properties:

Matrix	Nonwoven
Mass per Unit Area	6 oz/yd^2
Apparent Opening	≤ Sieve No. 70
Permittivity	≥ 0.5 sec-1
Grab Strength	≥ 130 lb
Puncture Strength	≥ 40 lb
Mullen Burst	≥ 210 psi
Trapezoidal Tear	≥ 40 lb
Ultraviolet strength retention	≥ 70%

4.8 Geosynthetic Clay Liner (GCL)

The GCL component of the final cover system shall have the following properties:

- Index flux not greater than 1 x 10^{-8} m^3/m^2-sec;
- Minimum interface/internal shear strength of 20 degrees;
- The GCL shall be dry during installation; and
- combined geotextile mass per unit area of 9 oz./yd^2.

4.9 Geomembrane Requirements

The geomembrane shall be HDPE and have a nominal thickness of 60-mil. The geomembrane shall be double-sided textured on the side slopes and may be smooth on the top deck.

4.10 Prepared Subgrade Requirements

The prepared subgrade shall have a maximum exposed particle diameter less than 1.5-inch.

4.11 Final Cover Surface Treatment

The final cover will require surface treatment to reduce surface erosion due to rainfall or wind forces. There are a wide variety of possible surface treatments to reduce

erosion. For example, cobbles or rip rap can be placed on the outer slope surfaces, aggregate base or crusher-run rock can be applied to flatter surfaces such as the top deck or roadways, and some areas can be treated chemically to bind the soil together. Side slopes typically require a different treatment than the top deck or roadways. The final selection of materials and treatment will be performed prior to commencing closure activities and will be consistent with the NDEP's guidelines for erosion mitigation.

5.0 CAMU POST-CLOSURE PLAN

This section of the permit application addresses post-closure activities for the BRC CAMU, which commence after final closure is completed and extends for a period of 30 years therefrom. This preliminary Post-Closure Plan provides a description of procedures that will be used to maintain the integrity of the final cover system. It is anticipated that the Post-Closure Plan will be updated prior to completing closure activities.

5.1 Requirements After Closure

After closure of the BRC CAMU, a notation on the landfill property deed, or any other instrument that is normally examined during a title search, will be recorded in Clark County. The notation on the deed, or other instrument, will in perpetuity notify any potential purchaser of the property that the land has been used as a landfill and that its use is restricted to uses that would not negatively affect the integrity of the landfill.

Permission may be requested in the future from Clark County to remove the notation from the deed, or other instrument, if all wastes are removed from the site. Any request would document that all wastes have been removed from the facility. Such documentation might include photographs, soil testing in the area where the wastes were deposited, and reports of waste removal activity.

5.2 Program for Postclosure

After closure of the BRC CAMU, a program for post-closure will be conducted as stipulated by the AOC3. This post-closure program will ensure that the integrity and effectiveness of the final cover will be maintained, including making repairs to the cover as necessary to correct the effects of settlement, subsidence, erosion or other events.

Following closure of the CAMU, certification will be submitted to the NDEP verifying closure. This will be signed by an independent Nevada registered professional engineer and will verify that the program was completed in accordance with the CAMU Closure Plan. The certification will be placed in the operating record. The certification

will be based on knowledge of the Closure Plan, observations made during closure, and documentation of closure activities.

Post-closure use of the property will be managed to not disturb the integrity of the final cover, liner or other components of the BRC CAMU (e.g., surface water drainage network, infiltration monitoring system, etc.).

5.3 Land Use

The post-closure use of the BRC CAMU site is to maintain it as open space containing a variety of native vegetation. Access to the site will continue to be restricted. This type of land use will reduce the likelihood that the final cover is inadvertently compromised due to incompatible development. It is anticipated that this land use will be maintained beyond the 30-year required post-closure monitoring duration. However, no land use will be allowed that would compromise the integrity of the final cover system, the liner system, or other components of the containment or monitoring systems.

A precise, metes-and-bounds survey of the closed BRC CAMU will be conducted and the resulting map recorded with the clerk of Clark County. The recordation will include a notation that the property is a Corrective Action Management Unit and contains remediation waste.

5.4 Personnel

Post-closure care personnel will have received adequate training in their specific job duties. This includes applicable OSHA health-and-safety training as well as pertinent training in BRC CAMU maintenance procedures. This staff will consist of a facility manager and various staff workers as needed. The name, address, and telephone number of the facility manager will be provided to the NDEP during the closure process.

Specific duties of these staff will include:

- Limiting access to the site and providing security;
- Performance of routine operations and maintenance activities;
- Responding to public or community inquiries;
- Ensuring regulatory compliance and maintaining appropriate documentation;
- Managing and coordinating post-closure monitoring (i.e., the leachate collection system); and
- Maintenance of the vegetative cover, if necessary.

5.5 Security

The perimeter fencing will remain after closure of the BRC CAMU. Security personnel will not be required 24-hrs because the waste will not be exposed nor will access by the public or domestic livestock pose a health hazard. The perimeter fence will be maintained to deter trespassing. The periodic site inspection walks to assess the cover system will include an evaluation of the perimeter fence.

5.6 Operation and Maintenance

Routine maintenance will be required to maintain the effectiveness of the various BRC CAMU sub-systems. This will include periodic maintenance, and repairs of the final cover, the surface water drainage system, the leachate collection system, and the vegetative cover.

Routine operations and maintenance activities will include frequent inspections of the BRC CAMU. Particular attention will be given to any conditions that could compromise the integrity of the final cover or the associated surface water drainage system or the soil moisture monitoring system. Normal erosion processes are expected to result in the need to periodically replace some cover material and to fill depressions caused by settlement. Extensive maintenance of the vegetative layer is not anticipated since it is being designed to be tolerant of the low rainfall and large temperature extremes in Las Vegas. Occasional fertilizing, if vegetated, may be needed, especially during the first few years after closure.

5.7 Post-Closure Inspections and Monitoring

Post-closure monitoring will be performed as outlined in Attachment N, Landfill (CAMU) Monitoring Plan. In summary, the final cover, leachate, settlement, and groundwater monitoring will be performed for a period of 30 years after closure of the BRC CAMU. Formal periodic inspections will be performed using site walks. These site walks will be performed within one week of significant precipitation events (e.g., greater than ½ inch of rain during a 24-hour period) that could potentially impact either the surface water drainage system or the BRC CAMU cover. At a minimum, a site-wide inspection will be performed at least bi-annually.

At least annually, an internal audit will be performed to verify that all activities at the site have been performed in accordance with the provisions of this Post-Closure Plan. Inspection records will kept and maintained in a log book in order to clearly document any changes in physical conditions. Copies of the inspection report will be provided to the NDEP annually. Post-closure inspections will occur for at least 30 years after BRC CAMU closure.

5.8 Reports and Recordkeeping

The condition of the facility will be documented with field notes, maps, and photographs, as appropriate. Evidence of potential compromises in the cover will be recorded including eroded patches, patches of dead vegetation, extensive or significant animal burrows, subsidence, and cracks along the cover. Surface water drainage features will be inspected for the presence of debris, physical integrity, and evidence of conditions that exceeded design assumptions.

A copy of the plans for closure and post-closure will be maintained in the operating records of the site.

6.0 REFERENCES

Frankel, F., Mueller, C., Bernhard, T., Perkins, D., Leyendecker, Dickman, N., Hanson, S., and Hopper, M., 1996. "Interim National Hazard Maps: Documentation," *Draft Report*, U.S. Geological Survey, Denver, Colorado.

Idriss, I.M., Sun, J.I., 1992."Users Manual for SHAKE91, A Computer Program for Conducting Equivalent Liner Seismic Response Analysis of Horizontally Layered Soil Deposits," Center for geotechnical Modeling, Department of Civil and Environmental Engineering, University of California, Davis, California, November.

Newmark, N.M., 1965. "Effects of Earthquakes on Dams and Embankments," Geotechnique, Vol. 15, No. 2, pp. 139-160.

PBS&J, 2006. "Technical Drainage Study for Eastside Landfill," Henderson, Nevada, October.

USEPA, 1993. "Solid Waste Disposal Facility Criteria, Technical Manual." EPA530-R-93-017. Soild Waste and Emergency Response, November.

Yan, L., Matasovic, N., and Kavazanjian, E.,1996. "YSLIP_PM- User's Guide," Research Report, GeoSyntec Consultants, Huntington Beach, California.

Attachment P
CAMU (Landfill) Final Cover Design – [Reserved]

Attachment Q
Closure and Post-Closure Cost Estimates

Attachment Q
Closure and Post-Closure Cost Estimates
Basic Remediation Company (BRC)
Corrective Action Management Unit (CAMU)
Henderson, Nevada

Table of Contents

1.0 Introduction 1

2.0 Closure costs 1

3.0 Post-Closure Costs 1

List of Tables

Table Q-1 Closure Cost Estimate

Table Q-2 Post-Closure Cost Estimate

1.0 INTRODUCTION

The estimated and projected cost to close and post close the BRC CAMU is explained in this Attachment. A breakdown of the costs is included in Tables Q-1 and Q-2 of this report. These cost estimates summarized herein are for budgeting and planning purposes only.

The estimate is based on the RS Means Heavy Construction Cost Data for 2006 and professional judgment and experience. The cost is then adjusted for indexes such as city costs and consulting costs. The cost estimates are based on the costs to the owner or operator for hiring a third party to close the facility.

The current closure and post closure cost estimates will remain on site during the operating life of the BRC CAMU.

2.0 CLOSURE COSTS

Components of the final cover system used for this estimate include liner, drainage, and soil cover materials, as shown in Table Q-1. The total cost of CAMU closure is currently estimated at $8,408,000.

3.0 POST-CLOSURE COSTS

The post-closure cost estimate is based on the 30-year cost of annual inspection, monitoring, and maintenance at the BRC CAMU. Inspections, monitoring, and maintenance activities are covered in detail in Attachment O, Closure and Post-Closure Plan. The components of post-closure cost estimate are broken down in Table Q-2. The Net Present Value (NPV) of the 30-year total cost of post-closure is $1,990,000, which is based on a 4% discount rate.

Table Q-1
Closure Cost Estimate
Basic Remediation Company
Corrective Action Management Unit
Henderson, Nevada

Capital Cost Item	Quantity	Units	Unit Cost	Total Cost	Notes
Topographical Site Survey	52	Acre	$ 133.00	$ 6,916	2006 Means Heavy Const. - 01100-700-1800
Layout Survey	15	day	$ 1,525.00	$ 22,875	2006 Means Heavy Const. - 01100-700-1200
Foundation Layer (existing cover)					
Mobilize grader, 2 dozers, 2 scrapers, 2 water trucks, and compactor	16	EA	$ 370.00	$ 5,920	2006 Means Heavy Const. - 02305-250-0400
Grade surface	277,780	SY	$ 0.64	$ 177,779	2006 Means Heavy Const. - 02310-100-0100
Cover Liner System					
Mobilization	1	EA	$ 6,000.00	$ 6,000	COMANCO Environmental Corporation
GCL	2,400,000	SF	$ 0.61	$ 1,471,200	COMANCO Environmental Corporation
Geomembrane	2,400,000	SF	$ 0.56	$ 1,334,400	COMANCO Environmental Corporation
Drainage Geocomposite	2,400,000	SF	$ 0.58	$ 1,396,800	COMANCO Environmental Corporation
Anchor Trench	10,500	LF	$ 10.00	$ 105,000	
6" diameter CPE Pipe	5,600	LF	$ 2.96	$ 16,576	2006 Means Heavy Const. - 02620-660-0060
Geotextile	39,200	SF	$ 0.30	$ 11,760	
Drainage Aggregate	700	CY	$ 65.00	$ 45,500	2006 Means Heavy Const. - 02620-300-0300
Cover Soil - 24" thick					
Purchase soil	177,780	CY	$ 3.00	$ 533,340	On-Site Source, Screening by Others
Load and haul, 20 CY bottom dump	177,780	CY	$ 5.00	$ 888,900	
Place soil	177,780	CY	$ 1.62	$ 288,004	2006 Means Heavy Const. - 02315-520-0020
Moisture condition soil	177,780	CY	$ 0.57	$ 101,335	2006 Means Heavy Const. - 02315-310-9030
Compact soil	177,780	CY	$ 0.21	$ 37,334	2006 Means Heavy Const. - 02315-310-5060
Surface Treatment (minimize erosion)					
Soil binder	11,000	gal	$ 8.00	$ 88,000	Soil Tac
Application	29,630	CY	$ 0.57	$ 16,889	Aply to top 4" of soil
Site Perimeter Fencing					
6' high chainlink fence w/ barbed wire	480	LF	$ 23.00	$ 11,040	2006 Means Heavy Const. - 02820-130-0300
6' high gate, 20' opening	2	EA	$ 1,550.00	$ 3,100	2002 Means Heavy Const. - 02820-130-5070
			Subtotal	$ 6,568,667	
Engineering Design			2%	$ 131,373	
Construction Management/Construction Quality Assurance			6%	$ 394,120	
Contingency			20%	$ 1,313,733	

Total Estimated Capital Cost: $ 8,407,894

Table Q-2
Post-Closure Cost Estimate
Basic Remediation Company
Corrective Action Management Unit
Henderson, Nevada

O&M Cost Item	Quantity	Units	Unit Cost	Total Cost	Notes
Topographical Site Survey	1	EA	$ 6,916.00	$ 23,918	every 5 years, 4% discount rate
Leachate Collection System Maintenance					
LeachateMonitoring Event	48	EA	$ 750.00	$ 622,513	quarterly for 30 years, 4% discount rate
Leachate Pump Maintenance	1	EA	$ 500.00	$ 4,323	bi-annually for 30 years, 4% discount rate
Groundwater Monitoring					
Reporting	1	EA	$ 3,500.00	$ 60,522	annually for 30 years, 4% discount rate
Project Management	1	EA	$ 2,630.00	$ 45,478	annually for 30 years, 4% discount rate
Semi-annual groundwater monitoring event, includes pan lysimeter	1	EA	$ 20,000.00	$ 345,841	annually for 30 years, 4% discount rate
Surface Water Control					
Surface treatment re-application	1	EA	$ 34,620.00	$ 197,555	every 3 years, 4% discount rate
Inspect V-ditches	2	EA	$ 500.00	$ 17,292	Prior to significant storm events for 30 years (average 2/yr), 4% discount rate
Clean out V-ditches	1	EA	$ 5,000.00	$ 43,230	bi-annually for 30 years, 4% discount rate
Cover Maintenance, including:	1	LS	$ 20,000.00	$ 172,920	bi-annually for 30 years, 4% discount rate
Gridwalk deck					
Surface faults/ponding					
Rodent damage					
Site Security					
Fence Inspection	12	EA	$ 250.00	$ 51,876	monthly for 30 years, 4% discount rate
Fence Repairs	1	LS	$ 2,000.00	$ 17,292	bi-annually for 30 years, 4% discount rate
Annual Report					
Reporting	1	EA	$ 6,000.00	$ 103,752	annually for 30 years, 4% discount rate
Project Management	1	EA	$ 2,630.00	$ 45,478	annually for 30 years, 4% discount rate
Bi-Annual Report					
Reporting	1	EA	$ 5,000.00	$ 43,230	bi-annually for 30 years, 4% discount rate
Project Management	1	EA	$ 2,500.00	$ 21,615	bi-annually for 30 years, 4% discount rate
Agency Interaction	1	LS	$ 10,000.00	$ 172,920	annually for 30 years, 4% discount rate
TOTAL ESTIMATED O&M COST				**$ 1,989,756**	

Attachment R
Financial Assurance

Attachment R
Financial Assurance
Basic Remediation Company (BRC)
Corrective Action Management Unit (CAMU)
Henderson, Nevada

The mechanism for financial assurance for the entire cleanup project, which includes post-closure costs associated with the CAMU itself, is discussed in the AOC3. Thus, no additional financial assurance guarantees are provided here.

Attachment S
Sudden and Non-sudden Insurance Documentation

Attachment S
Sudden and Non-sudden Insurance Documentation
Basic Remediation Company (BRC)
Corrective Action Management Unit (CAMU)
Henderson, Nevada

Provisions for insurance including sudden and non-sudden insurance coverage for the entire cleanup project are discussed in the AOC3. Thus, no additional details for such coverage are provided here.

Attachment T
Report and Recordkeeping Plan

Attachment T
Report and Recordkeeping Plan
Basic Remediation Company (BRC)
Corrective Action Management Unit (CAMU)
Henderson, Nevada

Table of Contents

1.0 Introduction T-1
2.0 Operational Recordkeeping and Reports T-1
2.1 Training Records T-1
2.2 Operational Records T-1
2.2.1 Construction Quality Control and Quality Assurance T-2
2.3 Interim Status Reports T-3
2.4 Annual Reports T-3
2.5 Biennial Reports T-3
3.0 Post CAMU Closure Reporting and Recordkeeping T-3

1.0 INTRODUCTION

Records of all data, drawings and calculations concerning work proposed or completed at the BRC CAMU will be kept on permanent file in the BRC Data Repository, consistent with document retention requirements specified in the AOC3. In addition, records will be maintained at the BRC offices in conjunction with investigative work at the BRC CAMU. Included in the reports will be appendices with copies of data sheets, log books, and laboratory analysis results. All investigative results will be incorporated into the reports detailed in the following section.

Prior to any document destruction, NDEP will be provided an opportunity to acquire the documents in question.

2.0 OPERATIONAL RECORDKEEPING AND REPORTS

2.1 Training Records

The Construction Manager will maintain records of training received by onsite workers. These records will include copies of certificates received prior to BRC CAMU site activities and site specific training received. The training records will be stored onsite at the facilities maintained by the Construction Manager. Records will be maintained onsite for a period consistent with that specified in the AOC3.

2.2 Operational Records

The contractor will prepare daily progress reports documenting daily BRC CAMU activities. Daily activity records include, but are not limited to, documentation that evidences the quantity of waste materials placed in the BRC CAMU and log in/out forms. In addition to this summary daily report, the contractor will also keep detailed field notes and daily logs documenting:

- the date, project name, location, and other identification;
- a summary of the weather conditions;
- a summary of locations where construction is occurring;
- equipment and personnel on the project; and
- a summary of meetings held and attendees.

Daily photographic and video record will be kept by BRC documenting disposal activities. Records and results of inspections will be maintained and kept onsite for a period consistent with the AOC3.

Records and results of waste analysis and waste determinations will be maintained and kept on site. In addition, monitoring, testing or analytical data, and corrective action records resulting from BRC CAMU releases shall be maintained for three years. Groundwater monitoring and clean up records will be maintained until closure of the BRC CAMU.

Summary reports of all incidents that require the use of the Contingency Plan will contain the details outlined in Attachment G, Accident Prevention, Contingency, and Emergency Response Plan. The incident reports will be maintained and kept onsite until completion of the post-closure period for the BRC CAMU.

Additional items to be included with the operating records are: closure and post-closure cost estimates, plans for closure and post-closure, EPA identification number, detailed chemical and physical analysis of a representative waste sample, Quality Control (QC) and Quality Assurance (QA) documentation.

2.2.1 Construction Quality Control and Quality Assurance

The CQA Site Manager will prepare daily reports that document the activities observed during each day of activity as detailed in the CQA Plans for the Base Liner and Final Cover Systems (Sections 3 and 6 in the SRAPI, respectively). The daily reports may include monitoring logs and testing data sheets. At a minimum, these logs and data sheets will include the following information:

- a description of materials used and references of results of testing and documentation;
- identification of deficient work and materials;
- results of re-testing corrected "deficient work;"
- an identifying sheet number for cross referencing and document control;
- descriptions and locations of construction inspected;
- type of construction and inspection performed;
- description of construction procedures and procedures used to evaluate construction;
- a summary of test data and results;
- calibrations or re-calibrations of test equipment and actions taken as a result of re-calibration;
- decisions made regarding acceptance of units of work and/or corrective actions to be taken in instances of substandard testing results;
- a discussion of agreements made between the interested parties which may affect the work; and
- signature of the respective CQA Site Manager.

2.3 Interim Status Reports

During remediation activities at the Site, BRC will submit monthly status reports to the NDEP. The purpose of the monthly status reports will be to keep the NDEP informed of the progress of remediation activities at the Site. The reports will present a summary of the remediation progress during the previous month, including as appropriate, significant milestones in BRC CAMU construction, locations of completed pond and ditch excavation (including graphical format), and estimates of soil volumes excavated and placed in the BRC CAMU.

2.4 Annual Reports

BRC will submit an annual report of the solid wastes received at the site to the NDEP. This report will be submitted in a format mutually agreed to between BRC and NDEP. The report will consist of data reported in units of tons and cubic yards for waste materials received at the BRC CAMU.

The annual report will be submitted to NDEP and will include data compiled throughout the year. The total quantity of wastes deposited and the remaining capacity of the BRC CAMU in cubic yards will be incorporated. In addition, the leachate quality data will be compiled and the status of the leachate collection, including quantity of leachate collected on-site and disposed on a monthly basis, reported. Finally, any changes from the approved report, plans, and specifications, with justifications.

2.5 Biennial Reports

BRC will submit a biennial report by March 1 of each even year to the NDEP on EPA form 8700-13B. The report will summarize activities at the BRC CAMU for the previous two years. The report will contain: EPA identification number, BRC CAMU address, dates covered, description of wastes received, method of waste disposal, most recent closure and post-closure cost estimates, methods utilized to reduce waste volume, and any changes in waste volumes. This report will be signed by BRC.

3.0 POST CAMU CLOSURE REPORTING AND RECORDKEEPING

Maintenance inspection records will kept and maintained in a log book in order to clearly document any changes in physical conditions. Copies of the inspection report will be provided to the NDEP annually.

Results of monitoring will be kept and maintained onsite for a period of at least 30 years after closure. Copies of the monitoring will be provided to NDEP with the inspection report annually.

The condition of the facility will be documented with field notes, maps, and photographs, as appropriate. Evidence of potential compromises in the cover will be recorded including eroded patches, patches of dead vegetation, animal burrows, subsidence, and cracks along the cover. Surface water drainage features will be inspected for the presence of debris, physical integrity, and evidence of conditions that exceeded design assumptions.

Attachment U
Compliance with applicable Federal Laws

Attachment U
Compliance with Applicable Federal Laws
Basic Remediation Company (BRC)
Corrective Action Management Unit (CAMU)
Henderson, Nevada

Table of Contents

1.0 Introduction U-1

1.1 The Wild and Scenic Rivers Act U-1

1.2 The National Historic Preservation Act of 1966 ..... U-1

1.3 The Endangered Species Act U-2

1.4 The Coastal Zone Management Act U-2

1.5 The Fish and Wildlife Coordination Act U-3

1.0 INTRODUCTION

This attachment discusses how the BRC CAMU is in compliance with the following Federal Laws.

1.1 The Wild and Scenic Rivers Act

The Wild and Scenic Rivers Acts protects river areas and their immediate environments for the present and future generations. Rivers are eligible for protection if they display one or more of the following characteristics:

1. *Wild river areas* -- Those rivers or sections of rivers that are free of impoundments and generally inaccessible except by trail, with watersheds or shorelines essentially primitive and waters unpolluted. These represent vestiges of primitive America.

2. *Scenic river areas* -- Those rivers or sections of rivers that are free of impoundments, with shorelines or watersheds still largely primitive and shorelines largely undeveloped, but accessible in places by roads.

3. *Recreational river areas* -- Those rivers or sections of rivers that are readily accessible by road or railroad, that may have some development along their shorelines, and that may have undergone some impoundment or diversion in the past.

There are no rivers in the vicinity of the BRC CAMU site with the exception of the Las Vegas Wash which is approximately 2 miles north of the Site, and the Las Vegas Wash is not designated as a Wild and Scenic River.

1.2 The National Historic Preservation Act of 1966

The National Historic Preservation Act protects, rehabilitates, restores and reconstructs the districts, sites, buildings, structures, and objects significant in American history, architecture, archaeology, or culture.

There are no locations of historical significance at the BRC CAMU site. BRC contacted the Nevada Natural Heritage Program and requested a search of their database. No locations of historical significance were identified as a result of this search. A copy of the seach result is provided in Appendix A to this Attachment.

1.3 The Endangered Species Act

The city of Henderson, along with other cities within Clark County, submitted an application to the EPA for a permit to incidentally take desert tortoises (*gopherus agassizii*), pursuant to section 10(a)(1)(B) of the Endangered Species Act of 1973, as amended (Act), in association with various proposed public and private projects in Clark County, Nevada. The permit allows incidental take of desert tortoises for a period of 30 years, resulting from development on up to 113,900 acres of private lands within Clark County, Nevada. The permit application was received September 28, 1994, and was accompanied by the Clark County Desert Conservation Plan (CCDCP), which serves as the Applicant's habitat conservation plan and details their proposed measures to minimize, monitor, and mitigate the impacts of the proposed take on the desert tortoise.

To minimize the impacts of take, Henderson provides a free pick-up and collection service for desert tortoises encountered in harm's way within the city. These desert tortoises will be made available for beneficial uses such as translocation studies and programs, research, education, zoos, museums, or other programs approved by the Service and Nevada Division of Wildlife. Sick or injured desert tortoises will be humanely euthanized.

Henderson approves the issuance of land development permits for otherwise lawful public and private project proponents during the 30-year period in which the proposed Federal permit is in effect. Henderson imposes a fee of $550 per acre of habitat disturbance to fund the measures to minimize and mitigate the impacts of the proposed action on desert tortoises.

The BRC CAMU will be in compliance with the Endangered Species Act through a fee of $550 per acre submitted with the grading permit application. If a Desert Tortoise is encountered during construction, the City of Henderson will be contacted and the tortoise relocated.

The above discussion notwithstanding, BRC does not believe that there are any threatened and endangered species in the CAMU area. BRC requested that Nevada Natural Heritage conduct a search related to such species. The letter from Nevada Natural Heritage provided in Appendix A to the Attachment confirms that there are no at risk taxa in this area.

1.4 The Coastal Zone Management Act

The Coastal Zone Management Act seeks to manage and preserve the nation's coastal resources, ensuring their protection for future generation.

The BRC CAMU site is not located near any coasts.

1.5 The Fish and Wildlife Coordination Act

The Act provides that whenever the waters or channel of a body of water are modified by a department or agency of the U.S., the department or agency first shall consult with the U.S. Fish and Wildlife Service and with the head of the agency exercising administration over the wildlife resources of the state where construction will occur, with a view to the conservation of wildlife resources. The Act provides that land, water and interests may be acquired by federal construction agencies for wildlife conservation and development. In addition, real property under jurisdiction or control of a federal agency and no longer required by that agency can be utilized for wildlife conservation by the state agency exercising administration over wildlife resources upon that property.

The BRC CAMU will not modify the waters or channel of a body of water.

Appendix A

Copy of Letter Received from Nevada Natural Heritage

Nevada Natural Heritage Program

Nevada Department of Conservation and Natural Resources
Richard H. Bryan Building
901 South Stewart Street, suite 5002 • Carson City, Nevada 89701-5245, U.S.A.
tel: (775) 684-2900 • internet: http://heritage.nv.gov

28 February 2007

Ranajit Sahu
Basic Remediation Company
875 W Warm Springs Rd.
Henderson, NV 89011

RE: Data request received 23 February 2007

Dear Mr. Sahu:

We are pleased to provide the information you requested on endangered, threatened, candidate, and/or At Risk plant and animal taxa recorded within or near the BRC Common Areas-CAMU Project area. We searched our database and maps for the following a 5 kilometer radius around including:

Township 22S Range 62E Sections 11 and 12

There are no at risk taxa recorded within the given area. However, habitat may be available for: the big free-tailed bat, *Nyctinomops macrotis*, a Nevada Bureau of Land Management (BLM) Sensitive Species; the spotted bat, *Euderma maculatum*, a Nevada BLM Special Status Species; the Arizona toad, *Bufo microscaphus*, a Nevada BLM Sensitive Species; the desert tortoise, *Gopherus agassizii*, a Federally Threatened Taxon; the chuckwalla, *Sauromalus ater*, a Nevada BLM Sensitive Species; and the banded Gila monster, *Heloderma suspectum cinctum*, a Nevada BLM Special Status Species. We do not have complete data on various raptors that may also occur in the area; for more information contact Ralph Phenix, Nevada Division of Wildlife at (775) 688-1565. Note that all cacti, yuccas, and Christmas trees are protected by Nevada state law (NRS 527.060-.120), including taxa not tracked by this office.

Please note that our data are dependent on the research and observations of many individuals and organizations, and in most cases are not the result of comprehensive or site-specific field surveys. Natural Heritage reports should never be regarded as final statements on the taxa or areas being considered, nor should they be substituted for on-site surveys required for environmental assessments.

Thank you for checking with our program. Please contact us for additional information or further assistance.

Sincerely,

Eric S. Miskow
Biologist III/Data Manager

Attachment V
Additional information required by NDEP

SUPPLEMENTAL
REMEDIAL ACTION PLAN (RAP)
PERMIT APPLICATION INFORMATION FOR
CORRECTIVE ACTION MANAGEMENT UNIT (CAMU)
HENDERSON, NEVADA

Submitted to:

Nevada Division of Environmental Protection
901 South Stewart Street – 4th Floor
Carson City, Nevada 89701
(775) 687-4670

Prepared for:

Basic Remediation Company
875 West Warm Springs Road
Henderson, Nevada 89015
(702) 567-0400

Prepared by:

GeoSyntec Consultants
10875 Rancho Bernardo Road, Ste. 200
San Diego, California 92127
(858) 674-6559

November 2006

Table of Contents

Section 1 – Permit Drawings

Figure J-1 Title Sheet and Drawing List
Figure J-2 Legend, Abbreviations, and General Notes
Figure J-3 Overall Site Plan
Figure J-4 Construction Sequence Plan
Figure J-5 Surcharge Plan
Figure J-6 Site Preparation Plan
Figure J-7 Construction Grading Plan
Figure J-8 Storm Drain Plan
Figure J-9 Final Cover Grading Plan
Figure J-10 Cross Sections
Figure J-11 Final Cover and Liner Details and Sections
Figure J-12 Fence Plan

Section 2 – Base Liner Calculation Packages

A. Cut Slope Stability
B. Final Waste Slope Stability
C. Drainage Pipe Size Requirement
D. Pipe Strength
E. Veneer Stability
F. Geotextile/Separation/Filtration Requirements
G. Geotextile Cushion Protection
H. Sump Capacity
I. Comparison of Flow Between a CCL and GCL
J. Tension Due to Wind Uplift
K. Anchorage Capacity
L. Geocomposite Equivalency Demonstration
M. Consolidation Analysis of the South Mesa
N. Consolidation Analysis of the North Mesa

Section 3 – Base Liner Construction Quality Assurance Plan

Section 4 – Base Liner Technical Specifications

Section 5 – Final Cover Calculation Packages

A. Geocomposite and Pipe Size Calculation
B. Veneer Stability
C. Cover Liner Sloughing Stability

D. Geotextile Filtration Requirements
E. Geotextile Puncture Protection
F. Pipe Strength
G. Seismic Performance Evaluation
    1. Seismic Hazard Evaluation and Evaluation of Design Ground Motions
    2. Site Response Analysis
    3. Seismic Deformation Charts
    4. Seismically-Induced Permanent Deformations

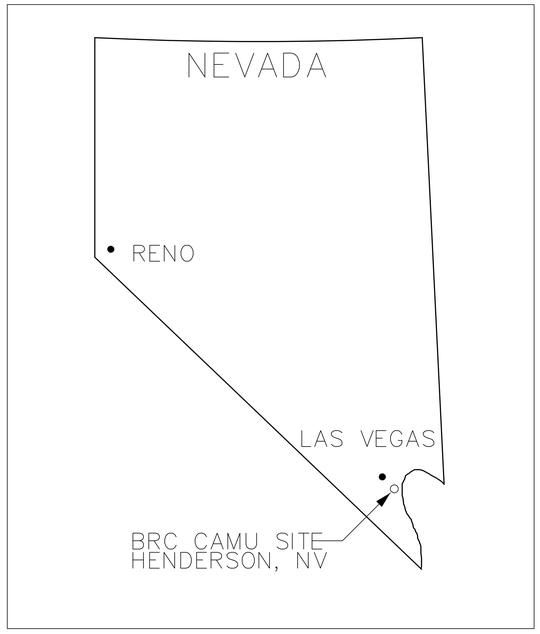
Section 6 – Final Cover Construction Quality Assurance Plan

Section 7 – Final Cover Technical Specifications

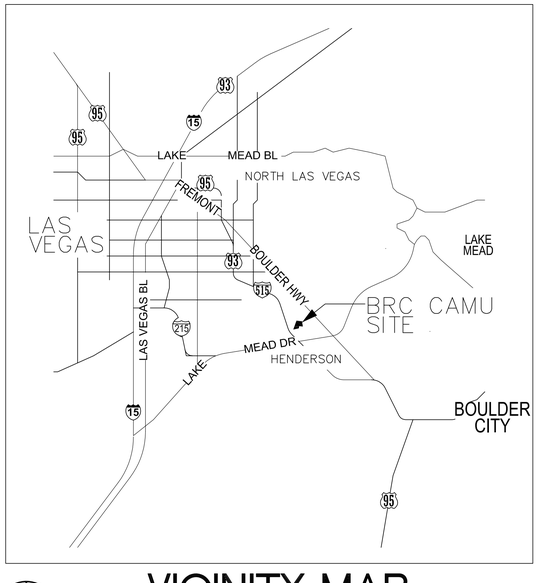
Section 8 – Previous Explorations

Section 1
Permit Drawings

PERMIT DRAWINGS
Basic Remediation Company
CORRECTIVE ACTION MANAGEMENT UNIT
CONTROL SYSTEMS DESIGN
HENDERSON, NEVADA
NOVEMBER 2006

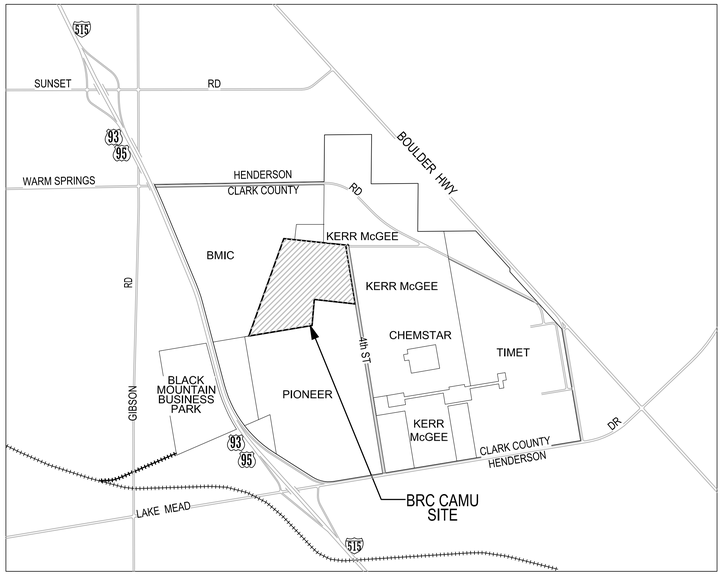


LOCATION MAP
NTS



VICINITY MAP
Approximate Scale: 1"=3 Miles

DRAWING LIST	DRAWING TITLE
J-1	TITLE SHEET AND DRAWING LIST
J-2	LEGEND, ABBREVIATIONS AND GENERAL NOTES
J-3	OVERALL SITE PLAN
J-4	CONSTRUCTION SEQUENCE PLAN
J-5	SURCHARGE PLAN
J-6	SITE PREPARATION PLAN
J-7	CONSTRUCTION GRADING PLAN
J-8	STORM DRAIN PLAN
J-9	FINAL COVER GRADING PLAN
J-10	CROSS SECTIONS
J-11	FINAL COVER AND LINER DETAILS AND SECTIONS
J-12	FENCE PLAN



SITE PLAN
Approximate Scale: 1"=1/2 Mile

GEOSYNTEC CONSULTANTS
10875 RANCHO BERNARDO ROAD, SUITE 200
SAN DIEGO, CALIFORNIA 92127
TELEPHONE: (858) 674-6559

PROJECT: BRC CAMU
HENDERSON/CLARK COUNTY NEVADA

TITLE: TITLE SHEET

MARK	DATE	REVISION	BY	APPROVED

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

SIGNATURE

DATE

SEAL

DATE: NOVEMBER 2006		SCALE:	AS SHOWN
DESIGN BY:	G.T.C.	JOB NO.:	SC0313
DRAWN BY:	J.R.H.	FILE NO:	
CHECKED BY:	G.T.C.	DOCUMENT NO:	
REVIEWED BY:	G.T.C.	DRAWING NO:	J-1
APPROVED BY:	G.T.C.		

P:\PRJ\SDCadd\CADD\SC0313\BRC\figures\Construction\Revised 11-6-06\SC0313_J-1_Title Sheet.dwg 11/14/06 10:22 jhall

ABBREVIATIONS

ABAN	ABANDON ABANDON IN PLACE .
CIP	CAST IRON PIPE
C-C	CENTER TO CENTER
CL	CENTER LINE
COH	CITY OF HENDERSON
CC	CLARK COUNTY
CCSD	CLARK COUNTY SANITATION DISTRICT
CO	CLEANOUT
COMM	COMMERCIAL
CONC, PCC	CONCRETE, PORTLAND CEMENT CONCRETE
CONST	CONSTRUCTION OR CONSTRUCT
CMP	CORRUGATED METAL PIPE
CU FT, CF	CUBIC FOOT
CU YD, CY	CUBIC YARD
CULV	CULVERT
CF	CURB FACE
DEPT	DEPARTMENT
△	DELTA = ANGLE
DIA, *	DIAMETER
DWG	DRAWING
DI	DROP INLET
DL	DRAIN LINE
EA	EACH
ESNT	EASEMENT
EO	EDGE OF OIL
EP	EDGE OF PAVEMENT
E	ELECTRIC OR ELECTRICAL
ELEV	ELEVATION
EMBK	EMBANKMENT
ECR	END OF CURB RETURN
EC	END OF CURVE
EVC	END OF VERTICAL CURVE
EXIST	EXISTING
FT	FEET, FOOT
FG	FINISH GRADE
FS	FINISH SURFACE
FH	FIRE HYDRANT
FL, F_L	FLOW LINE
GALV	GALVANIZED
G	GAS
GB	GRADE BREAK
HDWL	HEADWALL
HP	HIGH POINT
HPFL	HIGH POINT FLOW LINE
HORIZ	HORIZONTAL
IN	INCH
INT	INTERSECTION
INV	INVERT
LVVWD	LAS VEGAS VALLEY WATER DISTRICT
LF	LINEAR FEET
MH	MANHOLE
MAX	MAXIMUM
MIN	MINIMUM
NTS	NOT TO SCALE
OC	ON CENTER
PVMT	PAVEMENT
PCC	POINT OF COMPOUND CURVE
PC	POINT OF CURVE
PI	POINT OF INTERSECTION
PRC	POINT OF REVERSE CURVE
PT	POINT OF TANGENCY
PVI	POINT OF VERTICAL INFLECTION
PVC	POINT OF VERTICAL CURVE
PCC	PORTLAND CEMENT CONCRETE
PL, P_L	PROPERTY LINE
R	RADIUS OR RIDGE
REINF	REINFORCED
RCP	REINFORCED CONCRETE PIPE
R/W	RIGHT-OF-WAY
RD	ROAD
SS	SANITARY SEWER
SHT	SHEET
SW	SIDEWALK
SQ FT, SF	SQUARE FOOT
SQ YD, SY	SQUARE YARD
STA	STATION
SD	STORM DRAIN
STD	STANDARD
STL	STEEL
T	TELEPHONE
TEMP	TEMPORARY
TBA	TO BE ADJUSTED
TBR	TO BE REMOVED
TC	TOP OF CURB
TG	TOP OF GRATE
TOC	TOP OF CONCRETE
TP	TOP OF PIPE
TW	TOP OF WALL
TYP	TYPICAL
UG	UNDERGROUND
VAR	VARIABLE
VERT	VERTICAL
VC	VERTICAL CURVE
VCP	VITRIFIED CLAY PIPE
W	WATER
WWF	WELDED WIRE FABRIC
YD	YARD

LEGEND

EXISTING	NEW	DESCRIPTION
		CENTERLINE ~
		SECTION LINE
		RIGHT-OF-WAY OR PROPERTY LINE
		CUT LINE - ASPHALTIC OR PORTLAND CEMENT CONCRETE
	(LOW SIDE) (HIGH SIDE)	RETAINING WALL
		CHAINLINK FENCE
		BUILDING OR STRUCTURE
		CONCRETE BLOCK WALL
		ROAD
		EDGE OF PAVEMENT
		RIPRAP
		TEST HOLE
		CONCRETE (SHOWN ON CROSS SECTIONS)
		GRAVEL (SHOWN ON CROSS SECTIONS)
		GROUND (SHOWN ON CROSS SECTIONS)
		SAND (SHOWN ON CROSS SECTIONS)
		VEGETATIVE COVER (SHOWN ON CROSS SECTIONS)
		WING TYPE HEADWALL
		PLAIN HEADWALL
	TOP TOE	CUT OF FILL SLOPES
		DIRECTION OF SHEET FLOW
		FLOW LINE OF DITCH OR CHANNEL
		CULVERT
		STORM DRAIN CATCH BASIN
360	360	MAJOR CONTOUR LINE AND ELEVATION
		MINOR CONTOUR LINE
(351.00) FG	351.00 FG	FINISH GRADE ELEVATION
(351.00) FS	351.00 FS	FINISH SURFACE ELEVATION
(351.00) FL	351.00 FL	FLOW LINE ELEVATION
(351.00) HPFL	351.00 HPFL	HIGH POINT FLOW LINE ELEVATION
(351.00) TC	351.00 TC	TOP OF CURB ELEVATION
(351.00) TW	351.00 TW	TOP OF WALL ELEVATION
(351.00) INV	351.00 INV	INVERT ELEVATION
		UNDERGROUND WITH MANHOLE AND CASING
CO	CO	CLEANOUT
DL	DL	DRAIN LINE
DW	DW	DOMESTIC WATER
E	E	ELECTRICAL
G	G	GAS
SD	SD	STORM DRAIN
SS	SS	SANITARY SEWER
T	T	TELEPHONE/COMMUNICATIONS
		TELEPHONE/COMMUNICATIONS MANHOLE
W	W	WATER
		FIRE HYDRANT
		GATE VALVE
		REDUCER
		PLUG OR CAP
		UTILITY POLE
		UTILITY POLE WITH GUY ANCHOR
•GP	•GP	GUARD POST

GENERAL NOTES

1. UNLESS OTHERWISE INDICATED ON THE DRAWINGS, THE TOPOGRAPHY, INCLUDING HORIZONTAL AND VERTICAL CONTROLS ARE FROM A SURVEY BY PENTACORE GEOGRAPHIC INFORMATION SYSTEMS, 6763 WEST CHARLESTON BLVD, LAS VEGAS, NEVADA, DATED SEP. 9, 1999.

   1.1. BASIS OF VERTICAL CONTROL:
   CITY OF HENDERSON BENCHMARK NO. 5 – BOLT AND WASHER IN THE TOP OF THE CURB ON THE EAST SIDE OF HIGHWAY 93, 100 FEET +/- NORTHWEST OF THE CENTERLINE OF KING STREET.

   NAVD 1988 DATUM ELEVATION = 519.021 METERS 1702.821 FEET

   1.2. BASIS OF HORIZONTAL CONTROL:
   THE BASIS OF BEARINGS FOR THIS PROJECT IS GRID NORTH AS DEFINED BY THE NEVADA COORDINATE SYSTEM OF 1983 (NCS83), EAST ZONE, (2701), DETERMINED BY GIS CONTROL POINTS, "851" , "884" AND "W51" AS SHOWN ON A RECORD OF SURVEY ON FILE IN THE CLARK COUNTY RECORDER'S OFFICE, IN FILE 88 OF SURVEYS, AT PAGE 53.

2. A PRELIMINARY GEOTECHNICAL AND GEOLOGIC INVESTIGATION NO. 99-33437-01, DATED OCTOBER 22, 1999 PREPARED BY CONVERSE CONSULTANTS IS PART OF THE CONSTRUCTION DOCUMENTS.

3. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE FIELD INVESTIGATION OF THE EXISTING CONDITIONS AND FOR THE FIELD VERIFICATION OF EXISTING UNDERGROUND UTILITIES WITHIN THE PROPOSED WORK AREA. IF UNKNOWN UNDERGROUND UTILITIES ARE ENCOUNTERED DURING EXCAVATION, THE SUBCONTRACTOR SHALL IMMEDIATELY NOTIFY CONSTRUCTION MANAGER PRIOR TO CONTINUING THE WORK IN THE IMMEDIATE VICINITY.

4. THE CONTRACTOR SHALL PROTECT EXISTING UNDERGROUND AND ABOVEGROUND LINES AND ANY EXISTING IMPROVEMENTS AND EQUIPMENT WITHIN THE PROJECT LIMITS. ANY EXISTING CONSTRUCTION DAMAGED BY CONTRACTOR OPERATIONS SHALL BE REPAIRED OR REPLACED AT THE CONTRACTOR'S EXPENSE.

5. ALL UNDERGROUND UTILITIES SHALL BE PROPERLY PROTECTED DURING CONSTRUCTION FROM HEAVY EQUIPMENT BY THE USE OF SUITABLE TIMBER MAT OR STEEL MATTING.

6. DIMENSIONS, ELEVATIONS, AND LOCATION OF EXISTING UTILITIES ARE TO BE FIELD VERIFIED BY CONTRACTOR PRIOR TO START OF CONSTRUCTION.

7. STRAIGHT GRADE BETWEEN SPOT ELEVATIONS SHOWN UNLESS OTHERWISE INDICATED ON THE PLANS.

8. FINISHED SURFACES SHALL BE SLOPED UNIFORMLY FROM HIGH POINTS, RIDGE LINES, AND AROUND OBJECTS TO FLOW LINES AND AREA DRAINS UNLESS INDICATED OTHERWISE.

9. THE GEOTECHNICAL ENGINEER SHALL PROVIDE SUFFICIENT INSPECTIONS DURING THE EXCAVATION OF THE NATURAL GROUND AND THE PLACEMENT AND COMPACTION OF THE FILL TO BE SATISFIED THAT THE WORK IS BEING PERFORMED IN ACCORDANCE WITH THE PLANS AND SPECIFICATIONS.

10. EXCAVATION, EMBANKMENT, AND BACKFILL WORK AREAS SHALL BE CONTINUALLY AND EFFECTIVELY DRAINED. WATER SHALL NOT BE PERMITTED TO ACCUMULATE IN EXCAVATION OR FOUNDATION AREAS. THE SUBCONTRACTOR SHALL PROVIDE SUITABLE DIKES, DRAINS OR SHALL PROVIDE PUMPING EQUIPMENT AS REQUIRED TO DIVERT WATER FLOW AWAY FROM THE WORK AREAS.

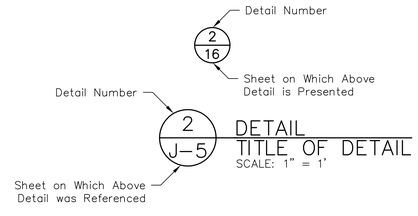
11. SLOPES SHOWN ON GRADING PLANS ARE FOR INFORMATION ONLY. ACTUAL LINES SHALL BE VERIFIED BY FIELD MEASUREMENTS.

12. THE CONTRACTOR SHALL PERFORM GRADING OPERATIONS IN ACCORDANCE WITH EARTHWORK SPECIFICATION, SECTION 02200.

13. SUBCONTRACTOR SHALL COORDINATE WITH OTHER SUBCONTRACTORS IN THE WORK AREA. ANY DISPUTES BETWEEN SUBCONTRACTORS SHALL BE RESOLVED THROUGH THE CONSTRUCTION MANAGER.

14. THE SUBCONTRACTOR SHALL IMMEDIATELY NOTIFY CONSTRUCTION MANAGER FOR PROVISIONS OF THE APPROPRIATE MEANS OF DECOMMISSIONING UNDERGROUND UTILITIES ENCOUNTERED IN THE FIELD WITHIN HIS WORK PACKAGE LIMITS.

DETAIL IDENTIFICATION LEGEND



Example: Detail Number 2 Presented on Sheet No. 16 was Referenced on Sheet No. 5.

NOTES: ABOVE REFERENCING SYSTEM ALSO APPLIES TO SECTION IDENTIFICATIONS.

GEOSYNTEC CONSULTANTS
10875 RANCHO BERNARDO ROAD, SUITE 200
SAN DIEGO, CALIFORNIA 92127
TELEPHONE: (858) 674-6559

PROJECT: BRC CAMU
HENDERSON/CLARK COUNTY NEVADA

TITLE: GENERAL NOTES, LEGEND, AND ABBREVIATIONS

MARK	DATE	REVISION	BY	APPROVED

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

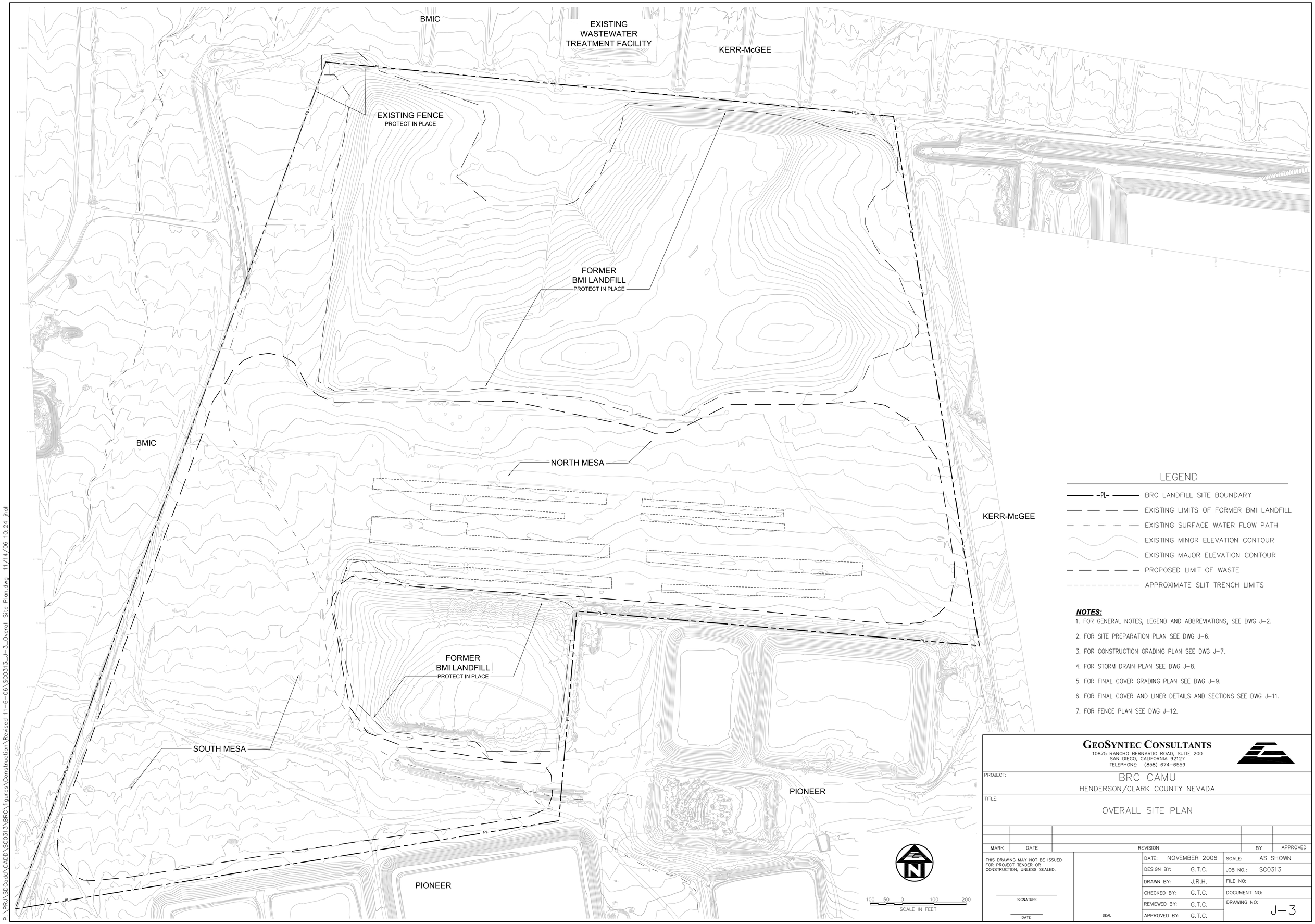
SIGNATURE

DATE

SEAL

DATE:	NOVEMBER 2006	SCALE:	AS SHOWN
DESIGN BY:	G.T.C.	JOB NO.:	SC0313
DRAWN BY:	J.R.H.	FILE NO:	
CHECKED BY:	G.T.C.	DOCUMENT NO:	
REVIEWED BY:	G.T.C.	DRAWING NO:	J-2
APPROVED BY:	G.T.C.		

P:\PRJ\SDCadd\CADD\SC0313\BRC\figures\Construction\Revised 11-6-06\SC0313_J-2_General Notes.dwg 11/14/06 10:23 jhall



NOTES:

1. FOR GENERAL NOTES, LEGEND AND ABBREVIATIONS, SEE DWG J-2.
2. FOR SITE PREPARATION PLAN SEE DWG J-6.
3. FOR CONSTRUCTION GRADING PLAN SEE DWG J-7.
4. FOR STORM DRAIN PLAN SEE DWG J-8.
5. FOR FINAL COVER GRADING PLAN SEE DWG J-9.
6. FOR FINAL COVER AND LINER DETAILS AND SECTIONS SEE DWG J-11.
7. FOR FENCE PLAN SEE DWG J-12.

GEOSYNTEC CONSULTANTS
10875 RANCHO BERNARDO ROAD, SUITE 200
SAN DIEGO, CALIFORNIA 92127
TELEPHONE: (858) 674-6559

PROJECT: BRC CAMU
HENDERSON/CLARK COUNTY NEVADA

TITLE: OVERALL SITE PLAN

MARK	DATE	REVISION	BY	APPROVED

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

SIGNATURE

DATE

SEAL

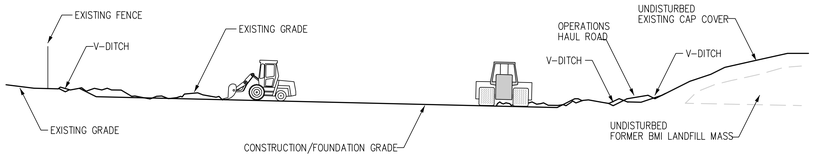
DATE:	NOVEMBER 2006	SCALE:	AS SHOWN
DESIGN BY:	G.T.C.	JOB NO.:	SC0313
DRAWN BY:	J.R.H.	FILE NO:	
CHECKED BY:	G.T.C.	DOCUMENT NO:	
REVIEWED BY:	G.T.C.	DRAWING NO:	J-3
APPROVED BY:	G.T.C.		

P:\PRJ\SDCadd\CADD\SC0313\BRC\figures\Construction\Revised 11-6-06\SC0313_J-3_Overall Site Plan.dwg 11/14/06 10:24 jhall

1

- REMOVE ANY INTERFERING PORTION OF EXISTING FENCE
- CLEAR AND REMOVE BRUSH AND RUBBLE
- INSTALL INTERIM PERIMETER FENCE AND ACCESS GATES
- CONSTRUCT OPERATIONS SUPPORT FACILITIES
- GRADE TO FOUNDATION TO RECEIVE LINER LAYER

- CONSTRUCT OPERATIONS HAUL ROAD
- CONSTRUCT EROSION CONTROL FEATURES – DITCHES, CULVERTS, SILT FENCES, CHECK DAMS, AND BASINS

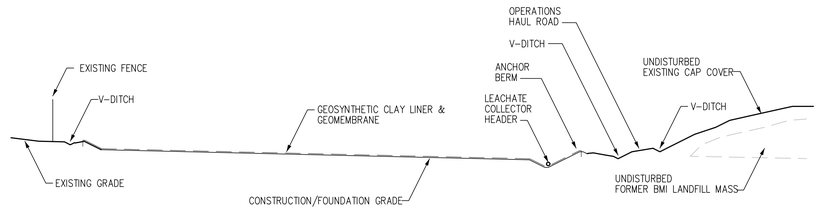


NOT TO SCALE

2

- CONSTRUCT FLOWLINES, SUMPS, AND BERMS FOR LEACHATE COLLECTION SYSTEM AND LINER ANCHOR

- INSTALL GEOSYNTHETIC CLAY LINER, GEOMEMBRANE AND GEOCOMPOSITE

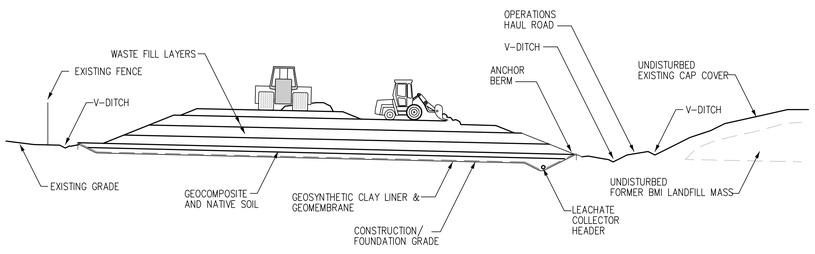


NOT TO SCALE

3

- INSTALL LEACHATE COLLECTION SYSTEM
- INSTALL BALANCE OF COMPOSITE LINER: GEOCOMPOSITE AND NATIVE SOIL

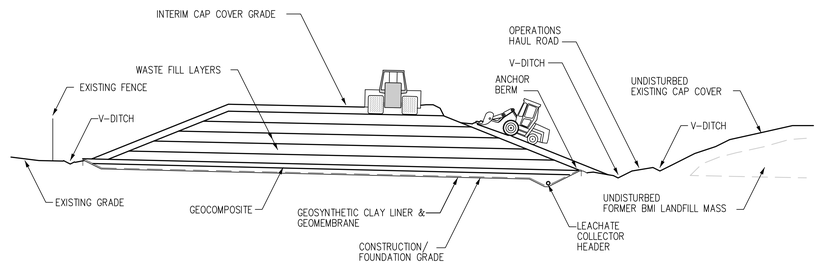
- AT REMOVAL SITE: STOCKPILE AND LOAD WASTE FOR TRANSPORT
- AT LANDFILL SITE: UNLOAD, PLACE, COMPACT AND GRADE WASTE FILL IN LAYERS



NOT TO SCALE

4

- PLACE, COMPACT AND GRADE SOILS MATERIAL FOR INTERIM CAP COVER

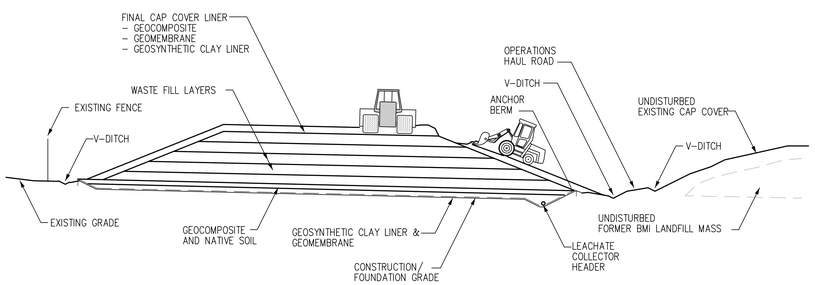


NOT TO SCALE

5

- REMOVE INTERIM CAP COVER

- INSTALL FINAL CAP COVER LINER – GCL, GEOMEMBRANE AND GEOCOMPOSITE

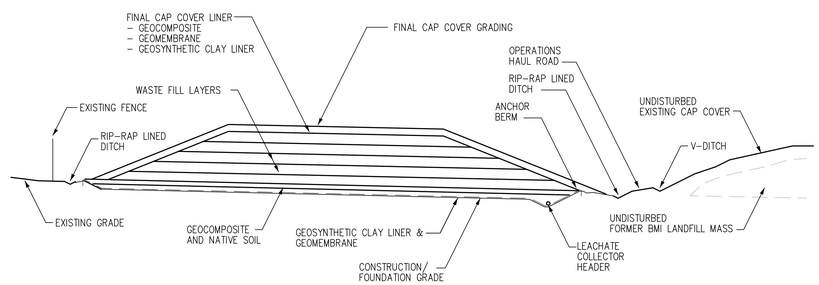


NOT TO SCALE

6

- PLACE, COMPACT AND GRADE SOILS MATERIAL FOR FINAL CAP COVER

- INSTALL PERMANENT STORM DRAINAGE FACILITIES (GUTTERS, DITCHES, CULVERTS, HEADWALLS, ETC)



NOT TO SCALE

GEOSYNTEC CONSULTANTS
10875 RANCHO BERNARDO ROAD, SUITE 200
SAN DIEGO, CALIFORNIA 92127
TELEPHONE: (858) 674-6559

PROJECT: BRC CAMU
HENDERSON/CLARK COUNTY NEVADA

TITLE: CONSTRUCTION SEQUENCE PLAN

MARK	DATE	REVISION	BY	APPROVED

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

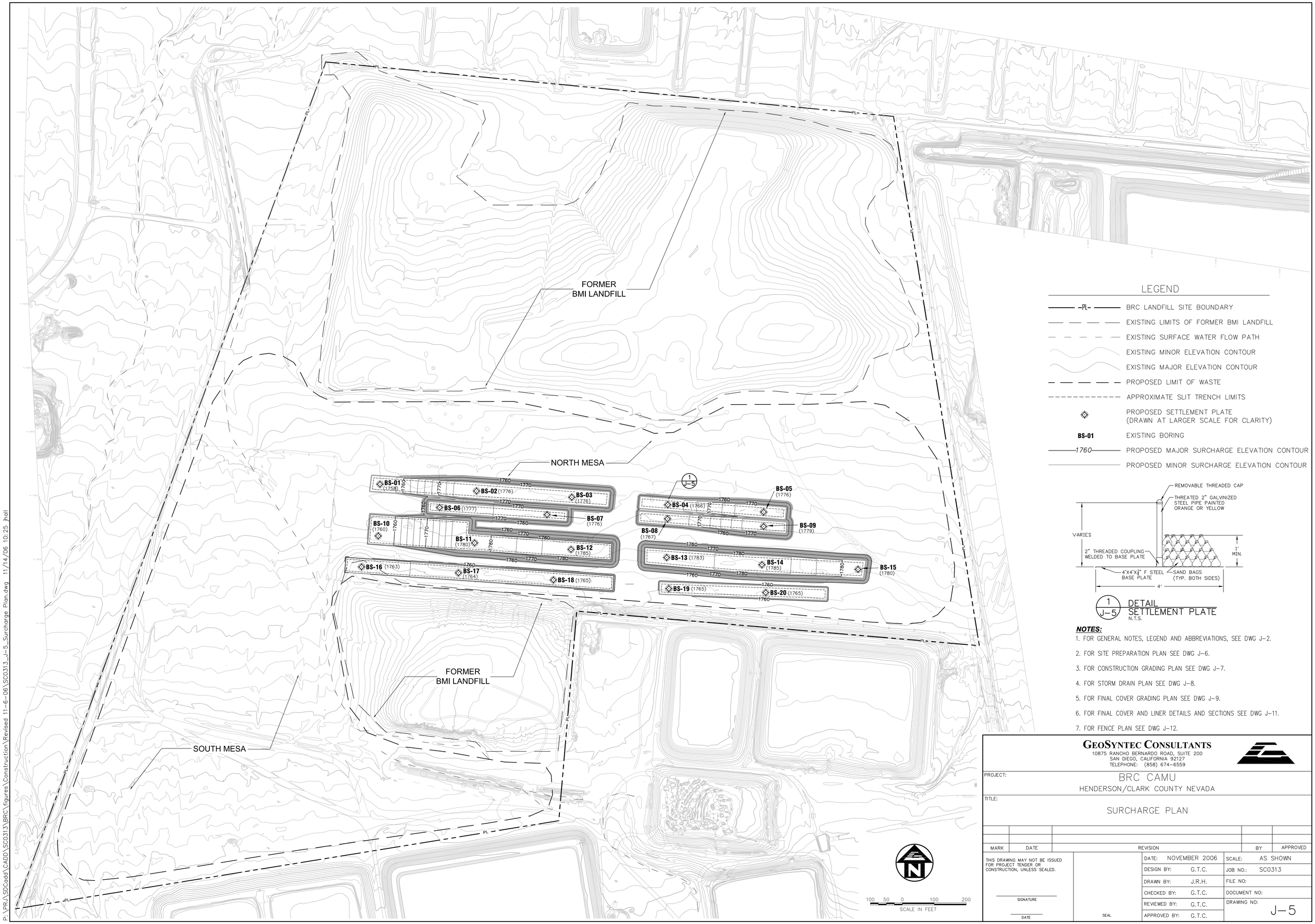
SIGNATURE

DATE

SEAL

DATE:	NOVEMBER 2006	SCALE:	AS SHOWN
DESIGN BY:	G.T.C.	JOB NO.:	SC0313
DRAWN BY:	J.R.H.	FILE NO:	
CHECKED BY:	G.T.C.	DOCUMENT NO:	
REVIEWED BY:	G.T.C.	DRAWING NO:	J-4
APPROVED BY:	G.T.C.		

P:\PRJ\SDCadd\CADD\SC0313\BRC\figures\Construction\Revised 11-6-06\SC0313_J-4_Construction Sequence.dwg 11/14/06 10:25 jhall



LEGEND

- BRC LANDFILL SITE BOUNDARY
- EXISTING LIMITS OF FORMER BMI LANDFILL
- EXISTING SURFACE WATER FLOW PATH
- EXISTING MINOR ELEVATION CONTOUR
- EXISTING MAJOR ELEVATION CONTOUR
- PROPOSED LIMIT OF WASTE
- APPROXIMATE SLIT TRENCH LIMITS
- PROPOSED SETTLEMENT PLATE (DRAWN AT LARGER SCALE FOR CLARITY)
- BS-01 EXISTING BORING
- 1760 PROPOSED MAJOR SURCHARGE ELEVATION CONTOUR
- PROPOSED MINOR SURCHARGE ELEVATION CONTOUR

1 / J-5 DETAIL SETTLEMENT PLATE
N.T.S.

NOTES:

1. FOR GENERAL NOTES, LEGEND AND ABBREVIATIONS, SEE DWG J-2.
2. FOR SITE PREPARATION PLAN SEE DWG J-6.
3. FOR CONSTRUCTION GRADING PLAN SEE DWG J-7.
4. FOR STORM DRAIN PLAN SEE DWG J-8.
5. FOR FINAL COVER GRADING PLAN SEE DWG J-9.
6. FOR FINAL COVER AND LINER DETAILS AND SECTIONS SEE DWG J-11.
7. FOR FENCE PLAN SEE DWG J-12.

GEOSYNTEC CONSULTANTS
10875 RANCHO BERNARDO ROAD, SUITE 200
SAN DIEGO, CALIFORNIA 92127
TELEPHONE: (858) 674-6559

PROJECT: BRC CAMU
HENDERSON/CLARK COUNTY NEVADA

TITLE: SURCHARGE PLAN

MARK	DATE	REVISION	BY	APPROVED

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

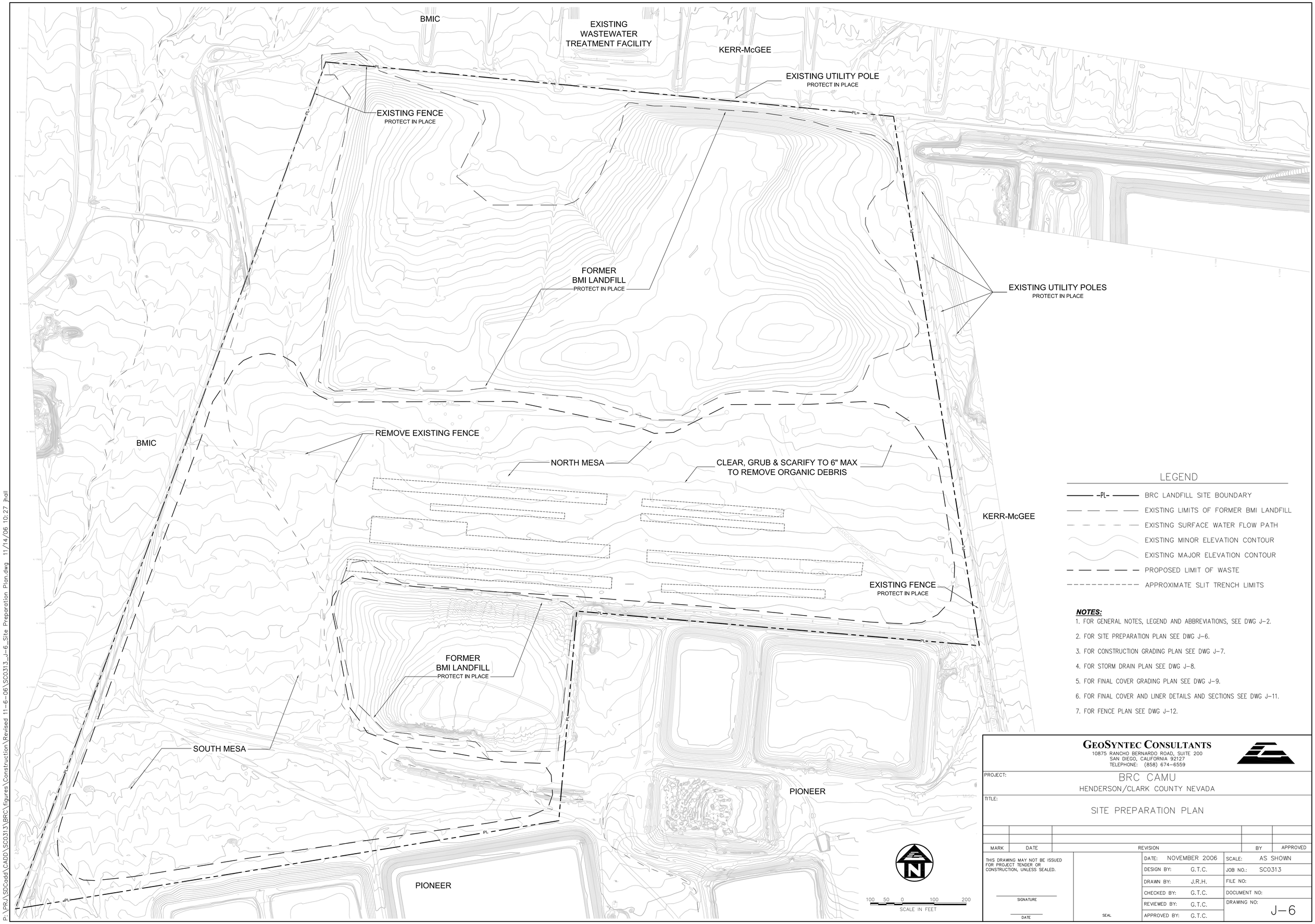
SIGNATURE

DATE

SEAL

DATE:	NOVEMBER 2006	SCALE:	AS SHOWN
DESIGN BY:	G.T.C.	JOB NO.:	SC0313
DRAWN BY:	J.R.H.	FILE NO:	
CHECKED BY:	G.T.C.	DOCUMENT NO:	
REVIEWED BY:	G.T.C.	DRAWING NO:	J-5
APPROVED BY:	G.T.C.		

P:\PRJ\SDCadd\CADD\SC0313\BRC\figures\Construction\Revised 11-6-06\SC0313_J-5_Surcharge Plan.dwg 11/14/06 10:25 jhall



LEGEND

- BRC LANDFILL SITE BOUNDARY
- EXISTING LIMITS OF FORMER BMI LANDFILL
- EXISTING SURFACE WATER FLOW PATH
- EXISTING MINOR ELEVATION CONTOUR
- EXISTING MAJOR ELEVATION CONTOUR
- PROPOSED LIMIT OF WASTE
- APPROXIMATE SLIT TRENCH LIMITS

NOTES:

1. FOR GENERAL NOTES, LEGEND AND ABBREVIATIONS, SEE DWG J-2.
2. FOR SITE PREPARATION PLAN SEE DWG J-6.
3. FOR CONSTRUCTION GRADING PLAN SEE DWG J-7.
4. FOR STORM DRAIN PLAN SEE DWG J-8.
5. FOR FINAL COVER GRADING PLAN SEE DWG J-9.
6. FOR FINAL COVER AND LINER DETAILS AND SECTIONS SEE DWG J-11.
7. FOR FENCE PLAN SEE DWG J-12.

GEOSYNTEC CONSULTANTS
10875 RANCHO BERNARDO ROAD, SUITE 200
SAN DIEGO, CALIFORNIA 92127
TELEPHONE: (858) 674-6559

PROJECT: BRC CAMU
HENDERSON/CLARK COUNTY NEVADA

TITLE: SITE PREPARATION PLAN

MARK	DATE	REVISION	BY	APPROVED

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

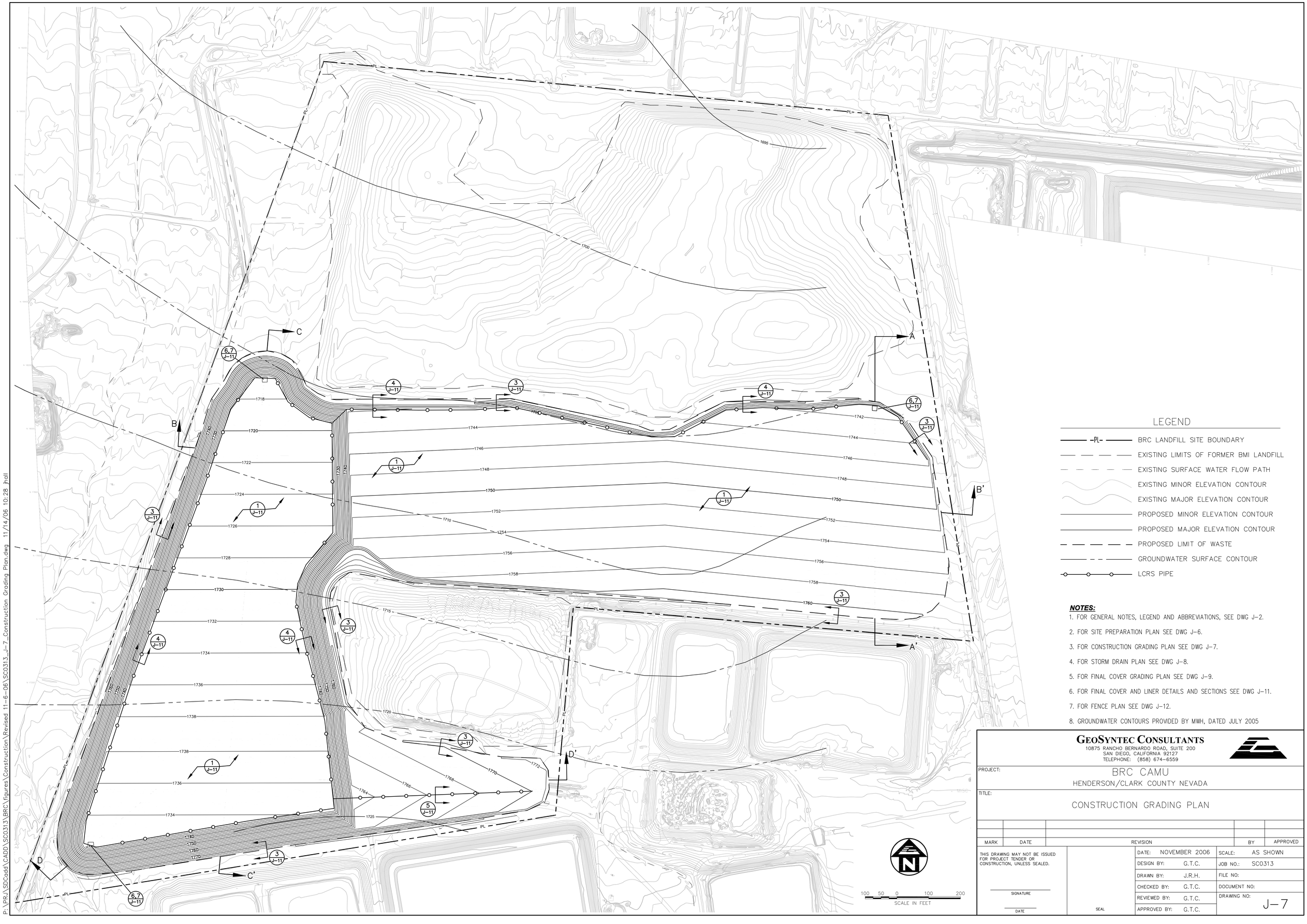
SIGNATURE

DATE

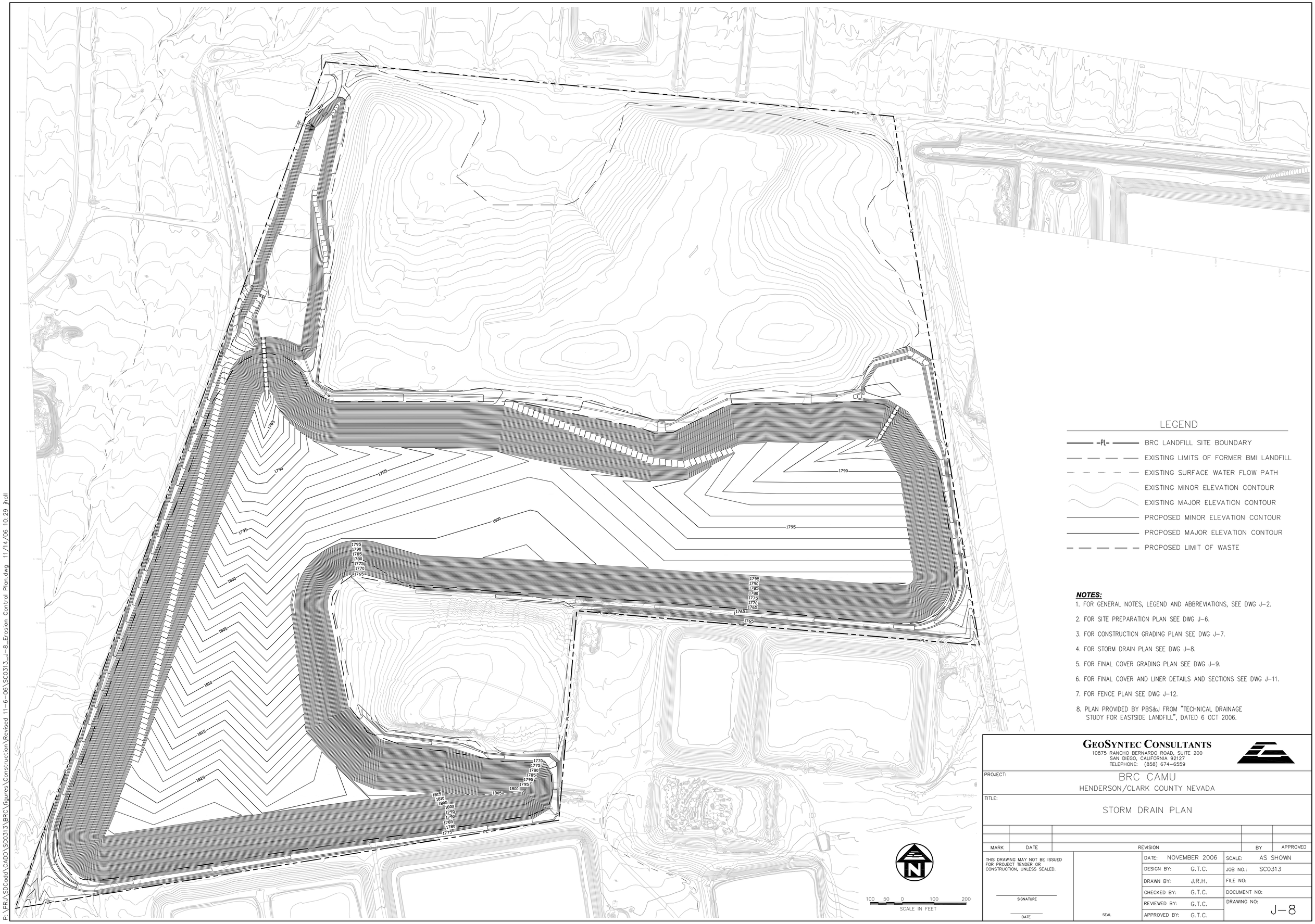
SEAL

DATE:	NOVEMBER 2006	SCALE:	AS SHOWN
DESIGN BY:	G.T.C.	JOB NO.:	SC0313
DRAWN BY:	J.R.H.	FILE NO:	
CHECKED BY:	G.T.C.	DOCUMENT NO:	
REVIEWED BY:	G.T.C.	DRAWING NO:	J-6
APPROVED BY:	G.T.C.		

P:\PRJ\SDCadd\CADD\SC0313\BRC\figures\Construction\Revised 11-6-06\SC0313_J-6_Site Preparation Plan.dwg 11/14/06 10:27 jhall



P:\PRJ\SDCadd\CADD\SC0313\BRC\figures\Construction\Revised 11-6-06\SC0313_J-7_Construction Grading Plan.dwg 11/14/06 10:28 jhall



NOTES:

1. FOR GENERAL NOTES, LEGEND AND ABBREVIATIONS, SEE DWG J-2.
2. FOR SITE PREPARATION PLAN SEE DWG J-6.
3. FOR CONSTRUCTION GRADING PLAN SEE DWG J-7.
4. FOR STORM DRAIN PLAN SEE DWG J-8.
5. FOR FINAL COVER GRADING PLAN SEE DWG J-9.
6. FOR FINAL COVER AND LINER DETAILS AND SECTIONS SEE DWG J-11.
7. FOR FENCE PLAN SEE DWG J-12.
8. PLAN PROVIDED BY PBS&J FROM "TECHNICAL DRAINAGE STUDY FOR EASTSIDE LANDFILL", DATED 6 OCT 2006.

GEOSYNTEC CONSULTANTS
10875 RANCHO BERNARDO ROAD, SUITE 200
SAN DIEGO, CALIFORNIA 92127
TELEPHONE: (858) 674-6559

PROJECT: BRC CAMU
HENDERSON/CLARK COUNTY NEVADA

TITLE: STORM DRAIN PLAN

MARK	DATE	REVISION	BY	APPROVED

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

SIGNATURE

DATE

SEAL

DATE: NOVEMBER 2006		SCALE:	AS SHOWN
DESIGN BY:	G.T.C.	JOB NO.:	SC0313
DRAWN BY:	J.R.H.	FILE NO:	
CHECKED BY:	G.T.C.	DOCUMENT NO:	
REVIEWED BY:	G.T.C.	DRAWING NO:	J-8
APPROVED BY:	G.T.C.		

P:\PRJ\SDCadd\CADD\SC0313\BRC\figures\Construction\Revised 11-6-06\SC0313_J-8_Erosion Control Plan.dwg 11/14/06 10:29 jhall

LEGEND

- PL — BRC LANDFILL SITE BOUNDARY
- EXISTING LIMITS OF FORMER BMI LANDFILL
- EXISTING SURFACE WATER FLOW PATH
- EXISTING MINOR ELEVATION CONTOUR
- EXISTING MAJOR ELEVATION CONTOUR
- PROPOSED MAJOR GRADING ELEVATION CONTOUR
- PROPOSED MINOR GRADING ELEVATION CONTOUR
- PROPOSED MINOR COVER ELEVATION CONTOUR
- PROPOSED MAJOR COVER ELEVATION CONTOUR
- PROPOSED LIMIT OF WASTE

NOTES:

1. FOR GENERAL NOTES, LEGEND AND ABBREVIATIONS, SEE DWG J-2.
2. FOR SITE PREPARATION PLAN SEE DWG J-6.
3. FOR CONSTRUCTION GRADING PLAN SEE DWG J-7.
4. FOR STORM DRAIN PLAN SEE DWG J-8.
5. FOR FINAL COVER GRADING PLAN SEE DWG J-9.
6. FOR FINAL COVER AND LINER DETAILS AND SECTIONS SEE DWG J-11.
7. FOR FENCE PLAN SEE DWG J-12.

GEOSYNTEC CONSULTANTS
10875 RANCHO BERNARDO ROAD, SUITE 200
SAN DIEGO, CALIFORNIA 92127
TELEPHONE: (858) 674-6559

PROJECT: BRC CAMU
HENDERSON/CLARK COUNTY NEVADA

TITLE: FINAL COVER GRADING PLAN

MARK	DATE	REVISION	BY	APPROVED

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

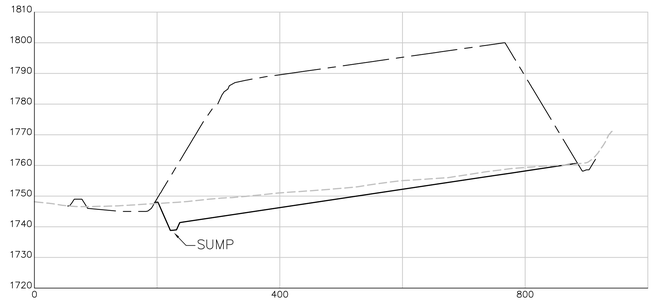
SIGNATURE

DATE

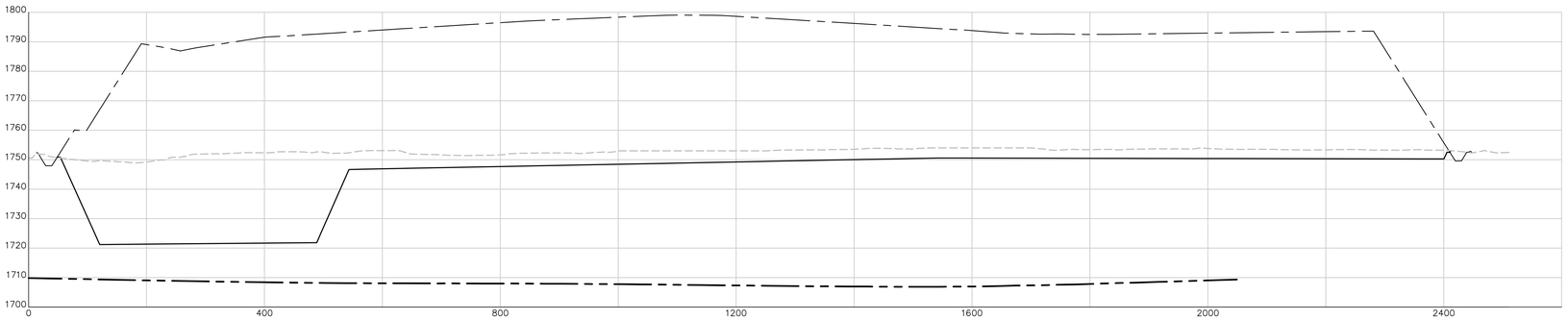
SEAL

DATE:	NOVEMBER 2006	SCALE:	AS SHOWN
DESIGN BY:	G.T.C.	JOB NO.:	SC0313
DRAWN BY:	J.R.H.	FILE NO:	
CHECKED BY:	G.T.C.	DOCUMENT NO:	
REVIEWED BY:	G.T.C.	DRAWING NO:	J-9
APPROVED BY:	G.T.C.		

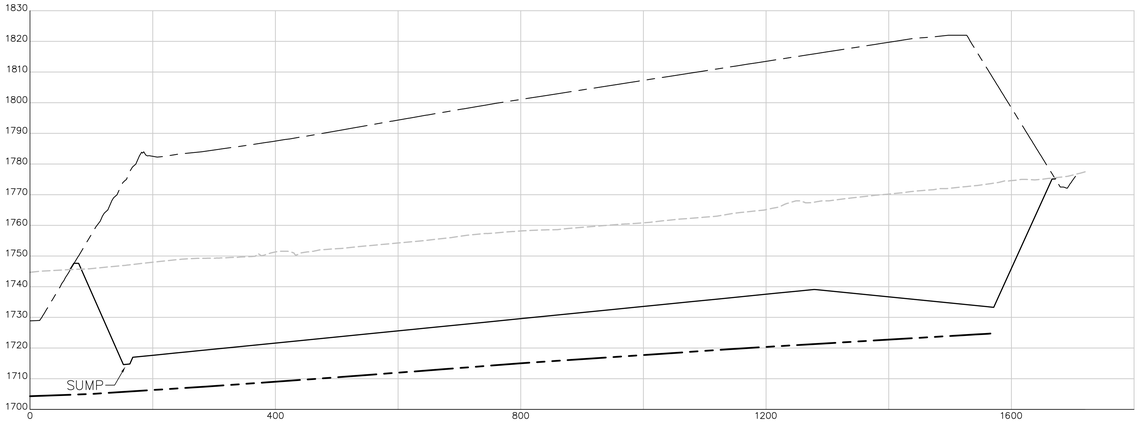
P:\PRJ\SDCadd\CADD\SC0313\BRC\figures\Construction\Revised 11-6-06\SC0313_J-9_Final Cover Plan.dwg 11/14/06 10:30 jhall



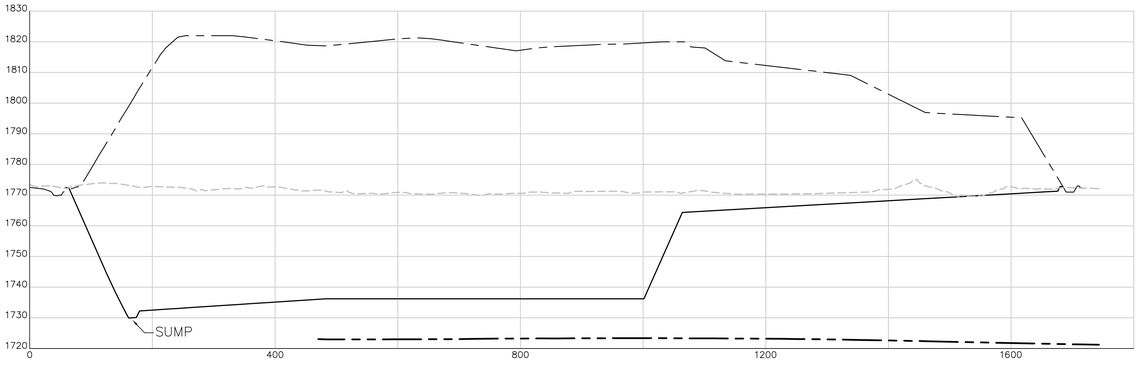
A–A 7,9 SECTION
SCALE: HORIZ. 1" = 100', VERT. 1" = 20'



B–B 7,9 SECTION
SCALE: HORIZ. 1" = 100', VERT. 1" = 20'



C–C 7,9 SECTION
SCALE: HORIZ. 1" = 100', VERT. 1" = 20'



D–D 7,9 SECTION
SCALE: HORIZ. 1" = 100', VERT. 1" = 20'

LEGEND

- FINAL COVER SURFACE
- EXCAVATION SURFACE
- EXISTING GROUND SURFACE
- GROUNDWATER SURFACE

NOTES:

1. GROUNDWATER CONTOURS PROVIDED BY MWH, DATED JULY 2005.

GEOSYNTEC CONSULTANTS
10875 RANCHO BERNARDO ROAD, SUITE 200
SAN DIEGO, CALIFORNIA 92127
TELEPHONE: (858) 674–6559

PROJECT: BRC CAMU
HENDERSON/CLARK COUNTY NEVADA

TITLE: GRADING CROSS SECTIONS

MARK	DATE	REVISION	BY	APPROVED

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

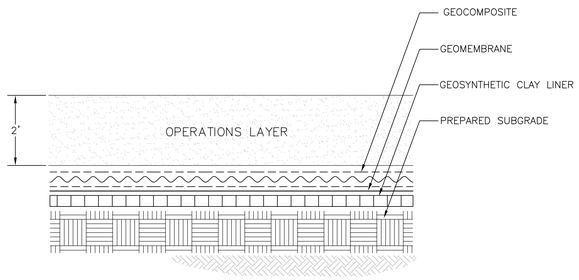
SIGNATURE

DATE

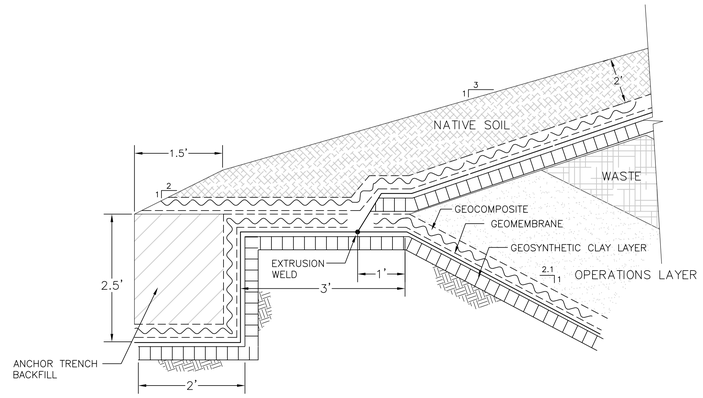
SEAL

DATE:	NOVEMBER 2006	SCALE:	AS SHOWN
DESIGN BY:	G.T.C.	JOB NO.:	SC0313
DRAWN BY:	J.R.H.	FILE NO:	
CHECKED BY:	G.T.C.	DOCUMENT NO:	
REVIEWED BY:	G.T.C.	DRAWING NO:	J–10
APPROVED BY:	G.T.C.		

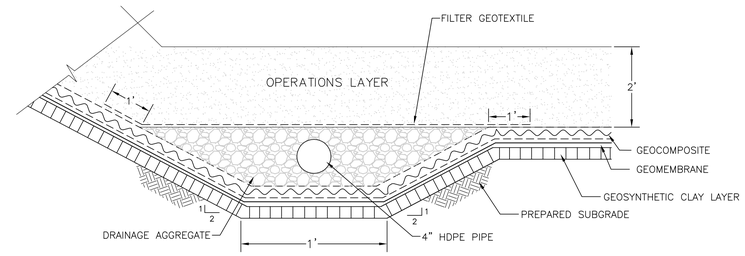
P:\PRJ\SDCadd\CADD\SC0313\BRC\figures\Construction\Revised 11-6-06\SC0313_J-10_Cross Sections.dwg 11/14/06 10:31 jhall



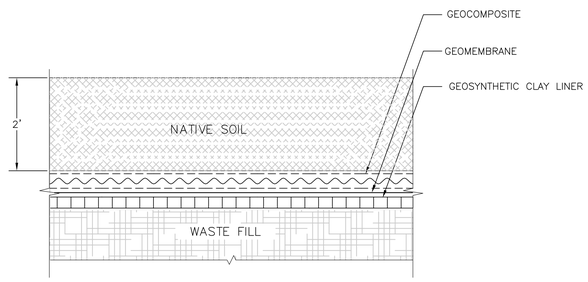
COMPOSITE LINER SECTION (1 / J-7)
NOT TO SCALE



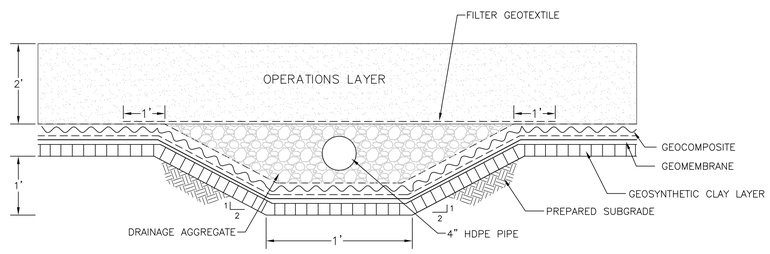
CROSS SECTION
ANCHOR TRENCH
NOT TO SCALE (3 / J-7)



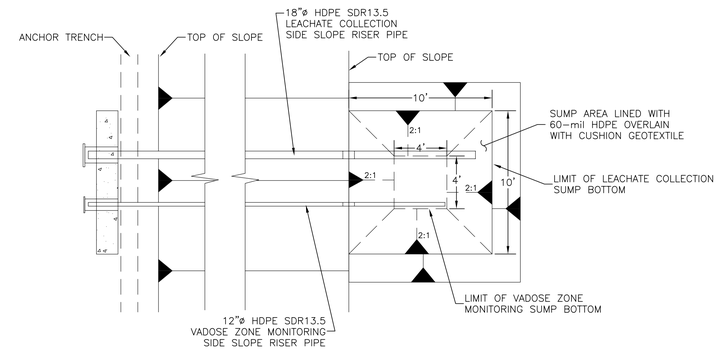
CROSS SECTION
LCRS COLLECTION TRENCH AT TOE OF SLOPE
NOT TO SCALE (4 / J-7)



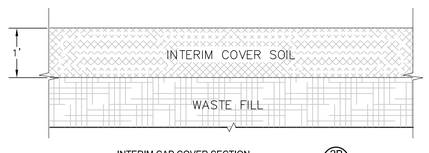
FINAL CAP COVER SECTION (2A / J-9)
NOT TO SCALE



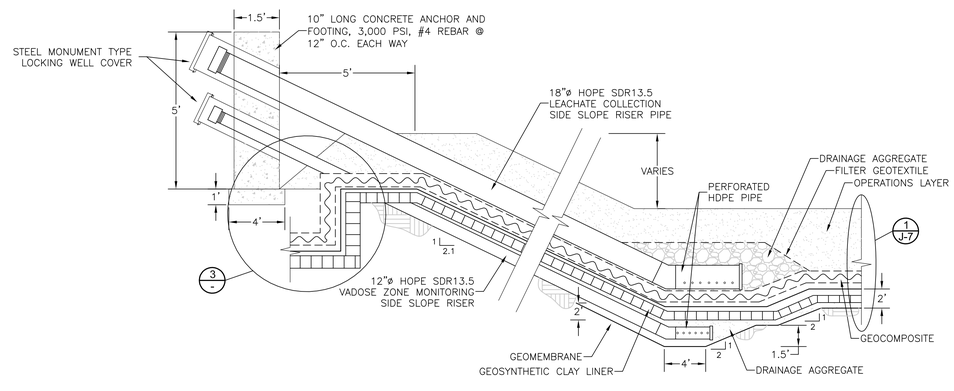
CROSS SECTION
LCRS COLLECTION TRENCH
NOT TO SCALE (5 / J-7)



DETAIL
LEACHATE COLLECTION AND VADOSE
ZONE MONITORING SUMP
NOT TO SCALE (6 / J-7)



INTERIM CAP COVER SECTION (2B / J-9)
NOT TO SCALE



CROSS SECTION
VADOSE ZONE MONITORING
SIDE SLOPE RISER
NOT TO SCALE (7 / J-7)

NOTES:
1. GEOSYNTHETIC MATERIALS SHOWN AT EXAGGERATED SCALE FOR CLARITY.

GEOSYNTEC CONSULTANTS
10875 RANCHO BERNARDO ROAD, SUITE 200
SAN DIEGO, CALIFORNIA 92127
TELEPHONE: (858) 674-6559

PROJECT: BRC CAMU
HENDERSON/CLARK COUNTY NEVADA

TITLE: FINAL COVER AND LINER DETAILS AND SECTIONS

MARK	DATE	REVISION	BY	APPROVED

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

SIGNATURE

DATE

SEAL

DATE: NOVEMBER 2006		SCALE:	AS SHOWN
DESIGN BY:	G.T.C.	JOB NO.:	SC0313
DRAWN BY:	J.R.H.	FILE NO:	
CHECKED BY:	G.T.C.	DOCUMENT NO:	
REVIEWED BY:	G.T.C.	DRAWING NO:	J-11
APPROVED BY:	G.T.C.		

P:\PRJ\SDCadd\CADD\SC0313\BRC\figures\Construction\Revised 11-6-06\SC0313_J-11_Details.dwg 11/14/06 10:31 jhall

LEGEND

- PL — BRC LANDFILL SITE BOUNDARY
- EXISTING LIMITS OF FORMER BMI LANDFILL
- EXISTING SURFACE WATER FLOW PATH
- EXISTING MINOR ELEVATION CONTOUR
- EXISTING MAJOR ELEVATION CONTOUR
- PROPOSED MINOR ELEVATION CONTOUR
- PROPOSED MAJOR ELEVATION CONTOUR
- PROPOSED LIMIT OF WASTE
- EXISTING FENCE
- PROPOSED FENCE

NOTES:

1. FOR GENERAL NOTES, LEGEND AND ABBREVIATIONS, SEE DWG J-2.
2. FOR SITE PREPARATION PLAN SEE DWG J-6.
3. FOR CONSTRUCTION GRADING PLAN SEE DWG J-7.
4. FOR STORM DRAIN PLAN SEE DWG J-8.
5. FOR FINAL COVER GRADING PLAN SEE DWG J-9.
6. FOR FINAL COVER AND LINER DETAILS AND SECTIONS SEE DWG J-11.
7. FOR FENCE PLAN SEE DWG J-12.

GEOSYNTEC CONSULTANTS
10875 RANCHO BERNARDO ROAD, SUITE 200
SAN DIEGO, CALIFORNIA 92127
TELEPHONE: (858) 674-6559

PROJECT: BRC CAMU
HENDERSON/CLARK COUNTY NEVADA

TITLE: FENCE PLAN

MARK	DATE	REVISION	BY	APPROVED

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

SIGNATURE

DATE

SEAL

DATE: NOVEMBER 2006		SCALE:	AS SHOWN
DESIGN BY:	G.T.C.	JOB NO.:	SC0313
DRAWN BY:	J.R.H.	FILE NO:	
CHECKED BY:	G.T.C.	DOCUMENT NO:	
REVIEWED BY:	G.T.C.	DRAWING NO:	J-12
APPROVED BY:	G.T.C.		

P:\PRJ\SDCadd\CADD\SC0313\BRC\figures\Construction\Revised 11-6-06\SC0313_J-12_Fence Plan.dwg 11/14/06 10:32 jhall

Section 2
Base Liner Calculation Packages

Section 2
Base Liner Calculation Packages

Calculation Package A
Cut Slope Stability

GeoSyntec Consultants

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: BRC **Project:** BRC CAMU **Project #:** SC0313 **Task #:** 01 02

Title of Computations: Slope Stability Evaluation – Cut Slopes

Computations By:

SIGNATURE — 27 March 2005 DATE

Edward M. Zielanski, P.E./Project Civil Engineer
PRINTED NAME AND TITLE

Assumptions and Procedures Checked By (Peer Reviewer):

SIGNATURE — 6/2/05 DATE

Gregory T. Corcoran, P.E./Associate
PRINTED NAME AND TITLE

Computations Checked By:

SIGNATURE — 6/2/05 DATE

Gregory T. Corcoran, P.E./Associate
PRINTED NAME AND TITLE

Computations Backchecked By (Originator):

SIGNATURE — 27 March 2005 ~~23 March 2000~~ DATE

Edward M. Zielanski, P.E./Project Civil Engineer
PRINTED NAME AND TITLE

Approved By (PM or Designate):

SIGNATURE — 6/2/05 DATE

Gregory T. Corcoran, P.E./Associate
PRINTED NAME AND TITLE

Approval Notes:

Revisions: (Number and Initial All Revisions)

No.	Sheet	Date	By	Checked By	Approval

Written by: Ed Zielanski Date: 5 / 27 / 05 (MM DD YY) Reviewed by: GTC Date: 6 / 2 / 05 (MM DD YY)

Client: BRC Project: BRC CAMU Project No.: SC0313 Task No. 01-02

SLOPE STABILITY EVALUATION
CUT SLOPES
BRC CAMU
HENDERSON, NEVADA

OBJECTIVE

The objective of this calculation package is to evaluate the stability of cut slopes (inclined at 2.1H:1V) at the BRC Corrective Action Management Unit (CAMU) in Henderson, Nevada.

DESIGN CRITERION

Because the cut slopes at the BRC CAMU will eventually be buttressed by waste they are considered interim slopes, which are normally required to exceed a static factor of safety of 1.3. However, due to limited information regarding shear strength parameters for on-site soils, GeoSyntec employed a static factor of safety equal to or greater than 1.4 as the interim slope static stability criterion. In consideration of the limited duration which the interim slopes will exist, seismic stability analyses of the cut slopes were not conducted.

METHOD OF ANALYSIS

The slope stability computer program PCSTABL5 (Achilleos, 1988) was employed for this analysis. PCSTABL5 employs limit equilibrium principles to provide general solutions to slope stability problems. Potential sliding surfaces, both circular and polygonal, can be specified or randomly generated. The Modified Janbu Method is used herein, as recommended in the PCSTABL5 manual (Achilleos 1998) for circular and polygonal failure surfaces.

In addition to the above analyses, the stability of the cut slopes is evaluated using the infinite slope methodology. An inifinite slope (or surficial sliding) without seepage in the slope is defined as:

$$FS = \frac{c}{\gamma H \cos^2\beta \tan\beta} \frac{\tan\phi}{\tan\beta} \quad \text{(Das 1994)} \qquad \text{(Equation 1)}$$

Written by: Ed Zielanski Date: 5 / 27 / 05 (MM DD YY) Reviewed by: GTC Date: 6 / 2 / 05 (MM DD YY)

Client: BRC Project: BRC CAMU Project No.: SC0313 Task No. 01-02

SUBSURFACE INFORMATION

Based on results of subsurface explorations by others (Converse 1999), the subsurface is characterized by alluvial granular soils overlying fine-grained soils encountered at depths from approximately 34-ft to 55-ft below the surface. The granular subsoils generally consist of medium to very dense granular fill and native soils overlying localized zones of moderately hard to hard cemented sand and gravel. The fine-grained soils consist of lean clays and high plasticity silts. Field and laboratory test results indicated that the native granular soils at the site have a low compressibility and moderate to high internal friction angles (Converse 1999). The fine-grained soils encountered at depth at the site generally were found to be moderately compressible, have a high expansion potential, and have relatively low permeability (Converse 1999). Groundwater was encountered at depths between 30-ft and 58-ft and was, in general, located at the approximate elevation of the lean clay layer (Converse 1999).

NATIVE MATERIAL PARAMETERS

Native material within the limits of the BRC CAMU consists of alluvial granular soils overlying fine-grained soils. Shear strength parameters for the native soil material were previously estimated and reported in the *Preliminary Geotechnical and Geologic Investigation - Industrial Non-Hazardous Disposal Facility* (Converse 1999). Twelve exploratorary borings were conducted by others to depths ranging from 33-ft to 60-ft (Converse 1999). In general, the native materials appear to be consistent between borings. Direct Shear tests were performed on selected samples retrieved from the exploratory borings. A summary of the Direct Shear test results as reported by Converse (1999) are presented in Attachment 1.

Based on data obtained by Converse (1999), the *in situ* silty sand with gravel material (fill and native) can be characterized by a moist unit weight of approximately 117 pcf (see Attachment 1 - boring logs). The sandy lean clay can be characterized by a saturated unit weight of approximately 102 pcf (see Attachment 1 - boring logs).

Based on the boring logs provided by Converse (1999), the average groundwater elevation in the vicinity of the cut slopes (borings B-8, B-12, B-5, B-4, and B-10) is approximately 49 feet below the surface (at the top of the CL layer).

Upon review of the direct shear tests performed by Converse at the BRC CAMU site, GeoSyntec has employed its own interpretation of the on-site material properties. The direct

Written by: Ed Zielanski Date: 5 / 27 / 05 (MM DD YY) Reviewed by: GTC Date: 6 / 2 / 05 (MM DD YY)

Client: BRC Project: BRC CAMU Project No.: SC0313 Task No. 01-02

shear tests performed by Converse involved shearing the soil at a relatively low normal stress, then returning the specimen to its original position, placing a larger normal stress and re-shearing the sample. This process was repeated for three different normal loads. Therefore, based on the description of the testing methods, it is unclear as to the appropriate design shear strength parameters for the on site soil.

In recognition of this, GeoSyntec has reviewed the borings logs in order to evaluate the design shear strength parameters. The boring logs indicate that the *in situ* silty sand with gravel soil (SM) is primarily dense to very dense (i.e, very high blow counts). Based on a correlation by Peck, Hanson, and Thornburn (1974), dense silty sands typically have internal friction angles on the order of 30 to 35 degrees (Attachment 4). Due to the high density of the SM material, it is assumed that the effective friction angle of the SM material to be 35 degrees. At numerous locations shown in the boring logs, the SM material was described as partially cemented. However, based on the borings logs, it is unclear as to the extent or the degree of cementation in the profile. Therefore, it is conservatively assumed that the effective cohesion of the SM material is zero.

A sandy lean clay (CL) layer exists approximately 34 to 55 feet below the surface. Based on a review of the boring logs in the area of the proposed cut slopes, the average depth to the CL layer (for borings B-8, B-12, B-5, B-4, and B-10) is approximately 49 ft. The moisture content of the lean clay is relatively close to the liquid limit, indicating a normally consolidated deposit. Therefore, the undrained shear strength of the lean clay layer can be approximated using correlations based on the plasticity index. A representative value from Converse (1999) for the plasticity index of the CL material is on the order of 32 percent (Attachment 1). Ladd (1990), presents a relationship between the plasticity index and the c/p ratio. Based on this correlation, the c/p ratio is approximately 0.24 (Attachment 2). An example calcuation to estimate the undrained shear strength at a depth of 54 feet is shown below:

Assume the SM material and water table extends to a depth of 49 ft. Therefore, the effective vertical stress, σ'_v *is:* $(\gamma_{SM})(z_{SM})+(\gamma' t_{CL}) = (117)(49\ ft)+(102-62.4)(54-49) = 5{,}931\ psf$. *The c/p ratio is assumed to be 0.24, therefore, the undrained strength is* $(0.24)(5931) \approx 1{,}400\ psf$.

Written by: Ed Zielanski Date: 5 / 27 / 05 (MM DD YY) Reviewed by: GTC Date: 6 / 2 / 05 (MM DD YY)

Client: BRC Project: BRC CAMU Project No.: SC0313 Task No. 01-02

CROSS SECTIONS

One cross section (cross section A-A') was developed to evaluate the stability of the cut slopes at the BRC CAMU. The location of this cross section is indicated on Figure 1. Cross section A-A' is a 44-ft high cut slope and represents the most critical cross section. The slope of the cross section is inclined at 2.1H:1V (horizontal:vertical).

ANALYSIS AND RESULTS

Proposed Cut Slopes – 2.1H:1V

Global Stability. Based on data from Converse (1999), the groundwater table appears to be located approximately at the elevation of the lean clay layer. In recognition of this, a piezometric surface was included in the analyses to represent the water table. The water table is placed at the top of the lean clay layer.

Two types of potential failure surfaces were analyzed, (i) circular, and (ii) polygonal. The polygonal potential failure surface assumes the failure surface occurs between the weakest interface between the silty sand (SM) and the lean clay (CL). Potential failure surfaces were evaluated using the search option of the PCSTABL5 program. Program input parameters, specifying the range of beginning and ending locations for potential circular failure surfaces, were varied by the user to focus on the location of the most critical potential failure surfaces for the given cross section.

Graphical output of the most critical potential failure surfaces of cross section A-A' is presented in Figures 2, 3, and 4. The graphical output of Figures 2 and 3 illustrates the ten most critical potential circular failure surfaces found by the PCSTABL5 analysis. The graphical output of Figures 2 and 3 illustrates the ten most critical polygonal failure. Analyses indicate that the most critical potential failure surface of cross section A-A', possesses a factor of safety of 1.46. This factor of safety satisfies the design criterion of a factor of safety equal to or greater than 1.4.

Computer output of the stability analyses for the potential surfaces of cross section A-A' is included in Attachment 3.

Surficial Sliding or Sloughing. Based on the assumption of zero cohesion for the SM material, Equation 1 becomes:

Written by: Ed Zielanski Date: 5 / 27 / 05 (MM DD YY) Reviewed by: GTC Date: 6 / 2 / 05 (MM DD YY)

Client: BRC Project: BRC CAMU Project No.: SC0313 Task No. 01-02

$$FS = \frac{\tan\phi}{\tan\beta} \qquad \text{(Equation 2)}$$

For the proposed slopes, the inclination is 2.1H:1V, therefore the factor of safety is:

$$FS = \frac{\tan 35}{1/2.1} = 1.47$$

CONCLUSIONS

- The minimum factor of safety for the proposed cut slopes (2.1H:1V) is 1.46;
- The undrained shear strength of the CL layer can be characterized with a c/p ratio of 0.24 and a unit weight of 102 pcf; and
- The shear strength of the SM material can be conservatively characterized as c'=0 and ϕ'=35 degrees and a unit weight of 117 pcf.

REFERENCES

Achilleos, E. (1988), "PC STABL5M, User Manual" *Information Report,* School of Civil Engineering, Purdue University, West Lafayette, Indiana, 132 p.

Converse (1999), "Preliminary Geotechnical and Geologic Investigation - Industrial Non-Hazardous Disposal Facility", prepared for Basic Management, Inc., October 1999. *(Attachment 1)*

Das B. M. (1994), "Principles of Geotechnical Engineering," Third Edition, PWS Publishing Company, Boston, MA

Peck, Hanson, and Thornburn (1974), "Foundation Engineering," Second Edition, John Wiley & Sons, Inc. New York. *(Attachment 4)*

Ladd, C. C., (1990) "Soft Ground Engineering," 13th Annual Spring Seminar, Geotechnical Engineering Group, Los Angeles Section of ASCE. *(Attachment 2)*

GTC 6/2/05

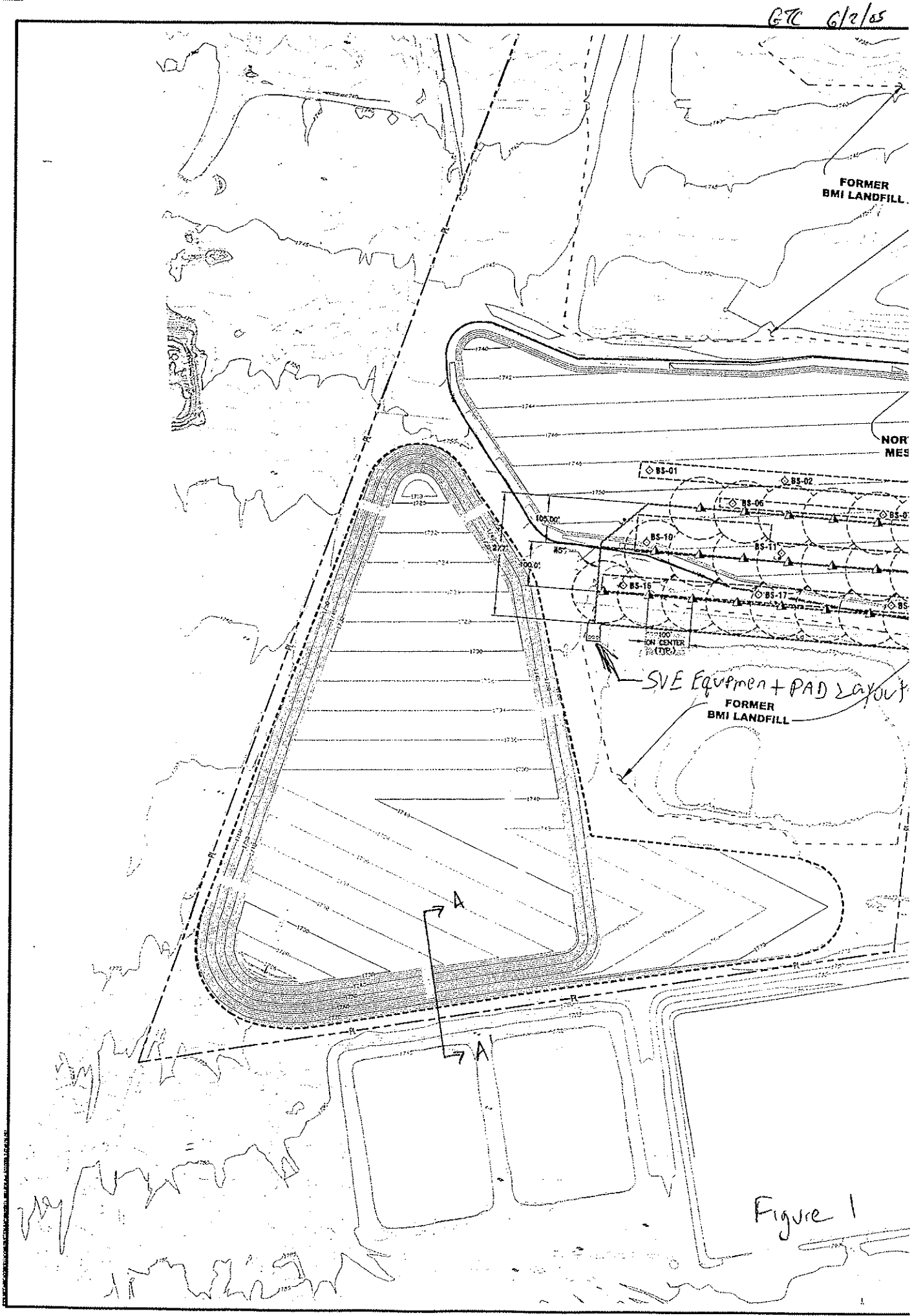
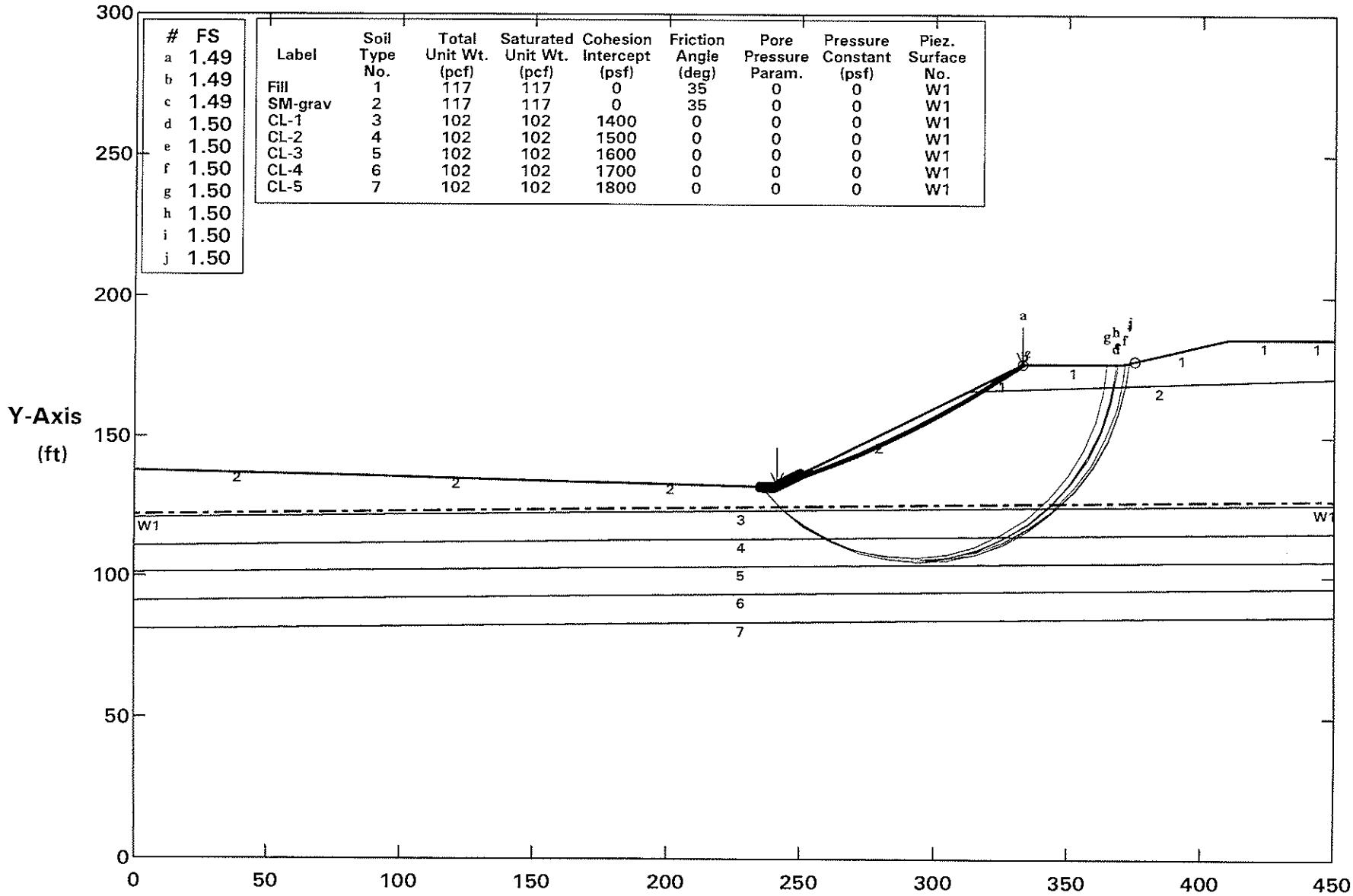


Figure 1

Section A-A' BRC CAMU, Henderson, Nevada

Ten Most Critical. C:ANEW.PLT By: EMZ 5/27/2005 9:56am



#	FS
a	1.49
b	1.49
c	1.49
d	1.50
e	1.50
f	1.50
g	1.50
h	1.50
i	1.50
j	1.50

Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Fill	1	117	117	0	35	0	0	W1
SM-grav	2	117	117	0	35	0	0	W1
CL-1	3	102	102	1400	0	0	0	W1
CL-2	4	102	102	1500	0	0	0	W1
CL-3	5	102	102	1600	0	0	0	W1
CL-4	6	102	102	1700	0	0	0	W1
CL-5	7	102	102	1800	0	0	0	W1

PCSTABL5 FSmin = 1.49 X-Axis (ft)

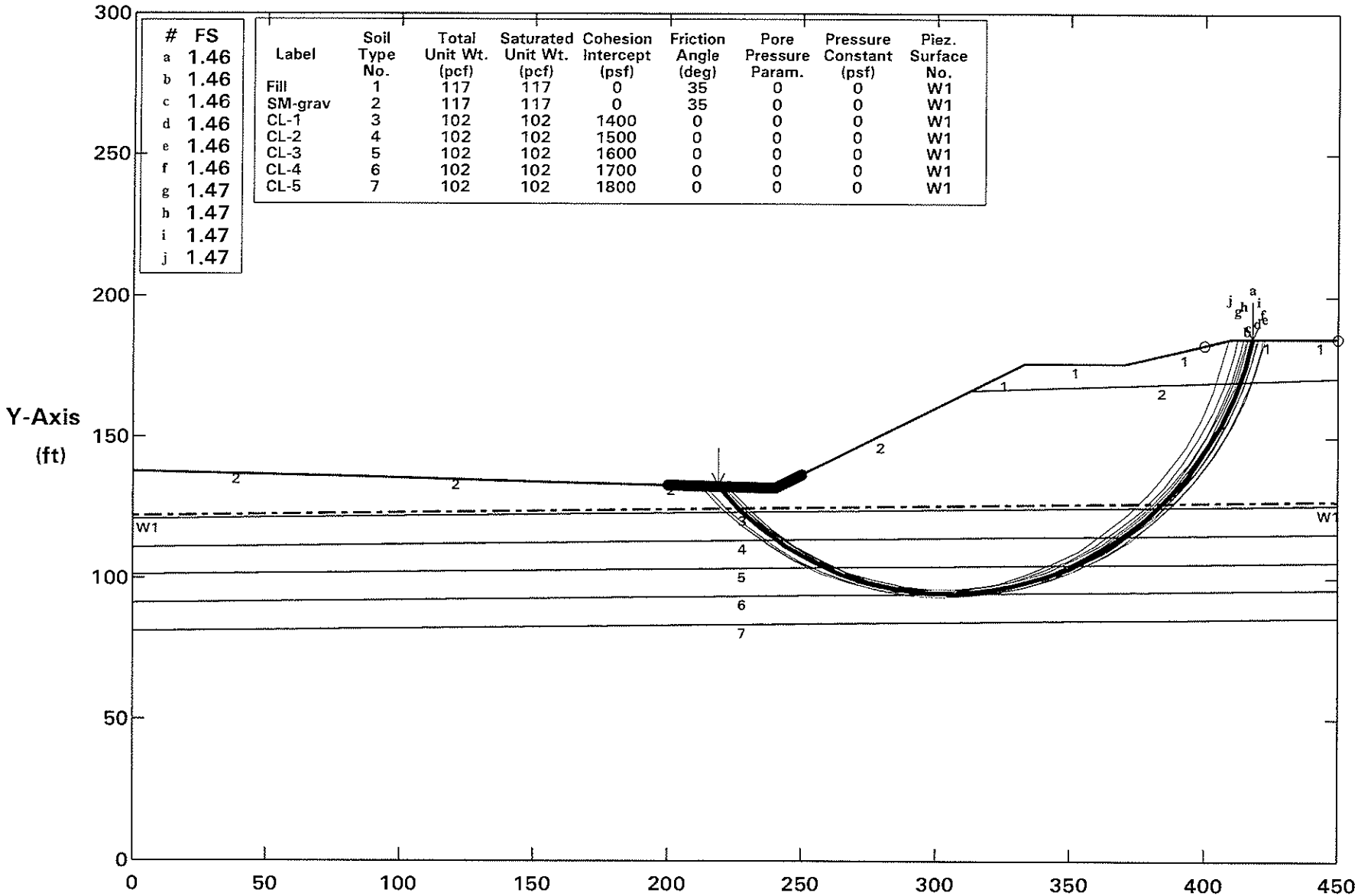
Factors Of Safety Calculated By The Modified Janbu Method

Figure 2

GTC 6/8/05

Section A-A' BRC CAMU, Henderson, Nevada

Ten Most Critical. C:A2NEW.PLT By: EMZ 5/27/2005 10:06am



#	FS
a	1.46
b	1.46
c	1.46
d	1.46
e	1.46
f	1.46
g	1.47
h	1.47
i	1.47
j	1.47

Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Fill	1	117	117	0	35	0	0	W1
SM-grav	2	117	117	0	35	0	0	W1
CL-1	3	102	102	1400	0	0	0	W1
CL-2	4	102	102	1500	0	0	0	W1
CL-3	5	102	102	1600	0	0	0	W1
CL-4	6	102	102	1700	0	0	0	W1
CL-5	7	102	102	1800	0	0	0	W1

PCSTABL5 FSmin = 1.46 X-Axis (ft)

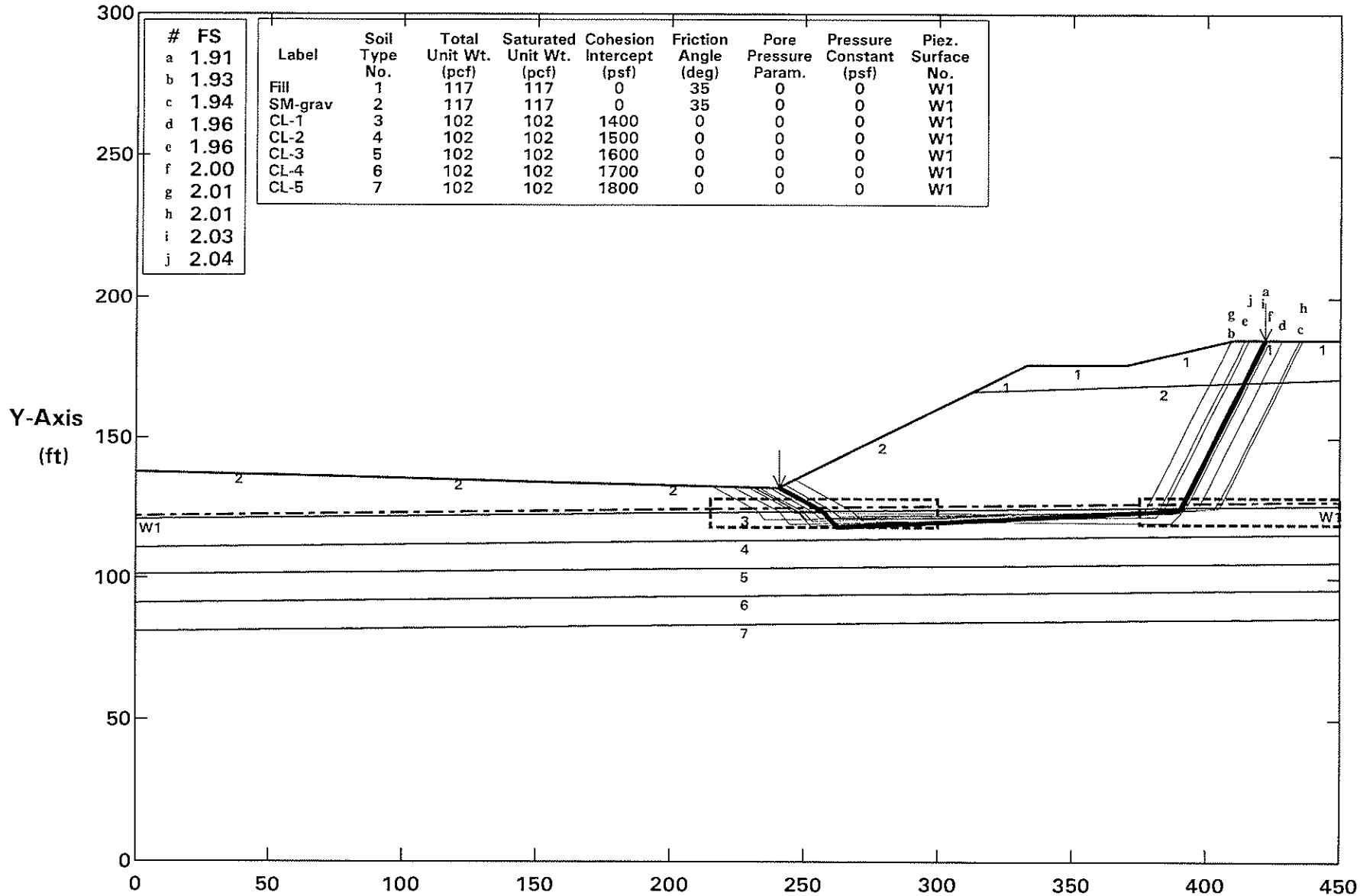
Factors Of Safety Calculated By The Modified Janbu Method

Figure 3

CRC 6/9/05

Section A-A' BRC CAMU, Henderson, Nevada

Ten Most Critical. C:A3NEW.PLT By: EMZ 5/27/2005 10:14am



#	FS
a	1.91
b	1.93
c	1.94
d	1.96
e	1.96
f	2.00
g	2.01
h	2.01
i	2.03
j	2.04

Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Fill	1	117	117	0	35	0	0	W1
SM-grav	2	117	117	0	35	0	0	W1
CL-1	3	102	102	1400	0	0	0	W1
CL-2	4	102	102	1500	0	0	0	W1
CL-3	5	102	102	1600	0	0	0	W1
CL-4	6	102	102	1700	0	0	0	W1
CL-5	7	102	102	1800	0	0	0	W1

PCSTABL5 FSmin = 1.91 X-Axis (ft)

Factors Of Safety Calculated By The Modified Janbu Method

Figure 4

GZC 6/2/05

Direct Shear Strength

A progressive direct shear test was performed on selected undisturbed samples using a constant strain rate direct shear machine in general accordance with ASTM D3080. The test specimen was trimmed and placed in the shear machine, a specified normal load was applied, and the specimen was sheared until maximum shear strength was developed. After the soil specimen had developed maximum shear resistance under the first normal load, the normal load was removed and the specimen was pushed back to its original undeformed configuration. Another normal load was then applied, and the specimen was sheared a second time. This process was repeated for three different normal loads. Results of the direct shear test are presented on Figures A-62 through A-69 and in the following table:

Exploration Location	Depth (feet)	Soil Description	Angle of Internal Friction (deg)	Coulomb Cohesion (ksf)
B-4	14-14.5	Silty sand with gravel	31	0.7
B-5	14-15	Silty sand with gravel	43	0.3
B-10	54-54.5	Sandy lean clay	26	0.85
B-12	14-15	Silty sand with gravel	40	0.3
B-101	39-40	Sandy lean clay	26	0.9
B-102	20-25	Silty sand with gravel	37	0.2
B-103	49-50	Sandy lean clay	37	1.0
B-104	10-15	Silty sand with gravel	43	0.1

Chemical Analysis

Chemical tests were performed on a representative soil samples to investigate the potential for soil corrosivity and chemical heave. Atlas Chemical Testing Laboratories, Inc. in Las Vegas performed the chemical analysis for water-soluble sulfates and sodium in general accordance with ASTM D516. The results of the chemical tests are presented on Drawing No. A-70.

AH. 1
1/3

© Converse Consultants

GTC MLD

Grain Size Distribution

Grain size distribution for soil samples were determined by sieve analysis in accordance with ASTM C136. A sieve analysis is conducted by passing the soil through a number of different sized sieves and measuring the amount of soils retained on each sieve. The test results and grain size distribution curves are presented on Drawing Nos. A-37 through A-48.

Atterberg Limits

The liquid limit, plastic limit and plasticity index of a representative sample of the fine-grained soils were determined to aid in the classification of the soils and in the evaluation of other engineering parameters. The test was performed in general accordance with ASTM test method D4318. The results of the tests are tabulated in the following table:

Exploration Location	Sample Depth, ft.	Liquid Limit, %	Plastic Limit, %	Plasticity Index	Unified Soils Classification
B-1	30-35	NP	NP	NP	SM
B-5	20-25	NP	NP	NP	SM
B-10	30-35	NP	NP	NP	SM
B-12	10-15	NP	NP	NP	SM
B-101	39-40	105	71	34	MH
B-101	54-55	54	44	10	ML
B-102	20-25	NP	NP	NP	SM
B-102	49-50	88	58	30	MH
B-103	30-35	NP	NP	NP	SM
B-104	10-15	NP	NP	NP	SM
B-105	20-25	NP	NP	NP	SW-SM
B-106	0-5	NP	NP	NP	SM

NP = Nonplastic

Attachment 1

GIC MLD

Log No. B- 8

Date of Drilling: 9/14/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 58.0

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Samples: Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SANDY LEAN CLAY With Gravel (CL); very stiff, dark brown, slightly moist	▼		49				
42									
44		---dry	▼		35/8"				K
46									
48									
		---partially cemented, moderately hard, white, dry							
		SANDY LEAN CLAY (CL); very stiff, dark brown, moist	▼		35/10"				pp=3.0
50									
52									
54			▼		16		52	71	108 pp=2.0
56									
58									
		SILTY SAND (SM); dense, brown, wet							
		SANDY LEAN CLAY (CL); stiff, dark brown, wet	▼		13		51	70	106 pp=3.0

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No.
99-33437-01

13701 GPJ

GTC MLD

Log No. B-12

Date of Drilling: 9/14/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 37.5

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY OLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SANDY LEAN CLAY (CL); very stiff, dark brown, moist	▼		44				
42									
44									
		---wet, stiff	▼		15		80	53	95 pp=1.5
46									
48									
			▼		11				
50									
52									
		---with gravel, very stiff							
54			▼		16		31	87	114 pp=1.5
56									
58									
			▼		18				pp=1.5

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

ON ATTACHED

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No.
99-33437-01

GTC MLD

Log No. B-101

Date of Drilling: 9/20/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 42.0

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
					10				
		SILTY SAND With Gravel (SM); medium dense, grayish brown, dry							
42									
		SANDY LEAN CLAY (CL); stiff, dark brown, moist							
44					11		45	67	97
46									
48									
					25				pp=1.5
50		---partially cemented lens, moderately hard, brownish white, wet							
52									
54					11		42	75	107 A
		---with gravel							
56									
58					14		42	74	106

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

NO ON FILE BY GLE

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No.
99-33437-01

43701.GPJ

GTC MLD

Log No. B- 1

Date of Drilling: 9/23/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 53.0

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SILTY SAND With Gravel (SM); dense, light brown, slightly moist			35				
22									G;P
24					35		7	108	116
26									
28		---grayish brown							
					35/6"				
30		---very dense			53				A
									G
32									
34					35/3"				
36									
38		---dense			35/6"				

End of Exploration at 55.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No.
99-33437-01

3343701.GP

48 GTC MLD

Log No. B- 4

Date of Drilling: 9/13/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 54.5

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SILTY SAND With Gravel (SM); very dense, brown, dry			35/2"				
22									
24		---dense			49				K
26									
28									
		---few gravel			35		7	107	114
30					42				
32									
34		---with gravel, very dense			35/8"		4		
36									
38		---with boulders							
		CEMENTED SAND AND GRAVEL; hard, brown, dry			20/0"				

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

3701 GPJ

GTC MLD

Log No. B- 5

Date of Drilling: 9/15/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 52.5

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		FILL: SILTY SAND With Gravel; tan, dry			9				
2									
4		---slightly moist			35/5"				
					58				
6									
8		---with cobbles							
		SILTY SAND With Gravel (SM); dense, tan, slightly moist			31		5	115	121
10					29				
12									K;Sol; Ch
14					43		4	111 115	DS
16									
18									
		---very dense			57/8"				

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No.
99-33437-01

GTC MLD

Log No. B- 5

Date of Drilling: 9/15/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 52.5

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SILTY SAND With Gravel (SM); dense, tan, slightly moist			32				A
22									G;P;Ch
24					58/8"				
		---very dense							
26									
28		---brown							
		CLAYEY SAND With Gravel (SC); dense, dark brown, slightly moist			35/5"		6	112	119
30					35/6"				
		SILTY SAND With Gravel (SM); dense, black, slightly moist							
32		---dark brown							
34		---very dense			50/3"				
36									
38		---with cobbles			50/6"				

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No.
99-33437-01

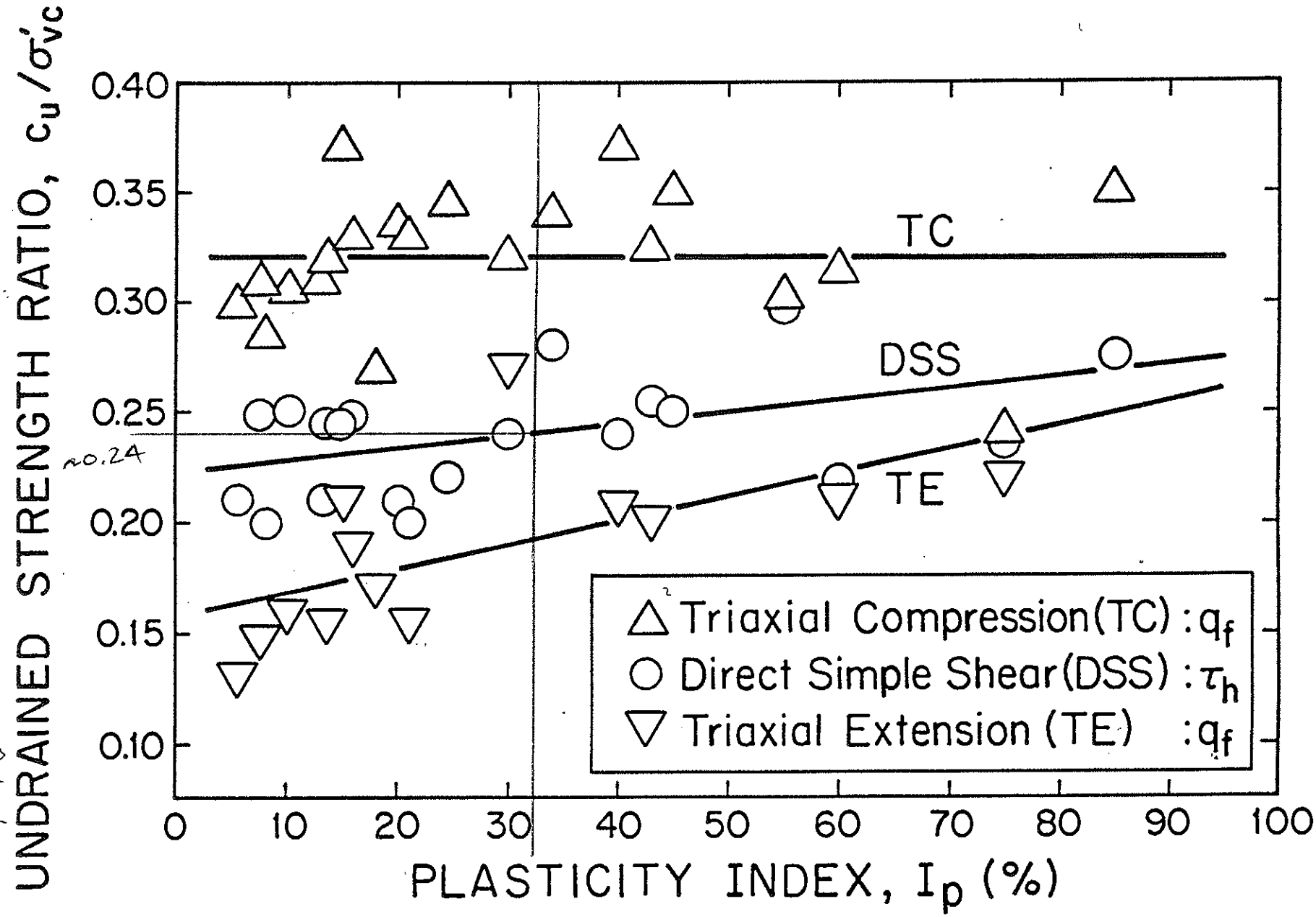


FIG. 15.-Undrained Strength Anisotropy from CK_oU Tests on Normally Consolidated Clays and Silts (data from Lefebvre et al. 1983; Vaid Campanella 1974; and various MIT and NGI reports)

** PCSTABL5 **

by
Purdue University

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

Run Date: 5/27/2005
Time of Run: 9:56am
Run By: EMZ
Input Data Filename: C:ANEW
Output Filename: C:ANEW.OUT
Plotted Output Filename: C:ANEW.PLT

PROBLEM DESCRIPTION Section A-A'
BRC CAMU, Henderson, Nevada

BOUNDARY COORDINATES

9 Top Boundaries
15 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	.00	138.00	80.00	136.00	2
2	80.00	136.00	164.00	134.00	2
3	164.00	134.00	240.00	132.00	2
4	240.00	132.00	313.00	166.50	2
5	313.00	166.50	333.00	176.00	1
6	333.00	176.00	370.00	176.00	1
7	370.00	176.00	410.00	185.00	1
8	410.00	185.00	436.00	185.00	1
9	436.00	185.00	450.00	185.00	1
10	313.00	166.50	450.00	170.75	2
11	.00	121.00	450.00	126.00	3
12	.00	111.00	450.00	116.00	4
13	.00	101.00	450.00	106.00	5
14	.00	91.00	450.00	96.00	6
15	.00	81.00	450.00	86.00	7

ISOTROPIC SOIL PARAMETERS

7 Type(s) of Soil

Attachment 3A

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	117.0	117.0	.0	35.0	.00	.0	1
2	117.0	117.0	.0	35.0	.00	.0	1
3	102.0	102.0	1400.0	.0	.00	.0	1
4	102.0	102.0	1500.0	.0	.00	.0	1
5	102.0	102.0	1600.0	.0	.00	.0	1
6	102.0	102.0	1700.0	.0	.00	.0	1
7	102.0	102.0	1800.0	.0	.00	.0	1

---

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 2 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	.00	122.00
2	450.00	127.00

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

2000 Trial Surfaces Have Been Generated.

10 Surfaces Initiate From Each Of200 Points Equally Spaced Along The Ground Surface Between X = 235.00 ft.
and X = 250.00 ft.

Each Surface Terminates Between X = 333.00 ft.
and X = 375.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = .00 ft.

11.00 ft. Line Segments Define Each Trial Failure Surface.

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Janbu Method * *

Failure Surface Specified By 11 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	241.18	132.56
2	251.59	136.12
3	261.90	139.96
4	272.10	144.08
5	282.18	148.48
6	292.14	153.14
7	301.97	158.08
8	311.67	163.27
9	321.22	168.73
10	330.62	174.45
11	333.02	176.00

*** 1.487 ***

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	249.77	136.62
2	260.26	139.95
3	270.62	143.64
4	280.84	147.70
5	290.92	152.12
6	300.83	156.89
7	310.56	162.01
8	320.11	167.47
9	329.46	173.27
10	333.55	176.00

*** 1.490 ***

Failure Surface Specified By 11 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	242.24	133.06
2	252.62	136.69
3	262.91	140.57
4	273.11	144.69
5	283.21	149.05
6	293.20	153.65
7	303.09	158.48
8	312.85	163.54
9	322.50	168.83
10	332.02	174.34
11	334.73	176.00

*** 1.491 ***

Failure Surface Specified By 18 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	235.00	132.13
2	242.78	124.36
3	251.61	117.79
4	261.29	112.57
5	271.62	108.80
6	282.39	106.57
7	293.37	105.91
8	304.33	106.85
9	315.04	109.37
10	325.27	113.41
11	334.82	118.88
12	343.46	125.68
13	351.04	133.65
14	357.38	142.64
15	362.36	152.45
16	365.87	162.88
17	367.83	173.70
18	367.91	176.00

*** 1.497 ***

Failure Surface Specified By 18 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	235.30	132.12

2	243.09	124.36
3	251.92	117.80
4	261.60	112.58
5	271.94	108.81
6	282.71	106.58
7	293.69	105.92
8	304.65	106.86
9	315.36	109.37
10	325.60	113.40
11	335.14	118.86
12	343.80	125.65
13	351.39	133.61
14	357.75	142.59
15	362.74	152.39
16	366.27	162.81
17	368.26	173.63
18	368.35	176.00

*** 1.498 ***

Failure Surface Specified By 18 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	235.08	132.13
2	242.89	124.39
3	251.72	117.83
4	261.38	112.57
5	271.69	108.72
6	282.43	106.36
7	293.40	105.53
8	304.38	106.25
9	315.14	108.51
10	325.48	112.26
11	335.20	117.42
12	344.09	123.90
13	351.98	131.56
14	358.72	140.26
15	364.16	149.81
16	368.21	160.04
17	370.79	170.73
18	371.32	176.30

*** 1.499 ***

Failure Surface Specified By 17 Coordinate Points

Point	X-Surf	Y-Surf

No.	(ft)	(ft)
1	235.08	132.13
2	242.89	124.39
3	251.77	117.89
4	261.51	112.79
5	271.90	109.18
6	282.72	107.16
7	293.71	106.76
8	304.64	108.00
9	315.26	110.85
10	325.35	115.25
11	334.67	121.09
12	343.02	128.25
13	350.21	136.57
14	356.09	145.87
15	360.53	155.93
16	363.42	166.54
17	364.54	176.00

*** 1.500 ***

Failure Surface Specified By 18 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	235.45	132.12
2	243.26	124.37
3	252.11	117.83
4	261.81	112.64
5	272.15	108.92
6	282.93	106.73
7	293.92	106.12
8	304.87	107.11
9	315.57	109.68
10	325.78	113.77
11	335.29	119.29
12	343.90	126.14
13	351.43	134.15
14	357.72	143.18
15	362.64	153.02
16	366.08	163.47
17	367.97	174.31
18	368.01	176.00

*** 1.500 ***

Failure Surface Specified By 18 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	235.38	132.12
2	243.17	124.36
3	251.97	117.76
4	261.61	112.45
5	271.89	108.55
6	282.62	106.11
7	293.58	105.19
8	304.56	105.81
9	315.35	107.96
10	325.73	111.59
11	335.51	116.64
12	344.48	123.00
13	352.48	130.55
14	359.35	139.14
15	364.95	148.61
16	369.18	158.76
17	371.95	169.41
18	372.78	176.63

*** 1.501 ***

Failure Surface Specified By 18 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	235.23	132.13
2	243.07	124.41
3	251.91	117.87
4	261.57	112.61
5	271.87	108.75
6	282.61	106.35
7	293.57	105.47
8	304.55	106.11
9	315.34	108.28
10	325.72	111.92
11	335.49	116.97
12	344.47	123.33
13	352.47	130.87
14	359.36	139.45
15	364.98	148.91
16	369.24	159.05
17	372.05	169.68
18	372.88	176.65

*** 1.501 ***

** PCSTABL5 **

by
Purdue University

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

Run Date: 5/27/2005
Time of Run: 10:14am
Run By: EMZ
Input Data Filename: C:A3NEW
Output Filename: C:A3NEW.OUT
Plotted Output Filename: C:A3NEW.PLT

PROBLEM DESCRIPTION Section A-A'
BRC CAMU, Henderson, Nevada

BOUNDARY COORDINATES

9 Top Boundaries
15 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	.00	138.00	80.00	136.00	2
2	80.00	136.00	164.00	134.00	2
3	164.00	134.00	240.00	132.00	2
4	240.00	132.00	313.00	166.50	2
5	313.00	166.50	333.00	176.00	1
6	333.00	176.00	370.00	176.00	1
7	370.00	176.00	410.00	185.00	1
8	410.00	185.00	436.00	185.00	1
9	436.00	185.00	450.00	185.00	1
10	313.00	166.50	450.00	170.75	2
11	.00	121.00	450.00	126.00	3
12	.00	111.00	450.00	116.00	4
13	.00	101.00	450.00	106.00	5
14	.00	91.00	450.00	96.00	6
15	.00	81.00	450.00	86.00	7

ISOTROPIC SOIL PARAMETERS

7 Type(s) of Soil

Attachment 3B

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	117.0	117.0	.0	35.0	.00	.0	1
2	117.0	117.0	.0	35.0	.00	.0	1
3	102.0	102.0	1400.0	.0	.00	.0	1
4	102.0	102.0	1500.0	.0	.00	.0	1
5	102.0	102.0	1600.0	.0	.00	.0	1
6	102.0	102.0	1700.0	.0	.00	.0	1
7	102.0	102.0	1800.0	.0	.00	.0	1

---

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 2 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	.00	122.00
2	450.00	127.00

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Sliding Block Surfaces, Has Been Specified.

The Active And Passive Portions Of The Sliding Surfaces Are Generated According To The Rankine Theory.

100 Trial Surfaces Have Been Generated.

2 Boxes Specified For Generation Of Central Block Base

Length Of Line Segments For Active And Passive Portions Of Sliding Block Is 11.0

Box No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Height (ft)
1	215.00	123.00	300.00	123.00	10.00
2	375.00	124.00	450.00	124.00	10.00

**** ERROR - BK12 ****
Points on active or passive wedges are outside defined ground surface

---

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Janbu Method * *

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	240.76	132.36
2	247.35	128.94
3	257.10	123.86
4	262.66	118.30
5	389.77	124.35
6	390.76	125.34
7	395.84	135.10
8	400.92	144.86
9	406.00	154.61
10	411.08	164.37
11	413.82	169.63
12	418.90	179.38
13	421.82	185.00

*** 1.908 ***

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	223.66	132.43
2	230.72	128.75
3	240.48	123.67
4	244.90	119.25
5	375.27	122.34
6	378.13	125.20
7	383.21	134.96
8	388.29	144.72
9	393.37	154.47
10	398.45	164.23
11	401.05	169.23
12	406.13	178.99
13	409.16	184.81

*** 1.926 ***

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	231.25	132.23
2	237.78	128.83
3	247.54	123.75
4	252.78	118.50
5	402.74	124.63
6	403.59	125.48
7	408.67	135.24
8	413.74	145.00
9	418.82	154.76
10	423.90	164.51
11	426.77	170.03
12	431.85	179.79
13	434.57	185.00

*** 1.939 ***

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	233.47	132.17
2	239.85	128.85
3	249.60	123.77
4	253.12	120.26
5	396.00	124.20
6	397.21	125.41
7	402.29	135.17
8	407.36	144.93
9	412.44	154.68
10	417.52	164.44
11	420.33	169.83
12	425.41	179.59
13	428.23	185.00

*** 1.956 ***

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	237.40	132.07
2	243.50	128.89
3	253.26	123.81
4	255.69	121.38
5	381.28	123.37
6	383.16	125.26
7	388.24	135.01
8	393.32	144.77
9	398.40	154.53
10	403.48	164.29
11	406.13	169.39
12	411.21	179.15
13	414.26	185.00

*** 1.959 ***

Failure Surface Specified By 14 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	246.87	135.25
2	249.00	134.14
3	258.76	129.06
4	268.51	123.98
5	272.04	120.46
6	386.92	119.71
7	392.57	125.36
8	397.64	135.12
9	402.72	144.88
10	407.80	154.63
11	412.88	164.39
12	415.64	169.68
13	420.72	179.44
14	423.61	185.00

*** 2.002 ***

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)

1	242.98	133.41
2	251.48	128.98
3	261.24	123.90
4	263.33	121.81
5	376.30	123.49
6	378.00	125.20
7	383.08	134.96
8	388.16	144.71
9	393.24	154.47
10	398.32	164.23
11	400.92	169.23
12	406.00	178.98
13	409.02	184.78

*** 2.013 ***

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	231.76	132.22
2	238.26	128.83
3	248.01	123.76
4	250.87	120.89
5	403.98	124.60
6	404.87	125.50
7	409.95	135.26
8	415.03	145.01
9	420.11	154.77
10	425.19	164.53
11	428.08	170.07
12	433.16	179.83
13	435.85	185.00

*** 2.014 ***

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	229.33	132.28
2	236.00	128.81
3	245.76	123.73
4	246.14	123.35
5	387.50	123.23
6	389.60	125.33
7	394.68	135.09

8	399.76	144.84
9	404.84	154.60
10	409.92	164.36
11	412.64	169.59
12	417.72	179.35
13	420.67	185.00

*** 2.028 ***

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	215.59	132.64
2	223.22	128.67
3	232.98	123.59
4	235.35	121.22
5	381.50	122.19
6	384.58	125.27
7	389.66	135.03
8	394.73	144.79
9	399.81	154.54
10	404.89	164.30
11	407.56	169.43
12	412.64	179.19
13	415.67	185.00

*** 2.041 ***

** PCSTABL5 **

by
Purdue University

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

Run Date:	5/27/2005
Time of Run:	10:06am
Run By:	EMZ
Input Data Filename:	C:A2NEW
Output Filename:	C:A2NEW.OUT
Plotted Output Filename:	C:A2NEW.PLT

PROBLEM DESCRIPTION Section A-A'
BRC CAMU, Henderson, Nevada

BOUNDARY COORDINATES

9 Top Boundaries
15 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	.00	138.00	80.00	136.00	2
2	80.00	136.00	164.00	134.00	2
3	164.00	134.00	240.00	132.00	2
4	240.00	132.00	313.00	166.50	2
5	313.00	166.50	333.00	176.00	1
6	333.00	176.00	370.00	176.00	1
7	370.00	176.00	410.00	185.00	1
8	410.00	185.00	436.00	185.00	1
9	436.00	185.00	450.00	185.00	1
10	313.00	166.50	450.00	170.75	2
11	.00	121.00	450.00	126.00	3
12	.00	111.00	450.00	116.00	4
13	.00	101.00	450.00	106.00	5
14	.00	91.00	450.00	96.00	6
15	.00	81.00	450.00	86.00	7

ISOTROPIC SOIL PARAMETERS

7 Type(s) of Soil

Attachment 3C

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	117.0	117.0	.0	35.0	.00	.0	1
2	117.0	117.0	.0	35.0	.00	.0	1
3	102.0	102.0	1400.0	.0	.00	.0	1
4	102.0	102.0	1500.0	.0	.00	.0	1
5	102.0	102.0	1600.0	.0	.00	.0	1
6	102.0	102.0	1700.0	.0	.00	.0	1
7	102.0	102.0	1800.0	.0	.00	.0	1

---

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 2 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	.00	122.00
2	450.00	127.00

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

2000 Trial Surfaces Have Been Generated.

10 Surfaces Initiate From Each Of200 Points Equally Spaced Along The Ground Surface Between X = 200.00 ft.
and X = 250.00 ft.

Each Surface Terminates Between X = 400.00 ft.
and X = 450.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = .00 ft.

11.00 ft. Line Segments Define Each Trial Failure Surface.

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Janbu Method * *

Failure Surface Specified By 25 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	218.59	132.56
2	226.38	124.79
3	234.86	117.79
4	243.97	111.63
5	253.62	106.35
6	263.73	102.01
7	274.20	98.64
8	284.95	96.28
9	295.87	94.94
10	306.86	94.64
11	317.84	95.38
12	328.69	97.16
13	339.33	99.95
14	349.66	103.74
15	359.58	108.49
16	369.01	114.15
17	377.86	120.68
18	386.06	128.02
19	393.53	136.10
20	400.19	144.84
21	406.01	154.18
22	410.91	164.03
23	414.86	174.30
24	417.82	184.89
25	417.84	185.00

*** 1.459 ***

Failure Surface Specified By 25 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	212.06	132.74
2	219.84	124.96
3	228.31	117.94
4	237.39	111.73
5	247.00	106.38
6	257.07	101.94

7	267.50	98.46
8	278.21	95.95
9	289.10	94.44
10	300.09	93.94
11	311.08	94.46
12	321.97	95.99
13	332.68	98.52
14	343.10	102.03
15	353.16	106.49
16	362.76	111.85
17	371.83	118.08
18	380.28	125.12
19	388.05	132.91
20	395.06	141.39
21	401.26	150.47
22	406.59	160.09
23	411.02	170.16
24	414.49	180.60
25	415.52	185.00

*** 1.463 ***

Failure Surface Specified By 24 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	220.60	132.51
2	228.41	124.76
3	236.93	117.80
4	246.08	111.69
5	255.77	106.49
6	265.92	102.25
7	276.43	99.01
8	287.21	96.80
9	298.14	95.63
10	309.14	95.52
11	320.10	96.47
12	330.92	98.48
13	341.49	101.51
14	351.72	105.55
15	361.52	110.56
16	370.78	116.49
17	379.44	123.28
18	387.39	130.87
19	394.58	139.20
20	400.94	148.18
21	406.40	157.73
22	410.91	167.76
23	414.44	178.18
24	416.03	185.00

*** 1.463 ***

Failure Surface Specified By 24 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	222.36	132.46
2	230.15	124.69
3	238.64	117.70
4	247.76	111.55
5	257.42	106.30
6	267.54	101.99
7	278.03	98.67
8	288.79	96.37
9	299.72	95.10
10	310.71	94.89
11	321.68	95.72
12	332.52	97.60
13	343.13	100.50
14	353.41	104.41
15	363.28	109.27
16	372.63	115.06
17	381.39	121.71
18	389.48	129.17
19	396.81	137.37
20	403.33	146.23
21	408.98	155.67
22	413.69	165.61
23	417.44	175.95
24	419.77	185.00

*** 1.464 ***

Failure Surface Specified By 25 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	222.11	132.47
2	229.92	124.73
3	238.43	117.75
4	247.55	111.60
5	257.21	106.34
6	267.32	102.00
7	277.79	98.63
8	288.53	96.26
9	299.44	94.90
10	310.44	94.58
11	321.42	95.29

12	332.28	97.02
13	342.93	99.76
14	353.28	103.50
15	363.23	108.18
16	372.70	113.78
17	381.60	120.24
18	389.86	127.51
19	397.39	135.52
20	404.15	144.21
21	410.06	153.48
22	415.07	163.28
23	419.14	173.49
24	422.24	184.05
25	422.42	185.00

*** 1.464 ***

Failure Surface Specified By 25 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	219.60	132.54
2	227.38	124.76
3	235.85	117.75
4	244.94	111.55
5	254.57	106.23
6	264.65	101.82
7	275.09	98.37
8	285.81	95.90
9	296.71	94.45
10	307.70	94.01
11	318.69	94.59
12	329.57	96.20
13	340.26	98.81
14	350.65	102.40
15	360.67	106.95
16	370.22	112.40
17	379.23	118.72
18	387.60	125.86
19	395.28	133.73
20	402.19	142.29
21	408.27	151.46
22	413.48	161.15
23	417.76	171.28
24	421.09	181.76
25	421.79	185.00

*** 1.464 ***

Failure Surface Specified By 24 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	217.84	132.58
2	225.69	124.87
3	234.24	117.96
4	243.42	111.90
5	253.15	106.76
6	263.32	102.59
7	273.86	99.41
8	284.65	97.27
9	295.59	96.18
10	306.59	96.15
11	317.54	97.18
12	328.34	99.27
13	338.89	102.39
14	349.09	106.52
15	358.84	111.61
16	368.05	117.62
17	376.64	124.49
18	384.53	132.16
19	391.64	140.55
20	397.90	149.59
21	403.26	159.20
22	407.67	169.28
23	411.09	179.73
24	412.26	185.00

*** 1.465 ***

Failure Surface Specified By 24 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	220.60	132.51
2	228.45	124.80
3	237.00	117.88
4	246.18	111.83
5	255.91	106.69
6	266.09	102.53
7	276.63	99.37
8	287.42	97.25
9	298.37	96.18
10	309.37	96.18
11	320.32	97.25
12	331.11	99.38
13	341.65	102.54
14	351.83	106.71
15	361.55	111.84
16	370.74	117.90

17	379.29	124.82
18	387.13	132.53
19	394.18	140.97
20	400.39	150.06
21	405.68	159.70
22	410.01	169.81
23	413.35	180.29
24	414.35	185.00

*** 1.465 ***

Failure Surface Specified By 25 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	213.57	132.70
2	221.36	124.93
3	229.82	117.91
4	238.89	111.68
5	248.49	106.30
6	258.53	101.82
7	268.94	98.26
8	279.63	95.67
9	290.51	94.05
10	301.50	93.44
11	312.49	93.82
12	323.40	95.20
13	334.15	97.56
14	344.63	100.89
15	354.77	105.15
16	364.48	110.32
17	373.68	116.35
18	382.29	123.19
19	390.25	130.79
20	397.49	139.07
21	403.94	147.98
22	409.56	157.44
23	414.29	167.37
24	418.11	177.69
25	420.08	185.00

*** 1.465 ***

Failure Surface Specified By 24 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)

1	212.31	132.73
2	220.09	124.95
3	228.58	117.96
4	237.70	111.81
5	247.37	106.56
6	257.50	102.27
7	267.99	98.97
8	278.75	96.69
9	289.68	95.45
10	300.68	95.26
11	311.65	96.14
12	322.48	98.05
13	333.08	101.00
14	343.34	104.95
15	353.18	109.87
16	362.50	115.71
17	371.22	122.41
18	379.26	129.93
19	386.54	138.17
20	393.00	147.08
21	398.57	156.56
22	403.20	166.54
23	406.86	176.91
24	408.80	184.73

*** 1.465 ***

stresses associated with failure. As the number of tests increases indefinitely, it is apparent that the envelope of the failure circles (Fig. 4.6*a*) represents the locus of points associated with failure of the specimens. The envelope is known as the *rupture line* for the given material under the specific conditions of the series of tests. For materials in general, the rupture line may be curved, and it may have an intercept c on the axis of shearing stress. Since the values of shearing strength t corresponding to the rupture line all represent failure, they are designated as values of shearing strength s, and the vertical axis in Fig. 4.6*a* is called the axis of shearing strength. If the rupture line is considered to be straight, it may be represented by

$$s = c + p \tan \phi \qquad 4.2$$

known as *Coulomb's equation*.

From the geometry of Fig. 4.6*b*, it may be seen that for any failure circle

$$2\alpha = 90^\circ + \phi$$

Therefore, the angle between the planes on which failure occurs and the plane on which the major principal stress acts is

$$\alpha = 45^\circ + \frac{\phi}{2} \qquad 4.3$$

4.6. Shearing Strength of Dry Sands and Gravels

The rupture lines for dry sands and gravels pass through the origin of the rupture diagram; hence, the intercept c is equal to zero. If the material is in a loose state, the rupture line is linear and may be represented accurately by the equation

$$s = p \tan \phi_d \qquad 4.4$$

where ϕ_d is the angle between the rupture line and the p-axis. For the same materials in a dense state, the rupture line has a slight downward curvature, but for practical purposes in foundation engineering it may also be represented by eq. 4.4.

For gravels, sands, silty sands, and inorganic cohesionless silts the value of ϕ_d depends primarily on the relative density, the grain-size distribution, and the shape of the grains. It may be estimated with the aid of Table 4.1.

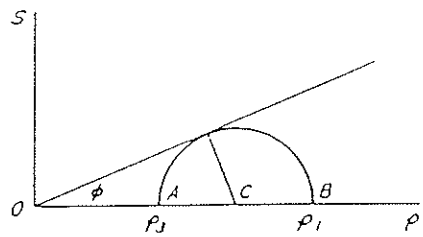
Table 4.1 Representative Values of ϕ_d for Sands and Silts

Material	Degrees	
	Loose	Dense
Sand, round grains, uniform	27.5	34
Sand, angular grains, well graded	33	45
Sandy gravel	35	50
Silty sand	27–33	30–35
Inorganic silt	27–30	30–34

ILLUSTRATIVE PROBLEM

A drained triaxial test is to be performed on a uniform dense sand with rounded grains. The all-around pressure p_3 is to be 2 tons/sq ft. At about what vertical pressure should the sample fail?

Solution. If $s = p \tan \phi$, it can be seen from the sketch that



$$\frac{p_1}{p_3} = \frac{OC + CB}{OC - AC} = \frac{OC + OC \sin \phi}{OC - OC \sin \phi}$$
$$= \frac{1 + \sin \phi}{1 - \sin \phi}$$

Whence by trigonometric transformation

$$\frac{p_1}{p_3} = \tan^2\left(45^\circ + \frac{\phi}{2}\right) = \frac{1}{\tan^2[45^\circ - (\phi/2)]}$$

According to Table 4.1, the value of ϕ_d is likely to be about 34°. Therefore,

$$\tan^2\left(45^\circ + \frac{\phi_d}{2}\right) = \tan^2(45^\circ + 17^\circ)$$
$$= 1.881^2 = 3.54$$

Attachment-2. 4

Calculation Package B
Final Waste Slope Stability

GeoSyntec Consultants

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: Basic Remediation Company

Project: BRC CAMU **Project/Proposal #:** SC0313 **Task #:** 01

Title of Computations: Slope Stability Evaluation – Final Waste Slopes

Computations By:
SIGNATURE — DATE 11/2/06
Meghan Lithgow, Staff Engineer
PRINTED NAME AND TITLE

Assumptions and Procedures Checked By (Peer Reviewer):
SIGNATURE — DATE 11/3/06
Gregory T. Corcoran, PE / Principal
PRINTED NAME AND TITLE

Computations Checked By:
SIGNATURE — DATE 11/3/06
Gregory T. Corcoran, PE / Principal
PRINTED NAME AND TITLE

Computations Backchecked By (Originator):
SIGNATURE — DATE 11/3/06
Meghan Lithgow, Staff Engineer
PRINTED NAME AND TITLE

Approved By (PM or Designate):
SIGNATURE — DATE 11/3/06
Gregory T. Corcoran, PE / Principal
PRINTED NAME AND TITLE

Approval Notes:

Revisions: (Number and Initial All Revisions)

No.	Sheet	Date	By	Checked By	Approval

Written by: Meghan Lithgow Date: 08 / 06 / 06 (MM DD YY) Reviewed by: GTC Date: 11 / 3 / 06 (MM DD YY)

Client: BRC Project: BRC CAMU Project No.: SC0313 Task No.: 01-02

SLOPE STABILITY EVALUATION
FINAL WASTE SLOPES
BRC CAMU

OBJECTIVE

The objective of this calculation package is to evaluate the stability of the final waste soil slopes of the BRC Corrective Action Management Unit (CAMU) located in Henderson, Nevada.

APPROACH OF ANALYSES

One of the important aspects in performing slope stability analyses is the selection of appropriate material parameters. With respect to landfill design, experience dictates that the weakest materials are typically the geosynthetic materials of the composite liner system. Hence, selection of material parameters for the composite liner system, specifically internal and interface shear strength properties are typically the most critical.

Ideally, lining shear strength properties should be determined from the results of laboratory testing conducted on site specific lining materials. In lieu of conducting a laboratory testing program with site specific materials, material shear strength properties may be adopted from values reported in literature or values gained from experience. However, shear strength properties are dependent on the laboratory testing conditions (e.g. confining pressures, shearing rate, degree of saturation). In addition, published material shear strength properties may be very general or explicitly product specific. Subsequently, employing published or experience-based shear strength parameters in slope stability analyses may require that restrictions be placed on the actual products and specific application conditions to ensure that the constructed slope is representative of the slope evaluated in stability analyses.

To minimize the restrictions placed on the actual products used and the specific application condition of the products in the construction of the BRC CAMU, the slope stability analyses presented herein were conducted using the following approach:

1. Determine the minimum shear strength parameters (internal or interface) of the composite liner components satisfying design criteria as indicated by results of slope stability analyses (i.e. back-analysis);

Written by: Meghan Lithgow Date: 08 / 06 / 06 (MM DD YY) Reviewed by: [illegible] Date: 11 / 03 / 06 (MM DD YY)

Client: BRC Project: BRC CAMU Project No.: SC0313 Task No.: 01-02

2. Demonstrate, using shear strength values reported in literature, that commercially available products exist which reportedly satisfy the minimum shear strength parameters; and
3. Based on the minimum shear strength parameters and shear strength values reported in literature, develop specific requirements for the composite liner system components which must be satisfied as demonstrated through results of laboratory testing of site specific materials to be included in the Technical Specifications.

DESIGN CRITERION

In current practice, a static factor of safety of 1.5 is generally required for final refuse slopes. To evaluate static stability at the BRC CAMU, GeoSyntec established a minimum static factor of safety of 1.5 as the stability criteria.

METHOD OF ANALYSIS

The slope stability computer program SLOPE/W (GeoStudio, 2006) was employed for this analysis. SLOPE/W employs limit equilibrium principles to provide general solutions to slope stability problems for a variety of slip surface shapes, pore-water pressure conditions, soil properties, analysis methods, and loading conditions. Potential sliding surfaces, both circular and polygonal, can be specified or randomly generated.

CROSS SECTIONS

Two cross sections were developed (cross sections A-A' and B-B') to evaluate stability of the waste soil slopes of the BRC CAMU. The locations of these cross sections are indicated in Figure 1. The cross sections were selected and developed considering that the most likely potential failure surfaces would propagate along the composite liner system. In addition, the slopes with the largest heights were chosen to represent the most critical conditions. Cross sections A-A' and B-B' are representative of approximately a 2% liner slope behind a 3H:1V (horizontal:vertical) 47-ft high slope of cover soil.

The slope stability calculations are based on the conceptual design grading plans developed by GeoSyntec. Additional calculations may have to be performed if changes are made to the aforementioned design grading plans.

Written by: Meghan Lithgow Date: 08 / 06 / 06 (MM DD YY) Reviewed by: GTC Date: 01 / 3 / 06 (MM DD YY)

Client: BRC Project: BRC CAMU Project No.: SC0313 Task No.: 01-02

MATERIAL PARAMETERS

In order to determine the critical material parameters of the composite liner system through back-analyses, it is necessary to establish the material parameters for non-liner system components of the slope configurations. Non-liner system components involved in the evaluation of waste soil stability include waste soil and native geologic materials. The selection of material parameters for the non-liner system components used for slope stability analyses are presented herein.

Waste Soil Material

For the purposes herein, the waste soil material is assumed to be similar to soils located at the BRC CAMU site. The *in situ* properties determined by Converse (1999) characterize the BRC CAMU site soils as alluvial granular soils overlying fine-grained soils encountered at depths from approximately 34-ft to 55-ft below the surface. Based on Converse (1999) the alluvial granular soils are classified as silty sand with gravel (SM). The fine-grained soils are classified as sandy lean clay (CL). Therefore, it is assumed that the waste soil can be classified as a silty sand with gravel (SM). A sample boring log is presented in Attachment 1 to represent the typical subsurface profile.

Direct shear tests were preformed on retrieved samples by Converse (1999). The *in situ* material properties evaluated by Converse (1999) are presented in Attachment 2. Based on results by Converse (1999) the silty sand with gravel is assumed to have a friction angle of 40 degrees and cohesion of 300 psf. For this analysis, GeoSyntec assumes a friction angle equal to 31 degrees and a cohesion of 300 psf.

Written by: Meghan Lithgow Date: 08 / 06 / 06 (MM DD YY) Reviewed by: GTC Date: 11 / 3 / 06 (MM DD YY)

Client: BRC Project: BRC CAMU Project No.: SC0313 Task No.: 01-02

Converse reported a maximum dry density of 132 pcf and an optimum water content of 8.7 percent for materials at the site. Therefore, assuming 95% relative compaction, the dry density in the field is approximately 125 pcf. Adding the weight of water, the unit weight is approximately 136 pcf.

Native Material

Native material within the limits of the BRC CAMU consists of alluvial granular soils overlying fine-grained soils. Shear strength parameters for the native soil material were previously estimated and reported in the *Preliminary Geotechnical and Geologic Investigation - Industrial Non-Hazardous Disposal Facility* (Converse 1999). Twelve exploratory borings were conducted by others to depths ranging from 33-ft to 60-ft (Converse 1999). In general, the native materials appear to be consistent between borings. Direct Shear tests were performed on selected undisturbed samples retrieved from the exploratory borings. A summary of the Direct Shear test results as reported by Converse (1999) is presented in Attachment 2.

GeoSyntec performed stability calculations for the proposed fill slopes at the BRC CAMU. Fill slope stability calculations are presented in Appendix X, "*Slope Stability Evaluation - Fill Slopes*".

RESULTS OF ANALYSES

Stability analyses were conducted on cross sections A-A' and B-B' using the computer program SLOPE/W. Because the composite liner system of solid waste landfills introduces the weakest materials within a typical cross section, polygonal or wedge shaped potential failure surfaces propagating along the composite liner system were investigated. Potential wedge failure surfaces were evaluated using the solver function of the SLOPE/W program to search for the lowest factor of safety using both force and moment analyses. The locations of potential failure surface searches were varied throughout the cross section by the user to focus on the location of the most critical potential failure surface (defined as the potential failure surface yielding the lowest factor of safety) for the given cross section.

A composite liner system represented by an apparent friction angle of 12 degrees and no geosynthetic adhesion yields a factor of safety of 1.7 for the most critical potential failure surface of cross section A-A' and 1.6 for cross section B-B' (Attachment 3).

Written by: Meghan Lithgow Date: 08 / 06 / 06 (MM DD YY) Reviewed by: GRC Date: 11 / 3 / 06 (MM DD YY)

Client: BRC Project: BRC CAMU Project No.: SC0313 Task No.: 01-02

REVIEW OF MATERIAL SHEAR STRENGTHS REPORTED IN LITERATURE

Results of the stability analyses indicate that the minimum allowable apparent internal or interface friction angle for components of the composite liner system is 12 degrees. The objective herein is to identify the potential internal and interface sliding surfaces of the composite liner system proposed for the BRC CAMU and to estimate potential values of internal and interface friction angles based on values reported in literature. The proposed base and side slope composite liner system is comprised of, from top to bottom:

- 2 ft. thick operations layer;
- Drainage geocomposite with an 8 oz/sy geotextile bonded to both sides of the geonet;
- 60 mil HDPE geomembrane liner (textured top and bottom);
- Geosynthetic clay liner (GCL); and
- Prepared subgrade or waste soil.

The estimated internal and/or interface shear strengths for each of the potential composite liner system materials as reported in literature and the corresponding reference are presented below. Values listed below, unless otherwise noted, represent post-peak or residual friction angles.

The type of GCL considered is a geotextile-backed GCL. The geotextile-backed GCL consists of a layer of bentonite between two geotextiles.

Written by: Meghan Lithgow Date: 08 / 06 / 06 (MM DD YY) Reviewed by: GTC Date: 11 / 3 / 06 (MM DD YY)

Client: BRC Project: BRC CAMU Project No.: SC0313 Task No.: 01 -02

The following presents a summary of published interface friction values:

Material/Interface	c', Friction Angle[1]	Reference
-Operations layer	0, 32 degrees	NAVFAC (1982) (Att. 4)[2,3]
-Operations layer/GT	0, 29 degrees	Koerner (1995) (Att. 5)[4]
-GT/leachate collection aggregate	0, 34 degrees	Koerner (1995) (Att. 5)[4,5]
-Leachate collection aggregate	0, 37 degrees	NAVFAC (1982) (Att. 4)[2,5]
-Geotextile/textured GM	0, 19 degrees	Li and Gilbert (1999) (Att. 7)[6]
-Textured GM/GCL	0, 12 degrees	Bentomat (Att. 6)[8]
-GCL (internal)	0, 16 degrees	Bentomat (Att. 6)[7]
-GCL (GT backed)/subgrade	0, 31 degrees	Bentomat (Att. 6)[8]
-Prepared Subgrade	0, 35 degrees	Converse (1999) (Att. 2)

where:
GT = geotextile
GM = geomembrane
GCL = geosynthetic clay liner

Notes:

1. For the sake of comparison herein, the adhesion of the geosynthetic interfaces (geosynthetic cohesion) is neglected. All values are presented in terms of effective stress strength parameters.

2. NAVFAC (1982) lists typical shear strength values for various soils based on 100 percent standard Proctor compaction. Actual construction materials would likely be placed at 90 percent of the modified Proctor compaction which for the sake of the comparison presented herein roughly corresponds to 100 percent standard Proctor compaction.

3. Value of friction angle for a silty sand designated under the USCS classification system as a SM.

4. Koerner (1995) suggests that an efficiency of greater than 90 percent for the interface of nonwoven, needle-punched geotextiles to various soils can be achieved. Efficiency values are based on the relationship, Efficiency = tan(interface friction angle)/tan(soil friction angle). The interface friction angle presented herein was calculated using a 90 percent efficiency and the estimated soil friction angle. Adhesion is neglected.

5. Value of friction angle for a well graded or poorly graded gravel designated under the USCS classification system as a GW or GP.

Written by: Meghan Lithgow Date: 08 / 06 / 06 (MM DD YY) Reviewed by: GTC Date: 11 / 3 / 06 (MM DD YY)

Client: BRC Project: BRC CAMU Project No.: SC0313 Task No.: 01-02

6. Li and Gilbert (1999) reports an average secant friction angle of a Gundline HDT 60-mil HDPE geomembrane/Trivira 1145 interface of 19 degrees under a confining pressure of 50 psi at a large-displacement (Attachment 8).

7. According to the Summary of Bentomat Direct Shear Test Data (Attachment 6) a friction angle of 24 degrees is represents typical reported peak displacement internal shear strength values for the GCLs. Note that this represents typical results of hydrated test conditions within the range of normal stresses from 14 to 142 psi. The peak displacement internal shear strength equals approximately 16 degrees when reduced by a factor of safety of 1.5. This reduction in the internal shear strength is conservative considered in the absence of site specific test data.

8. Reported data from the Summary of Bentomat Direct Shear Test Data (Attachment 6). Note that this represents typical results of hydrated test conditions within the range of normal stresses from 7.5 to 30 psi for the respective interface.

CONCLUSIONS

Results of stability analyses presented herein indicate that an apparent internal or interface friction angle (residual) of 12 degrees for any component of the composite liner system is the minimum allowable value providing for a static factor of safety that satisfies the design criteria of 1.5.

A review of potential internal and interface shear strengths reported in literature for materials representative of the components of the proposed composite liner system at the BRC CAMU was conducted. Based on the shear strength values reported in literature, proposed composite liner interfaces exhibit apparent internal and interface friction angles greater than the minimum allowable value of 12 degrees evaluated herein.

Furthermore, it is crucial that interface shear tests be conducted on the actual materials proposed for use in the composite liner system. Based on the analyses presented herein, results of interface shear tests on the actual materials proposed for use in the composite liner system must indicate that the weakest **apparent residual friction angle** of the composite liner system is equal to or greater than 12 degrees. Note that the **apparent friction angle** differs from the friction angle determined from the failure envelope developed directly from results of direct shear tests. The **apparent friction angle** is determined from the failure envelope of the data points from direct shear test results which have been linearly regressed through the origin of the normal stress/shear stress plot.

Written by: Meghan Lithgow Date: 08 / 06 / 06 (MM DD YY) Reviewed by: GC Date: 11 / 3 / 06 (MM DD YY)

Client: BRC Project: BRC CAMU Project No.: SC0313 Task No.: 01 -02

The results of interface shear testing are directly dependent on the test conditions including normal stress levels, rate of shear, degree of saturation, and amount of displacement. It is imperative that these test conditions are representative of the anticipated conditions at the BRC CAMU when testing actual materials proposed for use in the composite liner system.

LIST OF FIGURES

Figure 1 Location of Cross Sections, BRC CAMU

LIST OF ATTACHMENTS

Attachment 1 Sample Boring Log (Converse 1999)
Attachment 2 Direct Shear Tests (Converse 1999)
Attachment 3 SLOPE/W Analysis Output Cross Sections A-A' and B-B'
Attachment 4 Typical Properties of Compacted Soils (After NAVFAC, 1982)
Attachment 5 Friction Values and Efficiencies (After Koerner, 1995)
Attachment 6 Bentomat Direct Shear Testing Summary, (CETCO, Revised 3/98)
Attachment 7 Direct Shear Test Results of Textured HDPE geomembrane/ non-woven geotextile interface (Li and Gilbert 1999)
Attachment 8 Average Secant Friction Angles of Gundline HDT/Trevira 1145 Interfaces From Baseline and Slow Tests

Written by: Meghan Lithgow Date: 08 / 06 / 06 (MM DD YY) Reviewed by: GC Date: 11 / 3 / 06 (MM DD YY)

Client: BRC Project: BRC CAMU Project No.: SC0313 Task No.: 01 -02

REFERENCES

Achilleos, E. (1988), "PC STABL5M, User Manual", *Information Report,* School of Civil Engineering, Purdue University, West Lafayette, Indiana, 132 p.

CETCO (1997), Colloidal Environmental Technologies Company, Technical Data Sheet for Bentomat - Direct Shear Testing Summary, Manufacturer's Brochure.

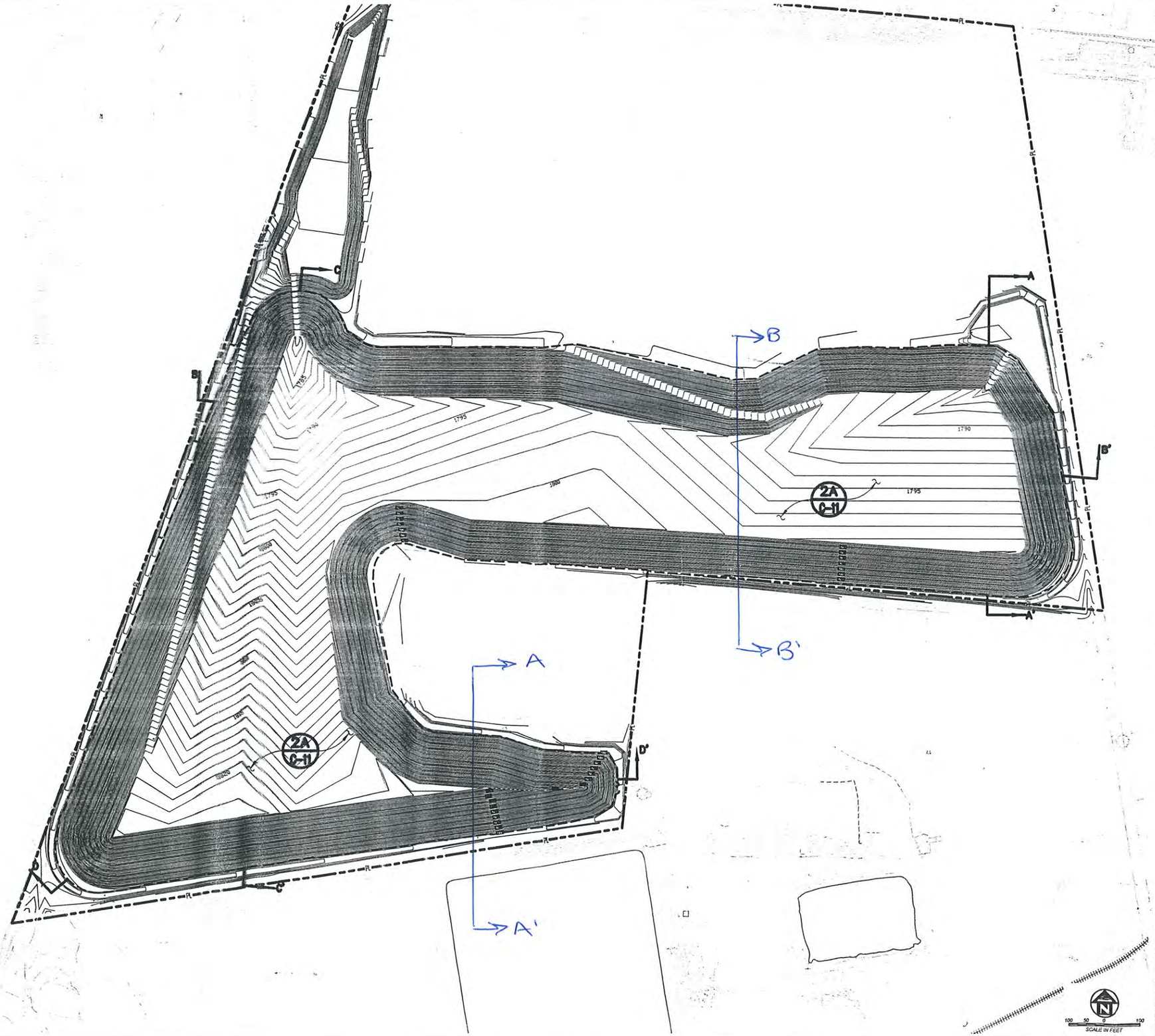
Koerner, R.M. (1995), *Designing with Geosynthetics*, Third Edition, Prentice Hall, New Jersey

Li, M-H, Gilbert, R. B. (1999), "Shear Strength of Textured Geomembrane and nonwoven Geotextile Interfaces, Geosynthetics 1999 Conference Proceedings, Vol. 1, April 30, 1999.

NAVFAC (1982), "Foundations and Earth Structures, Design Manual - 7.2," Department of Navy, Naval Facilities Engineering Command, May 1982.

Converse (1999), "Preliminary Geotechnical and Geologic Report - Industrial Non-Hazardous Disposal Facility (Converse 1999)", prepared for Basic Management, Inc., October 1999.

G-TC
11/7/06



LEGEND

- BRC LANDFILL SITE BOUNDARY
- EXISTING LIMITS OF FORMER BMI LANDFILL
- EXISTING MINOR ELEVATION CONTOUR
- EXISTING MAJOR ELEVATION CONTOUR
- PROPOSED MINOR ELEVATION CONTOUR
- PROPOSED MAJOR ELEVATION CONTOUR
- PROPOSED LIMIT OF WASTE

NOTES:

1. FOR GENERAL NOTES, LEGEND AND ABBREVIATIONS, SEE DWG C-2.
2. FOR SITE PREPARATION PLAN SEE DWG C-6.
3. FOR CONSTRUCTION GRADING PLAN SEE DWG C-7.
4. FOR EROSION CONTROL AND STORM DRAIN PLAN SEE DWG C-8.
5. FOR CROSSECTIONS SEE DWG C-10.
6. FOR FINAL COVER AND LINER DETAILS AND SECTIONS SEE DWG C-11.
7. FOR FENCE PLAN SEE DWG C-12.

100 50 0 100
SCALE IN FEET

FIGURE 1

GEOSYNTEC CONSULTANTS
10875 RANCHO BERNARDO ROAD, SUITE 300
SAN DIEGO, CALIFORNIA 92127
TELEPHONE: (858) 674-6099

PROJECT:
BRC CAMU
HENDERSON/CLARK COUNTY NEVADA

TITLE:
FINAL COVER GRADING PLAN
PERMITTING CONSTRUCTION PLAN

DATE: OCTOBER 2006	CHECKED BY:	G.T.C.	SCALE: 1"=100'		FIGURE NO:
DESIGN BY: TAW	REVIEWED BY (PRINCIPAL):	G.T.C.	JOB NO.: SC0313-01-04		8
DRAWN BY: T.L.Z.	DOCUMENT NO:		FILE NO:		

Direct Shear Strength

A progressive direct shear test was performed on selected undisturbed samples using a constant strain rate direct shear machine in general accordance with ASTM D3080. The test specimen was trimmed and placed in the shear machine, a specified normal load was applied, and the specimen was sheared until maximum shear strength was developed. After the soil specimen had developed maximum shear resistance under the first normal load, the normal load was removed and the specimen was pushed back to its original undeformed configuration. Another normal load was then applied, and the specimen was sheared a second time. This process was repeated for three different normal loads. Results of the direct shear test are presented on Figures A-62 through A-69 and in the following table:

Exploration Location	Depth (Feet)	Soil Description	Angle of Internal Friction (deg)	Coulomb Cohesion (ksf)
B-4	14-14.5	Silty sand with gravel	31	0.7
B-5	14-15	Silty sand with gravel	43	0.3
B-10	54-54.5	Sandy lean clay	26	0.85
B-12	14-15	Silty sand with gravel	40	0.3
B-101	39-40	Sandy lean clay	26	0.9
B-102	20-25	Silty sand with gravel	37	0.2
B-103	49-50	Sandy lean clay	37	1.0
B-104	10-15	Silty sand with gravel	43	0.1

Chemical Analysis

Chemical tests were performed on a representative soil samples to investigate the potential for soil corrosivity and chemical heave. Atlas Chemical Testing Laboratories, Inc. in Las Vegas performed the chemical analysis for water-soluble sulfates and sodium in general accordance with ASTM D516. The results of the chemical tests are presented on Drawing No. A-70.

AH. 1
1/3

GTC MLD

Grain Size Distribution

Grain size distribution for soil samples were determined by sieve analysis in accordance with ASTM C136. A sieve analysis is conducted by passing the soil through a number of different sized sieves and measuring the amount of soils retained on each sieve. The test results and grain size distribution curves are presented on Drawing Nos. A-37 through A-48.

Atterberg Limits

The liquid limit, plastic limit and plasticity index of a representative sample of the fine-grained soils were determined to aid in the classification of the soils and in the evaluation of other engineering parameters. The test was performed in general accordance with ASTM test method D4318. The results of the tests are tabulated in the following table:

Exploration Location	Sample Depth, ft.	Liquid Limit, %	Plastic Limit, %	Plasticity Index	Unified Soils Classification
B-1	30-35	NP	NP	NP	SM
B-5	20-25	NP	NP	NP	SM
B-10	30-35	NP	NP	NP	SM
B-12	10-15	NP	NP	NP	SM
B-101	39-40	105	71	34	MH
B-101	54-55	54	44	10	ML
B-102	20-25	NP	NP	NP	SM
B-102	49-50	88	58	30	MH
B-103	30-35	NP	NP	NP	SM
B-104	10-15	NP	NP	NP	SM
B-105	20-25	NP	NP	NP	SW-SM
B-106	0-5	NP	NP	NP	SM

NP = Nonplastic

Attachment 1

GTC

Direct Shear Strength

A progressive direct shear test was performed on selected undisturbed samples using a constant strain rate direct shear machine in general accordance with ASTM D3080. The test specimen was trimmed and placed in the shear machine, a specified normal load was applied, and the specimen was sheared until maximum shear strength was developed. After the soil specimen had developed maximum shear resistance under the first normal load, the normal load was removed and the specimen was pushed back to its original undeformed configuration. Another normal load was then applied, and the specimen was sheared a second time. This process was repeated for three different normal loads. Results of the direct shear test are presented on Figures A-62 through A-69 and in the following table:

Exploration Location	Depth (Feet)	Soil Description	Angle of Internal Friction (deg)	Coulomb Cohesion (ksf)
B-4	14-14.5	Silty sand with gravel	31	0.7
B-5	14-15	Silty sand with gravel	43	0.3
B-10	54-54.5	Sandy lean clay	26	0.85
B-12	14-15	Silty sand with gravel	40	0.3
B-101	39-40	Sandy lean clay	26	0.9
B-102	20-25	Silty sand with gravel	37	0.2
B-103	49-50	Sandy lean clay	37	1.0
B-104	10-15	Silty sand with gravel	43	0.1

Chemical Analysis

Chemical tests were performed on a representative soil samples to investigate the potential for soil corrosivity and chemical heave. Atlas Chemical Testing Laboratories, Inc. in Las Vegas performed the chemical analysis for water-soluble sulfates and sodium in general accordance with ASTM D516. The results of the chemical tests are presented on Drawing No. A-70.

Attachment 2

1/1

GTC MLD

Log No. B- 8

Date of Drilling: 9/14/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 58.0

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SANDY LEAN CLAY With Gravel (CL); very stiff, dark brown, slightly moist	▼		49				
42									
44		—dry	▼		35/8"				K
46									
48									
		---partially cemented, moderately hard, white, dry							
		SANDY LEAN CLAY (CL); very stiff, dark brown, moist	▼		35/10"				pp=3.0
50									
52									
54			▼		16		52	71	108 pp=2.0
56									
58		SILTY SAND (SM); dense, brown, wet							
		SANDY LEAN CLAY (CL); stiff, dark brown, wet	▼		13		51	70	106 pp=3.0

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No.
99-33437-01

701 GPJ

GTC MLD

Log No. B-12

Date of Drilling: 9/14/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 37.5

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Samples: Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SANDY LEAN CLAY (CL); very stiff, dark brown, moist			44				
42									
44									
		—wet, stiff			15		80	53	95 pp=1.5
46									
48									
					11				
50									
52									
		—with gravel, very stiff							
54					16		31	87	114 pp=1.5
56									
58									
					18				pp=1.5

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

ON

VIED BY

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No.
99-33437-01

134701.GPJ

GTC MLD

Log No. B-101

Date of Drilling: 9/20/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 42.0

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
					10				
		SILTY SAND With Gravel (SM); medium dense, grayish brown, dry							
42									
		SANDY LEAN CLAY (CL); stiff, dark brown, moist							
44					11		45	67	97
46									
48									
					25				pp=1.5
50		---partially cemented lens, moderately hard, brownish white, wet							
52									
54					11		42	75	107 A
		---with gravel							
56									
58					14		42	74	106

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

ON

ED BY

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No.
99-33437-01

43701.GPJ

GTC MLD

Log No. B- 1

Date of Drilling: 9/23/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 53.0

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY CLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SILTY SAND With Gravel (SM); dense, light brown, slightly moist			35				
22									G;P
24					35		7	108	116
26									
28		---grayish brown							
					35/6"				
30		---very dense			53				A
									G
32									
34					35/3"				
36									
38		---dense			35/6"				

End of Exploration at 55.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

334701.GPJ

GTC MLD

Log No. B- 4

Date of Drilling: 9/13/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 54.5

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Samples: Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SILTY SAND With Gravel (SM); very dense, brown, dry			35/2"				
22									
24		—dense			49				K
26									
28									
		---few gravel			35		7	107	114
30					42				
32									
34		---with gravel, very dense			35/8"		4		
36									
38		---with boulders							
		CEMENTED SAND AND GRAVEL; hard, brown, dry			20/0"				

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY GN

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No.
99-33437-01

1701 GPJ

GTC MLD

Log No. B- 5

Date of Drilling: 9/15/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 52.5

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt and Drop: 140#/30"

DRAFTED BY CLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		FILL: SILTY SAND With Gravel; tan, dry			9				
2									
4		---slightly moist			35/5"				
					58				
6									
8		---with cobbles							
		SILTY SAND With Gravel (SM); dense, tan, slightly moist			31		5	115	121
10					29				
12									K;Sol; Ch
14					43		4	111 / 115	DS
16									
18		---very dense			57/8"				

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

701.GPJ

GTC MLD

Log No. B- 5

Date of Drilling: 9/15/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 52.5

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SILTY SAND With Gravel (SM); dense, tan, slightly moist			32				A
22									G;P;Ch
24					58/8"				
		---very dense							
26									
28		---brown							
		CLAYEY SAND With Gravel (SC); dense, dark brown, slightly moist			35/5"		6	112	119
30					35/6"				
		SILTY SAND With Gravel (SM); dense, black, slightly moist							
32		---dark brown							
34		---very dense			50/3"				
36									
38		---with cobbles			50/6"				

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

NO ALTERATION BY

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No.
99-33437-01

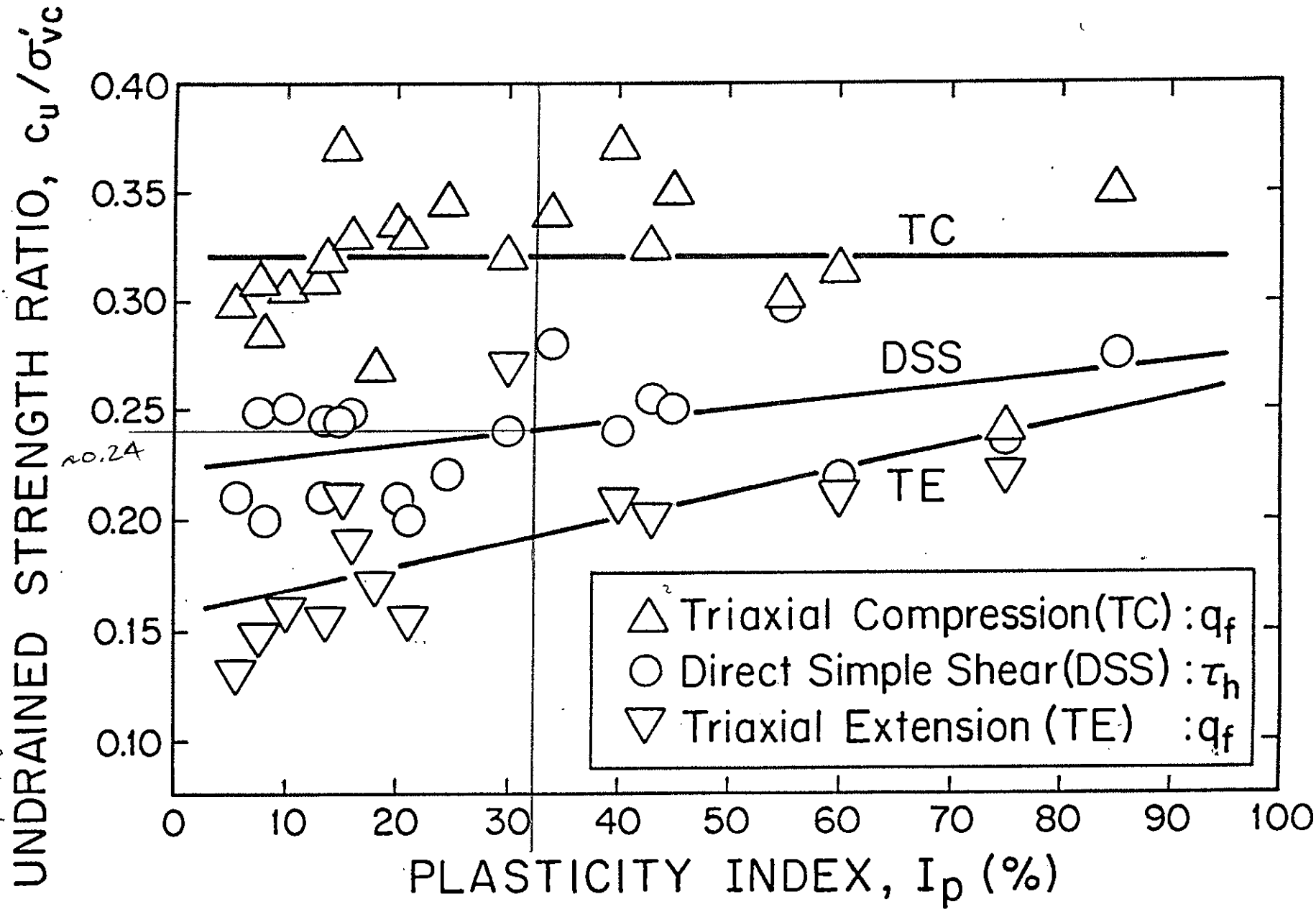
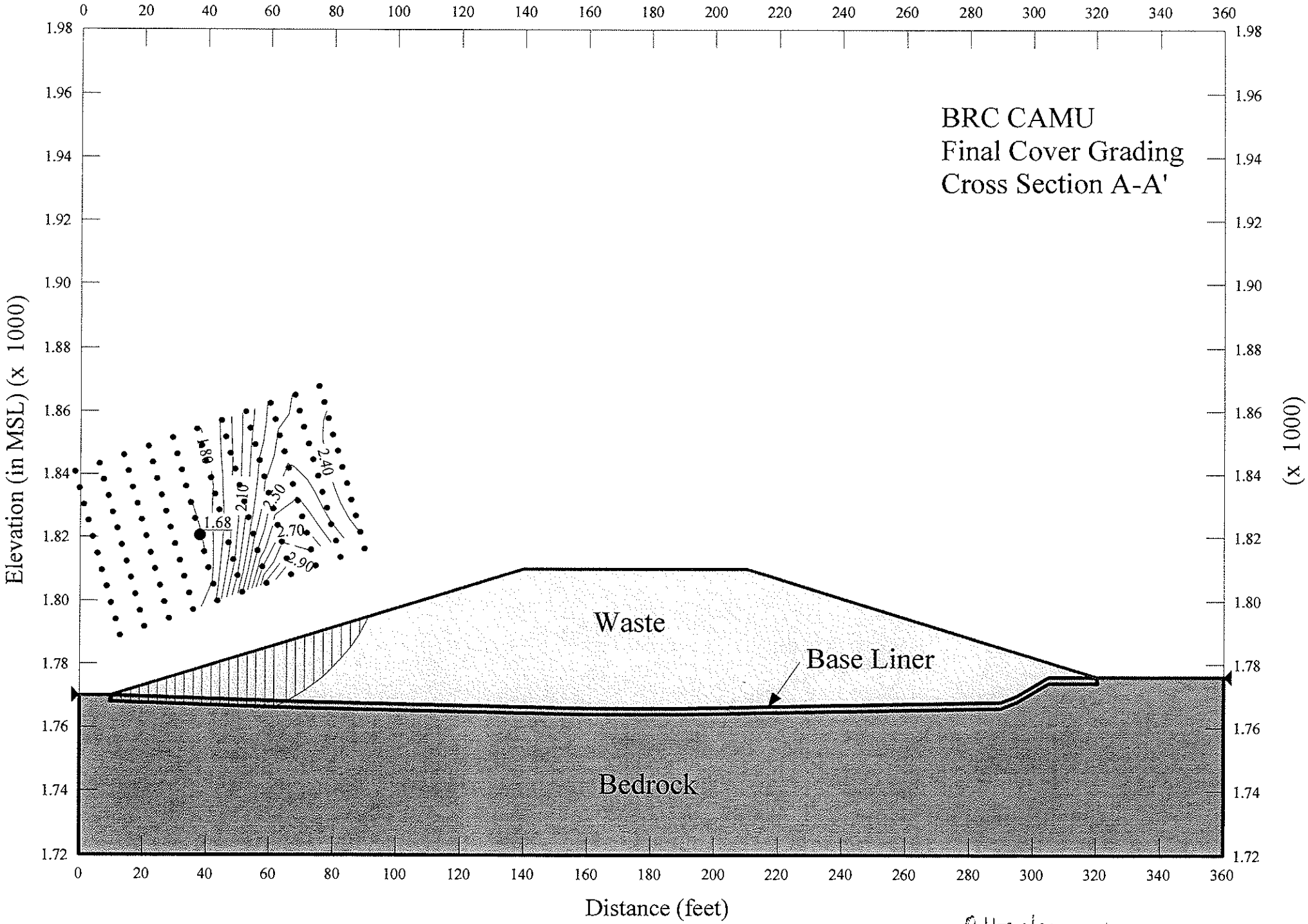
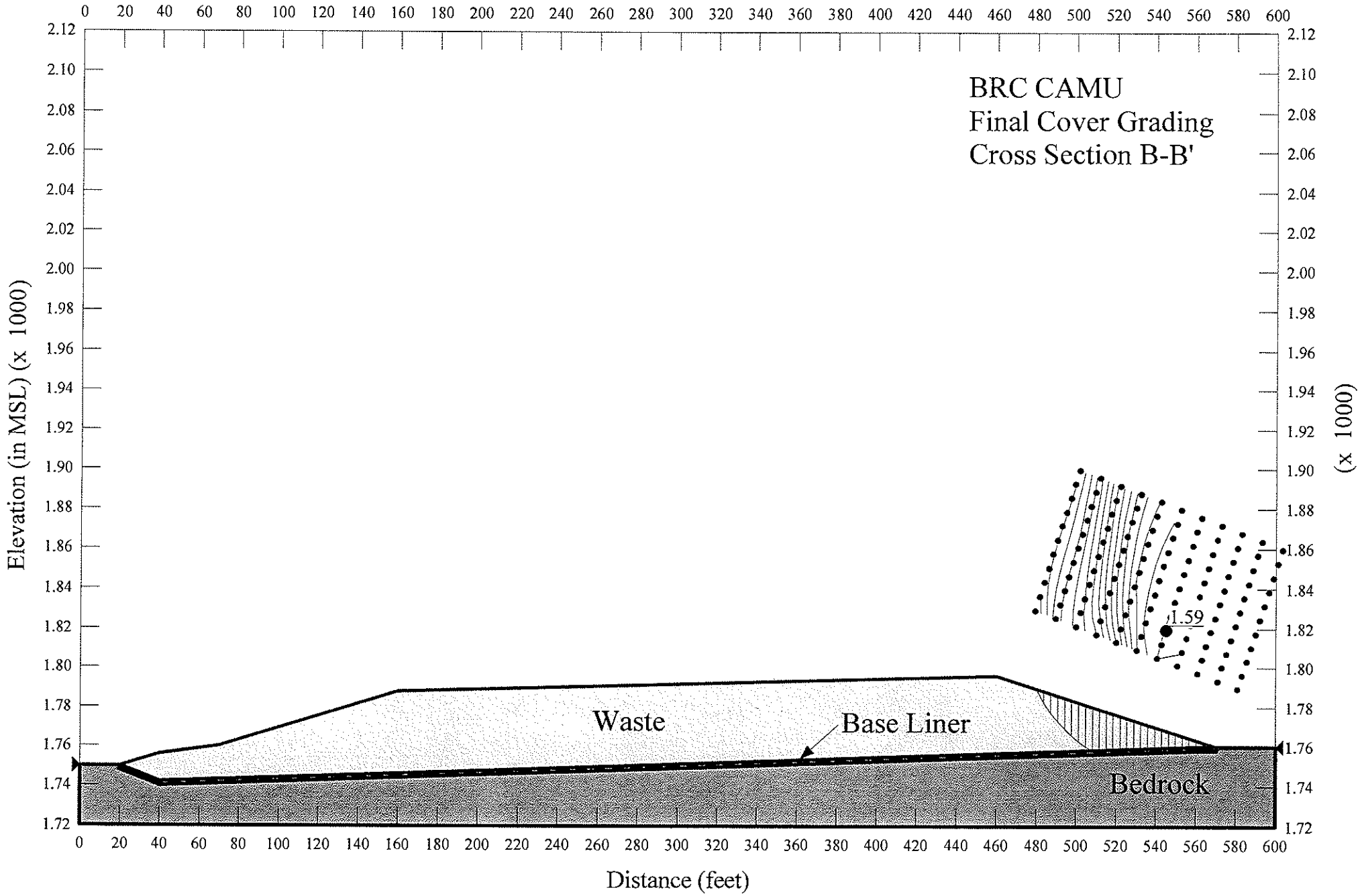


FIG. 15.-Undrained Strength Anisotropy from CK_oU Tests on Normally Consolidated Clays and Silts (data from Lefebvre et al. 1983; Vaid Campanella 1974; and various MIT and NGI reports)

Attachment 2



Attachment 3 1/2



Attachment 3

2/2

stresses associated with failure. As the number of tests increases indefinitely, it is apparent that the envelope of the failure circles (Fig. 4.6*a*) represents the locus of points associated with failure of the specimens. The envelope is known as the *rupture line* for the given material under the specific conditions of the series of tests. For materials in general, the rupture line may be curved, and it may have an intercept c on the axis of shearing stress. Since the values of shearing strength t corresponding to the rupture line all represent failure, they are designated as values of shearing strength s, and the vertical axis in Fig. 4.6*a* is called the axis of shearing strength. If the rupture line is considered to be straight, it may be represented by

$$s = c + p \tan \phi \qquad 4.2$$

known as *Coulomb's equation.*

From the geometry of Fig. 4.6*b*, it may be seen that for any failure circle

$$2\alpha = 90° + \phi$$

Therefore, the angle between the planes on which failure occurs and the plane on which the major principal stress acts is

$$\alpha = 45° + \frac{\phi}{2} \qquad 4.3$$

4.6. Shearing Strength of Dry Sands and Gravels

The rupture lines for dry sands and gravels pass through the origin of the rupture diagram; hence, the intercept c is equal to zero. If the material is in a loose state, the rupture line is linear and may be represented accurately by the equation

$$s = p \tan \phi_d \qquad 4.4$$

where ϕ_d is the angle between the rupture line and the p-axis. For the same materials in a dense state, the rupture line has a slight downward curvature, but for practical purposes in foundation engineering it may also be represented by eq. 4.4.

For gravels, sands, silty sands, and inorganic cohesionless silts the value of ϕ_d depends primarily on the relative density, the grain-size distribution, and the shape of the grains. It may be estimated with the aid of Table 4.1.

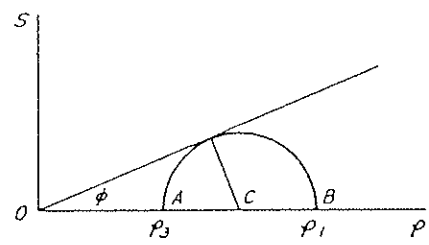
Table 4.1 Representative Values of ϕ_d for Sands and Silts

Material	Degrees	
	Loose	Dense
Sand, round grains, uniform	27.5	34
Sand, angular grains, well graded	33	45
Sandy gravel	35	50
Silty sand	27–33	30–35
Inorganic silt	27–30	30–34

ILLUSTRATIVE PROBLEM

A drained triaxial test is to be performed on a uniform dense sand with rounded grains. The all-around pressure p_3 is to be 2 tons/sq ft. At about what vertical pressure should the sample fail?

Solution. If $s = p \tan \phi$, it can be seen from the sketch that



$$\frac{p_1}{p_3} = \frac{OC + CB}{OC - AC} = \frac{OC + OC \sin \phi}{OC - OC \sin \phi}$$
$$= \frac{1 + \sin \phi}{1 - \sin \phi}$$

Whence by trigonometric transformation

$$\frac{p_1}{p_3} = \tan^2\left(45° + \frac{\phi}{2}\right) = \frac{1}{\tan^2[45° - (\phi/2)]}$$

According to Table 4.1, the value of ϕ_d is likely to be about 34°. Therefore,

$$\tan^2\left(45° + \frac{\phi_d}{2}\right) = \tan^2(45° + 17°)$$
$$= 1.881^2 = 3.54$$

Attachment 4

Calculation Package C
Drainage Pipe Size Requirement

GeoSyntec Consultants

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: Basic Remediation Company

Project: BRC CAMU **Project/Proposal #:** SC0313 **Task #:** 01

Title of Computations: Drainage Pipe Size Requirements

Computations By:

SIGNATURE — DATE 11/3/06

Rebecca Flynn, Staff Engineer
PRINTED NAME AND TITLE

Assumptions and Procedures Checked By (Peer Reviewer):

SIGNATURE — DATE 11/3/06

Greg Corcoran, PE / Principal
PRINTED NAME AND TITLE

Computations Checked By:

SIGNATURE — DATE 11/3/06

Greg Corcoran, PE / Principal
PRINTED NAME AND TITLE

Computations Backchecked By (Originator):

SIGNATURE — DATE 11/3/06

Rebecca Flynn, Staff Engineer
PRINTED NAME AND TITLE

Approved By (PM or Designate):

SIGNATURE — DATE 11/3/06

Greg Corcoran, PE / Principal
PRINTED NAME AND TITLE

Approval Notes:

Revisions: (Number and Initial All Revisions)

No.	Sheet	Date	By	Checked By	Approval

Written by: Rebecca Flynn Date: 06 / 08 / 29 (YY MM DD) Reviewed by: GTC Date: 06 / 11 / 13 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

DRAINAGE PIPE SIZE REQUIREMENTS

OBJECTIVE

The objective of this calculation package is to evaluate the drainage pipe size requirements for the base liner proposed for the drainage system for the BRC Corrective Action Management Unit (CAMU) located in Henderson, Nevada. It is proposed that the drainage system include an geocomposite drainage layer with a single drainage pipe, bedded in a drainage aggregate trench, located along the base of each cell. The pipe diameter and perforations must be able to handle the maximum flow into and through the pipe. This calculation will evaluate the required performance diameter and perforation size and spacing for the drainage pipe. In addition, the drainage aggregate must be sized as to not allow transport of materials through the pipe perforations.

SUMMARY OF ANALYSIS

The calculations suggest that a 4-inch diameter pipe with four ¼-inch perforations spaced at 1 foot on center will accommodate the maximum flow predicted by the HELP Model. The maximum particle size of the drainage aggregate is 1 in or less (as evaluated in the geomembrane puncture protection calculation) and D_{85} must be 0.5 inch or higher to prevent piping and material loss. AASHTO 67 material meets the drainage aggregate requirements.

SITE CONDITIONS

The proposed composite liner system will be comprised of the following components, from top to bottom (Figure 2):

- 2 ft of operations layer material;
- a drainage geocomposite;
- 60-mil (1.5 mm) HDPE geomembrane, textured on both sides;
- a geosynthetic clay liner (GCL); and
- prepared subgrade.

Written by: Rebecca Flynn Date: 06 / 08 / 29 (YY MM DD) Reviewed by: GTC Date: 06 / 11 / 3 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

ANALYSIS

HELP Analyses:

The Hydrologic Evaluation of Landfill Performance (HELP) model was used to estimate the peak daily quantity of liquid expected to be generated in the drainage pipe during or after a rainfall event. The HELP model is used to evaluate the worst case scenario which occurs *during the period when the cell contains a small quantity of waste*, such that any collected liquid is considered leachate, yet the majority of the cell is empty so the largest quantity of liquid will infiltrate through the operations layer to the drainage layer. This time period exists between the following activities:

- *Immediately after the composite liner system construction has been completed* (any collected liquid during construction is considered construction water and will not be contaminated);
- *Before the period of significant waste placement.* Leachate generation is reduced by the dry landfill moisture retention capacity. Separate calculation packages address the moisture retention capacity of the dry landfill soil and respective dry landfill requirements so that leachate generation is greatly reduced or completely stored in the waste soil.

No further analyses are needed because the above condition represents the worst case during the life of the landfill.

The rainfall history was synthetically generated by HELP over a 20 year period. The drainage pipes, pipe perforations, and portions of the drainage geocomposite layer (maintaining less than 1 ft of head over the liner) must accommodate the peak daily quantity over a 20 year rainfall history. This is conservative because the 20-year peak daily quantity is assumed to occur during a relatively short exposure period.

The initial water content of the placed soil is assumed to be the default water content initialized by HELP. This is conservative because the water content of the drainage aggregate and operations layer soil is likely to be relatively low due to high temperatures and low humidity at the site, creating a high pan evaporation rate. Therefore, the initial water content evaluated by HELP (based on a water content near steady state) will likely be higher than the actual site conditions.

Written by: Rebecca Flynn Date: 06 / 08 / 29 (YY MM DD) Reviewed by: GTC Date: 06 / 11 / 3 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

Model Parameters

Vertical Percolation Layer: The vertical percolation layer (type 1) is represented by default properties for a silty sand in HELP (texture number 3). However, the hydraulic conductivity is changed to represent worst case (high hydraulic conductivity) as estimated by Converse Consultants (Attachment G).

Geocomposite: The default material properties for the drainage geocomposite in the HELP model are used to represent the lateral drainage layer (type 2). The defalt properties for the geocomposite are represented by HELP texture number 20. The hydraulic conductivity of the goecomposite is assumed to be 10 cm/sec (required by 40 CFR 264.301 (c) (3) (ii)).

Geosynthetics: The geomembrane and GCL properties are estimated from the HELP model. The GCL is represented by texture number 17 and the geomembrane is represented by texture number 35.

Runoff: The SCS runoff curve number was evaluated assuming HELP texture number 3 at the surface (silty sand).

The default values in the HELP model are shown in the HELP output presented in Attachment A.

Figure 1 presents the locations of drainage pipes and HELP Model analyses listen in the following Table. Figure 2 shows the cross section of the base liner system.

HELP Results

The following results were obtained from the HELP analysis:

Location	Peak Daily Quantity	Area	Slope and Length[1]	File
Unit 1	306 ft^3	3.34 acres	2% and 200 ft	SOIL1SUM
Unit 2	568 ft^3	5.98 acres	2% and 400 ft	SOIL2SUM
Unit 3	1062 ft^3	10.9 acres	2% and 1050 ft	SOIL3SUM
Unit 4	1169 ft^3	11.9 acres	3% and 550 ft	SOIL4SUM
Unit 5	1313 ft^3	13.3 acres	3% and 650 ft	SOIL5SUM
Unit A	9833 ft^3	2.84 acres	48% and 100 ft	SOILASUM
Unit B	10471 ft^3	3.15 acres	48% and 75 ft	SOILBSUM

1) see Figure 1 for slope and length evaluation.

Written by: Rebecca Flynn Date: 06 / 08 / 29 (YY MM DD) Reviewed by: ETC Date: 06 / 11 / 3 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

Pipe Diameter Analysis

From the HELP Model analyses performed for each of the 5 units and 2 side slope conditions at this facility (Attachment A), the maximum peak daily quantity of liquid expected to be generated is 10457 cubic feet on Slope B (see Figure 1). Two pipes will be used to convey the drainage from Slopes B to the sump. The following flow rate for each pipe is calculated:

(10457 CF/day) / (24 hours/day) / (60 min/hour) / (60 sec/min)/2 = 0.0605 cfs

The following equation (Attachment B) can be used to estimate the flow rate in the pipe when flowing full:

$Q_{\frac{1}{2}\,full} = (1.486/n)(A)(R)^{2/3}(S)^{1/2}$
where;
n = the Mannings roughness coefficient, 0.009 for plastic pipe (Attachment B)
A = the area of the pipe
R = hydraulic radius = area/perimeter of the pipe (Attachment B)
S = minimum slope of pipe = 0.5 %

Assuming a 4" diameter pipe will be sufficient, and using the standard dimension ratio (SDR) of 13.5 determined in the pipe crushing calculation, the following values will be used in the above equation:

r = 1.92 in (SDR 13.5 HDPE pipe) (Attachment ~~A~~ C)
$A = \pi r^2 = \pi (1.92/12)^2 = 0.080\ ft^2$
$R = (0.080) / (2 \pi (1.92/12)) = 0.080$ ft

Placing the above values into the Mannings equation results in the following:

$Q_{\frac{1}{2}\,full} = (1.486/0.009)(0.080)(0.080)^{2/3}(.005)^{1/2}$

$Q_{\frac{1}{2}\,full}$ = 0.173 cfs, which is larger than the required flow rate of 0.061 cfs, therefore 4" diameter pipe will be sufficient for this application.

Perforations Analysis

A minimum of four penetrations, each 45 and 90 degrees from the bottom of the pipe, will be used to limit the amount of particulates entering the drainage pipe directly. Verify that 4 rows of ¼-inch holes spaced at 12 inches on center are adequate.

Written by: Rebecca Flynn Date: 06 / 08 / 29 (YY MM DD) Reviewed by: [illegible] Date: 06 / 11 / 3 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

The holes will be modeled as submerged orifices using the following equation:

$Q = C_d A (2gh)^{1/2}$ (Attachment D)

where:

C_d = coefficient of discharge = 0.62 (Attachment D)

A = area of hole = $\pi (0.125/12)^2 = 0.0003$ ft^2

h = head in feet = 1 ft based on maximum head allowed over the liner system

g = gravity = 32.2 ft/sec^2

$Q = (0.62)(0.0003)(2 \times 32.2 \times 1)^{1/2} = 0.0015$ cfs per hole

Q = 0.0015 cfs x 4 holes/foot of pipe = 0.006 cfs per foot of pipe

The conservative maximum discharge to the pipe is approximately 0.061 cfs. Since there is more than 100 ft of drainage pipe for each unit (6.1 cfs/100 ft of pipe) the perforation size and spacing is more than adequate for the predicted flow rates to the pipe.

Required Drainage Aggregate

The size of the perforations are 1/4 inch in diameter. The gradation of the drainage aggregate must be designed to insure that piping and material loss will not occur. The U.S. Bureau of Reclamation (1973) use the following criteria for gradation of filter materials in relation to holes:

(D_{85} of the filter material) / (hole diameter) > 2.0 (Attachment E)

Therefore, D_{85} of the filter material must be greater than 1/2 inch.

AASHTO 67 material has a maximum particle size of 1 inch, which is the criteria for puncture protection of the geomembrane. D_{85} of AASHTO 67 material ranges from approximately 0.5 to 0.7 inches, which satisfies the above criteria (see Attachment F).

CONCLUSIONS

In accordance with the above analysis, the drainage pipe shall be 4-inch diameter pipe with four ¼-inch perforations per foot of pipe. The drainage aggregate shall have a hydraulic conductivity greater than 1×10^{-2} cm/sec, a maximum particle diameter of 1 inch, and D_{85} greater than 1/2 inch. AASHTO 67 material satisfies this criteria.

REFERENCES

Written by: Rebecca Flynn Date: 06 / 08 / 29 (YY MM DD) Reviewed by: GTC Date: 06 / 11 / 3 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

Cedergren, H. R., (1989), "Seepage, Drainage, and Flow Nets," Third Edition, John Wiley and Sons, New York. p. 161

Chevron (1999), Plexco/Spirolite Engineering Manual

Converse (1999), "Preliminary Geotechnical and Geologic Investigation - Industrial Non-Hazardous Disposal Facility", prepared for Basic Management, Inc., October 1999.

Hwang, (1987), "Fundamentals of Hydraulic Engineering Systems," 2nd Edition, Prentice-Hall

Phillips 66, Driscopipe Sizes and Dimensions (1999)

U.S. Bureau of Reclamation (1973), "Design of Small Dams, U.S. Government Printing Office, Washington D.C., 2nd edition.

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     C:\HLP3\BRC\BRCPREC.D4
TEMPERATURE DATA FILE:       C:\HLP3\BRC\BRCTEMP.D7
SOLAR RADIATION DATA FILE:   C:\HLP3\BRC\BRCSOLAR.D13
EVAPOTRANSPIRATION DATA:     C:\HLP3\BRC\BRCEVAP.D11
SOIL AND DESIGN DATA FILE:   C:\HLP3\BRC\BRCSOIL1.D10
OUTPUT DATA FILE:            C:\HLP3\BRC\Summary\SOIL1SUM.OUT


TIME:   8: 3     DATE:   8/31/2006


******************************************************************************

     TITLE:  BRCUnit1

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                   TYPE 1 - VERTICAL PERCOLATION LAYER
                       MATERIAL TEXTURE NUMBER   3
          THICKNESS                  =     24.00   INCHES
          POROSITY                   =      0.4570 VOL/VOL
          FIELD CAPACITY             =      0.0830 VOL/VOL
          WILTING POINT              =      0.0330 VOL/VOL
          INITIAL SOIL WATER CONTENT =      0.1055 VOL/VOL
          EFFECTIVE SAT. HYD. COND.  =  0.310000009000E-02 CM/SEC


                                  LAYER  2
                                  --------

                     TYPE 2 - LATERAL DRAINAGE LAYER
```

MATERIAL TEXTURE NUMBER 20

THICKNESS	=	0.20	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0110	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000	CM/SEC
SLOPE	=	2.50	PERCENT
DRAINAGE LENGTH	=	200.0	FEET

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	0.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	0.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	4 - POOR	

LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.20	INCHES
POROSITY	=	0.7500	VOL/VOL
FIELD CAPACITY	=	0.7470	VOL/VOL
WILTING POINT	=	0.4000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000003000E-08	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 3 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 200. FEET.

SCS RUNOFF CURVE NUMBER	=	81.00	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	1.704	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.226	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.594	INCHES
INITIAL SNOW WATER	=	0.000	INCHES

INITIAL WATER IN LAYER MATERIALS	=	2.684	INCHES
TOTAL INITIAL WATER	=	2.684	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
LAS VEGAS NEVADA

STATION LATITUDE	=	36.08	DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00	
START OF GROWING SEASON (JULIAN DATE)	=	62	
END OF GROWING SEASON (JULIAN DATE)	=	321	
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	9.10	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	39.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	21.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	24.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	36.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
0.50	0.46	0.41	0.22	0.20	0.09
0.45	0.54	0.32	0.25	0.43	0.32

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
44.60	50.10	55.30	63.50	73.30	83.60
90.30	88.00	80.10	67.60	53.60	45.40

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA
AND STATION LATITUDE = 36.08 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.33	0.45	0.33	0.26	0.29	0.07
	0.51	0.51	0.34	0.17	0.49	0.28
STD. DEVIATIONS	0.37	0.49	0.34	0.23	0.33	0.13
	0.73	0.40	0.55	0.16	0.50	0.22
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.005	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.024	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.274	0.206	0.271	0.277	0.225	0.132
	0.364	0.338	0.298	0.156	0.379	0.248
STD. DEVIATIONS	0.306	0.171	0.285	0.258	0.200	0.109
	0.560	0.369	0.350	0.135	0.451	0.242
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	0.0579	0.0687	0.0968	0.0973	0.0851	0.0617
	0.0658	0.0649	0.0946	0.0838	0.0585	0.0585
STD. DEVIATIONS	0.0332	0.0691	0.1033	0.0592	0.0452	0.0303
	0.0441	0.0511	0.0657	0.0580	0.0360	0.0271
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3						
AVERAGES	0.0003	0.0003	0.0004	0.0005	0.0004	0.0003
	0.0003	0.0003	0.0004	0.0004	0.0003	0.0003
STD. DEVIATIONS	0.0002	0.0003	0.0005	0.0003	0.0002	0.0001
	0.0002	0.0002	0.0003	0.0003	0.0002	0.0001

****

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	INCHES		CU. FEET	PERCENT
PRECIPITATION	4.04	(1.532)	14676.1	100.00
RUNOFF	0.005	(0.0236)	19.14	0.130
EVAPOTRANSPIRATION	3.169	(1.3330)	11504.54	78.390
LATERAL DRAINAGE COLLECTED FROM LAYER 2	0.89371	(0.36544)	3244.172	22.10515
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00000	(0.00000)	0.009	0.00006
AVERAGE HEAD ON TOP OF LAYER 3	0.000	(0.000)		
CHANGE IN WATER STORAGE	-0.025	(0.4578)	-91.76	-0.625

****

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	1.83	6642.900
RUNOFF	0.105	382.7216
DRAINAGE COLLECTED FROM LAYER 2	0.02521	91.50326
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 3	0.004	
MAXIMUM HEAD ON TOP OF LAYER 3	0.010	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	0.74	2687.3430

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.1784

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0330

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

****

0

****

FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	2.0260	0.0844
2	0.0029	0.0148
3	0.0000	0.0000
4	0.1500	0.7500
SNOW WATER	0.000	

****
****

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     C:\HLP3\BRC\BRCPREC.D4
TEMPERATURE DATA FILE:       C:\HLP3\BRC\BRCTEMP.D7
SOLAR RADIATION DATA FILE:   C:\HLP3\BRC\BRCSOLAR.D13
EVAPOTRANSPIRATION DATA:     C:\HLP3\BRC\BRCEVAP.D11
SOIL AND DESIGN DATA FILE:   C:\HLP3\BRC\BRCSOIL2.D10
OUTPUT DATA FILE:            C:\HLP3\BRC\Summary\SOIL2SUM.OUT


TIME:   8: 5     DATE:   8/31/2006


******************************************************************************

     TITLE:  BRCUnit2

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                   TYPE 1 - VERTICAL PERCOLATION LAYER
                       MATERIAL TEXTURE NUMBER   3
          THICKNESS                    =     24.00   INCHES
          POROSITY                     =      0.4570 VOL/VOL
          FIELD CAPACITY               =      0.0830 VOL/VOL
          WILTING POINT                =      0.0330 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.1083 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.310000009000E-02 CM/SEC


                                  LAYER  2
                                  --------

                     TYPE 2 - LATERAL DRAINAGE LAYER
```

MATERIAL TEXTURE NUMBER 20

THICKNESS	=	0.20	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0108	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000	CM/SEC
SLOPE	=	2.00	PERCENT
DRAINAGE LENGTH	=	400.0	FEET

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	0.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	0.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	4 - POOR	

LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.20	INCHES
POROSITY	=	0.7500	VOL/VOL
FIELD CAPACITY	=	0.7470	VOL/VOL
WILTING POINT	=	0.4000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000003000E-08	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 3 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 400. FEET.

SCS RUNOFF CURVE NUMBER	=	80.20	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	1.969	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.226	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.594	INCHES
INITIAL SNOW WATER	=	0.000	INCHES

INITIAL WATER IN LAYER MATERIALS	=	2.752	INCHES
TOTAL INITIAL WATER	=	2.752	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
LAS VEGAS NEVADA

STATION LATITUDE	=	36.08	DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00	
START OF GROWING SEASON (JULIAN DATE)	=	62	
END OF GROWING SEASON (JULIAN DATE)	=	321	
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	9.10	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	39.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	21.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	24.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	36.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
0.50	0.46	0.41	0.22	0.20	0.09
0.45	0.54	0.32	0.25	0.43	0.32

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
44.60	50.10	55.30	63.50	73.30	83.60
90.30	88.00	80.10	67.60	53.60	45.40

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA
AND STATION LATITUDE = 36.08 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.33	0.45	0.33	0.26	0.29	0.07
	0.51	0.51	0.34	0.17	0.49	0.28
STD. DEVIATIONS	0.37	0.49	0.34	0.23	0.33	0.13
	0.73	0.40	0.55	0.16	0.50	0.22
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.005	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.021	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.346	0.320	0.328	0.281	0.286	0.166
	0.431	0.257	0.256	0.178	0.422	0.296
STD. DEVIATIONS	0.363	0.338	0.284	0.211	0.239	0.117
	0.712	0.200	0.317	0.117	0.493	0.264
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	0.0366	0.0424	0.0505	0.0443	0.0435	0.0330
	0.0351	0.0298	0.0460	0.0576	0.0407	0.0411
STD. DEVIATIONS	0.0305	0.0358	0.0484	0.0353	0.0389	0.0219
	0.0173	0.0175	0.0738	0.0683	0.0377	0.0284
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3						
AVERAGES	0.0004	0.0005	0.0006	0.0005	0.0005	0.0004
	0.0004	0.0003	0.0005	0.0007	0.0005	0.0005
STD. DEVIATIONS	0.0003	0.0005	0.0006	0.0004	0.0004	0.0003
	0.0002	0.0002	0.0009	0.0008	0.0004	0.0003

****

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	INCHES		CU. FEET	PERCENT
PRECIPITATION	4.04	(1.532)	14676.1	100.00
RUNOFF	0.005	(0.0208)	16.91	0.115
EVAPOTRANSPIRATION	3.567	(1.4731)	12948.16	88.226
LATERAL DRAINAGE COLLECTED FROM LAYER 2	0.50069	(0.25506)	1817.490	12.38402
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00000	(0.00000)	0.008	0.00006
AVERAGE HEAD ON TOP OF LAYER 3	0.000	(0.000)		
CHANGE IN WATER STORAGE	-0.029	(0.5316)	-106.48	-0.726

****

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	1.83	6642.900
RUNOFF	0.093	338.2043
DRAINAGE COLLECTED FROM LAYER 2	0.02617	95.01099
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 3	0.009	
MAXIMUM HEAD ON TOP OF LAYER 3	0.021	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	0.74	2687.3430

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.1924

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0330

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

****

****

FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	2.0124	0.0838
2	0.0032	0.0162
3	0.0000	0.0000
4	0.1500	0.7500
SNOW WATER	0.000	

****
****

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     C:\HLP3\BRC\BRCPREC.D4
TEMPERATURE DATA FILE:       C:\HLP3\BRC\BRCTEMP.D7
SOLAR RADIATION DATA FILE:   C:\HLP3\BRC\BRCSOLAR.D13
EVAPOTRANSPIRATION DATA:     C:\HLP3\BRC\BRCEVAP.D11
SOIL AND DESIGN DATA FILE:   C:\HLP3\BRC\BRCSOIL3.D10
OUTPUT DATA FILE:            C:\HLP3\BRC\Summary\SOIL3SUM.OUT


TIME:   8: 6     DATE:   8/31/2006


******************************************************************************

     TITLE:  BRCUnit3

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   3
          THICKNESS                    =     24.00   INCHES
          POROSITY                     =      0.4570 VOL/VOL
          FIELD CAPACITY               =      0.0830 VOL/VOL
          WILTING POINT                =      0.0330 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.1083 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.310000009000E-02 CM/SEC


                                  LAYER  2
                                  --------

                       TYPE 2 - LATERAL DRAINAGE LAYER
```

MATERIAL TEXTURE NUMBER 20

THICKNESS	=	0.20	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0122	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000	CM/SEC
SLOPE	=	2.00	PERCENT
DRAINAGE LENGTH	=	1050.0	FEET

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	0.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	0.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	4 - POOR	

LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.20	INCHES
POROSITY	=	0.7500	VOL/VOL
FIELD CAPACITY	=	0.7470	VOL/VOL
WILTING POINT	=	0.4000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000003000E-08	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 3 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 1050. FEET.

SCS RUNOFF CURVE NUMBER	=	79.10	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	1.969	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.226	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.594	INCHES
INITIAL SNOW WATER	=	0.000	INCHES

INITIAL WATER IN LAYER MATERIALS	=	2.753	INCHES
TOTAL INITIAL WATER	=	2.753	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
LAS VEGAS NEVADA

STATION LATITUDE	=	36.08	DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00	
START OF GROWING SEASON (JULIAN DATE)	=	62	
END OF GROWING SEASON (JULIAN DATE)	=	321	
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	9.10	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	39.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	21.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	24.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	36.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
0.50	0.46	0.41	0.22	0.20	0.09
0.45	0.54	0.32	0.25	0.43	0.32

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
44.60	50.10	55.30	63.50	73.30	83.60
90.30	88.00	80.10	67.60	53.60	45.40

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA
AND STATION LATITUDE = 36.08 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.33	0.45	0.33	0.26	0.29	0.07
	0.51	0.51	0.34	0.17	0.49	0.28
STD. DEVIATIONS	0.37	0.49	0.34	0.23	0.33	0.13
	0.73	0.40	0.55	0.16	0.50	0.22
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.004	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.016	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.348	0.321	0.330	0.283	0.287	0.167
	0.431	0.258	0.258	0.183	0.429	0.303
STD. DEVIATIONS	0.362	0.339	0.280	0.211	0.239	0.117
	0.712	0.199	0.316	0.125	0.489	0.260
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	0.0339	0.0402	0.0566	0.0436	0.0383	0.0330
	0.0351	0.0310	0.0438	0.0422	0.0262	0.0320
STD. DEVIATIONS	0.0305	0.0365	0.0626	0.0387	0.0309	0.0244
	0.0189	0.0193	0.0750	0.0597	0.0281	0.0211
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3						
AVERAGES	0.0010	0.0013	0.0017	0.0013	0.0011	0.0010
	0.0010	0.0009	0.0014	0.0013	0.0008	0.0010
STD. DEVIATIONS	0.0009	0.0012	0.0019	0.0012	0.0009	0.0008
	0.0006	0.0006	0.0023	0.0018	0.0009	0.0006

****

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	INCHES		CU. FEET	PERCENT
PRECIPITATION	4.04	(1.532)	14676.1	100.00
RUNOFF	0.004	(0.0159)	12.92	0.088
EVAPOTRANSPIRATION	3.598	(1.4548)	13062.02	89.002
LATERAL DRAINAGE COLLECTED FROM LAYER 2	0.45591	(0.24477)	1654.963	11.27659
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00000	(0.00000)	0.009	0.00006
AVERAGE HEAD ON TOP OF LAYER 3	0.001	(0.001)		
CHANGE IN WATER STORAGE	-0.015	(0.5598)	-53.82	-0.367

****

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	1.83	6642.900
RUNOFF	0.071	258.3089
DRAINAGE COLLECTED FROM LAYER 2	0.02685	97.45744
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 3	0.025	
MAXIMUM HEAD ON TOP OF LAYER 3	0.050	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	0.74	2687.3430

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.1937

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0330

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

****

****

FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	2.3023	0.0959
2	0.0036	0.0184
3	0.0000	0.0000
4	0.1500	0.7500
SNOW WATER	0.000	

****
****

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     C:\HLP3\BRC\BRCPREC.D4
TEMPERATURE DATA FILE:       C:\HLP3\BRC\BRCTEMP.D7
SOLAR RADIATION DATA FILE:   C:\HLP3\BRC\BRCSOLAR.D13
EVAPOTRANSPIRATION DATA:     C:\HLP3\BRC\BRCEVAP.D11
SOIL AND DESIGN DATA FILE:   C:\HLP3\BRC\BRCSOIL4.D10
OUTPUT DATA FILE:            C:\HLP3\BRC\Summary\SOIL4SUM.OUT


TIME:   8: 8     DATE:   8/31/2006


******************************************************************************

     TITLE:  BRCUnit4

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                 TYPE 1 - VERTICAL PERCOLATION LAYER
                     MATERIAL TEXTURE NUMBER   3
          THICKNESS                    =     24.00   INCHES
          POROSITY                     =      0.4570 VOL/VOL
          FIELD CAPACITY               =      0.0830 VOL/VOL
          WILTING POINT                =      0.0330 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.1083 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.310000009000E-02 CM/SEC


                                  LAYER  2
                                  --------

                 TYPE 2 - LATERAL DRAINAGE LAYER
```

MATERIAL TEXTURE NUMBER 20

THICKNESS	=	0.20	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0108	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000	CM/SEC
SLOPE	=	3.00	PERCENT
DRAINAGE LENGTH	=	550.0	FEET

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	0.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	0.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	4 - POOR	

LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.20	INCHES
POROSITY	=	0.7500	VOL/VOL
FIELD CAPACITY	=	0.7470	VOL/VOL
WILTING POINT	=	0.4000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000003000E-08	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 3 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 3.% AND A SLOPE LENGTH OF 550. FEET.

SCS RUNOFF CURVE NUMBER	=	80.00	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	1.969	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.226	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.594	INCHES
INITIAL SNOW WATER	=	0.000	INCHES

INITIAL WATER IN LAYER MATERIALS	=	2.752	INCHES
TOTAL INITIAL WATER	=	2.752	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
LAS VEGAS NEVADA

STATION LATITUDE	=	36.08	DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00	
START OF GROWING SEASON (JULIAN DATE)	=	62	
END OF GROWING SEASON (JULIAN DATE)	=	321	
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	9.10	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	39.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	21.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	24.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	36.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
0.50	0.46	0.41	0.22	0.20	0.09
0.45	0.54	0.32	0.25	0.43	0.32

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
44.60	50.10	55.30	63.50	73.30	83.60
90.30	88.00	80.10	67.60	53.60	45.40

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA
AND STATION LATITUDE = 36.08 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.33	0.45	0.33	0.26	0.29	0.07
	0.51	0.51	0.34	0.17	0.49	0.28
STD. DEVIATIONS	0.37	0.49	0.34	0.23	0.33	0.13
	0.73	0.40	0.55	0.16	0.50	0.22
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.004	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.020	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.346	0.320	0.328	0.281	0.286	0.166
	0.431	0.257	0.256	0.178	0.422	0.296
STD. DEVIATIONS	0.363	0.338	0.284	0.211	0.239	0.117
	0.712	0.200	0.317	0.117	0.493	0.264
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	0.0366	0.0424	0.0505	0.0443	0.0435	0.0330
	0.0351	0.0297	0.0463	0.0576	0.0407	0.0411
STD. DEVIATIONS	0.0305	0.0358	0.0484	0.0353	0.0389	0.0219
	0.0174	0.0174	0.0748	0.0683	0.0377	0.0284
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3						
AVERAGES	0.0004	0.0005	0.0005	0.0005	0.0005	0.0004
	0.0004	0.0003	0.0005	0.0006	0.0004	0.0004
STD. DEVIATIONS	0.0003	0.0004	0.0005	0.0004	0.0004	0.0002
	0.0002	0.0002	0.0008	0.0007	0.0004	0.0003

****

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	INCHES		CU. FEET	PERCENT
PRECIPITATION	4.04	(1.532)	14676.1	100.00
RUNOFF	0.004	(0.0199)	16.14	0.110
EVAPOTRANSPIRATION	3.567	(1.4731)	12948.16	88.226
LATERAL DRAINAGE COLLECTED FROM LAYER 2	0.50090	(0.25564)	1818.280	12.38940
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00000	(0.00000)	0.008	0.00006
AVERAGE HEAD ON TOP OF LAYER 3	0.000	(0.000)		
CHANGE IN WATER STORAGE	-0.029	(0.5316)	-106.49	-0.726

****

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	1.83	6642.900
RUNOFF	0.089	322.7272
DRAINAGE COLLECTED FROM LAYER 2	0.02705	98.20731
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 3	0.009	
MAXIMUM HEAD ON TOP OF LAYER 3	0.004	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	436.3 FEET	
SNOW WATER	0.74	2687.3430

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.1927
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0330

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

****

****

FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	2.0124	0.0838
2	0.0031	0.0157
3	0.0000	0.0000
4	0.1500	0.7500
SNOW WATER	0.000	

****
****

```
**************************************************************************
**************************************************************************
**                                                                      **
**                                                                      **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE           **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)            **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY               **
**                    USAE WATERWAYS EXPERIMENT STATION                 **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY          **
**                                                                      **
**                                                                      **
**************************************************************************
**************************************************************************


PRECIPITATION DATA FILE:     C:\HLP3\BRC\BRCPREC.D4
TEMPERATURE DATA FILE:       C:\HLP3\BRC\BRCTEMP.D7
SOLAR RADIATION DATA FILE:   C:\HLP3\BRC\BRCSOLAR.D13
EVAPOTRANSPIRATION DATA:     C:\HLP3\BRC\BRCEVAP.D11
SOIL AND DESIGN DATA FILE:   C:\HLP3\BRC\BRCSOIL5.D10
OUTPUT DATA FILE:            C:\HLP3\BRC\Summary\SOIL5SUM.OUT


TIME:   8:10     DATE:   8/31/2006


**************************************************************************

     TITLE:  BRCUnit5

**************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                LAYER  1
                                --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   3
          THICKNESS                    =     24.00   INCHES
          POROSITY                     =      0.4570 VOL/VOL
          FIELD CAPACITY               =      0.0830 VOL/VOL
          WILTING POINT                =      0.0330 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.1083 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.310000009000E-02 CM/SEC


                                LAYER  2
                                --------

                     TYPE 2 - LATERAL DRAINAGE LAYER
```

MATERIAL TEXTURE NUMBER 20

THICKNESS	=	0.20	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0109	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000	CM/SEC
SLOPE	=	3.00	PERCENT
DRAINAGE LENGTH	=	675.0	FEET

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	0.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	0.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	4 - POOR	

LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.20	INCHES
POROSITY	=	0.7500	VOL/VOL
FIELD CAPACITY	=	0.7470	VOL/VOL
WILTING POINT	=	0.4000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000003000E-08	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 3 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 3.% AND A SLOPE LENGTH OF 675. FEET.

SCS RUNOFF CURVE NUMBER	=	79.80	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	1.969	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.226	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.594	INCHES
INITIAL SNOW WATER	=	0.000	INCHES

INITIAL WATER IN LAYER MATERIALS	=	2.752	INCHES
TOTAL INITIAL WATER	=	2.752	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
LAS VEGAS NEVADA

STATION LATITUDE	=	36.08	DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00	
START OF GROWING SEASON (JULIAN DATE)	=	62	
END OF GROWING SEASON (JULIAN DATE)	=	321	
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	9.10	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	39.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	21.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	24.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	36.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
0.50	0.46	0.41	0.22	0.20	0.09
0.45	0.54	0.32	0.25	0.43	0.32

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
44.60	50.10	55.30	63.50	73.30	83.60
90.30	88.00	80.10	67.60	53.60	45.40

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA
AND STATION LATITUDE = 36.08 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.33	0.45	0.33	0.26	0.29	0.07
	0.51	0.51	0.34	0.17	0.49	0.28
STD. DEVIATIONS	0.37	0.49	0.34	0.23	0.33	0.13
	0.73	0.40	0.55	0.16	0.50	0.22
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.004	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.019	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.346	0.319	0.330	0.284	0.286	0.166
	0.430	0.257	0.256	0.180	0.424	0.301
STD. DEVIATIONS	0.363	0.338	0.282	0.210	0.239	0.117
	0.712	0.200	0.317	0.127	0.487	0.260
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	0.0366	0.0449	0.0524	0.0395	0.0416	0.0328
	0.0349	0.0303	0.0463	0.0541	0.0359	0.0383
STD. DEVIATIONS	0.0302	0.0391	0.0487	0.0306	0.0372	0.0217
	0.0181	0.0189	0.0756	0.0669	0.0312	0.0257
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3						
AVERAGES	0.0005	0.0006	0.0007	0.0005	0.0005	0.0004
	0.0004	0.0004	0.0006	0.0007	0.0005	0.0005
STD. DEVIATIONS	0.0004	0.0006	0.0006	0.0004	0.0005	0.0003
	0.0002	0.0002	0.0010	0.0009	0.0004	0.0003

****

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	INCHES		CU. FEET	PERCENT
PRECIPITATION	4.04	(1.532)	14676.1	100.00
RUNOFF	0.004	(0.0190)	15.38	0.105
EVAPOTRANSPIRATION	3.580	(1.4744)	12994.72	88.543
LATERAL DRAINAGE COLLECTED FROM LAYER 2	0.48768	(0.24897)	1770.263	12.06223
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00000	(0.00000)	0.008	0.00006
AVERAGE HEAD ON TOP OF LAYER 3	0.001	(0.000)		
CHANGE IN WATER STORAGE	-0.029	(0.5295)	-104.28	-0.711

****

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	1.83	6642.900
RUNOFF	0.085	307.6796
DRAINAGE COLLECTED FROM LAYER 2	0.02719	98.70956
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 3	0.011	
MAXIMUM HEAD ON TOP OF LAYER 3	0.022	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	0.74	2687.3430

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.1929

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0330

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

****

****

FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	2.0231	0.0843
2	0.0046	0.0232
3	0.0000	0.0000
4	0.1500	0.7500
SNOW WATER	0.000	

****
****

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     C:\HLP3\BRC\BRCPREC.D4
TEMPERATURE DATA FILE:       C:\HLP3\BRC\BRCTEMP.D7
SOLAR RADIATION DATA FILE:   C:\HLP3\BRC\BRCSOLAR.D13
EVAPOTRANSPIRATION DATA:     C:\HLP3\BRC\BRCEVAP.D11
SOIL AND DESIGN DATA FILE:   C:\HLP3\BRC\BRCSOILa.D10
OUTPUT DATA FILE:            C:\HLP3\BRC\Summary\SOILASUM.OUT


TIME:   8:11     DATE:   8/31/2006


******************************************************************************

     TITLE:  BRCUnitA

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   3
          THICKNESS                    =     24.00   INCHES
          POROSITY                     =      0.4570 VOL/VOL
          FIELD CAPACITY               =      0.0830 VOL/VOL
          WILTING POINT                =      0.0330 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.0565 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.310000009000E-02 CM/SEC


                                  LAYER  2
                                  --------

                     TYPE 2 - LATERAL DRAINAGE LAYER
```

MATERIAL TEXTURE NUMBER 20

THICKNESS	=	0.20	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0101	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000	CM/SEC
SLOPE	=	48.00	PERCENT
DRAINAGE LENGTH	=	100.0	FEET

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	0.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	0.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	4 - POOR	

LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.20	INCHES
POROSITY	=	0.7500	VOL/VOL
FIELD CAPACITY	=	0.7470	VOL/VOL
WILTING POINT	=	0.4000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000003000E-08	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 3 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 48.% AND A SLOPE LENGTH OF 100. FEET.

SCS RUNOFF CURVE NUMBER	=	83.20	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	0.594	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.226	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.594	INCHES
INITIAL SNOW WATER	=	0.000	INCHES

INITIAL WATER IN LAYER MATERIALS	=	1.507	INCHES
TOTAL INITIAL WATER	=	1.507	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
LAS VEGAS NEVADA

STATION LATITUDE	=	36.08	DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00	
START OF GROWING SEASON (JULIAN DATE)	=	62	
END OF GROWING SEASON (JULIAN DATE)	=	321	
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	9.10	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	39.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	21.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	24.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	36.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
0.50	0.46	0.41	0.22	0.20	0.09
0.45	0.54	0.32	0.25	0.43	0.32

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
44.60	50.10	55.30	63.50	73.30	83.60
90.30	88.00	80.10	67.60	53.60	45.40

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA
AND STATION LATITUDE = 36.08 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.33	0.45	0.33	0.26	0.29	0.07
	0.51	0.51	0.34	0.17	0.49	0.28
STD. DEVIATIONS	0.37	0.49	0.34	0.23	0.33	0.13
	0.73	0.40	0.55	0.16	0.50	0.22
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.005	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.022	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.018	0.015	0.009	0.010	0.008	0.002
	0.036	0.006	0.008	0.003	0.016	0.019
STD. DEVIATIONS	0.041	0.037	0.017	0.026	0.013	0.004
	0.094	0.008	0.018	0.003	0.033	0.040
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	0.3228	0.4337	0.3217	0.2672	0.2977	0.1287
	0.4109	0.4867	0.3369	0.2050	0.4156	0.2610
STD. DEVIATIONS	0.3156	0.3623	0.2745	0.1676	0.2297	0.0926
	0.6111	0.3682	0.4862	0.1405	0.4363	0.1747
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3						
AVERAGES	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000
	0.0001	0.0001	0.0001	0.0000	0.0001	0.0000
STD. DEVIATIONS	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000
	0.0001	0.0001	0.0001	0.0000	0.0001	0.0000

****

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	INCHES		CU. FEET	PERCENT
PRECIPITATION	4.04	(1.532)	14676.1	100.00
RUNOFF	0.005	(0.0223)	18.10	0.123
EVAPOTRANSPIRATION	0.149	(0.1470)	539.37	3.675
LATERAL DRAINAGE COLLECTED FROM LAYER 2	3.88799	(1.37123)	14113.411	96.16602
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00000	(0.00000)	0.009	0.00006
AVERAGE HEAD ON TOP OF LAYER 3	0.000	(0.000)		
CHANGE IN WATER STORAGE	0.001	(0.1516)	5.20	0.035

****

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	1.83	6642.900
RUNOFF	0.100	361.7648
DRAINAGE COLLECTED FROM LAYER 2	0.95379	3462.24854
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 3	0.005	
MAXIMUM HEAD ON TOP OF LAYER 3	0.007	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	0.74	2687.3430

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.0406

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0330

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

****

****

FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	1.3840	0.0577
2	0.0020	0.0101
3	0.0000	0.0000
4	0.1500	0.7500
SNOW WATER	0.000	

****
****

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     C:\HLP3\BRC\BRCPREC.D4
TEMPERATURE DATA FILE:       C:\HLP3\BRC\BRCTEMP.D7
SOLAR RADIATION DATA FILE:   C:\HLP3\BRC\BRCSOLAR.D13
EVAPOTRANSPIRATION DATA:     C:\HLP3\BRC\BRCEVAP.D11
SOIL AND DESIGN DATA FILE:   C:\HLP3\BRC\BRCSOILB.D10
OUTPUT DATA FILE:            C:\HLP3\BRC\Summary\SOILBSUM.OUT


TIME:   8:14     DATE:   8/31/2006


******************************************************************************

     TITLE:  BRCUnitB

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   3
          THICKNESS                    =     24.00   INCHES
          POROSITY                     =      0.4570 VOL/VOL
          FIELD CAPACITY               =      0.0830 VOL/VOL
          WILTING POINT                =      0.0330 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.0565 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.310000009000E-02 CM/SEC


                                  LAYER  2
                                  --------

                       TYPE 2 - LATERAL DRAINAGE LAYER
```

MATERIAL TEXTURE NUMBER 20

THICKNESS	=	0.20	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0100	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000	CM/SEC
SLOPE	=	48.00	PERCENT
DRAINAGE LENGTH	=	75.0	FEET

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	0.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	0.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	4 - POOR	

LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.20	INCHES
POROSITY	=	0.7500	VOL/VOL
FIELD CAPACITY	=	0.7470	VOL/VOL
WILTING POINT	=	0.4000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000003000E-08	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 3 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 48.% AND A SLOPE LENGTH OF 75. FEET.

SCS RUNOFF CURVE NUMBER	=	83.40	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	0.594	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.226	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.594	INCHES
INITIAL SNOW WATER	=	0.000	INCHES

INITIAL WATER IN LAYER MATERIALS	=	1.507	INCHES
TOTAL INITIAL WATER	=	1.507	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
LAS VEGAS NEVADA

STATION LATITUDE	=	36.08	DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00	
START OF GROWING SEASON (JULIAN DATE)	=	62	
END OF GROWING SEASON (JULIAN DATE)	=	321	
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	9.10	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	39.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	21.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	24.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	36.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
0.50	0.46	0.41	0.22	0.20	0.09
0.45	0.54	0.32	0.25	0.43	0.32

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
44.60	50.10	55.30	63.50	73.30	83.60
90.30	88.00	80.10	67.60	53.60	45.40

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA
AND STATION LATITUDE = 36.08 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.33	0.45	0.33	0.26	0.29	0.07
	0.51	0.51	0.34	0.17	0.49	0.28
STD. DEVIATIONS	0.37	0.49	0.34	0.23	0.33	0.13
	0.73	0.40	0.55	0.16	0.50	0.22
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.005	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.023	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.018	0.015	0.009	0.010	0.008	0.002
	0.036	0.006	0.007	0.003	0.016	0.019
STD. DEVIATIONS	0.041	0.037	0.017	0.026	0.013	0.004
	0.094	0.008	0.015	0.003	0.033	0.040
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	0.3226	0.4341	0.3212	0.2677	0.2978	0.1285
	0.4111	0.4865	0.3374	0.2053	0.4149	0.2614
STD. DEVIATIONS	0.3153	0.3621	0.2753	0.1679	0.2298	0.0927
	0.6112	0.3682	0.4889	0.1407	0.4363	0.1748
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3						
AVERAGES	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0001	0.0000	0.0001	0.0000	0.0001	0.0000

****

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	INCHES		CU. FEET	PERCENT
PRECIPITATION	4.04	(1.532)	14676.1	100.00
RUNOFF	0.005	(0.0235)	19.05	0.130
EVAPOTRANSPIRATION	0.148	(0.1460)	537.00	3.659
LATERAL DRAINAGE COLLECTED FROM LAYER 2	3.88839	(1.37242)	14114.859	96.17588
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00000	(0.00000)	0.009	0.00006
AVERAGE HEAD ON TOP OF LAYER 3	0.000	(0.000)		
CHANGE IN WATER STORAGE	0.001	(0.1520)	5.16	0.035

****

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	1.83	6642.900
RUNOFF	0.105	380.3883
DRAINAGE COLLECTED FROM LAYER 2	0.91576	3324.21558
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 3	0.005	
MAXIMUM HEAD ON TOP OF LAYER 3	0.005	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	0.74	2687.3430

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.0397

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0330

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

****

****

FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	1.3838	0.0577
2	0.0020	0.0101
3	0.0000	0.0000
4	0.1500	0.7500
SNOW WATER	0.000	

****
****

RC
SAN

Table VI Values of n for use with Manning Equation

Surface	n. Range	n, design
Polyethylene pipe	0.008-0.011	0.009 *
Uncoated cast or ductile iron pipe	0.012-0.015	0.013
Corrugated steel pipe	0.021-0.030	0.024
Concrete pipe	0.012-0.016	0.015
Vitrified clay pipe	0.011-0.017	0.013
Brick & cement mortar sewers	0.012-0.017	0.015
Wood stave	0.010-0.013	0.011
Rubble masonry	0.017-0.030	0.021

Some gravity flow piping systems may become very complex, especially if the pipeline grade varies, because friction loss will vary along the run. With a varying grade, parts of the line may develop internal pressure, or vacuum, and may have varying liquid levels in the bore.

Manning

For open channel water flow under conditions of constant grade, and uniform channel cross section, the Manning equation may be used. Open channel flow exists in a pipe when it runs partially full. Like the Hazen-Williams formula, the Manning equation is limited to water or liquids with a kinematic viscosity equal to water.

Manning Equation **(20)**

$$V = \frac{1.486}{n} r^{2/3} S^{1/2}$$

where

V = flow velocity, ft/sec
n = roughness coefficient, dimensionless
r = hydraulic radius, ft

$$r = \frac{A}{P} \quad * \quad (21)$$

A = channel cross section area, ft^2
P = perimeter wetted by flow, ft
S = hydraulic slope, ft/ft

$$S = \frac{h_1 - h_2}{L} = \frac{h_f}{L} \quad (22)$$

h_1 = upstream pipe elevation, ft
h_2 = downstream pipe elevation, ft
h_f = friction loss, ft of liquid

It is convenient to combine the Manning equation with

$$Q = A V \quad (23)$$

to obtain

$$Q = \frac{1.486A}{n} r^{2/3} S^{1/2} \quad * \quad (24)$$

where terms are as defined above, and

Q = flow, ft^3/secWhen a circular pipe is running full or half-full,

$$r = \frac{D}{4} = \frac{d}{48} \quad (25)$$

ATTACHMENT B, 1/1

CHEVRON PLEXCO/SAROLITE ENGINEERING MANUAL

Driscopipe 1000 Series Industrial Pipe: Sizes and Dimensions

Nom. Size, in.	Dimensions, inches OD	Min.Wall	DR	$P_{73.4°F}$ psig	Weight lb/100ft
3/4	1.050	0.095	11.0	160	12
1	1.315	0.120	11.0	160	19
1 3/4	1.660	0.151	11.0	160	31
1 1/2	1.900	0.173	11.0	160	41

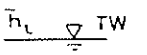
Nom. Size, in.	Dimensions, in. OD	Min.Wall	DR	$P_{73.4°F}$ psig	Weight lb/100ft
2	2.375	0.339	7.0	267	94
2	2.375	0.264	9.0	200	76
2	2.375	0.216	11.0	160	64
2	2.375	0.176	13.5	128	53
2	2.375	0.140	17.0	100	43
3	3.500	0.500	7.0	267	205
3	3.500	0.389	9.0	200	166
3	3.500	0.318	11.0	160	139
3	3.500	0.259	13.5	128	115
3	3.500	0.206	17.0	100	93
3	3.500	0.167	21.0	80	77
3	3.500	0.135	26.0	64	62
4	4.500	0.643	7.0	267	339
4	4.500	0.500	9.0	200	274
4	4.500	0.409	11.0	160	229
4	4.500	0.333	13.5	128	190
4	4.500	0.265	17.0	100	154
4	4.500	0.214	21.0	80	126
4	4.500	0.173	26.0	64	103
4	4.500	0.138	32.5	51	83
5	5.563	0.795	7.0	267	517
5	5.563	0.618	9.0	200	418
5	5.563	0.506	11.0	160	351
5	5.563	0.412	13.5	128	291
5	5.563	0.327	17.0	100	235
5	5.563	0.265	21.0	80	193
5	5.563	0.214	26.0	64	157
5	5.563	0.171	32.5	51	127
5.375	5.375	0.316	17.0	100	220
5.375	5.375	0.256	21.0	80	180
5.375	5.375	0.207	26.0	64	147
5.375	5.375	0.165	32.5	51	118
6	6.625	0.946	7.0	267	733
6	6.625	0.736	9.0	200	593
6	6.625	0.602	11.0	160	497
6	6.625	0.491	13.5	128	413
6	6.625	0.390	17.0	100	334
6	6.625	0.315	21.0	80	273
6	6.625	0.255	26.0	64	223
6	6.625	0.204	32.5	51	180

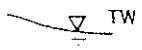
Nom. Size, in.	Dimensions, in. OD	Min.Wall	DR	$P_{73.4°F}$ psig	Wei lb/
7	7.125	1.018	7.0	267	84
7	7.125	0.792	9.0	200	6
7	7.125	0.648	11.0	160	5
7	7.125	0.528	13.5	128	4
7	7.125	0.420	17.0	100	3
7	7.125	0.340	21.0	80	3
7	7.125	0.274	26.0	64	2
7	7.125	0.220	32.5	51.0	2
8	8.625	1.232	7.0	267	12
8	8.625	0.958	9.0	200	10
8	8.625	0.784	11.0	160	8
8	8.625	0.639	13.5	128	7
8	8.625	0.507	17.0	100	5
8	8.625	0.411	21.0	80	4
8	8.625	0.332	26.0	64	3
8	8.625	0.255	32.5	51	3
10	10.750	1.536	7.0	267	19
10	10.750	1.194	9.0	200	15
10	10.750	0.977	11.0	160	13
10	10.750	0.796	13.5	128	10
10	10.750	0.632	17.0	100	8
10	10.750	0.512	21.0	80	7
10	10.750	0.413	26.0	64	5
10	10.750	0.331	32.5	51	4
12	12.750	1.821	7.0	267	27
12	12.750	1.417	9.0	200	21
12	12.750	1.159	11.0	160	18
12	12.750	0.944	13.5	128	15
12	12.750	0.750	17.0	100	12
12	12.750	0.607	21.0	80	10
12	12.750	0.490	26.0	64	8
12	12.750	0.392	32.5	51	6
14	14.000	2.000	7.0	267	32
14	14.000	1.556	9.0	200	26
14	14.000	1.273	11.0	160	22
14	14.000	1.037	13.5	128	18
14	14.000	0.824	17.0	100	14
14	14.000	0.667	21.0	80	12
14	14.000	0.538	26.0	64	9
14	14.000	0.431	32.5	51	8
16	16.000	2.286	7.0	267	42
16	16.000	1.778	9.0	200	34
16	16.000	1.455	11.0	160	29
16	16.000	1.185	13.5	128	24
16	16.000	0.941	17.0	100	19
16	16.000	0.762	21.0	80	15
16	16.000	0.615	26.0	64	13
16	16.000	0.492	32.5	51	10

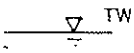
RC
SMM

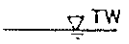
raulic conditions are dis-

the result of inadequate
ert discharge is primarily
and the head loss of the
ulvert flow can be treated
culvert. h_L, is the sum of









verts.

an entrance loss, h_{ent}, friction loss, h_f, and the
barrel.

$$h_L = h_{ent} + h_f + \frac{V^2}{2g}$$

Substituting Equations (3.32) and (3.16) for h_{ent} and h_f, respectively, we have

$$h_L = k_{ent}\left(\frac{V^2}{2g}\right) + \frac{n^2V^2L}{R_h^{4/3}} + \frac{V^2}{2g} \tag{8.17}$$

The entrance coefficient, k_{ent}, is approximately 0.5 for a square-edged entrance and approximately 0.1 for a well-rounded entrance. Common values used for the Manning's roughness coefficient are $n = 0.012$ for concrete pipe and $n = 0.024$ for corrugated steel pipe. Equation (8.17) may be rearranged to express the direct relationship between the discharge and the dimensions of the culvert at any given elevation difference, h_L, between tail water and head water. For a circular culvert,

$$h_L = \left[K_{ent} + \left(\frac{n^2L}{R_h^{4/3}}\right)(2g) + 1\right]\frac{8Q^2}{\pi^2gD^4} \tag{8.18}$$

where Q is the discharge, D is the diameter, and R_h is the hydraulic radius ($R_h = D/4$) of the culvert barrel. For culverts with noncircular cross sections, the head loss may be calculated by Equation (8.17) with the corresponding hydraulic radius calculated by using the cross-sectional area, A, and the wetted perimeter, P.

2. If the discharge carried in a culvert has a normal depth that is larger than the barrel height, the culvert will flow full even if the tail water level drops below that of the outlet. In this case, the discharge is controlled by the head loss and the level of the head water (HW). The hydraulics are the same as discussed before.
3. If the normal depth is less than the barrel height, with the inlet submerged and free discharge at the outlet, a partially full pipe flow condition will normally result, as illustrated in Figure 8.17(c). The culvert discharge is controlled by the entrance condition, and the flow is said to be under *entrance* control. The discharge can be calculated by

$$Q = C_dA\sqrt{2gh} \tag{8.19}$$

where h is the hydrostatic head above the center of the orifice and A is the cross-sectional area. C_d is the coefficient of discharge; common

HWANG "FUNDAMENTALS OF HYDRAULIC ENGINEERING SYSTEMS"
2nd EDITION, PRENTICE-HALL, 1987

ATTACHMENT D 1/2

values used in practice are $C_d = 0.62$ for a square-edged entrance and $C_d = 1.0$ for a well-rounded entrance.

4. When the hydrostatic head at the entrance is less than $1.2D$, air will break into the barrel and the culvert will flow under no pressure. In this case, the culvert slope and the barrel wall friction determine the flow condition in the culvert for open channel flow. Due to a sudden reduction of the water area at the entrance, the flow usually enters the culvert in a supercritical condition. The critical depth takes place at the entrance of the barrel. The friction of the barrel wall gradually dissipates the energy. If the rate of dissipation is higher than the flow could gain from the barrel slope, the depth of the flowing water will increase in the downstream direction. Depending on the tail water level, the supercritical flow may convert to subcritical flow through a hydraulic jump. The flow conditions can be computed by applying the water surface profiles developed for open channels.

Example 8.4

A corrugated steel pipe is used as a culvert that must carry a flow rate of 5.3 m^3/sec and discharge into the air. At the entrance, the maximum available water head is 3.2 m above the bottom as shown in Figure 8.18. The culvert is 35 m long and has a square-edged entrance and slope of 0.003. Determine the diameter of the pipe.

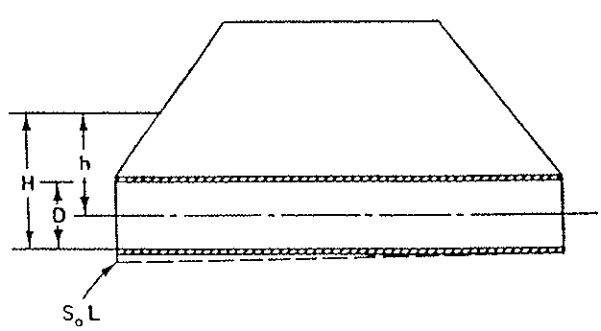


Figure 8.18

Solution

(a) Allowing full pipe flow, the energy balance of the culvert flow may be expressed as (see Figure 8.18),

$$h_L = H - D + S_o L = 3.2 - D + 0.003 \cdot 35$$
$$= 3.305 - D$$

where D is the diameter of the pipe. Also, from Equation (8.18), we have,

ATTACHMENT D, 2/2

The U.S. Bureau of Reclamation (1973) uses the following criterion for grain size of filter materials in relation to openings in pipes:

$$\frac{D_{85} \text{ of the filter nearest the pipe}}{\text{maximum opening of pipe drain}} = 2 \text{ or more} \tag{5.6}$$

Equations 5.4, 5.5, and 5.6 represent a reasonable range over which satisfactory performance can be expected.

An important development in the manufacture of drainage pipes is the slotted PVC pipe (Cedergren, 1987) which has slots machined to specified widths from a minimum of 0.010 in. (0.25 mm) up to 0.10 in. (2.54 mm) or larger. Figure 5.3 shows a PVC pipe 6 in. (15.2 cm) in diameter with sawed slots of uniform size. Close control over the width of the slots ensures free flow of water into the pipe without danger of clogging with soil when the slotwidths have been correctly established with Eq. 5.4.

5.3 EXAMPLES OF FILTER DESIGNS TO PREVENT PIPING

Historical

Before the development of rational and experimental filter design criteria drain design was considered more of an art than a science. Designers depended on judgment, instinct, or precedent. In many instances coarse stone or gravel was placed in direct contact with fine-grained soils with the result that drains often became clogged or soil piped through them, thus causing structural failures.

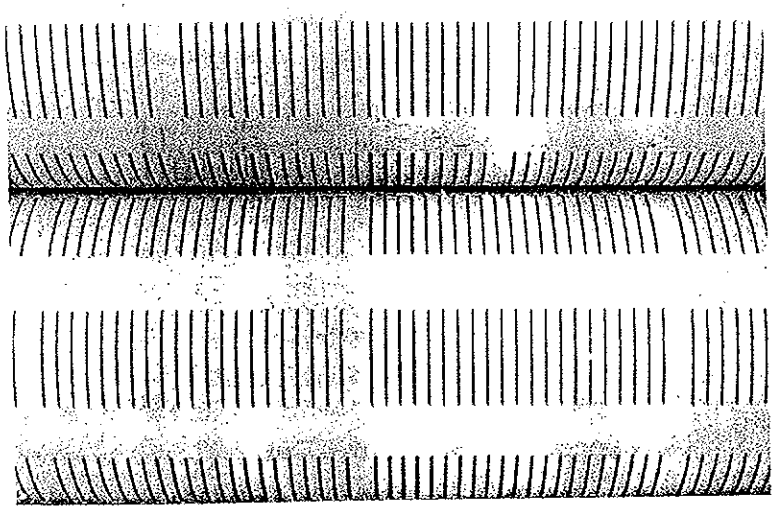
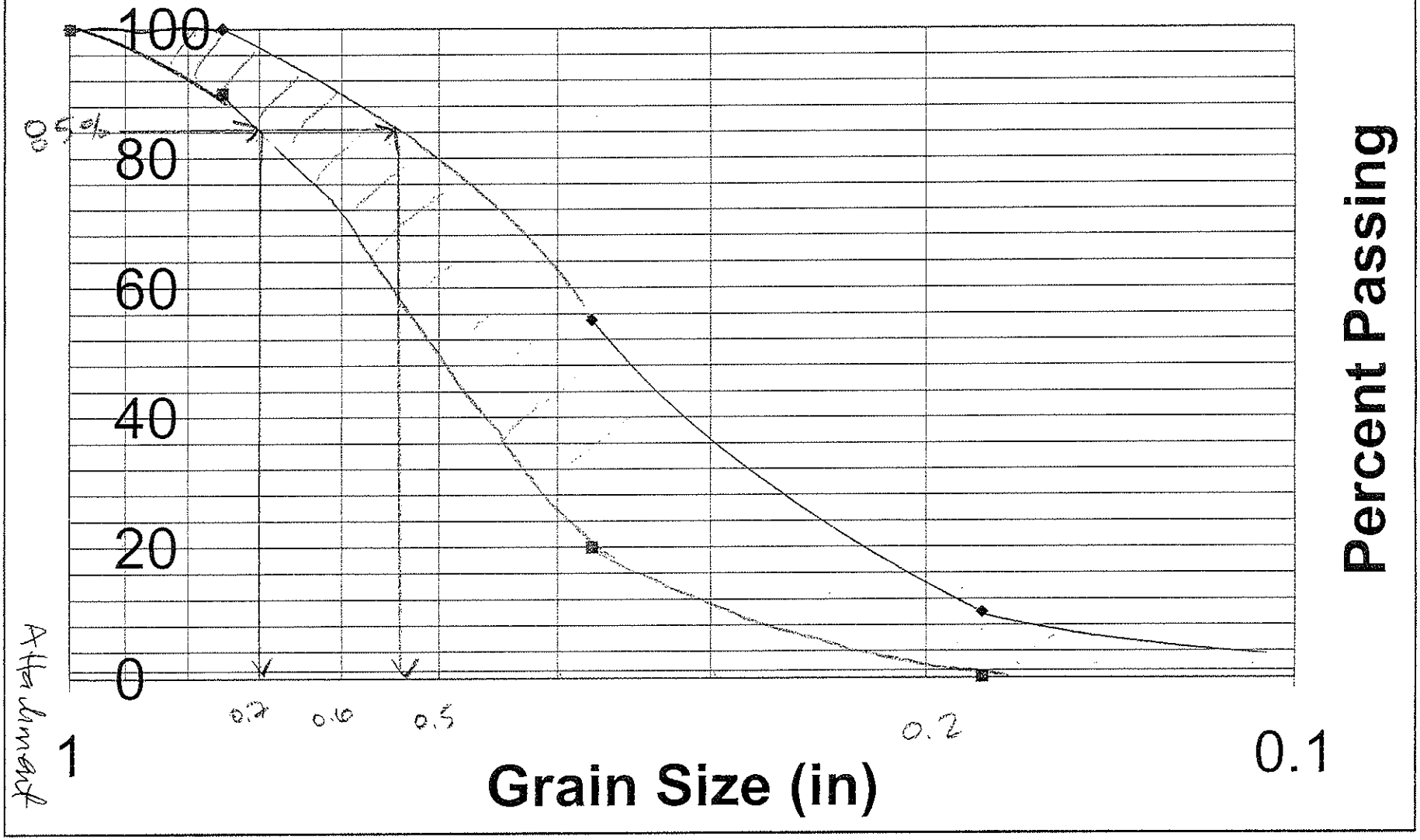


FIG. 5.3 Slotted PVC drain pipe 6-in. in diameter. Machined slots of uniform width provide good filter protection.

Attachment E
1/1

Gradation, AASHTO 67



LIBRARY COPY

STANDARD SPECIFICATIONS

for

TRANSPORTATION MATERIALS

and

METHODS OF SAMPLING AND TESTING

Seventeenth Edition

1995

PART I SPECIFICATIONS

Adopted by the

AMERICAN ASSOCIATION OF STATE HIGHWAY
AND TRANSPORTATION OFFICIALS

AH. F
2/4

Standard Specification
for

Sizes of Aggregate for Road and Bridge Construction

AASHTO DESIGNATION: M 43-88
(ASTM DESIGNATION: D 448-86)

1. SCOPE

1.1 This specification defines aggregate size designations and ranges in mechanical analyses for standard sizes of coarse aggregate and screenings for use in the construction and maintenance of various types of highways and bridges.

1.2 The values stated in SI units are to be regarded as the standard.

2. REFERENCED DOCUMENTS

2.1 *AASHTO Standards:*

T 27	Sieve Analysis of Fine and Coarse Aggregates
T 2	Sampling Aggregates
M 92	Wire-Cloth Sieves for Testing Purposes

3. SIGNIFICANCE AND USE

3.1 Contract documents may specify certain of these aggregate sizes for specific uses or may suggest one or more of these sizes as appropriate for the preparation of various end-product mixtures. In some cases, closer limits on variability of the aggregate grading may be required.

4. MANUFACTURE

4.1 The standard sizes of aggregate described in this classification may be manufactured by means of any suitable process used to separate raw material into the desired size ranges. Standard sizes may also be produced by blending two or more different components.

5. STANDARD SIZES

5.1 Standard sizes of coarse aggregate shall comply with the sizes given in Table 1. All sizes shall be determined by means of laboratory sieves having square openings and conforming to M 92.

6. BASIS OF CLASSIFICATION

6.1 Classification is based npon the size number and size ranges shown in Table 1 with the aggregate sampled in accordance with T 2 and tested for grading by T 27.

AH. F
3/4

TABLE 1 Standard Sizes of Processed Aggregate

Size Number	Nominal Size, Square Openings	Amounts Finer than Each Laboratory Sieve (Square Openings), Mass Percent														
		100-mm (4-in.)	90-mm (3½-in.)	75-mm (3-in.)	63-mm (2½-in.)	50-mm (2-in.)	37.5-mm (1½-in.)	25.0-mm (1-in.)	19.0-mm (¾-in.)	12.5-mm (½-in.)	9.5-mm (⅜-in.)	4.75-mm (No. 4)	2.36-mm (No. 8)	1.18-mm (No. 16)	300-µm (No. 50)	150-µm (No. 100)
1	90 to 37.5-mm (3½ to 1½-in.)	100	90 to 100	—	25 to 60	—	0 to 15	—	0 to 5	—	—	—	—	—	—	—
2	63 to 37.5-mm (2½ to 1½-in.)	—	—	100	90 to 100	35 to 70	0 to 15	—	0 to 5	—	—	—	—	—	—	—
24	63 to 19.0-mm (2½ to ¾-in.)	—	—	100	90 to 100	—	25 to 60	—	0 to 10	0 to 5	—	—	—	—	—	—
3	50 to 25.0-mm (2 to 1-in.)	—	—	—	100	90 to 100	35 to 70	0 to 15	—	0 to 5	—	—	—	—	—	—
357	50 to 4.75-mm (2-in. to No. 4)	—	—	—	100	95 to 100	—	35 to 70	—	10 to 30	—	0 to 5	—	—	—	—
4	37.5 to 19.0-mm (1½ to ¾-in.)	—	—	—	—	100	90 to 100	20 to 55	0 to 15	—	0 to 5	—	—	—	—	—
467	37.5 to 4.75-mm (1½ to No. 4)	—	—	—	—	100	95 to 100	—	35 to 70	—	10 to 30	0 to 5	—	—	—	—
5	25.0 to 12.5-mm (1 to ½-in.)	—	—	—	—	—	100	90 to 100	20 to 55	0 to 10	0 to 5	—	—	—	—	—
56	25.0 to 9.5-mm (1 to ⅜-in.)	—	—	—	—	—	100	90 to 100	40 to 85	10 to 40	0 to 15	0 to 5	—	—	—	—
57	25.0 to 4.75-mm (1 to No. 4)	—	—	—	—	—	100	95 to 100	—	25 to 60	—	0 to 10	0 to 5	—	—	—
6	19.0 to 9.5-mm (¾ to ⅜-in.)	—	—	—	—	—	—	100	90 to 100	20 to 55	0 to 15	0 to 5	—	—	—	—
67	19.0 to 4.75-mm (¾ to No. 4)	—	—	—	—	—	—	100	90 to 100	—	20 to 55	0 to 10	0 to 5	—	—	—
68	19.0 to 2.36-mm (¾ to No. 8)	—	—	—	—	—	—	100	90 to 100	—	30 to 65	5 to 25	0 to 10	0 to 5	—	—
7	12.5 to 4.75-mm (½ to No. 4)	—	—	—	—	—	—	—	100	90 to 100	40 to 70	0 to 15	0 to 5	—	—	—
78	12.5 to 2.36-mm (½ to No. 8)	—	—	—	—	—	—	—	100	90 to 100	40 to 75	5 to 25	0 to 10	0 to 5	—	—
8	9.5 to 2.36-mm (⅜ to No. 8)	—	—	—	—	—	—	—	—	100	85 to 100	10 to 30	0 to 10	0 to 5	—	—
89	9.5 to 1.18-mm (⅜ to No. 16)	—	—	—	—	—	—	—	—	100	90 to 100	20 to 55	5 to 30	0 to 10	0 to 5	—
9	4.75 to 1.18-mm (No. 4 to No. 16)	—	—	—	—	—	—	—	—	—	100	85 to 100	10 to 40	0 to 10	0 to 5	—
10	4.75-mm (No. 4 to 0)[A]	—	—	—	—	—	—	—	—	—	100	85 to 100	—	—	—	10 to 30

[A] Screenings.

AH. F
4/4

Exploration Location	Depth (feet)	Soil Description	Percent Sodium	Percent Sulfate	Total Available Water Soluble sodium Sulfate (%)
B-5	10-15	Silty sand with gravel	0.07	0.13	0.20
B-8	19-20	Silty sand with gravel	0.07	0.06	0.08
B-101	5-10	Silty sand with gravel	0.17	0.06	0.08
B-102	0-5	Fill – Silty sand with gravel	0.17	0.03	0.05
B-106	0-5	Silty sand with gravel	0.15	0.08	0.12
B-106	29-30	Silty sand with gravel	0.15	0.06	0.08

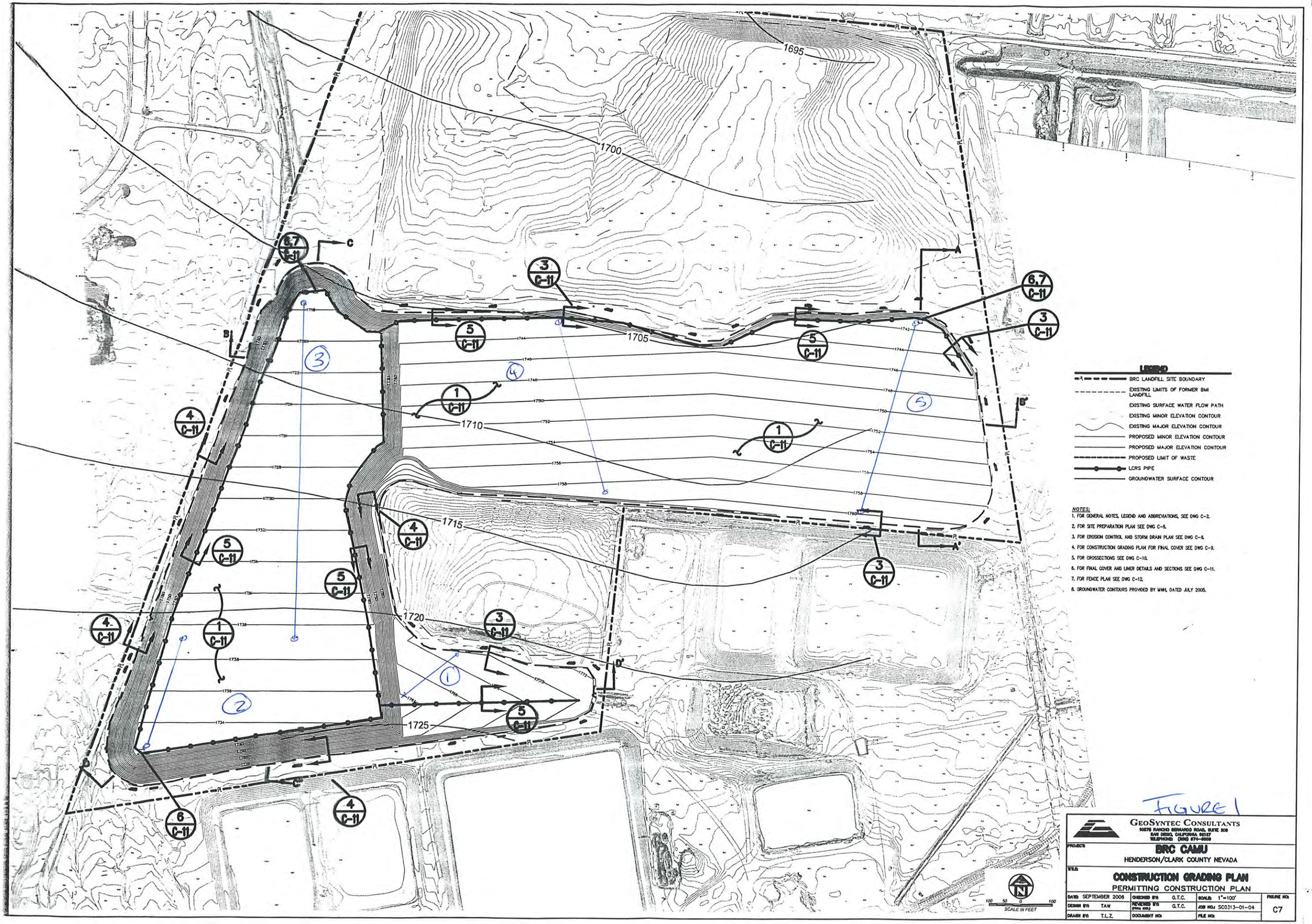
Permeability

Falling head permeability tests were conducted on remolded samples in general accordance with modified ASTM procedure D2434. The soil was compacted in a mold 4.6 inches long and 4.0 inches in diameter to 85 or 90 percent of maximum dry density and at optimum moisture content. A falling head was applied to the sample and the flow of water through the sample was monitored. The permeability was calculated after the flow rate had stabilized. The result of the falling head permeability test is presented in the following table:

Exploration Location	Sample Depth (Feet)	Soil Description	k (cm/s)
B-5	20-25	Silty sand with gravel	5.3×10^{-4}
B-12	10-15	Silty sand with gravel	4.0×10^{-4}
B-102	20-25	Silty sand with gravel	1.0×10^{-4}
B-105	20-25	Well graded sand with silt and gravel	1.2×10^{-3}

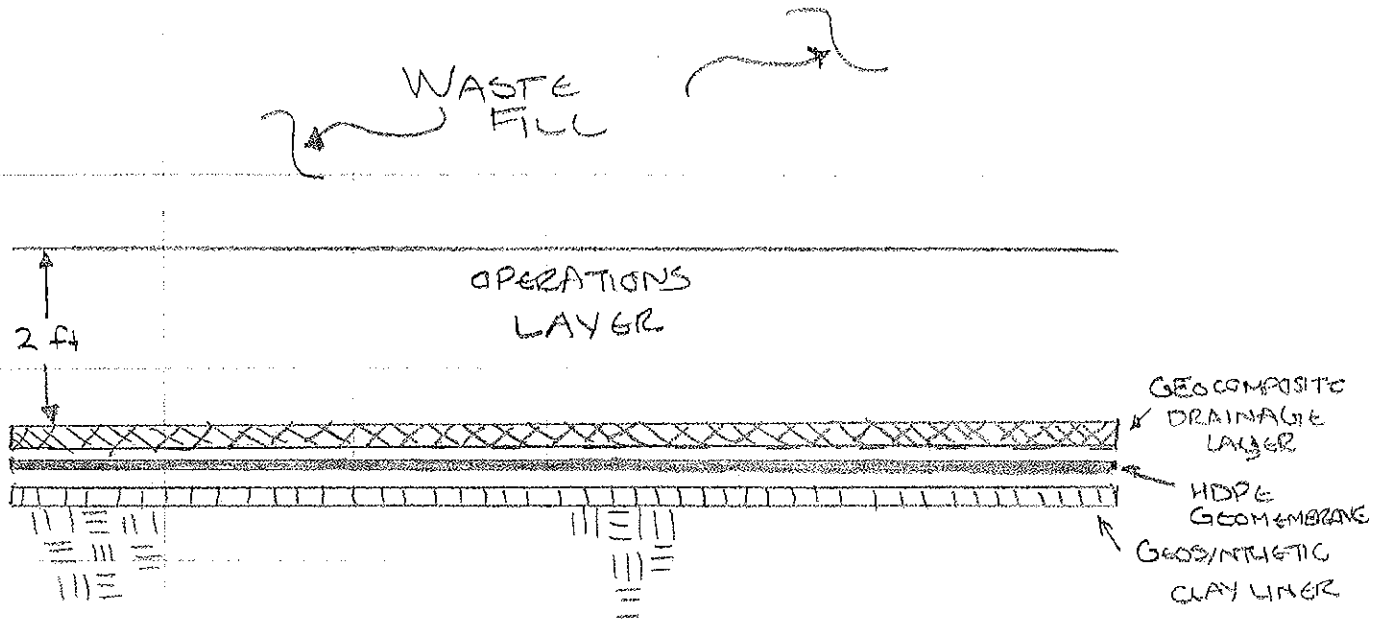
Flexible wall permeameter tests were performed on selected samples by AP Engineering and Testing, Inc according to ASTM D5084. With the exception of one sample (B-105), all tested samples were undisturbed ring samples. The samples were placed in a triaxial machine with a constant confining pressure at the approximate in-place effective stress pressures. Results were generally consistent with the fal-

Attachment G 1/1


1695
1700
1705
1710
1715
1720
1725
LEGEND
BRC LANDFILL SITE BOUNDARY
EXISTING LIMITS OF FORMER BMI LANDFILL
EXISTING SURFACE WATER FLOW PATH
EXISTING MINOR ELEVATION CONTOUR
EXISTING MAJOR ELEVATION CONTOUR
PROPOSED MINOR ELEVATION CONTOUR
PROPOSED MAJOR ELEVATION CONTOUR
PROPOSED LIMIT OF WASTE
LCRS PIPE
GROUNDWATER SURFACE CONTOUR
NOTES:
1. FOR GENERAL NOTES, LEGEND AND ABBREVIATIONS, SEE DWG C-2.
2. FOR SITE PREPARATION PLAN SEE DWG C-5.
3. FOR EROSION CONTROL AND STORM DRAIN PLAN SEE DWG C-8.
4. FOR CONSTRUCTION GRADING PLAN FOR FINAL COVER SEE DWG C-9.
5. FOR CROSSECTIONS SEE DWG C-10.
6. FOR FINAL COVER AND LINER DETAILS AND SECTIONS SEE DWG C-11.
7. FOR FENCE PLAN SEE DWG C-12.
8. GROUNDWATER CONTOURS PROVIDED BY MWH, DATED JULY 2005.
SCALE IN FEET
FIGURE 1
GEOSYNTEC CONSULTANTS
10875 RANCHO BERNARDO ROAD, SUITE 209
SAN DIEGO, CALIFORNIA 92127
TELEPHONE: (858) 674-9000
PROJECT
BRC CAMU
HENDERSON/CLARK COUNTY NEVADA
TITLE
CONSTRUCTION GRADING PLAN
PERMITTING CONSTRUCTION PLAN
DATE SEPTEMBER 2006
CHECKED BY G.T.C.
SCALE 1"=100'
DESIGN BY TAW
REVIEWED BY G.T.C.
JOB NO. SC0313-01-04
DRAWN BY T.L.Z.
DOCUMENT NO.
FILE NO.
FIGURE NO. C7

Written by: R. FLYNN Date: 21 / 08 / 06 (DD MM YY) Reviewed by: _____ Date: ___ / ___ / ___ (DD MM YY)

Client: BRC Project: BRC CAMV Project/Proposal No.: SC0313 Task No: 01 - 04



COMPOSITE LINER SYSTEM

NOT TO SCALE

FIGURE 2

Calculation Package D
Pipe Strength

GeoSyntec Consultants

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: Basic Remediation Company

Project: BRC CAMU **Project/Proposal #:** SC0313 **Task #:** 01

Title of Computations: Pipe Strength Calculations

Computations By:

SIGNATURE — DATE 11/3/06

Rebecca Flynn, Staff Engineer
PRINTED NAME AND TITLE

Assumptions and Procedures Checked By (Peer Reviewer):

SIGNATURE — DATE 11/6/06

Keaton Botelho, Staff Engineer
PRINTED NAME AND TITLE

Computations Checked By:

SIGNATURE — DATE 11/3/06

Gregory T. Corcoran, PE / Principal
PRINTED NAME AND TITLE

Computations Backchecked By (Originator):

SIGNATURE — DATE 11/3/06

Rebecca Flynn, Staff Engineer
PRINTED NAME AND TITLE

Approved By (PM or Designate):

SIGNATURE — DATE 11/3/06

Gregory T. Corcoran, PE / Principal
PRINTED NAME AND TITLE

Approval Notes:

Revisions: (Number and Initial All Revisions)

No.	Sheet	Date	By	Checked By	Approval

Written by: Rebecca Flynn Date: 06 / 08 / 21 (YY MM DD) Reviewed by: BTC Date: 06 / 11 / 03 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

PIPE STRENGTH CALCULATIONS
BRC CAMU
HENDERSON, NEVADA

OBJECTIVE

A 4-in diameter HDPE leachate collection pipe and 18-in diameter side slope riser will be constructed at the BRC Corrective Action Management Unit (CAMU) in Henderson, Nevada. The objective of this calculation package is to evaluate the pipe strength performance and size the pipe wall thickness (i.e., determine the SDR).

SITE CONDITIONS

Crushed gravel will be backfilled around the 4-in and 18-in pipes. The maximum height of waste soil placed above the pipes will be 93 ft. Short term construction and long-term conditions will be evaluated.

LOADING CONDITIONS

The following two loading conditions were evaluated:

1. Short-Term Loading: Haul Truck (H-20)

   The ground pressure applied by the haul truck was estimated to be 100 psi as shown in Attachment A, p. 2. Based on the maximum axle load of 18 kips, the total load on the tire is 9 kips. Therefore, the footprint of the tire is approximately 0.63 ft^2 (see Attachment A). During construction, it was assumed that a minimum of 1 ft (0.3 m) of cover soil will separate haul trucks from the leachate collection pipes. Using Boussinesq's solution for a uniformly loaded square area, the assumed vertical pressure on the top of the pipe is 25 psi (see Attachment A).

2. Long-Term: Waste Soil Overburden Pressure

   Post construction, the maximum overburden soil will exist over the pipe at the southwest sump at a total depth of 93 ft (28.3 m). The unit weight is assumed to be 136 pcf. Additional loads from equipment is assumed to be negligible. The vertical pressure is calculated by:

P = 93 ft (136 pcf) /144 in^2/ft^2 = 87.8 psi.

Therefore, the vertical pressure on the top of pipe in the long-term condition is 87.8 psi.

Since the long-term load (#2) is greater than short-term load (#1), only the long-term load (#2) was considered herein.

METHOD OF ANALYSES

Ring deflection, wall buckling, and wall crushing of the pipe were evaluated for the loading conditions. The Spangler's Modified Iowa Formula was used to calculate ring deflection. Recent literature indicates that the Modified Iowa Formula results in conservative values for pipe deformation (Brachman 1998). The actual deflection is likely lower due to the arching effects of soil via pipe deflection that are neglected in the Modified Iowa Formula. The manufacturer's design manual for Driscopipe (Philips 66, 1991) and Koerner's *Designing with Geosynthetics* (Koerner 1998) was used to evaluate wall buckling and wall crushing. The design criteria were based on the manufacturer's design manual for Driscopipe (Philips 66, 1991).

The method of analysis shown below solves directly for the SDR (Equation 2) of the pipe. Since the SDR is a dimensionless parameter, the diameter of the pipe does not need to be known.

ANALYSIS

Evaluating Variables

E' = 3,000 psi for crushed rock (Philips 66 1998)

P = Long-term loading. Soil Load = 93 ft of soil at 136 pcf = 12,648 psf = 87.8 psi
(Assume haul truck loading is negligible)

E = 30,000 psi
Attachment D (Philips 66, 1991) shows that the modulus of elasticity (E) is approximately 30,000 psi for a 100 year design life.

Design by Wall Buckling

Wall buckling is generally the critical failure case for buried pipes. Naturally, this is a starting point for initial values for the SDR.

Written by: Rebecca Flynn Date: 06 / 08 / 21 (YY MM DD) Reviewed by: GTC Date: 06 / 11 / 3 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

The SDR is defined as:

SDR = D/t (Equation 1)

where D= outside diameter of pipe
t = minimum pipe wall thickness

Assume a factor of safety of 2.0 for buckling (Philips 66 1998). Therefore:

$FS = 2.0 = P_{cb}/P_T$ (Equation 2) (Attachment D)

where P_{cb} = critical buckling pressure at top of the pipe, and
P_T = total soil pressure at the top of the pipe = 87.8 psi

Solving Equation 2 for the critical buckling pressure, P_{cb}, yields:

P_{cb} = 175.6 psi

The critical buckling pressure, P_{cb} is defined (Philips 66 1998) as:

$$P_{cb} = 0.8\sqrt{(E')(P_c)}$$ (Equation 3) (Attachment D)

where: P_c = critical collapse pressure
E' = soil modulus = 3,000 psi

The critical collapse pressure can be determined by the following equation:

$$P_c = \frac{2E(t/D)^3(D_{min}/D_{max})^3}{1-\mu^2}$$ (Equation 4)(Attachment D)

where: E = pipe modulus = 30,000 psi
D = outside diameter
t = thickness
$(D_{min}/D_{max}) = 0.95$
μ = Poisson's Ratio = 0.45 for HDPE pipe

Written by: Rebecca Flynn Date: 06 / 08 / 21 (YY MM DD) Reviewed by: EC Date: 06 / 11 / 3 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

Equation 4 can be reduced to the following equation:

$$P_c = \frac{2.15(E)}{SDR^3}$$ (Equation 5) (Attachment D)

Inserting Equation 5 and rearranging, Equation 3 becomes:

$$SDR^3 = 0.64(E')\frac{2.15E}{P_{cb}^{\ 2}}$$ (Equation 6)

By inserting the appropriate value determined above, the following result is obtained:

SDR = 15.9, use 13.5 (13.5 < 15.9, OK)

Check Wall Crushing

Wall crushing occurs when the compressive strength of the pipe is exceeded by the overburden soil pressure. For example, the compressive yield strength for HDPE pipe manufactured by Driscopipe is 1,500 psi (Philips 66, 1998). Assuming a factor of safety of 2.0, the required compressive strength of the pipe becomes:

$FS = 2.0 = 1500 \text{ psi} / S_A$, therefore $S_A = 750$ psi (Equation 7)(Attachment D)

The hoop stress in the pipe is expressed as:

$S_A = (SDR-1)P_T/2$ (Equation 8) (Attachment D)

where: P_T = total external pressure = 87.8 psi

Rearranging, Equation 9 becomes:

$SDR = [2(S_A)/P_T] + 1$ (Equation 9)

Therefore, the design SDR is shown below:

SDR = 18.1 > 13.5 O.K.

Written by: Rebecca Flynn Date: 06 / 08 / 21 (YY MM DD) Reviewed by: ETC Date: 06 / 11 / 3 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

Check Ring Deflection

Ring deflection is the change in the vertical diameter of the pipe as the pipe/aggregate system deforms under the external vertical pressure. Ring deflection can be evaluated using Spangler's Modified Iowa formula and can be expressed as follows (Koerner 1998):

$$\Delta y = \frac{D_L K_b W_c}{(EI / r^3) + 0.061E'}$$ (Equation 10) (Attachment B)

Rearranging Equation 11 to express SDR and the percent pipe deflection directly:

$$\frac{\Delta y}{D} = \frac{D_L K_b P}{(2E) / (3(SDR-1)^3) + 0.061E'}$$ (Equation 11)

where:

Δy	= pipe deflection or change in diameter, in.
D	= pipe diameter, in.
W_c	= prism soil load, lb/in of pipe
P	= prism soil load, psi = 87.8 psi
K	= bedding constant, typically 0.083 (Attachment E)
SDR	= standard dimension ratio (SDR) = 13.5
E	= modulus of elasticity of pipe, 30,000 psi
E'	= modulus of soil reaction, 3,000 psi
D_L	= deflection lag factor, 1.3 (range 1.0 to 1.5)

Solving for Equation 12 for the critical load yields:

$$\frac{\Delta y}{D} = \frac{(1.3)(0.083)(87.8)}{2(30{,}000)/3(13.5-1)^3 + 0.061(3000)} = 4.9\%$$

The maximum allowable ring deflection for SDR 13.5 pipe is approximately 5.1% at 1.5% strain (Attachment D). Therefore, the estimated ring deflection is acceptable.

Written by: Rebecca Flynn Date: 06 / 08 / 21 (YY MM DD) Reviewed by: GR Date: 06 / 11 / 3 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

SUMMARY AND CONCLUSIONS

Based upon these calculations for pipe ring deflection, wall buckling, and wall crushing, an HDPE pipe with an SDR of 13.5 satisfies the design criteria.

The pipe compressive strength and the design methods and criteria were based on the Driscopipe manufacturer's design manual (Philips 66, 1998). These parameters might be slightly different for the specific pipe used at BRC CAMU. However, the factors of safety against wall buckling and wall crushing calculated herein will account of uncertainty or differences in the pipe compressive strength or in the design methods and criteria.

CONSIDERATIONS FOR SPECIFICATIONS

In accordance with the above analyses, the following items should be included in the specifications for construction at the BRC CAMU:

- A pipe with a maximum SDR of 13.5.
- A minimum of 1 ft (0.3 m) of cover soil shall be placed over the pipes before a haul truck is allowed to drive over them.
- Compacted crushed rock shall be placed in the pipe trench.

REFERENCES

Das, B. M. "Principles of Geotechnical Engineering", Third Edition, PWS Publishing, p.236
Attachment A

Yoder E.J., Witczak M.W., Principles of Pavement Design, Second Edition, John Wiley and Sons, In.c, p. 13
Attachment A

Brachman, R.W. I., "Laboratory Investigation of the Effect of Coarse Stone Backfill on the Performance of Leachate Collection Pipe", Geosythetics 99, Atlanta, Georgia, March 1998

Koerner R.B. (1998), "Designing with Geosynthetics", Fourth Edition, Prentice Hall, p.676

Written by: Rebecca Flynn Date: 06 / 08 / 21 (YY MM DD) Reviewed by: ETC Date: 06 / 11 / 3 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

Attachment B

Philips 66 (1991), "Driscopipe Systems Design", 800-527-0062
Attachment C

Philips 66 (1998), "Driscopipe Systems Design", 800-527-0062
Attachment D

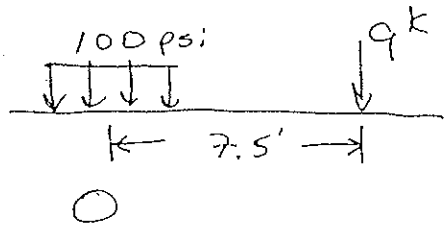
Written by: GLS Date: 00/01/26 (YY MM DD) Reviewed by: MLD GTC (3) 5/10/05 Date: 00/07/03 (YY MM DD)

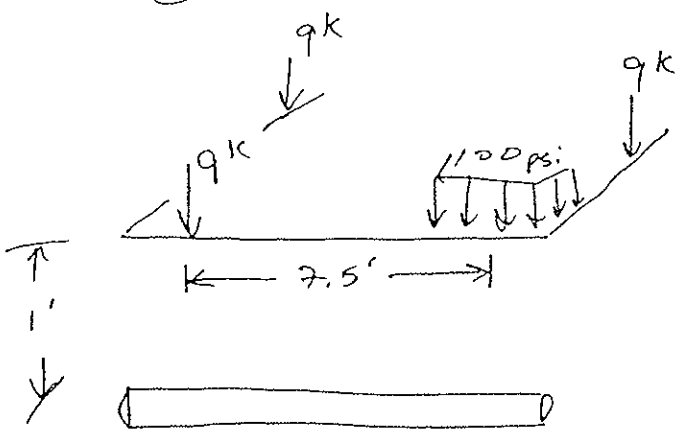
Client: Parsons Project: BRC Landfill Project/Proposal No.: HL0389 Task No.: 01

Haul truck loading (H-20)

- Assumptions: (AASHTO 94)
  - → max single axle load of 18 kip
  - → tire pressure of 100 psi (assumed) 1ft wide tires
  - → truck is 8½ wide

- Distribute Load
  - → assume distributed load of one wheel over pipe
  - → assume other loads are point loads





- Assume 1 ft cover soil

Attachment A

1/4

Written by: GLS Date: 00/02/13 Reviewed by: MJD CTC 5/10/05 Date: 00/07/03

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 02

→ From Das (1994)

Table 7.1, Variation of I_1

Due to shallow depths and large distance to point loads, influence of point load wheels are negligable.

→ From Das (1994)

Evaluate stress increases due to wheel directly above pipe:

- contact pressure of 100 psi
- radius of footprint = $R = \sqrt{\frac{P}{p\pi}} = \left[\frac{9K}{(100)(144)\pi}\right]^{1/2}$

$R = 0.45$ ft

- assume flexible circular footprint (Das, 1994)

$$\Delta p = q\left\{1 - \frac{1}{[(R/z)^2+1]^{3/2}}\right\}$$

$z = 1$ ft, $R = 0.45$ ft, $q = 100$ psi

$$\Delta p = 100\left\{1 - \frac{1}{[(0.45/1)^2+1]^{3/2}}\right\}$$

$\Delta p = 24$ psi

add soil 1 ft = 1310 psf/144 = 0.94 psi

$\boxed{\Delta p = 25 \text{ psi}}$: total external pressure

Attachment A
2/4

GTC (3) 5/10/05 MLD

vertical stress, dp, at point A caused by the load on the elemental area (which may be assumed to be a concentrated load) can be obtained from Eq. (7.11):

$$dp = \frac{3(qr\,dr\,d\alpha)}{2\pi}\frac{z^3}{(r^2+z^2)^{5/2}} \tag{7.24}$$

The increase in the stress at A caused by the entire loaded area can be found by integrating Eq. (7.24), or

$$\Delta p = \int dp = \int_{\alpha=0}^{\alpha=2\pi}\int_{r=0}^{r=R}\frac{3q}{2\pi}\frac{z^3 r}{(r^2+z^2)^{5/2}}\,dr\,d\alpha$$

So

$$\boxed{\Delta p = q\left\{1 - \frac{1}{[(R/z)^2+1]^{3/2}}\right\}} \tag{7.25}$$

The variation of $\Delta p/q$ with z/R as obtained from Eq. (7.25) is given in Table 7.5. A plot of this is also shown in Figure 7.17. The value of Δp decreases rapidly with depth, and, at $z = 5R$, it is about 6% of q, which is the intensity of pressure at the ground surface.

TABLE 7.5 Variation of $\Delta p/q$ with z/R [Eq. (7.25)]

z/R	$\Delta p/q$
0	1
0.02	0.9999
0.05	0.9998
0.10	0.9990
0.2	0.9925
0.4	0.9488
0.5	0.9106
0.8	0.7562
1.0	0.6465
1.5	0.4240
2.0	0.2845
2.5	0.1996
3.0	0.1436
4.0	0.0869
5.0	0.0571

Attachment A
3/4

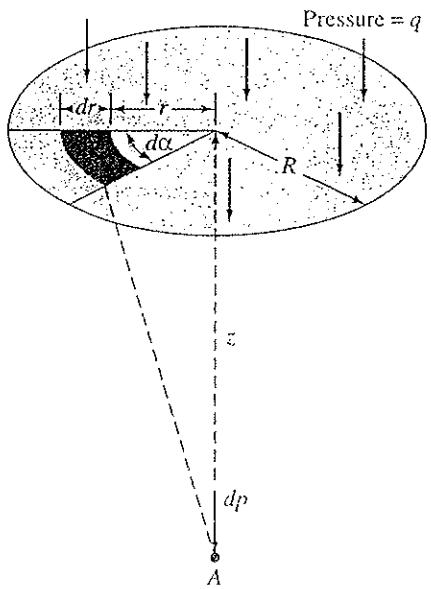
▼ **TABLE 7.4** Values of $\Delta p/q$ [Eq. (7.23)]

	$2z/B$								
$2x/B$	0	0.5	1.0	1.5	2.0	2.5	3.0	4.0	5.0
−3	0	0.0003	0.0018	0.00054	0.0107	0.0170	0.0235	0.0347	0.0422
−2	0	0.0008	0.0053	0.0140	0.0249	0.0356	0.0448	0.0567	0.0616
−1	0	0.0041	0.0217	0.0447	0.0643	0.0777	0.0854	0.0894	0.0858
0	0	0.0748	0.1273	0.1528	0.1592	0.1553	0.1469	0.1273	0.1098
1	0.5	0.4797	0.4092	0.3341	0.2749	0.2309	0.1979	0.1735	0.1241
2	0.5	0.4220	0.3524	0.2952	0.2500	0.2148	0.1872	0.1476	0.1211
3	0	0.0152	0.0622	0.1010	0.1206	0.1268	0.1258	0.1154	0.1026
4	0	0.0019	0.0119	0.0285	0.0457	0.0596	0.0691	0.0775	0.0776
5	0	0.0005	0.0035	0.0097	0.0182	0.0274	0.0358	0.0482	0.0546

7.8 VERTICAL STRESS BELOW THE CENTER OF A UNIFORMLY LOADED CIRCULAR AREA

Using Boussinesq's solution for vertical stress Δp caused by a point load [Eq. (7.11)], one can also develop an expression for the vertical stress below the center of a uniformly loaded flexible circular area.

From Figure 7.16, let the intensity of pressure on the circular area of radius R be equal to q. The total load on the elemental area (shaded in the figure) $= qr\,dr\,d\alpha$. The



▼ **FIGURE 7.16** Vertical stress below the center of a uniformly loaded flexible circular area

Attachment A

TABLE 1.2. Typical Runway Lengths for Several Aircraft and Conditions[a]

Plane Type	Normal Max Temp. of Hottest Month (°F)	Elevation (ft)	Length[b] (ft)
Boeing 707-100	100	Sea level	10,500
Boeing 707-100	75	3000	11,500
Boeing 707-100	75	1000	10,500
Boeing 727	75	1000	7,800
Boeing 747	75	1000	10,500
Douglas DC 9	75	1000	8,000
Convair Cv 880	75	1000	10,500
BAC 1-11	75	1000	7,500

[a] Data from charts in FAA publication (ref. 4).

[b] The lengths shown in the table are relative and are for illustrative purposes only since the required lengths are dependent upon many factors, including effective grade of the runway, setting of the wing flaps, and takeoff weight. Each runway must be analyzed for its own particular conditions and the critical plane using the runway.

In the majority of the problems, circular tire imprints are assumed. Hence the radius of contact is as follows:

$$a = \sqrt{\frac{P}{p\pi}} \qquad A = \frac{P}{p} \tag{1.1}$$

where a = radius of contact
P = total load on the tire
p = tire pressure (assumed to be equal to contact pressure)

For some cases tire imprints as illustrated on Figure 1.8 are used. The relationship between pressure and the geometry of the imprint is as shown on the figure.

DESIGN FACTORS

Pavement design consists of two broad categories: (1) design of the paving mixtures, and (2) structural design of the pavement components. These two design steps must go hand in hand.

The structural design of pavements is basically different from the structural design of bridges and buildings in that the pavement structure lies exposed upon the ground surface and, hence, is greatly influenced by environmental factors. Likewise, a highway, for example, will cross many different soil deposits and it becomes necessary for the design engineer to select in a rational manner a design value representative of the area under question. The strength of soil is affected by many factors, including density, moisture content, soil texture, soil structure, rate of load application, and degree of confinement. In addition, soils

Attachment A
4/4

7.2.2 Deflection Issues

An engineering approach to the quantification of deflection of buried pipelines has been developed by a sequential group of research faculty and students at Iowa State University. Beginning with Marston in the 1920s evaluating rigid conduits (the term used for shallow buried pipes), followed by Spangler in 1950–1970 evaluating flexible conduits, and into the present by Watkins, the group and their colleagues have "written the book" for this type of research [12]. Key issues in the development are the use of arching theory for gravitational force dissipation, the importance of subgrade stability, backfill type, and compaction conditions, and finally the flexibility of the pipe structure itself. Moser [13] presents the following equation, summarizing the Iowa State group's effort for the deflection behavior of flexible (in our case plastic) pipe.

$$\Delta X = \frac{D_L K_b W_c}{(\mathrm{EI}/r^3) + (0.061E')} \cong y \tag{7.17}$$

where

ΔX = horizontal increase in diameter (m),
y = vertical deflection (m),
D_L = deflection lag factor, which varies from 1.0 to 1.5 (dimensionless), 1.5 (conservative)
K_b = bedding constant, which varies from 0.83 to 0.110 (dimensionless), 0.1
W_c = Marston's prism load per unit length of pipe (kN/m) (note that arching is not taken into account in this formula),
E = modulus of elasticity of the pipe material (kPa),
I = moment of inertia of the pipe wall per unit length (m^3),
EI = bedding stiffness of the pipe ring per unit length (kN-m),
r = mean radius of the pipe (m), and
E' = modulus of soil reaction (kPa).

The last term (E') has been the subject of intense discussion and research. Howard [14] of the U.S. Bureau of Reclamation has recommended the values given in Table 7.9, which have relatively wide acceptance.

Eq. (7.17) can also be cast in terms of the laboratory plate loading test with the following result. The equation assumes a bedding constant $K_b = 0.2$ and uses the ring stiffness constant (RSC).

$$\frac{y}{D} = \frac{P(0.1L)}{[14.9(\mathrm{RSC})/D + 0.061E']} \tag{7.18}$$

where

y = vertical deflection (m),
D = inside pipe diameter (m),
P = load on pipe (kPa),
L = deflection lag factor (usually 1.0 to 1.5),
RSC = ring stiffness constant (kN/m), and
E' = modulus of soil reaction (kPa).

Attachment B

1/1

GTC (3) 5/10/05 MSD

Where: S_A = Actual compressive stress, psi
SDR = Standard Dimension Ratio
P_T = External Pressure, psi

Safety Factor = 1500 psi ÷ S_A where 1500 psi is the Compressive Yield Strength of Driscopipe.

Design by Wall Buckling: Local wall buckling is a longitudinal wrinkling of the pipe wall. Tests of *non-pressurized* Driscopipe show that buckling and collapse do not occur when the soil envelope is in full contact with the pipe and is compacted to a dense state. However, it can be forced to occur over the long term in *non-pressurized* pipe if the total external soil pressure, P_t, is allowed to exceed the pipe-soil system's critical buckling pressure, P_{cb}. If $P_t > P_{cb}$, gradual collapse may occur over the long term. A calculated, conservative value for the critical buckling pressure may be obtained by the following approximate formula. All pipe diameters with the same SDR in the same burial situation have the same critical collapse and critical buckling endurance

$$P_{cb} = 0.8\sqrt{E' \times P_c}$$

Where:

P_t = Total vertical soil pressure at the top of the pipe, psi

P_{cb} = Critical buckling soil pressure at the top of the pipe, psi

E' = Soil modulus in psi calculated as the ratio of the vertical soil pressure to vertical soil strain at a specified density

P_C = Hydrostatic, critical-collapse differential pressure, psi

$$P_C = \frac{2E\,(t/D)^3\,(D_{MIN}/D_{MAX})^3}{(1-\mu^2)}$$

$$P_c = \frac{2.32\,E}{(SDR)^3}$$

Where: (D_{MIN}/D_{MAX}) = .95
μ = Poission's Ratio
μ = .45 for Driscopipe
E = stress and time dependent tensile modulus of elasticity, psi

In a direct burial pressurized pipeline, the internal pressure is usually great enough to exceed the external critical-buckling soil pressure. When a pressurized line is to be shut down for a period, wall buckling should be examined.

Design by Wall Buckling Guidelines
Although wall buckling is seldom the limiting factor in the design of a Driscopipe system, a check of non-pressurized pipelines can be made according to the following steps to insure $P_t < P_{cb}$

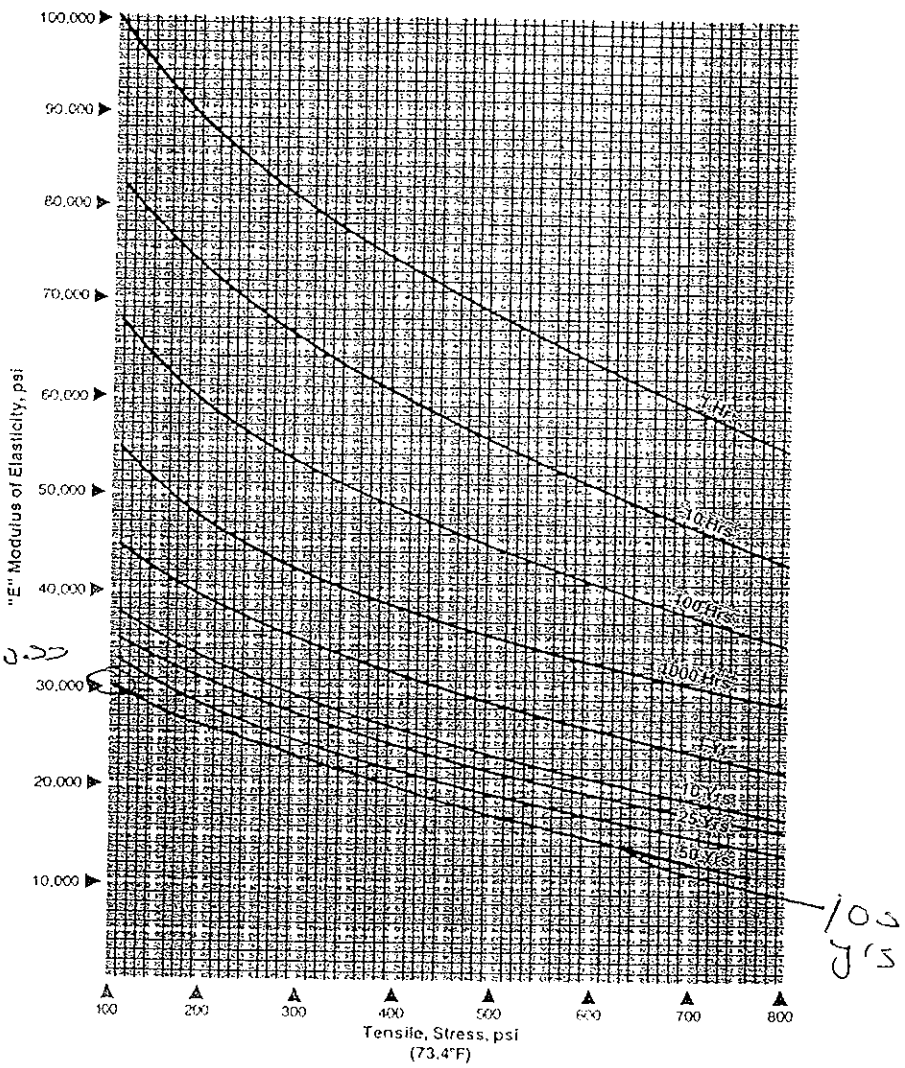
1. Calculate or estimate the total soil pressure, P_t, at the top of the pipe
2. Calculate the stress "S_A" in the pipe wall according to the formula:

$$S_A = \frac{(SDR - 1)\,P_t}{2}$$

3. Based upon the stress "S_A" and the estimated time duration of non-pressurization, use Chart 25 to find the value of the pipe's modulus of elasticity, E, in psi

Chart 25

Time Dependent Modulus of Elasticity for Polyethylene Pipe vs. Stress Intensity (73.4°F)



NOTE: The short term modulus of elasticity of Driscopipe per ASTM D 638 is approximately 100,000 psi. Due to the cold flow (creep) characteristic of the pipe material, this modulus is dependent upon the stress intensity and the time duration of the applied stress.

Attachment C
1/1

GTC (3) 5/10/05 MSD

TABLE 13: VALUE OF E' BASED ON SOIL TYPE (ASTM D2321) AND DEGREE OF COMPACTION

E' (psi) for Degree of Compaction (Standard Proctor Density, %)

	Soil Type of Initial Backfill Material	Loose 70%	Slight (70 - 85%)	Moderate (85- 95%)	High > 95%
I	Manufactured angular, granular materials (Crushed Stone, or rock, broken coral, cinders, etc.)	1,000	3,000	3,000	3,000
II	Coarse grained soils with little or no fines	Not Recommended	1,000	2,000	3,000
III	Coarse grained soils with fines	Not Recommended	Not Recommended	1,000	2,000
IV	Fine Grained Soils	Not Recommended	Not Recommended	Not Recommended	Not Recommended
V	Organic Soils (Peat, Muck, Clay, etc.)	Not Recommended	Not Recommended	Not Recommended	Not Recommended

Note: This summary of ASTM D 2321 is provided for the design engineer's convenience. This specification should be reviewed in detail before specifying burial conditions.

MINIMUM COVER There are no firm rules regarding minimum burial depth. The variables change for each installation, and the designer should check each design for wall crushing, wall buckling, and ring deflection. However, the following guidelines may be helpful.

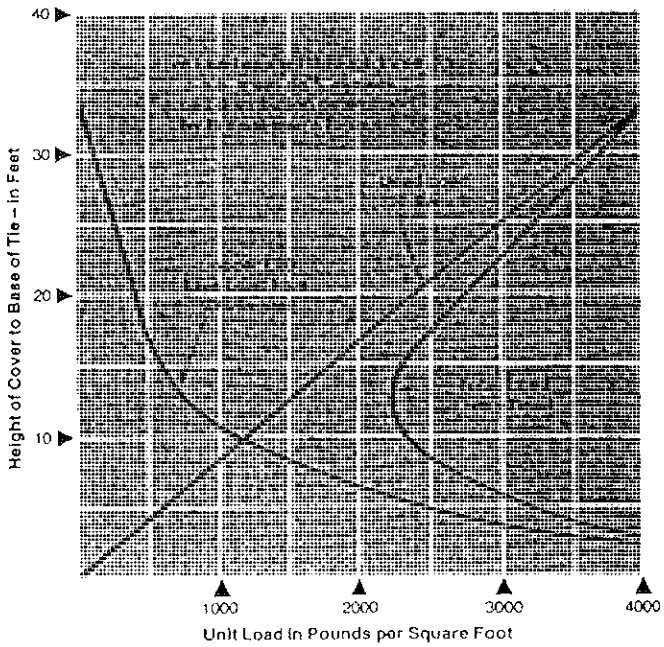
- Consider a burial depth below the local frost line.
- Where there will be no overland traffic, the designer may wish to consider a cover of 18" or one diameter, whichever is greater.
- Where truck traffic may be expected, the designer may wish to consider a burial depth of 36" or one diameter, whichever is greater.
- Where heavy off-the-road truck or locomotive traffic is expected, the designer may wish to consider a minimum cover of 5 feet or more.

CALCULATION OF TOTAL SOIL PRESSURE BY COMPONENTS Proper design of the polyethylene "pipe-soil" system balances the response of the pipe and surrounding soil against the total external soil pressure. Burial design by wall crushing, wall buckling, and ring deflection require the calculation of the total soil pressure, P_T, at the top of the pipe. There are many sources of soil pressure above the pipe. It is helpful to examine the total soil pressure as the sum of its components.

Attachment D
1/6

GTC (3) 5/10/05 MLD

FIGURE 6: COOPER E-80 LIVE LOADING



Note: Cooper E-80 live load assumes 80,000 pounds applied to three 2' x 8' areas on 5' centers such as might be encountered through live loading from a locomotive with three 80,000 pound axle loads.

Source: American Iron and Steel Institute, Washington, DC

APPARENT EXTERNAL PRESSURE DUE TO INTERNAL VACUUM, P_I Vacuum generates a compressive hoop stress in the wall of a pipe and acts to collapse the pipeline. Under vacuum conditions, the value of P_I is positive. P_I is added to the other two external pressure components, P_S and P_L, to obtain the total external pressure, P_T, acting on the pipe. An internal vacuum generates pressure equal to the absolute value of the vacuum. The maximum apparent external pressure due to a vacuum inside the pipe is 14.7 psi (2,117 psf).

BURIAL DESIGN GUIDELINES

The design engineer must select the proper pipe DR and specify the backfill conditions to obtain the desired performance of the "pipe-soil" system.

DESIGN BY WALL CRUSHING Wall crushing occurs when external vertical pressure causes the compressive stress in the pipe wall to exceed the long-term compressive strength of the pipe material. To design for wall crushing, the following check should be made:

$$S_A = \frac{(SDR - 1)}{2} P_T$$

Where:
- S_A = Actual compressive stress, psi
- SDR = Standard Dimension Ratio
- P_T = Total external pressure on the top of the pipe, psi

Safety Factor = 1500 psi /S_A (where 1500 psi is the compressive yield strength of Driscopipe HDPE pipe)

DESIGN BY WALL BUCKLING Local wall buckling is a longitudinal wrinkling of the pipe wall. Buckling can occur over the long term in non-pressurized pipe if the total external soil pressure, P_T, exceeds the pipe-soil system's critical buckling pressure, Pcb . Although wall buckling is seldom the limiting factor in the design of a Driscopipe system, a check of non-pressurized pipelines can be made according to the following steps to insure $P_T < P_{cb}$. All pipe diameters with the same DR in the same burial situation have the same critical collapse and critical buckling endurance.

Attachment D
2/4

GTC (3) 5/10/05 MLD

1. Calculate or estimate the total soil pressure, P_T, at the top of the pipe.

2. Calculate the stress, S_a, in the pipe wall:

$$S_A = \frac{(SDR-1)}{2} P_T$$

3. Based upon the stress, S_a, and the estimated time duration of non-pressurization, find the value of the pipe's modulus of elasticity, E, in psi (approximate value for E is 35,000 psi).

4. Calculate the pipes hydrostatic, critical-collapse differential pressure, P_c

$$P_c = \frac{2E(t/D)^3 (D_{MIN} / D_{MAX})^3}{(1-\mu^2)} \quad \text{or} \quad P_c = \frac{2.32(E)}{SDR^3}$$

$$P_c = \frac{2.15(E)}{SDR^3}$$

Where: $(D_{MIN}/D_{MAX}) = 0.95$
μ = Poission's Ratio = 0.45 for polyethylene pipe
E = stress and time dependent tensile modulus of elasticity, psi
E = 35,000 psi (approximate)
D = Outside Diameter, in.
t = thickness, in.

5 Calculate the soil modulus, E', by plotting the total external soil pressure, P_T, against a specified soil density to derive the soil strain as shown in the example problem below Figure 7.

6. Calculate the critical buckling pressure at the top of the pipe by the formula:

$$P_{cb} = 0.8\sqrt{(E')(P_c)}$$

Where: P_{cb} = Critical buckling soil pressure at the top of the pipe, psi
E' = Soil Modulus, psi
P_c = Hydrostatic critical-collapse differential pressure, psi

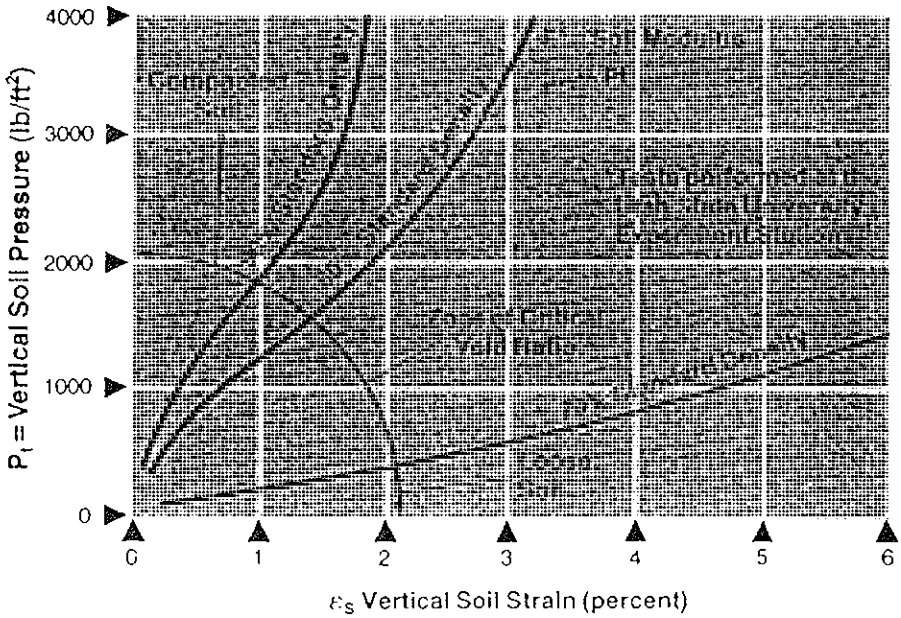
7. Calculate the Safety Factor: SF = P_{cb} / P_T.

8. The above procedures can be reversed to calculate the minimum pipe DR required for a given soil pressure and an estimated soil density.

In a direct burial pressurized pipeline, the internal pressure is usually great enough to exceed the external critical-buckling soil pressure. When a pressurized line is to be shut down for a period, wall buckling should be examined.

Attachment D
3/4

FIGURE 7: PLOT OF VERTICAL STRESS-STRAIN DATA FOR TYPCIAL TRENCH BACKFILL (EXCEPT CLAY) FROM ACTUAL TESTS



Example:
Find: E' @ 2000 psf and 80% density
Formula: $E' = PT/\varepsilon_s$
Calculations: E' = 2000 psf / (0.018 * 144) = 771 psi

Note: The curves shown on this chart are sample curves for a granular soil. If other types of soil are used for backfill such as clay or clay loam, curves should be developed from laboratory test data for the material used. Soil pressures greater than 4000 psf may be extrapolated with the slope of the curve or curves can be generated by testing at higher soil pressures. Probable error of curves is about half the distance between adjacent lines.

Design by Ring Deflection Ring deflection, by definition, is the ratio of the vertical change in diameter to the pipe's original diameter. It is often expressed as a percentage.

Driscopipe HDPE pipe is designed to be "flexible". This assumes the pipe will deflect the same as the vertical compression of the soil around it. Design by ring deflection matches the ability of the pipe to accommodate, without structural distress, the vertical compression of the surrounding soil. Design by ring deflection calculates the vertical soil strain and compares it to the allowable ring deflection of the pipe.

Attachment D
4/4

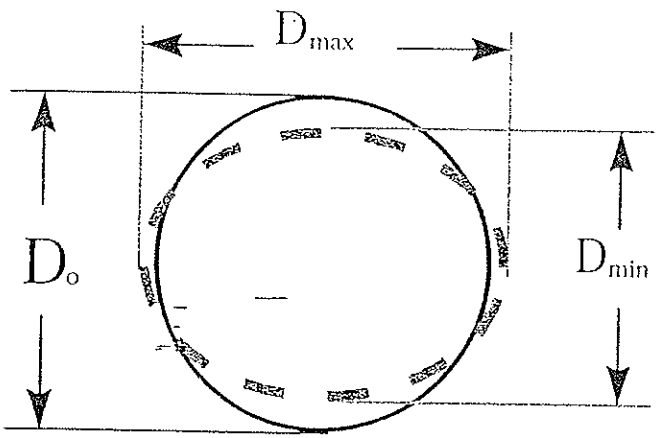
GTC (8) 5/10/05 MLD

TABLE 15: ALLOWABLE RING DEFLECTION OF DRISCOPIPE® POLYETHYLENE PIPE BASED UPON DR

DR	Allowable Ring Deflection
32.5	8.1%
26	6.5%
21	5.2%
19	4.7%
17	4.2%
15.5	3.9%
13.5	3.4%
11	2.7%

The allowable ring deflection of polyethylene pipe is limited to create no more than 1 to 1.5% tangential strain in the outer surface of the pipe wall. As the wall of a pipe becomes thicker (a "lower" DR value), the distance from the neutral axis to the outer surface increases. As a result, less deflection is required to create the allowable tangential strain. Deflection of the pipe-soil system is controlled by proper specification of the backfill compaction.

FIGURE 8: CALCULATING RING DEFLECTION



$$\%\,Ring\,Deflection = \left(1 - \frac{D_{min}}{D_o}\right) \times 100\%$$

The percentage ring deflection based upon strain for a given DR pipe can be calculated as follows:

$$\frac{\Delta Y}{D} = (0.25)(\varepsilon)(SDR)$$

Attachment D
5/6

Where:

	ΔY	= Vertical deflection, in.
	D	= Pipe OD, in.
	ε	= Tangential strain in the surface of the pipe ring, in./in.
	SDR	= Standard Dimension Ratio

Driscopipe recommends limiting tangential surface strain to 0.01. This value is based upon the following criteria:

- Most of the deflection of a flexible pipe occurs within a few days after final backfill is completed. Development of a soil arch over the pipe relieves the pipe of much of the vertical soil load by the arching action of the soil envelope and by the development of soil restraint at the sides of the pipe.
- An allowable strain value of 0.01 will allow for reasonable additional deflection due to disturbance of the backfill by earthquake, fluctuations of the water table, etc.
- An allowable design strain value of 0.01 allows for the normal deviation of temperature encountered during installation.

In summary, a soil density can be specified for the bedding and initial backfill so that total soil pressure at the top of the pipe, P_T, will not cause a given DR pipe to exceed its maximum allowable ring deflection.

Attachment D
60/60

Table 5-6
Support Spacing for Schedule 80 CPVC Pipe

Nominal Pipe Size, mm (in)	Maximum Support Spacing, m (ft) at Various Temperatures					
	23• C (73• F)	38• C (100• F)	49• C (120• F)	60• C (140• F)	71• C (160• F)	82• C (180• F)
25 (1)	1.83 (6.0)	1.83 (6.0)	1.68 (5.5)	1.52 (5.0)	1.07 (3.5)	0.91 (3.0)
40 (1.5)	2.13 (7.0)	1.98 (6.5)	1.83 (6.0)	1.68 (5.5)	1.07 (3.5)	0.91 (3.0)
50 (2)	2.13 (7.0)	2.13 (7.0)	1.98 (6.5)	1.83 (6.0)	1.22 (4.0)	1.07 (3.5)
80 (3)	2.44 (8.0)	2.44 (8.0)	2.29 (7.5)	2.13 (7.0)	1.37 (4.5)	1.22 (4.0)
100 (4)	2 59 (8.5)	2 59 (8.5)	2 59 (8.5)	2.29 (7.5)	1.52 (5.0)	1.37 (4.5)
150 (6)	3.05 (10.0)	2.90 (9.5)	2.74 (9.0)	2.44 (8.0)	1.68 (5.5)	1.52 (5.0)
200 (8)	3.35 (11.0)	3.20 (10.5)	3.05 (10.0)	2.74 (9.0)	1.83 (6.0)	1.68 (5.5)
250 (10)	3.51 (11.5)	3.35 (11.0)	3.20 (10.5)	2.90 (9.5)	1.98 (6.5)	1.83 (6.0)
300 (12)	3.81 (12.5)	3.66 (12.0)	3.51 (11.5)	3.20 (10.5)	2.29 (7.5)	1.98 (6.5)

Note: The above spacing values are based on test data developed by the manufacturer for the specific product and continuous spans. The piping is insulated and is full of liquid that has a specific gravity of 1.0.
Source: Harvel Plastics, Product Bulletin 112/401 (rev. 10/1/95), p. 63.

Table 5-7
Bedding Factor, K_x

Type of Installation	K_x
Shaped bottom with tamped backfill material placed at the sides of the pipe, 95% Proctor density or greater	0.083
Compacted coarse-grained bedding and backfill material placed at the side of the pipe, 70-100% relative density	0.083
Shaped bottom, moderately compacted backfill material placed at the sides of the pipe, 85-95% Proctor density	0.103
Coarse-grained bedding, lightly compacted backfill material placed at the sides of the pipe, 40-70% relative density	0.103
Flat bottom, loose material placed at the sides of the pipe (not recommended); <35% Proctor density, <40% relative density	0.110

Source: Reprinted from Schweitzer, Corrosion-Resistant Piping Systems, p. 49, by courtesy of Marcel Dekker, Inc.

Attachment E

Calculation Package E
Veneer Stability

GeoSyntec Consultants

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: Parsons **Project:** BRC CAMU **Project/Proposal #:** HL0389 **Task #:** 02

Title of Computations: Veneer Stability of Geosynthetic-Lined Slopes

Computations By: SIGNATURE (GS) DATE 3 May 2000
Geoffrey L. Smith / Staff Engineer
PRINTED NAME AND TITLE

Assumptions and Procedures Checked By (Peer Reviewer): SIGNATURE DATE 7/3/00
GREGORY T CORCORAN / PROJ. ENG.
PRINTED NAME AND TITLE

Computations Checked By: SIGNATURE DATE 2 May 2000
Matt Darr Staff Engr.
PRINTED NAME AND TITLE

Computations Backchecked By (Originator): SIGNATURE DATE 3 May 2000
Geoffrey L. Smith / Staff Engineer
PRINTED NAME AND TITLE

Approved By (PM or Designate): SIGNATURE DATE 10 July 2000
Bradford H. Cody / Project Manager
PRINTED NAME AND TITLE

Approval Notes:

Revisions: (Number and Initial All Revisions)

No.	Sheet	Date	By	Checked By	Approval

Written by: Geoff L. Smith GLS Date: 00 / 01 / 26 (YY MM DD) Reviewed by: MLD GTC Date: 00 / 07 / 03 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 04

SLOPE STABILITY EVALUATION
VENEER STABILITY OF GEOSYNTHETIC-SOIL LINED SIDESLOPES

OBJECTIVE

To evaluate the tension developed within the geosynthetic-soil layered sideslope of the BRC Corrective Action Management Unit (CAMU) located in Henderson, Nevada.

METHOD OF ANALYSIS

The stability analysis of the geosynthetic-soil layered systems was carried out using the approach outlined by McKelvey (1994). McKelvey (1994) calculates the tension of a geosynthetic component along a geosynthetic-soil layered sideslope and compares it to the allowable geosynthetic strength to evaluate the overall factor of safety against tension. McKelvey (1994) allows for the consideration of tapered slopes and equipment loads. The calculations herein were performed by a spreadsheet developed by McKelvey that has been verified numerous times, so verification will not be presented herein.

SIDESLOPE LINER SYSTEM

The sideslope liner system (Attachment A) consists of, from top to bottom:

- 2 ft (min) 2.5H:1V tapered operations layer material (10 ft max height),
- a drainage geocomposite;
- ~~a non-woven cushion geotextile;~~ GLS
- a 60-mil (1.5-mm) thick textured high density polyethylene (HDPE) geomembrane;
- a geosynthetic clay liner (GCL); and
- subgrade.

The sideslope inclination is 2.1H:1.0V. The maximum height of the side slope is 30 vertical feet.

Written by: Geoff L. Smith GLS Date: 00 / 01 / 26 (YY MM DD) Reviewed by: MLD GTC Date: 00 / 07 / 03 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 04

MATERIAL SHEAR STRENGTHS

Operations Layer Material and Drainage Aggregate:

The soil materials to be used overlying the side slope liner system will be native materials such as silty sands (SM) for the operations layer. The operations layer material is charaeterized by an internal angle of friction of 31 degrees (Attachment B). Converse reported a maximum dry density of 132 pcf and a optimum water content of 8.7 percent for materials at the site. Therefore, assuming 95% relative compaction, the dry density in the field is approximately 125 pcf. Adding the weight of water, the unit weight is approximately 136 pcf (Attachment B).

For this analysis, a shear strength of ~~31~~ 30 degrees and a unit weight of ~~132~~ 136 pcf will be used for the analyses performed herein.

Geosynthetic interface:

The following values for the interface friction between geosynthetic and soil components of the liner system will be used in this calculation:

Operations Layer to Geocomposite (NWGT side)	25 (Attachment D)
~~Geocomposite (GN side) to Cushion Geotextile~~	~~30 (Attachment D)~~
Cushion Geotextile to Textured HDPE	28 (Attachment E)
Textured HDPE to Dry GCL	18 (Attachment F)
Dry GCL to Subgrade	28 (Attachment F)

The critical loading for the side slope liner system occurs during construction when dozers are placing the ~~drainage aggregate and~~ operations layer materials up the slope. Global stability analyses have been performed to determine the long-term stability of the liner system. Therefore, the GCL component of the liner system was selected to be dry, since hydration will likely occur only after the construction phase is complete, and the normal stress used in obtaining the interface friction will be low (i.e. less than 5 psi).

The minimum shear strength along the geosynthetic interfaces of the sideslope liner system was assumed to occur at the interface of the textured HDPE geomembrane/GCL. A shear strength value of 18 degrees will be used in the tension analysis for the textured HDPE geomembrane/GCL interface as suggested in Attachment F.

Written by: Geoff L. Smith Date: 00 / 01 / 26 (YY MM DD) Reviewed by: MLD GTC Date: 00/07/03 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 04

DESIGN CRITERION

The geosynthetic-soil lined sideslopes are considered interim slopes because they will eventually be buttressed by placement of waste. Due to the limited duration during which the geosynthetic-soil lined slope will exist before it is buttressed by waste, seismic stability analyses were not conducted.

RESULTS AND CONCLUSIONS

The computer output for the analyses are presented in pages 4-~~7~~5. The results suggest the following:

Live Load Case (assuming placement of operations layer with a bulldozer no larger than Caterpillar D6H-LGP dozer in terms of operating weight and ground pressure), the side slope liner system will not be placed into tension.

REFERENCES

Converse (1999), "Preliminary Geotechnical and Geologic Report - Industrial Non-Hazardous Disposal Facility (Converse 1999)", prepared for Basic Management, Inc., October 1999.

Hunt R.E. (1986), *Geotechnical Engineering Techniques and Practices*, McGraw-Hill Book Company.

Koerner, R.M. (1990), *Designing with Geosynthetics*, Third Edition, Prentice Hall, New Jersey.

GeoSyntec Consultants

Page 4

Written By: Geoff Smith Date: 26-Apr-00 Reviewed by: MLD GTC 7/3/00 Dat

Client: Parsons Project: BRC CAMU Project No.:

GeoSyn

Written By:

Client:

Calculated Tension for : BRC CAMU - Side Slope, Final Thickness -Construction loads

Project variables

Cover soil unit weight :	136.00 pcf
Cover soil thickness :	2.00 feet
Cover soil internal angle of friction :	30.00 degrees
Angle of slope (ie nH:1V) :	2.10
Angle of cover (ie nH:1V) :	2.50
Slope height :	10.00 feet
Equipment load :	D6H

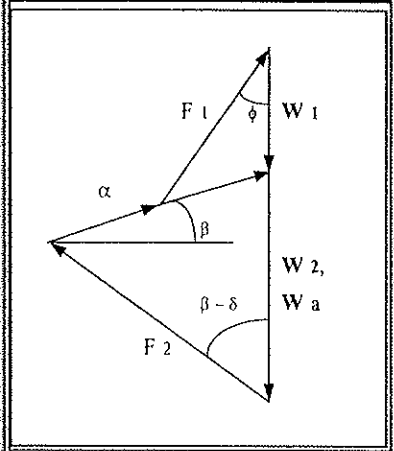
Geosynthetic variables

Minimum friction angle :	18.00 degrees
Load bearing product name :	60 MIL HDPE
Yield tensile strength :	126.00 ppi
Creep factor of safety :	5.00
installation damage factor of safety:	1.20
chemical degradation factor of safety:	1.50
biological degradation factor of safety:	1.00
Break strain factor of safety:	1.00

ANALYSIS OUTPUT

Slope angle:	25.46 degrees
Ramp angle:	21.80 degrees
Resisting force (W1) :	2,390 ppf
Driving force (W2) :	14,776 ppf
Equipment and special loads (Wa) :	6,477 ppf
estimated tension :	**0 ppf**
Geomembrane allowable strength :	168 ppf
Overall Factor of Safety for tension :	**INFINITE OK**

Free body diagram



Notes

1. 60 MIL HDPE assumed to carry load.

2. Minimum interface at GM/GCL

Taper Distances

x' (ft) :	4.00
y' (ft) :	1.60

GeoSyntec Consultants

Written By: Geoff Smith GS Date: 26-Apr-00 Reviewed by: MLD GK Date: 7/3/00

Client: Parsons Project: BRC CAMU Project No.:

Equipment load

PLACEMENT EQUIPMENT:	D6H
operating weight (lbs):	38,605
track width (in):	22.00
ground contact (in^2)	4,564
ground pressure (psi):	8.46
depth (ft):	2.74
ANALYSIS OUTPUT	
Surface stress (q) in psf :	1218.04
Track length in inches :	103.73
Length to width ratio (L/B) :	4.72
Length to depth ratio (N) :	1.58
Width to depth ratio (M) :	0.33
Influence coefficient (Io) :	0.0946
Stress at geosynthetic surface (s) in psf :	460.91
Equivalent track width due to attenuation (B') in feet :	2.98
Driving force of equipment (Wa) in ppf :	6,477
Special load (ppf) :	0

References

1. McKelvey, J.A. and Deutsch, W.L., (1991) "The Effect of Equipment Loading and Tapered Cover Soil Layers on Geosynthetic Lined Landfill Slopes", Proc. 14th Ann. Madison Waste Conference, Madison, WI:UWM, pp 395 - 4

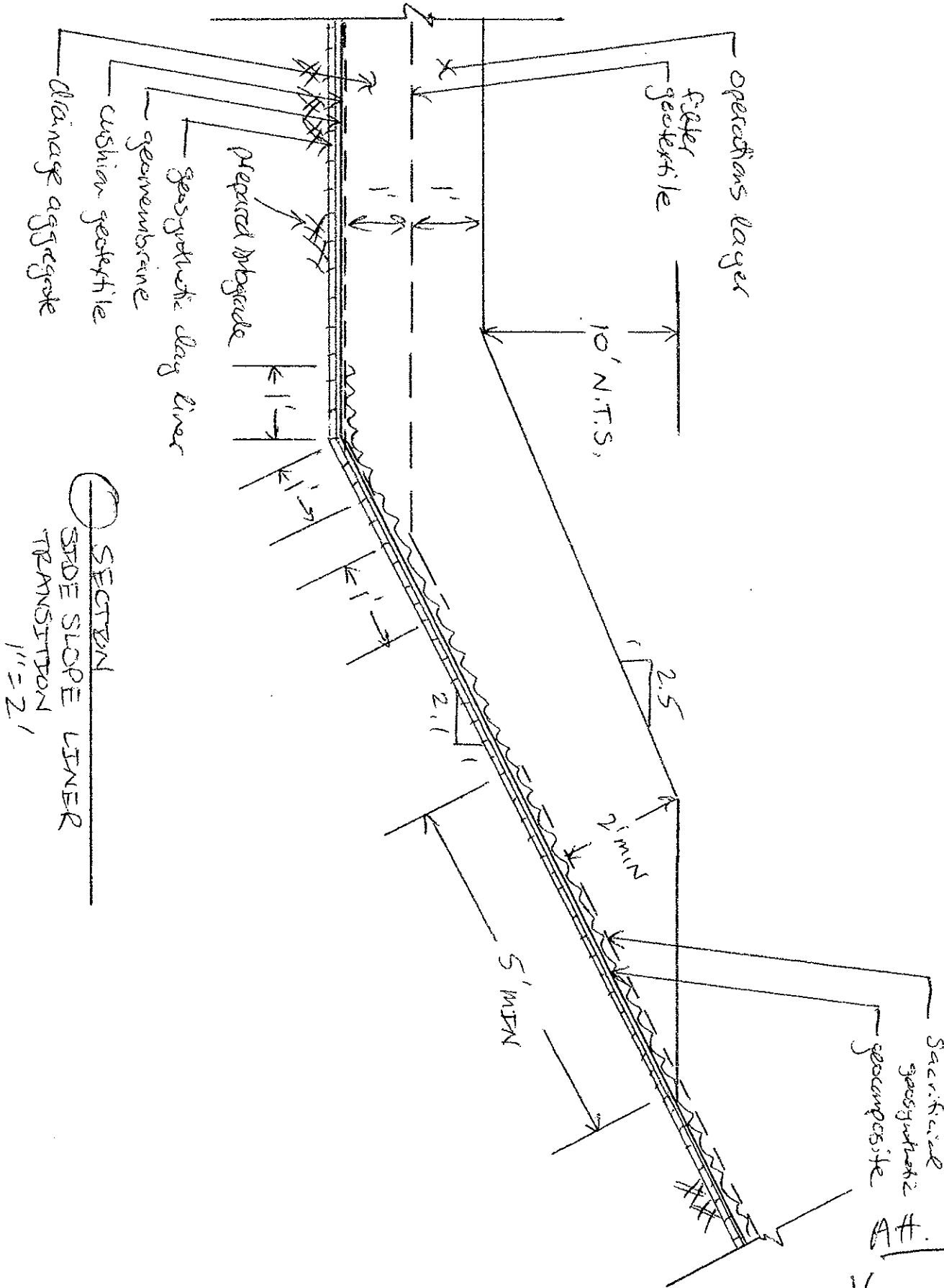
2. McKelvey, J.A. (1994) "Consideration of equipment loadings in geosynthetic lined slope designs", Proc. 8th Intc Conf. of the International Association for Computer Methods and Advances in Geomechanics, Morgantown, WV:Balkema, pp. 1371-1377.

GEOSYNTEC CONSULTANTS

Page ____ of ____

Written by: Geoff Smith Date: 00/04/18 (YY/MM/DD) Reviewed by: MLD GC Date: 00/07/03 (YY/MM/DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HC0398 Task No.: 02



SECTION
SIDE SLOPE LINER TRANSITION
1" = 2'

Att. A

1/1

GCC

Direct Shear Strength

A progressive direct shear test was performed on selected undisturbed samples using a constant strain rate direct shear machine in general accordance with ASTM D3080. The test specimen was trimmed and placed in the shear machine, a specified normal load was applied, and the specimen was sheared until maximum shear strength was developed. After the soil specimen had developed maximum shear resistance under the first normal load, the normal load was removed and the specimen was pushed back to its original undeformed configuration. Another normal load was then applied, and the specimen was sheared a second time. This process was repeated for three different normal loads. Results of the direct shear test are presented on Figures A-62 through A-69 and in the following table:

Exploration Location	Depth (Feet)	Soil Description	Angle of Internal Friction (deg)	Coulomb Cohesion (ksf)
B-4	14-14.5	Silty sand with gravel	31	0.7
B-5	14-15	Silty sand with gravel	43	0.3
B-10	54-54.5	Sandy lean clay	26	0.85
B-12	14-15	Silty sand with gravel	40	0.3
B-101	39-40	Sandy lean clay	26	0.9
B-102	20-25	Silty sand with gravel	37	0.2
B-103	49-50	Sandy lean clay	37	1.0
B-104	10-15	Silty sand with gravel	43	0.1

Chemical Analysis

Chemical tests were performed on a representative soil samples to investigate the potential for soil corrosivity and chemical heave. Atlas Chemical Testing Laboratories, Inc. in Las Vegas performed the chemical analysis for water-soluble sulfates and sodium in general accordance with ASTM D516. The results of the chemical tests are presented on Drawing No. A-70.

Converse Consultants, 1999 MLD

Attachment B, 1/2

© Converse Consultants

shown on Drawing Nos. A-49 through A-56, entitled *Consolidation Test* and are summarized on the following table:

Exploration Location	Depth (feet)	Soil Description	Dry Unit Weight, pcf	Moisture Content, %	Hydrocollapse (percent)*
B-1	29-30	Silty sand with gravel	105	6	3.2
B-8	39-40	Sandy lean clay	57.4	64	0.4
B-8	49-50	Sandy lean clay	69.5	51.1	-0.6
B-10	54-54.5	Sandy lean clay	60.7	67.7	-0.6
B-101	39-40	Sandy lean clay	65.8	45	-0.2
B-101	59-60	Sandy lean clay	73.2	38.3	-0.6
B-102	49-50	Sandy lean clay	67.3	48.7	-0.5
B-105	34-35	Well graded sand with silt and gravel	101	5	0.1

NA: Not available

* A negative sign indicates swell occurred upon inundation with water instead of collapse.

Laboratory Maximum Density

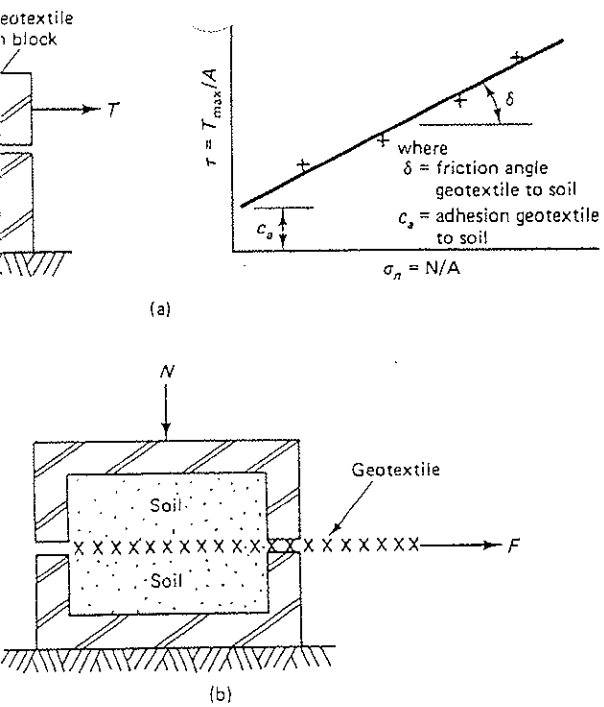
Laboratory maximum density tests were performed on selected samples of the granular soils. The purpose of the test was to define the compaction characteristics of these soils, and to aid in estimating soil shrinkage. The laboratory maximum density test was performed in general accordance with the ASTM D1557 test method. This test procedure uses 25 blow of a 10-pound hammer falling a height of 18 inches on each of five layers of soil in a 1/30 or 1/13 cubic foot cylinder. The test results are presented on Drawing Nos. A-57 through A-61 and in the following table:

Exploration Location	Depth (Feet)	Soil Description	Maximum Dry Unit Weight (pcf)	Optimum Moisture Content (percent) of dry weight)
B-1	20-25	Silty sand with gravel	129.4	8.2
B-5	20-25	Silty sand with gravel	132.1	8.2
B-12	10-15	Silty sand with gravel	129.7	7.9
B-101	5-10	Silty sand with gravel	130.6	8.7
B-105	20-25	Well graded sand with silt and gravel	131.8	7.5

TABLE 3.31
TYPICAL PROPERTIES OF COMPACTED SOILS*

Group symbol	Soil type	Range of maximum dry unit weight, pcf	Range of optimum moisture, %	Typical value of compression: Percent of original height: At 1.4 tsf (20 psi)	At 3.8 tsf (50 psi)	Typical strength characteristics: Cohesion (as compacted), psf	Cohesion (saturated), psf	Effective stress envelope ϕ, degrees	tan ϕ	Typical coefficient of permeability, ft/min	Range of CBR values	Range of subgrade modulus k_s, lb/in³
GW	Well-graded clean gravels, gravel-sand mixtures	125–135	11–8	0.3	0.6	0	0	>38	>0.79	5×10^{-2}	40–80	300–500
GP	Poorly graded clean gravels, gravel-sand mix	115–125	14–11	0.4	0.9	0	0	>37	>0.74	10^{-1}	30–60	250–400
GM	Silty gravels, poorly graded gravel-sand silt	120–135	12–8	0.5	1.1	...	...	>34	>0.67	$>10^{-6}$	20–60	100–400
GC	Clayey gravels, poorly graded gravel-sand-clay	115–130	14–9	0.7	1.6	...	...	>31	>0.60	$>10^{-7}$	20–40	100–300
SW	Well-graded clean sands, gravelly sands	110–130	16–9	0.6	1.2	0	0	38	0.79	$>10^{-3}$	20–40	200–300
SP	Poorly-graded clean sands, sand-gravel mix	100–120	21–12	0.8	1.4	0	0	37	0.74	$>10^{-3}$	10–40	200–300
SM	Silty sands, poorly graded sand-silt mix	110–125	16–11	0.8	1.6	1050	420	34	0.67	5×10^{-5}	10–40	100–300
SM-SC	Sand-silt clay mix with slightly plastic fines	110–130	15–11	0.8	1.4	1050	300	33	0.66	2×10^{-6}	...	
SC	Clayey sands, poorly graded sand-clay mix	105–125	19–11	1.1	2.2	1550	230	31	0.60	5×10^{-7}	5–20	100–300
ML	Inorganic silts and clayey silts	95–120	24–12	0.9	1.7	1400	190	32	0.62	10^{-5}	15 or less	100–200
ML-CL	Mixture of inorganic silt and clay	100–120	22–12	1.0	2.2	1350	460	32	0.62	5×10^{-7}	...	
CL	Inorganic clays of low to medium plasticity	95–120	24–12	1.3	2.5	1800	270	28	0.54	10^{-7}	15 or less	50–200
OL	Organic silts and silt-clays, low plasticity	80–100	33–21	...	...	...	...	...	...	...	5 or less	50–100
MH	Inorganic clayey silts, elastic silts	70–95	40–24	2.0	3.8	1500	420	25	0.47	5×10^{-7}	10 or less	50–100
CH	Inorganic clays of high plasticity	75–105	36–19	2.6	3.9	2150	230	19	0.35	10^{-7}	15 or less	50–150
OH	Organic clays and silty clays	65–100	45–21	...	...	...	...	...	...	...	5 or less	25–100

Hunt, 1986 MLD
Attachment C 1/1



nematic diagrams of test setups for friction and pullout evaluation of ls. (a) Soil-to-fabric friction test and results. (b) Fabric pullout (anchor-

between the fabric and the soil with no further increase in n the test is repeated at different normal stresses, a trend is shear strength parameters can be obtained. Note that these parameters are related to, but not necessarily the same as, the ers. They (the soil parameters) are, however, the conservative fabric parameters. Often an efficiency, as defined below, is of soil shear strength parameters that is mobilized, e.g.,

$$E_c = (c_a/c) \times 100 \tag{2.7}$$

$$E_\phi = (\tan \delta/\tan \phi) \times 100 \tag{2.8}$$

n cohesion,
n friction angle,
f soil to fabric,

c = the cohesion of soil,
δ = the friction angle of soil to fabric, and
ϕ = the friction angle of soil.

Results from such a test setup by Martin, et al. [13], are presented in Table 2.6 for four geotextile types against three different cohesionless soils. Soil-to-fabric friction angles are given, as well as the fabric efficiency versus the soil friction angle by itself as per Equation 2.8. Here it is seen that most geotextiles can mobilize a high percentage of the soil's friction and can be used to advantage in situations requiring this feature. A review and compilation of a number of direct shear tests on various fabrics against different granular soils is given by Richards and Scott [14]. Another review by Williams and Houlihan [15] covers a wider range of soils, including some sands, silts, and mixed soils.

2.2.3.11 Pullout (Anchorage) Tests

Geotextiles are often called upon to provide anchorage for many applications within the reinforcement function. Such anchorage usually has the fabric sandwiched between soil on each side of it. The resistance can be modeled in the laboratory using a pullout test, shown schematically in Figure 2.8b. The pullout resistance is obviously dependent on the normal force applied to the soil surrounding it, which mobilizes shear forces on both sides of the fabric.

Test results by Collios et al. [16] show a relationship of pullout test results to shear test results with some notable exceptions. If the soil particles are smaller than the fabric openings, efficiencies are higher; if not, they can be lower. In all cases, however, pullout test resistances are less than shear test resistances. This is due to the fact that the fabric is taut and exhibits large deformations. This in turn causes the soil particles to reorient themselves into a reduced-shear-strength situation at the soil-fabric interfaces, resulting in lower pullout resistance. The stress state mobilized in this test is a very complex one requiring additional research.

TABLE 2.6 SOIL-TO-FABRIC FRICTION ANGLES AND EFFICIENCIES (IN PARENTHESES) IN COHESIONLESS SOIL

Geotextile type	Manufacturer's designation	Concrete sand ϕ = 30 deg.	Rounded sand ϕ = 28 deg.	Silty sand ϕ = 26 deg.
Woven, monofilament	Polyfilter X	26 deg. (84%)	-	—
Woven, silt film	500X	24 deg. (77%)	24 deg. (84%)	23 deg. (87%)
Nonwoven, melt-bonded	3401	26 deg. (84%)	–	-
Nonwoven, needle-punched	CZ600	30 deg. (100%)	26 deg. (92%)	25 deg. (96%)

Source: After Martin et al. [13]

SLT North America, Inc.

FrictionFlex™ Application Data

SLT's FrictionFlex process provided the industry's first textured liner. It is the only geomembrane texturing process ever to be granted a U.S. Patent. It, in fact, has been awarded two*. In direct contrast to blown-film geomembranes which are textured or made rough by a process which actually erodes the sides of the sheet, the FrictionFlex process is additive. SLT begins with 24-foot wide SLT HyperFlex™ or UltraFlex™ sheet manufactured to the industry's most exacting standards. Only after the sheet passes all QC, is texturing added to one or both sides as required by the application. When the engineer utilizes SLT geomembranes textured by the FrictionFlex process, increased facility design capacity, service life and total revenue potential can be obtained. Containment slopes, vertical expansions and perimeter slopes in closures share the benefits of greater air-space and superior cover stability.

Most importantly, the advantages of FrictionFlex are available without compromise of any performance property or other issue of secure containment. The patented manufacturing process enables SLT to produce a textured liner exhibiting similar mechanical and chemical properties demanded of SLT's premium grades of smooth geomembrane liners, whether HDPE, VLDPE or LDPE.

An added feature of SLT's process is that an edge, 6-to-8 inches wide, is left smooth to aid in welding and field quality control. This allows standard installation equipment and procedures to ensure expedient construction.

The following reflects independent data confirming superior FrictionFlexed liner performance in contact with soils and synthetics:

- Highest coefficient of friction with soils
- Highest coefficient of friction with synthetics
- Premium grade mechanical and chemical properties

SLT Textured Liner Materials				Typical Smooth HDPE
Material	Coefficient of Friction	Adhesion (per square foot)	Average Friction Angle (degrees)	Comparable Friction Angle
Sandy Glacial Till	0.74	27	36	20
Sandy Clay	0.70	65	35	18
Smooth Clay	0.62	39	32	16
Ottawa Sand	0.59	21	30	19
Non-woven Polyester Geotextile	0.54	116	28	11
Non-woven Poly-propylene Geotextile	0.65	133	33	12

NOTE: The above data is approximate. SLT recommends that specific data be developed for all application designs. Shear box testing of the specific geosynthetic and natural components of the composite is necessary to establish an appropriate design basis. SLT will be pleased to provide any necessary material samples for such purposes and invites compararive procedures.

This data is provided for informational purposes only and is not intended as a warranty or guarantee. SLT assumes no liability in connection with the use of this data.

*U.S. Patent No. 4,885,201
5,075,135

For environmental lining solutions...the world comes to SLT.™

SLT NORTH AMERICA, INC.
Subsidiary of SLT Environmental, Inc.
200 S. Trade Center Parkway
Conroe, Texas 77385
(713) 350-1813 FAX (409) 273-2266

SLT Lining Technology GmbH
Pollhornweg 17
D-2102 Hamburg 93
Germany
49-40-751-0060
FAX 49-40-752-1988

SLT Lining Technology (Far East) Pte., Ltd.
182 Tagore Ln.
Singapore 2678
65-459-2466
FAX 65-459-4366

SLT Advanced Lining Technology Pty. Ltd.
5 Regent Crescent
Moorebank, New South Wales
Australia 2170
61-2-821-2977
FAX 61-602-9606

SUMMARY OF BENTOMAT DIRECT SHEAR TEST DATA

Lab[1]	Report Date	Interface Tested[2]	Normal Stresses (psi)	Bentomat Moisture[3]	Shear Rate (in/min)	Peak Friction Angle (deg)	Residual Friction Angle (deg)	Apparent Cohesion (psf)	Comments
J & L	05-30-90	NW/Sand	1 - 2 - 3	Hydrated	0.02	35	Not determined	10	
		NW/Sand *	1 - 2 - 3	Dry *	0.02	28 *	"	85	
		NW/Clay	1 - 2 - 3	Hydrated	0.02	41	"	77	
		NW/Clay	1 - 2 - 3	Dry	0.02	32	"	105	
STS	09-11-90	NW/40-mil Text. HDPE *	35 - 52 - 70	Dry *	0.2	18 *	Not determined	0	
		NW/80-mil Text. HDPE	35 - 52 - 70	Dry	0.2	37	"	0	
		W/80-mil Text. HDPE	35 - 52 - 70	Dry	0.2	24	"	0	
J & L	11-06-90	NW/Sandy soil	2 - 3.5 - 5	Dry	0.02	23	Not determined	119	
GRI	04-18-91	Internal	.5 - 1 - 5 - 10 - 20	Dry	0.035	42	Not determined	288	
		Internal	.1 - .5 - 1 - 5 - 10	Hydrated	0.035	37	"	115	
		Internal	.1 - .5 - 1 - 5 - 10	Hydrated	0.035	39	"	173	Hydrated in leachate
STS	05-28-91	NW/40-mil Text. HDPE	35 - 52 - 70	Hydrated	0.2	20	Not determined	0	
		W/80-mil Text. HDPE	35 - 52 - 70	Hydrated	0.2	19	"	0	
UTA	08-12-91	Internal	6 - 9 - 14 - 19	Hydrated	0.000131	26	Not determined	619	
J & L	09-09-91	W/Soil cover	0.6 - 1.25 - 1.88	Hydrated	0.035	22.5	20.5	55	
		W/Geonet	0.6 - 1.25 - 1.88	Hydrated	0.035	17	16	64	
		NW/2B Stone	0.6 - 1.25 - 1.88	Hydrated	0.035	53	52	10	
TRI	05-06-92	W/60-mil text. VLDPE	2 - 8 - 14	Hydrated	0.04	22	Not determined	113	Limited hydration
		W/60-mil sm. VLDPE	2 - 8 - 14	Hydrated	0.04	15	"	77	"
TRI	11-12-92	W/40-mil text. LLDPE	3.5 - 7 - 14	Hydrated	0.2	25	16.5	230	
TRI	03-16-93	W/Saturated soil	1 - 2 - 3	Hydrated	0.04	24	Not determined	100	Bentomat HS
		W/Dry soil	1 - 2 - 3	Hydrated	0.04	20	"	153	"
		NW/Drainage geocomp.	1 - 2 - 3	Dry	0.04	17	"	20	"

Calculation Package F
Geotextile/Separation/Filtration Requirements

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: Basic Remediation Company

Project: BRC CAMU **Project/Proposal #:** SC0313 **Task #:** 01

Title of Computations: Geotextile Performance Requirements

Computations By:
SIGNATURE — DATE 11/3/06
Rebecca Flynn, Staff Engineer
PRINTED NAME AND TITLE

Assumptions and Procedures Checked By (Peer Reviewer):
SIGNATURE — DATE 11/3/06
Gregory T. Corcoran, PE / Principal
PRINTED NAME AND TITLE

Computations Checked By:
SIGNATURE — DATE 11/3/06
Gregory T. Corcoran, PE / Principal
PRINTED NAME AND TITLE

Computations Backchecked By (Originator):
SIGNATURE — DATE 11/3/06
Rebecca Flynn, Staff Engineer
PRINTED NAME AND TITLE

Approved By (PM or Designate):
SIGNATURE — DATE 11/3/06
Gregory T. Corcoran, PE / Principal
PRINTED NAME AND TITLE

Approval Notes:

Revisions: (Number and Initial All Revisions)

No.	Sheet	Date	By	Checked By	Approval

Written by: Rebecca Flynn Date: 06/09/06 (YY MM DD) Reviewed by: GTC Date: 06/11/03 (YY MM DD)

Client: BRC Project: CAMU Project/Proposal No.: SC0313 Task No.: 01-04

GEOTEXTILE PERFORMANCE REQUIREMENTS
BRC CAMU
HENDERSON, NEVADA

OBJECTIVE

It is proposed that the drainage system for the BRC Corrective Action Management Unit (CAMU) located in Henderson, Nevada include a geonet overlaid by an 8 oz/sy geotextile on the top side of the geonet acting as a filter geotextile. The geotextile must retain the overlying protective soil to minimize impairment to the underlying geocomposite drainage layer material flow properties and have sufficient mechanical properties for durability. This calculation will evaluate the required performance properties of the filter geotextile.

SUMMARY OF ANALYSIS

The calculations suggest:

- that the separation/filtration geotextile overlying the aggregate drainage layer have an AOS less than sieve No. 70 (0.21 mm), a permittivity greater than 0.8 sec^{-1}, a minimum mass per unit area of 6 $oz./yd^2$, and sufficient mechanical strength properties as outlined in federal guidelines; and

- that the separation/filtration geotextile adhered to the geonet layer have an AOS less than sieve No. 70 (0.21 mm), a permittivity greater than 0.6 sec^{-1}, a minimum mass per unit area of 8 $oz./yd^2$, and sufficient mechanical strength properties as outlined in federal guidelines.

SITE CONDITIONS

The liner system consists of, from top to bottom:

- 2 ft. of operations layer material;
- Drainage geocomposite with an 8 oz/sy geotextile bonded to both sides of the geonet;
- a 60-mil (1.5-mm) textured high density polyethylene (HDPE) geomembrane;
- a geosynthetic clay liner (GCL); and
- subgrade.

Written by: Rebecca Flynn Date: 06/09/06 (YY MM DD) Reviewed by: GTC Date: 06/11/3 (YY MM DD)

Client: BRC Project: CAMU Project/Proposal No.: SC0313 Task No.: 01-04

A cross-section of the lining system is presented as Attachment A.

The operations layer material will consist of on-site material, which has been classified as silty sand to well-graded sand (SM, SM-SW according to the Unified Soils Classification System) (Converse Consultants, 1999) (Attachment F).

ANALYSIS

Filtration Requirements: The geotextile will minimize fine particles of the operations layer material from migrating into the geocomposite drainage layer material. Migration of fine particles would have the adverse effect of decreasing the transmissivity of the geocomposite drainage layer.

The filtration requirements for geotextiles can be evaluated using the "Geotextile Filter Design Manual" developed by Luettich et al., (1991) (Attachment B). Page 2 of Attachment B shows a chart in which soil properties are used to evaluate the retention criteria of the geotextile by determining the maximum allowable apparent opening size (AOS or O_{95}).

The soil cover has been classified as silty or clayey sand and well-graded sand. Both of these classifications suggest that less than fifty percent of the material is fine-grained soils (i.e., smaller than the No. 200, or 0.075 mm, sieve size). To be conservative in the calculations herein, the operations layer is assumed to consist of more than 20 percent clay and to be non-dispersive. Therefore, using page 2 of Attachment B,

> **O_{95} < 0.21 mm**, which corresponds to sieve No. 70, meaning that the geotextile apparent opening size (AOS) must be less than a No. 70 sieve size.

Permeability: The following equation can be used to evaluate the minimum allowable geotextile permeability:

$$k_g > i_s k_s$$ (Luettich et al. (1991), Att. B, p. 1)

where: k_g = permeability of geotextile (cm/s)
i_s = hydraulic gradient (dimensionless)
k_s = permeability of the protective soil cover (cm/s)

Written by: Rebecca Flynn Date: 06/09/06 (YY MM DD) Reviewed by: GTC Date: 06/11/03 (YY MM DD)

Client: BRC Project: CAMU Project/Proposal No.: SC0313 Task No.: 01-04

Hydraulic Gradient, i_s: Attachment B, page 3 from Luettich et al. (1991) lists typical hydraulic gradients for various geotextile drainage applications. In this attachment, a hydraulic gradient of 1.5 for landfill LCRS (landfill leachate collection and removal system) applications is recommended.

Soil Permeability, k_s: A permeability of 1.2×10^{-3} cm/s was used based on permeability testing of site specific soils. (Attachment F)

Therefore,

$$k_g > \quad i_s k_s = (1.5)(1.2\text{x}10^{-3})$$
$$k_g > \quad 1.8 \times 10^{-3} \text{ cm/s}$$

Koerner (1994) suggests applying partial factors of safety to the ultimate flow capacity of the geotextile to account for clogging of the geotextile. Using recommendations given in Table 2.13 on p. 160 of Koerner (1994) (Attachment D), the following partial safety values were applied:

soil clogging and blinding:	10 (5 – 10)	creep reduction of voids:	2.0 (1.5 – 2.0)
intrusion into voids:	1.2 (1.0 – 1.2)	chemical clogging:	1.5 (1.2 – 1.5)
biological clogging:	2.0 (2 – 50)		

Therefore,

$$k_g > \quad (1.8 \times 10^{-3})(10)(2)(1.2)(1.5)(2)$$
$$k_g > \quad 0.13 \text{ cm/s}$$

The thickness of 6 oz/yd^2 (205 g/m^2) and 8 oz/yd^2 (273 g/m^2) nonwoven geotextiles are approximately 65 mils (0.165 cm) and 90 mils (0.229 cm), respectively (Amoco technical literature, Attachment E, p. 1). Dividing the permeability by the thickness of the geotextile results in the following permittivity values:

6 oz./SY = 0.78 sec^{-1}
8 oz./SY = 0.57 sec^{-1}

Mechanical Property Requirements: To ensure proper manufacturing and durability of the geotextile, the geotextile should have appropriate strength requirements. Based on guidelines developed by Task Force 25 (see note below) (Attachment C) for mechanical properties of geotextiles used in applications requiring moderate survivability, the geotextile should have the following properties:

Written by: Rebecca Flynn Date: 06/09/06 (YY MM DD) Reviewed by: CTC Date: 06/11/03 (YY MM DD)

Client: BRC Project: CAMU Project/Proposal No.: SC0313 Task No.: 01-04

Property	Criteria
Grab strength	≥ 130 lb.
Puncture strength	≥ 40 lb.
Mullen burst	≥ 210 lb
Trapezoidal tear	≥ 40 lb
Ultraviolet strength retention	≥ 70 %

Note: Task Force 25 consisted of the American Associated of State and Transportation Officials (AASHTO), the American Building Contractors (ABC), and the American Road Builders and Transportation Association (ARBTA).

CONCLUSIONS

In accordance with the above analysis, the geotextile component of the drainage composite or separation/filtration geotextile shall have the following properties:

6 oz/yd^2

Property	Separation/Filtration Criteria
matrix	nonwoven
mass per unit area	6 oz/yd^2 (205 g/m^2)
apparent opening	≤ 0.21 mm (sieve No. 70)
permittivity	≥ 0.8 s^{-1}
grab strength	≥ 130 lb.
puncture strength	≥ 40 lb.
mullen burst	≥ 210 lb.
trapezoidal tear	≥ 40 lb.
ultraviolet strength retention	≥ 70 %

8 oz/yd^2

Property	Separation/Filtration Criteria
matrix	nonwoven
mass per unit area	8 oz/yd^2 (273 g/m^2)

Written by: Rebecca Flynn Date: 06/09/06 (YY MM DD) Reviewed by: GTC Date: 06/11/3 (YY MM DD)

Client: BRC Project: CAMU Project/Proposal No.: SC0313 Task No.: 01-04

apparent opening	≤ 0.21 mm (sieve No. 70)
permittivity	≥ 0.6 s^{-1}
grab strength	≥ 130 lb.
puncture strength	≥ 40 lb.
mullen burst	≥ 210 lb.
trapezoidal tear	≥ 40 lb.
ultraviolet strength retention	≥ 70 %

The following is a partial list of geotextile products that should meet the material requirements.

Amoco Fabrics & Fibers Co., Amoco 4506
Trevira 011/120
Synthetic Industries, Geotex 701

REFERENCES

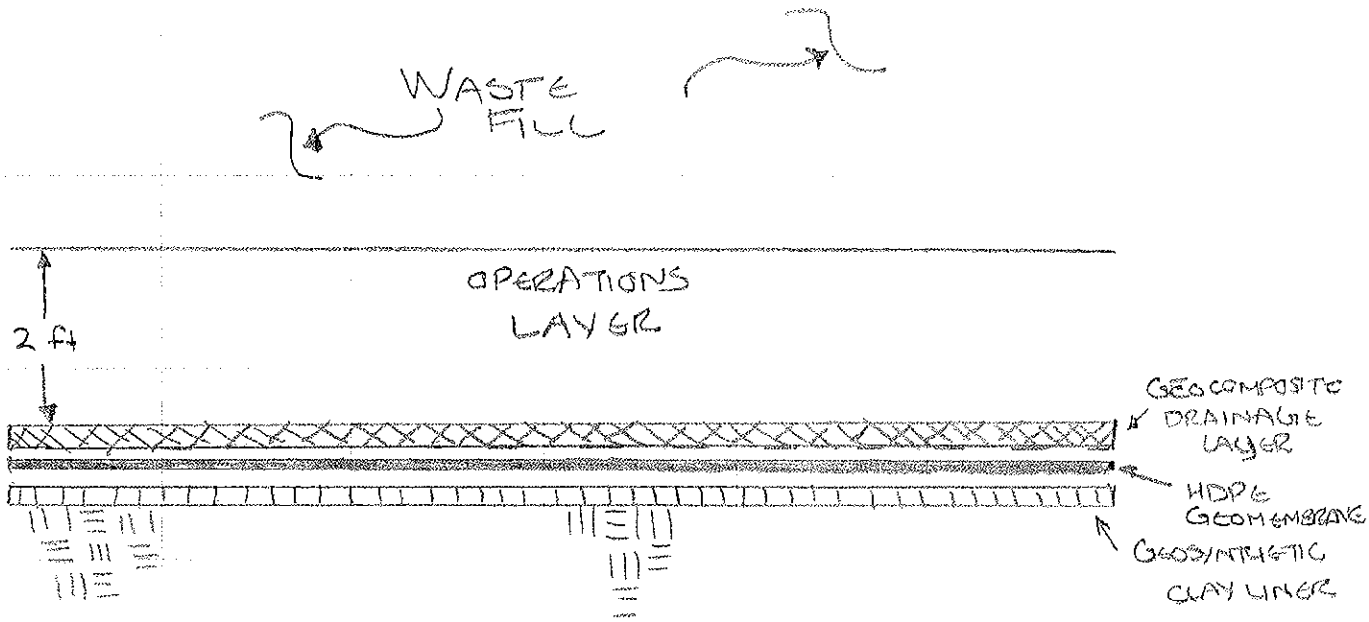
Amoco Fabrics and Fibers Company, Atlanta, Georgia, 404-984-4444

Luettich, S.M., Giroud, J.P., and Bachus, R.C. (1991), "Geotextile Filter Design Manual", report prepared for Nicolon Corporation, Norcross, GA *(Attachment B)*.

Converse Consultants (1999), "Preliminary Geotechnical and Geological Investigation", Prepared for Parsons Engineering Science, Inc., October 1999.

Written by: R. FLYNN Date: 21 / 08 / 06 (DD MM YY) Reviewed by: BTC Date: 06 / 11 / 13 (DD MM YY)

Client: BRC Project: BRC CAMV Project/Proposal No.: SC0313 Task No: 01 - 04



COMPOSITE LINER SYSTEM

ATTACHMENT A 1/1

MW

MLD

GTC

4.2 Define the Hydraulic Gradient for the Application (i_s)

The hydraulic gradient will vary depending on the application of the filter. Anticipated hydraulic gradients for various applications may be estimated using Figure 3.

4.3 Determine the Minimum Allowable Geotextile Permeability (k_g)

After determining the soil hydraulic conductivity and the hydraulic gradient, the following equation can be used to determine the minimum allowable geotextile permeability [Giroud, 1988]:

$$k_g > i_s k_s$$

The hydraulic conductivity (permeability) of the geotextile can be calculated from the permittivity test method ASTM D 4491; this value can often be obtained from the manufacturer's literature as well. The geotextile permeability is defined as the product of the permittivity, ψ, and the geotextile thickness, t_g:

$$k_g > \psi t_g$$

STEP 5. DETERMINE ANTI-CLOGGING REQUIREMENTS

To minimize the risk of clogging, the following criteria should be met:

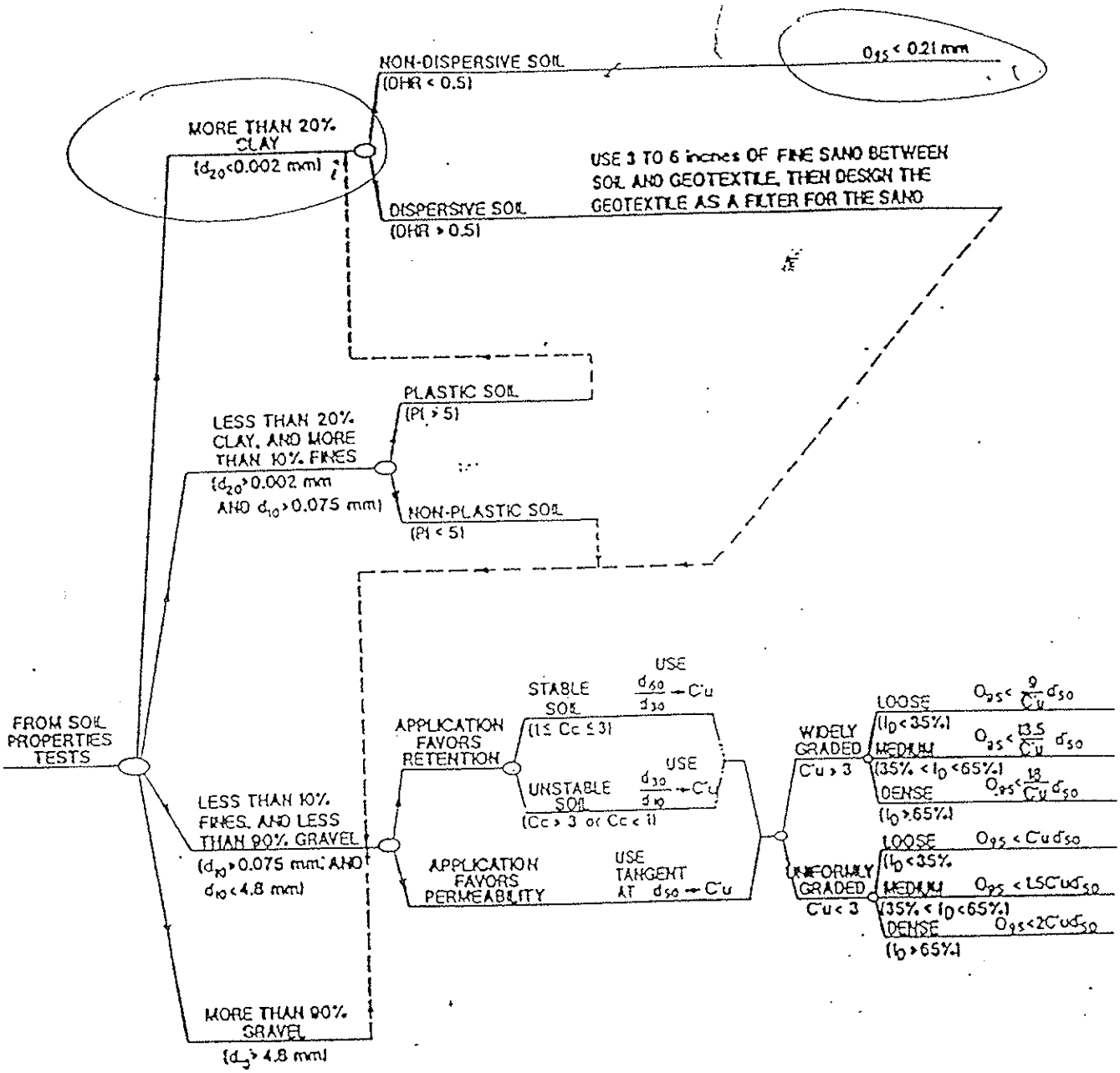
- Use the largest opening size (O_{95}) that satisfies the retention criteria.
- For nonwoven geotextiles, use the largest porosity available, but not less than 30 percent.
- For woven geotextiles, use the largest percent open area available, but not less than 4 percent.

Source: Luettich, S.M. Giroud, J.P. and Bachus R.C (1991) "Geotextile Filter Design Manual" Report prepared for Nicolon Corporation Norcross, GA

ATTACHMENT B

P 2/3

CHART 1
SOIL RETENTION CRITERIA
FOR STEADY-STATE FLOW CONDITIONS



NOTES:

d_x is the particle size of which x percent is smaller

$C'u = \sqrt{\frac{d'_{100}}{d'_0}}$ where: d'_{100} and d'_0 are the extremities of a straight line drawn through the particle-size distribution, as directed above; and d'_{50} is the midpoint of this line.

$Cc = \frac{(d_{30})^2}{d_{60} \times d_{10}}$

I_D is the relative density of the soil

PI is the plasticity index of the soil

DHR is the double-hydrometer ratio of the soil

Portions of this flow chart modified from Giroud (1988)

Source: Luettich, S.M., Giroud, J.P., and Bachus, R.C. (1991) "Geotextile Filter Design Manual" Report prepared for

ATTACHMENT B, 2/3

MN

MLD
GTC

FIGURE 3
TYPICAL HYDRAULIC GRADIENTS[a]

DRAINAGE APPLICATION	TYPICAL HYDRAULIC GRADIENT
STANDARD DEWATERING TRENCH	1.0
VERTICAL WALL DRAIN	1.5
PAVEMENT EDGE DRAIN	1[b]
LANDFILL LCDRS	1.5
LANDFILL LCRS	1.5
LANDFILL SWCRS	1.5
DAMS	10[b]
INLAND CHANNEL PROTECTION	1[b]
SHORELINE PROTECTION	10[b]
LIQUID IMPOUNDMENTS	10[b]

NOTES: (a) Table developed after Giroud, 1988.

(b) Critical applications may require designing with higher gradients than those given.

Attachment B
P. 3/3

Specification for *Survivability*

TABLE C-4 MINIMUM FABRIC PROPERTIES RECOMMENDED FOR FABRIC SURVIVABILITY[a]

Required degree of fabric survivability	Grab strength (lbs.)	Puncture strength[b] (lbs.)	Burst strength[c] (lb./in.^{2})	Trap tear[d] (lbs.)
Low	90	30	145	30
Moderate	130	40	210	40
High	180	75	290	50
Very high	270	110	430	75

(a) All values represent minimum values (i.e., any roll in a lot should meet or exceed the minimum values in this table).

(b) ASTM D751-68, tension testing machine with ring clamp, steel ball replaced with a 5/16-in.-diameter solid steel cylinder with hemispherical tip centered within the ring clamp.

(c) ASTM D751-68, diaphragm test method.

(d) ASTM D1117, either principal direction.

Appendix 2nd Edition
Attachment C 1/1

TABLE C-5 REQUIRED DEGREE OF SI \BILITY AS A FUN
CONDITIONS AND CONSTRUCTION EQ ENT[a]

Subgrade conditions	Construction e: Low ground-pressure equipment (≤4 lb./in.^{2})
Subgrade has been cleared of all obstacles except grass, weeds, leaves, and fine wood debris. Surface is smooth and level such that any shallow depressions and humps do not exceed 6 in. in depth and height. All larger depressions are filled. Alternatively, a smooth working table may be placed.	Low
Subgrade has been cleared of obstacles larger than small to moderate-sized tree limbs and rocks. Tree trunks and stumps should be removed or covered with a partial working table. Depressions and humps should not exceed 18 in. in depth and height. Larger depressions should be filled.	Moderate
Minimal site preparation is required. Trees may be felled, delimbed, and left in place. Stumps should be cut to project not more than 6 in. ± above subgrade. Fabric may be draped directly over tree trunks, stumps, large depressions and humps, holes, steam channels, and large boulders. Items should be removed only if placing the fabric and cover material over them will distort the finished road surface.	High

(a) Recommendations are for 6-12 in. initial lift thickness. For other init
12–18 in: reduce survivability requirement one level
18–24 in.: reduce survivability requirement two levels
>24 in.: reduce survivability requirement three levels
Survivability levels are, in increasing order: low, moderate, high, an
For special construction techniques such as prerutting, increase fabric
Placement of excessive initial cover material thickness may cause be

Source: After Christopher, B., and Holtz, R. D., Federal Highway Ad
Training Manual, Washington, DC.

MG

Table 2.13 Recommended partial factors of safety values for use in Equation 2.25

Application	Various Partial Factors of Safety				
	Soil Clogging and Blinding	Creep Reduction of Voids	Intrusion into Voids	Chemical Clogging	Biological Clogging
Retaining wall filters	2.0 to 4.0	1.5 to 2.0	1.0 to 1.2	1.0 to 1.2	1.0 to 1.3
Underdrain filters	5.0 to 10	1.0 to 1.5	1.0 to 1.2	1.2 to 1.5	2.0 to 4.0
Erosion control filters	2.0 to 10	1.0 to 1.5	1.0 to 1.2	1.0 to 1.2	2.0 to 4.0
Landfill filters	5.0 to 10	1.5 to 2.0	1.0 to 1.2	1.2 to 1.5	2.0 to 50
Gravity drainage	2.0 to 4.0	2.0 to 3.0	1.0 to 1.2	1.2 to 1.5	1.2 to 1.5
Pressure drainage	2.0 to 3.0	2.0 to 3.0	1.0 to 1.2	1.1 to 1.3	1.1 to 1.3

do not serve this function, the other, sometimes primary, function will not be served properly. This should not give the impression that geotextiles as separators always play a secondary role. Many situations call for separation only, and in such cases the geotextiles do serve a significant and worthwhile function.

2.5.1 Overview of Applications

Perhaps the target application that can best illustrate the use of geotextiles as separators is their placement between an underlying reasonably firm soil subgrade and a stone base course, aggregate, or ballast placed above the geotextile. We say "reasonably firm" because it is assumed that the subgrade deformation is not sufficiently large to mobilize uniformly high tensile stress in the geotextile. (The application of geotextiles in unpaved roads on soft soils wherein membrane-type reinforcement is developed is treated later in Section 2.6.) Thus for such a separation function to occur, the geotextile must be placed on the soil subgrade and then have stone placed, spread, and compacted on top of it. A number of scenar can be developed showing what geotextile properties are required for a given situation.

2.5.2 Burst Resistance

Consider a geotextile on a soil subgrade with stone of average particle diameter (d_a) placed above it. If the stone is uniformly sized, there will be voids within it that will be available for the geotextile to enter into. This entry is caused by the simultaneous action of the traffic loads being transmitted to the stone, through the geotextile, and into the underlying soil. The stressed soil then tries to push the geotextile up into the voids within the stone. The situation is shown schematically in Figure 2.26. Giroud [59] provides a formulation for the required geotextile strength which can be adopted for this application.

$$T_{reqd} = \frac{1}{2} p' d_v [f(\epsilon)] \tag{2.26}$$

where T_{reqd} = the required geotextile strength,
p' = the stress at the geotextile's surface, which is less than, or equal to,

Koerner (1994)

ATTACHMENT D 1/1

AMOCO WASTE RELATED GEOTEXTILES

MINIMUM PHYSICAL PROPERTIES
(Minimum Average Roll Values)

Property	Test Method	Units	4504	4506	4508	4510	4512	4516
Unit Weight	ASTM D-3776	Oz./yd.²	4.0	6.0	8.0	10.0	12.0	16.0
Grab Tensile	ASTM D-4632	lbs.	95	150	200	235	275	350
Grab Elongation	ASTM D-4632	%	50	50	50	50	50	50
Mullen Burst	ASTM D-3786	psi	225	350	450	550	650	750
Puncture	ASTM D-4833	lbs.	55	90	130	165	185	220
Trapezoid Tear	ASTM D-4533	lbs.	35	65	80	95	115	130
Apparent Opening Size	ASTM D-4751	US Sieve Number	70	70	100	100	100	100
Permittivity	ASTM D-4491	gal/min/ft² sec⁻¹	100 2.0	90 1.7	80 1.5	70 1.1	60 0.9	50 0.7
Permeability	ASTM D-4491	cm/sec	.2	.2	.2	.2	.2	.2
Thickness	ASTM D-1777	mils	40	65	90	110	130	175
U.V. Resistance	ASTM D-4355[1]	%[2]	70	70	70	70	70	70

1. Fabric conditioned per ASTM D-4355 2. Percent of minimum grab tensile after conditioning

TYPICAL PHYSICAL PROPERTIES

Property	Test Method	Units	4504	4506	4508	4510	4512	4516
Grab Tensile	ASTM D-4632	lbs.	130/115	225/200	275/270	315/310	410/370	510/470
Grab Elongation	ASTM D-4632	%	75	65	65	65	65	65
Mullen Burst	ASTM D-3786	psi	285	410	575	650	825	920
Puncture	ASTM D-4833	lbs	75	120	170	190	210	270
Trapezoid Tear	ASTM D-4533	lbs	60/50	100/80	140/120	160/140	185/155	220/180
Apparent Opening Size	ASTM D-4751	US Sieve Number	70/120	70/140	100/200	100+	100+	100+
Permittivity	ASTM D-4491	gal/min/ft² sec⁻¹	150 3.1	110 2.0	100 1.8	80 1.5	70 1.3	60 1.0
Permeability	ASTM D-4491	cm/sec	.35	.31	.27	.26	.25	.23
Thickness	ASTM D-1777	mils	50	75	115	130	150	195

PACKAGING

Dimensions		4504	4506	4508	4510	4512	4516
Roll Width	ft	15	15	15	15	15	15
Roll Length	ft.	1200	900	600	600	450	300

Amoco Technical Literature Appendix E
404 984-4444 p 1/1
MLD GTC

accuracy or reliability of said information or the performance of any product. All specifications [illegible] provided as information only and in no way modify, amend, enlarge or create any warranty. Nothing contained herein is to be construed as permission or as a recommendation to infringe any patent.

Exploration Location	Depth (feet)	Soil Description	Percent Sodium	Percent Sulfate	Total Available Water Soluble sodium Sulfate (%)
B-5	10-15	Silty sand with gravel	0.07	0.13	0.20
B-8	19-20	Silty sand with gravel	0.07	0.06	0.08
B-101	5-10	Silty sand with gravel	0.17	0.06	0.08
B-102	0-5	Fill – Silty sand with gravel	0.17	0.03	0.05
B-106	0-5	Silty sand with gravel	0.15	0.08	0.12
B-106	29-30	Silty sand with gravel	0.15	0.06	0.08

Permeability

Falling head permeability tests were conducted on remolded samples in general accordance with modified ASTM procedure D2434. The soil was compacted in a mold 4.6 inches long and 4.0 inches in diameter to 85 or 90 percent of maximum dry density and at optimum moisture content. A falling head was applied to the sample and the flow of water through the sample was monitored. The permeability was calculated after the flow rate had stabilized. The result of the falling head permeability test is presented in the following table:

Exploration Location	Sample Depth (Feet)	Soil Description	k (cm/s)
B-5	20-25	Silty sand with gravel	5.3×10^{-4}
B-12	10-15	Silty sand with gravel	4.0×10^{-4}
B-102	20-25	Silty sand with gravel	1.0×10^{-4}
B-105	20-25	Well graded sand with silt and gravel	1.2×10^{-3}

Flexible wall permeameter tests were performed on selected samples by AP Engineering and Testing, Inc according to ASTM D5084. With the exception of one sample (B-105), all tested samples were undisturbed ring samples. The samples were placed in a triaxial machine with a constant confining pressure at the approximate in-place effective stress pressures. Results were generally consistent with the fal-

Calculation Package G
Geotextile Cushion Protection

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: Basic Remediation Company

Project: BRC CAMU **Project/Proposal #:** SC0313 **Task #:** 01

Title of Computations: Geotextile Puncture Protection of Geomembrane

Computations By:
SIGNATURE — DATE 11/3/06
Rebecca Flynn, Staff Engineer
PRINTED NAME AND TITLE

Assumptions and Procedures Checked By (Peer Reviewer):
SIGNATURE — DATE 11/6/06
Keaton Botelho, Staff Engineer
PRINTED NAME AND TITLE

Computations Checked By:
SIGNATURE — DATE 11/3/06
Gregory T. Corcoran, PE / Principal
PRINTED NAME AND TITLE

Computations Backchecked By (Originator):
SIGNATURE — DATE 11/3/06
Rebecca Flynn, Staff Engineer
PRINTED NAME AND TITLE

Approved By (PM or Designate):
SIGNATURE — DATE 11/3/06
Gregory T. Corcoran, PE / Principal
PRINTED NAME AND TITLE

Approval Notes:

Revisions: (Number and Initial All Revisions)

No.	Sheet	Date	By	Checked By	Approval

Written by: Rebecca Flynn Date: 06 / 08 / 21 (YY MM DD) Reviewed by: GTC Date: 06 / 11 / 3 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

GEOTEXTILE PUNCTURE PROTECTION OF GEOMEMBRANE

OBJECTIVE

A composite liner system is proposed for the Corrective Action Maintenance Unit (CAMU) located in Henderson, Nevada. The objective of this calculation is to evaluate the maximum particle size of soil materials adjacent to the geomembrane that will not puncture the geomembrane. Specifically, the evaluation will consider the drainage aggregate overlying the geocomposite and geomembrane components of the liner system and the subgrade underlying the geomembrane and GCL components of the liner system.

SUMMARY OF ANALYSIS

The analysis suggests that the following maximum particle sizes and geotextile mass per unit areas will be required:

Soil Component of Liner	Maximum Particle Size	Minimum Mass Per Unit Area
Subgrade	0.75 in	9 oz./SY (GCL)
Angular Drainage Aggregate	1.00 in	16 oz./SY

SITE CONDITIONS

The composite liner system will be comprised of the following components, from top to bottom (Attachment A):

- 2 ft of operations layer material;
- a geocomposite drainage layer;
- 60-mil (1.5 mm) HDPE geomembrane, textured on both sides;
- a geosynthetic clay liner (GCL); and
- prepared subgrade.

The maximum height of waste to be placed within the lined area is 93 ft overlying the drainage sump in the South Mesa, based on the proposed waste fill plan. (Attachment B)

Written by: Rebecca Flynn Date: 06 / 08 / 21 (YY MM DD) Reviewed by: BTC Date: 06 / 11 / 3 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

- **OVERLYING PRESSURE:**

The overlying pressure can be estimated based on the maximum future fill height of 93 feet. The unit weight of the waste material was selected to be 136 pcf based on modified proctor tests conducted on soil samples from the site that are similar to the waste material to be placed with in the CAMU. The maximum dry density was determined to be 132 pcf at an optimum moisture content of 8.2%. Assuming that the material will be placed at a density less than 95% degree of compaction, the resulting dry density is 125.4 pcf. Adding the weight of the moisture in the soil results in a wet density of approximately 136 pcf. (Attachment C). Therefore, the overlying pressure is estimated as follows:

$$P = (93\ ft)(136\ pcf) = 12{,}648\ psf \text{ or } 606\ kPa$$

ANALYSIS

- **APPROACH – Protected Geomembrane**

Wilson-Fahmy, Narejo, and Koerner have evaluated puncture protection of geomembranes in a series of three papers. These papers are:

1) Wilson-Fahmy, R.F., Narejo, D., and Koerner, R.M (1996) "Puncture Protection of Geomembranes Part I: Theory", Geosynthetics International, Vol. 3, No. 5, pp. 605-628

2) Narejo, D., Koerner, RM. and Wilson-Fahmy, R.F. (1996) "Puncture Protection of Geomembranes Part II: Experimental", Geosynthetics International, Vol. 3, No. 5, pp. 629-653

3) Koerner, R.M., Wilson-Fahmy, R.F. and Narejo, D. (1996) "Puncture Protection of Geomembranes Part III: Examples", Geosynthetics International, Vol. 3, No. 5, pp. 655-675

These papers present an evaluation of geomembrane puncture theory, the results of a laboratory experimental program, and design examples in regards to puncture protection of geomembranes. The design methods and conclusions of these papers were used for the analysis herein.

According to these papers, the important parameters that affect the puncture protection of geomembranes are: overlying pressure, mass per area of the geotextile, and the particle size and shape of the material overlying the geotextile. For the analysis herein, the overlying pressure and the mass per unit area of the geotextile are given, and the maximum particle size is evaluated.

Written by: Rebecca Flynn Date: 06 / 08 / 21 (YY MM DD) Reviewed by: GTC Date: 06 / 11 / 3 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

- **MASS PER UNIT AREA OF GEOTEXTILE**

Two different mass per unit areas will be evaluated. The cushion geotextile overlying the liner system will be 16 oz./SY and the GCL underlying the liner system will have geotextile components with a minimum 9 oz./SY mass per unit area. (Attachment D)

- **SIZING MAXIMUM PARTICLE OF SOIL**

Narejo et al (1996, Attachment E) present the following equation for evaluating geotextile puncture protection of 60 mil (1.5 mm) HDPE geomembrane:

$H^2 = 450\ M_A / P_{allow}$ (Attachment E)

where:

M_A = mass per unit area geotextile (g/m^2)
= 542 (16 oz./SY) and 305 (9 oz./SY) g/m^2

H = cone height (mm), which corresponds to predicted effective protrusion height, which equals one half maximum stone size (Attachment E).

P_{allow} = maximum long term allowable pressure

where: $P_{allow} = P'_{allow}\ (MF_S \times MF_{PD} \times MF_A)(FS_{CR} \times FS_{CBD})$ (Attachment E)

where: MF_S, MF_{PD}, MF_A = modification factors (discussed below)
FS_{CR}, FS_{CBD} = partial factor of safety values (discussed below)

P'_{allow} = allowable pressure based on field conditions
= (FS) ($P_{actual\ field\ pressure}$) (Attachment E)

where: FS = global factor of safety, 3.0 (Attachment E)
$P_{actual\ field\ pressure}$ = 606 kPa
P'_{allow} = (606)(3) = 1,818 kPa

MF_S = shape factor: (Attachment E)
1.0 (assume angular particles)

MF_{PD} packing density: (Attachment E)
0.5 (assume packed stones)

Written by: Rebecca Flynn Date: 06 / 08 / 21 (YY MM DD) Reviewed by: BTC Date: 06 / 11 / 3 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

MF_A	soil arching: 0.75 (assume moderate)	(Attachment E)
FS_{CR}	partial factor of safety for creep 1.5 (see Table 12)	(Attachment E)
FS_{CBD}	partial factor of safety for chemical and biological degradation 1.5 (based on average value)	(Attachment E)

Solving for P_{allow} provides:

P_{allow} = (1,818) (1.0 x 0.5 x 0.75)(1.5 x 1.5)
P_{allow} = 1,534 kPa

Solving for H, the predicted effective protrusion height, provides:

$H^2 = 450\ M_A / P_{allow}$

$H_{cushion} = [(450)(M_A)/(1,534)]^{1/2}$
$M_A = 542\ g/m^2$ = 12.6 mm = 0.50 inches

$H_{GCL} = [(450)(M_A)/(1,534)]^{1/2}$
$M_A = 305\ g/m^2$ = 9.45 mm = 0.37 inches

The predicted effective protrusion height equals one half the maximum stone size. Therefore, the maximum stone size is twice the values listed above.

$M_A = 542\ g/m^2$ = 0.50 inches x 2 = 1.0 inches
$M_A = 305\ g/m^2$ = 0.37 inches x 2 = 0.75 inches

CONCLUSIONS

Assuming the following:

- the particle shape is angular for the drainage aggregate, and
- the approach presented by Wilson-Fahmy, Narejo, and Koerner for evaluating puncture protection of geomembranes is appropriate for the analysis herein,

then, the calculations suggest that THE MAXIMUM PARTICLE SIZE IS 1.0 IN. for a 16 oz/yd^2 geocomposite drainage layer and 0.75 IN. for a GCL with two geotextiles equating to 9 oz/yd^2.

Written by: Rebecca Flynn Date: 06 / 08 / 21 (YY MM DD) Reviewed by: GTC Date: 06 / 11 / 03 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

- **COMPLETE SET OF GEOTEXTILE PROPERTIES**

Typical nonwoven, needlepunched geotextile, when subjected to laboratory testing, should provide the following mechanical property values:

Property	**16 oz./SY Value**
puncture strength	> 240 lb
grab strength	> 390 lb
trapezoidal tear	> 150 lb
ultraviolet strength retention	> 70 %

REFERENCES

Geotechnical Fabrics Report, "2005 Specifiers Guide", Vol 22, No. 9, Dec. 2004.

Koerner, R.M., Wilson-Fahmy, R.F. and Narejo, D. (1996) "Puncture Protection of Geomembranes Part III: Examples", Geosynthetics International, Vol. 3, No. 5, pp. 655-675.

Narejo, D., Koerner, R.M. and Wilson-Fahmy, R.F. (1996) "Puncture Protection of Geomembranes Part II: Experimental", Geosynthetics International, Vol. 3, No. 5, pp. 629-653.

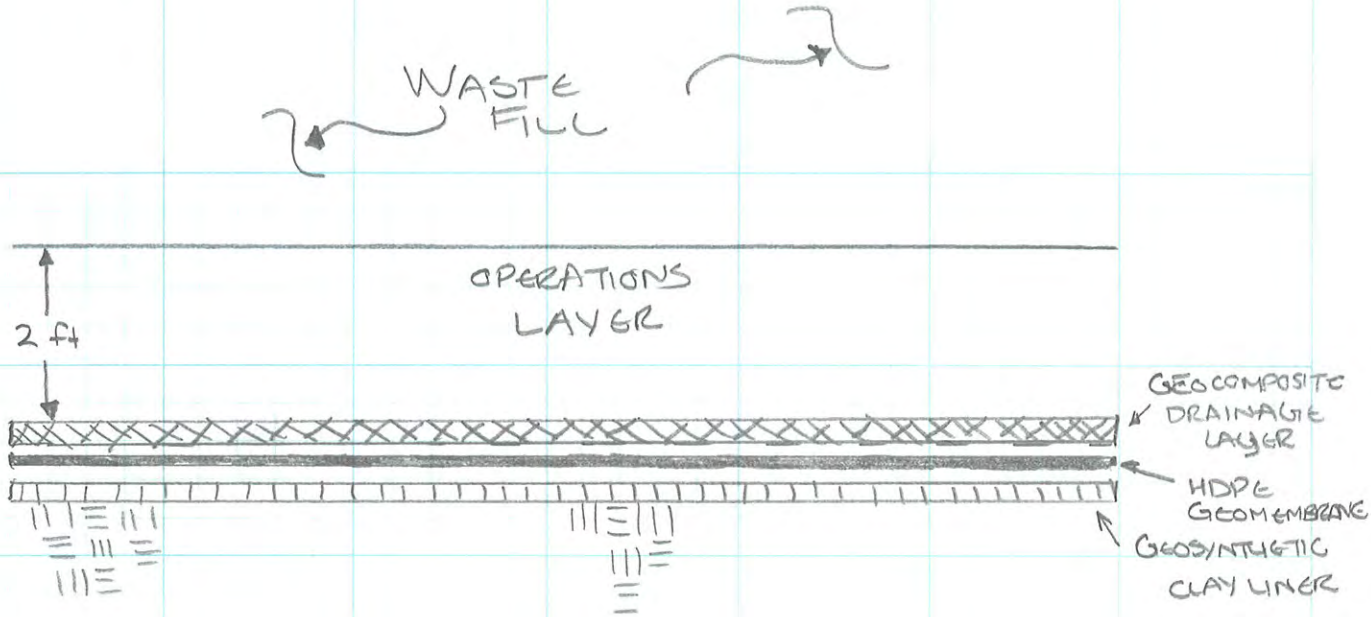
Wilson-Fahmy, R.F., Narejo, D., and Koerner, R.M. (1996) "Puncture Protection of Geomembranes Part I, Theory", Geosynthetics International, Vol. 3, No. 5, pp. 605-628.

GEOSYNTEC CONSULTANTS

Page _____ of _____

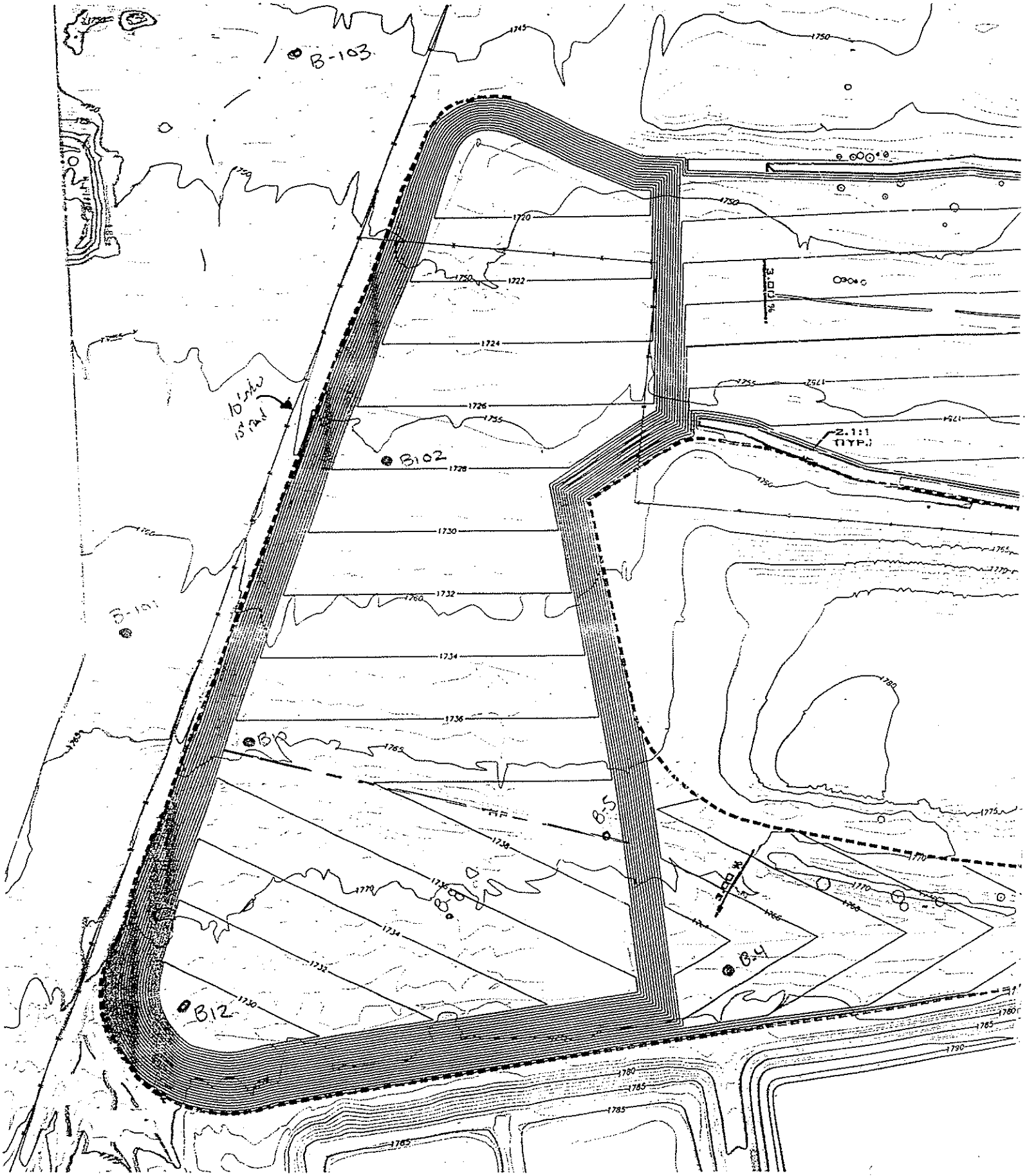
Written by: R. FLYNN Date: 21 / 08 / 06 (DD / MM / YY) Reviewed by: GTC Date: 03 / 11 / 06 (DD / MM / YY)

Client: BRC Project: BRC CAMV Project/Proposal No.: SC0313 Task No: 01 - 04



COMPOSITE LINER SYSTEM

ATTACHMENT A 1/1



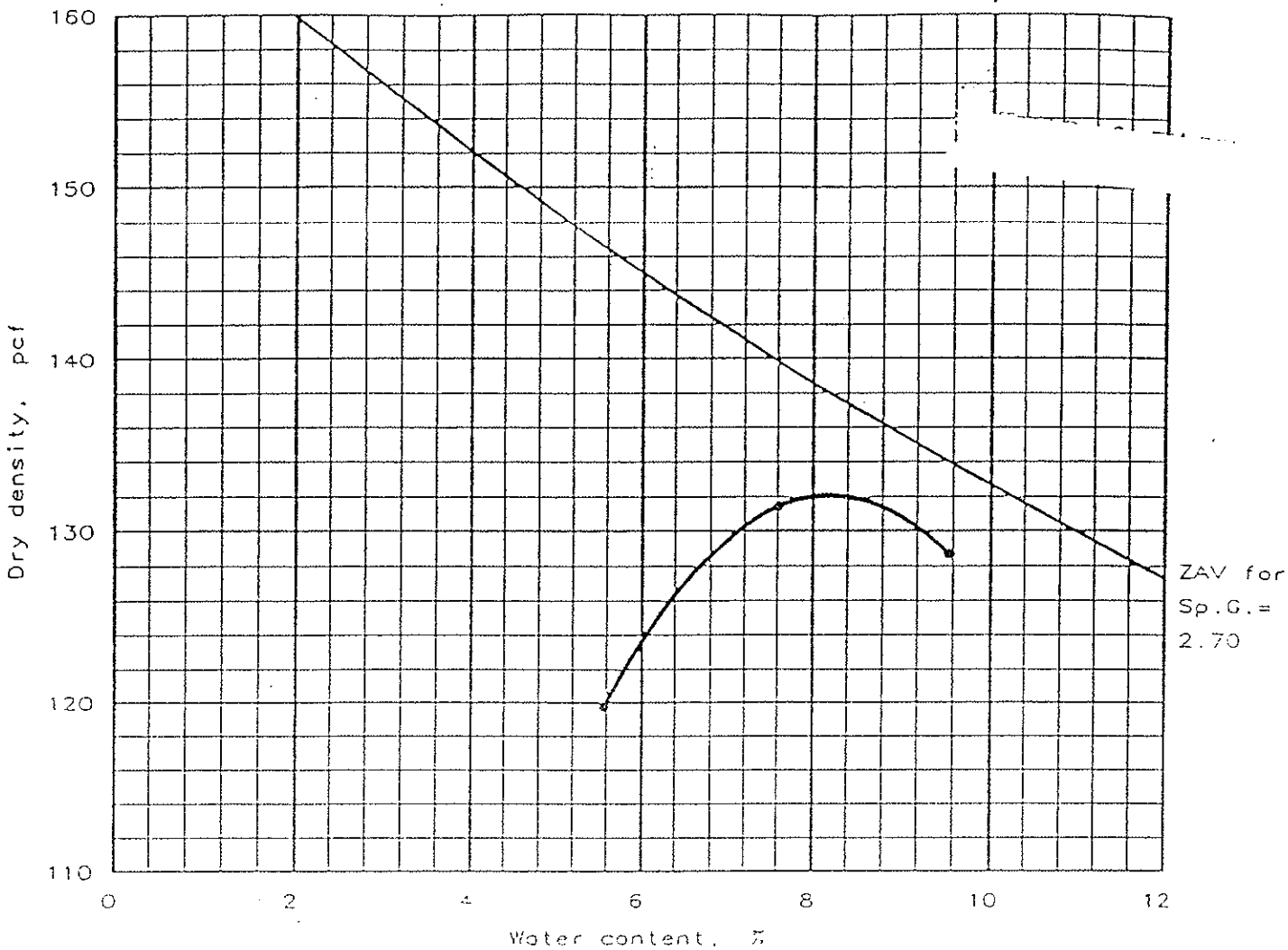
Attachment B

1/1

78 etc

(3) 5/10/05

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 1557-91 Procedure C, Modified

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/4 in	% < No.200
	USCS	AASHTO						
	SM				NV	NP	0 %	19.2 %

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 132.1 pcf Optimum moisture = 8.2 %	Silty Sand with Gravel

Project No.: 99-33437-01

Project: BMI Landfill

Location: B5 @ 20-25'

Date: 10-15-1999

MOISTURE-DENSITY RELATIONSHIP TEST

CONVERSE CONSULTANTS

Fig. No. A-58

ATTACHMENT C, 1/1 MLD

GEOSYNTHETIC CLAY LINERS

Product Name	Bonding Method	GCL Dimensional Properties: Panel Size Roll Width/Length m/m (ft/ft)	GCL Dimensional Properties: Average Roll Weight kg (lb)	GCL Dimensional Properties: Bentonite Mass/Unit Area ASTM D 5993 gm/m² (lb/ft²)	GCL Hydraulic Properties: Flux [1] ASTM D 5887 [2] m³/m²-s	Base Bentonite Properties: Swell Index ASTM D 5890 (min.) ml/2g	Base Bentonite Properties: Fluid Loss ASTM D 5891 ml	GCL Structural Components: Upper Geosynthetic: Type or Structure	GCL Structural Components: Upper Geosynthetic: Weight ASTM D 3776 g/m² (oz/yd²)	GCL Structural Components: Lower Geosynthetic: Type or Structure	GCL Structural Components: Lower Geosynthetic: Weight ASTM D 3776 or Thickness ASTM D 5199 g/m² or mm (oz/yd² or mil)	Manufacturer's Suggested Applications [3]
CETCO											www.cetco.com	
Bentomat ST	needle-punched	4.6/45.7 (15/150)	1180 (2600)	3670 (0.75)	1 x 10⁻⁸	24	18	woven	105 (3.2)	nonwoven	200 (6.0)	LL, LC, SIC
Bentomat SDN	needle-punched	4.4/45.7 (14.5/150)	1200 (2650)	3670 (0.75)	1 x 10⁻⁸	24	18	nonwoven	90 (2.7)	nonwoven	200 (6.0)	LL, LC, SIC
Bentomat DN	needle-punched	4.4/45.7 (14.5/150)	1200 (2650)	3670 (0.75)	1 x 10⁻⁸	24	18	nonwoven	200 (6.0)	nonwoven	200 (6.0)	LL, LC, SIC
Bentomat YSDN	needle-punched	4.4/60.9 (14.5/200)	1180 (2600)	2440 (0.50)	3 x 10⁻⁸	24	18	nonwoven	90 (2.7)	nonwoven	200 (6.0)	LC
Bentomat CL	needlepunched laminated	4.6/45.7 (15/150)	1250 (2750)	3670 (0.75)	1 x 10⁻⁸	24	18	FML/geotextile composite	NA	woven	105 (3.2)	LL, LC, SIC, CL, SIL
Bentomat CLT	needle-punched	4.6/45.7 (15/150)	1340 (2950)	3670 (0.75)	1 x 10⁻⁸	24	18	textured FML/geotextile composite	NA	woven	105 (3.2)	LL, LC, SIC, CL, SIL
Claymax 200R	adhesive	4.6/45.7 (15/150)	1225 (2700)	3670 (0.75)	1 x 10⁻⁸	24	18	nonwoven	75 (2.2)	nonwoven	90 (2.7)	LL, LC, SIC
Claymax [illegible]	adhesive	4.4/[illegible]	[illegible]	[illegible]	1 x 10⁻⁸	24	18	FML/nonwoven composite	NA	nonwoven	75 (2.2)	LL, LC, SIC, CL, SIL

Attachment D 1/2

3/5/10/05

GSE Gundseal Smooth HDPE	adhesive	5.3/61 (17.5/200)	1900 (4200)	3660 (0.75)	$\leq 4 \times 10^{-14}$	24	18	smooth HDPE geomembrane	0.4–2.0 mm (15–80 mil)	spunbonded geotextile	25 (0.75)	all
GSE Gundseal Textured HDPE	adhesive	5.3/55 (17.5/180)	1900 (4200)	3660 (0.75)	$\leq 4 \times 10^{-14}$	24	18	textured HDPE geomembrane	0.75–2.0 mm (30–80 mil)	spunbonded geotextile	25 (0.75)	all
Bentofix EC	needle-punched	4.7/46 (15.5/150)	980 (2160)	3660 (0.75)	1×10^{-5}	24	18	PP nonwoven	100 (3.0)	PP woven	105 (3.1)	all
Bentofix NWL	needle-punched	4.7/46 (15.5/150)	980 (2160)	3660 (0.75)	1×10^{-5}	24	18	PP nonwoven	200 (6.0)	PP nonwoven	200 (6.0)	all
Bentofix NSL	needle-punched	4.7/46 (15.5/150)	980 (2160)	3660 (0.75)	1×10^{-5}	24	18	PP nonwoven	200 (6.0)	PP woven	105 (3.1)	all
Bentofix CNSL	needlepunched, polymer-coated	4.7/46 (15.5/150)	1180 (2600)	3660 (0.75)	$\leq 1 \times 10^{-7}$	24	18	PP FML/nonwoven composite	200 (6.0)	PP woven	105 (3.1)	all

[1] Flux is defined as "Flow rate/unit area" which can be converted to permeability using the equation:
Permeability = flux/hydraulic gradient
[2] Report result at a confining stress of 69 kN/m^2 (10psi) and 34 Kpa (5psi) head pressure

[3] CL = Canal liner
LL = Landfill liner
SIC = Surface impoundment cover
LC = Landfill cover
SIL = Surface impoundment liner
NP = Not provided by manufacturer
NA = Not applicable, per manufacturer

Companies were requested to provide minimum average roll values (MARV). All claims are the responsibility of the manufacturer.

GFR recommends you contact the manufacturers before making any specifying/purchasing decisions.

GEOSYNTHETIC CLAY LINERS

Attachment B31 2/2

5/10/05

ion tile	Failur pressure (kPa)	Applied pressure (% of failure pressure)	Applied pressure (kPa)	Failure time (hours)
e	140	75	100	130
		50	70	170
		25	35	260
/m²	1750*	75	1300	10,000**
/m²	3400*	40	1300	10,000**
e	69	75	52	24
		50	34	42
		25	17	68
m²	320	75	240	140
		50	160	110
		25	80	310
m²	450	85	380	240
		70	310	390
		60	270	1000**
m²	610	75	460	10,000**
e	55	75	41	0.5
		50	28	2.5
		25	14	40
m²	83	75	62	3
		50	41	12
		25	21	200
m²	103	75	77	192
		50	52	1000**
m²	365	75	270	10,000**

ues using Equation 3. **Geomembrane showed signs of yield. † From short term cated cone puncture tests.

ORMULATION

Attachment E

on is presented in this section based on the experimental puncture previous sections. The resulting equations predict the allowable DPE geomembranes both with and without geotextile protection.

odification factors are then applied to correlate the truncated cone actual d conditions. The modification factors consider the stone shape, arr ent and soil arching. All of these modification factors have a magnitude of 1.0 or less since the experiments were conducted on a worst-case basis. Partial factors of safety are then incorporated into the design equations to account for creep and chemical/biological degradation. These partial factors of safety are equal to 1.0 or greater since longer periods of time are typically required for these factors to have an effect. Finally, a global factor of safety is applied to account for uncertainties in the formulation. The above described empirical formulation is presented in a step-by-step manner in order to emphasize the various factors involved.

6.2 Basic Design Equation

The formulation for predicting geomembrane failure pressure, p, is based on Figure 3 where it is seen that for each cone height, the failure pressure varies linearly with respect to the mass per unit area of the geotextile. Note that this failure pressure from the experiments is assumed to be the maximum allowable design pressure with an implied global factor of safety of 1.0. Thus, the maximum allowable pressure can be expressed as follows:

$$p_{allow} = d \times M_A \tag{1}$$

where: p_{allow} = maximum allowable pressure (with an implied factor of safety of 1.0); M_A = mass per unit area of the protection geotextile (g/m²); and d = constant. From Figure 3, it is found that the parameter d can be related to the cone height, H, according to the following equation:

$$d = \frac{450}{H^2} \tag{2}$$

where H is in millimeters.

Combining Equations 1 and 2, the failure pressure can be determined in terms of the cone height and mass per unit area of the protection geotextile as follows (a minimum pressure of 50 kPa is imposed which conservatively corresponds to the failure pressure of the 1.5 mm thick HDPE geomembrane without any protection material):

$$p_{allow} = 450 \frac{M_A}{H^2} \geq 50 \text{ kPa} \tag{3}$$

The accuracy of the above equation is depicted in Figure 6 which shows the relationship between the measured failure pressure and the failure pressure predicted using Equation 3. The data in Figure 6 are for polyester geotextiles made from cont s filaments, and polypropylene geotextiles made of staple fibers. Hence, Equatio plies to essentially all of the polymer and fiber types used in the nonwoven e-punched geotextiles.

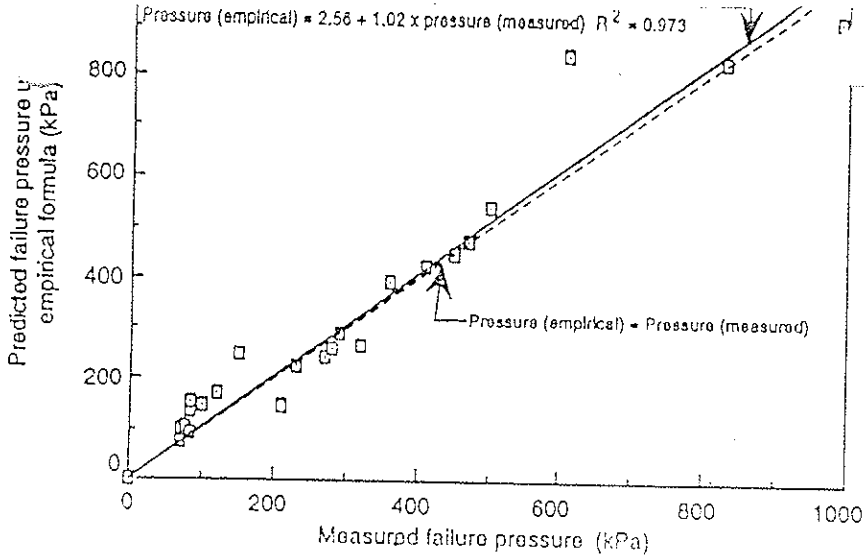


Figure 6. Measured versus empirically predicted failure pressures using Equation 3 for all nonwoven needle-punched geotextiles evaluated with a 1.5 mm thick HDPE geomembrane. Note: R = correlation coefficient.

6.3 Modification Factors

A series of modification factors is now sequentially applied to Equation 3 in order to arrive at a pressure representing field conditions. The modified pressure will be referred to as p'_{allow}.

6.3.1 *Modification Factor for the Protrusion Shape*

It was previously shown that the failure pressure depends on the protrusion shape. Rounded stones gave the highest failure pressure followed by subrounded stones. The lowest failure pressure is associated with angular stones and is approximately equal to the failure pressure of truncated cones. In order to account for the effect of stone shape, a modification factor is introduced into Equation 3 as follows:

$$p'_{allow} = p_{allow}\left(\frac{1}{MF_S}\right) \tag{4}$$

where MF_S is the modification factor for the protrusion shape. Hereafter, p'_{allow} refers to the empirically modified value of p_{allow} as is illustrated in Figure 6.

Based on the analysis of the data presented in Section 5.2.1, the modification factors for different stone shapes are presented in Table 9.

Attachment E 2/5

Stone shape	Modificati
Angular	
Subrounded	
Rounded	

6.3.2 *Modification Factor for Packing Density*

It is shown in Section 5.2.2 that the allowable pressure for higher than for isolated stones. Unfortunately, within the capac device, no failure could be achieved with the packed stones, ar relation with isolated stones could be made. However, using presented in Part I of this series of papers (Wilson-Fahmy et a yield for packed stones ($R_o/H = 2$) could be compared with the p lated stones ($R_o/H = 4$) where R_o is the horizontal distance from brane point of tangency with the protrusion tip to the undeform of tangency with the soil subgrade. The analysis was performed and without protection. Based on the results, a modification fa which provides a conservative estimate of the effect of packing 4 can be rewritten after introducing a modification factor for pac

$$p'_{allow} = p_{allow}\left(\frac{1}{MF_S \times MF_{PD}}\right)$$

where MF_{PD} is the modification factor for packing density. The r sented in Table 10 can be used for isolated protrusions and pack

6.3.3 *Modification Factor for Soil Arching*

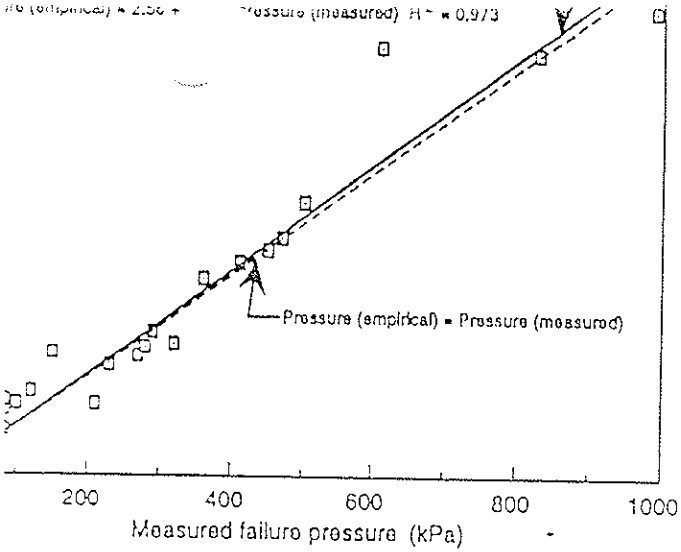
Equation 5 can be further modified as follows to include ing:

$$p'_{allow} = p_{allow}\left(\frac{1}{MF_S \times MF_{PD} \times MF_A}\right)$$

where MF_A is the modification factor for soil arching.

Table 10. Modification factors for packing density.

Protrusion arrangement	Modificati
Isolated protrusions	
Packed stones	



ed versus empirically predicted failure pressures using Equation 3 for all unched geotextiles evaluated with a 1.5 mm thick HDPE geomembrane. ion coefficient.

on Factors

ification factors is now sequentially applied to Equation 3 in order ure representing field conditions. The modified pressure will be re-

n Factor for the Protrusion Shape

shown that the failure pressure depends on the protrusion shape. ve the highest failure pressure followed by subrounded stones. The ure is associated with angular stones and is approximately equal to of truncated cones. In order to account for the effect of stone shape, or is introduced into Equation 3 as follows:

$$p'_{allow} = p_{allow}\left(\frac{1}{MF_S}\right) \tag{4}$$

modification factor for the protrusion shape. Hereafter, p'_{allow} refers modified value of p_{allow} as is illustrated in Figure 6.
ysis of the data presented in Section 5.2.1, the modification factors hapes are presented in Table 9.

Attachment E 3/5

Stone shape	Modification factor, MF_S
Angular	1.00
Subrounded	0.50
Rounded	0.25

6.3.2 *Modification Factor for Packing Density*

It is shown in Section 5.2.2 that the allowable pressure for packed stones is much higher than for isolated stones. Unfortunately, within the capacity of the experimental device, no failure could be achieved with the packed stones, and hence, no direct correlation with isolated stones could be made. However, using the theoretical analysis presented in Part I of this series of papers (Wilson-Fahmy et al. 1996), the pressure at yield for packed stones ($R_o/H = 2$) could be compared with the pressure at yield for isolated stones ($R_o/H = 4$) where R_o is the horizontal distance from a undeformed geomembrane point of tangency with the protrusion tip to the undeformed geomembrane point of tangency with the soil subgrade. The analysis was performed for geomembranes with and without protection. Based on the results, a modification factor of 0.5 is suggested which provides a conservative estimate of the effect of packing density. Thus, Equation 4 can be rewritten after introducing a modification factor for packing density as follows:

$$p'_{allow} = p_{allow}\left(\frac{1}{MF_S \times MF_{PD}}\right) \tag{5}$$

where MF_{PD} is the modification factor for packing density. The modification values presented in Table 10 can be used for isolated protrusions and packed stone arrangements.

6.3.3 *Modification Factor for Soil Arching*

Equation 5 can be further modified as follows to include the effect of soil arching:

$$p'_{allow} = p_{allow}\left(\frac{1}{MF_S \times MF_{PD} \times MF_A}\right) \tag{6}$$

where MF_A is the modification factor for soil arching.

Table 10. Modification factors for packing density.

Protrusion arrangement	Modification factor, MF_{PD}
Isolated protrusions	1.00
Packed stones	0.50

pressure by a factor of six in comparison with hydrostatic loading. This corresp[illegible]s to a [illegible]lication factor of 0.17. It may be noted, however, that the effect of so[illegible]ing o[illegible] pressure at yield may not be as great as the effect on the failure pres[illegible]. The deformations of the geomembrane up to yield may not be large enough to mobilize the soil arching effect; therefore, caution must be exercised when using the data in Table 7 for design. It is recommended that the values in Table 11 be used when soil arching is anticipated.

6.4 Partial Factors of Safety

After introducing the various modification factors (all of which are 1.0 or less), several partial factors of safety should be applied in order to determine the allowable pressure on the geomembrane. The partial factors of safety are equal to 1.0 or greater. Two factors are considered below, a partial factor of safety for long term creep and a partial factor of safety to account for long term chemical/biological degradation of the materials involved.

6.4.1 *Partial Factor of Safety for Creep*

A partial factor of safety for creep is incorporated into Equation 6, and the allowable pressure is now calculated as follows:

$$p'_{allow} = p_{allow}\left(\frac{1}{MF_S \times MF_{PD} \times MF_A}\right)\left(\frac{1}{FS_{CR}}\right) \qquad (7)$$

where FS_{CR} is the partial factor of safety for creep. Based on the creep data presented in Table 8, the recommended partial factors of safety for creep are given in Table 12.

Table 11. Modification factors for soil arching.

Soil arching effect	Modification factor, MF_A
None	1.00
Moderate	0.75
Maximum	0.50

Table 12. Partial factors of safety for creep.

Geotextile mass per unit area (g/m²)	Partial factors of safety for creep			
	Protrusion height (mm)			
	38	25	12	6
No geotextile	N/R	N/R	N/R	>>1.5
270	N/R	N/R	>1.5	1.5
550	N/R	1.5	1.3	1.2
1100	1.3	1.2	1.1	1.0
>1100	~1.2	~1.1	~1.0	1.0

Note: N/R = not recommended.

Attachment E 4/5

low in comparison with the factors of safety found in the literatu[illegible] tiles in tension. This may be explained by f[illegible]t that, in the pu[illegible] membrane and its protection material will c[illegible]rm more to the s[illegible] and hence the unsupported length will decrease with time. It was [illegible] series of papers (Wilson-Fahmy et al. 1996) that for the same app[illegible] mum stress mobilized at the protrusion tip will decrease as the [illegible] creases. Thus, a decrease in stress in the geomembrane and its [illegible] expected with time. Accordingly, a lower factor of safety for cr[illegible] puncture mode in comparison to the stress mode in which the n[illegible] a constant tensile stress.

6.4.2 *Partial Factor of Safety for Chemical/Biological Degraa*

The partial factor of safety against chemical/biological deg[illegible] cluded in Equation 7 as follows:

$$p'_{allow} = p_{allow}\left(\frac{1}{MF_S \times MF_{PD} \times MF_A}\right)\left(\frac{1}{FS_{CR} \times}\right.$$

Although not assessed in this study, the value of FS_{CBD} is felt to [illegible] 2.0 with an average value of 1.5; see Koerner (1994) for discuss[illegible]

6.5 Global Factor of Safety

After determining an allowable pressure that is suitably adj[illegible] factors and partial factors of safety (Equation 8), a global factor [illegible] by dividing the allowable pressure by the required pressure as f[illegible]

$$FS = \frac{p'_{allow}}{p_{reqd}}$$

where: p_{reqd} = maximum stress required on the geomembrane; a[illegible] factor of safety for uncertainties related to site specific conditio[illegible]

It is felt that the global factor of safety should never be less t[illegible] may be used depending on site specific conditions. For example [illegible] should be used in situations where large isolated stones are free[illegible] the subgrade. Also, a tightly installed geomembrane may also [illegible] factor of safety compared to a geomembrane installed with slac[illegible] dification has been included for in situ temperatures different f[illegible] temperature, i.e. ≈ 20°C. More definitive recommendations f[illegible] safety are made in Part III of this series of papers (Koerner et a[illegible]

5/10/95 ③ 30/10/95

...ctor of six in comparison with hydrostatic loading. This corresponds to factor of 0.17 ... be noted, however, that the effect of soil arching e at yield may ... as great as the effect on the failure pressure. The of the geomembrane up to yield may not be large enough to mobilize the fect; therefore, caution must be exercised when using the data in Table : is recommended that the values in Table 11 be used when soil arching

Factors of Safety

icing the various modification factors (all of which are 1.0 or less), sever- s of safety should be applied in order to determine the allowable pressure ibrane. The partial factors of safety are equal to 1.0 or greater. Two fac- ered below, a partial factor of safety for long term creep and a partial fac- account for long term chemical/biological degradation of the materials

Factor of Safety for Creep

or of safety for creep is incorporated into Equation 6, and the allowable calculated as follows:

$$p'_{allow} = p_{allow}\left(\frac{1}{MF_S \times MF_{PD} \times MF_A}\right)\left(\frac{1}{FS_{CR}}\right) \quad (7)$$

he partial factor of safety for creep. Based on the creep data presented recommended partial factors of safety for creep are given in Table 12.

lification factors for soil arching.

Soil arching effect	Modification factor, MF_A
None	1.00
Moderate	0.75
Maximum	0.50

ial factors of safety for creep.

Partial factors of safety for creep			
Protrusion height (mm)			
38	25	12	6
N/R	N/R	N/R	>>1.5
N/R	N/R	>1.5	1.5
N/R	1.5	1.3	1.2
1.3	1.2	1.1	1.0
~1.2	~1.1	~1.0	1.0

ecommended.

Attachment E5/5

...ow in comparison with the factors of safety found in the literature for creep of geotex- s in tension. This may be explained by the fact that, in the puncture ... the geo- membrane and its protection material will conform more to the subgrade ... they creep and hence the unsupported length will decrease with time. It was shown in Part I of this series of papers (Wilson-Fahmy et al. 1996) that for the same applied pressure the maximum stress mobilized at the protrusion tip will decrease as the unsupported length decreases. Thus, a decrease in stress in the geomembrane and its protection material is expected with time. Accordingly, a lower factor of safety for creep is required for the puncture mode in comparison to the stress mode in which the material is subjected to a constant tensile stress.

6.4.2 *Partial Factor of Safety for Chemical/Biological Degradation*

The partial factor of safety against chemical/biological degradation, FS_{CBD}, is included in Equation 7 as follows:

$$p'_{allow} = p_{allow}\left(\frac{1}{MF_S \times MF_{PD} \times MF_A}\right)\left(\frac{1}{FS_{CR} \times FS_{CBD}}\right) \quad (8)$$

Although not assessed in this study, the value of FS_{CBD} is felt to range between 1.0 and 2.0 with an average value of 1.5; see Koerner (1994) for discussion and details.

6.5 Global Factor of Safety

After determining an allowable pressure that is suitably adjusted for modification factors and partial factors of safety (Equation 8), a global factor of safety is determined by dividing the allowable pressure by the required pressure as follows:

$$FS = \frac{p'_{allow}}{p_{reqd}} \quad (9)$$

where: p_{reqd} = maximum stress required on the geomembrane; and FS = desired global factor of safety for uncertainties related to site specific conditions.

It is felt that the global factor of safety should never be less than 3.0. Higher values may be used depending on site specific conditions. For example, a high factor of safety should be used in situations where large isolated stones are frequently encountered on the subgrade. Also, a tightly installed geomembrane may also require a larger global factor of safety compared to a geomembrane installed with slack. Furthermore, no modification has been included for in situ temperatures different from the test procedure temperature, i.e. ≈ 20°C. More definitive recommendations for the global factor of safety are made in Part III of this series of papers (Koerner et al. 1996).

Calculation Package H
Sump Capacity

GeoSyntec Consultants

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: Basic Remediation Company

Project: BRC CAMU **Project/Proposal #:** SC0313 **Task #:** 01

Title of Computations: Sump Capacity

Computations By:

SIGNATURE DATE 11/3/06

Rebecca Flynn, Staff Engineer
PRINTED NAME AND TITLE

Assumptions and Procedures Checked By (Peer Reviewer):

SIGNATURE DATE 11/3/06

Gregory T. Corcoran, PE / Principal
PRINTED NAME AND TITLE

Computations Checked By:

SIGNATURE DATE 11/3/06

Gregory T. Corcoran, PE / Principal
PRINTED NAME AND TITLE

Computations Backchecked By (Originator):

SIGNATURE DATE 11/3/06

Rebecca Flynn, Staff Engineer
PRINTED NAME AND TITLE

Approved By (PM or Designate):

SIGNATURE DATE 11/3/06

Gregory T. Corcoran, PE / Principal
PRINTED NAME AND TITLE

Approval Notes:

Revisions: (Number and Initial All Revisions)

No.	Sheet	Date	By	Checked By	Approval

Written by: Rebecca B. Flynn Date: 08 /31 /06 (MM DD YY) Reviewed by: GTC Date: 11 / 3 /06 (MM DD YY)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 04

SUMP CAPACITY
BRC CAMU
HENDERSON, NEVADA

OBJECTIVE

The objective of this calculation is to evaluate if the sump and leachate aggregate have the capacity to hold the maximum average daily volume (evaluated by the HELP model in the drainage pipe sizing calculation) without exceeding the 12-inch head requirement.

SUMMARY OF ANALYSIS

The HELP model suggest that the maximum, average daily volume collected by the leachate collection system is 231 cubic feet. The capacity of the sump and a "pool" of leachate 1 ft deep within the leachate collection system is 453 ft^3. Therefore, the sump and adjacent drainage geocomposite capacity exceeds the estimated maximum average daily leachate volume from the drainage pipe.

SITE CONDITIONS

The proposed composite liner system will be comprised of the following components, from top to bottom:

- 2 ft of operations layer material;
- a drainage geocomposite;
- 60-mil (1.5 mm) HDPE geomembrane, textured on both sides;
- a geosynthetic clay liner (GCL); and
- prepared subgrade.

The proposed base grading plans are shown on in Figure 1. A berm will be placed around the cells and within the cells to contain and control runoff during construction and during the worst case scenario when the cell contains a small quantity of waste. A sump will be located at the low point of each cell. Each sump will be approximately 10 ft x 10ft x 2 ft deep. The grade of the lining system immediately adjacent to the sumps ranges from 2 to 3%.

The Hydrologic Evaluation of Landfill Performance (HELP) model was used to estimate the peak daily quantity of liquid expected to be generated in the drainage layer during or after a rainfall

Written by: Rebecca B. Flynn Date: 08 /31 /06 (MM DD YY) Reviewed by: BTC Date: 11 / 3 / 06 (MM DD YY)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 04

event. The HELP model is used to evaluate the worst case scenario which occurs *during the period where the cell contains a small quantity of waste*, such that any collected liquid is considered leachate, yet the majority of the cell is empty so the largest quantity of liquid will infiltrate through the operations layer to the drainage layer. The output and assumptions of the HELP analyses are presented in the pipe sizing calculation package. It is assumed that surface runoff will be controlled, therefore this sump capacity calculation package compares the capacity of the sump to the quantity of leachate collected from the drainage layer.

ANALYSIS

Each sump will be approximately 10 ft x 10ft x 2 ft deep (see attachment). The side slopes of the sumps are proposed to be inclined at 2:1 (horizontal:vertical), although the calculation conservatively assumes side slopes of 1:1. The porosity (n) of the drainage aggregate is assumed to be 0.4 (HELP value for gravel). Therefore, the capacity of each sump is:

V_{sump} = [volume of square + volume of triangle around circumference]*porosity
V_{sump} = [10*10*2+(2*2)/2*40]*0.4 = 112 ft^3

Additional storage capacity within the drainage aggregate within the upgradient drainage collection layer is available provided that the leachate level does not exceed 12 inches over the liner (in order to remain compliant with 40 CFR 264.301(c)(2)).

The HELP model runs performed for the pipe sizing calculation indicates the following maximum average daily volumes:

Sump 1	169 ft^3
Sump 2	231 ft^3
Sump 3	65 ft^3

As Sump 2 has the largest peak daily volume of the four sumps, the capacity of the drainage aggregate will be analyzed for this sump. The plan view of Sump 2 is presented in Attachment A. For Sump 2, the slope of the drainage aggregate is assumed to be 2%. Therefore, for a 12-inch height of leachate, the edge of the "pool" of water is located at:

distance from sump = 1 ft / 0.02 = 50 ft.

Written by: Rebecca B. Flynn Date: 08 /31 /06 (MM DD YY) Reviewed by: GC Date: 11/03/06 (MM DD YY)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 04

Based on the topography of Sump 2, the grading from Sump 2 varies from 1 to 2 percent from the sump (Figure 1). Therefore, the 2% slope assumption is conservative.

The limits of the "pool" of water is assumed to have a radius of 50 ft from the sump (i.e., constant 2% slope). Again, this assumption is conservative (see attachment). The area of the "pool" around the sump is approximately 1,963 ft^2 as shown in the attachment. The capacity of this volume of drainage geocomposite and operation layer is approximately 342 ft^3, based on a maximum leachate depth of 12 inches and considering the porosity of the geocomposite and operations layer. Adding the volume within the sump yields a total capacity of 453 ft^3 (112 + 342 ft^3). The geometry for the other sumps is similar to Sump 2, and can be considered adequate to handle the estimated maximum average daily leachate volume.

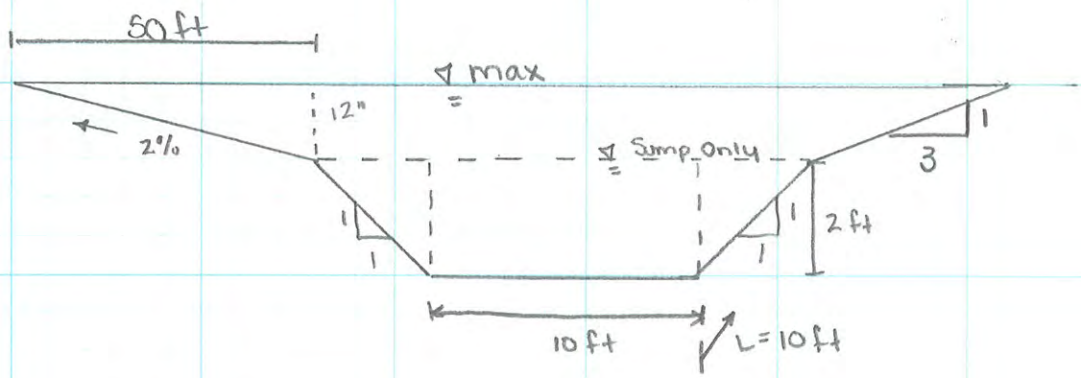
SUMMARY AND CONCLUSIONS

- The sump capacity by itself is 112 ft^3; and
- The capacity of the drainage aggregate sloping at 2% away from the sump without exceeding the 1 ft head requirement is approximately 342 ft^3.
- The capacity of the sump and drainage aggregate far exceeds the maximum average daily volume evaluated from the HELP model (pipe size calculations) without exceeding 12 inches of head on the liner.

Written by: _____ Date: ___/___/___ (DD/MM/YY) Reviewed by: BTC Date: 3/11/00 (DD/MM/YY)

Client: _____ Project: _____ Project/Proposal No.: _____ Task No: _____

Elevation - Sump 2



Capacity of sump only = $[10' \times 10' \times 2' + \frac{2' \times 2'}{2} \times 40'] \times 0.4$

↑ Circum. ↑ porosity

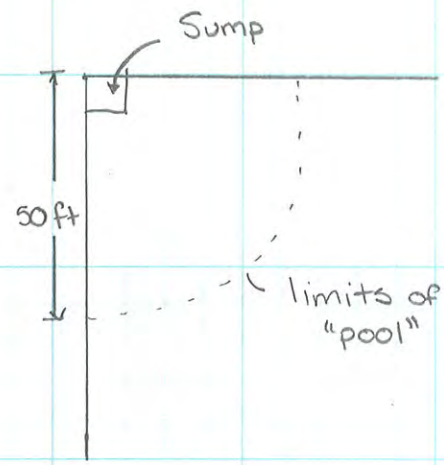
Sump Capacity: 112 ft^3

→ Since average daily flow is 231 ft^3 (HELP model) exceeds capacity, look at influence of overflow (into geocomposite and operations layer) capacity. Max head on liner = 12". See next page.

Written by: _____ Date: ___/___/___ (DD MM YY) Reviewed by: GTC Date: 03/11/06 (DD MM YY)

Client: _____ Project: _____ Project/Proposal No.: _____ Task No: _____

PLAN SUMP 2



To be conservative, and for ease of calculation, assume radius of +1 ft contour to be 50 ft from sump. Also, add volume directly above sump.

The area of the above "pool" is:

$$A = (50\,ft)^2 \pi \; 90/360 = 1963\,ft^2$$

The average depth of the leachate is 6" (mid-point of triangle shown on page 1). Therefore, the volume is:

$$V = (1963\,ft^2)\left[\underbrace{\underset{\text{Thickness}}{(0.2/12)}\;\underset{\text{Porosity}}{(0.8)}}_{\text{Geocomposite}} + \underbrace{\underset{\text{leachate level}}{\left(\frac{6-0.2}{12}\right)}\;\underset{\text{Porosity}}{(0.3)}}_{\text{Operations layer}}\right]$$

$V = 311\ ft^3$

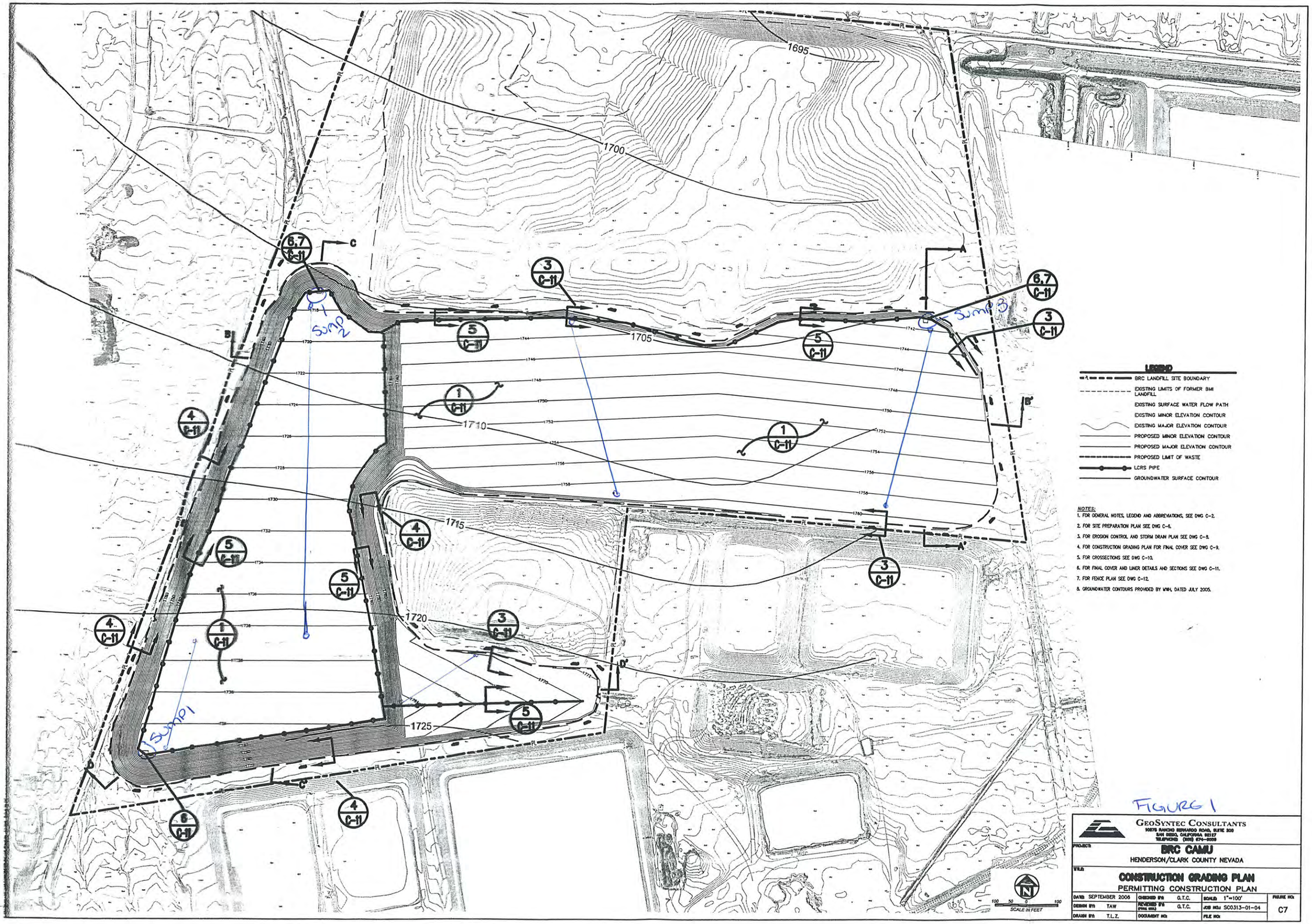
The capacity of the geocomposite and operations layer directly above the sump is:

$$V_S = (\text{length})(\text{width})\left[\left(\frac{0.2}{12}\right)(0.8) + \left(\frac{12-0.2}{12}\right)(0.3)\right]$$

$V_S = 30.8\,ft^3$

Total Volume of voids for 1 ft "pool" of leachate is:

$\underline{342\,ft^3}$


1695
1700
1705
1710
1715
1720
1725
6,7 C-11
3 C-11
5 C-11
1 C-11
4 C-11
6 C-11
Sump 1
Sump 2
Sump 3
A
A'
B
B'
C
C'
D
D'
LEGEND
BRC LANDFILL SITE BOUNDARY
EXISTING LIMITS OF FORMER BMI LANDFILL
EXISTING SURFACE WATER FLOW PATH
EXISTING MINOR ELEVATION CONTOUR
EXISTING MAJOR ELEVATION CONTOUR
PROPOSED MINOR ELEVATION CONTOUR
PROPOSED MAJOR ELEVATION CONTOUR
PROPOSED LIMIT OF WASTE
LCRS PIPE
GROUNDWATER SURFACE CONTOUR
NOTES:
1. FOR GENERAL NOTES, LEGEND AND ABBREVIATIONS, SEE DWG C-2.
2. FOR SITE PREPARATION PLAN SEE DWG C-6.
3. FOR EROSION CONTROL AND STORM DRAIN PLAN SEE DWG C-8.
4. FOR CONSTRUCTION GRADING PLAN FOR FINAL COVER SEE DWG C-9.
5. FOR CROSSECTIONS SEE DWG C-10.
6. FOR FINAL COVER AND LINER DETAILS AND SECTIONS SEE DWG C-11.
7. FOR FENCE PLAN SEE DWG C-12.
8. GROUNDWATER CONTOURS PROVIDED BY WHH, DATED JULY 2005.
FIGURE 1
GEOSYNTEC CONSULTANTS
10875 RANCHO BERNARDO ROAD, SUITE 200
SAN DIEGO, CALIFORNIA 92127
TELEPHONE: (858) 674-2020
PROJECT:
BRC CAMU
HENDERSON/CLARK COUNTY NEVADA
TITLE:
CONSTRUCTION GRADING PLAN
PERMITTING CONSTRUCTION PLAN
DATE: SEPTEMBER 2006
CHECKED BY: G.T.C.
SCALE: 1"=100'
DESIGN BY: TAW
REVIEWED BY (FINAL ONLY): G.T.C.
JOB NO.: SC0313-01-04
DRAWN BY: T.L.Z.
DOCUMENT NO.:
FILE NO.:
FIGURE NO.: C7
SCALE IN FEET
100 50 0 100

Calculation Package I
Comparison of Flow Between CCL and GCL

GeoSyntec Consultants

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: Parsons **Project:** BRC CAMU **Project/Proposal #:** HL0389 **Task #:** 02

Title of Computations: Comparison of Flow Through Prescriptive CCL and Alternative GCL

Computations By: SIGNATURE — 13 March 2000 DATE

Geoff L. Smith / Staff Engineer
PRINTED NAME AND TITLE

Assumptions and Procedures Checked By (Peer Reviewer): SIGNATURE — 7/3/00 DATE

GREGORY T CORCORAN/PROJ. ENG.
PRINTED NAME AND TITLE

Computations Checked By: SIGNATURE — 26 April 2000 DATE

Matt Darr Staff Eng.
PRINTED NAME AND TITLE

Computations Backchecked By (Originator): SIGNATURE — 3 May 2000 DATE

Geoff L. Smith / Staff Engineer
PRINTED NAME AND TITLE

Approved By (PM or Designate): SIGNATURE — 10 July 2000 DATE

Bradford H. Cody / Project Manager
PRINTED NAME AND TITLE

Approval Notes:

Revisions: (Number and Initial All Revisions)

No.	Sheet	Date	By	Checked By	Approval

Written by: Geoff L. Smith Date: 01/25/00 (MM DD YY) Reviewed by: GTC Date: 07/03/00 (MM DD YY)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 02

COMPARISON OF FLOW THROUGH THE PRESCRIPTIVE COMPOSITE LINER AND A PROPOSED ALTERNATIVE COMPOSITE LINER

OBJECTIVE

Evaluate an alternative composite lining system, consisting of a 60-mil HDPE geomembrane overlying a geosynthetic clay liner (GCL), to demonstrate equivalent or better fluid migration characteristics when compared with the prescriptive composite liner system, consisting of a 60-mil HDPE geomembrane overlying a compacted clay liner (CCL) having a saturated hydraulic conductivity less than 1×10^{-7} cm/s. The method outlined by Giroud, et al. (1997) will be employed to compare the fluid migration characteristics.

SUMMARY OF ANALYSIS

The calculations suggest that the flow rate through the prescriptive composite liner system is approximately 1.64 times greater than the flow rate through the alternative composite liner system. The fluid head on the geomembrane is assumed to be 12 in (305 mm), the maximum allowed as required in regulations 40 CFR §258.40(2).

In terms of limiting flow through the composite liner system, the alternative liner system performs better than the prescriptive liner system.

ANALYSIS

Liquid migration through a composite liner occurs essentially through defects of the geomembrane. According to Giroud, et al. (1997) (see Attachment 1), the rate of liquid migration through a defect in the geomembrane component of a composite liner is given by the following semi-empirical equation:

$$Q = 0.21[1+0.1(h/t)^{0.95}]\, a^{0.1}\ h^{0.9}\ k^{0.74} \qquad \text{Eq. (1)}$$

where:

Q = flow rate through one geomembrane defect, m^3/s
h = head of liquid above the geomembrane, m
t = thickness of soil component of composite liner, m
a = defect area, m^2
k = hydraulic conductivity of the soil component of composite liner, m/s

Using Eq. (1) the ratio between the rate of leachate flow through the prescriptive composite liner system and the alternative composite liner system can be compared as follows (Attachment 1):

$$\frac{q_{compCCL}}{q_{compGCL}} = \left(\frac{k_{CCL}}{k_{GCL}}\right)^{0.74} \frac{1+0.1(h/t_{CCL})^{0.95}}{1+0.1(h/t_{GCL})^{0.95}} \qquad \text{Eq. (2)}$$

where:

$q_{comp\ CCL}$ = unit rate of flow through a composite liner where soil component is a CCL
$q_{comp\ GCL}$ = unit rate of flow through a composite liner where soil component is a GCL

and other terms have previously been defined for Eq. (1).

EVALUATE FLOW THROUGH COMPOSITE LINER SYSTEMS

The values for the parameters in Eq. (2) are discussed below:

Properties of Compacted Clay Liner (CCL):

- $k_{CCL} = 1 \times 10^{-7}$ cm/s (the maximum hydraulic conductivity for the low-permeability soil component of the composite liner prescribed by 40 CFR §258.40(2))
- t_{CCL} = 2 ft (0.6 m) (minimum thickness prescribed by 40 CFR §258.40(2))

Properties of Geosynthetic Clay Liner (GCL):

- $k_{GCL} = 5 \times 10^{-9}$ cm/s (maximum hydraulic conductivity reported in manufacturer's documentation and typically allowed in technical specifications for GCLs)
- t_{GCL} = 0.20 in. (5 mm) (minimum thickness reported in manufacturer's documentation and typically allowed in technical specifications for GCLs)

Head Above Liner, (h):

40 CFR §258.40(2) states that the maximum allowable liquid head on a composite liner is less than 12 in. (305 mm).

Three cases comparing the flow rates through the prescriptive and alternative composite liner systems are evaluated using Eq. (2). The calculation is presented below:

Calculation:

Plugging the above values for Case 1, Eq. (2) becomes as follows:

$$q_{comp\ CCL} / q_{comp\ GCL} = (1 \times 10^{-7} / 5 \times 10^{-9})^{0.74} [(1+0.1(12.0/24.0)^{0.95}) / (1+0.1(12.0/0.20)^{0.95}] = 1.64$$

Thus, for a liquid head of 12.0 in. (305 mm) on the geomembrane, the flow through the prescriptive composite liner system that includes a CCL is 1.64 times greater than the flow through the alternative liner system that includes a GCL instead of a CCL.

SUMMARY AND CONCLUSIONS

- Using the method outlined by Giroud, et al. (1997), the flow rate through the prescriptive liner system (with CCL) was evaluated to be greater than the flow rate through the proposed alternative liner system (with GCL instead of CCL).
- The amount of flow through the prescriptive liner system was evaluated to be 1.64 times greater than flow through the alternative liner system for a leachate head of 12 in. (305 mm).
- In terms of limiting fluid flow through the composite liner system, the alternative liner system performs better than the prescriptive liner system.

REFERENCES

Giroud, J.P., Badu-Tweneboah, K., and Soderman, K.L. (1997), "Comparison of Leachate Flow Through Compacted Clay Liners and Geosynthetic Clay Liners in Landfill Liner Systems," Geosynthetic International, Vol. 4, No. 3-4, pp. 391-431.
(Attachment 1)

ATTACHMENT A
P 1/2

4 FLOW THROUGH COMPOSITE LINERS

4.1 Introduction

As indicated in Section 2.8, GCLs used in landfills are always used as the low-permeability soil component of composite liners. In other words, GCLs used in landfills are always associated with a geomembrane. The cases discussed in Section 3 were only relevant to the extreme design scenario where the geomembrane is ignored, and to other containment structures where GCLs may be used without a geomembrane.

In Section 4, the geomembrane is not ignored and the effectiveness of composite liners constructed with CCLs and GCLs is compared.

4.2 Rate of Leachate Migration Through Composite Liners With CCL and GCL

Development of Equation. As indicated by Giroud and Bonaparte (1989), liquid migration through a composite liner occurs essentially through defects of the geomembrane. According to Giroud (1997), the rate of liquid migration through a defect in the geomembrane component of a composite liner is given by the following semi-empirical equation:

$$\boxed{Q = 0.21\,[1 + 0.1(h/t)^{0.95}]\,a^{0.1}\,h^{0.9}\,k^{0.74}} \tag{51}$$

where: Q = flow rate through one geomembrane defect; h = head of liquid above the geomembrane; t = thickness of the soil component of the composite liner; a = defect area; and k = hydraulic conductivity of the soil component of the composite liner. It is important to note that Equation 51 can only be used with the following units: a (m^2), h (m), t (m), k (m/s).

As discussed in Sections 2.5 and 2.6, there are cases where it is prescribed by regulations, or simply envisioned by design engineers, to place a GCL on a layer of soil with a low hydraulic conductivity such as 1×10^{-8} or 1×10^{-7} m/s. An important conclusion from Section 3, is that, if a GCL is placed on a soil layer (even a soil layer with low permeability), the soil layer has no influence on leachate advective flow and only the GCL should be considered in leachate flow calculations. The same conclusion applies to the soil component of a composite liner. Accordingly, if, in a composite liner, a GCL is placed on a layer of low-permeability soil, only the GCL will be considered in Equation 51.

Using Equation 51, the ratio between the rate of leachate flow through a composite liner with a CCL and a composite liner with a GCL is as follows:

$$\frac{q_{comp\,CCL}}{q_{comp\,GCL}} = \frac{0.21\,N\,[1 + 0.1(h/t_{CCL})^{0.95}]\,a^{0.1}\,h^{0.9}\,k_{CCL}^{0.74}}{0.21\,N\,[1 + 0.1(h/t_{GCL})^{0.95}]\,a^{0.1}\,h^{0.9}\,k_{GCL}^{0.74}} \tag{52}$$

where: $q_{comp\,CCL}$ = unit rate of flow through a composite liner where the soil component is a CCL; $q_{comp\,GCL}$ = unit rate of flow through a composite liner where the soil component is a GCL; t_{CCL} = thickness of the CCL in the composite liner; t_{GCL} = thickness of the GCL

ATTACHMENT A
P 2/2 MW

in the composite liner; and N = number of geomembrane defects per unit area. After simplification, Equation 52 becomes:

$$\frac{q_{comp\ CCL}}{q_{comp\ GCL}} = \left(\frac{k_{CCL}}{k_{GCL}}\right)^{0.74} \frac{1 + 0.1(h/t_{CCL})^{0.95}}{1 + 0.1(h/t_{GCL})^{0.95}} \tag{53}$$

Discussion. It appears that the leachate flow rate ratio expressed by Equation 53 does not depend on the number and the size of defects. Numerical values of $q_{comp\ CCL}/q_{comp\ GCL}$ calculated using Equation 53 are presented in Table 7. It appears that, for leachate heads typically encountered in landfills (i.e. heads smaller than 0.3 m, and generally smaller than 0.1 m), the calculated advective flow control performance of a composite liner which consists of a geomembrane on a GCL is significantly better than the calculated advective flow control performance of the standard composite liner which consists of a geomembrane on the standard CCL (i.e. a CCL with a thickness of 0.6 m and a hydraulic conductivity of 1×10^{-9} m/s). Table 7 also shows that a composite liner with a GCL outperforms the standard composite liner for leachate heads up to approximately 1 to 7 m depending on the GCL hydraulic conductivity; such large heads should be a very rare occurrence in a landfill since they would correspond to a major malfunction of the leachate collection and removal system.

Table 7. Ratio between rates of advective flow through a composite liner including a CCL and a composite liner including a GCL, $q_{comp\ CCL}/q_{comp\ GCL}$.

GCL characteristics: Thickness, t_{GCL} (mm) Hydraulic conductivity, k_{GCL} (m/s)			5 5×10^{-12}	7 1×10^{-11}	9 5×10^{-11}
	(m)	(mm)	$q_{comp\ CCL}/q_{comp\ GCL}$	$q_{comp\ CCL}/q_{comp\ GCL}$	$q_{comp\ CCL}/q_{comp\ GCL}$
Leachate head on top of the liner, h	0	0	50.44	30.20	9.18
	0.01	10	42.36	26.54	8.28
	0.05	50	26.92	18.50	6.14
	0.1	100	18.87	13.66	4.71
	0.3	300	9.01	6.98	2.54
	0.6	600	5.31	4.23	1.58
	1.0		3.59	2.89	1.09
	3.0		1.65	1.35	0.52
	5.0		1.23	1.01	0.39
	7.0		1.04	0.85	0.33
	10		0.90	0.74	0.28
	∞		0.53	0.44	0.17

Notes: The tabulated values of the advective flow rate ratio were calculated using Equation 53 with the following CCL characteristics: thickness, t_{CCL} = 0.6 m; and hydraulic conductivity, $k_{CCL} = 1 \times 10^{-9}$ m/s. (This is the standard CCL defined in Section 2.5.) The characteristics of the GCL are from Table 2.

Calculation Package J
Tension Due to Wind Uplift

GeoSyntec Consultants

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: Parsons **Project:** BRC CAMU **Project/Proposal #:** HL0389 **Task #:** 02

Title of Computations: Geotextile Tension due to Wind Uplift

Computations By:
SIGNATURE — 28 June 2000 DATE
Geoff L. Smith / Staff Engineer
PRINTED NAME AND TITLE

Assumptions and Procedures Checked By (Peer Reviewer):
SIGNATURE — 7/3/00 DATE
GREGORY T CORCORAN / PROJ. ENG.
PRINTED NAME AND TITLE

Computations Checked By:
SIGNATURE — 7/3/00 DATE
GREGORY T. CORCORAN / PROJ. ENG.
PRINTED NAME AND TITLE

Computations Backchecked By (Originator):
SIGNATURE — 28 June 2000 DATE
Geoff L. Smith / Staff Engineer
PRINTED NAME AND TITLE

Approved By (PM or Designate):
SIGNATURE — 10 July 2000 DATE
Bradford H. Cook / Project Manager
PRINTED NAME AND TITLE

Approval Notes:

Revisions: (Number and Initial All Revisions)

No.	Sheet	Date	By	Checked By	Approval

Written by: Geoff L. Smith GN Date: 00 / 01 / 26 (YY MM DD) Reviewed by: GTC Date: 00 / 07 / 03 (YY MM DD)

Client: Parsons Project: BRC Landfill Project/Proposal No.: HL0389 Task No.: 01

GEOTEXTILE TENSION DUE TO WIND UPLIFT
BRC LANDFILL
HENDERSON, NEVADA

OBJECTIVE

Evaluate tension in a woven geotextile due to wind uplift. Use method outlined by Giroud, et al (1995). Tension generated by wind uplift will be compared to the anchor trench capacity and the ultimate strength of the woven geotextile.

SITE CONDITIONS

The side slope liner system considered in the wind uplift calculation consists (from top to bottom) of:

- woven geotextile U.V. protection layer
- geocomposite;
- 60-mil HDPE geomembrane
- GCL

The capacity of the anchor trench is determined in a separate calculation package.

ANALYSIS

The analysis will follow the method outlined by Giroud, et al, in "Uplift of Geomembrane by Wind" (Attachment A). Giroud et al offer the following equation for estimating the effective suction on a geomembrane (Attachment A):

$$S_E = 0.050\lambda V^2 e^{-[1.252E-4]z} - 9.81 M_{GM} \qquad \text{(Equation 1)}$$

where: S_E = effective suction (P_a)
λ = suction factor (dimensionless)
V = wind velocity (km/h)
z = altitude above sea level (m)
M_{GM} = mass per unit area of geomembrane (kg/m^2)

Written by: Geoff L. Smith Date: 00 / 01 / 26 (YY MM DD) Reviewed by: GTC Date: 00 / 07 / 03 (YY MM DD)

Client: Parsons Project: BRC Landfill Project/Proposal No.: HL0389 Task No.: 01

Evaluate Variables

λ Suction factor = 0.85 for the upper third of the slope being considered

V wind velocity = 90 mph = 145 km/h (the peak gust ever recorded after 1961, see Attachment B)

z altitude above sea level (m). A representative elevation for the base side slopes is approximately 1760 ft = 536 m

M_{GM} mass per unit area of geotextile (kg/m^2)
M_{GM} = 0.15 kg/m^2 (Attachment C)

Evaluate Suction

$S_E = (0.05)(0.85)(145)^2 e^{-(1.252E-4)536} - 9.81(0.15) = 834$ Pa

The height of the exposed slope (2.1H:1V) after the first phase of operations layer is placed is 20 vertical feet, so the total length of exposed slope, L, is $L/\sin\beta$ = 46.5 ft = 14.2 m

$S_E L = (821)(14.2) = 11.84$ kN/m

Evaluate Tension

The objective of this case is to evaluate tension in the geomembrane. Assuming the geomembrane stress-strain curve is linear, the tension can be expresses as:

$$T = J\varepsilon$$

where: T = tension
J = stiffness
ε = strain

To evaluate the tension in the geomembrane, the stiffness and stain must be evaluated.

Written by: Geoff L. Smith Date: 00 / 01 / 26 (YY MM DD) Reviewed by: GTC Date: 00 / 07 / 03 (YY MM DD)

Client: Parsons Project: BRC Landfill Project/Proposal No.: HL0389 Task No.: 01

Stiffness, J

For strains typically less than 10 percent, the stress-strain curve for woven geotextiles is approximately linear. Therefore, stiffness can be approximated as:

$$J = ET_{GT}$$

where: E = elastic modulus = 1535 kN/m (Koerner 1994)
T_{GM} = geotextile thickness, approximately 5 mils (Koerner 1994)

$$J = (1535 \text{ MPa})(0.000127 \text{ m}) = 195 \text{ kN/m}$$

Strain, ε

The strain on the woven geotextile induced by wind uplift loading can be estimated using the table by Giroud et al. (Attachment A).

$$\text{For } \frac{J}{S_E L} = \frac{195}{11.84} = 16.7$$

from Table 4, ε = 5.57%

The estimated strain in the woven geotextile is 5.57% percent, so the assumption of a linear stress-strain relationship is valid.

Evaluate tension

$$\mathbf{T} = 195\frac{5.57\%}{100} = \mathbf{10.9\ \ kN/m}$$

GEOTEXTILE ALLOWABLE TENSION

Since the woven geotextile (for U.V. protection) will be subjected to wind uplift forces, the woven geotextile will be designed for tension.

The estimated tensile force imposed on the geomembrane due to wind uplift suction is 14.5 kN/m for a design wind speed of 90 mph (145 kph). To account for uncertainties in the woven geotextile ultimate strength and wind speed, a factor of safety of 1.5 will be employed.

Written by: Geoff L. Smith Date: 00 / 01 / 26 (YY MM DD) Reviewed by: GTC Date: 00 / 07 / 03 (YY MM DD)

Client: Parsons Project: BRC Landfill Project/Proposal No.: HL0389 Task No.: 01

Therefore, the required ultimate strength of the geotextile shall be greater than or equal to 16 kN/m (91 ppi).

CONCLUSIONS

Based on the results herein, the woven geotextile U.V. protection layer shall have a wide width ultimate tensile strength greater than or equal to 16 kN/m (91 ppi).

The capacity of the anchor trench is determined in a separate calculation package.

REFERENCES

Giroud, J.P., Pelte., Bathurst, R.J. (1995), "Uplift of Geomembranes by Wind," Geosynthetic International, Vol. 2, No. 6., pp. 897-952
Attachment A

Western Regional Climate Center, Summary of Las Vegas Climate
www.wrcc.dri.edu
Attachment B

$$T = J\varepsilon \tag{34}$$

where: T = geomembrane tension; J = geomembrane tensile stiffness; and ε = geomembrane strain. The case of geomembranes with a linear tension-strain curve will be further discussed in Section 3.5.

It is important to note that geomembranes that are not reinforced with a fabric, for example PVC and PE geomembranes, have tensile characteristics that are highly dependent on temperature. Extensive data on the influence of temperature on the tensile characteristics of HDPE geomembranes are provided by Giroud (1994). The influence of temperature will be further discussed in Section 3.6.

3.2.3 *Suction Due to Wind*

In the subsequent analysis, the suction applied by the wind is assumed to be uniform over the entire length L. In reality, the suction due to the wind is not uniformly distributed as shown in Figure 4. Therefore, the design engineer using the method presented in this paper must exercise judgment in selecting the value of the length L and the value of the ratio λ defined by Equation 13.

In accordance with the discussions presented in Sections 2.3 and 2.4, the suction that effectively uplifts the geomembrane is:

$$S_e = S - \mu_{GM}\, g \tag{35}$$

where S_e is the "effective suction".

Combining Equations 2, 13 and 35 gives:

$$S_e = \lambda \rho V^2/2 - \mu_{GM}\, g \tag{36}$$

Combining Equations 3 and 36 gives:

$$S_e = \lambda \rho_o (V^2/2) e^{-\rho_o g z/p_o} - \mu_{GM}\, g \tag{37}$$

Using the values of ρ_o and p_o given in Section 2.1 and $g = 9.81$ m/s^2, Equation 37 gives:

- At sea level:

$$S_e = 0.6465 \lambda V^2 - 9.81 \mu_{GM} \tag{38}$$

with S_e(Pa), V(m/s), μ_{GM}(kg/m^2)

$$S_e = 0.050 \lambda V^2 - 9.81 \mu_{GM} \tag{39}$$

with S_e(Pa), V(km/h), μ_{GM}(kg/m^2)

Attachment A 1/3

- At altitude z above sea level:

$$S_e = 0.6465\lambda V^2 e^{-(1.252\times10^{-4})z} - 9.81\mu_{GM} \quad (40)$$

with S_e(Pa), V(m/s), z(m), μ_{GM}(kg/m^2)

$$S_e = 0.050\lambda V^2 e^{-(1.252\times10^{-4})z} - 9.81\mu_{GM} \quad (41)$$

with S_e(Pa), V(km/h), z(m), μ_{GM}(kg/m^2)

3.3 Determination of Geomembrane Tension and Strain

According to Equation 36, the effective suction results from two components: a component due to the wind-generated suction, which is normal to the geomembrane; and a component due to the geomembrane mass per unit area, which is not normal to the geomembrane. The component due to the geomembrane mass per unit area is generally small compared to the component due to the wind-generated suction. Therefore, the effective suction is essentially normal to the geomembrane. Since the effective suction is taken as normal to the geomembrane and has been assumed to be uniformly distributed over the length L of geomembrane, and since the problem is considered to be two-dimensional (see Section 3.2.2), the cross section of the uplifted geomembrane has a circular shape (Figure 9). As a result, the resultant F of the applied effective suction is equal to the effective suction multiplied by the length of chord AB, i.e. L:

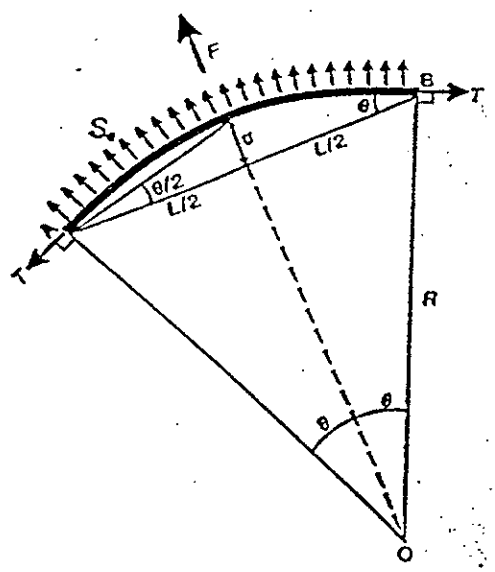


Figure 9. Schematic representation of uplifted geomembrane used for developing equations.

Attachment A
2/3

Table 4. Relationship between the strain of the geomembrane uplifted by the wind and the normalized tensile stiffness of the geomembrane for the case where the geomembrane has a linear tension-strain curve (Equation 57).

ε (%)	$\frac{J}{S_e L}$	ε (%)	$\frac{J}{S_e L}$	ε (%)	$\frac{J}{S_e L}$	ε (%)	$\frac{J}{S_e L}$
0	∞	3.6	31.347	7.2	11.607	10.8	6.607
0.1	6463.688	3.7	30.124	7.3	11.384	10.9	6.525
0.2	2288.342	3.8	28.981	7.4	11.168	11.0	6.443
0.3	1247.294	3.9	27.910	7.5	10.959	11.1	6.365
0.4	811.232	4.0	26.905	7.6	10.757	11.2	6.291
0.5	581.251	4.1	25.960	7.7	10.561	11.3	6.212
0.6	442.767	4.2	25.071	7.8	10.372	11.4	6.138
0.7	351.834	4.3	24.233	7.9	10.189	11.5	6.065
0.8	288.358	4.4	23.442	8.0	10.010	11.6	5.994
0.9	241.983	4.5	22.694	8.1	9.839	11.7	5.925
1.0	206.885	4.6	21.987	8.2	9.671	11.8	5.857
1.1	179.565	4.7	21.316	8.3	9.508	11.9	5.790
1.2	157.804	4.8	20.680	8.4	9.351	12.0	5.724
1.3	140.137	4.9	20.076	8.5	9.198	12.1	5.660
1.4	125.562	5.0	19.502	8.6	9.049	12.2	5.598
1.5	113.368	5.1	18.956	8.7	8.905	12.3	5.537
1.6	103.044	5.2	18.435	8.8	8.765	12.4	5.477
1.7	94.212	5.3	17.939	8.9	8.628	12.5	5.418
1.8	86.586	5.4	17.465	9.0	8.495	12.6	5.359
1.9	79.947	5.5	17.013	9.1	8.365	12.7	5.302
2.0	74.125	5.6	16.580	9.2	8.240	12.8	5.247
2.1	68.985	5.7	16.167	9.3	8.118	12.9	5.192
2.2	64.421	5.8	15.771	9.4	7.998	13.0	5.138
2.3	60.345	5.9	15.392	9.5	7.882	13.1	5.086
2.4	56.688	6.0	15.027	9.6	7.769	13.2	5.035
2.5	53.391	6.1	14.678	9.7	7.658	13.3	4.984
2.6	50.407	6.2	14.342	9.8	7.551	13.4	4.934
2.7	47.696	6.3	14.020	9.9	7.446	13.5	4.885
2.8	45.223	6.4	13.710	10.0	7.344	13.6	4.837
2.9	42.960	6.5	13.412	10.1	7.243	13.7	4.790
3.0	40.885	6.6	13.126	10.2	7.146	13.8	4.743
3.1	38.973	6.7	12.849	10.3	7.051	13.9	4.698
3.2	37.209	6.8	12.582	10.4	6.958	14.0	4.653
3.3	35.577	6.9	12.325	10.5	6.867	14.1	4.609
3.4	34.064	7.0	12.078	10.6	6.779	14.2	4.566
3.5	32.657	7.1	11.838	10.7	6.692	14.3	4.524

ATTACHMENT A
3/3

LAS VEGAS, NEVADA

NB GTC

NORMALS, MEANS, AND EXTREMES

LATITUDE: 36 Deg. 02 Min. N LONGITUDE: 115 Deg. 11 Min. W ELEVATION: FT. GRND 2286 BARO 2179 TIME ZONE: PACEFIC WBAN: 23169

	(a)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
TEMPERATURE (Deg. F)										
Normals										
-Daily Maximum		57.3	63.3	68.8	77.5	87.8	100.3	105.9	103.2	94.7
-Daily Minimum		33.6	38.8	43.8	50.7	60.2	69.4	76.2	74.2	66.2
-Monthly		45.5	51.1	56.3	64.1	74.0	84.9	91.1	88.7	80.5
Extremes										
-Record Highest	47	77	87	91	99	109	115	116	116	113
-Year		1975	1986	1966	1981	1951	1994	1985	1979	1950
-Record Lowest	47	8	16	23	31	40	48	60	56	46
-Year		1963	1989	1971	1975	1964	1993	1987	1968	1965
NORMAL DEGREE DAYS										
Heating (base 65 Deg. F)		605	389	292	143	14	0	0	0	0
Cooling (base 65 Deg. F)		0	0	22	116	293	597	809	735	465
% OF POSSIBLE SUNSHINE	46	77	81	83	87	88	93	88	88	91
MEAN SKY COVER(tenths)										
Sunrise - Sunset	47	4.9	4.8	4.6	3.9	3.5	2.1	2.8	2.5	2.1
MEAN NUMBER OF DAYS:										
Sunrise to Sunset										
-Clear	47	13.6	12.3	13.6	15.6	17.7	22.3	20.1	21.6	22.5
-Partly Cloudy	47	6.3	6.8	8.4	7.7	8.0	5.2	7.5	6.7	5.0
-Cloudy	47	11.1	9.1	9.0	6.8	5.3	2.5	3.4	2.8	2.5
Precipitation										
.01 inches or more	47	3.3	2.8	3.2	1.7	1.4	0.7	2.6	2.8	1.6
Snow, Ice Pellets, Hail										
1.0 inches or more	47	0.3	0.*	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thunderstorms	47	0.*	0.2	0.4	0.5	1.0	1.0	3.9	3.9	1.5
Heavy Fog Visibility										
1/4 mile or less	47	0.3	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.*
Temperature Deg. F										
-Maximum										
90 Deg. F and above	35	0.0	0.0	0.*	3.3	15.1	25.7	30.5	29.9	22.4
32 Deg. F and below	35	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
-Minimum										
32 Deg. F and below	35	11.9	4.2	1.1	0.1	0.0	0.0	0.0	0.0	0.0
0 Deg. F and below	35	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AV. STATION PRES. (mb)	23	942.4	940.7	937.3	935.9	933.9	933.6	934.9	935.5	936.0
RELATIVE HUMIDITY (%)										
Hour 04	35	56	51	46	35	32	25	28	34	33
Hour 10 (Local Time)	35	42	37	31	22	19	15	19	23	22
Hour 16	35	32	27	23	16	14	11	14	17	17
Hour 22	35	50	43	37	26	23	17	22	26	26
PRECIPITATION (in.)										
Water Equivalent										
-Normal		0.48	0.49	0.42	0.21	0.28	0.12	0.35	0.49	0.28
-Maximum Monthly	47	3.00	2.52	4.80	2.44	0.96	0.97	2.48	2.59	1.58
-Year		1995	1993	1992	1965	1969	1990	1984	1957	1963

Attachment B
1/2

Attachment B

-Minimum Monthly	47	T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-Year		1984	1977	1972	1962	1970	1982	1981	1980	1971
-Maximum in 24 hrs	47	1.09	1.30	1.27	0.97	0.83	0.97	1.36	2.59	1.07
-Year		1990	1993	1992	1965	1987	1990	1984	1957	1963
Snow, Ice Pellets, Hail										
-Maximum Monthly	47	16.7	1.4	0.1	T	0.0	0.0	0.0	T	0.0
-Year		1949	1990	1976	1970				1989	
-Maximum in 24 hrs	7 9	.0 6	.9 0	.1 T	0	.0 0	.0 0	.0 T	0	.0 T
-Year		1974	1979	1976	1970				1989	
WIND										
Mean Speed (mph)	47	7.4	8.5	10.2	11.0	11.1	11.1	10.3	9.6	9.0
Prevailing Direction through 1964		W	SW	SW	SW	SW	SW	SW	SW	SW
Fastest Mile										
-Direction(!!)	10	23	23	23	22	32	34	02	14	22
-Speed(mph) Avg. 44 mph		30	50	51	49	53	48	44	40	35
-Year		1987	1989	1989	1988	1991	1989	1994	1989	1989
Peak Gust										
-Direction(!!)	12	SW	NW	NW	W	NW	NE	NE	SE	SW
-Speed(mph) Avg 68	12	54	67	82	69	72	59	71	90	49
-Date		1987	1984	1994	1988	1991	1984	1994	1989	1989

(a) - Length of Record in Years, although individual months may be missing.
0.* or * - The value is between 0.0 and 0.05.
Normals - Based on the 1961 - 1990 record period.
Extremes - Dates are the most recent occurrence.
Wind Dir.- Numerals show tens of degrees clockwise from true north. "00" indicates calm.
Resultant Directions are given to whole degrees.

90 mph

Attachment B
2/2

GEOTEXTILES

Product Name (Structure [1]/ Polymer Type [2])	Mass Per Unit Area ASTM D 5261 g/m² (oz/yd²)	M288 Transportation-Related Applications: Filtration/Hydraulic Properties: Percent Open Area CWO-22125 %	Apparent Opening Size ASTM D 4751 mm (U.S. sieve)	Permittivity ASTM D 4491 sec⁻¹ Flow Rate (FH or CH) [3] l/min/m² (gal/min/ft²)	Physical Properties: Puncture ASTM D 4833 kN (lb)	Trapezoid Tearing Strength ASTM D 4533 kN (lb)	Grab Tensile/ Elongation ASTM D 4632 kN (lb)/%	M288 Survivability Class	M288 Applications [4]	Reinforcement Applications: Wide Width Tensile Properties ASTM D 4595 kN/m (lb/in.): Strength @ 5% Strain [5] MD	Strength @ 5% Strain [5] XD	Ultimate Strength % (T_{ult}) [5],[6] MD	Ultimate Strength % (T_{ult}) [5],[6] XD	Creep Limited Strength ASTM D 5262 [6], [7] kN/m (lb/ft)	T_{allow} GRI GT7 (in sand) [6]	Other Manufacturer's Suggested Applications [8]
Maccaferri Gabions Inc. (cont.)																
MacTex MXF2 (W-SF-PP)	95 (2.9)	<1 [A]	0.850 (20)	0.2/610 (15), FH	0.255 (58)	0.220x0.220 (50x50)	0.445x0.445 (100x100)/15x15	--	S/F	NA	NA	NA	NA	NA	NP	S/F
MacTex MXM10 (W-PP)	200 (5.9)	4 [A]	0.212 (70)	0.28/730 (18), CH	0.535 (120)	0.445x0.310 (100x70)	1.645x1.110 (370x250)/24x24	--	E, F, D	NA	NA	NA	NA	NA	NP	F
MacTex MXM20 (W-PP)	190 (5.7)	11 [A]	0.600 (30)	1.10/4480 (110), CH	0.510 (115)	0.510x0.335 (115x75)	1.845x0.980 (370x220)/25x15	--	E, F, D	NA	NA	NA	NA	NA	NP	E, F, D
MacTex MXW9 (W-SF-PP)	150 (4.5)	<1 [A]	0.425 (40)	0.07/240 (6), FH	0.445 (100)	0.330x0.330 (75x75)	0.890x0.890 (200x200)/15x15	--	SP, ST	8.7 (50)	9.6 (55)	21/9 (120)	21/7 (120)	NA	NP	ST, SP, R
MacTex MXW13 (W-SF-PP)	220 (6.5)	<1 [A]	0.212 (70)	0.06/200 (5), FH	0.555 (125)	0.530x0.530 (120x120)	1.400x1.400 (315x315)/15x15	--	SP, ST	8.7 (50)	10.5 (60)	30.6/10 (175)	30.6/8 (175)	NA	NP	ST, SP, R
Serrot International Inc./Fluid Systems																
Trevira 011/140	136 (4.0)	NA	0.3 (50)	2.01/102 (150)	0.222 (50)	0.178 (40)	0.489 (110)/60	NA	NA	NA	NA	NA	NA	NA	NA	SP, ST, F, A/O, D, E
Trevira 011/120	193 (5.7)	NA	0.21 (70)	1.74/88 (130)	0.356 (80)	0.267 (60)	0.711 (160)/60	NA	NA	NA	NA	NA	NA	NA	NA	SP, ST, F, A/O, D, E

Attachment C

Calculation Package K
Anchorage Capacity

GeoSyntec Consultants

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: Parsons **Project:** BRC CAMU **Project/Proposal #:** HL0389 **Task #:** 02

Title of Computations: Evaluation of Geosynthetic Anchorage Capacity

Computations By:
SIGNATURE — 28 June 2000 DATE
Geoff L. Smith / Staff Engineer
PRINTED NAME AND TITLE

Assumptions and Procedures Checked By (Peer Reviewer):
SIGNATURE — 7/3/00 DATE
GREGORY T CORCORAN / PROJ. ENG.
PRINTED NAME AND TITLE

Computations Checked By:
SIGNATURE — 7/3/00 DATE
GREGORY T. CORCORAN / PROJ. ENG.
PRINTED NAME AND TITLE

Computations Backchecked By (Originator):
SIGNATURE — 28 June 2000 DATE
Geoff L. Smith / Staff Engineer
PRINTED NAME AND TITLE

Approved By (PM or Designate):
SIGNATURE — 10 July 2000 DATE
Bradford H. Cooley / Project Manager
PRINTED NAME AND TITLE

Approval Notes:

Revisions: (Number and Initial All Revisions)

No.	Sheet	Date	By	Checked By	Approval

Written by: Geoff L. Smith Date: 01 / 27/ 00 (MM DD YY) Reviewed by: GTC Date: 07 / 03 / 00 (MM DD YY)

Client: Parsons Project: BRC CAMU Project No.: HL0389 Task No.: 01

EVALUATION OF LINER SYSTEM ANCHOR CAPACITY
BRC CAMU
HENDERSON, NEVADA

OBJECTIVE

The objective of this calculation package is to evaluate the tensile strength capacity for anchorage of the liner system at termination locations of the liner system with respect to wind uplift forces on the U.V. protective woven geotextile. One liner termination detail will be evaluated for the BRC CAMU.

SITE CONDITIONS

The proposed design for the BRC CAMU consists of a trench located a minimum of 3 ft from the crest of the slope. The width and depth of the trench is 2 ft and 2.5 ft, respectively. During the period of wind uplift exposure, there will be a 1 ft (0.3 m) high overburden placed above the anchor trench. The geosynthetic anchorage design is presented in Figure 1.

METHOD OF ANALYSIS

Koerner (1994) presents design equations developed from static equilibrium to evaluate the allowable geosynthetic tension from an anchor trench. The equation considers frictional resistance due to (i) overburden pressures, (ii) anchor trench side slopes, and (iii) base of the anchor trench. The proposed design equation for determination of the allowable geomembrane tension from an anchor trench is:

$$T_{allow} = F_U + F_L + F_{AT\text{-}SIDE1} + F_{AT\text{-}SIDE2} + F_{AT\text{-}BASE1} + F_{AT\text{-}BASE2} \quad (1)$$

Where: T_{allow} = Allowable tensile force in the geotextile;

F_U = Friction force above the geotextile;

F_L = Friction force below the geotextile;

$F_L = q\tan\delta(L_{RO})$

q = surcharge pressure due to soil overburden

Written by: Geoff L. Smith Date: 01 / 27/ 00 (MM DD YY) Reviewed by: GTC Date: 07/03/00 (MM DD YY)

Client: Parsons Project: BRC CAMU Project No.: HL0389 Task No.: 01

δ = minimum friction angle between liner system interfaces and the soil

L_{RO} = Runout length

$F_{AT\text{-}SIDE}$ = Friction force due to the side of the anchor trench;

$F_{AT\text{-}SIDE} = (\sigma_h)_{ave} \tan\delta(d_{AT})$

$(\sigma_h)_{ave}$ = average horizontal stress in the anchor trench = $K_o\sigma_v$

d_{AT} = depth of the anchor trench

K_o = coefficient of earth pressure at rest, = $(1\text{-}\sin\phi)$

σ_v = vertical overburden stress (at average depth of the anchor trench)

$F_{AT\text{-}BASE}$ = Friction force due to the base of the anchor trench;

$F_{AT\text{-}BASE} = q\tan\delta(L_{AT})$

L_{AT} = width of the anchor trench

ANALYSIS

Evaluating Variables

Since tension will develop in the U.V. protective layer (see the calculation package *Tension due to Wind Uplift*), frictional forces of the U.V. protective layer woven geotextile will be mobilized along the geosynthetic and soil interfaces on the side and base of the anchor trench. For the analysis presented herein:

- A friction angle of 8 degrees will be used to represent the friction angle between the geocomposite (non-woven geotextile side) and the woven geotextile. (Attachment 1 presents a typical friction angle between a non-woven geotextile and a *smooth* HDPE sheet as 8 degrees. The interface between a woven geotextile and the non-woven geotextile will be higher due to the slit film and raised surfaces of the woven geotextile. Therefore, it is conservative to assume a friction angle of 8 degrees);

- A friction angle of 26 degrees to represent the soil/ woven geotextile interface. (Attachment 1 presents typical efficiency values between woven and soil interfaces. The typical efficiency is on the order of 85 percent. The anchor trench soil compacted to 90 % modified proctor will have a friction angle on

Written by: Geoff L. Smith Date: 01 / 27/ 00 (MM DD YY) Reviewed by: _____ Date: ___/___/___ (MM DD YY)

Client: Parsons Project: BRC CAMU Project No.: HL0389 Task No.: 01

the order of 30 degrees - see final slope stability calculation package. Therefore, the interface friction angle is $\tan^{-1}(0.85*\tan(30))$=26 deg.).

For determination of the surcharge due to soil overburden, q, and the vertical and horizontal overburden stresses, σ_h and σ_v, a unit weight of overburden soil of 136 pcf was assumed (γ = 136 pcf). For evaluation of the effective horizontal overburden stress based on the coefficient of earth pressure at rest, a friction angle of 30° was assumed for the cover soil.

Analysis

From Equation (1):

$$T_{allow} = F_U + F_L + F_{AT\text{-}SIDE1} + F_{AT\text{-}SIDE2} + F_{AT\text{-}BASE1} + F_{AT\text{-}BASE2}$$

$$F_U = q\tan\delta(L_{RO}) = 1\text{ ft (136 pcf) tan 8°(2 ft)} = 38.2\text{ lb/ft}$$

$$F_L = q\tan\delta(L_{RO}) = 1\text{ ft (136 pcf) tan 26°(2 ft)} = 132.7\text{ lb/ft}$$

$$F_{AT\text{-}SIDE1} = (\sigma_h)_{ave}\tan\delta(d_{AT}) = Ko(\sigma_v)_{ave}\tan\delta(d_{AT}) = (1\text{-}\sin30^\circ)(2.25\text{ ft})(136\text{ pcf})\tan8^\circ(2.5\text{ ft}) = 53.8\text{ lb/ft}$$

$$F_{AT\text{-}SIDE2} = (\sigma_h)_{ave}\tan\delta(d_{AT}) = Ko(\sigma_v)_{ave}\tan\delta(d_{AT}) = (1\text{-}\sin30^\circ)(2.25\text{ ft})(136\text{ pcf})\tan26^\circ(2.5\text{ ft}) = 186\text{ lb/ft}$$

$$F_{AT\text{-}BASE1} = q\tan\delta(L_{AT}) = (3.5\text{ft})(136\text{ pcf})(\tan8^\circ)(2\text{ ft}) = 133.8\text{ lb/ft}$$

Written by: Geoff L. Smith Date: 01 / 27/ 00 (MM DD YY) Reviewed by: GTC Date: 01 / 03 / 00 (MM DD YY)

Client: Parsons Project: BRC CAMU Project No.: HL0389 Task No.: 01

$$F_{AT\text{-}BASE2} = q\tan\delta(L_{AT})$$
$$= (3.5\text{ft})(136\text{ pcf})(\tan 26^{\circ})(2\text{ ft})$$
$$= 464\text{ lb/ft}$$

$$T_{allow} = F_U + F_L + F_{AT\text{-}SIDE1} + F_{AT\text{-}SIDE2} + F_{AT\text{-}BASE1} + F_{AT\text{-}BASE2}$$
$$= 38.2 + 132.7 + 53.8 + 186 + 134 + 464$$
$$\mathbf{T_{allow} = 1{,}008\ lb/ft = 14.7\ kN/m}$$

CONCLUSIONS

The allowable tensile capacity of the anchorage system as calculated herein (as T_{allow}) exceeds the expected wind uplift tensile loads (from the calculation package entitled *Evaluation of Tension due to Wind Uplift*). The expected tensile load due to wind uplift was evaluated to be 10.9 kN/m. Since the design wind speed is the maximum peak gust recorded (90 mph), the required factor of safety against anchorage pullout is greater than 1.0. Therefore, the anchor capacity is adequate.

Based on the methods employed herein, results of analysis indicates that the design anchorage evaluated provides adequate tensile capacity to resist the U.V. protective geotextile tension induced by wind uplift forces.

REFERENCES

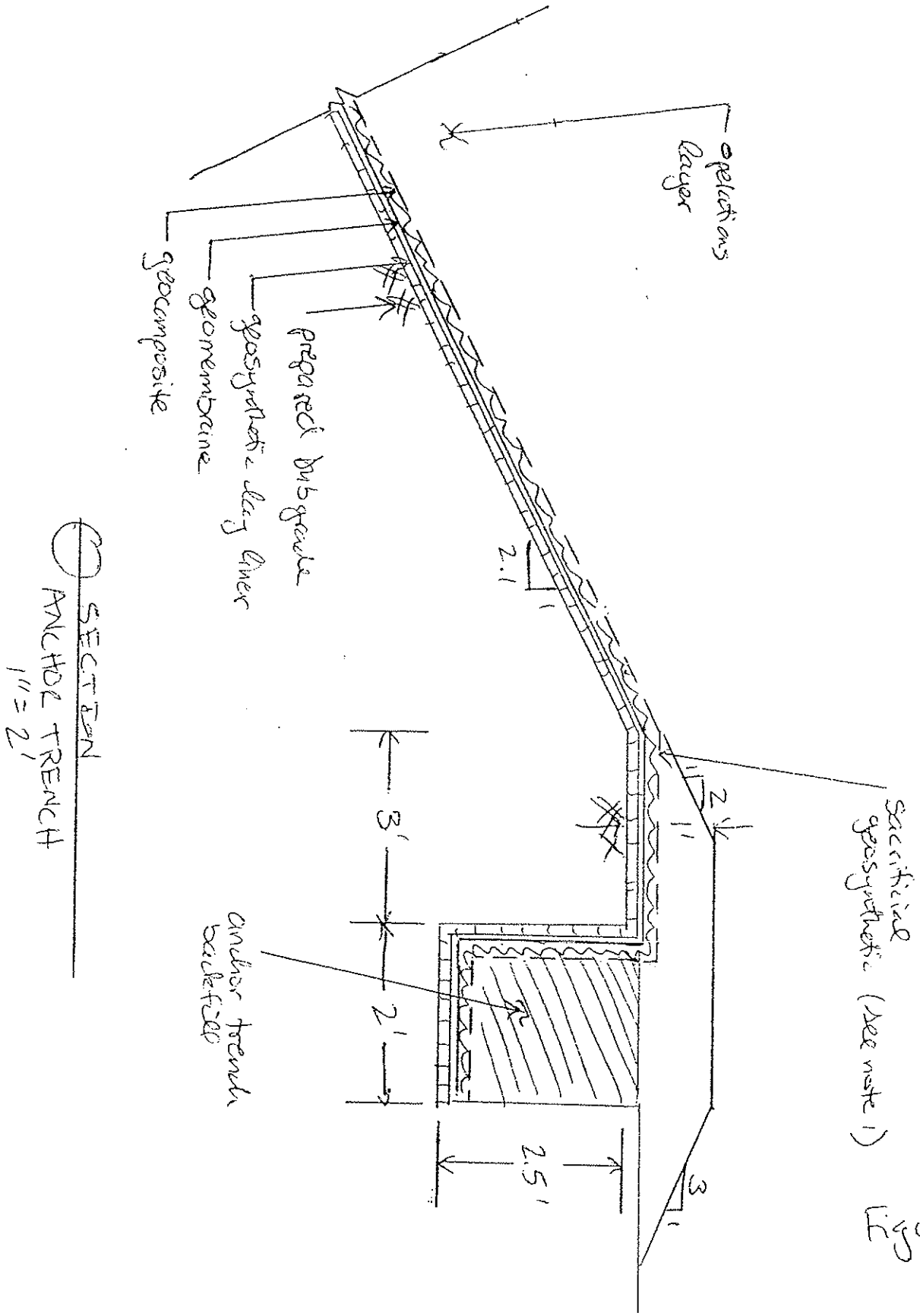
Koerner, R.M. (1994), "*Designing with Geosynthetics*," 3rd Edition., Englewood Cliffs, NJ, Prentice Hall
(Attachment 1)

GEOSYNTEC CONSULTANTS

Page ____ of ____

Written by: MY Date: __/__/__ (YY MM DD) Reviewed by: GTC Date: 00/07/03 (YY MM DD)

Client: ____ Project: ____ Project/Proposal No.: ____ Task No.: ____



SECTION
ANCHOR TRENCH
1" = 2'

Figure 1

Solution: From the design equations just presented,

$$T \cos \beta = 350\ (144)(0.030/12) \cos 18.4$$
$$= 120 \text{ lb./ft.}$$
$$T \sin \beta = 39.8 \text{ lb./ft.}$$
$$q_L = d_{CS}\ \gamma_{CS}$$
$$= (1.0)\ (100)$$
$$= 100 \text{ lb./ft.}^2$$

which, when substituted into Equation 5.27, gives

$$T \cos \beta = q_L \tan \delta\ (L_{RO}) + T \sin \beta \tan \delta$$
$$120 = 100 \tan 20\ (L_{RO}) + 39.8 \tan 20$$
$$120 = 36.4 L_{RO} + 14.5$$
$$L_{RO} = 2.9 \text{ ft.; use } 3.0 \text{ ft.}$$

Note that this value is strongly dependent on the value of mobilized allowable stress used in the analysis. To mobilize the full strength of the geomembrane would require a longer runout length or an anchor trench. This, however, might not be desirable. Pullout, without geomembrane failure, might be a preferable phenomenon. It is a site-specific situation.

The situation with an anchor trench at the end of the runout section is illustrated in Figure 5.31. The configuration requires some important assumptions regarding the state of stress within the anchor trench and its resistance mechanism. To establish static equilibrium, Daniel [41] has suggested using an imaginary and frictionless pulley as shown in Figure 5.31, which allows for the geomembrane to be considered in its continuous form.

$$T_{\text{allow}} = F_U + F_L + 2\ F_{AT} \tag{5.28}$$

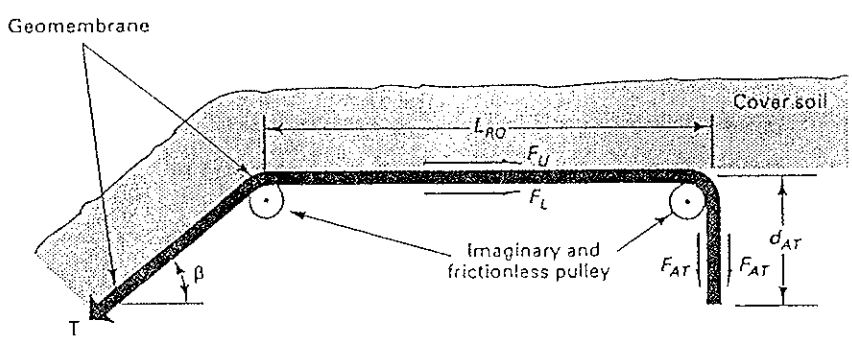


Figure 5.31 Cross section of geomembrane runout section with anchor trench and related stresses and forces involved.

Attachment A 1/3

where $T_{allow} = \sigma_{allow}\, t$, in which
σ_{allow} = the mobilized allowable geomembrane stress = σ_{ult}/FS,
σ_{ult} = the ultimate geomembrane stress (e.g., yield or break),
FS = the factor of safety, and
t = the geomembrane thickness,
F_U = the friction force above geomembrane (assumed to be negligible, since the cover soil probably moves along with the liner as it deforms),
$F_L = q \tan \delta\, (L_{RO})$, in which
q = the surcharge pressure = $d_{CS}\, \gamma_{CS}$,
d_{CS} = the depth of cover soil,
γ_{CS} = the unit weight of cover soil,
δ = the friction angle between geomembrane and soil, and
L_{RO} = (unknown) length of runout, and
$F_{AT} = (\sigma_h)_{ave} \tan \delta\, (d_{AT})$, in which
σ_h = the average horizontal stress in anchor trench = $K_O\, \sigma_V$,
$\sigma_V = \gamma\, H_{ave}$,
γ = the unit weight of backfill soil,
H_{ave} = the average depth of anchor trench (requires an estimate),
$K_O = 1 - \sin \phi$,
ϕ = the angle of shearing resistance of backfill soil, and
d_{AT} = the (unknown) depth of anchor trench.

This situation results in one equation with two unknowns; thus a choice of either L_{RO} or d_{AT} is necessary to calculate the other. As with the previous situation, the factor of safety is placed on the geomembrane force T, which is used as an allowable value (i.e., T_{allow}). An example illustrates the procedure.

Example:

Repeat the previous problem of a 30-mil VLDPE geomembrane of allowable stress 350 lb./in.^{2} on a 3(H) to 1(V) side slope. There is a 12-in. cover soil placed over the geomembrane weighing 100 lb./ft.^{3} (also the unit weight of the backfill soil). The friction angle between the liner and soil is 20 deg. and the soil itself is 30 deg. Determine the required length of runout for a 12-in.-deep anchor trench and for a zero-depth anchor trench to check the preceding example.

Solution: Using the previously developed design equations based on Figure 5.31,

$$T_{allow} = F_U + F_L + 2F_{AT}$$

$$\sigma_{allow}(t) = 0 + q \tan\delta\,(L_{RO}) + 2(K_O \sigma_{V_{ave}}) \tan\delta(d_{AT})$$

$$(350 \times 144)\left(\frac{0.030}{12}\right) = 0 + (1.0)(100) \tan 20(L_{RO}) + 1.5(0.5)(2.0 \times 100) \tan 20(d_{AT})$$

$$126 = 36.4 L_{RO} + 56.6 d_{AT}$$

Attachment A
2/3

GTC

Table 5.7 Friction values and efficiencies (in parentheses) for (a) soil-to-geomembrane, (b) geomembrane-to-geotextile, and (c) soil-to-geotextile combinations*

(a) Soil-to-Geomembrane Friction Angles

	Soil Types		
Geomembrane	*Concrete Sand* (ϕ = 30°)	*Ottawa Sand* (ϕ = 28°)	*Micha Schist Sand* (ϕ = 26°)
EPDM-R	24° (0.77)	20° (0.68)	24° (0.91)
PVC			
Rough	27° (0.88)	—	25° (0.96)
Smooth	25° (0.81)	—	21° (0.79)
CSPE-R	25° (0.81)	21° (0.72)	23° (0.87)
HDPE ~Smooth	18° (0.56)	18° (0.61)	17° (0.63)

(b) Geomembrane-to-Geotextile Friction Angles

	Geomembrane				
		PVC			
Geotextile	*EPDM-R*	*Rough*	*Smooth*	*CSPE-R*	*HDPE*
Nonwoven, needle punched	23°	23°	21°	15°	8°
Nonwoven, heat bonded	18°	20°	18°	21°	11°
Woven, monofilament	17°	11°	10°	9°	6°
Woven, slit film	21°	28°	24°	13°	10°

(c) Soil-to-Geotextile Friction Angles

	Soil Types		
Geotextile	*Concrete Sand* (ϕ = 30°)	*Ottawa Sand* (ϕ = 28°)	*Mica Schist Sand* (ϕ = 26°)
Nonwoven, needle punched	30° (1.00)	26° (0.92)	25° (0.96)
Nonwoven, heat bonded	26° (0.84)	—	—
Woven, monofilament	26° (0.84)	—	—
Woven, slit film	24° (0.77)	24° (0.84)	23° (0.87)

*Efficiency values in parentheses are based on the relationship $E = (\tan \delta)/(\tan \phi)$.

Source: After Martin et al. [14].

The frictional behavior of geomembranes placed on clay soils is of considerable importance in the composite liners of waste landfills. Current requirements are for the clay to have a hydraulic conductivity equal to or less than 2×10^{-7} ft./min. (1×10^{-7} cm/sec.) and for the geomembrane to be placed directly on the clay. While an indication of the shear strength parameters has been investigated (e.g., reference 15), the data are so sensitive to the variables listed previously that site-specific and material-specific tests should always be performed. In such cases, literature values should never be used for final design purposes.

5.1.3.9 Geomembrane Anchorage In certain problem situations a geomembrane might be sandwiched between two materials and then tensioned by an external force. The termination of a geomembrane liner within an anchor trench is such a situation. To simulate this behavior in a laboratory environment, one can use an 8.0-in. (200-mm)-wide geomembrane sandwiched between back-to-back channels.

Attachment A 3/3

Koerner, R.M. (1995), Designing with Geosynthetics, Third Edition, Prentice Hall, N.J.

Calculation Package L
Geocomposite Equivalency Demonstration

GeoSyntec Consultants

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: Parsons **Project:** BRC CAMU **Project/Proposal #:** HL0389 **Task #:** 02

Title of Computations: Drainage Geocomposite Equivalency Demonstration

Computations By:
SIGNATURE — 28 June 2000 DATE
Geoff L. Smith / Staff Engineer
PRINTED NAME AND TITLE

Assumptions and Procedures Checked By (Peer Reviewer):
SIGNATURE — 7/3/00 DATE
GREGORY T CORCORAN / PROJ. ENG.
PRINTED NAME AND TITLE

Computations Checked By:
SIGNATURE — 7/3/00 DATE
GREGORY T. CORCORAN / PROJ. ENG.
PRINTED NAME AND TITLE

Computations Backchecked By (Originator):
SIGNATURE — 28 June 2000 DATE
Geoff L. Smith / Staff Engineer
PRINTED NAME AND TITLE

Approved By (PM or Designate):
SIGNATURE — 10 July 2000 DATE
Bedford H. Cooley / Project Manager
PRINTED NAME AND TITLE

Approval Notes:

Revisions: (Number and Initial All Revisions)

No.	Sheet	Date	By	Checked By	Approval

Written by: Geoff L. Smith GLS Date: 00 / 06 / 28 (YY MM DD) Reviewed by: GTC Date: 00 / 07 / 03 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 02

DRAINAGE COMPOSITE EQUIVALENCY DEMONSTRATION
BRC CAMU
HENDERSON, NEVADA

OBJECTIVE

The objective of this analysis is to evaluate the hydraulic performance of a drainage composite, and compare it to the prescriptive leachate collection layer, consisting of drainage aggregate, within the BRC CAMU. A drainage composite, consisting of two 8 oz/sy nonwoven geotextiles bonded to either side of a geonet, is proposed. This analysis will demonstrate equivalence or performance exceedance of the drainage composite to the prescriptive 1-foot thick (0.3m) aggregate drainage layer. The method of analysis will compare the current transmissivity of the aggregate drainage layer and the equivalent transmissivity of the drainage composite.

SUMMARY OF ANALYSIS

The calculations suggest that a drainage composite having a transmissivity of $6.1*10^{-5}$ m^2/sec, at a maximum stress of 12,000 psf (574 kN/m^2) and a hydraulic gradient of ~~0.02~~ 0.10 GLS, will provide equivalence to the aggregate drainage layer.

METHOD OF ANALYSIS

The analysis was performed using procedures recommended by Koerner (1994). The procedure first evaluates the flow rate (transmissivity) through the aggregate drainage layer, using the basic flow equation described by Darcy, and then calculates the equivalent flow rate (transmissivity) of the drainage composite, and includes appropriate partial factors of safety for geosynthetic materials.

ANALYSIS

This calculation evaluates the flow rate within the drainage composite.

- **FLOW RATE (TRANSMISSIVITY) OF THE AGGREGATE DRAINAGE LAYER**

The maximum flow rate within the leachate collection zone is determined from Darcy's Law by the equation:

$$q = K\,i\,A$$

Written by: Geoff L. Smith GLS Date: 00 / 06 / 28 (YY MM DD) Reviewed by: GTC Date: 00 / 07 / 03 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 02

where:

q = flow rate within the leachate collection layer (m^3/sec)
K = hydraulic conductivity (m/sec)
i = hydraulic gradient (dimensionless)
A = area of flux (m^2)

The following properties will be used for the aggregate drainage layer material.

$K = 1*10^{-2}$ cm/sec = $1*10^{-4}$ m/sec.
i = 0.02 (minimum slope of base liner system)
A= (1 ft * 1 ft) = 1 ft^2 = 0.093 m^2

The hydraulic conductivity is the prescriptive minimum value for the aggregate drainage layer, and the hydraulic gradient is a function of the minimum base slope of the cell. The area of flux is based on the unit thickness of the aggregate drainage layer (1 foot minimum).

Therefore,

$q_{req} = (1*10^{-4}$ m/sec.)(0.02)(0.093 m^2)
$= 1.86*10^{-7}$ m^3/sec

This maximum flow rate through the aggregate drainage layer, is the required flow through the drainage composite (q_{req}).

The allowable flow rate is obtained from laboratory testing for design purposes. This value is determined using appropriate safety factors against the required flow rate. The factor of safety is expressed as the ratio of the allowable flow rate (q_{all}) to the required flow rate (q_{req}).

$$FS = q_{all} / q_{req}$$

Similarly, the factor of safety equation can be expressed as the ratio of allowable to required in plane flow, transmissivity (θ), where the factor of safety equals:

$$FS = \theta_{all} / \theta_{req}$$

Where the transmissivity is calculated by:

$$\theta_{req} = q_{req} / (i*W)$$ (Attachment A)

W = unit width of the drainage layer = 1 ft = 0.3408 m

Therefore,

$$\theta_{req} = \frac{(1.86*10^{-7}\ m^3/sec)}{(0.3048m)(0.02)}$$

$$= 3.05*10^{-5}\ m^2/sec.$$

The transmissivity of the aggregate drainage layer then becomes the minimum required transmissivity (θ_{req}) of the drainage composite.

- **TRANSMISSIVITY OF THE DRAINAGE COMPOSITE**

To ensure that the transmissivity of the proposed drainage composite meets or exceeds the required values over the life of the landfill, the required transmissivity must be increased through the use of appropriate partial factors of safety. These partial factors of safety make the adequate adjustment between the laboratory transmissivity values for drainage composite and actual field conditions.

As seen in Attachment A, Koerner suggests four factors of safety which should be accounted for: the intrusion of the adjacent geotextile into the core of the geonet (FS_{IN}), creep deformation of the geonet (FS_{CR}), factor of safety against chemical clogging of the geonet (FS_{CC}), and factor of safety against biological clogging of the geonet (FS_{BC}). Partial factor of safety values were applied to the geotextile in the filtration geotextile calculation to account for flow through the geotextile component of the drainage composite.

Attachment A shows the ranges for the partial factors of safety. For the purposes of the calculations made, the factors of safety were assumed to be:

FS_{IN} = 1.0 (Accounted for during the testing of the drainage composite)
FS_{CR} = 2.0
FS_{CC} = 1.0 (Accounted for in the Filter Calculation)
FS_{BC} = 1.0 (Accounted for in the Filter Calculation)

The ultimate transmissivity of the drainage composite then becomes:

$$\theta_{ultimate} = \theta_{req} * (\Sigma\ FS)$$

Written by: Geoff L. Smith GS Date: 00 / 06 / 28 (YY MM DD) Reviewed by: GTC Date: 00/07/03 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 02

Σ FS = product of all the partial factors of safety for the site specific conditions

The ultimate transmissivity of the drainage composite is then calculated as:

$$\theta_{geonet} = \theta_{req} * (\Sigma \text{ FS}) = 3.05*10^{-5} \text{ m}^2/\text{sec } [\ 1.0*2.0*1.0*1.0]$$

$$= 6.1*10^{-5} \text{ m}^2/\text{sec}$$

- **MAXIMUM STRESS**

The maximum height of the waste fill is 60 ft (18.3 m). Assuming a unit weight of 136 pcf and a factor of safety of 1.5, this translates to a overburden stress of approximately 12,000 psf (574 kPa).

- CONCLUSIONS

The required transmissivity of the geocomposite shall be $6.1*10^{-5}$ m^2/sec at a maximum stress of 12,000 psf and a gradient of ~~0.02~~. 0.10 GS

REFERENCES

Koerner, R.M. (1994) "Designing with Geosynthetics", 3rd Edition, Prentice Hall, New Jersey *(Attachment A)*

GTC

transportation-related systems, such as roads and walls, the problem does not appear to be too serious. In waste leachate related systems (e.g., landfill leachate collection systems), it might be another story. At the bottom of a landfill, temperatures are high, ample carbon (as a biological food source) is available, and bacteria and fungi could indeed thrive. Whether oxygen is available or not only dictates whether aerobic or anaerobic conditions prevail. No data regarding microorganisms in geonets are presently available, although research is currently ongoing. Procedurally, one must use a high flow rate factor of safety, or have systems designed so that flushing is possible. This area begs for future inquiry.

The last environmental consideration, resistance to light and weather, is not felt to be a serious concern for most situations in which geonets are used. Polyethylene is resistant to weather-related degradation, and carbon black is included in all of the known products. Nevertheless geonets should be covered as soon as possible after placement.

4.1.6 Allowable Flow Rate

As described previously, the essence of the design-by-function concept is the establishment of an adequate global factor of safety. For geonets, where flow rate is the primary function, this takes the following form:

$$FS = \frac{q_{allow}}{q_{req}} \tag{4.3}$$

where FS = the global factor of safety (to handle unknown loading conditions or uncertainties in design methods, etc.),
q_{allow} = the allowable flow rate as obtained from laboratory testing, and
q_{req} = the required flow rate as obtained from design of the actual system.

Alternatively, one could also work from a transmissivity basis to obtain the equivalent relationship.

$$FS = \frac{\theta_{allow}}{\theta_{req}} \tag{4.4}$$

where θ is the transmissivity under similar definitions as above. As described previously, however, it is preferable to design with flow rate rather than transmissivity because of nonlaminar flow conditions in geonets.

Concerning the allowable value, which comes from hydraulic testing of the type just described, one must assess the realism of the test setup in contrast to the actual field system. If it does not model real life adequately, then some adjustments to the laboratory value must be made. This is often the case. Thus the laboratory-

ATTACHMENT A, ~~#4~~ 1/2

GTC

Table 4.2 Recommended preliminary factor of safety values for determining allowable flow rate or transmissivity of geonets

	Partial Factor of Safety Value in Equation 4.5			
Application Area	FS_{IN}	FS_{CR}*	FS_{CC}	FS_{BC}
Sport fields	1.0 to 1.2	1.0 to 1.5	1.0 to 1.2	1.1 to 1.3
Capillary breaks	1.1 to 1.3	1.0 to 1.2	1.1 to 1.5	1.1 to 1.3
Roof and plaza decks	1.2 to 1.4	1.0 to 1.2	1.0 to 1.2	1.1 to 1.3
Retaining walls, seeping rock and soil slopes	1.3 to 1.5	1.2 to 1.4	1.1 to 1.5	1.0 to 1.5
Drainage blankets	1.3 to 1.5	1.2 to 1.4	1.0 to 1.2	1.0 to 1.2
Surface water drains for landfill caps	1.3 to 1.5	1.2 to 1.4	1.0 to 1.2	1.2 to 1.5
Secondary leachate collection (landfills)	1.5 to 2.0	1.4 to 2.0	1.5 to 2.0	1.5 to 2.0
Primary leachate collection (landfills)	1.5 to 2.0	1.4 to 2.0	1.5 to 2.0	1.5 to 2.0 *

*These values assume that the q_{ult} value was obtained using an applied normal pressure of 1.5 to 2 times the field-anticipated maximum value. If not, values must be increased.

done at the proper design load and hydraulic gradient and that this testing yielded a short-term between-rigid-plates value of 1.2 gal./min.-ft.

Solution: Since better information is not known, average values from Table 4.2 are used.

$$q_{allow} = q_{ult}\left[\frac{1}{FS_{IN} \times FS_{CR} \times FS_{CC} \times FS_{BC}}\right] \tag{4.5}$$

$$= 1.2\left[\frac{1}{1.1 \times 1.1 \times 1.1 \times 1.2}\right]$$

$$= 1.2\left[\frac{1}{1.60}\right]$$

$$= 0.75 \text{ gal./min.-ft.}$$

Example:

What is the allowable geonet flow rate to be used in the design of a secondary leachate collection system? Assume that laboratory testing at proper design load and proper hydraulic gradient gave a short-term between-rigid-plates value of 1.2 gal./min.-ft.

Solution: Average values from Table 4.2 are used; however, note the large reduction.

2/2

ATTACHMENT A, ~~#4~~

4.2 DESIGNING FC

This section wi
transportation-r
field.

4.2.1 Theoretic

Design by func

For geonets ser
aforementioned

where q_{allow} = t
q_{requ} = t

As stated prev
saturated condi
flow rate, name
equations 4.1 a

SM 3/14/99

Calculation Package M
Consolidation Analysis of the South Mesa

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: Basic Remediation Company

Project: BRC CAMU **Project/Proposal #:** SC0313 **Task #:** 01

Title of Computations: Consolidation Analysis of South Mesa

Computations By:
SIGNATURE — DATE 11/3/06
Rebecca Flynn, Staff Engineer
PRINTED NAME AND TITLE

Assumptions and Procedures Checked By (Peer Reviewer):
SIGNATURE — DATE 11/6/06
Keaton Botelho, Staff Engineer
PRINTED NAME AND TITLE

Computations Checked By:
SIGNATURE — DATE 11/3/06
Gregory T. Corcoran, PE / Principal
PRINTED NAME AND TITLE

Computations Backchecked By (Originator):
SIGNATURE — DATE 11/3/06
Rebecca Flynn, Staff Engineer
PRINTED NAME AND TITLE

Approved By (PM or Designate):
SIGNATURE — DATE 11/3/06
Gregory T. Corcoran, PE / Principal
PRINTED NAME AND TITLE

Approval Notes:

Revisions: (Number and Initial All Revisions)

No.	Sheet	Date	By	Checked By	Approval

Written by: Rebecca Flynn Date: 06 / 08 / 21 (YY MM DD) Reviewed by: BTC Date: 06 / 11 / 3 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

CONSOLIDATION ANALYSIS OF SOUTH MESA
BRC CAMU
HENDERSON, NEVADA

OBJECTIVE

The objective of this calculation package is to evaluate the consolidation settlement potential of the south mesa at the BRC Corrective Action Management Unit (CAMU) located in Henderson, Nevada. In particular, the amount of differential settlement and strain will be evaluated.

SUMMARY OF ANALYSIS

The calculations suggest that the strain on the liner system due to differential settlement is within tolerable amounts. In addition, the proposed grading plan will accommodate the calculated differential settlement without significant effects on drainage. Since limited information is available regarding the consolidation characteristics of the soil strata, interpretation was required and the analyses were approached on a conservative basis.

SITE BACKGROUND

Native material within the limits of the BRC CAMU consists of alluvial granular soils overlying fine-grained soils. Shear strength parameters for the native soil material were previously estimated and reported in the *Preliminary Geotechnical and Geologic Investigation - Industrial Non-Hazardous Disposal Facility* (Converse 1999). Twelve exploratory borings were conducted by others to depths ranging from 33-ft to 60-ft (Converse 1999). In general, the native materials appear to be consistent between borings. Six consolidation tests were performed on retrieved samples of sandy clay (CL). All samples were inundated with water at 2000 psf. The author has approximated the saturated consolidation curve for the purposes herein. A summary of the consolidation test results as reported by Converse (1999) are presented in Attachment 1.

ANALYSIS

Terzaghi's one-dimensional consolidation theory will be used to evaluate the consolidation potential of the south mesa at the BRC CAMU. The method of analysis to evaluate the maximum differential settlement is to compare the calculated settlement at each boring location.

Written by: Rebecca Flynn Date: 06 / 08 / 21 (YY MM DD) Reviewed by: BRC Date: 06 11 13 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

After the expected settlement is known for each location, the maximum differential settlement and strain can be calculated. The location of each boring is presented in Figure 1. An idealized profile for the borings is presented in Figure 2. The sandy clay (CL) layers are highlighted.

The Casagrande construction method was used to evaluate if the lean clay is normally consolidated and to construct the field consolidation curve. The construction is shown in Attachment 1. The following results are obtained:

Sample	Depth (ft)	Initial e_o	C_c	Liquid Limit (%)	Moisture Content (%)	Present Consolidation Pressure (ksf)	Previous Consolidation Pressure (ksf)
B-8	39.0	1.9	0.55		64	3.71	about 3.7
B-8	49.0	1.41	0.98		51	5.18	about 5.0
B-102	49.0	1.52	0.86	88	49	4.89	about 4.1
B-10	54.0	1.76	0.81		68	5.06	about 4.1
B-101	59.0	1.31	0.52		38	4.88	about 4.4
B-101	39.0	1.55	0.47	105	45	3.7	about 4.0
Avg.		1.58	0.73				

Based on the above results, the lean clay deposit can be categorized as normally consolidated (i.e., the previous consolidation pressure is relatively close to the present consolidation pressure).

The settlement calculations are presented in Attachment 2. The results are summarized below:

Boring	Thickness of CL (ft)	Calculated Settlement (ft)
B-10	22 ft (interbedded layers of SM)	2.54
B-12	24 ft	2.58
B-8	22 ft	2.35
B-102	8 ft	0.92
B-5	10 ft	1.18
B-4	5 ft	0.37

As shown in Figure 1, borings B-4, B-5, B-8, B-10, B-12, and B-102 were considered for this analysis. Borings B-101 and B-103 were not considered because they lie well outside the liner

limits. Settlement was calculated at the aforementioned boring locations (known CL thickness). However, consolidation tests were not necessarily performed at each of these locations. For locations were there was no consolidation data, the average values for e_o and C_c were used. See Attachment 2 for settlement calculations.

The shortest distance between borings and the largest differential settlement will result in the largest strain. This relationship is defined as:

$$\varepsilon = \Delta h/L$$

The maximum differential settlement at the shortest distance was between borings B-4, and boring B-8 (see Figure 1). The distance between the borings is 470 ft. The strain is:

$$\varepsilon = \Delta h/L = (2.35-0.37)/470 = 0.42 \text{ percent.}$$

Assuming a linear differential settlement profile, the calculated strain is well below the typical yield strength of HDPE geomembrane. Typical strain at the yield stress for HDPE geomembrane is approximately 12 percent (Koerner 1994).

CONCLUSIONS

Based on available information and the author's interpretation of the appropriate consolidation curves, the following can be concluded:

- The CL deposit can be characterized as normally consolidated;
- The maximum settlement expected in the south mesa is approximately 2 ft;
- The maximum strain expected in the south mesa is approximately 0.4%
- The liner system and proposed grading can accommodate the expected differential settlement and strain.

REFERENCES

Converse (1999), "Preliminary Geotechnical and Geologic Report - Industrial Non-Hazardous Disposal Facility (Converse 1999)", prepared for Basic Management, Inc., October 1999.

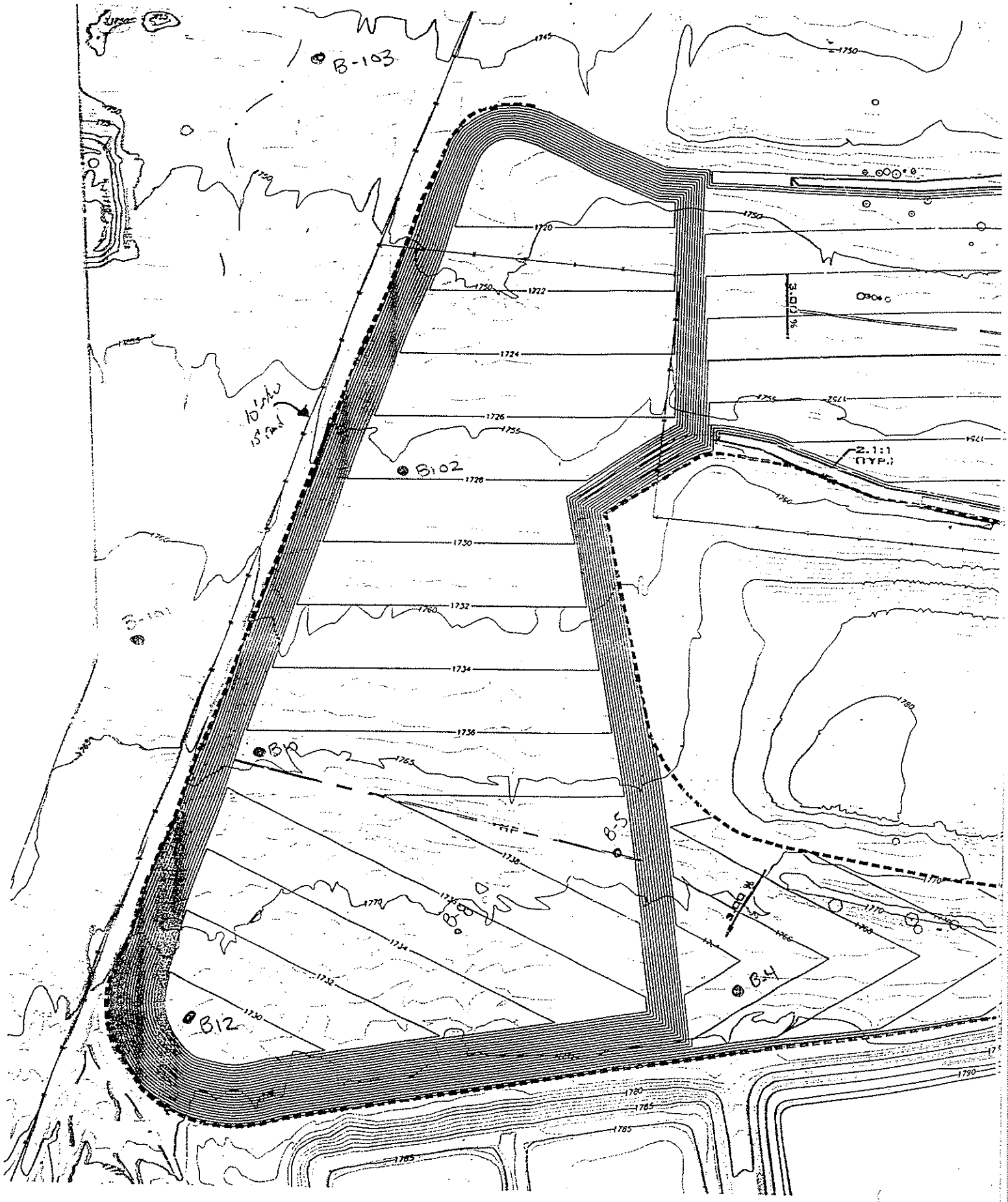

B-103
B-102
B-101
B-10
B-5
B-4
B-12
2:1:1
(TYP.)
10' sidw
15' rad
1720
1722
1724
1726
1728
1730
1732
1734
1736
1738
1740
1742
1744
1746
1750
1755
1760
1765
1770
1780
1785
1790

FIGURE 1

GEOSYNTEC CONSULTANTS

Page _____ of _____

Written by: R. FLYNN Date: 21 / 08 / 06 (DD / MM / YY) Reviewed by: _____ Date: ___ / ___ / ___ (DD / MM / YY)

Client: _____ Project: _____ Project/Proposal No.: _____ Task No: _____

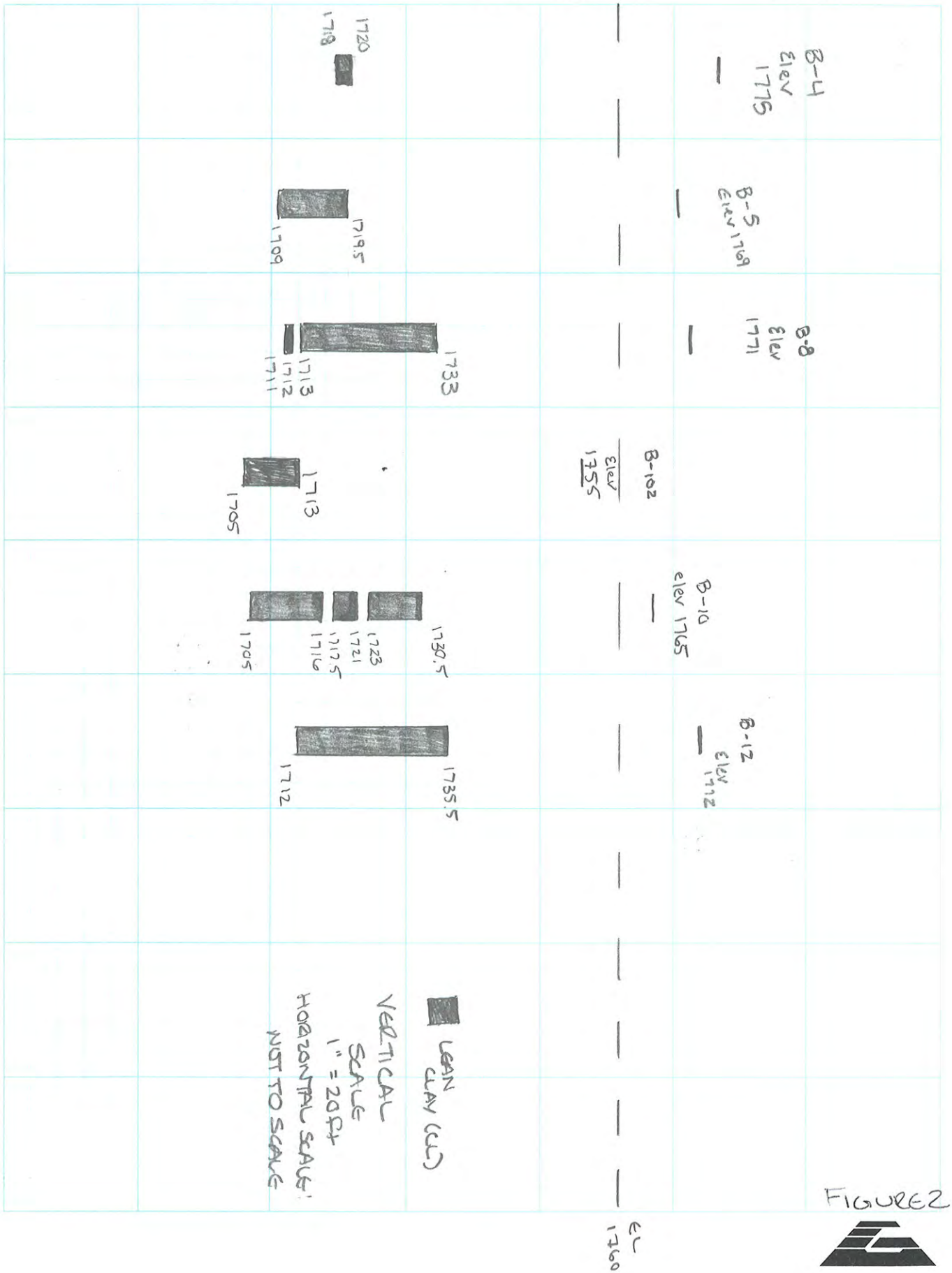
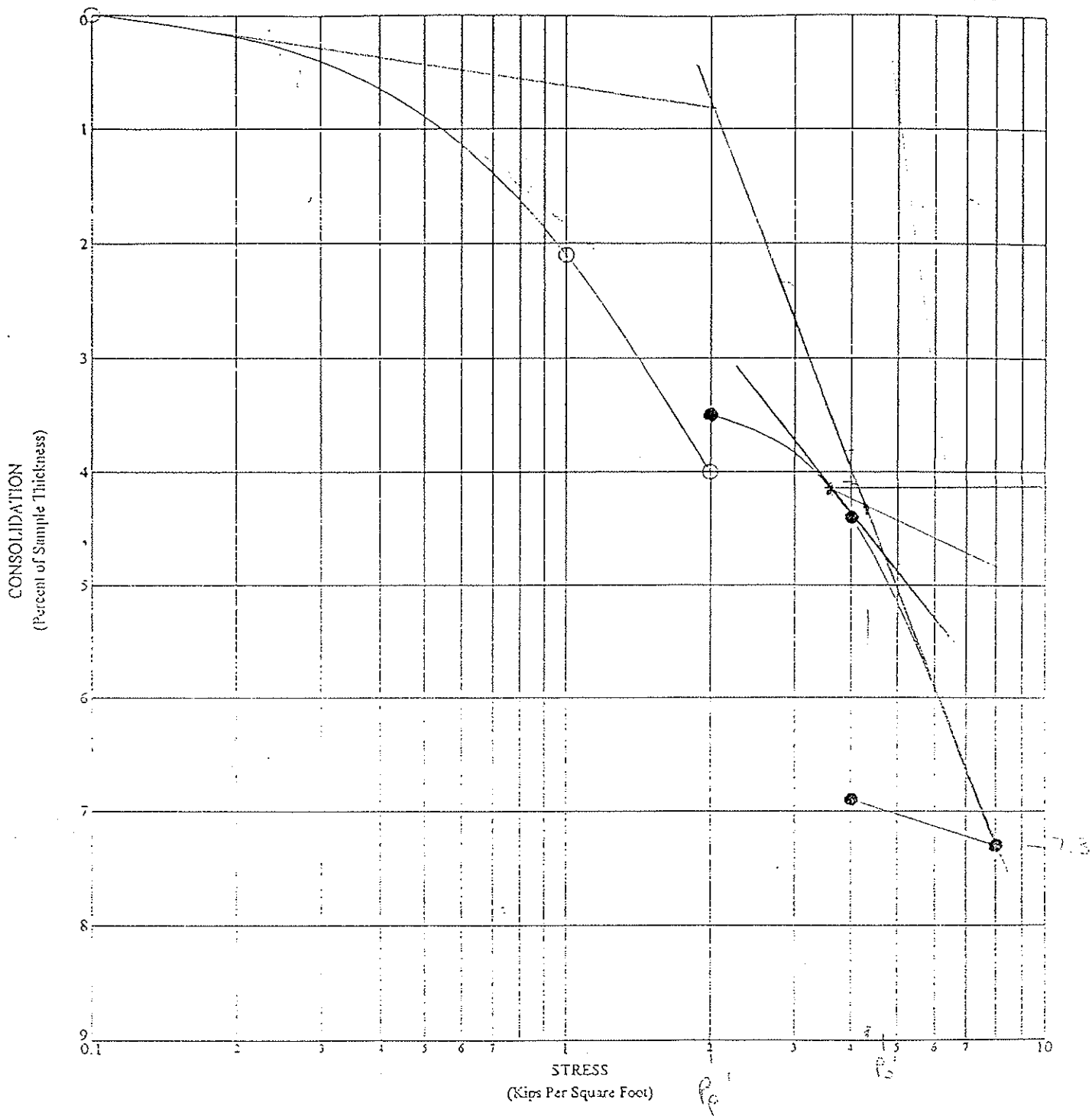


FIGURE 2



BORING NO: B-102 $C_c = 1.52$

DEPTH: 49.0

DESCRIPTION:

DRY DENSITY: 67 PCF

MOISTURE CONTENT: 49%

$C_c = \frac{0.13}{\log(5/4.5)} = 0.56$

Attachment 1

1/6

● READINGS AFTER SATURATION WITH WATER

CONSOLIDATION TEST

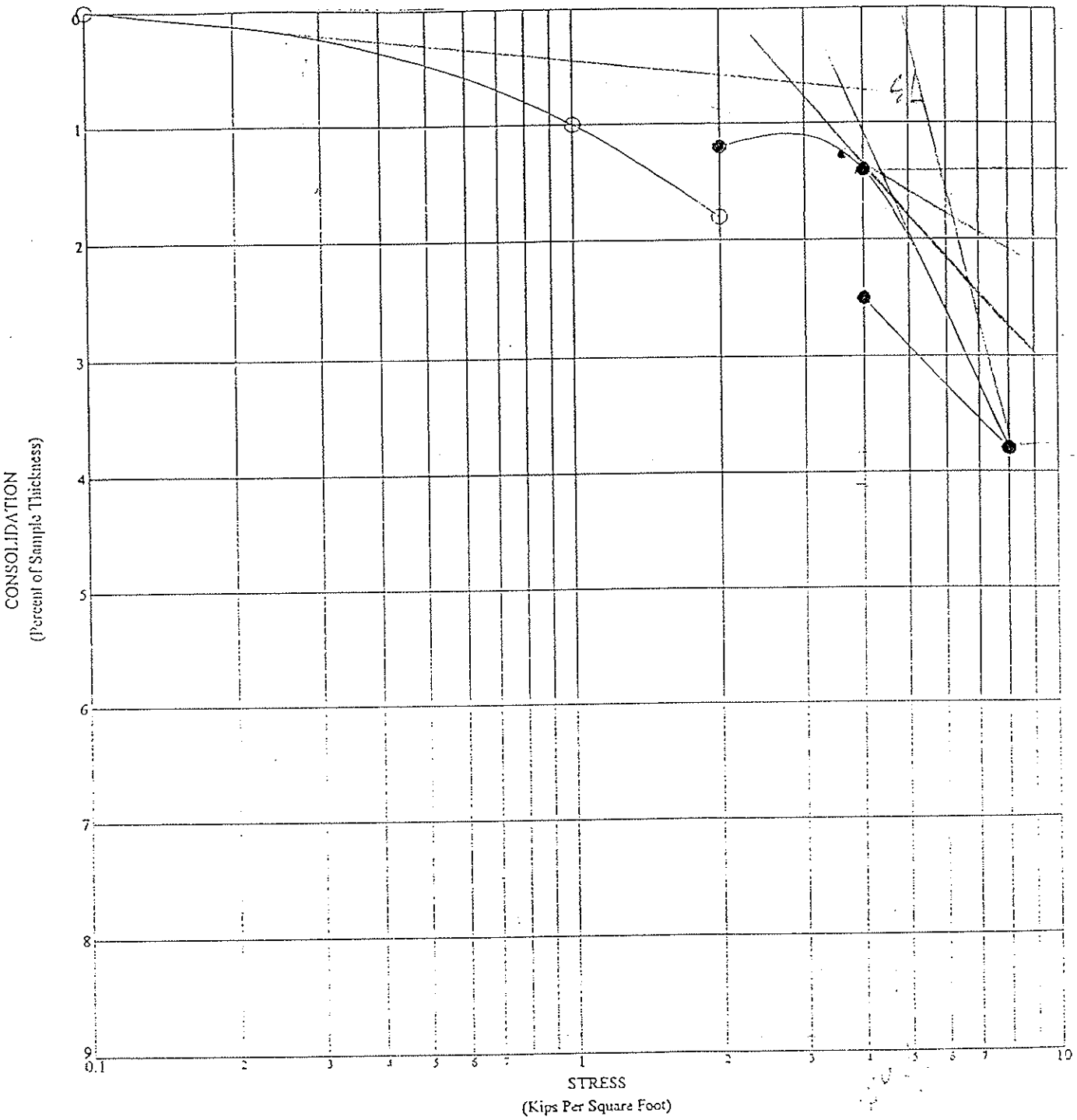
PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION

Project No. 99-33437-01

Converse Consultants

Geotechnical Engineering

Drawing No.



BORING NO: B-101
DEPTH: 59.0
DESCRIPTION: LEAN CLAY
DRY DENSITY: 73 PCF
MOISTURE CONTENT: 38%

Attachment 1
2/6

● READINGS AFTER SATURATION WITH WATER

CONSOLIDATION TEST

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION

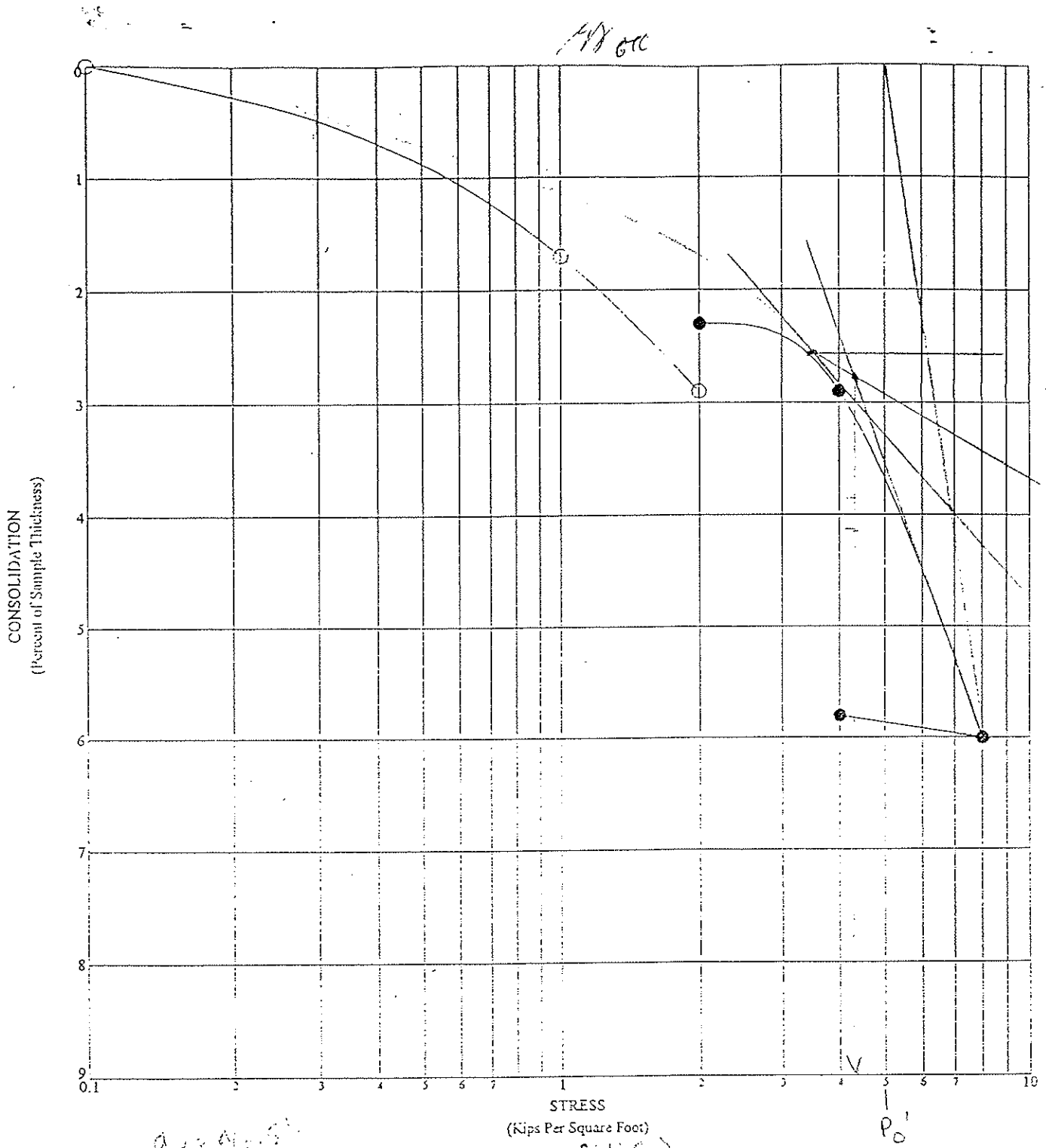
Project No.
99-33437-01

Geotechnical Engineering

Drawing No.

DRAFTED

APPROVED BY ON



DRAFT

PROVIDED BY ON

BORING NO: B-10
DEPTH: 54.0
DESCRIPTION: LEAN CLAY
DRY DENSITY: 61 PCF
MOISTURE CONTENT: 68%

$e_o = 1.70$

$P_o' = 5.0$

$C_c = \frac{\Delta e}{\log \frac{P_o'}{P_o'}} = 0.01$

Attachment 1
3/6

● READINGS AFTER SATURATION WITH WATER

CONSOLIDATION TEST

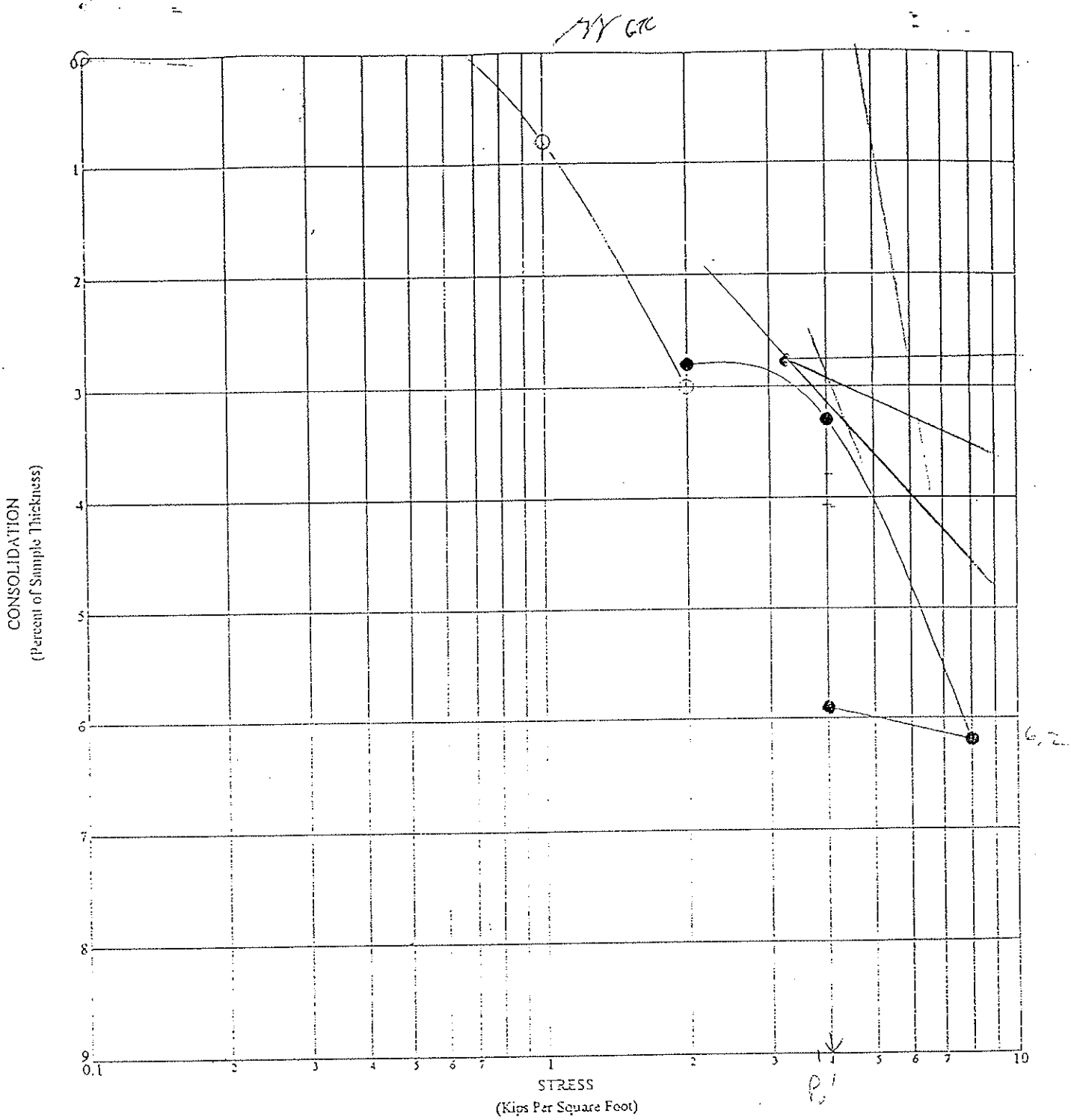
PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION

Project No.
99-33437-01

Converse Consultants

Geotechnical Engineering and Applied Science

Drawing No.



BORING NO: B-101
DEPTH: 39.0
DESCRIPTION: LEAN CLAY
DRY DENSITY: 66 PCF
MOISTURE CONTENT: 45%

Attachment 1
4/6

● READINGS AFTER SATURATION WITH WATER

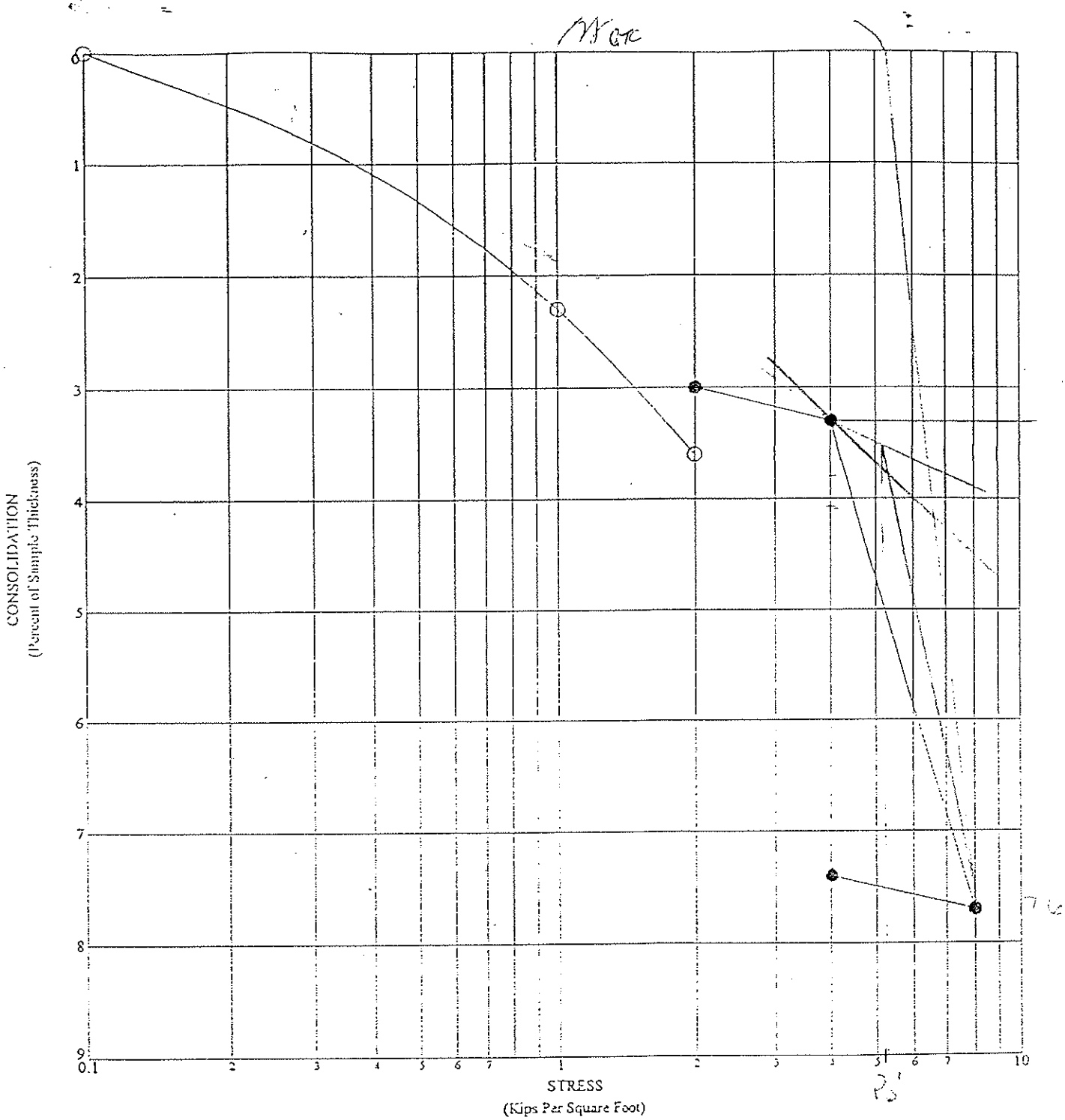
CONSOLIDATION TEST

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION

Project No. 99-33437-01

Geotechnical Engineering

Drawing No.



BORING NO: B- 8
DEPTH: 49.0
DESCRIPTION: LEAN CLAY
DRY DENSITY: 70 PCF
MOISTURE CONTENT: 51%

$G_s = 1.41$

$\Delta e = \frac{\Delta H}{H}(1+e_0) = 0.152$

$P_c' = 5.130$

$C_c = \frac{0.133}{\log(5/5.1)} = 0.94$

Attachment 1
5/6

● READINGS AFTER SATURATION WITH WATER

CONSOLIDATION TEST

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION

Project No. 99-33437-01

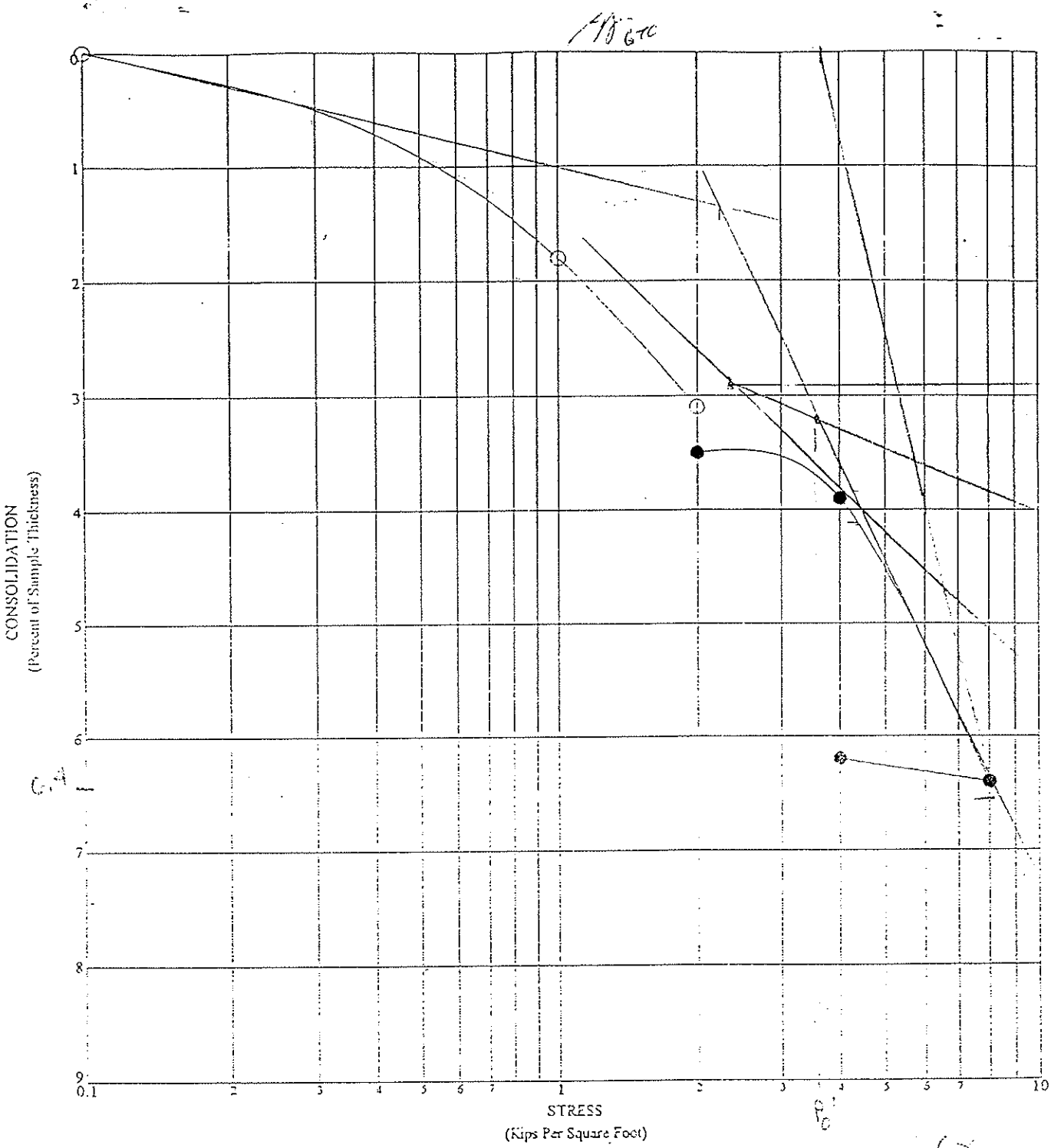
Geotechnical Engineering

Drawing No.

DRAFTED BY OL

APPROVED BY ON

DRAFT



BORING NO: B- 8
DEPTH: 39.0
DESCRIPTION: LEAN CLAY
DRY DENSITY: 58 PCF
MOISTURE CONTENT: 64%

$e_0 = 1.9$

$\gamma_w = 62.4$

$P_0' = 3110$ psf

$C_c = \frac{\Delta e}{\log(P_0'/P_0)} = \frac{0.156}{\log(8/3.1)} = 0.56$

$e_0 = \frac{G_s \gamma_w}{\gamma_d} - 1$

$\Delta e = \frac{S(\Delta e)}{H} = 0.156$

$H = 1''$

● READINGS AFTER SATURATION WITH WATER

CONSOLIDATION TEST

~~Attachment 1~~ 6/6

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION

Project No. 99-33437-01

Geotechnical Engineering

Drawing No.

PROVED BY ON

Written by: R. FLYNN Date: 21 / 08 / 06 (DD / MM / YY) Reviewed by: GTC Date: 07 / 11 / 06 (DD / MM / YY)

Client: _____ Project: _____ Project/Proposal No.: _____ Task No: _____

SETTLEMENT ANALYSIS FOR BORING B-102

→ ASSUME LAYER THICKNESS OF 8 ft
O.K THICKNESS FOR ANALYSIS

→ ASSUME $C_c = 0.86$ $e_0 = 1.52$

→ Assume 29 ft excavation of 117 pcf and replace at 136 pcf plus 42 ft of fill at 136 pcf

Therefore, $\Delta p = (29')(136-117) + 42'(136)$
$\Delta p = 6263$

→ Depth of mid-layer at depth = 46'
water table at 43 ft
Therefore,
$P_o' = 43ft\ (117pcf) + (117-62.4)(3ft)$

$P_o' = 5195$

$$S = \frac{C_c}{1+e_0} H \log\left(\frac{P_o' + \Delta p}{P_o'}\right)$$

$$S = \frac{0.86}{1+1.52}(8')\log\left(\frac{5159+6263}{5159}\right)$$

$S = 0.9\cancel{24}$ ft = 11.3 inches

.942 GTC

Attachment 2

1/4

Written by: R FLYNN Date: 21 / 08 / 06 (DD MM YY) Reviewed by: _____ Date: ___ / ___ / ___ (DD MM YY)

Client: _____ Project: _____ Project/Proposal No.: _____ Task No: _____

SETTLEMENT ANALYSIS FOR BORING B-5

→ ASSUME LAYER THICKNESS OF 10 ft
Too thick: do analysis for two 5ft layers

→ Assume $C_c = 0.73$ and $e_0 = 1.58$

→ ASSUME 30 ft of excavation and replacement at 136 pcf, plus 70 ft of fill at 136 pcf
Therefore

$$\Delta p = (30)(136-117) + 70(136)$$
$$\Delta p = 10,090$$

→ Depth of mid-layer #1 = 52.5 ft
$$P_0' = 52.5(117) = 6142 \text{ psf}$$

→ Depth of mid-layer #2 = 57.5 ft
$$P_0' = 52 \text{ ft}(117 \text{ pcf}) + (117-62.4)(57.5-52)$$
$$P_0' = 6385 \text{ psf}$$

$$S_1 = \frac{0.73}{1+1.58}(5)\log\left(\frac{6142+10090}{6142}\right)$$

$$S_1 = 0.597 \text{ ft} = 7.17 \text{ inches}$$

$$S_2 = \frac{0.73}{1+1.58}(5)\log\left(\frac{6385+10090}{6385}\right)$$

$$S_2 = 0.582 \text{ ft} = 6.99 \text{ inches}$$

$$S_{TOTAL} = 1.18 \text{ ft} = 14.15 \text{ inches}$$

Attachment 2

Written by: R. FLYNN Date: 21 / 08 / 06 (DD MM YY) Reviewed by: _____ Date: ___ / ___ / ___ (DD MM YY)

Client: _____ Project: _____ Project/Proposal No.: _____ Task No: _____

SETTLEMENT ANALYSIS FOR BORING B-4

→ ASSUME LAYER THICKNESS OF 5 ft

→ Assume $C_c = 0.73$ and $e_0 = 1.58$

→ $S = \frac{C_c}{1+e_0} H \log\left(\frac{P_0 + \Delta p}{P_0}\right)$

→ ASSUME 10 ft of excavation and replace at 136 pcf, plus 38 ft fill at 136 pcf

Therefore $\Delta p = (10)(136-117) + 38(136)$
$\Delta p = 5358$

→ DEPTH AT MID LAYER = 56 ft
WATERTABLE DEPTH AT 54 ft

THEREFORE $P_0' = 54(117 pcf) + 2'(117-62.4)$
$P_0' = 6427$ psf

$S = \frac{0.73}{1+1.58}(5ft) \log\left[\frac{6427 + 5358}{6427}\right]$

$S = 0.373$ ft → 4.5 inches

Attachment 2
3/4

Settlement Analysis for Boring B-8

H	22	ft
w%	51	%
Gs	2.7	
$\gamma_{d,\,max}$	70	pcf
% comp.	100	%
γ	105.7	pcf
e_o	1.406857	
C_c	0.76	
Δp	6668	

Layer	Thickness	Mid-Depth	Po'	Si
1	3	39.5	4621.5	0.367447
2	3	42.5	4972.5	0.349927
3	3	45.5	5323.5	0.334088
4	3	48.5	5674.5	0.319688
5	3	51.5	6025.5	0.306533
6	3	54.5	6376.5	0.294462
7	4	58	6786	0.375428
				2.347574

Settlement Analysis for Boring B-10

H	22	ft
w%	49	%
Gs	2.7	
$\gamma_{d,\,max}$	67	pcf
% comp.	100	%
γ	99.83	pcf
e_o	1.514627	
C_c	0.86	
Δp	6399	
water table	46	

Layer	Thickness	Mid-Depth	Po'	Si
1	3	39.5	4621.5	0.38723
2	3	42.5	4972.5	0.368582
3	3	45.5	5323.5	0.351735
4	3	48.5	5518.5	0.343057
5	3	51.5	5682.3	0.336106
6	3	54.5	5846.1	0.329444
7	4	58.5	6064.5	0.427971
	22			2.544125

Settlement Analysis for Boring B-12

H	24	ft
e_o	1.58	
C_c	0.73	
Δp	7753	

Layer	Thickness	Mid-Depth	Po'	Si
1	4	38	4446	0.496122
2	4	42	4914	0.465433
3	4	46	5382	0.43855
4	4	50	5850	0.414774
5	4	54	6318	0.393572
6	4	58	6786	0.37453
				2.582983

Attachment 2
4/4

Calculation Package N
Consolidation Analysis of the North Mesa

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: Basic Remediation Company

Project: BRC CAMU **Project/Proposal #:** SC0313 **Task #:** 01

Title of Computations: Consolidation Analysis of North Mesa

Computations By:
SIGNATURE DATE 11/3/06
Rebecca Flynn, Staff Engineer
PRINTED NAME AND TITLE

Assumptions and Procedures Checked By (Peer Reviewer):
SIGNATURE DATE 11/3/06
Gregory T. Corcoran, PE / Principal
PRINTED NAME AND TITLE

Computations Checked By:
SIGNATURE DATE 11/3/06
Gregory T. Corcoran, PE / Principal
PRINTED NAME AND TITLE

Computations Backchecked By (Originator):
SIGNATURE DATE 11/3/06
Rebecca Flynn, Staff Engineer
PRINTED NAME AND TITLE

Approved By (PM or Designate):
SIGNATURE DATE 11/3/06
Gregory T. Corcoran, PE / Principal
PRINTED NAME AND TITLE

Approval Notes:

Revisions: (Number and Initial All Revisions)

No.	Sheet	Date	By	Checked By	Approval

Written by: Rebeccca Flynn Date: 06 / 08 / 22 (YY MM DD) Reviewed by: GTC Date: 06 / 11 / 3 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

CONSOLIDATION ANALYSES OF SLIT TRENCHES
BRC CAMU
HENDERSON, NEVADA

OBJECTIVE

The objective of this calculation package is to evaluate the consolidation settlement potential of landfilled waste in the "slit trenches" of the North Mesa at the BRC Corrective Action Management Unit (CAMU) located in Henderson, Nevada. In particular, the amount of differential settlement and potential strain in an overlying geosynthetic liner will be evaluated. Finally, the height of surcharge material to be used in pre-loading the slit-trenches will be calculated.

SUMMARY OF ANALYSES

Since limited information is available regarding the consolidation characteristics of the soil strata, interpretation was required and the analyses were approached on a conservative basis. Should the liner system be constructed overlying the existing, unconsolidated "slit trenches", the calculations suggest that the strain on the liner system due to differential settlement is not within tolerable amounts. The strain on the liner system may be reduced to within tolerable amounts if the trenches are first 'pre-loaded' with approximately 40 feet of surcharge material.

SITE BACKGROUND

Native material within the limits of the BRC CAMU consists of alluvial granular soils overlying fine-grained soils. Shear strength parameters for the native soil material were previously estimated and reported in the *Preliminary Geotechnical and Geologic Investigation - Industrial Non-Hazardous Disposal Facility* (Converse 1999). Twelve exloratorary borings were conducted by others to depths ranging from 33-ft to 60-ft (Converse 1999). In general, the native materials appear to be consistent between borings.

In January 2005, BRC performed a subsurface investigation of the slit trenches, consisting of continuous, split-spoon sampling to determine the depth of landfilled waste. Twenty exploratory borings were advanced to depths ranging from 22-ft to 32-ft (Attachment A). The thickness of landfilled waste ranges between 5-ft to 26-ft, and consists of typical industrial waste and

construction/demolition debris: wood, paper, fabric, plastic, glass, and metal. The width of slit trenches ranges between 20 feet and 76 feet

The design of the proposed North Mesa landfill includes approximately 38-ft of waste and 2-ft of cover soil, resulting in approximately 40-ft of overburden material on the present base grades.

ANALYSIS

Consolidation Settlement

Terzaghi's one-dimensional consolidation theory will be used to evaluate the consolidation potential of the slit trenches of the North Mesa at the BRC CAMU. The method of analysis to evaluate the maximum differential settlement is to compare the calculated settlement at each boring location. After the expected settlement is known for each location, the maximum differential settlement and strain can be calculated.

There are two components to the total settlement calculated by one-dimensional consolidation theory, primary settlement and secondary settlement. The calculation of total consolidation settlement is governed by the following equation:

$$S_T = S_p + S_S$$

Where:

S_p = magnitude of primary consolidation settlement, ft
S_S = magnitude of secondary consolidation settlement, ft

The calculation of primary settlement is governed by the following equation:

$$S_p = C'_c \cdot H \cdot \log\left(\frac{p_o + \Delta p}{p_o}\right)$$ (Attachment B, 1 of 2)

Where:

S_p = magnitude of primary consolidation settlement, ft
C'_c = compression index for the compressible layer (waste) = 0.3
H = initial thickness of compressible layer (waste), ft
p_o = initial overburden pressure on the compressible layer, lb/ft^2
Δp = change in overburden pressure due to loading, lb/ft^2

Written by: Rebeccca Flynn Date: 06 / 08 / 22 (YY MM DD) Reviewed by: GTC Date: 06 / 11 / 3 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

Furthermore:

$$p_o = \frac{H}{2} \cdot \gamma_{waste} + H_{soil,overburden} \cdot \gamma_{soil,overburden}$$

H = initial thickness of compressible layer, ft
γ_{waste} = unit weight of waste = 85 lb/ft^3
$H_{soil,overburden}$ = thickness of soil overburden over waste, ft
$\gamma_{soil,\ overburden}$ = unit weight of soil overburden = 115 lb/ft^3

and $$\Delta p = H_{soil,waste} \cdot \gamma_{soil,waste} + H_{soil,coversystem} \cdot \gamma_{soil,coversystem}$$

$H_{soil,\ waste}$= thickness of waste to be placed in landfill, ft
γ_{waste} = unit weight of waste to be placed in landfill = 136 lb/ft^3
$H_{soil,\ coversystem}$ = thickness of soil in landfill cover system, ft
$\gamma_{soil,\ coversystem}$= unit weight of soil in landfill cover system = 125 lb/ft^3

The calculation of secondary settlement is governed by the following equation:

$$S_S = C'_\alpha \cdot H \cdot \log\left(\frac{t_2}{t_1}\right)$$ (Attachment B, 2 of 2)

Where:

S_S = magnitude of secondary consolidation settlement, ft
C'_α = secondary compression index for the compressible layer (waste) = 0.019
H = initial thickness of compressible layer (waste), ft
t_1 = time at beginning of secondary consolidation = 26 year (assuming waste placement ended in 1980)
t_2 = time at end of consolidation, years = 59 years (t_1 + 30 years post-closure maintenance + 3 years of landfill operation)

The compression index (C_c) and secondary compression index (C'_α) are normally determined through laboratory analyses of samples collected during subsurface investigation. In the absence of such testing, the following calculations use a conservatively high C_c value, as obtained from Deutsch, et al. (Attachment C), and a conservatively high C'_α value, as obtained from Bjarngard, et al. (Attachment D).

Written by: Rebeccca Flynn Date: 06 / 08 / 22 (YY MM DD) Reviewed by: BRC Date: 06 / 11 / 3 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

The consolidation settlement calculations are presented in Attachment E (1 of 3). The results are summarized below:

Location	Initial Waste Thickness (ft)	Total Settlement, S_T (ft)
BS-01	1	0.35
BS-02	6	1.10
BS-03	19	3.53
BS-04	10	1.86
BS-05	18	3.78
BS-06	20	4.46
BS-07	18	3.54
BS-08	12	1.74
BS-09	22	3.82
BS-10	0	0.00
BS-11	24	4.18
BS-12	26	5.42
BS-13	20	4.55
BS-14	26	5.00
BS-15	10	2.76
BS-16	5	0.04
BS-17	22	0.15
BS-18	11	1.24
BS-19	21	1.35
BS-20	8	0.83

Strain Due to Differential Settlement

The differential settlement between the compressible material in a slit trench and the relatively incompressible native material adjacent to the trench will result in strain in the overlying liner system. The maximum strain is assumed to occur at the middle of the trench, at the point of maximum settlement. This relationship is defined as:

$$\varepsilon = \frac{\sqrt{S_T^{\,2} + L^2}}{L} - 1$$

Written by: Rebeccca Flynn Date: 06 / 08 / 22 (YY MM DD) Reviewed by: CTC Date: 06 / 11 / 3 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

Where:

ε = strain in liner system due to differential settlement
L = half the width of the slit trench, ft
S_T = total settlement, ft

The maximum allowable strain in the liner system is selected to be 1% to maintain drainage of the leachate collection system (3%, as constructed) and acceptable for the geomembrane material properties. Those locations that exceed the allowable strain will require "pre-loading" prior to liner placement. The purpose of this "pre-loading" is to achieve consolidation settlement of the waste and minimize settlement induced strain. The required settlement to be achieved by pre-loading is calculated as follows:

$$S_{req} = S_T - \left(\varepsilon_{allow} \cdot L\right)$$

Where:

S_{req} = required settlement, ft
S_T = total settlement, ft
ε_{allow} = maximum allowable strain in liner system = 1%
L = half the width of the slit trench, ft

Written by: Rebeccca Flynn Date: 06 / 08 / 22 (YY MM DD) Reviewed by: OTC Date: 06 / 11 / 3 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

The strain calculations are presented in Attachment E (2 of 3). The results are summarized below:

Location	L (ft)	Strain, ε	S_{req} (ft)
BS-01	20	0.02%	-
BS-02	20	0.15%	-
BS-03	20	1.55%	2.52
BS-04	10	1.72%	0.85
BS-05	10	6.91%	2.77
BS-06	10	9.50%	3.45
BS-07	10	6.08%	2.53
BS-08	10	1.50%	0.73
BS-09	10	7.05%	2.81
BS-10	38	0.00%	-
BS-11	38	0.60%	-
BS-12	20	3.61%	4.41
BS-13	20	2.56%	3.54
BS-14	20	3.08%	3.99
BS-15	20	0.95%	-
BS-16	23	0.00%	-
BS-17	23	0.00%	-
BS-18	23	0.15%	-
BS-19	13	0.54%	-
BS-20	13	0.20%	-

Required Surcharge Height

The surcharge height necessary to preload the slit trenches and obtain the required settlement is calculated by rearranging the equation for primary consolidation settlement (S_P), as below:

$$H_{surcharge} = \frac{\left(10^{\left(\frac{S_{req}}{C_c \cdot H}\right)} \cdot p_o\right) - p_o}{\gamma_{surcharge}}$$

Written by: Rebeccca Flynn Date: 06 / 08 / 22 (YY MM DD) Reviewed by: [illegible] Date: 06 / 11 / 3 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

Where:

$H_{surcharge}$ = height of surcharge, ft
S_{req} = required settlement, ft
C_c = compression index for the compressible layer (waste) = 0.3
H = initial thickness of compressible layer (waste), ft
p_o = initial overburden pressure on the compressible layer, lb/ft^2
$\gamma_{surcharge}$ = unit weight of surcharge soil = 135 lb/ft^3

The surcharge height calculations are presented in Attachment E (3 of 3). The results are summarized below:

Location	S_{req} (ft)	$H_{surcharge}$ (ft)
BS-01	-	-
BS-02	-	-
BS-03	2.52	23
BS-04	0.85	12
BS-05	2.77	22
BS-06	3.45	24
BS-07	2.53	23
BS-08	0.73	12
BS-09	2.81	24
BS-10	-	-
BS-11	-	-
BS-12	4.41	29
BS-13	3.54	26
BS-14	3.99	28
BS-15	-	-
BS-16	-	-
BS-17	-	-
BS-18	-	-
BS-19	-	-
BS-20	-	-

Thus, it appears that a maximum of 29 feet of surcharge should be placed overlying the slit trenches to minimize the effects of settlement induced strain in the base liner system.

Written by: Rebeccca Flynn Date: 06 / 08 / 22 (YY MM DD) Reviewed by: PC Date: 06 / 11 / 3 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

CONCLUSIONS

Based on available information and the results of these consolidation analyses, the following can be concluded:

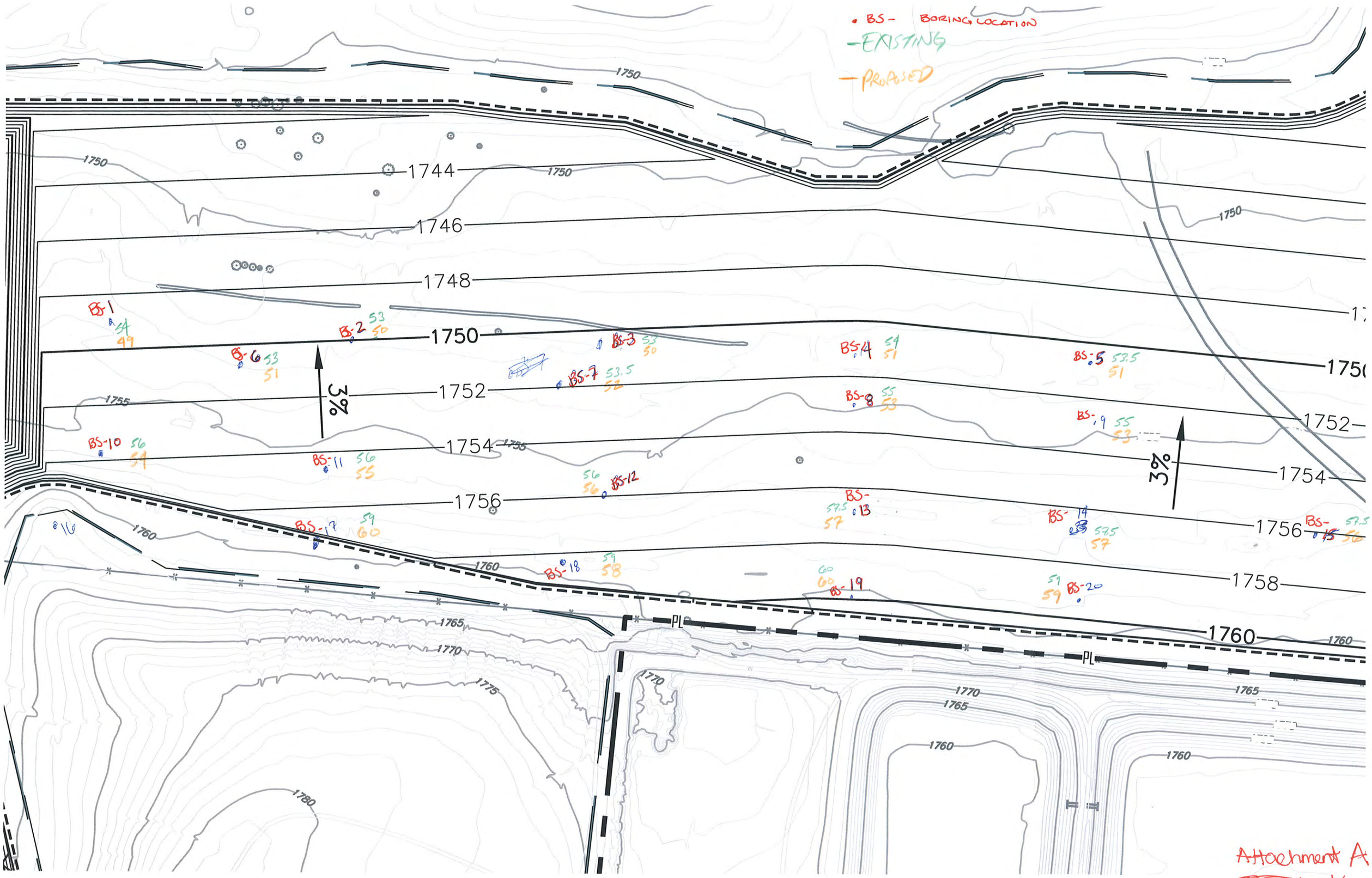
- The maximum differential settlement expected in the slit trenches of the North Mesa is approximately 4.96 ft;
- The height of surcharge required to pre-load the North Mesa is a maximum of 29 ft;
- The maximum strain expected in the slit trenches of the North Mesa, AFTER PRELOADING, is approximately 1% ; and
- The liner system and proposed grading can accommodate the expected differential settlement and strain.

REFERENCES

GeoSyntec (2005), "Permit Application for Class III Landfill, Henderson, Nevada", submitted to Clark County Health District, Las Vegas, Nevada. GeoSyntec Consultants, 2005.

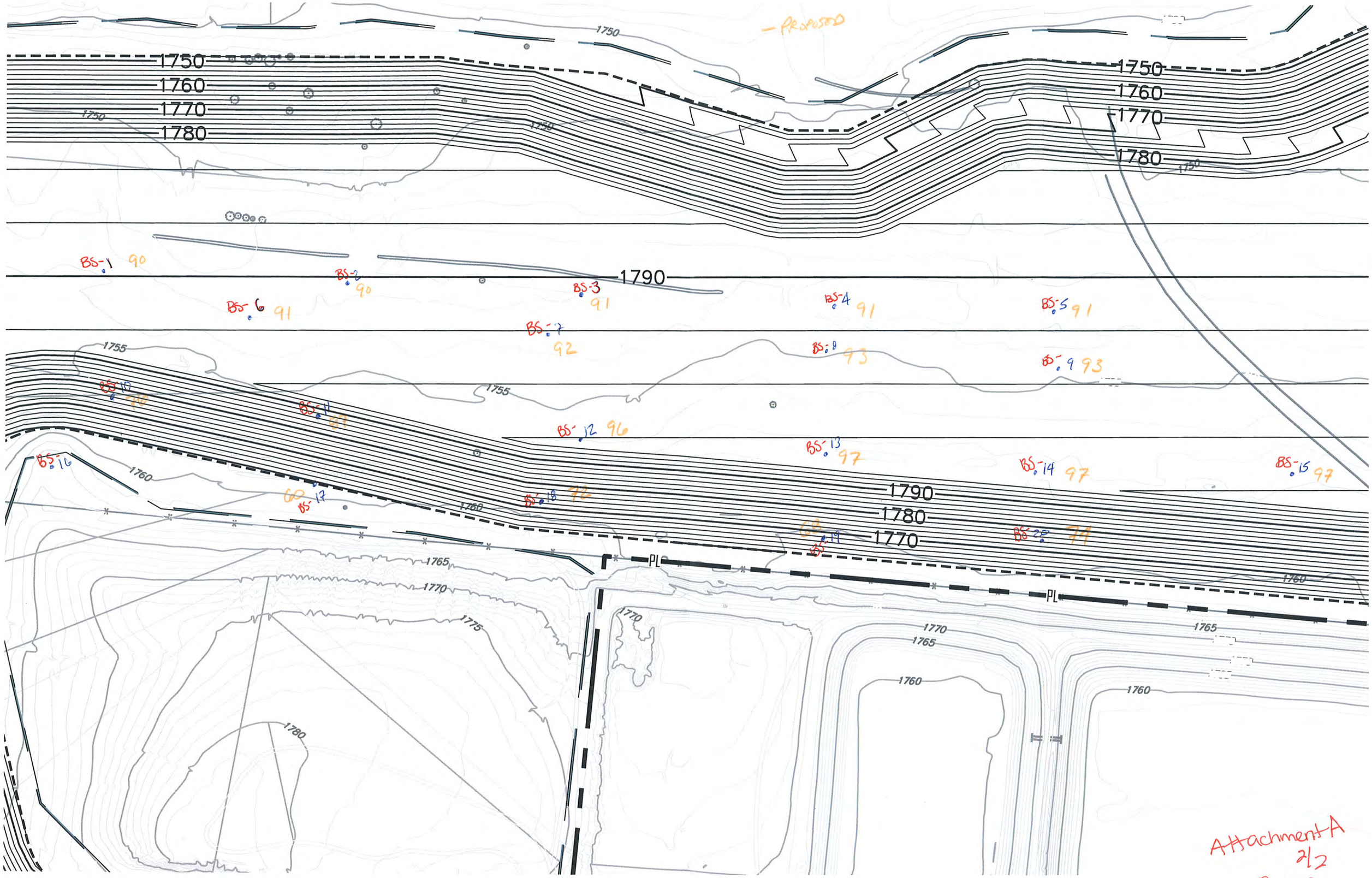
Converse (1999), "Preliminary Geotechnical and Geologic Report - Industrial Non-Hazardous Disposal Facility (Converse 1999)", prepared for Basic Management, Inc., October 1999.

Das, Braja M, (1998), "Principles of Geotechnical Engineering, 4th Edition", PWS Publishing Company, Boston, Massachusetts.



Attachment A

1/3



Attachment A
2/2

E.T.C
6/3/05

where e_O = initial void ratio at volume V_0. Thus, from Eqs. (8.11) through (8.14),

$$\Delta V = SA = \Delta e V_s = \frac{AH}{1 + e_O}\Delta e$$

or

$$S = H\frac{\Delta e}{1 + e_O} \tag{8.15}$$

For normally consolidated clays that exhibit a linear e–log p relationship (see Figure 8.9),

$$\Delta e = C_c[\log (p_O + \Delta p) - \log p_O] \tag{8.16}$$

where C_c = slope of the e–log p plot and is defined as the compression index. Substitution of Eq. (8.16) into Eq. (8.15) gives

$$\boxed{S = \frac{C_c H}{1 + e_O}\log\left(\frac{p_O + \Delta p}{p_O}\right)} \tag{8.17}$$

For a thicker clay layer, it is more accurate if the layer is divided into a number of sublayers and calculations for settlement are made separately for each sublayer. Thus, the total settlement for the entire layer can be given as

$$S = \sum\left[\frac{C_c H_i}{1 + e_O}\log\left(\frac{p_{Oi} + \Delta p_{ai}}{p_{Oi}}\right)\right]$$

where H_i = thickness of sublayer i
p_{Oi} = initial average effective overburden pressure for sublayer i
Δp_{ai} = increase of vertical pressure for sublayer i

In overconsolidated clays (see Figure 8.10), for $p_O + \Delta p \leq p_c$, field e–log p variation will be along the line hj, the slope of which will be approximately equal to that for the laboratory rebound curve. The slope of the rebound curve, C_s, is referred to as the *swell index,* so

$$\Delta e = C_s[\log (p_O + \Delta p) - \log p_O] \tag{8.18}$$

From Eqs. (8.15) and (8.18),

$$\boxed{S = \frac{C_s H}{1 + e_O}\log\left(\frac{p_O + \Delta p}{p_O}\right)} \tag{8.19}$$

If $p_O + \Delta p > p_c$, then

$$\boxed{S = \frac{C_s H}{1 + e_O}\log\frac{p_c}{p_O} + \frac{C_c H}{1 + e_O}\log\left(\frac{p_O + \Delta p}{p_c}\right)} \tag{8.20}$$

Attachment B, 1/2

GTC 6/3/05

The magnitude of the secondary consolidation can be calculated as

$$\boxed{S_s = C'_\alpha H \log\left(\frac{t_2}{t_1}\right)} \tag{8.27}$$

where

$$\boxed{C'_\alpha = \frac{C_\alpha}{1 + e_p}} \tag{8.28}$$

e_p = void ratio at the end of primary consolidation (see Figure 8.18)
H = thickness of clay layer

The general magnitudes of C'_α as observed in various natural deposits are given in Figure 8.19.

Secondary consolidation settlement is more important than primary consolidation in organic and highly compressible inorganic soils. In overconsolidated inorganic clays, the secondary compression index is very small and of less practical significance.

Several factors might affect the magnitude of secondary consolidation, some of which are not clearly understood (Mesri, 1973). The ratio of secondary to primary compression for a given thickness of soil layer depends on the ratio of the stress increment (Δp) to the initial effective stress (p). For small $\Delta p/p$ ratios, the secondary-to-primary compression ratio is larger.

EXAMPLE 8.4

For a normally consolidated clay layer in the field, the following are given:

- thickness of clay layer = 8.5 ft
- Void ratio (e_O) = 0.8
- Compression index (C_c) = 0.28
- Average effective pressure on the clay layer (p_O) = 2650 lb/ft^2
- Δp = 970 lb/ft^2
- Secondary compression index (C_α) = 0.02

What is the total settlement of the clay layer five years after the completion of primary consolidation settlement? (*Note:* Time for completion of primary settlement = 1.5 years.)

Solution From Eq. (8.28),

$$C'_\alpha = \frac{C_\alpha}{1 + e_p}$$

Attachment B 2/2

COFFMAN

GTC
6/3/05

MODELING SETTLEMENTS OF AN EXISTING MUNICIPAL SOLID WASTE LANDFILL SIDESLOPE USING AN EARTHEN SURCHARGE PILE

by

William L. Deutsch, Jr., Ph.D., P.E.
Technical Director
Geotechnical Engineering
Roy F. Weston, Inc.
West Chester, PA

Owen R. Esterly, P.E.
Facility Engineer
Chester County Solid Waste Authority, Lanchester Landfill

and

John Vitale
Assistant Engineer
Roy F. Weston, Inc.
West Chester, PA

INTRODUCTION

The large-scale field study discussed in this paper was completed for the purpose of determining design parameters for potential overfilling of existing landfill sideslopes at the Lanchester Landfill facility in Honey Brook, Pennsylvania. In particular, to maximize future waste disposal quantities at this facility, the Chester County Solid Waste Authority (CCSWA) is proposing to overfill additional municipal solid waste (MSW) within the available air space between the eastern sideslope of their closed Municipal Site Landfill and the adjacent western sideslope of Cell No. 1 of their currently active Area B landfill. In accordance with current Pennsylvania Department of Environmental Resources (DER) MSW landfill lining system regulations, CCSWA must initially install a geosynthetic lining/leachate collection system over the existing landfill sideslope prior to placement of additional waste at this location. The intent of this project was to simulate the total settlements and lateral movements of the existing waste mass when subjected to the additional applied stress of overfilled waste materials. These vertical and lateral movements would allow the maximum strains that these movements would generate within the geosynthetics of an overfill lining system to be calculated. Based on these calculated strains, appropriate geosynthetic reinforcement criteria for the overfill lining system could be developed. The reinforcement would protect the geosynthetic components of this lining system, in particular, the geomembrane, from excessive straining and possible tear resulting from underlying waste settlements.

To complete this study, an earthen surcharge pile, whose maximum height modeled the stress of the proposed overfilled waste, was constructed on the eastern sideslope of the closed Municipal Site Landfill following an initial survey of the topography of this slope.

Attachment C 1/2

GTC 6/9/05

Tabulated values of the independent variables are presented in Table 2 for each of the 64 nodal point locations. These values were subsequently input into Equation 2 in order to calculate the "modified compressibility index" (C′) of the waste. These values are also presented in Table 2 for each of the 64 nodal points.

It is evident from an inspection of Table 2 that the calculated values of C′ define a fairly limited range of values, with the exception of nodal points H1 through H8. In particular, the C′ values for the 56-nodal point database consisting of lines A through G varied from 0.15 to 0.39, averaging 0.22, while the C′ database consisting of H line values varied from 0.66 to 0.98, averaging 0.80. It is clear that the H line values are anomalous. This is believed to be due to the minimal and highly variable surcharge pile thicknesses that existed in the vicinity of the nodal points along the H line resulting from the sloping geometry of the back face of the pile at these locations. As a result, the surcharge loading varies considerably in the vicinity of each H line nodal point location. Therefore, there is significant error in assuming that the load at these nodal point locations can be accurately calculated using Equation 4. Based on the above discussion, it was believed appropriate to disregard the H line C′ values in generating pertinent statistics for this database as discussed in the following paragraph.

The 56-point database was analyzed statistically. A quantitative procedure was used to confirm that the database is normally distributed. The mean ($\bar{x}$), standard deviation (σ), variance (σ^2), and coefficient of variation (C_v) of the database were also calculated. These values are as follows:

$\bar{x} = 0.22$ $\qquad$ $\sigma^2 = 0.0016$

$\sigma = 0.0402$ $\qquad$ $C_v = 10.27\%$

.0402

Based on the properties of a normal distribution, it is known that 97.5% of the database lies below the random variable value of $\bar{x} + 2\sigma$. For this database, this value is equal to 0.22 + 2(0.402) = 0.30. Therefore, it can be concluded that calculation of surcharge load induced MSW settlement using Equation 1 with known values of H_w, $\bar{\sigma}_{o_w}$, and $\Delta\sigma_s$ will yield a conservative estimate of this settlement 97.5% of the time if a value of

$$\boxed{C' = \frac{C_c}{1 + e_o} = 0.30}$$

is used in the equation.

no relevance

II. Analysis Using a Multiple Linear Regression Model

The 56-point database was also analyzed using a multiple linear regression model, in which the dependent variable waste settlement (ΔH_w) was assumed to be a linear function of the independent variables waste thickness (H_w) and applied surcharge loading ($\Delta\sigma_s$). The form of this equation is as follows:

Attachment C, 2/2

GTC
6/3/05

Proceedings
Thirteenth Annual
Madison Waste Conference

Municipal & Industrial Waste

September 19-20, 1990

Department of Engineering Professional Development
University of Wisconsin-Madison
432 N. Lake Street
Madison, WI 53706
(608) 262-2061

These proceedings, and selected previous year proceedings, can be purchased at the above address for $35.

Printed on recycled paper.

Attachment D, 1/3

GTC 6/3/03

SETTLEMENT OF MUNICIPAL SOLID WASTE LANDFILLS

by Anders Bjarngard[1] and Lewis Edgers[2]

Abstract

Landfill settlement data from 24 case histories were collected and analyzed to establish engineering parameters for the prediction of landfill settlement. Several one-dimensional laboratory compression tests were performed to evaluate the load and time dependent compression characteristics of paper. Standard geotechnical engineering parameters were used to describe settlements.

Both the field and laboratory data show large initial settlements, followed by high logarithmic rates of delayed compression. Primary consolidation was generally not observed in the field or laboratory data. The field data suggest two phases of delayed compression, one dominated by mechanical compression and a later phase possibly showing the added effects of decomposition. The delayed (secondary) compression coefficient (C_α) ranged from 0.01 to 0.056 for the laboratory data and from 0.003 to 0.038 for the first phase of the field data. The second phase, at long time periods, showed field values of C_α as large as 0.51.

Introduction

The settlement of landfills is important in a number of ways. Settlement will affect the:

- design of protection systems such as caps, leachate collection and drainage systems.

---

1 Project Engineer, Goldberg-Zoino & Associates, Inc., Newton Upper Falls, Massachusetts.

2 Professor of Civil Engineering, Tufts University, Medford, Massachusetts.

Presented at the Thirteenth Annual Madison Waste Conference, September 19-20, 1990, Department of Engineering Professional Development, University of Wisconsin-Madison.

KUHI F. WE ... LIBRARY ...

Attachment D, 2/3

TABLE 6
COMPARISON OF FIELD AND LABORATORY SETTLEMENT PARAMETERS

	INITIAL SETTLEMENTS %		C_α	
	Avg.	Range	Avg.	Range
Field Case Histories	6.3	3-11.8	0.019 0.125	0.003-0.038 (min) 0.017-0.51 (max)
Laboratory Data	6.4[1] 2.5[2]	3.6-11[1] 0.7-5.4[2]	0.026	0.010-0.056

1. Initial settlements from the first load increment.
2. Initial settlements excluding first load increment.

Conclusions

Settlement of MSW landfills can be large and continue for very long time periods. This settlement is believed to occur due to mechanical compression, ravelling of particles and decomposition of the waste. This paper has reviewed available MSW landfill settlement data, compared these data with the results of one-dimensional laboratory tests on paper specimens, and quantified the measured compressions.

Review of settlement data from MSW landfills has shown little settlement due to primary consolidation. On the other hand, the long-term settlements due to mechanical effects (secondary compression), possible ravelling, piping or collapse, and possible chemical and biological decomposition develop over a long period of time and may become large. They are very difficult to predict because they are highly dependent upon site-specific factors such as moisture, density and composition which are usually not well defined.

The complex time-settlement behavior of landfills has been idealized by separating it into three phases: initial compression; early delayed compression; and late delayed compression. In the first phase, settlements are believed to occur because of rapid compression of the refuse and reduction of the gas voids. In the second phase, settlements are believed to be caused mostly by long-term reorientation, slippage at the particle contacts, and delayed compression of some of the MSW constituents. It is believed that in the third phase, the rate of delayed compression is greatly increased by decomposition. Ravelling may also be a contributing factor to the delayed compression phases.

The following measures of landfill settlement were observed from the case histories:

Basic Remediation Company
Corrective Action Management Unit
Henderson, Nevada

Consolidation Calculation

Material Properties

C_{cr}	0.3	*Note 1*
$C_{\alpha r}$	0.019	*Note 1*
e_o	0	
γ_{waste}	85	pcf
$\gamma_{soil\ overburden}$	115	pcf
$\gamma_{soil\ waste}$	136	pcf
$\gamma_{cover\ system}$	125	pcf

Secondary Consolidation Time

time t_1	26	years
time t_2	59	years

Location	Depth to Waste (ft)	Depth to Native (ft)	Initial Waste Thickness (ft) H_{waste}	Soil Overburden Thickness (ft) $H_{soil\ overburden}$	Initial Overburden Presure (psf) p_0	Waste Soil Thickness (ft) $H_{soil\ waste}$	Cover System Thickness (ft) $H_{cover\ system}$	Change Overburden Pressure (psf) Δp	Primary Settlement (ft) S_P	Secondary Settlement (ft) S_S	Total Settlement (ft) S_T	Approximate Elevations: Existing Grade	Approximate Elevations: Base Liner Grade	Approximate Elevations: Final Cover Grade
MWH - BRC - BS-01	3	4	1	3	388	34	2	4,874	0.34	0.01	0.35	1754.0	1749.0	1790.0
MWH - BRC - BS-02	13	19	6	13	1,750	35	2	5,010	1.06	0.04	1.10	1753.0	1750.0	1790.0
MWH - BRC - BS-03	8	27	19	8	1,728	36	2	5,146	3.42	0.11	3.53	1753.0	1750.0	1791.0
MWH - BRC - BS-04	11	21	10	11	1,690	35	2	5,010	1.80	0.06	1.86	1754.0	1751.0	1791.0
MWH - BRC - BS-05	5	23	18	5	1,340	36	2	5,078	3.68	0.10	3.78	1753.5	1751.0	1791.0
MWH - BRC - BS-06	3	23	20	3	1,195	36	2	5,146	4.35	0.11	4.46	1753.0	1751.0	1791.0
MWH - BRC - BS-07	7	25	18	7	1,570	37	2	5,214	3.44	0.10	3.54	1753.5	1752.0	1792.0
MWH - BRC - BS-08	19	31	12	19	2,695	36	2	5,146	1.67	0.07	1.74	1755.0	1753.0	1793.0
MWH - BRC - BS-09	9	31	22	9	1,970	36	2	5,146	3.69	0.13	3.82	1755.0	1753.0	1793.0
MWH - BRC - BS-10	0	0	0	0	0	18	2	2,698	0.00	0.00	0.00	1756.0	1754.0	1776.0
MWH - BRC - BS-11	5	29	24	5	1,595	29	2	4,194	4.04	0.14	4.18	1756.0	1755.0	1787.0
MWH - BRC - BS-12	3	29	26	3	1,450	38	2	5,418	5.27	0.15	5.42	1756.0	1756.0	1796.0
MWH - BRC - BS-13	3	23	20	3	1,195	38	2	5,350	4.44	0.11	4.55	1757.5	1757.0	1797.0
MWH - BRC - BS-14	5	31	26	5	1,680	38	2	5,350	4.85	0.15	5.00	1757.5	1757.0	1797.0
MWH - BRC - BS-15	3	13	10	3	770	38	2	5,350	2.71	0.05	2.76	1757.5	1756.0	1797.0
MWH - BRC - BS-16	3	8	5	3	558	0	0	0	0.00	0.04	0.04	1762.5	1762.5	1762.5
MWH - BRC - BS-17	3	25	22	3	1,280	0	0	0	0.00	0.15	0.15	1759.0	1760.0	1760.0
MWH - BRC - BS-18	8	19	11	8	1,388	11	2	1,746	1.17	0.07	1.24	1759.0	1758.0	1772.0
MWH - BRC - BS-19	9	30	21	9	1,928	6	2	1,066	1.21	0.14	1.35	1760.0	1760.0	1768.0
MWH - BRC - BS-20	13	21	8	13	1,835	13	2	2,018	0.78	0.05	0.83	1759.0	1759.0	1774.0

Note 1.

C_c' = 0.01 to 0.04, $C_\alpha C$ = 0.001 to 0.006 - low organic waste, C&D - "Settlement Evaluation for Cap Closure Performance", Zamiskie et. Al.

C_c' = 0.30 - MSW - "Modeling Settlements of an Existing MSW Landfill Side Slope Using an Earthen Surcharge Pile", Deutsch et. Al.

C_c' = 0.063, $C_\alpha C$ = 0.019 - MSW LFs - "Settlement of Municipal Waste Landfills", Bjarngard et. Al.

High values selected to reflect the uncompacted nature of the waste materials placed in the "slit trenches".

- input value

Basic Remediation Company
Corrective Action Management Unit
Henderson, Nevada

Strain Calculation				
Maximum Allowable Strain	1.00%			
Location	**Total Settlement (ft) S_T**	**Distance to Native** *Note 1* **(ft) L**	**Strain (%) ε**	**Surcharge Settlement (Required) (ft)**
MWH - BRC - BS-01	0.35	20	0.02%	0.00
MWH - BRC - BS-02	1.10	20	0.15%	0.00
MWH - BRC - BS-03	3.53	20	1.55%	2.52
MWH - BRC - BS-04	1.86	10	1.72%	0.85
MWH - BRC - BS-05	3.78	10	6.91%	2.77
MWH - BRC - BS-06	4.46	10	9.50%	3.45
MWH - BRC - BS-07	3.54	10	6.08%	2.53
MWH - BRC - BS-08	1.74	10	1.50%	0.73
MWH - BRC - BS-09	3.82	10	7.05%	2.81
MWH - BRC - BS-10	0.00	38	0.00%	0.00
MWH - BRC - BS-11	4.18	38	0.60%	0.00
MWH - BRC - BS-12	5.42	20	3.61%	4.41
MWH - BRC - BS-13	4.55	20	2.56%	3.54
MWH - BRC - BS-14	5.00	20	3.08%	3.99
MWH - BRC - BS-15	2.76	20	0.95%	0.00
MWH - BRC - BS-16	0.04	23	0.00%	0.00
MWH - BRC - BS-17	0.15	23	0.00%	0.00
MWH - BRC - BS-18	1.24	23	0.15%	0.00
MWH - BRC - BS-19	1.35	13	0.54%	0.00
MWH - BRC - BS-20	0.83	13	0.20%	0.00

Note 1
Half the width of the "Slit Trench".

- input value

Basic Remediation Company
Corrective Action Management Unit
Henderson, Nevada

Surcharge Height Calculation

Material Properties		
C_{cr}	0.3	*Note 1*
γ_{waste}	85	pcf
$\gamma_{soil\ overburden}$	115	pcf
$\gamma_{surcharge}$	135	pcf

Location	Depth to Waste (ft)	Depth to Native (ft)	Initial Waste Thickness (ft) H_{waste}	Soil Overburden Thickness (ft) $H_{soil\ overburden}$	Initial Overburden Presure (psf) p_0	Settlement Required (ft)	Surcharge Height (ft) $H_{surcharge}$	Minimum Surcharge Elevation
MWH - BRC - BS-01	3	4	1	3	388	0.00	0	1,754
MWH - BRC - BS-02	13	19	6	13	1,750	0.00	0	1,753
MWH - BRC - BS-03	8	27	19	8	1,728	2.52	23	1,776
MWH - BRC - BS-04	11	21	10	11	1,690	0.85	12	1,766
MWH - BRC - BS-05	5	23	18	5	1,340	2.77	22	1,776
MWH - BRC - BS-06	3	23	20	3	1,195	3.45	24	1,777
MWH - BRC - BS-07	7	25	18	7	1,570	2.53	23	1,776
MWH - BRC - BS-08	19	31	12	19	2,695	0.73	12	1,767
MWH - BRC - BS-09	9	31	22	9	1,970	2.81	24	1,779
MWH - BRC - BS-10	0	0	0	0	0	0.00	0	1,756
MWH - BRC - BS-11	5	29	24	5	1,595	0.00	0	1,756
MWH - BRC - BS-12	3	29	26	3	1,450	4.41	29	1,785
MWH - BRC - BS-13	3	23	20	3	1,195	3.54	26	1,783
MWH - BRC - BS-14	5	31	26	5	1,680	3.99	28	1,785
MWH - BRC - BS-15	3	13	10	3	770	0.00	0	1,758
MWH - BRC - BS-16	3	8	5	3	558	0.00	0	1,763
MWH - BRC - BS-17	3	25	22	3	1,280	0.00	0	1,759
MWH - BRC - BS-18	8	19	11	8	1,388	0.00	0	1,759
MWH - BRC - BS-19	9	30	21	9	1,928	0.00	0	1,760
MWH - BRC - BS-20	13	21	8	13	1,835	0.00	0	1,759

- input value

Section 3
Base Liner Construction Quality Assurance Plan

CONSTRUCTION QUALITY ASSURANCE PLAN
FOR THE
CONSTRUCTION OF

BASE LINER SYSTEM
AT
CORRECTIVE ACTION MANAGEMENT UNIT
BASIC REMEDIATION COMPANY
HENDERSON, NEVADA

Prepared for:

Basic Remediation Company
875 West Warm Springs Road
Henderson, Nevada 89015
(702) 567-0400

Prepared by:

GeoSyntec Consultants
11305 Rancho Bernardo Road, Suite 101
San Diego, California 92127
(858) 674-6559

3 November 2006

TABLE OF CONTENTS

1. INTRODUCTION 1

1.1 Terms of Reference 1
1.2 Purpose and Scope of the Construction Quality Assurance Plan 1
1.3 References 2
1.4 Organization of the Construction Quality Assurance Plan 2

2. DEFINITIONS RELATING TO CONSTRUCTION QUALITY ASSURANCE 3

3. PARTIES INVOLVED WITH CONSTRUCTION QUALITY ASSURANCE 4

3.1 Engineer 4
3.2 Project Manager 4
3.3 Contractor 4
3.4 Resin Supplier 5
3.5 Geosynthetics Manufacturer 5
3.6 Geosynthetic Installer 6
3.7 CQA Consultant 7
3.8 Surveyor 8
3.9 CQA Laboratory 8

4. CQA CONSULTANTS PERSONNEL ORGANIZATION AND DUTIES 10

4.1 Overview 10
4.2 CQA Personnel 11
4.2.1 CQA Officer 11
4.2.2 CQA Site Manager 12

5. SITE AND PROJECT CONTROL 14

5.1 Project Coordination Meetings 14
5.1.1 Resolution Meeting 14
5.1.2 Pre-Construction Meeting 15
5.1.3 Progress Meetings 17
5.1.4 Problem or Work Deficiency Meeting 17

6. DOCUMENTATION 18

6.1 Overview 18
6.2 Daily Recordkeeping 18
6.3 Construction Problems and Resolution Data Sheets 20
6.4 Photographic Documentation 21
6.5 Design and/or Specifications Changes 21
6.6 CQA Report 21

7. EARTHWORKS 24

7.1 Introduction 24
7.2 Testing Activities 24
7.2.1 Sample Frequency 25
7.2.2 Sample or Test Location Selection 25
7.3 CQA Monitoring Activities 26
7.3.1 Earthwork 26
7.3.2 Engineered Fill Material 27
7.3.3 Prepared Subgrade 28
7.3.4 Operations Layer Material 28
7.4 Deficiencies 29
7.4.1 Notification 29
7.4.2 Repairs and Re-Testing 29

8. DRAINAGE AGGREGATE 31

8.1 Introduction 31
8.2 Testing Activities 31
8.2.1 Sample Frequency 31
8.2.2 Sample Selection 32
8.3 CQA Monitoring Activities 32
8.3.1 Drainage Aggregate 32
8.4 Deficiencies 33
8.4.1 Notification 33
8.4.2 Repairs and Re-testing 33

9. HIGH DENSITY POLYETHYLENE (HDPE) PIPE AND FITTINGS 34

9.1 Material Requirements 34
9.2 Manufacturer 34
9.2.1 Submittals 34
9.2.2 Identification 34

9.3 Handling and Laying 35
9.4 Joints 35

10. GEOMEMBRANE 37

10.1 General 37
10.2 Geomembrane Material Conformance 37
10.2.1 Introduction 37
10.2.2 Review of Quality Control 38
10.2.3 Conformance Testing 40
10.3 Delivery 40
10.3.1 Transportation and Handling 40
10.3.2 Storage 41
10.4 Geomembrane Installation 41
10.4.1 Introduction 41
10.4.2 Earthwork 41
10.4.3 Geomembrane Placement 42
10.4.4 Field Seaming 46
10.4.5 Defects and Repairs 59
10.4.6 Lining System Acceptance 61

11. GEOTEXTILE 63

11.1 Introduction 63
11.2 Manufacturing 63
11.3 Labeling 64
11.4 Shipment and Storage 64
11.5 Conformance Testing 65
11.5.1 Tests 65
11.5.2 Sampling Procedures 65
11.5.3 Test Results 65
11.5.4 Conformance Sample Failure 65
11.6 Handling and Placement 66
11.7 Seams and Overlaps 67
11.8 Repair 67
11.9 Placement of Soil or Aggregate Materials 68

12. GEOSYNTHETIC CLAY LINER (GCL) 69

12.1 Introduction 69

12.2 Manufacturing 69
12.3 Labeling 70
12.4 Shipment and Storage 70
12.5 Conformance Testing 70
12.5.1 Tests 70
12.5.2 Conformance Sample Failure 71
12.6 GCL Delivery and Storage 72
12.7 GCL Installation 72

13. GEOCOMPOSITE 74

13.1 Introduction 74
13.2 Manufacturing 74
13.3 Labeling 74
13.4 Shipment and Storage 75
13.5 Conformance Testing 75
13.5.1 Tests 75
13.5.2 Sampling Procedures 76
13.5.3 Test Results 76
13.5.4 Conformance Test Failure 76
13.6 Handling and Placement 77
13.7 Drainage composite Seams and Overlaps 78
13.8 Repair 78
13.9 Placement of Soil Materials 79

14. SURVEYING 80

14.1 Survey Control 80
14.2 Precision and Accuracy 80
14.3 Lines and Grades 80
14.4 Frequency and Spacing 81
14.5 Documentation 82

1. INTRODUCTION

1.1 Terms of Reference

GeoSyntec Consultants (GeoSyntec) has prepared this Construction Quality Assurance (CQA) Plan for the construction of the Corrective Action Management Unit (CAMU) Base Liner System for Basic Remediation Company (BRC) located in Henderson, Nevada. Hereinafter, the CAMU construction is referred to as the Project.

This CQA Plan was prepared by Mr. Gregory T. Corcoran, P.E. of GeoSyntec Consultants (GeoSyntec) under the direction of Mr. James A. McKelvey III, P.E. In general accordance with the peer review policies of the firm, Mr. James A. McKelvey III, P.E. of GeoSyntec was responsible for senior peer review of the work presented in this plan.

1.2 Purpose and Scope of the Construction Quality Assurance Plan

The purpose of the CQA Plan is to address the CQA procedures and monitoring requirements for construction of the Project. The CQA Plan is intended to: (i) define the responsibilities of parties involved with the construction; (ii) provide guidance in the proper construction of the major components of the Project; (iii) establish testing protocols; (iv) establish guidelines for construction documentation; and (v) provide the means for assuring that the Project is constructed in conformance to the *Technical Specifications*, permit conditions, applicable regulatory requirements, and *Construction Drawings*.

This CQA Plan addresses the soils and geosynthetic components of the liner system for the project. The soils, geosynthetic, and appurtenant components include engineered fill, prepared subgrade, operations layer material, drainage aggregate, geosynthetic clay liner, geomembrane, geotextile, geocomposite, and polyethylene pipe. It should be emphasized that care and documentation are required in the placement and compaction of the soils and aggregate and in the production and installation of the geosynthetic materials placed during construction. The CQA Plan, therefore, delineates the procedures to be followed for monitoring construction of these materials.

The scope of this CQA Plan includes the CQA of the soil and geosynthetic components of the Project. The CQA monitoring activities during the selection,

evaluation, treatment, placement, and compaction of soils for earthworks, and drainage aggregate are included in the scope of this plan. The CQA protocols applicable to manufacturing, shipping, handling, and installing all geosynthetic materials are also included. However, this CQA Plan does not specifically address either installation specifications or specification of soils and geosynthetic materials as these requirements are addressed in the *Technical Specifications*.

1.3 References

The CQA Plan includes references to test procedures in the latest editions of the American Society for Testing and Materials (ASTM).

1.4 Organization of the Construction Quality Assurance Plan

The remainder of the CQA Plan is organized as follows:

- Section 2 presents definitions relating to CQA;
- Section 3 describes the parties involved with the CQA;
- Section 4 describes the responsibilities of the CQA personnel;
- Section 5 describes site and project control requirements;
- Section 6 presents CQA documentation;
- Section 7 presents CQA of earthworks;
- Section 8 presents CQA of the drainage aggregates;
- Section 9 presents CQA of the pipe and fittings;
- Section 10 presents CQA of the geomembrane;
- Section 11 presents CQA of the geotextile;
- Section 12 presents CQA of the geosynthetic clay liner;
- Section 13 presents CQA of the geocomposite; and
- Section 16 presents CQA surveying.

2. DEFINITIONS RELATING TO CONSTRUCTION QUALITY ASSURANCE

This CQA Plan is devoted to Construction Quality Assurance. In the context of this document, Construction Quality Assurance and Construction Quality Control are defined as follows:

Construction Quality Assurance (CQA) - A planned and systematic pattern of means and actions designed to assure adequate confidence that materials and/or services meet contractual and regulatory requirements and will perform satisfactorily in service.

Construction Quality Control (CQC) - Those actions which provide a means to measure and regulate the characteristics of an item or service in relation to contractual and regulatory requirements.

In the context of this document:

- CQA refers to means and actions employed by the CQA Consultant to assure conformity of the Project "Work" with this CQA Plan, the *Drawings*, and the *Technical Specifications*.

- Construction Quality Control refers to those actions taken by the Contractor, Manufacturer, or Geosynthetic Installer to verify that the materials and the workmanship meet the requirements of this CQA Plan, the *Drawings*, and the *Technical Specifications*. In the case of soil components, CQC is combined with CQA and is provided by the CQA Consultant. In the case of the geosynthetic components and piping of the Work, CQC is provided by the Manufacturer and Geosynthetic Installer and the Contractor. CQA testing of soil, pipe, and geosynthetic components is provided by the CQA Consultant.

3. PARTIES INVOLVED WITH CONSTRUCTION QUALITY ASSURANCE

3.1 Engineer

Responsibilities

The Engineer is responsible for the design, *Drawings*, and *Technical Specifications* for the Project Work. In this CQA Plan, the term "Engineer" refers to Parsons Engineering Science, Inc. (Parsons) and GeoSyntec.

Qualifications

The Engineer of Record shall be a qualified engineer, registered as required by Nevada state regulations. The Engineer should have expertise, which demonstrates significant familiarity with piping, geosynthetics and soils, as appropriate, including design and construction experience related to landfill liner systems.

3.2 Project Manager

Responsibilities

The Project Manager is responsible for implementing the design, and overseeing subcontractors. In this CQA Plan, the term "Project Manager" refers to a qualified BRC employee.

Qualifications

The Project Manager shall be a qualified engineer having familiarity with earthwork construction and installation of geosynthetic materials.

3.3 Contractor

Responsibilities

In this CQA Plan, Contractor refers to an independent party or parties, contracted by the Owner, performing the Work in general accordance with this CQA

Plan, the *Drawings*, and the *Technical Specifications*. The Contractor will be responsible for the installation of the soils and geosynthetic components of the liner system. This work will include excavation, placement and compaction of engineered fill and prepared subgrade, placement of drainage aggregate and native soil (operations layer material), installation and of piping and concrete manhole, installation of temporary erosion control features, and coordination of work with the Geosynthetic Installer and other subcontractors.

The Contractor will be responsible for constructing the liner system and appurtenant components in general accordance with the *Drawings* and complying with the quality control requirements specified in the *Technical Specifications*.

Qualifications

Qualifications of the Contractor are specific to the construction contract. The Contractor should have a demonstrated history of successful earthworks construction and maintain current state and federal licenses as appropriate.

3.4 Resin Supplier

Responsibilities

The Resin Supplier produces and delivers the resin to the Geosynthetics Manufacturer.

Qualifications

Qualifications of the Resin Supplier are specific to the Manufacturer's requirements. The Resin Supplier will have a demonstrated history of providing resin with consistent properties.

3.5 Geosynthetics Manufacturer

Responsibilities

The Manufacturer is responsible for the production of finished material (geomembrane, geotextile, geosynthetic clay liner, geocomposite, pipe, and other specified material) from appropriate raw materials.

Qualifications

The Manufacturer(s) will be able to provide sufficient production capacity and qualified personnel to meet the demands of the project. The Manufacturer(s) must be a well established firm(s) that meet the requirements identified in the *Technical Specifications*.

3.6 Geosynthetic Installer

Responsibilities

The Geosynthetic Installer is responsible for field handling, storage, placement, seaming, loading or anchoring against wind uplift, and other aspects of the geosynthetic material installation. The Geosynthetic Installer may also be responsible for specialized construction tasks (i.e., including construction of anchor trenches for the geosynthetic materials).

Qualifications

The Geosynthetic Installer will be trained and qualified to install the geosynthetic materials of the type specified for this project. The Geosynthetic Installer shall meet the qualification requirements identified in the *Technical Specifications*.

3.7 CQA Consultant

Responsibilities

The CQA Consultant is a party, independent from the Contractor, Manufacturer, and Geosynthetic Installer, who is responsible for observing, testing, and documenting activities related to the CQC and CQA of the earthwork, piping, and the geosynthetic components used in the construction of the Project. The CQA Consultant will also be responsible for issuing a CQA report at the completion of the Project construction, which details the earthworks, piping, and geosynthetic installation activities and associated CQA activities. The CQA report will be signed and sealed by the CQA Officer who will be a Professional Engineer registered in the State of Nevada.

The CQA Consultant will be responsible for obtaining and testing representative samples of all components used in construction of the Project as required by this CQA Plan and *Technical Specifications*. All tests will be conducted in general accordance with ASTM or other applicable state or federal standards. Test results must be submitted to the Project Manager within a reasonable timeframe, which will not impede or delay construction of the Project. The CQA Consultant will be responsible for inspecting all earthwork, piping, and geosynthetic operations to verify that the components are installed in general accordance with this CQA Plan and *Technical Specifications*.

Qualifications

The CQA Consultant is a well established firm specializing in geotechnical and geosynthetic engineering and possess the equipment, personnel, and licenses necessary to conduct the geotechnical and geosynthetic tests required by the project plans and *Technical Specifications*. The CQA Consultant will provide qualified staff for the project, as necessary, which will include, at a minimum, a CQA Officer, and a CQA Site Manager. The CQA Officer will be a professionally licensed engineer as required by Nevada State regulations.

The CQA Consultant will be experienced with earthwork construction and the installation of geosynthetic materials similar to those materials used in construction of the Project. The CQA Consultant will be experienced in the preparation of CQA documentation including CQA Plans, field documentation, field testing procedures,

laboratory testing procedures, construction specifications, construction drawings, and CQA reports.

The CQA Site Manager will be specifically familiar with the construction of earthworks, piping, and the installation of geosynthetic materials and will be trained by the CQA Consultant in the duties of a CQA Site Manager.

3.8 Surveyor

Responsibilities

The Surveyor is a party, independent from the Contractor, Manufacturer, and Geosynthetic Installer, that is responsible for surveying, documenting, and verifying the location of all significant components of the Work. The Surveyor's work is coordinated and employed by the Owner. The Surveyor is responsible for issuing record drawings of the construction.

Qualifications

The Surveyor will be a well established surveying company with at least 3 years experience in the profession of surveying services in the State of Nevada. The Surveyor will be a licensed professional as required by the State of Nevada regulations. The Surveyor shall be fully equipped and experienced in the use of total stations and AutoCAD Version 14. All surveying will be performed under the direct supervision of the Owner.

3.9 CQA Laboratory

Responsibilities

The CQA Laboratory is a party, independent from the Contractor, Manufacturer and Geosynthetic Installer, that is responsible for conducting tests in general accordance with ASTM and other applicable test standards on samples of geosynthetic materials, soil, and in the field and in either an on-site or off-site laboratory.

Qualifications

The CQA Laboratory will have experience in testing soils and geosynthetic materials and will be familiar with ASTM and other applicable test standards. The CQA Laboratory will be capable of providing test results within a maximum of seven days of receipt of samples and will maintain that capability throughout the duration of earthworks construction and geosynthetic materials installation. The CQA Laboratory will also be capable of transmitting geosynthetic destructive test results within 24 hours of receipt of samples and will maintain that capability throughout the duration of geosynthetic material installation.

4. CQA CONSULTANTS PERSONNEL ORGANIZATION AND DUTIES

4.1 Overview

The CQA Officer will provide supervision within the scope of work of the CQA Consultant. The scope of work for the CQA Consultant includes monitoring of construction activities including the following:

- excavation and screening of materials;
- placement and compaction of engineered fill, surcharge prepared subgrade, and operations layer material;
- installation of geotextile;
- installation of geosynthetic clay liner;
- installation of geomembrane;
- installation of drainage aggregate;
- installation of geocomposite;
- installation of cast-in-place concrete; and
- installation of piping.

The duties of the CQA personnel are discussed in the remainder of this section.

4.2 CQA Personnel

For construction of the Project, the CQA Consultant's personnel will include:

- the CQA Officer, who operates from the office of the CQA Consultant and who conducts periodic visits to the site as required; and

- the CQA Site Manager, who is located at the site.

The duties of the CQA Personnel are discussed in the following subsections.

4.2.1 CQA Officer

The CQA Officer shall supervise and be responsible for monitoring and CQA activities relating to the construction of the earthworks, piping, and installation of the geosynthetic materials of the Project. Specifically, the CQA Officer:

- reviews the project design, this CQA Plan, *Drawings*, and *Technical Specifications*;

- reviews other site-specific documentation; unless otherwise agreed, such reviews are for familiarization and for evaluation of constructability only, and hence the CQA Officer and the CQA Consultant assume no responsibility for the liner system design;

- reviews and approves the Geosynthetic Installer's QC Plan;

- attends resolution and/or pre-construction meetings as needed;

- administers the CQA program (i.e., provides supervision of and manages on-site CQA personnel, reviews field reports, and provides engineering review of CQA related activities);

- provides quality control of CQA documentation and conducts site visits;
- reviews the record drawings; and
- with the CQA Site Manager, prepares the CQA report documenting that the project was constructed in general accordance with the Construction Documents.

4.2.2 CQA Site Manager

The CQA Site Manager:

- acts as the on-site representative of the CQA Consultant;
- attends CQA-related meetings (e.g., resolution, pre-construction, daily, weekly (or designates a representative to attend the meeting));
- prepares or oversees the ongoing preparation of the record drawings;
- reviews test results provided by Contractor;
- assigns locations for testing and sampling;
- oversees the collection and shipping of laboratory test samples;
- reviews results of laboratory testing and makes appropriate recommendations;
- reviews the calibration and condition of on-site CQA equipment;
- prepares a daily summary report for the project;
- reviews the Manufacturer's QC documentation;

- reviews the Geosynthetic Installer's personnel Qualifications for conformance with those pre-approved for work on site;

- notes in the daily summary report and reports to the CQA Officer and Project Manager on-site activities that could result in damage to the geosynthetic materials or other completed work;

- reports unresolved deviations from the CQA Plan, *Drawings*, and *Technical Specifications* to the Project Manager; and

- assists with the preparation of the CQA report.

5. SITE AND PROJECT CONTROL

5.1 Project Coordination Meetings

Meetings of key project personnel are necessary to assure a high degree of quality during installation, and promote clear, open channels of communication. Therefore, Project Coordination Meetings are an essential element in the success of the project. Several types of Project Coordination Meetings are described below, including: (i) resolution meetings; (ii) pre-construction meetings; (iii) progress meetings; and (iv) problem or work deficiency meetings.

5.1.1 Resolution Meeting

Following the completion of the design, *Drawings*, and *Technical Specifications* for the project and prior to the start of construction, a Resolution Meeting will be held. This meeting may include the CQA Officer, the CQA Site Manager, the Engineer, and the Project Manager.

The purpose of this meeting is to begin planning for coordination of construction tasks, anticipate installation problems which might cause difficulties and delays in construction, and, above all, present the CQA Plan to the parties involved. It is very important that the criteria regarding testing, repair, and other CQA activities be known and accepted by the parties involved in the work prior to the installation of geosynthetic materials and construction of the soil components for the Project.

The first part of the Resolution Meeting may be devoted to a review of the *Drawings* and *Technical Specifications* for familiarity. This is different from the peer review of the design, including design calculations, which will have been carried out previously.

The Resolution Meeting may include the following activities:

- distribute relevant documents to all parties;
- review critical design details of the project;

- review this CQA Plan;
- review the Drawings and Technical Specifications;
- make appropriate modifications to the design criteria, *Drawings*, and *Technical Specifications* so that the fulfillment of the design specifications or performance standards can be determined through the implementation of the CQA Plan;
- reach a consensus on the quality control procedures, especially on methods of evaluating acceptability of the soils and geosynthetic materials;
- assign the responsibilities of each party;
- establish work area security and health and safety protocol;
- confirm the methods for documenting observations, reporting, and distributing documents and reports; and
- confirm the lines of authority and communication.

The Project Manager will appoint one of the meeting attendees to record the discussions and decisions of the Resolution Meeting. The record of the meeting will be documented by the appointee in the form of meeting minutes, which will be subsequently distributed to all attendees.

5.1.2 Pre-Construction Meeting

A Pre-Construction Meeting will be held at the site prior to construction of the Project. As a minimum, the Pre-Construction Meeting will be attended by the Contractor, the Geosynthetic Installer's Superintendent, the CQA Consultant, the Engineer, and the Project Manager.

Specific items for discussion at the pre-construction meeting include the following:

- appropriate modifications or clarifications to the CQA Plan;
- the Drawings and Technical Specifications;
- the responsibilities of each party;
- lines of authority and communication;
- methods for documenting and reporting, and for distributing documents and reports;
- acceptance and rejection criteria;
- protocols for testing;
- protocols for handling deficiencies, repairs, and re-testing;
- the time schedule for all operations;
- procedures for packaging and storing archive samples;
- panel layout and numbering systems for panels and seams;
- seaming procedures;
- repair procedures; and
- soil stockpiling locations.

The Project Manager will conduct a site tour to observe the current site conditions and to review construction material and equipment storage locations. A person in attendance at the meeting will be appointed by the Project Manager to record the discussions and decisions of the meeting in the form of meeting minutes. Copies of the meeting minutes will be distributed to all attendees.

5.1.3 Progress Meetings

Progress meetings will be held between the CQA Site Manager, the Contractor, Project Manager, and other concerned parties participating in the construction of the project. This meeting will include discussions on the current progress of the project, planned activities for the next week, and revisions to the work plan and/or schedule. The meeting will be documented in meeting minutes prepared by a person designated by the CQA Site Manager at the beginning of the meeting. Within 2 working days of the meeting, draft minutes will be transmitted to representatives of parties in attendance for review and comment. Corrections and/or comments to the draft minutes shall be made within 2 working days of receipt of the draft minutes to be incorporated in the final meeting minutes.

5.1.4 Problem or Work Deficiency Meeting

A special meeting will be held when and if a problem or deficiency is present or likely to occur. The meeting will be attended by the Contractor, the Project Manager, the CQA Site Manager, and other parties as appropriate. If the problem requires a design modification, the Engineer should either be present at, consulted prior to, or notified immediately upon conclusion of this meeting. The purpose of the work deficiency meeting is to define and resolve the problem or work deficiency as follows:

- define and discuss the problem or deficiency;
- review alternative solutions;
- select a suitable solution agreeable to all parties; and
- implement an action plan to resolve the problem or deficiency.

The Project Manager will appoint one attendee to record the discussions and decisions of the meeting. The meeting record will be documented in the form of meeting minutes and copies will be distributed to all affected parties. A copy of the minutes will be retained in facility records.

6. DOCUMENTATION

6.1 Overview

An effective CQA Plan depends largely on recognition of all construction activities that should be monitored and on assigning responsibilities for the monitoring of each activity. This is most effectively accomplished and verified by the documentation of quality assurance activities. The CQA Consultant will document that all quality assurance requirements have been addressed and satisfied.

The CQA Site Manager will provide the Project Manager with signed descriptive remarks, data sheets, and logs to verify that monitoring activities have been carried out. The CQA Site Manager will also maintain, at the job site, a complete file of *Drawings* and *Technical Specifications*, a CQA Plan, checklists, test procedures, daily logs, and other pertinent documents.

6.2 Daily Recordkeeping

Preparation of daily CQA documentation will consist of daily reports prepared by the CQA Site Manager which may include CQA monitoring logs, and testing data sheets. This information may be regularly submitted to and reviewed by the Project Manager.

The CQA Site Manager will prepare daily reports that document the activities observed during each day of activity. The daily reports may include monitoring logs and testing data sheets. At a minimum, these logs and data sheets will include the following information:

- the date, project name, location, and other identification;
- a summary of the weather conditions;
- a summary of locations where construction is occurring;
- equipment and personnel on the project;

- a summary of meetings held and attendees;
- a description of materials used and references of results of testing and documentation;
- identification of deficient work and materials;
- results of re-testing corrected “deficient work;”
- an identifying sheet number for cross referencing and document control;
- descriptions and locations of construction inspected;
- type of construction and inspection performed;
- description of construction procedures and procedures used to evaluate construction;
- a summary of test data and results;
- calibrations or re-calibrations of test equipment and actions taken as a result of re-calibration;
- decisions made regarding acceptance of units of work and/or corrective actions to be taken in instances of substandard testing results;
- a discussion of agreements made between the interested parties which may affect the work; and
- signature of the respective CQA Site Manager.

6.3 Construction Problems and Resolution Data Sheets

Construction Problems and Resolution Data Sheets, to be submitted with the daily reports prepared by the CQA Site Manager, describing special construction situations will be cross-referenced with daily reports, specific observation logs, and testing data sheets and will include the following information, where available:

- an identifying sheet number for cross-referencing and document control;
- a detailed description of the situation or deficiency;
- the location and probable cause of the situation or deficiency;
- how and when the situation or deficiency was found or located;
- documentation of the response to the situation or deficiency;
- final results of responses;
- measures taken to prevent a similar situation from occurring in the future; and
- signature of the CQA Site Manager and a signature indicating concurrence by the Project Manager.

The Project Manager will be made aware of significant recurring nonconformance with the *Drawings*, *Technical Specifications*, or CQA Plan. The cause of the nonconformance will be determined and appropriate changes in procedures or specifications will be recommended. These changes will be submitted to the Engineer for approval. When this type of evaluation is made, the results will be documented and any revision to procedures or specifications will be approved by the Contractor and Engineer.

A summary of supporting data sheets, along with final testing results and the CQA Site Manager's approval of the work, will be required upon completion of construction.

6.4 Photographic Documentation

Photographs will be taken and documented in order to serve as a pictorial record of work progress, problems, and mitigation activities. The basic file will contain color prints. Negatives will also be stored in a separate file in chronological order. These records will be presented to the Project Manager upon completion of the project. Photographic reporting data sheets, where used, will be cross-referenced with observation and testing data sheet(s), and/or construction problem and solution data sheet(s). Photographs used for documentation will be identified with the date, time, and location of the photograph.

6.5 Design and/or Specifications Changes

Design and/or specifications changes may be required during construction. In such cases, the CQA Site Manager will notify the Project Manager. Design and/or specification changes will be made with the written agreement of the Project Manager and the Engineer and will take the form of an addendum to the *Drawings* and *Technical Specifications*.

6.6 CQA Report

At the completion of the Project, the CQA Consultant will submit to the Project Manager the CQA report signed and sealed by the Professional Engineer licensed in the State of Nevada. The CQA report will acknowledge: (i) that the work has been performed in compliance with the *Drawings* and *Technical Specifications*; (ii) physical sampling and testing has been conducted at the appropriate frequencies; and (iii) that the summary document provides the necessary supporting information. At a minimum, this report will include:

- Manufacturers' quality control documentation;

- a summary report describing the CQA activities and indicating compliance with the *Drawings* and *Technical Specifications* which is signed and sealed by the CQA Officer;

- a summary of CQA/CQC testing, including failures, corrective measures, and retest results;

- contractor personnel resumes and qualifications;

- documentation that the geomembrane trial seams were performed in general accordance with the CQA Plan and *Technical Specifications*;

- documentation that field seams were non-destructively tested using a method in general accordance with the applicable test standards;

- documentation that nondestructive testing was monitored by the CQA Consultant, that the CQA Consultant informed the Geosynthetic Installer of any required repairs, and that the CQA Consultant inspected the seaming and patching operations for uniformity and completeness;

- records of sample locations, the name of the individual conducting the tests, and the results of tests;

- record drawings as provided by the Surveyor;

- documentation showing that piping was tested in general accordance with the *Technical Specifications*; and

- daily inspection reports.

The record drawings will include scale drawings depicting the location of the construction and details pertaining to the extent of construction (e.g., depths, plan dimensions, elevations, soil component thicknesses). Base maps required for

development of the record drawings and the record drawings will be prepared by a qualified Professional Land Surveyor registered in the State of Nevada. These documents will be reviewed by the CQA Consultant and included as part of the CQA Report.

7. EARTHWORKS

7.1 Introduction

This section prescribes the CQA activities to be performed to monitor that earthwork components are constructed in general accordance with *Drawings* and *Technical Specifications*. The earthworks construction procedures to be monitored by the CQA Consultant include:

- excavation;
- surcharge placement;
- engineered fill placement;
- anchor trench excavation and backfill;
- subgrade preparation; and
- operations layer material placement.

7.2 Testing Activities

Soil testing will be performed for material qualification, material conformance, and construction quality control (CQC). These three stages of testing are defined as follows:

- Material qualification tests are used to evaluate the conformance of a proposed soil source to the material specifications for qualification of the source prior to construction.

- Soils conformance testing is used to evaluate the conformance of a particular batch of soil from a qualified source to the material specifications prior to installation of the soil.

- CQC tests are performed on completed portions of the earthwork during construction to demonstrate that the placement procedures are resulting in a product that meets or exceeds both material and performance specifications.

The Contractor will be responsible for submitting material qualification test results to the Project Manager and to the CQA Site Manager for review. The CQA Laboratory will perform the conformance testing and CQC testing. Soil testing will be conducted in general accordance with the current versions of the corresponding American Society for Testing and Materials (ASTM) test procedures. The test methods indicated in Table 1 are those that will be used for this testing unless the test methods are updated or revised prior to construction. Revisions to the test methods will be reviewed and approved by the Engineer and the CQA Site Manager prior to their usage.

7.2.1 Sample Frequency

The frequency of soils testing for material qualification will conform to the minimum frequencies presented in Table 2. The frequency of soils testing for material conformance will conform to the minimum frequencies presented in Table 3. The actual frequency of testing required will be increased by the CQA Site Manager as necessary if variability of materials is noted at the site, during adverse conditions, or to isolate failing areas of the construction.

7.2.2 Sample or Test Location Selection

With the exception of qualification samples, sampling locations will be selected by the CQA Site Manager. Conformance samples will be obtained from borrow pits and/or stockpiles of material. The Contractor must plan the work and make soil available for sampling in a timely and organized manner so that the test results can be obtained before the material is installed. The CQA Site Manager must document sample locations so that failing areas can be immediately isolated. The CQA Site Manager will follow standard sampling procedures to obtain representative samples of the proposed soil materials.

CQC sample and test locations will be selected by the CQA Site Manager at the minimum test frequency specified in Table 4. Samples and test locations will generally be selected at random, however a special testing frequency will be used at the discretion of the CQA Site Manager when visual observations of construction performance indicate a potential problem. Additional testing for suspected areas will be considered when:

- rollers slip during rolling operation;

- lift thickness is greater than specified;
- fill is at improper and/or variable moisture content;
- less than specified number of roller passes are made;
- dirt-clogged rollers are used to compact the material;
- rollers may not have used optimum ballast;
- fill materials differ substantially from those specified;
- the degree of compaction is doubtful; and
- as directed by the Project Manager or the CQA Site Manager.

The frequency of testing may also be increased in the following situations:

- adverse weather conditions;
- breakdown of equipment;
- at the start and finish of grading;
- material fails to meet specifications; and
- the work area is reduced.

7.3 CQA Monitoring Activities

7.3.1 Earthwork

The CQA Site Manager will monitor and document the earthworks required for the Project. In general, monitoring the construction for earthwork includes the following activities:

- reviewing documentation of the material qualification test results provided by the Contractor;

- monitoring the prepared subgrade and subgrade surfaces for compliance with the *Technical Specifications* before geosynthetic materials are placed;

- sampling and testing for conformance of the materials to the *Technical Specifications*;

- documenting that the earthwork is constructed using the specified equipment and procedures;

- documenting that the earthwork is constructed to the lines and grades shown on the *Drawings*;

- monitoring that the construction activities do not cause damage to underlying geosynthetic materials;

- quality control testing to determine the acceptability of the work during construction; and

- monitoring the action of the compaction and heavy hauling equipment on the construction surface (i.e., penetration, pumping, cracking, etc.).

The specific activities required for CQA of each of the major soil components of the Liner System are presented in the following sections.

7.3.2 Engineered Fill Material

Monitoring the earthwork for the engineered fill material specifically includes the following:

- reviewing documentation of the qualification and conformance test results;

- monitoring soil for maximum particle size and deleterious materials;

- monitoring the thickness of lifts during placement of the materials;

- monitoring compaction operations; and

- measuring and recording the field density and the field moisture content of the in-place material.

7.3.3 Prepared Subgrade

During construction, the CQA Site Manager will monitor the prepared subgrade to document that the prepared subgrade soil characteristics are consistent with those specified in the *Technical Specifications*. The CQA Site Manager will monitor the construction activities to document that sharp rocks and other undesirable materials are removed and that the subgrade is prepared using the procedures and equipment specified in the *Technical Specifications*.

The upper portion of the subgrade can be damaged by excess moisture (causing softening) or insufficient moisture (causing desiccation and shrinkage). At a minimum, the CQA Site Manager will determine the suitability of the subgrade for geomembrane placement by:

- documenting that the surface is free of sharp rocks, debris and other undesirable materials;
- documenting that the surface is smooth, uniform, and free from desiccation cracks by visually monitoring proof rolling activities; and
- documenting that the subgrade surface meets the lines and grades shown on the *Drawings* by reviewing certified survey results.

7.3.4 Operations Layer Material

The CQA Site Manager will monitor the earthwork of the operations layer material for the following:

- the Contractor's submittals and qualification test results for consistency between the proposed methods and the approved methods;
- the conformance testing of the material and notifying the Contractor of results for compliance with material specifications;
- the thickness of lifts during placement;

- the placement equipment operation on the sideslopes is in general accordance with the *Technical Specifications*;

- the construction procedures to monitor that completed sections of liner and geomembrane are protected from damage; and

- the survey data to monitor that operations layer material is constructed to the proposed lines and grades and to the specified thickness.

7.4 Deficiencies

If a defect is discovered in the earthwork product, the CQA Site Manager will immediately determine the extent and nature of the defect. If the defect is indicated by an unsatisfactory test result, the CQA Site Manager will determine the extent of the deficient area by additional tests, observations, a review of records, or other means that the CQA Site Manager deems appropriate. If the defect is related to adverse site conditions, such as overly wet soils or surface desiccation, the CQA Site Manager will define the limits and nature of the defect.

7.4.1 Notification

After evaluating the extent and nature of a defect, the CQA Site Manager will notify the Project Manager and Contractor and schedule appropriate re-tests when the work deficiency is to be corrected.

7.4.2 Repairs and Re-Testing

At locations where the field testing indicates densities below the requirements of the specification, the failing area will be reworked. The Contractor will correct the deficiency to the satisfaction of the CQA Site Manager. If a project specification criterion cannot be met, or unusual weather conditions hinder work, then the CQA Site Manager will develop and present to the Engineer and/or Project Manager suggested solutions for his approval.

All re-tests recommended by the CQA Site Manager must verify that the defect has been corrected before any additional work is performed by the Contractor in the area of the deficiency. The CQA Site Manager will also verify that installation requirements are met and that submittals are provided.

8. DRAINAGE AGGREGATE

8.1 Introduction

This section prescribes the CQA activities to be performed to monitor that drainage aggregates are constructed in general accordance with *Drawings* and *Technical Specifications*. The drainage aggregates construction procedures to be monitored by the CQA Consultant include drainage aggregate placement.

8.2 Testing Activities

Aggregate testing will be performed for material qualification and material conformance. These two stages of testing are defined as follows:

- Material qualification tests are used to evaluate the conformance of a proposed aggregate source to the material specifications for qualification of the source prior to construction.

- Aggregate conformance testing is used to evaluate the conformance of a particular batch of aggregate from a qualified source to the material specifications prior to installation of the aggregate.

The Contractor will be responsible for submitting material qualification test results to the Project Manager and to the CQA Site Manager for review. The CQA Laboratory will perform the conformance testing and CQC testing. Aggregate testing will be conducted in general accordance with the current versions of the corresponding American Society for Testing and Materials (ASTM) test procedures. The test methods indicated in Table 5 are those that will be used for this testing unless the test methods are updated or revised prior to construction. Revisions to the test methods will be reviewed and approved by the Engineer and the CQA Site Manager prior to their usage.

8.2.1 Sample Frequency

The frequency of aggregate testing for material qualification will conform to the minimum frequencies presented in Table 6. The frequency of aggregate testing for material conformance will conform to the minimum frequencies presented in Table 7.

The actual frequency of testing required will be increased by the CQA Site Manager as necessary if variability of materials is noted at the site, during adverse conditions, or to isolate failing areas of the construction.

8.2.2 Sample Selection

With the exception of qualification samples, sampling locations will be selected by the CQA Site Manager. Conformance samples will be obtained from borrow pits and/or stockpiles of material. The Contractor must plan the work and make aggregate available for sampling in a timely and organized manner so that the test results can be obtained before the material is installed. The CQA Site Manager must document sample locations so that failing areas can be immediately isolated. The CQA Site Manager will follow standard sampling procedures to obtain representative samples of the proposed aggregate materials.

8.3 <u>CQA Monitoring Activities</u>

8.3.1 Drainage Aggregate

The CQA Site Manager will monitor and document the installation of the drainage aggregates. In general, monitoring the installation of the drainage aggregates includes the following activities:

- reviewing documentation of the material qualification test results provided by the Contractor;
- sampling and testing for conformance of the materials to the *Technical Specifications*;
- documenting that the drainage aggregates are installed using the specified equipment and procedures;
- documenting that the drainage aggregates are constructed to the lines and grades shown on the *Drawings*; and

- monitoring that the construction activities do not cause damage to underlying geosynthetic materials.

8.4 Deficiencies

If a defect is discovered in the drainage aggregates, the CQA Site Manager will evaluate the extent and nature of the defect. If the defect is indicated by an unsatisfactory test result, the CQA Site Manager will determine the extent of the deficient area by additional tests, observations, a review of records, or other means that the CQA Site Manager deems appropriate.

8.4.1 Notification

After evaluating the extent and nature of a defect, the CQA Site Manager will notify the Project Manager and Contractor and schedule appropriate re-tests when the work deficiency is to be corrected.

8.4.2 Repairs and Re-testing

The Contractor will correct the deficiency to the satisfaction of the CQA Site Manager. If a project specification criterion cannot be met, or unusual weather conditions hinder work, then the CQA Site Manager will develop and present to the Engineer and/or Project Manager suggested solutions for approval.

All re-tests recommended by the CQA Site Manager must verify that the defect has been corrected before any additional work is performed by the Contractor in the area of the deficiency. The CQA Site Manager will also verify that installation requirements are met and that submittals are provided.

9. HIGH DENSITY POLYETHYLENE (HDPE) PIPE AND FITTINGS

9.1 Material Requirements

HDPE pipe and fittings must conform to the requirements of the *Technical Specifications*. The CQA Consultant will document that the HDPE pipe and fittings meet those requirements through manufacturer's quality control certificates, conformance testing, and visual examination of materials arriving on site.

9.2 Manufacturer

9.2.1 Submittals

Prior to the installation of HDPE pipe, the Manufacturer will provide to the CQA Consultant:

- a properties' sheet including, at a minimum, all specified properties, measured using test methods indicated in the *Technical Specifications*, or equivalent; and

- a certification that property values given in the properties sheet are minimum values and are guaranteed by the Manufacturer.

The CQA Consultant will document that:

- the property values certified by the Manufacturer meet the *Technical Specifications*; and

- the measurements of properties by the Manufacturer are properly documented and that the test methods used are acceptable.

9.2.2 Identification

Prior to shipment, the Manufacturer will provide the Project Manager and the CQA Site Manager with a quality control certificate for each lot/batch of HDPE pipe provided. The quality control certificate will be signed by a responsible party

employed by the Manufacturer, such as the Production Manager. The quality control certificate will include:

- lot/batch numbers and identification; and
- sampling procedures and results of quality control tests.

The CQA Site Manager will:

- document that the quality control certificates have been provided at the specified frequency for all lots/batches of pipe, and that each certificate identifies the pipe lot/batch related to it; and

- review the quality control certificates and document that the certified properties meet the *Technical Specifications*.

9.3 Handling and Laying

Care will be taken during transportation of the pipe such that it will not be cut, kinked, or otherwise damaged.

Ropes, fabric, or rubber-protected slings and straps will be used when handling pipes. Chains, cables, or hooks inserted into the pipe ends will not be used. Two slings spread apart will be used for lifting each length of pipe. Pipe or fittings will not be dropped onto rocky or unprepared ground.

Pipes will be handled and stored in general accordance with the Manufacturer's recommendation. The handling of joined pipe will be in such a manner that the pipe is not damaged by dragging it over sharp and cutting objects. Slings for handling the pipe will not be positioned at butt-fused joints. Sections of the pipes with deep cuts and gauges will be removed and the ends of the pipe rejoined.

9.4 Joints

Lengths of pipe will be assembled into suitable installation lengths by the butt-fusion process. Butt-fusion means the butt-joining of the pipe by softening by heat the aligned faces of the pipe ends in a suitable apparatus and pressing them together under

controlled pressure. This process will be applied by personnel experienced with the process. Certification will be provided that the person performing this work is qualified by experience and instruction in the procedure. All pipe so joined will be made from the same class and type of raw material made by the same raw material supplier.

10. GEOMEMBRANE

10.1 General

This section discusses and outlines the CQA activities to be performed for high density polyethylene (HDPE) geomembrane installation. The CQA Site Manager will review the *Drawings*, and the *Technical Specifications*, and any approved Addenda regarding this material.

10.2 Geomembrane Material Conformance

10.2.1 Introduction

The CQA Site Manager will document that the geomembrane delivered to the site meets the requirements of the *Technical Specifications* prior to installation. The CQA Site Manager will:

- review the manufacturer's submittals for compliance with the *Technical Specifications*;
- document the delivery and proper storage of geomembrane rolls; and
- conduct conformance testing of the rolls before the geomembrane is installed.

The following sections describe the CQA activities required to verify the conformance of geomembrane.

10.2.2 Review of Quality Control

10.2.2.1 Material Properties Certification

The Manufacturer will provide the Project Manager and the CQA Site Manager with the following:

- a properties sheet including, at a minimum, all specified properties, measured using test methods indicated in the *Technical Specifications*, or equivalent;
- the sampling procedure and results of testing; and
- a certification that property values given in the properties sheet are guaranteed by the Manufacturer.

The CQA Site Manager will document that:

- the property values certified by the Manufacturer meet all of the *Technical Specifications*; and
- the measurements of properties by the Manufacturer are properly documented and that the test methods used are acceptable.

10.2.2.2 Resin Certification

The Manufacturer will also provide the Project Manager with the following information concerning the resin used to manufacture the geomembrane:

- the origin (Resin Supplier's name and resin production plant), identification (brand name, lot number), and production date of the resin; and
- the raw material quality control certificates.

The CQA Site Manager will:

- evaluate that the quality control certificates have been provided at the specified frequency, and that the certificate identifies the rolls related to it; and

- review the quality control certificates and evaluate that the certified properties meet the specifications.

10.2.2.3 Geomembrane Roll QC Certification

Prior to shipment, the Manufacturer will provide the Project Manager and the CQA Site Manager with a quality control certificate for every roll of geomembrane provided. The quality control certificate will be signed by a responsible party employed by the Geomembrane Manufacturer, such as the production manager. The quality control certificate will include:

- roll numbers and identification; and

- results of quality control tests - as a minimum, results will be given for thickness, specific gravity, carbon black content, carbon black dispersion, tensile properties, tear resistance, puncture resistance, and single point stress rupture evaluated in general accordance with the methods indicated in the specifications or equivalent methods approved by the Engineer.

The CQA Site Manager will:

- evaluate that the quality control certificates have been provided at the specified frequency, and that the certificate identifies the rolls related to the roll represented by the test results; and

- review the quality control certificates and evaluate that the certified roll properties meet the specifications.

10.2.3 Conformance Testing

Upon delivery of the rolls of geomembrane, the CQA Site Manager will document that the rolls are unloaded and stored on site as required by the *Technical Specifications*. Damage caused by unloading will be documented by the CQA Site Manager and the damaged material will not be installed. The CQA Site Manager shall obtain conformance samples at the specified frequency and forward them to the Geosynthetics CQA Laboratory for testing to monitor conformance to both the *Technical Specifications* and the list of properties certified by the Manufacturer. The test procedures will be as indicated in Table 8. Where optional procedures are noted in the test method, the requirements of the *Technical Specifications* will prevail.

Samples will be taken across the width of the roll and will not include the first linear 3 ft (1 m) of material. Unless otherwise specified, samples will be 3 ft (1 m) long by the roll width. The CQA Site Manager will mark the machine direction on the samples with an arrow along with the date and roll number. The required minimum sampling frequencies are provided in Table 8.

The CQA Site Manager will examine results from laboratory conformance testing and will report any non-conformance to the Project Manager and the Geosynthetic Installer. The procedure prescribed in the *Technical Specifications* will be followed in the event of a failing conformance test.

10.3 <u>Delivery</u>

10.3.1 Transportation and Handling

The CQA Site Manager will document that the transportation and handling does not pose a risk of damage to the geomembrane.

Upon delivery at the site, the Geosynthetic Installer and the CQA Site Manager will conduct a surface observation of the rolls for defects and damage. This

inspection will be conducted without unrolling unless defects or damages are found or suspected. The CQA Site Manager will indicate to the Project Manager:

- rolls, or portions thereof, which should be rejected and removed from the site because they have severe flaws; and

- rolls that include minor repairable flaws.

10.3.2 Storage

The Geosynthetic Installer will be responsible for the storage of the geomembrane on site. The Contractor will provide storage space in a location (or several locations) such that on-site transportation and handling are optimized if possible.

The CQA Site Manager will document that storage of the geomembrane provides adequate protection against sources of damage.

10.4 Geomembrane Installation

10.4.1 Introduction

The CQA Consultant will document that the geomembrane installation is carried out in general accordance with the *Drawings*, *Technical Specifications* and Manufacturer's recommendations.

10.4.2 Earthwork

10.4.2.1 Surface Preparation

The CQA Site Manager will document that:

- a qualified land surveyor has verified lines and grades;

- that the supporting prepared subgrade or subgrade meets the *Technical Specifications* and has been approved; and

- placement of the overlying materials does not damage, create large wrinkles, or induce excessive tensile stress in the underlying geosynthetic materials.

The Geosynthetic Installer will certify in writing that the surface on which the geomembrane will be installed is acceptable. The certificate of acceptance will be given by the Geosynthetic Installer to the Project Manager prior to commencement of geomembrane installation in the area under consideration. The CQA Site Manager will be given a copy of this certificate by the Project Manager.

After the supporting subgrade has been accepted by the Geosynthetic Installer, it will be the Geosynthetic Installer's responsibility to indicate to the Project Manager any change in the supporting soil condition that may require repair work. If the CQA Site Manager concurs with the Geosynthetic Installer, then the Project Manager will document that the supporting soil is repaired.

At any time before and during the geomembrane installation, the CQA Site Manager will indicate to the Project Manager locations that may not provide adequate support to the geomembrane.

10.4.2.2 Geosynthetic Termination

The CQA Site Manager will document that the geosynthetic terminations have been constructed in general accordance with the *Drawings*. Backfilling above the terminations will be conducted in general accordance with the *Technical Specifications*.

10.4.3 Geomembrane Placement

10.4.3.1 Panel Identification

A field panel is the unit area of geomembrane which is to be seamed in the field, i.e., a field panel is a roll or a portion of roll cut in the field. It will be the responsibility of the CQA Site Manager to document that each field panel is given an "identification code" (number or letter- number) consistent with the layout plan. This identification code will be agreed upon by the Project Manager, Geosynthetic Installer and CQA Site Manager. This field panel identification code will be as simple and

logical as possible. Roll numbers established in the manufacturing plant must be traceable to the field panel identification code.

The CQA Site Manager will establish documentation showing correspondence between roll numbers, and field panel identification codes. The field panel identification code will be used for all quality assurance records.

10.4.3.2 Field Panel Placement

Location

The CQA Site Manager will document that field panels are installed at the location indicated in the Geosynthetic Installer's layout plan, as approved or modified by the Engineer.

Installation Schedule

Field panels may be installed using one of the following schedules:

- all field panels are placed prior to field seaming in order to protect the subgrade from erosion by rain;
- field panels are placed one at a time and each field panel is seamed after its placement (in order to minimize the number of unseamed field panels exposed to wind); and
- any combination of the above.

If a decision is reached to place all field panels prior to field seaming, it is usually beneficial to begin at the high point area and proceed toward the low point with "shingle" overlaps to facilitate drainage in the event of precipitation. It is also usually beneficial to proceed in the direction of prevailing winds. Accordingly, an early decision regarding installation scheduling should be made if and only if weather conditions can be predicted with reasonable certainty. Otherwise, scheduling decisions must be made during installation, in general accordance with varying conditions. In any

event, the Geosynthetic Installer is fully responsible for the decision made regarding placement procedures.

The CQA Site Manager will evaluate every change in the schedule proposed by the Geosynthetic Installer and advise the Project Manager on the acceptability of that change. The CQA Site Manager will document that the condition of the supporting soil has not changed detrimentally during installation.

The CQA Site Manager will record the identification code, location, and date of installation of each field panel.

Weather Conditions

Geomembrane placement will not proceed unless otherwise authorized:

- when the ambient temperature is below 40°F or above 104°F;
- when the geomembrane sheet temperature is below 40°F or above 104°F; or
- when wind gusts are in excess of 20 mph.

Geomembrane placement will not be performed during any precipitation, in the presence of excessive moisture (e.g., fog, dew), in an area of ponded water, or in the presence of excessive winds (i.e., wind gusts in excess of 20 mph).

The CQA Site Manager will document that the above conditions are fulfilled. Additionally, the CQA Site Manager will document that the supporting soil has not been damaged by weather conditions. The Geosynthetics Installer will inform the Project Manager if the above conditions are not fulfilled.

Method of Placement

The CQA Site Manager will document the following:

- equipment used does not damage the geomembrane by handling, trafficking, excessive heat, leakage of hydrocarbons or other means;

- the surface underlying the geomembrane has not deteriorated since previous acceptance, and is still acceptable immediately prior to geomembrane placement;

- geosynthetic elements immediately underlying the geomembrane are clean and free of debris;

- personnel working on the geomembrane do not smoke, wear damaging shoes, or engage in other activities which could damage the geomembrane;

- the method used to unroll the panels does not cause scratches or crimps in the geomembrane and does not damage the supporting soil;

- the method used to place the panels minimizes wrinkles (especially differential wrinkles between adjacent panels); and

- adequate temporary loading and/or anchoring (e.g., sand bags, tires), not likely to damage the geomembrane, has been placed to prevent uplift by wind (in case of high winds, continuous loading, e.g., by adjacent sand bags, is recommended along edges of panels to minimize risk of wind flow under the panels).

The CQA Site Manager will inform the Project Manager if the above conditions are not fulfilled.

Damaged panels or portions of damaged panels that have been rejected will be marked and their removal from the work area recorded by the CQA Site Manager. Repairs will be made in general accordance with procedures described in Section 10.4.5.

10.4.4 Field Seaming

This section details CQA procedures to document that seams are properly constructed and tested in general accordance with the Manufacturer's specifications and industry standards.

10.4.4.1 Seam Layout

The Geosynthetic Installer will provide the Project Manager and the CQA Site Manager with a seam layout drawing, i.e., a drawing of the facility to be lined showing all expected seams. The CQA Site Manager will review the seam layout drawing and evaluate that it is consistent with the preliminary geomembrane panel layout. No panels may be seamed in the field without the Project Manager's approval. In addition, panels not specifically shown on the seam layout drawing may be used without the Project Manager's prior approval.

In general, seams should be oriented parallel to the line of maximum slope, i.e., oriented along, not across, the slope. In corners and odd-shaped geometric locations, the number of seams should be minimized. No horizontal seam should be less than 5 ft (1.5 m) from the toe of the slope, or areas of potential stress concentrations, unless otherwise authorized.

A seam numbering system compatible with the panel numbering system will be agreed upon at the Resolution and/or Pre-Construction Meeting.

10.4.4.2 Requirements of Personnel

All personnel performing seaming operations will be qualified by experience or by successfully passing seaming tests, as outlined in the *Technical Specifications*. The most experienced seamer, the "master seamer", will provide direct supervision over less experienced seamers.

The Geosynthetic Installer will provide the Project Manager and the CQA Site Manager with a list of proposed seaming personnel and their experience records. This document will be reviewed by the Project Manager and the Geosynthetics CQA Manager.

10.4.4.3 Seaming Equipment and Products

Approved processes for field seaming are fillet extrusion welding and fusion welding.

Fillet Extrusion Process

The fillet extrusion-welding apparatus will be equipped with gauges giving the temperature in the apparatus.

The Geosynthetic Installer will provide documentation regarding the extrudate to the Project Manager and the CQA Site Manager, and will certify that the extrudate is compatible with the specifications, and in any event is comprised of the same resin as the geomembrane sheeting.

The CQA Site Manager will log apparatus temperatures, ambient temperatures, and geomembrane surface temperatures at appropriate intervals.

The CQA Site Manager will document that:

- the Geosynthetic Installer maintains on site the number of spare operable seaming apparatus decided at the Resolution Meeting;
- equipment used for seaming is not likely to damage the geomembrane;
- the extruder is purged prior to beginning a seam until all heat-degraded extrudate has been removed from the barrel;
- the electric generator is placed on a smooth base such that no damage occurs to the geomembrane;
- a smooth insulating plate or fabric is placed beneath the hot welding apparatus after usage; and

- the geomembrane is protected from damage in heavily trafficked areas.

Fusion Process

The fusion-welding apparatus must be automated vehicular-mounted devices. The fusion-welding apparatus will be equipped with gauges giving the applicable temperatures and pressures.

The CQA Site Manager will log ambient, seaming apparatus, and geomembrane surface temperatures as well as seaming apparatus pressures.

The CQA Site Manager will also document that:

- the Geosynthetic Installer maintains on-site the number of spare operable seaming apparatus decided at the Resolution Meeting;

- equipment used for seaming is not likely to damage the geomembrane;

- for cross seams, the edge of the cross seam is ground to a smooth incline (top and bottom) prior to welding;

- the electric generator is placed on a smooth base such that no damage occurs to the geomembrane;

- a smooth insulating plate or fabric is placed beneath the hot welding apparatus after usage;

- the geomembrane is protected from damage in heavily trafficked areas; and

- a movable protective layer may be used directly below each overlap of geomembrane that is to be seamed to prevent build- up of moisture between the sheets.

10.4.4.4 Seam Preparation

The CQA Site Manager will document that:

- prior to seaming, the seam area is clean and free of moisture, dust, dirt, debris, and foreign material; and

- seams are aligned with the fewest possible number of wrinkles and "fishmouths."

10.4.4.5 Weather Conditions for Seaming

The normally required weather conditions for seaming are as follows unless authorized in writing by the Project Manager:

- seaming will only be approved between ambient temperatures of 40°F (4°C) and 104°F (40°C); and

- seaming will not be approved if sustained wind speed is in excess of 20 mph (32 km/hr).

If the Geosynthetic Installer wishes to use methods that may allow seaming at ambient temperatures below 40°F (4°C) or above 104°F (40°C), the Geosynthetic Installer will demonstrate and certify that such methods produce seams which are entirely equivalent to seams produced within acceptable temperature and wind requirements, and that the overall quality of the geomembrane is not adversely affected.

The CQA Site Manager will document that these seaming conditions are fulfilled and will advise the Project Manager if they are not. The Project Manager will then decide if the installation will be stopped or postponed.

10.4.4.6 Overlapping and Temporary Bonding

The CQA Site Manager will document that:

- the panels of geomembrane have a finished overlap of a minimum of 3 in. (75 mm) for both extrusion and fusion welding;

- no solvent or adhesive bonding material are to be used; and

- the procedure used to temporarily bond adjacent panels together does not damage the geomembrane.

The CQA Site Manager will log appropriate temperatures and conditions, and will log and report to the Project Manager non-compliances.

10.4.4.7 Trial Seams

Trial seams will be made on fragment pieces of geomembrane liner to verify that seaming conditions are adequate. Such trial seams will be made at the beginning of each seaming period, beginning of the day and after lunch, for each seaming apparatus used that day. Also, each seamer will make at least one trial seam each day. Trial seams will be made under the same conditions as actual seams.

Extrusion welded trial seam samples will be at least 3 ft (0.9 m) long by 1 ft (0.3 m) wide (after seaming) with the seam centered lengthwise. Fusion welded trial seam samples will be at least 5 ft (1.5 m) long by 1 ft (0.3 m) wide (after seaming) with the seam centered lengthwise. Seam overlap will be as indicated in Section 10.5.3.6.

Four specimens, each 1 in. (25 mm) wide, will be cut from the trial seam sample by the Geosynthetic Installer. One specimen will be tested for shear strength and three specimens will be tested for peel adhesion using a gauged tensiometer. All specimens tested will exhibit a Film Tear Bond (FTB) and will not fail in the seam. In addition, all specimens will meet or exceed the minimum strength requirements described in the *Technical Specifications*. If any of the four specimens fails, the entire trial seaming operation will be repeated. If any of the four additional specimens fails, the seaming apparatus and seamer will not be approved for production seaming until the deficiencies are corrected and two consecutive trial seam tests achieve the FTB requirements outlined above.

The CQA Site Manager will observe trial seam procedures. Trial seam samples will be assigned a number. The CQA Site Manager, will log the date, time, machine temperature(s), number of the seaming unit, name of the seamer, and pass or fail description for each trial seam sample tested.

10.4.4.8 General Seaming Procedure

Unless otherwise specified, the general seaming procedure used by the Geosynthetic Installer will be as follows:

- Fishmouths or wrinkles at the seam overlaps will be cut along the ridge of the wrinkle in order to achieve a flat overlap. The cut fishmouths or wrinkles will be seamed and any portion where the overlap is inadequate will then be patched with an oval or round patch of the same geomembrane extending a minimum of 6 in. (150 mm) beyond the cut in all directions.

- If seaming operations are carried out at night, adequate illumination will be provided at the Geosynthetic Installer's expense.

- Seaming will extend to the outside edge of panels to be placed in the anchor trench.

The CQA Site Manager will document that the above seaming procedures are followed, and will inform the Project Manager if they are not.

10.4.4.9 Nondestructive Seam Continuity Testing

Concept

The Geosynthetic Installer will non-destructively test field seams over their length using a vacuum test unit, air pressure test (for double fusion seams only), or other approved method. The purpose of nondestructive tests is to check the continuity of seams. It does not provide information on seam strength. Continuity testing will be carried out as the seaming work progresses, not at the completion of field seaming.

The CQA Site Manager will:

- observe continuity testing;
- record location, date, test unit number, name of person conducting the test, and the results of tests; and
- inform the Geosynthetic Installer and Project Manager of required repairs.

The Geosynthetic Installer will complete any required repairs in general accordance with Section 10.4.5.

The CQA Site Manager will:

- observe the repair and re-testing of the repair;
- mark on the geomembrane that the repair has been made; and
- document the results.

The following procedures will apply to locations where seams cannot be non-destructively tested:

All such seams will be cap-stripped with the same geomembrane.

- If the seam is accessible to testing equipment prior to final installation, the seam will be non-destructively tested prior to final installation.
- If the seam cannot be tested prior to final installation, the seaming and cap-stripping operations will be observed by the CQA Site Manager and Geosynthetic Installer for uniformity and completeness.

The seam number, date of observation, name of tester, and outcome of the test or observation will be recorded by the CQA Site Manager.

Vacuum Testing

The equipment will be comprised of the following:

- a vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, port hole or valve assembly, and a vacuum gauge;
- a steel vacuum tank and pump assembly equipped with a pressure controller and pipe connections;
- a rubber pressure/vacuum hose with fittings and connections;
- an approved applicator; and
- a soapy solution.

The following procedures will be followed:

- energize the vacuum pump and reduce the tank pressure to approximately 5 psi (35 kPa) (10 in. of Hg.) gauge;
- wet a strip of geomembrane approximately 12 in. by 48 in. (0.3 m by 1.2 m) with the soapy solution;
- place the box over the wetted area;
- close the bleed valve and open the vacuum valve;
- document that a leak tight seal is created;
- for a period of not less than ten seconds, examine the geomembrane through the viewing window for the presence of leaks indicated by soap bubbles;

- if no leaks appear after ten seconds, close the vacuum valve and open the bleed valve, move the box over the next adjoining area with a minimum 3 in. (75 mm) overlap, and repeat the process;

- areas where soap bubbles appear will be marked and repaired in general accordance with Section 10.4.5 and retested using the vacuum testing method.

Air Pressure Testing (For Double-Track Fusion Seam Only)

The following procedures are applicable to those processes that produce a double seam with an enclosed space.

The equipment will be comprised of the following:

- an air pump (manual or motor driven) equipped with pressure gauge capable of generating and sustaining a pressure of 30 psi (200 kPa) and mounted on a cushion to protect the geomembrane;

- a rubber hose with fittings and connections;

- a sharp hollow needle, or other approved pressure feed device.

The following procedures will be followed:

- seal both ends of the seam to be tested;

- insert needle or other approved pressure feed device into the tunnel created by the fusion weld;

- insert a protective cushion between the air pump and the geomembrane;

- energize the air pump to a pressure of 25 to 30 psi (170 to 204 kPa), close valve, and sustain pressure for not less than 5 minutes;

- if loss of pressure exceeds 3 psi (20 kPa) or does not stabilize, locate faulty area and repair in general accordance with Section 10.4.5;

- cut end of tested seam area, opposite the location of the pressure gauge, after completion of the five minute pressure hold period to verify complete testing of the seam. If the pressure gauge does not indicate a release of pressure, locate blockage of the air channel and retest until entire seam is tested; and

- remove needle or other approved pressure feed device and repair any holes in the geomembrane resulting from the air pressure testing procedure in general accordance with Section 10.4.5.

10.4.4.10 Destructive Testing

Concept

Destructive seam testing will be performed on site and at the independent CQA laboratory in general accordance with the *Drawings* and the *Technical Specifications*. Destructive seam tests will be performed at selected locations. The purpose of these tests is to evaluate seam strength. Seam strength testing will be done as the seaming work progresses, not at the completion of all field seaming.

Location and Frequency

The CQA Site Manager will select locations where seam samples will be cut out for laboratory testing. Those locations will be established as follows.

- The frequency of geomembrane seam testing is a minimum of one destructive sample per 500 feet of weld. The minimum frequency is to be evaluated as an average taken throughout the entire facility.

- A minimum of one test per seaming machine over the duration of the project phase.

- Test locations will be evaluated during seaming at CQA Site Manager's discretion. Selection of such locations may be prompted by suspicion of excess crystallinity, contamination, offset welds, or any other potential cause of imperfect welding.

The Geosynthetic Installer will not be informed in advance of the locations where the seam samples will be taken.

Sampling Procedure

Samples will be cut by the Geosynthetic Installer as the seaming progresses in order to have laboratory test results before the geomembrane is covered by another material. The CQA Site Manager will:

- observe sample cutting;
- assign a number to each sample, and mark it accordingly;
- record sample location on layout drawing; and
- record reason for taking the sample at this location (e.g., statistical routine, suspicious feature of the geomembrane).

Holes in the geomembrane resulting from destructive seam sampling will be immediately repaired in general accordance with repair procedures described in Section 10.4.5. The continuity of the new seams in the repaired area will be tested in general accordance with Section 10.4.4.9.

Size and Distribution of Samples

The destructive sample will be 12 in. (0.3 m) wide by 42 in. (1.1 m) long with the seam centered lengthwise. The sample will be cut into three parts and distributed as follows:

- one portion, measuring 12 in. × 12 in. (0.30 cm × 30 cm), to the Geosynthetic Installer for field testing;

- one portion, measuring 12 in. × 18 in. (30 cm × 45 cm), for CQA Laboratory testing; and

- one portion, measuring 12 in. × 12 in. (30 cm × 30 cm), to the Contractor for archive storage.

Final evaluation of the destructive sample sizes and distribution will be made at the Pre-Construction Meeting.

Field Testing

Field testing will be performed by the Geosynthetic Installer using a gauged tensiometer. Prior to field testing the Geosynthetic Installer shall submit a calibration certificate for gauge tensiometer to the CQA Consultant for review. Calibration must have been performed within one year of use on the current project. Five 1 in. (25 mm) wide strips will be taken for peel. The specimens shall not fail in the seam and shall meet the strength requirements outlined in the *Technical Specifications*. If any field test specimen fails, then the procedures outlined in *Procedures for Destructive Test Failures* of this section will be followed.

The CQA Site Manager will witness field tests and mark samples and portions with their number. The CQA Site Manager will also log the date and time, ambient temperature, number of seaming unit, name of seamer, welding apparatus temperatures and pressures, and pass or fail description.

CQA Laboratory Testing

Destructive test samples will be packaged and shipped, if necessary, under the responsibility of the CQA Site Manager in a manner that will not damage the test sample. The Project Manager will document that packaging and shipping conditions are acceptable. The Project Manager will be responsible for storing the archive samples. This procedure will be outlined at the Resolution Meeting. Samples will be tested by the CQA Laboratory. The CQA Laboratory will be selected by the CQA Site Manager with the concurrence of the Project Manager.

Testing will include “Bonded Seam Strength” and “Peel Adhesion.” The minimum acceptable values to be obtained in these tests are given in the *Technical Specifications*. At least five specimens will be tested for each test method. Specimens will be selected alternately by test from the samples (i.e., peel, shear, peel, shear...). A

passing test will meet the minimum required values in at least four out of five specimens.

The CQA Laboratory will provide test results no more than 24 hours after they receive the samples. The CQA Site Manager will review laboratory test results as soon as they become available, and make appropriate recommendations to the Project Manager.

Geosynthetic Installer's Laboratory Testing

The Geosynthetic Installer's laboratory test results will be presented to the Project Manager and the CQA Site Manager for comments.

Procedures for Destructive Test Failure

The following procedures will apply whenever a sample fails a destructive test, whether that test conducted by the CQA Laboratory, the Geosynthetic Installer's laboratory, or by gauged tensiometer in the field. The Geosynthetic Installer has two options:

- The Geosynthetic Installer can reconstruct the seam between two passed test locations.

- The Geosynthetic Installer can trace the welding path to an intermediate location at 10 ft (3 m) minimum from the point of the failed test in each direction and take a small sample for an additional field test at each location. If these additional samples pass the test, then full laboratory samples are taken. If these laboratory samples pass the tests, then the seam is reconstructed between these locations. If either sample fails, then the process is repeated to establish the zone in which the seam should be reconstructed.

Acceptable seams must be bounded by two locations from which samples passing laboratory destructive tests have been taken. In cases where the failed seam segment exceeds 150 ft (50 m), a destructive sample will be taken from the zone in which the seam has been reconstructed. Repairs will be made in general accordance with Section 10.4.5.

The CQA Site Manager will document actions taken in conjunction with destructive test failures.

10.4.5 Defects and Repairs

This section prescribes CQA activities to document that defects, tears, rips, punctures, damage, or failing seams shall be repaired.

10.4.5.1 Identification

Seams and non-seam areas of the geomembrane will be examined by the CQA Site Manager for identification of defects, holes, blisters, undispersed raw materials and signs of contamination by foreign matter. Because light reflected by the geomembrane helps to detect defects, the surface of the geomembrane will be clean at the time of examination.

10.4.5.2 Evaluation

Each suspect location both in seam and non-seam areas will be non-destructively tested using the methods described in Section 10.4.4.9 as appropriate. Each location that fails the nondestructive testing will be marked by the CQA Site Manager and repaired by the Geosynthetic Installer. Work will not proceed with any materials that will cover locations which have been repaired until laboratory test results with passing values are available.

10.4.5.3 Repair Procedures

Portions of the geomembrane exhibiting a flaw, or failing a destructive or nondestructive test, will be repaired. Several procedures exist for the repair of these areas. The final decision as to the appropriate repair procedure will be at the discretion of the CQA Consultant with input from the Project Manager and Geosynthetic Installer. The procedures available include:

- patching, used to repair large holes, tears, undispersed raw materials, and contamination by foreign matter;

- grinding and re-welding, used to repair small sections of extruded seams;

- spot welding or seaming, used to repair small tears, pinholes, or other minor, localized flaws;

- capping, used to repair large lengths of failed seams;

- removing bad seam and replacing with a strip of new material welded into place (used with large lengths of fusion seams).

In addition, the following provisions will be satisfied:

- surfaces of the geomembrane which are to be repaired will be abraded no more than 20 minutes prior to the repair;

- surfaces must be clean and dry at the time of the repair;

- all seaming equipment used in repairing procedures must be approved;

- the repair procedures, materials, and techniques will be approved in advance by the CQA Consultant with input from the Project Manager and Geosynthetic Installer;

- patches or caps will extend at least 6 in. (150 mm) beyond the edge of the defect, and all corners of patches will be rounded with a radius of at least 3 in. (75 mm); and

- the geomembrane below large caps should be appropriately cut to avoid water or gas collection between the two sheets.

10.4.5.4 Verification of Repairs

Each repair will be numbered and logged. Each repair will be non-destructively tested using the methods described in Section 10.4.4.9 as appropriate.

Repairs that pass the non- destructive test will be taken as an indication of an adequate repair. Large caps may be of sufficient extent to require destructive test sampling, at the discretion of the CQA Site Manager. Failed tests indicate that the repair will be redone and re-tested until a passing test results. The CQA Site Manager will observe all non-destructive testing of repairs and will record the number of each repair, date, and test outcome.

10.4.5.5 Large Wrinkles

When seaming of the geomembrane is completed (or when seaming of a large area of the geomembrane liner is completed) and prior to placing overlying materials, the CQA Site Manager will observe the geomembrane wrinkles. The CQA Site Manager will indicate to the Project Manager which wrinkles should be cut and re-seamed by the Geosynthetic Installer. The seam thus produced will be tested like any other seam.

10.4.6 Lining System Acceptance

The Geosynthetic Installer and the Manufacturer(s) will retain all responsibility for the geosynthetic materials in the liner system until acceptance by the Owner.

The geosynthetic liner system will be accepted by the Owner when:

- the installation is finished;
- verification of the adequacy of all seams and repairs, including associated testing, is complete;
- all documentation of installation is completed including the CQA Site Manager's acceptance report; and
- CQA report, including "as built" drawing(s), sealed by a registered professional engineer has been received by the Project Manager.

The CQA Site Manager will document that installation has proceeded in general accordance with the *Technical Specifications* for the project except as noted to the Project Manager.

11. GEOTEXTILE

11.1 Introduction

This section of the CQA Plan outlines the CQA activities to be performed for the geotextile installation. The CQA Consultant will review the *Drawings*, and the *Technical Specifications*, and any approved addenda or changes.

11.2 Manufacturing

The Manufacturer will provide the Project Manager with a list of guaranteed "minimum average roll value" properties (defined as the mean less two standard deviations), for each type of geotextile to be delivered. The Manufacturer will also provide the Project Manager with a written quality control certification signed by a responsible party employed by the Manufacturer that the materials actually delivered have property "minimum average roll values" which meet or exceed all property values guaranteed for that type of geotextile.

The quality control certificates will include:

- roll identification numbers; and
- results of quality control testing.

The Manufacturer will provide, as a minimum, test results for the following:

- mass per unit area (cushion geotextile only);
- grab strength (cushion and filtration geotextiles only);
- tear strength (cushion and filtration geotextiles only);
- burst strength (cushion and filtration geotextiles only);
- puncture strength (cushion and filtration geotextiles only);
- wide width tensile strength (UV protection geotextile only);
- permittivity (filtration geotextile only); and
- apparent opening size (filtration and UV protection geotextiles only).

Quality control tests must be performed, in general accordance with the test methods specified in Table 9, on geotextile produced for the project. The Manufacturer

will also provide a written certification that the nonwoven, needle-punched geotextiles are continuously inspected and found to be needle-free.

The CQA Site Manager will examine Manufacturer certifications to evaluate that the property values listed on the certifications meet or exceed those specified for the particular type of geotextile and the measurements of properties by the Manufacturer are properly documented, test methods acceptable and the certificates have been provided at the specified frequency properly identifying the rolls related to testing. Deviations will be reported to the Project Manager.

11.3 Labeling

The Manufacturer will identify all rolls of geotextile with the following:

- manufacturer's name;
- product identification;
- lot number;
- roll number; and
- roll dimensions.

The CQA Site Manager will examine rolls upon delivery and deviation from the above requirements will be reported to the Project Manager.

11.4 Shipment and Storage

During shipment and storage, the geotextile will be protected from ultraviolet light exposure, precipitation or other inundation, mud, dirt, dust, puncture, cutting or any other damaging or deleterious conditions. To that effect, geotextile rolls will be shipped and stored in relatively opaque and watertight wrappings.

Protective wrappings will be removed less than one hour prior to unrolling the geotextile. After the wrapping has been removed, a geotextile will not be exposed to sunlight for more than 15 days, except for UV protection geotextile, unless otherwise specified and guaranteed by the Manufacturer.

The CQA Site Manager will observe rolls upon delivery at the site and deviation from the above requirements will be reported to the Project Manager.

11.5 Conformance Testing

11.5.1 Tests

Upon delivery of the rolls of geotextiles, the CQA Site Manager will document that samples are removed and forwarded to the Geosynthetics CQA Laboratory for testing to evaluate conformance to *Technical Specifications*. Required test and testing frequency for the geotextiles are presented in Table 9.

These conformance tests will be performed in general accordance with the test methods specified in the *Technical Specifications*.

11.5.2 Sampling Procedures

Samples will be taken across the width of the roll and will not include the first three feet (linear meter). Unless otherwise specified, samples will be 3 ft (1 m) long by the roll width. The CQA Site Manager will mark the machine direction on the samples with an arrow.

Unless otherwise specified, samples will be taken at a rate as indicated in Table 9 for geotextiles.

11.5.3 Test Results

The CQA Site Manager will examine results from laboratory conformance testing and will report non-conformance to the Project Manager.

11.5.4 Conformance Sample Failure

The following procedure will apply whenever a sample fails a conformance test that is conducted by the CQA Laboratory:

- The Manufacturer will replace every roll of geotextile that is in nonconformance with the *Technical Specifications* with a roll(s) that meets *Technical Specifications*.

- The Geosynthetic Installer will remove conformance samples for testing by the CQA Laboratory from the closest numerical rolls on both sides of the failed roll. These two samples must conform to the *Technical Specifications*. If either of these samples fail, the numerically closest rolls on the side of the failed sample will be tested by the CQA Laboratory. These samples must conform to the *Technical Specifications*. If any of these samples fail, every roll of geotextile on site from this lot and every subsequently delivered roll that is from the same lot must be tested by the CQA Laboratory for conformance to the *Technical Specifications*. This additional conformance testing will be at the expense of the Manufacturer.

The CQA Site Manager will document actions taken in conjunction with conformance test failures.

11.6 Handling and Placement

The Geosynthetic Installer will handle all geotextiles in such a manner as to document they are not damaged in any way, and the following will be complied with:

- On slopes, the geotextiles will be securely anchored in the anchor trench and then rolled down the slope in such a manner as to continually keep the geotextile sheet in tension.

- In the presence of wind, all geotextiles will be weighted with sandbags or the equivalent. Such sandbags will be installed during placement and will remain until replaced with earth cover material.

- Geotextiles will be cut using an approved geotextile cutter only. If in place, special care must be taken to protect other materials from damage, which could be caused by the cutting of the geotextiles.

- The Geosynthetic Installer will take all necessary precautions to prevent damage to underlying layers during placement of the geotextile.

- During placement of geotextiles, care will be taken not to entrap in the geotextile stones, excessive dust, or moisture that could damage the geotextile, generate clogging of drains or filters, or hamper subsequent seaming.

- A visual examination of the geotextile will be carried out over the entire surface, after installation, to document that no potentially harmful foreign objects, such as needles, are present.

The CQA Site Manager will note non-compliance and report it to the Project Manager.

11.7 Seams and Overlaps

All geotextiles will be continuously sewn in accordance with *Technical Specifications*. Geotextiles will be overlapped 6 in. (0.15 m) prior to seaming. No horizontal seams will be allowed on side slopes (i.e. seams will be along, not across, the slope), except as part of a patch.

Sewing will be done using polymeric thread with chemical and ultraviolet resistance properties equal to or exceeding those of the geotextile.

11.8 Repair

Holes or tears in the geotextile will be repaired as follows:

- On slopes: A patch made from the same geotextile will be double seamed into place. Should a tear exceed 10 percent of the width of the roll, that roll will be removed from the slope and replaced.

- Non-slopes: A patch made from the same geotextile will be spot-seamed in place with a minimum of 6 in. (0.60 m) overlap in all directions.

Care will be taken to remove any soil or other material that may have penetrated the torn geotextile.

The CQA Site Manager will observe any repair, note any non-compliance with the above requirements and report them to the Project Manager.

11.9 Placement of Soil or Aggregate Materials

The Contractor will place all soil or aggregate materials located on top of a geotextile, in such a manner as to document:

- no damage of the geotextile;
- minimal slippage of the geotextile on underlying layers; and
- no excess tensile stresses in the geotextile.

Unless otherwise specified by the Engineer, all lifts of soil material will be in conformance with the following guidelines:

Equipment Ground Pressure		**Minimum Loose Lift Thickness**	
Psi	**kPa**	**in.**	**m**
<10	< 68	12	0.30
<20	< 138	24	0.60
>20	> 138	36	0.90

If portions of the geotextile are exposed, the CQA Site Manager will periodically place two (or more, at his discretion) marks on the geotextile 10 ft (3 m) apart along the slope and measure the elongation of the geotextile during the placement of soil. This elongation will be related, by the Engineer, to the tensile stress in the geotextile.

Non-compliance will be noted by the CQA Site Manager and reported to the Project Manager.

12. GEOSYNTHETIC CLAY LINER (GCL)

12.1 Introduction

This section of the CQA Plan outlines the CQA activities to be performed for the geosynthetic clay liner (GCL) installation. The CQA Consultant will review the *Drawings*, and the *Technical Specifications*, and approved addenda or changes.

12.2 Manufacturing

The Manufacturer will provide the Project Manager with a list of guaranteed "minimum average roll value" properties (defined as the mean less two standard deviations), for the GCL to be delivered. The Manufacturer will also provide the Project Manager with a written quality control certification signed by a responsible party employed by the Manufacturer that the materials actually delivered have property "minimum average roll values" which meet or exceed all property values guaranteed for that GCL.

The quality control certificates will include:

- roll identification numbers; and
- results of quality control testing.

The Manufacturer will provide, as a minimum, test results for the following:

- mass per unit area; and
- index flux.

Quality control tests must be performed, in general accordance with the test methods specified in Table 10, on GCL produced for the project.

The CQA Site Manager will examine Manufacturer certifications to verify that the property values listed on the certifications meet or exceed those specified for the GCL and the measurements of properties by the Manufacturer are properly documented, test methods acceptable and the certificates have been provided at the

specified frequency properly identifying the rolls related to testing. Deviations will be reported to the Project Manager.

12.3 Labeling

The Manufacturer will identify all rolls of GCL with the following:

- manufacturer's name;
- product identification;
- lot number;
- roll number; and
- roll dimensions.

The CQA Site Manager will examine rolls upon delivery and deviation from the above requirements will be reported to the Project Manager.

12.4 Shipment and Storage

During shipment and storage, the GCL will be protected from ultraviolet light exposure, precipitation or other inundation, mud, dirt, dust, puncture, cutting or any other damaging or deleterious conditions. To that effect, GCL rolls will be shipped and stored in relatively opaque and watertight wrappings.

The CQA Site Manager will observe rolls upon delivery at the site and any deviation from the above requirements will be reported to the Project Manager.

12.5 Conformance Testing

12.5.1 Tests

CQA personnel will sample the GCL either during production at the manufacturing facility or after delivery to the construction site. The samples will be forwarded to the Geosynthetics CQA Laboratory for testing to assess conformance with the *Technical Specifications*. The test methods and minimum testing frequencies are indicated in Table 10.

Samples will be taken across the width of the roll and will not include the first 3 ft (0.9 m) if the sample is cut on site. Unless otherwise specified, samples will be 3 ft (0.9 m) long by the roll width. The CQA Consultant will mark the machine direction with an arrow and the manufacturer's roll number on each sample.

The CQA Site Manager will examine results from laboratory conformance testing and will report non-conformance to the Project Manager.

12.5.2 Conformance Sample Failure

The following procedure will apply whenever a sample fails a conformance test that is conducted by the CQA Laboratory:

- The Manufacturer will replace every roll of GCL that is in nonconformance with the *Technical Specifications* with a roll(s) that meets *Technical Specifications*.

- The Geosynthetic Installer will remove conformance samples for testing by the CQA Laboratory from the closest numerical rolls on both sides of the failed roll. These two samples must conform to the *Technical Specifications*. If either of these samples fail, the numerically closest rolls on the side of the failed sample will be tested by the CQA Laboratory. These samples must conform to the *Technical Specifications*. If any of these samples fail, every roll of GCL on site from this lot and every subsequently delivered roll that is from the same lot must be tested by the CQA Laboratory for conformance to the *Technical Specifications*. This additional conformance testing will be at the expense of the Manufacturer.

The CQA Site Manager will document actions taken in conjunction with conformance test failures.

12.6 <u>GCL Delivery and Storage</u>

Upon delivery to the site, the CQA Consultant will check the GCL rolls for defects (e.g., tears, holes) and for damage. The CQA Consultant will report to the Project Manager and the Geosynthetics Installer:

- any rolls, or portions thereof, which should be rejected and removed from the site because they have severe flaws; and

- any rolls which include minor repairable flaws.

The GCL rolls delivered to the site will be checked by the CQA Consultant to document that the roll numbers correspond to those on the approved Manufacturer's quality control certificate of compliance.

12.7 GCL Installation

The CQA Consultant will monitor and document that the GCL is installed in general accordance with the *Drawings* and the *Technical Specifications*. The Geosynthetics Installer shall provide the CQA Consultant a certificate of subgrade acceptance prior to the installation of the GCL as outlined in the *Technical Specifications*. The GCL installation activities to be monitored and documented by the CQA Consultant include:

- monitoring that the GCL rolls are stored and handled in a manner which does not result in any damage to the GCL;

- monitoring that the GCL is not exposed to UV radiation for extended periods of time without prior approval;

- monitoring that the GCL are seamed in general accordance with the *Technical Specifications* and the Manufacturer's recommendations;

- monitoring and documenting that the GCL is installed on an approved subgrade, free of debris, protrusions, or uneven surfaces;

- monitoring that the GCL is not installed on a saturated subgrade or standing water and is not exposed such that it is hydrated prior to completion of the construction; and

- monitoring that any damage to the GCL is repaired as outlined in the *Technical Specifications*.

The CQA Site Manager will note non-compliance and report it to the Project Manager.

13. GEOCOMPOSITE

13.1 Introduction

This section of the CQA Plan outlines the CQA activities to be performed for the geocomposite installation. The CQA Consultant will review the *Drawings*, and the *Technical Specifications*, and any approved addenda or changes.

13.2 Manufacturing

The Manufacturer will provide the CQA Consultant with a list of certified "minimum average roll value" properties for the type of geocomposite to be delivered. The Manufacturer will also provide the CQA Consultant with a written certification signed by a responsible representative of the Manufacturer that the geocomposite actually delivered have "minimum average roll values" properties which meet or exceed all certified property values for that type of geocomposite.

The CQA Consultant will examine the Manufacturers' certifications to document that the property values listed on the certifications meet or exceed those specified for the particular type of geocomposite (geotextile and geonet). Deviations will be reported to the Project Manager.

13.3 Labeling

The Manufacturer will identify all rolls of geocomposite with the following:

- Manufacturer's name;
- product identification;
- lot number;
- roll number; and
- roll dimensions.

The CQA Site Manager will examine rolls upon delivery and deviation from the above requirements will be reported to the Project Manager.

13.4 Shipment and Storage

During shipment and storage, the geocomposite will be protected from ultraviolet light exposure, precipitation or other inundation, mud, dirt, dust, puncture, cutting or any other damaging or deleterious conditions. Therefore, geocomposite rolls will be shipped and stored in relatively opaque and watertight wrappings. The CQA Site Manager will observe rolls upon delivery to the site and deviation from the above requirements will be reported to the Project Manager. Damaged rolls will be rejected and replaced.

Wrapping protecting geocomposite rolls will be removed less than one hour prior to unrolling geocomposite before placement. After the wrapping has been removed, geocomposite should not be exposed to sunlight for more than 15 days, unless otherwise approved by the Manufacturer. Approval by the Manufacturer will be a guarantee that the properties of the exposed geotextile will not degrade upon prolonged exposure to such values that would cause the material to not meet the *Technical Specifications*. Any material that is exposed for more than 15 days, which has been approved for prolonged exposure by the Manufacturer, will be tested by the CQA Laboratory to document that the material properties are still in conformance with the *Technical Specifications*. Any material that fails to meet the *Technical Specifications* will be replaced by the Manufacturer.

The CQA Site Manager will observe that geocomposite is free of dirt and dust just before installation. The CQA Site Manager will report the outcome of this observation to the Project Manager, and if the geocomposite is judged dirty or dusty, they will be cleaned by the Geosynthetic Installer prior to installation.

13.5 Conformance Testing

13.5.1 Tests

The geocomposite material will be tested for transmissivity (ASTM D 4716) and for peel strength (ASTM D 413) at the frequencies presented in Table 11.

13.5.2 Sampling Procedures

Upon delivery of the geocomposite rolls, the CQA Site Manager will document that samples are obtained from individual rolls at the frequency specified in this CQA Plan. The geocomposite samples will be forwarded to the CQA Laboratory for testing to evaluate conformance to both the *Technical Specifications* and the list of physical properties certified by the Manufacturer.

Samples will be taken across the width of the roll and will not include the first 3 linear ft (1 linear m). Unless otherwise specified, samples will be 3 ft (1 m) long by the roll width. The CQA Consultant will mark the machine direction on the samples with an arrow.

13.5.3 Test Results

The CQA Site Manager will examine results from laboratory conformance testing and compare results to the *Technical Specifications*. The criteria used to evaluate acceptability are presented in the *Technical Specifications*. The CQA Site Manager will report any nonconformance to the Project Manager.

13.5.4 Conformance Test Failure

The following procedure will apply whenever a sample fails a conformance test that is conducted by the CQA Laboratory:

- The Manufacturer will replace every roll of geocomposite that is in nonconformance with the *Technical Specifications* with a roll that meets specifications.

- The Geosynthetic Installer will remove conformance samples for testing by the CQA Laboratory from the closest numerical rolls on both sides of the failed roll. These two samples must conform to the *Technical Specifications*. If either of these samples fail, the numerically closest rolls on the side of the failed sample that is not tested, will be tested by the CQA Laboratory. These samples must conform to the *Technical Specifications*. If any of these samples fail, every roll of geocomposite on site from this lot and every

subsequently delivered roll that is from the same lot must be tested by the CQA Laboratory for conformance to the *Technical Specifications*.

The CQA Site Manager will document actions taken in conjunction with conformance test failures.

13.6 Handling and Placement

The Geosynthetic Installer will handle all geocomposite in such a manner as to document they are not damaged in any way. The Geosynthetic Installer will comply with the following:

- In the presence of wind, the geocomposite will be weighted with sandbags or the equivalent. Sandbags will be used during installation only and will remain until replaced with the appropriate cover material.

- If in place, special care must be taken to protect other materials from damage, which could be caused by the cutting of the geocomposite.

- The Geosynthetic Installer will take any necessary precautions to prevent damage to underlying layers during placement of the geocomposite.

- During placement of geocomposite, care will be taken to prevent entrapment of dirt or excessive dust that could cause clogging of the drainage system, and/or stones that could damage the adjacent geomembrane. If dirt or excessive dust is entrapped in the geocomposite, it should be cleaned prior to placement of the next material on top of it. In this regard, care should be taken with the handling or sandbags, to prevent rupture or damage of the sandbag.

- A visual examination of the geocomposite will be carried out over the entire surface, after installation to document that no potentially harmful foreign objects are present.

The CQA Site Manager will note noncompliance and report it to the Project Manager.

13.7 Drainage composite Seams and Overlaps

Adjacent geocomposite panels will be joined in general accordance with *Construction Drawings* and *Technical Specifications*. As a minimum, the following requirements will be met:

- Adjacent rolls will be overlapped by at least 4 in. (100 mm).
- Each component of the geocomposite will be secured or seamed to the like component at overlaps.
- The geocomposite overlaps will be secured by tying, in general accordance with the *Technical Specifications*.
- The bottom layers of geotextile will be overlapped.
- The top layers of geotextile will be continuously sewn.

The CQA Consultant will note any noncompliance and report it to the Project Manager.

13.8 Repair

Holes or tears in the geocomposite will be repaired by placing a patch extending 2 ft (0.6 m) beyond edges of the hole or tear. The patch will be secured by tying with approved tying devices every 6 in. (150 mm) through the bottom geotextile and the geonet of the patch, and through the top geotextile and geonet components of the geocomposite needing repair. The top geotextile component of the patch will be heat sealed to the top geotextile of the geocomposite needing repair. If the hole or tear width across the roll is more than 50 percent of the width of the roll, the damaged area will be cut out and the two portions of the geocomposite will be joined in general accordance with Section 13.7.

The CQA Site Manager will observe repairs, note noncompliances with the above requirements and report them to the Project Manager.

13.9 Placement of Soil Materials

The Contractor will place all soil materials located on top of a geocomposite in such a manner as to document:

- the geocomposite and underlying liner materials are not damaged;
- minimal slippage of the geocomposite on underlying layers occurs; and
- no excess tensile stresses occur in the geocomposite.

Unless otherwise specified by the CQA Consultant, lifts of soil material will be in conformance with the *Technical Specifications*. If portions of the geocomposite are exposed, the CQA Consultant will periodically place marks on the geocomposite and the underlying geomembrane and measure the elongation of the geonet during the placement of soil.

Noncompliance will be noted by the CQA Consultant and reported to the Project Manager.

14. SURVEYING

14.1 Survey Control

Survey control will be performed by the Owner as needed. A permanent benchmark will be established for the site(s) in a location convenient for daily tie-in. The vertical and horizontal control for this benchmark will be established within normal land surveying standards.

14.2 Precision and Accuracy

A wide variety of survey equipment is available for the surveying requirements for these projects. The survey instruments used for this work should be sufficiently precise and accurate to meet the needs of the projects. Surveys shall be performed at 2nd order accuracy.

14.3 Lines and Grades

The following surfaces will be surveyed to verify the lines and grades achieved during soil placement and compaction.

- Excavation:
  - original grade surface;
  - completed excavation surface prior to fill placement.
- Engineered Fill:
  - subgrade surface; and
  - finished compacted engineered fill surface.
- Prepared Subgrade:
  - prepared subgrade surface.

The following structures will be surveyed to verify and document the lines and grades achieved during construction of the Project:

- all culverts, inlet, and drop structures;
- ditch bottoms and sideslopes;
- permanent erosion control features;
- geomembrane terminations and selected geomembrane seams, as indicated by the CQA Manager; and
- centerlines of pipes.

14.4 Frequency and Spacing

Surveying should be carried out immediately upon completion of a given installation to facilitate progress and avoid delaying commencement of the next installation. In addition, spot checks during placement and compaction will be necessary to assist the Contractor in compliance with required grades.

At the least the following minimum spacings and locations should be provided for survey points:

- all "flat" surfaces, such as the base of the landfill, with gradients less than 10 percent, should be surveyed on a square grid not wider spaced than 100 ft (30 m);
- on all slopes greater than 10 percent, a square grid not wider than 100 ft (30 m) should be used, but in any case, a line at the crest, midpoint, and toe of the slope should be taken;
- a line of survey points no further than 100 ft (30 m) apart must be taken along any slope break (this will include the inside edge and outside edge of any bench on a slope); and
- a line of survey points no further than 50 ft (15 m) apart must be taken at the invert of pipes or other appurtenances to the liner.

14.5 Documentation

Field survey notes should be retained by the Land Surveyor. The findings from the field surveys should be documented on a set of Survey Record Drawings, which shall be provided to the Engineer in AutoCADD 2000 format or other suitable format as directed by the Owner.

TABLE 1
TEST PROCEDURES FOR THE EVALUATION OF SOILS

TEST METHOD	DESCRIPTION	TEST STANDARD
Laboratory Test Procedures:		
Classification	Classification of Soils	ASTM D 2487
Modified Proctor	Moisture/Density Relationship of Soil (10 lb (4.54 kg) rammer and 18 in. (457 mm) drop)	ASTM D 1557
Hydrometer Analysis	Particle Size Distribution of Fine Fraction of Soils	ASTM D 422
Sieve Analysis	Particle Size Distribution of Coarse Fraction of Soils	ASTM D 422
Field Test Procedures:		
Nuclear Densometer	In Situ Soil Unit Weight In Situ Moisture Content	ASTM D 2922 ASTM D 3017
Sand Cone	In Situ Soil Unit Weight Moisture Content	ASTM D 1556 ASTM D 2216
Drive Cylinder	In Situ Soil Unit Weight Moisture Content	ASTM D 2937 ASTM D 2216

TABLE 2

MINIMUM SOILS TESTING FREQUENCIES FOR MATERIAL QUALIFICATION TESTING

TEST	ENGINEERED FILL
Sieve Analysis	1 per source
Hydrometer Analysis	1 per source
Soil Classification	1 per source
Modified Proctor	1 per source

TABLE 3

MINIMUM SOILS TESTING FREQUENCIES FOR CONFORMANCE TESTING

TEST	ENGINEERED FILL
Sieve Analysis	1 per 10,000 yd^3 (7,646 m^3)
Hydrometer Analysis	1 per 10,000 yd^3 (7,646 m^3)
Soil Classification	1 per 10,000 yd^3 (7,646 m^3)
Modified Proctor	1 per 10,000 yd^3 (7,646 m^3)

TABLE 4

MINIMUM SOIL TESTING FREQUENCIES FOR CONSTRUCTION QUALITY CONTROL

TEST	ENGINEERED FILL
Nuclear densometer	1 per 500 yd^3 (76 m^3)
Sand cone or drive cylinder	1 per 20 nuclear densometer tests

TABLE 5

TEST PROCEDURES FOR THE EVALUATION OF AGGREGATE

TEST METHOD	DESCRIPTION	TEST STANDARD
Sieve Analysis	Particle Size Distribution of Fine and Coarse Aggregates	ASTM C 136
Hydraulic Conductivity (Rigid Wall Permeameter)	Permeability of Aggregates	ASTM D 2434

TABLE 6

MINIMUM AGGREGATE TESTING FREQUENCIES FOR MATERIAL QUALIFICATION TESTING

TEST	DRAINAGE AGGREGATE
Sieve Analysis	1 per source
Hydraulic Conductivity	1 per source

TABLE 7

MINIMUM AGGREGATE TESTING FREQUENCIES FOR CONFORMANCE TESTING

TEST	TEST METHOD	DRAINAGE AGGREGATE
Sieve Analysis	ASTM C 136	1 per 5,000 yd^3 (3,823 m^3)
Hydraulic Conductivity	ASTM D 2434	1 per 10,000 yd^3 (7,646 m^3)

TABLE 8

GEOMEMBRANE CONFORMANCE TESTING REQUIREMENTS

TEST NAME	TEST METHOD	FREQUENCY
Specific Gravity	ASTM D 792 Method A or ASTM D 1505	100,000 ft^2 (9,290 m^2)
Thickness	ASTM D 5994	100,000 ft^2 (9,290 m^2)
Tensile Strength at Yield	ASTM D 638	100,000 ft^2 (9,290 m^2)
Tensile Strength at Break	ASTM D 638	100,000 ft^2 (9,290 m^2)
Elongation at Yield	ASTM D 638	100,000 ft^2 (9,290 m^2)
Elongation at Break	ASTM D 638	100,000 ft^2 (9,290 m^2)
Carbon Black Content	ASTM D 1603	100,000 ft^2 (9,290 m^2)
Carbon Black Dispersion	ASTM D 5596	100,000 ft^2 (9,290 m^2)

TABLE 9

GEOTEXTILE CONFORMANCE TESTING REQUIREMENTS

TEST NAME	TEST METHOD	MINIMUM FREQUENCY CUSHION	MINIMUM FREQUENCY FILTRATION	MINIMUM FREQUENCY UV PROTECTION
Mass per Unit Area	ASTM D 5261	1 test per 200,000 ft^2 (18,580 m^2)	---	---
Grab Strength	ASTM D 4632	1 test per 200,000 ft^2 (18,580 m^2)	1 test per 200,000 ft^2 (18,580 m^2)	---
Puncture Resistance	ASTM D 4833	1 test per 200,000 ft^2 (18,580 m^2)	1 test per 200,000 ft^2 (18,580 m^2)	---
Permittivity	ASTM D 4491	---	1 test per 200,000 ft^2 (18,580 m^2)	---
Apparent Opening Size	ASTM D 4751	---	1 test per 200,000 ft^2 (18,580 m^2)	1 test per 200,000 ft^2 (18,580 m^2)
Wide Width Tensile	ASTM D 4595	---	---	1 test per 200,000 ft^2 (18,580 m^2)

TABLE 10

GCL CONFORMANCE TESTING REQUIREMENTS

TEST NAME	TEST METHOD	MINIMUM FREQUENCY
Mass per Unit Area	ASTM D 3776	100,000 ft^2 (9,290 m2)
Index Flux	ASTM D 5887	400,000 ft^2 (37,160 m^2)
Residual Shear Strength	ASTM D 5321	See Technical Specifications

TABLE 11

GEOCOMPOSITE CONFORMANCE TESTING REQUIREMENTS

TEST NAME	TEST METHOD	MINIMUM FREQUENCY
Peel Strength	ASTM D 413	1 test per 200,000 ft^2 (18,580 m^2)
Hydraulic Transmissivity	ASTM D 4716	1 test per 200,000 ft^2 (18,580 m^2)

Note: Testing will be carried out at a frequency of one per lot or at listed frequency, whichever yields the greater number of samples.

Section 4
Base Liner Technical Specifications

TECHNICAL SPECIFICATIONS
FOR THE
CONSTRUCTION OF

BASE LINER SYSTEM
AT
CORRECTIVE ACTION MANAGEMENT UNIT
BASIC REMEDIATION COMPANY
HENDERSON, NEVADA

Prepared for:

Basic Remediation Company
875 West Warm Springs Road
Henderson, Nevada 89015
(702) 567-0400

Prepared by:

GeoSyntec Consultants
11305 Rancho Bernardo Road, Suite 101
San Diego, California 92127
(858) 674-6559

3 November 2006

TABLE OF CONTENTS

Section 02110	**—**	**Site Clearing**
Section 02200	**—**	**Earthwork**
Section 02225	**—**	**Drainage Aggregate**
Section 02711	**—**	**Polyethylene Pipe**
Section 02770	**—**	**Geomembrane**
Section 02771	**—**	**Geotextile**
Section 02772	**—**	**Geosynthetic Clay Liner**
Section 02773	**—**	**Geocomposite**
Section 02820	**—**	**Chain Link Fence**

SECTION 02110
SITE CLEARING

PART 1 – GENERAL

1.01 Description of Work

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, and equipment necessary to perform all work specified herein and as shown on the Drawings.

B. The Contractor shall remove and dispose of all debris, vegetation, other organic and deleterious material, and other materials not suitable for Engineered fill materials that exist within the designated construction limits.

1.02 Related Sections

Section 02200 — Earthwork

1.03 References

A. Drawings

B. Construction Quality Assurance (CQA) Plan

PART 2 – PRODUCTS

A. Not Used.

PART 3 – EXECUTION

3.01 General

A. The Contractor shall be responsible for all clearing and grubbing operations within the limits of work.

B. All vegetation, debris, deleterious and other organic material not suitable for Engineered fill materials shall be removed completely from within the construction limits.

C. No open burning of combustible materials will be allowed.

D. All materials removed during the clearing and grubbing operations shall be disposed of properly.

E. Prior to site clearing, Contractor shall have implemented erosion control plan.

PART 4 – MEASUREMENT AND PAYMENT

4.01 General

A. Providing for and complying with the requirements set forth in this Section for Clearing and Grubbing will be incidental to earthworks (Section 02200).

B. The following are considered incidental to the Work:

- Mobilization
- Layout survey

END OF SECTION

SECTION 02200
EARTHWORK

PART 1 – GENERAL

1.01 Description of Work

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, equipment, and incidentals necessary to perform all Earthwork. The work shall be carried out as specified herein and in accordance with the Drawings.

B. The Work shall include, but not be limited to excavating, hauling, placing, moisture conditioning, backfilling, compacting, grading, stockpiling, surcharging, and subgrade preparation. Earthwork shall conform to the dimensions, lines, grades and sections shown on the Drawings or as directed by the Engineer.

1.02 Related Sections

Section 02110 — Site Clearing

Section 02771 — Geotextile

Section 02772 — Geosynthetic Clay Liner

Section 02773 — Geocomposite

1.03 References

A. Drawings

B. Construction Quality Assurance (CQA) Plan

C. Latest version of American Society for Testing and Materials (ASTM) standards:

ASTM D 422	Standard Method for Particle-Size Analysis of Soils
ASTM D 1557	Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3))
ASTM D 2216	Standard Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures
ASTM D 2487	Standard Test Method for Classification of Soils for Engineering Purposes
ASTM D 2922	Standard Test Methods for Density of Soil and Soil-Aggregate In-Place by Nuclear Density Methods (Shallow Depth)
ASTM D 3017	Standard Test Method for Water Content of Soil and Rock In-Place by Nuclear Methods (Shallow Depth)

1.04 Submittals

A. The Contractor shall submit to the Engineer a description of equipment and methods proposed for Engineered Fill, Operations Layer, Anchor Trench Backfill, and Prepared Subgrade placement and compaction at least 7 days prior to the start of activities covered by this Section.

B. If the work of this Section is interrupted for reasons other than inclement weather, the Contractor shall notify the Engineer a minimum of 24 hours prior to the resumption of work.

C. The Contractor shall provide the Engineer with sufficient time to perform as-built surveys of the completed excavation, engineered fill, prepared subgrade, and operations layer.

D. If foreign borrow materials are proposed for any earthwork material on this project, the Contractor shall provide the Engineer information regarding the source of the material. In addition, the Contractor shall provide the Engineer an opportunity to obtain the necessary samples for conformance testing, prior to delivery of foreign borrow materials to the site.

1.05 Quality Assurance

A. The Contractor shall ensure that the materials and methods used for Earthwork meet the requirements of the Drawings and this Section. Any material or method that does not conform to these documents, or to alternatives approved in writing by the Engineer will be rejected and shall be repaired or replaced by the Contractor.

B. The Contractor shall be aware of and accommodate all monitoring and field/laboratory conformance testing required by the CQA Plan. This monitoring and testing, including random conformance testing of construction materials and completed work, will be performed by the Engineer. If nonconformances or other deficiencies are found in the materials or completed work, the Contractor will be required to repair the deficiency or replace the deficient materials.

PART 2 – PRODUCTS

2.01 Materials

A. Engineered fill shall consist of relatively homogeneous, natural soils that are free of debris, foreign objects, large rock fragments (greater than 6 inches in maximum dimension), roots, and organics. No materials larger than 6 inches shall be allowed within the Engineered fill. The Engineered fill shall be classified according to the Unified Soil Classification System (per ASTM D 2487) as SC, ML, CL, SM, SW, SP, GW, GP, GM, GC, or combinations of these materials. The Contractor may propose the use of other soil types as Engineered fill, but then such use shall be at the sole discretion of the Engineer.

B. Prepared subgrade is defined as the material directly underlying the geosynthetic liner system which shall meet the requirements listed above for Engineered fill. No materials larger than 3/4 inch shall project or protrude from the surface of the prepared subgrade.

C. Anchor Trench Backfill materials shall meet the requirements listed above for the Engineered fill.

D. Operations Layer materials shall meet the requirements listed above for the Engineered fill, except that the 12 inches of layer material to be placed overlying the geocomposite shall have a maximum particle size of 1 inch.

E. Surcharge materials shall have a minimum wet density, as compacted in place of 135 pounds per cubic foot.

2.02 Equipment

A. The Contractor shall furnish, operate, and maintain compaction equipment as is necessary to produce the required in-place soil density and moisture content.

B. The Contractor shall furnish, operate and maintain tank trucks, pressure distributors, or other equipment designed to apply water uniformly and in controlled quantities to variable surface widths.

C. The Contractor shall furnish, operate, and maintain miscellaneous equipment such as scarifiers or disks, earth excavating equipment, earth hauling equipment, and other equipment, as necessary for Earthwork construction.

PART 3 – EXECUTION

3.01 Familiarization

A. Prior to implementing any of the work in this Section, the Contractor shall become thoroughly familiar with the site, the site conditions, and all portions of the work falling within this and other related Sections.

B. Inspection:

- The Contractor shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the installation of the work specified in this Section may properly commence without adverse impact.

- If the Contractor has any concerns regarding the installed work of other Sections, the Engineer shall be notified in writing prior to commencing work. Failure to notify the Engineer or continuance of the work of this Section will be construed as Contractor's acceptance of the related work of all other Sections.

3.02 Site Preparation

A. The Contractor shall perform clearing and grubbing in accordance with the Drawings and Section 02110 of these Specifications prior to any Earthwork activity.

B. Prior to performing any earthworks on the site, the Contractor shall perform a baseline topographic survey. This survey shall be conducted by a Professional Land Surveyor licensed in the state of Nevada. This survey will serve as the starting point for earthwork quantities, both excavation and fill placement.

3.03 General Excavation

A. The Contractor shall excavate materials to the limits and grades shown on the Drawings.

B. All excavated materials not used for Engineered fill or operations layer shall be stockpiled in an area designated by the Owner in accordance with Part 3.06 of this Section.

C. Excavations in native soil shall not have slopes steeper than 2.1H:1V, unless otherwise approved by the Engineer.

3.04 Anchor Trench Excavation

A. The Contractor shall excavate the anchor trench to the limits and grades shown on the Drawings.

B. All excavated materials not used for Anchor Trench Backfill or Engineered fill shall be stockpiled in an area designated by the Owner in accordance with Part 3.06 of this Section.

3.05 Surcharge

A. The surcharge soil shall be placed and compacted as shown on the drawings.

B. Surcharge shall have slopes no steeper than 1H:1V.

C. Settlement plates shall be installed as shown on the drawings and shall be surveyed on a weekly basis, at a minimum.

D. Surcharge shall be removed once settlement has reached levels differing no more than 5% from previous readings or no more than 0.05 feet.

3.06 Subgrade Surface Preparation

A. The subgrade shall be prepared and made suitable as a foundation for placement and compaction of soil material, where applicable. The subgrade shall be firm and able to support the Contractor's construction equipment without the development of depressions or ruts. In addition, the subgrade shall provide adequate support such that the overlying fill material may be placed and compacted to the specified density.

3.07 Prepared Subgrade

A. The prepared subgrade shall be made suitable as a foundation for placement of the geosynthetic components of the liner system (prepared subgrade). The prepared subgrade shall be firm, meet the requirements outlined in Part 2.01, and be able to support the geosynthetic components of the liner system.

3.08 Stockpiling

A. Soil shall be stockpiled in areas designated by the Owner and shall be free of incompatible soil, clearing, clearing debris, or other objectionable materials.

B. Stockpiles shall be no steeper than 2.1H:1V (Horizontal:Vertical) or other slope approved by the Engineer, graded to drain, sealed by tracking parallel to the slope with a dozer or other means approved by the Engineer, and dressed daily during periods when fill is taken from the stockpile. The Contractor shall employ temporary erosion and sediment control measures (i.e. silt fence) as directed by the Engineer around stockpile areas.

3.09 Engineered Fill And Anchor Trench Backfill

A. The Engineered fill and Anchor Trench Backfill shall be placed to the lines and grades shown on the Drawings.

B. Soil used for the Engineered fill and Anchor Trench Backfill shall meet the requirements of Part 2.01 of this Section.

C. Soil used for the Engineered fill and Anchor Trench Backfill shall be placed in a loose lift that results in a compacted lift thickness of no greater than 12 inches. The maximum permissible pre-compaction soil clod size is 6 inches.

D. Each 12-inch horizontal lift of Engineered fill placed against a slope shall be keyed into the slope a minimum of 3 feet, as measured horizontally from the top of the 12-inch lift.

E. The Contractor shall compact each lift to at least 90 percent of its modified Proctor maximum dry density (ASTM D 1557). The Contractor shall utilize compaction equipment suitable for achieving the soil compaction requirements.

F. During wetting or drying, the material shall be regularly disced or otherwise mixed so that uniform moisture conditions in the appropriate range are obtained.

3.10 Operations Layer

A. Place only when underlying drainage aggregate and filter geotextile or geocomposite installation is complete including all Construction Quality Control (CQC) and CQA work.

B. The subgrade to the operations layer consists of a geotextile or geocomposite. Therefore, the Contractor shall avoid tearing, puncturing, folding, or damaging in any way the filter geotextile or geocomposite geotextile during placement of the operations layer material.

C. Any damage to the geosynthetic liner system which is caused by the Contractor or representatives of the Contractor shall be repaired by the Geosynthetics Installer at the expense of the Contractor.

D. No density requirements are specified for placement of the operations layer material. Operations layer material shall be placed at a moisture content less than the optimum moisture content for the soil.

E. The operations layer material shall be placed out in front of the equipment used to place the operations layer such that the minimum thickness requirements are maintained at all times between the geosynthetic materials and the wheels or tracks of the equipment used to place the operations layer material.

F. Care must be exercised by the operators of tracked equipment to avoid sharp pivoting turns that could displace the operations layer material and result in damage to the liner system.

G. The Contractor shall not push operations layer material down the side slope. All soil materials shall be placed from the toe of slope upward.

H. Equipment used in spreading the operations layer material on top of the geosynthetic liner system shall be restricted to the following maximum allowable equipment ground pressures:

MAXIMUM ALLOWABLE EQUIPMENT GROUND PRESSURE (psi)	INITIAL LIFT THICKNESS OF OVERLYING AGGREGATE (ft)
<20	2.0
>20	3.0

I. The operations layer shall be placed to a maximum vertical height of 10 ft at a slope inclination no steeper than 2.5H:1V as shown on the Drawings.

3.11 Field Testing

A. The minimum frequency and details of quality control testing are provided below. This testing will be performed by the Engineer. The Contractor shall take this testing frequency into account in planning the construction schedule.

1. Engineered fill material quality control testing:

a. particle-size analyses conducted in accordance with ASTM D 422 at a frequency of one test per 10,000 yd^3;

b. soil classification tests conducted in accordance with ASTM D 2487 at a frequency of one test per 10,000 yd^3; and

c. modified Proctor compaction tests conducted in accordance with ASTM D 1557 at a frequency of one test per 10,000 yd^3.

2. The Engineer will perform conformance tests on placed and compacted Engineered fill to evaluate compliance with these Specifications. These tests will include in-situ moisture content and dry density. The frequency and procedures for moisture-density testing are given in the CQA Plan. At a minimum, the dry density and moisture content of the soil will be measured in-situ in accordance with ASTM D 2922 and ASTM D 3017, respectively.

3. A special testing frequency will be used by the Engineer when visual observations of construction performance indicate a potential problem. Additional testing will be considered when:

   a. the rollers slip during rolling operation;
   b. the lift thickness is greater than specified;
   c. the fill is at improper and/or variable moisture content;
   d. fewer than the specified number of roller passes are made;
   e. dirt-clogged rollers are used to compact the material;
   f. the rollers do not have optimum ballast; or
   g. the degree of compaction is doubtful.

4. During construction, the frequency of testing will be increased by the Engineer in the following situations:

   a. adverse weather conditions;
   b. breakdown of equipment;
   c. at the start and finish of grading;
   d. if the material fails to meet specifications; or
   e. the work area is reduced.

B. Defective Areas:

1. If a defective area is discovered in the Earthwork, the Engineer will evaluate the extent and nature of the defect. If the defect is indicated by an unsatisfactory test result, the Engineer will determine the extent of the defective area by additional tests, observations, a review of records, or other means that the Engineer deems appropriate. If the defect is related to adverse site conditions, such as overly wet soils or surface desiccation, the Engineer shall define the limits and nature of the defect.

2. Once the extent and nature of a defect is determined, the Contractor shall correct the deficiency to the satisfaction of the Engineer. The Contractor shall not perform additional work in the area until the Engineer approves the correction of the defect.

3. Additional testing may be performed by the Engineer to verify that the defect has been corrected. This additional testing will be performed before any additional work is allowed in the area of deficiency. The cost of the additional testing shall be borne by the Contractor.

3.12 Survey Control

A. The Contractor shall perform all surveys necessary for construction layout and control.

3.13 Construction Tolerance

A. The Contractor shall perform the Earthwork construction to within ±0.1 ft on areas with a slope less than 10 percent and ±0.2 ft on areas with a slope greater than 10 percent of the grades indicated on the Drawings.

3.14 Protection of Work

A. The Contractor shall use all means necessary to protect completed work of this Section.

B. At the end of each day, the Contractor shall verify that the entire work area is left in a state that promotes drainage of surface water away from the area and from finished work. If threatening weather conditions are forecast, at a minimum, compacted surfaces shall be seal-rolled to protect finished work.

C. In the event of damage to prior work, the Contractor shall make repairs and replacements to the satisfaction of the Engineer.

PART 4 – MEASUREMENT AND PAYMENT

4.01 General

A. Providing for and complying with the requirements set forth in this Section for Excavation will be measured as in-place cubic yards (CY), prior to excavation, and payment will be based on the unit price provided on the Bid Schedule.

B. Providing for and complying with the requirements set forth in this Section for Engineered Fill will be measured as compacted and moisture conditioned in-place cubic yards (CY), and payment will be based on the unit price provided on the Bid Schedule.

C. Providing for and complying with the requirements set forth in this Section for Prepared Subgrade will be measured as square feet (SF), and payment will be based on the unit price provided on the Bid Schedule.

D. Providing for and complying with the requirements set forth in this Section for Anchor Trench Excavation and Backfill will be measured as linear feet (LF), and payment will be based on the unit price provided on the Bid Schedule.

E. Providing for and complying with the requirements set forth in this Section for Operations Layer will be measured as in-place cubic yards (CY), and payment will be based on the unit price provided on the Bid Schedule.

F. Providing for and complying with the requirements set forth in this section for Surcharge will be measured as in-place cubic yards (CY), and payment will be based on the unit price provided on the Bid Schedule.

G. The following are considered incidental to the Work:

- material samples, sampling, and testing.
- layout survey.
- rejected material removal, re-testing, handling, and repair.

- rejected material.
- mobilization.
- Stockpiling.
- settlement plates.
- surcharge removal.

END OF SECTION

SECTION 02225
DRAINAGE AGGREGATE

PART 1 – GENERAL

1.01 Description of Work

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, equipment and incidentals necessary for the installation of drainage aggregate. The work shall be carried out as specified herein and in accordance with the Drawings.

B. The work shall include, but not be limited to, delivery, storage, and placement of drainage aggregate (aggregate).

1.02 Related Sections

Section 02200 — Earthwork

Section 02771 — Geotextile

1.03 References

A. Drawings

B. Construction Quality Assurance (CQA) Plan

C. Latest Version of American Society for Testing and Materials (ASTM) Standards:

ASTM C 33	Standard Specification for Concrete Aggregates
ASTM C 136	Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM D 2434	Standard Test Method for Permeability of Granular Soils (Constant Head)

1.04 Submittals

A. The Contractor shall submit to the Engineer for approval, at least 7 days prior to the start of construction, Certificates of Compliance for proposed aggregate materials. Certificates of Compliance shall include, at a minimum, typical gradation and source of aggregate materials.

B. The Contractor shall submit to the Engineer a list of equipment and technical information for equipment proposed for use in placing the aggregate material in accordance with this Section.

1.05 Quality Assurance

A. The Contractor shall ensure that the materials and methods used for Earthwork meet the requirements of the Drawings and this Section. Any material or method that does not conform to these documents, or to alternatives approved in writing by the Engineer will be rejected and shall be repaired or replaced by the Contractor.

B. The Contractor shall be aware of all monitoring and field/laboratory conformance testing required by the CQA Plan. This monitoring and testing, including random conformance testing of construction materials and completed work, will be performed by the Engineer. If nonconformances or other deficiencies are found in the materials or completed work, the Contractor will be required to repair the deficiency or replace the deficient materials.

PART 2 – PRODUCTS

2.01 Materials

A. Aggregate shall meet the requirements specified in ASTM C-33 and shall have a maximum particle size of 1-inch. Aggregate shall have a minimum permeability of 1 x 10^{-2} cm/sec when tested in accordance with ASTM D 2434.

2.02 Equipment

A. The Contractor shall furnish, operate, and maintain hauling, placing, and grading equipment as necessary for aggregate placement.

PART 3 – EXECUTION

3.01 Familiarization

A. Prior to implementing any of the work in this Section, the Contractor shall become thoroughly familiar with the site, the site conditions, and all portions of the work falling within this and other related Sections.

B. Inspection:

1. The Contractor shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the installation of the work specified in this Section may properly commence without adverse impact.

2. If the Contractor has any concerns regarding the installed work of other Sections, the Engineer shall be notified in writing prior to commencing work. Failure to notify the Engineer or continuance of the work of this Section will be construed as Contractor's acceptance of the related work of all other Sections.

3.02 Placement

A. Place only when underlying geosynthetic installation is complete including all CQC and CQA work.

B. Place to the lines, grades, and dimensions shown on the Drawings.

C. The subgrade to the aggregate consists of a geotextile overlying a geomembrane. The Contractor shall avoid creating large wrinkles (greater than 6-inches high), tearing, puncturing, folding, or damaging in any way the geosynthetic materials during placement of the aggregate material.

D. Any damage to the geosynthetic liner system which is caused by the Contractor or his representatives shall be repaired by the Geosynthetic Installer.

E. No density or moisture requirements are specified for placement of the aggregate material.

F. Equipment used in spreading the aggregate material on top of the geosynthetic liner system shall be restricted to the following maximum allowable equipment ground pressures:

MAXIMUM ALLOWABLE EQUIPMENT GROUND PRESSURE (psi)	INITIAL LIFT THICKNESS OF OVERLYING AGGREGATE (ft)
<10	1.0
<20	2.0
>20	3.0

G. The aggregate material shall be placed out in front of the equipment used to place the aggregate such that the minimum thickness requirements are maintained at all times between the geosynthetic materials and the wheels or tracks of the equipment used to place the aggregate material.

H. All equipment to be used in placing the aggregate material must be approved in writing by the Engineer prior to use. The Contractor shall provide a list of the equipment to be used for placing the aggregate material and the necessary technical information (equipment specifications) on each piece of equipment to be approved at least two working days prior to use.

I. Care must be exercised by the operators of tracked equipment to avoid sharp pivoting turns that could displace the aggregate material and result in damage to the geosynthetic liner system. Care must also be exercised by the operators to avoid the formation of waves greater than 6-inches high in the underlying geosynthetic materials which, when formed and pushed out in front of the leading face of the aggregate material, may grow to such magnitude as to result in a fold in the underlying geosynthetic materials. The Contractor shall place, by backhoe or some other acceptable method, aggregate material on the geosynthetic liner system out in front of the leading face of the aggregate material to trap small waves in the underlying geosynthetic materials and prevent the small waves from combining and growing as the aggregate material is spread. Folds in the underlying geosynthetic materials shall be considered as damage to the liner and must be repaired by the Geosynthetic Installer at the expense of the Contractor.

J. Place filter geotextile overlying aggregate as shown on the Drawings and as specified in Section 02771.

3.03 Field Testing

A. The minimum frequency and details of quality control testing are provided below. This testing will be performed by the Engineer. The Contractor shall take this testing frequency into account in planning the construction schedule.

1. Aggregates quality control testing:

   a. particle-size analyses conducted in accordance with ASTM C-136 at a frequency of one test per 5,000 yd^3;

   b. permeability tests conducted in accordance with ASTM D 2434 at a frequency of one test per 10,000 yd^3.

3.04 Survey Control

A. The Contractor shall perform all surveys necessary for construction layout and control.

3.05 Construction Tolerance

A. The Contractor shall perform the aggregate construction to within +0.1 ft of the thickness indicated on the Drawings.

3.06 Protection Of Work

A. The Contractor shall use all means necessary to protect all work of this Section.

B. In the event of damage, the Contractor shall make repairs and replacements to the satisfaction of the Engineer.

PART 4 – MEASUREMENT AND PAYMENT

4.01 General

A. Providing for and complying with the requirements set forth in this Section for Drainage Aggregate will be measured as in-place cubic yards (CY) and payment will be based on the unit price provided on the Bid Schedule.

B. The following are considered incidental to the Work:

- material samples, sampling, and testing.
- layout survey.
- rejected material.
- rejected material removal, re-testing, handling, and repair.
- mobilization.

END OF SECTION

SECTION 02711
POLYETHYLENE PIPE

PART 1 – GENERAL

1.01 Description of Work

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, and equipment necessary to install perforated and solid wall high density polyethylene (HDPE) pipe and fittings as shown on the Drawings and specified herein.

1.02 Related Sections

Section 02225 — Drainage Aggregate

Section 02774 — Geotextile

1.03 References

A. Drawings

B. Construction Quality Assurance (CQA) Plan

C. Latest Version of American Society for Testing and Materials (ASTM) Standards:

ASTM F 714	Specification for Polyethylene Plastic Pipe (SDR-PR) Based on Outside Diameter
ASTM D 1248	Specification for Polyethylene Plastics Molding and Extrusion
ASTM D 2657	Standard Practice for Heat Fusion Joining of Polyolefin Pipe and Fittings
ASTM D 3035	Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Controlled Outside Diameter
ASTM D 3350	Specification for Polyethylene Plastic Pipe and Fitting Materials

1.04 Definitions

A. Standard Dimensional Ratio (SDR) is defined as the actual outside pipe diameter divided by the wall thickness.

1.05 Submittals

A. The Contractor shall submit, at least 7 days prior to installation of this material, to the Engineer, certificates of compliance for the pipe materials and fittings to be furnished.

B. The Contractor shall submit, at least 7 days prior to installation of this material, to the Engineer, copies of certifications for each operator responsible for welding pipe.

C. The Engineer will supply a surveyor to document the as-built conditions of the piping. The Contractor shall notify and allow the Engineer sufficient time to survey piping prior to backfilling the pipe.

1.06 Quality Assurance

A. The Contractor shall ensure that the materials and methods used for polyethylene pipe meet the requirements of the Drawings and this Section. Any material or method that does not conform to these documents, or to alternatives approved in writing by the Engineer will be rejected and shall be repaired or replaced by the Contractor.

PART 2 – PRODUCTS

2.01 Pipe

A. HDPE pipe sizes shown on the Drawings and specified in this Section reference nominal inside diameter. Pipe size shall be in accordance with ASTM F 714 and ASTM D 3035.

B. Pipe shall be, 4-inch, 6-inch, and 18-inch diameter, and shall be HDPE with a minimum standard dimension ratio (SDR) of 13.5, and have a cell classification of 345434C in accordance with ASTM D 3350.

C. Pipe shall conform to the following requirements:

1. Pipe and fittings shall contain no recycled compound except that generated in the Manufacturer's own plant and from resin of the same specification as the raw material supplier.

2. Pipe and fittings shall be homogeneous throughout and free of visible cracks, holes, foreign inclusions, or other deleterious defects, being uniform in color, capacity, density, and other physical properties.

D. The following information shall be continuously marked on the pipe or spaced at intervals not exceeding 5 feet.

1. Name and/or trademark of the pipe Manufacturer.

2. Nominal pipe size.

3. Standard Dimensional Ratio (SDR).

4. PE 3408.

5. A production code from which the date and place of manufacture can be determined.

PART 3 – EXECUTION

3.01 General

A. When shipping, delivering, and installing pipe, fittings, and accessories, do so to ensure a sound, undamaged installation. Provide adequate storage for all materials and equipment delivered to the job site. Handle and store pipe and fittings in accordance with the Manufacturer's recommendation.

3.02 Placing and Laying Pipe

A. Follow the Manufacturer's recommendations when hauling, unloading, and stringing the pipe.

B. HDPE solid and perforated pipe shall be installed as shown on the Drawings.

C. HDPE pipe shall be inspected for cuts, scratches, or other damages prior to installation. Any pipe showing damage, which in the opinion of the CQA Engineer will affect performance of the pipe, must be removed from the Site. The Contractor shall replace any material found to be defective at no additional cost to the Owner.

D. The Contractor shall place the Trench Backfill material around the polyethylene pipe so as to not deform or otherwise damage the pipe and fittings. Special care shall be taken when placing pipe bedding material beneath the spring-line of the pipe and fittings.

E. The Contractor shall clean out pipe interior, as necessary, to remove debris that may affect performance of pipe.

3.03 Fusion Welding Pipe

A. All pipe fusion shall be performed by the Supplier, or a by fusion operator certified by the Manufacturer.

B. Join the polyethylene pipe by the method of thermal butt fusion, as outlined in ASTM D 2657. Electro-fusion couplings shall not be used. Perform butt-fusion joining of pipe and fittings in accordance with the procedures established by the pipe Manufacturer. Of particular importance is the use of proper interface pressures and heater plate temperatures.

C. Do not perform pipe fusion on wet or excessively dirty pipe or when conditions are unsuitable for the work. Secure open ends of pipe when work is not in progress, so that no water, earth, or other substance will enter the pipe or fittings. Plug, cap, or valve off ends of pipe left for future connections, if any.

D. In order to allow the joining operation to continue in adverse weather conditions, a shelter may be required for the joining machine. Particular caution should be exercised to prevent water from entering the pipe and from coming in contact with the heater plate.

E. Only fully trained personnel will be allowed to perform the fusion, installation, supervision, or inspection of polyethylene fusion joints.

3.04 Construction Tolerance

A. The Contractor shall perform the work to within ±0.1 ft of the grades indicated on the Drawings.

PART 4 – MEASUREMENT AND PAYMENT

4.01 General

A. Providing for and complying with the requirements set forth in this Section for 4-inch HDPE solid wall pipe and fittings will be measured in linear feet (LF), and payment will be based on the unit price provided on the Bid Schedule.

B. Providing for and complying with the requirements set forth in this Section for 4-inch HDPE perforated pipe and fittings will be measured in linear feet (LF), and payment will be based on the unit price provided on the Bid Schedule.

C. Providing for and complying with the requirements set forth in this Section for 6-inch HDPE solid wall pipe and fittings will be measured in linear feet (LF), and payment will be based on the unit price provided on the Bid Schedule.

D. Providing for and complying with the requirements set forth in this Section for 18-inch HDPE perforated and solid wall pipe and fittings will be measured in linear feet (LF), and payment will be based on the unit price provided on the Bid Schedule.

E. Providing for and complying with the requirements set forth in this Section for 4-inch HDPE solid and perforated pipe and fittings for vertical installation in wells will be incidental to Section 02074 for well installation.

F. The following are considered incidental to the Work:

- shipping, handling and storage.
- layout survey.
- mobilization.
- Fittings, and other pipe appurtenances.
- Fusing and Joining.
- rejected material.
- rejected material removal, handling, re-testing, repair, and replacement.
- filtration Geotextile in accordance with Section 02771.
- trench Excavation and Backfill in accordance with Section 02200.

END OF SECTION

SECTION 02770
GEOMEMBRANE

PART 1 – GENERAL

1.01 Description of Work

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, equipment, and incidentals necessary for the installation of textured high-density polyethylene (HDPE) geomembrane, as shown on the Drawings. The work shall be carried out as specified herein and in accordance with Drawings.

B. The work shall include, but not be limited to, delivery, storage, placement, anchorage, and seaming of the geomembrane.

1.02 Related Sections

Section 02771 — Geotextile

Section 02772 — Geosynthetic Clay Liner

Section 02773 — Geocomposite

1.03 References

A. Drawings

B. Construction Quality Assurance (CQA) Plan

C. Latest version of the American Society for Testing and Materials (ASTM) standards:

ASTM D 638	Standard Test Method for Tensile Properties of Plastics
ASTM D 792	Standard Test Methods for Specific Gravity (Relative Density) and Density of Plastics by Displacement
ASTM D 1004	Standard Test Method of Initial Tear Resistance of Plastic Film and Sheeting
ASTM D 1505	Standard Test Methods for Density of Plastics by Density-Gradient Technique
ASTM D 1603	Standard Test Method for Carbon Black in Olefin Plastics
ASTM D 5321	Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method
ASTM D 5397	Test Method for Evaluation of Stress Crack Resistance of Polyolefin Geomembranes Using Notched Constant Tensile Load Test
ASTM D 5596	Recommended Practice for Microscopical Examination of Pigment Dispersion in Plastic Compounds
ASTM D 5641	Practice for Geomembrane Seam Evaluation by Vacuum Chamber

ASTM D 5820	Practice for Pressurized Air Channel Evaluation of Dual Seamed Geomembranes
ASTM D 5994	Standard Test Method for Measuring Core Thickness of Textured Geomembranes
ASTM D 6392	Test Method for Determining the Integrity of Non-reinforced Geomembrane Seams Produced using Thermo-Fusion Methods.

1.04 Qualifications

A. The Geomembrane Manufacturer shall be responsible for the production of geomembrane rolls from resin and shall have sufficient production capacity and qualified personnel to provide material meeting the requirements of this Section and the construction schedule for this project.

B. Geosynthetics Installer:

1. The Geosynthetics Installer shall be responsible and shall provide sufficient resources for field handling, deploying, seaming, temporarily restraining (against wind), and other aspects of the deployment and installation of the geomembrane and other geosynthetic components of the project.

2. The Geosynthetics Installer shall have successfully installed a minimum of 10,000,000 ft^2 of polyethylene geomembrane on previous projects.

3. The installation crew shall have the following experience.

   a. The Superintendent shall have supervised the installation of a minimum of 2,000,000 ft^2 of polyethylene geomembrane on at least five (5) different projects.

   b. At least one seamer shall have experience seaming a minimum of 1,000,000 square feet of polyethylene geomembrane using the same type of seaming apparatus to be used at this site. Seamers with such experience will be designated “master seamers” and shall provide direct supervision over less experienced seamers.

   c. All other seaming personnel shall have seamed at least 100,000 square feet of polyethylene geomembrane using the same type of seaming apparatus to be used at this site. Personnel who have seamed less than 100,000 square feet shall be allowed to seam only under the direct supervision of the master seamer or Superintendent.

1.05 Warranty

A. The Geosynthetic Installer shall furnish the Engineer a 20-year written warranty against defects in materials. Warranty conditions concerning limits of liability will be evaluated by, and must be acceptable to, the Engineer and Owner.

B. The Geosynthetic Installer shall furnish the Engineer with a 1-year written warranty against defects in workmanship. Warranty conditions concerning limits of liability will be evaluated by, and must be acceptable to, the Engineer and Owner.

1.06 Submittals

A. The Geosynthetic Installer shall submit the following documentation on the resin used to manufacture the geomembrane to the Engineer for approval 14 days prior to transporting any geomembrane to the site.

1. Copies of quality control certificates issued by the resin supplier including the production dates and origin of the resin used to manufacture the geomembrane for the project.

2. Results of tests conducted by the Geomembrane Manufacturer to verify the quality of the resin used to manufacture the geomembrane rolls assigned to the project.

3. Certification that no reclaimed polymer is added to the resin during the manufacturing of the geomembrane to be used for this project, or, if recycled polymer is used, the Manufacturer shall submit a certificate signed by the production manager documenting the quantity of recycled material, including a description of the procedure used to measure the quantity of recycled polymer.

B. The Geosynthetic Installer shall submit the following documentation on geomembrane roll production to the Engineer for approval 14 days prior to transporting any geomembrane to the site.

1. Quality control certificates, which shall include:

   a. roll numbers and identification; and

   b. results of quality control tests, including descriptions of the test methods used, outlined in Part 2.02 of this Section.

2. The manufacturer warranty specified in Part 1.05.A of this Section.

C. The Geosynthetic Installer shall submit the following information to the Engineer for approval 14 days prior to mobilization.

1. A drawing showing the installation layout identifying geomembrane panel configurations, dimensions, details, locations of seams, as well as any variance or additional details that deviate from the Drawings. The layout shall be adequate for use as a construction plan and shall include dimensions, details, etc. The layout drawings, as modified and/or approved by the Engineer, shall become part of these Specifications.

2. Installation schedule.

3. Copy of Geosynthetic Installer's letter of approval or license by the Geomembrane Manufacturer.

4. Installation capabilities, including:

   a. information on equipment proposed for this project;
   b. average daily production anticipated for this project; and
   c. quality control procedures.

5. A list of completed facilities for which the installer has installed a minimum of 10,000,000 ft^2 of polyethylene geomembrane, in accordance with Part 1.04 of this Specification. The following information shall be provided for each facility:

   a. the name and purpose of the facility, its location, and dates of installation;
   b. the names of the owner, project manager, and geomembrane manufacturer;

c. name of the supervisor of the installation crew; and
d. thickness and surface area of installed geomembrane.

6. In accordance with Part 1.04, a resume of the Superintendent to be assigned to this project, including dates and duration of employment, shall be submitted at least 7 days prior to beginning geomembrane installation.

7. In accordance with Part 1.04, resumes of all personnel who will perform seaming operations on this project, including dates and duration of employment, shall be submitted at least 7 days prior to beginning geomembrane installation.

D. A Certificate of Calibration less than 12 months old shall be submitted for each field tensiometer prior to installation of any geomembrane.

E. During installation, the Geosynthetic Installer shall be responsible for the timely submission to the Engineer of:

1. Quality control documentation; and

2. Subgrade acceptance certificates, signed by the Geosynthetic Installer, for each area to be covered by geosynthetic materials.

F. Upon completion of the installation, the Geosynthetic Installer shall be responsible for the submission to the Engineer of a warranty from the Geosynthetic Installer as specified in Part 1.05.B of this Section.

G. Upon completion of the installation, the Geosynthetic Installer shall be responsible for the submission to the Engineer of a record drawing showing the location and number of each panel and locations and numbers of destructive tests and repairs.

H. The Geosynthetic Installer shall submit the following documentation on welding rod to the Engineer for approval 14 days prior to transporting welding rod to the site:

1. Quality control documentation, including lot number, welding rod spool number, and results of quality control tests on the welding rod.

1.07 Quality Assurance

A. The Geosynthetic Installer shall ensure that the materials and methods used for installation of the geomembrane meet the requirements of the Drawings and this Section. Any material or method that does not conform to these documents, or to alternatives approved in writing by the Engineer, will be rejected and shall be repaired or replaced by the Geosynthetic Installer.

B. The Geosynthetic Installer shall be aware of and accommodate all monitoring and conformance testing required by the CQA Plan. This monitoring and testing, including random conformance testing of construction materials and completed work, will be performed by the Engineer. If nonconformances or other deficiencies are found in the Geosynthetic Installer's materials or completed work, the Geosynthetic Installer will be required to repair the deficiency or replace the deficient materials.

PART 2 – PRODUCTS

2.01 Geomembrane Properties

A. The Geomembrane Manufacturer shall furnish double-sided, textured geomembrane having properties that comply with the required property values shown in Table 02770-1.

B. In addition to the property values listed in Table 02770-1, the geomembrane shall:

1. Contain a maximum of 1 percent by weight of additives, fillers, or extenders (not including carbon black).

2. Not have striations, pinholes (holes), bubbles, blisters, nodules, undispersed raw materials, or any sign of contamination by foreign matter on the surface or in the interior.

2.02 Manufacturing Quality Control

A. Rolls:

1. The Geomembrane Manufacturer shall continuously monitor geomembrane during the manufacturing process for defects.

2. No geomembrane shall be accepted that exhibits any defects.

3. The Geomembrane Manufacturer shall measure and report the geomembrane thickness at regular intervals along the roll length.

4. No geomembrane shall be accepted that fails to meet the specified thickness.

5. The Geomembrane Manufacturer shall sample and test the geomembrane at a minimum of once every 50,000 ft^2 to demonstrate that its properties conform to the values specified in Table 02770-1. At a minimum, the following tests shall be performed:

Test	Procedure
Thickness	ASTM D 5994
Specific Gravity	ASTM D 792 Method A or ASTM D 1505
Tensile Properties	ASTM D 638
Puncture Resistance	ASTM D 4833
Carbon Black	ASTM D 1603
Carbon Black Dispersion	ASTM D 5596

6. Tests not listed above but listed in Table 02770-1 need not be run at the 1 per 50,000 ft^2 frequency. However, the Geomembrane Manufacturer shall certify that these tests are in compliance with this section and have been performed on a sample that is identical to the geomembrane to be used on this project. The Geosynthetic Installer shall provide the test result documentation to the Engineer.

7. Any geomembrane sample that does not comply with the requirements of this Section will result in rejection of the roll from which the sample was obtained and will not be used for this project.

8. If a geomembrane sample fails to meet the quality control requirements of this Section, the Geomembrane Manufacturer shall sample and test, at the expense of the Manufacturer, rolls manufactured, in the same resin batch, or at the same time, as the failing roll. Sampling and testing of rolls shall continue until a pattern of acceptable test results is established to bound the failed roll(s).

9. Additional testing may be performed at the Geomembrane Manufacturer's discretion and expense, to isolate and more closely identify the non-complying rolls and/or to qualify individual rolls.

B. The Geomembrane Manufacturer shall permit the Engineer to visit the manufacturing plant for project specific visits. If possible, such visits will be prior to or during the manufacturing of the geomembrane rolls for the specific project.

2.03 Labeling

A. Geomembrane rolls shall be labeled with the following information.

1. thickness of the material;
2. length and width of the roll;
3. name of Geomembrane Manufacturer;
4. product identification;
5. lot number; and
6. roll number.

2.04 Transportation, Handling and Storage

A. Handling and care of the geomembrane prior to and following installation at the site shall be the responsibility of the Geosynthetic Installer. The Geosynthetic Installer shall be liable for all damage to the materials incurred prior to final acceptance of the liner system by the Engineer.

B. Geosynthetic Installer shall be responsible for storage of the geomembrane at the site. The geomembrane shall be protected from excessive heat or cold, dirt, puncture, cutting, or other damaging or deleterious conditions. Any additional storage procedures required by the Geomembrane Manufacturer shall be the Geosynthetic Installer's responsibility. Geomembrane rolls shall not be stored or placed in a stack of more than two rolls high.

C. The geomembrane shall be delivered at least 14 days prior to the planned deployment date to allow the Engineer adequate time to perform conformance testing on the geomembrane samples as described in Part 3.05 or this Section. If the Engineer performed a visit to the manufacturing plant and performed the required conformance sampling, geomembrane can be delivered to the site within the 14 days prior to the planned deployment date as long as there is sufficient time for the Engineer to complete the conformance testing and confirm that the rolls shipped to the site are in compliance with this Section.

PART 3 – PART 3 — GEOMEMBRANE INSTALLATION

3.01 Familiarization

A. Prior to implementing any of the work described in this Section, the Geosynthetic Installer shall become thoroughly familiar with all portions of the work falling within this Section.

B. Inspection:

1. The Geosynthetic Installer shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the work of this Section may properly commence without adverse effect.

2. If the Geosynthetic Installer has any concerns regarding the installed work of other Sections, he shall notify the Engineer in writing prior to the start of the work of this Section. Failure to inform the Engineer in writing or installation of the geomembrane

will be construed as the Geosynthetic Installer's acceptance of the related work of all other Sections.

C. A pre-installation meeting shall be held to coordinate the installation of the geomembrane with the installation of other components of the composite liner system.

3.02 Geomembrane Deployment

A. Layout Drawings:

1. The Geosynthetic Installer shall deploy the geomembrane panel in general accordance with the layout drawing specified. The layout drawings must be approved by the Engineer prior to installation of any geomembrane.

B. Field Panel Identification:

1. A geomembrane field panel is a roll or a portion of roll cut in the field.

2. Each field panel shall be given an identification code (number or letter-number). This identification code shall be agreed upon by the Engineer and Geosynthetic Installer.

C. Field Panel Placement:

1. Field panels shall be installed, as approved or modified, at the location and positions indicated on the layout drawings.

2. Field panels shall be placed one at a time, and each field panel shall be seamed immediately after its placement.

3. Geomembrane shall not be placed when the ambient temperature is below 40°F or above 104°F, unless otherwise authorized in writing by the Engineer.

4. Geomembrane shall not be placed during any precipitation, in the presence of excessive moisture (e.g., fog, dew), in an area of ponded water, or in the presence of excessive winds.

5. The Geosynthetic Installer shall ensure that:

a. No vehicular traffic is allowed on the geomembrane.

b. Equipment used does not damage the geomembrane by handling, trafficking, or leakage of hydrocarbons (i.e., fuels).

c. Personnel working on the geomembrane do not smoke, wear damaging shoes, bring glass onto the geomembrane, or engage in other activities that could damage the geomembrane.

d. The method used to unroll the panels does not scratch or crimp the geomembrane and does not damage the supporting soil or geosynthetics.

e. The method used to place the panels minimizes wrinkles (especially differential wrinkles between adjacent panels). The method used to place the panels results in intimate contact with adjacent components.

f. Temporary ballast and/or anchors (e.g., sand bags), not likely to damage the geomembrane, are placed on the geomembrane to prevent wind uplift.

g. The geomembrane is especially protected from damage in heavily trafficked areas.

h. Any rub sheets to facilitate seaming are removed prior to installation of subsequent panels.

6. Any field panel or portion thereof that becomes seriously damaged (torn, twisted, or crimped) shall be replaced with new material. Less serious damage to the geomembrane may be repaired, as approved by the Engineer. Damaged panels or portions of damaged panels that have been rejected shall be removed from the work area.

D. If the Geosynthetic Installer intends to install geomembrane between one hour before sunset and one hour after sunrise, he shall notify the Engineer in writing prior to the start of the work. The Geosynthetic Installer shall indicate additional precautions, which shall be taken during these installation hours. The Geosynthetic Installer shall provide proper illumination for work during this time period.

3.03 Field Seaming

A. Seam Layout:

1. In corners and at odd-shaped geometric locations, the number of field seams shall be minimized. No horizontal seam shall be along a slope with an inclination steeper than 10 percent. Horizontal seams shall be considered as any seam having an alignment exceeding 20 degrees from being perpendicular to the slope contour lines, unless otherwise approved by the Engineer. No seams shall be located in an area of potential stress concentration.

B. Personnel:

1. All personnel performing seaming operations shall be qualified as indicated in Part 1.04 of this Section. No seaming shall be performed unless a “master seamer” is present on-site.

C. Weather Conditions for Seaming:

1. Unless authorized in writing by the Engineer, seaming shall not be attempted at ambient temperatures below 40°F or above 104°F. If the Geosynthetic Installer wishes to use methods that may allow seaming at ambient temperatures below 40°F or above 104°F, he shall use a procedure approved by the Engineer.

2. A meeting will be held with the Geosynthetic Installer and Engineer to establish acceptable installation procedures. In all cases, the geomembrane shall be dry and protected from wind damage.

3. Ambient temperatures shall be measured between 0 to 6 in. above the geomembrane surface.

D. Overlapping:

1. Geomembrane panels shall be sufficiently overlapped for welding and to allow peel tests to be performed on the seam. Any seams that cannot be destructively tested because of insufficient overlap shall be treated as failing seams.

E. Seam Preparation:

1. Prior to seaming, the seam area shall be clean and free of moisture, dust, dirt, debris of any kind, and foreign material.

2. If seam overlap grinding is required, the process shall be completed according to the Geomembrane Manufacturer's instructions within 20 minutes of the seaming operation and in a manner that does not damage the geomembrane. The grind depth shall not exceed ten percent of the geomembrane thickness.

3. Seams shall be aligned with the fewest possible number of wrinkles and “fishmouths.”

F. General Seaming Requirements:

1. Fishmouths or wrinkles at the seam overlaps shall be cut along the ridge of the wrinkle to achieve a flat overlap. The cut fishmouths or wrinkles shall be seamed and any portion where the overlap is insufficient shall be patched with an oval or round patch of geomembrane that extends a minimum of 6 in. beyond the cut in all directions.

2. Any electric generator shall be placed outside the area to be lined or mounted in a manner that protects the geomembrane from damage. The electric generator shall be properly grounded.

G. Seaming Process:

1. Approved processes for field seaming are extrusion welding and fusion welding. Only equipment identified as part of the approved submittal specified in Part 1.06 shall be used.

2. Extrusion Equipment and Procedures:

a. The Geosynthetics Installer shall maintain at least one spare operable seaming apparatus on site.

b. Extrusion welding apparatus shall be equipped with gauges giving the temperature in the apparatus.

c. Prior to beginning a seam, the extruder shall be purged until all heat-degraded extrudate has been removed from the barrel.

d. The Geosynthetics Installer shall provide documentation regarding the welding rod to the Engineer and shall certify that the welding rod is compatible with the specifications.

e. A smooth insulating plate or fabric shall be placed beneath the hot welding apparatus after use.

3. Fusion Equipment and Procedures:

a. The Geosynthetic Installer shall maintain at least one spare operable seaming apparatus on site.

b. Fusion-welding apparatus shall be automated vehicular-mounted devices equipped with gauges giving the applicable temperatures and speed.

c. A smooth insulating plate or fabric shall be placed beneath the hot welding apparatus after use.

H. Trial Seams:

1. Trial seams shall be made on fragment pieces of geomembrane to verify that seaming conditions are adequate. Trial seams shall be conducted on the same material to be installed and under similar field conditions as production seams. Such trial seams shall be made at the beginning of each seaming period, beginning of the day and after lunch, for each seaming apparatus used each day. The trial seam sample shall be a minimum of 5-ft long by 1-ft wide (after seaming) with the seam centered lengthwise for fusion equipment and at least 3-ft long by 1-ft wide for extrusion equipment. Seam overlap shall be as indicated in Part 3.03.D of this Section.

2. Four adjoining coupon specimens, each 1-in. wide, shall be cut from the trial seam sample by the installer using a die cutter to ensure precise 1-in. wide coupons. The coupons shall be tested in peel (outside (fusion only) and inside track) and shear using an electronic readout field tensiometer in accordance with ASTM D 4437, at a strain rate of 2 in./min., and they shall not fail in the seam (i.e., Film Tear Bond (FTB), which is failure in the parent material, is required). The required peel and shear seam strength is listed in Table 02770-2. Ideally, samples shall be conditioned at $23 \pm 2^{o}C$ at a relative humidity of $50 \pm 5\%$ for two hours prior to testing. If test conditions vary from these conditions, a 1-in. wide coupon of the parent geomembrane material (no weld) shall be tested in the same manner as the seam specimens to determine the break strength at this condition.

3. If a coupon specimen fails, the entire operation shall be repeated. If the additional coupon specimen fails, the seaming apparatus and seamer shall not be accepted and shall not be used for seaming until the deficiencies are corrected and two consecutive successful trial seams are achieved.

I. Nondestructive Seam Continuity Testing:

1. The Geosynthetic Installer shall nondestructively test for continuity on all field seams over their full length. Continuity testing shall be carried out as the seaming work progresses, not at the completion of all field seaming. The Geosynthetic Installer shall complete any required repairs in accordance with Part 3.03.K of this Section. The following procedures shall apply:

a. Vacuum testing in accordance with ASTM D 5641.

b. Air pressure testing (for double-track fusion seams only) in accordance with ASTM D 5820 and the following:

i. Energize the air pump to a pressure between 25 and 30 pounds per square inches, close valve, and sustain the pressure for not less than 5 minutes.

ii. If loss of pressure exceeds 3 pounds per square inches, or does not stabilize, locate faulty area and repair in accordance with Part 3.03.K of this Section.

iii. Cut opposite end of air channel from pressure gauge and observe release of pressure to ensure air channel is not blocked.

iv. Remove needle, or other approved pressure feed device, and seal repair in accordance with Part 3.03.K of this Section.

c. Spark testing shall be performed if the seam cannot be tested using other nondestructive methods.

J. Destructive Testing:

1. Destructive seam tests shall be performed on samples collected from selected locations to evaluate seam strength and integrity. Destructive tests shall be carried out as the seaming work progresses, not at the completion of all field seaming.

2. Sampling:

a. Destructive test samples shall be collected at a minimum average frequency of one test location per 500 ft of seam length. Test locations shall be determined during seaming, and may be prompted by suspicion of excess crystallinity, contamination, offset seams, or any other potential cause of imperfect seaming. The Engineer will be responsible for choosing the locations. The Geosynthetic Installer shall not be informed in advance of the locations where the seam samples will be taken. The Engineer reserves the right to increase the sampling frequency.

b. Samples shall be cut by the Geosynthetic Installer at the locations designated by the Engineer as the seaming progresses in order to obtain laboratory test results before the geomembrane is covered by another material. Each sample shall be numbered and the sample number and location identified on the panel layout drawing. All holes in the geomembrane resulting from the destructive seam sampling shall be immediately repaired in accordance with the repair procedures described in Part 3.03.K of this Section. The continuity of the new seams in the repaired areas shall be tested according to Part 3.03.I of this Section.

c. Two strips of dimensions 1-in. wide and 12 in. long with the seam centered parallel to the width shall be taken from either side of the sample location. These samples shall be tested in the field in accordance with Part 3.03.J.3 of this Section. If these samples pass the field test, a laboratory sample shall be taken. The laboratory sample shall be at least 1-ft wide by 3.5-ft long with the seam centered lengthwise. The sample shall be cut into three parts and distributed as follows:

i. One portion 12-in. long to the Geosynthetic Installer.
ii. One portion 18-in. long to the Geosynthetic CQA Laboratory for testing.
iii. One portion 12-in. long to the Engineer for archival storage.

3. Field Testing:

a. The two 1-in. wide strips shall be tested in the field tensiometer in the peel mode. The Engineer has the option to request an additional test in the shear mode. If any field test sample fails to meet the requirements in Table 02770-2, then the procedures outlined in Part 3.03.J.5 of this Section shall be followed.

4. Laboratory Testing:

   a. Testing by the Geosynthetics CQA Laboratory will include “Seam Strength” and “Peel Adhesion” (ASTM D 4437) with the 1-in. wide strip tested at a rate of 2 in./min. At least 5 specimens will be tested for each test method (peel and shear). Four of the five specimens per sample must pass both the shear strength test and peel adhesion test when tested in accordance with ASTM D 4437. The minimum acceptable values to be obtained in these tests are indicated in Table 02770-2. Both inside and outside tracks of the dual track fusion welds shall be tested in peel.

5. Destructive Test Failure:

   a. The following procedures shall apply whenever a sample fails a destructive test, whether the test is conducted by the Geosynthetic CQA's laboratory, the Geosynthetic Installer laboratory, or by a field tensiometer. The Geosynthetic Installer shall have two options:

      i. The Geosynthetic Installer can reconstruct the seam (e.g., remove the old seam and reseam) between any two passed destructive test locations.

      ii. The Geosynthetic Installer can trace the welding path to an intermediate location, a minimum of 10 feet from the location of the failed test (in each direction) and take a small sample for an additional field test at each location. If these additional samples pass the field tests, then full laboratory samples shall be taken. These full laboratory samples shall be tested in accordance with Part 3.03.J.4 of this Section. If these laboratory samples pass the tests, then the seam shall be reconstructed between these locations. If either sample fails, then the process shall be repeated to establish the zone in which the seam should be reconstructed. All acceptable seams must be bounded by two locations from which samples passing laboratory destructive tests have been taken. In cases exceeding 150 ft of reconstructed seam, a sample taken from within the reconstructed zone must pass destructive testing.

   b. Whenever a sample fails, the Engineer may require additional tests for seams that were formed by the same seamer and/or seaming apparatus or seamed during the same time shift.

K. Defects and Repairs:

1. The geomembrane will be inspected before and after seaming for evidence of defects, holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter. The surface of the geomembrane shall be clean at the time of inspection. The geomembrane surface shall be swept or washed by the Installer if surface contamination inhibits inspection.

2. Each suspected location, both in seam and non-seam areas, shall be nondestructively tested using the methods described Part 3.03.I of this Section, as appropriate. Each location that fails nondestructive testing shall be marked by the Engineer and repaired by the Geosynthetic Installer.

3. When seaming of a geomembrane is completed (or when seaming of a large area of a geomembrane is completed) and prior to placing overlying materials, the Engineer shall identify all excessive geomembrane wrinkles. The Geosynthetic Installer shall cut and reseam all wrinkles so identified. The seams thus produced shall be tested like any other seams.

4. Repair Procedures:

   a. Any portion of the geomembrane exhibiting a flaw, or failing a destructive or nondestructive test, shall be repaired by the Geosynthetic Installer. Several repair procedures exist. The final decision as to the appropriate repair procedure shall be agreed upon between the Engineer and the Geosynthetic Installer. The procedures available include:

      i. patching, used to repair holes larger than 1/16 inch, tears, undispersed raw materials, and contamination by foreign matter;

      ii. abrading and reseaming, used to repair small sections of extruded seams;

      iii. spot seaming, used to repair minor, localized flaws;

      iv. capping, used to repair long lengths of failed seams; and

      v. removing bad seam and replacing with a strip of new material seamed into place (used with long lengths of fusion seams).

   b. In addition, the following criteria shall be satisfied:

      i. surfaces of the geomembrane that are to be repaired shall be abraded no more than 20 minutes prior to the repair;

      ii. all surfaces must be clean and dry at the time of repair;

      iii. all seaming equipment used in repair procedures must be approved;

      iv. the repair procedures, materials, and techniques shall be approved in advance, for the specific repair, by the Engineer;

      v. patches or caps shall extend at least 6 in. beyond the edge of the defect, and all corners of patches shall be rounded with a radius of at least 3 in.; and

      vi. the geomembrane below large caps shall be appropriately cut to avoid water or gas collection between the two sheets.

5. Repair Verification:

   a. Each repair shall be nondestructively tested using the methods described in Part 3.03.I of this Section, as appropriate. Repairs that pass the nondestructive test shall be taken as an indication of an adequate repair. Failed tests will require the repair to be redone and retested until a passing test results. At the discretion of the Engineer, destructive testing may be required on large caps.

3.04 Materials In Contact With The Geomembrane

A. The Geosynthetic Installer shall take all necessary precautions to ensure that the geomembrane is not damaged during its installation. During the installation of other components of the liner system by the Contractor, the Contractor shall ensure that the geomembrane is not damaged. Any damage to the geomembrane shall be repaired by the Geosynthetic Installer , at the expense of the Contractor.

B. Soil and aggregate materials shall not be placed over the geomembranes at ambient temperatures below 40°F or above 104°F, unless otherwise specified.

C. All attempts shall be made to minimize wrinkles in the geomembrane.

D. Equipment shall not be driven directly on the geomembrane.

3.05 Conformance Testing

A. Samples of the geomembrane will be removed by the Engineer and sent to a Geosynthetic CQA Laboratory for testing to ensure conformance with the requirements of this Section. The Geosynthetic Installer shall assist the Engineer in obtaining conformance samples. The Geosynthetic Installer and Contractor shall account for this testing in the installation schedule. Only material that meets the requirements of Part 2.02 this Section shall be installed.

B. Samples will be selected by the Engineer in accordance with this Section and with the procedures outlined in the CQA Plan.

C. Samples will be taken at a minimum frequency of one sample per 100,000 ft^2.

D. The Engineer may increase the frequency of sampling in the event that test results do not comply with the requirements of Part 2.02 of this Section.

E. The following tests will be performed by the Engineer:

Test	Test Method
Specific Gravity	ASTM D 792 or D 1505
Thickness	ASTM D 5994
Tensile Properties	ASTM D 638
Carbon Black Content	ASTM D 1603
Carbon Black Dispersion	ASTM D 5596

F. Any geomembrane that is not certified in accordance with Part 1.07.C of this Section, or that conformance testing indicates do not comply with Part 2.02 of this Section, will be rejected. The Geosynthetic Installer shall replace the rejected material with new material.

3.06 Geomembrane Acceptance

A. The Geosynthetic Installer shall retain all ownership and responsibility for the geomembrane until accepted by the Engineer.

B. The geomembrane shall be accepted by the Engineer when:

1. the installation is completed;
2. all documentation is submitted;

3. verification of the adequacy of all field seams and repairs, including associated testing, is complete; and

4. all warranties are submitted.

3.07 Protection of Work

A. The Geosynthetic Installer and Contractor shall use all means necessary to protect all work of this Section.

B. In the event of damage, the Geosynthetic Installer shall make all repairs and replacements necessary, to the satisfaction of the Engineer.

PART 4 – MEASUREMENT AND PAYMENT

4.01 General

A. Providing for a complying with the requirements set forth in this Section for textured HDPE geomembrane will be measured as in-place square feet (SF), including geomembrane in the anchor trench to the limits shown on the Drawings, and payment will be based on the unit price provided on the Bid Schedule.

B. The following are considered incidental to the Work:

- shipping, handling and storage.
- layout survey.
- mobilization.
- rejected material.
- overlaps and seaming.
- rejected material removal, handling, re-testing, and repair.
- temporary anchorage.

TABLE 02770-1
REQUIRED HDPE GEOMEMBRANE PROPERTIES

PROPERTIES	QUALIFIERS	UNITS	SPECIFIED VALUES	TEST METHOD
Physical Properties				
Thickness	Average Minimum	mils mils	60 54	ASTM D 5994
Specific Gravity	Minimum	N/A	.94	ASTM D 792 Method A or ASTM D 1505
Mechanical Properties				
Tensile Properties (each direction)				
1. Tensile (Break) Strength Tensile (Break) Strength 2. Elongation at Break 3. Tensile (Yield) Strength 4. Elongation at Yield	Minimum	lb/in % lb/in %	90 100 126 12	ASTM D 638
Puncture	Minimum	lb	90	ASTM D 4833
Tear Resistance	Minimum	lb	42	ASTM D 1004
Interface Shear Strength	-	-	Note 1	ASTM D 5321
Environmental Properties				
Carbon Black Content	Range	%	2-3	ASTM D 1603
Carbon Black Dispersion	N/A	none	Note 2	ASTM D 5596
Environmental Stress Crack	Minimum	hr	400	ASTM D 5397

Notes: (1) Interface shear strength test(s) shall be performed, by the Engineer, on the composite liner system in accordance with Section 02772 — Geosynthetic Clay Liner.
(2) Minimum 8 of 10 in Categories 1 or 2; 10 in Categories 1, 2, or 3.

TABLE 02770-2
REQUIRED GEOMEMBRANE SEAM PROPERTIES

PROPERTIES	QUALIFIERS	UNITS	SPECIFIED VALUES	TEST METHOD
Shear Strength(1)				
Fusion	minimum	lb/in	120	ASTM D 6392
Extrusion	minimum	lb/in	120	ASTM D 6392
Peel Adhesion				
FTB(2)				
Fusion	minimum	lb/in	91	ASTM D 6392
Extrusion	minimum	lb/in	78	ASTM D 6392

Notes: (1) Also called "Bonded Seam Strength".
(2) FTB = Film Tear Bond means that failure is in the parent material, not the seam. The maximum seam separation is 25 percent of the seam area.

END OF SECTION

SECTION 02771
GEOTEXTILE

PART 1 – GENERAL

1.01 Description of Work

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, equipment, and incidentals necessary for the installation of the geotextile. The work shall be carried out as specified herein and in accordance with the Drawings.

B. The work shall include, but not be limited to, delivery, storage, placement, and seaming of the various geotextile components of the project.

C. Filter geotextile shall be used overlying the drainage aggregate. Cushion geotextile shall be used overlying the geomembrane and underlying the drainage aggregate. A UV protective geotextile shall be used overlying the exposed portions of geosynthetic components of the side slope liner system.

1.02 Related Sections

Section 02200 — Earthwork

Section 02225 — Drainage Aggregate

Section 02770 — Geomembrane

Section 02773 — Geocomposite

1.03 References

A. Drawings

B. Construction Quality Assurance (CQA) Plan

C. Latest version of American Society for Testing and Materials (ASTM) standards:

ASTM D 3786	Standard Test Method for Hydraulic Bursting Strength of Knitted Goods and Nonwoven Fabric-Diaphragm Bursting Strength Test Method
ASTM D 4355	Standard Test Method for Deterioration of Geotextile from Exposure to Ultraviolet Light and Water
ASTM D 4491	Standard Test Method for Water Permeability of Geotextile by Permittivity
ASTM D 4533	Standard Test Method for Trapezoid Tearing Strength of Geotextile
ASTM D 4595	Standard Test Method for Wide Width Tensile Properties of Geosynthetics
ASTM D 4632	Standard Test Method for Breaking Load and Elongation of Geotextile (Grab Method)
ASTM D 4751	Standard Test Method for Determining Apparent Opening Size of a Geotextile

ASTM D 4833 Standard Test Method for Index Puncture Resistance of Geotextile, Geomembranes, and Related Products

ASTM D 5261 Standard Test Method for Measuring Mass Per Unit Area of Geotextile

1.04 Submittals

A. The Geosynthetic Installer shall submit to the Engineer, at least 7 days prior to geotextile delivery, the following information regarding the proposed geotextile:

1. manufacturer and product name;
2. minimum property values of the proposed geotextile and the corresponding test procedures;
3. projected geotextile delivery dates; and
4. list of geotextile roll numbers for rolls to be delivered to the site.

B. At least 7 days prior to geotextile placement, the Geosynthetic Installer shall submit to the Engineer the manufacturing quality control certificates for each roll of geotextile. The certificates shall be signed by responsible parties employed by the geotextile manufacturer (such as the production manager). The quality control certificates shall include:

1. lot, batch, and/or roll numbers and identification; and
2. results of quality control tests, including a description of the test methods used.

1.05 Quality Assurance

A. The Geosynthetic Installer shall ensure that the geotextile and installation methods used meet the requirements of the Drawings and this Section. Any material or method that does not conform to these documents, or to alternatives approved in writing by the Engineer, will be rejected and shall be repaired or replaced by the Geosynthetic Installer.

B. The Geosynthetic Installer shall be aware of all monitoring and conformance testing required by the CQA Plan. This monitoring and testing, including random conformance testing of construction materials and completed work, will be performed by the Engineer. If nonconformances or other deficiencies are found in the Geosynthetic Installer's materials or completed work, the Geosynthetic Installer will be required to repair the deficiency or replace the deficient materials.

PART 2 – PRODUCTS

2.01 Geotextile Properties

A. Geotextile suppliers shall furnish materials in which the "Minimum Average Roll Values", as defined by the Federal Highway Administration (FHWA), meet or exceed the criteria specified in Table 02771-1.

B. The geotextile shall be nonwoven materials, suitable for use in filter/separation and cushion applications and woven geotextile for use as a UV protective layer.

2.02 Manufacturing Quality Control

A. The geotextile shall be manufactured with quality control procedures that meet or exceed generally accepted industry standards.

B. The Geotextile Manufacturer shall sample and test the geotextile to demonstrate that the material conforms to the requirements of these Specifications.

C. Any geotextile sample that does not comply with this Section shall result in rejection of the roll from which the sample was obtained. The Geosynthetic Installer shall replace any rejected rolls.

D. If a geotextile sample fails to meet the quality control requirements of this Section the Geotextile Manufacturer shall sample and test, at the expense of the Manufacturer, rolls manufactured in the same lot, or at the same time, as the failing roll. Sampling and testing of rolls shall continue until a pattern of acceptable test results is established to bound the failed roll(s).

E. Additional sample testing may be performed, at the Geotextile Manufacturer's discretion and expense, to identify more closely any non-complying rolls and/or to qualify individual rolls.

F. Sampling shall, in general, be performed on sacrificial portions of the geotextile material such that repair is not required. The Geotextile Manufacturer shall sample and test the geotextile, at a minimum once every 100,000 ft^2, to demonstrate that the geotextile properties conform to the values specified in Table 02771-1. At a minimum, the following manufacturing quality control tests shall be performed on each type of geotextile:

Test	Procedure	Cushion	Filtration	UV Protective
Mass per unit area	ASTM D 5261	Yes	No	No
Grab strength	ASTM D 4632	Yes	Yes	No
Puncture strength	ASTM D 4833	Yes	Yes	No
Permittivity	ASTM D 4491	No	Yes	No
A.O.S.	ASTM D 4751	No	Yes	Yes
Wide Width Tensile	ASTM D 4595	No	No	Yes

G. The Geotextile Manufacturer shall comply with the certification and submittal requirements of this Section.

2.03 Packing and Labeling

A. Geotextile shall be supplied in rolls wrapped in relatively impermeable and opaque protective covers.

B. Geotextile rolls shall be marked or tagged with the following information:

1. manufacturer's name;
2. product identification;
3. lot or batch number;

4. roll number; and
5. roll dimensions.

2.04 Transportation, Handling, and Storage

A. The Geosynthetic Installer shall be liable for any damage to the materials incurred prior to and during transportation to the site.

B. The geotextile shall be delivered to the site at least 14 days prior to the planned deployment date to allow the Engineer adequate time to perform conformance testing on the geotextile samples as described in Part 3.06 of this Section.

C. Handling, unloading, storage, and care of the geotextile prior to and following installation at the site, is the responsibility of the Geosynthetic Installer. The Geosynthetic Installer shall be liable for any damage to the materials incurred prior to final acceptance by the Engineer.

D. The Geosynthetic Installer shall be responsible for storage of the geotextile at the site.

E. The geotextile shall be protected from sunlight, excessive heat or cold, puncture, or other damaging or deleterious conditions. The geotextile shall be protected from mud, dirt, and dust. Any additional storage procedures required by the geotextile Manufacturer shall be the responsibility of the Geosynthetic Installer.

PART 3 – EXECUTION

3.01 Familiarization

A. Prior to implementing any of the work described in this Section, the Geosynthetic Installer shall become thoroughly familiar with the site, the site conditions, and all portions of the work falling within this Section.

B. Inspection:

1. The Geosynthetic Installer shall carefully inspect the installed work of all other Sections and verify that all such work is complete to the point where the installation of this Section may properly commence without adverse effect.

2. If the Geosynthetic Installer has any concerns regarding the installed work of other Sections or the site, the Engineer shall be notified, in writing, prior to commencing the work. Failure to notify the Engineer or installation of the geotextile will be construed as Geosynthetic Installer’s acceptance of the related work of all other Sections.

3.02 Placement

A. Geotextile installation shall not commence until CQA conformance evaluations, by the Engineer, of previous work are complete, including evaluations of the Contractor's survey results to confirm that the previous work was constructed to the required grades, elevations, and thicknesses. Should the Contractor begin the work of this Section prior to the completion of CQA evaluations, he does so at his own risk. The Contractor shall account for the CQA conformance evaluations in the construction schedule.

B. The Geosynthetic Installer shall handle all geotextile in such a manner as to ensure they are not damaged in any way.

C. The Geosynthetic Installer shall take any necessary precautions to prevent damage to underlying materials during placement of the geotextile.

D. After unwrapping the geotextile from its opaque cover, the filtration and cushion geotextile shall not be left exposed for a period in excess of 15 days unless a longer exposure period is approved in writing by the geotextile manufacturer.

E. The Geosynthetic Installer shall take care not to entrap stones, excessive dust, or moisture in the geotextile during placement.

F. The Geosynthetic Installer shall anchor or weight all geotextile with sandbags, or the equivalent, to prevent wind uplift.

G. The Geosynthetic Installer shall examine the entire geotextile surface after installation to ensure that no foreign objects are present that may damage the geotextile or adjacent layers. The Contractor shall remove any such foreign objects and shall replace any damaged geotextile.

3.03 Seams and Overlaps

A. On slopes steeper than 10 horizontal to 1 vertical, geotextiles shall be continuous down the slope; that is, no horizontal seams are allowed. Horizontal seams shall be considered as any seam having an alignment exceeding 20 degrees from being perpendicular to the slope contour lines, unless otherwise approved by the Engineer.

B. Geotextile shall be continuously sewn (i.e., spot sewing is not allowed) using a “single prayer” seam, with the stitching a minimum of 1.5 inches from the edge of the geotextile. Cushion to filtration geotextile shall be overlapped a minimum of 12 inches.

C. Geotextile shall be sewn with polymeric thread, having similar strength characteristics as the geotextile.

3.04 Repair

A. Any holes or tears in the geotextile shall be repaired using a patch made from the same geotextile. Geotextile patches will be sewn into place no closer than 1 inch from any panel edge. Should any tear exceed 50% of the width of the roll, that roll shall be removed and replaced.

B. Where geosynthetic materials underlie the geotextile being placed, care shall be taken to remove any soil or other material that may have penetrated the torn geotextile.

3.05 Placement of Soil Materials

A. The Contractor shall place soil materials on top of the geotextile in such a manner as to ensure that:

1. the geotextile and the underlying materials are not damaged;
2. minimum slippage occurs between the geotextile and the underlying layers during placement; and
3. excess stresses are not produced in the geotextile.

B. Equipment shall not be driven directly on the geotextile.

C. Unless otherwise approved in writing by the Engineer, all equipment operating on materials overlying the geotextile shall comply with Section 02200 and Section 02225.

3.06 Conformance Testing

A. Samples of the geotextile materials will be removed by the Engineer after the material has been received at the site and sent to a Geosynthetic CQA Laboratory for testing to ensure conformance with the requirements of this Section. This testing will be carried out, in accordance with the CQA Plan, prior to the start of the work of this Section.

B. Samples of each geotextile will be taken, by the Engineer, at a minimum frequency of one sample per 200,000 ft^2.

C. The Engineer may increase the frequency of sampling in the event that test results do not comply with requirements of Part 2.01 of this Section until passing conformance test results are obtained for all material that is received at the site. This additional testing shall be performed at the expense of the Contractor.

D. The following conformance tests will be performed:

Test	Procedure	Cushion	Filtration	UV Protective
Mass per unit area	ASTM D 5261	Yes	No	No
Grab strength	ASTM D 4632	Yes	Yes	No
Puncture strength	ASTM D 4833	Yes	Yes	No
Permittivity	ASTM D 4491	No	Yes	No
A.O.S.	ASTM D 4751	No	Yes	Yes
Wide Width Tensile	ASTM D 4595	No	No	Yes

E. Any geotextile that is not certified in accordance with Part 1.04 of this Section, or that conformance testing results do not comply with Part 2.01 of this Section, will be rejected. The Geosynthetic Installer shall replace the rejected material with new material.

3.07 Protection of Work

A. The Geosynthetic Installer shall use all means necessary to protect all work of this Section.

B. In the event of damage, the Geosynthetic Installer shall make repairs and replacements to the satisfaction of the Engineer at the expense of the Contractor.

PART 4 – MEASUREMENT AND PAYMENT

4.01 General

A. Providing for and complying with the requirements set forth in this Section for Cushion Geotextile will be measured as in-place square feet (SF), including Cushion Geotextile in the anchor trench to the limits shown on the Drawings, and payment will be based on the unit price provided on the Bid Schedule.

B. Providing for and complying with the requirements set forth in this Section for Filtration Geotextile will be measured as in-place square feet (SF), including Filtration Geotextile in the anchor trench to the limits shown on the Drawings, and payment will be based on the unit price provided on the Bid Schedule.

C. Providing for and complying with the requirements set forth in this Section for UV Protection Geotextile will be measured as in-place square feet (SF), including UV Protection Geotextile in the anchor trench to the limits shown on the Drawings, and payment will be based on the unit price provided on the Bid Schedule.

D. The following are considered incidental to the Work:

- shipping, handling and storage.
- layout survey.
- mobilization.
- rejected material.
- overlaps and seaming.
- rejected material removal, handling, re-testing, and repair.
- temporary anchorage.

TABLE 02771-1
REQUIRED PROPERTY VALUES FOR GEOTEXTILE

PROPERTIES	QUALIFIERS	UNITS	CUSHION SPECIFIED VALUES	FILTER SPECIFIED VALUES	UV PROTECTIVE SPECIFIED VALUES	TEST METHOD
Type			Nonwoven	nonwoven	Woven	(-)
Mass per unit area	minimum	oz/yd^2	16	6(1)	-	ASTM D 5261
Filter Requirements						
Apparent opening size (O_{95})	maximum	mm	-	0.21	0.43	ASTM D 4751
Permittivity	minimum	s^{-1}	-	0.8	-	ASTM D 4491
Mechanical Requirements						
Grab strength	minimum	lb	350	130	-	ASTM D 4632
Puncture strength	minimum	lb	155	40	-	ASTM D 4833
Wide Width Tensile Strength	minimum	ppi	-	-	110	ASTM D 4595
Durability						
Ultraviolet Resistance @ 500 hours	minimum	%	70	70	70	ASTM D 4355

Notes: (1) For information purposes only, not a required property.

END OF SECTION

SECTION 02772
GEOSYNTHETIC CLAY LINER

PART 1 – GENERAL

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, equipment, and incidentals necessary for installation of the geosynthetic clay liner (GCL). The work shall be carried out as specified herein and in accordance with the Drawings.

B. The work shall include, but not be limited to, delivery, storage, placement, anchorage, and seaming of the GCL.

1.02 Related Sections

Section 02200 — Earthworks

Section 02770 — Geomembrane

1.03 References

A. Drawings

B. Construction Quality Assurance (CQA) Plan

C. Latest Version American Society of Testing and Materials (ASTM) Standards:

ASTM D 2216	Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures
ASTM D 5321	Determination of the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method
ASTM D 5887	Test Method for Measurement of Index Flux Through Saturated Geosynthetic Clay Liner Specimens using a Flexible Wall Permeameter
ASTM D 5888	Guide for Storage and Handling of Geosynthetic Clay Liners
ASTM D 5890	Test Method for Swell Index of Clay Mineral Component of Geosynthetic Clay Liners
ASTM D 5891	Test Method for Fluid Loss of Clay Component of Geosynthetic Clay Liners
ASTM D 5993	Test Method for Measuring Mass per Unit Area of Geosynthetic Clay Liners

1.04 Qualifications

A. The Manufacturer shall be a well-established firm with more than ten years of experience in the manufacturing of GCL.

B. The Geosynthetic Installer shall install the GCL and shall meet the requirements of Section 02770 and this Section.

1.05 Submittals

A. At least 7 days before transporting any GCL to the site, the Manufacturer shall provide the following documentation to the Engineer for approval.

1. list of material properties, including test method, to which are attached GCL samples.

2. projected delivery dates for this project.

3. Manufacturing quality control certificates for each shift's production, signed by responsible parties employed by the Manufacturer (such as the production manager).

4. The quality control certificates shall include:

   a. roll numbers and identification; and

   b. results of quality control tests, including description of test methods used, outlined in Part 2.01 of this Section.

5. The Manufacturer shall certify that the GCL meets all the properties outlined in 2.01 of this Section.

1.06 Construction Quality Assurance Monitoring

A. The Geosynthetic Installer shall ensure that the materials and methods used for the GCL meet the requirements of the Drawings and this Section. Any material or method that does not conform to these documents, or to alternatives approved in writing by the Engineer, will be rejected and shall be repaired or replaced.

B. The Geosynthetic Installer shall be aware of all monitoring and conformance testing required by the CQA Plan. This monitoring and testing, including random conformance testing of construction materials and completed work, will be performed by the Engineer. If nonconformances or other deficiencies are found in the materials or completed work, the Geosynthetic Installer will be required to repair the deficiency or replace the deficient materials.

PART 2 – PRODUCTS

2.01 Material Properties

A. The flux of the GCL shall be no greater than 1×10^{-8} m^3/m^2-sec, when measured in a flexible wall permeameter in accordance with ASTM D 5887 under an effective confining stress of 5 pounds per square inch.

B. The GCL shall have the following minimum dimensions:

1. the minimum roll width shall be 15 feet; and

2. the liner length shall be long enough to conform with the requirements specified in this Section.

C. The bentonite used to fabricate the GCL shall have at least 90 percent sodium mortmorillonite.

D. The bentonite component of the GCL shall be applied at a minimum concentration of 0.75 pound per square foot, when measured at a water content of less than or equal to 0 percent.

E. The geotextile components of the GCL shall have a minimum combined mass per unit area of 9 oz/yd^2 in accordance with ASTM D 5261.

F. The GCL shall meet the required property values listed in Table 02772-1.

G. The bentonite will be adhered to the backing material(s) in a manner that prevents it from being dislodged when transported, handled, and installed in a manner prescribed by the Manufacturer. The method used to hold the bentonite in place shall not be detrimental to other components of the lining system.

H. An alternative GCL having a textured vapor barrier (i.e., geomembrane) as an integral component of the GCL may be provided. If an alternative GCL is used, the textured HDPE vapor barrier component shall be placed against the prepared subgrade and shall meet the following requirements:

1. have an average thickness of 30-mils in accordance with ASTM D 5994;

2. not have striations, pinholes, or bubbles on the surface or in the interior; and

3. be produced so as to be free of holes, blisters, undispersed raw materials, or any sign of contamination by foreign matter.

2.02 Interface Shear Testing

A. Interface Shear test(s) shall be performed on the proposed geosynthetic and soil components in accordance with ASTM D 5321. Tests shall be performed on several geosythetic interfaces as outlined below.

1. Dry GCL interface - the GCL shall be underlain by prepared subgrade compacted to 90% of the maximum dry density (ASTM D 1557) at the optimum moisture content and overlain by a textured 60-mil HDPE geomembrane, geocomposite, and operations layer material. The geosynthetic components of the liner system shall be allowed to “float” (i.e., not fixed) such that the failure surface can occur between any of the interfaces.

    a. The test shall be performed, under dry conditions, at normal stresses of 1, 3, and 5 psi at a shear rate of no more than 0.04 in./min. (1 mm/min.).

    b. The results of this test shall have a post peak apparent friction angle in excess of 18 degrees.

2. Hydrated GCL interface - the GCL shall be underlain by prepared subgrade compacted to 90% of the maximum dry density (ASTM D 1557) at the optimum moisture content and overlain by a textured 60-mil HDPE geomembrane, geocomposite, and operations layer material. The GCL component of the liner system shall be allowed to “float” (i.e., not fixed) such that the failure surface can occur at the top, bottom, or internal GCL interfaces.

    a. Before shearing, the GCL shall be hydrated under a loading of 240 psf (11 Kpa) for 48 hours. The test shall be performed under saturated conditions, at normal stresses of 20, 40, and 80 psi at a shear rate of no more than 0.04 in./min. (1 mm/min.).

    b. The results of this test shall have a post-peak apparent friction angle in excess of 12 degrees.

3. Hydrated GCL interface - If a GCL containing a geomembrane vapor barrier (i.e. Gundseal) is to be used, one additional shear strength test shall be performed. The GCL shall be underlain by prepared subgrade compacted to 90% of the maximum dry density (ASTM D 1557) at the optimum moisture content and covered by a textured 60 mil HDPE geomembrane, geocomposite, and operations layer material.

   a. The test shall evaluate the interface between the bentonite side of an unhydrated (i.e., dry) GCL containing a geomembrane vapor barrier and a textured 60 mil HDPE geomembrane. The test shall be set up such that the failure occurs between the bentonite component of the GCL and the textured geomembrane. The test shall be performed under dry conditions, at normal stresses of 20, 40, and 80 psi at a shear rate of no more than 0.04 in./min. (1 mm/min.).

   b. The acceptance criterion for the interface between the GCL consisting of a geomembrane vapor barrier component and the overlying geomembrane shall be as follows:

$$\tan^{-1}(0.25 \tan \delta_{hydrated} + 0.75 \tan\delta_{unhydrated}) \geq 12°$$

where $\delta_{hydrated}$ is the post-peak apparent friction angle in degrees determined in test No. 2 and $\delta_{unhydrated}$ is the post-peak apparent friction angle in degrees determined in test No. 3.

2.03 Manufacturing Quality Control

A. The GCL shall be manufactured with quality control procedures that meet or exceed generally accepted industry standards.

B. The Manufacturer shall sample and test the GCL to demonstrate that the material complies with the requirements of this Section.

C. Any GCL sample that does not comply with this Section will result in rejection of the roll from which the sample was obtained. The Manufacturer shall replace any rejected rolls.

D. If a GCL sample fails to meet the quality control requirements of this Section, the Engineer will require that the Manufacturer sample and test, at the expense of the Manufacturer, rolls manufactured in the same lot, or at the same time, as the failing roll. Sampling and testing of rolls shall continue until a pattern of acceptable test results is established to bound the failed roll(s).

E. Additional sample testing may be performed, at the Manufacturer's discretion and expense, to more closely identify any non-complying rolls and/or to qualify individual rolls.

F. Sampling shall, in general, be performed on sacrificial portions of the GCL material such that repair is not required. The Manufacturer shall sample and test the GCL to demonstrate that its properties conform to the requirements stated herein. At a minimum, the following tests shall be performed by the Manufacturer: dry mass per unit area and index flux at frequencies of at least 1 per 50,000 ft^2 and 1 per 200,000 ft^2, respectively.

G. The Manufacturer shall comply with the certification and submittal requirements of this Section.

2.04 Packing and Labeling

A. GCLs shall be supplied in rolls wrapped in impermeable and opaque protective covers.

B. GCLs shall be marked or tagged with the following information:

1. Manufacturer's name;
2. product identification;
3. lot number;
4. roll number; and
5. roll dimensions.

2.05 Transportation, Handling and Storage

A. Handling, storage, and care of the GCL, prior to and following installation, is the responsibility of the Geosynthetic Installer, until final acceptance by the Engineer.

B. The GCL shall be stored and handled in accordance with ASTM D 5888.

C. The Geosynthetic Installer shall be liable for all damage to the materials incurred prior to and during transportation to the site.

D. The GCL shall be on-site at least 14 days prior to the scheduled installation date to allow for completion of conformance testing described in Part 3.08 of this Section.

PART 3 – EXECUTION

3.01 Familiarization

A. Prior to implementing any of the work described in this Section, the Geosynthetic Installer shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the installation of this Section may properly commence without adverse impact.

B. Inspection:

1. The Geosynthetic Installer shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the installation of this Section may properly commence without adverse impact.

2. If the Geosynthetic Installer has any concerns regarding the installed work of other Sections, he should notify the Engineer in writing prior to commencing the work. Failure to notify the Engineer or installation of the GCL will be construed as Geosynthetic Installer's acceptance of the related work of all other Sections.

C. A pre-installation meeting shall be held to coordinate the installation of the GCL with the installation of other components of the lining system.

3.02 Surface Preparation

A. The Geosynthetics Installer shall provide certification in writing that the surface on which the GCL will be installed is acceptable. This certification of acceptance shall be given to the Engineer prior to commencement of geomembrane installation in the area under consideration.

B. Special care shall be taken to maintain the prepared soil surface.

C. No GCL shall be placed onto an area that has been softened by precipitation or that has cracked due to desiccation. The soil surface shall be observed daily to evaluate the effects of desiccation cracking and/or softening on the integrity of the prepared subgrade.

3.03 Crest Anchorage System

A. The anchor trench shall be excavated, prior to GCL placement, to the lines and grades shown on the Drawings.

B. No loose soil shall be allowed in the anchor trench beneath the GCL.

C. The GCL shall be temporarily anchored in the anchor trench until all geosynthetic layers are installed in the anchor trench as shown on the Drawings.

3.04 Handling and Placement

A. The Geosynthetic Installer shall handle all GCL in such a manner that they are not damaged in any way and so that they do not become hydrated prior to, or during, installation.

B. In the presence of wind, all GCLs shall be sufficiently weighted with sandbags to prevent their movement.

C. Any GCL damaged by stones or other foreign objects, or by installation activities, shall be repaired in accordance with Part 3.07 by the Geosynthetic Installer.

D. If an alternative GCL is used, the vapor barrier portion of the GCL shall be installed against the underlying prepared subgrade.

E. The GCL shall not be installed on an excessively moist subgrade or on standing water. The GCL shall be installed in a way that prevents hydration of the GCL prior to completion of construction of the liner system.

F. The GCL shall not be installed during precipitation or other conditions that may cause hydration of the GCL.

G. All hydrated GCL shall be removed and replaced by the Geosynthetic Installer.

3.05 Overlaps

A. On slopes steeper than 10 horizontal to 1 vertical, all GCL shall be continuous down the slope; that is, no horizontal seams shall be allowed on the slope. Horizontal seams shall be considered as any seam having an alignment exceeding 20 degrees from being perpendicular to the slope contour lines, unless otherwise approved by the Engineer.

B. All GCL shall be overlapped in accordance with the Manufacturer’s recommended procedures. As a minimum, along the length (i.e., the sides) of the GCL the overlap shall be 6 inches, and along the width (i.e., the ends) the overlap shall be 12 inches.

3.06 Materials in Contact With the GCL

A. Geomembrane installation shall immediately follow the GCL installation. All GCL that is placed during a day's work shall be covered with geomembrane before the Geosynthetic Installer leaves the site at the end of the day. The edges of GCL placement should be covered each day and protected from hydration due to storm water run-on.

B. Material shall not be placed on a GCL that is hydrated.

C. Installation of other components of the liner system shall be carefully performed to minimize damage to the GCL.

D. Equipment shall not be driven directly on the GCL.

E. Installation of the GCL in appurtenant areas, and connection of the GCL to appurtenances shall be made according to the Drawings. The Geosynthetic Installer shall ensure that the GCL is not damaged while working around the appurtenances.

3.07 Repair

A. Any holes or tears in the GCL shall be repaired by placing a GCL patch over the hole. On slopes steeper than 10 percent, the patch shall overlap the edges of the hole or tear by a minimum of 2 feet in all directions. On slopes 10 percent or flatter, the patch shall overlap the edges of the hole or tear by a minimum of 1 foot in all directions. The patch shall be secured with a water-based adhesive approved by the Manufacturer.

B. Care shall be taken to remove any soil or other material, which may have penetrated the torn GCL.

C. The patch shall not be nailed or stapled.

3.08 Conformance Testing

A. Samples of the GCL will be removed by the Engineer and sent to a Geosynthetic CQA Laboratory for testing to ensure conformance with the requirements of this Section. The Geosynthetic Installer shall assist the Engineer in obtaining conformance samples. The Geosynthetic Installer shall account for this testing in the installation schedule.

B. Samples shall be taken at a minimum frequency rate of one sample per 100,000 square feet.

C. The Engineer may increase the frequency of sampling in the event that test results do not comply with the requirements of Part 2.01 of this Section until passing conformance test results are obtained for all material that is received at the site. This additional testing shall be performed at the expense of the Contractor.

D. As a minimum, the following conformance tests will be performed: mass per unit area and index flux. All tests shall be carried out at a frequency of one sample per 100,000 ft^2 and 400,000 ft^2, respectively. In addition, the Engineer will perform a minimum of two interface shear strength tests in accordance with Part 2.02.

E. Any GCL that is not certified by the Manufacturer in accordance with Part 1.05 of this section or that does not meet the requirements specified in Part 2.01 shall be rejected and replaced by the Geosynthetic Installer.

3.09 Protection of Work

A. The Geosynthetic Installer shall use all means necessary to protect all work of this Section.

B. In the event of damage, the Geosynthetic Installer shall immediately make all repairs and replacements necessary to the approval of the Engineer.

PART 4 – MEASUREMENT AND PAYMENT

A. Providing for a complying with the requirements set forth in this Section for GCL will be measured as in-place square feet (SF), including GCL in the anchor trench to the limits shown on the Drawings, and payment will be based on the unit price provided on the Bid Schedule.

B. The following are considered incidental to the Work:

- shipping, handling and storage.
- overlaps and seaming.
- layout survey.
- mobilization.
- rejected material.
- rejected material removal, handling, re-testing, and repair.
- temporary anchorage.

TABLE 02772-1
REQUIRED GCL PROPERTY VALUES

PROPERTIES	QUALIFIERS	UNITS	SPECIFIED[1] VALUES	TEST METHOD
Liner System Properties				
Interface Shear Strength	minimum	degrees	18° (unhydrated) 12° (hydrated)	ASTM D 5321[2]
GCL Properties				
Bentonite Content[4]	minimum	lb/ft^2	0.75	ASTM D 5993
Bentonite Swell Index	minimum	mL/2g	24	ASTM D 5890
Bentonite Fluid Loss	maximum	mL	18	ASTM D 5891
Hydraulic Flux	minimum	m^3/m^2-s	1×10^{-8}	ASTM D 5887[3]
Moisture Content (Bentonite)	maximum	percent	25	ASTM D 2216

Notes: (1) All values represent minimum average roll values (i.e., any roll in a lot should meet or exceed the values in this table).
(2) Interface shear strength testing shall be performed, by the Engineer, in accordance with Part 2.02 of this Section.
(3) Hydraulic flux testing shall be performed under an effective confining stress of 5 pounds per square inch.
(4) Measured at a moisture content of 0 percent.

END OF SECTION

SECTION 02773
GEOCOMPOSITE

PART 1 – GENERAL

1.01 Description of Work

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, equipment, and incidentals necessary for the installation of the geocomposite. The work shall be carried out as specified herein and in accordance with the Drawings.

B. The work shall include, but not be limited to, delivery, storage, placement, and seaming of the geocomposite.

C. Geocomposite shall be used overlying the geomembrane and underlying the operations layer on the side slopes for the base liner system. Geocomposite shall be used overlying the geomembrane for the final cover liner system.

1.02 Related Sections

Section 02200 — Earthwork

Section 02770 — Geomembrane

Section 02771 — Geotextiles

1.03 References

A. Drawings

B. Construction Quality Assurance (CQA) Plan

C. Latest version of American Society for Testing and Materials (ASTM) standards:

ASTM D 413. Standard Test Method for Rubber Property-Adhesion to Flexible Substrate.

ASTM D 792. Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.

ASTM D 1603. Standard Test Method for Carbon Black in Olefin Plastics.

ASTM D 4491. Standard Test Methods for Water Permeability of Geotextiles by Permittivity.

ASTM D 4533. Standard Test Method for Trapezoid Tearing Strength of Geotextiles.

ASTM D 4632. Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.

ASTM D 4716. Standard Test Method for Constant Head Hydraulic Transmissivity (In-Plane Flow) of Geotextiles and Geotextile Related Products.

ASTM D 4751. Standard Test Method for Determining Apparent Opening Size of a Geotextile.

ASTM D 4833. Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.

ASTM D 5199. Standard Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes.

ASTM D 5261. Standard Test Method for Measuring Mass per Unit Area of Geotextiles.

1.04 Qualifications

A. The manufacturer shall be a well-established firm with more than one year experience in the manufacturing of geocomposite.

B. The Geosynthetic Installer shall install the geocomposite and shall meet the requirements of Section 02770 and this Section.

1.05 Submittals

A. The Geosynthetic Installer shall submit to the Engineer, at least 7 days prior to geocomposite delivery, the following information regarding the proposed geocomposite:

1. manufacturer and product name;
2. minimum property values of the proposed geocomposite and the corresponding test procedures;
3. projected geocomposite delivery dates; and
4. list of geocomposite roll numbers for rolls to be delivered to the site.

B. At least 7 days prior to geocomposite placement, the Geosynthetic Installer shall submit to the Engineer the manufacturing quality control certificates for each roll of geocomposite. The certificates shall be signed by responsible parties employed by the geocomposite manufacturer (such as the production manager). The quality control certificates shall include:

1. lot, batch, and/or roll numbers and identification; and
2. results of quality control tests, including a description of the test methods used.

1.06 Construction Quality Assurance Monitoring

A. The Geosynthetic Installer shall ensure that the geocomposite and installation methods used meet the requirements of the Drawings and this Section. Any material or method that does not conform to these documents, or to alternatives approved in writing by the Engineer, will be rejected and shall be repaired or replaced by the Geosynthetic Installer.

B. The Geosynthetic Installer shall be aware of and accommodate all monitoring and conformance testing required by the CQA Plan. This monitoring and testing, including random conformance testing of construction materials and completed work, will be performed by the Engineer. If nonconformances or other deficiencies are found in the Geosynthetic Installer's materials or completed work, the Geosynthetic Installer will be required to repair the deficiency or replace the deficient materials.

PART 2 – PRODUCTS

2.01 Geocomposite Properties

A. The Geocomposite Manufacturer shall furnish geocomposites having properties that comply with the required property values shown in Table 02773-1. The Geocomposite Manufacturer shall provide results of tests performed using the procedures listed in Table 02773-1, as well as certification that the materials meet or exceed the specified values.

B. Geotextiles will be thermally bonded to both sides of the geonet component of geocomposite material rather than chemically bonded.

C. Geocomposite suppliers shall furnish materials in which the "Minimum Average Roll Values", as defined by the Federal Highway Administration (FHWA), meet or exceed the criteria specified in Table 02773-1.

D. The geocomposite's geotextile components shall be nonwoven materials, suitable for use in filter/separation and cushion applications.

2.02 Manufacturing Quality Control

A. The geocomposite shall be manufactured with quality control procedures that meet or exceed generally accepted industry standards.

B. The geocomposite Manufacturer shall sample and test the geocomposite to demonstrate that the material conforms to the requirements of these Specifications.

C. Any geocomposite sample that does not comply with this Section shall result in rejection of the roll from which the sample was obtained. The Geosynthetic Installer shall replace any rejected rolls.

D. If a geocomposite sample fails to meet the quality control requirements of this Section the geocomposite Manufacturer shall sample and test, at the expense of the Manufacturer, rolls manufactured in the same lot, or at the same time, as the failing roll. Sampling and testing of rolls shall continue until a pattern of acceptable test results is established to bound the failed roll(s).

E. Additional sample testing may be performed, at the geocomposite Manufacturer's discretion and expense, to identify more closely any non-complying rolls and/or to qualify individual rolls.

F. Sampling shall, in general, be performed on sacrificial portions of the geocomposite material such that repair is not required. The Geocomposite Manufacturer shall sample and test the geocomposite, at a minimum once every 100,000 ft^2, to demonstrate that the geocomposite properties conform to the values specified in Table 02773-1. At a minimum, the following manufacturing quality control tests shall be performed on the geotextile component of the geocomposite:

Test	Procedure
Mass per unit area	ASTM D 5261
Grab strength	ASTM D 4632
Puncture strength	ASTM D 4833
Permittivity	ASTM D 4491
A.O.S.	ASTM D 4751

G. At a minimum, the following manufacturing quality control tests shall be performed on the geonet component of the geocomposite:

Test	Procedure
Specific gravity	ASTM D 792
Nominal thickness	ASTM D 5199

H. At a minimum, the following manufacturing quality control tests shall be performed on the geocomposite:

Test	Procedure
Transmissivity	ASTM D 4716
Peel strength	ASTM D 413

I. The geocomposite Manufacturer shall comply with the certification and submittal requirements of this Section.

2.03 Packing and Labeling

A. Geocomposite shall be supplied in rolls wrapped in relatively impermeable and opaque protective covers.

B. Geocomposite rolls shall be marked or tagged with the following information:

1. manufacturer's name;
2. product identification;
3. lot or batch number;
4. roll number; and
5. roll dimensions.

2.04 Transportation, Handling, and Storage

A. The Geosynthetic Installer shall be liable for any damage to the materials incurred prior to and during transportation to the site.

B. The geocomposite shall be delivered to the site at least 14 days prior to the planned deployment date to allow the Engineer adequate time to perform conformance testing on the geocomposite samples as described in Part 3.06 of this Section.

C. Handling, unloading, storage, and care of the geocomposite prior to and following installation at the site, is the responsibility of the Geosynthetic Installer. The Geosynthetic Installer shall be liable for any damage to the materials incurred prior to final acceptance by the Engineer.

D. The Geosynthetic Installer shall be responsible for storage of the geocomposite at the site.

E. The geocomposite shall be protected from sunlight, excessive heat or cold, puncture, or other damaging or deleterious conditions. The geocomposite shall be protected from mud, dirt, and dust. Any additional storage procedures required by the geocomposite Manufacturer shall be the responsibility of the Geosynthetic Installer.

PART 3 – EXECUTION

3.01 Familiarization

A. Prior to implementing any of the work described in this Section, the Geosynthetic Installer shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the installation of this Section may properly commence without adverse impact.

B. Inspection:

1. The Geosynthetic Installer shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the installation of this Section may properly commence without adverse impact.

2. If the Geosynthetic Installer has any concerns regarding the installed work of other Sections, he should notify the Engineer in writing prior to commencing the work. Failure to notify the Engineer or installation of the geocomposite will be construed as Geosynthetic Installer's acceptance of the related work of all other Sections.

C. A pre-installation meeting shall be held to coordinate the installation of the geocomposite with the installation of other components of the lining system.

3.02 Handling and Placement

A. The Geosynthetic Installer shall handle all geocomposite in such a manner that it is not damaged in any way.

B. Install the geocomposite down the slope not across the slope. Place ends into the anchor trenches in such a manner as to continually keep the geocomposite in tension.

C. Precautions shall be taken to prevent damage to underlying layers during placement of the geocomposite.

D. In the presence of wind, all geocomposites shall be sufficiently weighted with sandbags or the equivalent to prevent movement.

E. The geocomposite shall be positioned by hand after being unrolled to minimize wrinkles.

F. Care shall be taken during placement of geocomposites not to entrap dirt or excessive dust in the geocomposite that could cause clogging of the drainage system, and/or stones that could damage the adjacent geomembrane. If dirt or excessive dust is entrapped in the geocomposite, it should be cleaned prior to placement of the next material on top of it. Care shall be exercised when handling sandbags, to prevent rupture or damage of the sandbags.

G. Geocomposites shall only be cut using a hooked utility blade.

H. After unwrapping the geocomposite from its opaque cover, the geocomposite shall not be left exposed for a period in excess of 15 days.

3.03 Overlaps and Seams

A. Geonet Components:

1. The geonet components shall be overlapped a minimum 4 in. along the length. The geonet shall be overlapped by a minimum 1 ft. across the width.

2. Geonet overlaps shall be secured by tying with nylon cable ties. Tying devices shall be white or yellow for easy inspection. Metallic devices shall not be used.

3. Seaming of the geonet shall be performed by wrap-ties at 12-in. centers for end of panels and at 5-ft centers for edge of panel seams.

4. No end-of-panel seams shall be placed on slopes exceeding 10 %.

B. Geotextile Components:

1. The bottom layers of geotextile shall be overlapped. The top layers of geotextiles shall be continuously sewn.

2. Polymeric thread, with chemical resistance properties equal to or exceeding those of the geotextile component, shall be used for all sewing.

3.04 Placement of Overlying Materials

A. All overlying materials shall be placed in such a manner as to ensure that:

1. The geocomposite and underlying materials are not damaged;

2. Minimal slippage occurs between the geocomposite and underlying layers; and

3. Excess tensile stresses are not produced in the geocomposite.

4. Equipment shall not be driven directly on the geocomposite.

5. Unless otherwise approved in writing by the Engineer, all equipment operating on the materials overlying the geotextile shall comply with Section 02200 and Section 02225.

3.05 Conformance Testing

A. Samples of geocomposite will be removed by the Engineer and sent to a Geosynthetic CQA Laboratory for testing to ensure conformance with the requirements of this Section. The Geosynthetic Installer shall assist the Engineer in obtaining conformance samples. The Geosynthetic Installer shall account for this testing in the installation schedule.

B. Samples shall be taken at a minimum frequency rate of one sample per 200,000 square feet.

C. The Engineer may increase the frequency of sampling in the event that test results do not comply with the requirements of Part 2.01 of this Section until passing conformance test results are obtained for all material that is received at the site. This additional testing shall be performed at the expense of the Contractor.

D. As a minimum, transmissivity and peel strength will be performed on each sample.

E. Any geocomposite that is not certified by the Manufacturer in accordance with Part 1.05 of this section or that does not meet the requirements specified in Part 2.01 shall be rejected and replaced by the Geosynthetic Installer.

3.06 Protection of Work

A. The Geosynthetic Installer shall use all means necessary to protect all work of this Section.

B. In the event of damage, the Geosynthetic Installer shall immediately make all repairs and replacements necessary to the approval of the Engineer.

PART 4 – MEASUREMENT AND PAYMENT

A. Providing for a complying with the requirements set forth in this Section for geocomposite will be measured as in-place square feet (SF), including geocomposite in the anchor trench to the limits shown on the Drawings, and payment will be based on the unit price provided on the Bid Schedule.

B. The following are considered incidental to the Work:

- shipping, handling, and storage.
- overlaps and seaming.
- layout survey.
- mobilization.
- rejected material.
- rejected material removal, handling, re-testing, and repair.
- temporary anchorage.

TABLE 02773 - 1

GEOCOMPOSITE PROPERTY VALUES – BASE LINER SYSTEM

PROPERTIES	QUALIFIER	UNITS	SPECIFIED VALUES (1)	TEST METHOD
Geonet Component:				
Specific gravity	Minimum		0.935	ASTM D 792
Carbon black content	Range	%	2 – 3	ASTM D 1603
Nominal thickness	Minimum	mils	200	ASTM D 5199
Geotextile Components:				
Mass per unit area	Minimum	oz/yd^2	8	ASTM D 5261
Filter Requirements				
Apparent opening size	Maximum	mm	0.21 mm	ASTM D 4751
Permittivity	Minimum	1/s	0.6	ASTM D 4491
Mechanical Requirements				
Grab strength	Minimum	lb	190	ASTM D 4632
Puncture strength	Minimum	lb	110	ASTM D 4833
Geocomposite:				
Transmissivity (2)	Minimum	m^2/s	6.1×10^{-5}	ASTM D 4716
Peel Strength	Minimum	gm/in	500	ASTM D 413

Notes:

1. All values except transmissivity represent minimum average roll values (i.e., any roll in a lot should meet or exceed the values in this table).

2. The design transmissivity is the hydraulic transmissivity of the geocomposite measured using water at 68°F ±3°F (20°C ±1.5°C) with a hydraulic gradient of 0.1 under a compressive stress of not less than 12,000 psf (574 kPa). For the test, the geocomposite shall be sandwiched between a layer of operations material and a textured 60-mil HDPE geomembrane. The minimum test duration shall be 24 hours and the report for the test results shall include measurements at intervals over the entire test duration.

END OF SECTION

SECTION 02820
CHAIN LINK FENCE

PART 1 – GENERAL

1.01 Description of Work

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, equipment, and incidentals necessary to construct the Chain Link Fence. The Work shall be performed as specified herein and in accordance with the Drawings.

B. The Work shall include construction of footers, construction of posts, rails, and bracing, placement and securing the fence fabric, construction and installation of swing gates, and all other Work incidental to construction of a completed fence as shown on the Drawings and as described in this Section.

1.02 Related Sections

Section 01025 – Measurement and Payment

Section 01300 – Submittals

Section 01400 – Quality Control

Section 01500 – Construction Facilities

Section 01560 – Temporary Controls

Section 02200 – Earthwork

Section 03400 – Cast-in-Place Concrete

1.03 References

A. Drawings

B. Latest Version of American Society for Testing and Materials (ASTM) Standards:

ASTM A 153	Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A 1043	Standard Specification for Strength and Protective Coatings on Metal Industrial Chain Link Fence Framework

1.04 Delivery, Storage, and Handling

A. Deliver materials to Site in good condition, in unopened packaging, and with labels intact. Inspect materials upon delivery and replace damaged or contaminated materials.

B. Store materials above ground, under cover, in a dry place, and in a manner to prevent damage or staining.

C. Handle materials to prevent damage to surfaces, edges, and ends. Replace damaged materials at no additional cost to the Owner.

1.05 Submittals

A. The Contractor shall submit to the Construction Manager, at least 7 days prior to installation of fence material, certificates of compliance with the fence Manufacturer's specifications and that the material meets or exceeds all internal quality control requirements and the requirements of this Section.

1.06 Quality Assurance

A. The Contractor shall ensure that the materials and methods used for security chain link fence construction meet the requirements of the Manufacturer, the Drawings, and this Section. Any material or method that does not conform to these documents, or to alternatives approved in writing by the Design Engineer will be rejected and shall be repaired or replaced by the Contractor to the satisfaction of the CQA Engineer at the Contractor's expense.

PART 2 – PRODUCTS

2.01 Security Fence Fabric

A. Fence fabric: 2" by 2" mesh size, 11 gauge core size, hot-dip zinc galvanized steel wire.

B. Fence fabric shall be a commercial-grade fence system, as supplied by Master-Halco, or shall be equivalent in core material, metallic-coating material, and all coating processes and strengths.

C. Manufacturer shall warranty the fence materials against defects and deterioration, other than normal wear and tear, for a minimum of 12 years.

D. Fabric selvages shall be twisted (barbed) on the top and knuckled on the bottom.

E. The heights of fabric shall be sufficiently long so that no horizontal splices are required.

2.02 Framework

A. Framework includes all posts and rails.

B. Fencing framework shall be made of tubular galvanized steel pipe that conforms to ASTM F 1043, Group 1a. The framework shall be standard weight, schedule 40 steel pipe, galvanized by the hot-dip method, with a minimum average of 1.8 ounces per square foot of zinc-coated surface.

C. Dimensions of the framework components shall be as shown on the Drawings.

2.03 Footers

A. Post footers shall be made with concrete rated at a minimum of 2,500 pounds per square inch (psi) and shall be constructed to the dimensions as shown on the Drawings.

2.04 Swing Gates

A. Gates frames shall be of the same materials and coatings as for the fence fabric and framework.

B. Dimensions of the gates and gate components shall be as shown on the Drawings.

C. Gate frame members shall be welded at joints for a rigid connection.

D. Contractor shall provide and install the following hardware for each gate:

E. Hinges: provide hinges of type to, size, and material to suit gate size. Hinges shall be non-liftoff type, offset to permit 180 degree gate opening.

F. Latch: exit control lock and cylinder, as shown on the Drawings.

G. Latch rail: steel plate, weld to stiles at interior side of gate to receive and protect latch.

2.05 Hardware

A. Hardware shall include bolts, tension rods, and truss rods.

B. Hardware shall be made of galvanized steel as per ASTM A 153.

C. Bolts shall be 3/16” diameter self drilling hex head TEK screws with flat washers, as manufactured by Hilti, Red Head, or approved.

D. Tension rods shall be stainless steel, in standard lengths to equal full height of fabric, with maximum cross section to suit fabric openings. Provide one tension rod for each gate post and corner post.

E. Truss rods shall be minimum 3/8” diameter threaded, galvanized steel rod and turnbuckle.

2.06 Fittings

A. Fittings include: tension and brace bands, caps, eye tops, rail ends, sleeves, and tie wires.

B. All fittings, except tie wires, shall be hot-dip galvanized steel. Tie wires shall be zinc-coated steel wire.

PART 3 – EXECUTION

3.01 General

A. When shipping, delivering, and installing all fence materials, do so to ensure a sound, undamaged installation. Provide storage for all materials and equipment delivered to the Site that is protective of stored materials. Handle and store materials in accordance with the Manufacturer's recommendations.

B. Prior to installation, examine surfaces designated to receive Work described in the Section for conditions adversely affecting the finished Work. Repair or replace surfaces not meeting tolerances or quality requirements governing substrate construction prior to initiating this Work.

C. Do not begin installation and erection before construction of the concrete secondary containment portion of the Work is complete.

3.02 Installation

A. Install materials in accordance with accepted shop drawings and Manufacturer’s printed instructions.

B. Provide top and intermediate rails as shown on Drawings. Install each as one piece between posts. Offset as necessary to allow for depth of fabric.

C. Place chain link fabric on the outside of the area to enclosed. Secure one end and apply sufficient tension to remove all slack before making attachments elsewhere. Tighten the fabric to provide a smooth uniform appearance, free from sag.

D. Cut fabric by untwisting on picket and attach each span independently at all terminal posts. Install tension rods with bolts and washers at 15" on center.

E. Fasten fabric to all posts, rails, and gate frames with bolts and washers at 15" on center.

F. Gates: install gates plumb, level and secure, for full operation without interference. Adjust hardware for smooth operation and lubricate where necessary. Gates shall open outward form the area to be secured.

G. Clearances: install fencing and gates with a maximum ½" clearance between the perimeter of the fabric and the framing, between the framing and adjacent construction, and between the perimeter of each gate leaf and surrounding construction. Close off gaps exceeding 1/2"at the direction of the Construction Manager.

3.03 Cleaning Up

A. During the progress of the Work, the premises shall be kept free of debris and waste. Upon completion, remove from the Site and dispose of all debris and surplus materials in a lawful manner.

B. At completion of Work, touch up minor damage to all surfaces to the satisfaction of the Construction Manager. Protect completed Work until final acceptance by the Owner.

3.04 Survey

A. The locations of the fence posts shall be surveyed by the Surveyor, and shall be included in the Record Drawings.

PART 4 – MEASUREMENT AND PAYMENT

4.01 General

A. Providing for and complying with the requirements set forth in this Section for chain link fence will be measured as linear feet (LF), and payment will be based on the unit price provided on the Bid Schedule.

B. The following are considered incidental to the Work:

- Submittals.
- Mobilization.
- Quality Control.
- Shipping, handling and storage.
- Footers
- Framework
- Welding.
- Fence fabric
- Gates
- Hardware and fittings
- Clean up
- As-built survey.

END OF SECTION

Section 5
Final Cover Calculation Packages

Section 5
Final Cover Calculation Packages

Calculation Package A
Geocomposite and Pipe Size Calculation

GeoSyntec Consultants

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: Parsons **Project:** BRC CAMU **Project/Proposal #:** HL0389 **Task #:** 04

Title of Computations: Drainage Geocomposite and Pipe Size Requirements

Computations By:
SIGNATURE — DATE: 10 July 2000
Geoff L. Smith / Staff Engineer
PRINTED NAME AND TITLE

Assumptions and Procedures Checked By (Peer Reviewer):
SIGNATURE — DATE: 13 JULY 2000
MICHAEL E. KALINSKI / SR. STAFF ENG.
PRINTED NAME AND TITLE

Computations Checked By:
SIGNATURE — DATE: 7/14/00
GREGORY T CORCORAN / PROJ. ENG.
PRINTED NAME AND TITLE

Computations Backchecked By (Originator):
SIGNATURE — DATE: 7/14/00
Geoff L. Smith / Staff Engineer
PRINTED NAME AND TITLE

Approved By (PM or Designate):
SIGNATURE — DATE: 7/17/2000
Bradford H. Cody / Project Manager
PRINTED NAME AND TITLE

Approval Notes:

Revisions: (Number and Initial All Revisions)

No.	Sheet	Date	By	Checked By	Approval

Written by: Geoff L. Smith Date: 00 / 07 / 10 (YY MM DD) Reviewed by: 7.13.00 GTC Date: 00 / 07 / 14 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 04

DRAINAGE COMPOSITE AND PIPE SIZE REQUIREMENTS
BRC CAMU
HENDERSON, NEVADA

OBJECTIVE

The objective of this analysis is to evaluate the hydraulic performance of a drainage geocomposite and drainage pipe within the final cover system at the BRC Corrective Action Management Unit (CAMU). A drainage pipe is proposed to convey the collected water (from the geocomposite) to perimeter ditches. This calculation will evaluate the required criteria (e.g., transmissivity, pipe diameter) for the geocomposite and pipes.

SUMMARY OF ANALYSIS

The analyses indicate that the ultimate (or laboratory) transmissivity of the drainage composite shall be greater than 1×10^{-3} m^2/sec-m at $\sigma_n = 2000$ psf and $i = 0.10$. The drainage path shall be no longer than 1100 ft. The drainage pipe shall be 6-inch diameter perforated, corrugated polyethylene (CPE) pipe. The interior wall of the pipe shall be smooth.

METHOD OF ANALYSIS

The approach of the analysis is to first select a representative geocomposite from manufacturer data. Then, the ultimate transmissivity of the geocomposite will be evaluated from the manufacturer data. The allowable transmissivity of the geocomposite will be evaluated by reducing the ultimate transmissivity by partial factors of safety to account for field conditions. The allowable transmissivity will be used in an analysis performed using the Hydrological Evaluation of Landfill Performance (HELP) model developed by the EPA. The HELP model was developed to conduct water balance analysis of landfills, cover systems, and solid waste disposal and containment facilities.

Precipitation values used in this analysis are based on the assumed irrigation rates of a potential golf course that may be constructed overlying the final cover system. Based on verbal conversations with golf course landscape managers in Palm Springs, CA, approximately 3.5 inches of water per month is used from September to April and approximately 7 inches during the summer months. This equates to a total of about 56 inches per year. In addition, at the end of the model year, a 3-inch storm was simulated in HELP.

Written by: Geoff L. Smith Date: 00 / 07 / 10 (YY MM DD) Reviewed by: 7/13/00 Date: 00 / 07 / 14 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 04

The maximum drainage length of the geocomposite will be evaluated by varying its value to limit the head on the liner to a value less than the design criterion.

FINAL COVER LINER SYSTEM

The final cover system consists of, from top to bottom:

- 2 ft native material;
- a geocomposite;
- a 60-mil (1.5-mm) thick high density polyethylene (HDPE) geomembrane;
- a geosynthetic clay liner (GCL); and
- prepared subgrade.

The sideslope inclination is 3.0H:1.0V and the top deck area has a minimum grade of 2%. The maximum height of the side slope is 30 vertical feet (Figure 1).

DESIGN CRITERION

The design criteria consists of an allowable liquid head over the geomembrane component of the final cover system for the top deck area and side slopes. The allowable liquid head over the geomembrane for the side slopes is a negligible amount to limit potential sloughing failure of the vegetative cover soil component of the final cover system. The allowable head over the geomembrane for the top deck is less than twelve inches (0.3 m), to minimize unstable areas in the vegetative cover soil.

ANALYSIS

Geocomposite Design

A review of manufacturer literature suggests that an ultimate transmissivity of 1×10^{-3} m^2/sec can be achieved (see Attachment A) under gradients and normal stresses representative of the BRC CAMU final cover.

To ensure that the transmissivity of the proposed drainage composite meets or exceeds the required values over the life of the final cover, the ultimate transmissivity must be reduced through the use of appropriate partial factors of safety. These partial factors of safety

make the adequate adjustment between the laboratory transmissivity values for drainage composite and actual field conditions.

As seen in Attachment B, Koerner suggests four partial factor of safety values that should be accounted for: the intrusion of the adjacent geotextile into the core of the geonet (FS_{IN}), creep deformation of the geonet (FS_{CR}), factor of safety against chemical clogging of the geonet (FS_{CC}), and factor of safety against biological clogging of the geonet (FS_{BC}). Partial factor of safety values were applied to the geotextile in the filtration geotextile calculation to account for flow through the geotextile component of the drainage composite.

Attachment B shows the ranges for the partial factors of safety. For the purposes of this analysis, the following factors of safety values were selected:

$FS_{IN} = 1.0$ (Accounted for during the testing of the drainage composite)
$FS_{CR} = 1.3$
$FS_{CC} = 1.0$ (Surface water)
$FS_{BC} = 1.2$ (Surface water)

The allowable transmissivity of the drainage composite then becomes:

$$\theta_{allowable} = \theta_{ultimate} / (\prod FS)$$

$\prod FS$ = product of all the partial factors of safety for the site specific conditions

The allowable transmissivity of the drainage composite is then calculated as:

$$\theta_{allowable} = \theta_{ultimate} / (\prod FS) = 1 \times 10^{-3}\ m^2/sec\ /\ [\ 1.0*1.3*1.0*1.2]$$

$$= \mathbf{6.4 \times 10^{-4}\ m^2/sec\ at\ \sigma_n = 2000\ psf,\ i = 0.10}$$

The hydraulic conductivity and the thickness of the geocomposite are input for the HELP model to evaluate the maximum drainage distance. The hydraulic conductivity can be translated to transmissivity by using Darcy's Law as shown below:

$q = kiA = ki(t * W) = kti = \theta i$, therefore, for a unit width,
$k = \theta / t$

Written by: Geoff L. Smith GLS Date: 00 / 07 / 10 (YY MM DD) Reviewed by: BHC 7-13-00 GTC Date: 00 / 07 / 14 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 04

The thickness of the geocomposite can be ascertained from manufacturer information. (ATTACHMENT A) The thickness used herein is 225 mils (0.0057 m) for the Gundnet XL-14. Hence, the allowable hydraulic conductivity is 11 cm/sec (6.4×10^{-4} m^2/sec / 0.0057 m * 100) for the geocomposite.

HELP model output is presented in Attachment D. Typical near surficial soils exhibit a permeability of 5.3×10^{-4} cm/sec (Converse 1999) (Attachment C). Input parameters and results from the HELP model are presented below for the top deck area:

K_{veg} (cm/sec)	drainage length (ft)	Gradient (%)	$t_{geocomposite}$ (in)	$k_{geocomposite}$ (cm/sec)	Head on Liner (in)
5.3×10^{-4}	1100	2.0	0.225	11	8.2

Input parameters and results from the HELP model are presented below for the side slope area (Figure 1):

K_{veg} (cm/sec)	drainage length (ft)	Gradient (%)	$t_{geocomposite}$ (in)	$k_{geocomposite}$ (cm/sec)	Head on Liner (in)
5.3×10^{-4}	150	33.3	0.225	11	0.0

Since the head on the side slope liner is negligable, slope stability analyses for the side slope that includes seepage forces are not needed. BHC 7/17/00

Based on the above analyses, the drainage geocomposite and drainage distances meet the design criteria.

Pipe Size Design

A pipe diameter must be chosen for the final cover collection pipes and the downchutes for the final cover drainage system. The pipe is assumed to be a CPE pipe with a smooth wall interior. Figure 1 shows the maximum contributing area that a lateral must collect. This maximum contributing area is 13.2 acres (located in the South Mesa). From the HELP model analyses (Attachment D), the peak daily quantity of water expected to be generated is 926 cubic feet per acre. Assuming that all of this liquid will have to flow through one pipe, the following flow rate can be calculated:

(926 CF/day/acre) * 13.2 acres / (24 hours/day) / (60 min/hour) / (60 sec/min) = 0.14 cfs

Written by: Geoff L. Smith GLS Date: 00 / 07 / 10 (YY MM DD) Reviewed by: MSK 7.13.00 GTC Date: 00 / 07 / 14 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 04

Manning's Equation (Attachment E) can be used to estimate the flow rate in the pipe when flowing full:

$$Q_{full} = (1.486/n)(A)(R)^{2/3}(S)^{1/2}$$

where:
n = Manning's roughness coefficient, 0.012 from product literature (Attachment F)
A = area of pipe
R = hydraulic radius = area/wetting perimeter of the pipe (Attachment E)
S = slope of pipe, assume 0.5%

Assuming a 6-inch diameter corregated pipe flowing half-full, and using literature from ADS (Attachment F), the following values will be used in the above equation:

$r = 3.0$ in (Attachment F)
$A = \pi r^2 = \pi(3/12)^2 = 0.196 \text{ ft}^2$
$R = (0.196) / (2\pi(3/12)) = 0.125$ ft

Placing the above values into the Manning's equation results in the following:

$$Q_{full} = (1.486/0.012)(0.196)(0.125)^{2/3}(0.005)^{1/2}$$

$Q_{full} = 0.43 \text{ cfs} > 0.14$ O.K.

Therefore, a 6-inch nominal diameter pipe is acceptable.

NOTE TO SPECIFICATIONS

The ultimate transmissivity of the drainage composite shall be greater than or equal to 1×10^{-3} m^2/sec at $\sigma_n = 2000$ psf and $i = 0.10$. The drainage path shall be no longer than 1100 ft. The pipe shall be 6-inch diameter perforated corrugated polyethylene pipe with smooth interior wall.

Written by: Geoff L. Smith GLS Date: 00 / 07 / 10 (YY MM DD) Reviewed by: GC Date: 00 / 07 / 14 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 04

REFERENCES

Advanced Drainage Systems, Inc., Product Literature, (614) 457-3051. *(Attachment F)*

Koerner, R.M. (1994) "Designing with Geosynthetics", 3rd Edition, Prentice Hall, New Jersey *(Attachment B)*

Environmental Protection Agency (1994), "The Hydrologic Evaluation of Landfill Performance (HELP) Model," September 1994. *(model ouput presented in Attachment D)*

Converse Consultants (1999), "Preliminary Geotechnical and Geologic Investigation, Industrial Non-Hazardous Disposal Facility, Basic Management Incorporated, Clark County, Nevada," October 27, 1999, Las Vegas, Nevada. *(Attachment C)*

Chow, V.T. (1959) "Open Channel Hydraulics," McGraw-Hill, *(Attachment E)*

Product Description

Gundnet® XL-14 Drainage Media is a net-like product of two overlapping polyethylene strands which transmits fluids in the plane of the net.

Fabri-Net® XL-14 Drainage Composite consists of a geotextile fabric heat bonded to Gundnet® XL-14 Drainage Net on one or both sides.

- Gundnet® XL-14 and Fabri-Net® XL-14 drainage systems are rolled on 6 in. (15 cm) I.D. hollow cores.
- Each Gundnet® XL-14 roll is provided with a sling to aid handling on site.
- Fabri-Net® XL-14 Drainage Composite is wrapped in a protective plastic bag.
- Dimensions and weights are approximate.
- Custom lengths available.

Gundnet® XL-14 Drainage Net and Fabri-Net® XL-14 Drainage Composite

Gundnet® XL-14 Drainage Net and Fabri-Net® XL-14 Drainage Composite replace traditional one foot (0.3 m) thicknesses of drainage sand with typically 100 times the equivalent hydraulic conductivity of the sand drainage layer. They simultaneously add nearly one foot of air space to the project for each drainage layer they replace. Fabri-Net® XL-14 Drainage Composite allows single step deployment where geotextile separation of soils from drainage net is required. Double-sided Fabri-Net® XL-14 Drainage Composite (geotextile heat bonded on both sides) provides tremendous slope stability in combination with textured liner by gripping the geomembrane surface with velcro-like friction.

Standard Roll Dimensions

Gundnet® XL-14

Roll Width	6.5 ft. (2 m)	14 ft. (4.3 m)
Roll Length	100 ft. (30 m)	300 ft. (91 m)
Roll Weight	130 lbs (60 kg)	840 lbs (382 kg)

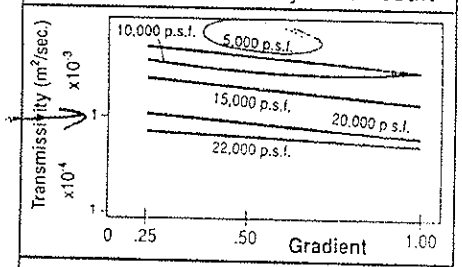
Fabri-Net® XL-14

Roll Width [1]	6.5 ft. (2 m)	14 ft. (4.3 m)
Roll Length [2]	100 ft. (30 m)	200 ft. (61 m)
Roll Weight [2]	194 lbs (88 kg)	835 lbs (380 kg)

[1] Width with geotextile overlap is 7 ft. for 6.5 ft. width and 15 ft. for 14 ft. width.
[2] Value for Fabri-Net® XL-14 double-sided with 6 ounce geotextile only. Bonding geotextile with different weights will change the final roll weight and length.

Material: Gundnet® XL-14
Fluid: Water Temperature: 60°F

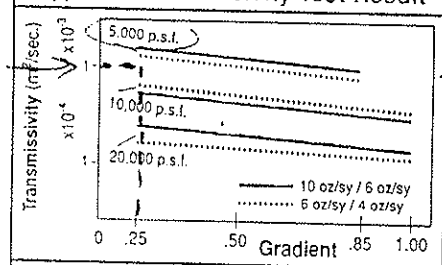
Typical Transmissivity Test Result



Section:
- Upper Load Plate
- Gundline® HD
- Gundnet® XL-14
- Gundline® HD
- Lower Load Plate

Material: Fabri-Net® XL-14
Fluid: Water Temperature: 70°F

Typical Transmissivity Test Result



Section:
- Upper Load Plate
- Sand
- Geotextile
- Gundnet® XL-14
- Geotextile
- Gundline® HD
- Lower Load Plate

Gundle Lining Systems Inc.

Gundle Lining Systems, Inc.
19103 Gundle Road
Houston, Texas 77073 U.S.A.

Phone: (713) 443-8564
Toll Free: (800) 435-2008
Telex: 166657 Gundle Hou
Fax: (713) 875-6010

Attachment A 1/1

© Gundle Lining Systems, Inc. 1994 20MSP1194

printed on recycled paper

7-10-02 MAGIC 7.13-02 GTC

TME CALCS 2/23

Table 4.2 Recommended preliminary factor of safety values for determining allowable flow rate or transmissivity of geonets

	Partial Factor of Safety Value in Equation 4.5			
Application Area	FS_{IN}	FS_{CR}*	FS_{CC}	FS_{BC}
Sport fields	1.0 to 1.2	1.0 to 1.5	1.0 to 1.2	1.1 to 1.3
Capillary breaks	1.1 to 1.3	1.0 to 1.2	1.1 to 1.5	1.1 to 1.3
Roof and plaza decks	1.2 to 1.4	1.0 to 1.2	1.0 to 1.2	1.1 to 1.3
Retaining walls, seeping rock and soil slopes	1.3 to 1.5	1.2 to 1.4	1.1 to 1.5	1.0 to 1.5
Drainage blankets	1.3 to 1.5	1.2 to 1.4	1.0 to 1.2	1.0 to 1.2
Surface water drains for landfill caps	1.3 to 1.5	1.2 to 1.4	1.0 to 1.2	1.2 to 1.5
Secondary leachate collection (landfills)	1.5 to 2.0	1.4 to 2.0	1.5 to 2.0	1.5 to 2.0
Primary leachate collection (landfills)	1.5 to 2.0	1.4 to 2.0	1.5 to 2.0	1.5 to 2.0

*These values assume that the q_{ult} value was obtained using an applied normal pressure of 1.5 to 2 times the field-anticipated maximum value. If not, values must be increased.

done at the proper design load and hydraulic gradient and that this testing yielded a short-term between-rigid-plates value of 1.2 gal./min.-ft.

Solution: Since better information is not known, average values from Table 4.2 are used.

$$q_{allow} = q_{ult}\left[\frac{1}{FS_{IN} \times FS_{CR} \times FS_{CC} \times FS_{BC}}\right] \tag{4.5}$$

$$= 1.2\left[\frac{1}{1.1 \times 1.1 \times 1.1 \times 1.2}\right]$$

$$= 1.2\left[\frac{1}{1.60}\right]$$

$$= 0.75 \text{ gal./min.-ft.}$$

Example:

What is the allowable geonet flow rate to be used in the design of a secondary leachate collection system? Assume that laboratory testing at proper design load and proper hydraulic gradient gave a short-term between-rigid-plates value of 1.2 gal./min.-ft.

Solution: Average values from Table 4.2 are used; however, note the large reduction.

Attachment B

SOURCE Koerner (1994)

1/1

FROM CONVERSE (1999)

Exploration Location	Depth (feet)	Soil Description	Percent Sodium	Percent Sulfate	Total Available Water Soluble sodium Sulfate (%)
B-5	10-15	Silty sand with gravel	0.07	0.13	0.20
B-8	19-20	Silty sand with gravel	0.07	0.06	0.08
B-101	5-10	Silty sand with gravel	0.17	0.06	0.08
B-102	0-5	Fill – Silty sand with gravel	0.17	0.03	0.05
B-106	0-5	Silty sand with gravel	0.15	0.08	0.12
B-106	29-30	Silty sand with gravel	0.15	0.06	0.08

Permeability

Falling head permeability tests were conducted on remolded samples in general accordance with modified ASTM procedure D2434. The soil was compacted in a mold 4.6 inches long and 4.0 inches in diameter to 85 or 90 percent of maximum dry density and at optimum moisture content. A falling head was applied to the sample and the flow of water through the sample was monitored. The permeability was calculated after the flow rate had stabilized. The result of the falling head permeability test is presented in the following table:

Exploration Location	Sample Depth (Feet)	Soil Description	k (cm/s)
B-5	20-25	Silty sand with gravel	5.3×10^{-4}
B-12	10-15	Silty sand with gravel	4.0×10^{-4}
B-102	20-25	Silty sand with gravel	1.0×10^{-4}
B-105	20-25	Well graded sand with silt and gravel	1.2×10^{-3}

Flexible wall permeameter tests were performed on selected samples by AP Engineering and Testing, Inc according to ASTM D5084. With the exception of one sample (B-105), all tested samples were undisturbed ring samples. The samples were placed in a triaxial machine with a constant confining pressure at the approximate in-place effective stress pressures. Results were generally consistent with the fal-

Attachment 1, 1/2

MY 7-13-00 GTC

ling head permeability test results for the granular materials. Laboratory results are presented on Drawing Nos. A-71 through A-76 and summarized below:

Exploration Location	Sample Depth (Feet)	Soil Description	k (cm/s)
B-1	14-15	Silty sand with gravel	1.57×10^{-4}
B-4	24-25	Silty sand with gravel	1.47×10^{-4}
B-8	44-45	Sandy silt	2.90×10^{-5}
B-12	39-39.5	Silty clay	1.76×10^{-7}
B-103	44-45	Silty clay	3.83×10^{-7}
B-105*	30-35	Silty sand	3.05×10^{-4}

* Sample remolded to 85% relative compaction at optimum moisture.

FROM CONVERSE (1999)

Attachment C
2/2

7-13-00 7-13-00 GTC

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:      r:\cawp\gls\help307\DATA44.D4
TEMPERATURE DATA FILE:        r:\cawp\gls\help307\DATA74.D7
SOLAR RADIATION DATA FILE:    r:\cawp\gls\help307\DATA134.D13
EVAPOTRANSPIRATION DATA:      r:\cawp\gls\help307\DATA114.D11
SOIL AND DESIGN DATA FILE:    r:\cawp\gls\help307\DATA104.D10
OUTPUT DATA FILE:             r:\cawp\gls\help307\TEST4.OUT


TIME:  11:11      DATE:    7/10/2000


******************************************************************************

     TITLE:  BRC CAMU, Condition 4
******************************************************************************
```

top deck w/ geocomposite

```
     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   7
          THICKNESS                  =       1.00   INCHES
          POROSITY                   =       0.4730 VOL/VOL
          FIELD CAPACITY             =       0.2220 VOL/VOL
          WILTING POINT              =       0.1040 VOL/VOL
          INITIAL SOIL WATER CONTENT =       0.2494 VOL/VOL
          EFFECTIVE SAT. HYD. COND.  =  0.520000001000E-03 CM/SEC
       NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  1.80
                FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

Att. D

61C

LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	23.00	INCHES
POROSITY	=	0.4730	VOL/VOL
FIELD CAPACITY	=	0.2220	VOL/VOL
WILTING POINT	=	0.1040	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3271	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.530000019000E-03	CM/SEC

LAYER 3

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.22	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.8500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	11.0000000000	CM/SEC
SLOPE	=	2.00	PERCENT
DRAINAGE LENGTH	=	1100.0	FEET

LAYER 4

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	2.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	1.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 5

GTC

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.20	INCHES
POROSITY	=	0.7500	VOL/VOL
FIELD CAPACITY	=	0.7470	VOL/VOL
WILTING POINT	=	0.4000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000003000E-08	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 7 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 1100. FEET.

SCS RUNOFF CURVE NUMBER	=	81.70	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	5.337	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.514	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.872	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	8.113	INCHES
TOTAL INITIAL WATER	=	8.113	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
LAS VEGAS NEVADA

STATION LATITUDE	=	36.08	DEGREES
MAXIMUM LEAF AREA INDEX	=	1.00	
START OF GROWING SEASON (JULIAN DATE)	=	62	
END OF GROWING SEASON (JULIAN DATE)	=	321	
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	9.10	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	39.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	21.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	24.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	36.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA

GIC

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
0.50	0.46	0.41	0.22	0.20	0.09
0.45	0.54	0.32	0.25	0.43	0.32

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
44.60	50.10	55.30	63.50	73.30	83.60
90.30	88.00	80.10	67.60	53.60	45.40

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA
AND STATION LATITUDE = 36.08 DEGREES

****

ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	61.72	224043.187	100.00
RUNOFF	0.845	3066.880	1.37
EVAPOTRANSPIRATION	57.247	207807.844	92.75
DRAINAGE COLLECTED FROM LAYER 3	3.4317	12457.194	5.56
PERC./LEAKAGE THROUGH LAYER 5	0.000008	0.028	0.00
AVG. HEAD ON TOP OF LAYER 4	0.0548		
CHANGE IN WATER STORAGE	0.196	711.629	0.32
SOIL WATER AT START OF YEAR	8.113	29451.367	
SOIL WATER AT END OF YEAR	8.309	30162.996	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00

G-1C

ANNUAL WATER BUDGET BALANCE -0.0001 -0.391 0.00

****

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 1

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.72	3.36	3.72	3.30	3.41	7.20
	7.75	8.05	7.52	3.55	3.60	6.54
STD. DEVIATIONS	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.845
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	2.805	3.292	4.494	3.871	3.646	7.066
	7.823	7.942	6.748	4.260	2.823	2.479
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
LATERAL DRAINAGE COLLECTED FROM LAYER 3						
TOTALS	2.4674	0.5061	0.2495	0.0039	0.0014	0.0008
	0.0001	0.0002	0.0000	0.0004	0.0004	0.2015
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 5						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

6TC

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 4

AVERAGES	0.5174	0.0159	0.0071	0.0001	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.1174
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

****

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 1

	INCHES		CU. FEET	PERCENT
PRECIPITATION	61.72	(0.000)	224043.2	100.00
RUNOFF	0.845	(0.0000)	3066.88	1.369
EVAPOTRANSPIRATION	57.247	(0.0000)	207807.84	92.753
LATERAL DRAINAGE COLLECTED FROM LAYER 3	3.43173	(0.00000)	12457.194	5.56018
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.00001	(0.00000)	0.028	0.00001
AVERAGE HEAD ON TOP OF LAYER 4	0.055	(0.000)		
CHANGE IN WATER STORAGE	0.196	(0.0000)	711.63	0.318

****

AA 7-10-00

GIC

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 1

	(INCHES)	(CU. FT.)
PRECIPITATION	3.00	10890.000
RUNOFF	0.845	3066.8796
DRAINAGE COLLECTED FROM LAYER 3	0.25524	926.53894
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.000002	0.00546
AVERAGE HEAD ON TOP OF LAYER 4	4.490	
MAXIMUM HEAD ON TOP OF LAYER 4	8.210	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	93.9 FEET	
SNOW WATER	0.16	579.4747

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.3497

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1515

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

****

AH. D

6C

****

FINAL WATER STORAGE AT END OF YEAR 1

LAYER	(INCHES)	(VOL/VOL)
1	0.2492	0.2492
2	7.7189	0.3356
3	0.1913	0.8500
4	0.0000	0.0000
5	0.1500	0.7500
SNOW WATER	0.000	

****
****

MM 7-10-00
MSK 7.13.00

MC

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:      r:\cawp\gls\help307\DATA44.D4
TEMPERATURE DATA FILE:        r:\cawp\gls\help307\DATA74.D7
SOLAR RADIATION DATA FILE:    r:\cawp\gls\help307\DATA134.D13
EVAPOTRANSPIRATION DATA:      r:\cawp\gls\help307\DATA114.D11
SOIL AND DESIGN DATA FILE:    r:\cawp\gls\help307\DATA105.D10
OUTPUT DATA FILE:             r:\cawp\gls\help307\TEST5.OUT


TIME:  13:22     DATE:   7/10/2000


******************************************************************************

    TITLE:  BRC CAMU, Condition 5
```

Title Proper

```
******************************************************************************


    NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
             COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                 TYPE 1 - VERTICAL PERCOLATION LAYER
                     MATERIAL TEXTURE NUMBER   7
        THICKNESS                    =      1.00   INCHES
        POROSITY                     =      0.4730 VOL/VOL
        FIELD CAPACITY               =      0.2220 VOL/VOL
        WILTING POINT                =      0.1040 VOL/VOL
        INITIAL SOIL WATER CONTENT   =      0.2892 VOL/VOL
        EFFECTIVE SAT. HYD. COND.    =  0.520000001000E-03 CM/SEC
      NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  1.80
               FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                  LAYER  2
                                  --------

                 TYPE 1 - VERTICAL PERCOLATION LAYER
                     MATERIAL TEXTURE NUMBER   0
        THICKNESS                    =     23.00   INCHES
        POROSITY                     =      0.4730 VOL/VOL
        FIELD CAPACITY               =      0.2220 VOL/VOL
        WILTING POINT                =      0.1040 VOL/VOL
        INITIAL SOIL WATER CONTENT   =      0.2546 VOL/VOL
```

Att. D

EFFECTIVE SAT. HYD. COND. = 0.530000019000E-03 CM/SEC

LAYER 3

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.22	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0158	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	11.0000000000	CM/SEC
SLOPE	=	33.30	PERCENT
DRAINAGE LENGTH	=	150.0	FEET

LAYER 4

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	2.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	1.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 5

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.20	INCHES
POROSITY	=	0.7500	VOL/VOL
FIELD CAPACITY	=	0.7470	VOL/VOL
WILTING POINT	=	0.4000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000003000E-08	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 7 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 33.% AND A SLOPE LENGTH OF 150. FEET.

SCS RUNOFF CURVE NUMBER	=	84.80	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	0.520	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	4.344	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.514	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.872	INCHES

INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	6.298	INCHES
TOTAL INITIAL WATER	=	6.298	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
LAS VEGAS NEVADA

STATION LATITUDE	=	36.08	DEGREES
MAXIMUM LEAF AREA INDEX	=	1.00	
START OF GROWING SEASON (JULIAN DATE)	=	62	
END OF GROWING SEASON (JULIAN DATE)	=	321	
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	9.10	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	39.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	21.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	24.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	36.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
0.50	0.46	0.41	0.22	0.20	0.09
0.45	0.54	0.32	0.25	0.43	0.32

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
44.60	50.10	55.30	63.50	73.30	83.60
90.30	88.00	80.10	67.60	53.60	45.40

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA
AND STATION LATITUDE = 36.08 DEGREES

****

ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	61.72	116502.453	100.00
RUNOFF	0.941	1776.331	1.52
EVAPOTRANSPIRATION	45.182	85284.914	73.20
DRAINAGE COLLECTED FROM LAYER 3	15.2152	28720.299	24.65

6-7C

PERC./LEAKAGE THROUGH LAYER 5	0.000002	0.005	0.00
AVG. HEAD ON TOP OF LAYER 4	0.0003		
CHANGE IN WATER STORAGE	0.382	721.107	0.62
SOIL WATER AT START OF YEAR	6.298	11888.534	
SOIL WATER AT END OF YEAR	6.680	12609.642	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	-0.0001	-0.200	0.00

****

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 1

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.72	3.36	3.72	3.30	3.41	7.20
	7.75	8.05	7.52	3.55	3.60	6.54
STD. DEVIATIONS	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.941
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	2.535	2.748	3.640	3.724	2.661	5.384
	6.433	5.925	4.995	3.087	2.107	1.943
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
LATERAL DRAINAGE COLLECTED FROM LAYER 3						
TOTALS	1.7294	0.7077	0.5946	0.3187	0.5837	1.5292
	1.3191	2.0582	2.4341	0.9180	1.1996	1.8228
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 5						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

6c

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 4

AVERAGES	0.0004	0.0002	0.0002	0.0001	0.0002	0.0004
	0.0003	0.0005	0.0007	0.0002	0.0003	0.0005
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 1

	INCHES		CU. FEET	PERCENT
PRECIPITATION	61.72	(0.000)	116502.5	100.00
RUNOFF	0.941	(0.0000)	1776.33	1.525
EVAPOTRANSPIRATION	45.182	(0.0000)	85284.91	73.204
LATERAL DRAINAGE COLLECTED FROM LAYER 3	15.21525	(0.00000)	28720.299	24.65210
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.00000	(0.00000)	0.005	0.00000
AVERAGE HEAD ON TOP OF LAYER 4	0.000	(0.000)		
CHANGE IN WATER STORAGE	0.382	(0.0000)	721.11	0.619

MM 7-10-02

GTC

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 1

	(INCHES)	(CU. FT.)
PRECIPITATION	3.00	5662.800
RUNOFF	0.941	1776.3307
DRAINAGE COLLECTED FROM LAYER 3	0.16183	305.47559
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.000000	0.00001
AVERAGE HEAD ON TOP OF LAYER 4	0.001	
MAXIMUM HEAD ON TOP OF LAYER 4	0.002	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	0.16	301.3268

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.2709
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1434

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

****

6C

****

FINAL WATER STORAGE AT END OF YEAR 1

LAYER	(INCHES)	(VOL/VOL)
1	0.2881	0.2881
2	6.2395	0.2713
3	0.0027	0.0121
4	0.0000	0.0000
5	0.1500	0.7500
SNOW WATER	0.000	

****
****

CHANNEL DESIGN

MB 7-10-00
MK 7-13-00

CIC.

well-known form

$$V = \frac{1.49}{n} R^{2/3} S^{1/2} \tag{5-6}$$

where V is the mean velocity in fps, R is the hydraulic radius in ft, S is the slope of energy line, and n is the coefficient of roughness, specifically known as *Manning's n*. This formula was developed from seven different formulas, based on Bazin's experimental data, and further verified by 170 observations.[1] Owing to its simplicity of form and to the satis-

---

a linear measure of roughness and $\phi(R/k)$ is a function of R/k. If $\phi(R/k)$ is considered dimensionless, n will have the same dimensions as those of $k^{1/6}$, that is, $L^{1/6}$.

On the other hand, of course, it is equally possible to assume that the numerator of $1.486/n$ can absorb the dimensions of $L^{1/3}T^{-1}$, or that $\phi(R/k)$ involves a dimensional factor, thus leaving no dimensions for n. Some authors, therefore, preferring the simpler choice, consider n a dimensionless coefficient.

It is interesting to note that the conversion of the units for the Manning formula is independent of the dimensions of n, as long as the same value of n is used in both systems of units. If n is assumed dimensionless, then the formula in English units gives the numerical constant $3.2808^{1/3} = 1.486$ since 1 meter = 3.2808 ft. Now, if n is assumed to have the dimensions of $L^{1/6}$, its numerical value in English units must be different from its value in metric units, unless a numerical correction factor is introduced for compensation. Let n be the value in metric units and n' the value in English units. Then, $n' = (3.2808^{1/6})n = 1.2190n$. When the formula is converted from metric to English units, the resulting form takes the numerical constant $3.2808^{1/3+1/6} = 3.2808^{1/2} = 1.811$, since n has the dimensions of $L^{1/6}$. Thus, the resulting equation should be written $V = 1.811R^{2/3}S^{1/2}/n'$. Since the same value of n is used in both systems, the practical form of the formula in the English system is $V = 1.811R^{2/3}S^{1/2}/1.2190n = 1.486R^{2/3}S^{1/2}/n$, which is identical with the formula derived on the assumption that n has no dimensions.

In a search of early literature on hydraulics, the author has failed to find any significant discussion regarding the dimensions of n. It seems that this was not a problem of concern to the forefathers of hydraulics. It is most likely, however, that n was unconsciously taken as dimensionless in the conversion of the Manning formula, because such a conversion, as shown above, is more direct and simpler.

Now, considering the approximations involved in the derivation of the formula and the uncertainty in the value of n, it seems unjustifiable to carry the numerical constant to more than three significant figures. For practical purposes, a value of 1.49 is believed to be sufficiently accurate [16].

Manning mentioned that the simplified form of the formula had been suggested independently by G. H. L. Hagen prior to Manning's own work, according to a statement by Major Cunningham [17]. Hagen's formula was believed to have appeared first in 1876 [7]. It is also known that Philippe-Gaspard Gauckler [18] had an early proposal of the simplified form of Manning's formula in 1868 and that Strickler [19] presented independently the same form of the formula in 1923.

[1] For the derivation of the exponent of R, use was made of Bazin's experimental data on artificial channels [12]. For different shapes and roughnesses, the average value of the exponent was found to vary from 0.6499 to 0.8395. Considering these variations, Manning adopted an approximate value of $\frac{2}{3}$ for the exponent. On the

Attachment E

Chow, V.T. "Open Channel Hydraulics", (1959) McGraw-Hill

1/1

Technical Notes

ADS
ADVANCED DRAINAGE SYSTEMS, INC.

Technical Note 2.109
Re: Flow Capacity
Date: March 1, 1995

It is the intent of this Technical Note to provide current hydraulic performance data for use by the engineering community. A bibliography is included for the engineer's use if further information or guidance is needed.

Manning's "n" values are offered for design purposes based on the best available data assembled from a variety of sources as indicated. Table 1 presents the Manning's "n" values recommended by the A.D.S. engineering staff for use in design.

Table 1
Manning's "n" Value For Design
(Storm & Sanitary Sewer and Culverts)

Pipe Type	"n"
A.D.S. Corrugated Polyethylene Pipe	
3" - 6" Diameter	0.015
8" Diameter	0.016
10" Diameter	0.017
12" - 15" Diameter	0.018
18" - 36" Diameter	0.020
A.D.S. N-12	0.012
Concrete Pipe	0.013
Corrugated Metal Pipe (2 2/3" x 1/2" corrugation)	
Annular	
Plain	0.024
Paved Invert	0.020
Fully Paved (smooth lined)	0.013
Helical	
Plain 15" Diameter	0.013
Plain 18" Diameter	0.015
Plain 24" Diameter	0.018
Plain 36" Diameter	0.021
Spiral-Rib	0.012
Plastic Pipe (SDR, S&D, Etc.)	0.011
Vitrified Clay	0.013

Attachment F

ADS N-12® PRODUCT ORMATION SHEET

Nominal Diameter	Inside Diameter, Average	Outside Diameter, Average	Wall Thickness, Minimum	Pipe Stiffness @ 5% Deflection	Weight lbs./20 ft. (kg./6 m.)	Area in.²/in.	"I" in.⁴/in.	"C" in.
4" (100 mm)	4.10" (104 mm)	4.78" (120 mm)	0.020" (0.50 mm)	50 psi (340 kN/m²)	8.10 lbs. (3.60 kg.)	0.070	0.0014	0.29
6" (150 mm)	6.00" (152 mm)	6.92" (176 mm)	0.020" (0.50 mm)	50 psi (340 kN/m²)	17.00 lbs. (7.71 kg.)	0.107	0.0036	0.25
8" (200 mm)	7.90" (200 mm)	9.11" (233 mm)	0.025" (0.64 mm)	50 psi (340 kN/m²)	30.80 lbs. (13.97 kg.)	0.135	0.0070	0.27
10" (250 mm)	9.90" (251 mm)	11.36" (287 mm)	0.025" (0.64 mm)	50 psi (340 kN/m²)	45.20 lbs. (20.50 kg.)	0.145	0.0110	0.34
12" (300 mm)	12.15" (308 mm)	14.45" (367 mm)	0.035" (0.89 mm)	50 psi (340 kN/m²)	63.80 lbs. (28.96 kg.)	0.188	0.0410	0.53
15" (375 mm)	14.98" (380 mm)	17.57" (448 mm)	0.035" (0.89 mm)	42 psi (290 kN/m²)	92.50 lbs. (42.00 kg.)	0.217	0.0660	0.66
18" (450 mm)	18.07" (459 mm)	21.20" (536 mm)	0.050" (1.27 mm)	40 psi (280 kN/m²)	128.60 lbs. (58.38 kg.)	0.250	0.0890	0.75
24" (600 mm)	24.08" (612 mm)	27.80" (719 mm)	0.050" (1.27 mm)	34 psi (240 kN/m²)	224.60 lbs. (101.97 kg.)	0.338	0.2310	1.07
30" (750 mm)	30.20" (767 mm)	36.07" (917 mm)	0.050" (1.27 mm)	28 psi (190 kN/m²)	308.30 lbs. (139.97 kg.)	0.353	0.4870	0.69
36" (900 mm)	36.20" (919 mm)	42.46" (1073 mm)	0.050" (1.27 mm)	22 psi (150 kN/m²)	361.20 lbs. (163.98 kg.)	0.361	0.5500	0.46
42" (1050 mm)	41.50" (1054 mm)	46.75" (1187 mm)	0.050" (1.27 mm)	19 psi (140 kN/m²)	530.00 lbs. (240.62 kg.)	0.420	0.7400	1.25
48" (1200 mm)	47.55" (1208 mm)	52.70" (1339 mm)	0.050" (1.27 mm)	17 psi (120 kN/m²)	640.00 lbs. (290.56 kg.)	0.420	0.7400	1.25

Date: March 1, 1996

Attachment E 2/2

SOURCE ADS 1996

Calculation Package B
Veneer Stability

GeoSyntec Consultants

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: Basic Remediation Company

Project: BRC CAMU **Project/Proposal #:** SC0313 **Task #:** 01

Title of Computations: Veneer Stability of Geosynthetic – Soil Lined Sideslope

Computations By:
SIGNATURE — DATE 11/6/06
Meghan Lithgow, Staff Engineer
PRINTED NAME AND TITLE

Assumptions and Procedures Checked By (Peer Reviewer):
SIGNATURE — DATE 11/4/06
Gregory T. Corcoran, PE / Principal
PRINTED NAME AND TITLE

Computations Checked By:
SIGNATURE — DATE 11/4/06
Gregory T. Corcoran, PE / Principal
PRINTED NAME AND TITLE

Computations Backchecked By (Originator):
SIGNATURE — DATE 11/6/06
Meghan Lithgow, Staff Engineer
PRINTED NAME AND TITLE

Approved By (PM or Designate):
SIGNATURE — DATE 11/4/06
Gregory T. Corcoran, PE / Principal
PRINTED NAME AND TITLE

Approval Notes:

Revisions: (Number and Initial All Revisions)

No.	Sheet	Date	By	Checked By	Approval

Written by: Meghan Lithgow Date: 09 / 25 / 06 (MM DD YY) Reviewed by: GTC Date: 11 / 4 / 06 (MM DD YY)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 1.2

SLOPE STABILITY EVALUATION
VENEER STABILITY OF GEOSYNTHETIC-SOIL LINED SIDESLOPES
COVER LINER SYSTEM
BRC CAMU

OBJECTIVE

To evaluate the tension developed within the geosynthetic-soil layered sideslopes of the cover liner system of the BRC Corrective Action Management Unit (CAMU) located in Henderson, Nevada.

SUMMARY OF RESULTS

The calculations suggest that a minimum geosynthetic interface friction angle of 20 degrees is required to prevent the development of tension in the geosynthetic components of the side slope liner final cover system. A review of the literature indicates that achieving a friction angle of 20 degrees is obtainable. The critical interface of the geosynthetics is likely the internal friction angle of the GCL.

METHOD OF ANALYSIS

The stability analysis of the geosynthetic-soil layered systems was carried out using the approach outlined by Koerner and Soong [1998] (Attachment F). This approach calculates the driving force of an active soil wedge along a geosynthetic-soil layered sideslope and compares it to the resisting force of the complementary passive soil wedge to evaluate the overall factor of safety against failure. The method presented by Koerner and Soong [1998] allows for the consideration of a uniform depth soil layer and the influence of dynamic equipment loading.

SIDESLOPE LINER SYSTEM

The sideslope liner system consists of, from top to bottom:

- 2 ft (min) cover soil;
- Double-sided geocomposite consisting of geonet sandwiched between two non-woven geotextiles;

Written by: Meghan Lithgow Date: 09 / 25 / 06 (MM DD YY) Reviewed by: GTC Date: 11 / 14 / 06 (MM DD YY)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 1.2

- 60-mil (1.5-mm) textured high density polyethylene (HDPE) geomembrane;
- Geosynthetic clay liner (GCL) consisting of bentonite sandwiched between a top nonwoven geotextile and a bottom woven geotextile needle-punched together
- Prepared subgrade.

The sideslope inclination is 3.0H:1.0V. The maximum height of a side slope is 47 vertical feet, located in the southwest corner of the South Mesa.

MATERIAL SHEAR STRENGTHS

Cover Soil Material:

The soil materials to be used overlying the side slope liner system will be native materials such as silty sands (SM) for the operations layer. Converse reported a maximum dry density of 132 pcf and a optimum water content of 8.7 percent for materials at the site (Attachment A). Therefore, assuming 95% relative compaction, the dry density in the field is approximately 125 pcf. Adding the weight of water, the unit weight is approximately 136 pcf. The cover soil material is characterized by a minimum internal angle of friction of 32 degrees in accordance with NAVFAC and the expected compaction criteria (see *review of reported interface strengths*).

For this analysis, a shear strength of 32 degrees, with 500 psf cohesion, and a unit weight of 136 pcf will be used for the analyses performed herein.

Geosynthetic Interface:

The geosynthetic interface friction angle was varied to evaluate the minimum allowable value to obtain no tension. A literature review was performed to evaluate if the calculated minimum allowable interface friction value is achievable. Adhesion is neglected for the analyses herein.

Written by: Meghan Lithgow Date: 09 / 25 / 06 (MM DD YY) Reviewed by: GR Date: 11 / 4 / 06 (MM DD YY)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 1.2

REVIEW OF REPORTED INTERFACE STRENGTHS IN THE LITERATURE

The following values for the interface friction between the geosynthetic and soil components of the liner system represent values reported in the literature:

Native Material (SM)	32	NAVFAC[1,2], 500 psf cohesion (Attachment B)
Cover Soil to Geocomposite (NWGT side)	29	Koerner[3] (Attachment C)
Geocomposite to Textured HDPE	28	(Professional Experience)
Textured HDPE to Hydrated GCL	20	Bentomat[4] (Attachment D)
Hydrated GCL to Subgrade	22	Bentomat[5] (Attachment D)

1. NAVFAC (1982) lists typical shear strength values for various soils based on 100 percent standard Proctor compaction. Actual construction materials would likely be placed at 90 percent of the modified Proctor compaction. To be conservative, a value of phi = 32 degree was used.

2. Value of friction angle for a silty sand designated under the USCS classification system as a SM. This value is a conservative friction angle estimate as compared to an SC soil, which would yield a greater friction angle.

3. Koerner (1995) suggests that an efficiency of greater than 90 percent for the interface of nonwoven, needle-punched geotextiles to various soils can be achieved. Efficiency values are based on the relationship, Efficiency = tan(interface friction angle)/tan(soil friction angle). The interface friction angle presented herein was calculated using a 90 percent efficiency and the estimated soil friction angle. Adhesion is neglected.

4. Values of residual friction angle reported for interface shear strength between 60 mil textured HDPE geomembrane and woven geotextile side of CETCO Bentomat GCL under hydrated conditions at a shearing rate of 0.04 in/min. Maximum displacement was not reported. Normal stresses of 1.4, 3.5, and 7.0 psi yielded a friction angle of 20.4 degrees.

5. Values of residual friction angle reported for interface shear strength between 60 mil textured HDPE geomembrane and woven geotextile side of CETCO Bentomat GCL under hydrated conditions at a shearing rate of 0.04 in/min. Maximum displacement was not reported. Normal stresses of 1.4, 3.5, and 7.0 psi yielded a friction angle of 22.1 degrees.

DESIGN CRITERION

For the geosynthetic-soil lined side slopes of BRC CAMU final cover system it was desired to evaluate the combination of operations layer soil height, inclination, and equipment loading which would introduce no geosynthetic tension. Subsequently, zero geosynthetic tension was established as the design criterion for veneer stability of the geosynthetic-soil lined side slopes.

Written by: Meghan Lithgow Date: 09 / 25 / 06 (MM DD YY) Reviewed by: GTC Date: 11 / 4 / 06 (MM DD YY)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 1.2

The geosynthetic-soil lined side slopes are considered permanent slopes because they will not eventually be buttressed by placement of waste. In consideration of the significance of no tension in the geosynthetic liner system and consistent with current practice, GeoSyntec will adopt a factor of safety (FS) equal to or greater than 1.5 for slope stability (CASE I, completed cover system). However, the construction of the cover system involves a very short period where the cover soil will be placed by construction equipment moving parallel to the slope, which imparts additional forces parallel to the liner system and may induce geosynthetic tension. Therefore, a factor of safety of 1.1 is established as the stability criterion for this case (CASE II, during construction).

ANALYSIS

CASE I: Veneer Stability on Side Slope

According to the Koerner and Soong approach, a soil veneer on a side slope is stable when the resultant driving force on the passive wedge (E_P) is equal to the resultant resistant force on the active wedge (E_A) (Figure 1). The following equations represent the resultant resistance and active forces, respectively:

$$E_A = \frac{FS(W_A - N_A \cos\beta) - (N_A \tan\delta + C_a)\sin\beta}{\sin\beta(FS)}$$ (Attachment E, 2 of 6)

$$E_P = \frac{C + W_P \tan\phi}{\cos\beta(FS) - \sin\beta\tan\phi}$$ (Attachment E, 2 of 6)

The variables will be defined in a subsequent section.

By setting E_A=E_P, the resulting equation may be arranged in the form of the quadratic equation $ax^2+bx+c=0$. Considering FS as the variable of interest, the resulting equation is as follows:

$$a(FS)^2 + b(FS) + c = 0$$ (Attachment E, 2 of 6)

The factor of safety may be obtained from the solution of the following equation:

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$ (Attachment E, 2 of 6)

Where the constants are defined, as in Attachment E, 6 of 6:

Written by: Meghan Lithgow Date: 09 / 25 / 06 (MM DD YY) Reviewed by: GTC Date: 11 / 4 / 06 (MM DD YY)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 1.2

$$a = (W_A - N_A \cos\beta)\cos\beta \quad (1)$$

$$b = -[(W_A - N_A \cos\beta)\sin\beta \tan\phi + (N_A \tan\delta + C_a)\sin\beta\cos\beta + \sin\beta(C + W_P \tan\phi)] \quad (2)$$

$$c = (N_A \tan\delta + C_a)\sin^2\beta \tan\phi \quad (3)$$

In which the variables are indicated on Figure 1 and defined as follows:

$$C = \frac{c \cdot h}{\sin\beta} \quad (4) \quad \text{(Attachment E, 2 of 6)}$$

$$C_a = c_a\left(L - \frac{h}{\sin\beta}\right) \quad (5) \quad \text{(Attachment E, 2 of 6)}$$

$$W_A = \gamma \cdot h^2\left(\frac{L}{h} - \frac{1}{\sin\beta} - \frac{\tan\beta}{2}\right) \quad (6) \quad \text{(Attachment E, 2 of 6)}$$

$$N_A = W_A \cos\beta \quad (7) \quad \text{(Attachment E, 2 of 6)}$$

$$W_P = \frac{\gamma \cdot h^2}{\sin 2\beta} \quad (8) \quad \text{(Attachment E, 2 of 6)}$$

β = soil slope angle beneath the geomembrane, **18.4°** for 3H:1V slope
δ = minimum interface friction angle of side slope liner system, **20°**
ϕ = friction angle of cover soil, **32°**
γ = unit weight of the cover soil, **136 pcf**
C = cohesive force along the failure plane of the passive wedge
c = cohesion of the cover soil, **500 psf**
C_a = adhesive force between the cover soil of the active wedge and the geomembrane
c_a = adhesion between the cover soil of the active wedge and the geomembrane, **0 psf**
h = thickness of the operations layer, **2 feet**
L = length of slope measured along the geomembrane beneath cover soil, **148.6 feet**
N_A = effective force normal to the failure plane of the active wedge
W_A = total weight of the active wedge
W_P = total weight of the passive wedge

Substituting the variables and solving equations (4)-(8), above:

Written by: Meghan Lithgow Date: 09 / 25 / 06 (MM DD YY) Reviewed by: GTC Date: 11 / 4 / 06 (MM DD YY)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 1.2

$$C = \frac{c \cdot h}{\sin\beta} = \frac{500 \cdot 2}{\sin(18.4)} = \mathbf{3163\ lbs/ft} \quad (4)$$

$$C_a = c_a\left(L - \frac{h}{\sin\beta}\right) = 0\left(148.7 - \frac{2}{\sin 21.8}\right) = \mathbf{0\ lbs/ft} \quad (5)$$

$$W_A = \gamma \cdot h^2\left(\frac{L}{h} - \frac{1}{\sin\beta} - \frac{\tan\beta}{2}\right) = 136 \cdot 2^2\left(\frac{148.7}{2} - \frac{1}{\sin 18.4} - \frac{\tan 18.4}{2}\right) = \mathbf{38{,}627\ lbs/ft} \quad (6)$$

$$N_A = W_A \cos\beta = 38{,}627 \cdot \cos 18.4. = \mathbf{36{,}646\ lbs/ft} \quad (7)$$

$$W_P = \frac{\gamma \cdot h^2}{\sin 2\beta} = \frac{136 \cdot 2^2}{\sin 2 \cdot 18.4} = \mathbf{907\ lbs/ft} \quad (8)$$

Next, substituting the solutions to equations (4)-(8) into equations (1)-(3):

$$a = (38{,}627 - 36{,}646 \cdot \cos 18.4)\cos 18.4 = \mathbf{3{,}663\ lbs/ft} \quad (1)$$

$$\begin{aligned} b = -[&(38{,}627 - 36{,}646 \cos 18.4) \sin 18.4 \tan 32 \\ &+ (36{,}646 \tan 20 + 0) \sin 18.4 \cos 18.4 \\ &+ \sin 18.4\,(3163 + 907 \tan 32) = \mathbf{-5942\ lbs/ft} \end{aligned} \quad (2)$$

$$c = (36{,}646 \cdot \tan 20 + 0)\sin^2 18.4 \cdot \tan 32 = \mathbf{833\ lbs/ft} \quad (3)$$

Finally, inserting the solutions to (1), (2) and (3) and solving the following equation:

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a} = \frac{-(-5942) + \sqrt{(-5942)^2 - 4(3663)(833)}}{2(3663)} = \mathbf{1.47}$$

Therefore, the factor of safety for the veneer stability of the operations layer on a sideslope composite liner system is 1.47. This factor of safety satisfies the stability criterion for permanent slopes of 1.5, as previously described.

CASE II: Veneer Stability during Dynamic Equipment Loading

In consideration of the loading due to soil placement equipment moving on the slope, the following equations represent the resultant resistant and active forces, respectively:

Written by: Meghan Lithgow Date: 09 / 25 / 06 (MM DD YY) Reviewed by: GTC Date: 11 / 4 / 06 (MM DD YY)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 1.2

$$E_A = \frac{FS[(W_A + W_e)\sin\beta + F_e]}{FS} - \frac{[(N_e + N_A)\tan\delta + C_a]}{FS}$$ (Attachment E, 5 of 6)

$$E_P = \frac{C + W_P \tan\phi}{\cos\beta(FS) - \sin\beta\tan\phi}$$ (Attachment E, 6 of 6)

Where the constants are defined, as in Attachment A, 6 of 6:

$$a = [(W_A + W_e)\sin\beta + F_e]\cos\beta \quad (9)$$

$$b = -\{[(N_e + N_A)\tan\delta + C_a]\cos\beta + [(W_A + W_e)\sin\beta + F_e]\sin\beta\tan\phi + (C + W_P\tan\phi)\} \quad (10)$$

$$c = [(N_e + N_A)\tan\delta + C_a]\sin\beta\tan\phi \quad (11)$$

In which the variables are indicated on Figure 1, defined previously and as follows:

$$q = \frac{W_b}{(2 \cdot w \cdot b)}$$ (12) (Attachment E, 3 of 6)

$$W_e = qwI$$ (13) (Attachment E, 3 of 6)

$$F_e = W_e\left(\frac{a}{g}\right)$$ (14) (Attachment E, 5 of 6)

$$N_e = W_e\cos\beta$$ (15) (Attachment E, 5 of 6)

a = acceleration of placement equipment (12km/hr, 2secs), **0.19 g** (Attachment E, 5of 6)
b = width of placement equipment track, **22 inches (D6R XL)** (Attachment F)
F_e = dynamic equipment loading force per unit parallel to slope at geomembrane interface
g = acceleration due to gravity, **32.2 ft/s^2**
I = influence factor at the geomembrane interface, **0.9** (Attachment E, 4 of 6)
N_e = effective equipment force normal to the failure plane of the active wedge
w = length of placement equipment track, **111 inches (D6R XL)** (Attachment F)
W_b = actual weight of the placement equipment, **42,300 lbs (D6R XL)** (Attachment F)
W_e = equivalent equipment force per unit width at the geomembrane interface

Substituting the variables and solving equations (4)-(8) and (12)-(15), above:

$$C = \frac{c \cdot h}{\sin\beta} = \frac{500 \cdot 2}{\sin(18.4)} = \mathbf{3163\ lbs/ft} \quad (4)$$

Written by: Meghan Lithgow Date: 09 / 25 / 06 (MM DD YY) Reviewed by: GTC Date: 11 / 4 / 06 (MM DD YY)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 1.2

$$C_a = c_a\left(L - \frac{h}{\sin\beta}\right) = 0\left(148.7 - \frac{2}{\sin 18.4}\right) = \mathbf{0\ lbs/ft} \quad (5)$$

$$W_A = \gamma \cdot h^2\left(\frac{L}{h} - \frac{1}{\sin\beta} - \frac{\tan\beta}{2}\right) = 136 \cdot 2^2\left(\frac{148.7}{2} - \frac{1}{\sin 18.4} - \frac{\tan 18.4}{2}\right) = \mathbf{38{,}627\ lbs/ft} \quad (6)$$

$$N_A = W_A \cos\beta = 38{,}627 \cdot \cos 18.4 = \mathbf{36{,}646\ lbs/ft} \quad (7)$$

$$W_P = \frac{\gamma \cdot h^2}{\sin 2\beta} = \frac{136 \cdot 2^2}{\sin 2 \cdot 18.4} = \mathbf{907\ lbs/ft} \quad (8)$$

$$q = \frac{W_b}{(2 \cdot w \cdot b)} = \frac{42{,}300}{(2 \cdot 111 \cdot 22)} = 8.66\ \text{psi} = \mathbf{1247\ psf} \quad (12)$$

$$W_e = qwl = 8.66 \cdot 111 \cdot 0.9 = 865\ \text{lbs/in} = \mathbf{10{,}381\ lbs/ft} \quad (13)$$

$$F_e = W_e\left(\frac{a}{g}\right) = 10{,}381\left(\frac{0.19 \cdot 32.2}{32.2}\right) = \mathbf{1{,}972\ lbs/ft} \quad (14)$$

$$N_e = W_e \cos\beta = 10{,}381 \cdot \cos 18.4 = \mathbf{9{,}482\ lbs/ft} \quad (15)$$

Next, substituting the solutions to equations (4)-(12) and (12)-(15) into equations (9)-(11):

$$a = [(38627 + 10381)\sin 18.4 + 1972]\cos 18.4 = \mathbf{16{,}571\ lbs/ft} \quad (9)$$

$$\begin{aligned} b = -\{&[9482 + 36646)\tan 20 + 0]\cos 18.4 \\ &+ [(38627 + 10381)\sin 18.4 + 1972]\sin 18.4 \tan 32 \\ &+ (3163 + 907 \tan 32)\} = \mathbf{-23{,}108\ lbs/ft} \end{aligned} \quad (10)$$

$$c = [(9482 + 36646)\tan 20 + 0]\sin 18.4 \tan 32 = \mathbf{3{,}317\ lbs/ft} \quad (11)$$

Finally, inserting the solutions to (9), (10) and (11) and solving the following equation:

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a} = \frac{-(-23108) + \sqrt{(-23108)^2 - 4(16571)(3317)}}{2(16571)} = \mathbf{1.23}$$

Therefore, the factor of safety for the stability of the operations layer on a sideslope composite liner system considering additional dynamic loading due to placement equipment is 1.23. This factor of safety satisfies the stability criterion for interim slopes of 1.1, as previously described.

Written by: Meghan Lithgow Date: 09 / 25 / 06 (MM DD YY) Reviewed by: GTC Date: 11 / 9 / 06 (MM DD YY)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 1.2

RESULTS AND CONCLUSIONS

The results suggest that the proposed final cover system satisfies the design criteria of no geosynthetic tension development:

Stability Condition	Soil Cover Layer Inclination (H:V)	Equipment Loading	Tension FS
Case I	3.0H:1V	NONE	1.47
Case II	3.0H:1V	CAT-D6H	1.23

Live Load Case (assuming placement of operations layer with a bulldozer no larger than Caterpillar D6R XL dozer in terms of operating weight and ground pressure), the side slope liner system will not be placed into tension.

Results of veneer stability analyses presented herein indicate that an apparent internal friction or interface friction angle (residual) of 20 degrees for any component of the composite liner system is the minimum allowable value providing for a static factor of safety that satisfies that design criteria of no tension in the geosynthetic liner system.

Based on the analyses herein, results of interface shear tests on the actual materials proposed for use in the composite liner system must indicate that the weakest apparent residual friction angle of the composite liner is equal to or greater than 20 degrees.

The results suggest that the following conditions satisfy the design criteria of no geosynthetic tension development:

- 3H:1 V side slopes;
- 2 feet thickness of operations layer soil/leachate collection layer on side slopes, placed to a vertical height of 47 feet;
- 136 pcf unit weight of operations layer soil;
- Minimum shear properties of operations layer soil - 500 psf cohesion and 32° friction angle;
- Minimum shear strength of composite liner system – 0 psf adhesion and 20° friction angle;
- Caterpillar D6R XL used as operations layer placement equipment;
- Acceptable factor of safety for interim slope stability is 1.3 (CASE I); and

- Acceptable factor of safety for dynamically loaded interim slopes is 1.1 (CASE II).

REFERENCES

Caterpillar, Inc., [1998], "Caterpillar Performance Handbook", Caterpillar Publications, Peoria, Illinois, October 1998. *(Attachment F)*

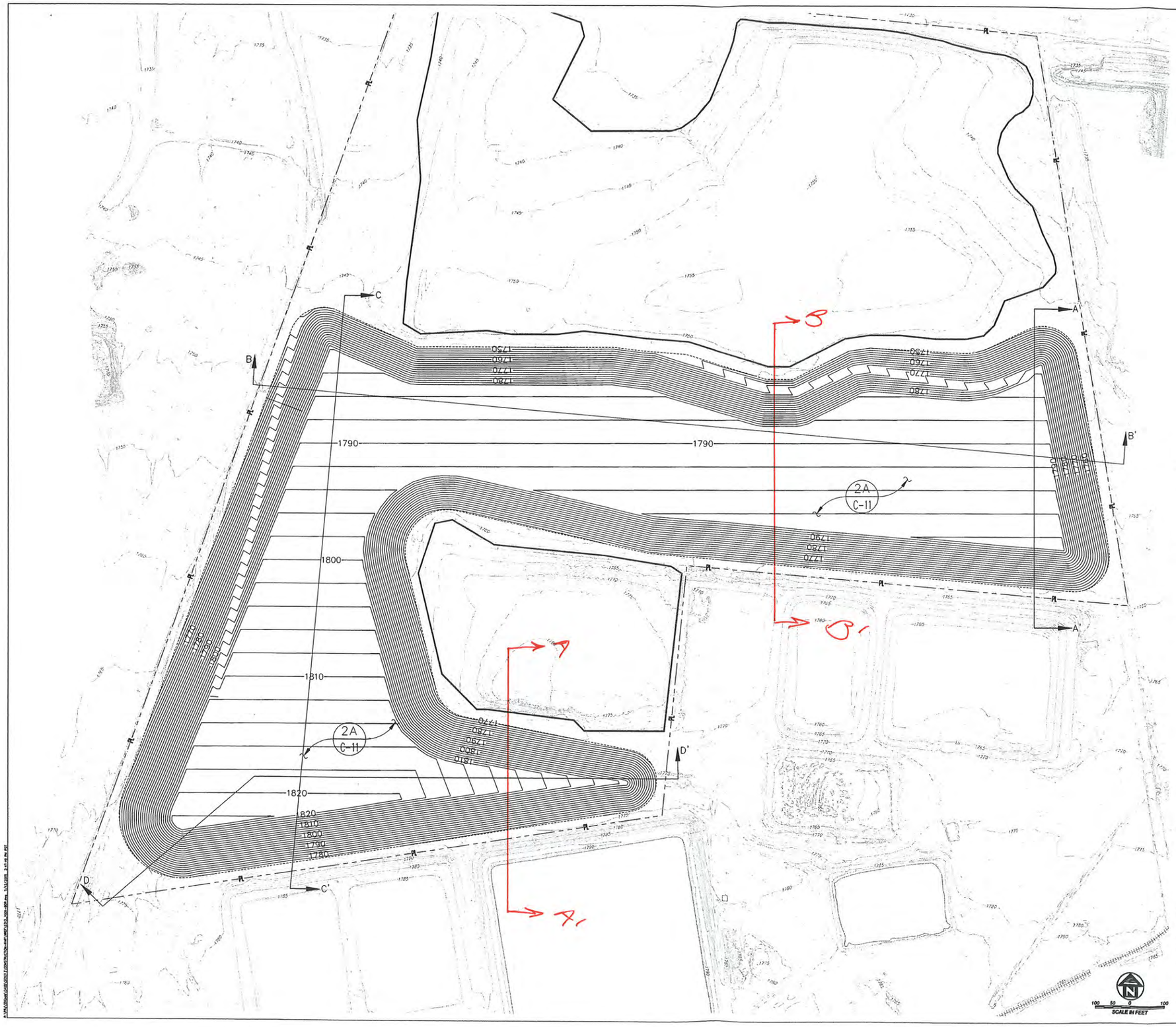
Converse Consultants (1999), "Preliminary Geotechnical and Geologic Investigation, Industrial Non-Hazardous Disposal Facility, Basic Management Incorporated, Clark County, Nevada," October 27, 1999, Las Vegas, Nevada. *(Attachment A)*

Koerner, R. K. and Soong, T.Y., [1998], "Analysis and Design of Veneer Cover Soils", Proceedings of the Sixth International Conference on Geosynthetics, Atlanta, Georgia, Vol. I, 1998. *(Attachment E)*

Koerner, R. M. (1997), "Designing with Geosynthetics," Simon and Schuster / A Viacom Company, Upper Saddle New Jersey, 07458, 1998 *(Attachment C)*

NAVFAC (1982), "Foundations and Earth Structures, Design Manual - 7.2," Department of Navy, Naval Facilities Engineering Command, May 1982 *(Attachment B)*

Bentomat Attachment! (*Attachment D)*



LEGEND

- BRC LANDFILL SITE BOUNDARY
- EXISTING LIMITS OF FORMER BMI LANDFILL
- EXISTING SURFACE WATER FLOW PATH
- EXISTING MINOR ELEVATION CONTOUR
- EXISTING MAJOR ELEVATION CONTOUR
- PROPOSED MINOR EXCAVATION ELEVATION CONTOUR
- 1770 PROPOSED MAJOR EXCAVATION ELEVATION CONTOUR
- PROPOSED LIMITS OF REFUSE

NOTES:

1. FOR GENERAL NOTES, LEGEND AND ABBREVIATIONS, SEE DWG C-2
2. FOR SITE PREPARATION PLAN SEE DWG C-6.
3. FOR CONSTRUCTION GRADING PLAN SEE DWG C-7.
4. FOR EROSION CONTROL AND STORM DRAIN PLAN SEE DWG C-8.
5. FOR CROSSECTIONS SEE DWG C-10.
6. FOR FINAL COVER AND LINER DETAILS AND SECTIONS SEE DWG C-11
7. FOR FENCE PLAN SEE DWG C-12.

GEOSYNTEC CONSULTANTS
10875 RANCHO BERNARDO ROAD, SUITE 200
SAN DIEGO, CALIFORNIA 92127
TELEPHONE: (858) 674-6559

PROJECT: BRC CAMU
HENDERSON/CLARK COUNTY NEVADA

TITLE: FINAL COVER GRADING PLAN
PERMITTING CONSTRUCTION PLAN

DATE: SEPTEMBER 2006	CHECKED BY: G.T.C	SCALE: 1"=100'	FIGURE NO:
DESIGN BY: TAW	REVIEWED BY (PRIN. MGR.) G.T.C	JOB NO.: SC0313-01-04	C9
DRAWN BY: T.L.Z.	DOCUMENT NO:	FILE NO:	

Figure 1

shown on Drawing Nos. A-49 through A-56, entitled *Consolidation Test* and are summarized on the following table:

Exploration Location	Depth (Feet)	Soil Description	Dry Unit Weight, pcf	Moisture Content, %	Hydrocollapse (percent)*
B-1	29-30	Silty sand with gravel	105	6	3.2
B-8	39-40	Sandy lean clay	57.4	64	0.4
B-8	49-50	Sandy lean clay	69.5	51.1	-0.6
B-10	54-54.5	Sandy lean clay	60.7	67.7	-0.6
B-101	39-40	Sandy lean clay	65.8	45	-0.2
B-101	59-60	Sandy lean clay	73.2	38.3	-0.6
B-102	49-50	Sandy lean clay	67.3	48.7	-0.5
B-105	34-35	Well graded sand with silt and gravel	101	5	0.1

NA: Not available

* A negative sign indicates swell occurred upon inundation with water instead of collapse.

Laboratory Maximum Density

Laboratory maximum density tests were performed on selected samples of the granular soils. The purpose of the test was to define the compaction characteristics of these soils, and to aid in estimating soil shrinkage. The laboratory maximum density test was performed in general accordance with the ASTM D1557 test method. This test procedure uses 25 blow of a 10-pound hammer falling a height of 18 inches on each of five layers of soil in a 1/30 or 1/13 cubic foot cylinder. The test results are presented on Drawing Nos. A-57 through A-61 and in the following table:

Exploration Location	Depth (Feet)	Soil Description	Maximum Dry Unit Weight (pcf)	Optimum Moisture Content (percent) of dry weight)
B-1	20-25	Silty sand with gravel	129.4	8.2
B-5	20-25	Silty sand with gravel	132.1	8.2
B-12	10-15	Silty sand with gravel	129.7	7.9
B-101	5-10	Silty sand with gravel	130.6	8.7
B-105	20-25	Well graded sand with silt and gravel	131.8	7.5

assume $\gamma_d = 130$ pcf, $w\% = 8\%$

SOURCE: CONVERSE (1999)

Attachment A 1/1

TABLE 1
Typical Properties of Compacted Soils

Group Symbol	Soil Type	Range of Maximum Dry Unit Weight, pcf	Range of Optimum Moisture, Percent	Typical Value of Compression: At 1.4 tsf (20 psi)	Typical Value of Compression: At 3.6 tsf (50 psi)	Typical Strength Characteristics: Cohesion (as compacted) psf	Typical Strength Characteristics: Cohesion (saturated) psf	Typical Strength Characteristics: φ (Effective Stress Envelope Degrees)	Typical Strength Characteristics: Tan φ	Typical Coefficient of Permeability ft./min.	Range of CBR Values	Range of Subgrade Modulus k lbs/cu in.
				Percent of Original Height								
GW	Well graded clean gravels, gravel-sand mixtures.	125 - 135	11 - 8	0.3	0.6	0	0	>38	>0.79	5×10^{-2}	40 - 80	300 - 500
GP	Poorly graded clean gravels, gravel-sand mix	115 - 125	14 - 11	0.4	0.9	0	0	>37	>0.74	10^{-1}	30 - 60	250 - 400
GM	Silty gravels, poorly graded gravel-sand-silt.	120 - 135	12 - 8	0.5	1.1	.....	.....	>34	>0.67	$>10^{-6}$	20 - 60	100 - 400
GC	Clayey gravels, poorly graded gravel-sand-clay.	115 - 130	14 - 9	0.7	1.6	.....	.....	>31	>0.60	$>10^{-7}$	20 - 40	100 - 300
SW	Well graded clean sands, gravelly sands.	110 - 130	16 - 9	0.6	1.2	0	0	38	0.79	$>10^{-3}$	20 - 40	200 - 300
SP	Poorly graded clean sands, sand-gravel mix.	100 - 120	21 - 12	0.8	1.4	0	0	37	0.74	$>10^{-3}$	10 - 40	200 - 300
SM	Silty sands, poorly graded sand-silt mix.	110 - 125	16 - 11	0.8	1.6	1050	420	34	0.67	$5 \times >10^{-5}$	10 - 40	100 - 300
SM-SC	Sand-silt clay mix with slightly plastic fines.	110 - 130	15 - 11	0.8	1.4	1050	300	33	0.66	$2 \times >10^{-6}$	5 - 30	100 - 300
SC	Clayey sands, poorly graded sand-clay-mix.	105 - 125	19 - 11	1.1	2.2	1550	230	31	0.60	$3 \times >10^{-7}$	5 - 20	100 - 300
ML	Inorganic silts and clayey silts.	95 - 120	24 - 12	0.9	1.7	1400	190	32	0.62	$>10^{-5}$	15 or less	100 - 200
ML-CL	Mixture of inorganic silt and clay.	100 - 120	22 - 12	1.0	2.2	1350	460	32	0.62	$5 \times >10^{-7}$	.....	
CL	Inorganic clays of low to medium plasticity.	95 - 120	24 - 12	1.3	2.5	1800	270	28	0.54	$>10^{-7}$	15 or less	50 - 200
OL	Organic silts and silt-clays, low plasticity.	80 - 100	33 - 21	.....	.....	.....	.....	.....	.....	.....	5 or less	50 - 100
MH	Inorganic clayey silts, elastic silts.	70 - 95	40 - 24	2.0	3.8	1500	420	25	0.47	$5 \times >10^{-7}$	10 or less	50 - 100
CH	Inorganic clays of high plasticity	75 - 105	36 - 19	2.6	3.9	2150	230	19	0.35	$>10^{-7}$	15 or less	50 - 150
OH	Organic clays and silty clays	65 - 100	45 - 21	.....	.....	.....	.....	.....	.....	.....	5 or less	25 - 100

Notes:

1. All properties are for condition of "Standard Proctor" maximum density, except values of k and CBR which are for "modified Proctor" maximum density.
2. Typical stength characteristics are for effective strength envelopes and are obtained from USBR data.
3. Compression values are for vertical loading with complete lateral confinement.
4. (>) indicates that typical property is greater than the value shown.
   (..) indicates insufficient data available for an estimate.

SOURCE - NAVFAC (1982) Attachment B 1/1

Page 13 of 66 (3)

Table 5.7 Friction values and efficiencies (in parentheses) for (a) soil-to-geomembrane, (b) geomembrane-to-geotextile, and (c) soil-to-geotextile combinations*

(a) Soil-to-Geomembrane Friction Angles

Geomembrane	Soil Types: Concrete Sand (ϕ = 30°)	Ottawa Sand (ϕ = 28°)	Micha Schist Sand (ϕ = 26°)
EPDM-R	24° (0.77)	20° (0.68)	24° (0.91)
PVC			
Rough	27° (0.88)	—	25° (0.96)
Smooth	25° (0.81)	—	21° (0.79)
CSPE-R	25° (0.81)	21° (0.72)	23° (0.87)
HDPE -Smooth	18° (0.56)	18° (0.61)	17° (0.63)

(b) Geomembrane-to-Geotextile Friction Angles

Geotextile	Geomembrane: EPDM-R	PVC: Rough	PVC: Smooth	CSPE-R	HDPE Smooth
Nonwoven, needle punched	23°	23°	21°	15°	8°
Nonwoven, heat bonded	18°	20°	18°	21°	11°
Woven, monofilament	17°	11°	10°	9°	6°
Woven, slit film	21°	28°	24°	13°	10°

(c) Soil-to-Geotextile Friction Angles

Geotextile	Soil Types: Concrete Sand (ϕ = 30°)	Ottawa Sand (ϕ = 28°)	Mica Schist Sand (ϕ = 26°)
Nonwoven, needle punched	30° (1.00)	26° (0.92)	25° (0.96)
Nonwoven, heat bonded	26° (0.84)	—	—
Woven, monofilament	26° (0.84)	—	—
Woven, slit film	24° (0.77)	24° (0.84)	23° (0.87)

*Efficiency values in parentheses are based on the relationship $E = (\tan \delta)/(\tan \phi)$.

Source: After Martin et al. [14].

The frictional behavior of geomembranes placed
erable importance in the composite liners of waste land
are for the clay to have a hydraulic conductivity equa
ft./min. (1×10^{-7} cm/sec.) and for the geomembrane t
clay. While an indication of the shear strength param
(e.g., reference 15), the data are so sensitive to the var
site-specific and material-specific tests should always b
literature values should never be used for final design

5.1.3.9 Geomembrane Anchorage In certain proble
might be sandwiched between two materials and the
force. The termination of a geomembrane liner within an anchor trench is such a
situation. To simulate this behavior in a laboratory environment, one can use an
8.0-in. (200-mm)-wide geomembrane sandwiched between back-to-back channels.

Jodrey - Koerner (1997)

Attachment C 1/1

SUMMARY OF BENTOMAT DIRECT SHEAR TEST DATA
INTERFACE W/ SOIL

Lab[1]	Report Date	Interface Tested[2]	Normal Stresses (psi)	Bentomat Moisture[3]	Shear Rate (in/min)	Peak Friction Angle (deg)	Residual Friction Angle (deg)[4]	Apparent Peak Cohesion (psf)	Comments
GSC	03-09-95	NW/ Soaked GC Soil	7.5 - 15 - 30	Hydrated	0.04	33	31	385	
CETCO	08-29-95	W/Silty Sand	1 - 2 - 3	Hydrated	0.04	32.3	ND	127	
GSC	03-12-96	NW/ Soaked Soil	2 - 4 - 6	Hydrated	0.04	29	29	70	
STS	05-30-96	NW/Silty Sandy Gravel	0.7 – 2 – 3.5	Hydrated	0.04	28	ND	222	
CETCO	07-08-96	NW/ Sandy Silty Gravel	0.7 - 2.0 - 3.5	Hydrated	0.04	40.4	ND	238	
	07-31-96	W/ Sandy Silty Gravel	0.7 - 2.0 - 3.5	Hydrated	0.04	37.8	ND	194	
AGP	11-08-96	NW/ SC Soil	1.4 - 3.5 - 7.0	Hydrated	0.04	27.8	ND	186	
		W/ SC Soil	1.4 - 3.5 - 7.0	Hydrated	0.04	23.5	22.1	187	
GSC	01-08-97	NW/ Soaked Soils	14 - 40 - 70	Hydrated	0.04	18	18	155	
TRI	09-23-97	NW/ Subbaase Soil	3.5 – 7 – 14	Hydrated	0.001	24.0	20.7	4	
		NW/ Subbase Soil	.35 - .7 – 1.4	Hydrated	0.001	35.5	37.2	88	
GSC	01-22-98	CLS/ SM soil	5 - 25 - 45	Hydrated	0.04	17	13	70	
CETCO	02-10-98	CLS/ SC Soil	0.5 – 1 – 1.5	Hydrated	0.04	9.5	ND	46	
VE	03-03-98	W/ Cover soil	1 - 2.1 – 4.9	Hydrated	0.04	37	33	50	
CETCO	08-11-98	W/ SC soil	2.1 – 4.2 – 6.3	Hydrated	0.04	33.6	35.2	183	
		NW/ Non-Pag Quartz Monzonite Waste	2.1 – 4.2 – 6.3	Hydrated	0.04	39.8	37.5	190	
TRI	09-22-98	NW/ soil	16 – 32 – 73	Hydrated	0.04	17.5	16.8	505	Residual @ 3"
CETCO	11-3-98	CLS/SM soil	0.5 – 1 – 1.5	Hydrated	0.04	27	27	80	
		CLS/SP soil	0.5 – 1 – 1.5	Hydrated	0.04	15.2	15.2	55	
GSC	6-24-00	CLS/drainage soil	139	Hydrated	0.04	24	0	13	Angle w/ origin

ATTACHMENT D 1/2

SUMMARY OF BENTOMAT DIRECT SHEAR TEST DATA
INTERFACE W/ GEOMEMBRANE

Lab[1]	Report Date	Interface Tested[2]	Normal Stresses (psi)	Bentomat Moisture[3]	Shear Rate (in/min)	Peak Friction Angle (deg)	Residual Friction Angle (deg)[4]	Apparent Peak Cohesion (psf)	Comments
GA	09-04-92	W/60-mil sm. HDPE	0.5 - 1 - 2 - 4 - 10	Hydrated	0.02	8	7	0	
		W/60-mil text. HDPE	0.5 - 1 - 2 - 4 - 10	Hydrated	0.02	28	28 / 6	29	bi-modal residual
GSC	12-08-94	W/60-mil text. HDPE	7.5 - 15 - 30	Hydrated	0.04	18	17	175	Diff. membrane manufacturers
		W/60-mil text. HDPE	7.5 - 15 - 30	Hydrated	0.04	16	12	345	
GSC	12-16-94	W/60-mil text. HDPE	1 -3 - 6 - (15)	Hydrated	0.04	25 (19)	10	100	(lower d at 15 psi)
AGP	07-12-95	W/80-mil Text. HDPE	14 - 28 - 69 - 104	Hydrated	0.04	18	8	192	
		W/80-mil Text. HDPE	14 - 28 - 69 - 104	Dry	0.04	30	14	0	
AGP	11-30-95	W/ Text. HDPE	10 - 26 - 38	Dry	0.08	30.2	13.3	0	
GSC	03-12-96	W/ 30 mil PVC	2 - 4 - 6	Hydrated	0.04	17	17	24	
GSC	05-29-96	NW/80mil Text. HDPE	140	Hydrated	0.04	19	5	475	Consol 24 hrs @140 psi
AGP	11-08-96	NW/60mil Text. HDPE	1.4 - 3.5 - 7.0	Hydrated	0.04	34.8	22.7	149	
		W/60 mil Text. HDPE	1.4 - 3.5 - 7.0	Hydrated	0.04	28.8	20.4 *	83	
GSC	01-08-97	NW/60mil Text. HDPE	14 - 40 - 70	Hydrated	0.04	17	9	255	
TRI	4-15-97	NW/60mil Text. HDPE	14 – 28 – 56	Hydrated	0.04	21.9	10.8	722	
Emcon	6-16-97	NW/40mil Text. LLPE	1.0 – 2.0 – 3.5	Hydrated	0.04	32.0	18.5	111	
		NW/40mil Text. LLPE	1.0 – 2.0 – 3.5	Hydrated	0.04	37.5	27.1	118	
TRI	10-15-97	NW/ 60mil Text.HDPE	3.5 – 7 – 14	Hydrated	0.04	20.3	18.6	278	
		NW/ 60mil Text.HDPE	.35 - .7 – 1.4	Hydrated	0.04	36.6	25.8	2	
TRI	12-01-97	NW/60mil Text. HDPE	0.35 – 0.7 – 1.4	Hydrated	0.001	25.6	23.3	54	Residual @ 4"
		NW/60mil Text. HDPE	3.5 – 7 – 14	Hydrated	0.001	23.2	17.8	85	"
Emcon	04-06-98	NW/60mil Text. HDPE	14 – 28 – 70	Hydrated	0.04	24.1	12.2	290	

Eshilor (3) GTC 5/11/01

- The issue of appropriate normal stress is greatly complicated if gas pressures are generated in the underlying waste. These gas pressures will counteract some (or all) of the gravitational stress of the cover soil. The resulting shear strength, and subsequent stability, can be significantly decreased. See Liu et al (1997) for insight into this possibility.
- Shear rates necessary to attain drained conditions (if this is the desired situation) are extremely slow, requiring long testing times.
- Deformations necessary to attain residual strengths require large relative movement of the two respective halves of the shear box. So as not to travel over the edges of the opposing shear box sections, devices should have the lower shear box significantly longer than 300 mm. However, with a lower shear box longer than the upper traveling section, new surface is constantly being added to the shearing plane. This influence is not clear in the material's response or in the subsequent behavior.
- The attainment of a true residual strength is difficult to achieve. ASTM D5321 states that one should "run the test until the applied shear force remains constant with increasing displacement". Many commercially available shear boxes have insufficient travel to reach this condition.
- The ring torsion shearing apparatus is an alternative device to determine true residual strength values, but is not without its own problems. Some outstanding issues are the small specimen size, nonuniform shear rates along the width of the specimen, anisotropic shearing with some geosynthetics and no standardized testing protocol. See Stark and Poeppel (1994) for information and data using this alternative test method.

2.3 Various Types of Loadings

There are a large variety of slope stability problems that may be encountered in analyzing and/or designing final covers of engineered landfills, abandoned dumps and remediation sites as well as leachate collection soils covering geomembranes beneath the waste. Perhaps the most common situation is a uniformly thick cover soil on a geomembrane placed over the soil subgrade at a given and constant slope angle. This "standard" problem will be analyzed in the next section. A variation of this problem will include equipment loads used during placement of cover soil on the geomembrane. This problem will be solved with equipment moving up the slope and then moving down the slope.

Unfortunately, cover soil slides have occurred and it is felt that the majority of the slides have been associated with seepage forces. Indeed, drainage above a geomembrane (or other barrier material) in the cover soil cross section must be accommodated to avoid the possibility of seepage forces. A section will be devoted to this class of slope stability problems.

Lastly, the possibility of seismic forces exists in earthquake prone locations. If an earthquake occurs in the vicinity of an engineered landfill, abandoned dump or remediation site, the seismic wave travels through the solid waste mass reaching the upper surface of the cover. It then decouples from the cover soil materials, producing a horizontal force which must be appropriately analyzed. A section will be devoted to the seismic aspects of cover soil slope analysis as well.

All of the above actions are destabilizing forces tending to cause slope instability. Fortunately, there are a number of actions that can be taken to increase the stability of slopes.

Other than geometrically redesigning the slope with a flatter slope angle or shorter slope length, a designer can add soil mass at the toe of the slope thereby enhancing stability. Both toe berms and tapered soil covers are available options and will be analyzed accordingly. Alternatively, the designer can always use geogrids or high strength geotextiles within the cover soil acting as reinforcement materials. This technique is usually referred to as veneer reinforcement. Cases of both intentional and nonintentional veneer reinforcement will be presented.

Thus it is seen that a number of strategies influence slope stability. Each will be described in the sections to follow. First, the basic gravitational problem will be presented followed by those additional loading situations which tend to decrease slope stability. Second, various actions that can be taken by the designer to increase slope stability will be presented. The summary will contrast the FS-values obtained in the similarly crafted numeric examples.

3 SITUATIONS CAUSING DESTABILIZATION OF SLOPES

This section treats the standard veneer slope stability problem and then superimposes upon it a number of situations, all of which tend to destabilize slopes. Included are gravitational, construction equipment, seepage and seismic forces. Each will be illustrated by a design graph and a numeric example.

3.1 Cover Soil (Gravitational) Forces

Figure 3 illustrates the common situation of a *finite* length, uniformly thick cover soil placed over a liner material at a slope angle "β". It includes a passive wedge at the toe and has a tension crack of the crest. The analysis that follows is after Koerner and Hwu (1991), but comparable analyses are available from Giroud and Beech (1989), McKelvey and Deutsch (1991), Ling and Leshchinsky (1997) and others.

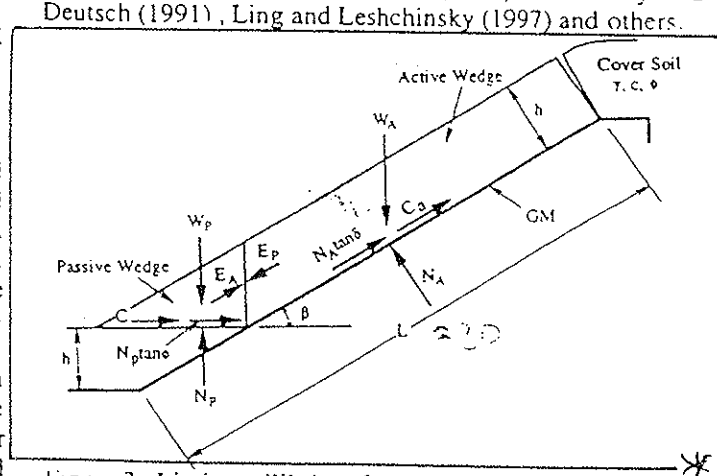


Figure 3. Limit equilibrium forces involved in a finite length slope analysis for a uniformly thick cover soil.

Attachment E 1/6

Eg 5/11/01 ⑤
GTC 5/11/01

The symbols used in Figure 3 are defined below.

W_A = total weight of the active wedge
W_P = total weight of the passive wedge
N_A = effective force normal to the failure plane of the active wedge
N_P = effective force normal to the failure plane of the passive wedge
γ = unit weight of the cover soil
h = thickness of the cover soil
L = length of slope measured along the geomembrane
β = soil slope angle beneath the geomembrane
ϕ = friction angle of the cover soil
δ = interface friction angle between cover soil and geomembrane
C_a = adhesive force between cover soil of the active wedge and the geomembrane
c_a = adhesion between cover soil of the active wedge and the geomembrane
C = cohesive force along the failure plane of the passive wedge
c = cohesion of the cover soil
E_A = interwedge force acting on the active wedge from the passive wedge
E_P = interwedge force acting on the passive wedge from the active wedge
FS = factor of safety against cover soil sliding on the geomembrane

The expression for determining the factor of safety can be derived as follows:

Considering the active wedge,

$$W_A = \gamma h^2\left(\frac{L}{h} - \frac{1}{\sin\beta} - \frac{\tan\beta}{2}\right) \quad (3)$$

$$N_A = W_A \cos\beta \quad (4)$$

$$C_a = c_a\left(L - \frac{h}{\sin\beta}\right) \quad (5)$$

By balancing the forces in the vertical direction, the following formulation results:

$$E_A \sin\beta = W_A - N_A \cos\beta - \frac{N_A \tan\delta + C_a}{FS}\sin\beta \quad (6)$$

Hence the interwedge force acting on the active wedge is:

$$E_A = \frac{(FS)(W_A - N_A\cos\beta) - (N_A\tan\delta + C_a)\sin\beta}{\sin\beta(FS)} \quad (7)$$

The passive wedge can be considered in a similar manner:

$$W_P = \frac{\gamma h^2}{\sin 2\beta} \quad (8)$$

$$N_P = W_P + E_P \sin\beta \quad (9)$$

$$C = \frac{(c)(h)}{\sin\beta} \quad (10)$$

By balancing the forces in the horizontal direction, the following formulation results:

$$E_P \cos\beta = \frac{C + N_P \tan\phi}{FS} \quad (11)$$

Hence the interwedge force acting on the passive wedge is:

$$E_P = \frac{C + W_P \tan\phi}{\cos\beta(FS) - \sin\beta\tan\phi} \quad (12)$$

By setting $E_A = E_P$, the resulting equation can be arranged in the form of the quadratic equation $ax^2 + bx + c = 0$ which in our case, using FS-values, is:

$$a(FS)^2 + b(FS) + c = 0 \quad (13)$$

where

$$a = (W_A - N_A\cos\beta)\cos\beta$$

$$b = -\left[(W_A - N_A\cos\beta)\sin\beta\tan\phi + (N_A\tan\delta + C_a)\sin\beta\cos\beta + \sin\beta(C + W_P\tan\phi)\right]$$

$$c = (N_A\tan\delta + C_a)\sin^2\beta\tan\phi \quad (14)$$

The resulting FS-value is then obtained from the solution of the quadratic equation:

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a} \quad (15)$$

When the calculated FS-value falls below 1.0, sliding of the cover soil on the geomembrane is to be anticipated. Thus a value of greater than 1.0 must be targeted as being the minimum factor of safety. How much greater than 1.0 the FS-value should be, is a design and/or regulatory issue. The issue of minimum allowable FS-values under different conditions will be assessed at the end of the paper. In order to better illustrate the implications of Eqs. 13, 14 and 15, typical design curves for various FS-values as a function of slope angle and interface friction angle are given in Figure 4. Note that the curves are developed specifically for the variables stated in the legend of the figure. Example 1 illustrates the use of the curves in what will be the standard example to which other examples will be compared.

Example 1:
Given a 30 m long slope with a uniformly thick 300 mm cover soil at a unit weight of 18 kN/m³. The soil has a friction angle of 30 deg. and zero cohesion, i.e., it is a sand. The cover soil is placed directly on a geomembrane as shown in Figure 3. Direct shear testing has resulted in a interface friction angle between the cover soil and geomembrane of 22 deg. with zero adhesion. What is the FS-value at a slope angle of 3(H)-to-1(V), i.e., 18.4 deg?

Attachment V 2/6

Solution:

Substituting Eq. 14 into Eq. 15 and solving for the FS-value results in the following which is seen to be in agreement with the curves of Figure 4.

$$\left.\begin{array}{l} a = 14.7\,kN/m \\ b = -21.3\,kN/m \\ c = 3.5\,kN/m \end{array}\right\} FS = 1.25$$

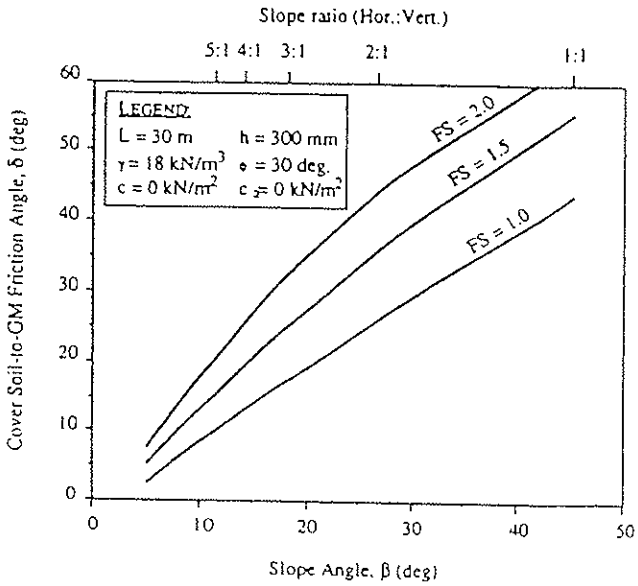


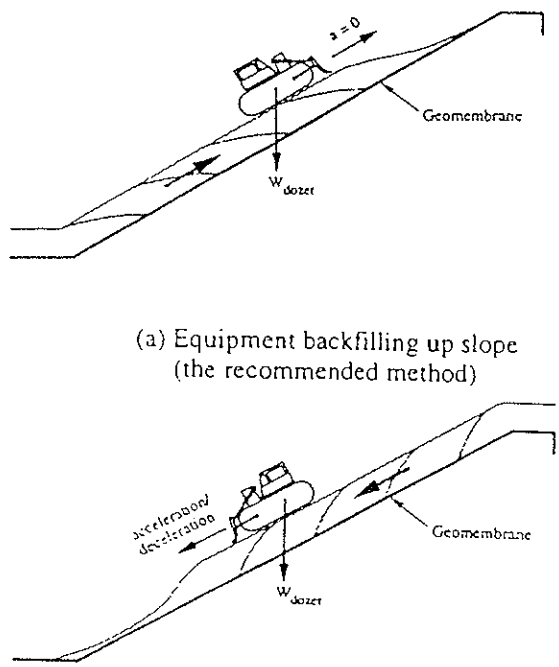
Figure 4. Design curves for stability of uniform thickness cohesionless cover soils on linear failure planes for various global factors-of-safety.

Comment:
In general, this is too low of a value for a final cover soil factor-of-safety and a redesign is necessary. While there are many possible options of changing the geometry of the situation, the example will be revisited later in this section using toe berms, tapered cover soil thickness and veneer reinforcement. Furthermore, this general problem will be used throughout the main body of this paper for comparison purposes to other cover soil slope stability situations.

3.2 Tracked Construction Equipment Forces

The placement of cover soil on a slope with a relatively low shear strength inclusion (like a geomembrane) should always be from the toe upward to the crest. Figure 5a shows the recommended method. In so doing, the gravitational forces of the cover soil and live load of the construction equipment are compacting previously placed soil and working with an ever present passive wedge and stable lower-portion beneath the active wedge. While it is necessary to specify low ground pressure equipment to place the soil, the reduction of the FS-value for this situation of equipment working up the slope will be seen to be relatively small.

For soil placement down the slope, however, a stability analysis cannot rely on toe buttressing and also a dynamic stress should be included in the calculation. These conditions decrease the FS-value and in some cases to a great extent. Figure 5b shows this procedure. Unless absolutely necessary, it is not recommended to place cover soil on a slope in this manner. If it is necessary, the design must consider the unsupported soil mass and the dynamic force of the specific type of construction equipment and its manner of operation.



(a) Equipment backfilling up slope (the recommended method)

(b) Equipment backfilling down slope (method is not recommended)

Figure 5. Construction equipment placing cover soil on slopes containing geosynthetics.

For the first case of a bulldozer pushing cover soil up from the toe of the slope to the crest, the analysis uses the free body diagram of Figure 6a. The analysis uses a specific piece of tracked construction equipment (like a bulldozer characterized by its ground contact pressure) and dissipates this force or stress through the cover soil thickness to the surface of the geomembrane. A Boussinesq analysis is used, see Poulos and Davis (1974). This results in an equipment force per unit width as follows:

$$W_e = q w I \qquad (16)$$

where

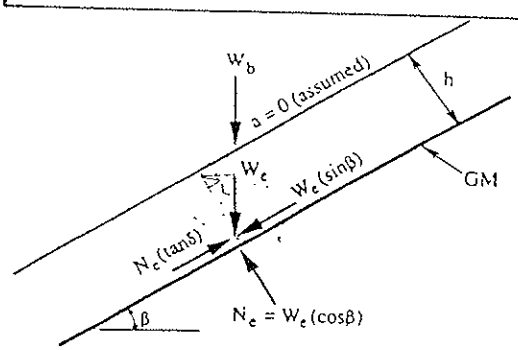
W_e = equivalent equipment force per unit width at the geomembrane interface

$q = W_b / (2 \times w \times b)$

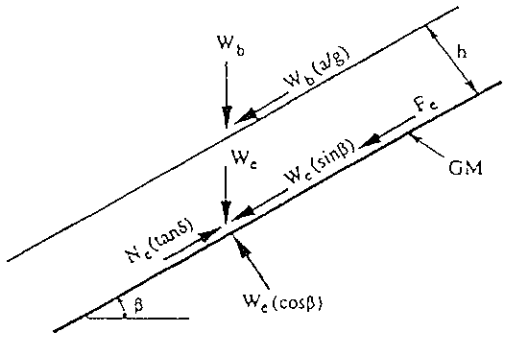
Attachment E 3/6

E 5/11/01 (3)
GTC 5/11/01

W_b = actual weight of equipment (e.g., a bulldozer)
w = length of equipment track
b = width of equipment track
I = influence factor at the geomembrane interface see Figure 7



(a) Equipment moving up slope
(load with no assumed acceleration)



(b) Equipment moving down slope
(load plus acceleration or deceleration)

Figure 6. Additional (to gravitational forces) limit equilibrium forces due to construction equipment moving on cover soil (see Figure 3 for the gravitational soil force to which the above forces are added).

Upon determining the additional equipment force at the cover soil-to-geomembrane interface, the analysis proceeds as described in Section 3.1 for gravitational forces only. In essence, the equipment moving up the slope adds an additional term, W_e, to the W_A-force in Eq. 3. Note, however, that this involves the generation of a resisting force as well. Thus, the net effect of increasing the driving force as well as the resisting force is somewhat neutralized insofar as the resulting FS-value is concerned. It should also be noted that no acceleration/deceleration forces are included in this analysis which is somewhat optimistic. Using these concepts (the same equations used in Section 3.1 are used here), typical design curves for various FS-values as a function of equivalent ground contact equipment pressures and cover soil thicknesses are given in Figure 8. Note that the curves are developed specifically for the variables stated in the legend. Example 2a illustrates the use of the formulation.

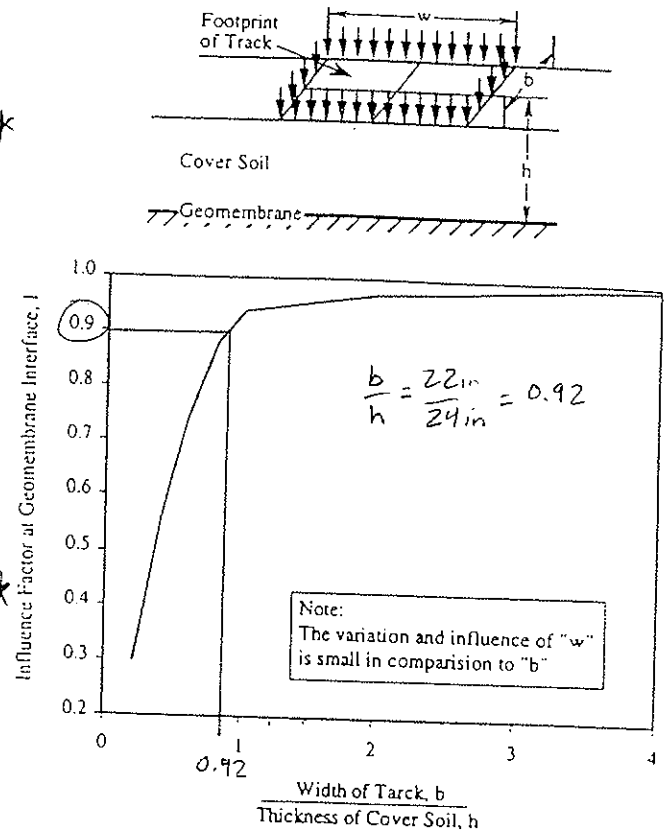


Figure 7. Values of influence factor, "I", for use in Eq. 16 to dissipate surface force of tracked equipment through the cover soil to the geomembrane interface, after Poulos and Davis (1974).

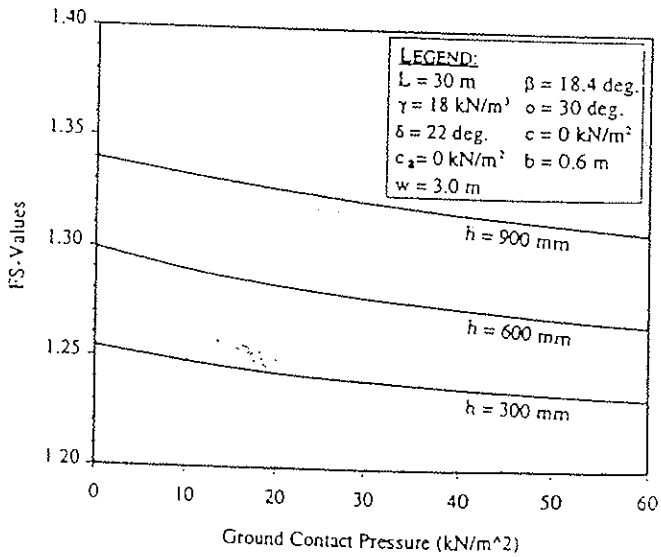


Figure 8. Design curves for stability of different thickness of cover soil for various values of tracked ground contact pressure construction equipment.

Attachment E 4/6

Example 2a:

Given 30 m long slope with uniform cover soil of 300 mm thickness at a unit weight of 18 kN/m^3. The soil has a friction angle of 30 deg. and zero cohesion, i.e., it is a sand. It is placed on the slope using a bulldozer moving from the toe of the slope up to the crest. The bulldozer has a ground pressure of 30 kN/m^2 and tracks that are 3.0 m long and 0.6 m wide. The cover soil to geomembrane friction angle is 22 deg. with zero adhesion. What is the FS-value at a slope angle of 3(H)-to-1(V), i.e., 18.4 deg.

Solution:
This problem follows Example 1 exactly except for the addition of the bulldozer moving up the slope. Using the additional equipment load Eq. 16, substituted into Eqs. 14 and 15 results in the following.

$$\left.\begin{aligned} a &= 73.1\,\text{kN/m} \\ b &= -104.3\,\text{kN/m} \\ c &= 17.0\,\text{kN/m} \end{aligned}\right\} \quad FS = 1.24$$

Comment:
While the resulting FS-value is low, the result is best assessed by comparing it to Example 1, i.e., the same problem except without the bulldozer. It is seen that the FS-value has only decreased from 1.25 to 1.24. Thus, in general, a low ground contact pressure bulldozer placing cover soil up the slope with negligible acceleration/deceleration forces does not significantly decrease the factor-of-safety.

For the <u>second case</u> of a bulldozer pushing cover soil down from the crest of the slope to the toe as shown in Figure 5b, the analysis uses the force diagram of Figure 6b. While the weight of the equipment is treated as just described, the lack of a passive wedge along with an additional force due to acceleration (or deceleration) of the equipment significantly changes the resulting FS-values. This analysis again uses a specific piece of construction equipment operated in a specific manner. It produces a force parallel to the slope equivalent to W_b (a/g), where W_b = the weight of the bulldozer, a = acceleration of the bulldozer and g = acceleration due to gravity. Its magnitude is equipment operator dependent and related to both the equipment speed and time to reach such a speed, see Figure 9. A similar behavior will be seen for deceleration.

The acceleration of the bulldozer, coupled with an influence factor "I" from Figure 7, results in the dynamic force per unit width at the cover soil to geomembrane interface, "F_e". The relationship is as follows:

$$F_e = W_e\left(\frac{a}{g}\right) \qquad (17)$$

where

F_e = dynamic force per unit width parallel to the slope at the geomembrane interface,

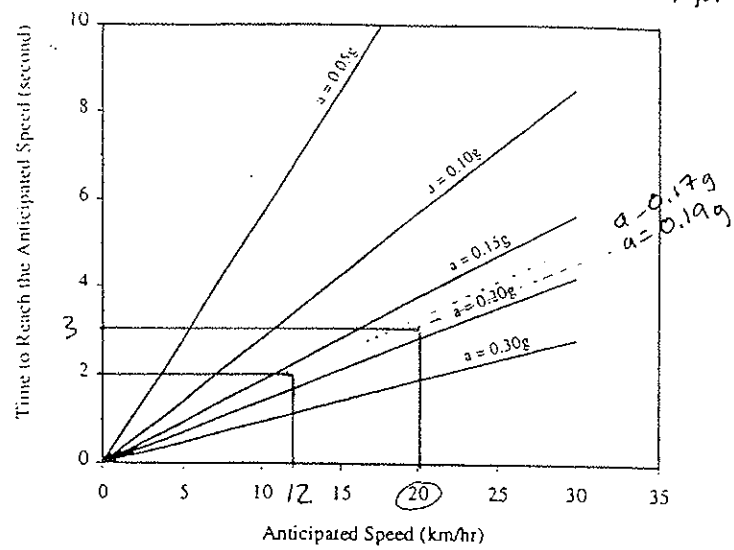


Figure 9. Graphic relationship of construction equipment speed and rise time to obtain equipment acceleration.

W_e = equivalent equipment (bulldozer) force per unit width at geomembrane interface, recall Eq. 16.
β = soil slope angle beneath geomembrane
a = acceleration of the bulldozer
g = acceleration due to gravity

Using these concepts, the new force parallel to the cover soil surface is dissipated through the thickness of the cover soil to the interface of the geomembrane. Again, a Boussinesq analysis is used, see Poulos and Davis (1974). The expression for determining the FS-value can now be derived as follows:

Considering the active wedge, and balancing the forces in the direction parallel to the slope, the following formulation results:

$$E_A + \frac{(N_e + N_A)\tan\delta + C_a}{FS} = (W_A + W_e)\sin\beta + F_e \qquad (18)$$

where

N_e = effective equipment force normal to the failure plane of the active wedge
= $W_e \cos\beta$ (19)

Note that all the other symbols have been previously defined.

The interwedge force acting on the active wedge can down be expressed as:

$$E_A = \frac{(FS)\left[(W_A + W_e)\sin\beta + F_e\right]}{FS} - \frac{\left[(N_e + N_A)\tan\delta + C_a\right]}{FS} \qquad (20)$$

The passive wedge can be treated in a similar manner. The following formulation of the interwedge force acting on the passive wedge results:

Attachment E 5/6

$$E_P = \frac{C + W_P \tan\phi}{\cos\beta(FS) - \sin\beta\tan\phi} \qquad (21)$$

By setting $E_A = E_P$, the following equation can be arranged in the form of Eq. 13 in which the "a", "b" and "c" terms are as follows:

$$a = \left[\left(W_A + W_e\right)\sin\beta + F_e\right]\cos\beta$$

$$b = -\left\{\left[\left(N_e + N_A\right)\tan\delta + C_a\right]\cos\beta + \left[\left(W_A + W_e\right)\sin\beta + F_e\right]\sin\beta\tan\phi + \left(C + W_P\tan\phi\right)\right\}$$

$$c = \left[\left(N_e + N_A\right)\tan\delta + C_a\right]\sin\beta\tan\phi \qquad (22)$$

Finally, the resulting FS-value can be obtained using Eq. 15. Using these concepts, typical design curves for various FS-values as a function of equipment ground contact pressure and equipment acceleration can be developed, see Figure 10. Note that the curves are developed specifically for the variables stated in the legend. Example 2b illustrates the use of the formulation.

Example 2b:

Given a 30 m long slope with uniform cover soil of 300 mm thickness at a unit weight of 18 kN/m^3. The soil has a friction angle of 30 deg. and zero cohesion, i.e., it is a sand. It is placed on the slope using a bulldozer moving from the crest of the slope down to the toe. The bulldozer has a ground contact pressure of 30 kN/m^2 and tracks that are 3.0 m long and 0.6 m wide. The estimated equipment speed is 20 km/hr and the time to reach this speed is 3.0 sec. The cover soil to geomembrane friction angle is 22 deg. with zero adhesion. What is the FS-value at a slope angle of 3(H)-to-1(V), i.e., 18.4 deg.

Solution:

Using the design curves of Figure 10 along with Eqs. 22 substituted into Eq. 15 the solution can be obtained:

- From Figure 9 at 20 km/hr and 3.0 sec. the bulldozer's acceleration is 0.19g.
- From Eq. 22 substituted into Eq. 15 we obtain

$$\left.\begin{aligned} a &= 88.8\,\text{kN/m} \\ b &= -107.3\,\text{kN/m} \\ c &= 17.0\,\text{kN/m} \end{aligned}\right\} \quad FS = 1.03$$

Comment:

This problem solution can now be compared to the previous two examples:

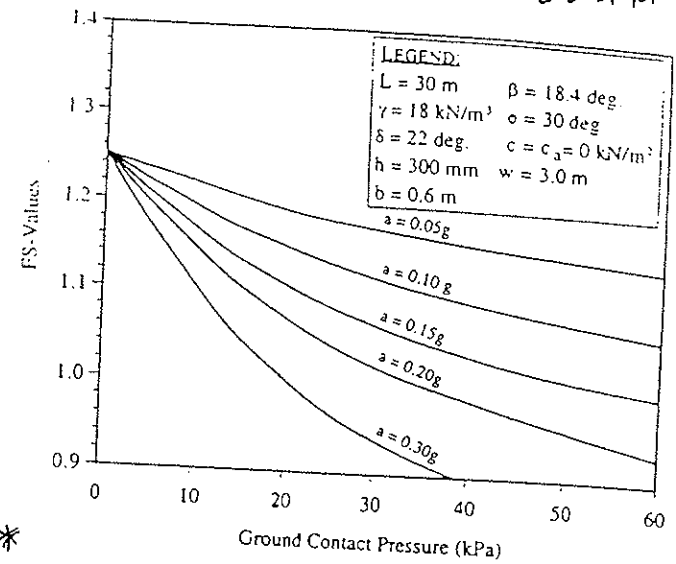


Figure 10. Design curves for stability of different construction equipment ground contact pressure for various equipment accelerations.

Ex. 1:	cover soil alone with no bulldozer loading	FS = 1.25
Ex. 2a:	cover soil plus bulldozer moving up slope	FS = 1.24
Ex. 2b:	cover soil plus bulldozer moving down slope	FS = 1.03

The inherent danger of a bulldozer moving down the slope is readily apparent. Note, that the same result comes about by the bulldozer decelerating instead of accelerating. The sharp breaking action of the bulldozer is arguable the more severe condition due to the extremely short times involved when stopping forward motion. Clearly, only in unavoidable situations should the cover soil placement equipment be allowed to work down the slope. If it is unavoidable, an analysis should be made of the specific stability situation and the construction specifications should reflect the exact conditions made in the design. The maximum allowable weight and ground contact pressure of the equipment should be stated along with suggested operator movement of the cover soil placement operations. Truck traffic on the slopes can also give as high, or even higher, stresses and should be avoided unless adequately designed. Additional detail is given in McKelvey (1994). The issue of access ramps is a unique subset of this example and one which deserves focused attention due to the high loads and decelerations that often occur.

3.3 Consideration of Seepage Forces

The previous sections presented the general problem of slope stability analysis of cover soils placed on slopes under different conditions. The tacit assumption throughout was that either permeable soil or a drainage layer was placed above the barrier layer with adequate flow capacity to efficiently remove permeating water safely way from the cross section. The amount of water to be removed is obviously a site specific situation. Note that in extremely

Attachment E 6/6

5/11/01 GTC 5/11/01

MODEL	D6R		D6R XL		D6R XL (IG)▶		D6R XR	
Flywheel Power	123 kW	165 hp	130 kW	175 hp	138 kW	185 hp	130 kW	175 hp
Operating Weight:*								
Power Shift	18 000 kg	39,700 lb	19 000 kg	41,900 lb	19 780 kg	43,600 lb	18 780 kg	41,400 lb
Direct Drive	18 053 kg**	39,800 lb	—		—		—	
Power Shift Differential Steer	18 200 kg	40,000 lb	19 200 kg	42,300 lb	19 960 kg	44,000 lb	18 910 kg	41,700 lb
Engine Model	3306T		3306T		3306T		3306T	
Rated Engine RPM	1900		1900		1900		1900	
No. of Cylinders	6		6		6		6	
Bore	121 mm	4.75"	121 mm	4.75"	121 mm	4.75"	121 mm	4.75"
Stroke	152 mm	6"	152 mm	6"	152 mm	6"	152 mm	6"
Displacement	10.5 L	638 in³	10.5 L	638 in³	10.5 L	638 in³	10.5 L	638 in³
Track Rollers (Each Side)	6		7		7		7	
Width of Standard Track Shoe	560 mm	1'10"	560 mm	1'10"	762 mm	2'6"	560 mm	1'10"
Length of Track on Ground	2.61 m	8'7"	2.82 m	9'3"	2.82 m	9'3"	2.75 m	9'0"
Ground Contact Area (W/Std. Shoe)	2.92 m²	4523 in²	3.16 m²	4888 in²	4.3 m²	6661 in²	3.08 m²	4771 in²
Track Gauge	1.88 m	6'2"	1.88 m	6'2"	2.03 m	6'8"	1.88 m	6'2"
GENERAL DIMENSIONS:								
Height (Stripped Top)***	2.38 m	7'5"	2.38 m	7'5"	2.38 m	7'5"	2.38 m	7'5"
Height (To Top of ROPS)	3.19 m	10'5"	3.19 m	10'5"	3.19 m	10'5"	3.19 m	10'5"
Height (To Top of Cab ROPS)	3.19 m	10'5"	3.19 m	10'5"	3.19 m	10'5"	3.19 m	10'5"
Height (To Top of ROPS Canopy)	—		—		—		—	
Overall Length (With S Blade)	5.11 m	16'9"	—		—		5.26 m	17'3"
(Without Blade)	4.08 m	13'4"	4.08 m	13'4"	—		4.22 m	13'10"
Width (Over Trunnion)	2.64 m	8'8"	2.64 m	8'8"	2.95 m	9'8"	2.64 m	8'8"
Width (W/O Trunnion — Std. Shoe)	2.44 m	8'0"	2.44 m	8'0"	2.74 m	9'0"	2.44 m	8'0"
Ground Clearance	383 mm	14.8"	383 mm	14.8"	383 mm	14.8"	383 mm	14.8"
Blade Types and Widths:								
Straight	3.35 m	11'0"	—		—		3.36 m	11'0"
Angle	—		—		—		—	
Angle Straight	4.16 m	13'7.8"	4.16 m	13'8"	—		4.16 m	13'8"
Full Angle	3.78 m	12'4.7"	3.78 m	12'5"	—		3.78 m	12'5"
Universal	—		—		—		—	
Semi-U	3.26 m	10'8"	3.26 m	10'8"	3.56 m	11'8"	3.26 m	10'8"
Fuel Tank Refill Capacity	383 L	101 U.S. gal	383 L	101 U.S. gal	383 L	101 U.S. gal	383 L	101 U.S. gal

*Operating Weight includes ROPS canopy, operator, lubricants, coolant, full fuel tank, hydraulic controls and fluid, straight dozer with tilt, horn, back-up alarm, retrieval hitch and front pull hook.

**Japan only.

***Height (stripped top) — without ROPS canopy, exhaust, seat back or other easily removed encumbrances

▶Intermediate Gauge offered as custom product.

Attachment F, 1/1

~~Attachment G~~

Calculation Package C
Cover Liner Sloughing Stability

GeoSyntec Consultants

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: BRC Project: BRC CAMU Project/Proposal #: SC0313 Task #: 01-02

Title of Computations: Slope Stability Evaluation – Sloughing Stability

Computations By: SIGNATURE — DATE: 24 May 2005

Edward M. Zielanski / Project Engineer
PRINTED NAME AND TITLE

Assumptions and Procedures Checked By (Peer Reviewer): SIGNATURE — DATE: 6/3/05

Gregory T. Corcoran / Associate Engineer
PRINTED NAME AND TITLE

Computations Checked By: SIGNATURE — DATE: 6/3/05

Gregory T. Corcoran / Associate Engineer
PRINTED NAME AND TITLE

Computations Backchecked By (Originator): SIGNATURE — DATE: 6/3/05

Edward M. Zielanski / Project Engineer
PRINTED NAME AND TITLE

Approved By (PM or Designate): SIGNATURE — DATE: 6/3/05

Gregory T. Corcoran / Associate Engineer

Approval Notes:

Revisions: (Number and Initial All Revisions)

No.	Sheet	Date	By	Checked By	Approval

Written by: Ed Zielanski (2) Date: 05 / 05 / 24 (YY MM DD) Reviewed by: _____ Date: ___/___/___ (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-02

SLOPE STABILITY EVALUATION
SLOUGHING STABILITY OF GEOSYNTHETIC-SOIL LINED SIDESLOPES
COVER LINER SYSTEM
BRC CAMU

OBJECTIVE

To evaluate the infinite slope stability (i.e., sloughing failure) within the geosynthetic-soil layered sideslopes of the cover liner system of the BRC Corrective Action Management Unit (CAMU) located in Henderson, Nevada.

SUMMARY OF RESULTS

Assuming that no head buildup is expected above the liner, the proposed slope meets the required factor of safety of 1.5. The minimum interface friction angle between the cover soil and geocomposite shall be greater than or equal to 27 degrees. The yield acceleration is 0.15 g.

METHOD OF ANALYSIS

The stability analyses presented herein are based on the principles of an infinite slope failure. The critical failure plane may occur within the cover soil mass or along the geotextile/cover soil interface. The procedure outlined below is based on published data from Thiel and Steward (1993) (Attachment A). The factor of safety, defined as the ratio of resisting shear strength divided by the driving shear stress, is:

$$FS = \frac{S}{\tau} = \frac{c' + \left[h_1\gamma_1 + (h_2 - h_w)\gamma_2 - h_w\gamma_w\right]\tan\phi'}{\left[h_1\gamma_1 + (h_2 - h_w)\gamma_2 + h_w\gamma_{sat}\right]\tan\beta} \qquad \text{(Equation 1)}$$

where:
- h_1 = thickness of topsoil;
- h_2 = thickness of drainage layer;
- h_w = average height of water in drainage layer normal to slope;
- γ_1 = saturated unit weight of topsoil;
- γ_2 = moist unit weight of drainage layer;
- γ_{2sat} = saturated unit weight of drainage layer;
- β = slope angle; and
- ϕ, c' = interface strength parameters.

Written by: Ed Zielanski Date: 05 / 05 / 24 (YY MM DD) Reviewed by: _____ Date: ___/___/___ (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-02

Since the results of the veneer stability calculation package indicate that there will be no tension developed in the geosynthetics, only the stability of the cover soil and interface between the cover soil and drainage composite will be analyzed herein.

The yield acceleration is the horizontal acceleration (in terms of gravity) required for the slope to have a factor of safety of 1.0. Matasovic (1991) (Attachment D) presents a formula to calcualate the yield acceleration for an infinite slope, defined as:

$$k_y = \frac{c/(\gamma z \cos^2 \beta) + \tan\phi[1 - \gamma_w (z - d_w)/(\gamma z)] - \tan\beta}{1 + \tan\beta \tan\phi} \qquad \text{(Equation 2)}$$

where:
k_y = yield acceleration (g)
ϕ = friction angle (deg.)

Since the head on the liner is negligable and the material is cohesionless, Equation 2 becomes:

$$k_y = \frac{\tan\phi - \tan\beta}{1 + \tan\beta \tan\phi} \qquad \text{(Equation 3)}$$

DESIGN CRITERION

For long term conditions, a design criterion is a factor of safety of 1.5.

SIDESLOPE LINER SYSTEM

The sideslope liner system of the cover liner system consists of, from top to bottom:

- 2 ft native material;
- a drainge geocomposite;
- a 60-mil (1.5-mm) thick textured high density polyethylene (HDPE) geomembrane;
- a geosynthetic clay liner (GCL); and
- waste soil fill.

The sideslope inclination is 3.0H:1.0V. The maximum height of a side slope is 42 vertical feet, located in the southwest corner of the South Mesa.

Written by: Ed Zielanski Date: 05 / 05 / 24 (YY MM DD) Reviewed by: _____ Date: ___/___/___ (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-02

MATERIAL SHEAR STRENGTHS

Cover Soil Material:

The soil materials to be used overlying the side slope liner system will be native materials such as silty sands (SM) for the operations layer. Converse reported a maximum dry density of 132 pcf and an optimum water content of 8.7 percent for materials at the site. Therefore, assuming 95% relative compaction, the dry density in the field is approximately 125 pcf. Adding the weight of water, the unit weight is approximately 136 pcf.

NAVFAC (1982) lists typical shear strength values for various soils based on 100 percent standard Proctor compaction (Attachment C). Actual construction materials would likely be placed at 90 percent of the modified Proctor compaction which for the sake of the comparison presented herein roughly corresponds to 95 percent standard Proctor compaction. NAVFAC (1982) lists typical shear strength values for a SM material to be 34 degrees. For the analysis herein, cohesion was neglected. Therefore, the shear strength can be approximately estimated to be 0.95(34 deg) = 32 degrees.

For this analysis, a shear strength of 32 degrees and a unit weight of 136 pcf will be used for the analyses performed herein.

ANALYSIS

Based on HELP model analyses (presented in a separate calculation package titled *Geocomposite and Pipe Size Requirements*), the side slopes will not develop a head on the liner system. In addition, a geocomposite will be used as a drainage layer in the cover liner system. Based on the assumption of a cohesionless material, Equation 1 becomes:

$$FS = \frac{S}{\tau} = \frac{\tan\phi'}{\tan\beta}$$

The design criteria dictates a minimum factor of safety of 1.5 for long term conditions. Therefore, the minimum allowable friction angle (interface or internal) is evaluated as:

$$\varphi = \tan^{-1}(FS\tan\beta)$$
$$\varphi = \tan^{-1}(1.5\tan 18.43) = 27$$

Written by: Ed Zielanski Date: 05 / 05 / 24 (YY MM DD) Reviewed by: _____ Date: ___/___/___ (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-02

To calculate the yield accleration, Equation 3 becomes:

$$k_y = \frac{\tan 27 - 0.333}{1 + (0.333)\tan 27} = 0.15 \text{ g}$$

RESULTS AND CONCLUSIONS

The calculations suggest that the minimum friction angle (interface or internal) of 26.5 degrees will meet the design criteria of a factor of safety equal to 1.5. The yield accleration is evaluated to be 0.15 g. The minimum friction angle should be obtained in the cover soil and the interface between the cover soil and geocomposite interface. A review of current literature suggests that the minimum friction angle can be obtained.

REFERENCES

Koerner, R. M. (1997), "Designing with Geosynthetics," Simon and Schuster / A Viacom Company, Upper Saddle New Jersey, 07458, 1998 *(Attachment B)*

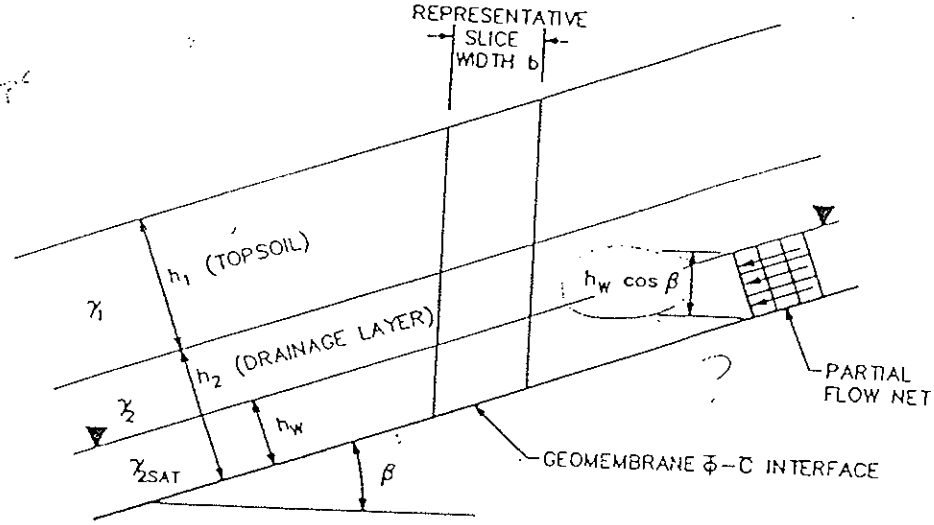
NAVFAC (1982), "Foundations and Earth Structures, Design Manual - 7.2," Department of Navy, Naval Facilities Engineering Command, May 1982 *(Attachment C)*

Thiel, R. S., Stewart, M.G., "Geosynthetic Landfill Cover Design Methodology and Construction Experience in the Pacific Northwest," Proceedings from Geosynthetics 1993, Vancouver, Canada. *(Attachment A)*

[redacted]

MKK 7-13-00
RC 7/27/00 GTC (32)

a) INFINITE SLOPE GEOMETRY AND MATERIAL PARAMETERS



b) FORCES

$W = [h_1 \gamma_1 + (h_2 - h_w)\gamma_2 + h_w \gamma_{2SAT}]\, b/\cos\beta$

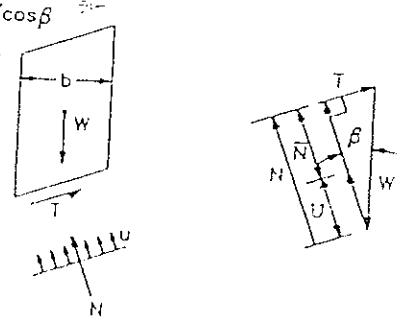
$u = \gamma_w h_w \cos\beta$

$U = ub/\cos\beta = \gamma_w h_w b$

$N = W\cos\beta$

$T = W\sin\beta$

$\bar{N} = N - U$



FREE BODY DIAGRAM FORCE POLYGON

Geometric Parameters: β = slope angle; h_1 = thickness of topsoil; h_2 = thickness of drainage layer; h_w = average height of water in drainage layer normal to slope; b = width of representative slice.

Material Parameters: γ_1 = saturated unit weight of topsoil; γ_2 = moist unit weight of drainage layer; γ_{2SAT} = saturated unit weight of drainage layer; γ_w = unit weight of water; $\bar{\phi}$ = effective friction parameter for shear strength at base of drainage layer; $\bar{c}$ = effective cohesion parameter for shear strength at base of drainage layer.

Forces: u = pore pressure on base of drainage layer; U = uplifting water force; W = total weight of slice; N = total force normal to slope exerted by weight; T = tangential force to slope exerted by weight; $\bar{N}$ = effective normal force.

FIGURE 4. INFINITE SLOPE STABILITY WITH SEEPAGE PARALLEL TO SLOPE (MODIFIED AFTER DUNN ET AL, 1980, p.241)

$$FS = \frac{\bar{c}' + \left[\left[\gamma_1 h_1 + h_2\gamma_2 - h_w\gamma_w\right]\frac{\cos\beta}{\cos\beta}\right]\tan\bar{\phi}}{\left[\gamma_1 h_1 + h_2\gamma_2 - h_w\gamma_w\right]\frac{\sin\beta}{\cos\beta} + \left(\frac{\gamma_w h_w}{\cos\beta}\right)}$$

Attachment A
1/2

SOURCE: THIEL & STEWART (1993)

The effective stress normal to base of the slice, $\bar{\sigma}$, is

$$\bar{\sigma} = \frac{\bar{N}}{b/\cos\beta} = [h_1\gamma_1 + (h_2 - h_w)\gamma_2 + h_w\gamma_{2\,SAT} - h_w\gamma_w]\cos\beta \tag{4}$$

The shear stress exerted tangential to the slice base, τ, is

$$\tau = \frac{T}{b/\cos\beta} = [h_1\gamma_1 + (h_2 - h_w)\gamma_2 + h_w\gamma_{2SAT}]\sin\beta \tag{5}$$

The shear strength at base of the slice, S, is

$$S = \bar{c} + \bar{\sigma}\tan\bar{\phi} \tag{6}$$

The factor of safety, defined as the ratio of the resisting shear strength divided by the driving shear stress, is

$$FS = \frac{S}{\tau} = \frac{\bar{c} + [h_1\gamma_1 + (h_2 - h_w)\gamma_2 + h_w\gamma_{2SAT} - h_w\gamma_w]\tan\bar{\phi}}{[h_1\gamma_1 + (h_2 - h_w)\gamma_2 + h_w\gamma_{2SAT}]\tan\beta} \tag{7}$$

Because the depth of saturation in the drainage layer varies, the FS would vary also. A common procedure is to compute the average FS by using the average water depth in the drainage layer, assumed to be half the maximum water depth (D) used in Equation (2). The method therefore computes an average factor of safety for the slope length between drainage discharge points. Locations upgradient of the average flow depth will have a slightly higher FS, and downgradient locations, a slightly lower FS.

The design methodology would be to compute the FS for a given cover geometry and materials properties using Equation (7), and using one half the maximum water depth (D) used in Equations (2) and (3). If the FS is acceptable, use the maximum drainage discharge spacing (L) computed in Equation (3). If the FS is unacceptably low, reduce the distance (L), recompute the average flow depth (D/2) in the drainage layer, and recompute the FS. Iterate until the FS is acceptable.

Design Example. Given: thickness (h_1) of 1.5 feet (45 cm) of topsoil with a saturated unit weight (γ_1) of 115 pcf (18 KN/m^3) and hydraulic conductivity (k_1) of 2×10^{-4} ft/min (1×10^{-4} cm/sec); thickness (h_2) of 1 foot (30 cm) of drainage layer with moist unit weight (γ_2) of 100 pcf (15.7KN/m^3), saturated unit weight (γ_{2SAT}) of 105 pcf (16.5 KN/m^3) and hydraulic conductivity (k_2) of 0.2 ft/min (0.1 cm/sec); slope angle (β) of 3:1 (18.4 degrees); and interface friction parameter (ϕ) of 30 degrees. Unit weight of water (γ_w) = 62.4 pcf (9.8 KN/m^3).

Find: Maximum allowable spacing (L_{max}) between drainage outlets designed subparallel to slope contours such that the maximum depth (D) of accumulated water in the drainage layer is one foot (30 cm), and a minimum average FS of 1.5 is maintained.

Solution:

$$L_{(max)} = (k_2)\sin(\beta)(D)/(k_1) = 0.2\sin(18.4)(1)/0.0002 = 316\,ft\,(96\,m)$$

$$FS = \frac{[(h_1)(\gamma_1) + (h_2 - D/2)(\gamma_2) + (D/2)(\gamma_{2SAT}) - (D/2)(\gamma_w)]\tan(\phi)}{[(h_1)(\gamma_1) + (h_2 - D/2)(\gamma_2) + (D/2)(\gamma_{2SAT})]\tan(\beta)} \tag{8}$$

$$= \frac{[(1.5)(115) + (1-.5)(100) + (.5)(105) - (.5)(62.4)]\tan(30)}{[(1.5)(115) + (1-.5)(100) + (.5)(105)]\tan(18.43)} = 1.5\ (ok)$$

Factor of Safety. Geotechnical engineers often feel comfortable with a minimum FS of 1.5 for long-term static slope stability conditions. This value originated from dam

MSW 1-13-00
KCF 7/27/00 GTC (2)

Table 5.7 Friction values and efficiencies (in parentheses) for (a) soil-to-geomembrane, (b) geomembrane-to-geotextile, and (c) soil-to-geotextile combinations*

(a) Soil-to-Geomembrane Friction Angles

	Soil Types		
Geomembrane	*Concrete Sand* (ϕ = 30°)	*Ottawa Sand* (ϕ = 28°)	*Micha Schist Sand* (ϕ = 26°)
EPDM-R	24° (0.77)	20° (0.68)	24° (0.91)
PVC			
Rough	27° (0.88)	—	25° (0.96)
Smooth	25° (0.81)	—	21° (0.79)
CSPE-R	25° (0.81)	21° (0.72)	23° (0.87)
HDPE	18° (0.56)	18° (0.61)	17° (0.63)

(b) Geomembrane-to-Geotextile Friction Angles

	Geomembrane				
		PVC			
Geotextile	*EPDM-R*	*Rough*	*Smooth*	*CSPE-R*	*HDPE*
Nonwoven, needle punched	23°	23°	21°	15°	8°
Nonwoven, heat bonded	18°	20°	18°	21°	11°
Woven, monofilament	17°	11°	10°	9°	6°
Woven, slit film	21°	25°	24°	15°	10°

(c) Soil-to-Geotextile Friction Angles

	Soil Types		
Geotextile	*Concrete Sand* (ϕ = 30°)	*Ottawa Sand* (ϕ = 28°)	*Mica Schist Sand* (ϕ = 26°)
Nonwoven, needle punched	30° (1.00)	26° (0.92)	25° (0.96)
Nonwoven, heat bonded	26° (0.84)	—	—
Woven, monofilament	26° (0.84)	—	—
Woven, slit film	24° (0.77)	24° (0.84)	23° (0.87)

*Efficiency values in parentheses are based on the relationship $E = (\tan \delta)/(\tan \phi)$.

Source: After Martin et al. [14].

The frictional behavior of geomembranes placed on clay soils is of considerable importance in the composite liners of waste landfills. Current requirements are for the clay to have a hydraulic conductivity equal to or less than 2×10^{-7} ft./min. (1×10^{-7} cm/sec.) and for the geomembrane to be placed directly on the clay. While an indication of the shear strength parameters has been investigated (e.g., reference 15), the data are so sensitive to the variables listed previously that site-specific and material-specific tests should always be performed. In such cases, literature values should never be used for final design purposes.

5.1.3.9 Geomembrane Anchorage In certain problem situations a geomembrane might be sandwiched between two materials and then tensioned by an external force. The termination of a geomembrane liner within an anchor trench is such a situation. To simulate this behavior in a laboratory environment, one can use an 8.0-in. (200-mm)-wide geomembrane sandwiched between back-to-back channels.

FROM KOERNER (1997) Attachment B 1/1

BLE 1

Typical Properties of Compacted Soils

Group Symbol	Soil Type	Range of Maximum Dry Unit Weight, pcf	Range of Optimum Moisture, Percent	Typical Value of Compression (Percent of Original Height): At 1.4 tsf (20 psi)	At 3.6 tsf (50 psi)	Typical Strength Characteristics: Cohesion (as compacted) psf	Cohesion (saturated) psf	φ (Effective Stress Envelope Degrees)	Tan φ	Typical Coefficient of Permeability ft./min.	Range of CBR Values	Range of Subgrade Modulus k lbs/cu in.
GW	Well graded clean gravels, gravel-sand mixtures.	125 - 135	11 - 8	0.3	0.6	0	0	>38	>0.79	5×10^{-2}	40 - 80	300 - 500
GP	Poorly graded clean gravels, gravel-sand mix	115 - 125	14 - 11	0.4	0.9	0	0	>37	>0.74	10^{-1}	30 - 60	250 - 400
GM	Silty gravels, poorly graded gravel-sand-silt.	120 - 135	12 - 8	0.5	1.1	.....	.....	>34	>0.67	$>10^{-6}$	20 - 60	100 - 400
GC	Clayey gravels, poorly graded gravel-sand-clay.	115 - 130	14 - 9	0.7	1.6	.....	.....	>31	>0.60	$>10^{-7}$	20 - 40	100 - 300
SW	Well graded clean sands, gravelly sands.	110 - 130	16 - 9	0.6	1.2	0	0	38	0.79	$>10^{-3}$	20 - 40	200 - 300
SP	Poorly graded clean sands, sand-gravel mix.	100 - 120	21 - 12	0.8	1.4	0	0	37	0.74	$>10^{-3}$	10 - 40	200 - 300
SM	Silty sands, poorly graded sand-silt mix.	110 - 125	16 - 11	0.8	1.6	1050	420	34	0.67	$5 \times >10^{-5}$	10 - 40	100 - 300
SM-SC	Sand-silt clay mix with slightly plastic fines.	110 - 130	15 - 11	0.8	1.4	1050	300	33	0.66	$2 \times >10^{-6}$	5 - 30	100 - 300
SC	Clayey sands, poorly graded sand-clay-mix.	105 - 125	19 - 11	1.1	2.2	1550	230	31	0.60	$5 \times >10^{-7}$	5 - 20	100 - 300
ML	Inorganic silts and clayey silts.	95 - 120	24 - 12	0.9	1.7	1400	190	32	0.62	$>10^{-5}$	15 or less	100 - 200
ML-CL	Mixture of inorganic silt and clay.	100 - 120	22 - 12	1.0	2.2	1350	460	32	0.62	$5 \times >10^{-7}$	.....	
CL	Inorganic clays of low to medium plasticity.	95 - 120	24 - 12	1.3	2.5	1600	270	28	0.54	$>10^{-7}$	15 or less	50 - 200
OL	Organic silts and silt-clays, low plasticity.	80 - 100	33 - 21	.....	.....	.....	.....	.....	.....	.....	5 or less	50 - 100
MH	Inorganic clayey silts, elastic silts.	70 - 95	40 - 24	2.0	3.8	1500	420	25	0.47	$5 \times >10^{-7}$	10 or less	50 - 100
CH	Inorganic clays of high plasticity	75 - 105	36 - 19	2.6	3.9	2150	230	19	0.35	$>10^{-7}$	15 or less	50 - 150
OH	Organic clays and silty clays	65 - 100	45 - 21	.....	.....	.....	.....	.....	.....	.....	5 or less	25 - 100

Notes:

1. All properties are for condition of "Standard Proctor" maximum density, except values of k and CBR which are for "modified Proctor" maximum density.
2. Typical stength characteristics are for effective strength envelopes and are obtained from USBR data.
3. Compression values are for vertical loading with complete lateral confinement.
4. (>) indicates that typical property is greater than the value shown.
   (..) indicates insufficient data available for an estimate.

NNEFNC

7.2-39

AH. C

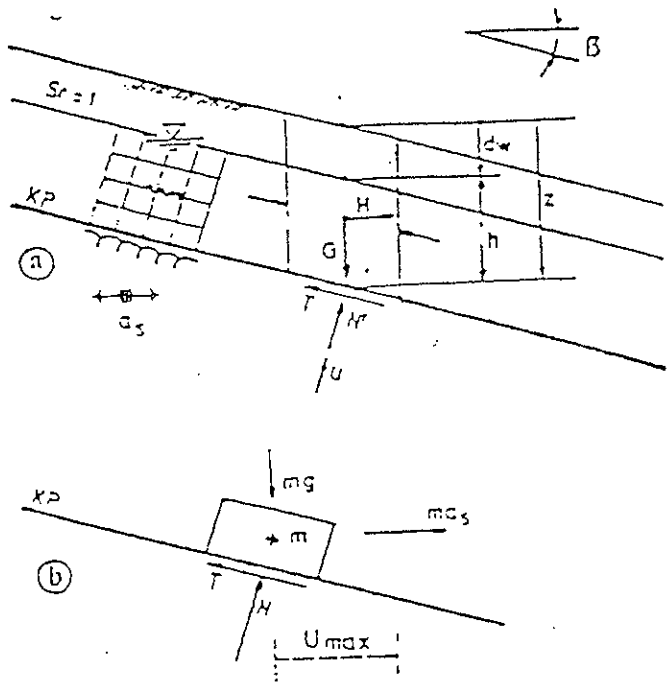
1/1

1/13-OC

KC 7/27/00 GTC

to get estimate of permanent displacement.

KL 4/27/00



- Ground Water Level
- Steady Seepage
- KP - Sliding Surface
- Seismic Exitation
- U_{max} - Permanent Displacement of sliding mass

Fig. 2 Model of an infinite slope

Based on the above assumptions, the principles of limit equilibrium and the notation introduced in Figure 2, the following expression for the factor of safety, F_s, has been derived (Matasovic, 1989):

$$F_s = \frac{c/(\gamma z \cos^2\beta) - \tan\Phi[1 - \gamma_w(z-d_w)/(\gamma z)] - k_s \tan\beta \tan\Phi}{k_s - \tan\beta} \qquad (1)$$

where γ, γ_w, c and Φ are the unit weight of slope material, the unit weight of water, cohesion and the angle of internal friction respectively.

Equation (1) defines the factor of safety for a general case of infinite slope stability. A similar expression, but for stability of cohesionless materials with pore pressure increase due to seismic loading, has been used by Hadj-Hamou and Kavazanjian (1985).

It should be noted that the value of factor of safety calculated by Equation (1) diminishes with depth in cohesive ($c \neq 0$, $\varphi = 0$) materials. Also, since the equation has been set for a case of limit equilibrium when $F_s = 1$, it is assumed that slope will generally resist seismic loading and will be stable if $F_s > 1.0$.

To estimate u_{max}, it is necessary, as a first step, to determine a_c, expressed by the product $k_c g$. The coefficient k_c can be determined iteratively by varying the amount of horizontal force until it reaches the value that gives the $F_s = 1$. However, for the model of infinite slope the coefficient of critical acceleration can be expressed explicitly by inserting $F_s = 1$ in Equation (1) and rearranging the variables:

$$k_c = \frac{c/(\gamma z \cos^2\beta) - \tan\Phi[1 - \gamma_w(z-d_w)/(\gamma z)] - \tan\beta}{1 - \tan\beta \tan\Phi} \qquad (2)$$

For a case without steady state seepage in the slope (if we insert $d_w = z$), Equation (2) becomes the expression for k_c used by Chang et Al. (1984).

REFERENCE: [Matasovic, 1991]

Attachment D

1/1

Calculation Package D
Geotextile Filtration Requirements

GeoSyntec Consultants

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: Parsons **Project:** BRC CAMU **Project/Proposal #:** HL0389 **Task #:** 04

Title of Computations: Geotextile Performance Requirements

Computations By: SIGNATURE — 10 July 2000 DATE

Geoff L. Smith / Staff Engineer
PRINTED NAME AND TITLE

Assumptions and Procedures Checked By (Peer Reviewer): SIGNATURE — 7-13-00 DATE

MICHAEL F. KRUSKI / SR. STAFF ENG.
PRINTED NAME AND TITLE

Computations Checked By: SIGNATURE — 7/14/00 DATE

GREGORY T. GOODMAN
PRINTED NAME AND TITLE

Computations Backchecked By (Originator): SIGNATURE — 7/14/00 DATE

Geoff L. Smith / Staff Engineer
PRINTED NAME AND TITLE

Approved By (PM or Designate): SIGNATURE — 7/17/2000 DATE

Bradford H. Cooley / Project Manager
PRINTED NAME AND TITLE

Approval Notes:

Revisions: (Number and Initial All Revisions)

No.	Sheet	Date	By	Checked By	Approval

Written by: Geoff L. Smith GLS Date: 00 / 07 / 13 (YY MM DD) Reviewed by: MSK 7.13.00 CTC Date: 00 / 07 / 14 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 04

GEOTEXTILE PERFORMANCE REQUIREMENTS
BRC CAMU

OBJECTIVE

It is proposed that the final cover for the BRC Corrective Action Management Unit (CAMU) located in Henderson, Nevada include a drainage geocomposite and a geotextile filter overlying the drainage aggregate. One geotextile bonded to a geonet will be used for the top deck and two geotextiles bonded to a geonet (geocomposite) will be used for the side slopes. The filtration geotextile must retain the overlying protective soil to minimize impairment of the drainage capacity of the underlying geonet or drainage aggregate. This calculation package focuses on the separation/filtration performance of the top geotextile and the required geotextile properties.

SUMMARY OF RESULTS

The calculations suggest that the separation/filtration geotextile must have an AOS less than sieve No. 70 (0.21 mm), a permittivity greater than 0.5 sec^{-1}, a minimum mass per unit area of 6 oz./sy, and sufficient mechanical strength properties as outlined in federal regulations.

SITE CONDITIONS

The final cover system is presented in Attachment F. The final cover system consists of, from top to bottom:

- 2 ft. cover soil;
- geocomposite;
- geomembrane;
- geosynthetic clay liner; and
- subgrade.

The final cover soils will consist of on-site material, which has been classified as silty sand to well-graded sand (SM, SM-SW according to the Unified Soils Classification System) (Converse Consultants, 1999) (Attachment A).

Written by: Geoff L. Smith Date: 00 / 07 / 13 (YY MM DD) Reviewed by: MSK 7-13-00 GTC Date: 00 / 07 / 14 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 04

ANALYSIS

Filtration Requirements: The geotextile will minimize fine particles of the cover soil layer from migrating into the underlying geonet or the underlying drainage aggregate. Migration of fine particles would have the adverse effect of decreasing the transmissivity of the geocomposite or clogging the drainage aggregate.

The filtration requirements for geotextiles can be evaluated using the "Geotextile Filter Design Manual," developed by Luettich et. al. (1991) (Attachment B). Page 2 of Attachment B shows a chart in which soil properties are used to evaluate the retention criteria of the geotextile by determining the maximum allowable apparent opening size (AOS or O_{95}).

The soil cover has been classified as silty or clayey sand and well-graded sand. Both of these classifications suggest that less than fifty percent of the material is fine-grained soils (i.e., smaller than the No. 200 sieve or 0.075 mm, sieve size). To be conservative in the calculations herein, the cover soil is assumed to consist of more than 20 percent clay and to be non-dispersive. Therefore, using Page 2 of Attachment B:

O_{95} < 0.21 mm, which corresponds to sieve No. 70, meaning that the geotextile apparent opening size (AOS) must be less than a No. 70 sieve size.

Permeability: The following equation can be used to evaluate the minimum allowable geotextile permeability:

$$k_g > i_s k_s$$

where: k_g = permeability of geotextile (cm/s)
i_s = hydraulic gradient (dimensionless)
k_s = permeability of the protective soil cover (cm/s)

Hydraulic gradient, i_s: Attachment B, page 3 from Luettich et al. (1991) lists typical hydraulic gradients for various geotextile drainage applications. In this attachment, a hydraulic gradient of 1.5 for landfill cover systems is recommended.

Soil Permeability, k_s: A permeability of 1.2×10^{-3} cm/s was used based on permeability testing of site specific soils (Attachment A).

Therefore,

Written by: Geoff L. Smith GLS Date: 00 / 07 / 13 (YY MM DD) Reviewed by: [illegible] GTC Date: 00 / 07 / 14 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 04

$k_g >$ $i_s k_s = (1.5)(1.2 \times 10^{-3})$
$k_g >$ 1.8×10^{-3} cm/s

Koerner (1994) suggests applying partial factors of safety to the ultimate flow capacity of the geotextile to account for clogging of the geotextile. Using recommendations given in Table 2.13 on p. 160 of Koerner (1994) (Attachment D), the following partial factor of safety values were applied:

soil clogging and blinding	10 (5-10)
intrusion into voids	1.2 (1.0-1.2) (Surface water – minimum)
biological clogging:	2.0 (2.0-4.0) GLS
creep reduction of voids:	1.5 (1.0-1.5)
chemical clogging:	1.2 (1.2-1.5) (Surface water – minimum)

Therefore,

$k_g > (1.8 \times 10^{-3})(10)(1.2)(2.0)(1.5)(1.2)$
$k_g > 0.08$ cm/s

The thickness of a 6 oz/yd^2 (205 g/m^2) geotextile is approximately 65 mils (0.165 cm) (Amoco technical literature, Attachment E, p.1). Dividing the permeability by the thickness of the geotextile results in the following permittivity values:

6 oz/sy = 0.5 sec^{-1}

Mechanical Property Requirements: To ensure proper manufacturing and durability of the geotextile, the geotextile should have appropriate strength requirements. Based on guidelines developed by Task Force 25 (see note below) (Attachment C) for mechanical properties of geotextiles used in applications requiring moderate survivability, the geotextile should have the following properties:

Property	**Criteria**
Grab Strength	≥130 lb
Puncture Protection	≥40 lb
Mullen Burst	≥210 psi
Trapezoidal Tear	≥40 lb
Ultraviolet strength retention	≥70% (typical value for geotextiles)

Written by: Geoff L. Smith Date: 00 / 07 / 13 (YY MM DD) Reviewed by: 7-13-00 GTC Date: 00 / 07 / 14 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 04

Note: Task Force 25 consisted of the American Association of State and Transporation Officials (AASHTO), the American Building Contractors (ABC), and the American Road Builders and Transportation Association (ARBTA).

CONCLUSIONS

In accordance with the above analyses, the top geotextile component of the drainage composite and the filtration geotextile overlying the drainage aggregate shall have the following properties:

Property	Separation/Filtration Criteria
matrix	nonwoven
mass per unit area	6 oz/sy (205 g/m^2)
apparent opening	≤0.21 mm (sieve No. 70)
permittivity	≥0.5 sec^{-1}
grab strength	≥130 lb
puncture strength	≥40 lb
Mullen burst	≥210 psi
trapezoidal tear	≥40 lb
ultraviolet strength reduction	≥70%

The following is a partial list of geotextile products that should meet the material requirements:

Amoco Fabrics & Fibers Co., Amoco 4506
Trevira 011/120
Synthetic Industries, Geotex 701

Written by: Geoff L. Smith Date: 00 / 07 / 13 (YY MM DD) Reviewed by: 7.13.00 GTC Date: 00 / 07 / 19 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 04

REFERENCES

Amoco Fabrics and Fibers Company, Atlanta, Georgia 404-984-4444 *(Attachment E)*

Converse Consultants (1999), "Preliminary Geotechnical and Geologic Investigation, Industrial Non-Hazardous Disposal Facility, Basic Management Incorporated, Clark County, Nevada," October 27, 1999, Las Vegas, Nevada. *(Attachment A)*

Koerner, R. M. (1994), "Designing with Geosynthetics," Prentice Hall, New Jersey, 1994 *(Attachment C, D)*

Luettich, S.M., Giroud, J.P., and Bachus, R.C. (1991), "Geotextile Filter Design Manual," report prepared for Nicolon Corporation, Norcross, GA *(Attachment B)*

Exploration Location	Depth (feet)	Soil Description	Percent Sodium	Percent Sulfate	Total Available Water Soluble sodium Sulfate (%)
B-5	10-15	Silty sand with gravel	0.07	0.13	0.20
B-8	19-20	Silty sand with gravel	0.07	0.06	0.08
B-101	5-10	Silty sand with gravel	0.17	0.06	0.08
B-102	0-5	Fill – Silty sand with gravel	0.17	0.03	0.05
B-106	0-5	Silty sand with gravel	0.15	0.08	0.12
B-106	29-30	Silty sand with gravel	0.15	0.06	0.08

Permeability

Falling head permeability tests were conducted on remolded samples in general accordance with modified ASTM procedure D2434. The soil was compacted in a mold 4.6 inches long and 4.0 inches in diameter to 85 or 90 percent of maximum dry density and at optimum moisture content. A falling head was applied to the sample and the flow of water through the sample was monitored. The permeability was calculated after the flow rate had stabilized. The result of the falling head permeability test is presented in the following table:

Exploration Location	Sample Depth (Feet)	Soil Description	k (cm/s)
B-5	20-25	Silty sand with gravel	5.3×10^{-4}
B-12	10-15	Silty sand with gravel	4.0×10^{-4}
B-102	20-25	Silty sand with gravel	1.0×10^{-4}
B-105	20-25	Well graded sand with silt and gravel	1.2×10^{-3}

Flexible wall permeameter tests were performed on selected samples by AP Engineering and Testing, Inc according to ASTM D5084. With the exception of one sample (B-105), all tested samples were undisturbed ring samples. The samples were placed in a triaxial machine with a constant confining pressure at the approximate in-place effective stress pressures. Results were generally consistent with the fal-

Laverse (1999)

Attachment A

4.2 Define the Hydraulic Gradient for the Application (i_s)

The hydraulic gradient will vary depending on the application of the filter. Anticipated hydraulic gradients for various applications may be estimated using Figure 3.

4.3 Determine the Minimum Allowable Geotextile Permeability (k_g)

After determining the soil hydraulic conductivity and the hydraulic gradient, the following equation can be used to determine the minimum allowable geotextile permeability [Giroud, 1988]:

$$k_g > i_s k_s$$

The hydraulic conductivity (permeability) of the geotextile can be calculated from the permittivity test method ASTM D 4491; this value can often be obtained from the manufacturer's literature as well. The geotextile permeability is defined as the product of the permittivity, ψ, and the geotextile thickness, t_g:

$$k_g > \varphi t_g$$

STEP 5. DETERMINE ANTI-CLOGGING REQUIREMENTS

To minimize the risk of clogging, the following criteria should be met:

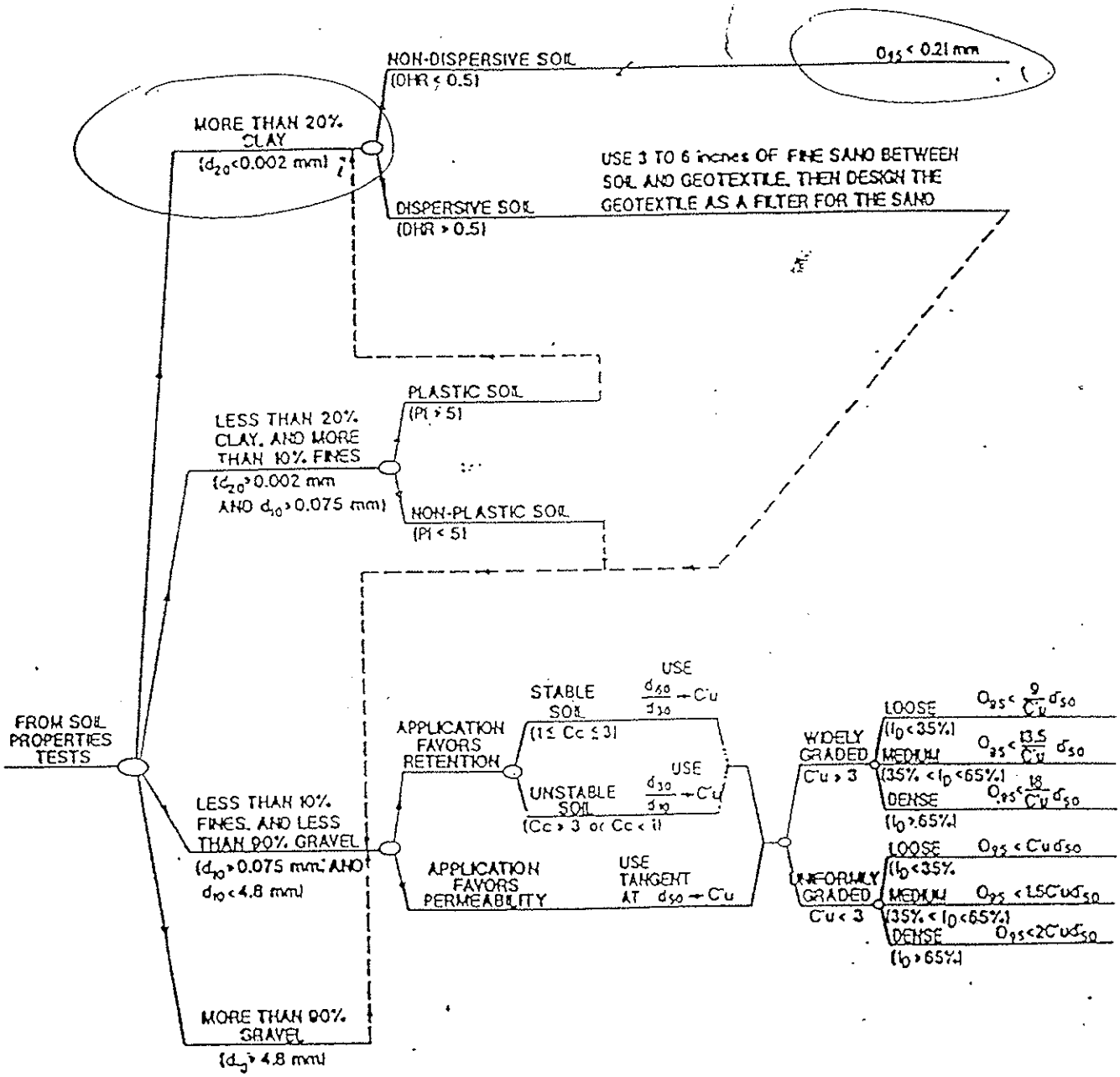
- Use the largest opening size (O_{95}) that satisfies the retention criteria.
- For nonwoven geotextiles, use the largest porosity available, but not less than 30 percent.
- For woven geotextiles, use the largest percent open area available, but not less than 4 percent.

Source: Luettich, S.M. Giroud, J.P. and Bachus R.C (1991) "Geotextile Filter Design Manual" Report prepared for Nicolon Corporation Norcross, GA

ATTACHMENT

P 2/3

CHART 1
SOIL RETENTION CRITERIA
FOR STEADY-STATE FLOW CONDITIONS



NOTES:

d_x is the particle size of which x percent is smaller

$Cu = \sqrt{\frac{d_{100}}{d_0}}$ where: d_{100} and d_0 are the extremities of a straight line drawn through the particle-size distribution, as directed above; and d_{50} is the midpoint of this line.

$Cc = \frac{(d_{30})^2}{d_{60} \times d_{10}}$

I_D is the relative density of the soil

PI is the plasticity index of the soil

DHR is the double-hydrometer ratio of the soil

Portions of this flow chart modified from Giroud (1980)

Source: Luettich, S.M., Giroud, J.P., and Bachus, R.C. (1991) "Geotextile Filter Design

FIGURE 3

TYPICAL HYDRAULIC GRADIENTS[a]

DRAINAGE APPLICATION	TYPICAL HYDRAULIC GRADIENT
STANDARD DEWATERING TRENCH	1.0
VERTICAL WALL DRAIN	1.5
PAVEMENT EDGE DRAIN	1[b]
LANDFILL LCDRS	1.5
~~LANDFILL LCRS~~	1.5
LANDFILL SWCRS	1.5
DAMS	10[b]
INLAND CHANNEL PROTECTION	1[b]
SHORELINE PROTECTION	10[b]
LIQUID IMPOUNDMENTS	10[b]

NOTES: (a) Table developed after Giroud, 1988.

(b) Critical applications may require designing with higher gradients than those given.

Luettich et al. (1991) Attachment B

p. 3/3

Specification for *Survivability*

TABLE C-4 MINIMUM FABRIC PROPERTIES RECOMMENDED FOR FABRIC SURVIVABILITY[a]

Required degree of fabric survivability	Grab strength (lbs.)	Puncture strength[b] (lbs.)	Burst strength[c] (lb./in.^{2})	Trap tear[d] (lbs.)
Low	90	30	145	30
* Moderate	130	40	210	40
High	180	75	290	50
Very high	270	110	430	75

(a) All values represent minimum values (i.e., any roll in a lot should meet or exceed the minimum values in this table).

(b) ASTM D751-68, tension testing machine with ring clamp, steel ball replaced with a 5/16-in.-diameter solid steel cylinder with hemispherical tip centered within the ring clamp.

(c) ASTM D751-68, diaphragm test method.

(d) ASTM D1117, either principal direction.

Korbaek 2nd Edition (1974)

Attachment C 1/1

TABLE C-5 REQUIRED DEGREE OF SI ... ITY AS A FUNC
CONDITIONS AND CONSTRUCTION EQ... ...T[a]

Subgrade conditions	Construction equi: Low ground-pressure equipment (≤4 lb./in.^{2})	N (
Subgrade has been cleared of all obstacles except grass, weeds, leaves, and fine wood debris. Surface is smooth and level such that any shallow depressions and humps do not exceed 6 in. in depth and height. All larger depressions are filled. Alternatively, a smooth working table may be placed.	Low	
Subgrade has been cleared of obstacles larger than small to moderate-sized tree limbs and rocks. Tree trunks and stumps should be removed or covered with a partial working table. Depressions and humps should not exceed 18 in. in depth and height. Larger depressions should be filled.	Moderate	
Minimal site preparation is required. Trees may be felled, delimbed, and left in place. Stumps should be cut to project not more than 6 in. ± above subgrade. Fabric may be draped directly over tree trunks, stumps, large depressions and humps, holes, steam channels, and large boulders. Items should be removed only if placing the fabric and cover material over them will distort the finished road surface.	High	

(a) Recommendations are for 6-12 in. initial lift thickness. For other initial
12–18 in: reduce survivability requirement one level
18–24 in.: reduce survivability requirement two levels
>24 in.: reduce survivability requirement three levels
Survivability levels are, in increasing order: low, moderate, high, and
For special construction techniques such as prerutting, increase fabric s
Placement of excessive initial cover material thickness may cause beari

Source: After Christopher, B., and Holtz, R. D., Federal Highway Admi
Training Manual, Washington, DC.

Table 2.13 Recommended partial factors of safety values for use in Equation 2.25

Application	Various Partial Factors of Safety				
	Soil Clogging and Blinding	*Creep Reduction of Voids*	*Intrusion into Voids*	*Chemical Clogging*	*Biological Clogging*
Retaining wall filters	2.0 to 4.0	1.5 to 2.0	1.0 to 1.2	1.0 to 1.2	1.0 to 1.3
Underdrain filters	5.0 to 10	1.0 to 1.5	1.0 to 1.2	1.2 to 1.5	2.0 to 4.0
Erosion control filters	2.0 to 10	1.0 to 1.5	1.0 to 1.2	1.0 to 1.2	2.0 to 4.0
Landfill filters	5.0 to 10	1.5 to 2.0	1.0 to 1.2	1.2 to 1.5	2.0 to 50
Gravity drainage	2.0 to 4.0	2.0 to 3.0	1.0 to 1.2	1.2 to 1.5	1.2 to 1.5
Pressure drainage	2.0 to 3.0	2.0 to 3.0	1.0 to 1.2	1.1 to 1.3	1.1 to 1.3

do not serve this function, the other, sometimes primary, function will not be served properly. This should not give the impression that geotextiles as separators always play a secondary role. Many situations call for separation only, and in such cases the geotextiles do serve a significant and worthwhile function.

2.5.1 Overview of Applications

Perhaps the target application that can best illustrate the use of geotextiles as separators is their placement between an underlying reasonably firm soil subgrade and a stone base course, aggregate, or ballast placed above the geotextile. We say "reasonably firm" because it is assumed that the subgrade deformation is not sufficiently large to mobilize uniformly high tensile stress in the geotextile. (The application of geotextiles in unpaved roads on soft soils wherein membrane-type reinforcement is developed is treated later in Section 2.6.) Thus for such a separation function to occur, the geotextile must be placed on the soil subgrade and then have stone placed, spread, and compacted on top of it. A number of scenarios can be developed showing what geotextile properties are required for a given situation.

2.5.2 Burst Resistance

Consider a geotextile on a soil subgrade with stone of average particle diameter (d_a) placed above it. If the stone is uniformly sized, there will be voids within it that will be available for the geotextile to enter into. This entry is caused by the simultaneous action of the traffic loads being transmitted to the stone, through the geotextile, and into the underlying soil. The stressed soil then tries to push the geotextile up into the voids within the stone. The situation is shown schematically in Figure 2.26. Giroud [59] provides a formulation for the required geotextile strength which can be adopted for this application.

$$T_{reqd} = \frac{1}{2} p' d_a [f(\epsilon)] \tag{2.26}$$

where T_{reqd} = the required geotextile strength,
p' = the stress at the geotextile's surface, which is less than, or equal to,

Koerner (1994) Attachment D 1/1

MCK 7-13-C

AMOCO WASTE RELATED GEOTEXTILES

MINIMUM PHYSICAL PROPERTIES
(Minimum Average Roll Values)

Property	Test Method	Units	4504	4506	4508	4510	4512	4516
Unit Weight	ASTM D-3776	Oz./yd.²	4.0	6.0	8.0	10.0	12.0	16.0
Grab Tensile	ASTM D-4632	lbs.	95	150	200	235	275	350
Grab Elongation	ASTM D-4632	%	50	50	50	50	50	50
Mullen Burst	ASTM D-3786	psi	225	350	450	550	650	750
Puncture	ASTM D-4833	lbs.	55	90	130	165	185	220
Trapezoid Tear	ASTM D-4533	lbs.	35	65	80	95	115	130
Apparent Opening Size	ASTM D-4751	US Sieve Number	70	70	100	100	100	100
Permittivity	ASTM D-4491	gal/min/ft² sec⁻¹	100 2.0	90 1.7	80 1.5	70 1.1	60 0.9	50 0.7
Permeability	ASTM D-4491	cm/sec	.2	.2	.2	.2	.2	.2
Thickness	ASTM D-1777	mils	40	65	90	110	130	175
U.V. Resistance	ASTM D-4355[1]	%[2]	70	70	70	70	70	70

1. Fabric conditioned per ASTM D-4355 2. Percent of minimum grab tensile after conditioning.

TYPICAL PHYSICAL PROPERTIES

Property	Test Method	Units	4504	4506	4508	4510	4512	4516
Grab Tensile	ASTM D-4632	lbs.	130/115	225/200	275/270	315/310	410/370	510/470
Grab Elongation	ASTM D-4632	%	75	65	65	65	65	65
Mullen Burst	ASTM D-3786	psi	285	410	575	650	825	920
Puncture	ASTM D-4833	lbs.	75	120	170	190	210	270
Trapezoid Tear	ASTM D-4533	lbs.	60/50	100/80	140/120	160/140	185/155	220/190
Apparent Opening Size	ASTM D-4751	US Sieve Number	70/120	70/140	100/200	100+	100+	100+
Permittivity	ASTM D-4491	gal/min/ft² sec⁻¹	150 3.1	110 2.0	100 1.8	80 1.5	70 1.3	60 1.0
Permeability	ASTM D-4491	cm/sec	.35	.31	.27	.26	.25	.23
Thickness	ASTM D-1777	mils	50	75	115	130	150	195

PACKAGING

Dimensions		4504	4506	4508	4510	4512	4516
Roll Width	ft.	15	15	15	15	15	15
Roll Length	ft.	1200	900	600	600	450	300

Amoco Technical Literature — Appendix E Y.
404 984-4441

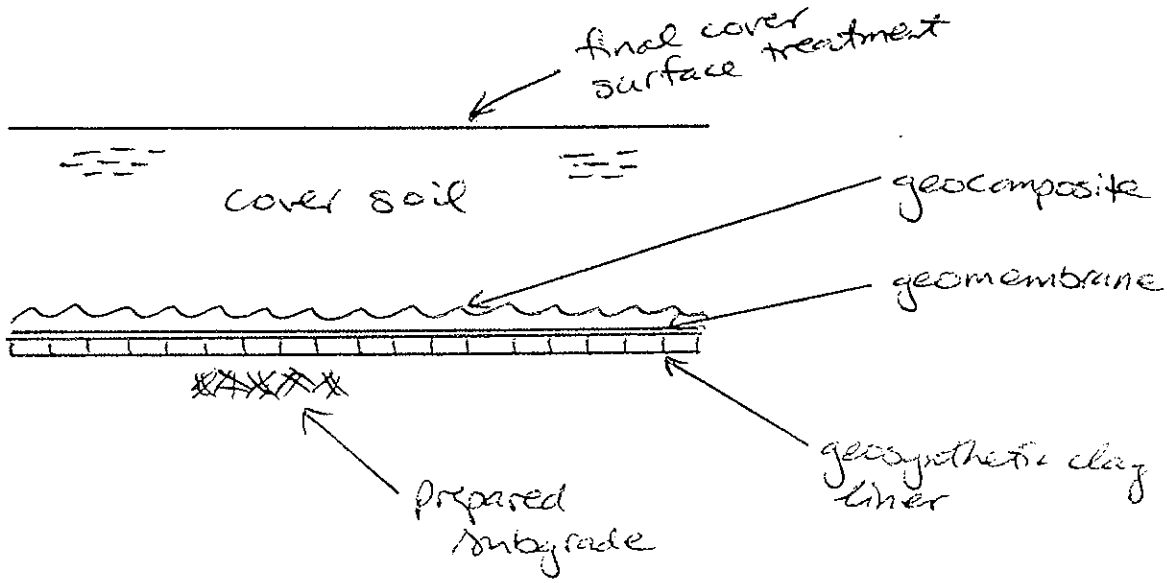
GTC

accuracy or reliability of said information or the performance of any product. Any specifications, properties ... provided as information only and in no way modify, amend, enlarge or create any warranty. Nothing contained herein is to be construed as permission or as a recommendation to infringe any patent.

Written by: GLS Date: 00/07/07 Reviewed by: MK 7-13-00 GTC Date: 00/07/14
YY MM DD YY MM DD

Client: Project: Project/Proposal No.: Task No.:

Final Cover Configuration



SECTION
FINAL COVER

Attachment F
1/1

Calculation Package E
Geotextile Puncture Protection

GeoSyntec Consultants

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: Parsons **Project:** BRC CAMU **Project/Proposal #:** HL0389 **Task #:** 04

Title of Computations: Geotextile Cushion Calculations

Computations By:
SIGNATURE — DATE: 6 July 2000
Geoff L. Smith / Staff Engineer
PRINTED NAME AND TITLE

Assumptions and Procedures Checked By (Peer Reviewer):
SIGNATURE — DATE: 7/11/00
GREGORY T CORCORAN / PROJECT ENG
PRINTED NAME AND TITLE

Computations Checked By:
SIGNATURE — DATE: 7/11/00
GREGORY T CORCORAN / PROJECT ENG
PRINTED NAME AND TITLE

Computations Backchecked By (Originator):
SIGNATURE — DATE: 14 July 2000
Geoff L. Smith / Staff Engineer
PRINTED NAME AND TITLE

Approved By (PM or Designate):
SIGNATURE — DATE: 7/17/2000
Bradford H. Cooley / Project Manager
PRINTED NAME AND TITLE

Approval Notes:

Revisions: (Number and Initial All Revisions)

No.	Sheet	Date	By	Checked By	Approval

Written by: Geoff L. Smith Date: 00 / 07 / 10 (YY MM DD) Reviewed by: Date: 00 / 07 / 11 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 4

GEOTEXTILE PUNCTURE PROTECTION OF GEOMEMBRANE COVER LINER SYSTEM FOR BRC CAMU HENDERSON, NEVADA

OBJECTIVE

A composite final cover liner system is proposed for the Corrective Action Maintenance Unit (CAMU) located in Henderson, Nevada. The objective of this calculation is to evaluate the maximum particle size of soil materials adjacent to the geomembrane that will not puncture the geomembrane. Specifically, the evaluation will consider the gravel component of the local soils (silty sand with gravel, Converse 1999) overlying the cushion geotextile and geomembrane components of the cover liner system and the waste soil underlying the geomembrane and GCL components of the cover liner system.

SUMMARY OF ANALYSIS

The analysis suggests that the following maximum particle sizes and geotextile mass per unit areas will be required:

Soil Component of Liner	Maximum Particle Size	Minimum Mass Per Unit Area
Subgrade	1.5 in	9 oz/yd^2 (GCL)
Silty Sand with Gravel	1.5 in	12 oz./yd^2 (double-sided geocomposite)
Silty Sand with Gravel	1 in	6 oz/yd^2 (single-sided geocomposite)

SITE CONDITIONS

The composite liner system will be comprised of the following components, from top to bottom (Attachment A):

- 2 ft of native soil;
- double-sided geocomposite on side slopes (geonet sandwiched between two 6 oz/yd^2 geotextiles (combined thickness of 12 oz/sy)) OR single-sided geocomposite on top deck (one 6 oz/yd^2 geotextile attached to top of geonet);

- 60-mil (1.5 mm) high-density polyethylene (HDPE) geomembrane;
- a geosynthetic clay liner (GCL) with a combined geotextile mass per unit area of 9 oz/sy; and
- prepared subgrade.

The maximum height of soil to be placed overlying the final cover system is assumed to be 10 ft overlying the geomembrane. This assumes future end-use fill of the area (e.g., golf course fill).

OVERLYING PRESSURE

The unit weight of the cover soil was selected to be 136 pcf based on modified proctor tests conducted on soil samples from the site that are similar to the waste material to be placed as cover soil (Attachment B). The maximum dry density was determined to be 132 pcf at an optimum moisture content of 8.2%. Assuming that the material will be placed at a density less than 95% degree of compaction, the resulting dry density is 125.4 pcf. Adding the weight of the moisture in the soil results in a wet density of approximately 136 pcf.

The following loading conditions was evaluated:

Haul Truck (H-20) Loading

The live load applied by the haul truck was estimated to be 8.7 psi as shown in Attachment D. The dead load consists of the 1.5 ft of cover soil overburden. Therefore the dead load is 1.4 psi (1.5 ft * 136 pcf / 144 psi/psf). The combined load from haul truck (H-20) loading is:

$P = P_{live} + P_{dead} = 8.7 + 1.4 = 10.1$ psi.

Therefore, the vertical pressure on the top of pipe due to H-20 loading is 10.1 psi.

ANALYSIS

APPROACH – Protected Geomembrane

Wilson-Fahmy, Narejo, and Koerner have evaluated puncture protection of geomembranes in a series of three papers. These papers are:

Written by: Geoff L. Smith Date: 00 / 07 / 10 (YY MM DD) Reviewed by: GTC Date: 00 / 07 / 11 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 4

1) Wilson-Fahmy, R.F., Narejo, D., and Koerner, R.M (1996) "Puncture Protection of Geomembranes Part I: Theory", Geosynthetics International, Vol. 3, No. 5, pp. 605-628

2) Narejo, D., Koerner, RM. and Wilson-Fahmy, R.F. (1996) "Puncture Protection of Geomembranes Part II: Experimental", Geosynthetics International, Vol. 3, No. 5, pp. 629-653

3) Koerner, R.M., Wilson-Fahmy, R.F. and Narejo, D. (1996) "Puncture Protection of Geomembranes Part III: Examples", Geosynthetics International, Vol. 3, No. 5, pp. 655-675

These papers present an evaluation of geomembrane puncture theory, the results of a laboratory experimental program, and design examples in regards to puncture protection of geomembranes. The design methods and conclusions of these papers were used for the analysis herein.

According to these papers, the important parameters that affect the puncture protection of geomembranes are: overlying pressure, mass per unit area of the geotextile, and the particle size and shape of the material overlying the geotextile. For the analysis herein, the overlying pressure and the mass per unit area of the geotextile are given, and the maximum particle size is evaluated.

MASS PER UNIT AREA OF GEOTEXTILE

The combined geotextile density overlying the geomembrane will be a minimum of 12 oz/yd^2 (405 g/m^2) on the sides slopes (double-sided geocomposite) and a minimum of 6 oz/yd^2 on the top deck (single-sided geocomposite). The combined geotextile density for the GCL is 9 oz/sy (305 g/m^2).

SIZING MAXIMUM PARTICLE OF SOIL

Narejo et al (1996, Attachment C) present the following equation for evaluating geotextile puncture protection of a 60 mil (1.5 mm) HDPE geomembrane:

$$H^2 = 450\ M_A / P_{allow} \qquad \text{(Attachment C)}$$

Written by: Geoff L. Smith GLS Date: 00 / 07 / 10 (YY MM DD) Reviewed by: GTC Date: 00 / 07 / 11 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 4

where:

M_A = mass per unit area geotextile (g/m^2)
= 405 (12 oz./yd^2 for double sided composite), 305 (9 oz/yd^2 for GCL), and 205 (6 oz./yd^2 single-sided geocomposite);

H = cone height (mm), which corresponds to predicted effective protrusion height, which equals one half maximum stone size (Attachment C).

P_{allow} = maximum allowable pressure = 10.1 psi (

where: P_{allow} = P'_{allow} (MF_S x MF_{PD} x MF_A)(FS_{CR} x FS_{CBD}) (Attachment C)

where: MF_S, MF_{PD}, MF_A = modification factors (discussed below)
FS_{CR}, FS_{CBD} = partial factor of safety values (discussed below)

P'_{allow} = allowable pressure based on field conditions
= (FS) ($P_{actual\ field\ pressure}$)

where: FS = global factor of safety, 3.0
$P_{actual\ field\ pressure}$ = 70 kPa
P'_{allow} = (70)(3) = 210 kPa

MF_S = shape factor:
1.0 (assume angular particles)

MF_{PD} packing density:
1.0 (assume isolated protrusions)

MF_A soil arching:
0.75 (assume moderate)

FS_{CR} partial factor of safety for creep
1.5 (see Table 12)

FS_{CBD} partial factor of safety for chemical and biological degradation
1.5 (based on average value) (Attachment C)

Solving for P_{allow} provides:

Written by: Geoff L. Smith Date: 00 / 07 / 10 (YY MM DD) Reviewed by: GTC Date: 00 / 07 / 11 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 4

P_{allow} = (210) (1.0 x 1.0 x 0.75)(1.5 x 1.5)
P_{allow} = 354 kPa

RESULTS

Solving for H, the predicted effective protrusion height, provides:

$H^2 = 450\ M_A / P_{allow}$

For the three geotextile weights, the following results are:

$H_{cushion} = ((450)(M_A)/(354))^{1/2}$
$M_A = 405\ g/m^2\ (12\ oz/yd^2)$ = 22.7 mm = 0.89 inches

$H_{cushion} = ((450)(M_A)/(354))^{1/2}$
$M_A = 305\ g/m^2\ (9\ oz/yd^2)$ = 19.7 mm = 0.78 inches

$H_{cushion} = ((450)(M_A)/(354))^{1/2}$
$M_A = 205\ g/m^2\ (6\ oz/yd^2)$ = 16.1 mm = 0.64 inches

The predicted effective protrusion height equals one half the maximum stone size. Therefore, the maximum stone size is twice the values listed above.

$M_A = 405\ g/m^2$ = 0.89 inches x 2 = 1.78 inches
$M_A = 305\ g/m^2$ = 0.78 inches x 2 = 1.56 inches
$M_A = 205\ g/m^2$ = 0.64 inches x 2 = 1.28 inches

CONCLUSIONS

Assuming the following:

- the particle shape is angular for the gravel component of the cover soils, and
- the approach presented by Wilson-Fahmy, Narejo, and Koerner for evaluating puncture protection of geomembranes is appropriate for the analysis herein.

then, the calculations suggest that THE MAXIMUM PARTICLE SIZE IS 1.5 IN. for a 12 oz/sy geotextile (combined weight of the double-sided geocomposite) and the 9 oz/sy geotextile

(combined weight for the GCL) and 1 inch for the 6 oz/sy geotextile (single-sided geocomposite).

REFERENCES

Advanced Drainage Systems (ADS) (1994), "ADS Specification Manual", PH: 615-457-3051
Attachment D

Converse Consultants, Inc (1999), *Preliminary Geotechnical and Geologic Investigation, Industrial Non-Hazardous Disposal Facility*, October 1999.
Attachment B

Attachment C:

Koerner, R.M., Wilson-Fahmy, R.F. and Narejo, D. (1996) "Puncture Protection of Geomembranes Part III: Examples", Geosynthetics International, Vol. 3, No. 5, pp. 655-675.

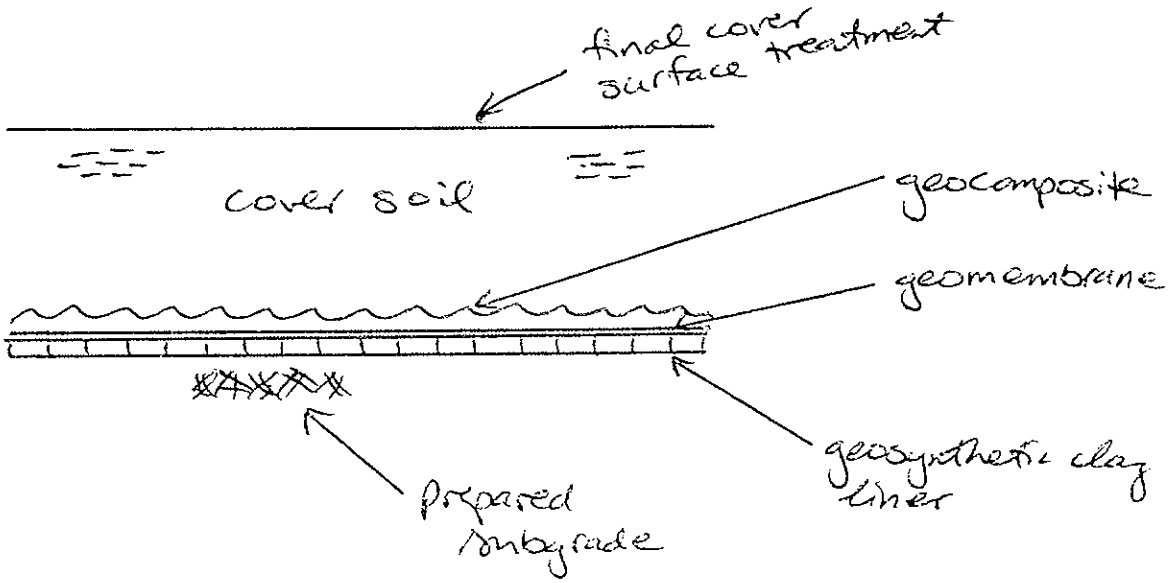
Narejo, D., Koerner, R.M. and Wilson-Fahmy, R.F. (1996) "Puncture Protection of Geomembranes Part II: Experimental", Geosynthetics International, Vol. 3, No. 5, pp. 629-653.

Wilson-Fahmy, R.F., Narejo, D., and Koerner, R.M. (1996) "Puncture Protection of Geomembranes Part I, Theory", Geosynthetics International, Vol. 3, No. 5, pp. 605-628.

Written by: GLS Date: 00/07/07 Reviewed by: GK Date: 00/07/11

Client: ____ Project: ____ Project/Proposal No.: ____ Task No.: ____

Final Cover Configuration



SECTION
FINAL COVER

Attachment A

1/1

shown on Drawing Nos. A-49 through A-56, entitled *Consolidation Test* and are summarized on the following table:

Exploration Location	Depth (feet)	Soil Description	Dry Unit Weight, pcf	Moisture Content, %	Hydrocollapse (percent)*
B-1	29-30	Silty sand with gravel	105	6	3.2
B-8	39-40	Sandy lean clay	57.4	64	0.4
B-8	49-50	Sandy lean clay	69.5	51.1	-0.6
B-10	54-54.5	Sandy lean clay	60.7	67.7	-0.6
B-101	39-40	Sandy lean clay	65.8	45	-0.2
B-101	59-60	Sandy lean clay	73.2	38.3	-0.6
B-102	49-50	Sandy lean clay	67.3	48.7	-0.5
B-105	34-35	Well graded sand with silt and gravel	101	5	0.1

NA: Not available

* A negative sign indicates swell occurred upon inundation with water instead of collapse.

Laboratory Maximum Density

Laboratory maximum density tests were performed on selected samples of the granular soils. The purpose of the test was to define the compaction characteristics of these soils, and to aid in estimating soil shrinkage. The laboratory maximum density test was performed in general accordance with the ASTM D1557 test method. This test procedure uses 25 blow of a 10-pound hammer falling a height of 18 inches on each of five layers of soil in a 1/30 or 1/13 cubic foot cylinder. The test results are presented on Drawing Nos. A-57 through A-61 and in the following table:

Exploration Location	Depth (Feet)	Soil Description	Maximum Dry Unit Weight (pcf)	Optimum Moisture Content (percent) of dry weight)
B-1	20-25	Silty sand with gravel	129.4	8.2
B-5	20-25	Silty sand with gravel	132.1	8.2
B-12	10-15	Silty sand with gravel	129.7	7.9
B-101	5-10	Silty sand with gravel	130.6	8.7
B-105	20-25	Well graded sand with silt and gravel	131.8	7.5

Attachment B

Failure pressure† (kPa)	Applied pressure (% of failure pressure)	Applied pressure (kPa)	Failure time (hours)
140	75	100	130
	50	70	170
	25	35	260
1750*	75	1300	10,000**
3400*	40	1300	10,000**
69	75	52	24
	50	34	42
	25	17	68
320	75	240	140
	50	160	110
	25	80	310
450	85	380	240
	70	310	390
	60	270	1000**
610	75	460	10,000**
55	75	41	0.5
	50	28	2.5
	25	14	40
83	75	62	3
	50	41	12
	25	21	200
103	75	77	192
	50	52	1000**
365	75	270	10,000**

s using Equation 3. **Geomembrane showed signs of yield. † From short term ted cone puncture tests.

RMULATION

on is presented in this section based on the experimental puncture previous sections. The resulting equations predict the allowable DPE geomembranes both with and without geotextile protection.

odification factors are then applied to correlate the truncated cone da actual conditions. The modification factors consider the stone shape, arran t and soil arching. All of these modification factors have a magnitude of 1.0 or le ince the experiments were conducted on a worst-case basis. Partial factors of safety are then incorporated into the design equations to account for creep and chemical/biological degradation. These partial factors of safety are equal to 1.0 or greater since longer periods of time are typically required for these factors to have an effect. Finally, a global factor of safety is applied to account for uncertainties in the formulation. The above described empirical formulation is presented in a step-by-step manner in order to emphasize the various factors involved.

6.2 Basic Design Equation

The formulation for predicting geomembrane failure pressure, p, is based on Figure 3 where it is seen that for each cone height, the failure pressure varies linearly with respect to the mass per unit area of the geotextile. Note that this failure pressure from the experiments is assumed to be the maximum allowable design pressure with an implied global factor of safety of 1.0. Thus, the maximum allowable pressure can be expressed as follows:

$$p_{allow} = d \times M_A \tag{1}$$

where: p_{allow} = maximum allowable pressure (with an implied factor of safety of 1.0); M_A = mass per unit area of the protection geotextile (g/m^2); and d = constant. From Figure 3, it is found that the parameter d can be related to the cone height, H, according to the following equation:

$$d = \frac{450}{H^2} \tag{2}$$

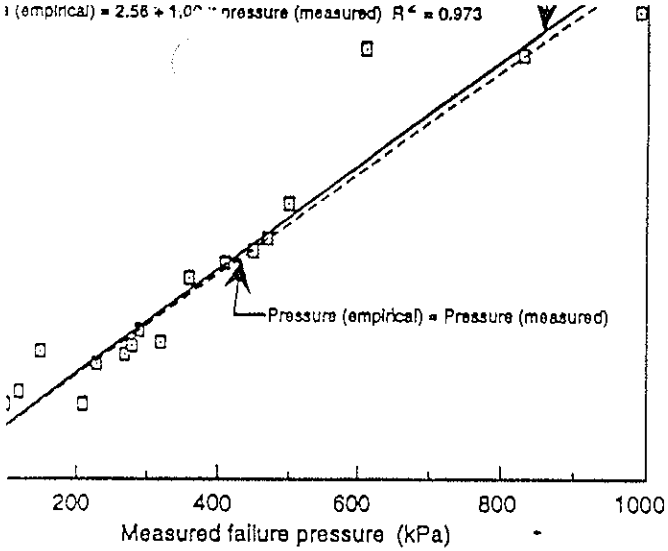
where H is in millimeters.

Combining Equations 1 and 2, the failure pressure can be determined in terms of the cone height and mass per unit area of the protection geotextile as follows (a minimum pressure of 50 kPa is imposed which conservatively corresponds to the failure pressure of the 1.5 mm thick HDPE geomembrane without any protection material):

$$p_{allow} = 450\frac{M_A}{H^2} \geq 50 \text{ kPa} \tag{3}$$

The accuracy of the above equation is depicted in Figure 6 which shows the relationship between the measured failure pressure and the failure pressure predicted using Equation 3. The data in Figure 6 are for polyester geotextiles made from continuous filaments, and polypropylene geotextiles made of staple fibers. Hence, Equation 3 applies to essentially all of the polymer and fiber types used in the nonwoven needle-punched geotextiles.

Attachment C 1/3



d versus empirically predicted failure pressures using Equation 3 for all nched geotextiles evaluated with a 1.5 mm thick HDPE geomembrane. on coefficient.

n Factors

ication factors is now sequentially applied to Equation 3 in order re representing field conditions. The modified pressure will be re-

Factor for the Protrusion Shape

shown that the failure pressure depends on the protrusion shape. e the highest failure pressure followed by subrounded stones. The ire is associated with angular stones and is approximately equal to of truncated cones. In order to account for the effect of stone shape, r is introduced into Equation 3 as follows:

$$p'_{allow} = p_{allow}\left(\frac{1}{MF_S}\right) \tag{4}$$

odification factor for the protrusion shape. Hereafter, p'_{allow} refers odified value of p_{allow} as is illustrated in Figure 6.
sis of the data presented in Section 5.2.1, the modification factors apes are presented in Table 9.

Stone shape	Modification factor, MF_S
Angular	1.00
Subrounded	0.50
Rounded	0.25

6.3.2 *Modification Factor for Packing Density*

It is shown in Section 5.2.2 that the allowable pressure for packed stones is much higher than for isolated stones. Unfortunately, within the capacity of the experimental device, no failure could be achieved with the packed stones, and hence, no direct correlation with isolated stones could be made. However, using the theoretical analysis presented in Part I of this series of papers (Wilson-Fahmy et al. 1996), the pressure at yield for packed stones ($R_o/H = 2$) could be compared with the pressure at yield for isolated stones ($R_o/H = 4$) where R_o is the horizontal distance from a undeformed geomembrane point of tangency with the protrusion tip to the undeformed geomembrane point of tangency with the soil subgrade. The analysis was performed for geomembranes with and without protection. Based on the results, a modification factor of 0.5 is suggested which provides a conservative estimate of the effect of packing density. Thus, Equation 4 can be rewritten after introducing a modification factor for packing density as follows:

$$p'_{allow} = p_{allow}\left(\frac{1}{MF_S \times MF_{PD}}\right) \tag{5}$$

where MF_{PD} is the modification factor for packing density. The modification values presented in Table 10 can be used for isolated protrusions and packed stone arrangements.

6.3.3 *Modification Factor for Soil Arching*

Equation 5 can be further modified as follows to include the effect of soil arching:

$$p'_{allow} = p_{allow}\left(\frac{1}{MF_S \times MF_{PD} \times MF_A}\right) \tag{6}$$

where MF_A is the modification factor for soil arching.

Table 10. Modification factors for packing density.

Protrusion arrangement	Modification factor, MF_{PD}
Isolated protrusions	1.00
Packed stones	0.50

Attachment C
2/3

'actor of 0.17. It be noted, however, that the effect of soil arching at yield may n s great as the effect on the failure pressure. The the geomembra up to yield may not be large enough to mobilize the ct; therefore, caution must be exercised when using the data in Table is recommended that the values in Table 11 be used when soil arching

'actors of Safety

ing the various modification factors (all of which are 1.0 or less), sever- of safety should be applied in order to determine the allowable pressure rane. The partial factors of safety are equal to 1.0 or greater. Two fac- ed below, a partial factor of safety for long term creep and a partial fac- ccount for long term chemical/biological degradation of the materials

'actor of Safety for Creep

r of safety for creep is incorporated into Equation 6, and the allowable calculated as follows:

$$p'_{allow} = p_{allow}\left(\frac{1}{MF_S \times MF_{PD} \times MF_A}\right)\left(\frac{1}{FS_{CR}}\right) \tag{7}$$

e partial factor of safety for creep. Based on the creep data presented ecommended partial factors of safety for creep are given in Table 12.

fication factors for soil arching.

il arching effect	Modification factor, MF_A
None	1.00
Moderate	0.75
Maximum	0.50

al factors of safety for creep.

Partial factors of safety for creep			
Protrusion height (mm)			
38	25	12	6
N/R	N/R	N/R	>>1.5
N/R	N/R	>1.5	1.5
N/R	1.5	1.3	1.2
1.3	1.2	1.1	1.0
~1.2	~1.1	~1.0	1.0

commended.

s in tension. This may be explained by the fact that, in the puncture m the geo- ibrane and its protection material will conform more to the subgrade y creep d hence the unsupported length will decrease with time. It was shown i. I of this series of papers (Wilson-Fahmy et al. 1996) that for the same applied pressure the maximum stress mobilized at the protrusion tip will decrease as the unsupported length decreases. Thus, a decrease in stress in the geomembrane and its protection material is expected with time. Accordingly, a lower factor of safety for creep is required for the puncture mode in comparison to the stress mode in which the material is subjected to a constant tensile stress.

6.4.2 *Partial Factor of Safety for Chemical/Biological Degradation*

The partial factor of safety against chemical/biological degradation, FS_{CBD}, is included in Equation 7 as follows:

$$p'_{allow} = p_{allow}\left(\frac{1}{MF_S \times MF_{PD} \times MF_A}\right)\left(\frac{1}{FS_{CR} \times FS_{CBD}}\right) \tag{8}$$

Although not assessed in this study, the value of FS_{CBD} is felt to range between 1.0 and 2.0 with an average value of 1.5; see Koerner (1994) for discussion and details.

6.5 Global Factor of Safety

After determining an allowable pressure that is suitably adjusted for modification factors and partial factors of safety (Equation 8), a global factor of safety is determined by dividing the allowable pressure by the required pressure as follows:

$$FS = \frac{p'_{allow}}{p_{reqd}} \tag{9}$$

where: p_{reqd} = maximum stress required on the geomembrane; and FS = desired global factor of safety for uncertainties related to site specific conditions.

It is felt that the global factor of safety should never be less than 3.0. Higher values may be used depending on site specific conditions. For example, a high factor of safety should be used in situations where large isolated stones are frequently encountered on the subgrade. Also, a tightly installed geomembrane may also require a larger global factor of safety compared to a geomembrane installed with slack. Furthermore, no modification has been included for in situ temperatures different from the test procedure temperature, i.e. ≈ 20°C. More definitive recommendations for the global factor of safety are made in Part III of this series of papers (Koerner et al. 1996).

Attachment C
3/3

ATTACHMENT E

GTC

Figure 4

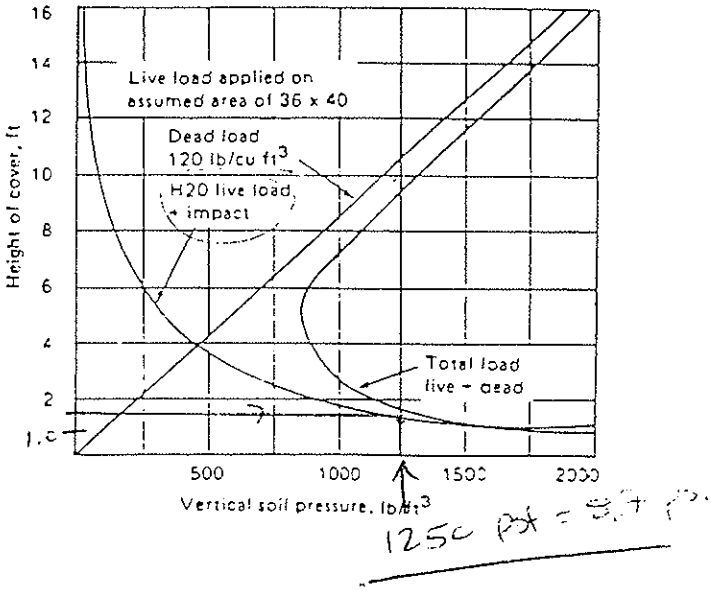


Figure 5

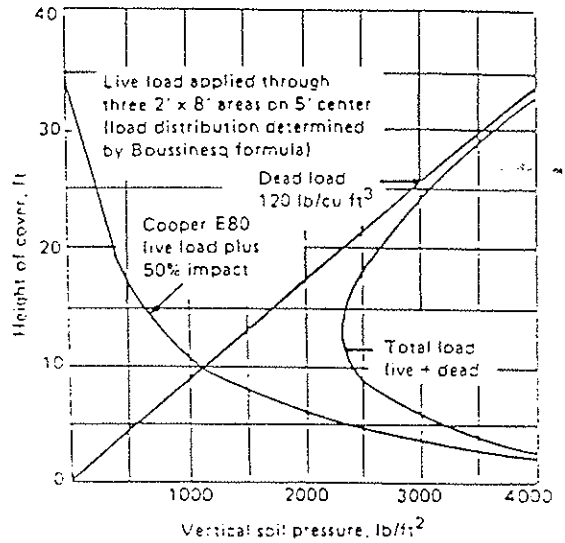
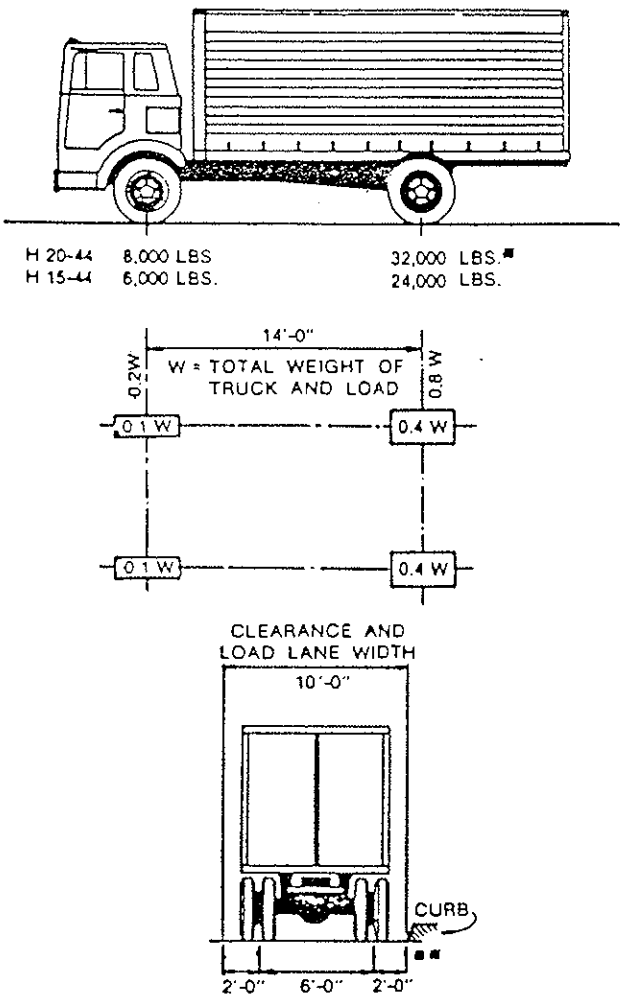
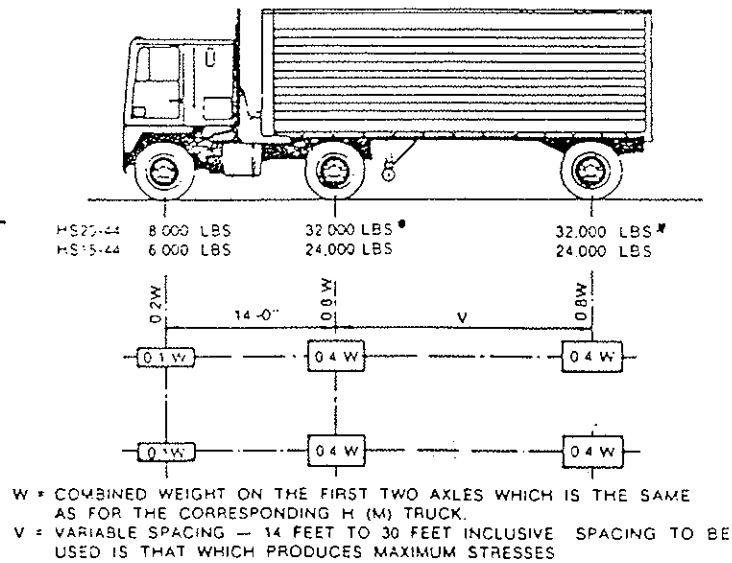


Figure 6





Attachment D
1/1

Calculation Package F
Pipe Strength

GeoSyntec Consultants

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: Parsons **Project:** BRC CAMU **Project/Proposal #:** HL0389 **Task #:** 04

Title of Computations: Pipe Strength Evaluation

Computations By:
SIGNATURE — DATE: 10 July 2000
Geoff L. Smith / Staff Engineer
PRINTED NAME AND TITLE

Assumptions and Procedures Checked By (Peer Reviewer):
SIGNATURE — DATE: 13 JULY 2000
MICHAEL E KALINSKI / SR. STAFF ENG.
PRINTED NAME AND TITLE

Computations Checked By:
SIGNATURE — DATE: 7/14/00
GREGORY T CORCORAN / PROJECT ENG.
PRINTED NAME AND TITLE

Computations Backchecked By (Originator):
SIGNATURE — DATE: 7/14/00
Geoff L. Smith / Staff Engineer
PRINTED NAME AND TITLE

Approved By (PM or Designate):
SIGNATURE — DATE: 7/17/00
Bradford H. Cooley / Project Manager
PRINTED NAME AND TITLE

Approval Notes:

Revisions: (Number and Initial All Revisions)

No.	Sheet	Date	By	Checked By	Approval

Written by: Geoff L. Smith Date: 00 / 07 / 10 (YY MM DD) Reviewed by: 7-13-00 Date: 00 / 07 / 14 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 02

PIPE STRENGTH CALCULATIONS
BRC CAMU
HENDERSON, NEVADA

OBJECTIVE

A 6-in diameter corrugated perforated polyethylene (CPE) pipe will be constructed at the BRC Corrective Action Management Unit (CAMU) in Henderson, Nevada. This pipe will collect and transport the water collected in the geocomposite located above the geomembrane. The objective of this calculation package is to evaluate the pipe strength performance.

SITE CONDITIONS

Crushed gravel will be backfilled around the 6-in pipes. The maximum height of cover soil placed above the pipes will be 1.5-ft.

LOADING CONDITIONS

The following loading condition was evaluated:

Haul Truck (H-20) Loading

The live load applied by the haul truck was estimated to be 8.7 psi as shown in Attachment C, p. 13. The dead load consists of the 1.5 ft of cover soil overburden. Therefore the dead load is 1.4 psi (1.5 ft * 136 pcf / 144 psi/psf). The combined load from haul truck (H-20) loading is:

$P = P_{live} + P_{dead} = 8.7 + 1.4 = 10.1$ psi.

Therefore, the vertical pressure on the top of pipe in the long-term condition is 10.1 psi.

METHOD OF ANALYSES

Ring deflection, wall buckling, and wall crushing of the pipe were evaluated for the loading conditions. The Spangler's Modified Iowa Formula was used to calculate ring deflection. The actual deflection is likely lower due to the arching effects of soil via pipe deflection that are

Written by: Geoff L. Smith Date: 00 / 07 / 10 (YY MM DD) Reviewed by: MSK 7-13-00 GLC Date: 00 / 07 / 14 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 02

neglected in the Modified Iowa Formula. The manufacturer's design manual for ADS corrugated HDPE pipe (ADS, 1994) was used to evaluate wall buckling and wall crushing. The design criteria were based on the manufacturer's design manual for ADS corrugated polyethylene pipe.

ANALYSIS

Evaluating Variables

E' = 1,000 psi for crushed rock, dumped (Attachment C, p. 8/19)

P = Loading of 10.1 psi

EI = pipe stiffness. ADS recommends replacing the pipe EI values with a minimum pipe stiffness value defined as $D^3PS/53.77$ (Attachment C, p. 9/19) where PS = 50 psi for 6-inch diameter pipe at 5% deflection (Attachment C, p. 1/19).

Design by Wall Buckling

Wall buckling is generally the critical failure case for buried pipes. Naturally, this is a starting point. GeoSyntec set the minimum factor of safety for buckling as 2.0.

The critical buckling pressure, P_{cr} is defined (ADS 1994) as:

$$P_{cr} = 2\sqrt{\frac{E'}{1-\nu^2}\left(\frac{D^3PS}{R^3 53.77}\right)}$$ (Equation 1) (Attachment C, p. 10/19)

where:
P_{cr} = critical buckling pressure (psi)
E' = soil modulus = 1,000 psi
ν = Poisson's Ratio = 0.45 for polyethylene pipe (Attachment D)
R = Pipe Radius (in) = 3 in
PS = 50 psi
D = 6 in

Solving Eqn. 4 for P_{cr}, the critical buckling is:

$P_{cr} = 193$ psi

The factor of safety for pipe buckling is defined as:

$FS = P_{cr}/P_T > 2.0$

where P_{cr} = critical buckling pressure at top of the pipe, and
P_T = total soil pressure at the top of the pipe = 10.1 psi

Therefore, the factor of safety for buckling is:

FS = 193 psi / 10.1 psi = 19 > 2.0 O.K.

Check Wall Crushing

The potential for wall crushing under load is checked in the AASHTO design procedure. Wall crushing occurs when the compressive strength of the pipe is exceeded by the overburden soil pressure. The thrust in the wall is calculated as follows:

$T = P * D/2$ (Equation 2) (Attachment C, p. 11/19)

where: T = thrust (lb/ft);
P = design load (psi); and
D = diameter (in).

The design load is 10.1 psi. Therefore, the thrust is evaluated to be:

T = 10.1 psi * 4 in / 2
T = 20.2 lb/in

Using the service load design, the following equation is used to determine the required wall thickness:

$A = T/f_a$

where: A = required wall area (in^2/ft);
T = thrust (lb/ft); and

Written by: Geoff L. Smith GW Date: 00 / 07 / 10 (YY MM DD) Reviewed by: MSC 7-13-00 GTC Date: 00 / 07 / 14 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 02

f_a = allowable minimum compressive strength (psi) divided by a factor of safety of 2.

The compressive yield strength for pipe manufactured by ADS should be limited to 3000 psi (Attachment A, p. 2/3). Assuming a factor of safety of 2.0, the allowable compressive strength of the pipe becomes:

FS = 2.0 = 3000 psi / f_a, therefore f_a = 1500 psi

The required area can then be calculated to be:

A = 50 lb/in / 1500 psi
A = 0.033 in^2 / in

The wall area for 6-inch ADS pipe is 0.107 in^2/in. Therefore, the pipe is sufficient to withstand compressive crushing.

$F.S. = \frac{.107}{.033} = 3.2$ ok.

Written by: Geoff L. Smith Date: 00 / 07 / 10 (YY MM DD) Reviewed by: GTC Date: 00 / 07 / 14 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 02

Check Ring Deflection

Ring deflection is the change in the vertical diameter of the pipe as the pipe/sand system deforms under the external vertical pressure. Ring deflection can be evaluated using Spangler's Modified Iowa Formula formula and can be expressed as follows (ADS 1994):

$$\Delta y = \frac{D_L K_b W_c r^3}{(D^3 PS/53.77) + 0.061 E' r^3}$$ (Equation 3) (Attachment C, p. 9/19)

where:

Δy	= pipe deflection or change in diameter, in.
r	= pipe radius, 3-inch
W_c	= prism soil load, lb/in of pipe, 136 pcf * 1.5 ft = 204 psf = 1.42 psi * 6-in pipe width = 8.5 lb/in of pipe
K_b	= bedding constant, typically 0.1 (Attachment B) (Attachment C, 6/19)
D	= pipe diameter, 6 inches
PS	= pipe stiffness, 50 psi at 5% deflection (Attachment C, 1/19)
E'	= modulus of soil reaction, 1,000 psi (Attachment C, 8/19)
D_L	= deflection lag factor, 1.5 long-term conditions (Attachment B)(Attachment C, 6/19)

Solving for Equation 12 for the critical load yields:

$$\Delta y = \frac{(1.5)(0.1)(8.5)(3^3)}{(6^3)(50)/53.77 + 0.061(1{,}000)(3^3)} = 0.019 \text{ in}$$

Koerner (1994) recommends ring deflections of less than 5 % (Attachment B). The ring deflection for this application is: 0.019-in / 6 in = 0.3 %. Therefore, the ring deflection is acceptable.

SUMMARY AND CONCLUSIONS

Based upon these calculations for pipe ring deflection, wall buckling, and wall crushing, ADS CPE pipe satisfies the design criterion.

Written by: Geoff L. Smith Date: 00 / 07 / 10 (YY MM DD) Reviewed by: MSK 7-13-00 GLC Date: 00 / 07 / 14 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 02

CONSIDERATIONS FOR SPECIFICATIONS

In accordance with the above analyses, the following items should be included in the specifications for construction at the BRC CAMU:

- Pipe shall be corrugated HDPE pipe with a smooth interior wall; and
- A minimum of 1 ft (0.3 m) of cover soil shall be placed over the pipes before a haul truck is allowed to drive over them.

REFERENCES

Advanced Drainage Systems (ADS) (1994), "ADS Specifications Manual", Ph: 614-457-3051
Attachments A and C

Philips 66 (1998), "Driscopipe Systems Design" 800-527-0062
Attachment D

Koerner R.B. (1998), "Designing with Geosynthetics", Fourth Edition, Prentice Hall, p.676
Attachment B

MMSK 7-17-00 GC

Technical Notes

ADS ADVANCED DRAINAGE SYSTEMS, INC.

Technical Note 2.130

Re: Structural Performance of Corrugated PE Pipe Using the Burns and Richard Solution

By: James B. Goddard, Norman E. Kampbell and David P. Kozman

INTRODUCTION

In 1964, Jerome Burns and Ralph Richard presented a break-through paper on the "Attenuation of Stresses for Buried Cylinders" which provided an improved understanding of the stresses around a buried pipe. The analysis is applicable to deeply buried structures where the structure is made from an elastic material and the soil is assumed to be an elastic medium. The circumferential stiffness of the pipe, the bending stiffness of the pipe, and the load transfer between the soil and pipe all influence the loads, in both magnitude and direction (tensile or compression loads). The solution is applicable to any pipe buried in an linearly elastic medium.

The elastic medium parameters are the modulus of elasticity (E′), Poisson's ratio of the soil (μ), the constrained modulus (M′), and the lateral stress ratio (K). These parameters are related by the following equations:

$$M' = \frac{E'(1-\mu)}{(1+\mu)(1-2\mu)} \tag{1}$$

$$K = \frac{\mu}{(1-\mu)} \tag{2}$$

Two additional constants relate to the lateral stress ratio:

$$B = \frac{1}{2}(1+K) = \frac{1}{2}\left(\frac{1}{1-\mu}\right) = \text{symmetrical lateral stress ratio} \tag{3}$$

and

$$C = \frac{1}{2}(1-K) = \frac{1}{2}\left(\frac{1-2\mu}{1-\mu}\right) = \text{antisymmetrical lateral stress ratio} \tag{4}$$

The pipe parameters are the mean radius of the pipe, the circumferential stiffness, and the pipe stiffness (bending stiffness). The circumferential stiffness (or ring compression stiffness) is given by the equation:

M

Attachment A

3300 RIVERSIDE DRIVE COLUMBUS, OH 43221 (614) 457-3051 http://www.ADS-pipe.com

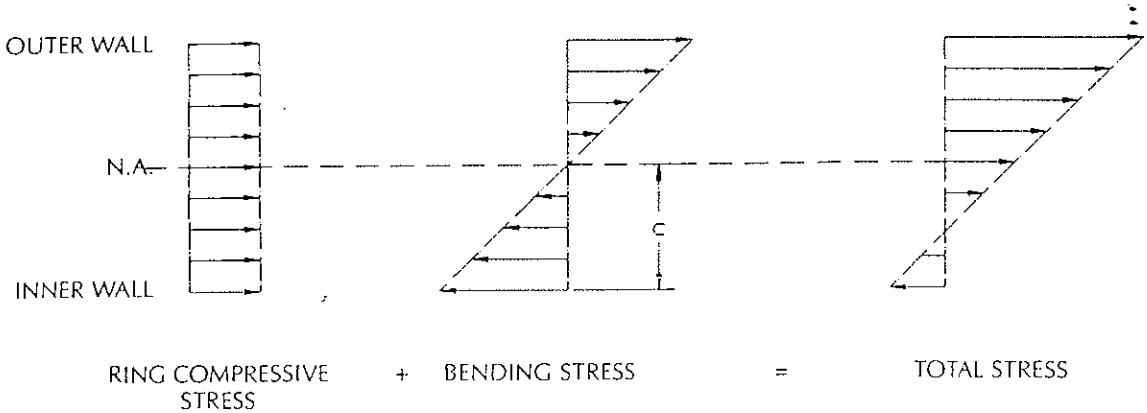


Figure 2: Stress distribution of pipe profile

A great deal can be learned from plots of pipe deflection versus pipe stiffness; moment versus pipe stiffness; thrust versus pipe stiffness; tension versus pipe stiffness ; and compression versus pipe stiffness. As pipe stiffness increases so does the moment, thrust, tension and compression in the pipe wall. All other things remaining constant, as pipe stiffness increases deflection changes very little; it is the soil stiffness that defines deflection performance. Thus it can be said a pipe that is more more compliant is a more structurally capable pipe.

For the design engineer, vertical deflection limits typically will determine the design limits; However, other parameters should also be checked. Circumferential shortening should he limited to less than 2%. Under total stress, inner and outer wall stress should be limited to less than 1,000 psi tensile stress and/or 3,000 psi compressive stress.

SUMMARY

This spreadsheet provides a powerful tool for the design engineer. Installation limits based on deflection, buckling, and circumferential shortening can be selected by the designer, based on his or her experience with pipe installations. It will provide more accurate predictions of pipe performance than the traditional approaches, particularly the "Iowa Formula" for thermoplastic pipes.

The problems with the Iowa Formula:

$$\Delta Y = \frac{W}{\left(EI/R^3 + E'\right)}$$

are:

1. It is assumed that the total stiffness (resistance to deformation) of the soil-pipe interaction system can be estimated by adding the separate stiffnesses of the pipe and the soil. It is far more complicated.
2. The pipe stiffness is a composite of a material stiffness (E) and a geometric stiffness (I/R^3). The soil stiffness (E′) is only a material stiffness.

*MSK 7-13-00 GC

3. The soil stiffness (E′) is empirically arrived at by back calculation of existing installations. This data is from installations with limited cover; typical 25' or less. This makes extrapolations above and beyond the pipes studied vulnerable to error. A single E′ is typically used for a given backfill material and compaction level regardless of depth, which is clearly in error.
4. The load (W) is not truly known. For flexible pipes it is often taken as the Marston load; $W = c_d \gamma B_c B_d$ where c_d is a coefficient dependent upon the depth of burial in the trench, the type of backfill soil, and the nature and extent of a soil arch; typically read from prepared charts. B_c is the OD of the pipe and B_d is the trench width.
5. For viscoelastic materials, like HDPE, the modulus value (E) typically used is based on a test specimen in bending only. There is no consideration of the effect of hoop compression and circumferential shortening; which do effect soil arching and, therefore, soil pressure on the pipe.

The Burns and Richard solution deals with these issues and provides a much more thorough analysis of the pipe response.

Table 1. Predefined MATNAM values and associated soil classes for the overburden dependent model

Young's Modulus (psi) for Overburden Pressures

Soil	MATNAM	5 psi	10 psi	15 psi	20 psi	25 psi	30 psi	40 psi	50 psi	Poisson's Ratio	Density (lb/ft^3)
Granular											
Good	G.GOOD	1,100	1,300	1,500	1,650	1,800	1,900	2,100	2,250	0.30-0.35	110-150
Fair	G.FAIR	550	750	850	1,000	1,100	1,150	1,300	1,400		
Mixed											
Good	M.GOOD	600	850	1,000	1,100	1,200	1,250	1,350	1,450	0.30-0.40	100-140
Fair	M.FAIR	400	550	600	700	750	800	900	900		
Cohesive											
Good	C.GOOD	250	325	375	375	400	400	400	400	0.35-0.40	100-130
Fair	C.FAIR	150	200	225	250	250	250	250	250		

AA

AA. A
3/3

where ΔX = the horizontal deflection or change in diameter, in.,
D_L = the deflection lag factor (varies from 1.0 to 1.5),
K = the bedding constant (varies from 0.83 to 0.110),
W_c = the Marston's prism load per unit length of pipe, lb./in. (note that arching is not taken into account in this formula),
E = the modulus of elasticity of the pipe material, lb./in.^{2},
I = the moment of inertia of the pipe wall per unit length, in.^{4}/in. = in.^{3},
r = the mean radius of the pipe, in., and
E' = the modulus of soil reaction, lb./in.^{2}.

The last mentioned term (E') has been the subject of intense discussion and research. Howard [13] of the U.S. Bureau of Reclamation has recommended the values given in Table 7.6, which have seen relatively wide acceptance.

The preceding equation can also be cast in terms of the laboratory plate loading test with the following result. The equation assumes a bedding constant $K = 0.2$ and uses the ring stiffness constant (RSC).

$$\frac{\Delta y}{d} = \frac{P}{144} \frac{0.1L}{(1.24(RSC)/d + 0.061\ E')} \tag{7.20}$$

where Δy = the vertical pipe deformation (in.),
d = the inside pipe diameter (in.),
P = the load on pipe (lb./ft.^{2}),
L = the deflection lag factor (usually 1.0 to 1.5),
RSC = the ring stiffness constant (lb./ft.), and
E' = the modulus of soil reaction (lb./ft.^{2}).

The ring stiffness constant reflects the sensitivity of the pipe to installation stresses. It is defined in terms of the pipe's deflection resulting from the load applied between parallel plates as per ASTM D2412 (recall Section 7.1.2.1). As described in ASTM F894, RSC is the valued obtained by dividing the parallel plate load in pounds per foot of length by the resulting deflection, in percent, at 3% deflection. Most plastic pipe manufacturers have an empirical formula, along with the necessary tables of their pipe products, for evaluation of RSC values (e.g., see reference 14). The equation also reflects strongly on the type, condition, and placement of backfill both on the sides of the pipe and above it (recall Table 7.6) for values of the modulus of soil reaction (E').

Recognizing the importance of the preceding formulation, several full-scale field and large-scale laboratory trials have been published which give valuable information. Watkins and Reeve [3] have evaluated 15-, 18-, and 24-in. corrugated plastic pipe under standard H-20 truck loadings to determine the minimum cover necessary to prevent pipe damage. They also performed high-pressure, large-scale laboratory tests. Regarding the minimum cover tests, their results showed the response given in Figure 7.9. It can be seen that for a limiting ring deflection of 5% (for this particular pipe), 12 to 15 in. of soil cover is necessary. For the large-scale laboratory tests the setup and typical data were shown in Figure 7.4e.

ADS N-12® PRODUCT FORMATION SHEET

Nominal Diameter	Inside Diameter, Average	Outside Diameter, Average	Wall Thickness, Minimum	Pipe Stiffness @ 5% Deflection	Weight lbs./20 ft. (kg./6 m.)	Area in.²/in.	"I" in.⁴/in.	"C" in.
4" (100 mm)	4.10" (104 mm)	4.78" (120 mm)	0.020" (0.50 mm)	50 psi (340 kN/m²)	8.10 lbs. (3.60 kg.)	0.070	0.0014	0.29
6" (150 mm)	6.00" (152 mm)	6.92" (176 mm)	0.020" (0.50 mm)	50 psi (340 kN/m²)	17.00 lbs. (7.71 kg.)	0.107	0.0036	0.25
8" (200 mm)	7.90" (200 mm)	9.11" (233 mm)	0.025" (0.64 mm)	50 psi (340 kN/m²)	30.80 lbs. (13.97 kg.)	0.135	0.0070	0.27
10" (250 mm)	9.90" (251 mm)	11.36" (287 mm)	0.025" (0.64 mm)	50 psi (340 kN/m²)	45.20 lbs. (20.50 kg.)	0.145	0.0110	0.34
12" (300 mm)	12.15" (308 mm)	14.45" (367 mm)	0.035" (0.89 mm)	50 psi (340 kN/m²)	63.80 lbs. (28.96 kg.)	0.188	0.0410	0.53
15" (375 mm)	14.98" (380 mm)	17.57" (448 mm)	0.035" (0.89 mm)	42 psi (290 kN/m²)	92.50 lbs. (42.00 kg.)	0.217	0.0660	0.66
18" (450 mm)	18.07" (459 mm)	21.20" (536 mm)	0.050" (1.27 mm)	40 psi (280 kN/m²)	128.60 lbs. (58.38 kg.)	0.250	0.0890	0.75
24" (600 mm)	24.08" (612 mm)	27.80" (719 mm)	0.050" (1.27 mm)	34 psi (240 kN/m²)	224.60 lbs. (101.97 kg.)	0.338	0.2310	1.07
30" (750 mm)	30.20" (767 mm)	36.07" (917 mm)	0.050" (1.27 mm)	28 psi (190 kN/m²)	308.30 lbs. (139.97 kg.)	0.353	0.4870	0.69
36" (900 mm)	36.20" (919 mm)	42.46" (1073 mm)	0.050" (1.27 mm)	22 psi (150 kN/m²)	361.20 lbs. (163.98 kg.)	0.361	0.5500	0.46
42" (1050 mm)	41.50" (1054 mm)	46.75" (1187 mm)	0.050" (1.27 mm)	19 psi (140 kN/m²)	530.00 lbs. (240.62 kg.)	0.420	0.7400	1.25
48" (1200 mm)	47.55" (1208 mm)	52.70" (1339 mm)	0.050" (1.27 mm)	17 psi (120 kN/m²)	640.00 lbs. (290.56 kg.)	0.420	0.7400	1.25

Date: March 1, 1996

Attach. C 1/9

Ag

10.4.96 1/13-00 GTC

MMK 1-13-00 GC

Technical Report

ADS
ADVANCED DRAINAGE SYSTEMS, INC.

Technical Report 4.103

Re: Plastic Pipe Design
Date: November 1, 1994
By: J. B. Goddard

Introduction

To most of the engineering profession there was little time spent on underground structure design, particularly small pipe design, in our undergraduate studies. Bridges, large buildings, and pavement design occupied most of our time and our interest. This occured despite the fact that nearly 10% of our transportation construction dollars go for drainage structures. This is particularly interesting since a number of engineering professors have stated that the three most important considerations in pavement design are drainage, drainage, and drainage.

This lack of emphasis in our training is further exacerbated when considering plastic pipe design in that our structural design courses focused on rigid and elastic materials but spent little or no time on viscoelastic materials. A review of my own college texts reveal a total of three pages on viscoelastic properties.

In considering pipe design, generally, pipes are divided into two categories, rigid and flexible. Rigid pipes are defined as those that will not accept deflection without structural distress. Flexible pipes are defined as those that will deflect at least 2% without structural distress. Concrete, clay, and cast iron pipe are examples of rigid pipes. Steel, aluminum and plastic pipes are usually considered flexible. Within those pipes defined as flexible, the metal pipes would be considered elastic and the thermoplastic pipes would be viscoelastic or viscoplastic. Individual pipe types may have different performance limits based on type, material and wall design. The strength to resist wall stresses due to external load is critical for rigid pipe; while for flexible pipe, stiffness is important in resisting deflection and possibly buckling. Wall area may also be a factor to consider in design. For all buried pipe, rigid or flexible, the "structural performance is dependent on soil structure interaction. The type and anticipated behavior of the material beneath the structure, adjacent to the structure, and over the structure must be considered". (From paragraph 17.1.6, AASHTO Standard Specifications for Highway Bridges). Also, "It must be recognized that a buried plastic pipe is a composite structure made up of the plastic ring and the soil envelope, and that both materials play a vital part in the structural design of plastic pipe". (From paragraph 18.1.1, AASHTO Standard Specifications for Highway Bridges). Both these statements apply to rigid or flexible pipe.

Attach. C

2/19

3300 RIVERSIDE DRIVE COLUMBUS, OH 43221 (614) 457-3051 http://www.ADS-pipe.com

MSK 7-13-00 GTC

To put the differences between rigid, elastic, and viscoelastic materials in the simplest possible terms consider the following; the hard candy stick, licorice, and a hershey bar. The hard candy (the rigid structure) shatters if you attempt to bend it, regardless of loading rate. The hershey bar (the elastic structure) flexes under load but returns to shape unless that load exceeds the yield point. Beyond the yield point, the material takes a permanent set or deformation. At some amount of strain, the elastic material fails. The licorice (the viscoelastic material) responds differently depending on the rate at which the load is applied. If the load is applied very rapidly, the strength of the material is quite high. If a much lower load is placed on the licorice, it will slowly elongate. If the elongation is fixed at some constant strain, the licorice will relieve itself of stress. Although helpful in visualizing the differences in these materials,this perspective is inaccurate in that the pipe wall in non-pressure pipe is normally in compression, not tension. Because of that, the tendency is for the pipe wall to compress and thicken under load rather than stretching and thinning (or necking down). The impact of that is to increase cross-sectional or wall area while, at the same time, stress relaxation is taking place. The impact of this is discussed later in the design section.

Design Theory

The proof of any design theory should be how accurately it predicts the point and mode of failure in the product under the anticipated loading conditions. Unfortunately, current non-pressure pipe design procedures do not pass this test, regardless of major pipe types. Rigid pipe practice tends to predict quartering of the pipe as a failure mode when in fact wall shear is more common. Metal pipe design predicts circumferential wall crushing as the failure mode, a phenomenum I have never seen in the field, where localized buckling is a more typical failure mode. In defense of both theories; however, they appear to be generally conservative in that there are few structural failures of standard production pipe supplied by either industry, unless blatantly abused in installation and handling.

The same can generally be said for standard production thermoplastic pipe supplied by the major producers in that there have been few structural failures of these products. Design theory for these products is considerably more confusing, in part because the products represented are only about 30 years old (versus 100 years for steel and antiquity for concrete) and in part because of the variation in wall design and materials (primarily PVC and HDPE).

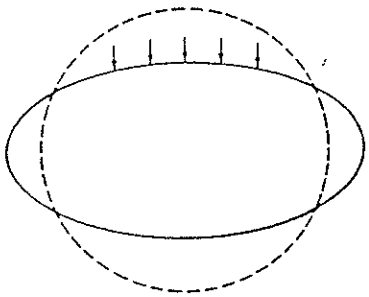
Prior to developing a design procedure, performance limits must be established. Deflection, wall buckling, stress, and strain are normally considered performance limits for flexible pipes.

AM

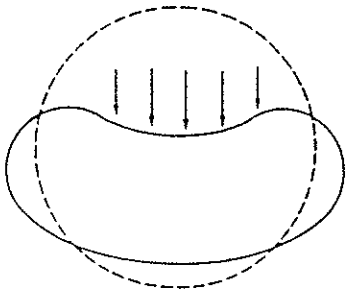
Att. C
3/19

MK 7/13-CC GC

Deflection limits are set to avoid reversal of curvature, limit bending stress and strain, and avoid pipe flattening. Excessive deflection may reduce the flow capacity of the pipe and may cause joint leakage. Deflection of flexible pipe is primarily controlled by the method of installation and the backfill and insitu soil properties.

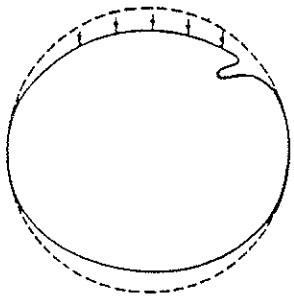


Ring deflection in a flexible pipe



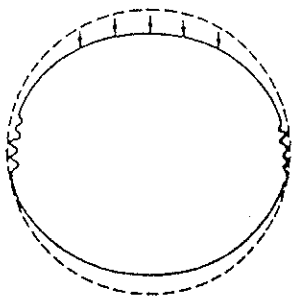
Reversal of curvature due to over-deflection

Wall buckling should be considered. Large diameter flexible pipe design may be governed by buckling, particularly when subjected to high soil pressures in low stiffness soils.



Localized wall buckling

Wall stress in compression can theoretically lead to wall crushing if excessive. If the ring compressive stress is greater than the compressive strength of the wall of the pipe, wall crushing may occur. The viscoelastic properties of thermoplastic material make this mode of failure very unlikely and field and lab tests tend to confirm that view.



Wall crushing at the 3 and 9 o'clock positions

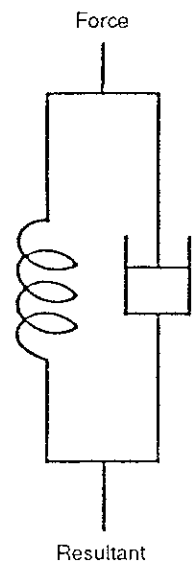
Pipe wall strain, generally in bending should be checked. Typically, these are outer wall fiber strains brought about by excessive deflection or localized deformations. Strain limits for thermoplastic pipe materials are generally assumed to be from 3.5 to 8% depending on wall design and resin used. Note that this is fiber strain, not deflection.

Att. C

4/17

The equations to determine deflections, wall buckling, wall stress, and wall strain were developed primarily for evaluating flexible pipes manufactured from elastic materials and do not adequately reflect the effect of viscoelastic properties; in some cases treating a positive attribute as a negative. Again, using an analogy, the viscoelastic material is treated as a spring and dash pot (or shock absorber) connected in parallel with the spring handling sudden or short term loads and the dash pot responding to long term loads. The effect of this combined response is significant on the soil structure interaction system. (Figure 1)

Figure 1



Design Practice

1. Deflection

Probably the most commonly used formula in plastic pipe design is Spangler's Iowa Deflection Formula. It, at least in some form, is referenced or utilized in the ASCE Plastic Design Manual; by Moser in his textbook, Buried Pipe Design; by Koerner in his textbook, Designing With Geosynthetics; by the Bureau of Reclamation; and by the Environmental Protection Agency. The most common form of the equation is:

$$\Delta x = D_L\,(kWr^3)/(EI + 0.061\,E'r^3) \qquad (1)$$

Where:	Δx	=	Horizontal deflection of the pipe in inches
	D_L	=	Deflection lag factor (usually 1.5)
	k	=	Bedding constant
	W	=	Load per unit length of pipe in lbs/linear inch
	r	=	Pipe radius in inches
	E	=	Modulus of elasticity of pipe material in lbs/in2
	I	=	Moment of inertia of the pipe wall in in4/in
	E'	=	Modulus of soil reactions in lbs/in2

Developed by Dr. Merlin G. Spangler based on work begun in 1927 with rigid and flexible pipes, this built on previous work by Dr. Marston which predicted loads on culverts. The form above is the modified formula developed by Dr. Reynold Watkins based on his work in 1958.

It should be noted that this equation was developed largely from test installations with from 15 to 25 feet of cover.

MSK 7-13-cc

GC

A number of factors in the equation are contentious and deserve explanation:

A. The deflection lag factor (D_L) was included in the equation because Dr. Spangler believed that deflections could increase as much as 30% over a period of 40 years. He recommended a D_L of 1.5 to be conservative. We now know virtually all of the deflection occurs during the first year, therefore a D_L of 1.0 may be used.

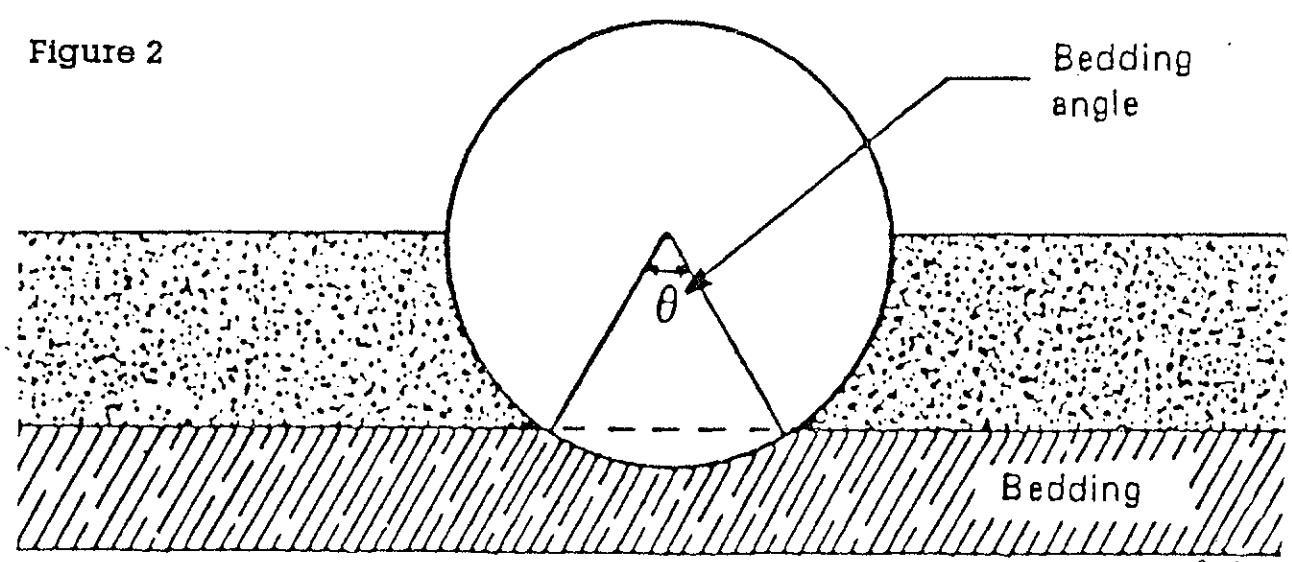
B. The bedding constant (k) is usually assumed to equal 0.1, although, as shown in Table 1, other values may be appropriate for specific installation conditions. A bedding angle (see Figure 2) of 0° would indicate a very firm foundation which would not be recommended for any pipe type.

Table 1

Values of Bedding Constant, K

Bedding angle, degrees	K
0	0.110
30	0.108
45	0.105
60	0.102
90	0.096
120	0.090
180	0.083

Figure 2



Att C.
6/19

C. The load per unit length of pipe (W) is Marston's prism load, which assumes that the entire weight of the vertical prism of soil over the pipe is pressing down on the pipe. For very deep fills, this is probably very conservative in that it assumes no soil arching. This may be unconservative for very shallow cover.

D. The modulus of soil reaction E' has been studied extensively and continues to be a point of contention between rigid and flexible pipe manufacturers. Probably the most used values are those developed by Amster Howard of the U.S. Bureau of Reclamation and shown in Table 2. These values are based on field measurements of flexible pipe installations whose installation conditions were known and then back calculating to find the E' values.

Recent work by Dr. Mike Duncan at V.P.I. indicates that E' varies with depth. When looked upon as a confining pressure, this seems logical. Amster Howard's work limits his E' values to 50 foot or less. Richard Chamber's work published in 1980 showed that E' can be replaced by M_s (constrained soil modulus) in the Iowa Formula. M_s does vary with depth. Dr. Duncan's values are shown in Table 3. These values may be more appropriate than those shown in Table 2.

Values of E' have been given as high as 8,000 psi in very high fills.

Selection of the appropriate E' value is up to the design engineer who must make that decision based on experience and knowledge of the project conditions. Clearly, values less than 400 psi would indicate backfill conditions inappropriate for pipe installation.

AH. C
7/19

7-13-00

Table 2

Average Values of Modulus of Soil Reaction, E'
(For Initial Flexible Pipe Deflection)

Soil type-pipe bedding material (Unified Classification System*)	E' for degree of compaction of bedding, lb/in²			
	Dumped	Slight, < 85% proctor, < 40% relative density	Moderate, 85%-95% proctor, 40%-70% relative density	High > 95% proctor > 70% relative density
Fine-grained soils (LL > 50) † Soils with medium to high plasticity CH, MH, CH-MH	No data available; consult a competent soils engineer; Otherwise use E' = 0			
Fine-grained soils (LL < 50) Soils with medium to no plasticity CL, ML, ML-CL, with less than 25% coarse-grained particles	50	200	400	1000
Fine-grained soils (LL < 50) Soils with medium to no plasticity CL, ML, ML-CL, with more than 25% coarse-grained particles Coarse-grained soils with fines GM, GC, SM, SC contains more than 12% fines	100	400	1000	2000
Coarse-grained soils with little or no fines GW, GP, SW, SP‡ contains less than 12% fines	200	1000	2000	3000
Crushed rock	1000	3000	3000	3000
Accuracy in terms of percentage deflection§	± 2	± 2	± 1	± 0.5

* ASTM Designation D2487, USBR Designation E-3
†LL - liquid limit
‡ Or any borderline soil beginning with one of these symbols (i.e., GM-GC, GC-SC)
§ For ± 1% acuracy and predicted deflection of 3%, actual deflection would be between 2 and 4%

NOTE: Values applicable only for fills less than 50 ft (15 m). Table does not include any safety factor. For use in predicting initial deflections only, appropriate deflection lag factor must be applied for long-term deflections. If bedding falls on the borderline between two compaction categories, select lower E' value or average the two values. Percentage proctor based on laboratory maximum dry density from test standards using about 12,500 ft-lb/ft³ (598,000 J/m¹) (ASTM D698, AASHTO T-99, USBR Designation E-11). 1 lb/in² = 6.9 kN/m².

SOURCE: Amster K. Howard, "Soil Reaction for Buried Flexible Pipe", U.S. Bureau of Reclamation, Denver, Colorado. Reprinted with Permission from American Society of Civil Enginers J. Geotech Eng. Div., January 1977, pp. 33-43.

Att. C
8/19

One variation to the Modified Iowa Formula that can simplify its use is replacing the pipe EI values with a minimum pipe stiffness value as shown below:

$$\Delta x = D_L\ [kWr^3/[(D^3PS/53.77) + (0.061\ E'r^3)]] \qquad (2)$$

Minimum pipe stiffness values are provided in the pipe specification in ASTM and AASHTO.

PS = Pipe stiffness in #/in/in
D = Pipe diameter in inches

One additional design approach intended in part to limit installation deflections and ensure construction survivability is the use of flexibility factor in the AASHTO design procedure. Based on earlier experience with corrugated steel and corrugated aluminum pipe, AASHTO has set a minimum flexibility factor for thermoplastic pipes at 0.095, based on the following formula:

$$FF = D^2/EI \qquad (3)$$

Where:
D = Pipe diameter in inches
E = Modulus of elasticity in PSI
I = Moment of inertia of the pipe wall in in^4/in.

To utilize minimum specified pipe stiffness (PS), this equation becomes:

$$FF = 53.77/(PS \times D) \qquad (4)$$

From this, Table 4 can be generated:

Table 4

Pipe Stiffness For FF = 0.095

Pipe Diameter (in)	Pipe Stiffness (#/in/in)
12	47.17
15	37.73
18	31.44
24	23.58
30	18.87
36	15.72
42	13.48
48	11.79
54	10.48
60	9.43

Att. C
9/19

Considerable experience with pipe sizes 48" and smaller and with stiffness values equal to or greater than those given has shown that these products perform well with good installation procedures. More flexible structures can be successfully installed if special care is exercised.

2. Wall Buckling

Wall buckling can govern design of flexible pipes subjected to high soil pressures, external hydrostatic pressure, or internal vacuum. The more flexible the pipe, the lower the resistance to buckling. Caution should be exercised when considering large diameter pipes or pipes in shallow burial. Buckling equations assume the external pressure is reasonably uniform around the pipe. From Dr. Moser's textbook, the following equation offers a relatively simple equation that has been shown to be conservative for thermoplastic pipe.

$$P_{cr} = 2\sqrt{\frac{E'}{1-v^2}\left(\frac{EI}{R^3}\right)} \qquad (5)$$

Where:

Pcr	=	Critical Buckling Pressure (PSI)
E'	=	Soil Modulus (PSI)
v	=	Poisson's Ratio
E	=	Modulus of Elasticity (Pipe Material) (PSI)
I	=	Moment of Inertia (in_4/in)
R	=	Pipe Radius (in)

AASHTO and ASCE use a somewhat different approach, relying on variations of the AWWA equation. The current AASHTO version is as follows:

$$Pcr = 9.24\ (R/Ap)\sqrt{C_W\ M_S\ EI/0.149R^3} \qquad (6)$$

Where:

R	=	Pipe Radius (in)
M_S	=	Soil Modulus (PSI)
C_W	=	Water Buoyancy Factor = (1 - 0.33 hw/h)
		Where hw = Height of water above top of pipe
		h = Height of ground surface above top of pipe
Ap	=	Pipe Wall area (in^2/in)

For viscoelastic materials, the E value in this equation is normally the long-term E value, either 10 yr or 50 yr.

MSK 7/3-00

GTC

3. Wall Crushing

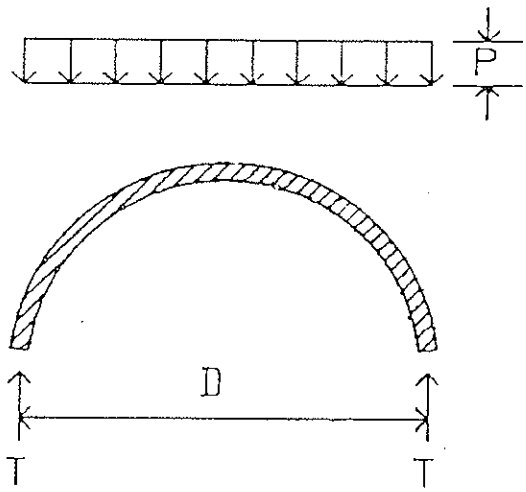
Based on ring compression theory developed for metal pipe, the potential for wall crushing under load is checked in the AASHTO design procedure. According to the AASHTO procedure, this can be addressed in two ways, using service load design or load factor design. Both start by calculating the thrust in the wall as follows:

$$T = P \times D/2 \qquad (7)$$

Where T = Thrust in pounds/foot
P = Design Load in PSI.
D = Diameter in ~~Feet~~ inches

This is represented by the free body diagram in Figure 3.

Figure 3



AH C.
11/19

MSK 7.13-CA

GK

The design load is generally assumed to be the weight of the soil load above the pipe calculated by multiplying the soil density times the height of cover. Any anticipate live load must be added to this dead load. Live loads are given in Table 5 and shown on Figure 4, 5, and 6.

Table 5

Live Loads on Flexible Pipe
(Live Load Transferred to Pipe, lb/in²)

Height of Cover	Highway	Railway	Airports
(FT)	H20	E80	
1	12.50	N.R.	N.R.
2	5.56	26.39	13.14
3	4.17	23.61	12.28
4	2.78	18.40	11.27
5	1.74	16.67	10.09
6	1.39	15.63	8.79
7	1.22	12.15	7.85
8	0.69	11.11	6.93
10	N.S.	7.64	6.08
12	-	5.56	4.76
14	-	4.17	3.06
16	-	3.47	2.29
18	-	2.78	1.91
20	-	2.08	1.53
22	-	1.91	1.14
24	-	1.74	1.05
26	-	1.39	N.S.
28	-	1.04	-
30	-	0.69	-
35	-	N.S.	-
40	-	-	-

Notes: H20 load simulates 20 ton truck traffic and impact.
E80 load simulates 80,000 lb./ft. railway load and impact.
Airport load simulates 180,000 lb. dual tandem gear, 26 inch spacing between tires and 66 inch center-to-center spacing between fore and aft tires under rigid pavement 12" thick plus impact.

N.S.= Not Significant
N.R.= Not Recommended

AH C.
12/19

MSK 7/13-00

GTC

Figure 4

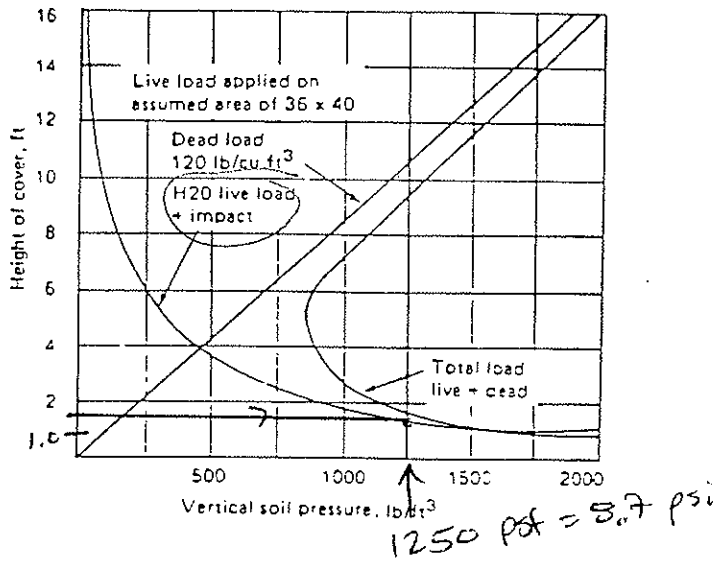


Figure 5

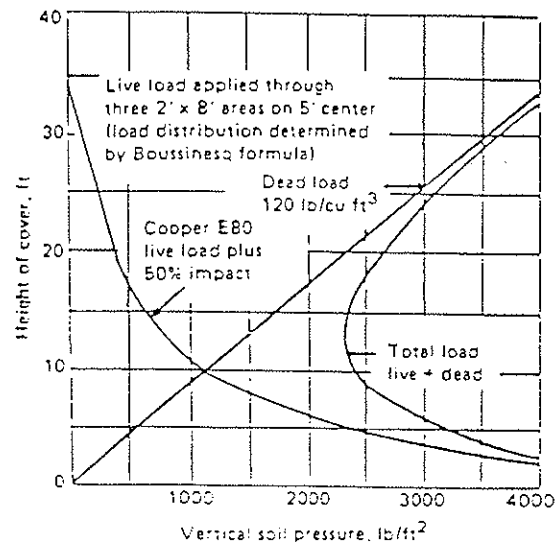
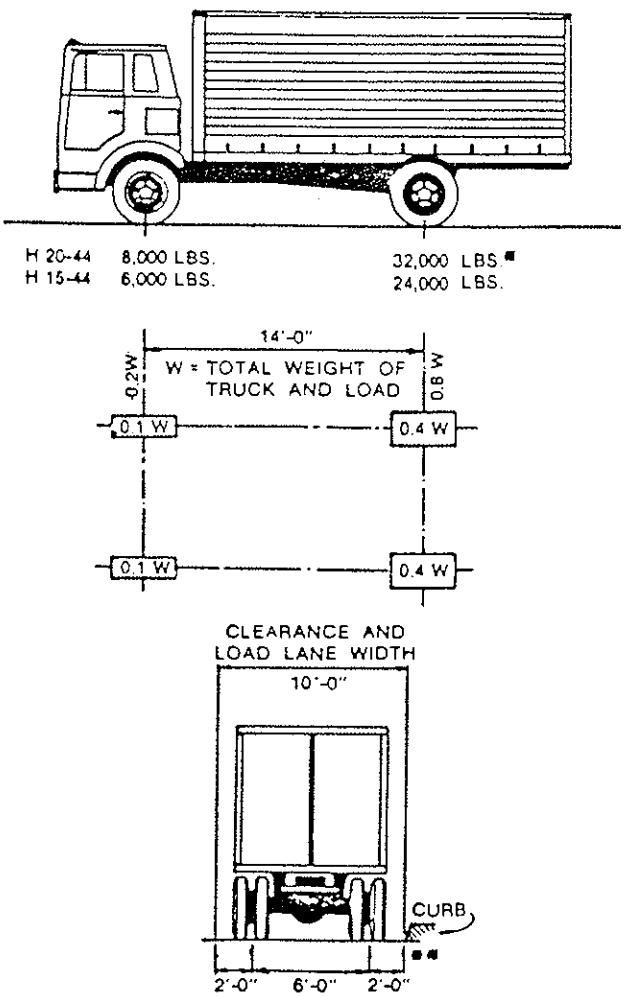
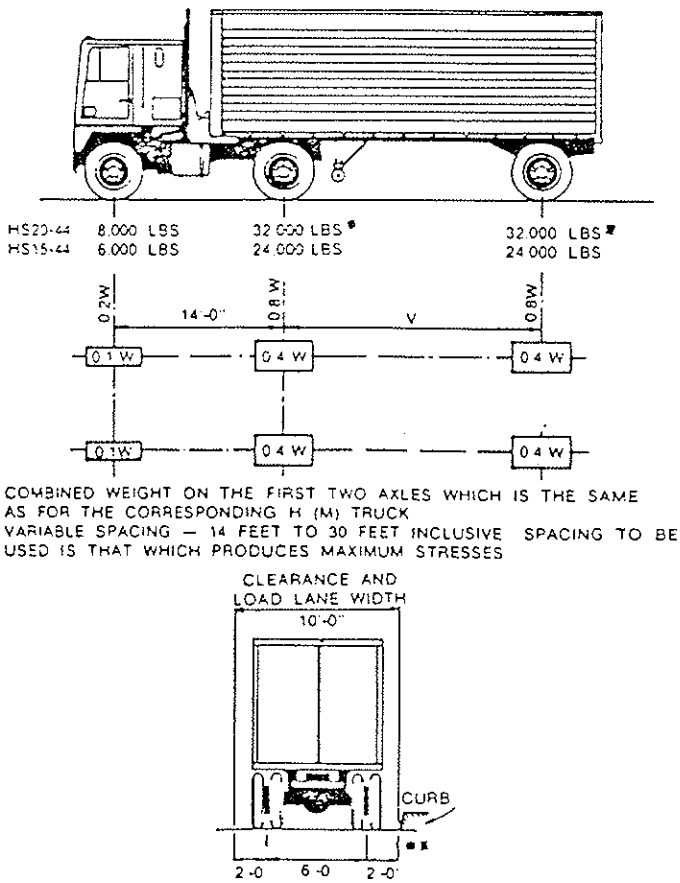


Figure 6





Att. C

13/19

With the wall thrust determined, the required pipe wall area necessary can then be calculated. AASHTO provides two approaches to this, Service Load Design and Load Factor Design. Service Load Design is a working stress method while Load Factor Design is based on ultimate strength principles. Using Service Load Design, the following equation is used to determine required wall area:

$$A = T/fa \qquad (8)$$

Where:	A	=	Required wall area in in^2/ft
	T	=	Thrust in #/ft
	fa	=	Allowable minimum tensile strength in PSI divided by a safety factor of 2

Using Load Factor Design, the following approach is used:

$$A = T_L/\varnothing\ fu \qquad (9)$$

Where:	T_L	=	Load factor modified thrust
	fu	=	Specified minimum tensile strength in PSI
	Ø	=	Capacity modification factor

For flexible conduits, $T_L = T/(1.5 \times 1.3)$, where 1.3 = load factor and 1.5 = beta factor (from section 3, AASHTO Bridge Guide Manual). Phi (Ø) equals 1.0 (from section 18).

This approach has been used successfully with metal pipe for many years. For plastic pipe (viscoelastic), there are a couple of fundamental errors that lead the designer to very conservative designs. The most obvious error is the use of tensile strength values in calculating wall area in compression. At least with the principle resins used in the manufacture of thermoplastic pipe, PVC, and HDPE, the allowable values should be higher in compression.

The second error is that the calculated soil load is still based on the weight of the soil prism over the pipe without any consideration of soil arching, which has been proven in a number of research studies to reduce the load considerably in very deep fills.

The third error is the use of long term material properties rather than initial strength in these calculations. When backfilled with Type I, Type II, or compacted Type III soils, it is appropriate to assume the pipe is subjected to repeated dynamic loads from the successive settling of the soil. Because stresses in the pipe wall relax, design should be based on the instantaneous modulus of elasticity and compressive strength.

4. Pipe wall strain is mostly a post-construction concern. Within the normally specified deflection limitations, allowable outer fiber tensile strains are not a concern. If, however, due to poor installation localized deformations occur, wall strain should be checked. Allowable strains for the resins used for thermoplastic

MSK 7-13-00

GK

pipe are 3.5 to 5% for PVC and 4 to 8% for HDPE. To check bending strain, the following equation should be used:

$$E_b = 6\left(\frac{t}{D}\right)\left(\frac{\Delta Y}{D}\right) \qquad (10)$$

Where:	E_b	=	Bending strain
	t	=	Wall thickness
	D	=	Diameter
	ΔY	=	Vertical deflection

Total circumferential strain may also include (in addition to bending strain) ring compression strain and strain due to Poisson's effect. Ring compression strain is:

$$E_c = P_v D/2tE \qquad (11)$$

Where:	E_c	=	Ring compression strain
	P_v	=	Vertical soil pressure
	E	=	Modulus of elasticity

The contribution to circumferential strain due to the Poisson effect caused by longitudinal strain is:

$$E = -v \times L_S \qquad (12)$$

Where:	E	=	Circumferential Poisson's strain
	v	=	Poisson's ratio
	L_S	=	Longitudinal strain

As noted, these strains are additive. Compressive strains reduce tensile strains.

In order to properly design any plastic pipe, it is necessary to know the section properties of the pipe; including inside and outside diameter, pipe wall area; wall centroid, and moment of inertia. Also, the minimum resin properties including short and long term tensile strength, modulus of elasticity, and compression strength as well as allowable long term strain. These values will be available in the referenced specifications or from the manufacturers.

Installation

As noted in the introduction, design of any buried structure, be it rigid or flexible, depends on the interaction of the pipe structure and the surrounding soil (or backfill). Sound installation practice assures satisfactory structural performance. Fortunately, for thermoplastic pipe, there is an excellent installation specification in ASTM, ASTM D2321, Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications. This specification is particularly helpful in its classification of embedment and backfill materials and its recommendations for

AH. C

15/19

MSK 7-13-00

GK

their use. It also includes guidance as to the compatibility of backfill materials with various soil types, particularly in terms of migration of fines. Minimum compaction levels for different backfill classes are provided and should be followed. These are based on providing an E' (modulus of soil reaction) value of 1,000 psi, as used in the deflection formula (1).

In typical conditions, the minimum trench width is determined by the size of the pipe and the ability to get compaction equipment between the pipe and the trench walls. The minimum trench width should not be less than the outside diameter plus 16 inches or the pipe outside diameter times 1.25 plus 12 inches; whichever is greater. High speed trenchers may enable satisfactory installation of pipe in narrower trenches. Poor insitu soil conditions such as peat, muck, running sands, or expansive clays will require substantially wider backfill as well as deeper foundation and bedding. Trench width and foundation depth should be based on a thorough site investigation.

Other means of trench control through poor insitu soils include wrapping the backfill and bedding material with a geotextile. Particularly severe conditions may require a geonet or geogrid, often in combination with a geotextile.

Bedding, to provide a stable and uniform base for the pipe should be 3 to 4 inches thick. Over rock or unyielding foundations, a minimum of 6" of bedding should be provided.

Backfill in the area up to the springline should be carefully placed and compacted to achieve a minimum E' value of 1,000 psi as detailed in ASTM D2321. A minimum of 12" of backfill should be placed and compacted above the crown of the pipe. It is typical for trenches to be backfilled entirely with Type I or Type II materials when under pavement. (Figure 7)

For pipe up to 48" diameter, and with pipe stiffness equal to or in excess of those required in AASHTO Section 18 (Table 4), a minimum of 12" of compacted cover is required prior to vehicle loadings. For larger or less stiff pipe, additional cover is recommended.

Recent development of flowable, low strength cement or fly ash backfill provides the ability to reduce trench widths and still get adequate backfill support. This can be particularly helpful in municipal street installations. Manufacturer's recommendations should be closely followed.

Flexible pipe should never be installed in a concrete cradle, as done for rigid pipe in a Class A installation. This type of installation could create concentrated forces at the ends of the cradle when the pipe has deformed.

10

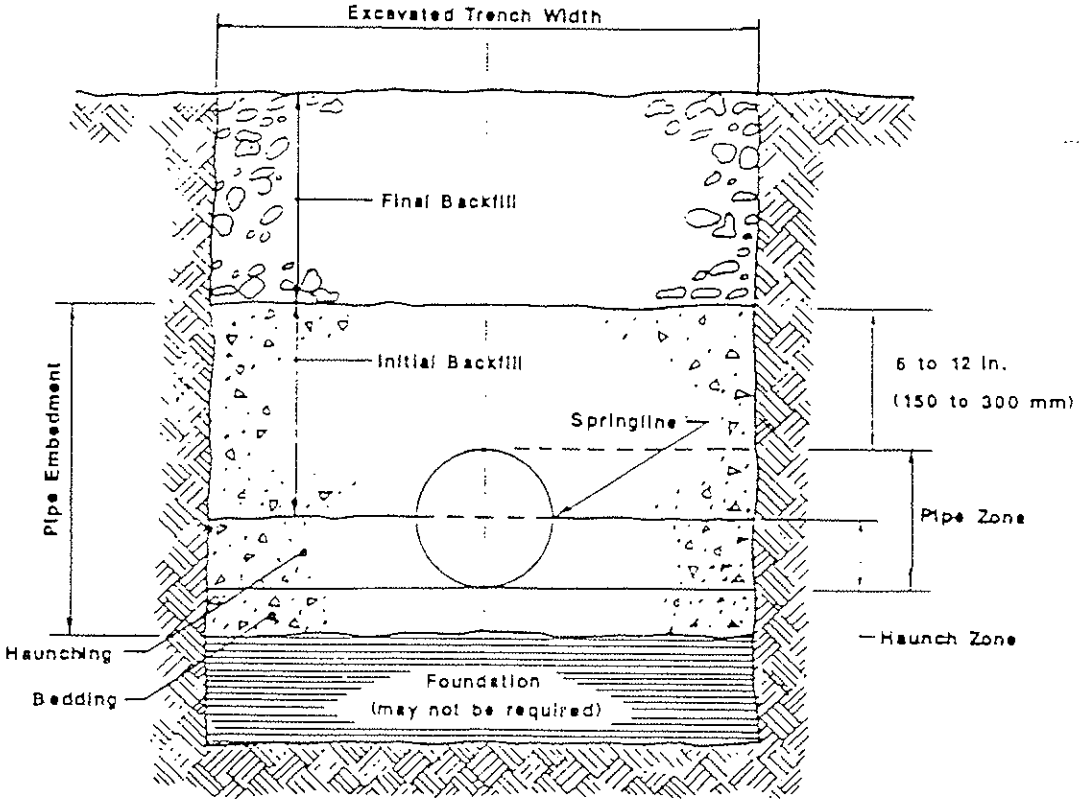
Att. C

16/17

MAS 1C 7.13-CU

GTC

Figure 7



Trench Cross Section

ATT. C
17/19

Research

One way to verify design and installation procedures for any product is to compare research findings with predicted performance. Over the past ten years, there has been a substantial amount of research done by the plastic pipe industry or by users of plastic pipe to verify the existing design procedures or to improve upon them.

A considerable amount of research has been conducted at Utah State University by either Dr. Reynold Watkins or Dr. Al Moser. Much of Dr. Watkins work has involved the large soil cell at U.S.U. to attempt to simulate very large soil pressures on buried pipe. Depending on the specific test, different backfill material and installation practice have been used as well. Based on work done in 1982 (TRR 903) (Figures 8 and 9) and 1990 on corrugated polyethylene pipe, the measured deflections were 1/2 to 2/3 those predicted by the Modified Iowa Formula (1) (Figure 10). At the soil pressures in the test cells in both tests, the resultant wall thrust exceeded that predicted by the AASHTO equations (8 & 9) by a factor of 2 using short-term material values and by a factor of 10 using long term (50 year) material values. In these tests, however, no wall thrust failure occurred, so ultimate wall thrust loads must be greater than those in these tests. These tests also exceeded the predicted wall buckling pressures by approximately 50%. With deflections less than 5% in these tests, wall strain was about 1%, well under the strain limit for HDPE.

In 1987, under the direction of Dr. Ernest Selig, a 24" diameter corrugated polyethylene pipe was installed in a 100' highway fill under I-279 North of Pittsburgh, PA as a test of the pipe's performance under high soil pressures in a realistic installation. Pipe shape and circumference have been monitored along with soil pressure at crown and springline, free field soil strain, and trench strain (pipe & backfill). Under 100 feet of fill, this pipe has shortened vertically 4.3%, with 1.6% of that reflected in circumferential shortening. The actual deflection is therefore only 2.7%. The free field soil strain is 4.2%. Because of the combination of circumferential shortening and deflection, a soil arch has developed over the pipe in the fill reducing the vertical soil pressure at the crown to only 22% of the predicted (by Marsten) soil pressure. Total vertical shortening is 55% of that predicted by the Iowa Formula (1) as deflection. Actual deflection (out of roundness) is only 35% of that predicted by the Iowa Formula. This study demonstrates that the soil arching and the circumferential shortening, which are not taken into consideration in the traditional calculations add a considerable degree of conservatism to the predicted performance values. Using the AASHTO design calculations, this pipe should have failed in wall crushing at about one half of the actual fill height. Dr. Selig has shown that finite element analysis programs, specifically CANDE and SOILCON, can predict the kind of results found in this study.

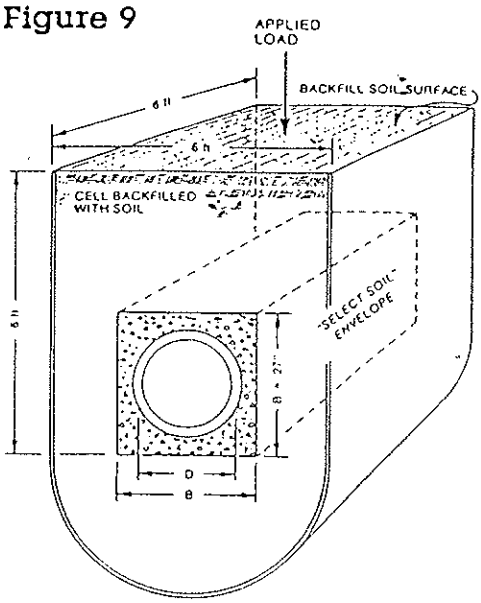
MAK 7-13-00

GTC

Figure 8

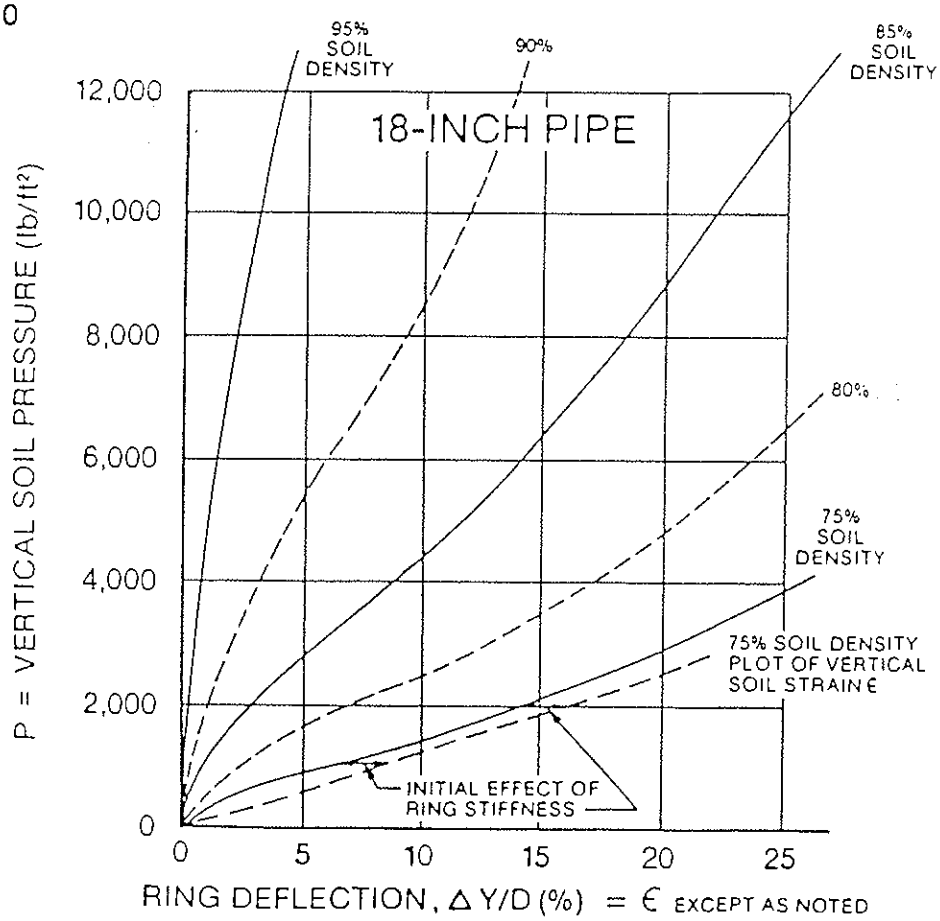
H-20 (32 kip axle load) being applied on 24-inch pipe with cover removed

Figure 9



Sketch of the small Utah State University high vertical soil pressure test cell, showing the setup for testing corrugated plastic pipe. The test can be conducted with or without the "select soil" envelope (gravel).

Figure 10



AH-C
19/17

AB

1. Calculate or estimate the total soil pressure, P_T, at the top of the pipe.

2. Calculate the stress, S_a, in the pipe wall:

$$S_A = \frac{(SDR - 1)}{2} P_T$$

3. Based upon the stress, S_a, and the estimated time duration of non-pressurization, find the value of the pipe's modulus of elasticity, E, in psi (approximate value for E is 35,000 psi).

4. Calculate the pipes hydrostatic, critical-collapse differential pressure, P_c

$$P_C = \frac{2E(t/D)^3 (D_{MIN} / D_{MAX})^3}{(1-\mu^2)} \quad \text{or} \quad P_c = \frac{2.32(E)}{SDR^3}$$

Where:
$(D_{MIN}/D_{MAX}) = 0.95$
μ = Poission's Ratio = 0.45 for polyethylene pipe
E = stress and time dependent tensile modulus of elasticity, psi
E = 35,000 psi (approximate)
D = Outside Diameter, in.
t = thickness, in.

5 Calculate the soil modulus, E', by plotting the total external soil pressure, P_T, against a specified soil density to derive the soil strain as shown in the example problem below Figure 7.

6. Calculate the critical buckling pressure at the top of the pipe by the formula:

$$P_{cb} = 0.8\sqrt{(E')(P_c)}$$

Where:
P_{cb} = Critical buckling soil pressure at the top of the pipe, psi
E' = Soil Modulus, psi
P_c = Hydrostatic critical-collapse differential pressure, psi

7. Calculate the Safety Factor: SF = P_{cb} / P_T.

8. The above procedures can be reversed to calculate the minimum pipe DR required for a given soil pressure and an estimated soil density.

In a direct burial pressurized pipeline, the internal pressure is usually great enough to exceed the external critical-buckling soil pressure. When a pressurized line is to be shut down for a period, wall buckling should be examined.

Attachment D

Calculation Package G
Seismic Performance Evaluation

Calculation Package G-1
Seismic Hazard Evaluation and Evaluation of Design Ground Motions

GeoSyntec Consultants

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: Parsons **Project:** BRC CAMU **Project/Proposal #:** HL 0389 **Task #:** 04

Title of Computations: Seismic Hazard Evaluation and Evaluation of Design Ground Motions

Computations By:
SIGNATURE — DATE: 05-04-2000
Neven Matasovic / Project Engineer
PRINTED NAME AND TITLE

Assumptions and Procedures Checked By (Peer Reviewer):
SIGNATURE — DATE: 07/24/00
Edward Kavazanjian, Jr. / Principal
PRINTED NAME AND TITLE

Computations Checked By:
SIGNATURE — DATE: 5/04/00
Geoffrey L. Smith / Staff Engineer
PRINTED NAME AND TITLE

Computations Backchecked By (Originator):
SIGNATURE — DATE: 07-26-00
Neven Matasovic / Project Engineer
PRINTED NAME AND TITLE

Approved By (PM or Designate):
SIGNATURE — DATE: 07/24/00
Edward Kavazanjian, Jr / Principal
PRINTED NAME AND TITLE

Approval Notes:

Revisions: (Number and Initial All Revisions)

No.	Sheet	Date	By	Checked By	Approval

Written by: Neven Matasovic Date: 05 / 03 / 00 Reviewed by: _____ Date: ___ / ___ / ___ (MM DD YY)

Client: Parsons Project: BRC CAMU Project No.: HL0389 Task No.: 04

SEISMIC HAZARD EVALUATION AND EVALUATION OF DESIGN GROUND MOTIONS BRC CAMU HENDERSON, NEVADA

BACKGROUND AND PURPOSE

The proposed BRC CAMU (BRC site) is located in Henderson, Nevada, approximately 10 miles (16 km) southeast of Las Vegas. The approximate site location is shown on Figure 1. Approximate coordinates of the geometric center of the site are 36.0412 North Latitude and -114.9964 West Longitude.

The purpose of the evaluations documented herein is:

- to estimate Peak Horizontal Ground Acceleration (PHGA) at hypothetical bedrock outcrop at the geometric center of the BRC site; and
- to develop representative ground motions for seismic site response analyses at the site.

EVALUATION OF SEISMIC HAZARD

GeoSyntec evaluated the seismic hazard at the site using the most recent United States Geological Survey (USGS) probabilistic seismic hazard maps [Frankel et al., 1996]. For compliance with the State of Nevada regulations, GeoSyntec considered motions with 2 percent probability of being exceeded in 50 years [2% PE in 50 yrs., which is equivalent to the 10% PE in 250 yrs. used by Algermissen et al., 1990]. The Frankel et al. [1996] maps are accessible via the Internet. In addition to bedrock free-field PHGA values, these maps also provide 5 percent damping elastic Spectral Acceleration (S_a) values for spectral periods of 0.2, 0.3 and 1.0 seconds. This data was used to establish the design free-field PHGA and set limits on the target acceleration response spectrum for design ground motions.

Information obtained from the USGS web site is enclosed in Appendix A. The Frankel et al. [1996] 2% PE in 50 yrs. map values indicate that the free-field bedrock PHGA at the site equals to 0.34 g. The same maps indicate that the 0.2, 0.3 and 1.0 seconds spectral acceleration values for 5 percent spectral damping equal 0.82 g, 0.64 g and 0.21 g, respectively. The map-derived

spectral acceleration values are plotted on Figure 2. The acceleration response spectrum defined by the above cited (spectral) acceleration points is referred to herein as the "target" spectrum and serves as the basis for evaluation of design ground motions for the site, as explained below.

Frankel et al. [1996] also provide limited disaggregated seismic hazard that can be used to establish the design earthquake magnitude. Tabulated disaggregated seismic hazard (contributing earthquake magnitudes) can be obtained from the USGS web site for the major cities in the area. To evaluate the design earthquake magnitude for the BRC CAMU site, GeoSyntec downloaded the disaggregated seismic hazard data for Las Vegas. Information obtained from the USGS web site is enclosed in Appendix A. The disaggregation of the seismic hazard for Las Vegas indicates that a Moment Magnitude (M_w) 6.5 earthquake governs the seismic hazard in the area.

EVALUATION OF DESIGN GROUND MOTIONS

A suite of representative acceleration time histories, time histories which conform to the target acceleration response spectrum and magnitude of the design earthquake, was selected for use in the seismic response analyses. GeoSyntec selected a suite of three time histories that enveloped the target response spectrum using the following methodology: (i) screen the database of acceleration time histories on the basis of earthquake magnitude to select a reduced set of accelerograms; and (ii) plot the acceleration response spectra of the candidate accelerograms against target acceleration response spectrum and select the representative accelerograms for use in design analyses.

Using the above methodology, GeoSyntec selected the following three candidate accelerograms to represent design ground motions at the BRC site:

- The Cholame Shandon Array No. 5 (355 deg) accelerogram, recorded during the M_w 6.3 Parkfield earthquake. The Parkfield earthquake occurred on 27 June 1966 on a strike-slip fault.

- The Superstition Mountain (135 deg) accelerogram, recorded during the M_w 6.5 Imperial Valley earthquake. The Imperial Valley earthquake occurred on 15 October 1979 on a strike-slip fault.

- The Big Bear Lake - Civic Center Grounds (360 deg) accelerogram, recorded during the M_w 6.7 Big Bear earthquake. The Big Bear earthquake occurred on 28 June 1992 on a strike-slip fault.

The acceleration response spectra of the scaled candidate design accelerograms are plotted against the target acceleration response spectrum on Figure 2. Figure 2 indicates that the acceleration response spectra of Cholame Shandon Array No. 5, Superstition Mountain and Big Bear Lake - Civic Center Grounds accelerograms match and exceed the target acceleration response spectrum in the period range of 0.1 to 1.0 seconds, the period range of interest for seismic design considerations at the site. Therefore, the Cholame Shandon Array No. 5, Superstition Mountain and Big Bear Lake - Civic Center Grounds accelerograms scaled to 0.34 g were selected as the representative acceleration time histories for use in seismic site response analyses at the BRC site.

REFERENCES

Algermissen, S.T., Perkins, D.M., Thenhaus, P.C., Hanson, S.L. and Bender, B.L. [1990], "Probabilistic Earthquake Acceleration and Velocity Maps for the United States and Puerto Rico," Miscellaneous Field Studies Map MF-2120, U.S. Geological Survey, Reston, Virginia.

Frankel, F., Mueller, C., Bernhard, T., Perkins, D., Leyendecker, Dickman, N., Hanson, S. and Hopper, M. [1996], "Interim National Hazard Maps: Documentation," *Draft Report*, U.S. Geological Survey, Denver, Colorado.

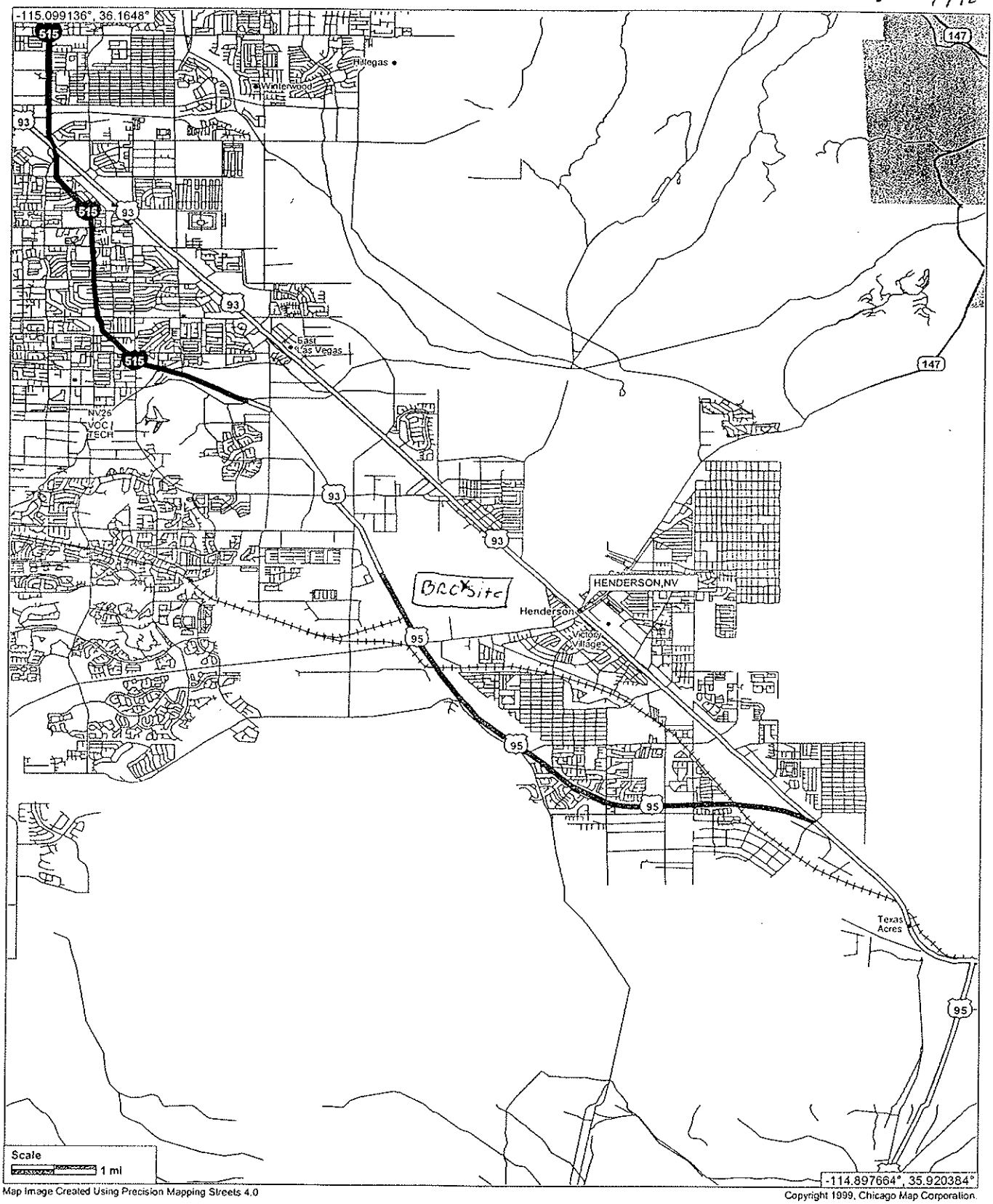
Calc.
MJB

N.M. 05-04-00

Fig. 1

Approximate Site Location

GK 07/24/00
4/12



Map Image Created Using Precision Mapping Streets 4.0

Copyright 1999, Chicago Map Corporation.

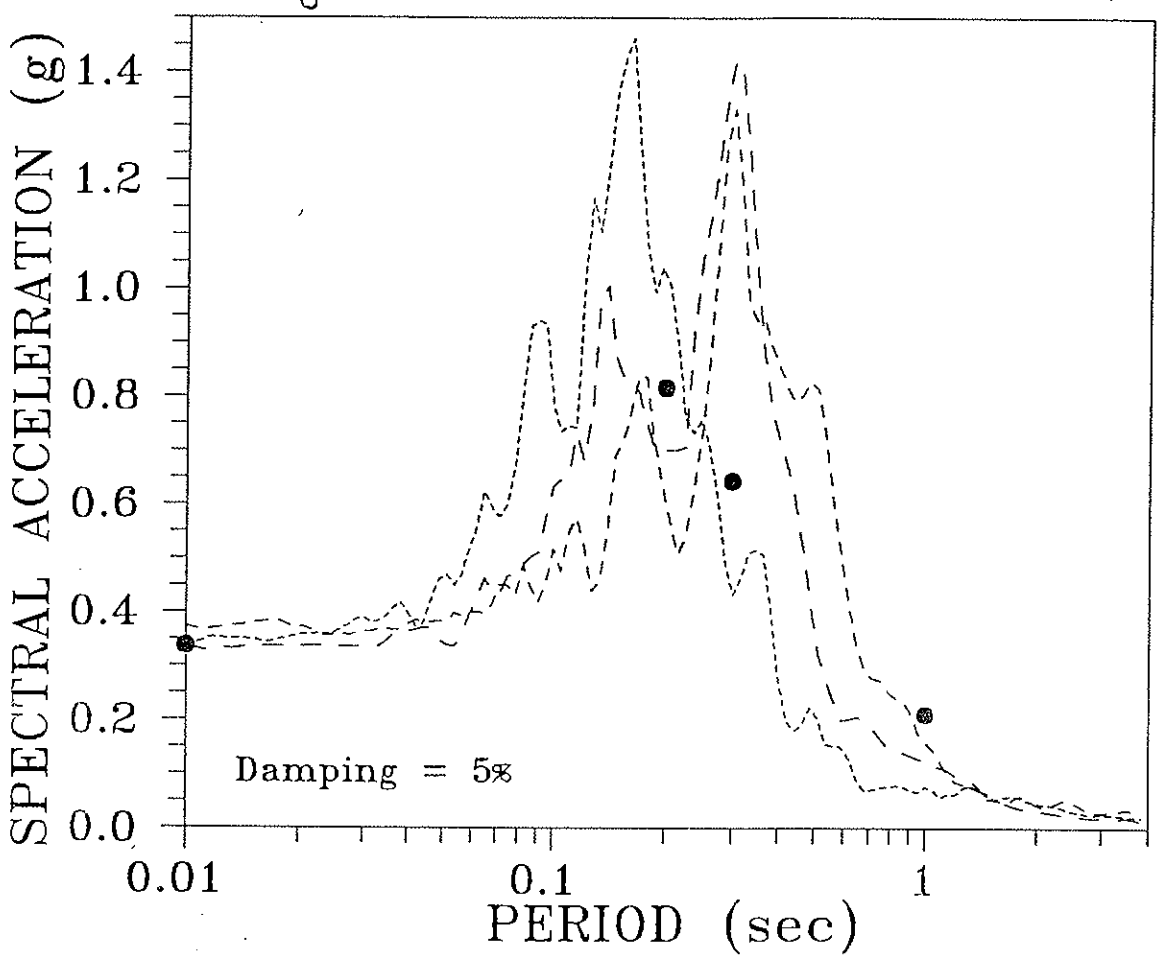
Calc

N.M. 35-04-00

EW: 07/24/00

Fig. 2

5/12



●●●●● Spectral values from USGS web site (2% PE in 50 yrs.)
------- Superstition Mountain Accelerogram (135 deg)
- - - - Cholame Shandon Array No. 5 Accel. (355 deg)
— — Big Bear Lake – Civic Center Grounds (360 deg)

APPENDIX A

SEISMIC HAZARD FOR THE BRC SITE
AND
DISAGGREGATED SEISMIC HAZARD FOR LAS VEGAS
(2% PE IN 50 YEARS)

Calc

N.M. 05-04-00

7/12

USGS

Home Page

Lat/Lon Lookup page

NATIONAL SEISMIC HAZARD MAPPING PROJECT

USGS, Central Region, Geologic Hazards Team
Golden, Colorado

The ground motion values for the requested point:

LOCATION	36.0412 Lat. -114.9964 Long.
DISTANCE TO NEAREST GRID POINT	4.58287299074001 kms
NEAREST GRID POINT	36.00000 Lat. -115.0000 Long.

Probabilistic ground motion values, in %g, at this point are:

	10%PE in 50 yr	5%PE in 50 yr	2%PE in 50 yr
PGA	13.85668	20.33881	33.70004 ✓
0.2 sec SA	31.82535	47.43614	81.64591
0.3 sec SA	27.39132	41.04289	64.31845
1.0 sec SA	8.801240	13.04513	21.02698

The program has detected a zero latitude and has assumed the end of valid input data.

EK 07/24/00

Calc 4/8

11.M. 05-04-00

USGS

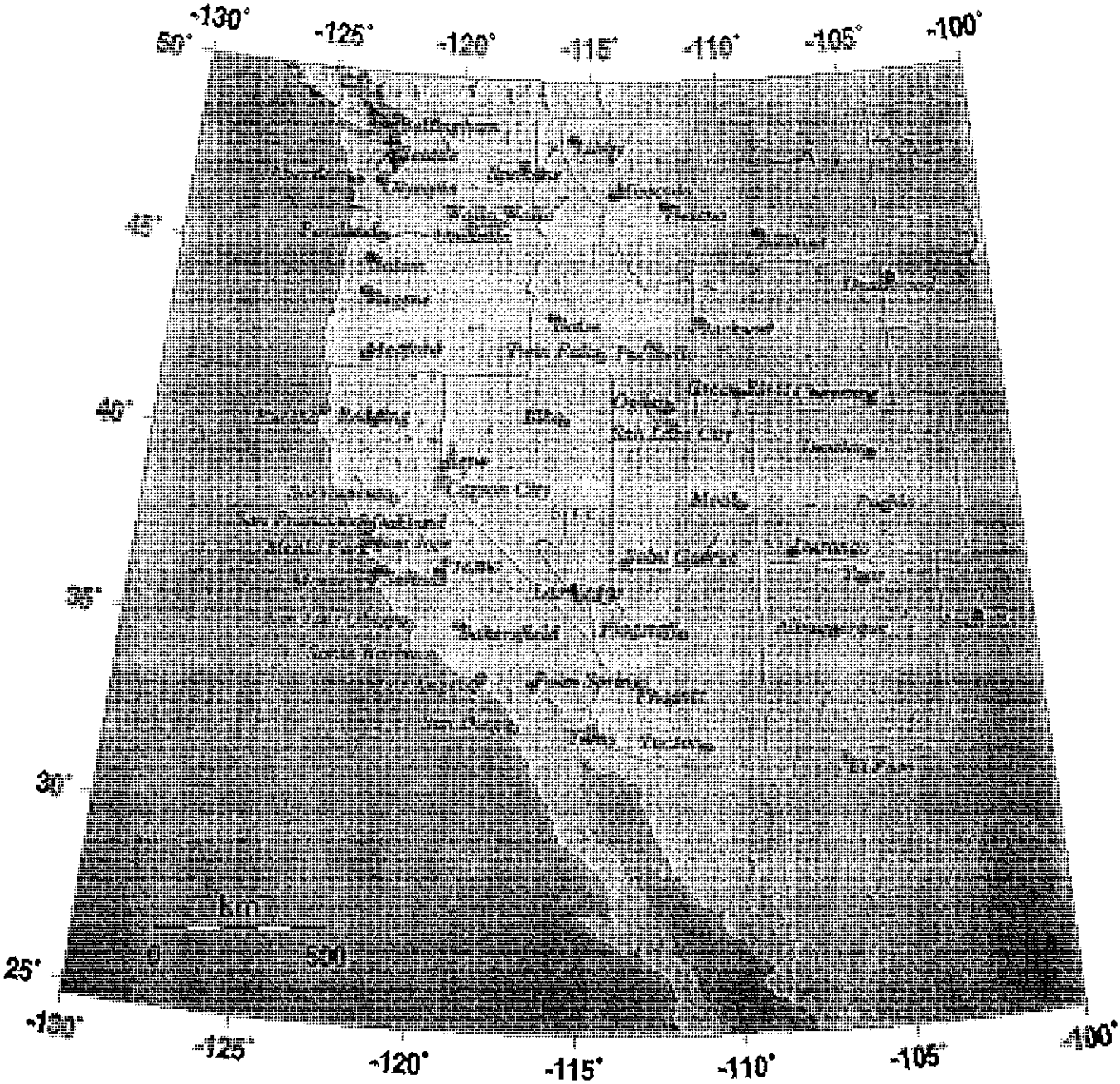
NATIONAL SEISMIC HAZARD MAPPING PROJECT 8/12
Golden, Colorado

EK 07/24/00

Please note that the image map on this page is a client-side image map.
YOU WILL NEED A BROWSER WHICH SUPPORTS CLIENT-SIDE IMAGE MAPS TO USE IT!!!
(such as Netscape Navigator 2.0 or Microsoft Internet Explorer 3.0 or the equivalent)

To obtain the four hazard matrices click on the city (red dot). The entries are per cent contribution to hazard. They will sum to 100 per cent for each matrix.

WUS Cities



Calc
RB

http://geohazards.cr.usgs.gov/eq/deagg/lasvegas.html

N.M. 05-04-00

9/12

EK
07/24/00

Deaggregated Seismic Hazard PE = 2% in 50 years pga
Las_Vegas NV 36.175 deg N 115.136 deg W PGA=0.27640 g

M<=	5.0	5.5	6.0	6.5	7.0	7.5
d<= 25.	0.000	16.873	15.484	47.082	16.578	0.000
50.	0.000	0.101	0.310	0.353	3.037	0.000
75.	0.000	0.003	0.007	0.051	0.064	0.000
100.	0.000	0.000	0.000	0.005	0.010	0.001
125.	0.000	0.000	0.000	0.002	0.005	0.000
150.	0.000	0.000	0.000	0.001	0.019	0.006
175.	0.000	0.000	0.000	0.000	0.002	0.005
200.	0.000	0.000	0.000	0.000	0.001	0.000

Deaggregated Seismic Hazard PE = 2% in 50 years 1hz
Las_Vegas NV 36.175 deg N 115.136 deg W SA= 0.18000 g

M<=	5.0	5.5	6.0	6.5	7.0	7.5
d<= 25.	0.000	3.479	7.223	47.502	19.347	0.000
50.	0.000	0.076	0.318	3.177	15.119	0.000
75.	0.000	0.004	0.022	0.510	1.095	0.000
100.	0.000	0.000	0.001	0.050	0.184	0.037
125.	0.000	0.000	0.000	0.023	0.125	0.000
150.	0.000	0.000	0.000	0.008	0.641	0.389
175.	0.000	0.000	0.000	0.006	0.073	0.413
200.	0.000	0.000	0.000	0.002	0.042	0.076
225.	0.000	0.000	0.000	0.005	0.012	0.000
300.	0.000	0.000	0.000	0.000	0.001	0.000
325.	0.000	0.000	0.000	0.000	0.003	0.000
350.	0.000	0.000	0.000	0.001	0.006	0.000
375.	0.000	0.000	0.000	0.001	0.009	0.000
400.	0.000	0.000	0.000	0.002	0.004	0.000
425.	0.000	0.000	0.000	0.002	0.002	0.000
450.	0.000	0.000	0.000	0.001	0.003	0.000
475.	0.000	0.000	0.000	0.001	0.002	0.000
500.	0.000	0.000	0.000	0.001	0.001	0.000

Deaggregated Seismic Hazard PE = 2% in 50 years 3.33 hz (0.3 s)
Las_Vegas NV 36.175 deg N 115.136 deg W SA= 0.55200 g

M<=	5.0	5.5	6.0	6.5	7.0	7.5
d<= 25.	0.000	10.013	12.605	50.737	17.888	0.000
50.	0.000	0.125	0.256	1.394	6.637	0.000
75.	0.000	0.003	0.008	0.111	0.158	0.000
100.	0.000	0.000	0.000	0.007	0.016	0.002
125.	0.000	0.000	0.000	0.002	0.008	0.000
150.	0.000	0.000	0.000	0.000	0.019	0.004
175.	0.000	0.000	0.000	0.000	0.001	0.003
200.	0.000	0.000	0.000	0.000	0.001	0.000

Deaggregated Seismic Hazard PE = 2% in 50 years 5hz
Las_Vegas NV 36.175 deg N 115.136 deg W SA= 0.62990 g

M<=	5.0	5.5	6.0	6.5	7.0	7.5
d<= 25.	0.000	13.541	14.177	49.428	16.715	0.000
50.	0.000	0.171	0.247	1.004	4.559	0.000
75.	0.000	0.003	0.005	0.061	0.070	0.000
100.	0.000	0.000	0.000	0.003	0.005	0.001
125.	0.000	0.000	0.000	0.001	0.002	0.000
150.	0.000	0.000	0.000	0.000	0.004	0.001

MN

N.A. 05-24-00 10/12

USGS

NATIONAL SEISMIC HAZARD MAPPING PROJECT
Golden, Colorado

EK 07/24/00

LAS VEGAS NV

Hazard matrices

The distance scale on the following two maps is accurate in the east-west direction,
but there is foreshortening in the north-south direction.

Disaggregated Seismic Hazard for 1 second Spectral Acceleration
GIF, PDF, PS
Disaggregated Seismic Hazard for 0.2 second Spectral Acceleration
GIF, PDF, PS

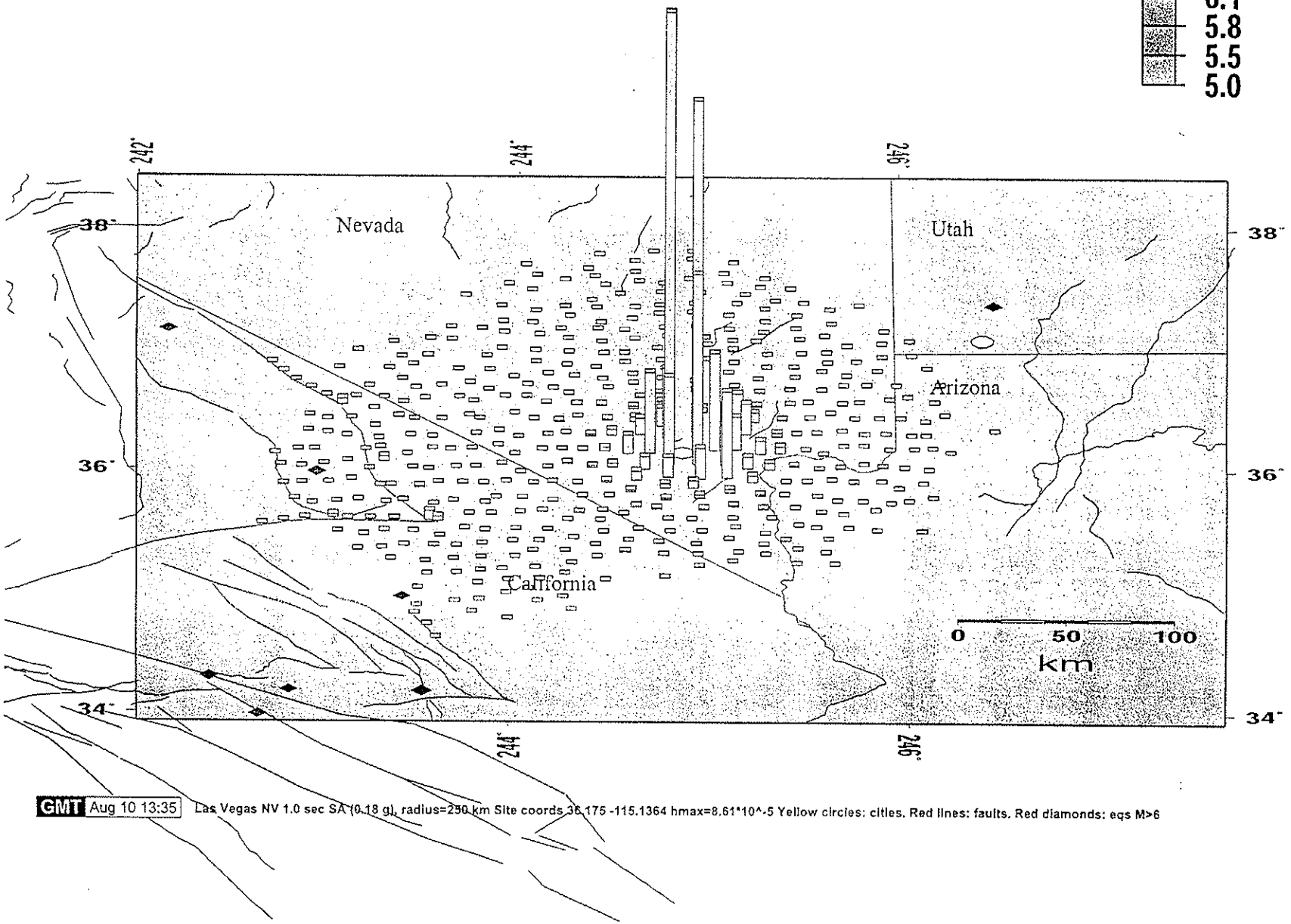
Las Vegas NV Disaggregated Seismic Hazard

for 1 second Spectral Acceleration, 0.18 g

PE = 2% per 50 yr. Hazard radius 250 km, DeltaR=10 km

Mw: Binned average; equal-area bins.

Most hazard from gridded seismicity; Eglington Fault ca. 5%



Calif

EK 07/24/00

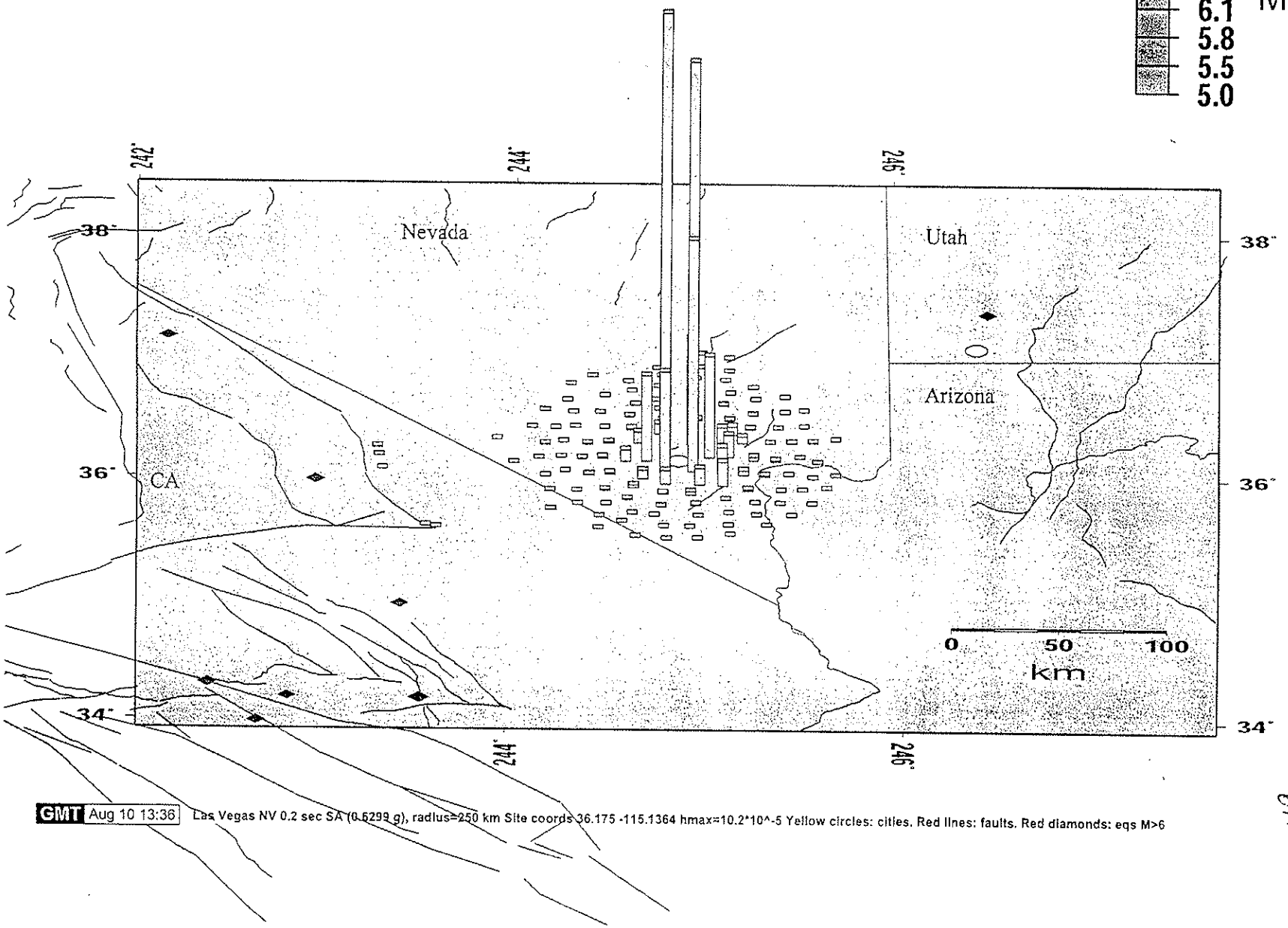
N.M. 05-06-00

11/12

Las Vegas NV Disaggregated Seismic Hazard

for 0.2 second Spectral Acceleration, 0.63 g

PE = 2% per 50 yr. Hazard radius 250 km, DeltaR=10 km
Mw: Binned average; equal-area bins.
Most hazard from gridded seismicity; Eglington Fault ca. 5%



GMT Aug 10 13:36 Las Vegas NV 0.2 sec SA (0.6299 g), radius=250 km Site coords 36.175 -115.1364 hmax=10.2*10^-5 Yellow circles: cities. Red lines: faults. Red diamonds: eqs M>6

Calif Fgs

N.Y. 07-01-00

12/12

EK 07/24/00

Calculation Package G-2
Site Response Analysis

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: Parsons **Project:** BRC CAMU **Project #:** HL0389 **Task #:** 04

Title of Computations: Seismic Site Response Analysis

Computations By:

SIGNATURE — DATE: 26 July 2000

Michael E. Kalinski / Senior Staff Engineer
PRINTED NAME AND TITLE

Assumptions and Procedures Checked By (Peer Reviewer):

SIGNATURE — DATE: 07-26-00

Neven Matasovic / Project Engineer
PRINTED NAME AND TITLE

Computations Checked By:

SIGNATURE — DATE: 7-26-00

Geoff Smith/Staff Engineer
PRINTED NAME AND TITLE

Computations Backchecked By (Originator):

SIGNATURE — DATE: 7-26-2000

Michael E. Kalinski / Senior Staff Engineer
PRINTED NAME AND TITLE

Approved By (PM or Designate):

SIGNATURE — DATE: 07/26/00

Edward Kavazanjian, Jr. / Principal
PRINTED NAME AND TITLE

Approval Notes: _____

Revisions:

No.	Date	Description	Approval

Written by: Michael E. Kalinski Date: 07 / 26 / 00 (MM DD YY) Reviewed by: Date: 07 / 26 / 00 (MM DD YY)

Client: Parsons Project: BRC CAMU Project No.: HL0389 Task No.: 04

PURPOSE

One-dimensional site response analyses were performed for the BRC Landfill in Henderson, Nevada using the SHAKE91 computer program [SHAKE91, 1992]. Analyses were performed to assess the dynamic site response of the compacted landfill to three design earthquake seismograms. This ~~memo~~ calculation package provides the details of the analyses. Synthetic accelerograms for the ground surface derived from these analyses were used in the companion computation package titled "Site-Specific Seismic Deformation Charts."

SUMMARY OF SHAKE91

SHAKE91 is a computer program for conducting an equivalent linear seismic response analysis of a horizontally layered soil deposit [SHAKE91, 1992]. SHAKE91 was originally written in 1972, but has undergone several modifications and revisions to its present form. SHAKE91 performs a frequency-domain analysis of a one-dimensional soil column subjected to earthquake shaking in bedrock at its base. SHAKE91 is based on the assumption that the earthquake is a vertically propagating shear wave.

The three main sets of input parameters for SHAKE91 are 1) information about the soil profile, 2) information about how the dynamic properties of the soil (shear modulus and damping) vary with strain and 3) input ground motion. Information about the soil profile includes layer thickness, small-strain shear modulus (G_{max}) and unit weight. Information about how the dynamic properties of the soil vary with strain are provided using curves of modulus reduction (G/G_{max}) and damping versus shearing strain. Different curves are used for the different types of material (i.e. sand, clay, rock and waste) in the profile. Seismograms recorded at earthquake stations near the site being evaluated are typically used as input ground motion.

To perform the site response analysis, SHAKE91 implements an iterative procedure using an 'equivalent linear' method. In this method, the linear response of the soil column to earthquake shaking is calculated using initial estimates for G_{max} and material damping. The resulting shear strains are plotted against the modulus reduction and damping curves and the dynamic soil properties are adjusted accordingly. The linear response of the soil column is re-calculated using the adjusted parameters. The re-calculated shear strains are used to re-adjust the dynamic soil properties and the linear response of the soil column is calculated again. This procedure is repeated until the difference in dynamic soil properties between iterations is

sufficiently small. The final result is typically expressed in terms of peak accelerations calculated at the surface of the model.

PROBLEM APPROACH

Site response analyses were performed using three seismogram records. Each input record was adjusted to a maximum amplitude of 0.337 g. This value is the predicted peak ground acceleration (PGA) for Las Vegas, Nevada with a 2% probability of occurrence in a 50-year period and is based on probabilistic analysis of available earthquake data by the United States Geological Survey [USGS, 2000]. The three seismograms (Parkfield, Superstition and Big Bear) were selected based on similarities between their response spectra and the target acceleration response spectrum as described in the companion computation package titled "Seismic Hazard Evaluation and Evaluation of Design Ground Motions."

Shear wave velocity and layer thickness data were derived from SASW testing performed by Dr. Barbara Luke at the University of Nevada at Las Vegas on February 25, 2000. SASW testing was performed on native material as shown in Fig. 1. The resulting shear wave velocity data are summarized in Table 1. These data were integrated with soil boring data [Converse Consultants, 1999] to identify units of silty sand (SM), lean clay (CL), waste and bedrock within the profiles. The interpreted shear wave velocity profile is included in Fig. 2 (GeoSyntec, 2000).

Estimated unit weights for the native soil spanned a reasonable range of 120 to 130 pcf. These values were varied according to shear wave velocity. Higher values were assigned to layers with higher shear wave velocities.

For characterizing bedrock, it was assumed that the bedrock material was a hard, competent rock with a relatively high shear wave velocity (7000 ft/s) and high unit weight (140 pcf). These values are comparable to typical values observed in other hard, competent rocks.

Separate modulus reduction and damping curves were used for the materials encountered in the two profiles. Reduction curves for the clay and sand were taken from research performed by Vucetic and Dobry [1991] where the effects of plasticity index on cyclic response were investigated for a wide variety of soil types and studies. To apply the Vucetic and Dobry data to this analysis, the plasticity indices of the silty sand and lean clay were assumed to be 0% and 15%, respectively. Modulus reduction curves corresponding to silty sand were used for the

compacted waste based on the assumption that the compacted waste will be classifiable as a silty sand.

Two SHAKE91 analyses were performed on hypothetical profiles representative of the final design of the new landfill. These profiles, shown in Fig. 3, consist of 1) the existing native material overlain by 30 ft of compacted waste and 2) 60 ft of waste embedded 30 ft into the native soil. For these analyses, shear wave velocities estimated for the native material were modified to account for the effect of increased confining stress on increased shear wave velocity. As shown in Table 2, shear wave velocities of the native material were used, but shear wave velocities less than 800 ft/s were set equal to 800 ft/s to account for the increased confining stress.

← North mesa
← South mesa

To characterize the compacted waste material, shear wave velocities and unit weights of 1000 ft/s and 120 pcf, respectively, were assumed. These are reasonable values for silty sands that are compacted at 90 to 95% of optimum water content, which is the anticipated nature of the compacted waste.

Based on results from SASW testing, the depth to bedrock could not be conclusively estimated. Therefore, three sets of SHAKE91 analyses were performed by varying the thickness of the silty sand layer present at the bottom of the native material profile (Fig. 2). Silty sand layer thicknesses of 50, 100 and 150 ft were used for the analyses.

Corresponding to bedrock either 201, 251, & 301 ft bgs EK
or 231, 281, & 331 ft below top of landfill. EK 07/26/00

RESULTS

Site response analyses were performed for the two scenarios (unembedded and embedded waste) using the procedures described in the previous section. A sample SHAKE91 input file is attached to this memorandum. Peak accelerations at the surface of the landfill and native material are summarized in Table 3. The calculated accelerations are all less than 0.50 g. Embedding the compacted waste causes a minor (less than 10%) reduction in predicted surface accelerations.

Calculated profile periods are summarized in Table 4. Profile periods for modeling with the 150-ft thick bottom soil layer are all greater than 1.09 s. Since this period is longer than the maximum-amplitude period on typical response spectra, it was believed that thicker bottom layers would produce longer periods, less amplification and smaller accelerations. Therefore, modeling with layer thicknesses greater than 150 ft was not considered necessary.

REFERENCES

Converse Consultants, (1999), "Preliminary Geotechnical and Geologic Investigation, Industrial Non-Hazardous Disposal Facility, Basic Management Incorporated, Clark County, Nevada," Converse Project No. 99-33437-01, October 27, 1999, Converse Consultants, Las Vegas, Nevada.

GeoSyntec, (2000), "Preliminary Results of SASW Testing, BRC Landfill, Henderson, Nevada," interoffice memorandum from Michael E. Kalinski to Jay McKelvey, 7 April 2000.

SHAKE91, (1992), "User's Manual for SHAKE91," Center for Geotechnical Modeling, Department of Civil & Environmental Engineering, University of California at Davis.

USGS, (2000), "National Seismic Hazard Mapping Project," USGS, Central Region, Geologic Hazards Team, http://geohazards.cr.usgs.gov/eq/.

Written by: Michael E. Kalinski Date: 07 / 26 / 00 (MM DD YY) Reviewed by: Date: 7 / 26 / 00 (MM DD YY)

Client: Parsons Project: BRC CAMU Project No.: HL0389 Task No.: 04

EK 07/26/00

TABLE 1
SHEAR WAVE VELOCITY PROFILES FROM SASW MEASUREMENTS PERFORMED AT THE BRC LANDFILL, HENDERSON NEVADA

Thickness (ft)	Depth (ft)	Shear Wave Velocity (ft/s)	Material Type
0.98	0.98	426	SM
1.31	2.29	754	SM
10.8	13.09	984	SM
3.28	16.37	1082	SM
16.4	32.77	1279	SM
7.28	40.05	1312	SM
81.9	121.95	1115	CL
29.5	151.45	1246	CL
Half-space	-	1968	SM

Written by: Michael E. Kalinski Date: 07 / 26 / 00 (MM DD YY) Reviewed by: Date: 7 / 26 / 00 (MM DD YY)

Client: Parsons Project: BRC CAMU Project No.: HL0389 Task No.: 04

07/26/00

TABLE 2
SHEAR WAVE VELOCITY PROFILES USED FOR SHAKE91 ANALYSIS
NATIVE MATERIAL WITH 30 FT OF OVERBURDEN WASTE

a) 30 ft waste placed on top of native material

Thickness (ft)	Depth (ft)	Shear Wave Velocity (ft/s)	Material Type
30.00	30.00	1000	compacted waste
0.98	30.98	800	SM
1.31	32.29	800	SM
10.8	43.09	984	SM
3.28	46.37	1082	SM
16.4	62.77	1279	SM
7.28	70.05	1312	SM
81.9	151.95	1115	CL
29.5	181.45	1246	CL
50, 100 or 150	231.45, 281.45 or 331.45	1968	SM
Half-space	-	7000	bedrock

b) 30-ft excavation filled with waste to elevation of 30 ft above native ground surface (60 ft total waste thickness)

Thickness (ft)	Depth (ft)	Shear Wave Velocity (ft/s)	Material Type
30.00	30.00	1000	compacted waste
30.00	60.00	1000	compacted waste
2.77	62.77	1279	SM
7.28	70.05	1312	SM
81.9	151.95	1115	CL
29.5	181.45	1246	CL
50, 100 or 150	231.45, 281.45 or 331.45	1968	SM
Half-space	-	7000	bedrock

TABLE 3
PEAK GROUND SURFACE ACCELERATIONS CALCULATED USING SHAKE91

EK 07/26/00

a) 30 ft Compacted Waste over Native Material

Earthquake	Bottom soil layer = 50 ft thick	Bottom soil layer = 100 ft thick	Bottom soil layer = 150 ft thick
Big Bear	0.47 g	0.50	0.46
Parkfield	0.43	0.47	0.48
Superstition	0.40	0.35	0.31
AVERAGE	**0.43**	**0.44**	**0.42**

b) 60 ft Compacted Waste Embedded into Native Material

Earthquake	Bottom soil layer = 50 ft thick	Bottom soil layer = 100 ft thick	Bottom soil layer = 150 ft thick
Big Bear	0.41 g	0.44	0.41
Parkfield	0.40	0.44	0.42
Superstition	0.38	0.34	0.31
AVERAGE	**0.40**	**0.41**	**0.38**

Written by: Michael E. Kalinski Date: 07 / 26 / 00 (MM DD YY) Reviewed by: Date: 7 / 26 / 00 (MM DD YY)

Client: Parsons Project: BRC CAMU Project No.: HL0389 Task No.: 04

07/26/00

TABLE 4
SOIL PROFILE PERIODS CALCULATED USING SHAKE91

a) 30 ft Compacted Waste Over Native Material

Earthquake	Bottom soil layer = 50 ft thick	Bottom soil layer = 100 ft thick	Bottom soil layer = 150 ft thick
Big Bear	0.95 s	1.10	1.22
Parkfield	0.94	1.05	1.19
Superstition	0.91	1.01	1.09

b) 60 ft Compacted Waste Embedded into Native Material

Earthquake	Bottom soil layer = 50 ft thick	Bottom soil layer = 100 ft thick	Bottom soil layer = 150 ft thick
Big Bear	0.98 s	1.11	1.22
Parkfield	0.95	1.06	1.21
Superstition	0.92	1.01	1.09

Written by: Michael E. Kalinski Date: 07 / 26 / 00 (MM DD YY) Reviewed by: Cole Date: 7 / 26 / 00 (MM DD YY)

Client: Parsons Project: BRC CAMU Project No.: HL0389 Task No.: 04

EK 07/26/00

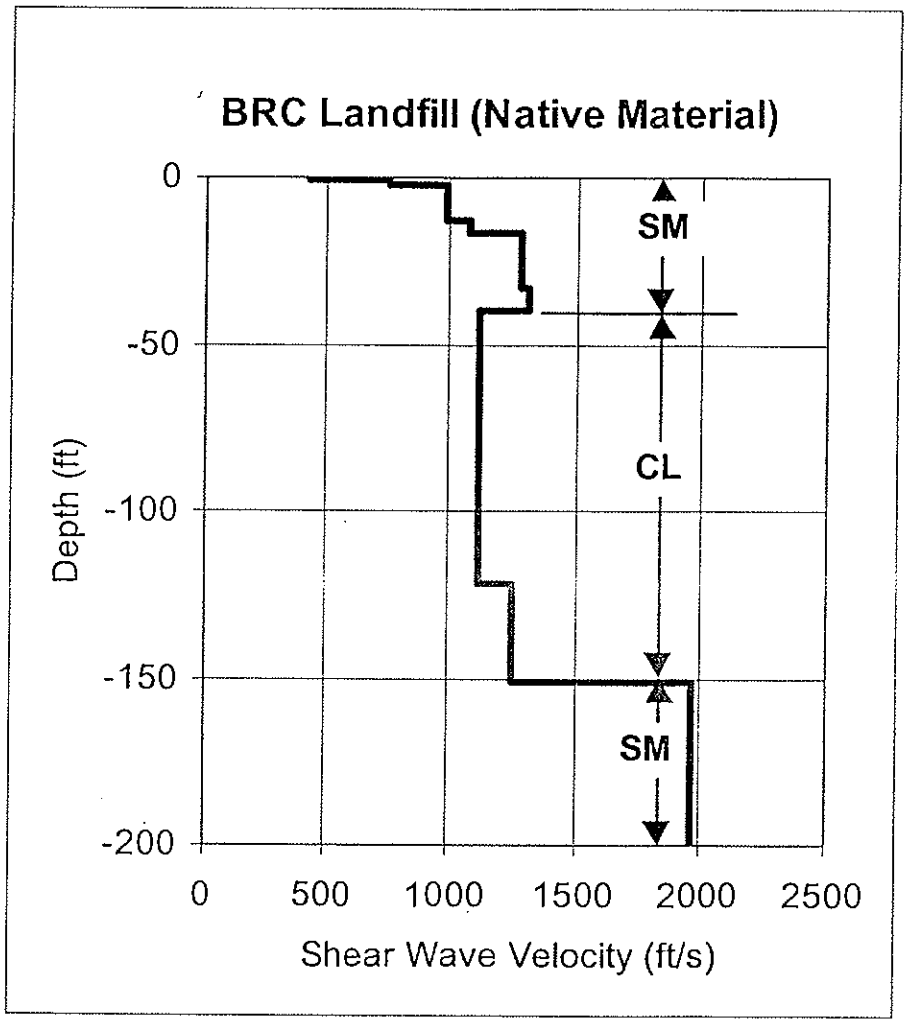


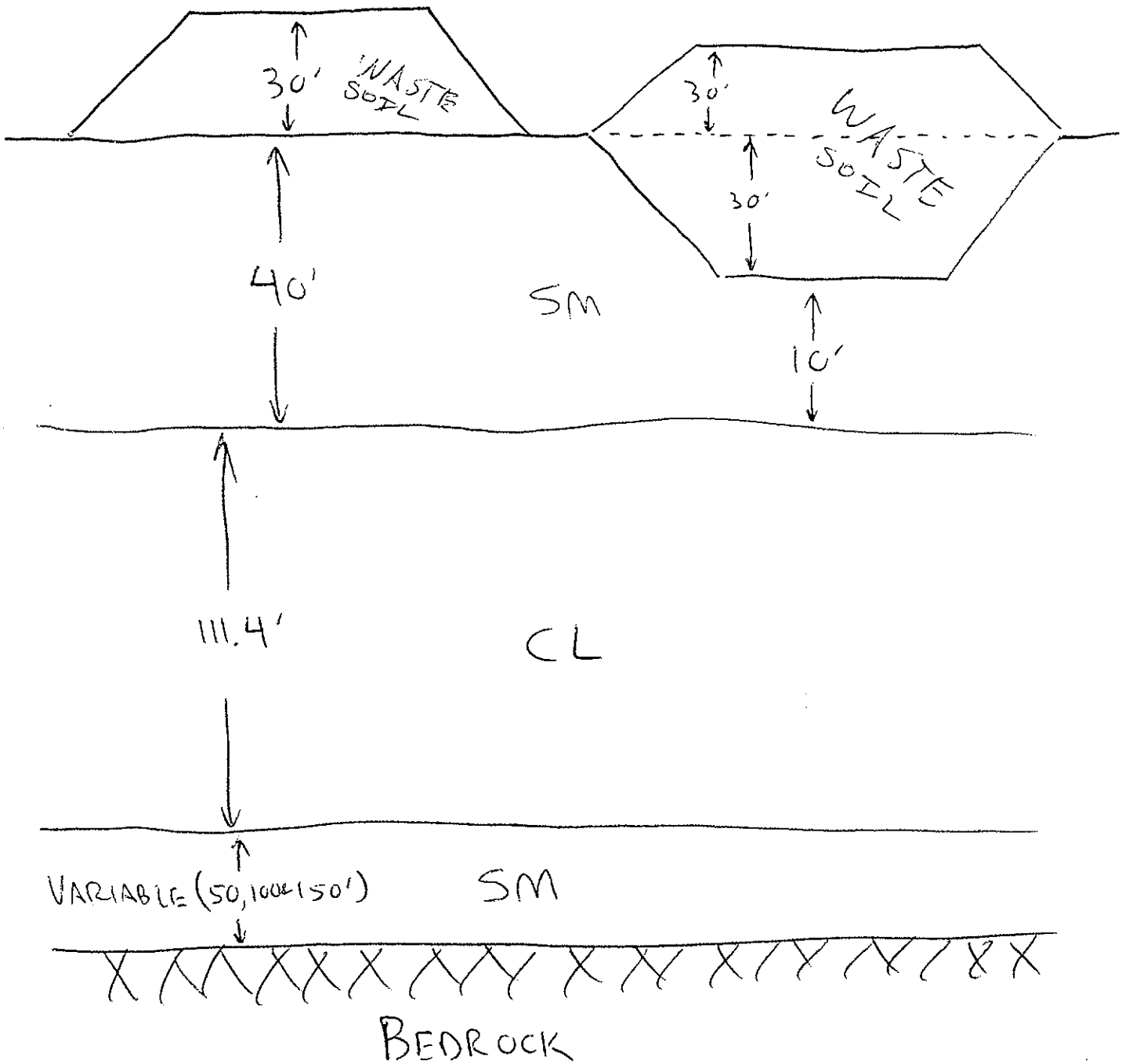
FIGURE 2. SHEAR WAVE VELOCITY PROFILE OF NATIVE MATERIAL FROM SASW DATA

Written by: VMC Date: / / (YY MM DD) Reviewed by: Cale Date: 7 / 26 / 00 (YY MM DD)

Client: Project: Project/Proposal No.: Task No.:

FIG 3 SOIL PROFILES USED FOR NEW COMPACTED LANDFILL.

ESK 07/26/00



Written by: Michael E. Kalinski Date: 07 / 26 / 00 (MM DD YY) Reviewed by: Calle Date: 9 - 20 - 00 (MM DD YY)

Client: Parsons Project: BRC CAMU Project No.: HL0389 Task No.: 04

EK 07/26/00

ATTACHMENT

SAMPLE SHAKE91 INPUT FILE

(Embedded Waste, Big Bear Earthquake, Bottom Soil Layer Thickness = 100 ft)

embedN2

7.26

Calc 1-20-00

14/15

```
option 1 - dynamic soil properties - (max is thirteen):
    1
    3
   10  #1 Modulus for Clay (PI=15) (Vucetic and Dobry, 1991)
    0.0001  0.000316     0.001   0.00316      0.01    0.0316
 0.1     0.316
        1.      3.16
     1.000     1.000     0.995     0.936     0.818     0.640     0
.405     0.210
     0.095     0.034
   10  #1 Damping for Clay (PI=15) (Vucetic and Dobry, 1991)
    0.0001  0.000316     0.001   0.00316      0.01    0.0316
 0.1     0.316
        1.      3.16
      0.85      1.04      1.55      2.58     4.635      7.77     1
1.67    16.085
     20.12     23.17
   10  #2 Modulus for Sand (PI=0) (Vucetic and Dobry, 1991)
   0.0001   0.000316     0.001   0.00316      0.01    0.0316
 0.1     0.316
      1.0      3.16
    1.000     1.000     0.964     0.870     0.712     0.474     0
.253     0.103
    0.028     0.004
    9  #2 Damping for Sand (PI=0) (Vucetic and Dobry, 1991)
   0.0001   0.000316    0.0010    0.0032      0.01    0.0316
 0.1     0.316
      1.0      3.16
     0.85      1.04      1.66     2.999      5.48     10.01     1
5.40     20.23
    23.94     26.17
    8  #3 Modulus for Rock
    0.0001    0.0003     0.001     0.003      0.01      0.03
 0.1       1.0
     1.000     1.000    0.9875    0.9525     0.900     0.810     0
.725     0.550
    5  #3 Damping for Rock
    0.0001     0.001      0.01       0.1       1.0
       0.4       0.8       1.5       3.0       4.6
    3    1    2    3
Option 2 -- Soil Profile
    2
    1    8      Profile embedN2 -- 60 ft waste embedded 30 ft
    1    2          30.00                .010      .120      1000
    2    2          30.00                .010      .120      1000
    3    2           2.77                .010      .125      1279
    4    2           7.28                .010      .125      1312
    5    1           81.9                .020      .125      1115
```

EK

07/26/0

MMK 7-26 Cale 7/26/00 15/15

```
    6    1            29.5                    .020       .125       1246
    7    2           100.0                    .010       .130       1968
    8    3                                    .005       .125       7000
Option 3 -- input motion:
    3
 2000 4096        .01 bigbear.acc                    (8f9.6)
                0.337      50.0    2    8
Option 4 -- sublayer for input motion (within (1) or outcropping (
0):
    4
    8    0
Option 5 -- number of iterations & ratio of avg strain to max stra
in
    5
    0   12        0.6
Option 6 -- sublayers for which accn time histories are computed &
 saved:
    6
    1    2    3    4    5    6    7    8
    1    1    1    1    1    1    1    1
    1    0    0    0    0    0    0    0
Option 7 -- sublayer for which shear stress or strain are computed
 & saved:
    7
    8    1    1      2000          -- stress at top of bedrock
    8    0    1      2000          -- strain at top of bedrock
Option 10 -- compute & save amplification spectrum:
   10
    8    0    1    0      0.25 -- ground surface/rock outcrop
execution will stop when program encounters 0
    0
```

EK 07/26/00

FIG. 1

10/15

CK 07/26/00

Cale 7-26 188

Approximate Boring Locations (... 11/21/90 B.S. NO. 2, FILE # 43701052)

PARSONS ENGINEERING SCIENCE, PASADENA, CAL

JOB NO. 7

Calculation Package G-3
Seismic Deformation Charts

GeoSyntec Consultants

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: Parsons **Project:** BRC CAMU **Project/Proposal #:** HL0389 **Task #:** 04

Title of Computations: Site-Specific Seismic Deformation Charts

Computations By:
SIGNATURE — DATE: ~~25~~ 26 July 2000
Geoff L. Smith / Staff Engineer
PRINTED NAME AND TITLE

Assumptions and Procedures Checked By (Peer Reviewer):
SIGNATURE — DATE: 07-26-00
Neven Matasovic / Project Engineer
PRINTED NAME AND TITLE

Computations Checked By:
SIGNATURE — DATE: 26 JULY 2000
Michael E. Kalinski / Senior Staff Engineer
PRINTED NAME AND TITLE

Computations Backchecked By (Originator):
SIGNATURE — DATE: 7-26-00
Geoff L. Smith / Staff Engineer
PRINTED NAME AND TITLE

Approved By (PM or Designate):
SIGNATURE — DATE: 07/26/00
Edward Kavazanjian, Jr. / Principal
PRINTED NAME AND TITLE

Approval Notes:

Revisions: (Number and Initial All Revisions)

No.	Sheet	Date	By	Checked By	Approval

Written by: Geoff L. Smith GLS Date: 07 / 25 / 00 (MM DD YY) Reviewed by: MRC 7.26 Date: / / (MM DD YY)

Client: Parsons Project: BRC CAMU Project No.: HL0389 Task No.: 04

SITE-SPECIFIC SEISMIC DEFORMATION CHARTS
BRC CAMU
HENDERSON, NEVADA

EK 07/26/00

BACKGROUND AND PURPOSE

The purpose of the analyses documented herein is to develop site-specific seismic deformation charts for the proposed BRC CAMU in Henderson, Nevada. Due to different geometry, the deformation response for the borth North Mesa and the South Mesa were evaluated. The North Mesa is characterized by a 30 ft (10 m) contaminated soil fill placed on native ground. The South Mesa is characterized by a 60 ft (20 m) thick comtaiminated soil fill that is embedded 30 ft (10 m) below native ground surface. The analyses presented herein are based on results documented in a companion calculation package (seismic site response analyses).

METHOD OF ANALYSIS

The site-specific seismic deformation charts were developed using the computer program YSLIP_PM [Yan et al. 1996]. YSLIP_PM is based upon the Newmark [1965] seismic deformation analysis.

The Newmark method assumes a rigid block on a plane. The block base is subjected to earthquake-induced accelerations. YSLIP_PM calculates the permanent displacement of the rigid block from pseudostatically-evaluated yield accelerations and block base accelerations evaluated in a site response analysis.

ANALYSIS

The analysis consisted of inputting site response acceleration time histories generated by SHAKE91 [Idriss and Sun 1992] into YSLIP_PM. Since bedrock is deep below the ground surface, the depth to the bedrock was varied. Depth to bedrock was assumed to be 201, 251, and 301 ft below the ground surface and 231, 281, and 331 feet below the top of the the landfill.

Written by: Geoff L. Smith Date: 07 / 25 / 00 (MM DD YY) Reviewed by: Date: / / (MM DD YY)

Client: Parsons Project: BRC CAMU Project No.: HL0389 Task No.: 04

EK 07/26/00

A suite of three accelerograms were used to represent the conditions at the BRC CAMU. The three accelerograms were:

- The Cholame Shandon Array No. 5 (355 deg.) accelerogram, recorded during the M_w 6.3 Parkfield earthquake. The Parkfield earthquake occurred on 27 June 1996 on a strike-slip fault.

- The Superstition Mountain (135 deg.) accelerogram, recorded during the M_w 6.5 Imperial Valley earthquake. The Imperial Valley earthquake occurred on 15 October 1979 on a strike-slip fault.

- The Big Bear Lake - Civic Center Grounds (360 deg.) accelerogram, recorded during the M_w 6.7 Big Bear earthquake. The Big Bear earthquake occurred on 28 June 1992 on a strike-slip fault.

The three depths to bedrock for each accelerogram for native and landfill site conditions were analyzed to evaluate a suite of site-specific seismic deformation responses.

RESULTS

The results of evaluations documented herein are plotted on the charts shown in Figure 1 (North Mesa characterized by 30 ft high landfill) and Figure 2 (South Mesa characterized by a 60 ft waste soil thickness embedded 30 ft below native ground suface). Inspection of Figures 1 and 2 indicate that the North Mesa displacement response is more critical than the South Mesa, although both ~~locations~~ responses are similar. The results further indicate that the largest seismic displacement response is calculated by applying the Parkfield record to the base of the 331 ft (101 m) high soil (soil/landfill) column.

Written by: Geoff L. Smith Date: 07 / 25 / 00 (MM DD YY) Reviewed by: Date: / / (MM DD YY)

Client: Parsons Project: BRC CAMU Project No.: HL0389 Task No.: 04

EK 07/26/00

REFERENCES

Idriss, I.M., Sun, J. I. (1992), "User's Manual for SHAKE91, A Computer Program for Conducting Equivalent Linear Seismic Response Analyses of Horizontally Layered Soil Deposits," Center for Geotechnical Modeling, Department of Civil and Environmental Engineering, University of California, Davis, California, November 1992.

Newmark, N.M. (1965), "Effects of Earthquakes on Dams and Embankments," Geotechnique, Vol. 15, No. 2, pp. 139-160.

Yan, L., Matasovic, N., and Kavazanjian, E. (1996), "YSLIP_PM - User's Guide," Research Report, GeoSyntec Consultants, Huntington Beach, California

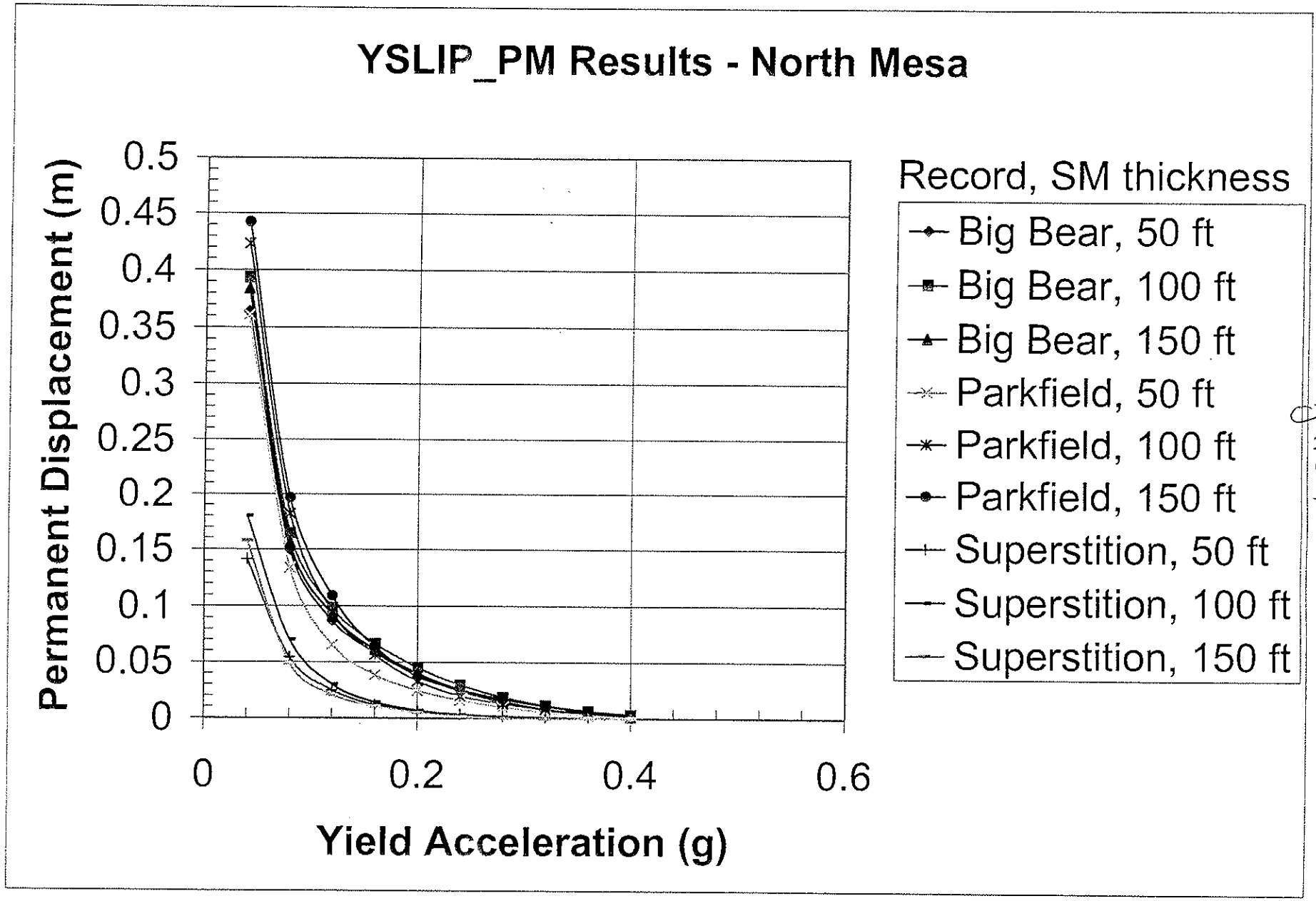


Figure 1

Page 7-7a

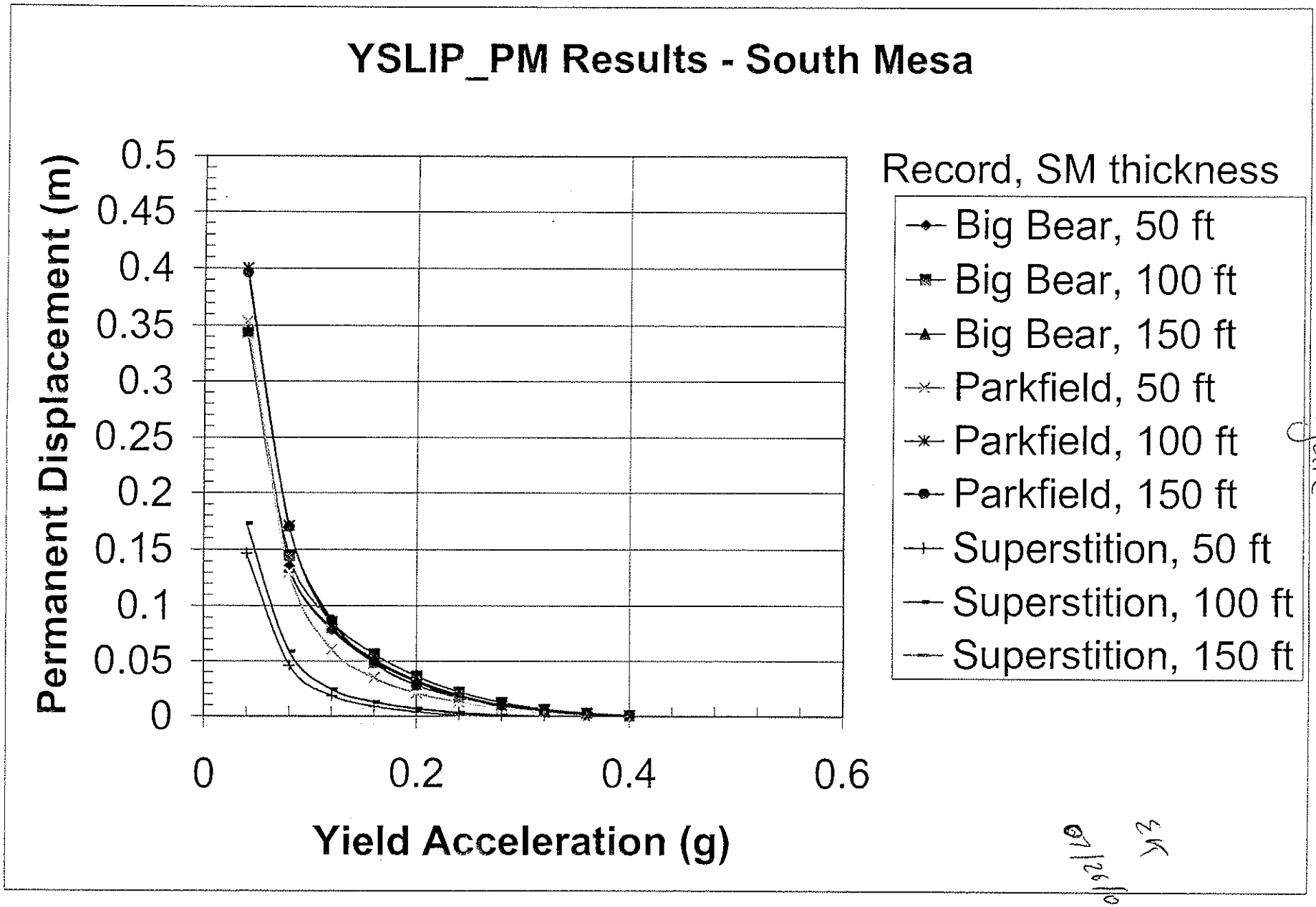


Figure 2

Fig 7-26

07/26/00

EK

SMGK 7-26

```
*********************************************
**                                         **
**                YSLIP_PM                 **
**        (VERSION 2.2, JANUARY 1996)      **
**                                         **
**   A COMPUTER PROGRAM FOR SIMULATION OF  **
**   DYNAMIC BEHAVIOR OF A RIGID BLOCK ON  **
**   AN INCLINED PLANE AND CALCULATION OF  **
**   PERMANENT DISPLACEMENTS OF THE BLOCK  **
**                                         **
**                   BY                    **
**                                         **
**              Liping Yan                 **
**           Neven Matasovic               **
**        Edward Kavazanjian, Jr.          **
**                                         **
*********************************************

***************REPRINT INPUT DATA**************

CARD  1: TITLE
         VARIATION OF Ky/Kh
CARD  2: SUBTITLE
         Parkfield Record 60 ft, SM thickness = 50 ft
CARD  3: KPAR  N     KACC  KCOM   g(m/s/s)  KOUT   KSLIP  KDIR
         0     10    1     1      9.807     0      0      0
CARD  4: Ky(1), ..., Ky(N)
         0.040 0.080 0.120 0.160 0.200 0.240 0.280 0.320 0.360 0.400
CARD  5: YIELD ACCELERATION DEGRADATION DATA
         Ky is constant.
CARD  6: INPUT HORIZONTAL ACC. TIME HISTORY FILE NAME
         p6050.out
CARD  7: NIDH  KREAD    NP      NLINE   DT      APH
         2     2        4096    512     0.02    0.4001
CARD  8: INPUT VERTICAL ACC. TIME HISTORY FILE NAME
         NO Av
CARD  9: NIDV  KREAD    NP      NLINE   DT      APV     TSHIFT
         NO INPUT
CARD 10: FILE NAME FOR OUTPUT OF SLIDING MOTION
         bbl.OUS
CARD 11: FILE NAME FOR OUTPUT OF ABSOLUTE MOTION
         bbl.OUA

MAX. VALUE OF INPUT HORI. ACC. =  .400062
INPUT HORI. ACC. TIMES A FACTOR = 1.000095 TO GET APH =  .400100

*****************RESULTS****************

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .040000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .3310 m/sec
        PERMANENT SLIDING DISPLACEMENT =  .3520 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .4161 m/sec
        PERMANENT SLIDING DISPLACEMENT =  .3537 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .080000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .2446 m/sec
        PERMANENT SLIDING DISPLACEMENT =  .0984 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .3471 m/sec
        PERMANENT SLIDING DISPLACEMENT =  .1303 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .120000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .1719 m/sec
        PERMANENT SLIDING DISPLACEMENT =  .0473 m
```

MAK 7-26

```
*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .2833 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0604 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .160000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1207 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0249 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .2267 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0349 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .200000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0758 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0111 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1724 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0209 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .240000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0421 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0034 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1231 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0128 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .280000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0156 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0008 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0817 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0072 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .320000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0004 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0430 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0032 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .360000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0155 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0008 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .400000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m
```

MSC 7-26

```
**********************************************
**                                          **
**                  YSLIP_PM                **
**          (VERSION 2.2, JANUARY 1996)     **
**                                          **
**   A COMPUTER PROGRAM FOR SIMULATION OF   **
**   DYNAMIC BEHAVIOR OF A RIGID BLOCK ON   **
**   AN INCLINED PLANE AND CALCULATION OF   **
**   PERMANENT DISPLACEMENTS OF THE BLOCK   **
**                                          **
**                    BY                    **
**                                          **
**                Liping Yan                **
**             Neven Matasovic              **
**          Edward Kavazanjian, Jr.         **
**                                          **
**********************************************

***************REPRINT INPUT DATA**************

CARD  1: TITLE
         VARIATION OF Ky/Kh
CARD  2: SUBTITLE
         Parkfield Record 60 ft, SM thickness = 100 ft
CARD  3: KPAR  N     KACC  KCOM   g(m/s/s)  KOUT   KSLIP  KDIR
         0     10    1     1      9.807    0      0      0
CARD  4: Ky(1), ..., Ky(N)
         0.040 0.080 0.120 0.160 0.200 0.240 0.280 0.320 0.360 0.400
CARD  5: YIELD ACCELERATION DEGRADATION DATA
         Ky is constant.
CARD  6: INPUT HORIZONTAL ACC. TIME HISTORY FILE NAME
         p60100.out
CARD  7: NIDH  KREAD   NP      NLINE   DT      APH
         2     2       4096    512     0.02    0.4395
CARD  8: INPUT VERTICAL ACC. TIME HISTORY FILE NAME
         NO Av
CARD  9: NIDV  KREAD   NP      NLINE   DT      APV     TSHIFT
         NO INPUT
CARD 10: FILE NAME FOR OUTPUT OF SLIDING MOTION
         bb1.OUS
CARD 11: FILE NAME FOR OUTPUT OF ABSOLUTE MOTION
         bb1.OUA

MAX. VALUE OF INPUT HORI. ACC. =  .439500
INPUT HORI. ACC. TIMES A FACTOR = 1.000000 TO GET APH =  .439500


*****************RESULTS****************

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .040000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
              MAX. SLIDING VELOCITY =   .3957 m/sec
       PERMANENT SLIDING DISPLACEMENT =   .3981 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
              MAX. SLIDING VELOCITY =   .4384 m/sec
       PERMANENT SLIDING DISPLACEMENT =   .3999 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .080000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
              MAX. SLIDING VELOCITY =   .3226 m/sec
       PERMANENT SLIDING DISPLACEMENT =   .1384 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
              MAX. SLIDING VELOCITY =   .3716 m/sec
       PERMANENT SLIDING DISPLACEMENT =   .1708 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .120000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
              MAX. SLIDING VELOCITY =   .2582 m/sec
       PERMANENT SLIDING DISPLACEMENT =   .0690 m
```

TASK 7-2C

```
*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .3115 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0834 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .160000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1966 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0386 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .2535 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0480 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .200000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1459 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0215 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1977 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0280 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .240000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0982 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0108 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1518 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0163 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .280000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0610 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0050 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1085 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0100 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .320000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0285 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0018 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0676 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0055 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .360000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0076 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0003 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0373 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0024 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .400000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0115 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0006 m
```

MSK 7-2C

```
**********************************************
**                                          **
**                  YSLIP_PM                **
**         (VERSION 2.2, JANUARY 1996)      **
**                                          **
**   A COMPUTER PROGRAM FOR SIMULATION OF   **
**   DYNAMIC BEHAVIOR OF A RIGID BLOCK ON   **
**   AN INCLINED PLANE AND CALCULATION OF   **
**   PERMANENT DISPLACEMENTS OF THE BLOCK   **
**                                          **
**                    BY                    **
**                                          **
**                Liping Yan                **
**             Neven Matasovic              **
**          Edward Kavazanjian, Jr.         **
**                                          **
**********************************************

***************REPRINT INPUT DATA**************

CARD  1: TITLE
         VARIATION OF Ky/Kh
CARD  2: SUBTITLE
         Parkfield Record 60 ft, SM thickness = 150 ft
CARD  3: KPAR  N    KACC  KCOM  g(m/s/s)  KOUT  KSLIP  KDIR
         0     10   1     1     9.807     0     0      0
CARD  4: Ky(1), ..., Ky(N)
         0.040 0.080 0.120 0.160 0.200 0.240 0.280 0.320 0.360 0.400
CARD  5: YIELD ACCELERATION DEGRADATION DATA
         Ky is constant.
CARD  6: INPUT HORIZONTAL ACC. TIME HISTORY FILE NAME
         p60150.out
CARD  7: NIDH  KREAD  NP    NLINE  DT    APH
         2     2      4096  512    0.02  0.4249
CARD  8: INPUT VERTICAL ACC. TIME HISTORY FILE NAME
         NO Av
CARD  9: NIDV  KREAD  NP    NLINE  DT    APV    TSHIFT
         NO INPUT
CARD 10: FILE NAME FOR OUTPUT OF SLIDING MOTION
         bbl.OUS
CARD 11: FILE NAME FOR OUTPUT OF ABSOLUTE MOTION
         bbl.OUA

MAX. VALUE OF INPUT HORI. ACC. =  .424949
INPUT HORI. ACC. TIMES A FACTOR =  .999885 TO GET APH =  .424900


*****************RESULTS****************

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .040000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
              MAX. SLIDING VELOCITY =   .4676 m/sec
       PERMANENT SLIDING DISPLACEMENT =   .3960 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
              MAX. SLIDING VELOCITY =   .4437 m/sec
       PERMANENT SLIDING DISPLACEMENT =   .3740 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .080000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
              MAX. SLIDING VELOCITY =   .3909 m/sec
       PERMANENT SLIDING DISPLACEMENT =   .1531 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
              MAX. SLIDING VELOCITY =   .3734 m/sec
       PERMANENT SLIDING DISPLACEMENT =   .1696 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .120000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
              MAX. SLIDING VELOCITY =   .3212 m/sec
       PERMANENT SLIDING DISPLACEMENT =   .0811 m
```

MGK 7-76

```
*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .3081 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0873 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .160000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .2540 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0457 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .2504 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0476 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .200000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1972 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0281 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1949 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0266 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .240000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1431 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0172 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1433 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0157 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .280000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0978 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0100 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1010 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0093 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .320000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0573 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0049 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0613 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0048 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .360000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0272 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0017 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0295 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0018 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .400000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0053 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0002 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0056 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0002 m
```

MSK 7-26

```
**********************************************
**                                          **
**                YSLIP_PM                  **
**        (VERSION 2.2, JANUARY 1996)       **
**                                          **
**   A COMPUTER PROGRAM FOR SIMULATION OF   **
**   DYNAMIC BEHAVIOR OF A RIGID BLOCK ON   **
**   AN INCLINED PLANE AND CALCULATION OF   **
**   PERMANENT DISPLACEMENTS OF THE BLOCK   **
**                                          **
**                    BY                    **
**                                          **
**               Liping Yan                 **
**             Neven Matasovic              **
**         Edward Kavazanjian, Jr.          **
**                                          **
**********************************************

***************REPRINT INPUT DATA**************

CARD  1: TITLE
         VARIATION OF Ky/Kh
CARD  2: SUBTITLE
         Parkfield Record 30 ft, SM thickness = 50 ft
CARD  3: KPAR  N     KACC  KCOM   g(m/s/s)  KOUT  KSLIP  KDIR
         0     10     1     1     9.807     0     0     0
CARD  4: Ky(1), ..., Ky(N)
         0.040 0.080 0.120 0.160 0.200 0.240 0.280 0.320 0.360 0.400
CARD  5: YIELD ACCELERATION DEGRADATION DATA
         Ky is constant.
CARD  6: INPUT HORIZONTAL ACC. TIME HISTORY FILE NAME
         p3050.out
CARD  7: NIDH  KREAD    NP      NLINE   DT      APH
         2     2        4096    512     0.02    0.4298
CARD  8: INPUT VERTICAL ACC. TIME HISTORY FILE NAME
         NO Av
CARD  9: NIDV  KREAD    NP      NLINE   DT      APV     TSHIFT
         NO INPUT
CARD 10: FILE NAME FOR OUTPUT OF SLIDING MOTION
         bbl.OUS
CARD 11: FILE NAME FOR OUTPUT OF ABSOLUTE MOTION
         bbl.OUA

MAX. VALUE OF INPUT HORI. ACC. =  .429801
INPUT HORI. ACC. TIMES A FACTOR =  .999998 TO GET APH =  .429800


*****************RESULTS****************

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .040000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .3252 m/sec
       PERMANENT SLIDING DISPLACEMENT =   .3609 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .4408 m/sec
       PERMANENT SLIDING DISPLACEMENT =   .3555 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .080000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .2552 m/sec
       PERMANENT SLIDING DISPLACEMENT =   .0970 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .3711 m/sec
       PERMANENT SLIDING DISPLACEMENT =   .1340 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .120000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .1973 m/sec
       PERMANENT SLIDING DISPLACEMENT =   .0509 m
```

MSK 7-26

```
*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .3112 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0656 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .160000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1451 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0291 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .2536 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0387 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .200000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1006 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0151 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1981 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0246 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .240000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0625 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0062 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1495 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0158 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .280000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0323 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0020 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1067 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0098 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .320000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0092 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0004 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0663 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0053 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .360000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0342 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0022 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .400000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0085 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0004 m
```

MGK 7.76

```
**********************************************
**                                          **
**                YSLIP_PM                  **
**        (VERSION 2.2, JANUARY 1996)       **
**                                          **
**   A COMPUTER PROGRAM FOR SIMULATION OF   **
**   DYNAMIC BEHAVIOR OF A RIGID BLOCK ON   **
**   AN INCLINED PLANE AND CALCULATION OF   **
**   PERMANENT DISPLACEMENTS OF THE BLOCK   **
**                                          **
**                   BY                     **
**                                          **
**              Liping Yan                  **
**            Neven Matasovic               **
**        Edward Kavazanjian, Jr.           **
**                                          **
**********************************************

***************REPRINT INPUT DATA**************

CARD  1: TITLE
         VARIATION OF Ky/Kh
CARD  2: SUBTITLE
         Parkfield Record 30 ft, SM thickness = 100 ft
CARD  3: KPAR  N     KACC  KCOM   g(m/s/s)   KOUT   KSLIP  KDIR
         0     10    1     1      9.807     0      0      0
CARD  4: Ky(1), ..., Ky(N)
         0.040 0.080 0.120 0.160 0.200 0.240 0.280 0.320 0.360 0.400
CARD  5: YIELD ACCELERATION DEGRADATION DATA
         Ky is constant.
CARD  6: INPUT HORIZONTAL ACC. TIME HISTORY FILE NAME
         p30100.out
CARD  7: NIDH  KREAD     NP        NLINE     DT        APH
         2     2         4096      512       0.02      0.469
CARD  8: INPUT VERTICAL ACC. TIME HISTORY FILE NAME
         NO Av
CARD  9: NIDV  KREAD     NP        NLINE     DT        APV       TSHIFT
         NO INPUT
CARD 10: FILE NAME FOR OUTPUT OF SLIDING MOTION
         bbl.OUS
CARD 11: FILE NAME FOR OUTPUT OF ABSOLUTE MOTION
         bbl.OUA

MAX. VALUE OF INPUT HORI. ACC. =  .469017
INPUT HORI. ACC. TIMES A FACTOR =  .999964 TO GET APH =  .469000


*****************RESULTS****************

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .040000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .4464 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .4231 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .4670 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .4123 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .080000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .3777 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .1421 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .4022 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .1820 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .120000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .3113 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .0753 m
```

MISK 7.26

```
*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .3420 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0950 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .160000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .2518 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0458 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .2839 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0566 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .200000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1979 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0290 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .2280 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0330 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .240000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1466 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0173 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1799 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0198 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .280000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1053 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0101 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1363 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0128 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .320000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0671 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0054 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0951 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0079 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .360000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0368 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0023 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0583 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0042 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .400000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0127 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0006 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0307 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0017 m
```

MAK 7-26

```
*********************************************
**                                         **
**                YSLIP_PM                 **
**        (VERSION 2.2, JANUARY 1996)      **
**                                         **
**   A COMPUTER PROGRAM FOR SIMULATION OF  **
**   DYNAMIC BEHAVIOR OF A RIGID BLOCK ON  **
**   AN INCLINED PLANE AND CALCULATION OF  **
**   PERMANENT DISPLACEMENTS OF THE BLOCK  **
**                                         **
**                   BY                    **
**                                         **
**              Liping Yan                 **
**           Neven Matasovic               **
**        Edward Kavazanjian, Jr.          **
**                                         **
*********************************************

***************REPRINT INPUT DATA**************

CARD  1: TITLE
         VARIATION OF Ky/Kh
CARD  2: SUBTITLE
         Parkfield Record 30 ft, SM thickness = 150 ft
CARD  3: KPAR  N    KACC  KCOM   g(m/s/s)  KOUT  KSLIP  KDIR
         0     10   1     1      9.807     0     0      0
CARD  4: Ky(1), ..., Ky(N)
         0.040 0.080 0.120 0.160 0.200 0.240 0.280 0.320 0.360 0.400
CARD  5: YIELD ACCELERATION DEGRADATION DATA
         Ky is constant.
CARD  6: INPUT HORIZONTAL ACC. TIME HISTORY FILE NAME
         p30150.out
CARD  7: NIDH  KREAD   NP      NLINE   DT      APH
         2     2       4096    512     0.02    0.4797
CARD  8: INPUT VERTICAL ACC. TIME HISTORY FILE NAME
         NO Av
CARD  9: NIDV  KREAD   NP      NLINE   DT      APV     TSHIFT
         NO INPUT
CARD 10: FILE NAME FOR OUTPUT OF SLIDING MOTION
         bbl.OUS
CARD 11: FILE NAME FOR OUTPUT OF ABSOLUTE MOTION
         bbl.OUA

MAX. VALUE OF INPUT HORI. ACC. =  .479704
INPUT HORI. ACC. TIMES A FACTOR =  .999992 TO GET APH =  .479700


*****************RESULTS****************

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .040000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .5281 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .4422 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .4656 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .4124 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .080000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .4522 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .1726 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .3967 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .1964 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .120000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .3817 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .0971 m
```

Page 7-26

```
*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .3344 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .1090 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .160000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .3180 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0582 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .2744 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0634 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .200000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .2566 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0372 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .2168 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0356 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .240000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .2011 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0255 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1679 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0195 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .280000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1521 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0170 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1232 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0116 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .320000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1055 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0105 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0812 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0067 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .360000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0689 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0057 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0469 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0032 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .400000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0356 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0024 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0196 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0010 m
```

MSK 7-26

```
**********************************************
**                                          **
**                YSLIP_PM                  **
**        (VERSION 2.2, JANUARY 1996)       **
**                                          **
**   A COMPUTER PROGRAM FOR SIMULATION OF   **
**   DYNAMIC BEHAVIOR OF A RIGID BLOCK ON   **
**   AN INCLINED PLANE AND CALCULATION OF   **
**   PERMANENT DISPLACEMENTS OF THE BLOCK   **
**                                          **
**                    BY                    **
**                                          **
**               Liping Yan                 **
**            Neven Matasovic               **
**         Edward Kavazanjian, Jr.          **
**                                          **
**********************************************

***************REPRINT INPUT DATA**************

CARD  1: TITLE
         VARIATION OF Ky/Kh
CARD  2: SUBTITLE
         Superstition 30'- SM layer thickness = 50'
CARD  3: KPAR  N     KACC  KCOM   g(m/s/s)  KOUT   KSLIP  KDIR
         0     10    1     1      9.807     0      0      0
CARD  4: Ky(1), ..., Ky(N)
         0.040 0.080 0.120 0.160 0.200 0.240 0.280 0.320 0.360 0.400
CARD  5: YIELD ACCELERATION DEGRADATION DATA
         Ky is constant.
CARD  6: INPUT HORIZONTAL ACC. TIME HISTORY FILE NAME
         sn3050.out
CARD  7: NIDH  KREAD     NP        NLINE     DT        APH
         2     2         4096      512       0.005     0.4046
CARD  8: INPUT VERTICAL ACC. TIME HISTORY FILE NAME
         NO Av
CARD  9: NIDV  KREAD     NP        NLINE     DT        APV       TSHIFT
         NO INPUT
CARD 10: FILE NAME FOR OUTPUT OF SLIDING MOTION
         bbl.OUS
CARD 11: FILE NAME FOR OUTPUT OF ABSOLUTE MOTION
         bbl.OUA

MAX. VALUE OF INPUT HORI. ACC. =  .404609
INPUT HORI. ACC. TIMES A FACTOR =  .999978 TO GET APH =  .404600


******************RESULTS*****************

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .040000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .2177 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .1389 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .2152 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .1415 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .080000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .1495 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .0532 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .1580 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .0542 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .120000
```

MSK 7-26

```
*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1128 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0207 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1253 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0248 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .160000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0801 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0089 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0980 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0117 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .200000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0518 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0035 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0735 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0060 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .240000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0282 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0013 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0523 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0030 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .280000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0100 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0003 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0338 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0014 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .320000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0184 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0006 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .360000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0068 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0001 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .400000
```

7-26

```
*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
      PERMANENT SLIDING DISPLACEMENT =    .0000 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0001 m/sec
      PERMANENT SLIDING DISPLACEMENT =    .0000 m
```

PMSK 7-26

```
**********************************************
**                                          **
**                YSLIP_PM                  **
**        (VERSION 2.2, JANUARY 1996)       **
**                                          **
**   A COMPUTER PROGRAM FOR SIMULATION OF   **
**   DYNAMIC BEHAVIOR OF A RIGID BLOCK ON   **
**   AN INCLINED PLANE AND CALCULATION OF   **
**   PERMANENT DISPLACEMENTS OF THE BLOCK   **
**                                          **
**                    BY                    **
**                                          **
**               Liping Yan                 **
**             Neven Matasovic              **
**          Edward Kavazanjian, Jr.         **
**                                          **
**********************************************

***************REPRINT INPUT DATA**************

CARD  1: TITLE
         VARIATION OF Ky/Kh
CARD  2: SUBTITLE
         Superstition 30'- SM layer thickness = 100'
CARD  3: KPAR  N     KACC  KCOM   g(m/s/s)  KOUT   KSLIP  KDIR
         0     10    1     1      9.807     0      0      0
CARD  4: Ky(1), ..., Ky(N)
         0.040 0.080 0.120 0.160 0.200 0.240 0.280 0.320 0.360 0.400
CARD  5: YIELD ACCELERATION DEGRADATION DATA
         Ky is constant.
CARD  6: INPUT HORIZONTAL ACC. TIME HISTORY FILE NAME
         sn30100.out
CARD  7: NIDH  KREAD     NP        NLINE     DT       APH
         2     2         4096      512       0.005    0.3467
CARD  8: INPUT VERTICAL ACC. TIME HISTORY FILE NAME
         NO Av
CARD  9: NIDV  KREAD     NP        NLINE     DT       APV       TSHIFT
         NO INPUT
CARD 10: FILE NAME FOR OUTPUT OF SLIDING MOTION
         bbl.OUS
CARD 11: FILE NAME FOR OUTPUT OF ABSOLUTE MOTION
         bbl.OUA

MAX. VALUE OF INPUT HORI. ACC. =  .346668
INPUT HORI. ACC. TIMES A FACTOR = 1.000092 TO GET APH =  .346700


******************RESULTS*****************

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .040000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .2369 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .1598 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .2412 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .1800 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .080000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .1683 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .0592 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .1843 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .0702 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .120000
```

MGK 7-26

```
*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1305 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0235 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1344 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0302 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .160000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0966 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0117 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0946 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0139 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .200000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0667 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0064 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0627 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0066 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .240000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0411 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0029 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0369 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0029 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .280000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0203 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0009 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0172 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0009 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .320000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0050 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0001 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0037 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0001 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .360000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .400000
```

MGK 7-26

```
*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
      PERMANENT SLIDING DISPLACEMENT =    .0000 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
      PERMANENT SLIDING DISPLACEMENT =    .0000 m
```

MSK 7-26

```
**********************************************
**                                          **
**                  YSLIP_PM                **
**          (VERSION 2.2, JANUARY 1996)     **
**                                          **
**    A COMPUTER PROGRAM FOR SIMULATION OF  **
**    DYNAMIC BEHAVIOR OF A RIGID BLOCK ON  **
**    AN INCLINED PLANE AND CALCULATION OF  **
**    PERMANENT DISPLACEMENTS OF THE BLOCK  **
**                                          **
**                     BY                   **
**                                          **
**                Liping Yan                **
**              Neven Matasovic             **
**          Edward Kavazanjian, Jr.         **
**                                          **
**********************************************

***************REPRINT INPUT DATA**************

CARD  1: TITLE
         VARIATION OF Ky/Kh
CARD  2: SUBTITLE
         Superstition 30'- SM layer thickness = 150'
CARD  3: KPAR  N     KACC  KCOM   g(m/s/s)  KOUT   KSLIP  KDIR
         0     10    1     1      9.807     0      0      0
CARD  4: Ky(1), ..., Ky(N)
         0.040 0.080 0.120 0.160 0.200 0.240 0.280 0.320 0.360 0.400
CARD  5: YIELD ACCELERATION DEGRADATION DATA
         Ky is constant.
CARD  6: INPUT HORIZONTAL ACC. TIME HISTORY FILE NAME
         sn30150.out
CARD  7: NIDH  KREAD     NP        NLINE     DT        APH
         2     2         4096      512       0.005     0.3088
CARD  8: INPUT VERTICAL ACC. TIME HISTORY FILE NAME
         NO Av
CARD  9: NIDV  KREAD     NP        NLINE     DT        APV       TSHIFT
         NO INPUT
CARD 10: FILE NAME FOR OUTPUT OF SLIDING MOTION
         bbl.OUS
CARD 11: FILE NAME FOR OUTPUT OF ABSOLUTE MOTION
         bbl.OUA

MAX. VALUE OF INPUT HORI. ACC. =  .308773
INPUT HORI. ACC. TIMES A FACTOR = 1.000087 TO GET APH =  .308800

*****************RESULTS****************

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .040000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .1835 m/sec
       PERMANENT SLIDING DISPLACEMENT =   .1271 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .2060 m/sec
       PERMANENT SLIDING DISPLACEMENT =   .1579 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .080000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .1431 m/sec
       PERMANENT SLIDING DISPLACEMENT =   .0485 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .1518 m/sec
       PERMANENT SLIDING DISPLACEMENT =   .0491 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .120000
```

MSK 7-26

```
*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1064 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0209 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1086 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0180 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .160000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0736 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0102 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0729 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0084 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .200000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0450 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0050 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0437 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0035 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .240000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0212 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0018 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0210 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0011 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .280000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0049 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0002 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0054 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0001 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .320000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .360000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .400000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
```

MAX. SLIDING VELOCITY = .0000 m/sec
PERMANENT SLIDING DISPLACEMENT = .0000 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
MAX. SLIDING VELOCITY = .0000 m/sec
PERMANENT SLIDING DISPLACEMENT = .0000 m

Mark 7-26

```
*********************************************
**                                         **
**                YSLIP_PM                 **
**        (VERSION 2.2, JANUARY 1996)      **
**                                         **
**   A COMPUTER PROGRAM FOR SIMULATION OF  **
**   DYNAMIC BEHAVIOR OF A RIGID BLOCK ON  **
**   AN INCLINED PLANE AND CALCULATION OF  **
**   PERMANENT DISPLACEMENTS OF THE BLOCK  **
**                                         **
**                   BY                    **
**                                         **
**              Liping Yan                 **
**           Neven Matasovic               **
**        Edward Kavazanjian, Jr.          **
**                                         **
*********************************************

***************REPRINT INPUT DATA**************

CARD  1: TITLE
         VARIATION OF Ky/Kh
CARD  2: SUBTITLE
         Superstition 60'- SM layer thickness = 150'
CARD  3: KPAR  N     KACC  KCOM   g(m/s/s)   KOUT   KSLIP  KDIR
         0     10    1     1      9.807     0      0      0
CARD  4: Ky(1), ..., Ky(N)
         0.040 0.080 0.120 0.160 0.200 0.240 0.280 0.320 0.360 0.400
CARD  5: YIELD ACCELERATION DEGRADATION DATA
         Ky is constant.
CARD  6: INPUT HORIZONTAL ACC. TIME HISTORY FILE NAME
         sn60150.out
CARD  7: NIDH  KREAD    NP        NLINE     DT       APH
         2     2        4096      512       0.005    0.3090
CARD  8: INPUT VERTICAL ACC. TIME HISTORY FILE NAME
         NO Av
CARD  9: NIDV  KREAD    NP        NLINE     DT       APV       TSHIFT
         NO INPUT
CARD 10: FILE NAME FOR OUTPUT OF SLIDING MOTION
         bbl.OUS
CARD 11: FILE NAME FOR OUTPUT OF ABSOLUTE MOTION
         bbl.OUA

MAX. VALUE OF INPUT HORI.'ACC. =  .308963
INPUT HORI. ACC. TIMES A FACTOR = 1.000120 TO GET APH =  .309000


*****************RESULTS****************

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .040000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .1797 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .1272 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .1887 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .1468 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .080000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .1401 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .0461 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .1434 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .0446 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .120000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .1044 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .0183 m
```

Wash 7-26

```
*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1044 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0157 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .160000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0726 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0086 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0711 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0069 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .200000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0450 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0037 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0432 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0029 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .240000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0222 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0011 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0210 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0010 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .280000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0054 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0001 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0055 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0001 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .320000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .360000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .400000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m
```

MSC 7.76

```
*********************************************
**                                         **
**                YSLIP_PM                 **
**        (VERSION 2.2, JANUARY 1996)      **
**                                         **
**   A COMPUTER PROGRAM FOR SIMULATION OF  **
**   DYNAMIC BEHAVIOR OF A RIGID BLOCK ON  **
**   AN INCLINED PLANE AND CALCULATION OF  **
**   PERMANENT DISPLACEMENTS OF THE BLOCK  **
**                                         **
**                   BY                    **
**                                         **
**               Liping Yan                **
**            Neven Matasovic              **
**         Edward Kavazanjian, Jr.         **
**                                         **
*********************************************

***************REPRINT INPUT DATA**************

CARD  1: TITLE
         VARIATION OF Ky/Kh
CARD  2: SUBTITLE
         Superstition 60'- SM layer thickness = 100'
CARD  3: KPAR  N    KACC  KCOM  g(m/s/s)  KOUT  KSLIP  KDIR
         0     10   1     1     9.807     0     0     0
CARD  4: Ky(1), ..., Ky(N)
         0.040 0.080 0.120 0.160 0.200 0.240 0.280 0.320 0.360 0.400
CARD  5: YIELD ACCELERATION DEGRADATION DATA
         Ky is constant.
CARD  6: INPUT HORIZONTAL ACC. TIME HISTORY FILE NAME
         sn60100.out
CARD  7: NIDH  KREAD  NP    NLINE  DT     APH
         2     2      4096  512    0.005  0.3379
CARD  8: INPUT VERTICAL ACC. TIME HISTORY FILE NAME
         NO Av
CARD  9: NIDV  KREAD  NP    NLINE  DT     APV    TSHIFT
         NO INPUT
CARD 10: FILE NAME FOR OUTPUT OF SLIDING MOTION
         bbl.OUS
CARD 11: FILE NAME FOR OUTPUT OF ABSOLUTE MOTION
         bbl.OUA

MAX. VALUE OF INPUT HORI. ACC. =  .337891
INPUT HORI. ACC. TIMES A FACTOR = 1.000027 TO GET APH =  .337900


*****************RESULTS****************

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .040000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .2146 m/sec
       PERMANENT SLIDING DISPLACEMENT =   .1509 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .2143 m/sec
       PERMANENT SLIDING DISPLACEMENT =   .1729 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .080000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .1588 m/sec
       PERMANENT SLIDING DISPLACEMENT =   .0550 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .1591 m/sec
       PERMANENT SLIDING DISPLACEMENT =   .0587 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .120000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .1225 m/sec
       PERMANENT SLIDING DISPLACEMENT =   .0243 m
```

MW 9-96

```
*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1170 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0217 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .160000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0901 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0126 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0823 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0102 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .200000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0614 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0066 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0537 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0046 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .240000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0366 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0030 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0302 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0018 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .280000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0168 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0009 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0123 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0004 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .320000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0029 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0001 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0012 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .360000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .400000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m
```

TASK 7-26

```
**********************************************
**                                          **
**                YSLIP_PM                  **
**        (VERSION 2.2, JANUARY 1996)       **
**                                          **
**   A COMPUTER PROGRAM FOR SIMULATION OF   **
**   DYNAMIC BEHAVIOR OF A RIGID BLOCK ON   **
**   AN INCLINED PLANE AND CALCULATION OF   **
**   PERMANENT DISPLACEMENTS OF THE BLOCK   **
**                                          **
**                   BY                     **
**                                          **
**              Liping Yan                  **
**            Neven Matasovic               **
**        Edward Kavazanjian, Jr.           **
**                                          **
**********************************************

***************REPRINT INPUT DATA**************

CARD  1: TITLE
         VARIATION OF Ky/Kh
CARD  2: SUBTITLE
         Superstition 60'- SM layer thickness = 50'
CARD  3: KPAR  N     KACC  KCOM   g(m/s/s)  KOUT   KSLIP  KDIR
         0     10    1     1      9.807     0      0      0
CARD  4: Ky(1), ..., Ky(N)
         0.040 0.080 0.120 0.160 0.200 0.240 0.280 0.320 0.360 0.400
CARD  5: YIELD ACCELERATION DEGRADATION DATA
         Ky is constant.
CARD  6: INPUT HORIZONTAL ACC. TIME HISTORY FILE NAME
         sn6050.out
CARD  7: NIDH  KREAD    NP      NLINE   DT      APH
         2     2        4096    512     0.005   0.3763
CARD  8: INPUT VERTICAL ACC. TIME HISTORY FILE NAME
         NO Av
CARD  9: NIDV  KREAD    NP      NLINE   DT      APV     TSHIFT
         NO INPUT
CARD 10: FILE NAME FOR OUTPUT OF SLIDING MOTION
         bbl.OUS
CARD 11: FILE NAME FOR OUTPUT OF ABSOLUTE MOTION
         bbl.OUA

MAX. VALUE OF INPUT HORI. ACC. =  .376289
INPUT HORI. ACC. TIMES A FACTOR = 1.000029 TO GET APH =  .376300

*****************RESULTS****************

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .040000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .2217 m/sec
        PERMANENT SLIDING DISPLACEMENT =  .1409 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .1932 m/sec
        PERMANENT SLIDING DISPLACEMENT =  .1427 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .080000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .1351 m/sec
        PERMANENT SLIDING DISPLACEMENT =  .0519 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .1526 m/sec
        PERMANENT SLIDING DISPLACEMENT =  .0510 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .120000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .0990 m/sec
        PERMANENT SLIDING DISPLACEMENT =  .0202 m
```

9/15/K 7-26

```
*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1203 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0201 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .160000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0674 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0095 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0917 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0101 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .200000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0403 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0045 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0663 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0051 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .240000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0188 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0014 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0442 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0024 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .280000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0048 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0002 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0257 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0010 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .320000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0112 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0003 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .360000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0016 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .400000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m
```

MSK 7.26

```
**********************************************
**                                          **
**                YSLIP_PM                  **
**        (VERSION 2.2, JANUARY 1996)       **
**                                          **
**   A COMPUTER PROGRAM FOR SIMULATION OF   **
**   DYNAMIC BEHAVIOR OF A RIGID BLOCK ON   **
**   AN INCLINED PLANE AND CALCULATION OF   **
**   PERMANENT DISPLACEMENTS OF THE BLOCK   **
**                                          **
**                   BY                     **
**                                          **
**              Liping Yan                  **
**            Neven Matasovic               **
**        Edward Kavazanjian, Jr.           **
**                                          **
**********************************************

***************REPRINT INPUT DATA**************

CARD  1: TITLE
         VARIATION OF Ky/Kh
CARD  2: SUBTITLE
         Big Bear Record 30' - SM thickness = 100 ft
CARD  3: KPAR  N     KACC  KCOM   g(m/s/s)  KOUT   KSLIP  KDIR
         0     10    1     1      9.807     0      0      0
CARD  4: Ky(I), ..., Ky(N)
         0.040 0.080 0.120 0.160 0.200 0.240 0.280 0.320 0.360 0.400
CARD  5: YIELD ACCELERATION DEGRADATION DATA
         Ky is constant.
CARD  6: INPUT HORIZONTAL ACC. TIME HISTORY FILE NAME
         b30100.out
CARD  7: NIDH  KREAD     NP        NLINE     DT        APH
         2     2         4096      512       0.01      0.4969
CARD  8: INPUT VERTICAL ACC. TIME HISTORY FILE NAME
         NO Av
CARD  9: NIDV  KREAD     NP        NLINE     DT        APV       TSHIFT
         NO INPUT
CARD 10: FILE NAME FOR OUTPUT OF SLIDING MOTION
         bbl.OUS
CARD 11: FILE NAME FOR OUTPUT OF ABSOLUTE MOTION
         bbl.OUA

MAX. VALUE OF INPUT HORI. ACC. =  .496930
INPUT HORI. ACC. TIMES A FACTOR =  .999940 TO GET APH =  .496900


*****************RESULTS****************

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .040000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .5224 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .3651 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .3417 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .3938 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .080000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .4477 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .1647 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .2547 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .1513 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .120000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .3783 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .0984 m
```

MSK 7.26

```
*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1779 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0649 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .160000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .3145 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0665 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1184 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0288 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .200000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .2562 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0452 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0807 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0131 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .240000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .2032 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0297 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0499 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0047 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .280000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1557 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0188 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0249 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0011 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .320000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1136 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0111 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0069 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0002 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .360000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0763 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0061 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .400000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0445 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0029 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m
```

PSK 7.26

```
**********************************************
**                                          **
**                YSLIP_PM                  **
**        (VERSION 2.2, JANUARY 1996)       **
**                                          **
**   A COMPUTER PROGRAM FOR SIMULATION OF   **
**   DYNAMIC BEHAVIOR OF A RIGID BLOCK ON   **
**   AN INCLINED PLANE AND CALCULATION OF   **
**   PERMANENT DISPLACEMENTS OF THE BLOCK   **
**                                          **
**                   BY                     **
**                                          **
**               Liping Yan                 **
**             Neven Matasovic              **
**         Edward Kavazanjian, Jr.          **
**                                          **
**********************************************

***************REPRINT INPUT DATA**************

CARD  1: TITLE
         VARIATION OF Ky/Kh
CARD  2: SUBTITLE
         Big Bear Record 30' - SM thickness = 50 ft
CARD  3: KPAR  N     KACC  KCOM   g(m/s/s)  KOUT   KSLIP  KDIR
         0     10    1     1      9.807     0      0      0
CARD  4: Ky(1), ..., Ky(N)
         0.040 0.080 0.120 0.160 0.200 0.240 0.280 0.320 0.360 0.400
CARD  5: YIELD ACCELERATION DEGRADATION DATA
         Ky is constant.
CARD  6: INPUT HORIZONTAL ACC. TIME HISTORY FILE NAME
         b3050.out
CARD  7: NIDH  KREAD     NP        NLINE     DT        APH
         2     2         4096      512       0.01      0.4652
CARD  8: INPUT VERTICAL ACC. TIME HISTORY FILE NAME
         NO Av
CARD  9: NIDV  KREAD     NP        NLINE     DT        APV       TSHIFT
         NO INPUT
CARD 10: FILE NAME FOR OUTPUT OF SLIDING MOTION
         bbl.OUS
CARD 11: FILE NAME FOR OUTPUT OF ABSOLUTE MOTION
         bbl.OUA

MAX. VALUE OF INPUT HORI. ACC. =  .465208
INPUT HORI. ACC. TIMES A FACTOR =  .999983 TO GET APH =  .465200


*****************RESULTS****************

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .040000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .4741 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .3345 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .3380 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .3638 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .080000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .3983 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .1498 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .2529 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .1481 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .120000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .3309 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .0872 m
```

NSK 7-26

```
*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1761 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0623 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .160000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .2716 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0584 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1094 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0265 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .200000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .2179 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0385 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0562 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0102 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .240000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1688 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0240 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0272 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0027 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .280000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1257 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0141 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0080 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0002 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .320000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0869 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0075 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .360000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0529 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0036 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .400000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0256 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0013 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m
```

MSC 7.26

```
**********************************************
**                                          **
**                YSLIP_PM                  **
**        (VERSION 2.2, JANUARY 1996)       **
**                                          **
**   A COMPUTER PROGRAM FOR SIMULATION OF   **
**   DYNAMIC BEHAVIOR OF A RIGID BLOCK ON   **
**   AN INCLINED PLANE AND CALCULATION OF   **
**   PERMANENT DISPLACEMENTS OF THE BLOCK   **
**                                          **
**                   BY                     **
**                                          **
**               Liping Yan                 **
**            Neven Matasovic               **
**         Edward Kavazanjian, Jr.          **
**                                          **
**********************************************

***************REPRINT INPUT DATA**************

CARD  1: TITLE
         VARIATION OF Ky/Kh
CARD  2: SUBTITLE
         Big Bear Record 30' - SM thickness = 150 ft
CARD  3: KPAR  N     KACC  KCOM   g(m/s/s)  KOUT   KSLIP  KDIR
         0     10     1     1     9.807     0      0      0
CARD  4: Ky(1), ..., Ky(N)
         0.040 0.080 0.120 0.160 0.200 0.240 0.280 0.320 0.360 0.400
CARD  5: YIELD ACCELERATION DEGRADATION DATA
         Ky is constant.
CARD  6: INPUT HORIZONTAL ACC. TIME HISTORY FILE NAME
         b30150.out
CARD  7: NIDH  KREAD    NP      NLINE    DT      APH
         2     2        4096    512      0.01    0.4570
CARD  8: INPUT VERTICAL ACC. TIME HISTORY FILE NAME
         NO Av
CARD  9: NIDV  KREAD    NP      NLINE    DT      APV     TSHIFT
         NO INPUT
CARD 10: FILE NAME FOR OUTPUT OF SLIDING MOTION
         bbl.OUS
CARD 11: FILE NAME FOR OUTPUT OF ABSOLUTE MOTION
         bbl.OUA

MAX. VALUE OF INPUT HORI. ACC. =  .457006
INPUT HORI. ACC. TIMES A FACTOR =  .999987 TO GET APH =  .457000


*****************RESULTS****************

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .040000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .5083 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .3525 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .3590 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .3839 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .080000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .4312 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .1558 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .2764 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .1452 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .120000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .3584 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .0923 m
```

MSK 7.26

```
*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .2026 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0643 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .160000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .2907 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0607 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1370 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0297 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .200000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .2288 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0399 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0818 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0142 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .240000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1734 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0251 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0386 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0053 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .280000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1247 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0149 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0112 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0009 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .320000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0830 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0079 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .360000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0483 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0036 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .400000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0211 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0011 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m
```

HGK 7.96

```
**********************************************
**                                          **
**                YSLIP_PM                  **
**        (VERSION 2.2, JANUARY 1996)       **
**                                          **
**   A COMPUTER PROGRAM FOR SIMULATION OF   **
**   DYNAMIC BEHAVIOR OF A RIGID BLOCK ON   **
**   AN INCLINED PLANE AND CALCULATION OF   **
**   PERMANENT DISPLACEMENTS OF THE BLOCK   **
**                                          **
**                    BY                    **
**                                          **
**               Liping Yan                 **
**             Neven Matasovic              **
**         Edward Kavazanjian, Jr.          **
**                                          **
**********************************************

***************REPRINT INPUT DATA**************

CARD  1: TITLE
         VARIATION OF Ky/Kh
CARD  2: SUBTITLE
         Big Bear Record 60' - SM thickness = 150 ft
CARD  3: KPAR  N    KACC  KCOM  g(m/s/s)  KOUT  KSLIP  KDIR
         0     10   1     1     9.807     0     0      0
CARD  4: Ky(1), ..., Ky(N)
         0.040 0.080 0.120 0.160 0.200 0.240 0.280 0.320 0.360 0.400
CARD  5: YIELD ACCELERATION DEGRADATION DATA
         Ky is constant.
CARD  6: INPUT HORIZONTAL ACC. TIME HISTORY FILE NAME
         b60150.out
CARD  7: NIDH  KREAD  NP    NLINE  DT    APH
         2     2      4096  512    0.01  0.4084
CARD  8: INPUT VERTICAL ACC. TIME HISTORY FILE NAME
         NO Av
CARD  9: NIDV  KREAD  NP    NLINE  DT    APV    TSHIFT
         NO INPUT
CARD 10: FILE NAME FOR OUTPUT OF SLIDING MOTION
         bbl.OUS
CARD 11: FILE NAME FOR OUTPUT OF ABSOLUTE MOTION
         bbl.OUA

MAX. VALUE OF INPUT HORI. ACC. =  .408391
INPUT HORI. ACC. TIMES A FACTOR = 1.000022 TO GET APH =  .408400


*****************RESULTS****************

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .040000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .4684 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .3155 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .3114 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .3454 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .080000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .3884 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .1351 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .2265 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .1202 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .120000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .3136 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .0802 m
```

MK 7.26

```
*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1512 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0485 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .160000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .2451 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0512 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0871 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0185 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .200000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1836 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0321 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0402 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0065 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .240000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1302 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0189 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0142 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0011 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .280000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0853 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0097 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0005 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .320000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0481 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0039 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .360000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0191 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0011 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .400000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0014 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m
```

AMK 7-26

```
**********************************************
**                                          **
**                YSLIP_PM                  **
**        (VERSION 2.2, JANUARY 1996)       **
**                                          **
**   A COMPUTER PROGRAM FOR SIMULATION OF   **
**   DYNAMIC BEHAVIOR OF A RIGID BLOCK ON   **
**   AN INCLINED PLANE AND CALCULATION OF   **
**   PERMANENT DISPLACEMENTS OF THE BLOCK   **
**                                          **
**                    BY                    **
**                                          **
**               Liping Yan                 **
**             Neven Matasovic              **
**          Edward Kavazanjian, Jr.         **
**                                          **
**********************************************

***************REPRINT INPUT DATA**************

CARD  1: TITLE
         VARIATION OF Ky/Kh
CARD  2: SUBTITLE
         Big Bear Record 60' - SM thickness = 100 ft
CARD  3: KPAR  N     KACC  KCOM   g(m/s/s)  KOUT   KSLIP  KDIR
         0     10    1     1      9.807     0      0      0
CARD  4: Ky(1), ..., Ky(N)
         0.040 0.080 0.120 0.160 0.200 0.240 0.280 0.320 0.360 0.400
CARD  5: YIELD ACCELERATION DEGRADATION DATA
         Ky is constant.
CARD  6: INPUT HORIZONTAL ACC. TIME HISTORY FILE NAME
         b60100.out
CARD  7: NIDH  KREAD    NP      NLINE   DT      APH
         2     2        4096    512     0.01    0.4448
CARD  8: INPUT VERTICAL ACC. TIME HISTORY FILE NAME
         NO Av
CARD  9: NIDV  KREAD    NP      NLINE   DT      APV     TSHIFT
         NO INPUT
CARD 10: FILE NAME FOR OUTPUT OF SLIDING MOTION
         bbl.OUS
CARD 11: FILE NAME FOR OUTPUT OF ABSOLUTE MOTION
         bbl.OUA

MAX. VALUE OF INPUT HORI. ACC. =  .444781
INPUT HORI. ACC. TIMES A FACTOR = 1.000043 TO GET APH =  .444800


*****************RESULTS****************

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .040000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .4677 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .3317 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .3117 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .3436 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .080000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .3908 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .1448 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .2199 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .1205 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .120000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .3210 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .0858 m
```

MGK 7.26

```
*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1377 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0488 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .160000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .2595 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0563 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0865 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0180 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .200000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .2044 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0363 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0506 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0049 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .240000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1549 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0220 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0226 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0011 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .280000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1107 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0124 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0043 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0001 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .320000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0727 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0062 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .360000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0405 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0026 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .400000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0153 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0007 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m
```

Tuck 7.26

```
*********************************************
**                                         **
**                YSLIP_PM                 **
**        (VERSION 2.2, JANUARY 1996)      **
**                                         **
**   A COMPUTER PROGRAM FOR SIMULATION OF  **
**   DYNAMIC BEHAVIOR OF A RIGID BLOCK ON  **
**   AN INCLINED PLANE AND CALCULATION OF  **
**   PERMANENT DISPLACEMENTS OF THE BLOCK  **
**                                         **
**                   BY                    **
**                                         **
**              Liping Yan                 **
**            Neven Matasovic              **
**        Edward Kavazanjian, Jr.          **
**                                         **
*********************************************

***************REPRINT INPUT DATA**************

CARD  1: TITLE
         VARIATION OF Ky/Kh
CARD  2: SUBTITLE
         Big Bear Record 60' - SM thickness = 50 ft
CARD  3: KPAR  N    KACC  KCOM  g(m/s/s)  KOUT  KSLIP  KDIR
         0     10   1     1     9.807     0     0      0
CARD  4: Ky(1), ..., Ky(N)
         0.040 0.080 0.120 0.160 0.200 0.240 0.280 0.320 0.360 0.400
CARD  5: YIELD ACCELERATION DEGRADATION DATA
         Ky is constant.
CARD  6: INPUT HORIZONTAL ACC. TIME HISTORY FILE NAME
         b6050.out
CARD  7: NIDH  KREAD  NP    NLINE  DT    APH
         2     2      4096  512    0.01  0.4108
CARD  8: INPUT VERTICAL ACC. TIME HISTORY FILE NAME
         NO Av
CARD  9: NIDV  KREAD  NP    NLINE  DT    APV    TSHIFT
         NO INPUT
CARD 10: FILE NAME FOR OUTPUT OF SLIDING MOTION
         bbl.OUS
CARD 11: FILE NAME FOR OUTPUT OF ABSOLUTE MOTION
         bbl.OUA

MAX. VALUE OF INPUT HORI. ACC. =  .410755
INPUT HORI. ACC. TIMES A FACTOR = 1.000110 TO GET APH =  .410800


*****************RESULTS****************

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .040000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .4468 m/sec
        PERMANENT SLIDING DISPLACEMENT =  .3073 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .3389 m/sec
        PERMANENT SLIDING DISPLACEMENT =  .3441 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .080000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .3635 m/sec
        PERMANENT SLIDING DISPLACEMENT =  .1357 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .2567 m/sec
        PERMANENT SLIDING DISPLACEMENT =  .1319 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .120000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .2871 m/sec
        PERMANENT SLIDING DISPLACEMENT =  .0784 m
```

MGK 7.26

```
*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1816 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0547 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .160000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .2249 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0500 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1151 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0228 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .200000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1723 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0311 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0598 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0087 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .240000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1255 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0175 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0232 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0020 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .280000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0841 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0087 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0020 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0001 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .320000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0488 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0036 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .360000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0205 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0011 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .400000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0018 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m
```

Calculation Package G-4
Seismically-Induced Permanent Deformations

GeoSyntec Consultants

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: Parsons **Project:** BRC CAMU **Project/Proposal #:** HL0389 **Task #:** 04

Title of Computations: Evaluation of Seismic-Induced Permanent Deformations

Computations By:
SIGNATURE — DATE: 28 July 2000
Geoff L. Smith / Staff Engineer
PRINTED NAME AND TITLE

Assumptions and Procedures Checked By (Peer Reviewer):
SIGNATURE — DATE: 07-26-00
Neven Matasovic / Project Engineer
PRINTED NAME AND TITLE

Computations Checked By:
SIGNATURE — DATE: 7-26-00
Michael E. Kalinski / Senior Staff Engineer
PRINTED NAME AND TITLE

Computations Backchecked By (Originator):
SIGNATURE — DATE: 7-26-00
Geoff L. Smith / Staff Engineer
PRINTED NAME AND TITLE

Approved By (PM or Designate):
SIGNATURE — DATE: 07/26/00
Edward Kavazanjian, Jr. / Principal
PRINTED NAME AND TITLE

Approval Notes:

Revisions: (Number and Initial All Revisions)

No.	Sheet	Date	By	Checked By	Approval

Written by: Geoff L. Smith Date: 07 / 25 / 00 (MM DD YY) Reviewed by: Date: / / (MM DD YY)

Client: Parsons Project: BRC CAMU Project No.: HL0389 Task No.: 04

EVALUATION OF SEISMICALLY-INDUCED PERMANENT DEFORMATIONS BRC CAMU HENDERSON, NEVADA

PURPOSE

The purpose of the analyses documented herein is to evaluate seismically-induced permanent deformations of the proposed BRC CAMU in Henderson, Nevada. The analyses are based on site-specific seismic deformation charts documented in a companion calculation package (*site-specific seismic deformation charts*).

METHOD OF ANALYSIS

Using the site-specific seismic deformation charts, seismically-induced permanent deformations may be evaluated. The site-specific seismic deformation charts are presented in two figures which represent the expected deformations of the North Mesa area and at the South Mesa area of the proposed landfill (see *site-specific deformation charts* calculation package). The North Mesa site-specific deformation chart shows a larger deformation response than the South Mesa chart. Therefore, for simplicity and conservatism, the North Mesa site-specific deformation chart will be used herein to represent the expected deformations at all locations. Figure 1 presents the North Mesa site-specific deformation chart. The site-specific seismic deformation chart has numerous curves that represent a suite of potential site responses. To be conservative, the curve that indicates the largest seismic deformation is used.

Seismically-induced permanent deformations are evaluated for the following locations:

- side slopes of the final cover;
- top deck of the final cover; and
- base liner.

Written by: Geoff L. Smith Date: 07 / 25 / 00 (MM DD YY) Reviewed by: RKC 7.26 Date: / / (MM DD YY)

Client: Parsons Project: BRC CAMU Project No.: HL0389 Task No.: 04

RK 07/26/00

DESIGN CRITERION

To evaluate seismically-induced permanent deformations at the BRC CAMU site, GeoSyntec established a maximum deformation of 12 in (0.3 m) for final cover slopes and 6 in (150 mm) for the base liner as the design criterion.

YIELD ACCELERATIONS

The yield accelerations presented here in were calculated in the final waste slopes and the final cover stability companion calculation packages. The yield accelerations evaluated from the stability calculations are as follows:

Location	Yield Acceleration
Final Cover Side Slopes	0.15 g
Final Cover Top Deck	>0.15 g
Base Liner	0.10 g

The yield acceleration of the final cover top deck is larger than the final cover side slopes due to the smaller slope inclination (e.g., 2% for the top deck compared to 3H:1V for the side slopes). The smaller slope inclination of the top deck produces a higher factor of safety than the final cover side slopes resulting in larger yield accelerations.

RESULTS

By inputting the yield acceleration into the site-specific deformation charts, the seismically-induced permanent deformations may be evaluated. Based on the site-specific seismic deformation charts, the permanent seismic deformations are estimated to be:

Location	Estimated Permanent Deformation
Final Cover Side Slopes	0.07 m (2.8 in)
Final Cover Top Deck	< 0.07 m (2.8 in)
Base Liner	0.15 m (5.9 in)

Based on the above results, the estimated seismically-induced permanent deformations meet the design criteria.

REFERENCES - COMPANION CALCULATION PACKAGES

- Site-specific Deformation Charts
- Seismic Hazard Evaluation and Design Ground Motions
- Seismic Site Response Analyses
- Slope Stability Evaluation - Final Waste Slopes
- Final Cover Sloughing Stability Calculations

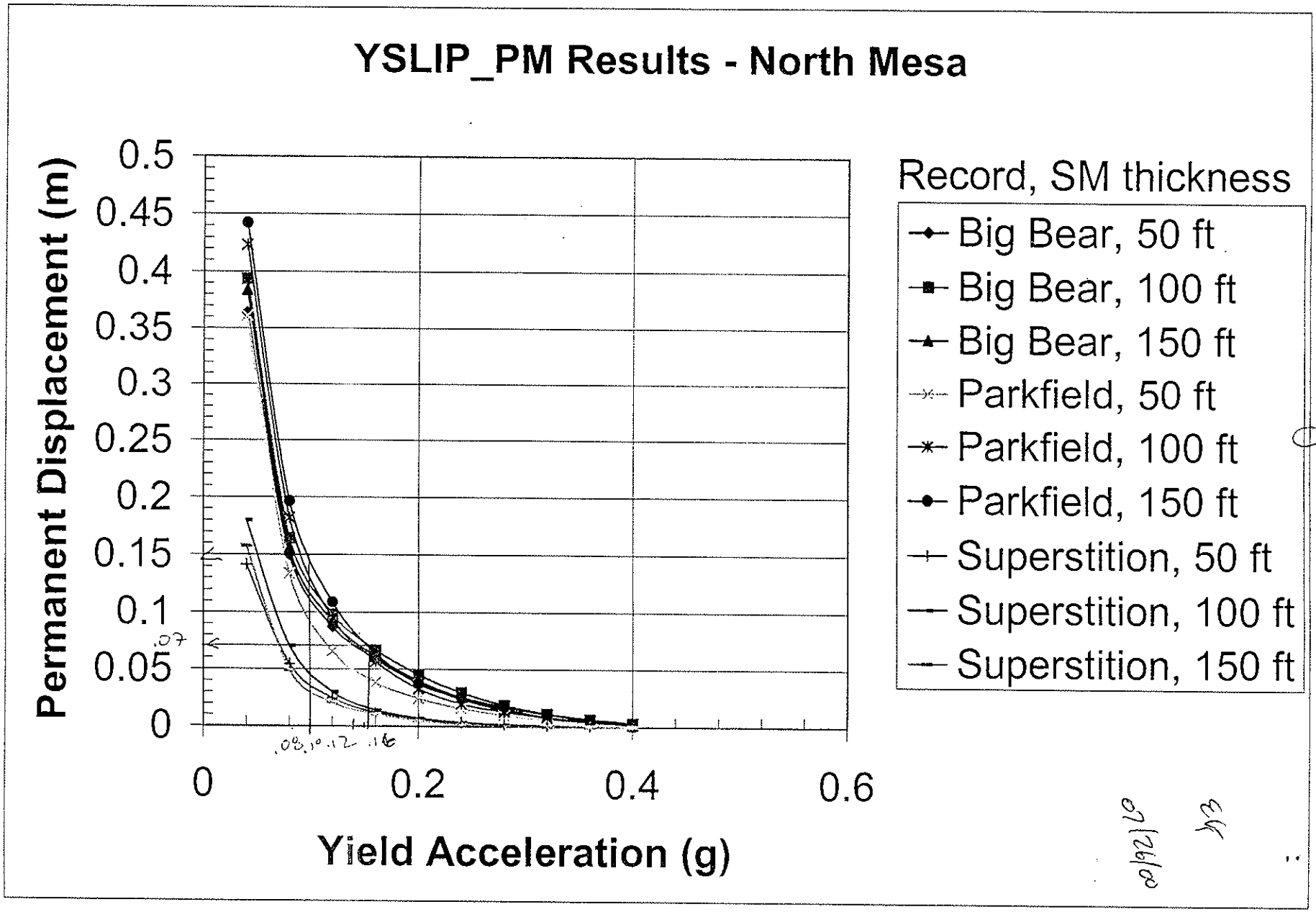


Figure 1

MSC 7.26

EK

09/26/00

Section 6
Final Cover Construction Quality Assurance Plan

CONSTRUCTION QUALITY ASSURANCE PLAN
FOR THE
CONSTRUCTION OF

FINAL COVER SYSTEM
AT
CORRECTIVE ACTION MANAGEMENT UNIT
BASIC REMEDIATION COMPANY
HENDERSON, NEVADA

Prepared for:

Basic Remediation Company
875 West Warm Springs Road
Henderson, Nevada 89015
(702) 567-0400

Prepared by:

GeoSyntec Consultants
11305 Rancho Bernardo Road, Suite 101
San Diego, California 92127
(858) 674-6559

3 November 2006

TABLE OF CONTENTS

1. INTRODUCTION 1

1.1 Terms of Reference 1
1.2 Purpose and Scope of the Construction Quality Assurance Plan 1
1.3 References 2
1.4 Organization of the Construction Quality Assurance Plan 2

2. DEFINITIONS RELATING TO CONSTRUCTION QUALITY ASSURANCE 3

3. PARTIES INVOLVED WITH CONSTRUCTION QUALITY ASSURANCE 4

3.1 Engineer 4
3.2 Project Manager 4
3.3 Contractor 5
3.4 Resin Supplier 5
3.5 Geosynthetics Manufacturer 6
3.6 Geosynthetic Installer 6
3.7 CQA Consultant 7
3.8 Surveyor 8
3.9 CQA Laboratory 9

4. CQA CONSULTANTS PERSONNEL ORGANIZATION AND DUTIES 10

4.1 Overview 10
4.2 CQA Personnel 11
4.2.1 CQA Officer 11
4.2.2 CQA Site Manager 12

5. SITE AND PROJECT CONTROL 14

5.1 Project Coordination Meetings 14
5.1.1 Resolution Meeting 14
5.1.2 Pre-Construction Meeting 15
5.1.3 Progress Meetings 17
5.1.4 Problem or Work Deficiency Meeting 17

6. DOCUMENTATION 18

6.1 Overview 18
6.2 Daily Recordkeeping 18
6.3 Construction Problems and Resolution Data Sheets 19
6.4 Photographic Documentation 21
6.5 Design and/or Specifications Changes 21
6.6 CQA Report 21

7. EARTHWORKS 24

7.1 Introduction 24
7.2 Testing Activities 24
7.2.1 Sample Frequency 25
7.2.2 Sample or Test Location Selection 25
7.3 CQA Monitoring Activities 26
7.3.1 Earthwork 26
7.3.2 Cover Soil Material 27
7.3.3 Prepared Subgrade 28
7.4 Deficiencies 28
7.4.1 Notification 28
7.4.2 Repairs and Re-Testing 29

8. DRAINAGE AGGREGATE 30

8.1 Introduction 30
8.2 Testing Activities 30
8.2.1 Sample Frequency 30
8.2.2 Sample Selection 31
8.3 CQA Monitoring Activities 31
8.3.1 Drainage Aggregate 31
8.4 Deficiencies 32
8.4.1 Notification 32
8.4.2 Repairs and Re-testing 32

9. CORRUGATED POLYETHYLENE (CPE) PIPE AND FITTINGS 33

9.1 Material Requirements 33
9.2 Manufacturer 33
9.2.1 Submittals 33

9.2.2 Identification 33
9.3 Handling and Laying 34
9.4 Joints 35

10. GEOMEMBRANE 36

10.1 General 36
10.2 Geomembrane Material Conformance 36
10.2.1 Introduction 36
10.2.2 Review of Quality Control 37
10.2.3 Conformance Testing 39
10.3 Delivery 39
10.3.1 Transportation and Handling 39
10.3.2 Storage 40
10.4 Geomembrane Installation 40
10.4.1 Introduction 40
10.4.2 Earthwork 40
10.4.3 Geomembrane Placement 41
10.4.4 Field Seaming 45
10.4.5 Defects and Repairs 58
10.4.6 Lining System Acceptance 60

11. GEOTEXTILE 62

11.1 Introduction 62
11.2 Manufacturing 62
11.3 Labeling 63
11.4 Shipment and Storage 63
11.5 Conformance Testing 64
11.5.1 Tests 64
11.5.2 Sampling Procedures 64
11.5.3 Test Results 64
11.5.4 Conformance Sample Failure 65
11.6 Handling and Placement 65
11.7 Seams and Overlaps 66
11.8 Repair 66
11.9 Placement of Soil Materials 67

12. GEOSYNTHETIC CLAY LINER (GCL) 68

12.1 Introduction 68
12.2 Manufacturing 68
12.3 Labeling 69
12.4 Shipment and Storage 69
12.5 Conformance Testing 69
12.5.1 Tests 69
12.5.2 Conformance Sample Failure 70
12.6 GCL Delivery and Storage 71
12.7 GCL Installation 71

13. GEOCOMPOSITE 73

13.1 Introduction 73
13.2 Manufacturing 73
13.3 Labeling 73
13.4 Shipment and Storage 74
13.5 Conformance Testing 74
13.5.1 Tests 74
13.5.2 Sampling Procedures 75
13.5.3 Test Results 75
13.5.4 Conformance Test Failure 75
13.6 Handling and Placement 76
13.7 Geocomposite Seams and Overlaps 77
13.8 Repair 77
13.9 Placement of Soil Materials 78

14. SURVEYING 79

14.1 Survey Control 79
14.2 Precision and Accuracy 79
14.3 Lines and Grades 79
14.4 Frequency and Spacing 80
14.5 Documentation 80

1. INTRODUCTION

1.1 Terms of Reference

GeoSyntec Consultants (GeoSyntec) has prepared this Construction Quality Assurance (CQA) Plan for the construction of the Corrective Action Management Unit (CAMU) Final Cover System for Basic Remediation Company (BRC) located in Henderson, Nevada. Hereinafter, the CAMU construction is referred to as the Project.

This CQA Plan was prepared by Mr. Gregory T. Corcoran, P.E. of GeoSyntec Consultants (GeoSyntec) under the direction of Mr. Brad Cooley, P.E. In general accordance with the peer review policies of the firm, Mr. Brad Cooley, P.E. of GeoSyntec was responsible for senior peer review of the work presented in this plan.

1.2 Purpose and Scope of the Construction Quality Assurance Plan

The purpose of the CQA Plan is to address the CQA procedures and monitoring requirements for construction of the Project. The CQA Plan is intended to: (i) define the responsibilities of parties involved with the construction; (ii) provide guidance in the proper construction of the major components of the Project; (iii) establish testing protocols; (iv) establish guidelines for construction documentation; and (v) provide the means for assuring that the Project is constructed in conformance to the *Technical Specifications*, permit conditions, applicable regulatory requirements, and *Construction Drawings*.

This CQA Plan addresses the soils and geosynthetic components of the final cover system for the project. The soils, geosynthetic, and appurtenant components include cover soil, prepared subgrade, drainage aggregate, geosynthetic clay liner, geomembrane, geotextile, geocomposite, and corrugated polyethylene (CPE) pipe. It should be emphasized that care and documentation are required in the placement and compaction of the soils and aggregate and in the production and installation of the geosynthetic materials placed during construction. The CQA Plan, therefore, delineates the procedures to be followed for monitoring construction of these materials.

The scope of this CQA Plan includes the CQA of the soil and geosynthetic components of the Project. The CQA monitoring activities during the selection, evaluation, treatment, placement, and compaction of soils for earthworks, and drainage aggregate are included in the scope of this plan. The CQA protocols applicable to manufacturing, shipping, handling, and installing all geosynthetic materials are also included. However, this CQA Plan does not specifically address either installation specifications or specification of soils and geosynthetic materials as these requirements are addressed in the *Technical Specifications*.

1.3 References

The CQA Plan includes references to test procedures in the latest editions of the American Society for Testing and Materials (ASTM).

1.4 Organization of the Construction Quality Assurance Plan

The remainder of the CQA Plan is organized as follows:

- Section 2 presents definitions relating to CQA;
- Section 3 describes the parties involved with the CQA;
- Section 4 describes the responsibilities of the CQA personnel;
- Section 5 describes site and project control requirements;
- Section 6 presents CQA documentation;
- Section 7 presents CQA of earthworks;
- Section 8 presents CQA of the drainage aggregates;
- Section 9 presents CQA of the pipe and fittings;
- Section 10 presents CQA of the geomembrane;
- Section 11 presents CQA of the geotextile;
- Section 12 presents CQA of the geosynthetic clay liner;
- Section 13 presents CQA of the geocomposite; and
- Section 14 presents CQA surveying.

2. DEFINITIONS RELATING TO CONSTRUCTION QUALITY ASSURANCE

This CQA Plan is devoted to Construction Quality Assurance. In the context of this document, Construction Quality Assurance and Construction Quality Control are defined as follows:

Construction Quality Assurance (CQA) - A planned and systematic pattern of means and actions designed to assure adequate confidence that materials and/or services meet contractual and regulatory requirements and will perform satisfactorily in service.

Construction Quality Control (CQC) - Those actions which provide a means to measure and regulate the characteristics of an item or service in relation to contractual and regulatory requirements.

In the context of this document:

- CQA refers to means and actions employed by the CQA Consultant to assure conformity of the Project "Work" with this CQA Plan, the *Drawings*, and the *Technical Specifications*.

- Construction Quality Control refers to those actions taken by the Contractor, Manufacturer, or Geosynthetic Installer to verify that the materials and the workmanship meet the requirements of this CQA Plan, the *Drawings*, and the *Technical Specifications*. In the case of soil components, CQC is combined with CQA and is provided by the CQA Consultant. In the case of the geosynthetic components and piping of the Work, CQC is provided by the Manufacturer and Geosynthetic Installer and the Contractor. CQA testing of soil, pipe, and geosynthetic components is provided by the CQA Consultant.

3. PARTIES INVOLVED WITH CONSTRUCTION QUALITY ASSURANCE

3.1 Engineer

Responsibilities

The Engineer is responsible for the design, *Drawings*, and *Technical Specifications* for the Project Work. In this CQA Plan, the term "Engineer" refers to Parsons Engineering Science, Inc. (Parsons) and GeoSyntec.

Qualifications

The Engineer of Record shall be a qualified engineer, registered as required by Nevada state regulations. The Engineer should have expertise, which demonstrates significant familiarity with piping, geosynthetics and soils, as appropriate, including design and construction experience related to landfill liner systems.

3.2 Project Manager

Responsibilities

The Project Manager is responsible for implementing the design, and overseeing subcontractors. In this CQA Plan, the term "Project Manager" refers to a qualified BRC employee.

Qualifications

The Project Manager shall be a qualified engineer having familiarity with earthwork construction and installation of geosynthetic materials.

3.3 Contractor

Responsibilities

In this CQA Plan, Contractor refers to an independent party or parties, contracted by the Owner, performing the Work in general accordance with this CQA Plan, the *Drawings*, and the *Technical Specifications*. The Contractor will be responsible for the installation of the soils and geosynthetic components of the liner system. This work will include excavation, placement and compaction of engineered fill and prepared subgrade, placement of drainage aggregate and native soil (operations layer material), installation and of piping and concrete manhole, installation of temporary erosion control features, and coordination of work with the Geosynthetic Installer and other subcontractors.

The Contractor will be responsible for constructing the liner system and appurtenant components in general accordance with the *Drawings* and complying with the quality control requirements specified in the *Technical Specifications*.

Qualifications

Qualifications of the Contractor are specific to the construction contract. The Contractor should have a demonstrated history of successful earthworks construction and maintain current state and federal licenses as appropriate.

3.4 Resin Supplier

Responsibilities

The Resin Supplier produces and delivers the resin to the Geosynthetics Manufacturer.

Qualifications

Qualifications of the Resin Supplier are specific to the Manufacturer's requirements. The Resin Supplier will have a demonstrated history of providing resin with consistent properties.

3.5 Geosynthetics Manufacturer

Responsibilities

The Manufacturer is responsible for the production of finished material (geomembrane, geotextile, geosynthetic clay liner, geocomposite, pipe, and other specified material) from appropriate raw materials.

Qualifications

The Manufacturer(s) will be able to provide sufficient production capacity and qualified personnel to meet the demands of the project. The Manufacturer(s) must be a well established firm(s) that meet the requirements identified in the *Technical Specifications*.

3.6 Geosynthetic Installer

Responsibilities

The Geosynthetic Installer is responsible for field handling, storage, placement, seaming, loading or anchoring against wind uplift, and other aspects of the geosynthetic material installation. The Geosynthetic Installer may also be responsible for specialized construction tasks (i.e., including construction of anchor trenches for the geosynthetic materials).

Qualifications

The Geosynthetic Installer will be trained and qualified to install the geosynthetic materials of the type specified for this project. The Geosynthetic Installer shall meet the qualification requirements identified in the *Technical Specifications*.

3.7 CQA Consultant

Responsibilities

The CQA Consultant is a party, independent from the Contractor, Manufacturer, and Geosynthetic Installer, who is responsible for observing, testing, and documenting activities related to the CQC and CQA of the earthwork, piping, and the geosynthetic components used in the construction of the Project. The CQA Consultant will also be responsible for issuing a CQA report at the completion of the Project construction, which details the earthworks, piping, and geosynthetic installation activities and associated CQA activities. The CQA report will be signed and sealed by the CQA Officer who will be a Professional Engineer registered in the State of Nevada.

The CQA Consultant will be responsible for obtaining and testing representative samples of all components used in construction of the Project as required by this CQA Plan and *Technical Specifications*. All tests will be conducted in general accordance with ASTM or other applicable state or federal standards. Test results must be submitted to the Project Manager within a reasonable timeframe, which will not impede or delay construction of the Project. The CQA Consultant will be responsible for inspecting all earthwork, piping, and geosynthetic operations to verify that the components are installed in general accordance with this CQA Plan and *Technical Specifications*.

Qualifications

The CQA Consultant is a well established firm specializing in geotechnical and geosynthetic engineering and possess the equipment, personnel, and licenses necessary to conduct the geotechnical and geosynthetic tests required by the project plans and *Technical Specifications*. The CQA Consultant will provide qualified staff

for the project, as necessary, which will include, at a minimum, a CQA Officer, and a CQA Site Manager. The CQA Officer will be a professionally licensed engineer as required by Nevada State regulations.

The CQA Consultant will be experienced with earthwork construction and the installation of geosynthetic materials similar to those materials used in construction of the Project. The CQA Consultant will be experienced in the preparation of CQA documentation including CQA Plans, field documentation, field testing procedures, laboratory testing procedures, construction specifications, construction drawings, and CQA reports.

The CQA Site Manager will be specifically familiar with the construction of earthworks, piping, and the installation of geosynthetic materials and will be trained by the CQA Consultant in the duties of a CQA Site Manager.

3.8 Surveyor

Responsibilities

The Surveyor is a party, independent from the Contractor, Manufacturer, and Geosynthetic Installer, that is responsible for surveying, documenting, and verifying the location of all significant components of the Work. The Surveyor's work is coordinated and employed by the Owner. The Surveyor is responsible for issuing record drawings of the construction.

Qualifications

The Surveyor will be a well established surveying company with at least 3 years experience in the profession of surveying services in the State of Nevada. The Surveyor will be a licensed professional as required by the State of Nevada regulations. The Surveyor shall be fully equipped and experienced in the use of total stations and AutoCAD Version 14. All surveying will be performed under the direct supervision of the Owner.

3.9 CQA Laboratory

Responsibilities

The CQA Laboratory is a party, independent from the Contractor, Manufacturer and Geosynthetic Installer, that is responsible for conducting tests in general accordance with ASTM and other applicable test standards on samples of geosynthetic materials and soil in the field and in either an on-site or off-site laboratory.

Qualifications

The CQA Laboratory will have experience in testing soils and geosynthetic materials and will be familiar with ASTM and other applicable test standards. The CQA Laboratory will be capable of providing test results within a maximum of seven days of receipt of samples and will maintain that capability throughout the duration of earthworks construction and geosynthetic materials installation. The CQA Laboratory will also be capable of transmitting geosynthetic destructive test results within 24 hours of receipt of samples and will maintain that capability throughout the duration of geosynthetic material installation.

4. CQA CONSULTANTS PERSONNEL ORGANIZATION AND DUTIES

4.1 Overview

The CQA Officer will provide supervision within the scope of work of the CQA Consultant. The scope of work for the CQA Consultant includes monitoring of construction activities including the following:

- screening of materials;
- placement and compaction of cover soil and prepared subgrade;
- installation of geotextile;
- installation of geosynthetic clay liner;
- installation of geomembrane;
- installation of drainage aggregate;
- installation of geocomposite; and
- installation of piping.

The duties of the CQA personnel are discussed in the remainder of this section.

4.2 CQA Personnel

For construction of the Project, the CQA Consultant's personnel will include:

- the CQA Officer, who operates from the office of the CQA Consultant and who conducts periodic visits to the site as required; and

- the CQA Site Manager, who is located at the site.

The duties of the CQA Personnel are discussed in the following subsections.

4.2.1 CQA Officer

The CQA Officer shall supervise and be responsible for monitoring and CQA activities relating to the construction of the earthworks, piping, and installation of the geosynthetic materials of the Project. Specifically, the CQA Officer:

- reviews the project design, this CQA Plan, *Drawings*, and *Technical Specifications*;

- reviews other site-specific documentation; unless otherwise agreed, such reviews are for familiarization and for evaluation of constructability only, and hence the CQA Officer and the CQA Consultant assume no responsibility for the liner system design;

- reviews and approves the Geosynthetic Installer's QC Plan;

- attends resolution and/or pre-construction meetings as needed;

- administers the CQA program (i.e., provides supervision of and manages on-site CQA personnel, reviews field reports, and provides engineering review of CQA related activities);

- provides quality control of CQA documentation and conducts site visits;
- reviews the record drawings; and
- with the CQA Site Manager, prepares the CQA report documenting that the project was constructed in general accordance with the Construction Documents.

4.2.2 CQA Site Manager

The CQA Site Manager:

- acts as the on-site representative of the CQA Consultant;
- attends CQA-related meetings (e.g., resolution, pre-construction, daily, weekly (or designates a representative to attend the meeting));
- prepares or oversees the ongoing preparation of the record drawings;
- reviews test results provided by Contractor;
- assigns locations for testing and sampling;
- oversees the collection and shipping of laboratory test samples;
- reviews results of laboratory testing and makes appropriate recommendations;
- reviews the calibration and condition of on-site CQA equipment;
- prepares a daily summary report for the project;
- reviews the Manufacturer's QC documentation;

- reviews the Geosynthetic Installer's personnel Qualifications for conformance with those pre-approved for work on site;

- notes in the daily summary report and reports to the CQA Officer and Project Manager on-site activities that could result in damage to the geosynthetic materials or other completed work;

- reports unresolved deviations from the CQA Plan, *Drawings*, and *Technical Specifications* to the Project Manager; and

- assists with the preparation of the CQA report.

5. SITE AND PROJECT CONTROL

5.1 Project Coordination Meetings

Meetings of key project personnel are necessary to assure a high degree of quality during installation, and promote clear, open channels of communication. Therefore, Project Coordination Meetings are an essential element in the success of the project. Several types of Project Coordination Meetings are described below, including: (i) resolution meetings; (ii) pre-construction meetings; (iii) progress meetings; and (iv) problem or work deficiency meetings.

5.1.1 Resolution Meeting

Following the completion of the design, *Drawings*, and *Technical Specifications* for the project and prior to the start of construction, a Resolution Meeting will be held. This meeting may include the CQA Officer, the CQA Site Manager, the Engineer, and the Project Manager.

The purpose of this meeting is to begin planning for coordination of construction tasks, anticipate installation problems which might cause difficulties and delays in construction, and, above all, present the CQA Plan to the parties involved. It is very important that the criteria regarding testing, repair, and other CQA activities be known and accepted by the parties involved in the work prior to the installation of geosynthetic materials and construction of the soil components for the Project.

The first part of the Resolution Meeting may be devoted to a review of the *Drawings* and *Technical Specifications* for familiarity. This is different from the peer review of the design, including design calculations, which will have been carried out previously.

The Resolution Meeting may include the following activities:

- distribute relevant documents to all parties;
- review critical design details of the project;

- review this CQA Plan;
- review the Drawings and Technical Specifications;
- make appropriate modifications to the design criteria, *Drawings*, and *Technical Specifications* so that the fulfillment of the design specifications or performance standards can be determined through the implementation of the CQA Plan;
- reach a consensus on the quality control procedures, especially on methods of evaluating acceptability of the soils and geosynthetic materials;
- assign the responsibilities of each party;
- establish work area security and health and safety protocol;
- confirm the methods for documenting observations, reporting, and distributing documents and reports; and
- confirm the lines of authority and communication.

The Project Manager will appoint one of the meeting attendees to record the discussions and decisions of the Resolution Meeting. The record of the meeting will be documented by the appointee in the form of meeting minutes, which will be subsequently distributed to all attendees.

5.1.2 Pre-Construction Meeting

A Pre-Construction Meeting will be held at the site prior to construction of the Project. As a minimum, the Pre-Construction Meeting will be attended by the Contractor, the Geosynthetic Installer's Superintendent, the CQA Consultant, the Engineer, and the Project Manager.

Specific items for discussion at the pre-construction meeting include the following:

- appropriate modifications or clarifications to the CQA Plan;
- the Drawings and Technical Specifications;
- the responsibilities of each party;
- lines of authority and communication;
- methods for documenting and reporting, and for distributing documents and reports;
- acceptance and rejection criteria;
- protocols for testing;
- protocols for handling deficiencies, repairs, and re-testing;
- the time schedule for all operations;
- procedures for packaging and storing archive samples;
- panel layout and numbering systems for panels and seams;
- seaming procedures;
- repair procedures; and
- soil stockpiling locations.

The Project Manager will conduct a site tour to observe the current site conditions and to review construction material and equipment storage locations. A person in attendance at the meeting will be appointed by the Project Manager to record

the discussions and decisions of the meeting in the form of meeting minutes. Copies of the meeting minutes will be distributed to all attendees.

5.1.3 Progress Meetings

Progress meetings will be held between the CQA Site Manager, the Contractor, Project Manager, and other concerned parties participating in the construction of the project. This meeting will include discussions on the current progress of the project, planned activities for the next week, and revisions to the work plan and/or schedule. The meeting will be documented in meeting minutes prepared by a person designated by the CQA Site Manager at the beginning of the meeting. Within 2 working days of the meeting, draft minutes will be transmitted to representatives of parties in attendance for review and comment. Corrections and/or comments to the draft minutes shall be made within 2 working days of receipt of the draft minutes to be incorporated in the final meeting minutes.

5.1.4 Problem or Work Deficiency Meeting

A special meeting will be held when and if a problem or deficiency is present or likely to occur. The meeting will be attended by the Contractor, the Project Manager, the CQA Site Manager, and other parties as appropriate. If the problem requires a design modification, the Engineer should either be present at, consulted prior to, or notified immediately upon conclusion of this meeting. The purpose of the work deficiency meeting is to define and resolve the problem or work deficiency as follows:

- define and discuss the problem or deficiency;
- review alternative solutions;
- select a suitable solution agreeable to all parties; and
- implement an action plan to resolve the problem or deficiency.

The Project Manager will appoint one attendee to record the discussions and decisions of the meeting. The meeting record will be documented in the form of meeting minutes and copies will be distributed to all affected parties. A copy of the minutes will be retained in facility records.

6. DOCUMENTATION

6.1 Overview

An effective CQA Plan depends largely on recognition of all construction activities that should be monitored and on assigning responsibilities for the monitoring of each activity. This is most effectively accomplished and verified by the documentation of quality assurance activities. The CQA Consultant will document that all quality assurance requirements have been addressed and satisfied.

The CQA Site Manager will provide the Project Manager with signed descriptive remarks, data sheets, and logs to verify that monitoring activities have been carried out. The CQA Site Manager will also maintain, at the job site, a complete file of *Drawings* and *Technical Specifications*, a CQA Plan, checklists, test procedures, daily logs, and other pertinent documents.

6.2 Daily Recordkeeping

Preparation of daily CQA documentation will consist of daily reports prepared by the CQA Site Manager which may include CQA monitoring logs, and testing data sheets. This information may be regularly submitted to and reviewed by the Project Manager.

The CQA Site Manager will prepare daily reports that document the activities observed during each day of activity. The daily reports may include monitoring logs and testing data sheets. At a minimum, these logs and data sheets will include the following information:

- the date, project name, location, and other identification;
- a summary of the weather conditions;
- a summary of locations where construction is occurring;
- equipment and personnel on the project;

- a summary of meetings held and attendees;
- a description of materials used and references of results of testing and documentation;
- identification of deficient work and materials;
- results of re-testing corrected “deficient work;”
- an identifying sheet number for cross referencing and document control;
- descriptions and locations of construction inspected;
- type of construction and inspection performed;
- description of construction procedures and procedures used to evaluate construction;
- a summary of test data and results;
- calibrations or re-calibrations of test equipment and actions taken as a result of re-calibration;
- decisions made regarding acceptance of units of work and/or corrective actions to be taken in instances of substandard testing results;
- a discussion of agreements made between the interested parties which may affect the work; and
- signature of the respective CQA Site Manager.

6.3 Construction Problems and Resolution Data Sheets

Construction Problems and Resolution Data Sheets, to be submitted with the daily reports prepared by the CQA Site Manager, describing special construction situations will be cross-referenced with daily reports, specific observation logs, and testing data sheets and will include the following information, where available:

- an identifying sheet number for cross-referencing and document control;
- a detailed description of the situation or deficiency;
- the location and probable cause of the situation or deficiency;
- how and when the situation or deficiency was found or located;
- documentation of the response to the situation or deficiency;
- final results of responses;
- measures taken to prevent a similar situation from occurring in the future; and
- signature of the CQA Site Manager and a signature indicating concurrence by the Project Manager.

The Project Manager will be made aware of significant recurring nonconformance with the *Drawings*, *Technical Specifications*, or CQA Plan. The cause of the nonconformance will be determined and appropriate changes in procedures or specifications will be recommended. These changes will be submitted to the Engineer for approval. When this type of evaluation is made, the results will be documented and any revision to procedures or specifications will be approved by the Contractor and Engineer.

A summary of supporting data sheets, along with final testing results and the CQA Site Manager's approval of the work, will be required upon completion of construction.

6.4 Photographic Documentation

Photographs will be taken and documented in order to serve as a pictorial record of work progress, problems, and mitigation activities. The basic file will contain color prints. Negatives will also be stored in a separate file in chronological order. These records will be presented to the Project Manager upon completion of the project. Photographic reporting data sheets, where used, will be cross-referenced with observation and testing data sheet(s), and/or construction problem and solution data sheet(s). Photographs used for documentation will be identified with the date, time, and location of the photograph.

6.5 Design and/or Specifications Changes

Design and/or specifications changes may be required during construction. In such cases, the CQA Site Manager will notify the Project Manager. Design and/or specification changes will be made with the written agreement of the Project Manager and the Engineer and will take the form of an addendum to the *Drawings* and *Technical Specifications*.

6.6 CQA Report

At the completion of the Project, the CQA Consultant will submit to the Project Manager the CQA report signed and sealed by the Professional Engineer licensed in the State of Nevada. The CQA report will acknowledge: (i) that the work has been performed in compliance with the *Drawings* and *Technical Specifications*; (ii) physical sampling and testing has been conducted at the appropriate frequencies; and (iii) that the summary document provides the necessary supporting information. At a minimum, this report will include:

- Manufacturers' quality control documentation;

- a summary report describing the CQA activities and indicating compliance with the *Drawings* and *Technical Specifications* which is signed and sealed by the CQA Officer;

- a summary of CQA/CQC testing, including failures, corrective measures, and retest results;

- contractor personnel resumes and qualifications;

- documentation that the geomembrane trial seams were performed in general accordance with the CQA Plan and *Technical Specifications*;

- documentation that field seams were non-destructively tested using a method in general accordance with the applicable test standards;

- documentation that nondestructive testing was monitored by the CQA Consultant, that the CQA Consultant informed the Geosynthetic Installer of any required repairs, and that the CQA Consultant inspected the seaming and patching operations for uniformity and completeness;

- records of sample locations, the name of the individual conducting the tests, and the results of tests;

- record drawings as provided by the Surveyor;

- documentation showing that piping was tested in general accordance with the *Technical Specifications*; and

- daily inspection reports.

The record drawings will include scale drawings depicting the location of the construction and details pertaining to the extent of construction (e.g., depths, plan dimensions, elevations, soil component thicknesses). Base maps required for development of the record drawings and the record drawings will be prepared by a

qualified Professional Land Surveyor registered in the State of Nevada. These documents will be reviewed by the CQA Consultant and included as part of the CQA Report.

7. EARTHWORKS

7.1 Introduction

This section prescribes the CQA activities to be performed to monitor that earthwork components are constructed in general accordance with *Drawings* and *Technical Specifications*. The earthworks construction procedures to be monitored by the CQA Consultant include:

- cover soil placement;
- anchor trench excavation and backfill; and
- subgrade preparation.

7.2 Testing Activities

Soil testing will be performed for material qualification, material conformance, and construction quality control (CQC). These three stages of testing are defined as follows:

- Material qualification tests are used to evaluate the conformance of a proposed soil source to the material specifications for qualification of the source prior to construction.

- Soils conformance testing is used to evaluate the conformance of a particular batch of soil from a qualified source to the material specifications prior to installation of the soil.

- CQC tests are performed on completed portions of the earthwork during construction to demonstrate that the placement procedures are resulting in a product that meets or exceeds both material and performance specifications.

The Contractor will be responsible for submitting material qualification test results to the Project Manager and to the CQA Site Manager for review. The CQA Laboratory will perform the conformance testing and CQC testing. Soil testing will be

conducted in general accordance with the current versions of the corresponding American Society for Testing and Materials (ASTM) test procedures. The test methods indicated in Table 1 are those that will be used for this testing unless the test methods are updated or revised prior to construction. Revisions to the test methods will be reviewed and approved by the Engineer and the CQA Site Manager prior to their usage.

7.2.1 Sample Frequency

The frequency of soils testing for material qualification will conform to the minimum frequencies presented in Table 2. The frequency of soils testing for material conformance will conform to the minimum frequencies presented in Table 3. The actual frequency of testing required will be increased by the CQA Site Manager as necessary if variability of materials is noted at the site, during adverse conditions, or to isolate failing areas of the construction.

7.2.2 Sample or Test Location Selection

With the exception of qualification samples, sampling locations will be selected by the CQA Site Manager. Conformance samples will be obtained from borrow pits and/or stockpiles of material. The Contractor must plan the work and make soil available for sampling in a timely and organized manner so that the test results can be obtained before the material is installed. The CQA Site Manager must document sample locations so that failing areas can be immediately isolated. The CQA Site Manager will follow standard sampling procedures to obtain representative samples of the proposed soil materials.

CQC sample and test locations will be selected by the CQA Site Manager at the minimum test frequency specified in Table 4. Samples and test locations will generally be selected at random, however a special testing frequency will be used at the discretion of the CQA Site Manager when visual observations of construction performance indicate a potential problem. Additional testing for suspected areas will be considered when:

- rollers slip during rolling operation;
- lift thickness is greater than specified;

- fill is at improper and/or variable moisture content;
- less than specified number of roller passes are made;
- dirt-clogged rollers are used to compact the material;
- rollers may not have used optimum ballast;
- fill materials differ substantially from those specified;
- the degree of compaction is doubtful; and
- as directed by the Project Manager or the CQA Site Manager.

The frequency of testing may also be increased in the following situations:

- adverse weather conditions;
- breakdown of equipment;
- at the start and finish of grading;
- material fails to meet specifications; and
- the work area is reduced.

7.3 CQA Monitoring Activities

7.3.1 Earthwork

The CQA Site Manager will monitor and document the earthworks required for the Project. In general, monitoring the construction for earthwork includes the following activities:

- reviewing documentation of the material qualification test results provided by the Contractor;

- monitoring the prepared subgrade and subgrade surfaces for compliance with the *Technical Specifications* before geosynthetic materials are placed;

- sampling and testing for conformance of the materials to the *Technical Specifications*;

- documenting that the earthwork is constructed using the specified equipment and procedures;

- documenting that the earthwork is constructed to the lines and grades shown on the *Drawings*;

- monitoring that the construction activities do not cause damage to underlying geosynthetic materials;

- quality control testing to determine the acceptability of the work during construction; and

- monitoring the action of the compaction and heavy hauling equipment on the construction surface (i.e., penetration, pumping, cracking, etc.).

The specific activities required for CQA of each of the major soil components of the Final Cover System are presented in the following sections.

7.3.2 Cover Soil Material

Monitoring the earthwork for the cover soil material specifically includes the following:

- reviewing documentation of the qualification and conformance test results;

- monitoring soil for maximum particle size and deleterious materials;

- monitoring the thickness of lifts during placement of the materials;

- monitoring compaction operations; and

- measuring and recording the field density and the field moisture content of the in-place material.

7.3.3 Prepared Subgrade

During construction, the CQA Site Manager will monitor the prepared subgrade to document that the prepared subgrade soil characteristics are consistent with those specified in the *Technical Specifications*. The CQA Site Manager will monitor the construction activities to document that sharp rocks and other undesirable materials are removed and that the subgrade is prepared using the procedures and equipment specified in the *Technical Specifications*.

The upper portion of the subgrade can be damaged by excess moisture (causing softening) or insufficient moisture (causing desiccation and shrinkage). At a minimum, the CQA Site Manager will determine the suitability of the subgrade for geomembrane placement by:

- documenting that the surface is free of sharp rocks, debris and other undesirable materials;
- documenting that the surface is smooth, uniform, and free from desiccation cracks by visually monitoring proof rolling activities; and
- documenting that the subgrade surface meets the lines and grades shown on the *Drawings* by reviewing certified survey results.

7.4 <u>Deficiencies</u>

If a defect is discovered in the earthwork product, the CQA Site Manager will immediately determine the extent and nature of the defect. If the defect is indicated by an unsatisfactory test result, the CQA Site Manager will determine the extent of the deficient area by additional tests, observations, a review of records, or other means that the CQA Site Manager deems appropriate. If the defect is related to adverse site conditions, such as overly wet soils or surface desiccation, the CQA Site Manager will define the limits and nature of the defect.

7.4.1 Notification

After evaluating the extent and nature of a defect, the CQA Site Manager will notify the Project Manager and Contractor and schedule appropriate re-tests when the work deficiency is to be corrected.

7.4.2 Repairs and Re-Testing

At locations where the field testing indicates densities below the requirements of the specification, the failing area will be reworked. The Contractor will correct the deficiency to the satisfaction of the CQA Site Manager. If a project specification criterion cannot be met, or unusual weather conditions hinder work, then the CQA Site Manager will develop and present to the Engineer and/or Project Manager suggested solutions for his approval.

All re-tests recommended by the CQA Site Manager must verify that the defect has been corrected before any additional work is performed by the Contractor in the area of the deficiency. The CQA Site Manager will also verify that installation requirements are met and that submittals are provided.

8. DRAINAGE AGGREGATE

8.1 Introduction

This section prescribes the CQA activities to be performed to monitor that drainage aggregates are constructed in general accordance with *Drawings* and *Technical Specifications*. The drainage aggregates construction procedures to be monitored by the CQA Consultant include drainage aggregate placement.

8.2 Testing Activities

Aggregate testing will be performed for material qualification and material conformance. These two stages of testing are defined as follows:

- Material qualification tests are used to evaluate the conformance of a proposed aggregate source to the material specifications for qualification of the source prior to construction.

- Aggregate conformance testing is used to evaluate the conformance of a particular batch of aggregate from a qualified source to the material specifications prior to installation of the aggregate.

The Contractor will be responsible for submitting material qualification test results to the Project Manager and to the CQA Site Manager for review. The CQA Laboratory will perform the conformance testing and CQC testing. Aggregate testing will be conducted in general accordance with the current versions of the corresponding American Society for Testing and Materials (ASTM) test procedures. The test methods indicated in Table 5 are those that will be used for this testing unless the test methods are updated or revised prior to construction. Revisions to the test methods will be reviewed and approved by the Engineer and the CQA Site Manager prior to their usage.

8.2.1 Sample Frequency

The frequency of aggregate testing for material qualification will conform to the minimum frequencies presented in Table 6. The frequency of aggregate testing for

material conformance will conform to the minimum frequencies presented in Table 7. The actual frequency of testing required will be increased by the CQA Site Manager as necessary if variability of materials is noted at the site, during adverse conditions, or to isolate failing areas of the construction.

8.2.2 Sample Selection

With the exception of qualification samples, sampling locations will be selected by the CQA Site Manager. Conformance samples will be obtained from borrow pits and/or stockpiles of material. The Contractor must plan the work and make aggregate available for sampling in a timely and organized manner so that the test results can be obtained before the material is installed. The CQA Site Manager must document sample locations so that failing areas can be immediately isolated. The CQA Site Manager will follow standard sampling procedures to obtain representative samples of the proposed aggregate materials.

8.3 CQA Monitoring Activities

8.3.1 Drainage Aggregate

The CQA Site Manager will monitor and document the installation of the drainage aggregates. In general, monitoring the installation of the drainage aggregates includes the following activities:

- reviewing documentation of the material qualification test results provided by the Contractor;
- sampling and testing for conformance of the materials to the *Technical Specifications*;
- documenting that the drainage aggregates are installed using the specified equipment and procedures;
- documenting that the drainage aggregates are constructed to the lines and grades shown on the *Drawings*; and

- monitoring that the construction activities do not cause damage to underlying geosynthetic materials.

8.4 Deficiencies

If a defect is discovered in the drainage aggregates, the CQA Site Manager will evaluate the extent and nature of the defect. If the defect is indicated by an unsatisfactory test result, the CQA Site Manager will determine the extent of the deficient area by additional tests, observations, a review of records, or other means that the CQA Site Manager deems appropriate.

8.4.1 Notification

After evaluating the extent and nature of a defect, the CQA Site Manager will notify the Project Manager and Contractor and schedule appropriate re-tests when the work deficiency is to be corrected.

8.4.2 Repairs and Re-testing

The Contractor will correct the deficiency to the satisfaction of the CQA Site Manager. If a project specification criterion cannot be met, or unusual weather conditions hinder work, then the CQA Site Manager will develop and present to the Engineer and/or Project Manager suggested solutions for approval.

All re-tests recommended by the CQA Site Manager must verify that the defect has been corrected before any additional work is performed by the Contractor in the area of the deficiency. The CQA Site Manager will also verify that installation requirements are met and that submittals are provided.

9. CORRUGATED POLYETHYLENE (CPE) PIPE AND FITTINGS

9.1 Material Requirements

CPE pipe and fittings must conform to the requirements of the *Technical Specifications*. The CQA Consultant will document that the CPE pipe and fittings meet those requirements through manufacturer's quality control certificates, conformance testing, and visual examination of materials arriving on site.

9.2 Manufacturer

9.2.1 Submittals

Prior to the installation of CPE pipe, the Manufacturer will provide to the CQA Consultant:

- a properties' sheet including, at a minimum, all specified properties, measured using test methods indicated in the *Technical Specifications*, or equivalent; and

- a certification that property values given in the properties sheet are minimum values and are guaranteed by the Manufacturer.

The CQA Consultant will document that:

- the property values certified by the Manufacturer meet the *Technical Specifications*; and

- the measurements of properties by the Manufacturer are properly documented and that the test methods used are acceptable.

9.2.2 Identification

Prior to shipment, the Manufacturer will provide the Project Manager and the CQA Site Manager with a quality control certificate for each lot/batch of CPE pipe

provided. The quality control certificate will be signed by a responsible party employed by the Manufacturer, such as the Production Manager. The quality control certificate will include:

- lot/batch numbers and identification; and
- sampling procedures and results of quality control tests.

The CQA Site Manager will:

- document that the quality control certificates have been provided at the specified frequency for all lots/batches of pipe, and that each certificate identifies the pipe lot/batch related to it; and

- review the quality control certificates and document that the certified properties meet the *Technical Specifications*.

9.3 Handling and Laying

Care will be taken during transportation of the pipe such that it will not be cut, kinked, or otherwise damaged.

Ropes, fabric, or rubber-protected slings and straps will be used when handling pipes. Chains, cables, or hooks inserted into the pipe ends will not be used. Two slings spread apart will be used for lifting each length of pipe. Pipe or fittings will not be dropped onto rocky or unprepared ground.

Pipes will be handled and stored in general accordance with the Manufacturer's recommendation. The handling of joined pipe will be in such a manner that the pipe is not damaged by dragging it over sharp and cutting objects. Slings for handling the pipe will not be positioned at joints. Sections of the pipes with deep cuts and gauges will be removed and the ends of the pipe rejoined.

9.4 Joints

Lengths of pipe will be assembled into suitable installation lengths by a manufacturer-recommended method.

10. GEOMEMBRANE

10.1 General

This section discusses and outlines the CQA activities to be performed for high density polyethylene (HDPE) geomembrane installation. The CQA Site Manager will review the *Drawings*, and the *Technical Specifications*, and any approved Addenda regarding this material.

10.2 Geomembrane Material Conformance

10.2.1 Introduction

The CQA Site Manager will document that the geomembrane delivered to the site meets the requirements of the *Technical Specifications* prior to installation. The CQA Site Manager will:

- review the manufacturer's submittals for compliance with the *Technical Specifications*;
- document the delivery and proper storage of geomembrane rolls; and
- conduct conformance testing of the rolls before the geomembrane is installed.

The following sections describe the CQA activities required to verify the conformance of geomembrane.

10.2.2 Review of Quality Control

10.2.2.1 Material Properties Certification

The Manufacturer will provide the Project Manager and the CQA Site Manager with the following:

- a properties sheet including, at a minimum, all specified properties, measured using test methods indicated in the *Technical Specifications*, or equivalent;
- the sampling procedure and results of testing; and
- a certification that property values given in the properties sheet are guaranteed by the Manufacturer.

The CQA Site Manager will document that:

- the property values certified by the Manufacturer meet all of the *Technical Specifications*; and
- the measurements of properties by the Manufacturer are properly documented and that the test methods used are acceptable.

10.2.2.2 Resin Certification

The Manufacturer will also provide the Project Manager with the following information concerning the resin used to manufacture the geomembrane:

- the origin (Resin Supplier's name and resin production plant), identification (brand name, lot number), and production date of the resin; and
- the raw material quality control certificates.

The CQA Site Manager will:

- evaluate that the quality control certificates have been provided at the specified frequency, and that the certificate identifies the rolls related to it; and

- review the quality control certificates and evaluate that the certified properties meet the specifications.

10.2.2.3 Geomembrane Roll QC Certification

Prior to shipment, the Manufacturer will provide the Project Manager and the CQA Site Manager with a quality control certificate for every roll of geomembrane provided. The quality control certificate will be signed by a responsible party employed by the Geomembrane Manufacturer, such as the production manager. The quality control certificate will include:

- roll numbers and identification; and

- results of quality control tests - as a minimum, results will be given for thickness, tensile properties, specific gravity, carbon black content, carbon black dispersion, tear resistance, puncture resistance, and single point stress rupture evaluated in general accordance with the methods indicated in the specifications or equivalent methods approved by the Engineer.

The CQA Site Manager will:

- evaluate that the quality control certificates have been provided at the specified frequency, and that the certificate identifies the rolls related to the roll represented by the test results; and

- review the quality control certificates and evaluate that the certified roll properties meet the specifications.

10.2.3 Conformance Testing

Upon delivery of the rolls of geomembrane, the CQA Site Manager will document that the rolls are unloaded and stored on site as required by the *Technical Specifications*. Damage caused by unloading will be documented by the CQA Site Manager and the damaged material will not be installed. The CQA Site Manager shall obtain conformance samples at the specified frequency and forward them to the Geosynthetics CQA Laboratory for testing to monitor conformance to both the *Technical Specifications* and the list of properties certified by the Manufacturer. The test procedures will be as indicated in Table 8. Where optional procedures are noted in the test method, the requirements of the *Technical Specifications* will prevail.

Samples will be taken across the width of the roll and will not include the first linear 3 ft (1 m) of material. Unless otherwise specified, samples will be 3 ft (1 m) long by the roll width. The CQA Site Manager will mark the machine direction on the samples with an arrow along with the date and roll number. The required minimum sampling frequencies are provided in Table 8.

The CQA Site Manager will examine results from laboratory conformance testing and will report any non-conformance to the Project Manager and the Geosynthetic Installer. The procedure prescribed in the *Technical Specifications* will be followed in the event of a failing conformance test.

10.3 <u>Delivery</u>

10.3.1 Transportation and Handling

The CQA Site Manager will document that the transportation and handling does not pose a risk of damage to the geomembrane.

Upon delivery at the site, the Geosynthetic Installer and the CQA Site Manager will conduct a surface observation of the rolls for defects and damage. This

inspection will be conducted without unrolling unless defects or damages are found or suspected. The CQA Site Manager will indicate to the Project Manager:

- rolls, or portions thereof, which should be rejected and removed from the site because they have severe flaws; and
- rolls that include minor repairable flaws.

10.3.2 Storage

The Geosynthetic Installer will be responsible for the storage of the geomembrane on site. The Contractor will provide storage space in a location (or several locations) such that on-site transportation and handling are optimized if possible.

The CQA Site Manager will document that storage of the geomembrane provides adequate protection against sources of damage.

10.4 Geomembrane Installation

10.4.1 Introduction

The CQA Consultant will document that the geomembrane installation is carried out in general accordance with the *Drawings*, *Technical Specifications* and Manufacturer's recommendations.

10.4.2 Earthwork

10.4.2.1 Surface Preparation

The CQA Site Manager will document that:

- a qualified land surveyor has verified lines and grades;

- that the supporting prepared subgrade or subgrade meets the *Technical Specifications* and has been approved; and

- placement of the overlying materials does not damage, create large wrinkles, or induce excessive tensile stress in the underlying geosynthetic materials.

The Geosynthetic Installer will certify in writing that the surface on which the geomembrane will be installed is acceptable. The certificate of acceptance will be given by the Geosynthetic Installer to the Project Manager prior to commencement of geomembrane installation in the area under consideration. The CQA Site Manager will be given a copy of this certificate by the Project Manager.

After the supporting subgrade has been accepted by the Geosynthetic Installer, it will be the Geosynthetic Installer's responsibility to indicate to the Project Manager any change in the supporting soil condition that may require repair work. If the CQA Site Manager concurs with the Geosynthetic Installer, then the Project Manager will document that the supporting soil is repaired.

At any time before and during the geomembrane installation, the CQA Site Manager will indicate to the Project Manager locations that may not provide adequate support to the geomembrane.

10.4.2.2 Geosynthetic Termination

The CQA Site Manager will document that the geosynthetic terminations have been constructed in general accordance with the *Drawings*. Backfilling above the terminations will be conducted in general accordance with the *Technical Specifications*.

10.4.3 Geomembrane Placement

10.4.3.1 Panel Identification

A field panel is the unit area of geomembrane which is to be seamed in the field, i.e., a field panel is a roll or a portion of roll cut in the field. It will be the

responsibility of the CQA Site Manager to document that each field panel is given an "identification code" (number or letter- number) consistent with the layout plan. This identification code will be agreed upon by the Project Manager, Geosynthetic Installer and CQA Site Manager. This field panel identification code will be as simple and logical as possible. Roll numbers established in the manufacturing plant must be traceable to the field panel identification code.

The CQA Site Manager will establish documentation showing correspondence between roll numbers, and field panel identification codes. The field panel identification code will be used for all quality assurance records.

10.4.3.2 Field Panel Placement

Location

The CQA Site Manager will document that field panels are installed at the location indicated in the Geosynthetic Installer's layout plan, as approved or modified by the Engineer.

Installation Schedule

Field panels may be installed using one of the following schedules:

- all field panels are placed prior to field seaming in order to protect the subgrade from erosion by rain;
- field panels are placed one at a time and each field panel is seamed after its placement (in order to minimize the number of unseamed field panels exposed to wind); and
- any combination of the above.

If a decision is reached to place all field panels prior to field seaming, it is usually beneficial to begin at the high point area and proceed toward the low point with "shingle" overlaps to facilitate drainage in the event of precipitation. It is also usually

beneficial to proceed in the direction of prevailing winds. Accordingly, an early decision regarding installation scheduling should be made if and only if weather conditions can be predicted with reasonable certainty. Otherwise, scheduling decisions must be made during installation, in general accordance with varying conditions. In any event, the Geosynthetic Installer is fully responsible for the decision made regarding placement procedures.

The CQA Site Manager will evaluate every change in the schedule proposed by the Geosynthetic Installer and advise the Project Manager on the acceptability of that change. The CQA Site Manager will document that the condition of the supporting soil has not changed detrimentally during installation.

The CQA Site Manager will record the identification code, location, and date of installation of each field panel.

Weather Conditions

Geomembrane placement will not proceed unless otherwise authorized:

- when the ambient temperature is below 40°F or above 104°F;
- when the geomembrane sheet temperature is below 40°F or above 104°F; or
- when wind gusts are in excess of 20 mph.

Geomembrane placement will not be performed during any precipitation, in the presence of excessive moisture (e.g., fog, dew), in an area of ponded water, or in the presence of excessive winds (i.e., wind gusts in excess of 20 mph).

The CQA Site Manager will document that the above conditions are fulfilled. Additionally, the CQA Site Manager will document that the supporting soil has not been damaged by weather conditions. The Geosynthetics Installer will inform the Project Manager if the above conditions are not fulfilled.

Method of Placement

The CQA Site Manager will document the following:

- equipment used does not damage the geomembrane by handling, trafficking, excessive heat, leakage of hydrocarbons or other means;

- the surface underlying the geomembrane has not deteriorated since previous acceptance, and is still acceptable immediately prior to geomembrane placement;

- geosynthetic elements immediately underlying the geomembrane are clean and free of debris;

- personnel working on the geomembrane do not smoke, wear damaging shoes, or engage in other activities which could damage the geomembrane;

- the method used to unroll the panels does not cause scratches or crimps in the geomembrane and does not damage the supporting soil;

- the method used to place the panels minimizes wrinkles (especially differential wrinkles between adjacent panels); and

- adequate temporary loading and/or anchoring (e.g., sand bags, tires), not likely to damage the geomembrane, has been placed to prevent uplift by wind (in case of high winds, continuous loading, e.g., by adjacent sand bags, is recommended along edges of panels to minimize risk of wind flow under the panels).

The CQA Site Manager will inform the Project Manager if the above conditions are not fulfilled.

Damaged panels or portions of damaged panels that have been rejected will be marked and their removal from the work area recorded by the CQA Site Manager. Repairs will be made in general accordance with procedures described in Section 10.4.5.

10.4.4 Field Seaming

This section details CQA procedures to document that seams are properly constructed and tested in general accordance with the Manufacturer's specifications and industry standards.

10.4.4.1 Seam Layout

The Geosynthetic Installer will provide the Project Manager and the CQA Site Manager with a seam layout drawing, i.e., a drawing of the facility to be lined showing all expected seams. The CQA Site Manager will review the seam layout drawing and evaluate that it is consistent with the preliminary geomembrane panel layout. No panels may be seamed in the field without the Project Manager's approval. In addition, panels not specifically shown on the seam layout drawing may be used without the Project Manager's prior approval.

In general, seams should be oriented parallel to the line of maximum slope, i.e., oriented along, not across, the slope. In corners and odd-shaped geometric locations, the number of seams should be minimized. No horizontal seam should be less than 5 ft (1.5 m) from the toe of the slope, or areas of potential stress concentrations, unless otherwise authorized.

A seam numbering system compatible with the panel numbering system will be agreed upon at the Resolution and/or Pre-Construction Meeting.

10.4.4.2 Requirements of Personnel

All personnel performing seaming operations will be qualified by experience or by successfully passing seaming tests, as outlined in the *Technical Specifications*. The most experienced seamer, the "master seamer", will provide direct supervision over less experienced seamers.

The Geosynthetic Installer will provide the Project Manager and the CQA Site Manager with a list of proposed seaming personnel and their experience records. This document will be reviewed by the Project Manager and the Geosynthetics CQA Manager.

10.4.4.3 Seaming Equipment and Products

Approved processes for field seaming are fillet extrusion welding and fusion welding.

Fillet Extrusion Process

The fillet extrusion-welding apparatus will be equipped with gauges giving the temperature in the apparatus.

The Geosynthetic Installer will provide documentation regarding the extrudate to the Project Manager and the CQA Site Manager, and will certify that the extrudate is compatible with the specifications, and in any event is comprised of the same resin as the geomembrane sheeting.

The CQA Site Manager will log apparatus temperatures, ambient temperatures, and geomembrane surface temperatures at appropriate intervals.

The CQA Site Manager will document that:

- the Geosynthetic Installer maintains on site the number of spare operable seaming apparatus decided at the Resolution Meeting;
- equipment used for seaming is not likely to damage the geomembrane;
- the extruder is purged prior to beginning a seam until all heat-degraded extrudate has been removed from the barrel;

- the electric generator is placed on a smooth base such that no damage occurs to the geomembrane;

- a smooth insulating plate or fabric is placed beneath the hot welding apparatus after usage; and

- the geomembrane is protected from damage in heavily trafficked areas.

Fusion Process

The fusion-welding apparatus must be automated vehicular-mounted devices. The fusion-welding apparatus will be equipped with gauges giving the applicable temperatures and pressures.

The CQA Site Manager will log ambient, seaming apparatus, and geomembrane surface temperatures as well as seaming apparatus pressures.

The CQA Site Manager will also document that:

- the Geosynthetic Installer maintains on-site the number of spare operable seaming apparatus decided at the Resolution Meeting;

- equipment used for seaming is not likely to damage the geomembrane;

- for cross seams, the edge of the cross seam is ground to a smooth incline (top and bottom) prior to welding;

- the electric generator is placed on a smooth base such that no damage occurs to the geomembrane;

- a smooth insulating plate or fabric is placed beneath the hot welding apparatus after usage; and

- the geomembrane is protected from damage in heavily trafficked areas.

10.4.4.4 Seam Preparation

The CQA Site Manager will document that:

- prior to seaming, the seam area is clean and free of moisture, dust, dirt, debris, and foreign material; and

- seams are aligned with the fewest possible number of wrinkles and "fishmouths."

10.4.4.5 Weather Conditions for Seaming

The normally required weather conditions for seaming are as follows unless authorized in writing by the Project Manager:

- seaming will only be approved between ambient temperatures of 40°F (4°C) and 104°F (40°C); and

- seaming will not be approved if sustained wind speed is in excess of 20 mph (32 km/hr).

If the Geosynthetic Installer wishes to use methods that may allow seaming at ambient temperatures below 40°F (4°C) or above 104°F (40°C), the Geosynthetic Installer will demonstrate and certify that such methods produce seams which are entirely equivalent to seams produced within acceptable temperature and wind requirements, and that the overall quality of the geomembrane is not adversely affected.

The CQA Site Manager will document that these seaming conditions are fulfilled and will advise the Project Manager if they are not. The Project Manager will then decide if the installation will be stopped or postponed.

10.4.4.6 Overlapping and Temporary Bonding

The CQA Site Manager will document that:

- the panels of geomembrane have a finished overlap of a minimum of 3 in. (75 mm) for both extrusion and fusion welding;
- no solvent or adhesive bonding material are to be used; and
- the procedure used to temporarily bond adjacent panels together does not damage the geomembrane.

The CQA Site Manager will log appropriate temperatures and conditions, and will log and report to the Project Manager non-compliances.

10.4.4.7 Trial Seams

Trial seams will be made on fragment pieces of geomembrane liner to verify that seaming conditions are adequate. Such trial seams will be made at the beginning of each seaming period, beginning of the day and after lunch, for each seaming apparatus used that day. Also, each seamer will make at least one trial seam each day. Trial seams will be made under the same conditions as actual seams.

Extrusion welded trial seam samples will be at least 3 ft (0.9 m) long by 1 ft (0.3 m) wide (after seaming) with the seam centered lengthwise. Fusion welded trial seam samples will be at least 5 ft (1.5 m) long by 1 ft (0.3 m) wide (after seaming) with the seam centered lengthwise. Seam overlap will be as indicated in Section 10.5.3.6.

Four specimens, each 1 in. (25 mm) wide, will be cut from the trial seam sample by the Geosynthetic Installer. One specimen will be tested for shear strength and three specimens will be tested for peel adhesion using a gauged tensiometer. All specimens tested will exhibit a Film Tear Bond (FTB) and will not fail in the seam. In addition, all specimens will meet or exceed the minimum strength requirements described in the *Technical Specifications*. If any of the four specimens fails, the entire trial seaming operation will be repeated. If any of the four additional specimens fails, the seaming apparatus and seamer will not be approved for production seaming until the

deficiencies are corrected and two consecutive trial seam tests achieve the FTB requirements outlined above.

The CQA Site Manager will observe trial seam procedures. Trial seam samples will be assigned a number. The CQA Site Manager, will log the date, time, machine temperature(s), number of the seaming unit, name of the seamer, and pass or fail description for each trial seam sample tested.

10.4.4.8 General Seaming Procedure

Unless otherwise specified, the general seaming procedure used by the Geosynthetic Installer will be as follows:

- Fishmouths or wrinkles at the seam overlaps will be cut along the ridge of the wrinkle in order to achieve a flat overlap. The cut fishmouths or wrinkles will be seamed and any portion where the overlap is inadequate will then be patched with an oval or round patch of the same geomembrane extending a minimum of 6 in. (150 mm) beyond the cut in all directions.

- If seaming operations are carried out at night, adequate illumination will be provided at the Geosynthetic Installer's expense.

- Seaming will extend to the outside edge of panels to be placed in the anchor trench.

The CQA Site Manager will document that the above seaming procedures are followed, and will inform the Project Manager if they are not.

10.4.4.9 Nondestructive Seam Continuity Testing

Concept

The Geosynthetic Installer will non-destructively test field seams over their length using a vacuum test unit, air pressure test (for double fusion seams only), or

other approved method. The purpose of nondestructive tests is to check the continuity of seams. It does not provide information on seam strength. Continuity testing will be carried out as the seaming work progresses, not at the completion of field seaming.

The CQA Site Manager will:

- observe continuity testing;
- record location, date, test unit number, name of person conducting the test, and the results of tests; and
- inform the Geosynthetic Installer and Project Manager of required repairs.

The Geosynthetic Installer will complete any required repairs in general accordance with Section 10.4.5.

The CQA Site Manager will:

- observe the repair and re-testing of the repair;
- mark on the geomembrane that the repair has been made; and
- document the results.

The following procedures will apply to locations where seams cannot be non-destructively tested:

All such seams will be cap-stripped with the same geomembrane.

- If the seam is accessible to testing equipment prior to final installation, the seam will be non-destructively tested prior to final installation.
- If the seam cannot be tested prior to final installation, the seaming and cap-stripping operations will be observed by the CQA Site Manager and Geosynthetic Installer for uniformity and completeness.

The seam number, date of observation, name of tester, and outcome of the test or observation will be recorded by the CQA Site Manager.

Vacuum Testing

The equipment will be comprised of the following:

- a vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, port hole or valve assembly, and a vacuum gauge;
- a steel vacuum tank and pump assembly equipped with a pressure controller and pipe connections;
- a rubber pressure/vacuum hose with fittings and connections;
- an approved applicator; and
- a soapy solution.

The following procedures will be followed:

- energize the vacuum pump and reduce the tank pressure to approximately 5 psi (35 kPa) (10 in. of Hg.) gauge;
- wet a strip of geomembrane approximately 12 in. by 48 in. (0.3 m by 1.2 m) with the soapy solution;
- place the box over the wetted area;
- close the bleed valve and open the vacuum valve;
- document that a leak tight seal is created;

- for a period of not less than ten seconds, examine the geomembrane through the viewing window for the presence of leaks indicated by soap bubbles;

- if no leaks appear after ten seconds, close the vacuum valve and open the bleed valve, move the box over the next adjoining area with a minimum 3 in. (75 mm) overlap, and repeat the process;

- areas where soap bubbles appear will be marked and repaired in general accordance with Section 10.4.5 and retested using the vacuum testing method.

Air Pressure Testing (For Double-Track Fusion Seam Only)

The following procedures are applicable to those processes that produce a double seam with an enclosed space.

The equipment will be comprised of the following:

- an air pump (manual or motor driven) equipped with pressure gauge capable of generating and sustaining a pressure of 30 psi (200 kPa) and mounted on a cushion to protect the geomembrane;

- a rubber hose with fittings and connections;

- a sharp hollow needle, or other approved pressure feed device.

The following procedures will be followed:

- seal both ends of the seam to be tested;

- insert needle or other approved pressure feed device into the tunnel created by the fusion weld;

- insert a protective cushion between the air pump and the geomembrane;

- energize the air pump to a pressure of 25 to 30 psi (170 to 204 kPa), close valve, and sustain pressure for not less than 5 minutes;

- if loss of pressure exceeds 3 psi (20 kPa) or does not stabilize, locate faulty area and repair in general accordance with Section 10.4.5;

- cut end of tested seam area, opposite the location of the pressure gauge, after completion of the five minute pressure hold period to verify complete testing of the seam. If the pressure gauge does not indicate a release of pressure, locate blockage of the air channel and retest until entire seam is tested; and

- remove needle or other approved pressure feed device and repair any holes in the geomembrane resulting from the air pressure testing procedure in general accordance with Section 10.4.5.

10.4.4.10 Destructive Testing

Concept

Destructive seam testing will be performed on site and at the independent CQA laboratory in general accordance with the *Drawings* and the *Technical Specifications*. Destructive seam tests will be performed at selected locations. The purpose of these tests is to evaluate seam strength. Seam strength testing will be done as the seaming work progresses, not at the completion of all field seaming.

Location and Frequency

The CQA Site Manager will select locations where seam samples will be cut out for laboratory testing. Those locations will be established as follows.

- The frequency of geomembrane seam testing is a minimum of one destructive sample per 500 feet of weld. The minimum frequency is to be evaluated as an average taken throughout the entire facility.

- A minimum of one test per seaming machine over the duration of the project phase.

- Test locations will be evaluated during seaming at CQA Site Manager's discretion. Selection of such locations may be prompted by suspicion of excess crystallinity, contamination, offset welds, or any other potential cause of imperfect welding.

The Geosynthetic Installer will not be informed in advance of the locations where the seam samples will be taken.

Sampling Procedure

Samples will be cut by the Geosynthetic Installer as the seaming progresses in order to have laboratory test results before the geomembrane is covered by another material. The CQA Site Manager will:

- observe sample cutting;
- assign a number to each sample, and mark it accordingly;
- record sample location on layout drawing; and
- record reason for taking the sample at this location (e.g., statistical routine, suspicious feature of the geomembrane).

Holes in the geomembrane resulting from destructive seam sampling will be immediately repaired in general accordance with repair procedures described in Section 10.4.5. The continuity of the new seams in the repaired area will be tested in general accordance with Section 10.4.4.9.

Size and Distribution of Samples

The destructive sample will be 12 in. (0.3 m) wide by 42 in. (1.1 m) long with the seam centered lengthwise. The sample will be cut into three parts and distributed as follows:

- one portion, measuring 12 in. × 12 in. (0.30 cm × 30 cm), to the Geosynthetic Installer for field testing;
- one portion, measuring 12 in. × 18 in. (30 cm × 45 cm), for CQA Laboratory testing; and
- one portion, measuring 12 in. × 12 in. (30 cm × 30 cm), to the Contractor for archive storage.

Final evaluation of the destructive sample sizes and distribution will be made at the Pre-Construction Meeting.

Field Testing

Field testing will be performed by the Geosynthetic Installer using a gauged tensiometer. Prior to field testing the Geosynthetic Installer shall submit a calibration certificate for gauge tensiometer to the CQA Consultant for review. Calibration must have been performed within one year of use on the current project. Five 1 in. (25 mm) wide strips will be taken for peel. The specimens shall not fail in the seam and shall meet the strength requirements outlined in the *Technical Specifications*. If any field test specimen fails, then the procedures outlined in *Procedures for Destructive Test Failures* of this section will be followed.

The CQA Site Manager will witness field tests and mark samples and portions with their number. The CQA Site Manager will also log the date and time, ambient temperature, number of seaming unit, name of seamer, welding apparatus temperatures and pressures, and pass or fail description.

CQA Laboratory Testing

Destructive test samples will be packaged and shipped, if necessary, under the responsibility of the CQA Site Manager in a manner that will not damage the test sample. The Project Manager will document that packaging and shipping conditions are acceptable. The Project Manager will be responsible for storing the archive samples. This procedure will be outlined at the Resolution Meeting. Samples will be tested by the CQA Laboratory. The CQA Laboratory will be selected by the CQA Site Manager with the concurrence of the Project Manager.

Testing will include "Bonded Seam Strength" and "Peel Adhesion." The minimum acceptable values to be obtained in these tests are given in the *Technical Specifications*. At least five specimens will be tested for each test method. Specimens will be selected alternately by test from the samples (i.e., peel, shear, peel, shear...). A passing test will meet the minimum required values in at least four out of five specimens.

The CQA Laboratory will provide test results no more than 24 hours after they receive the samples. The CQA Site Manager will review laboratory test results as soon as they become available, and make appropriate recommendations to the Project Manager.

Geosynthetic Installer's Laboratory Testing

The Geosynthetic Installer's laboratory test results will be presented to the Project Manager and the CQA Site Manager for comments.

Procedures for Destructive Test Failure

The following procedures will apply whenever a sample fails a destructive test, whether that test conducted by the CQA Laboratory, the Geosynthetic Installer's laboratory, or by gauged tensiometer in the field. The Geosynthetic Installer has two options:

- The Geosynthetic Installer can reconstruct the seam between two passed test locations.

- The Geosynthetic Installer can trace the welding path to an intermediate location at 10 ft (3 m) minimum from the point of the failed test in each direction and take a small sample for an additional field test at each location. If these additional samples pass the test, then full laboratory samples are taken. If these laboratory samples pass the tests, then the seam is reconstructed between these locations. If either sample fails, then the process is repeated to establish the zone in which the seam should be reconstructed.

Acceptable seams must be bounded by two locations from which samples passing laboratory destructive tests have been taken. In cases where the failed seam segment exceeds 150 ft (50 m), a destructive sample will be taken from the zone in which the seam has been reconstructed. Repairs will be made in general accordance with Section 10.4.5.

The CQA Site Manager will document actions taken in conjunction with destructive test failures.

10.4.5 Defects and Repairs

This section prescribes CQA activities to document that defects, tears, rips, punctures, damage, or failing seams shall be repaired.

10.4.5.1 Identification

Seams and non-seam areas of the geomembrane will be examined by the CQA Site Manager for identification of defects, holes, blisters, undispersed raw materials and signs of contamination by foreign matter. Because light reflected by the geomembrane helps to detect defects, the surface of the geomembrane will be clean at the time of examination.

10.4.5.2 Evaluation

Each suspect location both in seam and non-seam areas will be non-destructively tested using the methods described in Section 10.4.4.9 as appropriate.

Each location that fails the nondestructive testing will be marked by the CQA Site Manager and repaired by the Geosynthetic Installer. Work will not proceed with any materials that will cover locations which have been repaired until laboratory test results with passing values are available.

10.4.5.3 Repair Procedures

Portions of the geomembrane exhibiting a flaw, or failing a destructive or nondestructive test, will be repaired. Several procedures exist for the repair of these areas. The final decision as to the appropriate repair procedure will be at the discretion of the CQA Consultant with input from the Project Manager and Geosynthetic Installer. The procedures available include:

- patching, used to repair large holes, tears, undispersed raw materials, and contamination by foreign matter;
- grinding and re-welding, used to repair small sections of extruded seams;
- spot welding or seaming, used to repair small tears, pinholes, or other minor, localized flaws;
- capping, used to repair large lengths of failed seams;
- removing bad seam and replacing with a strip of new material welded into place (used with large lengths of fusion seams).

In addition, the following provisions will be satisfied:

- surfaces of the geomembrane which are to be repaired will be abraded no more than 20 minutes prior to the repair;
- surfaces must be clean and dry at the time of the repair;

- all seaming equipment used in repairing procedures must be approved;

- the repair procedures, materials, and techniques will be approved in advance by the CQA Consultant with input from the Project Manager and Geosynthetic Installer;

- patches or caps will extend at least 6 in. (150 mm) beyond the edge of the defect, and all corners of patches will be rounded with a radius of at least 3 in. (75 mm); and

- the geomembrane below large caps should be appropriately cut to avoid water or gas collection between the two sheets.

10.4.5.4 Verification of Repairs

Each repair will be numbered and logged. Each repair will be non-destructively tested using the methods described in Section 10.4.4.9 as appropriate. Repairs that pass the non- destructive test will be taken as an indication of an adequate repair. Large caps may be of sufficient extent to require destructive test sampling, at the discretion of the CQA Site Manager. Failed tests indicate that the repair will be redone and re-tested until a passing test results. The CQA Site Manager will observe all non-destructive testing of repairs and will record the number of each repair, date, and test outcome.

10.4.5.5 Large Wrinkles

When seaming of the geomembrane is completed (or when seaming of a large area of the geomembrane liner is completed) and prior to placing overlying materials, the CQA Site Manager will observe the geomembrane wrinkles. The CQA Site Manager will indicate to the Project Manager which wrinkles should be cut and re-seamed by the Geosynthetic Installer. The seam thus produced will be tested like any other seam.

10.4.6 Lining System Acceptance

The Geosynthetic Installer and the Manufacturer(s) will retain all responsibility for the geosynthetic materials in the liner system until acceptance by the Owner.

The geosynthetic liner system will be accepted by the Owner when:

- the installation is finished;
- verification of the adequacy of all seams and repairs, including associated testing, is complete;
- all documentation of installation is completed including the CQA Site Manager's acceptance report; and
- CQA report, including "as built" drawing(s), sealed by a registered professional engineer has been received by the Project Manager.

The CQA Site Manager will document that installation has proceeded in general accordance with the *Technical Specifications* for the project except as noted to the Project Manager.

11. GEOTEXTILE

11.1 Introduction

This section of the CQA Plan outlines the CQA activities to be performed for the geotextile installation. The CQA Consultant will review the *Drawings*, and the *Technical Specifications*, and any approved addenda or changes.

11.2 Manufacturing

The Manufacturer will provide the Project Manager with a list of guaranteed "minimum average roll value" properties (defined as the mean less two standard deviations), for each type of geotextile to be delivered. The Manufacturer will also provide the Project Manager with a written quality control certification signed by a responsible party employed by the Manufacturer that the materials actually delivered have property "minimum average roll values" which meet or exceed all property values guaranteed for that type of geotextile.

The quality control certificates will include:

- roll identification numbers; and
- results of quality control testing.

The Manufacturer will provide, as a minimum, test results for the following:

- grab strength;
- tear strength;
- burst strength;
- puncture strength;
- permittivity; and
- apparent opening size.

Quality control tests must be performed, in general accordance with the test methods specified in Table 9, on geotextile produced for the project. The Manufacturer

will also provide a written certification that the nonwoven, needle-punched geotextiles are continuously inspected and found to be needle-free.

The CQA Site Manager will examine Manufacturer certifications to evaluate that the property values listed on the certifications meet or exceed those specified for the particular type of geotextile and the measurements of properties by the Manufacturer are properly documented, test methods acceptable and the certificates have been provided at the specified frequency properly identifying the rolls related to testing. Deviations will be reported to the Project Manager.

11.3 Labeling

The Manufacturer will identify all rolls of geotextile with the following:

- manufacturer's name;
- product identification;
- lot number;
- roll number; and
- roll dimensions.

The CQA Site Manager will examine rolls upon delivery and deviation from the above requirements will be reported to the Project Manager.

11.4 Shipment and Storage

During shipment and storage, the geotextile will be protected from ultraviolet light exposure, precipitation or other inundation, mud, dirt, dust, puncture, cutting or any other damaging or deleterious conditions. To that effect, geotextile rolls will be shipped and stored in relatively opaque and watertight wrappings.

Protective wrappings will be removed less than one hour prior to unrolling the geotextile. After the wrapping has been removed, a geotextile will not be exposed to sunlight for more than 15 days, except for UV protection geotextile, unless otherwise specified and guaranteed by the Manufacturer.

The CQA Site Manager will observe rolls upon delivery at the site and deviation from the above requirements will be reported to the Project Manager.

11.5 Conformance Testing

11.5.1 Tests

Upon delivery of the rolls of geotextiles, the CQA Site Manager will document that samples are removed and forwarded to the Geosynthetics CQA Laboratory for testing to evaluate conformance to *Technical Specifications*. Required test and testing frequency for the geotextiles are presented in Table 9.

These conformance tests will be performed in general accordance with the test methods specified in the *Technical Specifications*.

11.5.2 Sampling Procedures

Samples will be taken across the width of the roll and will not include the first three feet (linear meter). Unless otherwise specified, samples will be 3 ft (1 m) long by the roll width. The CQA Site Manager will mark the machine direction on the samples with an arrow.

Unless otherwise specified, samples will be taken at a rate as indicated in Table 9 for geotextiles.

11.5.3 Test Results

The CQA Site Manager will examine results from laboratory conformance testing and will report non-conformance to the Project Manager.

11.5.4 Conformance Sample Failure

The following procedure will apply whenever a sample fails a conformance test that is conducted by the CQA Laboratory:

- The Manufacturer will replace every roll of geotextile that is in nonconformance with the *Technical Specifications* with a roll(s) that meets *Technical Specifications*.

- The Geosynthetic Installer will remove conformance samples for testing by the CQA Laboratory from the closest numerical rolls on both sides of the failed roll. These two samples must conform to the *Technical Specifications*. If either of these samples fail, the numerically closest rolls on the side of the failed sample will be tested by the CQA Laboratory. These samples must conform to the *Technical Specifications*. If any of these samples fail, every roll of geotextile on site from this lot and every subsequently delivered roll that is from the same lot must be tested by the CQA Laboratory for conformance to the *Technical Specifications*. This additional conformance testing will be at the expense of the Manufacturer.

The CQA Site Manager will document actions taken in conjunction with conformance test failures.

11.6 <u>Handling and Placement</u>

The Geosynthetic Installer will handle all geotextiles in such a manner as to document they are not damaged in any way, and the following will be complied with:

- In the presence of wind, all geotextiles will be weighted with sandbags or the equivalent. Such sandbags will be installed during placement and will remain until replaced with earth cover material.

- Geotextiles will be cut using an approved geotextile cutter only. If in place, special care must be taken to protect other materials from damage, which could be caused by the cutting of the geotextiles.

- The Geosynthetic Installer will take all necessary precautions to prevent damage to underlying layers during placement of the geotextile.

- During placement of geotextiles, care will be taken not to entrap in the geotextile stones, excessive dust, or moisture that could damage the geotextile, generate clogging of drains or filters, or hamper subsequent seaming.

- A visual examination of the geotextile will be carried out over the entire surface, after installation, to document that no potentially harmful foreign objects, such as needles, are present.

The CQA Site Manager will note non-compliance and report it to the Project Manager.

11.7 Seams and Overlaps

Geotextiles will be overlapped a minimum of 12 in. (0.3 m) prior to seaming.

11.8 Repair

Holes or tears in the geotextile will be repaired as follows:

- A patch made from the same geotextile will be spot-seamed in place with a minimum of 6 in. (0.60 m) overlap in all directions.

Care will be taken to remove any soil or other material that may have penetrated the torn geotextile.

The CQA Site Manager will observe any repair, note any non-compliance with the above requirements and report them to the Project Manager.

11.9 Placement of Soil Materials

The Contractor will place all soil materials located on top of a geotextile, in such a manner as to document:

- no damage of the geotextile;
- minimal slippage of the geotextile on underlying layers; and
- no excess tensile stresses in the geotextile.

Non-compliance will be noted by the CQA Site Manager and reported to the Project Manager.

12. GEOSYNTHETIC CLAY LINER (GCL)

12.1 Introduction

This section of the CQA Plan outlines the CQA activities to be performed for the geosynthetic clay liner (GCL) installation. The CQA Consultant will review the *Drawings*, and the *Technical Specifications*, and approved addenda or changes.

12.2 Manufacturing

The Manufacturer will provide the Project Manager with a list of guaranteed "minimum average roll value" properties (defined as the mean less two standard deviations), for the GCL to be delivered. The Manufacturer will also provide the Project Manager with a written quality control certification signed by a responsible party employed by the Manufacturer that the materials actually delivered have property "minimum average roll values" which meet or exceed all property values guaranteed for that GCL.

The quality control certificates will include:

- roll identification numbers; and
- results of quality control testing.

The Manufacturer will provide, as a minimum, test results for the following:

- mass per unit area; and
- index flux.

Quality control tests must be performed, in general accordance with the test methods specified in Table 10, on GCL produced for the project.

The CQA Site Manager will examine Manufacturer certifications to verify that the property values listed on the certifications meet or exceed those specified for the GCL and the measurements of properties by the Manufacturer are properly documented, test methods acceptable and the certificates have been provided at the

specified frequency properly identifying the rolls related to testing. Deviations will be reported to the Project Manager.

12.3 Labeling

The Manufacturer will identify all rolls of GCL with the following:

- manufacturer's name;
- product identification;
- lot number;
- roll number; and
- roll dimensions.

The CQA Site Manager will examine rolls upon delivery and deviation from the above requirements will be reported to the Project Manager.

12.4 Shipment and Storage

During shipment and storage, the GCL will be protected from ultraviolet light exposure, precipitation or other inundation, mud, dirt, dust, puncture, cutting or any other damaging or deleterious conditions. To that effect, GCL rolls will be shipped and stored in relatively opaque and watertight wrappings.

The CQA Site Manager will observe rolls upon delivery at the site and any deviation from the above requirements will be reported to the Project Manager.

12.5 Conformance Testing

12.5.1 Tests

CQA personnel will sample the GCL either during production at the manufacturing facility or after delivery to the construction site. The samples will be forwarded to the Geosynthetics CQA Laboratory for testing to assess conformance with the *Technical Specifications*. The test methods and minimum testing frequencies are indicated in Table 10.

Samples will be taken across the width of the roll and will not include the first 3 ft (0.9 m) if the sample is cut on site. Unless otherwise specified, samples will be 3 ft (0.9 m) long by the roll width. The CQA Consultant will mark the machine direction with an arrow and the manufacturer's roll number on each sample.

The CQA Site Manager will examine results from laboratory conformance testing and will report non-conformance to the Project Manager.

12.5.2 Conformance Sample Failure

The following procedure will apply whenever a sample fails a conformance test that is conducted by the CQA Laboratory:

- The Manufacturer will replace every roll of GCL that is in nonconformance with the *Technical Specifications* with a roll(s) that meets *Technical Specifications*.

- The Geosynthetic Installer will remove conformance samples for testing by the CQA Laboratory from the closest numerical rolls on both sides of the failed roll. These two samples must conform to the *Technical Specifications*. If either of these samples fail, the numerically closest rolls on the side of the failed sample will be tested by the CQA Laboratory. These samples must conform to the *Technical Specifications*. If any of these samples fail, every roll of GCL on site from this lot and every subsequently delivered roll that is from the same lot must be tested by the CQA Laboratory for conformance to the *Technical Specifications*. This additional conformance testing will be at the expense of the Manufacturer.

The CQA Site Manager will document actions taken in conjunction with conformance test failures.

12.6 GCL Delivery and Storage

Upon delivery to the site, the CQA Consultant will check the GCL rolls for defects (e.g., tears, holes) and for damage. The CQA Consultant will report to the Project Manager and the Geosynthetics Installer:

- any rolls, or portions thereof, which should be rejected and removed from the site because they have severe flaws; and

- any rolls which include minor repairable flaws.

The GCL rolls delivered to the site will be checked by the CQA Consultant to document that the roll numbers correspond to those on the approved Manufacturer's quality control certificate of compliance.

12.7 GCL Installation

The CQA Consultant will monitor and document that the GCL is installed in general accordance with the *Drawings* and the *Technical Specifications*. The Geosynthetics Installer shall provide the CQA Consultant a certificate of subgrade acceptance prior to the installation of the GCL as outlined in the *Technical Specifications*. The GCL installation activities to be monitored and documented by the CQA Consultant include:

- monitoring that the GCL rolls are stored and handled in a manner which does not result in any damage to the GCL;

- monitoring that the GCL is not exposed to UV radiation for extended periods of time without prior approval;

- monitoring that the GCL are seamed in general accordance with the *Technical Specifications* and the Manufacturer's recommendations;

- monitoring and documenting that the GCL is installed on an approved subgrade, free of debris, protrusions, or uneven surfaces;

- monitoring that the GCL is not installed on a saturated subgrade or standing water and is not exposed such that it is hydrated prior to completion of the construction; and

- monitoring that any damage to the GCL is repaired as outlined in the *Technical Specifications*.

The CQA Site Manager will note non-compliance and report it to the Project Manager.

13. GEOCOMPOSITE

13.1 Introduction

This section of the CQA Plan outlines the CQA activities to be performed for the geocomposite installation. The CQA Consultant will review the *Drawings*, and the *Technical Specifications*, and any approved addenda or changes.

13.2 Manufacturing

The Manufacturer will provide the CQA Consultant with a list of certified "minimum average roll value" properties for the type of geocomposite to be delivered. The Manufacturer will also provide the CQA Consultant with a written certification signed by a responsible representative of the Manufacturer that the geocomposite actually delivered have "minimum average roll values" properties which meet or exceed all certified property values for that type of geocomposite.

The CQA Consultant will examine the Manufacturers' certifications to document that the property values listed on the certifications meet or exceed those specified for the particular type of geocomposite (geotextile and geonet). Deviations will be reported to the Project Manager.

13.3 Labeling

The Manufacturer will identify all rolls of geocomposite with the following:

- Manufacturer's name;
- product identification;
- lot number;
- roll number; and
- roll dimensions.

The CQA Site Manager will examine rolls upon delivery and deviation from the above requirements will be reported to the Project Manager.

13.4 Shipment and Storage

During shipment and storage, the geocomposite will be protected from ultraviolet light exposure, precipitation or other inundation, mud, dirt, dust, puncture, cutting or any other damaging or deleterious conditions. Therefore, geocomposite rolls will be shipped and stored in relatively opaque and watertight wrappings. The CQA Site Manager will observe rolls upon delivery to the site and deviation from the above requirements will be reported to the Project Manager. Damaged rolls will be rejected and replaced.

Wrapping protecting geocomposite rolls will be removed less than one hour prior to unrolling geocomposite before placement. After the wrapping has been removed, geocomposite should not be exposed to sunlight for more than 15 days, unless otherwise approved by the Manufacturer. Approval by the Manufacturer will be a guarantee that the properties of the exposed geotextile will not degrade upon prolonged exposure to such values that would cause the material to not meet the *Technical Specifications*. Any material that is exposed for more than 15 days, which has been approved for prolonged exposure by the Manufacturer, will be tested by the CQA Laboratory to document that the material properties are still in conformance with the *Technical Specifications*. Any material that fails to meet the *Technical Specifications* will be replaced by the Manufacturer.

The CQA Site Manager will observe that geocomposite is free of dirt and dust just before installation. The CQA Site Manager will report the outcome of this observation to the Project Manager, and if the geocomposite is judged dirty or dusty, they will be cleaned by the Geosynthetic Installer prior to installation.

13.5 Conformance Testing

13.5.1 Tests

The geocomposite material will be tested for transmissivity (ASTM D 4716) and for peel strength (ASTM D 413) at the frequencies presented in Table 11.

13.5.2 Sampling Procedures

Upon delivery of the geocomposite rolls, the CQA Site Manager will document that samples are obtained from individual rolls at the frequency specified in this CQA Plan. The geocomposite samples will be forwarded to the CQA Laboratory for testing to evaluate conformance to both the *Technical Specifications* and the list of physical properties certified by the Manufacturer.

Samples will be taken across the width of the roll and will not include the first 3 linear ft (1 linear m). Unless otherwise specified, samples will be 3 ft (1 m) long by the roll width. The CQA Consultant will mark the machine direction on the samples with an arrow.

13.5.3 Test Results

The CQA Site Manager will examine results from laboratory conformance testing and compare results to the *Technical Specifications*. The criteria used to evaluate acceptability are presented in the *Technical Specifications*. The CQA Site Manager will report any nonconformance to the Project Manager.

13.5.4 Conformance Test Failure

The following procedure will apply whenever a sample fails a conformance test that is conducted by the CQA Laboratory:

- The Manufacturer will replace every roll of geocomposite that is in nonconformance with the *Technical Specifications* with a roll that meets specifications.

- The Geosynthetic Installer will remove conformance samples for testing by the CQA Laboratory from the closest numerical rolls on both sides of the failed roll. These two samples must conform to the *Technical Specifications*. If either of these samples fail, the numerically closest rolls on the side of the failed sample that is not tested, will be tested by the CQA Laboratory. These samples must

conform to the *Technical Specifications*. If any of these samples fail, every roll of geocomposite on site from this lot and every subsequently delivered roll that is from the same lot must be tested by the CQA Laboratory for conformance to the *Technical Specifications*.

The CQA Site Manager will document actions taken in conjunction with conformance test failures.

13.6 Handling and Placement

The Geosynthetic Installer will handle all geocomposite in such a manner as to document they are not damaged in any way. The Geosynthetic Installer will comply with the following:

- In the presence of wind, the geocomposite will be weighted with sandbags or the equivalent. Sandbags will be used during installation only and will remain until replaced with the appropriate cover material.

- If in place, special care must be taken to protect other materials from damage, which could be caused by the cutting of the geocomposite.

- The Geosynthetic Installer will take any necessary precautions to prevent damage to underlying layers during placement of the geocomposite.

- During placement of geocomposite, care will be taken to prevent entrapment of dirt or excessive dust that could cause clogging of the drainage system, and/or stones that could damage the adjacent geomembrane. If dirt or excessive dust is entrapped in the geocomposite, it should be cleaned prior to placement of the next material on top of it. In this regard, care should be taken with the handling or sandbags, to prevent rupture or damage of the sandbag.

- A visual examination of the geocomposite will be carried out over the entire surface, after installation to document that no potentially harmful foreign objects are present.

The CQA Site Manager will note noncompliance and report it to the Project Manager.

13.7 Geocomposite Seams and Overlaps

Adjacent geocomposite panels will be joined in general accordance with *Construction Drawings* and *Technical Specifications*. As a minimum, the following requirements will be met:

- Adjacent rolls will be overlapped by at least 4 in. (100 mm).
- Each component of the geocomposite will be secured or seamed to the like component at overlaps.
- The geocomposite overlaps will be secured by tying, in general accordance with the *Technical Specifications*.
- The bottom layers of geotextile, if applicable, will be overlapped.
- The top layers of geotextile will be continuously sewn.

The CQA Consultant will note any noncompliance and report it to the Project Manager.

13.8 Repair

Holes or tears in the geocomposite will be repaired by placing a patch extending 2 ft (0.6 m) beyond edges of the hole or tear. The patch will be secured by tying with approved tying devices every 6 in. (150 mm) through the bottom geotextile and the geonet of the patch, and through the top geotextile and geonet components of the geocomposite needing repair. The top geotextile component of the patch will be

heat sealed to the top geotextile of the geocomposite needing repair. If the hole or tear width across the roll is more than 50 percent of the width of the roll, the damaged area will be cut out and the two portions of the geocomposite will be joined in general accordance with Section 13.7.

The CQA Site Manager will observe repairs, note noncompliances with the above requirements and report them to the Project Manager.

13.9 Placement of Soil Materials

The Contractor will place all soil materials located on top of a geocomposite in such a manner as to document:

- the geocomposite and underlying liner materials are not damaged;
- minimal slippage of the geocomposite on underlying layers occurs; and
- no excess tensile stresses occur in the geocomposite.

Unless otherwise specified by the CQA Consultant, lifts of soil material will be in conformance with the *Technical Specifications*. If portions of the geocomposite are exposed, the CQA Consultant will periodically place marks on the geocomposite and the underlying geomembrane and measure the elongation of the geonet during the placement of soil.

Noncompliance will be noted by the CQA Consultant and reported to the Project Manager.

14. SURVEYING

14.1 Survey Control

Survey control will be performed by the Owner as needed. A permanent benchmark will be established for the site(s) in a location convenient for daily tie-in. The vertical and horizontal control for this benchmark will be established within normal land surveying standards.

14.2 Precision and Accuracy

A wide variety of survey equipment is available for the surveying requirements for these projects. The survey instruments used for this work should be sufficiently precise and accurate to meet the needs of the projects. Surveys shall be performed at 2nd order accuracy.

14.3 Lines and Grades

The following surfaces will be surveyed to verify the lines and grades achieved during soil placement and compaction.

- Prepared Subgrade:
  - prepared subgrade surface.
- Cover Soil:
  - finished compacted cover soil surface.

The following structures will be surveyed to verify and document the lines and grades achieved during construction of the Project:

- all culverts, inlet, and drop structures;
- ditch bottoms and sideslopes;
- permanent erosion control features;

- geomembrane terminations and selected geomembrane seams, as indicated by the CQA Manager; and

- centerlines of pipes.

14.4 Frequency and Spacing

Surveying should be carried out immediately upon completion of a given installation to facilitate progress and avoid delaying commencement of the next installation. In addition, spot checks during placement and compaction will be necessary to assist the Contractor in compliance with required grades.

At the least the following minimum spacings and locations should be provided for survey points:

- all "flat" surfaces with gradients less than 10 percent, should be surveyed on a square grid not wider spaced than 100 ft (30 m);

- on all slopes greater than 10 percent, a square grid not wider than 100 ft (30 m) should be used, but in any case, a line at the crest, midpoint, and toe of the slope should be taken;

- a line of survey points no further than 100 ft (30 m) apart must be taken along any slope break (this will include the inside edge and outside edge of any bench on a slope); and

- a line of survey points no further than 50 ft (15 m) apart must be taken at the invert of pipes or other appurtenances to the liner.

14.5 Documentation

Field survey notes should be retained by the Land Surveyor. The findings from the field surveys should be documented on a set of Survey Record Drawings, which shall be provided to the Engineer in AutoCADD V.14 format or other suitable format as directed by the Owner.

TABLE 1
TEST PROCEDURES FOR THE EVALUATION OF SOILS

TEST METHOD	DESCRIPTION	TEST STANDARD
Laboratory Test Procedures:		
Classification	Classification of Soils	ASTM D 2487
Moisture Content	Moisture Content	ASTM D 2216
Modified Proctor	Moisture/Density Relationship of Soil (10 lb (4.54 kg) rammer and 18 in. (457 mm) drop)	ASTM D 1557
Hydrometer Analysis	Particle Size Distribution of Fine Fraction of Soils	ASTM D 422
Sieve Analysis	Particle Size Distribution of Coarse Fraction of Soils	ASTM D 422
Field Test Procedures:		
Nuclear Densometer	In Situ Soil Unit Weight In Situ Moisture Content	ASTM D 2922 ASTM D 3017
Sand Cone	In Situ Soil Unit Weight Moisture Content	ASTM D 1556 ASTM D 2216
Drive Cylinder	In Situ Soil Unit Weight Moisture Content	ASTM D 2937 ASTM D 2216

TABLE 2

MINIMUM SOILS TESTING FREQUENCIES FOR MATERIAL QUALIFICATION TESTING

TEST	ENGINEERED FILL
Moisture Content	1 per source
Sieve Analysis	1 per source
Hydrometer Analysis	1 per source
Soil Classification	1 per source
Modified Proctor	1 per source

TABLE 3

MINIMUM SOILS TESTING FREQUENCIES FOR CONFORMANCE TESTING

TEST	COVER SOIL
Moisture Content	1 per 10,000 yd^3 (7,646 m^3)
Sieve Analysis	1 per 10,000 yd^3 (7,646 m^3)
Hydrometer Analysis	1 per 10,000 yd^3 (7,646 m^3)
Soil Classification	1 per 10,000 yd^3 (7,646 m^3)
Modified Proctor	1 per 10,000 yd^3 (7,646 m^3)

TABLE 4

MINIMUM SOIL TESTING FREQUENCIES FOR CONSTRUCTION QUALITY CONTROL

TEST	ENGINEERED FILL
Nuclear densometer	1 per 750 yd^3
Sand cone or drive cylinder	1 per 20 nuclear densometer tests

Notes: (1) Nuclear densometer testing of the first lift of cover soil placed above the final cover system geosynthetics shall be performed at a depth no greater than 6 in. (i.e., 8-in. deep hole in 12-in. thick cover).

TABLE 5

TEST PROCEDURES FOR THE EVALUATION OF AGGREGATE

TEST METHOD	DESCRIPTION	TEST STANDARD
Sieve Analysis	Particle Size Distribution of Fine and Coarse Aggregates	ASTM C 136
Hydraulic Conductivity (Rigid Wall Permeameter)	Permeability of Aggregates	ASTM D 2434

TABLE 6

MINIMUM AGGREGATE TESTING FREQUENCIES FOR MATERIAL QUALIFICATION TESTING

TEST	DRAINAGE AGGREGATE
Sieve Analysis	1 per source
Hydraulic Conductivity	1 per source

TABLE 7

MINIMUM AGGREGATE TESTING FREQUENCIES FOR CONFORMANCE TESTING

TEST	TEST METHOD	DRAINAGE AGGREGATE
Sieve Analysis	ASTM C 136	1 per 5,000 yd^3 (3,823 m^3)
Hydraulic Conductivity	ASTM D 2434	1 per 10,000 yd^3 (7,646 m^3)

TABLE 8

GEOMEMBRANE CONFORMANCE TESTING REQUIREMENTS

TEST NAME	TEST METHOD	FREQUENCY
Specific Gravity	ASTM D 792 Method A or ASTM D 1505	100,000 ft^2 (9,290 m^2)
Thickness	ASTM D 5994 or ASTM D 5199	100,000 ft^2 (9,290 m^2)
Tensile Strength at Yield	ASTM D 638	100,000 ft^2 (9,290 m^2)
Tensile Strength at Break	ASTM D 638	100,000 ft^2 (9,290 m^2)
Elongation at Yield	ASTM D 638	100,000 ft^2 (9,290 m^2)
Elongation at Break	ASTM D 638	100,000 ft^2 (9,290 m^2)
Carbon Black Content	ASTM D 1603	100,000 ft^2 (9,290 m^2)
Carbon Black Dispersion	ASTM D 5596	100,000 ft^2 (9,290 m^2)

TABLE 9

GEOTEXTILE CONFORMANCE TESTING REQUIREMENTS

TEST NAME	TEST METHOD	MINIMUM FREQUENCY
Grab Strength	ASTM D 4632	1 test per 260,000 ft^2
Puncture Resistance	ASTM D 4833	1 test per 260,000 ft^2
Permittivity	ASTM D 4491	1 test per 260,000 ft^2
Apparent Opening Size	ASTM D 4751	1 test per 260,000 ft^2

TABLE 10

GCL CONFORMANCE TESTING REQUIREMENTS

TEST NAME	TEST METHOD	MINIMUM FREQUENCY
Mass per Unit Area	ASTM D 3776	100,000 ft^2 (9,290 m2)
Index Flux	ASTM D 5084	400,000 ft^2 (37,160 m^2)
Residual Shear Strength	ASTM D 5321	See Technical Specifications

TABLE 11

GEOCOMPOSITE CONFORMANCE TESTING REQUIREMENTS

TEST NAME	TEST METHOD	MINIMUM FREQUENCY
Peel Strength	ASTM D 413	1 test per 200,000 ft^2 (18,580 m^2)
Hydraulic Transmissivity	ASTM D 4716	1 test per 200,000 ft^2 (18,580 m^2)

Note: Testing will be carried out at a frequency of one per lot or at listed frequency, whichever yields the greater number of samples.

Section 7
Final Cover Technical Specifications

TECHNICAL SPECIFICATIONS
FOR THE
CONSTRUCTION OF

FINAL COVER SYSTEM
AT
CORRECTIVE ACTION MANAGEMENT UNIT
BASIC REMEDIATION COMPANY
HENDERSON, NEVADA

Prepared for:

Basic Remediation Company
875 West Warm Springs Road
Henderson, Nevada 89015
(702) 567-0400

Prepared by:

GeoSyntec Consultants
11305 Rancho Bernardo Road, Suite 101
San Diego, California 92127
(858) 674-6559

3 November 2006

TABLE OF CONTENTS

Section 02200	**—**	**Earthwork**
Section 02225	**—**	**Drainage Aggregate**
Section 02711	**—**	**Polyethylene Pipe**
Section 02770	**—**	**Geomembrane**
Section 02771	**—**	**Geotextile**
Section 02772	**—**	**Geosynthetic Clay Liner**
Section 02773	**—**	**Geocomposite**

SECTION 02200
EARTHWORK

PART 1 — GENERAL

1.01 DESCRIPTION OF WORK

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, equipment, and incidentals necessary to perform all Earthwork. The work shall be carried out as specified herein and in accordance with the Drawings.

B. The Work shall include, but not be limited to excavating, hauling, placing, moisture conditioning, backfilling, compacting, grading, and subgrade preparation. Earthwork shall conform to the dimensions, lines, grades and sections shown on the Drawings or as directed by the Engineer.

1.02 RELATED SECTIONS

Section 02772 — Geosynthetic Clay Liner

Section 02773 — Geocomposite

1.03 REFERENCES

A. Drawings.

B. Site Construction Quality Assurance (CQA) Plan.

C. Latest version of American Society for Testing and Materials (ASTM) standards:

ASTM D 422	Standard Method for Particle-Size Analysis of Soils
ASTM D 1557	Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3))
ASTM D 2216	Standard Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures
ASTM D 2487	Standard Test Method for Classification of Soils for Engineering Purposes
ASTM D 2922	Standard Test Methods for Density of Soil and Soil-Aggregate In-Place by Nuclear Density Methods (Shallow Depth)
ASTM D 3017	Standard Test Method for Water Content of Soil and Rock In-Place by Nuclear Methods (Shallow Depth)

1.04 SUBMITTALS

A. The Contractor shall submit to the Engineer a description of equipment and methods proposed for Cover Soil, Anchor Trench Backfill, and Prepared Subgrade placement and compaction at least 7 days prior to the start of activities covered by this Section.

B. If the work of this Section is interrupted for reasons other than inclement weather, the Contractor shall notify the Engineer a minimum of 24 hours prior to the resumption of work.

C. The Contractor shall provide the Engineer with sufficient time to perform as-built surveys of the completed cover soil and prepared subgrade.

D. If foreign borrow materials are proposed for any earthwork material on this project, the Contractor shall provide the Engineer information regarding the source of the material. In addition, the Contractor shall provide the Engineer an opportunity to obtain the necessary samples for conformance testing, prior to delivery of foreign borrow materials to the site.

1.05 QUALITY ASSURANCE

A. The Contractor shall ensure that the materials and methods used for Earthwork meet the requirements of the Drawings and this Section. Any material or method that does not conform to these documents, or to alternatives approved in writing by the Engineer will be rejected and shall be repaired or replaced by the Contractor.

B. The Contractor shall be aware of and accommodate all monitoring and field/laboratory conformance testing required by the CQA Plan. This monitoring and testing, including random conformance testing of construction materials and completed work, will be performed by the Engineer. If nonconformances or other deficiencies are found in the materials or completed work, the Contractor will be required to repair the deficiency or replace the deficient materials.

PART 2 — PRODUCTS

2.01 MATERIALS

A. Cover soil shall consist of relatively homogeneous, natural soils that are free of debris, foreign objects, large rock fragments (greater than 6 inches in maximum dimension), roots, and organics. The first lift of cover soil placed directly overlying the geosynthetic components of the cover system shall have a maximum particle size of 1 inch. The cover soil shall be classified according to the Unified Soil Classification System (per ASTM D 2487) as SC, ML, CL, SM, SW, GW, GM, GC, or combinations of these materials. The Contractor may propose the use of other soil types as cover soil, but then such use shall be at the sole discretion of the Engineer.

B. Prepared subgrade is defined as the material directly underlying the geosynthetic liner system which shall meet the requirements listed above for cover soil. No materials larger than 1.5 inch shall project or protrude from the surface of the prepared subgrade.

C. Anchor Trench Backfill materials shall meet the requirements listed above for the cover soil.

2.02 EQUIPMENT

A. The Contractor shall furnish, operate, and maintain compaction equipment as is necessary to produce the required in-place soil density and moisture content.

B. The Contractor shall furnish, operate and maintain tank trucks, pressure distributors, or other equipment designed to apply water uniformly and in controlled quantities to variable surface widths.

C. The Contractor shall furnish, operate, and maintain miscellaneous equipment such as scarifiers or disks, earth excavating equipment, earth hauling equipment, and other equipment, as necessary for Earthwork construction.

PART 3 — EXECUTION

3.01 FAMILIARIZATION

A. Prior to implementing any of the work in this Section, the Contractor shall become thoroughly familiar with the site, the site conditions, and all portions of the work falling within this and other related Sections.

B. Inspection:

- The Contractor shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the installation of the work specified in this Section may properly commence without adverse impact.

- If the Contractor has any concerns regarding the installed work of other Sections, the Engineer shall be notified in writing prior to commencing work. Failure to notify the Engineer or continuance of the work of this Section will be construed as Contractor's acceptance of the related work of all other Sections.

3.02 SITE PREPARATION

A. Prior to performing any earthworks on the site, the Contractor shall perform a baseline topographic survey. This survey shall be conducted by a Professional Land Surveyor licensed in the state of Nevada. This survey will serve as the starting point for earthwork quantities.

3.03 ANCHOR TRENCH EXCAVATION

A. The Contractor shall excavate the anchor trench to the limits and grades shown on the Drawings.

B. All excavated materials not used for Anchor Trench Backfill or cover soil shall be stockpiled in an area designated by the Owner in accordance with Part 3.06 of this Section.

3.04 SUBGRADE SURFACE PREPARATION

A. The subgrade shall be prepared and made suitable as a foundation for placement and compaction of soil material, where applicable. The subgrade shall be firm and able to support the Contractor's construction equipment without the development of depressions or ruts. In addition, the subgrade shall provide adequate support such that the overlying fill material may be placed and compacted to the specified density.

3.05 PREPARED SUBGRADE

A. The prepared subgrade shall be made suitable as a foundation for placement of the geosynthetic components of the liner system (prepared subgrade). The prepared subgrade shall be firm, meet the requirements outlined in Part 2.01, and be able to support the geosynthetic components of the liner system.

3.06 STOCKPILING

A. Soil shall be stockpiled in areas designated by the Owner and shall be free of incompatible soil, clearing, clearing debris, or other objectionable materials.

B. Stockpiles shall be no steeper than 2.1H:1V (Horizontal:Vertical) or other slope approved by the Engineer, graded to drain, sealed by tracking parallel to the slope with a dozer or other means approved by the Engineer, and dressed daily during periods when fill is taken from the stockpile. The Contractor shall employ temporary erosion and sediment control measures (i.e. silt fence) as directed by the Engineer around stockpile areas.

3.07 ANCHOR TRENCH BACKFILL

A. The Anchor Trench Backfill shall be placed to the lines and grades shown on the Drawings.

B. Soil used for the Anchor Trench Backfill shall meet the requirements of Part 2.01 of this Section.

C. Soil used for the Anchor Trench Backfill shall be placed in a loose lift that results in a compacted lift thickness of no greater than 12 inches. The maximum permissible pre-compaction soil clod size is 6 inches.

D. The Contractor shall compact each lift to at least 90 percent of its modified Proctor maximum dry density (ASTM D 1557). The Contractor shall utilize compaction equipment suitable for achieving the soil compaction requirements.

3.08 COVER SOIL

A. The Cover Soil shall be placed to the lines and grades shown on the Drawings.

B. Soil used for the Cover Soil shall meet the requirements of Part 2.01 of this Section.

C. Place only when underlying geocomposite installation is complete including all Construction Quality Control (CQC) and CQA work.

D. Soil used for the Cover Soil shall be placed in a loose lift that results in a compacted lift thickness of no greater than 12 inches. The maximum permissible pre-compaction soil clod size is 6 inches.

E. During wetting or drying, the material shall be regularly disced or otherwise mixed so that uniform moisture conditions in the appropriate range are obtained.

F. The subgrade to the cover soil layer consists of a geocomposite. Therefore, the Contractor shall avoid tearing, puncturing, folding, or damaging in any way the geocomposite during placement of the cover soil material.

G. Any damage to the geosynthetic liner system which is caused by the Contractor or representatives of the Contractor shall be repaired by the Geosynthetics Installer at the expense of the Contractor.

H. The Contractor shall compact each lift to at least 90 percent of its modified Proctor maximum dry density (ASTM D 1557). The Contractor shall utilize compaction equipment suitable for achieving the soil compaction requirements.

I. The cover soil material shall be placed out in front of the equipment used to place the cover soil such that the minimum thickness requirements are maintained at all times between the geosynthetic materials and the wheels or tracks of the equipment used to place the cover soil material.

J. Care must be exercised by the operators of tracked equipment to avoid sharp pivoting turns that could displace the cover soil material and result in damage to the liner system.

K. The Contractor shall not push cover soil material down the side slope. All soil materials shall be placed from the toe of slope upward.

L. Equipment used in spreading the cover soil material on top of the geosynthetic liner system shall be restricted to the following maximum allowable equipment ground pressures:

MAXIMUM ALLOWABLE EQUIPMENT GROUND PRESSURE (psi)	INITIAL LIFT THICKNESS OF OVERLYING COVER SOIL (ft)
<10	1.0
>20	2.0

3.09 FIELD TESTING

A. The minimum frequency and details of quality control testing are provided below. This testing will be performed by the Engineer. The Contractor shall take this testing frequency into account in planning the construction schedule.

1. Cover Soil material quality control testing:

   a. particle-size analyses conducted in accordance with ASTM D 422 at a frequency of one test per 10,000 yd^3;

   b. moisture content tests conducted in accordance with ASTM D 2216 at a frequency of one test per 10,000 yd^3;

   c. soil classification tests conducted in accordance with ASTM D 2487 at a frequency of one test per 10,000 yd^3; and

   d. modified Proctor compaction tests conducted in accordance with ASTM D 1557 at a frequency of one test per 10,000 yd^3.

2. The Engineer will perform conformance tests on placed and compacted cover soil to evaluate compliance with these Specifications. These tests will include in-situ moisture content and dry density. The frequency and procedures for moisture-density testing are given in the CQA Plan. At a minimum, the dry density and moisture content of the soil will be measured in-situ in accordance with ASTM D 2922 and ASTM D 3017, respectively.

3. A special testing frequency will be used by the Engineer when visual observations of construction performance indicate a potential problem. Additional testing will be considered when:

   a. the rollers slip during rolling operation;

b. the lift thickness is greater than specified;
c. the fill is at improper and/or variable moisture content;
d. fewer than the specified number of roller passes are made;
e. dirt-clogged rollers are used to compact the material;
f. the rollers do not have optimum ballast; or
g. the degree of compaction is doubtful.

4. During construction, the frequency of testing will be increased by the Engineer in the following situations:

a. adverse weather conditions;
b. breakdown of equipment;
c. at the start and finish of grading;
d. if the material fails to meet specifications; or
e. the work area is reduced.

B. Defective Areas:

1. If a defective area is discovered in the Earthwork, the Engineer will evaluate the extent and nature of the defect. If the defect is indicated by an unsatisfactory test result, the Engineer will determine the extent of the defective area by additional tests, observations, a review of records, or other means that the Engineer deems appropriate. If the defect is related to adverse site conditions, such as overly wet soils or surface desiccation, the Engineer shall define the limits and nature of the defect.

2. Once the extent and nature of a defect is determined, the Contractor shall correct the deficiency to the satisfaction of the Engineer. The Contractor shall not perform additional work in the area until the Engineer approves the correction of the defect.

3. Additional testing may be performed by the Engineer to verify that the defect has been corrected. This additional testing will be performed before any additional work is allowed in the area of deficiency. The cost of the additional testing shall be borne by the Contractor.

3.10 SURVEY CONTROL

A. The Contractor shall perform all surveys necessary for construction layout and control.

3.11 CONSTRUCTION TOLERANCE

A. The Contractor shall perform the Earthwork construction to within ±0.1 ft on areas with a slope less than 10 percent and ±0.2 ft on areas with a slope greater than 10 percent of the grades indicated on the Drawings.

3.12 PROTECTION OF WORK

A. The Contractor shall use all means necessary to protect completed work of this Section.

B. At the end of each day, the Contractor shall verify that the entire work area is left in a state that promotes drainage of surface water away from the area and from finished work. If threatening weather conditions are forecast, at a minimum, compacted surfaces shall be seal-rolled to protect finished work.

C. In the event of damage to prior work, the Contractor shall make repairs and replacements to the satisfaction of the Engineer.

PART 4 — MEASUREMENT AND PAYMENT

4.01 GENERAL

A. Providing for and complying with the requirements set forth in this Section for Prepared Subgrade will be measured as square feet (SF), and payment will be based on the unit price provided on the Bid Schedule.

B. Providing for and complying with the requirements set forth in this Section for Anchor Trench Excavation and Backfill will be measured as linear feet (LF), and payment will be based on the unit price provided on the Bid Schedule.

C. Providing for and complying with the requirements set forth in this Section for Cover Soil will be measured as in-place cubic yards (CY), and payment will be based on the unit price provided on the Bid Schedule.

D. The following are considered incidental to the Work:

- material samples, sampling, and testing.
- layout survey.
- rejected material removal, re-testing, handling, and repair.
- rejected material.
- mobilization.

END OF SECTION

SECTION 02225
DRAINAGE AGGREGATE

PART 1 — GENERAL

1.01 DESCRIPTION OF WORK

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, equipment and incidentals necessary for the installation of drainage aggregate. The work shall be carried out as specified herein and in accordance with the Drawings.

B. The work shall include, but not be limited to, delivery, storage, and placement of drainage aggregate (aggregate).

1.02 RELATED SECTIONS

Section 02200 — Earthwork

Section 02771 — Geotextile

1.03 REFERENCES

A. Drawings

B. Site Construction Quality Assurance (CQA) Plan

C. Latest Version of American Society for Testing and Materials (ASTM) Standards:

ASTM C 33	Standard Specification for Concrete Aggregates
ASTM C 136	Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM D 2434	Standard Test Method for Permeability of Granular Soils (Constant Head)

1.04 SUBMITTALS

A. The Contractor shall submit to the Engineer for approval, at least 7 days prior to the start of construction, Certificates of Compliance for proposed aggregate materials. Certificates of Compliance shall include, at a minimum, typical gradation and source of aggregate materials.

1.05 QUALITY ASSURANCE

A. The Contractor shall ensure that the materials and methods used for Earthwork meet the requirements of the Drawings and this Section. Any material or method that does not conform to these documents, or to alternatives approved in writing by the Engineer will be rejected and shall be repaired or replaced by the Contractor.

B. The Contractor shall be aware of and accommodate all monitoring and field/laboratory conformance testing required by the CQA Plan. This monitoring and testing, including random conformance testing of construction materials and completed work, will be performed by the Engineer. If nonconformances or other deficiencies are found in the materials or completed work, the Contractor will be required to repair the deficiency or replace the deficient materials.

PART 2 — PRODUCTS

2.01 MATERIALS

A. Aggregate shall meet the requirements specified in ASTM C-33 and shall have a maximum particle size of 1-inch. Aggregate shall have a minimum permeability of 1×10^{-2} cm/sec when tested in accordance with ASTM D 2434.

2.02 EQUIPMENT

A. The Contractor shall furnish, operate, and maintain hauling, placing, and grading equipment as necessary for aggregate placement.

PART 3 — EXECUTION

3.01 FAMILIARIZATION

A. Prior to implementing any of the work in this Section, the Contractor shall become thoroughly familiar with the site, the site conditions, and all portions of the work falling within this and other related Sections.

B. Inspection:

- The Contractor shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the installation of the work specified in this Section may properly commence without adverse impact.

- If the Contractor has any concerns regarding the installed work of other Sections, the Engineer shall be notified in writing prior to commencing work. Failure to notify the Engineer or continuance of the work of this Section will be construed as Contractor's acceptance of the related work of all other Sections.

3.02 PLACEMENT

A. Place only when underlying geosynthetic and CPE pipe installation is complete including all CQC and CQA work.

B. Place to the lines, grades, and dimensions shown on the Drawings.

C. The subgrade to the aggregate consists of a geocomposite overlying a geomembrane. The Contractor shall avoid creating large wrinkles (greater than 6-inches high), tearing, puncturing, folding, or damaging in any way the geosynthetic materials during placement of the aggregate material.

D. Any damage to the geosynthetic liner system which is caused by the Contractor or his representatives shall be repaired by the Geosynthetic Installer.

E. No density or moisture requirements are specified for placement of the aggregate material.

F. Place filter geotextile overlying aggregate as shown on the Drawings and as specified in Section 02771.

3.03 FIELD TESTING

A. The minimum frequency and details of quality control testing are provided below. This testing will be performed by the Engineer. The Contractor shall take this testing frequency into account in planning the construction schedule.

1. Aggregates quality control testing:

a. particle-size analyses conducted in accordance with ASTM C-136 at a frequency of one test per 5,000 yd^3;

b. permeability tests conducted in accordance with ASTM D 2434 at a frequency of one test per 10,000 yd^3.

3.04 SURVEY CONTROL

A. The Contractor shall perform all surveys necessary for construction layout and control.

3.05 CONSTRUCTION TOLERANCE

A. The Contractor shall perform the aggregate construction to within +0.1 ft of the thickness indicated on the Drawings.

3.06 PROTECTION OF WORK

A. The Contractor shall use all means necessary to protect all work of this Section.

B. In the event of damage, the Contractor shall make repairs and replacements to the satisfaction of the Engineer.

PART 4 — MEASUREMENT AND PAYMENT

4.01 GENERAL

A. Providing for and complying with the requirements set forth in this Section for Drainage Aggregate around CPE pipe will be measured in linear feet (LF), and payment will be based on the unit price provided on the Bid Schedule.

B. Providing for and complying with the requirements set forth in this Section for Drainage Aggregate at geocomposite perimeter termination will be measured in linear feet (LF), and payment will be based on the unit price provided on the Bid Schedule.

C. The following are considered incidental to the Work:

- material samples, sampling, and testing.
- layout survey.
- rejected material.
- rejected material removal, re-testing, handling, and repair.
- mobilization.

END OF SECTION

SECTION 02711
CORRUGATED POLYETHYLENE PIPE

PART 1 — GENERAL

1.01 DESCRIPTION OF WORK

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, and equipment necessary to install perforated and solid wall corrugated polyethylene (CPE) pipe and fittings as shown on the Drawings and specified herein.

1.02 RELATED SECTIONS

Section 02200 — Earthwork

1.03 REFERENCES

A. Drawings

B. Site Construction Quality Assurance (CQA) Plan

C. Latest Version of American Society for Testing and Materials (ASTM) Standards:

ASTM F 405 Standard Specification for Corrugated Polyethylene (CPE) Pipe and Fittings

Latest American Association of State Highway and Transportation Officials (AASHTO) Standards:

AASHTO M252M-96 Corrugated Polyethylene Drainage Pipe

1.04 SUBMITTALS

A. The Contractor shall submit, at least 7 days prior to installation of this material, to the Engineer, certificates of compliance for the pipe materials and fittings to be furnished.

B. The Engineer will supply a surveyor to document the as-built conditions of the piping. The Contractor shall notify and allow the Engineer sufficient time to survey piping prior to backfilling the pipe.

1.05 QUALITY ASSURANCE

A. The Contractor shall ensure that the materials and methods used for corrugated polyethylene pipe meet the requirements of the Drawings and this Section. Any material or method that does not conform to these documents, or to alternatives approved in writing by the Engineer will be rejected and shall be repaired or replaced by the Contractor.

PART 2 — PRODUCTS

2.01 PIPE

A. HDPE pipe sizes shown on the Drawings and specified in this Section reference nominal inside diameter. Pipe material, markings, properties, and size shall be in accordance with AASHTO M252.

B. Pipes shall be corrugated polyethylene pipe with a smooth interior wall, Type SP with Class 2 perforations in accordance with AASHTO M252.

PART 3 — EXECUTION

3.01 GENERAL

A. When shipping, delivering, and installing pipe, fittings, and accessories, do so to ensure a sound, undamaged installation. Provide adequate storage for all materials and equipment delivered to the job site. Handle and store pipe and fittings in accordance with the Manufacturer's recommendation.

3.02 PLACING AND LAYING PIPE

A. Follow the Manufacturer's recommendations when hauling, unloading, and stringing the pipe.

B. Corrugated polyethylene solid and perforated pipe shall be installed as shown on the Drawings.

C. Corrugated polyethylene pipe shall be inspected for cuts, scratches, or other damages prior to installation. Any pipe showing damage, which in the opinion of the Engineer will affect performance of the pipe, must be removed from the site. Replace any material found to be defective.

3.03 CONSTRUCTION TOLERANCE

A. The Contractor shall perform the work to within ±0.1 ft of the grades indicated on the Drawings.

PART 4 — MEASUREMENT AND PAYMENT

4.01 GENERAL

A. Providing for and complying with the requirements set forth in this Section for 6-inch HDPE perforated and solid wall CPE pipe and fittings will be measured in linear feet (LF), and payment will be based on the unit price provided on the Bid Schedule.

B. Providing for and complying with the requirements set forth in this Section for 6-inch HDPE perforated and solid wall CPE pipe and fittings will be measured in linear feet (LF), and payment will be based on the unit price provided on the Bid Schedule.

C. The following are considered incidental to the Work:

- shipping, handling and storage.
- layout survey.
- mobilization.
- rejected material.
- rejected material removal, handling, re-testing, and repair.

END OF SECTION

SECTION 02770
GEOMEMBRANE

PART 1 — GENERAL

1.01 DESCRIPTION OF WORK

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, equipment, and incidentals necessary for the installation of double-sided textured high-density polyethylene (HDPE) and smooth HDPE geomembrane, as shown on the Drawings. The work shall be carried out as specified herein and in accordance with Drawings.

B. The work shall include, but not be limited to, delivery, storage, placement, anchorage, and seaming of the geomembrane.

C. Double-sided textured geomembrane shall be used on the side slopes and smooth geomembrane shall be used on the top deck as shown on the Drawings.

1.02 RELATED SECTIONS

Section 02772 — Geosynthetic Clay Liner

Section 02773 — Geocomposite

1.03 REFERENCES

A. Drawings

B. Site Construction Quality Assurance (CQA) Plan

C. Latest version of the American Society for Testing and Materials (ASTM) standards:

ASTM D 638	Standard Test Method for Tensile Properties of Plastics
ASTM D 792	Standard Test Methods for Specific Gravity (Relative Density) and Density of Plastics by Displacement
ASTM D 1004	Standard Test Method of Initial Tear Resistance of Plastic Film and Sheeting
ASTM D 1505	Standard Test Methods for Density of Plastics by Density-Gradient Technique
ASTM D 1603	Standard Test Method for Carbon Black in Olefin Plastics
ASTM D 4437	Standard Test Methods for Determining the Integrity of Field Seams Used in Joining Flexible Polymeric Geomembranes
ASTM D 5321	Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method
ASTM D 5397	Test Method for Evaluation of Stress Crack Resistance of Polyolefin Geomembranes Using Notched Constant Tensile Load Test

ASTM D 5596 Recommended Practice for Microscopical Examination of Pigment Dispersion in Plastic Compounds

ASTM D 5641 Practice for Geomembrane Seam Evaluation by Vacuum Chamber

ASTM D 5820 Practice for Pressurized Air Channel Evaluation of Dual Seamed Geomembranes

ASTM D 5994 Standard Test Method for Measuring Core Thickness of Textured Geomembranes

1.04 QUALIFICATIONS

A. Geomembrane Manufacturer:

1. The Geomembrane Manufacturer shall be responsible for the production of geomembrane rolls from resin and shall have sufficient production capacity and qualified personnel to provide material meeting the requirements of this Section and the construction schedule for this project.

2. Prequalified Geomembrane Manufacturers include the following:

GSE Lining Technology, Inc.
19103 Gundle Road
Houston, TX 77073
(800) 435-2008

Serrot International, Inc.
125 Cassia Way
Henderson, NV 89014
(800) 237-1777

B. Geosynthetics Installer:

1. The Geosynthetics Installer shall be responsible and shall provide sufficient resources for field handling, deploying, seaming, temporarily restraining (against wind), and other aspects of the deployment and installation of the geomembrane and other geosynthetic components of the project.

2. The Geosynthetics Installer shall have successfully installed a minimum of 2,000,000 ft^2 of polyethylene geomembrane on previous projects.

3. The installation crew shall have the following experience.

a. The Superintendent shall have supervised the installation of a minimum of 2,000,000 ft^2 of polyethylene geomembrane on at least five (5) different projects.

b. At least one seamer shall have experience seaming a minimum of 1,000,000 square feet of polyethylene geomembrane using the same type of seaming apparatus to be used at this site. Seamers with such experience will be designated “master seamers” and shall provide direct supervision over less experienced seamers.

c. All other seaming personnel shall have seamed at least 100,000 square feet of polyethylene geomembrane using the same type of seaming apparatus to be used at this site. Personnel who have seamed less than 100,000 square feet shall be allowed to seam only under the direct supervision of the master seamer or Superintendent.

1.05 WARRANTY

A. The Geosynthetic Installer shall furnish the Engineer a 20-year written warranty against defects in materials. Warranty conditions concerning limits of liability will be evaluated by, and must be acceptable to, the Engineer and Owner.

B. The Geosynthetic Installer shall furnish the Engineer with a 5-year written warranty against defects in workmanship. Warranty conditions concerning limits of liability will be evaluated by, and must be acceptable to, the Engineer and Owner.

1.06 SUBMITTALS

A. The Geosynthetic Installer shall submit the following documentation on the resin used to manufacture the geomembrane to the Engineer for approval 14 days prior to transporting any geomembrane to the site.

1. Copies of quality control certificates issued by the resin supplier including the production dates and origin of the resin used to manufacture the geomembrane for the project.

2. Results of tests conducted by the Geomembrane Manufacturer to verify the quality of the resin used to manufacture the geomembrane rolls assigned to the project.

3. Certification that no reclaimed polymer is added to the resin during the manufacturing of the geomembrane to be used for this project, or, if recycled polymer is used, the Manufacturer shall submit a certificate signed by the production manager documenting the quantity of recycled material, including a description of the procedure used to measure the quantity of recycled polymer.

B. The Geosynthetic Installer shall submit the following documentation on geomembrane roll production to the Engineer for approval 14 days prior to transporting any geomembrane to the site.

1. Quality control certificates, which shall include:

a. roll numbers and identification; and

b. results of quality control tests, including descriptions of the test methods used, outlined in Part 2.02 of this Section.

2. The manufacturer warranty specified in Part 1.05.A of this Section.

C. The Geosynthetic Installer shall submit the following information to the Engineer for approval 14 days prior to mobilization.

1. A drawing showing the installation layout identifying geomembrane panel configurations, dimensions, details, locations of seams, as well as any variance

or additional details that deviate from the Drawings. The layout shall be adequate for use as a construction plan and shall include dimensions, details, etc. The layout drawings, as modified and/or approved by the Engineer, shall become part of these Specifications.

2. Installation schedule.

3. Copy of Geosynthetic Installer's letter of approval or license by the Geomembrane Manufacturer.

4. Installation capabilities, including:

   a. information on equipment proposed for this project;
   b. average daily production anticipated for this project; and
   c. quality control procedures.

5. A list of completed facilities for which the installer has installed a minimum of 2,000,000 ft^2 of polyethylene geomembrane, in accordance with Part 1.04 of this Specification. The following information shall be provided for each facility:

   a. the name and purpose of the facility, its location, and dates of installation;

   b. the names of the owner, project manager, and geomembrane manufacturer;

   c. name of the supervisor of the installation crew; and

   d. thickness and surface area of installed geomembrane.

6. In accordance with Part 1.04, a resume of the Superintendent to be assigned to this project, including dates and duration of employment, shall be submitted at least 7 days prior to beginning geomembrane installation.

7. In accordance with Part 1.04, resumes of all personnel who will perform seaming operations on this project, including dates and duration of employment, shall be submitted at least 7 days prior to beginning geomembrane installation.

D. A Certificate of Calibration less than 12 months old shall be submitted for each field tensiometer prior to installation of any geomembrane.

E. During installation, the Geosynthetic Installer shall be responsible for the timely submission to the Engineer of:

1. Quality control documentation; and

2. Subgrade acceptance certificates, signed by the Geosynthetic Installer, for each area to be covered by geosynthetic materials.

F. Upon completion of the installation, the Geosynthetic Installer shall be responsible for the submission to the Engineer of a warranty from the Geosynthetic Installer as specified in Part 1.05.B of this Section.

G. Upon completion of the installation, the Geosynthetic Installer shall be responsible for the submission to the Engineer of a record drawing showing the location and number of each panel and locations and numbers of destructive tests and repairs.

H. The Geosynthetic Installer shall submit the following documentation on welding rod to the Engineer for approval 14 days prior to transporting welding rod to the site:

1. Quality control documentation, including lot number, welding rod spool number, and results of quality control tests on the welding rod.

1.07 QUALITY ASSURANCE

A. The Geosynthetic Installer shall ensure that the materials and methods used for installation of the geomembrane meet the requirements of the Drawings and this Section. Any material or method that does not conform to these documents, or to alternatives approved in writing by the Engineer, will be rejected and shall be repaired or replaced by the Geosynthetic Installer.

B. The Geosynthetic Installer shall be aware of and accommodate all monitoring and conformance testing required by the CQA Plan. This monitoring and testing, including random conformance testing of construction materials and completed work, will be performed by the Engineer. If nonconformances or other deficiencies are found in the Geosynthetic Installer's materials or completed work, the Geosynthetic Installer will be required to repair the deficiency or replace the deficient materials.

PART 2 — PRODUCTS

2.01 GEOMEMBRANE PROPERTIES

A. The Geomembrane Manufacturer shall furnish double-sided and smooth-textured geomembrane having properties that comply with the required property values shown in Table 02770-1.

B. In addition to the property values listed in Table 02770-1, the geomembrane shall:

1. Contain a maximum of 1 percent by weight of additives, fillers, or extenders (not including carbon black).

2. Not have striations, pinholes (holes), bubbles, blisters, nodules, undispersed raw materials, or any sign of contamination by foreign matter on the surface or in the interior.

2.02 MANUFACTURING QUALITY CONTROL

A. Rolls:

1. The Geomembrane Manufacturer shall continuously monitor geomembrane during the manufacturing process for defects.

2. No geomembrane shall be accepted that exhibits any defects.

3. The Geomembrane Manufacturer shall measure and report the geomembrane thickness at regular intervals along the roll length.

4. No geomembrane shall be accepted that fails to meet the specified thickness.

5. The Geomembrane Manufacturer shall sample and test the geomembrane at a minimum of once every 50,000 ft^2 to demonstrate that its properties conform to the values specified in Table 02770-1. At a minimum, the following tests shall be performed:

Test	Procedure
Thickness	ASTM D 5994
Specific Gravity	ASTM D 792 Method A or ASTM D 1505
Tensile Properties	ASTM D 638
Puncture Resistance	ASTM D 4833
Tear Resistance	ASTM D 1004
Carbon Black	ASTM D 1603
Carbon Black Dispersion	ASTM D 5596

6. Tests not listed above but listed in Table 02770-1 need not be run at the 1 per 50,000 ft^2 frequency. However, the Geomembrane Manufacturer shall certify that these tests are in compliance with this section and have been performed on a sample that is identical to the geomembrane to be used on this project. The Geosynthetic Installer shall provide the test result documentation to the Engineer.

7. Any geomembrane sample that does not comply with the requirements of this Section will result in rejection of the roll from which the sample was obtained and will not be used for this project.

8. If a geomembrane sample fails to meet the quality control requirements of this Section, the Geomembrane Manufacturer shall sample and test, at the expense of the Manufacturer, rolls manufactured, in the same resin batch, or at the same time, as the failing roll. Sampling and testing of rolls shall continue until a pattern of acceptable test results is established to bound the failed roll(s).

9. Additional testing may be performed at the Geomembrane Manufacturer's discretion and expense, to isolate and more closely identify the non-complying rolls and/or to qualify individual rolls.

B. The Geomembrane Manufacturer shall permit the Engineer to visit the manufacturing plant for project specific visits. If possible, such visits will be prior to or during the manufacturing of the geomembrane rolls for the specific project.

2.03 LABELING

A. Geomembrane rolls shall be labeled with the following information.

1. thickness of the material;
2. length and width of the roll;
3. name of Geomembrane Manufacturer;
4. product identification;
5. lot number; and
6. roll number.

2.04 TRANSPORTATION, HANDLING AND STORAGE

A. Handling and care of the geomembrane prior to and following installation at the site shall be the responsibility of the Geosynthetic Installer. The Geosynthetic Installer shall be liable for all damage to the materials incurred prior to final acceptance of the liner system by the Engineer.

B. Geosynthetic Installer shall be responsible for storage of the geomembrane at the site. The geomembrane shall be protected from excessive heat or cold, dirt, puncture, cutting, or other damaging or deleterious conditions. Any additional storage procedures required by the Geomembrane Manufacturer shall be the Geosynthetic Installer's responsibility. Geomembrane rolls shall not be stored or placed in a stack of more than two rolls high.

C. The geomembrane shall be delivered at least 14 days prior to the planned deployment date to allow the Engineer adequate time to perform conformance testing on the geomembrane samples as described in Part 3.05 or this Section. If the Engineer performed a visit to the manufacturing plant and performed the required conformance sampling, geomembrane can be delivered to the site within the 14 days prior to the planned deployment date as long as there is sufficient time for the Engineer to complete the conformance testing and confirm that the rolls shipped to the site are in compliance with this Section.

PART 3 — GEOMEMBRANE INSTALLATION

3.01 FAMILIARIZATION

A. Prior to implementing any of the work described in this Section, the Geosynthetic Installer shall become thoroughly familiar with all portions of the work falling within this Section.

B. Inspection:

1. The Geosynthetic Installer shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the work of this Section may properly commence without adverse effect.

2. If the Geosynthetic Installer has any concerns regarding the installed work of other Sections, he shall notify the Engineer in writing prior to the start of the work of this Section. Failure to inform the Engineer in writing or installation of the geomembrane will be construed as the Geosynthetic Installer's acceptance of the related work of all other Sections.

C. A pre-installation meeting shall be held to coordinate the installation of the geomembrane with the installation of other components of the composite liner system.

3.02 GEOMEMBRANE DEPLOYMENT

A. Layout Drawings:

1. The Geosynthetic Installer shall deploy the geomembrane panel in general accordance with the layout drawing specified. The layout drawings must be approved by the Engineer prior to installation of any geomembrane.

B. Field Panel Identification:

1. A geomembrane field panel is a roll or a portion of roll cut in the field.

2. Each field panel shall be given an identification code (number or letter-number). This identification code shall be agreed upon by the Engineer and Geosynthetic Installer.

C. Field Panel Placement:

1. Field panels shall be installed, as approved or modified, at the location and positions indicated on the layout drawings.

2. Field panels shall be placed one at a time, and each field panel shall be seamed immediately after its placement.

3. Geomembrane shall not be placed when the ambient temperature is below 40°F or above 104°F, unless otherwise authorized in writing by the Engineer.

4. Geomembrane shall not be placed during any precipitation, in the presence of excessive moisture (e.g., fog, dew), in an area of ponded water, or in the presence of excessive winds.

5. The Geosynthetic Installer shall ensure that:

a. No vehicular traffic is allowed on the geomembrane.

b. Equipment used does not damage the geomembrane by handling, trafficking, or leakage of hydrocarbons (i.e., fuels).

c. Personnel working on the geomembrane do not smoke, wear damaging shoes, bring glass onto the geomembrane, or engage in other activities that could damage the geomembrane.

d. The method used to unroll the panels does not scratch or crimp the geomembrane and does not damage the supporting soil or geosynthetics.

e. The method used to place the panels minimizes wrinkles (especially differential wrinkles between adjacent panels). The method used to place the panels results in intimate contact with adjacent components.

f. Temporary ballast and/or anchors (e.g., sand bags), not likely to damage the geomembrane, are placed on the geomembrane to prevent wind uplift.

g. The geomembrane is especially protected from damage in heavily trafficked areas.

h. Any rub sheets to facilitate seaming are removed prior to installation of subsequent panels.

6. Any field panel or portion thereof that becomes seriously damaged (torn, twisted, or crimped) shall be replaced with new material. Less serious damage to the geomembrane may be repaired, as approved by the Engineer. Damaged panels or portions of damaged panels that have been rejected shall be removed from the work area.

D. If the Geosynthetic Installer intends to install geomembrane between one hour before sunset and one hour after sunrise, he shall notify the Engineer in writing prior to the start of the work. The Geosynthetic Installer shall indicate additional precautions, which shall be taken during these installation hours. The Geosynthetic Installer shall provide proper illumination for work during this time period.

3.03 FIELD SEAMING

A. Seam Layout:

1. In corners and at odd-shaped geometric locations, the number of field seams shall be minimized. No horizontal seam shall be along a slope with an inclination steeper than 10 percent. Horizontal seams shall be considered as any seam having an alignment exceeding 20 degrees from being perpendicular to the slope contour lines, unless otherwise approved by the Engineer. No seams shall be located in an area of potential stress concentration.

B. Personnel:

1. All personnel performing seaming operations shall be qualified as indicated in Part 1.04 of this Section. No seaming shall be performed unless a "master seamer" is present on-site.

C. Weather Conditions for Seaming:

1. Unless authorized in writing by the Engineer, seaming shall not be attempted at ambient temperatures below 40°F or above 104°F. If the Geosynthetic Installer wishes to use methods that may allow seaming at ambient temperatures below 40°F or above 104°F, he shall use a procedure approved by the Engineer.

2. A meeting will be held with the Geosynthetic Installer and Engineer to establish acceptable installation procedures. In all cases, the geomembrane shall be dry and protected from wind damage.

3. Ambient temperatures shall be measured between 0 to 6 in. above the geomembrane surface.

D. Overlapping:

1. Geomembrane panels shall be sufficiently overlapped for welding and to allow peel tests to be performed on the seam. Any seams that cannot be destructively tested because of insufficient overlap shall be treated as failing seams.

E. Seam Preparation:

1. Prior to seaming, the seam area shall be clean and free of moisture, dust, dirt, debris of any kind, and foreign material.

2. If seam overlap grinding is required, the process shall be completed according to the Geomembrane Manufacturer's instructions within 20 minutes of the seaming operation and in a manner that does not damage the geomembrane. The grind depth shall not exceed ten percent of the geomembrane thickness.

3. Seams shall be aligned with the fewest possible number of wrinkles and "fishmouths."

F. General Seaming Requirements:

1. Fishmouths or wrinkles at the seam overlaps shall be cut along the ridge of the wrinkle to achieve a flat overlap. The cut fishmouths or wrinkles shall be seamed and any portion where the overlap is insufficient shall be patched with an oval or round patch of geomembrane that extends a minimum of 6 in. beyond the cut in all directions.

2. Any electric generator shall be placed outside the area to be lined or mounted in a manner that protects the geomembrane from damage. The electric generator shall be properly grounded.

G. Seaming Process:

1. Approved processes for field seaming are extrusion welding and fusion welding. Only equipment identified as part of the approved submittal specified in Part 1.06 shall be used.

2. Extrusion Equipment and Procedures:

a. The Geosynthetics Installer shall maintain at least one spare operable seaming apparatus on site.

b. Extrusion welding apparatus shall be equipped with gauges giving the temperature in the apparatus.

c. Prior to beginning a seam, the extruder shall be purged until all heat-degraded extrudate has been removed from the barrel.

d. The Geosynthetics Installer shall provide documentation regarding the welding rod to the Engineer and shall certify that the welding rod is compatible with the specifications.

e. A smooth insulating plate or fabric shall be placed beneath the hot welding apparatus after use.

3. Fusion Equipment and Procedures:

a. The Geosynthetic Installer shall maintain at least one spare operable seaming apparatus on site.

b. Fusion-welding apparatus shall be automated vehicular-mounted devices equipped with gauges giving the applicable temperatures and speed.

c. A smooth insulating plate or fabric shall be placed beneath the hot welding apparatus after use.

H. Trial Seams:

1. Trial seams shall be made on fragment pieces of geomembrane to verify that seaming conditions are adequate. Trial seams shall be conducted on the same material to be installed and under similar field conditions as production seams. Such trial seams shall be made at the beginning of each seaming period, beginning of the day and after lunch, for each seaming apparatus used each day. The trial seam sample shall be a minimum of 5-ft long by 1-ft wide (after seaming) with the seam centered lengthwise for fusion equipment and at least 3-ft long by 1-ft wide for extrusion equipment. Seam overlap shall be as indicated in Part 3.03.D of this Section.

2. Four adjoining coupon specimens, each 1-in. wide, shall be cut from the trial seam sample by the installer using a die cutter to ensure precise 1-in. wide coupons. The coupons shall be tested in peel (outside (fusion only) and inside track) and shear using an electronic readout field tensiometer in accordance with ASTM D 4437, at a strain rate of 2 in./min., and they shall not fail in the seam (i.e., Film Tear Bond (FTB), which is failure in the parent material, is required). The required peel and shear seam strength is listed in Table 02770-2. Ideally, samples shall be conditioned at $23 \pm 2^{o}C$ at a relative humidity of $50 \pm 5\%$ for two hours prior to testing. If test conditions vary from these conditions, a 1-in. wide coupon of the parent geomembrane material (no weld) shall be tested in the same manner as the seam specimens to determine the break strength at this condition.

3. If a coupon specimen fails, the entire operation shall be repeated. If the additional coupon specimen fails, the seaming apparatus and seamer shall not be accepted and shall not be used for seaming until the deficiencies are corrected and two consecutive successful trial seams are achieved.

I. Nondestructive Seam Continuity Testing:

1. The Geosynthetic Installer shall nondestructively test for continuity on all field seams over their full length. Continuity testing shall be carried out as the seaming work progresses, not at the completion of all field seaming. The Geosynthetic Installer shall complete any required repairs in accordance with Part 3.03.K of this Section. The following procedures shall apply:

   a. Vacuum testing in accordance with ASTM D 5641.

   b. Air pressure testing (for double-track fusion seams only) in accordance with ASTM D 5820 and the following:

      i. Energize the air pump to a pressure between 25 and 30 pounds per square inches, close valve, and sustain the pressure for not less than 5 minutes.

      ii. If loss of pressure exceeds 3 pounds per square inches, or does not stabilize, locate faulty area and repair in accordance with Part 3.03.K of this Section.

      iii. Cut opposite end of air channel from pressure gauge and observe release of pressure to ensure air channel is not blocked.

iv. Remove needle, or other approved pressure feed device, and seal repair in accordance with Part 3.03.K of this Section.

c. Spark testing shall be performed if the seam cannot be tested using other nondestructive methods.

J. Destructive Testing:

1. Destructive seam tests shall be performed on samples collected from selected locations to evaluate seam strength and integrity. Destructive tests shall be carried out as the seaming work progresses, not at the completion of all field seaming.

2. Sampling:

a. Destructive test samples shall be collected at a minimum average frequency of one test location per 500 ft of seam length. Test locations shall be determined during seaming, and may be prompted by suspicion of excess crystallinity, contamination, offset seams, or any other potential cause of imperfect seaming. The Engineer will be responsible for choosing the locations. The Geosynthetic Installer shall not be informed in advance of the locations where the seam samples will be taken. The Engineer reserves the right to increase the sampling frequency.

b. Samples shall be cut by the Geosynthetic Installer at the locations designated by the Engineer as the seaming progresses in order to obtain laboratory test results before the geomembrane is covered by another material. Each sample shall be numbered and the sample number and location identified on the panel layout drawing. All holes in the geomembrane resulting from the destructive seam sampling shall be immediately repaired in accordance with the repair procedures described in Part 3.03.K of this Section. The continuity of the new seams in the repaired areas shall be tested according to Part 3.03.I of this Section.

c. Two strips of dimensions 1-in. wide and 12 in. long with the seam centered parallel to the width shall be taken from either side of the sample location. These samples shall be tested in the field in accordance with Part 3.03.J.3 of this Section. If these samples pass the field test, a laboratory sample shall be taken. The laboratory sample shall be at least 1-ft wide by 3.5-ft long with the seam centered lengthwise. The sample shall be cut into three parts and distributed as follows:

i. One portion 12-in. long to the Geosynthetic Installer.

ii. One portion 18-in. long to the Geosynthetic CQA Laboratory for testing.

iii. One portion 12-in. long to the Engineer for archival storage.

3. Field Testing:

The two 1-in. wide strips shall be tested in the field tensiometer in the peel mode. The Engineer has the option to request an additional test in the shear mode. If any field test sample fails to meet the requirements in Table 02770-2, then the procedures outlined in Part 3.03.J.5 of this Section shall be followed.

4. Laboratory Testing:

Testing by the Geosynthetics CQA Laboratory will include "Seam Strength" and "Peel Adhesion" (ASTM D 4437) with the 1-in. wide strip tested at a rate of 2 in./min. At least 5 specimens will be tested for each test method (peel and shear). Four of the five specimens per sample must pass both the shear strength test and peel adhesion test when tested in accordance with ASTM D 4437. The minimum acceptable values to be obtained in these tests are indicated in Table 02770-2. Both inside and outside tracks of the dual track fusion welds shall be tested in peel.

5. Destructive Test Failure:

a. The following procedures shall apply whenever a sample fails a destructive test, whether the test is conducted by the Geosynthetic CQA's laboratory, the Geosynthetic Installer laboratory, or by a field tensiometer. The Geosynthetic Installer shall have two options:

i. The Geosynthetic Installer can reconstruct the seam (e.g., remove the old seam and reseam) between any two passed destructive test locations.

ii. The Geosynthetic Installer can trace the welding path to an intermediate location, a minimum of 10 feet from the location of the failed test (in each direction) and take a small sample for an additional field test at each location. If these additional samples pass the field tests, then full laboratory samples shall be taken. These full laboratory samples shall be tested in accordance with Part 3.03.J.4 of this Section. If these laboratory samples pass the tests, then the seam shall be reconstructed between these locations. If either sample fails, then the process shall be repeated to establish the zone in which the seam should be reconstructed. All acceptable seams must be bounded by two locations from which samples passing laboratory destructive tests have been taken. In cases exceeding 150 ft of reconstructed seam, a sample taken from within the reconstructed zone must pass destructive testing.

b. Whenever a sample fails, the Engineer may require additional tests for seams that were formed by the same seamer and/or seaming apparatus or seamed during the same time shift.

K. Defects and Repairs:

1. The geomembrane will be inspected before and after seaming for evidence of defects, holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter. The surface of the geomembrane shall be clean at the time of inspection. The geomembrane surface shall be swept or washed by the Installer if surface contamination inhibits inspection.

2. Each suspected location, both in seam and non-seam areas, shall be nondestructively tested using the methods described Part 3.03.I of this Section, as appropriate. Each location that fails nondestructive testing shall be marked by the Engineer and repaired by the Geosynthetic Installer.

3. When seaming of a geomembrane is completed (or when seaming of a large area of a geomembrane is completed) and prior to placing overlying materials, the Engineer shall identify all excessive geomembrane wrinkles. The Geosynthetic Installer shall cut and reseam all wrinkles so identified. The seams thus produced shall be tested like any other seams.

4. Repair Procedures:

a. Any portion of the geomembrane exhibiting a flaw, or failing a destructive or nondestructive test, shall be repaired by the Geosynthetic Installer. Several repair procedures exist. The final decision as to the appropriate repair procedure shall be agreed upon between the Engineer and the Geosynthetic Installer. The procedures available include:

i. patching, used to repair holes larger than 1/16 inch, tears, undispersed raw materials, and contamination by foreign matter;

ii. abrading and reseaming, used to repair small sections of extruded seams;

iii. spot seaming, used to repair minor, localized flaws;

iv. capping, used to repair long lengths of failed seams; and

v. removing bad seam and replacing with a strip of new material seamed into place (used with long lengths of fusion seams).

b. In addition, the following criteria shall be satisfied:

i. surfaces of the geomembrane that are to be repaired shall be abraded no more than 20 minutes prior to the repair;

ii. all surfaces must be clean and dry at the time of repair;

iii. all seaming equipment used in repair procedures must be approved;

iv. the repair procedures, materials, and techniques shall be approved in advance, for the specific repair, by the Engineer;

v. patches or caps shall extend at least 6 in. beyond the edge of the defect, and all corners of patches shall be rounded with a radius of at least 3 in.; and

vi. the geomembrane below large caps shall be appropriately cut to avoid water or gas collection between the two sheets.

5. Repair Verification:

a. Each repair shall be nondestructively tested using the methods described in Part 3.03.I of this Section, as appropriate. Repairs that pass the nondestructive test shall be taken as an indication of an adequate repair. Failed tests will require the repair to be redone and retested until a passing test results. At the discretion of the Engineer, destructive testing may be required on large caps.

3.04 MATERIALS IN CONTACT WITH THE GEOMEMBRANE

A. The Geosynthetic Installer shall take all necessary precautions to ensure that the geomembrane is not damaged during its installation. During the installation of other components of the liner system by the Contractor, the Contractor shall ensure that the geomembrane is not damaged. Any damage to the geomembrane shall be repaired by the Geosynthetic Installer , at the expense of the Contractor.

B. Soil and aggregate materials shall not be placed over the geomembranes at ambient temperatures below 40°F or above 104°F, unless otherwise specified.

C. All attempts shall be made to minimize wrinkles in the geomembrane.

D. Equipment shall not be driven directly on the geomembrane.

3.05 CONFORMANCE TESTING

A. Samples of the geomembrane will be removed by the Engineer and sent to a Geosynthetic CQA Laboratory for testing to ensure conformance with the requirements of this Section. The Geosynthetic Installer shall assist the Engineer in obtaining conformance samples. The Geosynthetic Installer and Contractor shall account for this testing in the installation schedule. Only material that meets the requirements of Part 2.02 this Section shall be installed.

B. Samples will be selected by the Engineer in accordance with this Section and with the procedures outlined in the CQA Plan.

C. Samples will be taken at a minimum frequency of one sample per 100,000 ft^2.

D. The Engineer may increase the frequency of sampling in the event that test results do not comply with the requirements of Part 2.02 of this Section.

E. The following tests will be performed by the Engineer:

Test	**Test Method**
Specific Gravity	ASTM D 792 or D 1505
Thickness	ASTM D 5994
Tensile Properties	ASTM D 638
Carbon Black Content	ASTM D 1603
Carbon Black Dispersion	ASTM D 5596

F. Any geomembrane that is not certified in accordance with Part 1.07.C of this Section, or that conformance testing indicates do not comply with Part 2.02 of this Section, will be rejected. The Geosynthetic Installer shall replace the rejected material with new material.

3.06 GEOMEMBRANE ACCEPTANCE

A. The Geosynthetic Installer shall retain all ownership and responsibility for the geomembrane until accepted by the Engineer.

B. The geomembrane shall be accepted by the Engineer when:

1. the installation is completed;

2. all documentation is submitted;

3. verification of the adequacy of all field seams and repairs, including associated testing, is complete; and

4. all warranties are submitted.

3.07 PROTECTION OF WORK

A. The Geosynthetic Installer and Contractor shall use all means necessary to protect all work of this Section.

B. In the event of damage, the Geosynthetic Installer shall make all repairs and replacements necessary, to the satisfaction of the Engineer.

PART 4 — MEASUREMENT AND PAYMENT

4.01 GENERAL

A. Providing for a complying with the requirements set forth in this Section for HDPE geomembrane will be measured as in-place square feet (SF), including geomembrane in the anchor trench to the limits shown on the Drawings, and payment will be based on the unit price provided on the Bid Schedule.

B. The following are considered incidental to the Work:

- shipping, handling and storage.
- layout survey.
- mobilization.
- rejected material.
- overlaps and seaming.
- rejected material removal, handling, re-testing, and repair.
- temporary anchorage.

TABLE 02770-1
REQUIRED HDPE GEOMEMBRANE PROPERTIES

PROPERTIES	QUALIFIERS	UNITS	SPECIFIED VALUES	TEST METHOD
Physical Properties				
Thickness	Average	mils	60	ASTM D 5994 or
	Minimum	mils	54	ASTM D 5199
Specific Gravity	Minimum	N/A	.94	ASTM D 792 Method A or ASTM D 1505
Asperity Height	Minimum	mils	10	GRI GM12
Mechanical Properties				
Tensile Properties (each direction)				
1. Tensile (Break) Strength	Minimum	lb/in	90	ASTM D 638
2. Elongation at Break		%	100	
3. Tensile (Yield) Strength		lb/in	126	
4. Elongation at Yield		%	12	
Puncture	Minimum	lb	90	ASTM D 4833
Tear Resistance	Minimum	lb	42	ASTM D 1004
Interface Shear Strength	-	-	Note 1	ASTM D 5321
Environmental Properties				
Carbon Black Content	Range	%	2-3	ASTM D 1603
Carbon Black Dispersion	N/A	none	Note 2	ASTM D 5596
Environmental Stress Crack	Minimum	hr	400	ASTM D 5397

Notes: (1) Interface shear strength test(s) shall be performed, by the Engineer, on the composite liner system in accordance with Section 02772 — Geosynthetic Clay Liner.
(2) Minimum 9 of 10 in Categories 1 or 2; 10 in Categories 1, 2, or 3.

TABLE 02770-2
REQUIRED GEOMEMBRANE SEAM PROPERTIES

PROPERTIES	QUALIFIERS	UNITS	SPECIFIED VALUES	TEST METHOD
Shear Strength[1]				
Fusion	minimum	lb/in	120	ASTM D 4437
Extrusion	minimum	lb/in	120	ASTM D 4437
Peel Adhesion				
FTB[2]				
Fusion	minimum	lb/in	91	ASTM D 4437
Extrusion	minimum	lb/in	78	ASTM D 4437

Notes: (1) Also called "Bonded Seam Strength".
(2) FTB = Film Tear Bond means that failure is in the parent material, not the seam. The maximum seam separation is 25 percent of the seam area.

END OF SECTION

SECTION 02771
GEOTEXTILE

PART 1 — GENERAL

1.01 DESCRIPTION OF WORK

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, equipment, and incidentals necessary for the installation of the geotextile. The work shall be carried out as specified herein and in accordance with the Drawings.

B. The work shall include, but not be limited to, delivery, storage, placement, and seaming of the various geotextile components of the project.

C. Filter geotextile shall be used overlying the drainage aggregate.

1.02 RELATED SECTIONS

Section 02200 — Earthwork

Section 02225 — Drainage Aggregate

1.03 REFERENCES

A. Drawings

B. Site Construction Quality Assurance (CQA) Plan

C. Latest version of American Society for Testing and Materials (ASTM) standards:

ASTM D 4355	Standard Test Method for Deterioration of Geotextile from Exposure to Ultraviolet Light and Water
ASTM D 4491	Standard Test Method for Water Permeability of Geotextile by Permittivity
ASTM D 4533	Standard Test Method for Trapezoid Tearing Strength of Geotextile
ASTM D 4595	Standard Test Method for Wide Width Tensile Properties of Geosynthetics
ASTM D 4632	Standard Test Method for Breaking Load and Elongation of Geotextile (Grab Method)
ASTM D 4751	Standard Test Method for Determining Apparent Opening Size of a Geotextile
ASTM D 4833	Standard Test Method for Index Puncture Resistance of Geotextile, Geomembranes, and Related Products
ASTM D 5261	Standard Test Method for Measuring Mass Per Unit Area of Geotextile

1.04 SUBMITTALS

A. The Geosynthetic Installer shall submit to the Engineer, at least 7 days prior to geotextile delivery, the following information regarding the proposed geotextile:

1. manufacturer and product name;

2. minimum property values of the proposed geotextile and the corresponding test procedures;

3. projected geotextile delivery dates; and

4. list of geotextile roll numbers for rolls to be delivered to the site.

B. At least 7 days prior to geotextile placement, the Geosynthetic Installer shall submit to the Engineer the manufacturing quality control certificates for each roll of geotextile. The certificates shall be signed by responsible parties employed by the geotextile manufacturer (such as the production manager). The quality control certificates shall include:

1. lot, batch, and/or roll numbers and identification; and

2. results of quality control tests, including a description of the test methods used.

1.05 QUALITY ASSURANCE

A. The Geosynthetic Installer shall ensure that the geotextile and installation methods used meet the requirements of the Drawings and this Section. Any material or method that does not conform to these documents, or to alternatives approved in writing by the Engineer, will be rejected and shall be repaired or replaced by the Geosynthetic Installer.

B. The Geosynthetic Installer shall be aware of and accommodate all monitoring and conformance testing required by the CQA Plan. This monitoring and testing, including random conformance testing of construction materials and completed work, will be performed by the Engineer. If nonconformances or other deficiencies are found in the Geosynthetic Installer's materials or completed work, the Geosynthetic Installer will be required to repair the deficiency or replace the deficient materials.

PART 2 — PRODUCTS

2.01 GEOTEXTILE PROPERTIES

A. Geotextile suppliers shall furnish materials in which the "Minimum Average Roll Values", as defined by the Federal Highway Administration (FHWA), meet or exceed the criteria specified in Table 02771-1.

B. The geotextile shall be nonwoven materials, suitable for use in filter/separation applications.

2.02 MANUFACTURING QUALITY CONTROL

A. The geotextile shall be manufactured with quality control procedures that meet or exceed generally accepted industry standards.

B. The Geotextile Manufacturer shall sample and test the geotextile to demonstrate that the material conforms to the requirements of these Specifications.

C. Any geotextile sample that does not comply with this Section shall result in rejection of the roll from which the sample was obtained. The Geosynthetic Installer shall replace any rejected rolls.

D. If a geotextile sample fails to meet the quality control requirements of this Section the Geotextile Manufacturer shall sample and test, at the expense of the Manufacturer, rolls manufactured in the same lot, or at the same time, as the failing roll. Sampling and testing of rolls shall continue until a pattern of acceptable test results is established to bound the failed roll(s).

E. Additional sample testing may be performed, at the Geotextile Manufacturer's discretion and expense, to identify more closely any non-complying rolls and/or to qualify individual rolls.

F. Sampling shall, in general, be performed on sacrificial portions of the geotextile material such that repair is not required. The Geotextile Manufacturer shall sample and test the geotextile, at a minimum once every 130,000 ft^2, to demonstrate that the geotextile properties conform to the values specified in Table 02771-1. At a minimum, the following manufacturing quality control tests shall be performed on each type of geotextile:

Test	Procedure	Filtration
Grab strength	ASTM D 4632	Yes
Tear strength	ASTM D 4533	Yes
Puncture strength	ASTM D 4833	Yes
Permittivity	ASTM D 4491	Yes
A.O.S.	ASTM D 4751	Yes

G. The Geotextile Manufacturer shall comply with the certification and submittal requirements of this Section.

2.03 PACKING AND LABELING

A. Geotextile shall be supplied in rolls wrapped in relatively impermeable and opaque protective covers.

B. Geotextile rolls shall be marked or tagged with the following information:

1. manufacturer's name;
2. product identification;
3. lot or batch number;
4. roll number; and
5. roll dimensions.

2.04 TRANSPORTATION, HANDLING, AND STORAGE

A. The Geosynthetic Installer shall be liable for any damage to the materials incurred prior to and during transportation to the site.

B. The geotextile shall be delivered to the site at least 14 days prior to the planned deployment date to allow the Engineer adequate time to perform conformance testing on the geotextile samples as described in Part 3.06 of this Section.

C. Handling, unloading, storage, and care of the geotextile prior to and following installation at the site, is the responsibility of the Geosynthetic Installer. The Geosynthetic Installer shall be liable for any damage to the materials incurred prior to final acceptance by the Engineer.

D. The Geosynthetic Installer shall be responsible for storage of the geotextile at the site.

E. The geotextile shall be protected from sunlight, excessive heat or cold, puncture, or other damaging or deleterious conditions. The geotextile shall be protected from mud, dirt, and dust. Any additional storage procedures required by the geotextile Manufacturer shall be the responsibility of the Geosynthetic Installer.

PART 3 — EXECUTION

3.01 FAMILIARIZATION

A. Prior to implementing any of the work described in this Section, the Geosynthetic Installer shall become thoroughly familiar with the site, the site conditions, and all portions of the work falling within this Section.

B. Inspection:

1. The Geosynthetic Installer shall carefully inspect the installed work of all other Sections and verify that all such work is complete to the point where the installation of this Section may properly commence without adverse effect.

2. If the Geosynthetic Installer has any concerns regarding the installed work of other Sections or the site, the Engineer shall be notified, in writing, prior to commencing the work. Failure to notify the Engineer or installation of the geotextile will be construed as Geosynthetic Installer's acceptance of the related work of all other Sections.

3.02 PLACEMENT

A. Geotextile installation shall not commence until CQA conformance evaluations, by the Engineer, of previous work are complete, including evaluations of the Contractor's survey results to confirm that the previous work was constructed to the required grades, elevations, and thicknesses. Should the Contractor begin the work of this Section prior to the completion of CQA evaluations, he does so at his own risk. The Contractor shall account for the CQA conformance evaluations in the construction schedule.

B. The Geosynthetic Installer shall handle all geotextile in such a manner as to ensure they are not damaged in any way.

C. The Geosynthetic Installer shall take any necessary precautions to prevent damage to underlying materials during placement of the geotextile.

D. After unwrapping the geotextile from its opaque cover, the filtration and cushion geotextile shall not be left exposed for a period in excess of 15 days unless a longer exposure period is approved in writing by the geotextile manufacturer.

E. The Geosynthetic Installer shall take care not to entrap stones, excessive dust, or moisture in the geotextile during placement.

F. The Geosynthetic Installer shall anchor or weight all geotextile with sandbags, or the equivalent, to prevent wind uplift.

G. The Geosynthetic Installer shall examine the entire geotextile surface after installation to ensure that no foreign objects are present that may damage the geotextile or adjacent layers. The Contractor shall remove any such foreign objects and shall replace any damaged geotextile.

3.03 SEAMS AND OVERLAPS

A. On slopes steeper than 10 horizontal to 1 vertical, geotextiles shall be continuous down the slope; that is, no horizontal seams are allowed. Horizontal seams shall be considered as any seam having an alignment exceeding 20 degrees from being perpendicular to the slope contour lines, unless otherwise approved by the Engineer.

B. Filtration geotextile shall be overlapped a minimum of 12 inches.

3.04 REPAIR

A. Any holes or tears in the geotextile shall be repaired using a patch made from the same geotextile. Geotextile patches will be sewn into place no closer than 1 inch from any panel edge. Should any tear exceed 50% of the width of the roll, that roll shall be removed and replaced.

B. Where geosynthetic materials underlie the geotextile being placed, care shall be taken to remove any soil or other material that may have penetrated the torn geotextile.

3.05 PLACEMENT OF SOIL MATERIALS

A. The Contractor shall place soil materials on top of the geotextile in such a manner as to ensure that:

1. the geotextile and the underlying materials are not damaged;

2. minimum slippage occurs between the geotextile and the underlying layers during placement; and

3. excess stresses are not produced in the geotextile.

B. Equipment shall not be driven directly on the geotextile.

C. Unless otherwise approved in writing by the Engineer, all equipment operating on materials overlying the geotextile shall comply with Section 02200.

3.06 CONFORMANCE TESTING

A. Samples of the geotextile materials will be removed by the Engineer after the material has been received at the site and sent to a Geosynthetic CQA Laboratory for testing to ensure conformance with the requirements of this Section. This testing will be carried out, in accordance with the CQA Plan, prior to the start of the work of this Section.

B. Samples of each geotextile will be taken, by the Engineer, at a minimum frequency of one sample per 260,000 ft^2.

C. The Engineer may increase the frequency of sampling in the event that test results do not comply with requirements of Part 2.01 of this Section until passing conformance test results are obtained for all material that is received at the site. This additional testing shall be performed at the expense of the Contractor.

D. The following conformance tests will be performed:

Test	Procedure	Filtration
Grab strength	ASTM D 4632	Yes
Puncture strength	ASTM D 4833	Yes
Permittivity	ASTM D 4491	Yes
A.O.S.	ASTM D 4751	Yes

E. Any geotextile that is not certified in accordance with Part 1.04 of this Section, or that conformance testing results do not comply with Part 2.01 of this Section, will be rejected. The Geosynthetic Installer shall replace the rejected material with new material.

3.07 PROTECTION OF WORK

A. The Geosynthetic Installer shall use all means necessary to protect all work of this Section.

B. In the event of damage, the Geosynthetic Installer shall make repairs and replacements to the satisfaction of the Engineer at the expense of the Contractor.

PART 4 — MEASUREMENT AND PAYMENT

4.01 GENERAL

A. Providing for and complying with the requirements set forth in this Section for Filtration Geotextile will be measured as in-place square feet (SF), and payment will be based on the unit price provided on the Bid Schedule.

B. The following are considered incidental to the Work:

- shipping, handling and storage.
- layout survey.
- mobilization.
- rejected material.
- overlaps and seaming.
- rejected material removal, handling, re-testing, and repair.
- temporary anchorage.

TABLE 02771-1
REQUIRED PROPERTY VALUES FOR GEOTEXTILE

PROPERTIES	QUALIFIERS	UNITS	FILTER SPECIFIED VALUES	TEST METHOD
Type			nonwoven	(-)
Mass per unit area	minimum	oz/yd^2	6[1]	ASTM D 5261
Filter Requirements				
Apparent opening size (O_{95})	maximum	mm	0.21	ASTM D 4751
Permittivity	minimum	s^{-1}	0.5	ASTM D 4491
Mechanical Requirements				
Grab strength	minimum	lb	130	ASTM D 4632
Tear strength	minimum	lb	40	ASTM D 4533
Puncture strength	minimum	lb	40	ASTM D 4833
Durability				
Ultraviolet Resistance @ 500 hours	minimum	%	70	ASTM D 4355

Notes: (1) For information purposes only, not a required property.

END OF SECTION

SECTION 02772
GEOSYNTHETIC CLAY LINER

PART 1 — GENERAL

1.01 SCOPE

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, equipment, and incidentals necessary for installation of the geosynthetic clay liner (GCL). The work shall be carried out as specified herein and in accordance with the Drawings.

B. The work shall include, but not be limited to, delivery, storage, placement, anchorage, and seaming of the GCL.

1.02 RELATED SECTIONS

Section 02200 — Earthworks

Section 02770 — Geomembrane

1.03 REFERENCES

A. Drawings

B. Site Construction Quality Assurance (CQA) Plan

C. Latest Version American Society of Testing and Materials (ASTM) Standards:

ASTM D 2216	Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures
ASTM D 5321	Determination of the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method
ASTM D 5887	Test Method for Measurement of Index Flux Through Saturated Geosynthetic Clay Liner Specimens using a Flexible Wall Permeameter
ASTM D 5888	Guide for Storage and Handling of Geosynthetic Clay Liners
ASTM D 5890	Test Method for Swell Index of Clay Mineral Component of Geosynthetic Clay Liners
ASTM D 5891	Test Method for Fluid Loss of Clay Component of Geosynthetic Clay Liners
ASTM D 5993	Test Method for Measuring Mass per Unit Area of Geosynthetic Clay Liners

1.04 QUALIFICATIONS

A. The Manufacturer shall be a well-established firm with more than one year of experience in the manufacturing of GCL.

B. The Geosynthetic Installer shall install the GCL and shall meet the requirements of Section 02770 and this Section.

1.05 SUBMITTALS

A. At least 7 days before transporting any GCL to the site, the Manufacturer shall provide the following documentation to the Engineer for approval.

1. list of material properties, including test method, to which are attached GCL samples.

2. projected delivery dates for this project.

3. Manufacturing quality control certificates for each shift's production, signed by responsible parties employed by the Manufacturer (such as the production manager).

4. The quality control certificates shall include:

a. roll numbers and identification; and

b. results of quality control tests, including description of test methods used, outlined in Part 2.01 of this Section.

5. The Manufacturer shall certify that the GCL meets all the properties outlined in 2.01 of this Section.

1.06 CONSTRUCTION QUALITY ASSURANCE MONITORING

A. The Geosynthetic Installer shall ensure that the materials and methods used for the GCL meet the requirements of the Drawings and this Section. Any material or method that does not conform to these documents, or to alternatives approved in writing by the Engineer, will be rejected and shall be repaired or replaced.

B. The Geosynthetic Installer shall be aware of and accommodate all monitoring and conformance testing required by the CQA Plan. This monitoring and testing, including random conformance testing of construction materials and completed work, will be performed by the Engineer. If nonconformances or other deficiencies are found in the materials or completed work, the Geosynthetic Installer will be required to repair the deficiency or replace the deficient materials.

PART 2 — PRODUCTS

2.01 MATERIAL PROPERTIES

A. The flux of the GCL shall be no greater than 1×10^{-8} m^3/m^2-sec, when measured in a flexible wall permeameter in accordance with ASTM D 5887 under an effective confining stress of 5 pounds per square inch.

B. The GCL shall have the following minimum dimensions:

1. the minimum roll width shall be 15 feet; and

2. the liner length shall be long enough to conform with the requirements specified in this Section.

C. The bentonite used to fabricate the GCL shall have at least 90 percent sodium mortmorillonite.

D. The bentonite component of the GCL shall be applied at a minimum concentration of 0.75 pound per square foot, when measured at a water content of less than or equal to 0 percent.

E. The geotextile components of the GCL shall have a minimum combined mass per unit area of 9 oz/yd^2 in accordance with ASTM D 5261.

F. The GCL shall meet the required property values listed in Table 02772-1.

G. The bentonite will be adhered to the backing material(s) in a manner that prevents it from being dislodged when transported, handled, and installed in a manner prescribed by the Manufacturer. The method used to hold the bentonite in place shall not be detrimental to other components of the lining system.

2.02 INTERFACE SHEAR TESTING

A. Interface Shear test(s) shall be performed on the proposed geosynthetic and soil components in accordance with ASTM D 5321. Tests shall be performed as outlined below.

1. Dry GCL interface - the GCL shall be underlain by prepared subgrade compacted to 90% of the maximum dry density (ASTM D 1557) at the optimum moisture content and overlain by a GCL textured 60-mil HDPE geomembrane, geocomposite, and cover soil. The GCL, geomembrane, and geocomposite components of the liner system shall be allowed to “float” (i.e., not fixed) such that the failure surface can occur at the any of these interfaces.

a. Before shearing, the GCL shall be hydrated under a loading of 120 psf (6 Kpa) for 48 hours. The test shall be performed under saturated conditions, at normal stresses of 1, 2, and 4 psi at a shear rate of no more than 0.04 in./min. (1 mm/min.).

b. The results of this test shall have a post-peak apparent friction angle in excess of 18 degrees.

2.03 MANUFACTURING QUALITY CONTROL

A. The GCL shall be manufactured with quality control procedures that meet or exceed generally accepted industry standards.

B. The Manufacturer shall sample and test the GCL to demonstrate that the material complies with the requirements of this Section.

C. Any GCL sample that does not comply with this Section will result in rejection of the roll from which the sample was obtained. The Manufacturer shall replace any rejected rolls.

D. If a GCL sample fails to meet the quality control requirements of this Section, the Engineer will require that the Manufacturer sample and test, at the expense of the Manufacturer, rolls manufactured in the same lot, or at the same time, as the failing roll. Sampling and testing

of rolls shall continue until a pattern of acceptable test results is established to bound the failed roll(s).

E. Additional sample testing may be performed, at the Manufacturer's discretion and expense, to more closely identify any non-complying rolls and/or to qualify individual rolls.

F. Sampling shall, in general, be performed on sacrificial portions of the GCL material such that repair is not required. The Manufacturer shall sample and test the GCL to demonstrate that its properties conform to the requirements stated herein. At a minimum, the following tests shall be performed by the Manufacturer: dry mass per unit area and index flux at frequencies of at least 1 per 50,000 ft^2 and 1 per 200,000 ft^2, respectively.

G. The Manufacturer shall comply with the certification and submittal requirements of this Section.

2.04 PACKING AND LABELING

A. GCLs shall be supplied in rolls wrapped in impermeable and opaque protective covers.

B. GCLs shall be marked or tagged with the following information:

1. Manufacturer's name;
2. product identification;
3. lot number;
4. roll number; and
5. roll dimensions.

2.05 TRANSPORTATION, HANDLING AND STORAGE

A. Handling, storage, and care of the GCL, prior to and following installation, is the responsibility of the Geosynthetic Installer, until final acceptance by the Engineer.

B. The GCL shall be stored and handled in accordance with ASTM D 5888.

C. The Geosynthetic Installer shall be liable for all damage to the materials incurred prior to and during transportation to the site.

D. The GCL shall be on-site at least 14 days prior to the scheduled installation date to allow for completion of conformance testing described in Part 3.08 of this Section.

PART 3 — EXECUTION

3.01 FAMILIARIZATION

A. Prior to implementing any of the work described in this Section, the Geosynthetic Installer shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the installation of this Section may properly commence without adverse impact.

B. Inspection:

1. The Geosynthetic Installer shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the installation of this Section may properly commence without adverse impact.

2. If the Geosynthetic Installer has any concerns regarding the installed work of other Sections, he should notify the Engineer in writing prior to commencing the work. Failure to notify the Engineer or installation of the GCL will be construed as Geosynthetic Installer's acceptance of the related work of all other Sections.

C. A pre-installation meeting shall be held to coordinate the installation of the GCL with the installation of other components of the lining system.

3.02 SURFACE PREPARATION

A. The Geosynthetics Installer shall provide certification in writing that the surface on which the GCL will be installed is acceptable. This certification of acceptance shall be given to the Engineer prior to commencement of geomembrane installation in the area under consideration.

B. Special care shall be taken to maintain the prepared soil surface.

C. No GCL shall be placed onto an area that has been softened by precipitation or that has cracked due to desiccation. The soil surface shall be observed daily to evaluate the effects of desiccation cracking and/or softening on the integrity of the prepared subgrade.

3.03 CREST ANCHORAGE SYSTEM

A. The anchor trench shall be excavated, prior to GCL placement, to the lines and grades shown on the Drawings.

B. No loose soil shall be allowed in the anchor trench beneath the GCL.

C. The GCL shall be temporarily anchored in the anchor trench until all geosynthetic layers are installed in the anchor trench as shown on the Drawings.

3.04 HANDLING AND PLACEMENT

A. The Geosynthetic Installer shall handle all GCL in such a manner that they are not damaged in any way and so that they do not become hydrated prior to, or during, installation.

B. In the presence of wind, all GCLs shall be sufficiently weighted with sandbags to prevent their movement.

C. Any GCL damaged by stones or other foreign objects, or by installation activities, shall be repaired in accordance with Part 3.07 by the Geosynthetic Installer.

D. If an alternative GCL is used, the vapor barrier portion of the GCL shall be installed against the underlying prepared subgrade.

E. The GCL shall not be installed on an excessively moist subgrade or on standing water. The GCL shall be installed in a way that prevents hydration of the GCL prior to completion of construction of the liner system.

F. The GCL shall not be installed during precipitation or other conditions that may cause hydration of the GCL.

G. All hydrated GCL shall be removed and replaced by the Geosynthetic Installer.

3.05 OVERLAPS

A. On slopes steeper than 10 horizontal to 1 vertical, all GCL shall be continuous down the slope; that is, no horizontal seams shall be allowed on the slope. Horizontal seams shall be considered as any seam having an alignment exceeding 20 degrees from being perpendicular to the slope contour lines, unless otherwise approved by the Engineer.

B. All GCL shall be overlapped in accordance with the Manufacturer's recommended procedures. As a minimum, along the length (i.e., the sides) of the GCL the overlap shall be 6 inches, and along the width (i.e., the ends) the overlap shall be 12 inches.

3.06 MATERIALS IN CONTACT WITH THE GCL

A. Geomembrane installation shall immediately follow the GCL installation. All GCL that is placed during a day's work shall be covered with geomembrane before the Geosynthetic Installer leaves the site at the end of the day. The edges of GCL placement should be covered each day and protected from hydration due to storm water run-on.

B. Material shall not be placed on a GCL that is hydrated.

C. Installation of other components of the liner system shall be carefully performed to minimize damage to the GCL.

D. Equipment shall not be driven directly on the GCL.

E. Installation of the GCL in appurtenant areas, and connection of the GCL to appurtenances shall be made according to the Drawings. The Geosynthetic Installer shall ensure that the GCL is not damaged while working around the appurtenances.

3.07 REPAIR

A. Any holes or tears in the GCL shall be repaired by placing a GCL patch over the hole. On slopes steeper than 10 percent, the patch shall overlap the edges of the hole or tear by a minimum of 2 feet in all directions. On slopes 10 percent or flatter, the patch shall overlap the edges of the hole or tear by a minimum of 1 foot in all directions. The patch shall be secured with a water-based adhesive approved by the Manufacturer.

B. Care shall be taken to remove any soil or other material, which may have penetrated the torn GCL.

C. The patch shall not be nailed or stapled.

3.08 CONFORMANCE TESTING

A. Samples of the GCL will be removed by the Engineer and sent to a Geosynthetic CQA Laboratory for testing to ensure conformance with the requirements of this Section. The Geosynthetic Installer shall assist the Engineer in obtaining conformance samples. The Geosynthetic Installer shall account for this testing in the installation schedule.

B. The Engineer may increase the frequency of sampling in the event that test results do not comply with the requirements of Part 2.01 of this Section until passing conformance test

results are obtained for all material that is received at the site. This additional testing shall be performed at the expense of the Contractor.

C. As a minimum, the following conformance tests will be performed: mass per unit area and index flux. All tests shall be carried out at a frequency of one sample per 100,000 ft^2 and 400,000 ft^2, respectively. In addition, the Engineer will perform a minimum of one interface shear strength test in accordance with Part 2.02.

D. Any GCL that is not certified by the Manufacturer in accordance with Part 1.05 of this section or that does not meet the requirements specified in Part 2.01 shall be rejected and replaced by the Geosynthetic Installer.

3.09 PROTECTION OF WORK

A. The Geosynthetic Installer shall use all means necessary to protect all work of this Section.

B. In the event of damage, the Geosynthetic Installer shall immediately make all repairs and replacements necessary to the approval of the Engineer.

PART 4 — MEASUREMENT AND PAYMENT

A. Providing for a complying with the requirements set forth in this Section for GCL will be measured as in-place square feet (SF), including GCL in the anchor trench to the limits shown on the Drawings, and payment will be based on the unit price provided on the Bid Schedule.

B. The following are considered incidental to the Work:

- shipping, handling and storage.
- overlaps and seaming.
- layout survey.
- mobilization.
- rejected material.
- rejected material removal, handling, re-testing, and repair.
- temporary anchorage.

TABLE 02772-1
REQUIRED GCL PROPERTY VALUES

PROPERTIES	QUALIFIERS	UNITS	SPECIFIED[1] VALUES	TEST METHOD
Liner System Properties				
Interface Shear Strength	minimum	degrees	20°	ASTM D 5321[2]
GCL Properties				
Bentonite Content	minimum	lb/ft^2	0.75	ASTM D 5993
Bentonite Swell Index	minimum	mL/2g	24	ASTM D 5890
Bentonite Fluid Loss	maximum	mL	18	ASTM D 5891
Index Flux	minimum	m^3/m^2-s	1×10^{-8}	ASTM D 5887[3]
Moisture Content (Bentonite)	maximum	percent	25	ASTM D 2216

Notes: (1) All values represent minimum average roll values (i.e., any roll in a lot should meet or exceed the values in this table).
(2) Interface shear strength testing shall be performed, by the Engineer, in accordance with Part 2.02 of this Section.
(3) Hydraulic flux testing shall be performed under an effective confining stress of 5 pounds per square inch.
(4) Measured at a moisture content of 0 percent.

END OF SECTION

SECTION 02773
GEOCOMPOSITE

PART 1 — GENERAL

1.01 DESCRIPTION OF WORK

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, equipment, and incidentals necessary for the installation of the geocomposite. The work shall be carried out as specified herein and in accordance with the Drawings.

B. The work shall include, but not be limited to, delivery, storage, placement, and seaming of the geocomposite.

C. Single-sided geocomposite shall be used overlying the geomembrane and underlying the cover soil on the top deck area of the cover system. Double-sided geocomposite shall be used overlying the geomembrane and underlying the cover soil on the side slopes of the cover system.

1.02 RELATED SECTIONS

Section 02200 — Earthwork

Section 02770 — Geomembrane

1.03 REFERENCES

A. Drawings

B. Site Construction Quality Assurance (CQA) Plan

C. Latest version of American Society for Testing and Materials (ASTM) standards:

1. ASTM D 413. Standard Test Method for Rubber Property-Adhesion to Flexible Substrate.

2. ASTM D 792. Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.

3. ASTM D 1603. Standard Test Method for Carbon Black in Olefin Plastics.

4. ASTM D 4491. Standard Test Methods for Water Permeability of Geotextiles by Permittivity.

5. ASTM D 4533. Standard Test Method for Trapezoid Tearing Strength of Geotextiles.

6. ASTM D 4632. Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.

7. ASTM D 4716. Standard Test Method for Constant Head Hydraulic Transmissivity (In-Plane Flow) of Geotextiles and Geotextile Related Products.

8. ASTM D 4751. Standard Test Method for Determining Apparent Opening Size of a Geotextile.

9. ASTM D 4833. Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.

10. ASTM D 5199. Standard Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes.

11. ASTM D 5261. Standard Test Method for Measuring Mass per Unit Area of Geotextiles.

1.04 QUALIFICATIONS

A. The manufacturer shall be a well-established firm with more than one year experience in the manufacturing of geocomposite.

B. The Geosynthetic Installer shall install the geocomposite and shall meet the requirements of Section 02770 and this Section.

1.05 SUBMITTALS

A. The Geosynthetic Installer shall submit to the Engineer, at least 7 days prior to geocomposite delivery, the following information regarding the proposed geocomposite:

1. manufacturer and product name;

2. minimum property values of the proposed geocomposite and the corresponding test procedures;

3. projected geocomposite delivery dates; and

4. list of geocomposite roll numbers for rolls to be delivered to the site.

B. At least 7 days prior to geocomposite placement, the Geosynthetic Installer shall submit to the Engineer the manufacturing quality control certificates for each roll of geocomposite. The certificates shall be signed by responsible parties employed by the geocomposite manufacturer (such as the production manager). The quality control certificates shall include:

1. lot, batch, and/or roll numbers and identification; and

2. results of quality control tests, including a description of the test methods used.

1.06 CONSTRUCTION QUALITY ASSURANCE MONITORING

A. The Geosynthetic Installer shall ensure that the geocomposite and installation methods used meet the requirements of the Drawings and this Section. Any material or method that does not conform to these documents, or to alternatives approved in writing by the Engineer, will be rejected and shall be repaired or replaced by the Geosynthetic Installer.

B. The Geosynthetic Installer shall be aware of and accommodate all monitoring and conformance testing required by the CQA Plan. This monitoring and testing, including random conformance testing of construction materials and completed work, will be

performed by the Engineer. If nonconformances or other deficiencies are found in the Geosynthetic Installer's materials or completed work, the Geosynthetic Installer will be required to repair the deficiency or replace the deficient materials.

PART 2 — PRODUCTS

2.01 GEOCOMPOSITE PROPERTIES

A. The Geocomposite Manufacturer shall furnish geocomposites having properties that comply with the required property values shown in Table 02773-1. The Geocomposite Manufacturer shall provide results of tests performed using the procedures listed in Table 02773-1, as well as certification that the materials meet or exceed the specified values.

B. Geotextiles will be thermally bonded to one and two sides of the geonet component of geocomposite material rather than chemically bonded.

C. Geocomposite suppliers shall furnish materials in which the "Minimum Average Roll Values", as defined by the Federal Highway Administration (FHWA), meet or exceed the criteria specified in Table 02773-1.

D. The geocomposite's geotextile components shall be nonwoven materials, suitable for use in filter/separation and cushion applications.

2.02 MANUFACTURING QUALITY CONTROL

A. The geocomposite shall be manufactured with quality control procedures that meet or exceed generally accepted industry standards.

B. The geocomposite Manufacturer shall sample and test the geocomposite to demonstrate that the material conforms to the requirements of these Specifications.

C. Any geocomposite sample that does not comply with this Section shall result in rejection of the roll from which the sample was obtained. The Geosynthetic Installer shall replace any rejected rolls.

D. If a geocomposite sample fails to meet the quality control requirements of this Section the geocomposite Manufacturer shall sample and test, at the expense of the Manufacturer, rolls manufactured in the same lot, or at the same time, as the failing roll. Sampling and testing of rolls shall continue until a pattern of acceptable test results is established to bound the failed roll(s).

E. Additional sample testing may be performed, at the geocomposite Manufacturer's discretion and expense, to identify more closely any non-complying rolls and/or to qualify individual rolls.

F. Sampling shall, in general, be performed on sacrificial portions of the geocomposite material such that repair is not required. The Geocomposite Manufacturer shall sample and test the geocomposite, at a minimum once every 100,000 ft^2, to demonstrate that the geocomposite properties conform to the values specified in Table 02773-1. At a minimum, the following manufacturing quality control tests shall be performed on the geotextile component of the geocomposite:

Test	Procedure
Mass per unit area	ASTM D 5261
Grab strength	ASTM D 4632
Tear strength	ASTM D 4533
Puncture strength	ASTM D 4833
Burst Strength	ASTM D 3786
Permittivity	ASTM D 4491
A.O.S.	ASTM D 4751

At a minimum, the following manufacturing quality control tests shall be performed on the geonet component of the geocomposite:

Test	Procedure
Specific gravity	ASTM D 792
Nominal thickness	ASTM D 5199

At a minimum, the following manufacturing quality control tests shall be performed on the geocomposite:

Test	Procedure
Transmissivity	ASTM D 4716
Peel strength	ASTM D 413

G. The geocomposite Manufacturer shall comply with the certification and submittal requirements of this Section.

2.03 PACKING AND LABELING

A. Geocomposite shall be supplied in rolls wrapped in relatively impermeable and opaque protective covers.

B. Geocomposite rolls shall be marked or tagged with the following information:

1. manufacturer's name;
2. product identification;
3. lot or batch number;
4. roll number; and
5. roll dimensions.

2.04 TRANSPORTATION, HANDLING, AND STORAGE

A. The Geosynthetic Installer shall be liable for any damage to the materials incurred prior to and during transportation to the site.

B. The geocomposite shall be delivered to the site at least 14 days prior to the planned deployment date to allow the Engineer adequate time to perform conformance testing on the geocomposite samples as described in Part 3.06 of this Section.

C. Handling, unloading, storage, and care of the geocomposite prior to and following installation at the site, is the responsibility of the Geosynthetic Installer. The Geosynthetic Installer shall be liable for any damage to the materials incurred prior to final acceptance by the Engineer.

D. The Geosynthetic Installer shall be responsible for storage of the geocomposite at the site.

E. The geocomposite shall be protected from sunlight, excessive heat or cold, puncture, or other damaging or deleterious conditions. The geocomposite shall be protected from mud, dirt, and dust. Any additional storage procedures required by the geocomposite Manufacturer shall be the responsibility of the Geosynthetic Installer.

PART 3 — EXECUTION

3.01 FAMILIARIZATION

A. Prior to implementing any of the work described in this Section, the Geosynthetic Installer shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the installation of this Section may properly commence without adverse impact.

B. Inspection:

1. The Geosynthetic Installer shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the installation of this Section may properly commence without adverse impact.

2. If the Geosynthetic Installer has any concerns regarding the installed work of other Sections, he should notify the Engineer in writing prior to commencing the work. Failure to notify the Engineer or installation of the geocomposite will be construed as Geosynthetic Installer's acceptance of the related work of all other Sections.

C. A pre-installation meeting shall be held to coordinate the installation of the geocomposite with the installation of other components of the lining system.

3.02 HANDLING AND PLACEMENT

A. The Geosynthetic Installer shall handle all geocomposite in such a manner that it is not damaged in any way.

B. Install the double-sided geocomposite down the slope not across the slope. Place ends into the anchor trenches in such a manner as to continually keep the geocomposite in tension.

C. Precautions shall be taken to prevent damage to underlying layers during placement of the geocomposite.

D. In the presence of wind, all geocomposites shall be sufficiently weighted with sandbags or the equivalent to prevent movement.

E. The geocomposite shall be positioned by hand after being unrolled to minimize wrinkles.

F. Care shall be taken during placement of geocomposites not to entrap dirt or excessive dust in the geocomposite that could cause clogging of the drainage system, and/or stones that could damage the adjacent geomembrane. If dirt or excessive dust is entrapped in the geocomposite, it should be cleaned prior to placement of the next material on top of it. Care shall be exercised when handling sandbags, to prevent rupture or damage of the sandbags.

G. Geocomposites shall only be cut using a hooked utility blade.

H. After unwrapping the geocomposite from its opaque cover, the geocomposite shall not be left exposed for a period in excess of 15 days.

3.03 OVERLAPS AND SEAMS

A. Geonet Components:

1. The geonet components shall be overlapped a minimum 4 in. along the length. The geonet shall be overlapped by a minimum 1 ft. across the width.

2. Geonet overlaps shall be secured by tying with nylon cable ties. Tying devices shall be white or yellow for easy inspection. Metallic devices shall not be used.

3. Seaming of the geonet shall be performed by wrap-ties at 12-in. centers for end of panels and at 5-ft centers for edge of panel seams.

4. No end-of-panel seams shall be placed on slopes exceeding 10 %.

B. Geotextile Components:

1. The bottom layers of geotextile shall be overlapped, if applicable. The top layers of geotextiles shall be continuously sewn.

2. Polymeric thread, with chemical resistance properties equal to or exceeding those of the geotextile component, shall be used for all sewing.

3.04 PLACEMENT OF OVERLYING MATERIALS

A. All overlying materials shall be placed in such a manner as to ensure that:

1. The geocomposite and underlying materials are not damaged;
2. Minimal slippage occurs between the geocomposite and underlying layers; and
3. Excess tensile stresses are not produced in the geocomposite.

B. Equipment shall not be driven directly on the geocomposite.

C. Unless otherwise approved in writing by the Engineer, all equipment operating on the materials overlying the geotextile shall comply with Section 02200.

3.05 CONFORMANCE TESTING

A. Samples of geocomposite will be removed by the Engineer and sent to a Geosynthetic CQA Laboratory for testing to ensure conformance with the requirements of this Section. The Geosynthetic Installer shall assist the Engineer in obtaining conformance samples. The Geosynthetic Installer shall account for this testing in the installation schedule.

B. Samples shall be taken at a minimum frequency rate of one sample per 200,000 square feet.

C. The Engineer may increase the frequency of sampling in the event that test results do not comply with the requirements of Part 2.01 of this Section until passing conformance test

results are obtained for all material that is received at the site. This additional testing shall be performed at the expense of the Contractor.

D. As a minimum, transmissivity and peel strength will be performed on each sample.

E. Any geocomposite that is not certified by the Manufacturer in accordance with Part 1.05 of this section or that does not meet the requirements specified in Part 2.01 shall be rejected and replaced by the Geosynthetic Installer.

3.06 PROTECTION OF WORK

A. The Geosynthetic Installer shall use all means necessary to protect all work of this Section.

B. In the event of damage, the Geosynthetic Installer shall immediately make all repairs and replacements necessary to the approval of the Engineer.

PART 4 — MEASUREMENT AND PAYMENT

A. Providing for a complying with the requirements set forth in this Section for geocomposite will be measured as in-place square feet (SF), including geocomposite in the anchor trench to the limits shown on the Drawings, and payment will be based on the unit price provided on the Bid Schedule.

B. The following are considered incidental to the Work:

- shipping, handling, and storage.
- overlaps and seaming.
- layout survey.
- mobilization.
- rejected material.
- rejected material removal, handling, re-testing, and repair.
- temporary anchorage.

TABLE 02773 - 1
GEOCOMPOSITE PROPERTY VALUES – FINAL COVER LINER SYSTEM

PROPERTIES	QUALIFIER	UNITS	SPECIFIED VALUES (1)	TEST METHOD
Geonet Component:				
Specific gravity	Minimum		0.935	ASTM D 792
Carbon black content	Range	%	2 – 3	ASTM D 1603
Nominal thickness	Minimum	mils	200	ASTM D 5199
Geotextile Components:				
Mass per unit area	Minimum	oz/yd^2 (g/m^2)	6 (203)	ASTM D 5291
Filter Requirements				
Apparent opening size	Maximum	mm	0_{95} ≈ 0.21 mm	ASTM D 4751
Permittivity	Minimum	1/s	0.5	ASTM D 4491
Mechanical Requirements				
Grab strength	Minimum	lb (N)	130 (578)	ASTM D 4632
Tear strength	Minimum	lb (N)	40 (178)	ASTM D 4533
Puncture strength	Minimum	lb (N)	40 (178)	ASTM D 4833
Geocomposite:				
Transmissivity (2)	Minimum	m^2/s	5×10^{-4}	ASTM D 4716
Peel Strength	Minimum	lb	0.5	ASTM D 413

Notes: (1) All values except transmissivity represent minimum average roll values (i.e., any roll in a lot should meet or exceed the values in this table).

(2) The design transmissivity is the hydraulic transmissivity of the geocomposite measured using water at 68°F ±3°F (20°C ±1.5°C) with a hydraulic gradient of 0.1 under a compressive stress of not less than 2,000 psf (96 kPa). For the test, the geocomposite shall be sandwiched between a layer of cover soil material and a textured 60-mil HDPE geomembrane. The minimum test duration shall be 24 hours and the report for the test results shall include measurements at intervals over the entire test duration.

END OF SECTION

Section 8
Previous Explorations

Converse Consultants
Over 50 Years of Dedication in Geotechnical Engineering and Environmental Sciences

PRELIMINARY GEOTECHNICAL AND GEOLOGIC INVESTIGATION

INDUSTRIAL NON-HAZARDOUS DISPOSAL FACILITY
BASIC MANAGEMENT INCOPORATED
CLARK COUNTY, NEVADA

Prepared for:

Parsons Engineering Science, Inc.
100 West Walnut Street
Pasadena, CA 91124

Converse Project No. 99-33437-01

October 27, 1999

18/69BG

Printed on Recycled Paper

731 Pilot Road, Suite H, Las Vegas, Nevada 89119-4429
Telephone: (702) 269-8336 ♦ Facsimile: (702) 269-8353 ♦ e-mail: postmaster@convrs.com

Converse Consultants
Over 50 Years of Dedication in Geotechnical Engineering and Environmental Sciences

October 27, 1999 99-33437-01

Parsons Engineering Science, Inc.
100 West Walnut Street
Pasadena, CA 91124

Attention: Mr. Jim Goepel

Subject: **Preliminary Geotechnical and Geologic Investigation**
Industrial Non-Hazardous Disposal Facility
Basic Management Incorporated
Clark County, Nevada

Gentlemen:

We are pleased to submit the results of our preliminary geotechnical and geologic investigation conducted for an industrial non-hazardous disposal facility at property owned by Basic Management Incorporated (BMI). The site is located immediately south and west of the operating BMI facility off Lake Mead Drive in Clark County, Nevada and is approximately 20 acres in size. The study was performed in general accordance with our proposal dated August 30, 1999, and your Notice-to-Proceed dated September 1, 1999.

The on-site soils are suitable for use as materials for structural and embankment fills for support of a disposal facility. There do not appear to be adverse geologic or engineering considerations that would severely restrict the development of the proposed facility.

Soils generally consisted of medium dense to very dense granular soils with occasional zones of moderately hard to hard cemented sand and gravel overlying very stiff clay and silts. Groundwater encountered in the borings explored for this project and ranged from 30 to 58 feet be-

Printed on Recycled Paper
731 Pilot Road, Suite H, Las Vegas, Nevada 89119-4429
Telephone: (702) 269-8336 ♦ Facsimile: (702) 269-8353 ♦ e-mail: postmaster@convrs.com

low the ground surface. Cemented soils were encountered at 9 out of 12 boring locations beginning at depths ranging from 7 to 49½ feet below ground surface. Rock excavation techniques may be required for deep cuts.

If you have questions concerning information contained in this report, please contact us at your convenience.

Respectfully submitted,

CONVERSE CONSULTANTS

Algirdas G. Leskys, P.E.
Principal

AGL:MKK:gm
18/69BG

Contents

		Page
1.0	Introduction	1
2.0	Scope of Services	2
3.0	Existing Site Conditions	3
3.1	Site Description	3
3.2	Subsurface	4
4.0	Site Conditions	6
4.1	Topography and Vegetation	6
4.2	Geologic Soil Units	7
5.0	Geologic Conditions	8
5.1	Geologic Setting	8
5.2	Drainage	8
5.3	Geologic and Environmental Hazards Review	8
5.4	Estimated Ground Accelerations	9
6.0	Site Evaluation and Preliminary Recommendations	10
6.1	General	10
6.2	Foundations	12
6.3	Cut Slopes and Fill Embankments	12
6.4	Retaining Walls	13
7.0	Construction Considerations	14
7.1	Site Grading	14

Page

7.2 Excavations 15
7.3 Soil Corrosivity 16
7.4 Final Design Recommendations 16

8.0 Closure 16

References

Drawing Nos. 1 through 3

Appendix A – Field and Laboratory Investigations

1.0 Introduction

This report presents the results of our preliminary geotechnical and geologic investigation performed for development of an industrial non-hazardous disposal facility at property owned by Basic Management Incorporated (BMI). The site is located immediately south and west of the operating BMI facility off Lake Mead Drive in Clark County, Nevada and is approximately 20 acres in size. We understand that BMI desires to excavate the existing near-surface soils at the site to approximate depths of the proposed disposal facility, which will be constructed some time in the future. Ideally, the excavated soils will be suitable as commercial aggregate materials that may be sold.

A vicinity map showing the location of the project within the Las Vegas Valley area is provided on Drawing No. 1. This scope of work included performing geologic mapping, field exploration, and laboratory testing and engineering analyses to provide preliminary geotechnical design criteria for the site. In conjunction with this scope of work, an environmental evaluation was performed to assess the existing residual chemical concentrations of the soils at the site. Results from this work have been submitted under separate cover.

The purposes of this investigation were to: (1) determine the geologic conditions and presence of any hazards or controlling features at the proposed site; (2) define general subsurface conditions at the sites, and delineate or determine, if possible, the presence of any features that might impact location of the project features; and (3) provide preliminary geotechnical design recommendations.

Designs are in the conceptual stage at this time. The specific type of disposal facility, related structures and other details have not been determined. Future studies will be necessary to address liner designs, slope stability, earthwork recommendations and foundation design.

2.0 Scope of Services

The following tasks were included in our scope of services:

1. A geologic and geotechnical reference search was conducted to confirm the geology and soil conditions in the area.

2. A field reconnaissance of the site was performed by our field geologist to determine the presence of geologic features that could have an impact on the project.

3. A field exploration program was conducted which consisted of drilling, logging, and sampling of twelve (12) exploratory borings to depths ranging from 33 to 60 feet. The approximate location of the borings is shown on Drawing No. 2. The location of the borings was determined in the field by PBS&J surveyors at locations requested by Parsons Engineering Science, Inc. Coordinates and elevations of the individual soil boring locations were not available at the time this report was prepared. Summaries of the subsurface conditions encountered are presented on the boring summary sheets, Drawing Nos. A-1 through A-34 presented in Appendix A. Field drilling and investigation procedures are further described in Appendix A. Samples of the subsurface soils were obtained from the borings and were taken to our laboratory for further evaluation and testing.

4. Laboratory tests were conducted on selected soil samples. Tests included solubility, Atterberg limits, grain size analysis, direct shear, moisture/density relationship, chemical analyses, solubility and permeability. Descriptions and results of the laboratory tests are presented in Appendix A.

5. Results of the field exploration and laboratory testing were evaluated and engineering analyses were performed develop appropriate preliminary recommendations for the design and construction of the proposed project.

6. This geotechnical report was prepared to present the findings, conclusions, and preliminary recommendations. Based on the soil boring logs, geologic cross sections were developed which show interpolated subsurface conditions and are presented on Drawing No. 3

3.0 Existing Site Conditions

3.1 Site Description

The site is located on the northwest portion of the Black Mountain Industrial Complex near Lake Mead Drive and Interstate 515. Two potential areas were investigated at the project site and evaluated for the proposed disposal facility. Six borings were drilled in each area.

Area 1 was located north and west of several evaporation ponds and north of the Pioneer Chlor Alkali Plant. The area was rough-graded and relatively level. A drainage ditch was located adjacent and north of Area 1. Several dirt roads crossed this area. Numerous groundwater wells were observed in this area during our site visit; however, they did not appear to be pumping. Access to this area was either through the BMI plant or by a gate accessed from Warm Springs Road. Soil borings B-1, B-4, B-5, B-8, B-10, and B12 were drilled to investigate this area and cross section A-A' developed from this information.

Area 2 was located north and west of Area 1 and nearly paralleled the west and north fence of the BMI property. Area 2 was less disturbed except near dirt roadways. Undeveloped areas generally were covered with desert vegetation and scattered debris at the time of our field investigation. Soil borings B-101 through B-106 were drilled to investigate this area and cross section B-B' shown on Drawing No. 3 was de-

veloped from this information. Only one of the borings (B-102) in Area 2 was located inside the fence of the BMI property.

Based on our investigation, no major subsurface variations were observed at either of the above areas at the site. The soil materials encountered in both areas were found to be of the same type and have the same engineering properties. The following sections present information applicable for both areas.

3.2 Subsurface

Based on results of our subsurface explorations and subsurface explorations performed by others, the subsurface is characterized by alluvial granular soils overlying fine-grained soils, the top of which generally coincides with the groundwater table. The depth of the contact between the granular soil top and the fine-grained soils was encountered from approximately 34 feet to 55 feet below ground surface. The location of this material contact is shown on geologic cross sections A-A' and B-B' on Drawing No. 3.

The granular subsoils generally consisted of medium dense to very dense granular fill and native soils overlying localized zones of moderately hard to hard cemented sand and gravel. The fine-grained soils consisted high plasticity silts and lean clays. Granular fill soils 2 to 14 feet deep were encountered in 10 of the borings. Small boulders and large cobbles were encountered in several of the borings. Cemented soils were not encountered in Boring Nos. 1, 5 and 8 for this investigation. The depths to the cemented soils for the other borings are provided below in Table No. 1.

Table 1 - Depth to and Thickness of Cemented Soils

Boring Location	Depth To Cemented Soils (Ft)	Thickness of Cemented Soils (Ft)	Cemented Soil Description
B-4	39	1	Hard
B-4	48	6	Moderately Hard to Hard

Boring Location	Depth To Cemented Soils (ft)	Thickness of Cemented Soils (ft)	Cemented Soil Description
B-10	14	16	Moderately Hard
B-12	21	2	Hard
B-101	49.5	0.5	Moderately Hard
B-102	7	10.5	Moderately Hard
B-102	38	2	Moderately Hard
B-103	37	5	Moderately Hard
B-104	25	4	Moderately Hard
B-104	40	3.5	Hard
B-105	17	3	Moderately Hard
B-105	38	>2	Hard
B-106	31	>2	Hard

Field and laboratory test results indicate that the native granular soils at the site have a low compressibility, moderate to high internal angles of friction, low potential for gypsum solubility, a low chemical (salt) heave potential, and contain sulfate salts in concentrations considered harmful to normal strength concrete. The fine-grained soils encountered at depth at the site generally were found to be moderately compressible, have a high expansion potential, and have relatively low permeabilities. Ranges of laboratory test results for the soils are summarized in Table No. 2 and the individual test results and procedures are presented in detail in Appendix A.

Table No. 2 - Summary of Laboratory Test Results

*Properties	Range of Results
Solubility	0.0 to 0.6 percent
Laboratory Max Density (ASTM D1557)	129.7 to 132.1 pcf
Optimum Moisture Content D 1557	7.5 to 8.7 percent
Angle of Internal Friction	26 to 43 degrees
Percent Passing the No. 200 Sieve	8 to 20 percent
Permeability (cm/s)	1.2×10^{-3} to 1.7×10^{-7}
Plasticity Index	Nonplastic to 34

*The laboratory tests are described in detail in Appendix A.

Free groundwater was encountered at depths between 30 and 58 feet below ground surface. Groundwater was measured in the borings immediately following drilling and levels may not have stabilized in the boreholes. A summary of the groundwater elevations encountered in the borings, which extended to groundwater is summarized in the following table:

Table 3 - Depth to Groundwater at Time of Drilling

Boring Location	Depth to Groundwater (ft)
B-1	53
B-4	54.5
B-5	52.5
B-8	58
B-10	46.5
B-12	37.5
B-101	42
B-102	43
B-103	42.5
B-104	43.5
B-105	30
B-106	30

4.0 Site Conditions

4.1 Topography and Vegetation

The native topography of the site is characterized by moderately sloping alluvial fans that lie at the base of the McCullough Range. These piedmont surfaces (areas geologically formed at the base of mountains) slope to the north and northeast, and coalesce in several areas near the proposed disposal facility. The relatively flat surfaces of the alluvial fans in the area are sparsely vegetated with creosote bushes, weeds, and other native plants typical of the Mojave Desert. The eastern two-thirds of Area 1 had been rough graded and was relatively level. Vegetation was very sparse in this area.

Several small north to northeast-trending washes cross the fans and the western portion of the site providing drainage for natural storm-water runoff from the uplands to the south. Most of these washes vary in size from about 10 to 20 feet across. The terrain within the washes consist of gentle to moderate bar-and-swale topography with numerous bar deposits of cobbles and gravel.

4.2 Geologic Soil Units

Our mapping has been based upon review of aerial photographs, published geologic and soils maps, site reconnaissance, and field exploration program. Within the general project area, two different geologic soil units were identified for the purposes of this work. The approximate boundary between the two units is the BMI property fence. Geologic descriptions of the units are based on the *Soil Conservation Service* (SCS) of soil classification and are given below:

Caliza Soil

This soil corresponds to *SCS Soil Map Unit 187* and is described as a very deep, well drained, cobbly fine sandy loam with 2 to 8 percent slopes. This soil is formed in alluvium derived from various types of rock and found on inset fan remnants. The subsurface is predominantly very gravelly coarse sand to a depth of 5 feet or more. Permeability is moderately rapid, available water capacity is low, and runoff is medium. The hazard of water erosion is slight, and the hazard of soil blowing is moderate if the surface is disturbed. Intermittent streams form the drainages in this unit. These drainages are subject to rare or occasional periods of high-velocity flooding.

Urban Land

This unit corresponds to *SCS Soil Map Unit 615* and consists of areas covered by asphalt, concrete, and buildings or other urban structures. The entire BMI complex including the undeveloped areas within the fenced property is mapped in this unit.

5.0 Geologic Conditions

5.1 Geologic Setting

The project area is located in the southeastern portion of the Las Vegas Valley, a structural basin of late Mesozoic and Tertiary block faulting origin. The valley is physiographically characteristic of the Basin and Range province. Valley deposits are Tertiary and Quaternary Age unconsolidated sediments derived from the surrounding mountains; the local sources of deposition are the McCullough Range to the south and the River Mountains to the east. Alluvial deposits consisting of gravel, sand, silt, and clay are overlain by lacustrine deposits of sand, silt, and clay in some portions of the valley. The alluvial and lacustrine sediments can be up to 4,000 feet thick in some parts of the valley. Coarse-grained alluvial fan deposits are located near the base of the mountains and grade into and interfinger with fine-grained sand, silt, and clay deposits in the central portion of the valley.

5.2 Drainage

Primary drainage for the valley is toward the southeast along four major wash systems: Las Vegas Wash, Flamingo Wash, Tropicana Wash, and Duck Creek Wash. These four systems consist of a series of channels of varying lengths and depths that originate along alluvial fans at the base of the Spring Mountains. The channels drain the valley to the southeast where they all coalesce into Las Vegas Wash. Several drainages near the proposed disposal facility divert stormwater runoff from the area to Las Vegas Wash and its tributaries.

5.3 Geologic and Environmental Hazards Review

Existing geologic data, including past Converse project files and references from the U.S. Soil Conservation Service, U.S. Geological Survey, Nevada Bureau of Mines and Geology, aerial photographs, and information through the State Universities were reviewed as part of this in-

vestigation. According to our review, two north-trending fault scarps are located approximately ½ mile northwest and southwest of the proposed site. The first is located along the fringe of the McCullough Mountains. The northern terminus of this fault scarp is located approximately 690 feet south of Lake Mead Drive and 1,050 feet west of Interstate 515. The second scarp is located near the vicinity of Gibson Road and American Pacific Drive. No evidence for faulting was observed within the proposed disposal facility site.

The *Subsidence-Related Faults and Fissures of the Las Vegas Valley Map*, published by the *Nevada Bureau of Mines and Geology, Subsidence in Las Vegas Valley 1980-91 Final Project Report*, John W. Bell and Jonathan G. Price, 1991, did not indicate topographic lineations regarded as a subsidence-related (compaction) fault were located near the proposed site. It is generally agreed that subsidence-related faults are not bedrock faults, although their displacement may have been at least partly induced by a seismic event. Others have dated the age of one of these escarpments in the southern part of the valley at about 14,000 to 35,000 years old. Fissures, surface expressions of differential stress resulting from regional and local subsidence due to withdrawal of groundwater, have been localized near subsidence-related faults. The nearest subsidence related faults and fissures are located approximately 2.3 miles northwest of the proposed disposal facility near Whitney Mesa.

The potential for landslides is believed to be low due to the nature and proximity of the topographic highlands to the project area and low precipitation in the region.

5.4 Estimated Ground Accelerations

Las Vegas Valley is located in Seismic Zone 2B as categorized in the Uniform Building Code. Zone 2B represents a low to moderately active seismic area. A regional map published by Algermissen and Perkins (1976) presents the expected peak horizontal ground acceleration for the Las Vegas Valley as approximately 0.1g. This value has a 10 per-

cent chance of being exceeded in a 50-year period. Site specific seismicity model analyses have been performed by Converse on other projects in the Las Vegas Valley. This analysis has typically found the peak horizontal ground acceleration of an event having a 10 percent chance of exceedance during a 100-year design life to range between 0.2g and 0.3g. For an event having a 10 percent chance of exceedance during a 50-year design life, the peak horizontal ground acceleration has ranged between 0.1g and 0.2g. The peak horizontal ground acceleration recommended for the design of the project is 0.15g. Based on our subsurface explorations and well drillers' logs in the area, a soil profile type of S_D per Table 16-J of the 1997 Uniform Building Code should be used for the site.

6.0 Site Evaluation and Preliminary Recommendations

6.1 General

Based on (1) our review of published geologic maps; (2) our geologic site reconnaissance, (3) the results of the preliminary field and laboratory investigations ; and (4) and assuming that the proposed facilities will not be developed to within 8 feet or closer of the fine-grained soils encountered at depth, it is our opinion that from a geotechnical engineering perspective, the site is suitable for support of the proposed disposal facility. We did not identify geologic hazards that would severely restrict development of the proposed disposal facility. Granular native site soils will provide support of the facility with some reworking. Cemented soils were found at shallow to moderate depths in 9 of the 12 borings drilled for this investigation. Based on observed excavation activities performed on other nearby projects, the majority of the soils should be rippable with conventional earthwork equipment, however, deep cuts into fully cemented soil deposits could require rock excavation techniques.

One design consideration will be requirements pertaining to liner permeability as related to the availability of near-surface, low-permeability native soils. As previously mentioned, the subsurface soils are char-

acterized by alluvial granular soils overlying fine-grained soils, the top of which coincides with the groundwater table. The granular soils above the fine-grained soils and groundwater table were tested to have relatively high permeabilities (greater that 1×10^{-5} cm/sec) and are not suitable as potential liner material. Due to regulatory requirements and the subsurface site conditions, development of the site as a disposal facility will probably require placement of either synthetic or non-synthetic (clay) liners. Synthetic liners could include membranes manufactured of high density polyethylene or a similar material. If a clay liner is used, a borrow source containing materials which meet regulatory permeability criteria would need to be identified and investigated. Another possible alternative, which is a combination of the above, is a geosynthetic clay liner which is constructed both of geotextile and/or geomembrane and bentonite. The appropriate regulatory agencies should be contacted during the design process to establish a dialogue as to which liner systems are allowed for the given waste stream and site conditions.

In order to provide geotechnical design recommendations for the proposed project, additional field explorations, laboratory testing, and engineering analyses should be performed. Additional field investigations related to excavatability of the on-site cemented soils may be desirable to perform and could include additional borings at cut areas and seismic refraction tests. After details of the project are finalized and design information is available, specific design recommendations should be developed in the design-level investigation.

The following sections present an engineering evaluation and preliminary considerations for the proposed site and facilities. The preliminary recommendations are for planning and should be confirmed with a final design-level investigation.

6.2 Foundations

Disturbed soils and undocumented fill soils are not considered suitable for the support of structures or retaining walls in the their present condition. It is our opinion that structures may be supported on spread footings founded on a zone of properly placed and compacted structural fill, undisturbed medium dense to very dense granular native soils or on moderately hard to hard cemented soils. Individual footings should not bear on both cemented soils and uncemented soils. Actual bearing materials can be determined after foundation loads and elevations have been determined.

Depending on the type of construction, the proposed structural loads, and the depths of footings, we estimate that the maximum allowable bearing pressures for conventional spread footings will range from 4,000 to 6,000 psf on cemented or non-cemented native granular soils or granular structural fill. Concrete floor slabs may be supported by a 4 to 6 inch layer of processed and compacted granular fill material underlain by structural fill or undisturbed, dense native soils.

6.3 Cut Slopes and Fill Embankments

Cut slopes into medium dense to very dense native granular soils or cemented soils should provide stable slopes on which waste disposal liners may be placed. For any proposed embankments, medium dense to very dense native granular soils or a zone of properly placed and compacted structural fill or cemented soils should provide adequate support for the embankments and disposal facilities after the surface vegetation and organics have been removed and the foundation preparation has been conducted. For embankments, we recommend a homogeneous embankment section consisting of either on-site or import soils. The on-site soils are suitable for use as materials for embankment fill or other structural fills. Fill soils and disturbed native granular soil beneath the embankment sections or any areas which will support liner systems will require scarification, moisture conditioning, and recompaction.

Surfaces of the cut or embankment slopes will need to be adequately protected from erosion due to rainfall and runoff. The stability of the cut or embankment slopes should be analyzed during the final design-level investigation after locations, geometry and heights have been determined. The ranges of cut and embankment slopes given in Table No. 4 may be used for preliminary planning.

Table No. 4 - Slopes for Preliminary Planning

Cut Slope or Embankment Soil Type	Approximate Slope (Horizontal:Vertical)
Sands and Gravels	1½:1 to 2:1

It should be noted that typical slopes on which liners will be constructed are usually not recommended to be steeper than 3:1 (horizontal to vertical). Slopes would need to analyzed on an individual basis with proposed liner types and expected loads for the appropriate maximum steepness in the design-level investigation.

6.4 Retaining Walls

We anticipate that conventional concrete retaining walls may be used for the project. The appropriateness of concrete walls will depend on the height, length, and configuration of the walls. After wall details have been determined, information on different options and approximate costs can be provided in the design-level investigation. Ranges of lateral earth pressures for restrained and unrestrained walls are given in Table 5 below:

Table No. 5 - Lateral Earth Pressures

Wall Type	Lateral Earth Pressures psf/ft
Restrained	38-45
Unrestrained	30-40

The site soils generally contain too high a percentage of fines to be free draining. On-site material may be processed to reduce the silt and clay content and to remove oversize material, to obtain a free draining backfill material. If free draining material is not used, a drainage system will need to be provided or the wall designed to resist hydrostatic forces.

7.0 Construction Considerations

7.1 Site Grading

It is anticipated that site grading will be a large component of development of the site. Site grading should consist of: (1) the removal of existing vegetation, pavements, debris, surface trash and possibly some underground utilities that may be relocated from the site; (2) the undocumented fill, loose or disturbed native soils should be processed and stockpiled for later use as engineered fill; (3) excavating down to medium dense to very dense granular soils or down to expose the underlying cemented soils for support of any foundations; (4) overexcavation and recompaction of the natural soils will be required for the support of any structures; and (5) the exposed native soils will require scarification, moisture conditioning and recompaction prior to placing structural fill in fill areas. Scarification and recompaction can be terminated where cemented soils are exposed. The existing on-site soils should be suitable for use as compacted structural fill. All fill at the site should be considered undocumented unless records of proper placement were prepared and are obtained. All undocumented fill at the site will be unsuitable for support of structures and settlement-sensitive facilities at the site will need to be reworked as structural fill. Rubble and debris resulting from excavating cemented soil deposits should be considered undocumented fill. Contingency plans should be considered for removing small boulders, cobbles, and broken cemented material resulting from excavations of cemented soil from the project site. Boulders, cobbles, and cemented material between 4 and 24 inches in diameter may possibly be used in deep fill where potential

settlement may be tolerated areas if special compaction procedures are used and full-time observation during placement is provided.

There will be shrinkage when excavating and compacting or scarifying and recompacting the non-cemented on-site soils, and swell when excavating and compacting cemented soils. The shrinkage and swell factors provided in Table No. 6 may be used for preliminary planning.

Table No. 6 - Shrinkage and Swell Factors for Preliminary Planning

Soil Type	Estimated Shrinkage (-) or Swell (+) Factor (percent)
Sands and Gravels	5 to 15 (-)
Cemented Soils	0 to 10 (+)

A shrinkage factor of 5 to 15 percent may be used for preliminary planning in areas where the exposed native soils will be compacted to a depth of 6 inches. For final design, the anticipated shrinkage and swell factors for the on-site soils should be determined in the design-level investigation.

7.2 Excavations

Based on observations made during our field explorations, the majority of non-cemented soils should be readily excavatable with conventional earthwork equipment. Partially to fully cemented (moderately hard to hard) soils were encountered during this investigation at depths of 7 to 49½ feet below the existing ground surface. Heavy-duty ripping, heavy-duty backhoe, headache ball, rocksaw, blasting, or Ho-ram should be anticipated for any deep excavations. The Contractor should be aware of the potential for vibrational damage to adjacent or nearby structures when using blasting or heavy impact equipment during removal of the hard cemented materials.

7.3 Soil Corrosivity

Laboratory test results indicate that according to Clark County Building Department standards, soils should be considered moderately to severely corrosive to buried metal and have sulfate levels above that considered harmful to normal strength concrete and soil cement. Consideration should be given to corrosion protection systems for buried metal. The concrete mixture recommendations to accommodate severely corrosive soils should be based on the design-level investigation.

7.4 Final Design Recommendations

Additional design-level investigations will be required, when final facility and structure layouts and dimensions have been determined. Borings should be located within the foot-print of the facilities or structures and laboratory testing should be performed to evaluate the nature and engineering properties of the native subsoils at those locations and, if possible, any potential import materials. It may also be desirable to evaluate the extent and rippability of cemented soils.

8.0 Closure

Our assumptions, conclusions, recommendations, and opinions presented herein are: (1) based upon the geologic site reconnaissance, (2) based upon our evaluation and interpretation of the findings of the preliminary field exploration and laboratory programs, (3) based upon an interpolation of soil conditions between and extrapolation beyond the boring locations, (4) based on our geotechnical experience in the locale, (5) not based on environmental regulatory requirements for disposal facility design and construction and are only based on standard geotechnical engineering considerations (6) subject to confirmation of the conditions encountered during a design-level investigation, and (7) prepared in accordance with generally accepted professional geotechnical engineering principles and practice. We make no other warranty, either express or implied.

It has been our pleasure to serve you on this project. If you have any questions, please contact this office.

Respectfully submitted,

CONVERSE CONSULTANTS

Lorraine Linnert Dunford
Project Geologist

Mike Klein, P.E.
Senior Engineer

Reviewed by:

James L. Werle, P.G.
Principal Geologist

REGISTERED PROFESSIONAL ENGINEER STATE OF NEVADA
MICHAEL K. KLEIN
CIVIL
NO. 11407

10-27-99

MKK:CMK:gm
18/69BG

Encl: Drawing Nos. 1 through 3
Appendix A

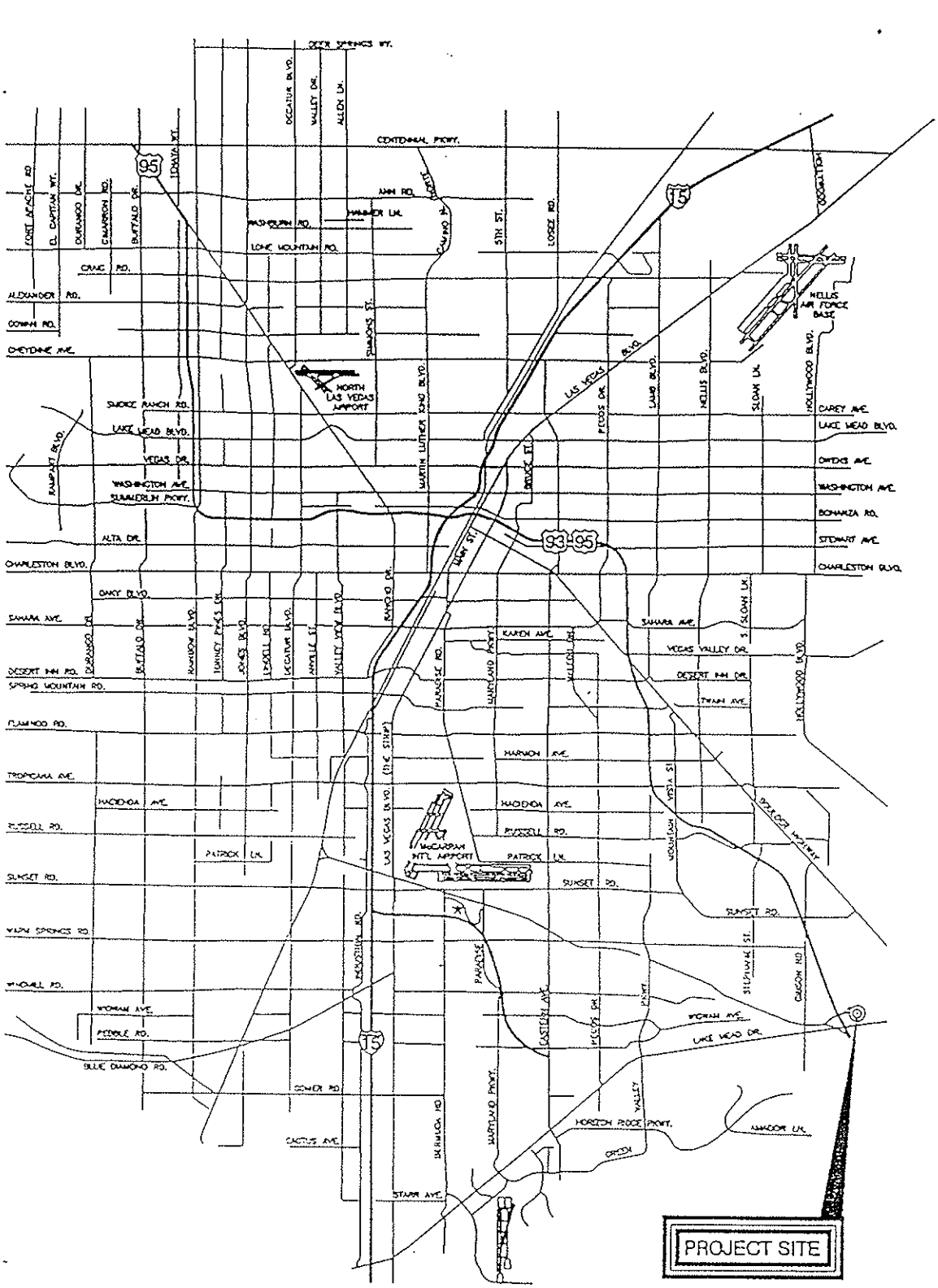
Dist: 3/Addressee

References

Bell, J.W., 1978, *Geologic Constraints Map, Las Vegas SE Folio*, Nevada Bureau of Mines and Geology, Environmental Series, Las Vegas Area.

Bell, J.W. and Price, J.G., 1991, *Subsidence-Related Faults and Fissures of the Las Vegas Valley Map*, Nevada Bureau of Mines and Geology, Subsidence in the Las Vegas Valley 1980-91 Final Project Report.

Soil Conservation Service, 1985, *Soil Survey of Las Vegas Valley Area, Nevada, Part of Clark County*: U.S. Department of Agriculture.



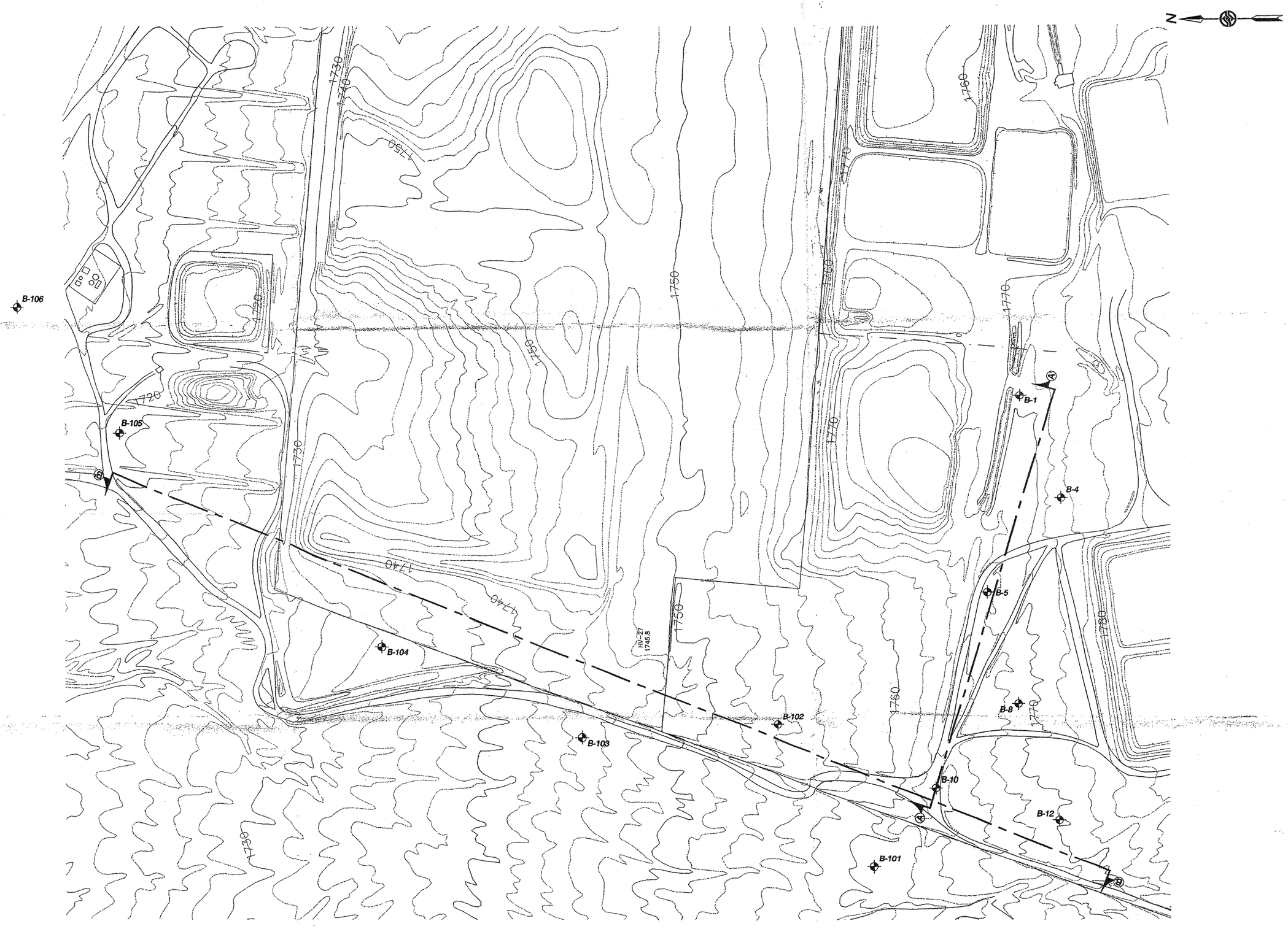
LAS VEGAS VICINITY

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Scale	N.T.S.
Date	10/21/99
Drafted By	CLE
Checked By	MKK
Approved By	
File No.	
Project No.	99-33437-01
Drawing No.	1

CONVERSE CONSULTANTS

Over 50 Years of Dedication in Engineering and Environmental Sciences



GRAPHIC SCALE

100 0 200 400

(In Feet)

EXPLANATION

APPROXIMATE SOIL BORING LOCATION

APPROXIMATE LOCATION OF GEOLOGIC SECTION (See Drawing No. 3)

REF: AutoCAD drawing file "site.dwg", supplied by client

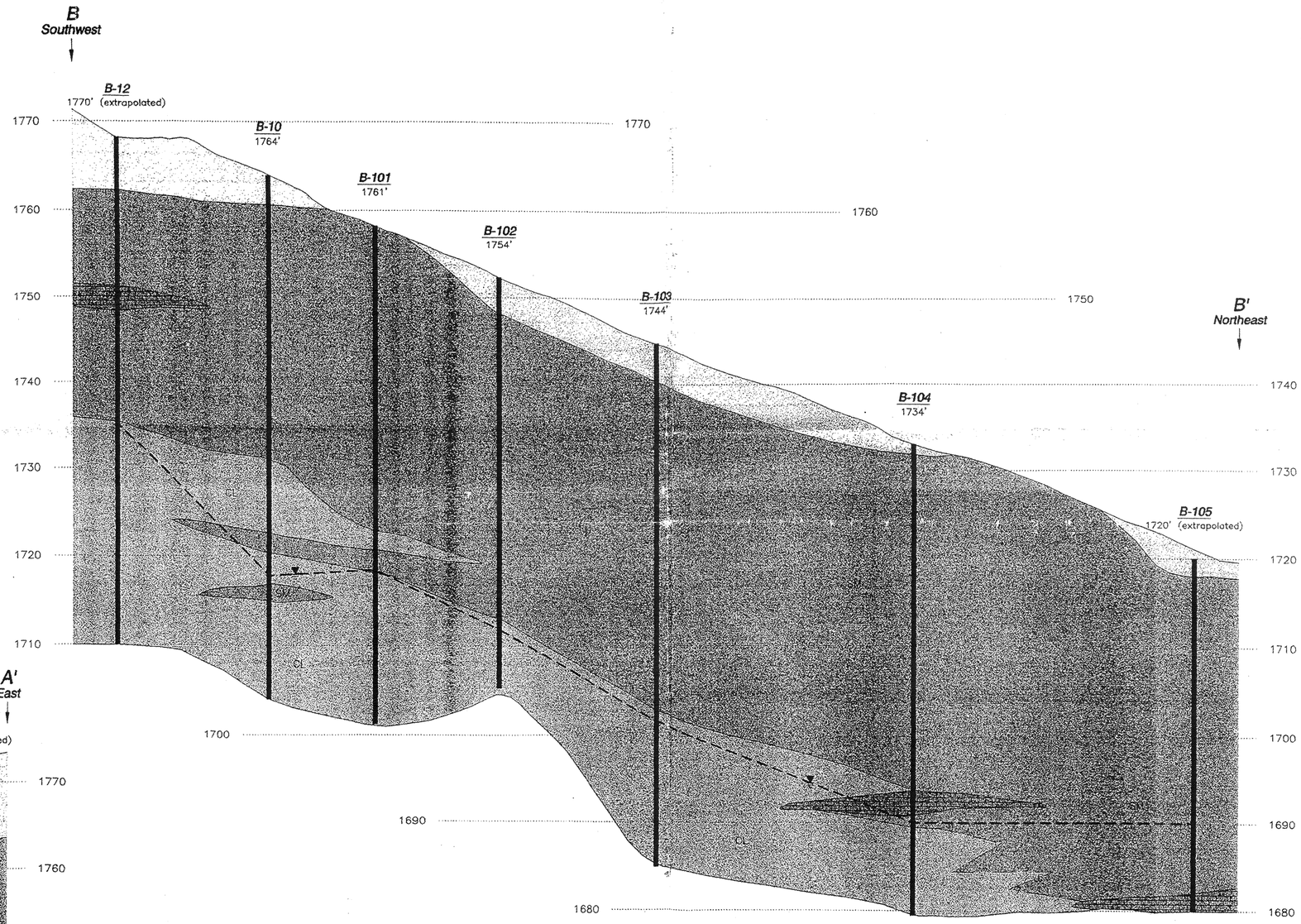
LOCATION OF SUBSURFACE EXPLORATIONS

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Scale	1" = 200'	File No.	43701002
Date	10/21/99	Project No.	99-33437-01
Drafted By	GLE	Drawing No.	2
Checked By	MKK		
Approved By			

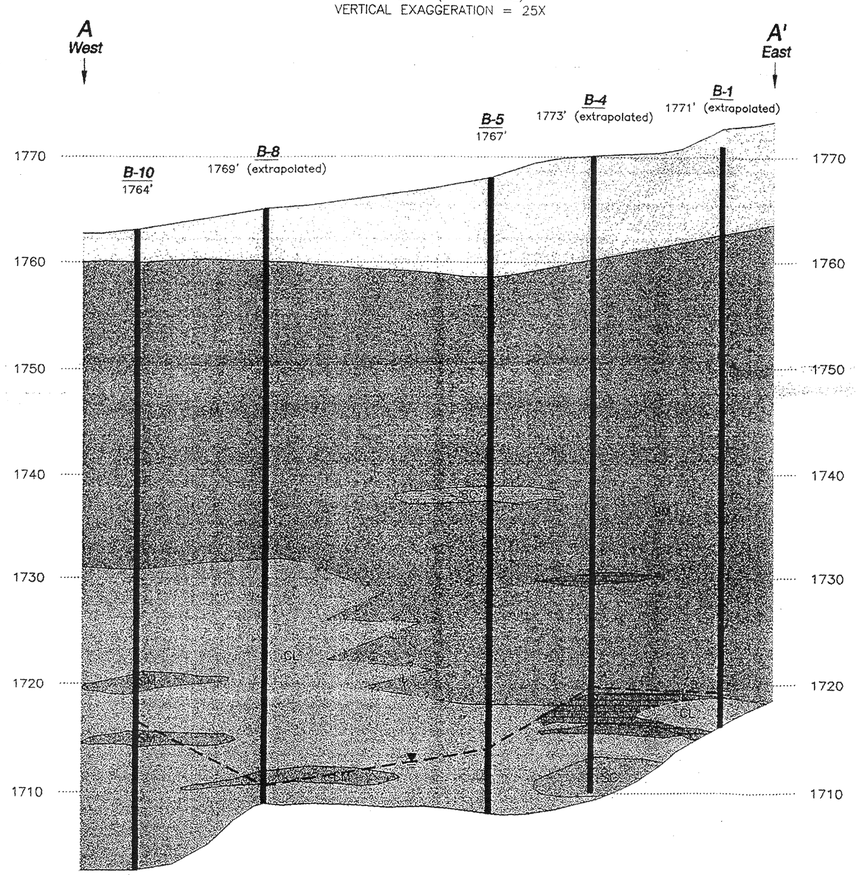
CONVERSE CONSULTANTS

Over 50 Years of Dedication in Engineering and Environmental Sciences



SECTION B-B'

SCALE: 1" = 10' (VERTICAL)
1" = 250' (HORIZONTAL)
VERTICAL EXAGGERATION = 25X



SECTION A-A'

SCALE: 1" = 10' (VERTICAL)
1" = 250' (HORIZONTAL)
VERTICAL EXAGGERATION = 25X

LEGEND

- FILL
- CLAY
- CLAYEY SAND
- SILTY SAND
- SAND
- CEMENTED SAND AND GRAVEL
- APPROXIMATE GROUNDWATER LEVEL MEASURED IMMEDIATELY AFTER DRILLING

NOTE: Ground surface elevations were extrapolated from a topographic map provided by the client. Locations and elevations of the soil borings are approximate. Data concerning subsurface conditions has been obtained at exploration locations only. Actual conditions between explorations may differ from the generalized profiles shown here.

GEOLOGIC SECTIONS

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

CONVERSE CONSULTANTS

Over 50 Years of Dedication in Engineering and Environmental Sciences

Scale	1" = 300'
Date	10/28/99
Drafted By	GLE
Checked By	LLD
Approved By	
File No.	43701003
Project No.	99-33437-01
Drawing No.	3

Field and Laboratory Investigations

Field Investigation

The subsurface soil conditions were explored by drilling 6 borings in each of the two areas (total of 12 for the site) to depths ranging from 33 to 60 feet below ground surface. The approximate locations of the explorations are shown on Drawing No. 2, Locations of Subsurface Explorations. Boring locations were located, surveyed, and staked by PBS&J surveyors, however, at the time this report was prepared this information was not available. Continuous logs of the subsurface conditions as encountered in the explorations were recorded at the time of drilling by a field geologist. The subsurface conditions encountered were visually classified in accordance with the Unified Soil Classification System. Summaries of the subsurface conditions encountered are presented on the boring summary sheets, Drawing Nos. A-1 through A-34. A key to soil symbols and terms is found on Drawing No. A-35. The soil classification system for engineering purposes is further explained on Drawing No. A-36.

Drilling was accomplished with a BK-81 hollow-stem auger drill rig equipped for soil sampling. Relatively undisturbed soil samples were obtained using a 2.42-inch inside diameter Converse sampler driven with a 140-pound hammer free-falling through a distance of 30 inches. Sampler driving resistance, expressed as blows per 12 inches of penetration, is presented on the boring logs at the respective sampling depths. The sampled soil is retained in brass rings 1-inch in height which line the sampler. A representative portion of each sample was retained and carefully sealed in waterproof plastic containers for transport to the geotechnical laboratory. Additional samples were collected in 6-inch high stainless steel sleeves for environmental laboratory analysis. Soils with stains and orders due to potential chemical contamination are noted on the soil boring logs. It should be noted that given the coarse grained materials encountered at the site, undisturbed sample recovery was low. Also, the encountered materials

in the borings classified as boulders could have also been cobble size as well as boulder size particles.

Pocket Penetrometer

At the time of drilling, pocket penetrometer tests (pp) were conducted in the ends of selected brass ring samples of fine-grained soils as they were received from the borings. The purpose of the tests was to give an indication of the unconfined compressive strength in tons per square foot (tsf) or unconfined shear strength in kips per square foot (ksf) of the soil. A Brainard-Kilman S-170 pocket penetrometer was used. The results of the tests are presented in the Field or Laboratory Tests column of the boring logs, Drawing Nos. A-1 through A-34.

Laboratory Investigation

Laboratory tests were conducted on representative soil samples for the purpose of classification, and determination of their physical properties and engineering characteristics. The amount and selection of the types of testing for a given study are based on the geotechnical conditions of the project. Test results are presented in the summary boring logs and in this appendix. A summary of the various laboratory tests conducted by our office for engineering purposes is presented as follows.

The soil samples presently stored in our laboratory will be discarded 30 days after the date of this report, unless this office receives a specific request to retain the samples for a longer period.

Moisture Content and Dry Density

Data obtained from these tests, performed on relatively undisturbed samples obtained from the field and in accordance with ASTM D2435, were used in the classification and correlation of the soils and to provide qualitative information regarding soils strength and compressibility. Test results are presented on the boring logs on Drawing Nos. A-1 through A-34.

Grain Size Distribution

Grain size distribution for soil samples were determined by sieve analysis in accordance with ASTM C136. A sieve analysis is conducted by passing the soil through a number of different sized sieves and measuring the amount of soils retained on each sieve. The test results and grain size distribution curves are presented on Drawing Nos. A-37 through A-48.

Atterberg Limits

The liquid limit, plastic limit and plasticity index of a representative sample of the fine-grained soils were determined to aid in the classification of the soils and in the evaluation of other engineering parameters. The test was performed in general accordance with ASTM test method D4318. The results of the tests are tabulated in the following table:

Exploration Location	Sample Depth, ft.	Liquid Limit, %	Plastic Limit, %	Plasticity Index	Unified Soils Classification
B-1	30-35	NP	NP	NP	SM
B-5	20-25	NP	NP	NP	SM
B-10	30-35	NP	NP	NP	SM
B-12	10-15	NP	NP	NP	SM
B-101	39-40	105	71	34	MH
B-101	54-55	54	44	10	ML
B-102	20-25	NP	NP	NP	SM
B-102	49-50	88	58	30	MH
B-103	30-35	NP	NP	NP	SM
B-104	10-15	NP	NP	NP	SM
B-105	20-25	NP	NP	NP	SW-SM
B-106	0-5	NP	NP	NP	SM

NP = Nonplastic

Solubility

Solubility tests were performed to determine the amount of water-soluble materials (principally gypsum) present in the soil. After drying a soil specimen weighing approximately 150 grams in a 60-degree centigrade oven, about 2 liters of tap water are passed through the specimen. The soil is then oven-dried and the amount of soluble materials lost is calculated based on the original dry weight of the soil. The results of the solubility test are presented in the following table:

Exploration Location	Sample Depth (Feet)	Soil Description	Solubility (% by Unit Weight)
B-4	2-2.5	Fill – Poorly graded sand	0.2
B-5	10-15	Silty sand with gravel	0.6
B-8	19-20	Silty sand with gravel	0.2
B-101	5-10	Silty sand with gravel	0.0
B-102	0-5	Fill - Silty sand with gravel	0.6
B-104	0-5	Silty sand with gravel and cobbles	0.4
B-106	0-5	Silty sand with gravel	0.0

Consolidation

The apparatus used for the consolidation tests is designed to receive a one-inch high brass ring containing an undisturbed soil sample as it comes from the field. Tests were performed in general accordance with ASTM D2435 test method. Loads are applied to the test specimen in several increments, while resulting deformations are recorded at selected time intervals. Porous stones are placed in contact with both ends of the specimen to permit the ready addition or release of water. Samples are initially tested at their field moisture content. After consolidating at the field moisture content with a 2 ksf surcharge load, the specimens are inundated with water. Additional consolidation that occurs with a 2 ksf load after the specimens are inundated with water (hydrocollapse) is measured. Subsequent consolidation with additional loads is measured at the increased moisture content to determine soil behavior under saturated conditions. Results of the tests are

shown on Drawing Nos. A-49 through A-56, entitled *Consolidation Test* and are summarized on the following table:

Exploration Location	Depth (feet)	Soil Description	Dry Unit Weight, pcf	Moisture Content, %	Hydrocollapse (percent)*
B-1	29-30	Silty sand with gravel	105	6	3.2
B-8	39-40	Sandy lean clay	57.4	64	0.4
B-8	49-50	Sandy lean clay	69.5	51.1	-0.6
B-10	54-54.5	Sandy lean clay	60.7	67.7	-0.6
B-101	39-40	Sandy lean clay	65.8	45	-0.2
B-101	59-60	Sandy lean clay	73.2	38.3	-0.6
B-102	49-50	Sandy lean clay	67.3	48.7	-0.5
B-105	34-35	Well graded sand with silt and gravel	101	5	0.1

NA: Not available

* A negative sign indicates swell occurred upon inundation with water instead of collapse.

Laboratory Maximum Density

Laboratory maximum density tests were performed on selected samples of the granular soils. The purpose of the test was to define the compaction characteristics of these soils, and to aid in estimating soil shrinkage. The laboratory maximum density test was performed in general accordance with the ASTM D1557 test method. This test procedure uses 25 blow of a 10-pound hammer falling a height of 18 inches on each of five layers of soil in a 1/30 or 1/13 cubic foot cylinder. The test results are presented on Drawing Nos. A-57 through A-61 and in the following table:

Exploration Location	Depth (Feet)	Soil Description	Maximum Dry Unit Weight (pcf)	Optimum Moisture Content (percent) - of dry weight)
B-1	20-25	Silty sand with gravel	129.4	8.2
B-5	20-25	Silty sand with gravel	132.1	8.2
B-12	10-15	Silty sand with gravel	129.7	7.9
B-101	5-10	Silty sand with gravel	130.6	8.7
B-105	20-25	Well graded sand with silt and gravel	131.8	7.5

Direct Shear Strength

A progressive direct shear test was performed on selected undisturbed samples using a constant strain rate direct shear machine in general accordance with ASTM D3080. The test specimen was trimmed and placed in the shear machine, a specified normal load was applied, and the specimen was sheared until maximum shear strength was developed. After the soil specimen had developed maximum shear resistance under the first normal load, the normal load was removed and the specimen was pushed back to its original undeformed configuration. Another normal load was then applied, and the specimen was sheared a second time. This process was repeated for three different normal loads. Results of the direct shear test are presented on Figures A-62 through A-69 and in the following table:

Exploration Location	Depth (Feet)	Soil Description	Angle of Internal Friction (deg)	Coulomb Cohesion (ksf)
B-4	14-14.5	Silty sand with gravel	31	0.7
B-5	14-15	Silty sand with gravel	43	0.3
B-10	54-54.5	Sandy lean clay	26	0.85
B-12	14-15	Silty sand with gravel	40	0.3
B-101	39-40	Sandy lean clay	26	0.9
B-102	20-25	Silty sand with gravel	37	0.2
B-103	49-50	Sandy lean clay	37	1.0
B-104	10-15	Silty sand with gravel	43	0.1

Chemical Analysis

Chemical tests were performed on a representative soil samples to investigate the potential for soil corrosivity and chemical heave. Atlas Chemical Testing Laboratories, Inc. in Las Vegas performed the chemical analysis for water-soluble sulfates and sodium in general accordance with ASTM D516. The results of the chemical tests are presented on Drawing No. A-70.

Exploration Location	Depth (feet)	Soil Description	Percent Sodium	Percent Sulfate	Total Available Water Soluble sodium Sulfate (%)
B-5	10-15	Silty sand with gravel	0.07	0.13	0.20
B-8	19-20	Silty sand with gravel	0.07	0.06	0.08
B-101	5-10	Silty sand with gravel	0.17	0.06	0.08
B-102	0-5	Fill – Silty sand with gravel	0.17	0.03	0.05
B-106	0-5	Silty sand with gravel	0.15	0.08	0.12
B-106	29-30	Silty sand with gravel	0.15	0.06	0.08

Permeability

Falling head permeability tests were conducted on remolded samples in general accordance with modified ASTM procedure D2434. The soil was compacted in a mold 4.6 inches long and 4.0 inches in diameter to 85 or 90 percent of maximum dry density and at optimum moisture content. A falling head was applied to the sample and the flow of water through the sample was monitored. The permeability was calculated after the flow rate had stabilized. The result of the falling head permeability test is presented in the following table:

Exploration Location	Sample Depth (Feet)	Soil Description	k (cm/s)
B-5	20-25	Silty sand with gravel	5.3×10^{-4}
B-12	10-15	Silty sand with gravel	4.0×10^{-4}
B-102	20-25	Silty sand with gravel	1.0×10^{-4}
B-105	20-25	Well graded sand with silt and gravel	1.2×10^{-3}

Flexible wall permeameter tests were performed on selected samples by AP Engineering and Testing, Inc according to ASTM D5084. With the exception of one sample (B-105), all tested samples were undisturbed ring samples. The samples were placed in a triaxial machine with a constant confining pressure at the approximate in-place effective stress pressures. Results were generally consistent with the fal-

ling head permeability test results for the granular materials. Laboratory results are presented on Drawing Nos. A-71 through A-76 and summarized below:

Exploration Location	Sample Depth (Feet)	Soil Description	k (cm/s)
B-1	14-15	Silty sand with gravel	1.57×10^{-4}
B-4	24-25	Silty sand with gravel	1.47×10^{-4}
B-8	44-45	Sandy silt	2.90×10^{-5}
B-12	39-39.5	Silty clay	1.76×10^{-7}
B-103	44-45	Silty clay	3.83×10^{-7}
B-105*	30-35	Silty sand	3.05×10^{-4}

* Sample remolded to 85% relative compaction at optimum moisture.

Log No. B- 1

Date of Drilling: 9/23/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 53.0

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		FILL: SILTY SAND With Gravel; light brown, dry	▼		21				
2									
4		---moist	▼		26				
			▼		42				
6			▼						
8									
			▼		26		4		
10		SILTY SAND With Gravel (SM): dense, light brown, slightly moist	▼		33				
12									
14			▼		44				K
16									
18		---very dense	▼		35/5"				

End of Exploration at 55.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and Environmental Sciences

Drawing No. A-1

LV-51 8334701 GPJ

Log No. B- 1

Date of Drilling: 9/23/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 53.0

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Samples: Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SILTY SAND With Gravel (SM); dense, light brown, slightly moist			35				
22									G;F
24					35		7	108	
26									
28		---grayish brown							
					35/6"				
30		---very dense			53				A
32									G
34					35/3"				
36									
38		---dense			35/6"				

End of Exploration at 55.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and Environmental Sciences

Drawing No. A-2

LV-B1 9343701 GP

Log No. B- 1

Date of Drilling: 9/23/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 53.0

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Samples: Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SILTY SAND With Gravel (SM); dense, grayish brown, slightly moist	▼		42				
42									
44		—very dense	▼		58/7"				
46									
48									
			▼		35/4"				
50									
52		---wet							
54		SANDY LEAN CLAY (CL); very stiff, dark brown, moist	▼		35/6"				
56									
58									

End of Exploration at 55.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No.
99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and Environmental Sciences

Drawing No.
A-3

Log No. B- 4

Date of Drilling: 9/13/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 54.5

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		FILL: SILTY SAND With Gravel; brown, dry			17				
2		---POORLY GRADED GRAVELLY SAND			45				Sol
4					66/7"		3		
					35/4"				
6									
8									
		---SILTY SAND With Gravel			35/5"				
10					36				
12									
14		SILTY SAND With Gravel (SM); very dense, brown, dry			35/8"		5		DS
16									
18		---dense							
					43				

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY CN

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No.
99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and

Drawing No.

01 93343701 GPJ

Log No. B- 4

Date of Drilling: 9/13/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 54.5

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SILTY SAND With Gravel (SM); very dense, brown, dry			35/2"				
22									
24		--dense			49				K
26									
28									
		---few gravel			35		7	107	
30					42				
32									
34		---with gravel, very dense			35/8"		4		
36									
38		---with boulders							
		CEMENTED SAND AND GRAVEL: hard, brown, dry			20/0"				

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY MD

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and Environmental Sci

Drawing No.

Log No. B- 4

Date of Drilling: 9/13/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 54.5

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Samples: Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SILTY SAND With Gravel (SM); very dense, brown, dry			35/1"				
42									
44		—with boulders			35/0"				
46									
48		---partially cemented, moderately hard							
					35/0"				
50									
		CEMENTED SAND AND GRAVEL; hard, gray, dry							
52									
54		POORLY GRADED SAND (SP); dense, black, moist, very strong odor, heavy staining			44				
		LEAN CLAY (CL); stiff, grayish brown, dry							pp=2.0
56									
		CLAYEY SAND (SC); medium dense, brown, wet							
58									
		---strong odor			23				

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and Environmental Sciences

Drawing No. A-6

Log No. B- 5

Date of Drilling: 9/15/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 52.5

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving WL and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		FILL: SILTY SAND With Gravel; tan, dry			9				
2									
4		---slightly moist			35/5"				
					58				
6									
8		---with cobbles							
		SILTY SAND With Gravel (SM); dense, tan, slightly moist			31		5	115	
10					29				
12									K;Sol; Ch
14					43		4	111	DS
16									
18		---very dense			57/8"				

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and

Drawing No.

B1 93343701 CPJ

Log No. B- 5

Date of Drilling: 9/15/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 52.5

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Samples: Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SILTY SAND With Gravel (SM); dense, tan, slightly moist			32				A
22									G;P;C
24					58/8"				
		---very dense							
26									
28		---brown							
		CLAYEY SAND With Gravel (SC); dense, dark brown, slightly moist			35/5"		6	112	
30					35/6"				
		SILTY SAND With Gravel (SM); dense, black, slightly moist							
32		---dark brown							
34		---very dense			50/3"				
36									
38		---with cobbles			50/6"				

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and

Drawing No.

Log No. B- 5

Date of Drilling: 9/15/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 52.5

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Samples: Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SILTY SAND With Gravel (SM); dense, black, slightly moist			35/6"				
42									
44					35/0"				
46									
48									
					36				
50		SANDY LEAN CLAY With Gravel (CL); very stiff, dark brown, slightly moist							
52									
54		---moist			32				pp=3.0
56									
58					18				

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and

Drawing No.

Log No. B- 8

Date of Drilling: 9/14/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 58.0

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		FILL: SILTY SAND With Gravel; tan, dry			8				
2									
4					28				
					16				
6									
8									
		SILTY SAND With Gravel (SM); very dense, tan, dry			35/8"		2		
10					32				
12									
14					33/6"				
16									
18									
		---dense			38		4		Ch Sol

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and Environmental Sciences

Drawing No. A-10

Log No. B- 8

Date of Drilling: 9/14/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 58.0

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Samples: Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SILTY SAND With Gravel (SM); very dense, tan, dry			60/9"				
22									
24					54/9"		4		
26									
28									
					35/8"				
30					45		4		
32									
34					55				
36									G
38		SANDY LEAN CLAY (CL); very stiff, dark brown, slightly moist							
		---with gravel			30		46	69	

APPROVED BY ON

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and

Drawing No.

1 0334370 1 CPJ

Log No. B- 8

Date of Drilling: 9/14/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 58.0

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Samples: Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SANDY LEAN CLAY With Gravel (CL); very stiff, dark brown, slightly moist	▼		49				
42									
44		—dry	▼		35/8"				K
46									
48									
		---partially cemented, moderately hard, white, dry							
		SANDY LEAN CLAY (CL); very stiff, dark brown, moist	▼		35/10"				pp=3.
50									
52									
54			▼		16		52	71	pp=2.(
56									
58		SILTY SAND (SM); dense, brown, wet							
		SANDY LEAN CLAY (CL); stiff, dark brown, wet	▼		13		51	70	pp=3.(

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery

APPROVED BY ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and

Drawing No. A-12

99 B1 9334370 1 GPJ

Log No. B-10

Date of Drilling: 9/13/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 46.5

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Samples: Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		FILL: SILTY SAND With Gravel; tan, dry			26				
2									
4		SILTY SAND With Gravel (SM); medium dense, tan, slightly moist			25		5		
					20				
6									
8									
		---very dense			39				
10					60/8"				
		---cobbles							
12									
14		---partially cemented, moderately hard			35/1"				
16									
18					35/1"				

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No.
99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and Environmental Sciences

Drawing No.
A-13

Log No. B-10

Date of Drilling: 9/13/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 46.5

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

Depth (ft)	Graphic Log	SUMMARY OF SUBSURFACE CONDITIONS	Samples: Drive	Samples: Bulk	Samples: Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.							
		SILTY SAND With Gravel (SM); partially cemented, moderately hard, tan, slightly moist			35/0"				
22									
24		—with cobbles			35/1"				
26									
28									
					35/0"				
30		SILTY SAND With Gravel and Cobbles (SM); very dense, brown, slightly moist			35/3"				
32									A.G
34		---cobbles and boulders			35/3"				
		LEAN CLAY With Gravel (CL); very stiff, light brown, dry							
36									
38					35/6"				

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and Environmental Sciences

Drawing No. A-14

B1 9334370 GPJ

Log No. B-10

Date of Drilling: 9/13/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 46.5

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		LEAN CLAY (CL); very stiff, light brown, dry	▼▲		35				
42		SILTY SAND With Boulders (SM); very dense, brown, dry							
44		LEAN CLAY With Gravel (CL); stiff, dark brown, moist	▼▲		13				pp=1.2
46									
48		SILTY SAND With Gravel and Caliche Nodules (SM); medium dense, dark brown, moist							
		SANDY LEAN CLAY (CL); very stiff, dark grayish brown, wet	▼▲		30		17	106	
50									
52									
54			▼▲		26		68	60	DS pp=1.5
56									
58			▼▲		16				

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No.
99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and Environmental Sciences

Drawing No.
A-15

99-33437-01 GPJ

Log No. B-12

Date of Drilling: 9/14/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 37.5

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		FILL: SILTY SAND With Gravel; tan, dry							
2					16				
4					25				
					35/4"				
6									
8									
					35/2"				
10		SILTY SAND With Gravel (SM): very dense, tan, dry			35/7"				
12		---cobbles							AGP KDS
14					35/7"		2		
16									
18		---cobbles							
		SILTY SAND With Gravel (SM); very dense, light brown, dry			35/6"				

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and Environmental Sciences

Drawing No. A-16

31 93343701 CPJ

Log No. B-12

Date of Drilling: 9/14/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 37.5

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Description	Samples: Drive	Samples: Bulk	Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SILTY SAND With Gravel (SM); very dense, light brown, dry			35/6"				
22		CEMENTED SAND AND GRAVEL; hard, grayish brown, dry							
		SILTY SAND With Gravel (SM); very dense, tan, dry							
24					35/5"		2		
26									
28									
		---with gypsum, dense			35		3		
30		---with clay			35				
32									
34					28		5		
36									
		SANDY LEAN CLAY (CL); very stiff, dark brown, moist							
38		---slight odor							
					21				K pp=3.0

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and Environmental Sciences

Drawing No. A-17

LV-B1 933437-01.GPJ

Log No. B-12

Date of Drilling: 9/14/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 37.5

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

Depth (ft)	Graphic Log	SUMMARY OF SUBSURFACE CONDITIONS This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.	Samples: Drive	Samples: Bulk	Samples: Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SANDY LEAN CLAY (CL); very stiff, dark brown, moist	▼		44				
42									
44									
		—wet, stiff	▼		15		80	53	pp=1..
46									
48									
			▼		11				
50									
52									
		---with gravel, very stiff							
54			▼		16		31	87	pp=1..
56									
58									
			▼		18				pp=1..

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY GN

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No.
99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and Environmental Sciences

Drawing No.
A-18

Log No. B-101

Date of Drilling: 9/20/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 42.0

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SILTY SAND With Gravel (SM); occasional cobbles, medium dense, tan, slightly moist			11				
2									
4		---dense			35				
					21				
6									G.P. Sol:Ch
8									
					42		4		
10					39				
12									
14					42				
16									
18									
		---very dense			35/1"				

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and Environmental Sciences

Drawing No. A-19

DRAFTED BY GLE
APPROVED BY ON
BK-81 03343701 CPJ

Log No. B-101

Date of Drilling: 9/20/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 42.0

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SILTY SAND With Gravel (SM); occasional cobbles, very dense, tan, slightly moist			55				
22									
24					35/7"		4		
26									
28									
		---dense			35/8"		4		
30					35				
32									
34					35/9"				
36									
38		SANDY LEAN CLAY (CL): very stiff, dark brown, slightly moist			21		52	64	ADS

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No.
99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and Environmental Sciences

Drawing No.
A-20

Log No. B-101

Date of Drilling: 9/20/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 42.0

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
					10				
		SILTY SAND With Gravel (SM); medium dense, grayish brown, dry							
42									
		SANDY LEAN CLAY (CL); stiff, dark brown, moist							
44					11		45	67	
46									
48									
					25				pp=1.5
50		---partially cemented lens, moderately hard, brownish white, wet							
52									
54					11		42	75	A
		---with gravel							
56									
58									
					14		42	74	

APPROVED BY ON

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and Environmental Sciences

Drawing No. A-21

99-33437-01.GPJ

Log No. B-102

Date of Drilling: 9/23/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 43.0

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

Depth (ft)	Graphic Log	SUMMARY OF SUBSURFACE CONDITIONS This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.	Samples: Drive	Samples: Bulk	Samples: Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SILTY SAND With Gravel (SM); very dense, light brown, slightly moist			35/5"				
22									A;G;K; DS
24					35/8"				
		---with cobbles							
26									
28									
					35/4"				
30					35/10"				
32									
34		---dense			35/6"		5		
36									
38		---partially cemented, moderately hard			35/0"				

End of Exploration at 50.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY CEH ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No.
99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and Environmental Sciences

Drawing No.
A-22

99 03343701 GPJ

Log No. B-102

Date of Drilling: 9/23/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 43.0

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Samples: Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SILTY SAND With Gravel (SM); trace clay, very dense, light brown, slightly moist			35/9"				
		---with cobbles							
42		SANDY LEAN CLAY (CL); very stiff, dark brown, moist							
44					28				
46									
48									
		---stiff			13		48	68	A
50									
52									
54									
56									
58									

APPROVED BY ON

End of Exploration at 50.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and Environmental Sciences

Drawing No. A-24

99-33437-01 GPJ

Log No. B-103

Date of Drilling: 9/21/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 42.5

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Samples: Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		FILL: SILTY SAND With Clay; tan, dry			14				
2									
4					14				
		SILTY SAND With Gravel (SM); dense, tan, dry			26				
6		---with cobbles							
8									
					35		4		
10					25				
12									
14					42				
16									
18									
					26		3		

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and Environmental Sciences

Drawing No. A-25

V-01 9333701.GPJ

Log No. B-103

Date of Drilling: 9/21/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 42.5

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Samples: Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SILTY SAND With Gravel (SM); medium dense, tan, dry			24				
22									
24		---with cobbles, very dense			35/5"		3		
26									
28									
					35/0"				
30					59/8"				
32									A.G
34					62/8"				
36									
38		---partially cemented, moderately hard			35/0"				

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and

Drawing No.

LAB 9334370 GPJ

Log No. B-103

Date of Drilling: 9/21/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 42.5

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Samples: Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SILTY SAND With Gravel (SM); partially cemented, moderately hard, tan, dry							
42		SANDY LEAN CLAY (CL); very stiff, dark brown, slightly moist							
44			▼		21				K
		---stiff	◆		13				pp=2.5
46			▲						
48									
			▽		12		88	51	DS
50			△						
52									
54			▽		10				
			△						
56									
58			▽		12				
			△						

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY GLE ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and Environmental Sciences

Drawing No. A-27

81 93343701.CPJ

Log No. B-104

Date of Drilling: 9/21/99
Driller: D. Wilson
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 43.5

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		FILL: SILTY SAND With Gravel; tan, dry			9				
2		SILTY SAND With Gravel and Cobbles (SM); dense, tan, slightly moist							Sol
4					35/7"		3		
		—very dense			35/3"				
6									
8									
					45				
10					35/6"				
12									A.G.DS
14					55/7"		1		
16									
18									
					35/2"				

End of Exploration at 54.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No.
99-33437-01

Drawing No.
A-28

Converse Consultants

Over 50 Years of Dedication in Engineering and Environmental Sciences

31 03343701 CPJ

Log No. B-104

Date of Drilling: 9/21/99
Driller: D. Wilson
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 43.5

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Samples: Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		CEMENTED SAND AND GRAVEL; hard, tan, dry							
42									
		SILTY SAND (SM); medium dense, gray, wet							
44		SANDY LEAN CLAY (CL); very stiff, dark brown, slightly moist			18				pp=1..
46									
48									
					16				
50									
52									
54									
56									
58									

APPROVED BY ON

End of Exploration at 54.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and

Drawing No. A-20

01 99-33437-01 GPJ

Log No. B-105

Date of Drilling: 9/22/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 30.0

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		FILL: SILTY SAND With Clay and Gravel; tan, dry			6				
2		WELL GRADED SAND With Silt and Gravel (SW-SM); trace clay, dense, tan, slightly moist							
		—with cobbles, very dense							
4					35/4"				
					35/7"				
6									
8									
		---dense			35/8"		5		
10					35/4"				
12									G
14		---very dense			60/9"		4		
16									
		---partially cemented, moderately hard							
18									
					52				

End of Exploration at 40.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and

Drawing No. A-24

Log No. B-105

Date of Drilling: 9/22/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 30.0

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Samples: Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		WELL GRADED SAND With Silt and Gravel (SW-SM); dense, grayish brown, slightly moist			44				
22									A;P;K
24					35/1"				
26									
28									
		---with cobbles			35/3"				
30					35/2"		3		
32									K
34					35		13	122	
36									
38		CEMENTED SAND AND GRAVEL; hard, grayish brown, slightly moist			35/0"				

End of Exploration at 40.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY GN

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and

Drawing No. A-22

99 9334370 1 GPJ

Log No. B-106

Date of Drilling: 9/22/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 30.0

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SILTY SAND With Gravel (SM); medium dense, grayish brown, dry			23				
2									A;G;Sol; Ch
4		---very dense			35/6"		7	111	
		---tan			52/9"				
6									
8									
					44				
10		---dense			37				
12									
		---very dense							
14					60/11"		5		
16									
18									
					58/7"				

End of Exploration at 33.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and

Drawing No. A-33

Log No. B-106

e of Drilling: 9/22/99
er: T. High
ged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 30.0

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Samples: Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SILTY SAND With Gravel (SM); dense, grayish brown, dry			35/2"				
22									
		—with cobbles							
24					35/6"				
26									
28									
					35/8"		15	114	Ch
30		---gray, wet							
		CEMENTED SAND AND GRAVEL; hard, gray, wet							
32									
34									
36									
38									

End of Exploration at 33.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

Drawing No. A-34

Converse Consultants

Over 50 Years of Dedication in Engineering and Environmental Sciences

99-33437-01.GPJ

KEY TO SOILS SYMBOLS AND TERMS

Terms used in this report for describing soils according to thier texture and grain size distributions are generally in accordance with the UNIFIED SOILS CLASSIFICATION SYSTEM.

TERMS DESCRIBING CONDITION, CONSISTENCY, AND HARDNESS

COARSE GRAINED SOILS (major portion retained on No. 200 sieve) includes cleon gravels, silty or clayey gravels, and silty, clayey, or gravelly sands. Consistency is rated according to relative density, os determined by laboratory tests.

DESCRIPTIVE TERM	RELATIVE DENSITY
very loose	0 to 15%
loose	15 to 40%
medium dense	40 to 70%
dense	70 to 85%
very dense	85 to 100%

FINE GRAINED SOILS (major portion passing No. 200 sieve) includes inorganic and organic silts and clays, gravelly, silty, or sandy clays, and clayey silts. Consistency is rated according to shearing strength as indicated by penetrometer readings or by direct shear tests.

DESCRIPTIVE TERM	SHEAR STRENGTH (ksf)
very soft	less than 0.25
soft	0.25 to 0.50
firm	0.50 to 1.00
stiff	1.00 to 2.00
very stiff	2.00 to 4.00
hard	4.00 and up

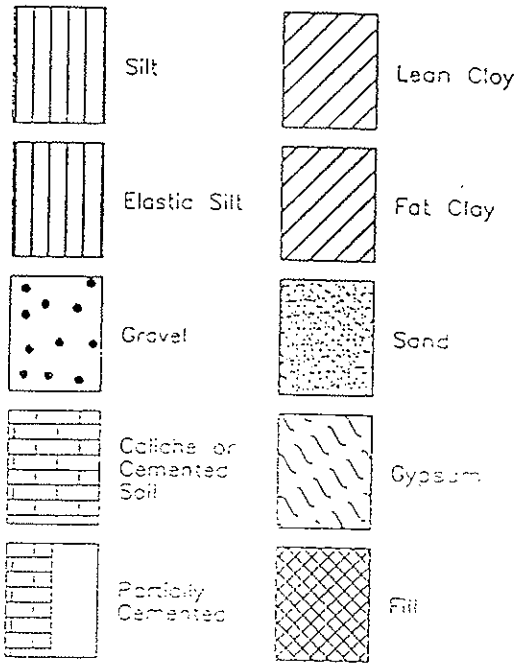
ROCK includes gravels, cobbles, rock, caliche, and bedrock materials. Hardness is relcted to field identification procedures described below.

DESCRIPTIVE TERM	SHEAR STRENGTH (ksf)
soft	can be dug by hand and crushed by fingers
moderately hard	friable, can be gouged deeply with knife and will crumble readily under light hammer blows
hard	knife scratch leaves dust trace and will withstand a few hammer blows before breaking
very hard	scratched with knife with difficulty and is difficult to break with hammer blows

SIZE PROPORTIONS

DESIGNATION	PERCENT BY WEIGHT
trace	0 to 5
few	5 to 10
little	15 to 25
some	30 to 45

SOIL TYPE GRAPHIC KEY



SOIL TYPE GRAPHIC KEY

MOISTURE CONTENT IS INDICATED BY

dry
slightly moist
moist
very moist
wet

LEGEND OF LABORATORY TESTS

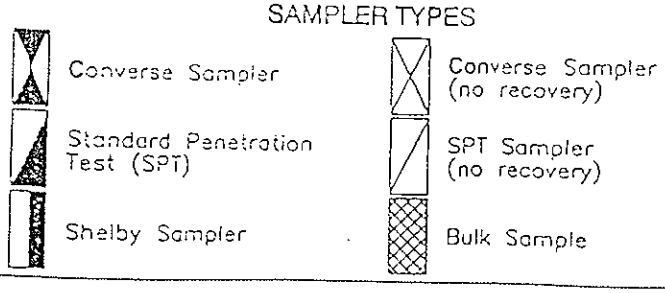
A	Liquid & Plastic Limits	G	Grain	R	Resistivity
C	Consolidation	H	Horticultural Tests	RV	R-Value
Ch	Chemical	K	Permeability	S	Swell
Disp	Dispersion	N	Chemical Heave	Sol	Solubility
DR	Drill Rate	P	Compaction	T	Triaxial
DS	Direct Shear	pp	Unconfined Compressive Strength (tsf)	UU	Unconsolidated, Undrained

GROUNDWATER LEVEL KEY

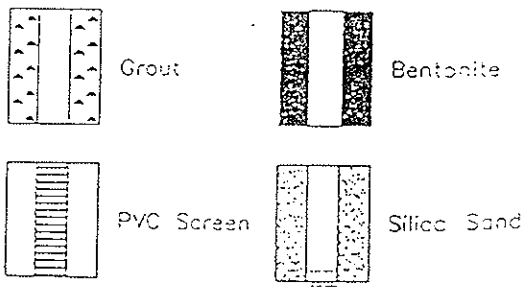
Water level during drilling

Stabilized water level

SAMPLER TYPES



WELL DESIGN GRAPHIC KEY



CONVERSE CONSULTANTS

Over 50 Years of Dedication in Engineering and Environmental Sciences

Drawing No.

A-35

CLASSIFICATION OF SOILS

ASTM Designation: D2487-93
(ASTM version of Unified Soil Classification System)

			Criteria for Assigning Group Symbols and Group Names using Laboratory Tests[a]	Soil Classification Group Symbol	Soil Classification Group Name[b]
COARSE-GRAINED SOILS More than 50% retained on No. 200 sieve	Gravels More than 50% of coarse fraction retained on #4 sieve	Clean Gravels Less than 5% fines[c]	$Cu \geq 4$ and $1 \leq Cc \leq 3$[e]	GW	Well-graded gravel[f]
			$Cu < 4$ and/or $Cc < 1$ or $Cc > 3$[e]	GP	Poorly graded gravel[f]
		Gravels with Fines More than 12% fines[c]	Fines classify as ML or MH	GM	Silty gravel[f,g,h]
			Fines classify as CL or CH	GC	Clayey gravel[f,g,h]
	Sands 50% or more of coarse fraction passes #4 sieve	Clean Sands Less than 5% fines[d]	$Cu \geq 6$ and $1 \leq Cc \leq 3$[e]	SW	Well-graded sand[i]
			$Cu < 6$ and/or $Cc < 1$ or $Cc > 3$[e]	SP	Poorly graded sand[i]
		Sands with Fines More than 12% fines[d]	Fines classify as ML or MH	SM	Silty sand[g,h,i]
			Fines classify as CL or CH	SC	Clayey sand[g,h,i]
FINE-GRAINED SOILS 50% or more passes the No. 200 sieve	Silts and Clays Liquid limit less than 50	Inorganic	PI > 7 and plots on or above "A" line[j]	CL	Lean clay[k,l,m]
			PI < 4 or plots below "A" line[j]	ML	Silt[k,l,m]
		Organic	Liquid limit - oven dried / Liquid limit - not dried < 0.75	OL	Organic clay[k,l,m,n] / Organic silt[k,l,m,o]
	Silts and Clays Liquid limit 50 or more	Inorganic	PI plots on or above "A" line	CH	Fat clay[k,l,m]
			PI plots below "A" line	MH	Elastic silt[k,l,m]
		Organic	Liquid limit - oven dried / Liquid limit - not dried < 0.75	OH	Organic clay[k,l,m,p] / Organic silt[k,l,m,q]
HIGHLY ORGANIC SOILS	Primarily organic matter, dark in color, and organic odor			PT	Peat

a. Based on the material passing the 3-in. (75-mm) sieve.

b. If field sample contained cobbles or boulders, or both, add "with cobbles" or "with boulders", or both to group name.

c. GW-GM well graded gravel with silt
GW-GC well graded gravel with clay
GP-GM poorly graded gravel with silt
GP-GC poorly graded gravel with clay

d. Sands with 5-12% fines require dual symbols:
SW-SM well graded sand with silt
SW-SC well graded sand with clay
SP-SM poorly graded sand with silt
SP-SC poorly graded sand with clay

e. $Cu = \frac{D_{60}}{D_{10}}$ $\quad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$

f. If soil contains ≥ 15% sand, add "with sand" to group name.

g. If fines classify as CL-ML, use dual symbol GC-GM or SC-SM.

h. If fines are organic, add "with organic fines" to group name.

i. If soil contains ≥ 15% gravel, add "with gravel" to group name.

j. If Atterberg limits plot in hatched area, soil is a CL-ML silty clay.

k. If soil contains 15-29% plus No. 200, add "with sand" or "with gravel", whichever is predominant.

l. If soil contains ≥ 30% plus No. 200, predominantly sand, add "sandy" to group name.

m. If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

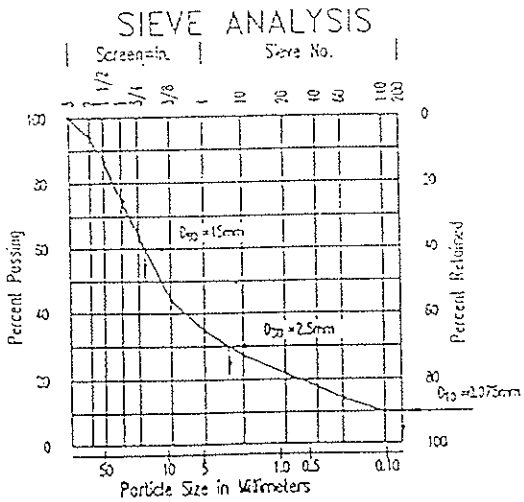
n. PI ≥ 4 and plots on or above "A" line

o. PI < 4 or plots below "A" line

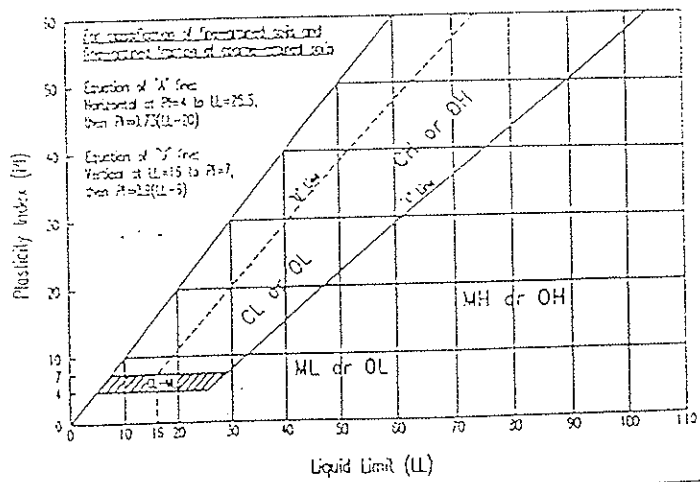
p. PI plots on or above "A" line

q. PI plots below "A" line

SIEVE ANALYSIS



$Cu = \frac{D_{60}}{D_{10}} = \frac{15}{0.075} = 200$ $\quad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}} = \frac{(2.5)^2}{0.075 \times 15} = 5.6$

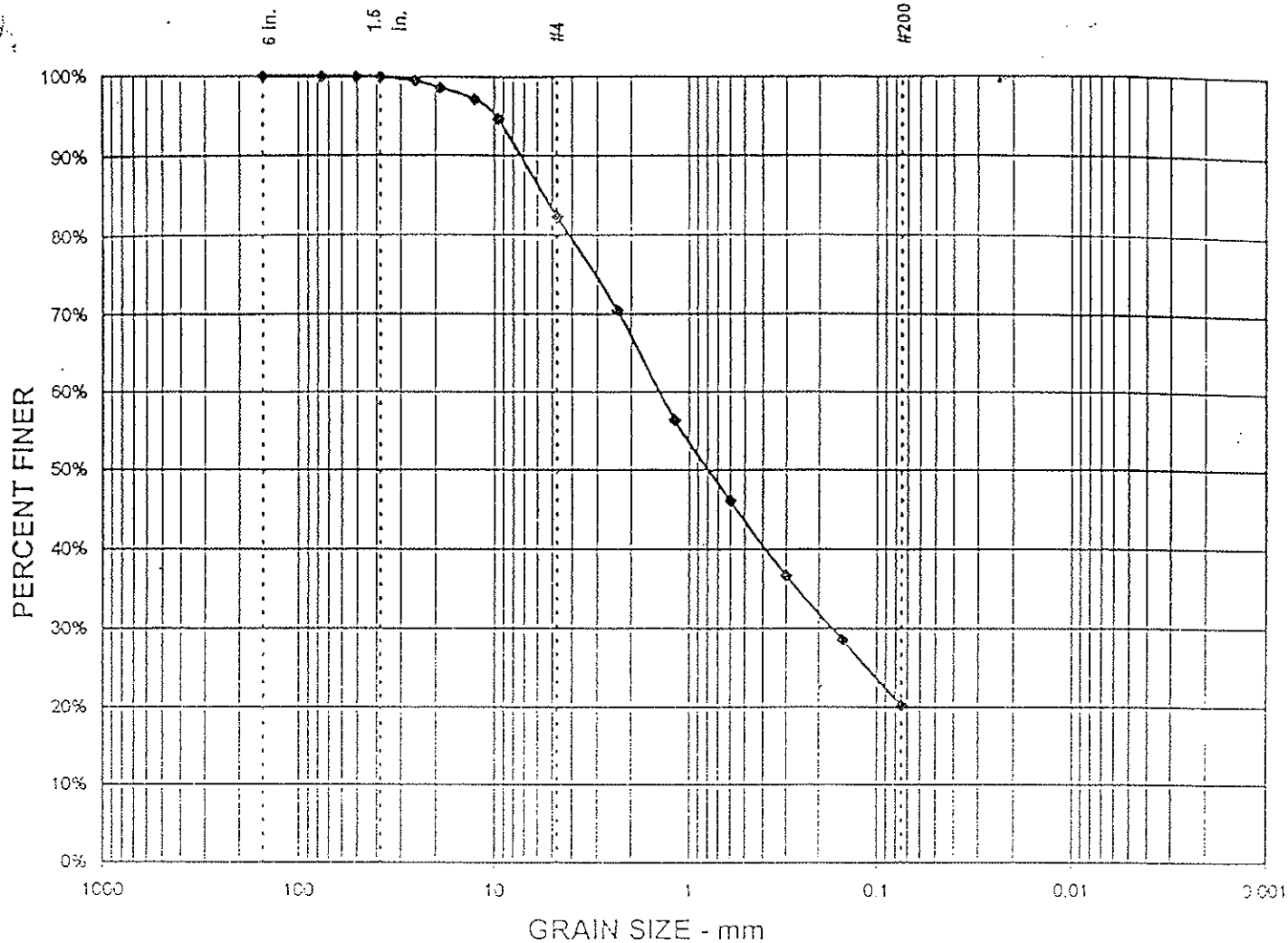


Drawing No.

CONVERSE CONSULTANTS

Over 50 Years of Dedication in Engineering and Environmental Sciences

GRAIN SIZE DISTRIBUTION GRAPH



TEST SUMMARY

% GRAVEL =	18%	D_{85} = 5.5	D_{15} =
% SAND =	62%	D_{50} = 1.4	D_{10} =
% SILT & CLAY =	20%	D_{50} = 0.8	C_u =
		D_{30} = 0.2	C_c =

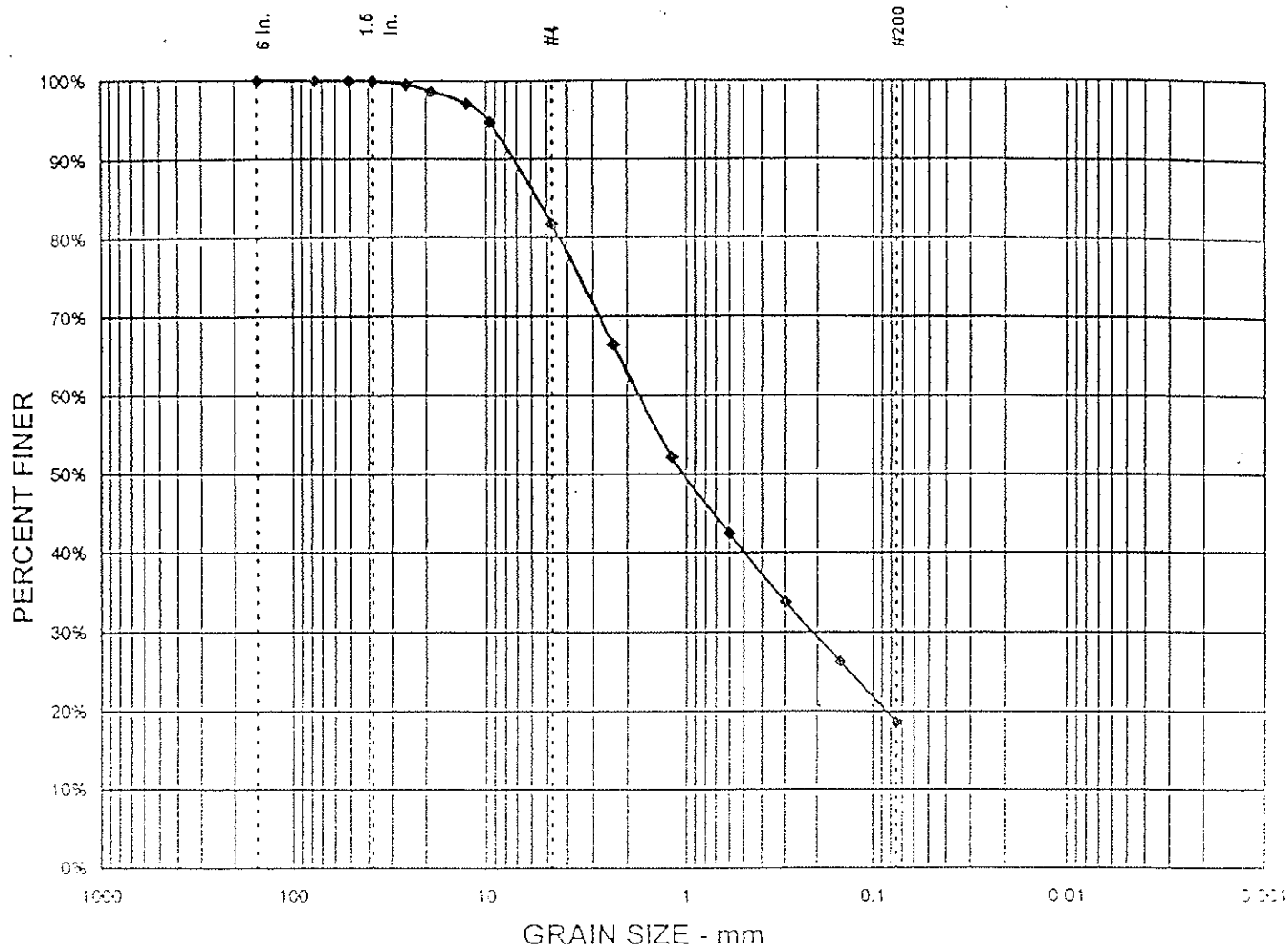
Project No.: 99-33437-01
Project Name: BMI Landfill
Date sampled: Oct 1999
Location: B 1 @ 20-25'
Silty Sand with Gravel

GRAIN SIZE DISTRIBUTION TEST REPORT

CONVERSE CONSULTANTS

Drawing No. A-37

GRAIN SIZE DISTRIBUTION GRAPH



TEST SUMMARY

% GRAVEL =	18%	D_{85} = 5.6	D_{15} =
% SAND =	63%	D_{60} = 1.7	D_{10} =
% SILT & CLAY =	19%	D_{50} = 1.0	C_u =
		D_{30} = 0.2	C_c =

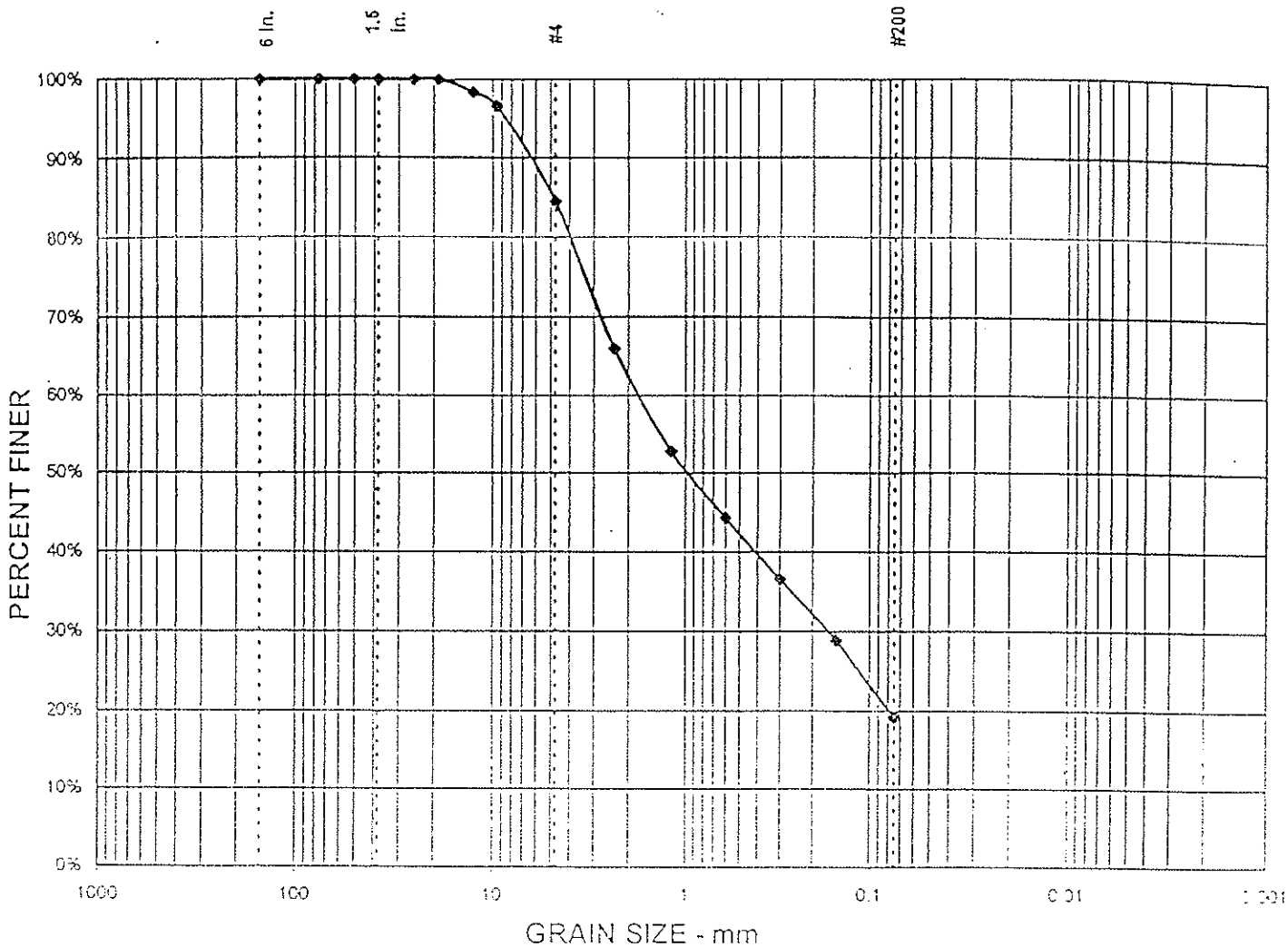
Project No.: 99-33437-01
Project Name: BMI Landfill
Date sampled: Oct 1999
Location: B 1 @ 30-35'
Silty Sand with Gravel

GRAIN SIZE DISTRIBUTION TEST REPORT

CONVERSE CONSULTANTS

Drawing No. A-38

GRAIN SIZE DISTRIBUTION GRAPH



TEST SUMMARY

% GRAVEL =	16%	D_{85} = 4.9	D_{15} =
% SAND =	65%	D_{60} = 1.7	D_{10} =
% SILT & CLAY =	19%	D_{50} = 0.9	C_u =
		D_{30} = 0.2	C_c =

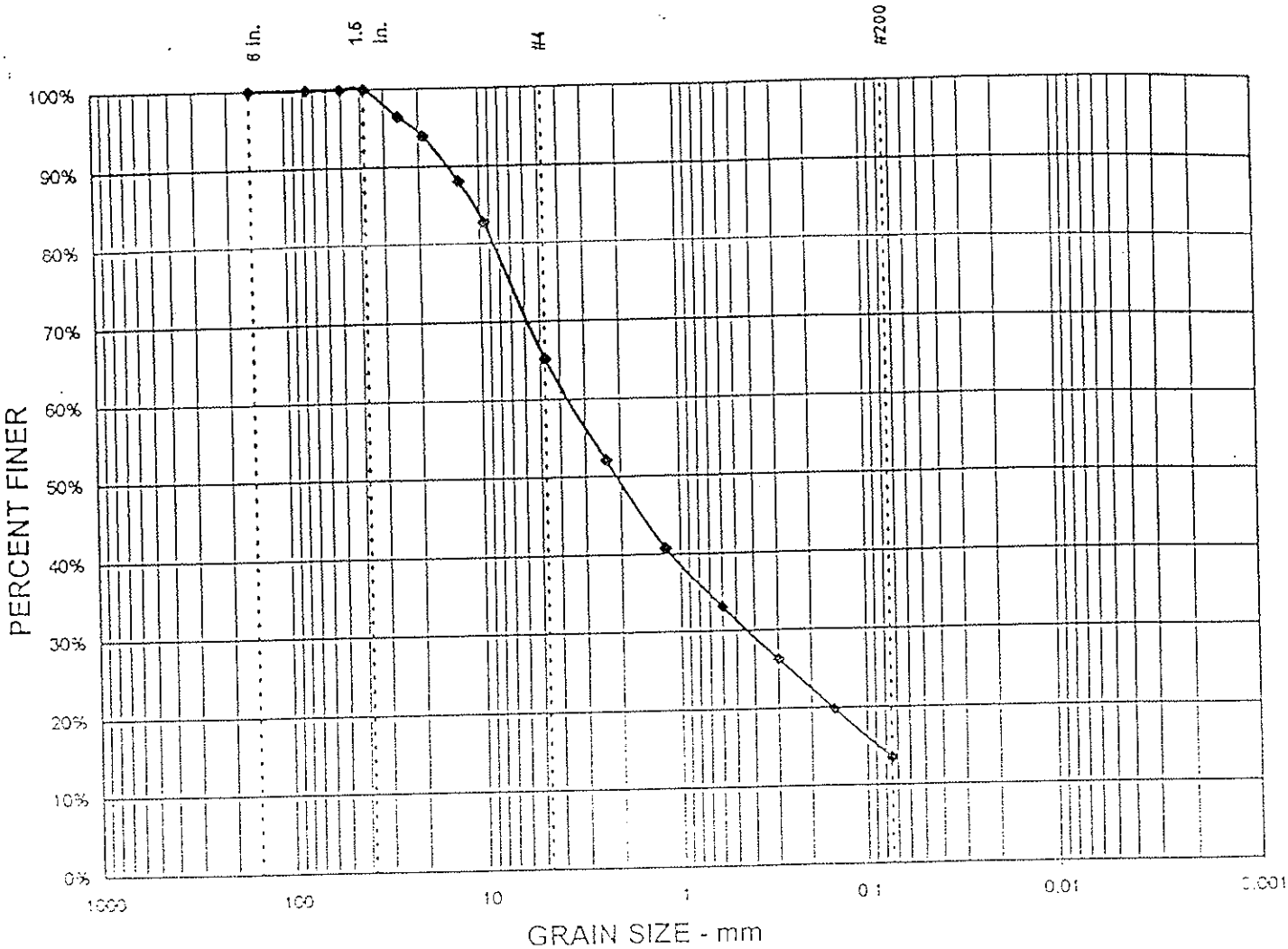
Project No.: 99-33437-01
Project Name: BMI Landfill
Date sampled: Oct 1999
Location: B5 @ 20-25'
Silty Sand with Gravel

GRAIN SIZE DISTRIBUTION TEST REPORT

CONVERSE CONSULTANTS

Drawing No. A-39

GRAIN SIZE DISTRIBUTION GRAPH



TEST SUMMARY

% GRAVEL =	35%	D_{35} = 10.8	D_{15} = 0.1
% SAND =	52%	D_{50} = 3.6	D_{10} =
% SILT & CLAY =	14%	D_{50} = 2.1	C_u =
		D_{30} = 0.4	C_c =

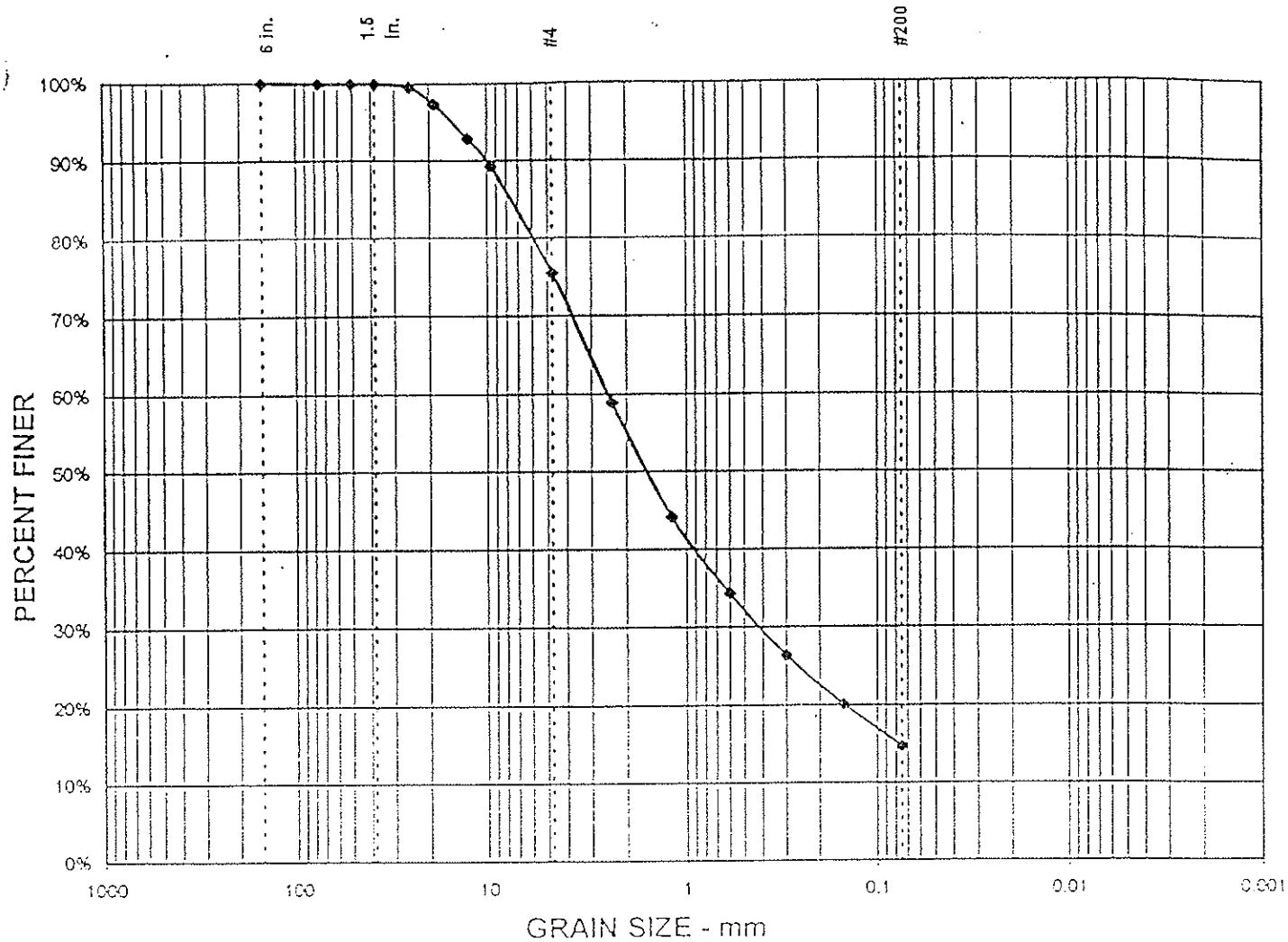
Project No.: 99-33437-01
Project Name: BMI Landfill
Date sampled: Oct 1999
Location: B 8 @ 35-40'
Silty Sand with Gravel

GRAIN SIZE DISTRIBUTION TEST REPORT

CONVERSE CONSULTANTS

Drawing No. A-4

GRAIN SIZE DISTRIBUTION GRAPH



TEST SUMMARY

% GRAVEL =	24%	D_{35} = 7.7	D_{15} = 0.1
% SAND =	61%	D_{50} = 2.5	D_{10} =
% SILT & CLAY =	15%	D_{50} = 1.5	C_u =
		D_{30} = 0.4	C_c =

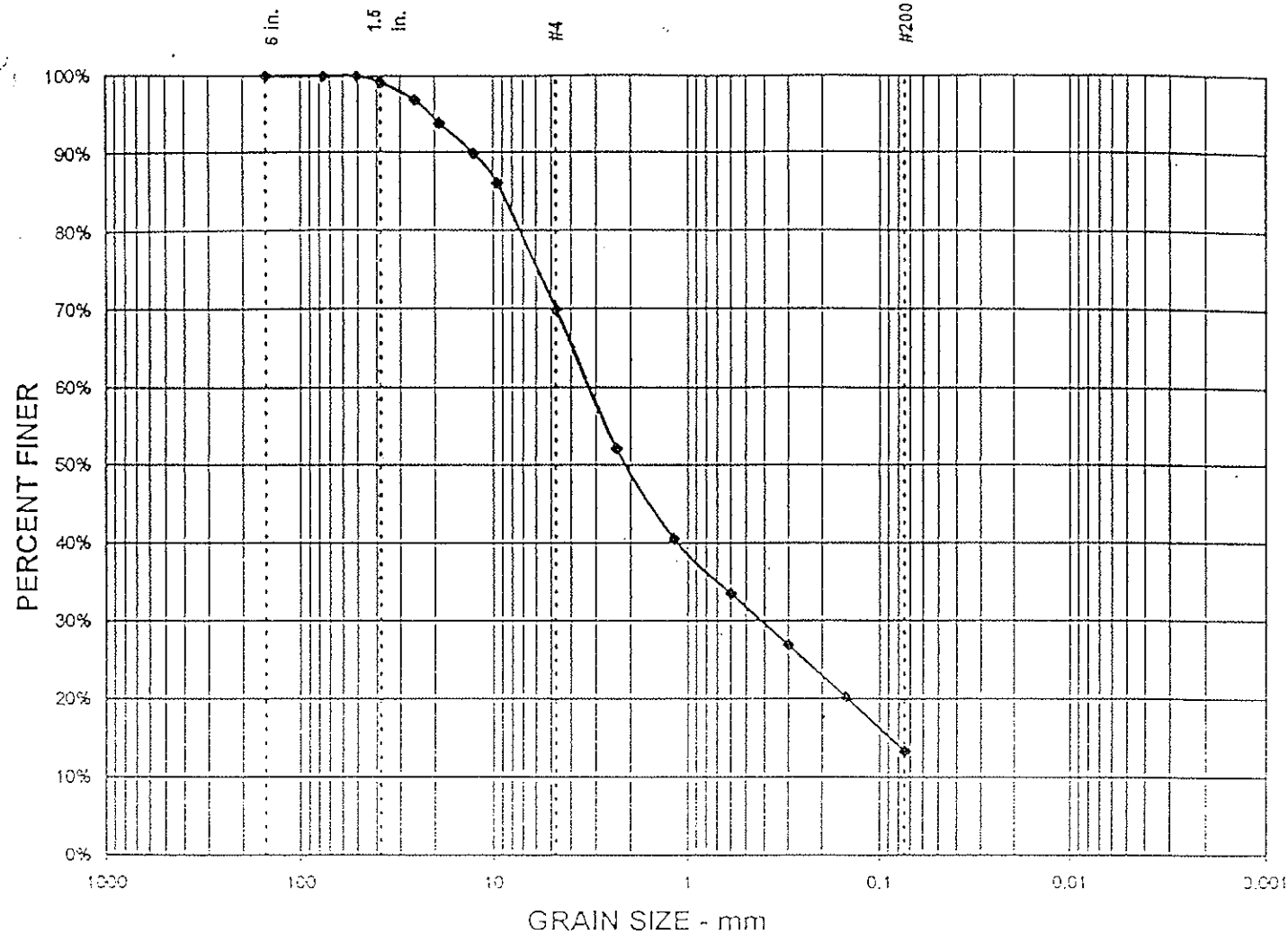
Project No.: 99-33437-01
Project Name: BMI Landfill
Date sampled: Oct 1999
Location: B 10 @ 30-35'
Silty Sand with Gravel

GRAIN SIZE DISTRIBUTION TEST REPORT

CONVERSE CONSULTANTS

Drawing No. A-41

GRAIN SIZE DISTRIBUTION GRAPH



TEST SUMMARY

% GRAVEL =	30%	D_{85} = 9.1	D_{15} = 0.1
% SAND =	57%	D_{60} = 3.2	D_{10} =
% SILT & CLAY =	13%	D_{50} = 2.1	C_u =
		D_{30} = 0.4	C_c =

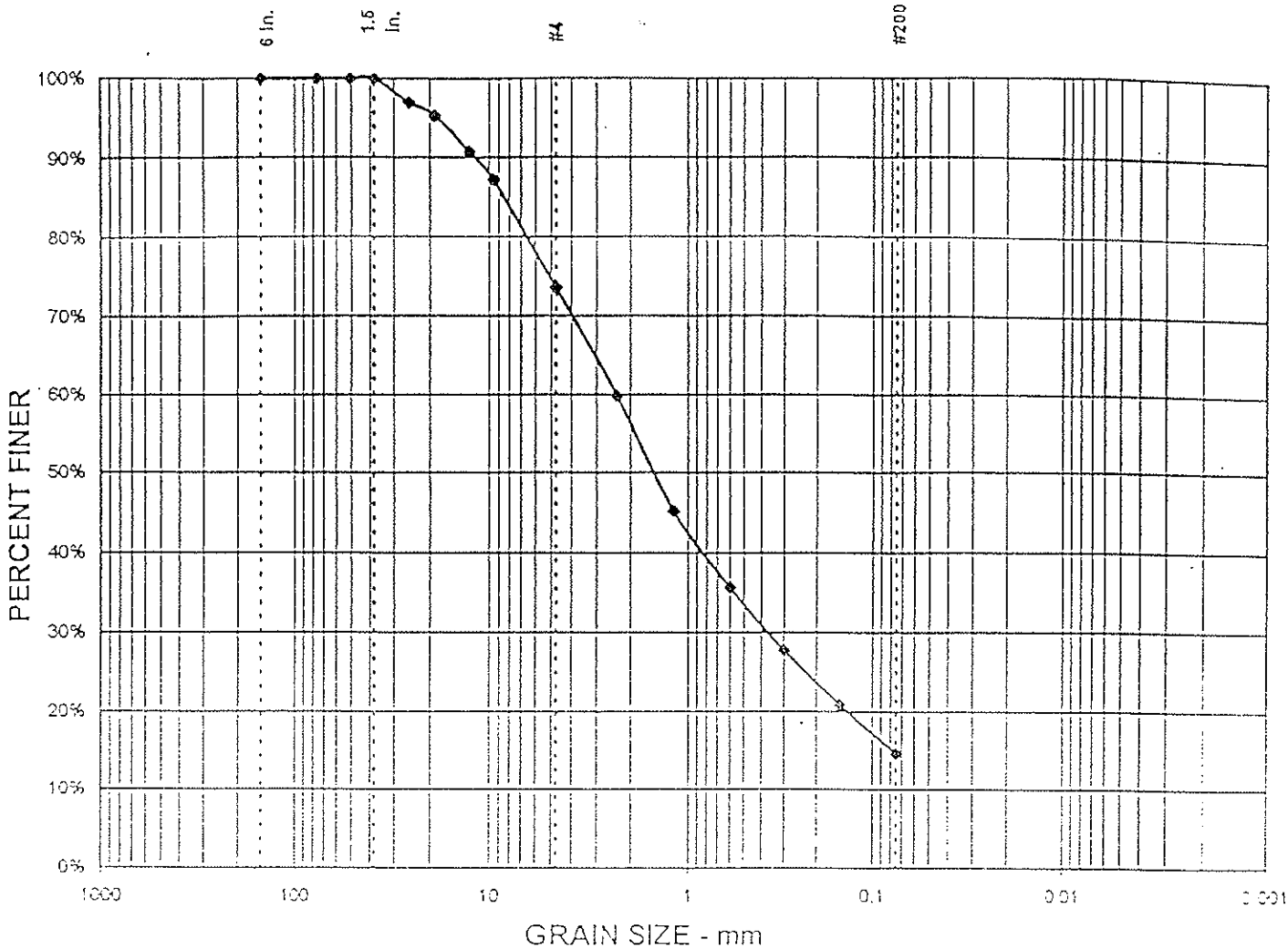
Project No.: 99-33437-01
Project Name: BMI Landfill
Date sampled: 10/01/99
Location: B12 @ 10-15'
Silty Sand with Gravel

GRAIN SIZE DISTRIBUTION TEST REPORT

CONVERSE CONSULTANTS

Drawing No. A-42

GRAIN SIZE DISTRIBUTION GRAPH



TEST SUMMARY

% GRAVEL =	26%	D_{85} = 8.5	D_{15} = 0.1
% SAND =	59%	D_{60} = 2.4	D_{10} =
% SILT & CLAY =	15%	D_{50} = 1.5	C_u =
		D_{30} = 0.4	C_c =

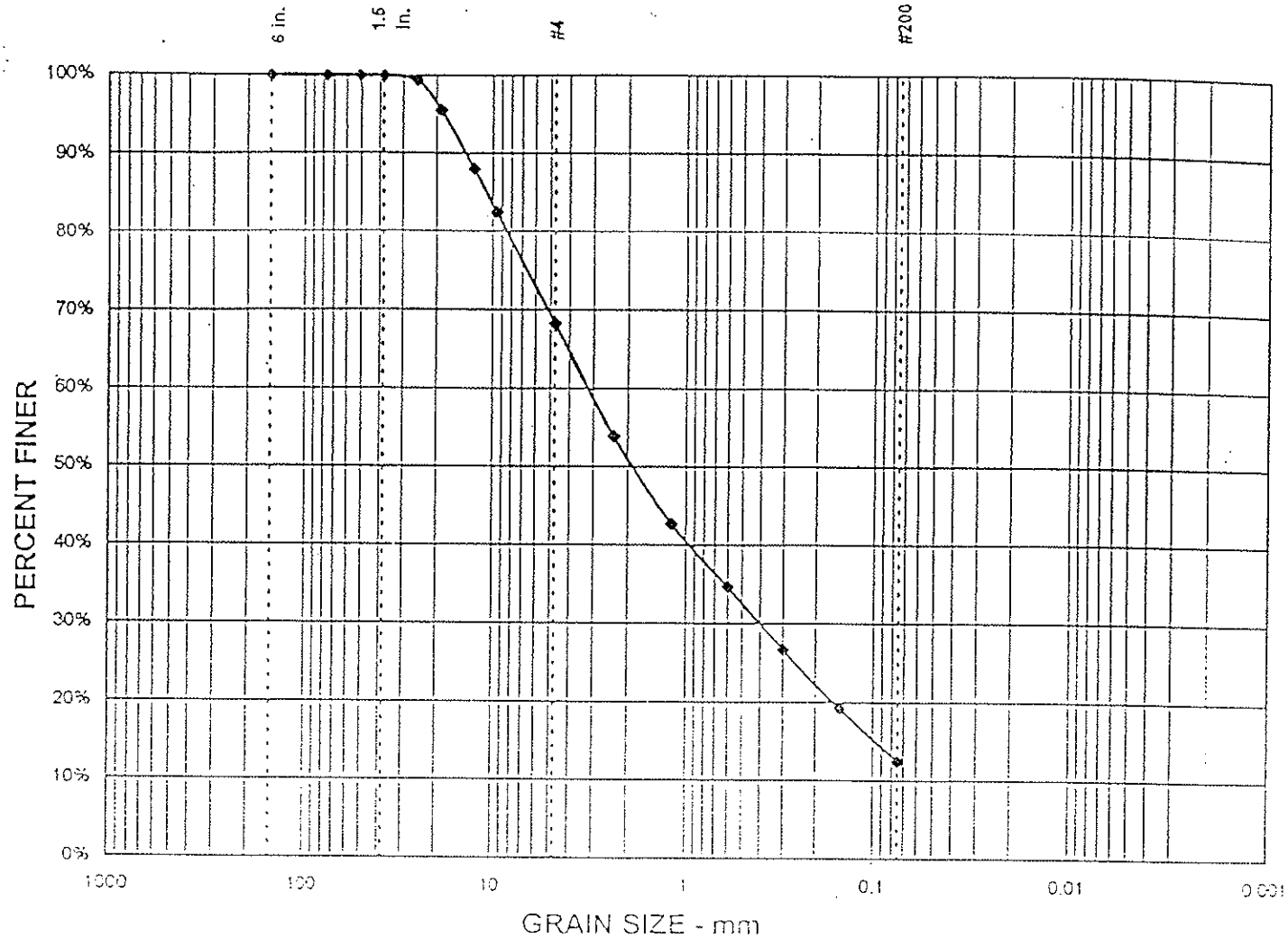
Project No.: 99-33437-01
Project Name: BMI Landfill
Date sampled: Oct 1999
Location: B 101 @ 5-10'
Silty Sand with Gravel

GRAIN SIZE DISTRIBUTION TEST REPORT

CONVERSE CONSULTANTS

Drawing No. A-4

GRAIN SIZE DISTRIBUTION GRAPH



TEST SUMMARY

% GRAVEL =	32%	D_{85} = 10.9	D_{15} = 0.1
% SAND =	56%	D_{60} = 3.2	D_{10} =
% SILT & CLAY =	12%	D_{50} = 1.9	C_u =
		D_{30} = 0.4	C_c =

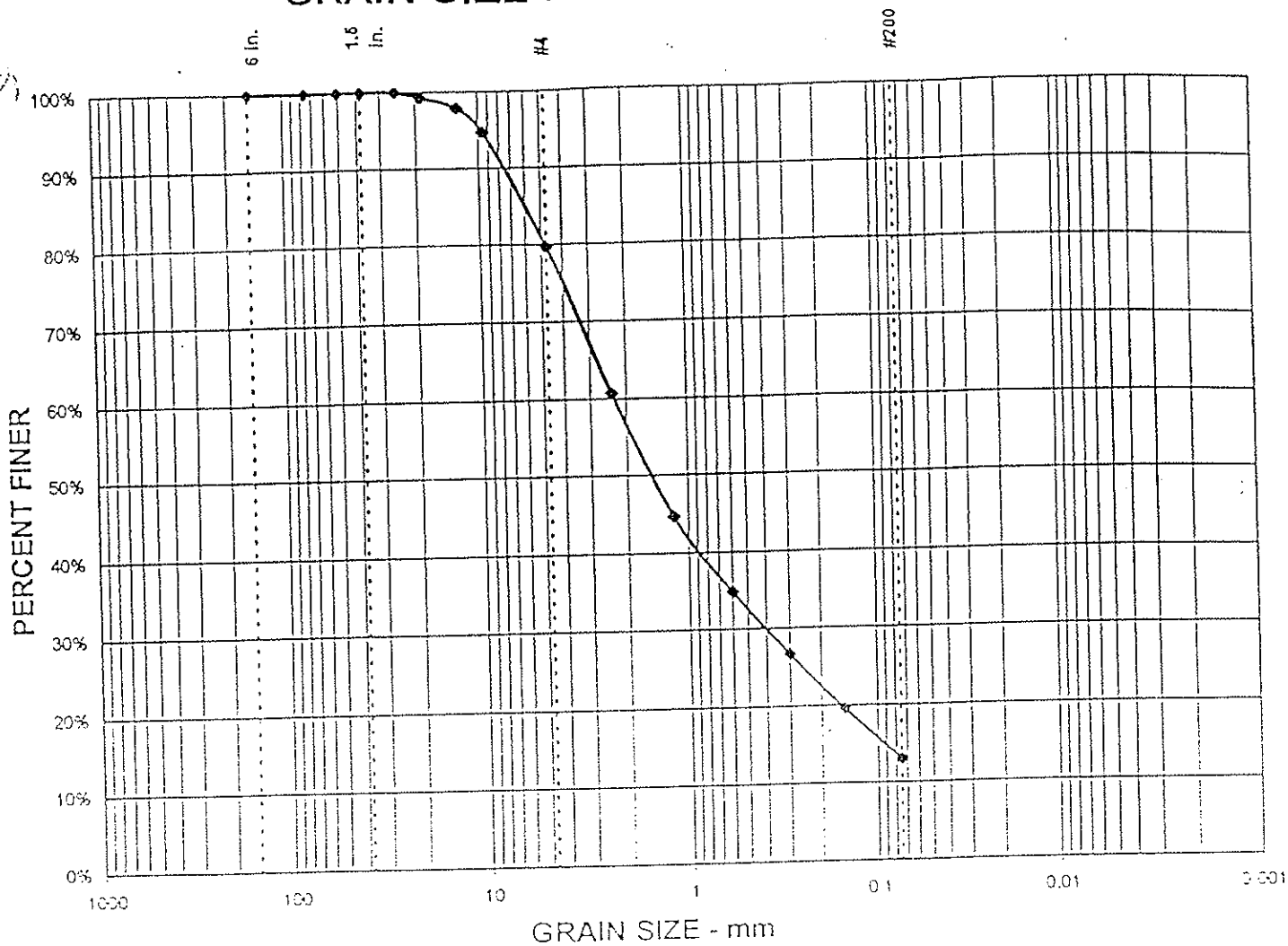
Project No.: 99-33437-01
Project Name: BMI Landfill
Date sampled: Oct 1999
Location: B 102 @ 20-25'
Silty Sand with Gravel

GRAIN SIZE DISTRIBUTION TEST REPORT

CONVERSE CONSULTANTS

Drawing No. A-44

GRAIN SIZE DISTRIBUTION GRAPH



TEST SUMMARY

% GRAVEL =	20%	D_{85} = 6.1	D_{15} = 0.1
% SAND =	67%	D_{60} = 2.3	D_{10} =
% SILT & CLAY =	13%	D_{50} = 1.5	C_u =
		D_{30} = 0.4	C_c =

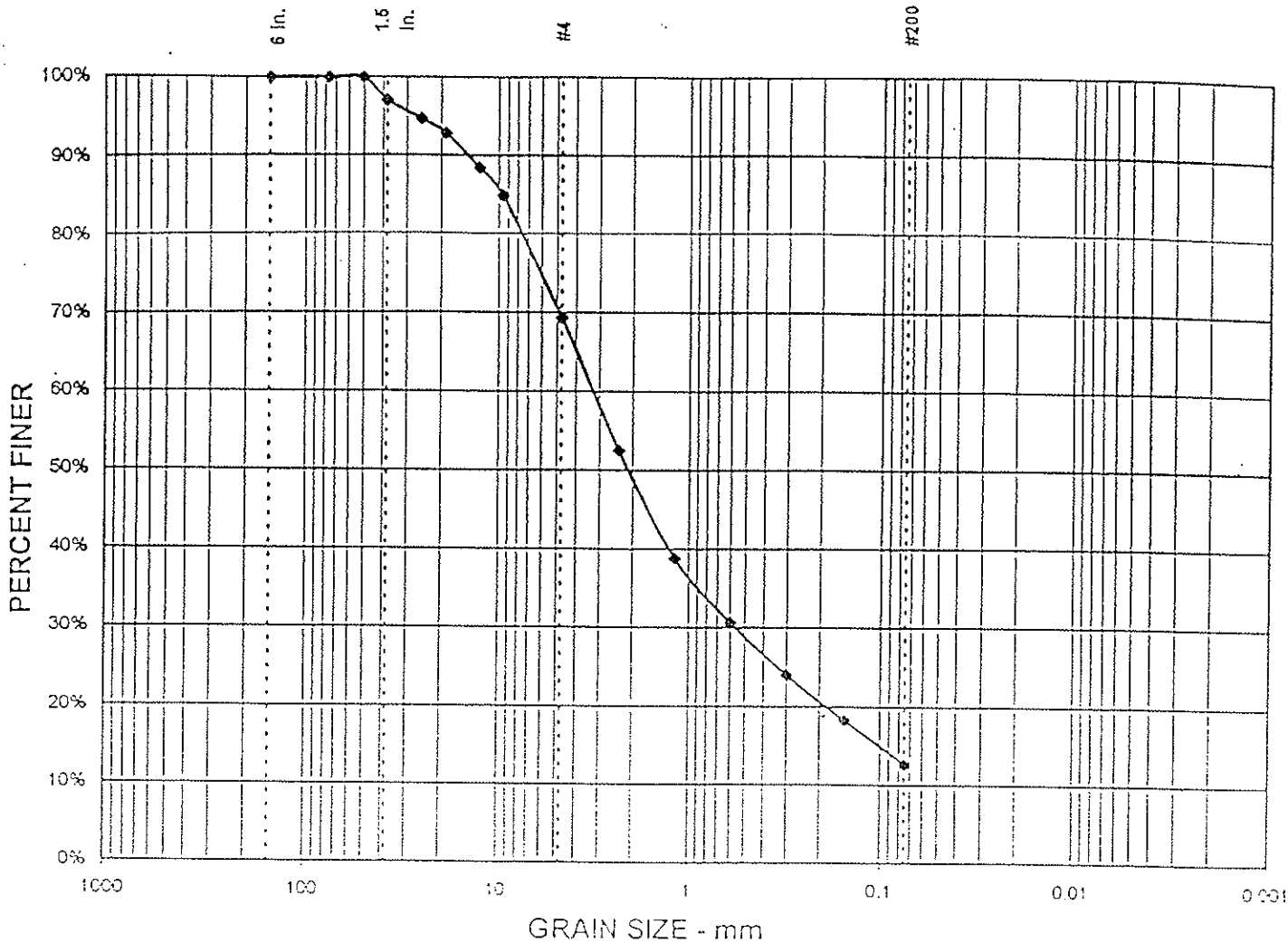
Project No.: 99-33437-01
Project Name: BMI Landfill
Date sampled: Oct 1999
Location: B 103 @ 30-35'
Silty Sand with Gravel

GRAIN SIZE DISTRIBUTION TEST REPORT

CONVERSE CONSULTANTS

Drawing No. A-4

GRAIN SIZE DISTRIBUTION GRAPH



TEST SUMMARY

% GRAVEL =	31%	D_{85} = 9.6	D_{15} = 0.1
% SAND =	57%	D_{60} = 3.2	D_{10} =
% SILT & CLAY =	13%	D_{50} = 2.1	C_u =
		D_{30} = 0.6	C_c =

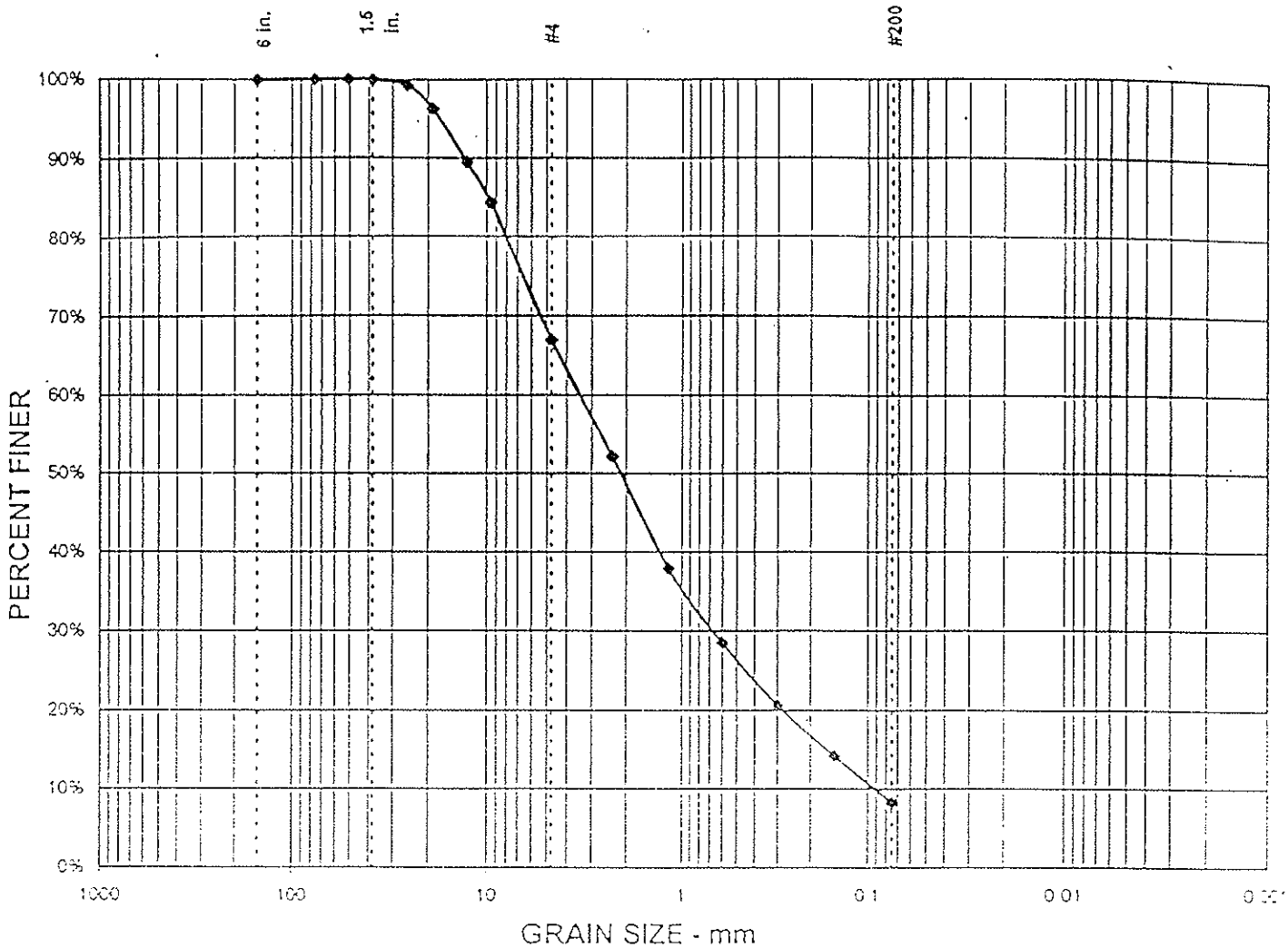
Project No.: 99-33437-01
Project Name: BMI Landfill
Date sampled: Oct 1999
Location: B 104 @ 10-15'
Silty Sand with Gravel

GRAIN SIZE DISTRIBUTION TEST REPORT

CONVERSE CONSULTANTS

Drawing No. A-46

GRAIN SIZE DISTRIBUTION GRAPH



TEST SUMMARY

% GRAVEL =	33%	D_{85} = 9.9	D_{15} = 0.2
% SAND =	59%	D_{60} = 3.4	D_{10} = 0.1
% SILT & CLAY =	8%	D_{50} = 2.1	C_u = 37.4
		D_{30} = 0.7	C_c = 1.4

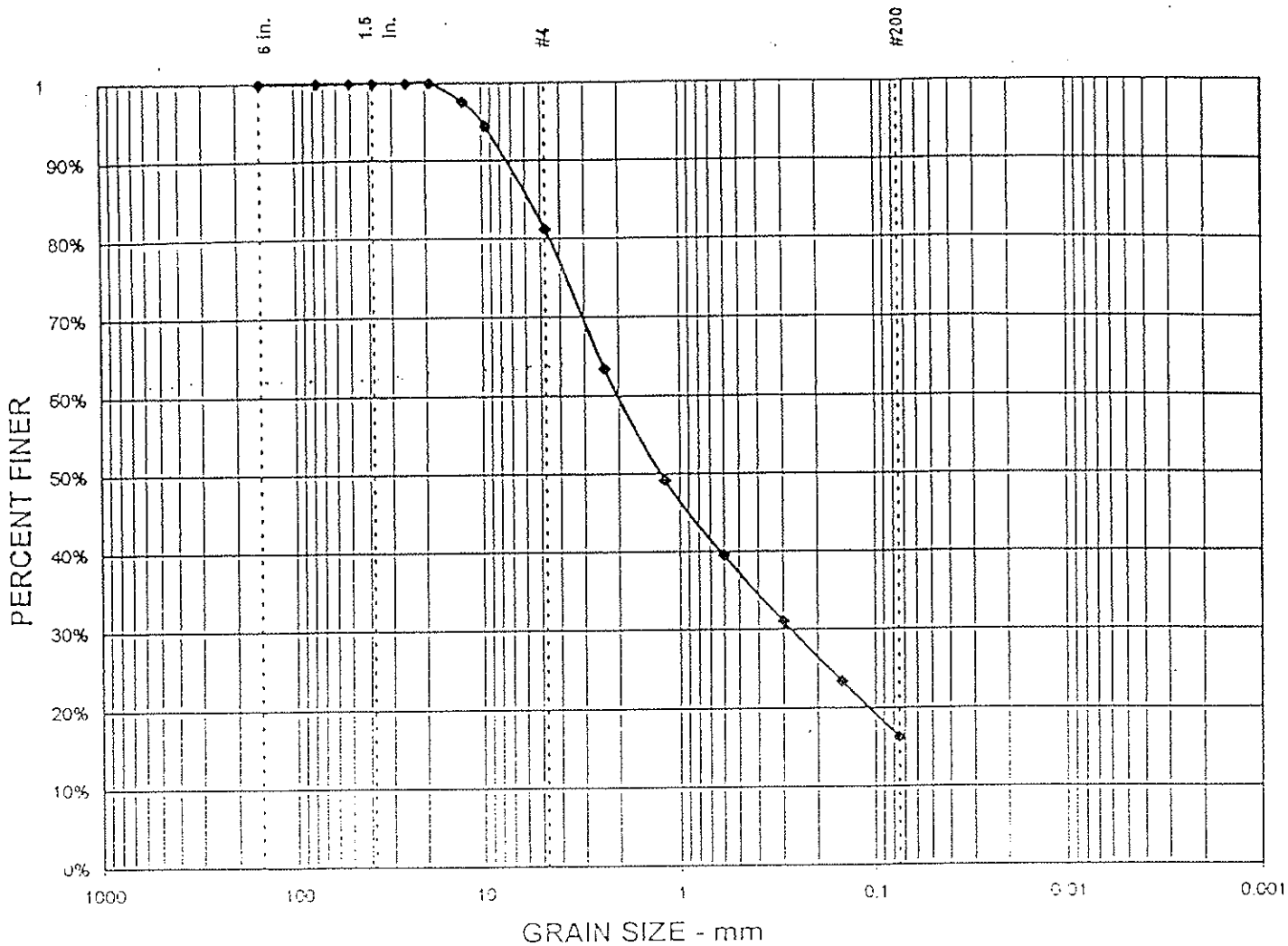
Project No.: 99-33437-01
Project Name: BMI Landfill
Date sampled: Oct 1999
Location: B105 @ 20-25'
Well Graded Sand with Silt & Gravel

GRAIN SIZE DISTRIBUTION TEST REPORT

CONVERSE CONSULTANTS

Drawing No. A-47

GRAIN SIZE DISTRIBUTION GRAPH



TEST SUMMARY

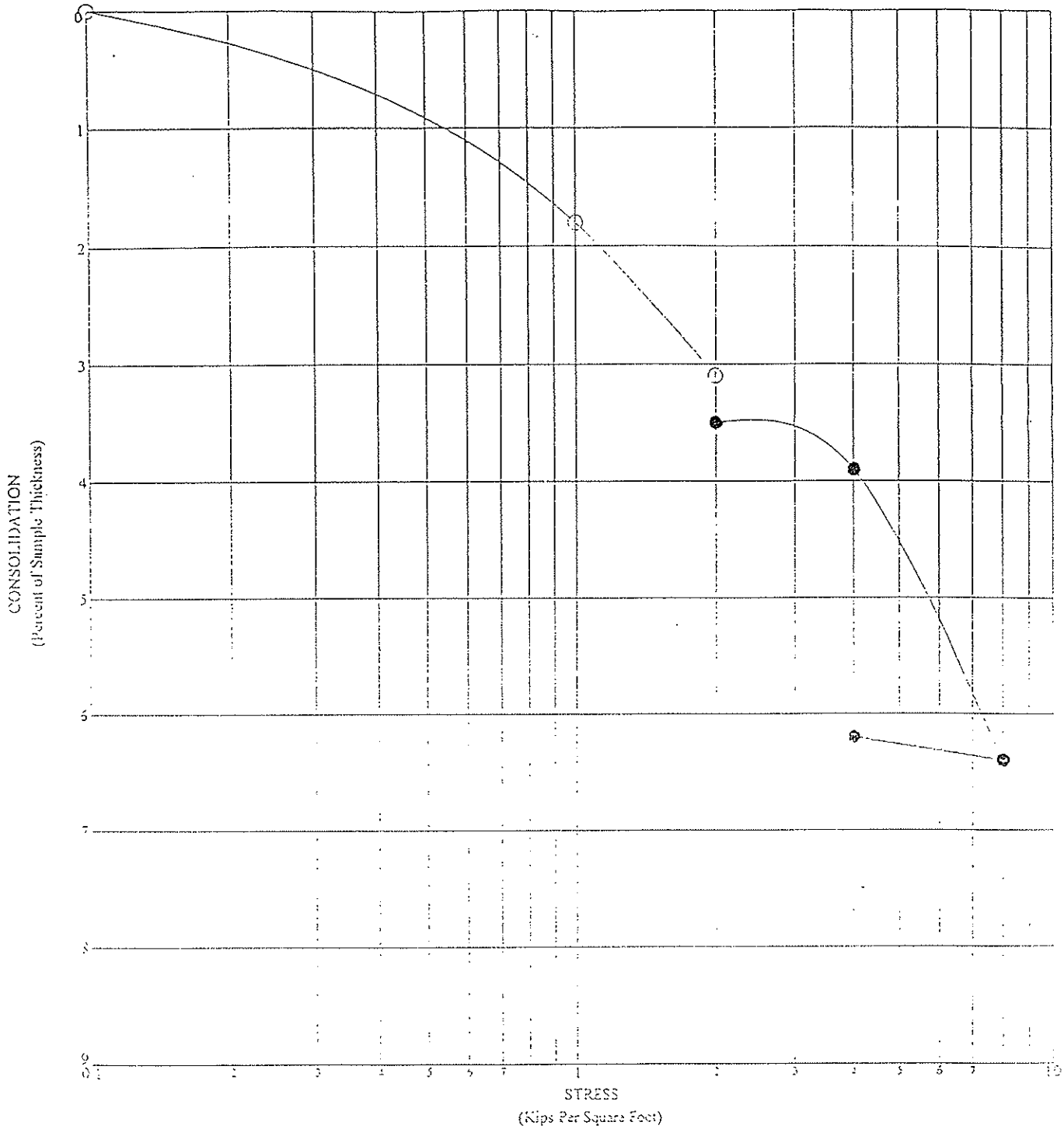
% GRAVEL =	19%	D_{85} = 5.8	D_{15} =
% SAND =	65%	D_{50} = 2.0	D_{10} =
% SILT & CLAY =	16%	D_{50} = 1.2	C_u =
		D_{30} = 0.3	C_c =

Project No.: 99-33437-01
Project Name: BMI Landfill
Date sampled: Oct 1999
Location: B 106 @ 0-5'
Silty Sand with Gravel

GRAIN SIZE DISTRIBUTION TEST REPORT

CONVERSE CONSULTANTS

Drawing No. A-4



BORING NO: B- 8
DEPTH: 39.0
DESCRIPTION: LEAN CLAY
DRY DENSITY: 58 PCF
MOISTURE CONTENT: 64%

● READINGS AFTER SATURATION WITH WATER

CONSOLIDATION TEST

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION

Project No. 99-33437-01

Converse Consultants

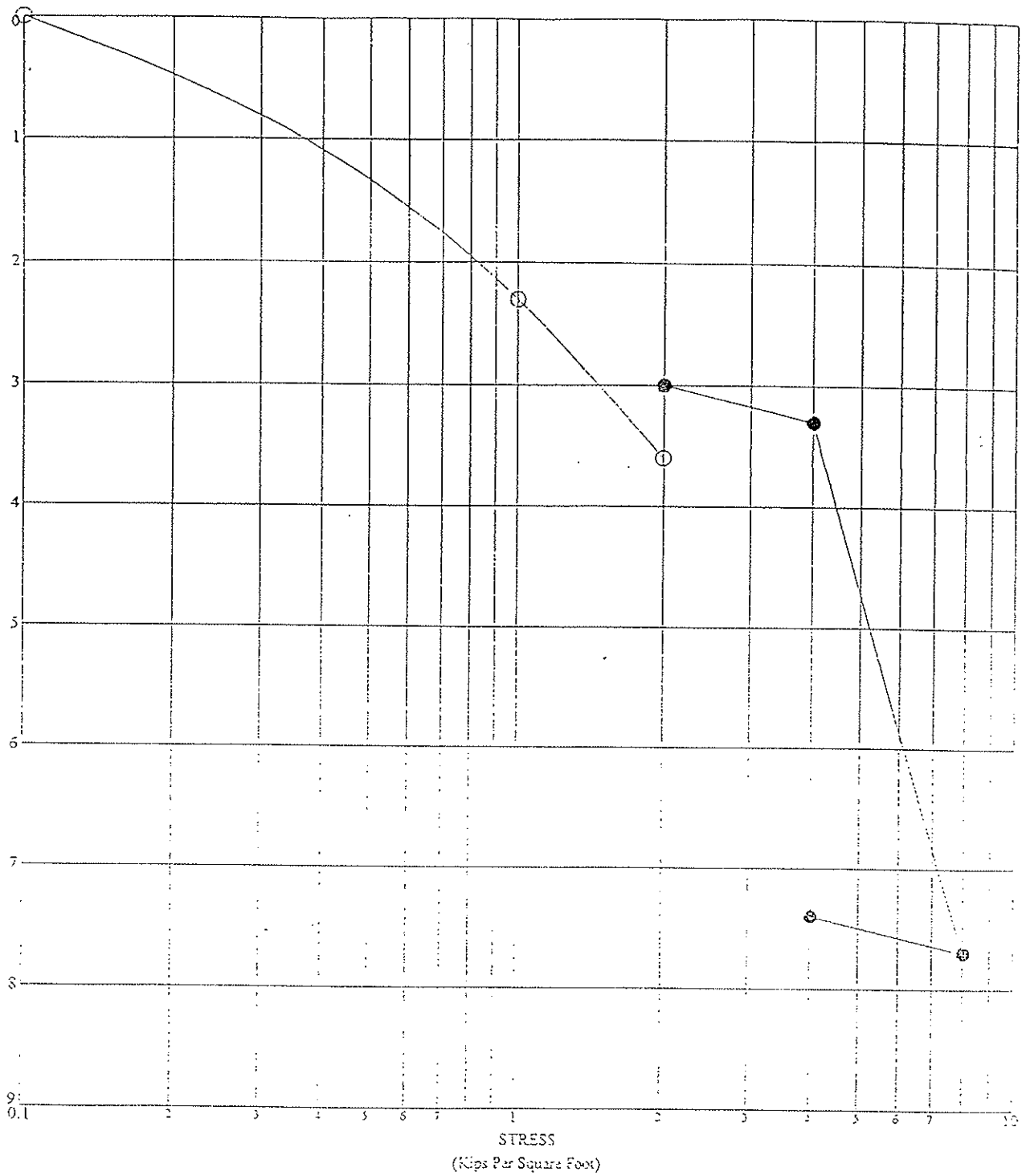
Geotechnical Engineering and Applied Sciences

Drawing No. A-50

DRAFT

APPROVED BY ON

DRAFTED BY GLE



APPROVED BY ON

BORING NO: B- 8
DEPTH: 49.0
DESCRIPTION: LEAN CLAY
DRY DENSITY: 70 PCF
MOISTURE CONTENT: 51 %

● READINGS AFTER SATURATION WITH WATER

CONSOLIDATION TEST

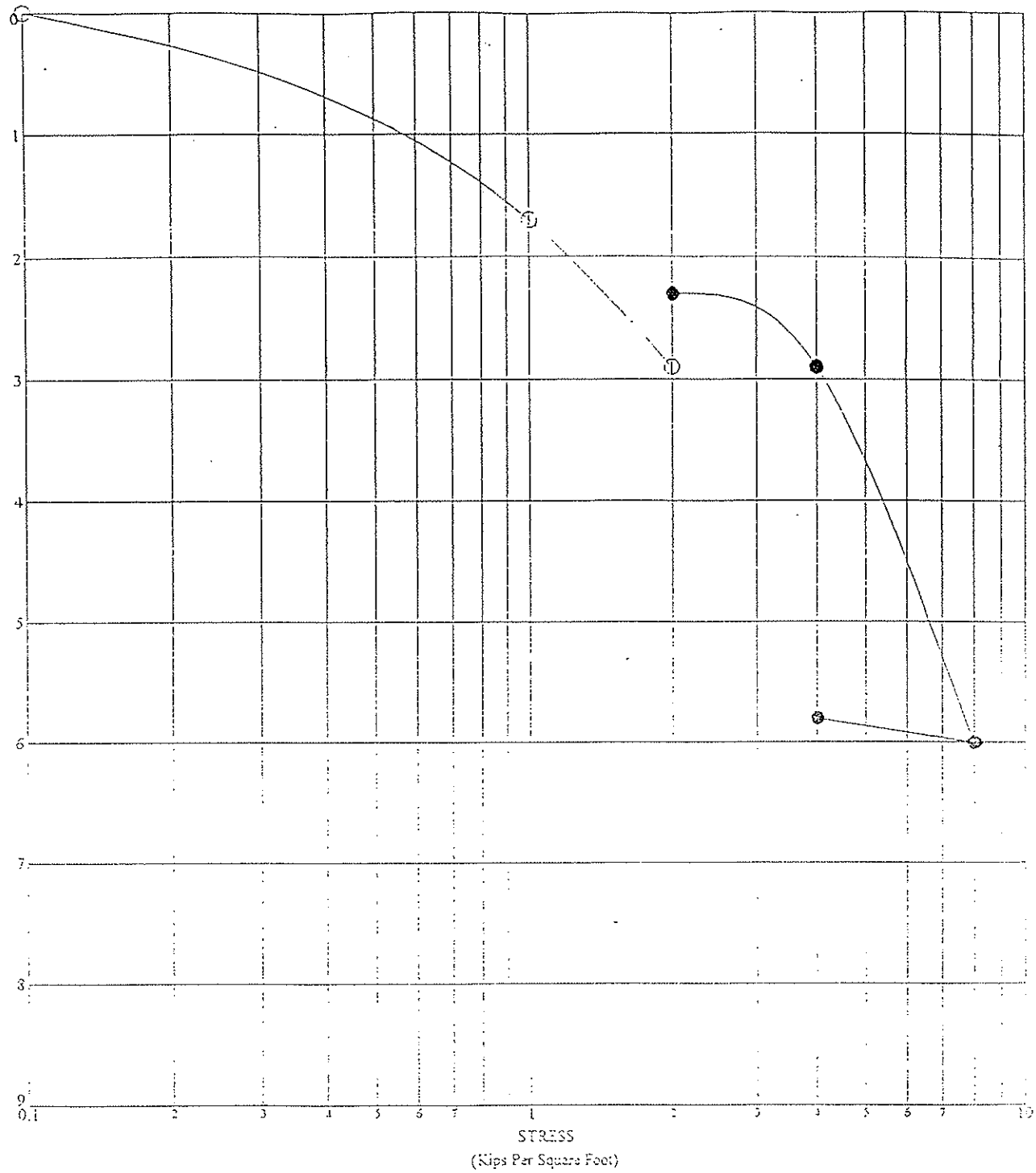
PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION

Project No. 99-33437-01

Converse Consultants

Geotechnical Engineering and Applied Sciences

Drawing No. A-51



BORING NO: B-10- -
DEPTH: 54.0
DESCRIPTION: LEAN CLAY
DRY DENSITY: 61 PCF
MOISTURE CONTENT: 68 %

● READINGS AFTER SATURATION WITH WATER

CONSOLIDATION TEST

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION

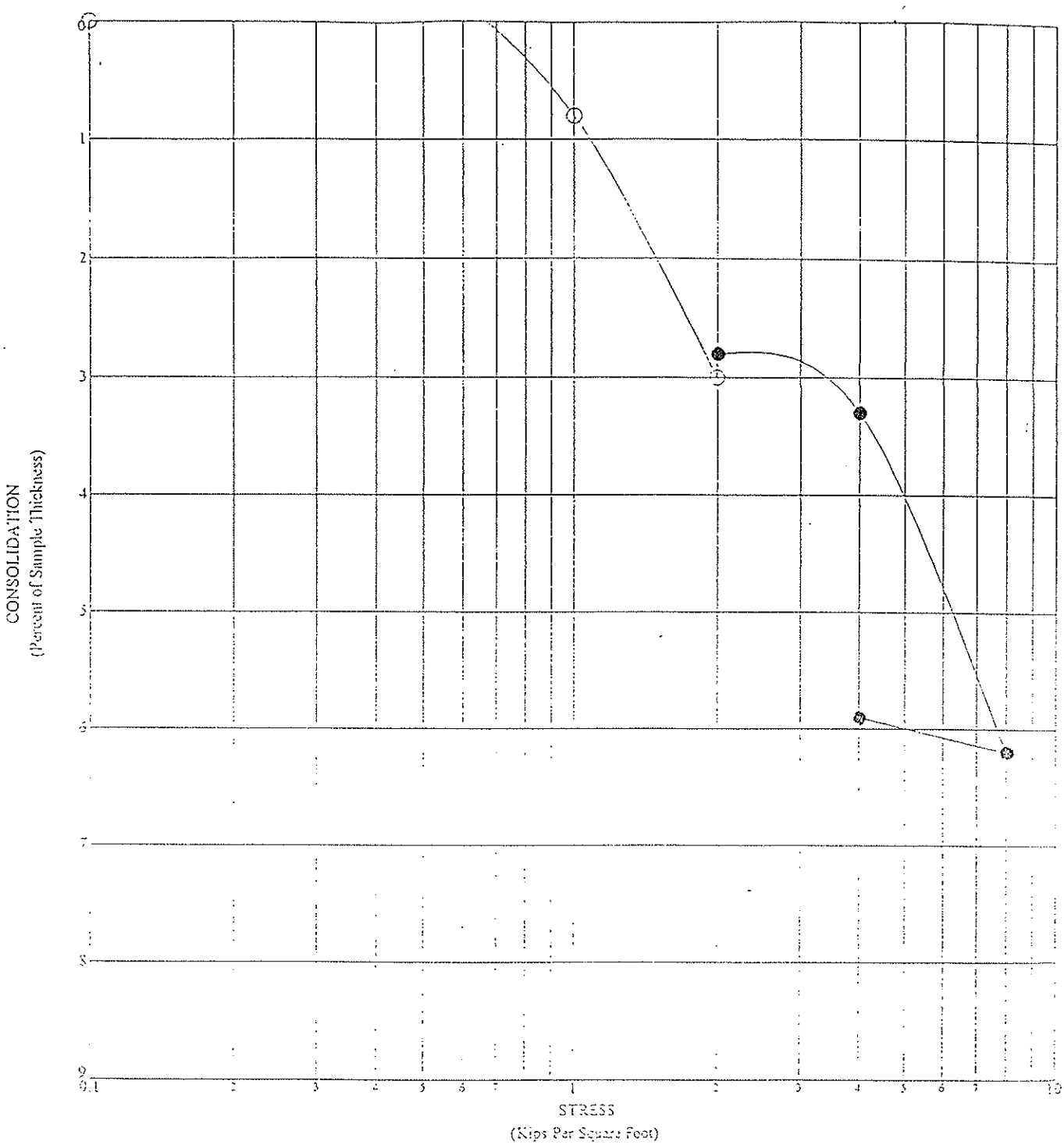
Project No. 99-33437-01

Converse Consultants

Geotechnical Engineering and Applied Sciences

Drawing No. A-52

DRAFTED BY GLE



APPROVED BY ON

BORING NO: B-101
DEPTH: 39.0
DESCRIPTION: LEAN CLAY
DRY DENSITY: 66 PCF
MOISTURE CONTENT: 45%

● READINGS AFTER SATURATION WITH WATER

CONSOLIDATION TEST

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION

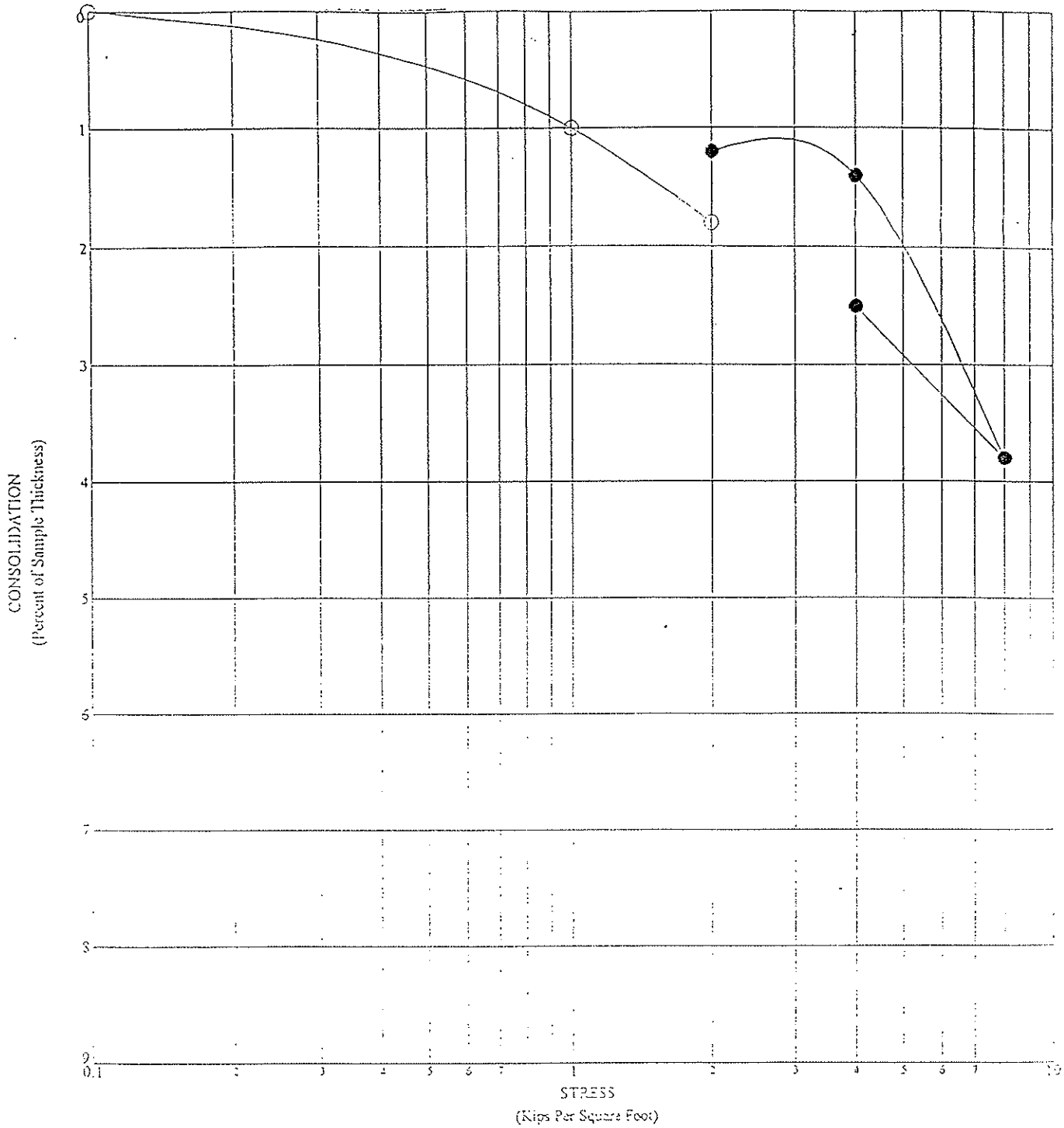
Project No. 99-33437-01

Converse Consultants

Geotechnical Engineering and Applied Sciences

Drawing No. A-53

DRAFTED BY GLE



APPROVED BY ON

BORING NO: B-101
DEPTH: 59.0
DESCRIPTION: LEAN CLAY
DRY DENSITY: 73 PCF
MOISTURE CONTENT: 38%

● READINGS AFTER SATURATION WITH WATER

CONSOLIDATION TEST

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION

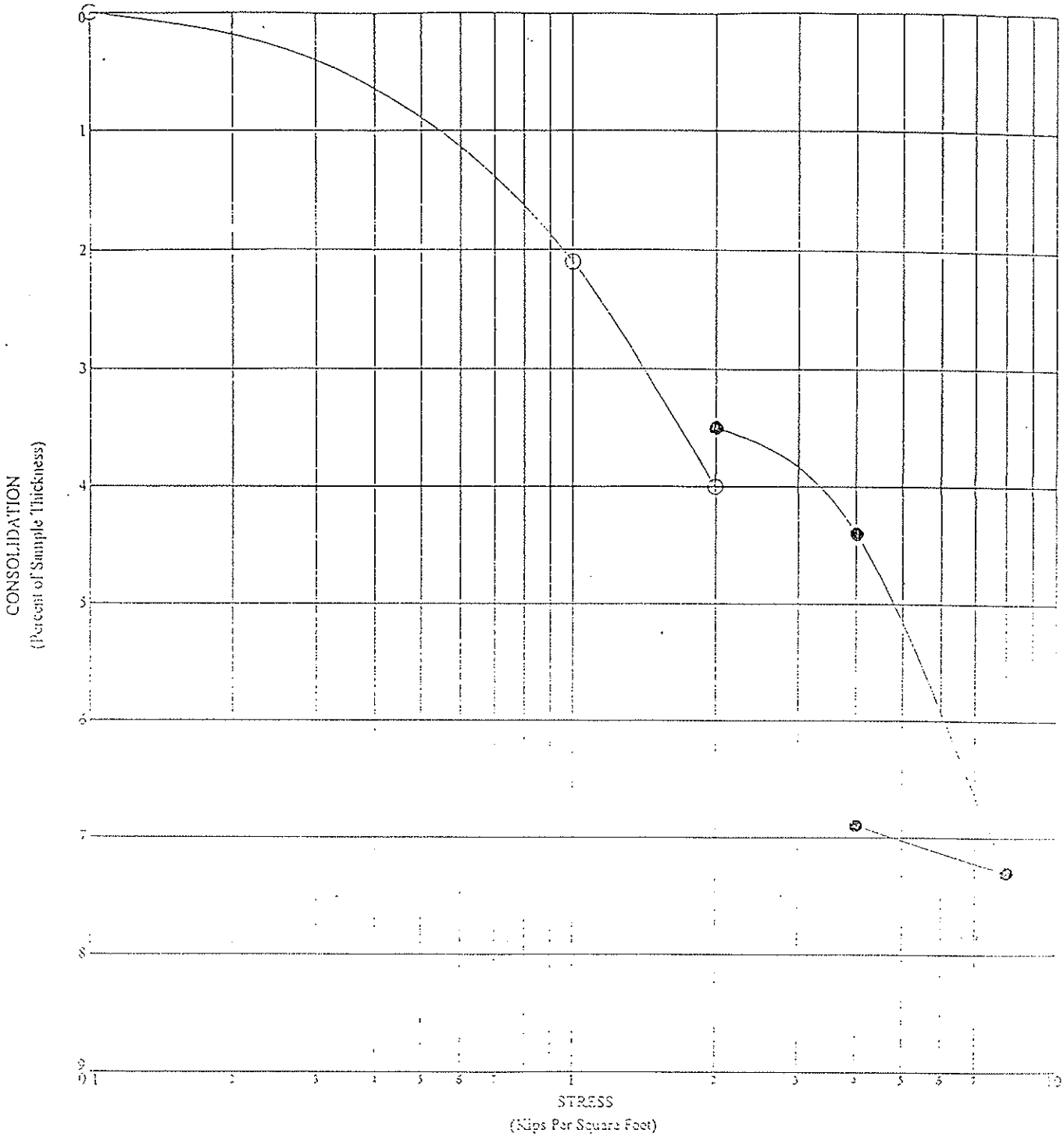
Project No. 99-33437-01

Converse Consultants

Geotechnical Engineering and Applied Sciences

Drawing No. A-54

DRAFTED BY GLE



APPROVED BY ON

BORING NO: B-102
DEPTH: 49.0
DESCRIPTION:
DRY DENSITY: 67 PCF
MOISTURE CONTENT: 49%

● READINGS AFTER SATURATION WITH WATER

CONSOLIDATION TEST

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION

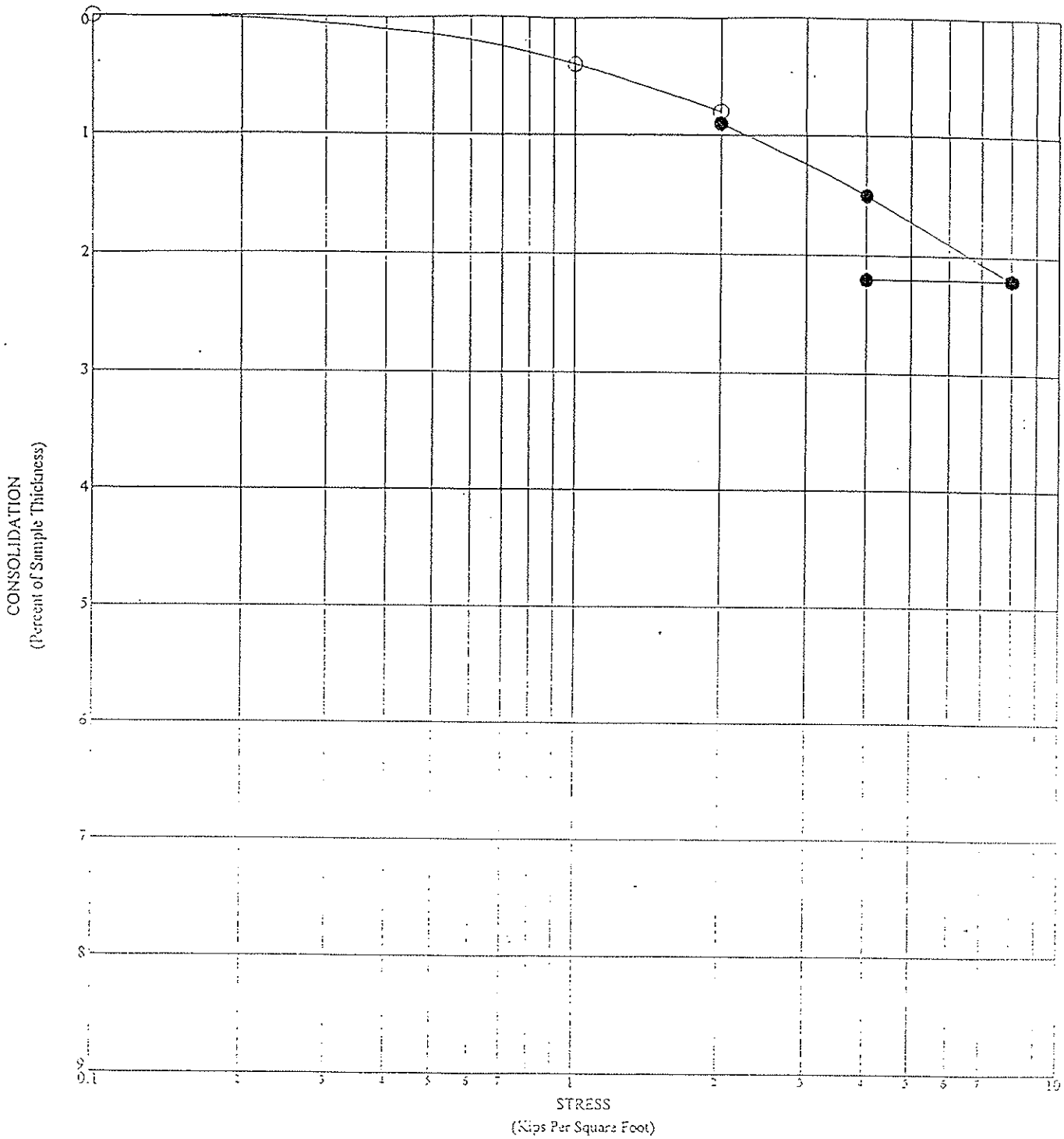
Project No. 99-33437-01

Converse Consultants

Geotechnical Engineering and Applied Sciences

Drawing No. A-55

DRAFTED BY GLE



APPROVED BY ON

BORING NO: B-105
DEPTH: 34.0
DESCRIPTION: SILTY SAND With Gravel
DRY DENSITY:101 PCF
MOISTURE CONTENT: 5 %

⊗ READINGS AFTER SATURATION WITH WATER

CONSOLIDATION TEST

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION

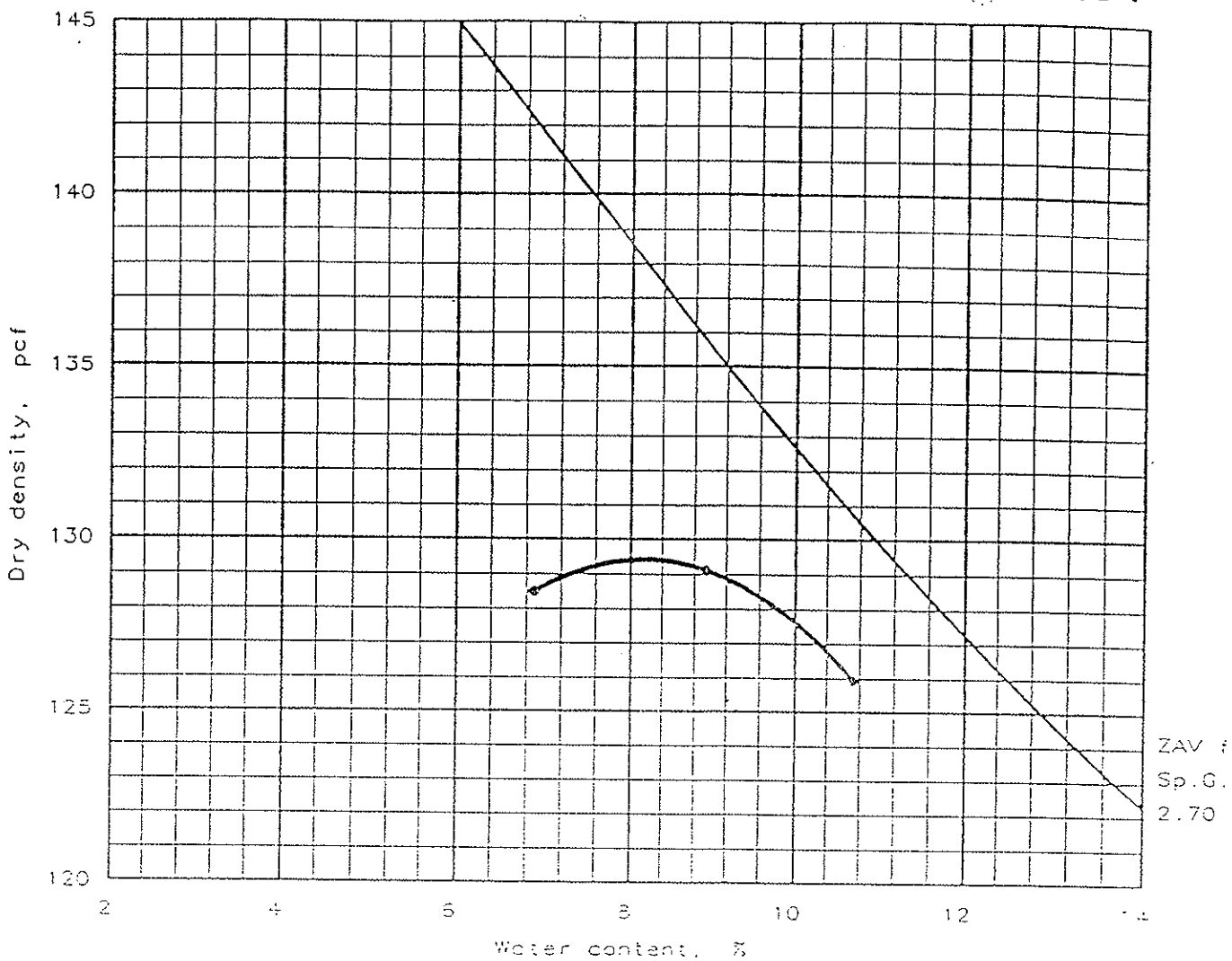
Project No. 99-33437-01

Converse Consultants

Geotechnical Engineering and Applied Sciences

Drawing No. A-56

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 1557-91 Procedure C, Modified

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/4 in	% < No.2
	USCS	AASHTO						
	SM				NV	NP	1.4 %	20.2

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 129.4 pcf Optimum moisture = 8.2 %	Silty Sand with Gravel

Project No.: 99-33437-01

Project: BMI Landfill

Location: B1 @ 20-25'

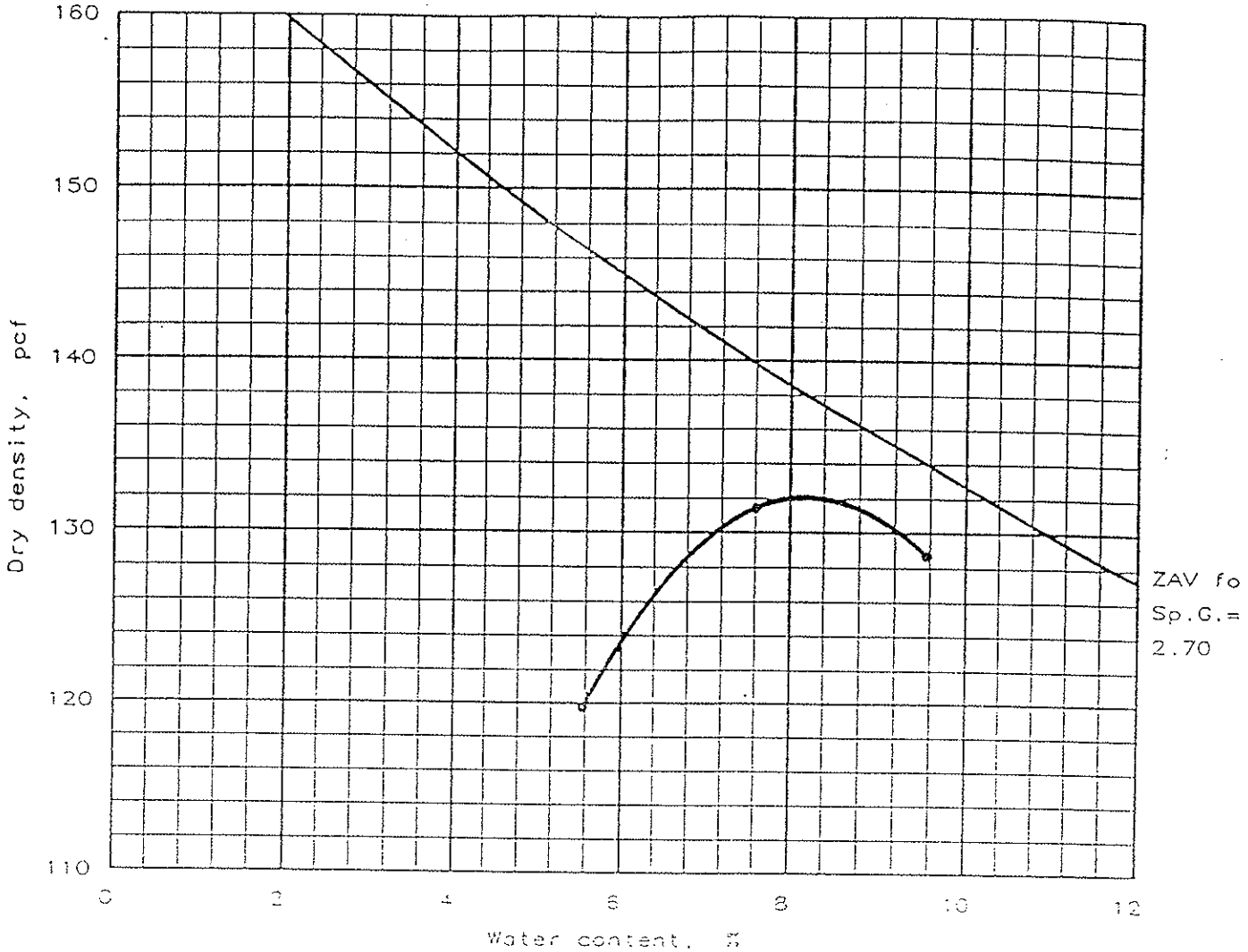
Date: 10-15-1999

MOISTURE-DENSITY RELATIONSHIP TEST

CONVERSE CONSULTANTS

Fig. No. A-57

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 1557-91 Procedure C, Modified

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/4 in	% < No.200
	USCS	AASHTO						
	SM				NV	NP	0 %	19.2 %

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 132.1 pcf Optimum moisture = 8.2 %	Silty Sand with Gravel

Project No.: 99-33437-01

Project: BMI Landfill

Location: B5 @ 20-25'

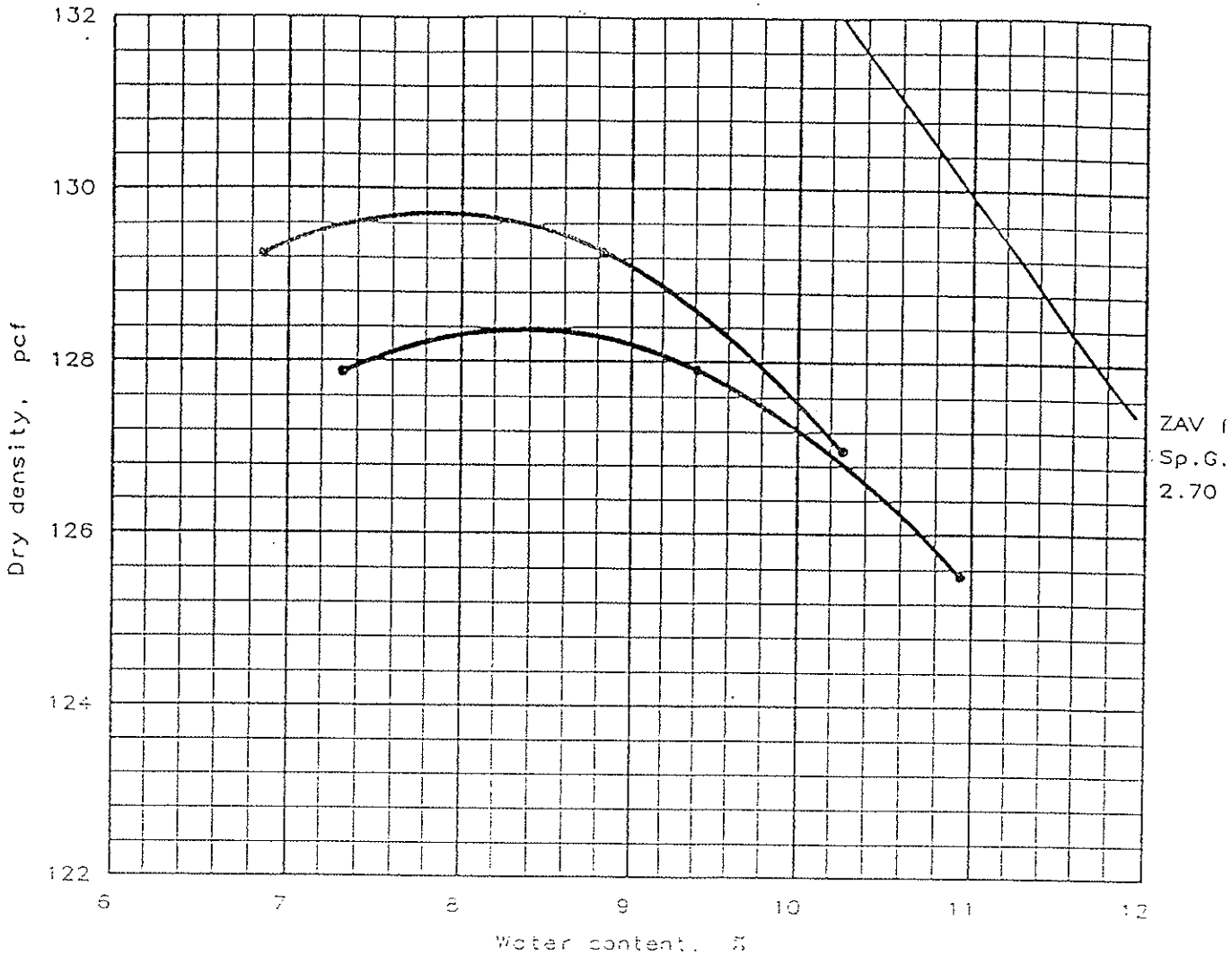
Date: 10-15-1999

MOISTURE-DENSITY RELATIONSHIP TEST

CONVERSE CONSULTANTS

Fig. No. A-58

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 1557-91 Procedure C, Modified

Oversize correction applied to each point

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/4 in	% < No.2
	USCS	AASHTO						
	SM				NV	NP	6.2 %	13.3

ROCK CORRECTED TEST RESULTS	UNCORRECTED	MATERIAL DESCRIPTION
Maximum dry density = 129.7 pcf Optimum moisture = 7.9 %	128.4 pcf 8.4 %	Silty Sand with Gravel

Project No.: 99-33437-01

Project: BMI Landfill

Location: B12 @ 10-15'

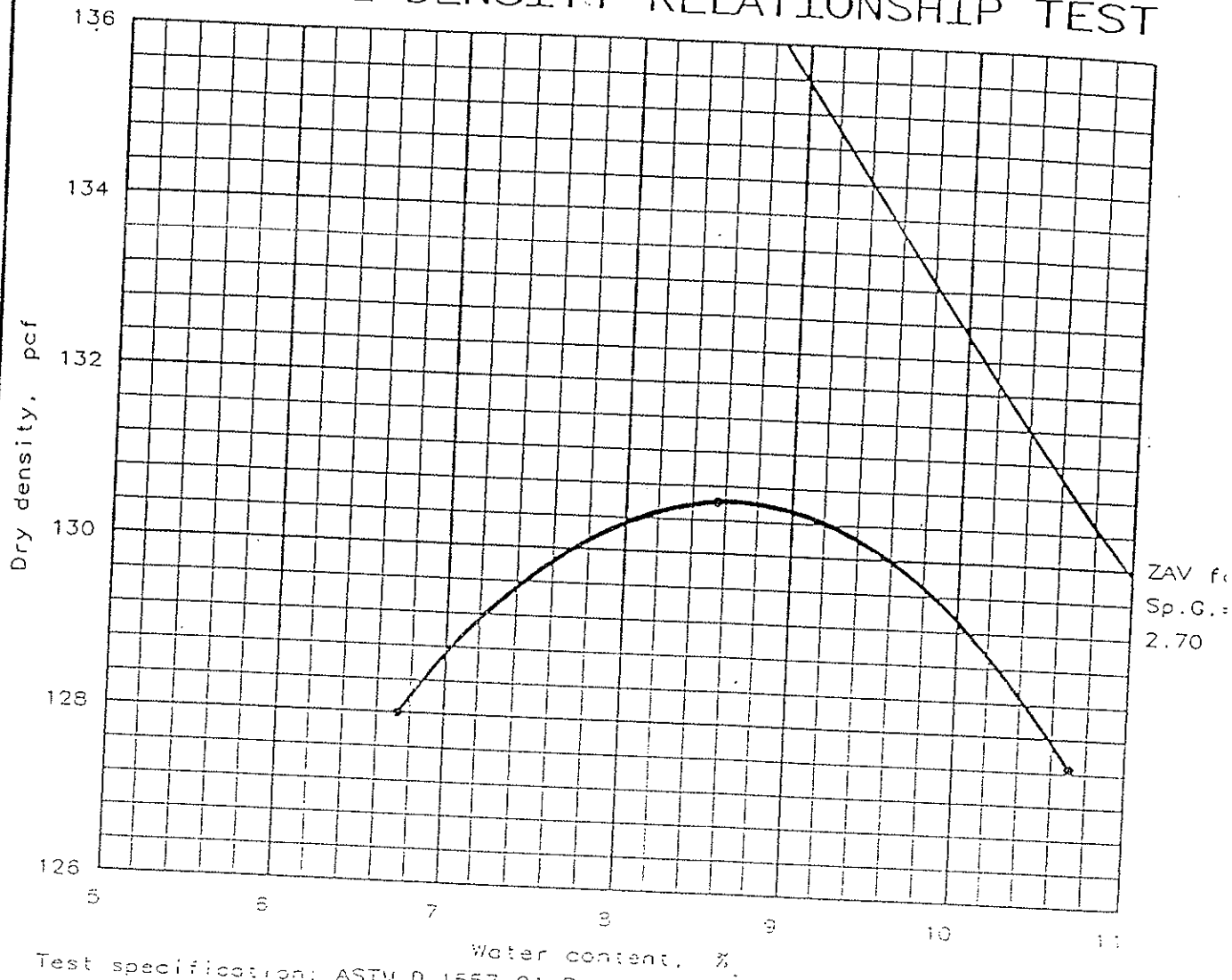
Date: 10-15-1999

MOISTURE-DENSITY RELATIONSHIP TEST

CONVERSE CONSULTANTS

Fig. No. A-59

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 1557-91 Procedure C, Modified

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/4 in	% < No.200
	USCS	AASHTO						
	SM				NV	NP	4.7 %	14.7 %

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 130.6 pcf Optimum moisture = 8.7 %	Silty Sand with Gravel

Project No.: 99-33437-01

Project: BMI Landfill

Location: B 101 @ 5-10'

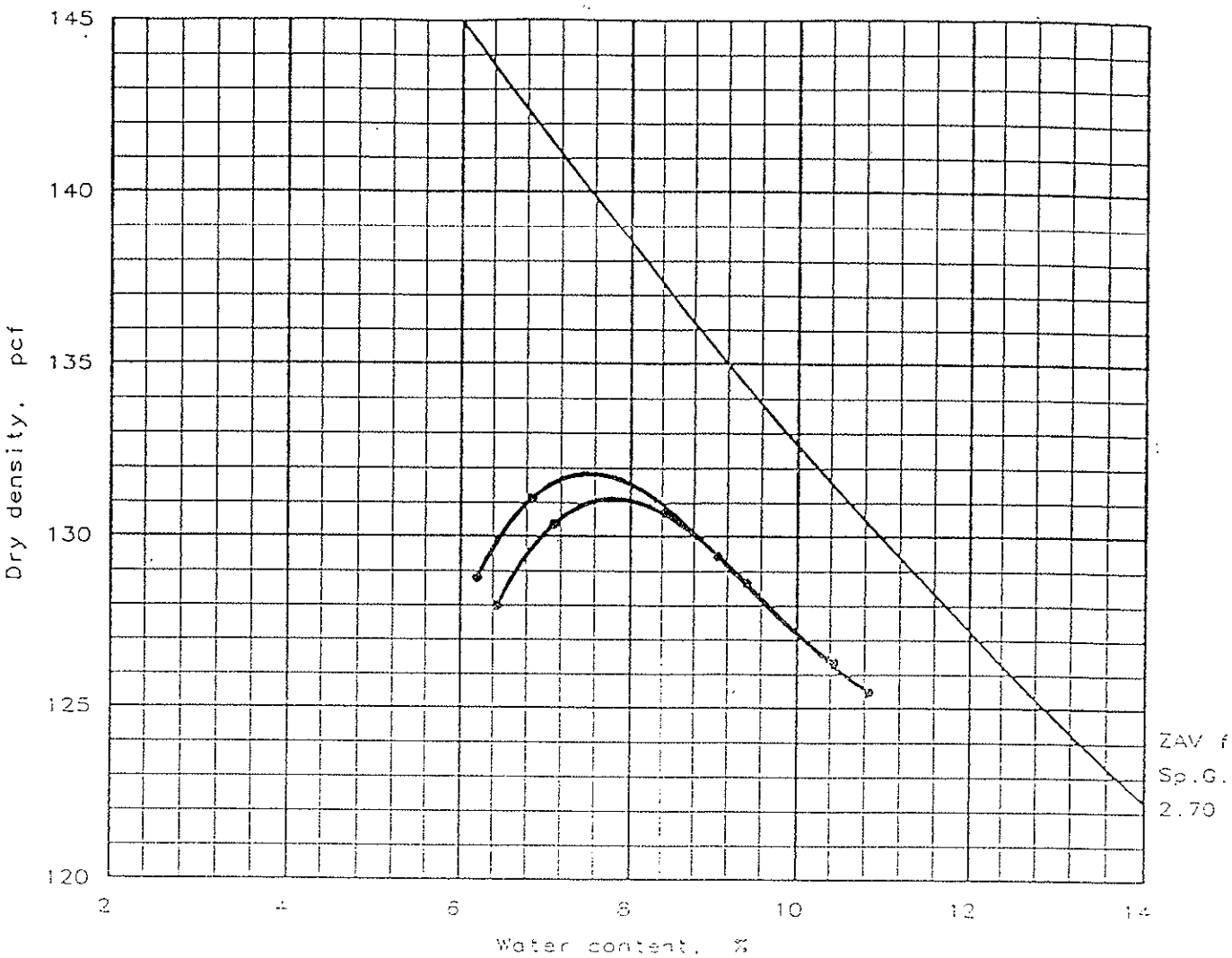
Date: 10-15-1999

MOISTURE-DENSITY RELATIONSHIP TEST

CONVERSE CONSULTANTS

Fig. No. A-60

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 1557-91 Procedure C, Modified

Oversize correction applied to each point

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/4 in	% < No.2
	USCS	AASHTO						
	SW-SM				NV	NP	3.7 %	5.3

ROCK CORRECTED TEST RESULTS	UNCORRECTED	MATERIAL DESCRIPTION
Maximum dry density = 131.8 pcf Optimum moisture = 7.5 %	131.1 pcf 7.8 %	Well Graded Sand with Silt & Gravel

Project No.: 99-33437-01

Project: BMI Landfill

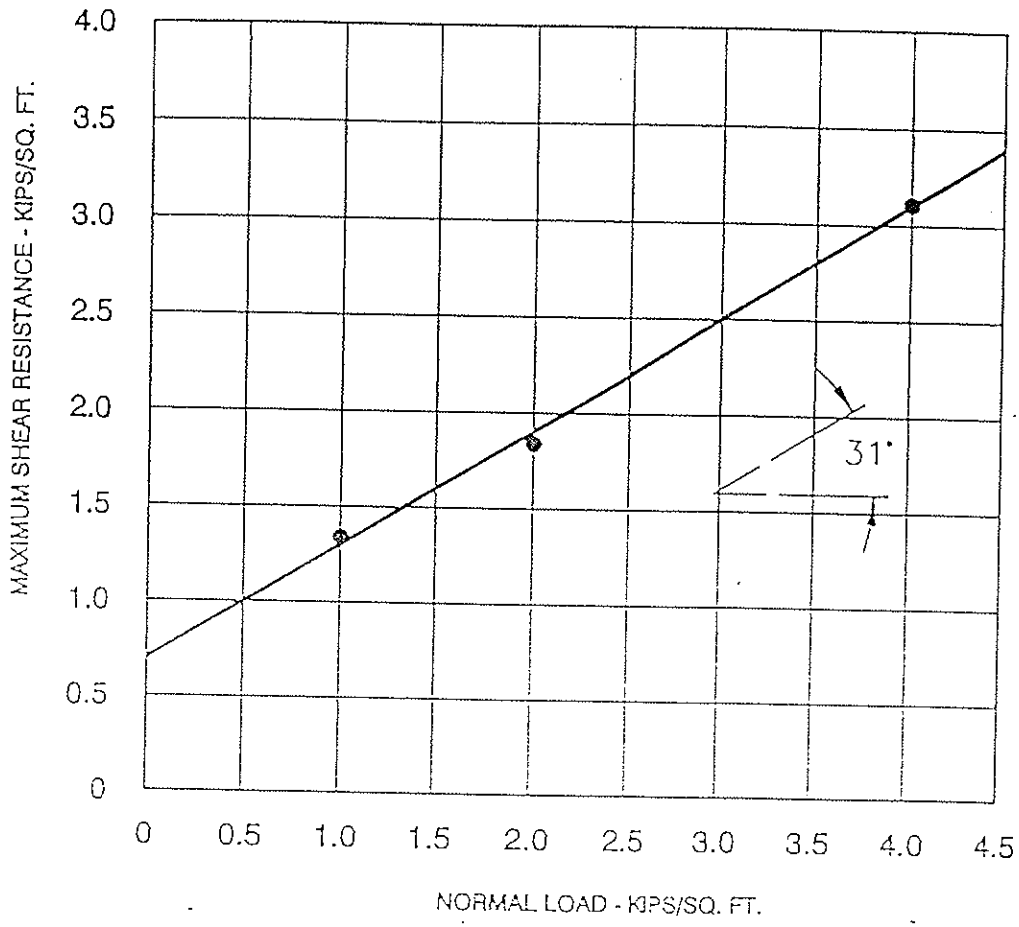
Location: B 105 @ 20-25'

Date: 10-15-1999

MOISTURE-DENSITY RELATIONSHIP TEST

CONVERSE CONSULTANTS

Fig. No. A-61



Exploration Location = B-4

Sample Depth = 14 - 14.5 FT

Angle of Shearing Resistance, Ø = 31°

Cohesion, c = 0.70 KIPS/SQ. FT.

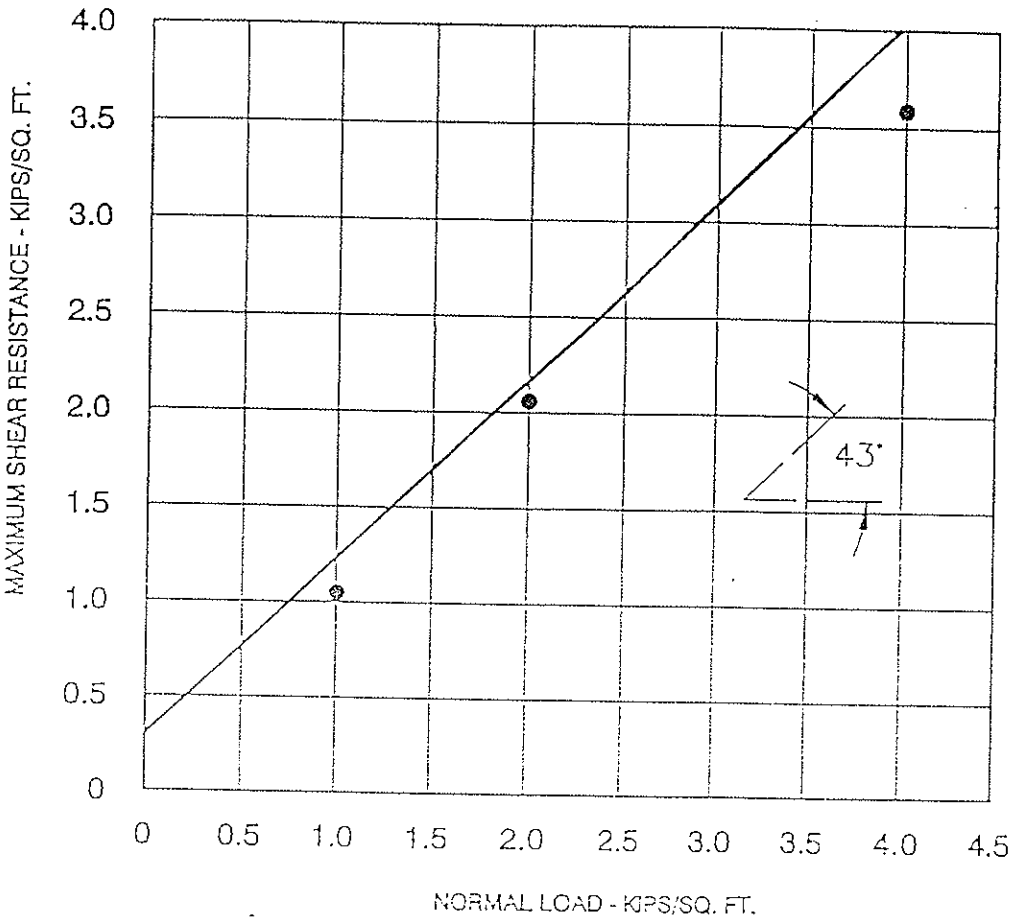
DIRECT SHEAR TEST RESULTS

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Scale	N/A
Date	10/20/99
Drafted By	TGLE
Checked By	MKK
Approved By	
File No.	4370183
Project No.	99-33437-01
Figure No.	A-62

CONVERSE CONSULTANTS

Over 50 Years of Dedication in Engineering and Environmental Sciences



Exploration Location = B-5

Sample Depth = 14 - 15 FT

Angle of Shearing Resistance, Ø = 43°

Cohesion, c = 0.30 KIPS/SQ. FT.

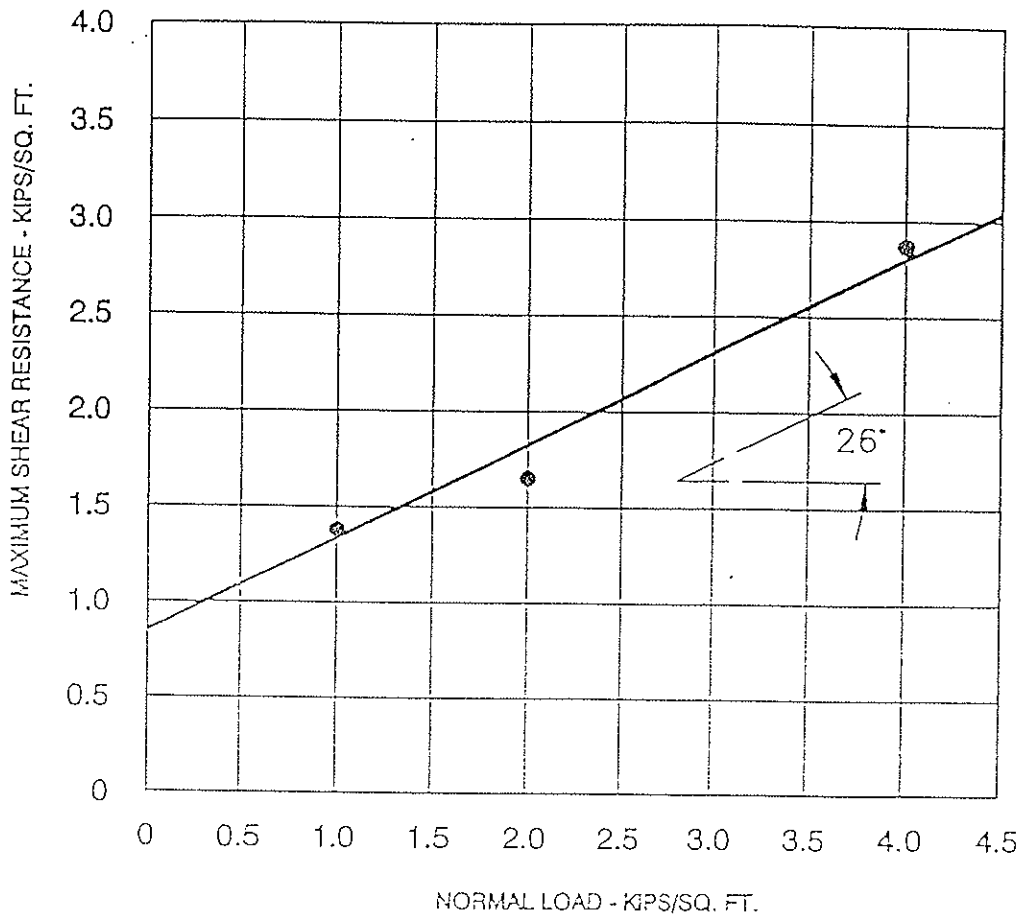
DIRECT SHEAR TEST RESULTS

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Scale	N/A
Date	10/20/99
Drafted By	CLE
Checked By	MKK
Approved By	
File No.	43701353
Project No.	99-33437-01
Figure No.	A-63

CONVERSE CONSULTANTS

Over 50 Years of Dedication in Engineering and Environmental Sciences



Exploration Location = B-10

Sample Depth = 54 - 54.5 FT

Angle of Shearing Resistance, Ø = 26°

Cohesion, c = 0.85 KIPS/SQ. FT.

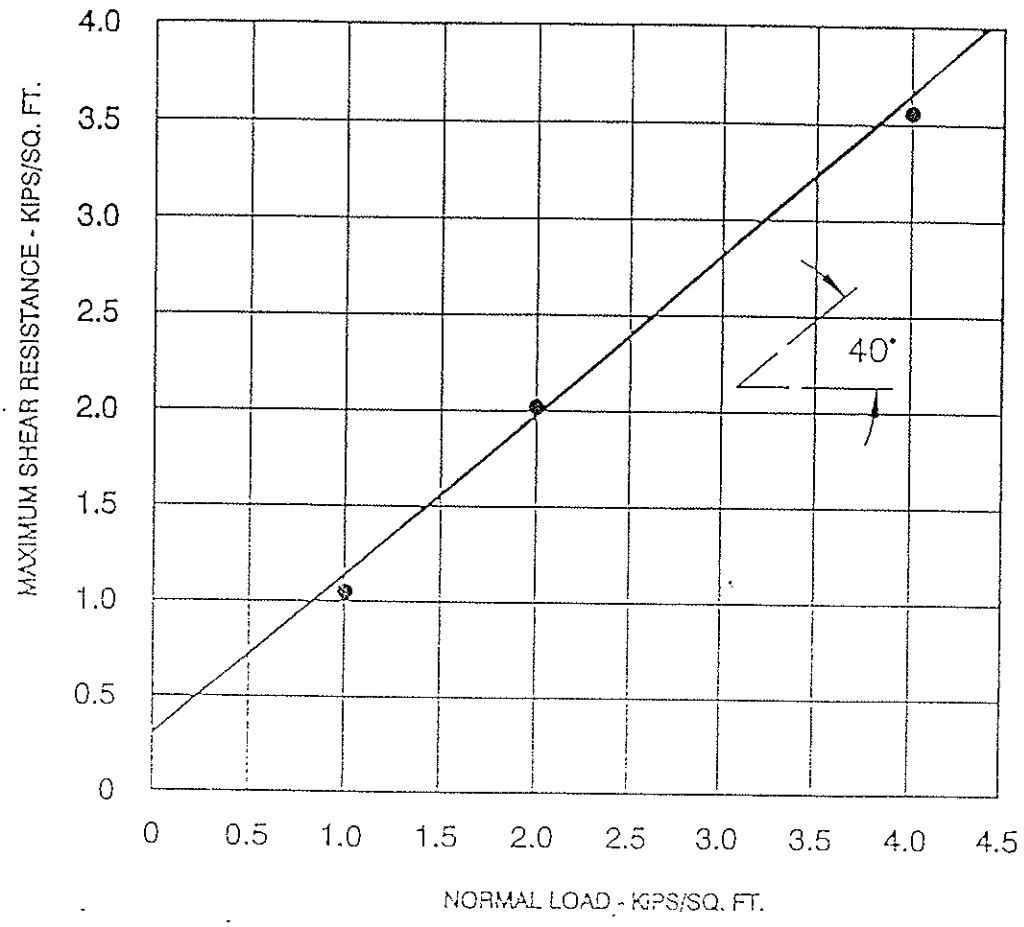
DIRECT SHEAR TEST RESULTS

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Scale	N/A
Date	10/20/99
Drafted By	GLE
Checked By	MKK
Approved By	
File No.	4370185
Project No.	99-33437-0
Figure No.	A-64

CONVERSE CONSULTANTS

Over 50 Years of Dedication in Engineering and Environmental Sciences



Exploration Location = B-12

Sample Depth = 14 - 15 FT

Angle of Shearing Resistance, Ø = 40°

Cohesion, c = 0.30 KIPS/SQ. FT.

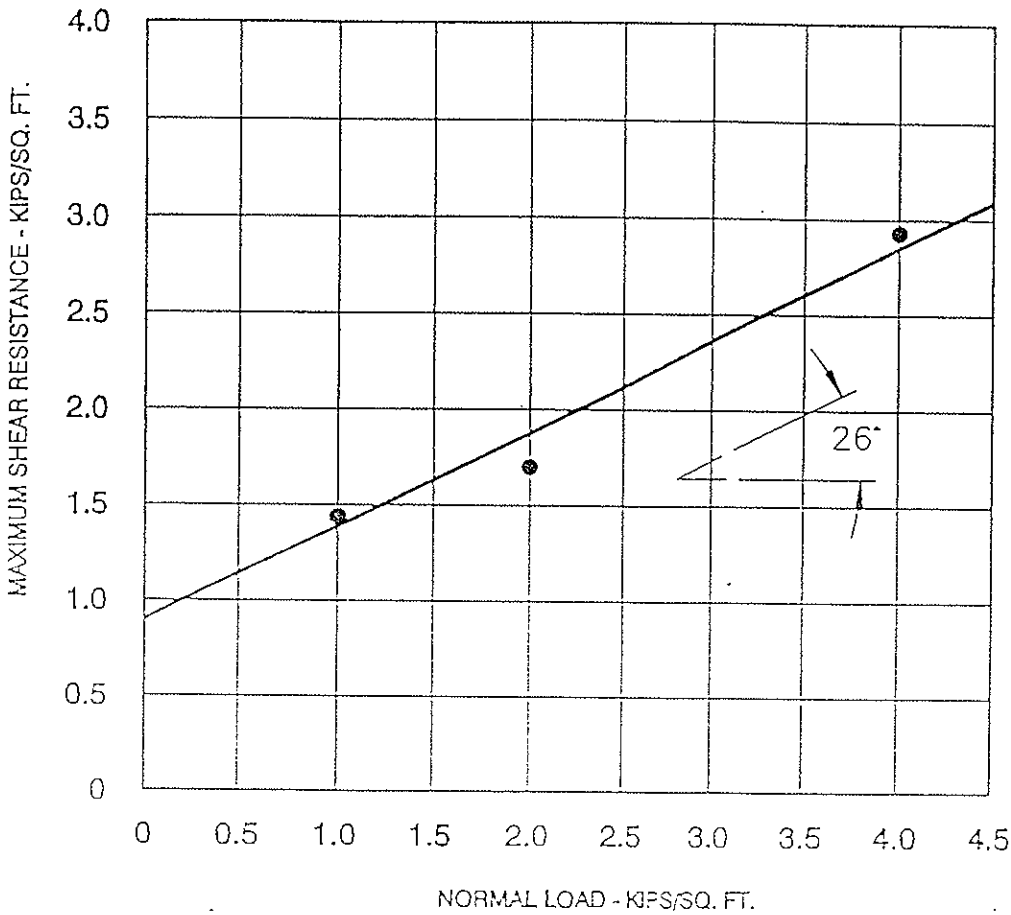
DIRECT SHEAR TEST RESULTS

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Scale	N/A
Date	10/20/99
Drafted By	OLE
Checked By	MKK
Approved By	
File No.	4370185
Project No.	99-33437-0
Figure No.	A-65

CONVERSE CONSULTANTS

Over 50 Years of Dedication in Engineering and Environmental Sciences



Exploration Location = B-101

Sample Depth = 39 - 40 FT

Angle of Shearing Resistance, Ø = 26°

Cohesion, c = 0.90 KIPS/SQ. FT.

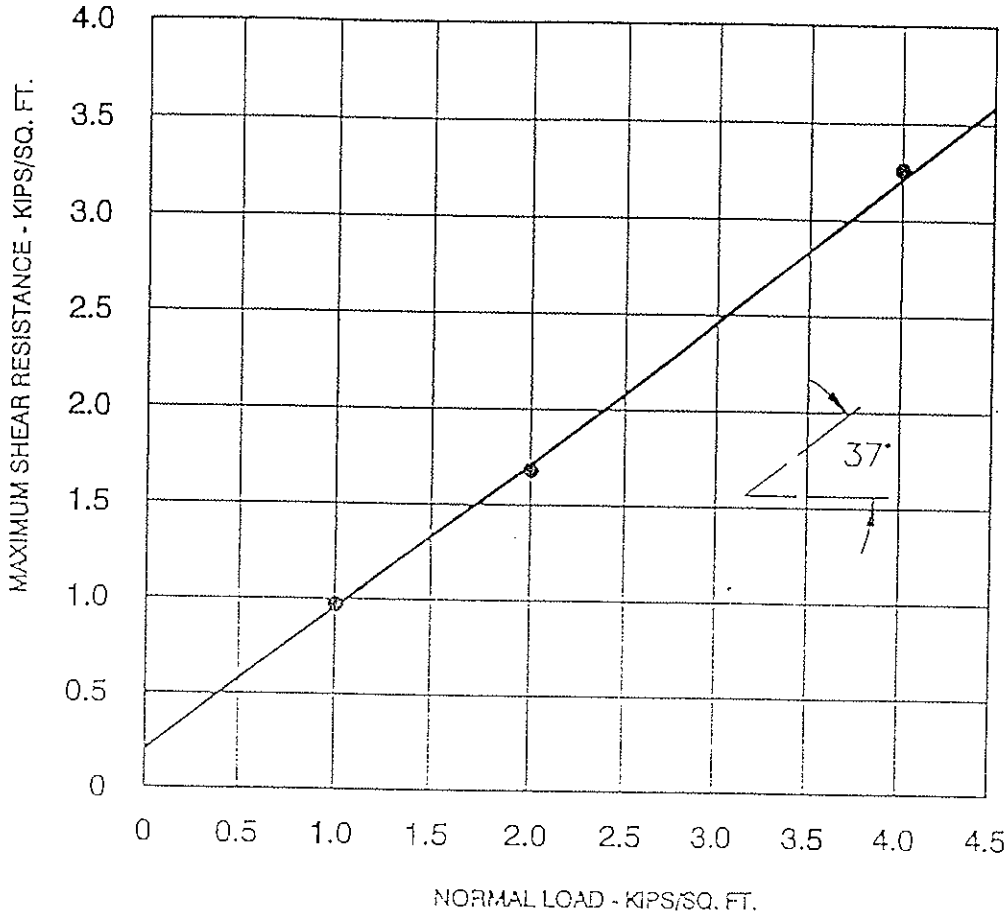
DIRECT SHEAR TEST RESULTS

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Scale	N/A
Date	10/20/99
Drafted By	GLE
Checked By	MKK
Approved By	
File No.	4370185
Project No.	99-33437-0
Figure No.	A-66

CONVERSE CONSULTANTS

Over 50 Years of Dedication in Engineering and Environmental Sciences



Exploration Location = B-102

Sample Depth = 20 - 25 FT

Angle of Shearing Resistance, Ø = 37°

Cohesion, c = 0.20 KIPS/SQ. FT.

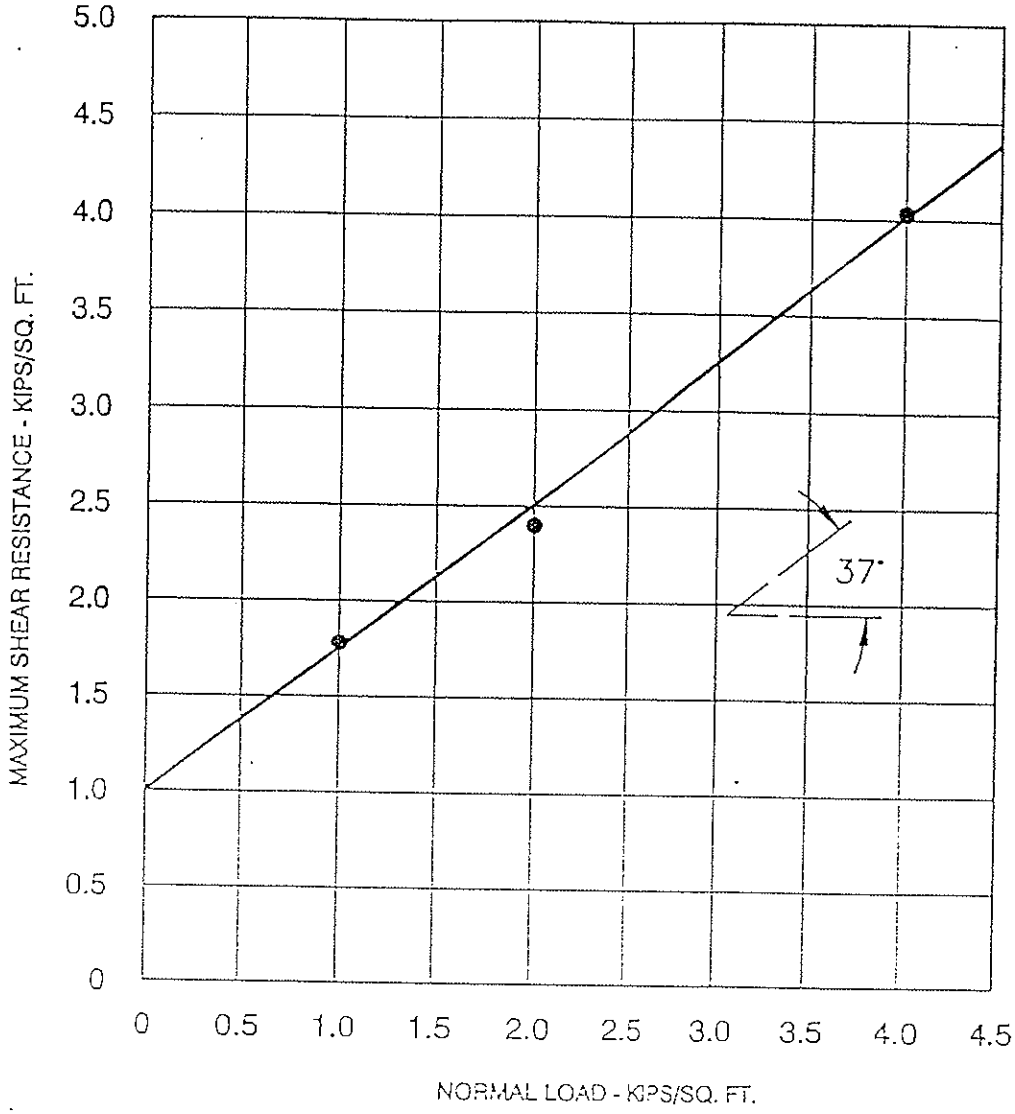
DIRECT SHEAR TEST RESULTS

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Scale	N/A
Date	10/20/99
Drafted By	GLF
Checked By	MKK
Approved By	
File No.	4370186
Project No.	99-33437-0
Figure No.	A-67

CONVERSE CONSULTANTS

Over 50 Years of Dedication in Engineering and Environmental Sciences



Exploration Location = B-103

Sample Depth = 49 - 50 FT

Angle of Shearing Resistance, Ø = 37°

Cohesion, c = 1.00 KIPS/SQ. FT.

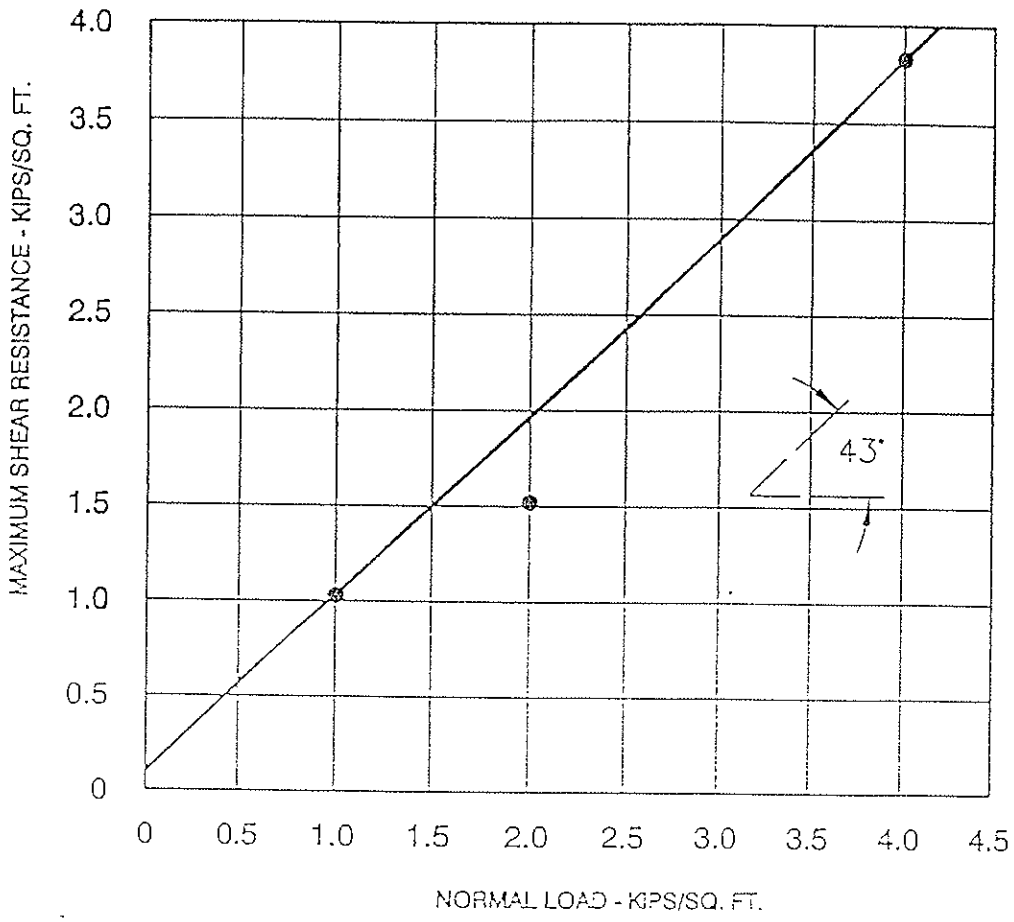
DIRECT SHEAR TEST RESULTS

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Scale	N/A
Date	10/20/99
Drafted By	GLE
Checked By	MKK
Approved By	
File No.	43701359
Project No.	99-33437-01
Figure No.	A-68

CONVERSE CONSULTANTS

Over 50 Years of Dedication in Engineering and Environmental Sciences



Exploration Location = B-104

Sample Depth = 10 - 15 FT

Angle of Shearing Resistance, Ø = 43°

Cohesion, c = 0.10 KIPS/SQ. FT.

DIRECT SHEAR TEST RESULTS

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Scale	N/A
Date	10/20/99
Drafted By	GLE
Checked By	MKK
Approved By	
File No.	4370186
Project No.	99-33437-0
Figure No.	A-69

CONVERSE CONSULTANTS

Over 50 Years of Dedication in Engineering and Environmental Sciences

Atlas Chemical Testing Laboratories

2120 Western Avenue, Suite C-6 • Las Vegas, Nevada 89102
(702) 383-1199 • Fax (702) 383-4983

CHEMICAL
PHYSICAL
FORENSIC

member of
AMERICAN SOCIETY FOR
TESTING MATERIALS

ACT LAB NO: 9218(b) DATE: October 13, 1999

PROJECT NO: 99-33437-01 P.O.: 18154

ANALYZED BY: Robert L. Simmons LAB ID:

WATER SOLUBLE SALT ANALYSIS IN SOIL

1:5 (soil:water) Aqueous Extraction

AWWA 3500-Na D, ASTM D 516

BMI LANDFILL

Sample No.	Location	Depth (Feet)	Sodium (Percent)	Water Soluble Sulfate (SO_4) (Percent)	Total Available Water Soluble Sodium Sulfate(Na_2SO (Percent)
	B-5	10-15	0.07	0.13	0.20
	B-8	19-20	0.07	0.06	0.08
	B-101	5-10	0.17	0.06	0.08
	B-102	0-5	0.17	0.03	0.05
	B-106	0-5	0.15	0.08	0.13
	B-106.	29-30	0.15	0.06	0.08

A-7C

Notes: The results for each constituent denote the percentage of that analyte, at a 1:5 (soil:water) extraction ratio, which is present in the soil. Sodium was determined by flame photometry, sulfate turbidimetrically, and sodium sulfate by calculation.

AP Engineering and Testing, Inc.

GEOTECHNICAL TESTING LABORATORY

FLEXIBLE WALL HYDRAULIC CONDUCTIVITY TEST
ASTM D5084

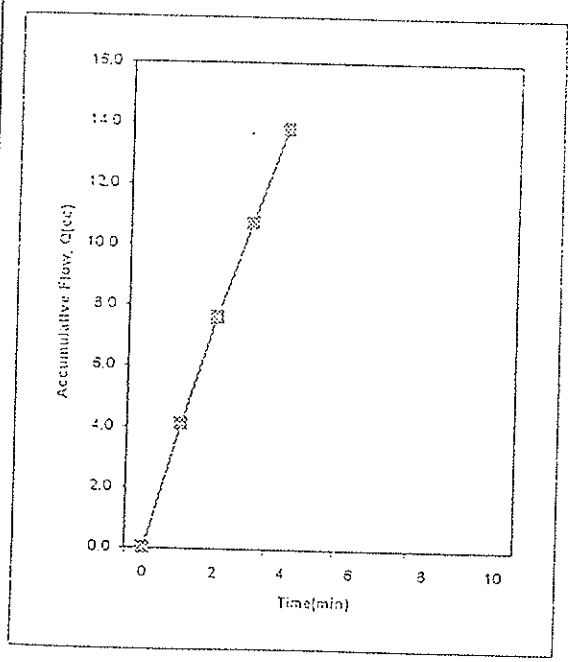
Project Name:	Preliminary Geologic Investigation	Tested by	PS	Date	10/12/99
Project No.:	99-33437-01	Calculated by	SY	Date	10/20/99
Boring No.:	B-1	Checked by	AP	Date	10/20/99
Sample No.:	— Depth: 14-15' feet				
Soil Description:	Olive Brown Silty Sand w/ gravel				
Test Condition:					
	Confining Pressure = 11 PSI				

INITIAL CONDITION OF SPECIMEN

Diameter (d)	2.42	in
Sample Area (A)	4.58	in².
Length (L)	2.48	in
Weight Before	286.60	g
Wet Density	95.97	pcf
Dry Density	91.48	pcf

	Before	After
Container No.		
Wt. Wet Soil+Container(gms)	340.95	361.62
Wt. Dry Soil+Container(gms)	327.35	316.16
Wt. Container (gms)	50.51	50.02
Moisture, (%)	4.91	17.07

TEST RESULTS



Time (min)	Flow Rdg (cm)	Burette Factor	Q (cc)	Head, h (psi)	h/L	Q/t (cc/s)
0	29.2	1	0.0	1.0	11.2	0
1	25.1	1	4.1	1.0	11.2	6.83E-02
2	21.6	1	7.6	1.0	11.2	5.83E-02
3	18.5	1	10.7	1.0	11.2	5.17E-02
4	15.4	1	13.8	1.0	11.2	5.17E-02

Hydraulic Conductivity (cm/sec): 1.57E-04

AP Engineering and Testing, Inc.

GEOTECHNICAL TESTING LABORATORY

FLEXIBLE WALL HYDRAULIC CONDUCTIVITY TEST
ASTM D5084

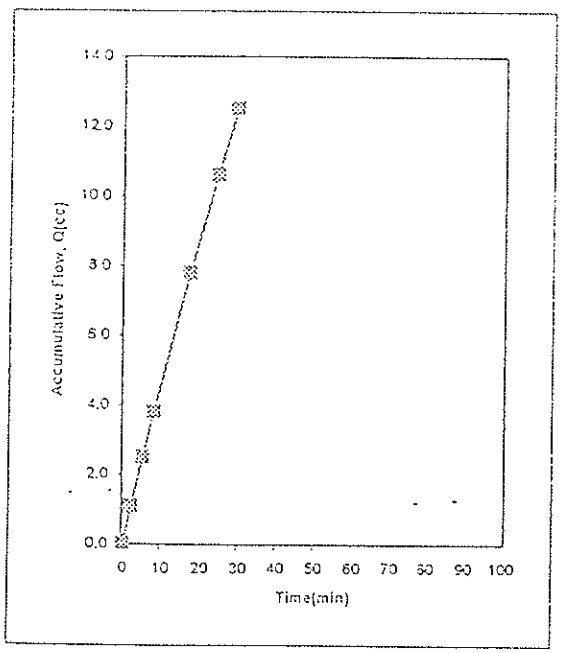
Project Name:	Preliminary Geologic Investigation	Tested by	PS	Date	10/12/99
Project No.:	99-33437-01	Calculated by	SY	Date	10/20/99
Boring No.:	B-8	Checked by	AP	Date	10/20/99
Sample No.:	— Depth: 44-45' feet				
Soil Description:	Lt Olive Brown Sandy Silt				
Test Condition:					
	Confining Pressure = 33 PSI				

INITIAL CONDITION OF SPECIMEN

Diameter (d)	2.42	in
Sample Area (A)	4.58	in²
Length (L)	3.48	in
Weight Before	457.60	g
Wet Density	109.24	pcf
Dry Density	85.69	pcf

	Before	After
Container No.		
Wt. Wet Soil+Container(gms)	248.6	412.7
Wt. Dry Soil+Container(gms)	205.71	323.46
Wt. Container (gms)	49.67	53.72
Moisture, (%)	27.49	33.03

TEST RESULTS



Time (min)	Flow Rdg (cm)	Burette Factor	Q (cc)	Head, h (psi)	h/L	Q/t (cc/s)
0	27.2	1	0.0	1.0	7.95	0
2	26.1	1	1.1	1.0	7.95	9.17E-03
5	24.7	1	2.5	1.0	7.95	7.78E-03
8	23.4	1	3.8	1.0	7.95	7.22E-03
17	19.4	1	7.8	1.0	7.95	7.41E-03
24	16.6	1	10.6	1.0	7.95	6.67E-03
29	14.7	1	12.5	1.0	7.95	6.33E-03
34	12.9	1	14.3	1.0	7.95	6.00E-03

Hydraulic Conductivity (cm/sec): 2.90E-05

AP Engineering and Testing, Inc.

GEOTECHNICAL TESTING LABORATORY

FLEXIBLE WALL HYDRAULIC CONDUCTIVITY TEST
ASTM D5084

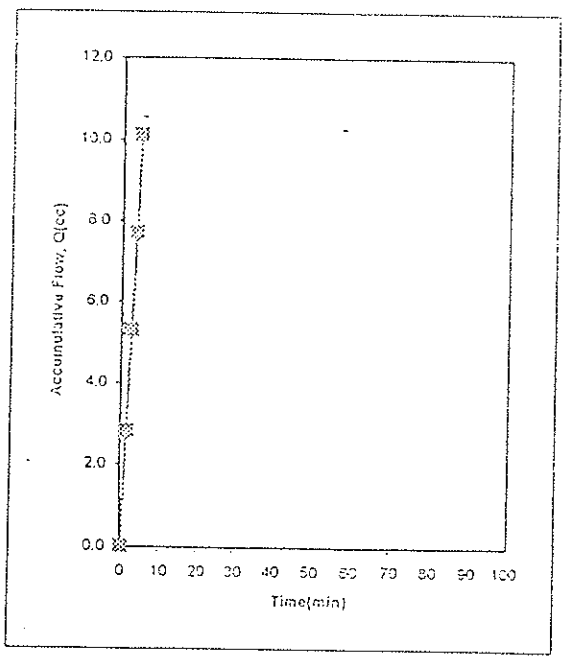
Project Name:	Preliminary Geologic Investigation	Tested by	PS	Date	10/12/99
Project No.:	99-33437-01	Calculated by	SY	Date	10/20/99
Boring No.:	B-4	Checked by	AP	Date	10/20/99
Sample No.:	— Depth: 24-25 feet				
Soil Description:	Lt Olive Brown Silty Sand w/ gravel				
Test Condition:					
	Confining Pressure = 18 PSI				

INITIAL CONDITION OF SPECIMEN

Diameter (d)	2.42	in
Sample Area (A)	4.58	in²
Length (L)	3.00	in
Weight Before	437.24	g
Wet Density	121.20	pcf
Dry Density	114.78	pcf

	Before	After
Container No.		
Wt. Wet Soil+Container(gms)	308.84	421.32
Wt. Dry Soil+Container(gms)	295.15	372.45
Wt. Container (gms)	50.05	49.46
Moisture, (%)	5.59	15.13

TEST RESULTS



Time (min)	Flow Rdg (cm)	Burette Factor	Q (cc)	Head, h (psi)	h/L	Q/t (cc/s)
0	32.6	1	0.0	1.0	9.23	0
1	29.3	1	2.8	1.0	9.23	4.67E-02
2	27.3	1	5.3	1.0	9.23	4.17E-02
3	24.9	1	7.7	1.0	9.23	4.00E-02
4	22.5	1	10.1	1.0	9.23	4.00E-02

Hydraulic Conductivity (cm/sec): 1.47E-04

AP Engineering and Testing, Inc.

GEOTECHNICAL TESTING LABORATORY

FLEXIBLE WALL HYDRAULIC CONDUCTIVITY TEST
ASTM D5084

Project Name: Preliminary Geologic Investigation
Project No.: 99-33437-01
Boring No.: B-12
Sample No.: — Depth: 39-39.5 feet
Soil Description: Yell Brown Silty Clay w/ siltstone
Test Condition:
Confining Pressure = 29 PSI

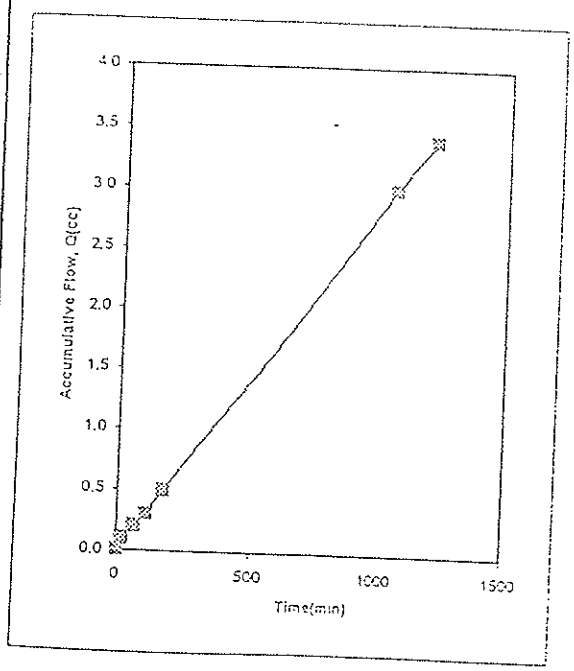
Tested by PS Date 10/14/99
Calculated by SY Date 10/20/99
Checked by AP Date 10/20/99

INITIAL CONDITION OF SPECIMEN

Diameter (d)	2.42	in
Sample Area (A)	4.58	in²
Length (L)	3.00	in
Weight Before	410.32	g
Wet Density	113.73	pcf
Dry Density	86.05	pcf

	Before	After
Container No.		
Wt. Wet Soil+Container(gms)	173.15	470.17
Wt. Dry Soil+Container(gms)	137.46	363.54
Wt. Container (gms)	26.53	50.02
Moisture, (%)	32.17	34.01

TEST RESULTS



Time (min)	Flow Rdg (cm)	Burette Factor	Q (cc)	Head, h (psi)	h/L	Q/t (cc/s)
0	22.3	1	0.0	1.0	9.23	0
19	22.2	1	0.1	1.0	9.23	8.77E-05
63	22.1	1	0.2	1.0	9.23	3.79E-05
109	22.0	1	0.3	1.0	9.23	3.62E-05
171	21.8	1	0.5	1.0	9.23	5.38E-05
1052	19.3	1	3.0	1.0	9.23	4.73E-05
1207	18.9	1	3.4	1.0	9.23	4.30E-05

Hydraulic Conductivity (cm/sec): 1.76E-07

AP Engineering and Testing, Inc.

GEOTECHNICAL TESTING LABORATORY

FLEXIBLE WALL HYDRAULIC CONDUCTIVITY TEST
ASTM D5084

Project Name: Preliminary Geologic Investigation
Project No.: 99-33437-01
Boring No.: B-105
Sample No.: --- Depth: 30-35 feet
Soil Description: Grayish Brown Silty Sand
Test Condition: Remolded to 85 % Relative Compaction @ Opt
Confining Pressure = 23 PSI

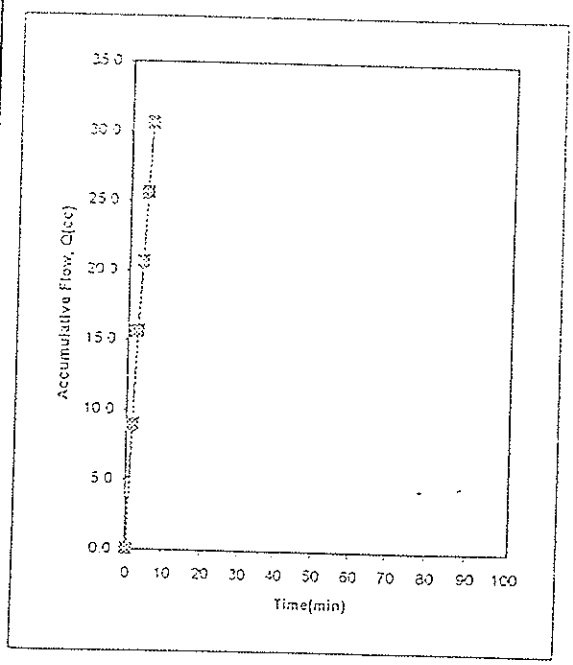
Tested by PS Date 10/14/99
Calculated by SY Date 10/20/99
Checked by AP Date 10/20/99

INITIAL CONDITION OF SPECIMEN

Diameter (d)	2.42	in
Sample Area (A)	4.58	in²
Length (L)	3.00	in
Weight Before	432.56	g
Wet Density	119.90	pcf
Dry Density	112.01	pcf

	Before	After
Container No.		
Wt. Wet Soil+Container(gms)	309.87	317.64
Wt. Dry Soil+Container(gms)	300.27	282.06
Wt. Container (gms)	164.05	49.93
Moisture, (%)	7.05	15.32

TEST RESULTS



Time (min)	Flow Rdg (cm)	Burette Factor	Q (cc)	Head, h (psi)	h/L	Q/t (cc/s)
0	45.3	1	0.0	1.0	9.23	0
1	36.4	1	8.9	1.0	9.23	1.48E-01
2	29.7	1	15.6	1.0	9.23	1.12E-01
3	24.7	1	20.6	1.0	9.23	8.33E-02
4	19.7	1	25.6	1.0	9.23	8.33E-02
5	14.7	1	30.6	1.0	9.23	8.33E-02

Hydraulic Conductivity (cm/sec): 3.05E-04

Log of Boring No. BRC-BS-01

CAMU

Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: HSA
Drilling Equipment: HSA LAR
Drilling Contractor: Water Development Corporation
Driller: James Duke

Borehole Total Depth: 32 ft bgs
Borehole Diameter: 8 in
Well ID: N/A
Depth to Water (ft. bgs): NA ▽

Sample Type: 2.5" Split Spoon
Sample Interval Continuous

Logged By: J. Wiley
Date Started: 01/15/05
Date Completed: 01/15/05

Monitoring Well Construction

Type of Surface Seal:	N/A	**Screen Slot Size:**	N/A
Blank Casing Type/Size:	N/A	**Top of Screen (ft. bgs):**	N/A
Screen Type/Size:	N/A	**Bottom of Screen (ft. bgs):**	N/A
Transition Sand Type:	N/A	**Type of Sand Pack:**	N/A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0							SP: Soil surface. (Odors not being observed due to potential chemical hazards.)	
							SP: @ 3', debris present, grey discolored soil and rubber cord with belt pieces.	
	Grab				0.1		SP: Poorly graded sand, dark greyish brown (10YR4/2), loose to medium dense, moist, fine to coarse subrounded sand and fine gravel, noncemented, no debris. Approximately trace gravel, 5% coarse sand, 85% medium sand and 10% fine sand.	
-10					0.6		Poorly graded sand, light brownish grey (10YR6/2), very dense, moist, fine to coarse, subangular to subrounded sand and fine gravel with increasing volcanics, noncemented silt. Approximately 5% gravel, 5% coarse sand, 65% medium sand, 25% fine sand and trace silt.	
	Grab				1.5		Poorly graded sand, brown (10YR5/3), loose to medium dense, moist, fine to coarse subangular to subrounded snad and fine gravel, no volcanics, noncemented, trace silt. Approximately 5% gravel, 15% coarse sand, 60% medium sand, 20% fine sand, trace silt.	
-20					1.4		Poorly graded sand, brown (10YR5/3), very dense, moist, moist, fine to coarse subangular volcanic sand and fine gravel, noncemented, trace silt. Approximately 5% gravel, 15% coarse sand, 60% medium sand, 20% fine sand, and trace silt.	
	Grab				0.5		Poorly graded sand, brown (10YR5/3) loose to medium dense, moist, fine to coarse subangular to subrounded sand and fine gravel, few volcanics, noncemented, trace silt. Approximately 5% gravel, 15% coarse sand, 60% medium sand, 20% fine sand and trace silt.	
-30					1.9		Poorly graded sand, brown (10YR5/3), very dense, moist, fine to coarse subangular to subrounded volcanic sand, and fine gravel, noncemented, slight solvent odor. Approximately 5% gravel, 15% coarse sand, 60% medium sand, 20% fine sand, and trace silt. Terminated borehole at 32' bgs.	

Log of Boring No. BRC-BS-02

CAMU

Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: HSA
Drilling Equipment: HSA LAR
Drilling Contractor: Water Development Corporation
Driller: James Duke

Borehole Total Depth: 32 ft bgs
Borehole Diameter: 8 in
Well ID: N/A
Depth to Water (ft. bgs): NA ▽

Sample Type: 2.5" Split Spoon
Sample Interval Continuous

Logged By: J. Wiley
Date Started: 01/14/05
Date Completed: 01/14/05

Monitoring Well Construction

Type of Surface Seal:	N/A	**Screen Slot Size:**	N/A
Blank Casing Type/Size:	N/A	**Top of Screen (ft. bgs):**	N/A
Screen Type/Size:	N/A	**Bottom of Screen (ft. bgs):**	N/A
Transition Sand Type:	N/A	**Type of Sand Pack:**	N/A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0							SP: Soil Surface, soil boring located in area of subsidence. (Odors not being observed due to potential chemical hazards.)	
	Grab				0.2		Poorly graded sand, yellowish brown (10YR5/4), loose, moist, fine to coarse, subrounded to rounded sand and fine gravel, noncemented, no debris. Approximately trace gravel, 10% coarse sand, 70% medium sand, 20% fine sand and trace silt.	
-10					0.0		Poorly graded sand, dark yellowish brown (10YR4/4), medium dense, moist, fine to coarse subrounded to rounded sand, and fine gravel, noncemented. Approximately trace gravel, 10% coarse sand, 70% medium sand, 20% fine sand and trace silt.	
	Grab				2.2		SP: Poorly graded sand, brown (10YR5/4), loose to medium dense, moist, fine to coarse subrounded sand and fine gravel, noncemented, minor debris (small paper shreds). Approximately trace gravel, 5% coarse sand, 75% medium sand and 20% fine sand and trace silt.	
					3.2		SP: Debris - wood, fabric, plastic, paper bags, white powder, and wet white chalky substance, strong solvent odor.	
-20							SP: Poorly graded sand, yellowish brown (10YR5/4), dense, moist, fine to coarse subrounded to subangular sand and fine gravel, noncemented, no debris.	
							@ 23' drillers note change in drilling - hard soil.	
	Grab				0.2		Poorly graded sand, brown (10YR5/3), moist, fine to coarse, angular to subrounded sand and fine gravel (includes volcanics), noncemented, no debris, trace silt. Approximately trace gravel, 5% coarse, 65% medium sand, 65% medium sand, 25% fine and 5% silt.	
-30					1.8		Poorly graded sand, brown (10YR5/3), very dense, moist, fine to coarse subanguar sand and fine gravel (including volcanics), noncemented, no debris, trace silt. Approximately trace gravel, trace coarse sand, 50% medium sand, 45% fine sand and 5% silt. Terminated borehole at 32' bgs.	

Log of Boring No. BRC-BS-03

CAMU

Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: HSA
Drilling Equipment: HSA LAR
Drilling Contractor: Water Development Corporation
Driller: James Duke

Borehole Total Depth: 32 ft bgs
Borehole Diameter: 8 in
Well ID: N/A
Depth to Water (ft. bgs): NA ⊻

Sample Type: 2.5" Split Spoon
Sample Interval Continuous

Logged By: J. Wiley
Date Started: 01/12/05
Date Completed: 01/12/05

Monitoring Well Construction

Type of Surface Seal:	N/A	**Screen Slot Size:**	N/A
Blank Casing Type/Size:	N/A	**Top of Screen (ft. bgs):**	N/A
Screen Type/Size:	N/A	**Bottom of Screen (ft. bgs):**	N/A
Transition Sand Type:	N/A	**Type of Sand Pack:**	N/A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0	Grab				0.0		GP: Soil surface; boring located within area of slight subsidence. (Odors not being observed due to potential chemical hazards.) SP: Poorly graded gravel with sand, yellowish brown (10YR5/4), loose, moist, medium to coarse subrounded sand and fine subrounded (pea) gravel, trace fine snad, noncemented. Approximately 60% gravel, 20% coarse sand, 20% medium sand and trace fine sand.	
-10	No Soil				2.6		SP: Poorly graded sand, yellowish brown (10YR5/4), medium dense, moist, fine to medium subrounded to angular sand and fine subangular gravel, noncemented, debris includes plastic, fabric, concrete chunks, and visqueen. Apporximately 10% gravel, 5% coarse sand, 65% medium sand and 20% fine sand.	
					1.0		DEBRIS/COBBLES: @15' cuttings consist mostly of debris - clothing mostly and plastic parts (one reads "janitorial toilet bowl cleaner"), some paper/cardboard, with cobbles up to 2.5" diameter.	
-20					1.5		@19' cannot pound sample - blocked - no recovery. @20' cannot pound sample - no recovery. Drill to 21' and try again. Cuttings consist of debris (paper/cardboard) with some cobbles/coarse gravel.	
-30					1.7		GP: @27' drillers noted that soil way more compacted - likely out of fill. Poorly graded gravel with sand, light yellowish brown (10YR6/4), very dense, moist, fine to coarse subangular sand and fine subangular gravel, trace silt, no debris. Approximately 60% gravel, 15% coarse sand, 15% medium sand, 10% fine sand and trace silt. Terminated borehole at 32' bgs.	

Log of Boring No. BRC-BS-04

CAMU

Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: HSA
Drilling Equipment: HSA LAR
Drilling Contractor: Water Development Corporation
Driller: James Duke

Borehole Total Depth: 32 ft bgs
Borehole Diameter: 8 in
Well ID: N/A
Depth to Water (ft. bgs): NA ▽

Sample Type: 2.5" Split Spoon
Sample Interval Continuous

Logged By: J. Wiley
Date Started: 01/17/05
Date Completed: 01/17/05

Monitoring Well Construction

Type of Surface Seal:	N/A	**Screen Slot Size:**	N/A
Blank Casing Type/Size:	N/A	**Top of Screen (ft. bgs):**	N/A
Screen Type/Size:	N/A	**Bottom of Screen (ft. bgs):**	N/A
Transition Sand Type:	N/A	**Type of Sand Pack:**	N/A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0							SP: Soil surface; soil boring located within subsidence cracks. (Odors not being observed due to potential chemical hazards.)	
	Grab				0.4		Poorly raded sand, dark yellowish brown (10YR4/4), loose to medium dense, moist, fine to coarse subrounded to rounded sand and fine gravel - not volcanic, noncemented, no debris. Approximately trace gravel, 20% coarse sand, 65% medium sand and 15% fine sand.	
-10					0.5		Poorly graded sand, dark yellowish brown (10YR4/4), dense, moist, fine to coarse subrounded to rounded sand and fine gravel - not volcanic, noncemented. Debris begins at 11.5', consists of paper bags and white powder, and wood splinters. Approximately 5% gravel, 20% coarse sand, 60% medium sand and 15% fine sand.	
	Grab				11.3		SP: Poorly graded sand, brown (10YR4/3), medium dense to dense, moist, fine to coarse subrounded to rounded sand and fine gravel - no volcanics, noncemented, paper and plastic debris, wood splinters. Approximately 5% gravel, 20% coarse sand, 60% medium sand and 15% fine sand.	
-20					3.6			
	Grab				12.0		SP: Poorly graded sand, brown (10YR4/3), very dense, moist, fine to coarse angular to subangular volcanic sand and fine gravel, noncemented, no debris. Drillers note change in hardness @ 21'. Cuttings appear to be from 15' - 20' interval - have plastic lid (~4' diameter) debris and trace metal straps. Approximately trace gravel, 10% coarse, 65% medium sand and 25% fine sand.	
-30							Poorly graded sand, brown (10YR4/3), very dense, moist, fine to coarse angular to subangular volcanic sand and fine gravel, noncemented, no debris. Approximately trace gravel, 10% coarse sand, 65% medium sand and 25% fine sand. Terminated borehole at 31' bgs.	

Log of Boring No. BRC-BS-05

CAMU

Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: HSA
Drilling Equipment: HSA LAR
Drilling Contractor: Water Development Corporation
Driller: James Duke

Borehole Total Depth: 32 ft bgs
Borehole Diameter: 8 in
Well ID: N/A
Depth to Water (ft. bgs): NA ▽

Sample Type: 2.5" Split Spoon
Sample Interval Continuous

Logged By: J. Wiley
Date Started: 01/19/05
Date Completed: 01/19/05

Monitoring Well Construction

Type of Surface Seal:	N/A	**Screen Slot Size:**	N/A
Blank Casing Type/Size:	N/A	**Top of Screen (ft. bgs):**	N/A
Screen Type/Size:	N/A	**Bottom of Screen (ft. bgs):**	N/A
Transition Sand Type:	N/A	**Type of Sand Pack:**	N/A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0							SP: Soil surface, boring located within area of subsidence. (Odors not being observed due to potential chemical hazards.) Debris begins @ 5'	
	Grab				0.7		SP: Poorly graded sand, yellowish brown (10YR5/4), loose, moist, fine to coarse sand and fine grained - subrounded to rounded - no volcanics, noncemented. Debris includes wood, metal, cobbles, and plastic. Approximately trace gravel, trace coarse sand, 70% medium sand and 30% fine sand.	
-10					4.3		Poorly graded sand, yellowish brown (10YR5/4), dense, moist, fine to coarse subrounded to rounded sand and fine gravel - no volcanics, noncemented, debris includes mostly wood, some plastic, metal, and white chalky material. Approximately 5% gravel, 10% coarse sand, 75% medium sand and 10% fine sand.	
	Grab				21.0		Poorly graded sand, brown (10YR4/3), loose to dense, moist, fine to coarse subangular to subrounded sand and fine gravel, no volcanics, noncemented, little debris, paper (small shreds). Approximately trace gravel, 5% coarse sand, 65% medium sand and 30% fine sand.	
-20					19.0		Poorly graded sand, dark grayish brown (10YR4/2), very dense, moist, fine to coarse subangular to subrounded sand and fine gravel, no volcanics, noncemented, debris includes wood, plastic lined paper bags with white chalky material, metal and newspaper. Approximately trace gravel, 5% coarse sand, 65% medium sand and 30% fine sand.	
	Grab				5.2		SP: Poorly graded sand, yellowish brown (10YR5/4), loose to dense, moist, fine to coarse angular to rounded sand and fine gravel - some volcanics, noncemented, no debris, trace silt. Approximately trace gravel, 5% coarse sand, 60% medium sand, 35% fine sand and trace silt.	
-30					0.4		Poorly graded sand, yellowish brown (10YR5/4), very dense, moist, fine to coarse angular to subangular sand and fine gravel - volcanic, noncemented, no debris. Approximately trace gravel, 5% coarse sand, 60% medium sand, 35% fine sand and trace silt. Terminated borehole at 32' bgs.	

Log of Boring No. BRC-BS-06
CAMU
Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: HSA
Drilling Equipment: HSA LAR
Drilling Contractor: Water Development Corporation
Driller: James Duke

Borehole Total Depth: 32 ft bgs
Borehole Diameter: 8 in
Well ID: N/A
Depth to Water (ft. bgs): NA ▽

Sample Type: 2.5" Split Spoon
Sample Interval Continuous

Logged By: J. Wiley
Date Started: 01/14/05
Date Completed: 01/14/05

Monitoring Well Construction

Type of Surface Seal:	N/A	**Screen Slot Size:**	N/A
Blank Casing Type/Size:	N/A	**Top of Screen (ft. bgs):**	N/A
Screen Type/Size:	N/A	**Bottom of Screen (ft. bgs):**	N/A
Transition Sand Type:	N/A	**Type of Sand Pack:**	N/A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0							SP: Soil surface. (Odors not being observed due to potential chemical hazards.) Poorly graded sand, brown (10YR4/3), loose, moist, fine to coarse subrounded to rounded sand and fine grained, noncemented. Approximately 5% gravel, 10% coarse sand, 65% medium sand and 20% fine sand.	
	Grab				30.6		SP: Begin debris at 3' bgs. wood, solvent odor. Poorly graded sand, brown (10YR4/3) loose to medium dense, moist, fine to coarse subrounded to rounded sand and fine gravel, noncemented, solvent odor, debris includes wood. Approximately trace gravel, 10% coarse sand 70% medium sand and 20% fine sand.	
-10					4.0		Poorly graded sand, brown (10YR4/3), dense, moist, fine to coarse subangular to subrounded sand, and trace fine gravel, noncemented, strong solvent odor, very little wood debris. Approximately trace gravel, 5% coarse sand, 75% medium sand and 20% fine sand.	
							@12' increased debris: wood, fabric, plastic, solvent odor.	
	Grab				15.0		Poorly graded sand, dark yellowish brown (10YR4/4), loose to medium dense, fine to coarse subrounded sand and fine gravel, noncemented, debris includes fabric with plastic and wood, solvent odor.	
-20					1.0		Poorly graded sand, dark yellowish brown (10YR4/4), dense, fine to coarse, subangular sand and fine gravel, noncemented, solvent odor. Approximately 5% gravel, 5% coarse sand, 50% medium sand, 40% fine sand and trace silt.	
	Grab				35.1		SP: Poorly graded sand, dark yellowish brown (10YR4/4), loose to medium dense, fine to coarse subangular sand and fine gravel, noncemented, solvent odor, no debris. Approximately 10% gravel, 5% coarse sand, 55% medium sand, 30% fine sand and trace silt.	
-30					0.8		Poorly graded sand, brown (10YR5/3), very dense, moist, fine to coarse volcanic sand (angular to subangular) and fine gravel, noncemented, no debris. Approximately trace gravel, 5% coarse snad 55% medium sand and 40% fine sand.	
							Terminated borehole at 32' bgs.	

Log of Boring No. BRC-BS-07
CAMU
Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: HSA
Drilling Equipment: HSA LAR
Drilling Contractor: Water Development Corporation
Driller: James Duke

Borehole Total Depth: 32 ft bgs
Borehole Diameter: 8 in
Well ID: N/A
Depth to Water (ft. bgs): NA ▽

Sample Type: 2.5" Split Spoon
Sample Interval Continuous

Logged By: J. Wiley
Date Started: 01/11/05
Date Completed: 01/11/05

Monitoring Well Construction

Type of Surface Seal:	N/A	**Screen Slot Size:**	N/A
Blank Casing Type/Size:	N/A	**Top of Screen (ft. bgs):**	N/A
Screen Type/Size:	N/A	**Bottom of Screen (ft. bgs):**	N/A
Transition Sand Type:	N/A	**Type of Sand Pack:**	N/A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0	Grab						SP: Soil surface; boring located adjacent to deep (3') area of subsidence, and is in line of subsidence areas. (Odors not being observed due to potential chemical hazards.) Poorly graded sand with gravel, yellowish brown (10YR5/4), loose, moist, fine to coarse subrounded to angular sand and fine angular gravel (fill), noncemented. Approximately 15% gravel, 10% coarse sand, 55% medium sand, 20% fine sand and trace silt.	
-10					1.1		DEBRIS: Debris-fabric (black) and plastic chunks (white to grey). Poor recovery.	
							SP: Poorly graded sand with gravel, pale brown (10YR6/3), moist, medium dense, fine to coarse subrounded to angular sand and fine subangular gravel, noncemented. Approximately 15% gravel, 20% coarse sand, 50% medium sand, 15% fine sand and trace silt.	
							SP: No recovery from cuttings due to fabric material caught in auger - likely debris in this interval.	
-20					0.1		SP: Poorly graded sand with gravel, pale brown (10YR6/3), moist, very dense, fine to coarse subrounded to angular sand and fine subangular gravel, noncemented, trace cobbles, has black fabric fragments. Approximately 15% gravel, 10% coarse sand, 45% medium sand, 30% fine sand and trace silt.	
	Grab						Poorly graded sand with gravel, brown (10YR5/3), moist, fine to coarse subrounded to subangular sand and subangular gravel, noncemented. Approximately 15% gravel, 5% coarse sand, 40% medium sand, 40% fine sand and trace silt.	
-30					3.0		Poorly graded sand with gravel, brown (10YR5/3), very dense, moist, fine to coarse subrounded to subangular sand and fine subangular gravel, noncemented, no fabric observed, drillers observed harder drilling after 25'. Approximately 15% gravel, 5% coarse sand, 40% medium sand, 40% fine sand and trace silt.	
							Terminated borehole at 32' bgs.	

Log of Boring No. BRC-BS-08

CAMU

Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: HSA
Drilling Equipment: HSA LAR
Drilling Contractor: Water Development Corporation
Driller: Ignacio Gutierrez

Borehole Total Depth: 32 ft bgs
Borehole Diameter: 8 in
Well ID: N/A
Depth to Water (ft. bgs): NA ⊻

Sample Type: 2.5" Split Spoon
Sample Interval Continuous

Logged By: J. Wiley
Date Started: 01/18/05
Date Completed: 01/18/05

Monitoring Well Construction

Type of Surface Seal:	N/A	**Screen Slot Size:**	N/A
Blank Casing Type/Size:	N/A	**Top of Screen (ft. bgs):**	N/A
Screen Type/Size:	N/A	**Bottom of Screen (ft. bgs):**	N/A
Transition Sand Type:	N/A	**Type of Sand Pack:**	N/A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0	Grab				-6.5		SP: Soil surface, boring located in slight depression area. (Odors not being observed due to potential chemical hazards.) Poorly graded sand, dark yellowish brown (10YR4/4), loose to dense, fine to coarse subrounded to rounded sand and fine gravel - no volcanics, trace silt, noncemented. Approximately 5% gravel, 5% coarse sand, 75% medium sand, 15% fine sand and trace silt.	
-10					16.2		Poorly graded sand, brown (10YR4/3), dense, moist, fine to coarse angular to subangular volcanic sand and fine gravel plus nonvolcanics, noncemented, solvent odor, grains have slight coating (dark brown), oily.	
	Grab				57.2		Poorly graded sand, very dark grayish brown, dense, fine to coarse angular to subangular volcanic sand and fine gravel, noncemented, oily coating (dark brown), solvent odor. Approximately trace gravel, 10% coarse sand, 70% medium sand and 20% fine sand.	
-20					1361		SP: Poorly graded sand, brown (10YR4/3), dense, moist, fine to coarse, subangular to subrounded sand and fine gravel - some volcanic. Thick oily residue covers grains. Has sheen when washed, strong solvent odor, weakly cemented from residues. Fill begins at ~19', consisting of wood fragments and white powder and paper bags - strong solvent odor. From 20'-25' soil is oily coated, difficult to wash grains - heavy sheen, some loose oil/sludge between grains.	
	Grab				1140		GP: Poorly graded gravel, very dark grey (10YR3/1), loose to dense, moist, fine to medium sand, fine gravel, heavy oily residue on grains, sheen when washed, strong solvent odor, traces of wood splinters, areas of pure sludge between grains. Approximately 80% gravel, 10% coarse sand, 5% medium sand and 5% fine sand.	
-30					2900		Poorly graded sand, dark brown (7.5YR3/4), very dense, fine to coarse angular to subangular volcanic sand and fine gravel, trace silt, noncemented sheen when washing grains. Approximately trace gravel, 10% coarse sand, 70% medium sand, 20% fine sand and trace silt. Terminated borehole at 31.5' bgs.	

Log of Boring No. BRC-BS-09

CAMU

Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: HSA
Drilling Equipment: HSA LAR
Drilling Contractor: Water Development Corporation
Driller: Ignacio Gutierrez

Borehole Total Depth: 32 ft bgs
Borehole Diameter: 8 in
Well ID: N/A
Depth to Water (ft. bgs): NA ⊻

Sample Type: 2.5" Split Spoon
Sample Interval Continuous

Logged By: J. Wiley
Date Started: 01/19/05
Date Completed: 01/19/05

Monitoring Well Construction

Type of Surface Seal:	N/A	**Screen Slot Size:**	N/A
Blank Casing Type/Size:	N/A	**Top of Screen (ft. bgs):**	N/A
Screen Type/Size:	N/A	**Bottom of Screen (ft. bgs):**	N/A
Transition Sand Type:	N/A	**Type of Sand Pack:**	N/A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0							SP: Soil surface, boring located within slight depression area. (Odors not being observed due to potential chemical hazards.)	
	Grab				2.1		Poorly graded sand, brown (10YR5/3), loose, moist, fine to coarse subrounded to rounded sand and fine gravel - no volcanic, noncemented, no debris. Approximately trace gravel 5% coarse sand, 70% medium sand and 25% fine sand. Trash begins at 9' bgs.	
-10					9.8		SP: Poorly graded sand as at 5', layered between debris - gray and white speckled cement/concrete - like material. Approximately trace gravel, 5% coarse sand, 70% medium sand and 25% fine sand. Drillers noted a change in drilling at ~16'.	
	Grab				5.2		Poorly graded sand, brown (10YR4/3), dense, moist, fine to coarse sand and fine gravel - subrounded to rounded, no volcanics, noncemented. Debris includes wood, fabric and plastic. Approximately trace gravel, trace coarse sand, 80% medium sand and 20% fine sand.	
-20					4.2		Poorly graded sand, dark gray (10YR4/1), dense, moist fine to coarse subrounded to rounded sand and fine gravel, noncemented, debris includes glass, paper and white chalky material, plastic bottles. Approximately trace gravel, trace coarse sand, 80% medium sand and 20% fine sand.	
	Grab				9.7		Poorly graded sand, brown (10R4/3), dense, moist, fine to coarse subangular to rounded sand and fine gravel, noncemented, debris including glass and paper, some metal. Approximately 10% gravel, 20% coarse sand, 50% medium sand and 20% fine sand.	
-30					7.4		Poorly graded sand, brown (10YR5/3), very dense, fine to coarse subangular to angular sand and fine gravel - volcanic, noncemented, no debris. Approximately 10% gravel, 20% coarse sand, 50% medium sand and 20% fine sand. Terminated borehole at 32' bgs.	

Log of Boring No. BRC-BS-10
CAMU
Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: HSA
Drilling Equipment: HSA LAR
Drilling Contractor: Water Development Corporation
Driller: James Duke

Borehole Total Depth: 22 ft bgs
Borehole Diameter: 8 in
Well ID: N/A
Depth to Water (ft. bgs): NA ⊻

Sample Type: 2.5" Split Spoon
Sample Interval Continuous

Logged By: J. Wiley
Date Started: 01/15/05
Date Completed: 01/15/05

Monitoring Well Construction

Type of Surface Seal:	N/A	**Screen Slot Size:**	N/A
Blank Casing Type/Size:	N/A	**Top of Screen (ft. bgs):**	N/A
Screen Type/Size:	N/A	**Bottom of Screen (ft. bgs):**	N/A
Transition Sand Type:	N/A	**Type of Sand Pack:**	N/A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0							SP: Soil surface - soil boring apears to be in possible slightly subsided area. (Odors not being observed due to potential chemical hazards.)	
	Grab				13.6		Poorly graded sand, brown (10YR4/3), loose to medium dense, fine to coarse, subrounded to rounded sand and fine gravel, no volcanics, trace silt, noncemented, no debris. Approximately 5% gravel, 5% coarse sand, 80% medium sand, 10% fine sand and trace silt.	
-10					3.5		Poorly graded sand, yellowish brown (10YR5/4), very dense, moist, fine to coarse subangular volcanic sand and fine gravel, noncemented, no odor, no debris. Approximately 5% gravel, 10% coarse sand, 60% medium sand and 25% fine sand.	
	Grab				4.1		Poorly graded sand, yellowish brown (10YR5/4), medium dense, moist, fine to coarse angular to subrounded sand and fine gravel including some volcanics, noncemented, trace silt. Approximately 5% gravel, 10% coarse sand, 65% medium sand, 10% fine sand and trace silt.	
-20							Poorly graded sand, yellowish brown (10YR5/4), very dense, moist, fine to coarse angular to subangular volcanic sand and fine gravel, noncemented. Aproximately 5% gravel, 15% coarse sand, 60% medium sand and 20% fine sand.	
							Terminate borehole at 22' due to no debris encountered. Fill material ended by 9'.	

Log of Boring No. BRC-BS-11
CAMU
Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: HSA
Drilling Equipment: HSA LAR
Drilling Contractor: Water Development Corporation
Driller: James Duke

Borehole Total Depth: 32 ft bgs
Borehole Diameter: 8 in
Well ID: N/A
Depth to Water (ft. bgs): NA ▽

Sample Type: 2.5" Split Spoon
Sample Interval Continuous

Logged By: J. Wiley
Date Started: 01/13/05
Date Completed: 01/13/05

Monitoring Well Construction

Type of Surface Seal:	N/A	**Screen Slot Size:**	N/A
Blank Casing Type/Size:	N/A	**Top of Screen (ft. bgs):**	N/A
Screen Type/Size:	N/A	**Bottom of Screen (ft. bgs):**	N/A
Transition Sand Type:	N/A	**Type of Sand Pack:**	N/A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0							SP: Soil surface. Poorly graded sand, yellowish brown (10YR5/4), loose, moist, fine to medium subangular to subrounded sand, trace subangular to subrounded gravel, trace silt, noncemented. Approximately trace gravel, 10% coarse sand, 60% medium sand, 30% fine sand and trace silt.	
	Grab				0.5		@ 5' bgs, debris encountered consisting of fabric and cobbles.	
-10							Poorly graded sand, yellowish brown (10YR5/4), loose, moist, fine to medium subangular to subrounded sand trace fine grained, trace silt, noncemented from 10-10.5' bgs, black fine material and gravel debris. Approximately trace gravel, 10% coarse sand, 60% medium sand, 30% fine sand and trace silt.	
	Grab				9.0		Poorly graded sand, very dark grayish brown (2.5Y3/2), loose, moist, fine to coarse subangular to subrounded sand, fine subrounded gravel, noncemented. Approximately 5% gravel, 5% coarse sand, 30% medium sand and 60% fine sand.	
-20					42.5		Poorly graded sand, brown (10YR5/3), medium dense, moist, fine to medium sand and fine gravel (as at 15'), noncemented, with paper debris and solvent odor. Approximately 10% gravel, 5% coarse, 25% medium sand and 60% fine sand.	
							@ 23', mostly debris-cobbles, wood, paper (receipts, paper pads), fabric, minor amounts of metal and plastic, paper bags, strong odor (solvent).	
							Drillers hit hard soil at 29.5' bgs.	
-30					70 0.2		Poorly graded sand, yellowish brown 10YR5/4), very dense, moist, fine to coarse sand, subangular to subrounded volcanic, trace gravel, noncemented. Approximately trace gravel, 5% coarse sand, 50% medium sand, 45% fine sand and trace silt. Borehole terminated @ 32 ft bgs.	

Log of Boring No. BRC-BS-12

CAMU

Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: HSA
Drilling Equipment: HSA LAR
Drilling Contractor: Water Development Corporation
Driller: James Duke

Borehole Total Depth: 32 ft bgs
Borehole Diameter: 8 in
Well ID: N/A
Depth to Water (ft. bgs): NA ▽

Sample Type: 2.5" Split Spoon
Sample Interval Continuous

Logged By: J. Wiley
Date Started: 01/12/05
Date Completed: 01/12/05

Monitoring Well Construction

Type of Surface Seal:	N/A	**Screen Slot Size:**	N/A
Blank Casing Type/Size:	N/A	**Top of Screen (ft. bgs):**	N/A
Screen Type/Size:	N/A	**Bottom of Screen (ft. bgs):**	N/A
Transition Sand Type:	N/A	**Type of Sand Pack:**	N/A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0							SP: Soil surface; boring located within area of slight subsidence. (Odors not being observed due to potential chemical hazards.)	
	Grab						Debris encountered - plastic lined paper bag pieces.	
					1.0		Poorly graded sand, brown (10YR4/3), loose, moist, fine to coarse subangular to subrounded sand and subrounded fine gravel, trace silt, noncemented, few paper and plastic debris fragments. Approximately 5% gravel, 20% coarse sand, 55% medium sand, 20% fine sand and trace silt.	
-10					7.6		Poorly graded sand, brown (10YR4/3), very dense, moist, fine to coarse, subrounded sand and subrounded fine gravel, trace silt, noncemented debris including paper, plastic and white cement fragments. Approximately 5% gravel, 10% coarse sand, 65% medium sand, 20% fine sand and trace silt.	
	Grab				7.0		Poorly graded sand, brown (10YR4/3), moist, fine to coarse subrounded sand and fine subrounded gravel, noncemented, paper and plastic debris. Approximately 5% gravel, 10% coarse sand, 65% medium sand, 20% fine sand and trace silt.	
							@18' bgs, increase in plastic lined paper bag remnants - writing on them reads "Montrose ODT".	
-20					0.6		Poorly graded sand, yellowish brown (10YR5/4), moist, dense, fine to coarse, subrounded sand and fine subrounded gravel, noncemented, paper and plastic debris. Approcimately 5% gravel, 15% coarse sand, 65% medium sand, 15% fine sand and trace silt.	
	Grab				11.7		Poorly graded sand, yellowish brown (10YR5/4), moist, fine to coarse subrounded sand and fine subrounded gravel, noncemented, small ammounts of paper and plastic. Approximately 5% gravel, 5% coarse sand, 60% medium sand, 30% fine sand and trace silt.	
-30					1.5		Poorly graded sand with gravel, yellowish brown (10YR5/4), moist, fine to coarse subrounded sand and fine subangular to angular gravel, noncemented, no debris. Approximately 15% gravel, 5% coarse sand, 40% medium sand and 40% fine sand.	
							Terminate borehole at 32' bgs.	

Log of Boring No. BRC-BS-13

CAMU

Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: HSA
Drilling Equipment: CME-75/HSA LAR
Drilling Contractor: Water Development Corporation
Driller: Ignacio Gutierrez

Borehole Total Depth: 31 ft bgs
Borehole Diameter: 8 in
Well ID: N/A
Depth to Water (ft. bgs): NA ▽

Sample Type: 2.5" Split Spoon
Sample Interval Continuous

Logged By: J. Wiley
Date Started: 01/18/05
Date Completed: 01/18/05

Monitoring Well Construction

Type of Surface Seal:	N/A	**Screen Slot Size:**	N/A
Blank Casing Type/Size:	N/A	**Top of Screen (ft. bgs):**	N/A
Screen Type/Size:	N/A	**Bottom of Screen (ft. bgs):**	N/A
Transition Sand Type:	N/A	**Type of Sand Pack:**	N/A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0	Grab				22		SP: Soil surface, boring located in area of subsidence. Poorly graded sand, yellowish brown (10YR5/4), loose to dense, fine to coarse subrounded to rounded sand and fine gravel, no volcanics, noncemented, trace debris, consisting of glass shards (very little). Approximately trace gravel, 10% coarse sand, 70% medium sand, 20% fine sand and trace silt.	
-10					29.1		At 9' bgs, debris begins, consisting of visqueen and rope. Poorly graded sand, brown (10YR4/3), yellowish brown (10YR5/4), medium dense, moist, fine to coarse subrounded sand and fine gravel, very few volcanics, noncemented, small layer of black (burned) paper bags. Approximately trace gravel, 10% coarse sand, 70% medium sand 20% fine sand and trace silt.	
	Grab				85.6		Poorly graded sand, dark grayish brown (10YR4/2), loose, fine to coarse subrounded to rounded sand and fine gravel, few volcanics, noncemented, abundant debris, entire paper (plastic lined) bags of lime (~80%) and DDT (~20%), solvent odor (flowery). Approximately trace gravel, 5% coarse sand, 65% medium sand, 30% fine sand and trace silt.	
-20					53.1		Entire bags of lime (~80%) and DDT (~20%) with very little sand mixed in, loose trash, solvent odor (flowery). Approximately trace gravel, 5% coarse sand, 65% medium sand, 30% fine sand, and trace silt.	
							Drillers indicated change of drilling at 23', out of trash zone.	
	Grab				0.4		Poorly graded sand, brown (7.5YR5/3), loose to dense, moist, fine to coarse subangular sand and fine gravel, increased volcanics, noncemented. Approximately trace gravel, 10% coarse sand, 60% medium sand, 30% fine sand and trace silt.	
							Poorly graded sand, light yellowish brown (10YR 6/4), very dense, moist, fine to coarse angular to subrounded volcanic sand and fine gravel, noncemented, trace silt. Approximately trace gravel, 5% coarse sand, 55% medium sand, 40% fine sand and trace silt.	
-30					1.1		Terminate borehole at 31' bgs.	

Log of Boring No. BRC-BS-14

CAMU

Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: HSA
Drilling Equipment: CME-75/HSA LAR
Drilling Contractor: Water Development Corporation
Driller: Ignacio Gutierrez

Borehole Total Depth: 31.5 ft bgs
Borehole Diameter: 8 in
Well ID: N/A
Depth to Water (ft. bgs): NA ▽

Sample Type: 2.5" Split Spoon
Sample Interval Continuous

Logged By: J. Wiley
Date Started: 01/19/05
Date Completed: 01/19/05

Monitoring Well Construction

Type of Surface Seal:	N/A	**Screen Slot Size:**	N/A
Blank Casing Type/Size:	N/A	**Top of Screen (ft. bgs):**	N/A
Screen Type/Size:	N/A	**Bottom of Screen (ft. bgs):**	N/A
Transition Sand Type:	N/A	**Type of Sand Pack:**	N/A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0							SP: Soi surface, boring located with in slight depression area. Poorly graded sand, strong brown (7.5YR4/6), loose, moist, fine to coarse subrounded to rounded sand, no volcanics, noncemented.	
	Grab				0.2		Debris begins at ~5' bgs: fabric, paper bags and plastic.	
-10		■		■	11.7		Poorly graded sand, strong brown (7.5YR4/6), dense, moist, fine to coarse subrounded to rounded sand, no volcanics, with trace medium sand size angular red brick fragments, noncemented, debris including paper and burned wood fragments, with some plastic. Approximately 5% gravel, 5% coarse sand 80% medium sand and 10% fine sand.	
	Grab				9.3		Poorly graded sand, very dark gray (7.5YR3/1), loose to dense, moist, fine to coarse subangular to rounded sand (some consisting of red brick fragments), fine gravel, noncemented, debris consists of plastic, paper, wood splinters and fabric. Approximately 5% gravel, 5% coarse sand, 70% medium sand and 20% fine sand.	
-20		■		■	13.2		Poorly graded sand, very dark gray (7.5YR3/1), very dense, moist, fine to course subangular to rounded sand (some consisting of red brick fragments), fine gravel and few cobbles, noncemented, debris is paper, plastic, fabric, and wood. Approximately 5% gravel, 5% coarse sand, 70% medium sand and 20% fine sand.	
	Grab				6.1		Poorly graded sand, very dark gray (7.5YR3/1), loose to dense, moist, fine to coarse subangular to rounded sand and fine gravel (with red brick fragments), noncemented, debris is paper and plastic. Approximately 5% gravel, 10% coarse sand, 60% medium sand and 25% fine sand.	
-30		■		■	0.4		Poorly graded sand, brown (7.5YR5/4), very dense, moist, fine to coarse angular to subangular volcanic sand and fine gravel, noncemented, no debris, drillers also noted a change in drilling. Approximately trace gravel, 5% coarse sand, 55% medium sand and 40% fine sand.	
							Terminatel boring at 31.5' bgs.	

Log of Boring No. BRC-BS-15

CAMU

Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: HSA
Drilling Equipment: CME-75/HSA LAR
Drilling Contractor: Water Development Corporation
Driller: Ignacio Gutierrez

Borehole Total Depth: 32 ft bgs
Borehole Diameter: 8 in
Well ID: N/A
Depth to Water (ft. bgs): NA ▽

Sample Type: 2.5" Split Spoon
Sample Interval Continuous

Logged By: J. Wiley
Date Started: 01/19/05
Date Completed: 01/19/05

Monitoring Well Construction

Type of Surface Seal:	N/A	**Screen Slot Size:**	N/A
Blank Casing Type/Size:	N/A	**Top of Screen (ft. bgs):**	N/A
Screen Type/Size:	N/A	**Bottom of Screen (ft. bgs):**	N/A
Transition Sand Type:	N/A	**Type of Sand Pack:**	N/A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0							SP: Soil surface located approximately 10' east of sunken pit from trench (moved from origional location, which was ~30' east of current).	
	Grab				1.5		Poorly graded sand, dark grayish brown (10YR4/2), moist, loose, fine to coarse subangular to rounded sand and fine gravel, few cobbles, debris includes wood, glass and cobbles coated in black residue. Approximately 10% gravel, 10% coarse sand, 60% medium sand and 20% fine sand.	
-10					0.8		Poorly graded sand, brown (10YR5/3), dense, moist, fine to coarse, angular to subangular sand and fine gravel, few volcanics, debris includes few wood splinters and paper (from bags). Approximately trace gravel, 5% coarse sand, 65% medium sand, 30% fine sand and trace silt.	
	Grab				0.3		Poorly graded sand, yellowish brown (10YR5/4), dense, moist, fine to coarse angular to subrounded sand and fine gravel, no volcanics, noncemented, no debris, trace silt, slight solvent odor. Approximately trace gravel, 5% coarse sand, 65% medium sand, 30% fine sand and trace silt.	
-20					0.4		Poorly graded sand, yellowish brown (10YR5/4), medium dense, moist, fine to coarse angular to subrounded sand and fine gravel, abundant volcanics, noncemented, no debris, trace silt, slight solvent odor. Approximately trace gravel, 5% coarse sand, 55% medium sand, 40% fine sand and trace silt.	
	Grab				1.3		Poorly graded sand, as at 15', no debris, medium dense, slight solvent odor. Approximatley trace gravel, 5% coarse sand, 65% medium sand, 30% fine sand and trace silt.	
-30					0.1		Poorly graded sand, yellowish brown (10YR5/4), very dense, moist, fine to coarse angular to subangular sand and fine gravel, volcanic areas of weak to moderate cementation, trace silt, no debris, slight solvent odor. Approximately trace gravel, 5% coarse sand, 55% medium sand, 40% fine sand and trace silt.	
							Terminate borehole at 32' bgs.	

Log of Boring No. BRC-BS-16
CAMU
Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: HSA
Drilling Equipment: CME-75/HSA LAR
Drilling Contractor: Water Development Corporation
Driller: James Duke

Borehole Total Depth: 32 ft bgs
Borehole Diameter: 8 in
Well ID: N/A
Depth to Water (ft. bgs): NA ▽

Sample Type: 2.5" Split Spoon
Sample Interval Continuous

Logged By: J. Wiley
Date Started: 01/15/05
Date Completed: 01/15/05

Monitoring Well Construction

Type of Surface Seal:	N/A	**Screen Slot Size:**	N/A
Blank Casing Type/Size:	N/A	**Top of Screen (ft. bgs):**	N/A
Screen Type/Size:	N/A	**Bottom of Screen (ft. bgs):**	N/A
Transition Sand Type:	N/A	**Type of Sand Pack:**	N/A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0							SP: Soil surface soil boring in a hill.	
							Debris begins at surface, consists of white powdery/chalky substance mixed with soil fill.	
	Grab				94.3		Poorly graded sand, grayish brown (10YR5/2), loose, fine to coarse subrounded to rounded sand and fine gravel, not volcanic, noncemented, solvent odor, with traces of debris - white chalky pieces and wood splinters. Approximately trace gravel, 20% coarse sand, 70% medium sand and 10% fine sand.	
-10					92.5		Poorly graded sand, brown (10YR5/3), medium dense, fine to coarse angular to subrounded sand and fine gravel - volcanic, strong solvent odor. Approximately 5% gravel, 15% coarse sand, 60% medium sand, 20% fine sand and trace silt.	
	Grab				2773		SP (as at 10'), very strong solvent odor (flowery smell). Approximately 5% gravel, 15% coarse sand, 60% medium sand, 20% fine sand and trace silt.	
-20					30.1		Poorly graded sand, yellowish brown (10YR5/4), fine to coarse subangular volcanic sand and fine gravel, noncemented, strong solvent odor. Approximately 5% gravel, 5% coarse sand, 70% medium sand and 20% fine sand.	
	Grab				NM		Poorly graded sand, yellowish brown (10YR5/4), fine to coarse subangular to rounded sand and fine gravel - some volcanic, noncemented, strong solvent odor. Approximately trace gravel, 20% coarse sand, 70% medium sand and 10% fine sand.	
-30					213		Poorly graded sand, yellowish brown (10YR5/4), fine to coarse angular to subangular sand and fine gravel- volcanic, noncemented, no odor, trace silt. Approximately 5% gravel, 5% coarse sand, 70% medium sand, 20% fine sand and trace silt.	
					6.3		Terminate borehole at 32' bgs.	

Log of Boring No. BRC-BS-17

CAMU

Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: HSA
Drilling Equipment: CME-75/HSA LAR
Drilling Contractor: Water Development Corporation
Driller: James Duke

Borehole Total Depth: 32 ft bgs
Borehole Diameter: 8 in
Well ID: N/A
Depth to Water (ft. bgs): NA ▽

Sample Type: 2.5" Split Spoon
Sample Interval Continuous

Logged By: J. Wiley
Date Started: 01/13/05
Date Completed: 01/13/05

Monitoring Well Construction

Type of Surface Seal:	N/A	**Screen Slot Size:**	N/A
Blank Casing Type/Size:	N/A	**Top of Screen (ft. bgs):**	N/A
Screen Type/Size:	N/A	**Bottom of Screen (ft. bgs):**	N/A
Transition Sand Type:	N/A	**Type of Sand Pack:**	N/A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0							SP: Soil surface, boring located with in area of subsidence.	
	Grab				NM		Poorly graded sand with gravel, pale brown (10YR6/3), loose, moist, fine to coarse subrounded to rounded sand and fine rounded gravel, noncemented, contains debris consisting of plastic-lined paper bags and wood. Approximately 20% gravel, 10% coarse sand, 50% medium sand and 20% fine sand.	
							@9' bgs, wood chunks.	
							DEBRIS: @ 9.75'-10' bgs, black powder (fine to fine end of medium sand size) carbon(?).	
-10							SP: Poorly graded sand with gravel, brown (10YR5/3), very dense, moist, fine to coarse subangular to subrounded sand and fine subrounded gravel, noncemented. Approximately 15% gravel, 10% coarse sand, 55% medium sand and 20% fine sand.	
							@13' bgs, debris includes plastic lined paper bags and black fine gravel sized debris.	
					20.4		Poorly graded sand, brown (10YR4/3), very dense, moist, fine to coarse subangular to subrounded sand and fine angular gravel sized black fragments. trace cobbles up to 2.5" long. Approximately 5% gravel, 10% coarse sand, 50% medium sand and 35% fine sand.	
-20							@ 21' bgs, drillers noted change in drilling to harder soil.	
					200		@ 22' bgs, color change to dark reddish brown (5YR2.5/2), strong odor.	
	Grab				238		Poorly graded sand, dark brown (7.5YR3/2), moist, fine to coarse subangular to subrounded sand and subangular fine gravel, noncemented, strong odor, no debris.	
					12.4		Poorly graded sand, brown (7.5YR 5/3), very dense, moist, fine to coarse subangular to subrounded sand and fine subangular to subrounded gravel, noncemented, strong odor. Approximately 5% gravel, 5% coarse sand, 40% medium sand and 40% fine sand.	
-30					345		Terminate borehole at 32' bgs.	

Log of Boring No. BRC-BS-18

CAMU

Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: HSA
Drilling Equipment: CME-75/HSA LAR
Drilling Contractor: Water Development Corporation
Driller: James Duke

Borehole Total Depth: 32 ft bgs
Borehole Diameter: 8 in
Well ID: N/A
Depth to Water (ft. bgs): NA ⊻

Sample Type: 2.5" Split Spoon
Sample Interval Continuous

Logged By: J. Wiley
Date Started: 01/13/05
Date Completed: 01/13/05

Monitoring Well Construction

Type of Surface Seal:	N/A	**Screen Slot Size:**	N/A
Blank Casing Type/Size:	N/A	**Top of Screen (ft. bgs):**	N/A
Screen Type/Size:	N/A	**Bottom of Screen (ft. bgs):**	N/A
Transition Sand Type:	N/A	**Type of Sand Pack:**	N/A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0							SP: Soil surface, boring located within area of subsidence.	
	Grab				2.6		Poorly graded sand with gravel, dark grayish brown (10YR4/2), medium dense to loose, fine to coarse subrounded to rounded sand and subrounded fine gravel, noncemented. Approximately 15% gravel, 40% coarse snad 40% medium sand, 5% fine sand and trace silt.	
-10					1.5		Poorly graded sand, light gray (10YR7/2), dense, moist, fine to medium subangular sand and fine subangular gravel, noncemented, containing debris - mostly rusted metal pipe fragments and small amounts of insullation material (fiberglass or asbestos). Approximately 5% gravel, 35% medium sand and 60% fine sand.	
					1.2		Poorly graded sand, light gray (10YR7/2), medium dense, moist, fine to medium subangular sand and fine subangular gravel, noncemented, coantains rusted metal pipe fragments and small amounts of insulation attached. Approximately 5% gravel, 35% medium sand and 60% fine sand.	
-20					0.2		Poorly graded sand, dark yellowish brown (10YR4/4), medium dense, moist, fine to coarse subangular to subrounded sand and fine subangular gravel, no debris observed. Approximately 5% gravel, 5% coarse sand, 50% medium sand, 40% fine sand and trace silt.	
	Grab				38.5		GP: Poorly graded gravel with sand, brown (10YR4/3), medium dense to loose, moist, fine to coarse subrounded sand and fine subrounded to rounded gravel, noncemented, debris includes fabric with cobbles. Approximately 55% gravel, 10% coarse sand, 30% medium sand and 5% fine sand.	
							SP: Poorly graded sand, brown (10YR4/3), very dense, moist, fine to medium subangular to subrounded sand and subangular gravel, noncemented, no debris, trace silt. Approximately 10% gravel, 10% coarse sand, 50% medium sand, 30% fine sand and trace silt. At 26' bgs, drilling in hard soil - drillers think we are out of fill.	
-30					5.7		Terminate boring at 32' bgs.	

Log of Boring No. BRC-BS-19

CAMU

Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: HSA
Drilling Equipment: CME-75/HSA LAR
Drilling Contractor: Water Development Corporation
Driller: Ignacio Gutierrez

Borehole Total Depth: 31.5 ft bgs
Borehole Diameter: 8 in
Well ID: N/A
Depth to Water (ft. bgs): NA ⊻

Sample Type: 2.5" Split Spoon
Sample Interval Continuous

Logged By: J. Wiley
Date Started: 01/18/05
Date Completed: 01/18/05

Monitoring Well Construction

Type of Surface Seal:	N/A	**Screen Slot Size:**	N/A
Blank Casing Type/Size:	N/A	**Top of Screen (ft. bgs):**	N/A
Screen Type/Size:	N/A	**Bottom of Screen (ft. bgs):**	N/A
Transition Sand Type:	N/A	**Type of Sand Pack:**	N/A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0							SP: Soil surface, boring located in area of subsidence.	
	Grab				0.5		Poorly graded sand, brown (7.5YR4/3), loose to dense, moist, fine to coarse subangular to subrounded, sand and fine gravel - no volcanics, noncemented, trace silt. Approximately trace gravel, 5% coarse sand, 55% medium sand, 40% fine sand and trace silt.	
-10					1.3		Poorly graded sand, brown (10YR4/3), moist, fine to coarse subangular to subrounded sand and fine gravel - no volcanics, noncemented, debris consists of white chalky powder. Approximately trace gravel, 5% coarse sand, 55% medium sand and 40% fine sand. At 9.5' bgs debris begins - consists of white powdery/chalky chunks of material from plastic lined paper bags.	
	Grab				0.7		Poorly graded sand, grayish brown (10YR5/2), loose to dense, moist, fine to coarse subangular to rounded sand and fine gravel - no volcanics, some cobbles, noncemented. Approximately 10% gravel, 15% coarse sand, 70% medium sand and 5% fine sand. From 15'-20', few bags - lime.	
-20					0.6		Poorly graded sand, yellowish brown (10YR5/4), dense, moist, fine to coarse subangular to rounded sand and fine gravel - few volcanics, noncemented, debris includes wood splinters and lime bags. Approximately 5% gravel, 15% coarse sand, 70% medium sand and 10% fine sand.	
	Grab				43.5		Poorly graded sand, yellowish brown (10YR5/4), loose to dense, moist, fine to coarse subangular to subrounded sand and fine gravel, few cobbles, no volcanics, noncemented, debris includes gravel fill, wood splinters and traces of white chalky substance. Approximately 5% gravel, 15% coarse sand, 70% medium sand and 10% fine sand.	
-30					12.5		Poorly graded sand , brown (10YR5/3), very dense, moist, fine to coarse angular to subangular sand and fine gravel - volcanic, noncemented, no debris. Approximately trace gravel, 5% coarse sand, 70% medium sand, 25% fine sand and trace silt. Terminate borehole at 31.5' bgs.	

Log of Boring No. BRC-BS-20

CAMU

Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: HSA
Drilling Equipment: CME-75/HSA LAR
Drilling Contractor: Water Development Corporation
Driller: Ignacio Gutierrez

Borehole Total Depth: 31 ft bgs
Borehole Diameter: 8 in
Well ID: N/A
Depth to Water (ft. bgs): NA ⊻

Sample Type: 2.5" Split Spoon
Sample Interval Continuous

Logged By: J. Wiley
Date Started: 01/18/05
Date Completed: 01/18/05

Monitoring Well Construction

Type of Surface Seal:	N/A	**Screen Slot Size:**	N/A
Blank Casing Type/Size:	N/A	**Top of Screen (ft. bgs):**	N/A
Screen Type/Size:	N/A	**Bottom of Screen (ft. bgs):**	N/A
Transition Sand Type:	N/A	**Type of Sand Pack:**	N/A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0							SP: Soil surface, boring located in area of subsidence.	
	Grab				0.2		Poorly graded sand, dark yellowish brown (10YR4/4), loose to dense, moist, fine to coarse subangular to subrounded sand and fine gravel - no volcanics, noncemented, no debris, trace silt. Approximately trace gravel, 5% coarse sand, 65% medium sand, 30% fine sand and trace silt.	
-10					1.7		Poorly graded sand, dark yellowish brown (10YR4/4), dense, moist, fine to coarse subangular to subrounded sand and fine gravel - few volcanics, noncemented, trace silt, no debris.	
	Grab				21.0		Poorly graded sand, dark yellowish brwon (10YR4/4), loose, fine to coarse subangular to rounded sand and fine gravel - no volcanics, noncemented, debris consists of DDT and lime bags, solvent odor (flowery). Approximately 5% gravel, 10% coarse sand, 75% medium sand and 10% fine sand.	
							@ 19', plastic debris and paper bags (DDT and lime) with SP.	
-20					22.0		CL: Sandy lean clay, olive yellow (2.5Y6/6), soft, wet, fine sand and trace medium sand, noncemented, medium plasticity, petroleum hydrocarbon odor, clay was found in sampler shoe and stuck to outside of sampler. Approximately trace medium sand, 30% fine sand and 70% clay.	
							SP	
	Grab				21.0		@ 25' Pooly graded sand as at 15', no debris. Drillers noted change of drilling at 20.5'.	
-30					0.4		Poorly graded sand, brown (10YR5/3), very dense, moist, fine to coarse angular to subangular volcanic and fine gravel, weak cementation, no debris. Approximately trace gravel, 5% coarse sand, 80% medium sand and 15% fine sand. Terminate borehole at 31' bgs.	

Log of Boring No. BW-8B

BMI Landfill CAMU Investigation

Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: Rotary Sonic
Drilling Equipment: GEFCO
Drilling Contractor: Water Development Corporation
Driller: Mike Wilkerson

Borehole Total Depth: 75 ft bgs
Borehole Diameter: 7 5/8" O.D. Casing / 7 7/8" O.D. Bit
Well ID: GW-AA-BW-08A
Depth to Water (ft. bgs): 50' bgs ▽

Sample Type: N/A
Sample Interval Continuous

Logged By: A. Norris
Date Started: 03/15/05
Date Completed: 03/15/05

Monitoring Well Construction

Type of Surface Seal:	Bentonite-Grout	**Screen Slot Size:**	0.010 in
Blank Casing Type/Size:	4" Sch 80 PVC	**Top of Screen (ft. bgs):**	37.5 ft bgs
Screen Type/Size:	4" Sch 80 PVC	**Bottom of Screen (ft. bgs):**	57.5 ft bgs
Transition Sand Type:	N/A	**Type of Sand Pack:**	#2/12

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0					0.0		SM: Silty sand with gravel, moist, (fill).	Locking Monument Well Box Surrounded by Concrete slab and Traffic Ballards
					0.0			
							Silty sand with gravel, moist to dry, trace local debris (wood fragments, plastic) (fill).	
					0.0			
					0.0		Silty sand with gravel, dry, trace local debris (plastic, wood, metal fragments) (fill). Note: soils @ 0' to 12' bgs essentially same as logged a BW-8A. See boring log BW-8A for details.	
-10								Cement Backfill
					0.0			
					0.0		Silty sand with gravel, dry.	
					0.0			
								4" Blank PVC Riser Pipe
					0.0		Silty sand with gravel, dry. Note: soils @12' to 20" bgs essentially same as logged @ BW-8A. See boring log BW-8A for details.	
					0.0			
-20					0.0		Silty sand with gravel, dry.	
					0.0		Silty sand with gravel, dry.	
					0.0			Cement Backfill

BMI Landfill CAMU Investigation

Henderson, Nevada

Basic Remediation COMPANY

Log of Boring No. BW-8B

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
					0.0		Silty sand with gravel, dry. Note: soils @ 20' to 30' bgs essentailly same as logged @ BW-8A. See boring log BW-8A for details.	
-30				■	0.0		Silty sand with gravel, dry.	Bentonite Seal
					0.0		Silty sand with gravel, dry.	
					0.0			#2/12 Sand Pack
							Silty sand with gravel, dry. Note: soils @ 30' to 40' bgs essentially same as logged @ BW-8A. See boring log BW-8A for details.	
					0.0			
-40					0.0		Silty sand with gravel, dry.	4" 0.010 Slot PVC screen
					0.0			
							Silty sand with gravel, dry.	
					0.0		Silty sand with gravel, dry to moist. Note: soils @ 40' to 50' bgs essentially same as logged @ BW-8A. See boring log BW-8A for details.	
					0.0			
-50				■			Silty sand with gravel, wet @ 50' to 57' bgs.	
					0.0		Silty sand with gravel, wet.	
					0.0			
					0.0		GW: Well graded gravel, multicolored, wet, subangular to subrounded fine to coarse volcanic gravel (up to 3" long). Approximately 100% gravel.	Threaded PVC Well Base Cap
					0.0		ML: Silt with sand, light brownish gray (10YR6/2), moist to wet, nonplastic to low plasticity fines, subangular to subrounded sand. Approximately 15% fine sand, 85% silt and trace clay.	
-60					0.0		CALICHE: Caliche, strongly cemented. Silty sand with gravel, white (10YR8/1), dry.	
					0.0			
					0.0			

BMI Landfill CAMU Investigation

Henderson, Nevada

Basic Remediation COMPANY

Log of Boring No. BW-8B

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
					5.5		ML: Clayey silt, yellowish brown (10YR5/4), moist, very low to low plasticity fines. Approximately 5% fine sand, 80% silt and 15% clay.	Basal Bentonite Seal
					14.2		Clayey silt, yellowish brown (10YR5/4), moist, very low to low plasticity fines. Approximately 85% silt and 15% clay.	
					3.0		Silt with sand, yellowish brown (10YR5/4), moist, nonplastic to very low plasticity fines, subangular to subrounded sand. Approximately 15% fine sand, 85% silt and trace clay.	
-70					8.2		Clayey silt, yellowish brown (10YR5/4). moist, very low to low plasticity fines. Approximately 85% silt and 15% clay.	
					28.7		Clayey silt, light yellowish brown (10YR6/4), moist, very low to low plasticity fines. Approximately 85% silt and 15% clay.	
					2.0 1.0			
					3.0		Bottom of hole @ 75' bgs.	
					0.0			

Log of Boring No. BW-8C

BMI Landfill CAMU Investigation

Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: Rotary Sonic
Drilling Equipment: GEFCO
Drilling Contractor: Water Development Corporation
Driller: Mike Wilkerson

Borehole Total Depth: 75 ft bgs
Borehole Diameter: 7 5/8" O.D. Casing / 7 7/8" O.D. Bit
Well ID: GW-AA-BW-08B
Depth to Water (ft. bgs): 47' bgs ⊻

Sample Type: N/A
Sample Interval Continuous

Logged By: A. Norris
Date Started: 03/16/05
Date Completed: 03/16/05

Monitoring Well Construction

Type of Surface Seal:	Bentonite-Grout	**Screen Slot Size:**	0.010 in
Blank Casing Type/Size:	4" Sch 80 PVC	**Top of Screen (ft. bgs):**	43 ft bgs
Screen Type/Size:	4" Sch 80 PVC	**Bottom of Screen (ft. bgs):**	63 ft bgs
Transition Sand Type:	N/A	**Type of Sand Pack:**	#2/12

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0					0.0		SM: Silty sand with gravel, dry.	Locking monument well box with concrete apron and ballards
					0.0		Silty sand with gravel, dry.	Cement Bentonite Grout
					0.0		Silty sand with gravel, dry. Note: Soils @ 0' to 10' bgs essentially same a logged @ BW-8A. See boring log BW-8A for details.	
-10					0.0			4" Blank PVC Riser Pipe
					0.0		Silty sand with gravel, dry.	
					0.0		Silty sand with gravel, dry, trace fill material, (wood fragments).	
					0.0		Note: Soil encountered @ 10' to 20' bgs essentially same as logged @ BW-8A. See boring log BW-8A for details.	
-20					0.0		Silty sand with gravel, dry.	
					0.0		Silty sand with gravel, dry.	

BMI Landfill CAMU Investigation

Henderson, Nevada

Basic Remediation COMPANY

Log of Boring No. BW-8C

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
							Silty sand with gravel, dry.	Cement Bentonite Grout
							Note: Soil encountered @ 20' to 30' bgs essentially same as logged @ BW-8A. See boring log BW-8A for details.	
-30					0.0		Silty sand with gravel, dry.	
					0.0		Silty sand with gravel, dry.	
					0.0		Silty sand with gravel, dry.	Bentonite seal
					0.0		Note: soils encountered @ 30' to 40' bgs essentially same as logged @ BW-8A. See boring log BW-8A for details.	
-40					0.0		Silty sand with gravel, dry.	#2/12 Sand Pack
					0.0		Silty sand with gravel, dry. Note: Soils encountered @ 40' to 47' bgs essentially same as logged @ BW-8A. See boring log BW-8A for details.	4" 0.010 Slot PVC screen
					3.6		Silty sand with gravel, grayish brown (10YR5/2), wet, subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 1.5" long). Approximately 15% gravel, 15% coarse sand, 30%medium sand, 25% fine sand and 15% silt.	
-50					4.0			
					6.2		ML: Silt with sand, light brownish gray (10YR6/2), dry to moist, nonplastic to low plasticity silt, subangular to subrounded sand. Approximately 15% fine sand and 85% silt.	
					113		SM: Silty sand with gravel, light grey (10YR6/1), dry, subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 1" long), weakly to strongly cemented. Approximately 15% gravel, 15% coarse sand, 30% medium sand, 25% fine sand, 15% silt.	
					22.6			
					3.5		CALICHE: Caliche: strongly cemented. Silty sand with gravel, white (10YR8/1), dry.	
					4.5		SM: Silty sand with gravel, gray (10YR5/1), wet, subangular to subrounded sand, nonplastic silt, subangular to subrouneded fine to coarse volcanic gravel (up to 1.5" long). Approximately 15% gravel, 15% coarse sand, 35% medium sand, 20% fine sand, 15% silt.	
					3.2			
					0.0		ML: Silt with sand, light brownish gray (10YR6/2), dry, nonplastic to very low plasticity silt, subangular to subrounded sand. Approximately 15% fine sand and 85% silt.	
					2.0			#2/12 Sand Pack
-60							CALICHE: Caliche: strongly cemented. Silty sand with gravel, white (10YR8/1), dry.	
					3.3		ML: Clayey silt, yellowish brown (10YR5/4), moist, very low to low plasticity fines, trace subangular to subrounded sand. Approximately 5% fine sand, 80% silt and 15% clay.	

BMI Landfill CAMU Investigation

Henderson, Nevada

Basic Remediation COMPANY

Log of Boring No. BW-8C

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
					3.8		Clayey silt, brown (7.5YR5/4), moist, very low to low plasticity fines, stiff. Approximately 85% silt and 15% clay.	Threaded PVC Well Base Cap
					2.3			
					16.1			
					14.4			
					65.3		Clayey silt, brown (7.5YR5/4) moist, very low to low plasticity fines, stiff. Approximately 85% fine sand and 15% silt.	
					2.9			
-70	Grab				77.2			
					104		Silt, pale brown (10YR6/3), moist, nonplastic to very low plasticity silt. Approximately 5% fine sand and 95% silt. (Sample BRC-BW-08C-70 collected).	Basal Bentonite Seal
					10.9			
					6.4			
					3.4			
					15.1		Bottom of hole @ 75' bgs.	

Log of Boring No. BW-10A

BMI Landfill CAMU Investigation

Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: Rotary Sonic
Drilling Equipment: GEFCO
Drilling Contractor: Water Development Corporation
Driller: Mike Wilkerson

Borehole Total Depth: 80 ft bgs
Borehole Diameter: 7 5/8" O.D. Casing / 7 7/8" O.D. Bit
Well ID: GW-MCF-BW-10
Depth to Water (ft. bgs): 60.0 ft bgs ▽

Sample Type: 2" Split Spoon
Sample Interval Continuous

Logged By: A. Norris
Date Started: 03/23/05
Date Completed: 03/23/05

Monitoring Well Construction

Type of Surface Seal:	Bentonite-Grout	**Screen Slot Size:**	0.010 in
Blank Casing Type/Size:	4" Sch 80 PVC	**Top of Screen (ft. bgs):**	57 ft bgs
Screen Type/Size:	4" Sch 80 PVC	**Bottom of Screen (ft. bgs):**	72 ft bgs
Transition Sand Type:	N/A	**Type of Sand Pack:**	#2/12 sand

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0					0.0		SM: Silty sand with gravel, brown (7.5YR5/4), dry to moist, subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 3" long), locally partly indurated to weakly cemented. Approximately 20% gravel, 15% coarse sand, 15% medium sand, 30% fine sand and 20% silt. (Sample BRC-BW-10A-0 collected).	Locking monument well box with concrete apron and ballards
					0.0		Silty sand with gravel, brown (7.5YR5/4), dry to moist, subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 3" long), locally partly indurated to weakly cemented. Approximately 20% gravel, 15% coarse sand, 15% medium sand, 35% fine sand and 15% silt.	Cement Bentonite Grout
					0.0			
					0.0		Silty sand with gravel, light brown (7.5YR6/3), dry, subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 2.5" long). Approximately 20% gravel, 15% coarse sand 10% medium sand, 40% fine sand and 15% silt.	
-10					0.0			4" Blank PVC Riser Pipe
					0.0		Silty sand with gravel, brown (7.5YR 5/3) dry subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 3" long). Approximately 20% gravel, 15% coarse sand, 15% medium sand, 35% fine sand and 15% silt.	
					0.0		Silty sand, light brown (7.5YR6/4), dry, subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 3" long). Approximately 20% gravel, 15% coarse sand, 15% medium sand, 30% fine sand and 20% silt. (Sample BRC-BW-10A-18 collected).	
					0.0			
-20					0.0		Silty sand with gravel, pale brown (10YR6/3), dry, angular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 1.5" long), locally partly indurated to weakly cemented. Approximately 20% gravel, 15% coarse sand, 15% medium sand, 30% fine sand and 20% silt.	
					0.0		Silty sand, light brownish gray (10YR6/2), dry, subangular to subrounded sand,nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 3" long), locally partly indurated to weakly cemented.	

BMI Landfill CAMU Investigation

Henderson, Nevada

Basic Remediation COMPANY

Log of Boring No. BW-10A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
					0.0		Silty sand with gravel, light brown (7.5YR6/3), dry, subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 1" long), locally partly indurated to weakly cemented. Approximately 15% gravel, 15% coarse sand, 15% medium sand, 35% fine sand and 20% silt.	
					0.0			
-30					0.0		Silty sand with gravel, yellowish brown (10YR5/4), dry, subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 3" long), locally partly indurated to weakly cemented. Approximtaely 20% gravel, 15% coarse sand, 15% medium sand, 35% fine sand and 15% silt. (Sample BRC-BW-10A-30 collected).	Cement Bentonite Grout
					0.0			
					0.0		Silty sand with gravel, yellowish brown (10YR5/4), dry, subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 3" long), locally partly indurated to weakly cemented. Approximately 20% gravel, 15% coarse sand, 15% medium sand, 35% fine sand and 15% silt.	
					0.0			
-40					0.0		ML: Silt with sand, strong brown (7.5YR5/6), moist, nonplastic silt, subangular to subrounded sand. Approximately 15% fine sand and 85% silt.	
					0.0		Silt with sand, brown (7.5YR5/4), moist, nonplastic silt, subangular to subrounded sand. Approximately trace medium sand, 20% fine sand and 80% silt.	
					0.0		Silt with sand, strong brown (7.5YR5/6), moist, nonplastic silt, subangular to subrounded sand. Approximtaely 15% fine sand and 85% silt.	
					0.0		Silt with sand, strong brown (7.5YR5/6), moist, nonplastic to low plasticity fines, subangular to subrounded sand. Approximately 15% fine sand, 80% silt and 5% clay.	
-50					0.0		Clayey silt, brown (10YR5/4), moist, very low to low plasticity fines, stiff. Approximately 5% fine sand, 80% silt and 15% clay. (Sample BRC-BW-10A-50 collected).	Bentonite seal
					0.0		Silt with clay, light olive brown (5Y6/2), moist, very low to low plasticity fines, stiff. Approximately 90% silt and 10% clay.	
					0.0		Silt with clay, brwon (10YR5/3), moist, very low to low plasticity fines, stiff. Approximately 90% silt and 10% clay.	#2/12 Sand Pack
					0.0			4" 0.010 Slot PVC screen
-60					0.0		Becomes wet @ 60' to 64' bgs. Silt with sand, brown (7.5YR5/4), wet, nonplastic to low plasticity fines, subangular to subrounded sand. Approximatley 5% medium sand, 20% fine sand, 70% silt and 5% clay.	4" 0.010 Slot PVC screen

BMI Landfill CAMU Investigation

Henderson, Nevada

Basic Remediation COMPANY

Log of Boring No. BW-10A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
					0.0		Clayey silt, brown (7.5YR5/4), moist, very low to low plasticity fines, stiff, trace subangular to subrounded sand. Approximately 5% fine sand, 80% silt and 15% clay.	#2/12 Sand Pack
					0.0			
					0.0		Clayey silt, brown (7.5YR5/4), moist, very low to low plasticity fines, stiff. Approximately 80% silt and 20% clay.	
-70					0.0		Clayey silt, brown (7.5YR5/4), moist, very low to low plasticity fines, stiff. Approximately 85% silt and 15% clay.	Threaded PVC Well Base Cap
					0.0			Basal Bentonite Seal
					0.0		Clayey silt, strong brown (7.5YR5/6), moist, very low to low plasticity fines, stiff. Approximately 80% silt and 20% clay.	
-80					0.0			

Log of Boring No. BW-11A

BMI Landfill CAMU Investigation

Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: Rotary Sonic
Drilling Equipment: GEFCO
Drilling Contractor: Water Development Corporation
Driller: Mike Wilkerson

Borehole Total Depth: 80 ft bgs
Borehole Diameter: 7 5/8" O.D. Casing / 7 7/8" O.D. Bit
Well ID: GW-MCF-BW-11
Depth to Water (ft. bgs): 60' bgs ▽

Sample Type: 2" Split Spoon
Sample Interval Continuous

Logged By: A. Norris
Date Started: 03/22/05
Date Completed: 03/22/05

Monitoring Well Construction

Type of Surface Seal:	Bentonite-Grout	**Screen Slot Size:**	0.010 in
Blank Casing Type/Size:	4" Sch 80 PVC	**Top of Screen (ft. bgs):**	57 ft bgs
Screen Type/Size:	4" Sch 80 PVC	**Bottom of Screen (ft. bgs):**	72 ft bgs
Transition Sand Type:	N/A	**Type of Sand Pack:**	#2/12

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0					0.0		SM: Silty sand with gravel, yellowish brown (10YR5/4), dry to moist, subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 2" long). Approximately 15% gravel, 10% coarse sand, 15% medium sand 45% fine sand and 15% silt. (Sample BRC-BW-11A-0 collected).	Locking monument well box with concrete apron and ballards
					0.0			
					0.0		Silty sand with gravel, yellowish brown (10YR5/4), dry to moist, subangular to subrounded sand, nonplastic to very low plasticity silt, subangular to subrounded fine to coarse volcanic gravel (up to 2" long). Approximately 15% gravel, 10% coarse sand, 15% medium sand, 40% fine sand and 20% silt.	
					2.0			
					1.8			
					2.0			Cement Bentonite Grout
					4.0		Silty sand with gravel, brown (7.5YR5/4), dry to moist, subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 2" long). Approximately 20% gravel, 15% coarse sand, 15% medium sand, 35% fine sand and 15% silt.	
					3.7			
					4.1			
					4.7			
-10					14.2		Silty sand with gravel, brown (7.5YR5/4), dry to moist, subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 2.5" long). Approximately 15% gravel, 10% coarse sand 15% medium sand, 45% fine sand and 15% silt.	4" Blank PVC Riser Pipe
					9.1			
					25.3			
					17.7		Silty sand with gravel, brown (7.5YR5/4), dry to moist, subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 1" long). Approximately 15% gravel, 10% coarse sand, 15% medium sand, 45% fine sand and 15% silt.	
					22.5			
					20.9			
					19.3		Silty sand with gravel, pale brown (10YR6/3), dry, subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 2.5" long), locally partly indurated. Approximately 20% gravel, 15% coarse sand, 15% medium sand, 30% fine sand and 20% silt. (Sample BRC-BW-11A-18 collected).	
					53.5			
					54.3			
-20					30.9		Silty sand with gravel, brown (7.5YR5/3), dry, subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 3" long). locally partly indurated to weakly cemented. Approximately 20% gravel, 15% coarse sand, 15% medium sand, 35% fine sand and 15% silt.	
					14.7			
					57.0			
					49.3			
					59.1		Silty sand with gravel, light brown (7.5YR6/3), dry subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 2" long), locally partly indurated to weakly cemented. Approximately 15% gravel, 15% coarse sand, 15% medium sand, 35% fine sand and 20% silt.	
					118			
					50.0			

BMI Landfill CAMU Investigation

Henderson, Nevada

Basic Remediation COMPANY

Log of Boring No. BW-11A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
					46.7		Silty sand with gravel, light brown (7.5YR6/4), dry subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 1" long), locally partly indurated to weakly cemented. Approximately 15% gravel, 10% coarse sand, 10% medium sand, 50% fine sand and 15% silt.	
					44.3			
					46.8			
-30					100		(Sample BRC-BW-11A-30 collected).	
					29.2			
					60.8		Silty sand with gravel, brown (7.5YR5/4), dry, subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 2" long). Approximately 20% gravel, 15% coarse sand 15% medium sand, 35% fine sand and 15% silt.	
					41.1			
					45.2			
					27.2		Silty sand with gravel, brown (7.5YR5/3), dry, subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 3" long). Approximately 20% gravel, 15% coarse sand, 15% medium sand, 35% fine sand and 15% silt.	Cement Bentonite Grout
					25.7			
					14.6			
					10.0		Silty sand with gravel, gray (10YR6/2), dry, subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 3" long), locally partly indurated to weakly cemented, trace local volcanic cobbles (up to 4" long). Approximately 20% gravel, 15% coarse sand, 15% medium sand, 35% fine sand and 15% silt.	
-40					5.7		CALICHE: Caliche: strongly cemented. Silty sand, white (10YR8/1), dry.	
					22.6		SM: Silty sand, light gray (10YR7/2), dry, subangular to subrounded sand, nonplastic silt, locally weakly to strongly cemented. Approximately 5% coarse sand, 15% medium sand, 60% fine sand and 20% silt.	
					22.5			
					38.4			
					0.0			
					0.0		Silty sand, very pale brown (10YR8/2), dry, subangular to subrounded sand, nonplastic silt, locally partly indurated to weakly cemented. Approximately 5% gravel, 5% coarse sand, 10% medium sand, 60% fine sand and 20% silt.	
					0.0			
					0.0			
					0.0		Silty sand, brown (10YR5/3), dry, subangular to subrounded sand, nonplastic silt, locally weakly to strongly cemented. Approximately 5% gravel, 5% coarse sand, 10% medium sand, 60% fine sand and 20% silt.	
	Grab				0.0		(Sample BRC-BW-11A-49 collected).	
-50					12.2			Bentonite seal
					0.0			
					0.0		ML: Clayey silt, brown (7.5YR5/4), moist, very low to low plasticity fines, stiff. Approximately 80% silt and 20% clay.	
					0.0			
					0.0			
					0.0		Clayey silt, brown (7.5YR5/4), moist, very low to low plasticity fines, stiff to very stiff. Approximately 80% silt and 20% clay.	#2/12 Sand Pack
					0.0			
					0.0			
					0.0			
					0.0			
-60	Grab				0.0		Silt with sand, brown (7.5YR5/4), wet, nonplastic to low plasticity fines, subangular to subrounded sand. Approximately trace medium sand, 20% fine sand, 80% silt and trace clay. (Sample BRC-BW-11A-60 collected). Becomes wet @ 60' to 61.5' bgs.	4" 0.010 Slot PVC screen
					0.0			

BMI Landfill CAMU Investigation

Henderson, Nevada

Basic Remediation COMPANY

Log of Boring No. BW-11A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
					0.0			
					0.0			
					0.0			
					0.0		Clayey silt, yellowish brown (10YR5/4), moist, very low to low plasticity fines, stiff. Approximately trace fine sand, 85% silt and 15% clay.	#2/12 Sand Pack
					0.0			
					0.0			
					0.0			4" 0.010 Slot PVC screen
					0.0			
-70					0.0		Clayey silt, brown (7.5YR5/4), moist, very low to low plasticity fines, stiff. Approximately trace fine sand, 85% silt and 15% clay.	
					0.0			
					0.0			Threaded PVC Well Base Cap
					0.0		(Sample BRC-BW-11A-73 collected).	
					0.0		Clayey silt, brown (7.5YR5/4), very low to low plasticity fines, stiff to very stiff. Approximately trace fine sand, 85% silt and 15% clay.	Basal Bentonite Seal
					0.0			
					0.0			
					0.0		Clayey silt, brown (7.5YR5/4), moist, very low to low plasticity fines, stiff. Approximately 85% silt and 15% clay.	
					0.0			
					0.0		Bottom of hole @ 80' bgs.	Native Backfill
-80								

Log of Boring No. BW-12A
BMI Landfill CAMU Investigation
Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: Rotary Sonic
Drilling Equipment: GEFCO
Drilling Contractor: Water Development Corporation
Driller: Mike Wilkerson

Borehole Total Depth: 131.5 ft bgs
Borehole Diameter: 7 5/8" O.D. Casing / 7 7/8" O.D. Bit
Well ID: N/A
Depth to Water (ft. bgs): 68' bgs ▽

Sample Type: 2" Split Spoon
Sample Interval Continuous

Logged By: M. Manwaring
Date Started: 03/25/05
Date Completed: 03/26/05

Monitoring Well Construction

Type of Surface Seal:	N/A	**Screen Slot Size:**	N/A
Blank Casing Type/Size:	N/A	**Top of Screen (ft. bgs):**	N/A
Screen Type/Size:	N/A	**Bottom of Screen (ft. bgs):**	N/A
Transition Sand Type:	N/A	**Type of Sand Pack:**	N/A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0					0.0		SM: Silty sand with gravel, dark yellowish brown (10YR4/4), dry to slightly moist, sand and gravel is subrounded to subangular (volcanic coarse material), soil may be fill. Approximately 15% gravel, 15% coarse sand, 20% medium sand, 30% fine sand, 20% silt and trace clay. (Sample BRC-BW-12A-0 collected).	No Well
					0.0		Silty sand, yellowish brown (10YR5/6), slightly moist, as above. Approximately 5% gravel, 15% coarse sand, 25% medium sand, 35% fine sand, 20% silt and trace clay.	
					0.0			
					0.0		Silty sand with gravel, light yellowish brown (10YR6/4), dry, gravel and coarse sand material is likely volcanic, material is slightly cemented (the fine sand and silt sizes). Approximately 20% gravel, 20% coarse sand, 15% medium sand, 30% fine sand, 15% silt and trace clay.	
					1.6			
-10					0.4		Silty sand, brown (7.5YR5/4), dry, subrounded to subangular. Approximately 10% gravel, 15% coarse sand, 25% medium sand, 20% fine sand, 30% silt and trace clay.	
					0.0			
					0.4			
					0.8		Silty sand with gravel, light brown (7.5YR6/3), dry gravel is likely volcanic, subrounded to subangular (gravel is up to 2"-3" diameter). Approximately 15% gravel, 15% coarse sand, 20% medium sand, 25% fine sand, 25% silt and trace clay. (Sample BRC-BW-12A-18 collected).	
					0.0			
					0.4			
-20					0.7		Silty sand, brown (7.5YR5/4), dry, some coarse gravels (2"-3" diameter), subrounded to subangular, slight odor, loose. Approximately 10% gravel, 5% coarse, 15% medium, 30% fine sand, 30% silt and trace clay.	
					1.7		Silty sand with clay and gravel, dark yellowish brown (10YR4/4), abundant coarse angular to subangular gravel (3/4"-1" diameter), dry, slight odor, when wetted soil has low to medium plasticity. Approximately 20% gravel, 5% coarse sand, 10% medium sand, 25% fine sand, 30% silt and 10% clay.	

BMI Landfill CAMU Investigation

Henderson, Nevada

Basic Remediation COMPANY

Log of Boring No. BW-12A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
					0.3		Silty sand with clay, dry, brown (7.5YR5/4), low to medium plasticity (when wetted), no odor. Approximately 10% gravel, 5% coarse sand, 10% medium sand, 25% fine sand, 35% silt and 15% trace clay. (Sample BRC-BW-12A-30 collected).	
-30					0.3			
					0.4		SM: Silty sand with clay, brown (7.5YR5/4), dry to slightly moist, loose, low plasticity. Approximately 10% gravel, 5% coarse sand, 10% medium sand, 25% fine sand, 35% silt and 15% clay.	
					1.1			
					0.3		SM: Silty sand, dark yellowish brown (10YR4/4), slightly moist, loose, some subrounded to subangular sand and gravel, low plasticity. Approximately 10% gravel, 5% coarse sand, 15% medium sand, 35% fine sand, 30% silt and 5% clay.	
-40					0.0		SM: Silty sand, grayish brown (10YR5/2), dry, loose, abundant broken rock, gravel and coarse sand crushed rock. Approximately 10% gravel, 10% coarse sand, 15% medium sand, 25% fine sand, 30% silt and 10% clay.	
					0.0		Silty sand with gravel, silt with abundant coarse sand and gravels, angular to subangular, dry matrix, light grayish brown (10YR6/2), rock color varies. Approximately 20% gravel, 15% coarse sand, 20% medium sand, 20% fine sand, 15% silt and 5% clay.	
					0.3			
					0.0		Same as above to 50' bgs, brechia-volcanics (rock)	
-50							(Sample BRC-BW-12A-50 collected)	
					0.0			
					0.6		Silty sand with gravel, grayish brown (10YR5/2), dry to slighty moist, (below 52' bgs), slight odor. Approximately 20% gravel, 5% coarse sand, 10% medium sand, 25% fine sand, 30% silt and 10% clay.	
					4.6			
					4.2		SM: Silty sand with clay, gray (5Y5/1), with gravels (subangular to angular) moist, slight odor, trace clay. Approximately 10% gravel, 10% coarse sand, 5% medium sand, 30% fine sand, 30% silt and 15% clay.	
					8.5		ML: Clayey silt with sand and gravel, as above, grayish brown (10YR5/2). Approximately 25% gravel, 10% coarse sand, 5% medium sand, 20% fine sand, 25% silt and 15% clay.	
-60					2.0		Clayey silt with sand, strong brown (7.5YR5/6), moist, to very moist, slight odor, trace light gray silt size lenses and gravels, firm to stiff, low plasticity. Approximately 5% gravel, trace coarse sand, 20% fine sand, 55% silt and 20% clay.	

BMI Landfill CAMU Investigation

Henderson, Nevada

Basic Remediation COMPANY

Log of Boring No. BW-12A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
					1.9			
					1.6			
							Clayey silt with sand. Approximately 5% gravel, 20% fine sand, 55% silt and 20% clay.	
					0.6		Silt with clay, trace gravel, brown (7.5YR4/4), wet to very moist, medium plasticity no odor, firm (stiff and moist, not wet below 70').	
-70					1.1			
					0.5			
					0.4		Clayey silt with sand, brown (7.5YR5/4), moist, as above, low to medium plasticity. Approximately trace gravel, 20% fine sand, 65% silt and 15% clay. Silt, wet zone (74'-74.5'), brown, with clay, medium plasticity.	
					1.6			
					2.6		Silt with clay, light gray (10YR7/2), very moist to wet, low plasticity fines. Approximately 10% gravel, 5% fine sand, 75% silt and 10% clay.	
					2.8		Clayey silt with sand, very moist to moist. Approximately trace gravel, 15% fine sand, 65% silt and 15% clay.	
-80					0.4			
							No recovery. Likely soft clayey silt.	
-90								

BMI Landfill CAMU Investigation

Henderson, Nevada

Basic Remediation COMPANY

Log of Boring No. BW-12A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
							No recovery. Likely soft clayey silt.	
-100								
-110								
					0.0		Clayey silt with trace angular gravel, brown (7.5YR5/4), trace angular gravel, very moist to saturated (not wet), stiff, low to medium plasticity, trace light brown to pale brown silt size/sand size gypsum crystals, (no odor). Approximately trace gravel, trace fine sand, 60% silt and 40% clay.	
-120					0.0			
					0.0		Clayey silt, yellowish brown (10YR5/4), trace angular gravel and sand size fractured rock fragments (gypsum), firm to stiff (some very stiff), medium to low plasticity, saturated to very moist (not wet), no odor. Approximately trace gravel, 70% silt and 30% clay.	
					0.0			
					0.0		Clayey silt, strong brown (7.5YR5/6), medium plasticity, stiff, saturated trace gypsum nodules. Approximately 70% silt and 30% clay.	
-130							End borehole at 130'bgs at 3-26-05.	

Log of Boring No. BW-12B
BMI Landfill CAMU Investigation
Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: Rotary Sonic
Drilling Equipment: GEFCO
Drilling Contractor: Water Development Corporation
Driller: Mike Wilkerson

Borehole Total Depth: 200 ft bgs
Borehole Diameter: 7 5/8" O.D. Casing / 7 7/8" O.D. Bit
Well ID: GW-AA-BW-12
Depth to Water (ft. bgs): 59.5 ft bgs ▽

Sample Type: N/A
Sample Interval Continuous

Logged By: A. Norris
Date Started: 02/13/05
Date Completed: 02/15/05

Monitoring Well Construction

Type of Surface Seal:	Bentonite-Grout	**Screen Slot Size:**	0.010 in
Blank Casing Type/Size:	4" Sch 80 PVC	**Top of Screen (ft. bgs):**	49 ft bgs
Screen Type/Size:	4" Sch 80 PVC	**Bottom of Screen (ft. bgs):**	69 ft bgs
Transition Sand Type:	N/A	**Type of Sand Pack:**	#2/12 sand

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0					0.0		SM: Silty sand with gravel, dark yellowish brown (10YR4/4), moist, subangular to surounded sand, nonplastic to very low plasticity silt, fine to coarse subangular to subrounded volcanic gravel (up to 3" long), locally partly indurated to weakly cemented, trace local volcanic cobbles. Approximately 15% gravel, 15% coarse sand, 20% medium sand, 30% fine sand and 20% silt.	Locking monument well box with concrete apron and ballards
					0.0			
					0.0		Silty sand with gravel, yellowish brown (10YR5/4), moist, subangular to subrounded sand, nonplastic silt, fine to coarse subangular to subrounded volcanic gravel (up to 3" long), locally partly indurated to weakly cemented. Approximately 15% gravel, 15% coarse sand, 25% medium sand, 30% fine sand and 15% silt.	Cement Bentonite Grout
					0.0		Silty sand with gravel, pale brown (10YR6/3), dry, subangular to subrounded sand, nonplastic silt, fine to coarse subangular to subrounded volcanic gravel (up to 3" long), locally partly indurated to weakly cemented. Approximately 15% gravel, 15% coarse sand, 20% medium sand, 35% fine sand and 15% silt.	
-10					0.0		Silty sand with gravel, pale brown (10YR6/3), dry, subangular to subrounded sand, nonplastic silt, fine to coarse subangular to subrounded volcanic gravel (up to 3" long). Approximately 15% gravel, 10% coarse sand, 20% medium sand, 40% fine sand and 15% silt.	4" Blank PVC Riser Pipe
					0.0		Silty sand with gravel, light yellowish brown (10YR6/4), dry, subangular to subrounded sand, nonplastic silt, fine to coarse subangular to subrounded volcanic gravel (up to 2" long). Approximately 15% gravel, 15% coarse sand, 25% medium sand, 30% fine sand and 15% silt.	
					0.0		Silty sand with gravel, light yellowish brown (10YR6/4), dry, subangular to subrounded sand, nonplastic silt, fine to coarse subangular to subrounded volcanic gravel (up to 2" long). Approximately 15% gravel, 15% coarse sand, 15% medium sand, 40% fine sand and 15% silt.	
-20					0.0		Silty sand with gravel, pale brown (10YR6/3), dry, subangular to subrounded sand, nonplastic silt, fine to coarse subangular to subrounded volcanic gravel (up to 2" long). Approximately 15% gravel, 15% coarse sand, 20% medium sand, 35% fine sand and 15% silt.	
					0.0		Silty sand with gravel, pale brown (10YR6/3), dry, subangular to subrounded sand, nonplastic silt, fine to coarse subangular to subrounded volcanic gravel (up to 3" long). Some local volcanic cobbles (up to 4" long). Approximately 20% gravel, 10% coarse sand, 20% medium sand, 35% fine sand and 15% silt.	

BMI Landfill CAMU Investigation

Henderson, Nevada

Basic Remediation COMPANY

Log of Boring No. BW-12B

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
					0.0		Silty sand with gravel, pale brown (10YR6/3), dry, angular to subrounded sand, nonplastic silt, fine to coarse angular to subrounded volcanic gravel (up to 1.5" long), locally partly indurated to weakly cemented. Approximately 40% gravel, 15% coarse sand, 15% medium sand, 15% fine sand and 15% silt.	
-30					0.0		Silty sand with gravel, very pale brown (10YR7/3), dry, subangular to subrounded sand, nonplastic silt, fine to coarse angular to subrounded volcanic gravel (up to 1" long), locally partly indurated to weakly cemented. Approximately 15% gravel, 15% coarse sand, 20% medium sand, 35% fine sand and 15% silt.	Cement Bentonite Grout
					0.0		Silty sand with gravel, very pale brown (10YR7/3), dry, angular to subrounded sand, nonplastic silt, fine to coarse sngular to subrounded volcanic gravel (up to 2" long), locally partly indurated to weakly cemented. Approximately 15% gravel, 15% coarse sand, 20% medium sand, 35% fine sand and 15% silt.	
					0.0			
-40					0.0		Silty sand with gravel, brown (10YR5/3), dry, angular to subrounded sand, nonplastic silt, fine to coarse angular to subrounded volcanic gravel (up to 1" long), locally partly indurated to weakly cemented. Approximately 15% gravel. 10% coarse sand, 20% medium sand, 35% fine sand and 20% silt.	Bentonite seal
					0.0		Silty sand with gravel, light brownish gray (10YR6/2), dry, subangular to subrounded sand, nonplastic silt, fine to coarse subangular to subrounded volcanic gravel (up to 1.5" long). Approximately 15% gravel, 15% coarse sand, 15% medium sand, 40% fine sand and 15% silt.	
					0.0			#2/12 Sand Pack
-50					0.0		Silty sand with gravel, light brownish gray (10YR6/2), dry, subangular to subrounded sand, fine to coarse subangular to subrounded volcanic gravel (up to 1.5" long) locally partly indurated to weakly cemented. Approximately 20% gravel, 10% coarse sand, 15% medium sand, 40% fine sand and 15% silt.	
					0.0			4" 0.010 Slot PVC screen
					0.0		Silty sand with gravel, light brownish gray (10YR6/2), dry, angular to subrounded sand, nonplastic silt, fine to coarse angular to subrounded volanic gravel (up to 3" long), locally partly indurated to weakly cemented. Some local volcanic cobbles. Approximtely 15% gravel, 10% coarse sand, 30% medium sand, 30% fine sand, and 15% silt.	
					1.0			
					2.0		Becomes wet and black (2.5Y2.5/1) @ 59.5' bgs to 60' bgs.	
-60					11.6		ML: Clayey silt, yellowish brown (10YR5/4), moist, stiff, nonplastic to low plasticity fines. Approximately trace fine sand, 80% silt and 20% clay.	#2/12 Sand Pack

BMI Landfill CAMU Investigation

Henderson, Nevada

Basic Remediation COMPANY

Log of Boring No. BW-12B

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
					1.3		Clayey silt, yellowish brown (10YR5/4), moist, stiff, nonplastic to low plasticity fines. Approximtely trace fine sand, 85% silt and 15% clay.	
					6.6			4" 0.010 Slot PVC screen
					0.0		Clayey silt, light gray (10YR7/2), moist, stiff to very stiff, low plasticity fines. Approximately trace fine sand, 65% silt and 35% clay.	Threaded PVC Well Base Cap
-70								
					0.0		Becomes yellowish brown (10YR5/4) @ 71' bgs.	
							Clayey silt, yellowish brown (10YR5/4), moist, stiff, nonplastic to low plasticity fines. Approximately trace fine sand, 85% silt and 15% clay.	
					0.0			
							Clayey silt, yellowish bown (10YR5/4), moist, stiff, nonplastic to low plasticity fines, locally partly indurated. Approximately 5% fine sand, 80% silt and 15% clay.	Basal Bentonite Seal
					0.0			
-80					0.0		Clayey silt, yellowish brown (10YR5/4), moist, stiff, very low to low plasticity fines. Approximately 75% silt and 25% clay.	
					0.0			
							Clayey silt, yellowish brown (10YR5/4), moist, stiff, very low to low plasticity fines, subangular to subrounded sand. Approximately 5% fine sand, 70% silt and 25% clay.	
					0.0			
					0.0			
-90							Clayey silt, yellowish brown (10YR5/4), moist, stiff, very low to low plasticity fines, subangular to subrounded sand. Approximately trace medium sand, 5% fine sand, 75% silt and 20% clay.	
					0.0			
							Clayey silt, yellowish brown (10YR5/4), moist, stiff, very low to low plasticity fines. Approximately trace fine sand, 85% silt and 15% clay.	
					0.0			

Basic Remediation COMPANY

Log of Boring No. BW-12B

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
							Clayey silt, yellowish brown (10YR5/4), moist, stiff, very low to low plasticity fines. Approximately 80% silt and 20% clay.	
					0.0			
-100					0.0		Clayey silt, yellowish brown (10YR5/4), moist, stiff, very low to low plasticity fines. Approximately 80% silt and 20% clay.	
					0.0			
					0.0			
							Clayey silt, yellowish brown (10YR5/4), moist, stiff, very low to low plasticity fines. Approximately 80% silt and 20% clay.	
					0.0			
					0.0		Clayey silt, light yellowish brown (10YR6/4), moist, stiff to very stiff, nonplastic to low plasticity fines. Approximately trace fine sand, 85% silt and 15% clay.	
-110								Basal Bentonite Seal
					0.0		Clayey silt, yellowish brown (10YR5/4), moist, stiff, very low to low plasticity fines. Approximately 80% silt and 20% clay.	
					0.0		Clayey silt, strong brown (7.5YR5/6), moist, very low to low plasticity fines. Approximately trace fine sand, 80% silt and 20% clay.	
					0.0		Clayey silt, brown (7.5YR5/4), moist, very low to low plasticity fines, trace subangular to subrounded sand. Approximately 5% fine sand 75% silt and 20% clay.	
-120								
					1.0		Clayey silt with sand, brown (7.5YR5/4), wet, nonplastic to low plasticity fines, subangular to subrounded sand. Note: wet zone @ 120' to 130.5' bgs. Approximately trace medium sand, 15% fine sand, 70% silt and 15% clay.	
	Chemical				1.0		(Sample BRC-BW-12B-122 collected). Saturated Soil.	
							Clayey silt with sand, brown (7.5YR5/4), wet, nonplastic to low plasticity fines, subangular to subrounded sand. Approximtely 15% fine sand, 70% silt and 15% clay.	
					1.0			
					1.0			
-130							Clayey silt, brown (7.5YR5/4), wet, nonplastic to low plasticity fines, trace subangular to subrounded sand. Becomes moist @ 130.5' bgs. Approximately 5% fine sand, 75% silt and 20% clay.	
					0.0			
							Clayey silt, brown (7.5YR5/4), moist, very low to low plasticity fines, medium stiff to stiff.	

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
							Approximately trace fine sand, 80% silt and 20% clay.	
					0.0		Clayey silt, brown (7.5YR5/4), moist, stiff, very low to low plasticity fines. Approximately trace fine sand, 80% silt and 20% clay.	
					0.0		Clayey silt, brown (7.5YR5/4), moist, stiff to very stiff, very low to low plasticity fines. Approximately trace fine sand, 80% silt and 20% clay.	
					0.0			
-140					0.0		Clayey silt, brown (7.5YR5/4), moist, very stiff, low plasticity fines, some local silty clay seams. Approximately 60% silt and 40% clay.	
					0.0			
							Clayey silt, yellowish brown (10YR5/4), moist, very stiff, nonplastic to low plasticity fines. Approximately trace fine sand, 70% silt and 30% clay.	Basal Bentonite Seal
					0.0			
					0.0		Clayey silt, yellowish brown (10YR5/4), moist, very stiff, nonplastic to low plasticity fines. Approximately trace fine sand, 85% silt and 15% clay.	
-150								
					0.0			
							Clayey silt, yellowish brown (10YR5/4), moist, very stiff, nonplastic to low plasticity fines. Approximately 85% silt and 15% clay.	
					0.0			
							Clayey silt, yellowish brown (10YR5/4), moist, very stiff, nonplastic to low plasticity fines. Approximately 85% silt and 15% clay.	
					0.0			
-160					0.0		Clayey silt, brown (7.5YR5/4), moist, stiff, very low to low plasticity fines. Approximately 65% silt and 35% clay.	
					0.0			
							Clayey silt, brown (7.5YR5/4), moist, stiff, very low to low plasticity fines. Approximately 70% silt and 30% clay.	
					0.0			

BMI Landfill CAMU Investigation

Henderson, Nevada

Basic Remediation COMPANY

Log of Boring No. BW-12B

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
-170					0.0		Clayey silt, brown (7.5YR5/4), moist, stiff, very low to low plasticity fines. Approximately 75% silt and 25% clay.	
					0.0		Clayey silt, yellowish brown (10YR5/4), moist, stiff, very low to low plasticity fines. Approximately 80% silt and 20% clay.	
					0.0		Clayey silt, yellowish brown (10YR5/4), moist, stiff to very stiff, very low to low plasticity fines. Approximately trace fine sand, 80% silt and 20% clay.	
					0.0		Clayey silt, yellowish brown (10YR5/4), moist, very stiff, nonplastic to low plasticity fines. Approximately 80% silt and 20% clay.	
-180					0.0		Clayey silt, brown (7.5YR5/4), moist, stiff, very low to low plasticity fines. Approximately 70% silt and 30% clay.	Basal Bentonite Seal
					0.0		Clayey silt, brown (7.5YR5/4), moist, stiff, very low to low plasticity fines. Approximately 65% silt and 35% clay.	
					0.0		Clayey silt, yellowish brown (10YR5/4), moist, stiff to very stiff, nonplastic to low plasticity fines, trace local cementation. Approximately trace fine sand 85% silt and 15% clay.	
-190					0.0		Clayey silt, yellowish brown (10YR5/4), moist, stiff, very low to low plasticity fines. Approximately 70% silt and 30%.	
					0.0		Clayey silt, yellowish brown (10YR5/4), moist, stiff to very stiff, nonplastic to low plasticity fines. Approximately 75% silt and 25% clay.	
					0.0		Clayey silt, brown (7.5YR5/4), moist, very stiff, nonplastic to low plasticity fines, trace subangular to subrounded sand, trace local cementation. Approximately trace medium sand, 5% fine sand, 80% silt and 15% clay.	
-200					0.0		Clayey silt, yellowish brown (10YR5/4), moist, very stiff, nonplastic to low plasticity fines, trace local cementation. Approximately trace fine sand, 80% silt and 20% clay. Bottom of hole @ 200' bgs. End Borehole @ 200 ft bgs.	

Log of Boring No. BW-13A

BMI Landfill CAMU Investigation

Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: Rotary Sonic
Drilling Equipment: GEFCO
Drilling Contractor: Water Development Corporation
Driller: Mike Wilkerson

Borehole Total Depth: 86.5 ft bgs
Borehole Diameter: 7 5/8" O.D. Casing / 7 7/8" O.D. Bit
Well ID: GW-MCF-BW-13
Depth to Water (ft. bgs): 29' bgs ▽

Sample Type: 2" Split Spoon
Sample Interval Continuous

Logged By: M. Manwaring
Date Started: 03/27/05
Date Completed: 03/28/05

Monitoring Well Construction

Type of Surface Seal:	Bentonite-Grout	**Screen Slot Size:**	0.010 in
Blank Casing Type/Size:	4" Sch 80 PVC	**Top of Screen (ft. bgs):**	59 ft bgs
Screen Type/Size:	4" Sch 80 PVC	**Bottom of Screen (ft. bgs):**	69 ft bgs
Transition Sand Type:	N/A	**Type of Sand Pack:**	#2/12

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0					0.4		SM: Silty sand with gravel, dark grayish brown (10YR4/2), silghtly moist to dry, loose, (0"-2" asphalt), hand auger to 3' (refusal in cobbles/gravels begin rotosonic - slowly to 10' bgs), fill to about 4' bgs/road base). Approximately 15% gravel, 10% coarse sand, 20% medium sand, 40% fine sand and 15% silt. (Sample BRC-BW-13A-0 collected).	Flush mount well box with concrete apron
					0.2		Silty sand with gravel, dark yellowish brown (10YR3/4), dry to slightly moist, angular, becoming angular volcanic rock below 7' bgs. (gray to strong brown). Approximately 15% gravel, 10% coarse sand, 15% medium sand, 30% fine sand, 30% silt and trace clay. Approximately 10% gravel, 15% coarse sand, 20% medium sand, 25% fine sand, 30% silt and trace clay.	Cement Bentonite Grout
-10							COBBLES: Cobbles/Boulders, gray (7.5YR5/1), vessicular volcanic rock, drill bit crushed rock into fine silt size, dry. Approximately 100% cobbles and boulders.	4" Blank PVC Riser Pipe
					0.0		SM: Silty sand with gravel, yellowish brown (10YR5/4), gravels are angular to subangular volcanics (up to 2"-3" diameter). Approximately 25% gravel, 5% coarse sand, 15% medium sand, 25% fine sand, 30% silt and trace clay.	Bentonite seal
					0.0			
					0.0		Silty sand with gravel, brown (10YR5/3), subangular to angular (broken) gravels (volcanics). Approximately 20% gravel, 5% coarse sand, 15% medium sand, 30% fine sand, 30% silt and trace clay.	#2/12 Sand Pack
-20					0.0			
					0.0		GP-GM: Gravel with silt and sand, large gravels and silty sand, large subangular to subrounded, dry, gray (10YR5/1-6/1), when cobbles cored, broken material silty and angular gravel. Approximately 75% gravel and cobbles, 5% coarse sand, 10% fine sand and 10% silt.	
					0.0		Silty gravel with sand, gray (10YR6/1), subangular to angular (broken) moist at 27' bgs, increased silt and fine sand, wet, at 29' bgs (casing to 30') [water lever meter indicates water to 27'8" bgs]. Approximately 60% gravel, 20% fine sand, 20% silt and trace clay. Becomming	4" 0.010 Slot PVC screen

BMI Landfill CAMU Investigation

Henderson, Nevada

Basic Remediation COMPANY

Log of Boring No. BW-13A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
							moist at 25' bgs.	
					0.4		SM: Silty sand with gravel, very moist, lenses of medium sand, very moist to wet, brown (10YR4/3), gravel is subangular to angular, firm. Approximately 20% gravel, 15% coarse sand, 10% medium sand, 20% fine sand, 30% silt and 5% clay.	
					1.8		Approximately 20% gravel, 5% coarse sand, 15% medium sand 30% fine sand, 30% silt and trace clay. (Sample BRC-BW-13A-30 collected).	
-30					2.1			4" 0.010 Slot PVC screen
					0.0			
					NR			
					NR		ML/SM: Sandy silt with gravel, brown (7.5YR4/3), very moist, increased fines (silt and clay), driller had trouble holding samples from ~30' - 36' in corebarrel. Approximately 10% gravel, 5% coarse sand, 15% medium sand, 20% fine sand, 40% silt and 10% clay.	#2/12 Sand Pack
					1.6			Threaded PVC Well Base Cap
-40					2.8		Sandy silt with clay, several thin (<0.3") fine to medium sand lenses, dark yellowish brown (10YR4/4), trace silty gypsum, small gravel are angular volcanics. Approximately 10% gravel, 5% coarse sand, 10% medium sand, 25% fine sand, 40% silt and 10% clay.	
					7.5			
					29			
					44			Basal Bentonite Seal
					6.9		ML: Sandy silt with clay, subangular to subrounded, trace thin (0.3" - 0.5"), fine to medium sand lenses (subrounded volcanic sands), very moist (not wet) but saturated, no odors. Approximately 5% gravel, 5% coarse sand, 10% medium sand, 20% fine sand, 50% silt and 10% clay.	
-50							(Casing advanced to 50' bgs).	
							Sandy silt with clay, brown silt (7.5YR4/4), most pronounced at 51.5' - 52.5', very moist to saturated (wet), silt is firm, sand is loose, trace clay, low to medium plasticity, some local sand lenses (<1" thick). Approximately trace gravel, 5% coarse sand, 10% medium sand, 20% fine sand, 55% silt and 10% clay. (Sample BRC-BW-13A-53 collected).	
							Clayey silt with sand, brown (7.5YR4/3), medium plasticity, saturated (wet 56' - 57' bgs). Approximately trace gravel, 15% fine sand, 65% silt and 20% clay.	
					0.5			
							Silt with clay, gravel and sand, (chert/gypsum?), brocken by corebarrel, moist. Approximately 15% gravel, 10% medium sand, 15% fine sand, 55% silt and 10% clay.	
-60					0.3		Clayey silt, strong brown (7.5YR5/6), medium plasticity clay, becomes wet @ 60' - 63' bgs, slightly firm. Approximately 10% gravel, 10% fine sand, 60% silt and 20% clay.	

BMI Landfill CAMU Investigation

Henderson, Nevada

Basic Remediation COMPANY

Log of Boring No. BW-13A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
					0.0		Clayey silt with gravel, brown (7.5YR5/4), moist to very moist, (saturated not wet), low plasticity, firm to stiff, some gypsum content. Approximately 15% gravel, 10% fine sand, 60% silt and 15% clay.	
					0.0		Silt with clay and gravel, yellowish brown (10YR5/4), moist, firm. Approxiamtely 15% gravel, 75% silt and 10% clay.	
							Silt, brown (7.5YR5/4), low plasticity, firm to stiff, some gypsum content. Approximately 10% gravel, 10% fine sand, 75% silt and 5% clay.	
-70					0.0			
					0.0		Clayey silt with gravel, brown (7.5YR5/4). Approximately 15% gravel, 10% fine sand, 60% silt and 15% clay.	
					0.0		Clayey silt, sand and trace gravels, (gypsum fragments), angular to subangular, firm to stiff, moist (not wet), low plasticity. Approximately 5% gravel, 10% fine sand, 70% silt and 15% clay.	
					0.0			
							Clayey silt, trace gravel size gypsum fragments, (angular) visible crystals on some fragments firm to stiff, low plasticity, moist. Approximately trace gravel, 10% fine sand, 75% silt and 15% clay.	
					0.0			
-80					0.0		Clayey silt, brown (7.5YR5/3), moist, low plasticity, firm to stiff. Approximately 5% fine gravel, 5% medium sand, 10% fine sand, 65% silt and 15% clay. (Casing to 80' bgs)	
					0.0			
							Clayey silt, trace angular gravel size rocks (gypsum), moist, firm/stiff. Approximately 5% gravel, 10% fine sand, 70% silt and 15% clay. (Sample BRC-BW-13A-85 collected). Bottom of hole @ 86.5 ft bgs.	

Log of Boring No. BW-13B

BMI Landfill CAMU Investigation

Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: Rotary Sonic
Drilling Equipment: GEFCO
Drilling Contractor: Water Development Corporation
Driller: Mike Wilkerson

Borehole Total Depth: 60 ft bgs
Borehole Diameter: 7 5/8" O.D. Casing / 7 7/8" O.D. Bit
Well ID: GW-AA-BW-13
Depth to Water (ft. bgs): 29' bgs ▽

Sample Type: N/A
Sample Interval Continuous

Logged By: A. Norris
Date Started: 03/29/05
Date Completed: 03/30/05

Monitoring Well Construction

Type of Surface Seal:	Bentonite-Grout	**Screen Slot Size:**	0.010 in
Blank Casing Type/Size:	4" Sch 80 PVC	**Top of Screen (ft. bgs):**	18 ft bgs
Screen Type/Size:	4" Sch 80 PVC	**Bottom of Screen (ft. bgs):**	38 ft bgs
Transition Sand Type:	N/A	**Type of Sand Pack:**	#2/12

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0					0.0		SM: Silty sand with gravel, dark yellowish brown (10YR4/4), moist to dry, subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 2" long), locally partly indurated to weakly cemented. Approximately 20% gravel, 15% coarse sand, 15% medium sand, 30% fine sand and 20% silt. Note: Asphalt pavement (5" thick) @ ground surface.	Locking monument well box with concrete apron and ballards
					0.0		Silty sand with gravel, dark yellowish brown (10YR4/4), dry to moist, subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 3" long), locally partly indurated to weakly cemented, trace local volcanic cobbles (up to 4" long). Approximately 35% gravel, 10% coarse sand, 10% medium sand, 30% fine sand and 15% silt.	Cement Bentonite Grout
					0.0		Silty sand with gravel, brown (10YR5/3), dry, subangular to surounded sand, nonplastic silt, subangular to subronded fine to coarse volcanic gravel (up to 3" long), locally partly indurated to weakly cemented. Approximately 30% gravel, 10% coarse sand, 10% medium sand, 30% fine sand and 20% silt.	
-10					0.0			4" Blank PVC Riser Pipe
					0.0		Silty sand with gravel, light brownish gray (10YR6/2), dry, subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 3" long), some local volcanic cobbles (up to 5" long). Approximately 30% gravel, 15% coarse sand, 10% medium sand, 30% fine sand and 15% silt.	Bentonite seal
					0.0		Silty sand with gravel, dark grayish (10YR4/2), dry to moist, subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 3" long), trace local volcanic cobbles (up to 5" long). Approximatley 30% gravel, 15% coarse sand, 10% medium sand, 25% fine sand and 20% silt. Becomes yellowish brown (10YR5/4) @ 17' bgs.	
					0.0		ML: Silt with sand, brown (10YR4/3), moist, nonplastic to very low plasticity silt, subangular to subrounded sand. Approximately 5% medium sand, 15% fine sand and 80% silt.	#2/12 Sand Pack
-20					0.0		SM: Silty sand with gravel, light brownish gray (10YR6/2), moist, subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 2" long), locally partly indurated to weakly cemented. Approximately 20% gravel, 15% coarse sand, 15% medium sand, 35% fine sand and 15% silt.	
					0.0		Silty sand with gravel, light brownish gray (10YR6/2), moist, subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 2" long), locally partly indurated to weakly cemented, trace local strong cementation. Approximately 20% gravel,	4" 0.010 Slot PVC screen

BMI Landfill CAMU Investigation

Henderson, Nevada

Basic Remediation COMPANY

Log of Boring No. BW-13B

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
					0.0		15% coarse sand, 10% medium sand, 25% fine sand and 30% silt.	
-30					0.0		Silty sand with gravel, light brownish gray (10YR6/2), wet, subangular to subrounded sand, nonplastic to very low plasticity silt, fine to coarse subangular to subrounded volcanic gravel (up to 3" long), locally partly indurated to weakly cemented, trace local volcanic cobbles (up to 5" long). Approximately 20% gravel, 10% coarse sand, 10% medium sand, 35% fine sand and 25% silt. First water @ 29' bgs.	4" 0.010 Slot PVC screen
					0.0		Silty sand with gravel, brown (7.5YR5/2), wet, subangular to subrounded sand, nonplastic to very low plasticity silt, subangular to subrounded fine to coarse volcanic gravel (up to 2" long), locally cemented. Approximately 15% gravel, 10% coarse sand, 10% medium sand, 40% fine sand and 25% silt.	
					0.0		ML: Silt with sand, pink (7.5YR7/3), moist, nonplastic to very low plasticity silt, subangular to subrounded sand, very stiff to hard. Approximately 20% fine sand and 80% silt.	#2/12 Sand Pack
					0.0 0.0		Silt wit clay, brown (7.5YR5/4), moist, very low to low plasticity fines, subangular to subrounded sand, stiff. Approximately 10% fine sand, 80% silt and 10% clay.	Threaded PVC Well Base Cap
-40					0.0		Silt with clay, brown (7.5YR5/4), moist, very low to low plasticity fines, subangular to subrounded sand, stiff. Approximately 10% fine sand, 80% silt and 10% clay.	
					0.0		Silt with clay and sand, brown (7.5YR5/4), moist, very low to low plasticity fines, subangular to subrounded sand, very stiff. Approximately 5% gravel, 5% coarse sand 5% medium sand, 10% fine sand, 65% silt and 10% clay.	Basal Bentonite Seal
					0.0		Clayey silt, brown (7.5YR5/4), moist, very low to low plasticity fines, very stiff. Approximately 5% fine sand, 80% silt and 15% clay.	
-50					0.0		Clayey silt, strong brown (7.5YR5/6), moist, very low to low plasticity fines, stiff. Approximately 80% silt and 20% clay.	
					0.0 0.0		Clayey silt, brown (7.5YR5/4), moist, very low to low plasticity fines, stiff to very stiff. Approximately 85% silt and 15% clay.	
					0.0		Clayey silt, brown (7.5YR5/4), moist, very low to low plasticity fines, stiff, subangular to subrounded sand. Approximately 5% coarse sand, 5% medium sand, 5% fine sand, 70% silt and 15% clay. 1" thick Sandy silt seam @59' bgs. Wet seam bound above and below by moist clayey silt. Seam: Approximately 40% fine to coarse sand and 60% silt. 59.1' to 60' bgs: Clayey silt. brown (7.5YR5/4), moist, very low to low plasticity fines, stiff. Approximtaely 80% silt and 20% clay.	
-60					0.0		Bottom of hole @ 60' bgs.	

Attachment X
Copy of NDEP Approval Letters for Closure of Phases I, II, IIIA, IIIB, and IV and for BMI North and BMI South Landfills

Basic Remediation Company (BRC)
Corrective Action Management Unit (CAMU)
Henderson, Nevada

ndep
NEVADA DIVISION OF ENVIRONMENTAL PROTECTION
protecting the future for generations

STATE OF NEVADA
Department of Conservation & Natural Resources
DIVISION OF ENVIRONMENTAL PROTECTION

Jim Gibbons, Governor
Allen Biaggi, Director
Leo M. Drozdoff, P.E., Administrator

July 8, 2010

Mr. Mark Paris
Basic Remediation Company (BRC)
875 West Warm Springs
Henderson, NV 89011

Re.: Nevada Division of Environmental Protection Response to:
South BMI Closure Construction Quality Assurance Report BMI Common Areas Remediation Project
dated June 2010 (received June 15, 2010)
NDEP Facility ID# H-000688

Dear Mr. Paris:

The NDEP has received and reviewed BRC's Deliverable identified above and finds that it is acceptable.

Should you have any questions or concerns, please do not hesitate to contact me at (775) 687-9373 or glovato@ndep.nv.gov.

Sincerely,

Greg Lovato, P.E.
Supervisor, Remediation Branch
Bureau of Corrective Actions
Fax: (775) 687-8335

GL:s

ec: Jim Najima, NDEP, BCA, Carson City
Brian Rakvica, McGinley and Associates
Steve Morrow, ASW
Barry Conaty, Holland & Hart LLP
Brenda Pohlmann, City of Henderson
Mitch Kaplan, U.S. Environmental Protection Agency, Region 9
Ebrahim Juma, Clark County DAQEM
Jeff Gibson, AMPAC
Ranajit Sahu, BRC
Rick Kellogg, BRC
Rex Heppe, ATC
Craig Wilkinson, TIMET
Kirk Stowers, Broadbent & Associates
George Crouse, Syngenta Crop Protection, Inc.
Nicholas Pogoncheff, PES Environmental, Inc.
Keith Bailey, Environmental Answers
Matt Paque, Tronox LLC
Roy Widmann, Tronox LLC
Lee Erickson, Stauffer Management Company
Michael Bellotti, Olin Corporation
Curt Richards, Olin Corporation
Paul Sundberg, Montrose Chemical Corporation of CA
Joe Kelly, Montrose Chemical Corporation of CA
Deni Chambers, Northgate Environmental Management, Inc.

cc: Robert Williams, Clark County Fire Department, 575 East Flamingo Road, Las Vegas, Nevada 89119
David Sadoff, AIG Consultants, Inc., 121 Spear Street, 3rd Floor, San Francisco, CA 94105
Leslie Hill, U.S. Department of Justice, PO Box 23896, Washington, DC 20026-3986
Susan Crowley, C/O Tronox LLC, PO Box 55, Henderson, Nevada 89009
Mike Skromyda, Tronox LLC, PO Box 55, Henderson, Nevada 89009
Robert Infelise, Cox Castle Nicholson, 555 California Street, 10th Floor, San Francisco, CA 94104-1513
Michael Ford, Polsinelli Shughart, Security Title Plaza, 3636 N. Central Avenue, Suite 1200, Phoenix, AZ 85012

ndep
NEVADA DIVISION OF ENVIRONMENTAL PROTECTION
protecting the future for generations

STATE OF NEVADA
Department of Conservation & Natural Resources
DIVISION OF ENVIRONMENTAL PROTECTION

Jim Gibbons, Governor
Allen Biaggi, Director
Leo M. Drozdoff, P.E., Administrator

June 25, 2010

Mr. Mark Paris
Basic Remediation Company (BRC)
875 West Warm Springs
Henderson, NV 89011

Re.: Nevada Division of Environmental Protection Response to:
CAMU Partial Final Closure Construction Quality Assurance Report, Phase I, IIIB, IV & Portions of Phases II and V, Basic Remediation Company Corrective Action Management Unit, Henderson, Nevada; Response to Nevada Division of Environmental Protection Comments dated 14 June 2010
dated June 18, 2010
NDEP Facility ID# H-000688

Dear Mr. Paris:

The NDEP has received and reviewed BRC's Deliverable identified above and finds that it is acceptable.

Should you have any questions or concerns, please do not hesitate to contact me at (775) 687-9373 or glovato@ndep.nv.gov.

Sincerely,

Greg Lovato, P.E.
Supervisor, Remediation Branch
Bureau of Corrective Actions
Fax: (775) 687-8335

GL:s

ec: Jim Najima, NDEP, BCA, Carson City
Brian Rakvica, McGinley and Associates
Dave Gratson, Neptune and Company, Inc.
Barry Conaty, Holland & Hart LLP
Brenda Pohlmann, City of Henderson
Mitch Kaplan, U.S. Environmental Protection Agency, Region 9
Ebrahim Juma, Clark County DAQEM
Jeff Gibson, AMPAC
Ranajit Sahu, BRC
Rick Kellogg, BRC
Rex Heppe, ATC
Craig Wilkinson, TIMET
Kirk Stowers, Broadbent & Associates
George Crouse, Syngenta Crop Protection, Inc.
Nicholas Pogoncheff, PES Environmental, Inc.
Keith Bailey, Environmental Answers
Matt Paque, Tronox LLC
Roy Widmann, Tronox LLC
Lee Erickson, Stauffer Management Company
Michael Bellotti, Olin Corporation
Curt Richards, Olin Corporation
Paul Sundberg, Montrose Chemical Corporation of CA
Joe Kelly, Montrose Chemical Corporation of CA
Deni Chambers, Northgate Environmental Management, Inc.

cc: Robert Williams, Clark County Fire Department, 575 East Flamingo Road, Las Vegas, Nevada 89119
David Sadoff, AIG Consultants, Inc., 121 Spear Street, 3rd Floor, San Francisco, CA 94105
Leslie Hill, U.S. Department of Justice, PO Box 23896, Washington, DC 20026-3986
Susan Crowley, C/O Tronox LLC, PO Box 55, Henderson, Nevada 89009
Mike Skromyda, Tronox LLC, PO Box 55, Henderson, Nevada 89009
Robert Infelise, Cox Castle Nicholson, 555 California Street, 10th Floor, San Francisco, CA 94104-1513
Michael Ford, Polsinelli Shughart, Security Title Plaza, 3636 N. Central Avenue, Suite 1200, Phoenix, AZ 85012

May 17, 2010

Mr. Mark Paris
Basic Remediation Company (BRC)
875 West Warm Springs
Henderson, NV 89011

Re.: Nevada Division of Environmental Protection Response to:
CAMU Partial Final Closure Construction Quality Assurance Report Phase IIIA & Portion of Phase II, Basic Remediation Company, Corrective Action Management Unit, Henderson, Nevada dated April 2010 (received April 23, 2010)
NDEP Facility ID# H-000688

Dear Mr. Paris:

The NDEP has received and reviewed BRC's Deliverable identified above and finds that it is acceptable.

Should you have any questions or concerns, please do not hesitate to contact me at (775) 687-9373 or glovato@ndep.nv.gov.

Sincerely,

Greg Lovato, P.E.
Supervisor, Remediation Branch
Bureau of Corrective Actions
Fax: (775) 687-8335

GL:s

ec: Jim Najima, NDEP, BCA, Carson City
Brian Rakvica, McGinley and Associates
Steve Morrow, ASW

cc: Barry Conaty, Holland & Hart LLP, 975 F Street, N.W., Suite 900,Washington, D.C. 20004
Brenda Pohlmann, City of Henderson, PO Box 95050, Henderson, NV 89009
Mitch Kaplan, U.S. Environmental Protection Agency, Region 9, mail code: WST-5, 75 Hawthorne Street, San Francisco, CA 94105-3901
Ebrahim Juma, Clark County DAQEM, 500 South Grand Central Parkway, PO Box 555210, Las Vegas, NV, 89155-5210
Robert Williams, Clark County Fire Department, 575 East Flamingo Road, Las Vegas, Nevada 89119
Ranajit Sahu, BRC, 311 North Story Place, Alhambra, CA 91801
Rick Kellogg, BRC, 875 West Warm Springs, Henderson, NV 89011
Rex Heppe, 2925 East Patrick Lane, Suite M, Las Vegas, NV 89120-2457
David Sadoff, AIG Consultants, Inc., 121 Spear Street, 3rd Floor, San Francisco, CA 94105
Leslie Hill, U.S. Department of Justice, PO Box 23896, Washington, DC 20026-3986
Craig Wilkinson, TIMET, PO Box 2128, Henderson, Nevada, 89009-7003
Kirk Stowers, Broadbent & Associates, 8 West Pacific Avenue, Henderson, Nevada 89015
George Crouse, Syngenta Crop Protection, Inc., 410 Swing Road, Greensboro, NC 27409
Nicholas Pogoncheff, PES Environmental, Inc., 1682 Novato Blvd., Suite 100, Novato, CA 94947-7021
Susan Crowley, Crowley Environmental LLC, 366 Esquina Dr., Henderson, NV 89014
Susan Crowley, Tronox LLC, PO Box 55, Henderson, Nevada 89009
Mike Skromyda, Tronox LLC, PO Box 55, Henderson, Nevada 89009
Keith Bailey, Environmental Answers, 3229 Persimmon Creek Dr, Edmond, Oklahoma 73013
Matt Paque, Tronox LLC, 3301 NW 150th, Oklahoma City, OK 73134
Roy Widmann, Tronox LLC, 3301 NW 150th, Oklahoma City, OK 73134
Lee Erickson, Stauffer Management Company, P.O. Box 18890, Golden, Co 80402
Michael Bellotti, Olin Corporation, 3855 North Ocoee Street, Suite 200, Cleveland, TN 37312
Curt Richards, Olin Corporation, 3855 North Ocoee Street, Suite 200, Cleveland, TN 37312
Paul Sundberg, Montrose Chemical Corporation, 10733 Wave Crest Court Stockton, CA 95209
Joe Kelly, Montrose Chemical Corporation of CA, 600 Ericksen Avenue NE, Suite 380, Bainbridge Island, WA 98110
Deni Chambers, Northgate Environmental Management, Inc., 300 Frank H. Ogawa Plaza, Suite 510, Oakland, CA 94612
Robert Infelise, Cox Castle Nicholson, 555 California Street, 10th Floor, San Francisco, CA 94104-1513
Michael C. Ford, Polsinelli Shughart, Security Title Plaza, 3636 N. Central Avenue Suite 1200, Phoenix, AZ 85012
Jeff Gibson, AMPAC, 3883 Howard Hughes Pkwy, Ste 700, Las Vegas, NV 89169

ndep
NEVADA DIVISION OF ENVIRONMENTAL PROTECTION
protecting the future for generations

STATE OF NEVADA
Department of Conservation & Natural Resources
DIVISION OF ENVIRONMENTAL PROTECTION

Jim Gibbons, Governor
Allen Biaggi, Director
Leo M. Drozdoff, P.E., Administrator

June 25, 2010

Mr. Mark Paris
Basic Remediation Company (BRC)
875 West Warm Springs
Henderson, NV 89011

Re.: Nevada Division of Environmental Protection Response to:
North BMI Partial Final Closure Construction Quality Assurance Report, BMI Common Areas Remediation Project
dated June 2010 (received June 11, 2010)
NDEP Facility ID# H-000688

Dear Mr. Paris:

The NDEP has received and reviewed BRC's Deliverable identified above and finds that it is acceptable.

Should you have any questions or concerns, please do not hesitate to contact me at (775) 687-9373 or glovato@ndep.nv.gov.

Sincerely,

Greg Lovato, P.E.
Supervisor, Remediation Branch
Bureau of Corrective Actions
Fax: (775) 687-8335

GL:s

ec: Jim Najima, NDEP, BCA, Carson City
Brian Rakvica, McGinley and Associates
Dave Gratson, Neptune and Company, Inc.
Barry Conaty, Holland & Hart LLP
Brenda Pohlmann, City of Henderson
Mitch Kaplan, U.S. Environmental Protection Agency, Region 9
Ebrahim Juma, Clark County DAQEM
Jeff Gibson, AMPAC
Ranajit Sahu, BRC
Rick Kellogg, BRC
Rex Heppe, ATC
Craig Wilkinson, TIMET
Kirk Stowers, Broadbent & Associates
George Crouse, Syngenta Crop Protection, Inc.
Nicholas Pogoncheff, PES Environmental, Inc.
Keith Bailey, Environmental Answers
Matt Paque, Tronox LLC
Roy Widmann, Tronox LLC
Lee Erickson, Stauffer Management Company
Michael Bellotti, Olin Corporation
Curt Richards, Olin Corporation
Paul Sundberg, Montrose Chemical Corporation of CA
Joe Kelly, Montrose Chemical Corporation of CA
Deni Chambers, Northgate Environmental Management, Inc.

cc: Robert Williams, Clark County Fire Department, 575 East Flamingo Road, Las Vegas, Nevada 89119
David Sadoff, AIG Consultants, Inc., 121 Spear Street, 3rd Floor, San Francisco, CA 94105
Leslie Hill, U.S. Department of Justice, PO Box 23896, Washington, DC 20026-3986
Susan Crowley, C/O Tronox LLC, PO Box 55, Henderson, Nevada 89009
Mike Skromyda, Tronox LLC, PO Box 55, Henderson, Nevada 89009
Robert Infelise, Cox Castle Nicholson, 555 California Street, 10th Floor, San Francisco, CA 94104-1513
Michael Ford, Polsinelli Shughart, Security Title Plaza, 3636 N. Central Avenue, Suite 1200, Phoenix, AZ 85012

Attachment Y
Long Term Groundwater Monitoring Plan

Basic Remediation Company (BRC)
Corrective Action Management Unit (CAMU)
Henderson, Nevada

(To Be Provided Upon Approval by the NDEP-BCA)

May 2, 2013

Mr. Michael Friend, P.E.
Nevada Division of Environmental Protection
Bureau of Corrective Actions
2030 E. Flamingo Road, Suite 230
Las Vegas, Nevada89119-0818

Subject: BRC Corrective Action Management Unit (CAMU) Long-Term Groundwater Monitoring Plan, BMI Complex, Henderson, Nevada (Revision 0)

Dear Michael:

Per our discussions, Basic Remediation Company (BRC) is providing this long-term Groundwater Monitoring Plan (GMP) for the BRC Corrective Action Management Unit (CAMU) in Clark County, Nevada. While we accept that such monitoring is required per regulations, we note that upgradient water quality in the vicinity of the CAMU makes it impossible at this time to quantitatively use any monitoring data to identify leaks in the CAMU, should such leaks occur. We note, of course, that the likelihood of any leaks from the CAMU, given its recent construction and the care (QA/QC) taken during its construction, including oversight by the NDEP and its consultants, makes the likelihood of any leaks very low.

Table 1 summarizes the workplan including wells that are proposed to be monitored and the respective analytes. Figure 1 shows the wells. Details of the monitoring program are discussed below.

Scope of Work

The scope of work has been divided into three main tasks: 1) Field Implementation; 2) Data Evaluation; and 2) Reporting.

Task 1: Field Implementation

The requirements for sample collection and analysis are established in the *BRC Quality Assurance Project Plan* (QAPP; BRC and ERM 2009) and the *Field Sampling and Standard Operating Procedures* (FSSOP; BRC, ERM and MWH 2009), which are stand-alone NDEP-approved project documents.

Pre-Field Activities

The pre-field activities will be conducted in accordance with applicable standard operating procedures (SOPs; BRC, ERM and MWH 2009). The BRC QAPP (BRC and ERM 2009) and *BRCHealth and Safety Plan* (BRC and MWH 2005) prepared for the BMI Common Areas will

be used for this proposed scope of work. All work will be completed under the direction of a State of Nevada Certified Environmental Manager.

Water Level Measurements

Water levels will be measured in all wells proposed for sampling within this CAMU long-term GMP, as shown on Figure 1 and Table 1. These water level measurement events will be conducted over a one--day period. Water level measurements will be performed in accordance with procedures described in the project specific SOP-5 (Water Sampling and Field Measurements).

Annual Water Quality Sampling and Analysis

Water quality samples will be collected from the wells in Figure 1/Table 1. Samples will be collected once per year, typically in April, in coordination with other parties, included OSSM, who also collect annual water samples at that time. Note that BRC will coordinate with OSSM for to ensure certain wells and analytes are included in their program. BRC will ensure any data gaps are covered by our sampling plan.

As approved by the NDEP in a July 25, 2006, meeting between BRC and the NDEP, BRC will use the micro-purge and sampling methodology that were used for previous groundwater monitoring events. BRC-owned wells have been equipped with QED® Well Wizard (A-system) dedicated bladder pumps for the monitoring and sampling of wells for the CAMU long-term GMP. QED® MP10H high pressure micro-purge controllers will be used. The Well Wizard A-system has been installed in all shallow zone wells.

Field quality control measures to be implemented during the groundwater sampling events will be performed according to BRC QAPP requirements and BRC SOPs. Specific wells where quality control (QC) samples will be collected will be identified at the beginning of each sampling event by BRC or its field consultant. The required QC sample frequencies and field QC measures will generally be:

- Collection of 10% field duplicates, 5% equipment blanks, 5% trip blanks, and 10% matrix spike/matrix spike duplicate samples;

SOPs specific to groundwater sampling and field analytical procedures are presented in SOP-5 and SOP-30.

Waste Management

Purge water resulting from groundwater sampling will be contained on-site in Department of Transportation-approved containers and allowed to settle. Containers will be labeled by field personnel to identify contents, date, and source location. Following settlement, the purge water will be disposed of in accordance with the applicable state and local regulations. All generated wastes (i.e. purge and decontamination water) will be analyzed for the appropriate waste criteria for characterization prior to disposal. SOP-35 will be followed during waste sampling activities.

Well Maintenance and Inspections

Every monitoring well scheduled for water level measurement or sampling will be inspected for deficiencies and problems. An inspection checklist will be completed, noting any deficiencies and problems, and will include the following information:

- Date, inspector's initials, well identification number; and

- Description of condition for:
  - Security posts, well pad, security casing, and dedicated sampling components, if applicable;
  - Gasket, lock, well casing, well head, flange bolt tightness; and
  - Straightness of the well head.

In addition to the routine well inspection, each well total depth will be measured to determine if formation material surrounding the well has migrated into and accumulated inside the well casing. Wells that contain an accumulation of material that exceeds 20% of the screened interval will be considered for redevelopment.

Routine maintenance such as lubricating the well cap lock with graphite, replacing the lock, replacing the well gasket, replacing the well head bolts, and tapping out the bolt holes will be performed each water level monitoring event, as needed, for on-site (i.e., BRC owned) wells only. For all off-site wells requiring maintenance, the respective site owners will be notified. All maintenance performed will be documented in a bound logbook. If well components are damaged and cannot be repaired on the spot (such as bent security posts or casing, or a cracked concrete well pad), the problem will be described and recommended for correction under a well maintenance task. These routine maintenance activities will be summarized in the long-term groundwater monitoring reports.

Analytical Program

The proposed list of chemicals and analytical methods for the CAMU long-term GMP is provided in Table 1, and has been developed to reflect the analytes associated with soils removed from Eastside and placed within the CAMU and their potential to mobilize to groundwater.

Certain analytes detected in Eastside or CAMU area soils are excluded from the long-term GMP as summarized below:

- Asbestos - omitted due to the physical characteristics of this constituent, which is generally considered inert in the subsurface;
- Dioxins/furans – omitted due to the physical characteristics of these constituents, which are relatively immobile in the subsurface;
- Volatile organic compounds (VOCs) – omitted because of their limited historical detections in Eastside soils, and the expectation that they would have been volatilized during excavation and placement activities;
- Radionuclides – omitted due to the high variability in historical detections in groundwater in the CAMU area;
- PCBs – omitted due to the physical characteristics of these constituents, which are relatively immobile in the subsurface; and

- The following metals, which were not frequently detected in Eastside or CAMU soils:antimony, boron, mercury, molybdenum, selenium, silver, tin, and tungsten.

BRC acknowledges that should a leak be detected and confirmed to be coming from the CAMU we will be required to sample for all contituents that were found in the waste analysis plan included in the NDEP approved Remedial Action Plan (March 2007).

The QAPP specifies the project-specific detection and quantitation limits, calibration and calibration verification, and QC procedures and specifications. The QAPP also requires that analyses be performed according to the method-specific SOPs, which have also been revised to be site-specific stand-alone documents. Analytical laboratories that will performing the analyses will be required to have Nevada State certification for the methods to be performed.

Task 2: Data Evaluation

Measurement data will be assessed and documented to determine whether objectives were met. Once the data are collected, BRC will subject the data to validation per procedures agreed to previously with the NDEP and consistent with the BRC QAPP (BRC and ERM 2009) and SOP-40. Only those data determined by the quality assurance/quality control (QA/QC) review to be suitable for use will be considered for the event data set. A separate Data Validation Summary Report will be prepared and submitted to NDEP for each monitoring event.

Task 2: Reporting

Once per year, the results from each event will be reported to the NDEP via a long-term groundwater monitoring report for that year. The report will also contain historical data collected in prior years in appropriate tables and trend figures. BRC will qualitatively review all data collected in each annual monitoring event to look for anomalous data different than historic trends (i.e. qualitative trend analyses will be performed). We reiterate that no quantitative, statistical, analysis will be conducted since poor upgradient water quality makes such an analysis meaningless as far as leak detection is concerned.

BRC currently maintains a comprehensive project database for all data it collects and has historically collected. All new data collected pursuant to this long-term GMP will be incorporated into the project database. Each laboratory will provide the analytical data in electronic format for storage in the project analytical database. The Data Manager (currently ERM) will amend the project database with each new set of data provided by the laboratory, perform accuracy checks between the hardcopy and electronic data reports, and maintain any data qualifiers resulting from data validation activities.

<u>Schedule</u>

Once final approval of the long-term GMP is received from NDEP, BRC will attempt to collect the data at the next synchronized event with the other BMI companies (typically in April). BRC will provide NDEP with at least one week notice prior to the initiation of field activities at the Site. It is anticipated that this annual monitoring can be completed within one week, depending on field conditions. The groundwater samples will be submitted to the laboratories and placed on a standard turn around time, which is 28 days for the analyte list proposed. A data validation report will be submitted to the NDEP within 4 weeks after all analytical data are received. After

the validation report is approved, a final event report will be submitted within 4 weeks of approval of the validation report.

Closing Remarks

Please see below for appropriate certification language and signature. Please direct any remaining questions or comments you may have to me at 626-382-0001.

Sincerely,

Basic Remediation Company

Ranajit Sahu, CEM
Project Manager

Attachments: Table 1 – Proposed GMP Wells and Analyte List
Figure 1 – Proposed CAMU GMP Monitoring Wells

REFERENCES

BRC, ERM and MWH.2009. BRC Field Sampling and Standard Operating Procedures, BMI Common Areas, Clark County, Nevada.December.

BRC and ERM-West, Inc. (ERM). 2009. BRC Quality Assurance Project Plan. BMI Common Areas, Clark County, Nevada.May.

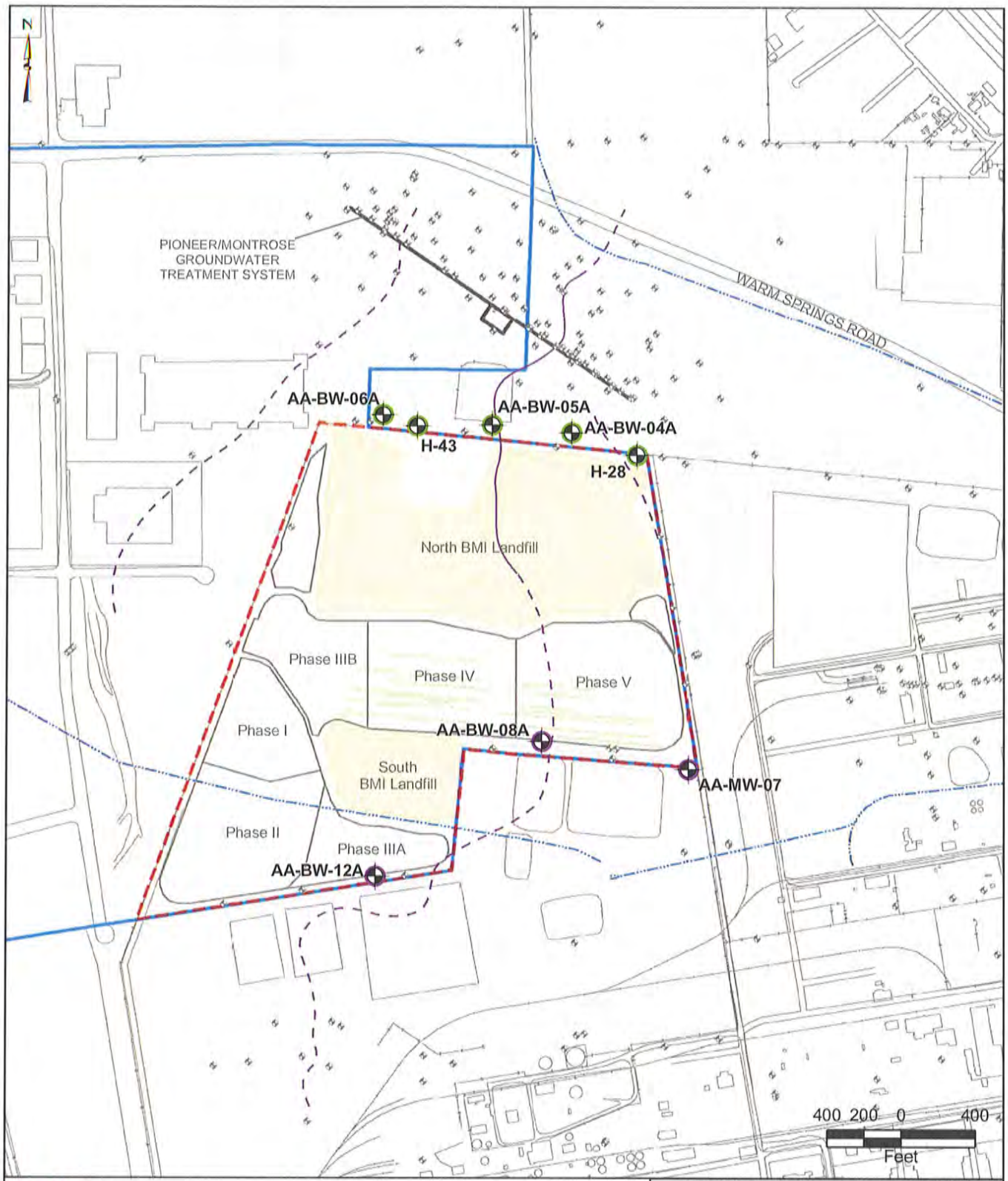
Basic Remediation Company (BRC) and MWH. 2005. BRC Health and Safety Plan. BMI Common Areas, Clark County, Nevada.October.

I hereby certify that I am responsible for the services described in this document and for the preparation of this document. The services described in this document have been provided in a manner consistent with the current standards of the profession and to the best of my knowledge comply with all applicable federal, state and local statutes, regulations and ordinances. I hereby certify that all laboratory analytical data was generated by a laboratory certified by the NDEP for each constituent and media presented herein.

June 14, 2012

Dr. Ranajit Sahu, C.E.M. (No. EM-1699, Exp. 10/07/2013) Date
BRC Project Manager

FIGURES



CAMU Site

Site Groundwater Boundary

Slit Trenches

Other Monitoring Wells

Paleochannels (solid where deeply incised, dashed where relatively shallow and/or inferred)

CAMU Long-Term Monitoring Program Wells

Upgradient, Shallow Well

Downgradient, Shallow Well

Corrective Action Management Unit (CAMU)
BMI Complex, Henderson, Nevada

FIGURE 1

PROPOSED CAMU LONG-TERM GROUNDWATER MONITORING PLAN WELLS

Basic Remediation COMPANY

Prepared by	Date	JOB No. 0074742
MKJ (ERM)	06/14/12	FILE: GIS/BRC/CAMU_GMP/FIGURE_1.MXD

TABLES

TABLE 1
PROPOSED CAMU LONG-TERM GROUNDWATER MONITORING PLAN WELLS AND ANALYTE LIST
CAMU AREA, CLARK COUNTY, NEVADA

				Field Sampling				Laboratory Analytical Suite				
Well ID	**Zone Monitored**	**Hydrologic Position**	**Frequency**	**Water Level Measurement**	**NAPL Measurement**	**Dissolved Oxygen (field) per SOP5[a]**	**Water Quality Sampling**	**General Chemistry and Ions**	**SVOCs**	**Organochlorine Pesticides**	**Metals**	**Water Quality Parameters including TDS**
AA-BW-04A	Shallow	Downgradient	Annual	B	B	B	B	B	B	B	B	B
AA-BW-05A	Shallow	Downgradient	Annual	B	B	B	B	B	B	B	B	B
AA-BW-06A	Shallow	Downgradient	Annual	B	B	B	B	B	B	B	B	B
AA-BW-08A	Shallow	Upgradient	Annual	B	B	B	B	B	B	B	B	B
AA-BW-12A	Shallow	Upgradient	Annual	B	B	B	B	B	B	B	B	B
AA-MW-07	Shallow	Upgradient	Annual	B	B	B	B	B	B	B	B	B
H-28	Shallow	Downgradient	Annual	B	B	B	B	B	B	B	B	B
H-43	Shallow	Downgradient	Annual	B	B	B	B	B	B	B	B	B

B: BRC to conduct measurement unless it determines that another party, such as OSSM, is already analyzing for this parameter - this will be coordinated with OSSM each year, prior to sampling.

TABLE
PROPOSED CAMU LONG-TERM GROUNDWATER MONITORING PLAN ANALYTES
CAMU AREA, CLARK COUNTY, NEVADA
(Page 1 of 3)

Parameter of Interest	Preparation Method	Analytical Method	Compound List	CAS Number	Laboratory Limits	
Ions	EPA 300.0	EPA 300.0	Bromide	24959-67-9	0.25	mg/L
			Bromine	7726-95-6	0.5	mg/L
			Chlorate	14866-68-3	0.5	mg/L
			Chloride	16887-00-6	0.2	mg/L
			Chlorine (soluble)	7782-50-5	0.5	mg/L
			Chlorite	14998-27-7	0.02	mg/L
			Fluoride	16984-48-8	0.1	mg/L
			Ion Balance		NA	--
			Nitrate (as N)	14797-55-8	0.02	mg/L
			Nitrite (as N)	14797-65-0	0.02	mg/L
			Orthophosphate	14265-44-2	0.5	mg/L
			Sulfate	14808-79-8	0.5	mg/L
	EPA 6850	EPA 6850	Perchlorate	14797-73-0	4	µg/L
Metals	EPA 3010M	EPA 6020/6010B	Aluminum	7429-90-5	30	µg/L
			Antimony	7440-36-0	5	µg/L
			Arsenic	7440-38-2	0.95	µg/L
			Barium	7440-39-3	2	µg/L
			Beryllium	7440-41-7	0.5	µg/L
			Boron	7440-42-8	50	µg/L
			Cadmium	7440-43-9	0.5	µg/L
			Calcium	7440-70-2	100	µg/L
			Chromium	7440-47-3	10	µg/L
			Cobalt	7440-48-4	2	µg/L
			Copper	7440-50-8	1	µg/L
			Iron	7439-89-6	50	µg/L
			Lead	7439-92-1	3	µg/L
			Lithium	1313-13-9	50	µg/L
			Magnesium	7439-95-4	50	µg/L
			Manganese	7439-96-5	2	µg/L
			Molybdenum	7439-98-7	5	µg/L
			Nickel	7440-02-0	5	µg/L
			Potassium	7440-09-7	100	µg/L
			Selenium	7782-49-2	5	µg/L
			Silver	7440-22-4	2	µg/L
			Sodium	7440-23-5	50	µg/L
			Strontium	7440-24-6	5	µg/L
			Thallium	7440-28-0	2	µg/L
			Tin	7440-31-5	2	µg/L
			Titanium	7440-32-6	2	µg/L
			Tungsten	7440-33-7	5	µg/L
			Uranium	7440-61-1	1	µg/L
			Vanadium	7440-62-2	10	µg/L
			Zinc	7440-66-6	10	µg/L
	EPA 3060A	EPA 7196A	Chromium (VI)	18540-29-9	10	µg/L
	EPA 7470A	EPA 7470A	Mercury	7439-97-6	0.2	µg/L
Organochlorine Pesticides	EPA 3520C	EPA 8081A	2,4'-DDD	53-19-0	0.05	µg/L
			2,4'-DDE	3424-82-6	0.05	µg/L
			4,4'-DDD	72-54-8	0.05	µg/L
			4,4'-DDE	72-55-9	0.05	µg/L
			4,4'-DDT	50-29-3	0.05	µg/L
			Aldrin	309-00-2	0.05	µg/L
			alpha-BHC	319-84-6	0.05	µg/L
			alpha-Chlordane	5103-71-9	0.05	µg/L
			beta-BHC	319-85-7	0.05	µg/L
			Chlordane	57-74-9	0.5	µg/L
			delta-BHC	319-86-8	0.05	µg/L
			Dieldrin	60-57-1	0.05	µg/L

TABLE
PROPOSED CAMU LONG-TERM GROUNDWATER MONITORING PLAN ANALYTES
CAMU AREA, CLARK COUNTY, NEVADA
(Page 2 of 3)

Parameter of Interest	Preparation Method	Analytical Method	Compound List	CAS Number	Laboratory Limits	
Organochlorine Pesticides (continued)			Endosulfan I	959-98-8	0.05	µg/L
			Endosulfan II	33213-65-9	0.05	µg/L
			Endosulfan sulfate	1031-07-8	0.05	µg/L
			Endrin	72-20-8	0.05	µg/L
			Endrin aldehyde	7421-93-4	0.05	µg/L
			Endrin ketone	53494-70-5	0.05	µg/L
			gamma-BHC (Lindane)	58-89-9	0.05	µg/L
			gamma-Chlordane	5103-74-2	0.05	µg/L
			Heptachlor	76-44-8	0.05	µg/L
			Heptachlor epoxide	1024-57-3	0.05	µg/L
			Methoxychlor	72-43-5	0.1	µg/L
			Toxaphene	8001-35-2	2	µg/L
Polynuclear Aromatic Hydrocarbons	EPA 3510C	EPA 8270SIM	Acenaphthene	83-32-9	5	µg/L
			Acenaphthylene	208-96-8	5	µg/L
			Anthracene	120-12-7	5	µg/L
			Benzo(a)anthracene	56-55-3	5	µg/L
			Benzo(a)pyrene	50-32-8	5	µg/L
			Benzo(b)fluoranthene	205-99-2	5	µg/L
			Benzo(g,h,i)perylene	191-24-2	5	µg/L
			Benzo(k)fluoranthene	207-08-9	5	µg/L
			Chrysene	218-01-9	5	µg/L
			Dibenzo(a,h)anthracene	53-70-3	5	µg/L
			Indeno(1,2,3-cd)pyrene	193-39-5	5	µg/L
			Phenanthrene	85-01-8	5	µg/L
			Pyrene	129-00-0	5	µg/L
Semivolatile Organic Compounds	EPA 3510C	EPA 8270C	1,2,4,5-Tetrachlorobenzene	95-94-3	10	µg/L
			1,2-Diphenylhydrazine	122-66-7	10	µg/L
			1,4-Dioxane	123-91-1	10	µg/L
			2,4,5-Trichlorophenol	95-95-4	10	µg/L
			2,4,6-Trichlorophenol	88-06-2	10	µg/L
			2,4-Dichlorophenol	120-83-2	10	µg/L
			2,4-Dimethylphenol	105-67-9	10	µg/L
			2,4-Dinitrophenol	51-28-5	50	µg/L
			2,4-Dinitrotoluene	121-14-2	10	µg/L
			2,6-Dinitrotoluene	606-20-2	10	µg/L
			2-Chloronaphthalene	91-58-7	10	µg/L
			2-Chlorophenol	95-57-8	10	µg/L
			2-Methylnaphthalene	91-57-6	10	µg/L
			2-Nitroaniline	88-74-4	50	µg/L
			2-Nitrophenol	88-75-5	10	µg/L
			3,3'-Dichlorobenzidine	91-94-1	50	µg/L
			3-Nitroaniline	99-09-2	50	µg/L
			2,2'-Dichlorobenzil	21854-95-5	10	µg/L
			4-Bromophenyl phenyl ether	101-55-3	10	µg/L
			4-Chloro-3-methylphenol	59-50-7	10	µg/L
			4-Chlorophenyl phenyl ether	7005-72-3	10	µg/L
			4-Chlorothioanisole	123-09-1	50	µg/L
			4-Chlorothiophenol	106-54-7	10	µg/L
			4-Nitroaniline	100-01-6	50	µg/L
			4-Nitrophenol	100-02-7	50	µg/L
			Acetophenone	98-86-2	10	µg/L
			Aniline	62-53-3	10	µg/L
			Benzoic acid	65-85-0	50	µg/L
			Benzyl alcohol	100-51-6	10	µg/L
			bis(2-Chloroethoxy)methane	111-91-1	10	µg/L
			bis(2-Chloroethyl) ether	111-44-4	10	µg/L
			bis(2-Chloroisopropyl) ether	108-60-1	10	µg/L
			bis(2-Ethylhexyl) phthalate	117-81-7	10	µg/L

TABLE
PROPOSED CAMU LONG-TERM GROUNDWATER MONITORING PLAN ANALYTES
CAMU AREA, CLARK COUNTY, NEVADA
(Page 3 of 3)

Parameter of Interest	Preparation Method	Analytical Method	Compound List	CAS Number	Laboratory Limits	
Semivolatile Organic Compounds (continued)	EPA 3510C	EPA 8270C	bis(p-Chlorophenyl) sulfone	80-07-9	10	µg/L
			bis(p-Chlorophenyl)disulfide	1142-19-4	10	µg/L
			Butylbenzylphthalate	85-68-7	10	µg/L
			Carbazole	86-74-8	10	µg/L
			Dibenzofuran	132-64-9	10	µg/L
			Diethyl phthalate	84-66-2	10	µg/L
			Dimethyl phthalate	131-11-3	10	µg/L
			Di-n-butyl phthalate	84-74-2	10	µg/L
			Di-n-octyl phthalate	117-84-0	10	µg/L
			Diphenyl disulfide	882-33-7	10	µg/L
			Diphenyl sulfide	139-66-2	10	µg/L
			Diphenyl sulfone	127-63-9	10	µg/L
			Fluoranthene	206-44-0	10	µg/L
			Fluorene	86-73-7	10	µg/L
			Hexachlorobenzene	118-74-1	50	µg/L
			Hexachlorobutadiene	87-68-3	50	µg/L
			Hexachlorocyclopentadiene	77-47-4	50	µg/L
			Hexachloroethane	67-72-1	10	µg/L
			Hydroxymethyl phthalimide	118-29-6	10	µg/L
			Isophorone	78-59-1	10	µg/L
			m,p-Cresol	65794-96-9	20	µg/L
			Naphthalene	91-20-3	10	µg/L
			Nitrobenzene	98-95-3	10	µg/L
			N-nitrosodi-n-propylamine	621-64-7	10	µg/L
			o-Cresol	95-48-7	10	µg/L
			Octachlorostyrene	29082-74-4	10	µg/L
			p-Chloroaniline (4-Chloroaniline)	106-47-8	10	µg/L
			Pentachlorobenzene	608-93-5	10	µg/L
			Pentachlorophenol	87-86-5	50	µg/L
			Phenol	108-95-2	10	µg/L
			Pyridine	110-86-1	20	µg/L
			Thiophenol	108-98-5	10	µg/L
			Tentatively Identified Compounds (TICs)		NA	µg/L
Water Quality Parameters	EPA 130.2	EPA 130.2	Hardness, total	HARD	5	mg/L
	EPA 160.1	EPA 160.1	Total dissolved solids	10-33-3	5	mg/L
	EPA 310.1	EPA 310.1	Alkalinity, Total (as $CACO_3$)	ALKALINITY	5	mg/L
			Bicarbonate alkalinity	ALKB	5	mg/L
			Carbonate alkalinity	ALKC	5	mg/L
			Hydroxide alkalinity	OH-ALK	5	mg/L

Reporting Limits - Based on laboratory limits for primary laboratories (TestAmerica and GEL).
Laboratory limits are subject to matrix interferences and may not always be achieved in all samples.
The laboratory will be instructed to report the top 25 Tentatively Identified Compounds (TICs) under method 8270C.
µg/L = micrograms per liter
mg/L = milligrams per liter
NA = Not applicable

Attachment Z
Final Leachate Monitoring Plan

Basic Remediation Company (BRC)
Corrective Action Management Unit (CAMU)
Henderson, Nevada

Prepared for

Basic Remediation Company
875 West Warm Springs Road
Henderson, NV 89015

FINAL LEACHATE MONITORING PLAN

BASIC REMEDIATION COMPANY
CORRECTIVE ACTION MANAGEMENT UNIT
HENDERSON, NEVADA

Prepared by

Geosyntec consultants

engineers | scientists | innovators
10875 Rancho Bernardo Rd., Suite 200
San Diego, CA 92127

Project Number SC0313

October 2009

Geosyntec consultants

TABLE OF CONTENTS

1. INTRODUCTION 1
   1.1 Terms of Reference 1
   1.2 Purpose 1
   1.3 Responsible parties 1

2. BACKGROUND 3
   2.1 Sump Construction 3

3. MONITORING EQUIPMENT 5
   3.1 Control Panels 5
   3.2 Transducers 5
   3.3 LCRS Sump Pumps 6
   3.4 Vadose Zone Sump Pumps 7

4. LEACHATE MONITORING 8
   4.1 Leachate Depth Monitoring 8
   4.2 Sample Collection 9
      4.2.1 Purge Volume 9
      4.2.2 Analytical Testing 10
   4.3 Leachate Removal 11
   4.4 Leachate Disposal 11
   4.5 Decontamination 11

5. REPORTING 12

6. REFERENCES 14

LIST OF FIGURES

Figure 1: Location of CAMU Sumps

Figure 2: Typical Sump Cross-Section

Figure 3: Phase I Vadose Zone and LCRS Monitoring Measurements

Figure 4: Phase II Vadose Zone and LCRS Monitoring Measurements

Figure 5: Phase IIIB Vadose Zone and LCRS Monitoring Measurements

Figure 6: Phase V Vadose Zone and LCRS Monitoring Measurements

LIST OF TABLES

Table 1 – Leachate Testing Analytes

LIST OF APPENDICES

Appendix A – CAMU Sump Pump Product Information

Appendix B – CAMU Sump Pump O&M Manual

1. INTRODUCTION

1.1 Terms of Reference

This document comprises the Final Leachate Monitoring Plan for the leachate and vadose zone sumps at the Basic Remediation Company (BRC) Corrective Action Management Unit (CAMU).

1.2 Purpose

The purpose of this monitoring plan is to outline the general monitoring procedures and manufacturer information relevant to the leachate monitoring and removal systems. This plan includes procedures for monitoring the integrity of the system, which is comprised of leachate and vadose zone sump pumps, pump controls, and water level transducers.

1.3 Responsible parties

BRC is ultimately responsible for maintaining the integrity of the systems. ENTACT, currently under contract to BRC, is responsible for operating and maintaining the system, troubleshooting the system, and notifying BRC of potential problems during the construction and operation of the CAMU. This Plan shall be amended if conditions and/or responsibilities change.

The following parties are currently involved with the monitoring of the system. NDEP will be notified and this monitoring plan will be revised if BRC changes the involved parties or their roles.

Owner

Basic Remediation Company
875 West Warm Springs Road
Henderson, Nevada 89011
Contact: Lee Farris
Phone: (702) 567-0400
Fax: (702) 567-0475

Monitoring Contractor ENTACT 3030 Tara Murphy Drive Henderson, Nevada 89044 Contact: Erik Gehringer Phone: (561) 707-7088
Environmental Consultant Geotechnical and Environmental Services, Inc 7150 Placid Street Las Vegas, Nevada, 89119 Contact: Richard A. Cooke Phone: (702) 365-1001

2. BACKGROUND

The BRC CAMU is an approximately 52-acre composite lined landfill currently being constructed in 6 phases concurrently with the BMI Common Areas Remediation Project. The CAMU is designed with storage capacity for approximately 3.4 million cubic yards (MCY) of soil and sludge waste received from the Eastside Area, Western Ditch, and Slit Trenches. The CAMU has been designed as a "dry landfill," meaning that the waste to be placed in the CAMU will not generate leachate. This was demonstrated in the Waste Processing and Placement Plan (WPPP) (Geosyntec 2008). The WPPP has established, through laboratory and field testing, minimum placement requirements for the material such that leachate will not be generated from the waste materials being placed in the CAMU.

Following rain events in February 2009, leachate was discovered in the Phase I and II LCRS sumps and liquid was detected in the Phase I vadose zone sump. The Phase II vadose zone sump did not have any detectable liquid present. Nevada Division of Environmental Protection (NDEP) has requested a Leachate Management Plan as a result of the discovery of leachate in the leachate collection and recovery system (LCRS) sump in Phases I and II and vadose zone monitoring sump in Phase I.

At the time of this Plan completion, Phase I, II, and IIIB sumps have been constructed. This report will be amended following construction of the Phase V sumps. The locations of the sumps are shown in Figure 1.

2.1 Sump Construction

Four LCRS sumps with underlying vadose zone monitoring sumps are designed for the BRC CAMU in Phases I, II, IIIB, and V. The LCRS sumps have bottom dimensions of 10 feet (ft) wide (W) by 10 ft long (L) by 2 ft deep (D) with 2:1 horizontal to vertical (H:V) side slopes (Figure 2). The underlying vadose zone sump is 4 ft W by 4 ft L at the bottom of the sump by 1.5 ft D with 2:1 H:V side slopes (Figure 2).

The sumps are constructed, from bottom to top, with the following components:

- Geosynthetic clay liner, CETCO Bentomat DN®;
- 60 mil Agru Microspike™ High Density Polyethylene (HDPE) Geomembrane;
- SKAPS 240 mil Geocomposite;
- 1.5 ft Drainage Aggregate;
- Geosynthetic clay liner, CETCO Bentomat DN®;

- 60 mil Agru Microspike™ HDPE Geomembrane;
- SKAPS 240 mil Geocomposite;
- 2 ft Drainage Aggregate; and
- Filtration Geotextile.

The sumps are accessed by a 12 inch (in.) diameter HDPE pipe and an 18 in. diameter HDPE pipe for the vadose zone and LCRS sump, respectively. The pipe layouts for Phases I through IIIB vadose zone and LCRS sumps are shown on Figures 3 through 5. The pipe layout for Phase V will be included following construction of the sumps.

3. MONITORING EQUIPMENT

The sumps are equipped with a transducer, leachate pump, and associated control equipment. Manufacturer's information is provided in Appendix A.

3.1 Control Panels

The LCRS and vadose zone pump and level sensor control panels are EPG Model No. L975PTG. Each control panel will operate each pump independently via generator supplied power. The control panel includes simulators, 2 flow meters, pump call light, voltage monitor and disconnect for 12 volt DC battery backup and 12 volt DC terminals. The enclosure is NEMA 4 rated.

3.2 Transducers

Each LCRS and vadose zone sump contains an EPG LevelMaster™ pressure transducer calibrated to measure the depth of liquid in each sump. The pressure transducers are installed in each sump with the sump pumps; however, they can monitor the depth of liquid in the sumps without the pump present.

The transducers are suspended by polyurethane jacketed shielded cable with a polyethylene vent tube and Kevlar tension members. The cable has self-healing properties; in the event of damage to the cable, the water block feature just inside the jacket will self-seal. The depth reading of the transducer is accurate from 0 to 138.4 inches (0 – 5 pounds per square inch [psi]) with built-in temperature compensation.

3.3 LCRS Sump Pumps

The following table presents the pump information for each LCRS sump.

Phase	Model	Motor	Motor Lead	Level Sensor Lead	Suspension Cable
I	WSDPT5-3, EPG SurePump	¾ HP 230 VAC 1 phase	14 AWG Jacketed (110 ft)	(110 ft)	1/8 inch cable with clamps (110 ft)
II	WSDPT5-3, EPG SurePump	¾ HP 230 VAC 1 phase	14 AWG Jacketed (120 ft)	(120 ft)	1/8 inch cable with clamps (120 ft)
IIIB	WSDPT5-3, EPG SurePump	¾ HP 230 VAC 1 phase	14 AWG Jacketed (70 ft)	(70 ft)	1/8 inch cable with clamps (70 ft)
V	WSDPT5-3, EPG SurePump	¾ HP 230 VAC 1 phase	14 AWG Jacketed (70 ft)	(70 ft)	1/8 inch cable with clamps (70 ft)

3.4 Vadose Zone Sump Pumps

The following table presents the pump information for each vadose zone sump.

Phase	Model	Motor	Motor Lead	Level Sensor Lead	Suspension Cable
I	WSDPT2-3, EPG SurePump	½ HP 230 VAC 1 phase	14 AWG Jacketed (110 ft)	(110 ft)	1/8 inch cable with clamps (110 ft)
II	WSDPT2-3, EPG SurePump	½ HP 230 VAC 1 phase	14 AWG Jacketed (120 ft)	(120 ft)	1/8 inch cable with clamps (120 ft)
IIIB	WSDPT2-3, EPG SurePump	½ HP 230 VAC 1 phase	14 AWG Jacketed (70 ft)	(70 ft)	1/8 inch cable with clamps (70 ft)
V	WSDPT2-3, EPG SurePump	½ HP 230 VAC 1 phase	14 AWG Jacketed (70 ft)	(70 ft)	1/8 inch cable with clamps (70 ft)

4. LEACHATE MONITORING

4.1 Leachate Depth Monitoring

Leachate depth monitoring in both the LCRS and vadose zone sumps will be performed by the Monitoring Contractor listed in Section 1. Monitoring will be conducted as follows:

LCRS Sumps

Monitoring Frequency	LCRS Leachate Accumulation Rate (gpd)
Daily	>480
Every other day	320 – 480
Twice weekly	135 – 320
Weekly	30 – 135
Monthly	0 – 30
Quarterly	0

Vadose Zone Sumps

Monitoring Frequency	Vadose Zone Leachate Accumulation Rate (gpd)
Daily	>90
Every other day	60 – 90
Twice weekly	25 – 60
Weekly	5 – 25
Monthly	0 – 5
Quarterly	0

Upon completion of three years of quarterly monitoring with results of 0 gpd, monitoring will be reduced to annual.

Following 0.25-inch storm events, prior to cell closure, monitoring during quarterly and annual monitoring events will be conducted daily for 3 consecutive days after the event. If monitoring indicates a rise in leachate generation, monitoring will continue per frequency specified previously. For example, monthly while greater than 0 gpd and less than 30 gpd, weekly while greater than 30 gpd and less than 135 gpd, etc. If monitoring

indicates no rise in leachate generation, monitoring will return to the previous quarterly or annual monitoring.

Monitoring will be performed by recording the depth indicated by the transducer on the digital read out screen for each sump. The depth of the leachate will be recorded prior to and after leachate removal from each sump pumped.

4.2 Sample Collection

Following leachate depth monitoring, and before commencement of any pumping, liquid sample collection will be performed under the following conditions:

- Both the LCRS and vadose zone monitoring sumps will be sampled if transducers indicate liquid in the vadose zone monitoring sump not previously present;
- Both the LCRS and vadose zone monitoring sumps will be sampled if liquid levels in the vadose zone sump increase in depth by 1 inch or more from the previous monitoring event; and/or
- The LCRS sump will be sampled monthly, if sufficient liquids are present to collect a sample, while LCRS monitoring is daily, weekly, or monthly. The LCRS sump will be sampled during each monitoring event, if sufficient liquids are present to collect a sample, while LCRS monitoring is quarterly or annually.

If no change or decreasing liquid levels are recorded, no additional samples will be collected from the LCRS or vadose zone sumps. All samples will be collected from the respective sample port located at the top of the sump riser pipe.

If sample collection is required, the Monitoring Contractor will alert BRC. BRC will be responsible for coordinating sample collection with the Environmental Consultant. Sample collection will be performed by the Environmental Consultant listed in Section 1.

4.2.1 Purge Volume

Prior to sample collection, if liquid was previously pumped from the sump, the remaining liquid in the discharge piping will be purged. A sample will be collected after the following minimum volumes are removed from the pipes:

Sump	Volume (gallons)
Phase I Vadose	3.24
Phase I LCRS	7.5
Phase II Vadose	3.63
Phase II LCRS	8.4
Phase IIIB Vadose	1.66
Phase IIIB LCRS	3.8

If the volume of leachate or liquid required for sample collection is unavailable following the pipe purge, samples will not be collected.

4.2.2 Analytical Testing

The following analyses will be conducted on the leachate samples:

1. Metals by EPA Method 6010B;
2. Total Dissolved Solids by 2540C;
3. Volatile Organic Compounds by EPA 8260B;
4. Pesticides by EPA 8081A; and
5. Other analytes as requested by NDEP. It is noted that NDEP must provide sufficient advance notice to allow GES to acquire the proper sample containers.

Specific analytes are included in Table 1. Samples will be sent to a laboratory certified by the State of Nevada for analyses under chain-of-custody procedures. Results of analytical testing will be provided to NDEP during routine reporting as specified in Section 5.

4.3 Leachate Removal

Following leachate sample collection, if applicable, the leachate removal from the LCRS sumps will be required if depth is recorded at greater than 36-inches. The vadose zone sump will be pumped if the depth is recorded at greater than 8-inches. NDEP will be notified when the depth is recorded at greater than 36-inches in the LCRS sump.

Leachate will be removed by connecting permanent pumps to the generator provided by the Monitoring Contractor. Pump will be activated manually and will automatically stop pumping when liquid levels fall to 8 inches. The pumped volume (gallons) of leachate will be recorded for each sump based on the pumped volume indicated by the respective inline flow meter.

4.4 Leachate Disposal

During continued CAMU construction and operation, leachate will be disposed of in accordance with the Monitoring Contractor's Water Management Plan and the Technical Specifications. Following CAMU closure, leachate will be disposed of off-site in an appropriately permitted facility.

4.5 Decontamination

All equipment placed within the LCRS and/or vadose zone monitoring side slope riser pipes and sumps shall be decontaminated before placement and after removal. The equipment will be washed in water with a non-phosphate detergent, rinsed with potable water, followed by a final rinse with distilled water.

5. REPORTING

During each monitoring event, the Monitoring Contractor will document the following:

- level of leachate in each sump before and after any required pumping;
- document if samples are collected; and
- record the volume of leachate pumped from each sump.

The Monitoring Contractor will provide BRC with monitoring documentation no later than 1 day following the monitoring event via a cumulative spreadsheet that documents all historical monitoring performed.

The Environmental Consultant will provide BRC with the sample collection field forms, chain-of-custody, and analytical data. Sample collection field forms shall include the following at a minimum:

- weather;
- date/time;
- leachate depth before sample collection;
- purge volume; and
- name of field personnel.

NDEP reporting will be dependent on monitoring frequency. NDEP reporting will occur as follows:

Reporting Frequency	Monitoring Frequency	LCRS Leachate Accumulation Rate (gpd)
Weekly[1]	Daily	>480
Monthly	Every other day	320 – 480
Monthly	Twice weekly	135 – 320
Monthly	Weekly	30 – 135
Monthly	Monthly	0 – 30
Quarterly	Quarterly	0
Annually	Annually	0

Note: 1 – Weekly reporting will be conducted by summary email containing, at a minimum, leachate depths, historical leachate depths, volume(s) of leachate removed,

and total leachate removed. A monthly report will be provided which will include the weekly report information and a summary table of current and past analytical testing and laboratory results of current analytical testing.

If liquid is detected in a previously dry vadose zone sump, NDEP will be notified within one day of the detection. Following the initial notification, vadose zone monitoring reporting will be as follows:

Reporting Frequency	**Monitoring Frequency**	**Vadose Zone Leachate Accumulation Rate (gpd)**
Weekly	Daily	>90
Weekly	Every other day	60 – 90
Weekly	Twice weekly	25 – 60
Weekly	Weekly	5 – 25
Monthly	Monthly	0 – 5
Quarterly	Quarterly	0
Annually	Annually	0

NDEP reporting will include a summary of the monitoring event(s) that occurred since the previous report. The summary will include, at a minimum, leachate depths, historical leachate depths, volume(s) of leachate removed, total leachate removed, a summary table of current and past analytical testing, and laboratory results of current analytical testing.

Samples will have expedited, or “rush” turnaround times, as necessary, so analytical reports are included in the report.

6. REFERENCES

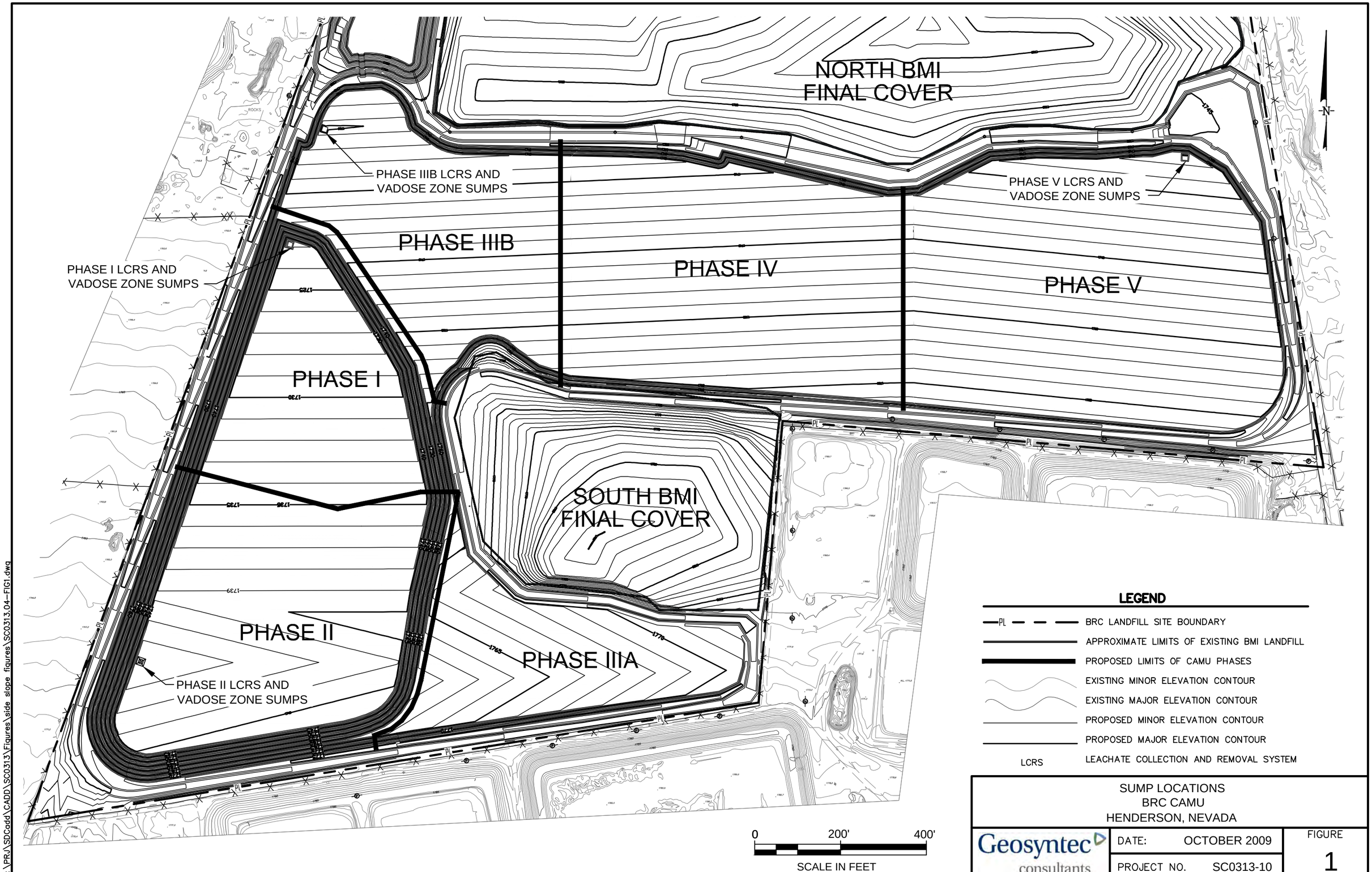
Geosyntec, 2008, Waste Placement and Processing Plan, October.

TABLES

Table 1
Leachate Testing Analytes
BRC CAMU
Henderson, Nevada

Volatile Organic Compounds	**Pesticides**
1,1,1,2-Tetrachloroethane	4,4´-DDD
1,1,1-Trichloroethane	4,4´-DDE
1,1,2,2-Tetrachloroethane	4,4´-DDT
1,1,2-Trichloroethane	Aldrin
1,1-Dichloroethane	alpha-BHC
1,1-Dichloroethene	beta-BHC
1,1-Dichloropropene	Chlordane (Technical)
1,2,3-Trichlorobenzene	delta-BHC
1,2,3-Trichloropropane	Dieldrin
1,2,4-Trichlorobenzene	Endosulfan I
1,2,4-Trimethylbenzene	Endosulfan II
1,2-Dibromo-3-chloropropane (DBCP)	Endosulfan sulfate
1,2-Dibromoethane (EDB)	Endrin
1,2-Dichlorobenzene	Endrin aldehyde
1,2-Dichloroethane	gamma-BHC (Lindane)
1,2-Dichloropropane	Heptachlor
1,3,5-Trimethylbenzene	Heptachlor epoxide
1,3-Dichlorobenzene	Methoxychlor
1,3-Dichloropropane	Mirex
1,4-Dichlorobenzene	Toxaphene
2,2-Dichloropropane	**Metals**
2-Chlorotoluene	Antimony (Sb)
4-Chlorotoluene	Arsenic (As)
4-Isopropyltoluene	Barium (Ba)
Benzene	Beryllium (Be)
Bromobenzene	Cadmium (Cd)
Bromochloromethane	Chromium (Cr)
Bromodichloromethane	Cobalt (Co)
Bromoform	Copper (Cu)
Bromomethane	Lead (Pb)
Carbon tetrachloride	Mercury (Hg)
Chlorobenzene	Molybdenum (Mo)
Chloroethane	Nickel (Ni)
Chloroform	Selenium (Se)
Chloromethane	Silver (Ag)
cis-1,2-Dichloroethene	Thallium (Tl)
cis-1,3-Dichloropropene	Vanadium (V)
Dibromochloromethane	Zinc (Zn)
Dibromomethane	**Total Dissolved Solids**
Dichlorodifluoromethane	Solids, Total Dissolved (TDS)
Dichloromethane	
Ethylbenzene	
Hexachlorobutadiene	
Isopropylbenzene	
m,p-Xylene	
Methyl tert-butyl ether (MTBE)	
Naphthalene	
n-Butylbenzene	
n-Propylbenzene	
o-Xylene	
sec-Butylbenzene	
Styrene	
tert-Butylbenzene	
Tetrachloroethene	
Toluene	
trans-1,2-Dichloroethene	
trans-1,3-Dichloropropene	
Trichloroethene	
Trichlorofluoromethane	
Vinyl chloride	

FIGURES

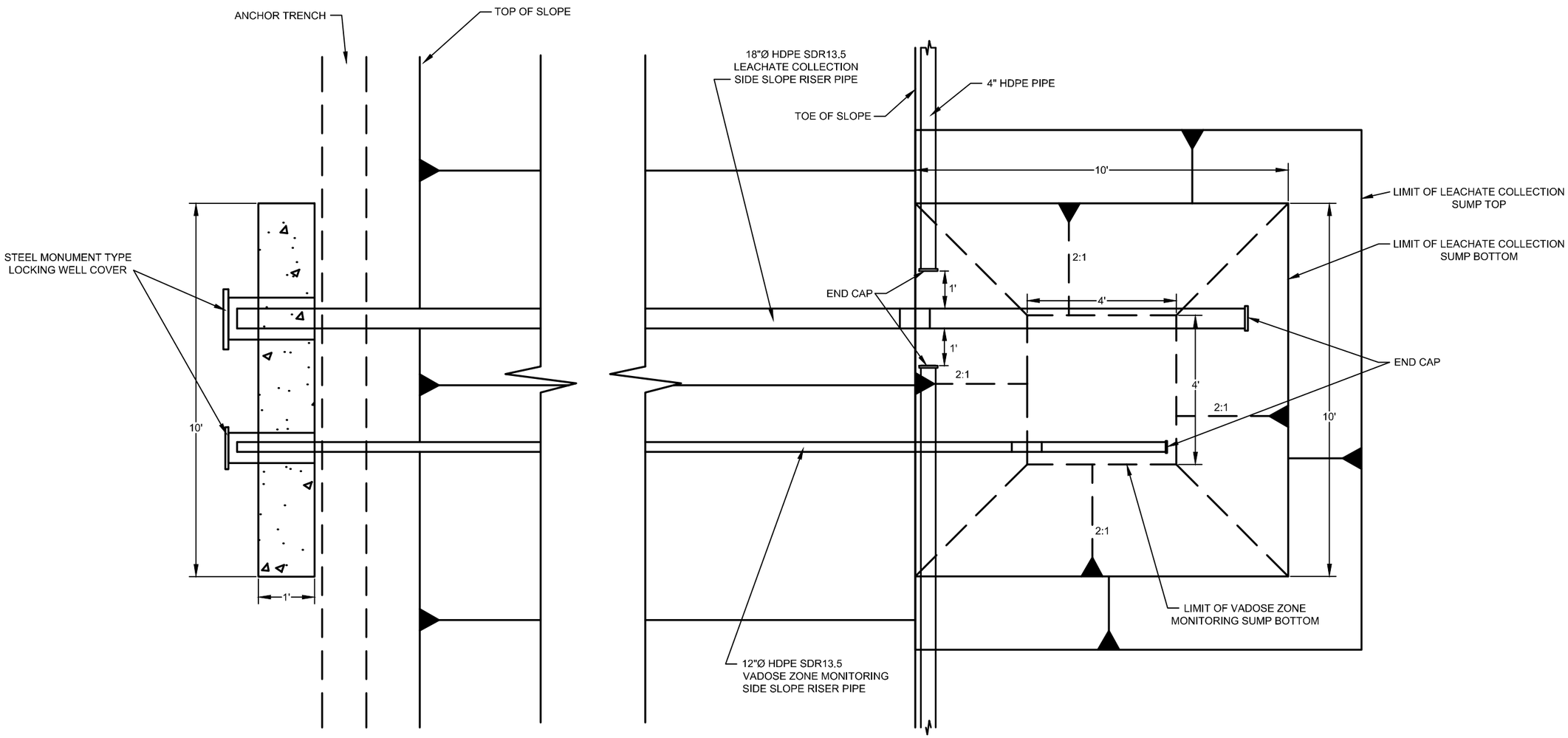


SUMP LOCATIONS
BRC CAMU
HENDERSON, NEVADA

Geosyntec consultants

DATE:	OCTOBER 2009	FIGURE
PROJECT NO.	SC0313-10	1

P:\PRJ\SDCadd\CADD\SC0313\Figures\side slope figures\SC0313.04-FIG1.dwg



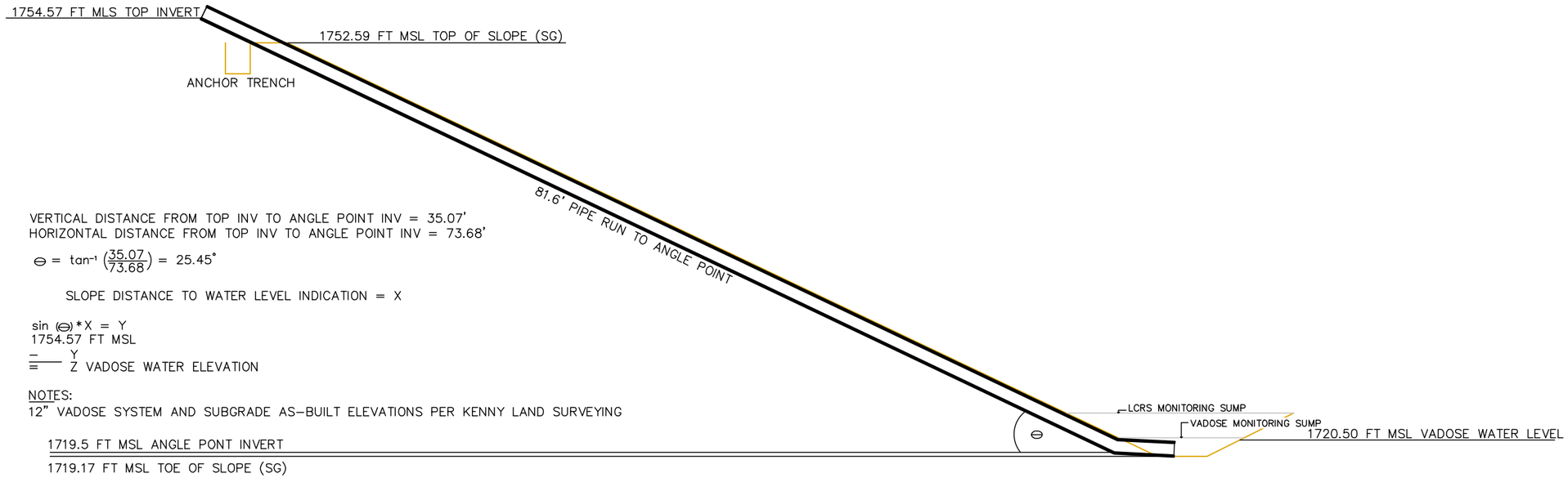
PLAN VIEW

SCALE: 1" = 3'

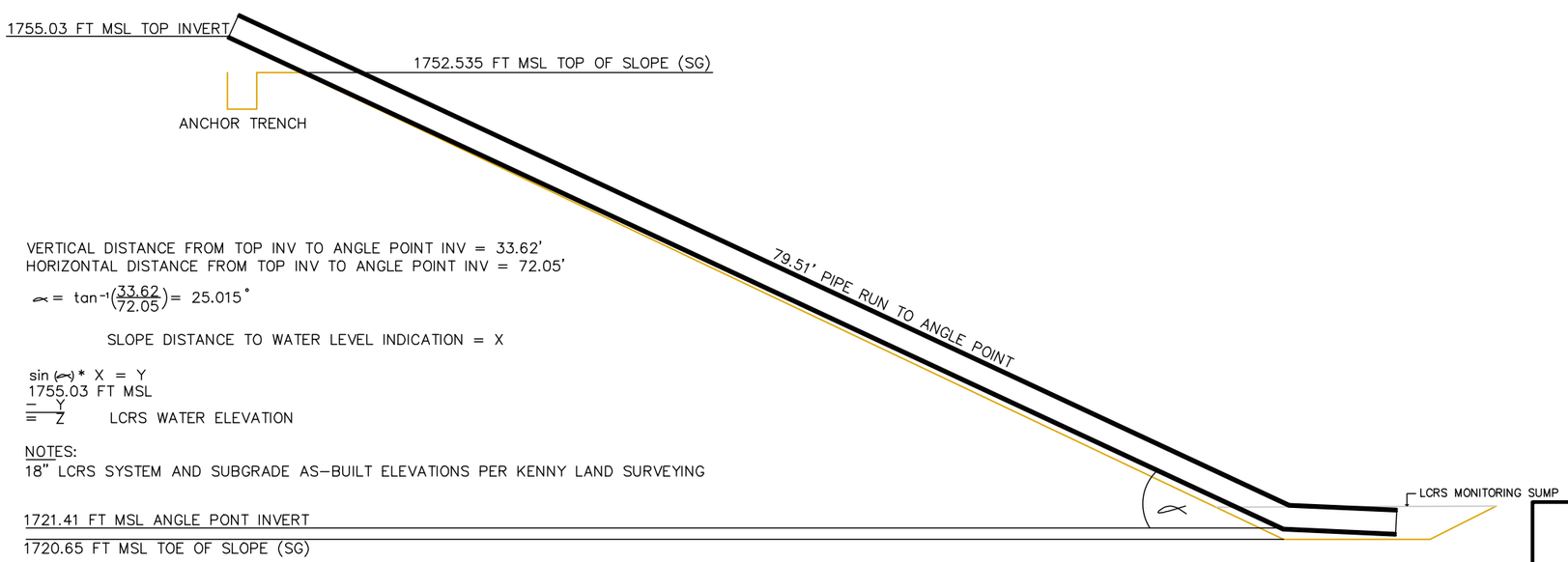
TYPICAL LEACHATE COLLECTION AND VADOSE ZONE SUMP
BRC CAMU
HENDERSON, NEVADA

Geosyntec consultants	DATE: OCTOBER 2009	FIGURE
	PROJECT NO. SC0313-10	2

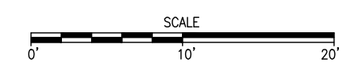
P:\PRJ\SDCadd\CADD\SC0313\Figures\side slope figures\SC0313.04-FIG2.dwg



PHASE I 12" VADOSE MONITORING SIDE SLOPE RISER



PHASE I 18" LCRS MONITORING SIDE SLOPE RISER



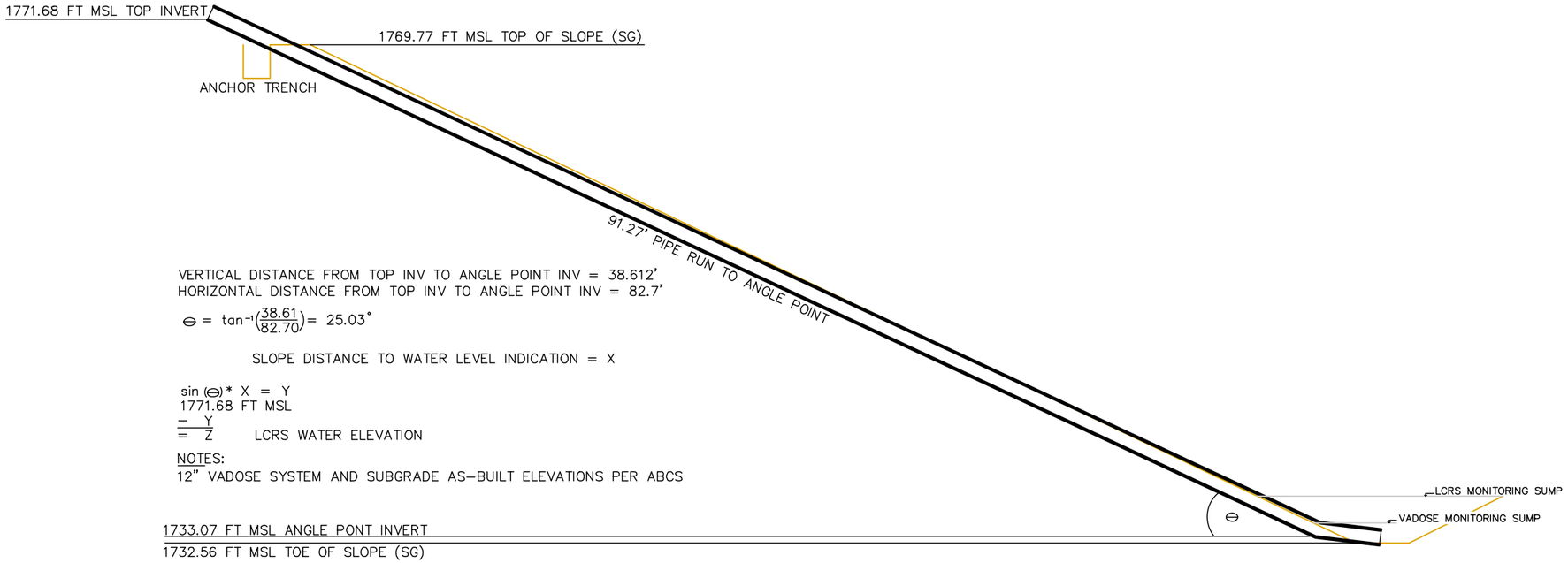
NOTES:
1. CROSS-SECTION DETAILS PROVIDED BY ENTACT.
2. FT MSL: FEET MEAN SEA LEVEL

PHASE I SIDE SLOPE RISER DETAILS
BRC CAMU
HENDERSON, NEVADA

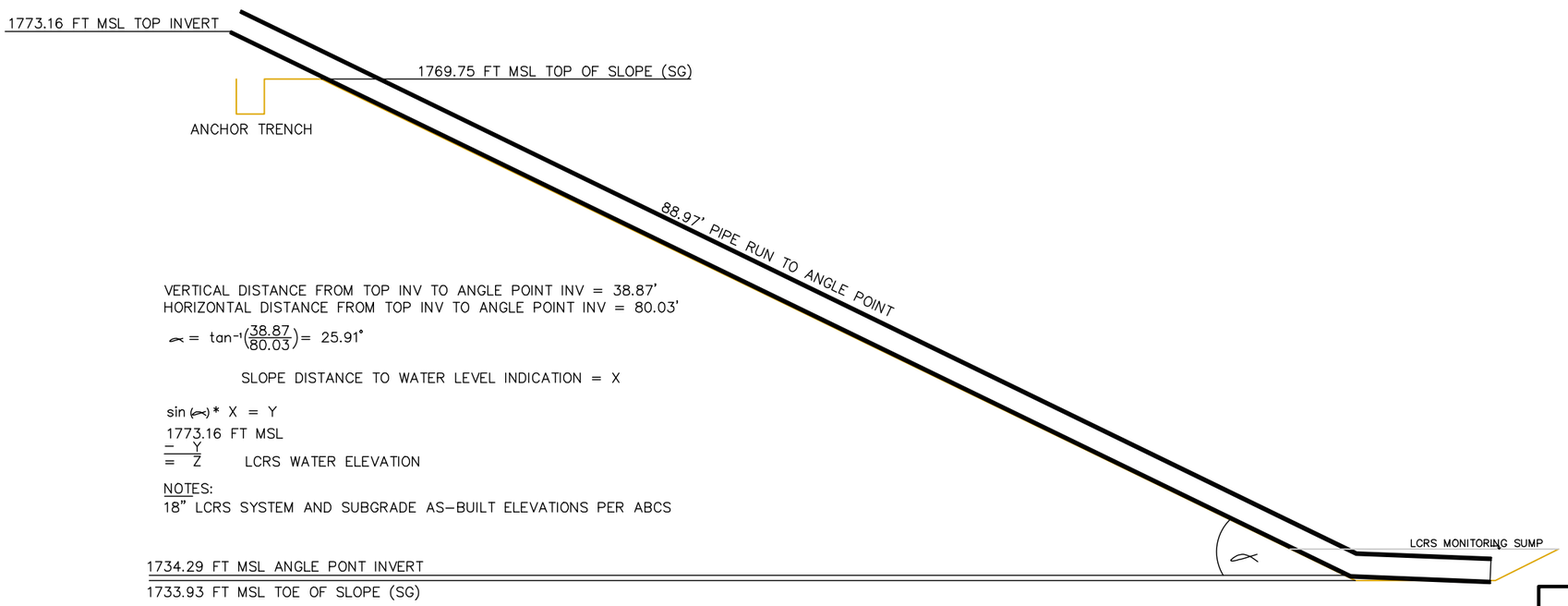
Geosyntec consultants

DATE:	OCTOBER 2009	FIGURE
PROJECT NO.	SC0313-10	3

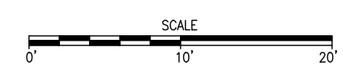
P:\PRJ\SDCadd\CADD\SC0313\Figures\side slope figures\SC0313.04-FIG3-4.dwg



PHASE II 12" VADOSE MONITORING SIDE SLOPE RISER



PHASE II 18" LCRS MONITORING SIDE SLOPE RISER



NOTES:
1. CROSS-SECTION DETAILS PROVIDED BY ENTACT.
2. FT MSL: FEET MEAN SEA LEVEL

PHASE II SIDE SLOPE RISER DETAILS
BRC CAMU
HENDERSON, NEVADA

Geosyntec consultants

DATE:	OCTOBER 2009	FIGURE
PROJECT NO.	SC0313-10	4

P:\PRJ\SDCadd\CADD\SC0313\Figures\side slope figures\SC0313.04-FIG3-4.dwg

VERTICAL DISTANCE FROM TOP INV TO ANGLE POINT INV = 38.61'
HORIZONTAL DISTANCE FROM TOP INV TO ANGLE POINT INV = 82.70'

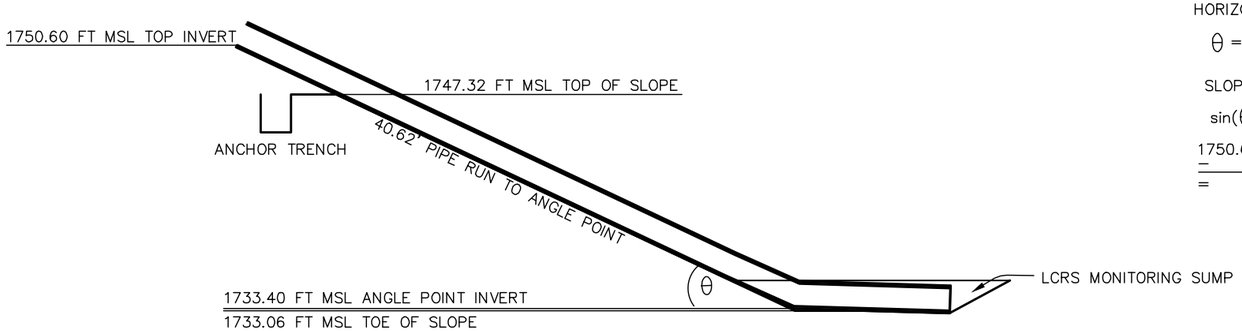
VERTICAL DISTANCE FROM TOP INV TO ANGLE POINT INV = 17.20'
HORIZONTAL DISTANCE FROM TOP INV TO ANGLE POINT INV = 36.80'

$$\theta = \tan^{-1}\left(\frac{17.20'}{36.80'}\right) = 25.05^\circ$$

SLOPE DISTANCE TO WATER LEVEL INDICATION = X

$\sin(\theta) * X = Y$

1750.60 FT MSL
− Y
= Z PIPE WATER ELEVATION



PHASE IIIB 18" LCRS MONITORING SIDE SLOPE RISER

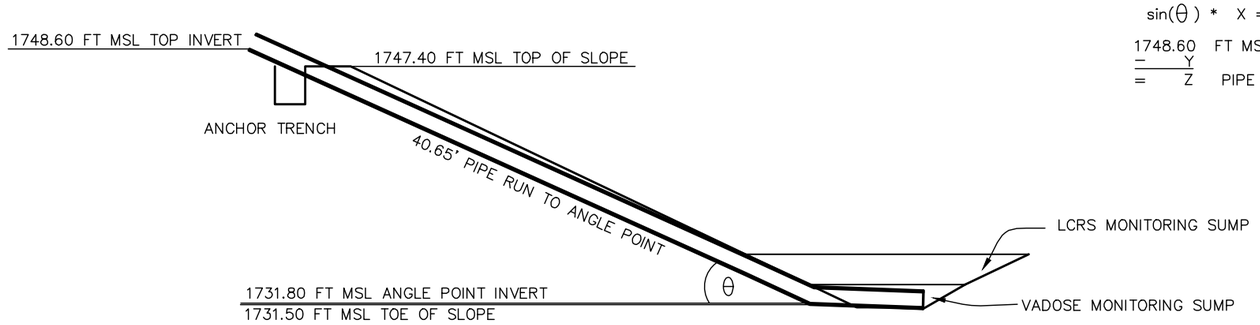
VERTICAL DISTANCE FROM TOP INV TO ANGLE POINT INV = 16.80'
HORIZONTAL DISTANCE FROM TOP INV TO ANGLE POINT INV = 37.05'

$$\theta = \tan^{-1}\left(\frac{16.80'}{37.05'}\right) = 24.39^\circ$$

SLOPE DISTANCE TO WATER LEVEL INDICATION = X

$\sin(\theta) * X = Y$

1748.60 FT MSL
− Y
= Z PIPE WATER ELEVATION



PHASE IIIB 12" VADOSE MONITORING SIDE SLOPE RISER

NOTES:
1. CROSS-SECTION DETAILS PROVIDED BY ENTACT.
2. FT MSL: FEET MEAN SEA LEVEL

PHASE IIIB SIDE SLOPE RISER DETAILS
BRC CAMU
HNEDERSON, NEVADA

Geosyntec consultants

DATE:	OCTOBER 2009	FIGURE
PROJECT NO.	SC0313-10	5

P:\PRJ\SDCadd\CADD\SC0313\Figures\side slope figures\SC0313.04-FIG5.dwg

VERTICAL DISTANCE FROM TOP INV TO ANGLE POINT INV = 16.1666'
HORIZONTAL DISTANCE FROM TOP INV TO ANGLE POINT INV = 35.3151'

$$\theta = \tan^{-1}\left(\frac{16.1666'}{35.3151'}\right) = 24.597^{\circ}$$

SLOPE DISTANCE TO WATER LEVEL INDICATION = X

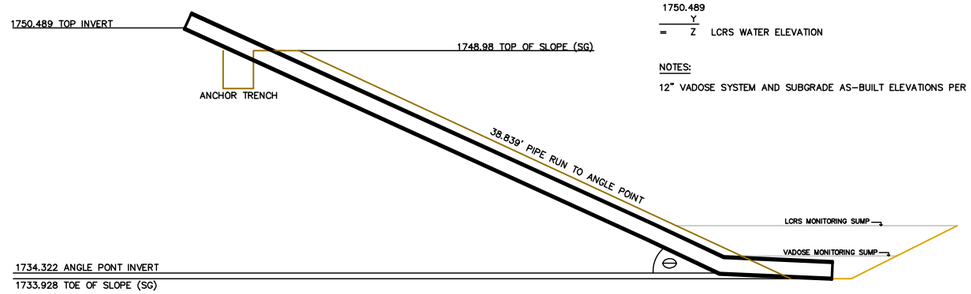
$$\sin(\theta) * X = Y$$

1750.489

$$\frac{Y}{= \quad Z}$$ LCRS WATER ELEVATION

NOTES:

12" VADOSE SYSTEM AND SUBGRADE AS-BUILT ELEVATIONS PER ABCS



PHASE V 12" VADOSE MONITORING SIDE SLOPE RISER

VERTICAL DISTANCE FROM TOP INV TO ANGLE POINT INV = 16.6017'
HORIZONTAL DISTANCE FROM TOP INV TO ANGLE POINT INV = 36.0025'

$$\alpha = \tan^{-1}\left(\frac{16.6017'}{36.0025}\right) = 24.756^{\circ}$$

SLOPE DISTANCE TO WATER LEVEL INDICATION = X

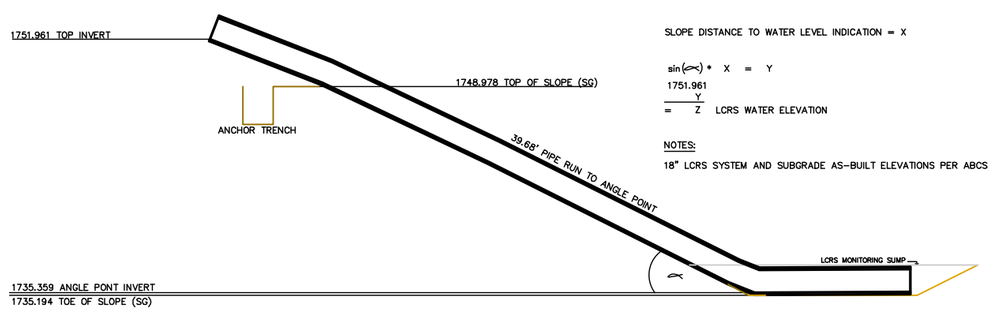
$$\sin(\alpha) * X = Y$$

1751.961

$$\frac{Y}{= \quad Z}$$ LCRS WATER ELEVATION

NOTES:

18" LCRS SYSTEM AND SUBGRADE AS-BUILT ELEVATIONS PER ABCS



PHASE V 18" LCRS MONITORING SIDE SLOPE RISER

SCALE
0' 10' 20'

NOTES:
1. CROSS-SECTION DETAILS PROVIDED BY ENTACT.
2. FT MSL: FEET MEAN SEA LEVEL

PHASE I SIDE SLOPE RISER DETAILS
BRC CAMU
HENDERSON, NEVADA

Geosyntec consultants

DATE:	OCTOBER 2009	FIGURE
PROJECT NO.	SC0313-10	6

P:\PRJ\SDCadd\CADD\SC0313\Figures\side slope figures\SC0313.04-FIG6.dwg

APPENDIX A

EPG Companies Inc.

SUBMITTAL

FOR

Entact Environmental Services, Inc. Henderson, NV

X No Exception Taken
__ Revise And Resubmit
__ Correct As Noted
__ Submit Specified Item
__ Rejected

The review of these drawings is for general conformance with the design concept and contract documents. Markings or comments shall not be constructed as relieving the contractor from compliance with the project plans and specifications nor departures therefrom, nor shall they relieve the contractor from responsibility for all quantities and dimensions, for selecting fabrication processes, for techniques of assembly, and for performing the work in a safe manner.

Checked By [signature] Date 5/27/09
BRC Initials LCF

BASIC REMEDIATION COMPANY

EPG Job #09-9356

Submittal Index

Entact Environmental Services, Inc. – Henderson, NV

Job #09-9356

Bulletin	1055	Equipment List
Drawing	05773-0000	Series 5 SurePump™
Drawing	05773-0010	Series 5 Size 4 Sump Drainer
Bulletin	0335g	Engineer's Specification EPG WSDPT SurePump™ Wheeled Sump Drainer for side slope riser installations with built-in level sensor
Bulletin	0335g	Engineer's Specification EPG WSDPT SurePump™ Wheeled Sump Drainer for side slope riser installations with built-in level sensor
Bulletin	0335g	Engineer's Specification EPG WSDPT SurePump™ Wheeled Sump Drainer for side slope riser installations with built-in level sensor
Drawing	05771-0000	Series 2 SurePump™
Drawing	05771-0010	Series 2 Size 4 Sump Drainer
Bulletin	0335g	Engineer's Specification EPG WSDPT SurePump™ Wheeled Sump Drainer for side slope riser installations with built-in level sensor
Bulletin	0335g	Engineer's Specification EPG WSDPT SurePump™ Wheeled Sump Drainer for side slope riser installations with built-in level sensor
Bulletin	0335g	Engineer's Specification EPG WSDPT SurePump™ Wheeled Sump Drainer for side slope riser installations with built-in level sensor
Bulletin	0480e	Materials of Construction
Drawing	08373-0250	L975PTG Control Panel Schematics
Bulletin	0121c	Engineer's Specification EPG LevelMaster™ Submersible Level Sensor
Drawing	02523-0605	BJBL600B Breakout Junction Box for Level Sensor
Drawing	03626-0500	BJBP500 Breakout Junction Box for Motor Lead
Bulletin	1010c	Sensor Data Sheet E-Series Liquid Flow Sensor
Bulletin	0170d	Flow Meter Operations
Bulletin	1005	Caution
Drawing	05392-0000C	PVC Flow Spool 1 ½" MNPT Ends
Drawing	07761-0000C	1" PVC SCH 40 Flow Spool with 1" MNPT Ends
Bulletin	0200c	Limited Warranty
Form	127a	Submittal Acceptance Form

© 2009 EPG Companies Inc.

EPG Companies Inc.

List of Equipment

Entact Environmental Services, Inc. – Henderson, NV

EPG Job # 09-9356

Phase 1 Control Panel and Pumps

1 each L975PTG

PumpMaster control panel to operate (1)ea. 1/2 HP 230 VAC 1 phase motor and (1)ea. 3/4 HP 230 VAC 1 phase motor independently via generator supplied power. Includes LevelMaster level control meters with simulators, 2 ea. flow meters, pump call light, voltage monitor and disconnect for 12 volt DC battery backup, includes 12 Volt DC terminals. Enclosure is rated NEMA 4.

Note: Panel logic- 12 volt DC level meters call for either pump, operator turns on site supplied generator, pump called will run, flow meters will register.
Note: Site will need to supply marine batteries, battery boxes, cables and hardwire to control panel.

LCRS Pump

1 each WSDPT5-3

EPG SurePump patented, wheeled, stainless steel sump drainer with a 3/4 HP 230 VAC 1 phase motor. Includes 110' of 14 AWG jacketed motor lead, submersible level sensor with 110' lead, and a 110' length of 1/8" cable with clamps.

Vadose Pump

1 each WSDPT2-3

EPG SurePump patented, wheeled, stainless steel # 4 sump drainer with a 1/2 HP 230 VAC 1 phase motor. Includes 110' of 14 AWG jacketed motor lead, submersible level sensor with 110' lead, and a 110' length of 1/8" stainless steel suspension cable with clamps.

Phase 2 Control Panel and Pumps

1 each L975PTG

PumpMaster control panel to operate (1)ea. 1/2 HP 230 VAC 1 phase motor and (1)ea. 3/4 HP 230 VAC 1 phase motor independently via generator supplied power. Includes LevelMaster level control meters with simulators, 2 ea. flow meters, pump call light, voltage monitor and disconnect for 12 volt DC battery backup, includes 12 Volt DC terminals. Enclosure is rated NEMA 4.

Note: Panel logic- 12 volt DC level meters call for either pump, operator turns on site supplied generator, pump called will run, flow meters will register.
Note: Site will need to supply marine batteries, battery boxes, cables and hardwire to control panel.

© EPG Companies Inc. 2009

LCRS Pump

1 each WSDPT5-3

EPG SurePump patented, wheeled, stainless steel sump drainer with a 3/4 HP 230 VAC 1 phase motor. Includes 120' of 14 AWG jacketed motor lead, submersible level sensor with 120' lead, and a 120' length of 1/8" cable with clamps.

Vadose Pump

1 each WSDPT2-3

EPG SurePump patented, wheeled, stainless steel # 4 sump drainer with a 1/2 HP 230 VAC 1 phase motor. Includes 120' of 14 AWG jacketed motor lead, submersible level sensor with 120' lead, and a 120' length of 1/8" stainless steel suspension cable with clamps.

Phase 3 Control Panels and Pumps

2 each L975PTG

PumpMaster control panel to operate (1)ea. 1/2 HP 230 VAC 1 phase motor and (1)ea. 3/4 HP 230 VAC 1 phase motor independently via generator supplied power. Includes LevelMaster level control meters with simulators, 2 ea. flow meters, pump call light, voltage monitor and disconnect for 12 volt DC battery backup, includes 12 Volt DC terminals. Enclosure is rated NEMA 4.

Note: Panel logic- 12 volt DC level meters call for either pump, operator turns on site supplied generator, pump called will run, flow meters will register.
Note: Site will need to supply marine batteries, battery boxes, cables and hardwire to control panel.

LCRS Pumps

2 each WSDPT5-3

EPG SurePump patented, wheeled, stainless steel sump drainer with a 3/4 HP 230 VAC 1 phase motor. Includes 70' of 14 AWG jacketed motor lead, submersible level sensor with 70' lead, and a 70' length of 1/8" cable with clamps.

Vadose Pumps

2 each WSDPT2-3

EPG SurePump patented, wheeled, stainless steel # 4 sump drainer with a 1/2 HP 230 VAC 1 phase motor. Includes 70' of 14 AWG jacketed motor lead, submersible level sensor with 70' lead, and a 70' length of 1/8" stainless steel suspension cable with clamps.

 © EPG Companies Inc. 2009

Junction Boxes Power and Sensor

8 each BJBL600B
EPG Breakout Box, NEMA 4X non-metallic enclosure, junction box for 1 ea. level sensor. Includes desiccant dryer, bellows, and connection terminals.

8 each BJBP500
EPG Breakout Box, NEMA 4X non-metallic enclosure for 1 ea. motor lead, includes connection terminals.

4 each EP15P04M15M15S
EPG Paddlewheel Flow Sensor, 1.5", PVC schedule 40 flow sensor with MNPT 1.5" inlet end, MNPT 1.5" outlet end, and paddlewheel sensor with 25' lead.

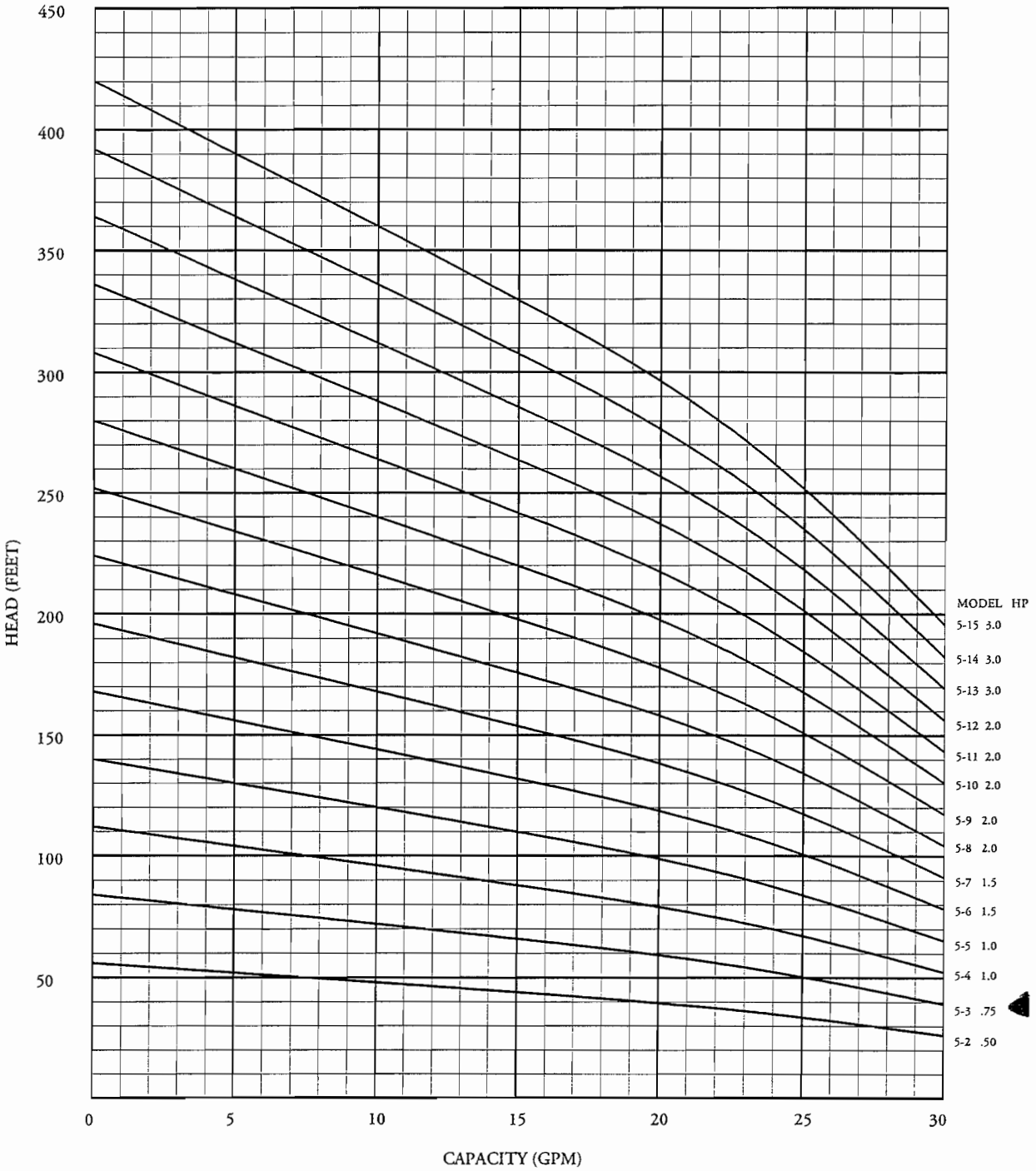
4 each EP10P04M10M10S
EPG Flow Sensor, 1", SCH 40 PVC with 1" MNPT ends, and paddlewheel sensor with 25' lead.

© EPG Companies Inc. 2009

SERIES 5 SurePump™

Flow Range 15-30 GPM

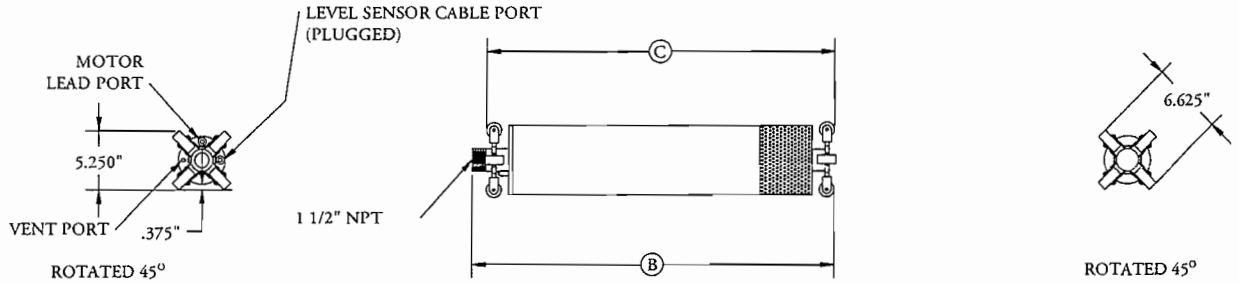
60 Hz



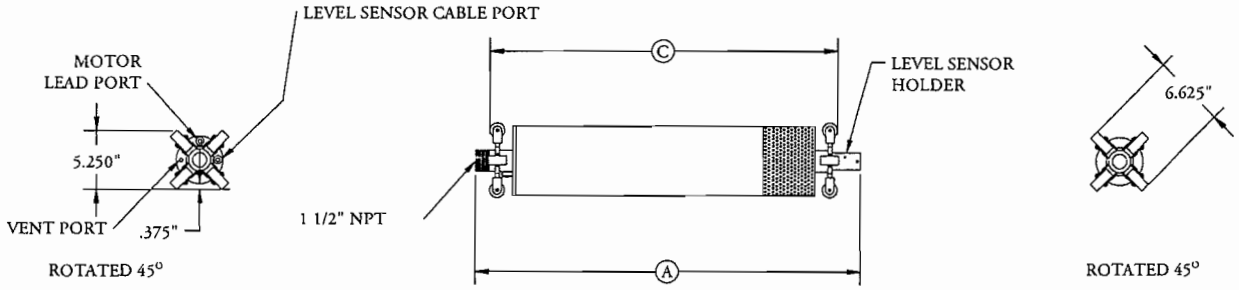
DATA SUBJECT TO CHANGE WITHOUT NOTICE

© 2009 EPG Companies Inc.
SurePump is a Reg. TM of EPG Companies Inc.

SERIES 5 SIZE 4 WHEELED SUMP DRAINER



WSD



WSDPT

MODEL	HP	PHASE	A	B	C	*APPROX. SHIPPING WEIGHT	
						WSD	WSDPT
5-2	0.50	1	31.02	29.90	29.15	61.47	66.47
5-2	0.50	3	31.02	29.90	29.15	61.47	66.47
5-3	0.75	1	32.98	31.86	31.11	66.24	71.24
5-3	0.75	3	32.98	31.86	31.11	66.24	71.24
5-4	1.00	1	34.90	33.78	33.03	70.98	75.98
5-4	1.00	3	34.90	33.78	33.03	70.98	75.98
5-5	1.00	1	35.73	34.61	33.86	71.88	76.88
5-5	1.00	3	35.73	34.61	33.86	71.88	76.88
5-6	1.50	1	38.43	37.31	36.56	79.22	84.22
5-6	1.50	3	36.56	35.44	34.69	72.77	77.77
5-7	1.50	1	39.26	38.14	37.39	80.12	85.12
5-7	1.50	3	37.39	36.27	35.52	73.67	78.67
5-8	2.00	1	41.59	40.47	39.72	85.17	90.17
5-8	2.00	3	40.09	38.97	38.22	81.01	86.01

MODEL	HP	PHASE	A	B	C	*APPROX. SHIPPING WEIGHT	
						WSD	WSDPT
5-9	2.00	1	42.42	41.30	40.55	86.07	91.07
5-9	2.00	3	40.92	39.80	39.05	81.90	86.90
5-10	2.00	1	43.25	42.13	41.38	86.96	91.96
5-10	2.00	3	41.75	40.63	39.88	82.80	87.80
5-11	2.00	1	44.08	42.96	42.21	87.86	92.86
5-11	2.00	3	42.58	41.46	40.71	83.69	88.69
5-12	2.00	1	44.91	43.79	43.04	88.75	93.75
5-12	2.00	3	53.41	52.29	51.54	92.35	97.35
5-13	3.00	1	54.24	53.12	52.37	119.24	124.24
5-13	3.00	3	51.24	50.12	49.37	105.91	110.91
5-14	3.00	1	55.07	53.95	53.20	120.14	125.14
5-14	3.00	3	52.07	50.95	50.20	106.81	111.81
5-15	3.00	1	55.90	54.78	54.03	121.03	126.03
5-15	3.00	3	52.90	51.78	51.03	107.70	112.70

NOTE: ALL DIMENSIONS ARE IN INCHES.

*SHIPPING WEIGHT INCLUDES
WSD: CRATE, 50' OF 14-4 MOTOR LEAD, 50' OF 1/8" SS CABLE.
WSDPT: CRATE, 50' OF 14-4 MOTOR LEAD, 50' OF 1/8" SS CABLE,
LEVEL SENSOR AND CABLE.

© 2009 EPG Companies Inc.
SurePump is a Reg. TM of EPG Companies Inc.

ENGINEER'S SPECIFICATION

EPG WSDPT SurePump™ Wheeled Sump Drainer

for side slope riser installations
with built-in level sensor

Furnish __1__ centrifugal submersible EPG WSDPT SurePump Wheeled Sump Drainer(s) (U.S. patented), Model WSDPT __5__ - __3__ with __3__ impeller stages. Each unit shall be suitable for side slope riser installation. Each unit shall be equipped with a __¾__ HP, submersible electric motor for operation on __230__ Volts, __1__ phase, 60 Hertz service with __110__ feet of power cable. Each SurePump Wheeled Sump Drainer shall have a __1 ½__ inch MNPT threaded discharge nozzle and be capable of delivering __25__ GPM at __50__ feet of TDH. Each SurePump will be fitted with __110__ feet of stainless steel lifting cable of sufficient strength to permit removal of the unit.

DESIGN

Each SurePump Wheeled Sump Drainer shall be capable of pumping contaminated ground water for spill recovery, leachate, condensate, and purge applications. A removable transmitter mount (patent pending) shall be installed at the center bottom of the Sump Drainer for liquid level control. The Sump Drainer shall permit the unit to "pump down" to within __8__ inches of the sump bottom without any loss of performance or damage to the pump. External "priming" shall not be required nor allowed. The Sump Drainer shall be equipped with a vent valve to assist with the evacuation of air from the Sump Drainer.

MATERIALS

Major components shall be made of 304 stainless steel, seal rings are to be made of E-Glide™, and bearings are to be E-Glide. In addition, all fasteners shall be 304 stainless steel.

CHECK VALVE

Each unit shall include a built-in check valve with non-metallic seat, and housing and disc of 304 stainless steel.

SHAFT

The shaft shall be of 304 stainless steel and rotate on E-Glide bearings that are fluid lubricated.

DIFFUSER CHAMBER

The diffuser chambers for each impeller shall be 304 stainless steel and fitted with E-Glide impeller seal rings.

IMPELLERS

The impeller(s) shall be closed and consist of 304 stainless steel.

MOTOR

The motor shall be a submersible, hermetically sealed Franklin motor in __Pollution Recovery__ construction. The motor shall be designed for continuous duty, capable of sustaining up to __100__ starts per day. The motor shall be connected to the pump via a motor adaptor and coupling in 304 stainless steel. Single phase motors in ½ HP to 1 HP only shall have thermal protection in the motor windings to protect the windings from overload. The unit will restart automatically after the motor cools down. Larger horsepower single phase motors and three phase motors shall have thermal protection located in the control panel that is manually reset.

MOTOR LEAD WIRE

The lead wire shall be no-splice with EPG's "CP" waterproof and chemically resistant jacket over 600 Volt insulation and be of the length specified.

© 2009 EPG Companies Inc.
SurePump & E-Glide are Reg.
TM of EPG Companies Inc.

ENGINEER'S SPECIFICATION

EPG WSDPT SurePump™ Wheeled Sump Drainer

for side slope riser installations
with built-in level sensor

Furnish __1__ centrifugal submersible EPG WSDPT SurePump Wheeled Sump Drainer(s) (U.S. patented), Model WSDPT __5__ - __3__ with __3__ impeller stages. Each unit shall be suitable for side slope riser installation. Each unit shall be equipped with a __¾__ HP, submersible electric motor for operation on __230__ Volts, __1__ phase, 60 Hertz service with __120__ feet of power cable. Each SurePump Wheeled Sump Drainer shall have a __1 ½__ inch MNPT threaded discharge nozzle and be capable of delivering __25__ GPM at __50__ feet of TDH. Each SurePump will be fitted with __120__ feet of stainless steel lifting cable of sufficient strength to permit removal of the unit.

DESIGN

Each SurePump Wheeled Sump Drainer shall be capable of pumping contaminated ground water for spill recovery, leachate, condensate, and purge applications. A removable transmitter mount (patent pending) shall be installed at the center bottom of the Sump Drainer for liquid level control. The Sump Drainer shall permit the unit to "pump down" to within __8__ inches of the sump bottom without any loss of performance or damage to the pump. External "priming" shall not be required nor allowed. The Sump Drainer shall be equipped with a vent valve to assist with the evacuation of air from the Sump Drainer.

MATERIALS

Major components shall be made of 304 stainless steel, seal rings are to be made of E-Glide™, and bearings are to be E-Glide. In addition, all fasteners shall be 304 stainless steel.

CHECK VALVE

Each unit shall include a built-in check valve with non-metallic seat, and housing and disc of 304 stainless steel.

SHAFT

The shaft shall be of 304 stainless steel and rotate on E-Glide bearings that are fluid lubricated.

DIFFUSER CHAMBER

The diffuser chambers for each impeller shall be 304 stainless steel and fitted with E-Glide impeller seal rings.

IMPELLERS

The impeller(s) shall be closed and consist of 304 stainless steel.

MOTOR

The motor shall be a submersible, hermetically sealed Franklin motor in __Pollution Recovery__ construction. The motor shall be designed for continuous duty, capable of sustaining up to __100__ starts per day. The motor shall be connected to the pump via a motor adaptor and coupling in 304 stainless steel. Single phase motors in ½ HP to 1 HP only shall have thermal protection in the motor windings to protect the windings from overload. The unit will restart automatically after the motor cools down. Larger horsepower single phase motors and three phase motors shall have thermal protection located in the control panel that is manually reset.

MOTOR LEAD WIRE

The lead wire shall be no-splice with EPG's "CP" waterproof and chemically resistant jacket over 600 Volt insulation and be of the length specified.

© 2009 EPG Companies Inc.
SurePump & E-Glide are Reg.
TM of EPG Companies Inc.

ENGINEER'S SPECIFICATION

EPG WSDPT SurePump™ Wheeled Sump Drainer

for side slope riser installations
with built-in level sensor

Furnish _2_ centrifugal submersible EPG WSDPT SurePump Wheeled Sump Drainer(s) (U.S. patented), Model WSDPT _5_ - _3_ with _3_ impeller stages. Each unit shall be suitable for side slope riser installation. Each unit shall be equipped with a _¾_ HP, submersible electric motor for operation on _230_ Volts, _1_ phase, 60 Hertz service with _70_ feet of power cable. Each SurePump Wheeled Sump Drainer shall have a _1 ½_ inch MNPT threaded discharge nozzle and be capable of delivering _25_ GPM at _50_ feet of TDH. Each SurePump will be fitted with _70_ feet of stainless steel lifting cable of sufficient strength to permit removal of the unit.

DESIGN
Each SurePump Wheeled Sump Drainer shall be capable of pumping contaminated ground water for spill recovery, leachate, condensate, and purge applications. A removable transmitter mount (patent pending) shall be installed at the center bottom of the Sump Drainer for liquid level control. The Sump Drainer shall permit the unit to "pump down" to within _8_ inches of the sump bottom without any loss of performance or damage to the pump. External "priming" shall not be required nor allowed. The Sump Drainer shall be equipped with a vent valve to assist with the evacuation of air from the Sump Drainer.

MATERIALS
Major components shall be made of 304 stainless steel, seal rings are to be made of E-Glide™, and bearings are to be E-Glide. In addition, all fasteners shall be 304 stainless steel.

CHECK VALVE
Each unit shall include a built-in check valve with non-metallic seat, and housing and disc of 304 stainless steel.

SHAFT
The shaft shall be of 304 stainless steel and rotate on E-Glide bearings that are fluid lubricated.

DIFFUSER CHAMBER
The diffuser chambers for each impeller shall be 304 stainless steel and fitted with E-Glide impeller seal rings.

IMPELLERS
The impeller(s) shall be closed and consist of 304 stainless steel.

MOTOR
The motor shall be a submersible, hermetically sealed Franklin motor in _Pollution Recovery_ construction. The motor shall be designed for continuous duty, capable of sustaining up to _100_ starts per day. The motor shall be connected to the pump via a motor adaptor and coupling in 304 stainless steel. Single phase motors in ½ HP to 1 HP only shall have thermal protection in the motor windings to protect the windings from overload. The unit will restart automatically after the motor cools down. Larger horsepower single phase motors and three phase motors shall have thermal protection located in the control panel that is manually reset.

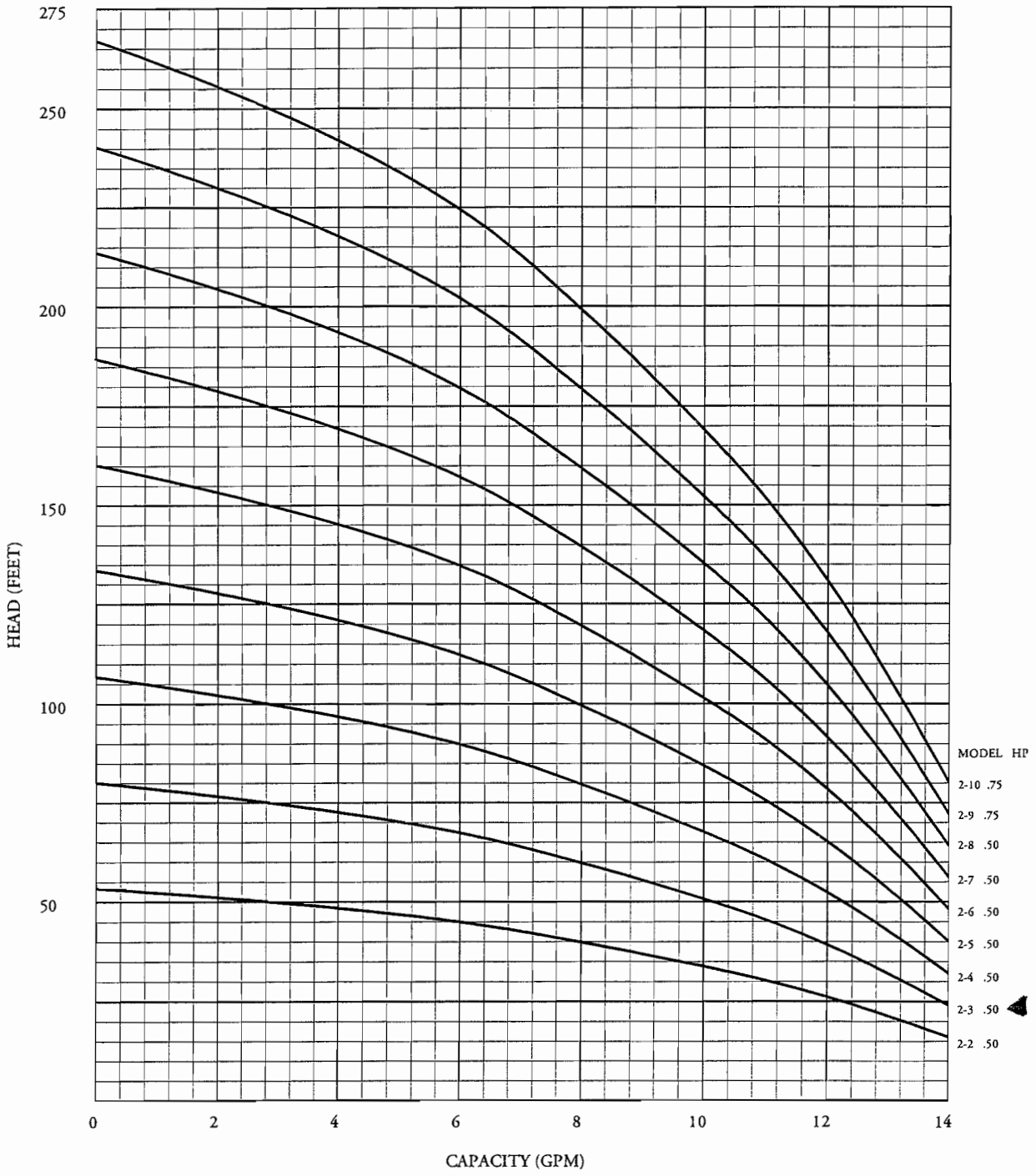
MOTOR LEAD WIRE
The lead wire shall be no-splice with EPG's "CP" waterproof and chemically resistant jacket over 600 Volt insulation and be of the length specified.

© 2009 EPG Companies Inc.
SurePump & E-Glide are Reg.
TM of EPG Companies Inc.

SERIES 2 SurePump™

Flow Range 4-14 GPM

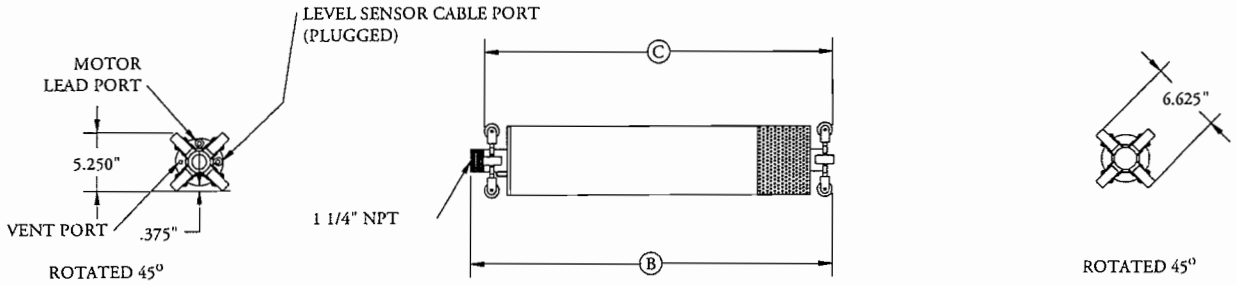
60 Hz



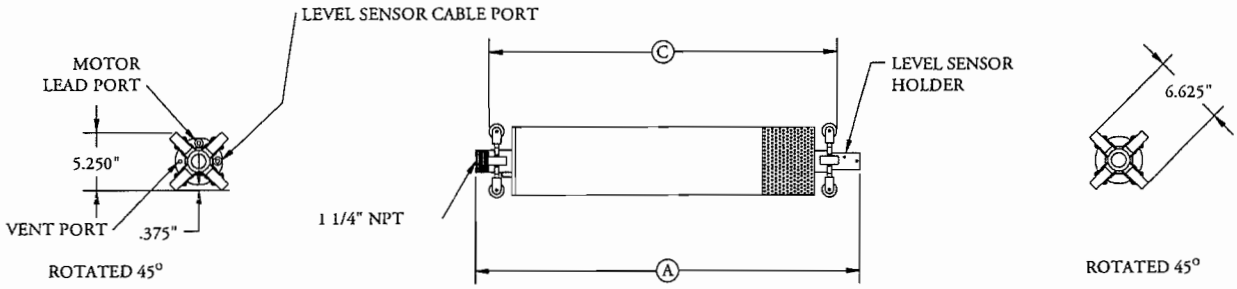
DATA SUBJECT TO CHANGE WITHOUT NOTICE

© 2009 EPG Companies Inc.
SurePump is a Reg. TM of EPG Companies Inc.

SERIES 2 SIZE 4 WHEELED SUMP DRAINER



WSD



WSDPT

MODEL	HP	PHASE	A	B	C	*APPROX. SHIPPING WEIGHT	
						WSD	WSDPT
2-2	0.50	1	31.02	29.90	29.15	61.47	66.47
2-2	0.50	3	31.02	29.90	29.15	61.47	66.47
2-3	0.50	1	31.85	30.73	29.98	62.37	67.37
2-3	0.50	3	31.85	30.73	29.98	62.37	67.37
2-4	0.50	1	32.68	31.56	30.81	63.26	68.26
2-4	0.50	3	32.68	31.56	30.81	63.26	68.26
2-5	0.50	1	33.51	32.39	31.64	64.15	69.15
2-5	0.50	3	33.51	32.39	31.64	64.15	69.15
2-6	0.50	1	34.34	33.22	32.47	65.05	70.05
2-6	0.50	3	34.34	33.22	32.47	65.05	70.05
2-7	0.50	1	35.17	34.05	33.30	65.94	70.94
2-7	0.50	3	35.17	34.05	33.30	65.94	70.94
2-8	0.50	1	36.00	34.88	34.13	66.84	71.84
2-8	0.50	3	36.00	34.88	34.13	66.84	71.84
2-9	0.75	1	37.96	36.84	36.09	71.61	76.61
2-9	0.75	3	37.96	36.84	36.09	71.61	76.61
2-10	0.75	1	38.79	37.67	36.92	72.50	77.50
2-10	0.75	3	38.79	37.67	36.92	72.50	77.50

NOTE: ALL DIMENSIONS ARE IN INCHES.

*SHIPPING WEIGHT INCLUDES
WSD: CRATE, 50' OF 14-4 MOTOR LEAD, 50' OF 1/8" SS CABLE.
WSDPT: CRATE, 50' OF 14-4 MOTOR LEAD, 50' OF 1/8" SS CABLE,
LEVEL SENSOR AND CABLE.

© 2009 EPG Companies Inc.
SurePump is a Reg. TM of EPG Companies Inc.

ENGINEER'S SPECIFICATION

EPG WSDPT SurePump™ Wheeled Sump Drainer

for side slope riser installations
with built-in level sensor

Furnish __1__ centrifugal submersible EPG WSDPT SurePump Wheeled Sump Drainer(s) (U.S. patented), Model WSDPT __2__ - __3__ with __3__ impeller stages. Each unit shall be suitable for side slope riser installation. Each unit shall be equipped with a __½__ HP, submersible electric motor for operation on __230__ Volts, __1__ phase, 60 Hertz service with __110__ feet of power cable. Each SurePump Wheeled Sump Drainer shall have a __1 ¼__ inch MNPT threaded discharge nozzle and be capable of delivering __10__ GPM at __50__ feet of TDH. Each SurePump will be fitted with __110__ feet of stainless steel lifting cable of sufficient strength to permit removal of the unit.

DESIGN

Each SurePump Wheeled Sump Drainer shall be capable of pumping contaminated ground water for spill recovery, leachate, condensate, and purge applications. A removable transmitter mount (patent pending) shall be installed at the center bottom of the Sump Drainer for liquid level control. The Sump Drainer shall permit the unit to "pump down" to within __8__ inches of the sump bottom without any loss of performance or damage to the pump. External "priming" shall not be required nor allowed. The Sump Drainer shall be equipped with a vent valve to assist with the evacuation of air from the Sump Drainer.

MATERIALS

Major components shall be made of 304 stainless steel, seal rings are to be made of E-Glide™, and bearings are to be E-Glide. In addition, all fasteners shall be 304 stainless steel.

CHECK VALVE

Each unit shall include a built-in check valve with non-metallic seat, and housing and disc of 304 stainless steel.

SHAFT

The shaft shall be of 304 stainless steel and rotate on E-Glide bearings that are fluid lubricated.

DIFFUSER CHAMBER

The diffuser chambers for each impeller shall be 304 stainless steel and fitted with E-Glide impeller seal rings.

IMPELLERS

The impeller(s) shall be closed and consist of 304 stainless steel.

MOTOR

The motor shall be a submersible, hermetically sealed Franklin motor in __Pollution Recovery__ construction. The motor shall be designed for continuous duty, capable of sustaining up to __100__ starts per day. The motor shall be connected to the pump via a motor adaptor and coupling in 304 stainless steel. Single phase motors in ½ HP to 1 HP only shall have thermal protection in the motor windings to protect the windings from overload. The unit will restart automatically after the motor cools down. Larger horsepower single phase motors and three phase motors shall have thermal protection located in the control panel that is manually reset.

MOTOR LEAD WIRE

The lead wire shall be no-splice with EPG's "CP" waterproof and chemically resistant jacket over 600 Volt insulation and be of the length specified.

© 2009 EPG Companies Inc.
SurePump & E-Glide are Reg.
TM of EPG Companies Inc.

ENGINEER'S SPECIFICATION

EPG WSDPT SurePump™ Wheeled Sump Drainer

for side slope riser installations
with built-in level sensor

Furnish __1__ centrifugal submersible EPG WSDPT SurePump Wheeled Sump Drainer(s) (U.S. patented), Model WSDPT __2__ - __3__ with __3__ impeller stages. Each unit shall be suitable for side slope riser installation. Each unit shall be equipped with a __½__ HP, submersible electric motor for operation on __230__ Volts, __1__ phase, 60 Hertz service with __120__ feet of power cable. Each SurePump Wheeled Sump Drainer shall have a __1 ¼__ inch MNPT threaded discharge nozzle and be capable of delivering __10__ GPM at __50__ feet of TDH. Each SurePump will be fitted with __120__ feet of stainless steel lifting cable of sufficient strength to permit removal of the unit.

DESIGN

Each SurePump Wheeled Sump Drainer shall be capable of pumping contaminated ground water for spill recovery, leachate, condensate, and purge applications. A removable transmitter mount (patent pending) shall be installed at the center bottom of the Sump Drainer for liquid level control. The Sump Drainer shall permit the unit to "pump down" to within __8__ inches of the sump bottom without any loss of performance or damage to the pump. External "priming" shall not be required nor allowed. The Sump Drainer shall be equipped with a vent valve to assist with the evacuation of air from the Sump Drainer.

MATERIALS

Major components shall be made of 304 stainless steel, seal rings are to be made of E-Glide™, and bearings are to be E-Glide. In addition, all fasteners shall be 304 stainless steel.

CHECK VALVE

Each unit shall include a built-in check valve with non-metallic seat, and housing and disc of 304 stainless steel.

SHAFT

The shaft shall be of 304 stainless steel and rotate on E-Glide bearings that are fluid lubricated.

DIFFUSER CHAMBER

The diffuser chambers for each impeller shall be 304 stainless steel and fitted with E-Glide impeller seal rings.

IMPELLERS

The impeller(s) shall be closed and consist of 304 stainless steel.

MOTOR

The motor shall be a submersible, hermetically sealed Franklin motor in __Pollution Recovery__ construction. The motor shall be designed for continuous duty, capable of sustaining up to __100__ starts per day. The motor shall be connected to the pump via a motor adaptor and coupling in 304 stainless steel. Single phase motors in ½ HP to 1 HP only shall have thermal protection in the motor windings to protect the windings from overload. The unit will restart automatically after the motor cools down. Larger horsepower single phase motors and three phase motors shall have thermal protection located in the control panel that is manually reset.

MOTOR LEAD WIRE

The lead wire shall be no-splice with EPG's "CP" waterproof and chemically resistant jacket over 600 Volt insulation and be of the length specified.

© 2009 EPG Companies Inc.
SurePump & E-Glide are Reg.
TM of EPG Companies Inc.

ENGINEER'S SPECIFICATION

EPG WSDPT SurePump™ Wheeled Sump Drainer

for side slope riser installations
with built-in level sensor

Furnish __2__ centrifugal submersible EPG WSDPT SurePump Wheeled Sump Drainer(s) (U.S. patented), Model WSDPT __2__ - __3__ with __3__ impeller stages. Each unit shall be suitable for side slope riser installation. Each unit shall be equipped with a __½__ HP, submersible electric motor for operation on __230__ Volts, __1__ phase, 60 Hertz service with __70__ feet of power cable. Each SurePump Wheeled Sump Drainer shall have a __1 ¼__ inch MNPT threaded discharge nozzle and be capable of delivering __10__ GPM at __50__ feet of TDH. Each SurePump will be fitted with __70__ feet of stainless steel lifting cable of sufficient strength to permit removal of the unit.

DESIGN

Each SurePump Wheeled Sump Drainer shall be capable of pumping contaminated ground water for spill recovery, leachate, condensate, and purge applications. A removable transmitter mount (patent pending) shall be installed at the center bottom of the Sump Drainer for liquid level control. The Sump Drainer shall permit the unit to "pump down" to within __8__ inches of the sump bottom without any loss of performance or damage to the pump. External "priming" shall not be required nor allowed. The Sump Drainer shall be equipped with a vent valve to assist with the evacuation of air from the Sump Drainer.

MATERIALS

Major components shall be made of 304 stainless steel, seal rings are to be made of E-Glide™, and bearings are to be E-Glide. In addition, all fasteners shall be 304 stainless steel.

CHECK VALVE

Each unit shall include a built-in check valve with non-metallic seat, and housing and disc of 304 stainless steel.

SHAFT

The shaft shall be of 304 stainless steel and rotate on E-Glide bearings that are fluid lubricated.

DIFFUSER CHAMBER

The diffuser chambers for each impeller shall be 304 stainless steel and fitted with E-Glide impeller seal rings.

IMPELLERS

The impeller(s) shall be closed and consist of 304 stainless steel.

MOTOR

The motor shall be a submersible, hermetically sealed Franklin motor in __Pollution Recovery__ construction. The motor shall be designed for continuous duty, capable of sustaining up to __100__ starts per day. The motor shall be connected to the pump via a motor adaptor and coupling in 304 stainless steel. Single phase motors in ½ HP to 1 HP only shall have thermal protection in the motor windings to protect the windings from overload. The unit will restart automatically after the motor cools down. Larger horsepower single phase motors and three phase motors shall have thermal protection located in the control panel that is manually reset.

MOTOR LEAD WIRE

The lead wire shall be no-splice with EPG's "CP" waterproof and chemically resistant jacket over 600 Volt insulation and be of the length specified.

© 2009 EPG Companies Inc.
SurePump & E-Glide are Reg.
TM of EPG Companies Inc.

Materials of Construction

EPG SurePump™

	STANDARD
Check Valve Housing	304 Stainless Steel
Check Valve	304 Stainless Steel
Check Valve Seat	E-Glide™
Diffuser Chamber	304 Stainless Steel
Impeller Seal Ring	E-Glide™
Impeller	304 Stainless Steel
Motor Adapter	304 Stainless Steel
Inlet Screen	304 Stainless Steel
Pump Shaft	304 Stainless Steel
Coupling	329/420/431 Stainless Steel
Fasteners	304 Stainless Steel
Bearings	E-Glide™

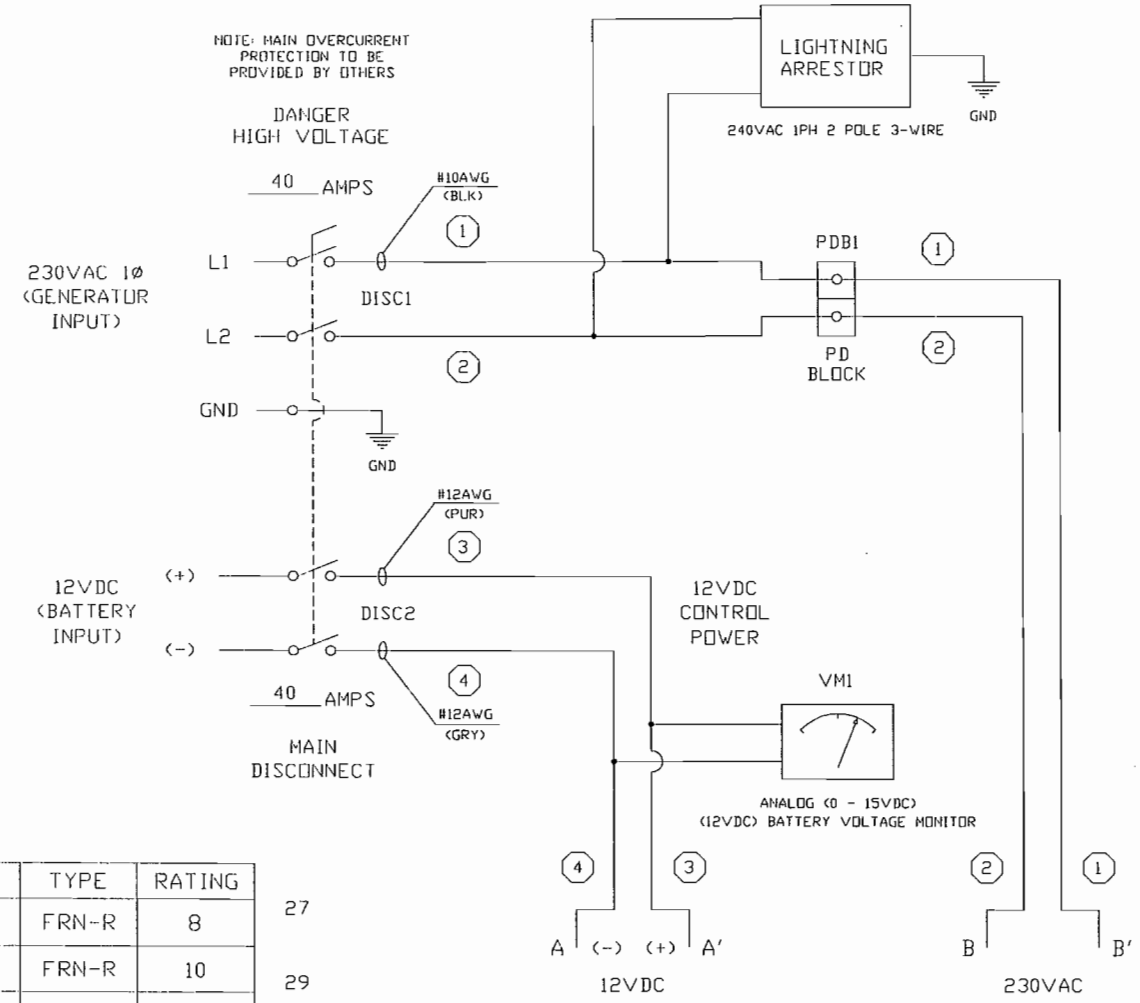
FRANKLIN ELECTRIC MOTORS

	1/3 to 2 HORSEPOWER	3 to 5 HORSEPOWER	5 to 10 HORSEPOWER
End Bell Castings	304 Stainless Steel over Iron	304 Stainless Steel over Iron	304 Stainless Steel over Iron
Stator Shell	301 Stainless Steel	301 Stainless Steel	301 Stainless Steel
Shaft Extension	303 Stainless Steel	303 Stainless steel	303 Stainless Steel
Fasteners	316 Stainless Steel	300 Stainless Steel	316 Stainless Steel
Seal Cover	Tefzel	Sintered Bronze	Tefzel
Shaft Seal	Viton	Viton, Carbon, Ceramic Face Seal	Viton
Diaphragm	Viton	Nitrile Rubber	Viton
Diaphragm Plate	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Diaphragm Spring	302 Stainless Steel	302 Stainless Steel	302 Stainless Steel
Diaphragm Cover	316 Stainless Steel	304 Stainless Steel	316 Stainless Steel
Slinger	Viton	Nitrile Rubber	Viton
Lead Sleeve	316 Stainless Steel	316 Stainless Steel	316 Stainless Steel
Lead Jam Nut	316 Stainless Steel	N/A	316 Stainless Steel
Lead Jam Clamp	N/A	300 Stainless Steel	N/A
Lead Potting	Epoxy	Epoxy	Epoxy
Lead Bushing	Viton	Viton	Viton

© 2009 EPG Companies Inc.
SurePump is a Reg. TM of EPG Companies Inc.

MOTOR	HP	VOLTAGE	FLA	FUSE SIZE
LCRS PUMP	1/2	230	5.0	8A
VADOSE PUMP	3/4	230	6.8	10A

PHASE 1, 2 & 3B
CONTROL PANELS AND PUMPS



FIELD WIRING TERMINALS

LINE (GENERATOR)

L1 / L2	230VAC 1Ø 60Hz 15.05 AMPS	
GND	GROUND	

LINE (BATTERY)

(+) / (-)	12VDC 0.91 AMPS

FUSE	TYPE	RATING
F1-F2	FRN-R	8
F3-F4	FRN-R	10
F5-F6	FRN-R	2-1/2
F7	FNM	1-1/4
F8	FNM	3-1/2
F9	ABC	1-1/2
F10	MDL	1/2
F11	ABC	1/2
F12	ABC	1/2

FOR NOTES AND REVISIONS SEE SHEET 8

JOB No. 09-9356ABC

* NOTICE * © EPG Companies Inc. 2009
THIS DRAWING IS THE PROPERTY OF EPG COMPANIES FOR REFERENCE ONLY.

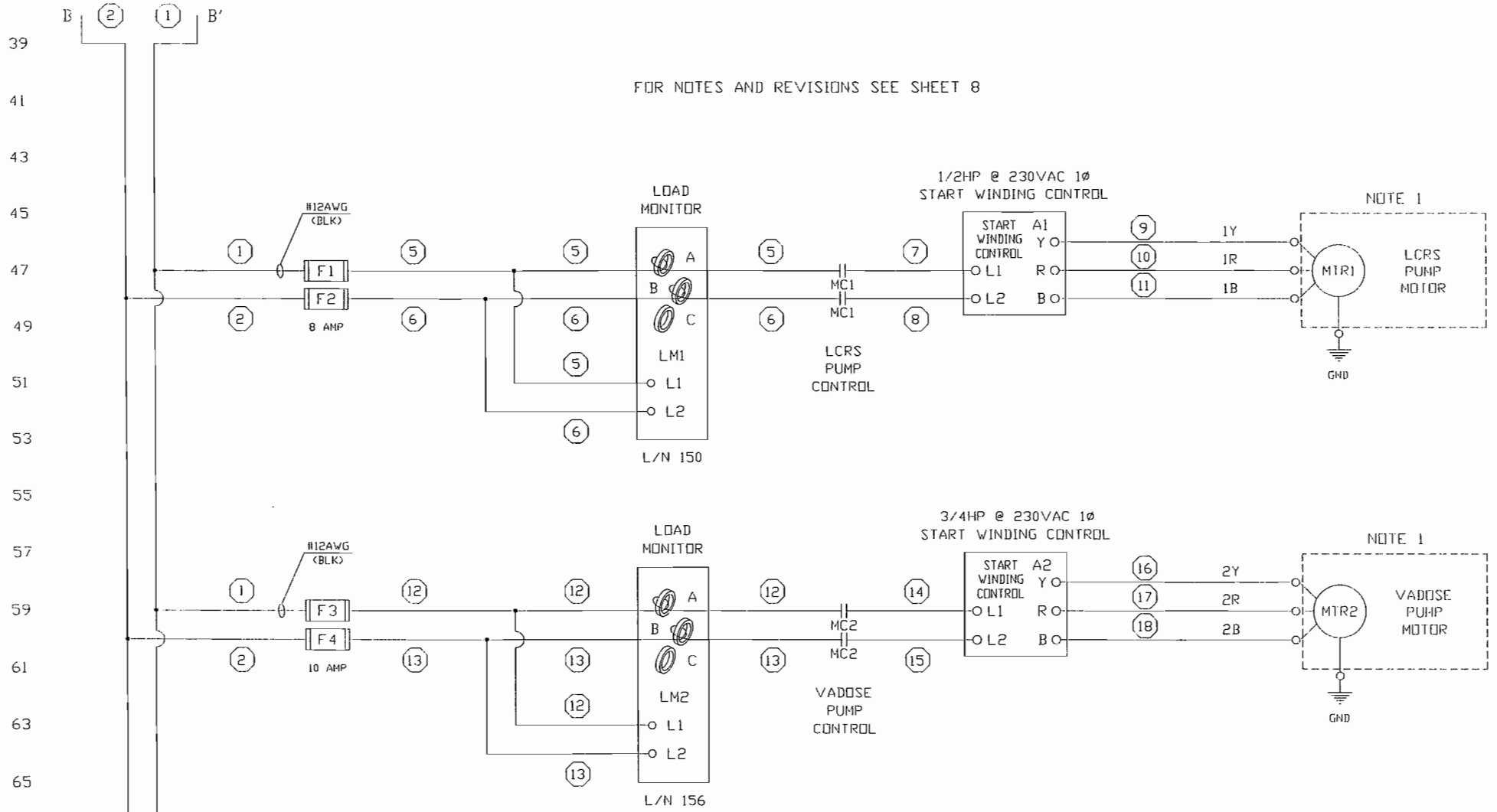
TOLERANCES (EXCEPT AS NOTED)
DECIMAL ±
FRACTIONAL ±
ANGULAR ±

REVISIONS

NO.	DATE	BY
1		
2		
3		
4		
5		

EPG COMPANIES
L975PTG CONTROL PANEL
230VAC 1Ø SH 1 OF 8

DESIGN	RCK	SCALE	MATERIAL
DRAWN	RCK	DATE 05-20-09	DRAWING NO. 08373-0250
CHK'D		APP'D	



FIELD WIRING TERMINALS

LOAD (230VAC)

1Y	LCRS PUMP MOTOR
1R	
1B	
GND	

FIELD WIRING TERMINALS

LOAD (230VAC)

2Y	VADOSE PUMP MOTOR
2R	
2B	
GND	

JOB No.	09-9356ABC

* NOTICE * © EPG Companies Inc. 2009
THIS DRAWING IS THE PROPERTY OF EPG COMPANIES FOR REFERENCE ONLY.

TOLERANCES (EXCEPT AS NOTED)
DECIMAL ±
FRACTIONAL ±
ANGULAR ±

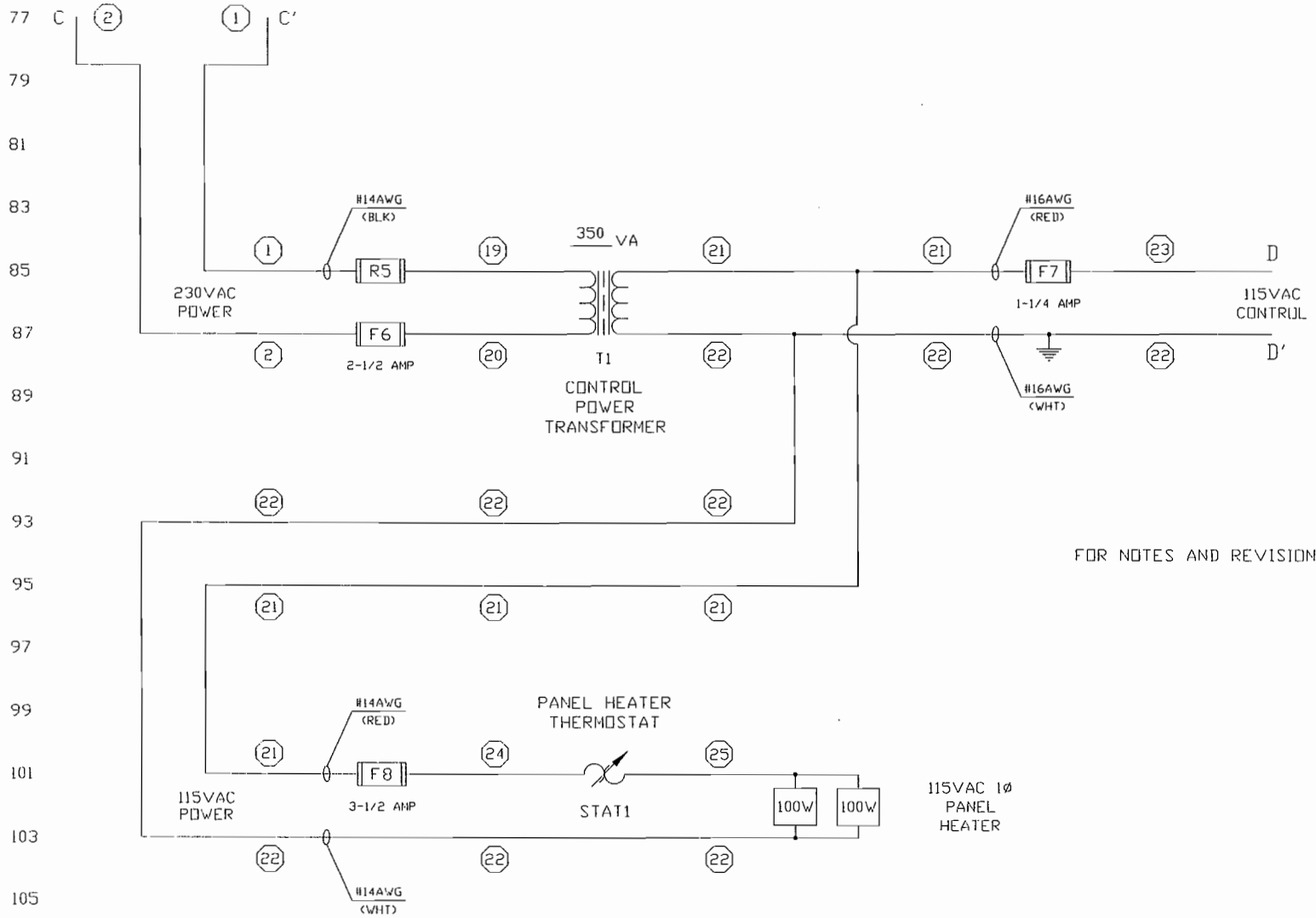
REVISIONS

NO.	DATE	BY
1		
2		
3		
4		
5		

EPG COMPANIES

L975PTG CONTROL PANEL
230VAC 1Ø SH 2 OF 8

DESIGN	RCK	SCALE	MATERIAL
DRAWN	RCK	DATE 05-20-09	DRAWING NO. 08373-0251
CHK'D		APP'D	



FOR NOTES AND REVISIONS SEE SHEET 8

JOB No.	09-9356ABC

* NOTICE * © EPG Companies Inc. 2009

THIS DRAWING IS THE PROPERTY OF EPG COMPANIES FOR REFERENCE ONLY.

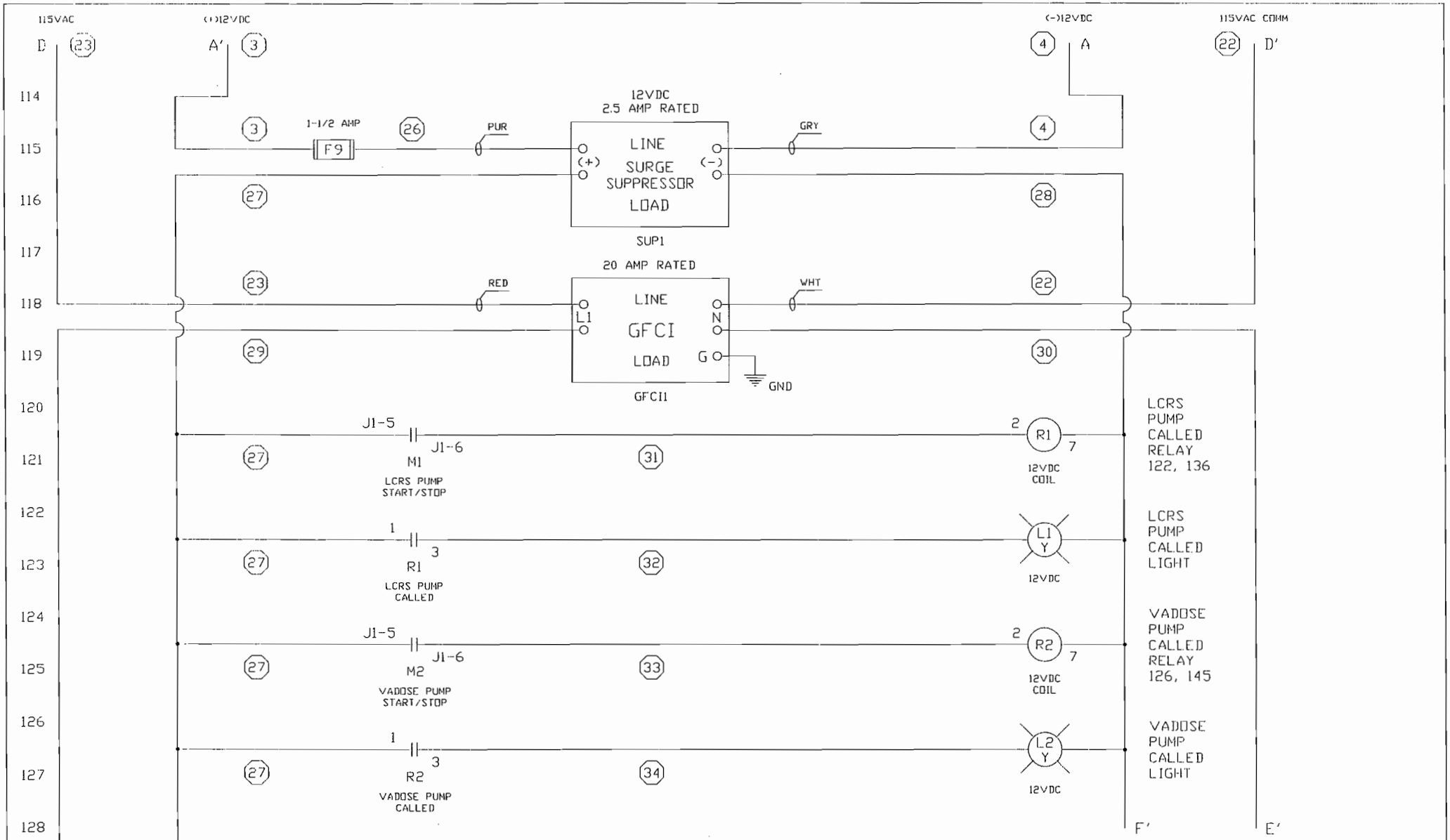
TOLERANCES (EXCEPT AS NOTED)
DECIMAL ±
FRACTIONAL ±
ANGULAR ±

REVISIONS		
NO	DATE	BY
1		
2		
3		
4		
5		

EPG COMPANIES

L975PTG CONTROL PANEL
230VAC 1Ø SH 3 OF 8

DESIGN	RCK	SCALE	MATERIAL
DRAWN	RCK	DATE 05-20-09	DRAWING NO. 08373-0252
CHK'D		APP'D	



FOR NOTES AND REVISIONS SEE SHEET 8

JOB No.	09-9356ABC

* NOTICE * © EPG Companies Inc. 2009
THIS DRAWING IS THE PROPERTY OF EPG COMPANIES FOR REFERENCE ONLY.

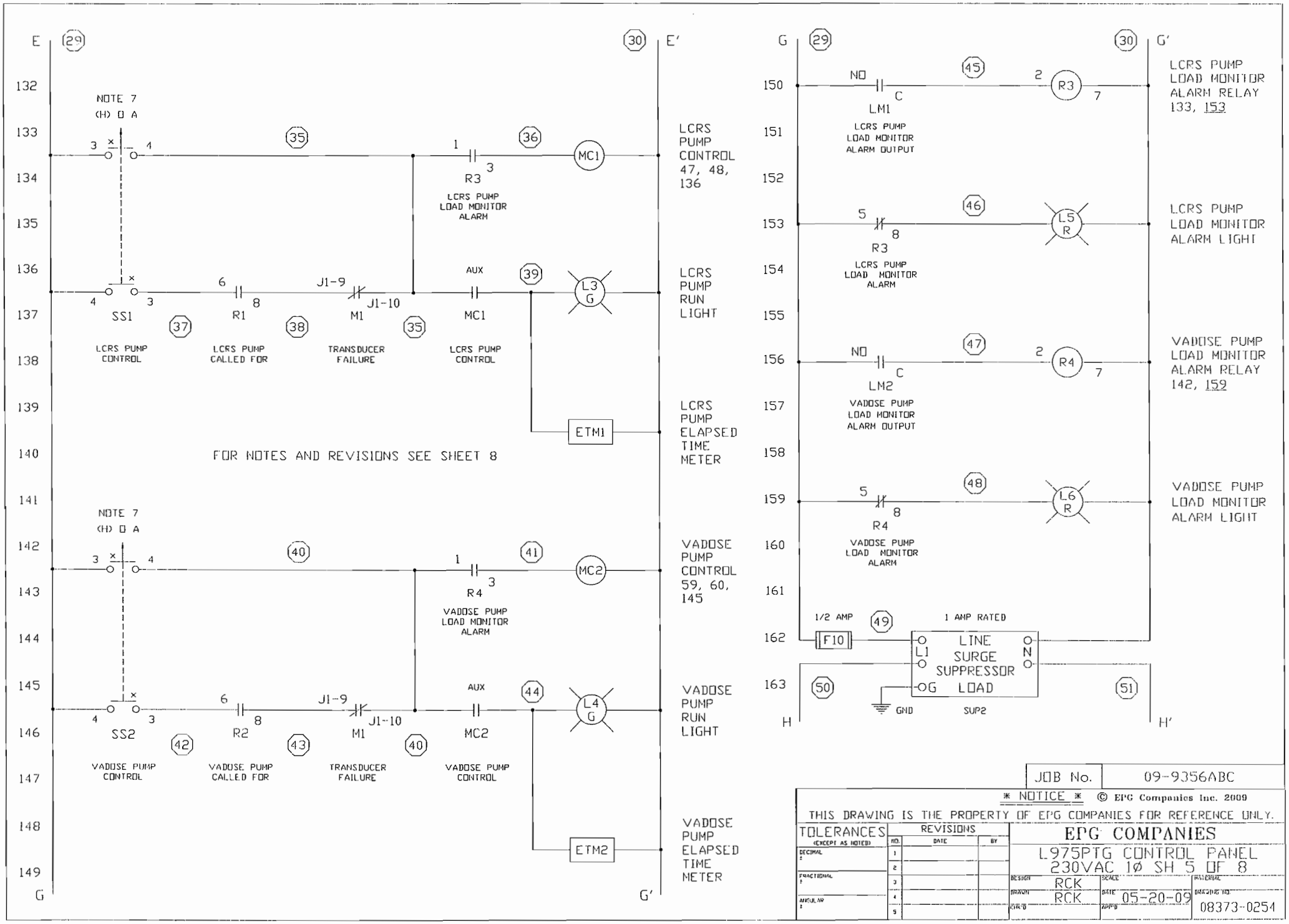
TOLERANCES (EXCEPT AS NOTED)
DECIMAL ±
FRACTIONAL ±
ANGULAR ±

REVISIONS		
NO.	DATE	BY
1		
2		
3		
4		
5		

EPG COMPANIES

L975PTG CONTROL PANEL
230VAC 1Ø SH 4 OF 8

DESIGN	RCK	SCALE	MATERIAL
DRAWN	RCK	DATE 05-20-09	DRAWING NO. 08373-0253
CHK'D		APP'D	



JOB No. 09-9356ABC

* NOTICE * © EPG Companies Inc. 2009
THIS DRAWING IS THE PROPERTY OF EPG COMPANIES FOR REFERENCE ONLY.

TOLERANCES (EXCEPT AS NOTED)
DECIMAL ±
FRACTIONAL ±
ANGULAR ±

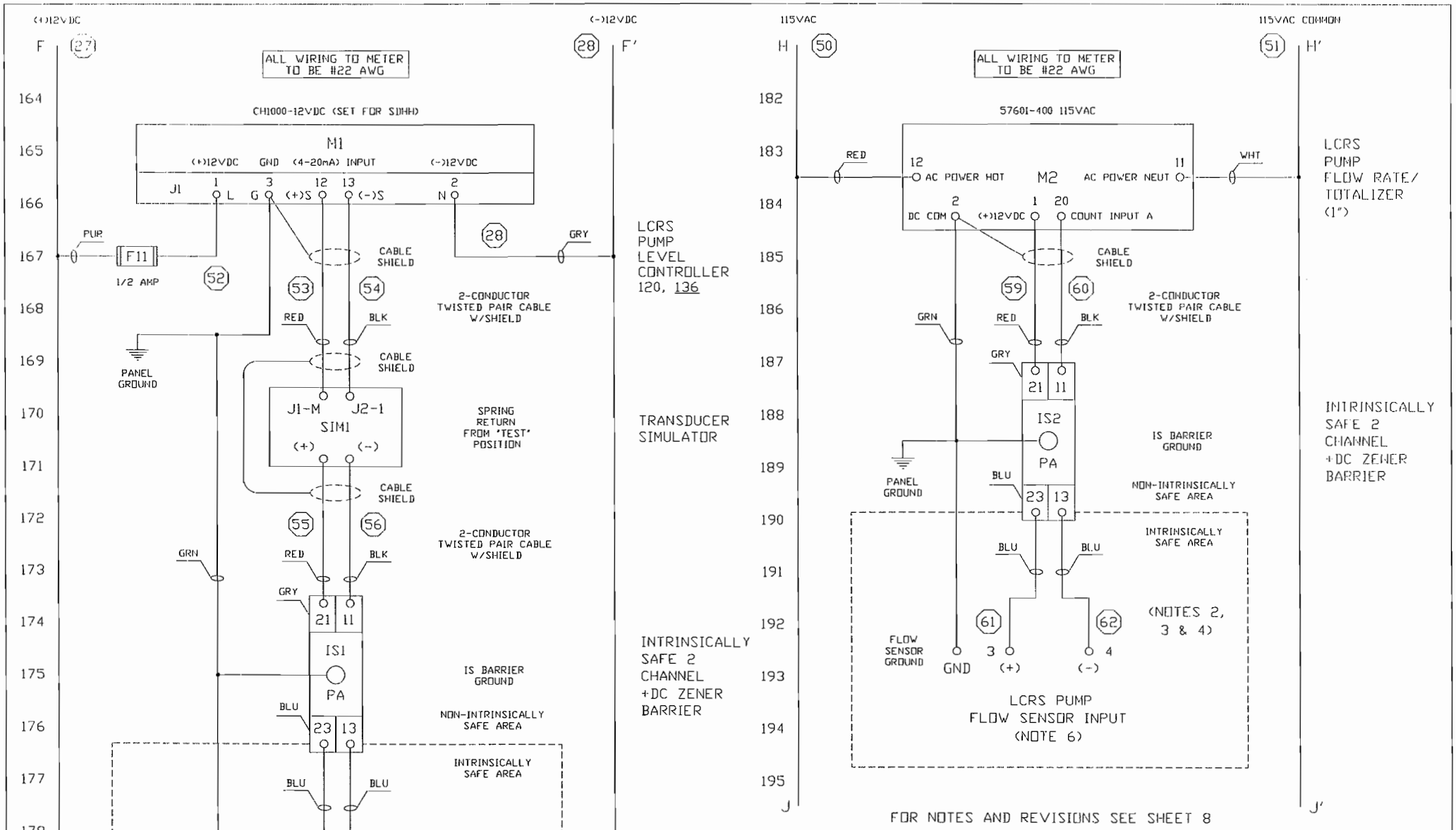
REVISIONS

NO.	DATE	BY
1		
2		
3		
4		
5		

EPG COMPANIES

L975PTG CONTROL PANEL
230VAC 1Ø SH 5 OF 8

DESIGN	RCK	SCALE	MATERIAL
DRAWN	RCK	DATE 05-20-09	DRAWING NO. 08373-0254
CHK'D		APP'D	



JOB No. 09-9356ABC

* NOTICE * © EPG Companies Inc. 2009

THIS DRAWING IS THE PROPERTY OF EPG COMPANIES FOR REFERENCE ONLY.

TOLERANCES (EXCEPT AS NOTED)

REVISIONS

EPG COMPANIES

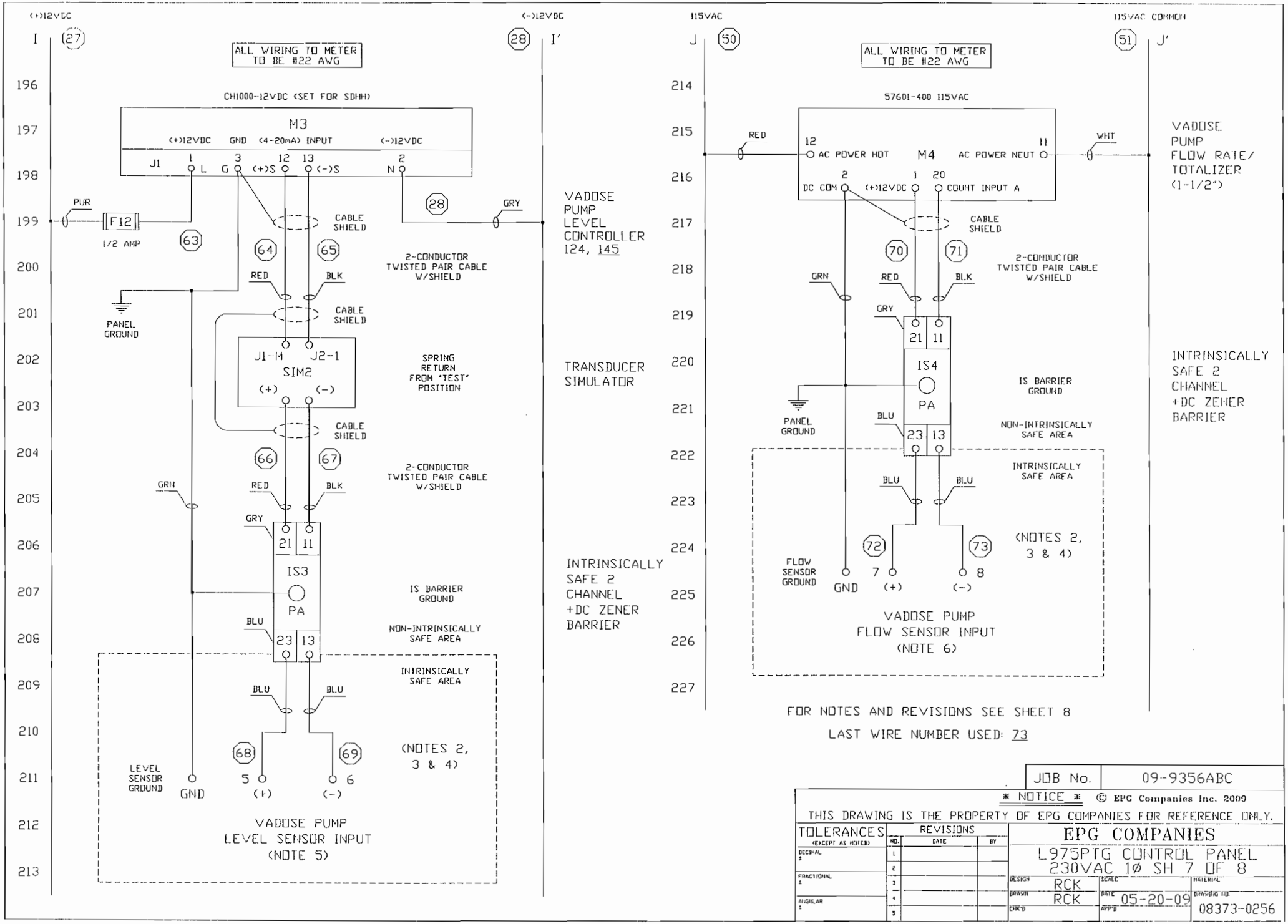
L975PTG CONTROL PANEL 230VAC 1Ø SH 6 OF 8

DESIGN RCK

DRAWN RCK

DATE 05-20-09

DRAWING NO. 08373-0255


(+)12VDC
(-)12VDC
115VAC
115VAC COMMON
ALL WIRING TO METER TO BE #22 AWG
CH1000-12VDC (SET FOR SDHH)
M3
(+)12VDC GND (4-20mA) INPUT (-)12VDC
J1 1 L G 3 (+)S 12 13 (-)S 2 N
PUR
F12
1/2 AMP
63
64
65
28
GRY
CABLE SHIELD
2-CONDUCTOR TWISTED PAIR CABLE W/SHIELD
RED
BLK
PANEL GROUND
J1-M J2-1
SIM2
(+) (-)
SPRING RETURN FROM 'TEST' POSITION
66
67
GRN
GRY
21 11
IS3
PA
23 13
BLU
IS BARRIER GROUND
NON-INTRINSICALLY SAFE AREA
INTRINSICALLY SAFE AREA
68
69
(NOTES 2, 3 & 4)
LEVEL SENSOR GROUND
GND
5 (+)
6 (-)
VADOSE PUMP LEVEL SENSOR INPUT (NOTE 5)
VADOSE PUMP LEVEL CONTROLLER 124, 145
TRANSDUCER SIMULATOR
INTRINSICALLY SAFE 2 CHANNEL +DC ZENER BARRIER
57601-400 115VAC
12 AC POWER HOT
M4
AC POWER NEUT 11
DC COM 2
(+)12VDC 1
COUNT INPUT A 20
WHT
70
71
IS4
72
73
FLOW SENSOR GROUND
7 (+)
8 (-)
VADOSE PUMP FLOW SENSOR INPUT (NOTE 6)
VADOSE PUMP FLOW RATE/ TOTALIZER (1-1/2")
INTRINSICALLY SAFE 2 CHANNEL +DC ZENER BARRIER
FOR NOTES AND REVISIONS SEE SHEET 8
LAST WIRE NUMBER USED: 73
JOB No. 09-9356ABC
* NOTICE * © EPG Companies Inc. 2009
THIS DRAWING IS THE PROPERTY OF EPG COMPANIES FOR REFERENCE ONLY.
TOLERANCES (EXCEPT AS NOTED)
DECIMAL ±
FRACTIONAL ±
ANGULAR ±
REVISIONS
NO. DATE BY
EPG COMPANIES
L975PTG CONTROL PANEL 230VAC 1Ø SH 7 OF 8
DESIGN RCK
DRAWN RCK
CHK'D
SCALE
DATE 05-20-09
APP'D
MATERIAL
DRAWING NO. 08373-0256

FIELD WIRING TERMINALS

LEVEL SENSOR (INTRINSICALLY SAFE TERMINALS)

1	— RED	LCRS PUMP LEVEL SENSOR INPUT (NOTES 2, 3, 4 & 5)
2	— BLACK	
GND	— SHIELD GROUND	

FLOW SENSOR (INTRINSICALLY SAFE TERMINALS)

3	— RED	LCRS PUMP FLOW SENSOR INPUT (1") (NOTES 2, 3, 4 & 6)
4	— WHITE	
GND	— BLACK	

LEVEL SENSOR (INTRINSICALLY SAFE TERMINALS)

5	— RED	VADOSE PUMP LEVEL SENSOR INPUT (NOTES 2, 3, 4 & 5)
6	— BLACK	
GND	— SHIELD GROUND	

FLOW SENSOR (INTRINSICALLY SAFE TERMINALS)

7	— RED	VADOSE PUMP FLOW SENSOR INPUT (1-1/2") (NOTES 2, 3, 4 & 6)
8	— WHITE	
GND	— BLACK	

NOTE:

1. NOT PART OF CONTROLLER
2. REFERENCE INSTALLATION OF INTRINSICALLY SAFE INSTRUMENT SYSTEMS IN CLASS I HAZARDOUS LOCATIONS, ANSI/ISA-RP 12.6-1987, SECTION 4.5.4
3. WARNING: SUBSTITUTION OF COMPONENTS MAY IMPAIR INTRINSIC SAFETY
4. INSTALL IN ACCORDANCE WITH ARTICLE 504 OF THE NATIONAL ELECTRIC CODE
5. MAXIMUM CABLE LENGTH TO THE LEVEL SENSOR IS 3000 FEET
6. MAXIMUM CABLE LENGTH TO THE FLOW SENSOR IS 500 FEET
7. SELECTOR SWITCHES, (SS1-SS2) WILL SPRING RETURN FROM THE "HAND" POSITION

JOB No.	09-9356ABC

* NOTICE * © EPG Companies Inc. 2009
THIS DRAWING IS THE PROPERTY OF EPG COMPANIES FOR REFERENCE ONLY.

TOLERANCES (EXCEPT AS NOTED)
DECIMAL ±
FRACTIONAL ±
ANGULAR ±

REVISIONS

NO.	DATE	BY
1		
2		
3		
4		
5		

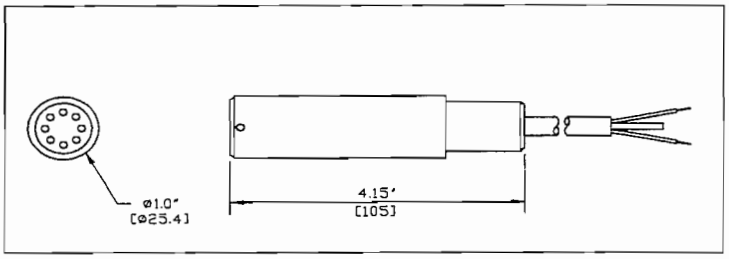
EPG COMPANIES

L975PTG CONTROL PANEL
230VAC 1Ø SH 8 OF 8

DESIGN	RCK	SCALE	MATERIAL
DRAWN	RCK	DATE 05-20-09	DRAWING NO. 08373-0257
CHK'D		APP'D	

ENGINEER'S SPECIFICATION

EPG LevelMaster™ PT Submersible Level Sensor



GENERAL FEATURES

* Application: The LevelMaster sensor is designed specifically to work with the EPG SurePump™, but its durability, accuracy and weight make it the logical choice for stand alone level applications. The chemical resistant jacketed cable with water block contains a vent tube for atmospheric pressure compensation.
* Ranges Available: 0-55" through 0-690' models are standard. Call EPG for other available ranges.
* Accuracy: The LevelMaster sensor has built-in temperature compensation as well as precise calibration giving an accuracy of ±1.0% at ambient temperature and a combined repeatability and hysteresis error of ±.125%.
* Fully Submersible: The LevelMaster sensor is fully submersible in any liquid compatible with 316 stainless steel and the chemical resistant polyurethane cable jacket. It is designed for submergence at depths greater than operating level without sustaining damage. Call EPG for more severe service.
* Self-Sealing Cable: If a cut occurs in the outer jacket of the cable, a water block feature just inside the outer jacket will self-seal in most cases guarding against the incursion of water.
* Superior Noise Immunity: Designed for heavy duty use in hostile environments, the LevelMaster sensor gives outstanding noise immunity. Unlike transducers, whose signals may be distorted by outside interference, the LevelMaster sensor utilizes a conditioned compensated 4-20 mA output to maximize signal strength and accuracy. The sensor also features a shielded lead to help prevent signal disruption from outside sources.

PERFORMANCE

* Depth Range:	0-55" thru 0-690' (0-2 PSI thru 0-300 PSI)
* Static Accuracy[1]:	±1.0% BFSL FSL maximum
* Thermal Error[2]:	0.05% FSO/°C worst case
* Proof Depth:	1.5 X rated depth
* Burst Depth:	2.0 X rated depth
* Resolution:	Infinitesimal

1. Static accuracy includes the combined errors due to nonlinearity, hysteresis and non-repeatability on a Best Fit Straight Line basis, at 25°C per ISA S51.1.
2. Thermal error is the maximum allowable deviation from the Best Fit Straight Line due to a change in temperature, per ISA S51.1.

© 2009 EPG Companies Inc.
LevelMaster & SurePump are Reg. TM of EPG Companies Inc.

ELECTRICAL

* Excitation: 10 to 40 VDC, Red = (+) excitation, Black = (-) excitation
* Input Current: 20 mA maximum
* Output: 4-20 mA (2 wire)
* Zero offset (max): 4-20 mA, ±.12mA
* Output impedance: <10 ohms
* Insulation resistance: 100 megohms at 50VDC
* Circuit protection: Polarity, surge & shorted output
* Power supply rejection: <±.05% FSO/VDC (mA output)
* Electrical termination: 2-24 AWG conductors in a shielded cable with sensor breather and polyurethane jacket

ENVIRONMENTAL

* Compensated temp range: 0° to 50°C
* Operating temp range: -20° to 70°C

PHYSICAL

* Dimensions: Nominal diameter of 1.0" X 4.15" length
* Weight: 7 oz. (not including cable)
* Cable: Polyurethane jacketed shielded cable with polyethylene vent tube and Kevlar tension members
* Wetted materials: 316 SS, Viton
* Mounting provision: Suspended by cable
* Lightning Protection: Increases length to 8.15"

MODEL {Call EPG for other ranges available – specify length (---)}

PART #	DESCRIPTION	RANGE
PT05X---	Submersible Pressure Transmitter	0-11'
PT07X---	" " "	0-16'
PT10X---	" " "	0-23'
PT20X---	" " "	0-46'
PT25X---	" " "	0-57'

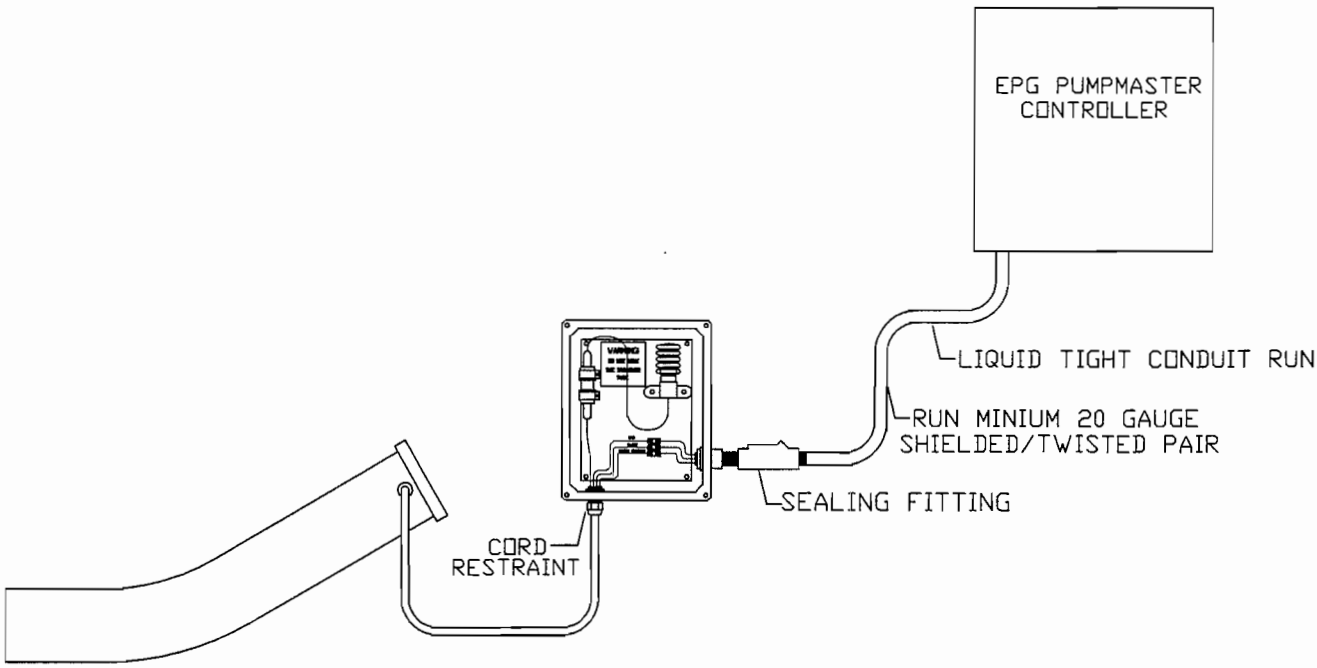
OPTIONS

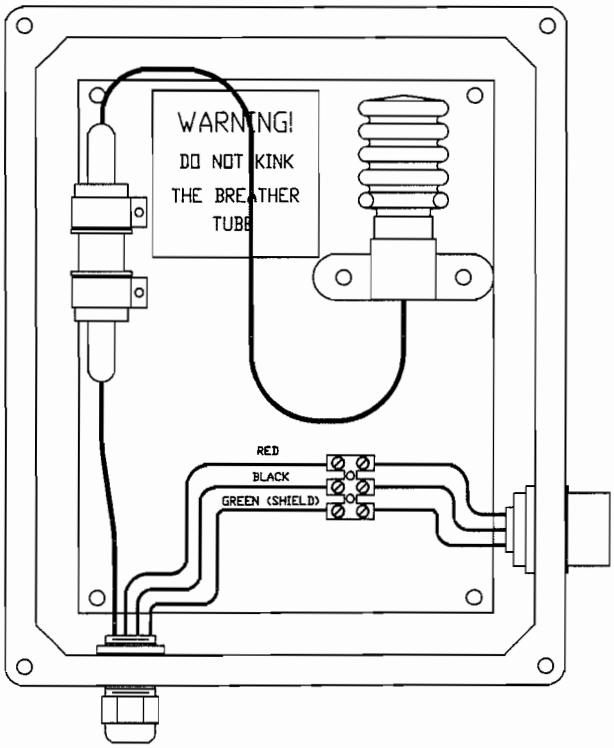
* Tefzel® Cable: Used for highly corrosive environments
* Titanium Housing: Used for highly corrosive environments
* Lightning Protection: Protects against transient voltages and lightning associated surges up to 20,000 amperes with proper grounding
* Temperature Sensor: A sensor with 4-20 mA output for temperature (0-50°C) is available – Excitation: 9-30 VDC, White = (+) excitation, Green = (-) excitation

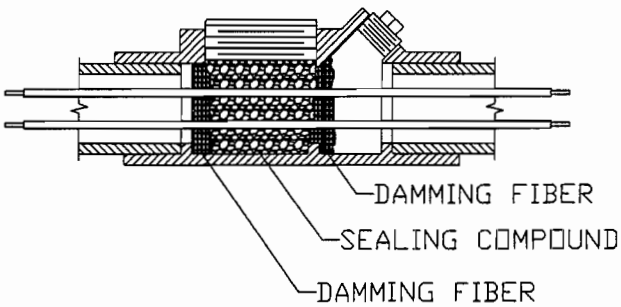
© 2009 EPG Companies Inc.
LevelMaster & SurePump are Reg. TM of EPG Companies Inc.

BJBL 600B

BREAKOUT JUNCTION BOX FOR LEVEL SENSOR







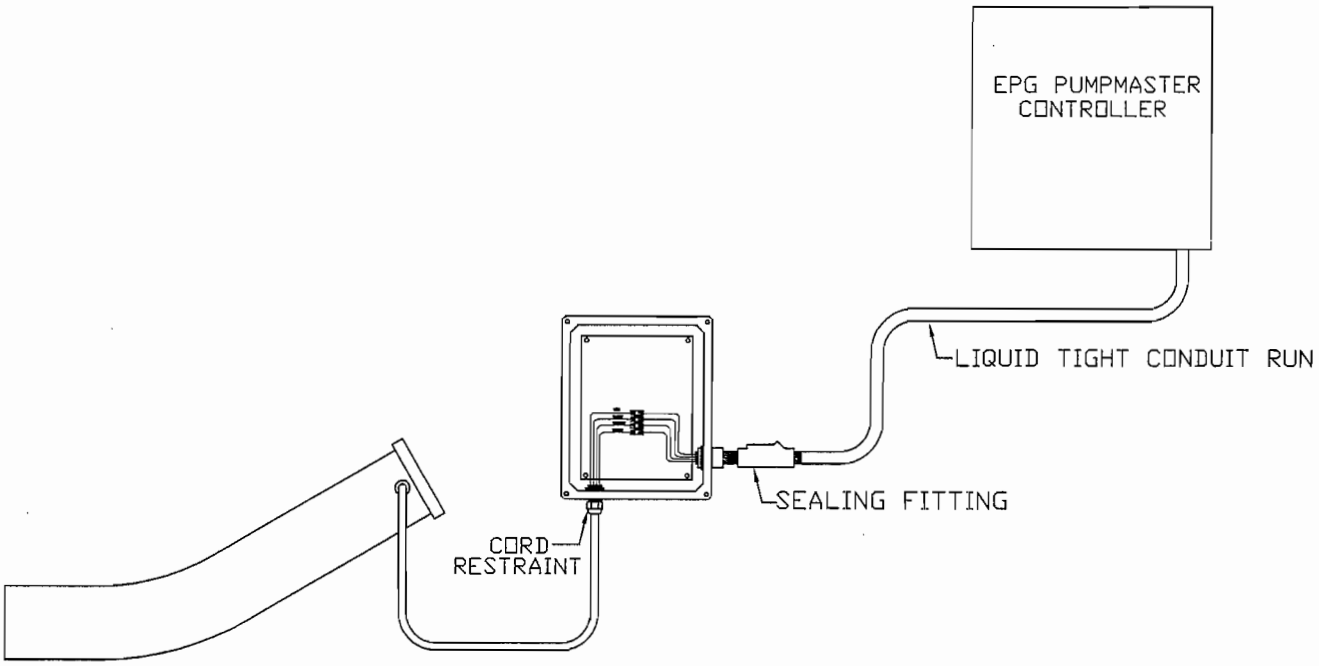
* NOTICE * © EPG Companies Inc. 2002

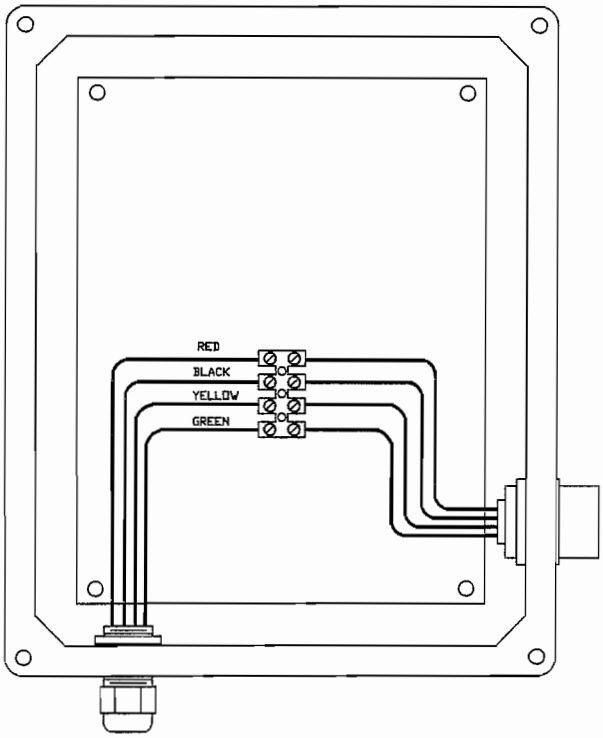
REFERENCE

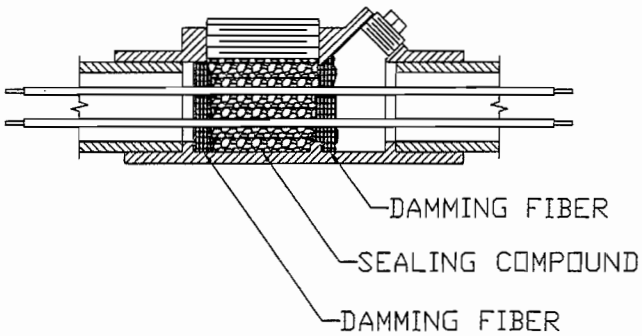
TOLERANCES (EXCEPT AS NOTED)	REVISIONS NO.	DATE	BY	EPG COMPANIES		
DECIMAL ±	1			TYPICAL INSTALLATION		
	2					
FRACTIONAL ±	3			DESIGN C.A.S.	SCALE NONE	MATERIAL
	4			DRAWN C.A.S.	DATE 05/07/02	DRAWING NO. 02523-0605
ANGULAR ±	5			CHK'D	APP'D	

BJBP 500

BREAKOUT JUNCTION BOX FOR MOTOR LEAD







* NOTICE * © EPG Companies Inc. 2002

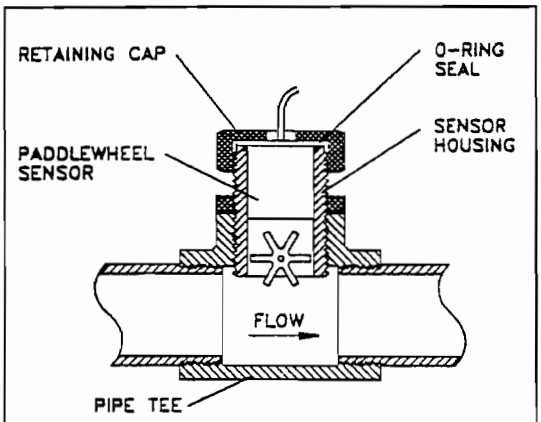
REFERENCE

TOLERANCES (EXCEPT AS NOTED)	REVISIONS			EPG COMPANIES			
	NO.	DATE	BY	TYPICAL INSTALLATION			
DECIMAL ±	1						
	2						
FRACTIONAL ±	3			DESIGN C.A.S.	SCALE NONE	MATERIAL	
	4			DRAWN C.A.S.	DATE 05/07/02	DRAWING NO. 03626-0500	
ANGULAR ±	5			CHK'D	APP'D		

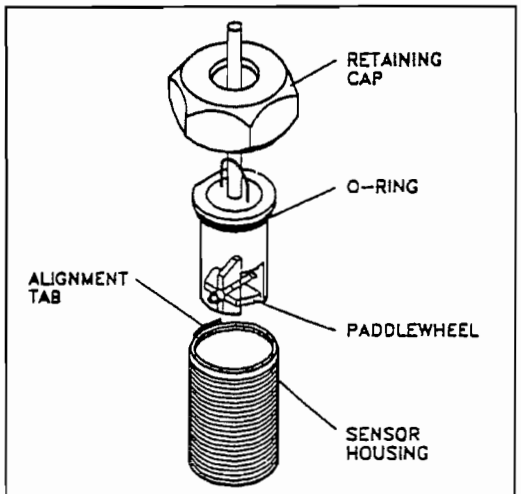
SENSOR
DATA SHEET

EPG E-Series
Liquid Flow Sensor

* Low cost
* 2 Year Warranty
* High reliability
* High sensitivity
* Wide range 2 – 10,000 GPM
* Pipe sizes from ¾"- 14"
* Patented six blade, non-magnetic design
* Available in DELRIN or KYNAR
* One paddlewheel fits ALL SIZES
* Transmits up to 1000 feet without the need for additional amplifiers
* Direct logic pulse output
* Flow velocities range of 1.5 to 27 fps
* Operating pressure to 200 PSIG
* Liquid temperatures to 250° F



CROSS SECTION OF FLOW SENSOR



STANDARD E-SERIES ASSEMBLY

One major problem with most paddlewheel type flow sensors having magnets in the paddles is that metal particles tend to stick to the magnets. The collecting material then causes a change in the flow characteristics in the paddle. To eliminate this problem, EPG Companies flow sensor uses a special axle and dual magnet drum design that takes the magnets out of the paddles. This dual magnetic drum design with rapidly changing polarity, along with fluid velocity causes the metallic particles to drop off into the flow stream and are swept away.

 © 2009 EPG Companies Inc.

INSTALLATION HINTS

1. Pipe must be full for accurate reading.

2. Minimum velocity is 1.5 ft./second. Recommended maximum velocity is 27 ft./second.

3. The flow must be uniform at the point where the flow sensor is installed or an incorrect reading will result. To accommodate a uniform flow allow at least ten (10) pipe diameters upstream and five (5) pipe diameters downstream of the flow sensor. Non-uniform flow is often caused by elbows, partially open valves or an increase in pipe diameter.

Model Number	Nominal Pipe Size	Recommended Range 1.5 ft/sec Flow Rate GPM	27 ft/sec Flow Rate GPM
EP 075	¾"	2.0	37.2
EP 100	1"	3.7	66.2
EP 125	1¼"	5.7	103.4
EP 150	1½"	8.3	148.8
EP 200	2"	14.7	264.6
EP 250	2½"	23.0	413.4
EP 300	3"	33.1	595.4
EP 400	4"	58.8	1058.4
EP 500	5"	91.9	1653.8
EP 600	6"	132.3	2381.4

 © 2009 EPG Companies Inc.

Flow Meter Operation

EPG's meter system is an 8 digit Flow Rate/Totalizer. The meter counts pulses from a flow sensor and converts this information into flow rate and total flow using programmed scaling factors.

The meter features menu driven programming to simplify meter set-up. The meter stores parameters entered into non-volatile memory. This memory retains the parameters even when power to the panel is shut off.

Figure 1 shows the meter display and keypad and gives a brief description of each key's function.

Two Line LCD Display - Shows totalizer and rate values when the unit is in the run mode. Displays programming information when the unit is in the program mode.

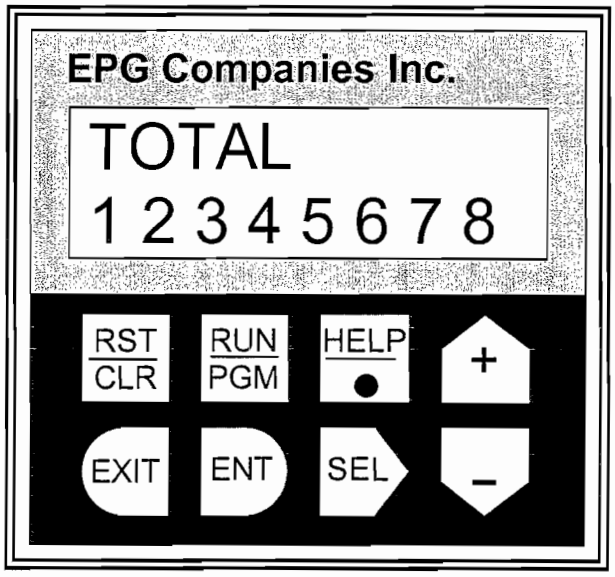


Figure 1. Meter Display and Keypad

 © 2009 EPG Companies Inc.

Key Functions

Reset/Clear Key - This key can be programmed to reset the totalizer when in the run mode. In the program mode it zeros numeric data that is selected for editing.

Run/Program Key - Press this key followed by the Enter key (ENT) to enter the program mode. Pressing this key while in the program mode returns the control to the run mode.

Help Key - In the run mode this key causes the Help Screens to be displayed. In the program mode this key is used to set the decimal point positions for totalizer and rate scaler displays.

Up Arrow/Plus (+) Key - In the run mode this key is used to select one of the three different display screens. In the program mode this key is used to step vertically up through the menus and increment the value of selected digits when changing numeric values.

Exit Key - This key is used in the program mode to exit program changes that have been selected but not yet entered.

Enter Key - This key is used in the program mode to cause the displayed program changes to be entered.

Select Key - This key is used in the program to move into more detailed menus and select the digits of numeric values needed for programming.

Down Arrow/Minus (-) Key - In the run mode this key is used to select one of the two different display screens. In the program mode this key is used to step vertically down through the menus and decrease the value of selected digits when changing numeric values.

Program Scalers:

Setting	Value	Function
C DEC PT	- - - - - -	Sets decimal point to the right of the last digit on the TOTAL Display.
R DEC PT	- - - - - -	Sets decimal point to the right of the last digit on the FLOW RATE Display.
C SCALER	See Below	Used to convert sensor pulses into Total Gallons.
R SCALER	See Below	Used to convert sensor pulses into Gallons/Minute.

Program Options:

Setting	Value	Function
RST KEY	RST EDG	Reset Key will Clear Totalizer Count.

Tables 1 and 2 show the keystroke operations necessary to change scale parameters and "Reset Key" enable/disable function.

 © 2009 EPG Companies Inc.

Flow meter setup procedures for scalers

STEP NO.	ACTION
1	Press **Run/PGM** to exit "Run" mode.
2	Press **ENT** to enter "Program" mode.
3	Press – to scroll through main menu. Find "Program Scalers" on the meter display.
4	Press **SEL** to enter "SCALERS" menu.
5	Press – to scroll the "SCALERS" menu and bring up the "C SCALER" option on the meter display.
6	Press **SEL** to select the "C SCALER" and begin operation on the left most digit of the "C SCALER" value. Use the + and – keys to increase or decrease the digit to achieve the desired number. Press **SEL** to enter this digit and move to the next digit. Repeat this step until the meter displays the desired value for the "C SCALER"
7	Press **ENT** to enter the "C SCALER " value into non-volatile memory.
8	Press – to display the "C DEC PT" option. Use the **SEL** key to select the last dash on the right as displayed on the meter. Use the **HELP/.** key to place the decimal point to the right of this position (decimal point will not be visible).
9	Press **ENT** to enter this selection into memory.
10	Press – to bring up the "R SCALER" option on the meter display.
11	Press **SEL** to select the "R SCALER" and begin operation on the left most digit of the "R SCALER" value. Use the + and – keys to increase or decrease the digit to achieve the desired number. Press **SEL** to enter this digit and move to the next digit. Repeat this step until the desired value for the "R SCALER" is in the meter display. Also use the **SEL** and **HELP/.** Keys to position the decimal point to the desired position.
12	Press **ENT** to enter this value into the non-volatile memory.
13	Press – to display the "R DEC PT" option. Use the **SEL** key to select the last dash on the right as displayed on the meter. Use the **HELP/.** key to place the decimal point to the right of this position (decimal point will not be visible).
14	Press **ENT** to enter this selection into non-volatile memory.
15	Press **EXIT** to exit "Program" mode.
16	Press **RUN/PGM** to enter "Run" mode.

Table 1. Flow Meter Scaler Sequence

 © 2009 EPG Companies Inc.

Flow meter setup procedures for reset key

STEP NO.	ACTION
1	Press **Run/PGM** to exit "Run" mode.
2	Press **ENT** to enter "Program" mode.
3	Press + to scroll through main menu. Find "Program Options" on the meter display.
4	Press **SEL** to enter "OPTIONS" menu.
5	Press + to scroll the "OPTIONS" menu and bring up the "RST KEY" option on the meter display.
6	Press **SEL** to select the "RST KEY" menu.
7	Press + to display the desired key option. Options include: RST KEY DISABLED — This option prevents the reset key from clearing the totalizer count. RST KEY RST EDG — This option allows clearing of the totalizer count using the reset key.
8	Press **ENT** to select the desired option.
9	Press **EXIT** to exit "Program" mode.
10	Press **RUN/PGM** to enter "Run" mode.

Table 2. Reset Key Programming Sequence

The programmed scaling factors used are dependent upon the inside pipe diameter of the flow sensor tube. Tables 3 to 6 list the various scaling factors used for the different diameter (nominal O.D.) and schedule (wall thickness) of Stainless Steel and PVC pipes.

Pipe Size	C SCALER	R SCALER
1.0" Low Flow	.01808	1.0849
1.00	.02996	1.7973
1.25	.05184	3.1105
1.50	.07056	4.2338
2.00	.11631	6.9784
2.50	.16595	9.9567
3.00	.25623	15.374
4.00	.44124	26.474
6.00	1.0014	60.081
8.00	1.7340	104.04

Table 3. Flow Meter Settings – Stainless Steel Schedule 40

 © 2009 EPG Companies Inc.

Pipe Size	C SCALER	R SCALER
1.0" Low Flow	.01808	1.0849
1.00	.02493	1.4959
1.25	.04446	2.6677
1.50	.06125	3.6750
2.00	.10235	6.1409
2.50	.14690	8.8140
3.00	.22894	13.736
4.00	.39849	23.909
6.00	.90348	54.209
8.00	1.5827	94.963

Table 4. Flow Meter Settings – Stainless Steel Schedule 80

Pipe Size	C SCALER	R SCALER
1.00	.02996	1.7973
1.25	.05184	3.1105
1.50	.07056	4.2338
2.00	.11631	6.9784
2.50	.16595	9.9567
3.00	.25623	15.374
4.00	.44124	26.474
6.00	1.0014	60.081
8.00	1.7340	104.04

Table 5. Flow Meter Settings – PVC Schedule 40

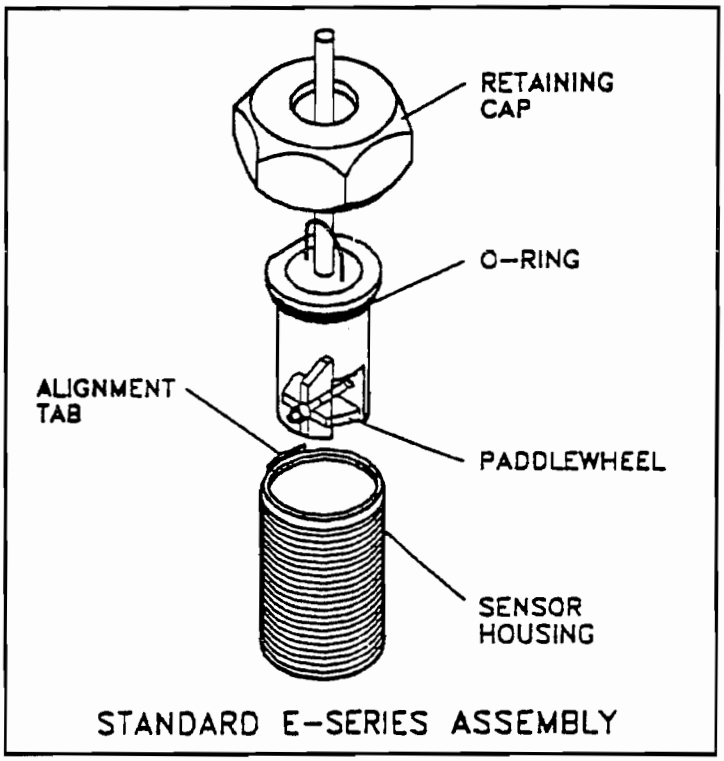
Pipe Size	C SCALER	R SCALER
1.00	.02493	1.4959
1.25	.04446	2.6677
1.50	.06125	3.6750
2.00	.10235	6.1409
2.50	.14690	8.8140
3.00	.22894	13.736
4.00	.39849	23.909
6.00	.90348	54.209
8.00	1.5827	94.963

Table 6. Flow Meter Settings – PVC Schedule 80

 © 2009 EPG Companies Inc.

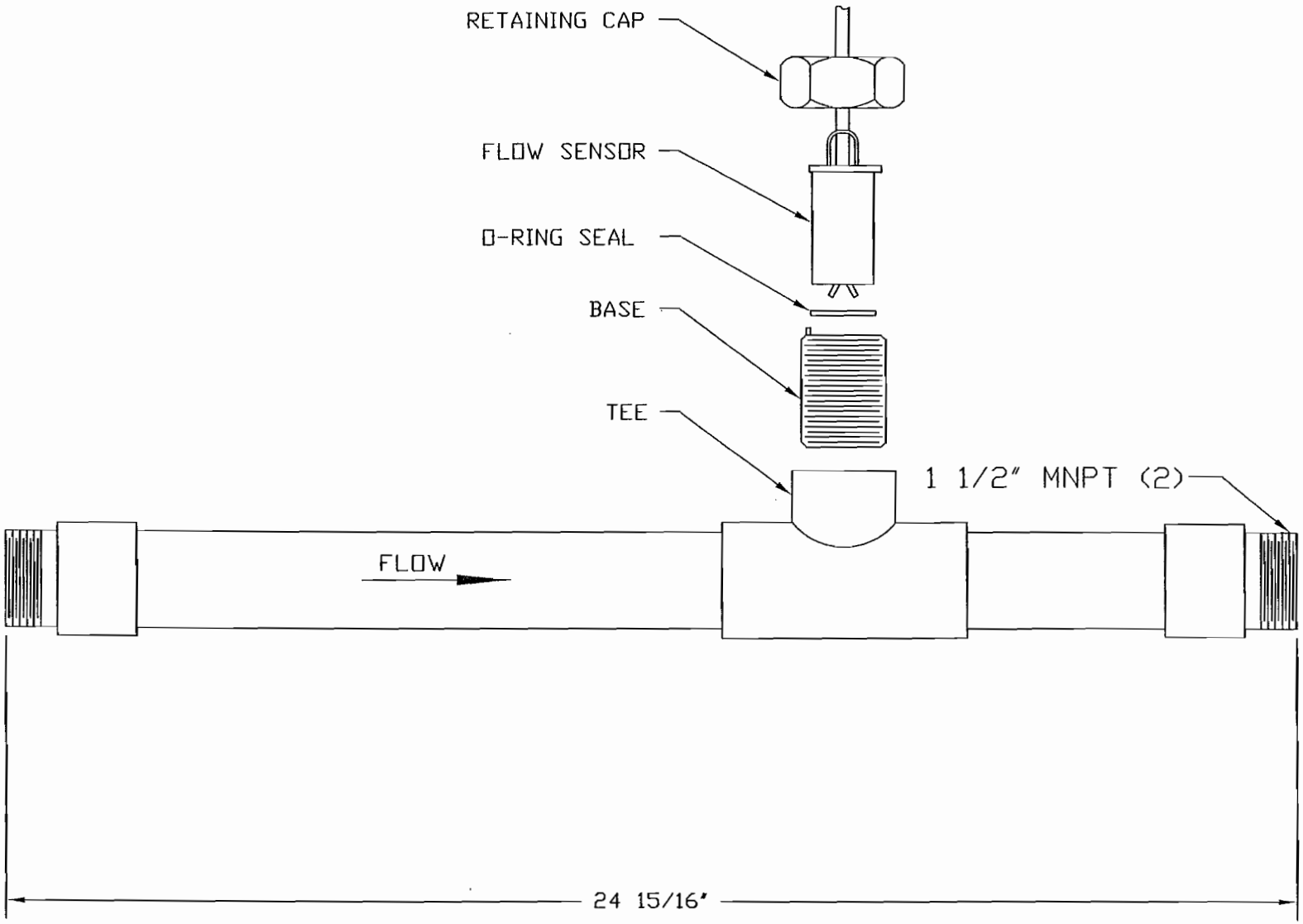
CAUTION

DO NOT OVERTIGHTEN PADDLEWHEEL FLOW SENSOR NUT!



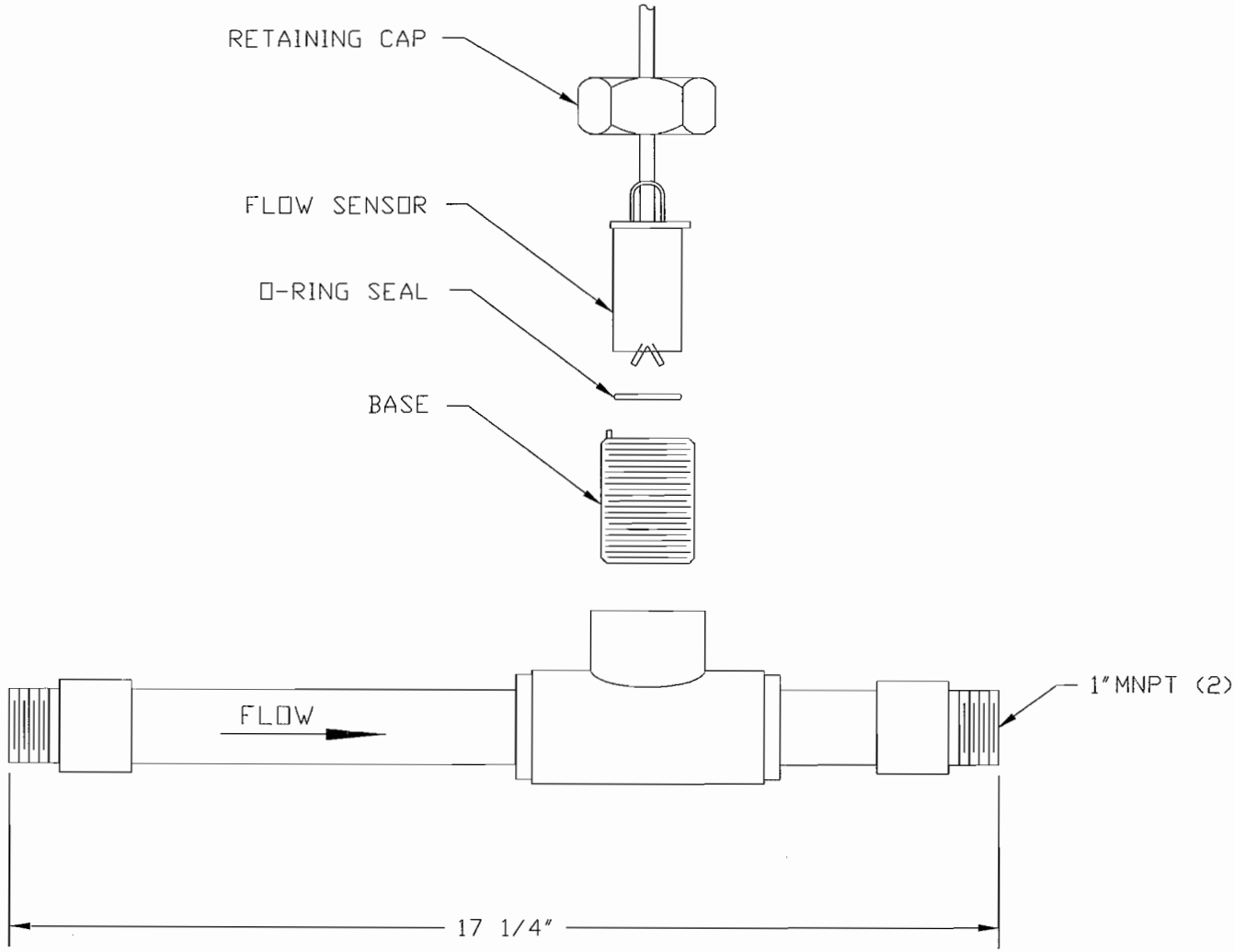
Damage can be caused to the paddlewheel sensor, o-ring, or sensor housing. Please hand tighten nut only!

EPG Companies Inc. © 2009



* NOTICE * © EPG Companies Inc. 2001
THIS DRAWING IS THE PROPERTY OF EPG COMPANIES FOR REFERENCE ONLY.

TOLERANCES (EXCEPT AS NOTED)	REVISIONS			EPG COMPANIES		
DECIMAL ± .06	NO.	DATE	BY	PVC FLOW SPOOL (1 1/2" MNPT ENDS)		
FRACTIONAL ± 1/16	1			DESIGN C.A.S.	SCALE NONE	MATERIAL
ANGULAR ± 1°	2			DRAWN C.A.S.	DATE 07/30/01	DRAWING NO. 05392-0000C
	3			CHK'D	APP'D	
	4					



JOB No.

* NOTICE * © EPG Companies Inc. 2006

THIS DRAWING IS THE PROPERTY OF EPG COMPANIES FOR REFERENCE ONLY.

TOLERANCES (EXCEPT AS NOTED)	REVISIONS			EPG COMPANIES			
DECIMAL ± .06	NO.	DATE	BY	1" PVC,SCH.40, FLOW SPOOL (W/1"MNPT ENDS)			
FRACTIONAL ± 1/16	1			DESIGN C.A.S.	SCALE 4"=1'	MATERIAL	
ANGULAR ± 1°	2			DRAWN C.A.S.	DATE 11/01/06	DRAWING NO 07761-0000C	
	3			CHK'D	APP'D		
	4						
	5						

LIMITED WARRANTY

This agreement shall be deemed to have been entered into in the State of Minnesota, and shall be construed in accordance with the laws of the State of Minnesota, including Minnesota's enactment of the Uniform Commercial Code. Buyer hereby stipulates and agrees that Hennepin County, Minnesota shall be the proper jurisdiction for adjudicating all claims and controversies arising from this agreement.

Products manufactured by EPG Companies Inc. are warranted for a period of 12 months from date of installation or eighteen (18) months from date of manufacture* to be free from defects of materials and workmanship. It is expressly agreed that the exclusive remedy under this warranty is limited solely to the repair or replacement, at the sole discretion of EPG, of the part that failed. The cost of labor for any field repairs is not covered by this warranty. EPG Companies will not be liable for any damage or wear due to abnormal conditions or improper installation.

Products not manufactured by EPG Companies Inc. are covered by the original manufacturer's warranty, which EPG Companies passes through to the purchaser. The actual manufacturer will make warranty determination.

To have a defective part repaired or replaced, you must return the defective product to EPG Companies. Please call (800) 443-7426 or (763) 424-2613 to obtain a Return Goods Authorization (RGA) number. Send defective product (freight prepaid) with RGA #, description of installation, installation data and failure date to EPG Companies Inc., 19900 County Rd. 81, Maple Grove, MN 55311.

EPG Companies will not be held liable for any incidental or consequential damages, losses or expenses incurred from installation, use or any other reason. THERE ARE NO OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING IMPLIED WARRANTIES OF EITHER FITNESS FOR A PARTICULAR PURPOSE OR OF MERCHANTABILITY, WHICH EXTEND BEYOND THOSE SPECIFICALLY LISTED HERE.

If equipment is to be stored for a period greater than six months, proper storage precautions must be taken if the warranty is to be maintained. Please call EPG Companies for specific requirements regarding product storage.

The following is a partial list of items, which will void the warranty:

- Opening the motor for any reason.
- Using undersized electrical wire.
- Making unauthorized circuit changes. Please call EPG Companies before making any changes.
- Operating a three phase submersible motor from single phase power through a phase converter unless 3-leg ambient-compensated quick trip overload protectors are used and complete details are sent in writing to EPG Companies.

* To qualify for the delayed installation warranty you must contact EPG Companies Inc., at (800) 443-7426 or (763) 424-2613 within 60 days of purchase.

© EPG Companies Inc. 2009

EPG Companies Inc.

SUBMITTAL ACCEPTANCE FORM

IMPORTANT NOTICE: These submittals have been provided for your prompt review. **Your order will not be entered into production until we receive this signed acceptance form.** Shipment of your order **will not be scheduled** until after we receive this submittal acceptance form.

Submitted to: Entact Environmental Services, Inc. – Henderson, NV
(Company Name)

Date of Submittals: 5-20-09

Submittals Accepted by: _____

Print Name: _____

Title: _____

Date of Acceptance: _____

EPG Job No.: 09-9356

Return to: EPG Companies Inc.
P.O. Box 427
Rogers, MN 55374
Fax (763) 493-4812

APPENDIX B

EPG Companies Inc.

Operations & Maintenance Manual

FOR

Entact Environmental Services Inc. Henderson, NV

EPG Job #09-9356

Operations & Maintenance Manual
Index

- List of EPG Equipment

- Sump Pump System Design/As-Built Installation Information by Phase

    - Phase I Engineer's Specification
    - Phase I As-Built Control Panel Schematics
    - Phase I Installation Records
    - Phase I As-Built Control Panel Setup Parameters
    - Phase I As-Built Photos

    - Phase II Engineer's Specification
    - Phase II As-Built Control Panel Schematics
    - Phase II Installation Records
    - Phase II As-Built Control Panel Setup Parameters
    - Phase II As-Built Photos

    - Phase IIIB Engineer's Specification
    - Phase IIIB As-Built Control Panel Schematics
    - Phase IIIB Installation Records
    - Phase IIIB As-Built Control Panel Setup Parameters
    - Phase IIIB As-Built Photos

    - Phase V Engineer's Specification
    - Phase V As-Built Control Panel Schematics
    - Phase V Installation Records
    - Phase V As-Built Control Panel Setup Parameters
    - Phase V As-Built Photos

- Installation / O&M Instructions

- Pump Operation Standard Operating Procedures

List of EPG Equipment Installed

EPG Companies Inc.

List of Equipment

Entact Environmental Services, Inc. – Henderson, NV

EPG Job # 09-9356

Phase 1 Control Panel and Pumps

1 each L975PTG

PumpMaster control panel to operate (1)ea. 1/2 HP 230 VAC 1 phase motor and (1)ea. 3/4 HP 230 VAC 1 phase motor independently via generator supplied power. Includes LevelMaster level control meters with simulators, 2 ea. flow meters, pump call light, voltage monitor and disconnect for 12 volt DC battery backup, includes 12 Volt DC terminals. Enclosure is rated NEMA 4.

Note: Panel logic- 12 volt DC level meters call for either pump, operator turns on site supplied generator, pump called will run, flow meters will register.
Note: Site will need to supply marine batteries, battery boxes, cables and hardwire to control panel.

LCRS Pump

1 each WSDPT5-3

EPG SurePump patented, wheeled, stainless steel sump drainer with a 3/4 HP 230 VAC 1 phase motor. Includes 110' of 14 AWG jacketed motor lead, submersible level sensor with 110' lead, and a 110' length of 1/8" cable with clamps.

Vadose Pump

1 each WSDPT2-3

EPG SurePump patented, wheeled, stainless steel # 4 sump drainer with a 1/2 HP 230 VAC 1 phase motor. Includes 110' of 14 AWG jacketed motor lead, submersible level sensor with 110' lead, and a 110' length of 1/8" stainless steel suspension cable with clamps.

Phase 2 Control Panel and Pumps

1 each L975PTG

PumpMaster control panel to operate (1)ea. 1/2 HP 230 VAC 1 phase motor and (1)ea. 3/4 HP 230 VAC 1 phase motor independently via generator supplied power. Includes LevelMaster level control meters with simulators, 2 ea. flow meters, pump call light, voltage monitor and disconnect for 12 volt DC battery backup, includes 12 Volt DC terminals. Enclosure is rated NEMA 4.

Note: Panel logic- 12 volt DC level meters call for either pump, operator turns on site supplied generator, pump called will run, flow meters will register.
Note: Site will need to supply marine batteries, battery boxes, cables and hardwire to control panel.

© EPG Companies Inc. 2009

LCRS Pump

1 each WSDPT5-3

EPG SurePump patented, wheeled, stainless steel sump drainer with a 3/4 HP 230 VAC 1 phase motor. Includes 120' of 14 AWG jacketed motor lead, submersible level sensor with 120' lead, and a 120' length of 1/8" cable with clamps.

Vadose Pump

1 each WSDPT2-3

EPG SurePump patented, wheeled, stainless steel # 4 sump drainer with a 1/2 HP 230 VAC 1 phase motor. Includes 120' of 14 AWG jacketed motor lead, submersible level sensor with 120' lead, and a 120' length of 1/8" stainless steel suspension cable with clamps.

Phase 3 Control Panels and Pumps

2 each L975PTG

PumpMaster control panel to operate (1)ea. 1/2 HP 230 VAC 1 phase motor and (1)ea. 3/4 HP 230 VAC 1 phase motor independently via generator supplied power. Includes LevelMaster level control meters with simulators, 2 ea. flow meters, pump call light, voltage monitor and disconnect for 12 volt DC battery backup, includes 12 Volt DC terminals. Enclosure is rated NEMA 4.

Note: Panel logic- 12 volt DC level meters call for either pump, operator turns on site supplied generator, pump called will run, flow meters will register.
Note: Site will need to supply marine batteries, battery boxes, cables and hardwire to control panel.

LCRS Pumps

2 each WSDPT5-3

EPG SurePump patented, wheeled, stainless steel sump drainer with a 3/4 HP 230 VAC 1 phase motor. Includes 70' of 14 AWG jacketed motor lead, submersible level sensor with 70' lead, and a 70' length of 1/8" cable with clamps.

Vadose Pumps

2 each WSDPT2-3

EPG SurePump patented, wheeled, stainless steel # 4 sump drainer with a 1/2 HP 230 VAC 1 phase motor. Includes 70' of 14 AWG jacketed motor lead, submersible level sensor with 70' lead, and a 70' length of 1/8" stainless steel suspension cable with clamps.

 © EPG Companies Inc. 2009

Junction Boxes Power and Sensor

8 each BJBL600B
EPG Breakout Box, NEMA 4X non-metallic enclosure, junction box for 1 ea. level sensor. Includes desiccant dryer, bellows, and connection terminals.

8 each BJBP500
EPG Breakout Box, NEMA 4X non-metallic enclosure for 1 ea. motor lead, includes connection terminals.

4 each EP15P04M15M15S
EPG Paddlewheel Flow Sensor, 1.5", PVC schedule 40 flow sensor with MNPT 1.5" inlet end, MNPT 1.5" outlet end, and paddlewheel sensor with 25' lead.

4 each EP10P04M10M10S
EPG Flow Sensor, 1", SCH 40 PVC with 1" MNPT ends, and paddlewheel sensor with 25' lead.

 © EPG Companies Inc. 2009

Phase I
Engineer's Specification

ENGINEER'S SPECIFICATION

PHASE I LCRS

EPG WSDPT SurePump™ Wheeled Sump Drainer

for side slope riser installations with built-in level sensor

Furnish __1__ centrifugal submersible EPG WSDPT SurePump Wheeled Sump Drainer(s) (U.S. patented), Model WSDPT __5__ - __3__ with __3__ impeller stages. Each unit shall be suitable for side slope riser installation. Each unit shall be equipped with a __¾__ HP, submersible electric motor for operation on __230__ Volts, __1__ phase, 60 Hertz service with __110__ feet of power cable. Each SurePump Wheeled Sump Drainer shall have a __1 ½__ inch MNPT threaded discharge nozzle and be capable of delivering __25__ GPM at __50__ feet of TDH. Each SurePump will be fitted with __110__ feet of stainless steel lifting cable of sufficient strength to permit removal of the unit.

DESIGN

Each SurePump Wheeled Sump Drainer shall be capable of pumping contaminated ground water for spill recovery, leachate, condensate, and purge applications. A removable transmitter mount (patent pending) shall be installed at the center bottom of the Sump Drainer for liquid level control. The Sump Drainer shall permit the unit to "pump down" to within __8__ inches of the sump bottom without any loss of performance or damage to the pump. External "priming" shall not be required nor allowed. The Sump Drainer shall be equipped with a vent valve to assist with the evacuation of air from the Sump Drainer.

MATERIALS

Major components shall be made of 304 stainless steel, seal rings are to be made of E-Glide™, and bearings are to be E-Glide. In addition, all fasteners shall be 304 stainless steel.

CHECK VALVE

Each unit shall include a built-in check valve with non-metallic seat, and housing and disc of 304 stainless steel.

SHAFT

The shaft shall be of 304 stainless steel and rotate on E-Glide bearings that are fluid lubricated.

DIFFUSER CHAMBER

The diffuser chambers for each impeller shall be 304 stainless steel and fitted with E-Glide impeller seal rings.

IMPELLERS

The impeller(s) shall be closed and consist of 304 stainless steel.

MOTOR

The motor shall be a submersible, hermetically sealed Franklin motor in __Pollution Recovery__ construction. The motor shall be designed for continuous duty, capable of sustaining up to __100__ starts per day. The motor shall be connected to the pump via a motor adaptor and coupling in 304 stainless steel. Single phase motors in ½ HP to 1 HP only shall have thermal protection in the motor windings to protect the windings from overload. The unit will restart automatically after the motor cools down. Larger horsepower single phase motors and three phase motors shall have thermal protection located in the control panel that is manually reset.

MOTOR LEAD WIRE

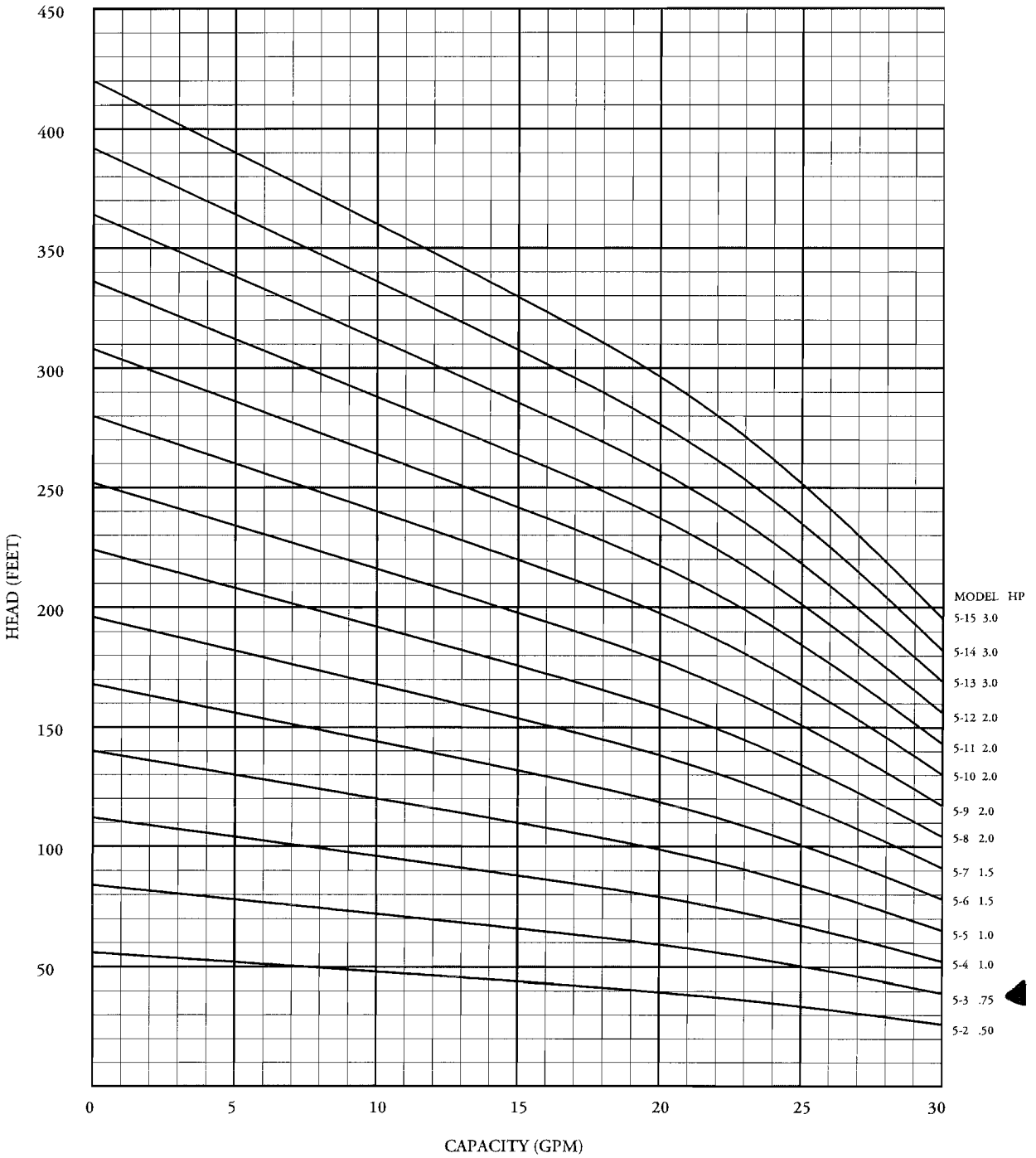
The lead wire shall be no-splice with EPG's "CP" waterproof and chemically resistant jacket over 600 Volt insulation and be of the length specified.

© 2009 EPG Companies Inc.
SurePump & E-Glide are Reg. TM of EPG Companies Inc.

SERIES 5 SurePump™

Flow Range 15-30 GPM

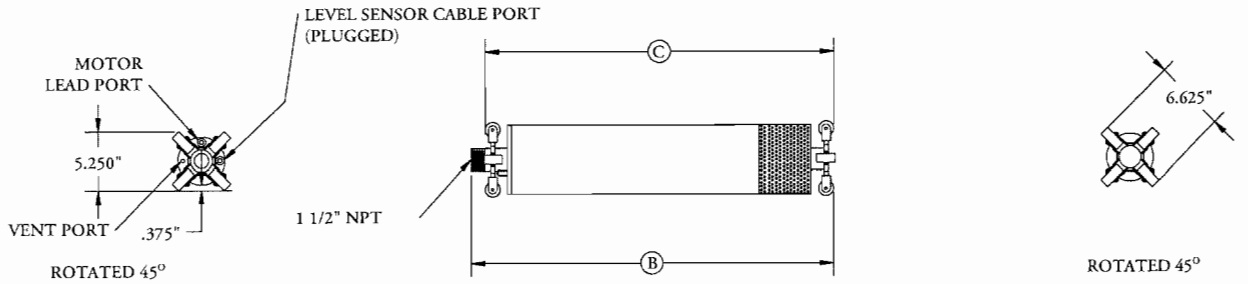
60 Hz



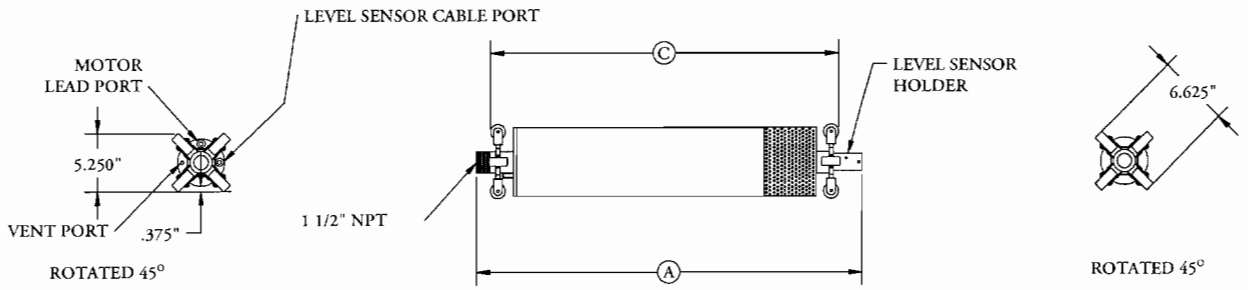
DATA SUBJECT TO CHANGE WITHOUT NOTICE

© 2009 EPG Companies Inc.
SurePump is a Reg. TM of EPG Companies Inc.

SERIES 5 SIZE 4 WHEELED SUMP DRAINER



WSD



WSDPT

MODEL	HP	PHASE	A	B	C	*APPROX. SHIPPING WEIGHT	
						WSD	WSDPT
5-2	0.50	1	31.02	29.90	29.15	61.47	66.47
5-2	0.50	3	31.02	29.90	29.15	61.47	66.47
5-3	0.75	1	32.98	31.86	31.11	66.24	71.24
5-3	0.75	3	32.98	31.86	31.11	66.24	71.24
5-4	1.00	1	34.90	33.78	33.03	70.98	75.98
5-4	1.00	3	34.90	33.78	33.03	70.98	75.98
5-5	1.00	1	35.73	34.61	33.86	71.88	76.88
5-5	1.00	3	35.73	34.61	33.86	71.88	76.88
5-6	1.50	1	38.43	37.31	36.56	79.22	84.22
5-6	1.50	3	36.56	35.44	34.69	72.77	77.77
5-7	1.50	1	39.26	38.14	37.39	80.12	85.12
5-7	1.50	3	37.39	36.27	35.52	73.67	78.67
5-8	2.00	1	41.59	40.47	39.72	85.17	90.17
5-8	2.00	3	40.09	38.97	38.22	81.01	86.01

MODEL	HP	PHASE	A	B	C	*APPROX. SHIPPING WEIGHT	
						WSD	WSDPT
5-9	2.00	1	42.42	41.30	40.55	86.07	91.07
5-9	2.00	3	40.92	39.80	39.05	81.90	86.90
5-10	2.00	1	43.25	42.13	41.38	86.96	91.96
5-10	2.00	3	41.75	40.63	39.88	82.80	87.80
5-11	2.00	1	44.08	42.96	42.21	87.86	92.86
5-11	2.00	3	42.58	41.46	40.71	83.69	88.69
5-12	2.00	1	44.91	43.79	43.04	88.75	93.75
5-12	2.00	3	53.41	52.29	51.54	92.35	97.35
5-13	3.00	1	54.24	53.12	52.37	119.24	124.24
5-13	3.00	3	51.24	50.12	49.37	105.91	110.91
5-14	3.00	1	55.07	53.95	53.20	120.14	125.14
5-14	3.00	3	52.07	50.95	50.20	106.81	111.81
5-15	3.00	1	55.90	54.78	54.03	121.03	126.03
5-15	3.00	3	52.90	51.78	51.03	107.70	112.70

NOTE: ALL DIMENSIONS ARE IN INCHES.

*SHIPPING WEIGHT INCLUDES
WSD: CRATE, 50' OF 14-4 MOTOR LEAD, 50' OF 1/8" SS CABLE.
WSDPT: CRATE, 50' OF 14-4 MOTOR LEAD, 50' OF 1/8" SS CABLE,
LEVEL SENSOR AND CABLE.

© 2009 EPG Companies Inc.
SurePump is a Reg. TM of EPG Companies Inc.

ENGINEER'S SPECIFICATION

EPG WSDPT SurePump™ Wheeled Sump Drainer

for side slope riser installations with built-in level sensor

PHASE I VADOSE

Furnish __1__ centrifugal submersible EPG WSDPT SurePump Wheeled Sump Drainer(s) (U.S. patented), Model WSDPT __2__ - __3__ with __3__ impeller stages. Each unit shall be suitable for side slope riser installation. Each unit shall be equipped with a __½__ HP, submersible electric motor for operation on __230__ Volts, __1__ phase, 60 Hertz service with __110__ feet of power cable. Each SurePump Wheeled Sump Drainer shall have a __1 ¼__ inch MNPT threaded discharge nozzle and be capable of delivering __10__ GPM at __50__ feet of TDH. Each SurePump will be fitted with __110__ feet of stainless steel lifting cable of sufficient strength to permit removal of the unit.

DESIGN

Each SurePump Wheeled Sump Drainer shall be capable of pumping contaminated ground water for spill recovery, leachate, condensate, and purge applications. A removable transmitter mount (patent pending) shall be installed at the center bottom of the Sump Drainer for liquid level control. The Sump Drainer shall permit the unit to "pump down" to within __8__ inches of the sump bottom without any loss of performance or damage to the pump. External "priming" shall not be required nor allowed. The Sump Drainer shall be equipped with a vent valve to assist with the evacuation of air from the Sump Drainer.

MATERIALS

Major components shall be made of 304 stainless steel, seal rings are to be made of E-Glide™, and bearings are to be E-Glide. In addition, all fasteners shall be 304 stainless steel.

CHECK VALVE

Each unit shall include a built-in check valve with non-metallic seat, and housing and disc of 304 stainless steel.

SHAFT

The shaft shall be of 304 stainless steel and rotate on E-Glide bearings that are fluid lubricated.

DIFFUSER CHAMBER

The diffuser chambers for each impeller shall be 304 stainless steel and fitted with E-Glide impeller seal rings.

IMPELLERS

The impeller(s) shall be closed and consist of 304 stainless steel.

MOTOR

The motor shall be a submersible, hermetically sealed Franklin motor in __Pollution Recovery__ construction. The motor shall be designed for continuous duty, capable of sustaining up to __100__ starts per day. The motor shall be connected to the pump via a motor adaptor and coupling in 304 stainless steel. Single phase motors in ½ HP to 1 HP only shall have thermal protection in the motor windings to protect the windings from overload. The unit will restart automatically after the motor cools down. Larger horsepower single phase motors and three phase motors shall have thermal protection located in the control panel that is manually reset.

MOTOR LEAD WIRE

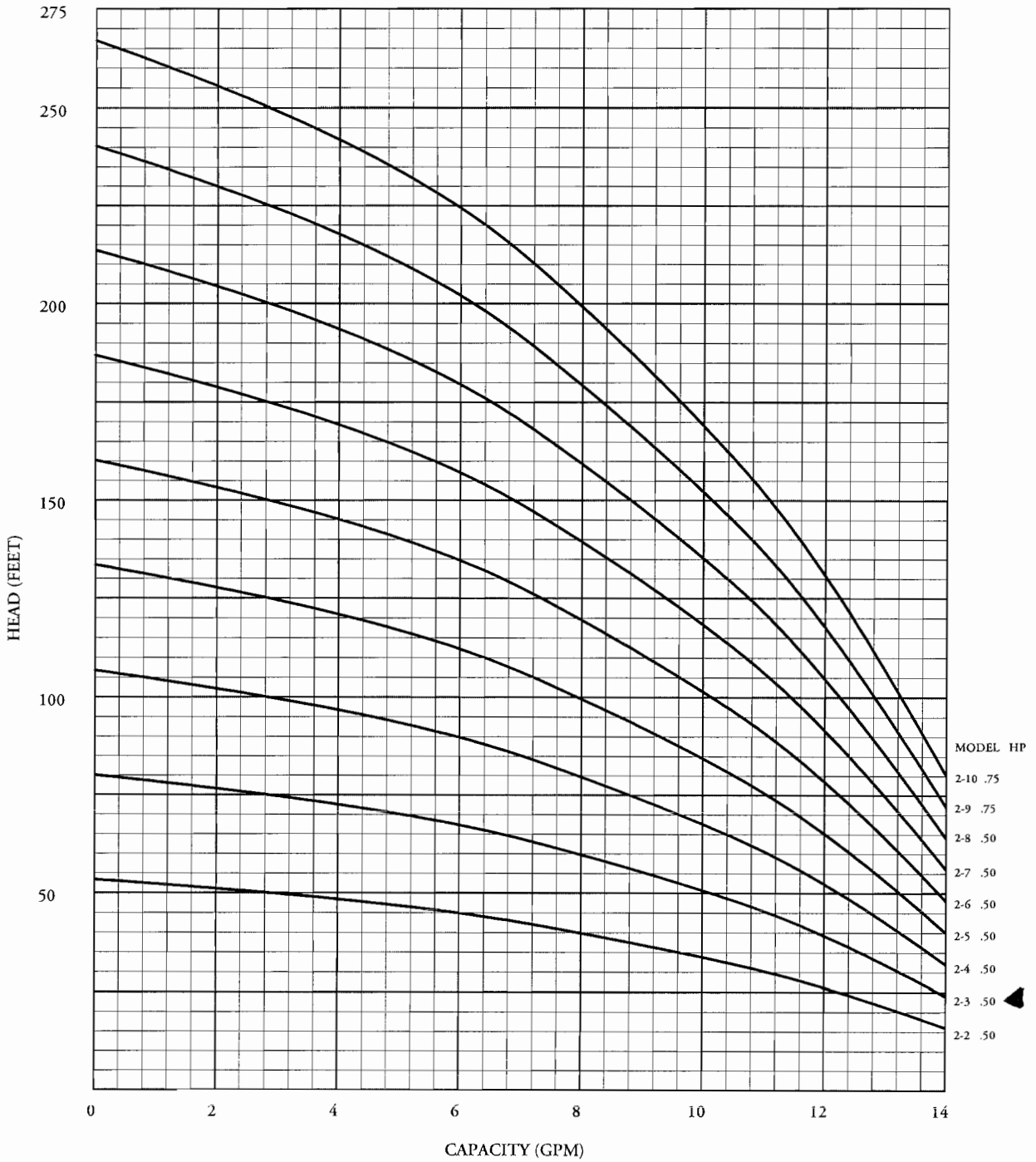
The lead wire shall be no-splice with EPG's "CP" waterproof and chemically resistant jacket over 600 Volt insulation and be of the length specified.

© 2009 EPG Companies Inc.
SurePump & E-Glide are Reg. TM of EPG Companies Inc.

SERIES 2 SurePump™

Flow Range 4-14 GPM

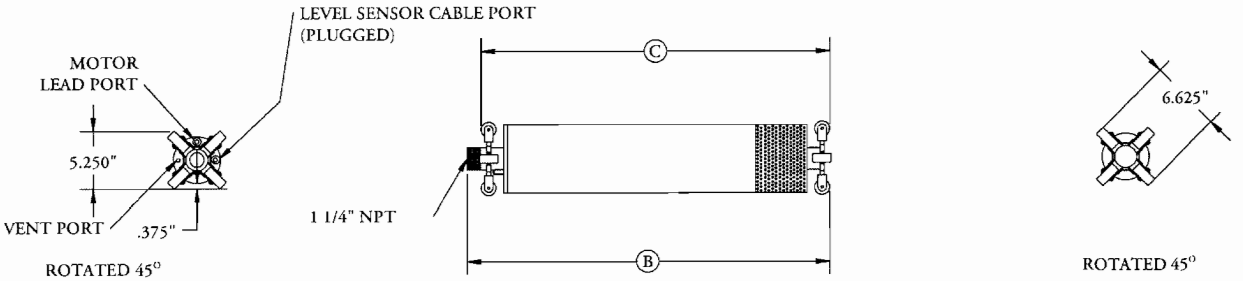
60 Hz



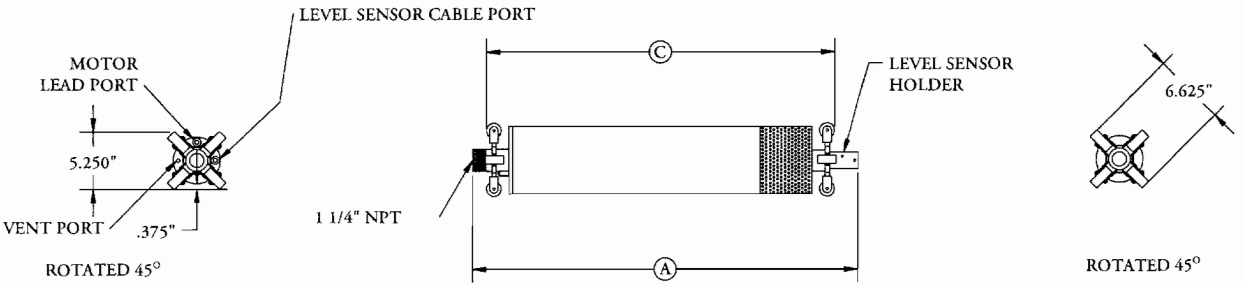
DATA SUBJECT TO CHANGE WITHOUT NOTICE

© 2009 EPG Companies Inc.
SurePump is a Reg. TM of EPG Companies Inc.

SERIES 2 SIZE 4 WHEELED SUMP DRAINER



WSD



WSDPT

MODEL	HP	PHASE	A	B	C	*APPROX. SHIPPING WEIGHT	
						WSD	WSDPT
2-2	0.50	1	31.02	29.90	29.15	61.47	66.47
2-2	0.50	3	31.02	29.90	29.15	61.47	66.47
2-3	0.50	1	31.85	30.73	29.98	62.37	67.37
2-3	0.50	3	31.85	30.73	29.98	62.37	67.37
2-4	0.50	1	32.68	31.56	30.81	63.26	68.26
2-4	0.50	3	32.68	31.56	30.81	63.26	68.26
2-5	0.50	1	33.51	32.39	31.64	64.15	69.15
2-5	0.50	3	33.51	32.39	31.64	64.15	69.15
2-6	0.50	1	34.34	33.22	32.47	65.05	70.05
2-6	0.50	3	34.34	33.22	32.47	65.05	70.05
2-7	0.50	1	35.17	34.05	33.30	65.94	70.94
2-7	0.50	3	35.17	34.05	33.30	65.94	70.94
2-8	0.50	1	36.00	34.88	34.13	66.84	71.84
2-8	0.50	3	36.00	34.88	34.13	66.84	71.84
2-9	0.75	1	37.96	36.84	36.09	71.61	76.61
2-9	0.75	3	37.96	36.84	36.09	71.61	76.61
2-10	0.75	1	38.79	37.67	36.92	72.50	77.50
2-10	0.75	3	38.79	37.67	36.92	72.50	77.50

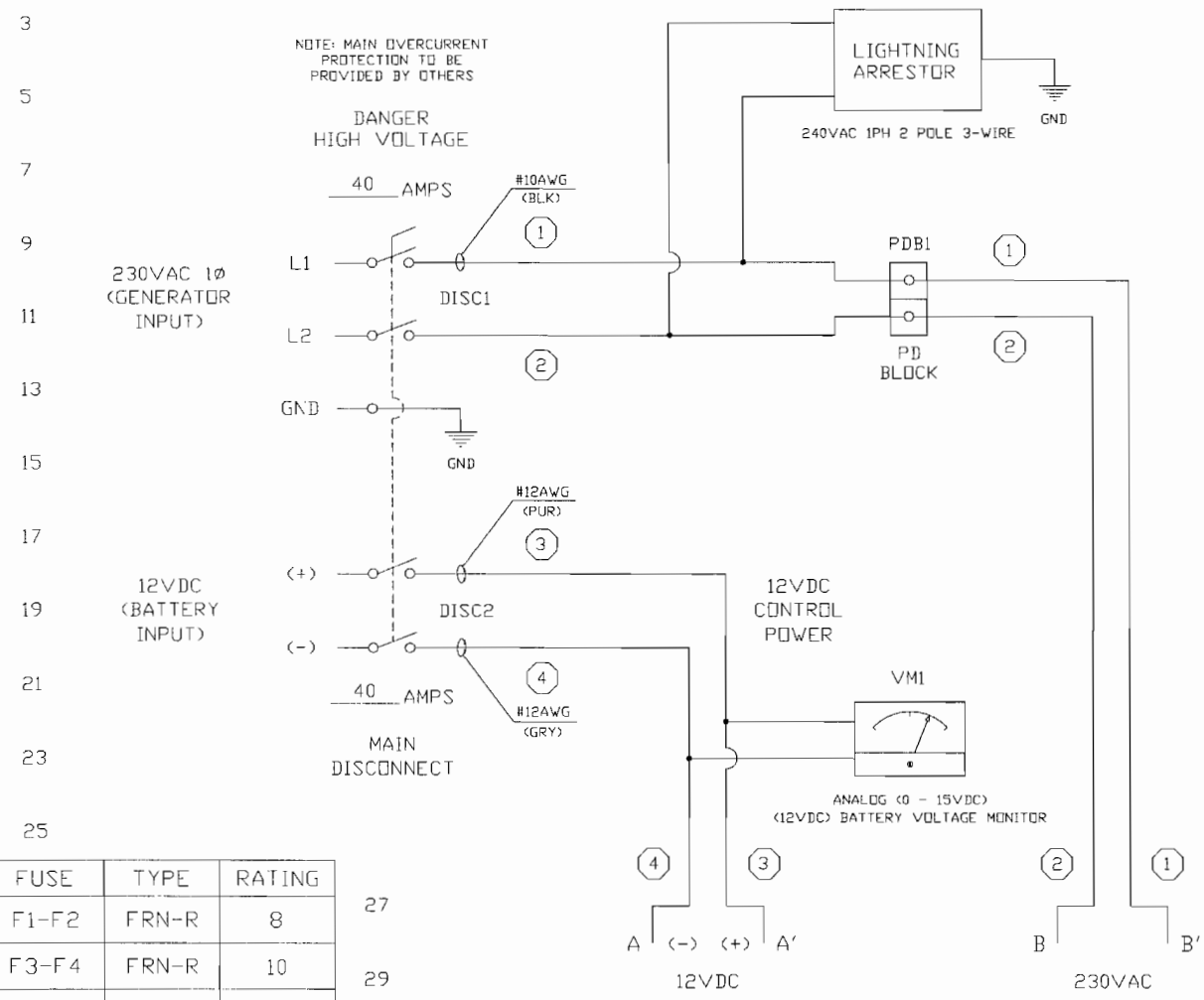
NOTE: ALL DIMENSIONS ARE IN INCHES.

*SHIPPING WEIGHT INCLUDES
WSD: CRATE, 50' OF 14-4 MOTOR LEAD, 50' OF 1/8" SS CABLE.
WSDPT: CRATE, 50' OF 14-4 MOTOR LEAD, 50' OF 1/8" SS CABLE,
LEVEL SENSOR AND CABLE.

© 2009 EPG Companies Inc.
SurePump is a Reg. TM of EPG Companies Inc.

Phase I
As-Built Control Panel Schematics

MOTOR	HP	VOLTAGE	FLA	FUSE SIZE
VADOSE PUMP	1/2	230	5.0	8A
LCRS PUMP	3/4	230	6.8	10A



PHASES 1, 2 & 3B CONTROL PANEL AND PUMPS

FIELD WIRING TERMINALS

LINE (GENERATOR)

L1, L2 — 230VAC 1Ø 60Hz, 15.05 AMPS

GND — GROUND

LINE (BATTERY)

(+), (-) — 12VDC, 0.91 AMPS

FUSE	TYPE	RATING
F1-F2	FRN-R	8
F3-F4	FRN-R	10
F5-F6	FRN-R	2-1/2
F7	FNM	1-1/4
F8	FNM	3-1/2
F9	ABC	1-1/2
F10	MDL	1/2
F11	ABC	1/2
F12	ABC	1/2

FOR NOTES AND REVISIONS SEE SHEET 8

AS BUILT

JOB No. 09-9356A

* NOTICE * © EPG Companies Inc. 2009
THIS DRAWING IS THE PROPERTY OF EPG COMPANIES FOR REFERENCE ONLY.

TOLERANCES (EXCEPT AS NOTED)
DECIMAL ±
FRACTIONAL ±
ANGULAR ±

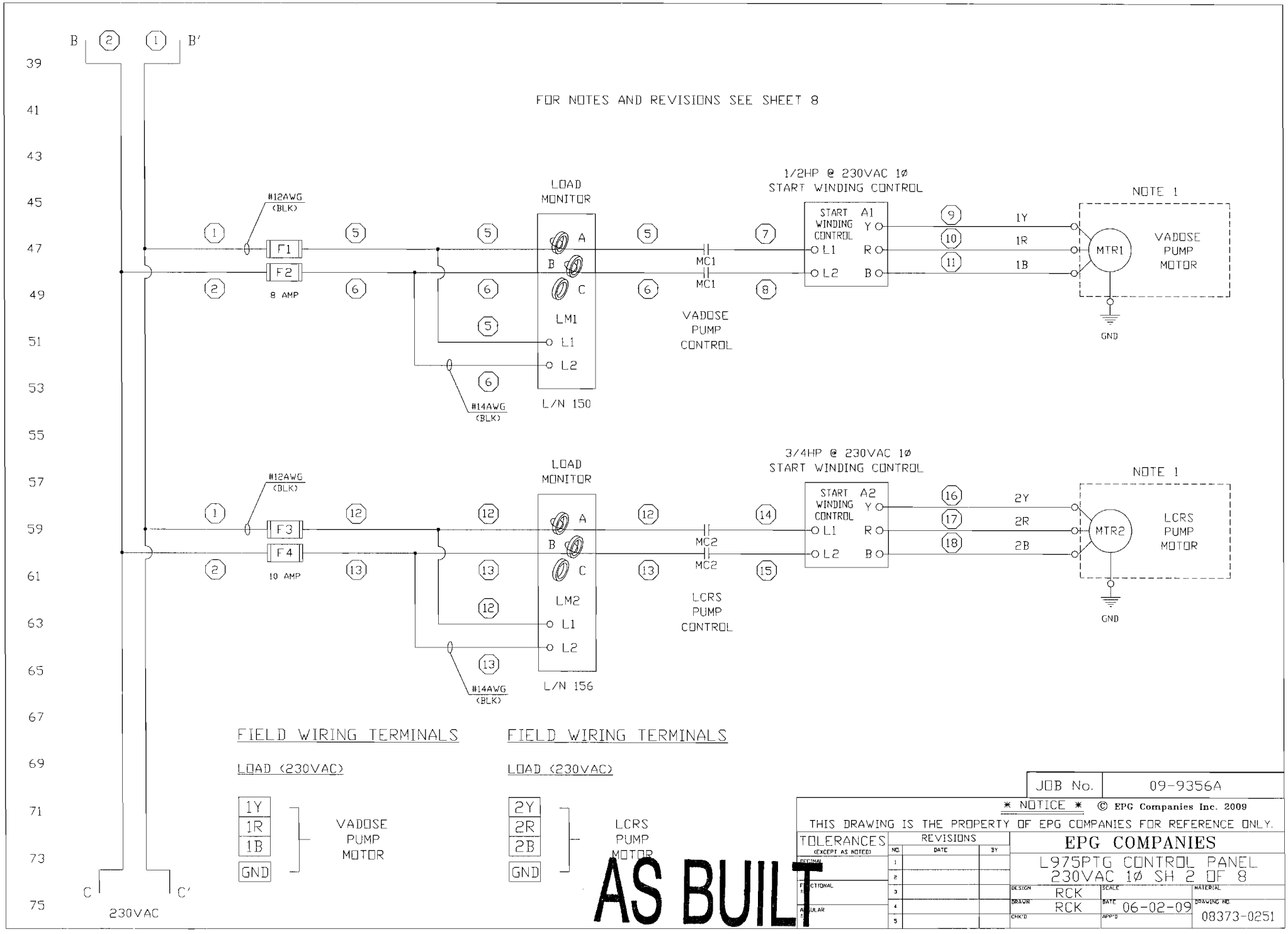
REVISIONS

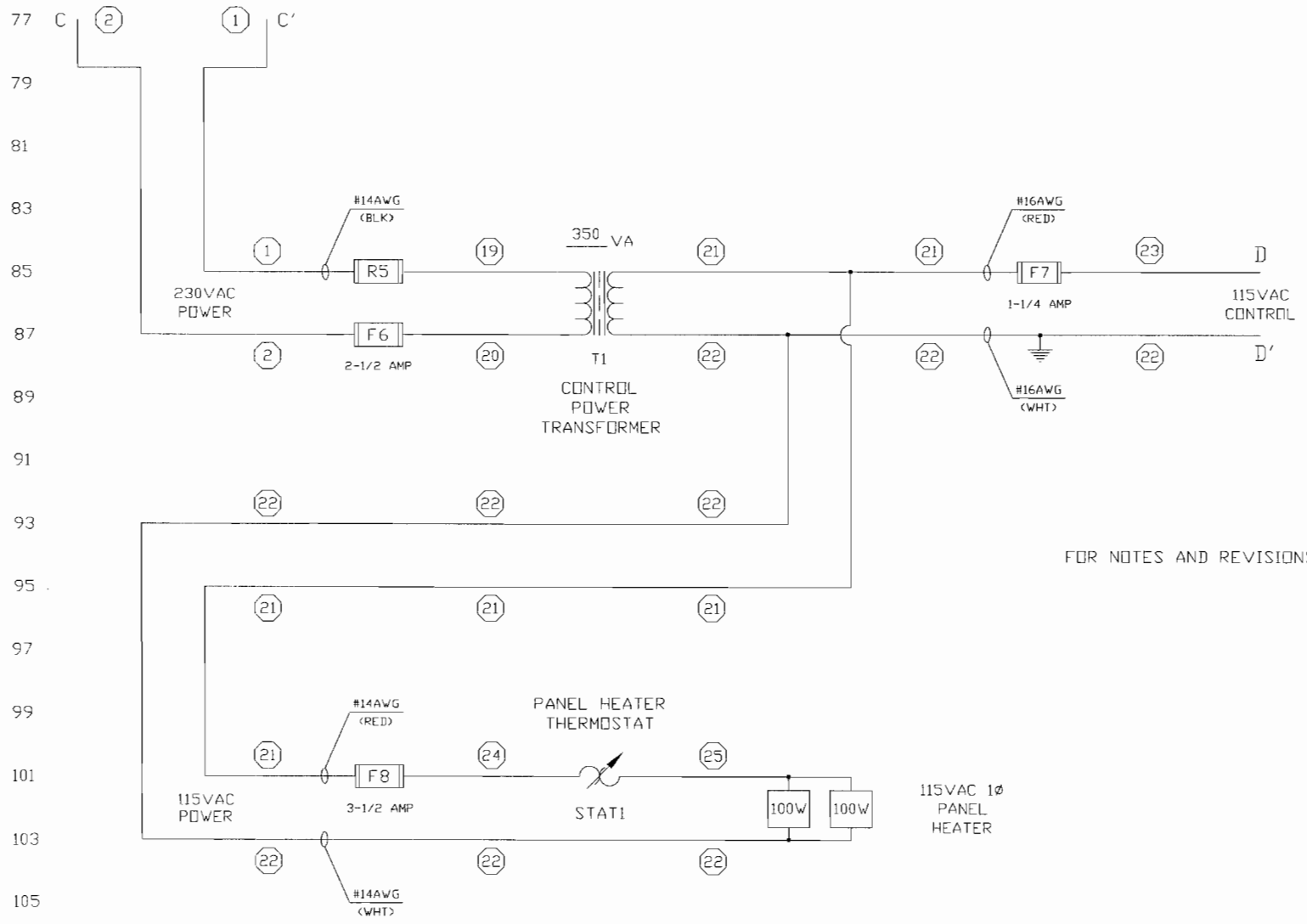
NO.	DATE	BY
1		
2		
3		
4		
5		

EPG COMPANIES

L975PTG CONTROL PANEL 230VAC 1Ø SH 1 OF 8

DESIGN	RCK	SCALE	MATERIAL
DRAWN	RCK	DATE 06-02-09	DRAWING NO. 08373-0250
CHK'D		APP'D	


B
B'
C
C'
230VAC
FOR NOTES AND REVISIONS SEE SHEET 8
#12AWG (BLK)
F1
F2
8 AMP
LOAD MONITOR
A
B
C
LM1
L1
L2
L/N 150
#14AWG (BLK)
MC1
MC1
VADOSE PUMP CONTROL
1/2HP @ 230VAC 1Ø
START WINDING CONTROL
START WINDING CONTROL
A1
Y
R
B
L1
L2
1Y
1R
1B
NOTE 1
MTR1
VADOSE PUMP MOTOR
GND
#12AWG (BLK)
F3
F4
10 AMP
LOAD MONITOR
LM2
L/N 156
#14AWG (BLK)
MC2
MC2
LCRS PUMP CONTROL
3/4HP @ 230VAC 1Ø
START WINDING CONTROL
A2
2Y
2R
2B
MTR2
LCRS PUMP MOTOR
GND
FIELD WIRING TERMINALS
LOAD (230VAC)
1Y
1R
1B
GND
VADOSE PUMP MOTOR
FIELD WIRING TERMINALS
LOAD (230VAC)
2Y
2R
2B
GND
LCRS PUMP MOTOR
AS BUILT
JOB No.
09-9356A
* NOTICE * © EPG Companies Inc. 2009
THIS DRAWING IS THE PROPERTY OF EPG COMPANIES FOR REFERENCE ONLY.
TOLERANCES (EXCEPT AS NOTED)
REVISIONS
NO. DATE BY
EPG COMPANIES
L975PTG CONTROL PANEL
230VAC 1Ø SH 2 OF 8
DESIGN RCK
DRAWN RCK
DATE 06-02-09
SCALE
MATERIAL
DRAWING NO. 08373-0251



FOR NOTES AND REVISIONS SEE SHEET 8

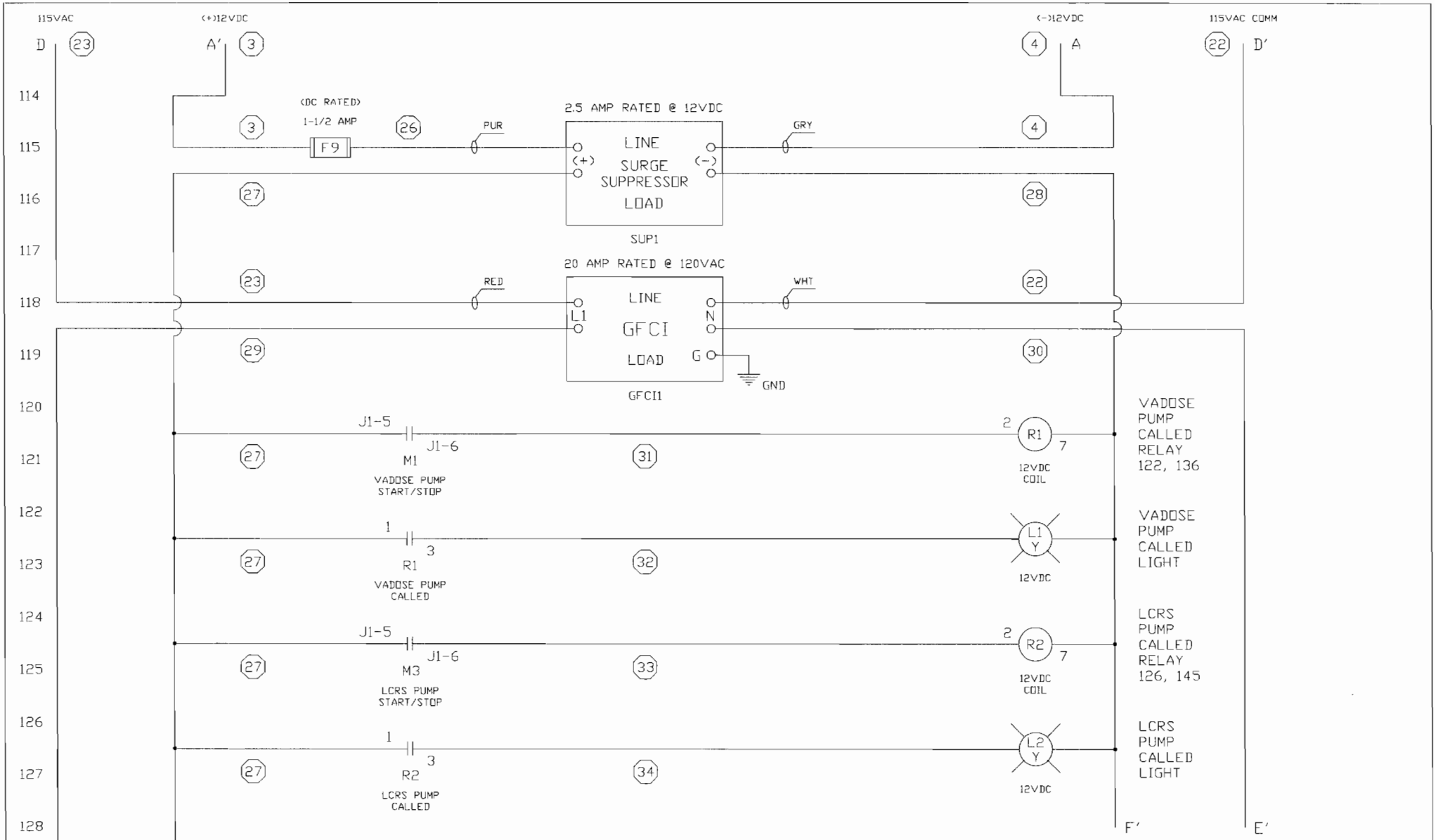
AS BUILT

JOB No.	09-9356A

* NOTICE * © EPG Companies Inc. 2009

THIS DRAWING IS THE PROPERTY OF EPG COMPANIES FOR REFERENCE ONLY.

TOLERANCES (EXCEPT AS NOTED)	REVISIONS NO.	DATE	BY	EPG COMPANIES
DECIMAL ±	1			L975PTG CONTROL PANEL 230VAC 1Ø SH 3 OF 8
FRACTIONAL ±	2			
ANGULAR ±	3			DESIGN RCK · SCALE · MATERIAL
	4			DRAWN RCK · DATE 06-02-09 · DRAWING NO. 08373-0252
	5			CHK'D · APP'D



FOR NOTES AND REVISIONS SEE SHEET 8

AS BUILT

JOB No.	09-9356A

* NOTICE * © EPG Companies Inc. 2009

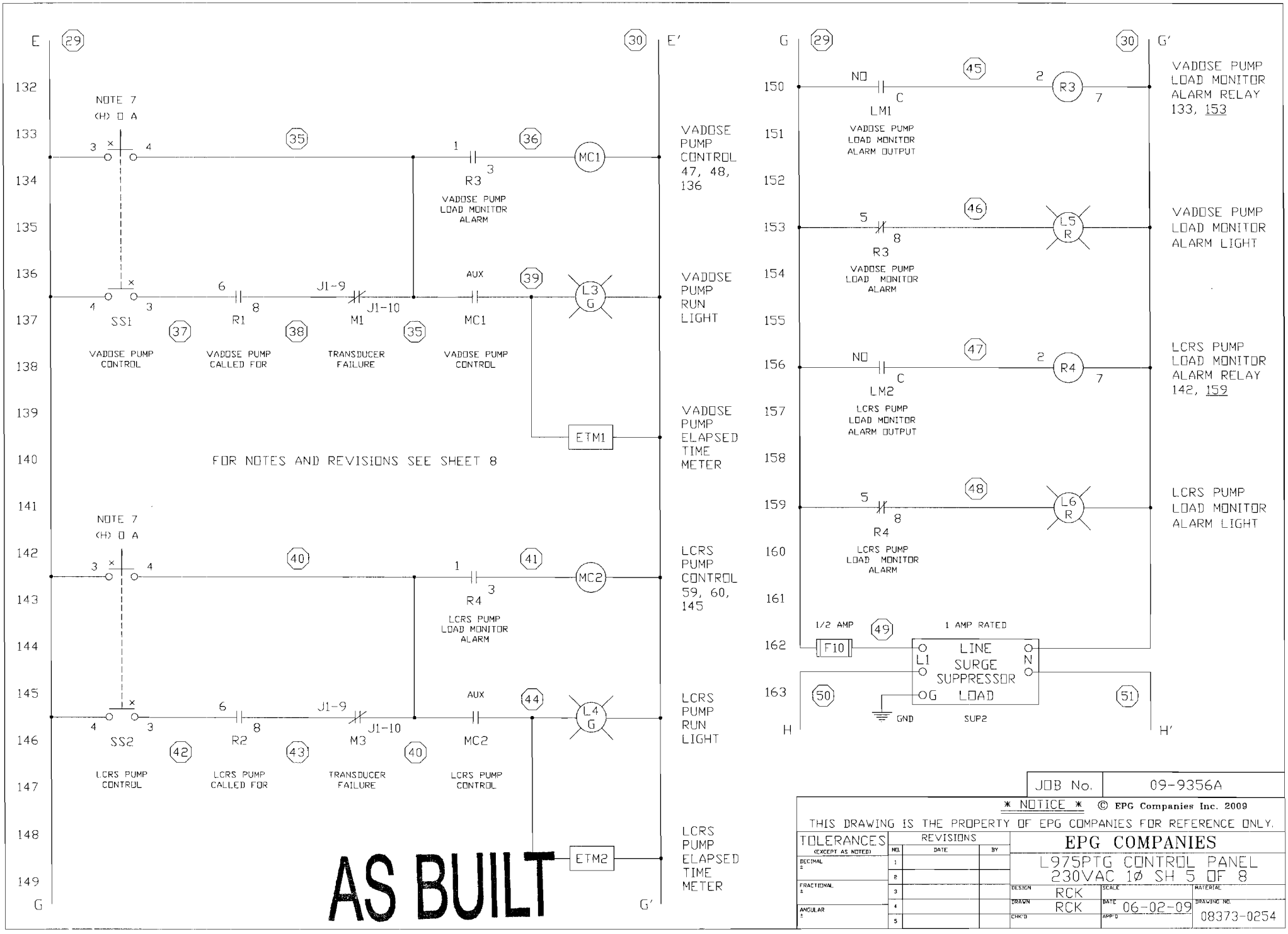
THIS DRAWING IS THE PROPERTY OF EPG COMPANIES FOR REFERENCE ONLY.

TOLERANCES (EXCEPT AS NOTED)	REVISIONS NO.	DATE	BY
DECIMAL ±	1		
	2		
FRACTIONAL ±	3		
ANGULAR ±	4		
	5		

EPG COMPANIES

L975PTG CONTROL PANEL
230VAC 1Ø SH 4 OF 8

DESIGN	RCK	SCALE	MATERIAL
DRAWN	RCK	DATE 06-02-09	DRAWING NO. 08373-0253
CHK'D		APP'D	

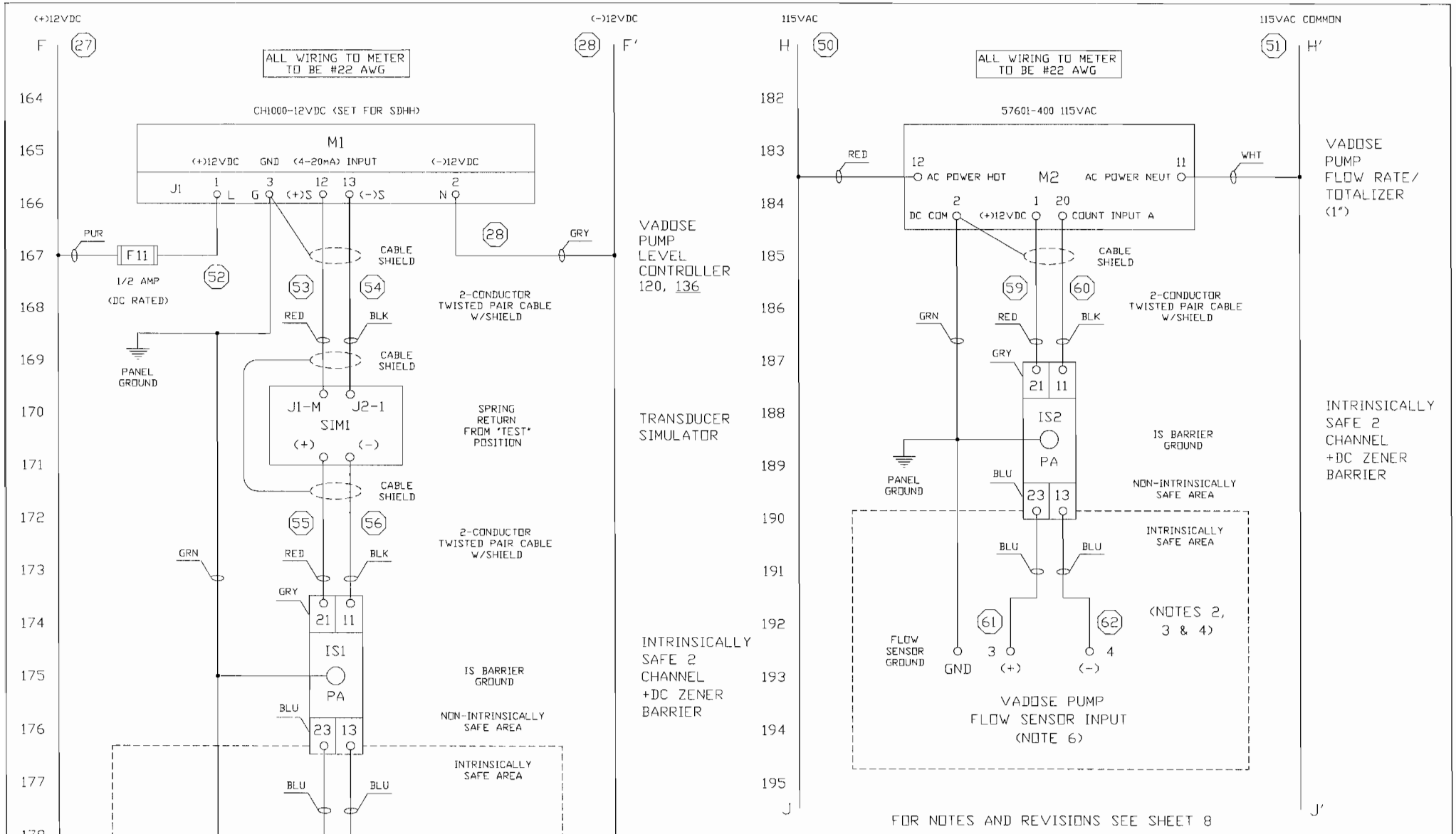


JOB No.	09-9356A

* NOTICE * © EPG Companies Inc. 2009

THIS DRAWING IS THE PROPERTY OF EPG COMPANIES FOR REFERENCE ONLY.

TOLERANCES (EXCEPT AS NOTED)	REVISIONS NO.	DATE	BY	EPG COMPANIES		
DECIMAL ±	1			L975PTG CONTROL PANEL 230VAC 1Ø SH 5 OF 8		
FRACTIONAL ±	2					
ANGULAR ±	3			DESIGN RCK	SCALE	MATERIAL
	4			DRAWN RCK	DATE 06-02-09	DRAWING NO. 08373-0254
	5			CHK'D	APP'D	



JOB No.	09-9356A

* NOTICE * © EPG Companies Inc. 2009

THIS DRAWING IS THE PROPERTY OF EPG COMPANIES FOR REFERENCE ONLY.

TOLERANCES (EXCEPT AS NOTED)
DECIMAL ±
FRACTIONAL ±
ANGULAR ±

REVISIONS

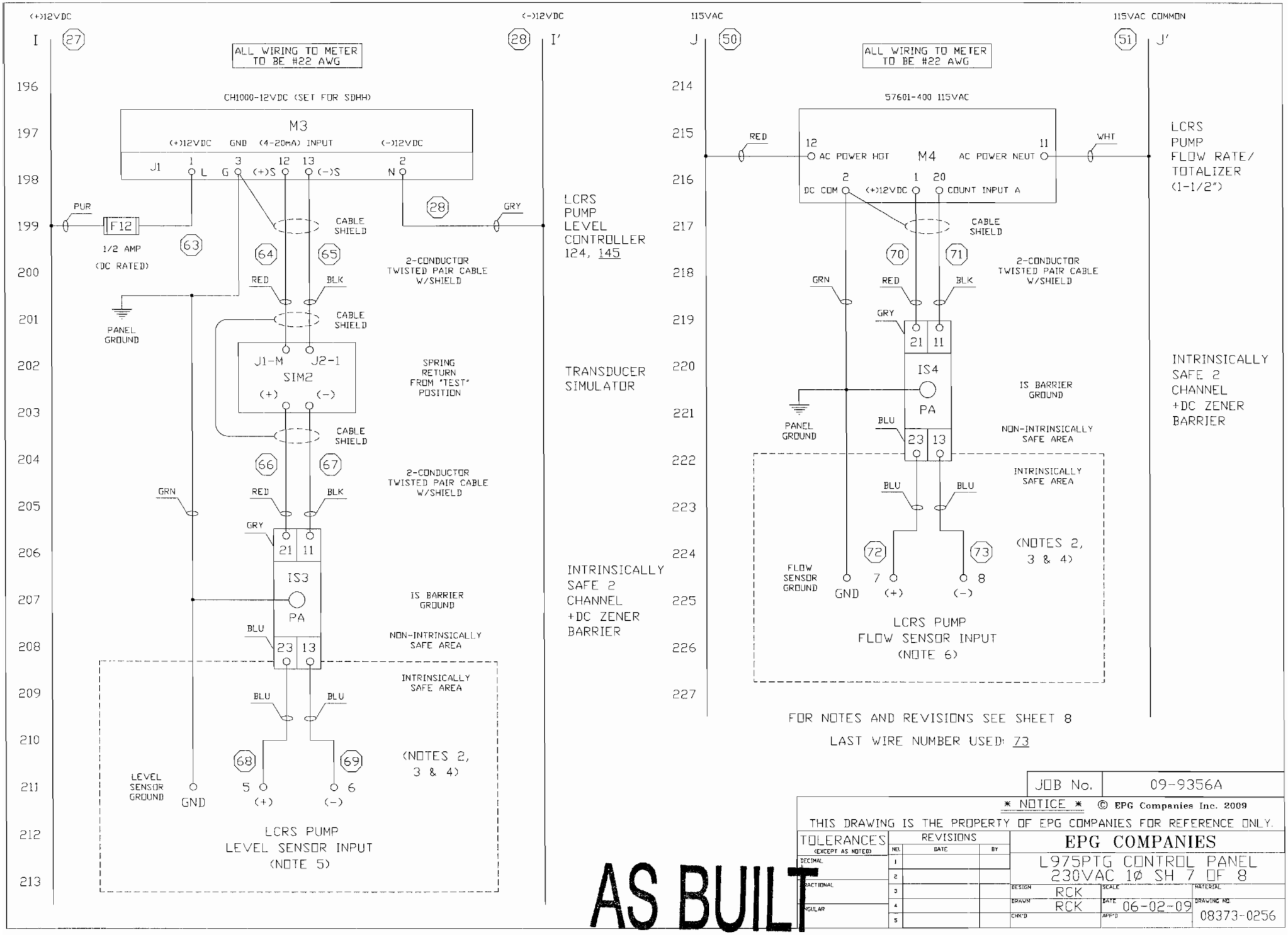
NO.	DATE	BY
1		
2		
3		
4		
5		

EPG COMPANIES

L975PTG CONTROL PANEL
230VAC 1Ø SH 6 OF 8

DESIGN	SCALE	MATERIAL
RCK		
DRAWN RCK	DATE 06-02-09	DRAWING NO. 08373-0255
CHK'D	APP'D	

AS BUILT


(+)12VDC
(-)12VDC
115VAC
115VAC COMMON
ALL WIRING TO METER TO BE #22 AWG
CH1000-12VDC (SET FOR SDHH)
M3
(+)12VDC GND (4-20mA) INPUT (-)12VDC
J1 1 L 3 G 12 (+)S 13 (-)S 2 N
PUR
F12
1/2 AMP
(DC RATED)
PANEL GROUND
CABLE SHIELD
RED
BLK
GRY
GRN
BLU
J1-M J2-1
SIM2
(+) (-)
IS3
PA
21 11
23 13
LEVEL SENSOR GROUND
GND
5 (+)
6 (-)
LCRS PUMP LEVEL SENSOR INPUT (NOTE 5)
LCRS PUMP LEVEL CONTROLLER 124, 145
2-CONDUCTOR TWISTED PAIR CABLE W/SHIELD
SPRING RETURN FROM 'TEST' POSITION
TRANSDUCER SIMULATOR
IS BARRIER GROUND
NON-INTRINSICALLY SAFE AREA
INTRINSICALLY SAFE AREA
(NOTES 2, 3 & 4)
INTRINSICALLY SAFE 2 CHANNEL +DC ZENER BARRIER
57601-400 115VAC
M4
12 AC POWER HOT
11 AC POWER NEUT
2 DC COM
1 (+)12VDC
20 COUNT INPUT A
WHT
IS4
FLOW SENSOR GROUND
7 (+)
8 (-)
LCRS PUMP FLOW SENSOR INPUT (NOTE 6)
LCRS PUMP FLOW RATE/ TOTALIZER (1-1/2")
FOR NOTES AND REVISIONS SEE SHEET 8
LAST WIRE NUMBER USED: 73
JOB No. 09-9356A
* NOTICE * © EPG Companies Inc. 2009
THIS DRAWING IS THE PROPERTY OF EPG COMPANIES FOR REFERENCE ONLY.
TOLERANCES (EXCEPT AS NOTED)
DECIMAL
FRACTIONAL
ANGULAR
REVISIONS
NO. DATE BY
EPG COMPANIES
L975PTG CONTROL PANEL
230VAC 1Ø SH 7 OF 8
DESIGN RCK
DRAWN RCK
DATE 06-02-09
CHK'D
APP'D
SCALE
MATERIAL
DRAWING NO. 08373-0256
AS BUILT

FIELD WIRING TERMINALS

LEVEL SENSOR (INTRINSICALLY SAFE TERMINALS)

1	RED	VADOSE PUMP LEVEL SENSOR INPUT (NOTES 2, 3, 4 & 5)
2	BLACK	
GND	SHIELD GROUND	

FLOW SENSOR (INTRINSICALLY SAFE TERMINALS)

3	RED	VADOSE PUMP FLOW SENSOR INPUT (1") (NOTES 2, 3, 4 & 6)
4	WHITE	
GND	BLACK	

LEVEL SENSOR (INTRINSICALLY SAFE TERMINALS)

5	RED	LCRS PUMP LEVEL SENSOR INPUT (NOTES 2, 3, 4 & 5)
6	BLACK	
GND	SHIELD GROUND	

FLOW SENSOR (INTRINSICALLY SAFE TERMINALS)

7	RED	LCRS PUMP FLOW SENSOR INPUT (1-1/2") (NOTES 2, 3, 4 & 6)
8	WHITE	
GND	BLACK	

NOTE:

1. NOT PART OF CONTROLLER
2. REFERENCE INSTALLATION OF INTRINSICALLY SAFE INSTRUMENT SYSTEMS IN CLASS I HAZARDOUS LOCATIONS, ANSI/ISA-RP 12.6-1987, SECTION 4.5.4
3. WARNING: SUBSTITUTION OF COMPONENTS MAY IMPAIR INTRINSIC SAFETY
4. INSTALL IN ACCORDANCE WITH ARTICLE 504 OF THE NATIONAL ELECTRIC CODE
5. MAXIMUM CABLE LENGTH TO THE LEVEL SENSOR IS 3000 FEET
6. MAXIMUM CABLE LENGTH TO THE FLOW SENSOR IS 500 FEET
7. SELECTOR SWITCHES, (SS1-SS2) WILL SPRING RETURN FROM THE "HAND" POSITION

AS BUILT

JOB No. 09-9356A

* NOTICE * © EPG Companies Inc. 2009
THIS DRAWING IS THE PROPERTY OF EPG COMPANIES FOR REFERENCE ONLY.

TOLERANCES (EXCEPT AS NOTED)
DECIMAL ±
FRACTIONAL ±
ANGULAR ±

REVISIONS

NO.	DATE	BY
1		
2		
3		
4		
5		

EPG COMPANIES

L975PTG CONTROL PANEL
230VAC 1Ø SH 8 OF 8

DESIGN RCK	SCALE	MATERIAL	
DRAWN RCK	DATE 06-02-09	DRAWING NO. 08373-0257	
CHK'D	APP'D		

Phase I
Installation Records

EPG Companies Inc.

SurePump™ Installation Record

Form Completed by: KEY Installation Date: 8/28/09
Company: HAMPTON TEDDER ELECTRIC EPG Serial #: 09-9356A

PUMPS, CONTROLS AND POWER SUPPLY

Installer:	Address:	Installation Location:
HTE	4920 ALTO AVE. LAS VEGAS, NV 89115	PHASE 1 LCRS

Motor Model	HP	Volts:	Max Amps Rating:	Pump Model:
WSDPT-5-3	3/4	230	6.8	EPG WSDPT SURE PUMP

Power Supply Transformers: Number Used: KVA Each:	Hertz:	Comments:
	60	

Pump Control Panel: Mfg. & Model #	Motor Starter Size:	Overload Heater Part or setting range:	IEC Starters:
EPG LG75PTG	.75	NA	

Lightning Arrestors: Mfg. & Model:	Surge Capacitors:	Disconnect Fuse or Circuit Breaker
Intermatic AG2402	Yes ____ No ✓	Amp Rating: 40

Primary Flow Control Devices:
(Low Level Control, Flow Control, Valve, System Back Pressure, etc.)
—

OPERATING DATA (Measurements at Control Panel)

PUMP CONDITIONS: GPM	VOLTS			AMPS		
Pump Not Running (LINE) 0	R-Y 0	R-B 0	B-Y 216	0		
Open Discharge	R-Y	R-B	B-Y	R	Y	B
Normal Operation	R-Y 0	R-B 0	B-Y 215	R 0	Y 6.6	B 6.8
Run Time						
Off Time						

EPG Companies Inc.

INSTALLATION DATA

Discharge Line Size: 1.5"	Discharge Pressure:	Pump Submergence:	Fluid Temp: ____ °F ____ °C
External Check Valve Used? NO	Location:	Cable Length & Size: 14GA ~~75'~~ 110' @	Ground Resistance 3 Ω
Insulation Megohm Readings:	Before Installation: 3 G	After Installation: 6.69G	After 30 min. Run: NA

SENSORS

Type of Level Sensor: Pressure Transmitter ✓ Load Monitor ____ Floats ____ Other ____	Transmitter Serial Number:
Length of Sensor Lead: @ 110' ~~75'~~	Ohm Readings Across I.S. Barrier: 230
mA Readings on Transmitter Lead:	Voltage Reading Entering Level Meter: 12 VDC Voltage Leaving Level Meter: 12 VDC
Are Flow Sensors Used: Yes ✓ No ____	Flow Spool Made of: PVC ✓ Stainless Steel ____

Comments: _____

Place one copy of this record in the control panel, return one copy to EPG, and retain original for your records

In case of problems or questions, contact EPG Companies Inc., 19900 County Road 81, Maple Grove, MN 55311 Phone: 800-762-8418 FAX: 763-493-4812

© EPG Companies Inc. 2009

EPG SurePump™ Installation Record

EPG Job No. 09-9356

Installer's Name HAMPTON TODDER ELECTRIC CO.

Address 4920 AUTO AVE.

City LAS VEGAS State NV. Zip 89115

Phone (702) 646-7449 Fax (702) 453-5412

Contact name ROGER CATES

Owner's Name BASIC REMEDIATION CO.

Address 875 W. WARM SPRINGS RD.

City HENDERSON State NV. Zip 89011

Phone (702) 567-0400 Fax (702) 567-5524

Contact name LEE C. FARRIS, PE

Sump Name/ID PHASE 1 LCRS Date Installed 8/28/09

Leachate or Condensate Temp _____ °F Or °C

Pump:

Model No. WSDPT 5-3

Rating: 30 GPM@ 60 Ft. TDH

HP .75 Voltage 230 Phase 1

Actual Pump Delivery _____ GPM@ _____ PSI

Operating Cycle _____ ON (Min/Hr) _____ OFF (Min/Hr) (Circle Min. or Hr. as appropriate)

Side Slope Riser Information:

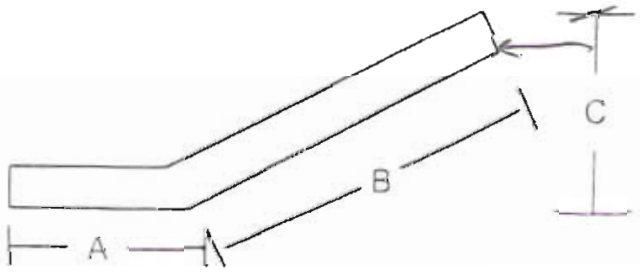
Slope 2.1 :1

Length of riser Pipe (A+B) 88.6 ft.

Vertical Distance = Sump to Top of Riser Pipe (C) 34.2 ft

Riser ID PHASE 1 LCRS SDR 11

Distance From Top of Riser Pipe to Controller 15 ft



Power Supply:

Cable: Service Entrance to Control Distance _____ ft Wire size _____ AWG/MCM

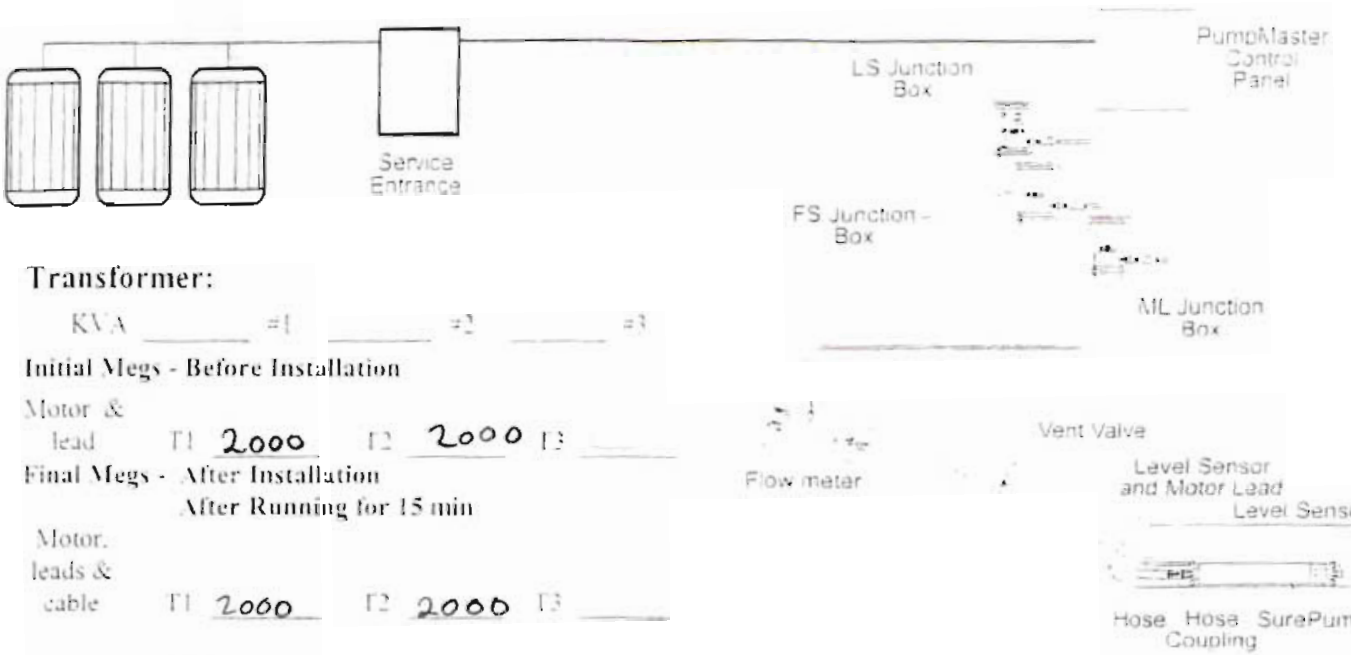
Copper Jacketed Aluminum Individual Conductor

Cable: Control to Motor _____ ft _____ AWG/MCM

Copper Jacketed

EPG Companies Inc.

July 2002



Transformer:

KVA _____ #1 _____ #2 _____ #3

Initial Megs - Before Installation

Motor & lead T1 2000 T2 2000 T3 _____

Final Megs - After Installation
After Running for 15 min

Motor, leads & cable T1 2000 T2 2000 T3 _____

Incoming Voltage:

No Load L1-L2 238 L2-L3 _____ L1-L3 _____

Full Load L1-L2 238 L2-L3 _____ L1-L3 _____

Running Amps:

Hookup:1

Full Load L1 8.0 L2 8.0 L3 _____ % unbalanced 0

Hookup:2

Full Load L1 _____ L2 _____ L3 _____ % unbalanced _____

Hookup:3

Full Load L1 _____ L2 _____ L3 _____ % unbalanced _____

Ground wire size _____ AWG MCM

DC Ground Current _____ mA Ground Test 3 Ohms

Motor Surge Protection ✓ Yes _____ No

Control Panel:

Model # L97PTG

Short Circuit Device

Circuit Breaker _____ Rating _____ Setting

Fuses FRNR 10 Type 10 Rating

_____ Standard ✓ Time Delay

Controls are Grounded to:

_____ Motor

X Rod

_____ Power Supply

Start Overloads:

Set at NA amps

Name HOWARD LESTER

Company EPG COMPANIES

Date SEPT 17 09

© EPG Companies Inc. 2009

INSTALLATION GUIDE

EPG SurePump™ Pumping System

- ✓ 1. Verify that equipment and supply voltage match
- ✓ 2. Inspect equipment, look for shipping damage, dirt, and rough handling
- ✓ 3. Control panel should be mounted in a secure way at least 15' from riser or sump and 36" above grade to bottom of control panel.
- ✓ 4. Inspect inside of control panel. Look for items which might have come loose during shipping
- ✓ 5. Test level sensor in bucket of water. Does it return back to zero? Control panel needs to be installed and have power to it.
- ✓ 6. Install vent valve and tubing. See Bulletin 0130e
- ✓ 7. Install suspension cable. See Bulletin 6090a.
- ✓ 8. Fasten motor lead and sensor cable to discharge line every 5' to 7' with straps or plastic wire ties. It's best if they are on separate sides of line; use padding between cables and any metal straps.
- ✓ 9. Run pump down riser slowly using stainless steel suspension cable as hold back. Make sure motor lead and sensor cable are slack as you lower pump.
- ✓ 10. Take ohm reading of each motor lead wire to wire and compare the values in Table 13 of the Franklin Electric motor manual for 1Ø and Table 21 for 3Ø. Be sure to add wire resistance value to value from table 13& 21. See page 39 for wire resistance.
- ✓ 11. Check insulation resistance as pump is lowered down riser. Resistance may drop gradually as pump and cable enter the liquid, but any sudden drop indicates a problem.
- ✓ 12. Run sensor leads and power cables in separated conduits to control panel. It is a good idea to use breakout junction boxes. See Design Guide 05644.
- ✓ 13. If you have to remove dryer from end of transducer cable to pull cable through fittings or conduit. Seal end of the vent tube with a piece of tape. Reinstall dryer as soon as possible. See Bulletin 0550a
- ✓ 14. Megger motor leads. Resistance must be 1 megohm or greater
- ✓ 15. Connect pump to control panel complying with local and national codes. Controller terminal strips motor leads, and sensor leads are all labeled and or color coded to simplify connections
- ✓ 16. Inspect wire connections. Are they the correct colors? Are they tight?
- ✓ 17. If color-coded wires were not continued from sump or riser, you need to mill out each circuit
- ✓ 18. Measure resistance to ground. It must be less than 25 ohms. If greater, drop work and report to owner. It should be 1 ohm or less to protect electronic equipment

2009 EPG Companies Inc.

- ☑ 19. Measure voltage prior to control panel or at entrances to control panel. Measure and record voltage line to line and line to ground.
- ☑ 20. Compare these reading to voltage listed on drawing and label in control panel.
- ☑ 21. Review equipment list and drawings for any accessory circuits. If present, run volt and ohm test.
- ☑ 22. Check and make sure all hand switches are in the off position. If you have a water level indicator verify leachate level in sump or riser.
- ☑ 23. Turn on power at panel main disconnect.
- ☑ 24. Level meters display should light up. Record displayed reading. How does this reading compare to your measured level reading?
- ☑ 25. If level and flow meter do not light up check GFCI, reset if necessary.
- ☑ 26. Are any indicator lights on?
- ☑ 27. Should they be on?
- ☑ 28. Make sure pump is turned off. Using built in or hand held simulator, verify level meter settings are correct for this site. See meter data sheet for factory settings and meter instructions.
- ☑ 29. Bump pump by turning switch to hand two or three times to make sure pump has reached its resting point. You should have minimum of 3' of slack in the cables.
- ☑ 30. To verify correct rotation place hand around discharge line. It will torque right if the rotation is correct.
- ☑ 31. When pump is running measure and record amperage and voltage. Check 3Ø systems for current balance within 5% of average.
- ☑ 32. Verify that starting, running and stopping causes no significant vibration or hydraulic shocks.
- ☑ 33. After 15 minutes of running time measure volts and amperage to see if they are stable. Are they as specified?
- ☐ 34. After pump and level sensor have been tested pot seal offs.
- ☑ 35. Complete Form 200. Note: If this form is not completed and returned to EPG it will impact system warranty.

2009 EPG Companies Inc.
[illegible]

START UP CHECKLIST

EPG SurePump™ Pumping System

QUESTIONS FOR CONTRACTOR OR INSTALLER

- ✓ A: Were sensor and power cable tied or strapped to discharge line?
- ✓ B: On what kind of spacing? 5 FT
- ✓ C: What is the as built length of riser and sump? Were cables long enough? There should be 3 or more feet of slack in the cables.
- ✓ D: What size cable was run for supply power? 14 GA
- ☐ E: What is the distance from power supply transformer to pump control panel?
- ✓ F: How did they verify that pump is down into sump? LEVEL
- ✓ G: Did they test level sensor prior to installing?
- ✓ H: Did they test pump prior to installing or prior to your arrival?
- ✓ I: Do they have any questions or concerns?
- ✓ J: Complete form 200

PHYSICAL INSPECTION OF CONTROL PANEL

- ✓ A: Is the control panel located 15' from sump or riser and 36" above grade to bottom of panel.
- ✓ B: Are power and sensor cable run in separate conduit? If not, stop work and have this corrected.
- ✓ C: Are seal offs installed in both sensor and power runs? If not, suggest breakout junction boxes or have seal off installed.
- ☐ D: Are seal offs potted? If not, stop work and have them potted
- ✓ E: Will inner and outer door of enclosure open and close freely? If not loosen enclosure mounting bolts and shim until it is level and square. Then retighten mounting bolts.
- ✓ F: Make sure ground wire is in place between outer door and enclosure

2009 EPG Companies Inc.

PRIOR TO ENERGIZING CONTROL PANEL

- ✓ A: Measure resistance to ground. It must be less than 25 ohms. If greater stop work and report to owner. It should be 1 ohm or less to protect electronic equipment.
- ✓ B: Measure voltage prior to control panel or at entrances to control panel. Measure and record voltage line to line and line to ground.
- ✓ C: Compare these reading to voltage listed on drawing and label in control panel.
- ✓ D: Megger motor leads resistance must be 1 megohm or greater.
- ✓ E: Take ohm reading of each motor lead wire to wire and compare these to values in Table 13 of the Franklin Electric motor manual for 1O and Table 21 for 3O. Be sure to add wire resistance value to value from table 13& 21. See page 39 for wire resistance.
- ✓ F: Inspect inside of control panel. Look for items which may have come loose during shipping
- ✓ G: Inspect wire connections. Are they the correct colors? Are they tight?
- ✓ H: If color-coded wires were not continued from sump or riser you need to ohm out each circuit.
- ✓ I: Review equipment list and drawings from any accessory circuits. If present, run volt and ohm test.
- ✓ J: Check and make sure all hand switches are in off position. If you have a water level indicator verify leachate level in sump or riser.

POWER UP

- ✓ A: Turn on power at panel main disconnect.
- ✓ B: Level meters display should light up. Record displayed reading. How does this reading compare to your measured level reading?
- ✓ C: If level and flow meter do not light up check GFCI, reset if necessary
- ✓ D: Are any indicator lights on?
- ✓ E: Should they be on?
- ✓ F: Make sure pumps turned off. Using built in or hand held simulator verify level meter settings are correct for this site
- ✓ G: Bump pump by turning hand switch two or three times to make sure pump has reached its resting point. You should have minimum of 3' of slack in the cables

2009 EPG Companies Inc

- ✓ H: To verify correct rotation place hand around discharge line. It will torque right if the rotation is correct.
- ✓ I: If there is liquid in sump with level about pump start set point and below 150". Then turn pump selector switch to AUTO. Run pump through one complete cycle.
- ✓ J: When pump is running measure and record amperage and voltage. Check 3O systems for current balance within 5% of average.
- ✓ K: Verify that starting, running and stopping causes no significant vibration or hydraulic shocks.

EPG Companies Inc.

SurePump™ Installation Record

Form Completed by: KEY Installation Date: 8/28/09
Company: HAMPTON TEDDER ELECTRIC EPG Serial #: 09-93564

PUMPS, CONTROLS AND POWER SUPPLY

Installer: HTE	Address: 4920 ALTO AVE. LAS VEGAS, NV 89115	Installation Location: PHASE I UADOSE
Motor Model: WSDPT-2-3 HP: 1/2	Volts: 230 Max Amps Rating: 5.0	Pump Model: EPG WSDPT ~~SURE PUMP~~
Power Supply Transformers: Number Used: KVA Each:	Hertz: 60 Comments:	
Pump Control Panel: Mfg. & Model #: EPG L975PTG	Motor Starter Size: 5 hp	Overload Heater Part or setting range: NA IEC Starters:
Lightning Arrestors: Mfg. & Model: Intermatic AG2401	Surge Capacitors: Yes ____ No ✓	Disconnect Fuse or Circuit Breaker Amp Rating: 40A
Primary Flow Control Devices: (Low Level Control, Flow Control, Valve, System Back Pressure, etc.) —		

OPERATING DATA (Measurements at Control Panel)

PUMP CONDITIONS:	GPM	VOLTS	AMPS
Pump Not Running (Line)	0	R-Y 0 R-B 0 B-Y 216	0
Open Discharge		R-Y ____ R-B ____ B-Y ____	R ____ Y ____ B ____
Normal Operation Run Time 15 sec Off Time		R-Y 0 R-B 0 B-Y 215	R 0 Y 4.4 B 4.7

© EPG Companies Inc. 2009

EPG Companies Inc.

INSTALLATION DATA

Discharge Line Size: 1"	Discharge Pressure:	Pump Submergence:	Fluid Temp: ____ °F ____ °C
External Check Valve Used? No	Location:	Cable Length & Size: 14 GA 113 FT	Ground Resistance 3 Ω
Insulation Megohm Readings:	Before Installation: 3.3 G	After Installation: 7.17G	After 30 min. Run: NA

SENSORS

Type of Level Sensor: Pressure Transmitter ✓ Load Monitor ____ Floats ____ Other ____	Transmitter Serial Number:
Length of Sensor Lead: 113 FT	Ohm Readings Across I.S. Barrier: 230
mA Readings on Transmitter Lead:	Voltage Reading Entering Level Meter: 12 VDC Voltage Leaving Level Meter: 11 VDC
Are Flow Sensors Used: Yes ✓ No ____	Flow Spool Made of: PVC ✓ Stainless Steel ____

Comments: ____

Place one copy of this record in the control panel, return one copy to EPG, and retain original for your records.

In case of problems or questions, contact EPG Companies Inc., 19900 County Road 81, Maple Grove, MN 55311 Phone: 800-762-8418 FAX: 763-493-4812

© EPG Companies Inc. 2009

EPG SurePump™ Installation Record

EPG Job No. 09-9356

Installer's Name HAMPTON TEDDER ELECTRIC CO.

Address 4920 ALTO AVE.

City LAS VEGAS State NV. Zip 89115

Phone (702) 646-7449 Fax (702) 453-5412

Contact name ROGER CATES

Owner's Name BASIC REMEDIATION CO.

Address 875 W. WARM SPRINGS, RD

City HENDERSON State NV. Zip 89011

Phone (702) 567-0400 Fax (702) 567-5524

Contact name LEE C. FARRIS, PE

Sump Name/ID PHASE 1 VADOSE Date Installed 8/28/09

Leachate or Condensate Temp _____ °F Or °C

Pump:

Model No. WSDPT 2-3

Rating: 10 GPM@ 50 Ft. TDH

HP .5 Voltage 230 Phase 1

Actual Pump Delivery _____ GPM@ _____ PSI

Operating Cycle _____ ON (Min/Hr) _____ OFF (Min/Hr) (Circle Min. or Hr. as appropriate)

Side Slope Riser Information:

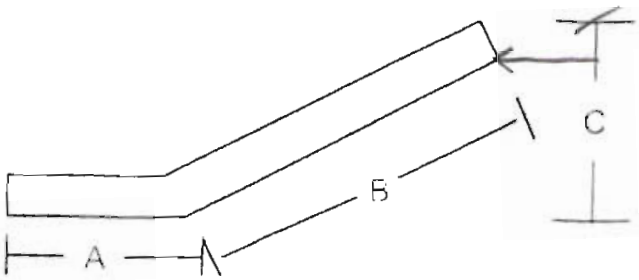
Slope 2.1 :1

Length of riser Pipe (A-B) 86.4 ft

Vertical Distance = Sump to INV. Top of Riser Pipe (C) 35.1 ft

Riser ID PHASE 1 VADOSE SDR 11

Distance From Top of Riser Pipe to Controller 15 ft



Power Supply:

Cable: Service Entrance to Control Distance _____ ft Wire Size _____ AWG/MCM

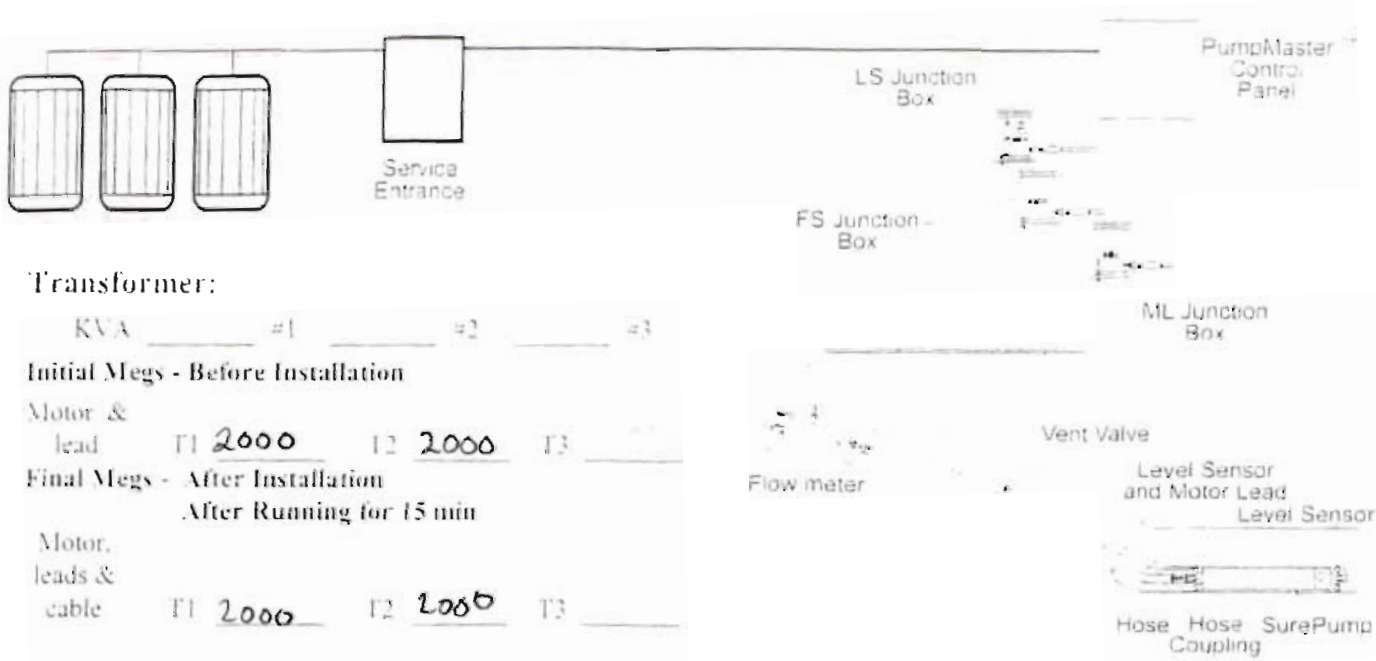
Copper _____ Jacketed _____ Aluminum _____ Individual conductors _____

Cable: Control to Motor _____ ft _____ AWG/MCM

Copper _____ Jacketed _____

EPG Companies Inc.

July 2002



Transformer:

KVA _____ #1 _____ #2 _____ #3 _____

Initial Megs - Before Installation

Motor & lead T1 2000 T2 2000 T3 _____

Final Megs - After Installation
After Running for 15 min

Motor, leads & cable T1 2000 T2 2000 T3 _____

Incoming Voltage:

No Load L1-L2 238 L2-L3 _____ L1-L3 _____

Full Load L1-L2 238 L2-L3 _____ L1-L3 _____

Running Amps:

4.9 0

Hookup:1

Full Load L1 4.9 L2 _____ L3 _____ % unbalanced 0

Hookup:2

Full Load L1 _____ L2 _____ L3 _____ % unbalanced _____

Hookup:3

Full Load L1 _____ L2 _____ L3 _____ % unbalanced _____

Ground wire size _____ AWG MCM

DC Ground Current _____ mA Ground Test 3 Ohms

Motor Surge Protection ✓ Yes _____ No

Control Panel:

Model # L975PTG

Short Circuit Device

Circuit Breaker _____ Rating _____ Setting _____

Fuses FRNR Type 8 Rating _____

_____ Standard ✓ Time Delay _____

Controls are Grounded to:

_____ Motor

✓ Rod

_____ Power Supply

Start Overloads:

Set at N/A amps

Name HOWARD LESTER

Company EPG COMPANIES

Date SEPT 17 09

© EPG Companies Inc. 2009

INSTALLATION GUIDE

EPG SurePump™ Pumping System

✓ 1. Verify that equipment and supply voltage match.

✓ 2. Inspect equipment, look for shipping damage, dirt, and rough handling.

✓ 3. Control panel should be mounted in a secure way at least 15' from riser or sump and 36" above grade to bottom of control panel.

✓ 4. Inspect inside of control panel. Look for items which might have come loose during shipping.

✓ 5. Test level sensor in bucket of water. Does it return back to zero? Control panel needs to be installed and have power to it.

✓ 6. Install vent valve and tubing. See Bulletin 0130e.

✓ 7. Install suspension cable. See Bulletin 6090a.

✓ 8. Fasten motor lead and sensor cable to discharge line every 5' to 7' with straps or plastic wire ties. It's best if they are on separate sides of line; use padding between cables and any metal straps.

✓ 9. Run pump down riser slowly using stainless steel suspension cable as hold back. Make sure motor lead and sensor cable are slack as you lower pump.

✓ 10. Take ohm reading of each motor lead wire to wire and compare the values in Table 13 of the Franklin Electric motor manual for 1Ø and Table 21 for 3Ø. Be sure to add wire resistance value to value from table 13& 21. See page 39 for wire resistance.

✓ 11. Check insulation resistance as pump is lowered down riser. Resistance may drop gradually as pump and cable enter the liquid, but any sudden drop indicates a problem.

✓ 12. Run sensor leads and power cables in separated conduits to control panel. It is a good idea to use breakout junction boxes. See Design Guide 05644.

✓ 13. If you have to remove dryer from end of transducer cable to pull cable through fittings or conduit. Seal end of the vent tube with a piece of tape. Reinstall dryer as soon as possible. See Bulletin 0550a.

✓ 14. Megger motor leads. Resistance must be 1 megohm or greater.

✓ 15. Connect pump to control panel complying with local and national codes. Controller terminal strips, motor leads, and sensor leads are all labeled and/or color coded to simplify connections.

✓ 16. Inspect wire connections. Are they the correct colors? Are they tight?

✓ 17. If color-coded wires were not continued from sump or riser you need to ohm out each circuit.

✓ 18. Measure resistance to ground. It must be less than 25 ohms. If greater, stop work and report to owner. It should be 1 ohm or less to protect electronic equipment.

2009 EPG Companies Inc.
[illegible]

✓ 19. Measure voltage prior to control panel or at entrances to control panel. Measure and record voltage line to line and line to ground.

✓ 20. Compare these reading to voltage listed on drawing and label in control panel.

✓ 21. Review equipment list and drawings for any accessory circuits. If present, run volt and ohm test.

✓ 22. Check and make sure all hand switches are in the off position. If you have a water level indicator verify leachate level in sump or riser.

✓ 23. Turn on power at panel main disconnect

✓ 24. Level meters display should light up. Record displayed reading. How does this reading compare to your measured level reading?

✓ 25. If level and flow meter do not light up check GFCI, reset if necessary.

✓ 26. Are any indicator lights on?

✓ 27. Should they be on?

✓ 28. Make sure pump is turned off. Using built in or hand held simulator, verify level meter settings are correct for this site. See meter data sheet for factory settings and meter instructions.

✓ 29. Bump pump by turning switch to hand two or three times to make sure pump has reached its resting point. You should have minimum of 3' of slack in the cables.

✓ 30. To verify correct rotation place hand around discharge line. It will torque right if the rotation is correct.

✓ 31. When pump is running measure and record amperage and voltage. Check 3Ø systems for current balance within 5% of average.

✓ 32. Verify that starting, running and stopping causes no significant vibration or hydraulic shocks.

✓ 33. After 15 minutes of running time measure volts and amperage to see if they are stable. Are they as specified?

✓ 34. After pump and level sensor have been tested pot seal offs.

✓ 35. Complete Form 200. Note: <u>If this form is not completed and returned to EPG it will impact system warranty.</u>

2009 EPG Companies Inc

START UP CHECKLIST

EPG SurePump™ Pumping System

QUESTIONS FOR CONTRACTOR OR INSTALLER

- ✓ A: Were sensor and power cable tied or strapped to discharge line?
- ✓ B: On what kind of spacing? 4FT
- ✓ C: What is the as built length of riser and sump? Were cables long enough? There should be 3 or more feet of slack in the cables.
- ✓ D: What size cable was run for supply power?
- ✓ E: What is the distance from power supply transformer to pump control panel?
- ✓ F: How did they verify that pump is down into sump? LEVEL
- ✓ G: Did they test level sensor prior to installing?
- ✓ H: Did they test pump prior to installing or prior to your arrival? YES
- ✓ I: Do they have any questions or concerns?
- ✓ J: Complete form 200

PHYSICAL INSPECTION OF CONTROL PANEL

- ✓ A: Is the control panel located 15' from sump or riser and 36" above grade to bottom of panel.
- ✓ B: Are power and sensor cable run in separate conduit? If not, stop work and have this corrected
- ✓ C: Are seal offs installed in both sensor and power runs? If not, suggest breakout junction boxes or have seal off installed.
- ✓ D: Are seal offs potted? If not, stop work and have them potted. NOT AT INSPECTION
- ✓ E: Will inner and outer door of enclosure open and close freely? If not loosen enclosure mounting bolts and shim until it is level and square. Then retighten mounting bolts.
- ✓ F: Make sure ground wire is in place between outer door and enclosure

2009 EPG Companies Inc.

PRIOR TO ENERGIZING CONTROL PANEL

- ✓ A: Measure resistance to ground. It must be less than 25 ohms. If greater stop work and report to owner. It should be 1 ohm or less to protect electronic equipment.
- ✓ B: Measure voltage prior to control panel or at entrances to control panel. Measure and record voltage line to line and line to ground.
- ✓ C: Compare these reading to voltage listed on drawing and label in control panel.
- ✓ D: Megger motor leads resistance must be 1 megohm or greater.
- ✓ E: Take ohm reading of each motor lead wire to wire and compare these to values in Table 13 of the Franklin Electric motor manual for 1O and Table 21 for 3O. Be sure to add wire resistance value to value from table 13& 21. See page 39 for wire resistance.
- ✓ F: Inspect inside of control panel. Look for items which may have come loose during shipping
- ✓ G: Inspect wire connections. Are they the correct colors? Are they tight?
- ☐ H: If color-coded wires were not continued from sump or riser you need to ohm out each circuit.
- ☐ I: Review equipment list and drawings from any accessory circuits. If present, run volt and ohm test.
- ☐ J: Check and make sure all hand switches are in off position. If you have a water level indicator verify leachate level in sump or riser.

POWER UP

- ✓ A: Turn on power at panel main disconnect.
- ✓ B: Level meters display should light up. Record displayed reading. How does this reading compare to your measured level reading?
- ✓ C: If level and flow meter do not light up check GFCI reset if necessary
- ✓ D: Are any indicator lights on?
- ✓ E: Should they be on?
- ✓ F: Make sure pump is turned off. Using built in or hand held simulator verify level meter settings are correct for this site
- ✓ G: Bump pump by turning hand switch two or three times to make sure pump has reached its resting point. You should have minimum of 3' of slack in the cables

2009 EPG Companies Inc.

- ☑ H: To verify correct rotation place hand around discharge line. It will torque right if the rotation is correct.
- ☐ I: If there is liquid in sump with level about pump start set point and below 150". Then turn pump selector switch to AUTO. Run pump through one complete cycle.
- ☑ J: When pump is running measure and record amperage and voltage. Check 3O systems for current balance within 5% of average.
- ☑ K: Verify that starting, running and stopping causes no significant vibration or hydraulic shocks.

2009 EPG Companies Inc

Phase I
As-Built Control Panel Setup Parameters

EPG LevelMaster Pump controller

Panel S/N: 09-9356A
Meter S/N: 060409-03

LCRS Pump Level Control Meter PHASE I

Default setting - Operating Parameters - Setup Code 35

Meter Designation(s): M3

Parameter	Value	Operation
Pr Hi	28	Turns Pump on when level on meter reads ~~28~~ ". 20"
Pr Lo	16	Turns Pump off when level on meter reads ~~16~~ ". 7"
AL H1	34	Turns High Level Light on when meter reads ~~34~~ ". 36.1"
Hy Hi	1	Keeps High Level Light on until level drops 1 " below AL Hi.
AL H2	143	Turns Pumps off it meter reads 143" or greater. Indicates a possible sensor failure.
Hy H2	0	Not used.

Default Settings - Sensor Parameters - Setup Code 25 (0 - 5PSI)

Parameter	Value	Operation
dp	8888.8	Sets Meter to read in 0.1"
OFFSET	-34.6	Provides a "0" reading when sensor inputs 4.0ma
SCALE	0.8656	Converts current input into inches - 1.0ma = 8.656 inches.

AS BUILT

EPG Companies Inc.

December 2004

EPG LevelMaster Pump controller

Panel S/N: 09-9356A
Meter S/N: 060409-04

Vadose Pump Level Control Meter PHASE I

Default setting - Operating Parameters - Setup Code 35

Meter Designation(s): M1

Parameter	Value	Operation
Pr Hi	28	Turns Pump on when level on meter reads ~~28~~ ". 17"
Pr Lo	16	Turns Pump off when level on meter reads ~~16~~ ". 7"
AL H1	34	Turns High Level Light on when meter reads ~~34~~ ". 4"
Hy Hi	1	Keeps High Level Light on until level drops 1 " below AL Hi.
AL H2	143	Turns Pumps off it meter reads 143" or greater. Indicates a possible sensor failure.
Hy H2	0	Not used.

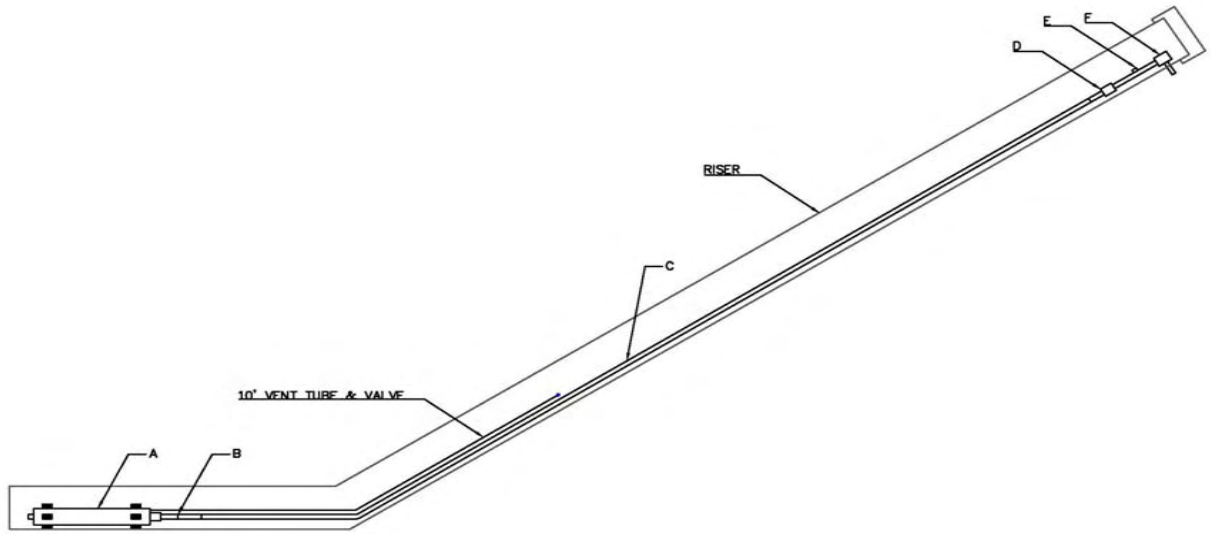
Default Settings - Sensor Parameters - Setup Code 25 (0 - 5PSI)

Parameter	Value	Operation
dp	8888.8	Sets Meter to read in 0.1"
OFFSET	-32.6 ~~-34.6~~	Provides a "0" reading when sensor inputs 4.0ma
SCALE	0.8656	Converts current input into inches - 1.0ma = 8.656 inches.

AS BUILT

Phase I
As-Built Pump Installation Cross Sections

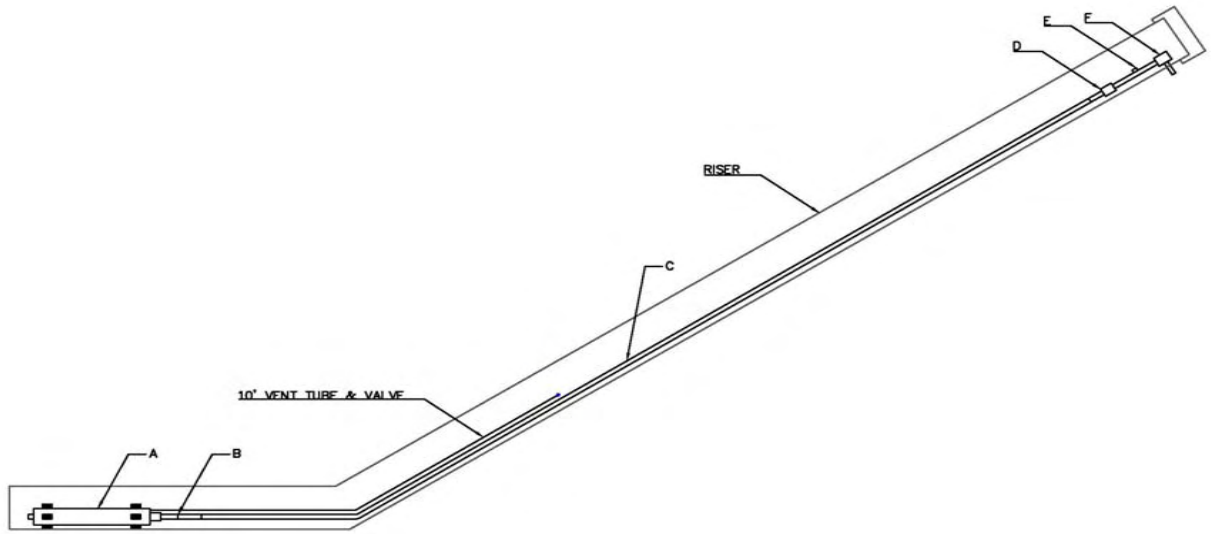
PHASE I LCRS SUMP PUMP INSTALLATION



ITEM	DESCRIPTION	LENGTH (FT)
A	WSDPT5-3 PUMP (S/N 2009-3131)	2.6
B	CONNECTIONS/FITTINGS/TRANSITIONS	1.1
C	1.5" DISCHARGE LINE	80.3
D	CONNECTIONS/FITTINGS/TRANSITIONS	1.1
E	FLOW METER	2.4
F	EPG FITTING "T"	0.4

NOT TO SCALE

PHASE I VADOSE SUMP PUMP INSTALLATION

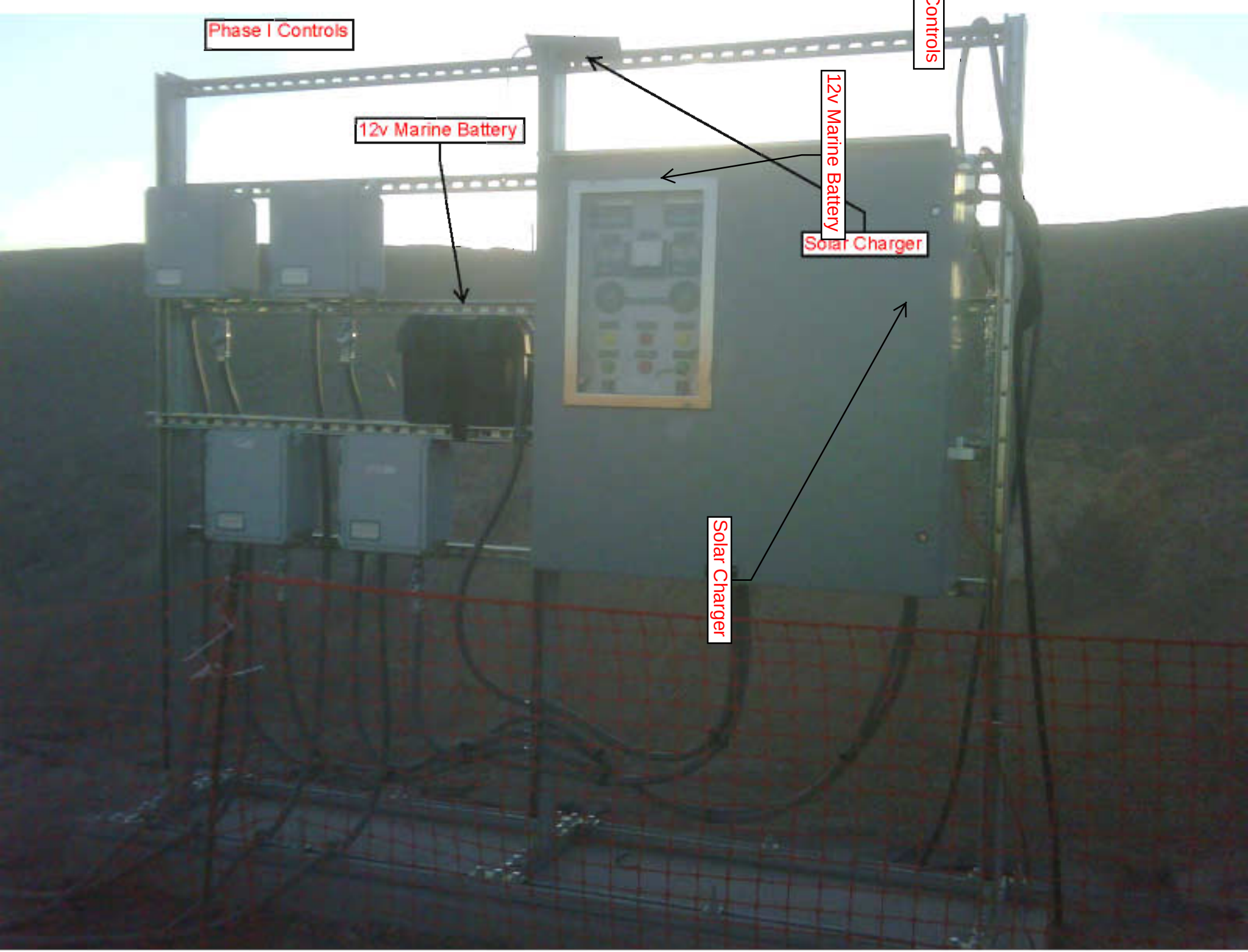


ITEM	DESCRIPTION	LENGTH (FT)
A	WSDPT2-3 PUMP (S/N 2009-3109)	2.5
B	CONNECTIONS/FITTINGS/TRANSITIONS	1.1
C	1.0" DISCHARGE LINE	77.7
D	CONNECTIONS/FITTINGS/TRANSITIONS	0.7
E	FLOW METER	1.7
F	EPG FITTING "T"	0.3

NOT TO SCALE

Phase I
As-Built Photos

Phase I Controls & Risers
Phase I Controls & Risers


Phase I Controls
12v Marine Battery
12v Marine Battery
Solar Charger
Solar Charger

Phase II
Engineer's Specification

ENGINEER'S SPECIFICATION

PHASE II LCRS

EPG WSDPT SurePump™ Wheeled Sump Drainer

for side slope riser installations with built-in level sensor

Furnish __1__ centrifugal submersible EPG WSDPT SurePump Wheeled Sump Drainer(s) (U.S. patented), Model WSDPT __5__ - __3__ with __3__ impeller stages. Each unit shall be suitable for side slope riser installation. Each unit shall be equipped with a __¾__ HP, submersible electric motor for operation on __230__ Volts, __1__ phase, 60 Hertz service with __120__ feet of power cable. Each SurePump Wheeled Sump Drainer shall have a __1 ½__ inch MNPT threaded discharge nozzle and be capable of delivering __25__ GPM at __50__ feet of TDH. Each SurePump will be fitted with __120__ feet of stainless steel lifting cable of sufficient strength to permit removal of the unit.

DESIGN

Each SurePump Wheeled Sump Drainer shall be capable of pumping contaminated ground water for spill recovery, leachate, condensate, and purge applications. A removable transmitter mount (patent pending) shall be installed at the center bottom of the Sump Drainer for liquid level control. The Sump Drainer shall permit the unit to "pump down" to within __8__ inches of the sump bottom without any loss of performance or damage to the pump. External "priming" shall not be required nor allowed. The Sump Drainer shall be equipped with a vent valve to assist with the evacuation of air from the Sump Drainer.

MATERIALS

Major components shall be made of 304 stainless steel, seal rings are to be made of E-Glide™, and bearings are to be E-Glide. In addition, all fasteners shall be 304 stainless steel.

CHECK VALVE

Each unit shall include a built-in check valve with non-metallic seat, and housing and disc of 304 stainless steel.

SHAFT

The shaft shall be of 304 stainless steel and rotate on E-Glide bearings that are fluid lubricated.

DIFFUSER CHAMBER

The diffuser chambers for each impeller shall be 304 stainless steel and fitted with E-Glide impeller seal rings.

IMPELLERS

The impeller(s) shall be closed and consist of 304 stainless steel.

MOTOR

The motor shall be a submersible, hermetically sealed Franklin motor in __Pollution Recovery__ construction. The motor shall be designed for continuous duty, capable of sustaining up to __100__ starts per day. The motor shall be connected to the pump via a motor adaptor and coupling in 304 stainless steel. Single phase motors in ½ HP to 1 HP only shall have thermal protection in the motor windings to protect the windings from overload. The unit will restart automatically after the motor cools down. Larger horsepower single phase motors and three phase motors shall have thermal protection located in the control panel that is manually reset.

MOTOR LEAD WIRE

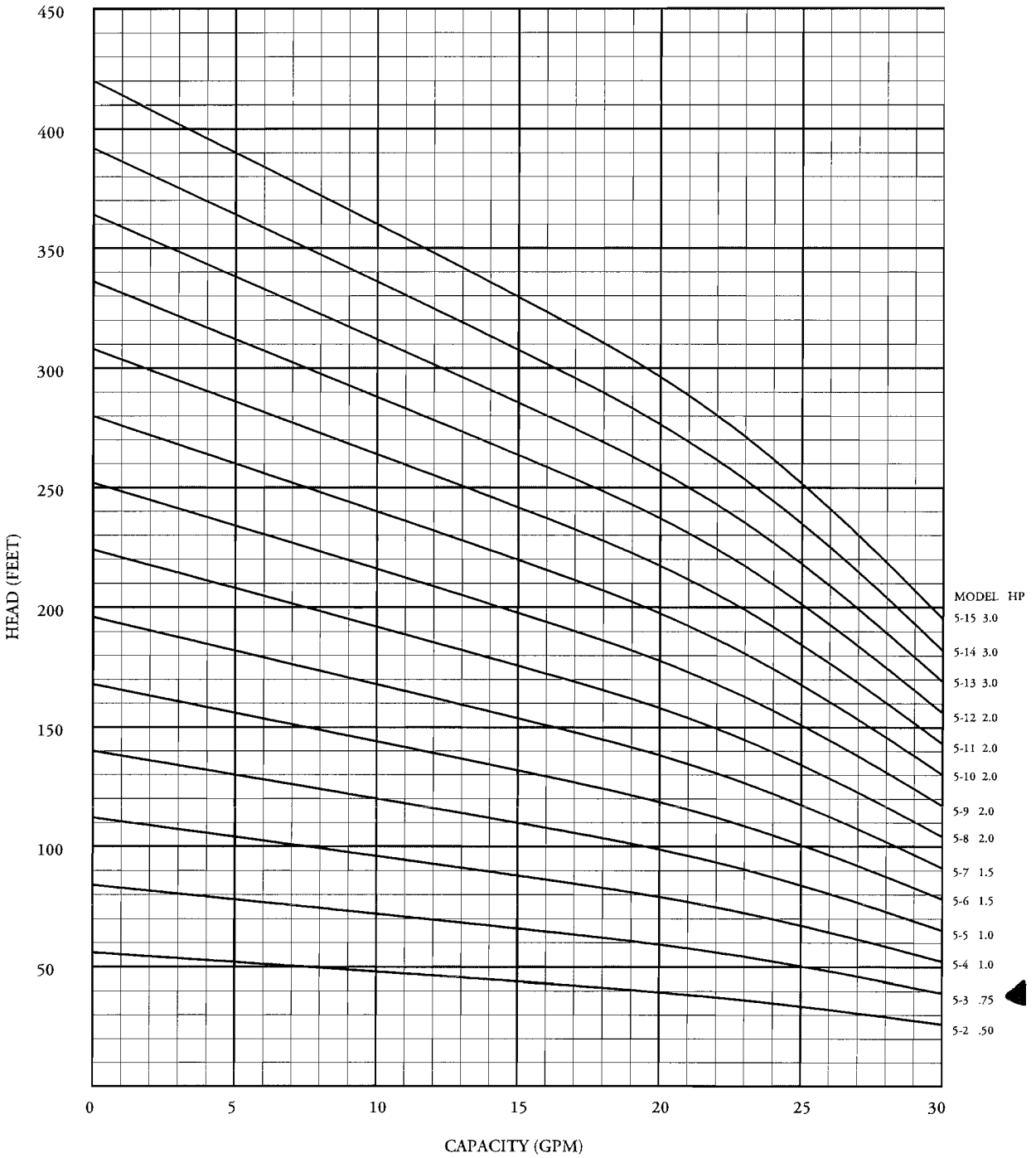
The lead wire shall be no-splice with EPG's "CP" waterproof and chemically resistant jacket over 600 Volt insulation and be of the length specified.

© 2009 EPG Companies Inc.
SurePump & E-Glide are Reg. TM of EPG Companies Inc.

SERIES 5 SurePump™

Flow Range 15-30 GPM

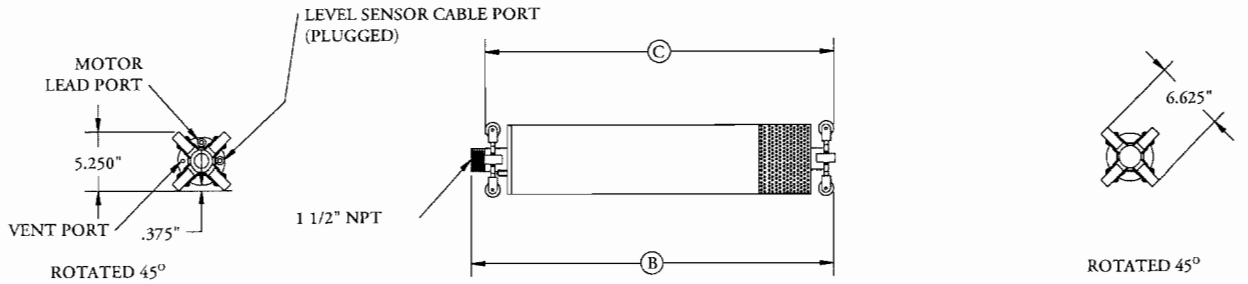
60 Hz



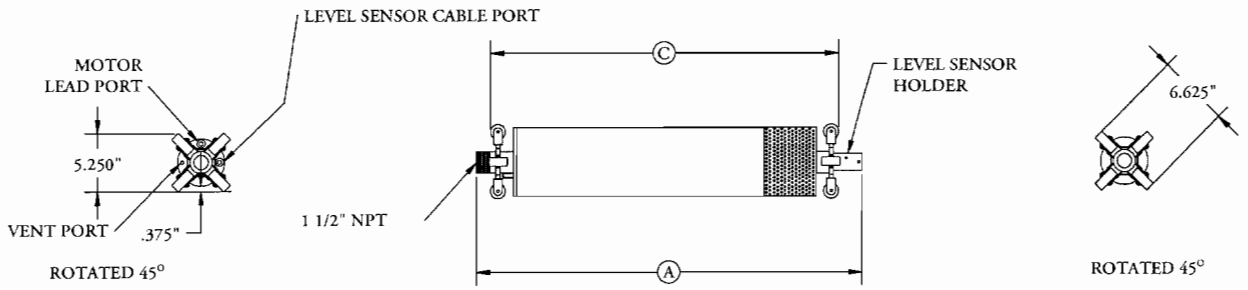
DATA SUBJECT TO CHANGE WITHOUT NOTICE

© 2009 EPG Companies Inc.
SurePump is a Reg. TM of EPG Companies Inc.

SERIES 5 SIZE 4 WHEELED SUMP DRAINER



WSD



WSDPT

MODEL	HP	PHASE	A	B	C	*APPROX. SHIPPING WEIGHT	
						WSD	WSDPT
5-2	0.50	1	31.02	29.90	29.15	61.47	66.47
5-2	0.50	3	31.02	29.90	29.15	61.47	66.47
5-3	0.75	1	32.98	31.86	31.11	66.24	71.24
5-3	0.75	3	32.98	31.86	31.11	66.24	71.24
5-4	1.00	1	34.90	33.78	33.03	70.98	75.98
5-4	1.00	3	34.90	33.78	33.03	70.98	75.98
5-5	1.00	1	35.73	34.61	33.86	71.88	76.88
5-5	1.00	3	35.73	34.61	33.86	71.88	76.88
5-6	1.50	1	38.43	37.31	36.56	79.22	84.22
5-6	1.50	3	36.56	35.44	34.69	72.77	77.77
5-7	1.50	1	39.26	38.14	37.39	80.12	85.12
5-7	1.50	3	37.39	36.27	35.52	73.67	78.67
5-8	2.00	1	41.59	40.47	39.72	85.17	90.17
5-8	2.00	3	40.09	38.97	38.22	81.01	86.01

MODEL	HP	PHASE	A	B	C	*APPROX. SHIPPING WEIGHT	
						WSD	WSDPT
5-9	2.00	1	42.42	41.30	40.55	86.07	91.07
5-9	2.00	3	40.92	39.80	39.05	81.90	86.90
5-10	2.00	1	43.25	42.13	41.38	86.96	91.96
5-10	2.00	3	41.75	40.63	39.88	82.80	87.80
5-11	2.00	1	44.08	42.96	42.21	87.86	92.86
5-11	2.00	3	42.58	41.46	40.71	83.69	88.69
5-12	2.00	1	44.91	43.79	43.04	88.75	93.75
5-12	2.00	3	53.41	52.29	51.54	92.35	97.35
5-13	3.00	1	54.24	53.12	52.37	119.24	124.24
5-13	3.00	3	51.24	50.12	49.37	105.91	110.91
5-14	3.00	1	55.07	53.95	53.20	120.14	125.14
5-14	3.00	3	52.07	50.95	50.20	106.81	111.81
5-15	3.00	1	55.90	54.78	54.03	121.03	126.03
5-15	3.00	3	52.90	51.78	51.03	107.70	112.70

NOTE: ALL DIMENSIONS ARE IN INCHES.

*SHIPPING WEIGHT INCLUDES
WSD: CRATE, 50' OF 14-4 MOTOR LEAD, 50' OF 1/8" SS CABLE.
WSDPT: CRATE, 50' OF 14-4 MOTOR LEAD, 50' OF 1/8" SS CABLE,
LEVEL SENSOR AND CABLE.

© 2009 EPG Companies Inc.
SurePump is a Reg. TM of EPG Companies Inc.

ENGINEER'S SPECIFICATION

EPG WSDPT SurePump™ Wheeled Sump Drainer

for side slope riser installations with built-in level sensor

PHASE II VADOSE

Furnish __1__ centrifugal submersible EPG WSDPT SurePump Wheeled Sump Drainer(s) (U.S. patented), Model WSDPT _2_ - _3_ with _3_ impeller stages. Each unit shall be suitable for side slope riser installation. Each unit shall be equipped with a _½_ HP, submersible electric motor for operation on __230__ Volts, _1_ phase, 60 Hertz service with __120__ feet of power cable. Each SurePump Wheeled Sump Drainer shall have a __1 ¼ inch MNPT threaded discharge nozzle and be capable of delivering __10__ GPM at __50__ feet of TDH. Each SurePump will be fitted with __120__ feet of stainless steel lifting cable of sufficient strength to permit removal of the unit.

DESIGN

Each SurePump Wheeled Sump Drainer shall be capable of pumping contaminated ground water for spill recovery, leachate, condensate, and purge applications. A removable transmitter mount (patent pending) shall be installed at the center bottom of the Sump Drainer for liquid level control. The Sump Drainer shall permit the unit to "pump down" to within __8__ inches of the sump bottom without any loss of performance or damage to the pump. External "priming" shall not be required nor allowed. The Sump Drainer shall be equipped with a vent valve to assist with the evacuation of air from the Sump Drainer.

MATERIALS

Major components shall be made of 304 stainless steel, seal rings are to be made of E-Glide™, and bearings are to be E-Glide. In addition, all fasteners shall be 304 stainless steel.

CHECK VALVE

Each unit shall include a built-in check valve with non-metallic seat, and housing and disc of 304 stainless steel.

SHAFT

The shaft shall be of 304 stainless steel and rotate on E-Glide bearings that are fluid lubricated.

DIFFUSER CHAMBER

The diffuser chambers for each impeller shall be 304 stainless steel and fitted with E-Glide impeller seal rings.

IMPELLERS

The impeller(s) shall be closed and consist of 304 stainless steel.

MOTOR

The motor shall be a submersible, hermetically sealed Franklin motor in _Pollution Recovery_ construction. The motor shall be designed for continuous duty, capable of sustaining up to _100_ starts per day. The motor shall be connected to the pump via a motor adaptor and coupling in 304 stainless steel. Single phase motors in ½ HP to 1 HP only shall have thermal protection in the motor windings to protect the windings from overload. The unit will restart automatically after the motor cools down. Larger horsepower single phase motors and three phase motors shall have thermal protection located in the control panel that is manually reset.

MOTOR LEAD WIRE

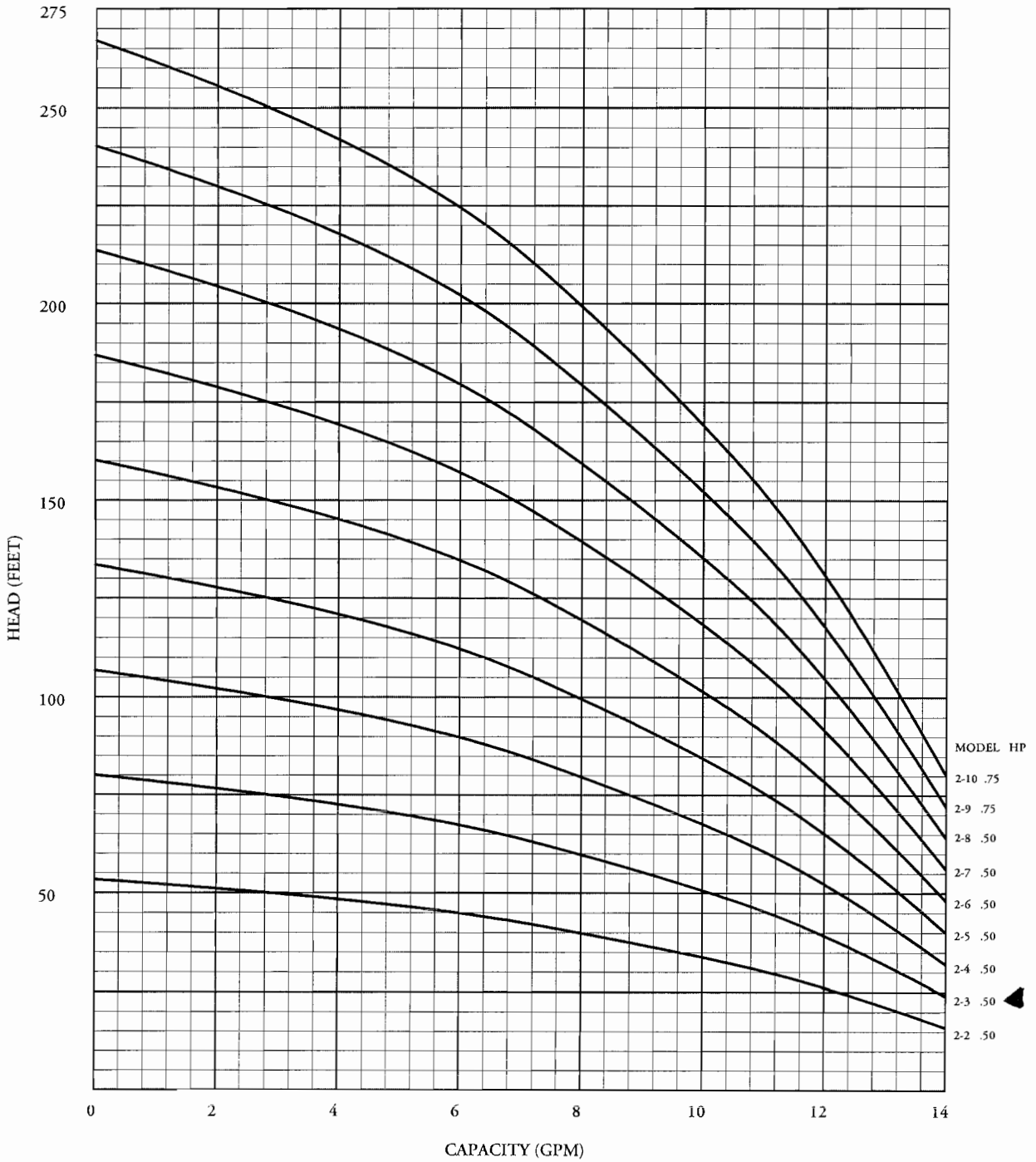
The lead wire shall be no-splice with EPG's "CP" waterproof and chemically resistant jacket over 600 Volt insulation and be of the length specified.

© 2009 EPG Companies Inc.
SurePump & E-Glide are Reg. TM of EPG Companies Inc.

SERIES 2 SurePump™

Flow Range 4-14 GPM

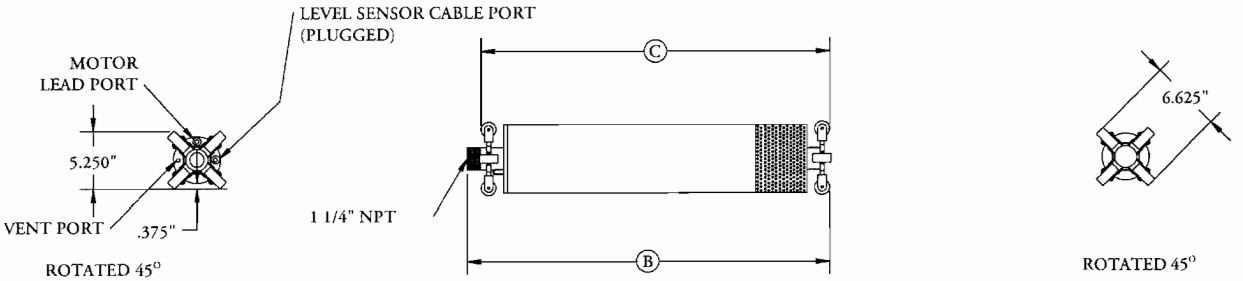
60 Hz



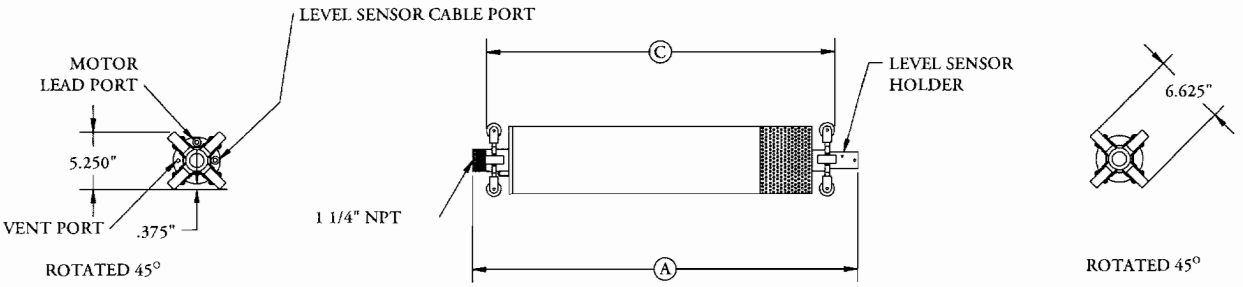
DATA SUBJECT TO CHANGE WITHOUT NOTICE

© 2009 EPG Companies Inc.
SurePump is a Reg. TM of EPG Companies Inc.

SERIES 2 SIZE 4 WHEELED SUMP DRAINER



WSD



WSDPT

MODEL	HP	PHASE	A	B	C	*APPROX. SHIPPING WEIGHT	
						WSD	WSDPT
2-2	0.50	1	31.02	29.90	29.15	61.47	66.47
2-2	0.50	3	31.02	29.90	29.15	61.47	66.47
2-3	0.50	1	31.85	30.73	29.98	62.37	67.37
2-3	0.50	3	31.85	30.73	29.98	62.37	67.37
2-4	0.50	1	32.68	31.56	30.81	63.26	68.26
2-4	0.50	3	32.68	31.56	30.81	63.26	68.26
2-5	0.50	1	33.51	32.39	31.64	64.15	69.15
2-5	0.50	3	33.51	32.39	31.64	64.15	69.15
2-6	0.50	1	34.34	33.22	32.47	65.05	70.05
2-6	0.50	3	34.34	33.22	32.47	65.05	70.05
2-7	0.50	1	35.17	34.05	33.30	65.94	70.94
2-7	0.50	3	35.17	34.05	33.30	65.94	70.94
2-8	0.50	1	36.00	34.88	34.13	66.84	71.84
2-8	0.50	3	36.00	34.88	34.13	66.84	71.84
2-9	0.75	1	37.96	36.84	36.09	71.61	76.61
2-9	0.75	3	37.96	36.84	36.09	71.61	76.61
2-10	0.75	1	38.79	37.67	36.92	72.50	77.50
2-10	0.75	3	38.79	37.67	36.92	72.50	77.50

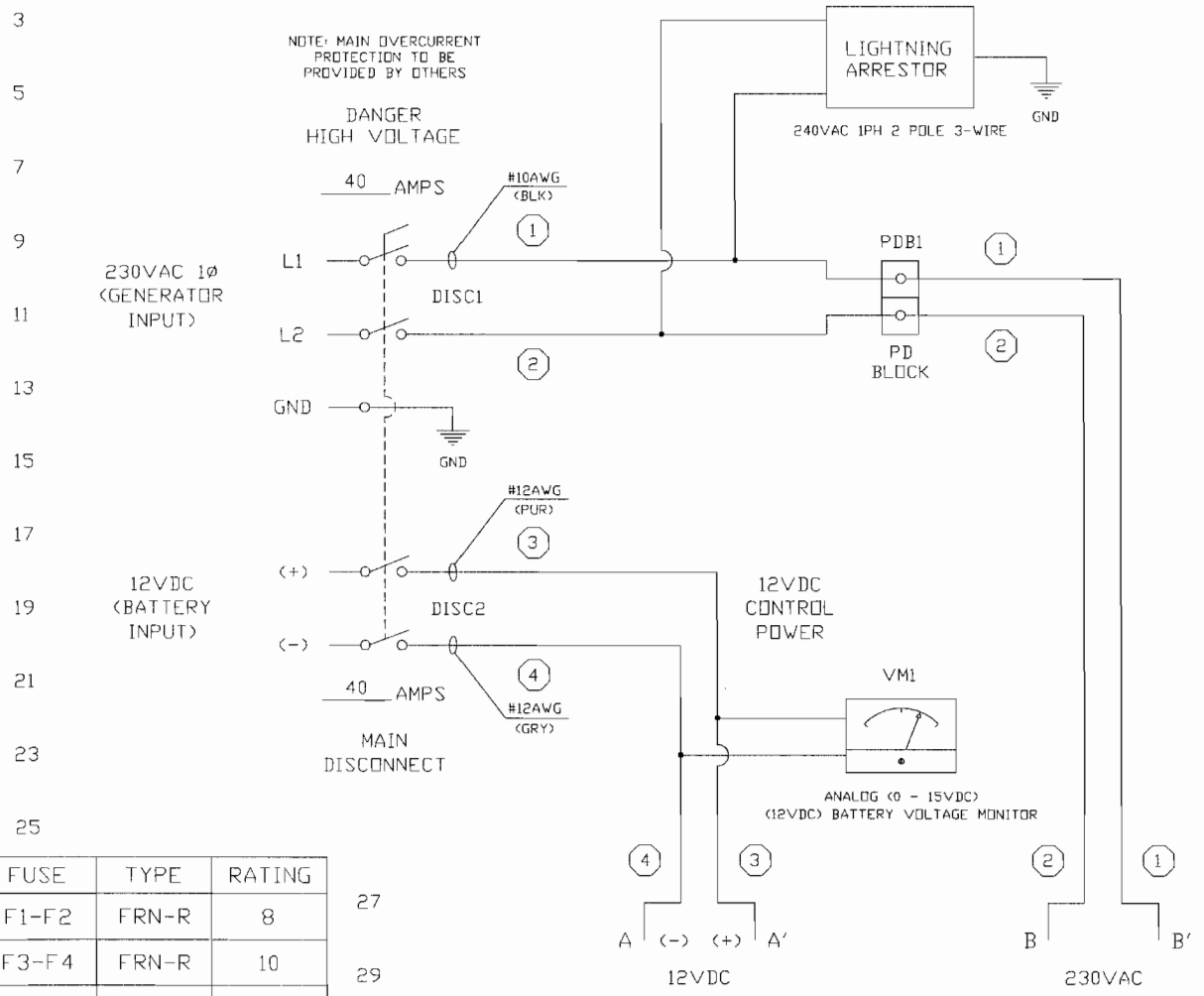
NOTE: ALL DIMENSIONS ARE IN INCHES.

*SHIPPING WEIGHT INCLUDES
WSD: CRATE, 50' OF 14-4 MOTOR LEAD, 50' OF 1/8" SS CABLE.
WSDPT: CRATE, 50' OF 14-4 MOTOR LEAD, 50' OF 1/8" SS CABLE,
LEVEL SENSOR AND CABLE.

© 2009 EPG Companies Inc.
SurePump is a Reg. TM of EPG Companies Inc.

Phase II
As-Built Control Panel Schematics

MOTOR	HP	VOLTAGE	FLA	FUSE SIZE
VADOSE PUMP	1/2	230	5.0	8A
LCRS PUMP	3/4	230	6.8	10A



FUSE	TYPE	RATING
F1-F2	FRN-R	8
F3-F4	FRN-R	10
F5-F6	FRN-R	2-1/2
F7	FNM	1-1/4
F8	FNM	3-1/2
F9	ABC	1-1/2
F10	MDL	1/2
F11	ABC	1/2
F12	ABC	1/2

FOR NOTES AND REVISIONS SEE SHEET 8

AS BUILT

PHASE 2
CONTROL PANEL AND PUMPS

FIELD WIRING TERMINALS

LINE (GENERATOR)

L1, L2 — 230VAC 1Ø 60Hz 15.05 AMPS

GND — GROUND

LINE (BATTERY)

(+), (-) — 12VDC 0.91 AMPS

JOB No. 09-9356B

* NOTICE * © EPG Companies Inc. 2009
THIS DRAWING IS THE PROPERTY OF EPG COMPANIES FOR REFERENCE ONLY.

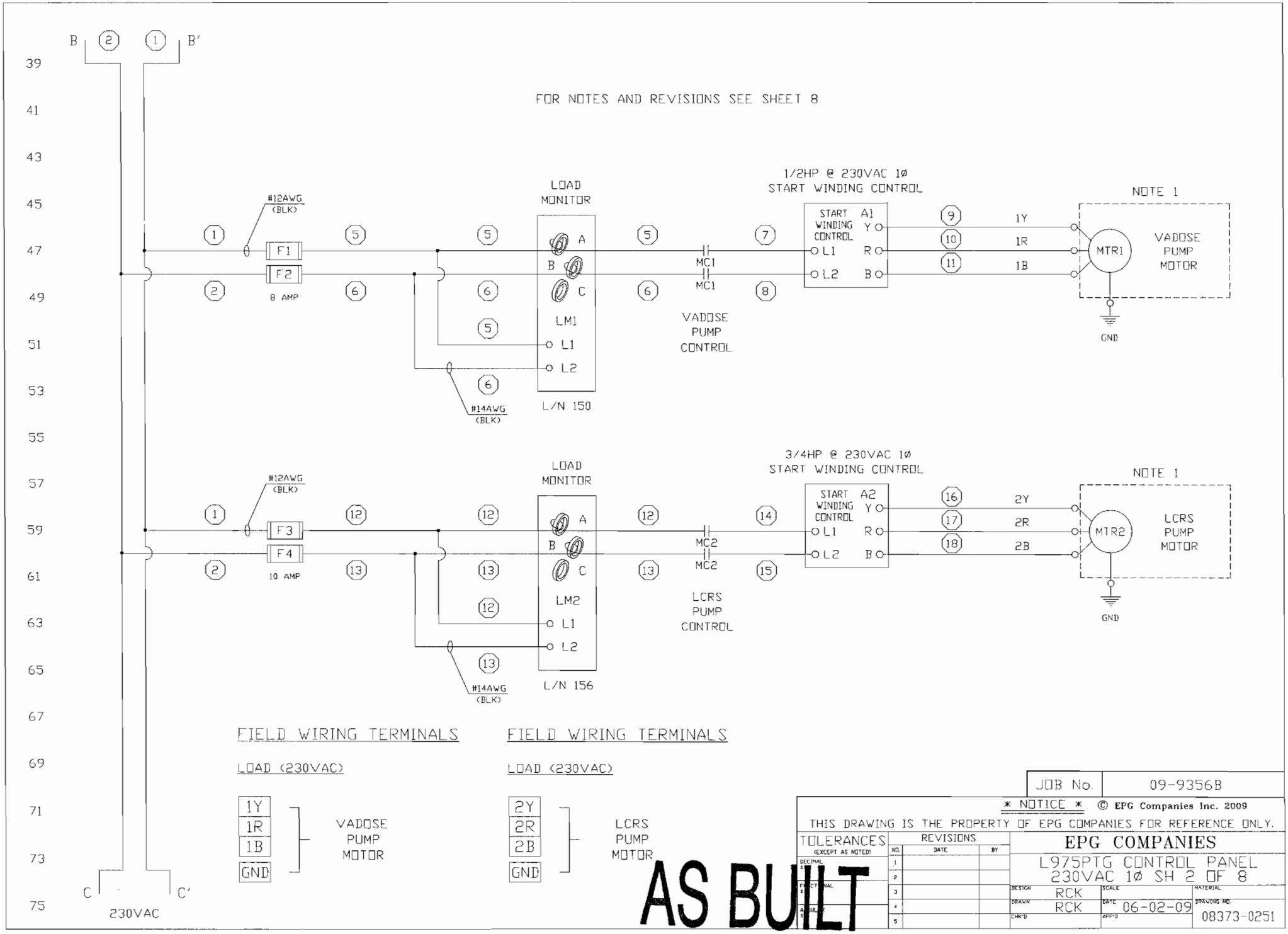
TOLERANCES (EXCEPT AS NOTED): DECIMAL ±; FRACTIONAL ±; ANGULAR ±

REVISIONS: NO. / DATE / BY

EPG COMPANIES

L975PTG CONTROL PANEL 230VAC 1Ø SH 1 OF 8

DESIGN RCK | DRAWN RCK | DATE 06-02-09 | CHK'D | APP'D | SCALE | MATERIAL | DRAWING NO. 08373-0250



JOB No.	09-9356B

* NOTICE * © EPG Companies Inc. 2009

THIS DRAWING IS THE PROPERTY OF EPG COMPANIES FOR REFERENCE ONLY.

TOLERANCES (EXCEPT AS NOTED)

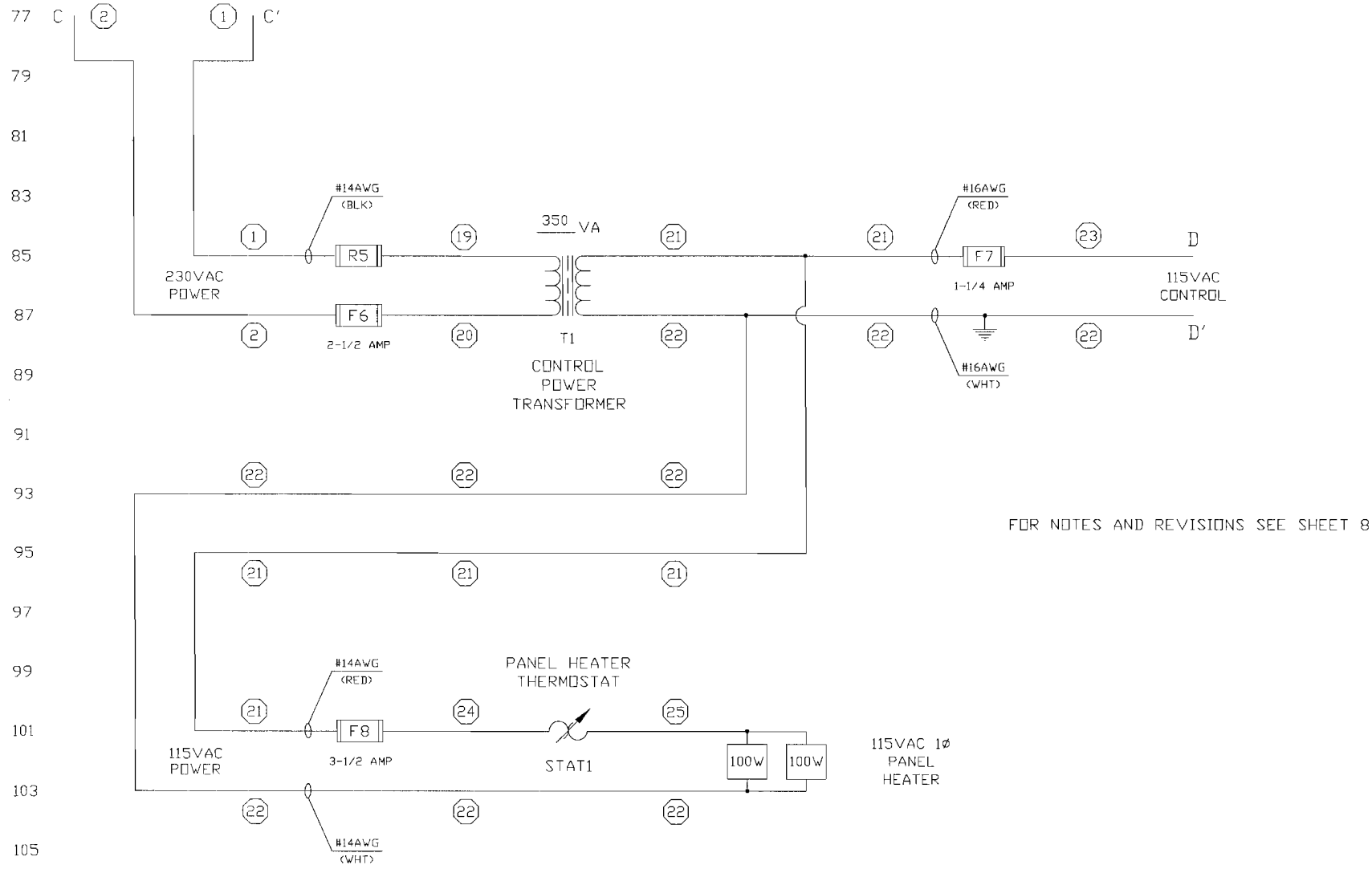
REVISIONS

NO.	DATE	BY
1		
2		
3		
4		
5		

EPG COMPANIES

L975PTG CONTROL PANEL
230VAC 1Ø SH 2 OF 8

DESIGN	RCK	SCALE	MATERIAL
DRAWN	RCK	DATE 06-02-09	DRAWING NO. 08373-0251
CHK'D		APP'D	



FOR NOTES AND REVISIONS SEE SHEET 8

AS BUILT

JOB No.	09-9356B

* NOTICE * © EPG Companies Inc. 2009
THIS DRAWING IS THE PROPERTY OF EPG COMPANIES FOR REFERENCE ONLY.

TOLERANCES (EXCEPT AS NOTED)
DECIMAL ±
FRACTIONAL ±
ANGULAR ±

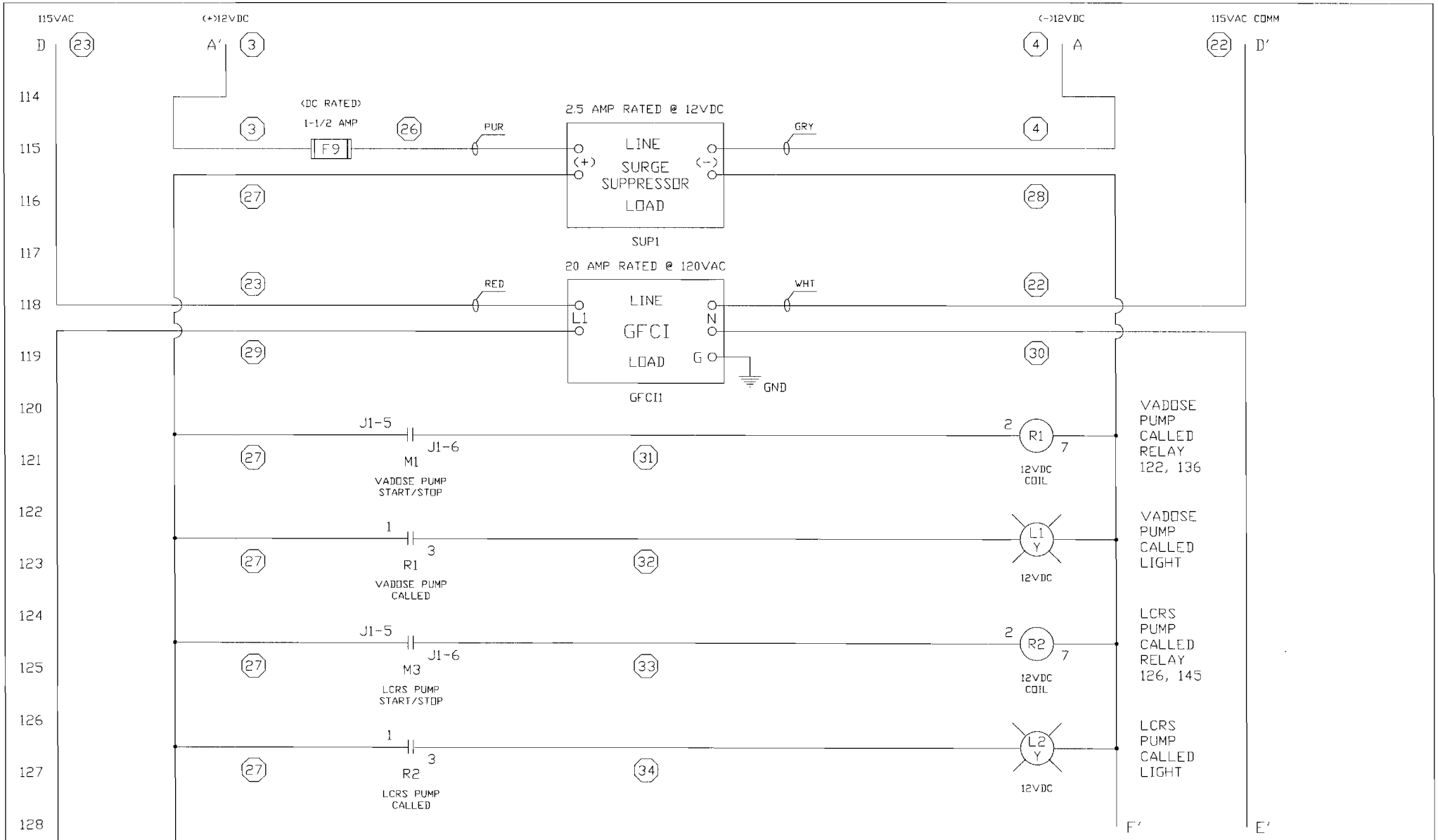
REVISIONS

NO.	DATE	BY
1		
2		
3		
4		
5		

EPG COMPANIES

L975PTG CONTROL PANEL
230VAC 1Ø SH 3 OF 8

DESIGN	RCK	SCALE	MATERIAL
DRAWN	RCK	DATE 06-02-09	DRAWING NO. 08373-0252
CHK'D		APP'D	



FOR NOTES AND REVISIONS SEE SHEET 8

AS BUILT

JOB No.	09-9356B

* NOTICE * © EPG Companies Inc. 2009

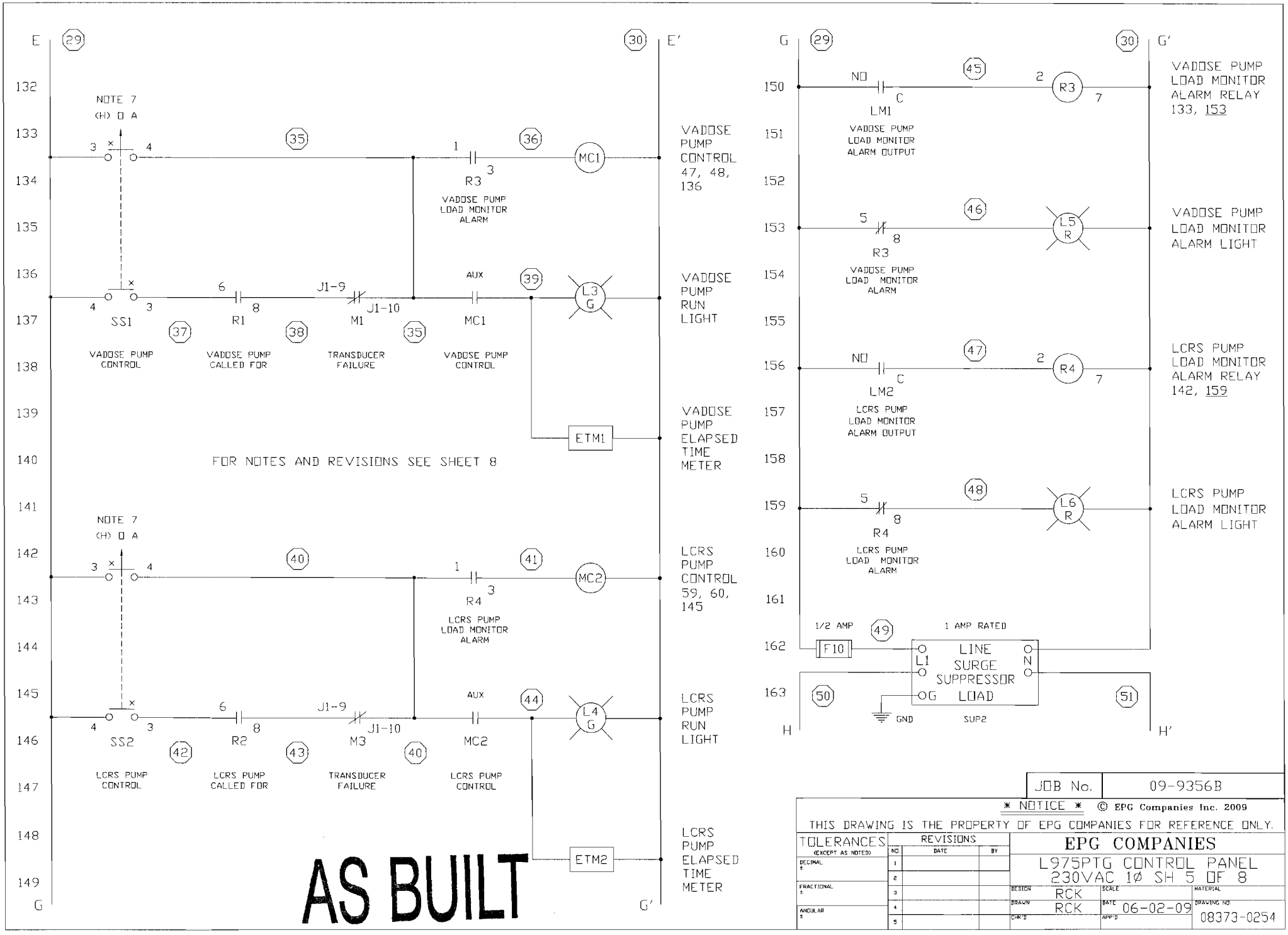
THIS DRAWING IS THE PROPERTY OF EPG COMPANIES FOR REFERENCE ONLY.

TOLERANCES (EXCEPT AS NOTED)	REVISIONS NO.	DATE	BY
DECIMAL ±	1		
	2		
FRACTIONAL ±	3		
ANGULAR ±	4		
	5		

EPG COMPANIES

L975PTG CONTROL PANEL
230VAC 1Ø SH 4 OF 8

DESIGN	SCALE	MATERIAL
RCK		
DRAWN RCK	DATE 06-02-09	DRAWING NO. 08373-0253
CHK'D	APP'D	



AS BUILT

JOB No.	09-9356B

* NOTICE * © EPG Companies Inc. 2009
THIS DRAWING IS THE PROPERTY OF EPG COMPANIES FOR REFERENCE ONLY.

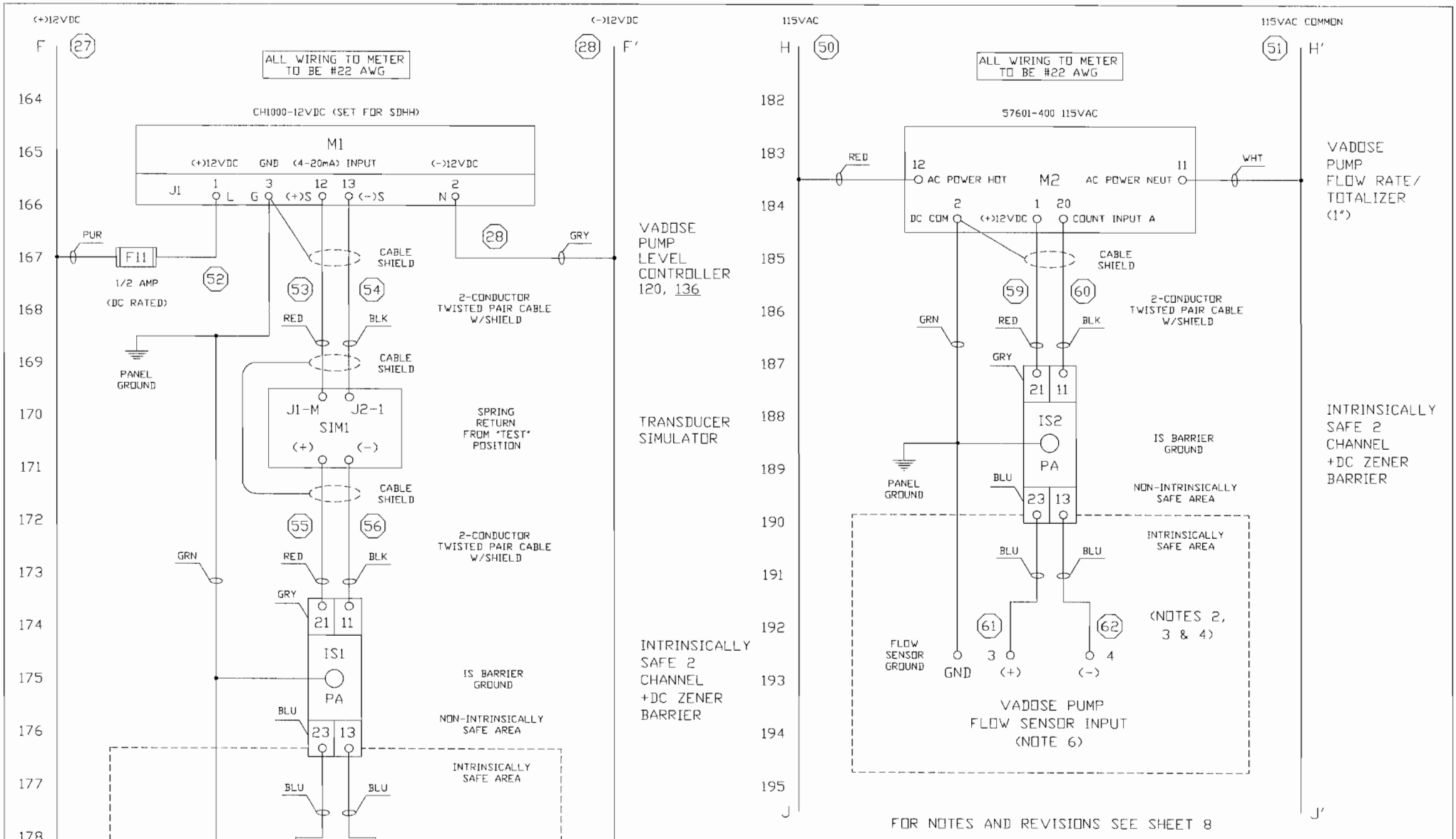
TOLERANCES (EXCEPT AS NOTED)
DECIMAL ±
FRACTIONAL ±
ANGULAR ±

REVISIONS		
NO.	DATE	BY
1		
2		
3		
4		
5		

EPG COMPANIES

L975PTG CONTROL PANEL
230VAC 1Ø SH 5 OF 8

DESIGN	RCK	SCALE	MATERIAL
DRAWN	RCK	DATE 06-02-09	DRAWING NO. 08373-0254
CHK'D		APP'D	



FOR NOTES AND REVISIONS SEE SHEET 8

AS BUILT

JOB No. 09-9356B

* NOTICE * © EPG Companies Inc. 2009
THIS DRAWING IS THE PROPERTY OF EPG COMPANIES FOR REFERENCE ONLY.

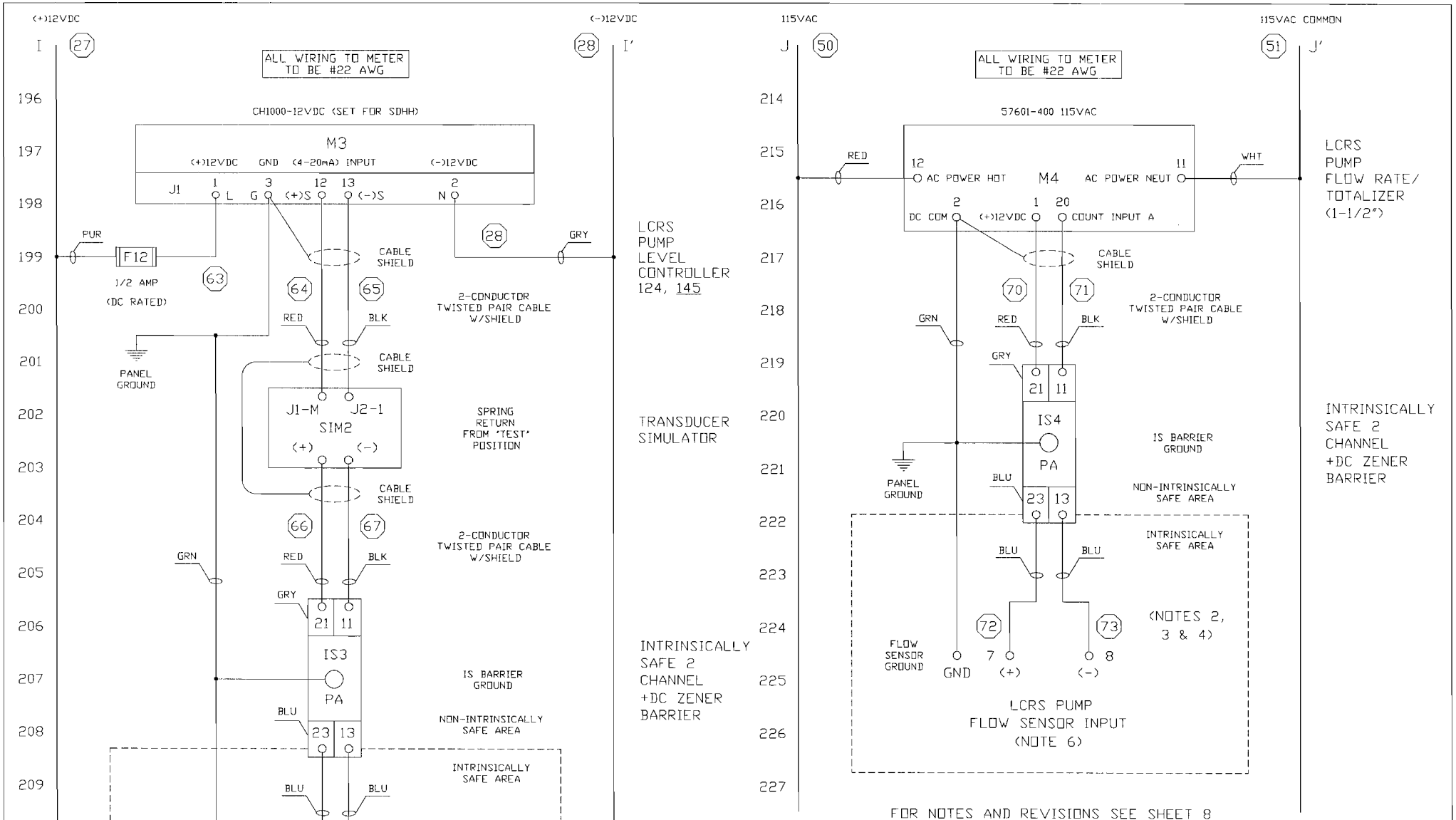
TOLERANCES (EXCEPT AS NOTED)
DECIMAL
FRACTIONAL
ANGULAR

REVISIONS		
NO.	DATE	BY
1		
2		
3		
4		
5		

EPG COMPANIES

L975PTG CONTROL PANEL
230VAC 1Ø SH 6 OF 8

DESIGN	RCK	SCALE	MATERIAL
DRAWN	RCK	DATE 06-02-09	DRAWING NO. 08373-0255
CHK'D		APP'D	



FOR NOTES AND REVISIONS SEE SHEET 8

LAST WIRE NUMBER USED: 73

JOB No. 09-9356B

* NOTICE * © EPG Companies Inc. 2009
THIS DRAWING IS THE PROPERTY OF EPG COMPANIES FOR REFERENCE ONLY.

TOLERANCES (EXCEPT AS NOTED)
DECIMAL ±
FRACTIONAL ±
ANGULAR ±

REVISIONS

NO.	DATE	BY
1		
2		
3		
4		
5		

EPG COMPANIES

L975PTG CONTROL PANEL
230VAC 1Ø SH 7 OF 8

DESIGN	SCALE	MATERIAL
RCK		
DRAWN RCK	DATE 06-02-09	DRAWING NO. 08373-0256
CHK'D	APP'D	

AS BUILT

FIELD WIRING TERMINALS

LEVEL SENSOR (INTRINSICALLY SAFE TERMINALS)

1	RED	VADOSE PUMP LEVEL SENSOR INPUT (NOTES 2, 3, 4 & 5)
2	BLACK	
GND	SHIELD GROUND	

FLOW SENSOR (INTRINSICALLY SAFE TERMINALS)

3	RED	VADOSE PUMP FLOW SENSOR INPUT (1") (NOTES 2, 3, 4 & 6)
4	WHITE	
GND	BLACK	

LEVEL SENSOR (INTRINSICALLY SAFE TERMINALS)

5	RED	LCRS PUMP LEVEL SENSOR INPUT (NOTES 2, 3, 4 & 5)
6	BLACK	
GND	SHIELD GROUND	

FLOW SENSOR (INTRINSICALLY SAFE TERMINALS)

7	RED	LCRS PUMP FLOW SENSOR INPUT (1-1/2") (NOTES 2, 3, 4 & 6)
8	WHITE	
GND	BLACK	

NOTE:

1. NOT PART OF CONTROLLER
2. REFERENCE INSTALLATION OF INTRINSICALLY SAFE INSTRUMENT SYSTEMS IN CLASS I HAZARDOUS LOCATIONS, ANSI/ISA-RP 12.6-1987, SECTION 4.5.4
3. WARNING: SUBSTITUTION OF COMPONENTS MAY IMPAIR INTRINSIC SAFETY
4. INSTALL IN ACCORDANCE WITH ARTICLE 504 OF THE NATIONAL ELECTRIC CODE
5. MAXIMUM CABLE LENGTH TO THE LEVEL SENSOR IS 3000 FEET
6. MAXIMUM CABLE LENGTH TO THE FLOW SENSOR IS 500 FEET
7. SELECTOR SWITCHES, (SS1-SS2) WILL SPRING RETURN FROM THE "HAND" POSITION

AS BUILT

JOB No.	09-9356B

* NOTICE * © EPG Companies Inc. 2009
THIS DRAWING IS THE PROPERTY OF EPG COMPANIES FOR REFERENCE ONLY.

TOLERANCES (EXCEPT AS NOTED)
DECIMAL ±
FRACTIONAL ±
ANGULAR ±

REVISIONS

NO.	DATE	BY
1		
2		
3		
4		
5		

EPG COMPANIES

L975PTG CONTROL PANEL
230VAC 1Ø SH 8 OF 8

DESIGN	RCK	SCALE	MATERIAL
DRAWN	RCK	DATE 06-02-09	DRAWING NO. 08373-0257
CHK'D		APP'D	

Phase II
Installation Records

EPG Companies Inc.

SurePump™ Installation Record

Form Completed by: KEY Installation Date: 8/28/09

Company: HAMPTON ROADER ELECTRIC EPG Serial #: 09-9356B

PUMPS, CONTROLS AND POWER SUPPLY

Installer:	Address:	Installation Location:
HTE	4920 ALTO AVE. LAS VEGAS, NV. 89115	PHASE 2 LCRS

Motor Model	HP	Volts:	Max Amps Rating:	Pump Model:
WSDPT5-3	3/4	230	6.8	EPG WSDPT SURE PUMP

Power Supply Transformers: Number Used: KVA Each:	Hertz:	Comments:
.350	60	

Pump Control Panel: Mfg. & Model #:	Motor Starter Size:	Overload Heater Part or setting range:	IEC Starters:
EPG L975PTG	.75 HP	NA	

Lightning Arrestors: Mfg. & Model:	Surge Capacitors:	Disconnect Fuse or Circuit Breaker Amp Rating:
Intermatic AG2401	Yes ____ No ✓	40

Primary Flow Control Devices:
(Low Level Control, Flow Control, Valve, System Back Pressure, etc.)
—

OPERATING DATA (Measurements at Control Panel)

PUMP CONDITIONS: GPM	VOLTS	AMPS
Pump Not Running (Line) 0	R-Y 0 R-B 0 B-Y 233	0
Open Discharge	R-Y ____ R-B ____ B-Y ____	R ____ Y ____ B ____
Normal Operation	R-Y 0 R-B 0 B-Y 230.9	R 0 Y 6.9 B 6.9
Run Time		
Off Time		

EPG Companies Inc.

INSTALLATION DATA

Discharge Line Size: 1 1/2"	Discharge Pressure:	Pump Submergence:	Fluid Temp: ____ °F ____ °C
External Check Valve Used? NO	Location:	Cable Length & Size: 120' 14 GA	Ground Resistance 3 OHMS
Insulation Megohm Readings:	Before Installation:	After Installation: 119 Meg	After 30 min. Run: NA

SENSORS

Type of Level Sensor: Pressure Transmitter ✓ Load Monitor ____ Floats ____ Other ____	Transmitter Serial Number:
Length of Sensor Lead: 120'	Ohm Readings Across I.S. Barrier: 230
mA Readings on Transmitter Lead:	Voltage Reading Entering Level Meter: 12 VAC Voltage Leaving Level Meter: 12 VAC
Are Flow Sensors Used: Yes ✓ No ____	Flow Spool Made of: PVC ✓ Stainless Steel ____

Comments: _____

Place one copy of this record in the control panel, return one copy to EPG, and retain original for your records.

In case of problems or questions, contact EPG Companies Inc., 19900 County Road 81, Maple Grove, MN 55311 Phone: 800-762-8418 FAX: 763-493-4812

EPG SurePump™ Installation Record

EPG Job No. 09-93556

Installer's Name HAMPTON TEDDER ELECTRIC CO.

Address 4920 ALTO AVE

City LAS VEGAS State NV Zip 89115

Phone (702) 646-7449 Fax (702) 453-5412

Contact name ROGER OATES

Owner's Name BASIC REMEDIATION CO.

Address 875 W. WARM SPRINGS, RD.

City HENDERSON State NV Zip 89011

Phone (702) 567-0400 Fax (702) 567-5524

Contact name LEE C. FARRIS, PE

Sump Name ID PHASE 2 LCRS Date Installed 8/28/09

Leachate or Condensate Temp _____ °F Or °C

Pump:

Model No. WSOPT 5-3

Rating: 30 GPM@ 60 Ft. TDH

HP .75 Voltage 230 Phase 1

Actual Pump Delivery _____ GPM@ _____ PSI

Operating Cycle _____ ON (Min/Hr) _____ OFF (Min/Hr) (Circle Min. or Hr. as appropriate)

Side Slope Riser Information:

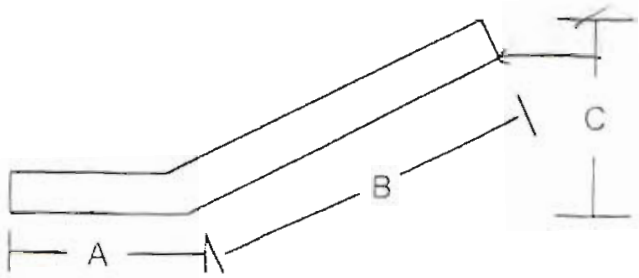
Slope 2.1 :1

Length of riser Pipe (A+B) 101.2 ft

Vertical Distance - Sump to INV Top of Riser Pipe (C) 39.9 ft

Riser ID PHASE 2 LCRS SDR 11

Distance From Top of Riser Pipe to Controller 15 ft



Power Supply:

Cable: Service Entrance to Control Distance _____ ft Wire size _____ AWG/MCM

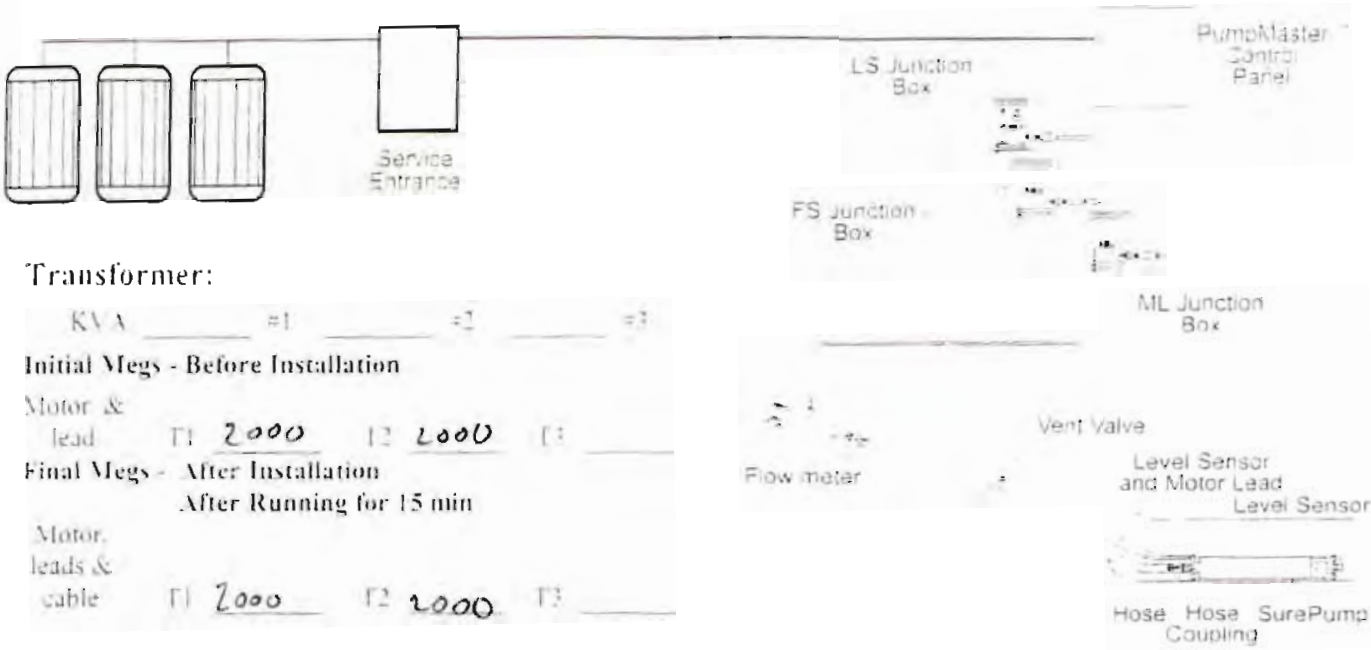
Copper _____ Jacketed _____ Aluminum _____ Individual conductors _____

Cable: Control to Motor _____ ft _____ AWG/MCM

Copper _____ Jacketed _____

EPG Companies Inc.

July 2002



Transformer:

KVA _____ #1 _____ #2 _____ #3 _____

Initial Megs - Before Installation

Motor & lead T1 2000 T2 2000 T3 _____

Final Megs - After Installation
After Running for 15 min

Motor, leads & cable T1 2000 T2 2000 T3 _____

Incoming Voltage:

No Load L1-L2 233 L2-L3 _____ L1-L3 _____

Full Load L1-L2 233 L2-L3 _____ L1-L3 _____

Running Amps:

Hookup:1

Full Load L1 8 L2 8 L3 _____ % unbalanced _____

Hookup:2

Full Load L1 _____ L2 _____ L3 _____ % unbalanced _____

Hookup:3

Full Load L1 _____ L2 _____ L3 _____ % unbalanced _____

Ground wire size _____ AWG MCM

DC Ground Current _____ mA Ground Test 3 Ohms

Motor Surge Protection _____ Yes _____ No

Control Panel:

Model # L975PTG

Short Circuit Device

Circuit Breaker _____ Rating _____ Setting _____

Fuses FNRNR Type 10 Rating

_____ Standard ✓ Time Delay

Controls are Grounded to:

_____ Motor

✓ Rod

_____ Power Supply

Start Overloads:

Set at N/A amps

Name HOWARD LESTER

Company EPG COMPANIES

Date SEPT 17 09

© EPG Companies Inc. 2000

INSTALLATION GUIDE

EPG SurePump™ Pumping System

1. Verify that equipment and supply voltage match.

2. Inspect equipment, look for shipping damage, dirt, and rough handling.

3. Control panel should be mounted in a secure way at least 15' from riser or sump and 36" above grade to bottom of control panel.

4. Inspect inside of control panel. Look for items which might have come loose during shipping.

5. Test level sensor in bucket of water. Does it return back to zero? Control panel needs to be installed and have power to it.

6. Install vent valve and tubing. See Bulletin 0130c.

7. Install suspension cable. See Bulletin 6090a.

8. Fasten motor lead and sensor cable to discharge line every 5' to 7' with straps or plastic wire ties. It's best if they are on separate sides of line; use padding between cables and any metal straps.

9. Run pump down riser slowly using stainless steel suspension cable as hold back. Make sure motor lead and sensor cable are slack as you lower pump.

10. Take ohm reading of each motor lead wire to wire and compare the values in Table 13 of the Franklin Electric motor manual for 1Ø and Table 21 for 3Ø. Be sure to add wire resistance value to value from table 13& 21. See page 39 for wire resistance.

11. Check insulation resistance as pump is lowered down riser. Resistance may drop gradually as pump and cable enter the liquid, but any sudden drop indicates a problem.

12. Run sensor leads and power cables in separated conduits to control panel. It is a good idea to use breakout junction boxes. See Design Guide 05644.

13. If you have to remove dryer from end of transducer cable to pull cable through fittings or conduit. Seal end of the vent tube with a piece of tape. Reinstall dryer as soon as possible. See Bulletin 0550a.

14. Megger motor leads. Resistance must be 1 megohm or greater.

15. Connect pump to control panel complying with local and national codes. Controller terminal strips, motor leads, and sensor leads are all labeled and or color coded to simplify connections.

16. Inspect wire connections. Are they the correct colors? Are they tight?

17. If color-coded wires were not continued from sump or riser, you need to point out each circuit.

18. Measure resistance to ground. It must be less than 25 ohms. If greater, stop work and report to owner. It should be 1 ohm or less to protect electronic equipment.

© 2000 EPG Companies Inc.

☑ 19. Measure voltage prior to control panel or at entrances to control panel. Measure and record voltage line to line and line to ground.

☑ 20. Compare these reading to voltage listed on drawing and label in control panel.

☑ 21. Review equipment list and drawings for any accessory circuits. If present, run volt and ohm test.

☑ 22. Check and make sure all hand switches are in the off position. If you have a water level indicator verify leachate level in sump or riser.

☑ 23. Turn on power at panel main disconnect.

☑ 24. Level meters display should light up. Record displayed reading. How does this reading compare to your measured level reading?

☑ 25. If level and flow meter do not light up check GFCI, reset if necessary.

☑ 26. Are any indicator lights on?

☑ 27. Should they be on?

☑ 28. Make sure pump is turned off. Using built in or hand held simulator, verify level meter settings are correct for this site. See meter data sheet for factory settings and meter instructions.

☑ 29. Bump pump by turning switch to hand two or three times to make sure pump has reached its resting point. You should have minimum of 3' of slack in the cables.

☑ 30. To verify correct rotation place hand around discharge line. It will torque right if the rotation is correct.

☑ 31. When pump is running measure and record amperage and voltage. Check 3Ø systems for current balance within 5% of average.

☑ 32. Verify that starting, running and stopping causes no significant vibration or hydraulic shocks.

☑ 33. After 15 minutes of running time measure volts and amperage to see if they are stable. Are they as specified?

☑ 34. After pump and level sensor have been tested pot seal offs.

☑ 35. Complete Form 200. Note: If this form is not completed and returned to EPG it will impact system warranty.

2009 EPG Companies Inc.

START UP CHECKLIST

EPG SurePump™ Pumping System

QUESTIONS FOR CONTRACTOR OR INSTALLER

- ✓ A: Were sensor and power cable tied or strapped to discharge line?
- ✓ B: On what kind of spacing?
- ✓ C: What is the as built length of riser and sump? Were cables long enough? There should be 3 or more feet of slack in the cables.
- ✓ D: What size cable was run for supply power?
- ✓ E: What is the distance from power supply transformer to pump control panel?
- ✓ F: How did they verify that pump is down into sump?
- ✓ G: Did they test level sensor prior to installing?
- ✓ H: Did they test pump prior to installing or prior to your arrival?
- ✓ I: Do they have any questions or concerns?
- ✓ J: Complete form 200

PHYSICAL INSPECTION OF CONTROL PANEL

- ✓ A: Is the control panel located 15' from sump or riser and 36" above grade to bottom of panel
- ✓ B: Are power and sensor cable run in separate conduit? If not, stop work and have this corrected.
- ✓ C: Are seal offs installed in both sensor and power runs? If not, suggest breakout junction boxes or have seal off installed.
- ✓ D: Are seal offs potted? If not, stop work and have them potted.
- ✓ E: Will inner and outer door of enclosure open and close freely? If not loosen enclosure mounting bolts and shim until it is level and square. Then retighten mounting bolts.
- ✓ F: Make sure ground wire is in place between outer door and enclosure

2009 EPG Companies Inc.

PRIOR TO ENERGIZING CONTROL PANEL

- ✓ A: Measure resistance to ground. It must be less than 25 ohms. If greater stop work and report to owner. It should be 1 ohm or less to protect electronic equipment.
- ✓ B: Measure voltage prior to control panel or at entrances to control panel. Measure and record voltage line to line and line to ground.
- ✓ C: Compare these reading to voltage listed on drawing and label in control panel.
- ✓ D: Megger motor leads resistance must be 1 megohm or greater.
- ✓ E: Take ohm reading of each motor lead wire to wire and compare these to values in Table 13 of the Franklin Electric motor manual for 1O and Table 21 for 3O. Be sure to add wire resistance value to value from table 13& 21. See page 39 for wire resistance.
- ✓ F: Inspect inside of control panel. Look for items which may have come loose during shipping
- ✓ G: Inspect wire connections. Are they the correct colors? Are they tight?
- ✓ H: If color-coded wires were not continued from sump or riser you need to ohm out each circuit.
- ✓ I: Review equipment list and drawings from any accessory circuits. If present, run volt and ohm test.
- ✓ J: Check and make sure all hand switches are in off position. If you have a water level indicator verify leachate level in sump or riser.

POWER UP

- ✓ A: Turn on power at panel main disconnect.
- ✓ B: Level meters display should light up. Record displayed reading. How does this reading compare to your measured level reading?
- ✓ C: If level and flow meter do not light up check GFCI, reset if necessary
- ✓ D: Are any indicator lights on?
- ✓ E: Should they be on?
- ✓ F: Make sure pump is turned off. Using built in or hand held simulator verify level meter settings are correct for this site
- ✓ G: Bump pump by turning hand switch two or three times to make sure pump has reached its resting point. You should have minimum of 3' of slack in the cables

- ❑ H: To verify correct rotation place hand around discharge line. It will torque right if the rotation is correct.
- ❑ I: If there is liquid in sump with level about pump start set point and below 150". Then turn pump selector switch to AUTO. Run pump through one complete cycle.
- ✓ J: When pump is running measure and record amperage and voltage. Check 3O systems for current balance within 5% of average.
- ✓ K: Verify that starting, running and stopping causes no significant vibration or hydraulic shocks.

2009 EPG Companies Inc.

EPG Companies Inc.

SurePump™ Installation Record

Form Completed by: KEY Installation Date: 8/28/09
Company: HAMPTON TEDDER CONNER EPG Serial #: 09-9356B

PUMPS, CONTROLS AND POWER SUPPLY

Installer:	Address:	Installation Location:
HTE	4920 AVO AVE LAS VEGAS, NV. 89115	PHASE 2 VADOSE

Motor Model	HP	Volts:	Max Amps Rating:	Pump Model:
WSDPT2-3	1/2	230	5.0A	EPG WSDPT Sure Pump

Power Supply Transformers:	Hertz:	Comments:
Number Used: 1 KVA Each: .350	60	

Pump Control Panel: Mfg. & Model #	Motor Starter Size:	Overload Heater Part or setting range:	IEC Starters:
EPG L975PTG	Siemens 42BF15AF (5hp)	NA	

Lightning Arrestors: Mfg. & Model:	Surge Capacitors:	Disconnect Fuse or Circuit Breaker Amp Rating:
Intermatic AG2401	Yes ____ No ✓	40A

Primary Flow Control Devices:
(Low Level Control, Flow Control, Valve, System Back Pressure, etc.)
—

OPERATING DATA (Measurements at Control Panel)

PUMP CONDITIONS:	GPM	VOLTS			AMPS		
Pump Not Running (LINE)	0	R-Y 0	R-B 0	B-Y 233	0		
Open Discharge		R-Y ____	R-B ____	B-Y ____	R ____	Y ____	B ____
Normal Operation		R-Y 0	R-B 0	B-Y 232.9	R ____	Y 4.3	B 4.4
Run Time Off Time							

© EPG Companies Inc. 2009

EPG Companies Inc.

INSTALLATION DATA

Discharge Line Size: 1"	Discharge Pressure:	Pump Submergence:	Fluid Temp: _____ °F _____ °C
External Check Valve Used? NO	Location:	Cable Length & Size: 14GA 113	Ground Resistance 3 OHm
Insulation Megohm Readings:	Before Installation:	After Installation: 11.5G	After 30 min. Run: NA

SENSORS

Type of Level Sensor: Pressure Transmitter ✓ Load Monitor ____ Floats ____ Other ____	Transmitter Serial Number:
Length of Sensor Lead: 113'	Ohm Readings Across I.S. Barrier: 230
mA Readings on Transmitter Lead:	Voltage Reading Entering Level Meter: 12 VDC Voltage Leaving Level Meter: 12 VDC
Are Flow Sensors Used: Yes ✓ No ____	Flow Spool Made of: PVC ✓ Stainless Steel ____

Comments: No able to test 30 MINUTES due to dry sump.

Place one copy of this record in the control panel, return one copy to EPG, and retain original for your records.

In case of problems or questions, contact EPG Companies Inc., 19900 County Road 81, Maple Grove, MN 55311 Phone: 800-762-8418 FAX: 763-493-4812

© EPG Companies Inc. 2009

EPG SurePump™ Installation Record

EPG Job No. 09-9356

Installer's Name HAMPTON TEDDER ELECTRIC CO.

Address 4920 ARTO AVE.

City LAS VEGAS State NV. Zip 89115

Phone (702) 646-7449 Fax (702) 453-5412

Contact name ROGER CATES

Owner's Name BASIC REMEDIATION CO

Address 875 W. WARM SPRINGS RD.

City HENDERSON State NV. Zip 89011

Phone (702) 567-0400 Fax (702) 567-5524

Contact name LEE C. FARRIS, PE

Sump Name ID PHASE 2 VADOSE Date Installed 8/28/09

Leachate or Condensate Temp _____ °F Or °C

Pump:

Model No. WSDP T 2-3

Rating 10 GPM@ 50 Ft. TDH

HP .5 Voltage 230 Phase 1

Actual Pump Delivery _____ GPM@ _____ PSI

Operating Cycle _____ ON (Min Hr) _____ OFF (Min Hr) (Circle Min. or Hr. as appropriate)

Side Slope Riser Information:

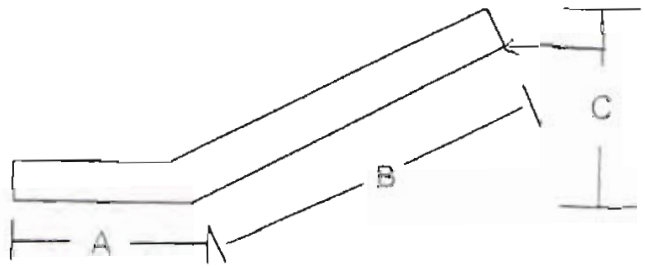
Slope 2.1 :1

Length of riser Pipe (A+B) 96.1 ft.

Vertical Distance - Sump to INV. Top of Riser Pipe (C) 38.6 ft.

Riser ID PHASE 2 VADOSE SDR 11

Distance From Top of Riser Pipe to Controller 15 ft



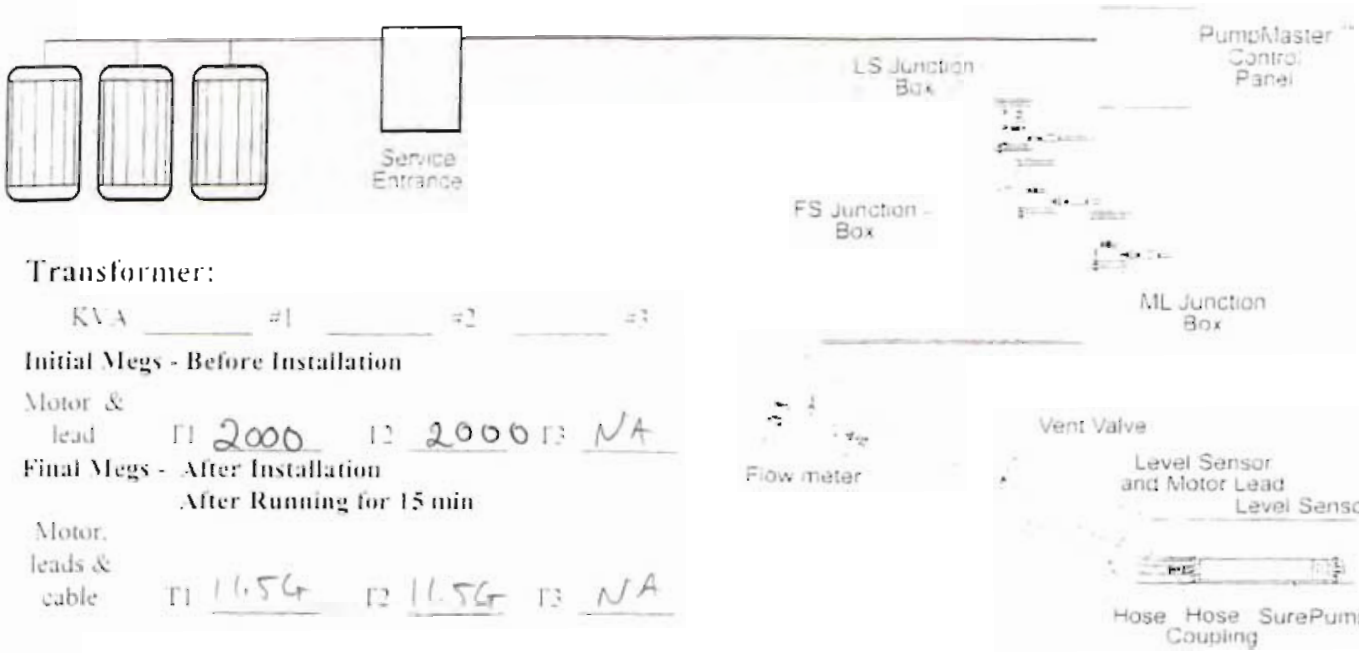
Power Supply:

Cable Service Entrance to Control Distance _____ ft Wire Size _____ AWG MCM

Copper Jacketed Aluminum Individual conductors

Cable Control to Motor _____ ft _____ AWG MCM

Copper Jacketed _____



Transformer:

KVA _____ #1 _____ #2 _____ #3

Initial Megs - Before Installation

Motor & lead T1 2000 T2 2000 T3 NA

Final Megs - After Installation

After Running for 15 min

Motor, leads & cable T1 1.5G T2 1.5G T3 NA

Incoming Voltage:

No Load	L1-L2 233	L2-L3 NA	L1-L3 NA
Full Load	L1-L2 230	L2-L3 NA	L1-L3 NA

Running Amps:

Hookup:1

Full Load L1 _____ L2 _____ L3 _____ % unbalanced _____

Hookup:2

Full Load L1 _____ L2 _____ L3 _____ % unbalanced _____

Hookup:3

Full Load L1 _____ L2 _____ L3 _____ % unbalanced _____

NA

Ground wire size _____ AWG MCM

DC Ground Current _____ mA Ground Test 3 Ohms

Motor Surge Protection ✓ Yes _____ No

Control Panel:

Model # See startup sheets L975PTG

Short Circuit Device

Circuit Breaker _____ Rating _____ Setting

Fuses FRNR Type 8 Rating

_____ Standard ✓ Time Delay

Controls are Grounded to:

_____ Motor

X Rod

_____ Power Supply

Start Overloads:

Set at N/A amps

Name HOWARD LESTER

Company EPG COMPANIES

Date SEP 17 09

© EPG Companies Inc. 2009

INSTALLATION GUIDE

EPG SurePump™ Pumping System

1. Verify that equipment and supply voltage match.

2. Inspect equipment, look for shipping damage, dirt, and rough handling.

3. Control panel should be mounted in a secure way at least 15" from riser or sump and 36" above grade to bottom of control panel.

4. Inspect inside of control panel. Look for items which might have come loose during shipping.

5. Test level sensor in bucket of water. Does it return back to zero? Control panel needs to be installed and have power to it.

6. Install vent valve and tubing. See Bulletin 0130c.

7. Install suspension cable. See Bulletin 6090a.

8. Fasten motor lead and sensor cable to discharge line every 5' to 7' with straps or plastic wire ties. It's best if they are on separate sides of line; use padding between cables and any metal straps.

9. Run pump down riser slowly using stainless steel suspension cable as hold back. Make sure motor lead and sensor cable are slack as you lower pump.

10. Take ohm reading of each motor lead wire to wire and compare the values in Table 13 of the Franklin Electric motor manual for 1Ø and Table 21 for 3Ø. Be sure to add wire resistance value to value from table 13& 21. See page 39 for wire resistance.

11. Check insulation resistance as pump is lowered down riser. Resistance may drop gradually as pump and cable enter the liquid, but any sudden drop indicates a problem.

12. Run sensor leads and power cables in separated conduits to control panel. It is a good idea to use breakout junction boxes. See Design Guide 0564.

13. If you have to remove dryer from end of transducer cable to pull cable through fittings or conduit. Seal end of the vent tube with a piece of tape. Reinstall dryer as soon as possible. See Bulletin 0550a.

14. Megger motor leads. Resistance must be 1 megohm or greater.

15. Connect pump to control panel complying with local and national codes. Controller terminal strips, motor leads, and sensor leads are all labeled and or color coded to simplify connections.

16. Inspect wire connections. Are they the correct colors? Are they tight?

17. If color-coded wires were not continued from sump or riser you need to ohm out each circuit.

18. Measure resistance to ground. It must be less than 25 ohms. If greater stop work and report to owner. It should be 1 ohm or less to protect electronic equipment.

2009 EPG Companies Inc.

☑ 19. Measure voltage prior to control panel or at entrances to control panel. Measure and record voltage line to line and line to ground.

☑ 20. Compare these reading to voltage listed on drawing and label in control panel.

☑ 21. Review equipment list and drawings for any accessory circuits. If present, run volt and ohm test.

☑ 22. Check and make sure all hand switches are in the off position. If you have a water level indicator verify leachate level in sump or riser.

☑ 23. Turn on power at panel main disconnect.

☐ 24. Level meters display should light up. Record displayed reading. How does this reading compare to your measured level reading?

☑ 25. If level and flow meter do not light up check GFCI, reset if necessary.

☐ 26. Are any indicator lights on?

☐ 27. Should they be on?

☐ 28. Make sure pump is turned off. Using built in or hand held simulator, verify level meter settings are correct for this site. See meter data sheet for factory settings and meter instructions.

☑ 29. Bump pump by turning switch to hand two or three times to make sure pump has reached its resting point. You should have minimum of 3' of slack in the cables.

☑ 30. To verify correct rotation place hand around discharge line. It will torque right if the rotation is correct.

☑ 31. When pump is running measure and record amperage and voltage. ☑ Check 3Ø systems for current balance within 5% of average. ☐ NA

☑ 32. Verify that starting, running and stopping causes no significant vibration or hydraulic shocks.

☐ 33. After 15 minutes of running time measure volts and amperage to see if they are stable. Are they as specified?

☐ 34. After pump and level sensor have been tested pot seal offs.

☐ 35. Complete Form 200. Note: If this form is not completed and returned to EPG it will impact system warranty.

START UP CHECKLIST

EPG SurePump™ Pumping System

QUESTIONS FOR CONTRACTOR OR INSTALLER

- ☑ A: Were sensor and power cable tied or strapped to discharge line?
- ☑ B: On what kind of spacing? 5'
- ☑ C: What is the as built length of riser and sump? Were cables long enough? There should be 3 or more feet of slack in the cables.
- ☑ D: What size cable was run for supply power? 14GA
- ☐ E: What is the distance from power supply transformer to pump control panel?
- ☑ F: How did they verify that pump is down into sump? LEVEL
- ☑ G: Did they test level sensor prior to installing?
- ☑ H: Did they test pump prior to installing or prior to your arrival?
- ☑ I: Do they have any questions or concerns?
- ☑ J: Complete form 200

PHYSICAL INSPECTION OF CONTROL PANEL

- ☑ A: Is the control panel located 15' from sump or riser and 36" above grade to bottom of panel
- ☑ B: Are power and sensor cable run in separate conduit? If not, stop work and have this corrected.
- ☑ C: Are seal offs installed in both sensor and power runs? If not, suggest breakout junction boxes or have seal off installed.
- ☐ D: Are seal offs potted? If not, stop work and have them potted.
- ☑ E: Will inner and outer door of enclosure open and close freely? If not loosen enclosure mounting bolts and shim until it is level and square. Then retighten mounting bolts.
- ☑ F: Make sure ground wire is in place between outer door and enclosure.

2009 EPG Companies Inc.

PRIOR TO ENERGIZING CONTROL PANEL

- ✓ A: Measure resistance to ground. It must be less than 25 ohms. If greater stop work and report to owner. It should be 1 ohm or less to protect electronic equipment.
- ✓ B: Measure voltage prior to control panel or at entrances to control panel. Measure and record voltage line to line and line to ground.
- ✓ C: Compare these reading to voltage listed on drawing and label in control panel.
- ✓ D: Megger motor leads resistance must be 1 megohm or greater.
- ✓ E: Take ohm reading of each motor lead wire to wire and compare these to values in Table 13 of the Franklin Electric motor manual for 1Ø and Table 21 for 3Ø. Be sure to add wire resistance value to value from table 13& 21. See page 39 for wire resistance.
- ✓ F: Inspect inside of control panel. Look for items which may have come loose during shipping
- ✓ G: Inspect wire connections. Are they the correct colors? Are they tight?
- ☐ H: If color-coded wires were not continued from sump or riser you need to ohm out each circuit.
- ✓ I: Review equipment list and drawings from any accessory circuits. If present, run volt and ohm test.
- ✓ J: Check and make sure all hand switches are in off position. If you have a water level indicator verify leachate level in sump or riser.

POWER UP

- ✓ A: Turn on power at panel main disconnect.
- ✓ B: Level meters display should light up. Record displayed reading. How does this reading compare to your measured level reading?
- ☐ ✓ C: If level and flow meter do not light up check GFCI, reset if necessary.
- ✓ D: Are any indicator lights on?
- ✓ E: Should they be on?
- ✓ F: Make sure pump is turned off. Using built in or hand held simulator verify level meter settings are correct for this site.
- ✓ G: Bump pump by turning hand switch two or three times to make sure pump has reached its resting point. You should have minimum of 3" of slack in the cables.

© 2009 EPG Companies Inc.

- ☐ H: To verify correct rotation place hand around discharge line. It will torque right if the rotation is correct.
- ☐ I: If there is liquid in sump with level about pump start set point and below 150". Then turn pump selector switch to AUTO. Run pump through one complete cycle.
- ☑ J: When pump is running measure and record amperage and voltage. Check 3O systems for current balance within 5% of average.
- ☑ K: Verify that starting, running and stopping causes no significant vibration or hydraulic shocks.

2009 EPG Companies Inc.

Phase II
As-Built Control Panel Setup Parameters

EPG Companies Inc.

December 2004

EPG LevelMaster Pump controller

Panel S/N: 09-9356B
Meter S/N: 060409-08

LCRS Pump Level Control Meter PHASE II

Default setting - Operating Parameters - Setup Code 35

Meter Designation(s): M3

Parameter	Value	Operation
Pr Hi	28	Turns Pump on when level on meter reads ~~28~~ ". 20"
Pr Lo	16	Turns Pump off when level on meter reads ~~16~~ ". 7"
AL H1	34	Turns High Level Light on when meter reads ~~34~~ ". 36.1"
Hy Hi	1	Keeps High Level Light on until level drops 1 " below AL Hi.
AL H2	143	Turns Pumps off it meter reads 143" or greater. Indicates a possible sensor failure.
Hy H2	0	Not used.

Default Settings - Sensor Parameters - Setup Code 25 (0 - 5PSI)

Parameter	Value	Operation
dp	8888.8	Sets Meter to read in 0.1"
OFFSET	-34.6	Provides a "0" reading when sensor inputs 4.0ma
SCALE	0.8656	Converts current input into inches - 1.0ma = 8.656 inches.

AS BUILT

EPG Companies Inc.

December 2004

EPG LevelMaster Pump controller

Panel S/N: 09-9356B
Meter S/N: 060509-01

Vadose Pump Level Control Meter PHASE II

Default setting - Operating Parameters - Setup Code 35

Meter Designation(s): M1

Parameter	Value	Operation
Pr Hi	28	Turns Pump on when level on meter reads ~~28~~ ". 17"
Pr Lo	16	Turns Pump off when level on meter reads ~~16~~ ". 7"
AL H1	34	Turns High Level Light on when meter reads ~~34~~ ". .5"
Hy Hi	1	Keeps High Level Light on until level drops ~~1~~ " below AL Hi. .5"
AL H2	143	Turns Pumps off it meter reads 143" or greater. Indicates a possible sensor failure.
Hy H2	0	Not used.

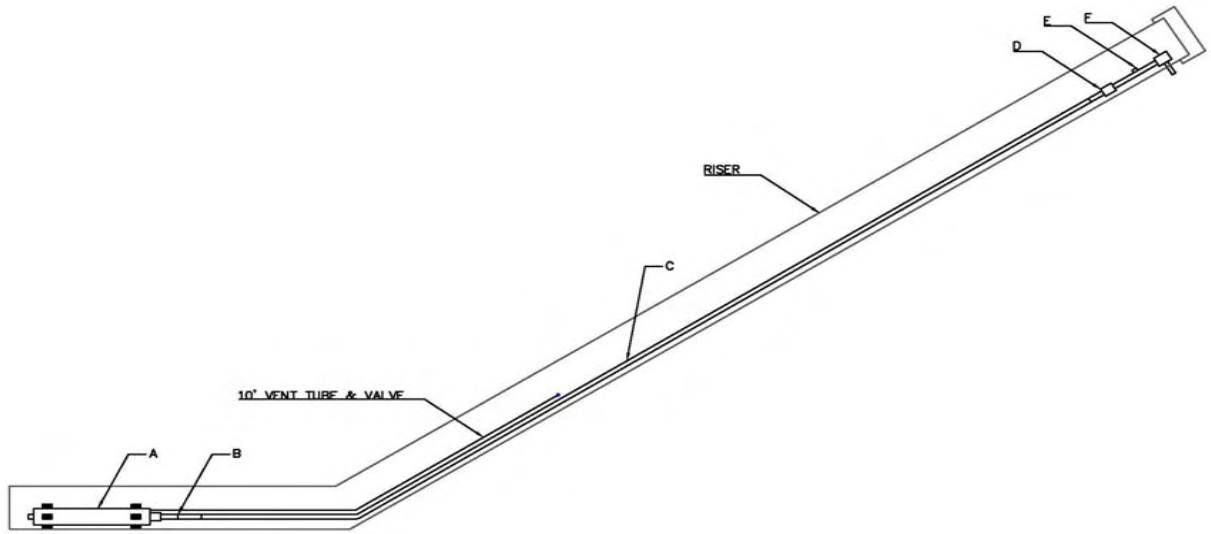
Default Settings - Sensor Parameters - Setup Code 25 (0 - 5PSI)

Parameter	Value	Operation
dp	8888.8	Sets Meter to read in 0.1"
OFFSET	-34.6	Provides a "0" reading when sensor inputs 4.0ma
SCALE	0.8656	Converts current input into inches - 1.0ma = 8.656 inches.

AS BUILT

Phase II
As-Built Pump Installation Cross Sections

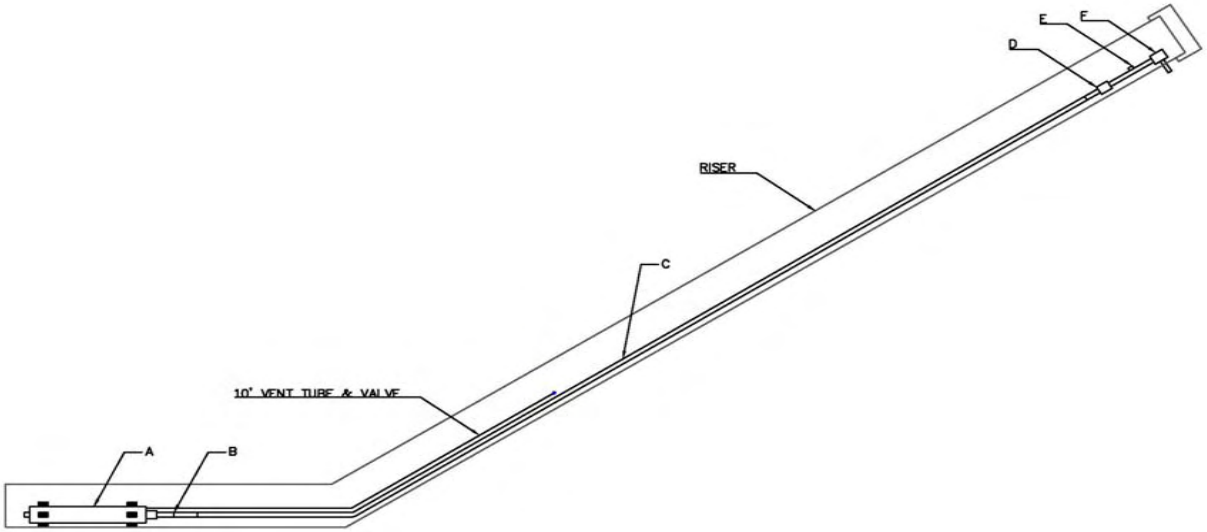
PHASE II LCRS SUMP PUMP INSTALLATION



ITEM	DESCRIPTION	LENGTH (FT)
A	WSDPT5-3 PUMP (S/N 2009-3134)	2.6
B	CONNECTIONS/FITTINGS/TRANSITIONS	0.4
C	1.5" DISCHARGE LINE	92.6
D	CONNECTIONS/FITTINGS/TRANSITIONS	0.6
E	FLOW METER	2.3
F	EPG FITTING "T"	0.4

NOT TO SCALE

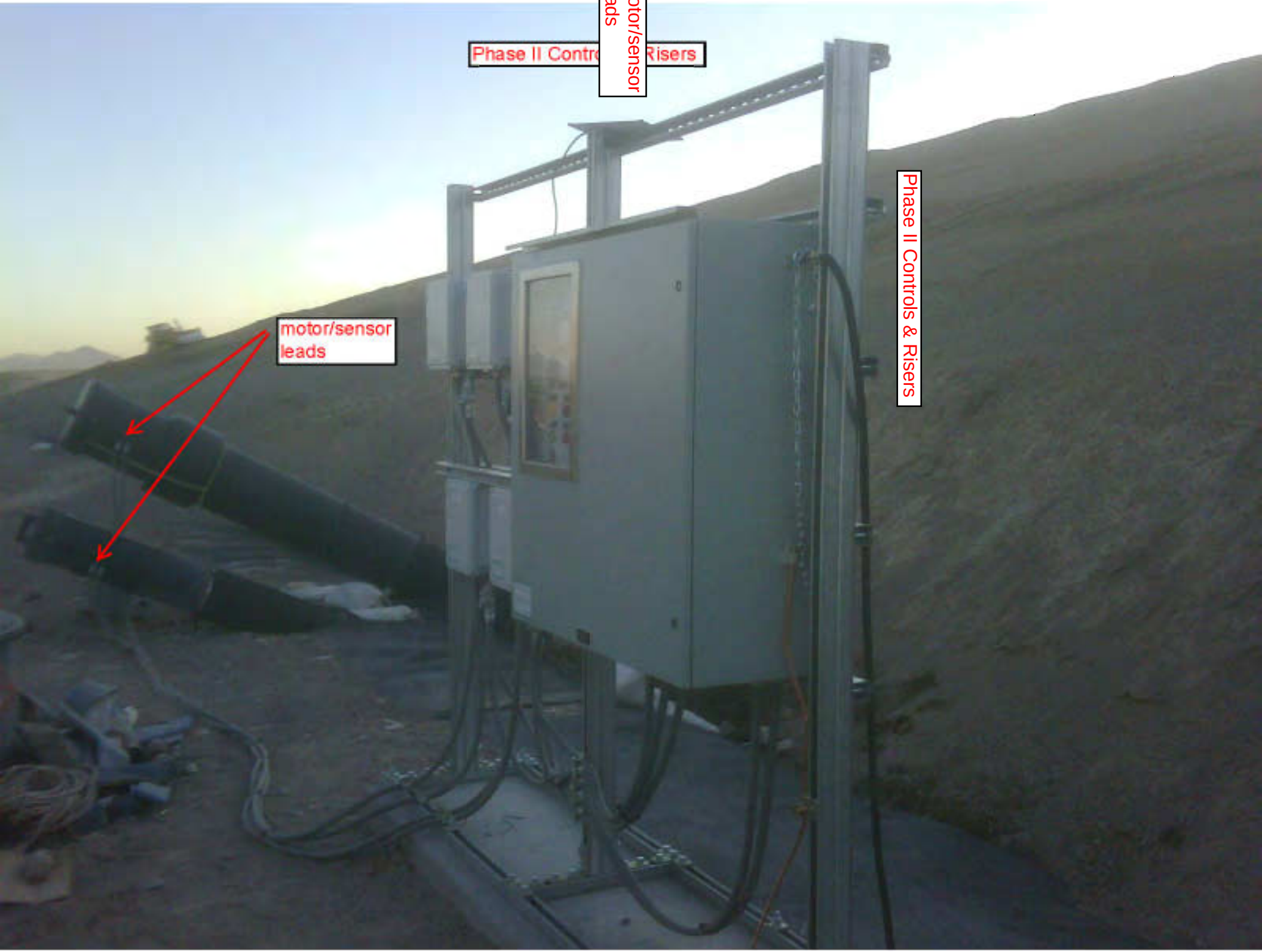
PHASE II VADOSE SUMP PUMP INSTALLATION

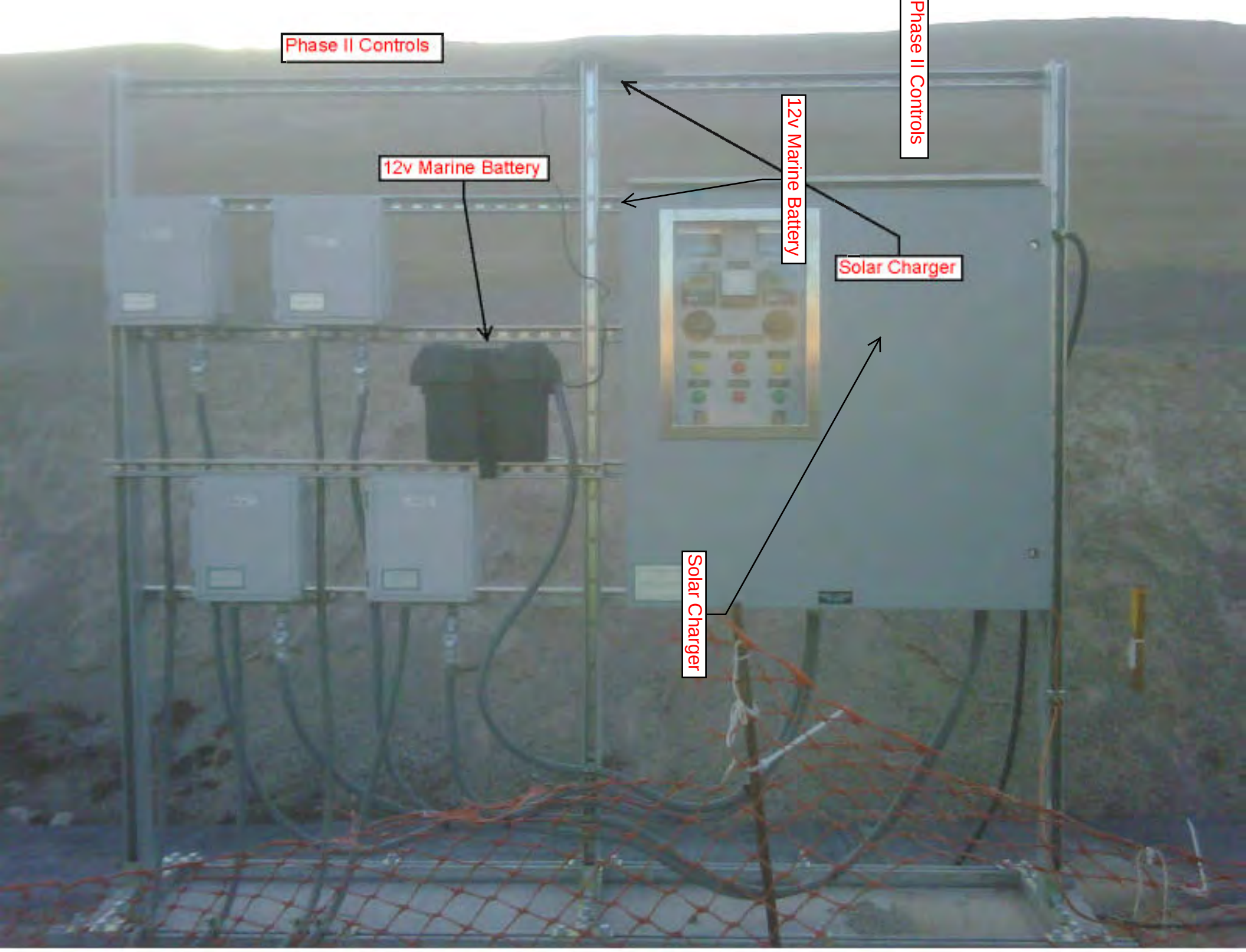


ITEM	DESCRIPTION	LENGTH (FT)
A	WSDPT2-3 PUMP (S/N 2009-3140)	2.6
B	CONNECTIONS/FITTINGS/TRANSITIONS	0.6
C	1.0" DISCHARGE LINE	88.8
D	CONNECTIONS/FITTINGS/TRANSITIONS	0.8
E	FLOW METER	2.5
F	EPG FITTING "T"	0.3

NOT TO SCALE

Phase II
As-Built Photos


Phase II Contr Risers
motor/sensor
leads
motor/sensor
leads
Phase II Controls & Risers


Phase II Controls
12v Marine Battery
12v Marine Battery
Phase II Controls
Solar Charger
Solar Charger

Phase IIIB
Engineer's Specification

ENGINEER'S SPECIFICATION

PHASE IIIB LCRS

EPG WSDPT SurePump™ Wheeled Sump Drainer

for side slope riser installations with built-in level sensor

Furnish ~~2~~ 1 centrifugal submersible EPG WSDPT SurePump Wheeled Sump Drainer(s) (U.S. patented), Model WSDPT 5 - 3 with 3 impeller stages. Each unit shall be suitable for side slope riser installation. Each unit shall be equipped with a ¾ HP, submersible electric motor for operation on 230 Volts, 1 phase, 60 Hertz service with 70 feet of power cable. Each SurePump Wheeled Sump Drainer shall have a 1 ½ inch MNPT threaded discharge nozzle and be capable of delivering 25 GPM at 50 feet of TDH. Each SurePump will be fitted with 70 feet of stainless steel lifting cable of sufficient strength to permit removal of the unit.

DESIGN

Each SurePump Wheeled Sump Drainer shall be capable of pumping contaminated ground water for spill recovery, leachate, condensate, and purge applications. A removable transmitter mount (patent pending) shall be installed at the center bottom of the Sump Drainer for liquid level control. The Sump Drainer shall permit the unit to "pump down" to within 8 inches of the sump bottom without any loss of performance or damage to the pump. External "priming" shall not be required nor allowed. The Sump Drainer shall be equipped with a vent valve to assist with the evacuation of air from the Sump Drainer.

MATERIALS

Major components shall be made of 304 stainless steel, seal rings are to be made of E-Glide™, and bearings are to be E-Glide. In addition, all fasteners shall be 304 stainless steel.

CHECK VALVE

Each unit shall include a built-in check valve with non-metallic seat, and housing and disc of 304 stainless steel.

SHAFT

The shaft shall be of 304 stainless steel and rotate on E-Glide bearings that are fluid lubricated.

DIFFUSER CHAMBER

The diffuser chambers for each impeller shall be 304 stainless steel and fitted with E-Glide impeller seal rings.

IMPELLERS

The impeller(s) shall be closed and consist of 304 stainless steel.

MOTOR

The motor shall be a submersible, hermetically sealed Franklin motor in Pollution Recovery construction. The motor shall be designed for continuous duty, capable of sustaining up to 100 starts per day. The motor shall be connected to the pump via a motor adaptor and coupling in 304 stainless steel. Single phase motors in ½ HP to 1 HP only shall have thermal protection in the motor windings to protect the windings from overload. The unit will restart automatically after the motor cools down. Larger horsepower single phase motors and three phase motors shall have thermal protection located in the control panel that is manually reset.

MOTOR LEAD WIRE

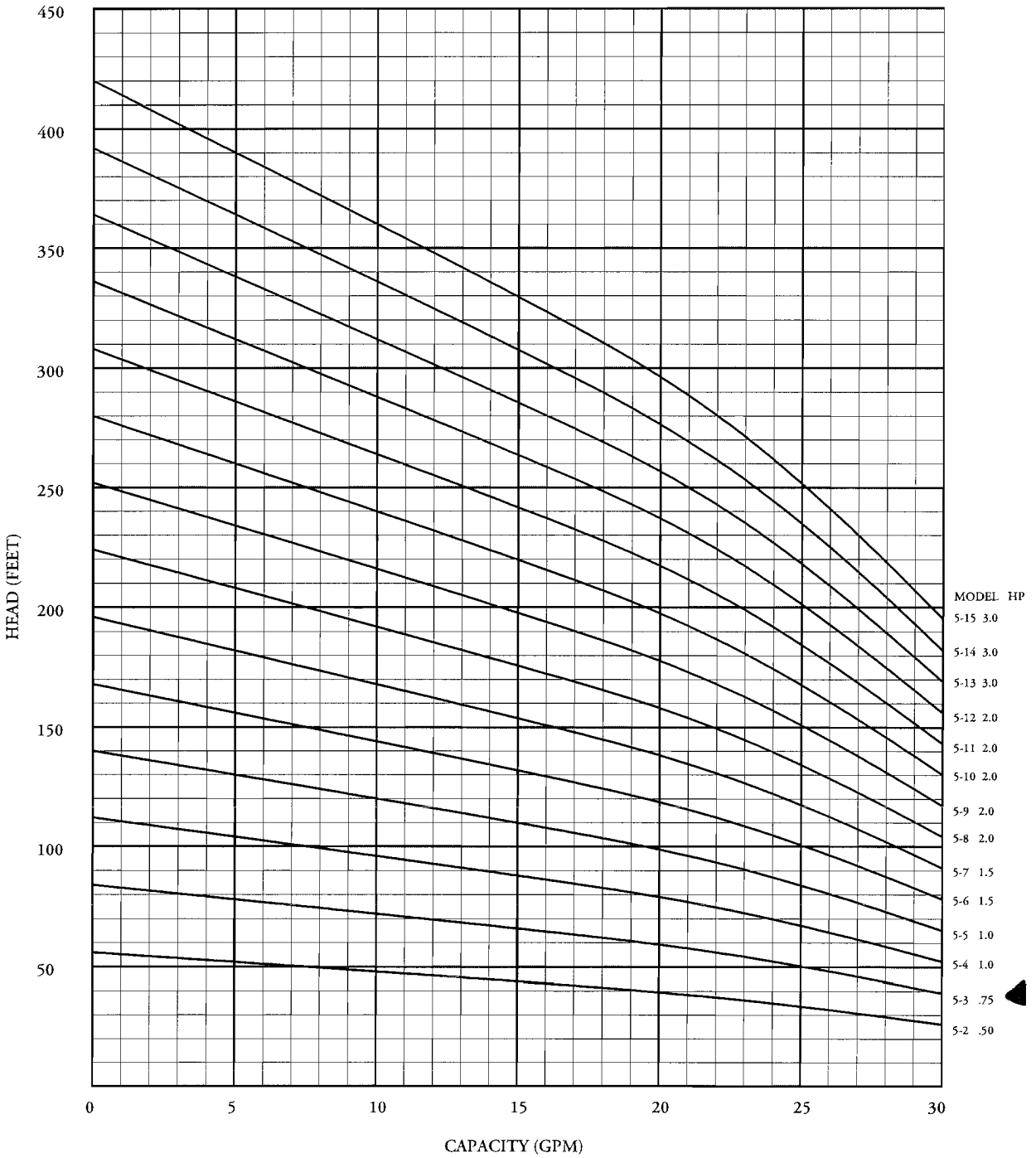
The lead wire shall be no-splice with EPG's "CP" waterproof and chemically resistant jacket over 600 Volt insulation and be of the length specified.

© 2009 EPG Companies Inc.
SurePump & E-Glide are Reg. TM of EPG Companies Inc.

SERIES 5 SurePump™

Flow Range 15-30 GPM

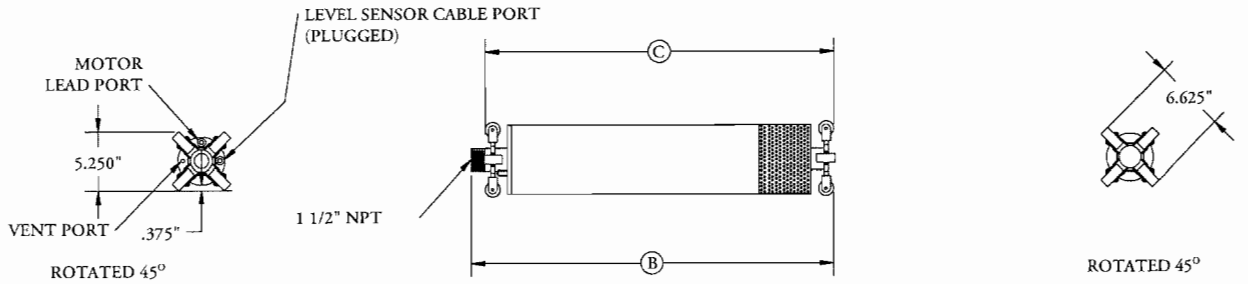
60 Hz



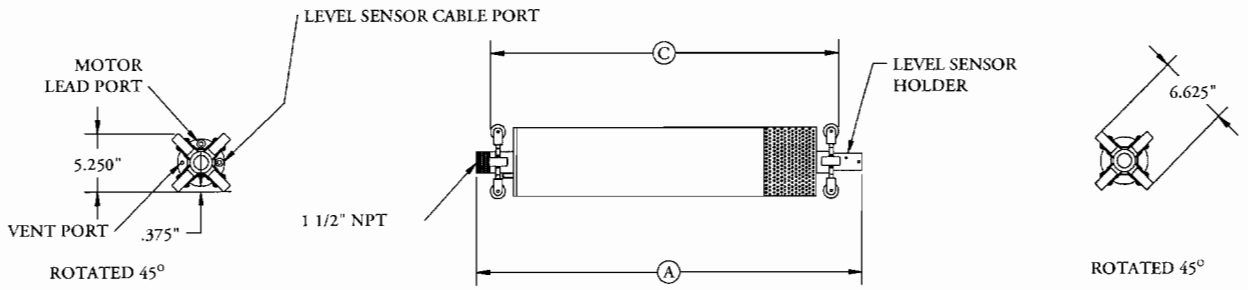
DATA SUBJECT TO CHANGE WITHOUT NOTICE

© 2009 EPG Companies Inc.
SurePump is a Reg. TM of EPG Companies Inc.

SERIES 5 SIZE 4 WHEELED SUMP DRAINER



WSD



WSDPT

MODEL	HP	PHASE	A	B	C	*APPROX. SHIPPING WEIGHT	
						WSD	WSDPT
5-2	0.50	1	31.02	29.90	29.15	61.47	66.47
5-2	0.50	3	31.02	29.90	29.15	61.47	66.47
5-3	0.75	1	32.98	31.86	31.11	66.24	71.24
5-3	0.75	3	32.98	31.86	31.11	66.24	71.24
5-4	1.00	1	34.90	33.78	33.03	70.98	75.98
5-4	1.00	3	34.90	33.78	33.03	70.98	75.98
5-5	1.00	1	35.73	34.61	33.86	71.88	76.88
5-5	1.00	3	35.73	34.61	33.86	71.88	76.88
5-6	1.50	1	38.43	37.31	36.56	79.22	84.22
5-6	1.50	3	36.56	35.44	34.69	72.77	77.77
5-7	1.50	1	39.26	38.14	37.39	80.12	85.12
5-7	1.50	3	37.39	36.27	35.52	73.67	78.67
5-8	2.00	1	41.59	40.47	39.72	85.17	90.17
5-8	2.00	3	40.09	38.97	38.22	81.01	86.01

MODEL	HP	PHASE	A	B	C	*APPROX. SHIPPING WEIGHT	
						WSD	WSDPT
5-9	2.00	1	42.42	41.30	40.55	86.07	91.07
5-9	2.00	3	40.92	39.80	39.05	81.90	86.90
5-10	2.00	1	43.25	42.13	41.38	86.96	91.96
5-10	2.00	3	41.75	40.63	39.88	82.80	87.80
5-11	2.00	1	44.08	42.96	42.21	87.86	92.86
5-11	2.00	3	42.58	41.46	40.71	83.69	88.69
5-12	2.00	1	44.91	43.79	43.04	88.75	93.75
5-12	2.00	3	53.41	52.29	51.54	92.35	97.35
5-13	3.00	1	54.24	53.12	52.37	119.24	124.24
5-13	3.00	3	51.24	50.12	49.37	105.91	110.91
5-14	3.00	1	55.07	53.95	53.20	120.14	125.14
5-14	3.00	3	52.07	50.95	50.20	106.81	111.81
5-15	3.00	1	55.90	54.78	54.03	121.03	126.03
5-15	3.00	3	52.90	51.78	51.03	107.70	112.70

NOTE: ALL DIMENSIONS ARE IN INCHES.

*SHIPPING WEIGHT INCLUDES
WSD: CRATE, 50' OF 14-4 MOTOR LEAD, 50' OF 1/8" SS CABLE.
WSDPT: CRATE, 50' OF 14-4 MOTOR LEAD, 50' OF 1/8" SS CABLE,
LEVEL SENSOR AND CABLE.

© 2009 EPG Companies Inc.
SurePump is a Reg. TM of EPG Companies Inc.

ENGINEER'S SPECIFICATION

PHASE IIIB VADOSE

EPG WSDPT SurePump™ Wheeled Sump Drainer

for side slope riser installations with built-in level sensor

Furnish ~~2~~ 1 centrifugal submersible EPG WSDPT SurePump Wheeled Sump Drainer(s) (U.S. patented), Model WSDPT 2 - 3 with 3 impeller stages. Each unit shall be suitable for side slope riser installation. Each unit shall be equipped with a ½ HP, submersible electric motor for operation on 230 Volts, 1 phase, 60 Hertz service with 70 feet of power cable. Each SurePump Wheeled Sump Drainer shall have a 1 ¼ inch MNPT threaded discharge nozzle and be capable of delivering 10 GPM at 50 feet of TDH. Each SurePump will be fitted with 70 feet of stainless steel lifting cable of sufficient strength to permit removal of the unit.

DESIGN

Each SurePump Wheeled Sump Drainer shall be capable of pumping contaminated ground water for spill recovery, leachate, condensate, and purge applications. A removable transmitter mount (patent pending) shall be installed at the center bottom of the Sump Drainer for liquid level control. The Sump Drainer shall permit the unit to "pump down" to within 8 inches of the sump bottom without any loss of performance or damage to the pump. External "priming" shall not be required nor allowed. The Sump Drainer shall be equipped with a vent valve to assist with the evacuation of air from the Sump Drainer.

MATERIALS

Major components shall be made of 304 stainless steel, seal rings are to be made of E-Glide™, and bearings are to be E-Glide. In addition, all fasteners shall be 304 stainless steel.

CHECK VALVE

Each unit shall include a built-in check valve with non-metallic seat, and housing and disc of 304 stainless steel.

SHAFT

The shaft shall be of 304 stainless steel and rotate on E-Glide bearings that are fluid lubricated.

DIFFUSER CHAMBER

The diffuser chambers for each impeller shall be 304 stainless steel and fitted with E-Glide impeller seal rings.

IMPELLERS

The impeller(s) shall be closed and consist of 304 stainless steel.

MOTOR

The motor shall be a submersible, hermetically sealed Franklin motor in Pollution Recovery construction. The motor shall be designed for continuous duty, capable of sustaining up to 100 starts per day. The motor shall be connected to the pump via a motor adaptor and coupling in 304 stainless steel. Single phase motors in ½ HP to 1 HP only shall have thermal protection in the motor windings to protect the windings from overload. The unit will restart automatically after the motor cools down. Larger horsepower single phase motors and three phase motors shall have thermal protection located in the control panel that is manually reset.

MOTOR LEAD WIRE

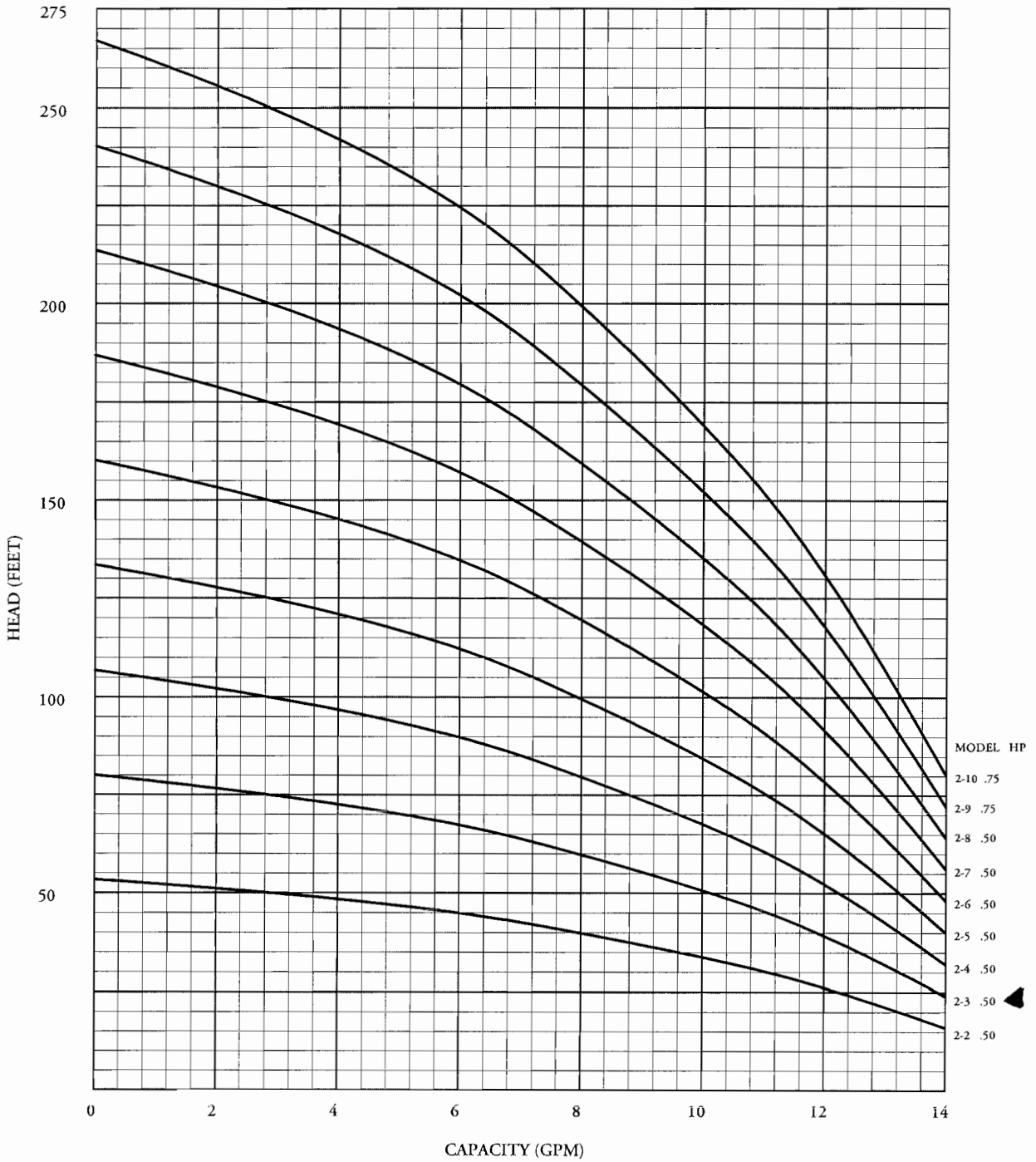
The lead wire shall be no-splice with EPG's "CP" waterproof and chemically resistant jacket over 600 Volt insulation and be of the length specified.

© 2009 EPG Companies Inc.
SurePump & E-Glide are Reg. TM of EPG Companies Inc.

SERIES 2 SurePump™

Flow Range 4-14 GPM

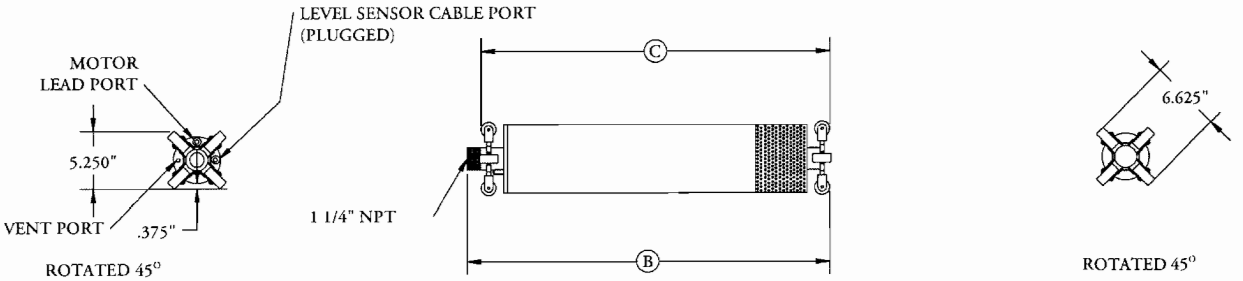
60 Hz



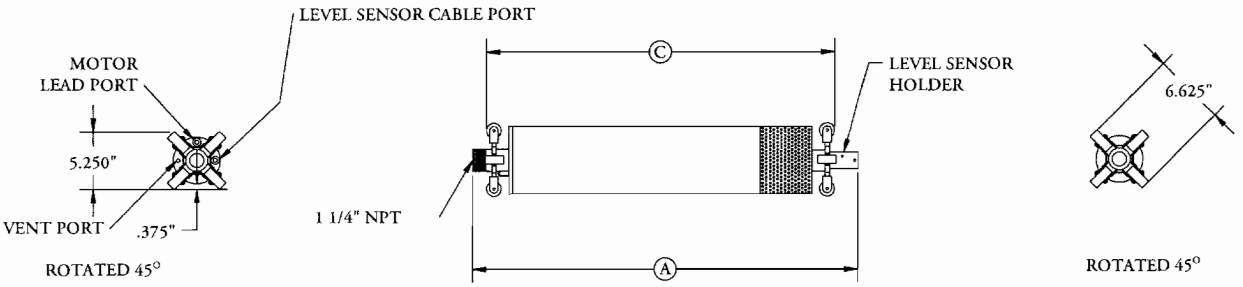
DATA SUBJECT TO CHANGE WITHOUT NOTICE

© 2009 EPG Companies Inc.
SurePump is a Reg. TM of EPG Companies Inc.

SERIES 2 SIZE 4 WHEELED SUMP DRAINER



WSD



WSDPT

MODEL	HP	PHASE	A	B	C	*APPROX. SHIPPING WEIGHT	
						WSD	WSDPT
2-2	0.50	1	31.02	29.90	29.15	61.47	66.47
2-2	0.50	3	31.02	29.90	29.15	61.47	66.47
2-3	0.50	1	31.85	30.73	29.98	62.37	67.37
2-3	0.50	3	31.85	30.73	29.98	62.37	67.37
2-4	0.50	1	32.68	31.56	30.81	63.26	68.26
2-4	0.50	3	32.68	31.56	30.81	63.26	68.26
2-5	0.50	1	33.51	32.39	31.64	64.15	69.15
2-5	0.50	3	33.51	32.39	31.64	64.15	69.15
2-6	0.50	1	34.34	33.22	32.47	65.05	70.05
2-6	0.50	3	34.34	33.22	32.47	65.05	70.05
2-7	0.50	1	35.17	34.05	33.30	65.94	70.94
2-7	0.50	3	35.17	34.05	33.30	65.94	70.94
2-8	0.50	1	36.00	34.88	34.13	66.84	71.84
2-8	0.50	3	36.00	34.88	34.13	66.84	71.84
2-9	0.75	1	37.96	36.84	36.09	71.61	76.61
2-9	0.75	3	37.96	36.84	36.09	71.61	76.61
2-10	0.75	1	38.79	37.67	36.92	72.50	77.50
2-10	0.75	3	38.79	37.67	36.92	72.50	77.50

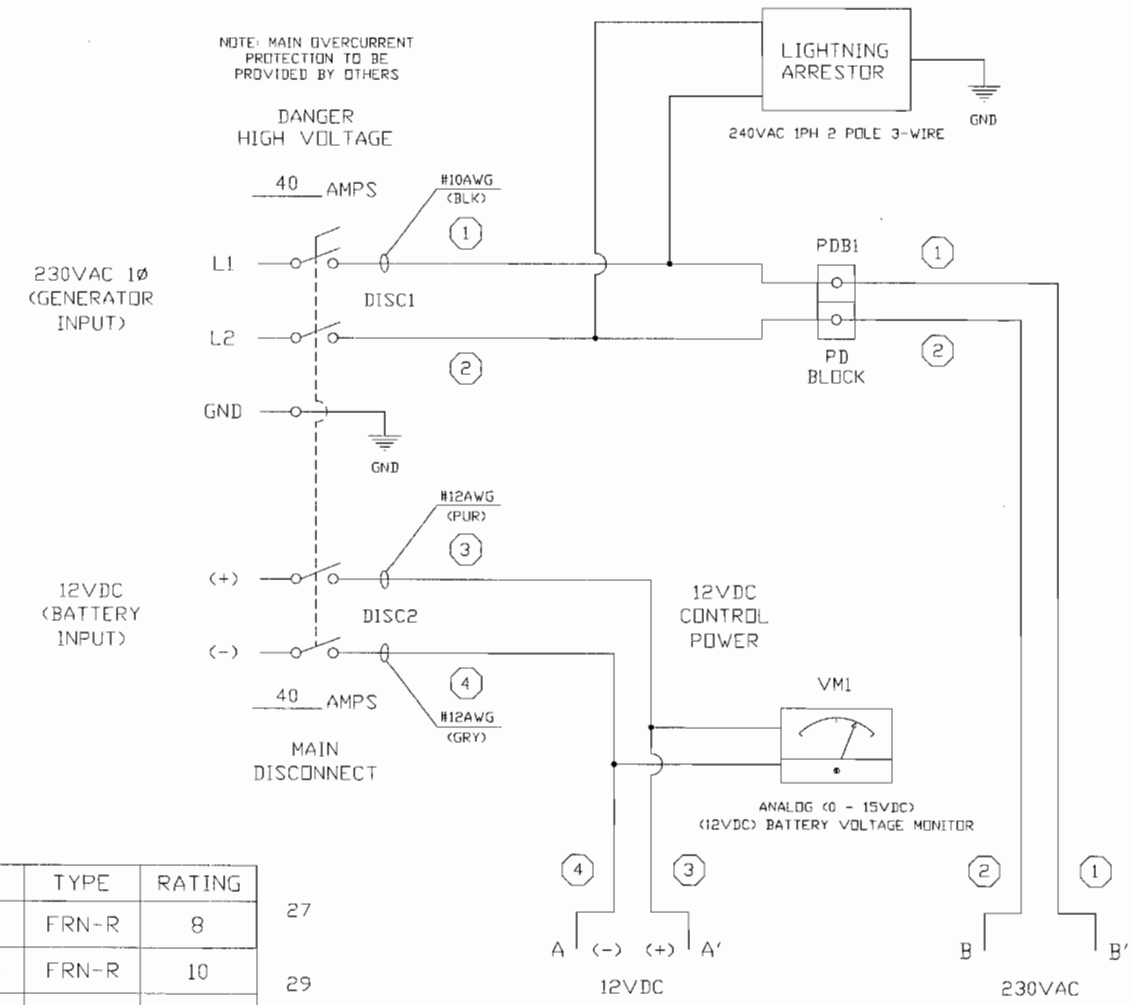
NOTE: ALL DIMENSIONS ARE IN INCHES.

*SHIPPING WEIGHT INCLUDES
WSD: CRATE, 50' OF 14-4 MOTOR LEAD, 50' OF 1/8" SS CABLE.
WSDPT: CRATE, 50' OF 14-4 MOTOR LEAD, 50' OF 1/8" SS CABLE,
LEVEL SENSOR AND CABLE.

© 2009 EPG Companies Inc.
SurePump is a Reg. TM of EPG Companies Inc.

Phase IIIB
As-Built Control Panel Schematics

MOTOR	HP	VOLTAGE	FLA	FUSE SIZE
VADOSE PUMP	1/2	230	5.0	8A
LCRS PUMP	3/4	230	6.8	10A



FUSE	TYPE	RATING
F1-F2	FRN-R	8
F3-F4	FRN-R	10
F5-F6	FRN-R	2-1/2
F7	FNM	1-1/4
F8	FNM	3-1/2
F9	ABC	1-1/2
F10	MDL	1/2
F11	ABC	1/2
F12	ABC	1/2

PHASE 3B
CONTROL PANEL AND PUMPS

FIELD WIRING TERMINALS

LINE (GENERATOR)

L1, L2 — 230VAC 1Ø 60Hz, 15.05 AMPS

GND — GROUND

LINE (BATTERY)

(+), (-) — 12VDC, 0.91 AMPS

FOR NOTES AND REVISIONS SEE SHEET 8

AS BUILT

JOB No. 09-9356D

* NOTICE * © EPG Companies Inc. 2009
THIS DRAWING IS THE PROPERTY OF EPG COMPANIES FOR REFERENCE ONLY.

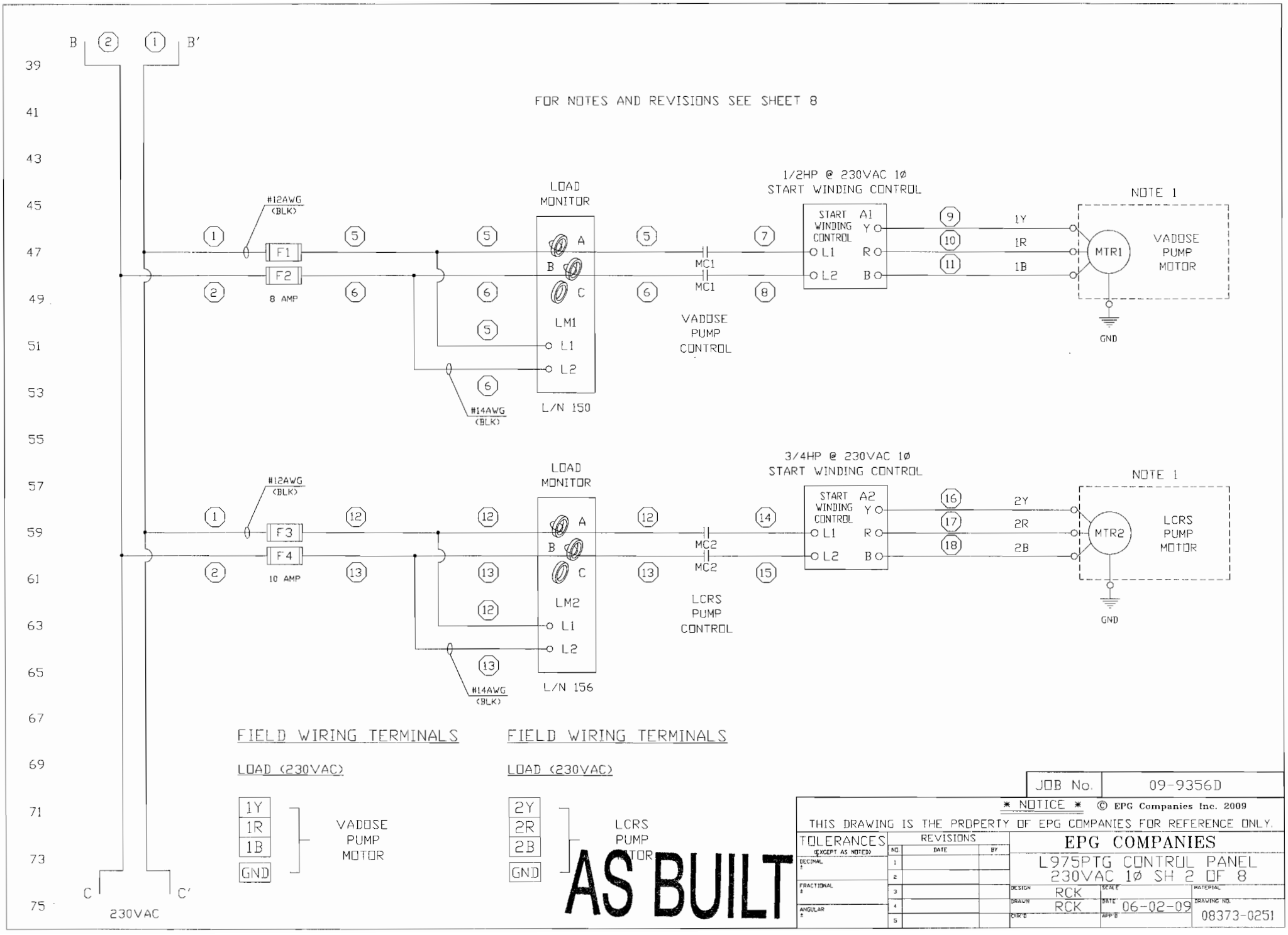
TOLERANCES (EXCEPT AS NOTED): DECIMAL ±, FRACTIONAL ±, ANGULAR ±

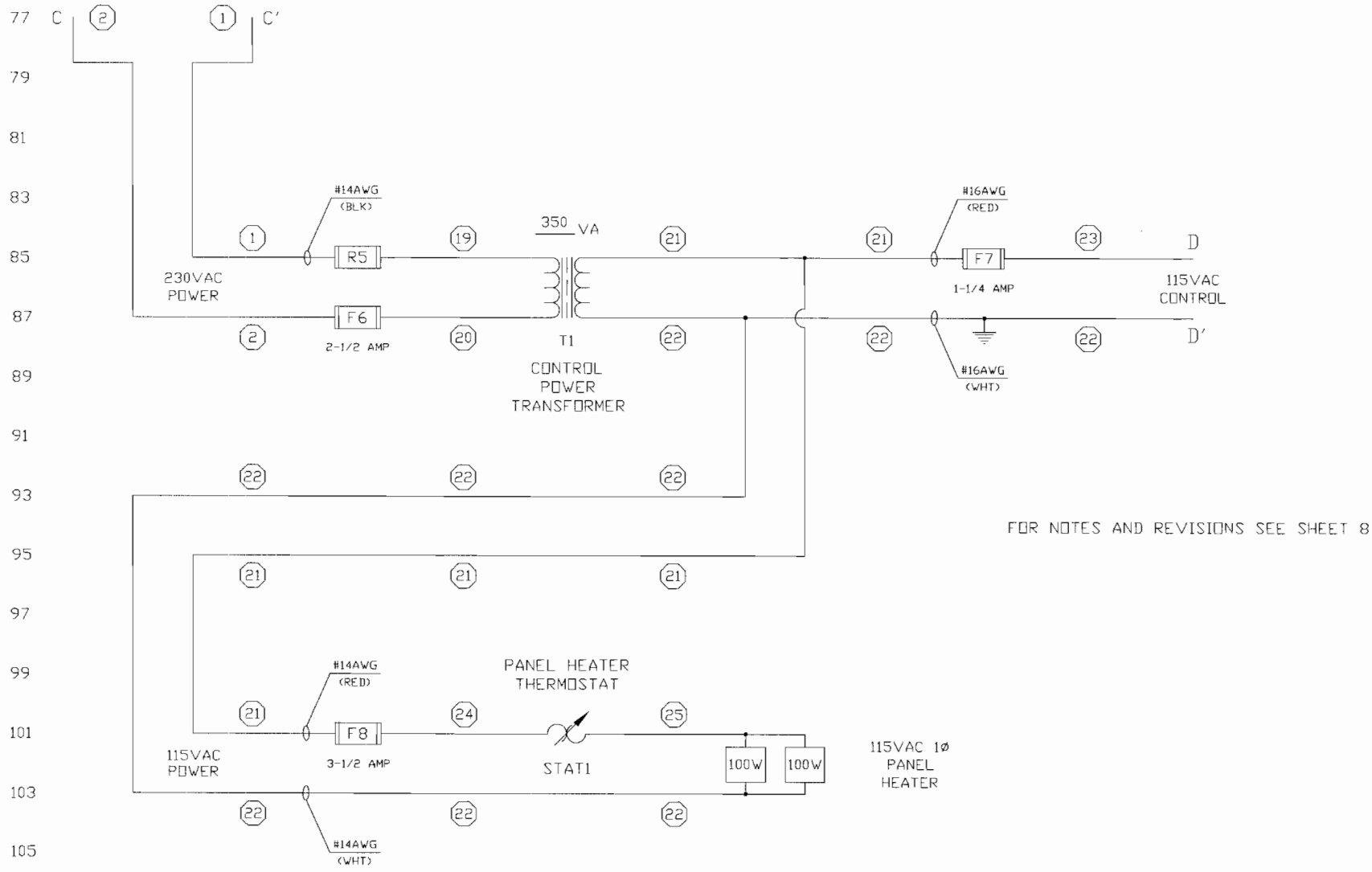
REVISIONS: NO. | DATE | BY

EPG COMPANIES

L975PTG CONTROL PANEL
230VAC 1Ø SH 1 OF 8

DESIGN RCK | DRAWN RCK | CHK'D | APP'D | SCALE | DATE 06-02-09 | MATERIAL | DRAWING NO. 08373-0250


FOR NOTES AND REVISIONS SEE SHEET 8
B
B'
C
C'
230VAC
#12AWG (BLK)
F1
F2
8 AMP
#14AWG (BLK)
LOAD MONITOR
A
B
C
LM1
L1
L2
L/N 150
MC1
VADOSE PUMP CONTROL
1/2HP @ 230VAC 1Ø
START WINDING CONTROL
START WINDING CONTROL
A1
Y
R
B
L1
L2
1Y
1R
1B
NOTE 1
MTR1
VADOSE PUMP MOTOR
GND
F3
F4
10 AMP
LM2
L/N 156
MC2
LCRS PUMP CONTROL
3/4HP @ 230VAC 1Ø
START WINDING CONTROL
A2
2Y
2R
2B
MTR2
LCRS PUMP MOTOR
FIELD WIRING TERMINALS
LOAD (230VAC)
1Y
1R
1B
GND
VADOSE PUMP MOTOR
FIELD WIRING TERMINALS
LOAD (230VAC)
2Y
2R
2B
GND
LCRS PUMP MOTOR
AS BUILT
JOB No. 09-9356D
* NOTICE * © EPG Companies Inc. 2009
THIS DRAWING IS THE PROPERTY OF EPG COMPANIES FOR REFERENCE ONLY.
TOLERANCES (EXCEPT AS NOTED)
DECIMAL ±
FRACTIONAL ±
ANGULAR ±
REVISIONS
NO. DATE BY
EPG COMPANIES
L975PTG CONTROL PANEL
230VAC 1Ø SH 2 OF 8
DESIGN RCK
DRAWN RCK
CHK'D
SCALE
DATE 06-02-09
APP'D
MATERIAL
DRAWING NO. 08373-0251



AS BUILT

JOB No.	09-9356D

* NOTICE * © EPG Companies Inc. 2009

THIS DRAWING IS THE PROPERTY OF EPG COMPANIES FOR REFERENCE ONLY.

TOLERANCES (EXCEPT AS NOTED)
DECIMAL ±
FRACTIONAL ±
ANGULAR ±

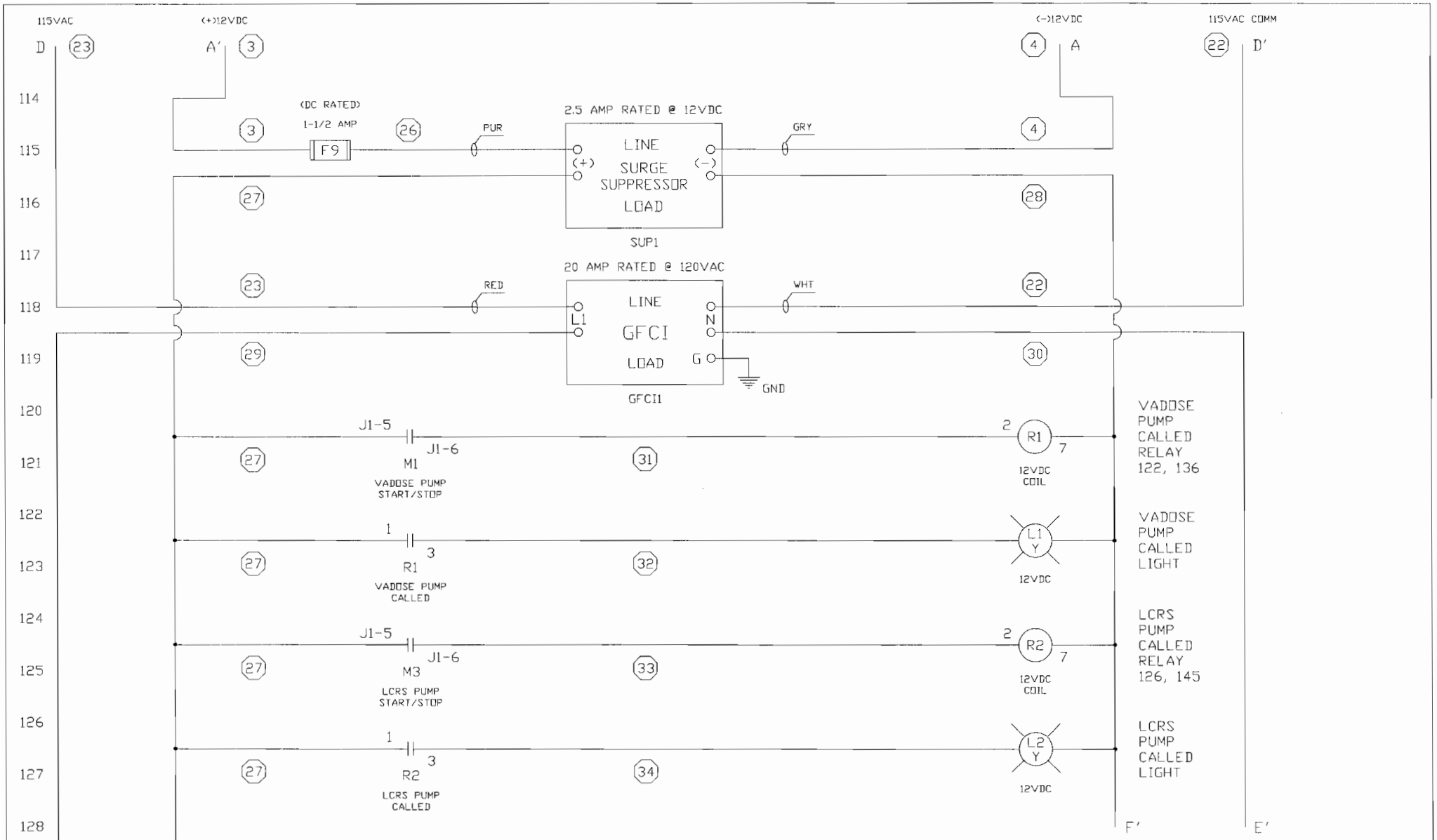
REVISIONS

NO.	DATE	BY
1		
2		
3		
4		
5		

EPG COMPANIES

L975PTG CONTROL PANEL
230VAC 1Ø SH 3 OF 8

DESIGN	SCALE	MATERIAL
RCK		
DRAWN RCK	DATE 06-02-09	DRAWING NO. 08373-0252
CHK'D	APP'D	



FOR NOTES AND REVISIONS SEE SHEET 8

AS BUILT

JOB No.	09-9356D

* NOTICE * © EPG Companies Inc. 2009

THIS DRAWING IS THE PROPERTY OF EPG COMPANIES FOR REFERENCE ONLY.

TOLERANCES (EXCEPT AS NOTED)
DECIMAL ±
FRACTIONAL ±
ANGULAR ±

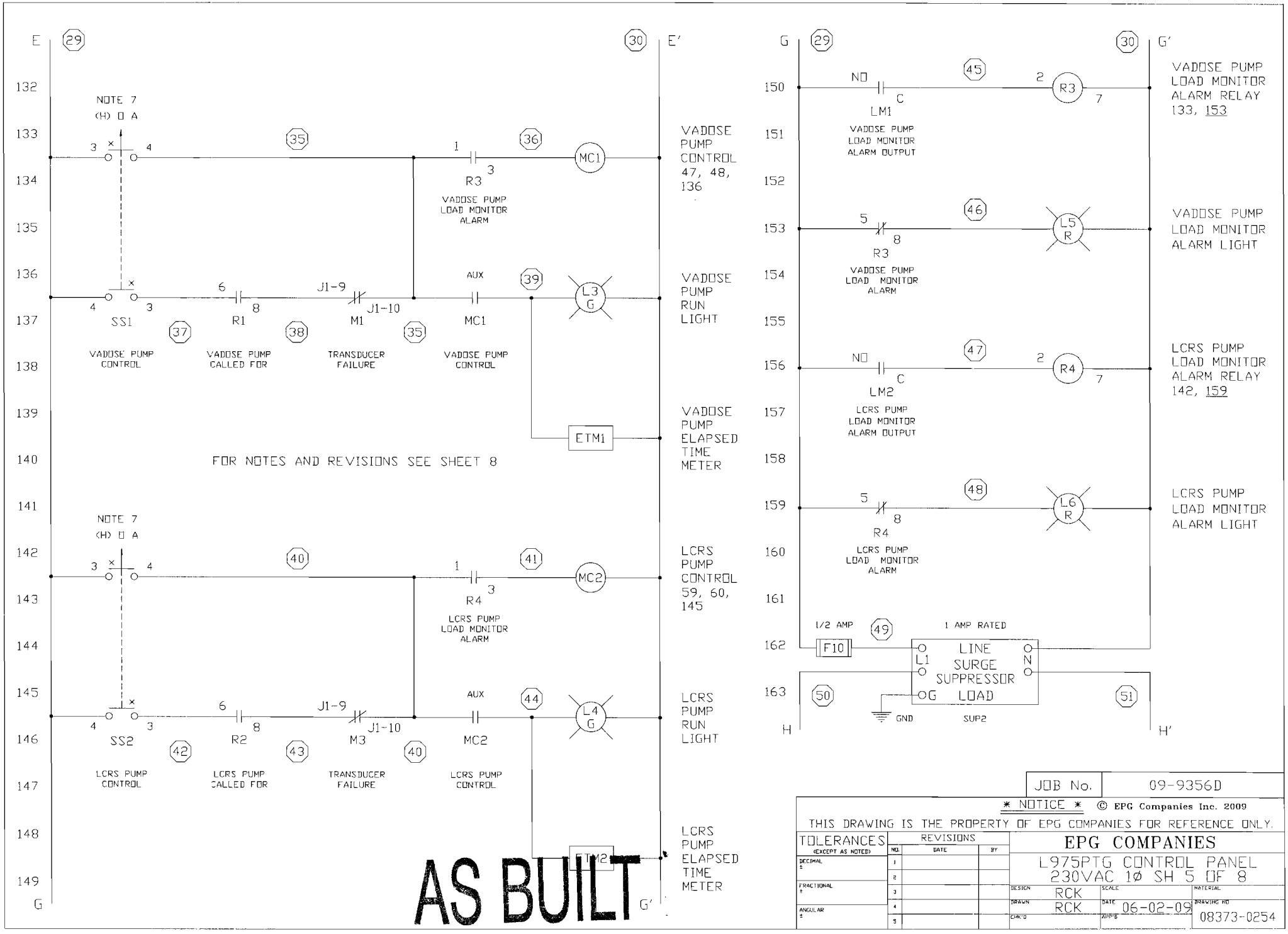
REVISIONS

NO.	DATE	BY
1		
2		
3		
4		
5		

EPG COMPANIES

L975PTG CONTROL PANEL
230VAC 1Ø SH 4 OF 8

DESIGN	RCK	SCALE	MATERIAL
DRAWN	RCK	DATE 06-02-09	DRAWING NO. 08373-0253
CHK'D		APP'D	



JOB No.	09-9356D

* NOTICE * © EPG Companies Inc. 2009

THIS DRAWING IS THE PROPERTY OF EPG COMPANIES FOR REFERENCE ONLY.

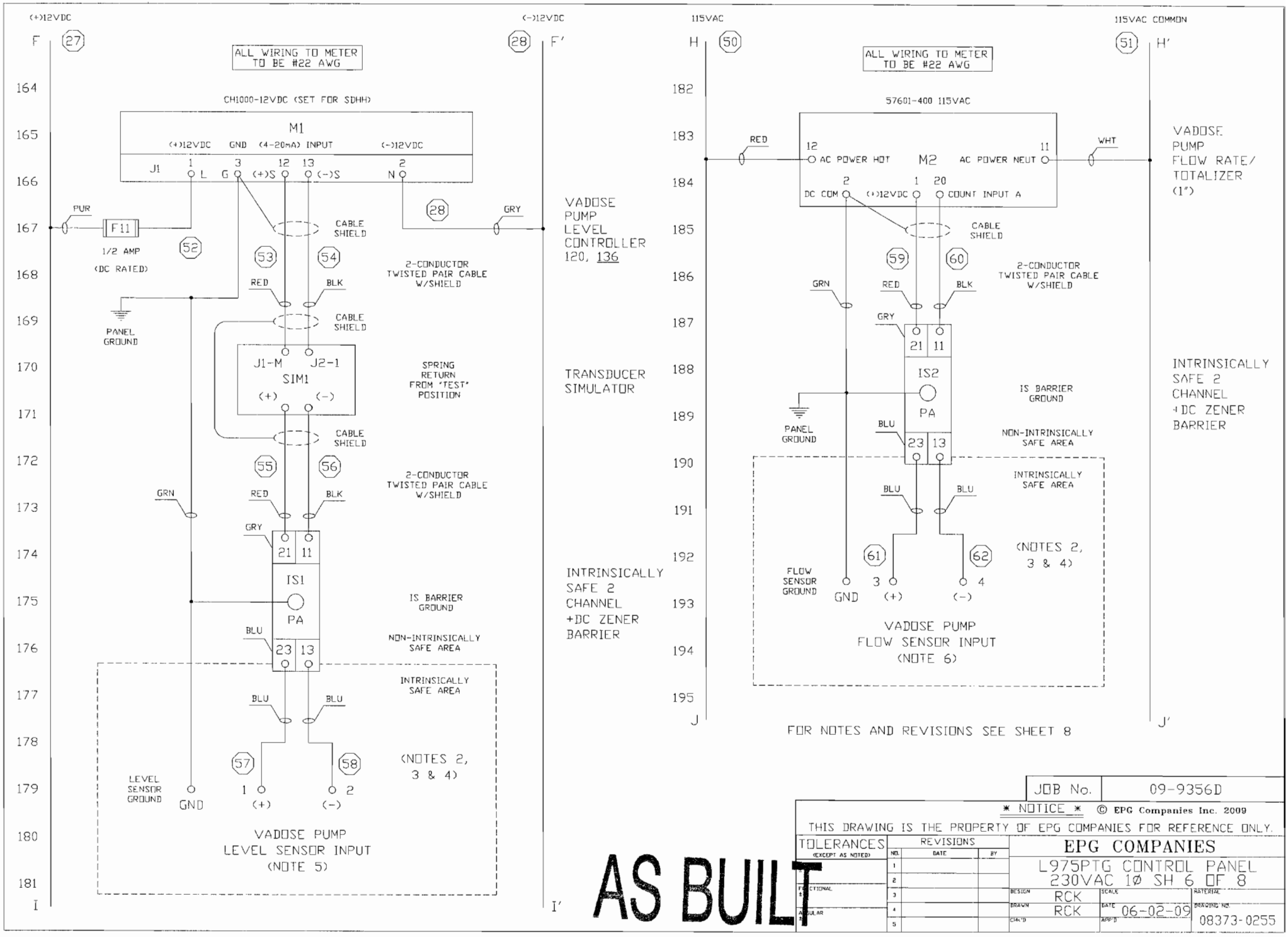
TOLERANCES (EXCEPT AS NOTED): DECIMAL ±; FRACTIONAL ±; ANGULAR ±

REVISIONS: NO. | DATE | BY

EPG COMPANIES

L975PTG CONTROL PANEL
230VAC 1Ø SH 5 OF 8

DESIGN	RCK	SCALE	MATERIAL
DRAWN	RCK	DATE 06-02-09	DRAWING NO 08373-0254
CHK'D		APP'D	



JOB No.	09-9356D

* NOTICE * © EPG Companies Inc. 2009
THIS DRAWING IS THE PROPERTY OF EPG COMPANIES FOR REFERENCE ONLY.

TOLERANCES (EXCEPT AS NOTED)

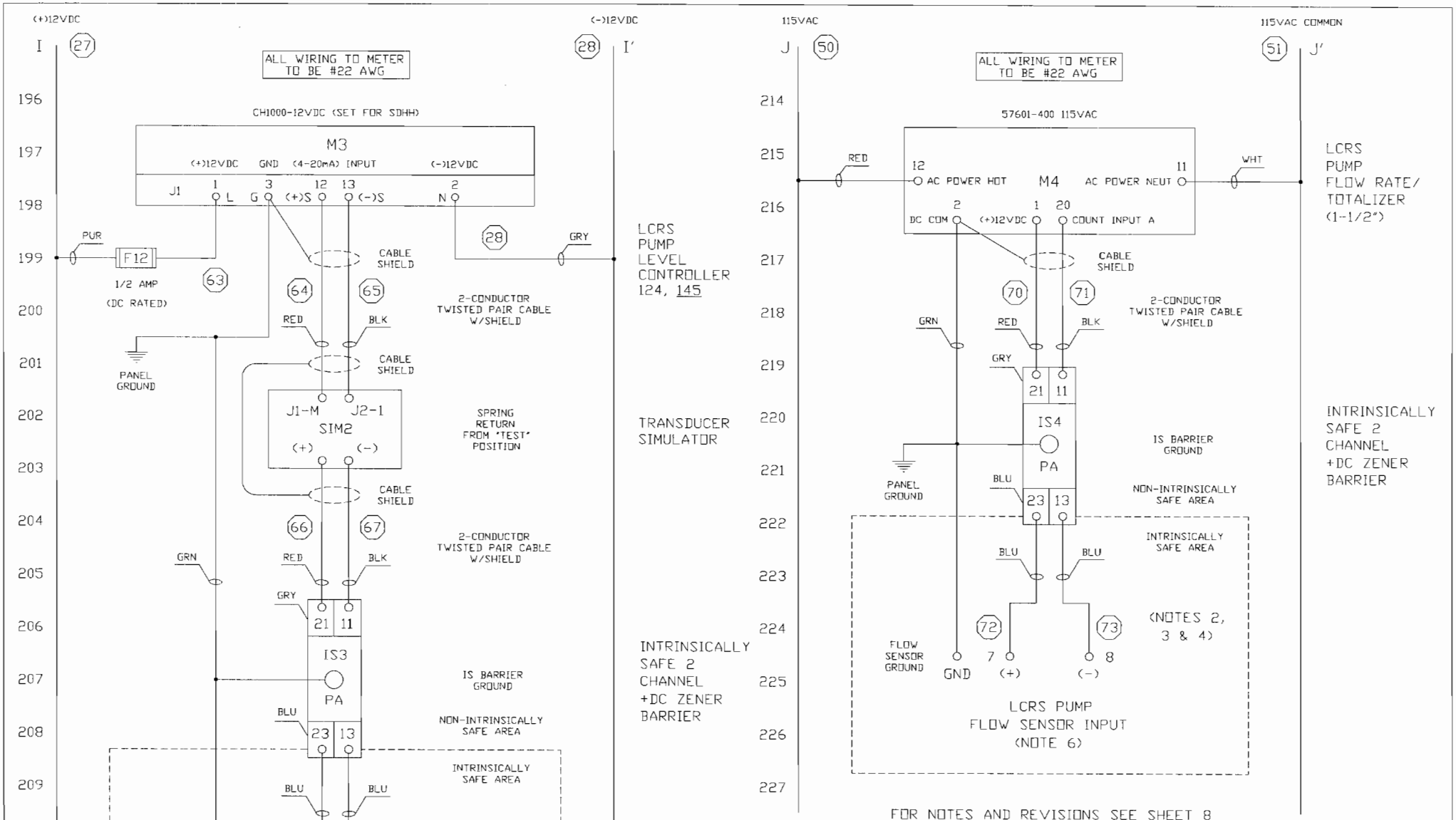
REVISIONS

NO.	DATE	BY
1		
2		
3		
4		
5		

EPG COMPANIES

L975PTG CONTROL PANEL
230VAC 1Ø SH 6 OF 8

DESIGN	RCK	SCALE	MATERIAL
DRAWN	RCK	DATE 06-02-09	DRAWING NO. 08373-0255
CHK'D		APP'D	



FOR NOTES AND REVISIONS SEE SHEET 8

LAST WIRE NUMBER USED: 73

JOB No. 09-9356D

* NOTICE * © EPG Companies Inc. 2009

THIS DRAWING IS THE PROPERTY OF EPG COMPANIES FOR REFERENCE ONLY.

TOLERANCES (EXCEPT AS NOTED)

REVISIONS

NO.	DATE	BY
1		
2		
3		
4		
5		

EPG COMPANIES

L975PTG CONTROL PANEL 230VAC 1Ø SH 7 OF 8

DESIGN RCK	SCALE	MATERIAL	
DRAWN RCK	DATE 06-02-09	DRAWING NO. 08373-0256	
CHK'D	APP'D		

AS BUILT

FIELD WIRING TERMINALS

LEVEL SENSOR (INTRINSICALLY SAFE TERMINALS)

1	RED	VADOSE PUMP LEVEL SENSOR INPUT (NOTES 2, 3, 4 & 5)
2	BLACK	
GND	SHIELD GROUND	

FLOW SENSOR (INTRINSICALLY SAFE TERMINALS)

3	RED	VADOSE PUMP FLOW SENSOR INPUT (1") (NOTES 2, 3, 4 & 6)
4	WHITE	
GND	BLACK	

LEVEL SENSOR (INTRINSICALLY SAFE TERMINALS)

5	RED	LCRS PUMP LEVEL SENSOR INPUT (NOTES 2, 3, 4 & 5)
6	BLACK	
GND	SHIELD GROUND	

FLOW SENSOR (INTRINSICALLY SAFE TERMINALS)

7	RED	LCRS PUMP FLOW SENSOR INPUT (1-1/2") (NOTES 2, 3, 4 & 6)
8	WHITE	
GND	BLACK	

NOTE:

1. NOT PART OF CONTROLLER
2. REFERENCE INSTALLATION OF INTRINSICALLY SAFE INSTRUMENT SYSTEMS IN CLASS I HAZARDOUS LOCATIONS, ANSI/ISA-RP 12.6-1987, SECTION 4.5.4
3. WARNING: SUBSTITUTION OF COMPONENTS MAY IMPAIR INTRINSIC SAFETY
4. INSTALL IN ACCORDANCE WITH ARTICLE 504 OF THE NATIONAL ELECTRIC CODE
5. MAXIMUM CABLE LENGTH TO THE LEVEL SENSOR IS 3000 FEET
6. MAXIMUM CABLE LENGTH TO THE FLOW SENSOR IS 500 FEET
7. SELECTOR SWITCHES, (SS1-SS2) WILL SPRING RETURN FROM THE "HAND" POSITION

AS BUILT

JOB No. 09-9356D

* NOTICE * © EPG Companies Inc. 2009
THIS DRAWING IS THE PROPERTY OF EPG COMPANIES FOR REFERENCE ONLY.

TOLERANCES (EXCEPT AS NOTED)
±
FRACTIONAL ±
ANGULAR

REVISIONS		
NO.	DATE	BY
1		
2		
3		
4		
5		

EPG COMPANIES

L975PTG CONTROL PANEL
230VAC 1Ø SH 8 OF 8

DESIGN	RCK	SCALE	MATERIAL
DRAWN	RCK	DATE 06-02-09	DRAWING NO. 08373-0257
CHK'D		APP'D	

Phase IIIB
Installation Records

EPG Companies Inc.

SurePump™ Installation Record

Form Completed by: KEY Installation Date: 8/28/09

Company: HAMPTON ROBBER ELECTRIC EPG Serial #: 09-9356D

PUMPS, CONTROLS AND POWER SUPPLY

Installer: HTE	Address: 4920 ALTO AVE. LAS VEGAS, NV. 89115	Installation Location: PHASE 3B LCRS
Motor Model: WSDPT-5-3 HP: 3/4	Volts: 230 VAC Max Amps Rating: 6.8	Pump Model: EPG WSDPT SURE PUMP
Power Supply Transformers: Number Used: KVA Each: .350	Hertz: 60 Comments:	
Pump Control Panel: Mfg. & Model #: LS75PTG	Motor Starter Size: 5hp	Overload Heater Part or setting range: NA IEC Starters:
Lightning Arrestors: Mfg. & Model:	Surge Capacitors: Yes ____ No ✓	Disconnect Fuse or Circuit Breaker Amp Rating: 40
Primary Flow Control Devices: (Low Level Control, Flow Control, Valve, System Back Pressure, etc.) —		

OPERATING DATA (Measurements at Control Panel)

PUMP CONDITIONS:	GPM	VOLTS	AMPS
Pump Not Running	0	R-Y 0 R-B 0 B-Y 216	0
Open Discharge		R-Y ____ R-B ____ B-Y ____	R ____ Y ____ B ____
Normal Operation		R-Y 0 R-B 0 B-Y 215	R 0 Y 6.5 B 6.6
Run Time			
Off Time			

© EPG Companies Inc. 2009

EPG Companies Inc.

INSTALLATION DATA

Discharge Line Size: 1 1/2	Discharge Pressure:	Pump Submergence:	Fluid Temp: _____ °F _____ °C
External Check Valve Used? NO	Location:	Cable Length & Size: 70' 14GA	Ground Resistance
Insulation Megohm Readings:	Before Installation:	After Installation: 5.29G	After 30 min. Run: NA

SENSORS

Type of Level Sensor: Pressure Transmitter ✓ Load Monitor ____ Floats ____ Other ____	Transmitter Serial Number:
Length of Sensor Lead: 70'	Ohm Readings Across I.S. Barrier: 230
mA Readings on Transmitter Lead:	Voltage Reading Entering Level Meter: 20. VAC Voltage Leaving Level Meter: ____ VAC 21.4 VDC
Are Flow Sensors Used: Yes ✓ No ____	Flow Spool Made of: PVC ✓ Stainless Steel ____

Comments: _____

Place one copy of this record in the control panel, return one copy to EPG, and retain original for your records.

In case of problems or questions, contact EPG Companies Inc., 19900 County Road 81, Maple Grove, MN 55311 Phone: 800-762-8418 FAX: 763-493-4812

EPG SurePump™ Installation Record

EPG Job No. 09-9356

Installer's Name HAMPTON TEDDER ELECTRIC CO.

Address 4920 ALTO AVE

City LAS VEGAS State NV. Zip 89115

Phone (702) 646-7449 Fax (702) 453-5412

Contact name ROGER CATES

Owner's Name BASIL REMEDIATION CO.

Address 875 W. WARM SPRINGS RD.

City HENDERSON State NV. Zip 89011

Phone (702) 567-0400 Fax (702) 567-5524

Contact name LEE C. FARRES, PE

Sump Name/ID PHASE III B LCRS Date Installed 8/28/09

Leachate or Condensate Temp _____ °F Or °C

Pump:

Model No. WSDPT 5-3

Rating: 10 GPM@ 50 Ft. TDH

HP .5 Voltage 230 Phase 1

Actual Pump Delivery _____ GPM@ _____ PSI

Operating Cycle _____ ON (Min/Hr) _____ OFF (Min/Hr) (Circle Min. or Hr. as appropriate)

Side Slope Riser Information:

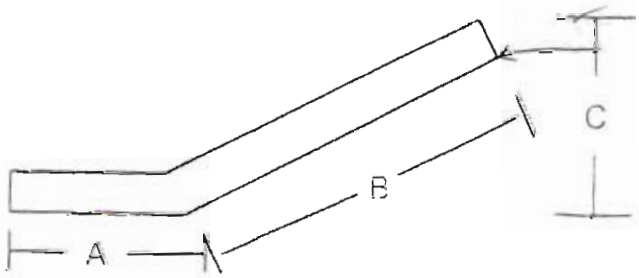
Slope 2.1 :1

Length of riser Pipe (A-B) 509 ft

Vertical Distance - Sump to INV Top of Riser Pipe (C) 17.2 ft

Riser ID PHASE III B LCRS SDR 11

Distance From Top of Riser Pipe to Controller 15 ft



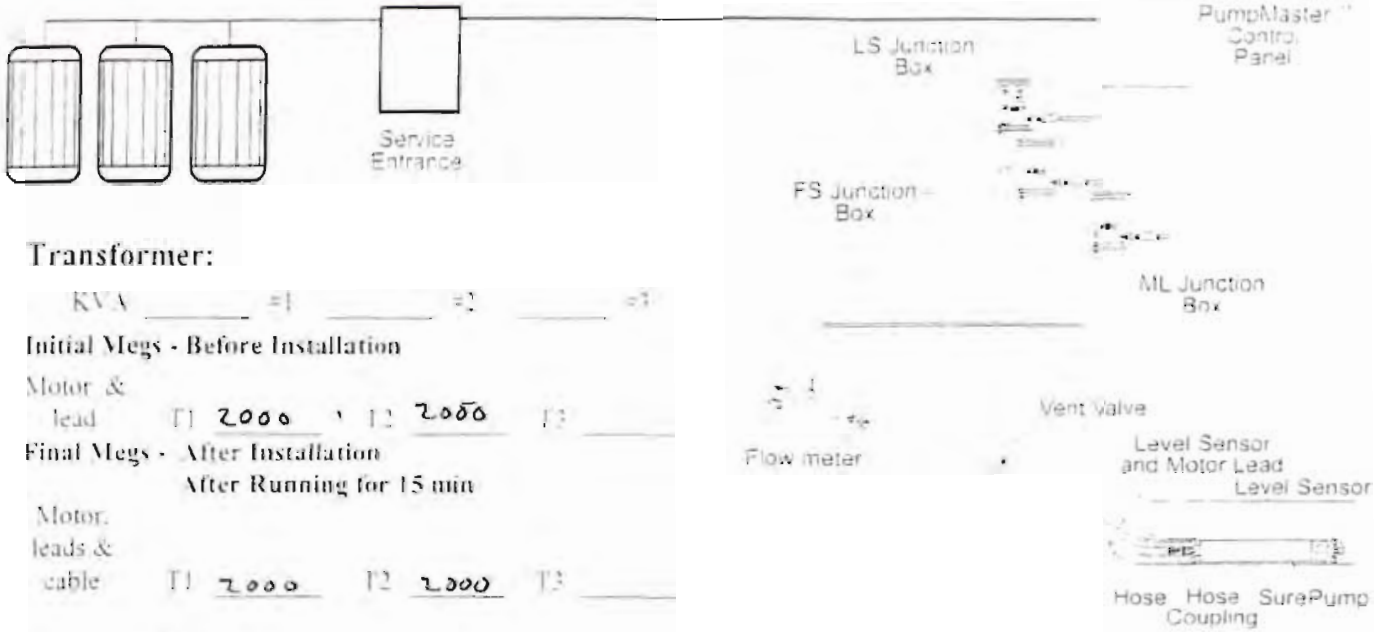
Power Supply:

Cable Service Entrance to Control Distance _____ ft Wire size _____ AWG MCM

Copper _____ Jacketed _____ Aluminum _____ Individual conductors _____

Cable Control to Motor _____ ft _____ AWG MCM

Copper _____ Jacketed _____



Transformer:

KVA _____ #1 _____ #2 _____ #3 _____

Initial Megs - Before Installation

Motor & lead T1 2000 T2 2000 T3 _____

Final Megs - After Installation
After Running for 15 min

Motor, leads & cable T1 2000 T2 2000 T3 _____

Incoming Voltage:

No Load L1-L2 235 L2-L3 _____ L1-L3 _____

Full Load L1-L2 235 L2-L3 _____ L1-L3 _____

Running Amps:

Hookup:1

Full Load L1 5 L2 5 L3 _____ % unbalanced 0

Hookup:2

Full Load L1 _____ L2 _____ L3 _____ % unbalanced _____

Hookup:3

Full Load L1 _____ L2 _____ L3 _____ % unbalanced _____

Ground wire size _____ AWG MCM

DC Ground Current _____ mA Ground Test 3 Ohms

Motor Surge Protection _____ Yes _____ No

Control Panel:

Model # L975PTG

Short Circuit Device

Circuit Breaker _____ Rating _____ Setting

Fuses FRNR8 Type 8 Rating

_____ Standard X Time Delay

Controls are Grounded to:

_____ Motor

X Rod

_____ Power Supply

Start Overloads:

Set at N/A amps

Name H LESTER

Company EPG COMPANIES

Date SEPT 17 01

© EPG Companies Inc. 2000

INSTALLATION GUIDE

EPG SurePump™ Pumping System

1. Verify that equipment and supply voltage match.

2. Inspect equipment, look for shipping damage, dirt, and rough handling.

3. Control panel should be mounted in a secure way at least 15' from riser or sump and 36" above grade to bottom of control panel.

4. Inspect inside of control panel. Look for items which might have come loose during shipping.

5. Test level sensor in bucket of water. Does it return back to zero? Control panel needs to be installed and have power to it.

6. Install vent valve and tubing. See Bulletin 0130c.

7. Install suspension cable. See Bulletin 6090a.

8. Fasten motor lead and sensor cable to discharge line every 5' to 7' with straps or plastic wire ties. It's best if they are on separate sides of line; use padding between cables and any metal straps.

9. Run pump down riser slowly using stainless steel suspension cable as hold back. Make sure motor lead and sensor cable are slack as you lower pump.

10. Take ohm reading of each motor lead wire to wire and compare the values in Table 13 of the Franklin Electric motor manual for 1Ø and Table 21 for 3Ø. Be sure to add wire resistance value to value from table 13& 21. See page 39 for wire resistance.

11. Check insulation resistance as pump is lowered down riser. Resistance may drop gradually as pump and cable enter the liquid, but any sudden drop indicates a problem.

12. Run sensor leads and power cables in separated conduits to control panel. It is a good idea to use breakout junction boxes. See Design Guide 05644.

13. If you have to remove dryer from end of transducer cable to pull cable through fittings or conduit. Seal end of the vent tube with a piece of tape. Reinstall dryer as soon as possible. See Bulletin 0550a.

14. Megger motor leads. Resistance must be 1 megohm or greater.

15. Connect pump to control panel complying with local and national codes. Controller terminal strips, motor leads, and sensor leads are all labeled and/or color coded to simplify connections.

16. Inspect wire connections. Are they the correct colors? Are they tight?

17. If color-coded wires were not continued from sump or riser you need to ohm out each circuit.

18. Measure resistance to ground. It must be less than 25 ohms. If greater stop work and report to owner. It should be 1 ohm or less to protect electronic equipment.

© 2009 EPG Companies Inc.

☑ 19. Measure voltage prior to control panel or at entrances to control panel. Measure and record voltage line to line and line to ground.

☑ 20. Compare these reading to voltage listed on drawing and label in control panel.

☑ 21. Review equipment list and drawings for any accessory circuits. If present, run volt and ohm test.

☑ 22. Check and make sure all hand switches are in the off position. If you have a water level indicator verify leachate level in sump or riser.

☑ 23. Turn on power at panel main disconnect.

☑ 24. Level meters display should light up. Record displayed reading. How does this reading compare to your measured level reading?

☑ 25. If level and flow meter do not light up check GFCI, reset if necessary.

☑ 26. Are any indicator lights on?

☑ 27. Should they be on?

☑ 28. Make sure pump is turned off. Using built in or hand held simulator, verify level meter settings are correct for this site. See meter data sheet for factory settings and meter instructions.

☑ 29. Bump pump by turning switch to hand two or three times to make sure pump has reached its resting point. You should have minimum of 3' of slack in the cables.

☑ 30. To verify correct rotation place hand around discharge line. It will torque right if the rotation is correct

☑ 31. When pump is running measure and record amperage and voltage. Check 3Ø systems for current balance within 5% of average.

☑ 32. Verify that starting, running and stopping causes no significant vibration or hydraulic shocks.

☑ 33. After 15 minutes of running time measure volts and amperage to see if they are stable. Are they as specified?

☑ 34. After pump and level sensor have been tested pot seal offs.

☑ 35. Complete Form 200. Note: If this form is not completed and returned to EPG it will impact system warranty.

2009 EPG Companies Inc.
EcoMatrix & SolePump are
Reg. TM of EPG Companies Inc.

START UP CHECKLIST

EPG SurePump™ Pumping System

QUESTIONS FOR CONTRACTOR OR INSTALLER

- ☑ A: Were sensor and power cable tied or strapped to discharge line?
- ☑ B: On what kind of spacing?
- ☑ C: What is the as built length of riser and sump? Were cables long enough? There should be 3 or more feet of slack in the cables.
- ☑ D: What size cable was run for supply power?
- ☑ E: What is the distance from power supply transformer to pump control panel?
- ☑ F: How did they verify that pump is down into sump?
- ☑ G: Did they test level sensor prior to installing?
- ☑ H: Did they test pump prior to installing or prior to your arrival?
- ☑ I: Do they have any questions or concerns?
- ☑ J: Complete form 200

PHYSICAL INSPECTION OF CONTROL PANEL

- ☑ A: Is the control panel located 15' from sump or riser and 36" above grade to bottom of panel.
- ☑ B: Are power and sensor cable run in separate conduit? If not, stop work and have this corrected.
- ☑ C: Are seal offs installed in both sensor and power runs? If not, suggest breakout junction boxes or have seal off installed.
- ☑ D: Are seal offs potted? If not, stop work and have them potted.
- ☑ E: Will inner and outer door of enclosure open and close freely? If not loosen enclosure mounting bolts and shim until it is level and square. Then retighten mounting bolts.
- ☑ F: Make sure ground wire is in place between outer door and enclosure.

2009 EPG Companies Inc.

PRIOR TO ENERGIZING CONTROL PANEL

- ☑ A: Measure resistance to ground. It must be less than 25 ohms. If greater stop work and report to owner. It should be 1 ohm or less to protect electronic equipment.
- ☑ B: Measure voltage prior to control panel or at entrances to control panel. Measure and record voltage line to line and line to ground.
- ☑ C: Compare these reading to voltage listed on drawing and label in control panel.
- ☑ D: Megger motor leads resistance must be 1 megohm or greater.
- ☑ E: Take ohm reading of each motor lead wire to wire and compare these to values in Table 13 of the Franklin Electric motor manual for 1O and Table 21 for 3O. Be sure to add wire resistance value to value from table 13& 21. See page 39 for wire resistance.
- ☑ F: Inspect inside of control panel. Look for items which may have come loose during shipping
- ☑ G: Inspect wire connections. Are they the correct colors? Are they tight?
- ☑ H: If color-coded wires were not continued from sump or riser you need to ohm out each circuit.
- ☑ I: Review equipment list and drawings from any accessory circuits. If present, run volt and ohm test.
- ☑ J: Check and make sure all hand switches are in off position. If you have a water level indicator verify leachate level in sump or riser.

POWER UP

- ☑ A: Turn on power at panel main disconnect.
- ☑ B: Level meters display should light up. Record displayed reading. How does this reading compare to your measured level reading?
- ☑ C: If level and flow meter do not light up check GFCI, reset if necessary
- ☑ D: Are any indicator lights on?
- ☑ E: Should they be on?
- ☑ F: Make sure pump is turned off. Using built in or hand held simulator, verify level meter settings are correct for this site.
- ☑ G: Bump pump by turning hand switch two or three times to make sure pump has reached its resting point. You should have minimum of 3' of slack in the cables.

2009 EPG Companies Inc.

- ☐ H: To verify correct rotation place hand around discharge line. It will torque right if the rotation is correct.
- ☐ I: If there is liquid in sump with level about pump start set point and below 150". Then turn pump selector switch to AUTO. Run pump through one complete cycle.
- ☑ J: When pump is running measure and record amperage and voltage. Check 3O systems for current balance within 5% of average.
- ☑ K: Verify that starting, running and stopping causes no significant vibration or hydraulic shocks.

2009 EPG Companies Inc.

EPG Companies Inc.

SurePump™ Installation Record

Form Completed by: KEY Installation Date: 8/28/09

Company: HAMPTON ROOFING EQUIPMENT EPG Serial #: 09-9356D

PUMPS, CONTROLS AND POWER SUPPLY

Installer:	Address:	Installation Location:
HTE	4920 ALTO AVE. LAS VEGAS, NV. 89115	PHASE 3B VADOSE

Motor Model	HP	Volts:	Max Amps Rating:	Pump Model:
WSDPT2-3	1/2	230	5.0	EPG WSOPT SURE PUMP

Power Supply Transformers: Number Used: KVA Each: .35	Hertz: 60	Comments:

Pump Control Panel: Mfg. & Model #:	Motor Starter Size:	Overload Heater Part or setting range:	IEC Starters:
L975PTE	.5hp	NA	

Lightning Arrestors: Mfg. & Model:	Surge Capacitors:	Disconnect Fuse or Circuit Breaker
Intermatic AG2401	Yes ____ No ✓	Amp Rating: 40

Primary Flow Control Devices:
(Low Level Control, Flow Control, Valve, System Back Pressure, etc.)

—

OPERATING DATA (Measurements at Control Panel)

PUMP CONDITIONS:	GPM	VOLTS			AMPS
Pump Not Running (Line)	0	R-Y 0	R-B 0	B-Y 214	0
Open Discharge		R-Y ____	R-B ____	B-Y ____	R ____ Y ____ B ____
Normal Operation		R-Y 0	R-B 0	B-Y 214	R 0 Y 5.29 B 5.16
Run Time					
Off Time					

© EPG Companies Inc. 2009

EPG Companies Inc.

INSTALLATION DATA

Discharge Line Size: 1"	Discharge Pressure:	Pump Submergence:	Fluid Temp: ____ °F ____ °C
External Check Valve Used? NO	Location:	Cable Length & Size: 73' 14GA	Ground Resistance 2 ohms
Insulation Megohm Readings:	Before Installation:	After Installation: 5.76G	After 30 min. Run: NA

SENSORS

Type of Level Sensor: Pressure Transmitter ✓ Load Monitor ____ Floats ____ Other ____	Transmitter Serial Number:
Length of Sensor Lead: ~~143~~ 73'	Ohm Readings Across I.S. Barrier: 230
mA Readings on Transmitter Lead:	Voltage Reading Entering Level Meter: 12 VDC Voltage Leaving Level Meter: 12 VDC
Are Flow Sensors Used: Yes ✓ No ____	Flow Spool Made of: PVC ✓ Stainless Steel ____

Comments: _____

Place one copy of this record in the control panel, return one copy to EPG, and retain original for your records.

In case of problems or questions, contact EPG Companies Inc., 19900 County Road 81, Maple Grove, MN 55311. Phone: 800-762-8418. FAX: 763-493-4812

© EPG Companies Inc. 2009

EPG SurePump™ Installation Record

EPG Job No 09 - 9356

Installer's Name HAMPTON TEDDER ELECTRIC CO.

Address 4920 ALTO AVE.

City LAS VEGAS State NV. Zip 89115

Phone (702) 646-7449 Fax (702) 453-5412

Contact name ROGER CATES

Owner's Name BASIL RENOVATION CO.

Address 875 W. WARM SPRINGS RD.

City HENDERSON State NV Zip 89011

Phone (702) 567-0400 Fax (702) 567-5524

Contact name LEE C. FARRIS, PE

Sump Name ID PHASE III B VADOSE Date Installed 8/20/09

Leachate or Condensate Temp _____ °F Or °C

Pump:

Model No WSDPT2-3

Rating: 10 GPM@ 50 Ft. TDH

HP .5 Voltage 230 Phase 1

Actual Pump Delivery _____ GPM@ _____ PSI

Operating Cycle _____ ON (Min/Hr) _____ OFF (Min/Hr) (Circle Min. or Hr. as appropriate)

Side Slope Riser Information:

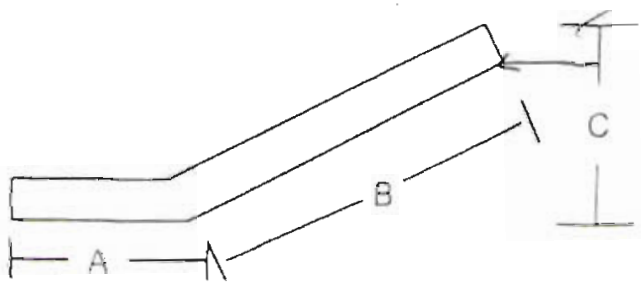
Slope 2:1 :1

Length of riser Pipe (A-B) 48.1 ft

Vertical Distance - Sump to INV. Top of Riser Pipe (C) 16.8 ft

Riser ID PHASE IIIB VADOSE SDR 11

Distance From Top of Riser Pipe to Controller 15 ft



Power Supply:

Cable: Service Entrance to Control Distance _____ ft Wire size _____ AWG/MCM

Copper _____ Jacketed _____ Aluminum _____ Individual conductors _____

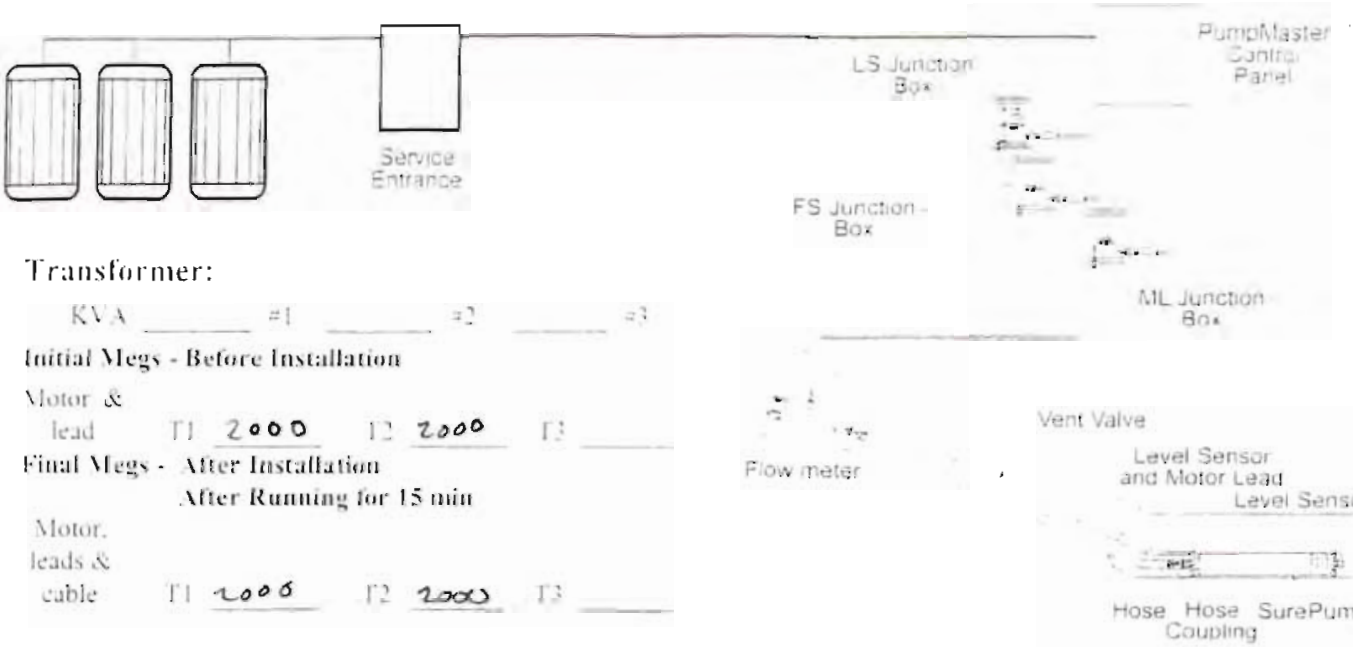
Cable: Control to Motor _____ ft _____ AWG/MCM

Copper _____ Jacketed _____

EPG Companies Inc. 2009

EPG Companies Inc.

July 2002



Transformer:

KVA _____ #1 _____ #2 _____ #3 _____

Initial Megs - Before Installation

Motor & lead T1 2000 T2 2000 T3 _____

Final Megs - After Installation
After Running for 15 min

Motor, leads & cable T1 2000 T2 2000 T3 _____

Incoming Voltage:

No Load L1-L2 235 L2-L3 _____ L1-L3 _____

Full Load L1-L2 236 L2-L3 _____ L1-L3 _____

Running Amps:

Hookup:1

Full Load L1 5 L2 5 L3 _____ % unbalanced 0

Hookup:2

Full Load L1 _____ L2 _____ L3 _____ % unbalanced _____

Hookup:3

Full Load L1 _____ L2 _____ L3 _____ % unbalanced _____

Ground wire size _____ AWG MCM

DC Ground Current _____ mA Ground Test 2 Ohms

Motor Surge Protection _____ Yes _____ No

Control Panel:

Model # L975PTG

Short Circuit Device

Circuit Breaker _____ Rating _____ Setting

Fuses FENR 8 Type 8 Rating

_____ Standard ✓ Time Delay

Controls are Grounded to:

_____ Motor

X Rod

_____ Power Supply

Start Overloads:

Set at N/A amps

Name HOWARD LESTER

Company EPG COMPANIES

Date SEPT 17 09

© EPG Companies Inc. 2009

INSTALLATION GUIDE

EPG SurePump™ Pumping System

1. Verify that equipment and supply voltage match.

2. Inspect equipment, look for shipping damage, dirt, and rough handling

3. Control panel should be mounted in a secure way at least 15' from riser or sump and 36" above grade to bottom of control panel.

4. Inspect inside of control panel. Look for items which might have come loose during shipping

5. Test level sensor in bucket of water. Does it return back to zero? Control panel needs to be installed and have power to it.

6. Install vent valve and tubing. See Bulletin 0130c.

7. Install suspension cable. See Bulletin 6090a.

8. Fasten motor lead and sensor cable to discharge line every 5' to 7' with straps or plastic wire ties. It's best if they are on separate sides of line; use padding between cables and any metal straps.

9. Run pump down riser slowly using stainless steel suspension cable as hold back. Make sure motor lead and sensor cable are slack as you lower pump.

10. Take ohm reading of each motor lead wire to wire and compare the values in Table 13 of the Franklin Electric motor manual for 1Ø and Table 21 for 3O. Be sure to add wire resistance value to value from table 13& 21. See page 39 for wire resistance.

11. Check insulation resistance as pump is lowered down riser. Resistance may drop gradually as pump and cable enter the liquid, but any sudden drop indicates a problem.

12. Run sensor leads and power cables in separated conduits to control panel. It is a good idea to use breakout junction boxes. See Design Guide 05644.

13. If you have to remove dryer from end of transducer cable to pull cable through fittings or conduit. Seal end of the vent tube with a piece of tape. Reinstall dryer as soon as possible. See Bulletin 0550a.

14. Megger motor leads. Resistance must be 1 megohm or greater.

15. Connect pump to control panel complying with local and national codes. Controller terminal strips, motor leads, and sensor leads are all labeled and/or color coded to simplify connections.

16. Inspect wire connections. Are they the correct colors? Are they tight?

17. If color-coded wires were not continued from sump or riser you need to ohm out each circuit.

18. Measure resistance to ground. It must be less than 25 ohms. If greater stop work and report to owner. It should be 1 ohm or less to protect electronic equipment.

© 2009 EPG Companies Inc.

☑ 19. Measure voltage prior to control panel or at entrances to control panel. Measure and record voltage line to line and line to ground.

☑ 20. Compare these reading to voltage listed on drawing and label in control panel.

☑ 21. Review equipment list and drawings for any accessory circuits. If present, run volt and ohm test.

☑ 22. Check and make sure all hand switches are in the off position. If you have a water level indicator verify leachate level in sump or riser.

☑ 23. Turn on power at panel main disconnect

☑ 24. Level meters display should light up. Record displayed reading. How does this reading compare to your measured level reading?

☑ 25. If level and flow meter do not light up check GFCI, reset if necessary.

☑ 26. Are any indicator lights on?

☑ 27. Should they be on?

☑ 28. Make sure pump is turned off. Using built in or hand held simulator, verify level meter settings are correct for this site. See meter data sheet for factory settings and meter instructions.

☑ 29. Bump pump by turning switch to hand two or three times to make sure pump has reached its resting point. You should have minimum of 3' of slack in the cables.

☑ 30. To verify correct rotation place hand around discharge line. It will torque right if the rotation is correct.

☑ 31. When pump is running measure and record amperage and voltage. Check 3Ø systems for current balance within 5% of average.

☑ 32. Verify that starting, running and stopping causes no significant vibration or hydraulic shocks.

☑ 33. After 15 minutes of running time measure volts and amperage to see if they are stable. Are they as specified?

☑ 34. After pump and level sensor have been tested pot seal offs.

☑ 35. Complete Form 200. Note: <u>If this form is not completed and returned to EPG it will impact system warranty.</u>

START UP CHECKLIST

EPG SurePump™ Pumping System

QUESTIONS FOR CONTRACTOR OR INSTALLER

- ☑ A: Were sensor and power cable tied or strapped to discharge line?
- ☑ B: On what kind of spacing?
- ☑ C: What is the as built length of riser and sump? Were cables long enough? There should be 3 or more feet of slack in the cables.
- ☑ D: What size cable was run for supply power?
- ☑ E: What is the distance from power supply transformer to pump control panel?
- ☑ F: How did they verify that pump is down into sump?
- ☑ G: Did they test level sensor prior to installing?
- ☑ H: Did they test pump prior to installing or prior to your arrival?
- ☑ I: Do they have any questions or concerns?
- ☑ J: Complete form 200

PHYSICAL INSPECTION OF CONTROL PANEL

- ☐ A: Is the control panel located 15' from sump or riser and 36" above grade to bottom of panel.
- ☑ B: Are power and sensor cable run in separate conduit? If not, stop work and have this corrected.
- ☑ C: Are seal offs installed in both sensor and power runs? If not, suggest breakout junction boxes or have seal off installed.
- ☑ D: Are seal offs potted? If not, stop work and have them potted.
- ☑ E: Will inner and outer door of enclosure open and close freely? If not loosen enclosure mounting bolts and shim until it is level and square. Then retighten mounting bolts.
- ☑ F: Make sure ground wire is in place between outer door and enclosure.

2009 EPG Companies Inc

PRIOR TO ENERGIZING CONTROL PANEL

- ✓ A: Measure resistance to ground. It must be less than 25 ohms. If greater stop work and report to owner. It should be 1 ohm or less to protect electronic equipment.
- ✓ B: Measure voltage prior to control panel or at entrances to control panel. Measure and record voltage line to line and line to ground.
- ✓ C: Compare these reading to voltage listed on drawing and label in control panel.
- ✓ D: Megger motor leads resistance must be 1 megohm or greater.
- ✓ E: Take ohm reading of each motor lead wire to wire and compare these to values in Table 13 of the Franklin Electric motor manual for 1O and Table 21 for 3O. Be sure to add wire resistance value to value from table 13& 21. See page 39 for wire resistance.
- ✓ F: Inspect inside of control panel. Look for items which may have come loose during shipping
- ✓ G: Inspect wire connections. Are they the correct colors? Are they tight?
- ✓ H: If color-coded wires were not continued from sump or riser you need to ohm out each circuit.
- ✓ I: Review equipment list and drawings from any accessory circuits. If present, run volt and ohm test.
- ✓ J: Check and make sure all hand switches are in off position. If you have a water level indicator verify leachate level in sump or riser.

POWER UP

- ✓ A: Turn on power at panel main disconnect.
- ✓ B: Level meters display should light up. Record displayed reading. How does this reading compare to your measured level reading?
- ✓ C: If level and flow meter do not light up check GFCI, reset if necessary.
- ✓ D: Are any indicator lights on?
- ✓ E: Should they be on?
- ✓ F: Make sure pump is turned off. Using built in or hand held simulator verify level meter settings are correct for this site.
- ✓ G: Bump pump by turning hand switch two or three times to make sure pump has reached its resting point. You should have minimum of 3' of slack in the cables.

2009 EPG Companies Inc.

- ☐ H: To verify correct rotation place hand around discharge line. It will torque right if the rotation is correct.
- ☐ I: If there is liquid in sump with level about pump start set point and below 150". Then turn pump selector switch to AUTO. Run pump through one complete cycle.
- ☑ J: When pump is running measure and record amperage and voltage. Check 3O systems for current balance within 5% of average.
- ☑ K: Verify that starting, running and stopping causes no significant vibration or hydraulic shocks.

Phase IIIB
As-Built Control Panel Setup Parameters

EPG LevelMaster Pump controller

Panel S/N: 09-9356D
Meter S/N: 060509-02

LCRS Pump Level Control Meter PHASE IIIB

Default setting - Operating Parameters - Setup Code 35

Meter Designation(s): M3

Parameter	Value	Operation
Pr Hi	28	Turns Pump on when level on meter reads ~~28~~ ". 20"
Pr Lo	16	Turns Pump off when level on meter reads ~~16~~ ". 7"
AL H1	34	Turns High Level Light on when meter reads ~~34~~ ". 36.1"
Hy Hi	1	Keeps High Level Light on until level drops 1 " below AL Hi.
AL H2	143	Turns Pumps off it meter reads 143" or greater. Indicates a possible sensor failure.
Hy H2	0	Not used.

Default Settings - Sensor Parameters - Setup Code 25 (0 - 5PSI)

Parameter	Value	Operation
dp	8888.8	Sets Meter to read in 0.1"
OFFSET	-34.6	Provides a "0" reading when sensor inputs 4.0ma
SCALE	0.8656	Converts current input into inches - 1.0ma = 8.656 inches.

AS BUILT

EPG LevelMaster Pump controller

Panel S/N: 09-9356D
Meter S/N: 060409-05

Vadose Pump Level Control Meter PHASE IIIB

Default setting - Operating Parameters - Setup Code 35

Meter Designation(s): M1

Parameter	Value	Operation
Pr Hi	28	Turns Pump on when level on meter reads ~~28~~ ". 17"
Pr Lo	16	Turns Pump off when level on meter reads ~~16~~ ". 7"
AL H1	34	Turns High Level Light on when meter reads ~~34~~ ". .5"
Hy Hi	1	Keeps High Level Light on until level drops ~~1~~ " below AL Hi. .5"
AL H2	143	Turns Pumps off it meter reads 143" or greater. Indicates a possible sensor failure.
Hy H2	0	Not used.

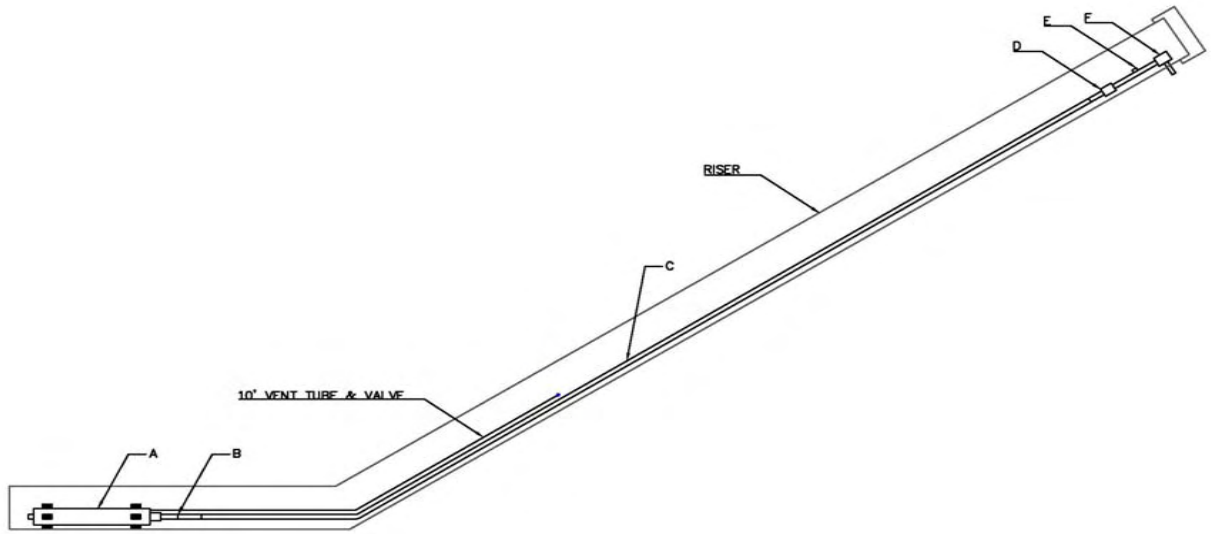
Default Settings - Sensor Parameters - Setup Code 25 (0 - 5PSI)

Parameter	Value	Operation
dp	8888.8	Sets Meter to read in 0.1"
OFFSET	-34.6	Provides a "0" reading when sensor inputs 4.0ma
SCALE	0.8656	Converts current input into inches - 1.0ma = 8.656 inches.

AS BUILT

Phase IIIB
As-Built Pump Installation Cross Sections

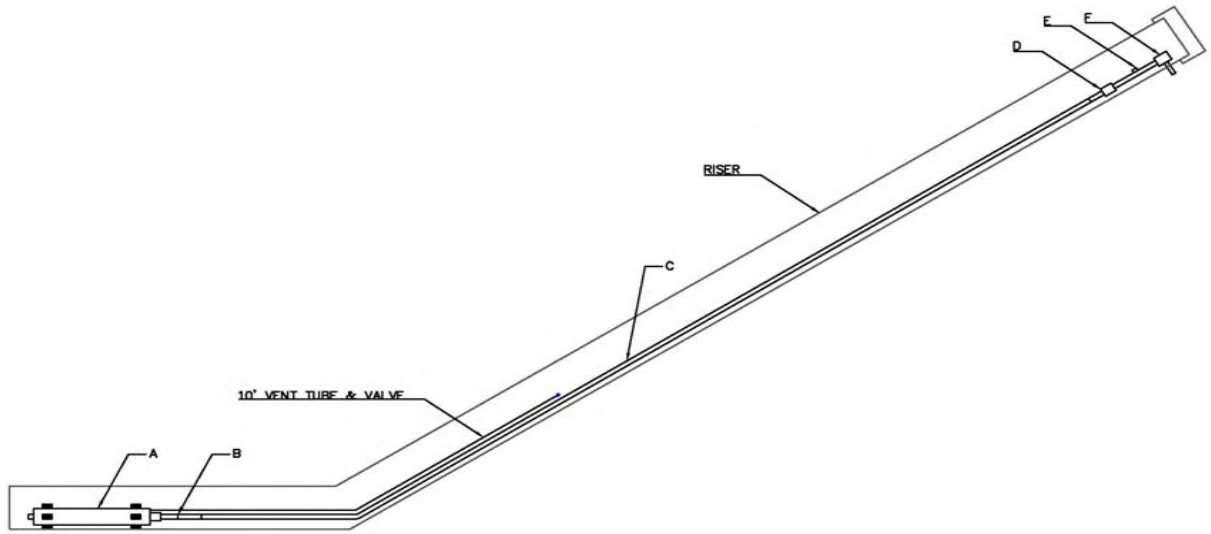
PHASE IIIB LCRS SUMP PUMP INSTALLATION



ITEM	DESCRIPTION	LENGTH (FT)
A	WSDPT5-3 PUMP (S/N 2009-3132)	2.7
B	CONNECTIONS/FITTINGS/TRANSITIONS	0.8
C	1.5" DISCHARGE LINE	36.8
D	CONNECTIONS/FITTINGS/TRANSITIONS	0.7
E	FLOW METER	2.2
F	EPG FITTING "T"	0.4

NOT TO SCALE

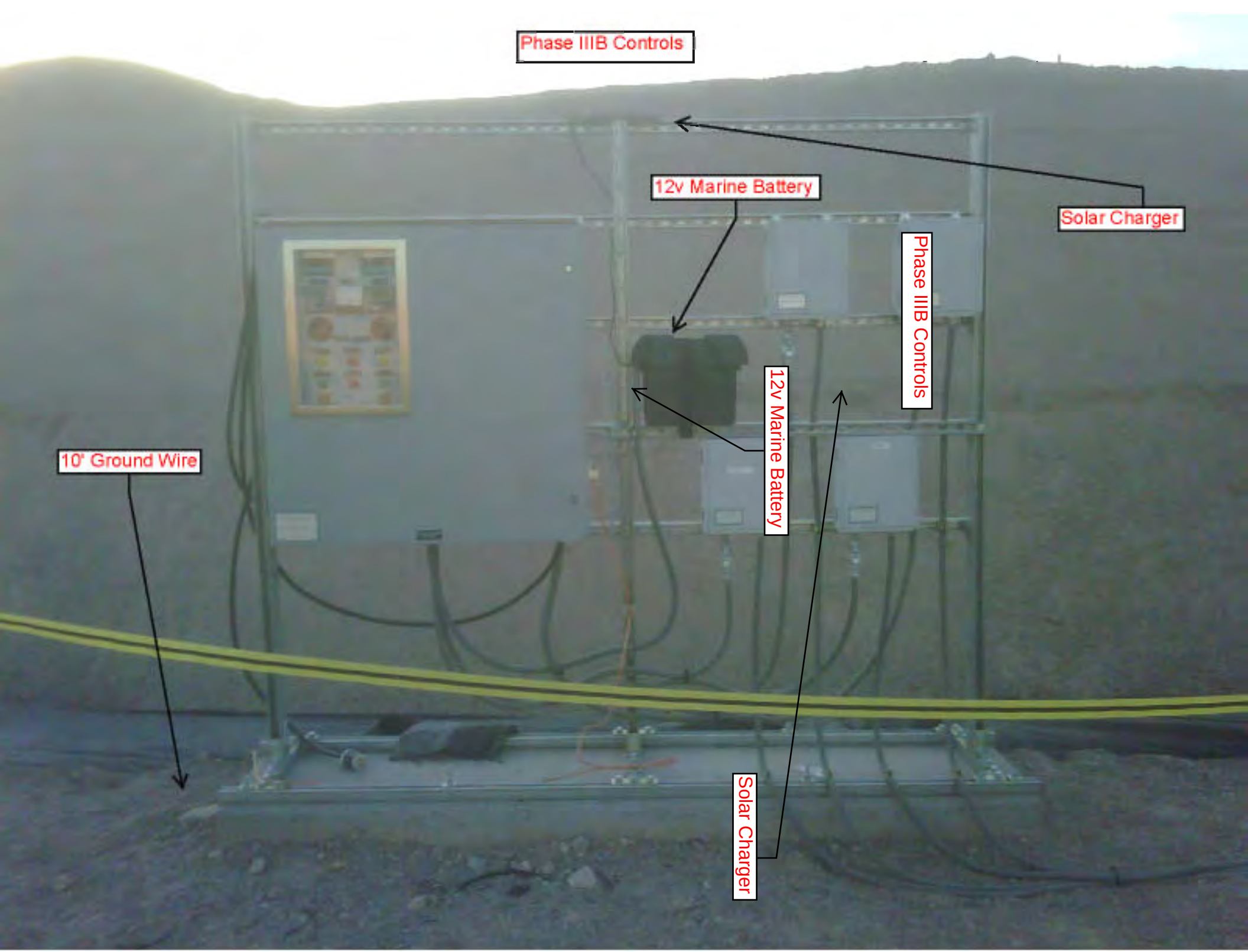
PHASE IIIB VADOSE SUMP PUMP INSTALLATION

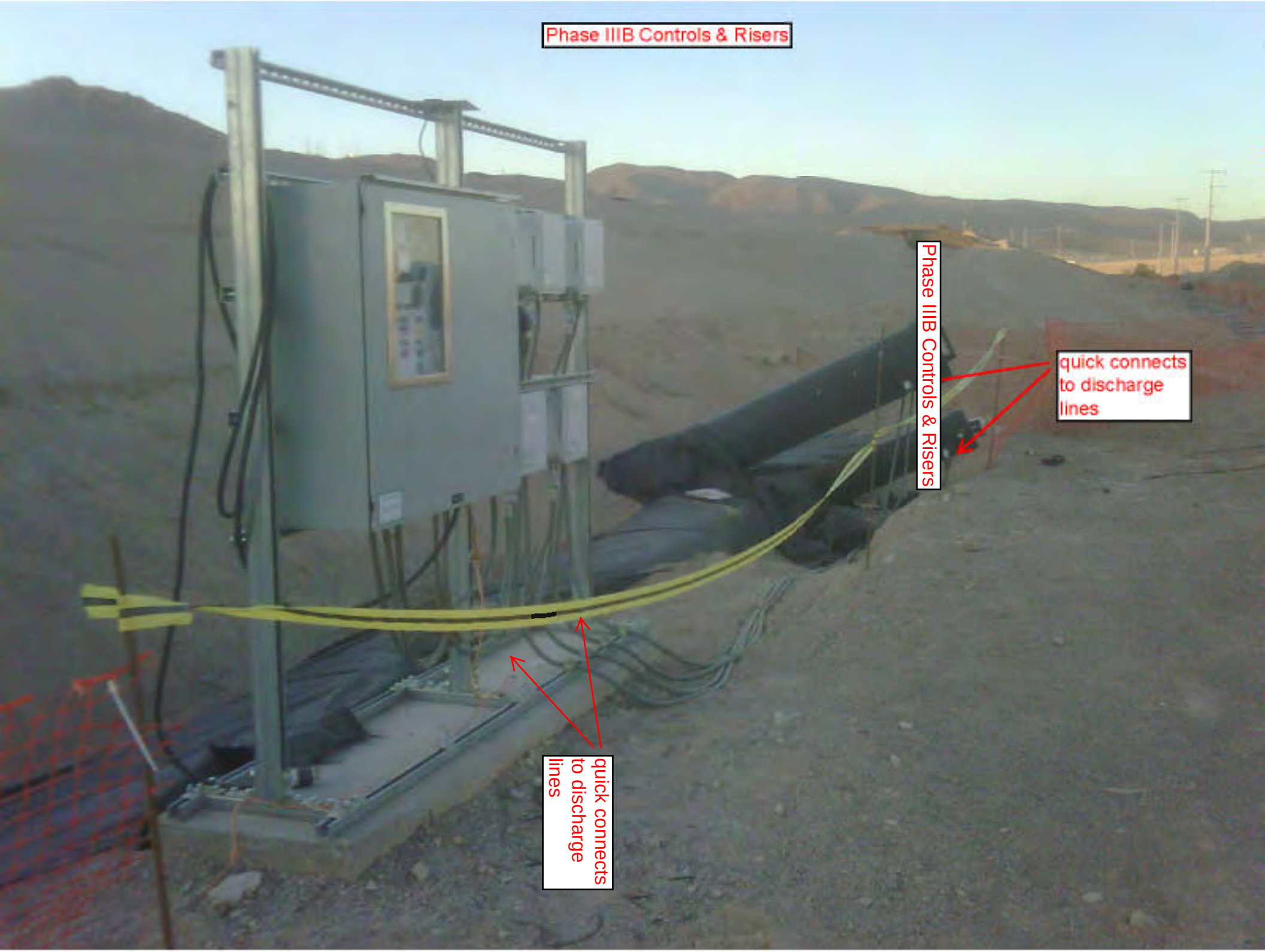


ITEM	DESCRIPTION	LENGTH (FT)
A	WSDPT2-3 PUMP (S/N 2009-3136)	2.6
B	CONNECTIONS/FITTINGS/TRANSITIONS	1.1
C	1.0" DISCHARGE LINE	37.4
D	CONNECTIONS/FITTINGS/TRANSITIONS	0.5
E	FLOW METER	1.9
F	EPG FITTING "T"	0.3

NOT TO SCALE

Phase IIIB
As-Built Photos


Phase IIIB Controls
12v Marine Battery
Solar Charger
Phase IIIB Controls
12v Marine Battery
10' Ground Wire
Solar Charger


Phase IIIB Controls & Risers
Phase IIIB Controls & Risers
quick connects to discharge lines
quick connects to discharge lines

Phase V
Engineer's Specification

ENGINEER'S SPECIFICATION

PHASE V LCRS

EPG WSDPT SurePump™ Wheeled Sump Drainer

for side slope riser installations with built-in level sensor

Furnish ~~2~~ 1 centrifugal submersible EPG WSDPT SurePump Wheeled Sump Drainer(s) (U.S. patented), Model WSDPT 5 - 3 with 3 impeller stages. Each unit shall be suitable for side slope riser installation. Each unit shall be equipped with a ¾ HP, submersible electric motor for operation on 230 Volts, 1 phase, 60 Hertz service with 70 feet of power cable. Each SurePump Wheeled Sump Drainer shall have a 1 ½ inch MNPT threaded discharge nozzle and be capable of delivering 25 GPM at 50 feet of TDH. Each SurePump will be fitted with 70 feet of stainless steel lifting cable of sufficient strength to permit removal of the unit.

DESIGN

Each SurePump Wheeled Sump Drainer shall be capable of pumping contaminated ground water for spill recovery, leachate, condensate, and purge applications. A removable transmitter mount (patent pending) shall be installed at the center bottom of the Sump Drainer for liquid level control. The Sump Drainer shall permit the unit to "pump down" to within 8 inches of the sump bottom without any loss of performance or damage to the pump. External "priming" shall not be required nor allowed. The Sump Drainer shall be equipped with a vent valve to assist with the evacuation of air from the Sump Drainer.

MATERIALS

Major components shall be made of 304 stainless steel, seal rings are to be made of E-Glide™, and bearings are to be E-Glide. In addition, all fasteners shall be 304 stainless steel.

CHECK VALVE

Each unit shall include a built-in check valve with non-metallic seat, and housing and disc of 304 stainless steel.

SHAFT

The shaft shall be of 304 stainless steel and rotate on E-Glide bearings that are fluid lubricated.

DIFFUSER CHAMBER

The diffuser chambers for each impeller shall be 304 stainless steel and fitted with E-Glide impeller seal rings.

IMPELLERS

The impeller(s) shall be closed and consist of 304 stainless steel.

MOTOR

The motor shall be a submersible, hermetically sealed Franklin motor in Pollution Recovery construction. The motor shall be designed for continuous duty, capable of sustaining up to 100 starts per day. The motor shall be connected to the pump via a motor adaptor and coupling in 304 stainless steel. Single phase motors in ½ HP to 1 HP only shall have thermal protection in the motor windings to protect the windings from overload. The unit will restart automatically after the motor cools down. Larger horsepower single phase motors and three phase motors shall have thermal protection located in the control panel that is manually reset.

MOTOR LEAD WIRE

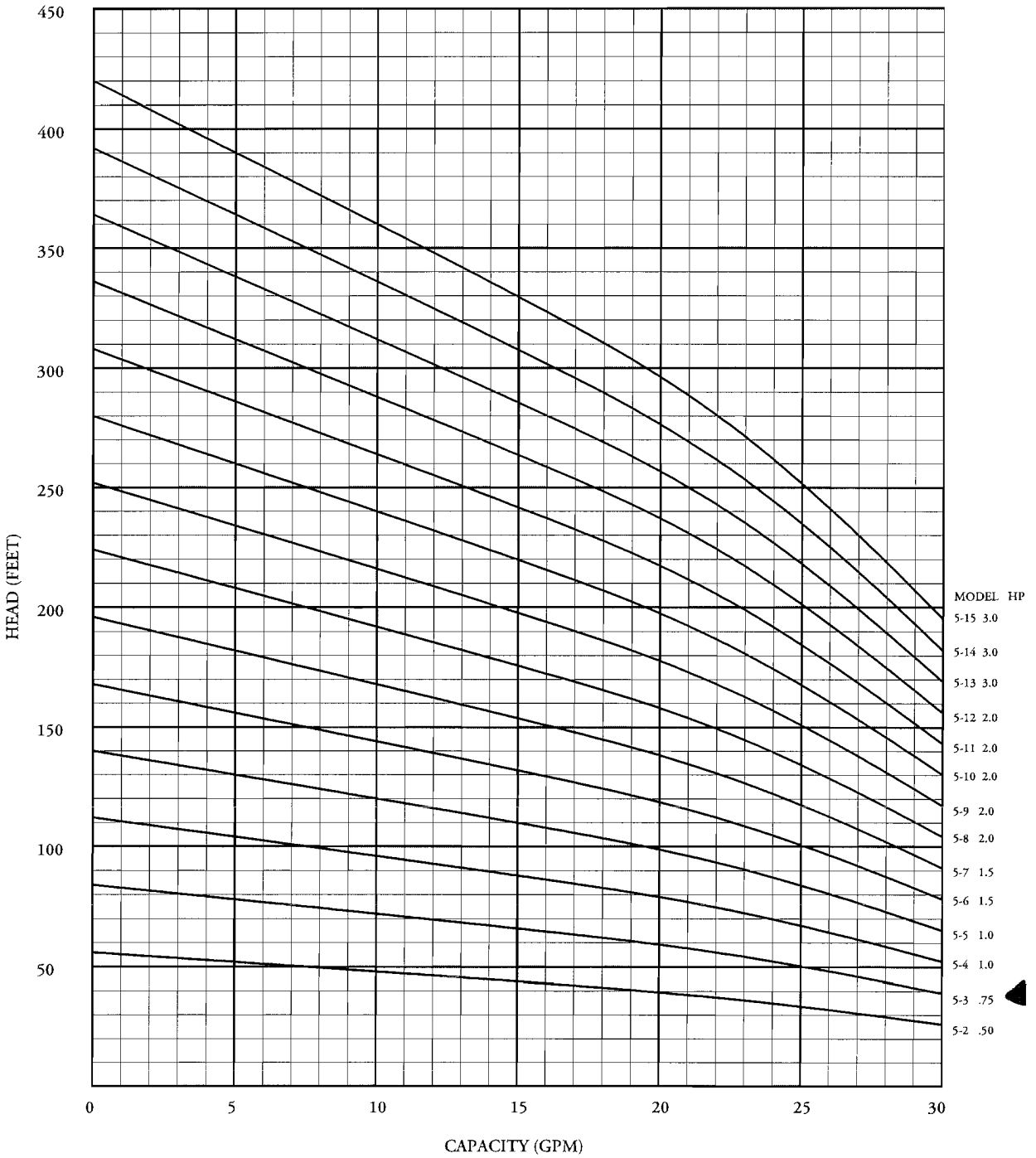
The lead wire shall be no-splice with EPG's "CP" waterproof and chemically resistant jacket over 600 Volt insulation and be of the length specified.

© 2009 EPG Companies Inc.
SurePump & E-Glide are Reg. TM of EPG Companies Inc.

SERIES 5 SurePump™

Flow Range 15-30 GPM

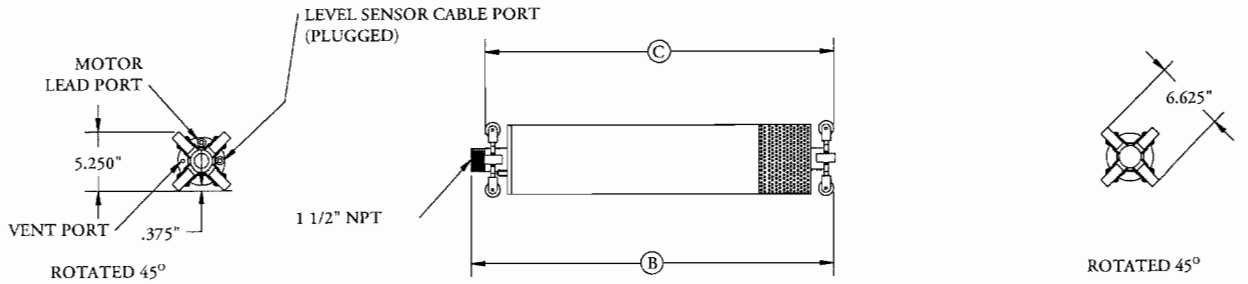
60 Hz



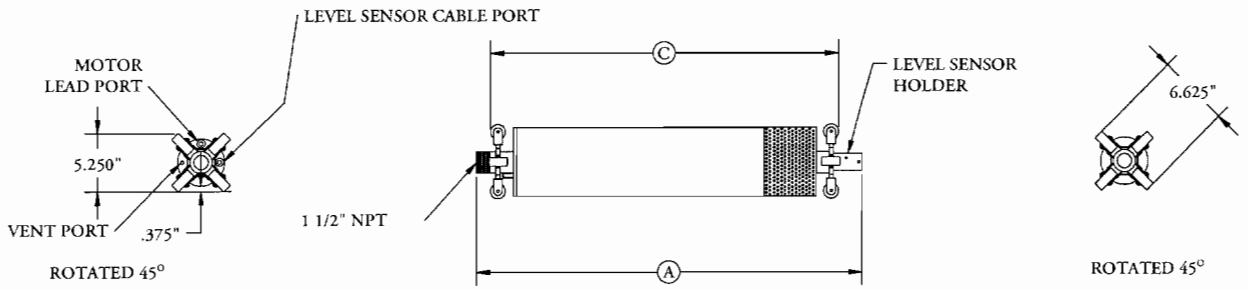
DATA SUBJECT TO CHANGE WITHOUT NOTICE

© 2009 EPG Companies Inc.
SurePump is a Reg. TM of EPG Companies Inc.

SERIES 5 SIZE 4 WHEELED SUMP DRAINER



WSD



WSDPT

MODEL	HP	PHASE	A	B	C	*APPROX. SHIPPING WEIGHT	
						WSD	WSDPT
5-2	0.50	1	31.02	29.90	29.15	61.47	66.47
5-2	0.50	3	31.02	29.90	29.15	61.47	66.47
5-3	0.75	1	32.98	31.86	31.11	66.24	71.24
5-3	0.75	3	32.98	31.86	31.11	66.24	71.24
5-4	1.00	1	34.90	33.78	33.03	70.98	75.98
5-4	1.00	3	34.90	33.78	33.03	70.98	75.98
5-5	1.00	1	35.73	34.61	33.86	71.88	76.88
5-5	1.00	3	35.73	34.61	33.86	71.88	76.88
5-6	1.50	1	38.43	37.31	36.56	79.22	84.22
5-6	1.50	3	36.56	35.44	34.69	72.77	77.77
5-7	1.50	1	39.26	38.14	37.39	80.12	85.12
5-7	1.50	3	37.39	36.27	35.52	73.67	78.67
5-8	2.00	1	41.59	40.47	39.72	85.17	90.17
5-8	2.00	3	40.09	38.97	38.22	81.01	86.01

MODEL	HP	PHASE	A	B	C	*APPROX. SHIPPING WEIGHT	
						WSD	WSDPT
5-9	2.00	1	42.42	41.30	40.55	86.07	91.07
5-9	2.00	3	40.92	39.80	39.05	81.90	86.90
5-10	2.00	1	43.25	42.13	41.38	86.96	91.96
5-10	2.00	3	41.75	40.63	39.88	82.80	87.80
5-11	2.00	1	44.08	42.96	42.21	87.86	92.86
5-11	2.00	3	42.58	41.46	40.71	83.69	88.69
5-12	2.00	1	44.91	43.79	43.04	88.75	93.75
5-12	2.00	3	53.41	52.29	51.54	92.35	97.35
5-13	3.00	1	54.24	53.12	52.37	119.24	124.24
5-13	3.00	3	51.24	50.12	49.37	105.91	110.91
5-14	3.00	1	55.07	53.95	53.20	120.14	125.14
5-14	3.00	3	52.07	50.95	50.20	106.81	111.81
5-15	3.00	1	55.90	54.78	54.03	121.03	126.03
5-15	3.00	3	52.90	51.78	51.03	107.70	112.70

NOTE: ALL DIMENSIONS ARE IN INCHES.

*SHIPPING WEIGHT INCLUDES
WSD: CRATE, 50' OF 14-4 MOTOR LEAD, 50' OF 1/8" SS CABLE.
WSDPT: CRATE, 50' OF 14-4 MOTOR LEAD, 50' OF 1/8" SS CABLE,
LEVEL SENSOR AND CABLE.

© 2009 EPG Companies Inc.
SurePump is a Reg. TM of EPG Companies Inc.

ENGINEER'S SPECIFICATION

PHASE V VADOSE

EPG WSDPT SurePump™ Wheeled Sump Drainer

for side slope riser installations with built-in level sensor

Furnish ~~2~~ 1 centrifugal submersible EPG WSDPT SurePump Wheeled Sump Drainer(s) (U.S. patented), Model WSDPT 2 - 3 with 3 impeller stages. Each unit shall be suitable for side slope riser installation. Each unit shall be equipped with a ½ HP, submersible electric motor for operation on 230 Volts, 1 phase, 60 Hertz service with 70 feet of power cable. Each SurePump Wheeled Sump Drainer shall have a 1 ¼ inch MNPT threaded discharge nozzle and be capable of delivering 10 GPM at 50 feet of TDH. Each SurePump will be fitted with 70 feet of stainless steel lifting cable of sufficient strength to permit removal of the unit.

DESIGN

Each SurePump Wheeled Sump Drainer shall be capable of pumping contaminated ground water for spill recovery, leachate, condensate, and purge applications. A removable transmitter mount (patent pending) shall be installed at the center bottom of the Sump Drainer for liquid level control. The Sump Drainer shall permit the unit to "pump down" to within 8 inches of the sump bottom without any loss of performance or damage to the pump. External "priming" shall not be required nor allowed. The Sump Drainer shall be equipped with a vent valve to assist with the evacuation of air from the Sump Drainer.

MATERIALS

Major components shall be made of 304 stainless steel, seal rings are to be made of E-Glide™, and bearings are to be E-Glide. In addition, all fasteners shall be 304 stainless steel.

CHECK VALVE

Each unit shall include a built-in check valve with non-metallic seat, and housing and disc of 304 stainless steel.

SHAFT

The shaft shall be of 304 stainless steel and rotate on E-Glide bearings that are fluid lubricated.

DIFFUSER CHAMBER

The diffuser chambers for each impeller shall be 304 stainless steel and fitted with E-Glide impeller seal rings.

IMPELLERS

The impeller(s) shall be closed and consist of 304 stainless steel.

MOTOR

The motor shall be a submersible, hermetically sealed Franklin motor in Pollution Recovery construction. The motor shall be designed for continuous duty, capable of sustaining up to 100 starts per day. The motor shall be connected to the pump via a motor adaptor and coupling in 304 stainless steel. Single phase motors in ½ HP to 1 HP only shall have thermal protection in the motor windings to protect the windings from overload. The unit will restart automatically after the motor cools down. Larger horsepower single phase motors and three phase motors shall have thermal protection located in the control panel that is manually reset.

MOTOR LEAD WIRE

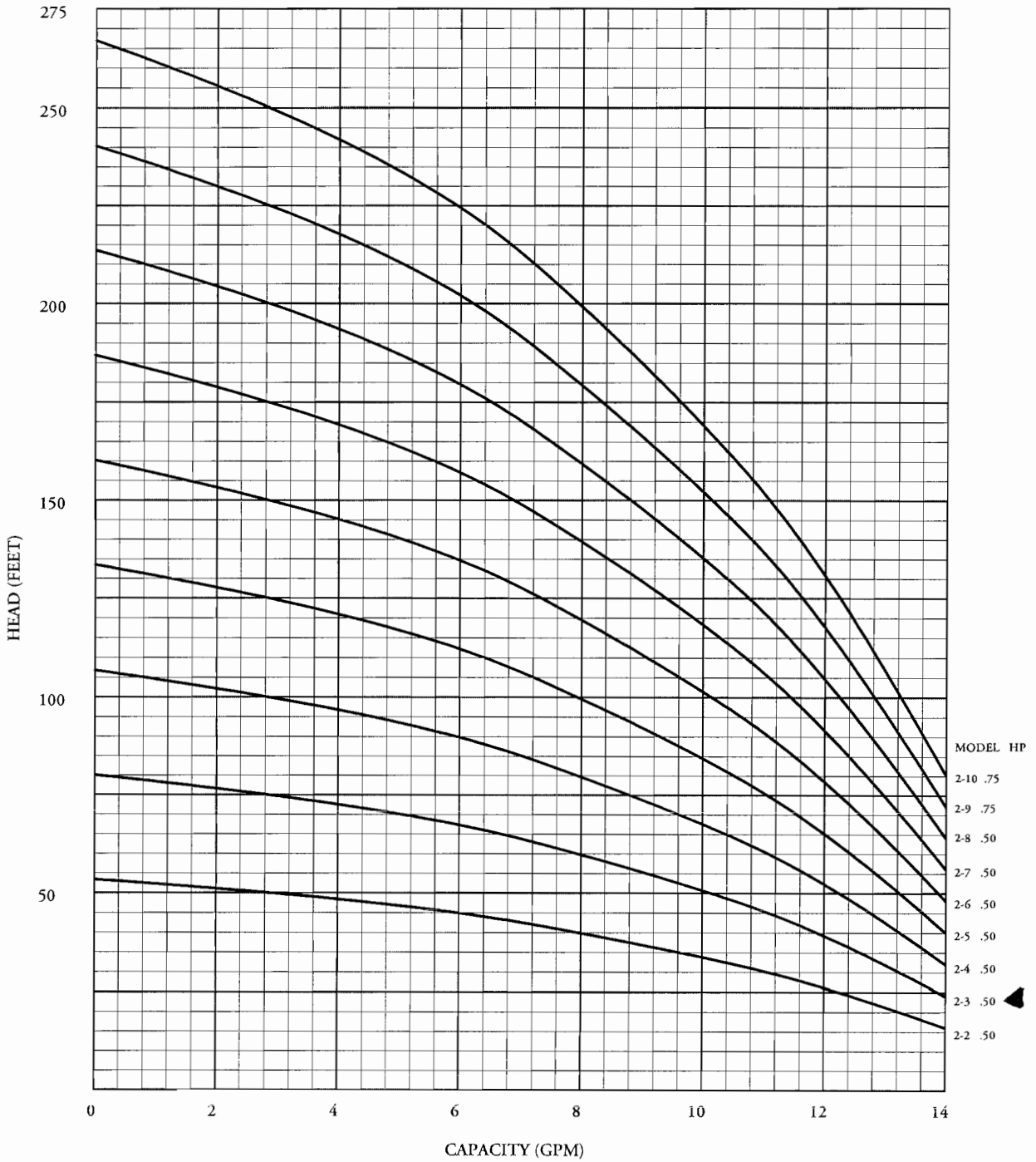
The lead wire shall be no-splice with EPG's "CP" waterproof and chemically resistant jacket over 600 Volt insulation and be of the length specified.

© 2009 EPG Companies Inc.
SurePump & E-Glide are Reg. TM of EPG Companies Inc.

SERIES 2 SurePump™

Flow Range 4-14 GPM

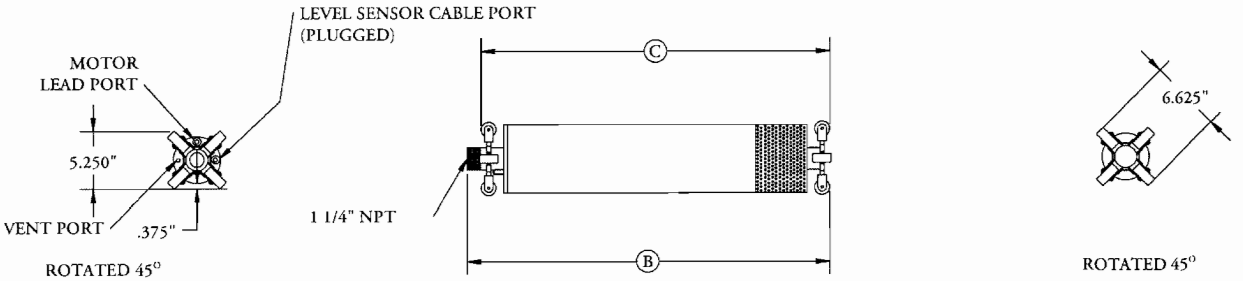
60 Hz



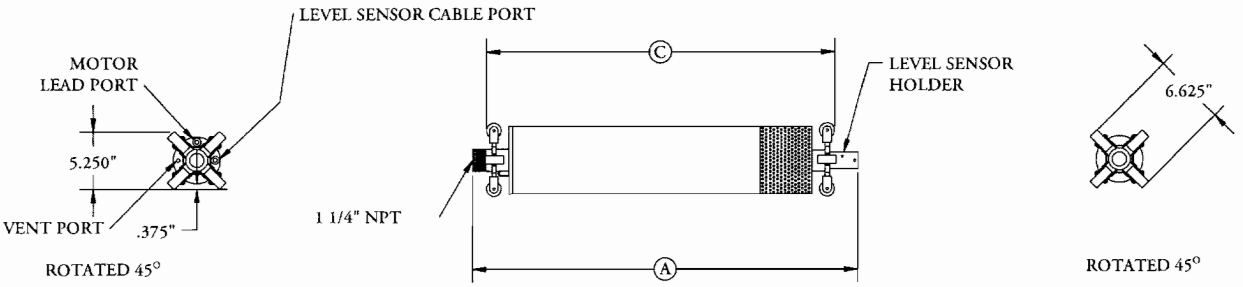
DATA SUBJECT TO CHANGE WITHOUT NOTICE

© 2009 EPG Companies Inc.
SurePump is a Reg. TM of EPG Companies Inc.

SERIES 2 SIZE 4 WHEELED SUMP DRAINER



WSD



WSDPT

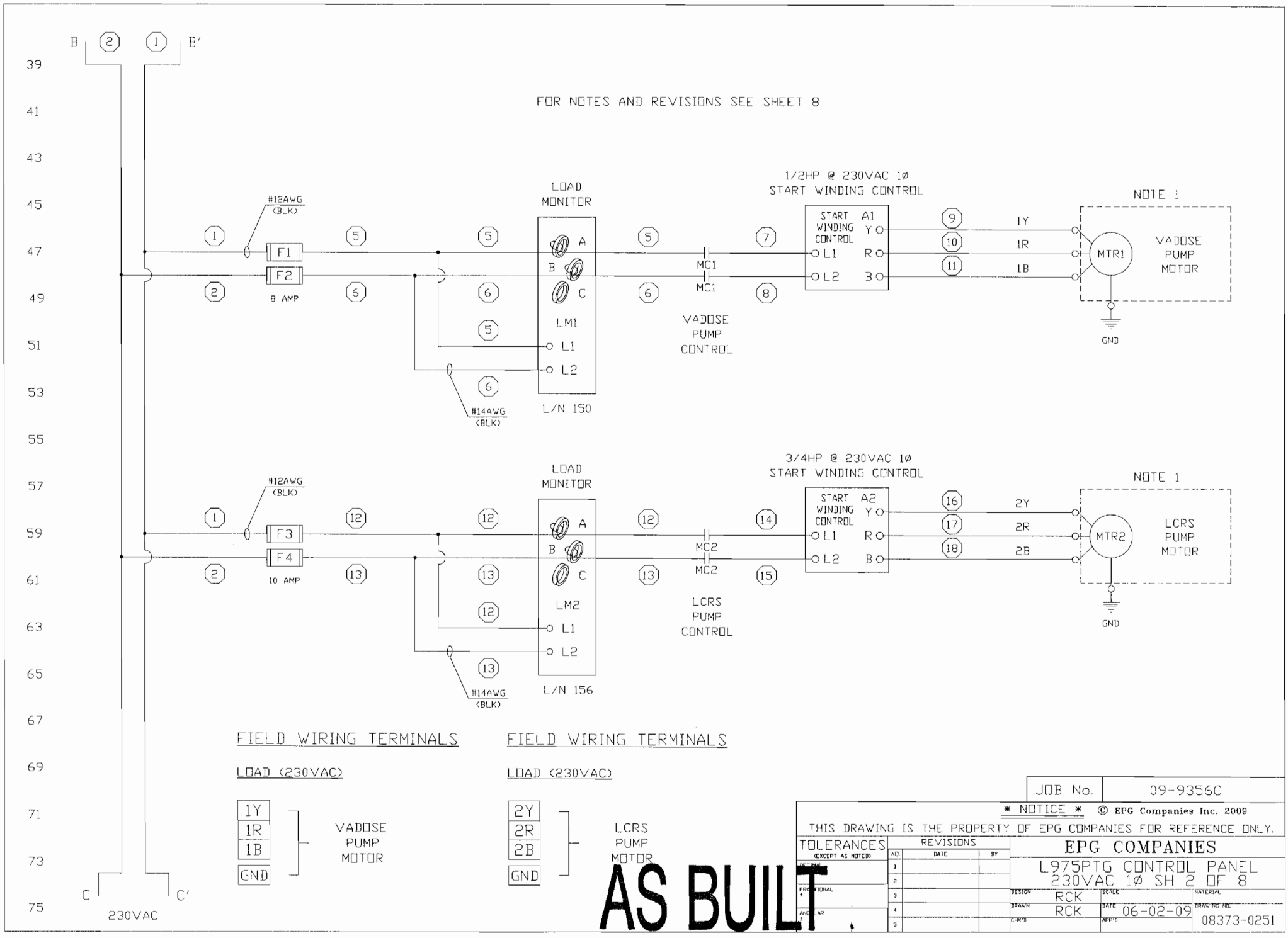
MODEL	HP	PHASE	A	B	C	*APPROX. SHIPPING WEIGHT	
						WSD	WSDPT
2-2	0.50	1	31.02	29.90	29.15	61.47	66.47
2-2	0.50	3	31.02	29.90	29.15	61.47	66.47
2-3	0.50	1	31.85	30.73	29.98	62.37	67.37
2-3	0.50	3	31.85	30.73	29.98	62.37	67.37
2-4	0.50	1	32.68	31.56	30.81	63.26	68.26
2-4	0.50	3	32.68	31.56	30.81	63.26	68.26
2-5	0.50	1	33.51	32.39	31.64	64.15	69.15
2-5	0.50	3	33.51	32.39	31.64	64.15	69.15
2-6	0.50	1	34.34	33.22	32.47	65.05	70.05
2-6	0.50	3	34.34	33.22	32.47	65.05	70.05
2-7	0.50	1	35.17	34.05	33.30	65.94	70.94
2-7	0.50	3	35.17	34.05	33.30	65.94	70.94
2-8	0.50	1	36.00	34.88	34.13	66.84	71.84
2-8	0.50	3	36.00	34.88	34.13	66.84	71.84
2-9	0.75	1	37.96	36.84	36.09	71.61	76.61
2-9	0.75	3	37.96	36.84	36.09	71.61	76.61
2-10	0.75	1	38.79	37.67	36.92	72.50	77.50
2-10	0.75	3	38.79	37.67	36.92	72.50	77.50

NOTE: ALL DIMENSIONS ARE IN INCHES.

*SHIPPING WEIGHT INCLUDES
WSD: CRATE, 50' OF 14-4 MOTOR LEAD, 50' OF 1/8" SS CABLE.
WSDPT: CRATE, 50' OF 14-4 MOTOR LEAD, 50' OF 1/8" SS CABLE,
LEVEL SENSOR AND CABLE.

© 2009 EPG Companies Inc.
SurePump is a Reg. TM of EPG Companies Inc.

Phase V
As-Built Control Panel Schematics



JOB No. 09-9356C

* NOTICE * © EPG Companies Inc. 2009
THIS DRAWING IS THE PROPERTY OF EPG COMPANIES FOR REFERENCE ONLY.

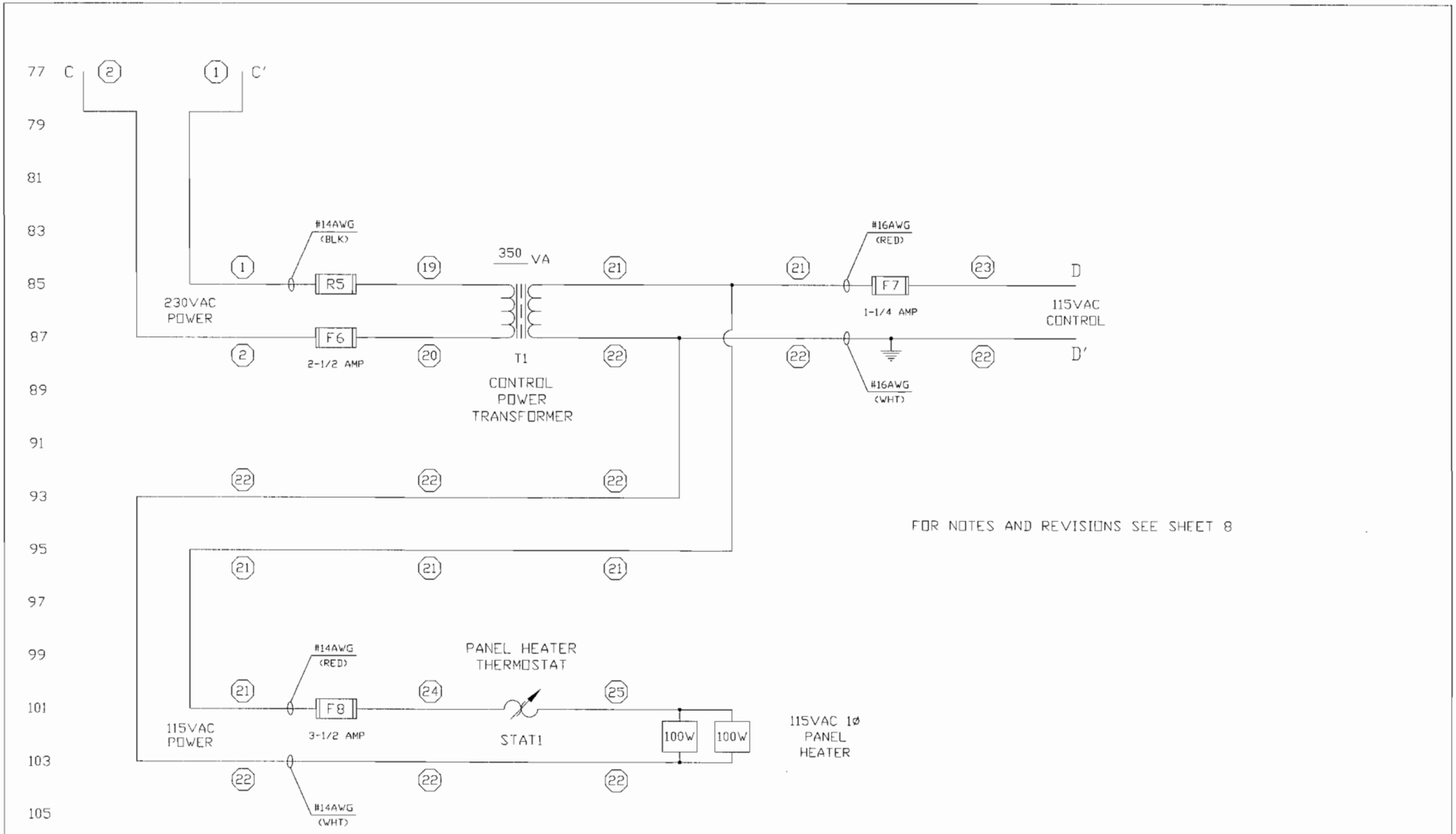
TOLERANCES (EXCEPT AS NOTED)
DECIMAL
FRACTIONAL ±
ANGULAR ±

REVISIONS		
NO.	DATE	BY
1		
2		
3		
4		
5		

EPG COMPANIES

L975PTG CONTROL PANEL
230VAC 1Ø SH 2 OF 8

DESIGN RCK	SCALE	MATERIAL	
DRAWN RCK	DATE 06-02-09	DRAWING NO. 08373-0251	
CHK'D	APP'D		



FOR NOTES AND REVISIONS SEE SHEET 8

AS BUILT

JOB No.	09-9356C

* NOTICE * © EPG Companies Inc. 2009
THIS DRAWING IS THE PROPERTY OF EPG COMPANIES FOR REFERENCE ONLY.

TOLERANCES (EXCEPT AS NOTED)
DEC ±
FRACTIONAL ±
ANGULAR ±

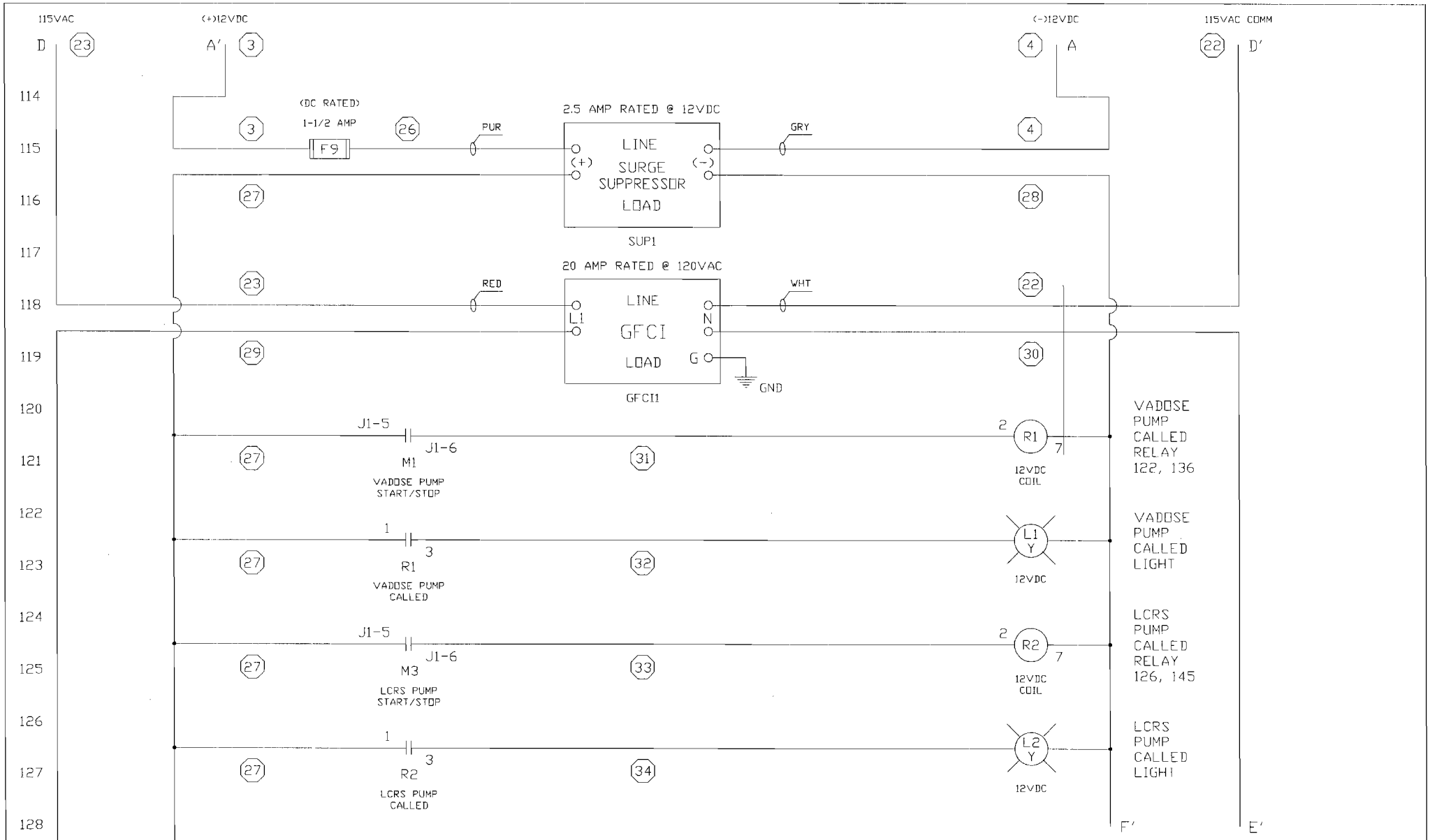
REVISIONS

NO.	DATE	BY
1		
2		
3		
4		
5		

EPG COMPANIES

L975PTG CONTROL PANEL
230VAC 1Ø SH 3 OF 8

DESIGN	SCALE	MATERIAL
RCK		
DRAWN RCK	DATE 06-02-09	DRAWING NO. 08373-0252
CHK'D	APP'D	



FOR NOTES AND REVISIONS SEE SHEET 8

AS BUILT

JOB No.	09-9356C

* NOTICE * © EPG Companies Inc. 2009

THIS DRAWING IS THE PROPERTY OF EPG COMPANIES FOR REFERENCE ONLY.

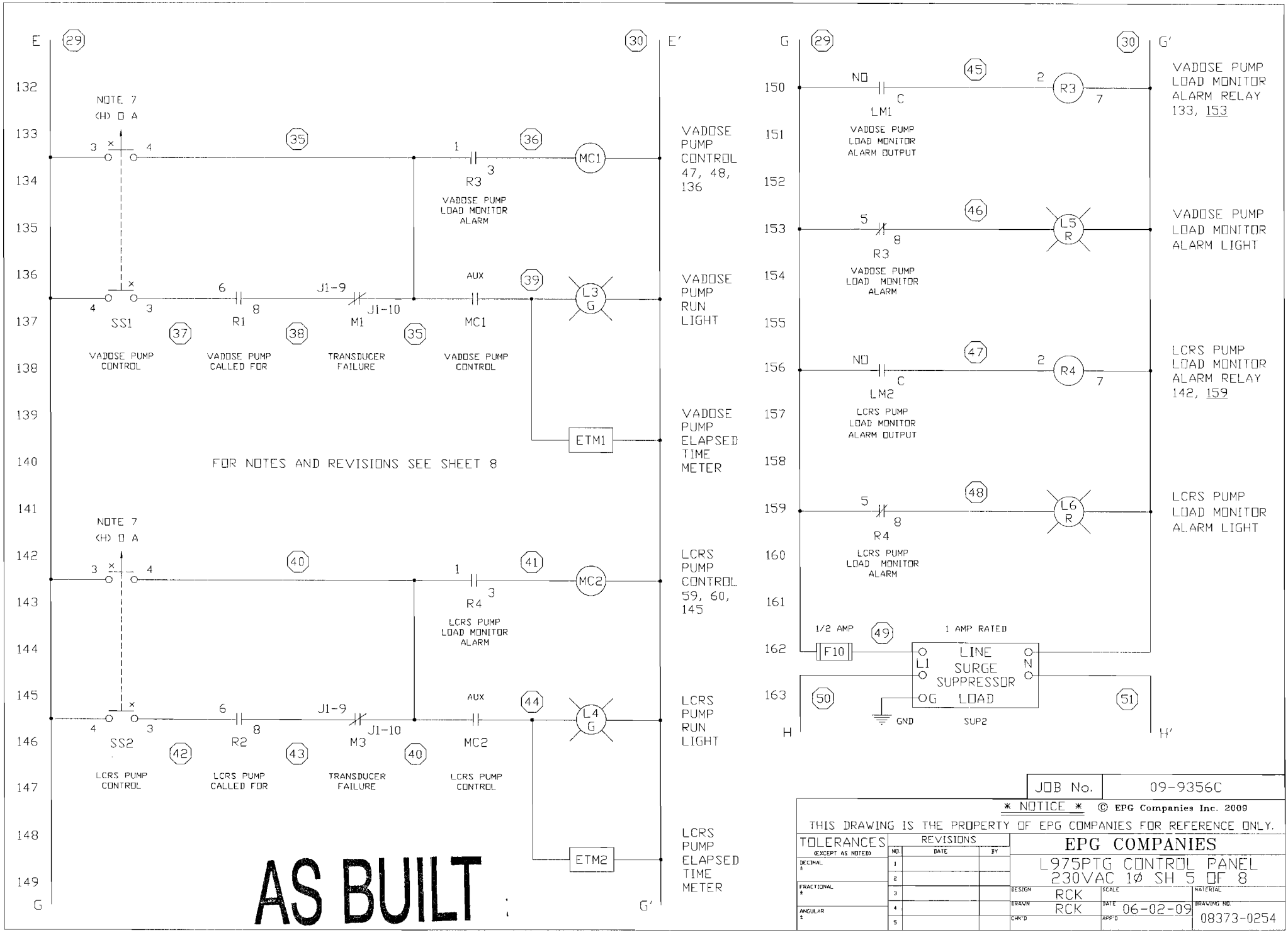
TOLERANCES (EXCEPT AS NOTED)
DECIMAL
FRACTIONAL
ANGULAR

REVISIONS		
NO.	DATE	BY
1		
2		
3		
4		
5		

EPG COMPANIES

L975PTG CONTROL PANEL
230VAC 1Ø SH 4 OF 8

DESIGN	RCK	SCALE	MATERIAL
DRAWN	RCK	DATE 06-02-09	DRAWING NO. 08373-0253
CHK'D		APP'D	

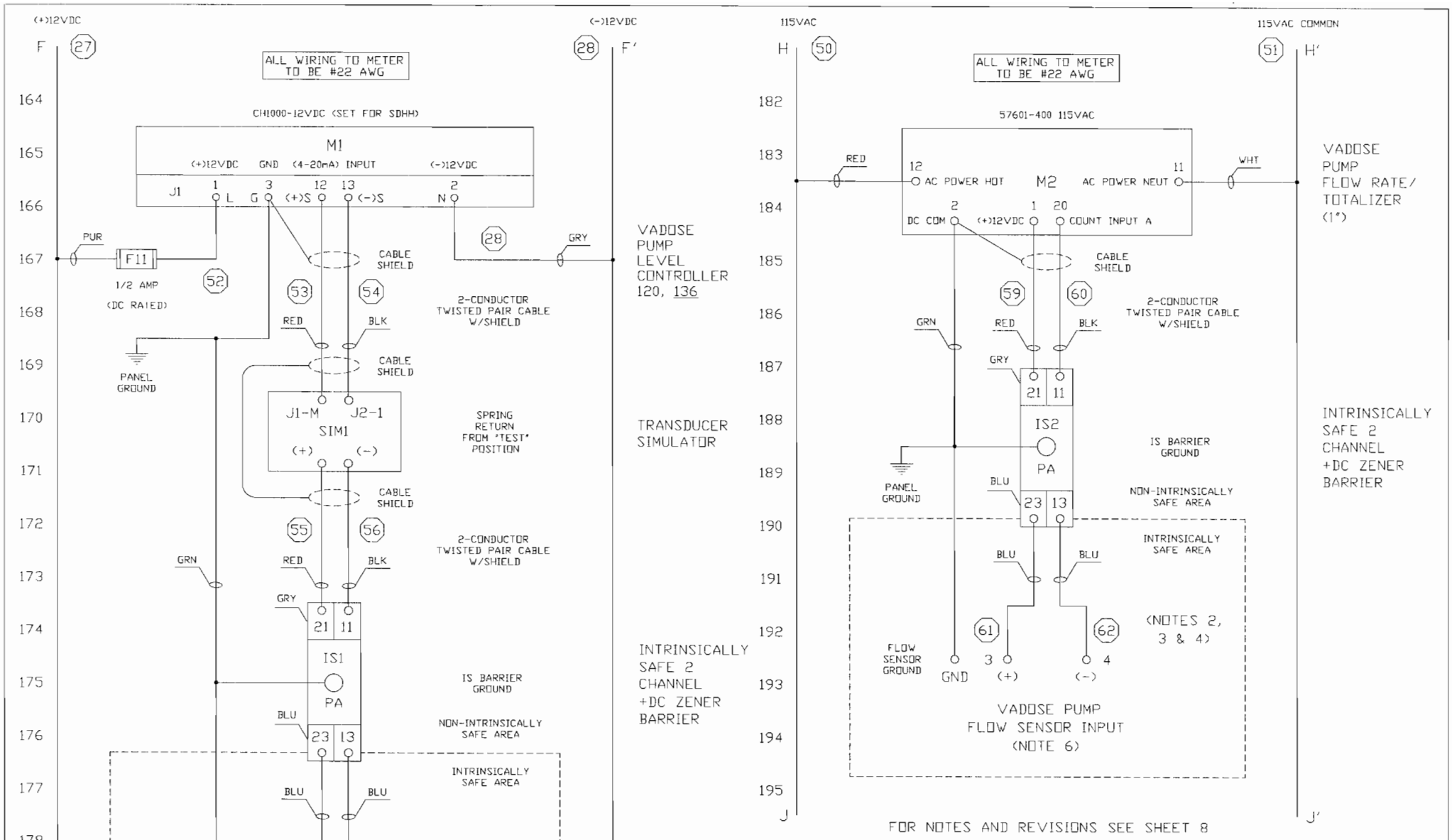


JOB No.	09-9356C

* NOTICE * © EPG Companies Inc. 2009

THIS DRAWING IS THE PROPERTY OF EPG COMPANIES FOR REFERENCE ONLY.

TOLERANCES (EXCEPT AS NOTED)	REVISIONS NO.	DATE	BY	EPG COMPANIES		
DECIMAL ±	1			L975PTG CONTROL PANEL 230VAC 1Ø SH 5 OF 8		
FRACTIONAL ±	2			DESIGN RCK	SCALE	MATERIAL
ANGULAR ±	3			DRAWN RCK	DATE 06-02-09	DRAWING NO. 08373-0254
	4			CHK'D	APP'D	
	5					



JOB No.	09-9356C

* NOTICE * © EPG Companies Inc. 2009

THIS DRAWING IS THE PROPERTY OF EPG COMPANIES FOR REFERENCE ONLY.

TOLERANCES (EXCEPT AS NOTED)
DECIMAL
FRACTIONAL
ANGULAR

REVISIONS

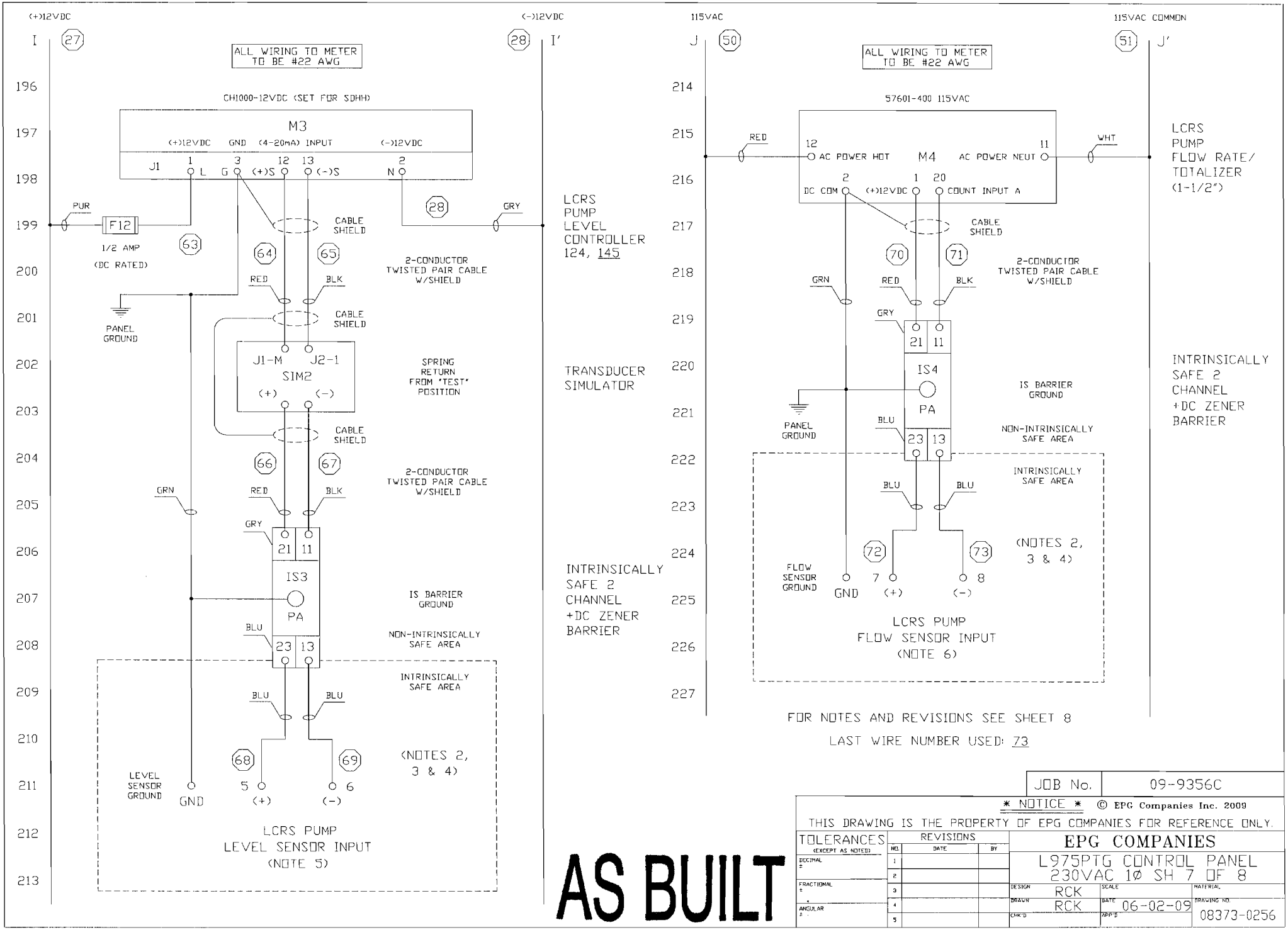
NO.	DATE	BY
1		
2		
3		
4		
5		

EPG COMPANIES

L975PTG CONTROL PANEL
230VAC 1Ø SH 6 OF 8

DESIGN	RCK	SCALE	MATERIAL
DRAWN	RCK	DATE 06-02-09	DRAWING NO. 08373-0255
CHK'D		APP'D	

AS BUILT



FOR NOTES AND REVISIONS SEE SHEET 8

LAST WIRE NUMBER USED: 73

AS BUILT

JOB No.	09-9356C

* NOTICE * © EPG Companies Inc. 2009
THIS DRAWING IS THE PROPERTY OF EPG COMPANIES FOR REFERENCE ONLY.

TOLERANCES (EXCEPT AS NOTED)
DECIMAL ±
FRACTIONAL ±
ANGULAR ±

REVISIONS

NO.	DATE	BY
1		
2		
3		
4		
5		

EPG COMPANIES

L975PTG CONTROL PANEL
230VAC 1Ø SH 7 OF 8

DESIGN	SCALE	MATERIAL
RCK		
DRAWN RCK	DATE 06-02-09	DRAWING NO. 08373-0256
CHK'D	APP'D	

FIELD WIRING TERMINALS

LEVEL SENSOR (INTRINSICALLY SAFE TERMINALS)

1	RED	VADOSE PUMP LEVEL SENSOR INPUT (NOTES 2, 3, 4 & 5)
2	BLACK	
GND	SHIELD GROUND	

FLOW SENSOR (INTRINSICALLY SAFE TERMINALS)

3	RED	VADOSE PUMP FLOW SENSOR INPUT (1") (NOTES 2, 3, 4 & 6)
4	WHITE	
GND	BLACK	

LEVEL SENSOR (INTRINSICALLY SAFE TERMINALS)

5	RED	LCRS PUMP LEVEL SENSOR INPUT (NOTES 2, 3, 4 & 5)
6	BLACK	
GND	SHIELD GROUND	

FLOW SENSOR (INTRINSICALLY SAFE TERMINALS)

7	RED	LCRS PUMP FLOW SENSOR INPUT (1-1/2") (NOTES 2, 3, 4 & 6)
8	WHITE	
GND	BLACK	

NOTE:

1. NOT PART OF CONTROLLER
2. REFERENCE INSTALLATION OF INTRINSICALLY SAFE INSTRUMENT SYSTEMS IN CLASS I HAZARDOUS LOCATIONS, ANSI/ISA-RP 12.6-1987, SECTION 4.5.4
3. WARNING: SUBSTITUTION OF COMPONENTS MAY IMPAIR INTRINSIC SAFETY
4. INSTALL IN ACCORDANCE WITH ARTICLE 504 OF THE NATIONAL ELECTRIC CODE
5. MAXIMUM CABLE LENGTH TO THE LEVEL SENSOR IS 3000 FEET
6. MAXIMUM CABLE LENGTH TO THE FLOW SENSOR IS 500 FEET
7. SELECTOR SWITCHES, (SS1-SS2) WILL SPRING RETURN FROM THE "HAND" POSITION

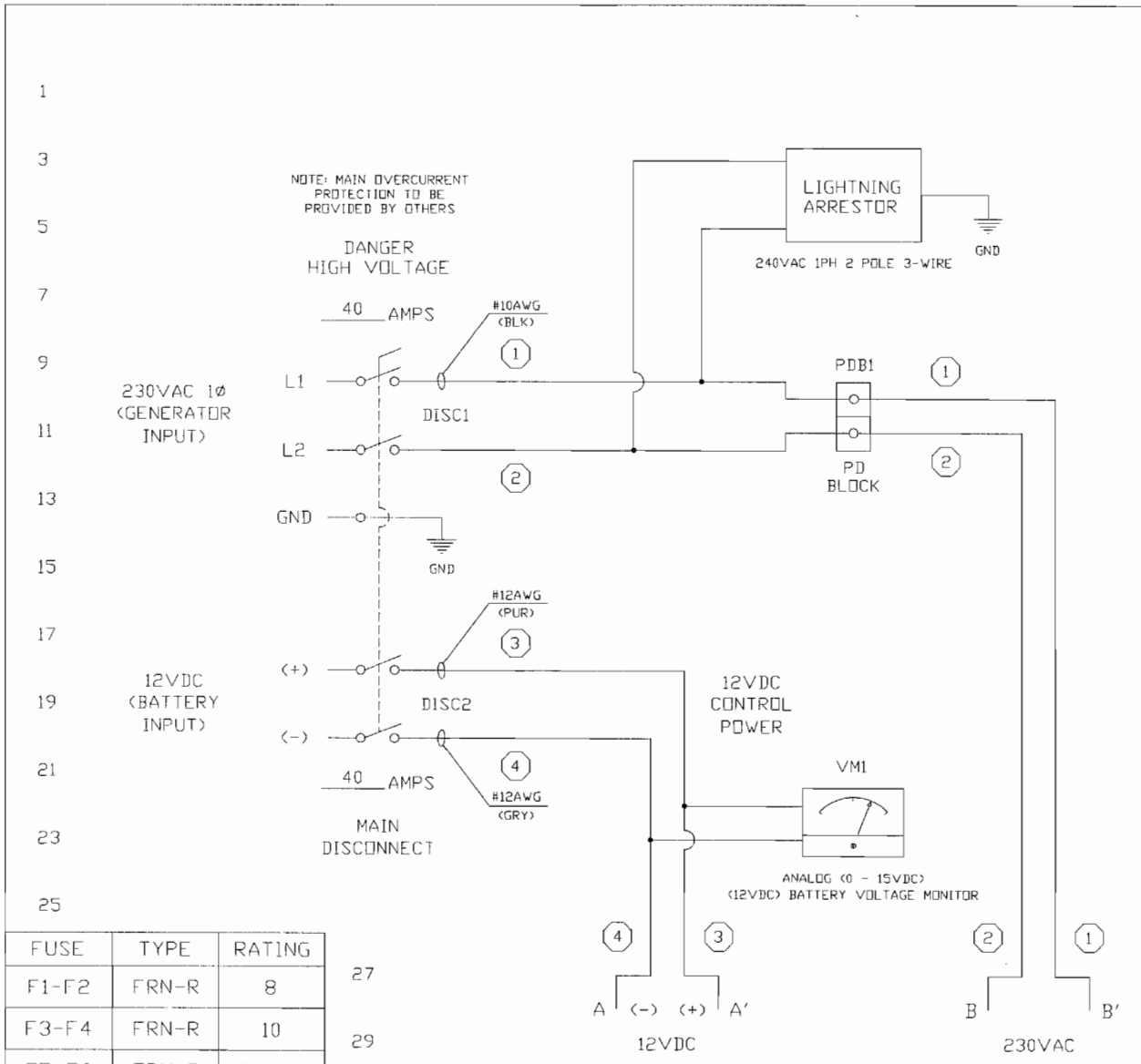
AS BUILT

JOB No.	09-9356C

* NOTICE * © EPG Companies Inc. 2009
THIS DRAWING IS THE PROPERTY OF EPG COMPANIES FOR REFERENCE ONLY.

TOLERANCES (EXCEPT AS NOTED)	REVISIONS NO.	DATE	BY	EPG COMPANIES		
DECIMAL ±	1			L975PTG CONTROL PANEL 230VAC 1Ø SH 8 OF 8		
	2					
FRACTIONAL ±	3			DESIGN RCK	SCALE	MATERIAL
	4			DRAWN RCK	DATE 06-02-09	DRAWING NO. 08373-0257
ANGULAR ± °	5			CHK'D	APP'D	

MOTOR	HP	VOLTAGE	FLA	FUSE SIZE
VADOSE PUMP	1/2	230	5.0	8A
LCRS PUMP	3/4	230	6.8	10A



PHASE 3B
CONTROL PANEL AND PUMPS

FIELD WIRING TERMINALS

LINE (GENERATOR)

L1, L2 — 230VAC 1Ø 60Hz 15.05 AMPS

GND — GROUND

LINE (BATTERY)

(+), (-) — 12VDC 0.91 AMPS

FUSE	TYPE	RATING
F1-F2	FRN-R	8
F3-F4	FRN-R	10
F5-F6	FRN-R	2-1/2
F7	FNM	1-1/4
F8	FNM	3-1/2
F9	ABC	1-1/2
F10	MDL	1/2
F11	ABC	1/2
F12	ABC	1/2

FOR NOTES AND REVISIONS SEE SHEET 8

AS BUILT

JOB No. 09-9356C

* NOTICE * © EPG Companies Inc. 2009
THIS DRAWING IS THE PROPERTY OF EPG COMPANIES FOR REFERENCE ONLY.

TOLERANCES (EXCEPT AS NOTED)
DECIMAL ±
FRACTIONAL ±
ANGULAR ±

REVISIONS

NO.	DATE	BY
1		
2		
3		
4		
5		

EPG COMPANIES
L975PTG CONTROL PANEL
230VAC 1Ø SH 1 OF 8

DESIGN RCK	SCALE	MATERIAL	
DRAWN RCK	DATE 06-02-09	DRAWING NO. 08373-0250	
CHK'D	APP'D		

Phase V
Installation Records

EPG Companies Inc.

SurePump™ Installation Record

Form Completed by: KEY Installation Date: 9/14/09

Company: HAMPTON TEODER ELECTRIC EPG Serial #: 09-93560

PUMPS, CONTROLS AND POWER SUPPLY

Installer: HTE	Address: 4920 AUTO AVE. LAS VEGAS, NV. 89115	Installation Location: PHASE 5 LCRS
Motor Model: WSDPT-5-3 HP: 3/4	Volts: 230 Max Amps Rating: 6.8	Pump Model: EPG WSDPT SURE PUMP
Power Supply Transformers: Number Used: KVA Each: .350	Hertz: 60 Comments:	
Pump Control Panel: Mfg. & Model #: EPG 2975PTG	Motor Starter Size: .75 hp	Overload Heater Part or setting range: NA IEC Starters:
Lightning Arrestors: Mfg. & Model: Intermatic AG2401	Surge Capacitors: Yes ____ No ✓	Disconnect Fuse or Circuit Breaker Amp Rating: 40
Primary Flow Control Devices: (Low Level Control, Flow Control, Valve, System Back Pressure, etc.) —		

OPERATING DATA (Measurements at Control Panel)

PUMP CONDITIONS:	GPM	VOLTS	AMPS
Pump Not Running	0	R-Y 0 R-B 0 B-Y 217	
Open Discharge		R-Y ____ R-B ____ B-Y ____	R ____ Y ____ B ____
Normal Operation Run Time ____ Off Time ____		R-Y 0 R-B 0 B-Y ____	R 0 Y 6.63 B 6.67

© EPG Companies Inc. 2009
PumpMaster, LevelMaster & SurePump are Reg. TM of EPG Companies Inc.

EPG Companies Inc.

INSTALLATION DATA

Discharge Line Size: 1½	Discharge Pressure:	Pump Submergence:	Fluid Temp: _____°F _____°C
External Check Valve Used? NO	Location:	Cable Length & Size: 73' 14GA	Ground Resistance 6 ohm
Insulation Megohm Readings:	Before Installation:	After Installation: 9.754	After 30 min. Run:

SENSORS

Type of Level Sensor: Pressure Transmitter ✓ Load Monitor _____ Floats _____ Other _____	Transmitter Serial Number:
Length of Sensor Lead: 73	Ohm Readings Across I.S. Barrier: 230
mA Readings on Transmitter Lead:	Voltage Reading Entering Level Meter: 12 VDC Voltage Leaving Level Meter: 12 VDC
Are Flow Sensors Used: Yes ✓ No _____	Flow Spool Made of: PVC ✓ Stainless Steel _____

Comments: _____

Place one copy of this record in the control panel, return one copy to EPG, and retain original for your records.

In case of problems or questions, contact EPG Companies Inc., 19900 County Road 81, Maple Grove, MN 55311. Phone: 800-762-8418 FAX: 763-493-4812

© EPG Companies Inc. 2009
PumpMaster, LevelMaster & SurePump are Reg. TM of EPG Companies Inc.

EPG Companies Inc.

July 2002

EPG SurePump™ Installation Record

EPG Job No. 09-9356

Installer's Name HAMPTON TEDDER ELECTRIC CO.

Address 4920 ALTO AVE.

City LAS VEGAS State NV. Zip 89115

Phone (702) 646-7449 Fax (702) 453-5412

Contact name ROGER CATES

Owner's Name BASIC REMEDIATION CO.

Address 875 W. WARM SPRINGS RD.

City HENDERSON State NV Zip 89011

Phone (702) 567-0400 Fax (702) 567-5524

Contact name LEE C. FARRIS, PE

Sump Name/ ID PHASE 5 LCRS Date Installed 9/14/09

Leachate or Condensate Temp _____ °F Or °C

Pump:

Model No. WSDPT 5-3

Rating: 30 GPM@ 60 Ft. TDH

HP .75 Voltage 230 Phase 1

Actual Pump Delivery _____ GPM@ _____ PSI

Operating Cycle _____ ON (Min/Hr) _____ OFF (Min/Hr) (Circle Min. or Hr. as appropriate)

Side Slope Riser Information:

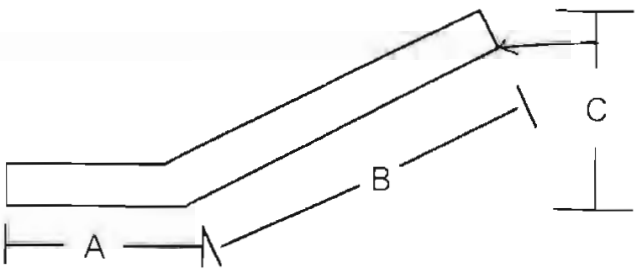
Slope 2.1 :1

Length of riser Pipe (A+B) 50' ft.

Vertical Distance = Sump to INV. Top of Riser Pipe (C) 16.6 ft.

Riser ID PHASE 5 LCRS SDR 11

Distance From Top of Riser Pipe to Controller 15 ft.



Power Supply:

Cable: Service Entrance to Control Distance _____ ft Wire Size _____ AWG/MCM

Copper ____ Jacketed _____ Aluminum ____ Individual conductors ____

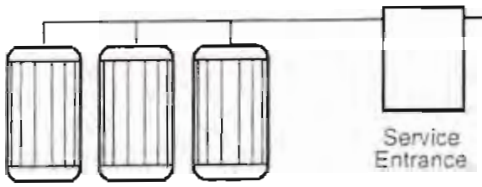
Cable: Control to Motor ____ ft _____ AWG/MCM

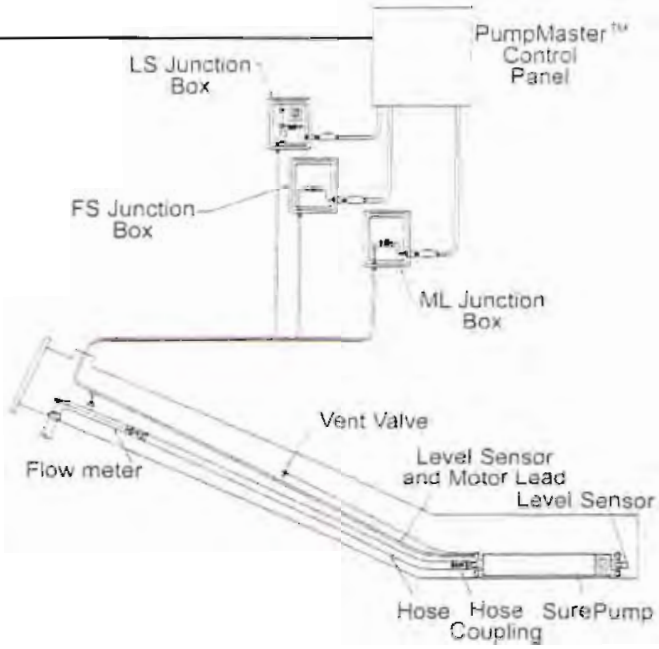
Copper ____ Jacketed ____

© EPG Companies Inc. 2009
PumpMaster & SurePump are Reg. TM of EPG Companies Inc.

EPG Companies Inc.

July 2002





Transformer:

KVA _____ #1 _____ #2 _____ #3

Initial Megs - Before Installation

Motor & lead T1 2000 T2 2000 T3 _____

Final Megs - After Installation
After Running for 15 min

Motor, leads & cable T1 2000 T2 2000 T3 _____

Incoming Voltage:

No Load L1-L2 234 L2-L3 _____ L1-L3 _____

Full Load L1-L2 236 L2-L3 _____ L1-L3 _____

Running Amps:

Hookup:1

Full Load L1 8 L2 8 L3 _____ % unbalanced 0

Hookup:2

Full Load L1 _____ L2 _____ L3 _____ % unbalanced _____

Hookup:3

Full Load L1 _____ L2 _____ L3 _____ % unbalanced _____

Ground wire size _____ AWG/MCM

DC Ground Current _____ mA Ground Test 6 Ohms

Motor Surge Protection _____ Yes _____ No

Control Panel:

Model # L975PTG

Short Circuit Device

Circuit Breaker _____ Rating _____ Setting

Fuses FRNR10 Type 10 Rating

_____ Standard ✓ Time Delay

Controls are Grounded to:

_____ Motor

X Rod

_____ Power Supply

Start Overloads:

Set at NA amps

Name: HOWARD LESTER

Company EPG COMPANIES

Date SEPT 16 09

© EPG Companies Inc. 2009
PumpMaster & SurePump are
Reg. TM of EPG Companies Inc

INSTALLATION GUIDE

EPG SurePump™ Pumping System

- ✓ 1. Verify that equipment and supply voltage match.
- ✓ 2. Inspect equipment, look for shipping damage, dirt, and rough handling.
- ✓ 3. Control panel should be mounted in a secure way at least 15' from riser or sump and 36" above grade to bottom of control panel.
- ✓ 4. Inspect inside of control panel. Look for items which might have come loose during shipping.
- ✓ 5. Test level sensor in bucket of water. Does it return back to zero? Control panel needs to be installed and have power to it.
- ✓ 6. Install vent valve and tubing. See Bulletin 0130c.
- ✓ 7. Install suspension cable. See Bulletin 6090a.
- ✓ 8. Fasten motor lead and sensor cable to discharge line every 5' to 7' with straps or plastic wire ties. It's best if they are on separate sides of line; use padding between cables and any metal straps.
- ✓ 9. Run pump down riser slowly using stainless steel suspension cable as hold back. Make sure motor lead and sensor cable are slack as you lower pump.
- ✓ 10. Take ohm reading of each motor lead wire to wire and compare the values in Table 13 of the Franklin Electric motor manual for 1Ø and Table 21 for 3Ø. Be sure to add wire resistance value to value from table 13& 21. See page 39 for wire resistance.
- ✓ 11. Check insulation resistance as pump is lowered down riser. Resistance may drop gradually as pump and cable enter the liquid, but any sudden drop indicates a problem.
- ✓ 12. Run sensor leads and power cables in separated conduits to control panel. It is a good idea to use breakout junction boxes. See Design Guide 05644.
- ✓ 13. If you have to remove dryer from end of transducer cable to pull cable through fittings or conduit. Seal end of the vent tube with a piece of tape. Reinstall dryer as soon as possible. See Bulletin 0550a.
- ✓ 14. Megger motor leads. Resistance must be 1 megohm or greater.
- ✓ 15. Connect pump to control panel complying with local and national codes. Controller terminal strips, motor leads, and sensor leads are all labeled and/or color coded to simplify connections.
- ✓ 16. Inspect wire connections. Are they the correct colors? Are they tight?
- ✓ 17. If color-coded wires were not continued from sump or riser you need to ohm out each circuit.
- ✓ 18. Measure resistance to ground. It must be less than 25 ohms. If greater stop work and report to owner. It should be 1 ohm or less to protect electronic equipment.

© 2009 EPG Companies Inc.

☑ 19. Measure voltage prior to control panel or at entrances to control panel. Measure and record voltage line to line and line to ground.

☑ 20. Compare these reading to voltage listed on drawing and label in control panel.

☑ 21. Review equipment list and drawings for any accessory circuits. If present, run volt and ohm test.

☑ 22. Check and make sure all hand switches are in the off position. If you have a water level indicator verify leachate level in sump or riser.

☑ 23. Turn on power at panel main disconnect.

☑ 24. Level meters display should light up. Record displayed reading. How does this reading compare to your measured level reading?

☑ 25. If level and flow meter do not light up check GFCI, reset if necessary.

☑ 26. Are any indicator lights on?

☑ 27. Should they be on?

☑ 28. Make sure pump is turned off. Using built in or hand held simulator, verify level meter settings are correct for this site. See meter data sheet for factory settings and meter instructions.

☑ 29. Bump pump by turning switch to hand two or three times to make sure pump has reached its resting point. You should have minimum of 3' of slack in the cables.

☑ 30. To verify correct rotation place hand around discharge line. It will torque right if the rotation is correct

☑ 31. When pump is running measure and record amperage and voltage. Check 3Ø systems for current balance within 5% of average.

☑ 32. Verify that starting, running and stopping causes no significant vibration or hydraulic shocks.

☑ 33. After 15 minutes of running time measure volts and amperage to see if they are stable. Are they as specified?

☑ 34. After pump and level sensor have been tested pot seal offs.

☑ 35. Complete Form 200. Note: <u>If this form is not completed and returned to EPG it will impact system warranty.</u>

2009 EPG Companies Inc.

START UP CHECKLIST

EPG SurePump™ Pumping System

QUESTIONS FOR CONTRACTOR OR INSTALLER

- ☑ A: Were sensor and power cable tied or strapped to discharge line?
- ☑ B: On what kind of spacing?
- ☑ C: What is the as built length of riser and sump? Were cables long enough? There should be 3 or more feet of slack in the cables.
- ☑ D: What size cable was run for supply power?
- ☑ E: What is the distance from power supply transformer to pump control panel?
- ☑ F: How did they verify that pump is down into sump?
- ☑ G: Did they test level sensor prior to installing?
- ☑ H: Did they test pump prior to installing or prior to your arrival?
- ☑ I: Do they have any questions or concerns?
- ☑ J: Complete form 200

PHYSICAL INSPECTION OF CONTROL PANEL

- ☐ A: Is the control panel located 15' from sump or riser and 36" above grade to bottom of panel.
- ☑ B: Are power and sensor cable run in separate conduit? If not, stop work and have this corrected.
- ☑ C: Are seal offs installed in both sensor and power runs? If not, suggest breakout junction boxes or have seal off installed.
- ☑ D: Are seal offs potted? If not, stop work and have them potted.
- ☑ E: Will inner and outer door of enclosure open and close freely? If not loosen enclosure mounting bolts and shim until it is level and square. Then retighten mounting bolts.
- ☑ F: Make sure ground wire is in place between outer door and enclosure.

2009 EPG Companies Inc

PRIOR TO ENERGIZING CONTROL PANEL

- ☑ A: Measure resistance to ground. It must be less than 25 ohms. If greater stop work and report to owner. It should be 1 ohm or less to protect electronic equipment.
- ☑ B: Measure voltage prior to control panel or at entrances to control panel. Measure and record voltage line to line and line to ground.
- ☑ C: Compare these reading to voltage listed on drawing and label in control panel.
- ☑ D: Megger motor leads resistance must be 1 megohm or greater.
- ☑ E: Take ohm reading of each motor lead wire to wire and compare these to values in Table 13 of the Franklin Electric motor manual for 1Ø and Table 21 for 3Ø. Be sure to add wire resistance value to value from table 13& 21. See page 39 for wire resistance.
- ☑ F: Inspect inside of control panel. Look for items which may have come loose during shipping
- ☑ G: Inspect wire connections. Are they the correct colors? Are they tight?
- ☑ H: If color-coded wires were not continued from sump or riser you need to ohm out each circuit.
- ☑ I: Review equipment list and drawings from any accessory circuits. If present, run volt and ohm test.
- ☑ J: Check and make sure all hand switches are in off position. If you have a water level indicator verify leachate level in sump or riser.

POWER UP

- ☑ A: Turn on power at panel main disconnect.
- ☑ B: Level meters display should light up. Record displayed reading. How does this reading compare to your measured level reading?
- ☑ C: If level and flow meter do not light up check GFCI, reset if necessary.
- ☑ D: Are any indicator lights on?
- ☑ E: Should they be on?
- ☑ F: Make sure pump is turned off. Using built in or hand held simulator, verify level meter settings are correct for this site.
- ☑ G: Bump pump by turning hand switch two or three times to make sure pump has reached its resting point. You should have minimum of 3' of slack in the cables

2009 EPG Companies Inc.

- ❑ H: To verify correct rotation place hand around discharge line. It will torque right if the rotation is correct.
- ❑ I: If there is liquid in sump with level about pump start set point and below 150". Then turn pump selector switch to AUTO. Run pump through one complete cycle.
- ☑ J: When pump is running measure and record amperage and voltage. Check 3O systems for current balance within 5% of average.
- ☑ K: Verify that starting, running and stopping causes no significant vibration or hydraulic shocks.

© 2009 EPG Companies Inc

EPG Companies Inc.

SurePump™ Installation Record

Form Completed by: KEY Installation Date: 9/14/09
Company: HAMPTON ROADS ELECTRIC EPG Serial #: 09-9356C

PUMPS, CONTROLS AND POWER SUPPLY

Installer:	Address:	Installation Location:
HTE	4920 ALTO AVE. LAS VEGAS, NV. 89115	PHASE 5 VADOSE

Motor Model	HP	Volts:	Max Amps Rating:	Pump Model:
WSDPT-2-3	1/2	230	5.0	EPG WSDPT SURE PUMP

Power Supply Transformers: Number Used: KVA Each:	Hertz:	Comments:
350	60	

Pump Control Panel: Mfg. & Model #:	Motor Starter Size:	Overload Heater Part or setting range:	IEC Starters:
EPG LGTS PTG	.5HP	NA	

Lightning Arrestors: Mfg. & Model:	Surge Capacitors:	Disconnect Fuse or Circuit Breaker Amp Rating:
Intermatic AG2401	Yes ____ No ✓	40

Primary Flow Control Devices:
(Low Level Control, Flow Control, Valve, System Back Pressure, etc.)
—

OPERATING DATA (Measurements at Control Panel)

PUMP CONDITIONS:	GPM	VOLTS	AMPS
Pump Not Running	0	R-Y 0 R-B 0 B-Y 217	0
Open Discharge		R-Y ____ R-B ____ B-Y ____	R ____ Y ____ B ____
Normal Operation Run Time ____ Off Time ____		R-Y 0 R-B 0 B-Y 216	R 0 Y 5.07 B 5.09

© EPG Companies Inc. 2009
PumpMaster, LevelMaster & SurePump are Reg. TM of EPG Companies Inc.

EPG Companies Inc.

INSTALLATION DATA

Discharge Line Size: 1"	Discharge Pressure:	Pump Submergence:	Fluid Temp: ____°F ____°C
External Check Valve Used? No	Location:	Cable Length & Size: 73' 14GA	Ground Resistance 4 OHM
Insulation Megohm Readings:	Before Installation:	After Installation: 152G	After 30 min. Run:

SENSORS

Type of Level Sensor: Pressure Transmitter ✓ Load Monitor ____ Floats ____ Other ____	Transmitter Serial Number:
Length of Sensor Lead: 73' @ ~~113~~	Ohm Readings Across I.S. Barrier: 230
mA Readings on Transmitter Lead:	Voltage Reading Entering Level Meter: 12 VAC Voltage Leaving Level Meter: 12 VAC
Are Flow Sensors Used: Yes ✓ No ____	Flow Spool Made of: PVC ✓ Stainless Steel ____

Comments: _____

Place one copy of this record in the control panel, return one copy to EPG, and retain original for your records.

In case of problems or questions, contact EPG Companies Inc., 19900 County Road 81, Maple Grove, MN 55311. Phone: 800-762-8418 FAX: 763-493-4812

© EPG Companies Inc. 2009
PumpMaster, LevelMaster & SuperPump are Reg. TM of EPG Companies Inc.

EPG SurePump™ Installation Record

EPG Job No. 09-9356

Installer's Name HAMPTON TUDDER ELECTRIC CO

Address 4920 ARTO AVE.

City LAS VEGAS State NV. Zip 89115

Phone (702) 646-7449 Fax (702) 453-5412

Contact name ROGER GATES

Owner's Name BASEL REMEDIATION CO.

Address 875 W. WARM SPRINGS RD.

City HENDERSON State NV. Zip 89011

Phone (702) 567-0400 Fax (702) 567-5524

Contact name LEE C. FARRIS, PE

Sump Name/ID PHASE 5 VADOSE Date Installed 9/14/09

Leachate or Condensate Temp _____ °F Or °C

Pump:

Model No. WSOPT 2-3

Rating: 10 GPM@ 50 Ft. TDH

HP .5 Voltage 230 Phase 1

Actual Pump Delivery _____ GPM@ _____ PSI

Operating Cycle _____ ON (Min/Hr) _____ OFF (Min/Hr) (Circle Min. or Hr. as appropriate)

Side Slope Riser Information:

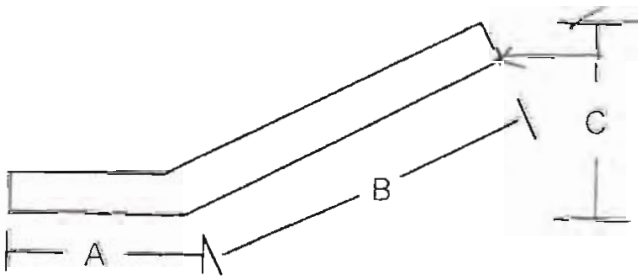
Slope 2.1 :1

Length of riser Pipe (A+B) 46.2 ft.

Vertical Distance = Sump to INV. Top of Riser Pipe (C) 16.2 ft.

Riser ID PHASE 5 VADOSE SDR 11

Distance From Top of Riser Pipe to Controller 15 ft.



Power Supply:

Cable: Service Entrance to Control Distance _____ ft Wire Size _____ AWG/MCM

Copper ___ Jacketed ___ Aluminum ___ Individual conductors

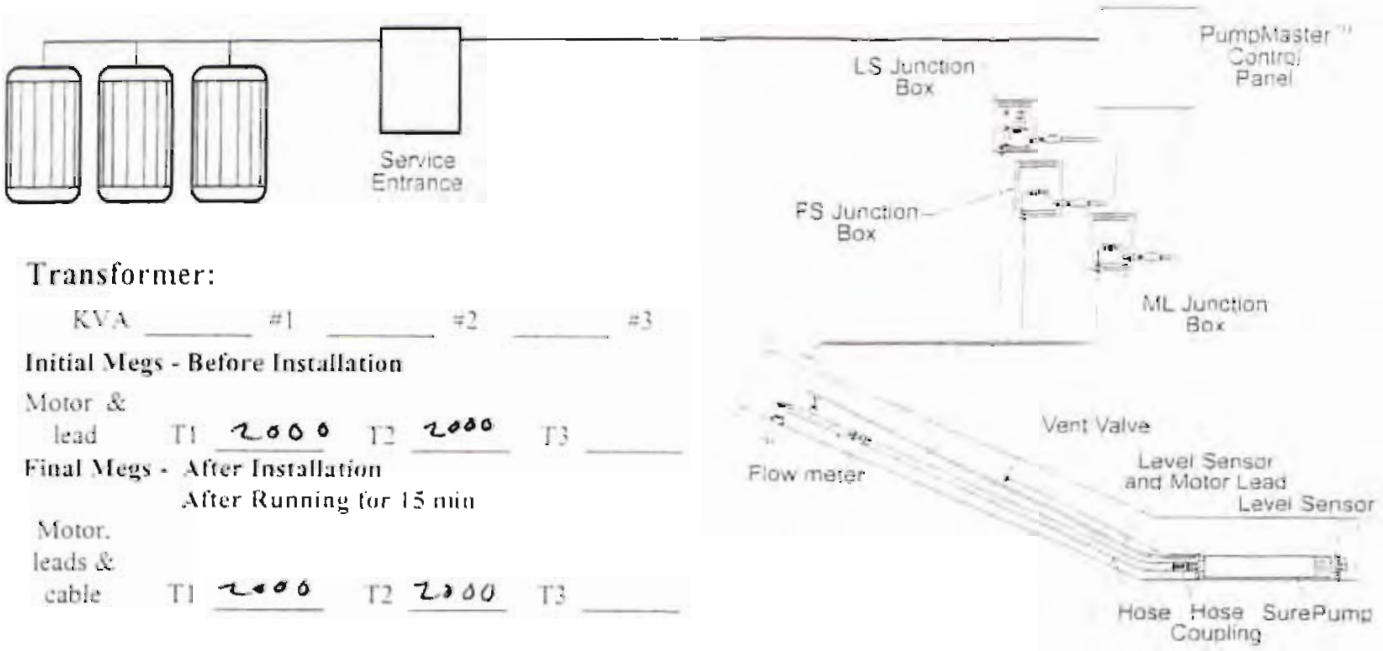
Cable: Control to Motor ___ ft ___ AWG/MCM

Copper ___ Jacketed ___

© EPG Companies Inc. 2009
PumpMaster & SurePump are Reg. TM of EPG Companies Inc.

EPG Companies Inc.

July 2002



Transformer:

KVA _____ #1 _____ #2 _____ #3

Initial Megs - Before Installation

Motor & lead T1 2000 T2 2000 T3 _____

Final Megs - After Installation
After Running for 15 min

Motor, leads & cable T1 2000 T2 2000 T3 _____

Incoming Voltage:

No Load L1-L2 233 L2-L3 _____ L1-L3 _____

Full Load L1-L2 235 L2-L3 _____ L1-L3 _____

Running Amps:

Hookup:1

Full Load L1 5 L2 5 L3 _____ % unbalanced 0

Hookup:2

Full Load L1 _____ L2 _____ L3 _____ % unbalanced _____

Hookup:3

Full Load L1 _____ L2 _____ L3 _____ % unbalanced _____

Ground wire size _____ AWG/MCM

DC Ground Current _____ mA Ground Test 4 Ohms

Motor Surge Protection _____ Yes _____ No

Control Panel:

Model # L975PT6

Short Circuit Device

Circuit Breaker _____ Rating _____ Setting

Fuses FRNR8 Type 8 Rating

_____ Standard X Time Delay

Controls are Grounded to:

_____ Motor

X Rod

_____ Power Supply

Start Overloads:

Set at N/A amps

Name: HOWARD LESTER

Company EPG COMPANIES

Date SEP 17 09

© EPG Companies Inc. 2009
PumpMaster & SurePump are Reg. TM of EPG Companies Inc.

INSTALLATION GUIDE

EPG SurePump™ Pumping System

1. Verify that equipment and supply voltage match.

2. Inspect equipment, look for shipping damage, dirt, and rough handling

3. Control panel should be mounted in a secure way at least 15" from riser or sump and 36" above grade to bottom of control panel.

4. Inspect inside of control panel. Look for items which might have come loose during shipping

5. Test level sensor in bucket of water. Does it return back to zero? Control panel needs to be installed and have power to it.

6. Install vent valve and tubing. See Bulletin 0130c.

7. Install suspension cable. See Bulletin 6090a.

8. Fasten motor lead and sensor cable to discharge line every 5' to 7' with straps or plastic wire ties. It's best if they are on separate sides of line; use padding between cables and any metal straps.

9. Run pump down riser slowly using stainless steel suspension cable as hold back. Make sure motor lead and sensor cable are slack as you lower pump.

10. Take ohm reading of each motor lead wire to wire and compare the values in Table 13 of the Franklin Electric motor manual for 1Ø and Table 21 for 3Ø. Be sure to add wire resistance value to value from table 13& 21. See page 39 for wire resistance.

11. Check insulation resistance as pump is lowered down riser. Resistance may drop gradually as pump and cable enter the liquid, but any sudden drop indicates a problem.

12. Run sensor leads and power cables in separated conduits to control panel. It is a good idea to use breakout junction boxes. See Design Guide 05644

13. If you have to remove dryer from end of transducer cable to pull cable through fittings or conduit. Seal end of the vent tube with a piece of tape. Reinstall dryer as soon as possible. See Bulletin 0550a

14. Megger motor leads. Resistance must be 1 megohm or greater.

15. Connect pump to control panel complying with local and national codes. Controller terminal strips, motor leads, and sensor leads are all labeled and/or color coded to simplify connections.

16. Inspect wire connections. Are they the correct colors? Are they tight?

17. If color-coded wires were not continued from sump or riser you need to ohm out each circuit.

18. Measure resistance to ground. It must be less than 25 ohms. If greater stop work and report to owner. It should be 1 ohm or less to protect electronic equipment.

© 2009 EPG Companies Inc.

☑ 19. Measure voltage prior to control panel or at entrances to control panel. Measure and record voltage line to line and line to ground.

☑ 20. Compare these reading to voltage listed on drawing and label in control panel.

☑ 21. Review equipment list and drawings for any accessory circuits. If present, run volt and ohm test.

☑ 22. Check and make sure all hand switches are in the off position. If you have a water level indicator verify leachate level in sump or riser.

☑ 23. Turn on power at panel main disconnect.

☑ 24. Level meters display should light up. Record displayed reading. How does this reading compare to your measured level reading?

☑ 25. If level and flow meter do not light up check GFCI, reset if necessary.

☑ 26. Are any indicator lights on?

☑ 27. Should they be on?

☑ 28. Make sure pump is turned off. Using built in or hand held simulator, verify level meter settings are correct for this site. See meter data sheet for factory settings and meter instructions.

☑ 29. Bump pump by turning switch to hand two or three times to make sure pump has reached its resting point. You should have minimum of 3' of slack in the cables.

☑ 30. To verify correct rotation place hand around discharge line. It will torque right if the rotation is correct.

☑ 31. When pump is running measure and record amperage and voltage. Check 3Ø systems for current balance within 5% of average.

☑ 32. Verify that starting, running and stopping causes no significant vibration or hydraulic shocks.

☑ 33. After 15 minutes of running time measure volts and amperage to see if they are stable. Are they as specified?

☑ 34. After pump and level sensor have been tested pot seal offs.

☑ 35. Complete Form 200. Note: <u>If this form is not completed and returned to EPG it will impact system warranty.</u>

2009 EPG Companies Inc.

START UP CHECKLIST

EPG SurePump™ Pumping System

QUESTIONS FOR CONTRACTOR OR INSTALLER

- ✓ A: Were sensor and power cable tied or strapped to discharge line?
- ✓ B: On what kind of spacing?
- ✓ C: What is the as built length of riser and sump? Were cables long enough? There should be 3 or more feet of slack in the cables.
- ✓ D: What size cable was run for supply power?
- ✓ E: What is the distance from power supply transformer to pump control panel?
- ✓ F: How did they verify that pump is down into sump?
- ✓ G: Did they test level sensor prior to installing?
- ✓ H: Did they test pump prior to installing or prior to your arrival?
- ✓ I: Do they have any questions or concerns?
- ✓ J: Complete form 200

PHYSICAL INSPECTION OF CONTROL PANEL

- ✓ A: Is the control panel located 15' from sump or riser and 36" above grade to bottom of panel.
- ✓ B: Are power and sensor cable run in separate conduit? If not, stop work and have this corrected.
- ✓ C: Are seal offs installed in both sensor and power runs? If not, suggest breakout junction boxes or have seal off installed.
- ✓ D: Are seal offs potted? If not, stop work and have them potted.
- ✓ E: Will inner and outer door of enclosure open and close freely? If not loosen enclosure mounting bolts and shim until it is level and square. Then retighten mounting bolts.
- ✓ F: Make sure ground wire is in place between outer door and enclosure.

© 2009 EPG Companies Inc.

PRIOR TO ENERGIZING CONTROL PANEL

- ☑ A: Measure resistance to ground. It must be less than 25 ohms. If greater stop work and report to owner. It should be 1 ohm or less to protect electronic equipment.
- ☑ B: Measure voltage prior to control panel or at entrances to control panel. Measure and record voltage line to line and line to ground.
- ☑ C: Compare these reading to voltage listed on drawing and label in control panel.
- ☑ D: Megger motor leads resistance must be 1 megohm or greater.
- ☑ E: Take ohm reading of each motor lead wire to wire and compare these to values in Table 13 of the Franklin Electric motor manual for 1Ø and Table 21 for 3Ø. Be sure to add wire resistance value to value from table 13& 21. See page 39 for wire resistance.
- ☑ F: Inspect inside of control panel. Look for items which may have come loose during shipping
- ☑ G: Inspect wire connections. Are they the correct colors? Are they tight?
- ☑ H: If color-coded wires were not continued from sump or riser you need to ohm out each circuit.
- ☑ I: Review equipment list and drawings from any accessory circuits. If present, run volt and ohm test.
- ☑ J: Check and make sure all hand switches are in off position. If you have a water level indicator verify leachate level in sump or riser.

POWER UP

- ☑ A: Turn on power at panel main disconnect.
- ☑ B: Level meters display should light up. Record displayed reading. How does this reading compare to your measured level reading?
- ☑ C: If level and flow meter do not light up check GFCI, reset if necessary
- ☑ D: Are any indicator lights on?
- ☑ E: Should they be on?
- ☑ F: Make sure pump is turned off. Using built in or hand held simulator verify level meter settings are correct for this site
- ☑ G: Bump pump by turning hand switch two or three times to make sure pump has reached its resting point. You should have minimum of 3" of slack in the cables

2009 EPG Companies Inc.

- ☐ H: To verify correct rotation place hand around discharge line. It will torque right if the rotation is correct.
- ☐ I: If there is liquid in sump with level about pump start set point and below 150". Then turn pump selector switch to AUTO. Run pump through one complete cycle.
- ☑ J: When pump is running measure and record amperage and voltage. Check 3O systems for current balance within 5% of average.
- ☑ K: Verify that starting, running and stopping causes no significant vibration or hydraulic shocks.

2009 EPG Companies Inc

Phase V
As-Built Control Panel Setup Parameters

EPG LevelMaster Pump controller

Panel S/N: 09-9356C
Meter S/N: 060409-07

LCRS Pump Level Control Meter PHASE V

Default setting - Operating Parameters - Setup Code 35

Meter Designation(s): M3

Parameter	Value	Operation
Pr Hi	28	Turns Pump on when level on meter reads ~~28~~ ". 20"
Pr Lo	16	Turns Pump off when level on meter reads ~~16~~ ". 7"
AL H1	34	Turns High Level Light on when meter reads ~~34~~ ". 36.1"
Hy Hi	1	Keeps High Level Light on until level drops 1 " below AL Hi.
AL H2	143	Turns Pumps off it meter reads 143" or greater. Indicates a possible sensor failure.
Hy H2	0	Not used.

Default Settings - Sensor Parameters - Setup Code 25 (0 - 5PSI)

Parameter	Value	Operation
dp	8888.8	Sets Meter to read in 0.1"
OFFSET	-34.6	Provides a "0" reading when sensor inputs 4.0ma
SCALE	0.8656	Converts current input into inches - 1.0ma = 8.656 inches.

AS BUILT

EPG LevelMaster Pump controller

Panel S/N: 09-9356C
Meter S/N: 060409-06

Vadose Pump Level Control Meter PHASE V

Default setting - Operating Parameters - Setup Code 35

Meter Designation(s): M1

Parameter	Value	Operation
Pr Hi	28	Turns Pump on when level on meter reads ~~28~~ ". 17"
Pr Lo	16	Turns Pump off when level on meter reads ~~16~~ ". 7"
AL H1	34	Turns High Level Light on when meter reads ~~34~~ ". .5"
Hy Hi	1	Keeps High Level Light on until level drops ~~1~~ " below AL Hi. .5"
AL H2	143	Turns Pumps off it meter reads 143" or greater. Indicates a possible sensor failure.
Hy H2	0	Not used.

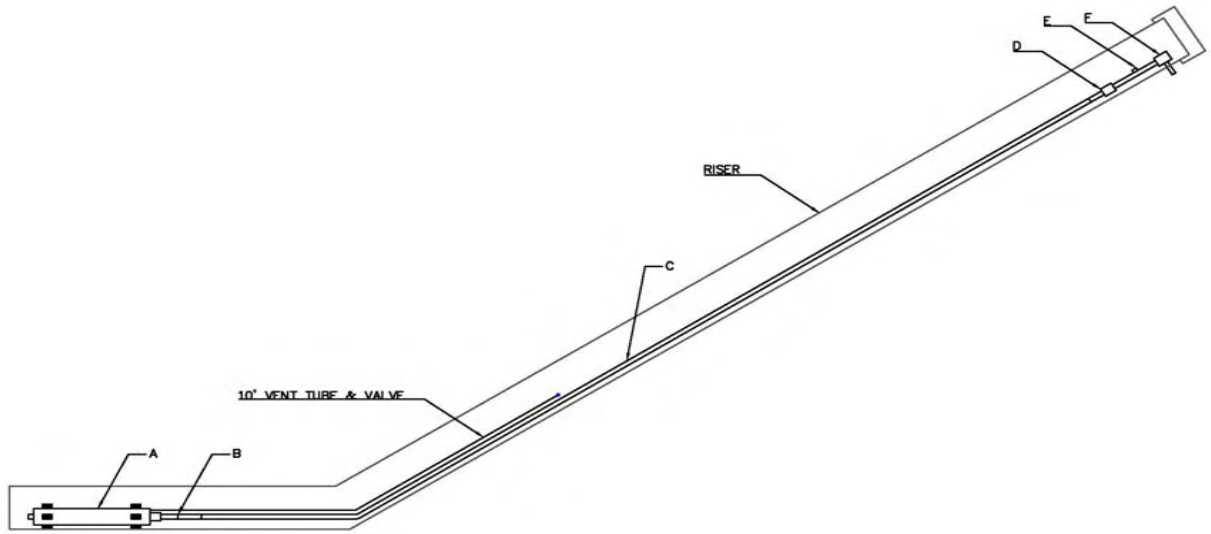
Default Settings - Sensor Parameters - Setup Code 25 (0 - 5PSI)

Parameter	Value	Operation
dp	8888.8	Sets Meter to read in 0.1"
OFFSET	-34.6	Provides a "0" reading when sensor inputs 4.0ma
SCALE	0.8656	Converts current input into inches - 1.0ma = 8.656 inches.

AS BUILT

Phase V
As-Built Pump Installation Cross Sections

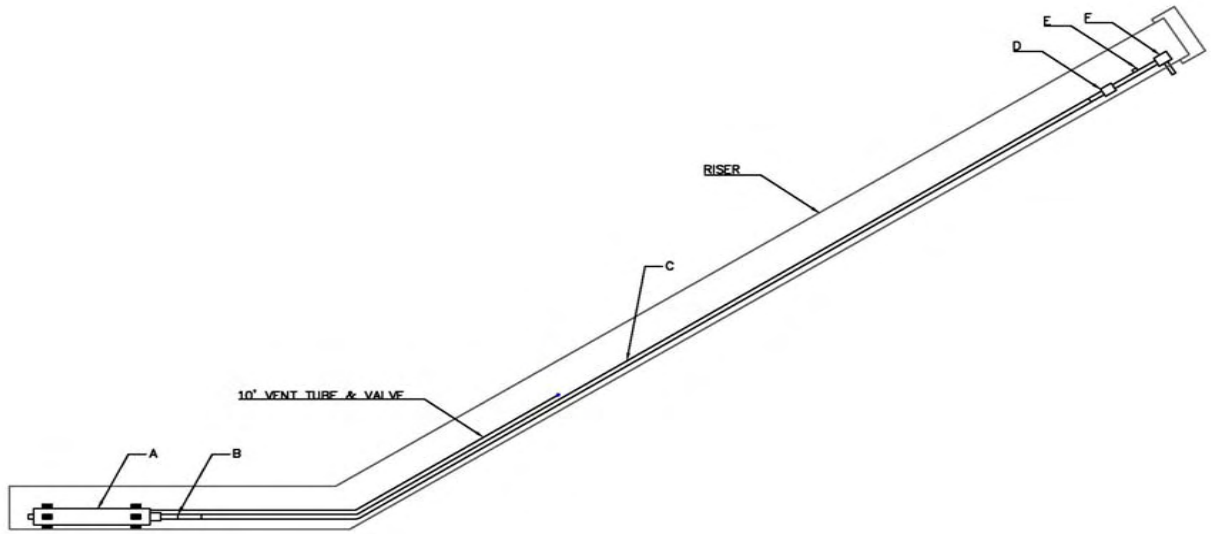
PHASE V LCRS SUMP PUMP INSTALLATION



ITEM	DESCRIPTION	LENGTH (FT)
A	WSDPT5-3 PUMP (S/N 2009-3133)	2.7
B	CONNECTIONS/FITTINGS/TRANSITIONS	1.2
C	1.5" DISCHARGE LINE	41.3
D	CONNECTIONS/FITTINGS/TRANSITIONS	0.6
E	FLOW METER	2.2
F	EPG FITTING "T"	0.4

NOT TO SCALE

PHASE V VADOSE SUMP PUMP INSTALLATION



ITEM	DESCRIPTION	LENGTH (FT)
A	WSDPT2-3 PUMP (S/N 2009-3100)	2.5
B	CONNECTIONS/FITTINGS/TRANSITIONS	1.2
C	1.0" DISCHARGE LINE	38.8
D	CONNECTIONS/FITTINGS/TRANSITIONS	0.5
E	FLOW METER	1.5
F	EPG FITTING "T"	0.3

NOT TO SCALE

Phase V
As-Built Photos

Phase V Controls
Solar Charger
12v Marine Battery
Solar Charger

Phase V Controls
& Risers
Phase V Controls
& Risers

Installation / O&M Instructions

Materials of Construction

EPG SurePump™

	STANDARD
Check Valve Housing	304 Stainless Steel
Check Valve	304 Stainless Steel
Check Valve Seat	E-Glide™
Diffuser Chamber	304 Stainless Steel
Impeller Seal Ring	E-Glide™
Impeller	304 Stainless Steel
Motor Adapter	304 Stainless Steel
Inlet Screen	304 Stainless Steel
Pump Shaft	304 Stainless Steel
Coupling	329/420/431 Stainless Steel
Fasteners	304 Stainless Steel
Bearings	E-Glide™

FRANKLIN ELECTRIC MOTORS

	1/3 to 2 HORSEPOWER	3 to 5 HORSEPOWER	5 to 10 HORSEPOWER
End Bell Castings	304 Stainless Steel over Iron	304 Stainless Steel over Iron	304 Stainless Steel over Iron
Stator Shell	301 Stainless Steel	301 Stainless Steel	301 Stainless Steel
Shaft Extension	303 Stainless Steel	303 Stainless steel	303 Stainless Steel
Fasteners	316 Stainless Steel	300 Stainless Steel	316 Stainless Steel
Seal Cover	Tefzel	Sintered Bronze	Tefzel
Shaft Seal	Viton	Viton, Carbon, Ceramic Face Seal	Viton
Diaphragm	Viton	Nitrile Rubber	Viton
Diaphragm Plate	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Diaphragm Spring	302 Stainless Steel	302 Stainless Steel	302 Stainless Steel
Diaphragm Cover	316 Stainless Steel	304 Stainless Steel	316 Stainless Steel
Slinger	Viton	Nitrile Rubber	Viton
Lead Sleeve	316 Stainless Steel	316 Stainless Steel	316 Stainless Steel
Lead Jam Nut	316 Stainless Steel	N/A	316 Stainless Steel
Lead Jam Clamp	N/A	300 Stainless Steel	N/A
Lead Potting	Epoxy	Epoxy	Epoxy
Lead Bushing	Viton	Viton	Viton

© 2009 EPG Companies Inc.
SurePump is a Reg. TM of EPG Companies Inc.

EPG Sump Drainer Vent Tube / Check Valve

INSTALLATION INSTRUCTIONS

EPG's patented sump drainer* enables a submersible pump to pump down and restart in applications that would normally cause the pump to air lock.

Critical to the operation of the sump drainer is the installation of the vent tube and air check valve. The vent tube / check valve assembly has two functions. First, as the sump drainer fills with fluid the vent tube assembly allows air trapped inside of the sump drainer to escape, allowing the sump drainer to completely fill with fluid. When the sump drainer pump starts the vent assembly then closes, allowing the pump to draw liquid through the screen at the opposite end of the sump drainer. The closed check valve enables the pump to continue pumping even though the fluid level in the sump is below the normal intake of the pump.

The vent tube may be tied off to the pump discharge line. The vent check valve will operate correctly even if submerged.

INSTALLATION

Refer to Figure 1 for help in completing this procedure.

1. Slip the free end of the plastic vent tube onto the adapter on the top of the sump drainer.

2. Verify the open end of the check valve is labeled "VAC".

3. As you lower the sump drainer into the sump, uncoil the vent tube and fasten it to the discharge pipe. We recommend you keep the check valve above the fluid level. The check valve will work if it is submerged, but can foul with particles in the fluid.

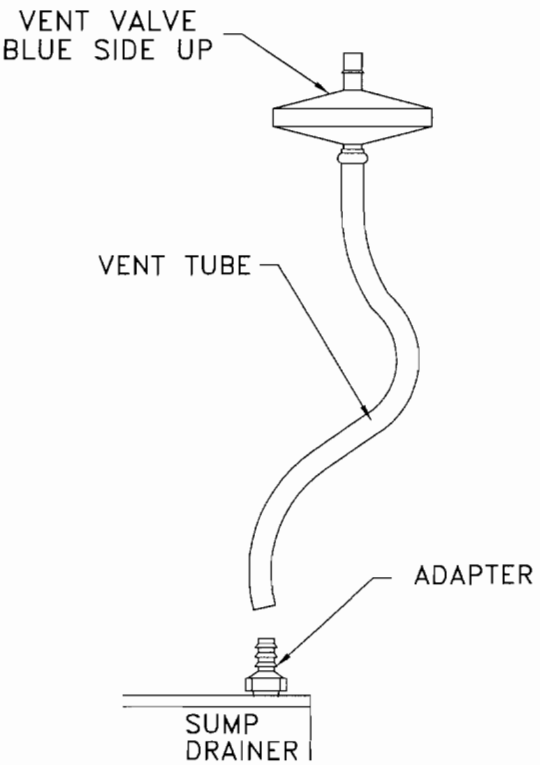


Figure 1. Vent Tube / Check Valve Assembly

* U.S. Patent #4,966,534 and 4,992,030

© EPG Companies Inc. 2009

EPG SurePump™ with LevelMaster™ Level Sensor Disassembly / Assembly

OPERATION & MAINTENANCE INSTRUCTIONS

NOTE: Refer to Table B for list of tools needed for disassembly, assembly, and testing.

1. Place the pump on a suitable work surface with blocks to prevent the pump from rolling. Remove the vent tube by pulling straight out from the top. In cold weather it is better to unscrew the vent hose barb adaptor with tube attached rather than trying to pull the tube off the hose barb.

2. Unscrew the cord restraint nuts and pull inserts out about two (2) feet along the motor lead and level sensor lead. Loosen the insert from the wires so they are free to move through the cord restraint.

3. Mark the alignment of the tube and top (check for factory alignment marks). Center punch new marks in top and tube if factory marks can not be found. The alignment marks will make reassembly easier.

4. Remove the three (3) cap screws that secure the tube to the top and carefully pull the top, with pump and motor attached, out of the tube. Do not hammer, pry, or pound on tube or top. Allow the sensor lead wire to slide through the cord restraint.

5. Remove the three (3) socket head setscrews from the level sensor housing on the bottom of the tube. Carefully pull the level sensor up and out from the bottom of the tube. Carefully remove the sensor lead wire by pulling the controller end back through the top. Cover the end of the sensor lead wire with tape to prevent moisture and dirt from entering. If the sensor is unused or put into storage, remove the dryer from the controller and install on end of vent tube during storage period.

6. Remove the nuts (4) that secure the motor to the pump and pull the motor from the pump. Do not remove the motor lead from the motor unless it will be replaced with a new lead. It is recommended that a new motor lead be used whenever the old lead is removed from the motor because of possible damage to the lead or distortion of the rubber seal that may prevent resealing.

7. Unscrew the motor lead nut from the motor. Work the lead back and forth to loosen seal and unplug the lead from the motor connector. Remove the lead by pulling the controller end back through the top.

8. Unscrew the pump assembly from the top using cloth strap wrenches to prevent damage to the metal surfaces.

CAUTION

Do not attempt to disassemble level sensor or pump motor. Any disassembly will void the warranty.

© EPG Companies Inc. 2009
SurePump, LevelMaster, & PumpMaster are Reg. TM of EPG Companies Inc.

ASSEMBLY

1. Apply pipe sealing compound to the top threads and screw the pump to the top. To prevent damage to the top sealing surface or the pump bowls, tighten pump to top using cloth strap wrenches.

2. Slide motor and pump together and align motor shaft splines to pump splines by turning the motor shaft. Align the motor lead connector with the cutaway in the pump flange. Secure motor to pump with four (4) nuts.

3. Slide the long end of the motor lead through the cord restraint cap and nut in the top. Insert plug into the motor connector. Tighten motor lead connector nut to secure lead to motor.

4. Inspect upper and inside surface of tube and remove any sharp edges or burrs. Wipe surface of tube and top to remove any dirt, sand, or metal filings. Remove the O-ring and clean sealing groove in the top. If original O-ring installation used a spacer / shim between the top and O-ring, clean the shim and reinstall into the sealing groove in the top.

5. Carefully slide level sensor lead wire through the top cord restraint and nut.

> **CAUTION**
> Use care while handling the level sensor lead wire to prevent damage to the conductors and center vent tube.

6. Slide the level sensor and center it within the sensor housing at the bottom of the tube. Secure it with the three (3) socket head setscrews. To prevent damage to the sensor case, do not over tighten the setscrews.

7. Position the tube vertically and carefully slide the pump and motor assembly into the tube. Guide the assembly past the sensor lead wire to prevent crushing or cutting the lead wire. Remove slack from the sensor lead wire by pulling the lead wire out through the top.

8. Install a new top O-ring and liberally apply white petroleum jelly (Vaseline or equivalent) to the O-ring and cover sealing surfaces. Align the screw holes in the top with the holes in the tube and carefully slide the top into the tube making sure that the O-ring is not damaged.

9. Remove the slack from the motor lead and sensor lead wire. Secure the top to the tube with three (3) cap screws. Tighten cap screws until sealing grease starts to bead out from the top-to-tube joint. Do not over tighten.

10. Secure motor lead and sensor lead wire with the cord restraint nuts. Tighten the nut until the edge of the insert can be seen on the inside edge. Install vent hose.

© EPG Companies Inc. 2009
SurePump, LevelMaster, & PumpMaster are Reg. TM of EPG Companies Inc.

SEAL TEST PROCEDURE

NOTE: Refer to Figure 2.

1. Install mechanical plug into the discharge pipe connection located in pump top. Tighten to recommended specifications. Refer to Table A.

2. Connect gage tubing to vent fitting.

3. Connect magnehelic gage to gage tubing.

4. Fill five gallon pail with water to the rim.

5. Place pump assembly, as depicted on Figure 2, in the filled five gallon pail.

6. Observe the magnehelic gage. The pressure should read about 5" W.C. and hold steady.
   a. If the pressure holds steady, the pump is ready to be installed. Remove the gauge tubing and the mechanical plug.
   b. If the gauge pressure does not hold steady, there is an air leak in the top assembly.
      b.1. Remove the pump assembly from the five gallon pail and refill the pail with water.
      b.2. Mix a solution of soap and water in a hand pump spray application bottle and spray the top assembly.
      b.3. Place the pump assembly in the five gallon pail and observe the top assembly for bubbles to determine point of the seal leak.
      b.4. Make necessary adjustments to the pump assembly and repeat items b.1. through b.3. until the leak has been corrected and the gauge pressure holds steady.

INSTALLATION

1. Remove the gage tubing and the mechanical plug and install the vent tube with vent valve.

2. Run the level sensor lead wire to the PumpMaster™ control panel or breakout box and connect the sensor RED wire to the (-) terminal and BLACK wire to the (+) terminal. Connect the level sensor vent tube to the dryer and check for kinks and crushed areas in the tube connection area. The vent tube must be open to allow atmospheric pressure change compensation in the sensor.

3. Repeat bucket test to verify level sensor operation.

4. Install pump into place.

5. Check the level sensor readings before running pump. The LevelMaster meter should indicate the proper depth of the sensor when immersed in liquid. If the meter shows -34.7 the lead wires connections are reversed, not connected or damaged. Be certain to check correct voltages at the controller and measure the resistance of the motor lead and motor to assure proper wiring.

© EPG Companies Inc. 2009
SurePump, LevelMaster, & PumpMaster are Reg. TM of EPG Companies Inc.

Table A

MECHANICAL PLUG SPECIFICATION

Nominal Pipe Size	Maximum Allowable Back Pressure PSIG		Tightening Torque
	Air	Water	
1"	5	110	20 in. lbs.
1.25"	5	100	30 in. lbs.
1.5"	5	70	5 ft. lbs.
2"	5	40	10 ft. lbs.
3"	5	30	12 ft. lbs.

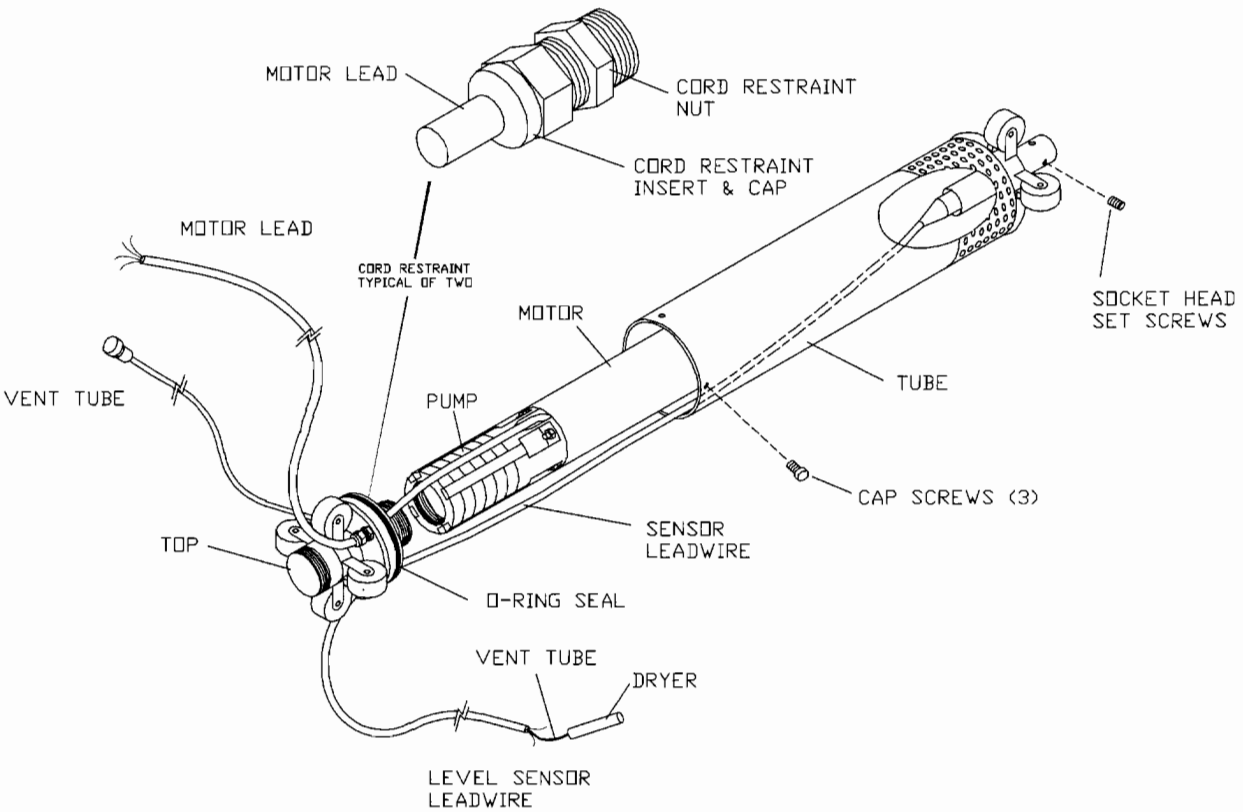
Table B

TOOLS AND ITEMS REQUIRED FOR MAINTENANCE OF EPG SUREPUMP

* 0-32 Screw with 5/16" hex head
* 5/16" Nut driver
* 10-32 x 5/16" long stainless steel set screw
* 3/32" Allen wrench
* .0005" Shim stock (blue)
* O-ring set 4, 5, and 6
* White petroleum jelly (Vaseline)
* Anti-seize compound
* Small channel lock pliers
* Magnehelic gage (Model 2010)
* Scissors to cut shim stock
* Flat blade screwdriver
* 1/2" Open end wrench
* 24" of 1/4" OD nylon tubing
* Mechanical plug set -- 1", 1.25", 1.5", 2", and 3"
* Torque wrench

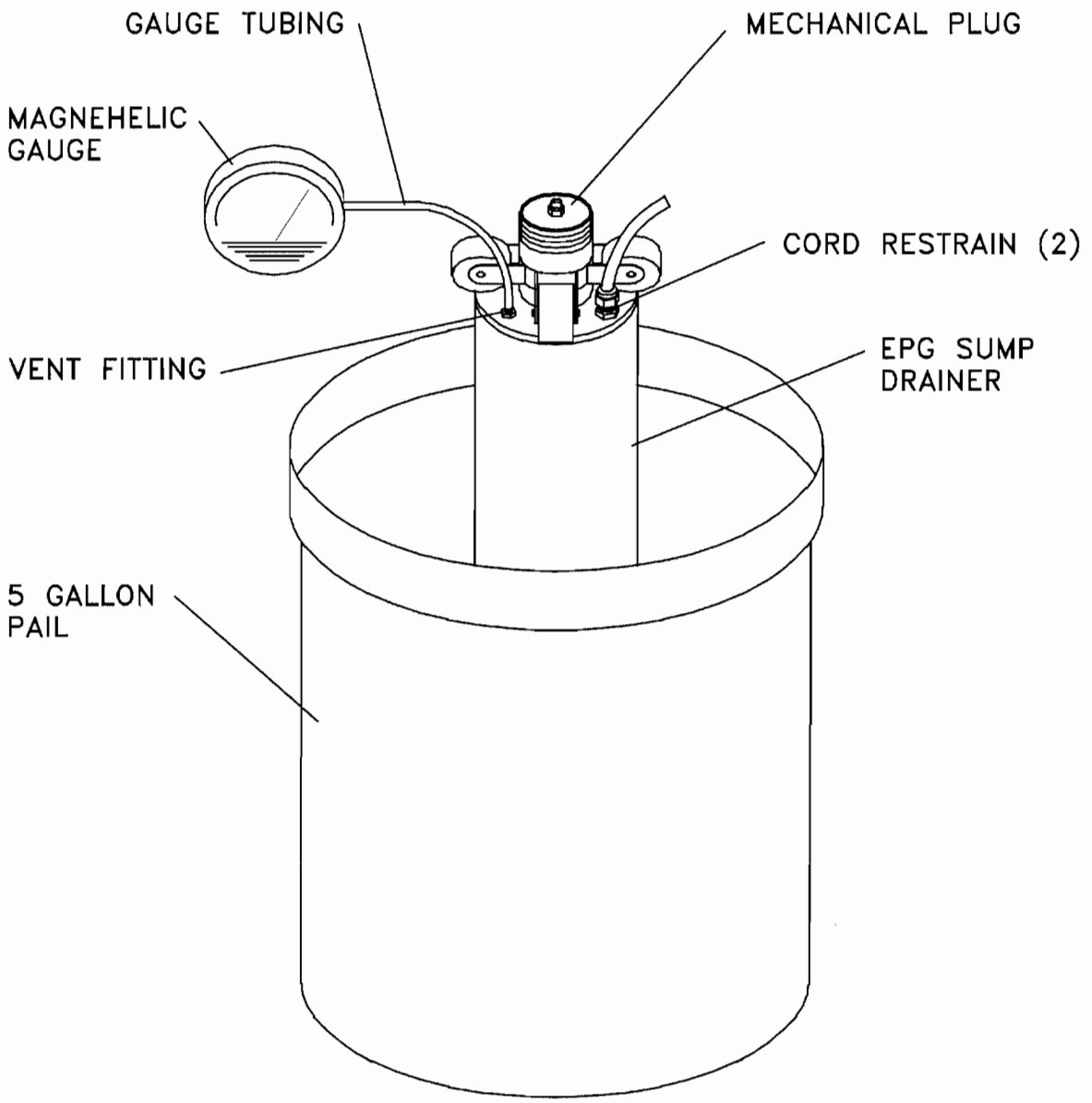
© EPG Companies Inc. 2009
SurePump, LevelMaster, & PumpMaster are Reg. TM of EPG Companies Inc.

Figure 1



© EPG Companies Inc. 2009
SurePump, LevelMaster, & PumpMaster are Reg. TM of EPG Companies Inc.

Figure 2



© EPG Companies Inc. 2009
SurePump, LevelMaster, & PumpMaster are Reg. TM of EPG Companies Inc.

EPG SurePump™ with LevelMaster™ Level Sensor

REPLACEMENT INSTRUCTIONS FOR LEVEL SENSOR IN WHEELED SUMP DRAINER

1. Use a 15/16 open end wrench to loosen and then remove the cord restraint nut (2).
2. Slide the cord restraint nut (2) and the grommet (3) off of the level sensor cable (1).
3. Use a 3/32" hex key to loosen the three set screws (4) from the locking collar.
4. Tie a string to the top end of the level sensor cable (1) and use electrician's tape to secure the string. Remove desiccant dryer from vent tube and close vent tube with tape.
5. Push several inches of the level sensor cable (1) into the sump drainer. Pull the level sensor holder (8) and the level sensor (6) out of the locking collar (5).
6. Pull the level sensor cable (1) through the sump drainer to a point where the electrician's tape can be removed.

   CAUTION: Do not pull the string through the sump drainer, it will be used to assist installation of the new level sensor.
7. Use the 3/32" hex key to loosen the four set screws (7) in the level sensor holder (8) and remove the level sensor.
8. Remove the string from the level sensor cable (1).
9. Remove the foam protective cover from the new level sensor.

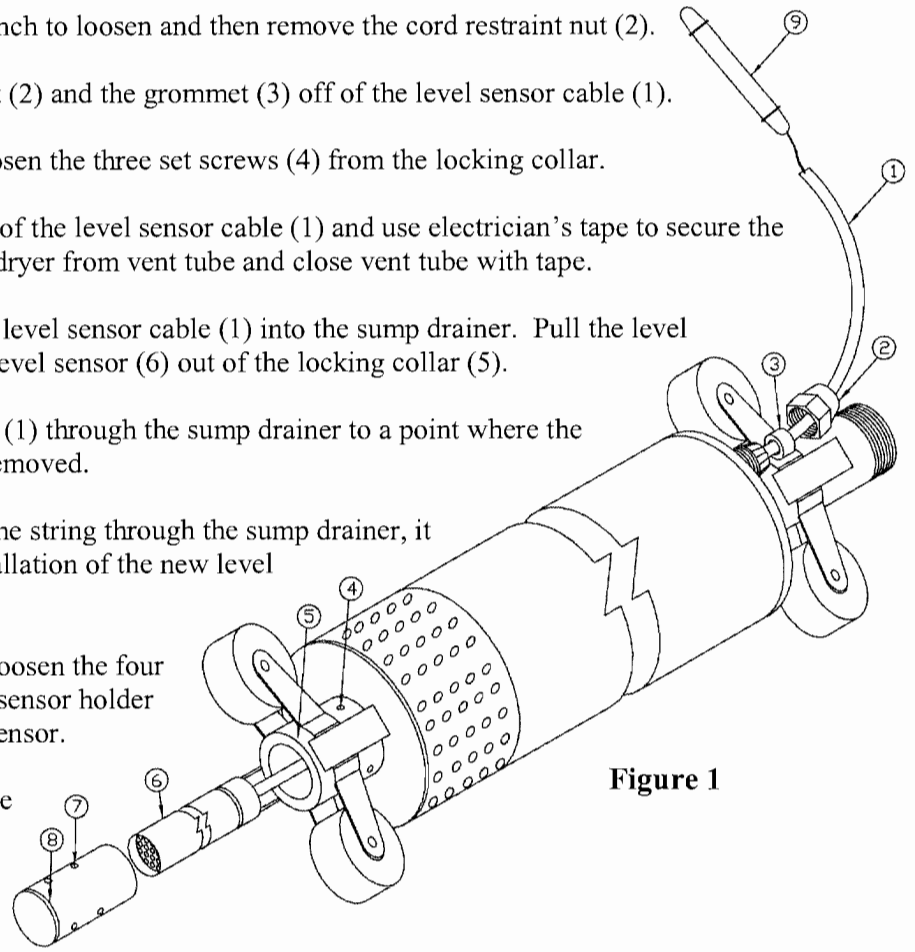


Figure 1

10. Remove the desiccant dryer tube (9) and seal the vent tube with electrician's tape.

    CAUTION: The vent tube must have a dessicant dryer installed at all times or be sealed with electrician's tape. It is very important not to allow any dirt or moisture to enter the vent tube.
11. Place the new level sensor (6) in the level sensor holder (8). Secure the two setscrews with the 3/32 hex key and torque to a maximum of seven-inch pounds.

    CAUTION: Do not over tighten the setscrews. Over tightening can damage the level sensor. Seven-inch pounds torque will secure the level sensor (6) in place.

© 2009 EPG Companies Inc.
SurePump, LevelMaster, & PumpMaster are Reg. TM of EPG Companies Inc.

12. Tie the string to the new level sensor cable end (1) and use electrician's tape to secure the string.

13. At the sump drainer's discharge end, pull the string and level sensor cable (1) through the sump drainer until the level sensor holder (8) is seated in the locking collar (5).

    CAUTION: Do not pull the cable tight. Allow two to three inches of slack in the sump drainer.

14. Insure the level sensor holder (8) is securely seated in the locking collar (5) and tighten the three set screws (4). Torque to 15-inch pounds.

15. Remove the electrician's tape and string from the level sensor cable.

16. Reinstall the grommet (3) and the cord restraint nut (2). Tighten with the 15/16 open end wrench

17. Remove the tape from the vent tube and reinstall the dryer (9).

Tools/Equipment needed:

- 15/16 open end wrench
- 3/32 hex key
- String-2 or 3 feet longer than the sump drainer
- Electrician's tape
- Torque wrench with inch pound scale

© 2009 EPG Companies Inc.
SurePump, LevelMaster, & PumpMaster are Reg. TM of EPG Companies Inc.

TEST EQUIPMENT

To insure proper installation, EPG recommends the following instruments. When working with electrical circuits, use caution to avoid electrical shock.

Megohmmeter:	To measure insulation value of motor and motor leads to ground. The higher the reading, the better.
Ohmmeter:	(Must be able to read less than 1 ohm) To measure resistance winding to winding in motor, check quality of any connections made in motor circuit to test coils of relays and continuity of circuits.
Volt Meter:	To verify correct supply voltage and measure system requirements when running.
Clamp on Amp Meter:	To measure current draw in system.

© EPG Companies Inc. 2009

TROUBLESHOOTING GUIDE

FAULT	POSSIBLE CAUSE	HOW TO CHECK	HOW TO CORRECT
Pump or blower does not run.	No electricity at controller.	Check for voltage at controller.	If no voltage at controller, check for cause. Contact power company if voltage is incorrect.
	Fuses are blown or circuit breakers are tripped.	Check fuses for correct size and check for loose, dirty, or corroded connections in fuse receptacle, terminal strip and at splice points.	Replace with proper fuse or reset circuit breaker. If new fuses blow or circuit breaker trips, the electrical installation, motor and leads must be checked.
	Motor starter overloads have tripped out.	Check for voltage on line and load side of starter. Check megohm value of motor and lead.	Reset heaters or replace. Inspect starter for other damage. If heater trips again, check the supply voltage. Replace motor or lead as needed.
	Motor and/or cable are defective.	Turn off voltage, disconnect drop leads from controller to the motor. Measure the lead-to-lead resistances with ohmeter (RX-1). Measure lead-to-ground values with megohm meter. Record measured values.	If open winding or ground is found, remove pump and recheck values at the surface. Repair or replace motor or cable.

 © EPG Companies Inc. 2009

FAULT	POSSIBLE CAUSE	HOW TO CHECK	HOW TO CORRECT
	Starter does not energize.	Energize control circuit and check for voltage at the holding coil.	If no voltage, check control circuit. If voltage, check holding coil for shorts. Replace bad coil.
	Defective controls.	Check all sensors and safety switches for operation. Inspect contact in control devices.	Replace worn or defective parts.
	Defective capacitor. (Single phase only.)	Turn off voltage, discharge capacitor. Check with megohm meter. Record measured values.	Replace if defective.
Pump runs but does not deliver liquid.	Liquid level in sump is too low or sump infiltration rate is reduced or intranded gas.	Check sump draw down.	See pump data sheet for minimum submergence values.
	Vent valve not installed or improperly installed.	Make sure valve is attached to the to of the sump drainer and that it is not installed backward.	Replace valve if missing. Reverse valve if installed upside down.
	Inlet strainer is clogged.	Install pressure gauge, start pump, gradually close the discharge valve and read pressure at shutoff.	Remove pump and inspect for blockage. Clean screen as needed. Inspect check valve for blockage. Rinse out pump and reinstall.

 © EPG Companies Inc. 2009

FAULT	POSSIBLE CAUSE	HOW TO CHECK	HOW TO CORRECT
	Pump is defective or worn.	Same as description above.	Convert PSI to feet (PSI x 2.31 ft/PSI = ___ ft.), add elevation from pressure gauge to liquid level to the converted pressure reading. Refer to specific pump curve for shutoff head for that pump model. If calculated value is close to curve, pump is probably OK. If not, remove pump & inspect.
Pump runs continuously.	Leak in system.	Check system for leaks.	Replace damaged pipes or repair leaks.
	Worn pump.	Install pressure gauge, start pump, gradually close the discharge valve and read pressure at shut-off.	Pull pump and inspect. Replace worn impellers, bearings or other close fitting parts.
	Loose or broken motor shaft.	Little or no liquid will be delivered if the pump/motor coupling is loose or if the motor shaft has sheared off.	Check for damaged shafts if coupling is loose and replace worn or defective units.
	Pump intake or impellers blocked.	Restricted flow may indicate a clogged intake screen or partially blocked impellers. Pump may be installed in mud or sand.	Clean screen and reset pump. It may be necessary to clean impellers.

 © EPG Companies Inc. 2009

FAULT	POSSIBLE CAUSE	HOW TO CHECK	HOW TO CORRECT
Pump runs but at reduced capacity.	Wrong rotation.	Check for proper electrical connection in control box.	Correct wiring and change leads as required.
	Leak in system.	Check system for leaks.	Replace damaged pipes or repair leaks.
	Pump strainer or check valve is clogged.	Remove pump and inspect.	Clean, repair, rinse out and re-install pump. It may be necessary to take pump apart and clean impellers. Check discharge line for any obstructions.

 © EPG Companies Inc. 2009

Wire Cable Clamp

INSTALLATION INSTRUCTIONS

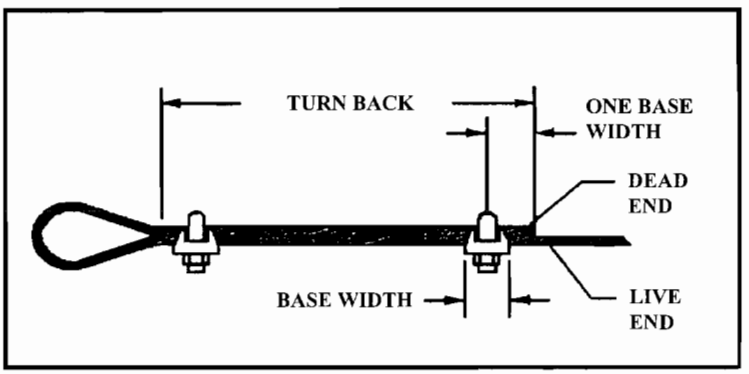
Recommended Method of Applying Clamps to get Maximum Holding Power

1. *Turn back* the specified amount of cable from the loop. Apply the first clamp one base width from the dead end of the wire cable (U-bolt over dead end - live end rests in clamp saddle). Tighten nuts evenly to recommended torque.

2. *Apply the next clamp* as near the loop as possible. Turn on nuts firm, take up rope slack, and tighten nuts evenly to recommended torque.

3. Do not use clamps on plastic coated wire rope.

4. Never use clamps to connect two straight lengths of wire rope.



Attaching Clamps

A termination made in accordance with instruction and using the number of clamps shown has an approximate 80% efficiency rating. This rating is based upon the catalog breaking strength of wire rope.

Number of Clamps Recommended

Clamp Size Inches	Minimum No. of Clamps	Amount of Cable to Turn Back in Inches	Breaking Strength FT/LBS	Clamp Torque FT/LBS	Cable Strength with Clamps FT/LBS
1/8	2	3 1/4	1,760	4.5	1400
3/16	2	3 3/4	3,700	7.5	2960
1/4	2	4 3/4	6,400	15	5120

© EPG Companies Inc. 2009

STORAGE INFORMATION

SUREPUMP™

1. The ideal storage condition for SurePump is in a warm dry location. Although SurePump will tolerate a light freeze, temperatures should not fall below -3°C (27°F). Repeated freezing and thawing should be avoided to prevent possible loss of motor fluid.

2. Limit storage time to less than two years if storage area temperatures exceed 100°F. Limit storage time to one year or less if storage area temperatures exceed 130°F.

3. To prevent motor seal damage and/or fluid loss, always store SurePump vertically.

LEVELMASTER™

1. IMPORTANT: During any short or long term storage, to prevent moisture damage to internal components, the desiccant dryer must be installed on the vent tube of the submersible level sensor signal cable. Store in a warm dry location to prevent internal condensation in the meter enclosure.

2. If the level sensor is installed in a SurePump, pump must be stored in a vertical position. Coil the sensor signal cable and place in a box or protected area to prevent damage to the signal cable. Do not stack heavy items on top of level sensor signal cable.

3. Make certain that the desiccant dryer is attached to the end of the level sensor vent tube. Inspect dryer periodically and replace if crystals are pink or white.

PUMPMASTER™ CONTROLS

1. To prevent condensation/moisture damage within the control cabinet, store the PumpMaster in a warm dry location.

2. Check that the corrosion inhibitor cartridge is installed in the interior of the cabinet. If the PumpMaster control will be stored for over six months, contact EPG Companies Inc. for additional corrosion inhibitor cartridges

NOTE

The non-volatile memory of level and flow meters may deteriorate if left without power for periods greater than one year. If storage times are expected to exceed one year contact EPG Companies Inc. for special precautions.

© EPG Companies Inc. 2009
PumpMaster, LevelMaster & SurePump are Reg. TM of EPG Companies Inc.

CAUTION

EPG submersible level sensors are designed for rugged use. However, care should be taken to protect these devices from over pressure and sudden impact. When lowering the level sensor into a liquid, penetrate the surface slowly and only to the depth that the unit is designed for. Do not drop or wash with high pressure since this may damage the unit.

© EPG Companies Inc. 2009

EPG Controllers With Intrinsically Safe Circuit(s)

Field Installation Instructions

PURPOSE: Provide instructions to install EPG control panels with Intrinsically Safe (IS) Circuits wired to EPG Level Sensors, EPG Flow Sensors, and Single and Dual Level Float Sensors.

PROCEDURE:
Familiarize yourself with the electrical components and the panel electrical schematics. Read these instructions thoroughly before attempting installation of intrinsically safe circuits. Reference: Installation of intrinsically safe instrument systems in CLASS I HAZARDOUS LOCATIONS, ANSI/ISA-RP 12.6-1987, SECTION 4.5.4.

Install in accordance with Article 504 of the National Electrical Code.

This control panel and its intrinsically safe circuit(s) must be connected to a ground system with very low impedance (1 OHM or less) per NEC 504-50 and 250-50.

See control panel drawings for device wiring. Only simple apparatus (NEC 504-2) and those specifically called out in the controller drawing are to be connected to the intrinsically safe circuit(s). The attached drawings show specific device wiring for level, flow, single level float and dual level float sensors

Where intrinsically safe circuits enter or exit a hazardous (classified) area, a means must be provided to prevent the passage of gases or vapors per NEC 501-5. A seal device must be installed to conduit entering the enclosure and then filled with appropriate sealant.

Wiring of intrinsically safe circuits shall be physically separated from non-intrinsically safe circuits per NEC 504. Do not run intrinsically safe and non-intrinsically safe circuits in the same conduit.

Do not exceed maximum cable lengths stated in the control panel drawings.

Field wiring supplied by others is to have 600 Volt insulation rating.

Conductors of intrinsically safe circuits must be separated by at least 5" from conductors of any non-intrinsically safe circuits

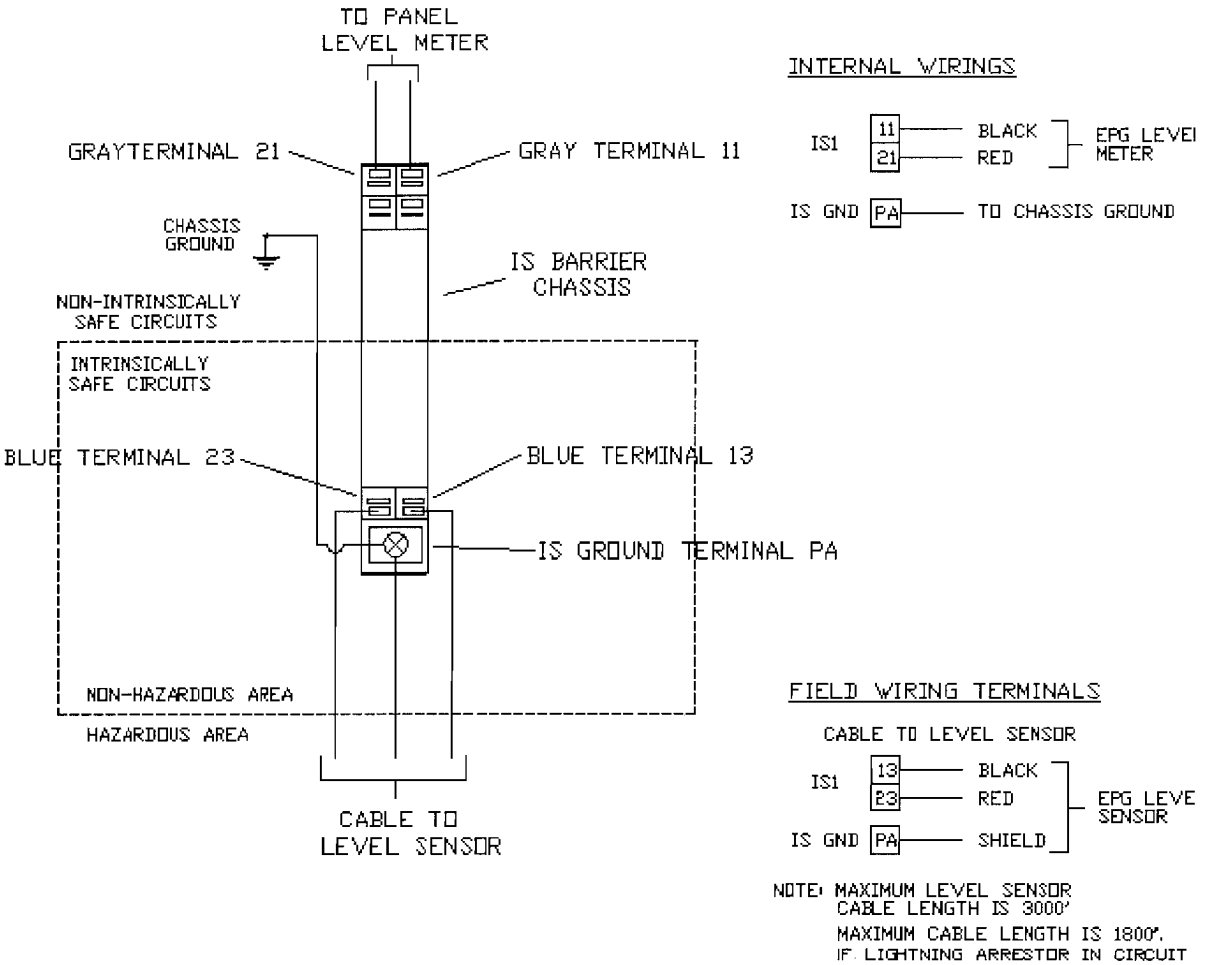
If field wiring is terminated in field supplied junction boxes there must be a minimum of 8" between intrinsically safe and non-intrinsically safe field wiring terminals.

Do not substitute parts. Use only the same make, model and part number as originally supplied.

Replace fuses only with fuses of same type and rating.

 © EPG Companies Inc. 2009

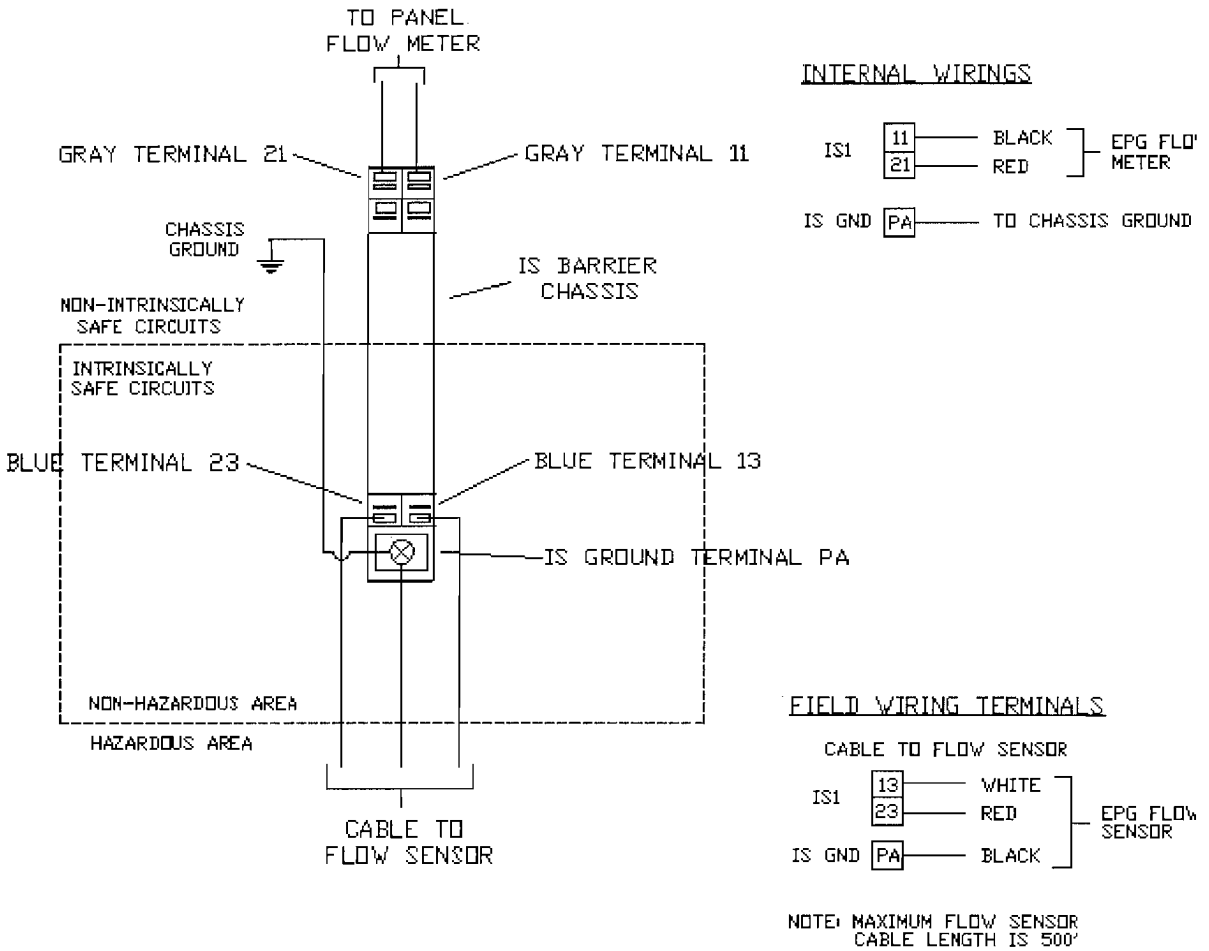
I.S. BARRIER - LEVEL SENSOR



NOTE:
1. PROVIDES INTRINSICALLY SAFE CIRCUIT EXTENSIONS FOR USE IN CLASS 1 GROUPS C & D HAZARDOUS LOCATIONS WHEN CONNECTED PER EPG BULLETIN 8000.
2. REFERENCE INSTALLATION OF INTRINSICALLY SAFE SYSTEMS IN CLASS 1 HAZARDOUS LOCATIONS, ANSI/ISA-RP 12.6-1987, SECTION 4.5.4.
3. WARNING SUBSTITUTION OF COMPONENTS MAY IMPAIR INTRINSIC SAFETY.
4. INSTALL IN ACCORDANCE WITH ARTICLE 504 OF THE NATIONAL ELECTRICAL CODE.
5. MAXIMUM CABLE LENGTH TO EPG LEVEL SENSOR IS 3000 FEET. MAXIMUM LENGTH IS 1800 FEET IF LIGHTNING ARRESTOR IN CIRCUIT.

 © EPG Companies Inc. 2009

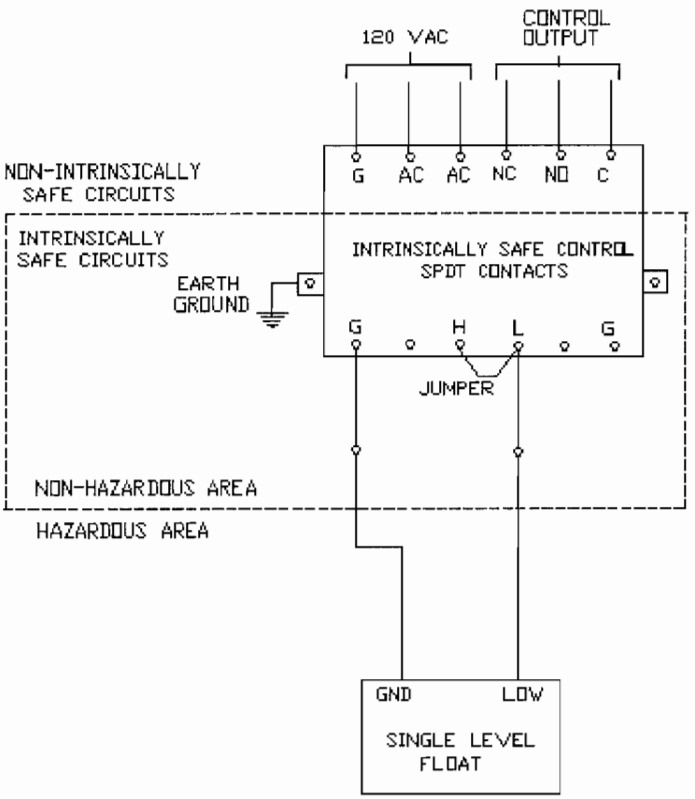
I.S. BARRIER - FLOW SENSOR

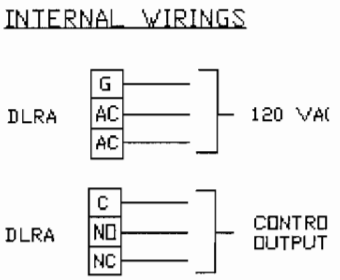


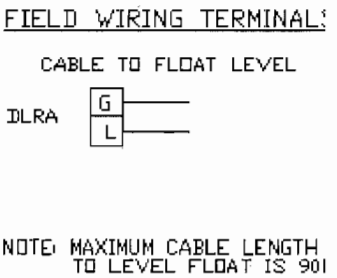
NOTE:
1. PROVIDES INTRINSICALLY SAFE CIRCUIT EXTENSIONS FOR USE IN CLASS 1 GROUPS C & D HAZARDOUS LOCATIONS WHEN CONNECTED PER EPG BULLETIN 8000.
2. REFERENCE INSTALLATION OF INTRINSICALLY SAFE SYSTEMS IN CLASS 1 HAZARDOUS LOCATIONS, ANSI/ISA-RP 12.6-1987, SECTION 4.5.4.
3. WARNING SUBSTITUTION OF COMPONENTS MAY IMPAIR INTRINSIC SAFETY.
4. INSTALL IN ACCORDANCE WITH ARTICLE 504 OF THE NATIONAL ELECTRICAL CODE.
5. MAXIMUM CABLE LENGTH TO EPG FLOW SENSOR IS 500 FEET.

 © EPG Companies Inc. 2009

I.S. RELAY BARRIER - SINGLE LEVEL



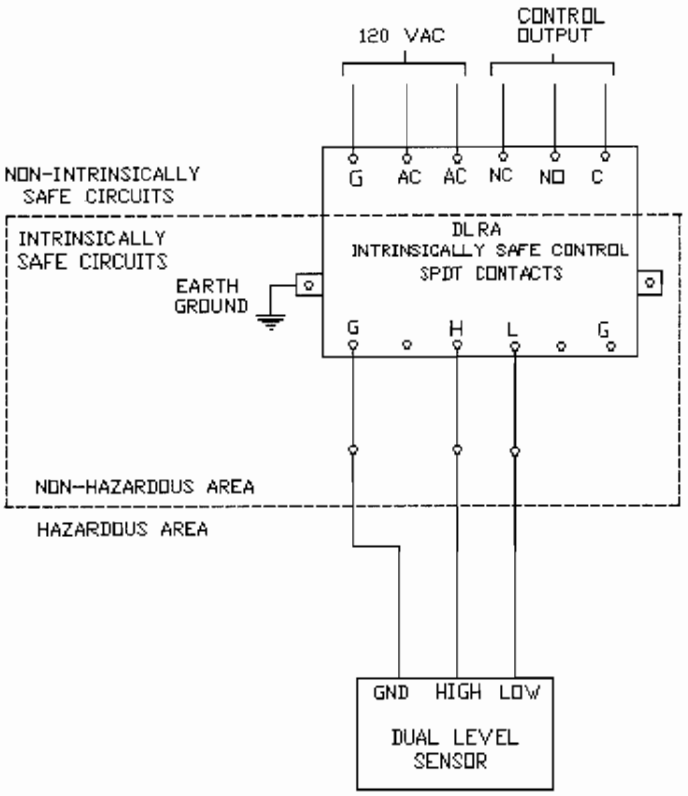


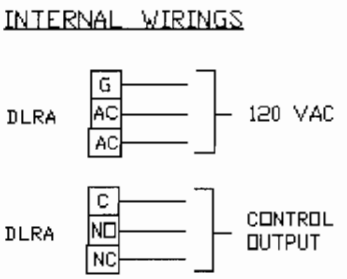


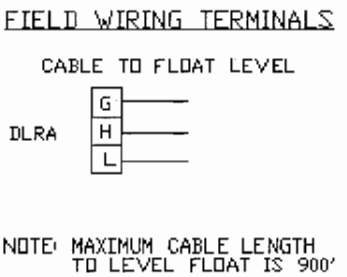
NOTE: 1. PROVIDES INTRINSICALLY SAFE CIRCUIT EXTENSIONS FOR USE IN CLASS 1 GROUPS A, B, C, & D HAZARDOUS LOCATIONS WHEN CONNECTED PER EPG BULLETIN 8000.
2. REFERENCE INSTALLATION OF INTRINSICALLY SAFE SYSTEMS IN CLASS 1 HAZARDOUS LOCATIONS, ANSI/ISA-RP 12.6-1987, SECTION 4.5.4.
3. WARNING SUBSTITUTION OF COMPONENTS MAY IMPAIR INTRINSIC SAFETY.
4. INSTALL IN ACCORDANCE WITH ARTICLE 504 OF THE NATIONAL ELECTRICAL CODE.
5. MAXIMUM CABLE LENGTH TO LEVEL FLOAT SENSOR IS 900 FEET.

 © EPG Companies Inc. 2009

I.S. RELAY BARRIER - DUAL LEVEL





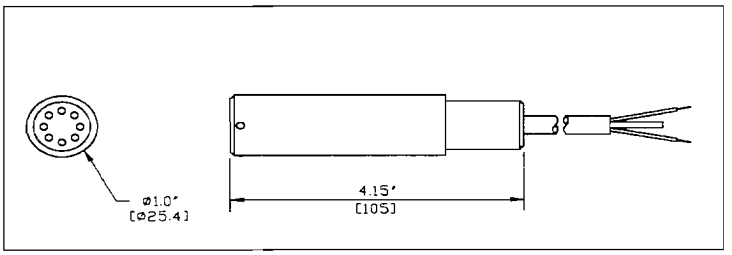


NOTE: 1. PROVIDES INTRINSICALLY SAFE CIRCUIT EXTENSIONS FOR USE IN CLASS 1 GROUPS A, B, C, & D HAZARDOUS LOCATIONS WHEN CONNECTED PER EPG BULLETIN 8000.
2. REFERENCE INSTALLATION OF INTRINSICALLY SAFE SYSTEMS IN CLASS 1 HAZARDOUS LOCATIONS, ANSI/ISA-RP 12.6-1987, SECTION 4.5.4.
3. WARNING SUBSTITUTION OF COMPONENTS MAY IMPAIR INTRINSIC SAFETY.
4. INSTALL IN ACCORDANCE WITH ARTICLE 504 OF THE NATIONAL ELECTRICAL CODE.
5. MAXIMUM CABLE LENGTH TO LEVEL FLOAT SENSOR IS 900 FEET.

 © EPG Companies Inc. 2009

ENGINEER'S SPECIFICATION

EPG LevelMaster™ PT Submersible Level Sensor



GENERAL FEATURES

* Application: The LevelMaster sensor is designed specifically to work with the EPG SurePump™, but its durability, accuracy and weight make it the logical choice for stand alone level applications. The chemical resistant jacketed cable with water block contains a vent tube for atmospheric pressure compensation.
* Ranges Available: 0-55" through 0-690' models are standard. Call EPG for other available ranges.
* Accuracy: The LevelMaster sensor has built-in temperature compensation as well as precise calibration giving an accuracy of ±1.0% at ambient temperature and a combined repeatability and hysteresis error of ±.125%.
* Fully Submersible: The LevelMaster sensor is fully submersible in any liquid compatible with 316 stainless steel and the chemical resistant polyurethane cable jacket. It is designed for submergence at depths greater than operating level without sustaining damage. Call EPG for more severe service.
* Self-Sealing Cable: If a cut occurs in the outer jacket of the cable, a water block feature just inside the outer jacket will self-seal in most cases guarding against the incursion of water.
* Superior Noise Immunity: Designed for heavy duty use in hostile environments, the LevelMaster sensor gives outstanding noise immunity. Unlike transducers, whose signals may be distorted by outside interference, the LevelMaster sensor utilizes a conditioned compensated 4-20 mA output to maximize signal strength and accuracy. The sensor also features a shielded lead to help prevent signal disruption from outside sources.

PERFORMANCE

* Depth Range:	0-55" thru 0-690' (0-2 PSI thru 0-300 PSI)
* Static Accuracy[1]:	±1.0% BFSL FSL maximum
* Thermal Error[2]:	0.05% FSO/°C worst case
* Proof Depth:	1.5 X rated depth
* Burst Depth:	2.0 X rated depth
* Resolution:	Infinitesimal

1. Static accuracy includes the combined errors due to nonlinearity, hysteresis and non-repeatability on a Best Fit Straight Line basis, at 25°C per ISA S51.1.
2. Thermal error is the maximum allowable deviation from the Best Fit Straight Line due to a change in temperature, per ISA S51.1.

© 2009 EPG Companies Inc.
LevelMaster & SurePump are Reg. TM of EPG Companies Inc.

ELECTRICAL

* Excitation: 10 to 40 VDC, Red = (+) excitation, Black = (-) excitation
* Input Current: 20 mA maximum
* Output: 4-20 mA (2 wire)
* Zero offset (max): 4-20 mA, ±.12mA
* Output impedance: <10 ohms
* Insulation resistance: 100 megohms at 50VDC
* Circuit protection: Polarity, surge & shorted output
* Power supply rejection: <±.05% FSO/VDC (mA output)
* Electrical termination: 2-24 AWG conductors in a shielded cable with sensor breather and polyurethane jacket

ENVIRONMENTAL

* Compensated temp range: 0° to 50°C
* Operating temp range: -20° to 70°C

PHYSICAL

* Dimensions: Nominal diameter of 1.0" X 4.15" length
* Weight: 7 oz. (not including cable)
* Cable: Polyurethane jacketed shielded cable with polyethylene vent tube and Kevlar tension members
* Wetted materials: 316 SS, Viton
* Mounting provision: Suspended by cable
* Lightning Protection: Increases length to 8.15"

MODEL {Call EPG for other ranges available – specify length (---)}

PART #	DESCRIPTION	RANGE
PT05X---	Submersible Pressure Transmitter	0-11'
PT07X---	" " "	0-16'
PT10X---	" " "	0-23'
PT20X---	" " "	0-46'
PT25X---	" " "	0-57'

OPTIONS

* Tefzel® Cable: Used for highly corrosive environments
* Titanium Housing: Used for highly corrosive environments
* Lightning Protection: Protects against transient voltages and lightning associated surges up to 20,000 amperes with proper grounding
* Temperature Sensor: A sensor with 4-20 mA output for temperature (0-50°C) is available – Excitation: 9-30 VDC, White = (+) excitation, Green = (-) excitation

© 2009 EPG Companies Inc.
LevelMaster & SurePump are Reg. TM of EPG Companies Inc.

EPG LevelMaster™ Level Sensor

OPERATION & MAINTENANCE INSTRUCTIONS

Characteristics of the LevelMaster Level Sensor

EPG Companies Inc. LevelMaster level sensor is a submersible pressure transmitter. The pressure transmitter is a precision measurement devise that incorporates isolated diaphragm sensors that are specifically designed for use with hostile fluids and gases. The sensor utilizes a silicon pressure cell that has been fitted into a stainless steel package with a stainless steel barrier diaphragm. The sensor assembly is housed in a rugged 316 stainless steel case.

The device features a high performance internal signal conditioning. Standard output is 4 to 20 mA. All units have surge and reverse polarity protection.

All EPG transmitters are permanently etched with wiring information, part number (P/N), serial number (S/N), date of manufacture (DOM), range, excitation, and output.

All EPG transmitters are designed for rugged use. However, care should be taken to protect these devices from overpressure and sharp impact. When lowering submersible pressure transmitters into a liquid, penetrate the surface slowly and only to the depth necessary. Do not drop the unit from above the surface. All transmitters can be cleaned by rinsing them in mild detergent. Do not pressure wash.

Vent Filter / Water Vapor Trap

The vent filter and water vapor trap is a replaceable vent tube dehumidifier intended for use with the submersible pressure transmitters. This device is specifically designed to protect sensitive electronic components from mildew, corrosion, rust, and other forms of deterioration while at the same time preventing the formation of a liquid column.

Vent filters should be changed when they are 85% spent. Do not remove the old filter until a new one is available. The number one failure mode is moisture and corrosion damage due to lack of maintenance of the vent filter. The vent filter connects to the existing vent tube as it exits the cable at the junction box via a tube.

Replacement vent filters can be ordered by calling EPG at 800-443-7426. The vent filter and water vapor trap can be exposed to air, industrial gases, refrigerants, organic liquids, and solvents. However, they should not be used when ammonia is present.

Specifications

Most installations of submersible pressure transmitters connect the cable directly to the control panel or to a breakout box (junction box). From this breakout box, end users must run cable to the required instrumentation. Specifications for the polyurethane or Tefzel jacketed cable is as follows:

 © EPG Companies Inc. 2009

* Excitation:	10 to 40 VDC, Red = (+) excitation, Black = (-) excitation
* Input Current:	20 mA maximum
* Output:	4-20 mA (2 wire)
* Zero offset (max):	4-20 mA, ±.12mA
* Output impedance:	<10 ohms
* Insulation resistance:	100 megohms at 50VDC
* Circuit protection:	Polarity, surge & shorted output
* Power supply rejection:	<±.05% FSO/VDC (mA output)
* Electrical termination:	2-24 AWG conductors in a shielded cable with sensor breather, water block, and polyurethane jacket
* Compensated temp range:	0° to 50°C
* Operating temp range:	-20° to 70°C
* Dimensions:	Nominal diameter of 1.0" X 4.15" length
* Weight:	7 oz. (not including cable)
* Cable:	Polyurethane jacketed shielded cable with polyethylene vent tube and Kevlar tension members
* Wetted materials:	316 SS, Viton
* Mounting provision:	Suspended by cable

Polyurethane Cable

The standard cable is polyurethane and will handle most environments and has a self-sealing feature. If a cut occurs in the outer jacket of the cable, a water block feature below the outer jacket will self-seal in most cases to guard against the incursion of water.

Chemical Resistance of Polyurethane

Potable Water, Waste Water, Borax, Butane, Animal Fat, Carbonic Acid, Citric Acid, Cod Liver Oil, Corn Oil, Glycerin, Glycol, Mineral Oils, Potassium Nitrate, Potassium Sulfate, Silicone Oils, Stoddard Solvent, Tannic Acid (10), Tartaric Acid, Turbine Oil, and most Leachate.

Tefzel® Cable

Optional Tefzel cable is recommended for use in highly corrosive environments. It offers additional resistance in corrosive environments over the standard polyurethane cable.

Chemical Resistance of Tefzel

Acetic Acid (Glacial), Acetic Anhydride, Acetone, Aluminum Chloride, Anti-Freeze, Bromine, Calcium Chloride, Calcium Hydroxide, Chlorine, Copper Chloride, Ferrous Chloride, Hydrochloric Acid, Ketones, Lacquer Thinners, Leachate, and Sulfuric Acid.

 © EPG Companies Inc. 2009

Cable Lengths

The maximum length of cable to be used with the submersible pressure transmitter is up to 10,000 feet.

OPTIONS

* Titanium Housing:	Used for highly corrosive environments
* Lightning Protection:	Protects against transient voltages and lightning associated surges up to 20,000 amperes
* Temperature Sensor:	A sensor with 4-20 mA output for temperature (0-50ºC) is available – Excitation: 9-30 VDC, White = (+) excitation, Green = (-) excitation.

 © EPG Companies Inc. 2009

EPG LevelMaster™ Level Meter

Model CH1000-SDHH

OPERATION & SET UP INSTRUCTIONS

The EPG LevelMaster system uses a submersible pressure transmitter to detect changes in fluid levels and a programmable meter featuring a digital LED display and front panel keypad to monitor and control fluid levels. The user can program the desired control parameters for a single pump and one other high level control function. The LevelMaster display is in inches unless otherwise programmed. During a pumping and/or an alarm condition, the display alternates between the message and the current liquid level reading. The message indicates which function is active (see below).

GENERAL SETUP OPERATIONS

IMPORTANT: During setup, if three (3) minutes elapse without a keypad entry the meter automatically returns to the run mode without the entered changes being stored. **DO NOT USE FINGERNAIL OR OTHER SHARP OBJECT TO PROGRAM METER. DAMAGE TO KEYPAD MAY RESULT.**

DISPLAY	INSTRUCTION
SETUP	At this prompt, enter the lockout code (35) in order to enter the set point setup mode.
Pr Hl	At this prompt, followed by the current setting, select the Pump Relay High set point. This is the **pump ON** set point.
Pr Lo	At this prompt, followed by the current setting, select the Pump Relay Low set point. This is the **pump OFF** set point.
AL Hi	At this prompt, followed by the current setting, select the Alarm High Relay set point. This is the **high level alarm** set point.
Hy Hi	At this prompt, followed by the current setting, select the hysteresis for the Alarm High Relay set point. This value, when subtracted from the high level alarm set point, sets the **shut off point for the high level alarm**.
AL H2	At this prompt, followed by the current setting, select the Alarm High-High Relay set point. This is the **high-high alarm** level set point and is factory set.
Hy H2	At this prompt, followed by the current setting, select the hysteresis for the Alarm High-High Relay set point. This value, when subtracted from the high-high level alarm set point, sets the **shut off point for the high-high level alarm** and is factory set.

DISPLAY	MESSAGE
P	Pump activated. "P" and the current level reading will alternate on the display.
HiP	High alarm & pump activated. "HiP" and the current level reading will alternate on the display.
HiPH2	High-High alarm & pump deactivated. "HiPH2" and the current level reading will alternate on the display.

© 2009 EPG Companies Inc.
LevelMaster is a Reg. TM of EPG Companies Inc.

SET UP PROCEDURES FOR SIMPLEX OPERATION – SDHH METER

STEP NO.	ACTION
1	Push SETUP/ENTER button. Wait for the meter to display 0.
2	Push arrow buttons to set a value of 35 on meter display. Push SETUP/ENTER.
3	Meter shows **Pr Hl** (pump ON set point) followed by current value.
4	Push arrow buttons to set the desired level for pump ON. Push SETUP/ENTER button.
5	Meter shows **Pr Lo** (pump OFF set point) followed by current value.
6	Push arrow buttons to set the desired pump OFF level. Push SETUP/ENTER button.
7	Meter shows **AL Hi** (High Level Alarm) followed by current value.
8	Press arrow buttons to set desired high level alarm point. Push SETUP/ENTER button.
9	Meter shows **Hy Hi**. Press arrow buttons to select how far below the high level point the alarm will shut off. Push SETUP/ENTER button.
10	Meter shows **AL H2** (High-High level alarm set point) followed by current value. Factory setting is 150.0". **NOTE: This fail safe feature shuts off the pump if the level sensor fails and should not be changed in the field.**
11	Meter shows **Hy H2**. Press arrow buttons to select value of 0.0". Not used.
12	Push SETUP/ENTER button. Meter returns to normal operation.

EXAMPLE:

If the desired levels for the pump were:	Pump ON	18.0"
	Pump OFF	12.0"
	High Level Alarm	30.0"
	High Level Alarm Hys.	1.0"

Complete steps 1 – 3 above.

Select **18.0** with arrow buttons for the **Pr Hl** value. Push SETUP/ENTER.

Pr Lo is displayed, select **12.0** with the arrow buttons for the Pump OFF value. Push SETUP/ENTER.

AL Hi is displayed, select **30.0** with the arrow buttons for the High Alarm value. Push SETUP/ENTER.

Hy Hi is displayed, select **1.0** with the arrow buttons for the High Level Alarm OFF value (value determined by subtracting from high-level-alarm set-point). Push SETUP/ENTER.

© 2009 EPG Companies Inc.
LevelMaster is a Reg. TM of EPG Companies Inc.

INSTALLATION NOTES AND TROUBLESHOOTING

BACKGROUND: Numerous installations of the EPG LevelMaster system have proven its long-term reliability. The majority of malfunctions of the LevelMaster system are the result of improper installation and handling of the pressure transmitter sensor. During new installations, be certain to check for any shipping damage, loose controller connections or parts that may have come loose during shipment.

CAUTION
Do not use any other programming codes other than setup code (35).

SYMPTOM / DISPLAY	PROBABLE CAUSES	HOW TO CORRECT
Continuous above full scale reading (above 139"), or Continuous reading.	If pump has been off for a long period of time, liquid level may actually be quite high.	Reprogram meter if above 150" or pull pump up slightly to initiate pump start.
	Loose connections in circuit.	Repair connections in controller.
	Short circuit in sensor lead wire or connector or circuit.	Inspect for shorted connections at breakout box (junction box) and at controller. If connections are good, replace sensor.
	Faulty sensor.	Replace sensor.
-34.6 reading.	Lead wire damaged or reversed connections.	Check schematic, repair connections.
	Open circuit in sensor lead wire or controller connections.	Replace sensor and lead wire. Test IS barrier and meter with simulator.
	Faulty power supply in meter.	Replace meter.
Erratic readings.	Damaged sensor lead wire.	Check schematic, repair connections.
	Improper connections.	Replace sensor and lead wire. Test meter with simulator.
	Faulty meter.	If faulty meter, replace meter.

© 2009 EPG Companies Inc.
LevelMaster is a Reg. TM of EPG Companies Inc.

Pump starts at normal reading, runs for a few seconds and stops.	Low liquid recovery rate. Screen on pump may be clogged. Sump clogged or plugged.	Remove pump and clean screen. May also need to disassemble pump and clean pump impellers. Remove pump and clean out sump.

FACTORY SETTINGS

LevelMaster Model SDHH Meter

Panel S/N: _____

Meter S/N: _____

Meter Designation: _____

Operating Parameters – Setup Code 35

PARAMETER	VALUE	OPERATION
Pr Hl	inches	Turns Pump ON when level on meter reads ___
Pr Lo	"	Turns Pump OFF when level on meter reads ___
AL Hi	"	Turns High Level Light ON when level on meter reads ___
Hy Hi	"	Keeps High Level Light ON until level drops ___ below AL Hi
AL H2	150.0	Turns Pump OFF when level meter reads 150.0". Greater indicates a probable level sensor failure.
Hy H2	0.0	Not used

NOTE: If the up arrow is pressed any time that the meter is operating, the highest level that the meter has observed since power was applied will be displayed.

© 2009 EPG Companies Inc.
LevelMaster is a Reg. TM of EPG Companies Inc.

S3070-PT TRANSDUCER SIMULATOR
Operation

The model 3070-PT Transducer Simulator is a device designed for testing an EPG LevelMaster™ level controller circuit while temporarily bypassing the existing level sensor.

In the "Run" (normal operation) mode liquid level in the sump applies pressure on the level sensor. The sensor converts that force into an electrical signal. The electrical signal is transmitted by the sensor cable to the level meter where it is converted into a liquid level display.

The "Test" mode simulates a level sensor signal. Rotating the potentiometer changes the electrical signal forcing the system to function as if a level sensor were in the circuit. Varying the electrical signal changes the level meter display in the same manner in which the level sensor signal would effect the system. By turning the simulator knob slowly clockwise from top to bottom the meter will display each set point such as start, stop and alarms. With the toggle switch turned back to the "Run" position the potentiometer is removed from the circuit and the level sensor controls according to the set points. Meter values register actual liquid level.

"**CAUTION**", care must be taken when using this device in "Test" mode to avoid damaging the motor by running it dry. In normal test mode the pump switch should be turned to OFF.

 © EPG Companies Inc. 2009

S3070-PT TRANSDUCER SIMULATOR
Test Procedure

1. When the toggle switch is in the "Run" position the controls should function normally.

2. When the toggle switch is in the "Test" position (pressure transducer temporarily removed from he control circuit) the level meter should display the liquid level. By turning the simulator knob slowly clockwise from top to bottom the meter will display each set point such as start, stop, and alarms. Care must be taken when using this device in the "Test" mode to avoid damaging the motor by running it dry. In normal test mode the pump switches should be off.

3. Make sure that the potentiometer has full travel (270 degrees maximum) in both clockwise and counter-clockwise directions.

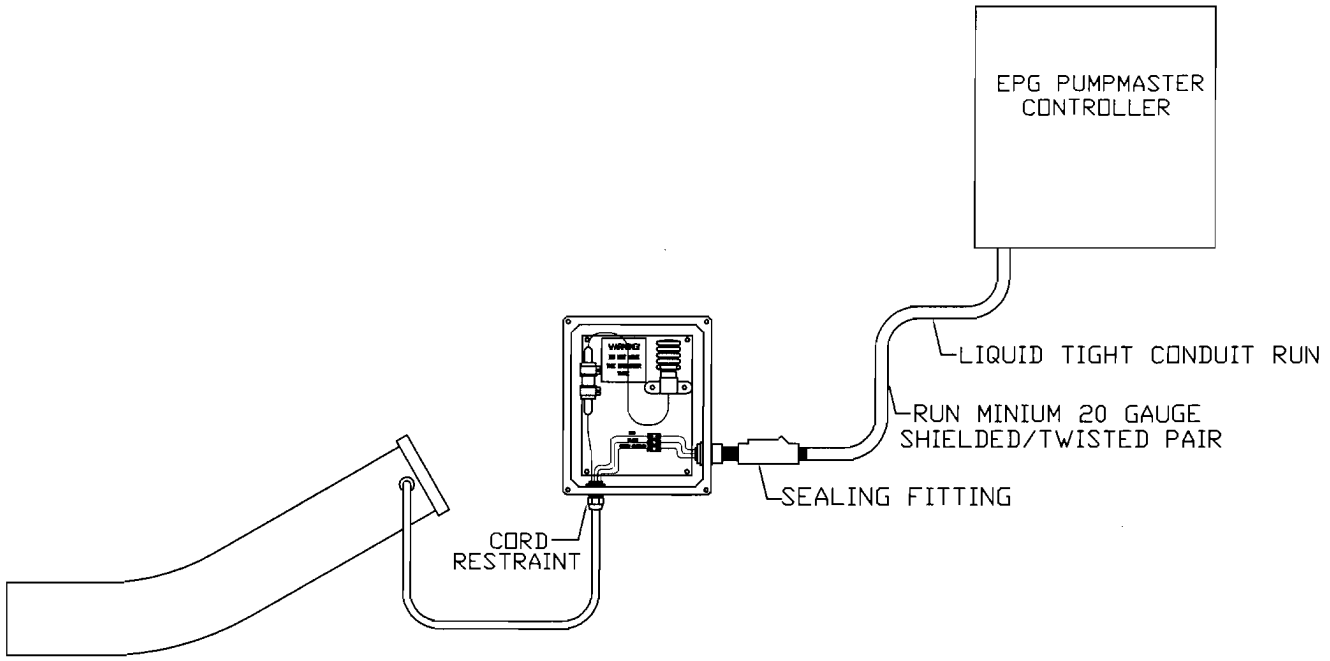
4. Make sure that all of the wires on the rear of the simulator (wires 200, 201, 202, 203) are connected in the proper position.

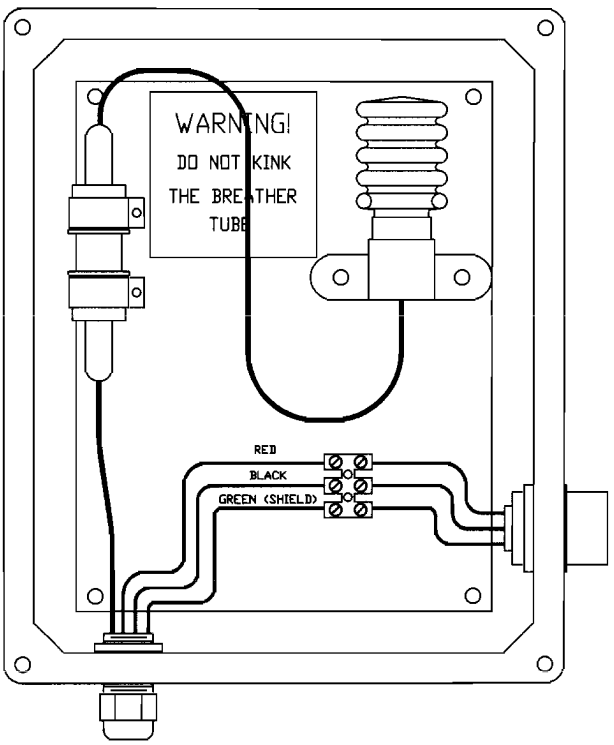
5. Replace the transducer simulator if it does not function as described above.

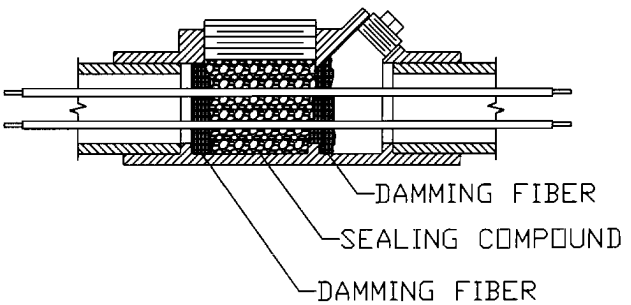
© EPG Companies Inc. 2009

BJBL 600B

BREAKOUT JUNCTION BOX FOR LEVEL SENSOR



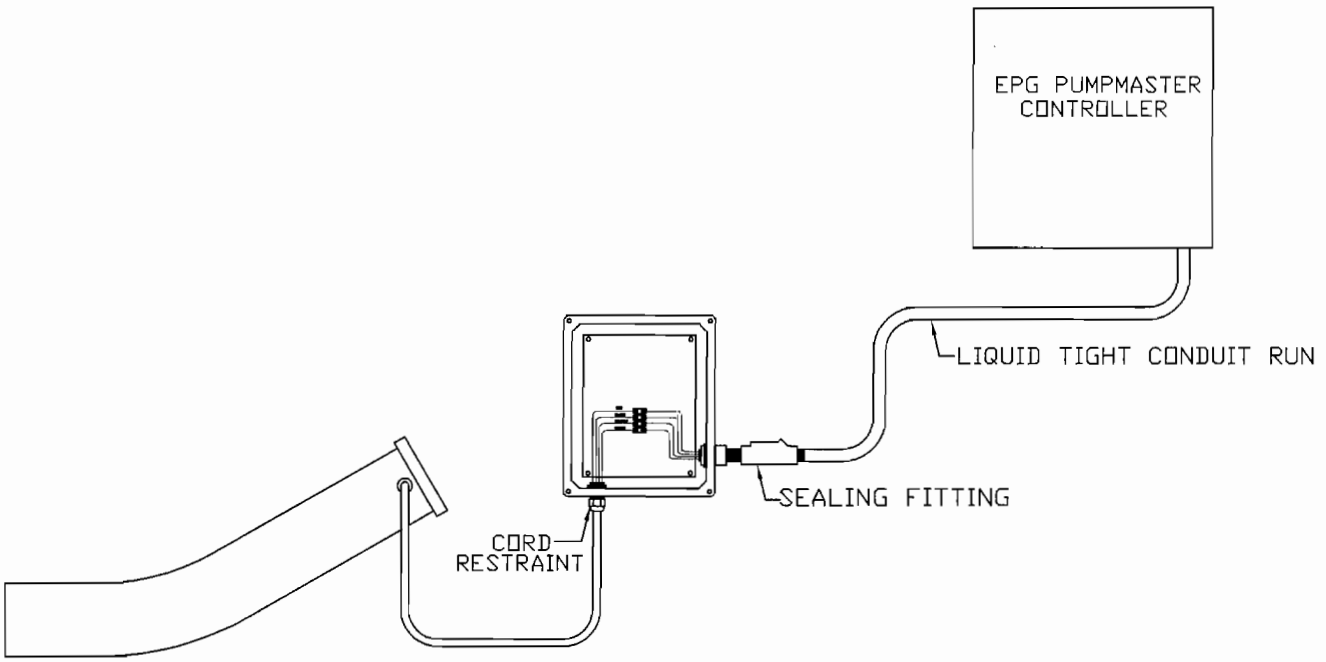


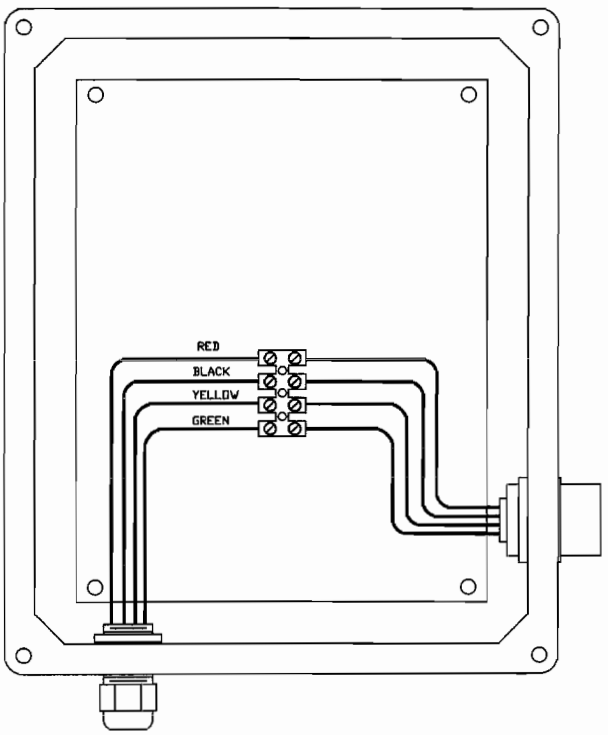


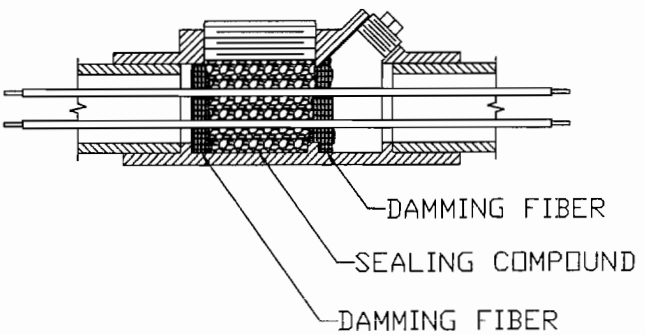
			* NOTICE *	© EPG Companies Inc. 2002	
			REFERENCE		
TOLERANCES (EXCEPT AS NOTED)	REVISIONS		EPG COMPANIES		
	NO.	DATE	BY	TYPICAL INSTALLATION	
DECIMAL ±	1				
	2				
FRACTIONAL ±	3			DESIGN C.A.S. / SCALE NONE	MATERIAL
	4			DRAWN C.A.S. / DATE 05/07/02	DRAWING NO. 02523-0605
ANGULAR ±	5			CHK'D / APP'D	

BJBP 500

BREAKOUT JUNCTION BOX FOR MOTOR LEAD







* NOTICE * © EPG Companies Inc. 2002

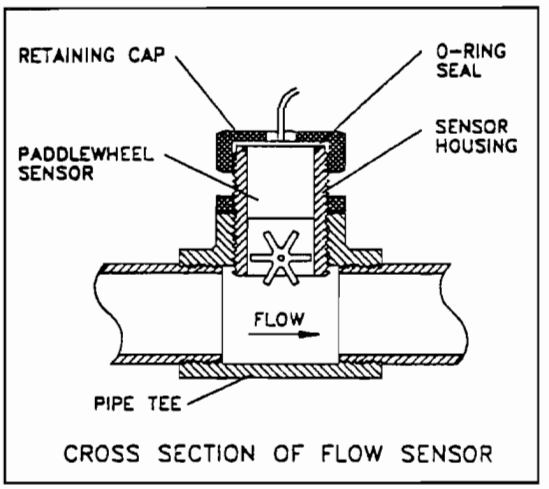
REFERENCE

TOLERANCES (EXCEPT AS NOTED)	REVISIONS NO.	DATE	BY	EPG COMPANIES			
DECIMAL ±	1			TYPICAL INSTALLATION			
	2						
FRACTIONAL ±	3			DESIGN C.A.S.	SCALE NONE	MATERIAL	
	4			DRAWN C.A.S.	DATE 05/07/02	DRAWING NO. 03626-0500	
ANGULAR ±	5			CHK'D	APP'D		

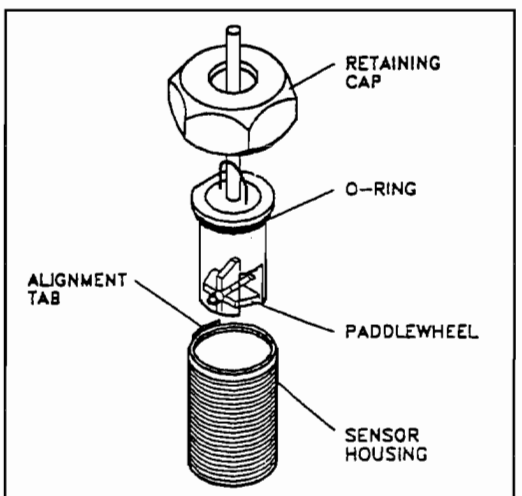
SENSOR
DATA SHEET

EPG E-Series
Liquid Flow Sensor

* Low cost
* 2 Year Warranty
* High reliability
* High sensitivity
* Wide range 2 – 10,000 GPM
* Pipe sizes from ¾"- 14"
* Patented six blade, non-magnetic design
* Available in DELRIN or KYNAR
* One paddlewheel fits ALL SIZES
* Transmits up to 1000 feet without the need for additional amplifiers
* Direct logic pulse output
* Flow velocities range of 1.5 to 27 fps
* Operating pressure to 200 PSIG
* Liquid temperatures to 250° F



CROSS SECTION OF FLOW SENSOR



STANDARD E-SERIES ASSEMBLY

One major problem with most paddlewheel type flow sensors having magnets in the paddles is that metal particles tend to stick to the magnets. The collecting material then causes a change in the flow characteristics in the paddle. To eliminate this problem, EPG Companies flow sensor uses a special axle and dual magnet drum design that takes the magnets out of the paddles. This dual magnetic drum design with rapidly changing polarity, along with fluid velocity causes the metallic particles to drop off into the flow stream and are swept away.

 © 2009 EPG Companies Inc.

INSTALLATION HINTS

1. Pipe must be full for accurate reading.

2. Minimum velocity is 1.5 ft./second. Recommended maximum velocity is 27 ft./second.

3. The flow must be uniform at the point where the flow sensor is installed or an incorrect reading will result. To accommodate a uniform flow allow at least ten (10) pipe diameters upstream and five (5) pipe diameters downstream of the flow sensor. Non-uniform flow is often caused by elbows, partially open valves or an increase in pipe diameter.

Model Number	Nominal Pipe Size	Recommended Range 1.5 ft/sec Flow Rate GPM	27 ft/sec Flow Rate GPM
EP 075	¾"	2.0	37.2
EP 100	1"	3.7	66.2
EP 125	1¼"	5.7	103.4
EP 150	1½"	8.3	148.8
EP 200	2"	14.7	264.6
EP 250	2½"	23.0	413.4
EP 300	3"	33.1	595.4
EP 400	4"	58.8	1058.4
EP 500	5"	91.9	1653.8
EP 600	6"	132.3	2381.4

 © 2009 EPG Companies Inc.

Flow Meter Operation

EPG's meter system is an 8 digit Flow Rate/Totalizer. The meter counts pulses from a flow sensor and converts this information into flow rate and total flow using programmed scaling factors.

The meter features menu driven programming to simplify meter set-up. The meter stores parameters entered into non-volatile memory. This memory retains the parameters even when power to the panel is shut off.

Figure 1 shows the meter display and keypad and gives a brief description of each key's function.

Two Line LCD Display - Shows totalizer and rate values when the unit is in the run mode. Displays programming information when the unit is in the program mode.

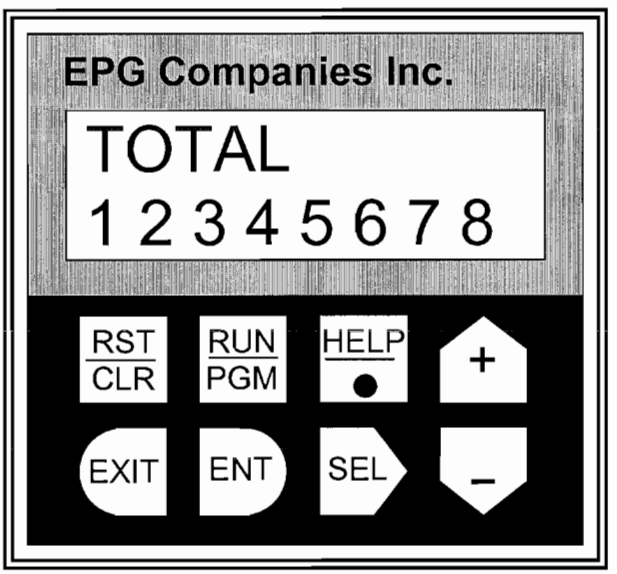


Figure 1. Meter Display and Keypad

 © 2009 EPG Companies Inc.

Key Functions

Reset/Clear Key - This key can be programmed to reset the totalizer when in the run mode. In the program mode it zeros numeric data that is selected for editing.

Run/Program Key - Press this key followed by the Enter key (ENT) to enter the program mode. Pressing this key while in the program mode returns the control to the run mode.

Help Key - In the run mode this key causes the Help Screens to be displayed. In the program mode this key is used to set the decimal point positions for totalizer and rate scaler displays.

Up Arrow/Plus (+) Key - In the run mode this key is used to select one of the three different display screens. In the program mode this key is used to step vertically up through the menus and increment the value of selected digits when changing numeric values.

Exit Key - This key is used in the program mode to exit program changes that have been selected but not yet entered.

Enter Key - This key is used in the program mode to cause the displayed program changes to be entered.

Select Key - This key is used in the program to move into more detailed menus and select the digits of numeric values needed for programming.

Down Arrow/Minus (-) Key - In the run mode this key is used to select one of the two different display screens. In the program mode this key is used to step vertically down through the menus and decrease the value of selected digits when changing numeric values.

Program Scalers:

Setting	Value	Function
C DEC PT	- - - - - -	Sets decimal point to the right of the last digit on the TOTAL Display.
R DEC PT	- - - - - -	Sets decimal point to the right of the last digit on the FLOW RATE Display.
C SCALER	See Below	Used to convert sensor pulses into Total Gallons.
R SCALER	See Below	Used to convert sensor pulses into Gallons/Minute.

Program Options:

Setting	Value	Function
RST KEY	RST EDG	Reset Key will Clear Totalizer Count.

Tables 1 and 2 show the keystroke operations necessary to change scale parameters and "Reset Key" enable/disable function.

 © 2009 EPG Companies Inc.

Flow meter setup procedures for scalers

STEP NO.	ACTION
1	Press **Run/PGM** to exit "Run" mode.
2	Press **ENT** to enter "Program" mode.
3	Press **–** to scroll through main menu. Find "Program Scalers" on the meter display.
4	Press **SEL** to enter "SCALERS" menu.
5	Press **–** to scroll the "SCALERS" menu and bring up the "C SCALER" option on the meter display.
6	Press **SEL** to select the "C SCALER" and begin operation on the left most digit of the "C SCALER" value. Use the **+** and **–** keys to increase or decrease the digit to achieve the desired number. Press **SEL** to enter this digit and move to the next digit. Repeat this step until the meter displays the desired value for the "C SCALER"
7	Press **ENT** to enter the "C SCALER " value into non-volatile memory.
8	Press **–** to display the "C DEC PT" option. Use the **SEL** key to select the last dash on the right as displayed on the meter. Use the **HELP/.** key to place the decimal point to the right of this position (decimal point will not be visible).
9	Press **ENT** to enter this selection into memory.
10	Press **–** to bring up the "R SCALER" option on the meter display.
11	Press **SEL** to select the "R SCALER" and begin operation on the left most digit of the "R SCALER" value. Use the **+** and **–** keys to increase or decrease the digit to achieve the desired number. Press **SEL** to enter this digit and move to the next digit. Repeat this step until the desired value for the "R SCALER" is in the meter display. Also use the **SEL** and **HELP/.** Keys to position the decimal point to the desired position.
12	Press **ENT** to enter this value into the non-volatile memory.
13	Press **–** to display the "R DEC PT" option. Use the **SEL** key to select the last dash on the right as displayed on the meter. Use the **HELP/.** key to place the decimal point to the right of this position (decimal point will not be visible).
14	Press **ENT** to enter this selection into non-volatile memory.
15	Press **EXIT** to exit "Program" mode.
16	Press **RUN/PGM** to enter "Run" mode.

Table 1. Flow Meter Scaler Sequence

 © 2009 EPG Companies Inc.

Flow meter setup procedures for reset key

STEP NO.	ACTION
1	Press **Run/PGM** to exit "Run" mode.
2	Press **ENT** to enter "Program" mode.
3	Press + to scroll through main menu. Find "Program Options" on the meter display.
4	Press **SEL** to enter "OPTIONS" menu.
5	Press + to scroll the "OPTIONS" menu and bring up the "RST KEY" option on the meter display.
6	Press **SEL** to select the "RST KEY" menu.
7	Press + to display the desired key option. Options include: RST KEY DISABLED — This option prevents the reset key from clearing the totalizer count. RST KEY RST EDG — This option allows clearing of the totalizer count using the reset key.
8	Press **ENT** to select the desired option.
9	Press **EXIT** to exit "Program" mode.
10	Press **RUN/PGM** to enter "Run" mode.

Table 2. Reset Key Programming Sequence

The programmed scaling factors used are dependent upon the inside pipe diameter of the flow sensor tube. Tables 3 to 6 list the various scaling factors used for the different diameter (nominal O.D.) and schedule (wall thickness) of Stainless Steel and PVC pipes.

Pipe Size	C SCALER	R SCALER
1.0" Low Flow	.01808	1.0849
1.00	.02996	1.7973
1.25	.05184	3.1105
1.50	.07056	4.2338
2.00	.11631	6.9784
2.50	.16595	9.9567
3.00	.25623	15.374
4.00	.44124	26.474
6.00	1.0014	60.081
8.00	1.7340	104.04

Table 3. Flow Meter Settings – Stainless Steel Schedule 40

 © 2009 EPG Companies Inc.

Pipe Size	C SCALER	R SCALER
1.0" Low Flow	.01808	1.0849
1.00	.02493	1.4959
1.25	.04446	2.6677
1.50	.06125	3.6750
2.00	.10235	6.1409
2.50	.14690	8.8140
3.00	.22894	13.736
4.00	.39849	23.909
6.00	.90348	54.209
8.00	1.5827	94.963

Table 4. Flow Meter Settings – Stainless Steel Schedule 80

Pipe Size	C SCALER	R SCALER
1.00	.02996	1.7973
1.25	.05184	3.1105
1.50	.07056	4.2338
2.00	.11631	6.9784
2.50	.16595	9.9567
3.00	.25623	15.374
4.00	.44124	26.474
6.00	1.0014	60.081
8.00	1.7340	104.04

Table 5. Flow Meter Settings – PVC Schedule 40

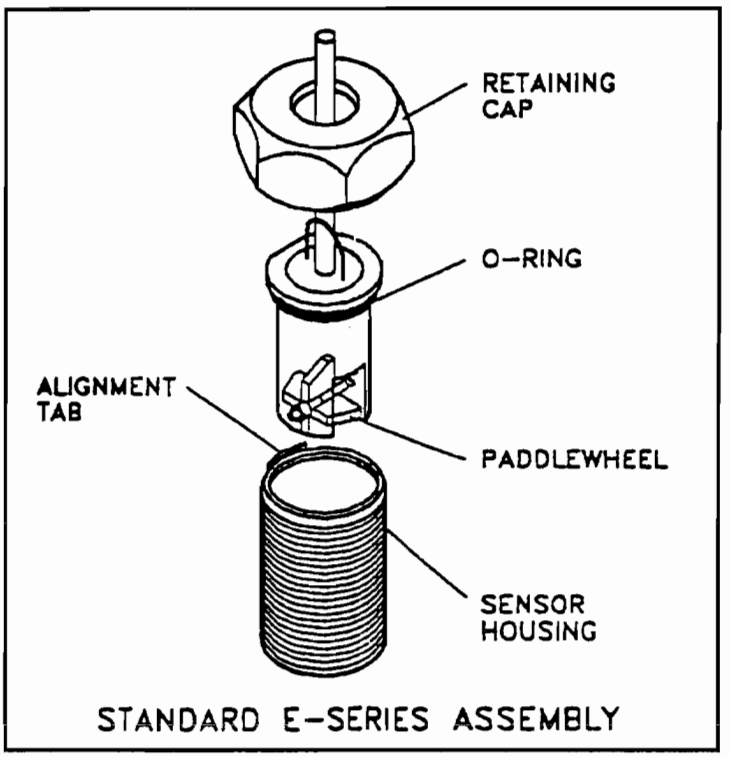
Pipe Size	C SCALER	R SCALER
1.00	.02493	1.4959
1.25	.04446	2.6677
1.50	.06125	3.6750
2.00	.10235	6.1409
2.50	.14690	8.8140
3.00	.22894	13.736
4.00	.39849	23.909
6.00	.90348	54.209
8.00	1.5827	94.963

Table 6. Flow Meter Settings – PVC Schedule 80

 © 2009 EPG Companies Inc.

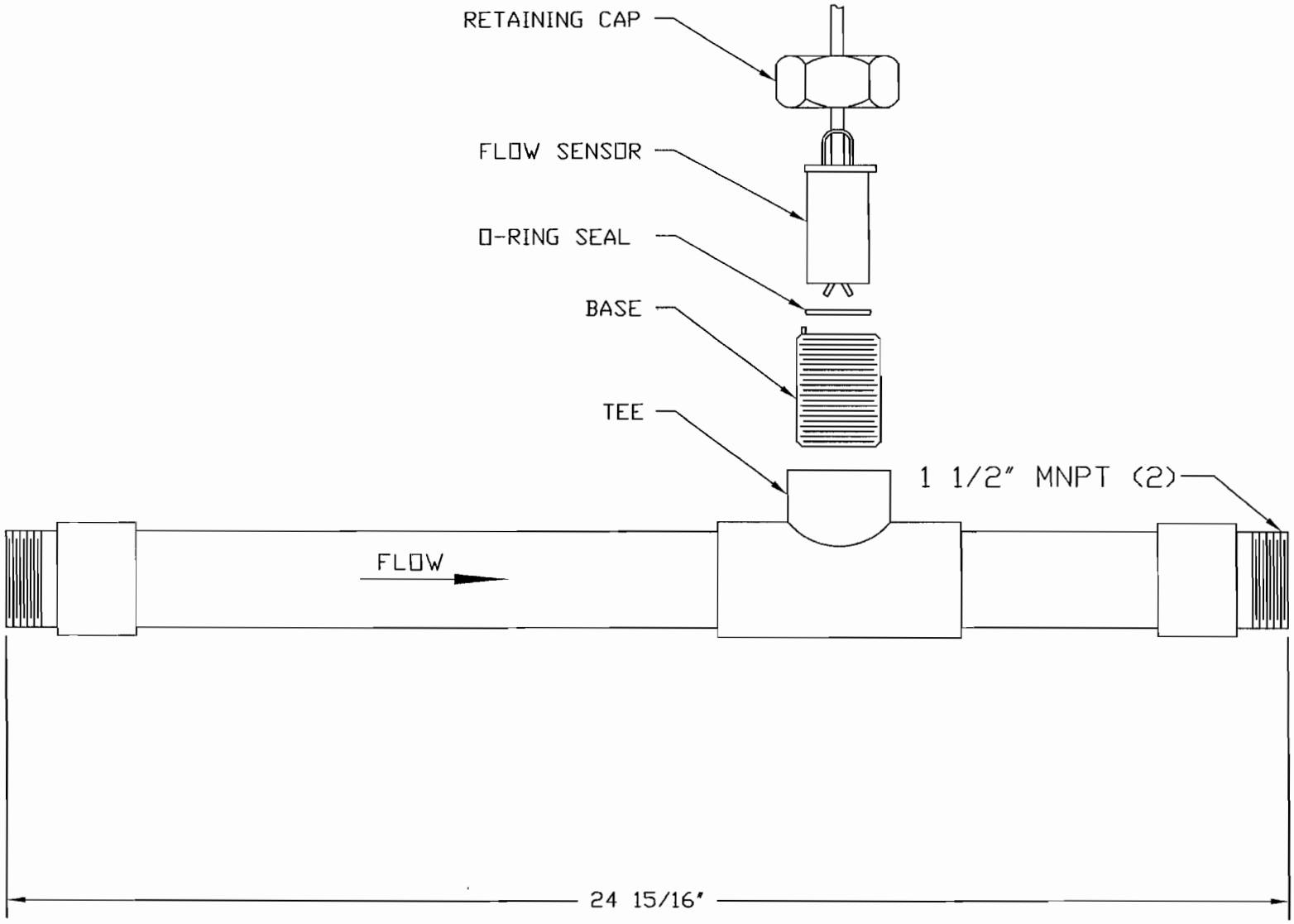
CAUTION

DO NOT OVERTIGHTEN PADDLEWHEEL FLOW SENSOR NUT!



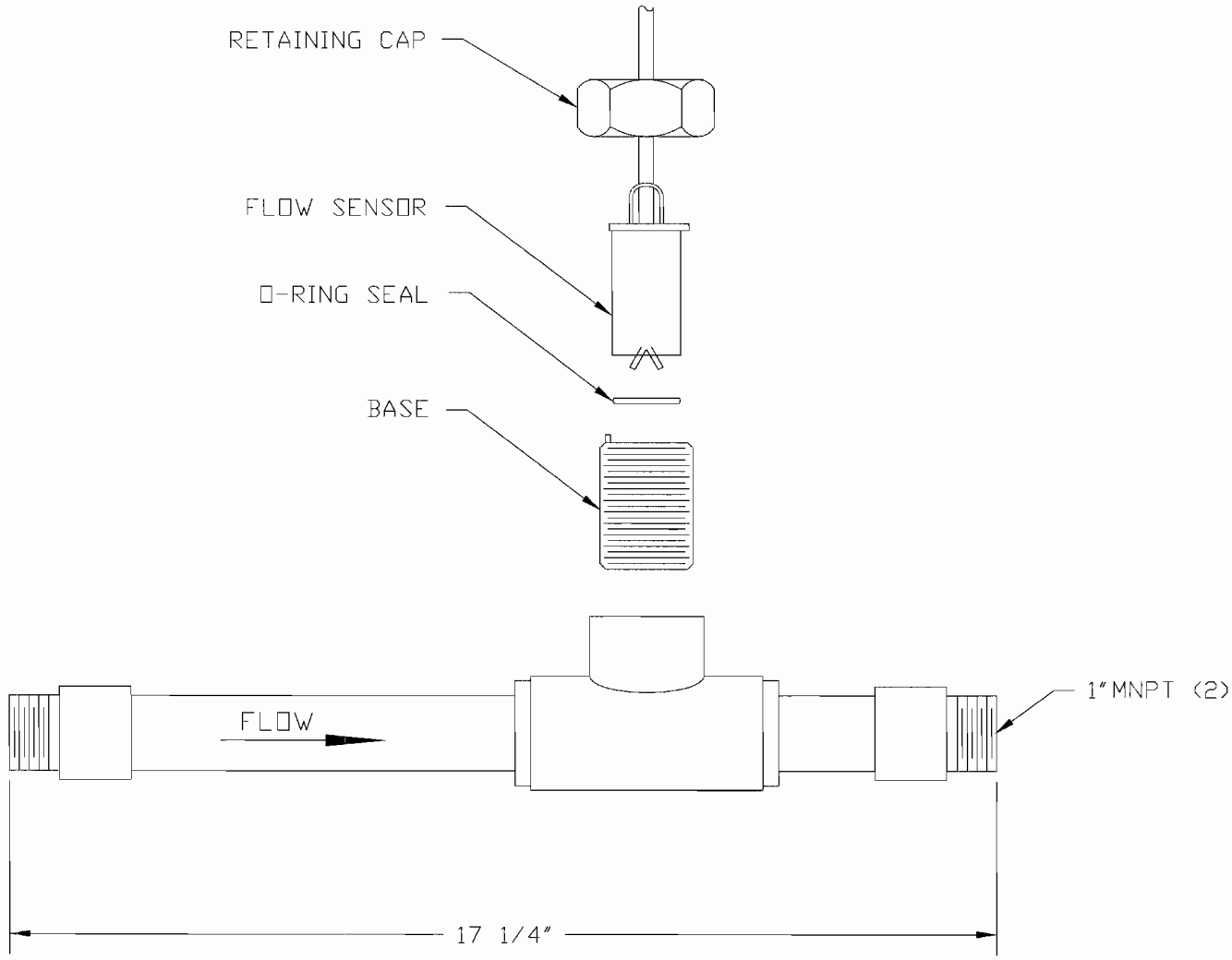
Damage can be caused to the paddlewheel sensor, o-ring, or sensor housing. Please hand tighten nut only!

EPG Companies Inc. © 2009



* NOTICE * © EPG Companies Inc. 2001
THIS DRAWING IS THE PROPERTY OF EPG COMPANIES FOR REFERENCE ONLY.

TOLERANCES (EXCEPT AS NOTED)	REVISIONS			EPG COMPANIES		
DECIMAL ± .06	NO.	DATE	BY	PVC FLOW SPOOL (1 1/2" MNPT ENDS)		
FRACTIONAL ± 1/16	1			DESIGN C.A.S.	SCALE NONE	MATERIAL
ANGULAR ± 1°	2			DRAWN C.A.S.	DATE 07/30/01	DRAWING NO. 05392-0000C
	3			CHK'D	APP'D	
	4					
	5					



JOB No.

* NOTICE * © EPG Companies Inc. 2006

THIS DRAWING IS THE PROPERTY OF EPG COMPANIES FOR REFERENCE ONLY.

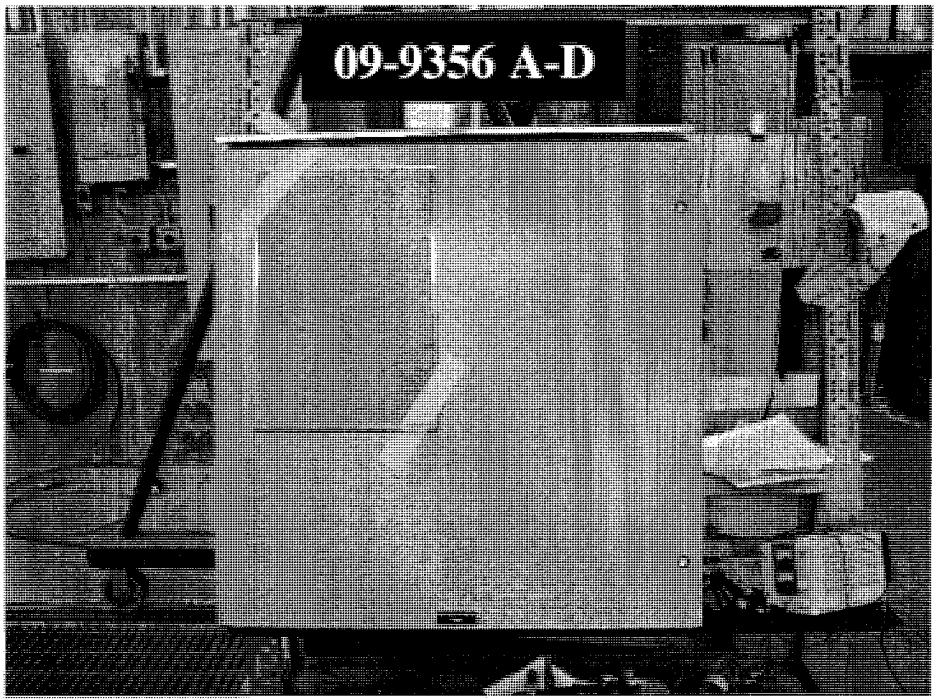
TOLERANCES (EXCEPT AS NOTED)	
DECIMAL ±	.06
FRACTIONAL ±	1/16
ANGULAR ±	1°

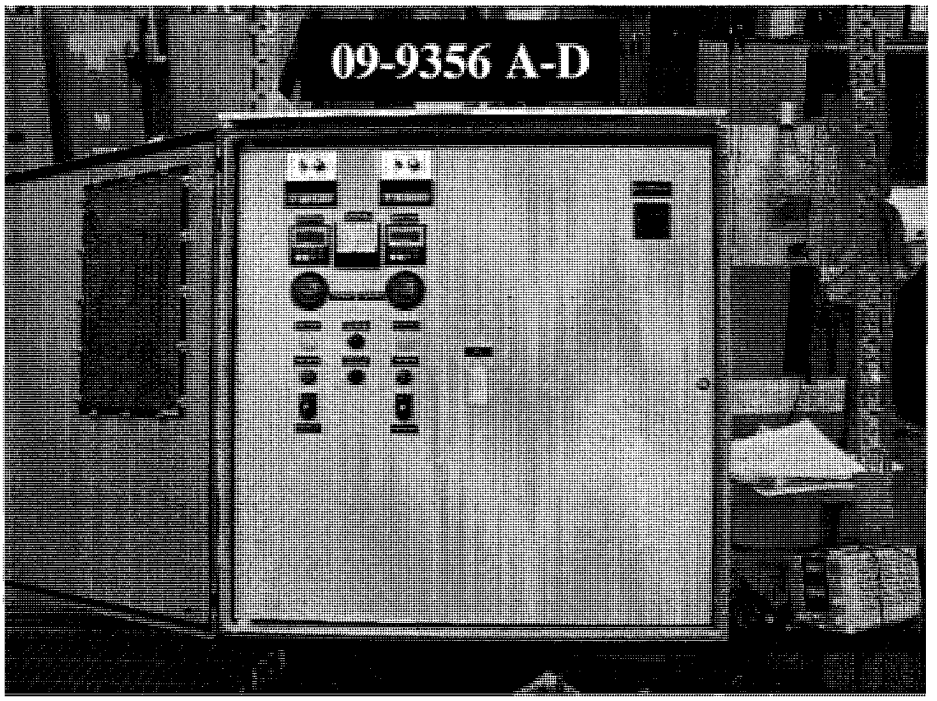
REVISIONS		
NO.	DATE	BY
1		
2		
3		
4		
5		

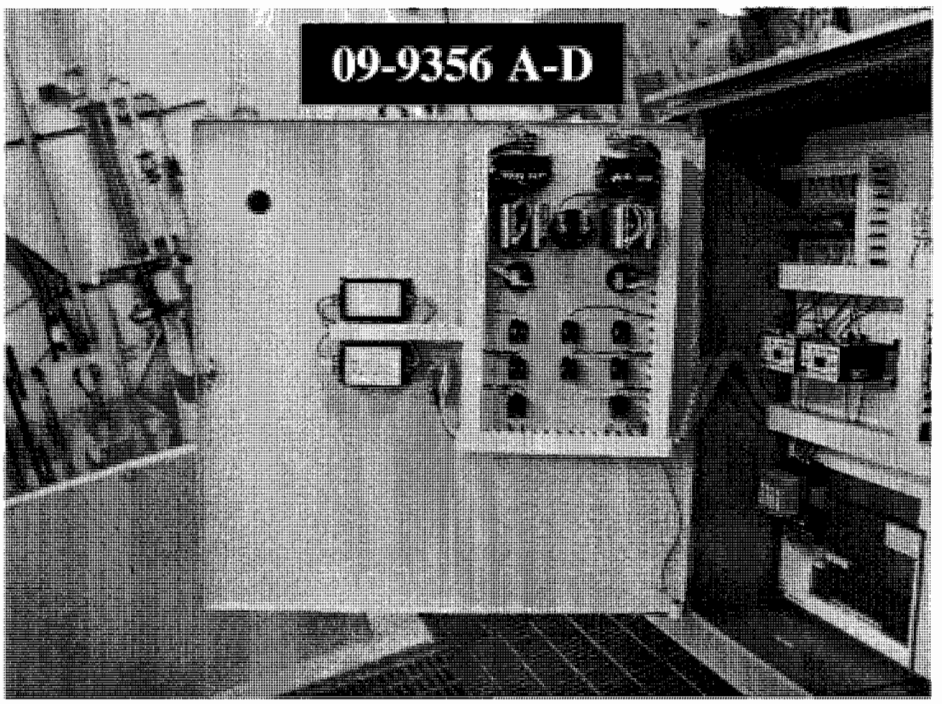
EPG COMPANIES

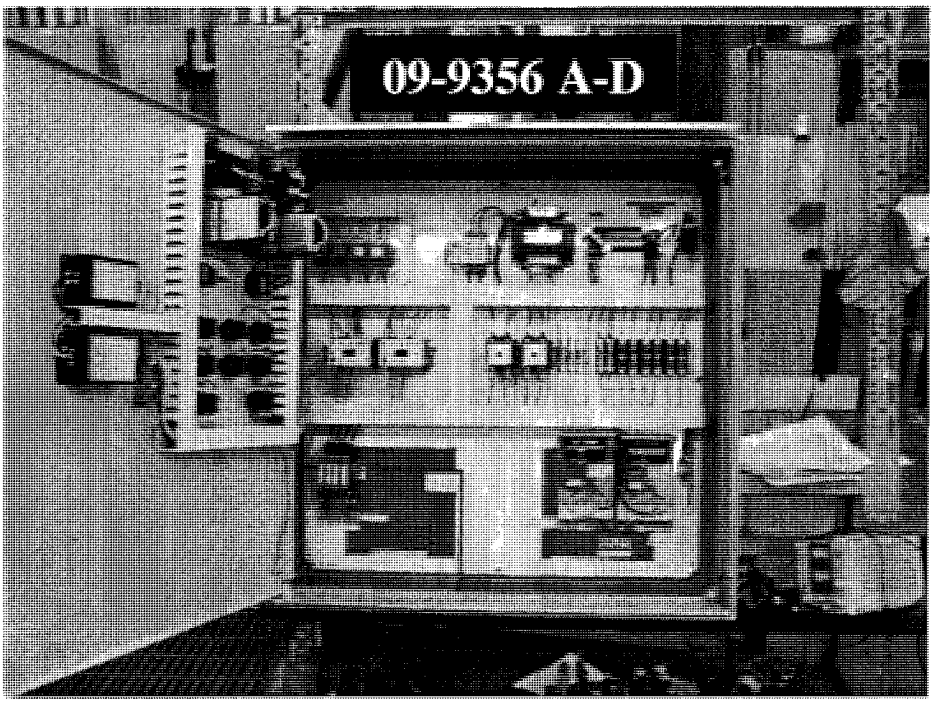
1" PVC,SCH.40, FLOW SPOOL
(W/1"MNPT ENDS)

DESIGN	C.A.S.	SCALE 4"=1'	MATERIAL
DRAWN	C.A.S.	DATE 11/01/06	DRAWING NO. 07761-0000C
CHK'D		APP'D	


09-9356 A-D


09-9356 A-D


09-9356 A-D


09-9356 A-D

LIMITED WARRANTY

This agreement shall be deemed to have been entered into in the State of Minnesota, and shall be construed in accordance with the laws of the State of Minnesota, including Minnesota's enactment of the Uniform Commercial Code. Buyer hereby stipulates and agrees that Hennepin County, Minnesota shall be the proper jurisdiction for adjudicating all claims and controversies arising from this agreement.

Products manufactured by EPG Companies Inc. are warranted for a period of 12 months from date of installation or eighteen (18) months from date of manufacture* to be free from defects of materials and workmanship. It is expressly agreed that the exclusive remedy under this warranty is limited solely to the repair or replacement, at the sole discretion of EPG, of the part that failed. The cost of labor for any field repairs is not covered by this warranty. EPG Companies will not be liable for any damage or wear due to abnormal conditions or improper installation.

Products not manufactured by EPG Companies Inc. are covered by the original manufacturer's warranty, which EPG Companies passes through to the purchaser. The actual manufacturer will make warranty determination.

To have a defective part repaired or replaced, you must return the defective product to EPG Companies. Please call (800) 443-7426 or (763) 424-2613 to obtain a Return Goods Authorization (RGA) number. Send defective product (freight prepaid) with RGA #, description of installation, installation data and failure date to EPG Companies Inc., 19900 County Rd. 81, Maple Grove, MN 55311.

EPG Companies will not be held liable for any incidental or consequential damages, losses or expenses incurred from installation, use or any other reason. THERE ARE NO OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING IMPLIED WARRANTIES OF EITHER FITNESS FOR A PARTICULAR PURPOSE OR OF MERCHANTABILITY, WHICH EXTEND BEYOND THOSE SPECIFICALLY LISTED HERE.

If equipment is to be stored for a period greater than six months, proper storage precautions must be taken if the warranty is to be maintained. Please call EPG Companies for specific requirements regarding product storage.

The following is a partial list of items, which will void the warranty:

- Opening the motor for any reason.
- Using undersized electrical wire.
- Making unauthorized circuit changes. Please call EPG Companies before making any changes.
- Operating a three phase submersible motor from single phase power through a phase converter unless 3-leg ambient-compensated quick trip overload protectors are used and complete details are sent in writing to EPG Companies.

* To qualify for the delayed installation warranty you must contact EPG Companies Inc., at (800) 443-7426 or (763) 424-2613 within 60 days of purchase.

© EPG Companies Inc. 2009

Pump Operation Standard Operating Procedures

Pump Operation Standard Operating Procedure

1. Evaluate current leachate levels by referencing the appropriate level sensor meters.
2. If there is sufficient leachate present in the sump in accordance with the Pump System Control Panel parameters specified in this plan, then proceed to the following steps.
3. Securely connect discharge hose to the riser outlet and to the water truck.
4. Temporarily turn off the Control Panel Main Power Switch and connect Control Panel plug into 230VAC 1 Phase compatible generator.
5. Start Generator.
6. Turn back on Control Panel Main Power Switch.
7. Note current Flow Meter value or press clear to start with 0 gal.
8. Turn pump switch to "Auto"...the pump is now activated and you should see the flow meter total gallons pumped and flow rate readings update.
9. Flow rates should be in general accordance with design specifications...If not, straighten out discharge line to ensure unhindered flow.
10. Pump will remain on until minimum draw down parameters are met, as specified in this plan.
11. Once the draw down parameters are met, the pump will turn off.
12. Turn pump switch to off position (middle position between "Hand" and "Auto").
13. Note gallons pumped.
14. Temporarily turn off Control Panel Main Power Switch and turn off generator.
15. Turn back on Control Panel Main Power Switch and ensure level sensor meter is on.
16. Carefully disconnect discharge line from riser.
17. Carefully dispense of excess leachate within the hose into a 5 gallon bucket.
18. Dispose of leachate within the 5 gallon bucket into the water truck.
19. Carefully disconnect discharge line from water truck and repeat steps 17 and 18 above.

Other points of consideration when operating system

1. If you have to remove the pump from the riser for maintenance, you must utilize the pumps 1/8" stainless steel suspension cable (DO NOT PULL ON THE DISCHARGE LINE COMPONENTS).
2. As you remove the pump from the riser, you must 1st remove the flow meter and then clip the zip ties that connect the motor and level sensor leads to the discharge line...once you see the blue vent valve, you can stop cutting the zip ties and pull the pump out.
3. Place pump on a garbage bag to prevent dirt from entering the pump inlet.

4. When you are ready to insert the pump components back into the riser, lower the pump SLOWLY and replace the zip ties removed during extraction.

Attachment AA
Geosyntec Letter Regarding Invenergy Design

Basic Remediation Company (BRC)
Corrective Action Management Unit (CAMU)
Henderson, Nevada

Geosyntec consultants

10875 Rancho Bernardo Road, Suite 200
San Diego, California 92127
PH 858.674.6559
FAX 858.674.6586
www.geosyntec.com

9 August 2011

Lee C. Farris, P.E.
Vice President
Basic Remediation Company
875 West Warm Springs Road
Henderson, Nevada 89015

Subject: CAMU/BMI Landfill Surface Use Photovoltaic Project
Invenergy Solar Development
Henderson, Nevada

Dear Mr. Farris:

In accordance with your request, Geosyntec Consultants (Geosyntec) is pleased to submit to Basic Remediation Company (BRC) the following comments regarding the subject report, prepared by Invenergy Solar Development LLC dated 27 July 2011.

1. Based on the weight information provided, the ground pressure is approximately 351 psf or 2.43 psi. The loading is less than the loads used in the design (10.1 psi at the top of the geosynthetic liner system) of the final cover system. Therefore, the proposed loading should not adversely impact the performance of the cover system geomembrane barrier.

2. Based on the weight information provided, the additional loading is insignificant and should not affect global stability of the CAMU.

3. Panel locations are not proposed on the side slopes, therefore veneer stability should not be affected.

4. No wind loading was provided, but there may be an increase in the bearing pressure from eccentric loading associated with wind. However, as long as the total loading is less than 10.1 psi at the top of the geosynthetic liner system, the cover system should not be adversely affected.

5. The panels are shown in the “open” areas of BMI North and Phase V and the figures don’t reflect the revised Phase V grading.

6. Trenching will need to be monitored and the installer will need to be aware of the potential repair requirements if the geosynthetic materials are damaged.

7. Based on the cover system design calculations, traffic loads on the cover system should be limited to a loading that does not exceed 10.1 psi at the top of the geosynthetic liner system.

If you have any questions or require additional information, please contact me at (858) 674-6559.

Sincerely,

Gregory T. Corcoran, P.E.
Principal

Attachment AB
Future Solar Partner Design Documents
[Reserved]

Basic Remediation Company (BRC)
Corrective Action Management Unit (CAMU)
Henderson, Nevada

Attachment AC
Responses to Interim CAMU Design Review

Basic Remediation Company (BRC)
Corrective Action Management Unit (CAMU)
Henderson, Nevada

Geosyntec consultants

10875 Rancho Bernardo Road
Suite 200
San Diego, CA 92127

PH 858.674.6559
FAX 858.674.6586

www.geosyntec.com

8 January 2008

Mr. Brian Rakvica, P.E.
Nevada Division of Environmental Protection
Bureau of Corrective Actions
2030 E. Flamingo Road, Suite 230
Las Vegas, NV 89119

Subject: Response to Interim CAMU Design Review Report
BMI Industrial Complex Remediation Design Review
Henderson, Nevada
Geosyntec Project: SC0313

Dear Mr. Rakvica:

On behalf of Basic Remediation Company (BRC), Geosyntec Consultants (Geosyntec) hereby responds to the 14 December 2007 letter written by Applied Soil Water Technologies, LLC (ASW) to Nevada Department of Environmental Protection (NDEP) regarding the Interim CAMU Design Review. The ASW review focused on the following aspects of the CAMU design:

- Base liner system design standard equivalency;
- Geomembrane Chemical Compatibility; and
- Waste Placement Phasing.

For ease of review, the ASW's discussion will be repeated in italics with Geosyntec's response following.

Design Standard/Basis of Design - Discussion

GCL Hydraulic Conductivity

The GCL hydraulic conductivity used in the equivalency evaluation was $5x10^{-9}$ cm/sec was justified by stating "...the maximum hydraulic conductivity reported in manufacturer's documentation and typically allowed in technical specifications for GCLs." There is considerable literature available that indicates that the sodium in the bentonite within the GCL

is readily replaced through cation exchange which can cause an increase in hydraulic conductivity. Exchange has been observed in cases of both direct pore water contact in saturated soils and in contact with moist soil. There is some indication that, for base liners subject to higher compressive stresses, the increase in hydraulic conductivity may not be significant. Due to the arid nature of the site, calcium, magnesium, and potassium cations may be available in the native soils. The close proximity of ground water, provided the potential for the GCL to hydrate and for cation exchange to occur. When the hydraulic conductivity of the GCL is increased by one-half order of magnitude to $1x10^{-8}$ cm/sec the ratio of prescriptive liner system flow to alternate liner system flow is reduced to 0.97 using a 3-feet thick Compacted Soil liner.

The potential for the geosynthetic clay liner's (GCL) hydraulic conductivity to increase due to cation exchange was discussed during the 20 December 2007 meeting with NDEP. It was agreed that the site specific design and proposed operation of the CAMU result in high normal stresses on the liner system and sufficient separation from groundwater to minimize the potential for cation exchange.

Time for Break-Through and Attenuation

Other performance criteria to consider when evaluating equivalency include the time it will take potential fugitive solution to break-through the bottom of the liner system and the difference in attenuation potential of constituent concentrations as fugitive solution migrates through the soil component of the liner system.

Time for break-through and attenuation was discussed during the 20 December 2007 meeting with NDEP and it was decided the calculations would not add value.

Consistency with the Technical Specifications

The technical specifications do not specify a maximum hydraulic conductivity, rather a maximum flux rate of "...no greater than $1x10^{-8}$ m^3/m^2-sec when measured in a flexible wall permeameter in accordance with ASTM D5887 under an effective confining stress of 5 pounds per square inch." The designer should verify that this specification is consistent with the assumptions used in the equivalency evaluation.

Current industry standard utilizes flux rate (ASTM D 5887) in lieu of hydraulic conductivity (ASTM D 5084) to measure the liquid flow through a geosynthetic clay liner (GCL). A flux rate of $1x10^{-8}$ m^3/m^2-sec and a hydraulic conductivity $5x10^{-9}$ cm/sec are generally equivalent at an effective confining stress of 5 psi.

There is no minimum thickness specified. The designer should provide assurance that the assumptions with respect to thickness used in the equivalency evaluation are maintained during construction.

Koerner and Daniel (1993) report that the "...bentonite layer is typically 7 to 10 mm thick and is placed at a unit weight of approximately 5.0 kg/m^2." This thickness range, 0.27 to 0.39 inches, is higher than the value of 0.2 inches used in the calculation, which results in a conservative evaluation of the GCL equivalency.

Allowance for "...an alternative GCL having a textured vapor barrier (i.e., geomembrane) as an integral component of the GCL may be provided." The designer should verify that this material is consistent with the assumptions used in the equivalency evaluation.

A GCL with a textured vapor barrier, or geomembrane, component will provide greater protection than the standard geotextile encased GCL as it provides a second geomembrane. Geomembranes have a typical hydraulic conductivity value of less than 1×10^{-13} cm/s which would reduce flow in series with the GCL's 5×10^{-9} cm/s hydraulic conductivity.

Seams

There is no requirement for granular bentonite to be placed between the overlap at the seams. The designer should justify the hydraulic integrity of the seams as currently specified.

The seaming requirement described in the Specifications states that GCL shall be seamed with the Manufacturer's recommended procedures. The Manufacturer's typical seaming recommendations include bentonite-enhanced seams with a bentonite application rate of one quarter pound per lineal foot.

High Density Polyethylene (HDPE) Chemical Compatibility

The designer should address the potential for chemical degradation of the HDPE component of the base liner system from all potential sources including the slit trench soils and mitigating measures that have been or will be taken. Consideration of potential impacts to the bentonite component of the GCL should also be made.

In accordance with Section 02205, Part 3.09.M, a minimum of 6 feet (2 feet of operations layer soil and 4 feet of contaminated soils) shall be placed prior to placement of Slit Trench waste material. This requirement, coupled with the dry nature of the waste material placed in the

CAMU, will limit the potential for high concentrations of chemicals from contacting the geosynthetic liner system components. Also, the nature of the slit trench waste is typically not at concentrations that are representative of pure chemical and are not representative of typical chemical compatibility testing solutions.

Waste Placement Phasing-Discussion

The designer should discuss phasing of the waste placement in the landfill in coordination with mitigation of potential chemical degradation.

The construction schedule is phased such that the slit trench wastes will be placed into Phase I and II cells after placement of the 6-foot depth of contaminated soils. In general, the anticipated CAMU construction schedule will be as follows:

Construction Element	Start (month)	Finish (month)
Stomwater Controls	1	2
Phase I Cell Construction	2	4
Phase II Cell Construction	4	5
Western Ditch Excavation	4	5
Slit Trench Excavation	5	7
East Side Soil Excavation	5	18
Phase IIIA Cell Construction	5	6
Phase IIIB Cell Construction	9	11
Phase IV Cell Construction	7	12
Phase V Cell Construction	8	13

Upon award of the project to a general contractor, a detailed construction schedule can be provided.

Since the East Side Area and Western Ditch Material soils will be closest to the geomembrane the compatibility of the chemicals and concentrations in these soils should be evaluated.

The concentrations of chemicals within the East Side Area and Western Ditch Material soils are not great enough to cause compatibility issues with the HDPE geomembrane. In addition, the dry nature of the soil when placed will limit the contact of chemicals with the liner system

components. A summary of soil sampling results is provided in Attachment C of the RAP. A summary of geotechnical data related to the East Side Area waste materials is contained in the Geotechnical & Environmental Services, Inc. (GES) report dated 1 October 2007, which is attached to this letter.

Miscellaneous

Consideration should be given to constructing a shallow ditch or other means to secure the solid LCRS pipe between phases I and II.

The LCRS pipe will be secured against the side slope between phases II and IIIA with several separate lifts of 2-ft thick operations layer soil placed in 10-ft vertical lifts during construction and subsequent waste placement. Upon completion of the cell construction, the LCRS pipe will be secured with operations layer 10-ft vertical up the side slope and 10-ft across the top of the slope. The LCRS pipe will be positioned prior to operations layer placmenet to minimize kinking or other potential damage.

On Sheet 20 or 45 in the legend the symbol for the existing monitoring wells states "Existing Monitoring Well (Protect in Place)." If these monitoring wells are to be protected in place there should be details for the penetration of the HDPE and GCL for both the base liner system and the cover line system. If the monitoring wells are to be abandoned, the note should be changed. This note should be checked in the entire set of drawings and modified or detailed accordingly.

The drawing set has been revised to distinguish between wells to be abandoned and wells to be protected in place (located along the perimeter of the CAMU). Also, at the start of construction, wells will have already been abandoned and the wells that will remain in place will have protection during construction.

If you have any additional questions please feel free to contact me at (858) 674-6559

Sincerely,

Rebecca Flynn, E.I.T.
Senior Staff Engineer

Gregory T. Corcoran, P.E.
Principal

Attachments: Eastside Geotech Sampling Report dated 1 October 2007, prepared by GES for Basic Remediation Company
Saturated Veneer Stability Calculation Package

Copies to: Ranajit Sahu, C.E.M., Ph.D., Basic Remediation Company
Robert B. Valceschini, P.E.

References:

Koerner, R.M., and Daniel, D.E.; "Technical Equivalency Assessment of GCLs to CCLs"; Proceedings of the 7th GRI Seminar, Philadelphia, PA, December 1993.

GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.

PROVIDING
- Geotechnical Engineering
- Construction Materials Engineering
- Environmental Engineering
- Drilling Services

October 1, 2007
Project No. 20072247V1

Mr. Ranajit Sahu, C.E.M., Ph.D.
Basic Remediation Company
875 West Warm Springs Road
Henderson, Nevada 89011

RE: Eastside Geotech Sampling, Henderson, Nevada

Dear Dr. Sahu:

On September 13, 2007 Geotechnical and Environmental Services, Inc. (GES) implemented sampling 26 total locations predetermined by BRC. This activity report details the scope of services performed, which consisted of the following:

- Survey of each sample location with a GPS Trimble ProXH Unit.
- Sampled locations included each of the sixteen (16) Timet Ponds and ten (10) Upper Pond samples (See Figure 2 and Table 1 for sample descriptions). General site conditions and visual material descriptions were made for each sample. The soil samples were submitted to the GES laboratory for the following analysis: sieve/minus #200 wash, Atterberg Limits, Maximum Density (proctor), and moisture content.

Field Investigation Methodology

Soils - Soil samples were taken from twenty six (26) locations with a shovel from depths ranging from approximately two (2) inches to three (3) feet. At many locations, native soil was washed or blown over the pond material, and was removed prior to sample collection. Approximately fifty (50) pounds of pond material were placed in each bulk bag. After each bag was filled, the tops were twisted and sealed with duct tape to prevent moisture loss prior to laboratory analysis. Field condition descriptions were given for samples that were taken from areas where there was very little pond material present (Table 1).

Soil samples were logged according to the USCS Classification by a qualified Geologist. The USCS classification and color of each sample presented in Table 1 is based upon visual characteristics and laboratory analysis.

Laboratory analysis of each sample is presented in the enclosures at the back of this report. At each sample location, the samples were collected in a clean plastic bulk bag. Each sample was provided a unique sampling number with the following designation: Sample Location, Project Number, Date, and Bag Number. For example, the first sampling location was identified as TP04, 20072247V1, 9/13/07. The soil samples were transported directly to the GES soil testing lab.

We appreciate this opportunity to provide our professional services. If you have questions or comment, feel free to contact our office at (702) 365-1001.

Sincerely,

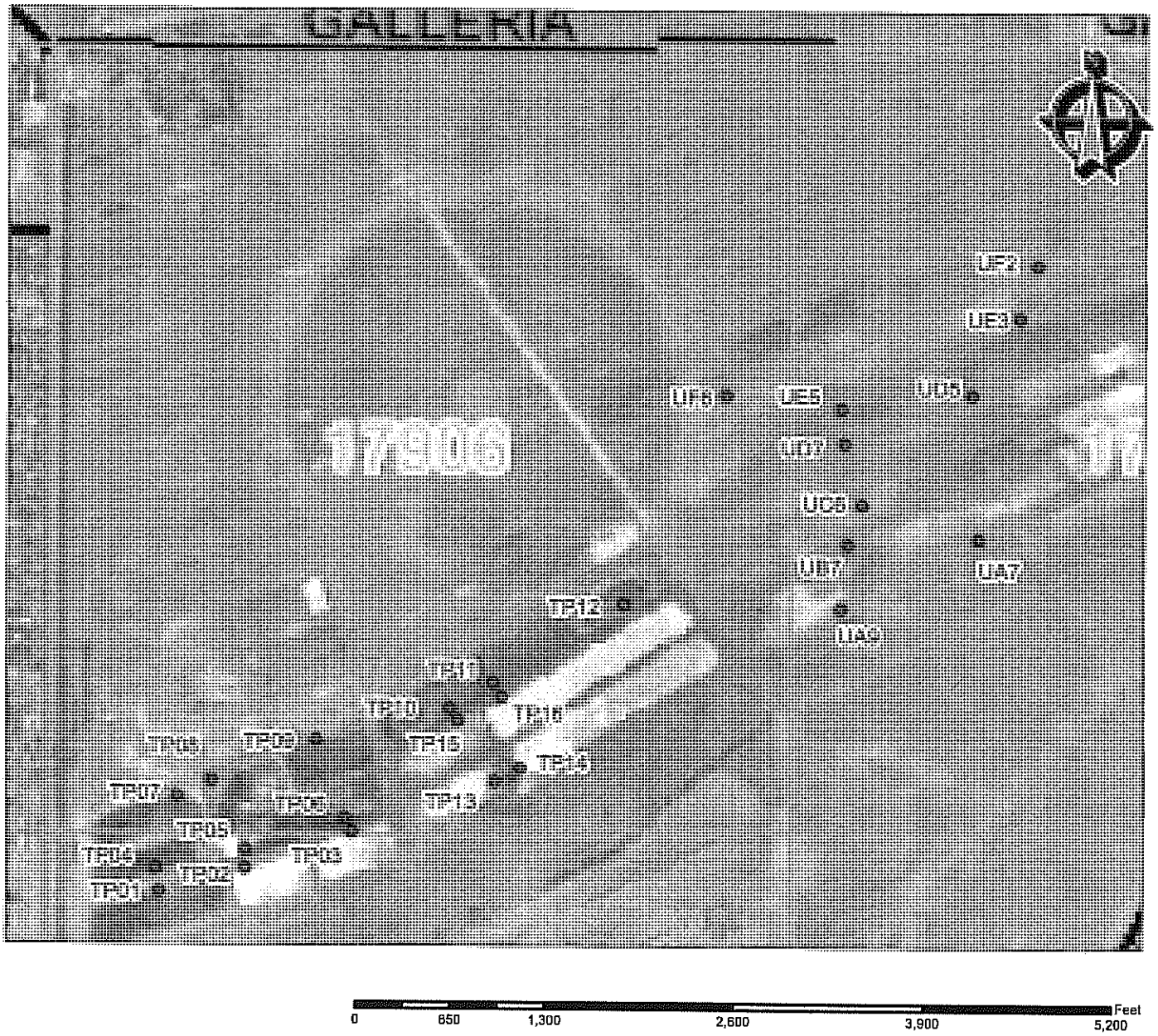
Geotechnical & Environmental Services, Inc.

Monty Mellhorn
Staff Geologist

Kyle S. Hansen
Environmental Program Manager

vm
Enc.: Figure 2
Table 1
Field Activity Report (1)
Laboratory Results (1)

Dist: 2 originals mailed to addressee
1 pdf e-mailed to addressee at sahuron@earthlink.net
1 cc to project file



0 650 1,300 2,600 3,900 5,200 Feet

Legend

- Bulk Sample Location

GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.
7150 Placid St.
Las Vegas, NV 89119
702-365-1001
www.gesnevada.com

NOTE: Data presented on this map is a compilation of GIS Metadata extracted from a variety of sources. Major Streets, Freeways, Mapped Washes and Clark County mapped faults is all data obtained from the Southern Nevada GIS Management Office. This data is downloaded by GES for incorporation into drawings generated by GES. Data contained within this page is to be used for informational purposes only. GES has not modified the data contained herein and uses it as it is acquired from the respective agency.

Bulk Sample Location Map
BRC Eastside Geotech Sampling

Drawn By:	Date Drawn:
MM	9/14/07
Project No.	Figure No.
20072247V1	2

/:\Jobs\2007_Jobs\20072247\V1\GIS\Maps\Figure2

TABLE 1
POND MATERIAL SUMMARY

Pond	Material Description
TP1	Black (10 YR 2/1) sandy SILT (ML, sludge) , moist and soft.
TP2	White (10 YR 8/1) SILT (ML, salt crust), moist and hard.
	Very pale brown (10 YR 2/2) SILT (ML, salt), wet and soft.
TP3	White (10 YR 8/1) SILT (ML, salt crust), dry and hard.
	Light gray (10 YR 7/1) SILT (ML, salt), loose and wet.
TP4	Mottled dark brown (7.5 YR 3/3) SILT (ML, sludge), wet and soft.
TP5	Dark yellowish brown (10 YR 3/6) SILT (ML) moist and soft.
TP6	Light yellowish brown (10 YR 6/4) SILT (ML), moist
TP7	Dark olive brown (2.5 Y 3/3) SILT (ML), wet and loose.
TP8	Black (2.5 YR 2/1) SILT (ML, sludge), wet and soft.
TP9	Dark brown (7.5 YR 3/4) SILT (ML, sludge), wet and soft.
TP10	Dark yellowish brown (10 YR 4/4) SILT (ML, sludge), wet and soft.
TP11	Black (10 YR 2/1) SILT (ML, sludge), wet and soft.
TP12	Red (2.5 YR 4/8) SILT (ML, salt), wet and soft.
TP13	Pale yellow brown (2.5 Y 7/3) SILT (ML, salt crystals), wet and soft. Salt crust occurs as several layers.
TP14	Very pale brown (10 YR 2/2) silty SAND (SM, sand as salt crystals), moist and loose.
TP15	Light yellowish brown (2.5 YR 6/6) SILT (ML, Salt crust) dry and firm.
	Light yellowish brown (2.5 YR 6/6) SILT (ML, sludge), wet and firm.
TP16	Yellowish brown (10 YR 6/6) SILT (ML, salt), wet and soft.
UA7	Greenish gray (5 GY 5/1) silty SAND (SM), dry and medium dense. 6" thick.
UA9	Greenish gray (5 GY 5/1) SILT (ML), dry and stiff. 1.0' thick.
UB9	Greenish gray (5 GY 5/1) SILT with sand (ML), dry and stiff. 1.0' thick.
UC6	Greenish gray (5 GY 5/1) silty SAND (SM), dry and stiff. Greater than 2.0' thick.
UD5	Greenish gray (5 GY 5/1) well-graded SAND with silt (SW-SM), dry and stiff. Sediment confined to depressions only.
UD7	Greenish gray (5 GY 5/1) silty SAND (SM), dry and medium dense. 1.0' thick.
UE3	Greenish gray (5 GY 5/1) silty SAND (SM), dry and medium dense. Sediment is 2" thick, confined to depressions only.
UE5	Greenish gray (5 GY 5/1) silty SAND (SM), dry and medium dense. 6" thick.
UF2	Greenish gray (5 GY 5/1) silty SAND (SM), dry and stiff. 2" thick, native material could not be separated in field.
UF6	Greenish gray (5 GY 5/1) silty SAND with gravel (SM), dry and medium dense. 1" thick, native material could not be separated in field.

FIELD ACTIVITY REPORT

GES

Report Number/Date: 9/13/07

Project Name: BRC - Eastside Geotech Sampling	Project Number: 2007Z247V1
Report By: Monty Mehlhorn	Personnel: Phil Brinkerhoff
Location: BRC Commons Area	Equipment: Trimble ProXH, Shovel
Client: BRC	Weather: Windy, Party Cloudy, ≈90°F

0700 We arrive at BRC Commons Area; Perform site recon.
0715 Arrive, prepare for sampling at TP01.
0740 Collect TP01 bulk.
0750 Collect TP04 bulk.
0805 Collect TP02 bulk
0810 Collect ~~TP03~~ TP05 bulk.
0820 Collect TP03 bulk.
0830 Collect TP06 bulk.
0845 Collect TP07 bulk.
0900 Collect TP08 bulk.
0915 Collect TP09 bulk
0935 Collect TP10 and TP15 bulks.
0945 Collect TP11 and TP16 bulks.
1010 Collect TP12 bulk.
1030 Collect TP13 and TP14 bulks.
1042 Leave site. Go to GES office to deliever 1st batch of samples.
1230 Depart ~~sit~~ mm GES office.
1315 Arrive at UF-2 site. Prepare GPS and equipment. There is only a trace of fine-grained material at this site.
1325 Collect UF2. Only to 2" appeared as precipate.
1345 Collect UF-6; ≈1" of material.
1400 Collet UE-3; ≈2" of material in depressions.
1410 Collet UD5; sediment confined to depressions.
1420 Collect UE-5, ≈6" of sediment.
1425 Collect UD-7, ≈1.0' of sediment.
1440 Collect UC-6; >2' of sediment.
1450 Collect UB-9; same as above.
1455 Collect UA-7; 6" sediment.
1510 UA-10 is filled; sample UA-9.
1520 UA-9 sampled; 1' of sediment.
1525 Leave Site.
1600 Arrived at GES office

Printed Name/Signature: Monty Mehlhorn / Monty Mehlhorn

GEOTECHNICAL &
ENVIRONMENTAL
SERVICES, INC.

7150 Placid Street
Las Vegas, NV 89119
(702) 365-1001

Moisture Content Log

Project Name: EASTSIDE GEOTECH SAMPLING **Project No.:** 20072247V1 **Lab No.:** 8670

Date Sampled: 09/13/07 **Tested By:** AS **Date:** 9/18/2007

Sample:	TP-1	TP-2	TP-3	TP-4	TP-5	TP-6
Depth:						
WET WT. + TARE	267.27	330.46	325.83	413.90	428.90	296.69
DRY WT. + TARE	183.14	317.66	321.10	302.12	294.86	204.68
TARE WT.	106.90	105.12	99.80	160.90	168.40	100.70
DRY WT.	76.24	212.54	221.30	141.22	126.46	103.98
WEIGHT LOST	84.13	12.80	4.73	111.78	134.04	92.01
% MOISTURE	110.3	6.0	2.1	79.2	106.0	88.5

Remarks/Condition: _____

GEOTECHNICAL &
ENVIRONMENTAL
SERVICES, INC.

7150 Placid Street
Las Vegas, NV 89119
(702) 365-1001

Moisture Content Log

Project Name: EASTSIDE GEOTECH SAMPLING **Project No.:** 20072247V1 **Lab No.:** 8670

Date Sampled: 09/13/07 **Tested By:** AS **Date:** 9/18/2007

Sample:	TP-7	TP-8	TP-9	TP-10	TP-11	TP-12
Depth:						
WET WT. + TARE	265.70	208.75	216.64	205.60	199.10	439.80
DRY WT. + TARE	217.89	154.80	163.75	158.93	145.33	388.78
TARE WT.	162.70	101.40	99.00	99.70	100.20	95.10
DRY WT.	55.19	53.40	64.75	59.23	45.13	293.68
WEIGHT LOST	47.81	53.95	52.89	46.67	53.77	51.02
% MOISTURE	86.6	101.0	81.7	78.8	119.1	17.4

Remarks/Condition: _____

GEOTECHNICAL &
ENVIRONMENTAL
SERVICES, INC.

7150 Placid Street
Las Vegas, NV 89119
(702) 365-1001

Moisture Content Log

Project Name: EASTSIDE GEOTECH SAMPLING **Project No.:** 20072247V1 **Lab No.:** 8670

Date Sampled: 09/13/07 **Tested By:** AS **Date:** 9/18/2007

Sample:	TP-13	TP-14	TP-15	TP-16	UA-7	UA-9
Depth:						
WET WT. + TARE	281.70	1226.00	362.05	366.02	381.35	261.28
DRY WT. + TARE	215.37	978.47	315.31	281.59	365.53	253.90
TARE WT.	98.80	162.30	104.00	103.90	100.95	107.40
DRY WT.	116.57	816.17	211.31	177.69	264.58	146.50
WEIGHT LOST	66.33	247.53	46.74	84.43	15.82	7.38
% MOISTURE	56.9	30.3	22.1	47.5	6.0	5.0

Remarks/Condition: _____

GEOTECHNICAL &
ENVIRONMENTAL
SERVICES, INC.

7150 Placid Street
Las Vegas, NV 89119
(702) 365-1001

Moisture Content Log

Project Name: EASTSIDE GEOTECH SAMPLING **Project No.:** 20072247V1 **Lab No.:** 8670

Date Sampled: 09/13/07 **Tested By:** AS **Date:** 9/18/2007

Sample:	UA-10	UB-9	UC-6	UD-5	UD-7	UE-3
Depth:	NO SAMPLE					
WET WT. + TARE		288.36	498.02	667.92	435.49	723.51
DRY WT. + TARE		273.28	475.00	654.38	419.71	714.63
TARE WT.		100.37	160.85	163.56	170.01	116.96
DRY WT.		172.91	314.15	490.82	249.70	597.67
WEIGHT LOST		15.08	23.02	13.54	15.78	8.88
% MOISTURE		8.7	7.3	2.8	6.3	1.5

Remarks/Condition: _____

GEOTECHNICAL &
ENVIRONMENTAL
SERVICES, INC.

7150 Placid Street
Las Vegas, NV 89119
(702) 365-1001

Moisture Content Log

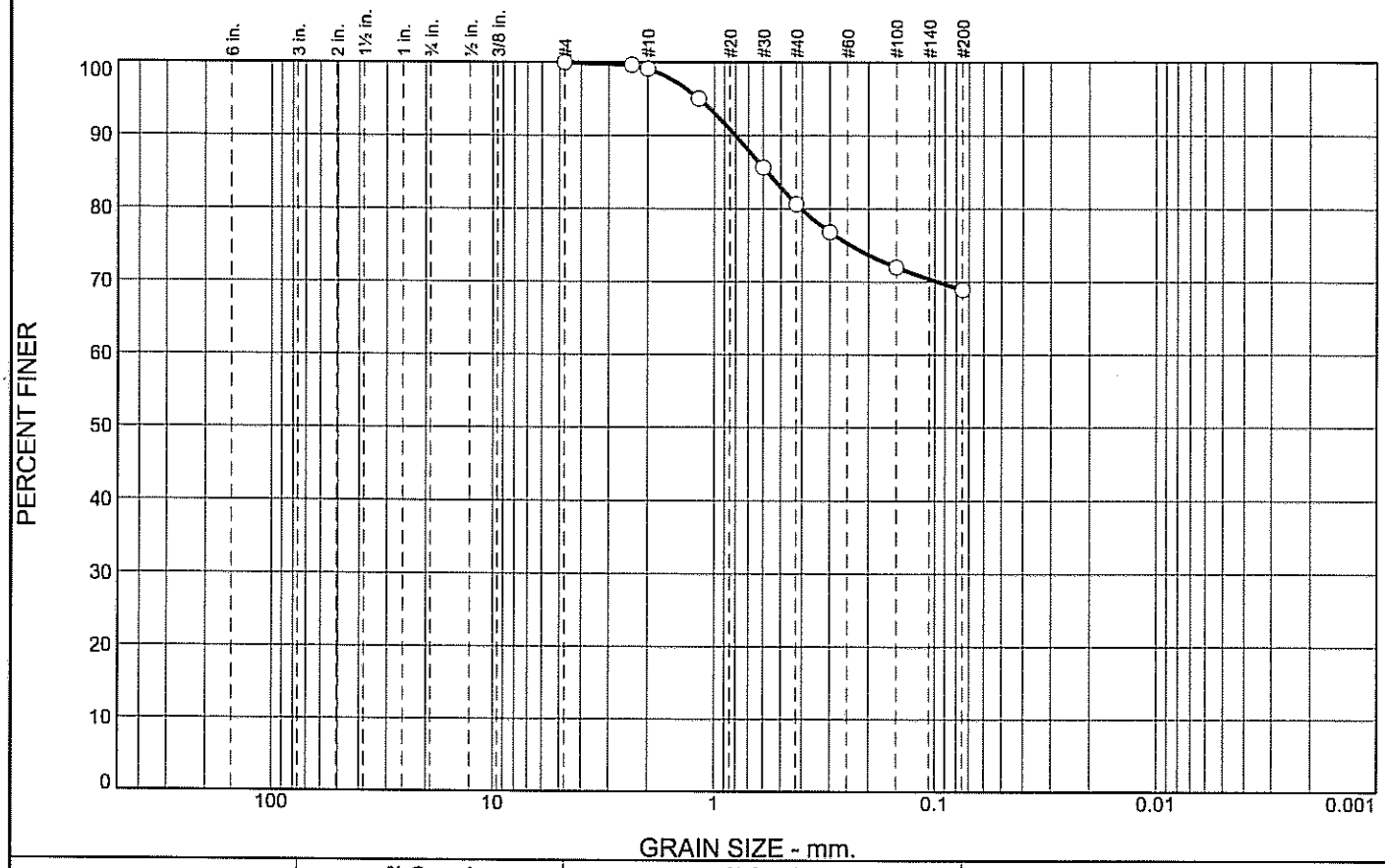
Project Name: EASTSIDE GEOTECH SAMPLING **Project No.:** 20072247V1 **Lab No.:** 8670

Date Sampled: 09/13/07 **Tested By:** AS **Date:** 9/18/2007

Sample:	UE-5	UF-2	UF-6			
Depth:						
WET WT. + TARE	487.33	667.06	524.09			
DRY WT. + TARE	466.94	661.24	492.60			
TARE WT.	117.38	118.71	119.07			
DRY WT.	349.56	542.53	373.53			
WEIGHT LOST	20.39	5.82	31.49			
% MOISTURE	5.8	1.1	8.4			

Remarks/Condition: _____

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.9	18.5	11.7	68.9	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#4	100.0		
#8	99.6		
#10	99.1		
#16	95.1		
#30	85.7		
#40	80.6		
#50	76.8		
#100	72.0		
#200	68.9		

* (no specification provided)

Soil Description

Sandy silt

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{85}= 0.5750 D_{60}= D_{50}=
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= ML AASHTO= A-4(0)

Remarks

ENTERED BY:BLW

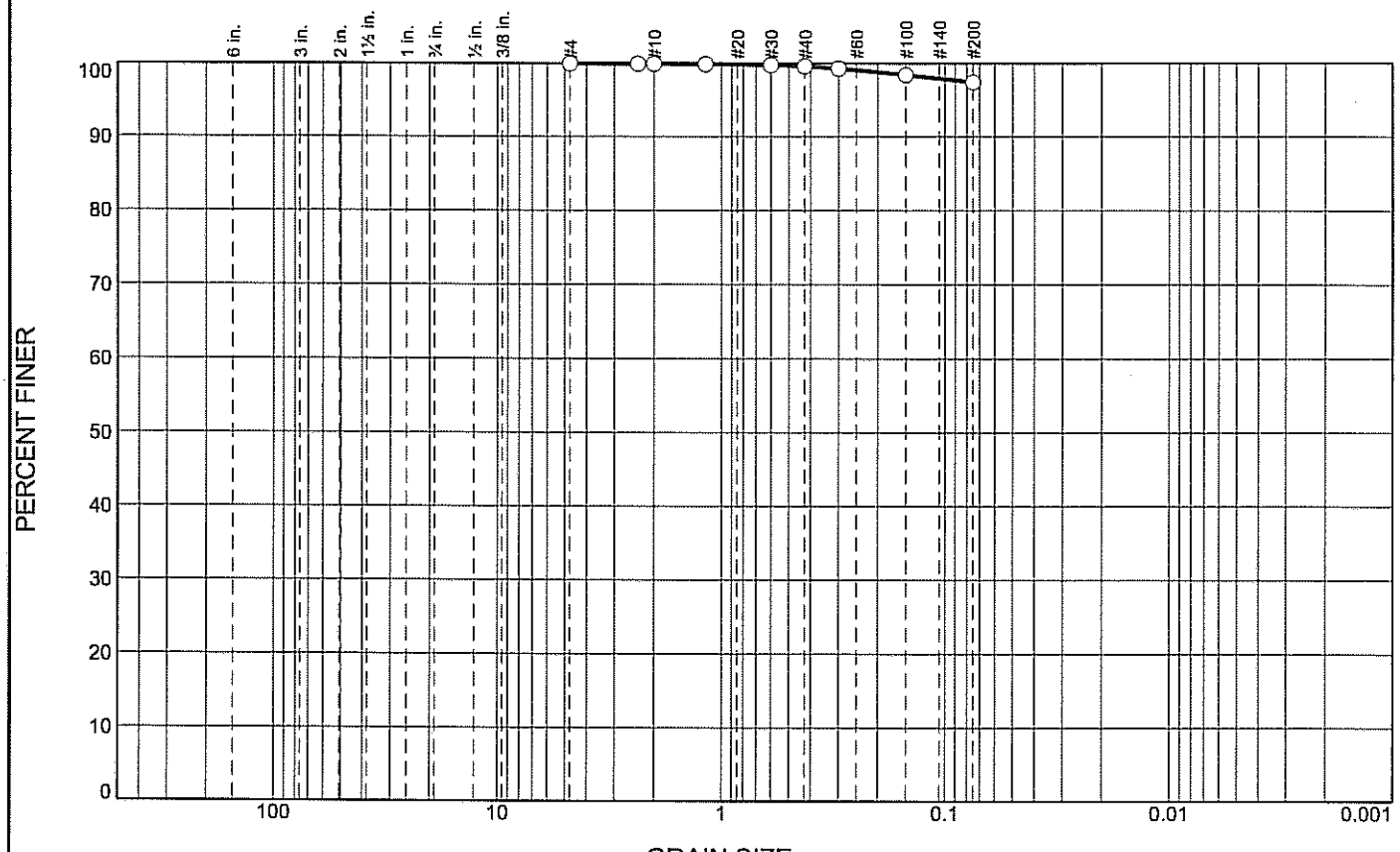
Sample No.: TP-1 **Source of Sample:** LAB#8670 **Date:** 9/26/07
Location: TP-1 **Elev./Depth:**

GES GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.

Client: BRC
Project: BRC EAST SIDE GEOTECH SAMPLING
Project No: 20072247V1 **Figure** 8670

Tested By: JM **Checked By:** BLW

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.4	2.2	97.4	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#4	100.0		
#8	100.0		
#10	100.0		
#16	99.9		
#30	99.8		
#40	99.6		
#50	99.3		
#100	98.4		
#200	97.4		

* (no specification provided)

Soil Description

Silt

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{85}= D_{60}= D_{50}=
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= ML AASHTO= A-4(0)

Remarks

SAMPLED:09/13/07
ENTERED BY:AS

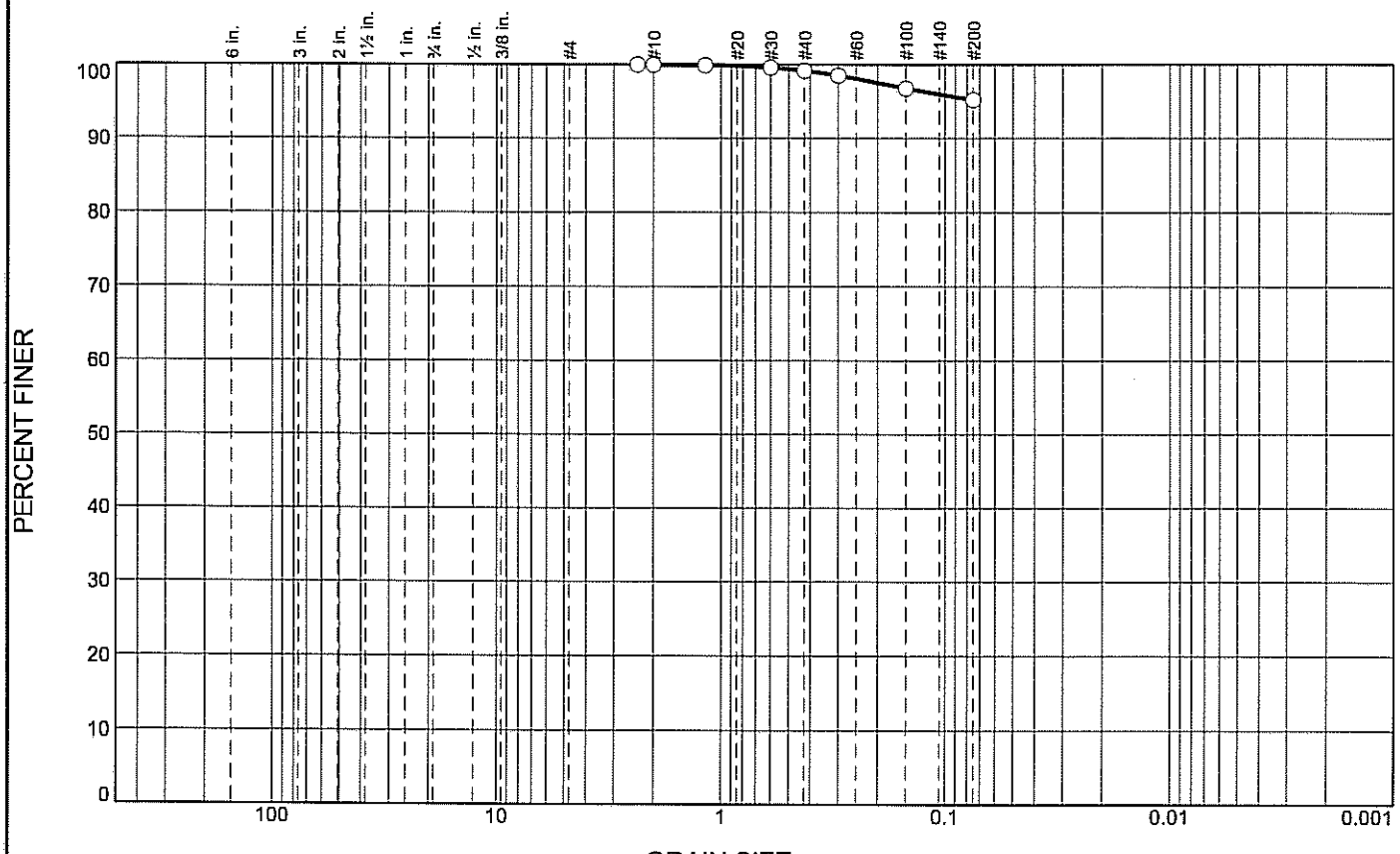
Sample No.: TP-2 **Source of Sample:** LAB#8670 **Date:** 09/21/07
Location: TP-2 **Elev./Depth:**

GES GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.

Client: BRC
Project: BRC EAST SIDE GEOTECH SAMPLING
Project No: 20072247V1 **Figure** 8670

Tested By: DG **Checked By:** AS

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.8	4.0	95.2	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#8	100.0		
#10	100.0		
#16	99.9		
#30	99.6		
#40	99.2		
#50	98.5		
#100	96.8		
#200	95.2		

* (no specification provided)

Soil Description

Silt

Atterberg Limits

PL= 22 LL= 25 PI= 3

Coefficients

D_{85}= D_{60}= D_{50}=
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= ML AASHTO= A-4(2)

Remarks

ENTERED BY:BLW

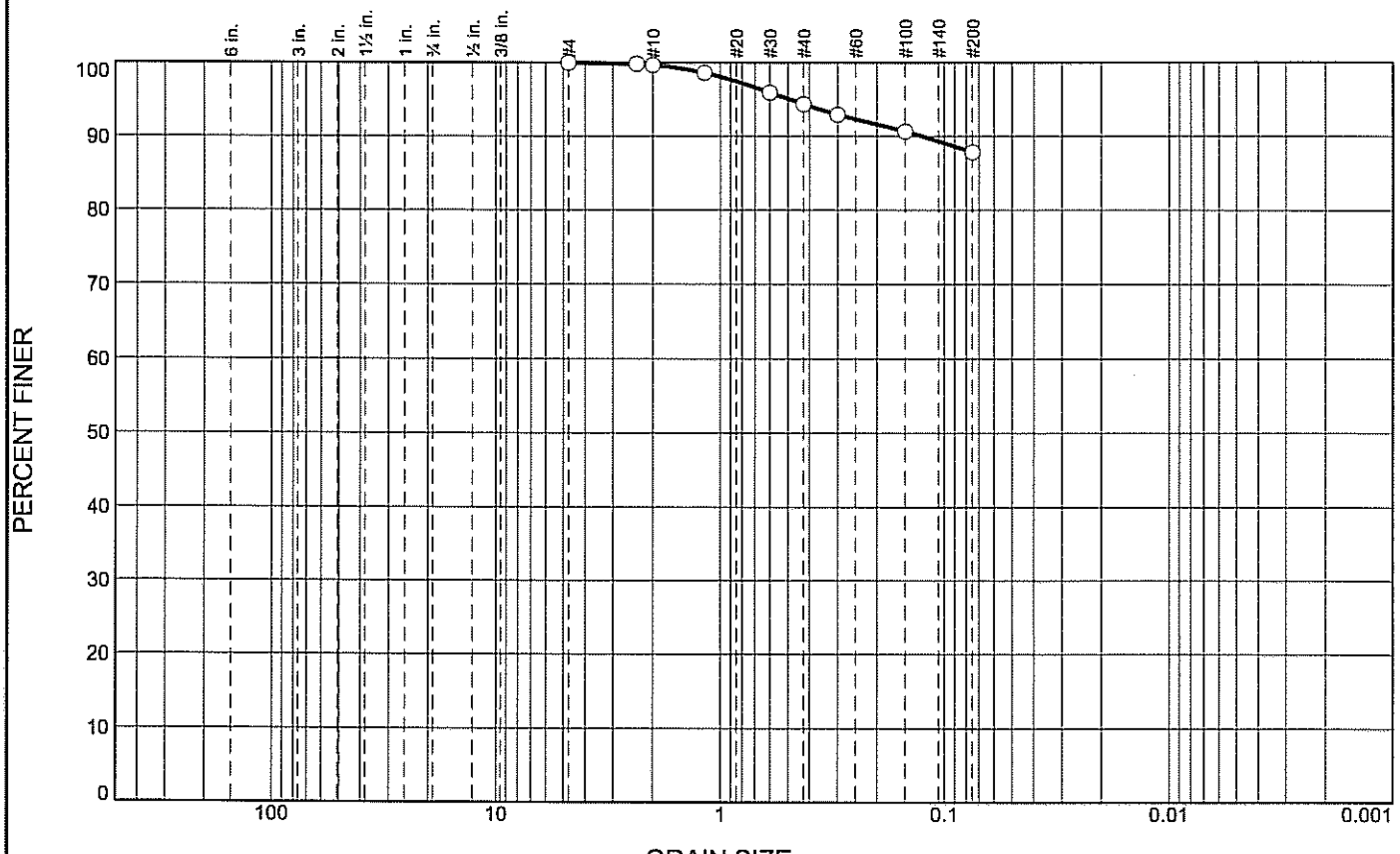
Sample No.: TP-3 **Source of Sample:** LAB#8670 **Date:** 9/26/07
Location: TP-3 **Elev./Depth:**

GES GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.

Client: BRC
Project: BRC EAST SIDE GEOTECH SAMPLING
Project No: 20072247V1 **Figure** 8670

Tested By: DG **Checked By:** BLW

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.3	5.3	6.6	87.8	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#4	100.0		
#8	99.8		
#10	99.7		
#16	98.6		
#30	96.0		
#40	94.4		
#50	93.0		
#100	90.7		
#200	87.8		

* (no specification provided)

Soil Description

Silt

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{85}= D_{60}= D_{50}=
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= ML AASHTO= A-4(0)

Remarks

ENTERED BY:BLW

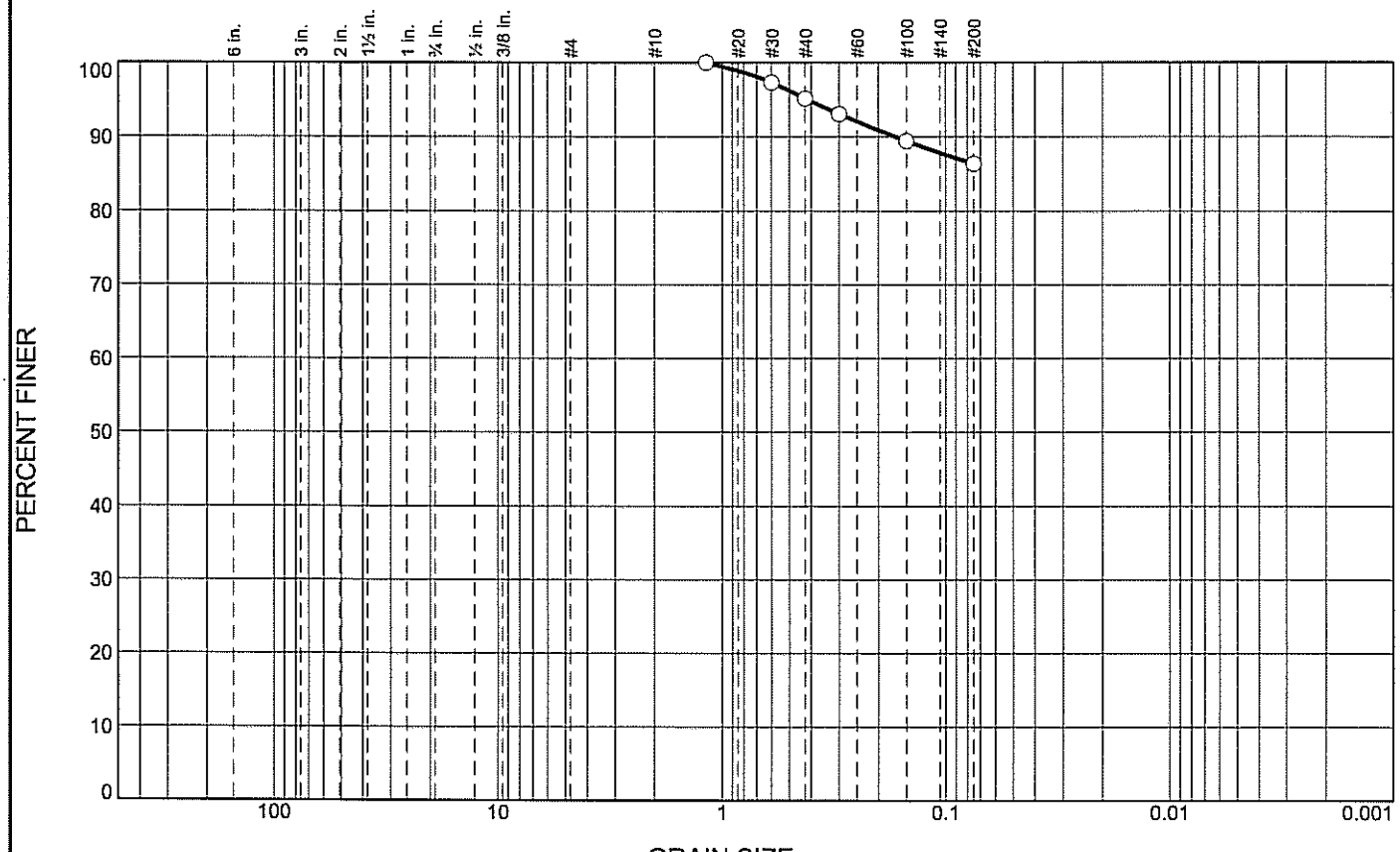
Sample No.: TP-4 **Source of Sample:** LAB#8670 **Date:** 9/26/07
Location: TP-4 **Elev./Depth:**

GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.
GES

Client: BRC
Project: BRC EAST SIDE GEOTECH SAMPLING
Project No: 20072247V1 **Figure** 8670

Tested By: JM **Checked By:** BLW

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	4.8	8.9	86.3	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#16	100.0		
#30	97.3		
#40	95.2		
#50	93.1		
#100	89.4		
#200	86.3		

* (no specification provided)

Soil Description

Silt

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{85}= D_{60}= D_{50}=
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= ML AASHTO= A-4(0)

Remarks

ENTERED BY:BLW

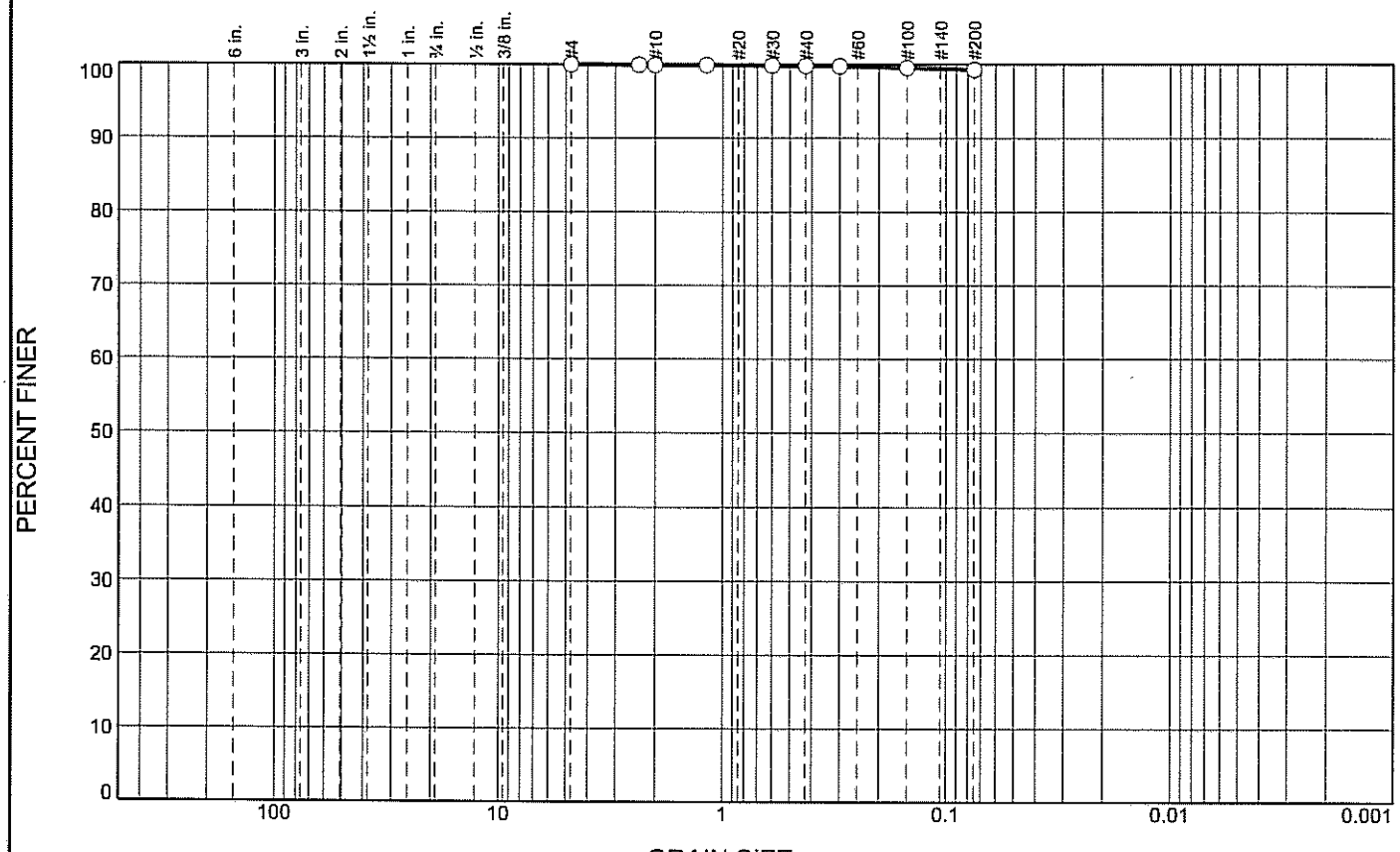
Sample No.: TP-5 **Source of Sample:** LAB#8670 **Date:** 9/26/07
Location: TP-5 **Elev./Depth:**

GES GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.

Client: BRC
Project: BRC EAST SIDE GEOTECH SAMPLING
Project No: 20072247V1 **Figure** 8670

Tested By: JM **Checked By:** BLW

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.1	0.1	0.5	99.3	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#4	100.0		
#8	99.9		
#10	99.9		
#16	99.9		
#30	99.9		
#40	99.8		
#50	99.7		
#100	99.6		
#200	99.3		

* (no specification provided)

Soil Description

Silt

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{85}= D_{60}= D_{50}=
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= ML AASHTO= A-4(0)

Remarks

ENTERED BY:BLW

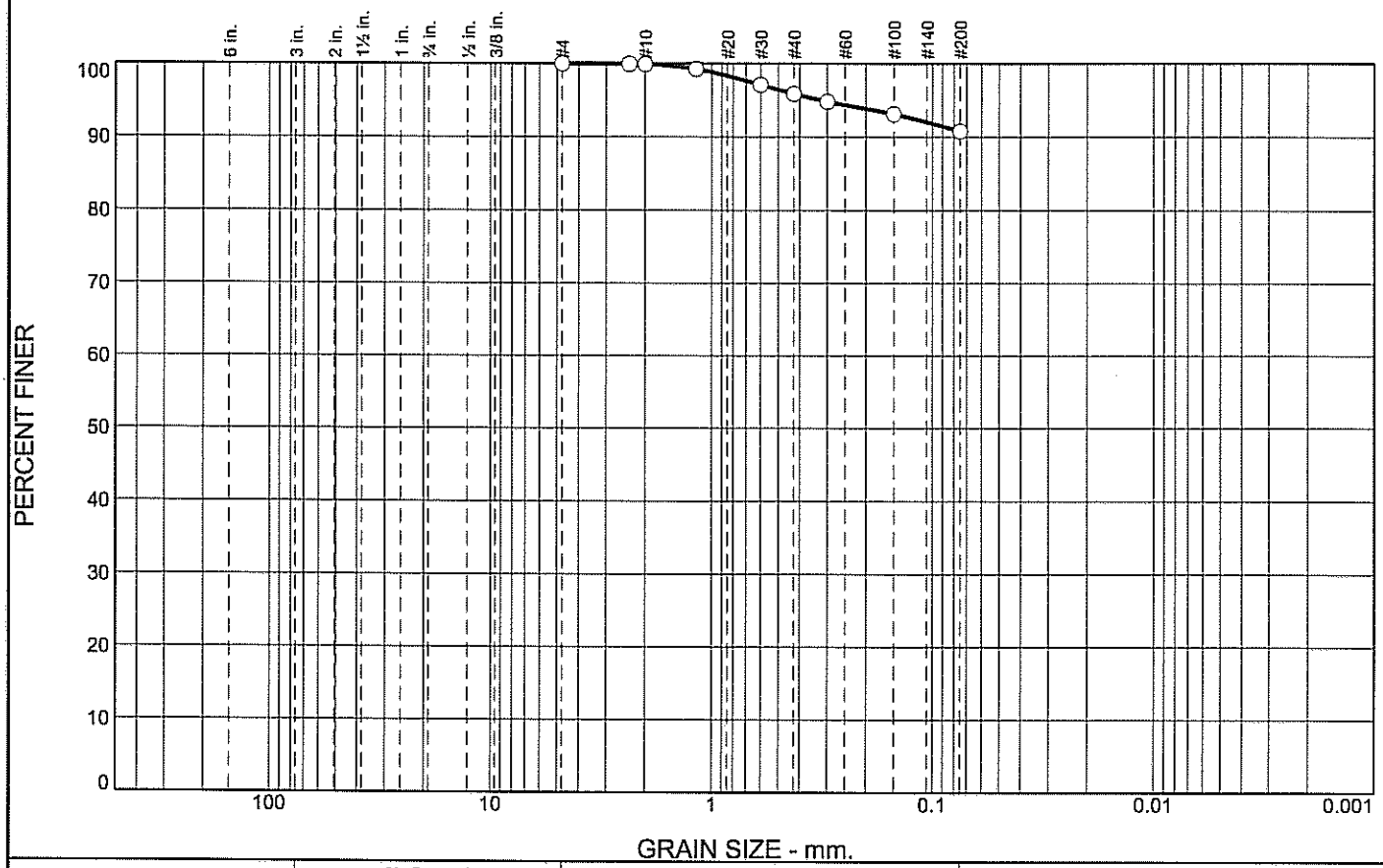
Sample No.: TP=6 **Source of Sample:** LAB#8670 **Date:** 9/26/07
Location: TP-6 **Elev./Depth:**

GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.
GES

Client: BRC
Project: BRC EAST SIDE GEOTECH SAMPLING
Project No: 20072247V1 **Figure** 8670

Tested By: JM **Checked By:** BLW

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.1	4.0	5.1	90.8	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#4	100.0		
#8	100.0		
#10	99.9		
#16	99.3		
#30	97.1		
#40	95.9		
#50	94.8		
#100	93.2		
#200	90.8		

* (no specification provided)

Soil Description

Silt

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{85}= D_{60}= D_{50}=
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= ML AASHTO= A-4(0)

Remarks

ENTERED BY:BLW

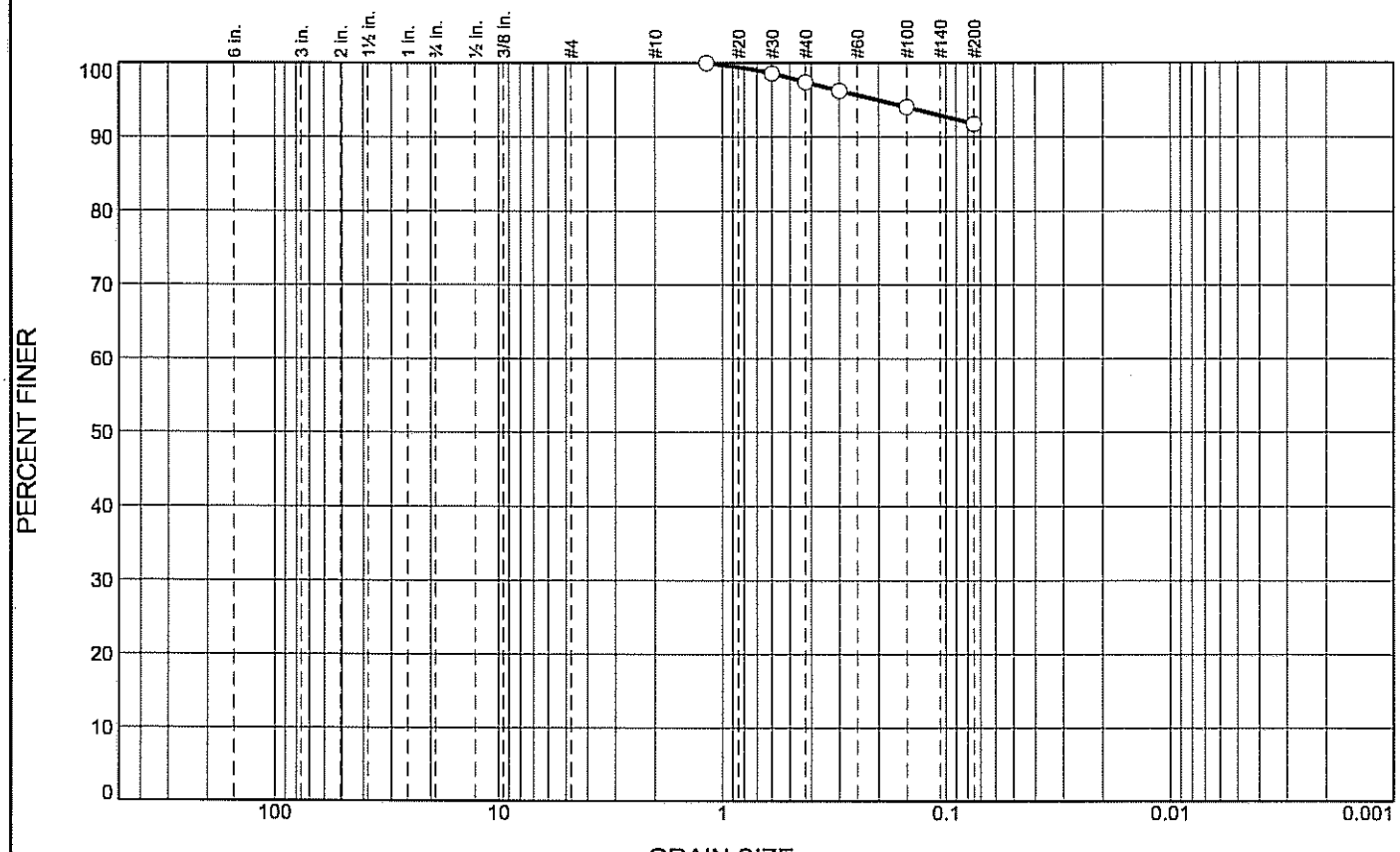
Sample No.: TP-7 **Source of Sample:** LAB#8670 **Date:** 9/26/07
Location: TP-7 **Elev./Depth:**

GES GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.

Client: BRC
Project: BRC EAST SIDE GEOTECH SAMPLING
Project No: 20072247V1 **Figure** 8670

Tested By: JM **Checked By:** BLW

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	2.6	5.6	91.8	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#16	100.0		
#30	98.6		
#40	97.4		
#50	96.2		
#100	94.1		
#200	91.8		

* (no specification provided)

Soil Description

Silt

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{85}= D_{60}= D_{50}=
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= ML AASHTO= A-4(0)

Remarks

ENTERED BY:BLW

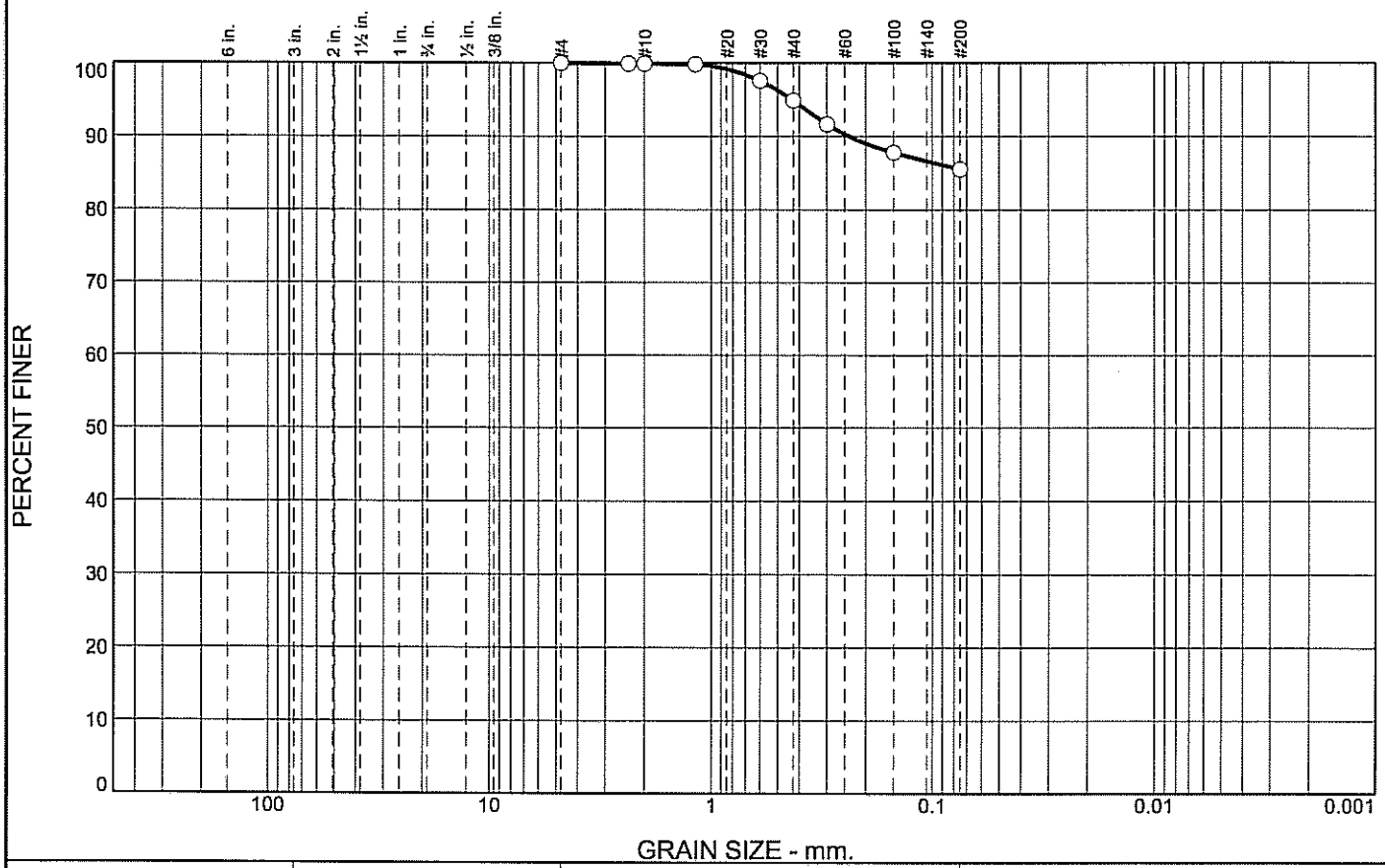
Sample No.: TP-8 **Source of Sample:** LAB#8670 **Date:** 9/26/07
Location: TP-8 **Elev./Depth:**

GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.
GES

Client: BRC
Project: BRC EAST SIDE GEOTECH SAMPLING
Project No: 20072247V1 **Figure** 8670

Tested By: JM **Checked By:** BLW

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.1	5.0	9.4	85.5	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#4	100.0		
#8	99.9		
#10	99.9		
#16	99.9		
#30	97.6		
#40	94.9		
#50	91.6		
#100	87.8		
#200	85.5		

* (no specification provided)

Soil Description

Silt

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{85}= D_{60}= D_{50}=
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= ML AASHTO= A-4(0)

Remarks

ENTERED BY:BLW

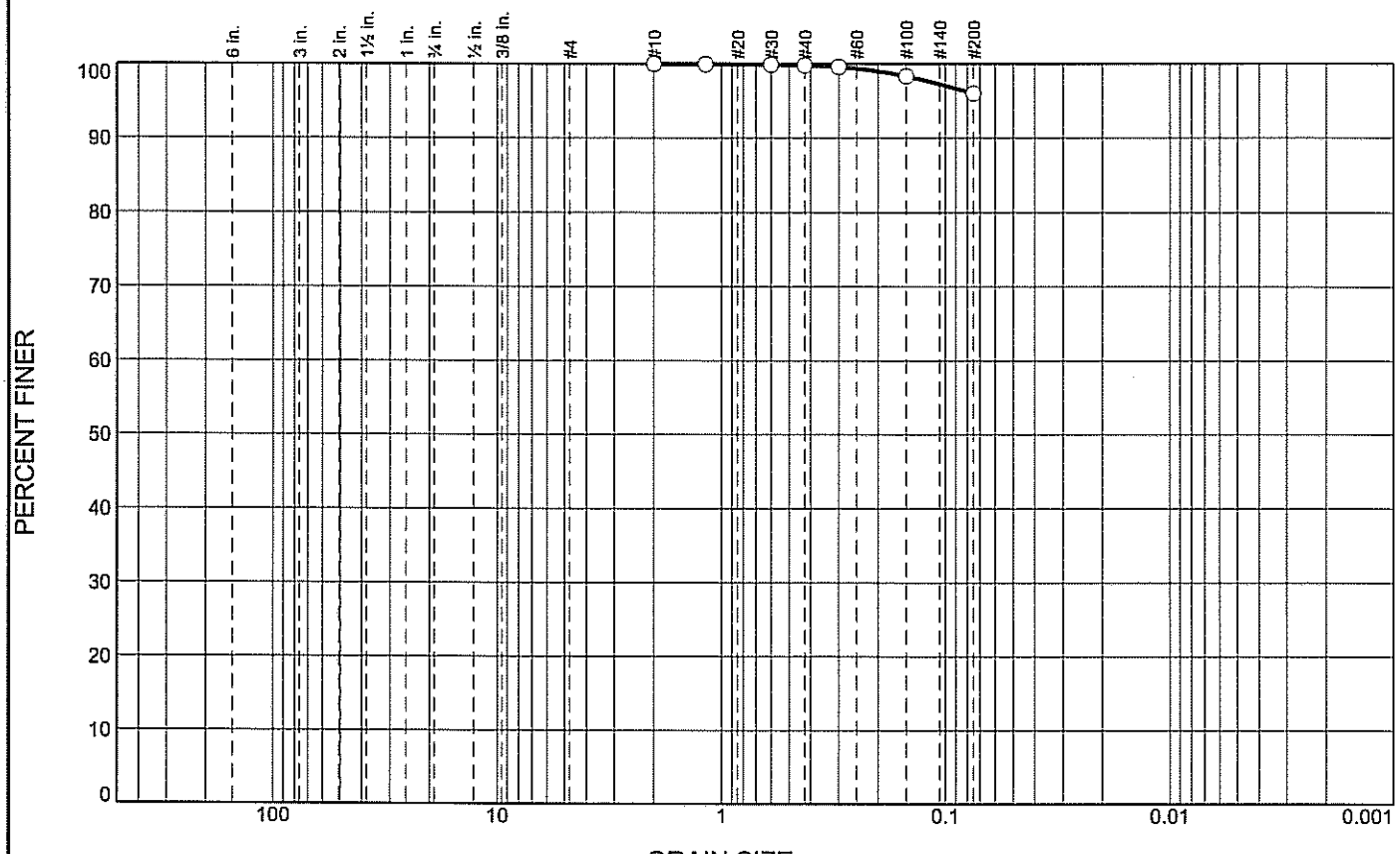
Sample No.: TP-9 **Source of Sample:** LAB#8670 **Date:** 9/26/07
Location: TP-9 **Elev./Depth:**

GES GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.

Client: BRC
Project: BRC EAST SIDE GEOTECH SAMPLING
Project No: 20072247V1 **Figure** 8670

Tested By: JM **Checked By:** BLW

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.2	3.8	96.0	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#16	100.0		
#30	99.9		
#40	99.8		
#50	99.6		
#100	98.3		
#200	96.0		

* (no specification provided)

Soil Description

Silt

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{85}= D_{60}= D_{50}=
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= ML AASHTO= A-4(0)

Remarks

ENTERED BY:BLW

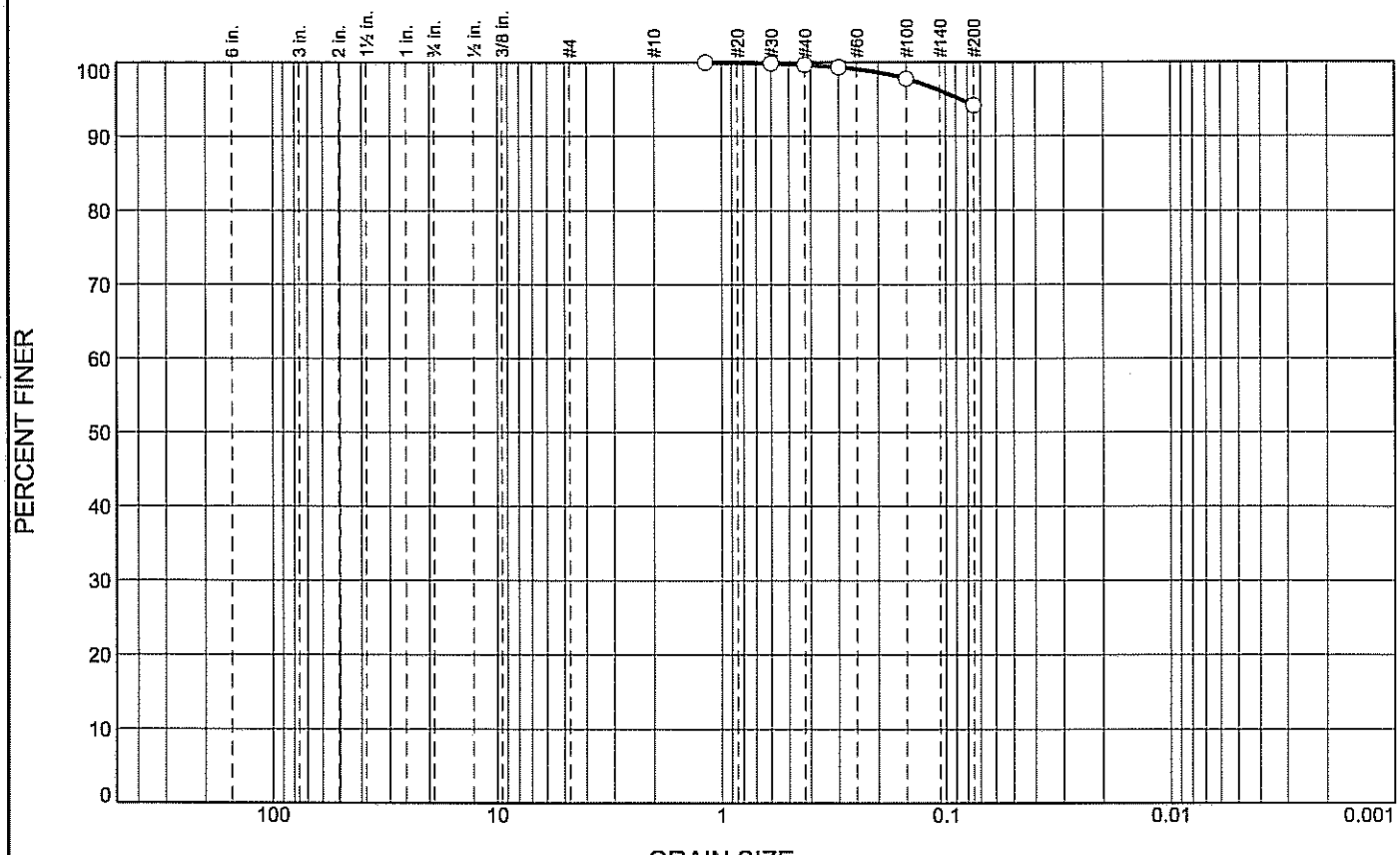
Sample No.: TP-10 **Source of Sample:** LAB#8670 **Date:** 9/26/07
Location: TP-10 **Elev./Depth:**

GES GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.

Client: BRC
Project: BRC EAST SIDE GEOTECH SAMPLING
Project No: 20072247V1 **Figure** 8670

Tested By: DG **Checked By:** BLW

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.3	5.5	94.2	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#16	100.0		
#30	99.9		
#40	99.7		
#50	99.3		
#100	97.8		
#200	94.2		

* (no specification provided)

Soil Description

Silt

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{85}= D_{60}= D_{50}=
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= ML AASHTO= A-4(0)

Remarks

ENTERED BY:BLW

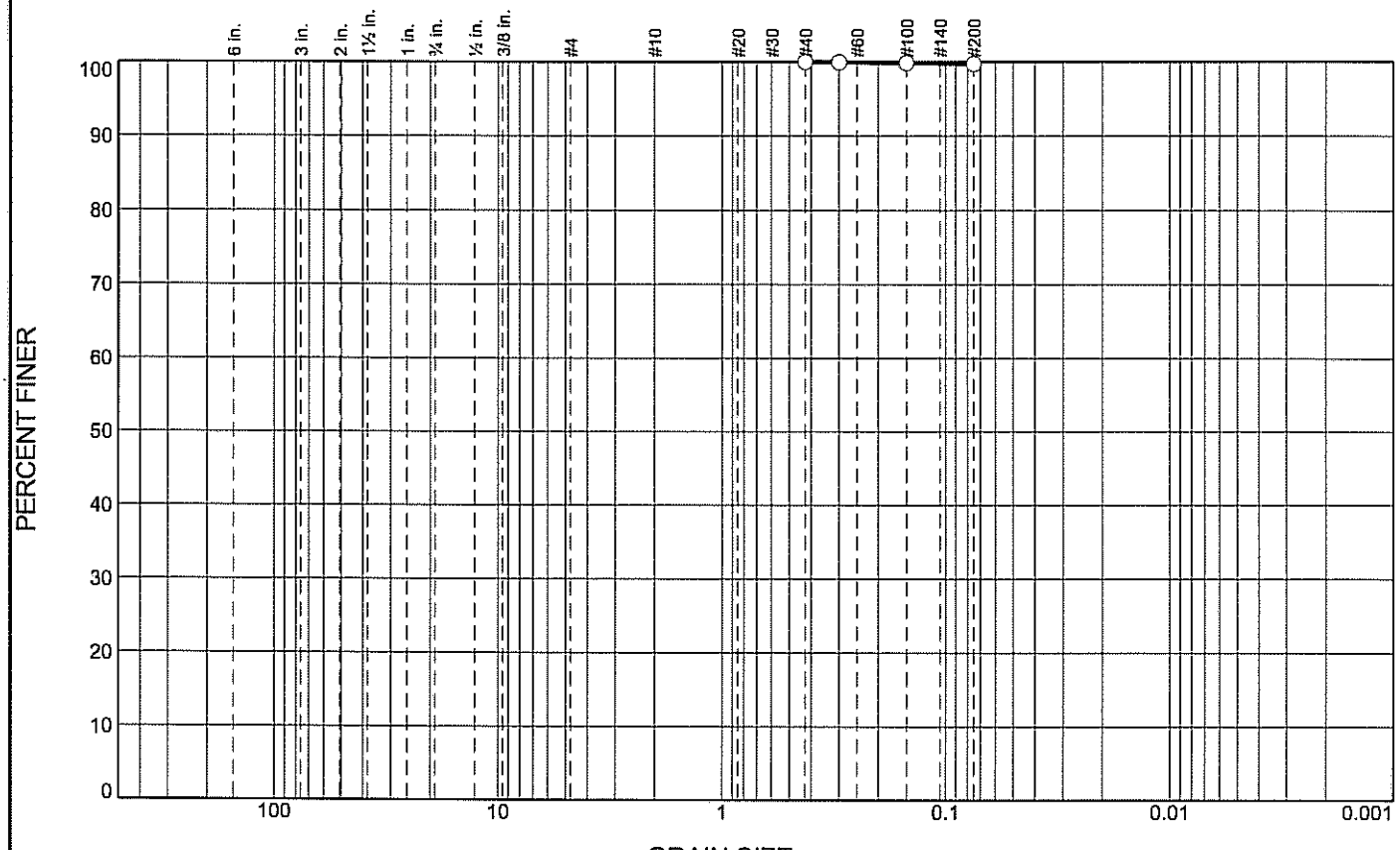
Sample No.: TP-11 **Source of Sample:** LAB#8670 **Date:** 9/26/07
Location: TP-11 **Elev./Depth:**

GES GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.

Client: BRC
Project: BRC EAST SIDE GEOTECH SAMPLING
Project No: 20072247V1 **Figure** 8670

Tested By: DG **Checked By:** BLW

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.0	0.3	99.7	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#40	100.0		
#50	100.0		
#100	99.9		
#200	99.7		

* (no specification provided)

Soil Description

Silt

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{85}= D_{60}= D_{50}=
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= ML AASHTO= A-4(0)

Remarks

ENTERED BY:

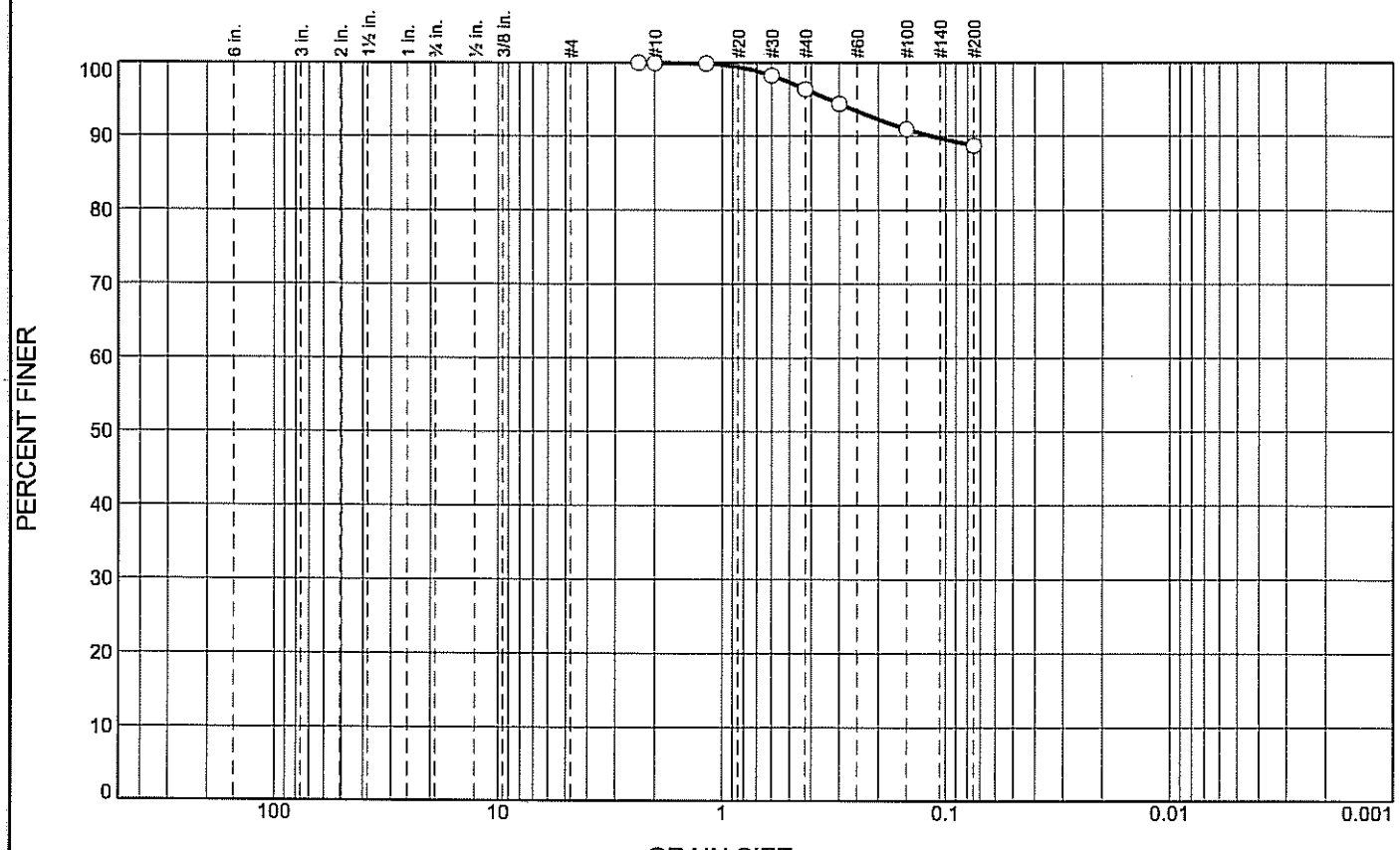
Sample No.: TP-12 **Source of Sample:** LAB#8670 **Date:** 9/26/07
Location: TP-12 **Elev./Depth:**

GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.
GES

Client: BRC
Project: BRC EAST SIDE GEOTECH SAMPLING
Project No: 20072247V1 **Figure** 8670

Tested By: DG **Checked By:** BLW

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	3.6	7.7	88.7	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#8	100.0		
#10	100.0		
#16	99.9		
#30	98.3		
#40	96.4		
#50	94.4		
#100	90.9		
#200	88.7		

* (no specification provided)

Soil Description

Silt

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{85}= D_{60}= D_{50}=
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= ML AASHTO= A-4(0)

Remarks

ENTERED BY:BLW

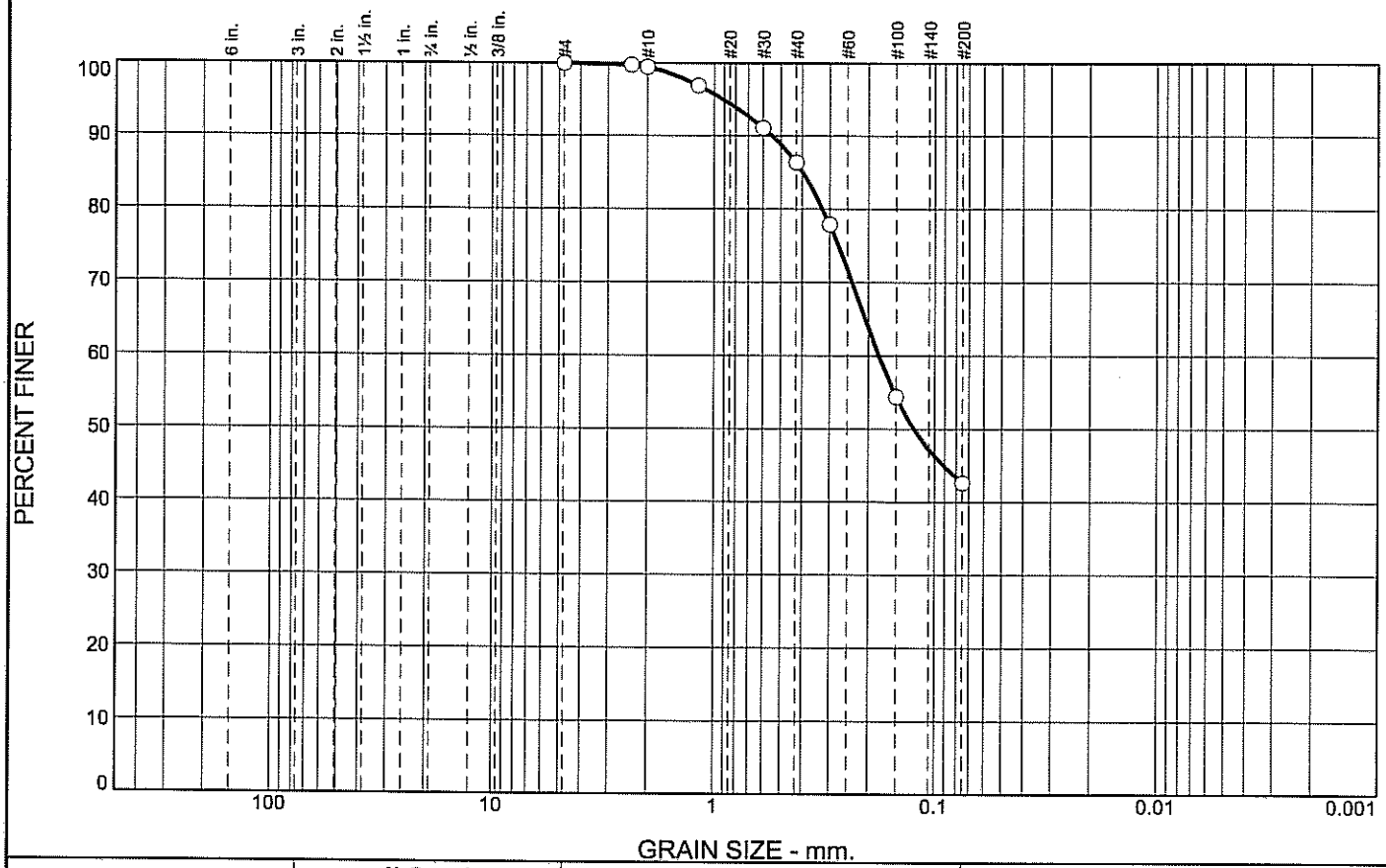
Sample No.: TP-13 **Source of Sample:** LAB#8670 **Date:** 9/26/07
Location: TP-13 **Elev./Depth:**

GES GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.

Client: BRC
Project: BRC EAST SIDE GEOTECH SAMPLING
Project No: 20072247V1 **Figure** 8670

Tested By: DG **Checked By:** BLW

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.5	13.2	43.7	42.6	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#4	100.0		
#8	99.8		
#10	99.5		
#16	97.0		
#30	91.1		
#40	86.3		
#50	77.9		
#100	54.4		
#200	42.6		

* (no specification provided)

Soil Description

Silty sand

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{85}= 0.3966 D_{60}= 0.1795 D_{50}= 0.1245
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= SM AASHTO= A-4(0)

Remarks

SAMPLED:09/13/07
ENTERED BY:AS

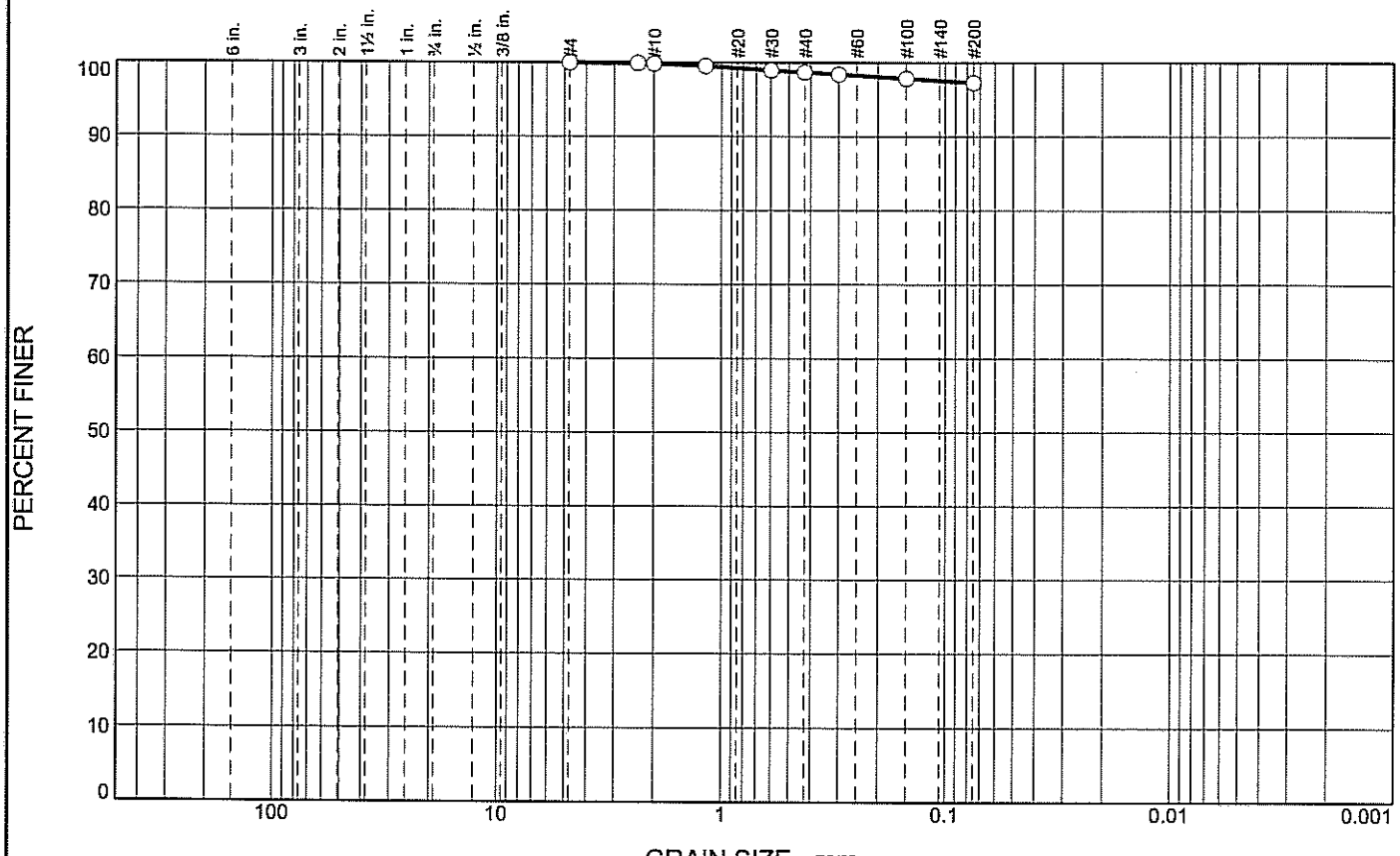
Sample No.: TP-14 **Source of Sample:** LAB#8670 **Date:** 09/21/07
Location: TP-14 **Elev./Depth:**

GES GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.

Client: BRC
Project: BRC EAST SIDE GEOTECH SAMPLING
Project No: 20072247V1 **Figure** 8670

Tested By: AS **Checked By:** AS

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.1	1.2	1.4	97.3	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#4	100.0		
#8	99.9		
#10	99.9		
#16	99.6		
#30	99.0		
#40	98.7		
#50	98.4		
#100	97.9		
#200	97.3		

* (no specification provided)

Soil Description

Silt

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{85}= D_{60}= D_{50}=
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= ML AASHTO= A-4(0)

Remarks

ENTERED BY:BLW

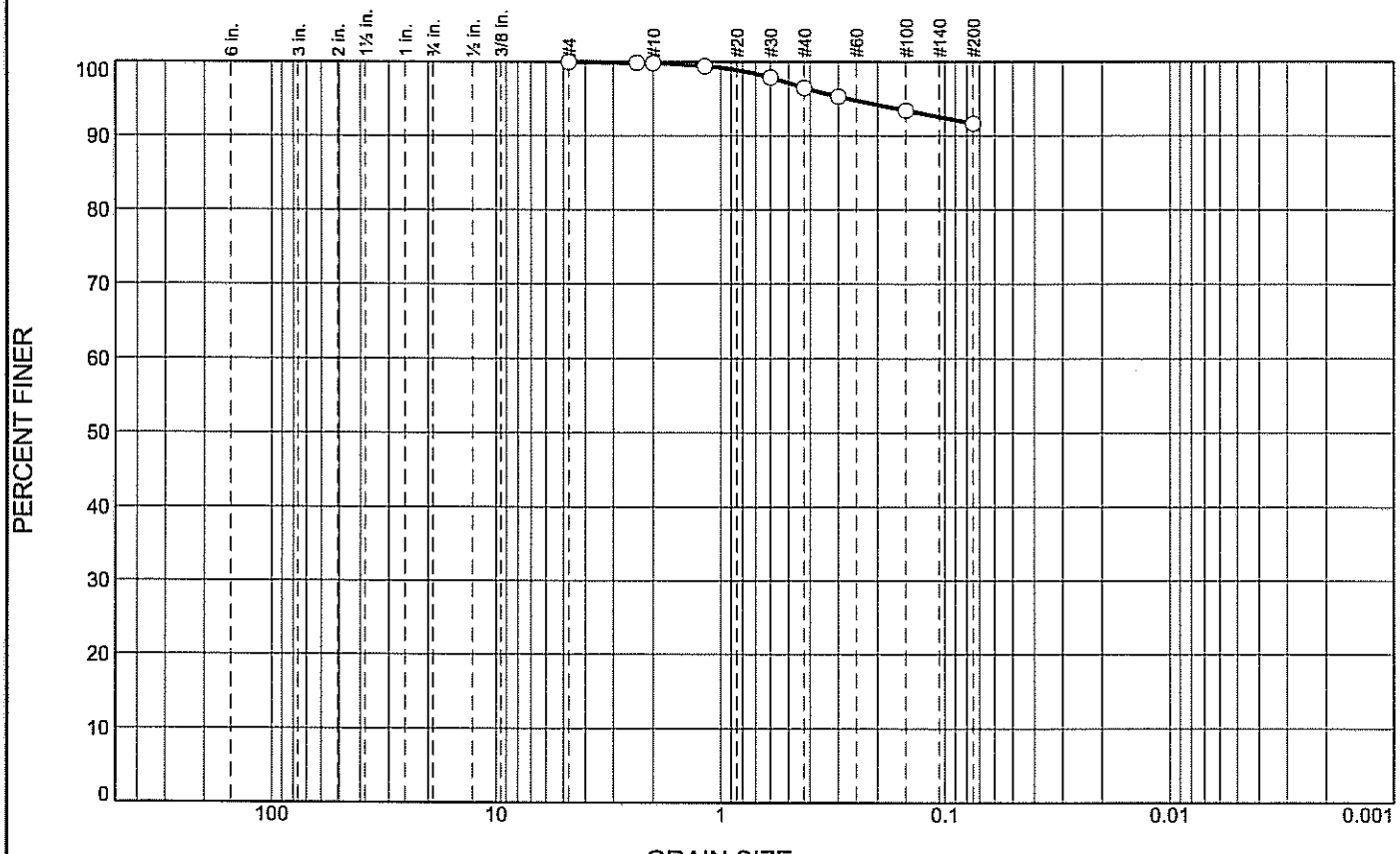
Sample No.: TP-15 **Source of Sample:** LAB#8670 **Date:** 9/26/07
Location: TP-15 **Elev./Depth:**

GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.
GES

Client: BRC
Project: BRC EAST SIDE GEOTECH SAMPLING
Project No: 20072247V1 **Figure** 8670

Tested By: DG **Checked By:** BLW

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.1	3.4	4.8	91.7	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#4	100.0		
#8	99.9		
#10	99.9		
#16	99.5		
#30	97.9		
#40	96.5		
#50	95.3		
#100	93.5		
#200	91.7		

* (no specification provided)

Soil Description

Silt

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{85}= D_{60}= D_{50}=
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= ML AASHTO= A-4(0)

Remarks

ENTERED BY:BLW

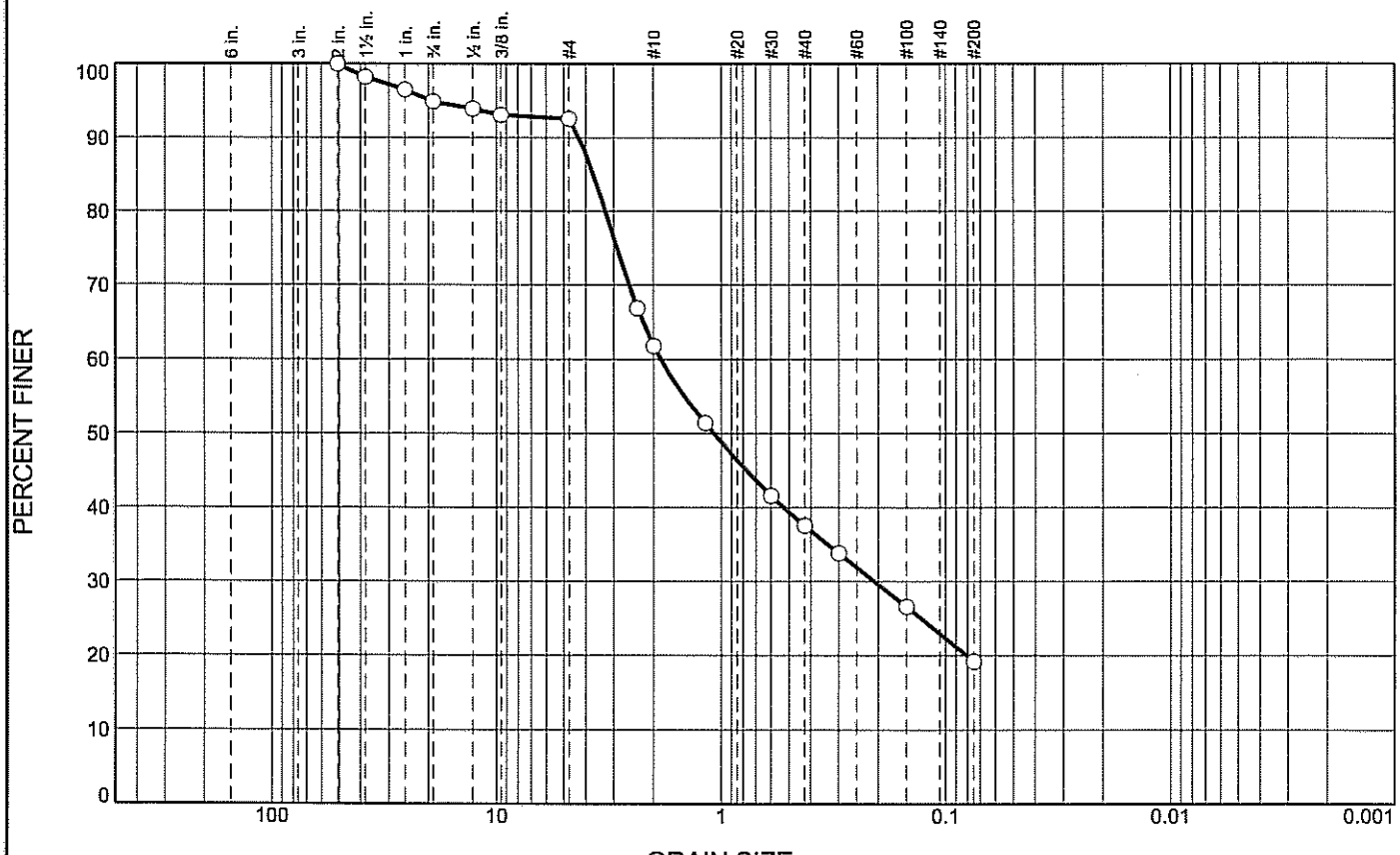
Sample No.: TP-16 **Source of Sample:** LAB#8670 **Date:** 9/26/07
Location: TP-16 **Elev./Depth:**

GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.
GES

Client: BRC
Project: BRC EAST SIDE GEOTECH SAMPLING
Project No: 20072247V1 **Figure** 8670

Tested By: DG **Checked By:** BLW

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	5.1	2.3	30.8	24.2	18.4	19.2	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
2	100.0		
1.5	98.2		
1	96.5		
.75	94.9		
.5	93.9		
.375	93.1		
#4	92.6		
#8	66.8		
#10	61.8		
#16	51.4		
#30	41.6		
#40	37.6		
#50	33.8		
#100	26.6		
#200	19.2		

* (no specification provided)

Soil Description

Silty sand

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{85}= 3.6968 D_{60}= 1.8594 D_{50}= 1.0785
D_{30}= 0.2084 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= SM AASHTO= A-1-b

Remarks

ENTERED BY:BLW

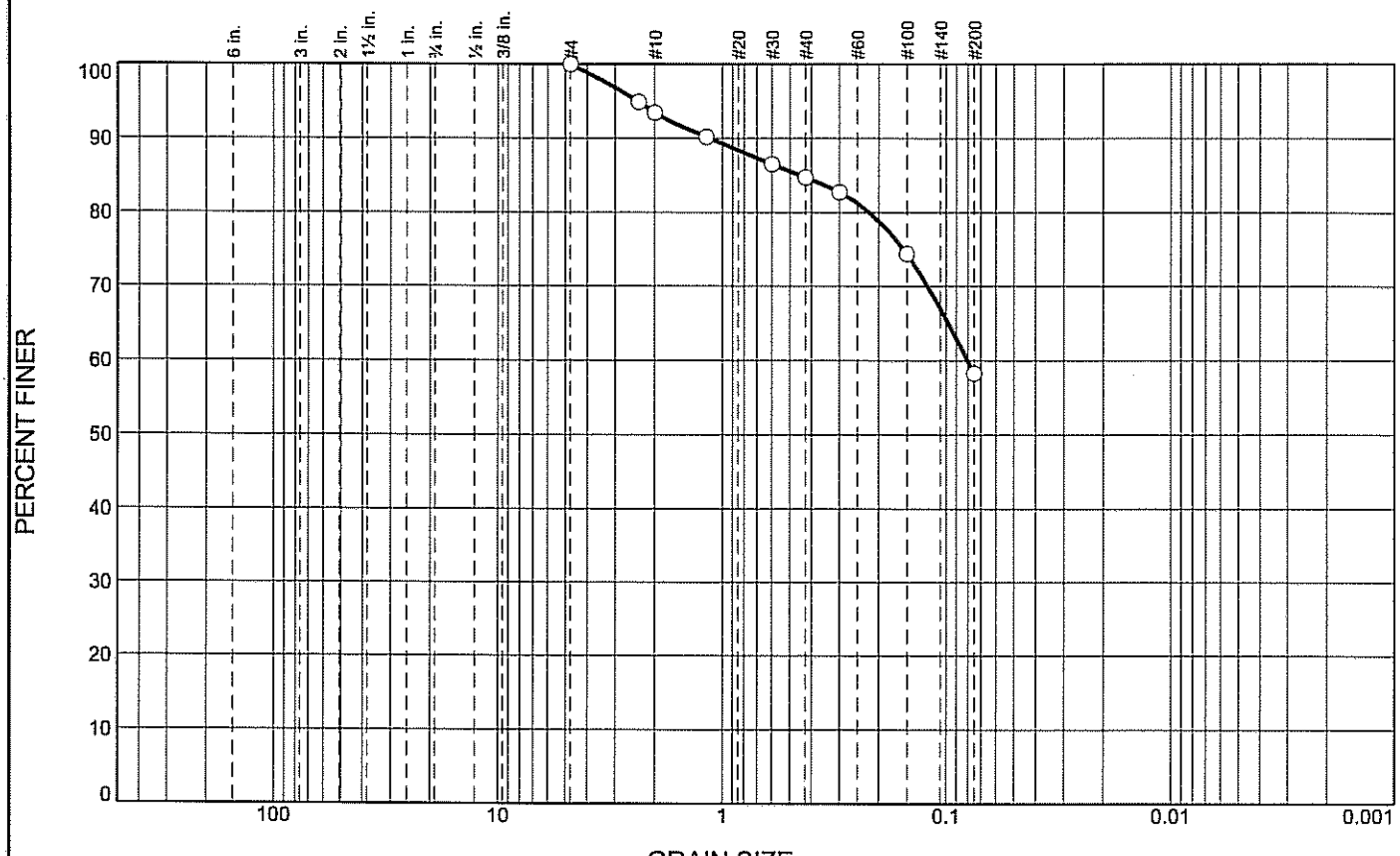
Sample No.: UA-7 **Source of Sample:** LAB#8670 **Date:** 9/26/07
Location: UA-7 **Elev./Depth:**

GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.
GES

Client: BRC
Project: BRC EAST SIDE GEOTECH SAMPLING
Project No: 20072247V1 **Figure** 8670

Tested By: DG **Checked By:** BLW

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	6.5	8.8	26.4	58.3	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#4	100.0		
#8	94.9		
#10	93.5		
#16	90.2		
#30	86.5		
#40	84.7		
#50	82.8		
#100	74.4		
#200	58.3		

* (no specification provided)

Soil Description

Sandy silt

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{85}= 0.4497 D_{60}= 0.0802 D_{50}=
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= ML AASHTO= A-4(0)

Remarks

SAMPLED:09/13/07
ENTERED BY:AS

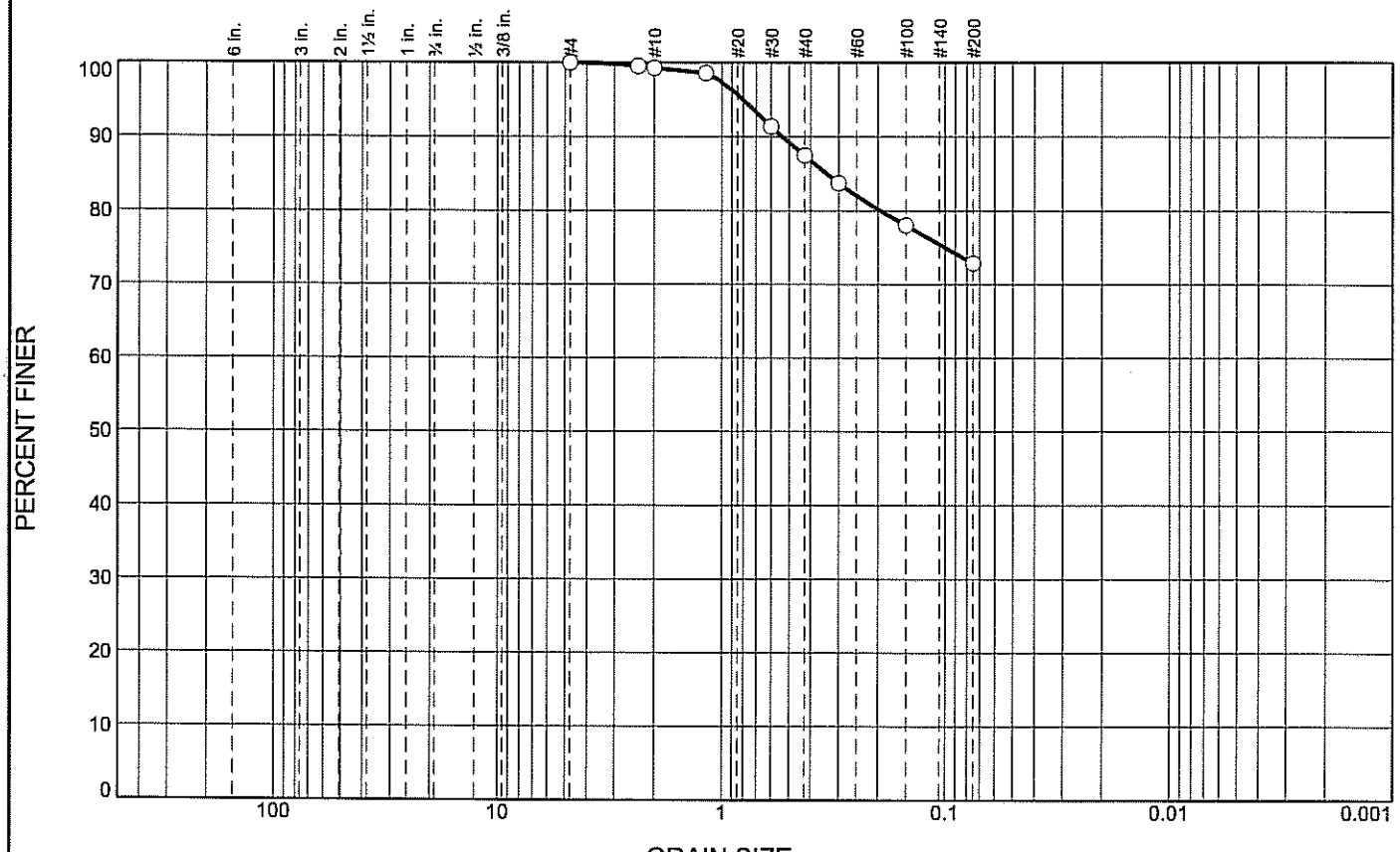
Sample No.: UA-9 **Source of Sample:** LAB#8670 **Date:** 09/21/07
Location: UA-9 **Elev./Depth:**

GES GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.

Client: BRC
Project: BRC EAST SIDE GEOTECH SAMPLING
Project No: 20072247V1 **Figure** 8670

Tested By: JM **Checked By:** AS

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.7	11.8	14.6	72.9	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#4	100.0		
#8	99.5		
#10	99.3		
#16	98.6		
#30	91.4		
#40	87.5		
#50	83.8		
#100	78.1		
#200	72.9		

* (no specification provided)

Soil Description

Silt with sand

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{85}= 0.3386 D_{60}= D_{50}=
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= ML AASHTO= A-4(0)

Remarks

ENTERED BY:BLW

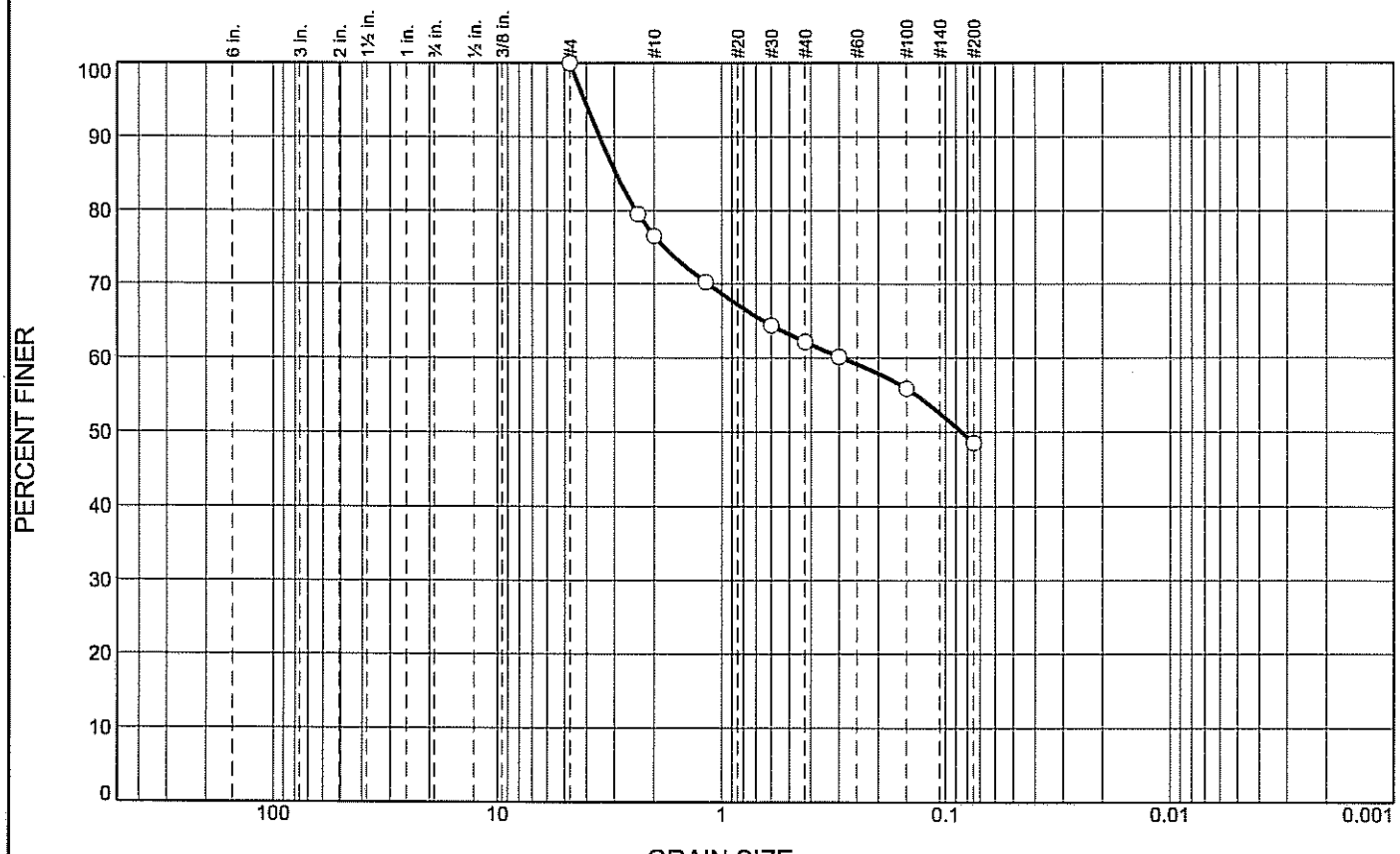
Sample No.: UB-9 **Source of Sample:** LAB#8670 **Date:** 9/26/07
Location: UB-9 **Elev./Depth:**

GES GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.

Client: BRC
Project: BRC EAST SIDE GEOTECH SAMPLING
Project No: 20072247V1 **Figure** 8670

Tested By: JM **Checked By:** BLW

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	23.5	14.4	13.5	48.6	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#4	100.0		
#8	79.5		
#10	76.5		
#16	70.3		
#30	64.4		
#40	62.1		
#50	60.1		
#100	55.9		
#200	48.6		

* (no specification provided)

Soil Description

Silty sand

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{85}= 2.9533 D_{60}= 0.2922 D_{50}= 0.0848
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= SM AASHTO= A-4(0)

Remarks

ENTERED BY:BLW

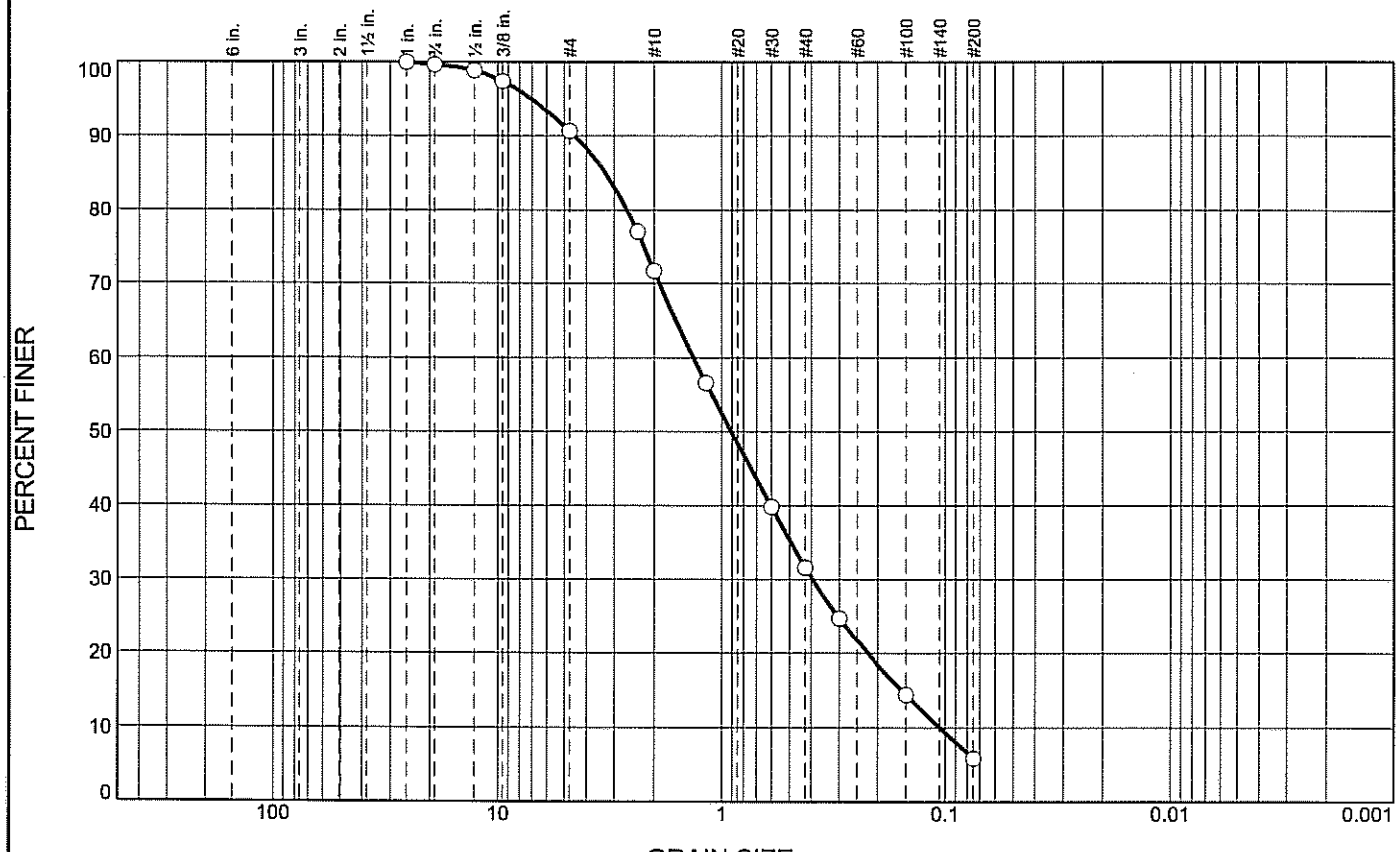
Sample No.: UC-6 **Source of Sample:** LAB#8670 **Date:** 9/26/07
Location: UC-6 **Elev./Depth:**

GES GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.

Client: BRC
Project: BRC EAST SIDE GEOTECH SAMPLING
Project No: 20072247V1 **Figure** 8670

Tested By: JM **Checked By:** BLW

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.3	9.0	19.0	40.1	25.7	5.9	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1	100.0		
.75	99.7		
.5	98.9		
.375	97.4		
#4	90.7		
#8	77.0		
#10	71.7		
#16	56.6		
#30	39.8		
#40	31.6		
#50	24.8		
#100	14.5		
#200	5.9		

* (no specification provided)

Soil Description

Well-graded sand with silt

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{85}= 3.2837 D_{60}= 1.3408 D_{50}= 0.9080
D_{30}= 0.3950 D_{15}= 0.1563 D_{10}= 0.1055
C_u= 12.71 C_c= 1.10

Classification

USCS= SW-SM AASHTO= A-1-b

Remarks

ENTERED BY:BLW

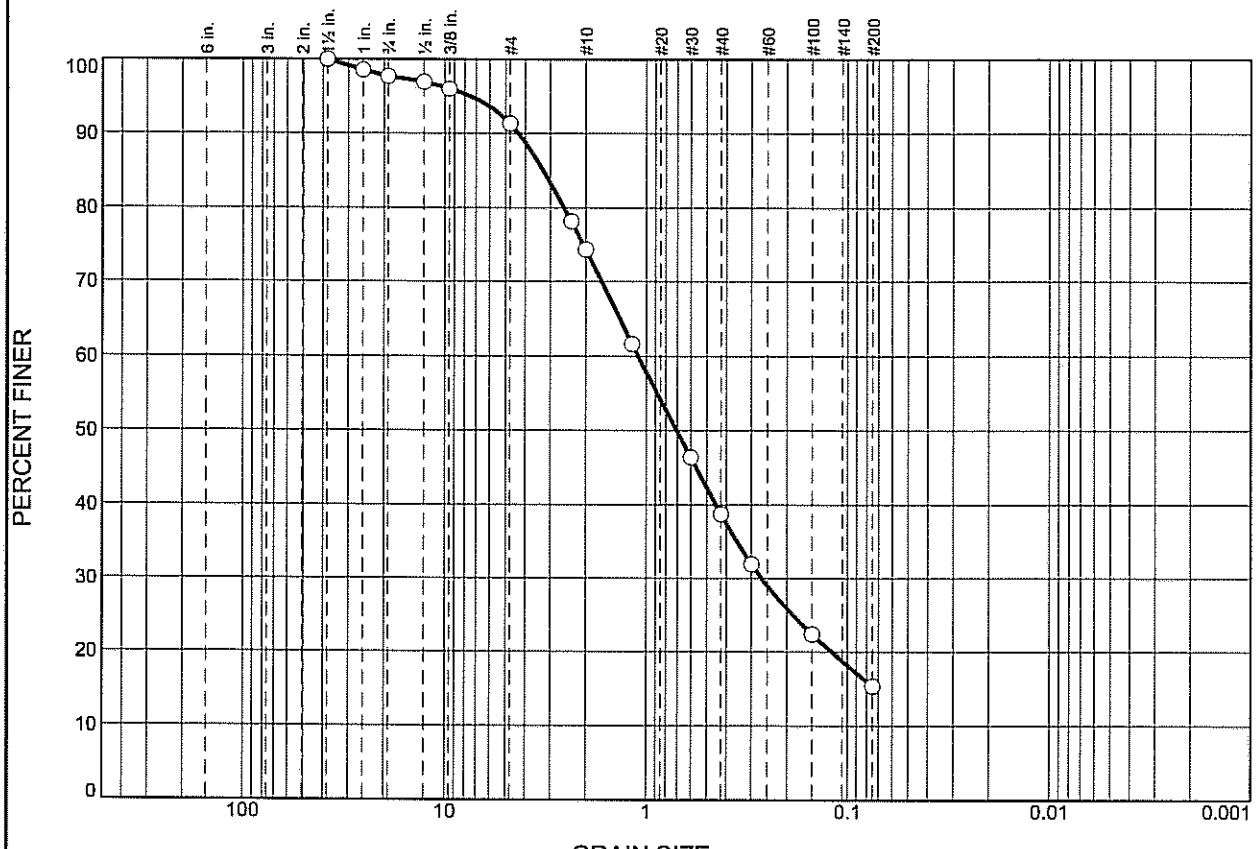
Sample No.: UD-5 **Source of Sample:** LAB#8670 **Date:** 9/26/07
Location: UD-5 **Elev./Depth:**

GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.
GES

Client: BRC
Project: BRC EAST SIDE GEOTECH SAMPLING
Project No: 20072247V1 **Figure** 8670

Tested By: DG **Checked By:** BLW

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	2.3	6.4	17.0	35.6	23.3	15.4	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1.5	100.0		
1	98.6		
.75	97.7		
.5	97.0		
.375	96.0		
#4	91.3		
#8	78.1		
#10	74.3		
#16	61.6		
#30	46.4		
#40	38.7		
#50	31.9		
#100	22.4		
#200	15.4		

* (no specification provided)

Soil Description

Silty sand

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{85}= 3.2435 D_{60}= 1.0994 D_{50}= 0.7046
D_{30}= 0.2671 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= SM AASHTO= A-1-b

Remarks

ENTERED BY:BLW

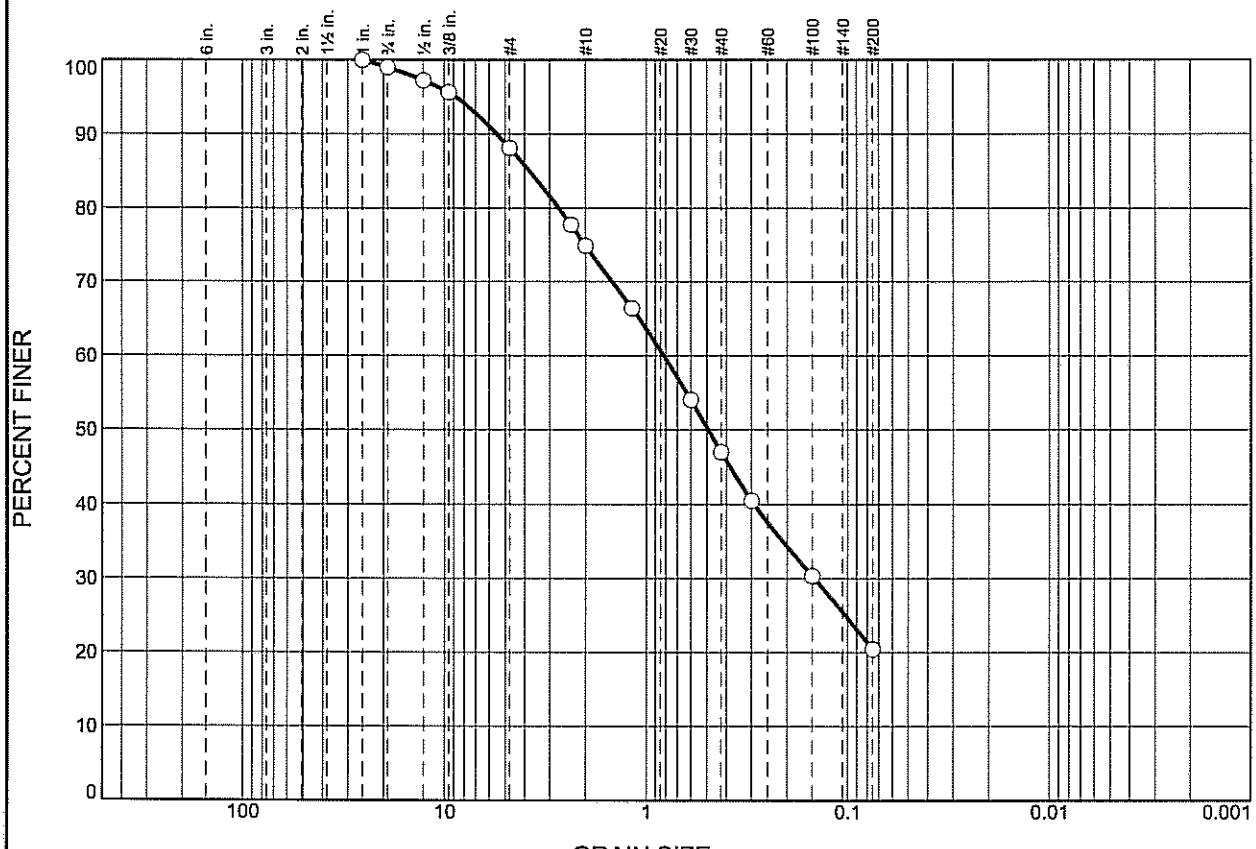
Sample No.: UD-7 **Source of Sample:** LAB#8670 **Date:** 9/26/07
Location: UD-7 **Elev./Depth:**

GES GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.

Client: BRC
Project: BRC EAST SIDE GEOTECH SAMPLING
Project No: 20072247V1 **Figure** 8670

Tested By: JM **Checked By:** BLW

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	1.0	10.9	13.2	27.9	26.5	20.5	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1	100.0		
.75	99.0		
.5	97.3		
.375	95.7		
#4	88.1		
#8	77.7		
#10	74.9		
#16	66.4		
#30	54.1		
#40	47.0		
#50	40.5		
#100	30.4		
#200	20.5		

* (no specification provided)

Soil Description

Silty sand

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{85}= 3.7763 D_{60}= 0.8173 D_{50}= 0.4920
D_{30}= 0.1461 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= SM AASHTO= A-1-b

Remarks

SAMPLED:09/13/07
ENTERED BY:AS

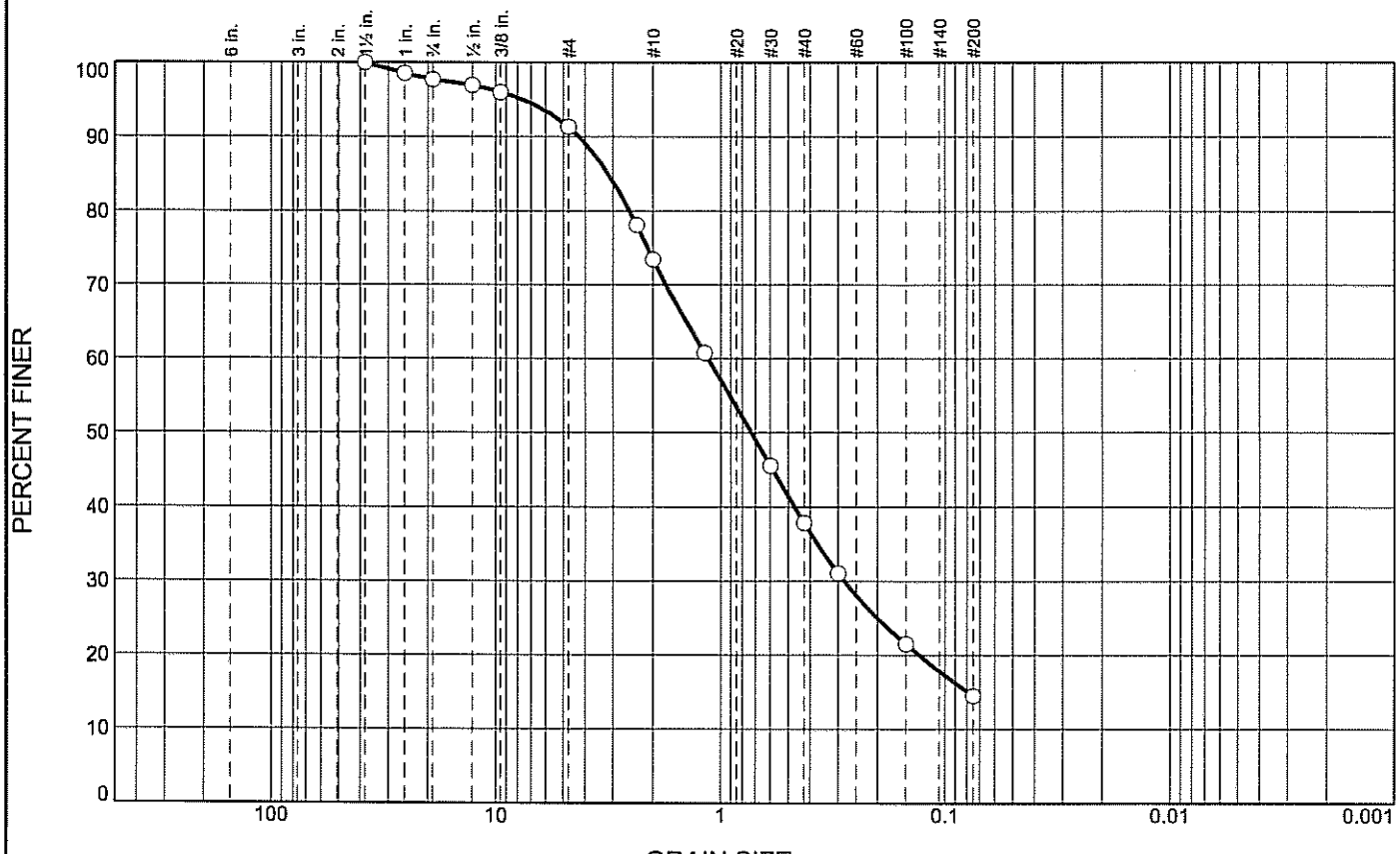
Sample No.: UE-3 **Source of Sample:** LAB#8670 **Date:** 09/21/07
Location: UE-3 **Elev./Depth:**

GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.
GES

Client: BRC
Project: BRC EAST SIDE GEOTECH SAMPLING
Project No: 20072247V1 **Figure** 8670

Tested By: DG **Checked By:** AS

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	2.3	6.4	17.9	35.5	23.4	14.5	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1.5	100.0		
1	98.6		
.75	97.7		
.5	97.0		
.375	96.0		
#4	91.3		
#8	78.1		
#10	73.4		
#16	60.8		
#30	45.5		
#40	37.9		
#50	31.1		
#100	21.5		
#200	14.5		

* (no specification provided)

Soil Description

Silty sand

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{85}= 3.1542 D_{60}= 1.1397 D_{50}= 0.7304
D_{30}= 0.2819 D_{15}= 0.0790 D_{10}=
C_u= C_c=

Classification

USCS= SM AASHTO= A-1-b

Remarks

ENTERED BY:BLW

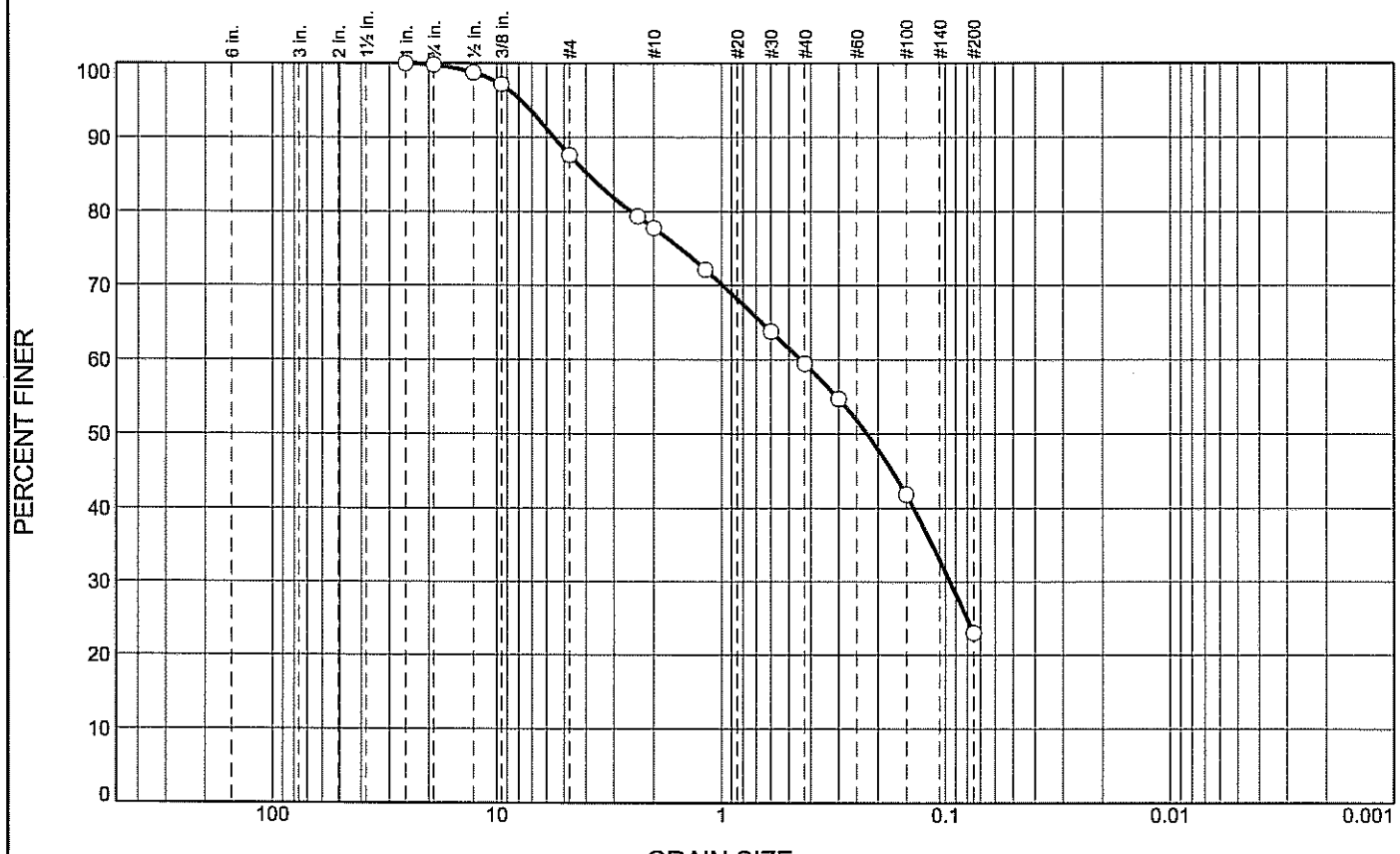
Sample No.: UE-5 **Source of Sample:** LAB#8670 **Date:** 9/26/07
Location: UE-5 **Elev./Depth:**

GES GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.

Client: BRC
Project: BRC EAST SIDE GEOTECH SAMPLING
Project No: 20072247V1 **Figure** 8670

Tested By: JM **Checked By:** BLW

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.2	12.2	9.8	18.3	36.5	23.0	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1	100.0		
.75	99.8		
.5	98.8		
.375	97.2		
#4	87.6		
#8	79.4		
#10	77.8		
#16	72.1		
#30	63.8		
#40	59.5		
#50	54.7		
#100	41.9		
#200	23.0		

* (no specification provided)

Soil Description

Silty sand

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{85}= 3.9227 D_{60}= 0.4423 D_{50}= 0.2238
D_{30}= 0.0955 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= SM AASHTO= A-2-4(0)

Remarks

SAMPLED:09/13/07
ENTERED BY:AS

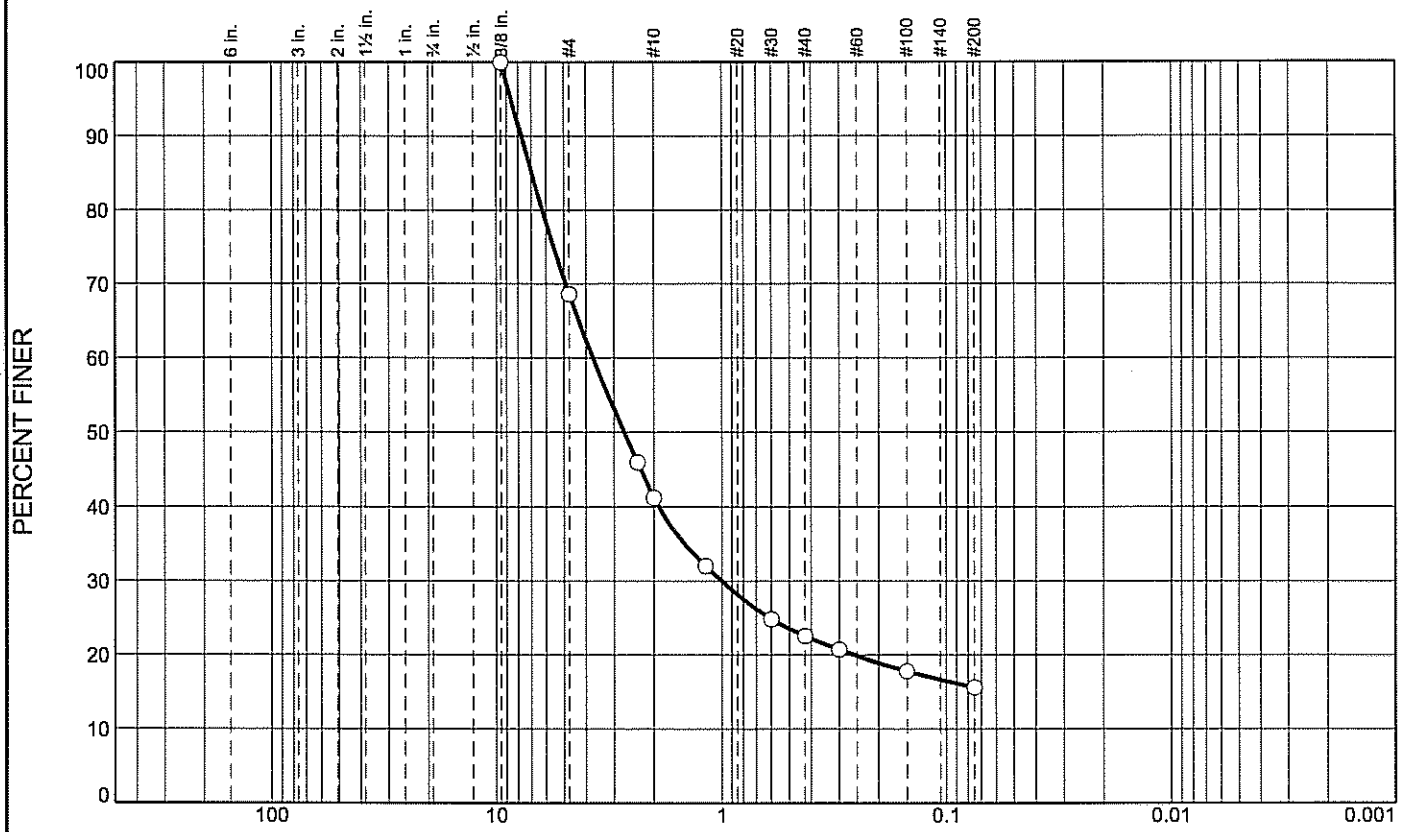
Sample No.: UF-2 **Source of Sample:** LAB#8670 **Date:** 09/21/07
Location: UF-2 **Elev./Depth:**

GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.
GES

Client: BRC
Project: BRC EAST SIDE GEOTECH SAMPLING
Project No: 20072247V1 **Figure** 8670

Tested By: DG **Checked By:** AS

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	31.4	27.4	18.6	7.0	15.6	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.375	100.0		
#4	68.6		
#8	46.0		
#10	41.2		
#16	32.0		
#30	24.9		
#40	22.6		
#50	20.7		
#100	17.8		
#200	15.6		

* (no specification provided)

Soil Description

Silty sand with gravel

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{85}= 6.9558 D_{60}= 3.7300 D_{50}= 2.7034
D_{30}= 0.9981 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= SM AASHTO= A-1-b

Remarks

ENTERED BY:BLW

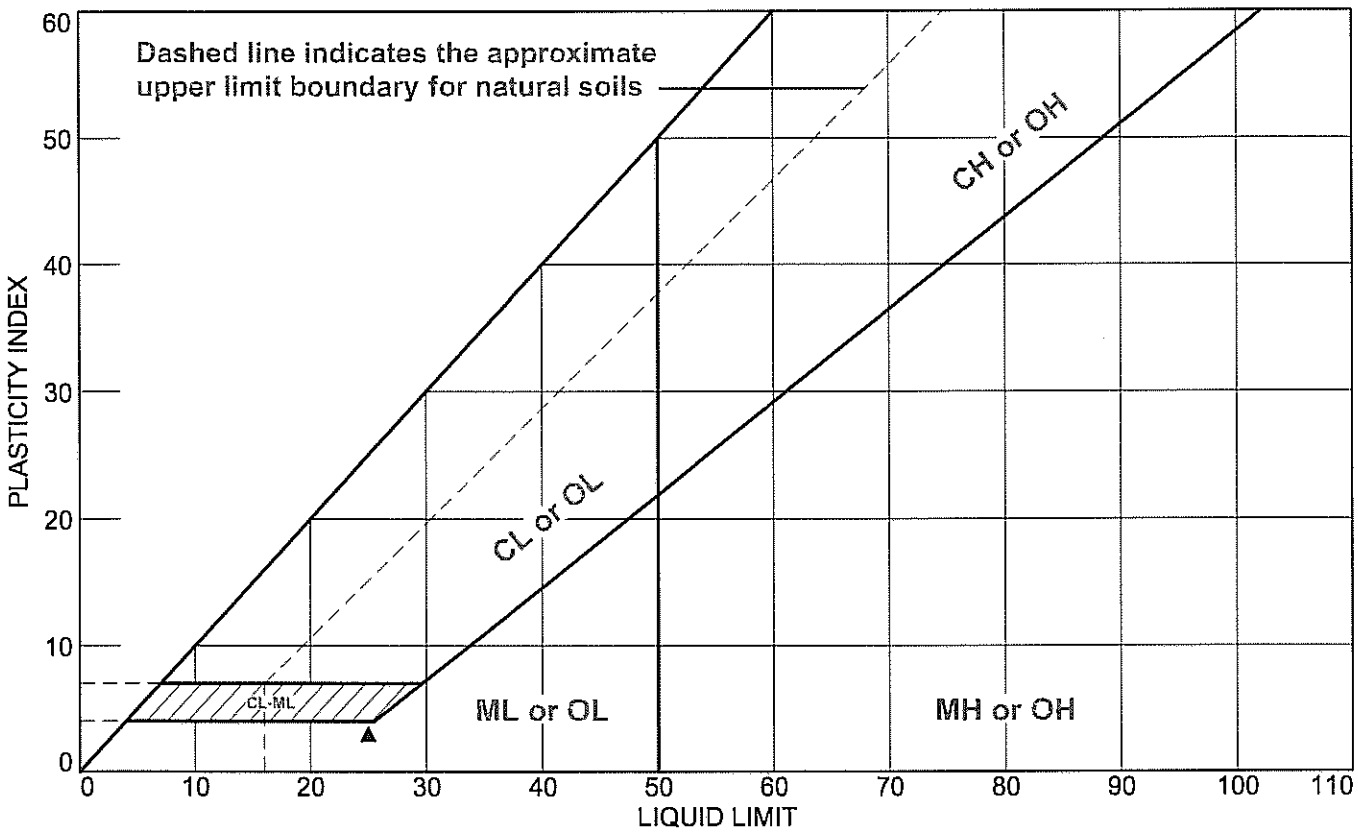
Sample No.: UF-6 **Source of Sample:** LAB#8670 **Date:** 9/26/07
Location: UF-6 **Elev./Depth:**

GES GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.

Client: BRC
Project: BRC EAST SIDE GEOTECH SAMPLING
Project No: 20072247V1 **Figure** 8670

Tested By: JM **Checked By:** BLW

LIQUID AND PLASTIC LIMITS TEST REPORT



SOIL DATA

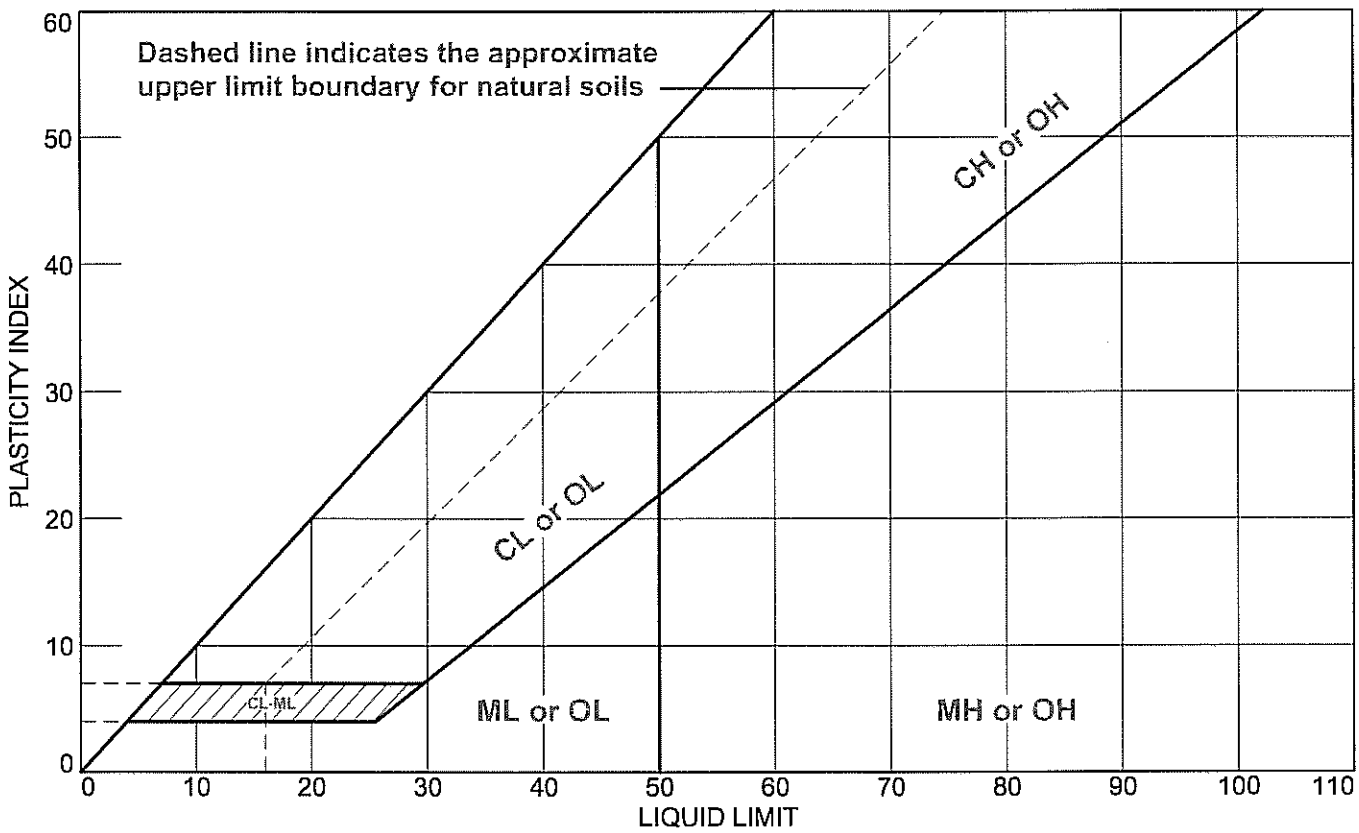
	SOURCE	SAMPLE NO.	DEPTH (ft.)	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
●	LAB#8670	TP-1			NP	NV	NP	ML
■	LAB#8670	TP-2			NP	NV	NP	ML
▲	LAB#8670	TP-3			22	25	3	ML
◆	LAB#8670	TP-4			NP	NV	NP	ML
▼	LAB#8670	TP-5			NP	NV	NP	ML
✱	LAB#8670	TP-6			NP	NV	NP	ML
⊕	LAB#8670	TP-7			NP	NV	NP	ML
⊞	LAB#8670	TP-8			NP	NV	NP	ML
⊗	LAB#8670	TP-9			NP	NV	NP	ML
⊠	LAB#8670	TP-10			NP	NV	NP	ML

GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.
GES

Client: BRC
Project: BRC EAST SIDE GEOTECH SAMPLING
Project No.: 20072247V1 **Figure** 8670-1

Tested By: JK **Checked By:** AS

LIQUID AND PLASTIC LIMITS TEST REPORT



SOIL DATA

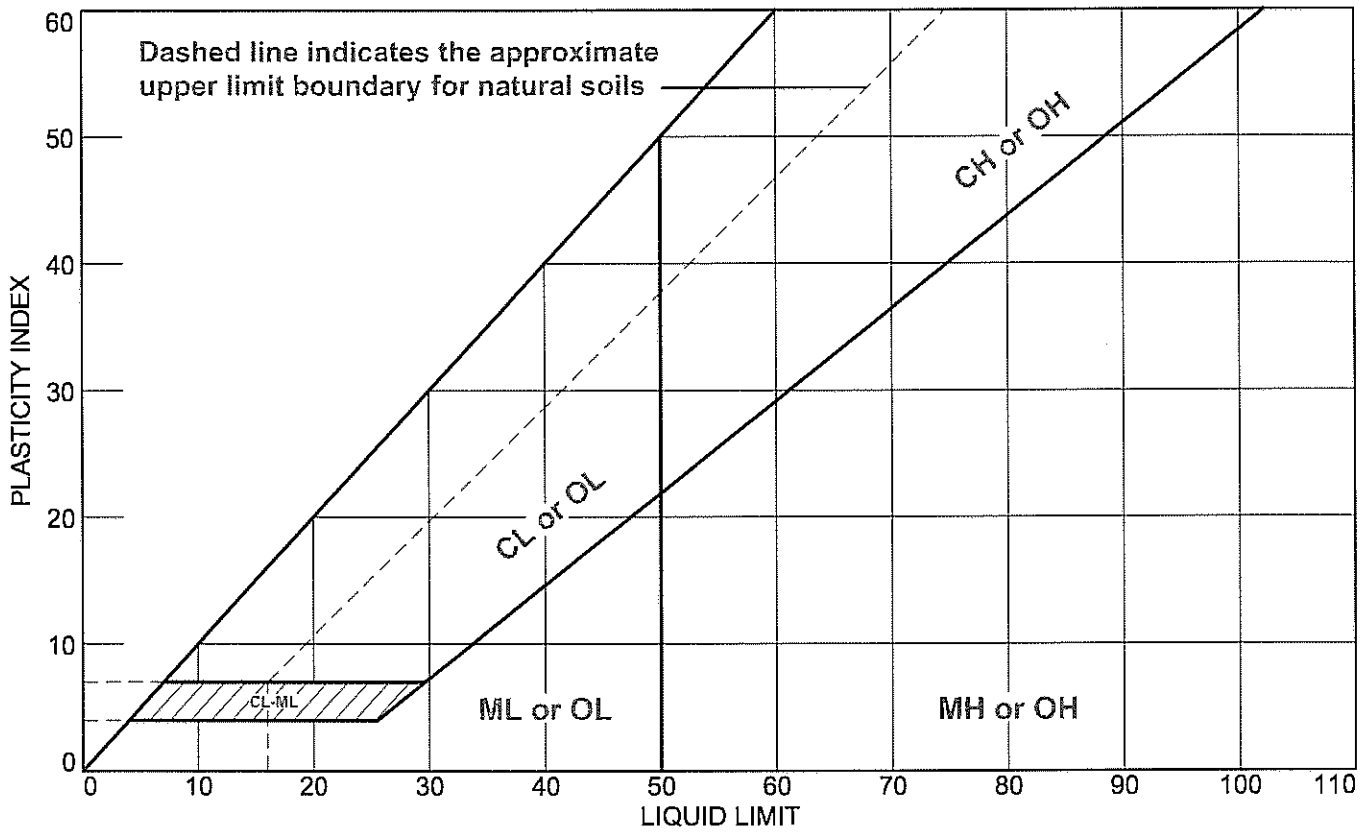
	SOURCE	SAMPLE NO.	DEPTH (ft.)	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
●	LAB#8670	TP-11			NP	NV	NP	ML
■	LAB#8670	TP-12			NP	NV	NP	ML
▲	LAB#8670	TP-13			NP	NV	NP	ML
◆	LAB#8670	TP-14			NP	NV	NP	SM
▼	LAB#8670	TP-15			NP	NV	NP	ML
✱	LAB#8670	TP-16			NP	NV	NP	ML
⊕	LAB#8670	UA-7			NP	NV	NP	SM
⊞	LAB#8670	UA-9			NP	NV	NP	ML
⊗	LAB#8670	UB-9			NP	NV	NP	ML
⊠	LAB#8670	UC-6			NP	NV	NP	SM

GES GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.

Client: BRC
Project: BRC EAST SIDE GEOTECH SAMPLING
Project No.: 20072247V1 **Figure** 8670-2

Tested By: JK **Checked By:** AS

LIQUID AND PLASTIC LIMITS TEST REPORT



SOIL DATA

	SOURCE	SAMPLE NO.	DEPTH (ft.)	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
●	LAB#8670	UD-5			NP	NV	NP	SW-SM
■	LAB#8670	UD-7			NP	NV	NP	SM
▲	LAB#8670	UE-3			NP	NV	NP	SM
◆	LAB#8670	UE-5			NP	NV	NP	SM
▼	LAB#8670	UF-2			NP	NV	NP	SM
*	LAB#8670	UF-6			NP	NV	NP	SM

GES GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.

Client: BRC
Project: BRC EAST SIDE GEOTECH SAMPLING
Project No.: 20072247V1 **Figure** 8670-3

Tested By: JK **Checked By:** AS

COMPACTION TEST REPORT

Curve No.: 8670

Project No.: 20072247V1 **Date:** 9/28/07

Project: BRC EAST SIDE GEOTECH SAMPLING

Location: TP-1

Elev./Depth: **Sample No.** TP-1

Remarks: ENTERED BY:BLW

MATERIAL DESCRIPTION

Description: Sandy silt

Classifications - **USCS:** ML **AASHTO:** A-4(0)

Nat. Moist. = **Sp.G. =** 2.65

Liquid Limit = NV **Plasticity Index =** NP

% > No.4 = 0.0 % **% < No.200 =** 68.9 %

TEST RESULTS
Maximum dry density = 86.5 pcf
Optimum moisture = 22.5 %

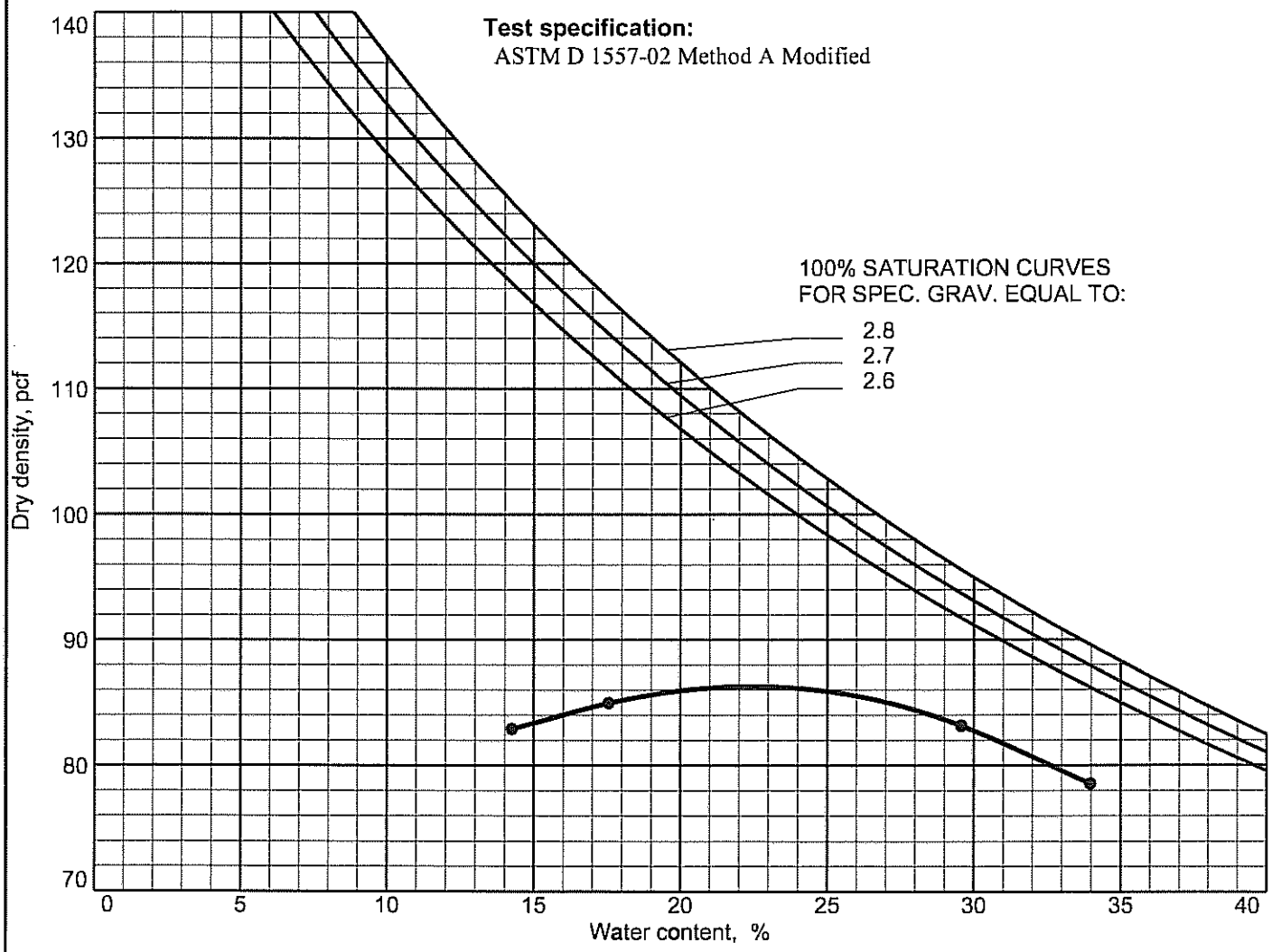


Figure 8670

GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.

COMPACTION TEST REPORT

Curve No.: 8670

Project No.: 20072247V1 **Date:** 09/23/07

Project: BRC EAST SIDE GEOTECH SAMPLING

Location: TP-2

Elev./Depth: **Sample No.** TP-2

Remarks: ENTERED BY:AS

MATERIAL DESCRIPTION

Description: Silt

Classifications - **USCS:** ML **AASHTO:** A-4(0)

Nat. Moist. = **Sp.G. =** 2.65

Liquid Limit = NV **Plasticity Index =** NP

% > No.4 = 0.0 % **% < No.200 =** 97.4 %

ROCK CORRECTED TEST RESULTS
Maximum dry density = 105.0 pcf
Optimum moisture = 12.0 %

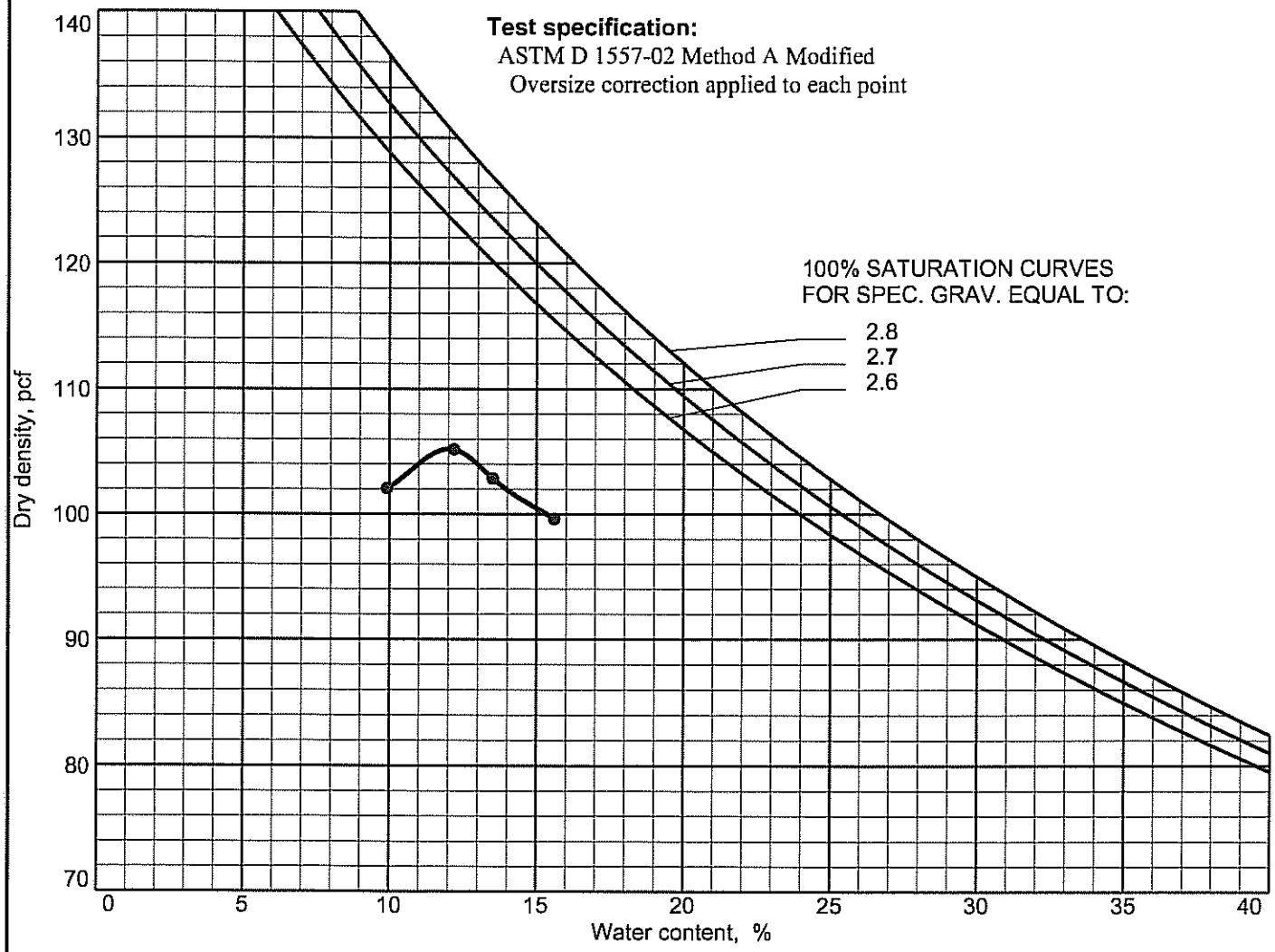


Figure 8670

GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.

COMPACTION TEST REPORT

Curve No.: 8670

Project No.: 20072247V1 **Date:** 9/25/07

Project: BRC EAST SIDE GEOTECH SAMPLING

Location: TP-3

Elev./Depth: **Sample No.** TP-3

Remarks: ENTERED BY:BLW

MATERIAL DESCRIPTION

Description:

Classifications - **USCS:** ML **AASHTO:** A-4(2)

Nat. Moist. = **Sp.G. =** 2.50

Liquid Limit = 25 **Plasticity Index =** 3

% > No.4 = % **% < No.200 =** 95.2 %

TEST RESULTS
Maximum dry density = 102.5 pcf
Optimum moisture = 12.0 %

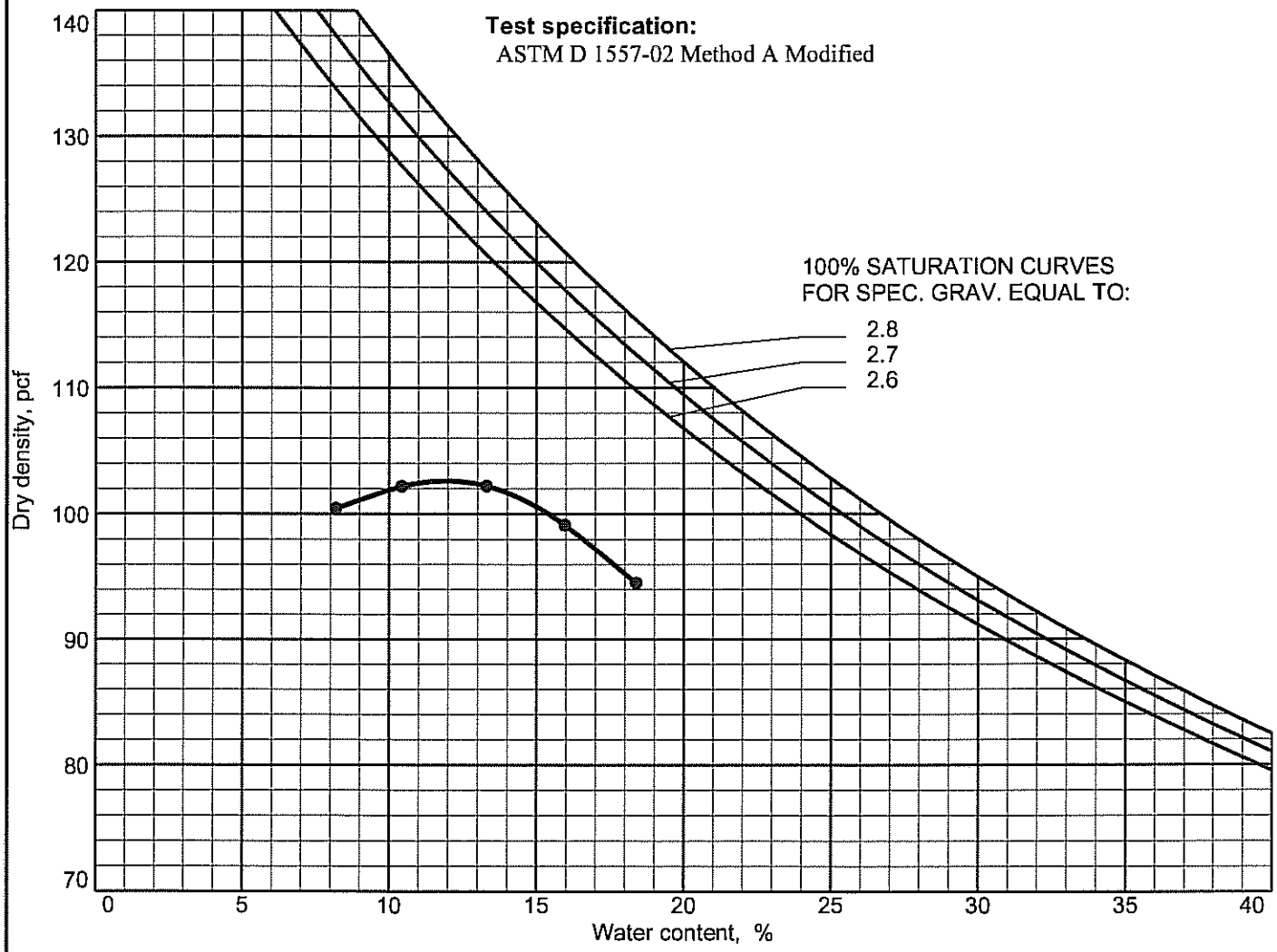


Figure 8670

GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.

COMPACTION TEST REPORT

Curve No.: 8670

Project No.: 20072247V1 **Date:** 09/27/07

Project: BRC EAST SIDE GEOTECH SAMPLING

Location: TP-4

Elev./Depth: **Sample No.** TP-4

Remarks: ENTERED BY:AS

MATERIAL DESCRIPTION

Description:

Classifications - **USCS:** ML **AASHTO:** A-4(0)

Nat. Moist. = **Sp.G. =** 2.65

Liquid Limit = NV **Plasticity Index =** NP

% > No.4 = 0.0 % **% < No.200 =** 87.8 %

ROCK CORRECTED TEST RESULTS
Maximum dry density = 81.0 pcf
Optimum moisture = 33.0 %

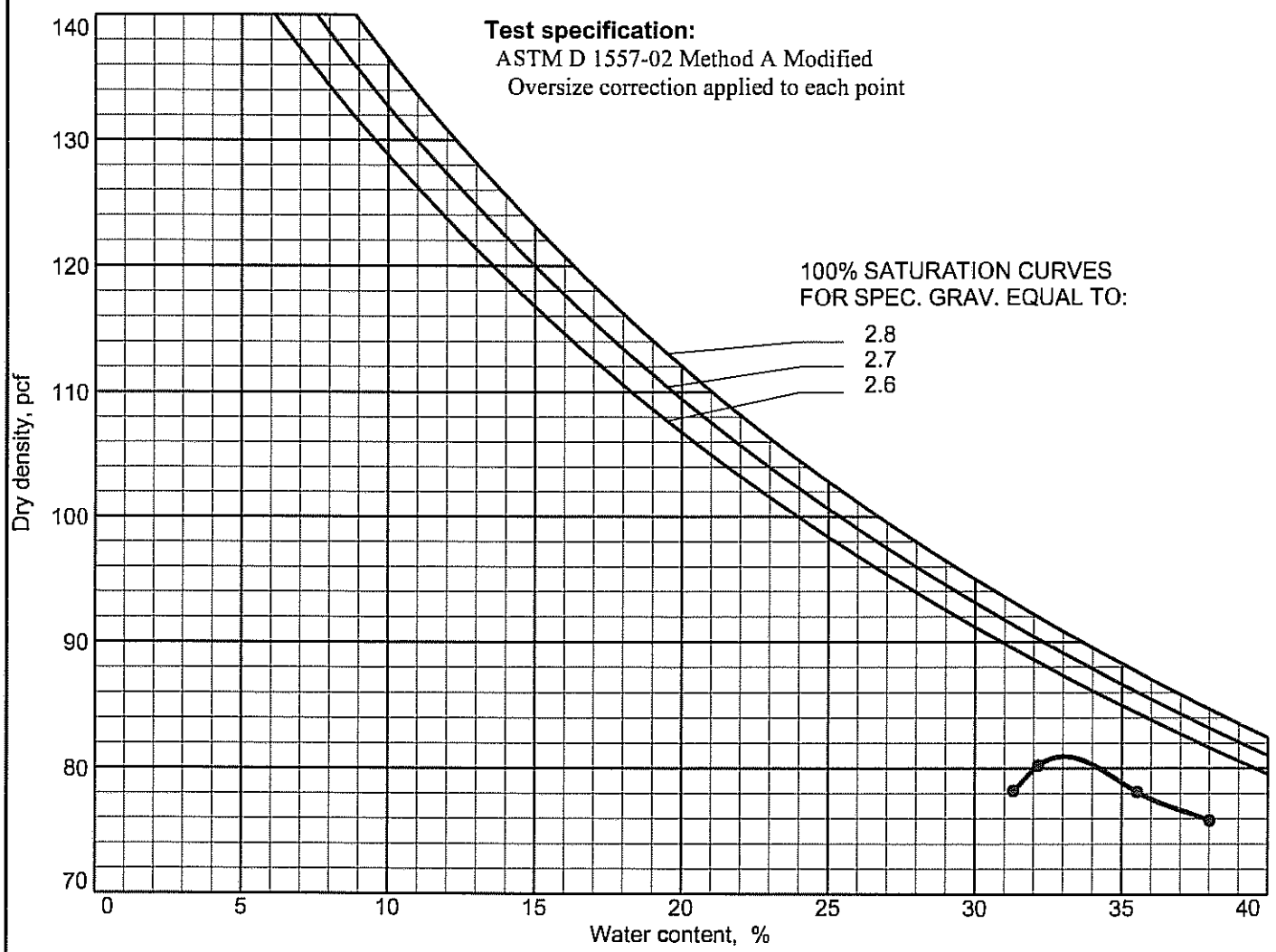


Figure 8670

GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.

COMPACTION TEST REPORT

Curve No.: 8683

Project No.: 20072247V1 **Date:** 09/30/07

Project: BRC EAST SIDE GEOTECH SAMPLING

Location: TP-5

Elev./Depth: **Sample No.** TP-5

Remarks: ENTERED BY:AS

MATERIAL DESCRIPTION

Description:

Classifications - **USCS:** ML **AASHTO:** A-4(0)

Nat. Moist. = **Sp.G. =**

Liquid Limit = NV **Plasticity Index =** NP

% > No.4 = 0.0 % **% < No.200 =** 86.3 %

TEST RESULTS
Maximum dry density = 81.5 pcf
Optimum moisture = 33.0 %

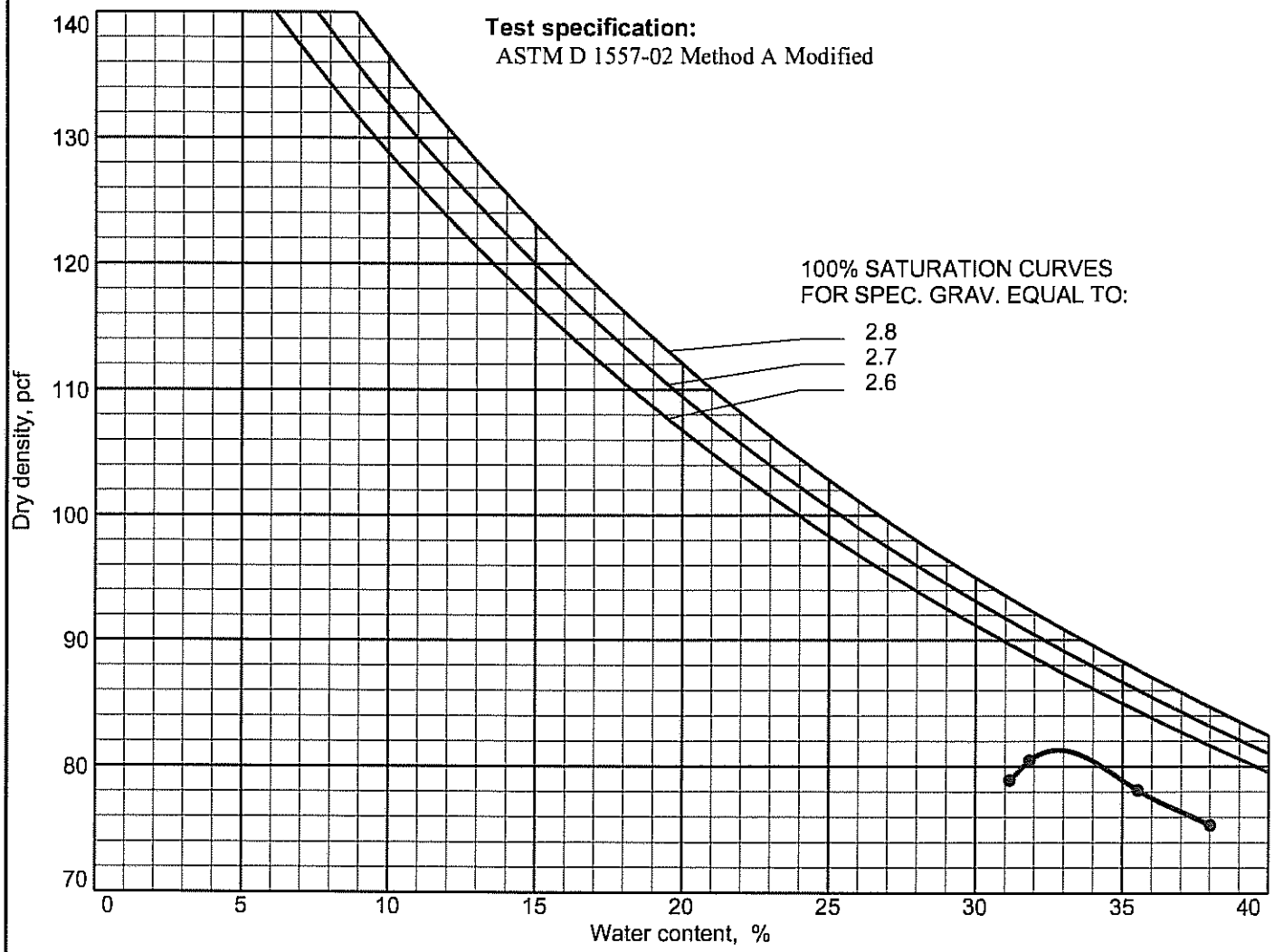


Figure 8670

GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.

COMPACTION TEST REPORT

Curve No.: 8670

Project No.: 20072247V1 **Date:** 09/30/07

Project: BRC EAST SIDE GEOTECH SAMPLING

Location: TP-6

Elev./Depth: **Sample No.** TP-6

Remarks: ENTERED BY:AS

MATERIAL DESCRIPTION

Description:

Classifications - **USCS:** ML **AASHTO:** A-4(0)

Nat. Moist. = **Sp.G. =** 2.65

Liquid Limit = NV **Plasticity Index =** NP

% > No.4 = 0.0 % **% < No.200 =** 99.3 %

TEST RESULTS
Maximum dry density = 85.0 pcf
Optimum moisture = 30.0 %

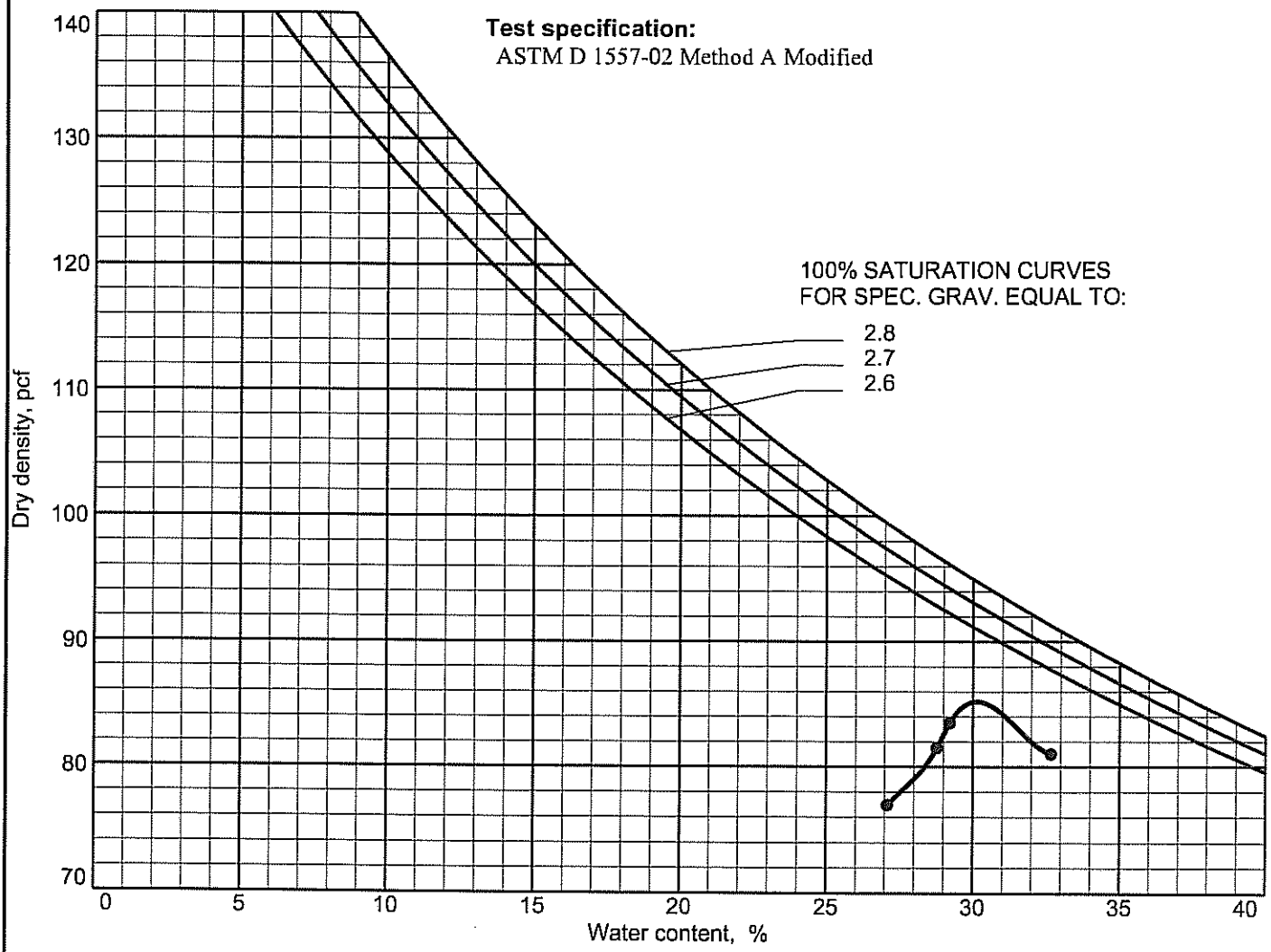


Figure 8670

GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.

COMPACTION TEST REPORT

Curve No.: 8670

Project No.: 20072247V1 **Date:** 09/27/07

Project: BRC EAST SIDE GEOTECH SAMPLING

Location: TP-7

Elev./Depth: **Sample No.** TP-7

Remarks: ENTERED BY:AS

MATERIAL DESCRIPTION

Description:

Classifications - **USCS:** ML **AASHTO:** A-4(0)

Nat. Moist. = **Sp.G. =** 2.65

Liquid Limit = NV **Plasticity Index =** NP

% > No.4 = 0.0 % **% < No.200 =** 90.8 %

ROCK CORRECTED TEST RESULTS
Maximum dry density = 83.0 pcf
Optimum moisture = 30.0 %

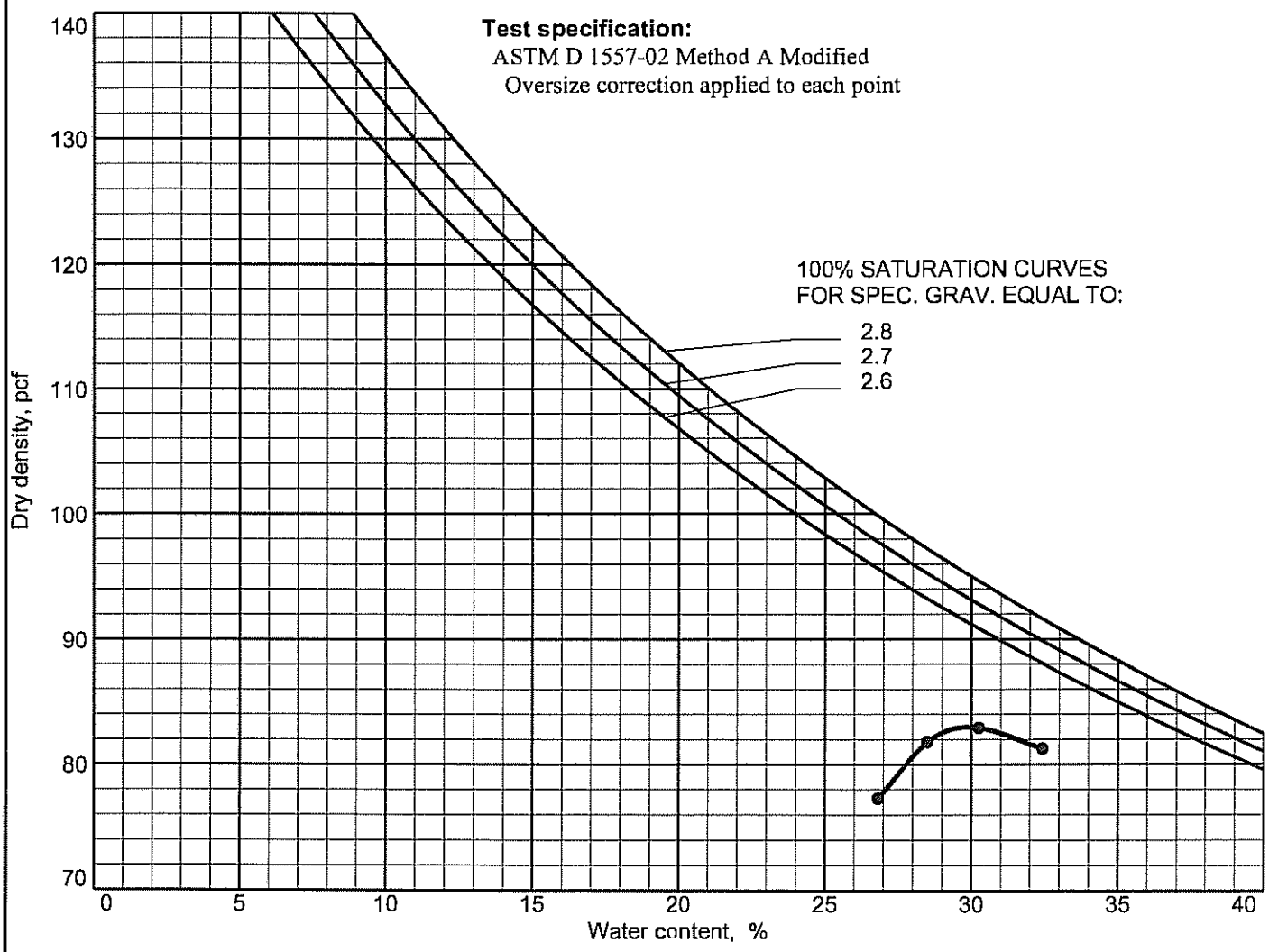


Figure 8670

GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.

COMPACTION TEST REPORT

Curve No.: 8670

Project No.: 20072247V1 **Date:** 09/25/07

Project: BRC EAST SIDE GEOTECH SAMPLING

Location: TP-8

Elev./Depth: **Sample No.** TP-8

Remarks: ENTERED BY:AS

MATERIAL DESCRIPTION

Description:

Classifications - **USCS:** ML **AASHTO:**

Nat. Moist. = **Sp.G. =** 2.65

Liquid Limit = NV **Plasticity Index =** NP

% > No.4 = 0.0 % **% < No.200 =** 91.8 %

TEST RESULTS
Maximum dry density = 87.0 pcf
Optimum moisture = 21.5 %

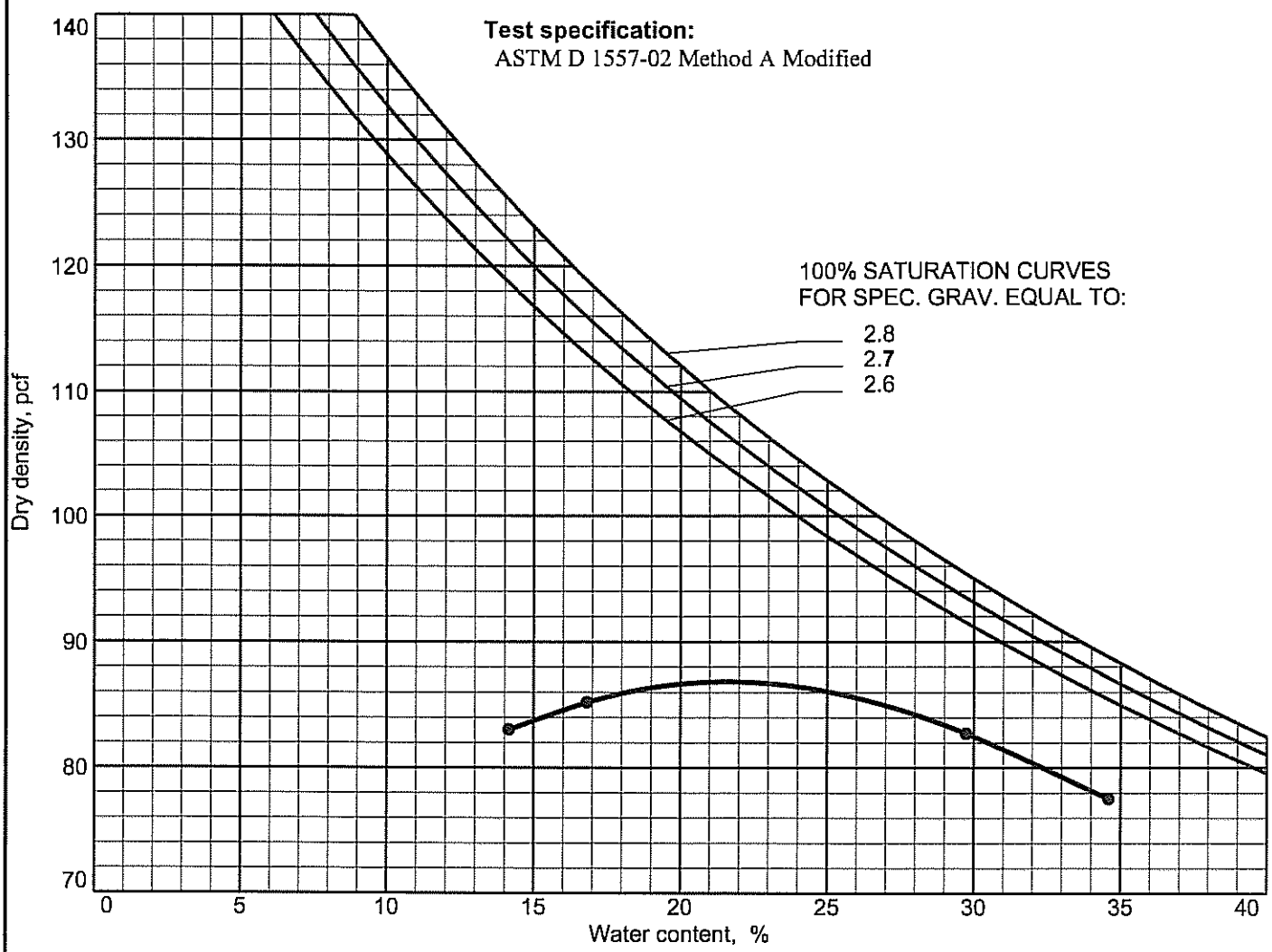


Figure 8670

COMPACTION TEST REPORT

Curve No.: 8670

Project No.: 20072247V1 **Date:** 09/26/07

Project: BRC EAST SIDE GEOTECH SAMPLING

Location: TP-9

Elev./Depth: **Sample No.** TP-9

Remarks: ENTERED BY:AS

MATERIAL DESCRIPTION

Description:

Classifications - **USCS:** ML **AASHTO:** A-4(0)

Nat. Moist. = **Sp.G. =** 2.65

Liquid Limit = NV **Plasticity Index =** NP

% > No.4 = 0.0 % **% < No.200 =** 85.5 %

TEST RESULTS
Maximum dry density = 80.5 pcf
Optimum moisture = 33.0 %

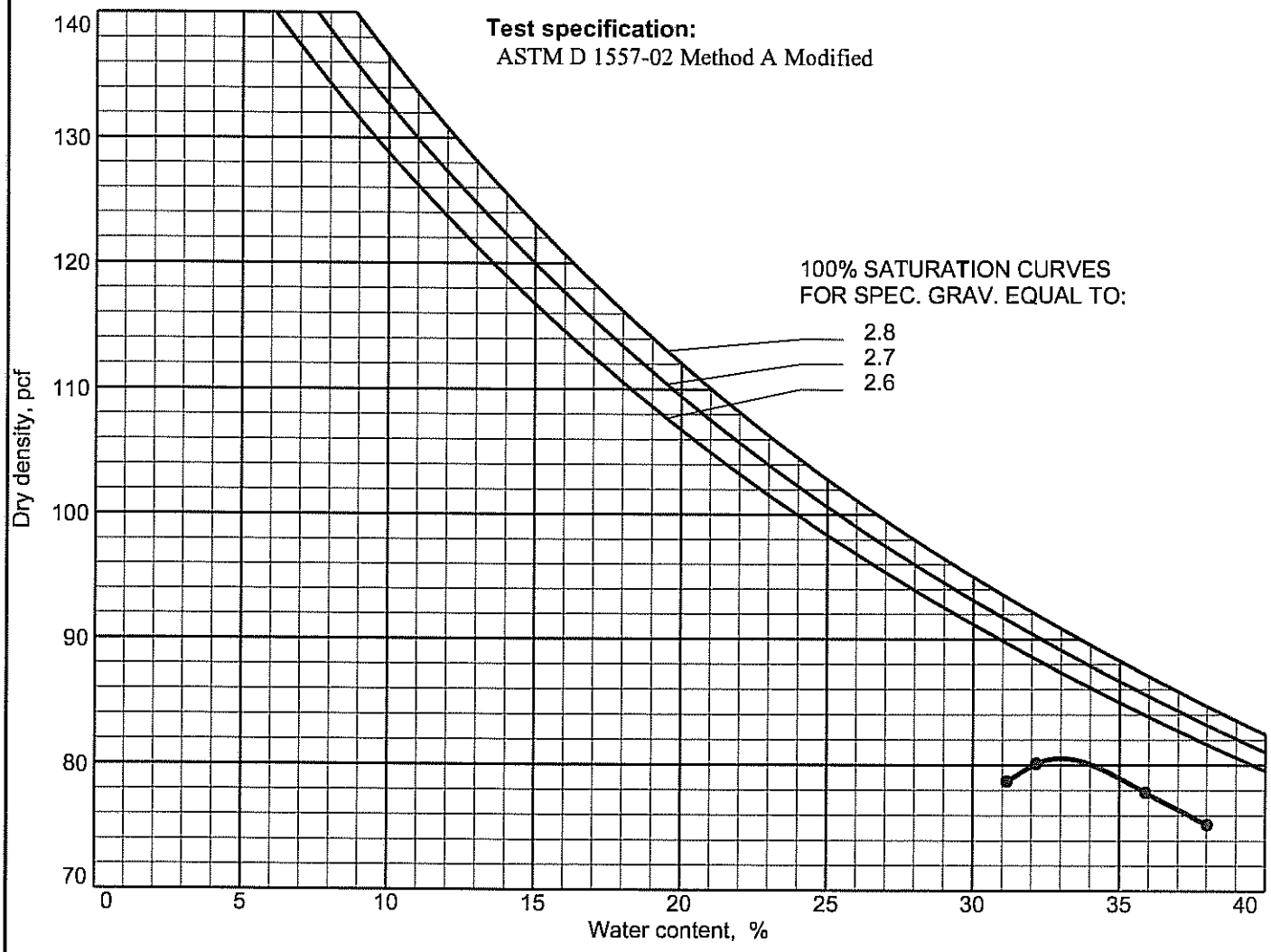


Figure 8670

GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.

COMPACTION TEST REPORT

Curve No.: 8670

Project No.: 20072247V1 **Date:** 09/28/07

Project: BRC EAST SIDE GEOTECH SAMPLING

Location: TP-10

Elev./Depth: **Sample No.** TP-10

Remarks: ENTERED BY:AS

MATERIAL DESCRIPTION

Description:

Classifications - **USCS:** ML **AASHTO:** A-4(0)

Nat. Moist. = **Sp.G. =** 2.65

Liquid Limit = NV **Plasticity Index =** NP

% > No.4 = 0.0 % **% < No.200 =** 96.0 %

ROCK CORRECTED TEST RESULTS
Maximum dry density = 95.0 pcf
Optimum moisture = 11.0 %

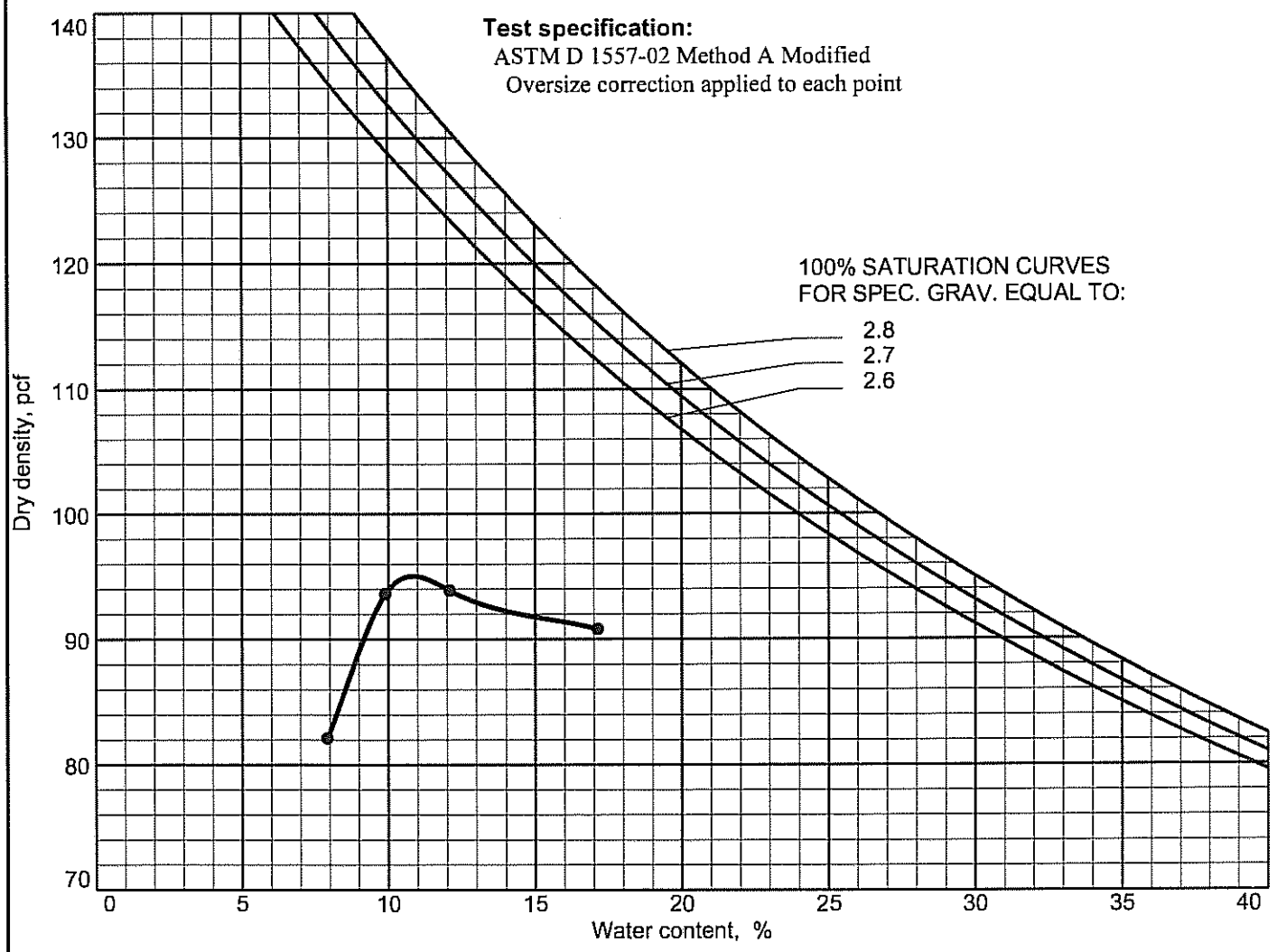


Figure 8670

GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.

COMPACTION TEST REPORT

Curve No.: 8670

Project No.: 20072247V1 **Date:** 09/27/07

Project: BRC EAST SIDE GEOTECH SAMPLING

Location: TP-11

Elev./Depth: **Sample No.** TP-11

Remarks: ENTERED BY:AS

MATERIAL DESCRIPTION

Description:

Classifications - **USCS:** ML **AASHTO:** A-4(0)

Nat. Moist. = **Sp.G. =** 2.65

Liquid Limit = NV **Plasticity Index =** NP

% > No.4 = 0.0 % **% < No.200 =** 94.2 %

TEST RESULTS
Maximum dry density = 104.5 pcf
Optimum moisture = 8.5 %

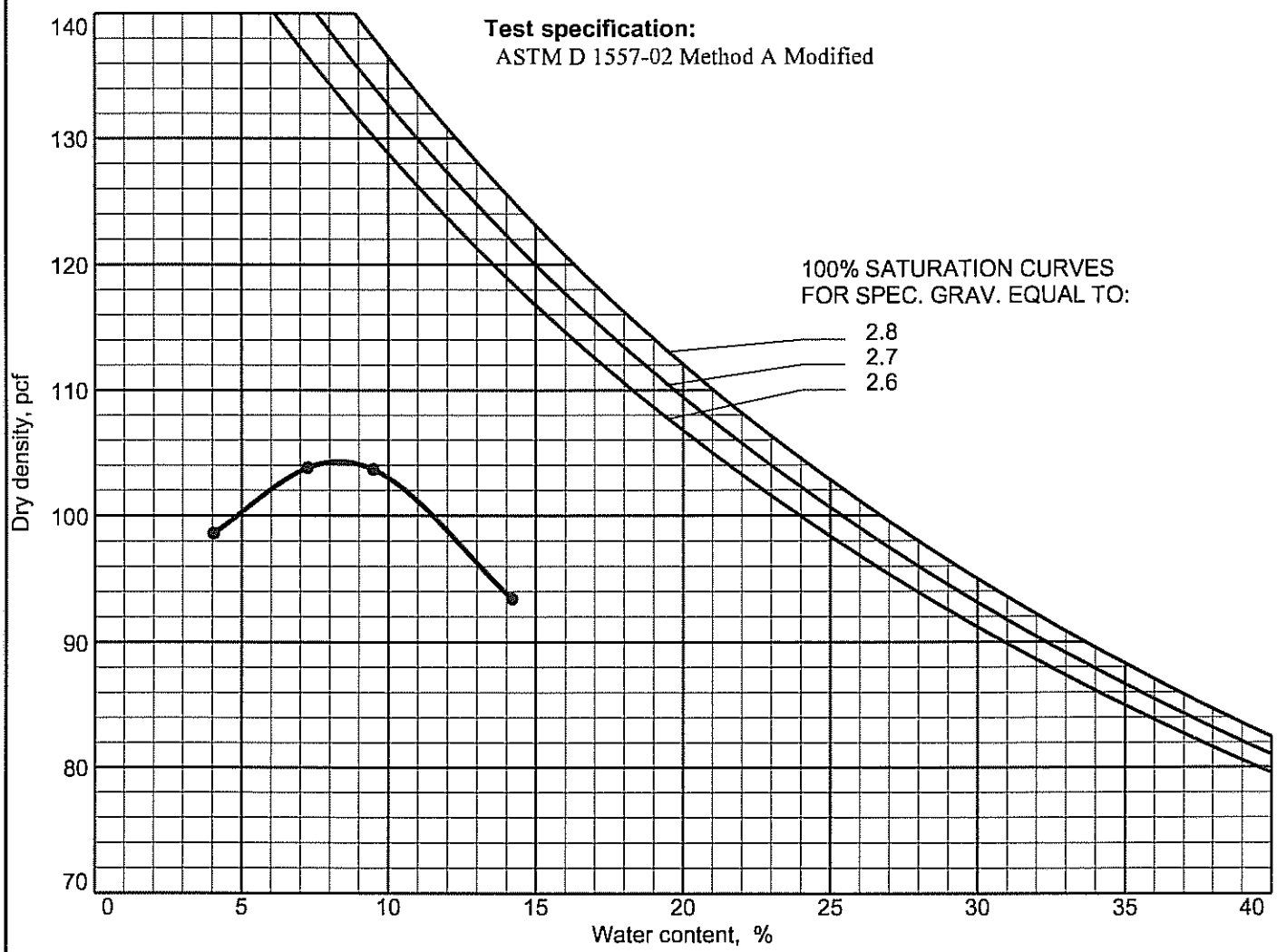


Figure 8670

COMPACTION TEST REPORT

Curve No.: 8670

Project No.: 20072247V1 **Date:** 09/28/07

Project: BRC EAST SIDE GEOTECH SAMPLING

Location: TP-12

Elev./Depth: **Sample No.** TP-12

Remarks: ENTERED BY:AS

MATERIAL DESCRIPTION

Description:

Classifications - **USCS:** ML **AASHTO:** A-4(0)

Nat. Moist. = **Sp.G. =** 2.65

Liquid Limit = NV **Plasticity Index =** NP

% > No.4 = 0.0 % **% < No.200 =** 99.7 %

ROCK CORRECTED TEST RESULTS
Maximum dry density = 104.5 pcf
Optimum moisture = 8.0 %

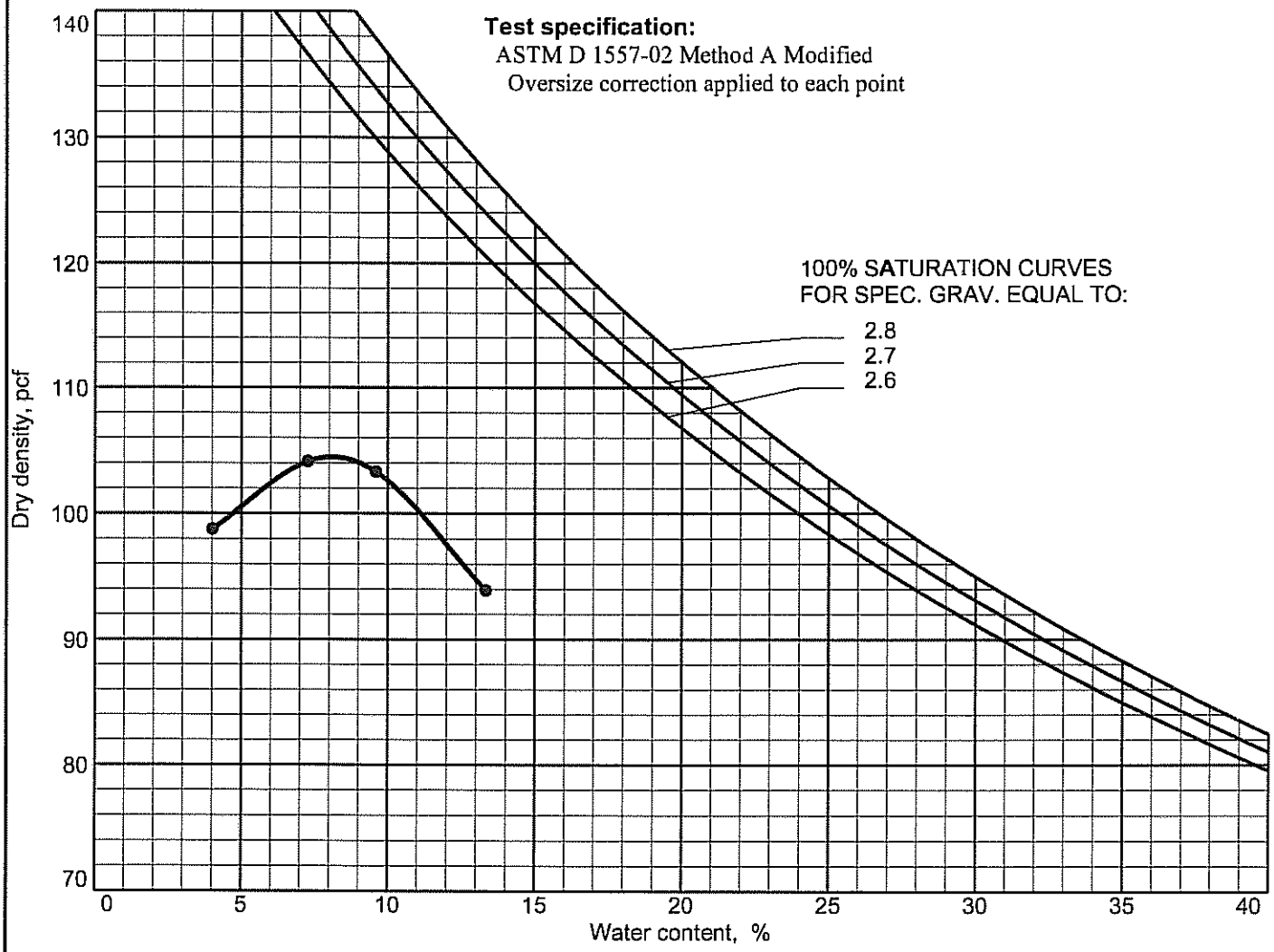


Figure 8670

GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.

COMPACTION TEST REPORT

Curve No.: 8670

Project No.: 20072247V1 **Date:** 09/28/07

Project: BRC EAST SIDE GEOTECH SAMPLING

Location: TP-13

Elev./Depth: **Sample No.** TP-13

Remarks: ENTERED BY:AS

MATERIAL DESCRIPTION

Description:

Classifications - **USCS:** ML **AASHTO:** A-4(0)

Nat. Moist. = **Sp.G. =** 2.65

Liquid Limit = NV **Plasticity Index =** NP

% > No.4 = 0.0 % **% < No.200 =** 88.7 %

TEST RESULTS
Maximum dry density = 87.0 pcf
Optimum moisture = 15.5 %

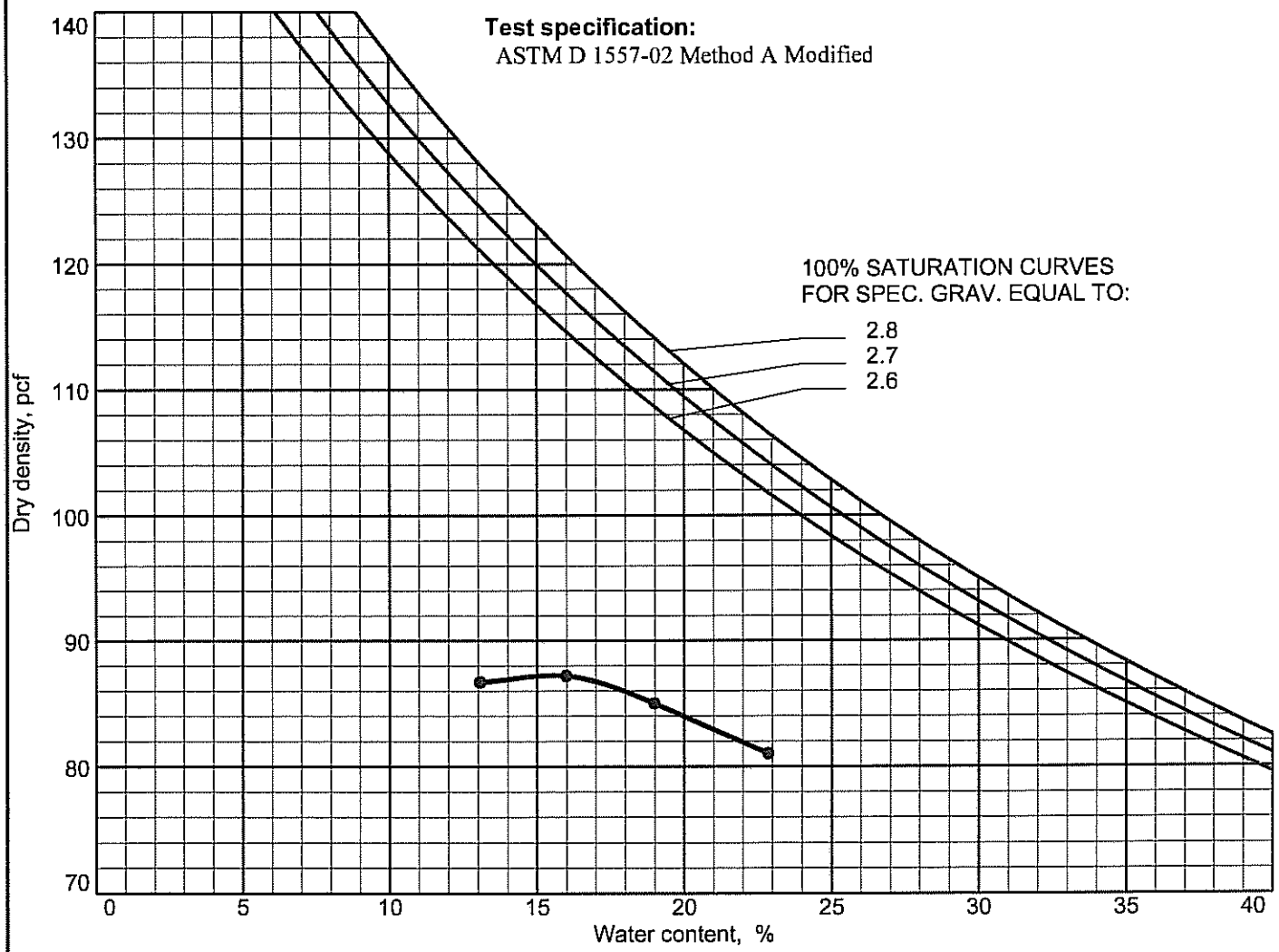


Figure 8670

GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.

COMPACTION TEST REPORT

Curve No.: 8670

Project No.: 20072247V1 **Date:** 09/23/07

Project: BRC EAST SIDE GEOTECH SAMPLING

Location: TP-14

Elev./Depth: **Sample No.** TP-14

Remarks: ENTERED BY:AS

MATERIAL DESCRIPTION

Description: SILTY SAND

Classifications - **USCS:** SM **AASHTO:** A-4(0)

Nat. Moist. = **Sp.G. =** 2.65

Liquid Limit = NV **Plasticity Index =** NP

% > No.4 = 0.0 % **% < No.200 =** 42.6 %

ROCK CORRECTED TEST RESULTS
Maximum dry density = 73.5 pcf
Optimum moisture = 44.0 %

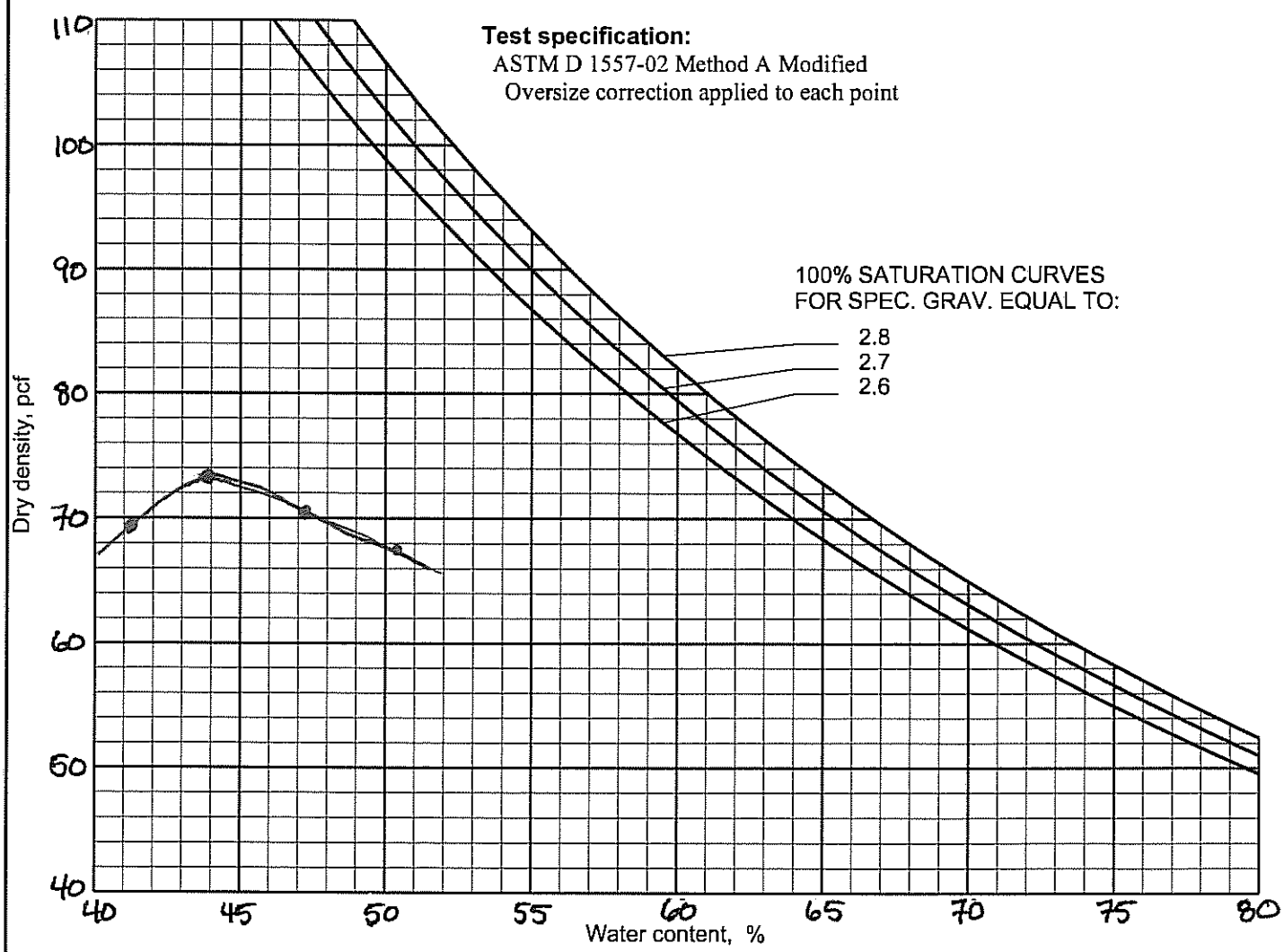


Figure 8670

GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.

COMPACTION TEST REPORT

Curve No.: 8670

Project No.: 20072247V1 **Date:** 09/26/07

Project: BRC EAST SIDE GEOTECH SAMPLING

Location: TP-15

Elev./Depth: **Sample No.** TP-15

Remarks: ENTERED BY:AS

MATERIAL DESCRIPTION

Description:

Classifications - **USCS:** ML **AASHTO:** A-4(0)

Nat. Moist. = **Sp.G. =** 2.65

Liquid Limit = NV **Plasticity Index =** NP

% > No.4 = 0 % **% < No.200 =** 97.3 %

TEST RESULTS
Maximum dry density = 102.0 pcf
Optimum moisture = 8.5 %

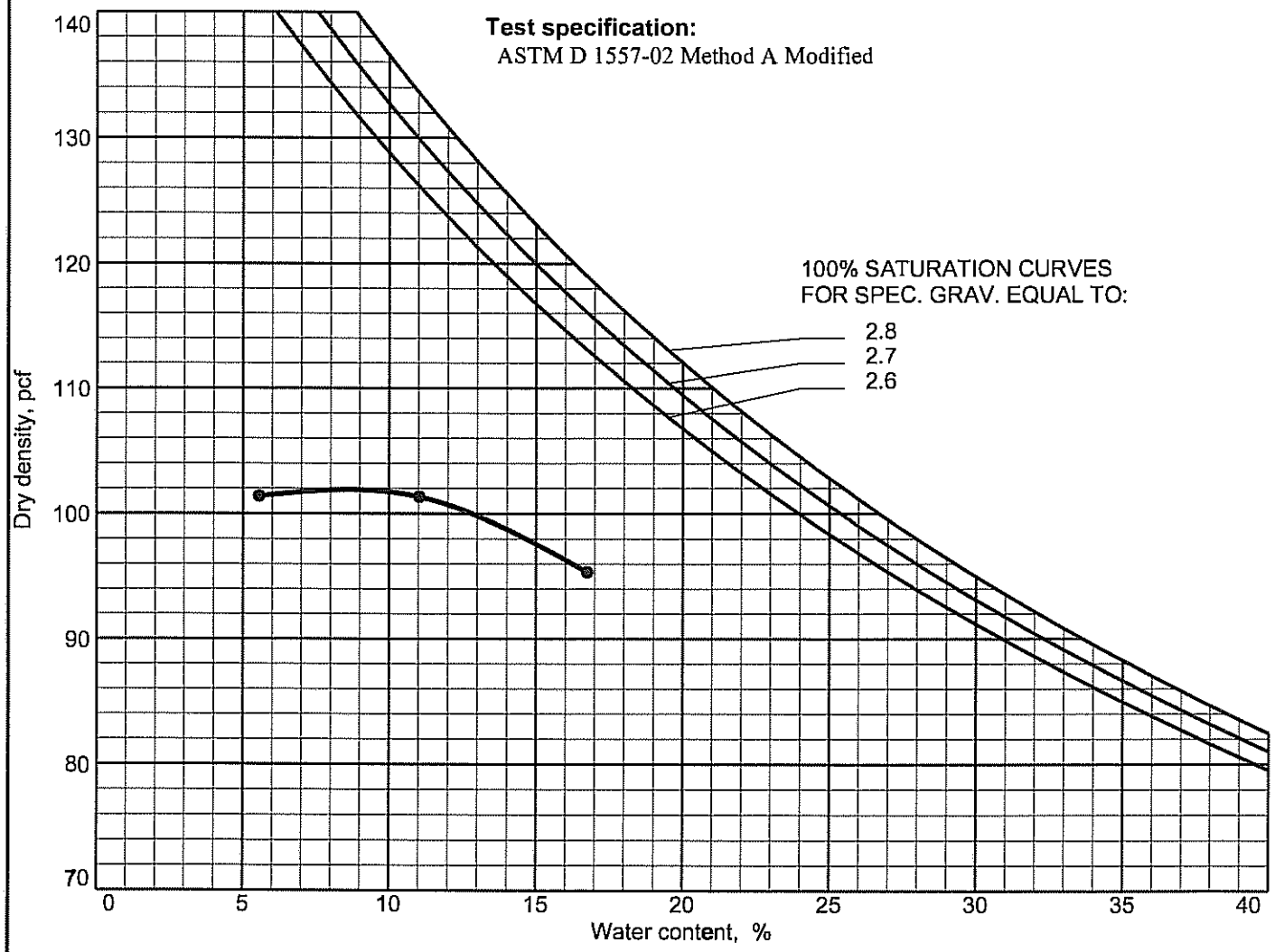


Figure 8670

COMPACTION TEST REPORT

Curve No.: 8670

Project No.: 20072247V1 **Date:** 09/28/07

Project: BRC EAST SIDE GEOTECH SAMPLING

Location: TP-16

Elev./Depth: **Sample No.** TP-16

Remarks: ENTERED BY:AS

MATERIAL DESCRIPTION

Description:

Classifications - **USCS:** ML **AASHTO:** A-4(0)

Nat. Moist. = **Sp.G. =** 2.65

Liquid Limit = NV **Plasticity Index =** NP

% > No.4 = 0.0 % **% < No.200 =** 91.7 %

ROCK CORRECTED TEST RESULTS
Maximum dry density = 83.0 pcf
Optimum moisture = 21.0 %

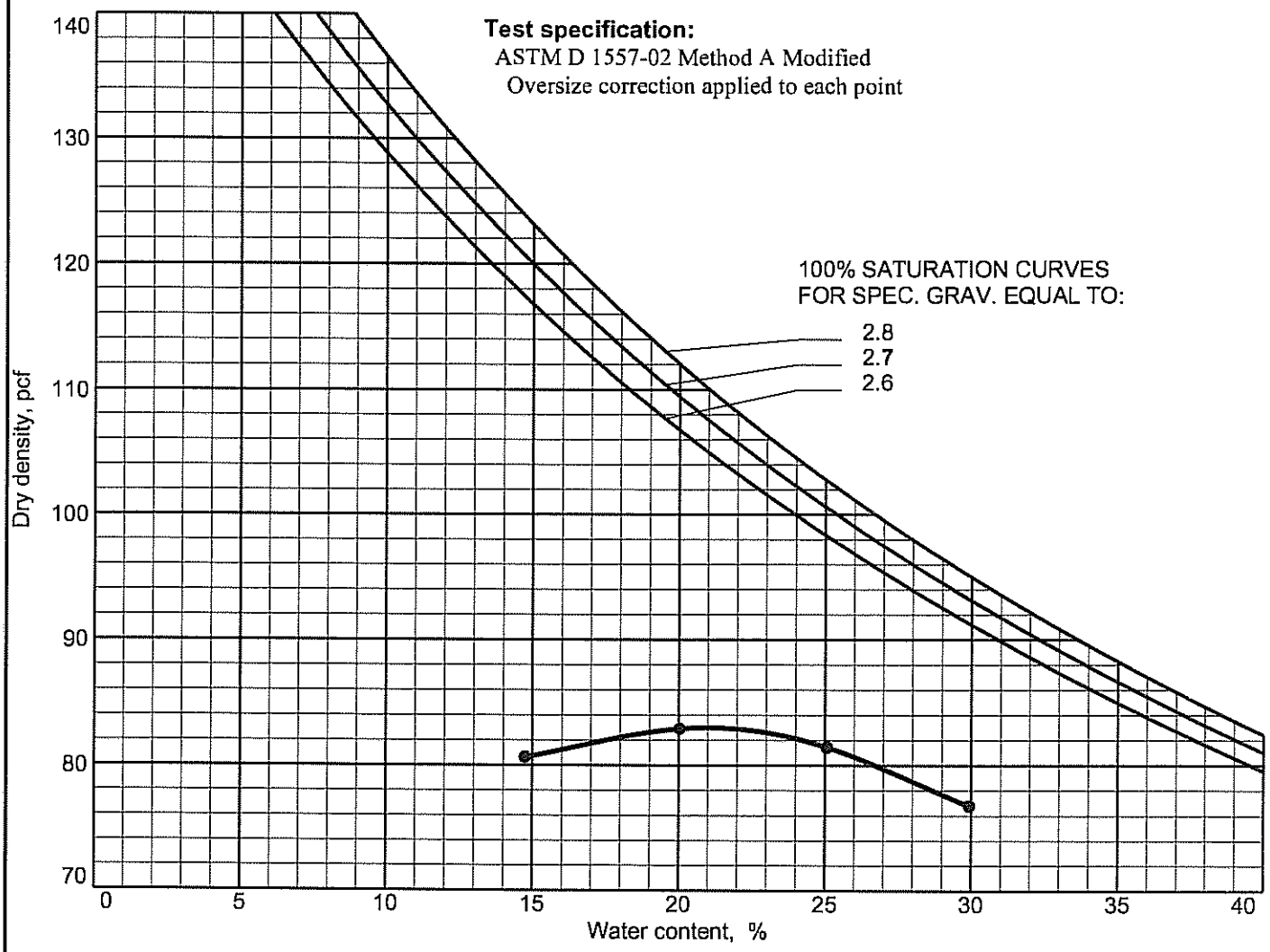


Figure 8670

GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.

COMPACTION TEST REPORT

Curve No.: 8670

Project No.: 20072247V1 **Date:** 09/26/07

Project: BRC EAST SIDE GEOTECH SAMPLING

Location: UA-7

Elev./Depth: **Sample No.** UA-7

Remarks: ENTERED BY:AS

MATERIAL DESCRIPTION

Description:

Classifications - **USCS:** SM **AASHTO:** A-1-b

Nat. Moist. = **Sp.G. =** 2.65

Liquid Limit = NV **Plasticity Index =** NP

% > No.4 = 0.0 % **% < No.200 =** 19.2 %

TEST RESULTS
Maximum dry density = 71.5 pcf
Optimum moisture = 49.5 %

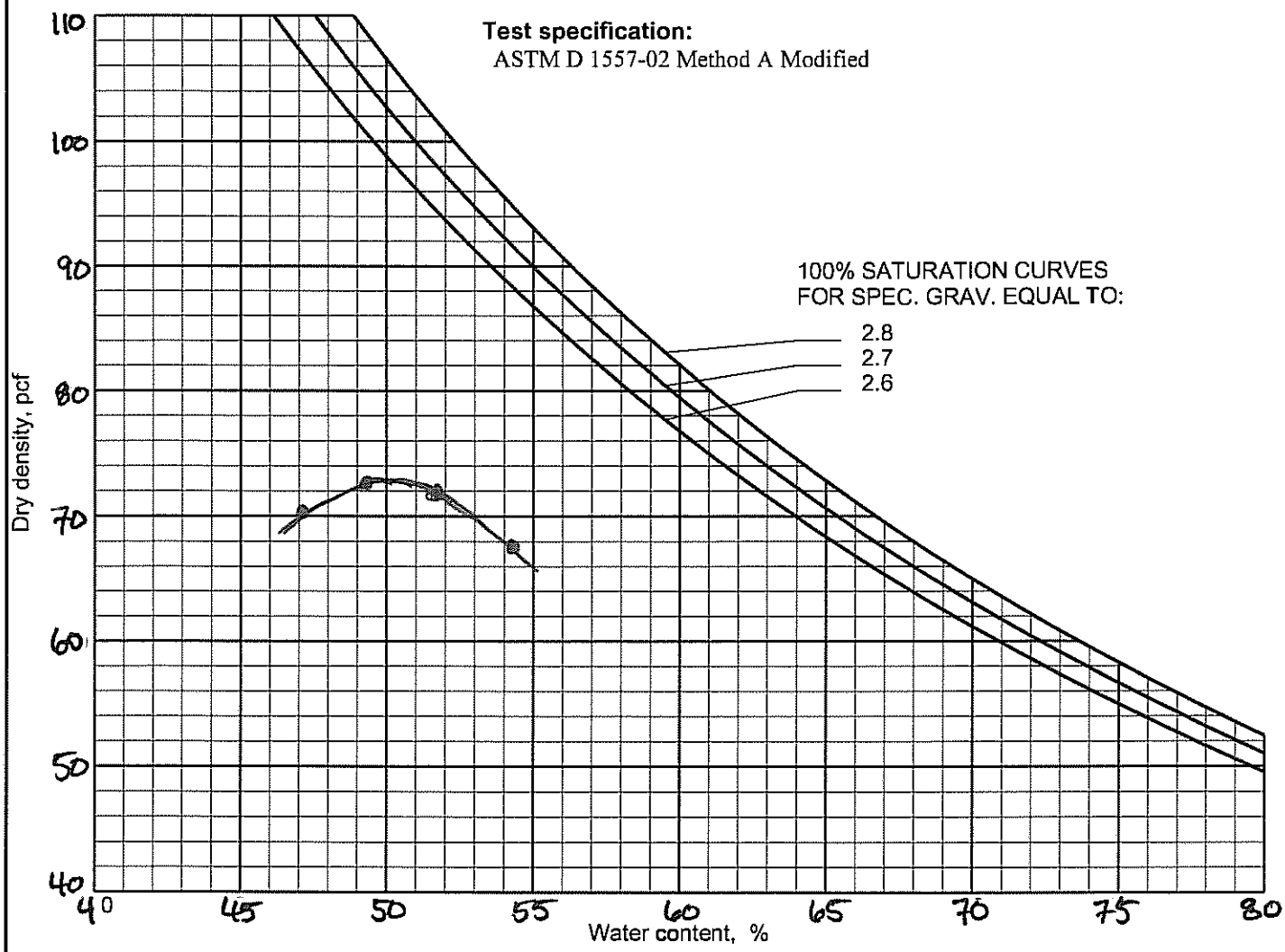


Figure 8670

COMPACTION TEST REPORT

Curve No.: 8670

Project No.: 20072247V1 **Date:** 09/24/07

Project: BRC EAST SIDE GEOTECH SAMPLING

Location: UA-9

Elev./Depth: **Sample No.** UA-9

Remarks: ENTERED BY:AS

MATERIAL DESCRIPTION

Description: SANDY SILT

Classifications - **USCS:** ML **AASHTO:** A-4(0)

Nat. Moist. = **Sp.G. =** 2.65

Liquid Limit = NV **Plasticity Index =** NP

% > No.4 = 0.0 % **% < No.200 =** 58.3 %

ROCK CORRECTED TEST RESULTS
Maximum dry density = 70.5 pcf
Optimum moisture = 47.0 %

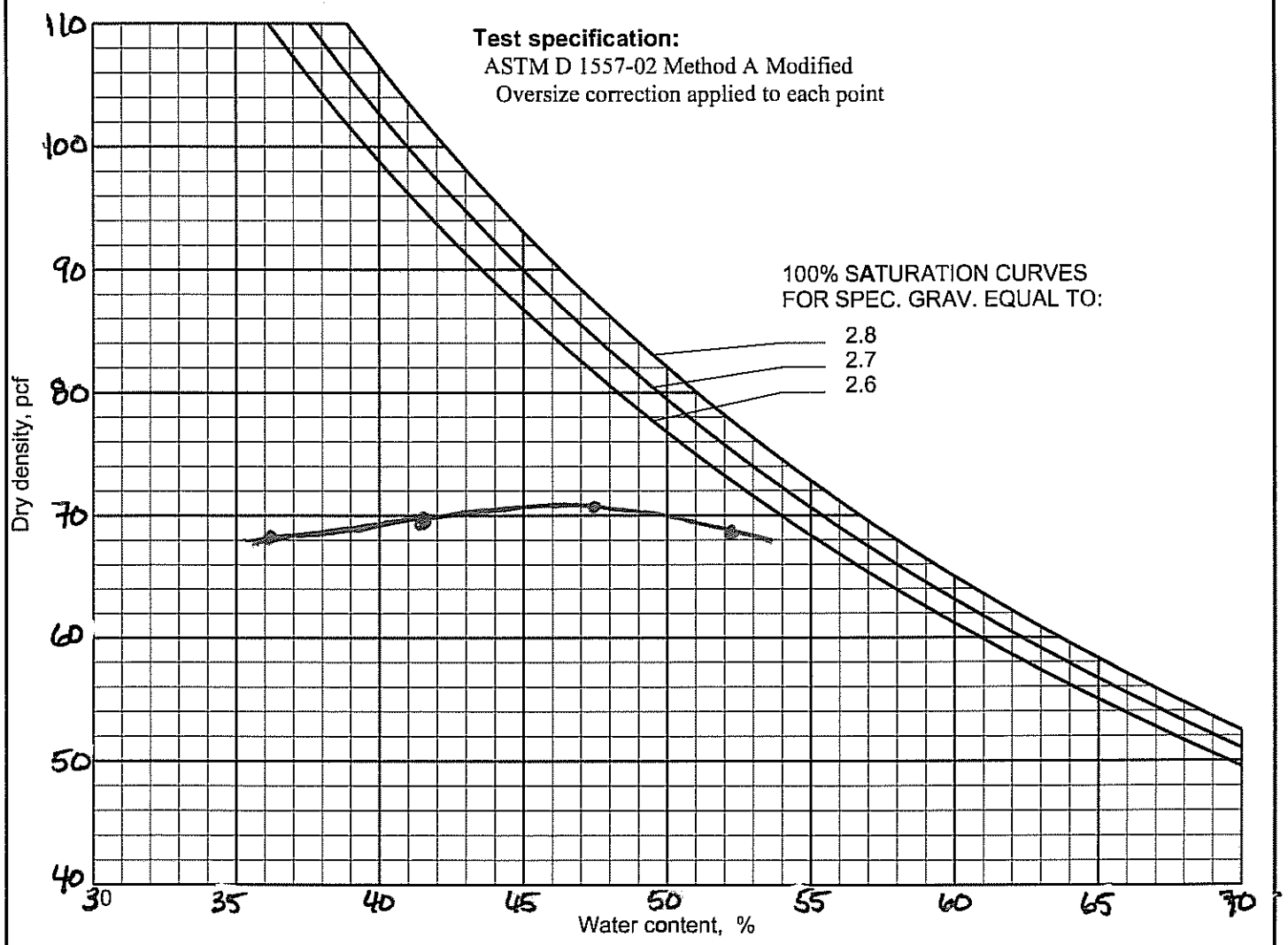


Figure 8670

GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.

COMPACTION TEST REPORT

Curve No.: 8670

Project No.: 20072247V1 **Date:** 09/23/07

Project: BRC EAST SIDE GEOTECH SAMPLING

Location: UB-9

Elev./Depth: **Sample No.** UB-9

Remarks: ENTERED BY:AS

MATERIAL DESCRIPTION

Description:

Classifications - **USCS:** ML **AASHTO:** A-4(0)

Nat. Moist. = **Sp.G. =** 2.65

Liquid Limit = NV **Plasticity Index =** NP

% > No.4 = % **% < No.200 =** 72.9 %

ROCK CORRECTED TEST RESULTS
Maximum dry density = 67.5 pcf
Optimum moisture = 44.5 %

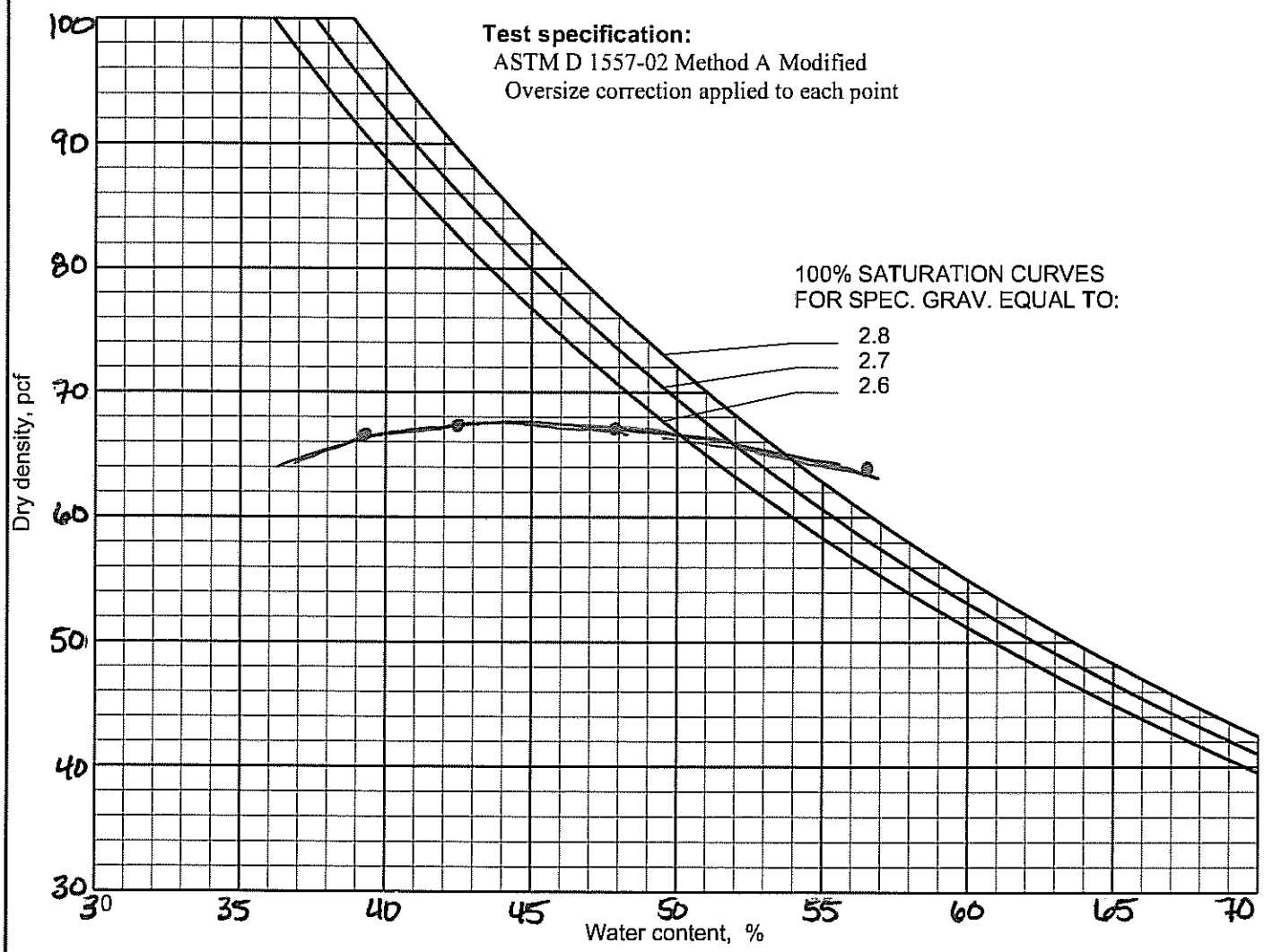


Figure 8670

GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.

COMPACTION TEST REPORT

Curve No.: 8670

Project No.: 20072247V1 **Date:** 9/25/07

Project: BRC EAST SIDE GEOTECH SAMPLING

Location: UC-6

Elev./Depth: **Sample No.** UC-6

Remarks: ENTERED BY:BLW

MATERIAL DESCRIPTION

Description:

Classifications - **USCS:** SM **AASHTO:** A-4(0)

Nat. Moist. = **Sp.G. =** 2.50

Liquid Limit = NV **Plasticity Index =** NP

% > No.4 = % **% < No.200 =** 48.6 %

TEST RESULTS
Maximum dry density = 77.5 pcf
Optimum moisture = 37.5 %

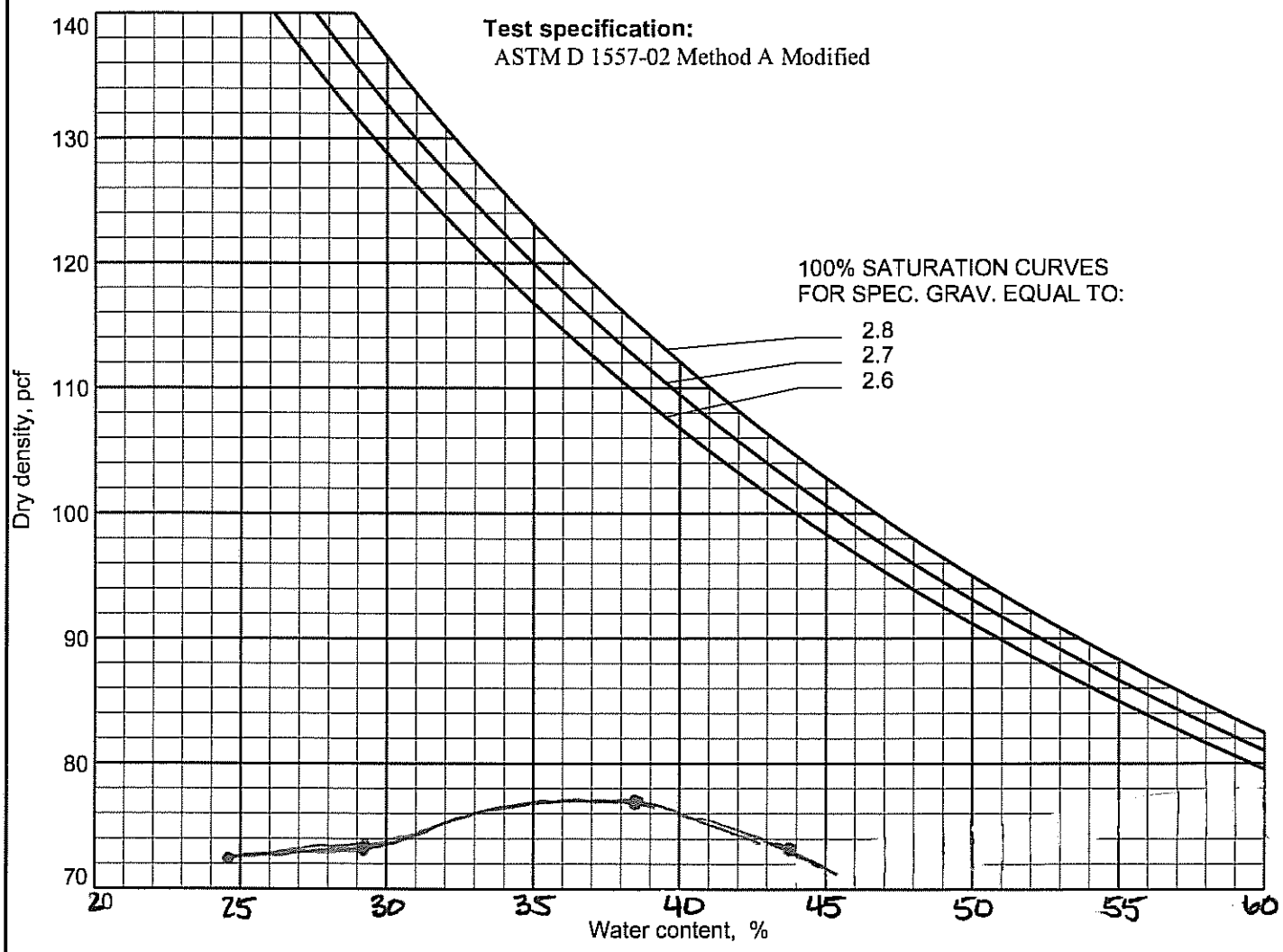


Figure 8670

GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.

COMPACTION TEST REPORT

Curve No.: 8670

Project No.: 20072247V1 **Date:**

Project: BRC EAST SIDE GEOTECH SAMPLING

Location: UD-5

Elev./Depth: **Sample No.** UD-5

Remarks:

MATERIAL DESCRIPTION

Description:

Classifications - **USCS:** SW-SM **AASHTO:** A-1-b

Nat. Moist. = **Sp.G. =** 2.65

Liquid Limit = NV **Plasticity Index =** NP

% > No.4 = 0.0 % **% < No.200 =** 5.9 %

TEST RESULTS
Maximum dry density = 88.0 pcf
Optimum moisture = 30.0 %

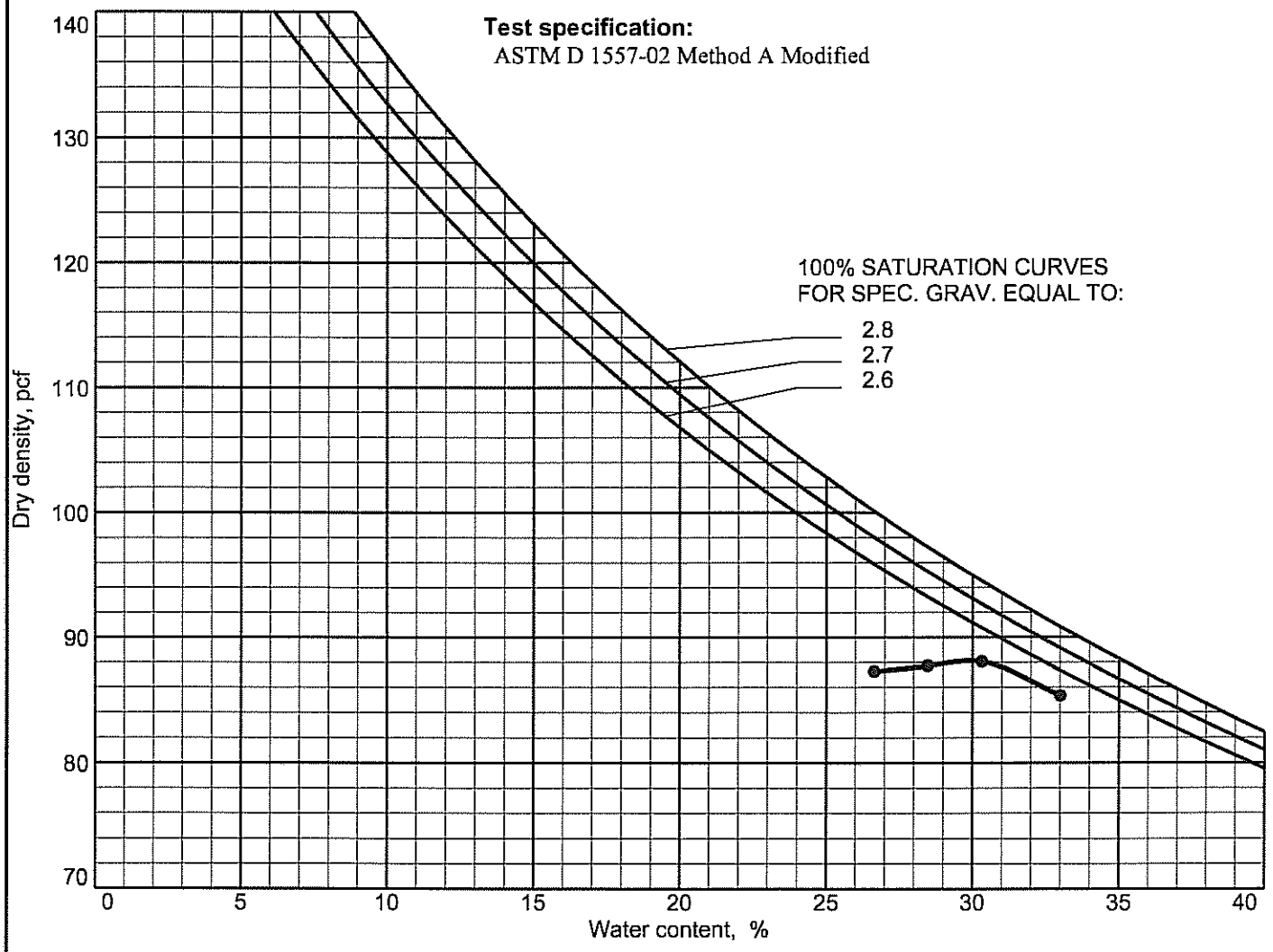


Figure 8670

GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.

COMPACTION TEST REPORT

Curve No.: 8670

Project No.: 20072247V1 **Date:** 9/25/07

Project: BRC EAST SIDE GEOTECH SAMPLING

Location: UD-7

Elev./Depth: **Sample No.** UD-7

Remarks: ENTERED BY:BLW

MATERIAL DESCRIPTION

Description:

Classifications - **USCS:** SM **AASHTO:** A-1-b

Nat. Moist. = **Sp.G. =** 2.5

Liquid Limit = NV **Plasticity Index =** NP

% > No.4 = % **% < No.200 =** 15.4 %

TEST RESULTS
Maximum dry density = 68.5 pcf
Optimum moisture = 49.0 %

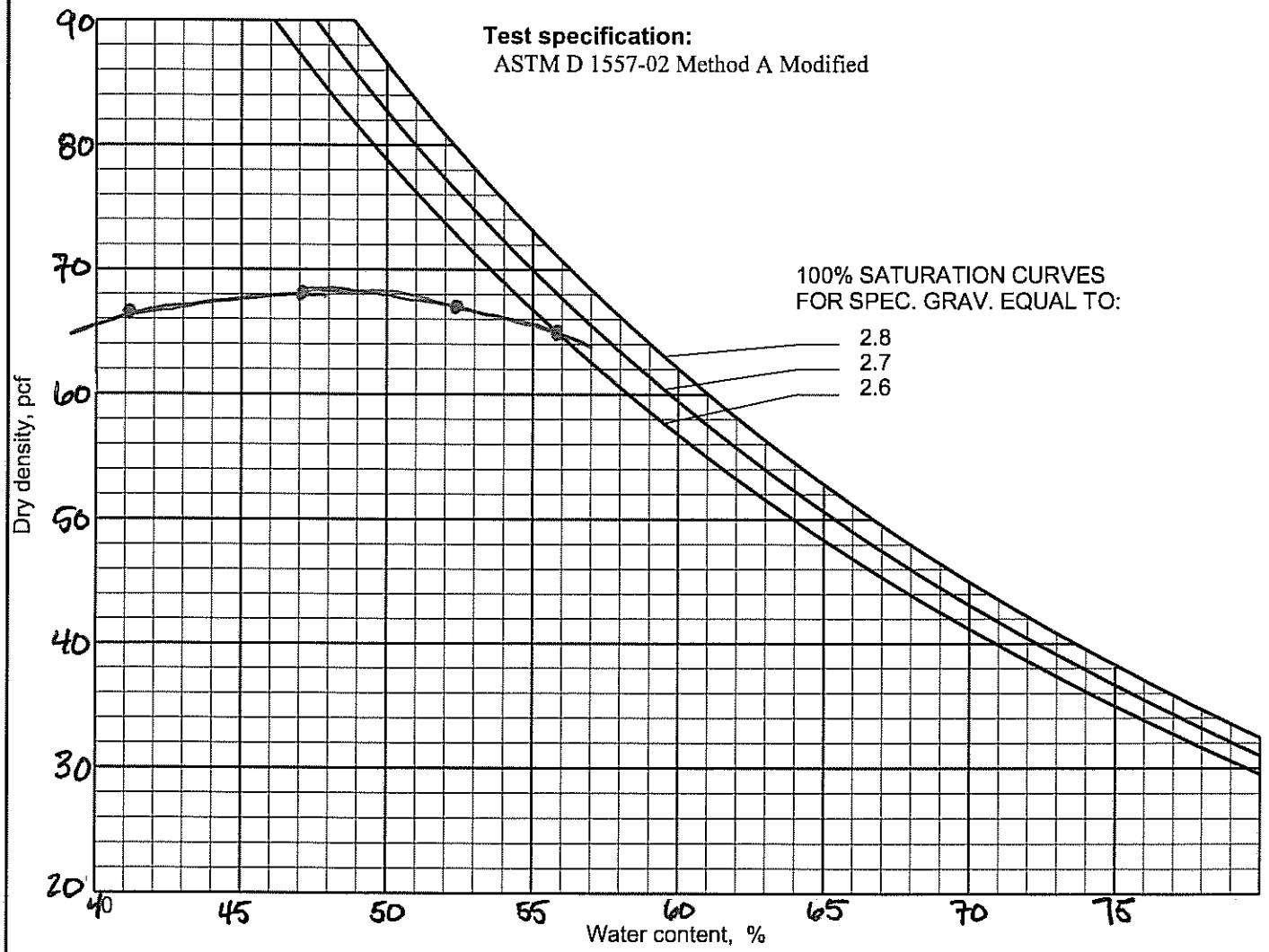


Figure 8670

COMPACTION TEST REPORT

Curve No.: 8670

Project No.: 20072247V1 **Date:** 09/21/07

Project: BRC EAST SIDE GEOTECH SAMPLING

Location: UE-3

Elev./Depth: **Sample No.** UE-3

Remarks: ENTERED BY:AS

MATERIAL DESCRIPTION

Description: SILTY SAND

Classifications - **USCS:** SM **AASHTO:** A-1-b

Nat. Moist. = **Sp.G. =** 2.65

Liquid Limit = NV **Plasticity Index =** NP

% > No.4 = 12.0 % **% < No.200 =** 20 %

ROCK CORRECTED TEST RESULTS
Maximum dry density = 109.5 pcf
Optimum moisture = 17.5 %

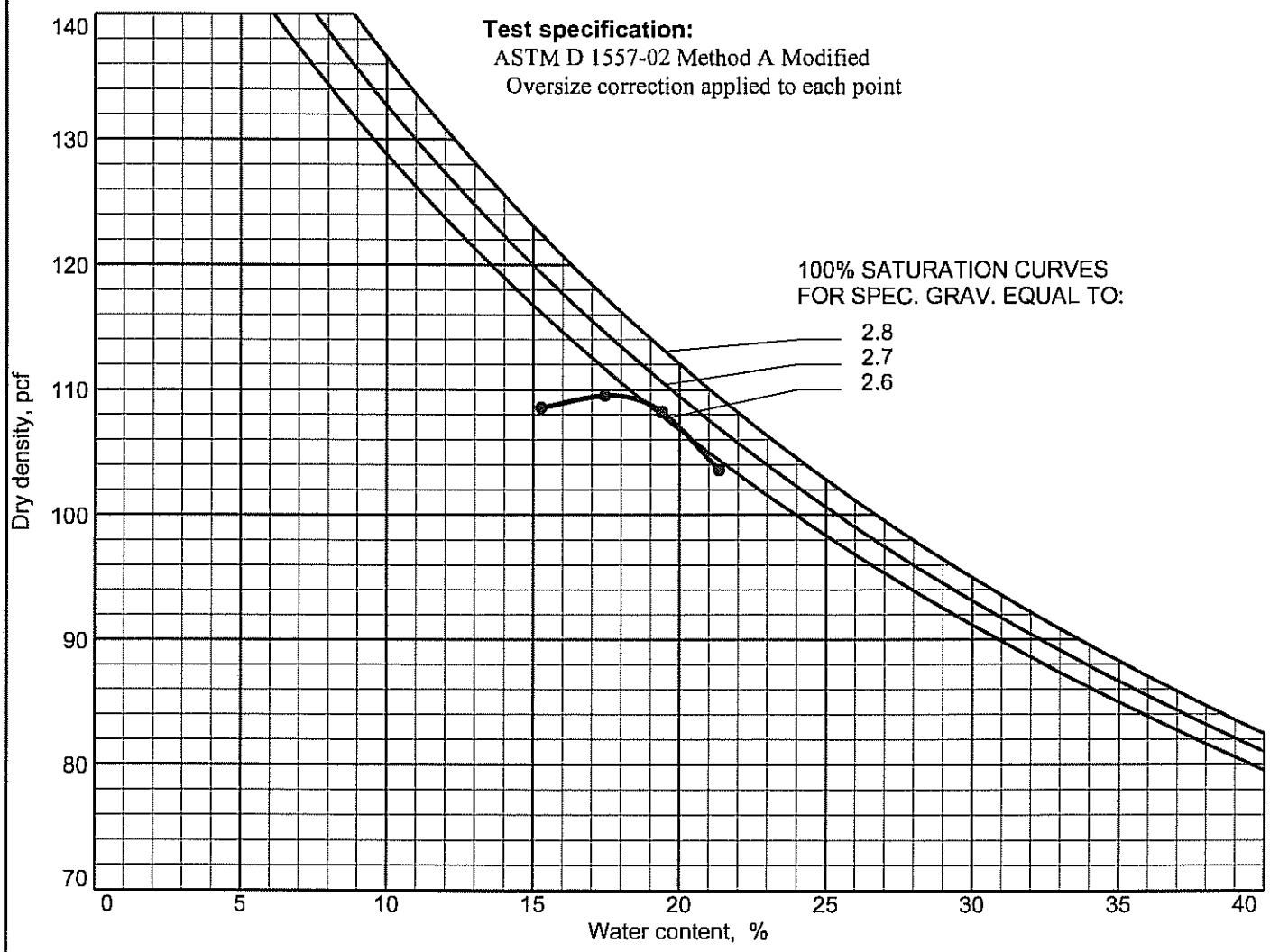


Figure 8670

GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.

COMPACTION TEST REPORT

Curve No.: 8670

Project No.: 20072247V1 **Date:** 8670

Project: BRC EAST SIDE GEOTECH SAMPLING

Location: UE-5

Elev./Depth: **Sample No.** UE-5

Remarks: ENTERED BY:AS

MATERIAL DESCRIPTION

Description:

Classifications - **USCS:** SM **AASHTO:** A-1-b

Nat. Moist. = **Sp.G. =** 2.65

Liquid Limit = NV **Plasticity Index =** NP

% > No.4 = 0.0 % **% < No.200 =** 14.5 %

TEST RESULTS
Maximum dry density = 73.0 pcf
Optimum moisture = 44.5 %

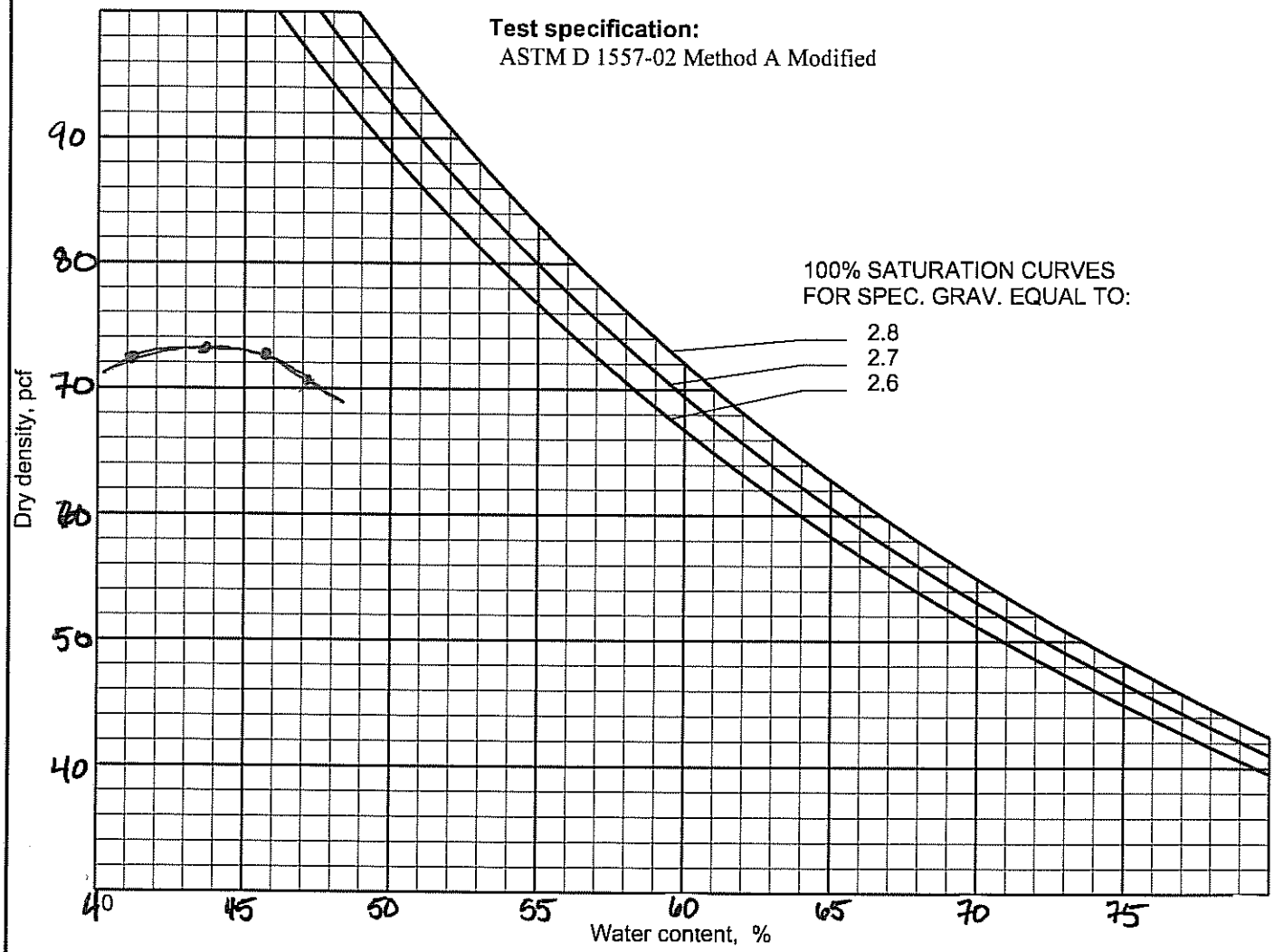


Figure 8670

COMPACTION TEST REPORT

Curve No.: 8670

Project No.: 20072247V1 **Date:** 09/21/07

Project: BRC EAST SIDE GEOTECH SAMPLING

Location: UF-2

Elev./Depth: **Sample No.** UF-2

Remarks: ENTERED BY:AS

MATERIAL DESCRIPTION

Description: SILTY SAND

Classifications - **USCS:** SM **AASHTO:** A-2-4(0)

Nat. Moist. = **Sp.G. =** 2.65

Liquid Limit = NV **Plasticity Index =** NP

% > No.4 = 12.0 % **% < No.200 =** 23.0 %

ROCK CORRECTED TEST RESULTS
Maximum dry density = 117.0 pcf
Optimum moisture = 12.5 %

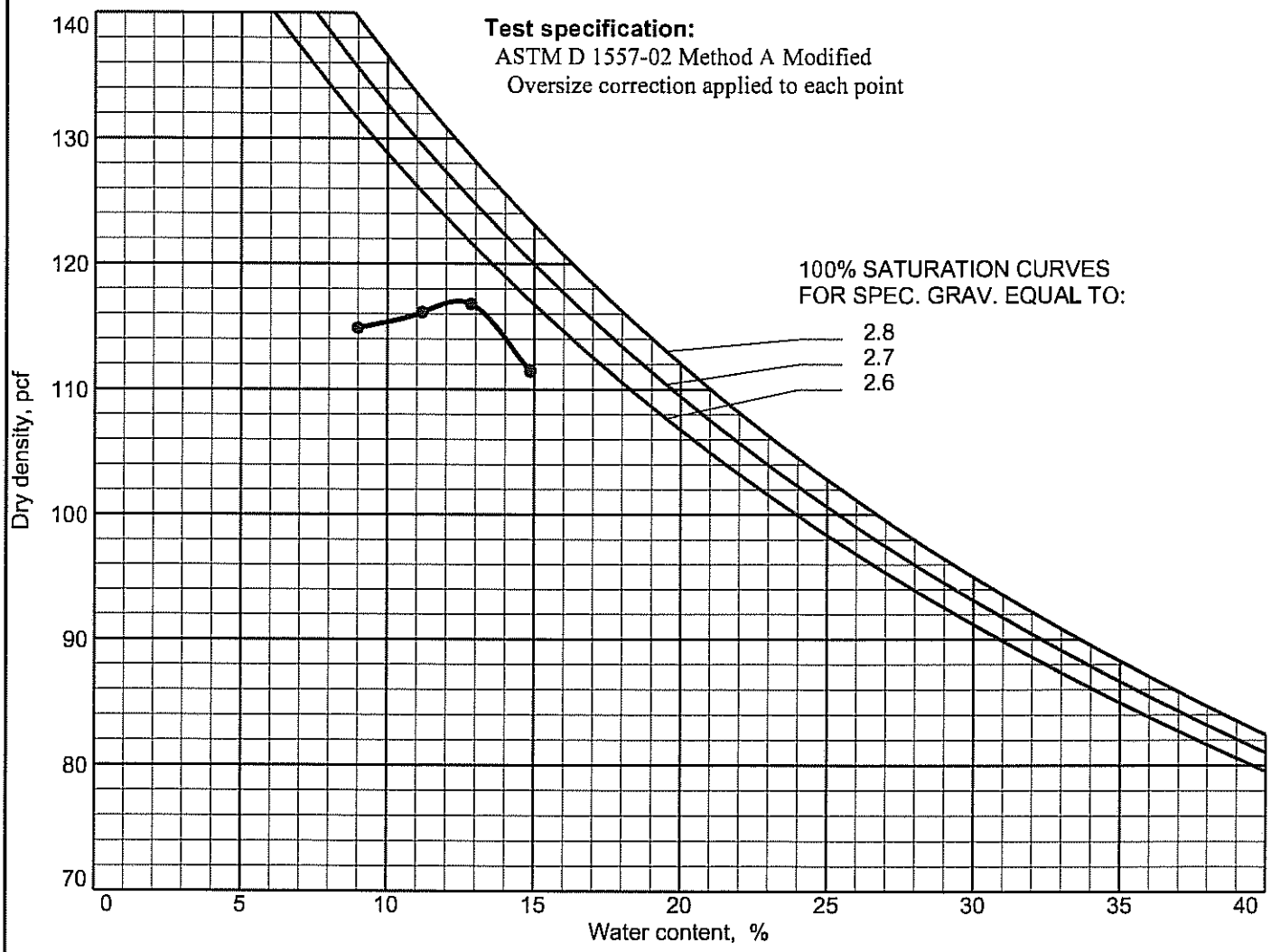


Figure 8670

GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.

COMPACTION TEST REPORT

Curve No.: 8670

Project No.: 20072247V1 **Date:** 9/25/07

Project: BRC EAST SIDE GEOTECH SAMPLING

Location: UF-6

Elev./Depth: **Sample No.** UF-6

Remarks: ENTERED BY:BLW

MATERIAL DESCRIPTION

Description:

Classifications - **USCS:** SM **AASHTO:** A-1-b

Nat. Moist. = **Sp.G. =** 2.30

Liquid Limit = NV **Plasticity Index =** NP

% > No.4 = % **% < No.200 =** 15.6 %

TEST RESULTS
Maximum dry density = 69.0 pcf
Optimum moisture = 45.5 %

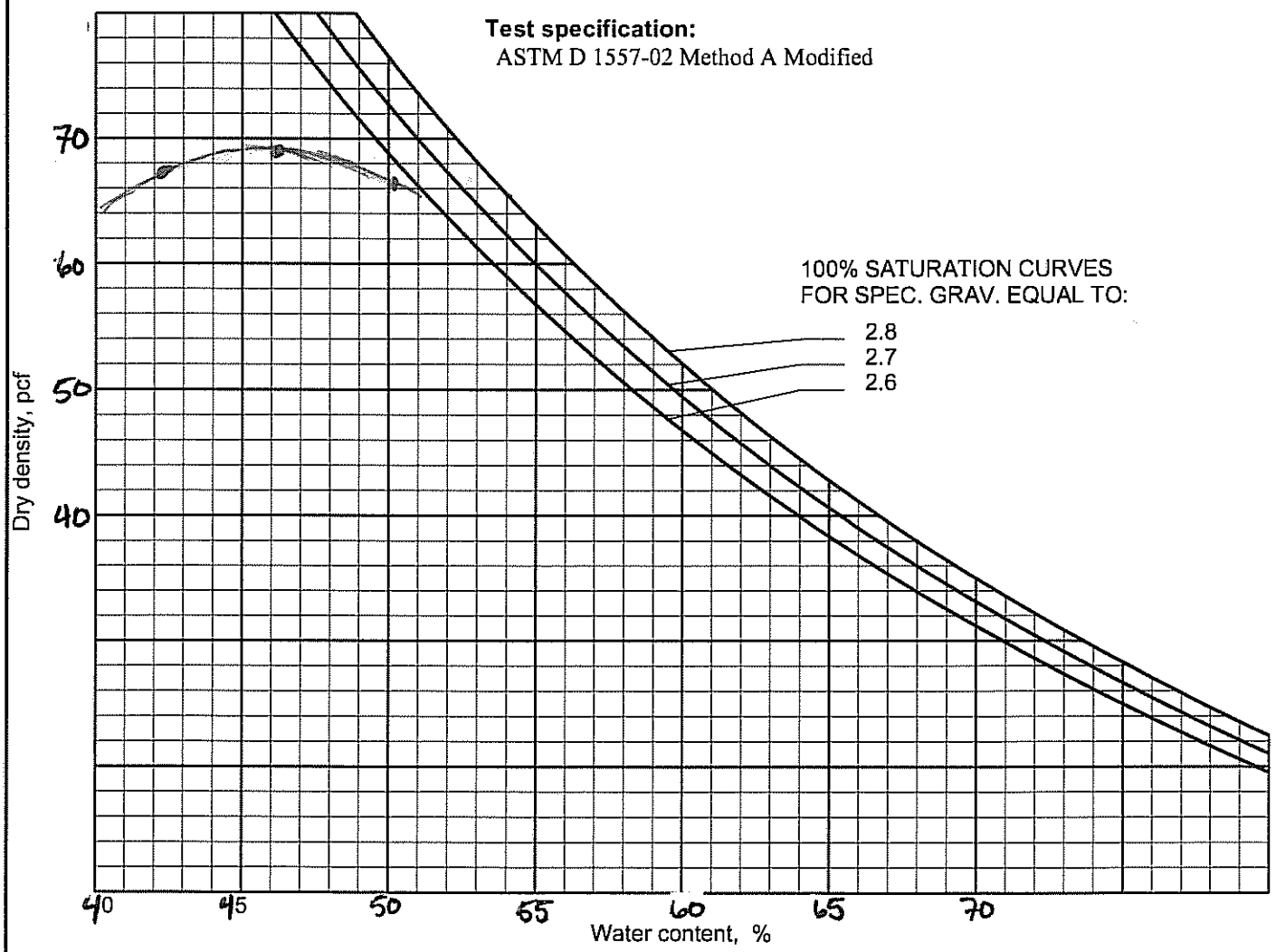


Figure 8670

GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.

Geosyntec consultants

COMPUTATION COVER SHEET

Client: BRC Project: BRC CAMU Project/ Proposal No.: SC0313 Task No.

Title of Computations **VENEER STABILITY OF GEOSYNTHETIC-SATURATED SOIL LINED SIDESLOPES- COVER LINER SYSTEM**

Computations by:
Signature
Printed Name Rebecca Flynn
Title Senior Staff Engineer
Date 1/8/08

Assumptions and Procedures Checked by: (peer reviewer)
Signature
Printed Name Gregory T. Corcoran
Title Principal
Date 1/8/08

Computations Checked by:
Signature
Printed Name Gregory T. Corcoran
Title Principal
Date 1/8/08

Computations backchecked by: (originator)
Signature
Printed Name Rebecca Flynn
Title Senior Staff Engineer
Date 1/8/08

Approved by: (pm or designate)
Signature
Printed Name Gregory T. Corcoran
Title Principal
Date 1/8/08

Approval notes:

Revisions (number and initial all revisions)

No.	Sheet	Date	By	Checked by	Approval

Written by:	R. Flynn	Date:	01/08/08	Reviewed by:	G. Corcoran	Date:	01/08/08
Client:	BRC	Project:	BRC CAMU	Project/ Proposal No.:	SC0313	Task No.:	

VENEER STABILITY OF GEOSYNTHETIC-SATURATED SOIL LINED SIDESLOPES COVER LINER SYSTEM BRC CAMU

OBJECTIVE

To evaluate the tension developed within the geosynthetic-saturated soil layered sideslopes of the cover liner system of the BRC Corrective Action Management Unit (CAMU) located in Henderson, Nevada.

SUMMARY OF RESULTS

The calculations suggest that a minimum geosynthetic interface friction angle of 20 degrees is required to prevent the development of tension in the geosynthetic components of the side slope liner final cover system. A review of the literature indicates that achieving a friction angle of 20 degrees is obtainable. The critical interface of the geosynthetics is likely the internal friction angle of the GCL.

METHOD OF ANALYSIS

The stability analysis of the geosynthetic-soil layered systems was carried out using the approach outlined by Koerner and Soong [1998] (Attachment H). This approach calculates the driving force of an active soil wedge along a geosynthetic-soil layered sideslope and compares it to the resisting force of the complementary passive soil wedge to evaluate the overall factor of safety against failure. The method presented by Koerner and Soong [1998] allows for the consideration of a uniform depth soil layer and the influence of dynamic equipment loading.

SIDESLOPE LINER SYSTEM

The sideslope liner system consists of, from top to bottom:

- 2 ft (min) saturated cover soil;

- Double-sided geocomposite consisting of geonet sandwiched between two non-woven geotextiles;
- 60-mil (1.5-mm) textured high density polyethylene (HDPE) geomembrane;
- Geosynthetic clay liner (GCL) consisting of bentonite sandwiched between a top nonwoven geotextile and a bottom woven geotextile needle-punched together; and
- Prepared subgrade.

The sideslope inclination is 3.0H:1.0V. The maximum height of a side slope is 47 vertical feet, located in the southwest corner of the South Mesa.

MATERIAL SHEAR STRENGTHS

Cover Soil Material:

The soil materials to be used overlying the side slope liner system will be native materials such as silty sands (SM). Converse reported a maximum dry density of 132.1 pcf and an optimum water content of 8.2 percent for materials at the site (Attachment C). Therefore, assuming 95% relative compaction, conservatively high based on specification requirement of 90%, the dry density in the field is approximately 125.5 pcf. Adding the weight of water at 8.2%, the wet unit weight is approximately 136 pcf. The cover soil material is characterized by a minimum internal angle of friction of 32 degrees in accordance with NAVFAC and the expected compaction criteria (see *review of reported interface strengths*).

To evaluate the cover soil in the saturated condition, the saturated unit weight of the soil must be estimated. The saturated soil unit weight will be determined using a phase diagram approach.

Given:

density, γ= 136 pcf

water content, w = 8.2%

Specific Gravity of Soil Solids, G_s= 2.7

porosity, n = 0.23 (Attachment A)

Saturated density is thereby found using the equation:

$\gamma_{sat} = [(1-n)G_s + n]\,\gamma_w$ (Attachment B)

Where:
γ_{sat} = Saturated Density
γ_w = Density of water = 62.4 lb/ft^3
$\gamma_{sat} = [(1-0.23) \times 2.7 + 0.23] \times 62.4 = 144$ lb/ft^3

For this analysis, a shear strength of 32 degrees, with 500 psf cohesion, and a unit weight of 144 pcf will be used for the analyses performed herein.

Geosynthetic Interface:

The geosynthetic interface friction angle was varied to evaluate the minimum allowable value to obtain no tension. A literature review was performed to evaluate if the calculated minimum allowable interface friction value is achievable. Adhesion is neglected for the analyses herein.

REVIEW OF REPORTED INTERFACE STRENGTHS IN THE LITERATURE

The following values for the interface friction between the geosynthetic and soil components of the liner system represent values reported in the literature:

Native Material (SM)	32	NAVFAC[1,2], 500 psf cohesion (Attachment D)
Cover Soil to Geocomposite (NWGT side)	29	Koerner[3] (Attachment E)
Geocomposite to Textured HDPE	28	(Professional Experience)
Textured HDPE to Hydrated GCL	20	Bentomat[4] (Attachment G)
Hydrated GCL to Subgrade	22	Bentomat[5] (Attachment F)

1. NAVFAC (1982) lists typical shear strength values for various soils based on 100 percent standard Proctor compaction. Actual construction materials would likely be placed at 90 percent of the modified Proctor compaction. To be conservative, a value of phi = 32 degree was used.

2. Value of friction angle for a silty sand designated under the USCS classification system as a SM. This value is a conservative friction angle estimate as compared to an SC soil, which would yield a greater friction angle.

3. Koerner (1995) suggests that an efficiency of greater than 90 percent for the interface of nonwoven, needle-punched geotextiles to various soils can be achieved. Efficiency values are based on the relationship, Efficiency = tan(interface friction angle)/tan(soil friction angle). The interface friction angle presented herein was calculated using a 90 percent efficiency and the estimated soil friction angle. Adhesion is neglected.

4. Values of residual friction angle reported for interface shear strength between 60 mil textured HDPE geomembrane and woven geotextile side of CETCO Bentomat GCL under hydrated conditions at a shearing rate of 0.04 in/min. Maximum displacement was not reported. Normal stresses of 1.4, 3.5, and 7.0 psi yielded a friction angle of 20.4 degrees.

5. Values of residual friction angle reported for interface shear strength between 60 mil textured HDPE geomembrane and woven geotextile side of CETCO Bentomat GCL under hydrated conditions at a shearing rate of 0.04 in/min. Maximum displacement was not reported. Normal stresses of 1.4, 3.5, and 7.0 psi yielded a friction angle of 22.1 degrees.

DESIGN CRITERION

For the geosynthetic-soil lined side slopes of BRC CAMU final cover system it was desired to evaluate the combination of operations layer soil height, inclination, and equipment loading which would introduce no geosynthetic tension. Subsequently, zero geosynthetic tension was established as the design criterion for veneer stability of the geosynthetic-soil lined side slopes.

The geosynthetic-soil lined side slopes are considered permanent slopes because they will not eventually be buttressed by placement of waste. In consideration of the significance of no tension in the geosynthetic liner system and consistent with current practice, GeoSyntec will adopt a factor of safety (FS) equal to or greater than 1.5 for slope stability (CASE I, completed cover system).

ANALYSIS

CASE I: Veneer Stability on Side Slope

According to the Koerner and Soong approach, a soil veneer on a side slope is stable when the resultant driving force on the passive wedge (E_P) is equal to the resultant resistant force on the active wedge (E_A). The following equations represent the resultant resistance and active forces, respectively:

$$E_A = \frac{FS(W_A - N_A \cos\beta) - (N_A \tan\delta + C_a)\sin\beta}{\sin\beta(FS)}$$ (Attachment H, 2 of 6)

$$E_P = \frac{C + W_P \tan\phi}{\cos\beta(FS) - \sin\beta\tan\phi}$$ (Attachment H, 2 of 6)

The variables will be defined in a subsequent section.

By setting E_A=E_P, the resulting equation may be arranged in the form of the quadratic equation $ax^2+bx+c=0$. Considering FS as the variable of interest, the resulting equation is as follows:

$$a(FS)^2 + b(FS) + c = 0$$ (Attachment H, 2 of 6)

The factor of safety may be obtained from the solution of the following equation:

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$ (Attachment H, 2 of 6)

Where the constants are defined, as in Attachment E, 6 of 6:

$$a = (W_A - N_A \cos\beta)\cos\beta \quad (1)$$

$$b = -[(W_A - N_A \cos\beta)\sin\beta\tan\phi + (N_A \tan\delta + C_a)\sin\beta\cos\beta + \sin\beta(C + W_P \tan\phi)] \quad (2)$$

$$c = (N_A \tan\delta + C_a)\sin^2\beta\tan\phi \quad (3)$$

In which the variables are indicated on Figure 1 and defined as follows:

$$C = \frac{c \cdot h}{\sin\beta} \quad (4)$$ (Attachment H, 2 of 6)

$$C_a = c_a\left(L - \frac{h}{\sin\beta}\right) \quad (5)$$ (Attachment H, 2 of 6)

$$W_A = \gamma \cdot h^2\left(\frac{L}{h} - \frac{1}{\sin\beta} - \frac{\tan\beta}{2}\right) \quad (6)$$ (Attachment H, 2 of 6)

$$N_A = W_A \cos\beta \qquad (7) \qquad \text{(Attachment H, 2 of 6)}$$

$$W_P = \frac{\gamma \cdot h^2}{\sin 2\beta} \qquad (8) \qquad \text{(Attachment H, 2 of 6)}$$

β = soil slope angle beneath the geomembrane, **18.4°** for 3H:1V slope
δ = minimum interface friction angle of side slope liner system, **20°**
ϕ = friction angle of cover soil, **32°**
γ = unit weight of the cover soil, **144 pcf**
C = cohesive force along the failure plane of the passive wedge
c = cohesion of the cover soil, **500 psf**
C_a = adhesive force between the cover soil of the active wedge and the geomembrane
c_a = adhesion between the cover soil of the active wedge and the geomembrane, **0 psf**
h = thickness of the operations layer, **2 feet**
L = length of slope measured along the geomembrane beneath cover soil, **148.6 feet**
N_A = effective force normal to the failure plane of the active wedge
W_A = total weight of the active wedge
W_P = total weight of the passive wedge

Substituting the variables and solving equations (4)-(8), above:

$$C = \frac{c \cdot h}{\sin\beta} = \frac{500 \cdot 2}{\sin(18.4)} = \mathbf{3178\ lbs/ft} \qquad (4)$$

$$C_a = c_a\left(L - \frac{h}{\sin\beta}\right) = 0\left(148.7 - \frac{2}{\sin 21.8}\right) = \mathbf{0\ lbs/ft} \qquad (5)$$

$$W_A = \gamma \cdot h^2\left(\frac{L}{h} - \frac{1}{\sin\beta} - \frac{\tan\beta}{2}\right) = 142 \cdot 2^2\left(\frac{148.7}{2} - \frac{1}{\sin 18.4} - \frac{\tan 18.4}{2}\right) = \mathbf{40{,}899\ lbs/ft} \qquad (6)$$

$$N_A = W_A \cos\beta = 40{,}331 \cdot \cos 18.4. = \mathbf{38{,}801\ lbs/ft} \qquad (7)$$

$$W_P = \frac{\gamma \cdot h^2}{\sin 2\beta} = \frac{142 \cdot 2^2}{\sin 2 \cdot 18.4} = \mathbf{960\ lbs/ft} \qquad (8)$$

Next, substituting the solutions to equations (4)-(8) into equations (1)-(3):

Based on the analyses herein, results of interface shear tests on the actual materials proposed for use in the composite liner system must indicate that the weakest apparent residual friction angle of the composite liner is equal to or greater than 20 degrees.

The results suggest that the following conditions satisfy the design criteria of no geosynthetic tension development:

- 3H:1 V side slopes;
- 2 feet thickness of operations layer soil/leachate collection layer on side slopes, placed to a vertical height of 47 feet;
- 136 pcf unit weight of cover soil, 144 pcf saturated unit weight of cover soil;
- Minimum shear properties of cover soil - 500 psf cohesion and 32° friction angle; and
- Minimum shear strength of composite liner system – 0 psf adhesion and 20° friction angle

REFERENCES

CETCO (2000), "Bentomat/Claymax Technical Manual: Direct Shear Testing Summary," September.

Converse Consultants (1999), "Preliminary Geotechnical and Geologic Investigation, Industrial Non-Hazardous Disposal Facility, Basic Management Incorporated, Clark County, Nevada," October 27, 1999, Las Vegas, Nevada. *(Attachment C)*

Das (1990), "Principals of Geotechnical Engineering," PWS-KENT Publishing Company, Boston, Massachusetts. (*Attachment B*)

Holtz and Kovacs (1981), "A Introduction to Geotechnical Engineering," Prentice-Hall, Englewood Cliffs, New Jersey 07632. (*Attachment A*)

Koerner, R. K. and Soong, T.Y., (1998), "Analysis and Design of Veneer Cover Soils", Proceedings of the Sixth International Conference on Geosynthetics, Atlanta, Georgia, Vol. I, 1998. *(Attachment H)*

$$a = (40{,}899 - 38{,}801 \cdot \cos 18.4)\cos 18.4 = \mathbf{3{,}878\ lbs/ft} \quad (1)$$

$$\begin{aligned} b = -[&(40{,}899 - 38{,}801 \cos 18.4) \sin 18.4 \tan 32 \\ &+ (38{,}801 \tan 20 + 0) \sin 18.4 \cos 18.4 \\ &+ \sin 18.4\,(3878 + 960 \tan 32) = \mathbf{-6{,}233\ lbs/ft} \end{aligned} \quad (2)$$

$$c = (38{,}801 \cdot \tan 20 + 0)\sin^2 18.4 \cdot \tan 32 = \mathbf{882\ lbs/ft} \quad (3)$$

Finally, inserting the solutions to (1), (2) and (3) and solving the following equation:

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a} = \frac{-(-6233) + \sqrt{(-6233)^2 - 4(3{,}878)(882)}}{2(3{,}878)} = \mathbf{1.45}$$

Therefore, the factor of safety for the veneer stability of the operations layer on a sideslope composite liner system is 1.45. This factor of safety satisfies the stability criterion for permanent slopes of 1.5, as previously described.

RESULTS AND CONCLUSIONS

The results suggest that the proposed final cover system satisfies the design criteria of no geosynthetic tension development:

Stability Soil Cover Layer Inclination (H:V)	Equipment Loading	Tension FS
3.0H:1V	NONE	1.45

Results of veneer stability analyses presented herein indicate that an apparent internal friction or interface friction angle (residual) of 20 degrees for any component of the composite liner system is the minimum allowable value providing for a static factor of safety that satisfies that design criteria of no tension in the geosynthetic liner system.

Koerner, R. M. (1997), "Designing with Geosynthetics," Simon and Schuster / A Viacom Company, Upper Saddle New Jersey, 07458, 1998 *(Attachment E)*

NAVFAC (1982), "Foundations and Earth Structures, Design Manual - 7.2," Department of Navy, Naval Facilities Engineering Command, May 1982 *(Attachment D)*

GTC
1/9/08

TABLE 4-2 Typical Index Properties for Granular Soils*

	Particle Size and Gradation				Voids			
	Approx. Size		Approx.	Approx. Range	Void Ratio		Porosity (%)	
	Range (mm) D_{max}	D_{min}	D_{10} (mm)	C_u	e_{max} (loose)	e_{min} (dense)	n_{max} (loose)	n_{min} (dense)
1. Uniform materials:								
(a) Equal spheres	—	—	—	1.0	0.92	0.35	48	26
(b) Standard Ottawa sand	0.84	0.59	0.67	1.1	0.80	0.50	44	33
(c) Clean, uniform sand (fine or medium)	—	—	—	1.2 to 2.0	1.0	0.40	50	29
(d) Uniform, inorganic silt	0.05	0.005	0.012	1.2 to 2.0	1.1	0.40	52	29
2. Well-graded materials:								
(a) Silty sand	2.0	0.005	0.02	5 to 10	0.90	0.30	47	23 *
(b) Clean, fine to coarse sand	2.0	0.05	0.09	4 to 6	0.95	0.20	49	17
(c) Micaceous sand	—	—	—	—	1.2	0.40	55	29
(d) Silty sand and gravel	100	0.005	0.02	15 to 300	0.85	0.14	46	12

*Modified after B. K. Hough (1969), *Basic Soils Engineering*, © 1969 by the Ronald Press, Co. Reprinted by permission of John Wiley & Sons, Inc.

TABLE 4-2 Continued

	Density (Mg/m³)†						
	Dry Density, ρ_d			Wet Density, ρ		Submerged Density, ρ'	
	Min. (loose)	100% Mod. Proctor	Max. (dense)	Min. (loose)	Max. (dense)	Min. (loose)	Max. (dense)
1. Uniform materials:							
(a) Equal spheres (theoretical values)	—	—	—	—	—	—	—
(b) Standard Ottawa sand	1.49	—	1.78	1.51	2.12	0.93	1.12
(c) Clean, uniform sand (fine or medium)	1.35	1.86	1.92	1.37	2.20	0.85	1.18
(d) Uniform, inorganic silt	1.29	—	1.92	1.31	2.20	0.83	1.18
2. Well-graded materials:							
(a) Silty sand	1.41	1.98	2.06	1.43	2.30	0.88	1.28
(b) Clean, fine to course sand	1.38	2.14	2.23	1.40	2.39	0.86	1.40
(c) Micaceous sand	1.23	—	1.95	1.24	2.23	0.77	1.23
(d) Silty sand and gravel	1.44	—	2.36	1.46	2.51	0.91	1.49

†Tabulation is based on $\rho_s = 2.65$ Mg/m³. Multiply by 62.4 to obtain lbf/ft³.

Source: (Holtz and Kovacs, 1981)

Attachment A (1/1)

GTC, 1/9/08

Table 2.1 Various Forms of Relationships for γ, γ_d, and γ_{sat}

Unit-weight relationship	Eq. no.
$\gamma = \dfrac{(1+w)G_s\gamma_w}{1+e}$	(2.15)
$\gamma = \dfrac{(G_s + Se)\gamma_w}{1+e}$	(2.26)
$\gamma = \dfrac{(1+w)G_s\gamma_w}{1+\dfrac{wG_s}{S}}$	(2.27)
$\gamma = G_s\gamma_w(1-n)(1+w)$	(2.28)
Dry unit weight	
$\gamma_d = \dfrac{\gamma}{1+w}$	(2.12)
$\gamma_d = \dfrac{G_s\gamma_w}{1+e}$	(2.16)
$\gamma_d = G_s\gamma_w(1-n)$	(2.22)
$\gamma_d = \dfrac{G_s}{1+\dfrac{wG_s}{S}}\gamma_w$	(2.29)
$\gamma_d = \dfrac{eS\gamma_w}{(1+e)w}$	(2.30)
$\gamma_d = \gamma_{sat} - n\gamma_w$	(2.31)
$\gamma_d = \gamma_{sat} - \left(\dfrac{e}{1+e}\right)\gamma_w$	(2.32)
Saturated unit weight	
$\gamma_{sat} = \dfrac{(G_s + e)\gamma_w}{1+e}$	(2.18)
$\gamma_{sat} = [(1-n)G_s + n]\gamma_w$	(2.24) *
$\gamma_{sat} = \left(\dfrac{1+w}{1+wG_s}\right)G_s\gamma_w$	(2.33)
$\gamma_{sat} = \left(\dfrac{e}{w}\right)\left(\dfrac{1+w}{1+e}\right)\gamma_w$	(2.34)
$\gamma_{sat} = \gamma_d + n\gamma_w$	(2.35)
$\gamma_{sat} = \gamma_d + \left(\dfrac{e}{1+e}\right)\gamma_w$	(2.36)

The proofs of some of these relationships are left to the students.

Source: (Das, 1990)

Attachment B (1/1)

shown on Drawing Nos. A-49 through A-56, entitled *Consolidation Test* and are summarized on the following table:

Exploration Location	Depth (Feet)	Soil Description	Dry Unit Weight, pcf	Moisture Content, %	Hydrocollapse (percent)*
B-1	29-30	Silty sand with gravel	105	6	3.2
B-8	39-40	Sandy lean clay	57.4	64	0.4
B-8	49-50	Sandy lean clay	69.5	51.1	-0.6
B-10	54-54.5	Sandy lean clay	60.7	67.7	-0.6
B-101	39-40	Sandy lean clay	65.8	45	-0.2
B-101	59-60	Sandy lean clay	73.2	38.3	-0.6
B-102	49-50	Sandy lean clay	67.3	48.7	-0.5
B-105	34-35	Well graded sand with silt and gravel	101	5	0.1

NA: Not available

* A negative sign indicates swell occurred upon inundation with water instead of collapse.

Laboratory Maximum Density

Laboratory maximum density tests were performed on selected samples of the granular soils. The purpose of the test was to define the compaction characteristics of these soils, and to aid in estimating soil shrinkage. The laboratory maximum density test was performed in general accordance with the ASTM D1557 test method. This test procedure uses 25 blow of a 10-pound hammer falling a height of 18 inches on each of five layers of soil in a 1/30 or 1/13 cubic foot cylinder. The test results are presented on Drawing Nos. A-57 through A-61 and in the following table:

Exploration Location	Depth (Feet)	Soil Description	Maximum Dry Unit Weight (pcf)	Optimum Moisture Content (percent) of dry weight)
B-1	20-25	Silty sand with gravel	129.4	8.2
B-5	20-25	Silty sand with gravel	132.1	8.2
B-12	10-15	Silty sand with gravel	129.7	7.9
B-101	5-10	Silty sand with gravel	130.6	8.7
B-105	20-25	Well graded sand with silt and gravel	131.8	7.5

assume $\gamma_d = 130$ pcf, $w\% = 8\%$

SOURCE: CONVERSE (1999)

Attachment C 1/1

TABLE 1
Typical Properties of Compacted Soils

Group Symbol	Soil Type	Range of Maximum Dry Unit Weight, pcf	Range of Optimum Moisture, Percent	Typical Value of Compression: At 1.4 tsf (20 psi)	Typical Value of Compression: At 3.6 tsf (50 psi)	Typical Strength Characteristics: Cohesion (as compacted) psf	Cohesion (saturated) psf	ϕ (Effective Stress Envelope Degrees)	Tan ϕ	Typical Coefficient of Permeability ft./min.	Range of CBR Values	Range of Subgrade Modulus k lbs/cu in.
				Percent of Original Height								
GW	Well graded clean gravels, gravel-sand mixtures.	125 - 135	11 - 8	0.3	0.6	0	0	>38	>0.79	3×10^{-2}	40 - 80	300 - 500
GP	Poorly graded clean gravels, gravel-sand mix	115 - 125	14 - 11	0.4	0.9	0	0	>37	>0.74	10^{-1}	30 - 60	250 - 400
GM	Silty gravels, poorly graded gravel-sand-silt.	120 - 135	12 - 8	0.5	1.1	.....	.....	>34	>0.67	$>10^{-6}$	20 - 60	100 - 400
GC	Clayey gravels, poorly graded gravel-sand-clay.	115 - 130	14 - 9	0.7	1.6	.....	.....	>31	>0.60	$>10^{-7}$	20 - 40	100 - 300
SW	Well graded clean sands, gravelly sands.	110 - 130	16 - 9	0.6	1.2	0	0	38	0.79	$>10^{-3}$	20 - 40	200 - 300
SP	Poorly graded clean sands, sand-gravel mix.	100 - 120	21 - 12	0.8	1.4	0	0	37	0.74	$>10^{-3}$	10 - 40	200 - 300
SM	Silty sands, poorly graded sand-silt mix.	110 - 125	16 - 11	0.8	1.6	1050	420	34	0.67	$5 \times >10^{-5}$	10 - 40	100 - 300
SM-SC	Sand-silt clay mix with slightly plastic fines.	110 - 130	15 - 11	0.8	1.4	1050	300	33	0.66	$2 \times >10^{-6}$	5 - 30	100 - 300
SC	Clayey sands, poorly graded sand-clay-mix.	105 - 125	19 - 11	1.1	2.2	1550	230	31	0.60	$3 \times >10^{-7}$	5 - 20	100 - 300
ML	Inorganic silts and clayey silts.	95 - 120	24 - 12	0.9	1.7	1400	190	32	0.62	$>10^{-5}$	15 or less	100 - 200
ML-CL	Mixture of inorganic silt and clay.	100 - 120	22 - 12	1.0	2.2	1350	460	32	0.62	$5 \times >10^{-7}$	.....	
CL	Inorganic clays of low to medium plasticity.	95 - 120	24 - 12	1.3	2.5	1800	270	28	0.54	$>10^{-7}$	15 or less	50 - 200
OL	Organic silts and silt-clays, low plasticity.	80 - 100	33 - 21	.....	.....	.....	.....	.....	.....	.....	5 or less	50 - 100
MH	Inorganic clayey silts, elastic silts.	70 - 95	40 - 24	2.0	3.8	1500	420	25	0.47	$5 \times >10^{-7}$	10 or less	50 - 100
CH	Inorganic clays of high plasticity	75 - 105	36 - 19	2.6	3.9	2150	230	19	0.35	$>10^{-7}$	15 or less	50 - 150
OH	Organic clays and silty clays	65 - 100	43 - 21	.....	.....	.....	.....	.....	.....	.....	5 or less	25 - 100

Notes:

1. All properties are for condition of "Standard Proctor" maximum density, except values of k and CBR which are for "modified Proctor" maximum density.
2. Typical strength characteristics are for effective strength envelopes and are obtained from USBR data.
3. Compression values are for vertical loading with complete lateral confinement.
4. (>) indicates that typical property is greater than the value shown.
   (..) indicates insufficient data available for an estimate.

Source: Nunnally (1982) Attachment 1/1 D

Page 13 of 66

Table 5.7 Friction values and efficiencies (in parentheses) for (a) soil-to-geomembrane, (b) geomembrane-to-geotextile, and (c) soil-to-geotextile combinations*

(a) Soil-to-Geomembrane Friction Angles

Geomembrane	Soil Types: Concrete Sand (ϕ = 30°)	Ottawa Sand (ϕ = 28°)	Micha Schist Sand (ϕ = 26°)
EPDM-R	24° (0.77)	20° (0.68)	24° (0.91)
PVC			
Rough	27° (0.88)	—	25° (0.96)
Smooth	25° (0.81)	—	21° (0.79)
CSPE-R	25° (0.81)	21° (0.72)	23° (0.87)
HDPE -Smooth	18° (0.56)	18° (0.61)	17° (0.63)

(b) Geomembrane-to-Geotextile Friction Angles

Geotextile	Geomembrane: EPDM-R	PVC Rough	PVC Smooth	CSPE-R	HDPE Smooth
Nonwoven, needle punched	23°	23°	21°	15°	8°
Nonwoven, heat bonded	18°	20°	18°	21°	11°
Woven, monofilament	17°	11°	10°	9°	6°
Woven, slit film	21°	28°	24°	13°	10°

(c) Soil-to-Geotextile Friction Angles

Geotextile	Soil Types: Concrete Sand (ϕ = 30°)	Ottawa Sand (ϕ = 28°)	Mica Schist Sand (ϕ = 26°)
Nonwoven, needle punched	30° (1.00)	26° (0.92)	25° (0.96)
Nonwoven, heat bonded	26° (0.84)	—	—
Woven, monofilament	26° (0.84)	—	—
Woven, slit film	24° (0.77)	24° (0.84)	23° (0.87)

*Efficiency values in parentheses are based on the relationship $E = (\tan \delta)/(\tan \phi)$.

Source: After Martin et al. [14].

The frictional behavior of geomembranes placed
erable importance in the composite liners of waste land
are for the clay to have a hydraulic conductivity equa
ft./min. (1×10^{-7} cm/sec.) and for the geomembrane t
clay. While an indication of the shear strength param
(e.g., reference 15), the data are so sensitive to the var
site-specific and material-specific tests should always b
literature values should never be used for final design

5.1.3.9 Geomembrane Anchorage In certain proble
might be sandwiched between two materials and the
force. The termination of a geomembrane liner within an anchor trench is such a situation. To simulate this behavior in a laboratory environment, one can use an 8.0-in. (200-mm)-wide geomembrane sandwiched between back-to-back channels.

Jubrek - Kuhner (1977)

Attachment E
1/1

SUMMARY OF BENTOMAT DIRECT SHEAR TEST DATA
INTERFACE W/ SOIL

Lab[1]	Report Date	Interface Tested[2]	Normal Stresses (psi)	Bentomat Moisture[3]	Shear Rate (in/min)	Peak Friction Angle (deg)	Residual Friction Angle (deg)[4]	Apparent Peak Cohesion (psf)	Comments
GSC	03-09-95	NW/ Soaked GC Soil	7.5 - 15 - 30	Hydrated	0.04	33	31	385	
CETCO	08-29-95	W/Silty Sand	1 - 2 - 3	Hydrated	0.04	32.3	ND	127	
GSC	03-12-96	NW/ Soaked Soil	2 - 4 - 6	Hydrated	0.04	29	29	70	
STS	05-30-96	NW/Silty Sandy Gravel	0.7 – 2 – 3.5	Hydrated	0.04	28	ND	222	
CETCO	07-08-96	NW/ Sandy Silty Gravel	0.7 - 2.0 - 3.5	Hydrated	0.04	40.4	ND	238	
	07-31-96	W/ Sandy Silty Gravel	0.7 - 2.0 - 3.5	Hydrated	0.04	37.8	ND	194	
AGP	11-08-96	NW/ SC Soil	1.4 - 3.5 - 7.0	Hydrated	0.04	27.8	ND	186	
		W/ SC Soil	1.4 - 3.5 - 7.0	Hydrated	0.04	23.5	22.1	187	
GSC	01-08-97	NW/ Soaked Soils	14 - 40 - 70	Hydrated	0.04	18	18	155	
TRI	09-23-97	NW/ Subbaase Soil	3.5 – 7 – 14	Hydrated	0.001	24.0	20.7	4	
		NW/ Subbase Soil	.35 - .7 – 1.4	Hydrated	0.001	35.5	37.2	88	
GSC	01-22-98	CLS/ SM soil	5 - 25 - 45	Hydrated	0.04	17	13	70	
CETCO	02-10-98	CLS/ SC Soil	0.5 – 1 – 1.5	Hydrated	0.04	9.5	ND	46	
VE	03-03-98	W/ Cover soil	1 - 2.1 – 4.9	Hydrated	0.04	37	33	50	
CETCO	08-11-98	W/ SC soil	2.1 – 4.2 – 6.3	Hydrated	0.04	33.6	35.2	183	
		NW/ Non-Pag Quartz Monzonite Waste	2.1 – 4.2 – 6.3	Hydrated	0.04	39.8	37.5	190	
TRI	09-22-98	NW/ soil	16 – 32 – 73	Hydrated	0.04	17.5	16.8	505	Residual @ 3"
CETCO	11-3-98	CLS/SM soil	0.5 – 1 – 1.5	Hydrated	0.04	27	27	80	
		CLS/SP soil	0.5 – 1 – 1.5	Hydrated	0.04	15.2	15.2	55	
GSC	6-24-00	CLS/drainage soil	139	Hydrated	0.04	24	0	13	Angle w/ origin

Attachment F (1/1)

SUMMARY OF BENTOMAT DIRECT SHEAR TEST DATA
INTERFACE W/ GEOMEMBRANE

Lab[1]	Report Date	Interface Tested[2]	Normal Stresses (psi)	Bentomat Moisture[3]	Shear Rate (in/min)	Peak Friction Angle (deg)	Residual Friction Angle (deg)[4]	Apparent Peak Cohesion (psf)	Comments
GA	09-04-92	W/60-mil sm. HDPE	0.5 - 1 - 2 - 4 - 10	Hydrated	0.02	8	7	0	
		W/60-mil text. HDPE	0.5 - 1 - 2 - 4 - 10	Hydrated	0.02	28	28 / 6	29	bi-modal residual
GSC	12-08-94	W/60-mil text. HDPE	7.5 - 15 - 30	Hydrated	0.04	18	17	175	Diff. membrane
		W/60-mil text. HDPE	7.5 - 15 - 30	Hydrated	0.04	16	12	345	manufacturers
GSC	12-16-94	W/60-mil text. HDPE	1 -3 - 6 - (15)	Hydrated	0.04	25 (19)	10	100	(lower d at 15 psi)
AGP	07-12-95	W/80-mil Text. HDPE	14 - 28 - 69 - 104	Hydrated	0.04	18	8	192	
		W/80-mil Text. HDPE	14 - 28 - 69 - 104	Dry	0.04	30	14	0	
AGP	11-30-95	W/ Text. HDPE	10 - 26 - 38	Dry	0.08	30.2	13.3	0	
GSC	03-12-96	W/ 30 mil PVC	2 - 4 - 6	Hydrated	0.04	17	17	24	
GSC	05-29-96	NW/80mil Text. HDPE	140	Hydrated	0.04	19	5	475	Consol 24 hrs @140 psi
AGP	11-08-96	NW/60mil Text. HDPE	1.4 - 3.5 - 7.0	Hydrated	0.04	34.8	22.7	149	
		W/60 mil Text. HDPE	1.4 - 3.5 - 7.0	Hydrated	0.04	28.8	20.4 *	83	
GSC	01-08-97	NW/60mil Text. HDPE	14 - 40 - 70	Hydrated	0.04	17	9	255	
TRI	4-15-97	NW/60mil Text. HDPE	14 – 28 – 56	Hydrated	0.04	21.9	10.8	722	
Emcon	6-16-97	NW/40mil Text. LLPE	1.0 – 2.0 – 3.5	Hydrated	0.04	32.0	18.5	111	
		NW/40mil Text. LLPE	1.0 – 2.0 – 3.5	Hydrated	0.04	37.5	27.1	118	
TRI	10-15-97	NW/ 60mil Text.HDPE	3.5 – 7 – 14	Hydrated	0.04	20.3	18.6	278	
		NW/ 60mil Text.HDPE	.35 - .7 – 1.4	Hydrated	0.04	36.6	25.8	2	
TRI	12-01-97	NW/60mil Text. HDPE	0.35 – 0.7 – 1.4	Hydrated	0.001	25.6	23.3	54	Residual @ 4"
		NW/60mil Text. HDPE	3.5 – 7 – 14	Hydrated	0.001	23.2	17.8	85	"
Emcon	04-06-98	NW/60mil Text. HDPE	14 – 28 – 70	Hydrated	0.04	24.1	12.2	290	

Attachment G (1/1)

- The issue of appropriate normal stress is greatly complicated if gas pressures are generated in the underlying waste. These gas pressures will counteract some (or all) of the gravitational stress of the cover soil. The resulting shear strength, and subsequent stability, can be significantly decreased. See Liu et al (1997) for insight into this possibility.
- Shear rates necessary to attain drained conditions (if this is the desired situation) are extremely slow, requiring long testing times.
- Deformations necessary to attain residual strengths require large relative movement of the two respective halves of the shear box. So as not to travel over the edges of the opposing shear box sections, devices should have the lower shear box significantly longer than 300 mm. However, with a lower shear box longer than the upper traveling section, new surface is constantly being added to the shearing plane. This influence is not clear in the material's response or in the subsequent behavior.
- The attainment of a true residual strength is difficult to achieve. ASTM D5321 states that one should "run the test until the applied shear force remains constant with increasing displacement". Many commercially available shear boxes have insufficient travel to reach this condition.
- The ring torsion shearing apparatus is an alternative device to determine true residual strength values, but is not without its own problems. Some outstanding issues are the small specimen size, nonuniform shear rates along the width of the specimen, anisotropic shearing with some geosynthetics and no standardized testing protocol. See Stark and Poeppel (1994) for information and data using this alternative test method.

2.3 Various Types of Loadings

There are a large variety of slope stability problems that may be encountered in analyzing and/or designing final covers of engineered landfills, abandoned dumps and remediation sites as well as leachate collection soils covering geomembranes beneath the waste. Perhaps the most common situation is a uniformly thick cover soil on a geomembrane placed over the soil subgrade at a given and constant slope angle. This "standard" problem will be analyzed in the next section. A variation of this problem will include equipment loads used during placement of cover soil on the geomembrane. This problem will be solved with equipment moving up the slope and then moving down the slope.

Unfortunately, cover soil slides have occurred and it is felt that the majority of the slides have been associated with seepage forces. Indeed, drainage above a geomembrane (or other barrier material) in the cover soil cross section must be accommodated to avoid the possibility of seepage forces. A section will be devoted to this class of slope stability problems.

Lastly, the possibility of seismic forces exists in earthquake prone locations. If an earthquake occurs in the vicinity of an engineered landfill, abandoned dump or remediation site, the seismic wave travels through the solid waste mass reaching the upper surface of the cover. It then decouples from the cover soil materials, producing a horizontal force which must be appropriately analyzed. A section will be devoted to the seismic aspects of cover soil slope analysis as well.

All of the above actions are destabilizing forces tending to cause slope instability. Fortunately, there are a number of actions that can be taken to increase the stability of slopes.

Other than geometrically redesigning the slope with a flatter slope angle or shorter slope length, a designer can add soil mass at the toe of the slope thereby enhancing stability. Both toe berms and tapered soil covers are available options and will be analyzed accordingly. Alternatively, the designer can always use geogrids or high strength geotextiles within the cover soil acting as reinforcement materials. This technique is usually referred to as veneer reinforcement. Cases of both intentional and nonintentional veneer reinforcement will be presented.

Thus it is seen that a number of strategies influence slope stability. Each will be described in the sections to follow. First, the basic gravitational problem will be presented followed by those additional loading situations which tend to decrease slope stability. Second, various actions that can be taken by the designer to increase slope stability will be presented. The summary will contrast the FS-values obtained in the similarly crafted numeric examples.

3 SITUATIONS CAUSING DESTABILIZATION OF SLOPES

This section treats the standard veneer slope stability problem and then superimposes upon it a number of situations, all of which tend to destabilize slopes. Included are gravitational, construction equipment, seepage and seismic forces. Each will be illustrated by a design graph and a numeric example.

3.1 Cover Soil (Gravitational) Forces

Figure 3 illustrates the common situation of a *finite* length, uniformly thick cover soil placed over a liner material at a slope angle "β". It includes a passive wedge at the toe and has a tension crack of the crest. The analysis that follows is after Koerner and Hwu (1991), but comparable analyses are available from Giroud and Beech (1989), McKelvey and Deutsch (1991), Ling and Leshchinsky (1997) and others.

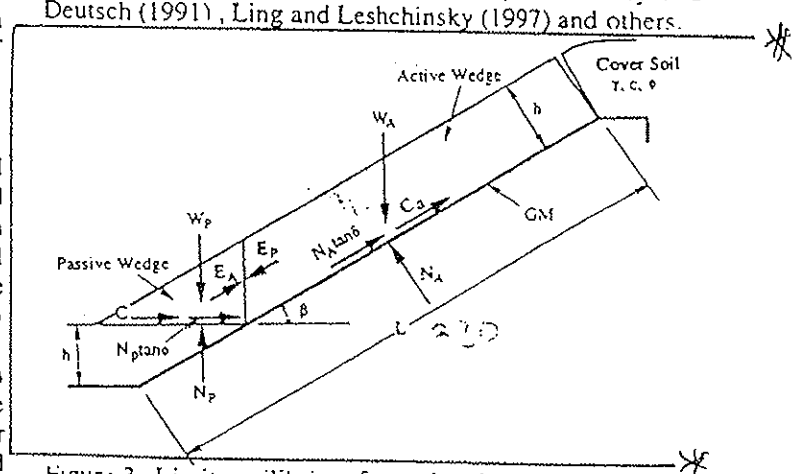


Figure 3. Limit equilibrium forces involved in a finite length slope analysis for a uniformly thick cover soil.

Attachment H 1/6

5/11/01 ②
GTC 5/11/01

The symbols used in Figure 3 are defined below.

W_A = total weight of the active wedge
W_P = total weight of the passive wedge
N_A = effective force normal to the failure plane of the active wedge
N_P = effective force normal to the failure plane of the passive wedge
γ = unit weight of the cover soil
h = thickness of the cover soil
L = length of slope measured along the geomembrane
β = soil slope angle beneath the geomembrane
ϕ = friction angle of the cover soil
δ = interface friction angle between cover soil and geomembrane
C_a = adhesive force between cover soil of the active wedge and the geomembrane
c_a = adhesion between cover soil of the active wedge and the geomembrane
C = cohesive force along the failure plane of the passive wedge
c = cohesion of the cover soil
E_A = interwedge force acting on the active wedge from the passive wedge
E_P = interwedge force acting on the passive wedge from the active wedge
FS = factor of safety against cover soil sliding on the geomembrane

The expression for determining the factor of safety can be derived as follows:

Considering the active wedge,

$$W_A = \gamma h^2\left(\frac{L}{h} - \frac{1}{\sin\beta} - \frac{\tan\beta}{2}\right) \quad (3)$$

$$N_A = W_A \cos\beta \quad (4)$$

$$C_a = c_a\left(L - \frac{h}{\sin\beta}\right) \quad (5)$$

By balancing the forces in the vertical direction, the following formulation results:

$$E_A \sin\beta = W_A - N_A \cos\beta - \frac{N_A \tan\delta + C_a}{FS}\sin\beta \quad (6)$$

Hence the interwedge force acting on the active wedge is:

$$E_A = \frac{(FS)(W_A - N_A\cos\beta) - (N_A\tan\delta + C_a)\sin\beta}{\sin\beta(FS)} \quad (7)$$

The passive wedge can be considered in a similar manner:

$$W_P = \frac{\gamma h^2}{\sin 2\beta} \quad (8)$$

$$N_P = W_P + E_P \sin\beta \quad (9)$$

$$C = \frac{(c)(h)}{\sin\beta} \quad (10)$$

By balancing the forces in the horizontal direction, the following formulation results:

$$E_P \cos\beta = \frac{C + N_P \tan\phi}{FS} \quad (11)$$

Hence the interwedge force acting on the passive wedge is:

$$E_P = \frac{C + W_P \tan\phi}{\cos\beta(FS) - \sin\beta\tan\phi} \quad (12)$$

By setting $E_A = E_P$, the resulting equation can be arranged in the form of the quadratic equation $ax^2 + bx + c = 0$ which in our case, using FS-values, is:

$$a(FS)^2 + b(FS) + c = 0 \quad (13)$$

where

$$a = (W_A - N_A\cos\beta)\cos\beta$$

$$b = -\left[(W_A - N_A\cos\beta)\sin\beta\tan\phi + (N_A\tan\delta + C_a)\sin\beta\cos\beta + \sin\beta(C + W_P\tan\phi)\right]$$

$$c = (N_A\tan\delta + C_a)\sin^2\beta\tan\phi \quad (14)$$

The resulting FS-value is then obtained from the solution of the quadratic equation:

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a} \quad (15)$$

When the calculated FS-value falls below 1.0, sliding of the cover soil on the geomembrane is to be anticipated. Thus a value of greater than 1.0 must be targeted as being the minimum factor of safety. How much greater than 1.0 the FS-value should be, is a design and/or regulatory issue. The issue of minimum allowable FS-values under different conditions will be assessed at the end of the paper. In order to better illustrate the implications of Eqs. 13, 14 and 15, typical design curves for various FS-values as a function of slope angle and interface friction angle are given in Figure 4. Note that the curves are developed specifically for the variables stated in the legend of the figure. Example 1 illustrates the use of the curves in what will be the standard example to which other examples will be compared.

Example 1:
Given a 30 m long slope with a uniformly thick 300 mm cover soil at a unit weight of 18 kN/m³. The soil has a friction angle of 30 deg. and zero cohesion, i.e., it is a sand. The cover soil is placed directly on a geomembrane as shown in Figure 3. Direct shear testing has resulted in a interface friction angle between the cover soil and geomembrane of 22 deg. with zero adhesion. What is the FS-value at a slope angle of 3(H)-to-1(V), i.e., 18.4 deg?

Attachment H (2/6)

Solution:

Substituting Eq. 14 into Eq. 15 and solving for the FS-value results in the following which is seen to be in agreement with the curves of Figure 4.

$$\left.\begin{aligned} a &= 14.7\,kN/m \\ b &= -21.3\,kN/m \\ c &= 3.5\,kN/m \end{aligned}\right\} FS = 1.25$$

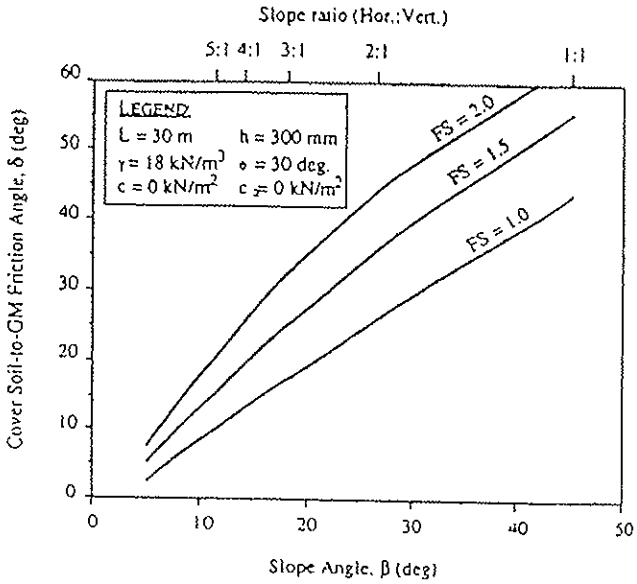


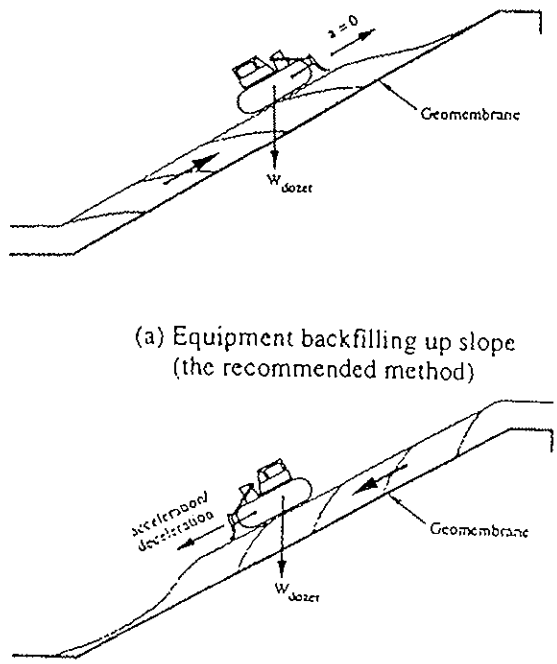
Figure 4. Design curves for stability of uniform thickness cohesionless cover soils on linear failure planes for various global factors-of-safety.

Comment:
In general, this is too low of a value for a final cover soil factor-of-safety and a redesign is necessary. While there are many possible options of changing the geometry of the situation, the example will be revisited later in this section using toe berms, tapered cover soil thickness and veneer reinforcement. Furthermore, this general problem will be used throughout the main body of this paper for comparison purposes to other cover soil slope stability situations.

3.2 Tracked Construction Equipment Forces

The placement of cover soil on a slope with a relatively low shear strength inclusion (like a geomembrane) should always be from the toe upward to the crest. Figure 5a shows the recommended method. In so doing, the gravitational forces of the cover soil and live load of the construction equipment are compacting previously placed soil and working with an ever present passive wedge and stable lower-portion beneath the active wedge. While it is necessary to specify low ground pressure equipment to place the soil, the reduction of the FS-value for this situation of equipment working up the slope will be seen to be relatively small.

For soil placement down the slope, however, a stability analysis cannot rely on toe buttressing and also a dynamic stress should be included in the calculation. These conditions decrease the FS-value and in some cases to a great extent. Figure 5b shows this procedure. Unless absolutely necessary, it is not recommended to place cover soil on a slope in this manner. If it is necessary, the design must consider the unsupported soil mass and the dynamic force of the specific type of construction equipment and its manner of operation.



(a) Equipment backfilling up slope (the recommended method)

(b) Equipment backfilling down slope (method is not recommended)

Figure 5. Construction equipment placing cover soil on slopes containing geosynthetics.

For the first case of a bulldozer pushing cover soil up from the toe of the slope to the crest, the analysis uses the free body diagram of Figure 6a. The analysis uses a specific piece of tracked construction equipment (like a bulldozer characterized by its ground contact pressure) and dissipates this force or stress through the cover soil thickness to the surface of the geomembrane. A Boussinesq analysis is used, see Poulos and Davis (1974). This results in an equipment force per unit width as follows:

$$W_e = q w I \qquad (16)$$

where

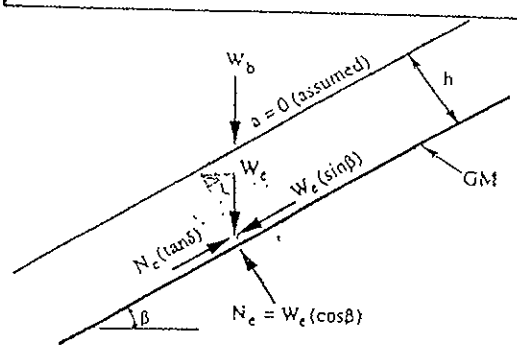
W_e = equivalent equipment force per unit width at the geomembrane interface

$q = W_b / (2 \times w \times b)$

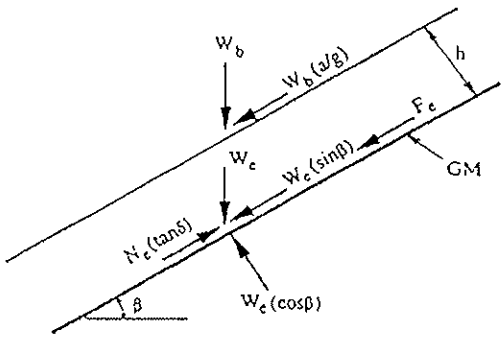
Attachment M (3/6)

5/11/01 (3)
GTC 5/11/01

W_b = actual weight of equipment (e.g., a bulldozer)
w = length of equipment track
b = width of equipment track
I = influence factor at the geomembrane interface see Figure 7



(a) Equipment moving up slope
(load with no assumed acceleration)



(b) Equipment moving down slope
(load plus acceleration or deceleration)

Figure 6. Additional (to gravitational forces) limit equilibrium forces due to construction equipment moving on cover soil (see Figure 3 for the gravitational soil force to which the above forces are added).

Upon determining the additional equipment force at the cover soil-to-geomembrane interface, the analysis proceeds as described in Section 3.1 for gravitational forces only. In essence, the equipment moving up the slope adds an additional term, W_c, to the W_A-force in Eq. 3. Note, however, that this involves the generation of a resisting force as well. Thus, the net effect of increasing the driving force as well as the resisting force is somewhat neutralized insofar as the resulting FS-value is concerned. It should also be noted that no acceleration/deceleration forces are included in this analysis which is somewhat optimistic. Using these concepts (the same equations used in Section 3.1 are used here), typical design curves for various FS-values as a function of equivalent ground contact equipment pressures and cover soil thicknesses are given in Figure 8. Note that the curves are developed specifically for the variables stated in the legend. Example 2a illustrates the use of the formulation.

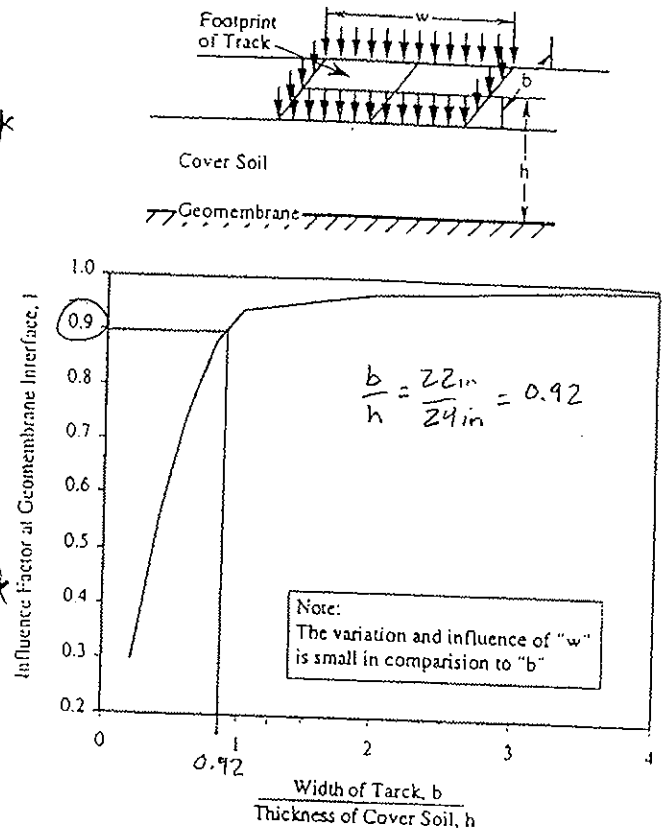


Figure 7. Values of influence factor, "I", for use in Eq. 16 to dissipate surface force of tracked equipment through the cover soil to the geomembrane interface, after Poulos and Davis (1974).

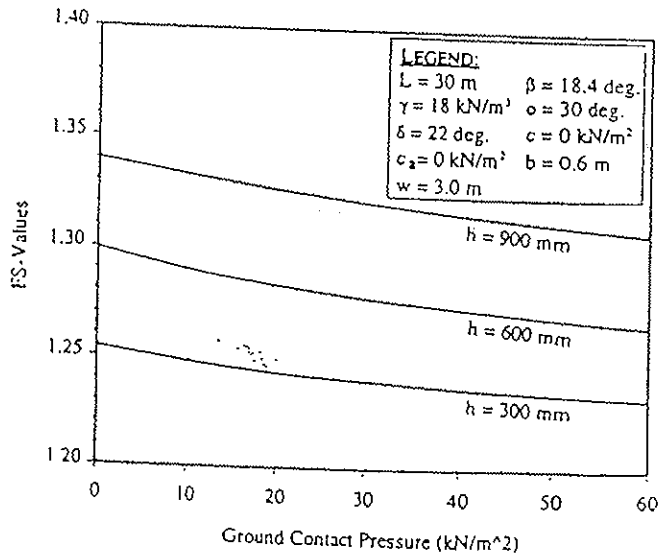


Figure 8. Design curves for stability of different thickness of cover soil for various values of tracked ground contact pressure construction equipment.

Attachment H (4/6)

Example 2a:

Given 30 m long slope with uniform cover soil of 300 mm thickness at a unit weight of 18 kN/m³. The soil has a friction angle of 30 deg. and zero cohesion, i.e., it is a sand. It is placed on the slope using a bulldozer moving from the toe of the slope up to the crest. The bulldozer has a ground pressure of 30 kN/m² and tracks that are 3.0 m long and 0.6 m wide. The cover soil to geomembrane friction angle is 22 deg. with zero adhesion. What is the FS-value at a slope angle of 3(H)-to-1(V), i.e., 18.4 deg.

Solution:
This problem follows Example 1 exactly except for the addition of the bulldozer moving up the slope. Using the additional equipment load Eq. 16, substituted into Eqs. 14 and 15 results in the following.

$$\left.\begin{aligned} a &= 73.1\,\text{kN/m} \\ b &= -104.3\,\text{kN/m} \\ c &= 17.0\,\text{kN/m} \end{aligned}\right\} \quad FS = 1.24$$

Comment:
While the resulting FS-value is low, the result is best assessed by comparing it to Example 1, i.e., the same problem except without the bulldozer. It is seen that the FS-value has only decreased from 1.25 to 1.24. Thus, in general, a low ground contact pressure bulldozer placing cover soil up the slope with negligible acceleration/deceleration forces does not significantly decrease the factor-of-safety.

For the second case of a bulldozer pushing cover soil down from the crest of the slope to the toe as shown in Figure 5b, the analysis uses the force diagram of Figure 6b. While the weight of the equipment is treated as just described, the lack of a passive wedge along with an additional force due to acceleration (or deceleration) of the equipment significantly changes the resulting FS-values. This analysis again uses a specific piece of construction equipment operated in a specific manner. It produces a force parallel to the slope equivalent to W_b (a/g), where W_b = the weight of the bulldozer, a = acceleration of the bulldozer and g = acceleration due to gravity. Its magnitude is equipment operator dependent and related to both the equipment speed and time to reach such a speed, see Figure 9. A similar behavior will be seen for deceleration.

The acceleration of the bulldozer, coupled with an influence factor "I" from Figure 7, results in the dynamic force per unit width at the cover soil to geomembrane interface, "F_e". The relationship is as follows:

$$F_e = W_e\left(\frac{a}{g}\right) \qquad (17)$$

where

F_e = dynamic force per unit width parallel to the slope at the geomembrane interface,

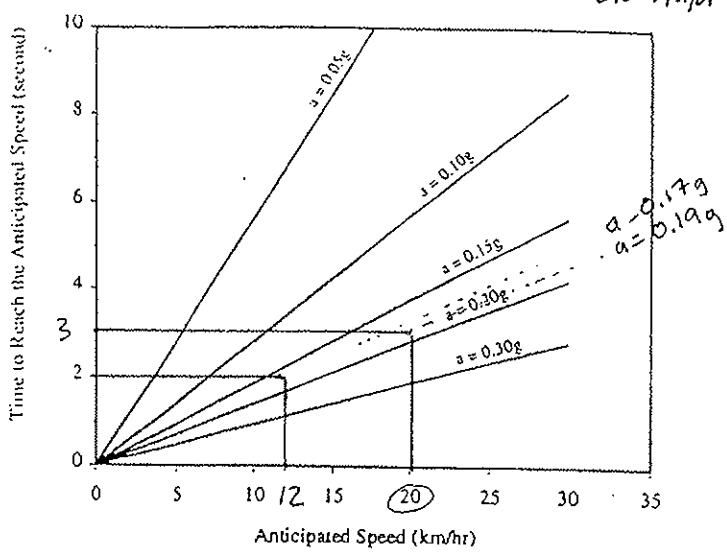


Figure 9. Graphic relationship of construction equipment speed and rise time to obtain equipment acceleration.

W_e = equivalent equipment (bulldozer) force per unit width at geomembrane interface, recall Eq. 16.
β = soil slope angle beneath geomembrane
a = acceleration of the bulldozer
g = acceleration due to gravity

Using these concepts, the new force parallel to the cover soil surface is dissipated through the thickness of the cover soil to the interface of the geomembrane. Again, a Boussinesq analysis is used, see Poulos and Davis (1974). The expression for determining the FS-value can now be derived as follows:

Considering the active wedge, and balancing the forces in the direction parallel to the slope, the following formulation results:

$$E_A + \frac{(N_e + N_A)\tan\delta + C_a}{FS} = (W_A + W_e)\sin\beta + F_e \qquad (18)$$

where

N_e = effective equipment force normal to the failure plane of the active wedge
= $W_e \cos\beta$ (19)

Note that all the other symbols have been previously defined.

The interwedge force acting on the active wedge can down be expressed as:

$$E_A = \frac{(FS)\left[(W_A + W_e)\sin\beta + F_e\right]}{FS} - \frac{\left[(N_e + N_A)\tan\delta + C_a\right]}{FS} \qquad (20)$$

The passive wedge can be treated in a similar manner. The following formulation of the interwedge force acting on the passive wedge results:

Attachment H (5/6)

$$E_P = \frac{C + W_P \tan\phi}{\cos\beta(FS) - \sin\beta\tan\phi} \qquad (21)$$

By setting $E_A = E_P$, the following equation can be arranged in the form of Eq. 13 in which the "a", "b" and "c" terms are as follows:

$$a = \left[\left(W_A + W_e\right)\sin\beta + F_e\right]\cos\beta$$

$$b = -\left\{\left[\left(N_e + N_A\right)\tan\delta + C_a\right]\cos\beta + \left[\left(W_A + W_e\right)\sin\beta + F_e\right]\sin\beta\tan\phi + \left(C + W_P\tan\phi\right)\right\}$$

$$c = \left[\left(N_e + N_A\right)\tan\delta + C_a\right]\sin\beta\tan\phi \qquad (22)$$

Finally, the resulting FS-value can be obtained using Eq. 15. Using these concepts, typical design curves for various FS-values as a function of equipment ground contact pressure and equipment acceleration can be developed, see Figure 10. Note that the curves are developed specifically for the variables stated in the legend. Example 2b illustrates the use of the formulation.

Example 2b:

Given a 30 m long slope with uniform cover soil of 300 mm thickness at a unit weight of 18 kN/m^3. The soil has a friction angle of 30 deg. and zero cohesion, i.e., it is a sand. It is placed on the slope using a bulldozer moving from the crest of the slope down to the toe. The bulldozer has a ground contact pressure of 30 kN/m^2 and tracks that are 3.0 m long and 0.6 m wide. The estimated equipment speed is 20 km/hr and the time to reach this speed is 3.0 sec. The cover soil to geomembrane friction angle is 22 deg. with zero adhesion. What is the FS-value at a slope angle of 3(H)-to-1(V), i.e., 18.4 deg.

Solution:

Using the design curves of Figure 10 along with Eqs. 22 substituted into Eq. 15 the solution can be obtained:

- From Figure 9 at 20 km/hr and 3.0 sec. the bulldozer's acceleration is 0.19g.
- From Eq. 22 substituted into Eq. 15 we obtain

$$\left.\begin{aligned} a &= 88.8\ \text{kN/m} \\ b &= -107.3\ \text{kN/m} \\ c &= 17.0\ \text{kN/m} \end{aligned}\right\} \quad FS = 1.03$$

Comment:

This problem solution can now be compared to the previous two examples:

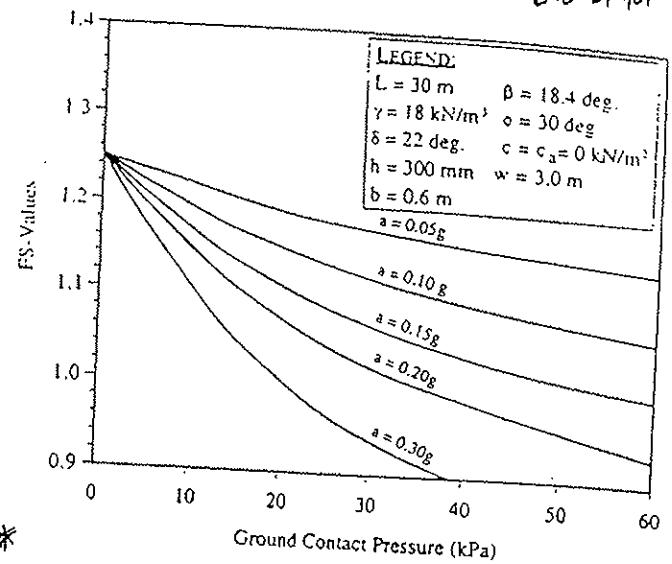


Figure 10. Design curves for stability of different construction equipment ground contact pressure for various equipment accelerations.

Ex. 1:	cover soil alone with no bulldozer loading	FS = 1.25
Ex. 2a:	cover soil plus bulldozer moving up slope	FS = 1.24
Ex. 2b:	cover soil plus bulldozer moving down slope	FS = 1.03

The inherent danger of a bulldozer moving down the slope is readily apparent. Note, that the same result comes about by the bulldozer decelerating instead of accelerating. The sharp breaking action of the bulldozer is arguable the more severe condition due to the extremely short times involved when stopping forward motion. Clearly, only in unavoidable situations should the cover soil placement equipment be allowed to work down the slope. If it is unavoidable, an analysis should be made of the specific stability situation and the construction specifications should reflect the exact conditions made in the design. The maximum allowable weight and ground contact pressure of the equipment should be stated along with suggested operator movement of the cover soil placement operations. Truck traffic on the slopes can also give as high, or even higher, stresses and should be avoided unless adequately designed. Additional detail is given in McKelvey (1994). The issue of access ramps is a unique subset of this example and one which deserves focused attention due to the high loads and decelerations that often occur.

3.3 Consideration of Seepage Forces

The previous sections presented the general problem of slope stability analysis of cover soils placed on slopes under different conditions. The tacit assumption throughout was that either permeable soil or a drainage layer was placed above the barrier layer with adequate flow capacity to efficiently remove permeating water safely way from the cross section. The amount of water to be removed is obviously a site specific situation. Note that in extremely

Geosyntec consultants

Written By: Rebecca Flynn Date: 8-Jan-08 Reviewed by: _____ Date: _____

Client: Basic Remediation Company Project: BRC CAMU Project No.: SC0313

CALCULATION OF VENEER STABILITY

(1) Project Variables

Unit weight of soil (g):	144	pcf
Cover thickness at crest (hc):	2	ft
Slope Height (H):	47.0	ft
Length of Slope	148.67	ft
Friction angle of soil (f):	32	degrees
	0.56	radians
Cohesion of soil (c):	500	psf
Cover soil and Liner inclination (nH:1V):	3	
Slope angle	0.32	radians
Slope angle	18.4	degrees

(2) Geosynthetic Properties

Minimum friction angle :	20	degrees	
	0.35	radians	
Adhesion Intercept (ca)	0	psf	
Product name :	**Geocomposite/Geomembrane**		
Allowable tensile strength:	84	ppi	**need to select geoc

(3) Equipment Loading

Equipment Type:	None	
Width of placement track, b	22.0	inches
Influence Factor, I	0.90	(see Figure 7, Attachment A)
Length of placement track, w	111.0	inches
Actual weight of equipment, Wb	42,300	lbs
Acceleration of equipment, a	0.19	g

(4) Analysis Output

Cohesion Force along failure plane of passive wedge (C)	3163	ppf
Adhesive Force b/w operations layer of active wedge and geomembrane (Ca)	0	ppf
Total weight of active wedge (Wa)	40899	ppf
Effective force normal to failure plane of the active wedge (Na)	38801	ppf
Total weight of passive wedge (Wp)	960	ppf
Surface stress (q)	NA	psf
Vertical force of equipment (We)	NA	ppf
Dynamic Equipment Loading, parallel to slope (Fe)	NA	ppf
Equiment force Normal to to Active Wedge (Ne)	NA	ppf

Factor of Safety (FS) 1.45

Reference:
Koerner, R. M., Soong, T. [1998]. "Analysis and Design of Veneer Cover Soils", Proceedings of the Sixth International Conference on Geosynthetics.
Programmed by: J. Soule, 2005

Geosyntec consultants

10875 Rancho Bernardo Road
Suite 200
San Diego, CA 92127

PH 858.674.6559
FAX 858.674.6586
www.geosyntec.com

23 January 2008

Mr. Brian Rakvica, P.E.
Nevada Division of Environmental Protection
Bureau of Corrective Actions
2030 E. Flamingo Road, Suite 230
Las Vegas, NV 89119

Subject: Response to Interim CAMU Design Review Report No. 2
BMI Industrial Complex Remediation Design Review
Henderson, Nevada
Geosyntec Project: SC0313

Dear Mr. Rakvica:

On behalf of Basic Remediation Company (BRC), Geosyntec Consultants (Geosyntec) hereby responds to the 14 January 2008 letter written by Applied Soil Water Technologies, LLC (ASW) to Nevada Department of Environmental Protection (NDEP) regarding the Interim CAMU Design Review. The ASW review focused on the following aspects of the CAMU design:

- Geotextile Separation/Filtration Review;
- Geocomposite Equivalency;
- HELP Model Results;
- Sump Capacity;
- Vadose Zone Monitoring; and
- Grading Plan.

For ease of review, the ASW's discussion will be repeated in italics with Geosyntec's response following.

Geotextile Separation/Filtration Review

Discussion

The design calculations entail three functions, separation, water permittivity and filtration.

We generally agree with the approach and conclusions associated with permittivity and filtration. However we have the following comments;

- *The calculations were based on the assumption that the operations layer would be two-feet thick and comprised of "…on-site material, which has been*

classified as silty sand to well-graded sand (SM, SM-SW according to the Unified Soil Classification System…". Laboratory hydraulic conductivity data from work performed by Converse Consultants presented in their 1999 report was used in the calculations.

- *The current specifications indicate that the operations layer will be comprised of soils derived from East Side Area and Western Ditch Materials as indicated in the Technical Specification. These materials are described in the Technical Specifications, Section 02205. It is not clear if these materials are consistent with the assumptions used in the calculations, specifically;*
    - *With respect to filtration, the finest soil criteria was used to select the minimum AOS sieve size so it should not be impacted by a difference in soil type, however, it should be acknowledged during construction,*

The retention portion of the filtration calculation was conservatively based on non-dispersive clay soil, which is not indicative of soils found on site, while the permittivity portion of the calculation was conservatively based on a higher hydraulic conductivity soil. Soil from the Western Ditch will likely be used for operations layer for a majority of the project and is generally a well graded to silty sand material that meets with the design intent. Soils excavated from the Eastside Area will entail silts (represented in GES investigation of silts and sludge materials from Eastside Area) and underlying sandy silt materials that will be mixed during the excavation process (silts are generally thin deposits that will be removed in the total 4 foot thickness of silt and soil mixture) that meets the design intent. Although we agree that the text of the calculation package indicates well graded and silty sand materials will be used, the assumptions in the calculation are sufficiently conservative to allow for finer grained materials to be used as operations layer.

- *The hydraulic conductivity used in the calculations, 1.2×10^{-3} centimeters per second (cm/sec) is most likely conservatively high, however, this should be verified during construction. If soils with a higher hydraulic conductivity are encountered they should not be placed in the operations layer.*

We agree with the factors of safety used in the required permittivity calculations.

Based on our understanding of the soil materials available for use on-site (native or waste materials), clean sands or gravels are not available for use as operations layer and agree that the assumed hydraulic conductivity is conservative. Therefore, we do not believe that hydraulic conductivity testing during construction is warranted.

With respect to separation and related durability of the geotextile we have the following comments;

- *In specifying the required mechanical properties of the geotextile the "…mechanical properties of geotextiles used in applications requiring moderate survivability…" were used. In our opinion, at minimum the*

requirements for a geotextile requiring "high survivability" should be used in reference to AASHTO Task Force 25 recommendations used in the calculations.

The required degree of survivability is based on the subgrade conditions and the construction equipment. Based on the subgrade preparation requirements outlined in the Technical Specifications Section 02200, performance of construction quality assurance, and the limitation of equipment ground pressure on soils overlying the geotextile, moderate survivability geotextile is adequate (Koerner, 1998).

Project Specifications

- *The mechanical material properties referenced in the calculation package include;*
  - *Grab Strength* *≥ 130 lb.*
  - *Puncture Strength* *≥ 40 lb*
  - *Mullen Burst* *≥ 210 lb*
  - *Trapezoidal Tear* *≥ 40 lb*
  - *Ultraviolet Strength Retention* *≥70%*

- *The project mechanical specifications require;*
  - *Grab Strength* *≥ 190 lb*
  - *Puncture Strength* *≥110 lb*

The designer should justify the omission of at least mullen burst and trapezoidal tear from the project specifications or they should be included.

Mullen burst and trapezoidal tear properties have been added to the Technical Specifications.

The designer should also verify that the test methods used to develop the AASHTO Task 25 values are the same test methods used in the project specifications.

AASHTO Task 25 values were obtained with the following ASTM test methods:

ASTM D4632 – Standard Test Method for Breaking Load and Elongation of Geotextile (Grab Method)

ASTM D4533 – Standard Test Method for Trapezoid Tearing Strength of Geotextile

ASTM D4833 – Standard Test Method for Index Puncture Resistance of Geotextile, Geomembranes, and Related Products

These methods are the same methods identified for testing geotextile in Section 02771 of the Technical Specifications.

- *The permittivity requirement from the calculation package is;*
  - *≥ 0.57 sec^{-1}*

- *The project permittivity specification is;*
  - *≥0.6 l/sec*

  The designer should verify that the permittivity value specified in the project's technical specifications meets the minimum required in the calculation package.

The project specification for permittivity of the filter geotextile is specified as 0.6 sec^{-1}, which greater than the permittivity requirement from the calculation package.

- *The project's technical specifications do not specify the polymer that the geotextile shall be manufactured from. The designer should specify a polymer or polymers that are compatible with the waste.*

Due to pricing, non-woven geotextiles used in the construction industry that are available in the United States are manufactured using polypropylene. Non-woven geotextiles manufactured from other polymers, which meet the requirements of the Technical Specifications, would be acceptable for use on this project.

Geocomposite Equivalency Review

Discussion
We agree with the calculation method as proposed by Koerner (1994) and, when using the same criteria, arrived at the same result.

Equivalency Partial Factors of Safety
According to the calculation method four partial factors of safety are accounted for in determining equivalency. These factors of safety include, the factor of safety due to intrusion of the adjacent geotextile into the core of the geonet (FS_{IN}), the factor of safety for creep deformation of the geonet (FS_{CR}), the factor of safety against chemical clogging of the geonet (FS_{CC}), and the factor of safety against biological clogging of the geonet (FS_{BC}).

The partial factors of safety used for the equivalency calculation for this project are as follows: FS_{IN} = 1.0, FS_{CR} = 2.0, FS_{CC} = 1.0 and FS_{BC} =1.0. According to the design method, the recommended range of partial factors of safety at 1.5 to 2.0 times the maximum anticipated stress on the geocomposite are FS_{IN} = 1.5 to 2.0, FS_{CR} = 1.4 to 2.0, FS_{CC} = 1.5 to 2.0 and FS_{BC} =1.5 to 2.0.

It was noted in the design calculations package that the lower factors of safety used were due to factors of safety being accounted for in other related calculations and/or during the anticipated testing of the drainage composite. ASW is requesting for

clarification on how the redundant factors of safety were applied in the equivalency calculations.

The transmissivity testing outlined in the Technical Specifications requires the use of operations layer soil and a loading of 24 hours, which will effectively model the intrusion of the geotextile into the geonet and therefore the factor of safety was selected as 1.0. The factor of safety for creep was maximized to be conservative. The factor of safety for chemical clogging was selected to be 1.0 based on the waste material characterized in the RAP. The waste material will be blended and dried so they are placed at below optimum moisture content, minimizing the generation of leachate and therefore limit the mobilization of soluble materials that could precipitate out of solution in the geocomposite. The factor of safety for biological clogging was selected to be 1.0 as the waste material does not contain biodegradable materials that would provide a source of food for biological growth. Furthermore, the geotextile filtration calculation accounts for partial factor of safety values for clogging.

Hydraulic Gradient
The hydraulic gradient used in the flow rate calculation in evaluating a prescriptive aggregate drainage layer was i= 0.02 (minimum slope of base liner system). In the calculation package a hand correction was made changing the hydraulic gradient from 0.02 to 0.10. ASW is requesting that support be provided for this correction.

The hydraulic gradient in the calculation package was changed from 0.02 to 0.10 to facilitate laboratory testing. The minimum, realistic hydraulic gradient achievable in a lab setting is typically 0.10. In addition, because hydraulic gradient is inversely proportional to transmissivity, this generates a more conservative value.

Maximum Stress
In the calculation package an anticipated maximum height of the waste fill is expected to be 60-feet. According to our review of the construction drawings the anticipated height of the waste fill including the final cover system is anticipated to be between 75-feet to 90-feet in the Phase I and Phase II portion of the facility.

The maximum height will be between 75 feet and 90 feet in Phases I and II. The calculation has been revised and is included as an attachment to this letter.

Project Specifications
For the base liner system the project's technical specifications require that the normal load applied to the system during transmissivity testing is only 7,000 psf. The normal load required in the technical specifications should be consistent with the design calculations.

The Technical Specifications have been updated to reflect a normal stress of 12,000 psf.

HELP Model Results
A review of the Hydrologic Evaluation of Landfill Performance (HELP) model results was performed.

> *Discussion*
> *Due to the overall intent of the design, to minimize the infiltration of water into the CAMU facility upon completion of construction, we are in agreement that the modeling should be performed to accommodate liquid introduced to the area within containment during construction activities to provide a worst case scenario event. However, it is our opinion that that the HELP model might not present the best interpretation of a high intensity short duration storm event that is typical of the project area. Especially since the evaluated area is in containment and any surface runoff would eventually report to the LCRS. Additionally the HELP model accounts for evaporation and evapotranspiration which would also provide less conservative results.*

Geosyntec agrees that runoff should not be accounted for in the HELP modeling. However, the pipe size does not need to be increased since the runoff will occur over the operations layer to the sump where it will permeate through the operations layer into the sump and therefore never travel in the piping. The current model presented in the RAP accounts for no evapotranspiration with a leaf area index set to 0. Evaporation in the model is set to 18 inches, which is considered conservative for the project area.

> *It should also be noted that according to the design report, the 25 year 24 hour storm event is anticipated to generate 2.3-inches of precipitation.*

The HELP modeling was evaluated over a 20 year period using a worst case condition of the first shovel full of waste having been placed in the lined area (HELP model was set up with no waste). The modeling resulted in a peak daily rain event of 1.83 inches. As the waste placement in the cells will occur over a short period of time (greater than 5,000 CY per day waste placement is anticipated), it is highly unlikely that the cell will be fully exposed to a rain event of this magnitude without having waste placement well underway.

Sump Capacity
A review of the sump capacity was performed.

> *Discussion*
>
> *Sump Volumes*
> *Regarding the peak daily flows for the sumps evaluated, it is unclear as to what values were used to calculate those volumes. ASW is requesting that the variables for the sump calculations be presented for clarification.*

The average daily values used in the sump sizing calculations were based on the average annual totals (average annual total/365 days/year). The following table presents the sump calculation values:

Location	Average Yearly Drainage Collected (cu. ft.)	Area (acre)	Annual Total (cu.ft.)	Average Daily Value (cu. ft.)	Sump
Unit 1	3244	3.34	10835.0	29.7	1
Unit 2	1817	5.98	10865.7	29.8	1
Unit 3	1655	10.9	18039.5	49.4	2
Unit 4	1818	11.9	21634.2	59.3	2
Unit 5	1770	13.3	23541.0	64.5	3
Unit A	14113	2.84	40080.9	109.8	1
Unit B	14115	3.15	44462.3	121.8	2

Therefore the totals for Sumps 1, 2, and 3 are as follows:

Sump 1 = 29.7 ft^3 + 29.8 ft^3 + 110 ft^3 = 169 ft^3

Sump 2 = 49.4 ft^3 + 59.3 ft^3 + 122 ft^3 = 231 ft^3

Sump 3 = 64.5 ft^3 = 65 ft^3

The three sumps have since been split into four sumps, with sump 2 now becoming two different sumps. This provides for a conservative sump sizing as sump 2 was used to calculate the size of all of the sumps in the calculation package. When runoff is included in these values, the sump designs are still conservative with the following values:

	Average Yearly Drainage Collected (cu. ft.)	Average Yearly Runoff Collected (cu. ft.)	Area (acre)	Annual Total (cu.ft.)	Average Daily Value (cu. ft.)	Sump
Unit 1	3244	19	3.34	10898.4	29.9	1
Unit 2	1817	17	5.98	10967.3	30.0	1
Unit 3	1655	13	10.9	18181.2	49.8	2
Unit 4	1818	16	11.9	21824.6	59.8	2
Unit 5	1770	15	13.3	23740.5	65.0	3
Unit A	14113	18	2.84	40132.0	110.0	1
Unit B	14115	19	3.15	44522.1	122.0	2

The totals for sumps 1, 2, and 3 with runoff included are 169 ft^3, 231 ft^3, and 65 ft^3, respectively.

Maximum Head on Liner System

The leachate storage calculation in the drainage layer allows for the leachate pool to extend approximately 50 feet from the sump while allowing a maximum head of 1 foot on the liner system. Therefore there will be a minimum of 2 feet of head on top of the liner system in the sumps. We do understand that a vadose zone monitoring system will be installed beneath the sumps. However, we recommend that the technical specifications outline the importance for the contractor to remove water from the sumps in a timely fashion minimize the head on the liner in and around the sump locations.

The operations manual and monitoring requirements should also emphasize this point.

Section 01500, Part 1.24.A.5 of the technical specifications requires the contractor to not allow the liquid level in the sump to exceed 3 feet (2 foot deep sump plus 1 foot depth over lined area adjacent to sump).

Sump Locations
It should also be noted that according to the construction drawings there will be a total of four sumps installed within the CAMU facility whereas the sump calculations considered three different sump locations.

The additional sump has divided two previous areas flowing into one sump. Since the sumps have all been sized the same to account for the largest amount of leachate collected, the new sump is conservatively large.

Vadose Zone Monitoring System
A review of the vadose monitoring system was performed.

According to the construction drawings sheet No. 36 of 45, Details-LCRS, details are not provided for the vadose zone monitoring pipe installation and associated components. It is not clear in the drawings whether there is secondary containment provided beneath the collection pipe. If a resistive barrier is intended beneath the vadose zone monitoring collection pipe then details should be provided.

The vadose zone monitoring sump is to be lined with 60 mil HDPE geomembrane.

Grading Plan
A review of the grading plan presented in the construction drawings was performed.

Discussion
The grading plan at the base of the landfill appears to be adequate based on the major design premise that there will be minimal leachate generation.

During construction and prior to completion of the final cover there is the potential for water to be collected at various portions of the facility and pool (e.g. the south side of Phase 1 prior to completion of Phase 2). It is our opinion that a design storm should be agreed on that will need to be accounted for during construction and during the

interim stage prior to completion of the final cover. After this storm is agreed on either;

1. *The Owner retains a firm to prepare a detailed storm water control plan that accounts for various stages of construction and details the approximate volume of water that could be generated within the landfill and how the water should be handled, or*
2. *A detailed specification and separate bid item be prepared and added to the contract that clearly defines the contractors responsibilities with respect to storm water control that includes at a minimum the items listed in 1 above.*

Section 01500 of the technical specifications requires the Contractor to prepare a Water Management plan describing methods of handling water in CAMU cells and other excavation areas.

Interim cover composed on non-contaminated material is specified to be placed over the waste in areas where storm water has the potential to wash landfilled material off of the lined area. Consideration should also be given to the potential for stormwater flows to concentrate at the haul roads and wash material off of the lined area.

Section 01500 of the technical specifications requires the Contractor to prepare a Water Management plan describing methods of handling water in CAMU cells and other excavation areas. Also, the Contractor is required to develop a storm water pollution prevent plan which will address concerns of stormwater flows over the haul roads and lined areas.

If you have any additional questions please feel free to contact us at (858) 674-6559

Sincerely,

Digitally signed by Greg Corcoran
DN: CN = Greg Corcoran, C = US, O = Geosyntec, OU = San Diego
Date: 2008.01.22 22:06:40 -08'00'

Rebecca Flynn, E.I.T.
Senior Staff Engineer

Gregory T. Corcoran, P.E.
Principal

Attachments: Revised Technical Specifications
Revised Geocomposite Equivalency Calculation Package

Copies to: Ranajit Sahu, C.E.M., Ph.D., Basic Remediation Company
Robert B. Valceschini, P.E., ASW

Geosyntec consultants

10875 Rancho Bernardo Road
Suite 200
San Diego, CA 92127

PH 858.674.6559
FAX 858.674.6586

www.geosyntec.com

29 January 2008

Mr. Brian Rakvica, P.E.
Nevada Division of Environmental Protection
Bureau of Corrective Actions
2030 E. Flamingo Road, Suite 230
Las Vegas, NV 89119

Subject: Response to Interim CAMU Design Review Report No. 3
BMI Industrial Complex Remediation Design Review
Henderson, Nevada
Geosyntec Project: SC0313

Dear Mr. Rakvica,

On behalf of Basic Remediation Company (BRC), Geosyntec Consultants (Geosyntec) hereby responds to the 22 January 2008 letter written by Applied Soil Water Technologies, LLC (ASW) to Nevada Department of Environmental Protection (NDEP) regarding the Interim CAMU Design Review. The ASW review focused on the following aspects of the CAMU design:

- Earthworks;
- Fills;
- Waste Placement Plan;
- Interim Cover Specifications;
- Technical Specifications;
- Construction Quality Assurance (CQA) Plan; and
- Design Drawings.

For ease of review, the ASW's discussion will be repeated in italics with Geosyntec's response following.

Earthworks, Fills
A review of the earthworks, pertaining to fill material, was performed.

Documents Reviewed
Technical Specifications for the BRC East Side Common Area Soils Remediation, Henderson, Nevada, October 2007

Discussion

Waste placement in the CAMU during construction is critical in supporting the overall design premise to minimize the production of leachate within the facility. This includes the placement of the 2-foot-thick operations layer overlain by the 4-foot-thick compacted contaminated material to be placed before the introduction of Silt Trench Contaminated material.

Operations Layer

According to the technical specifications, the operations layer will consist of Eastside Area or Western Ditch materials meeting the specification of Engineered fill. Additional placement specifications include minimum top surface grade, moisture conditioning, and compaction. The Eastside Geotech Sampling Report, dated 1 October 2007, prepared by GES for Basic Remediation Company, presents various soils material testing results of samples obtained during the field exploration. Moisture contents well above the laboratory determined optimum moisture, as determined by ASTM D1557, were reported for the Eastside Area soils. Therefore, the handling and processing of these soils in preparation of placement of the operations layer is a critical path item. The technical specifications do address these components in various sections of the specifications. Due to the critical nature of this facility component, it is our opinion that a summary be presented in a single location that outlines the critical path items associated with material selection, processing and placement of the operations layer.

Compacted Contaminated Material Overlying Operations Layer

Based on our review of the current version of the technical specifications, it is not clear how the compacted contaminated material will be placed. It is our understanding that an updated version of the specification, regarding the placement of 4-feet of waste material overlying the operations layer prior to placement of Slit Trench waste materials, will be provided by Geosyntec with the response to Interim Report #2.

Section 02205.3.11 of the Technical Specifications details soil-like material placement within the CAMU.

Slit Trench Backfill

According to the technical specifications Section 02200.3.08.B, Soil used for the Slit Trench Backfill shall be on-site materials meeting the requirements of Subpart 2.01, Slit Trench Backfill shall consist of "…earthen materials excavated from the slit trenches that are separated and earthen materials adjacent to the slit trenches." Section 02205.2.01.B states that the Slit Trench Cover Soil is to be composed of clean soil materials. ASW suggests that clarification be made in Section 02200 that the Slit Trench Backfill be clean or non-contaminated materials for consistency.

All impacted slit trench materials are to be excavated, to the maximum extent possible. Given that, NDEP agreed that the adjacent soils can be used as backfill within the slit trench excavation since the area was being capped by both the base liner and final cover systems of the CAMU. Therefore, the qualifier "clean" in Section 02200.3.08.B has been removed.

Waste (Material) Placement
A review of the material placement specifications for the CAMU was performed.

Documents Reviewed
Technical Specifications for the BRC East Side Common Area Soils Remediation, Henderson, Nevada, October 2007

Discussion
As previously noted, the placement of the various material components in the CAMU is critical to the overall design. The various material specifications regarding type, moisture conditioning and placement are provided within the technical specifications. However, due to the critical nature of these construction components we recommend that references be included, within the subpart 2.01 of Section 02205, that direct the reader to the critical components associated with waste material specifications.

As mentioned in other areas of this report, liner system separation distances, both side slope and base liner, are not clear. Clarification should be made, perhaps in the form of a table or figure.

A table has been added to clarify the issue of waste placement separation distances.

Interim Cover
A review of the interim cover specifications for the CAMU was performed.

Documents Reviewed
Technical Specifications for the BRC East Side Common Area Soils Remediation, Henderson, Nevada, October 2007

Discussion
Upon review of the Interim Cover specifications, provision should be provided for wind ballast for the standard 6 mil visqueen required to cover interim slopes between phases.

The following has been added to Section 02205.3.08.B: "The visqueen shall be nailed and/or sufficiently weighted to prevent wind uplift."

Section 02205.3.06.d specifies an interim cover placement compaction specification of 85% (minimum) of ASTM D1557 maximum dry density. Due to the fact that a minimum of 1-foot of interim cover is specified to be placed beneath the entire final cover, the designer should justify the adequacy of the lower than typical compaction requirement.

The compaction specification has been changed to 90%.

Technical Specifications
A review of the technical specifications was performed.

Documents Reviewed

Technical Specifications for the BRC East Side Common Area Soils Remediation, Henderson, Nevada, October 2007

Discussion
The following comments were made regarding certain sections of the technical specifications.

SECTION 01010 - SUMMARY OF WORK

1.02 A. *…final CAMU cover system and associated storm water management features will be held as Option Scope…*

Is this correct that the final cover may not be constructed under this contract?

This statement occurs in numerous sections in the Technical Specifications. Please clarify.

The final cover and associated storm water features will be held as option scope for this contract. A cover will be placed over the CAMU; however, a different contractor may be contracted to build it.

B.2.a. *Regarding placement of interim cover*
Listed as Option Scope; is this correct that placement of interim cover may not be a part of this contract? It is described as being placed at the end of each day of waste placement under certain circumstances. Please clarify.

Through addendums with bidders and subsequent revisions of the Technical Specifications and bid package, the interim cover is now a bid item with the base bid package. It will be measured by in-place cubic yards and will be the responsibility of the Contractor to place during waste placement.

SECTION 01050 - FIELD ENGINEERING

3.01 A. 9. *Consider destructive seam sample locations be incorporated on As-built drawings also.*

Each destructive seam sample will be repaired and as such documented on the as-built drawing.

SECTION 01500 - CONSTRUCTION FACILITIES

1.24 A. 5. *Monitor leachate levels within the sumps and at no time allow levels within sump to exceed 3 feet in depth*

Need to specify where the depth is measure from, i.e. the top of the geomembrane.

Section 01500.1.24.A.5 has been revised to state: "Monitor leachate levels within the sumps and at no time allow levels within sumps to exceed 3 feet in depth as measured from the top of the geomembrane."

SECTION 02200 - EARTHWORK

1.04 C. *Regarding; "…laboratory test data for cover soils demonstrating shear strength cohesion"*

Need to provide more detailed requirements, i.e. testing parameters and required values.

Section 02200.1.04.C has been revised to include "Shear strength tests shall be conducted at 90% maximum dry density."

Required shear strength values are not necessary because they will not be criteria for acceptance or rejection of cover soil materials. It is for informational purposes to be included with the CQA report.

2.01 B. *Regarding remolded shear strength requirements;*

Need to provide test method, normal loads, saturated conditions if applicable and frequency.

Section 02200.2.01.B has been revised to state "Cover soil shall have a remolded minimum shear strength of 32 degrees and 500 psf cohesion at 90% compaction, based on Modified Proctor, at optimum moisture content, as measured by ASTM D3080."

Please note that suggested changes are provided below and can be identified by the underlining.

3.06 B. *Stockpiles shall be sealed by tracking ~~parallel~~ <u>perpendicular?</u> to slope…Please clarify.*

Section 02200.3.06.B has been revised to state "Stockpiles shall be sealed by tracking parallel with the direction of the slope".

3.08 E. *compaction specification should have moisture specification as well as density*

Section 02200.3.08.E. has been revised to state "the Contractor shall compact each lift to at least 90 percent of its modified Proctor maximum dry density (ASTM D 1557) at a moisture content between -4% and +4% of the optimum moisture content for the soil.

3.10 A. *place only when ... <u>and approved by construction manager</u>*

Section 02200.3.10.A has been revised to include the suggested change.

D. *This seems to indicate that only the top of the top lift will be compacted. Is this correct? Please clarify.*

Section 02200.3.10.D. has been revised to state "the Contractor shall compact each lift of final cover soil to at least 90 percent of its modified Proctor maximum dry density (ASTM D 1557) at a moisture content between -4% and +4% of the optimum moisture content for the soil.

SECTION 02205 - REMEDIAL EXCAVATING AND FILLING

2.01 ***F.*** *Interim slopes between phases shall be covered with standard 6 mil visqueen*

ASW Comment: May want to require wind ballast.

The following has been added to Section 02205.3.08.B: "The visqueen shall be nailed and/or sufficiently weighted to prevent wind uplift."

Interim slopes shall be covered prior to forecasted precipitation events.

ASW Comment: May want to specify with what.

Section 02205.3.08.B states: "Visqueen shall be placed when precipitation is forecasted."

3.07 ***A.*** *place only when...<u>and approved by construction manager</u>*

Section 02205.3.07.A has been revised to include the recommended change.

L. *"…maintain less than 3 feet of fluid levels in the leachate collection system sump."*

ASW Comment: Need to specify where the depth is measure from, i.e. the top of the geomembrane.

Section 02205.3.11.L has been revised to state: "…maintain less than 3 feet of fluid levels in the leachate collection system sump as measured from the top of the geomembrane."

M. 3. *Specifies "…4-foot thick layer of compacted contaminated material must be placed across the CAMU bottom ahead of the working face of Slit Trench contaminated material …"*

Does the 2-feet of Operations layer count as part of the 4-feet?
What is the minimum set-back from the side slopes?

Section 02205.3.11.M has been revised to state: "A minimum of a 150-foot-wide, 4-foot-thick layer of compacted contaminated material above the 2-foot thick operations layer, for a total of 6-feet of compacted contaminated material must be placed across the CAMU bottom ahead of the working face of Slit Trench contaminated material subsequently placed in the CAMU."

Section 02205.3.11.Q.a states: "All materials placed from the outer extent (CAMU side) of the operational protective layer to a point 15 feet (measured laterally) from the CAMU liner or final cover system shall have a maximum particle size of 6 inches. No other debris or oversized material with particle dimensions greater than 6 inches may be placed within this zone."

O. 1. b. *Is there a minimum distance from bottom?*

Section 02205.3.11.M has been revised to state: "A minimum of a 150-foot-wide, 4-foot-thick layer of compacted contaminated material above the 2-foot thick operations layer, for a total of 6-feet of compacted contaminated material must be placed across the CAMU bottom ahead of the working face of Slit Trench contaminated material subsequently placed in the CAMU."

Q. 1. a. *Is there a minimum distance from bottom?*

Section 02205.3.11.M has been revised to state: "A minimum of a 150-foot-wide, 4-foot-thick layer of compacted contaminated material above the 2-foot thick operations layer, for a total of 6-feet of compacted contaminated material must be placed across the CAMU bottom ahead of the working face of Slit Trench contaminated material subsequently placed in the CAMU."

3.10 D. 1. *Regarding the requirement for One-Dimensional Consolidation Testing;*

Will these results be used for informational purposes only or is there a criteria associated with these results that the contractor will be held accountable for? How should the results be presented? What is the maximum load that the test will need to accommodate?

One-dimensional consolidation testing results will be reported in the Construction Quality Assurance (CQA) report provided to NDEP. The consolidation testing will be used to determine leachate generation and the contractor will not be held accountable for the testing results. The CQA plan states that "Normal stress for test shall be equivalent to final depth of sample (based on final cover system topography) multiplied by unit weight of overlying waste and cover system materials."

SECTION 02225 - DRAINAGE AGGREGATE

3.02 A. *Place when...<u>and approved by construction manager.</u>*

Section 02225.3.02.A has been revised to include the suggested change.

SECTION 02770 - GEOMEMBRANE

1.04 B. 3. a. *minimum experience with geomembrane requirement seems low*

Experience has been increased to 5,000,000 SF.

b. *minimum experience with geomembrane requirement low*

Experience is comparable to industry standard (based on GSE Field Installation Quality Assurance Manual).

1.06 E. 2. *Regarding subgrade acceptance;*

This section conflicts with 3.02 A. Since the geomembrane will be installed on a GCL, the subgrade acceptance criteria and procedures may be more appropriate in the GCL section.

The submittal requirement in Section 02770.1.06.E.2 has been moved to Section 02772.1.05. The subgrade acceptance statement in Section 02770.3.02.A has been deleted and Section 02772.3.02.A states: "The Geosynthetics Installer shall provide certification in writing that the surface on which the GCL shall be installed is acceptable. This certification of acceptance shall be given to the Construction Manager prior to commencement of GCL installation in the area under consideration."

2.02 A. 7. *Need to add more detail on sampling adjacent rolls, etc.*

Section 02770.2.02.A.7 shall be revised to state: "If a geomembrane sample fails to meet the quality control requirements of this Section the Geomembrane Manufacturer shall sample and test, at the expense of the Manufacturer, rolls manufactured in the same lot, or at the same time, as the failing roll. Sampling and testing of rolls shall continue until a pattern of acceptable test results is established to bound the failed roll(s)."

3.02 A. *This appears to conflict with 1.06 E. 2., See comments on that section above.*

The subgrade acceptance statement in Section 02770.3.02.A has been deleted and Section 02772.3.02.A states: "The Geosynthetics Installer shall provide certification in writing that the surface on which the GCL shall be installed is acceptable. This certification of acceptance shall be given to the Construction Manager prior to commencement of GCL installation in the area under consideration."

3.03 G. 3. b. *should also have a means of measuring and monitoring roller pressure.*

Fusion welders do not typically provide a means to measure roller pressure, rather the welder pressure is set when the rollers are engaged on the geomembrane when initiating the welding process. As this varies from fusion welder to fusion welder, it is difficult to require a means of measuring the roller pressure. As such we typically do not require the monitoring of the roller pressure.

H. 2. *ASTM D 4437; Is this the correct test method?*

The new test method is ASTM D 6392, which replaces ASTM D 4437 for high density polyethylene geomembrane seams.

Record welder temperature, speed, & pressure and make sure settings are the same during production welding.

As previously discussed, roller pressure is a difficult setting to measure. Therefore, we do not typically document roller pressure.

J. 4. a. *ASTM D 4437; Is this the correct method?*

The new test method is ASTM D 6392, which replaces ASTM D 4437 for high density polyethylene geomembrane seams.

3.06 A. *Allow for sampling at manufacturing location?*

At the end of Section 02770.3.06.A, the following has been added: "Conformance sampling may be conducted at the manufacturing facility shipment to the site."

SECTION 02771 - GEOTEXTILE

2.02 D. *Need similar statement in the related geomembrane section?*

Section 02770.2.02.A.7 shall be revised to state: "If a geotextile sample fails to meet the quality control requirements of this Section the Manufacturer shall sample and test, at the expense of the Manufacturer, rolls manufactured in the same lot, or at the same time, as the failing roll. Sampling and testing of rolls shall continue until a pattern of acceptable test results is established to bound the failed roll(s)."

SECTION 02772 - GEOSYNTHETIC CLAY LINER

2.01 ***A.*** *Addressed in previous report.*
G. *Addressed in previous report.*

2.02 *Regarding Interface Friction Testing*

Additional comments may be provided as part of the ASW review of the Final Cover requirements.

Please explain how this section matches Final Waste Slope Stability Calculations?

Section 02772.2.02.A.1: This represents the veneer stability of final soil lined slopes calculation. The calculation was performed based on an assumed weakest peak interface strength angle of 20 degrees between the textured HDPE geomembrane and hydrated GCL.

Section 02772.2.02.A.2: This represents the global stability of the base liner system. The slope stability calculation was performed based on a weakest interface strength of 12 degrees between the textured HDPE geomembrane and hydrated GCL.

Section 02772.2.02.A.3: This represents the global stability of the base liner system when a GCL with a vapor barrier is used.

3.02 A. *"...prior to commencement of ~~geomembrane~~ GCL? installation..."*

Section 02772.3.02.A has been revised to state: "The Geosynthetics Installer shall provide certification in writing that the surface on which the GCL shall be installed is acceptable. This certification of acceptance shall be given to the Construction Manager prior to commencement of GCL installation in the area under consideration."

3.10 *Consider provision to allow sampling at point of manufacture.*

Section 02772.3.10.A, the following has been added: "Conformance sampling may be conducted at the manufacturing facility shipment to the site."

Provide detailed procedures in the event of a failure.

Section 02772.3.10.C shall be revised to state: "If a GCL sample fails to meet the quality control requirements of this Section the GCL Manufacturer shall sample and test, at the expense of the Manufacturer, rolls manufactured in the same lot, or at the same time, as the failing roll. Sampling and testing of rolls shall continue until a pattern of acceptable test results is established to bound the failed roll(s)."

3.11 *Should address protection against rain on both exposed and covered GCL.*

Section 02772.3.11.C has been included and states: "Contractor shall be responsible for protecting GCL from hydration from precipitation, dust spraying activities, or any other activities which could lead to GCL hydration."

SECTION 02773 - GEOCOMPOSITE

3.02 C. *"...inspect and verify geomembrane surface below geocomposite is free of loose soil and rocks greater than 1 inch."*

In our opinion 1 inch is too large of a particle size to be in contact with the geomembrane. Please discuss.

Section 02773.3.02.C has been revised to state states: "...inspect and verify geomembrane surface below geocomposite is free of loose soil and rock."

H. *Consider specifying a maximum particle size for the sandbag fill material.*

Section 02770.3.02.D.5.g. has been revised to include "Sand bags shall be filled with sand material with a maximum particle size of ½ inch."

3.06 *Consider provision for sampling at point of manufacture*

Section 02773.3.06.A the following has been added: "Conformance sampling may be conducted at the manufacturing facility shipment to the site."

D. *Provide detail on what to do if sample fails.*

Section 02773.3.06.D shall be revised to state: "If a geocomposite sample fails to meet the quality control requirements of this Section the Manufacturer shall sample and test, at the expense of the Manufacturer, rolls manufactured in the same lot, or at the same time, as the failing roll. Sampling and testing of rolls shall continue until a pattern of acceptable test results is established to bound the failed roll(s)."

Construction Quality Assurance Plan
A review of the CQA plan was performed.

Documents Reviewed
Construction Quality Assurance Plan for the Construction of the Corrective Action Management Unit (CAMU), Basic Remediation Company, Henderson, Nevada, October 2007

Discussion
The following comments were made regarding certain sections of the CQA plan.

4.2.1 *CQA Officer should be a licensed engineer in Nevada and be required to stamp the CQA report.*

The following statement has been added to Section 4.2.1: "The CQA Officer shall be a licensed engineer in the State of Nevada and shall stamp the final CQA report."

6.6 *In places where the CQA Report is referenced may want to consider changing "…in compliance with…" to "… in substantial compliance with…".*

Document will be changed as suggested.

7.2 *"The CQA Laboratory will perform the conformance testing and CQC testing." Confusing to mix CQA and CQC.*

The section will be revised and the "… and CQC testing." will be removed.

Are hydrometer tests necessary as part of the CQA program? These could become a major undertaking and slow construction. They are not clearly specified in the Technical Specifications and we are not clear as to where the hydrometer results can be used as an acceptance or rejection criteria. The designer should clarify.

Hydrometer testing will be removed.

7.3.4 *Should also monitor for wrinkles and trampolining of the geomembrane.*

Section 7.3.4 has been revised to include that the CQA Site Manager will document that "…placement of the overlying materials does not damage, create large wrinkles, or induce excessive tensile stress in the underlying geosynthetic materials."

7.3.5 *Should also monitor for adequate separation of different waste materials from the liner system.*

Section 7.3.5 has been revised to include "…monitor the distance between slit trench wastes and debris and the both the base and side slope liner system…"

7.4.2 *Add procedures for delineating the extent of the failed area.*

Section 7.4.2 has been revised to include "Additional tests shall be taken at half the distance to the next passing test. If the retest has failed, half the distance from the retest to the passing test shall be tested, and continue until the test passes. If a test passes, half the distance from the passing retest to the failed test shall be considered failed."

8.3.1 *Monitoring that the construction activities do not cause damage to underlying geosynthetic materials <u>and leachate collection pipes</u>.*
Should also monitor for wrinkles and trampolining of the geomembrane.

Section 8.3.1 has been revised to include that the CQA Site Manager will document that "…placement of the overlying materials does not damage, create large wrinkles, or induce excessive tensile stress in the underlying geosynthetic materials and leachate collection pipes."

10.2.3 *Consider making provision for sampling at point of manufacture.*

Section 10.2.3 has been revised to state: "CQA personnel will sample the geocomposite either during production at the manufacturing facility or after delivery to the construction site."

There are no detailed procedures to follow in the specifications in the event of a failing conformance sample as reference in the CQA Plan.

The following procedures are outlined in the Technical Specifications:

02770.3.06.F. - Any geomembrane that is not certified in accordance with Part 1.07.C of this Section, or that conformance testing indicates do not comply with Part 2.02 of this Section, shall be rejected. The Geosynthetic Installer shall replace the rejected material with new material.

02772.3.10.E. - Any GCL that is not certified by the Manufacturer in accordance with Part 1.05 of this section or that does not meet the requirements specified in Part 2.01 shall be rejected and replaced by the Geosynthetic Installer.

02773.3.06.E. - Any geocomposite that is not certified by the Manufacturer in accordance with Part 1.05 of this section or that does not meet the requirements specified in Part 2.01 shall be rejected and replaced by the Geosynthetic Installer.

We have had problems in the past with minor scratches in the conformance test specimens having a major impact on the tensile break strength and elongation values. This is especially prevalent when the conformance samples are obtained in the field. Consideration should be given to the possibility of tensile at break criteria failures due to scratches and not material defects.

Conformance samples will be collected in the manufacturing facility. In addition, the geomembrane is textured, making it less susceptible to scratch induced failures.

10.4.2.1 *The geomembrane is being deployed on GCL. It may be better to put the detailed sub-grade acceptance procedures in the GCL section.*

Section 10.4.2 has been excluded. Section 10.4.2.1 has been moved and included as Section 12.7 with the exception of the statement "…placement of the overlying materials does not damage, create large wrinkles, or induce excessive tensile stress in the underlying geosynthetic materials" which has been moved to Section 7.3.4.

10.4.3.2 *Should consider protecting both the sub-grade and GCL from rain damage.*

Rain protection is the responsibility of the Contractor. The CQA Monitors will document subgrade and GCL conditions during installation.

10.4.4.3 *Seaming apparatus pressures need to be incorporated into the Technical Specifications.*

Document that production welding setting are consistent with settings used during trial seams.

Section 10.4.4.3 is revised to include "… production welding settings are consistent with settings used during trial seams."

10.4.4.7 *For trial fusion welds, test both tracks in peel?*

As required in ASTM D 6392, each external seam will be peel tested.

10.4.4.9 *Resolution of pressure gauge should be specified.*

None required.

10.4.4.10 *Make Field Testing section consistent with specifications which tests one strip on each side before testing the destructive sample.*

Contractor is responsible for cutting destructive sample for CQA testing and will therefore dictate sample collection upon completion of "bone" testing on each side of the destructive location.

CQA Laboratory Testing section should specify that samples will be shipped the same day with next day delivery, depending on delivery schedule of selected vendor

Section 10.4.4.10 is revised to state "Destructive test samples will be packaged and shipped same day with next day delivery, if necessary, under the responsibility of the CQA Site Manager in a manner that will not damage the test sample."

10.4.5.3 *define "large holes" and "small tears"*

The Section has been revised to define small holes as <1/8 inch and small tears as <1/2 inch.

10.4.6 *Geosynthetic liner system not accepted until CQA report and as-built drawings received by Construction Manager—will this delay deployment of cover composite?*

NDEP requires that a CQA Report be submitted prior to allowing waste placement. In order to fulfill this requirement, BRC proposes to submit a letter upon completion of the liner system to satisfy this requirement and not impair the construction schedule or product quality.

12.2 *for "minimum average roll value" properties, use definition that is consistent with Technical Specifications.*

The CQA Plan will be revised to include minimum average roll value defined in accordance with Federal Highway Administration.

12.5.1 *incorporate provision to sample GCL during production at the manufacturing facility into the Technical Specifications.*

Section 02772.3.10.A has been revised.

12.7 *Consider taking Section 10.4.2.1 regarding subgrade acceptance from the Geomembrane Section and incorporating it here.*

Section 10.4.2.1 has been moved and included as Section 12.7 with the exception of the statement "…placement of the overlying materials does not damage, create large wrinkles, or induce excessive tensile stress in the underlying geosynthetic materials" which has been moved to Section 7.3.4.

13.5.4 *"...remove conformance samples for testing by the CQA Laboratory from the closest numerical rolls on both sides of the failed roll"—incorporate these procedures for a failed conformance sample into the Technical Specifications.*

Technical Specifications have been revised with similar language as discussed above.

13.6 *need to add paragraph regarding presence of soil and oversize particles on geomembrane.*

Section 13.6 has been revised to include the statement: "Prior to geocomposite installation, a visual examination of the geomembrane will be performed and documented.

13.7 *make minimum overlap consistent with specifications*

Section 13.7 has been revised to state: "The geonet components shall be overlapped a minimum of 4-inches along the length and a minimum of 12-inches along the width."

13.9 *make equipment requirements and maximum loads consistent with specifications*

Section 13.9 has been revised.

Design Drawings
Comments have been made to the design drawing in previous reports.

Documents Reviewed
Drawings titled, FINAL DESIGN, Basic Remediation Company, CORRECTIVE ACTION MANAGEMENT UNIT, CONTROL SYSTEMS DESIGN, HENDERSON, NEVADA, OCTOBER 2007, prepared by Geosyntec Consultants.

Discussion

Our review is essentially complete with the following comment,

> *The material to be used to backfill the leachate collection sump should be specified in the details.*

The drawing will be revised to include the drainage aggregate specified on the leachate collection sump details.

If you have any additional questions please feel free to contact us at (858) 674-6559

Sincerely,

Digitally signed by Greg Corcoran
DN: CN = Greg Corcoran, C = US, O = Geosyntec, OU = San Diego
Date: 2008.01.29 20:33:27 - 08'00'

Rebecca Flynn, E.I.T.
Senior Staff Engineer

Gregory T. Corcoran, P.E.
Principal

Attachments: Revised Technical Specifications
Revised Construction Quality Assurance Plan

Copies to: Ranajit Sahu, C.E.M., Ph.D., Basic Remediation Company
Robert B. Valceschini, P.E., ASW

Geosyntec consultants

10875 Rancho Bernardo Road
Suite 200
San Diego, CA 92127

PH 858.674.6559
FAX 858.674.6586

www.geosyntec.com

22 February 2008

Mr. Brian Rakvica, P.E.
Supervisor, Special Projects Branch
Nevada Division of Environmental Protection
Bureau of Corrective Actions
2030 E. Flamingo Road, Suite 230
Las Vegas, NV 89119

Subject: Geosyntec Response to ASW Comments on Response to Interim CAMU Design Review Report #1, #2, and #3
BMI Industrial Complex Remediation Design Review
Applied Soil Water Technologies, LLC Proj. No. 039-001
Geosyntec Project: SC0313

Dear Mr. Rakvica,

On behalf of Basic Remediation Company (BRC), Geosyntec Consultants (Geosyntec) hereby responds to the 1 and 7 February 2008 letters written by Applied Soil Water Technologies, LLC (ASW) to Nevada Department of Environmental Protection (NDEP) regarding the Interim CAMU Design Review. In addition, this letter responds to the 12 February 2008 email prepared by Mr. Brian Rakvica of NDEP. The ASW review focused on Geosyntec's response to the Interim Design Review Report #1, #2, and #3 dated 8, 23, and 29 January 2008, respectively, and the final cover liner system design review.

For ease of review, ASW's discussion will be repeated in italics with Geosyntec's response following. Review Report #1 comments and responses are as follows:

Design Standard/Basis of Design – Discussion
GCL Hydraulic Conductivity and Time for Break-Through and Attenuation

ASW is in agreement with the response provided. Both of these design considerations are reliant on the major design premise of minimizing the potential for leachate generation. Therefore, it is critical that moisture within the placed waste material and stormwater during construction activities be managed in strict accordance with the project's Technical Specifications for the duration of the project.

<u>Consistency with the Technical Specifications</u>

Geosyntec's response states that, "A flux rate of $1x10^{-8}$ m^3/m^2-sec and a hydraulic conductivity $5x10^{-9}$ cm/sec are generally equivalent at an effective confining stress of 5 psi."

ASW requests that a reference or other justification be provided which presents the calculation used to derive the conversion.

The attached CETCO Bentomat ST certified properties sheet notes for GCL index flux and GCL hydraulic conductivity indicates the following (Attachment A):
"ASTM D5887 Index flux and hydraulic conductivity testing with deaired distilled/deionized water at 80 psi (551 kPa) cell pressure, 77 psi (531 kPa) headwater pressure and 75 psi (517 kPa) tailwater pressure. Reported value is equivalent to 92 gal/acre/day. This flux value is equivalent to a permeability of 5×10^{-10} cm/sec for typical GCL thickness."

Geosyntec referenced Koerner and Daniel (1993) indicating that "…bentonite layer is typically 7 to 10mm thick…" It is further indicated that "this thickness range, 0.27 to 0.39 inches, is higher than the value of 0.2 inches used in the calculation, which results in a conservative evaluation of the GCL equivalency."

ASW is in agreement with the conservative evaluation. However, we recommend that the design engineer specify a minimum thickness in the project's Technical Specifications consistent with the equivalency evaluation. Based on the response it does not appear that it will be a problem for manufacturers to meet the minimum thickness requirement.

In the 18 February 2008 conference call between ASW, Geosyntec, and BRC, all parties agreed the mass per unit area testing, performed in accordance with ASTM D 5993, specified at a frequency of one per 100,000 square feet is sufficient for demonstrating the equivalency evaluation.

Geosyntec stated that, "The seaming requirement described in the Specifications states that GCL shall be seamed with Manufacturer's recommended procedures. The Manufacturer's typical seaming recommendations include bentonite-enhanced seams with a bentonite application rate of one quarter pound per lineal foot."

ASW recommends that a minimum standard be specified in the project's Technical Specifications rather than relying on a yet-to-be-determined-Manufacturer's procedures.

The following statement has been added to Section 02772.3.06.of the Technical Specifications (Attachment B):

C. GCL shall be seamed, at a minimum, as follows:

1. CETCO Super Groove and GSE Gundseal products: No bentonite required.
2. All others: bentonite application rate of one quarter pound per linear foot.

<u>High Density Polyethylene (HDPE) Chemical Compatibility / Waste Placement Phasing</u>

Geosyntec's response states that, "In accordance with Section 02205, Part 3.09.M, a minimum of 6 feet (2 feet of operations layer soil and 4 feet of contaminated soils) shall be placed prior to placement of Slit Trench waste material. This requirement, coupled with the dry nature of the waste material placed in the CAMU, will limit the potential for high concentrations of chemicals from contacting the geosynthetic liner system components. Also, the nature of the slit trench waste is typically not at concentrations that are representative of pure chemical and are not representative of typical chemical compatibility testing solutions."

Geosyntec also stated that, "The concentrations of chemicals within the East Side Area and Western Ditch Material Soils are not great enough to cause compatibility issues with the HDPE geomembrane. In addition the dry nature of the soil when placed will limit the contact of chemicals with the liner system components…"

ASW recommends that, at a minimum, concentration thresholds of chemical constituents anticipated to be encountered during the project that could potentially adversely affect the performance of the HDPE geomembrane be determined. Areas with sample results that exceed these values could be handled accordingly.

Section 02205.3.10 of the Technical Specifications describes waste handling procedures for all debris, hazardous and non-hazardous, to be disposed in the CAMU. While mixing and blending of materials will occur based on the nature of the excavation and disposal process, additional mixing will be required if a large mass of suspected hazardous material is encountered. Currently, the Specifications define hazardous and suspected hazardous material based on visual observation and they require the Construction Manager to be present if the material is encountered. Therefore, the Construction Manager will ultimately decide if additional blending of the material is necessary.

<u>Veneer Stability of Geosynthetic-Saturated Soil Lined Sideslopes, Cover Liner System</u>

ASW preformed a review of the stability analysis as presented by Geosyntec Consultants dated January 8, 2008. The analysis utilized an approach outlined in Koerner, R. K. and Soong, T.Y., (1998), "Analysis and Design of Veneer Cover Soils", Proceedings of the Sixth International Conference on Geosynthetics, Atlanta, Georgia, Vol. I, 1998.

In summary of the Geosyntec analysis, "The calculations suggest that a minimum geosynthetic interface friction angle of 20 degrees is required to prevent the development of tension in the geosynthetic components of the side slope liner final cover system. A review of the literature indicates that a friction angle of 20 degrees is obtainable. The critical interface is likely the internal friction angle of the GCL."

ASW verified the veneer calculations by performing an analysis as outlined in Koerner, R.M. and Soong, T. Y., (2005), "Analysis and design of veneer cover soils", Geosynthetics

International, Special Issue on the Giroud Lectures, 12 No. 1, 28-49, 2005. The primary difference between this method and the method utilized in the Geosyntec analysis is that this method considers porewater pressures due to water accumulating at the toe of the slope and seepage forces due to flow parallel to the slope.

In summary, utilizing the same input values used in the Geosyntec analysis it was determined that the factor of safety becomes less than one when toe saturation reaches an approximate height of 17-feet within the cover liner system. Considering adequate toe drainage and the anticipated material properties for the final cover system, this condition is unlikely to occur.

ASW recommends that Geosyntec verify the calculations that consider water accumulation at the toe and/or seepage forces for inclusion in the final design.

As mentioned in a previous report, verification of interface friction assumptions of the final cover liner system using soils and materials that will be incorporated into the constructed product is critical.

During the 18 February 2008 conference call between ASW, Geosyntec, and BRC, all parties agreed that the veneer stability evaluation performed is sufficient.

Review Report #2 comments and responses are as follows:

Geotextile Separation/Filtration Review

Geosyntec's response states that, "The retention portion of the filtration calculation was conservatively based on non-dispersive clay soil, which is not indicative of soils found on site, while the permittivity portion of the calculation was conservatively based on higher hydraulic conductivity soil." …" the assumptions in the calculation are sufficiently conservative to allow for finer grained materials to be used as operations layer."

ASW agrees that if a more conservative soil was considered for the analysis then the anticipated site soils should meet the design intent for this design component. However, ASW recommends that consideration be made regarding the hydraulic conductivity of the operations layer in the general vicinity of the sumps. This item is discussed in further detail in subsequent sections.

Geosyntec's response states that regarding the operations layer, "…we do not believe that hydraulic conductivity testing during construction is warranted."

As presented herein, ASW recommends that the design engineer consider the material properties of the operations layer soils in the general vicinity of the facility sumps. If the design engineer determines that further consideration be made to these soil material properties, ASW would suggest at a minimum performing hydraulic conductivity testing for these soils.

Hydraulic conductivity is unnecessary because water will either report to the sumps or, more likely, pond above the operations layer. Stormwater collected in the sump or ponded on the operations layer will be removed and used for dust control or disposed as outlined in the Technical Specifications (Attachment B).

Degree of Survivability
We agree with the using "moderate survivability" for the geotextile overlying the geocomposite in the base liner system. However, the placement specification for the operations layer was changed from a minimum compaction specification to a performance specification utilizing a D6 dozer. The specification should be more specific as to the model of D6 that is acceptable (e.g. D6N LGP) due to the fact that the pressures applied by some models of D6 exceed the maximum ground pressure criteria for moderate survivability presented in Koerner.

The attached puncture calculation demonstrates the 6 oz/yd^2 geotextile can withstand ground pressure of greater than 10 psi, which is a higher ground pressure than a standard Caterpillar D6 dozer (Attachment C).

<u>Geocomposite Equivalency Review</u>

Geosyntec's response states, "…The factor of safety for chemical clogging was selected to be 1.0 based on the waste material characterized in the RAP. The waste material will be blended and dried so they are placed at below optimum moisture content, minimizing the generation of leachate and therefore limit the mobilization of soluble materials that could precipitate out of solution in the geocomposite."

According to the design specifications regarding material placement in the CAMU, the waste material is to be moisture conditioned to at or less than optimum moisture content. In the event that one or more significant storm events occur during construction activities, following the placement of the operations layer and prior to the placement of the overlying compacted waste, it is likely that the operations layer will remain at the soils field capacity. Considering that the operations layer soils are contaminated soils and that potential stormwater introduced to the operations layer during construction activities will have likely contacted waste, and also be contaminated, it is ASW's opinion that the factor of safety for chemical clogging should be greater than 1.0.

The calculation package has been revised to account for chemical clogging by increasing the factor of safety for chemical clogging from 1.0 to 1.5. With the increased chemical clogging factor of safety, the required transmissivity has been increased from 6.1×10^{-5} cm/sec to 9.2×10^{-5} cm/sec(Attachment D). The technical specifications have been updated accordingly (Attachment B).

<u>HELP Model Results</u>

Geosyntec's report states that,"…runoff will occur over the operations layer to the sump where it will permeate through the operations layer into the sump and therefore never travel in the piping. …Evaporation in the model is set to 18 inches, which is considered conservative for the project area."

It is ASW's opinion that there is the potential that storm water runoff that reports to the sump areas will not be able to permeate through operations layer fast enough to prevent excessive pooling in the event of a major storm event.

Geosyntec's response also states, "…it is highly unlikely that the cell will be fully exposed to a rain event of this magnitude without having waste placement well underway."

It is ASW's understanding that the design premise is based on the fact that the waste material will be moisture conditioned and compacted in order to minimize the potential for meteoric water to infiltrate into the waste thereby minimizing the potential for long-term leachate generation. Therefore, it should be expected that a very large percentage of storm water introduced to the facility during construction activities will eventually report to the sumps or other low lying areas and will need to be managed by the contractor.

Hydraulic conductivity is unnecessary because water will either report to the sumps or, more likely, pond above the operations layer. Stormwater collected in the sump or ponded on the operations layer will be removed and used for dust control or disposed as outlined in the Technical Specifications (Attachment B).

<u>Sump Capacity</u>

Geosyntec's response states that sump capacities were designed based on average annual total HELP model results that were used to calculate average daily values. Therefore, peak daily events were not considered when sizing the sumps. The HELP reported a peak daily rain event of 1.83-inches.

The totals for Sumps 1,2 and 3 based on average annual data are as follows:
Sump 1 = 169 ft^3
Sump 2 = 231 ft^3
Sump 3 = 65 ft^3

According to the Geosyntec response regarding the HELP model results, runoff will occur over the operations layer to the sump where it will permeate through the operations layer into the sump. Therefore consideration should be given to peak daily events. As mentioned above there is the potential for a large percentage of a storm event to report to the sumps during construction. ASW recommends that the design engineer consider the potential for managing these volumes of water to avoid a release from containment.

We give caution in using the peak daily values reported by the HELP model directly for this evaluation. For some reason the model allocated approximately 40-percent of the total peak

precipitation to Snow Water. This should not have an impact on the sizing of the collection pipes due to the fact they had much more capacity then needed; however, the design engineer may want to review the results.

Please see above response for stormwater management. In addition, the Contractor is required to submit a storm water management plan to be approved by the Construction Manager. The storm water management plan will outline what measures the Contractor will take to minimize leachate generation and respond to storm events.

Vadose Zone Monitoring System

Geosyntec's response states that, "The vadose zone monitoring sump is to be lined with 60 mil HDPE geomembrane."

ASW recommends that details associated with vadose zone monitoring system's liner should be included in the Construction Drawings (e.g. type, termination, anchorage etc).

Detail 12 of the Construction Drawings will be modified to show the vadose zone monitoring sump material types, limits, and dimensions.

Grading Plan

According to Geosyntec's response, the technical specifications require the Contractor to prepare a Water Management plan. Specifically it was stated in the discussion regarding maximum head on the liner system, that the specifications requires the contractor to not allow the liquid level in the sump to exceed 3 feet.

Considering that the major design premise is to manage water during construction such that there will be minimal potential to generation leachate. It is ASW's opinion that there should be more upfront engineering to manage water during construction and less reliance on the contactor.

The current Technical Specifications require the Contractor to submit a storm water management plan to be approved by the Construction Manager. This plan will detail steps the Contractor will implement prior to, during, and after a storm event to handle water.

Operation Layer General Comment

When the specification was changed the moisture content at placement specification was deleted. The moisture content at placement needs to be specified.

Section 02205.3.08.D of the Technical Specifications has been updated to include the following statement: "Moisture content shall be less than or equal to optimum."

Review report responses #3

Slit Trench Backfill

According to the technical specifications Section 02200.3.08.B, Soil used for the Slit Trench Backfill shall be on-site materials meeting the requirements of Subpart 2.01, Slit Trench Backfill shall consist of "...earthen materials excavated from the slit trenches that are separated and earthen materials adjacent to the slit trenches." Section 02205.2.01.B states that the Slit Trench Cover Soil is to be composed of clean soil materials. ASW suggests that clarification be made in Section 02200 that the Slit Trench Backfill be clean or non-contaminated materials for consistency.

All impacted slit trench materials are to be excavated, to the maximum extent possible. Given that, NDEP agreed that the adjacent soils can be used as backfill within the slit trench excavation since the area was being capped by both the base liner and final cover systems of the CAMU.

Based on the 18 February 2008 conference call, a clarification of adjacent materials is requested for slit trench backfill materials.

Adjacent materials specified for slit trench backfill include excavated surface material from CAMU Cells IV and V and non-contaminated materials from grading of slit trench sides (dictated by OSHA slope set-back requirements).

If you have any additional questions please feel free to contact us at (858) 674-6559

Sincerely,

Rebecca Flynn, E.I.T.
Senior Staff Engineer

Gregory T. Corcoran, P.E.
Principal

Attachment A:	CETCO Bentomat ST Certified Properties Sheet
Attachment B:	Revised Technical Specifications
Attachment C:	6 oz/yd^2 Puncture Protection Calculation
Attachment D:	Revised Geocomposite Equivalency Calculation

Copies to: Ranajit Sahu, C.E.M., Ph.D., Basic Remediation Company
Robert B. Valceschini, P.E., ASW

ATTACHMENT A
CETCO Bentomat ST Certified Properties Sheet

BENTOMAT® ST CERTIFIED PROPERTIES

MATERIAL PROPERTY	TEST METHOD	TEST FREQUENCY $ft^2(m^2)$	REQUIRED VALUES
Bentonite Swell Index[1]	ASTM D 5890	1 per 50 tonnes	24 ml/2g min.
Bentonite Fluid Loss[1]	ASTM D 5891	1 per 50 tonnes	18 ml max.
Bentonite Mass/Area[2]	ASTM D 5993	40,000 ft^2 (4,000 m^2)	0.75 lb/ft^2 (3.6 kg/m^2) min
GCL Grab Strength[3]	ASTM D 4632 ASTM D 6768	200,000 ft^2 (20,000 m^2)	90 lbs (400 N) MARV 22.5 lbs/in (40 N/cm) MARV
GCL Peel Strength[3]	ASTM D 4632 ASTM D 6496	40,000 ft^2 (4,000 m^2)	15 lbs (65 N) min 2.5 lbs/in (4.4 N/cm) min
GCL Index Flux[4]	ASTM D 5887	Weekly	1 x 10^{-8} m^3/m^2/sec max
GCL Hydraulic Conductivity[4]	ASTM D 5887	Weekly	5 x 10^{-9} cm/sec max
GCL Hydrated Internal Shear Strength[5]	ASTM D 5321 ASTM D 6243	Periodic	500 psf (24 kPa) typ @ 200 psf 6,500 psf (311 kPa) typ @ 10,800 psf

Bentomat ST is a reinforced GCL consisting of a layer of sodium bentonite between a woven and a nonwoven geotextiles, which are needlepunched together.

Notes

[1] Bentonite property tests performed at a bentonite processing facility before shipment to CETCO's GCL production facilities.

[2] Bentonite mass/area reported at 0 percent moisture content.

[3] All tensile strength and peel strength testing is performed in the machine direction using 4 inch grips per modified ASTM D 4632. Results are reported as minimum average roll values unless otherwise indicated. Upon request, tensile strength can be reported per ASTM D 6768 and peel strength can be reported per ASTM D 6496.

[4] Index flux and permeability testing with deaired distilled/deionized water at 80 psi (551kPa) cell pressure, 77 psi (531 kPa) headwater pressure and 75 psi (517 kPa) tailwater pressure. Reported value is equivalent to 925 gal/acre/day. This flux value is equivalent to a permeability of 5x10^{-9} cm/sec for typical GCL thickness. Actual flux values vary with field condition pressures. The last 20 weekly values prior the end of the production date of the supplied GCL may be provided.

[5] Peak values measured at 200 psf (10 kPa) and 10,800 psf (517 kPa) normal stress for a specimen hydrated for 48 hours. Site-specific materials, GCL products, and test conditions must be used to verify internal and interface strength of the proposed design.

CETCO has developed an edge enhancement system that eliminates the need to use additional granular sodium bentonite within the overlap area of the seams. We call this edge enhancement, SuperGroove™, and it comes standard on both longitudinal edges of Bentomat® ST. It should be noted that SuperGroove™ does not appear on the end-of-roll overlaps and recommend the continued use of supplemental bentonite for all end-of-roll seams.

CETCO® LINING TECHNOLOGIES

1500 W. Shure Drive Arlington Heights, IL 60004 USA 800.527.9948 Fax 847.577.5571
For the most up-to-date information please visit our website, www.cetco.com
A wholly owned subsidiary of AMCOL International

The information and date contained herein are believed to be accurate and reliable. CETCO makes no warranty of any kind and accepts no responsibility for the results obtained through application of this information.

Revised 09/04
TR 401-BMST

ATTACHMENT B
Revised Technical Specifications

TECHNICAL SPECIFICATIONS
FOR THE
BRC EASTSIDE COMMON AREAS SOILS REMEDIATION
HENDERSON, NEVADA

Prepared for:

Basic Remediation Company
875 West Warm Springs Road
Henderson, Nevada 89015
(702) 567-0400

Prepared by:

Geosyntec Consultants
10875 Rancho Bernard Road, Suite 200
San Diego, California 92127
(858) 674-6559

February 2008

DRAFT

CERTIFICATION PAGE

TECHNICAL SPECIFICATIONS
CORRECTIVE ACTION MANAGEMENT UNIT
BASIC REMEDIATION COMPANY
HENDERSON, NEVADA

The Engineering material and data contained in these Technical Specifications were prepared under the supervision and direction of the undersigned, whose seal as a registered Professional Engineer is affixed below.

Ronald S. Johnson, P.E.
Engineer of Record

DRAFT

TABLE OF CONTENTS

Section 01010	**—**	**Summary of Work**
Section 01025	**—**	**Measurement & Payment**
Section 01050	**—**	**Field Engineering**
Section 01100	**—**	**Project Meetings and Procedures**
Section 01110	**—**	**Health and Safety Requirements**
Section 01300	**—**	**Submittals**
Section 01400	**—**	**Quality Control**
Section 01500	**—**	**Construction Facilities**
Section 01505	**—**	**Mobilization / Demobilization**
Section 01560	**—**	**Temporary Controls**
Section 01700	**—**	**Contract Closeout**
Section 02010	**—**	**Demolition**
Section 02110	**—**	**Site Clearing**
Section 02200	**—**	**Earthwork**
Section 02205	**—**	**Remedial Excavation and Filling**
Section 02225	**—**	**Drainage Aggregate**
Section 02711	**—**	**Leachate Collection Polyethylene Pipe**
Section 02712	**—**	**Corrugated Polyethylene Pipe**
Section 02770	**—**	**Geomembrane**
Section 02771	**—**	**Geotextile**
Section 02772	**—**	**Geosynthetic Clay Liner**
Section 02773	**—**	**Geocomposite**
Section 02820	**—**	**Chain Link Fence**

DRAFT

Section 03400 — Cast-in-Place Concrete

Section 03410 — Reinforced Concrete Pipe

DRAFT

SECTION 01010
SUMMARY OF WORK

PART 1 – GENERAL

1.01 SUMMARY

A. The subject site is near the BMI Industrial Complex, in Clark County, Nevada, approximately 13 miles south of Las Vegas, within the City of Henderson. The property represents a portion of what is known as the BMI Common Areas. The BMI Common Areas is comprised of two areas: the Eastside Area where remedial excavation shall occur and the Corrective Action Management Unit (CAMU) where the containment structure for the remedial wastes shall be constructed. The total extent of the Site including the Eastside Area and the CAMU, as shown on the Construction Drawings, is approximately 2,330 acres. The Eastside Area covers approximately 2,200 contiguous acres, of which approximately 240 acres will be soil and sludge remediation and 93 acres of haul roads, and the CAMU area covers the balance of 130 acres.

B. The Eastside Area consists of:

1. land on which unlined wastewater effluent evaporation ponds (and associated conveyance ditches) were built and into which various plant wastewaters were discharged from 1942 through 1976;

2. land on which lined wastewater effluent ponds were constructed and into which effluent from the Titanium Metals Company plant was discharged from 1976 to 2005;

3. land on which the City of Henderson constructed municipal wastewater infiltration basins (i.e., the Southern Rapid Infiltration Basins (RIBs);

4. land on which unlined wastewater effluent ponds were constructed but which were never used; and

5. land which has remained virgin desert.

C. The CAMU area consists primarily of land which contains:

1. the closed North and South BMI Landfills;

2. a series of trenches (the "Slit Trenches") into which various wastes were deposited;

3. the western ditch; and

4. vacant land.

1.02 DESCRIPTION OF WORK

A. The Work generally involves the construction of six (6) phases of cell development for the CAMU, placement of waste material in the CAMU, and construction of final cover systems over the CAMU and North and South BMI Landfills. Construction of the final CAMU cover system and associated storm water management features overlying the CAMU will be held as Option Scope that may be added to the contract via Contract Modification at the Owner's sole discretion. If the Owner decides to exercise its option to add the Option Scope, the Construction Manager will notify the Contractor no later than 30 days after receipt of the final Eastside Area confirmation sampling results. Excavation, stockpiling, hauling to the CAMU, and placement in the CAMU of an estimated 1.9 million cubic yards of contaminated soil and sludge from the Eastside Area shall generally occur concurrently with CAMU construction. In addition to contaminated Eastside Area

DRAFT

soil and sludge, the western ditch contaminated soil and slit trench wastes, located on the CAMU site and as shown on the Construction Drawings, shall be placed in the CAMU.

B. There will be nine (9) parts to the BRC Eastside Common Areas Soils Remediation project: six (6) phases of CAMU cell construction, final waste placement, and Capping of the CAMU, BMI North, and BMI South Landfills. The following construction activities will occur during the 9 parts of the project:

1. 6 Phased CAMU Construction and Waste Placement:

   a. Mobilization.

   b. Clearing and Grubbing.

   c. Demolition.

   d. Initial topographic survey.

   e. Mass excavation.

   f. Engineered fill.

   g. Storm water control installation: detention basins, storm drain pipe, manholes, channels

   h. Subgrade preparation.

   i. Post-excavation grade survey.

   j. Sump construction.

   k. Vadose zone monitoring system installation, including side slope riser pipe installation, geomembrane installation, cushion geotextile placement, drainage aggregate placement.

   l. Liner installation, including: GCL, geomembrane, geocomposite, and operations layer.

   m. Leachate collection system installation, including: side slope riser, concrete wall, leachate collection pipes, drainage aggregate, and filter geotextile.

   n. Excavation, scraping, hauling, mixing, solidifying, and placement of CAMU Area soils and wastes and Eastside Areas contaminated soils and sludges.

   o. Confirmation sampling, by Construction Manager, of completed Eastside Areas excavations.

   p. Slit trench backfilling with engineered fill.

   q. Slit trench waste excavation and placement

   r. Slit trench PCB impacted material excavation, hauling, and off-site disposal in accordance with all state and federal regulations.

   s. Placement of Interim cover

   t. As-built preparation and submittal

2. Final Cover System– CAMU (Option Scope)

   a. Placement of interim cover.

b. Prepared Subgrade.

c. Post-fill grade survey.

d. Liner installation, including: GCL, geomembrane, geocomposite, and final cover soil layer.

e. Drainage system installation, including: drainage pipes, drainage aggregate, and filter geotextile.

f. Aggregate base road

g. Storm water management features.

h. As-built preparation and submittal.

3. Final Cover –BMI Landfills

a. Waste excavation.

b. Engineered fill.

c. Prepared subgrade,

d. Final cover installation, including: GCL, geomembrane, geocomposite, and cover soil.

e. As-built preparation and submittal.

1.03 MANDATORY SEQUENCE OF WORK

A. Contractor shall follow the following mandatory sequences of work.

1. Contractor shall secure the CAMU perimeter and Eastside and CAMU staging areas with fencing and install security measures at the CAMU and Eastside Areas prior to starting any other physical work.

2. Contractor shall submit to the Construction Manager, for approval all required pre-Notice to Proceed submittals. Construction Manager approval is required prior to starting the work.

3. Erosion control best management practices, in accordance with Contractor's approved Surface Water Pollution Prevention Plan (SWPPP), shall be installed before any other soil surfaces are disturbed.

4. The Northwest Retention Basin shall be installed first, followed by the Northeast Retention Basin and associated storm drain piping and manholes before any clearing and grubbing commences on the CAMU site.

5. The western perimeter stormwater channels shall be excavated to the grades shown before any clearing and grubbing commences on the CAMU site.

6. Phase I shall be the first phase constructed and shall be 100% constructed and approved prior to placement of waste within the lined area and prior to commencing excavation of Phase II.

7. All decontamination areas and the vacuum station shall be established and constructed prior to any waste excavation or transport.

DRAFT

8. Western Ditch waste shall be excavated to provide operations layer material for Phase I before placement of any other waste within Phase I. Western Ditch excavation shall continue during Phase II excavation. Western Ditch soils shall be screen, if necessary for operations layer, and placed in Phase I.

9. Phase II shall be constructed immediately after Phase I and shall be 100% constructed and approved prior to placement of waste within the lined area.

10. Phases IIIA, IIIB, IV, and, V may be constructed concurrently with Phase II however, they must be completed in numerical order with each respective phase being 100% constructed and approved prior to placement of waste within the respective phased area.

11. Slit trench waste shall be excavated during Phase II cell construction and filling, with waste material placed in Phase I and Phase II of the CAMU. Slit trenches shall be backfilled and compacted as soon as Construction Manager approves of individual slit trench waste removal completion and Owner has conducted the post-excavation survey.

12. Concurrent with Slit Trench waste excavation, commence East Side Area waste excavation and transport to the CAMU

13. East Side Area waste excavation shall proceed in the following order with each preceeding area being 100% completed before proceeding to the next successive area.

    a. Sewer line alignment within the Beta ditch

    b. Parcel 7A.

    c. Remainder of Beta Ditch.

    d. Remainder of Eastside area with remediation proceeding from east to west. Hot spot areas identified through confirmation sampling that require excavation shall receive priority attention and shall be excavated and removed before excavating other wastes.

1.04 DEFINITIONS

A. OWNER - The term Owner means Basic Remediation Company (BRC) for whom the Work is to be provided.

B. CONSTRUCTION MANAGER – The term Construction Manager means the firm responsible for project administration and project documentation control (Weston Solutions, Inc). All formal documents shall be submitted to the Construction Manager for proper distribution and/or review. During the period of Work the Construction Manager shall act as an authorized representative of the Owner.

C. DESIGN ENGINEER - The term Design Engineer(s) means the firm(s) responsible for the design and preparation of the Construction Documents and is the Engineer-of-Record for the project. The Engineer is responsible for approving all design changes, modifications, or clarifications encountered during construction. The Design Engineer reports directly to the Owner.

D. CQA ENGINEER – The term CQA Engineer refers to the firm responsible for CQA related monitoring and testing activities. The CQA Engineer's authorized personnel shall include CQA Engineer-of-Record and Lead CQA Monitor. The CQA Engineer may also perform CQC work as appropriate. The CQA Engineer reports directly to the Owner.

E. CONTRACTOR - The term Contractor means the firm that is responsible for the Work. The Contractor's responsibilities include the Work of any and all subcontractors and suppliers. The Contractor reports directly to the Construction Manager. All subcontractors report directly to the Contractor.

DRAFT

F. SURVEYOR – The term Surveyor means the firm that shall perform field surveys and provide as-built Record Drawings for the Work. A Surveyor shall be employed by the Contractor to provide construction layout, as-built Record Drawings, base-line surveys, and quantity estimates. A third party Surveyor, employed and paid for by the Owner, will perform quality assurance checks of control points, as-builts, and quantities, as directed by the Construction Manager. The Surveyor shall be a Registered Land Surveyor, licensed to practice in the State of Nevada.

G. SITE - The term Site refers to all approved staging areas, and all areas where the Work is to be performed, both public and privately owned.

H. WORK - The term Work means the entire completed construction, or various separately identifiable parts thereof, required to be furnished under the Contract Documents. Work includes any and all labor, services, materials, equipment, tools, supplies, and facilities required by the Contract Documents and necessary for the completion of the project. Work is the result of performing services, furnishing labor, and furnishing and incorporating materials and equipment into the construction, all as required by the Contract Documents.

I. DAY - A calendar day.

J. CONTRACT DOCUMENTS - Contract Documents consist of all documents identified in the Agreement executed between the Owner and the Contractor.

1.05 REFERENCES

A. ~~The Contractor is encouraged to familiarize itself with the following documents in preparing its bid. Unless otherwise noted, the documents are available on BRC's website at www.landwellco.com. Proceed to "Data Repository" under "Current".~~

~~1. Basic Remediation Company (BRC), 2006, "Community Involvement Plan (CIP)," November.~~

~~2. BRC, 2006. "Corrective Action Plan (CAP) For The Basic Remediation Company (BRC) Common Areas Remediation Project," September.~~

~~a. Appendix C: Dust Control and Mitigation Plan~~

~~3. BRC, 2005. "Perimeter Air Monitoring Plan For Soil Remediation Activities BMI Upper and Lower Ponds and Ditches, Clark County, Nevada," April~~

~~4. BRC, Environmental Resources Management (ERM), and Daniel B. Stevens & Associates (DBS&A), 2007, "BRC Closure Plan: BMI Common Areas, Clark County, Nevada," May.~~

~~5. BRC, Geosyntec, ERM, 2007, "Draft: Remedial Alternative Study for the Slit Trench Area," July.~~

~~6. BRC and MWH, 2005, "BRC CAMU area, 2005 soil, soil vapor, groundwater, and slit trench investigation report," October.~~

~~7. Clark County Department of Comprehensive Planning, Land Use Planning, Land Use Permit No. UC-0389-06 dated May 10, 2006. (Provided in Bid Package)~~

~~8. Daniel B Stephens & Associates, Inc (DBS&A), 2006, "Conceptual Site Model, Proposed CAMU Site, Henderson, Nevada," October.~~

~~9. Geosyntec, 2007 "Construction Quality Assurance Plan for the Construction of the Corrective Action Management Unit, Basic Remediation Company, Henderson, Nevada," August.~~

DRAFT

10. ~~Geosyntec, 2007. "Revised Remedial Action Plan (RAP) Permit Application for Corrective Action Management Unit (CAMU), Henderson, Nevada," Prepared for Basic Remediation Company, Submitted to Nevada Department of Environmental Protection, March.~~

11. ~~Geotechnical & Environmental Services, Inc (GES), 2007, "Eastside Geotech Sampling, Henderson, Nevada," Prepared for Basic Remediation Company, October."Nevada Department of Environmental Protection, 2001, "Record of Decision: Remediation of Soils and Sediments in the Upper and Lower Ponds at the BMI Complex, Henderson, Nevada," November.~~

12. ~~Nevada Department of Environmental Protection (NDEP), Permit for Hazardous Remediation Waste Management Activity, issued 24 September 2007. (Provided in Bid Package)~~

13. ~~NDEP, 2007, "Record of Decision: Remediation of Soil in the Slit Trench Area of the BMI Common Areas, Henderson, Nevada," September.~~

14. ~~NDEP, 2001, "Record of Decision: Remediation of Soils and Sediments in the Upper and Lower Ponds at the BMI Complex, Henderson, Nevada."~~

15. ~~Nevada Department of Transportation (NDOT) Traffic Permit No. 91464 2006 dated 13 April 2006.~~

16. ~~PBS&J, 2006, "Landwell Haul Route: Traffic Control Plan, Boulder Highway and Warm Springs Road intersection," Prepared for The Landwell Company, April.~~

17. ~~PBS&J, 2006, "Technical Drainage Study for the Eastside Landfill," prepared for Basic Remediation Company, October.~~

18. ~~Conceptual Drainage Study~~

19. ~~Pond and Sludge Dewatering Studies:~~

    a. ~~Hart Crowser, 2004, "Draft: Assessment of Geotextile Tube Dewatering Technology for Timet Ponds, Henderson, Nevada," Prepared for Basic Remediation Company, November.~~

    b. ~~Pincock Allen & Holt, 2004 "Assessment of Geotextile Tube Dewatering Technology for Timet Ponds, Henderson, Nevada," Prepared for Basic Remediation Company, July.~~

    c. ~~Ocean and Coastal Consultants, Inc, 2005, "Timet Ponds Drying Recommendations," April.~~

A. The Contractor is required to familiarize itself with the following documents in preparing its bid. These documents have been provided with the Contract Documents.

    1. BRC, 2006. "Appendix C: Dust Control and Mitigation Plan, Corrective Action Plan (CAP) For The Basic Remediation Company (BRC) Common Areas Remediation Project," September.

    2. BRC, 2005. "Perimeter Air Monitoring Plan For Soil Remediation Activities BMI Upper and Lower Ponds and Ditches, Clark County, Nevada," April

    3. BRC, Geosyntec, ERM, 2007, "Draft: Remedial Alternative Study for the Slit Trench Area," July.

    4. BRC and MWH, 2005, "BRC CAMU area, 2005 soil, soil vapor, groundwater, and slit trench investigation report," October.

DRAFT

5. Clark County Department of Comprehensive Planning, Land Use Planning, Land Use Permit No. UC-0389-06 dated May 10, 2006. (Provided in Bid Package)

6. Geosyntec, 2007 "Construction Quality Assurance Plan for the Construction of the Corrective Action Management Unit, Basic Remediation Company, Henderson, Nevada," August.

7. Geotechnical & Environmental Services, Inc (GES), 2007, "Eastside Geotech Sampling, Henderson, Nevada," Prepared for Basic Remediation Company, October."Nevada Department of Environmental Protection, 2001, "Record of Decision: Remediation of Soils and Sediments in the Upper and Lower Ponds at the BMI Complex, Henderson, Nevada," November.

8. Nevada Department of Environmental Protection (NDEP), Permit for Hazardous Remediation Waste Management Activity, issued 24 September 2007. (Provided in Bid Package)

9. Nevada Department of Transportation (NDOT) Traffic Permit No. 91464-2006 dated 13 April 2006.

10. PBS&J, 2006, "Landwell Haul Route: Traffic Control Plan, Boulder Highway and Warm Springs Road intersection," Prepared for The Landwell Company, April.

B. The Contractor is encouraged to familiarize itself with the following documents in preparing its bid. These documents have been provided with the Supplemental Documents

1. Basic Remediation Company (BRC), 2006, "Community Involvement Plan (CIP)," November.

2. BRC, 2006. "Corrective Action Plan (CAP) For The Basic Remediation Company (BRC) Common Areas Remediation Project," September.

3. BRC, Environmental Resources Management (ERM), and Daniel B. Stevens & Associates (DBS&A), 2007, "BRC Closure Plan: BMI Common Areas, Clark County, Nevada," May.

4. Daniel B Stephens & Associates, Inc (DBS&A), 2006, "Conceptual Site Model, Proposed CAMU Site, Henderson, Nevada," October.

5. Geosyntec, 2007. "Revised Remedial Action Plan (RAP) Permit Application for Corrective Action Management Unit (CAMU), Henderson, Nevada," Prepared for Basic Remediation Company, Submitted to Nevada Department of Environmental Protection, March.

6. NDEP, 2007, "Record of Decision: Remediation of Soil in the Slit Trench Area of the BMI Common Areas, Henderson, Nevada," September.

7. NDEP, 2001, "Record of Decision: Remediation of Soils and Sediments in the Upper and Lower Ponds at the BMI Complex, Henderson, Nevada."

8. PBS&J, 2006, "Technical Drainage Study for the Eastside Landfill," prepared for Basic Remediation Company, October.

9. Conceptual Drainage Study

10. Pond and Sludge Dewatering Studies:

    a. Hart Crowser, 2004, "Draft: Assessment of Geotextile Tube Dewatering Technology for Timet Ponds, Henderson, Nevada," Prepared for Basic Remediation Company, November.

DRAFT

b. Pincock Allen & Holt, 2004 "Assessment of Geotextile Tube Dewatering Technology for Timet Ponds, Henderson, Nevada," Prepared for Basic Remediation Company, July.

c. Ocean and Coastal Consultants, Inc, 2005, "Timet Ponds Drying Recommendations," April. "

1.06 SUBMITTALS

A. The following shall be submitted prior to issuance of Notice to Proceed:

1. Performance and Payment Bond

2. Insurance Certificates

3. Approved City of Henderson and Clark County Land-use permits

B. The Contractor shall submit to the Construction Manager the CAMU Grading Permit and Eastside Area Grading Permit in accordance with Subpart 1.12 of this Section.

1.07 CONTRACTOR QUALIFICATIONS

A. The Contractor, and all subcontractors, shall be licensed at the time of bidding, and throughout the period of the Contract, by the State of Nevada to do the type of work required under terms of these Contract Documents. By submitting a bid, the Contractor certifies that he is skilled, competent, and knowledgeable on the nature, extent and inherent conditions of the Work to be performed and has been regularly engaged in the general class and type of work called for in these Contract Documents and meets the qualifications required in these Specifications.

B. By submission of a bid for this Project, the Contractor acknowledges that he is thoroughly familiar with the Site conditions.

1.08 CONTRACTOR'S RESPONSIBILITIES

A. Start, layout, construct, and complete the Project in accordance with the Contract Documents.

B. Provide a competent Site superintendent, capable of reading and understanding the Construction Documents, who shall receive instructions from the Construction Manager.

C. Provide labor, construction supplies, equipment, tools, machinery, and other services and facilities necessary to properly execute and complete the work, and pay the cost thereof.

D. Establish means, techniques, and procedures for constructing and otherwise executing the Work.

E. Establish and maintain proper Health and Safety practices for the duration of the Project. The Contractor shall be responsible for health and safety of the personnel on site including: Contractor's personnel, Owner, Construction Manager and personnel, consultants, subcontractors, suppliers, and visitors. In particular, the Contractor shall account for site specific Health and Safety issues (hazards), including but not limited to waste excavation, heat, construction activities, etc.

F. Pay cost of legally required sales, consumer, and use taxes and governmental fees.

G. Perform Work in accordance with codes, ordinances, rules, regulations, orders, and other legal requirements of governmental bodies and public agencies bearing on performance of Work.

H. Forward submittals and communications to the Construction Manager. Where applicable, the Construction Manager shall coordinate submittals and communications with the representatives who shall give approvals and directions through the Construction Manager.

I. Maintain order, safe practices, and proper conduct at all times among Contractor's employees. The Construction Manager, and its authorized representative, may require that disciplinary action be taken against an employee of the Contractor for disorderly, improper, or unsafe conduct. Should an employee of the Contractor be dismissed from his duties for misconduct, incompetence, or unsafe practice, or combination thereof, that employee shall not be rehired for the duration of the Work.

J. Coordinate the Work with the utilities, private utilities, and/or other parties performing work on or adjacent to the Site. Other parties include those responsible for construction management, construction quality assurance monitoring, air and dust monitoring, and conformance sampling. Other parties also includes Owner, utility representatives, regulatory agencies, and/or inspectors. Eliminate or minimize delays in the Work and conflicts with those utilities or contractors. Coordinate activities with the Construction Manager. Schedule private utility and public utility Work relying on survey points, lines, and grades established by the Contractor to occur immediately after those points, lines and grades have been established.

K. Coordinate activities of the several trades, suppliers, and subcontractors, if any, performing the Work.

L. The Contractor shall cooperate with all other parties engaged in project-related activities to the greatest extent possible. Disputes or problems shall be referred to the Construction Manager for resolution.

M. The Contractor is responsible for becoming familiar with all aspects of the Work prior to performing the Work.

N. The Contractor shall provide documentation for the following training for site personnel:

1. All on-site personnel (except administrative staff):

   a. 40 hour OSHA HAZWOPER training meeting 29 CFR 1910

   b. 8 hour OSHA Refresher training meeting 29 CFR 1910

   c. Respirator Fit Test

2. All on-site supervisors:

   a. 8 hour OSHA Supervisor training meeting 29 CFR 1910

   b. Red Cross First Aid and CPR training

3. Geosynthetic Material Installation Technicians

   a. Qualifications and experience installing similar materials

4. Landfill Manager

   a. SWANA Manager of Landfill Operations Training

1.09 CONFORMANCE

A. Work shall conform to the Technical Specifications, CQA Plan, and Drawings that form a part of these Contract Documents.

B. Omissions from the Technical Specifications, CQA Plan, and Drawings or the misdescription of details of Work which are necessary to carry out the intent of the Contract Documents are customarily performed, shall not relieve the Contractor from performing such omitted or

DRAFT

misdescribed details of the Work, but they shall be performed as if fully and correctly set forth and described in the Technical Specifications, CQA Plan, and Drawings.

1.10 CONTRACTOR USE OF WORK SITE

A. Confine Site operations to areas permitted by law, ordinances, permits, and the Contract Documents. The Contractor shall ensure that all persons under his control (including Subcontractors and their workers and agents) are kept within the boundaries of the Site and shall be responsible for any acts of trespass or damage to property by persons who are under his control. Consider the safety of the Work, and that of people and property on and adjacent to work Site, when determining amount, location, movement, and use of materials and equipment on work Site.

B. The Contractor shall be responsible for protecting private and public property including pavements, drainage culverts, electricity, highway, telephone, and similar property and shall make good of, or pay for, all damage caused thereto. Control of erosion throughout the project is of prime importance and is the responsibility of the Contractor. The Contractor shall provide and maintain all necessary measures to control erosion during progress of the Work to the satisfaction of the Construction Manager and all applicable laws and regulations, and shall remove such measures and collected debris upon completion of the project. All provisions for erosion and sedimentation control apply equally to all areas of the Work.

C. Contractor shall promptly notify the Construction Manager in writing of any subsurface or latent physical conditions at the Site that differ materially from those indicated or referred to in the Contract Documents. Construction Manager shall promptly review those conditions and advise Owner in writing if further investigations or tests are necessary. If the Construction Manager finds that the results of such investigations or tests indicate that there are subsurface and latent physical conditions which differ materially from those intended in the Contract Documents, and which could not reasonably have been anticipated by Contractor, a Change Order shall be issued incorporating the necessary revisions.

D. At no time shall Contractor interfere with operations of businesses on or in the vicinity of the Site. Should the Contractor need to work outside the regular working hours, the Contractor is required to submit a written request and obtain approval by the Construction Manager.

1.11 EXISTING UTILITIES

A. The Contractor shall be responsible for locating, uncovering, protecting, flagging, and identifying all existing utilities encountered while performing the Work. The Contractor shall request that Underground Service Alert (USA) locate and identify the existing utilities. The request shall be made 48 hours in advance.

B. The Contractor shall locate all overhead utilities that enter the construction boundary and locate these lines until they terminate or exit the site to ensure that no underground utilities originate from these overhead utilities. If underground utilities do originate from these overhead lines, the Contractor shall locate the underground utility until it terminates or exits the construction boundary.

C. All located live underground utilities shall be put on the as-built drawings and staked 50 feet on center or marked with other equal physical markings, and shall be protected until all intrusive work is completed in the area. Markings shall indicate both the horizontal and vertical position of the utilities.

D. The Contractor shall not proceed with any intrusive work at the East Side Area, the CAMU, any integrated peripheral property, the haul roads, including Boulder Highway and West Warm Springs Road, or any other discrete work area until the utility locates have been completed, the Contractor has requested authorization to proceed, and written approval is obtained from the Construction Manager.

DRAFT

E. Where the work may encounter existing utilities:

1. The Contractor shall de-energize the utilities. When this affects other utility users the Contractor shall make arrangements for alternate service if required.

2. The Contractor shall determine and comply with the requirements of the utility owner for protection of that utility. The Contractor shall provide adequate advance notice to the utility owner, of work near an existing utility.

F. When the Work requires the Contractor to be near or to cross locations of known utilities, the Contractor shall carefully uncover, support and protect these utilities and shall not cut, damage, or otherwise disturb them without prior authorization from the Construction Manager.

G. Costs resulting from damage to utilities shall be borne by the Contractor. Costs of damage shall include repair and compensation for incidental costs resulting from the unscheduled loss of utility service to affected parties.

H. The Contractor shall immediately stop work and notify the Construction Manager of all utilities encountered and/or damaged. The Contractor shall also Survey the exact location of any utilities encountered during construction.

1.12 PRESERVATION OF SCIENTIFIC INFORMATION

A. Federal and State legislation provides for the protection, preservation, and collection of data having scientific, prehistoric, historical, or archaeological value (including relics and specimens) that might otherwise be lost due to alteration of the terrain as a result of any construction work. If evidence of such information is discovered during the course of the Work, the Contractor shall notify the Construction Manager immediately, giving the location and nature of the findings. written confirmation shall be forwarded within two (2) working days.

B. The Contractor shall exercise care so as not to damage artifacts uncovered during excavation operations, and shall provide such cooperation and assistance as may be necessary to preserve the findings for removal or other disposition by the Construction Manager or Government agency.

C. Where appropriate, by reason of a discovery, the Construction Manager may order delays in the time of performance, or changes in the Work, or both. If such delays, or changes, or both, are ordered, the time of performance and contract price shall be adjusted in accordance with the applicable clauses of the Contract.

1.13 ADDITIONAL REQUIREMENTS

A. SURVEYING - The Surveyor shall be employed by the Contractor to provide construction layout, as-built Record Drawings, base-line surveys, and quantity estimates. A third party Surveyor, employed and paid for by the Owner, will perform quality assurance checks of control points, as-builts, and quantities, as directed by the Construction Manager. Surveying shall be conducted such that all applicable standards required by the State of Nevada are in accordance with Section 01050 of these Specifications. The Surveyor shall be a Registered Land Surveyor, licensed to practice in the State of Nevada.

B. PERMITS – The following permits shall be obtained by the Owner and Contractor for the Work.

1. The Owner will provide the following permits:

a. Remedial Action Plan (RAP) Permit, Nevada Department of Environmental Protection; and

b. Traffic – District Permit No. 91464-2006, obtained from NDOT for allowing material haulage across Boulder Highway with up to 120 ton haul trucks permitted. Permits for use of Warm Springs Road and Boulder Highway crossing shall be supported with the provided Traffic Control Plan as necessary. The Traffic Control Plan describes changes to the signaling procedures at the Boulder Highway/Warm Springs interchange, as well as the presence of flagmen and other temporary traffic control procedures as necessary. Additional requirements for public haul roads are in specified in Section 01500.

c. CAMU Land Use Permit, Clark County, Department of Comprehensive Planning, Land Use Planning Permit No. UC-0389-06.

2. The Contractor shall be required to obtain permits in accordance with construction of the facility. Permits include:

a. Dust Control Permit – Obtained from the Air Pollution Control Division of the Clark County Health District. Owner shall provide Contractor with Dust Control Mitigation Plan and Perimeter Air Monitoring Plan outlining procedures for Dust Control Permit compliance.

b. Zero-Discharge Permit - If deemed appropriate by the Bureau of Water pollution, "Zero Discharge" permits shall be obtained to address temporary ponds associated with remediation (i.e., decontamination rinse water, TIMET pond dewatering).

c. Traffic – The Contractor shall obtain a Traffic Permit for use of West Warm Springs Road. The Permit shall be supported with the provided Traffic Control Plan as necessary. The Traffic Control Plan describes changes to the signaling procedures at the Boulder Highway/Warm Springs interchange, as well as the presence of flagmen and other temporary traffic control procedures as necessary. Additional requirements for public haul roads are in specified in Section 01500.

d. Eastside Grading – Contractor shall file and receive a grading permit for the Eastside areas with the COH based on the approved Conceptual Drainage Study (CDS) provided by the Owner.

i. Contractor shall ensure the 100-year storm flows shall not increase or be redirected from the current condition established in the approved CDS.

ii. Contractor shall ensure interim site conditions shall not increase or redirect flows from current conditions.

e. CAMU Grading – The Contractor shall apply for the CAMU grading permit from Clark County. The Owner shall provide to the Contractor the following:

i. Technical Drainage Study (TDS)

ii. Improvement Plans

iii. Comments and Approval from the building department

f. Land-use Permit - Within 10 business days of project award, the Contractor shall submit, to the Construction Manager, a completed project specific City of Henderson/Clark County Land Use Permit that covers all work required for this project. The Land Use Permit will subsequently be submitted by the Construction Manager to the Landwell Design Review Committee for review and approval. Once approved by the Design Review Committee, the Owner will submit the Land Use Permit to the City of Henderson for review and approval. The Contractor shall expect that the review and approval process, from the time the Contractor submits the Land Use Permit to final

approval by the City of Henderson, will take approximately 4 weeks. A Notice to Proceed will not be issued before final approval of the Land Use Permit.

C. SEDIMENTATION, EROSION CONTROL, AND DEWATERING - Contractor shall comply with all laws, ordinances, and permits for controlling erosion, water pollution, and dust emissions resulting from construction activities; the Contractor shall be responsible for any fines imposed due to noncompliance. The Contractor shall prepare and perform work in accordance with the Storm Water Pollution Prevention Plan (SWPPP) in accordance with Section 01100 Subpart 3.08 of these Specifications. Stormwater shall be handled in accordance with SWPPP. SWPPP shall address disposal of contaminated stormwater by off site disposal or as dust control over waste placed in lined areas of the CAMU. Contaminated stormwater is defined as water that contacts waste materials, water collected from sumps, and stormwater removed from waste excavations. Contaminated stormwater shall not be used for dust control on clean, interim or final cover.

D. PROTECTION OF EXISTING WELLS - The Contractor shall exercise care to avoid disturbing or damaging the existing monitor wells that are to remain in place. All wells damaged by the Contractor shall be immediately repaired by the Contractor to the satisfaction of the Construction Manager at no additional cost.

E. WORKING HOURS - Contractor shall establish normal working hours and notify Construction Manager when work is scheduled outside of those hours. Available working hours are 24 hours a day, 7 days a week.with restricted work hours for the following:

1. 7 pm to 6 am: use of non-highway approved trucks up to 120 tons gross weight are allowed for use to haul waste materials from the Eastside Area to the CAMU, crossing Boulder Highway, in accordance with Nevada Department of Transportation (NDOT) permit 91464-2006 obtained by the Owner.

2. Work which creates noise in excess of limits specified in Section 01560 shall be restricted during hours specified in that Section.

F. BURNING - The use of open fires for any reason is prohibited.

G. TEMPORARY ROADS - The Contractor shall be responsible for constructing and maintaining all temporary roads and lay down areas that the Contractor may require in the execution of the Work in accordance with Section 01500.

H. CONSTRUCTION WATER - The Contractor shall obtain and pay for water from the City of Henderson Utilities Division for construction and dust control..

I. SAFEGUARDS - The Contractor shall provide and use all personnel safety equipment, barricades, guardrails, signs, lights, flares, and flagmen as required by OSHA, state, or local codes and ordinances.

J. SECURITY - The Contractor is responsible for 24-hour site security and the safety and condition of all of his tools and equipment. The Contractor shall maintain security in accordance with Section 01100, Part 3.07.

K. ACCEPTANCE OF WORK - The Contractor shall retain ownership and responsibility for all Work until Substantial Completion has been issued by Construction Manager.

PART 2 – PRODUCTS

[NOT USED]

PART 3 – EXECUTION

3.01 CONSTRUCTION DRAWINGS

A. Three sets of construction drawings comprise the Construction Drawings:

1. Construction Drawings, Basic Remediation Company, Corrective Action Management Unit, Henderson, Nevada, August 2007 – prepared by Geosyntec Consultants, dated August 2007.

2. Improvement Plans for Eastside Landfill – prepared by PBS&J, dated October 2006.

3. Improvement Plans for Eastside Common Area Remediation- prepared by PBS&J, dated August 2007.

B. Dimensions shown on the drawings take precedence over scaled dimensions. Large-scale details have precedence over smaller scale.

PART 4 – MEASUREMENT AND PAYMENT

[NOT USED]

[END OF SECTION]

DRAFT

SECTION 01025
MEASUREMENT AND PAYMENT

PART 1 – GENERAL

1.01 DESCRIPTION OF WORK

A. This section covers measurement and payment criteria applicable to the Work performed under lump sum and unit price payment methods, and non-payment for rejected work.

1.02 RELATED SECTIONS

A. This section relates to all other sections of the contract.

1.03 SUBMITTALS

A. Comply with pertinent provisions of Section 01300, "Submittals."

B. With each request for payment, the Contractor shall submit supporting information as necessary to justify the payment request as specified elsewhere throughout these specifications.

C. Weight tickets when measurement for payment is by weight.

1.04 AUTHORITY

A. Measurement methods delineated in the individual specification sections are intended to complement the criteria of this section. In the event of conflict, the requirements of the individual specification section shall govern.

B. A surveyor, licensed in the State of Nevada, hired by the Contractor shall take all measurements. All measurements, cross-sections and quantities shall be stamped and certified by the licensed surveyor and submitted to the Construction Manager. The Construction Manager maintains the right to provide additional measurements and calculation of quantities to verify measurements and quantities submitted by the Contractor.

1.05 GENERAL

A. Undefined items shall be included in the closed related item on the Bid Schedule.

1.06 LUMP SUM ITEMS

A. Lump-sum measurement will be for the entire item or unit of work, or combination thereof, as specified and as indicated in the Bid Schedule of the Bid Form.

1. If the Contractor requests progress payments for lump-sum items or amounts in the Bid Schedule, such progress payments will be made in accordance with a well-balanced, detailed program of payment-apportioning, prepared by the Contractor and submitted to the Construction Manager for approval.

2. Such program for each applicable lump-sum item shall show fixed definable and measurable quantities where possible and unit prices therefore as developed and assigned by the Contractor to the different features of the work and major subdivisions thereof. The summation of extensions of quantities and unit prices and related costs shall equal the amount of the lump-sum bid item indicated on the Bid Schedule.

3. Following the Construction Manager's approval, progress payments will be made in accordance with the Contractor's payment-apportioning program and from the approved

DRAFT

progress schedule, reflecting the progress which occurred during the payment period as approved by the Construction Manager.

1.07 UNIT PRICE ITEMS

A. Values of Unit Prices:

1. The number of units and quantities in the Bid Schedule as estimated quantities are approximate only, and final payment will be made for the actual number of units and quantities which are incorporated in the Work and required by the Contract.

B. Measurement Standards:

1. All work to be paid for at Contract price per unit measurement, as indicated in the Bid Schedule, will be measured by the Surveyor and verified by the Owner in accordance with United States Standard Measures.

C. Measurement by Volume:

1. Measurement by volume will be by the cubic dimension indicated in the Bid Schedule. Method of volume measurement will be by the unit volume in place or removed as specified.

2. Measurement shall be by the cubic dimension using mean lengths, widths and heights or thickness, or by average end area method as measured by Contractor's surveyor and as verified by Owner's surveyor as appropriate. All measurement shall be the difference between the original ground surface and the design ("neat-line") dimensions and grades.

3. Quantities and measurements indicated in the Bid Schedule are for bidding and contract purposes only. Quantities and measurements supplied or placed in the Work and verified by the Construction Manager shall determine payment. If the actual work requires more or fewer quantities than those quantities indicated, the Contractor shall provide the required quantities at the lump sum and unit prices contracted unless modified elsewhere in these Contract Documents.

D. Measurement by Area: measurement by area will be by the square dimension shown as specified. Measurement shall be by the square dimension using mean lengths and widths and/or radius as measured by Contractor's surveyor and as verified by Owner's surveyor as appropriate. All measurement shall be the difference between the original ground surface and the design ("neat-line") dimensions and grades.

E. Linear Measurement: linear measurement will be by the linear dimension listed in the Bid Schedule. Unless otherwise indicated, items, components, or work to be measured on a linear basis will be measured at the centerline of the item in place.

1.08 PAYMENT

A. Payment includes full compensation for all required labor, products, tools, equipment, transportation, services and incidentals; erection, application or installation of an item of the Work; and all overhead and profit. Final payment for Work governed by unit prices shall be made on the basis of the actual measurements and quantities accepted by the Construction Manager multiplied by the unit price for Work which is incorporated in or made necessary by the Work.

B. A monthly progress payment schedule shall be used to compensate the Contractor for the Work. The monthly amount to be paid to the Contractor is calculated as the percent of completed work for each bid item multiplied by the total anticipated work for that bid item.

DRAFT

1.09 NON-PAYMENT FOR REJECTED PRODUCTS

A. Payment shall not be made for any of the following:

1. Products wasted or disposed of in a manner that is not acceptable.
2. Products determined as unacceptable before or after placement.
3. Products not completely unloaded from the transporting vehicle.
4. Products placed beyond the design lines, dimensions, grades and levels of the required Work.
5. Products remaining on hand after completion of the Work.
6. Loading, hauling, and disposing of rejected Products.
7. Products rejected because of contamination (i.e. soil residues, fuel spills, solvents, etc.).

1.10 BID ITEMS

A. The bid items provided in the Bid Schedule shall be used by the Construction Manager and Contractor to bid the Work described in these bid documents.

B. The bid schedule is broken into four categories for the measurement and payment of the Work:

1. Base Items: Bid items comprising Phases I through V of CAMU construction, Interim CAMU cover placement, storm water controls, and cover construction for the North and South BMI Landfills
2. Option Scope Items: Construction of the final CAMU cover system and associated storm water management features overlying the CAMU will be held as Option Scope items that may be added to the contract via Contract Modification at the Owner's sole discretion.
3. Alternative Added/Deleted Items: Bid items including costs associated for additional waste placement greater than 15 percent of initial engineer's estimate. Costs provided in this table shall be Contractor's hourly labor rate and fleet vehicle hourly rates. Contractor shall provide two vendors' rental quotes for equipment used but not listed in the bid schedule. The lesser of the two quotes shall be the daily cost for payment.
4. Alternative Standby Items: Bid items to be used to calculate standby costs. Costs provided in this table shall be fleet vehicle daily rates. If rental equipment is used or if equipment used is not listed in the bid schedule, the Contractor shall provide documentation of two vendor rental quotes and the lesser of the two quotes shall be the daily cost for payment.

C. Incidentals to be included in bid items are described in the associated Section.

PART 2 – PRODUCTS

[NOT USED]

PART 3 – EXECUTION

[NOT USED]

PART 4 – MEASUREMENT AND PAYMENT

[NOT USED]

DRAFT

[END OF SECTION]

DRAFT

SECTION 01050

FIELD ENGINEERING

PART 1 – GENERAL

1.01 DESCRIPTION OF WORK

A. This section covers field surveys, contractor design (not including shop drawing designs), as-built documentation, and locations of sampling and testing points.

B. The Owner shall provide 3rd party quality assurance surveying to verify as-built documentation based on control points and to provide measurement for payment.

C. The Contractor shall perform all surveying work to complete the Project except where survey work is specifically indicated in the Contract documents to be the Owner's responsibility.

D. Costs for replacement by the Construction Manager of Construction Manager-established reference monuments damaged or destroyed by the Contractor shall be charged to the Contractor at the actual cost of labor, materials, supplies, and equipment to repair or replace such damaged or destroyed Construction Manager-established monuments and reference points.

1.02 RELATED SECTIONS

Section 01100—Project Meetings and Procedures

Section 01300—Submittals

Section 01400—Quality Control

Section 01500—Construction Facilities

Section 01560—Temporary Controls

Section 02200—Earthwork

Section 02205—Remedial Excavating and Filling

1.03 SUBMITTALS

A. Contractor shall submit documentation verifying surveying field supervisor is a Registered Land Surveyor in the State of Nevada.

B. Original field books and electronic data not related to pay requests.

C. Survey data and drawings of all sampling and testing location information shall be submitted to the Construction Manager showing coordinates and elevations. Horizontal coordinates shall be within ± 1.0 foot and vertical locations shall be within ± 0.1 foot.

D. Survey information, drawings, survey data reductions, and calculations used to calculate the progress pay estimate quantities to the Construction Manager with each request for progress payment. Survey information shall include copies of original field books and electronic data.

DRAFT

E. Survey data for final payment for applicable work: The Contractor shall reduce the field notes and calculate final quantities for payment purposes. Documentation shall bear the seal and signature of a Nevada Registered Land Surveyor. Specific submittals include:

1. Measurement or survey field books or field notes, including original field books, electronic data, and note reductions. Field books or notes shall include signatures of all personnel participating in the survey or measurements.

2. Measurement drawings, topographic survey drawings, and cross-section drawings.

3. Calculation sheets used to derive an actual quantity. Each calculation sheet shall clearly indicate the subject, calculations, totals, date, and signature of author.

F. Written notification to Construction Manager of any survey work or layout work to be done.

G. Survey as-built data.

1.04 QUALITY ASSURANCE

A. The Contractor shall provide experienced construction surveyors. All survey and layout work, and work quantity estimate documentation performed by the Contractor shall be performed under the supervision and direction of a Land Surveyor licensed in the State of Nevada with a minimum of 3 years responsible charge of construction surveys for construction work similar in nature to that required by the Project. The Contractor shall maintain sufficient qualified personnel to perform required surveying work, including having a Registered Land Surveyor in the field overseeing the survey crew(s) at all times that survey work is performed.

B. The Contractor instruments and other survey equipment shall be accurate, suitable for the surveys required in accordance with recognized professional standards, and in proper condition and adjustment at all times. Any equipment found to be inaccurate (beyond allowable tolerances) or defective shall immediately be repaired or removed from the work site by the Contractor.

C. Contractor shall establish three reference points at the Eastside Area and an additional three reference points at the CAMU area for project control by QA/QC Survey.

PART 2 – PRODUCTS

[Not Used]

PART 3 – EXECUTION

3.01 FIELD SURVEYS

A. Field Surveys, at a minimum, shall be performed:

1. initially before any soil disturbance at the CAMU and Eastside,

2. for verification of the final surface at the CAMU Detention Basin and Equilizer Basin,

3. for verification of subgrade, base grade, and final finish grades of East and West CAMU Drainage Channels,

4. for as-built conditions of CAMU Storm Drain

5. for verification of excavated surfaces at Eastside,

6. after slit trench excavations, prior to backfilling,

7. each successive excavated surface that needs to be excavated after conformance sampling,

8. phased liner subgrade at CAMU,

9. for as-built conditions of installed geomembrane showing panel corners, and the location of all recorded defects and repairs,

10. interim waste surface, monthly, at CAMU,

11. final waste surface at CAMU,

12. final interim cover surface,

13. final geosynthetic CAMU and North and South BMI Landfill cover subgrade,

14. final cover surfaces at CAMU and North and South BMI Landfills, and

15. final condition of all site areas disturbed.

B. Electronic survey data submittals shall consist of the following:

1. Hard copy printouts from survey data collector with observations and position of points showing coordinates and elevations.

2. Copy of field books used during data collection.

3. Electronic file of all points used in volume calculations in ASCI format.

4. Electronic files of all drawings in AutoCAD, 2007 format or better, or in a DXF format that can be converted to AutoCAD.

5. Electronic files shall be delivered to the Construction Manager on compact disk.

6. Hard copies of all drawings, cross-sections, and other information generated during survey data collection, including drawings that show control points used for each survey.

C. The Contractor shall utilize 50 foot by 50 foot design grid system provided by Construction Manager during construction. ~~Construction Manager shall provide additional points for visible grade changes and at other significant locations that are not located on the grid system.~~ All initial surveys and grade changes will be based on this grid system. The design grades shall be verified based on this system.

D. Data gathered from incremental surveys performed of a respective surface (liner subgrade, Eastside remediated surfaces, final waste surface at CAMU, etc.) shall be combined and coordinated into a single cumulative composite drawing file that presents the entire surface as it is incrementally developed.

E. The Contractor shall establish the final grade for backfill work by resurveying and staking the grid system points. The Contractor survey work shall demonstrate that drainage patterns have not changed, unless changes were specifically authorized by the Construction Manager. Where it is practical, the Contractor may propose alternate methods for establishing original and final grades within small excavation areas. Such alternate methods shall be approved by the Construction Manager prior to commencing the survey.

F. Horizontal coordinates shall be within ±1.0 ft and vertical locations shall be within ± 0.1 ft.

DRAFT

G. The Contractor shall conduct such other surveys as are required to calculate payment quantities, document completion of a phase of excavation or backfill, or other documentation required for a complete record of Project activities and actions.

H. The Construction Manager may at any time use line and grade points and markers established by the Contractor. The Contractor's surveys are a part of the work and may be checked by the Construction Manager. The Contractor shall be responsible for any lines, grades, or measurements which do not comply with specified or proper tolerances, or that are otherwise defective, and for any resultant defects in the work. The Contractor shall be required to conduct resurveys or check surveys to correct errors.

I. The Contractor shall establish lines and grades necessary to control the work, and shall be responsible for measurements for execution of the work prescribed in these specifications or on the drawings. The Contractor shall establish, place, and replace stakes, markers, and other monuments for survey control, interim checks, and guidance of construction operation.

J. The Contractor shall provide all materials and equipment for performing survey work, including, but not limited to instruments, stakes, spikes, steel pins, templates, and tools. Except for material that is to be incorporated in the work or left in place, all such materials and equipment shall remain property of the Contractor.

K. Before commencing any layout of work and surveys, the Contractor shall provide written notice to the Construction Manager so the Construction Manager may witness or independently check such work.

L. Prior to commencing excavation on existing ditch lines, and/or culverts planned for removal and replacement, a survey of existing features shall be performed by the Contractor. The survey shall be used as a control to establish the ditch/culvert alignment during reconstruction. The survey shall be sufficiently accurate to allow reinstalled and/or replacement ditches, or culverts to perform in a manner that is hydraulically equivalent to the original ditches, or culverts.

M. On a monthly basis, the Contractor shall provide survey data to the Construction Manager on the excavation and backfill production during the previous month.

N. Copies of all surveying notes and drawings prepared by the Construction Manager for verification of Contractor surveys shall be made available to the Contractor, when requested.

O. The Contractor shall secure all field measurements required for proper and accurate fabrication and installation of the work included in this Contract. Exact measurements are the Contractor's responsibility. The Contractor shall furnish or obtain all templates, patterns, and setting instructions required for the installation of all work. All dimensions shall be verified by the Contractor by survey in the field.

P. Unless otherwise stated in these Specifications, or by Construction Manager approval, tolerances in layout of work shall not exceed the following:

TYPE OF LINE OR MARK	HORIZONTAL POSITION	ELEVATION
Permanent reference points	1 in 10,000	± 0.02 ft.
Reference points for general excavation and earthwork	1 in 2,000	± 0.10 ft.

Q. The Construction Manager shall perform sufficient field surveys to verify that the Contractor's field survey work is within acceptable tolerances and accurately depicts requirements of the drawings and these specifications. In the event that the Construction Manager's survey differs from the Contractor's survey, the Construction Manager's survey shall govern.

R. The use of aerial survey for quantity determination shall not be allowed on this Project. All survey work shall be performed with land survey methods that have been approved by the Construction Manager.

PART 4 – MEASUREMENT AND PAYMENT

4.01 GENERAL

A. No separate measurement or payment shall be made for requirements of this section. Full compensation for conforming to such requirements shall be included in the price bid for Bid Schedule Items of Work and no additional compensation shall be allowed.

[END OF SECTION]

DRAFT

SECTION 01100

PROJECT MEETINGS AND PROCEDURES

PART 1 – GENERAL

1.01 SCOPE

A. This section covers preconstruction meeting, project meetings, regulatory oversight, community relations, site security, permits, final inspection, and project record documents

1.02 RELATED SECTIONS

Section 01010—Summary of Work

Section 01050—Field Engineering

Section 01300—Submittals

Section 01560 – Temporary Controls

1.03 REFERENCES

A. Geosyntec, 2007. "Revised Remedial Action Plan (RAP) Permit Application for Corrective Action Management Unit (CAMU), Henderson, Nevada," Prepared for Basic Remediation Company, Submitted to Nevada Department of Environmental Protection, March.

B. Basic Remediation Company (BRC), 2006, "Community Involvement Plan (CIP)," November.

C. BRC, 2006. "Corrective Action Plan (CAP) For The Basic Remediation Company (BRC) Common Areas Remediation Project," September.

D. BRC, 2005. "Perimeter Air Monitoring Plan For Soil Remediation Activities BMI Upper and Lower Ponds and Ditches, Clark County, Nevada," April

E. Clark County Department of Comprehensive Planning and U.S. Fish and Wildlife Service, 2000, "Clark County Multiple Species Habitat Conservation Plan (CCMSHCP)," September.

1.04 SUBMITTALS

A. Comply with pertinent provisions of Section 01300, "Submittals"

B. The following shall be submitted prior to issuance of Notice to Proceed:

1. Site Security Plan: The Site Security Plan shall describe the type and number of personnel and the system to be used to ensure that access to the site is restricted to authorized personnel only. The Construction Manager shall review the Plan and return it to the Contractor with comments or approval 5 days after receiving the Plan. The Contractor shall obtain Site Security Plan approval from the Construction Manager prior to beginning any work at the site.

2. Storm Water Pollution Prevention Plan

C. The Contractor shall submit the following to the Construction Manager daily:

1. Progress Reports

2. Inspection Checklists

DRAFT

D. The Contractor shall submit weekly inspection reports to the Construction Manager

E. The Contractor shall submit the following to the Construction Manager monthly:

1. Status Report

2. Inspection Checklist

F. The Contractor shall submit monthly inspection reports to the Construction Manager

G. Within 24-hours after a storm event, the Contractor shall submit to the Construction Manager a post-storm inspection checklist

H. The Contractor shall submit to the Construction Manager incident reports as needed within 24-hours of the incident occurance.

I. Job Set of Project Record Documents

J. If the Work discussed in these Specifications is interrupted for reasons other than inclement weather, the Contractor shall notify the in writing Construction Manager a minimum of 24 hours prior to the resumption of Work.

PART 2 – PRODUCTS

2.01 NOT USED

PART 3 – EXECUTION

3.01 PRECONSTRUCTION MEETINGS

A. Construction Manager shall arrange a preconstruction meeting with the Contractor within 21 days of notice of award and before receipt of Notice to Proceed (NTP). The preconstruction meeting shall be required prior to issuing NTP.

B. Authorized representatives of the Contractor, including the Bid Preparer, Project Manager, and On-Site Superintendent shall attend the preconstruction meeting.

C. Data shall be distributed and/or discussed as necessary by the Construction Manager or Contractor as appropriate. The Project site shall be toured with the Contractor representative present, and at the least, the following items shall be addressed.

1. Organizational arrangement of the forces and personnel, and those of the Contractor, the material and equipment suppliers, Subcontractors, and the Construction Manager.

2. Procedures and protocol for Project communication.

3. Contractor's mobilization schedule. The Contractor shall discuss how equipment, personnel, materials, etc., are to be mobilized throughout this Project and the effects of mobilization on the construction schedule.

4. Construction schedule, work hours, planned overtime, and sequence of work.

5. A narrative of the Contractor's general method of approach for each sequence of the work.

6. Processing of shop drawings, submittals, and other data for Construction Manager for review.

7. Procedures for Field Directives and Change Orders.

DRAFT

8. Rules and regulations governing performance of the work.

9. Training requirements.

10. Procedures for safety and first aid, security, quality control, housekeeping, and related matters.

11. Work quantity measurement and payment request procedures.

3.02 PROJECT MEETINGS

A. Weekly construction progress meetings shall be conducted between the Construction Manager and Contractor. The Contractor's Project Manager shall attend these construction meetings. The meeting shall be conducted at the Project support facilities area and the time shall be coordinated between the Construction Manager and Contractor.

B. At a minimum, the following items shall be discussed at the weekly meetings.

1. Review of applicable specifications.

2. Review of safety issues.

3. Required equipment and personnel.

4. Weekly progress and production.

5. Two-week look-ahead schedule.

C. Major Construction Activity meetings shall be conducted between the Construction Manager and Contractor prior to starting each general sequence of construction. Meetings will be conducted prior to each of the following major construction activities

1. Storm water collection system

2. CAMU excavation and embankment placement

3. Liner system installation

4. Remedial waste excavation and transport and filling

5. Slit Trench excavation

6. Cover installation

These meetings may be combined with other Project meetings with the mutual consent of the Construction Manager and Contractor. The intent of these meetings is to review and discuss specification requirements for that particular construction activity. A "dry run" walkthrough of major process may be required prior to starting each sequence, if deemed appropriate by the Construction Manager. The meetings shall assess, as examples

1. Specification Requirements

2. Adequacy of planning and procedures.

3. Availability of equipment, personnel, and materials.

4. Safety, emergency preparedness, and hazard analysis.

5. Regulatory compliance.

DRAFT

The results of these meetings shall be formally documented by the Construction Manager and the applicable portions shall be provided to the Contractor. The Contractor shall address any identified concerns prior to the start of the reviewed work activity.

D. Plan of the Day (POD) Meetings: The Construction Manager shall hold daily planning meeting that will not exceed 1 hour. Daily planning meetings shall be attended by the Contractor's Project Manager, Operations Superintendent, Project Engineer, and Health and Safety Manager. The Quality Assurance Manager attendance at the POD meetings is optional. The Contractor shall provide a list of all activities planned for the next day. If changes to the daily plan are necessary, the Contractor shall verbally notify the Construction Manager Project Manager as soon as need for the change is identified by the Contractor. The intent of the meeting will be to discuss issues, concerns, and resolutions encountered during the day and the work plan for the next day.

E. Problem or Work Deficiency Meetings: A special meeting shall be held when and if a problem or deficiency is present or likely to occur. The meeting shall be attended by the Contractor, the Construction Manager, the CQA Site Manager, and other parties as appropriate.

3.03 PROJECT REPORTING AND RECORDKEEPING

A. The Contractor shall provide the following records to the Construction Manager daily:

1. Daily progress reports documenting daily construction activities. Records include:

   a. Date, Project Name, Location, and other Identification;

   b. Summary of weather conditions;

   c. Summary of construction location(s) and activities;

   d. Daily production records;

   e. Equipment and personnel on the project; and

   f. Meeting summary and attendance record.

2. Inspection Checklist documenting: health and safety, haul roads, surface and storm water, waste placement, security, equipment.

B. The Contractor shall provide inspection checklists to the Construction Manager weekly:

C. The Contractor shall provide the following records to the Construction Manager monthly:

1. Inspection Checklist documenting: health and safety, haul roads, surface and storm water, waste placement, security, equipment.

2. Monthly status report summarizing:

   a. Significant milestones in construction;

   b. Completed milestones in construction;

   c. Estimated volumes of soil excavation, engineered fill, waste excavation and disposal or placement in CAMU, operations layer, interim cover, and final cover;

   d. Estimated quantity of liner system components delivered to the project and/or installed.

D. The Contractor shall provide inspection checklists to the Construction Manager quarterly:

E. The Contractor shall provide the following record to the Construction Manager post-storm:

DRAFT

1. Inspection Checklist documenting: health and safety, haul roads, surface and storm water.

F. The Contractor shall provide incident reports to the Construction Manager as-needed. Incident reports shall summarize all incidents of: injury, fire, shut down, and/or hazardous or toxic Materials Release. The summary report shall include:

a. Date, time, and type of incident;

b. Name and quantity of material(s) involved;

c. Assessment of actual or potential hazards to human health or the environment, where applicable; and

d. Estimated quantity and disposition of recovered material that resulted from the incident.

G. The Contractor shall maintain all personnel records onsite and shall make records available to Construction Manager upon request. Records include:

1. Name of the employee filling each position

2. A written job description including: requisite skill, education, or other qualifications

3. Assigned duties of employee

4. Description of training

5. Records documenting completion of training.

3.04 REGULATORY OVERSIGHT

A. Authorized agents of the Nevada Department of Environmental Protection (NDEP), Nevada Department of Transportation (NDOT), Clark County, the City of Henerson, and other agencies designated by the Construction Manager shall have right of access to inspect the work covered by the Contract documents during the performance of this Contract. These inspections shall be performed in conjunction with an inspection by the Construction Manager. The Construction Manager shall coordinate inspections with the Contractor.

3.05 COMMUNITY RELATIONS

A. BRC has developed a Community Involvement Plan (CIP) that shall be made available to the Contractor. The Contractor is expected to facilitate relations with the community to the extent possible during the duration of the Project. The Contractor shall encourage employee participation in community activities, encourage relocation to the community during the Project, and discourage problematic employee behavior. The Contractor shall direct public inquiries to the Construction Manager and shall provide information necessary to respond to public inquiries as requested by the Construction Manager.

3.06 ENDANGERED SPECIES

A. In accordance with the CCMSHCP and the RAP, the Contractor shall contact the City of Henderson if a desert tortoise (gopherus agassizii) is encountered at the BMI Common Areas during construction.

B. The Contractor shall protect any desert tortoises encountered on Site until the City of Henderson is available to relocate the tortoise off site.

DRAFT

3.07 SITE SECURITY

A. The Contractor shall protect the work and control the site for the duration of the Project, except that control of the project site shall not become the responsibility of the Contractor until the effective date of the Notice to Proceed. Site security, including manned patrols during non-work hours, shall be maintained 24 hours per day, 7 days per week, including shutdown periods.

B. The Contractor shall submit a Site Security Plan. The Contractor shall identify a primary representative and an alternate representative responsible for day-to-day functions associated with site security. This plan shall be in accordance with the following minimum security requirements outlined in the CAP and RAP for the Eastside and CAMU areas, respectively:

1. Eastside:

   a. Security shall be 24 hours/day, 7 days a week

   b. Continuously manned guard station shall be established at site entrance

   c. Gates shall be kept locked except for periods of continuous ingress/egress

   d. Fences shall be installed and maintained around exclusion zones

   e. Visitors shall use sign in/sign out log

   f. Visitors shall not be allowed in exclusion zone.

2. CAMU:

   a. Contractor shall establish 24 hours/day, 7 days/week security either with full-time on-site personnel during non manned hours or using remote video equipment

   b. Contractor shall provide continuously manned guard station at site entrance during working hours.

   c. Contractor shall be responsible for daily policing of site perimeter

   d. Contractor shall establish continuously manned guard station at CAMU entrance

   e. Gates shall be kept locked except for periods of continuous ingress/egress

   f. Fences shall be installed and maintained around site perimeter.

   g. Contractor shall report any security problems to the Construction Manager

C. Communication: Security guards shall have mobile phones and two-way radios as specified in Section 01500.

D. Exterior Fence Signage:

1. Owner will install and maintain signs for exterior fences at Eastside Area.

2. Contractor shall install and maintain “Danger. Construction Area. No Trespassing” bilingual signs at 100 foot intervals along the CAMU perimeter fence. Signs shall be 18 inch x 12 inch aluminum with red or black l-inch lettering.

E. Visitor Access: See Section 01560, Subpart 1.06 Access Control

DRAFT

3.08 STORM WATER POLLUTION PREVENTION PLAN

A. The Contractor shall develop Storm Water Pollution Prevention Plan(s) (SWPPP) in accordance with the requirements of the Nevada Water Quality Act for all areas where work shall be taking place. The Contractor may divide the site into manageable units and submit a separate SWPPP for each unit. For the BRC Properties, the SWPPP shall be developed to show pollution prevention measures to be applied at various stages of excavation and backfill and measures to be applied after completion of excavation and backfill. The Contractor may not disturb any area until the pertinent SWPPP is accepted by the Construction Manager and the BMP's identified in the SWPPP have been installed.

B. All SWPPPs prepared by the Contractor must incorporate the following performance requirements:

1. During the Contract performance period, the Contractor shall prevent storm-water runoff from leaving contaminated areas of the Project site. Under no circumstances shall runoff water be allowed to flow from a contaminated area to an uncontaminated or previously decontaminated area. The Contractor shall construct and maintain temporary storm-water pollution-control measures as necessary throughout the duration of the Project.

2. Storm-water runoff shall include runoff water from any source. The Contractor is responsible for controlling storm-water runoff and erosion for all other areas disturbed under this Contract. Temporary erosion-control provisions shall be coordinated with permanent erosion-control features, if any, to the extent practical to assure economical, effective, and continuous erosion control throughout construction.

3. Storm-water pollution and erosion control measures may include, but are not limited to, berms, dams, ditches, sediment/water retention basins, fiber mats, netting, gravel, mulches, grasses, slope drains, silt fences, and other methods as appropriate. Pumping water to runoff water control facilities is also an option. Water removed from contaminated excavations or collected as leachate shall be considered to be contaminated material and shall be used for dust control of contaminated areas.

4. Contractor shall conduct storm water system inspections, at a minimum, after every storm exceeding ½ inch in 24 hours. Storm water conveyance system shall be inspected quarterly during the dry season and weekly during the wet season. Conveyance system shall be inspected for sediment and debris build-up and scour or other damage.

3.09 FINAL INSPECTION

A. At the completion of this Project, the Contractor representative shall attend the final inspection to document any deficiencies in the completed Project. A Notice of Final Completion Inspection form shall be completed by the Construction Manager, with one copy delivered to the Contractor in accordance with the Terms and Conditions.

B. The Contractor may request an inspection of work items at the time of completion, but these items shall be inspected again during the final inspection to verify compliance with the Contract.

C. The Contractor shall schedule all inspections with the Construction Manager.

3.10 PROJECT RECORD DOCUMENTS

A. Promptly following receipt of the Notice to Proceed, the Contractor shall secure from the Construction Manager, at no charge to the Contractor, ten sets of full-size drawings and specifications. Throughout progress of the Project, the Contractor shall maintain a neat, current, and accurate record of the as-built status of the Project on the job set of the Project record documents. Two sets of the full-size drawings shall be used to record as-built survey data only.

The drawings and these specifications are the Project record documents. As-built documents shall include documentation of all deviations from the original or revised drawings and these specifications.

B. Upon receipt of the job set, identify each of the documents with the title, "RECORD DOCUMENTS—JOB SET."

C. Store Record Documents separate from documents used for construction.

D. Record information concurrent with construction progress.

E. Contractor shall maintain on site, one set of the following record documents and record actual revisions to the Work.

1. Drawings.

2. Specifications.

3. Addenda.

4. Change Orders and other Modifications to the Contract.

5. Reviewed Shop Drawings, product data, and samples.

F. The Contractor shall thoroughly document changes on each page of the specifications and each sheet of drawings and other documents where such entry is required to show all changes. Documentation shall include the Change Order number as appropriate and shall be initialed and dated by the individual making the entry.

G. Make entries within 24 hours after receipt of information that a change has occurred.

H. Project record document entries shall be made using terminology and drafting standards that match those used in the Contract documents. Deviations from standards, if required, shall be noted on glossaries, legends, or other appropriate lists of definitions included in the Project record documents for that work.

I. Record Documents and Shop Drawings: Legibly mark each item to record actual construction including:

1. Measured horizontal and vertical location of underground utilities and appurtenances referenced to permanent surface features.

2. Measured locations of internal utilities and appurtenances concealed in construction, referenced to visible, accessible, and permanent features of the Work.

3. Field changes of dimension and detail.

4. Details not shown on original Construction Drawings.

5. Making entries on drawings

a. Use an erasable colored pencil (not ink or indelible pencil) and clearly describe the change by graphic line and note.

b. Date and initial all entries.

c. Call attention to the entry by a "cloud" drawn around the area or areas affected and reference the Change Order number as appropriate.

DRAFT

d. In the event of overlapping changes, use a different color for each overlapping changes.

J. Specifications: Legibly mark and record at each product Section a description of actual products installed, including the following:

1. Manufacturer's name and product model and number.

2. Product substitutions or alternates utilized.

3. Changes made by Addenda and Modifications.

K. Following the completion of each phase cell liner and leachate collection system construction, the Contractor shall provide to the Construction Manager the set of as-built Project record documents for the completed liner and leachate collection system.

L. Contract drawings and Specifications shall submitted to the Construction Manager at completion of the work in accordance with Section this section. The requirements for submitting as-built survey data shall not relieve the Contractor in any way from the Contractor's responsibility to conform to the requirements of the work.

M. As-built Project Record Documents

1. The Contractor shall provide surveying services to document as-built conditions for completed work. The Contractor shall provide survey data to confirm that as-built locations of the work conform to the drawings where coordinates and/or elevations are shown. Where the drawings or specifications permit variable locations or detail for specific items of work, the Contractor shall survey the as-built locations or details. Surveys shall be sufficient to define the features or details at any given location.

2. Submit the job set of as-built Project record documents to the Construction Manager after Construction Manager acceptance of the work. Construction Manager acceptance of the as-built documents is required before any release of payment retainage shall be allowed.

3. Verification of as-built locations shall be performed by Owner based on control points.

PART 4 – MEASUREMENT AND PAYMENT

4.01 GENERAL

A. No separate measurement or payment shall be made for requirements of this section. Full compensation for conforming to such requirements shall be included in the price bid for Bid Schedule Items of Work and no additional compensation shall be allowed.

[END OF SECTION]

DRAFT

SECTION 01110
HEALTH AND SAFETY REQUIREMENTS

PART 1 – GENERAL

1.01 DESCRIPTION OF WORK

A. This section describes the Project health and safety requirements. All work performed shall be conducted in accordance with safety and health regulations promulgated by the Federal and State Occupational Safety and Health Administration (OSHA), Subcontract documents, and other Federal, State, and local agencies.

B. The Contractor shall protect the health and safety of Contractor employees, visitors, and the public; prevent damage to property, materials, supplies, and equipment; and avoid work interruptions.

1.02 RELATED SECTIONS

Section 01010 – Scope of Work

Section 01560 – Temporary Controls

Section 02200 – Earthwork

Section 02205 – Remedial Excavation and Filling

1.03 REFERENCES

A. American National Standards Institute (ANSI)

1. ANSI Z88.2 Practices for Respiratory Protection
2. ANSI Z89.1 Safety Requirements for Industrial Head Protection
3. ANSI Z41.1-75 Men's Safety Toe Footwear

B. Code of Federal Regulations (CFR)

1. 29 CFR Labor

1.04 SUBMITTALS

A. The Contractor shall submit a Health and Safety Plan to the Construction Manager prior to Notice to Proceed. The Construction Manager shall review the Plan and forward any questions to the Contractor, within 14 days of receipt, but shall not approve the Plan.

B. Contractor shall submit to Construction Manager resumes for on-site Safety Officer and on-site Safety Technicians.

PART 2 – PRODUCTS

[Not Used]

DRAFT

PART 3 – EXECUTION

3.01 GENERAL REQUIREMENTS

A. The Contractor shall not conduct any work at the site, including mobilization, until Construction Manager has reviewed the Contractor's Health and Safety Plan.

B. The Contractor shall conduct daily health and safety tailgate meetings and record those in attendance.

C. The Contractor shall conduct quarterly site specific health and safety meetings to review site specific hazards and incidents of the past quarter.

D. The Contractor shall maintain and regularly update a site map showing active areas of remediation with exclusion, decontamination, and support zones clearly indicated. Map shall be posted in work area and include general wind direction, evacuation routes, refuge locations, and hospital route.

E. The Contractor shall maintain on site all training records of employees. Training records shall be made available to Construction Manager upon request.

F. The Contractor shall maintain records of analytical reports and monitoring data, provided by the Construction Manager or obtained by the Contractor, that document potential health hazards to employees. The Construction Manager will supply monitoring data as required by Federal, State, and local regulations or upon Contractor request.

G. The Contractor shall provide appropriate safety barricades, signs, and signal lights in accordance with 29 CFR 1926 Subpart G, and 29 CFR 1910.144.

H. Safety Inspections

1. The Contractor shall conduct and document daily inspections and maintenance of personal protective equipment (PPE). The Contractor shall replace defective PPE promptly to avoid hazardous Project site conditions and practices.

2. The Contractor shall conduct and document daily inspections of the job site, materials, and equipment for unsafe conditions or practices. Corrective action shall be taken promptly to avoid hazardous Project site conditions and practices.

3. The Contractor shall perform initial safety inspections of vehicles, heavy equipment, and materials prior to commencement of work. Vehicles, heavy equipment, or materials that do not meet Federal OSHA standards shall not be used on site unless approved by the Construction Manager.

4. A minimum of one full time, qualified safety officer and one safety technician shall be on-site during all work activities. An on-site safety officer shall be appointed to oversee the performance of the safety engineers. Qualifications should include a B.S. degree in safety engineering or certification by the Board of Certified Safety Professionals. Equivalent experience may be acceptable at the discretion of the Contractor. During waste excavation and placement activities, a minimum of two full time qualified safety officers and two safety technicians shall be on site during all work activities.

I. Occupational Medical Examination: Prior to work on the site, Contractor and subcontractor personnel assigned to work on a hazardous substance site shall have a medical examination that meets the requirements addressed in 29 CFR 1910.120. The examination shall include, as appropriate, a medical screening for the use of respiratory protective devices and asbestos abatement. Subsequent annual physical examinations are required.

DRAFT

1. Records of all employee physicals and heavy metals sampling, where required, shall be maintained on site by the Contractor. The records shall be made available, at the Construction Manager's request, for review by the Construction Manager.

2. Contractor and subcontractors' personnel entering the site may be required to provide heavy metal baseline sample information prior to start of employment on the site and at the start of each construction season, as directed by the Construction Manager. The Contractor shall provide to the Construction Manager results of each baseline sample analysis, signed by the physician. The results of the baseline analysis shall be submitted to the Construction Manager prior to the Construction Manager authorizing entry to the site. Each person may be required to provide the heavy metals sampling results at the end of each construction season, at termination of employee's work on site, or after completion of the Project, whichever comes first, as directed by the Construction Manager.

3.02 HEALTH AND SAFETY PROGRAM AND PLAN

A. The Contractor shall have a written Health and Safety Program that complies with all applicable OSHA regulations prior to commencement of work. Certification of such program shall be submitted to the Construction Manager

B. One site-specific Health and Safety Plan (HASP) shall be developed by the Contractor. The Contractor shall maintain and distribute the HASP. This HASP shall meet OSHA requirements contained in 29 CFR 1910.120 and be prepared and signed by a certified industrial hygenist.

C. The HASP shall include the following at a minimum:

1. Site location and description
2. Scope of work
3. Project team and organization
4. Unique issues and concerns
5. Contaminants or conditions of concern
6. Personal Protective Equipment (PPE)
7. Exposure assessment and air monitoring
8. Activity hazard analysis
9. Emergency assistance network
10. General health and safety procedures for waste operations
    a. Injury and illness prevention
    b. Health and safety organization
    c. Personnel training
    d. Medical surveillance
    e. PPE
    f. Site controls
    g. Personal and equipment decontamination

DRAFT

h. Emergency response plan

i. Documentation

j. Thermal stress and severe weather

k. General contaminate of concern information

l. Biological hazards

m. Standard operating procedures

n. Common physical hazards and controls

11. The following figures, at a minimum, shall be included:

a. Site location

b. Hospital route

c. Sample protective equipment ensembles

d. Diagram of site work zones

12. The following tables, at a minimum, shall be included:

a. Occupational health exposure and toxicological properties for contaminants of occupational health concern

b. Activity hazard analysis form

c. Emergency supplies

d. Typical level D, C, and B decontamination approach

D. The HASP shall also address the chemicals brought onsite by the Contractor for the Project. The HASP shall reference the MSDS binders.

E. Employee Termination

1. Notification of Employee Termination: The Contractor shall provide to the Construction Manager, within 5 days of termination a list of employees who have entered the BMI Common Areas and are terminated from employment at the Project. This requirement includes employees of subcontractors. Termination physicals are required in accordance with 29 CFR 1910.120 for hazardous waste site workers if a physical has not been performed within the last 6 months prior to termination.

2. An exit physical examination that meets the requirements addressed in 29 CFR 1910.120 shall be conducted at termination, which is defined as termination of employee's work on site or completion of the Project, whichever comes first.

F. A Spill Prevention and Response Plan shall be contained within the site-specific HASP. The Spill Response Plan shall be maintained in the cab of each haul vehicle.

G. Consequences of Noncompliance

1. Failure of a worker to comply with the health and safety requirements shall be considered ample cause for suspension by the Contractor, pending correction of the problem. Suspension shall be at the Contractor's expense.

2. Repeated or serious violations of health and safety rules and/or requirements by a worker shall be cause to restrict or disqualify the worker from further on-site work. This requirement is at the discretion of the Construction Manager after review of documentation of violations and shall be enforced by the Contractor. Such violations by any Contractor or subcontractor personnel may result in further actions by the Construction Manager up to and including Subcontract Termination for Default in accordance with the Terms and Conditions.

H. The Contractor shall permit only those employees qualified by training and/or experience to operate equipment and machinery. Records of such qualification shall be maintained on site by the Contractor and made available for review upon request by the Construction Manager.

3.03 TRAINING REQUIREMENTS

1. All on-site personnel (except administrative staff):

   a. 40 hour OSHA HAZWOPER training meeting 29 CFR 1910

   b. 8 hour OSHA Refresher training meeting 29 CFR 1910

   c. Respirator Fit Test

2. All on-site supervisors:

   a. 8 hour OSHA Supervisor training meeting 29 CFR 1910

   b. Red Cross First Aid and CPR training

3. Contractor shall provide quarterly on-the-job fire training.

3.04 CONTAMINATION CONTROL AND MONITORING

A. Personal Protective Equipment

1. The Contractor shall supply personal protective equipment (PPE) based on the requirements in the site-specific HASP.

2. PPE shall be supplied and maintained by the Contractor for use by all visitors, Construction Manager, Owner, Owner's consultants, Contractor, and subcontractor personnel for the duration of the Contract.

3. All safety equipment required by OSHA standards shall be provided and maintained by the Contractor except as specifically noted to be the responsibility of others.

B. Personal and Area Monitoring

1. Owner shall perform perimeter and breathing zone air monitoring for the entire site.

2. Owner shall perform breathing zone monitoring for total organic vapor and dust every 30 minutes during excavation.

3. Owner will conduct perimeter air monitoring during remediation activities. Perimeter air monitoring shall involve continuous MIE Data RAM sampling and GilAir sampling pumps during excavation and waste placement.

4. Personal air monitoring shall be required if breathing and work zone monitoring indicates health and safety problems. The Contractor shall be responsible for personal air monitoring and shall be in accordance with the following:

a. The Monitoring and Sampling Program shall be in compliance with 29 CFR 1910 and 1926 requirements.

b. Contractor personal air monitoring data shall be made available to the Construction Manager by the Contractor.

c. The Construction Manager will review the Contractor's monitoring and sampling program and monitoring and sampling results to check the adequacy of controls and to ensure adequate protection of workers, the environment, and the public.

5. Any monitoring data obtained by the Construction Manager throughout the course of work activities performed by the Contractor shall be made available to the Contractor upon initiation of a formal request for this information.

6. Any tampering with monitoring equipment shall be cause for suspension of affected work, and shall be cause for termination of any employee involved in the tampering.

C. Work Clothing: Adequate levels of protection for personnel on the Project site shall be identified by task in the site-specific HASP. Clothing such as tank tops, shirts cut off at the midriff, cutoff pants, moon boots, sandals, sneakers, and jogging shoes are considered unacceptable dress and will not be permitted.

1. In general, work clothing should consist of the following:

a. Full-length trousers/slacks/jeans in good condition.

b. Sturdy work shoes, boots, or other footwear meeting the requirements of ANSI Standards Z41.1-75.

c. Shirts that cover the shoulders, with sleeves at least T-shirt length.

d. Hard hats that meet the requirements of ANSI Standard Z-89.1.

2. Orange safety vests or "hunter orange" colored shirts shall be worn at all times. Exception may be granted by the Construction Manager.

3. When PPE coveralls are required, a worker may wear modesty clothing under the coveralls in lieu of items 1.a and 1.c above (e.g., undershirts, smocks, swim shorts, shorts, leggings). Modesty clothing shall be provided by the Contractor.

D. Exclusion Zones: All active excavation areas are considered to be restricted for the purposes of access control. The following requirements shall be enforced by the Contractor in these areas from the time that construction begins until the area is cleared for general access or verified uncontaminated by the Construction Manager.

1. Access-Control Points: Access to exclusion zones shall be controlled through a designated Access-Control Point. Workers leaving the exclusion zone shall be monitored by Contractor Personnel for contamination. If contamination is found, workers will be required to perform decontamination activities. Such decontamination shall be directed by the Contractor’s safety professional. Install and maintain access-control fencing as shown on the drawings. Establish an Access-Control Point and maintain access-control fencing until conformance sampling results indicate remediation is complete.

2. The Contractor shall restrict unescorted access to trained personnel.

3. Workers who willfully fail to follow the established health and safety procedures will be disqualified and restricted from the exclusion zone. Retraining at the Contractor's expense, as a minimum, shall be necessary to regain qualification.

4. The Contractor shall take full responsibility for any Contractor, subcontractor, supplier, vendor, and other contractor-related employees who violate any safety rule.

5. Exclusion zones shall have a 5 foot temporary boundary fence surrounding all excavations.

E. Support Zones: All areas that do not contain hazardous substances shall be considered uncontrolled areas. The Contractor shall be responsible for general site security requirements in uncontrolled areas, but is not required to provide access control in these areas in addition to overall site access control. Areas that have been remediated and verified clean may be reclassified as uncontrolled areas.

3.05 GENERAL HAZARD REQUIREMENTS

A. The site-specific HASP shall identify hazards and controls including hazards of using contaminated water for dust control and the recycling of decontamination water.

B. The Contractor is responsible for inspecting the site before and during construction activities to identify hazards, and shall take all necessary actions to protect the workers, the environment, and the general public against such known hazards. The Contractor shall notify the Construction Manager immediately of any previously unidentified hazards, and of any accidents, injuries, or illness that have occurred. Newly identified hazards shall be discussed during the daily health and safety tailgate meeting.

C. Buried Utility Lines: Underground utilities (abandoned and active) may be encountered during the performance of the Project. Overhead utilities may be located over work areas. Utilities known or suspected by the Contractor are shown on the drawings. Refer to Section 01010, "Summary of Work," for requirements for Contractor utility location, protection, and replacement.

1. Manually excavate active utility lines shown on the drawings. Notify the local utility company if:

   a. The line is not found within 18 inches of the estimated depth at the marked position;

   b. There is evidence of leaks in utility lines (Do not disturb this ground further until after the responsible utility and the Construction Manager have been notified and the Construction Manager authorizes further work in this area.);

   c. The line has been nicked, cut, or damaged in any way; or

   d. The corrosion-protection tape on a steel line has been nicked.

2. The following actions shall be taken if there is a strong odor of gas or a line is broken:

   a. Remove the equipment bucket from the immediate vicinity of the break.

   b. ***Do Not*** move the equipment. Shut off equipment. Do not restart any vehicles in the area.

   c. Leave the area immediately.

   d. Notify the local utility company or the local Fire Department if there is no answer at the utility company. Give the following information: your name, location of incident, nature of incident, and type or color of pipe damaged (if known).

   e. Secure the area to prevent access by anyone except the utility company.

   f. Do not attempt to repair or stop the gas flow.

DRAFT

3. Notify the Construction Manager immediately of any utility damage and any suspicious odors or soil discolorations encountered during the work.

D. Industrial Hygiene/Chemicals Concerns

1. Noise Limitations

a. Noise level restrictions as specified in Section 01560 and as measured from the property line, shall supersede noise restrictions discussed in this section.

b. Construction equipment, including trucks, shall not exceed 85 dB(A) at 50 feet for a stationary noise limit per 40 CFR 202.21.

c. Noise surveys shall be conducted by the Contractor on equipment.

d. Hearing protection shall be provided by the Contractor and shall be worn when noise levels exceed 85 dB(A). Hearing protection shall be made available to all employees whose noise exposure may exceed an 82-dB(A) 8-hour time-weighted average (TWA). The Construction Manager may monitor the Contractor's equipment and on-site personnel. This monitoring shall be considered incidental to the Contract.

e. The Contractor shall institute a hearing conservation program for its employees per 29 CFR 1910.95.

2. The Contractor shall maintain MSDSs on site for all chemicals the Contractor brings onto the Project site. Chemicals include, but are not limited to, cements, fuels, lubricants, bleaches, and cleaners. Material Safety Data Sheet (MSDS) books shall be provided by and made available by the Contractor. The books shall be clearly marked and located in the work space or at the Access-Control Point for chemicals used within the exclusion zone. MSDS books stored in equipment or vehicles are not acceptable.

E. Industrial Safety Concerns

1. Refueling: Refueling shall only be permitted in the refueling area as identified in the Fueling Plan.

2. Storage of Combustible Liquids: When storing 5 gallons or more of combustible liquids, or 5 pounds of flammable gas, a 10B fire extinguisher shall be provided by the Contractor within 50 feet of the storage area.

3.06 INCIDENT REPORTING

A. The Contractor shall provide the Construction Manager a report detailing incidents occurring at the Site. The report shall include:

1. Name, address, and telephone number of the operator;

2. Name, address, and telephone number of the site;

3. Date, time, and type of incident;

4. Name and quantity of material(s) involved;

5. Extent of injuries, if any;

6. Assessment of actual or potential hazards to human health or the environment, where applicable; and

7. The estimated quantity and disposition of recovered material that resulted from the incident.

PART 4 – MEASUREMENT AND PAYMENT

4.01 GENERAL

A. Providing for and complying with the requirements set forth in this Section for Health and Safety Requirements shall be incidental to Earthworks, Section 02200, and Remedial Excavation, Section 02205.

B. Providing for and complying with the requirements set forth in this Section for the Health and Safety Plan shall be considered as incidental to Mobilization, Section 01505.

[END OF SECTION]

DRAFT

SECTION 01300
SUBMITTALS

PART 1 – GENERAL

1.01 DESCRIPTION OF WORK

A. This section contains requirements for administrative and work-related submittals such as construction progress schedules, Shop Drawings, test results, operation and maintenance data, and other submittals required by Contract Documents.

B. Submit required materials to the Construction Manager for proper distribution and review in accordance with requirements of the Contract Documents.

1.02 CONSTRUCTION PROJECT SCHEDULES

A. Project Schedules shall be prepared in the form of a horizontal bar chart. The Project Schedule shall include the following items.

1. A separate horizontal bar for each activity. The following shall be included for each activity:

   a. Activity duration

   b. Percent complete

   c. Remaining duration

   d. Early finish

   e. Calendar used.

2. A horizontal time scale, which identifies the first workday of each week.

3. A time scale with spacing to allow space for notations and future revisions.

4. Listings arranged in order of early start for each item of the Work.

5. Critical milestone dates and mandatory construction sequence constraints.

B. The Project Schedule for construction of the Work shall include the following items where applicable.

1. Submittals: dates for beginning and completion of each major element of construction and installation dates for major items. Elements shall include, but not be limited to, the following items which are applicable:

   a. Mobilization schedule

   b. Demobilization schedule.

   c. Major elements for each phase as outline in Section 01010 Subpart 1.02:

   d. Final site clean-up.

   e. Show weekly, as of the first day of each week, anticipated percent of completion for each item..

   f. Show each individual Bid Item with adequate support detail.

C. Schedule Revisions:

1. Weekly to reflect changes in progress of Work.

2. Indicate progress of each activity at submittal date.

3. Show changes occurring since the previous schedule submittal. Changes shall include the following.

   a. Major changes in scope.

   b. Logic changes.

   c. Activities modified since previous submittal such as:

      i. name changes

      ii. duration changes

   d. Revised projections of progress and completion.

   e. Other identifiable changes that affect the projected project completion.

4. Provide a log of changes made to schedule since last version to define:

   a. Problem areas, anticipated delays, and impact on schedule.

   b. Recommended corrective action and its effect.

1.03 DESIGN SUBMITTALS

A. Prepare and submit to the Construction Manager detailed designs and plans for the construction facilities and temporary controls indicated or specified to be designed by the Contractor.

B. Design submittals include:

1. Slit Trench Shoring

2. Excavations deeper than 20 ft bgs

3. Haul Roads

4. Decontamination Pads

5. Debris Storage Area

6. Access Ramp Design

C. Each design submittal shall include:

1. All field, geotechnical, survey, environmental, or other investigations performed to support the design.

2. Descriptions of all design criteria, assumptions, calculations, or other documents that support the basis of the design.

3. Blueline or blackline prints, one reproducible hard copy, and one electronic copy of all drawings. Electronic copies shall be in AutoCAD 2007 format or in a format readily convertible to AutoCAD 2007.

DRAFT

4. Notes on the drawings or specifications that explain construction procedures, methods, and performance criteria.

D. Designs prepared by the Contractor shall bear the seal and signature of a Professional Engineer registered in the State of Nevada.

E. The designs shall be reviewed by the Construction Manager for acceptability based on comparison with the minimum performance criteria set forth in these specifications and on the drawings. The Construction Manager shall forward, within 14 days after receiving the design documentation, any questions related to the design to the Contractor in writing requesting clarification. The Contractor shall respond in writing within five days after receiving the request for clarification from the Construction Manager.

1.04 SHOP DRAWINGS AND SAMPLES

A. Shop Drawings, product data, and samples shall be submitted as required in individual Sections of the Specifications.

B. The Contractor's Responsibilities:

1. Review Shop Drawings, product data, and samples prior to submittal.

2. Determine and verify:

a. Field measurements.

b. Field construction criteria.

c. Catalog numbers and similar data.

d. Conformance with Specifications.

3. Coordinate each submittal with requirements of the Work and Contract Documents.

4. Notify the Construction Manager in writing, at the time of the submittal, of deviations from requirements of Contract Documents.

5. Begin no fabrication or Work pertaining to required submittals until return of the submittals with appropriate approval.

6. Designate dates for submittal and receipt of reviewed Shop Drawings and samples in the construction progress schedule.

C. Submittals shall contain:

1. Date of submittal and dates of previous submittals.

2. Project title and number.

3. Contract identification.

4. Names of:

a. The Contractor.

b. Supplier.

c. Manufacturer.

DRAFT

5. Summary of items contained in the submittal.

6. Identification of the product with identification numbers, and the Drawing and Specification section numbers.

7. Clearly identified field dimensions.

8. Details required on the Drawings and in the Specifications.

9. Manufacturer, model number, dimensions, and clearances, where applicable.

10. Relation to adjacent or critical features of the Work or materials.

11. Applicable standards, such as ASTM or Federal Specification numbers.

12. Identification of deviations from Contract Documents.

13. Identification of revisions on re-submittals.

14. 8-in. by 3-in. blank space for the Contractor's proper approval stamp.

15. The Contractor's stamp, signed, certifying to review of the submittal, verification of the products, field measurements, field construction criteria, and coordination of information within the submittal with requirements of Work and Contract Documents.

D. Submittal Response – Within 14 days of submittal receipt, Construction Manager will stamp and provide two copies to the Contractor. Construction Manager will respond as follows:

1. No exceptions taken: Contractor shall file submittal and proceed with associated work.

2. Correct as noted: Contractor shall make corrections noted and ~~resubmit submittal.~~ proceed with associated work.

3. Rejected: Contractor shall not proceed with the associated work.

4. Revise and resubmit: Contractor shall revise submittal and resubmit to Construction Manager.

5. Submit Specified Items: Contractor shall submit specified items to provide Construction Manager information for appropriate review of submittal.

E. Re-submittal Requirements:

1. Re-submittal is required when corrections or changes in submittals are required by the Construction Manager. Re-submittals are required until all comments by the Construction Manager, Design Engineer, or CQA Engineer is addressed and the submittal is approved.

2. Shop Drawings and Product Data:

a. Revise initial drawings or data and resubmit as specified for initial submittal.

b. Indicate changes made other than those requested by the Construction Manager.

1.05 TEST RESULTS AND CERTIFICATION

A. Results of tests conducted by the Contractor on materials or products shall be submitted for review.

B. Certification of products shall be submitted for review.

1.06 SUBMITTAL REQUIREMENTS

A. Provide complete copies of required submittals as follows.

1. Project Schedule

   a. Six copies of initial schedule.

   b. Six copies of each revision.

2. Shop Drawings: Six copies.

3. Certification Test Results: Six copies.

4. Other Required Submittals:

   a. Six copies if required for review.

   b. Six copies if required for record.

B. Deliver the required copies of the submittals to the Construction Manager.

PART 2 – PRODUCTS

[Not Used]

PART 3 – EXECUTION

[Not Used]

PART 4 – MEASUREMENT AND PAYMENT

[Not Used]

[END OF SECTION]

DRAFT

SECTION 01400
QUALITY CONTROL

PART 1 – GENERAL

1.01 DESCRIPTION OF WORK

A. Monitor quality control over suppliers, Manufacturers, products, services, Site conditions, and workmanship, to produce Work of specified quality.

B. Comply with Manufacturers' instructions, including each step in sequence.

C. Should Manufacturers' instructions conflict with Technical Specifications, request clarification from Construction Manager before proceeding.

D. Comply with specified standards as minimum quality for the Work except where more stringent tolerances, codes, or specified requirements indicate higher standards or more precise workmanship.

E. Perform Work by persons qualified to produce workmanship of specified quality.

1.02 TOLERANCES

A. Monitor tolerance control of installed products to produce acceptable Work. Do not permit tolerances to accumulate.

B. Comply with Manufacturers' tolerances. Should Manufacturers' tolerances conflict with Technical Specifications, request clarification from Construction Manager before proceeding.

C. Adjust products to appropriate dimensions; position before securing products in place.

1.03 REFERENCES

A. For products or workmanship specified by association, trade, or other consensus standards, complies with requirements of the standard, except when more rigid requirements are specified or are required by applicable codes.

B. Conform to reference standard by date of current issue on date of Notice to Proceed with construction, except where a specific date is established by code.

C. Obtain copies of standards where required by product Specification sections.

1.04 INSPECTING AND TESTING SERVICES

A. The CQA Engineer shall perform construction quality assurance (CQA) inspections, tests, and other services specified in individual Sections of the Specification.

B. The Contractor shall provide labor and equipment to assist in sample collection as needed for testing as well as assist in the preparation of test locations.

C. The Contractor shall cooperate with CQA Engineer; furnish samples of materials, design mix, equipment, tools, storage, safe access, and assistance by incidental labor as requested.

D. CQA testing or inspecting does not relieve Contractor, subcontractors, and suppliers from their requirements to perform quality control Work as indicated in the Technical Specifications.

E. Owner’s Surveyor will perform QA monitoring of as-built documents using control points.

DRAFT

PART 2 – PRODUCTS

[Not Used]

PART 3 – EXECUTION

[Not Used]

PART 4 – MEASUREMENT AND PAYMENT

[Not Used]

[END OF SECTION]

DRAFT

SECTION 01500
CONSTRUCTION FACILITIES

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Construction facilities include furnishing of all equipment, materials, tools, accessories, incidentals, labor, and performing all work for the installation of equipment and for construction of facilities, including their maintenance, operation, and removal, if required, at the completion of the Work under the Contract.

1.02 DESCRIPTION OF WORK

A. Construction facilities include, but are not limited to, the following equipment, materials, facilities, areas, and services:

1. Parking Areas.
2. Temporary Roads.
3. Temporary Trailers.
4. Temporary Utilities.
5. Temporary Sanitary Facilities.
6. Lighting
7. Storage of Materials and Equipment.
8. Dust control water storage
9. Temporary Water.
10. Vacuum Truck Staging Area
11. Decontamination Area
12. Construction Equipment.
13. First Aid Facilities.
14. Health and Safety.
15. Security.

B. Construct/install, maintain, and operate construction facilities in accordance with the applicable federal, state, and local laws, rules, and regulations, and the Contract Documents.

1.03 RELATED SECTIONS

Section 01100 – Project Meetings and Proceedures

Section 01110 – Health and Safety Requirements

Section 02110 – Site Clearing

DRAFT

Section 02200 – Earthwork

Section 02205 – Remedial Excavation and Filling

1.04 SUBMITTALS

A. The following submittals shall be submitted prior to issuance of Notice to Proceed:

1. Construction facilities layout plan
2. Staging area layout plan
3. Haul road design plan
4. ~~Debris lined storage area design~~
5. ~~Water management plan: the Construction Manager shall review the Plan and forward any questions to the Contractor, but shall not approve the Plan.~~

B. Contractor shall submit the Public Haul Road Maintenance and Repair Plan(s) in accordance with the traffic permits as required by the City of Henderson and Nevada Department of Transportation

C. Debris lined storage area design

D. Water management plan: the Construction Manager shall review the Plan and forward any questions to the Contractor, but shall not approve the Plan.

1.05 REFERENCES

A. Construction Drawings

B. BRC, 2006. "Corrective Action Plan (CAP) For The Basic Remediation Company (BRC) Common Areas Remediation Project," September.

C. Geosyntec, 2007. "Revised Remedial Action Plan (RAP) Permit Application for Corrective Action Management Unit (CAMU), Henderson, Nevada," Prepared for Basic Remediation Company, Submitted to Nevada Department of Environmental Protection, March.

D. Nevada Department of Transportation (NDOT) Traffic Permit No. 91464-2006 dated 13 April 2006.

E. United States Department of Transportation, Federal Highway Administration: Manual on Uniform Traffic Control Devices, 20 November 2003.

1.06 GENERAL REQUIREMENTS

A. Contractor shall not proceed with the construction of any facilities until the initial field survey has been completed. This is a hold point.

B. Contractor is responsible for furnishing, installing, constructing, operating, maintaining, removing and disposing of the construction facilities, as specified in this Section, and as required for the completion of the Work under the Contract.

C. Contractor shall maintain construction facilities in a clean, safe and sanitary condition at all times until completion of the Work.

DRAFT

D. Contractor shall minimize land disturbances related to the construction facilities to the greatest extent possible and restore land, to the extent reasonable and practical, to its original contours by grading in accordance with grading permits

E. Contractor shall establish construction facilities at locations specified on the Construction Drawings, unless otherwise approved by Construction Manager.

F. The Contractor shall be responsible for general housekeeping during construction. Upon completion of the Work, the Contractor shall remove all of his equipment, temporary improvements, facilities, construction materials, and trash. All disturbed surface areas shall be re-paved, re-vegetated, or otherwise put into the pre-existing condition before performing the Work, or a condition satisfactory to the Construction Manager.

G. The following plywood signs shall be placed at the entrance to the Work Areas:

1. Entrance to the CAMU, signs shall be posted in English and Spanish:

   a. Private Operation: Basic Remediation Company – Corrective Action Management Unit

   b. Owner: Basic Remediation Company;

   c. Operator: Weston Solutions, Inc;

   d. Hours of operation: 24 hours a day; and

   e. Materials accepted or excluded.

2. Eastside Area and CAMU, signs shall be posted in English and Spanish stating:

   a. Safety measures at the site;

   b. Mandating that all instruction from site personnel be obeyed; and

   c. "Danger. Construction Area. No Trespassing."

1.07 TEMPORARY ROADS AND PARKING AREAS

A. Temporary roads and parking areas are existing private roads that are improved or new private roads constructed by Contractor for convenience of Contractor in the performance of the Work under the Contract.

B. Transportation of contaminated materials shall be restricted to the haul road corridors as shown on the drawings.

C. Public haul roads consist of sections of West Warm Springs Road and Boulder Highway between the Eastside Areas and the CAMU, as shown on Construction Drawings.

1. Public haul roads are shown on Construction Drawings. Hauling on public roads shall be on Boulder Highway and West Warm Springs Road only as per Nevada Department of Transportation (NDOT) Permit No. 91464-2006. Contractor is responsible for all conditions of the permit.

2. Prior to beginning work, the Contractor shall perform a walk through with the Construction Manager, City of Henderson, and NDOT personnel. This meeting is part of an overall process to establish a baseline condition of Boulder Highway and West Warm Springs Road. It will also serve as a kick-off meeting with COH and NDOT to determine the following:

a. Establish a process to monitor the roadway condition.

b. Establish a process to repair the roadway when necessary.

3. The Contractor shall prepare a Public Haul Road Maintenance and Repair Plan to monitor and repair the pavement sections used for haul between the Eastside Area and the CAMU, as shown on the Construction Drawings. The plan shall be submitted to both NDOT and COH and shall include:

   a. Establishing a new pavement section for a specific lane of traffic to be determined by the COH, NDOT, and Contractor

   b. Determine a routine maintenance program to eliminate major damage to the roadway.

4. The Contractor shall establish necessary improvements to reduce damage to Boulder Highway and West Warm Springs Road prior to commencement of hauling activities.

D. Submit a Haul Road Plan consisting of a detailed engineering design for the road and drainage facilities to the Construction Manager for approval. Haul roads shall be designed and constructed to safely accommodate the weight and size of vehicles that the Contractor shall use on the haul roads.

E. Haul Road Plan shall address and include provision for the following:

1. Coordination of construction with Construction Manager and local utilities, fire, and police departments.

2. Keep erosion to a minimum and maintain suitable grade and radii of curves to facilitate ease of movement of vehicles and equipment.

3. Furnish and install longitudinal and cross drainage facilities, including, but not limited to, ditches, structures, pipes and the like.

4. Maintain drainage paths crossed by haul roads through use of BMP's or paving of ditches depending on haul trucks used. Features shall be designed to withstand the 10 year storm event of 610 cubic feet per second (cfs).

5. Mud or dirt transported by equipment on paved roads both on-site and off-site shall immediately be vacuumed.

6. Constructing improvements within the haul-road corridor between the Eastside and CAMU shall be restricted to using clean materials only.

7. Interior haul roads and parking areas shall facilitate dust control and adequate control for surface runoff. At a minimum, parking areas and haul roads shall have 1" of cap rock maintained throughout the project.

8. Inspection of the private haul roads and parking areas shall be daily and maintained by the Contractor in accordance with the following criteria:

   a. The private roads and parking area shall be graded to efficiently carry water off the traveled surface to collection ditches. Ponding on the road or parking surface is unacceptable and shall be immediately corrected by the Contractor.

      i. Private haul roads and parking areas shall conform to grading requirements specified in Section 01010.

DRAFT

b. Drainage ditches and culverts intended to handle runoff from the roadway and parking areas shall be installed and maintained in proper condition to prevent ponding adjacent to the roadway. Ponding adjacent to the roadway or on the parking area greater than 3 inches deep or that is suspected to be adversely affecting the structural integrity of the roadway or parking areas shall be immediately corrected by the Contractor.

c. Corrugations or washboarding on the roadway surface shall not exceed 2 inches in depth.

d. The surface of the road and parking area shall be maintained in a condition that prevents visible dust.

e. Potholes greater than 2 feet in diameter and 2 inches in depth shall be immediately corrected by the Contractor.

f. Rutting greater than 3 inches deep shall be immediately corrected by the Contractor.

g. Loose aggregate on the road surface or aggregate berms on the roadway shoulder or less traveled roadway areas greater than 4 inches in depth shall be immediately corrected by the Contractor.

h. Signs, markings, and traffic control devices along the haul road shall conform to the Federal Highway Administration Manual on Uniform Traffic Control Devices for Streets and Highways.

9. If haul road is constructed over existing BMI Landfills, Contractor shall place a minimum of 3 inches of soil over the portion of haul road corridor on the landfill. The Contractor shall not displace BMI Landfill soils in road construction. Contractor shall not construct haul road over completed BMI Landfill cover systems.

10. Haul Roads used for transport of clean materials shall be separate from haul roads used for transport of contaminated materials.

F. Construction vehicle traffic on public roads shall comply with all applicable traffic control requirements as established by the City of Henderson, Clark County, and the Nevada Department of Transportation (NDOT).

1.08 TEMPORARY FACILITY REQUIREMENTS

A. The Contractor shall prepare all surfaces to be adequate for utility and facility installation and to provide adequate stability and durability during the duration of this Contract.

B. The Contractor shall consider the efficient use of space available at the Project site and schedule material deliveries, equipment use, and other remedial action activities to minimize storage and field facility requirements. The Contractor may locate, arrange, and lay out the facilities to best suit an efficient operation within the parameters defined herein. Obtain Construction Manager approval of building or trailer sizes and locations prior to mobilization.

C. During the Project mobilization phase, the Contractor shall develop and establish the Project staging and stockpile areas in accordance with Construction Drawings. The staging area shall be used for Contractor construction material storage, laydown yard equipment, prefabrication of Project elements, acceptance testing (as appropriate), storage, uncontaminated construction vehicle parking, construction water source, vehicle maintenance, and any other temporary items associated with the Project. The Project staging area shall not include offices.

D. Staging areas shall be located at both the Eastside and CAMU Areas in accordance with Construction Drawings.

E. The staging areas for receipt/storage of clean equipment, supplies, and materials shall not be located in a contaminated or controlled area.

F. Construction Facilities Layout Plan shall include the location, size, layout, and traffic patterns of the staging, stockpile, and support facility areas at each different stage of the Project.

G. Except for private vehicles, all vehicles and equipment associated with the Project, but not currently involved in remedial activities, shall be parked in the Contractor's staging area.

H. All facilities and utilities shall be designed and installed to allow uninterrupted service during all seasons.

1.09 LIGHTING REQUIREMENTS

A. Illumination shall be in accordance with 29 CFR 1926.56. The following illumination requirements apply.

1. Decontamination pad shall include the following:

   a. A minimum of 10-foot candles in all working areas.

   b. Direct lighting shall be available for both sides of any vehicle to eliminate shadowing.

2. Active excavation areas shall include the following:

   a. A minimum of 3-foot candles in all working areas.

   b. Lighting shall be placed around perimeter of work area so light is evenly distributed around the perimeter.

3. Equipment staging areas and refueling areas shall have a minimum of 3-foot candles.

4. All minimum illumination guidelines shall be maintained from ground level to a height of six feet.

B. Lighting shall be in accordance with 19.10.7 Operational performance standards in the Henderson Development Code:

1. Freestanding light fixtures within 50 ft of Eastside western property line shall be no greater than 20 ft in height.

2. Freestanding light fixtures 50 ft to 150 ft from Eastside western property line shall be no greater than 25 ft in height.

3. Freestanding light fixtures at the CAMU and further than 150 ft from the Eastside western property line shall be no greater than 30 ft in height.

4. Height shall be measured from the top of the light fixture to the adjacent grade at the base of the support for the light fixture.

5. All lighting shall be directed downward and away from adjoining property and shall be shielded to prevent unnecessary glare.

C. Security lighting shall be protected by weather- and vandal-resistant covering, shall be a managed light source, and shall be directed down to minimize glare and intrusiveness.

D. White, full-spectrum “white light” shall be used at all times.

DRAFT

1.10 TEMPORARY TRAILERS

A. Contractor is responsible for providing Contractor's, Construction Managers, and CQA Engineer's trailer and shall be located at the Eastside Areas staging area. The exact trailer locations shall be coordinated with Construction Manager.

B. Construction Manager and CQA Engineer's trailer shall be a minimum of one 60 foot single double-wide trailer with two offices at each end. The trailer shall be furnished with six layout tables, eight desks, eight rolling chairs, plan table, drafting stool, plan rack, five – five drawer filing cabinets that can account for legal size, minimum 4' x 8' conference table, and twelve conference chairs. Four five-ft high particians panels adequate for isolating four desks in the common area shall be provided. Operating heating and air conditioning of sufficient capacity shall be provided. ~~Electric power shall be provided to include a minimum of 4 duplex convenience outlets, illumination at the desks and conference table area, and an outside light.~~ Electric power shall be every 6 feet with duplex convenience outlets, illumination at the desks and conference table area, and an outside light. Three outside phone lines and service shall be provided within the trailer.

C. Trailers shall be equipped with high speed internet capabilities, DSL or cable internet equivalent with an N-wireless modem capable of a minimum download rate of 1.5 mega bit/sec.

D. Trailers shall be equipped with a black and white printer, copier, scanner combination capable of, at minimum, the following:

1. Copy/print rate of at least 40 pages per minute for 8 ½ inch x 11 inch paper size;
2. Copying/printing/scanning up to 11 x 17 inch pages;
3. Sorting capabilities up to 20 copies;
4. Copy/print/scan 2 sided documents; and
5. Compatible operating system: Windows 2000 through Windows Vista

E. Trailers shall be equipped with a fax machine capable of printing single pages at a rate of 20 pages per minute.

F. Trailers shall be equipped with four telephone numbers: one fax line, three voice lines. A minimum of 12 telephone jacks shall be in the trailer capable of reaching all three voice lines. One telephone jack shall be provided for the fax machine.

G. Contractor is responsible for coordinating temporary trailer utilities with local agencies. Available utilities are shown on the Construction Drawings.

1.11 ON-SITE COMMUNICATION

A. Contractor shall provide Construction Manager with two-way radios for all of the Construction Manager's field staff, Security, the Owner, and the Owner's consultants providing onsite field services (air monitoring, CQA, surveying, conformation sampling).

B. Additional radios shall be maintained in the trailers on same or duel frequency to monitor site conversations and for contacting contractor representatives.

C. Permits, licenses, and any equipment necessary for Contractor use of two-way radios shall be the responsibility of the Contractor.

DRAFT

1.12 TEMPORARY SANITARY FACILITIES

A. Provide temporary male and female sanitary facilities at each office trailer. Sanitary facilities onsite will need to be provide for all employees and persons engaged in the Work, including subcontractors, their employees and authorized visitors, Construction Manager (4 persons), and CQA Engineer (3 persons).

B. Sanitary facilities include enclosed chemical toilets and washing facilities. These facilities must meet the requirements of local public health standards.

C. Locate sanitary facilities as approved by Construction Manager, and maintain in a sanitary condition during the entire course of the Work.

D. Sanitary Facilities shall be placed at both the CAMU and Eastside Areas.

E. Sanitary Facilities shall be serviced weekly.

1.13 TEMPORARY WATER

A. Make all arrangements for water needs with the Construction Manager and the City of Henderson.

B. Provide drinking water for all personnel at the site.

C. The Contractor shall provide temporary pipes, hoses, and water as required for dust and moisture control during excavation and backfill operations, for the decontamination facilities, and for other remediation requirements. Water can be potable or reclaim water obtained from the City of Henderson. Contractor shall make arrangements with the City for access to water. Reclaimed water access locations are shown on Construction Drawings. Non-potable water sources and trucks shall be clearly marked with "NON-POTABLE WATER."

D. Available water sources for both potable and reclaimed water are shown on the Construction Drawings. The Contractor is responsible for obtaining a hydrant meter from the City. The Contractor shall not add substances (such as soap) to construction water. The Contractor shall utilize measuring devices that allow him to track the volume of water used. Such usage records shall be maintained and provided to the Construction Manager.

E. The Contractor shall obtain permission to use an existing potable water source for construction purposes. The Contractor shall make arrangements with the City of Henderson and shall be responsible for payment of all water used by the Contractor.

F. Any hookups to a domestic potable water supply shall have a backflow- prevention device installed at the service connection to allow cross-connection control.

   1. Devices shall be equal in size to the service line and installed per manufacturer's recommendations.

   2. All water supply hookups shall be inspected, as required, by the appropriate local governing agency.

1.14 STORAGE OF MATERIALS AND EQUIPMENT

A. Storage areas shall be presented in the Staging Area Layout Plan. Locations and configurations of approved facilities are subject to the acceptance of the Construction Manager.

B. Optional staging areas are shown on the Construction Drawings. Confirm staging areas with Construction Manager

C. Confine all operations, including storage of materials, to approved areas. Store materials in accordance with these Technical Specifications and the Construction Drawings.

D. Store construction materials and equipment within boundaries of designated areas. Storage of gasoline or similar fuels must conform to state and local regulations and be limited to the areas approved for this purpose by the Construction Manager.

E. The Contractor shall deliver packaged materials to the site in the manufacturer's original, unopened, labeled containers. Containers shall not be opened until the approximate time of use or as agreed to by the Contractor for the purposes of inspecting and testing.

1.15 ADDITIONAL STORAGE AREAS

A. Design of the following storage areas shall be included with the Construction Facilities Layout Plans submittals. Design shall only be resubmitted when revised for a specific phase.

1. VACUUM TRUCK STAGING AREA - The Contractor shall designate and maintain a vacuum truck staging area as shown on the Construction Drawings.

2. DECONTAMINATION AREA - The Contractor shall provide a decontamination area with a concrete pad draining into a collection area at the Eastside Area and CAMU area. Locations of decontamination areas shall be in accordance with Construction Drawings. The Contractor shall provide a storage tank to hold decontamination water prior to disposal. Contractor shall provide additional decontamination areas at the Eastside and CAMU, as needed, consisting of bermed/sloped areas lined with plastic sheeting if necessary. The private haul road between the Decontamination Area and Warm Springs Road shall have a minimum of 3-inches of gravel a minimum of 20-feet wider than the largest truck.

3. DEBRIS STORAGE AREA – The Contractor shall provide an 150 foot (ft) x 60 ft HDPE-lined debris storage area constructed in accordance with Section 02770 of these Specifications. Debris storage area shall be built on top of existing ground with 3-ft lined berms and a sump for collection and removal of rain water. Additional 1-ft berms shall be constructed within the debris storage area to segregate potentially hazardous matierals. A minimum 1 foot protection layer of soil, or other material, with particles no larger than 1 inch shall be placed above the HDPE liner prior to debris disposal.

1.16 CONSTRUCTION EQUIPMENT

A. Erect, equip, and maintain all construction equipment in accordance with all applicable statutes, laws, ordinances, rules, and regulations or other authority having jurisdiction.

B. Provide and maintain scaffolding, staging, hoists, barricades, and similar equipment required for performance of the Work. Provide hoists or similar equipment with operators and signals, as required.

C. Provide, maintain, and remove upon completion of the Work, all temporary rigging, scaffolding, hoisting equipment, debris boxes, barricades around openings and excavations, fences, ladders, and all other temporary work, as required for all Work hereunder.

D. Construction equipment and temporary work must conform to all the requirements of state, county, and local authorities, OSHA, and underwriters that pertain to operation, safety, and fire hazard. Furnish and install all items necessary for conformity with such requirements, whether or not called for under separate Sections of these Technical Specifications.

DRAFT

1.17 ELECTRICITY

A. Using existing electrical sources on the property (as shown on the drawings), the Contractor shall provide temporary electric service as required for remediation purposes. The Contractor shall be responsible for any damage to the electrical system caused by the Contractor's improper use of the system.

B. The Contractor shall verify the existing electrical service capacity and equipment available at the site, and verify the equipment and load requirements of temporary facilities to be provided. The Contractor shall provide any additions or modifications to the minimum allowable services as required by code, utility company, or municipal agency having jurisdiction to connect the required temporary facilities. Such additions or modifications shall include acquiring permits, fees, and all other administrative requirements. Additions or modifications to the minimum electrical service requirements shall be reviewed by the Construction Manager and shall be provided at no additional cost to the Construction Manager. (no change)

1.18 TELEPHONE SERVICE

A. The Contractor shall be responsible for establishment of service and establishment costs for telephone service including: telephone conduits, telephone hardware, and connection of service lines to the Construction Facilities. The Owner will be responsible for monthly costs associated with telephone use.

B. The Contractor shall provide telephone with the following capabilities:

1. Minimum capacity of 3 lines;
2. Voicemail;
3. Speaker phone;
4. Redial;
5. Memory;
6. Transfer; and
7. Hold.

1.19 WEATHER PROTECTION

A. The Contractor shall provide all heating for remedial work that requires cold-weather protection. All temporary heating arrangements shall comply with applicable codes and regulations. Equipment and surroundings shall be kept clean and safe.

B. Open-flame heating devices or oil burning salamander-type devices may be used when approved by the Construction Manager. Approval shall be dependent on the Contractor's ability to provide adequate safety protection.

C. The Contractor shall furnish and install temporary enclosures as needed to protect construction from damage due to weather or elements, or to maintain suitable temperature during the installation or finishing of work. At all times, the Contractor shall provide protection against freezing, storms, wind, rain, or heat to maintain work, materials, and equipment free from injury or damage. At the end of each day's work, all work susceptible to damage shall be protected.

DRAFT

1.20 TRASH AND DEBRIS CONTROL

A. The Contractor shall inspect the site daily and remove uncontaminated trash/debris that has accumulated and properly dispose of it off site.

B. Uncontaminated debris shall not be disposed of in the HDPE lined containment area.

C. Contractor generated debris will be properly disposed of off-site at the expense of the Contractor.

1.21 HEALTH AND SAFETY

A. Provide necessary first aid equipment and supplies, health and safety monitoring equipment and personal protective equipment in accordance with Contractor prepared Site Health and Safety Plan and Section 01110 of these Specifications.

1.22 SECURITY

A. Make all necessary provisions and be responsible for the security of the Work and the Site until final inspection and acceptance of the Work, unless otherwise directed by the Construction Manager and in accordance with Section 01100, Part 3.07.

1.23 TEMPORARY FACILITIES MAINTENANCE AND REMOVAL

A. Maintain temporary facilities and controls as long as needed for safe and proper completion of the Project. All installed facilities shall be maintained in a clean, safe, and sanitary condition at all times until completion of the Contract.

B. The Contractor shall provide janitorial services for all temporary support facilities, including trailers provided by the Contractor, established under the Contract. These services shall include cleaning the floors and restroom facilities twice weekly.

C. Remove temporary facilities and controls as soon as the progress of the Project permits, as otherwise specified in the Contract documents, or as directed by the Construction Manager.

D. Upon completion of the Work, or prior thereto, when so required by Construction Manager:

1. If off-road trucks or overloaded trucks are used during remediation activities, upon completion of remedial haul operations, the Contractor shall coordinate with COH and NDOT to replace the entire length of the haul route used during construction down to the subgrade. Reconstruction of Boulder Highway West Warm Springs Road shall be discussed in the Public Haul Road Maintenance and Repair Plans.

2. Interior haul roads shall have the top 6 inch surface removed and disposed of in the CAMU as indicated on the Construction Drawings.

3. Remove and dispose of all construction facilities. Similarly, all areas utilized for temporary facilities shall be returned to near original, natural state, or as otherwise indicated or directed by the Construction Manager.

4. The Eastside and CAMU decontamination apron pads and concrete rubble and pads shall be removed, broken up, tested for contamination, and disposed of off site.

5. At Project completion, demobilize the Contractor's staging area and reclaim support facilities areas installed under this Contract. Regrade areas to match existing contours and promote drainage without erosion.

DRAFT

1.24 SITE WATER MANAGEMENT

A. The Contractor shall:

1. Control and manage storm water runoff;

2. Control discharges from dewatering activities;

3. Direct use of clean and contaminated water for dust control; and

4. Control water levels in all storm water sedimentation ponds on the site.

5. Monitor leachate levels within the sumps and at no time allow levels within sump to exceed 3 feet in depth as measured from the top of the geomembrane.

B. The Water Management Plan shall describe how the Contractor shall dewater the Eastside Areas and active and inactive CAMU cells and other excavated areas, utilize water at the site, incorporating restrictions placed on the use of water for dust control, use of leachate for dust control, and control of water levels in the ponds. The Contractor shall coordinate the information in the Plan with the requirements of the Contractor Storm Water Pollution Prevention Plan.

C. During the Contract performance period, and prior to completion of permanent runoff control features, including non-working hours such as holidays, the Contractor shall prevent runoff water from leaving contaminated areas of the Project site. The Contractor shall comply by using techniques that may include, but are not limited to, the following:

1. Excavation of temporary swales, ditches, and/or retention ponds.

2. Construction of temporary diversion dikes and berms.

3. Pumping water to runoff water control facilities or using the water for dust control in contaminated areas. Water removed from contaminated excavations or runoff ponds shall be considered to be contaminated.

D. Adequate runoff water control shall be maintained at all times in contaminated and/or controlled areas where the pre-existing surfaces have been removed or disturbed, and in stockpiles of materials on the Project site, so that water is prevented from flowing from contaminated areas to uncontaminated areas.

E. Contractor shall prioritize contaminated water disposal in the following ways, in accordance with Health and Safety procedures indicated in the Health and Safety Plan:

1. Dust control of contaminated materials within lined areas of CAMU;

2. Waste placement moisture conditioning in the CAMU; and

3. Off-site disposal. If contaminated water is disposed of off-site, Contractor shall:

a. Follow waste manifest procedure for hauling of contaminated water.

b. Contractor shall be responsible for establishing the waste profile for disposal purposes.

F. The Contractor shall establish controls to keep runoff water from noncontaminated areas from entering the CAMU and any contaminated area.

G. The Contractor shall install temporary drainage piping to control overland flow, route natural drainage under temporary roadways, and intercept groundwater flows, if necessary. The Contractor shall select the size and type of piping to be used, and shall be responsible for the

performance of the temporary piping. The Contractor shall adequately compact materials around the drainage piping to ensure protection of the piping and adequacy of fill over the piping. The Contractor shall perform regular maintenance of any temporary piping as necessary to prevent plugging or reduced capacity.

H. Water coming into contact with waste and operations layer materials shall be handled and disposed of as contaminated water.

PART 2 – PRODUCTS

[Not Used]

PART 3 – EXECUTION

[Not Used]

PART 4 – MEASUREMENT AND PAYMENT

A. Providing for and complying with the requirements set forth in this Section for Construction Facilities shall be considered as incidental to Mobilization and Demobilization, Section 01505, and payment shall be based on the lump sum price provided on the Bid Schedule.

[END OF SECTION]

DRAFT

SECTION 01505
MOBILIZATION / DEMOBILIZATION

PART 1 – GENERAL

1.01 DESCRIPTION OF WORK

A. Mobilization consists of preparatory work and operations, including but not limited to those necessary for the movement of personnel and project safety; including: adequate personnel, equipment, supplies, and incidentals to the project Site; establishment of facilities necessary for work on the project; premiums on insurance for the project and for other work and operations the Contractor must perform or costs the Contractor must incur before beginning work on the project, which are not covered in other bid items.

B. Demobilization consists of work and operations including, but not limited to, movement of personnel, equipment, supplies, incidentals, and temporary facilities including trailers, haul roads, parking lots, and decontamination pads off-site.

PART 2 – PRODUCTS

[Not Used]

PART 3 – EXECUTION

[Not Used]

PART 4 – MEASUREMENT AND PAYMENT

4.01 GENERAL

A. Providing for and complying with the requirements set forth in this Section for Mobilization and Demobilization shall be lump sum (LS) and payment shall be based on the prices provided on the Bid Schedule.

B. The Contractor shall include the following specified items as incidental to Mobilization and Demobilization and shall be included in the lump sum costs provided on the Base Bid Schedule. With the noted exceptions, the lump sum costs shall include initial set up and removal, operational and maintenance costs shall be included as incidental to Earthworks and Remedial Excavation and Filling, Sections 02200 and 02205, respectively:

1. Construction Facilities

   a. Parking Areas

   b. Temporary Roads

      i. Haul Road Maintenance and Repair Plan

      ii. Haul Road Plan

   c. Temporary Trailers

   d. Temporary Utilities

   e. On-site communications

   f. Weather Protection

DRAFT

g. Contractor Generated Debris and Trash Control

h. Temporary Sanitary Facilities: includes initial set-up, maintenance, and removal

i. Lighting

j. Material and Equipment Storage

k. Dust Control Water Storage

l. Vacuum Truck Staging Area

m. Decontamination Area

n. Construction Equipment

o. First Aid Facilities

p. HDPE-lined Storage Area

2. Contract Close-out

3. Temporary Controls:

a. Dust Control

i. Dust Control and Mitigation Plan

b. Pollution Control

i. Fuel Plan

c. Traffic and Safety Control

i. Signs

ii. Traffic control equipment: cones, baracades

d. Access Control

i. Guard Stations

ii. Gates and Fences

iii. Site Security Plan

e. Decontamination

i. Decontamination Pad

ii. Decontamination Water Storage Tank

f. Noise Control

i. Equipment Mufflers

4. Health and Safety Plan

a. Spill Prevention and Response Plan

DRAFT

5. And all other incidentals necessary for mobilization and demobilization.

C. The Contract Price for Mobilization / Demobilization shall include the provision for movement of equipment onto the job site; removal of all facilities and equipment at the completion of the project; permits; preparation of a Health and Safety Plan; and all other related mobilization and demobilization costs. Price bid for mobilization shall not exceed 10 percent of the total bid for the Project. ~~Fifty percent of the mobilization bid price, less retention, shall be paid on the initial billing provided all equipment and temporary facilities are in place. The remaining 50 percent of the mobilization bid price shall be paid on satisfactory removal of all facilities and equipment on completion of the project.~~

[END OF SECTION]

DRAFT

SECTION 01560
TEMPORARY CONTROLS

PART 1 – GENERAL

1.01 DESCRIPTION OF WORK

A. Temporary Controls required during the term of the Contract for the protection of the environment and the health and safety of workers and general public.

B. Furnishing all equipment, materials, tools, accessories, incidentals, and labor, and performing all work for the installation of equipment and construction of facilities, including their maintenance and operation during the term of the Contract.

C. Temporary Controls include:

1. Dust Control.
2. Pollution Control.
3. Traffic and Safety Controls.
4. Access Control.
5. Decontamination
6. Noise Control

D. Perform Work as specified in the Technical Specifications and as required by the Construction Manager. Maintain equipment and accessories in clean, safe and sanitary condition at all times until completion of the Work.

1.02 RELATED SECTIONS

Section 01505 – Mobilization/Demobilization

Section 02820 – Chain Link Fence

1.03 SUBMITTALS

A. Dust Control Permit and Mitigation Plan

B. Fuel Plan

C. Site Security Plan

D. Decontamination Plan

1.04 REFERENCES

A. Construction Drawings

B. BRC, 2006. "Corrective Action Plan (CAP) For The Basic Remediation Company (BRC) Common Areas Remediation Project," September.

C. BRC, 2005. "Perimeter Air Monitoring Plan For Soil Remediation Activities BMI Upper and Lower Ponds and Ditches, Clark County, Nevada," April

DRAFT

D. PBS&J, 2006, "Landwell Haul Route: Traffic Control Plan, Boulder Highway and Warm Springs Road intersection," Prepared for The Landwell Company, April.

E. Geosyntec, 2007. "Revised Remedial Action Plan (RAP) Permit Application for Corrective Action Management Unit (CAMU), Henderson, Nevada," Prepared for Basic Remediation Company, Submitted to Nevada Department of Environmental Protection, March.

F. Nevada Department of Transportation (NDOT) Traffic Permit No. 91464-2006 dated 13 April 2006.

G. United States Department of Transportation, Federal Highway Administration: Manual on Uniform Traffic Control Devices, 20 November 2003.

1.05 DUST CONTROL

A. Provide dust control measures in-accordance with the Technical Specifications, Dust Control Permit, Mitigation Plan, and Perimeter Air Monitoring Plan. Dust control measures must meet requirements of applicable laws, codes, ordinances.

B. The Contractor is responsible for applying for, obtaining, and complying with a Dust Control Permit and Mitigation Plan for construction activities through the Air Pollution Control District of the Clark County Health District. An example Dust Control Permit and Mitigation Plan is included as Appendix C of the Corrective Action Plan (CAP).

C. Dust control consists of transporting water, furnishing required equipment, testing of equipment, additives, accessories and incidentals, and carrying out proper and efficient measures wherever and as often as necessary to reduce dust nuisance, and to prevent dust originating from construction operations throughout the duration of the Work.

D. Dust suppression shall include all roadways, stockpiles, excavations, and other areas.

E. Dust suppression activities shall be conducted as necessary, 7 days per week, 24 hours per day, including holidays.

F. The Contractor shall take necessary measures to eliminate dust. Visible dust is not allowed. The Contractor may use techniques that include, but are not limited to, the following:

1. Minimize disturbance of vegetated areas.

2. Enforcement of lower speed limits on all vehicles traveling within the Project site.

3. Suppressing dust generation by spraying the area with water or a Construction Manager-accepted dust retardant.

G. Adequate moisture content shall be maintained at all times in contaminated areas where the pre-existing surfaces have been removed or disturbed, and in materials that have been stockpiled on the job site, so that dust shall not be generated.

H. The Contractor shall protect all areas from any refuse or dust generated by the work.

I. The Contractor shall provide surface covering to maintain mud-free conditions at the ingress/egress locations of the facility support area and at Project access locations indicated on the drawings. The Contractor shall maintain the covering for the duration of the Project.

J. The Contractor shall not use contaminated leachate for dust control in uncontaminated or previously remediated areas. Contaminated water shall not be used for dust-control purposes on the haul road.

1.06 POLLUTION CONTROL

A. Pollution of Waterways:

1. Perform Work using methods that prevent entrance or accidental spillage of solid or liquid matter, contaminants, debris, and other objectionable pollutants and wastes into watercourses, flowing or dry, and underground water sources.

2. Such pollutants and wastes shall include, but shall not be limited to, refuse, earth and earth products, garbage, cement, concrete, sewage effluent, industrial waste, hazardous chemicals, oil and other petroleum products, aggregate processing tailings, and mineral salts.

B. Existing Eastside Area pollutants shall be disposed of at the HDPE lined disposal cell, and tested by the Owner. Pollutants shall be transported for disposal off-site.

C. Contractor shall be responsible for disposal of pollutants resulting from Contractor's operations.

D. Contractor shall only perform fueling activities and maintenance and repair activities in designated areas as shown on the Construction Drawings and in accordance with the Fuel Plan.

E. Contractor shall be responsible for pollution that results from refueling, maintenance, or repair of construction equipment, or work activities resulting in pollutant release.

F. All trucks shall be driven across gravel aprons prior to entering Warm Springs Road to remove loose soil. Gravel aprons shall extend from decontamination area to West Warm Springs Road.

G. Storage and Disposal of Petroleum Product:

1. Petroleum products covered by this Section include gasoline, diesel fuel, lubricants, and refined and used oil. During project construction, store all petroleum products in such a way as to prevent contamination of all ground and surface waters and in accordance with local, state, and federal regulations.

2. Lubricating oil may be brought into the project area in steel drums or other means, as the Contractor elects. Store used lubricating oil in steel drums, or other approved means, and return them to the supplier for disposal. Do not burn or otherwise dispose of at the Site.

3. Secondary containment shall be provided for products stored on site, in accordance with the Contractor provided Storm Water Pollution Prevention Plan.

H. Contaminated Material Spills

1. In the event of a spill of contaminated material in an uncontrolled area, a total Project work stoppage shall be initiated by the Contractor. During the work stoppage, safety and procedural reviews, determination of root causes, and corrective actions shall be determined by the Construction Manager and implemented by the Contractor prior to resuming the work. No compensation shall be provided to the Contractor for work stoppages that result from spills. Work shall not be resumed without Construction Manager approval.

2. In the event of spillage at Boulder Highway crossing, Contractor shall immediately sweep and vacuum spilled materials.

I. At the daily conclusion of transport operations, Contractor shall vacuum the Boulder Highway crossing and public rights of way.

1.07 TRAFFIC AND SAFETY CONTROLS

A. Traffic controls shall be in accordance with the Owner provided Traffic Control Plan.

B. Post construction areas and roads with traffic control signs or devices used for protection of workmen, the public, and equipment. Signs and devices must conform to the American National Standards Institute (ANSI) Manual on Uniform Traffic Control Devices for Streets and Highways.

C. Interior private haul roads shall direct trucks to pond excavations, decontamination areas, refueling area, truck wash and repair, and designated disposal areas within the CAMU. Contractor shall post weather-proof signs along haul roads indicating active areas of remediation and waste placement.

D. Remove signs or traffic control devices after they have finished serving their purpose. It is particularly important to remove any markings on road surfaces that under conditions of poor visibility could cause a driver to turn off the road or into traffic moving in the opposite direction.

E. Provide flag persons, properly equipped with International Orange protective clothing and flags, as necessary, to direct or divert pedestrian or vehicular traffic.

F. Barricades for protection of employees must conform to the portions of the ANSI Manual on Uniform Traffic Control Devices for Streets and Highways, relating to barricades.

G. Guard and protect all workers, pedestrians, and the public from excavations, construction equipment, all obstructions, and other dangerous items or areas by means of adequate railings, guard rails, temporary walks, barricades, warning signs, sirens, directional signs, overhead protection, planking, decking, danger lights, etc.

H. Construct and maintain fences, planking, barricades, lights, shoring, and warning signs as required by local authorities and federal and state safety ordinances, and as required to protect all property from injury or loss and as necessary for the protection of the public, and provide walks around any obstructions made in a public place for carrying out the Work covered in this Contract. Leave all such protection in place and maintained until removal is authorized by the Construction Manager.

I. At the beginning of haul operations for the day, the Contractor shall inspect light signals at Boulder Highway and West Warm Springs Road intersection. Traffic and pedestrian light shall be in good, working order. If light signals are inoperable, Contractor shall provide flag persons, properly equipped with International Orange protective clothing and flags, as necessary, to direct or divert pedestrian or vehicular traffic.

1.08 ACCESS CONTROL

A. As remediation progresses, the Contractor shall maintain contamination-control boundaries between "clean" areas and exclusion areas.

B. Perimeter fencing shall be installed and/or repaired to restrict, reduce, or eliminate access by the public, livestock, and wildlife into the work area. Interior fencing shall be installed at the Eastside Areas around the remediation area. Fence type(s) shall be in accordance with Section 02820 of these specifications and as indicated on the drawings. Fencing shall be placed and moved as necessary to minimize disruption to ongoing operations at the Project site and adjacent properties.

C. The Contractor shall maintain CAMU site perimeter fences, gates, and signs to prevent intrusion by the general public. Maintenance includes keeping fences taut, performing all minor repairs that do not require additional materials, and placement of signs as designated by the Construction Manager. The Contractor shall remove or thin trees/brush so that the signs are visible.

D. The Contractor shall install and maintain Eastside Area exclusion zone fences, and gates to prevent access by individuals without proper training. Maintenance includes keeping fences taut, performing all minor repairs that do not require additional materials designated by the Construction Manager. Eastside Area site perimeter fence will be maintained by Owner. Owner will provide and maintain site perimeter signs.

E. Private and personal vehicles not used for authorized construction purposes shall not access the controlled areas. Parking of private or personal vehicles shall be restricted to the designated support facilities area near the Eastside Areas and CAMU work areas as shown on the Construction Drawings. All Contractor vehicles shall comply with applicable licensing regulations.

F. The Contractor shall provide gate attendants' offices at the Eastside access gate and CAMU access gate off Warm Spring Rd. to be continuously manned and serve as a checkpoints.

G. Contractor shall maintain a sign-in/sign-out log for all visitors. Contractor is responsible for logged visitors while visitors are on-site. Visitors shall not enter remedial excavation exclusion or support zones without documented proof of current training in accordance with Title 29 of the Code of Federal Regulations (CFR) Part 1910.120. Contractor shall provide tailgate health and safety briefing to all visitors prior to entering exclusion zone.

1.09 DECONTAMINATION

A. Construction equipment shall be decontaminated as follows prior to leaving both the Eastside and CAMU areas:

1. Personnel shall be dressed in proper PPE

2. Trucks shall be decontaminated such that there is no visible soil material build-up on sides, mud-flaps, undercarriage, or tires when leaving decontamination areas.

3. Contractor shall steam clean equipment as recommended in the CAP. An alternative method of decontamination shall be permitted if shown by Contractor to be more economical and as effective as steam cleaning.

4. Decontamination water shall be pumped from the collection area into a storage tank. Water shall be sampled if disposed of off-site at the Owner's expense.

B. Contractor shall provide personnel at access points to inspect trucks prior to entering public roadways. Trucks shall be inspected for caked soil and mud as well as tarps or covers over waste materials.

1.10 NOISE CONTROL

A. The Contractor is responsible for managing site construction noise at levels in accordance with Sections 19.10.7 and 19.14 of the City of Henderson Development Code.

B. The following sound levels are the maximum allowed at the Eastside area, as measured from the property line, during the given times:

Time of Day	Maximum Permitted Sound Level (dBA) Outdoors
7 am to 9 pm	65 – Daytime
9 pm to 7 am	60 – Nightime
24 hour	70 (Not to exceed for greater than 15 minutes in a 24-hr period

C. The following sound levels are the maximum allowed at the CAMU area, as measured from the property line, during the given times:

Time of Day	Maximum Permitted Sound Level (dBA) Outdoors
5 am to 8 pm	73 – Daytime
8 pm to 5 am	73 – Nightime
24 hour	73 (Not to exceed for greater than 15 minutes in a 24-hr period

D. If the noise is not smooth and continuous or is not present between the hours of 10 pm and 7 am, one or more of the following corrections shall be applied to the above sound levels:

Noise Source/Timing	Correction in dBA
Daytime operation only	+5
Noise source operates less than 20 percent of any one hour period	+5
Noise source operates less than 5 percent of any one hour period	+10
Noise of impulsive character such as hammering	-5
Noise of periodic character such as humming or screeching	-5

E. Noise shall be measured by a sound level meter or noise dosimeter meeting current American Standards Institute (ASI) Specification for Sound Level Meter, S1.4 (1983) Type S2A and set to use the A-weighted network with slow meter response.

F. Contractor shall not operate equipment with unmuffled exhausts.

G. Contractor shall not operate equipment with sound control devices less effective than those provided on the original equipment.

1.11 MAINTENANCE

A. Maintain all temporary controls in good working conditions during the term of the Contract for the safe and efficient transport of equipment and supplies, and for construction of permanent works.

1.12 STATUS AT COMPLETION

A. Upon completion of the Work, or prior thereto as approved by the Construction Manager, remove all temporary controls and restore disturbed areas.

PART 2 – PRODUCTS

[Not Used]

PART 3 – EXECUTION

[Not Used]

DRAFT

PART 4 – MEASUREMENT AND PAYMENT

4.01 GENERAL

A. Providing for and complying with the requirements set forth in this Section for establishing and removing Temporary Controls shall be considered as incidental to Mobilization and Demobilization, Section 01505, and payment shall be based on the lump sum price provided on the Bid Schedule.

B. Providing for and complying with the requirements set forth in this Section for operations and maintenance of Temporary Controls shall be considered as incidental to Earthworks and Remedial Excavation, Sections 02200 and 02205, respectively, and payment shall be based on the unit prices provided on the Bid Schedule.

[END OF SECTION]

DRAFT

SECTION 01700
CONTRACT CLOSEOUT

PART 1 – GENERAL

1.01 CLOSEOUT PROCEDURES

A. Contractor shall submit written certification that the Technical Specifications, CQA Plan, and Drawings have been reviewed, Work has been inspected, and that Work is complete and in-accordance with the Technical Specifications, CQA Plan, and Drawings and ready for Construction Manager's inspection.

1.02 RELATED SECTIONS

Section 01505 – Mobilization/Demobilization

1.03 FINAL CLEANING

A. Contractor shall execute final cleaning prior to final inspection.

B. Contractor shall clean equipment and fixtures to a sanitary condition.

C. Contractor shall remove waste and surplus materials, rubbish, and construction facilities from the construction Site.

1.04 AS-BUILT DOCUMENTATION

A. Contractor shall provide Construction Manager with all record documents.

PART 2 – PRODUCTS

[Not Used]

PART 3 – EXECUTION

[Not Used]

PART 4 – MEASUREMENT AND PAYMENT

4.01 GENERAL

A. Providing for and complying with the requirements set forth in this Section for Contract Closeout shall be considered as incidental to Mobilization and Demobilization, Section 01505, and payment shall be based on the lump sum price provided on the Base Bid Schedule.

[END OF SECTION]

DRAFT

SECTION 02010
DEMOLITION

PART 1 – GENERAL

1.01 DESCRIPTION OF WORK

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, and equipment necessary to perform all Work specified herein and as shown on the Construction Drawings.

B. The Contractor shall remove, transport, dispose, and pay all costs thereof, the materials to be demolished as shown on the Construction Drawings.

1.02 RELATED SECTIONS

Section 02110 – Site Clearing

1.03 REFERENCES

A. Construction Drawings

1.04 DEFINITIONS

A. Clean Debris: Clean debris are demolished materials which is not contaminated as verified by analytical testing, or debris originally located within the CAMU Area, and can be disposed of in a municipal, solid waste landfill.

B. Contaminated Debris: Contaminated debris are demolished materials outside of the Eastside Area Ponds found to be contaminated by analytical testing and cannot be disposed of in a municipal, solid waste landfill.

1.05 SUBMITTALS

A. The Contractor shall submit to the Construction Manager a description of equipment and methods proposed for the removal, transport, and disposal of materials to be demolished at least 7 days prior to the start of activities covered by this Section.

PART 2 – PRODUCTS

PART 3 – EXECUTION

3.01 GENERAL

A. The Contractor shall be responsible for demolition, removal, transport, and off-site disposal of the existing chain link fence as shown on the Construction Drawings.

B. The Contractor shall be responsible for removing and proper off-site disposal of surficial debris from within the limits of work. If Eastside Area surficial debris exhibits evidence of containing potentially hazardous materials, it shall be stockpiled separately within the HDPE-lined Debris Storage Area as described in Section 01500 of these Specifications. Eastside Area debris stockpiled in the lined debris storage area will be tested by the Owner prior to release from site.

C. The Contractor shall not demolish any materials outside of the areas specified on the Drawings without prior written approval by the Construction Manager. Any unauthorized demolition of property features shall be repaired, to the satisfaction of the Construction Manager, at the Contractor's expense.

DRAFT

3.02 DISPOSAL

A. Eastside and CAMU Area clean debris shall be disposed off in an off-site municipal solid waste facility.

B. Eastside debris found to be hazardous through testing shall be disposed of at an off-site hazardous waste facility.

C. Contractor shall not place any demolition materials or surficial debris, hazardous or non-hazardous, within the CAMU.

PART 4 – MEASUREMENT AND PAYMENT

4.01 GENERAL

A. Providing for and complying with the requirements set forth in this Section for clean debris disposal shall be per ton (TON) and payment shall be based on the unit price for clean debris/vegetation disposal provided on the Base Bid Schedule.

B. Providing for and complying with the requirements set forth in this Section for contaminated debris disposal shall be per ton (TON) and and payment shall be based on the unit price for contaminated debris/vegetation disposal provided on the Base Bid Schedule.

[END OF SECTION]

DRAFT

SECTION 02110
SITE CLEARING

PART 1 – GENERAL

1.01 DESCRIPTION OF WORK

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, and equipment necessary to perform all Work specified herein and as shown on the Construction Drawings.

B. The Contractor shall remove and dispose of all debris, vegetation, other organic and deleterious material, and other materials not suitable for Engineered fill materials that exist within the designated construction limits.

1.02 RELATED SECTIONS

Section 02200 – Earthwork

Section 02770 – Geomembrane

1.03 REFERENCES

A. Construction Drawings

1.04 DEFINITIONS

A. Clean Vegetation/Debris: Clean vegetation/debris is vegetation/debris which is not contaminated as verified by analytical testing, or vegetation originally located within the CAMU Area, and can be disposed of in a municipal, solid waste landfill.

B. Contaminated Vegetation/Debris: Contaminated vegetation/debris outside of the Eastside Area Ponds is vegetation found to be contaminated by analytical testing and cannot be disposed of in a municipal, solid waste landfill.

PART 2 – PRODUCTS

[Not Used]

PART 3 – EXECUTION

3.01 GENERAL

A. The Contractor shall be responsible for all clearing and grubbing operations within the limits of work.

B. No open burning of combustible materials shall be allowed.

C. All materials removed during the site clearing operations shall be disposed of properly off site.

D. Prior to site clearing, Contractor shall have implemented SWPPP.

DRAFT

3.02 CAMU CLEARING

A. All vegetation, debris, deleterious and other organic material not suitable for Engineered fill materials shall be removed completely from within the construction limits and disposed of off site.

3.03 EASTSIDE CLEARING

A. Vegetation and debris cleared from the Eastside Area shall be stored in the HDPE-Lined Debris Storage Area until determination is made for off-site municipal or hazardous landfill disposal.

B. Debris will visible indication of contamination cleared from the Eastside Area shall be stored in the HDPE-Lined Debris Storage Area until determination is made for off-site municipal or hazardous landfill disposal.

C. Owner will sample debris and vegetation for hazardous materials and bioaccumulation. Debris shall be disposed of at an off-site municipal or hazardous landfill at the Contractor's expense. If testing indicated debris is hazardous, it shall be disposed of within 30 days.

D. Discolored soils beneath debris shall be sampled by the Owner and disposed of at an off-site hazardous landfill.

PART 4 – MEASUREMENT AND PAYMENT

4.01 GENERAL

A. Providing for and complying with the requirements set forth in this Section for clean vegetation disposal shall be per ton (TON) and payment shall be based on the unit price for clean debris/vegetation disposal provided on the Base Bid Schedule.

B. Providing for and complying with the requirements set forth in this Section for contaminated vegetation disposal shall be per ton (TON) and payment shall be based on the unit price for contaminated debris/vegetation disposal provided on the Base Bid Schedule.

[END OF SECTION]

DRAFT

SECTION 02200
EARTHWORK

PART 1 – GENERAL

1.01 DESCRIPTION OF WORK

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, and equipment necessary to perform all Work specified herein and as shown on the Construction Drawings.

B. The Work shall include, but not be limited to excavating, hauling, placing, moisture conditioning, backfilling, compacting, grading, stockpiling, and subgrade preparation, including subgrade preparation for storm water pipeline and appurtenances. Earthwork shall conform to the dimensions, lines, grades and sections shown on the Drawings or as directed by the Construction Manager.

C. Construction of the final CAMU cover system and associated storm water management features overlying the CAMU will be held as an Option Scope that may be added to the contract via Contract Modification at the Owner's sole discretion. If the Owner decides to exercise its option to add the Option Scope, the Construction Manager will notify the Contractor no later than 30 days after receipt of the final Eastside Area confirmation sampling

1.02 RELATED SECTIONS

Section 01025 — Measurement and Payment

Section 02110 — Site Clearing

Section 02205 — Remedial Excavating and Filling

Section 02771 — Geotextile

Section 02772 — Geosynthetic Clay Liner

Section 02773 — Geocomposite

Section 03400 — Cast-in-Place Concrete

1.03 REFERENCES

A. Construction Drawings

B. Clark County Area Uniform Standard Specifications (CCAUSS) and Clark County Area Uniform Standard Drawings (CCAUSD).

C. Geosyntec, 2007 "Construction Quality Assurance Plan for the Construction of the Corrective Action Management Unit, Basic Remediation Company, Henderson, Nevada," August.

D. Latest version of American Society for Testing and Materials (ASTM) standards:

ASTM D 422 Standard Method for Particle-Size Analysis of Soils

DRAFT

ASTM D 1557 Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3))

ASTM D 2216 Standard Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures

ASTM D 2487 Standard Test Method for Classification of Soils for Engineering Purposes

ASTM D 2922 Standard Test Methods for Density of Soil and Soil-Aggregate In-Place by Nuclear Density Methods (Shallow Depth)

ASTM D 3017 Standard Test Method for Water Content of Soil and Rock In-Place by Nuclear Methods (Shallow Depth)

ASTM D 3080 Standard Test Method for Direct Shear Test of Soils Under Consolidated Drained Conditions

ASTM D 4318 Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

E. Latest version of American Association of State Highway and Transportation Officials (AASHTO) standards:

AASHTO T 180 Standard Method of Test for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop

1.04 SUBMITTALS

A. Prior to beginning earthwork, Contractor shall perform baseline topographic survey on a minimum 50-foot grid and at all grade breaks. Baseline topographical survey shall be submitted to the Construction Manager within 20 working days of notice to proceed.

B. The Contractor shall submit to the Construction Manager a notice of completion for within 24 hours of completed excavation, engineered fill, prepared subgrade and cover layer as-built survey to provide the Owner with sufficient time to verify as-built surveys

C. The Contractor shall submit to the Construction Manager laboratory test data for cover soils demonstrating shear strength cohesion. Shear strength tests shall be conducted at 90 percent maximum dry density.

D. The Contractor shall submit to the Construction Manager the GPS excavation control methods the Contractor has available for use.

E. The Contractor shall submit to the Construction Manager the Stockpile Plan prior to Notice to Proceed.

F. The Contractor shall submit to the Construction Manager product data sheets and manufacturer's recommendations for soil binder material that will be used.

1.05 QUALITY ASSURANCE

A. The Contractor shall ensure that the materials and methods used for Earthwork meet the requirements of the Construction Drawings and this Section. Any material or method that does not conform to these documents, or to alternatives approved in writing by the Construction Manager shall be rejected and shall be repaired or replaced by the Contractor.

B. The Contractor shall be aware of and accommodate all monitoring and field/laboratory conformance testing required by the CQA Plan. This monitoring and testing, including random conformance testing of construction materials and completed work, shall be performed by the CQA Engineer. If nonconformances or other deficiencies are found in the materials or completed work, the Contractor shall be required to repair the deficiency or replace the deficient materials.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and protect products brought to the Project site in accordance with this Section.

B. Stockpiles

1. Stockpile materials at locations in accordance with the Stockpile Plan or as agreed to by the Contractor and the Construction Manager. Stockpiles shall be located so as not to interfere with other aspects of the work.

2. Clear stockpile areas and install erosion and sedimention controls before depositing fill or excavated materials on approved stockpile areas.

3. Prevent segregation of fill materials and mixing of one type of fill material with other types.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Engineered fill shall consist of on-site relatively homogeneous, natural soils that contain <5% of debris, foreign objects, large rock fragments (greater than 6 inches in maximum dimension), roots, and organics. No materials larger than 6 inches shall be allowed within the Engineered fill. The Engineered fill shall be classified according to the Unified Soil Classification System (per ASTM D 2487) as SC, ML, CL, SM, SW, SP, GW, GP, GM, GC, or combinations of these materials. The Contractor may propose the use of other soil types as Engineered fill, but then such use shall be at the sole discretion of the Engineer.

B. Cover soil shall consist of on-site relatively homogeneous, natural soils that are free of debris, foreign objects, large rock fragments (greater than 6 inches in maximum dimension), roots, and organics. The first lift of cover soil placed directly overlying the geosynthetic components of the cover system shall have a maximum particle size of 1 inch. The cover soil shall be classified according to the Unified Soil Classification System (per ASTM D 2487) as SC, ML, CL, SM, SW, GW, GM, GC, or combinations of these materials. The Contractor may propose the use of other soil types as cover soil, but then such use shall be at the sole discretion of the Engineer. Cover soil shall have a remolded minimum shear strength of 32 degrees and 500 psf cohesion at 90% compaction, based on Modified Proctor, at optimum moisture content, as measured by ASTM D3080.

C. Operations layer shall consist of Eastside Area or Western Ditch materials conforming to Specifications in Section 02205.

D. Prepared subgrade is defined as the material directly underlying the geosynthetic liner system which shall meet the requirements listed above for Engineered fill. No materials larger than 3/4 inch shall project or protrude from the surface of the prepared subgrade. Prepared subgrade limits are the top inside edge of the perimeter anchor trench.

DRAFT

E. Pipe Trench Backfill shall be in accordance with CCAUSS Section 208 and the Construction Drawings.

F. Anchor Trench Backfill materials shall meet the requirements listed above for the Engineered Fill.

G. Slit Trench Backfill shall consist of earthen materials excavated from the slit trenches that are separated and earthen materials adjacent to the slit trenches.

H. Structure Embankment shall conform to CCAUSS Section 207 and the requirements shown on the Construction Drawings.

I. Aggregate base for storm water channels and CAMU Base Road shall conform to CCAUSS Section 704.03.04 for Type II Aggregate Base and the Construction Drawings.

J. Grouted Riprap atop 6-inch Type II aggregate base along the embankment channels shall have D50 = 12-inch rip rap. Grouted rip rap shall be in accordance with CCAUSS Section 610 and the Construction Drawings.

K. Grout shall be in accordance with CCAUSS Section 706 and the Construction Drawings.

L. Final cover side slope surface treatment layer (gravel mulch) shall be 3/4-inch "Vista Gold" by Vista Landscape, Henderson, NV; telephone (702) 565-6611, or Construction Manager approved equal.

M. Soil binder shall be long lasting plant derived material such as pitch and rosin emulsion, polymeric emulsion blends, or Portland cement based material as approved by the Construction Manager

2.02 EQUIPMENT

A. The Contractor shall furnish, operate, and maintain compaction equipment as is necessary to produce the required in-place soil density and moisture content.

B. The Contractor shall furnish, operate and maintain tank trucks, pressure distributors, or other equipment designed to apply water uniformly and in controlled quantities to variable surface widths.

C. The Contractor shall furnish, operate, and maintain miscellaneous equipment such as scarifiers or disks, earth excavating equipment, earth hauling equipment, and other equipment, as necessary for Earthwork construction.

D. Equipment used in spreading the cover layer material on top of the geosynthetic liner system shall be restricted to the following maximum allowable equipment ground pressures:

DRAFT

MAXIMUM ALLOWABLE EQUIPMENT GROUND PRESSURE (psi)	INITIAL LIFT THICKNESS OF OVERLYING AGGREGATE (ft)
<10	1.0
<20	2.0
>20	3.0

PART 3 – EXECUTION

3.01 FAMILIARIZATION

A. Prior to implementing any of the work in this Section, the Contractor shall become thoroughly familiar with the site, the site conditions, and all portions of the work falling within this and other related Sections.

B. Inspection:

1. The Contractor shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the installation of the work specified in this Section may properly commence without adverse impact.

2. If the Contractor has any concerns regarding the installed work of other Sections, the Construction Manager shall be notified in writing prior to commencing work. Failure to notify the Construction Manager or continuance of the work of this Section shall be construed as Contractor's acceptance of the related work of all other Sections.

3.02 SITE PREPARATION

A. Prior to performing any earthworks on the site, the ~~Owner and~~ Contractor shall perform a baseline topographic survey. The survey, at a minimum shall be performed on a 50 foot grid and account for grade breaks and other topographic features affecting volume of earthworks. This survey shall be conducted by a Professional Land Surveyor licensed in the state of Nevada. This survey shall serve as the starting point for earthwork quantities, both excavation and fill placement.

B. The Contractor shall perform demolition and site clearing in accordance with the Construction Drawings and Sections 02010 and 02110 of these Specifications prior to any Earthwork activity.

C. Prior to performing earthworks on the site, the Contractor shall install drainage and erosion-control measures in accordance with the SWPPP.

3.03 GENERAL EXCAVATION

A. The Contractor shall excavate materials to the limits and grades shown on the Drawings.

B. All excavated materials not used for Engineered Fill shall be stockpiled in accordance with the Stockpile Plan or in an area designated by the Construction Manager in accordance with Subpart 3.06 of this Section.

DRAFT

C. Excavated materials shall be used onsite only. Contractor shall not export excavated CAMU soils.

D. Excavations in native soil shall not have slopes steeper than 2.1H:1V, unless otherwise indicated on the Construction Drawings or when approved by the Construction Manager.

E. No excavations deeper than 4 feet with side slopes steeper than 2:1 (horizontal:vertical) shall be made unless otherwise indicated on the Construction Drawings or without the prior approval of the Construction Manager. When shoring is required, the design and inspection of such shoring shall be the Contractor's responsibility and shall be subject to the review of the Construction Manager prior to use. No personnel shall Work within or next to an excavation requiring shoring until such shoring has been installed, inspected, and approved by an engineer registered in the State of Nevada. The Contractor shall be responsible for any fines imposed due to violation of any laws and regulations relating to the safety of the Contractor's personnel.

F. Excavations shall be kept free from water.

G. The Contractor shall notify the Construction Manager at once of springs, seeps, or wet zones found in excavations.

H. Oversized materials encountered within the excavation or that result from screening operations of clean fill shall be segregated and stockpiled in accordance with the Stockpile Plan and Subpart 2.06 of this Section or in a location approved by the Construction Manager.

I. Permanent Ditches and Channels:

1. Cut ditches and channels accurately to the cross sections, grades, and elevations indicated on the drawings. Do not cut below indicated grades without prior Construction Manager authorization.

2. Do not deposit excavated material within 4 feet from the edge of a ditch or channel, unless the material is fill placed as indicated and specified.

3. Keep completed ditches and channels free from blockage or obstruction by leaves, brush, sticks, trash, sediment, and other debris.

4. Storm water ditch excavation through the Western Ditch shall be excavated 2.5 feet lower than grades shown on Construction Drawings. Excavated Western Ditch soil shall be stockpiled over the Western Ditch within the footprint of the Cell II in accordance with the Stockpile Plan. The storm water ditch shall immediately have 2.5 foot over excavation backfilled with clean soil to the grades shown on the construction drawings.

3.04 ANCHOR TRENCH EXCAVATION

A. The Contractor shall excavate the anchor trench to the limits and grades shown on the Drawings.

B. All excavated materials not used for Anchor Trench Backfill or Engineered fill shall be stockpiled in areas shown on Construction Drawings or as designated by the Construction Manager in accordance with Subpart 3.06 of this Section and the Stockpile Plan.

DRAFT

3.05 SUBGRADE SURFACE PREPARATION

A. The subgrade shall be prepared and made suitable as a foundation for placement and compaction of soil material and geosynthetic components of liner system, where applicable. The prepared subgrade shall be proof-rolled and meet the requirements outlined in Subpart 2.01 The subgrade shall be firm and able to support the Contractor's construction equipment without the development of depressions or ruts. In addition, the subgrade shall provide adequate support such that the overlying fill material may be placed and compacted to the specified density.

3.06 STOCKPILING

A. Soil shall be stockpiled in areas shown on Construction Drawings and in accordance with the Stockpile Plan, or as designated by the Construction Manager. Stockpile shall be free of incompatible soil, clearing, clearing debris, or other objectionable materials.

B. Stockpiles shall be no steeper than 2H:1V (Horizontal:Vertical) or other slope approved by the Construction Manager, graded to drain, sealed by tracking parallel with the direction of ~~to~~ the slope with a dozer or other means approved by the Construction Manager, and dressed daily during periods when fill is taken from the stockpile. The Contractor shall employ temporary erosion and sediment control measures (i.e. silt fence) in accordance with the Contractor prepared SWPPP or as directed by the Construction Manager around stockpile areas.

C. Western Ditch soil excavated during Phase IIIA shall be stockpiled over the Western Ditch within Cell II or placed within the lined areas of the CAMU as waste fill in accordance with Section 02205 of these Specifications.

3.07 PIPE TRENCH EXCAVATION AND BACKFILL

A. See CCAUSS Sections 206, 207, and 208.

B. Trench excavation and backfill shall conform to the lines and grades shown on the Construction Drawings.

3.08 ENGINEERED FILL, SLIT TRENCH BACKFILL, AND ANCHOR TRENCH BACKFILL

A. The Engineered Fill, Slit Trench Backfill, and Anchor Trench Backfill shall be placed to the lines and grades shown on the Drawings.

B. Soil used for the Engineered Fill, Slit Trench Backfill, and Anchor Trench Backfill shall be on-site materials meeting the requirements of Subpart 2.01 of this Section.

C. Soil used for the Engineered Fill, Slit Trench Backfill, and Anchor Trench Backfill shall be placed in a loose lift that results in a compacted lift thickness of no greater than 12 inches. The maximum permissible pre-compaction soil clod size is 6 inches.

D. Each 12-inch horizontal lift of Engineered Fill and Slit Trench Backfill placed against a slope shall be keyed into the slope a minimum of 3 feet, as measured horizontally from the top of the 12-inch lift.

E. The Contractor shall compact each lift to at least 90 percent of its modified Proctor maximum dry density (ASTM D 1557) at a moisture content of between -4% and +4% of

DRAFT

the optimum moisture content for the soil. The Contractor shall utilize compaction equipment suitable for achieving the soil compaction requirements.

F. Contaminated water shall not be used for moisture conditioning or as dust control of final cover soils.

G. During wetting or drying, the material shall be regularly disced or otherwise mixed so that uniform moisture conditions in the appropriate range are obtained.

3.09 STRUCTURE EXCAVATION AND EMBANKMENT

A. This shall include, but not be limited to, the following: detention basins, footings for riprap, concrete-lined storm water channels, aggregate-lined storm water channels, and cut-off walls for concrete aprons

B. Refer to CCAUSS Sections 206 and 207 for Structure Excavation and Structure Backfill, respectively.

3.10 FINAL COVER SOIL

A. Place only when underlying drainage aggregate and filter geotextile or geocomposite installation is complete including all Construction Quality Control (CQC) and CQA work and approved by the Construction Manager.

B. The subgrade to the cover soil consists of a geotextile or geocomposite. Therefore, the Contractor shall avoid tearing, puncturing, folding, or damaging in any way the filter geotextile or geocomposite geotextile during placement of the cover layer material.

C. Any damage to the geosynthetic liner system which is caused by the Contractor or representatives of the Contractor shall be repaired by the Geosynthetics Installer at the expense of the Contractor.

D. The Contractor shall compact each final lift of final cover soil to at least 90 percent of its modified Proctor maximum dry density (ASTM D 1557) at a moisture content between -4% and +4% of the optimum moisture content for the soil. The Contractor shall utilize compaction equipment suitable for achieving the soil compaction requirements.

E. The cover soil material shall be placed out in front of the equipment used to place the cover layer such that a 1-foot minimum thickness requirement is maintained at all times between the geosynthetic materials and the wheels or tracks of the equipment used to place the cover layer material.

F. Care must be exercised by the operators of tracked equipment to avoid sharp pivoting turns that could displace the cover layer material and result in damage to the liner system.

G. Contaminated water shall not be used for moisture conditioning or as dust control of final cover soils.

~~H. A 2 inch layer of ¾ inch gravel mulch shall be placed on side slopes exceeding 5H:1V .~~

H. A 2 inch layer of ¾ inch gravel mulch shall be placed on side slopes equal and greater than 5H:1V for all CAMU and BMI Landfill Covers.

DRAFT

I. Soil binder shall be placed on top deck areas less than 5H:1V. Soil binder shall be applied at rates as recommended by the manufacturer for the prevention of water and wind induced erosion on exposed soils.

3.11 AGGREGATE BASE

A. Aggregate base placement and compaction shall be in accordance with CCAUSS Section 301 and 302 for Type II aggregate base. Aggregate base shall be compacted to not less than 95% compaction as determined by AASHTO T 180.

3.12 GROUTED RIPRAP

A. Grouted rip rap shall be placed in accordance with Section 610 of the CCAUSS and the Construction Drawings.

3.13 FIELD TESTING

A. The minimum frequency and details of quality control testing for engineered fill and final cover soil are provided below. The Contractor shall provide equipment and operators to accommodate testing. This testing shall be performed by the CQA Engineer and is not separate from the testing outlined in the CQA Plan (i.e. QC and QA testing are the same and will not be duplicated). The Contractor shall take this testing frequency into account in planning the construction schedule.

1. Engineered fill and final cover soil material quality control testing:

   a. particle-size analyses conducted in accordance with ASTM D 422 at a frequency of one test per 10,000 yd^3;

   b. Atterberg Limits conducted in accordance with ASTM D 4318 at a frequency of one test per 10,000 yd^3;

   c. soil classification tests conducted in accordance with ASTM D 2487 at a frequency of one test per 10,000 yd^3; and

   d. modified Proctor compaction tests conducted in accordance with ASTM D 1557 at a frequency of one test per 10,000 yd^3/lift.

2. The CQA Engineer shall perform conformance tests on placed and compacted engineered fill and cover soil to evaluate compliance with these Specifications. These tests shall include in-situ moisture content and dry density. The frequency and procedures for moisture-density testing are given in the CQA Plan. At a minimum, the dry density and moisture content of the soil shall be measured in-situ in accordance with ASTM D 2922 and ASTM D 3017, respectively.

3. A special testing frequency shall be used by the CQA Engineer when visual observations of construction performance indicate a potential problem. Additional testing shall be considered when:

   a. the rollers slip during rolling operation;

   b. the lift thickness is greater than specified;

   c. the fill is at improper and/or variable moisture content;

DRAFT

d. fewer than the specified number of roller passes are made;

e. dirt-clogged rollers are used to compact the material;

f. the rollers do not have optimum ballast; or

g. the degree of compaction is doubtful.

4. During construction, the frequency of testing shall be increased by the CQA Engineer in the following situations:

a. adverse weather conditions;

b. breakdown of equipment;

c. at the start and finish of grading;

d. if the material fails to meet specifications; or

e. the work area is reduced.

B. Defective Areas:

1. If a defective area is discovered in the Earthwork, the CQA Engineer shall evaluate the extent and nature of the defect. If the defect is indicated by an unsatisfactory test result, the CQA Engineer shall determine the extent of the defective area by additional tests, observations, a review of records, or other means that the CQA Engineer deems appropriate. If the defect is related to adverse site conditions, such as overly wet soils or surface desiccation, the CQA Engineer shall define the limits and nature of the defect.

2. Once the extent and nature of a defect is determined, the Contractor shall correct the deficiency to the satisfaction of the CQA Engineer. The Contractor shall not perform additional work in the area until the CQA Engineer approves the correction of the defect.

3. Additional testing may be performed by the CQA Engineer to verify that the defect has been corrected. This additional testing shall be performed before any additional work is allowed in the area of deficiency. The cost of the additional testing after failure shall be borne by the Contractor.

3.14 SURVEY CONTROL

A. The Contractor shall perform all surveys necessary for construction layout and control.

3.15 CONSTRUCTION TOLERANCE

A. The Contractor shall perform the Earthwork construction to within ±0.1 ft on areas with a slope less than 10 percent and ±0.2 ft on areas with a slope greater than 10 percent of the grades indicated on the Drawings.

3.16 PROTECTION OF WORK

A. The Contractor shall use all means necessary to protect completed work of this Section.

DRAFT

B. At the end of each day, the Contractor shall verify that the entire work area is left in a state that promotes drainage of surface water away from the area and from finished work. If threatening weather conditions are forecast, at a minimum, compacted surfaces shall be seal-rolled to protect finished work.

C. In the event of damage to prior work, the Contractor shall make repairs and replacements to the satisfaction of the Construction Manager.

PART 4 – MEASUREMENT AND PAYMENT

4.01 GENERAL

A. Providing for and complying with the requirements set forth in this Section for CAMU Excavation shall be measured as Lump Sum (LS) and payment shall be based on the lump sum price provided on the Bid Schedule. Specified items incidental to CAMU Excavation include:

1. Anchor trench excavation
2. Storm water channel excavation
3. Stockpiling
4. Prepared subgrade
5. And all other incidentals necessary for a complete CAMU excavation.

B. Providing for and complying with the requirements set forth in this Section for CAMU Engineered Fill shall be measured as Lump Sum (LS) and payment shall be based on the lump sum price provided on the Bid Schedule. Anchor trench backfill shall be incidental to CAMU Engineered Fill. This lump sum shall include all incidentals necessary for a complete CAMU Engineered Fill.

C. Providing for and complying with the requirements set forth in this Section for Slit Trench Backfill shall be measured as compacted and moisture conditioned in-place cubic yards (CY), and payment shall be based on the unit price provided on the Bid Schedule. Incidental to Slit Trench Backfill shall be slit trench cover excavation. This lump sum shall include all incidentals necessary for a complete slit trench backfill.

~~D. Providing for and complying with the requirements set forth in this Section for the BMI Landfills Cover Soil shall be measured as Lump Sum (LS), and payment shall be based on the lump sum price provided on the Bid Schedule. Incidental to the BMI Landfill Cover Soil shall be soil binder. This lump sum shall include all incidentals necessary for a complete Cover soil placement on the BMI Landfills.~~

D. Providing for and complying with the requirements set forth in this Section for the BMI Landfills Cover Soil shall be measured as Lump Sum (LS), and payment shall be based on the lump sum price provided on the Bid Schedule. Incidental to the BMI Landfill Cover Soil shall be soil binder and gravel mulch. This lump sum shall include all incidentals necessary for a complete Cover soil placement on the BMI Landfills.

E. Providing for and complying with the requirements set forth in this Section for CAMU Cover Soil shall be measured as in-place cubic yards (CY), and payment shall be based on the unit price provided on the Option Scope Bid Item Schedule. Incidental to CAMU Cover

DRAFT

soil shall be gravel mulch rip-rap and soil binder. The unit price shall include all incidentals necessary for a complete CAMU cover soil placement.

F. Providing for and complying with the requirements set forth in this Section for the Storm Water Channel Excavation and Embankment shall be measured as Lump Sum (LS), and payment shall be based on the lump sum price provided on the Bid Schedule. The following are considered incidental to Storm water channel excavation and embankment:

1. Subgrade preparation
2. Aggregate base
3. All other necessary incidentals for complete installation of storm water channels.

G. Providing for and complying with the requirements set forth in this Section for the Storm Water Detention Basin Excavation and Embankment shall be measured as Lump Sum (LS), and payment shall be based on the lump sum price provided on the Bid Schedule. Lump sum shall include all necessary incidentals for complete installation of storm water detention basins.

~~H. Providing for and complying with the requirements set forth in this Section for the Storm Water Collection Improvements- Concrete Channel at the CAMU shall be measured as Lump Sum (LS), and payment shall be based on the lump sum price provided on the Bid Schedule. The following are considered incidental to Storm Water Collection Improvements:~~

~~1. Cast-in-place concrete~~
~~2. Rip Rap~~
~~3. Aggregate base~~
~~4. Subgrade Preparation~~
~~5. All necessary incidentals for complete installation of storm water concrete channels.~~

H. Providing for and complying with the requirements set forth in this Section for the Storm Water Collection Improvements- Riprap at the CAMU shall be measured as Lump Sum (LS), and payment shall be based on the lump sum price provided on the Bid Schedule. The following are considered incidental to Storm Water Collection Improvements:

1. Rip Rap
2. Aggregate base
3. Subgrade Preparation
4. All necessary incidentals for complete installation of storm water concrete channels.

I. Providing for and complying with the requirements set forth in this Section for Aggregate Base Road shall be measured as ~~in-place square feet (SF)~~, lump sum (LS) and payment shall be based on the ~~unit price~~ lump sum price provided on the Option Scope Bid Schedule. The ~~unit~~ price shall include all incidentals necessary for a complete aggregate base road installation.

DRAFT

J. Providing for and complying with the requirements set forth in this Section for CAMU cover embankment channel grouted rip rap shall be measured as Square Foot (SF), and payment shall be based on the unit price provided on the Option Scope Bid Schedule. Specified items incidental to CAMU cover embankment channel rip rap are as follows:

1. Grout
2. Aggregate Base
3. Subgrade preparation
4. All other necessary incidentals for a complete CAMU cover embankment channel installation.

K. Providing for and complying with the following incidentals shall be included in the Earthworks and Remedial Excavation and Filling, Sections 02200 and 02205, costs on the Bid Schedules:

1. Construction and Dust Control Water
2. Uncontaminated Dewatering
3. Contaminated Water Management
4. Dust Control
5. Vacuum Trucks
6. Spill Clean up
7. Health and Safety
   a. Personal Protective Equipment
   b. Monitoring
8. Operations and Maintenance of the following items:
   a. Parking Areas
   b. Temporary Roads
   c. Temporary Trailers
   d. Temporary Utilities
   e. On-site communications
   f. Weather Protection
   g. Contractor Generated Debris and Trash Control
   h. Temporary Sanitary Facilities
   i. Lighting

DRAFT

j. Material and Equipment Storage

k. Dust Control Water Storage

l. Vacuum Truck Staging Area

m. Decontamination Area

n. Construction Equipment

o. First Aid Facilities

p. HDPE-lined Storage Area

q. Dust Control

r. Pollution Control

s. Traffic and Safety Control

t. Access Control

u. Decontamination

v. Noise Control

9. And all other incidentals necessary for Earthwork

[END OF SECTION]

DRAFT

SECTION 02205
REMEDIAL EXCAVATING AND FILLING

PART 1 – GENERAL

1.01 DESCRIPTION OF WORK

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, and equipment necessary to perform all Work specified herein and as shown on the Construction Drawings.

B. The work shall include, but not be limited to the following:

1. Excavating contaminated materials from the slit trenches, western ditch, and eastside area.
2. Temporary Excavation Support.
3. Dewatering and site drainage during excavation of contaminated materials and subsequent slit trench backfill.
4. Procedures for handling hazardous and suspected hazardous substances.
5. Verifying depth and lateral extent of contamination in excavations.
6. Loading, hauling, placement, moisture conditioning, and compaction of waste materials within the CAMU.
7. Placement of interim and daily cover.

1.02 RELATED SECTIONS

Section 01010—Summary of Work

Section 01025—Measurement and Payment

Section 01300—Submittals

Section 01400—Quality Control

Section 01500—Construction Facilities

Section 01560—Temporary Controls

Section 02050—Demolition

Section 02110— Site Clearing

Section 02200— Earthwork

1.03 REFERENCES

A. Construction Drawings

B. Geosyntec, 2007, "Construction Quality Assurance (CQA) Plan for the Construction of the Corrective Action Management Unit (CAMU), Henderson, Nevada," September.

DRAFT

C. Geosyntec, 2007, "Remedial Alternative Study (RAS) for the Slit trench Area, Henderson, Nevada," July.

D. Conceptual Drainage Study

E. Pond and Sludge Dewatering Studies:

1. Pincock Allen & Holt, 2004 "Assessment of Geotextile Tube Dewatering Technology for Timet Ponds, Henderson, Nevada," Prepared for Basic Remediation Company, July.

2. Hart Crowser, 2004, "Draft: Assessment of Geotextile Tube Dewatering Technology for Timet Ponds, Henderson, Nevada," Prepared for Basic Remediation Company, November.

3. Ocean and Coastal Consultants, Inc, 2005, "Timet Ponds Drying Recommendations," April.

F. BRC, Environmental Resources Management (ERM), and Daniel B. Stevens & Associates (DBS&A), 2007, "BRC Closure Plan: BMI Common Areas, Clark County, Nevada," May.

G. BRC, 2006. "Corrective Action Plan (CAP) For The Basic Remediation Company (BRC) Common Areas Remediation Project," September.

H. Geosyntec, 2007. "Revised Remedial Action Plan (RAP) Permit Application for Corrective Action Management Unit (CAMU), Henderson, Nevada," Prepared for Basic Remediation Company, Submitted to Nevada Department of Environmental Protection, March.

I. BRC and MWH, 2005, "BRC CAMU area, 2005 soil, soil vapor, groundwater, and slit trench investigation report," October.

J. DBS&A, 2006, "Conceptual Site Model, Proposed CAMU Site, Henderson, Nevada," October.

K. Daniel B Stephens & Associates, Inc, 2006 "Conceptual Site Model, Proposed CAMU Site, Henderson Nevada," October.

L. Latest Version of American Society for Testing and Materials (ASTM) Standards:

ASTM D 1556	Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D 1557	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified
ASTM D 2167	Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D 2216	Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
ASTM D 2435	Standard Test methods for One-Dimensional Consolidation Properties of Soils Using Incremental Loading

DRAFT

ASTM D 2922	Standard Test Methods for Density of Soil and Soil-Aggregate In-Place by Nuclear Density Methods (Shallow Depth)
ASTM D 3017	Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth)
ASTM D 4643	Standard Test Method for Determination of Water (Moisture) Content of Soil by the Microwave Oven Method

1.04 SUBMITTALS

A. Comply with pertinent provisions of Section 01300, "Submittals."

~~B. The following shall be submitted prior to Notice to Proceed:~~

~~1. Waste Excavation Plan, including:~~

~~a. Excavation Plan (for excavations deeper than 20 feet)~~

~~b. Temporary Excavation Support Design~~

~~2. The Contractor shall submit to the Construction Manager the GPS excavation control methods the Contractor has available for use.~~

~~3. Access Ramp Design and Analysis~~

B. Waste Excavation Plan, including:

1. Excavation Plan (for excavations deeper than 20 feet)

2. Temporary Excavation Support Design

C. Notice of discovery of hazardous or suspect hazardous substances

D. Hazardous or suspect hazardous substances disposal location data

E. Asbestos-containing material (ACM) disposal location data

F. Preliminary and Final Results of Quality Control Tests and Waste Characterization

~~G. Asbestos: as-built location submittal~~

G. The Contractor shall submit to the Construction Manager the GPS excavation control methods the Contractor has available for use.

H. Pre-excavation Survey

I. Post-excavation Survey

J. Access Ramp Design and Analysis

1.05 QUALITY ASSURANCE

A. The Contractor shall provide dust and sediment control in accordance with the provisions of Section 01560, "Temporary Controls," and the SWPPP.

DRAFT

B. The Contractor shall ensure that the materials and methods used for Remedial Excavation meet the requirements of the Construction Drawings and this Section. Any material or method that does not conform to these documents, or to alternatives approved in writing by the Construction Manager shall be rejected and shall be repaired or replaced by the Contractor.

C. The Contractor shall be aware of and accommodate all monitoring, field/laboratory conformance, and conformance testing required by the CQA Plan and Closure Plan. This monitoring and testing, including random conformance testing of construction materials and completed work, shall be performed by the CQA Engineer. If nonconformances or other deficiencies are found in the materials or completed work, the Contractor shall be required to repair the deficiency or replace the deficient materials.

1.06 SEQUENCING AND SCHEDULING

A. The Contractor shall obtain clearances from Construction Manager at the following hold points before proceeding.

1. Acceptance of Excavation Plan and Water Management Plan; before starting excavation or dewatering work in contaminated areas.

2. Authorization for over-excavation beyond expected depth of contamination; before starting over-excavation.

3. Verification that cleanup criteria are met and surveying of excavation is complete; before placing backfill or other clean material in excavated areas.

4. Authorization to resume work or move equipment; before proceeding in an area where suspected hazardous substances are observed.

5. Acceptance of changes to excavation and dewatering plan before affecting the changes.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Eastside Contaminated Material: Soil- and sludge-like materials originating in Eastside Area ponds identified in Construction Drawings. This includes the top 6-inches of haul road soils to be removed at the conclusion of Eastside excavation and hauling operations. These materials are to be excavated, moisture conditioned, transported, and placed within the CAMU.

B. Slit Trench Cover Soil – soil material, containing no debris or visible signs of waste, overlying the slit trench waste material to be segregated and stockpiled and used for backfilling portions of the slit trenches upon completion of slit trench waste removal.

C. Slit Trench Contaminated Material: Debris or debris intermingled with soil containing, but not limited, to the following materials; metal scraps, newspaper, dark brown to black oily residue/sludge, cement, glass, black fine material, plastic bottles, rope, charred wood, red brick, clay with hydrocarbon odor, rusted metal pipe fragments with insulation material coating, rubber cord, belt pieces, paper including empty DDT bags, wood, fabric, plastic, paper bags, chalky white powder, concrete, plastic sheeting, cardboard, greenish white powder, and debris and soils containing PCB's. See BRC CAMU area, 2005 soil, soil vapor,

groundwater, and slit trench investigation report prepared by BRC and MWH for boring logs and Drawings for locations of borings and approximate limits of slit trenches.

D. Western Ditch – Contaminated soils that are located within the Phase II, Phase IIIA, and western stormwater channels within and around the CAMU, as indicated on the Construction Drawings. Western Ditch soils shall be excavated as part of the Phase II , Phase IIIA and the stormwater channel construction and shall be placed within the CAMU. Stockpiling of Phase IIIA and stormwater channel contaminated soil shall be over the Western Ditch within Phase II. Limits of Western Ditch Phase II contaminated soils excavation are the prepared subgrade for the liner system construction and vertical walls, as shown on the Construction Drawings, along the northern and southern limits of the Western Ditch extending from the existing surface to the Phase II liner system prepared subgrade. Limits of Western Ditch Phase IIIA contaminated soils excavation are the prepared subgrade for the liner system construction, vertical walls, and anchor trenches as shown on the Construction Drawings. The limits of the Western Ditch within the storm water channel are 2.5 feet below grades shown on the Construction Drawings through the width of the Western Ditch as shown on the Construction Drawings.

E. Operations Layer materials: Eastside Area or Western Ditch materials. ~~meeting the requirements listed in Section 02200 Subpart 2.01 for Engineered Fill, except that~~ The 12 inches of layer material to be placed directly overlying the geocomposite shall have a maximum particle size of 1 inch. The upper 12 inches of the 24 inch layer shall have a maximum particle size of 6 inches. The Eastside Area and Western Ditch materials shall be screened, as necessary, to meet the requirements for the operations layer.

F. Interim Cover – clean, non-contaminated earthen material used to cover exposed debris waste materials within the CAMU. Final side slopes where run-off water can exit the lined areas of the CAMU shall be covered with 1 foot of interim cover upon completion of waste placement for the day. Interim slopes between phases shall be covered with standard 6 mil visqueen. Soil shall not be placed over visqueen when waste placement proceeds to adjacent cell in the following work phase. Interim slopes shall be covered prior to forecasted precipitation events. One foot of soil material below the final cover system geosynthetic materials shall be final interim cover.

G. Daily Cover – Eastside Area materials shall be used to cover slit trench material daily. A minimum of 6-inches of soil material shall be used to cover exposed slit trench waste.

2.02 EXCLUSION ZONE ACCESS CONTROL FENCES

A. Temporary exclusion zone fence shall be ~~made of plastic and~~ a minimum of 5 feet high.

2.03 EQUIPMENT

A. The Contractor shall furnish, operate, and maintain compaction equipment as is necessary to produce the required in-place soil density and moisture content.

B. The Contractor shall furnish, operate and maintain tank trucks, pressure distributors, or other equipment designed to apply water uniformly and in controlled quantities to variable surface widths.

C. The Contractor shall furnish, operate, and maintain miscellaneous equipment such as scarifiers or disks, earth excavating equipment, earth hauling equipment, and other equipment, as necessary for Remediation Excavation and waste placement.

D. Equipment used in spreading the operations layer material on top of the geosynthetic liner system shall be restricted to the following maximum allowable equipment ground pressures:

MAXIMUM ALLOWABLE EQUIPMENT GROUND PRESSURE (psi)	INITIAL LIFT THICKNESS OF OVERLYING MATERIALS (ft)
<10	1.0
≤20	2.0
21-50	3.0
51-80	4.0
81+	5.0

PART 3 – EXECUTION

3.01 GENERAL REQUIREMENTS

A. Contractor's Health and Safety Plan shall address hazards associated with Remedial excavation and provide appropriate guidance for the required Level B Personal Protective Equipment.

B. The Contractor shall establish the required lines, levels, contours, and datum before excavating and backfilling.

C. The Contractor shall keep work involving contaminated materials separated from uncontaminated earthwork.

D. Contaminated materials shall only be stockpiled in contaminated areas.

E. Surface-water run-off from contaminated areas shall be controlled so that it does not flow onto uncontaminated areas.

F. Excavated spoil, equipment, and materials shall be kept at a sufficient setback from excavations to prevent cave-ins or bank slides.

G. The following shall be protected from damage by traffic or construction activities.

1. Bench marks and survey monuments.

2. Utilities not specified for removal.

3. Monitoring wells not to be abandoned or destroyed.

4. Archaeological artifacts encountered during the work.

H. If utilities are uncovered during excavation activities, utilities shall be supported and backfilled in accordance with City of Henderson specifications upon verification of cleanup.

DRAFT

I. No excavations deeper than 4 feet with side slopes steeper than 2:1 (horizontal:vertical) shall be made unless otherwise indicated on the Construction Drawings or without the prior approval of the Construction Manager and the Construction Manager. When shoring is required, the design and inspection of such shoring shall be the Contractor's responsibility and shall be subject to the review of the Construction Manager prior to use. No personnel shall Work within or next to an excavation requiring shoring until such shoring has been installed, inspected, and approved by an engineer registered in the State of Nevada. The Contractor shall be responsible for any fines imposed due to violation of any laws and regulations relating to the safety of the Contractor's personnel.

J. Contractor shall survey remediated surface after each disturbance so depth and volume of additional removed material can be calculated.

3.02 SLIT TRENCH PERSONAL PROTECTIVE EQUIPMENT

A. To provide adequate protection of workers, Level B Personal Protective Equipment (PPE) shall be required at all times in the slit trench excavation work area and waste placement areas within the CAMU. Level B PPE shall, at a minimum, consist of:

1. Self Contained Breathing Apparatus (SCBA);
2. Protective clothing;
3. Outer and inner gloves;
4. Outer boots;
5. Safety glasses;
6. Hard hat; and
7. Hard-toed boots.

B. Level B PPE shall be worn at CAMU during placement of slit trench wastes until daily cover is placed.

C. Contractor shall provide a safe working space for personnel within the limits of excavations.

D. Exclusion zone fencing and delineation and decontamination zones and supplies shall be provided by the Contractor at all times during waste excavation.

3.03 SITE PREPARATION

A. The Contractor shall lay out the boundaries of contaminated and uncontaminated materials, based on the available information, prior to the start of remedial work in each excavation area identified in the Excavation Plan. Do not begin clearing, grubbing, or excavation in an excavation area until the boundaries are established.

B. The Owner shall provide weather-proof signage with the pond identification, ditch section, or other identifiers and initial excavation depths at all Eastside Area remediation locations. Contractor shall place and maintain signs at ponds.

C. Clear and grub brush, roots, and similar material down to the existing ground surface in accordance with Section 02110.

DRAFT

3.04 EXCAVATION, DEWATERING, AND RUNOFF CONTROL

A. Waste Excavation Plan: The Contractor shall prepare a plan for excavating contaminated areas and hauling the materials to the CAMU. The Waste Excavation and Haul Road Plan shall be coordinated with dewatering plans described in the Water Management Plan submitted in accordance with Section "01500 Construction Facilities". At a minimum, the Plan shall include the following information:

1. Overall excavation sequence for Slit Trench excavation including Temporary Excavation Support, showing how work shall progress, and in what order Slit Trenches shall be excavated.

2. Overall excavation sequence for Western Ditch and Eastside Area excavations showing how work shall progress, and in what order ponds shall be excavated.

3. Contractor shall limit removal of overburden to expose a maximum of 40,000 Square Feet of Slit Trench waste at any time.

4. Methods for mixing of dry soils and wet sludges to moisture content less than optimum.

5. Procedures for handling surface water during construction to minimize contaminated runoff that needs to be collected and treated.

6. Procedures for odor control.

7. Procedures for excavations around monitoring wells and active utility lines.

8. Daily cover of exposed slit trench waste materials placed within the CAMU.

9. A statement of how contaminated waters shall be prevented from mixing with uncontaminated waters and from flowing onto uncontaminated areas.

10. The Contractor shall obtain Construction Manager approval of any substantive changes to the Plan before implementing changes.

B. The Contractor shall excavate clean, non-contaminated over-burden material at slit trenches until visible signs of contaminated materials are evident.

C. Materials not in accordance with the sizing requirements of Subpart 3.08 B of these Specifications shall be crushed or cut to conform to sizing requirements unless otherwise approved by Construction Manager.

D. The Contractor shall stockpile clean, non-contaminated slit trench over-burden material in accordance with Section 02200, Subpart 3.06, which shall be used as Slit Trench Backfill.

E. The Contractor shall remove contamination from areas which have been re-contaminated or were previously clean and have become contaminated as a result of Contractor's actions, at no additional cost to the Owner.

F. The Contractor shall excavate contaminated slit trench materials until the Construction Manager visually verifies the bottom of contamination is reached. Slit trench excavation shall be in accordance with the following:

DRAFT

1. Excavations shall be continuously monitored by the Construction Manager. Monitoring shall be conducted either visually or with instrumentation as appropriate to ensure only contaminated material is removed from the excavation.

2. Contractor shall not excavate beyond the approximate depth of contamination except as required for verification or as otherwise authorized in advance by the Construction Manager. Minimize to the extent possible by selective (NOT PRECISION) excavating of clean material to limit the placement of clean material in the CAMU. Contractor shall stop excavating and notify the Construction Manager if there are no visible signs of contaminated material even if the expected depths of excavation have not been reached. The 1:1 slopes shown on the drawings are not required until equipment and or personnel enter the excavation. Slit trench excavations shall be protected with temporary fencing as an exclusion zone. Contractor is not entitled to payment for unauthorized over-excavation.

3. Excavation of contaminated materials shall be considered unclassified excavation. All debris and materials encountered shall be removed and sized as part of excavation activities as described in Subpart 3.08 B. of this section.

G. The Contractor shall excavate contaminated eastside materials to the estimated depths indicated on the Construction Drawings.

1. Excavations shall proceed from east to west and from upgradient to downgradient to prevent recontamination of remediated surfaces.

2. Excavations shall be continuously monitored by the Construction Manager. Monitoring shall be conducted either visually or with instrumentation as appropriate to ensure only contaminated material is removed from the excavation.

3. Contractor shall not excavate beyond the approximate depth of contamination except as required for verification or as otherwise authorized in advance by the Construction Manager.

4. Contractor shall bench and slope excavations in accordance with 29 CFR 1926 Subpart P – excavations (Appendix B). Excavations deeper than 20 feet shall be designed by a Register Professional Engineer licensed in the State of Nevada. Portions of the walls shall be flattened or backfilled to support vehicle traffic or soil handling activities.

5. The Contractor shall coordinate with the Construction Manager as needed to identify areas that are ready for Construction Manager verification and that all required contaminated materials have been removed from the excavated areas. Verification procedure shall be in accordance with Subpart 3.04 of this Section.

6. Excavation of contaminated materials shall be considered unclassified excavation. Only soil- and sludge-like materials from eastside areas shall be disposed of in the CAMU. Encountered debris shall be dispositioned according to the requirements of Section 02010

H. In accordance with Contractor's Water Management Plan, keep working areas free of standing water so that excavation and verification work can be performed in dry conditions.

1. Excavations lying below groundwater shall be dewatered at the time of construction.

DRAFT

2. Divert and control isolated seeps or springs within work areas.

3. Divert and control storm-water runoff, and other surface waters in working areas.

4. Use best management practices identified in Contractor's SWPPP.

I. Temporary Excavation Support

1. Vertical excavations required to remove the slit trenches shall be supported by temporary retaining walls (such as soldier beam and lagging or sheet pile walls with tieback anchors) as shown on the Construction Drawings.

2. The temporary retaining walls shall be designed by the Contractor, or specialty wall Subcontractor, and stamped by a Registered Professional Engineer in the State of Nevada. The temporary retaining walls shall be designed in accordance with the following criteria:

   a. The wall shall be designed to resist lateral loads from a soil with a unit weight of 117 pounds per cubic foot, a friction angle of 35 degrees, and no cohesion.

   b. The wall shall be designed to resist lateral loads from a surcharge on the back of the wall from potential vehicular traffic of 100 pounds per square foot acting vertically behind the top of wall.

   c. The bottom of the wall shall be embedded a minimum of 5 feet below the bottom of the maximum excavation depth to satisfy global stability requirements.

   d. The wall shall be supported by tie back anchors to minimize movement of the top of the wall.

3. If groundwater is encountered during the construction of the wall, dewatering shall be required to drawdown the water table at least 5 feet below the bottom of the proposed excavation.

4. The design of the temporary wall support shall be submitted to the Construction Manager for the project for review at least 30 days prior to the start of wall construction.

5. The Contractor is responsible for all construction permits for the wall.

6. Contractor shall remove temporary excavation support above ground surface to a minimum of 3 ft below the design liner subgrade surface if support is left in place after excavation and backfill are complete.

3.05 EASTSIDE VERIFICATION PROCEDURES

A. When excavation depth indicated on the Construction Drawings is reached, Contractor shall suspend work activities at the pond for Verification Procedures. Work suspension at the pond shall continue until the Construction Manager receives confirmation sampling laboratory results. Upon receipt of results, approximately 45 to 65 days after sampling, Construction Manager shall direct Contractor to remove additional materials from the pond or proceed with measurement survey.

1. Contractor shall assume that additional excavation will be required once in each area to achieve satisfactory confirmation sample results. If additional excavation is

required for a second time in a given area, the Contractor shall be compensated on a time and materials basis.

B. Contractor shall sectioned off verification area with a rope barrier to indicate the verification process has engaged and all contaminated equipment and personnel shall stay out of the area.

C. Excavation may continue in areas where verification measurements are not being performed.

D. If an area fails to meet cleanup criteria

1. The Contractor shall return to the affected area and continue excavation as directed by Construction Manager.

2. Suspend excavation as directed to allow the Construction Manager to take additional verification measurements.

3. Continue this cycle until verification measurements confirm that the cleanup criteria have been met.

E. If an area meets cleanup criteria

1. The Contractor shall not begin backfilling, if backfilling is required by the drawings or specifications, until the Construction Manager gives written authorization.

2. The area shall be delineated as "clean" by the Contractor by means of a visible barrier and no equipment, materials, or personnel shall be allowed to enter the verified area from an unverified area.

3.06 HAZARDOUS AND SUSPECTED HAZARDOUS SUBSTANCES

A. Hazardous and suspected hazardous substances include, but are not limited to, substances listed in B below. Other substances may be identified by the Construction Manager that shall be designated to be included in this category.

B. Stop work and notify Construction Manager immediately if evidence of previously unidentified suspect hazardous substances not shown on drawings is found. Typical evidence of suspected hazardous substances may include:

1. Soil or other materials that are odorous or that emits organic vapors or trace gases.

2. Soil with unusual texture or consistency, such as crystals or sludge-like material.

3. Free liquids, other than ordinary surface water or groundwater.

4. Sustained readings of 5 parts per million (minimum) of organic vapors, measured with a photo-ionization detector at the air/soil contact in freshly disturbed soil.

5. Surface water or groundwater with a visible sheen or phase separation.

6. Tanks, cisterns, sumps, drain lines, landfills, or surface impoundments.

7. Containers suspected to contain chemical waste or products and leaking or empty containers associated with staining or discoloration.

DRAFT

8. Casings or internal components of lead-acid batteries.

9. Electrical transformers or capacitors.

10. Workers experiencing unusual physical sensations such as dizziness, headache, nausea, or metallic taste in mouth.

11. Plants or animals that are dead or have inhibited growth that may be attributed to contamination.

12. Conditions designated by Construction Manager as evidence of suspected hazardous substances.

C. Immediately notify workers to stay away from area of suspected hazardous substance. Install a physical barrier, such as a rope barrier, around the area until further direction is provided by the Construction Manager. Leave equipment and tools that contacted the suspected hazardous substance in place until Construction Manager gives clearance to remove equipment and tools.

D. Apply suitable health and safety measures in accordance with the Contractor's Health and Safety Plan, whenever working with or near suspected hazardous substance or hazardous substance.

3.07 INTERIM COVER PLACEMENT

A. Interim cover consisting of 1 foot of clean, non-contaminated soil shall be placed on final side slopes or other areas where run-off water can enter the storm water channels upon completion of waste placement for the day.

B. The Contractor shall ensure a minimum 6-mil visqueen is placed over the slopes which could allow run-off to enter unlined areas of the CAMU. Visqueen shall be placed when precipitation is forecasted. Interim cover shall be placed above areas of exposed side slope. Interim cover shall be placed from the bottom of the slope upwards. Soil shall not be placed above visqueen. The visqueen shall be nailed and/or sufficiently weighted to prevent wind uplift. Damaged visqueen shall be replaced prior to next forecasted storm event. The Contractor shall berm or cover the top of waste, or otherwise channel contaminated storm water, to prevent clean, unlined areas of the CAMU and external storm water channels from encountering contaminated storm water.

C. At the conclusion of waste placement, a 1-foot layer of final interim cover shall be placed across the entire CAMU top. The geosynthetic materials shall overlie this interim cover as shown on the Construction Drawings.

D. Final interim cover shall be compacted to ~~85~~ 90 percent (minimum) of ASTM D1557 maximum dry density at less than or equal to optimum moisture content.

E. Surface of final interim cover shall have no projections or protrusions greater than ¾ -inch.

3.08 OPERATIONS LAYER PLACEMENT

A. Place only when underlying drainage aggregate and filter geotextile or geocomposite installation is complete, including all Construction Quality Control (CQC) and CQA work, and approved by Construction Manager.

B. The subgrade to the operations layer consists of a geotextile or geocomposite. Therefore, the Contractor shall avoid tearing, puncturing, folding, or damaging in any way the filter geotextile or geocomposite geotextile during placement of the operations layer material.

C. Any damage to the geosynthetic liner system which is caused by the Contractor or representatives of the Contractor shall be repaired by the Geosynthetics Installer at the expense of the Contractor.

D. ~~Operations layer shall be compacted to 85 percent (minimum) of ASTM D1557 maximum dry density at less than or equal to optimum moisture content.~~ The operations layer shall be compacted with 4 passes by a D-6 dozer, or equivalent upon approval by Construction Manager. Moisture content shall be less than or equal to optimum.

E. The operations layer material shall be placed out in front of the equipment used to place the operations layer such that a 1-foot minimum thickness requirement is maintained at all times between the geosynthetic materials and the wheels or tracks of the equipment used to place the operations layer material.

F. Care must be exercised by the operators of tracked equipment to avoid sharp pivoting turns that could displace the operations layer material and result in damage to the liner system.

G. The Contractor shall not push operations layer material down the side slope. All soil materials shall be placed from the toe of slope upward.

H. The operations layer placed on the sideslopes shall be placed to a maximum vertical height above the horizontal surface of 10 ft at a slope inclination no steeper than 2.1H:1V as shown on the Drawings.

3.09 WASTE ACCEPTANCE CRITERIA

A. Dispose of the following slit trench materials in the CAMU, subject to sizing, placement restrictions, and other special management as specified in Subpart ~~3.08 B~~ 3.11.I of this Section.

1. Soil, organic soil matter, and rock fragments. Spread and compact as contaminated fill.

2. Pieces of wood, concrete, and masonry. Process, size, and place.

3. Structural steel members and similar long items. Size and place.

4. Other structural debris. Size and place.

5. Pipes and ducts. Process, size, and place.

6. Geomembranes and similar products from decommissioned ponds, ditches, and other temporary facilities. Process and size.

7. Tires excavated from contaminated areas. Process, size, and place.

8. Free liquids that do not pass the paint filter test, but do not contain hazardous or suspect hazardous substances. Dewater or stabilize to pass the paint filter test before placement.

DRAFT

9. Sludges that require stabilization for efficient handling, but do not contain hazardous or suspect hazardous substances. Stabilize as necessary before placement.

10. Containerized waste and already packaged asbestos. Handle and place.

11. Lead-based paint and objects coated with such paint. Place as specified for debris and oversized materials.

12. Contaminated trash and debris from construction operations. Place as specified for organic materials.

13. Other materials as directed by the Construction Manager.

B. Dispose of the following slit trench materials in the CAMU only if specified procedures for hazardous or suspect hazardous substances have been observed and if suitable pretreatment has been performed. Disposal is subject to sizing, placement restrictions, and other special management as specified.

1. Free liquids or sludges containing hazardous or suspect hazardous substances.

2. Waste oils, volatile organic compounds, and similar wastes.

3. Asbestos requiring protective packaging.

4. Automotive batteries.

5. Materials with highly concentrated contaminants, such as metallic sludges.

6. Substances that may pose imminent safety or health hazards.

C. Dispose of only eastside soil- and sludge-like materials from ponds as shown on Construction Drawings in CAMU.

D. Do not dispose of the following materials in the CAMU.

1. Contractor-owned items that can be readily decontaminated.

2. Tires used by the Contractor in the course of the Project.

3. Materials containing hazardous or suspect hazardous substances that have not been properly characterized or subjected to suitable pretreatment.

4. Debris from the eastside area.

5. Other materials considered by the Construction Manager to be unsuitable for disposal in the CAMU.

6. Trash and debris generated during construction of the CAMU.

E. The Construction Manager shall determine the acceptability of contaminated materials not falling clearly under any of the waste acceptance criteria.

F. The Construction Manager may direct in specific cases that materials subject to special management, with or without pretreatment, be disposed off site and not within the CAMU.

DRAFT

Off-site disposal of contaminated materials originating on the site is the responsibility of the Owner under this contract.

3.10 MATERIAL PLACEMENT IN CAMU

A. Layout and staging of ramps and haul roads within the CAMU and an analysis of the ramps that demonstrates that geosynthetics shall be adequately protected and that the ramps shall not be unstable during the placement process.

B. The Contractor shall be responsible for protecting geosynthetics during waste placement. Any damage to geosynthetics caused by the Contractor shall be repaired by the Geosynthetics Installer at the expense of the Contractor.

C. The Contractor shall be responsible for removing, or otherwise managing, all fluids within the CAMU through all seasons of the year for the duration of the Project. All fluids from the CAMU shall either be used for dust control in contaminated areas or shall be properly disposed of off-site.

D. During placement of contaminated material, the top surface shall be placed so that the surface is graded at a slope no flatter than 3 percent and side slopes shall be no steeper than 3H:1V.

E. Contaminated material shall be placed parallel to surfaces sloped at 10H:1V or flatter shall be considered horizontal lifts. If surfaces to receive fill are steeper than 10H:1V, place fill in horizontal lifts abutting the surface.

F. Daily cover consisting of 6 inches of eastside materials shall be placed over the entire surface of exposed Slit Trench contaminated material placed in the CAMU.

G. Dust suppression requirements apply at all times.

H. Contaminated water used for dust control shall not come into contact with clean, interim cover soils or unlined areas of the CAMU.

I. Material Sizing and Processing: Process the following slit trench materials to be placed in the CAMU.

1. Wood, Concrete, Masonry: Cut or break up to a maximum 3-foot size measured in any dimension.

2. Structural Steel Members, Pipes, Ducts, Other Long Items: Cut into maximum 10-foot lengths.

3. Concrete, Clay Tile, and Other Pipes: Crush concrete and clay tile pipes. Crush other pipes and ducts that are 6 inches or greater in diameter or, if crushing is impractical, cut pipes and ducts in half longitudinally. Do not crush asbestos-cement pipe.

4. Rubber Tires Excavated at the Site: Cut into two halves around the circumference.

5. Geomembranes: shred to a maximum strip size of 3 ~~inches~~ feet by 3 ~~inches~~ feet.

6. Other Sheet Material: Cut into strips a maximum of 4 feet wide by 4 feet long.

J. Material Blending and Conditioning

1. Eastside area excavated material shall be mixed with sludge contained in the lined TIMET ponds as needed to achieve moisture content less than or equal to optimum moisture content. Solidified waste shall be transported and disposed of in the CAMU.

2. Dry material if blending cannot achieve optimum or less moisture content.

3. Do not add water (except to minimum extent needed for dust control) after material is delivered to CAMU.

4. Remove materials within the CAMU that do not achieve specified moisture content. Re-blend or recondition material at a location within the CAMU that allows sufficient area for re-blending or reconditioning to meet specification requirements. Perform removal, re-blending or reconditioning, and replacement at no extra cost to the Owner.

K. Spreading and Compacting: Place contaminated materials, and soil-like materials with particle dimensions of 6 inches (maximum) as compacted contaminated fill.

1. Spread contaminated fill in 1 foot maximum thickness horizontal lifts, measured before compaction.

2. Lifts placed parallel to surfaces sloped at 10 (horizontal) to 1 (vertical) or flatter shall be considered horizontal lifts. If surfaces to receive fill are steeper than 10 (horizontal) to 1 (vertical), place fill in horizontal lifts abutting the surface. Lifts shall be placed across the entire base area for each phase prior to proceeding with subsequent lifts.

3. Placement of contaminated fill shall begin at bottom of slope and progress to top of slope in horizontal lifts. Under no circumstances shall materials be pushed down the side slopes.

4. Compact to 85 percent (minimum) of ASTM D 1557 maximum dry density, at less than or equal to optimum moisture content.

L. Dewatering in CAMU: During placement of contaminated materials into the CAMU, during periods of temporary shutdown, and during other inactive periods after contaminated materials have been placed into the CAMU, the Contractor shall be responsible for dewatering the CAMU at a rate that shall allow all work to be accomplished in dry conditions and that shall maintain less than 3 feet of fluid levels in the leachate collection system sump as measured from the top of the geomembrane. All water removed from the CAMU shall be discharged for use as dust control or taken off site and shall be coordinated with the Contractor's approved Water Management Plan.

M. Placement of materials in the CAMU shall conform to the following requirements as specified in the following sections:

Material	Maximum Size	Minimum Distance from Base Liner	Minimum Distance from Side-slope Liner	Minimum Distance from Final Cover Liner	Minimum Width of Compacted Eastside Material prior to material placement
Wood/ Concrete/	3 ft (any	15 ft	15 ft	15 ft	N.S.

Masonry	direction)				
Structural Steel Members/ pipes/ ducts/ other long items	10 linear ft	15 ft	15 ft	15 ft	N.S.
Rubber Tires Excavated at the Site	Cut in half	15 ft	15 ft	15 ft	N.S.
Geomembranes	3 ft x 3 ft	6 ft	15 ft	15 ft	N.S.
Other Sheet Material	4 ft x 4 ft	6 ft	15 ft	15 ft	N.S.
Slit Trench Material: Non-hazardous	<6” >6”	6 ft 15 ft	6 ft 15 ft	6 ft 15 ft	150 ft 150 ft
Slit Trench Material: Hazardous or Suspected Hazardous	<6” >6”	6 ft 15 ft	100 ft 100 ft	6 ft 6 ft	150 ft 150 ft

N.S. – Not Specified

N. ~~M.~~ Restrictions for Placement of Materials in CAMU

1. The Contractor shall remove all clean fill ramps used for construction of the CAMU prior to placement of contaminated materials in the CAMU. Any clean fill ramps placed over the liner shall be removed to within 2 feet of the liner in all areas. Portions of clean fill ramps over liners that are left in place shall not exceed 2,000 yd^3/ramp.

2. Materials must be placed into the CAMU in a manner that prevents damage to the geosynthetic components and does not produce slope stability failures.

3. A minimum of a 150-foot-wide, 4-foot-thick layer of compacted contaminated material above the 2-foot thick operations layer, for a total of 6-feet of compacted contaminated material must be placed across the CAMU bottom ahead of the working face of Slit Trench contaminated material subsequently placed in the CAMU.

4. Vehicle access to the CAMU is limited to access ramps authorized by the Construction Manger. Under no circumstances shall any vehicles access the CAMU over the sideslopes.

5. Alternatives to access ramps can be proposed by the Contractor. Such proposals shall include relevant analyses and be submitted to the Construction Manager for evaluation.

O. ~~N.~~ Requirements for Access Ramps

DRAFT

1. Design and analyses must be performed to verify that each ramp has a minimum factor of safety against slope failure of 1.5 when considering the transient loading of the equipment that shall use the access ramp. The analyses shall consider both internal failure of the ramp and block failure of the ramp at the geosynthetic/liner interface. Ramp design and analysis shall be stamped by a Registered Professional Engineer in the State of Nevada and shall be experienced and competent in the field of geosynthetic liner design and related construction operations.

2. Construction of ramps for use during placement of contaminated materials must begin at the bottom of the slope and progress to the top of the slope. Under no circumstances shall materials be pushed down the sideslopes.

3. The Contractor shall not construct more than two ramps per phase into/out of the CAMU for use during placement of contaminated materials.

4. All parts of the ramp(s) shall be at least 100 feet horizontally away from any part of any sump.

P. ~~O.~~ Selective Placement of Materials: Place the following materials at specified locations in CAMU.

1. Hazardous or Suspected Hazardous Substances: May be dispersed throughout CAMU.

   a. The Contractor shall prepare and maintain records of the vertical and horizontal location within the CAMU of each load of hazardous or suspected hazardous substances placed in the CAMU to within ± 0.5 foot. The recorded vertical and horizontal locations shall be at approximately the centers of the areas where these substances are spread. Records also shall include a description of the materials placed at each location. Each location shall be plotted on the as-built drawings with ties to field survey data and other related records.

   b. Hazardous or suspected hazardous substances shall be transported to the disposal site and disposed in an area of the CAMU that is at least 100 feet horizontally from the CAMU sideslopes at the level of contaminated material where the substances shall be buried. The substances shall be placed in one layer and shall be covered immediately with at least 2 feet of soil, compacted as specified for the contaminated material placement.

Q. ~~P.~~ Asbestos Handling and Placement

1. The vertical and horizontal limits of each Asbestos Containing Material (ACM) disposal area in the CAMU shall be surveyed to within + 0.5 foot and shown on the as-built drawings.

2. All ACM shall be buried within 24 hours with at least 2 feet of eastside material.

3. After ACM has been transported, work areas and transport vehicles shall be cleaned with significant assurance that no asbestos fibers shall become airborne when other work takes place. Decontamination water from asbestos decontamination shall be segregated from site decontamination water and disposed of off site at an appropriate treatment and/or disposal facility. Asbestos decontamination water shall not be used for dust control.

DRAFT

4. The Contractor shall conduct required air monitoring during all ACM handling, transport, and disposal processes. The Contractor must obtain clearance from the Construction Manager prior to re-deploying any equipment or supplies that were used to handle, transport, or dispose of ACM.

5. Provide PPE as required in the Contractors Heath and Safety Plan during ACM handling, transport, and placement. Contractor shall provide adequate PPE to all site workers who may come in contact with ACM at no additional cost to the Owner.

R. ~~Q.~~ Debris and Oversized Material: Place sized debris, bulky special-management waste, and material with particle dimensions greater than 6 inches as follows:

1. Do not place debris or oversized material in the following parts of the CAMU.

a. All materials placed from the outer extent (CAMU side) of the operational protective layer to a point 15 feet (measured laterally) from the CAMU liner or final cover system shall have a maximum particle size of 6 inches. No other debris or oversized material with particle dimensions greater than 6 inches may be placed within this zone.

b. Material placed further than 100 ft (measured laterally) from the CAMU liner shall be placed per all current requirements of the Construction Drawings and Construction Specifications. Place large debris and bulky items individually, at widely separated locations in the lower part of the CAMU.

2. Where individual placement is impractical, place debris and oversized material in piles or rows 2 to 3 feet high, spaced no less than 100 feet apart (measured horizontally).

3. Place debris and oversized material to avoid nesting or creation of large voids. Fill voids with loose soil to minimize open space.

4. Surround debris and oversized material with soil, placed and compacted as specified.

3.11 FIELD QUALITY CONTROL

A. Observation by Construction Manager: Do not place contaminated materials in the CAMU unless the Construction Manager is present to observe the work. Construction Manager may waive observation at Construction Manager's discretion.

B. Sampling: Take the number and size of samples required to perform the specified tests.

C. Contractor shall provide equipment and operator for testing, testing shall be perfomred by CQA Consultant: Test for in-place density and moisture content.

1. Reference Density: ASTM D1557. Provide maximum dry density and optimum moisture content for each distinct type of material or contaminated soil being placed.

a. Obtain one test (minimum) per distinct type of material or contaminated soil to be placed in the CAMU.

2. In-Place Density: ASTM D 1556, ASTM D 2167, or ASTM D 2922.

a. One test (minimum) per 2,500 cubic yards placed, or fraction thereof.

b. Additional density tests whenever definite changes in moisture content or quality of compaction are observed.

c. At least one density test per shift in which contaminated fill is placed, regardless of volume placed.

3. In-Place Moisture Content: ASTM D 2216, ASTM D 3017, or ASTM D 4643. Obtain one test with each in-place density test.

D. One-Dimensional Consolidation: ASTM D 2435

1. Obtain one in-situ Shelby Tube Sampler (minimum) per 50,000 cubic yards placed.

E. Correction of Nonconforming Work

1. Either re-work or remove and replace materials that do not conform to specified density or moisture content requirements.

2. Perform additional density and in-place moisture content tests as needed to identify the limits of the nonconforming materials.

3. Continue rework or removal and replacement until the compacted material conforms to the specified density and moisture content requirements, at no additional cost to the Owner.

3.12 SURVEY CONTROL

A. Prior to any disturbance of soils, Contractor shall perform initial layout survey.

B. Contractor shall provide post excavation grade survey map with 0.5 foot contour intervals.

PART 4 – MEASUREMENT AND PAYMENT

4.01 GENERAL

A. Providing for and complying with the requirements set forth in this Section for slit trench backfill shall be measured by Cubic Yard (CY) and payment shall be based on the unit price provided in the Base Bid Schedule. Slit trench cover soil excavation shall be incidental to slit trench backfill.

B. Providing for and complying with the requirements set forth in this Section for waste and debris excavation shall be measured by the in-place Cubic Yard (CY) of material excavated from the Eastside Area, Slit Trenches, and Western Ditch. Measurement shall be accomplished by calculating the volume of material excavated based on the Owner's field survey cross-sections taken before start of waste/debris excavation and post excavation. Field survey cross-sections shall be taken at intervals not to exceed 50 feet, at major grade breaks, and at other significant locations as agreed to by the Construction Manager and Contractor. Payment will be provided based on the following bid schedules and estimated volume of soil:

1. Base Bid Schedule: remediated volumes within +/-15 percent of the estimated quantity for excavated material placed in the CAMU. Payment will be made based on the unit price provided on the base bid schedule; and

2. Alternative Bid Items Schedule: remediated volumes above 15 percent of the estimated quantity for excavated material placed in the CAMU, if necessary. Payment will be based on a time and materials basis at the unit prices proved on the alternative bid items schedule.

Payment shall be based on the unit prices provided on the bid schedules. Specified items incidental to the Waste Soil Excavation item on the Base Bid Schedule include:

1. Access Ramp Design
2. Waste Excavation Plan
3. Temporary excavation support
4. Material excavation, screening, processing, moisture conditioning, transporting, placing, and compaction in the CAMU
5. Eastside material used for operations layer
6. Odor Control
7. Excavation Dewatering
8. Contaminated Water Dewatering
9. Temporary Exclusion Zone Control Fencing
10. Daily cover
11. Visqueen
12. All other incidentals necessary for complete remedial excavation and filling of the CAMU.

C. Measurement for special procedures or activities directed by the Construction Manager for handling, management, or treatment of hazardous or suspected hazardous substances shall be in accordance with the Alternative Bid Item Schedule to be Add/Deleted from Scope. Payment for special procedures or activities directed by the Contractor for handling, management, or treatment of hazardous or suspected hazardous substances shall be on a time and materials basis in accordance with prices provided on the Alternative Bid Item Schedule. These costs shall include all necessary incidentals to complete the alternative bid items.

D. Providing for and complying with the requirements set forth in this section for PCB contaminated soil excavation shall be by ton of PCB contaminated material excavated from the Slit Trenches, as defined on the Drawings. Payment for the excavating, transport, and disposal of PCB contaminated soil shall be made by unit price bid per ton excavated from the Slit Trenches. The unit price shall include all necessary incidentals for complete PCB contaminated soil excavation, transport, and disposal. The volume of PCB contaminated waste excavation shall be deducted from the Slit Trench Excavation volume described in A.

E. Providing for and complying with the following incidentals shall be included in the Earthworks and Remedial Excavation and Filling, Sections 02200 and 02205, costs on the Bid Schedules:

DRAFT

1. Construction and Dust Control Water
2. Uncontaminated Dewatering
3. Contaminated Water Management
4. Dust Control
5. Vacuum Trucks
6. Spill Clean up
7. Health and Safety
    a. Personal Protective Equipment
    b. Monitoring
8. Operations and Maintenance of the following items:
    a. Parking Areas
    b. Temporary Roads
    c. Temporary Trailers
    d. Temporary Utilities
    e. On-site communications
    f. Weather Protection
    g. Contractor Generated Debris and Trash Control
    h. Temporary Sanitary Facilities
    i. Lighting
    j. Material and Equipment Storage
    k. Dust Control Water Storage
    l. Vacuum Truck Staging Area
    m. Decontamination Area
    n. Construction Equipment
    o. First Aid Facilities
    p. HDPE-lined Storage Area
    q. Dust Control
    r. Pollution Control

DRAFT

s. Traffic and Safety Control

t. Access Control

u. Decontamination

v. Noise Control

9. And all other incidentals necessary for Remedial Excavation and Filling

F. Providing for and complying with the requirements set forth in this Section, Interim Cover shall be measured by the in-place cubic yard (cy) of material placed as determined by field survey cross sections taken at maximum 50 foot spacing and at major grade breaks. Payment shall be based on the Bid Schedule Item "Interim Soil Cover."

[END OF SECTION]

DRAFT

SECTION 02225
DRAINAGE AGGREGATE

PART 1 – GENERAL

1.01 DESCRIPTION OF WORK

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, and equipment necessary to perform all Work specified herein and as shown on the Construction Drawings.

B. Construction of the final CAMU cover system and associated storm water management features overlying the CAMU will be held as an Option Scope that may be added to the contract via Contract Modification at the Owner's sole discretion. If the Owner decides to exercise its option to add the Option Scope, the Construction Manager will notify the Contractor no later than 30 days after receipt of the final Eastside Area confirmation sampling

1.02 RELATED SECTIONS

Section 02200 —Earthwork

Section 02711 — Polyethylene Pipe

Section 02712 — Corrugated Polyethylene Pipe

Section 02771 — Geotextile

1.03 REFERENCES

A. Construction Drawings

B. Geosyntec, 2007 "Construction Quality Assurance Plan for the Construction of the Corrective Action Management Unit, Basic Remediation Company, Henderson, Nevada," August.

C. Latest Version of American Society for Testing and Materials (ASTM) Standards:

ASTM C 33 Standard Specification for Concrete Aggregates

ASTM C 136 Test Method for Sieve Analysis of Fine and Coarse Aggregates

ASTM D 2434 Standard Test Method for Permeability of Granular Soils (Constant Head)

1.04 SUBMITTALS

A. The Contractor shall submit to the Construction Manager for approval, at least 7 days prior to the start of construction, Certificates of Compliance for proposed aggregate materials. Certificates of Compliance shall include, at a minimum, typical gradation and source of aggregate materials.

1.05 QUALITY ASSURANCE

A. The Contractor shall ensure that the materials and methods used for Drainage Aggregate meet the requirements of the Drawings and this Section. Any material or method that does

DRAFT

not conform to these documents, or to alternatives approved in writing by the Construction Manager shall be rejected and shall be repaired or replaced by the Contractor.

B. The Contractor shall be aware of all monitoring and field/laboratory conformance testing required by the CQA Plan. This monitoring and testing, including random conformance testing of construction materials and completed work, shall be performed by the CQA Engineer. If nonconformances or other deficiencies are found in the materials or completed work, the Contractor shall be required to repair the deficiency or replace the deficient materials.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Aggregate shall meet the requirements specified in ASTM C-33 and shall have a maximum particle size of 1-inch. Aggregate shall have a minimum permeability of 1 x 10-2 cm/sec when tested in accordance with ASTM D 2434.

2.02 EQUIPMENT

A. The Contractor shall furnish, operate, and maintain hauling, placing, and grading equipment as necessary for aggregate placement.

PART 3 – EXECUTION

3.01 FAMILIARIZATION

A. Prior to implementing any of the work in this Section, the Contractor shall become thoroughly familiar with the site, the site conditions, and all portions of the work falling within this and other related Sections.

B. Inspection:

1. The Contractor shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the installation of the work specified in this Section may properly commence without adverse impact.

2. If the Contractor has any concerns regarding the installed work of other Sections, the Construction Manager shall be notified in writing prior to commencing work. Failure to notify the Construction Manager or continuance of the work of this Section shall be construed as Contractor's acceptance of the related work of all other Sections.

3.02 PLACEMENT

A. Place only when underlying geosynthetic installation is complete, including all CQC and CQA work, and approved by Construction Manager.

B. Place to the lines, grades, and dimensions shown on the Drawings.

C. The subgrade to the aggregate consists of a geotextile overlying a geomembrane. The Contractor shall avoid tearing, puncturing, folding, or damaging in any way the geosynthetic materials during placement of the aggregate material.

D. Any damage to the geosynthetic liner system which is caused by the Contractor or his representatives shall be repaired by the Geosynthetic Installer at the Contractor's expense.

DRAFT

E. No density or moisture requirements are specified for placement of the aggregate material.

F. All equipment to be used in placing the aggregate material must be approved in writing by the Construction Manager prior to use. The Contractor shall provide a list of the equipment to be used for placing the aggregate material and the necessary technical information (equipment specifications) on each piece of equipment to be approved at least two working days prior to use.

G. Place filter geotextile overlying aggregate as shown on the Drawings and as specified in Section 02771.

3.03 FIELD TESTING

A. The minimum frequency and details of quality control testing are provided below. This testing shall be performed by the CQA Engineer. The Contractor shall take this testing frequency into account in planning the construction schedule.

1. Aggregates quality control testing:

a. particle-size analyses conducted in accordance with ASTM C-136 at a frequency of one test per 5,000 yd^3;

b. permeability tests conducted in accordance with ASTM D 2434 at a frequency of one test per 10,000 yd^3.

3.04 CONSTRUCTION TOLERANCE

A. The Contractor shall perform the aggregate construction to within +0.1 ft of the thickness indicated on the Drawings.

3.05 PROTECTION OF WORK

A. The Contractor shall use all means necessary to protect all work of this Section.

B. In the event of damage, the Contractor shall make repairs and replacements to the satisfaction of the Construction Manager.

PART 4 – MEASUREMENT AND PAYMENT

4.01 GENERAL

A. Providing for and complying with the requirements set forth in this Section for Drainage Aggregate shall be incidental to leachate collection polyethylene pipe and corrugated polyethylene pipe.

[END OF SECTION]

DRAFT

SECTION 02711
LEACHATE COLLECTION POLYETHYLENE PIPE

PART 1 – GENERAL

1.01 DESCRIPTION OF WORK

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, and equipment necessary to perform all Work specified herein and as shown on the Construction Drawings.

1.02 RELATED SECTIONS

Section 02225 — Drainage Aggregate

Section 02771 — Geotextile

1.03 REFERENCES

A. Drawings

B. Construction Quality Assurance (CQA) Plan

C. Latest Version of American Society for Testing and Materials (ASTM) Standards:

ASTM F 714	Specification for Polyethylene Plastic Pipe (SDR-PR) Based on Outside Diameter
ASTM D 1248	Specification for Polyethylene Plastics Molding and Extrusion
ASTM D 2657	Standard Practice for Heat Fusion Joining of Polyolefin Pipe and Fittings
ASTM D 3035	Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Controlled Outside Diameter
ASTM D 3350	Specification for Polyethylene Plastic Pipe and Fitting Materials

1.04 DEFINITIONS

A. Standard Dimensional Ratio (SDR) is defined as the actual outside pipe diameter divided by the wall thickness.

1.05 SUBMITTALS

A. The Contractor shall submit, at least 14 days prior to installation of this material, to the Construction Manager, certificates of compliance for the pipe materials and fittings to be furnished.

B. The Contractor shall submit, at least 14 days prior to installation of this material, to the Construction Manager, copies of certifications for each operator responsible for welding pipe.

C. The Construction Manager shall supply a surveyor to document the as-built conditions of the piping. The Contractor shall notify and allow the Construction Manager sufficient time to survey piping prior to backfilling the pipe.

DRAFT

D. Contractor shall submit Manufacturer Butt-Fusion Training documentation for HDPE Pipe Joining Technicians

1.06 QUALITY ASSURANCE

A. The Contractor shall ensure that the materials and methods used for polyethylene pipe meet the requirements of the Construction Drawings and this Section. Any material or method that does not conform to these documents, or to alternatives approved in writing by the Construction Manager shall be rejected and shall be repaired or replaced by the Contractor.

PART 2 – PRODUCTS

2.01 PIPE

A. HDPE pipe sizes shown on the Drawings and specified in this Section reference nominal inside diameter. Pipe size shall be in accordance with ASTM F 714 and ASTM D 3035.

B. Pipe shall be 4-inch, 12-inch, and 18-inch diameter, and shall be HDPE with a minimum standard dimension ratio (SDR) of 13.5, and have a cell classification of 345434C in accordance with ASTM D 3350.

C. Pipe shall conform to the following requirements:

1. Pipe and fittings shall contain no recycled compound except that generated in the Manufacturer's own plant and from resin of the same specification as the raw material supplier.

2. Pipe and fittings shall be homogeneous throughout and free of visible cracks, holes, foreign inclusions, or other deleterious defects, being uniform in color, capacity, density, and other physical properties.

D. The following information shall be continuously marked on the pipe or spaced at intervals not exceeding 5 feet.

1. Name and/or trademark of the pipe Manufacturer.

2. Nominal pipe size.

3. Standard Dimensional Ratio (SDR).

4. PE 3408.

5. A production code from which the date and place of manufacture can be determined.

PART 3 – EXECUTION

3.01 GENERAL

A. When shipping, delivering, and installing pipe, fittings, and accessories, do so to ensure a sound, undamaged installation. Provide adequate storage for all materials and equipment delivered to the job site. Handle and store pipe and fittings in accordance with the Manufacturer's recommendation.

DRAFT

3.02 PLACING AND LAYING PIPE

A. Follow the Manufacturer's recommendations when hauling, unloading, and stringing the pipe.

B. Protect liners and other geosynthetic materials from damage while installing the leachate collection and removal systems.

C. HDPE solid and perforated pipe shall be installed as shown on the Drawings.

D. HDPE pipe shall be inspected for cuts, scratches, or other damages prior to installation. Any pipe showing damage, which in the opinion of the Construction Manager shall affect performance of the pipe, must be removed from the Site. The Contractor shall replace any material found to be defective at no additional cost to the Construction Manager.

E. The Contractor shall place HDPE solid and perforated pipe in such a manner that does not damage the pipe.

F. The Contractor shall place the drainage aggregate material around the polyethylene pipe so as to not deform or otherwise damage the pipe and fittings. Special care shall be taken when placing pipe bedding material beneath the spring-line of the pipe and fittings.

G. The Contractor shall clean out pipe interior, as necessary, to remove debris that may affect performance of pipe.

3.03 JOINING PIPE

A. All pipe fusion shall be performed by the Supplier, or a by fusion operator certified by the Manufacturer.

B. Join the polyethylene pipe by the method of thermal butt fusion, as outlined in ASTM D 2657. Electro-fusion couplings shall not be used. Perform butt-fusion joining of pipe and fittings in accordance with the procedures established by the pipe Manufacturer. Of particular importance is the use of proper interface pressures and heater plate temperatures.

C. Do not perform pipe fusion on wet or excessively dirty pipe or when conditions are unsuitable for the work. Secure open ends of pipe when work is not in progress, so that no water, earth, or other substance shall enter the pipe or fittings. Plug, cap, or valve off ends of pipe left for future connections, if any.

D. In order to allow the joining operation to continue in adverse weather conditions, a shelter may be required for the joining machine. Particular caution should be exercised to prevent water from entering the pipe and from coming in contact with the heater plate.

E. Only fully trained personnel shall be allowed to perform the fusion, installation, supervision, or inspection of polyethylene fusion joints.

F. Pipe joints made with couplings can be slipped fitted for perforated pipe. Solid wall pipe shall be joined with butt fusion or fusion coupler methods only.

DRAFT

PART 4 – MEASUREMENT AND PAYMENT

4.01 GENERAL

A. Providing for and complying with the requirements set forth in this Section for 4-inch , 12-inch, and 18-inch HDPE solid wall and perforated pipe, fittings, and gravel shall be measured as lump sum (LS), and payment shall be based on the lump sum price for LCRS HDPE piping and gravel provided on the Bid Schedule. Specified items incidental to LCRS HDPE piping and gravel include:

1. Filter geotextile
2. Drainage aggregate
3. And all other incidentals necessary for a complete installation of LCRS HDPE Pipe

[END OF SECTION]

DRAFT

SECTION 02712
CORRUGATED POLYETHYLENE PIPE

PART 1 – GENERAL

1.01 DESCRIPTION OF WORK

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, and equipment necessary to perform all Work specified herein and as shown on the Construction Drawings.

B. Construction of the final CAMU cover system will be held as an Option Scope that may be added to the contract via Contract Modification at the Owner's sole discretion. If the Owner decides to exercise its option to add the Option Scope, the Construction Manager will notify the Contractor no later than 30 days after receipt of the final Eastside Area confirmation sampling

1.02 RELATED SECTIONS

Section 02200 — Earthwork

1.03 REFERENCES

A. Construction Drawings

B. Site Construction Quality Assurance (CQA) Plan

C. Latest Version of American Society for Testing and Materials (ASTM) Standards:

ASTM F 405	Standard Specification for Corrugated Polyethylene (CPE) Pipe and Fittings

D. Latest American Association of State Highway and Transportation Officials (AASHTO) Standards:

AASHTO M252M-96	Corrugated Polyethylene Drainage Pipe

1.04 SUBMITTALS

A. The Contractor shall submit, at least 14 days prior to installation of this material, to the Construction Manager, certificates of compliance for the pipe materials and fittings to be furnished.

B. The ~~Construction Manager~~ Contractor shall supply a surveyor to document the as-built conditions of the piping. The Contractor shall notify and allow the Construction Manager sufficient time to survey piping prior to backfilling the pipe. Owner shall verify survey as-built conditions using control points.

1.05 QUALITY ASSURANCE

A. The Contractor shall ensure that the materials and methods used for corrugated polyethylene pipe meet the requirements of the Drawings and this Section. Any material or method that does not conform to these documents, or to alternatives approved in writing by the Construction Manager shall be rejected and shall be repaired or replaced by the Contractor.

DRAFT

PART 2 – PRODUCTS

2.01 PIPE

A. HDPE pipe sizes shown on the Drawings and specified in this Section reference nominal inside diameter. Pipe material, markings, properties, and size shall be in accordance with AASHTO M252.

B. Pipes shall be corrugated polyethylene pipe with a smooth interior wall, Type SP with Class 2 perforations in accordance with AASHTO M252.

PART 3 – EXECUTION

3.01 GENERAL

A. When shipping, delivering, and installing pipe, fittings, and accessories, do so to ensure a sound, undamaged installation. Provide adequate storage for all materials and equipment delivered to the job site. Handle and store pipe and fittings in accordance with the Manufacturer's recommendation.

3.02 PLACING AND LAYING PIPE

A. Follow the Manufacturer's recommendations when hauling, unloading, and stringing the pipe.

B. Corrugated polyethylene solid and perforated pipe shall be installed as shown on the Drawings.

C. Corrugated polyethylene pipe shall be inspected for cuts, scratches, or other damages prior to installation. Any pipe showing damage, which in the opinion of the Construction Manager shall affect performance of the pipe, must be removed from the site. Replace any material found to be defective.

3.03 CONSTRUCTION TOLERANCE

A. The Contractor shall perform the work to within ±0.1 ft of the grades indicated on the Drawings.

PART 4 – MEASUREMENT AND PAYMENT

4.01 GENERAL

A. Providing for and complying with the requirements set forth in this Section for 4-inch HDPE perforated and solid wall CPE pipe and fittings shall be measured in linear feet (LF), and payment shall be based on the unit price provided on the Option Scope Bid Schedule. Specified items considered incidental to 4-inch Corrugate Polyethylene Pipe include:

1. Filter Geotextile
2. Drainage Aggregate
3. And all other incidentals necessary for a complete installation of HDPE CPE Pipe.

[END OF SECTION]

DRAFT

SECTION 02770
GEOMEMBRANE

PART 1 – GENERAL

1.01 DESCRIPTION OF WORK

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, and equipment necessary to perform all Work specified herein and as shown on the Construction Drawings

B. Construction of the final CAMU cover system will be held as an Option Scope that may be added to the contract via Contract Modification at the Owner's sole discretion. If the Owner decides to exercise its option to add the Option Scope, the Construction Manager will notify the Contractor no later than 30 days after receipt of the final Eastside Area confirmation sampling

1.02 RELATED SECTIONS

Section 02771 — Geotextile

Section 02772 — Geosynthetic Clay Liner

Section 02773 — Geocomposite

1.03 REFERENCES

A. Construction Drawings

B. Geosyntec, 2007 "Construction Quality Assurance Plan for the Construction of the Corrective Action Management Unit, Basic Remediation Company, Henderson, Nevada," August.

C. Latest version of the American Society for Testing and Materials (ASTM) standards:

ASTM D 638	Standard Test Method for Tensile Properties of Plastics
ASTM D 792	Standard Test Methods for Specific Gravity (Relative Density) and Density of Plastics by Displacement
ASTM D 1004	Standard Test Method of Initial Tear Resistance of Plastic Film and Sheeting
ASTM D 1505	Standard Test Methods for Density of Plastics by Density-Gradient Technique
ASTM D 1603	Standard Test Method for Carbon Black in Olefin Plastics
ASTM D 5321	Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method
ASTM D 5397	Test Method for Evaluation of Stress Crack Resistance of Polyolefin Geomembranes Using Notched Constant Tensile Load Test
ASTM D 5596	Recommended Practice for Microscopical Examination of Pigment Dispersion in Plastic Compounds

DRAFT

ASTM D 5641	Practice for Geomembrane Seam Evaluation by Vacuum Chamber
ASTM D 5820	Practice for Pressurized Air Channel Evaluation of Dual Seamed Geomembranes
ASTM D 5994	Standard Test Method for Measuring Core Thickness of Textured Geomembranes
ASTM D 6392	Test Method for Determining the Integrity of Non-reinforced Geomembrane Seams Produced using Thermo-Fusion Methods.

1.04 QUALIFICATIONS

A. The Geomembrane Manufacturer shall be responsible for the production of geomembrane rolls from resin and shall have sufficient production capacity and qualified personnel to provide material meeting the requirements of this Section and the construction schedule for this project.

B. Geosynthetics Installer:

1. The Geosynthetics Installer shall be responsible and shall provide sufficient resources for field handling, deploying, seaming, temporarily restraining (against wind), and other aspects of the deployment and installation of the geomembrane and other geosynthetic components of the project.

2. The Geosynthetics Installer shall have successfully installed a minimum of 10,000,000 ft2 of polyethylene geomembrane on previous projects. The Geosynthetics Installer shall provide documentation of installations to the Construction Manager.

3. The installation crew shall have the following experience.

a. The Superintendent shall have supervised the installation of a minimum of ~~2,000,000~~ 5,000,000 ft^2 of polyethylene geomembrane on at least five (5) different projects. The Superintendent shall provide documentation of installations to the Construction Manager.

b. At least one seamer shall have experience seaming a minimum of 1,000,000 square feet of polyethylene geomembrane using the same type of seaming apparatus to be used at this site. Seamers with such experience shall be designated "master seamers" and shall provide direct supervision over less experienced seamers. The master seamer shall provide documentation of experience to the Construction Manager.

c. All other seaming personnel shall have seamed at least 100,000 square feet of polyethylene geomembrane using the same type of seaming apparatus to be used at this site. Personnel who have seamed less than 100,000 square feet shall be allowed to seam only under the direct supervision of the master seamer or Superintendent. The other seamers shall provide documentation of seaming experiences to the Construction Manager.

C. Contractor shall provide resumes for all geomembrane installation technicians with documentation of Manufacturer training on seaming geomembrane.

DRAFT

1.05 WARRANTY

A. The Geosynthetic Installer shall furnish the Construction Manager a 20-year written warranty against defects in materials. Warranty conditions concerning limits of liability shall be evaluated by, and must be acceptable to, the Construction Manager.

B. The Geosynthetic Installer shall furnish the Construction Manager with a 1-year written warranty against defects in workmanship. Warranty conditions concerning limits of liability shall be evaluated by, and must be acceptable to, the Construction Manager.

1.06 SUBMITTALS

A. The Geosynthetic Installer shall submit the following documentation on the resin used to manufacture the geomembrane to the Construction Manager for approval 21 days prior to transporting any geomembrane to the site.

1. Copies of quality control certificates issued by the resin supplier including the production dates and origin of the resin used to manufacture the geomembrane for the project.

2. Results of tests conducted by the Geomembrane Manufacturer to verify the quality of the resin used to manufacture the geomembrane rolls assigned to the project.

3. Certification that no reclaimed polymer is added to the resin during the manufacturing of the geomembrane to be used for this project, or, if recycled polymer is used, the Manufacturer shall submit a certificate signed by the production manager documenting the quantity of recycled material, including a description of the procedure used to measure the quantity of recycled polymer.

B. The Geosynthetic Installer shall submit the following documentation on geomembrane roll production to the Construction Manager for approval 21 days prior to transporting any geomembrane to the site.

1. Quality control certificates, which shall include:

a. roll numbers and identification; and

b. results of quality control tests, including descriptions of the test methods used, outlined in Part 2.02 of this Section.

2. The manufacturer warranty specified in Part 1.05.A of this Section.

C. The Geosynthetic Installer shall submit the following information to the Construction Manager for approval 21 days prior to mobilization.

1. A drawing showing the installation layout identifying geomembrane panel configurations, dimensions, details, locations of seams, as well as any variance or additional details that deviate from the Drawings. The layout shall be adequate for use as a construction plan and shall include dimensions, details, etc. The layout drawings, as modified and/or approved by the Construction Manager, shall become part of these Specifications.

2. Copy of Geosynthetic Installer's letter of approval or license by the Geomembrane Manufacturer.

DRAFT

3. Installation capabilities, including:

   a. information on equipment proposed for this project;

   b. average daily production anticipated for this project; and

   c. quality control procedures.

4. A list of completed facilities for which the installer has installed a minimum of 10,000,000 ft2 of polyethylene geomembrane, in accordance with Part 1.04 of this Specification. The following information shall be provided for each facility:

   a. the name and purpose of the facility, its location, and dates of installation;

   b. the names of the owner, project manager, and geomembrane manufacturer;

   c. name of the supervisor of the installation crew; and

   d. thickness and surface area of installed geomembrane.

5. In accordance with Part 1.04, a resume of the Superintendent to be assigned to this project, including dates and duration of employment, shall be submitted at least 14 days prior to beginning geomembrane installation.

6. In accordance with Part 1.04, resumes of all personnel who shall perform seaming operations on this project, including dates and duration of employment, shall be submitted at least 14 days prior to beginning geomembrane installation.

D. A Certificate of Calibration less than 12 months old shall be submitted for each field tensiometer prior to installation of any geomembrane. Certificates of Calibration shall be renewed as necessary to provide certificates less than 12 months old throughout project duration.

E. During installation, the Geosynthetic Installer shall be responsible for the timely submission to the Construction Manager of Quality Control documentation.

   ~~1. Quality control documentation; and~~

   ~~2. Subgrade acceptance certificates, signed by the Geosynthetic Installer, for each area to be covered by geosynthetic materials.~~

F. Upon completion of the installation, the Geosynthetic Installer shall be responsible for the submission to the Construction Manager of a warranty from the Geosynthetic Installer as specified in Part 1.05.B of this Section.

G. The Geosynthetic Installer shall submit the following documentation on welding rod to the Construction Manager for approval 21 days prior to transporting welding rod to the site:

   1. Quality control documentation, including lot number, welding rod spool number, and results of quality control tests on the welding rod.

1.07 QUALITY ASSURANCE

A. The Geosynthetic Installer shall ensure that the materials and methods used for installation of the geomembrane meet the requirements of the Drawings and this Section. Any material

or method that does not conform to these documents, or to alternatives approved in writing by the Construction Manager, shall be rejected and shall be repaired or replaced by the Geosynthetic Installer.

B. The Geosynthetic Installer shall be aware of and accommodate all monitoring and conformance testing required by the CQA Plan. This monitoring and testing, including random conformance testing of construction materials and completed work, shall be performed by the CQA Engineer. If nonconformances or other deficiencies are found in the Geosynthetic Installer's materials or completed work, the Geosynthetic Installer shall be required to repair the deficiency or replace the deficient materials.

PART 2 – PRODUCTS

2.01 GEOMEMBRANE PROPERTIES

A. The Geomembrane Manufacturer shall furnish double-sided, 60-mil textured geomembrane having properties that comply with the required property values shown in Table 02770-1.

B. In addition to the property values listed in Table 02770-1, the geomembrane shall:

1. Contain a maximum of 1 percent by weight of additives, fillers, or extenders (not including carbon black).

2. Not have striations, pinholes (holes), bubbles, blisters, nodules, undispersed raw materials, or any sign of contamination by foreign matter on the surface or in the interior.

2.02 MANUFACTURING QUALITY CONTROL

A. Rolls:

1. The Geomembrane Manufacturer shall continuously monitor geomembrane during the manufacturing process for defects.

2. No geomembrane shall be accepted that exhibits any defects.

3. The Geomembrane Manufacturer shall measure and report the geomembrane thickness at regular intervals along the roll length.

4. No geomembrane shall be accepted that fails to meet the specified thickness.

5. The Geomembrane Manufacturer shall sample and test the geomembrane at a minimum of once every 50,000 ft2 to demonstrate that its properties conform to the values specified in Table 02770-1. At a minimum, the following tests shall be performed:

Test	Procedure
Thickness	ASTM D 5994
Specific Gravity	ASTM D 792 Method A or ASTM D 1505
Tensile Properties	ASTM D 638
Puncture Resistance	ASTM D 4833
Carbon Black	ASTM D 1603
Carbon Black Dispersion	ASTM D 5596

6. Tests not listed above but listed in Table 02770-1 need not be run at the 1 per 50,000 ft2 frequency. However, the Geomembrane Manufacturer shall certify that these tests are in compliance with this section and have been performed on a sample that is identical to the geomembrane to be used on this project. The Geosynthetic Installer shall provide the test result documentation to the Construction Manager.

7. Any geomembrane sample that does not comply with the requirements of this Section shall result in rejection of the roll from which the sample was obtained and shall not be used for this project. If a geomembrane sample fails to meet the quality control requirements of this Section the Geomembrane Manufacturer shall sample and test, at the expense of the Manufacturer, rolls manufactured in the same lot, or at the same time, as the failing roll. Sampling and testing of rolls shall continue until a pattern of acceptable test results is established to bound the failed roll(s).

8. If a geomembrane sample fails to meet the quality control requirements of this Section, the roll shall be rejected and shall not be delivered to site.

B. The Geomembrane Manufacturer shall permit the CQA Engineer to visit the manufacturing plant for project specific visits. If possible, such visits shall be prior to or during the manufacturing of the geomembrane rolls for the specific project.

2.03 LABELING

A. Geomembrane rolls shall be labeled with the following information.

1. thickness of the material;
2. length and width of the roll;
3. name of Geomembrane Manufacturer;
4. product identification;
5. lot number; and
6. roll number.

2.04 TRANSPORTATION, HANDLING AND STORAGE

A. Handling and care of the geomembrane prior to and following installation at the site shall be the responsibility of the Geosynthetic Installer. The Geosynthetic Installer shall be liable for all damage to the materials incurred prior to final acceptance of the liner system by the Construction Manager.

B. Geosynthetic Installer shall be responsible for storage of the geomembrane at the site. The geomembrane shall be protected from excessive heat or cold, dirt, puncture, cutting, or other damaging or deleterious conditions. Any additional storage procedures required by the Geomembrane Manufacturer shall be the Geosynthetic Installer's responsibility. Geomembrane rolls shall not be stored or placed in a stack of more than two rolls high.

C. The geomembrane shall be delivered at least 30 days prior to the planned deployment date to allow the Construction Manager adequate time to coordinate conformance testing on the geomembrane samples as described in Part 3.05 or this Section. If the CQA Engineer visited the manufacturing plant and performed the required conformance sampling,

DRAFT

geomembrane can be delivered to the site within the 14 days prior to the planned deployment date as long as there is sufficient time for the CQA Engineer to complete conformance testing and confirm that the rolls shipped to the site are in compliance with this Section.

D. The CQA Engineer shall follow Chain-of-Custody procedures for sample transportation.

PART 3 – GEOMEMBRANE INSTALLATION

3.01 FAMILIARIZATION

A. Prior to implementing any of the work described in this Section, the Geosynthetic Installer shall become thoroughly familiar with all portions of the work falling within this Section.

B. Inspection:

1. The Geosynthetic Installer shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the work of this Section may properly commence without adverse effect.

2. If the Geosynthetic Installer has any concerns regarding the installed work of other Sections, he shall notify the Construction Manager in writing prior to the start of the work of this Section. Failure to inform the Construction Manager in writing or installation of the geomembrane shall be construed as the Geosynthetic Installer's acceptance of the related work of all other Sections.

C. A pre-installation meeting shall be held to coordinate the installation of the geomembrane with the installation of other components of the composite liner system.

3.02 GEOMEMBRANE DEPLOYMENT

~~A. Prior to geomembrane deployment, Geosynthetic installer shall verify subgrade meets the requirements of Section 02200 for subgrade preparation. The Contractor shall provide the Construction Manager with a subgrade acceptance certificate.~~

A. Layout Drawings:

1. The Geosynthetic Installer shall deploy the geomembrane panel in general accordance with the layout drawing submitted to the Construction Manager.

B. Field Panel Identification:

1. A geomembrane field panel is a roll or a portion of roll cut in the field.

2. Each field panel shall be given an identification code (number or letter-number). This identification code shall be agreed upon by the Construction Quality Assurance Manager and Geosynthetic Installer.

C. Field Panel Placement:

1. Field panels shall be installed, as approved or modified, at the location and positions indicated on the layout drawings.

2. Field panels shall be placed one at a time, and each field panel shall be seamed immediately after its placement. Panels shall be overlapped so that the flow of liquid

above the liner is across the top of the weld and not into the flap area of the fusion weld (shingled to allow water to cross seam).

3. Geomembrane shall not be placed when the ambient temperature is below 40°F or above 104°F, unless otherwise authorized in writing by the Construction Manager.

4. Geomembrane shall not be placed during any precipitation, in the presence of excessive moisture (e.g., fog, dew), in an area of ponded water, or in the presence of excessive winds.

5. The Geosynthetic Installer shall ensure that:

   a. Vehicular traffic shall be limited to vehicles that exhibit a ground pressure less than that of foot traffic pressure.

   b. Equipment used does not damage the geomembrane by handling, trafficking, or leakage of hydrocarbons (i.e., fuels).

   c. Only hook knives are used to cut geomembrane.

   d. Personnel working on the geomembrane do not smoke, wear damaging shoes, bring glass onto the geomembrane, or engage in other activities that could damage the geomembrane.

   e. The method used to unroll the panels does not scratch or crimp the geomembrane and does not damage the supporting soil or geosynthetics.

   f. The method used to place the panels minimizes wrinkles (especially differential wrinkles between adjacent panels). The method used to place the panels results in intimate contact with adjacent components.

   g. Temporary ballast and/or anchors (e.g., sand bags), not likely to damage the geomembrane, are placed on the geomembrane to prevent wind uplift. Sand bags shall be filled with sand material with a maximum particle size of ½ inch.

   h. The geomembrane is especially protected from damage in heavily trafficked areas.

   i. Any rub sheets to facilitate seaming are removed prior to installation of subsequent panels.

6. Any field panel or portion thereof that becomes seriously damaged (torn, twisted, or crimped) shall be replaced with new material. Less serious damage to the geomembrane may be repaired, as approved by the CQA Engineer. Damaged panels or portions of damaged panels that have been rejected shall be removed from the work area. Any damaged materials shall be replaced at the Geosynthetic Installers' expense.

D. If the Geosynthetic Installer intends to install geomembrane between one hour before sunset and one hour after sunrise, he shall notify the Construction Manager in writing prior to the start of the work. The Geosynthetic Installer shall indicate additional precautions, which shall be taken during these installation hours. The Geosynthetic Installer shall provide proper, adequate illumination for work during this time period.

DRAFT

3.03 FIELD SEAMING

A. Seam Layout:

1. In corners and at odd-shaped geometric locations, the number of field seams shall be minimized. No horizontal seam shall be along a slope with an inclination steeper than 10 percent. Horizontal seams shall be considered as any seam having an alignment exceeding 20 degrees from being perpendicular to the slope contour lines, unless otherwise approved by the Construction Manager. No seams shall be located in an area of potential stress concentration.

B. Personnel:

1. All personnel performing seaming operations shall be qualified as indicated in Part 1.04 of this Section. No seaming shall be performed unless a "master seamer" is present on-site.

C. Weather Conditions for Seaming:

1. Unless authorized in writing by the Construction Manager, seaming shall not be attempted at ambient temperatures below 40°F or above 104°F. If the Geosynthetic Installer wishes to use methods that may allow seaming at ambient temperatures below 40°F or above 104°F, he shall use a procedure approved by the Construction Manager.

2. A meeting shall be held with the Geosynthetic Installer and Construction Manager to establish acceptable installation procedures. In all cases, the geomembrane shall be dry and protected from wind damage.

3. Ambient temperatures shall be measured between 0 to 6 in. above the geomembrane surface.

D. Overlapping:

1. Geomembrane panels shall be sufficiently overlapped for welding and to allow peel tests to be performed on the seam. Any seams that cannot be destructively tested because of insufficient overlap shall be treated as failing seams.

E. Seam Preparation:

1. Prior to seaming, the seam area shall be clean and free of moisture, dust, dirt, debris of any kind, and foreign material.

2. If seam overlap grinding is required, the process shall be completed according to the Geomembrane Manufacturer's instructions within 20 minutes of the seaming operation and in a manner that does not damage the geomembrane. The grind depth shall not exceed ten percent of the geomembrane thickness.

3. Seams shall be aligned with the fewest possible number of wrinkles and "fishmouths."

F. General Seaming Requirements:

1. Fishmouths or wrinkles at the seam overlaps shall be cut along the ridge of the wrinkle to achieve a flat overlap. The cut fishmouths or wrinkles shall be seamed and

DRAFT

any portion where the overlap is insufficient shall be patched with an oval or round patch of geomembrane that extends a minimum of 6 in. beyond the cut in all directions.

2. Any electric generator shall be placed outside the area to be lined or mounted in a manner that protects the geomembrane from damage. The electric generator shall be properly grounded.

G. Seaming Process:

1. Approved processes for field seaming are extrusion welding and fusion welding. Only equipment identified as part of the approved submittal specified in Part 1.06 shall be used.

2. Extrusion Equipment and Procedures:

a. The Geosynthetics Installer shall maintain at least one spare operable seaming apparatus on site.

b. Extrusion welding apparatus shall be equipped with gauges giving the temperature in the apparatus.

c. Prior to beginning a seam, the extruder shall be purged until all heat-degraded extrudate has been removed from the barrel.

d. A smooth insulating plate or fabric shall be placed beneath the hot welding apparatus after use.

3. Fusion Equipment and Procedures:

a. The Geosynthetic Installer shall maintain at least one spare operable seaming apparatus on site.

b. Fusion-welding apparatus shall be automated vehicular-mounted devices equipped with gauges giving the applicable temperatures and speed.

c. A smooth insulating plate or fabric shall be placed beneath the hot welding apparatus after use.

H. Trial Seams:

1. Trial seams shall be made on fragment pieces of geomembrane to verify that seaming conditions are adequate. Trial seams shall be conducted on the same material to be installed and under similar field conditions as production seams. Such trial seams shall be made at the beginning of each seaming period, beginning of the day and after lunch, for each seaming apparatus used each day. The trial seam sample shall be a minimum of 5-ft long by 1-ft wide (after seaming) with the seam centered lengthwise for fusion equipment and at least 3-ft long by 1-ft wide for extrusion equipment. Seam overlap shall be as indicated in Part 3.03.D of this Section. The CQA Engineer shall be present during trial seaming.

2. The CQA Engineer shall collect four adjoining coupon specimens, each 1-in. wide, cut from the trial seam sample by the installer using a die cutter to ensure precise 1-in. wide coupons. The coupons shall be tested by the CQA Engineer in peel (outside (fusion only) and inside track) and shear using an electronic readout field tensiometer

DRAFT

in accordance with ASTM D ~~4437~~ 6392, at a strain rate of 2 in./min., and they shall not fail in the seam (i.e., Film Tear Bond (FTB), which is failure in the parent material, is required). The required peel and shear seam strength is listed in Table 02770-2. Ideally, samples shall be conditioned at 23±2oC at a relative humidity of 50±5% for two hours prior to testing. If test conditions vary from these conditions, a 1-in. wide coupon of the parent geomembrane material (no weld) shall be tested in the same manner as the seam specimens to determine the break strength at this condition.

3. If a coupon specimen fails, the entire operation shall be repeated. If the additional coupon specimen fails, the seaming apparatus and seamer shall not be accepted and shall not be used for seaming until the deficiencies are corrected and two consecutive successful trial seams are achieved.

I. Nondestructive Seam Continuity Testing:

1. The Geosynthetic Installer shall nondestructively test for continuity on all field seams over their full length. Continuity testing shall be carried out as the seaming work progresses, not at the completion of all field seaming. The Geosynthetic Installer shall complete any required repairs in accordance with Part 3.03.K of this Section. The following procedures shall apply:

   a. Vacuum testing in accordance with ASTM D 5641.

   b. Air pressure testing (for double-track fusion seams only) in accordance with ASTM D 5820 and the following:

      i. Energize the air pump to a pressure between 25 and 30 pounds per square inches, close valve, and sustain the pressure for not less than 5 minutes.

      ii. If loss of pressure exceeds 3 pounds per square inches, or does not stabilize, locate faulty area and repair in accordance with Part 3.03.K of this Section.

      iii. Cut opposite end of air channel from pressure gauge and observe release of pressure to ensure air channel is not blocked.

      iv. Remove needle, or other approved pressure feed device, and seal repair in accordance with Part 3.03.K of this Section.

   c. Spark testing shall be performed if the seam cannot be tested using other nondestructive methods.

J. Destructive Testing:

1. Destructive seam tests shall be performed on samples collected from selected locations to evaluate seam strength and integrity. Destructive tests shall be carried out as the seaming work progresses, not at the completion of all field seaming.

2. Sampling:

   a. Test locations shall be determined during seaming, and may be prompted by suspicion of excess crystallinity, contamination, offset seams, or any other potential cause of imperfect seaming. The CQA Engineer shall be responsible for coordinating the locations. The Geosynthetic Installer shall not be informed in

advance of the locations where the seam samples shall be taken. The CQA Engineer reserves the right to increase the sampling frequency.

b. Obtain 1 sample (minimum) for each 500 linear feet, or fraction thereof, of fusion welded seam for each welding machine/welding technician combination.

c. After completing a number of consecutive destructive sample laboratory tests for each welding machine/welding technician combination, as outlined in the following table, the frequency for the specific welding machine/welding technician may be adjusted as indicated in the following table.

Number of Destructive Samples per Welding Machine/Welding Technician	Failures	Frequency (ft)
0-10	0/≥1	500/500
11-20	0/≥1	750/500
21+	≤1/≥2	1000/750

d. Destructive testing of extrusion seams may be conducted upon scrap material that has been extrusion welded past the initial startup seam for the shift if the footage of extrusion weld for the shift is less than 200 linear feet and if the Contractor concurs

e. Samples shall be cut by the Geosynthetic Installer at the locations designated by the CQA Engineer as the seaming progresses in order to obtain laboratory test results before the geomembrane is covered by another material. Each sample shall be numbered and the sample number and location identified on the panel layout drawing. All holes in the geomembrane resulting from the destructive seam sampling shall be immediately repaired in accordance with the repair procedures described in Part 3.03.K of this Section. The continuity of the new seams in the repaired areas shall be tested according to Part 3.03.I of this Section.

f. Two strips of dimensions 1-in. wide and 12 in. long with the seam centered parallel to the width shall be taken from either side of the sample location. These samples shall be tested in the field in accordance with Part 3.03.J.3 of this Section. If these samples pass the field test, a laboratory sample shall be taken. The laboratory sample shall be at least 1-ft wide by 42-inches long with the seam centered lengthwise. The sample shall be cut into three parts and distributed as follows:

   i. One portion 12-in. long to the Geosynthetic Installer.

   ii. One portion 18-in. long to the Geosynthetic CQA Laboratory for testing.

   iii. One portion 12-in. long to the Construction Manager for archival storage.

3. Field Testing:

a. The two 1-in. wide strips shall be tested in the field tensiometer in the peel mode. The CQA Engineer has the option to request an additional test in the shear mode. If any field test sample fails to meet the requirements in Table 02770-2, then the procedures outlined in Part 3.03.J.5 of this Section shall be followed.

4. Laboratory Testing:

a. Testing by the Geosynthetics CQA Laboratory shall include "Seam Strength" and "Peel Adhesion" (ASTM D 4437) with the 1-in. wide strip tested at a rate of 2 in./min. At least 5 specimens shall be tested for each test method (peel and shear). Four of the five specimens per sample must pass both the shear strength test and peel adhesion test when tested in accordance with ASTM D ~~4437~~ 6392. The minimum acceptable values to be obtained in these tests are indicated in Table 02770-2. Both inside and outside tracks of the dual track fusion welds shall be tested in peel.

5. Destructive Test Failure:

a. The following procedures shall apply whenever a sample fails a destructive test, whether the test is conducted by the Geosynthetic CQA's laboratory, the Geosynthetic Installer laboratory, or by a field tensiometer. The Geosynthetic Installer shall have two options:

i. The Geosynthetic Installer can reconstruct the seam (e.g., remove the old seam and reseam) between any two passed destructive test locations.

ii. The Geosynthetic Installer can trace the welding path to an interim location, a minimum of 10 feet from the location of the failed test (in each direction) and take a small sample for an additional field test at each location. If these additional samples pass the field tests, then full laboratory samples shall be taken. These full laboratory samples shall be tested in accordance with Part 3.03.J.4 of this Section. If these laboratory samples pass the tests, then the seam shall be reconstructed between these locations. If either sample fails, then the process shall be repeated to establish the zone in which the seam should be reconstructed. All acceptable seams must be bounded by two locations from which samples passing laboratory destructive tests have been taken. In cases exceeding 150 ft of reconstructed seam, a sample taken from within the reconstructed zone must pass destructive testing.

b. Whenever a sample fails, the CQA Engineer may require additional tests for seams that were formed by the same seamer and/or seaming apparatus or seamed during the same time shift.

K. Defects and Repairs:

1. The geomembrane shall be inspected before and after seaming for evidence of defects, holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter. The surface of the geomembrane shall be clean at the time of inspection. The geomembrane surface shall be swept or washed by the Installer if surface contamination inhibits inspection.

2. Each suspected location, both in seam and non-seam areas, shall be nondestructively tested using the methods described Part 3.03.I of this Section, as appropriate. Each

location that fails nondestructive testing shall be marked by the CQA Engineer and repaired by the Geosynthetic Installer.

3. When seaming of a geomembrane is completed (or when seaming of a large area of a geomembrane is completed) and prior to placing overlying materials, the CQA Engineer shall identify all excessive geomembrane wrinkles (Wrinkles with a height to width ratio greater than 1H:6W,e.g., 2" height over 12" width). The Geosynthetic Installer shall cut and reseam all wrinkles so identified. The seams thus produced shall be tested like any other seams.

4. Repair Procedures:

   a. Any portion of the geomembrane exhibiting a flaw, or failing a destructive or nondestructive test, shall be repaired by the Geosynthetic Installer. Several repair procedures exist. The final decision as to the appropriate repair procedure shall be agreed upon between the CQA Engineer and the Geosynthetic Installer. The procedures available include:

      i. patching, used to repair holes larger than 1/16 inch, tears, undispersed raw materials, and contamination by foreign matter;

      ii. abrading and reseaming, used to repair small sections of extruded seams;

      iii. spot seaming, used to repair minor, localized flaws;

      iv. capping, used to repair long lengths of failed seams; and

      v. removing bad seam and replacing with a strip of new material seamed into place (used with long lengths of fusion seams).

   b. In addition, the following criteria shall be satisfied:

      i. surfaces of the geomembrane that are to be repaired shall be abraded no more than 20 minutes prior to the repair;

      ii. all surfaces must be clean and dry at the time of repair;

      iii. all seaming equipment used in repair procedures must be approved;

      iv. the repair procedures, materials, and techniques shall be approved in advance, for the specific repair, by the CQA Engineer;

      v. patches or caps shall extend at least 6 in. beyond the edge of the defect, and all corners of patches shall be rounded with a radius of at least 3 in.; and

      vi. the geomembrane below large caps shall be appropriately cut to avoid water or gas collection between the two sheets.

5. Repair Verification:

   a. Each repair shall be nondestructively tested using the methods described in Part 3.03.I of this Section, as appropriate. Repairs that pass the nondestructive test shall be taken as an indication of an adequate repair. Failed tests shall require the repair to be redone and retested until a passing test results. At the discretion of the CQA Engineer, destructive testing may be required on large caps.

DRAFT

3.04 ANCHORAGE

A. Temporary anchorage of the geomembrane shall be in accordance with the Construction Drawings and consist of the geomembrane extended approximately 10 ft from the toe of the waste slope and have two feet of operations layer placed on top. The edge of the geomembrane shall be protected with plywood.

B. Temporary anchor trenches shall be as shown on the Construction Drawings.

C. Permanent anchorage shall be as shown on the Construction Drawings and in accordance with the Specifications for Anchor Trenching in Section 02200.

3.05 MATERIALS IN CONTACT WITH THE GEOMEMBRANE

A. The Geosynthetic Installer shall take all necessary precautions to ensure that the geomembrane is not damaged during its installation. During the installation of other components of the liner system by the Contractor, the Contractor shall ensure that the geomembrane is not damaged. Any damage to the geomembrane shall be repaired by the Geosynthetic Installer , at the expense of the Contractor.

B. Soil and aggregate materials shall not be placed over the geomembranes at ambient temperatures below 40°F or above 104°F, unless otherwise specified.

C. All attempts shall be made to minimize wrinkles in the geomembrane.

D. Equipment shall not be driven directly on the geomembrane. Equipment shall only be driven above operations layer.

3.06 CONFORMANCE TESTING

A. Samples of the geomembrane shall be removed by the CQA Engineer and sent to a Geosynthetic CQA Laboratory for testing to ensure conformance with the requirements of this Section. The Geosynthetic Installer shall assist the CQA Engineer in obtaining conformance samples. The Geosynthetic Installer and Construction Manager shall account for this testing in the installation schedule. Only material that meets the requirements of Part 2.02 this Section shall be installed. Conformance sampling may be conducted at the manufacturing facility prior to shipment to the site.

B. Samples shall be selected by the CQA Engineer in accordance with this Section and with the procedures outlined in the CQA Plan.

C. Samples shall be taken at a minimum frequency of one sample per 100,000 ft2.

D. The CQA Engineer may increase the frequency of sampling in the event that test results do not comply with the requirements of Part 2.02 of this Section.

E. The following tests shall be performed by the CQA Engineer:

Test	Test Method
Specific Gravity	ASTM D 792 or D 1505
Thickness	ASTM D 5994
Tensile Properties	ASTM D 638
Carbon Black Content	ASTM D 1603
Carbon Black Dispersion	ASTM D 5596

F. Any geomembrane that is not certified in accordance with Part 1.07.C of this Section, or that conformance testing indicates do not comply with Part 2.02 of this Section, shall be rejected. The Geosynthetic Installer shall replace the rejected material with new material.

3.07 GEOMEMBRANE ACCEPTANCE

A. The Geosynthetic Installer shall retain all ownership and responsibility for the geomembrane until accepted by the CQA Engineer.

B. The geomembrane shall be accepted by the CQA Engineer when:

1. the installation is completed;

2. all documentation is submitted;

3. verification of the adequacy of all field seams and repairs, including associated testing, is complete; and

4. all warranties are submitted.

3.08 PROTECTION OF WORK

A. The Geosynthetic Installer and Contractor shall use all means necessary to protect all work of this Section.

B. In the event of damage, the Geosynthetic Installer shall make all repairs and replacements necessary, to the satisfaction of the CQA Engineer.

PART 4 – MEASUREMENT AND PAYMENT

4.01 GENERAL

A. Providing for a complying with the requirements set forth in this Section for textured HDPE geomembrane for the CAMU Liner Geosynthetic System shall be measured as Lump Sum (LS), including geomembrane in the anchor trench to the limits shown on the Drawings, and payment shall be included with the lump sum price for CAMU Liner System geosynthetic materials provided on the Base Bid Schedule.

B. Providing for a complying with the requirements set forth in this Section for textured HDPE geomembrane for the North and South BMI Landfill Cover systems shall be measured as Lump Sum (LS), including geomembrane in the anchor trench to the limits shown on the Drawings, and payment shall be included with the lump sum price for North and South BMI Landfill Cover liner systems lump sum price provided on the Bid Schedule.

C. Providing for a complying with the requirements set forth in this Section for textured HDPE geomembrane for the CAMU Cover system shall be measured as in-place square feet (SF), including geomembrane in the anchor trench to the limits shown on the Drawings, and payment shall be included in the unit price for CAMU Cover- geosynthetic system provided on the Option Scope Bid Schedule.

D. The Lump Sum costs shall include all incidentals necessary for a complete installation of Geomembrane liner.

DRAFT

TABLE 02770-1
REQUIRED HDPE GEOMEMBRANE PROPERTIES

PROPERTIES	QUALIFIERS	UNITS	SPECIFIED VALUES	TEST METHOD
Physical Properties				
Thickness	Average Minimum	mils mils	60 54	ASTM D 5994
Specific Gravity	Minimum	N/A	.940	ASTM D 792 Method A or ASTM D 1505
Mechanical Properties				
Tensile Properties (each direction)				
1. Tensile (Break) Strength Tensile (Break) Strength 2. Elongation at Break 3. Tensile (Yield) Strength 4. Elongation at Yield	Minimum	lb/in % lb/in %	90 100 126 12	ASTM D 638
Puncture	Minimum	lb	90	ASTM D 4833
Tear Resistance	Minimum	lb	42	ASTM D 1004
Interface Shear Strength	-	-	Note 1	ASTM D 5321
Environmental Properties				
Carbon Black Content	Range	%	2-3	ASTM D 1603
Carbon Black Dispersion	N/A	none	Note 2	ASTM D 5596
Environmental Stress Crack	Minimum	hr	300	ASTM D 5397

Notes: (1) Interface shear strength test(s) shall be performed, by the CQA Engineer, on the composite liner system in accordance with Section 02772 —Geosynthetic Clay Liner.
(2) Minimum 8 of 10 in Categories 1 or 2; 10 in Categories 1, 2, or 3.

DRAFT

TABLE 02770-2
REQUIRED GEOMEMBRANE SEAM PROPERTIES

PROPERTIES	QUALIFIERS	UNITS	SPECIFIED VALUES	TEST METHOD
Shear Strength(1)				
Fusion	minimum	lb/in	120	ASTM D 6392
Extrusion	minimum	lb/in	120	ASTM D 6392
Peel Adhesion				
FTB(2)				
Fusion	minimum	lb/in	91	ASTM D 6392
Extrusion	minimum	lb/in	78	ASTM D 6392

Notes: (1) Also called "Bonded Seam Strength".
(2) FTB = Film Tear Bond means that failure is in the parent material, not the seam. The maximum seam separation is 25 percent of the seam area.

[END OF SECTION]

DRAFT

SECTION 02771
GEOTEXTILE

PART 1 – GENERAL

1.01 DESCRIPTION OF WORK

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, and equipment necessary to perform all Work specified herein and as shown on the Construction Drawings

B. The work shall include, but not be limited to, delivery, storage, placement, and seaming of the various geotextile components of the project.

C. Filter geotextile shall be used overlying the drainage aggregate. A UV protective geotextile shall be used overlying the exposed portions of geosynthetic components of the side slope liner system.

D. Construction of the final CAMU cover system and associated storm water management features overlying the CAMU will be held as an Option Scope that may be added to the contract via Contract Modification at the Owner's sole discretion. If the Owner decides to exercise its option to add the Option Scope, the Construction Manager will notify the Contractor no later than 30 days after receipt of the final Eastside Area confirmation sampling

1.02 RELATED SECTIONS

Section 02200 — Earthwork

Section 02225 — Drainage Aggregate

Section 02770 — Geomembrane

Section 02773 — Geocomposite

1.03 REFERENCES

A. Drawings

B. Construction Quality Assurance (CQA) Plan

C. Latest version of American Society for Testing and Materials (ASTM) standards:

ASTM D 3786	Standard Test Method for Hydraulic Bursting Strength of Knitted Goods and Nonwoven Fabric-Diaphragm Bursting Strength Test Method
ASTM D 4355	Standard Test Method for Deterioration of Geotextile from Exposure to Ultraviolet Light and Water
ASTM D 4491	Standard Test Method for Water Permeability of Geotextile by Permittivity
ASTM D 4533	Standard Test Method for Trapezoid Tearing Strength of Geotextile
ASTM D 4595	Standard Test Method for Wide Width Tensile Properties of Geosynthetics

DRAFT

ASTM D 4632	Standard Test Method for Breaking Load and Elongation of Geotextile (Grab Method)
ASTM D 4751	Standard Test Method for Determining Apparent Opening Size of a Geotextile
ASTM D 4833	Standard Test Method for Index Puncture Resistance of Geotextile, Geomembranes, and Related Products
ASTM D 5261	Standard Test Method for Measuring Mass Per Unit Area of Geotextile

1.04 SUBMITTALS

A. The Geosynthetic Installer shall submit to the Construction Manager, at least 21 days prior to geotextile delivery, the following information regarding the proposed geotextile:

1. manufacturer and product name;
2. minimum property values of the proposed geotextile and the corresponding test procedures;
3. projected geotextile delivery dates; and
4. list of geotextile roll numbers for rolls to be delivered to the site.

B. At least 21 days prior to geotextile placement, the Geosynthetic Installer shall submit to the Construction Manager the manufacturing quality control certificates for each roll of geotextile. The certificates shall be signed by responsible parties employed by the geotextile manufacturer (such as the production manager). The quality control certificates shall include:

1. lot, batch, and/or roll numbers and identification; and
2. results of quality control tests, including a description of the test methods used.

C. ~~The Contractor shall submit to the Construction Manager within 21 days after geomembrane installation, as-build conditions of installed geomembrane. As-built shall have locations of panel corners and all recorded defects and repairs.~~

1.05 QUALITY ASSURANCE

A. The Geosynthetic Installer shall ensure that the geotextile and installation methods used meet the requirements of the Drawings and this Section. Any material or method that does not conform to these documents, or to alternatives approved in writing by the Construction Manager, shall be rejected and shall be repaired or replaced by the Geosynthetic Installer.

B. The Geosynthetic Installer shall be aware of all monitoring and conformance testing required by the CQA Plan. This monitoring and testing, including random conformance testing of construction materials and completed work, shall be performed by the CQA Engineer. If nonconformances or other deficiencies are found in the Geosynthetic Installer's materials or completed work, the Geosynthetic Installer shall be required to repair the deficiency or replace the deficient materials.

DRAFT

PART 2 – PRODUCTS

2.01 GEOTEXTILE PROPERTIES

A. Geotextile suppliers shall furnish materials in which the "Minimum Average Roll Values", as defined by the Federal Highway Administration (FHWA), meet or exceed the criteria specified in Table 02771-1.

B. The geotextile shall be nonwoven materials, suitable for use in filter/separation applications and woven geotextile for use as a UV protective layer.

2.02 MANUFACTURING QUALITY CONTROL

A. The geotextile shall be manufactured with quality control procedures that meet or exceed generally accepted industry standards.

B. The Geotextile Manufacturer shall sample and test the geotextile to demonstrate that the material conforms to the requirements of these Specifications.

C. Any geotextile sample that does not comply with this Section shall result in rejection of the roll from which the sample was obtained. The Geosynthetic Installer shall replace any rejected rolls.

D. ~~If a geotextile sample fails to meet the quality control requirements of this Section the Geotextile Manufacturer shall sample and test, at the expense of the Manufacturer, rolls manufactured in the same lot, or at the same time, as the failing roll. Sampling and testing of rolls shall continue until a pattern of acceptable test results is established to bound the failed roll(s).~~ If a geotextile sample fails to meet the quality control requirements of this Section the Manufacturer shall sample and test, at the expense of the Manufacturer, rolls manufactured in the same lot, or at the same time, as the failing roll. Sampling and testing of rolls shall continue until a pattern of acceptable test results is established to bound the failed roll(s)."

E. Additional sample testing may be performed, at the Geotextile Manufacturer's discretion and expense, to identify more closely any non-complying rolls and/or to qualify individual rolls.

F. Sampling shall, in general, be performed on sacrificial portions of the geotextile material such that repair is not required. The Geotextile Manufacturer shall sample and test the geotextile, at a minimum once every 100,000 ft2, to demonstrate that the geotextile properties conform to the values specified in Table 02771-1. At a minimum, the following manufacturing quality control tests shall be performed on each type of geotextile:

Test	Procedure	Filtration	UV Protective
Grab strength	ASTM D 4632	Yes	No
Puncture strength	ASTM D 4833	Yes	No
Mullen Burst	ASTM D 3786	Yes	No
Trapezoidal Tear	ASTM D 4533	Yes	No
Permittivity	ASTM D 4491	Yes	No

DRAFT

A.O.S.	ASTM D 4751	Yes	Yes
Wide Width Tensile	ASTM D 4595	No	Yes

G. The Geotextile Manufacturer shall comply with the certification and submittal requirements of this Section.

2.03 PACKING AND LABELING

A. Geotextile shall be supplied in rolls wrapped in relatively impermeable and opaque protective covers.

B. Geotextile rolls shall be marked or tagged with the following information:

1. manufacturer's name;
2. product identification;
3. lot or batch number;
4. roll number; and
5. roll dimensions.

2.04 TRANSPORTATION, HANDLING, AND STORAGE

A. The Geosynthetic Installer shall be liable for any damage to the materials incurred prior to and during transportation to the site.

B. The geotextile shall be delivered to the site at least 30 days prior to the planned deployment date to allow the CQA Engineer adequate time to perform conformance testing on the geotextile samples as described in Part 3.06 of this Section.

C. Handling, unloading, storage, and care of the geotextile prior to and following installation at the site, is the responsibility of the Geosynthetic Installer. The Geosynthetic Installer shall be liable for any damage to the materials incurred prior to final acceptance by the Construction Manager.

D. The Geosynthetic Installer shall be responsible for storage of the geotextile at the site.

E. The geotextile shall be protected from sunlight, excessive heat or cold, puncture, or other damaging or deleterious conditions. The geotextile shall be protected from mud, dirt, and dust. Any additional storage procedures required by the geotextile Manufacturer shall be the responsibility of the Geosynthetic Installer.

PART 3 – EXECUTION

3.01 FAMILIARIZATION

A. Prior to implementing any of the work described in this Section, the Geosynthetic Installer shall become thoroughly familiar with the site, the site conditions, and all portions of the work falling within this Section.

DRAFT

B. Inspection:

1. The Geosynthetic Installer shall carefully inspect the installed work of all other Sections and verify that all such work is complete to the point where the installation of this Section may properly commence without adverse effect.

2. If the Geosynthetic Installer has any concerns regarding the installed work of other Sections or the site, the Construction Manager shall be notified, in writing, prior to commencing the work. Failure to notify the Construction Manager or installation of the geotextile shall be construed as Geosynthetic Installer's acceptance of the related work of all other Sections.

3.02 PLACEMENT

A. Geotextile installation shall not commence until CQA conformance evaluations, by the CQA Engineer, of previous work are complete, including evaluations of the Contractor's survey results to confirm that the previous work was constructed to the required grades, elevations, and thicknesses. Should the Contractor begin the work of this Section prior to the completion of CQA evaluations, he does so at his own risk. The Contractor shall account for the CQA conformance evaluations in the construction schedule.

B. The Geosynthetic Installer shall handle all geotextile in such a manner as to ensure they are not damaged in any way.

C. The Geosynthetic Installer shall take any necessary precautions to prevent damage to underlying materials during placement of the geotextile.

D. After unwrapping the geotextile from its opaque cover, the filtration geotextile shall not be left exposed for a period in excess of 15 days unless a longer exposure period is approved in writing by the geotextile manufacturer.

E. The Geosynthetic Installer shall take care not to entrap stones, excessive dust, or moisture in the geotextile during placement.

F. The Geosynthetic Installer shall anchor or weight all geotextile with sandbags, or the equivalent, to prevent wind uplift.

G. The Geosynthetic Installer shall examine the entire geotextile surface after installation to ensure that no foreign objects are present that may damage the geotextile or adjacent layers. The Contractor shall remove any such foreign objects and shall replace any damaged geotextile.

3.03 SEAMS AND OVERLAPS

A. On slopes steeper than 10 horizontal to 1 vertical, geotextiles shall be continuous down the slope; that is, no horizontal seams are allowed. Horizontal seams shall be considered as any seam having an alignment exceeding 20 degrees from being perpendicular to the slope contour lines, unless otherwise approved by the Construction Manager.

B. Geotextile shall be continuously sewn (i.e., spot sewing is not allowed) using a "single prayer" seam, with the stitching a minimum of 1.5 inches from the edge of the geotextile.

C. Geotextile shall be sewn with polymeric thread, having similar strength characteristics as the geotextile.

DRAFT

3.04 REPAIR

A. Any holes or tears in the geotextile shall be repaired using a patch made from the same geotextile. Geotextile patches shall be sewn into place no closer than 1 inch from any panel edge. Should any tear exceed 50% of the width of the roll, that roll shall be removed and replaced.

B. Where geosynthetic materials underlie the geotextile being placed, care shall be taken to remove any soil or other material that may have penetrated the torn geotextile.

3.05 PLACEMENT OF SOIL MATERIALS

A. The Contractor shall place soil materials on top of the geotextile in such a manner as to ensure that:

1. the geotextile and the underlying materials are not damaged;

2. minimum slippage occurs between the geotextile and the underlying layers during placement; and

3. excess stresses are not produced in the geotextile.

B. Equipment shall not be driven directly on the geotextile.

C. Unless otherwise approved in writing by the Construction Manager, all equipment operating on materials overlying the geotextile shall comply with Section 02200 and Section 02225.

3.06 CONFORMANCE TESTING

A. Samples of the geotextile materials shall be removed by the CQA Engineer after the material has been received at the site and sent to a Geosynthetic CQA Laboratory for testing to ensure conformance with the requirements of this Section. This testing shall be carried out, in accordance with the CQA Plan, prior to the start of the work of this Section.

B. Samples of each geotextile shall be taken, by the CQA Engineer, at a minimum frequency of one sample per 200,000 ft2.

C. The CQA Engineer may increase the frequency of sampling in the event that test results do not comply with requirements of Part 2.01 of this Section until passing conformance test results are obtained for all material that is received at the site. This additional testing shall be performed at the expense of the Contractor.

D. The following conformance tests shall be performed:

Test	Procedure	Filtration	UV Protective
Grab strength	ASTM D 4632	Yes	No
Puncture strength	ASTM D 4833	Yes	No
Mullen Burst	ASTM D 3786	Yes	No
Trapezoidal Tear	ASTM D 4533	Yes	No

DRAFT

Permittivity	ASTM D 4491	Yes	No
A.O.S.	ASTM D 4751	Yes	Yes
Wide Width Tensile	ASTM D 4595	No	Yes

E. Any geotextile that is not certified in accordance with Part 1.04 of this Section, or that conformance testing results do not comply with Part 2.01 of this Section, shall be rejected. The Geosynthetic Installer shall replace the rejected material with new material.

3.07 PROTECTION OF WORK

A. The Geosynthetic Installer shall use all means necessary to protect all work of this Section.

B. In the event of damage, the Geosynthetic Installer shall make repairs and replacements to the satisfaction of the Construction Manager at the expense of the Contractor.

PART 4 – MEASUREMENT AND PAYMENT

4.01 GENERAL

A. Providing for and complying with the requirements set forth in this Section for Filtration Geotextile shall be measured as incidental to:

1. Base Bid Schedule: LCRS HDPE piping and gravel on the Base Bid Schedule; and
2. Option Scope Bid Schedule:
   a. CAMU Cover – 4-inch Corrugated Polyethylene Pipe
   b. Aggregate Road Base

B. Providing for and complying with the requirements set forth in this Section for UV Protection Geotextile shall be measured included as incidental to the CAMU Liner System Geosynthetic Materials, including UV Protection Geotextile in the anchor trench to the limits shown on the Drawings.

C. The bid item costs shall include all incidentals necessary for a complete installation of Geotextile.

DRAFT

TABLE 02771-1
REQUIRED PROPERTY VALUES FOR GEOTEXTILE

PROPERTIES	QUALIFIERS	UNITS	FILTER SPECIFIED VALUES	UV PROTECTIVE SPECIFIED VALUES	TEST METHOD
Type			nonwoven	woven	(-)
Mass per unit area	minimum	oz/yd^2	6(1)	-	ASTM D 5261
Filter Requirements					
Apparent opening size (O_{95})	maximum	mm	0.21	0.43	ASTM D 4751
Permittivity	minimum	s^{-1}	0.6	-	ASTM D 4491
Mechanical Requirements					
Grab strength	minimum	lb	130	-	ASTM D 4632
Puncture strength	minimum	lb	40	-	ASTM D 4833
Mullen Burst	minimum	psi	210	-	ASTM D 3786
Trapezoidal Tear	minimum	lb	40	-	ASTM D 4533
Wide Width Tensile Strength	minimum	ppi	-	110	ASTM D 4595
Durability					
Ultraviolet Resistance @ 500 hours	minimum	%	70	70	ASTM D 4355

Notes: (1) For information purposes only, not a required property.

[END OF SECTION]

DRAFT

SECTION 02772
GEOSYNTHETIC CLAY LINER

PART 1 – GENERAL

1.01 DESCRIPTION OF WORK

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, and equipment necessary to perform all Work specified herein and as shown on the Construction Drawings

B. The work shall include, but not be limited to, delivery, storage, placement, anchorage, and seaming of the GCL.

C. Construction of the final CAMU cover system will be held as an Option Scope that may be added to the contract via Contract Modification at the Owner's sole discretion. If the Owner decides to exercise its option to add the Option Scope, the Construction Manager will notify the Contractor no later than 30 days after receipt of the final Eastside Area confirmation sampling

1.02 RELATED SECTIONS

Section 02200 — Earthworks

Section 02770 — Geomembrane

1.03 REFERENCES

A. Drawings

B. Construction Quality Assurance (CQA) Plan

C. Latest Version American Society of Testing and Materials (ASTM) Standards:

ASTM D 2216	Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures
ASTM D 5321	Determination of the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method
ASTM D 5887	Test Method for Measurement of Index Flux Through Saturated Geosynthetic Clay Liner Specimens using a Flexible Wall Permeameter
ASTM D 5888	Guide for Storage and Handling of Geosynthetic Clay Liners
ASTM D 5890	Test Method for Swell Index of Clay Mineral Component of Geosynthetic Clay Liners
ASTM D 5891	Test Method for Fluid Loss of Clay Component of Geosynthetic Clay Liners
ASTM D 5993	Test Method for Measuring Mass per Unit Area of Geosynthetic Clay Liners

DRAFT

1.04 QUALIFICATIONS

A. The Manufacturer shall be a well-established firm with more than ten years of documented experience in the manufacturing of GCL.

B. The Geosynthetic Installer shall install the GCL and shall meet the requirements of Section 02770 and this Section.

1.05 SUBMITTALS

A. At least 21 days before transporting any GCL to the site, the Manufacturer shall provide the following documentation to the Construction Manager for approval.

1. documentation of Geomembrane Manufacturer's experience in manufacturing GCL.

2. list of material properties, including test method, to which are attached GCL samples.

3. projected delivery dates for this project.

4. Manufacturing quality control certificates for each shift's production, signed by responsible parties employed by the Manufacturer (such as the production manager).

5. The quality control certificates shall include:

   a. roll numbers and identification; and

   b. results of quality control tests, including description of test methods used, outlined in Part 2.01 of this Section.

6. The Manufacturer shall certify that the GCL meets all the properties outlined in 2.01 of this Section.

B. Contractor shall submit to Construction Manager results of interface shear test(s) performed on the proposed geosynthetic and soil components in accordance with ASTM D 5321 as specified in Subpart 2.02 of this Section.

C. During installation, the Geosynthetic Installer shall be responsible for the timely submission to the Construction Manager of:

1. Quality control documentation; and

2. Subgrade acceptance certificates, signed by the Geosynthetic Installer, for each area to be covered by geosynthetic materials.

1.06 CONSTRUCTION QUALITY ASSURANCE MONITORING

A. The Geosynthetic Installer shall ensure that the materials and methods used for the GCL meet the requirements of the Drawings and this Section. Any material or method that does not conform to these documents, or to alternatives approved in writing by the Construction Manager, shall be rejected and shall be repaired or replaced.

B. The Geosynthetic Installer shall be aware of all monitoring and conformance testing required by the CQA Plan. This monitoring and testing, including random conformance testing of construction materials and completed work, shall be performed by the CQA Engineer. If nonconformances or other deficiencies are found in the materials or completed

DRAFT

work, the Geosynthetic Installer shall be required to repair the deficiency or replace the deficient materials.

PART 2 – PRODUCTS

2.01 MATERIAL PROPERTIES

A. The flux of the GCL shall be no greater than 1 x 10-8 m3/m2-sec, when measured in a flexible wall permeameter in accordance with ASTM D 5887 under an effective confining stress of 5 pounds per square inch.

B. The GCL shall have the following minimum dimensions:

1. the minimum roll width shall be 15 feet; and

2. the liner length shall be long enough to conform with the requirements specified in this Section.

C. The bentonite component of the GCL shall be applied at a minimum concentration of 0.75 pound per square foot, when measured at a water content of less than or equal to 0 percent.

D. The geotextile components of the GCL shall have a minimum combined mass per unit area of 9 oz/yd2 in accordance with ASTM D 5261.

E. The GCL shall meet the required property values listed in Table 02772-1.

F. The bentonite shall be adhered to the backing material(s) in a manner that prevents it from being dislodged when transported, handled, and installed in a manner prescribed by the Manufacturer. The method used to hold the bentonite in place shall not be detrimental to other components of the lining system.

G. An alternative GCL having a textured vapor barrier (i.e., geomembrane) as an integral component of the GCL may be provided. If an alternative GCL is used, the textured HDPE vapor barrier component shall be placed against the prepared subgrade and shall meet the following requirements:

1. have an average thickness of 30-mils in accordance with ASTM D 5994;

2. not have striations, pinholes, or bubbles on the surface or in the interior; and

3. be produced so as to be free of holes, blisters, undispersed raw materials, or any sign of contamination by foreign matter.

2.02 INTERFACE SHEAR TESTING

A. Interface Shear test(s) shall be performed on the proposed geosynthetic and soil components in accordance with ASTM D 5321. Tests shall be performed on several geosythetic interfaces as outlined below.

1. Hydrated GCL interface - the GCL shall be underlain by prepared subgrade compacted to 90% of the maximum dry density (ASTM D 1557) at the optimum moisture content and overlain by a textured 60-mil HDPE geomembrane, geocomposite, and operations layer material. The geosynthetic components of the liner system shall be allowed to “float” (i.e., not fixed) such that the failure surface can occur between any of the interfaces.

DRAFT

a. Before shearing, the GCL shall be hydrated under a loading of 240 psf (11 Kpa) for 48 hours. The test shall be performed at normal stresses of 1, 2, and 3 psi at a shear rate of no more than 0.04 in./min. (1 mm/min.).

b. The results of this test shall have a peak apparent friction angle in excess of 20 degrees.

2. Hydrated GCL interface - the GCL shall be underlain by prepared subgrade compacted to 90% of the maximum dry density (ASTM D 1557) at the optimum moisture content and overlain by a textured 60-mil HDPE geomembrane, geocomposite, and operations layer material. The GCL component of the liner system shall be allowed to "float" (i.e., not fixed) such that the failure surface can occur at the top, bottom, or internal GCL interfaces.

   a. Before shearing, the GCL shall be hydrated under a loading of 240 psf (11 Kpa) for 48 hours. The test shall be performed under saturated conditions, at normal stresses of 20, 40, and 80 psi at a shear rate of no more than 0.04 in./min. (1 mm/min.).

   b. The results of this test shall have a post-peak apparent friction angle in excess of 12 degrees.

3. Hydrated GCL interface - If a GCL containing a geomembrane vapor barrier (i.e. Gundseal) is to be used, one additional shear strength test shall be performed. The GCL shall be underlain by prepared subgrade compacted to 90% of the maximum dry density (ASTM D 1557) at the optimum moisture content and covered by a textured 60 mil HDPE geomembrane, geocomposite, and operations layer material.

   a. The test shall evaluate the interface between the bentonite side of an unhydrated (i.e., dry) GCL containing a geomembrane vapor barrier and a textured 60 mil HDPE geomembrane. The test shall be set up such that the failure occurs between the bentonite component of the GCL and the textured geomembrane. The test shall be performed under dry conditions, at normal stresses of 20, 40, and 80 psi at a shear rate of no more than 0.04 in./min. (1 mm/min.).

   b. The acceptance criterion for the interface between the GCL consisting of a geomembrane vapor barrier component and the overlying geomembrane shall be as follows:

      $$\tan^{-1}(0.25 \tan \delta_{hydrated} + 0.75 \tan\delta_{unhydrated}) \geq 12°$$

      where $\delta_{hydrated}$ is the post-peak apparent friction angle in degrees determined in test No. 2 and $\delta_{unhydrated}$ is the post-peak apparent friction angle in degrees determined in test No. 3.

2.03 MANUFACTURING QUALITY CONTROL

A. The GCL shall be manufactured with quality control procedures that meet or exceed generally accepted industry standards.

B. The Manufacturer shall sample and test the GCL to demonstrate that the material complies with the requirements of this Section.

C. Any GCL sample that does not comply with this Section shall result in rejection of the roll from which the sample was obtained. The Manufacturer shall replace any rejected rolls.

D. If a GCL sample fails to meet the quality control requirements of this Section, the Construction Manager shall require that the Manufacturer sample and test, at the expense of the Manufacturer, rolls manufactured in the same lot, or at the same time, as the failing roll. Sampling and testing of rolls shall continue until a pattern of acceptable test results is established to bound the failed roll(s).

E. Additional sample testing may be performed, at the Manufacturer's discretion and expense, to more closely identify any non-complying rolls and/or to qualify individual rolls.

F. Sampling shall, in general, be performed on sacrificial portions of the GCL material such that repair is not required. The Manufacturer shall sample and test the GCL to demonstrate that its properties conform to the requirements stated herein. At a minimum, the following tests shall be performed by the Manufacturer: dry mass per unit area and index flux at frequencies of at least 1 per 50,000 ft2 and 1 per 200,000 ft2, respectively.

G. The Manufacturer shall comply with the certification and submittal requirements of this Section.

2.04 PACKING AND LABELING

A. GCLs shall be supplied in rolls wrapped in impermeable and opaque protective covers.

B. GCLs shall be marked or tagged with the following information:

1. Manufacturer's name;
2. product identification;
3. lot number;
4. roll number; and
5. roll dimensions.

2.05 TRANSPORTATION, HANDLING AND STORAGE

A. Handling, storage, and care of the GCL, prior to and following installation, is the responsibility of the Geosynthetic Installer, until final acceptance by the Construction Manager.

B. The GCL shall be stored and handled in accordance with ASTM D 5888.

C. The Geosynthetic Installer shall be liable for all damage to the materials incurred prior to and during transportation to the site.

D. The GCL shall be on-site at least 30 days prior to the scheduled installation date to allow for completion of conformance testing described in Part 3.08 of this Section.

PART 3 – EXECUTION

3.01 FAMILIARIZATION

A. Prior to implementing any of the work described in this Section, the Geosynthetic Installer shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the installation of this Section may properly commence without adverse impact.

B. Inspection:

1. The Geosynthetic Installer shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the installation of this Section may properly commence without adverse impact.

2. If the Geosynthetic Installer has any concerns regarding the installed work of other Sections, he should notify the Construction Manager in writing prior to commencing the work. Failure to notify the Construction Manager or installation of the GCL shall be construed as Geosynthetic Installer's acceptance of the related work of all other Sections.

C. A pre-installation meeting shall be held to coordinate the installation of the GCL with the installation of other components of the lining system.

3.02 SURFACE PREPARATION

A. The Geosynthetics Installer shall provide certification in writing that the surface on which the GCL shall be installed is acceptable. This certification of acceptance shall be given to the Construction Manager prior to commencement of ~~geomembrane~~ GCL installation in the area under consideration.

B. Special care shall be taken to maintain the prepared soil surface so no loose materials greater than 1-inch are on the subgrade.

C. No GCL shall be placed onto an area that has been softened by precipitation or that has cracked due to desiccation. The soil surface shall be observed daily to evaluate the effects of desiccation cracking and/or softening on the integrity of the prepared subgrade. Subgrade shall have no cracks larger than 1/16-inch and there shall be no visible damp/wet areas.

D. Subgrade shall conform to requirements of Section 02200, Subpart 2.01.

3.03 CREST ANCHORAGE SYSTEM

A. The anchor trench shall be excavated, prior to GCL placement, to the lines and grades shown on the Drawings.

B. No loose soil shall be allowed in the anchor trench beneath the GCL.

C. The GCL shall be temporarily anchored in the anchor trench until all geosynthetic layers are installed in the anchor trench as shown on the Drawings.

3.04 HANDLING AND PLACEMENT

A. The Geosynthetic Installer shall handle all GCL in such a manner that they are not damaged in any way and so that they do not become hydrated prior to, or during, installation.

B. In the presence of wind, all GCLs shall be sufficiently weighted with sandbags to prevent their movement.

C. Any GCL damaged by stones or other foreign objects, or by installation activities, shall be repaired in accordance with Part 3.07 by the Geosynthetic Installer.

D. If an alternative GCL is used, the vapor barrier portion of the GCL shall be installed against the underlying prepared subgrade.

DRAFT

E. The GCL shall not be installed on an excessively moist subgrade or on standing water. The GCL shall be installed in a way that prevents hydration of the GCL prior to completion of construction of the liner system.

F. The GCL shall not be installed during precipitation or other conditions that may cause hydration of the GCL.

G. All hydrated GCL shall be removed and replaced by the Geosynthetic Installer.

3.05 WESTERN DITCH LINER INSTALLATION

A. GCL installers conducting GCL installation above the Western Ditch Area shall have current 40 hour Occupational Safety and Health Administration Hazardous Waste Operations and Emergency Response Standard (OSHA HAZWOPER) training.

B. PPE required by the Contractor's Health and Safety Plan shall be worn while installing GCL above Western Ditch Area.

3.06 OVERLAPS

A. On slopes steeper than 10 horizontal to 1 vertical, all GCL shall be continuous down the slope; that is, no horizontal seams shall be allowed on the slope. Horizontal seams shall be considered as any seam having an alignment exceeding 20 degrees from being perpendicular to the slope contour lines, unless otherwise approved by the Construction Manager.

B. All GCL shall be overlapped in accordance with the Manufacturer's recommended procedures. As a minimum, along the length (i.e., the sides) of the GCL the overlap shall be 6 inches, and along the width (i.e., the ends) the overlap shall be 12 inches.

C. GCL shall be seamed in accordance with Manufacturer's bentonite seaming recommendations as follows:

1. CETCO Super groove and Gundseal: No bentonite required.

2. All others: bentonite application rate of one quarter pound per linear foot.

3.07 MATERIALS IN CONTACT WITH THE GCL

A. Geomembrane installation shall immediately follow the GCL installation. All GCL that is placed during a day's work shall be covered with geomembrane before the Geosynthetic Installer leaves the site at the end of the day. The edges of GCL placement should be covered each day and protected from hydration due to storm water run-on.

B. Material shall not be placed on a GCL that is hydrated.

C. Installation of other components of the liner system shall be carefully performed to minimize damage to the GCL.

D. Vehicular traffic shall be limited to vehicles that exhibit a ground pressure less than that of foot traffic pressure.

E. Installation of the GCL in appurtenant areas, and connection of the GCL to appurtenances shall be made according to the Drawings. The Geosynthetic Installer shall ensure that the GCL is not damaged while working around the appurtenances.

DRAFT

3.08 REPAIR

A. Any holes or tears in the GCL shall be repaired by placing a GCL patch over the hole. On slopes steeper than 10 percent, the patch shall overlap the edges of the hole or tear by a minimum of 2 feet in all directions. On slopes 10 percent or flatter, the patch shall overlap the edges of the hole or tear by a minimum of 1 foot in all directions. The patch shall be secured with a water-based adhesive or hot air welded in place, in accordance with the manufacturers approved installation methods.

B. Care shall be taken to remove any soil or other material, which may have penetrated the torn GCL.

C. The patch shall not be nailed or stapled.

3.09 ANCHORAGE

A. Temporary anchorage of the GCL shall be in accordance with the Construction Drawings and consist of the GCL extended approximately 10 ft from the toe of the waste slope beneath the geomembrane.

B. Temporary anchor trenches shall be as shown on the Construction Drawings.

C. Permanent anchorage shall be as shown on the Construction Drawings and in accordance with the Specifications for Anchor Trenching in Section 02200.

3.10 CONFORMANCE TESTING

A. Samples of the GCL shall be removed by the CQA Engineer and sent to a Geosynthetic CQA Laboratory for testing to ensure conformance with the requirements of this Section. The Geosynthetic Installer shall assist the CQA Engineer in obtaining conformance samples. The Geosynthetic Installer shall account for this testing in the installation schedule. Conformance sampling may be conducted at the manufacturing facility prior to shipment to the site.

B. Samples shall be taken at a minimum frequency rate of one sample per 100,000 square feet.

C. ~~The CQA Engineer may increase the frequency of sampling in the event that test results do not comply with the requirements of Part 2.01 of this Section until passing conformance test results are obtained for all material that is received at the site. This additional testing shall be performed at the expense of the Contractor.~~ If a GCL sample fails to meet the quality control requirements of this Section the GCL Manufacturer shall sample and test, at the expense of the Manufacturer, rolls manufactured in the same lot, or at the same time, as the failing roll. Sampling and testing of rolls shall continue until a pattern of acceptable test results is established to bound the failed roll(s).

D. As a minimum, the following conformance tests shall be performed: mass per unit area and index flux. All tests shall be carried out at a frequency of one sample per 100,000 ft2 and 400,000 ft2, respectively. In addition, the CQA Engineer shall perform a minimum of two interface shear strength tests in accordance with Part 2.02.

E. Any GCL that is not certified by the Manufacturer in accordance with Part 1.05 of this section or that does not meet the requirements specified in Part 2.01 shall be rejected and replaced by the Geosynthetic Installer.

DRAFT

3.11 PROTECTION OF WORK

A. The Geosynthetic Installer shall use all means necessary to protect all work of this Section.

B. In the event of damage, the Geosynthetic Installer shall immediately make all repairs and replacements necessary to the approval of the Construction Manager.

C. Contractor shall be responsible for protecting GCL from hydration from precipitation, dust spraying activities, or any other activities which could lead to GCL hydration.

PART 4 – MEASUREMENT AND PAYMENT

A. Providing for a complying with the requirements set forth in this Section for CAMU Liner GCL shall be measured as Lump Sum (LS), including GCL in the anchor trench to the limits shown on the Drawings, and payment shall be included with the lump sum price provided on the Base Bid Schedule for Liner System Geosynthetic Materials.

B. Providing for a complying with the requirements set forth in this Section for North and South BMI Landfill Cover GCL shall be measured as Lump Sum (LS), including GCL in the anchor trench to the limits shown on the Drawings, and payment shall be included with the lump sum price provided on the Base Bid Schedule for North and South BMI Landfill Cover System Geosynthetic Materials.

C. Providing for a complying with the requirements set forth in this Section for CAMU Cover GCL shall be measured as square foot (SF), including GCL in the anchor trench to the limits shown on the Drawings, and payment shall be included with the unit price provided on the Option Scope Bid Schedule for CAMU Cover Geosynthetic System.

D. The bid item costs shall include all incidentals necessary for a complete installation of GCL.

DRAFT

TABLE 02772-1
REQUIRED GCL PROPERTY VALUES

PROPERTIES	QUALIFIERS	UNITS	SPECIFIED[1] VALUES	TEST METHOD
Liner System Properties				
Interface Shear Strength	minimum	degrees	12 (liner) 20 (cover)	ASTM D 5321[2]
GCL Properties				
Bentonite Content[4]	minimum	lb/ft^2	0.75	ASTM D 5993
Bentonite Swell Index	minimum	mL/2g	24	ASTM D 5890
Bentonite Fluid Loss	maximum	mL	18	ASTM D 5891
Hydraulic Flux	minimum	m^3/m^2-s	1×10^{-8}	ASTM D 5887[3]
Moisture Content (Bentonite)	maximum	percent	25	ASTM D 2216

Notes: (1) All values represent minimum average roll values (i.e., any roll in a lot should meet or exceed the values in this table).
(2) Interface shear strength testing shall be performed, by the CQA Engineer, in accordance with Part 2.02 of this Section.
(3) Hydraulic flux testing shall be performed under an effective confining stress of 5 pounds per square inch.
(4) Measured at a moisture content of 0 percent.

END OF SECTION

DRAFT

SECTION 02773
GEOCOMPOSITE

PART 1 – GENERAL

1.01 DESCRIPTION OF WORK

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, and equipment necessary to perform all Work specified herein and as shown on the Construction Drawings

B. The work shall include, but not be limited to, delivery, storage, placement, and seaming of the geocomposite.

C. Geocomposite shall be used overlying the geomembrane and underlying the operations layer on the floor and side slopes for the base liner system. Geocomposite shall be used overlying the geomembrane for the final cover liner system.

D. Construction of the final CAMU cover system will be held as an Option Scope that may be added to the contract via Contract Modification at the Owner's sole discretion. If the Owner decides to exercise its option to add the Option Scope, the Construction Manager will notify the Contractor no later than 30 days after receipt of the final Eastside Area confirmation sampling.

1.02 RELATED SECTIONS

Section 02200 — Earthwork

Section 02770 — Geomembrane

Section 02771 — Geotextiles

1.03 REFERENCES

A. Drawings

B. Construction Quality Assurance (CQA) Plan

C. Latest version of American Society for Testing and Materials (ASTM) standards:

ASTM D 413. Standard Test Method for Rubber Property-Adhesion to Flexible Substrate.

ASTM D 792. Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.

ASTM D 1603. Standard Test Method for Carbon Black in Olefin Plastics.

ASTM D 4491. Standard Test Methods for Water Permeability of Geotextiles by Permittivity.

ASTM D 4533. Standard Test Method for Trapezoid Tearing Strength of Geotextiles.

ASTM D 4632. Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.

DRAFT

ASTM D 4716. Standard Test Method for Constant Head Hydraulic Transmissivity (In-Plane Flow) of Geotextiles and Geotextile Related Products.

ASTM D 4751. Standard Test Method for Determining Apparent Opening Size of a Geotextile.

ASTM D 4833. Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.

ASTM D 5199. Standard Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes.

ASTM D 5261. Standard Test Method for Measuring Mass per Unit Area of Geotextiles.

1.04 QUALIFICATIONS

A. The manufacturer shall be a well-established firm with more than one year documented experience in the manufacturing of geocomposite.

B. The Geosynthetic Installer shall install the geocomposite and shall meet the requirements of Section 02770 and this Section.

1.05 SUBMITTALS

A. The Geosynthetic Installer shall submit to the Construction Manager, at least 21 days prior to geocomposite delivery, the following information regarding the proposed geocomposite:

1. manufacturer and product name;
2. manufacturer documentation of at least 1-year of experience manufacturing geocomposite
3. minimum property values of the proposed geocomposite and the corresponding test procedures;
4. projected geocomposite delivery dates; and
5. list of geocomposite roll numbers for rolls to be delivered to the site.

B. At least 21 days prior to geocomposite placement, the Geosynthetic Installer shall submit to the Construction Manager the manufacturing quality control certificates for each roll of geocomposite. The certificates shall be signed by responsible parties employed by the geocomposite manufacturer (such as the production manager). The quality control certificates shall include:

1. lot, batch, and/or roll numbers and identification; and
2. results of quality control tests, including a description of the test methods used.

1.06 CONSTRUCTION QUALITY ASSURANCE MONITORING

A. The Geosynthetic Installer shall ensure that the geocomposite and installation methods used meet the requirements of the Drawings and this Section. Any material or method that does not conform to these documents, or to alternatives approved in writing by the Construction Manager, shall be rejected and shall be repaired or replaced by the Geosynthetic Installer.

DRAFT

B. The Geosynthetic Installer shall be aware of and accommodate all monitoring and conformance testing required by the CQA Plan. This monitoring and testing, including random conformance testing of construction materials and completed work, shall be performed by the CQA Engineer. If nonconformances or other deficiencies are found in the Geosynthetic Installer's materials or completed work, the Geosynthetic Installer shall be required to repair the deficiency or replace the deficient materials.

PART 2 – PRODUCTS

2.01 GEOCOMPOSITE PROPERTIES

A. The Geocomposite Manufacturer shall furnish geocomposites having properties that comply with the required property values shown in Table 02773-1. The Geocomposite Manufacturer shall provide results of tests performed using the procedures listed in Table 02773-1, as well as certification that the materials meet or exceed the specified values.

B. Geotextiles shall be thermally bonded to both sides of the geonet component of geocomposite material rather than chemically bonded.

C. Geocomposite suppliers shall furnish materials in which the "Minimum Average Roll Values", as defined by the Federal Highway Administration (FHWA), meet or exceed the criteria specified in Table 02773-1.

D. The geocomposite's geotextile components shall be nonwoven materials, suitable for use in filter/separation and cushion applications.

2.02 MANUFACTURING QUALITY CONTROL

A. The geocomposite shall be manufactured with quality control procedures that meet or exceed generally accepted industry standards.

B. The geocomposite Manufacturer shall sample and test the geocomposite to demonstrate that the material conforms to the requirements of these Specifications.

C. Any geocomposite sample that does not comply with this Section shall result in rejection of the roll from which the sample was obtained. The Geosynthetic Installer shall replace any rejected rolls.

D. If a geocomposite sample fails to meet the quality control requirements of this Section the geocomposite Manufacturer shall sample and test, at the expense of the Manufacturer, rolls manufactured in the same lot, or at the same time, as the failing roll. Sampling and testing of rolls shall continue until a pattern of acceptable test results is established to bound the failed roll(s).

E. Additional sample testing may be performed, at the geocomposite Manufacturer's discretion and expense, to identify more closely any non-complying rolls and/or to qualify individual rolls.

F. Sampling shall, in general, be performed on sacrificial portions of the geocomposite material such that repair is not required. The Geocomposite Manufacturer shall sample and test the geocomposite, at a minimum once every 100,000 ft2, to demonstrate that the geocomposite properties conform to the values specified in Table 02773-1. At a minimum, the following manufacturing quality control tests shall be performed on the geotextile component of the geocomposite:

DRAFT

Test	Procedure
Mass per unit area	ASTM D 5261
Grab strength	ASTM D 4632
Puncture strength	ASTM D 4833
Mullen Burst	ASTM D 3786
Trapezoidal Tear	ASTM D 4533
Permittivity	ASTM D 4491
A.O.S.	ASTM D 4751

G. At a minimum, the following manufacturing quality control tests shall be performed on the geonet component of the geocomposite:

Test	Procedure
Specific gravity	ASTM D 792
Nominal thickness	ASTM D 5199

H. At a minimum, the following manufacturing quality control tests shall be performed on the geocomposite:

Test	Procedure
Transmissivity	ASTM D 4716
Peel strength	ASTM D 413

I. The geocomposite Manufacturer shall comply with the certification and submittal requirements of this Section.

2.03 PACKING AND LABELING

A. Geocomposite shall be supplied in rolls wrapped in relatively impermeable and opaque protective covers.

B. Geocomposite rolls shall be marked or tagged with the following information:

1. manufacturer's name;
2. product identification;
3. lot or batch number;
4. roll number; and
5. roll dimensions.

2.04 TRANSPORTATION, HANDLING, AND STORAGE

A. The Geosynthetic Installer shall be liable for any damage to the materials incurred prior to and during transportation to the site.

DRAFT

B. The geocomposite shall be delivered to the site at least 30 days prior to the planned deployment date to allow the CQA Engineer adequate time to perform conformance testing on the geocomposite samples as described in Part 3.06 of this Section.

C. Handling, unloading, storage, and care of the geocomposite prior to and following installation at the site, is the responsibility of the Geosynthetic Installer. The Geosynthetic Installer shall be liable for any damage to the materials incurred prior to final acceptance by the Construction Manager.

D. The Geosynthetic Installer shall be responsible for storage of the geocomposite at the site.

E. The geocomposite shall be protected from sunlight, excessive heat or cold, puncture, or other damaging or deleterious conditions. The geocomposite shall be protected from mud, dirt, and dust. Any additional storage procedures required by the geocomposite Manufacturer shall be the responsibility of the Geosynthetic Installer.

PART 3 – EXECUTION

3.01 FAMILIARIZATION

A. Prior to implementing any of the work described in this Section, the Geosynthetic Installer shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the installation of this Section may properly commence without adverse impact.

B. Inspection:

1. The Geosynthetic Installer shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the installation of this Section may properly commence without adverse impact.

2. If the Geosynthetic Installer has any concerns regarding the installed work of other Sections, he should notify the Construction Manager in writing prior to commencing the work. Failure to notify the Construction Manager or installation of the geocomposite shall be construed as Geosynthetic Installer's acceptance of the related work of all other Sections.

C. A pre-installation meeting shall be held to coordinate the installation of the geocomposite with the installation of other components of the lining system.

3.02 HANDLING AND PLACEMENT

A. The Geosynthetic Installer shall not begin geocomposite installation until all QC/QA documentation is complete for underlying materials.

B. The Geosynthetic Installer shall handle all geocomposite in such a manner that it is not damaged in any way.

C. The Geosynthetic Installer shall inspect and verify geomembrane surface below geocomposite is free of loose soil and rocks. ~~greater than 1 inch~~. Geosynthetic installer shall remove loose soil and rocks from geomembrane surface prior to geocomposite placement.

D. Install the geocomposite down the slope not across the slope. Place ends into the anchor trenches in such a manner as to continually keep the geocomposite in tension.

DRAFT

E. Precautions shall be taken to prevent damage to underlying layers during placement of the geocomposite.

F. In the presence of wind, all geocomposites shall be sufficiently weighted with sandbags or the equivalent to prevent movement.

G. The geocomposite shall be positioned by hand after being unrolled to minimize wrinkles.

H. Care shall be taken during placement of geocomposites not to entrap dirt or excessive dust in the geocomposite that could cause clogging of the drainage system, and/or stones that could damage the adjacent geomembrane. If dirt or excessive dust is entrapped in the geocomposite, it should be cleaned prior to placement of the next material on top of it. Care shall be exercised when handling sandbags, to prevent rupture or damage of the sandbags.

I. Geocomposites shall only be cut using a hooked utility blade.

J. After unwrapping the geocomposite from its opaque cover, the geocomposite shall not be left exposed for a period in excess of 15 days.

3.03 OVERLAPS AND SEAMS

A. Geonet Components:

1. The geonet components shall be overlapped a minimum 4 in. along the length. The geonet shall be overlapped by a minimum 1 ft. across the width.

2. Geonet overlaps shall be secured by tying with nylon cable ties. Tying devices shall be white or yellow for easy inspection. Metallic devices shall not be used.

3. Seaming of the geonet shall be performed by wrap-ties at 12-in. centers for end of panels and at 5-ft centers for edge of panel seams.

4. No end-of-panel seams shall be placed on slopes exceeding 10 %.

B. Geotextile Components:

1. The bottom layers of geotextile shall be overlapped. The top layers of geotextiles shall be continuously sewn.

2. Polymeric thread, with chemical resistance properties equal to or exceeding those of the geotextile component, shall be used for all sewing.

3.04 PLACEMENT OF OVERLYING MATERIALS

A. All overlying materials shall be placed in such a manner as to ensure that:

1. The geocomposite and underlying materials are not damaged;

2. Minimal slippage occurs between the geocomposite and underlying layers; and

3. Excess tensile stresses are not produced in the geocomposite.

4. Equipment shall not be driven directly on the geocomposite.

DRAFT

5. Unless otherwise approved in writing by the Construction Manager, all equipment operating on the materials overlying the geotextile shall comply with Section 02200 and Section 02225.

3.05 ANCHORAGE

A. Temporary anchorage of the geocomposite shall be in accordance with the Construction Drawings and consist of the geocomposite extended approximately 10 ft from the toe of the waste slope and have two feet of operations layer placed on top.

B. Visqueen shall be placed around liner system anchorage as shown on the Construction Drawings.

C. Temporary anchor trenches shall be as shown on the Construction Drawings.

D. Permanent anchorage shall be as shown on the Construction Drawings and in accordance with the Specifications for Anchor Trenching in Section 02200.

3.06 CONFORMANCE TESTING

A. Samples of geocomposite shall be removed by the CQA Engineer and sent to a Geosynthetic CQA Laboratory for testing to ensure conformance with the requirements of this Section. The Geosynthetic Installer shall assist the CQA Engineer in obtaining conformance samples. Conformance sampling may be conducted at the manufacturing facility prior to shipment to the site. The Geosynthetic Installer shall account for this testing in the installation schedule.

B. Samples shall be taken at a minimum frequency rate of one sample per 200,000 square feet.

C. The CQA Engineer may increase the frequency of sampling in the event that test results do not comply with the requirements of Part 2.01 of this Section until passing conformance test results are obtained for all material that is received at the site. This additional testing shall be performed at the expense of the Contractor.

D. If a geocomposite sample fails to meet the quality control requirements of this Section the Manufacturer shall sample and test, at the expense of the Manufacturer, rolls manufactured in the same lot, or at the same time, as the failing roll. Sampling and testing of rolls shall continue until a pattern of acceptable test results is established to bound the failed roll(s).

E. ~~D.~~ As a minimum, transmissivity and peel strength shall be performed on each sample.

F. Any geocomposite that is not certified by the Manufacturer in accordance with Part 1.05 of this section or that does not meet the requirements specified in Part 2.01 shall be rejected and replaced by the Geosynthetic Installer.

3.07 PROTECTION OF WORK

A. The Geosynthetic Installer shall use all means necessary to protect all work of this Section.

B. In the event of damage, the Geosynthetic Installer shall immediately make all repairs and replacements necessary to the approval of the Construction Manager.

DRAFT

PART 4 – MEASUREMENT AND PAYMENT

4.01 GENERAL

A. Providing for a complying with the requirements set forth in this Section for CAMU Liner Geocomposite shall be measured as Lump Sum (LS), including Geocomposite in the anchor trench to the limits shown on the Drawings, and payment shall be included with the lump sum price provided on the Base Bid Schedule for Liner System Geosynthetic Materials.

B. Providing for a complying with the requirements set forth in this Section for North and South BMI Landfill Cover Geocomposite shall be measured as Lump Sum (LS), including Geocomposite in the anchor trench to the limits shown on the Drawings, and payment shall be included with the lump sum price provided on the Base Bid Schedule for North and South BMI Landfill Cover System Geosynthetic Materials.

C. Providing for a complying with the requirements set forth in this Section for CAMU Cover Geocomposite shall be measured as square foot (SF), including Geocomposite in the anchor trench to the limits shown on the Drawings, and payment shall be included with the unit price provided on the Option Scope Bid Schedule for CAMU Cover Geosynthetic System.

D. The bid item costs shall include all incidentals necessary for a complete installation of Geocomposite.

DRAFT

TABLE 02773 - 1

GEOCOMPOSITE PROPERTY VALUES

PROPERTIES	QUALIFIER	UNITS	SPECIFIED VALUES (1)		TEST METHOD
			Base Liner	Final Cover	
Geonet Component:					
Specific gravity	Minimum		0.935	0.935	ASTM D 792
Carbon black content	Range	%	2 – 3	2 – 3	ASTM D 1603
Nominal thickness	Minimum	mils	200	200	ASTM D 5199
Geotextile Components:					
Mass per unit area	Minimum	oz/yd^2	8	6	ASTM D 5261
Filter Requirements					
Apparent opening size	Maximum	mm	0.21	0.21	ASTM D 4751
Permittivity	Minimum	1/s	0.6	0.5	ASTM D 4491
Mechanical Requirements					
Grab strength	Minimum	lb	190	130	ASTM D 4632
Puncture strength	Minimum	lb	110	40	ASTM D 4833
Mullen Burst	Minimum	psi	350	210	
Trapezoidal Tear	Minimum	lb	85	40	
Geocomposite:					
Transmissivity	Minimum	m^2/s	~~6~~ 9.2x 10^{-5} (2)	5 x 10^{-4} (3)	ASTM D 4716
Peel Strength	Minimum	gm/in	500	500	ASTM D 413

Notes:

1. All values except transmissivity represent minimum average roll values (i.e., any roll in a lot should meet or exceed the values in this table).

2. The design transmissivity is the hydraulic transmissivity of the base liner geocomposite measured using water at 68°F ±3°F (20°C ±1.5°C) with a hydraulic gradient of 0.1 under a compressive stress of not less than ~~7,000~~ 12,000 psf. For the test, the geocomposite shall be sandwiched between a layer of operations material and a textured 60-mil HDPE geomembrane. The minimum test duration shall be 24 hours and the report for the test results shall include measurements at intervals over the entire test duration.

3. The design transmissivity is the hydraulic transmissivity of the final cover geocomposite measured using water at 68°F ±3°F (20°C ±1.5°C) with a hydraulic gradient of 0.1 under a compressive stress of not less than 300 psf. For the test, the geocomposite shall be sandwiched between a layer of cover soil material and a textured 60-mil HDPE geomembrane. The minimum test duration shall be 24 hours and the report for the test results shall include measurements at intervals over the entire test duration.

END OF SECTION

DRAFT

SECTION 02820
CHAIN LINK FENCE

PART 1 – GENERAL

1.01 DESCRIPTION OF WORK

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, and equipment necessary to perform all Work specified herein and as shown on the Construction Drawings

B. The Work shall include construction of footers, construction of posts, rails, and bracing, placement and securing the fence fabric, construction and installation of swing gates, and all other Work incidental to construction of a completed fence as shown on the Drawings and as described in this Section.

1.02 RELATED SECTIONS

Section 01025 – Measurement and Payment

Section 01050 – Field Engineering

Section 01300 – Submittals

Section 01400 – Quality Control

Section 01500 – Construction Facilities

Section 01560 – Temporary Controls

Section 02200 – Earthwork

Section 03400 – Cast-in-Place Concrete

1.03 REFERENCES

A. Construction Drawings

B. Latest Version of American Society for Testing and Materials (ASTM) Standards:

ASTM A 153	Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A 392	Zinc-Coated Steel Chain Link Fence Fabric
ASTM A 1043	Standard Specification for Strength and Protective Coatings on Metal Industrial Chain Link Fence Framework

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to Site in good condition, in unopened packaging, and with labels intact. Inspect materials upon delivery and replace damaged or contaminated materials.

B. Store materials above ground, under cover, in a dry place, and in a manner to prevent damage or staining.

DRAFT

C. Handle materials to prevent damage to surfaces, edges, and ends. Replace damaged materials at no additional cost to the Construction Manager.

1.05 SUBMITTALS

A. The Contractor shall submit to the Construction Manager, at least 14 days prior to installation of fence material, certificates of compliance with the fence Manufacturer's specifications and that the material meets or exceeds all internal quality control requirements and the requirements of this Section.

B. The Contractor shall submit the locations of the fence posts shall be surveyed by the Surveyor, and shall be included in the Record Drawings in accordance with Section 01050 of these Specifications.

1.06 QUALITY ASSURANCE

A. The Contractor shall ensure that the materials and methods used for security chain link fence construction meet the requirements of the Manufacturer, the Drawings, and this Section. Any material or method that does not conform to these documents, or to alternatives approved in writing by the Construction Manager shall be rejected and shall be repaired or replaced by the Contractor to the satisfaction of the CQA Engineer at the Contractor's expense.

PART 2 – PRODUCTS

2.01 SECURITY FENCE FABRIC

A. Fence height shall be consistent with fence currently on site.

B. Fence fabric: 2" by 2" mesh size, 11 gauge core size, hot-dip zinc galvanized steel wire.

C. Fence fabric shall be a commercial-grade fence system, as supplied by Master-Halco, or shall be equivalent in core material, metallic-coating material, and all coating processes and strengths.

D. Manufacturer shall warranty the fence materials against defects and deterioration, other than normal wear and tear, for a minimum of 12 years.

E. Fabric selvages shall be twisted (barbed) on the top and knuckled on the bottom.

F. The heights of fabric shall be sufficiently long so that no horizontal splices are required.

2.02 FRAMEWORK

A. Framework includes all posts and rails.

B. Fencing framework shall be made of tubular galvanized steel pipe that conforms to ASTM F 1043, Group 1a. The framework shall be standard weight, schedule 40 steel pipe, galvanized by the hot-dip method, with a minimum average of 1.8 ounces per square foot of zinc-coated surface.

C. Dimensions of the framework components shall be as shown on the Drawings.

DRAFT

2.03 FOOTERS

A. Post footers shall be made with concrete rated at a minimum of 2,500 pounds per square inch (psi) and shall be constructed to the dimensions as shown on the Construction Drawings.

2.04 SWING GATES

A. Gates frames shall be of the same materials and coatings as for the fence fabric and framework.

B. Dimensions of the gates and gate components shall be as shown on the Construction Drawings.

C. Gate frame members shall be welded at joints for a rigid connection.

D. Contractor shall provide and install the following hardware for each gate:

1. Hinges: provide hinges of type to, size, and material to suit gate size. Hinges shall be non-liftoff type, offset to permit 180 degree gate opening.

2. Latch: exit control lock and cylinder, as shown on the Drawings.

3. Latch rail: steel plate, weld to stiles at interior side of gate to receive and protect latch.

2.05 HARDWARE

A. Hardware shall include bolts, tension rods, and truss rods.

B. Hardware shall be made of galvanized steel as per ASTM A 153.

C. Bolts shall be 3/16” diameter self drilling hex head TEK screws with flat washers, as manufactured by Hilti, Red Head, or approved.

D. Tension rods shall be in standard lengths to equal full height of fabric, with maximum cross section to suit fabric openings. Provide one tension rod for each gate post and corner post.

E. Truss rods shall be minimum 3/8” diameter threaded, galvanized steel rod and turnbuckle.

2.06 FITTINGS

A. Fittings include: tension and brace bands, caps, eye tops, rail ends, sleeves, and tie wires.

B. All fittings, except tie wires, shall be hot-dip galvanized steel. Tie wires shall be zinc-coated steel wire.

PART 3 – EXECUTION

3.01 GENERAL

A. ~~In the Eastside Area, Contractor shall erect fence around the perimeter of the active work area shown on the Construction Drawings, while the Owner maintains existing site perimeter fence.~~

DRAFT

B. When shipping, delivering, and installing all fence materials, do so to ensure a sound, undamaged installation. Provide storage for all materials and equipment delivered to the Site that is protective of stored materials. Handle and store materials in accordance with the Manufacturer's recommendations.

C. Prior to installation, examine surfaces designated to receive Work described in the Section for conditions adversely affecting the finished Work. Repair or replace surfaces not meeting tolerances or quality requirements governing substrate construction prior to initiating this Work.

D. Do not begin installation and erection before construction of the concrete secondary containment portion of the Work is complete.

3.02 INSTALLATION

A. Install materials in accordance with accepted shop drawings and Manufacturer's printed instructions.

B. Provide top and interim rails as shown on Drawings. Install each as one piece between posts. Offset as necessary to allow for depth of fabric.

C. Place chain link fabric on the outside of the area to enclosed. Secure one end and apply sufficient tension to remove all slack before making attachments elsewhere. Tighten the fabric to provide a smooth uniform appearance, free from sag.

D. Set line posts equidistant at 10 foot (maximum) spacings.

E. Set terminal (end, corner, and pull) and gate posts at 500 foot (maximum) spacings.

F. Install braces and truss rods at gate posts and terminal posts.

G. Install fence fabric 1 inch above ground level.

H. Cut the fence fabric at the terminal posts.

I. Cut fabric by untwisting on picket and attach each span independently at all terminal posts. Install tension rods with bolts and washers at 15" on center.

J. Fasten fabric to all posts, rails, and gate frames with bolts and washers at 15" on center.

K. Clearances: install fencing and gates with a maximum ½" clearance between the perimeter of the fabric and the framing, between the framing and adjacent construction, and between the perimeter of each gate leaf and surrounding construction. Close off gaps exceeding 1/2"at the direction of the Construction Manager.

3.03 GATES

A. Install gates plumb, level and secure, for full operation without interference. Adjust hardware for smooth operation and lubricate where necessary. Gates shall open outward form the area to be secured.

B. Set keepers, stops, and other accessories into concrete as indicated and in accordance with manufacturer's instructions.

C. Adjust hardware for smooth operation and lubrication where necessary

3.04 CLEANING UP

A. During the progress of the Work, the premises shall be kept free of debris and waste. Upon completion, remove from the Site and dispose of all debris and surplus materials in a lawful manner.

B. At completion of Work, touch up minor damage to all surfaces to the satisfaction of the Construction Manager. Protect completed Work until final acceptance by the Construction Manager.

C. Repair of Galvanized Surfaces: use galvanize repair compound (stick form) or other method to repair galvanized surfaces. Comply with manufacturer's instructions.

3.05 SURVEY

A. The locations of the fence posts shall be surveyed by the Surveyor, and shall be included in the Record Drawings in accordance with Section 01050 of these Specifications.

PART 4 – MEASUREMENT AND PAYMENT

4.01 GENERAL

A. Providing for and complying with the requirements set forth in this Section for chain link fence shall be included with the Mobilization and Demobilization lump sum costs provided on the Base Bid Schedule.

B. The bid item costs shall include all incidentals necessary for a complete installation of Chain Link Fence.

END OF SECTION]

DRAFT

SECTION 03400
CAST-IN-PLACE CONCRETE

PART 1 – GENERAL

1.01 DESCRIPTION OF WORK

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, and equipment necessary to perform all Work specified herein and as shown on the Construction Drawings

B. The Work shall include, but not be limited to, procurement, delivery, subgrade preparation, formwork, concrete placement, control joints, surface treatment, and curing.

1.02 RELATED SECTIONS

Section 02200 – Earthwork

1.03 REFERENCES

A. Construction Drawings

B. Geosyntec, 2007 "Construction Quality Assurance Plan for the Construction of the Corrective Action Management Unit, Basic Remediation Company, Henderson, Nevada," August.

C. Clark County Area Uniform Standard Specifications (CCAUSS) and Clark County Area Uniform Standard Drawings (CCAUSD).

D. Latest version of American Concrete Institute (ACI) standards:

ACI 117	Tolerances for Concrete Construction and Materials
ACI 211.1	Selecting Proportions for Normal, Heavyweight, and Mass Concrete
ACI 301	Structural Concrete for Buildings
ACI 304R	Measuring, Mixing, Transporting, and Placing Concrete
ACI 308	Standard Practice for Curing Concrete
ACI 318	Building Code Requirements for Reinforced Concrete
ACI 347R	Formwork for Concrete

E. Latest version of the American Society for Testing and Materials (ASTM) standards:

ASTM A185	Welded Steel Wire Fabric for Concrete Reinforcement
ASTM A497	Welded Deformed Steel Wire Fabric for Concrete Reinforcement
ASTM A 615	Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
ASTM C 33	Concrete Aggregates

DRAFT

ASTM C 39	Compressive Strength of Cylindrical Concrete Specimens
ASTM C 94	Ready- Mixed Concrete
ASTM C 127	Specific Gravity and Adsorption of Coarse Aggregate
ASTM C 128	Specific Gravity and Adsorption of Fine Aggregate
ASTM C 143	Slump of Hydraulic Cement Concrete
ASTM C 150	Portland Cement
ASTM C 171	Sheet Materials for Curing Concrete
ASTM C 172	Standard Practice for Sampling Freshly Mixed Concrete
ASTM C 192	Making and Curing Concrete Test Specimens in the Laboratory
ASTM C 260	Air Entraining Admixtures for Concrete.
ASTM C 293	Standard Test Method for Flexural Strength of Concrete (Using Simple Beam With Center-Point Loading)
ASTM C 309	Liquid Membrane - Forming Compounds for Curing Concrete
ASTM C 403	Time of Setting of Concrete Mixtures by Penetration Resistance
ASTM C 494	Chemical Admixtures for Concrete
ASTM C 618	Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete
ASTM D 1751	Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction.
ASTM D 1752	Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction.

F. Latest version of Federal Standards (FS):

FS TT-C-800	Curing Compound, Concrete, for New and Existing Surfaces.

1.04 SUBMITTALS

A. At least 14 days prior to construction of the concrete, Contractor shall submit a mix design for the type of concrete to the Construction Manager. The Contractor shall submit a complete list of materials including types, brands, sources, amount of cement, fly ash, pozzolans, retardants, and admixtures, and applicable reference specifications for the following:

1. Slump design based on total gallons of water per cubic yard.
2. Type and quantity of cement.
3. Brand, type, ASTM designation, active chemical ingredients, and quantity of each admixture.

DRAFT

4. Compressive strength based on 28-day compression tests.

B. Delivery Tickets:

1. Provide duplicate delivery tickets with each load of concrete delivered, one for Contractor's records and one for Construction Manager, with the following information:

a. Date and serial number of ticket.

b. Name of ready-mixed concrete plant, operator, and job location.

c. Type of cement, admixtures, if any, and brand name.

d. Cement content, in bags per cubic yard (CY) of concrete, and mix design.

e. Truck number, time loaded, and name of dispatcher.

f. Amount of concrete (CY) in load delivered.

g. Gallons of water added at job, if any, and slump of concrete after water was added.

h. Identification of mix design number.

C. Contractor shall submit Record Drawings presenting the dimensions, locations and elevations of the features.

1.05 MANUFACTURER QUALITY CONTROL (MQC)

A. Aggregates shall be sampled and tested in accordance with ASTM C 33.

B. Concrete test specimens shall be made, cured, and stored in conformity with ASTM C 192 and tested in conformity with ASTM C 39.

C. Slump shall be determined in accordance with ASTM C 143.

1.06 LIMITING REQUIREMENTS

A. Unless otherwise specified, each concrete mix shall be designed and concrete shall be controlled within the following limits:

1. Concrete slump shall be kept as low as possible, consistent with proper handling and thorough compaction. Unless otherwise authorized by the Construction Manager, slump shall not exceed 4 in.

2. The admixture content, batching method, and time of introduction to the mix shall be in accordance with the manufacturer's recommendations for minimum shrinkage and for compliance with this Section. A water-reducing admixture may be included in concrete.

DRAFT

PART 2 – PRODUCTS

2.01 CONCRETE

A. Concrete Materials

1. Portland cement concrete shall be in accordance with CCAUSS Section 501.

2. Cement: ASTM C150 Sulphate Resistant-Type V low alkali Portland type only, gray color; shall conform to CCAUSS Section 701.

3. Fine and Coarse Aggregates: Shall conform to ASTM C33, and Section 706 of the Standard Specifications. Coarse aggregates shall be 1 ½ inches maximum size, except otherwise specified within.

4. Water: Clean and not detrimental to concrete. Water shall be of potable quality.

2.02 FORM MATERIALS

A. Conform to ACI 301.

2.03 REINFORCEMENT

A. Reinforcing materials shall be in accordance with CCAUSS Section 713. Reinforcing Steel: ASTM A615; Grade 60; plain or deformed billet steel bars, as noted on Drawings.

B. Welded Steel Wire Fabric: Plain type, ANSI/ASTM A185; in flat sheets; uncoated.

C. Tie Wire: Annealed steel, minimum 16 gage size.

D. Dowels: ASTM A615; 40 ksi yield grade, plain steel, uncoated finish.

2.04 ACCESSORIES

A. Concrete curing materials and admixtures shall be in accordance with CCAUSS Section 702. Curing Compound: FS TT-C-800, Type 1, 30 percent solids.

B. Joint material shall conform to CCAUSS Section 707, except as otherwise noted on drawings or by Engineer.

2.05 ADMIXTURES

A. Air Entrainment: ASTM C260.

B. Chemical Admixture: ASTM C494, Type A - water reducing, or Type D water reducing and retarding.

2.06 CONCRETE MIX

A. Concrete shall conform to the requirements of CCAUSS Section 501 and to the requirements of ASTM C94, subject to the modifications and supplemental requirements contained in these Specifications.

B. Concrete mix shall be Class AA - 3,000 psi, 28 day compressive strength.

DRAFT

C. The Contractor is hereby cautioned that the cement contents shown above are minimum values and for general information. The contractor or concrete supplier shall, at its own expense, furnish additional quantities of cement as required to consistently obtain the compressive strengths designated above. Mix design shall be per governing agency standards and specifications.

PART 3 – EXECUTION

3.01 SUBGRADE PREPARATION

A. Subgrade preparation shall be in accordance with Section 02200.

B. Subgrade shall be graded to the lines and elevations as shown on the Drawings.

C. Standing water, mud, debris, and foreign matter shall be removed before concrete is placed.

3.02 INSPECTION

A. Provide written verification that compacted granular base is ready to support paving and imposed loads.

B. Provide written verification that gradients and elevations of base are correct.

C. Beginning of installation means acceptance of existing conditions.

3.03 PREPARATION

A. Moisten base to minimize absorption of water from fresh concrete.

B. Notify Construction Manager a minimum of 24 hours prior to commencement of concreting operations.

3.04 FORMING

A. Place and secure forms to correct location, dimension, and profile.

B. Assemble formwork to permit easy stripping and dismantling without damaging concrete.

C. Place joint fillers vertical in position, in straight lines. Secure to formwork during concrete placement.

3.05 REINFORCEMENT

A. Place reinforcement at mid-height of slabs-on-grade unless otherwise indicated on Drawings.

B. Interrupt reinforcement at joints as shown on Drawings.

C. Provide dowelled joints at interruptions of concrete with one end of dowel lubricated to allow longitudinal movement.

3.06 FORMED JOINTS

A. Locate joints as specified herein or shown on the plans.

DRAFT

B. Make all joints perpendicular and straight.

C. Contraction Joints.

1. Contraction joints shall be constructed every 10 feet (maximum) and shall conform to CCAUSS Section 613 unless otherwise noted on Drawings or by the Construction Manager.

2. Contraction joints shall be constructed every 10 feet (maximum) by using steel templates not less than 1/8 inch nor more than 3/16 inch in thickness. The templates shall be removed as soon as the concrete has set sufficiently to hold its shape. Where concrete is placed by slipform methods, the contraction joints every 10 feet may be provided by cutting into the fresh concrete to a minimum depth of 1-1/2 inches to create a plane of weakness. The edges of such joints shall be rounded to provide a neat workmanship appearance.

3. Immediately after the forms are removed, the Construction Manager shall inspect the contraction joints carefully. Any concrete or mortar that has sealed across the joint shall be cut neatly and removed.

D. Expansion joints.

1. Expansion joints, ½ inch in thickness, shall be constructed every 30 feet and at changes in direction by using premolded expansion joint filler and shall conform to CCAUSS Section 613 unless otherwise noted on Drawings or by the Construction Manager.

3.07 PLACING CONCRETE

A. Place concrete in accordance with ACI 301 and CCAUSS Section 502.

B. Ensure reinforcement, inserts, embedded parts, formed joints and dowels are not disturbed during concrete placement.

C. Place concrete continuously between predetermined construction joints. Do not break or interrupt successive pours such that cold joints occur.

D. Place concrete to straight line pattern.

3.08 FINISHING OF CONCRETE SURFACES

A. All finished or formed surfaces shall conform accurately to the shape, alignment, grades and sections as shown or requested. Surfaces shall be free of fins, bulges, ridges, offsets, honeycombing, or roughness of any kind, and shall present a finished, smooth, continuous, hard surface.

B. Exposed vertical corners of all concrete structures shall be given a ¾ inch chamfer. Forms shall not be removed until permission to do so has been received from the Construction Manager.

C. Excessive floating of surfaces while the concrete is plastic shall not be permitted. Exposed uniformed surfaces of concrete shall be given the following finishes: Area paving – broom finish; Other surfaces – steel trowel finish.

DRAFT

D. Dusting on of dry cement or sand to absorb excess moisture shall not be permitted. Unless otherwise shown, the edges of all exposed horizontal surfaces shall be finished with an edging tool to a radius of ½ inch.

E. All concrete surfaces on which pedestrians can walk shall be finished such that the minimum static coefficient of friction between the surface and normal hard soled shoes shall be in strict accordance with ADA Guidelines, latest edition.

3.09 CURING

A. Place curing compound on exposed concrete surfaces immediately after finishing. All structural concrete shall be cured by being moist for fourteen (14) days after placing or, at the option of the Contractor, may be cured by use of a curing compound meeting the requirements of CCAUSS Section 702, and which has been approved by the Engineer and Construction Manager.

B. The curing compound shall be applied in accordance with the manufacturer's instructions at a minimum coverage rate of 150 square feet per gallon in such a manner as to cover the surface with a uniform film which will seal thoroughly.

3.10 FIELD QUALITY CONTROL

A. Concrete Tests

1. A set of four (4) concrete cylinders shall be taken for every 75 cubic yards, or fraction thereof, of each class of concrete placed each day. One (1) additional test cylinder will be taken during cold weather and cured on site under the same conditions as the concrete it represents.

2. One (1) slump test shall be per 20 cubic yards, or fraction thereof, of concrete.

3. Maintain records of placed concrete items. Record data, location of placement, quantity, air temperature, and test samples taken.

4. Portland cement concrete shall be subject to the requirements and test methods contained in CCAUSS Section 501.02.03. ASTM C 293 shall be performed at a frequency of 1 test per 300 cubic yards of concrete.

5. The determination of compressive strength in psi shall be made by testing 6 inch diameter by 12 inch cylinders, made and cured in accordance with ASTM C31 and ASTM C39. Tests and analysis of the aggregates and of the resulting concrete will be made by the Construction Manager and the mixes used shall be changed whenever, in the opinion of the Construction Manager, such change is necessary or desirable to secure the required workability, density, impermeability, surface finish and strength; and the Contractor shall be entitled to no additional compensation because of such changes. The cost of laboratory tests on cement, aggregate, and concrete will be borne by the Contractor. The Contractor shall assist the Construction Manager in obtaining specimens for testing.

3.11 PROTECTION

A. Immediately after placement, protect concrete from premature drying, excessive hot or cold temperatures, and mechanical injury.

DRAFT

3.12 SURVEY

A. The Surveyor shall locate the features of the concrete structure. The dimensions, locations and elevations of the features shall be presented on the Surveyor's Record Drawings.

PART 4 – MEASUREMENT AND PAYMENT

4.01 GENERAL

A. Providing for and complying with the requirements set forth in this Section for LCRS Cast-In-Place Concrete Anchors shall be on a per-anchor basis (EA) and payment shall be based on the unit price for LCRS Concrete Anchors provided on the Bid Schedule.

B. Providing for and complying with the requirements set forth in this Section for Storm water collection improvements at the CAMU – Concrete Channel shall be lump sum (LS), and payment shall be based on the Lump Sum price provided on the Bid Schedule. Specified items incidental to storm water improvements – concrete channel are:

1. concrete channel
2. aggregate base
3. subgrade preparation

C. The bid item costs shall include all incidentals necessary for a complete installation of Cast-in-Place Concrete.

[END OF SECTION]

DRAFT

SECTION 03410
REINFORCED CONCRETE PIPE

PART 1 – GENERAL

1.01 DESCRIPTION OF WORK

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, and equipment necessary to perform all Work specified herein and as shown on the Construction Drawings

1.02 RELATED SECTIONS

Section 02200 – Earthwork

1.03 REFERENCES

A. Construction Drawings

B. Clark County Area Uniform Standard Specifications (CCAUSS) and Clark County Area Uniform Standard Drawings (CCAUSD)

C. Construction Quality Assurance (CQA) Plan

D. Latest version of American Concrete Institute (ACI) standards:

ACI 117	Tolerances for Concrete Construction and Materials
ACI 211.1	Selecting Proportions for Normal, Heavyweight, and Mass Concrete
ACI 301	Structural Concrete for Buildings
ACI 304R	Measuring, Mixing, Transporting, and Placing Concrete
ACI 308	Standard Practice for Curing Concrete
ACI 318	Building Code Requirements for Reinforced Concrete
ACI 347R	Formwork for Concrete

E. Latest version of the American Society for Testing and Materials (ASTM) standards:

ASTM A 615	Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
ASTM C 33	Concrete Aggregates
ASTM C 39	Compressive Strength of Cylindrical Concrete Specimens
ASTM C 94	Ready- Mixed Concrete
ASTM C 127	Specific Gravity and Adsorption of Coarse Aggregate
ASTM C 128	Specific Gravity and Adsorption of Fine Aggregate
ASTM C 143	Slump of Hydraulic Cement Concrete

DRAFT

ASTM C 150	Portland Cement
ASTM C 171	Sheet Materials for Curing Concrete
ASTM C 192	Making and Curing Concrete Test Specimens in the Laboratory
ASTM C 309	Liquid Membrane - Forming Compounds for Curing Concrete
ASTM C 403	Time of Setting of Concrete Mixtures by Penetration Resistance
ASTM C 494	Chemical Admixtures for Concrete
ASTM C 618	Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete

1.04 SUBMITTALS

A. At least 14 days prior to construction of the concrete, Contractor shall submit a mix design for the type of concrete to the Construction Manager. The Contractor shall submit a complete list of materials including types, brands, sources, amount of cement, fly ash, pozzolans, retardants, and admixtures, and applicable reference specifications for the following:

1. Slump design based on total gallons of water per cubic yard.
2. Type and quantity of cement.
3. Brand, type, ASTM designation, active chemical ingredients, and quantity of each admixture.
4. Compressive strength based on 28-day compression tests.

B. Delivery Tickets:

1. Provide duplicate delivery tickets with each load of concrete delivered, one for Contractor's records and one for Construction Manager, with the following information:

   a. Date and serial number of ticket.
   b. Name of ready-mixed concrete plant, operator, and job location.
   c. Type of cement, admixtures, if any, and brand name.
   d. Cement content, in bags per cubic yard (CY) of concrete, and mix design.
   e. Truck number, time loaded, and name of dispatcher.
   f. Amount of concrete (CY) in load delivered.
   g. Gallons of water added at job, if any, and slump of concrete after water was added.
   h. Identification of mix design number.

DRAFT

C. Contractor shall submit Record Drawings presenting the dimensions, locations and elevations of the features.

1.05 MANUFACTURER QUALITY CONTROL (MQC)

A. Aggregates shall be sampled and tested in accordance with ASTM C 33.

B. Concrete test specimens shall be made, cured, and stored in conformity with ASTM C 192 and tested in conformity with ASTM C 39.

C. Slump shall be determined in accordance with ASTM C 143.

1.06 LIMITING REQUIREMENTS

A. Unless otherwise specified, each concrete mix shall be designed and concrete shall be controlled within the following limits:

1. Concrete slump shall be kept as low as possible, consistent with proper handling and thorough compaction. Unless otherwise authorized by the Construction Manager, slump shall not exceed 4 in.

2. The admixture content, batching method, and time of introduction to the mix shall be in accordance with the manufacturer's recommendations for minimum shrinkage and for compliance with this Section. A water-reducing admixture may be included in concrete.

PART 2 – PRODUCTS

2.01 REINFORCED CONCRETE PIPE

A. Reinforced Concrete Pipe (RCP) shall be in accordance with CCAUSS Sections 601, 603, 708, and the Construction Drawings.

2.02 MANHOLES

A. Manholes shall be in accordance with CCAUSS Section 609 and the Construction Drawings.

PART 3 – EXECUTION

3.01 GENERAL

A. RCP: Refer to CCAUSS Sections 601, 603, 708, and the Construction Drawings for pipe execution.

B. Manholes: Refer to CCAUSS Section 609 and the Construction Drawings for execution.

PART 4 – MEASUREMENT AND PAYMENT

4.01 GENERAL

A. Providing for and complying with the requirements set forth in this Section for Reinforced Concrete Pipe and Manholes and Inlets shall be measured as Lump Sum (LS), and payment shall be based on the lump sum price for Storm water collection improvements at CAMU – storm drain piping provided on the Bid Schedule. Incidental to RCP and Manholes are:

DRAFT

1. Earthworks
2. Backfill
3. Subgrade Preparation
4. All other necessary incidentals for a complete installation of RCP pipe, manholes, and inlets.

[END OF SECTION]

DRAFT

ATTACHMENT C
6 oz/yd^2 Puncture Protection Calculation

Geosyntec consultants

COMPUTATION COVER SHEET

Client: **BRC** Project: **BRC CAMU** Project/ Proposal No.: **SC0313** Task No. **04**

Title of Computations **CUSHION FABRIC CALCULATIONS**

Computations by:	Signature	Meghan Lithgow	2/22/08
	Printed Name	Meghan Lithgow	Date
	Title	Staff Engineer	
Assumptions and Procedures Checked by: (peer reviewer)	Signature		2/22/08
	Printed Name	Rebecca B. Flynn	Date
	Title	Senior Staff Engineer	
Computations Checked by:	Signature		
	Printed Name	Gregory T. Corcoran, P.E.	Date
	Title	Principal Engineer	
Computations backchecked by: (originator)	Signature	Meghan Lithgow	2/22/08
	Printed Name	Meghan Lithgow	Date
	Title	Staff Engineer	
Approved by: (pm or designate)	Signature		
	Printed Name	Gregory T. Corcoran, P.E.	Date
	Title	Principal Engineer	

Approval notes:

Revisions (number and initial all revisions)

No.	Sheet	Date	By	Checked by	Approval

Written by:	M. Lithgow	Date:	02/19/08	Reviewed by:	G. Corcoran	Date:	
Client:	BRC	Project:	BRC CAMU	Project/ Proposal No.:	SC0313	Task No.:	04

CUSHION FABRIC CALCULATIONS
BRC CAMU
HENDERSON, NEVADA

OBJECTIVE

The project involves placement of a composite liner system for the Corrective Action Management Unit (CAMU) in Henderson, Nevada. The proposed liner system is shown in Attachment A. The objective of this calculation is to evaluate the maximum particle sizes of soil/aggregate materials adjacent to the geotextile in the leachate collection system that will not puncture or damage the geotextile. Specifically, this calculation will consider the maximum pressure exerted by equipment after backfilling an operations layer and traffic loads are imposed to evaluate the survivability of the proposed 6 oz/yd^2 geotextile.

SUMMARY OF ANALYSIS

The analyses suggest that the proposed geotextile with a mass per unit area of 6 oz/yd^2 placed over aggregate with a maximum particle size of 1.0 inches and overlain by 1 ft of operations layer soil with a maximum particle size of 1-inch will be adequate to ensure the survivability of the geotextile during operations construction.

SITE CONDITIONS

The proposed composite liner system in the area of interest will be comprised of the following components, from top to bottom (Figure 1):

- First 1-ft lift of operations layer material with a maximum particle size of 1-inch;
- a 6 oz/yd^2 nonwoven separation/filter geotextile;
- 1 ft of leachate collection aggregate surrounding leachate collection pipe;
- a 16 oz/yd^2 nonwoven cushion geotextile;
- 60-mil (1.5 mm) HDPE geomembrane, textured on both sides;

- a geosynthetic clay liner (GCL); and
- prepared subgrade.

For this analysis, we will specifically be analyzing the 6 oz/yd^2 nonwoven separation/geotextile for its survivability during installation.

APPROACH

Koerner has evaluated the geotextile survivability of the installation process in his text titled, "Designing with Geosynthetics" (Koerner, 1999). The design methods and conclusions of these papers were used for the analysis herein.

According to Koerner's approach, the important parameters that affect the puncture protection of geotextiles are: overlying pressure, mass per area of the geotextile, and the particle size and shape of the material overlying the geotextile. For the analysis herein, the overlying pressure and the mass per unit area of the geotextile are given and the maximum particle size is evaluated for the geotextile.

ANALYSES

$$F_{reqd} = p' d_a^2 S_1 S_2 S_3$$ (Attachment B)

where:

F_{reqd} = required vertical force to be resisted;

d_a = average diameter of the puncturing aggregate or sharp object;

p' = pressure exerted on the geotextile;

S_1 = protrusion factor = h_h/d_a;

S_2 = scale factor to adjust the ASTM D4833 puncture test value (which uses an 8.0 mm diameter probe) to the diameter of the actual puncturing object = d_{probe}/d_a;

S_3 = shape factor to adjust the ASTM D4833 flat puncture probe to the actual shape of puncturing object = $1-A_p/A_c$ (values for A_p/A_c range

from 0.8 for rounded sand, to 0.7 for run-of-bank gravel, to 0.4 for crushed rock, to 0.3 for shot rock);

A_p = projected area of puncturing particle; and

A_c = area of smallest circumscribed circle around puncturing particle.

$F_{reqd} = p' d_a^2 S_1 S_2 S_3$

p' = 10 psi x (6.894 kPa/1 psi) = 69 kPa (note: 10 psi is maximum allowable load on 1-ft lift of operations layer in accordance with Technical Specifications)

d_a = 1.0 inch x (25.4 mm/1 inch) = 25.4 mm

h_h = 0.5 inch

d_{probe} = 8.0 mm

$S_1 = h_h/d_a = 0.5/1 = 0.5$

$S_2 = d_{probe}/d_a$ = 8.0 mm/ 25.4 mm = 0.31

$S_3 = 1 - A_P/A_C = 1 - 0.4$ (crushed rock) = 0.6

F_{reqd} = (69 kPa)(1000 Pa/1 kPa)(25.4 x 0.001 mm/1 m)^2(0.5)(0.31)(0.6) = 4.14 N

The proposed 6 oz/yd^2 geotextile has a puncture strength of approximately 40 lbs (178 N). A cumulative reduction factor is calculated to account for installation and site specific criteria which may affect geotextile strength properties. The cumulative reduction factor is determined as follows:

$\prod RF = RF_{ID} \times RF_{CR} \times RF_{CD} \times RF_{BD}$

where:

$\prod RF$ = Cumulative reduction factors

RF_{ID} = Reduction factor for installation damage = 2.5 (Attachment A)

RF_{CR} = Reduction factor for creep = 2.5 (Attachment A)

RF_{CD} = Reduction factor for chemical degradation = 1.5 (Attachment A)

RF_{BD} = Reduction factor for biological degradation = 1.0 (Attachment A)

The ultimate puncture strength (F_{Ult}) is reduced by the cumulative reduction factor as follows:

$$F_{allow} = F_{Ult} \times \frac{1}{\prod RF} = 178N \times \frac{1}{2.5 \times 2.5 \times 1.5 \times 1.0} = 18.9N$$

The factor of safety is as follows:

$$FS = \frac{F_{allow}}{F_{reqd}} = \frac{18.9}{4.14} = 4.57 \text{, which is acceptable}$$

CONCLUSIONS

The proposed 6 oz/yd^2 nonwoven geotextile with a puncture strength of 40 lbs placed over an aggregate layer with a maximum particle size of 1.0-inch will be adequate to survive the installation process.

REFERENCES

Koerner, R.M., "Designing with Geosynthetics", 4th Ed., Prentice Hall, Upper Saddle River, 1999. (Attachment A)

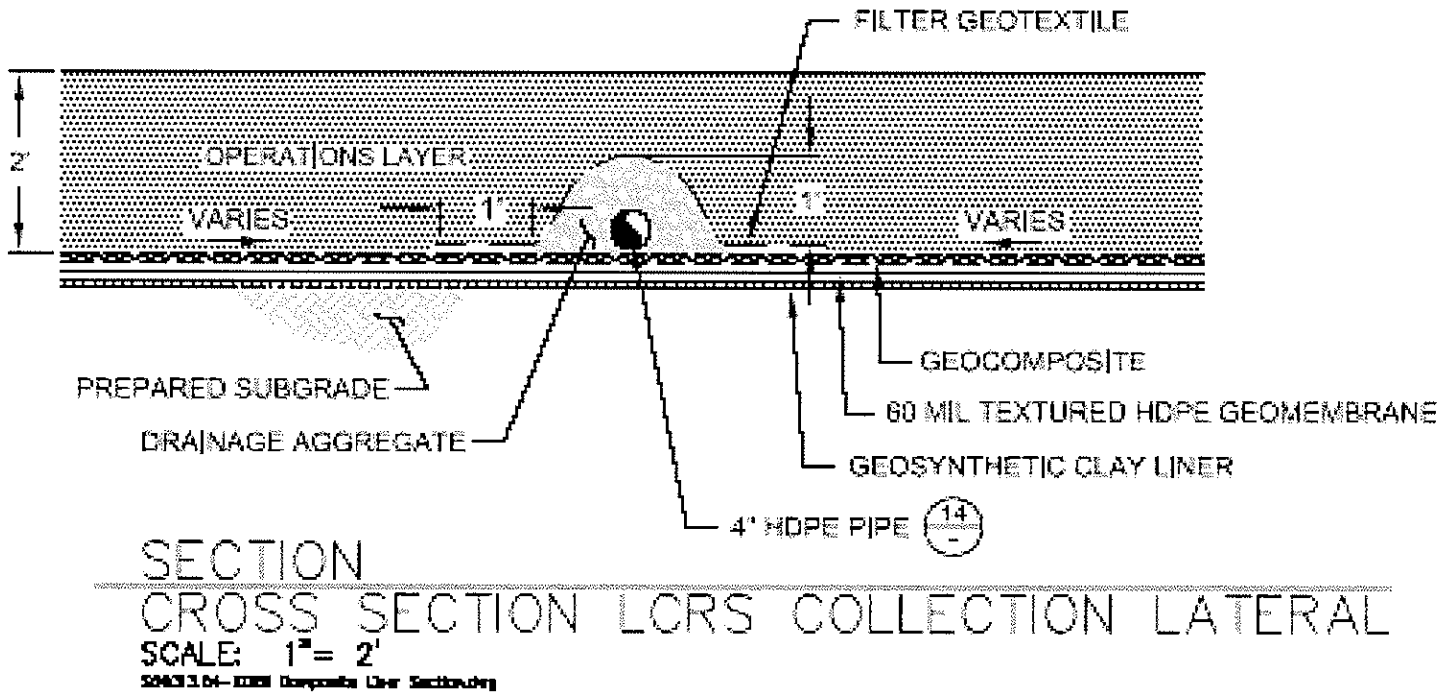

FILTER GEOTEXTILE
2'
OPERATIONS LAYER
VARIES
1'
1'
VARIES
GEOCOMPOSITE
PREPARED SUBGRADE
60 MIL TEXTURED HDPE GEOMEMBRANE
DRAINAGE AGGREGATE
GEOSYNTHETIC CLAY LINER
4" HDPE PIPE
14
SECTION
CROSS SECTION LCRS COLLECTION LATERAL
SCALE: 1"= 2'

Figure 1

properties will sort out into their respective categories and uses, but most organizations are looking at the complete collection of tests as they were presented here.

Table 2.10 is a summary table of geotextile properties. The rapidly changing market and its demands make it difficult to give accurate values, but for typical commercially available geotextiles, Table 2.10 gives the range of current values. For the specific values of specific types of geotextiles, the respective manufacturers should be consulted.

2.4 ALLOWABLE VERSUS ULTIMATE GEOTEXTILE PROPERTIES

It is important to recognize that many of the preceding geotextile test properties represent idealized conditions and therefore result in the maximum possible numeric values when used directly in design; that is, they result in upper-bound values. In the design-by-function concept described in Section 2.1.3, the factor of safety was formulated around an allowable test value (Eqs. 2.2a and 2.2b). Thus, most laboratory test values cannot generally be used directly; they must be suitably modified for the in situ conditions. This could be done directly in the test procedure, for example, by conducting a completely simulated performance test; but in most cases this simply is not possible. Simulating installation damage, performing long-term creep testing, using site-specific liquids, reproducing in situ pore-water stresses, providing complete stress state modeling, and so on, are generally not feasible. To account for such differences between the laboratory measured test value and the desired performance value, two approaches can be taken:

1. Use an extremely high factor of safety at the end of a problem.
2. Use reduction factors on the laboratory-generated test value to make it into a site-specific allowable value.

The latter alternative of *reduction factors*‡ will be used in this book. By doing this, the usual value of the factor of safety can be used in the final analysis. Our approach will be to refer to the general laboratory-obtained value as an *ultimate* value and to modify it by reduction factors to an *allowable* value.

2.4.1 Strength-Related Problems

For problems dealing with geotextile strength, such as in separation and reinforcement applications, the formulation of the allowable values takes the following form. Typical values for reduction factors are given in Table 2.11. Note that these values, however, must be tempered by the site-specific considerations. If the laboratory test includes the mechanism listed, it appears in the equation as a value of 1.0.

$$T_{\text{allow}} = T_{\text{ult}}\left(\frac{1}{\text{RF}_{ID} \times \text{RF}_{CR} \times \text{RF}_{CD} \times \text{RF}_{BD}}\right) \tag{2.24a}$$

$$T_{\text{allow}} = T_{\text{ult}}\left(\frac{1}{\Pi\text{RF}}\right) \tag{2.24b}$$

‡In previous editions of this book, reduction factors were called partial factors of safety. This edition is changed to reflect the current trend in agency specifications and the more appropriate terminology.

Attachment A (1/5)

TABLE 2.11 RECOMMENDED REDUCTION FACTOR VALUES FOR USE IN EQ. (2.24a)

Application Area	Range of Reduction Factors			
	Installation Damage	Creep*	Chemical Degradation	Biological Degradation
Separation	1.1 to 2.5	1.5 to 2.5	1.0 to 1.5	1.0 to 1.2
Cushioning	1.1 to 2.0	1.2 to 1.5	1.0 to 2.0	1.0 to 1.2
Unpaved roads	1.1 to 2.0	1.5 to 2.5	1.0 to 1.5	1.0 to 1.2
Walls	1.1 to 2.0	2.0 to 4.0	1.0 to 1.5	1.0 to 1.3
Embankments	1.1 to 2.0	2.0 to 3.5	1.0 to 1.5	1.0 to 1.3
Bearing capacity	1.1 to 2.0	2.0 to 4.0	1.0 to 1.5	1.0 to 1.3
Slope stabilization	1.1 to 1.5	2.0 to 3.0	1.0 to 1.5	1.0 to 1.3
Pavement overlays	1.1 to 1.5	1.0 to 2.0	1.0 to 1.5	1.0 to 1.1
Railroads (filter/sep.)	1.5 to 3.0	1.0 to 1.5	1.5 to 2.0	1.0 to 1.2
Flexible forms	1.1 to 1.5	1.5 to 3.0	1.0 to 1.5	1.0 to 1.1
Silt fences	1.1 to 1.5	1.5 to 2.5	1.0 to 1.5	1.0 to 1.1

*The low end of the range refers to applications which have relatively short service lifetimes and/or situations where creep deformations are not critical to the overall system performance.

where

T_{allow} = allowable tensile strength,
T_{ult} = ultimate tensile strength,
RF_{ID} = reduction factor for installation damage,
RF_{CR} = reduction factor for creep,
RF_{CD} = reduction factor for chemical degradation,
RF_{BD} = reduction factor for biological degradation, and
ΠRF = value of cumulative reduction factors.

Note that Eq. (2.24a) could have included additional site-specific terms, such as reduction factors for seams and intentionally made holes. It also could have been formulated with fractional multipliers (values ≤ 1.0) placed in the numerator of the equation or on the opposite side of the equation, as with the *load-factor design method*. It has been put in this form following other studies (e.g., Voskamp and Risseeuw [63]). While the equation indicates tensile strength, it can be applied to burst strength, tear strength, puncture strength, impact strength, and so on.

2.4.2 Flow-Related Problems

For problems dealing with flow through or within a geotextile, such as filtration and drainage applications, the formulation of the allowable values takes the following form. Typical values for reduction factors are given in Table 2.12. Note that these values must be tempered by the site-specific conditions, as in Section 2.4.1. If the laboratory test includes the mechanism listed, it appears in the equation as a value of 1.0.

$$q_{allow} = q_{ult}\left(\frac{1}{RF_{SCB} \times RF_{CR} \times RF_{IN} \times RF_{CC} \times RF_{BC}}\right) \tag{2.25a}$$

Attachment A (2/5)

cess acting on the geo-
ne mode: tensile stress
is locked into position
it. A lateral or in-plane
e of aggregate is forced
alogy to the grab tensile
re we can estimate the
tone wedges itself down
ere S ~ $d/2$ and l_f = de-
e or stone breakage can

is independent of particle
33% given the idealized

2.30 Geotextile being subjected
sile stress as surface pressure is ap-
and stone base attempts to spread
lly.

(upper-bound) assumptions stated above. The tensile force being mobilized is related to the pressure exerted on the stone as follows [64].

$$T_{\text{reqd}} = p'(d_v)^2[f(\varepsilon)] \tag{2.29}$$

where

T_{reqd} = required grab tensile force;
p' = applied pressure;
d_v = maximum void diameter $\simeq 0.33\ d_a$, where
d_a = average stone diameter; and
$f(\varepsilon)$ = strain function of the deformed geotextile;
$= \frac{1}{4}\left(\frac{2y}{b} + \frac{b}{2y}\right)$, where
b = width of stone void, and
y = deformation into stone void.

Example 2.8 illustrates the design procedure above.

Example 2.8

Given a 700 kPa truck-tire inflation pressure on a stone-base course consisting of 50 mm maximum-size stone with a geotextile beneath it, calculate **(a)** the required grab tensile stress on the geotextile, and **(b)** the factor of safety for a geotextile whose grab strength at 33% is 500 N with cumulative reduction factors of 2.5 and $f(\varepsilon) = 0.52$.

Solution: (a) Using an empirical relationship that $d_v = 0.33\ d_a$ and $f(\varepsilon) = 0.52$, the required grab tensile strength from Eq. (2.29) is as follows.

$$\begin{aligned} T_{\text{reqd}} &= p'(d_v)^2(0.52) \\ &= p'(0.33d_a)^2(0.52) \\ &= 0.057\ p'd_a^2 \\ &= 0.057(700)(1000)(0.050)^2 \\ &= 100\ \text{N} \end{aligned}$$

(b) The factor of safety for a 500 N grab tensile geotextile at 33% strain with cumulative reduction factors of 2.5 is as follows.

$$\begin{aligned} \text{FS} &= \frac{T_{\text{allow}}}{T_{\text{reqd}}} \\ &= \frac{500/2.5}{100} \\ &= 2.0 \qquad \text{which is acceptable.} \end{aligned}$$

2.5.4 Puncture Resistance

The geotextile must survive the installation process. This is not just related to the function of separation; indeed, fabric survivability is critical in all types of applications—without it the best of designs are futile (recall Figure 2.19). In this regard, sharp stones,

(Attachment A, 3/5)

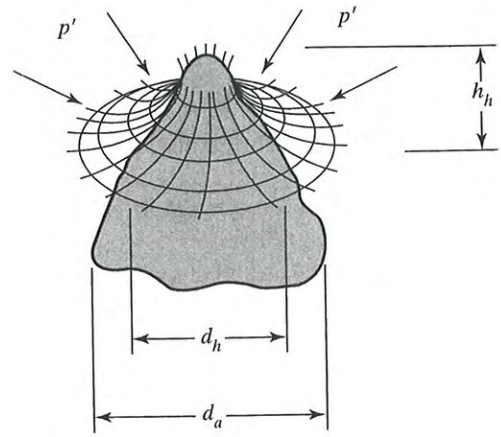


Figure 2.31 Visualization of a stone puncturing a geotextile as pressure is applied from above.

tree stumps, roots, miscellaneous debris, and other items, either on the ground surface beneath the geotextile or placed above it, could puncture through the geotextile after backfilling and traffic loads are imposed. The design method suggested for this situation is shown schematically in Figure 2.31. For these conditions, the vertical force exerted on the geotextile (which is gradually tightening around the protruding object) is as follows:

$$F_{\text{reqd}} = p' d_a^2 S_1 S_2 S_3 \tag{2.30}$$

where

F_{reqd} = required vertical force to be resisted;
d_a = average diameter of the puncturing aggregate or sharp object;
p' = pressure exerted on the geotextile (approximately 100% of tire inflation pressure at the ground surface for thin covering thicknesses);
S_1 = protrusion factor = h_h/d_a;
h_h = protrusion height $\leq d_a$;
S_2 = scale factor to adjust the ASTM D4833 puncture test value (which uses an 8.0 mm diameter puncture probe) to the diameter of the actual puncturing object = d_{probe}/d_a;
S_3 = shape factor to adjust the ASTM D4833 flat puncture probe to the actual shape of puncturing object = $1 - A_p/A_c$, (values for A_p/A_c range from 0.8 for rounded sand, to 0.7 for run-of-bank gravel, to 0.4 for crushed rock, to 0.3 for shot rock);
A_p = projected area of puncturing particle;
A_c = area of smallest circumscribed circle around puncturing particle.

Example 2.9

What is the factor of safety against puncture of a geotextile from a 50 mm stone on the ground surface mobilized by a loaded truck with a tire inflation pressure of 550 kPa traveling on the surface of the base course? The geotextile has an ultimate puncture strength of 200 N, according to ASTM D4833.

(Attachment A 4/5)

/isualization of a stone
:eotextile as pressure is ap-
ɔve.

on the ground surface
gh the geotextile after
ıggested for this situa-
, the vertical force ex-
e protruding object) is

(2.30)

ıarp object;
100% of tire inflation
icknesses);

est value (which uses
ter of the actual punc-

ure probe to the actual
ɔr A_p/A_c range from
l, to 0.4 for crushed

turing particle.

om a 50 mm stone on the
pressure of 550 kPa travel-
imate puncture strength of

Solution: Using the full stress on the geotextile of 550 kPa and the values 0.33, 0.15, and 0.6 for the factors S_1, S_2, and S_3, respectively,

$$\begin{aligned} F_{reqd} &= p' d_a^2 S_1 S_2 S_3 \\ &= (550)(1000)(50 \times 0.001)^2(0.33)(0.15)(0.6) \\ &= 40.8 \text{ N} \end{aligned}$$

Assuming that the cumulative reduction factors are 2.0, the factor of safety is as follows:

$$\begin{aligned} FS &= \frac{F_{allow}}{F_{reqd}} \\ &= \frac{200/2.0}{40.8} \\ &= 2.4 \qquad \text{which is acceptable} \end{aligned}$$

Using the following assumptions (which can be modified as desired), a design guide can be developed as shown in Figure 2.32: the geotextile has an angular subgrade

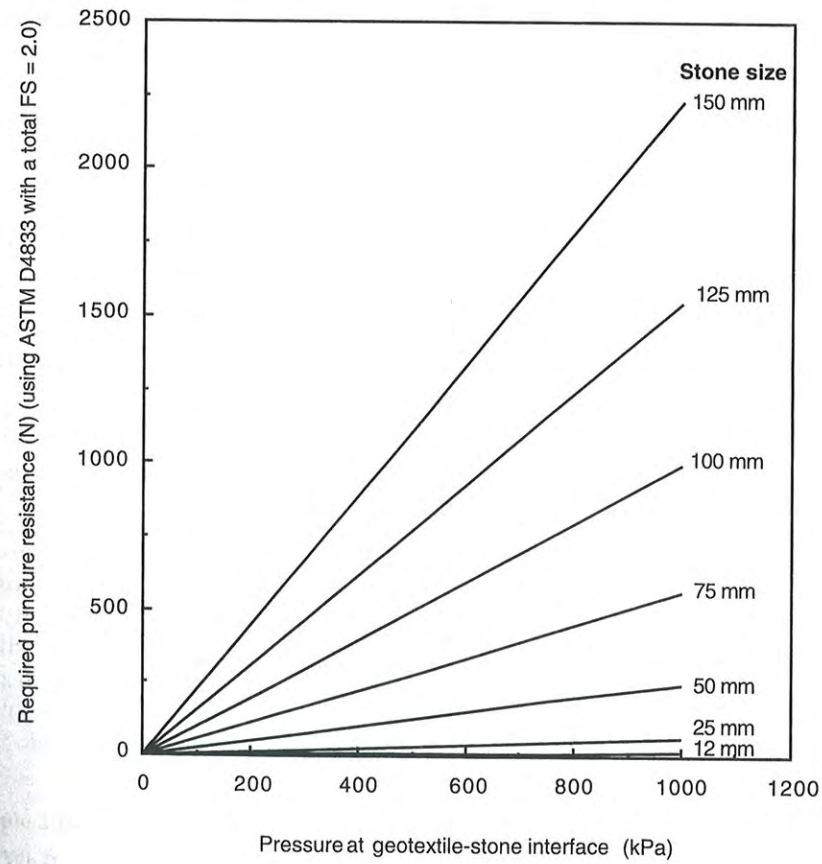


Figure 2.32 Puncture resistance design guide based on cumulative reduction factors of 2.0, a factor of safety of 2.0, and conditions stated in text.

(Attachment A, 5/5)

ATTACHMENT D
Revised Geocomposite Equivalency Calculation

Written by: Geoff L. Smith Date: 00 / 06 / 28 (YY MM DD) Reviewed by: _____ Date: ___/___/___ (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 02

DRAINAGE COMPOSITE EQUIVALENCY DEMONSTRATION
BRC CAMU
HENDERSON, NEVADA

OBJECTIVE

The objective of this analysis is to evaluate the hydraulic performance of a drainage composite, and compare it to the prescriptive leachate collection layer, consisting of drainage aggregate, within the BRC CAMU. A drainage composite, consisting of two 8 oz/sy nonwoven geotextiles bonded to either side of a geonet, is proposed. This analysis will demonstrate equivalence or performance exceedance of the drainage composite to the prescriptive 1-foot thick (0.3m) aggregate drainage layer. The method of analysis will compare the current transmissivity of the aggregate drainage layer and the equivalent transmissivity of the drainage composite.

SUMMARY OF ANALYSIS

The calculations suggest that a drainage composite having a transmissivity of $9.2*10^{-5}$ m^2/sec, at a maximum stress of 12,000 psf (574 kN/m^2) and a hydraulic gradient of 0.10, will provide equivalence to the aggregate drainage layer.

METHOD OF ANALYSIS

The analysis was performed using procedures recommended by Koerner (1994). The procedure first evaluates the flow rate (transmissivity) through the aggregate drainage layer, using the basic flow equation described by Darcy, and then calculates the equivalent flow rate (transmissivity) of the drainage composite, and includes appropriate partial factors of safety for geosynthetic materials.

ANALYSIS

This calculation evaluates the flow rate within the drainage composite.

- **FLOW RATE (TRANSMISSIVITY) OF THE AGGREGATE DRAINAGE LAYER**

The maximum flow rate within the leachate collection zone is determined from Darcy's Law by the equation:

$$q = K\,i\,A$$

Written by: Geoff L. Smith Date: 00 / 06 / 28 (YY MM DD) Reviewed by: _____ Date: ___/___/___ (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 02

where:

q = flow rate within the leachate collection layer (m^3/sec)
K = hydraulic conductivity (m/sec)
i = hydraulic gradient (dimensionless)
A = area of flux (m^2)

The following properties will be used for the aggregate drainage layer material.

$K = 1*10^{-2}$ cm/sec = $1*10^{-4}$ m/sec.
i = 0.02 (minimum slope of base liner system)
A= (1 ft * 1 ft) = 1 ft^2 = 0.093 m^2

The hydraulic conductivity is the prescriptive minimum value for the aggregate drainage layer, and the hydraulic gradient is a function of the minimum base slope of the cell. The area of flux is based on the unit thickness of the aggregate drainage layer (1 foot minimum).

Therefore,

$$q_{req} = (1*10^{-4} \text{ m/sec.})(0.02)(0.093 \text{ m}^2)$$
$$= 1.86*10^{-7} \text{ m}^3/\text{sec}$$

This maximum flow rate through the aggregate drainage layer, is the required flow through the drainage composite (q_{req}).

The allowable flow rate is obtained from laboratory testing for design purposes. This value is determined using appropriate safety factors against the required flow rate. The factor of safety is expressed as the ratio of the allowable flow rate (q_{all}) to the required flow rate (q_{req}).

$$FS = q_{all} / q_{req}$$

Similarly, the factor of safety equation can be expressed as the ratio of allowable to required in plane flow, transmissivity (θ), where the factor of safety equals:

$$FS = \theta_{all} / \theta_{req}$$

Where the transmissivity is calculated by:

$$\theta_{req} = q_{req} / (i*W) \qquad \text{(Attachment A)}$$

Written by: Geoff L. Smith Date: 00 / 06 / 28 (YY MM DD) Reviewed by: _____ Date: ___/___/___ (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 02

W = unit width of the drainage layer = 1 ft = 0.3408 m

Therefore,

$$\theta_{req} = \frac{(1.86*10^{-7}\ m^3/sec)}{(0.3048m)(0.02)}$$

$$= 3.05*10^{-5}\ m^2/sec.$$

The transmissivity of the aggregate drainage layer then becomes the minimum required transmissivity (θ_{req}) of the drainage composite.

- **TRANSMISSIVITY OF THE DRAINAGE COMPOSITE**

To ensure that the transmissivity of the proposed drainage composite meets or exceeds the required values over the life of the landfill, the required transmissivity must be increased through the use of appropriate partial factors of safety. These partial factors of safety make the adequate adjustment between the laboratory transmissivity values for drainage composite and actual field conditions.

As seen in Attachment A, Koerner suggests four factors of safety which should be accounted for: the intrusion of the adjacent geotextile into the core of the geonet (FS_{IN}), creep deformation of the geonet (FS_{CR}), factor of safety against chemical clogging of the geonet (FS_{CC}), and factor of safety against biological clogging of the geonet (FS_{BC}). Partial factor of safety values were applied to the geotextile in the filtration geotextile calculation to account for flow through the geotextile component of the drainage composite.

Attachment A shows the ranges for the partial factors of safety. For the purposes of the calculations made, the factors of safety were assumed to be:

FS_{IN} = 1.0 (Accounted for during the testing of the drainage composite)
FS_{CR} = 2.0
FS_{CC} = 1.5
FS_{BC} = 1.0 (Accounted for in the Filter Calculation)

The ultimate transmissivity of the drainage composite then becomes:

$$\theta_{ultimate} = \theta_{req} * (\Sigma\ FS)$$

Written by: Geoff L. Smith Date: 00 / 06 / 28 (YY MM DD) Reviewed by: _____ Date: ___/___/___ (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 02

Σ FS = product of all the partial factors of safety for the site specific conditions

The ultimate transmissivity of the drainage composite is then calculated as:

$$\theta_{gconct} = \theta_{req} * (\Sigma \text{ FS}) = 3.05*10^{-5} \text{ m}^2/\text{sec } [\ 1.0*2.0*1.5*1.0]$$

$$= 9.2*10^{-5} \text{ m}^2/\text{sec}$$

- **MAXIMUM STRESS**

The maximum height of the waste fill is 60 ft (18.3 m). Assuming a unit weight of 136 pcf and a factor of safety of 1.5, this translates to a overburden stress of approximately 12,000 psf (574 kPa).

- **CONCLUSIONS**

The required transmissivity of the geocomposite shall be $9.2*10^{-5}$ m^2/sec at a maximum stress of 12,000 psf and a gradient of 0.1.

REFERENCES

Koerner, R.M. (1994) "Designing with Geosynthetics", 3rd Edition, Prentice Hall, New Jersey *(Attachment A)*

GTC

transportation-related systems, such as roads and walls, the problem does not appear to be too serious. In waste leachate related systems (e.g., landfill leachate collection systems), it might be another story. At the bottom of a landfill, temperatures are high, ample carbon (as a biological food source) is available, and bacteria and fungi could indeed thrive. Whether oxygen is available or not only dictates whether aerobic or anaerobic conditions prevail. No data regarding microorganisms in geonets are presently available, although research is currently ongoing. Procedurally, one must use a high flow rate factor of safety, or have systems designed so that flushing is possible. This area begs for future inquiry.

The last environmental consideration, resistance to light and weather, is not felt to be a serious concern for most situations in which geonets are used. Polyethylene is resistant to weather-related degradation, and carbon black is included in all of the known products. Nevertheless geonets should be covered as soon as possible after placement.

4.1.6 Allowable Flow Rate

As described previously, the essence of the design-by-function concept is the establishment of an adequate global factor of safety. For geonets, where flow rate is the primary function, this takes the following form:

$$FS = \frac{q_{allow}}{q_{req}} \tag{4.3}$$

where FS = the global factor of safety (to handle unknown loading conditions or uncertainties in design methods, etc.),
q_{allow} = the allowable flow rate as obtained from laboratory testing, and
q_{req} = the required flow rate as obtained from design of the actual system.

Alternatively, one could also work from a transmissivity basis to obtain the equivalent relationship.

$$FS = \frac{\theta_{allow}}{\theta_{req}} \tag{4.4}$$

where θ is the transmissivity under similar definitions as above. As described previously, however, it is preferable to design with flow rate rather than transmissivity because of nonlaminar flow conditions in geonets.

Concerning the allowable value, which comes from hydraulic testing of the type just described, one must assess the realism of the test setup in contrast to the actual field system. If it does not model real life adequately, then some adjustments to the laboratory value must be made. This is often the case. Thus the laboratory-

ATTACHMENT A, 1/2

GTC

Table 4.2 Recommended preliminary factor of safety values for determining allowable flow rate or transmissivity of geonets

Application Area	Partial Factor of Safety Value in Equation 4.5			
	FS_{IN}	FS_{CR}*	FS_{CC}	FS_{BC}
Sport fields	1.0 to 1.2	1.0 to 1.5	1.0 to 1.2	1.1 to 1.3
Capillary breaks	1.1 to 1.3	1.0 to 1.2	1.1 to 1.5	1.1 to 1.3
Roof and plaza decks	1.2 to 1.4	1.0 to 1.2	1.0 to 1.2	1.1 to 1.3
Retaining walls, seeping rock and soil slopes	1.3 to 1.5	1.2 to 1.4	1.1 to 1.5	1.0 to 1.5
Drainage blankets	1.3 to 1.5	1.2 to 1.4	1.0 to 1.2	1.0 to 1.2
Surface water drains for landfill caps	1.3 to 1.5	1.2 to 1.4	1.0 to 1.2	1.2 to 1.5
Secondary leachate collection (landfills)	1.5 to 2.0	1.4 to 2.0	1.5 to 2.0	1.5 to 2.0
Primary leachate collection (landfills)	1.5 to 2.0	1.4 to 2.0	1.5 to 2.0	1.5 to 2.0 *

*These values assume that the q_{ult} value was obtained using an applied normal pressure of 1.5 to 2 times the field-anticipated maximum value. If not, values must be increased.

done at the proper design load and hydraulic gradient and that this testing yielded a short-term between-rigid-plates value of 1.2 gal./min.-ft.

Solution: Since better information is not known, average values from Table 4.2 are used.

$$q_{allow} = q_{ult}\left[\frac{1}{FS_{IN} \times FS_{CR} \times FS_{CC} \times FS_{BC}}\right] \tag{4.5}$$

$$= 1.2\left[\frac{1}{1.1 \times 1.1 \times 1.1 \times 1.2}\right]$$

$$= 1.2\left[\frac{1}{1.60}\right]$$

$$= 0.75 \text{ gal./min.-ft.}$$

Example:

What is the allowable geonet flow rate to be used in the design of a secondary leachate collection system? Assume that laboratory testing at proper design load and proper hydraulic gradient gave a short-term between-rigid-plates value of 1.2 gal./min.-ft.

Solution: Average values from Table 4.2 are used; however, note the large reduction.

2/2

ATTACHMENT A, #4

4.2 DESIGNING FC

This section wi
transportation-r
field.

4.2.1 Theoretic

Design by func

For geonets ser
aforementioned

where q_{allow} = t
q_{requ} = t

As stated prev
saturated condi
flow rate, name
equations 4.1 a

SMM 3/14/99

SUPPLEMENTAL
REMEDIAL ACTION PLAN (RAP)
PERMIT APPLICATION INFORMATION FOR
CORRECTIVE ACTION MANAGEMENT UNIT (CAMU)
HENDERSON, NEVADA

Submitted to:

Nevada Division of Environmental Protection
901 South Stewart Street – 4th Floor
Carson City, Nevada 89701
(775) 687-4670

Prepared for:

Basic Remediation Company
875 West Warm Springs Road
Henderson, Nevada 89015
(702) 567-0400

Prepared by:

GeoSyntec Consultants
10875 Rancho Bernardo Road, Ste. 200
San Diego, California 92127
(858) 674-6559

November 2006

Table of Contents

Section 1 – Permit Drawings

Figure J-1 Title Sheet and Drawing List
Figure J-2 Legend, Abbreviations, and General Notes
Figure J-3 Overall Site Plan
Figure J-4 Construction Sequence Plan
Figure J-5 Surcharge Plan
Figure J-6 Site Preparation Plan
Figure J-7 Construction Grading Plan
Figure J-8 Storm Drain Plan
Figure J-9 Final Cover Grading Plan
Figure J-10 Cross Sections
Figure J-11 Final Cover and Liner Details and Sections
Figure J-12 Fence Plan

Section 2 – Base Liner Calculation Packages

A. Cut Slope Stability
B. Final Waste Slope Stability
C. Drainage Pipe Size Requirement
D. Pipe Strength
E. Veneer Stability
F. Geotextile/Separation/Filtration Requirements
G. Geotextile Cushion Protection
H. Sump Capacity
I. Comparison of Flow Between a CCL and GCL
J. Tension Due to Wind Uplift
K. Anchorage Capacity
L. Geocomposite Equivalency Demonstration
M. Consolidation Analysis of the South Mesa
N. Consolidation Analysis of the North Mesa

Section 3 – Base Liner Construction Quality Assurance Plan

Section 4 – Base Liner Technical Specifications

Section 5 – Final Cover Calculation Packages

A. Geocomposite and Pipe Size Calculation
B. Veneer Stability
C. Cover Liner Sloughing Stability

D. Geotextile Filtration Requirements
E. Geotextile Puncture Protection
F. Pipe Strength
G. Seismic Performance Evaluation
    1. Seismic Hazard Evaluation and Evaluation of Design Ground Motions
    2. Site Response Analysis
    3. Seismic Deformation Charts
    4. Seismically-Induced Permanent Deformations

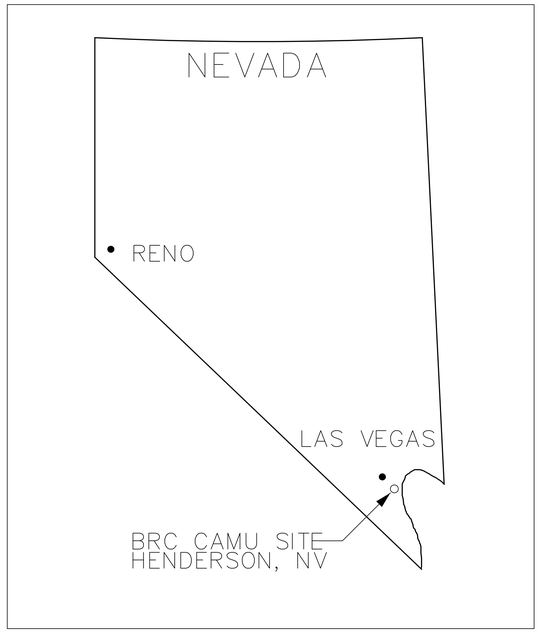
Section 6 – Final Cover Construction Quality Assurance Plan

Section 7 – Final Cover Technical Specifications

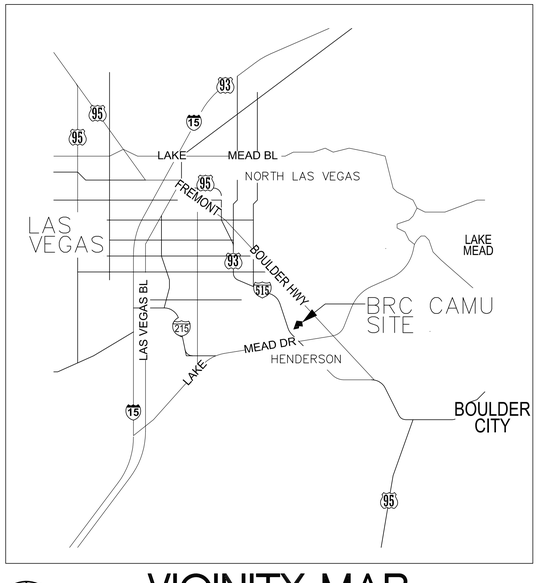
Section 8 – Previous Explorations

Section 1
Permit Drawings

PERMIT DRAWINGS
Basic Remediation Company
CORRECTIVE ACTION MANAGEMENT UNIT
CONTROL SYSTEMS DESIGN
HENDERSON, NEVADA
NOVEMBER 2006

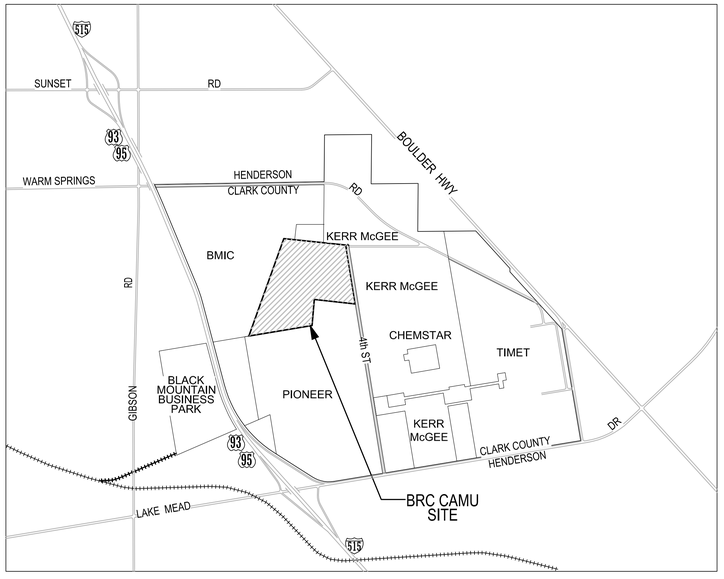


LOCATION MAP
NTS



VICINITY MAP
Approximate Scale: 1"=3 Miles

DRAWING LIST	DRAWING TITLE
J-1	TITLE SHEET AND DRAWING LIST
J-2	LEGEND, ABBREVIATIONS AND GENERAL NOTES
J-3	OVERALL SITE PLAN
J-4	CONSTRUCTION SEQUENCE PLAN
J-5	SURCHARGE PLAN
J-6	SITE PREPARATION PLAN
J-7	CONSTRUCTION GRADING PLAN
J-8	STORM DRAIN PLAN
J-9	FINAL COVER GRADING PLAN
J-10	CROSS SECTIONS
J-11	FINAL COVER AND LINER DETAILS AND SECTIONS
J-12	FENCE PLAN



SITE PLAN
Approximate Scale: 1"=1/2 Mile

GEOSYNTEC CONSULTANTS
10875 RANCHO BERNARDO ROAD, SUITE 200
SAN DIEGO, CALIFORNIA 92127
TELEPHONE: (858) 674-6559

PROJECT: BRC CAMU
HENDERSON/CLARK COUNTY NEVADA

TITLE: TITLE SHEET

MARK	DATE	REVISION	BY	APPROVED

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

SIGNATURE

DATE

SEAL

DATE: NOVEMBER 2006		SCALE:	AS SHOWN
DESIGN BY:	G.T.C.	JOB NO.:	SC0313
DRAWN BY:	J.R.H.	FILE NO:	
CHECKED BY:	G.T.C.	DOCUMENT NO:	
REVIEWED BY:	G.T.C.	DRAWING NO:	J-1
APPROVED BY:	G.T.C.		

P:\PRJ\SDCadd\CADD\SC0313\BRC\figures\Construction\Revised 11-6-06\SC0313_J-1_Title Sheet.dwg 11/14/06 10:22 jhall

ABBREVIATIONS

ABAN	ABANDON ABANDON IN PLACE .
CIP	CAST IRON PIPE
C-C	CENTER TO CENTER
CL	CENTER LINE
COH	CITY OF HENDERSON
CC	CLARK COUNTY
CCSD	CLARK COUNTY SANITATION DISTRICT
CO	CLEANOUT
COMM	COMMERCIAL
CONC, PCC	CONCRETE, PORTLAND CEMENT CONCRETE
CONST	CONSTRUCTION OR CONSTRUCT
CMP	CORRUGATED METAL PIPE
CU FT, CF	CUBIC FOOT
CU YD, CY	CUBIC YARD
CULV	CULVERT
CF	CURB FACE
DEPT	DEPARTMENT
Δ	DELTA = ANGLE
DIA, *	DIAMETER
DWG	DRAWING
DI	DROP INLET
DL	DRAIN LINE
EA	EACH
ESNT	EASEMENT
EO	EDGE OF OIL
EP	EDGE OF PAVEMENT
E	ELECTRIC OR ELECTRICAL
ELEV	ELEVATION
EMBK	EMBANKMENT
ECR	END OF CURB RETURN
EC	END OF CURVE
EVC	END OF VERTICAL CURVE
EXIST	EXISTING
FT	FEET, FOOT
FG	FINISH GRADE
FS	FINISH SURFACE
FH	FIRE HYDRANT
FL, F_L	FLOW LINE
GALV	GALVANIZED
G	GAS
GB	GRADE BREAK
HDWL	HEADWALL
HP	HIGH POINT
HPFL	HIGH POINT FLOW LINE
HORIZ	HORIZONTAL
IN	INCH
INT	INTERSECTION
INV	INVERT
LVVWD	LAS VEGAS VALLEY WATER DISTRICT
LF	LINEAR FEET
MH	MANHOLE
MAX	MAXIMUM
MIN	MINIMUM
NTS	NOT TO SCALE
OC	ON CENTER
PVMT	PAVEMENT
PCC	POINT OF COMPOUND CURVE
PC	POINT OF CURVE
PI	POINT OF INTERSECTION
PRC	POINT OF REVERSE CURVE
PT	POINT OF TANGENCY
PVI	POINT OF VERTICAL INFLECTION
PVC	POINT OF VERTICAL CURVE
PCC	PORTLAND CEMENT CONCRETE
PL, P_L	PROPERTY LINE
R	RADIUS OR RIDGE
REINF	REINFORCED
RCP	REINFORCED CONCRETE PIPE
R/W	RIGHT-OF-WAY
RD	ROAD
SS	SANITARY SEWER
SHT	SHEET
SW	SIDEWALK
SQ FT, SF	SQUARE FOOT
SQ YD, SY	SQUARE YARD
STA	STATION
SD	STORM DRAIN
STD	STANDARD
STL	STEEL
T	TELEPHONE
TEMP	TEMPORARY
TBA	TO BE ADJUSTED
TBR	TO BE REMOVED
TC	TOP OF CURB
TG	TOP OF GRATE
TOC	TOP OF CONCRETE
TP	TOP OF PIPE
TW	TOP OF WALL
TYP	TYPICAL
UG	UNDERGROUND
VAR	VARIABLE
VERT	VERTICAL
VC	VERTICAL CURVE
VCP	VITRIFIED CLAY PIPE
W	WATER
WWF	WELDED WIRE FABRIC
YD	YARD

LEGEND

EXISTING	NEW	DESCRIPTION
		CENTERLINE ~
		SECTION LINE
		RIGHT-OF-WAY OR PROPERTY LINE
		CUT LINE - ASPHALTIC OR PORTLAND CEMENT CONCRETE
	(LOW SIDE) (HIGH SIDE)	RETAINING WALL
		CHAINLINK FENCE
		BUILDING OR STRUCTURE
		CONCRETE BLOCK WALL
		ROAD
		EDGE OF PAVEMENT
		RIPRAP
		TEST HOLE
		CONCRETE (SHOWN ON CROSS SECTIONS)
		GRAVEL (SHOWN ON CROSS SECTIONS)
		GROUND (SHOWN ON CROSS SECTIONS)
		SAND (SHOWN ON CROSS SECTIONS)
		VEGETATIVE COVER (SHOWN ON CROSS SECTIONS)
		WING TYPE HEADWALL
		PLAIN HEADWALL
	TOP TOE	CUT OF FILL SLOPES
		DIRECTION OF SHEET FLOW
		FLOW LINE OF DITCH OR CHANNEL
		CULVERT
		STORM DRAIN CATCH BASIN
360	360	MAJOR CONTOUR LINE AND ELEVATION
		MINOR CONTOUR LINE
(351.00) FG	351.00 FG	FINISH GRADE ELEVATION
(351.00) FS	351.00 FS	FINISH SURFACE ELEVATION
(351.00) FL	351.00 FL	FLOW LINE ELEVATION
(351.00) HPFL	351.00 HPFL	HIGH POINT FLOW LINE ELEVATION
(351.00) TC	351.00 TC	TOP OF CURB ELEVATION
(351.00) TW	351.00 TW	TOP OF WALL ELEVATION
(351.00) INV	351.00 INV	INVERT ELEVATION
		UNDERGROUND WITH MANHOLE AND CASING
CO	CO	CLEANOUT
DL	DL	DRAIN LINE
DW	DW	DOMESTIC WATER
E	E	ELECTRICAL
G	G	GAS
SD	SD	STORM DRAIN
SS	SS	SANITARY SEWER
T	T	TELEPHONE/COMMUNICATIONS
		TELEPHONE/COMMUNICATIONS MANHOLE
W	W	WATER
		FIRE HYDRANT
		GATE VALVE
		REDUCER
		PLUG OR CAP
		UTILITY POLE
		UTILITY POLE WITH GUY ANCHOR
•GP	•GP	GUARD POST

GENERAL NOTES

1. UNLESS OTHERWISE INDICATED ON THE DRAWINGS, THE TOPOGRAPHY, INCLUDING HORIZONTAL AND VERTICAL CONTROLS ARE FROM A SURVEY BY PENTACORE GEOGRAPHIC INFORMATION SYSTEMS, 6763 WEST CHARLESTON BLVD, LAS VEGAS, NEVADA, DATED SEP. 9, 1999.

   1.1. BASIS OF VERTICAL CONTROL:
   CITY OF HENDERSON BENCHMARK NO. 5 – BOLT AND WASHER IN THE TOP OF THE CURB ON THE EAST SIDE OF HIGHWAY 93, 100 FEET +/- NORTHWEST OF THE CENTERLINE OF KING STREET.

   NAVD 1988 DATUM ELEVATION = 519.021 METERS 1702.821 FEET

   1.2. BASIS OF HORIZONTAL CONTROL:
   THE BASIS OF BEARINGS FOR THIS PROJECT IS GRID NORTH AS DEFINED BY THE NEVADA COORDINATE SYSTEM OF 1983 (NCS83), EAST ZONE, (2701), DETERMINED BY GIS CONTROL POINTS, "851" , "884" AND "W51" AS SHOWN ON A RECORD OF SURVEY ON FILE IN THE CLARK COUNTY RECORDER'S OFFICE, IN FILE 88 OF SURVEYS, AT PAGE 53.

2. A PRELIMINARY GEOTECHNICAL AND GEOLOGIC INVESTIGATION NO. 99-33437-01, DATED OCTOBER 22, 1999 PREPARED BY CONVERSE CONSULTANTS IS PART OF THE CONSTRUCTION DOCUMENTS.

3. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE FIELD INVESTIGATION OF THE EXISTING CONDITIONS AND FOR THE FIELD VERIFICATION OF EXISTING UNDERGROUND UTILITIES WITHIN THE PROPOSED WORK AREA. IF UNKNOWN UNDERGROUND UTILITIES ARE ENCOUNTERED DURING EXCAVATION, THE SUBCONTRACTOR SHALL IMMEDIATELY NOTIFY CONSTRUCTION MANAGER PRIOR TO CONTINUING THE WORK IN THE IMMEDIATE VICINITY.

4. THE CONTRACTOR SHALL PROTECT EXISTING UNDERGROUND AND ABOVEGROUND LINES AND ANY EXISTING IMPROVEMENTS AND EQUIPMENT WITHIN THE PROJECT LIMITS. ANY EXISTING CONSTRUCTION DAMAGED BY CONTRACTOR OPERATIONS SHALL BE REPAIRED OR REPLACED AT THE CONTRACTOR'S EXPENSE.

5. ALL UNDERGROUND UTILITIES SHALL BE PROPERLY PROTECTED DURING CONSTRUCTION FROM HEAVY EQUIPMENT BY THE USE OF SUITABLE TIMBER MAT OR STEEL MATTING.

6. DIMENSIONS, ELEVATIONS, AND LOCATION OF EXISTING UTILITIES ARE TO BE FIELD VERIFIED BY CONTRACTOR PRIOR TO START OF CONSTRUCTION.

7. STRAIGHT GRADE BETWEEN SPOT ELEVATIONS SHOWN UNLESS OTHERWISE INDICATED ON THE PLANS.

8. FINISHED SURFACES SHALL BE SLOPED UNIFORMLY FROM HIGH POINTS, RIDGE LINES, AND AROUND OBJECTS TO FLOW LINES AND AREA DRAINS UNLESS INDICATED OTHERWISE.

9. THE GEOTECHNICAL ENGINEER SHALL PROVIDE SUFFICIENT INSPECTIONS DURING THE EXCAVATION OF THE NATURAL GROUND AND THE PLACEMENT AND COMPACTION OF THE FILL TO BE SATISFIED THAT THE WORK IS BEING PERFORMED IN ACCORDANCE WITH THE PLANS AND SPECIFICATIONS.

10. EXCAVATION, EMBANKMENT, AND BACKFILL WORK AREAS SHALL BE CONTINUALLY AND EFFECTIVELY DRAINED. WATER SHALL NOT BE PERMITTED TO ACCUMULATE IN EXCAVATION OR FOUNDATION AREAS. THE SUBCONTRACTOR SHALL PROVIDE SUITABLE DIKES, DRAINS OR SHALL PROVIDE PUMPING EQUIPMENT AS REQUIRED TO DIVERT WATER FLOW AWAY FROM THE WORK AREAS.

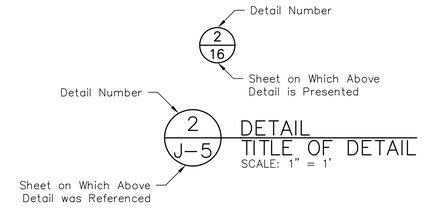
11. SLOPES SHOWN ON GRADING PLANS ARE FOR INFORMATION ONLY. ACTUAL LINES SHALL BE VERIFIED BY FIELD MEASUREMENTS.

12. THE CONTRACTOR SHALL PERFORM GRADING OPERATIONS IN ACCORDANCE WITH EARTHWORK SPECIFICATION, SECTION 02200.

13. SUBCONTRACTOR SHALL COORDINATE WITH OTHER SUBCONTRACTORS IN THE WORK AREA. ANY DISPUTES BETWEEN SUBCONTRACTORS SHALL BE RESOLVED THROUGH THE CONSTRUCTION MANAGER.

14. THE SUBCONTRACTOR SHALL IMMEDIATELY NOTIFY CONSTRUCTION MANAGER FOR PROVISIONS OF THE APPROPRIATE MEANS OF DECOMMISSIONING UNDERGROUND UTILITIES ENCOUNTERED IN THE FIELD WITHIN HIS WORK PACKAGE LIMITS.

DETAIL IDENTIFICATION LEGEND



Example: Detail Number 2 Presented on Sheet No. 16 was Referenced on Sheet No. 5.

NOTES: ABOVE REFERENCING SYSTEM ALSO APPLIES TO SECTION IDENTIFICATIONS.

GEOSYNTEC CONSULTANTS
10875 RANCHO BERNARDO ROAD, SUITE 200
SAN DIEGO, CALIFORNIA 92127
TELEPHONE: (858) 674-6559

PROJECT: BRC CAMU
HENDERSON/CLARK COUNTY NEVADA

TITLE: GENERAL NOTES, LEGEND, AND ABBREVIATIONS

MARK	DATE	REVISION	BY	APPROVED

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

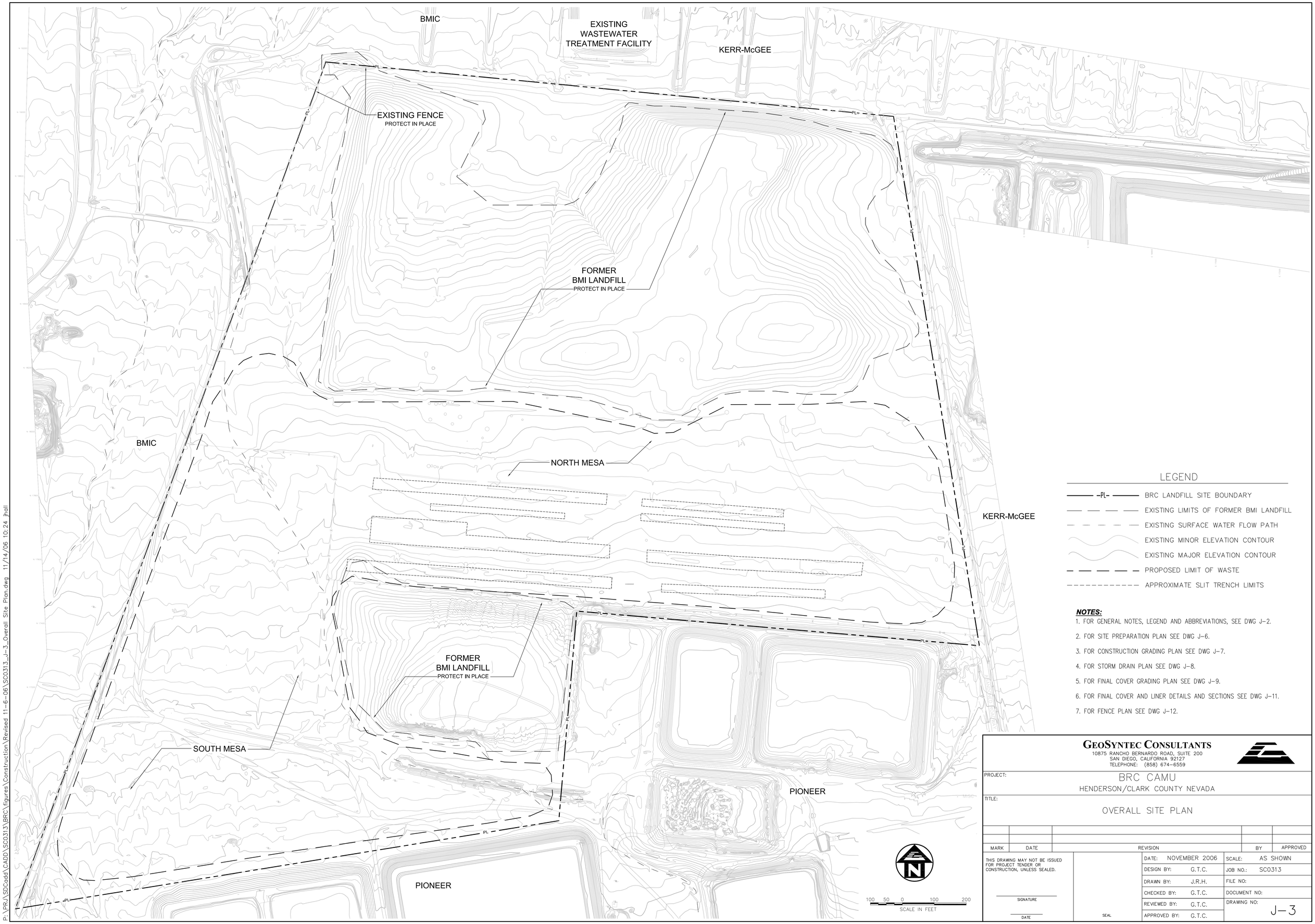
SIGNATURE

DATE

SEAL

DATE:	NOVEMBER 2006	SCALE:	AS SHOWN
DESIGN BY:	G.T.C.	JOB NO.:	SC0313
DRAWN BY:	J.R.H.	FILE NO:	
CHECKED BY:	G.T.C.	DOCUMENT NO:	
REVIEWED BY:	G.T.C.	DRAWING NO:	J-2
APPROVED BY:	G.T.C.		

P:\PRJ\SDCadd\CADD\SC0313\BRC\figures\Construction\Revised 11-6-06\SC0313_J-2_General Notes.dwg 11/14/06 10:23 jhall



P:\PRJ\SDCadd\CADD\SC0313\BRC\figures\Construction\Revised 11-6-06\SC0313_J-3_Overall Site Plan.dwg 11/14/06 10:24 jhall

GEOSYNTEC CONSULTANTS
10875 RANCHO BERNARDO ROAD, SUITE 200
SAN DIEGO, CALIFORNIA 92127
TELEPHONE: (858) 674-6559

PROJECT: BRC CAMU
HENDERSON/CLARK COUNTY NEVADA

TITLE: OVERALL SITE PLAN

MARK	DATE	REVISION	BY	APPROVED

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

SIGNATURE

DATE

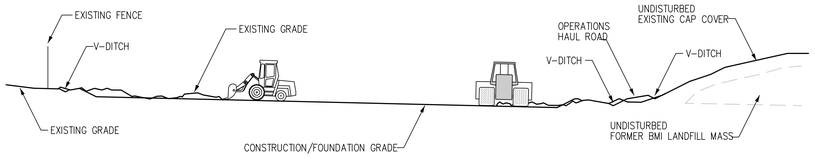
SEAL

DATE:	NOVEMBER 2006	SCALE:	AS SHOWN
DESIGN BY:	G.T.C.	JOB NO.:	SC0313
DRAWN BY:	J.R.H.	FILE NO:	
CHECKED BY:	G.T.C.	DOCUMENT NO:	
REVIEWED BY:	G.T.C.	DRAWING NO:	J-3
APPROVED BY:	G.T.C.		

1

- REMOVE ANY INTERFERING PORTION OF EXISTING FENCE
- CLEAR AND REMOVE BRUSH AND RUBBLE
- INSTALL INTERIM PERIMETER FENCE AND ACCESS GATES
- CONSTRUCT OPERATIONS SUPPORT FACILITIES
- GRADE TO FOUNDATION TO RECEIVE LINER LAYER

- CONSTRUCT OPERATIONS HAUL ROAD
- CONSTRUCT EROSION CONTROL FEATURES – DITCHES, CULVERTS, SILT FENCES, CHECK DAMS, AND BASINS

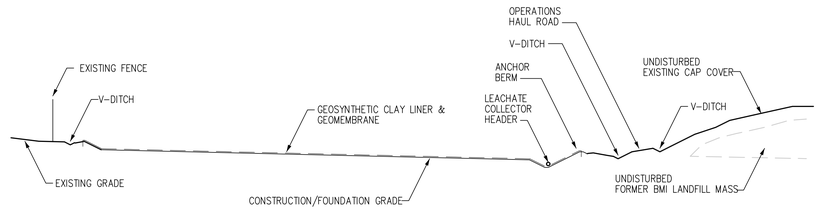


NOT TO SCALE

2

- CONSTRUCT FLOWLINES, SUMPS, AND BERMS FOR LEACHATE COLLECTION SYSTEM AND LINER ANCHOR

- INSTALL GEOSYNTHETIC CLAY LINER, GEOMEMBRANE AND GEOCOMPOSITE

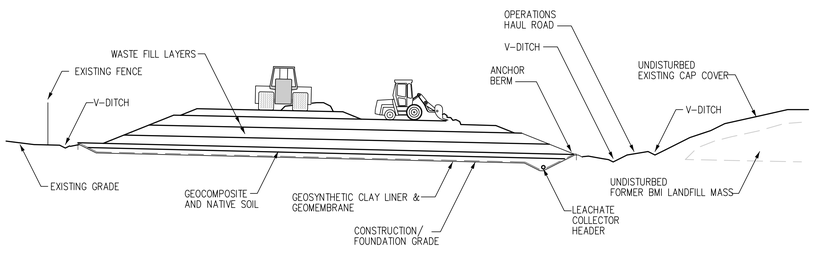


NOT TO SCALE

3

- INSTALL LEACHATE COLLECTION SYSTEM
- INSTALL BALANCE OF COMPOSITE LINER: GEOCOMPOSITE AND NATIVE SOIL

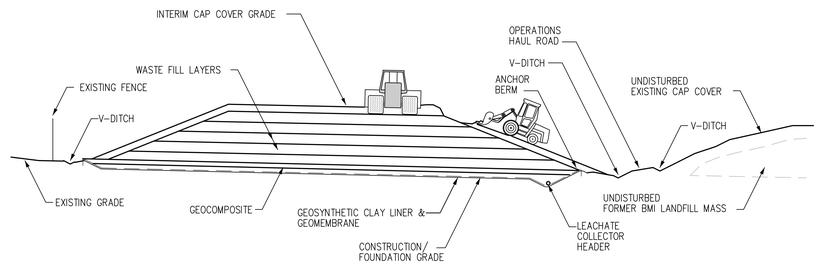
- AT REMOVAL SITE: STOCKPILE AND LOAD WASTE FOR TRANSPORT
- AT LANDFILL SITE: UNLOAD, PLACE, COMPACT AND GRADE WASTE FILL IN LAYERS



NOT TO SCALE

4

- PLACE, COMPACT AND GRADE SOILS MATERIAL FOR INTERIM CAP COVER

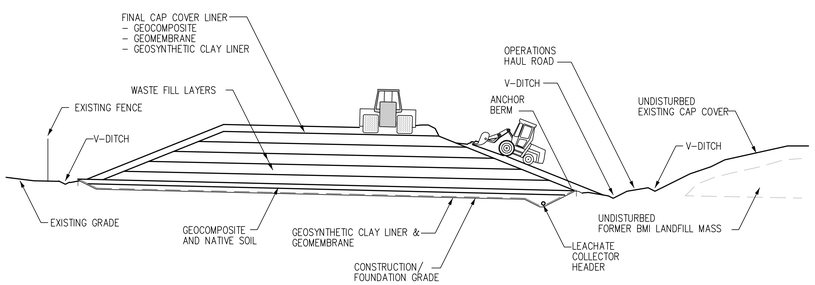


NOT TO SCALE

5

- REMOVE INTERIM CAP COVER

- INSTALL FINAL CAP COVER LINER – GCL, GEOMEMBRANE AND GEOCOMPOSITE

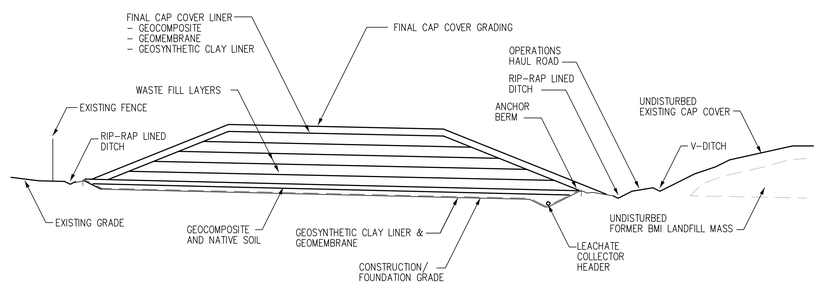


NOT TO SCALE

6

- PLACE, COMPACT AND GRADE SOILS MATERIAL FOR FINAL CAP COVER

- INSTALL PERMANENT STORM DRAINAGE FACILITIES (GUTTERS, DITCHES, CULVERTS, HEADWALLS, ETC)



NOT TO SCALE

GEOSYNTEC CONSULTANTS
10875 RANCHO BERNARDO ROAD, SUITE 200
SAN DIEGO, CALIFORNIA 92127
TELEPHONE: (858) 674-6559

PROJECT: BRC CAMU
HENDERSON/CLARK COUNTY NEVADA

TITLE: CONSTRUCTION SEQUENCE PLAN

MARK	DATE	REVISION	BY	APPROVED

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

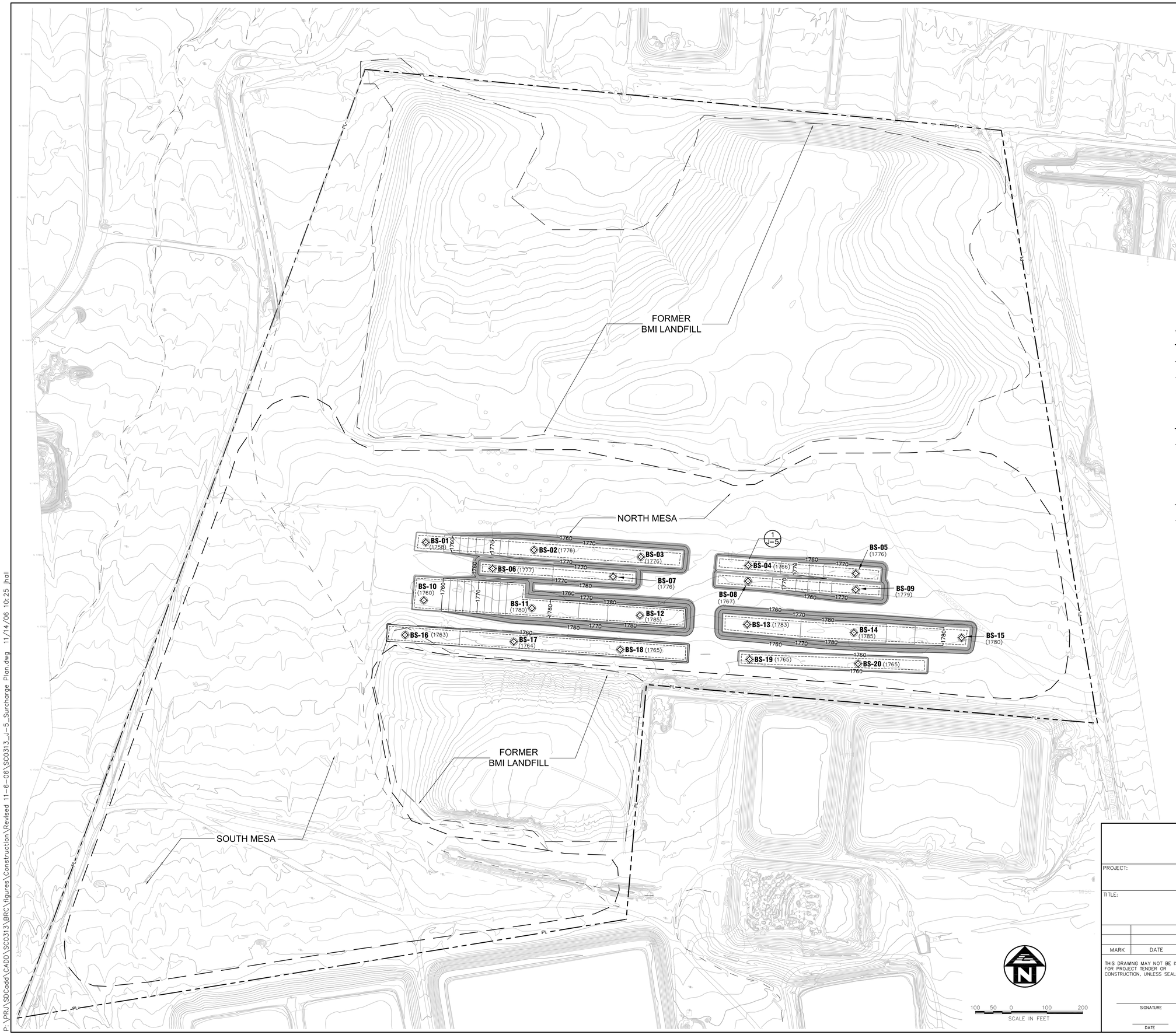
SIGNATURE

DATE

SEAL

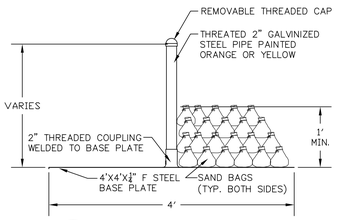
DATE: NOVEMBER 2006		SCALE:	AS SHOWN
DESIGN BY:	G.T.C.	JOB NO.:	SC0313
DRAWN BY:	J.R.H.	FILE NO:	
CHECKED BY:	G.T.C.	DOCUMENT NO:	
REVIEWED BY:	G.T.C.	DRAWING NO:	J-4
APPROVED BY:	G.T.C.		

P:\PRJ\SDCadd\CADD\SC0313\BRC\figures\Construction\Revised 11-6-06\SC0313_J-4_Construction Sequence.dwg 11/14/06 10:25 jhall



LEGEND

- BRC LANDFILL SITE BOUNDARY
- EXISTING LIMITS OF FORMER BMI LANDFILL
- EXISTING SURFACE WATER FLOW PATH
- EXISTING MINOR ELEVATION CONTOUR
- EXISTING MAJOR ELEVATION CONTOUR
- PROPOSED LIMIT OF WASTE
- APPROXIMATE SLIT TRENCH LIMITS
- PROPOSED SETTLEMENT PLATE (DRAWN AT LARGER SCALE FOR CLARITY)
- BS-01 EXISTING BORING
- 1760 PROPOSED MAJOR SURCHARGE ELEVATION CONTOUR
- PROPOSED MINOR SURCHARGE ELEVATION CONTOUR



1 / J-5 DETAIL SETTLEMENT PLATE
N.T.S.

NOTES:

1. FOR GENERAL NOTES, LEGEND AND ABBREVIATIONS, SEE DWG J-2.
2. FOR SITE PREPARATION PLAN SEE DWG J-6.
3. FOR CONSTRUCTION GRADING PLAN SEE DWG J-7.
4. FOR STORM DRAIN PLAN SEE DWG J-8.
5. FOR FINAL COVER GRADING PLAN SEE DWG J-9.
6. FOR FINAL COVER AND LINER DETAILS AND SECTIONS SEE DWG J-11.
7. FOR FENCE PLAN SEE DWG J-12.

GEOSYNTEC CONSULTANTS
10875 RANCHO BERNARDO ROAD, SUITE 200
SAN DIEGO, CALIFORNIA 92127
TELEPHONE: (858) 674-6559

PROJECT: BRC CAMU
HENDERSON/CLARK COUNTY NEVADA

TITLE: SURCHARGE PLAN

MARK	DATE	REVISION	BY	APPROVED

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

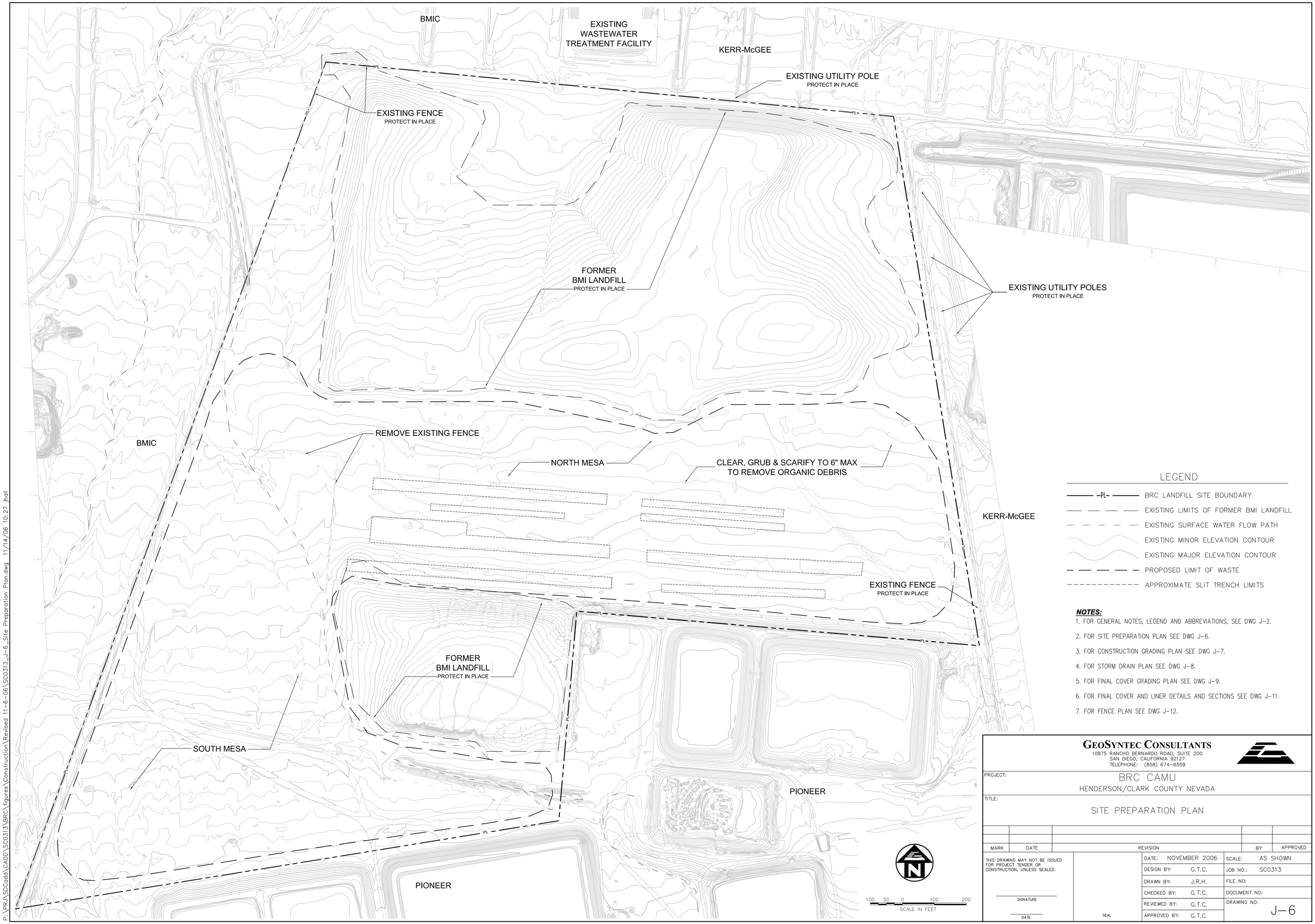
SIGNATURE

DATE

SEAL

DATE:	NOVEMBER 2006	SCALE:	AS SHOWN
DESIGN BY:	G.T.C.	JOB NO.:	SC0313
DRAWN BY:	J.R.H.	FILE NO:	
CHECKED BY:	G.T.C.	DOCUMENT NO:	
REVIEWED BY:	G.T.C.	DRAWING NO:	J-5
APPROVED BY:	G.T.C.		

P:\PRJ\SDCadd\CADD\SC0313\BRC\figures\Construction\Revised 11-6-06\SC0313_J-5_Surcharge Plan.dwg 11/14/06 10:25 jhall



NOTES:

1. FOR GENERAL NOTES, LEGEND AND ABBREVIATIONS, SEE DWG J-2.
2. FOR SITE PREPARATION PLAN SEE DWG J-6.
3. FOR CONSTRUCTION GRADING PLAN SEE DWG J-7.
4. FOR STORM DRAIN PLAN SEE DWG J-8.
5. FOR FINAL COVER GRADING PLAN SEE DWG J-9.
6. FOR FINAL COVER AND LINER DETAILS AND SECTIONS SEE DWG J-11.
7. FOR FENCE PLAN SEE DWG J-12.

GEOSYNTEC CONSULTANTS
10875 RANCHO BERNARDO ROAD, SUITE 200
SAN DIEGO, CALIFORNIA 92127
TELEPHONE: (858) 674-6559

PROJECT: BRC CAMU
HENDERSON/CLARK COUNTY NEVADA

TITLE: SITE PREPARATION PLAN

MARK	DATE	REVISION	BY	APPROVED

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

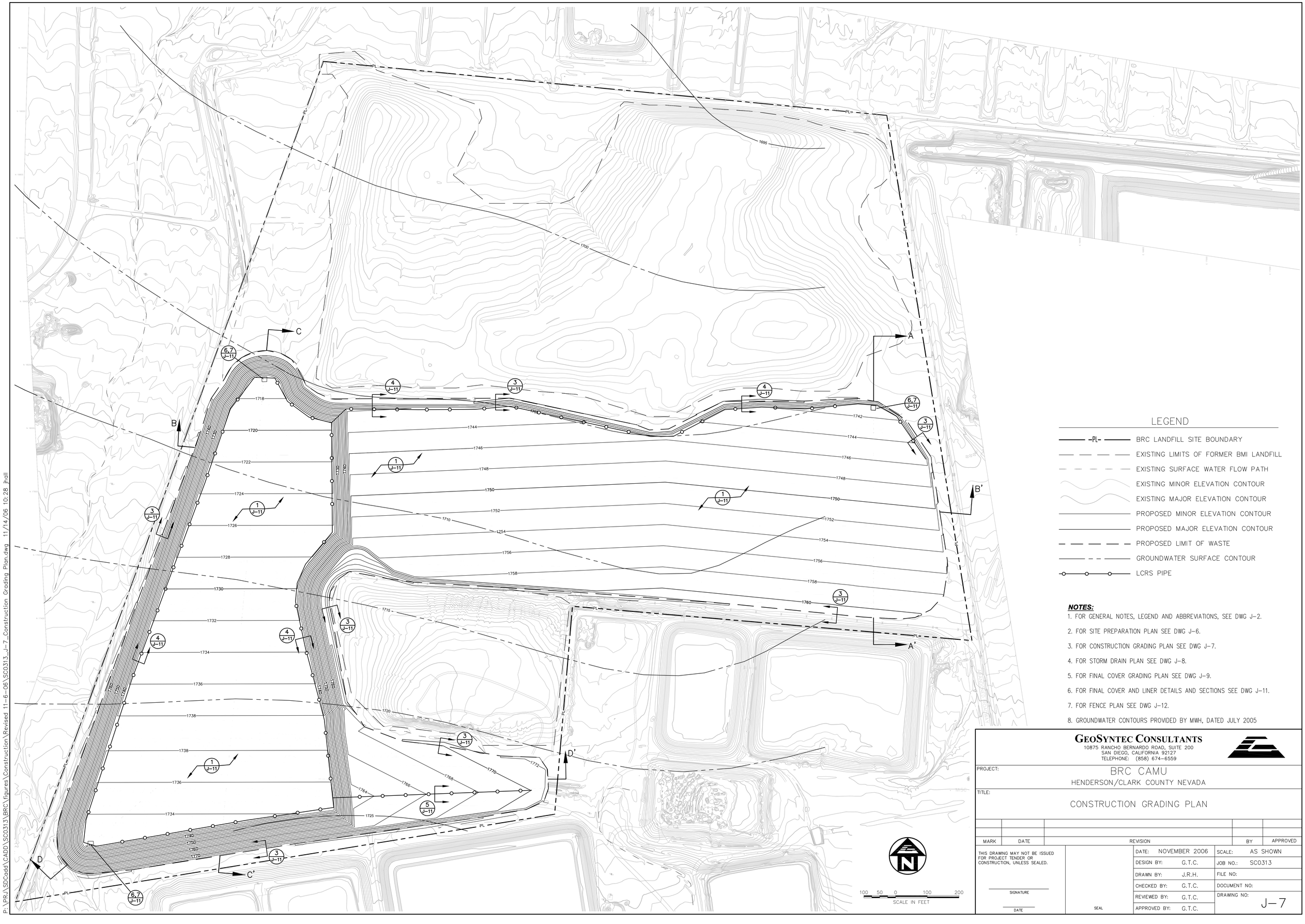
SIGNATURE

DATE

SEAL

DATE:	NOVEMBER 2006	SCALE:	AS SHOWN
DESIGN BY:	G.T.C.	JOB NO.:	SC0313
DRAWN BY:	J.R.H.	FILE NO:	
CHECKED BY:	G.T.C.	DOCUMENT NO:	
REVIEWED BY:	G.T.C.	DRAWING NO:	J-6
APPROVED BY:	G.T.C.		

P:\PRJ\SDCadd\CADD\SC0313\BRC\figures\Construction\Revised 11-6-06\SC0313_J-6_Site Preparation Plan.dwg 11/14/06 10:27 jhall



NOTES:

1. FOR GENERAL NOTES, LEGEND AND ABBREVIATIONS, SEE DWG J-2.
2. FOR SITE PREPARATION PLAN SEE DWG J-6.
3. FOR CONSTRUCTION GRADING PLAN SEE DWG J-7.
4. FOR STORM DRAIN PLAN SEE DWG J-8.
5. FOR FINAL COVER GRADING PLAN SEE DWG J-9.
6. FOR FINAL COVER AND LINER DETAILS AND SECTIONS SEE DWG J-11.
7. FOR FENCE PLAN SEE DWG J-12.
8. GROUNDWATER CONTOURS PROVIDED BY MWH, DATED JULY 2005

GEOSYNTEC CONSULTANTS
10875 RANCHO BERNARDO ROAD, SUITE 200
SAN DIEGO, CALIFORNIA 92127
TELEPHONE: (858) 674-6559

PROJECT: BRC CAMU
HENDERSON/CLARK COUNTY NEVADA

TITLE: CONSTRUCTION GRADING PLAN

MARK	DATE	REVISION	BY	APPROVED

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

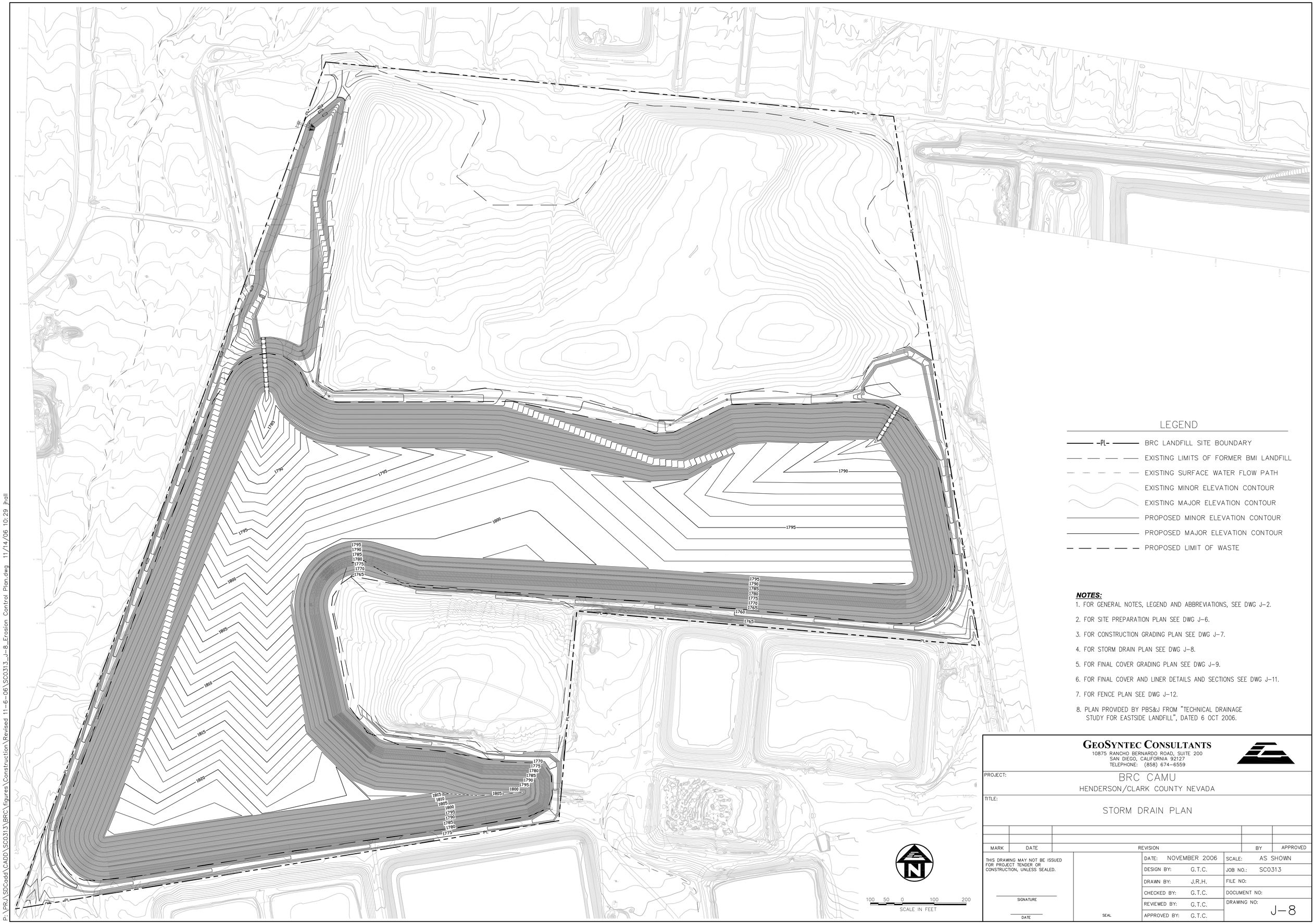
SIGNATURE

DATE

SEAL

DATE:	NOVEMBER 2006	SCALE:	AS SHOWN
DESIGN BY:	G.T.C.	JOB NO.:	SC0313
DRAWN BY:	J.R.H.	FILE NO:	
CHECKED BY:	G.T.C.	DOCUMENT NO:	
REVIEWED BY:	G.T.C.	DRAWING NO:	J-7
APPROVED BY:	G.T.C.		

P:\PRJ\SDCadd\CADD\SC0313\BRC\figures\Construction\Revised 11-6-06\SC0313_J-7_Construction Grading Plan.dwg 11/14/06 10:28 jhall



LEGEND

- PL — BRC LANDFILL SITE BOUNDARY
- EXISTING LIMITS OF FORMER BMI LANDFILL
- EXISTING SURFACE WATER FLOW PATH
- EXISTING MINOR ELEVATION CONTOUR
- EXISTING MAJOR ELEVATION CONTOUR
- PROPOSED MINOR ELEVATION CONTOUR
- PROPOSED MAJOR ELEVATION CONTOUR
- PROPOSED LIMIT OF WASTE

NOTES:

1. FOR GENERAL NOTES, LEGEND AND ABBREVIATIONS, SEE DWG J-2.
2. FOR SITE PREPARATION PLAN SEE DWG J-6.
3. FOR CONSTRUCTION GRADING PLAN SEE DWG J-7.
4. FOR STORM DRAIN PLAN SEE DWG J-8.
5. FOR FINAL COVER GRADING PLAN SEE DWG J-9.
6. FOR FINAL COVER AND LINER DETAILS AND SECTIONS SEE DWG J-11.
7. FOR FENCE PLAN SEE DWG J-12.
8. PLAN PROVIDED BY PBS&J FROM "TECHNICAL DRAINAGE STUDY FOR EASTSIDE LANDFILL", DATED 6 OCT 2006.

GEOSYNTEC CONSULTANTS
10875 RANCHO BERNARDO ROAD, SUITE 200
SAN DIEGO, CALIFORNIA 92127
TELEPHONE: (858) 674-6559

PROJECT: BRC CAMU
HENDERSON/CLARK COUNTY NEVADA

TITLE: STORM DRAIN PLAN

MARK	DATE	REVISION	BY	APPROVED

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

SIGNATURE

DATE

SEAL

DATE: NOVEMBER 2006		SCALE:	AS SHOWN
DESIGN BY:	G.T.C.	JOB NO.:	SC0313
DRAWN BY:	J.R.H.	FILE NO:	
CHECKED BY:	G.T.C.	DOCUMENT NO:	
REVIEWED BY:	G.T.C.	DRAWING NO:	J-8
APPROVED BY:	G.T.C.		

P:\PRJ\SDCadd\CADD\SC0313\BRC\figures\Construction\Revised 11-6-06\SC0313_J-8_Erosion Control Plan.dwg 11/14/06 10:29 jhall

LEGEND

- PL — BRC LANDFILL SITE BOUNDARY
- EXISTING LIMITS OF FORMER BMI LANDFILL
- EXISTING SURFACE WATER FLOW PATH
- EXISTING MINOR ELEVATION CONTOUR
- EXISTING MAJOR ELEVATION CONTOUR
- PROPOSED MAJOR GRADING ELEVATION CONTOUR
- PROPOSED MINOR GRADING ELEVATION CONTOUR
- PROPOSED MINOR COVER ELEVATION CONTOUR
- PROPOSED MAJOR COVER ELEVATION CONTOUR
- PROPOSED LIMIT OF WASTE

NOTES:

1. FOR GENERAL NOTES, LEGEND AND ABBREVIATIONS, SEE DWG J-2.
2. FOR SITE PREPARATION PLAN SEE DWG J-6.
3. FOR CONSTRUCTION GRADING PLAN SEE DWG J-7.
4. FOR STORM DRAIN PLAN SEE DWG J-8.
5. FOR FINAL COVER GRADING PLAN SEE DWG J-9.
6. FOR FINAL COVER AND LINER DETAILS AND SECTIONS SEE DWG J-11.
7. FOR FENCE PLAN SEE DWG J-12.

GEOSYNTEC CONSULTANTS
10875 RANCHO BERNARDO ROAD, SUITE 200
SAN DIEGO, CALIFORNIA 92127
TELEPHONE: (858) 674-6559

PROJECT: BRC CAMU
HENDERSON/CLARK COUNTY NEVADA

TITLE: FINAL COVER GRADING PLAN

MARK	DATE	REVISION	BY	APPROVED

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

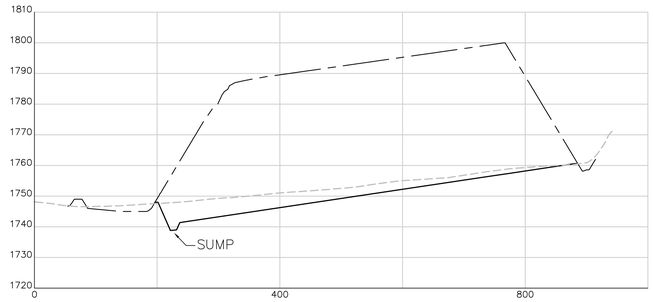
SIGNATURE

DATE

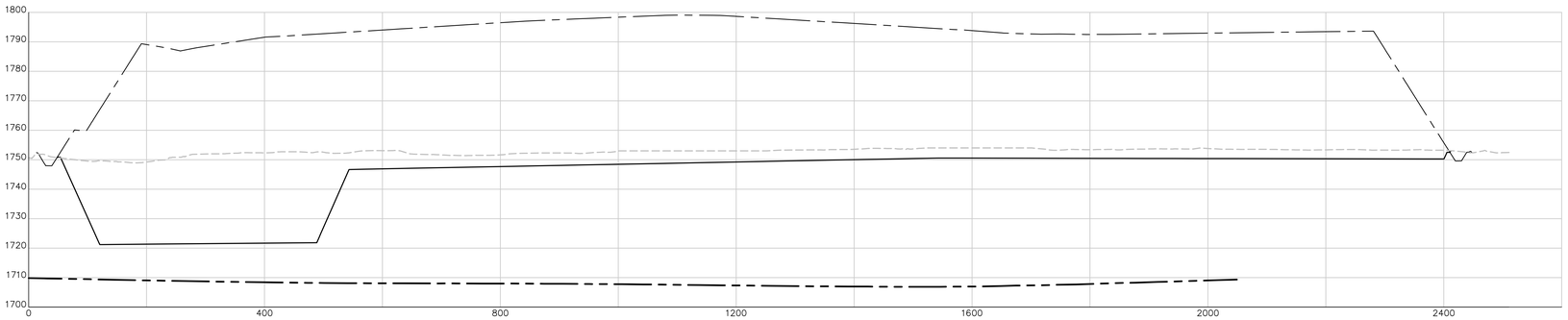
SEAL

DATE:	NOVEMBER 2006	SCALE:	AS SHOWN
DESIGN BY:	G.T.C.	JOB NO.:	SC0313
DRAWN BY:	J.R.H.	FILE NO:	
CHECKED BY:	G.T.C.	DOCUMENT NO:	
REVIEWED BY:	G.T.C.	DRAWING NO:	J-9
APPROVED BY:	G.T.C.		

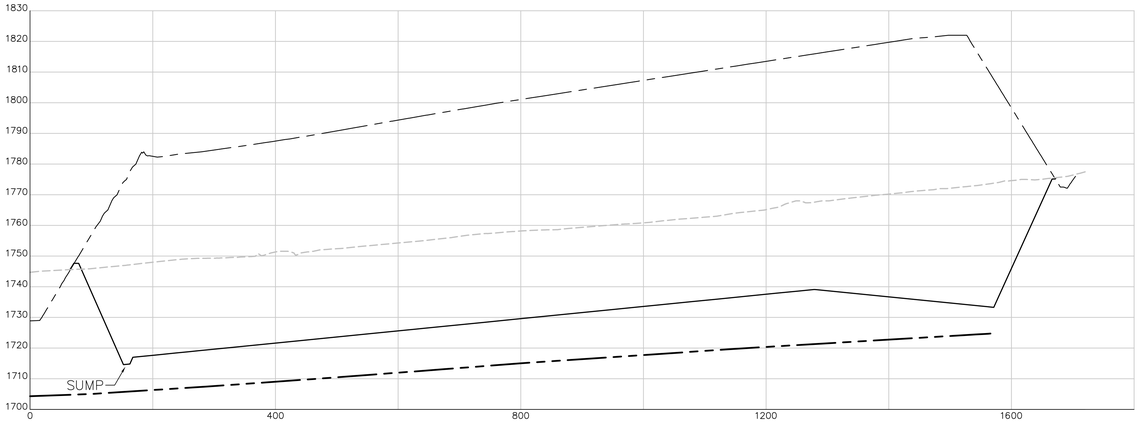
P:\PRJ\SDCadd\CADD\SC0313\BRC\figures\Construction\Revised 11-6-06\SC0313_J-9_Final Cover Plan.dwg 11/14/06 10:30 jhall



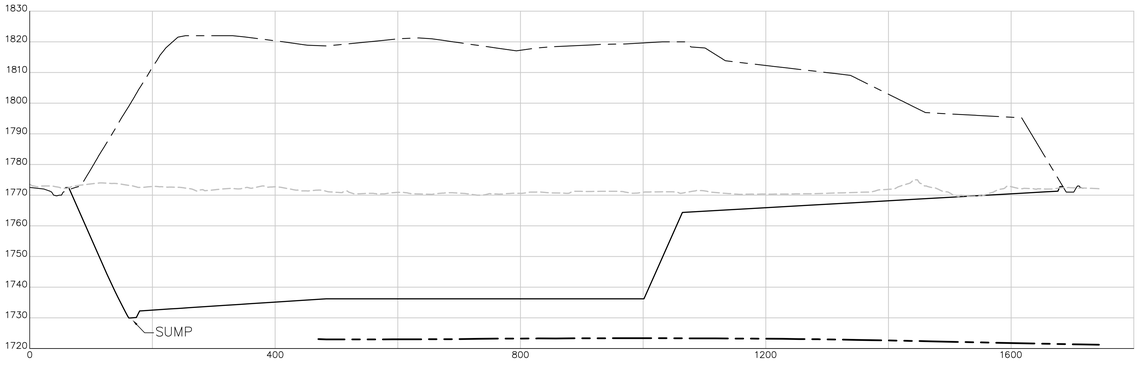
A–A 7,9 SECTION
SCALE: HORIZ. 1" = 100', VERT. 1" = 20'



B–B 7,9 SECTION
SCALE: HORIZ. 1" = 100', VERT. 1" = 20'



C–C 7,9 SECTION
SCALE: HORIZ. 1" = 100', VERT. 1" = 20'



D–D 7,9 SECTION
SCALE: HORIZ. 1" = 100', VERT. 1" = 20'

LEGEND

- FINAL COVER SURFACE
- EXCAVATION SURFACE
- EXISTING GROUND SURFACE
- GROUNDWATER SURFACE

NOTES:

1. GROUNDWATER CONTOURS PROVIDED BY MWH, DATED JULY 2005.

GEOSYNTEC CONSULTANTS
10875 RANCHO BERNARDO ROAD, SUITE 200
SAN DIEGO, CALIFORNIA 92127
TELEPHONE: (858) 674–6559

PROJECT: BRC CAMU
HENDERSON/CLARK COUNTY NEVADA

TITLE: GRADING CROSS SECTIONS

MARK	DATE	REVISION	BY	APPROVED

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

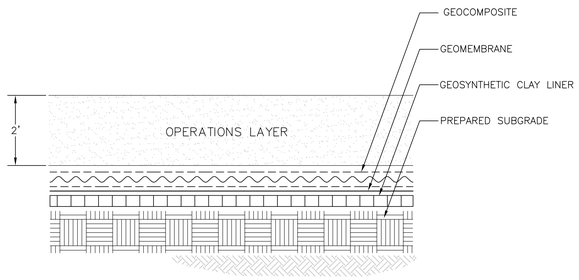
SIGNATURE

DATE

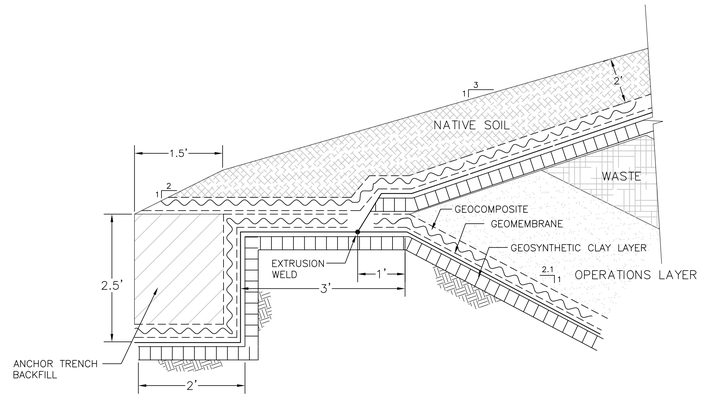
SEAL

DATE:	NOVEMBER 2006	SCALE:	AS SHOWN
DESIGN BY:	G.T.C.	JOB NO.:	SC0313
DRAWN BY:	J.R.H.	FILE NO:	
CHECKED BY:	G.T.C.	DOCUMENT NO:	
REVIEWED BY:	G.T.C.	DRAWING NO:	J–10
APPROVED BY:	G.T.C.		

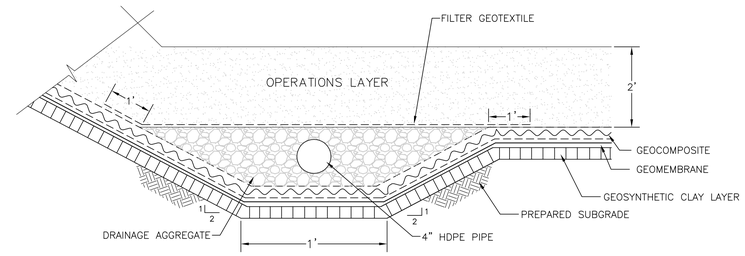
P:\PRJ\SDCadd\CADD\SC0313\BRC\figures\Construction\Revised 11-6-06\SC0313_J-10_Cross Sections.dwg 11/14/06 10:31 jhall



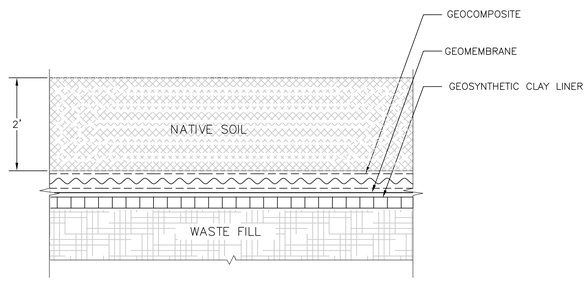
COMPOSITE LINER SECTION (1 / J-7)
NOT TO SCALE



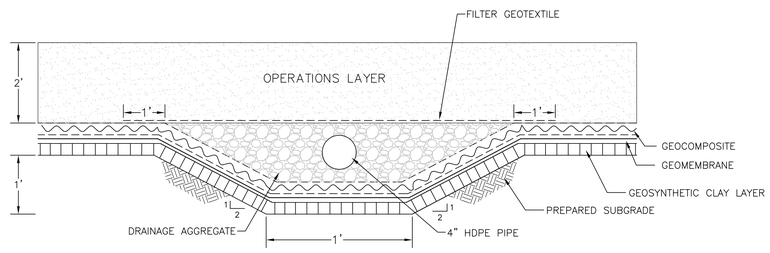
CROSS SECTION
ANCHOR TRENCH
NOT TO SCALE (3 / J-7)



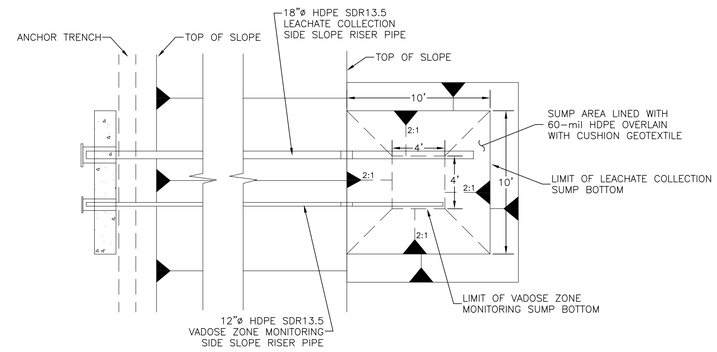
CROSS SECTION
LCRS COLLECTION TRENCH AT TOE OF SLOPE
NOT TO SCALE (4 / J-7)



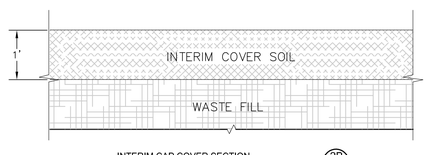
FINAL CAP COVER SECTION (2A / J-9)
NOT TO SCALE



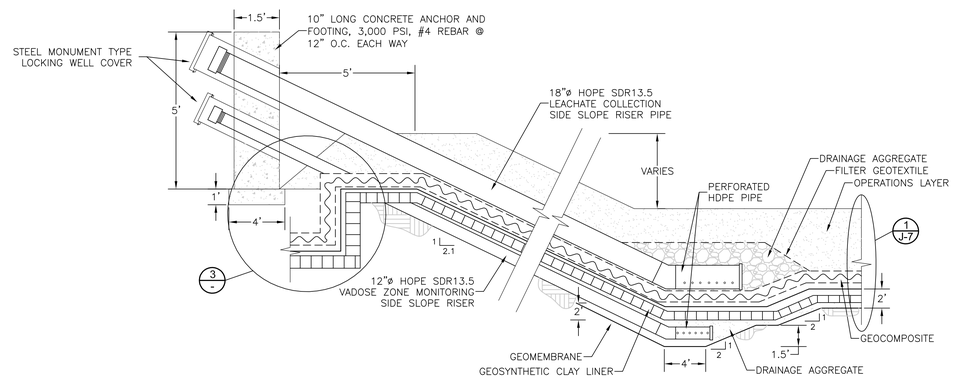
CROSS SECTION
LCRS COLLECTION TRENCH
NOT TO SCALE (5 / J-7)



DETAIL
LEACHATE COLLECTION AND VADOSE
ZONE MONITORING SUMP
NOT TO SCALE (6 / J-7)



INTERIM CAP COVER SECTION (2B / J-9)
NOT TO SCALE



CROSS SECTION
VADOSE ZONE MONITORING
SIDE SLOPE RISER
NOT TO SCALE (7 / J-7)

NOTES:
1. GEOSYNTHETIC MATERIALS SHOWN AT EXAGGERATED SCALE FOR CLARITY.

GEOSYNTEC CONSULTANTS
10875 RANCHO BERNARDO ROAD, SUITE 200
SAN DIEGO, CALIFORNIA 92127
TELEPHONE: (858) 674-6559

PROJECT: BRC CAMU
HENDERSON/CLARK COUNTY NEVADA

TITLE: FINAL COVER AND LINER DETAILS AND SECTIONS

MARK	DATE	REVISION	BY	APPROVED

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

SIGNATURE

DATE

SEAL

DATE:	NOVEMBER 2006	SCALE:	AS SHOWN
DESIGN BY:	G.T.C.	JOB NO.:	SC0313
DRAWN BY:	J.R.H.	FILE NO:	
CHECKED BY:	G.T.C.	DOCUMENT NO:	
REVIEWED BY:	G.T.C.	DRAWING NO:	J-11
APPROVED BY:	G.T.C.		

P:\PRJ\SDCadd\CADD\SC0313\BRC\figures\Construction\Revised 11-6-06\SC0313_J-11_Details.dwg 11/14/06 10:31 jhall

LEGEND

—PL—	BRC LANDFILL SITE BOUNDARY
	EXISTING LIMITS OF FORMER BMI LANDFILL
	EXISTING SURFACE WATER FLOW PATH
	EXISTING MINOR ELEVATION CONTOUR
	EXISTING MAJOR ELEVATION CONTOUR
	PROPOSED MINOR ELEVATION CONTOUR
	PROPOSED MAJOR ELEVATION CONTOUR
	PROPOSED LIMIT OF WASTE
	EXISTING FENCE
—x—x—	PROPOSED FENCE

NOTES:

1. FOR GENERAL NOTES, LEGEND AND ABBREVIATIONS, SEE DWG J–2.
2. FOR SITE PREPARATION PLAN SEE DWG J–6.
3. FOR CONSTRUCTION GRADING PLAN SEE DWG J–7.
4. FOR STORM DRAIN PLAN SEE DWG J–8.
5. FOR FINAL COVER GRADING PLAN SEE DWG J–9.
6. FOR FINAL COVER AND LINER DETAILS AND SECTIONS SEE DWG J–11.
7. FOR FENCE PLAN SEE DWG J–12.

GEOSYNTEC CONSULTANTS
10875 RANCHO BERNARDO ROAD, SUITE 200
SAN DIEGO, CALIFORNIA 92127
TELEPHONE: (858) 674–6559

PROJECT: BRC CAMU
HENDERSON/CLARK COUNTY NEVADA

TITLE: FENCE PLAN

MARK	DATE	REVISION	BY	APPROVED

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.	DATE: NOVEMBER 2006	SCALE: AS SHOWN	
	DESIGN BY: G.T.C.	JOB NO.: SC0313	
	DRAWN BY: J.R.H.	FILE NO:	
SIGNATURE	CHECKED BY: G.T.C.	DOCUMENT NO:	
	REVIEWED BY: G.T.C.	DRAWING NO: J–12	
DATE	SEAL	APPROVED BY: G.T.C.	

P:\PRJ\SDCadd\CADD\SC0313\BRC\figures\Construction\Revised 11-6-06\SC0313_J-12_Fence Plan.dwg 11/14/06 10:32 jhall

Section 2
Base Liner Calculation Packages

Section 2
Base Liner Calculation Packages

Calculation Package A
Cut Slope Stability

GeoSyntec Consultants

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: BRC **Project:** BRC CAMU **Project #:** SC0313 **Task #:** 01 02

Title of Computations: Slope Stability Evaluation – Cut Slopes

Computations By:

SIGNATURE — 27 March 2005 DATE

Edward M. Zielanski, P.E./Project Civil Engineer
PRINTED NAME AND TITLE

Assumptions and Procedures Checked By (Peer Reviewer):

SIGNATURE — 6/2/05 DATE

Gregory T. Corcoran, P.E./Associate
PRINTED NAME AND TITLE

Computations Checked By:

SIGNATURE — 6/2/05 DATE

Gregory T. Corcoran, P.E./Associate
PRINTED NAME AND TITLE

Computations Backchecked By (Originator):

SIGNATURE — 27 March 2005 ~~23 March 2000~~ DATE

Edward M. Zielanski, P.E./Project Civil Engineer
PRINTED NAME AND TITLE

Approved By (PM or Designate):

SIGNATURE — 6/2/05 DATE

Gregory T. Corcoran, P.E./Associate
PRINTED NAME AND TITLE

Approval Notes:

Revisions: (Number and Initial All Revisions)

No.	Sheet	Date	By	Checked By	Approval

Written by: Ed Zielanski Date: 5 / 27 / 05 (MM DD YY) Reviewed by: GTC Date: 6 / 2 / 05 (MM DD YY)

Client: BRC Project: BRC CAMU Project No.: SC0313 Task No. 01-02

SLOPE STABILITY EVALUATION
CUT SLOPES
BRC CAMU
HENDERSON, NEVADA

OBJECTIVE

The objective of this calculation package is to evaluate the stability of cut slopes (inclined at 2.1H:1V) at the BRC Corrective Action Management Unit (CAMU) in Henderson, Nevada.

DESIGN CRITERION

Because the cut slopes at the BRC CAMU will eventually be buttressed by waste they are considered interim slopes, which are normally required to exceed a static factor of safety of 1.3. However, due to limited information regarding shear strength parameters for on-site soils, GeoSyntec employed a static factor of safety equal to or greater than 1.4 as the interim slope static stability criterion. In consideration of the limited duration which the interim slopes will exist, seismic stability analyses of the cut slopes were not conducted.

METHOD OF ANALYSIS

The slope stability computer program PCSTABL5 (Achilleos, 1988) was employed for this analysis. PCSTABL5 employs limit equilibrium principles to provide general solutions to slope stability problems. Potential sliding surfaces, both circular and polygonal, can be specified or randomly generated. The Modified Janbu Method is used herein, as recommended in the PCSTABL5 manual (Achilleos 1998) for circular and polygonal failure surfaces.

In addition to the above analyses, the stability of the cut slopes is evaluated using the infinite slope methodology. An inifinite slope (or surficial sliding) without seepage in the slope is defined as:

$$FS = \frac{c}{\gamma H \cos^2\beta \tan\beta} \frac{\tan\phi}{\tan\beta} \quad \text{(Das 1994)} \qquad \text{(Equation 1)}$$

Written by: Ed Zielanski Date: 5 / 27 / 05 (MM DD YY) Reviewed by: GTC Date: 6 / 2 / 05 (MM DD YY)

Client: BRC Project: BRC CAMU Project No.: SC0313 Task No. 01-02

SUBSURFACE INFORMATION

Based on results of subsurface explorations by others (Converse 1999), the subsurface is characterized by alluvial granular soils overlying fine-grained soils encountered at depths from approximately 34-ft to 55-ft below the surface. The granular subsoils generally consist of medium to very dense granular fill and native soils overlying localized zones of moderately hard to hard cemented sand and gravel. The fine-grained soils consist of lean clays and high plasticity silts. Field and laboratory test results indicated that the native granular soils at the site have a low compressibility and moderate to high internal friction angles (Converse 1999). The fine-grained soils encountered at depth at the site generally were found to be moderately compressible, have a high expansion potential, and have relatively low permeability (Converse 1999). Groundwater was encountered at depths between 30-ft and 58-ft and was, in general, located at the approximate elevation of the lean clay layer (Converse 1999).

NATIVE MATERIAL PARAMETERS

Native material within the limits of the BRC CAMU consists of alluvial granular soils overlying fine-grained soils. Shear strength parameters for the native soil material were previously estimated and reported in the *Preliminary Geotechnical and Geologic Investigation - Industrial Non-Hazardous Disposal Facility* (Converse 1999). Twelve exploratorary borings were conducted by others to depths ranging from 33-ft to 60-ft (Converse 1999). In general, the native materials appear to be consistent between borings. Direct Shear tests were performed on selected samples retrieved from the exploratory borings. A summary of the Direct Shear test results as reported by Converse (1999) are presented in Attachment 1.

Based on data obtained by Converse (1999), the *in situ* silty sand with gravel material (fill and native) can be characterized by a moist unit weight of approximately 117 pcf (see Attachment 1 - boring logs). The sandy lean clay can be characterized by a saturated unit weight of approximately 102 pcf (see Attachment 1 - boring logs).

Based on the boring logs provided by Converse (1999), the average groundwater elevation in the vicinity of the cut slopes (borings B-8, B-12, B-5, B-4, and B-10) is approximately 49 feet below the surface (at the top of the CL layer).

Upon review of the direct shear tests performed by Converse at the BRC CAMU site, GeoSyntec has employed its own interpretation of the on-site material properties. The direct

Written by: Ed Zielanski Date: 5 / 27 / 05 (MM DD YY) Reviewed by: GTC Date: 6 / 2 / 05 (MM DD YY)

Client: BRC Project: BRC CAMU Project No.: SC0313 Task No. 01-02

shear tests performed by Converse involved shearing the soil at a relatively low normal stress, then returning the specimen to its original position, placing a larger normal stress and re-shearing the sample. This process was repeated for three different normal loads. Therefore, based on the description of the testing methods, it is unclear as to the appropriate design shear strength parameters for the on site soil.

In recognition of this, GeoSyntec has reviewed the borings logs in order to evaluate the design shear strength parameters. The boring logs indicate that the *in situ* silty sand with gravel soil (SM) is primarily dense to very dense (i.e, very high blow counts). Based on a correlation by Peck, Hanson, and Thornburn (1974), dense silty sands typically have internal friction angles on the order of 30 to 35 degrees (Attachment 4). Due to the high density of the SM material, it is assumed that the effective friction angle of the SM material to be 35 degrees. At numerous locations shown in the boring logs, the SM material was described as partially cemented. However, based on the borings logs, it is unclear as to the extent or the degree of cementation in the profile. Therefore, it is conservatively assumed that the effective cohesion of the SM material is zero.

A sandy lean clay (CL) layer exists approximately 34 to 55 feet below the surface. Based on a review of the boring logs in the area of the proposed cut slopes, the average depth to the CL layer (for borings B-8, B-12, B-5, B-4, and B-10) is approximately 49 ft. The moisture content of the lean clay is relatively close to the liquid limit, indicating a normally consolidated deposit. Therefore, the undrained shear strength of the lean clay layer can be approximated using correlations based on the plasticity index. A representative value from Converse (1999) for the plasticity index of the CL material is on the order of 32 percent (Attachment 1). Ladd (1990), presents a relationship between the plasticity index and the c/p ratio. Based on this correlation, the c/p ratio is approximately 0.24 (Attachment 2). An example calcuation to estimate the undrained shear strength at a depth of 54 feet is shown below:

Assume the SM material and water table extends to a depth of 49 ft. Therefore, the effective vertical stress, σ'_v *is:* $(\gamma_{SM})(z_{SM})+(\gamma' t_{CL}) = (117)(49\ ft)+(102-62.4)(54-49) = 5{,}931\ psf$. *The c/p ratio is assumed to be 0.24, therefore, the undrained strength is* $(0.24)(5931) \approx 1{,}400\ psf$.

Written by: Ed Zielanski Date: 5 / 27 / 05 (MM DD YY) Reviewed by: GTC Date: 6 / 2 / 05 (MM DD YY)

Client: BRC Project: BRC CAMU Project No.: SC0313 Task No. 01-02

CROSS SECTIONS

One cross section (cross section A-A') was developed to evaluate the stability of the cut slopes at the BRC CAMU. The location of this cross section is indicated on Figure 1. Cross section A-A' is a 44-ft high cut slope and represents the most critical cross section. The slope of the cross section is inclined at 2.1H:1V (horizontal:vertical).

ANALYSIS AND RESULTS

Proposed Cut Slopes – 2.1H:1V

Global Stability. Based on data from Converse (1999), the groundwater table appears to be located approximately at the elevation of the lean clay layer. In recognition of this, a piezometric surface was included in the analyses to represent the water table. The water table is placed at the top of the lean clay layer.

Two types of potential failure surfaces were analyzed, (i) circular, and (ii) polygonal. The polygonal potential failure surface assumes the failure surface occurs between the weakest interface between the silty sand (SM) and the lean clay (CL). Potential failure surfaces were evaluated using the search option of the PCSTABL5 program. Program input parameters, specifying the range of beginning and ending locations for potential circular failure surfaces, were varied by the user to focus on the location of the most critical potential failure surfaces for the given cross section.

Graphical output of the most critical potential failure surfaces of cross section A-A' is presented in Figures 2, 3, and 4. The graphical output of Figures 2 and 3 illustrates the ten most critical potential circular failure surfaces found by the PCSTABL5 analysis. The graphical output of Figures 2 and 3 illustrates the ten most critical polygonal failure. Analyses indicate that the most critical potential failure surface of cross section A-A', possesses a factor of safety of 1.46. This factor of safety satisfies the design criterion of a factor of safety equal to or greater than 1.4.

Computer output of the stability analyses for the potential surfaces of cross section A-A' is included in Attachment 3.

Surficial Sliding or Sloughing. Based on the assumption of zero cohesion for the SM material, Equation 1 becomes:

Written by: Ed Zielanski Date: 5 / 27 / 05 (MM DD YY) Reviewed by: GTC Date: 6 / 2 / 05 (MM DD YY)

Client: BRC Project: BRC CAMU Project No.: SC0313 Task No. 01-02

$$FS = \frac{\tan\phi}{\tan\beta} \qquad \text{(Equation 2)}$$

For the proposed slopes, the inclination is 2.1H:1V, therefore the factor of safety is:

$$FS = \frac{\tan 35}{1/2.1} = 1.47$$

CONCLUSIONS

- The minimum factor of safety for the proposed cut slopes (2.1H:1V) is 1.46;
- The undrained shear strength of the CL layer can be characterized with a c/p ratio of 0.24 and a unit weight of 102 pcf; and
- The shear strength of the SM material can be conservatively characterized as c'=0 and ϕ'=35 degrees and a unit weight of 117 pcf.

REFERENCES

Achilleos, E. (1988), "PC STABL5M, User Manual" *Information Report,* School of Civil Engineering, Purdue University, West Lafayette, Indiana, 132 p.

Converse (1999), "Preliminary Geotechnical and Geologic Investigation - Industrial Non-Hazardous Disposal Facility", prepared for Basic Management, Inc., October 1999. *(Attachment 1)*

Das B. M. (1994), "Principles of Geotechnical Engineering," Third Edition, PWS Publishing Company, Boston, MA

Peck, Hanson, and Thornburn (1974), "Foundation Engineering," Second Edition, John Wiley & Sons, Inc. New York. *(Attachment 4)*

Ladd, C. C., (1990) "Soft Ground Engineering," 13th Annual Spring Seminar, Geotechnical Engineering Group, Los Angeles Section of ASCE. *(Attachment 2)*

GTC 6/2/05

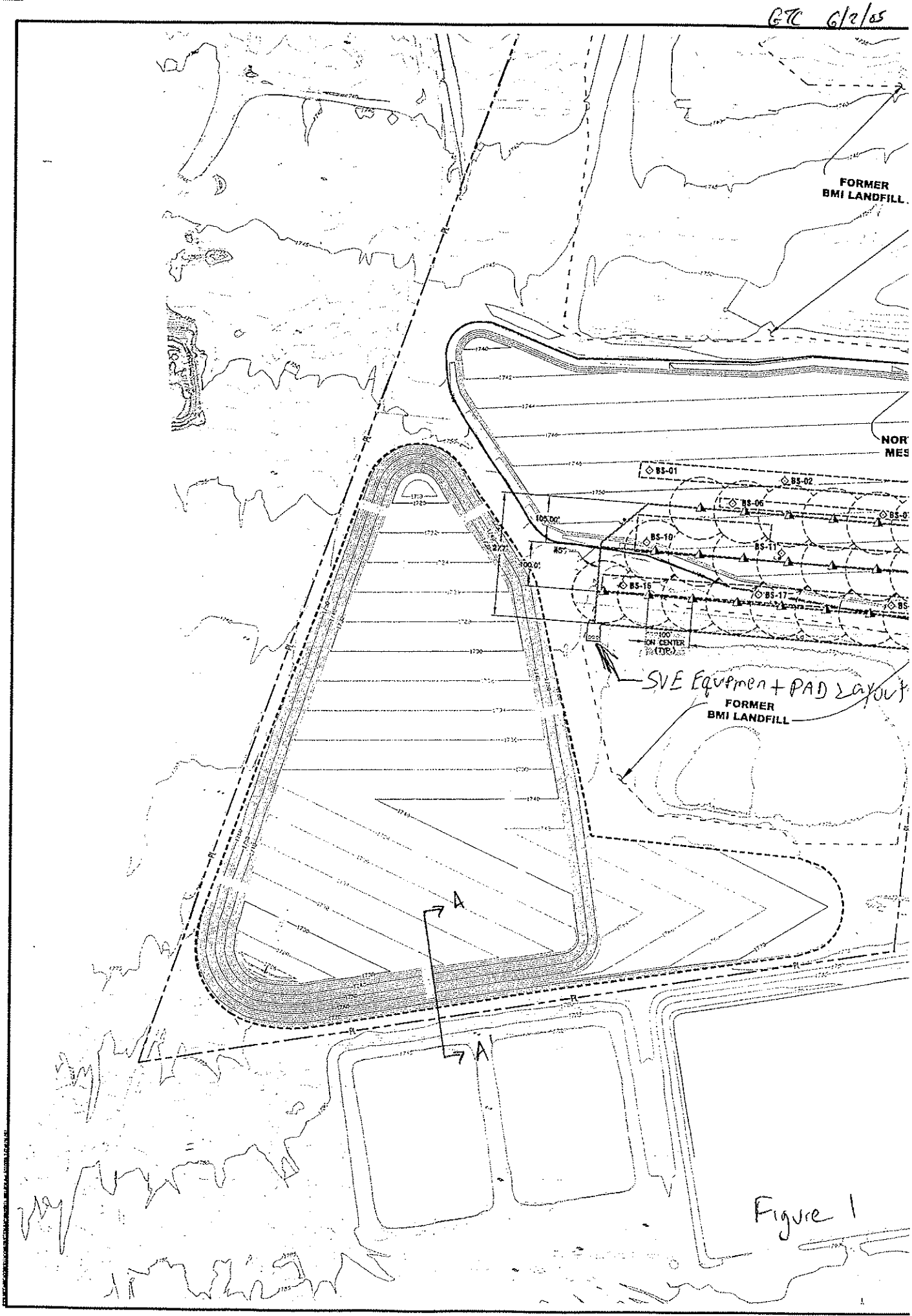
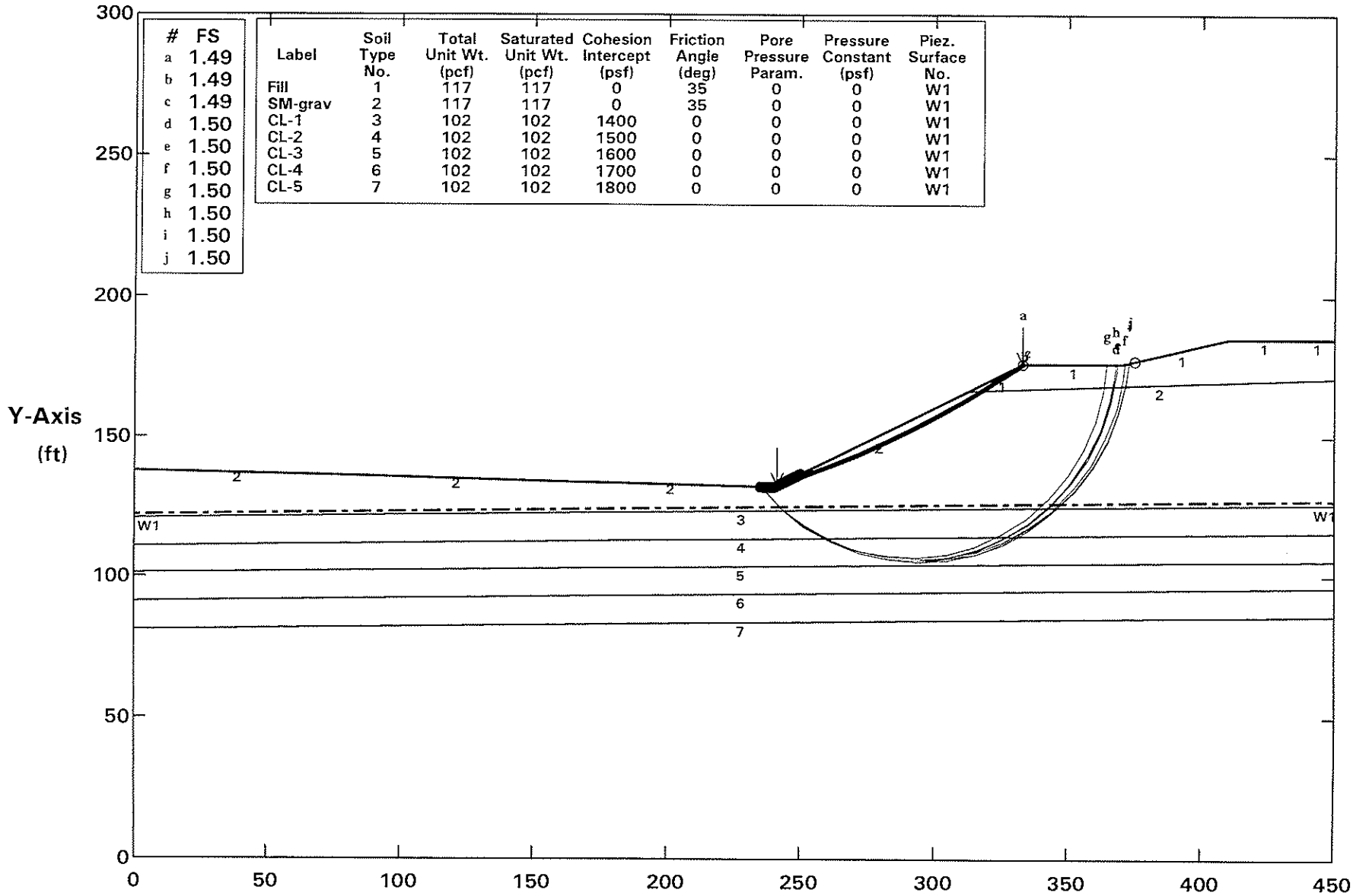


Figure 1

Section A-A' BRC CAMU, Henderson, Nevada

Ten Most Critical. C:ANEW.PLT By: EMZ 5/27/2005 9:56am



#	FS
a	1.49
b	1.49
c	1.49
d	1.50
e	1.50
f	1.50
g	1.50
h	1.50
i	1.50
j	1.50

Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Fill	1	117	117	0	35	0	0	W1
SM-grav	2	117	117	0	35	0	0	W1
CL-1	3	102	102	1400	0	0	0	W1
CL-2	4	102	102	1500	0	0	0	W1
CL-3	5	102	102	1600	0	0	0	W1
CL-4	6	102	102	1700	0	0	0	W1
CL-5	7	102	102	1800	0	0	0	W1

PCSTABL5 FSmin = 1.49 X-Axis (ft)

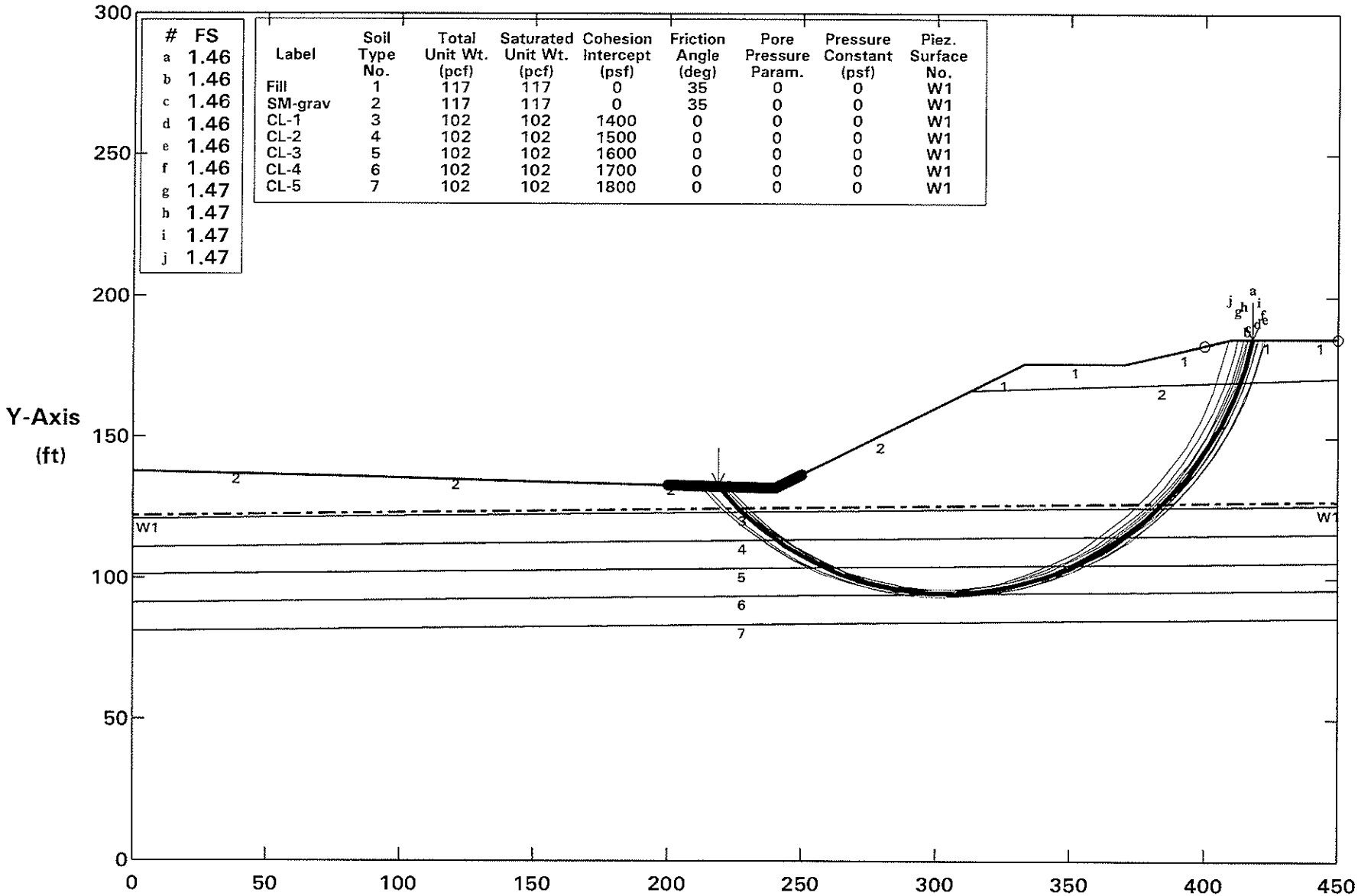
Factors Of Safety Calculated By The Modified Janbu Method

Figure 2

GTC 6/8/05

Section A-A' BRC CAMU, Henderson, Nevada

Ten Most Critical. C:A2NEW.PLT By: EMZ 5/27/2005 10:06am



#	FS
a	1.46
b	1.46
c	1.46
d	1.46
e	1.46
f	1.46
g	1.47
h	1.47
i	1.47
j	1.47

Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Fill	1	117	117	0	35	0	0	W1
SM-grav	2	117	117	0	35	0	0	W1
CL-1	3	102	102	1400	0	0	0	W1
CL-2	4	102	102	1500	0	0	0	W1
CL-3	5	102	102	1600	0	0	0	W1
CL-4	6	102	102	1700	0	0	0	W1
CL-5	7	102	102	1800	0	0	0	W1

PCSTABL5 FSmin = 1.46 X-Axis (ft)

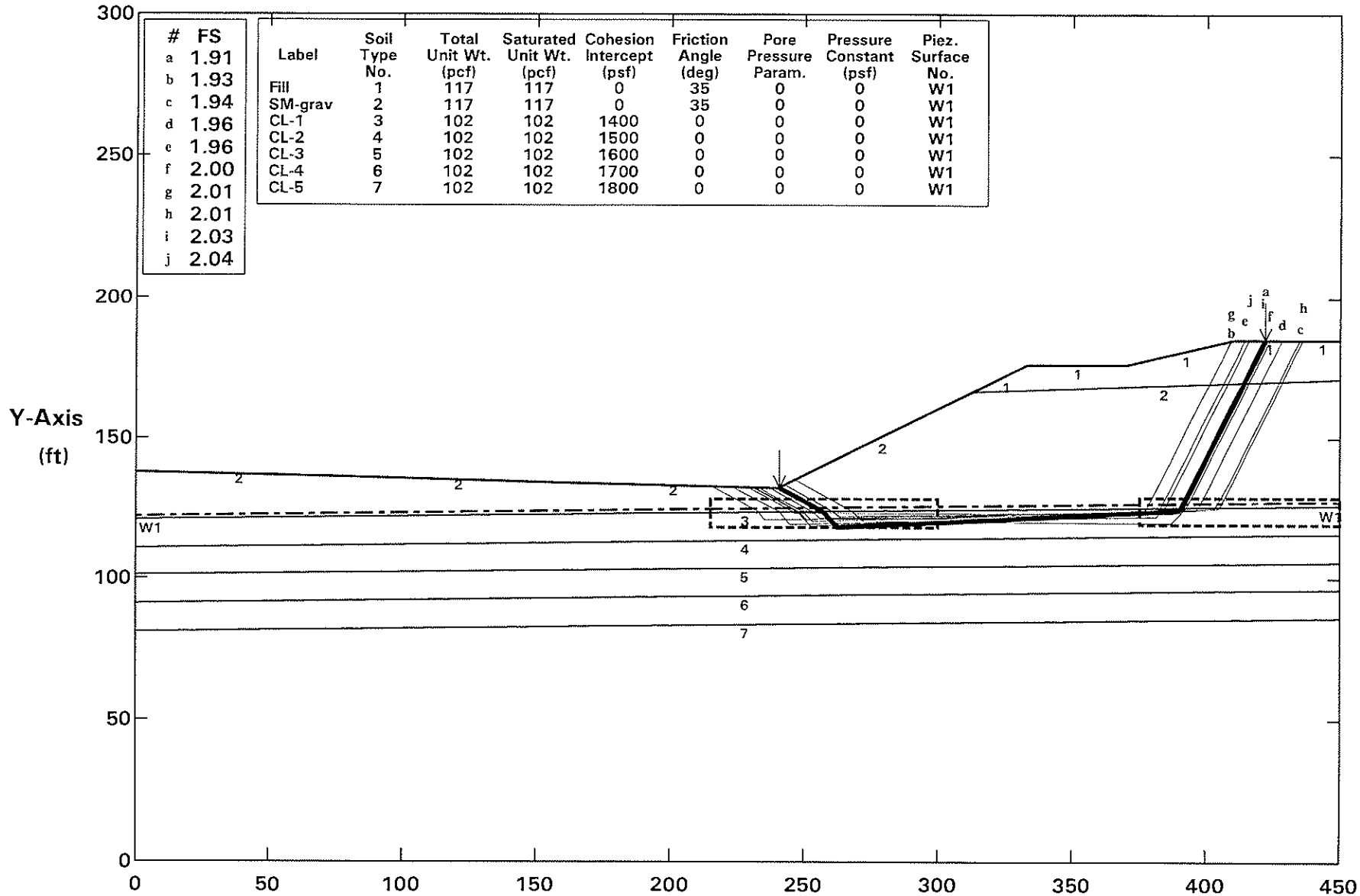
Factors Of Safety Calculated By The Modified Janbu Method

Figure 3

CRC 6/9/05

Section A-A' BRC CAMU, Henderson, Nevada

Ten Most Critical. C:A3NEW.PLT By: EMZ 5/27/2005 10:14am



#	FS
a	1.91
b	1.93
c	1.94
d	1.96
e	1.96
f	2.00
g	2.01
h	2.01
i	2.03
j	2.04

Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Fill	1	117	117	0	35	0	0	W1
SM-grav	2	117	117	0	35	0	0	W1
CL-1	3	102	102	1400	0	0	0	W1
CL-2	4	102	102	1500	0	0	0	W1
CL-3	5	102	102	1600	0	0	0	W1
CL-4	6	102	102	1700	0	0	0	W1
CL-5	7	102	102	1800	0	0	0	W1

PCSTABL5 FSmin = 1.91 X-Axis (ft)

Factors Of Safety Calculated By The Modified Janbu Method

Figure 4

GZC 6/2/05

Direct Shear Strength

A progressive direct shear test was performed on selected undisturbed samples using a constant strain rate direct shear machine in general accordance with ASTM D3080. The test specimen was trimmed and placed in the shear machine, a specified normal load was applied, and the specimen was sheared until maximum shear strength was developed. After the soil specimen had developed maximum shear resistance under the first normal load, the normal load was removed and the specimen was pushed back to its original undeformed configuration. Another normal load was then applied, and the specimen was sheared a second time. This process was repeated for three different normal loads. Results of the direct shear test are presented on Figures A-62 through A-69 and in the following table:

Exploration Location	Depth (feet)	Soil Description	Angle of Internal Friction (deg)	Coulomb Cohesion (ksf)
B-4	14-14.5	Silty sand with gravel	31	0.7
B-5	14-15	Silty sand with gravel	43	0.3
B-10	54-54.5	Sandy lean clay	26	0.85
B-12	14-15	Silty sand with gravel	40	0.3
B-101	39-40	Sandy lean clay	26	0.9
B-102	20-25	Silty sand with gravel	37	0.2
B-103	49-50	Sandy lean clay	37	1.0
B-104	10-15	Silty sand with gravel	43	0.1

Chemical Analysis

Chemical tests were performed on a representative soil samples to investigate the potential for soil corrosivity and chemical heave. Atlas Chemical Testing Laboratories, Inc. in Las Vegas performed the chemical analysis for water-soluble sulfates and sodium in general accordance with ASTM D516. The results of the chemical tests are presented on Drawing No. A-70.

AH. 1
1/3

© Converse Consultants

GTC MLD

Grain Size Distribution

Grain size distribution for soil samples were determined by sieve analysis in accordance with ASTM C136. A sieve analysis is conducted by passing the soil through a number of different sized sieves and measuring the amount of soils retained on each sieve. The test results and grain size distribution curves are presented on Drawing Nos. A-37 through A-48.

Atterberg Limits

The liquid limit, plastic limit and plasticity index of a representative sample of the fine-grained soils were determined to aid in the classification of the soils and in the evaluation of other engineering parameters. The test was performed in general accordance with ASTM test method D4318. The results of the tests are tabulated in the following table:

Exploration Location	Sample Depth, ft.	Liquid Limit, %	Plastic Limit, %	Plasticity Index	Unified Soils Classification
B-1	30-35	NP	NP	NP	SM
B-5	20-25	NP	NP	NP	SM
B-10	30-35	NP	NP	NP	SM
B-12	10-15	NP	NP	NP	SM
B-101	39-40	105	71	34	MH
B-101	54-55	54	44	10	ML
B-102	20-25	NP	NP	NP	SM
B-102	49-50	88	58	30	MH
B-103	30-35	NP	NP	NP	SM
B-104	10-15	NP	NP	NP	SM
B-105	20-25	NP	NP	NP	SW-SM
B-106	0-5	NP	NP	NP	SM

NP = Nonplastic

Attachment 1

GIC MLD

Log No. B- 8

Date of Drilling: 9/14/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 58.0

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Samples: Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SANDY LEAN CLAY With Gravel (CL); very stiff, dark brown, slightly moist	▼		49				
42									
44		---dry	▼		35/8"				K
46									
48									
		---partially cemented, moderately hard, white, dry							
		SANDY LEAN CLAY (CL); very stiff, dark brown, moist	▼		35/10"				pp=3.0
50									
52									
54			▼		16		52	71	108 pp=2.0
56									
58									
		SILTY SAND (SM); dense, brown, wet							
		SANDY LEAN CLAY (CL); stiff, dark brown, wet	▼		13		51	70	106 pp=3.0

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No.
99-33437-01

13701 GPJ

GTC MLD

Log No. B-12

Date of Drilling: 9/14/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 37.5

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY OLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SANDY LEAN CLAY (CL); very stiff, dark brown, moist	▼		44				
42									
44									
		---wet, stiff	▼		15		80	53	95 pp=1.5
46									
48									
			▼		11				
50									
52									
		---with gravel, very stiff							
54			▼		16		31	87	114 pp=1.5
56									
58									
			▼		18				pp=1.5

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

ON ATTACHED

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No.
99-33437-01

GTC MLD

Log No. B-101

Date of Drilling: 9/20/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 42.0

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
					10				
		SILTY SAND With Gravel (SM); medium dense, grayish brown, dry							
42									
		SANDY LEAN CLAY (CL); stiff, dark brown, moist							
44					11		45	67	97
46									
48									
					25				pp=1.5
50		---partially cemented lens, moderately hard, brownish white, wet							
52									
54					11		42	75	107 A
		---with gravel							
56									
58					14		42	74	106

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

NO ON FILE BY GLE

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No.
99-33437-01

43701.GPJ

GTC MLD

Log No. B- 1

Date of Drilling: 9/23/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 53.0

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SILTY SAND With Gravel (SM); dense, light brown, slightly moist			35				
22									G;P
24					35		7	108	116
26									
28		---grayish brown							
					35/6"				
30		---very dense			53				A
									G
32									
34					35/3"				
36									
38		---dense			35/6"				

End of Exploration at 55.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No.
99-33437-01

3343701.GP

48 GTC MLD

Log No. B- 4

Date of Drilling: 9/13/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 54.5

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SILTY SAND With Gravel (SM); very dense, brown, dry			35/2"				
22									
24		---dense			49				K
26									
28									
		---few gravel			35		7	107	114
30					42				
32									
34		---with gravel, very dense			35/8"		4		
36									
38		---with boulders							
		CEMENTED SAND AND GRAVEL; hard, brown, dry			20/0"				

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

3701 GPJ

GTC MLD

Log No. B- 5

Date of Drilling: 9/15/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 52.5

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		FILL: SILTY SAND With Gravel; tan, dry			9				
2									
4		---slightly moist			35/5"				
					58				
6									
8		---with cobbles							
		SILTY SAND With Gravel (SM); dense, tan, slightly moist			31		5	115	121
10					29				
12									K;Sol; Ch
14					43		4	111 115	DS
16									
18									
		---very dense			57/8"				

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No.
99-33437-01

GTC MLD

Log No. B- 5

Date of Drilling: 9/15/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 52.5

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SILTY SAND With Gravel (SM); dense, tan, slightly moist			32				A
22									G;P;Ch
24					58/8"				
		---very dense							
26									
28		---brown							
		CLAYEY SAND With Gravel (SC); dense, dark brown, slightly moist			35/5"		6	112	119
30					35/6"				
		SILTY SAND With Gravel (SM); dense, black, slightly moist							
32		---dark brown							
34		---very dense			50/3"				
36									
38		---with cobbles			50/6"				

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No.
99-33437-01

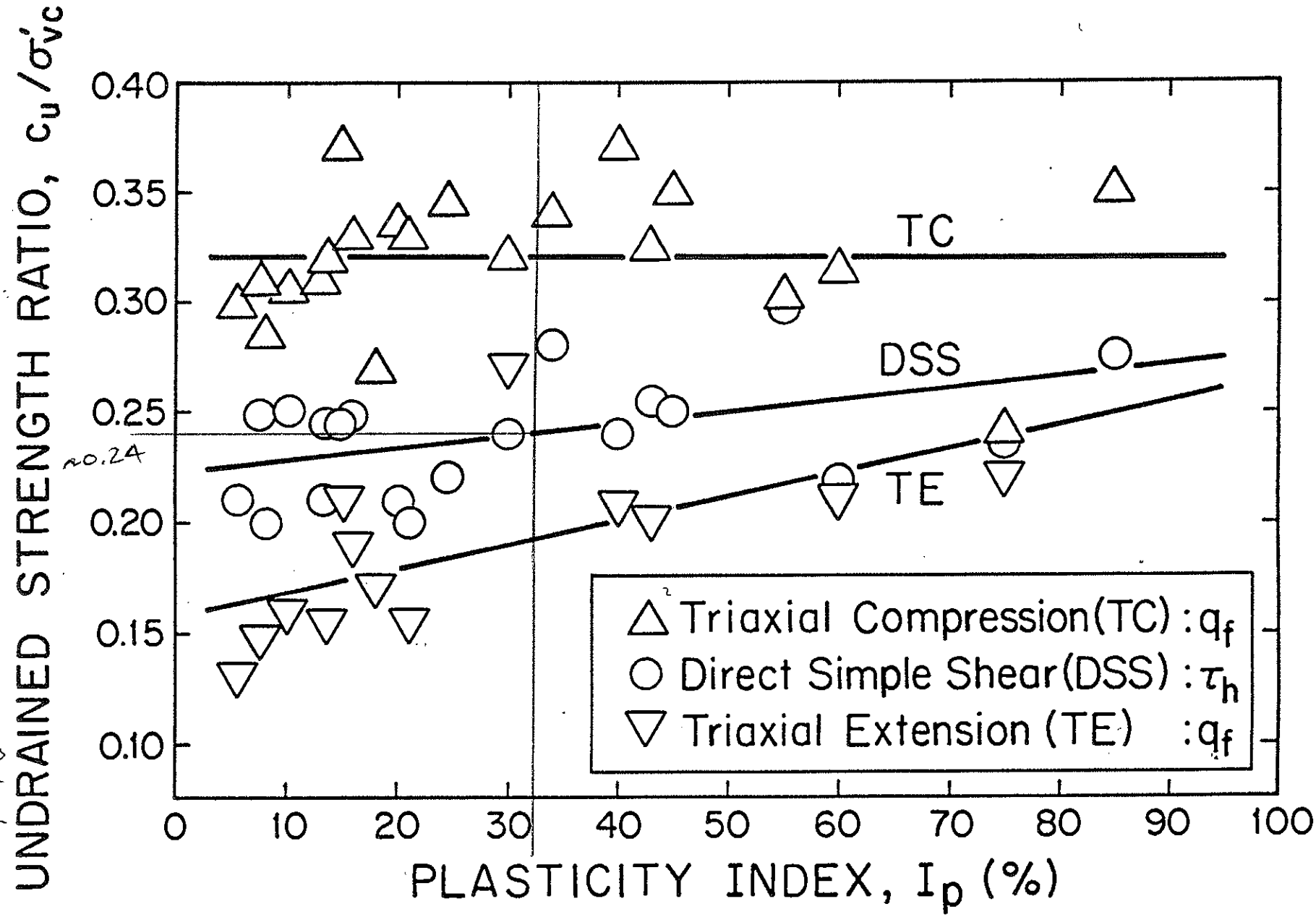


FIG. 15.-Undrained Strength Anisotropy from CK_oU Tests on Normally Consolidated Clays and Silts (data from Lefebvre et al. 1983; Vaid Campanella 1974; and various MIT and NGI reports)

** PCSTABL5 **

by
Purdue University

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

Run Date: 5/27/2005
Time of Run: 9:56am
Run By: EMZ
Input Data Filename: C:ANEW
Output Filename: C:ANEW.OUT
Plotted Output Filename: C:ANEW.PLT

PROBLEM DESCRIPTION Section A-A'
BRC CAMU, Henderson, Nevada

BOUNDARY COORDINATES

9 Top Boundaries
15 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	.00	138.00	80.00	136.00	2
2	80.00	136.00	164.00	134.00	2
3	164.00	134.00	240.00	132.00	2
4	240.00	132.00	313.00	166.50	2
5	313.00	166.50	333.00	176.00	1
6	333.00	176.00	370.00	176.00	1
7	370.00	176.00	410.00	185.00	1
8	410.00	185.00	436.00	185.00	1
9	436.00	185.00	450.00	185.00	1
10	313.00	166.50	450.00	170.75	2
11	.00	121.00	450.00	126.00	3
12	.00	111.00	450.00	116.00	4
13	.00	101.00	450.00	106.00	5
14	.00	91.00	450.00	96.00	6
15	.00	81.00	450.00	86.00	7

ISOTROPIC SOIL PARAMETERS

7 Type(s) of Soil

Attachment 3A

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	117.0	117.0	.0	35.0	.00	.0	1
2	117.0	117.0	.0	35.0	.00	.0	1
3	102.0	102.0	1400.0	.0	.00	.0	1
4	102.0	102.0	1500.0	.0	.00	.0	1
5	102.0	102.0	1600.0	.0	.00	.0	1
6	102.0	102.0	1700.0	.0	.00	.0	1
7	102.0	102.0	1800.0	.0	.00	.0	1

---

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 2 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	.00	122.00
2	450.00	127.00

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

2000 Trial Surfaces Have Been Generated.

10 Surfaces Initiate From Each Of200 Points Equally Spaced Along The Ground Surface Between X = 235.00 ft.
and X = 250.00 ft.

Each Surface Terminates Between X = 333.00 ft.
and X = 375.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = .00 ft.

11.00 ft. Line Segments Define Each Trial Failure Surface.

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Janbu Method * *

Failure Surface Specified By 11 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	241.18	132.56
2	251.59	136.12
3	261.90	139.96
4	272.10	144.08
5	282.18	148.48
6	292.14	153.14
7	301.97	158.08
8	311.67	163.27
9	321.22	168.73
10	330.62	174.45
11	333.02	176.00

*** 1.487 ***

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	249.77	136.62
2	260.26	139.95
3	270.62	143.64
4	280.84	147.70
5	290.92	152.12
6	300.83	156.89
7	310.56	162.01
8	320.11	167.47
9	329.46	173.27
10	333.55	176.00

*** 1.490 ***

Failure Surface Specified By 11 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	242.24	133.06
2	252.62	136.69
3	262.91	140.57
4	273.11	144.69
5	283.21	149.05
6	293.20	153.65
7	303.09	158.48
8	312.85	163.54
9	322.50	168.83
10	332.02	174.34
11	334.73	176.00

*** 1.491 ***

Failure Surface Specified By 18 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	235.00	132.13
2	242.78	124.36
3	251.61	117.79
4	261.29	112.57
5	271.62	108.80
6	282.39	106.57
7	293.37	105.91
8	304.33	106.85
9	315.04	109.37
10	325.27	113.41
11	334.82	118.88
12	343.46	125.68
13	351.04	133.65
14	357.38	142.64
15	362.36	152.45
16	365.87	162.88
17	367.83	173.70
18	367.91	176.00

*** 1.497 ***

Failure Surface Specified By 18 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	235.30	132.12

2	243.09	124.36
3	251.92	117.80
4	261.60	112.58
5	271.94	108.81
6	282.71	106.58
7	293.69	105.92
8	304.65	106.86
9	315.36	109.37
10	325.60	113.40
11	335.14	118.86
12	343.80	125.65
13	351.39	133.61
14	357.75	142.59
15	362.74	152.39
16	366.27	162.81
17	368.26	173.63
18	368.35	176.00

*** 1.498 ***

Failure Surface Specified By 18 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	235.08	132.13
2	242.89	124.39
3	251.72	117.83
4	261.38	112.57
5	271.69	108.72
6	282.43	106.36
7	293.40	105.53
8	304.38	106.25
9	315.14	108.51
10	325.48	112.26
11	335.20	117.42
12	344.09	123.90
13	351.98	131.56
14	358.72	140.26
15	364.16	149.81
16	368.21	160.04
17	370.79	170.73
18	371.32	176.30

*** 1.499 ***

Failure Surface Specified By 17 Coordinate Points

Point	X-Surf	Y-Surf

No.	(ft)	(ft)
1	235.08	132.13
2	242.89	124.39
3	251.77	117.89
4	261.51	112.79
5	271.90	109.18
6	282.72	107.16
7	293.71	106.76
8	304.64	108.00
9	315.26	110.85
10	325.35	115.25
11	334.67	121.09
12	343.02	128.25
13	350.21	136.57
14	356.09	145.87
15	360.53	155.93
16	363.42	166.54
17	364.54	176.00

*** 1.500 ***

Failure Surface Specified By 18 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	235.45	132.12
2	243.26	124.37
3	252.11	117.83
4	261.81	112.64
5	272.15	108.92
6	282.93	106.73
7	293.92	106.12
8	304.87	107.11
9	315.57	109.68
10	325.78	113.77
11	335.29	119.29
12	343.90	126.14
13	351.43	134.15
14	357.72	143.18
15	362.64	153.02
16	366.08	163.47
17	367.97	174.31
18	368.01	176.00

*** 1.500 ***

Failure Surface Specified By 18 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	235.38	132.12
2	243.17	124.36
3	251.97	117.76
4	261.61	112.45
5	271.89	108.55
6	282.62	106.11
7	293.58	105.19
8	304.56	105.81
9	315.35	107.96
10	325.73	111.59
11	335.51	116.64
12	344.48	123.00
13	352.48	130.55
14	359.35	139.14
15	364.95	148.61
16	369.18	158.76
17	371.95	169.41
18	372.78	176.63

*** 1.501 ***

Failure Surface Specified By 18 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	235.23	132.13
2	243.07	124.41
3	251.91	117.87
4	261.57	112.61
5	271.87	108.75
6	282.61	106.35
7	293.57	105.47
8	304.55	106.11
9	315.34	108.28
10	325.72	111.92
11	335.49	116.97
12	344.47	123.33
13	352.47	130.87
14	359.36	139.45
15	364.98	148.91
16	369.24	159.05
17	372.05	169.68
18	372.88	176.65

*** 1.501 ***

** PCSTABL5 **

by
Purdue University

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

Run Date: 5/27/2005
Time of Run: 10:14am
Run By: EMZ
Input Data Filename: C:A3NEW
Output Filename: C:A3NEW.OUT
Plotted Output Filename: C:A3NEW.PLT

PROBLEM DESCRIPTION Section A-A'
BRC CAMU, Henderson, Nevada

BOUNDARY COORDINATES

9 Top Boundaries
15 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	.00	138.00	80.00	136.00	2
2	80.00	136.00	164.00	134.00	2
3	164.00	134.00	240.00	132.00	2
4	240.00	132.00	313.00	166.50	2
5	313.00	166.50	333.00	176.00	1
6	333.00	176.00	370.00	176.00	1
7	370.00	176.00	410.00	185.00	1
8	410.00	185.00	436.00	185.00	1
9	436.00	185.00	450.00	185.00	1
10	313.00	166.50	450.00	170.75	2
11	.00	121.00	450.00	126.00	3
12	.00	111.00	450.00	116.00	4
13	.00	101.00	450.00	106.00	5
14	.00	91.00	450.00	96.00	6
15	.00	81.00	450.00	86.00	7

ISOTROPIC SOIL PARAMETERS

7 Type(s) of Soil

Attachment 3B

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	117.0	117.0	.0	35.0	.00	.0	1
2	117.0	117.0	.0	35.0	.00	.0	1
3	102.0	102.0	1400.0	.0	.00	.0	1
4	102.0	102.0	1500.0	.0	.00	.0	1
5	102.0	102.0	1600.0	.0	.00	.0	1
6	102.0	102.0	1700.0	.0	.00	.0	1
7	102.0	102.0	1800.0	.0	.00	.0	1

---

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 2 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	.00	122.00
2	450.00	127.00

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Sliding Block Surfaces, Has Been Specified.

The Active And Passive Portions Of The Sliding Surfaces Are Generated According To The Rankine Theory.

100 Trial Surfaces Have Been Generated.

2 Boxes Specified For Generation Of Central Block Base

Length Of Line Segments For Active And Passive Portions Of Sliding Block Is 11.0

Box No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Height (ft)
1	215.00	123.00	300.00	123.00	10.00
2	375.00	124.00	450.00	124.00	10.00

**** ERROR - BK12 ****
Points on active or passive wedges are outside defined ground surface

---

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Janbu Method * *

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	240.76	132.36
2	247.35	128.94
3	257.10	123.86
4	262.66	118.30
5	389.77	124.35
6	390.76	125.34
7	395.84	135.10
8	400.92	144.86
9	406.00	154.61
10	411.08	164.37
11	413.82	169.63
12	418.90	179.38
13	421.82	185.00

*** 1.908 ***

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	223.66	132.43
2	230.72	128.75
3	240.48	123.67
4	244.90	119.25
5	375.27	122.34
6	378.13	125.20
7	383.21	134.96
8	388.29	144.72
9	393.37	154.47
10	398.45	164.23
11	401.05	169.23
12	406.13	178.99
13	409.16	184.81

*** 1.926 ***

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	231.25	132.23
2	237.78	128.83
3	247.54	123.75
4	252.78	118.50
5	402.74	124.63
6	403.59	125.48
7	408.67	135.24
8	413.74	145.00
9	418.82	154.76
10	423.90	164.51
11	426.77	170.03
12	431.85	179.79
13	434.57	185.00

*** 1.939 ***

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	233.47	132.17
2	239.85	128.85
3	249.60	123.77
4	253.12	120.26
5	396.00	124.20
6	397.21	125.41
7	402.29	135.17
8	407.36	144.93
9	412.44	154.68
10	417.52	164.44
11	420.33	169.83
12	425.41	179.59
13	428.23	185.00

*** 1.956 ***

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	237.40	132.07
2	243.50	128.89
3	253.26	123.81
4	255.69	121.38
5	381.28	123.37
6	383.16	125.26
7	388.24	135.01
8	393.32	144.77
9	398.40	154.53
10	403.48	164.29
11	406.13	169.39
12	411.21	179.15
13	414.26	185.00

*** 1.959 ***

Failure Surface Specified By 14 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	246.87	135.25
2	249.00	134.14
3	258.76	129.06
4	268.51	123.98
5	272.04	120.46
6	386.92	119.71
7	392.57	125.36
8	397.64	135.12
9	402.72	144.88
10	407.80	154.63
11	412.88	164.39
12	415.64	169.68
13	420.72	179.44
14	423.61	185.00

*** 2.002 ***

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)

1	242.98	133.41
2	251.48	128.98
3	261.24	123.90
4	263.33	121.81
5	376.30	123.49
6	378.00	125.20
7	383.08	134.96
8	388.16	144.71
9	393.24	154.47
10	398.32	164.23
11	400.92	169.23
12	406.00	178.98
13	409.02	184.78

*** 2.013 ***

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	231.76	132.22
2	238.26	128.83
3	248.01	123.76
4	250.87	120.89
5	403.98	124.60
6	404.87	125.50
7	409.95	135.26
8	415.03	145.01
9	420.11	154.77
10	425.19	164.53
11	428.08	170.07
12	433.16	179.83
13	435.85	185.00

*** 2.014 ***

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	229.33	132.28
2	236.00	128.81
3	245.76	123.73
4	246.14	123.35
5	387.50	123.23
6	389.60	125.33
7	394.68	135.09

8	399.76	144.84
9	404.84	154.60
10	409.92	164.36
11	412.64	169.59
12	417.72	179.35
13	420.67	185.00

*** 2.028 ***

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	215.59	132.64
2	223.22	128.67
3	232.98	123.59
4	235.35	121.22
5	381.50	122.19
6	384.58	125.27
7	389.66	135.03
8	394.73	144.79
9	399.81	154.54
10	404.89	164.30
11	407.56	169.43
12	412.64	179.19
13	415.67	185.00

*** 2.041 ***

** PCSTABL5 **

by
Purdue University

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

Run Date:	5/27/2005
Time of Run:	10:06am
Run By:	EMZ
Input Data Filename:	C:A2NEW
Output Filename:	C:A2NEW.OUT
Plotted Output Filename:	C:A2NEW.PLT

PROBLEM DESCRIPTION Section A-A'
BRC CAMU, Henderson, Nevada

BOUNDARY COORDINATES

9 Top Boundaries
15 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	.00	138.00	80.00	136.00	2
2	80.00	136.00	164.00	134.00	2
3	164.00	134.00	240.00	132.00	2
4	240.00	132.00	313.00	166.50	2
5	313.00	166.50	333.00	176.00	1
6	333.00	176.00	370.00	176.00	1
7	370.00	176.00	410.00	185.00	1
8	410.00	185.00	436.00	185.00	1
9	436.00	185.00	450.00	185.00	1
10	313.00	166.50	450.00	170.75	2
11	.00	121.00	450.00	126.00	3
12	.00	111.00	450.00	116.00	4
13	.00	101.00	450.00	106.00	5
14	.00	91.00	450.00	96.00	6
15	.00	81.00	450.00	86.00	7

ISOTROPIC SOIL PARAMETERS

7 Type(s) of Soil

Attachment 3C

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	117.0	117.0	.0	35.0	.00	.0	1
2	117.0	117.0	.0	35.0	.00	.0	1
3	102.0	102.0	1400.0	.0	.00	.0	1
4	102.0	102.0	1500.0	.0	.00	.0	1
5	102.0	102.0	1600.0	.0	.00	.0	1
6	102.0	102.0	1700.0	.0	.00	.0	1
7	102.0	102.0	1800.0	.0	.00	.0	1

---

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 2 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	.00	122.00
2	450.00	127.00

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

2000 Trial Surfaces Have Been Generated.

10 Surfaces Initiate From Each Of200 Points Equally Spaced Along The Ground Surface Between X = 200.00 ft.
and X = 250.00 ft.

Each Surface Terminates Between X = 400.00 ft.
and X = 450.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = .00 ft.

11.00 ft. Line Segments Define Each Trial Failure Surface.

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Janbu Method * *

Failure Surface Specified By 25 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	218.59	132.56
2	226.38	124.79
3	234.86	117.79
4	243.97	111.63
5	253.62	106.35
6	263.73	102.01
7	274.20	98.64
8	284.95	96.28
9	295.87	94.94
10	306.86	94.64
11	317.84	95.38
12	328.69	97.16
13	339.33	99.95
14	349.66	103.74
15	359.58	108.49
16	369.01	114.15
17	377.86	120.68
18	386.06	128.02
19	393.53	136.10
20	400.19	144.84
21	406.01	154.18
22	410.91	164.03
23	414.86	174.30
24	417.82	184.89
25	417.84	185.00

*** 1.459 ***

Failure Surface Specified By 25 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	212.06	132.74
2	219.84	124.96
3	228.31	117.94
4	237.39	111.73
5	247.00	106.38
6	257.07	101.94

7	267.50	98.46
8	278.21	95.95
9	289.10	94.44
10	300.09	93.94
11	311.08	94.46
12	321.97	95.99
13	332.68	98.52
14	343.10	102.03
15	353.16	106.49
16	362.76	111.85
17	371.83	118.08
18	380.28	125.12
19	388.05	132.91
20	395.06	141.39
21	401.26	150.47
22	406.59	160.09
23	411.02	170.16
24	414.49	180.60
25	415.52	185.00

*** 1.463 ***

Failure Surface Specified By 24 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	220.60	132.51
2	228.41	124.76
3	236.93	117.80
4	246.08	111.69
5	255.77	106.49
6	265.92	102.25
7	276.43	99.01
8	287.21	96.80
9	298.14	95.63
10	309.14	95.52
11	320.10	96.47
12	330.92	98.48
13	341.49	101.51
14	351.72	105.55
15	361.52	110.56
16	370.78	116.49
17	379.44	123.28
18	387.39	130.87
19	394.58	139.20
20	400.94	148.18
21	406.40	157.73
22	410.91	167.76
23	414.44	178.18
24	416.03	185.00

*** 1.463 ***

Failure Surface Specified By 24 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	222.36	132.46
2	230.15	124.69
3	238.64	117.70
4	247.76	111.55
5	257.42	106.30
6	267.54	101.99
7	278.03	98.67
8	288.79	96.37
9	299.72	95.10
10	310.71	94.89
11	321.68	95.72
12	332.52	97.60
13	343.13	100.50
14	353.41	104.41
15	363.28	109.27
16	372.63	115.06
17	381.39	121.71
18	389.48	129.17
19	396.81	137.37
20	403.33	146.23
21	408.98	155.67
22	413.69	165.61
23	417.44	175.95
24	419.77	185.00

*** 1.464 ***

Failure Surface Specified By 25 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	222.11	132.47
2	229.92	124.73
3	238.43	117.75
4	247.55	111.60
5	257.21	106.34
6	267.32	102.00
7	277.79	98.63
8	288.53	96.26
9	299.44	94.90
10	310.44	94.58
11	321.42	95.29

12	332.28	97.02
13	342.93	99.76
14	353.28	103.50
15	363.23	108.18
16	372.70	113.78
17	381.60	120.24
18	389.86	127.51
19	397.39	135.52
20	404.15	144.21
21	410.06	153.48
22	415.07	163.28
23	419.14	173.49
24	422.24	184.05
25	422.42	185.00

*** 1.464 ***

Failure Surface Specified By 25 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	219.60	132.54
2	227.38	124.76
3	235.85	117.75
4	244.94	111.55
5	254.57	106.23
6	264.65	101.82
7	275.09	98.37
8	285.81	95.90
9	296.71	94.45
10	307.70	94.01
11	318.69	94.59
12	329.57	96.20
13	340.26	98.81
14	350.65	102.40
15	360.67	106.95
16	370.22	112.40
17	379.23	118.72
18	387.60	125.86
19	395.28	133.73
20	402.19	142.29
21	408.27	151.46
22	413.48	161.15
23	417.76	171.28
24	421.09	181.76
25	421.79	185.00

*** 1.464 ***

Failure Surface Specified By 24 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	217.84	132.58
2	225.69	124.87
3	234.24	117.96
4	243.42	111.90
5	253.15	106.76
6	263.32	102.59
7	273.86	99.41
8	284.65	97.27
9	295.59	96.18
10	306.59	96.15
11	317.54	97.18
12	328.34	99.27
13	338.89	102.39
14	349.09	106.52
15	358.84	111.61
16	368.05	117.62
17	376.64	124.49
18	384.53	132.16
19	391.64	140.55
20	397.90	149.59
21	403.26	159.20
22	407.67	169.28
23	411.09	179.73
24	412.26	185.00

*** 1.465 ***

Failure Surface Specified By 24 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	220.60	132.51
2	228.45	124.80
3	237.00	117.88
4	246.18	111.83
5	255.91	106.69
6	266.09	102.53
7	276.63	99.37
8	287.42	97.25
9	298.37	96.18
10	309.37	96.18
11	320.32	97.25
12	331.11	99.38
13	341.65	102.54
14	351.83	106.71
15	361.55	111.84
16	370.74	117.90

17	379.29	124.82
18	387.13	132.53
19	394.18	140.97
20	400.39	150.06
21	405.68	159.70
22	410.01	169.81
23	413.35	180.29
24	414.35	185.00

*** 1.465 ***

Failure Surface Specified By 25 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	213.57	132.70
2	221.36	124.93
3	229.82	117.91
4	238.89	111.68
5	248.49	106.30
6	258.53	101.82
7	268.94	98.26
8	279.63	95.67
9	290.51	94.05
10	301.50	93.44
11	312.49	93.82
12	323.40	95.20
13	334.15	97.56
14	344.63	100.89
15	354.77	105.15
16	364.48	110.32
17	373.68	116.35
18	382.29	123.19
19	390.25	130.79
20	397.49	139.07
21	403.94	147.98
22	409.56	157.44
23	414.29	167.37
24	418.11	177.69
25	420.08	185.00

*** 1.465 ***

Failure Surface Specified By 24 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)

1	212.31	132.73
2	220.09	124.95
3	228.58	117.96
4	237.70	111.81
5	247.37	106.56
6	257.50	102.27
7	267.99	98.97
8	278.75	96.69
9	289.68	95.45
10	300.68	95.26
11	311.65	96.14
12	322.48	98.05
13	333.08	101.00
14	343.34	104.95
15	353.18	109.87
16	362.50	115.71
17	371.22	122.41
18	379.26	129.93
19	386.54	138.17
20	393.00	147.08
21	398.57	156.56
22	403.20	166.54
23	406.86	176.91
24	408.80	184.73

*** 1.465 ***

stresses associated with failure. As the number of tests increases indefinitely, it is apparent that the envelope of the failure circles (Fig. 4.6*a*) represents the locus of points associated with failure of the specimens. The envelope is known as the *rupture line* for the given material under the specific conditions of the series of tests. For materials in general, the rupture line may be curved, and it may have an intercept c on the axis of shearing stress. Since the values of shearing strength t corresponding to the rupture line all represent failure, they are designated as values of shearing strength s, and the vertical axis in Fig. 4.6*a* is called the axis of shearing strength. If the rupture line is considered to be straight, it may be represented by

$$s = c + p \tan \phi \qquad 4.2$$

known as *Coulomb's equation*.

From the geometry of Fig. 4.6*b*, it may be seen that for any failure circle

$$2\alpha = 90^\circ + \phi$$

Therefore, the angle between the planes on which failure occurs and the plane on which the major principal stress acts is

$$\alpha = 45^\circ + \frac{\phi}{2} \qquad 4.3$$

4.6. Shearing Strength of Dry Sands and Gravels

The rupture lines for dry sands and gravels pass through the origin of the rupture diagram; hence, the intercept c is equal to zero. If the material is in a loose state, the rupture line is linear and may be represented accurately by the equation

$$s = p \tan \phi_d \qquad 4.4$$

where ϕ_d is the angle between the rupture line and the p-axis. For the same materials in a dense state, the rupture line has a slight downward curvature, but for practical purposes in foundation engineering it may also be represented by eq. 4.4.

For gravels, sands, silty sands, and inorganic cohesionless silts the value of ϕ_d depends primarily on the relative density, the grain-size distribution, and the shape of the grains. It may be estimated with the aid of Table 4.1.

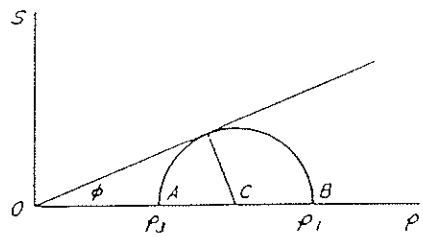
Table 4.1 Representative Values of ϕ_d for Sands and Silts

Material	Degrees	
	Loose	Dense
Sand, round grains, uniform	27.5	34
Sand, angular grains, well graded	33	45
Sandy gravel	35	50
Silty sand	27–33	30–35
Inorganic silt	27–30	30–34

ILLUSTRATIVE PROBLEM

A drained triaxial test is to be performed on a uniform dense sand with rounded grains. The all-around pressure p_3 is to be 2 tons/sq ft. At about what vertical pressure should the sample fail?

Solution. If $s = p \tan \phi$, it can be seen from the sketch that



$$\frac{p_1}{p_3} = \frac{OC + CB}{OC - AC} = \frac{OC + OC \sin \phi}{OC - OC \sin \phi}$$
$$= \frac{1 + \sin \phi}{1 - \sin \phi}$$

Whence by trigonometric transformation

$$\frac{p_1}{p_3} = \tan^2\left(45^\circ + \frac{\phi}{2}\right) = \frac{1}{\tan^2[45^\circ - (\phi/2)]}$$

According to Table 4.1, the value of ϕ_d is likely to be about 34°. Therefore,

$$\tan^2\left(45^\circ + \frac{\phi_d}{2}\right) = \tan^2(45^\circ + 17^\circ)$$
$$= 1.881^2 = 3.54$$

Attachment-2. 4

Calculation Package B
Final Waste Slope Stability

Geosyntec consultants

COMPUTATION COVER SHEET

Client: **BRC** Project: **BRC CAMU** Project/ Proposal No.: **SC0313** Task No. **13**

Title of Computations **Updated Stability Analysis for Waste Capacity Increase**

Computations by:	Signature		4/11/13 Date
	Printed Name	Jay Griffin	
	Title	Senior Staff Engineer	
Assumptions and Procedures Checked by: (peer reviewer)	Signature		4/11/13 Date
	Printed Name	Rebecca Flynn, P.E.	
	Title	Project Engineer	
Computations Checked by:	Signature		4/11/13 Date
	Printed Name	Rebecca Flynn, P.E.	
	Title	Project Engineer	
Computations backchecked by: (originator)	Signature		4/11/13 Date
	Printed Name	Jay Griffin	
	Title	Senior Staff Engineer	
Approved by: (pm or designate)	Signature		4/11/13 Date
	Printed Name	Greg Corcoran, P.E.	
	Title	Principal Engineer	

Approval notes:

Revisions (number and initial all revisions)

No.	Sheet	Date	By	Checked by	Approval

Written by:	J. Griffin	Date:	4/5/2013	Reviewed by:	R. Flynn	Date:	
Client:	BRC	Project:	BRC CAMU	Project/ Proposal No.:	SC0313	Task No.:	13

UPDATED STABILITY ANALYSIS FOR WASTE CAPACITY INCREASE BRC CAMU HENDERSON, NEVADA

BACKGROUND AND OBJECTIVE

The objective of this calculation package is to update previous slope stability analysis performed for the final closure slopes of the Basic Remediation Company (BRC) Corrective Action Management Unit (CAMU). The original analysis subject to this update is presented in the "Supplemental Remedial Action Plan (RAP) Permit Application Information for Corrective Action Management Unit (CAMU), Henderson, Nevada," prepared by Geosyntec Consultants and dated November 2006. The updated analysis incorporates an approximate 34 foot increase in height of Phase V of the CAMU, as detailed in Design Change Notifications (DCN) 47 and 48.

This updated analysis will evaluate the global static stability of the updated final closure slopes located in Phase V of the CAMU.

DESIGN CRITERION

In current practice a static factor of safety of 1.5 is generally required for final refuse slopes. To evaluate static stability of the updated slopes at the BRC CAMU, Geosyntec established a minimum static factor of safety of 1.5 as the stability criteria.

METHOD OF ANALYSIS

Two-dimensional analysis was performed using the modified Spencer's Method of Slices as coded in the computer program GEO-SLOPE 2004, Version 6.22 (SLOPE/W). The modified Spencer's Method of Slices satisfies both moment and force equilibrium by assuming a constant inclination of interslice shear force and allows for a composite linear/circular sliding surfaces representative of observed failures in composite-lined landfills.

CROSS SECTIONS

Phase V generally consists of 3H:1V (horizontal:vertical) slopes. Two representative cross sections within Phase V, Section A-A' and Section B-B', were selected to represent the longest slopes to be evaluated. Section A-A' is a north-south trending section encompassing the southern slopes of Phase V and Section B-B' is an east-west trending section encompassing the eastern slopes of Phase V. Both sections include an approximately 13-foot wide access road at approximately mid-slope. These sections are presented on Figure 1.

MATERIAL PARAMETERS

The following table summarizes the Mohr-Coulomb material parameters used in the updated slope stability analysis.

Material	Unit Weight (pcf)	Friction Angle (degrees)	Cohesion/Adhesion (psf)
Waste Material	128	32	360
Liner	100	11	625
Underlying Material	Bedrock (Impenetrable)		

Waste Soil Material

The waste material consists of sediments and soil/sludge material originating from the Eastside Remediation Project.

Triaxial shear tests and in-place nuclear moisture density tests were performed on samples collected during test pad construction of the Eastside waste material and summarized in the "Revised Waste Processing and Placement Plan Memorandum" prepared by Geosyntec (Geosyntec, 2008). These samples are assumed to be representative of the waste in its final, compacted state within the CAMU. Test results at 2% strain indicate an internal friction angle of 32 degrees and 360 pounds per square foot (psf) cohesion (Attachment 1). In-place nuclear moisture density tests indicate a field dry density of 119.8 pounds per cubic foot (pcf) and field moisture content of 6.6%. From basic soil phase relationships, a total unit weight of 128 pcf is calculated for the waste material. The unit weight calculated from the in-place nuclear moisture

place nuclear moisture density tests is higher, and more conservative, than the unit weight calculated from the Shelby tube samples collected from the same material.

Geosynthetic Liner Material

Interface shear testing was performed on the materials used for the liner construction, in accordance with the Construction Quality Assurance Plan. Testing was performed with the following materials, representing the as-built liner system (from top to bottom):

- Operation layer lightly compacted at as-received moisture content
- SKAPS TN-240-2-8 geocomposite clamped to upper shear box
- Agru 60-mil Microspike HDPE geomembrane clamped to upper shear box with small spike (dull) side down
- Hydrated Bentomat DN GCL with black geotextile side down
- Lower Shear Box: Subgrade soil compacted to approximately 90% of maximum modified Proctor density at optimum moisture content as determined by ASTM D1557.

Prior to shearing, the GCL was hydrated under a loading of 240 psf for 48 hours. The test was performed under saturated conditions at normal stresses of 20, 40, and 80 psi at a shear rate of 0.04 in/min.

Results of the laboratory testing indicate that the residual interface friction angle and adhesion for components of the composite liner system is 11 degrees and 625 pcf (Attachment 2). Geosyntec assumed a unit weight of 100 pcf for the geosynthetic liner.

Underlying Material

The material underlying the waste is modeled as impenetrable bedrock to force a failure surface to occur within the waste slopes and/or liner system elements.

RESULTS

The critical failure surface for both cross sections runs from the top of the slope through the waste material and along the liner system as shown on Figures 2 and 3. The following table summarizes the results of the stability analysis.

Section	Factor of Safety
A-A'	2.1
B-B'	2.0

CONCLUSIONS

Results of the stability analysis presented herein indicate that the slope stability of the waste material after the final elevation increase exceeds the design criteria (minimum factor of safety of 1.5).

REFERENCES

GeoStudio, 2004, Version 6.22, Build 2148, Geo-slope International, Ltd., 2001-2007.

Geosyntec Consultants (2013). "Design Change Notification, DCN-048 for the BRC Eastside Common Areas Soil Remediation, Henderson, Nevada."

Geosyntec Consultants (2008). "Memorandum, BRC CAMU, Revised Waste Processing and Placement Plan, Geosyntec Project Number SC0313," dated 14 October.

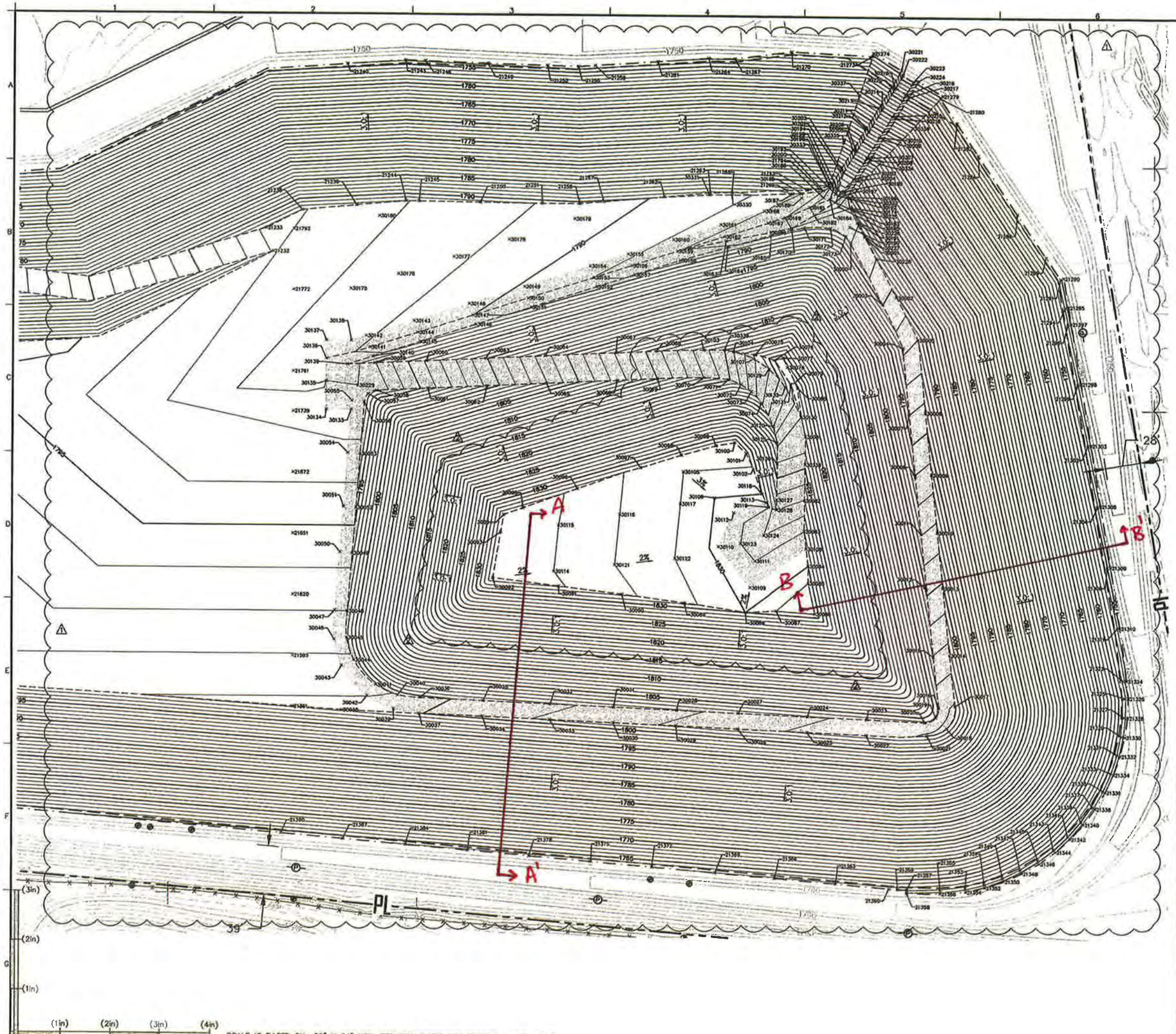
Geosyntec Consultants (2006). "Supplemental Remedial Action Plan (RAP) Permit Application Information for Corrective Action Management Unit (CAMU), Henderson, Nevada," dated November.

LIST OF FIGURES

Figure 1 Location of Cross Sections, BRC CAMU Phase V, Grading Plan
Figure 2 Slope/W Analysis Output, Cross Section A-A'
Figure 3 Slope/W Analysis Output, Cross Section B-B'

LIST OF ATTACHMENTS

Attachment 1 Waste Material Test Results
Attachment 2 Interface Shear Test Results



LEGEND

- BRC LANDFILL SITE BOUNDARY
- EXISTING LIMITS OF FORMER BMI LANDFILL
- EXISTING MINOR ELEVATION CONTOUR
- EXISTING MAJOR ELEVATION CONTOUR
- APPROXIMATE LIMITS OF EXISTING BMI LANDFILL
- PROPOSED MINOR ELEVATION CONTOUR
- PROPOSED MAJOR ELEVATION CONTOUR
- PROPOSED LIMIT OF WASTE
- LIMITS OF GRADING
- GRADE BREAK
- CONSTRUCTION SURVEY CONTROL POINT
- EXISTING POWER POLE (PROTECT IN PLACE)
- EXISTING MONITORING WELL (PROTECT IN PLACE)
- 3/4" CRUSHED ROCK
- D_{50} 12" RIP RAP
- D_{50} 12" GROUTED RIP RAP

N

40 20 0 40 80
SCALE IN FEET

CONFORMED

Figure 1 - Location of Cross-Sections

NOTES:

1. FOR GENERAL NOTES, LEGEND AND ABBREVIATIONS, SEE DWG 2.

REV	DATE	DESCRIPTION	DRN	AP
2	6/20/12	DCN-48, REVISED PHASE V TO ADD CAPACITY; REVISED CONTROL POINTS	MMC	GT
1	6/20/12	DCN-47, REVISED PHASE V TO ADD CAPACITY; ADDED NEW SHEETS 39A AND 39B	MMC	GT

Geosyntec consultants
10875 RANCHO BERNARDO RD, SUITE 200
SAN DIEGO, CA 92127
PHONE: 858.674.6559

Basic Remediation Company
875 WEST WARM SPRINGS ROAD
HENDERSON, NEVADA 89015

TITLE: PHASE V FINAL COVER GRADING CONSTRUCTION SURVEY CONTROL POINTS – PLAN

PROJECT: FINAL DESIGN BRC CAMU

SITE: HENDERSON, NEVADA

THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.

SIGNATURE

PROFESSIONAL ENGINEER-STATE OF NEVADA
RONALD S. JOHNSON
CIVIL

DESIGN BY:	JA	DATE:	OCTOBER 200
DRAWN BY:	MD/JA/MC	PROJECT NO.:	SC0313-04
CHECKED BY:	RF	FILE:	
REVIEWED BY:	RJ	DRAWING NO.:	

Plotted by: mcarlson on 2/14/2013 11:01 AM
P:\PRJ\SDOcdd\CADD\SC0313\SC0313-13-01\Planset_Current Set\DCN-48 (Sheets 39, 39A, and 39B)\SC0313.13-01-39.dwg Last Edited by: mcarlson

Figure 2 - Section A-A'

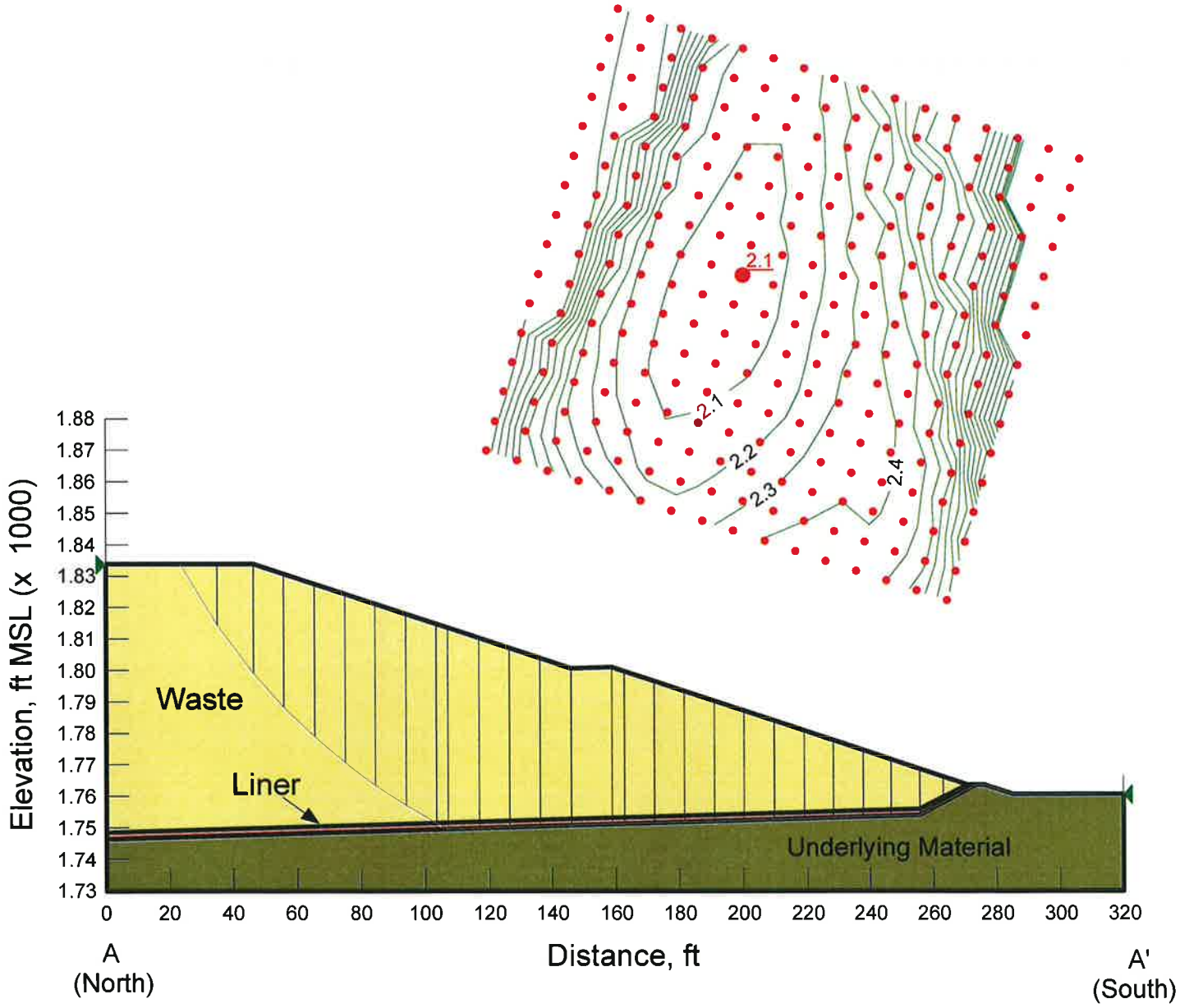
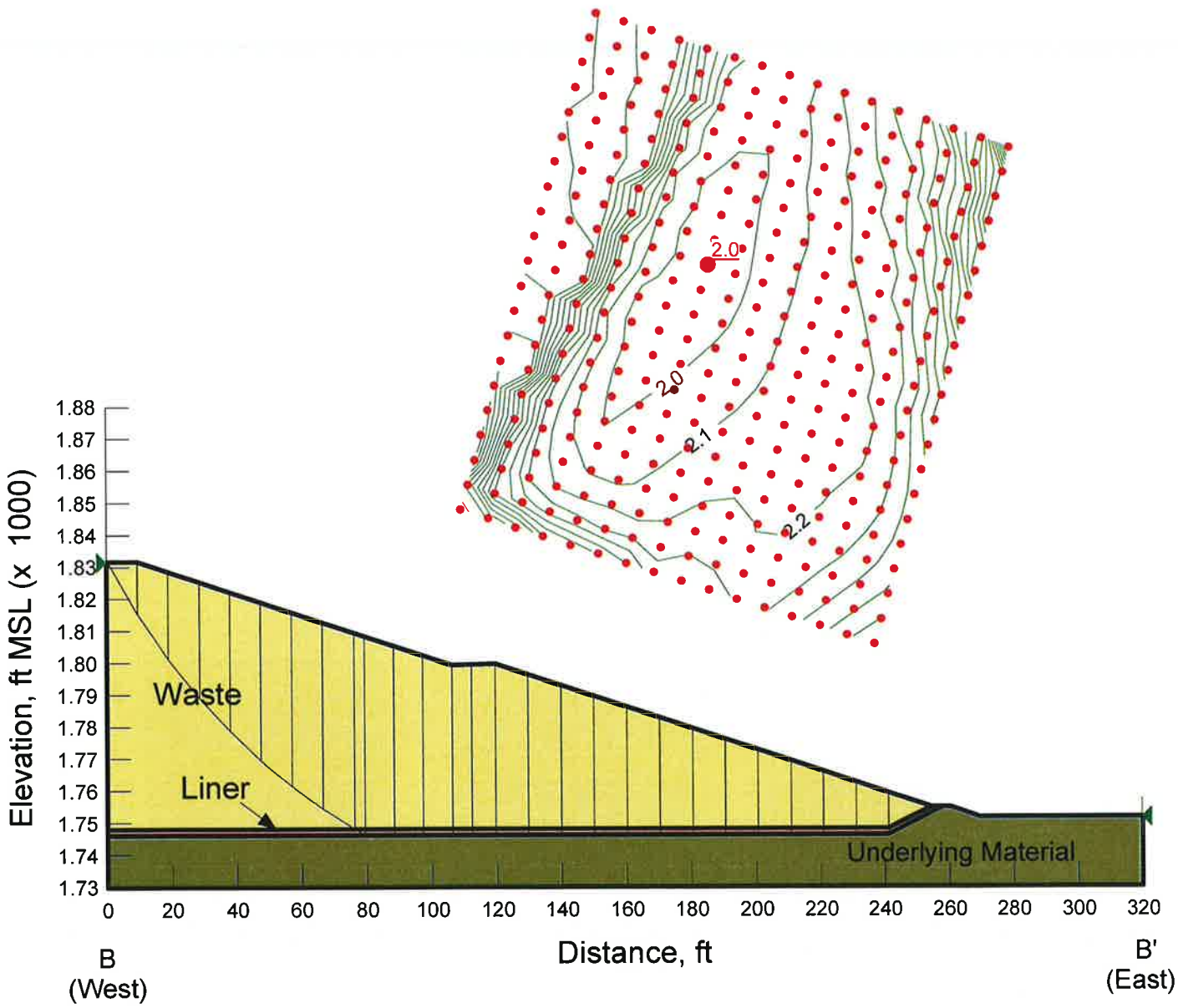


Figure 3 - Section B-B'



Once three (3) complete passes of the compactor operating in vibratory mode were made and field testing was completed on TP#2-2, a loaded 40-ton JD D400 was backed onto and pulled off of the test pad. The JD D400 was operated in a relatively straight line and the surface of each test pad was observed while the truck was moving and stopped. Once the truck was pulled off of the test pad surface, the rutting and track marks were visually monitored. The rutting and track marks did not exceed ½ to ¾ inches in depth. Pumping of the waste materials was not observed.

Upon completion of the fifth pass of the compactor on TP#1-2 and TP#2-2, the following samples were collected:

1. One in-situ sample, W-033, was collected using a 6-inch long thin wall sampler (Shelby Tube) from field density test location number 56 (6-inch depth field density test) on TP#1-2 for moisture/density and rapid compression testing.
2. One in-situ sample, W-034, was collected using a 6-inch long thin wall sampler (Shelby Tube) from field density test location number 58 (6-inch depth field density test) on TP#2-2 for moisture/density and rapid compression testing.
3. One 1-gallon grab sample, W-031, was collected from TP#1-2 for rapid compression, specific gravity, one point standard proctor at received moisture content, and grain size testing.
4. One 1-gallon grab sample, W-032, was collected from TP#2-2 for rapid compression, and one point standard proctor at received moisture content testing.
5. Four in-situ samples, W-035 through W-038, were collected from TP#2-2 using 6-inch long thin wall samplers (Shelby Tubes) from density test location numbers 60, 62, 64, and 66 (6-inch depth field density test) for shear strength testing.
6. One 2.5-gallon grab sample, W-039, was collected from TP#2-2 for standard proctor testing.

The results of the test pad field and laboratory testing are summarized below.

Field Density Test Number**	Field Dry Density (pcf)	Field Moisture Content	Corrected Field Dry Density* (pcf)	Lab Sample Number	Shelby Tube Lab Dry Density (pcf)	Shelby Tube Lab Moisture Content (%)
56 – TP #1-2	116.9	6.8%	105.5	W-033	95.8	18.3%
58 – TP #2-2	119.8	6.6%	106.8	W-034	100.0	19.6%

* - Corrected to reflect laboratory moisture content value determined for in-situ Shelby Tube samples.

** - Field density test numbers 56 and 58 represent 6-inch deep density values, which were taken to correlate to the 6-inch Shelby Tube samples collected at the same locations.

Attachment 1 (1/2)

The waste materials sampled on pre-determined frequency, samples W-006 through W-025, exhibited no visible liquid squeeze out under loads of 15,000 psf. However, the weights of the porous stones did change, likely attributable to salt and waste material particles adhering to the stone as well as potential moisture equilibrium, resulting in less than 0.5% of the sample volume for the 15,000 psf loading. Axial strain averaged 2.1%. Moisture content averaged 10.8% and percent solids averaged 89.2% for the as-received waste samples.

The waste materials sampled from the dry ponds, samples W-026 through W-030, exhibited no visible liquid squeeze out under loads of 15,000 psf. However, the weights of the porous stones did change, likely attributable to salt and waste material particles adhering to the stone as well as potential moisture equilibrium, resulting in less than 0.5% of the sample volume for the 15,000 psf loading. Axial strain averaged 1.8%. Moisture content averaged 7.5% and percent solids averaged 92.5% for the as received waste samples.

The waste materials sampled from the test pads, samples W-031 through W-034, exhibited no visible liquid squeeze out under loads of 15,000 psf. However, the weights of the porous stones did change, likely attributable to salt and waste material particles adhering to the stone as well as potential moisture equilibrium, resulting in less than 0.5% of the sample volume for the 15,000 psf loading. Axial strain averaged 3.2%. Moisture content averaged 19.0% and percent solids averaged 81.0% for the as-received waste samples.

Specific gravity and grain size was measured on selected samples that represented different material types based on color. The specific gravity of the waste material ranged between 2.51 and 3.11, uncorrected and between 2.03 and 2.94, corrected for dissolvable content within the waste material samples. The percent passing the #200 sieve ranged between 18.1% and 71.7%.

Single point standard proctor values, prepared at as-received moisture content, ranged between 60.0 pcf and 113.7 pcf.

Standard proctor maximum dry density for waste material included in TP#2-2 was 100.0 pcf at an optimum moisture content of 21.2%.

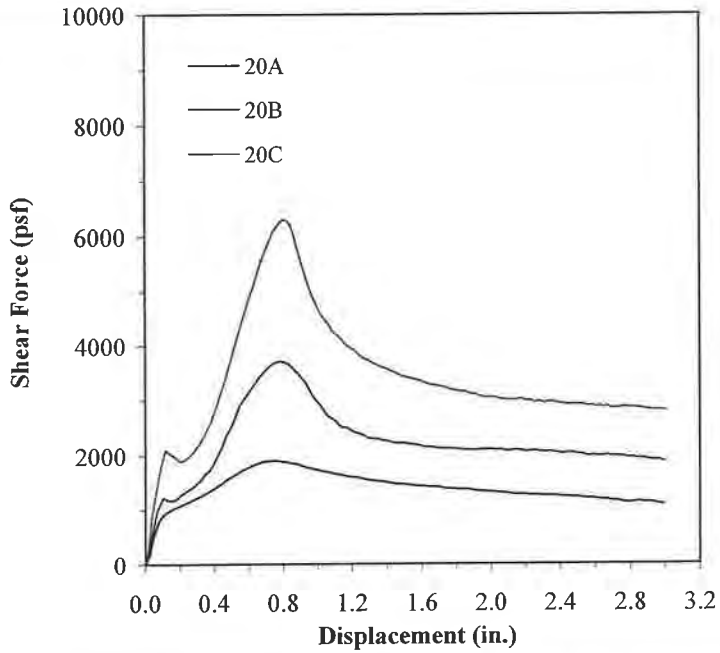
Shear strength of the waste material sampled from TP#2-2 shows a peak (measured at 2% strain), effective friction angle of approximately 32 degrees with cohesion of 360 psf. This strength values exceed the design strength value of 30 degrees with cohesion of 100 psf, and will therefore form stable slopes.

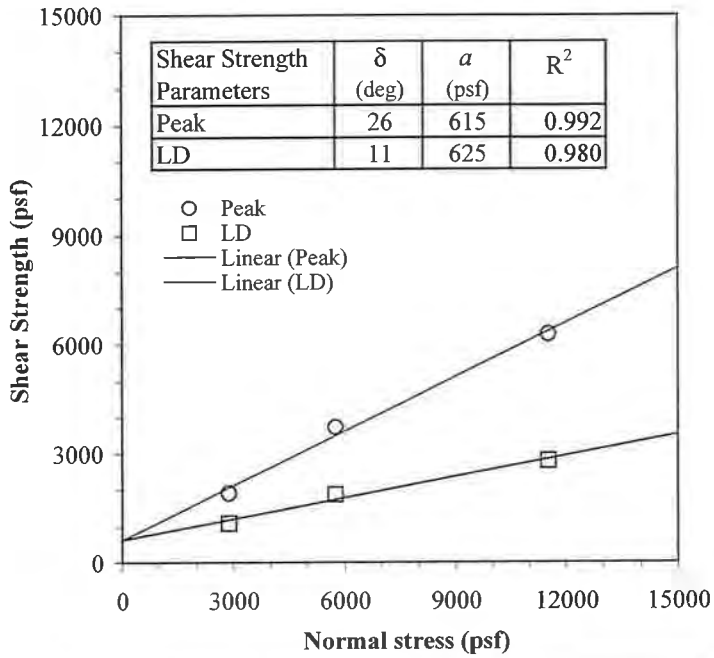
Hydraulic conductivity of the waste material ranges from 6.5×10^{-8} cm/sec to 2.8×10^{-5} cm/sec at a confining pressure of 30 psi and from 1.1×10^{-7} cm/sec to 4.6×10^{-5} cm/sec at a confining pressure

Attachment 1 (2/2)

GEOSYNTEC CONSULTANTS - BRC EASTSIDE REMEDIATION
INTERFACE DIRECT SHEAR TESTING (ASTM D 5321)

Upper Shear Box: Operation layer lightly compacted at as-received moisture content/
SKAPS TN-240-2-8 geocomposite # 269730320 **clamped to upper shear box**/
Agru 60-mil Microspike HDPE geomembrane # 942104 **clamped to upper shear box** with small spike (dull) side down/
Hydrated Bentomat DN GCL (Lot #200849LO/Roll #13098) with black geotextile side down/
Lower Shear Box: Subgarde soil compacted to approximately 90% of max modified Proctor density at optimum moisture content





Shear Strength Parameters	δ (deg)	a (psf)	R^2
Peak	26	615	0.992
LD	11	625	0.980

Test No.	Shear Box Size (in. x in.)	Normal Stress (psf)	Shear Rate (in./min)	GCL Soaking Stress (psf)	GCL Soaking Time (hour)	Consolidation[1] Stress (psf)	Consolidation[1] Time (hour)	Subgrade Soil γ_d (pcf)	Subgrade Soil ω_i (%)	Subgrade Soil ω_f (%)	Operation Layer Soil γ_d (pcf)	Operation Layer Soil ω_i (%)	Operation Layer Soil ω_f (%)	GCL ω_i (%)	GCL ω_f (%)	Shear Stress τ_P (psf)	Shear Stress τ_{LD} (psf)	Failure Mode
20A	12 x 12	2880	0.04	240	48	2880	24	114.8	8.0	9.5	-	-	-	-	83.3	1902	1088	(2)
20B	12 x 12	5760	0.04	240	48	5760	24	115.0	7.8	9.8	-	-	-	-	69.6	3708	1870	(2)
20C	12 x 12	11520	0.04	240	48	11520	24	114.3	8.5	10.6	-	-	-	-	47.5	6281	2799	(2)

NOTES:
(1) Consolidation of entire sandwich.
(2) Shear failure occurred at the interface between the white side of GCL and dull side of Microspike geomembrane.

Attachment 2 (1/1)

DATE OF REPORT:	1/4/2009
FIGURE NO.	C-20
PROJECT NO.	SGI8021
DOCUMENT NO.	
FILE NO.	

SGI TESTING SERVICES, LLC

Calculation Package C
Drainage Pipe Size Requirement

GeoSyntec Consultants

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: Basic Remediation Company

Project: BRC CAMU **Project/Proposal #:** SC0313 **Task #:** 01

Title of Computations: Drainage Pipe Size Requirements

Computations By:

SIGNATURE DATE 11/3/06

Rebecca Flynn, Staff Engineer
PRINTED NAME AND TITLE

Assumptions and Procedures Checked By (Peer Reviewer):

SIGNATURE DATE 11/3/06

Greg Corcoran, PE / Principal
PRINTED NAME AND TITLE

Computations Checked By:

SIGNATURE DATE 11/3/06

Greg Corcoran, PE / Principal
PRINTED NAME AND TITLE

Computations Backchecked By (Originator):

SIGNATURE DATE 11/3/06

Rebecca Flynn, Staff Engineer
PRINTED NAME AND TITLE

Approved By (PM or Designate):

SIGNATURE DATE 11/3/06

Greg Corcoran, PE / Principal
PRINTED NAME AND TITLE

Approval Notes:

Revisions: (Number and Initial All Revisions)

No.	Sheet	Date	By	Checked By	Approval

Written by: Rebecca Flynn Date: 06 / 08 / 29 (YY MM DD) Reviewed by: GTC Date: 06 / 11 / 13 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

DRAINAGE PIPE SIZE REQUIREMENTS

OBJECTIVE

The objective of this calculation package is to evaluate the drainage pipe size requirements for the base liner proposed for the drainage system for the BRC Corrective Action Management Unit (CAMU) located in Henderson, Nevada. It is proposed that the drainage system include an geocomposite drainage layer with a single drainage pipe, bedded in a drainage aggregate trench, located along the base of each cell. The pipe diameter and perforations must be able to handle the maximum flow into and through the pipe. This calculation will evaluate the required performance diameter and perforation size and spacing for the drainage pipe. In addition, the drainage aggregate must be sized as to not allow transport of materials through the pipe perforations.

SUMMARY OF ANALYSIS

The calculations suggest that a 4-inch diameter pipe with four ¼-inch perforations spaced at 1 foot on center will accommodate the maximum flow predicted by the HELP Model. The maximum particle size of the drainage aggregate is 1 in or less (as evaluated in the geomembrane puncture protection calculation) and D_{85} must be 0.5 inch or higher to prevent piping and material loss. AASHTO 67 material meets the drainage aggregate requirements.

SITE CONDITIONS

The proposed composite liner system will be comprised of the following components, from top to bottom (Figure 2):

- 2 ft of operations layer material;
- a drainage geocomposite;
- 60-mil (1.5 mm) HDPE geomembrane, textured on both sides;
- a geosynthetic clay liner (GCL); and
- prepared subgrade.

Written by: Rebecca Flynn Date: 06 / 08 / 29 (YY MM DD) Reviewed by: GTC Date: 06 / 11 / 3 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

ANALYSIS

HELP Analyses:

The Hydrologic Evaluation of Landfill Performance (HELP) model was used to estimate the peak daily quantity of liquid expected to be generated in the drainage pipe during or after a rainfall event. The HELP model is used to evaluate the worst case scenario which occurs *during the period when the cell contains a small quantity of waste*, such that any collected liquid is considered leachate, yet the majority of the cell is empty so the largest quantity of liquid will infiltrate through the operations layer to the drainage layer. This time period exists between the following activities:

- *Immediately after the composite liner system construction has been completed* (any collected liquid during construction is considered construction water and will not be contaminated);
- *Before the period of significant waste placement.* Leachate generation is reduced by the dry landfill moisture retention capacity. Separate calculation packages address the moisture retention capacity of the dry landfill soil and respective dry landfill requirements so that leachate generation is greatly reduced or completely stored in the waste soil.

No further analyses are needed because the above condition represents the worst case during the life of the landfill.

The rainfall history was synthetically generated by HELP over a 20 year period. The drainage pipes, pipe perforations, and portions of the drainage geocomposite layer (maintaining less than 1 ft of head over the liner) must accommodate the peak daily quantity over a 20 year rainfall history. This is conservative because the 20-year peak daily quantity is assumed to occur during a relatively short exposure period.

The initial water content of the placed soil is assumed to be the default water content initialized by HELP. This is conservative because the water content of the drainage aggregate and operations layer soil is likely to be relatively low due to high temperatures and low humidity at the site, creating a high pan evaporation rate. Therefore, the initial water content evaluated by HELP (based on a water content near steady state) will likely be higher than the actual site conditions.

Written by: Rebecca Flynn Date: 06 / 08 / 29 (YY MM DD) Reviewed by: GTC Date: 06 / 11 / 3 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

Model Parameters

Vertical Percolation Layer: The vertical percolation layer (type 1) is represented by default properties for a silty sand in HELP (texture number 3). However, the hydraulic conductivity is changed to represent worst case (high hydraulic conductivity) as estimated by Converse Consultants (Attachment G).

Geocomposite: The default material properties for the drainage geocomposite in the HELP model are used to represent the lateral drainage layer (type 2). The defalt properties for the geocomposite are represented by HELP texture number 20. The hydraulic conductivity of the goecomposite is assumed to be 10 cm/sec (required by 40 CFR 264.301 (c) (3) (ii)).

Geosynthetics: The geomembrane and GCL properties are estimated from the HELP model. The GCL is represented by texture number 17 and the geomembrane is represented by texture number 35.

Runoff: The SCS runoff curve number was evaluated assuming HELP texture number 3 at the surface (silty sand).

The default values in the HELP model are shown in the HELP output presented in Attachment A.

Figure 1 presents the locations of drainage pipes and HELP Model analyses listen in the following Table. Figure 2 shows the cross section of the base liner system.

HELP Results

The following results were obtained from the HELP analysis:

Location	Peak Daily Quantity	Area	Slope and Length[1]	File
Unit 1	306 ft^3	3.34 acres	2% and 200 ft	SOIL1SUM
Unit 2	568 ft^3	5.98 acres	2% and 400 ft	SOIL2SUM
Unit 3	1062 ft^3	10.9 acres	2% and 1050 ft	SOIL3SUM
Unit 4	1169 ft^3	11.9 acres	3% and 550 ft	SOIL4SUM
Unit 5	1313 ft^3	13.3 acres	3% and 650 ft	SOIL5SUM
Unit A	9833 ft^3	2.84 acres	48% and 100 ft	SOILASUM
Unit B	10471 ft^3	3.15 acres	48% and 75 ft	SOILBSUM

1) see Figure 1 for slope and length evaluation.

Written by: Rebecca Flynn Date: 06 / 08 / 29 (YY MM DD) Reviewed by: ETC Date: 06 / 11 / 3 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

Pipe Diameter Analysis

From the HELP Model analyses performed for each of the 5 units and 2 side slope conditions at this facility (Attachment A), the maximum peak daily quantity of liquid expected to be generated is 10457 cubic feet on Slope B (see Figure 1). Two pipes will be used to convey the drainage from Slopes B to the sump. The following flow rate for each pipe is calculated:

(10457 CF/day) / (24 hours/day) / (60 min/hour) / (60 sec/min)/2 = 0.0605 cfs

The following equation (Attachment B) can be used to estimate the flow rate in the pipe when flowing full:

$Q_{\frac{1}{2}\,full} = (1.486/n)(A)(R)^{2/3}(S)^{1/2}$
where;
n = the Mannings roughness coefficient, 0.009 for plastic pipe (Attachment B)
A = the area of the pipe
R = hydraulic radius = area/perimeter of the pipe (Attachment B)
S = minimum slope of pipe = 0.5 %

Assuming a 4" diameter pipe will be sufficient, and using the standard dimension ratio (SDR) of 13.5 determined in the pipe crushing calculation, the following values will be used in the above equation:

r = 1.92 in (SDR 13.5 HDPE pipe) (Attachment ~~A~~ C)
$A = \pi r^2 = \pi (1.92/12)^2 = 0.080\ ft^2$
$R = (0.080) / (2 \pi (1.92/12)) = 0.080$ ft

Placing the above values into the Mannings equation results in the following:

$Q_{\frac{1}{2}\,full} = (1.486/0.009)(0.080)(0.080)^{2/3}(.005)^{1/2}$

$Q_{\frac{1}{2}\,full}$ = 0.173 cfs, which is larger than the required flow rate of 0.061 cfs, therefore 4" diameter pipe will be sufficient for this application.

Perforations Analysis

A minimum of four penetrations, each 45 and 90 degrees from the bottom of the pipe, will be used to limit the amount of particulates entering the drainage pipe directly. Verify that 4 rows of ¼-inch holes spaced at 12 inches on center are adequate.

Written by: Rebecca Flynn Date: 06 / 08 / 29 (YY MM DD) Reviewed by: [illegible] Date: 06 / 11 / 3 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

The holes will be modeled as submerged orifices using the following equation:

$Q = C_d A (2gh)^{1/2}$ (Attachment D)

where:

C_d = coefficient of discharge = 0.62 (Attachment D)

A = area of hole = $\pi (0.125/12)^2 = 0.0003$ ft^2

h = head in feet = 1 ft based on maximum head allowed over the liner system

g = gravity = 32.2 ft/sec^2

$Q = (0.62)(0.0003)(2 \times 32.2 \times 1)^{1/2} = 0.0015$ cfs per hole

Q = 0.0015 cfs x 4 holes/foot of pipe = 0.006 cfs per foot of pipe

The conservative maximum discharge to the pipe is approximately 0.061 cfs. Since there is more than 100 ft of drainage pipe for each unit (6.1 cfs/100 ft of pipe) the perforation size and spacing is more than adequate for the predicted flow rates to the pipe.

Required Drainage Aggregate

The size of the perforations are 1/4 inch in diameter. The gradation of the drainage aggregate must be designed to insure that piping and material loss will not occur. The U.S. Bureau of Reclamation (1973) use the following criteria for gradation of filter materials in relation to holes:

(D_{85} of the filter material) / (hole diameter) > 2.0 (Attachment E)

Therefore, D_{85} of the filter material must be greater than 1/2 inch.

AASHTO 67 material has a maximum particle size of 1 inch, which is the criteria for puncture protection of the geomembrane. D_{85} of AASHTO 67 material ranges from approximately 0.5 to 0.7 inches, which satisfies the above criteria (see Attachment F).

CONCLUSIONS

In accordance with the above analysis, the drainage pipe shall be 4-inch diameter pipe with four ¼-inch perforations per foot of pipe. The drainage aggregate shall have a hydraulic conductivity greater than 1×10^{-2} cm/sec, a maximum particle diameter of 1 inch, and D_{85} greater than 1/2 inch. AASHTO 67 material satisfies this criteria.

REFERENCES

Written by: Rebecca Flynn Date: 06 / 08 / 29 (YY MM DD) Reviewed by: GTC Date: 06 / 11 / 3 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

Cedergren, H. R., (1989), "Seepage, Drainage, and Flow Nets," Third Edition, John Wiley and Sons, New York. p. 161

Chevron (1999), Plexco/Spirolite Engineering Manual

Converse (1999), "Preliminary Geotechnical and Geologic Investigation - Industrial Non-Hazardous Disposal Facility", prepared for Basic Management, Inc., October 1999.

Hwang, (1987), "Fundamentals of Hydraulic Engineering Systems," 2nd Edition, Prentice-Hall

Phillips 66, Driscopipe Sizes and Dimensions (1999)

U.S. Bureau of Reclamation (1973), "Design of Small Dams, U.S. Government Printing Office, Washington D.C., 2nd edition.

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     C:\HLP3\BRC\BRCPREC.D4
TEMPERATURE DATA FILE:       C:\HLP3\BRC\BRCTEMP.D7
SOLAR RADIATION DATA FILE:   C:\HLP3\BRC\BRCSOLAR.D13
EVAPOTRANSPIRATION DATA:     C:\HLP3\BRC\BRCEVAP.D11
SOIL AND DESIGN DATA FILE:   C:\HLP3\BRC\BRCSOIL1.D10
OUTPUT DATA FILE:            C:\HLP3\BRC\Summary\SOIL1SUM.OUT


TIME:   8: 3     DATE:   8/31/2006


******************************************************************************

     TITLE:  BRCUnit1

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                   TYPE 1 - VERTICAL PERCOLATION LAYER
                       MATERIAL TEXTURE NUMBER   3
          THICKNESS                  =     24.00   INCHES
          POROSITY                   =      0.4570 VOL/VOL
          FIELD CAPACITY             =      0.0830 VOL/VOL
          WILTING POINT              =      0.0330 VOL/VOL
          INITIAL SOIL WATER CONTENT =      0.1055 VOL/VOL
          EFFECTIVE SAT. HYD. COND.  =  0.310000009000E-02 CM/SEC


                                  LAYER  2
                                  --------

                     TYPE 2 - LATERAL DRAINAGE LAYER
```

MATERIAL TEXTURE NUMBER 20

THICKNESS	=	0.20	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0110	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000	CM/SEC
SLOPE	=	2.50	PERCENT
DRAINAGE LENGTH	=	200.0	FEET

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	0.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	0.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	4 - POOR	

LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.20	INCHES
POROSITY	=	0.7500	VOL/VOL
FIELD CAPACITY	=	0.7470	VOL/VOL
WILTING POINT	=	0.4000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000003000E-08	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 3 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 200. FEET.

SCS RUNOFF CURVE NUMBER	=	81.00	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	1.704	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.226	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.594	INCHES
INITIAL SNOW WATER	=	0.000	INCHES

INITIAL WATER IN LAYER MATERIALS	=	2.684	INCHES
TOTAL INITIAL WATER	=	2.684	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
LAS VEGAS NEVADA

STATION LATITUDE	=	36.08	DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00	
START OF GROWING SEASON (JULIAN DATE)	=	62	
END OF GROWING SEASON (JULIAN DATE)	=	321	
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	9.10	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	39.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	21.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	24.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	36.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
0.50	0.46	0.41	0.22	0.20	0.09
0.45	0.54	0.32	0.25	0.43	0.32

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
44.60	50.10	55.30	63.50	73.30	83.60
90.30	88.00	80.10	67.60	53.60	45.40

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA
AND STATION LATITUDE = 36.08 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.33	0.45	0.33	0.26	0.29	0.07
	0.51	0.51	0.34	0.17	0.49	0.28
STD. DEVIATIONS	0.37	0.49	0.34	0.23	0.33	0.13
	0.73	0.40	0.55	0.16	0.50	0.22
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.005	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.024	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.274	0.206	0.271	0.277	0.225	0.132
	0.364	0.338	0.298	0.156	0.379	0.248
STD. DEVIATIONS	0.306	0.171	0.285	0.258	0.200	0.109
	0.560	0.369	0.350	0.135	0.451	0.242
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	0.0579	0.0687	0.0968	0.0973	0.0851	0.0617
	0.0658	0.0649	0.0946	0.0838	0.0585	0.0585
STD. DEVIATIONS	0.0332	0.0691	0.1033	0.0592	0.0452	0.0303
	0.0441	0.0511	0.0657	0.0580	0.0360	0.0271
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3						
AVERAGES	0.0003	0.0003	0.0004	0.0005	0.0004	0.0003
	0.0003	0.0003	0.0004	0.0004	0.0003	0.0003
STD. DEVIATIONS	0.0002	0.0003	0.0005	0.0003	0.0002	0.0001
	0.0002	0.0002	0.0003	0.0003	0.0002	0.0001

****

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	INCHES		CU. FEET	PERCENT
PRECIPITATION	4.04	(1.532)	14676.1	100.00
RUNOFF	0.005	(0.0236)	19.14	0.130
EVAPOTRANSPIRATION	3.169	(1.3330)	11504.54	78.390
LATERAL DRAINAGE COLLECTED FROM LAYER 2	0.89371	(0.36544)	3244.172	22.10515
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00000	(0.00000)	0.009	0.00006
AVERAGE HEAD ON TOP OF LAYER 3	0.000	(0.000)		
CHANGE IN WATER STORAGE	-0.025	(0.4578)	-91.76	-0.625

****

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	1.83	6642.900
RUNOFF	0.105	382.7216
DRAINAGE COLLECTED FROM LAYER 2	0.02521	91.50326
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 3	0.004	
MAXIMUM HEAD ON TOP OF LAYER 3	0.010	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	0.74	2687.3430

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.1784

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0330

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

****

0

****

FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	2.0260	0.0844
2	0.0029	0.0148
3	0.0000	0.0000
4	0.1500	0.7500
SNOW WATER	0.000	

****
****

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     C:\HLP3\BRC\BRCPREC.D4
TEMPERATURE DATA FILE:       C:\HLP3\BRC\BRCTEMP.D7
SOLAR RADIATION DATA FILE:   C:\HLP3\BRC\BRCSOLAR.D13
EVAPOTRANSPIRATION DATA:     C:\HLP3\BRC\BRCEVAP.D11
SOIL AND DESIGN DATA FILE:   C:\HLP3\BRC\BRCSOIL2.D10
OUTPUT DATA FILE:            C:\HLP3\BRC\Summary\SOIL2SUM.OUT


TIME:   8: 5     DATE:   8/31/2006


******************************************************************************

     TITLE:  BRCUnit2

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                   TYPE 1 - VERTICAL PERCOLATION LAYER
                       MATERIAL TEXTURE NUMBER   3
          THICKNESS                    =     24.00   INCHES
          POROSITY                     =      0.4570 VOL/VOL
          FIELD CAPACITY               =      0.0830 VOL/VOL
          WILTING POINT                =      0.0330 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.1083 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.310000009000E-02 CM/SEC


                                  LAYER  2
                                  --------

                     TYPE 2 - LATERAL DRAINAGE LAYER
```

MATERIAL TEXTURE NUMBER 20

THICKNESS	=	0.20	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0108	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000	CM/SEC
SLOPE	=	2.00	PERCENT
DRAINAGE LENGTH	=	400.0	FEET

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	0.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	0.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	4 - POOR	

LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.20	INCHES
POROSITY	=	0.7500	VOL/VOL
FIELD CAPACITY	=	0.7470	VOL/VOL
WILTING POINT	=	0.4000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000003000E-08	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 3 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 400. FEET.

SCS RUNOFF CURVE NUMBER	=	80.20	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	1.969	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.226	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.594	INCHES
INITIAL SNOW WATER	=	0.000	INCHES

INITIAL WATER IN LAYER MATERIALS	=	2.752	INCHES
TOTAL INITIAL WATER	=	2.752	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
LAS VEGAS NEVADA

STATION LATITUDE	=	36.08	DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00	
START OF GROWING SEASON (JULIAN DATE)	=	62	
END OF GROWING SEASON (JULIAN DATE)	=	321	
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	9.10	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	39.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	21.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	24.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	36.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
0.50	0.46	0.41	0.22	0.20	0.09
0.45	0.54	0.32	0.25	0.43	0.32

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
44.60	50.10	55.30	63.50	73.30	83.60
90.30	88.00	80.10	67.60	53.60	45.40

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA
AND STATION LATITUDE = 36.08 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.33	0.45	0.33	0.26	0.29	0.07
	0.51	0.51	0.34	0.17	0.49	0.28
STD. DEVIATIONS	0.37	0.49	0.34	0.23	0.33	0.13
	0.73	0.40	0.55	0.16	0.50	0.22
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.005	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.021	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.346	0.320	0.328	0.281	0.286	0.166
	0.431	0.257	0.256	0.178	0.422	0.296
STD. DEVIATIONS	0.363	0.338	0.284	0.211	0.239	0.117
	0.712	0.200	0.317	0.117	0.493	0.264
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	0.0366	0.0424	0.0505	0.0443	0.0435	0.0330
	0.0351	0.0298	0.0460	0.0576	0.0407	0.0411
STD. DEVIATIONS	0.0305	0.0358	0.0484	0.0353	0.0389	0.0219
	0.0173	0.0175	0.0738	0.0683	0.0377	0.0284
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3						
AVERAGES	0.0004	0.0005	0.0006	0.0005	0.0005	0.0004
	0.0004	0.0003	0.0005	0.0007	0.0005	0.0005
STD. DEVIATIONS	0.0003	0.0005	0.0006	0.0004	0.0004	0.0003
	0.0002	0.0002	0.0009	0.0008	0.0004	0.0003

****

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	INCHES		CU. FEET	PERCENT
PRECIPITATION	4.04	(1.532)	14676.1	100.00
RUNOFF	0.005	(0.0208)	16.91	0.115
EVAPOTRANSPIRATION	3.567	(1.4731)	12948.16	88.226
LATERAL DRAINAGE COLLECTED FROM LAYER 2	0.50069	(0.25506)	1817.490	12.38402
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00000	(0.00000)	0.008	0.00006
AVERAGE HEAD ON TOP OF LAYER 3	0.000	(0.000)		
CHANGE IN WATER STORAGE	-0.029	(0.5316)	-106.48	-0.726

****

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	1.83	6642.900
RUNOFF	0.093	338.2043
DRAINAGE COLLECTED FROM LAYER 2	0.02617	95.01099
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 3	0.009	
MAXIMUM HEAD ON TOP OF LAYER 3	0.021	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	0.74	2687.3430

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.1924

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0330

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

****

****

FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	2.0124	0.0838
2	0.0032	0.0162
3	0.0000	0.0000
4	0.1500	0.7500
SNOW WATER	0.000	

****
****

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     C:\HLP3\BRC\BRCPREC.D4
TEMPERATURE DATA FILE:       C:\HLP3\BRC\BRCTEMP.D7
SOLAR RADIATION DATA FILE:   C:\HLP3\BRC\BRCSOLAR.D13
EVAPOTRANSPIRATION DATA:     C:\HLP3\BRC\BRCEVAP.D11
SOIL AND DESIGN DATA FILE:   C:\HLP3\BRC\BRCSOIL3.D10
OUTPUT DATA FILE:            C:\HLP3\BRC\Summary\SOIL3SUM.OUT


TIME:   8: 6     DATE:   8/31/2006


******************************************************************************

     TITLE:  BRCUnit3

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   3
          THICKNESS                    =     24.00   INCHES
          POROSITY                     =      0.4570 VOL/VOL
          FIELD CAPACITY               =      0.0830 VOL/VOL
          WILTING POINT                =      0.0330 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.1083 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.310000009000E-02 CM/SEC


                                  LAYER  2
                                  --------

                       TYPE 2 - LATERAL DRAINAGE LAYER
```

MATERIAL TEXTURE NUMBER 20

THICKNESS	=	0.20	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0122	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000	CM/SEC
SLOPE	=	2.00	PERCENT
DRAINAGE LENGTH	=	1050.0	FEET

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	0.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	0.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	4 - POOR	

LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.20	INCHES
POROSITY	=	0.7500	VOL/VOL
FIELD CAPACITY	=	0.7470	VOL/VOL
WILTING POINT	=	0.4000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000003000E-08	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 3 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 1050. FEET.

SCS RUNOFF CURVE NUMBER	=	79.10	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	1.969	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.226	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.594	INCHES
INITIAL SNOW WATER	=	0.000	INCHES

INITIAL WATER IN LAYER MATERIALS	=	2.753	INCHES
TOTAL INITIAL WATER	=	2.753	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
LAS VEGAS NEVADA

STATION LATITUDE	=	36.08	DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00	
START OF GROWING SEASON (JULIAN DATE)	=	62	
END OF GROWING SEASON (JULIAN DATE)	=	321	
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	9.10	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	39.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	21.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	24.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	36.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
0.50	0.46	0.41	0.22	0.20	0.09
0.45	0.54	0.32	0.25	0.43	0.32

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
44.60	50.10	55.30	63.50	73.30	83.60
90.30	88.00	80.10	67.60	53.60	45.40

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA
AND STATION LATITUDE = 36.08 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.33	0.45	0.33	0.26	0.29	0.07
	0.51	0.51	0.34	0.17	0.49	0.28
STD. DEVIATIONS	0.37	0.49	0.34	0.23	0.33	0.13
	0.73	0.40	0.55	0.16	0.50	0.22
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.004	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.016	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.348	0.321	0.330	0.283	0.287	0.167
	0.431	0.258	0.258	0.183	0.429	0.303
STD. DEVIATIONS	0.362	0.339	0.280	0.211	0.239	0.117
	0.712	0.199	0.316	0.125	0.489	0.260
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	0.0339	0.0402	0.0566	0.0436	0.0383	0.0330
	0.0351	0.0310	0.0438	0.0422	0.0262	0.0320
STD. DEVIATIONS	0.0305	0.0365	0.0626	0.0387	0.0309	0.0244
	0.0189	0.0193	0.0750	0.0597	0.0281	0.0211
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3						
AVERAGES	0.0010	0.0013	0.0017	0.0013	0.0011	0.0010
	0.0010	0.0009	0.0014	0.0013	0.0008	0.0010
STD. DEVIATIONS	0.0009	0.0012	0.0019	0.0012	0.0009	0.0008
	0.0006	0.0006	0.0023	0.0018	0.0009	0.0006

****

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	INCHES		CU. FEET	PERCENT
PRECIPITATION	4.04	(1.532)	14676.1	100.00
RUNOFF	0.004	(0.0159)	12.92	0.088
EVAPOTRANSPIRATION	3.598	(1.4548)	13062.02	89.002
LATERAL DRAINAGE COLLECTED FROM LAYER 2	0.45591	(0.24477)	1654.963	11.27659
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00000	(0.00000)	0.009	0.00006
AVERAGE HEAD ON TOP OF LAYER 3	0.001	(0.001)		
CHANGE IN WATER STORAGE	-0.015	(0.5598)	-53.82	-0.367

****

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	1.83	6642.900
RUNOFF	0.071	258.3089
DRAINAGE COLLECTED FROM LAYER 2	0.02685	97.45744
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 3	0.025	
MAXIMUM HEAD ON TOP OF LAYER 3	0.050	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	0.74	2687.3430

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.1937

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0330

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

****

****

FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	2.3023	0.0959
2	0.0036	0.0184
3	0.0000	0.0000
4	0.1500	0.7500
SNOW WATER	0.000	

****
****

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     C:\HLP3\BRC\BRCPREC.D4
TEMPERATURE DATA FILE:       C:\HLP3\BRC\BRCTEMP.D7
SOLAR RADIATION DATA FILE:   C:\HLP3\BRC\BRCSOLAR.D13
EVAPOTRANSPIRATION DATA:     C:\HLP3\BRC\BRCEVAP.D11
SOIL AND DESIGN DATA FILE:   C:\HLP3\BRC\BRCSOIL4.D10
OUTPUT DATA FILE:            C:\HLP3\BRC\Summary\SOIL4SUM.OUT


TIME:   8: 8     DATE:   8/31/2006


******************************************************************************

     TITLE:  BRCUnit4

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                 TYPE 1 - VERTICAL PERCOLATION LAYER
                     MATERIAL TEXTURE NUMBER   3
          THICKNESS                    =     24.00   INCHES
          POROSITY                     =      0.4570 VOL/VOL
          FIELD CAPACITY               =      0.0830 VOL/VOL
          WILTING POINT                =      0.0330 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.1083 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.310000009000E-02 CM/SEC


                                  LAYER  2
                                  --------

                 TYPE 2 - LATERAL DRAINAGE LAYER
```

MATERIAL TEXTURE NUMBER 20

THICKNESS	=	0.20	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0108	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000	CM/SEC
SLOPE	=	3.00	PERCENT
DRAINAGE LENGTH	=	550.0	FEET

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	0.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	0.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	4 - POOR	

LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.20	INCHES
POROSITY	=	0.7500	VOL/VOL
FIELD CAPACITY	=	0.7470	VOL/VOL
WILTING POINT	=	0.4000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000003000E-08	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 3 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 3.% AND A SLOPE LENGTH OF 550. FEET.

SCS RUNOFF CURVE NUMBER	=	80.00	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	1.969	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.226	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.594	INCHES
INITIAL SNOW WATER	=	0.000	INCHES

INITIAL WATER IN LAYER MATERIALS	=	2.752	INCHES
TOTAL INITIAL WATER	=	2.752	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
LAS VEGAS NEVADA

STATION LATITUDE	=	36.08	DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00	
START OF GROWING SEASON (JULIAN DATE)	=	62	
END OF GROWING SEASON (JULIAN DATE)	=	321	
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	9.10	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	39.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	21.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	24.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	36.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
0.50	0.46	0.41	0.22	0.20	0.09
0.45	0.54	0.32	0.25	0.43	0.32

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
44.60	50.10	55.30	63.50	73.30	83.60
90.30	88.00	80.10	67.60	53.60	45.40

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA
AND STATION LATITUDE = 36.08 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.33	0.45	0.33	0.26	0.29	0.07
	0.51	0.51	0.34	0.17	0.49	0.28
STD. DEVIATIONS	0.37	0.49	0.34	0.23	0.33	0.13
	0.73	0.40	0.55	0.16	0.50	0.22
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.004	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.020	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.346	0.320	0.328	0.281	0.286	0.166
	0.431	0.257	0.256	0.178	0.422	0.296
STD. DEVIATIONS	0.363	0.338	0.284	0.211	0.239	0.117
	0.712	0.200	0.317	0.117	0.493	0.264
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	0.0366	0.0424	0.0505	0.0443	0.0435	0.0330
	0.0351	0.0297	0.0463	0.0576	0.0407	0.0411
STD. DEVIATIONS	0.0305	0.0358	0.0484	0.0353	0.0389	0.0219
	0.0174	0.0174	0.0748	0.0683	0.0377	0.0284
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3						
AVERAGES	0.0004	0.0005	0.0005	0.0005	0.0005	0.0004
	0.0004	0.0003	0.0005	0.0006	0.0004	0.0004
STD. DEVIATIONS	0.0003	0.0004	0.0005	0.0004	0.0004	0.0002
	0.0002	0.0002	0.0008	0.0007	0.0004	0.0003

****

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	INCHES		CU. FEET	PERCENT
PRECIPITATION	4.04	(1.532)	14676.1	100.00
RUNOFF	0.004	(0.0199)	16.14	0.110
EVAPOTRANSPIRATION	3.567	(1.4731)	12948.16	88.226
LATERAL DRAINAGE COLLECTED FROM LAYER 2	0.50090	(0.25564)	1818.280	12.38940
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00000	(0.00000)	0.008	0.00006
AVERAGE HEAD ON TOP OF LAYER 3	0.000	(0.000)		
CHANGE IN WATER STORAGE	-0.029	(0.5316)	-106.49	-0.726

****

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	1.83	6642.900
RUNOFF	0.089	322.7272
DRAINAGE COLLECTED FROM LAYER 2	0.02705	98.20731
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 3	0.009	
MAXIMUM HEAD ON TOP OF LAYER 3	0.004	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	436.3 FEET	
SNOW WATER	0.74	2687.3430

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.1927
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0330

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

****

****

FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	2.0124	0.0838
2	0.0031	0.0157
3	0.0000	0.0000
4	0.1500	0.7500
SNOW WATER	0.000	

****
****

```
**************************************************************************
**************************************************************************
**                                                                      **
**                                                                      **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE           **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)            **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY               **
**                    USAE WATERWAYS EXPERIMENT STATION                 **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY          **
**                                                                      **
**                                                                      **
**************************************************************************
**************************************************************************


PRECIPITATION DATA FILE:     C:\HLP3\BRC\BRCPREC.D4
TEMPERATURE DATA FILE:       C:\HLP3\BRC\BRCTEMP.D7
SOLAR RADIATION DATA FILE:   C:\HLP3\BRC\BRCSOLAR.D13
EVAPOTRANSPIRATION DATA:     C:\HLP3\BRC\BRCEVAP.D11
SOIL AND DESIGN DATA FILE:   C:\HLP3\BRC\BRCSOIL5.D10
OUTPUT DATA FILE:            C:\HLP3\BRC\Summary\SOIL5SUM.OUT


TIME:   8:10     DATE:   8/31/2006


**************************************************************************

     TITLE:  BRCUnit5

**************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                LAYER  1
                                --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   3
          THICKNESS                    =     24.00   INCHES
          POROSITY                     =      0.4570 VOL/VOL
          FIELD CAPACITY               =      0.0830 VOL/VOL
          WILTING POINT                =      0.0330 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.1083 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.310000009000E-02 CM/SEC


                                LAYER  2
                                --------

                     TYPE 2 - LATERAL DRAINAGE LAYER
```

MATERIAL TEXTURE NUMBER 20

THICKNESS	=	0.20	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0109	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000	CM/SEC
SLOPE	=	3.00	PERCENT
DRAINAGE LENGTH	=	675.0	FEET

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	0.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	0.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	4 - POOR	

LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.20	INCHES
POROSITY	=	0.7500	VOL/VOL
FIELD CAPACITY	=	0.7470	VOL/VOL
WILTING POINT	=	0.4000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000003000E-08	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 3 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 3.% AND A SLOPE LENGTH OF 675. FEET.

SCS RUNOFF CURVE NUMBER	=	79.80	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	1.969	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.226	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.594	INCHES
INITIAL SNOW WATER	=	0.000	INCHES

INITIAL WATER IN LAYER MATERIALS	=	2.752	INCHES
TOTAL INITIAL WATER	=	2.752	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
LAS VEGAS NEVADA

STATION LATITUDE	=	36.08	DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00	
START OF GROWING SEASON (JULIAN DATE)	=	62	
END OF GROWING SEASON (JULIAN DATE)	=	321	
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	9.10	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	39.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	21.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	24.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	36.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
0.50	0.46	0.41	0.22	0.20	0.09
0.45	0.54	0.32	0.25	0.43	0.32

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
44.60	50.10	55.30	63.50	73.30	83.60
90.30	88.00	80.10	67.60	53.60	45.40

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA
AND STATION LATITUDE = 36.08 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.33	0.45	0.33	0.26	0.29	0.07
	0.51	0.51	0.34	0.17	0.49	0.28
STD. DEVIATIONS	0.37	0.49	0.34	0.23	0.33	0.13
	0.73	0.40	0.55	0.16	0.50	0.22
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.004	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.019	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.346	0.319	0.330	0.284	0.286	0.166
	0.430	0.257	0.256	0.180	0.424	0.301
STD. DEVIATIONS	0.363	0.338	0.282	0.210	0.239	0.117
	0.712	0.200	0.317	0.127	0.487	0.260
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	0.0366	0.0449	0.0524	0.0395	0.0416	0.0328
	0.0349	0.0303	0.0463	0.0541	0.0359	0.0383
STD. DEVIATIONS	0.0302	0.0391	0.0487	0.0306	0.0372	0.0217
	0.0181	0.0189	0.0756	0.0669	0.0312	0.0257
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3						
AVERAGES	0.0005	0.0006	0.0007	0.0005	0.0005	0.0004
	0.0004	0.0004	0.0006	0.0007	0.0005	0.0005
STD. DEVIATIONS	0.0004	0.0006	0.0006	0.0004	0.0005	0.0003
	0.0002	0.0002	0.0010	0.0009	0.0004	0.0003

****

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	INCHES		CU. FEET	PERCENT
PRECIPITATION	4.04	(1.532)	14676.1	100.00
RUNOFF	0.004	(0.0190)	15.38	0.105
EVAPOTRANSPIRATION	3.580	(1.4744)	12994.72	88.543
LATERAL DRAINAGE COLLECTED FROM LAYER 2	0.48768	(0.24897)	1770.263	12.06223
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00000	(0.00000)	0.008	0.00006
AVERAGE HEAD ON TOP OF LAYER 3	0.001	(0.000)		
CHANGE IN WATER STORAGE	-0.029	(0.5295)	-104.28	-0.711

****

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	1.83	6642.900
RUNOFF	0.085	307.6796
DRAINAGE COLLECTED FROM LAYER 2	0.02719	98.70956
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 3	0.011	
MAXIMUM HEAD ON TOP OF LAYER 3	0.022	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	0.74	2687.3430

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.1929

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0330

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

****

****

FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	2.0231	0.0843
2	0.0046	0.0232
3	0.0000	0.0000
4	0.1500	0.7500
SNOW WATER	0.000	

****
****

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     C:\HLP3\BRC\BRCPREC.D4
TEMPERATURE DATA FILE:       C:\HLP3\BRC\BRCTEMP.D7
SOLAR RADIATION DATA FILE:   C:\HLP3\BRC\BRCSOLAR.D13
EVAPOTRANSPIRATION DATA:     C:\HLP3\BRC\BRCEVAP.D11
SOIL AND DESIGN DATA FILE:   C:\HLP3\BRC\BRCSOILa.D10
OUTPUT DATA FILE:            C:\HLP3\BRC\Summary\SOILASUM.OUT


TIME:   8:11     DATE:   8/31/2006


******************************************************************************

     TITLE:  BRCUnitA

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   3
          THICKNESS                    =     24.00   INCHES
          POROSITY                     =      0.4570 VOL/VOL
          FIELD CAPACITY               =      0.0830 VOL/VOL
          WILTING POINT                =      0.0330 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.0565 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.310000009000E-02 CM/SEC


                                  LAYER  2
                                  --------

                     TYPE 2 - LATERAL DRAINAGE LAYER
```

MATERIAL TEXTURE NUMBER 20

THICKNESS	=	0.20	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0101	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000	CM/SEC
SLOPE	=	48.00	PERCENT
DRAINAGE LENGTH	=	100.0	FEET

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	0.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	0.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	4 - POOR	

LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.20	INCHES
POROSITY	=	0.7500	VOL/VOL
FIELD CAPACITY	=	0.7470	VOL/VOL
WILTING POINT	=	0.4000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000003000E-08	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 3 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 48.% AND A SLOPE LENGTH OF 100. FEET.

SCS RUNOFF CURVE NUMBER	=	83.20	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	0.594	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.226	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.594	INCHES
INITIAL SNOW WATER	=	0.000	INCHES

INITIAL WATER IN LAYER MATERIALS	=	1.507	INCHES
TOTAL INITIAL WATER	=	1.507	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
LAS VEGAS NEVADA

STATION LATITUDE	=	36.08	DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00	
START OF GROWING SEASON (JULIAN DATE)	=	62	
END OF GROWING SEASON (JULIAN DATE)	=	321	
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	9.10	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	39.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	21.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	24.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	36.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
0.50	0.46	0.41	0.22	0.20	0.09
0.45	0.54	0.32	0.25	0.43	0.32

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
44.60	50.10	55.30	63.50	73.30	83.60
90.30	88.00	80.10	67.60	53.60	45.40

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA
AND STATION LATITUDE = 36.08 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.33	0.45	0.33	0.26	0.29	0.07
	0.51	0.51	0.34	0.17	0.49	0.28
STD. DEVIATIONS	0.37	0.49	0.34	0.23	0.33	0.13
	0.73	0.40	0.55	0.16	0.50	0.22
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.005	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.022	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.018	0.015	0.009	0.010	0.008	0.002
	0.036	0.006	0.008	0.003	0.016	0.019
STD. DEVIATIONS	0.041	0.037	0.017	0.026	0.013	0.004
	0.094	0.008	0.018	0.003	0.033	0.040
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	0.3228	0.4337	0.3217	0.2672	0.2977	0.1287
	0.4109	0.4867	0.3369	0.2050	0.4156	0.2610
STD. DEVIATIONS	0.3156	0.3623	0.2745	0.1676	0.2297	0.0926
	0.6111	0.3682	0.4862	0.1405	0.4363	0.1747
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3						
AVERAGES	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000
	0.0001	0.0001	0.0001	0.0000	0.0001	0.0000
STD. DEVIATIONS	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000
	0.0001	0.0001	0.0001	0.0000	0.0001	0.0000

****

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	INCHES		CU. FEET	PERCENT
PRECIPITATION	4.04	(1.532)	14676.1	100.00
RUNOFF	0.005	(0.0223)	18.10	0.123
EVAPOTRANSPIRATION	0.149	(0.1470)	539.37	3.675
LATERAL DRAINAGE COLLECTED FROM LAYER 2	3.88799	(1.37123)	14113.411	96.16602
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00000	(0.00000)	0.009	0.00006
AVERAGE HEAD ON TOP OF LAYER 3	0.000	(0.000)		
CHANGE IN WATER STORAGE	0.001	(0.1516)	5.20	0.035

****

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	1.83	6642.900
RUNOFF	0.100	361.7648
DRAINAGE COLLECTED FROM LAYER 2	0.95379	3462.24854
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 3	0.005	
MAXIMUM HEAD ON TOP OF LAYER 3	0.007	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	0.74	2687.3430

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.0406

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0330

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

****

****

FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	1.3840	0.0577
2	0.0020	0.0101
3	0.0000	0.0000
4	0.1500	0.7500
SNOW WATER	0.000	

****
****

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     C:\HLP3\BRC\BRCPREC.D4
TEMPERATURE DATA FILE:       C:\HLP3\BRC\BRCTEMP.D7
SOLAR RADIATION DATA FILE:   C:\HLP3\BRC\BRCSOLAR.D13
EVAPOTRANSPIRATION DATA:     C:\HLP3\BRC\BRCEVAP.D11
SOIL AND DESIGN DATA FILE:   C:\HLP3\BRC\BRCSOILB.D10
OUTPUT DATA FILE:            C:\HLP3\BRC\Summary\SOILBSUM.OUT


TIME:   8:14     DATE:   8/31/2006


******************************************************************************

     TITLE:  BRCUnitB

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   3
          THICKNESS                    =     24.00   INCHES
          POROSITY                     =      0.4570 VOL/VOL
          FIELD CAPACITY               =      0.0830 VOL/VOL
          WILTING POINT                =      0.0330 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.0565 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.310000009000E-02 CM/SEC


                                  LAYER  2
                                  --------

                       TYPE 2 - LATERAL DRAINAGE LAYER
```

MATERIAL TEXTURE NUMBER 20

THICKNESS	=	0.20	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0100	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000	CM/SEC
SLOPE	=	48.00	PERCENT
DRAINAGE LENGTH	=	75.0	FEET

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	0.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	0.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	4 - POOR	

LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.20	INCHES
POROSITY	=	0.7500	VOL/VOL
FIELD CAPACITY	=	0.7470	VOL/VOL
WILTING POINT	=	0.4000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000003000E-08	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 3 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 48.% AND A SLOPE LENGTH OF 75. FEET.

SCS RUNOFF CURVE NUMBER	=	83.40	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	0.594	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.226	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.594	INCHES
INITIAL SNOW WATER	=	0.000	INCHES

INITIAL WATER IN LAYER MATERIALS	=	1.507	INCHES
TOTAL INITIAL WATER	=	1.507	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
LAS VEGAS NEVADA

STATION LATITUDE	=	36.08	DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00	
START OF GROWING SEASON (JULIAN DATE)	=	62	
END OF GROWING SEASON (JULIAN DATE)	=	321	
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	9.10	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	39.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	21.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	24.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	36.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
0.50	0.46	0.41	0.22	0.20	0.09
0.45	0.54	0.32	0.25	0.43	0.32

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
44.60	50.10	55.30	63.50	73.30	83.60
90.30	88.00	80.10	67.60	53.60	45.40

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA
AND STATION LATITUDE = 36.08 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.33	0.45	0.33	0.26	0.29	0.07
	0.51	0.51	0.34	0.17	0.49	0.28
STD. DEVIATIONS	0.37	0.49	0.34	0.23	0.33	0.13
	0.73	0.40	0.55	0.16	0.50	0.22
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.005	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.023	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.018	0.015	0.009	0.010	0.008	0.002
	0.036	0.006	0.007	0.003	0.016	0.019
STD. DEVIATIONS	0.041	0.037	0.017	0.026	0.013	0.004
	0.094	0.008	0.015	0.003	0.033	0.040
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	0.3226	0.4341	0.3212	0.2677	0.2978	0.1285
	0.4111	0.4865	0.3374	0.2053	0.4149	0.2614
STD. DEVIATIONS	0.3153	0.3621	0.2753	0.1679	0.2298	0.0927
	0.6112	0.3682	0.4889	0.1407	0.4363	0.1748
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3						
AVERAGES	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0001	0.0000	0.0001	0.0000	0.0001	0.0000

****

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	INCHES		CU. FEET	PERCENT
PRECIPITATION	4.04	(1.532)	14676.1	100.00
RUNOFF	0.005	(0.0235)	19.05	0.130
EVAPOTRANSPIRATION	0.148	(0.1460)	537.00	3.659
LATERAL DRAINAGE COLLECTED FROM LAYER 2	3.88839	(1.37242)	14114.859	96.17588
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00000	(0.00000)	0.009	0.00006
AVERAGE HEAD ON TOP OF LAYER 3	0.000	(0.000)		
CHANGE IN WATER STORAGE	0.001	(0.1520)	5.16	0.035

****

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	1.83	6642.900
RUNOFF	0.105	380.3883
DRAINAGE COLLECTED FROM LAYER 2	0.91576	3324.21558
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 3	0.005	
MAXIMUM HEAD ON TOP OF LAYER 3	0.005	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	0.74	2687.3430

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.0397

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0330

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

****

****

FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	1.3838	0.0577
2	0.0020	0.0101
3	0.0000	0.0000
4	0.1500	0.7500
SNOW WATER	0.000	

****
****

RC
SAN

Table VI Values of n for use with Manning Equation

Surface	n. Range	n, design
Polyethylene pipe	0.008-0.011	0.009 *
Uncoated cast or ductile iron pipe	0.012-0.015	0.013
Corrugated steel pipe	0.021-0.030	0.024
Concrete pipe	0.012-0.016	0.015
Vitrified clay pipe	0.011-0.017	0.013
Brick & cement mortar sewers	0.012-0.017	0.015
Wood stave	0.010-0.013	0.011
Rubble masonry	0.017-0.030	0.021

Some gravity flow piping systems may become very complex, especially if the pipeline grade varies, because friction loss will vary along the run. With a varying grade, parts of the line may develop internal pressure, or vacuum, and may have varying liquid levels in the bore.

Manning

For open channel water flow under conditions of constant grade, and uniform channel cross section, the Manning equation may be used. Open channel flow exists in a pipe when it runs partially full. Like the Hazen-Williams formula, the Manning equation is limited to water or liquids with a kinematic viscosity equal to water.

Manning Equation **(20)**

$$V = \frac{1.486}{n} r^{2/3} S^{1/2}$$

where

V = flow velocity, ft/sec
n = roughness coefficient, dimensionless
r = hydraulic radius, ft

$$r = \frac{A}{P} \quad * \quad (21)$$

A = channel cross section area, ft^2
P = perimeter wetted by flow, ft
S = hydraulic slope, ft/ft

$$S = \frac{h_1 - h_2}{L} = \frac{h_f}{L} \quad (22)$$

h_1 = upstream pipe elevation, ft
h_2 = downstream pipe elevation, ft
h_f = friction loss, ft of liquid

It is convenient to combine the Manning equation with

$$Q = A V \quad (23)$$

to obtain

$$Q = \frac{1.486A}{n} r^{2/3} S^{1/2} \quad * \quad (24)$$

where terms are as defined above, and

Q = flow, ft^3/secWhen a circular pipe is running full or half-full,

$$r = \frac{D}{4} = \frac{d}{48} \quad (25)$$

ATTACHMENT B, 1/1

CHEVRON PLEXCO/SAROLITE ENGINEERING MANUAL

Driscopipe 1000 Series Industrial Pipe: Sizes and Dimensions

Nom. Size, in.	Dimensions, inches OD	Min.Wall	DR	$P_{73.4°F}$ psig	Weight lb/100ft
3/4	1.050	0.095	11.0	160	12
1	1.315	0.120	11.0	160	19
1 3/4	1.660	0.151	11.0	160	31
1 1/2	1.900	0.173	11.0	160	41

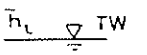
Nom. Size, in.	Dimensions, in. OD	Min.Wall	DR	$P_{73.4°F}$ psig	Weight lb/100ft
2	2.375	0.339	7.0	267	94
2	2.375	0.264	9.0	200	76
2	2.375	0.216	11.0	160	64
2	2.375	0.176	13.5	128	53
2	2.375	0.140	17.0	100	43
3	3.500	0.500	7.0	267	205
3	3.500	0.389	9.0	200	166
3	3.500	0.318	11.0	160	139
3	3.500	0.259	13.5	128	115
3	3.500	0.206	17.0	100	93
3	3.500	0.167	21.0	80	77
3	3.500	0.135	26.0	64	62
4	4.500	0.643	7.0	267	339
4	4.500	0.500	9.0	200	274
4	4.500	0.409	11.0	160	229
4	4.500	0.333	13.5	128	190
4	4.500	0.265	17.0	100	154
4	4.500	0.214	21.0	80	126
4	4.500	0.173	26.0	64	103
4	4.500	0.138	32.5	51	83
5	5.563	0.795	7.0	267	517
5	5.563	0.618	9.0	200	418
5	5.563	0.506	11.0	160	351
5	5.563	0.412	13.5	128	291
5	5.563	0.327	17.0	100	235
5	5.563	0.265	21.0	80	193
5	5.563	0.214	26.0	64	157
5	5.563	0.171	32.5	51	127
5.375	5.375	0.316	17.0	100	220
5.375	5.375	0.256	21.0	80	180
5.375	5.375	0.207	26.0	64	147
5.375	5.375	0.165	32.5	51	118
6	6.625	0.946	7.0	267	733
6	6.625	0.736	9.0	200	593
6	6.625	0.602	11.0	160	497
6	6.625	0.491	13.5	128	413
6	6.625	0.390	17.0	100	334
6	6.625	0.315	21.0	80	273
6	6.625	0.255	26.0	64	223
6	6.625	0.204	32.5	51	180

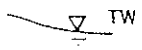
Nom. Size, in.	Dimensions, in. OD	Min.Wall	DR	$P_{73.4°F}$ psig	Wei lb/
7	7.125	1.018	7.0	267	84
7	7.125	0.792	9.0	200	6
7	7.125	0.648	11.0	160	5
7	7.125	0.528	13.5	128	4
7	7.125	0.420	17.0	100	3
7	7.125	0.340	21.0	80	3
7	7.125	0.274	26.0	64	2
7	7.125	0.220	32.5	51.0	2
8	8.625	1.232	7.0	267	12
8	8.625	0.958	9.0	200	10
8	8.625	0.784	11.0	160	8
8	8.625	0.639	13.5	128	7
8	8.625	0.507	17.0	100	5
8	8.625	0.411	21.0	80	4
8	8.625	0.332	26.0	64	3
8	8.625	0.255	32.5	51	3
10	10.750	1.536	7.0	267	19
10	10.750	1.194	9.0	200	15
10	10.750	0.977	11.0	160	13
10	10.750	0.796	13.5	128	10
10	10.750	0.632	17.0	100	8
10	10.750	0.512	21.0	80	7
10	10.750	0.413	26.0	64	5
10	10.750	0.331	32.5	51	4
12	12.750	1.821	7.0	267	27
12	12.750	1.417	9.0	200	21
12	12.750	1.159	11.0	160	18
12	12.750	0.944	13.5	128	15
12	12.750	0.750	17.0	100	12
12	12.750	0.607	21.0	80	10
12	12.750	0.490	26.0	64	8
12	12.750	0.392	32.5	51	6
14	14.000	2.000	7.0	267	32
14	14.000	1.556	9.0	200	26
14	14.000	1.273	11.0	160	22
14	14.000	1.037	13.5	128	18
14	14.000	0.824	17.0	100	14
14	14.000	0.667	21.0	80	12
14	14.000	0.538	26.0	64	9
14	14.000	0.431	32.5	51	8
16	16.000	2.286	7.0	267	42
16	16.000	1.778	9.0	200	34
16	16.000	1.455	11.0	160	29
16	16.000	1.185	13.5	128	24
16	16.000	0.941	17.0	100	19
16	16.000	0.762	21.0	80	15
16	16.000	0.615	26.0	64	13
16	16.000	0.492	32.5	51	10

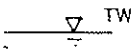
RC
SMM

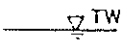
raulic conditions are dis-

the result of inadequate
ert discharge is primarily
and the head loss of the
ulvert flow can be treated
culvert. h_L, is the sum of









verts.

an entrance loss, h_{ent}, friction loss, h_f, and the
barrel.

$$h_L = h_{ent} + h_f + \frac{V^2}{2g}$$

Substituting Equations (3.32) and (3.16) for h_{ent} and h_f, respectively, we have

$$h_L = k_{ent}\left(\frac{V^2}{2g}\right) + \frac{n^2V^2L}{R_h^{4/3}} + \frac{V^2}{2g} \tag{8.17}$$

The entrance coefficient, k_{ent}, is approximately 0.5 for a square-edged entrance and approximately 0.1 for a well-rounded entrance. Common values used for the Manning's roughness coefficient are $n = 0.012$ for concrete pipe and $n = 0.024$ for corrugated steel pipe. Equation (8.17) may be rearranged to express the direct relationship between the discharge and the dimensions of the culvert at any given elevation difference, h_L, between tail water and head water. For a circular culvert,

$$h_L = \left[K_{ent} + \left(\frac{n^2L}{R_h^{4/3}}\right)(2g) + 1\right]\frac{8Q^2}{\pi^2gD^4} \tag{8.18}$$

where Q is the discharge, D is the diameter, and R_h is the hydraulic radius ($R_h = D/4$) of the culvert barrel. For culverts with noncircular cross sections, the head loss may be calculated by Equation (8.17) with the corresponding hydraulic radius calculated by using the cross-sectional area, A, and the wetted perimeter, P.

2. If the discharge carried in a culvert has a normal depth that is larger than the barrel height, the culvert will flow full even if the tail water level drops below that of the outlet. In this case, the discharge is controlled by the head loss and the level of the head water (HW). The hydraulics are the same as discussed before.
3. If the normal depth is less than the barrel height, with the inlet submerged and free discharge at the outlet, a partially full pipe flow condition will normally result, as illustrated in Figure 8.17(c). The culvert discharge is controlled by the entrance condition, and the flow is said to be under *entrance* control. The discharge can be calculated by

$$Q = C_dA\sqrt{2gh} \tag{8.19}$$

where h is the hydrostatic head above the center of the orifice and A is the cross-sectional area. C_d is the coefficient of discharge; common

HWANG "FUNDAMENTALS OF HYDRAULIC ENGINEERING SYSTEMS"
2nd EDITION, PRENTICE-HALL, 1987

ATTACHMENT D 1/2

values used in practice are $C_d = 0.62$ for a square-edged entrance and $C_d = 1.0$ for a well-rounded entrance.

4. When the hydrostatic head at the entrance is less than $1.2D$, air will break into the barrel and the culvert will flow under no pressure. In this case, the culvert slope and the barrel wall friction determine the flow condition in the culvert for open channel flow. Due to a sudden reduction of the water area at the entrance, the flow usually enters the culvert in a supercritical condition. The critical depth takes place at the entrance of the barrel. The friction of the barrel wall gradually dissipates the energy. If the rate of dissipation is higher than the flow could gain from the barrel slope, the depth of the flowing water will increase in the downstream direction. Depending on the tail water level, the supercritical flow may convert to subcritical flow through a hydraulic jump. The flow conditions can be computed by applying the water surface profiles developed for open channels.

Example 8.4

A corrugated steel pipe is used as a culvert that must carry a flow rate of 5.3 m^3/sec and discharge into the air. At the entrance, the maximum available water head is 3.2 m above the bottom as shown in Figure 8.18. The culvert is 35 m long and has a square-edged entrance and slope of 0.003. Determine the diameter of the pipe.

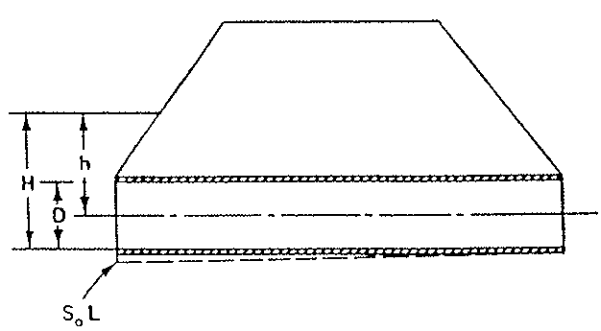


Figure 8.18

Solution

(a) Allowing full pipe flow, the energy balance of the culvert flow may be expressed as (see Figure 8.18),

$$h_L = H - D + S_o L = 3.2 - D + 0.003 \cdot 35$$
$$= 3.305 - D$$

where D is the diameter of the pipe. Also, from Equation (8.18), we have,

ATTACHMENT D, 2/2

The U.S. Bureau of Reclamation (1973) uses the following criterion for grain size of filter materials in relation to openings in pipes:

$$\frac{D_{85} \text{ of the filter nearest the pipe}}{\text{maximum opening of pipe drain}} = 2 \text{ or more} \tag{5.6}$$

Equations 5.4, 5.5, and 5.6 represent a reasonable range over which satisfactory performance can be expected.

An important development in the manufacture of drainage pipes is the slotted PVC pipe (Cedergren, 1987) which has slots machined to specified widths from a minimum of 0.010 in. (0.25 mm) up to 0.10 in. (2.54 mm) or larger. Figure 5.3 shows a PVC pipe 6 in. (15.2 cm) in diameter with sawed slots of uniform size. Close control over the width of the slots ensures free flow of water into the pipe without danger of clogging with soil when the slotwidths have been correctly established with Eq. 5.4.

5.3 EXAMPLES OF FILTER DESIGNS TO PREVENT PIPING

Historical

Before the development of rational and experimental filter design criteria drain design was considered more of an art than a science. Designers depended on judgment, instinct, or precedent. In many instances coarse stone or gravel was placed in direct contact with fine-grained soils with the result that drains often became clogged or soil piped through them, thus causing structural failures.

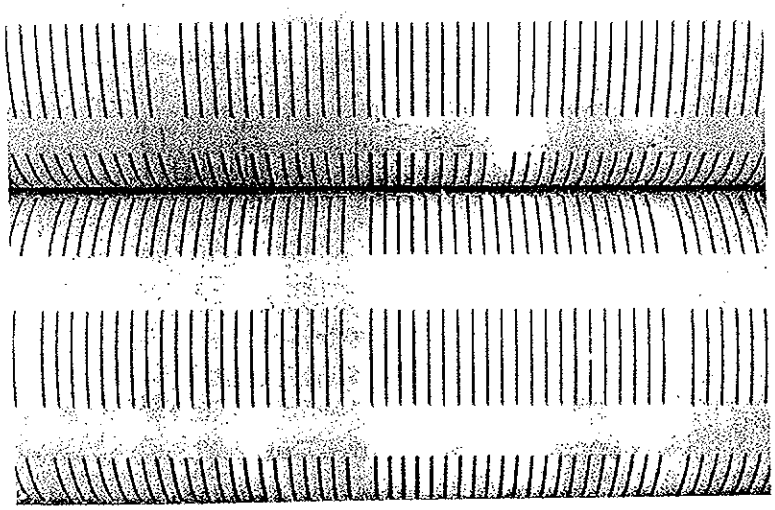
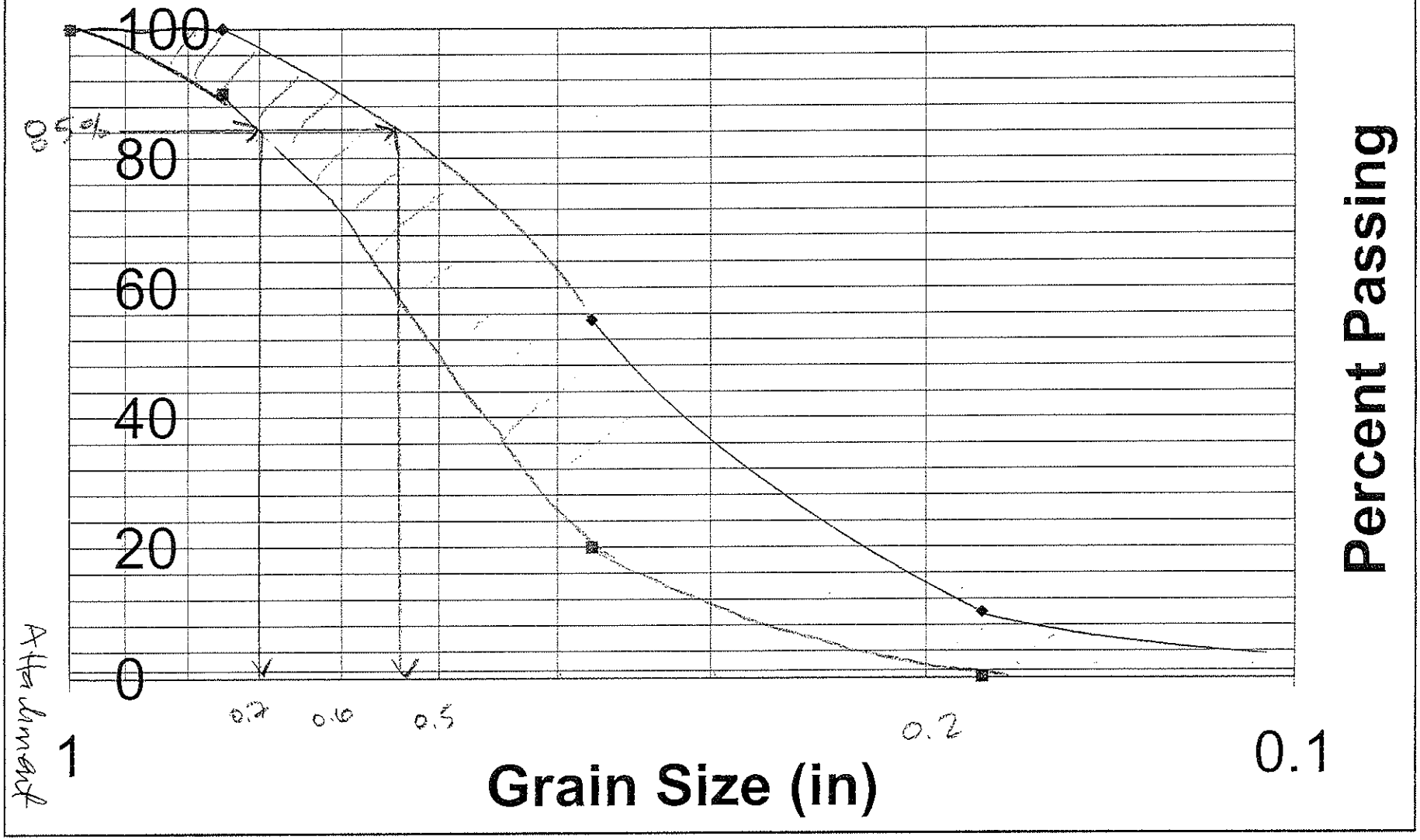


FIG. 5.3 Slotted PVC drain pipe 6-in. in diameter. Machined slots of uniform width provide good filter protection.

Attachment E
1/1

Gradation, AASHTO 67



LIBRARY COPY

STANDARD SPECIFICATIONS

for

TRANSPORTATION MATERIALS

and

METHODS OF SAMPLING AND TESTING

Seventeenth Edition

1995

PART I SPECIFICATIONS

Adopted by the

AMERICAN ASSOCIATION OF STATE HIGHWAY
AND TRANSPORTATION OFFICIALS

AH. F
2/4

Standard Specification
for

Sizes of Aggregate for Road and Bridge Construction

AASHTO DESIGNATION: M 43-88
(ASTM DESIGNATION: D 448-86)

1. SCOPE

1.1 This specification defines aggregate size designations and ranges in mechanical analyses for standard sizes of coarse aggregate and screenings for use in the construction and maintenance of various types of highways and bridges.

1.2 The values stated in SI units are to be regarded as the standard.

2. REFERENCED DOCUMENTS

2.1 *AASHTO Standards:*

T 27	Sieve Analysis of Fine and Coarse Aggregates
T 2	Sampling Aggregates
M 92	Wire-Cloth Sieves for Testing Purposes

3. SIGNIFICANCE AND USE

3.1 Contract documents may specify certain of these aggregate sizes for specific uses or may suggest one or more of these sizes as appropriate for the preparation of various end-product mixtures. In some cases, closer limits on variability of the aggregate grading may be required.

4. MANUFACTURE

4.1 The standard sizes of aggregate described in this classification may be manufactured by means of any suitable process used to separate raw material into the desired size ranges. Standard sizes may also be produced by blending two or more different components.

5. STANDARD SIZES

5.1 Standard sizes of coarse aggregate shall comply with the sizes given in Table 1. All sizes shall be determined by means of laboratory sieves having square openings and conforming to M 92.

6. BASIS OF CLASSIFICATION

6.1 Classification is based npon the size number and size ranges shown in Table 1 with the aggregate sampled in accordance with T 2 and tested for grading by T 27.

AH. F
3/4

TABLE 1 Standard Sizes of Processed Aggregate

Size Number	Nominal Size, Square Openings	Amounts Finer than Each Laboratory Sieve (Square Openings), Mass Percent														
		100-mm (4-in.)	90-mm (3½-in.)	75-mm (3-in.)	63-mm (2½-in.)	50-mm (2-in.)	37.5-mm (1½-in.)	25.0-mm (1-in.)	19.0-mm (¾-in.)	12.5-mm (½-in.)	9.5-mm (⅜-in.)	4.75-mm (No. 4)	2.36-mm (No. 8)	1.18-mm (No. 16)	300-µm (No. 50)	150-µm (No. 100)
1	90 to 37.5-mm (3½ to 1½-in.)	100	90 to 100	—	25 to 60	—	0 to 15	—	0 to 5	—	—	—	—	—	—	—
2	63 to 37.5-mm (2½ to 1½-in.)	—	—	100	90 to 100	35 to 70	0 to 15	—	0 to 5	—	—	—	—	—	—	—
24	63 to 19.0-mm (2½ to ¾-in.)	—	—	100	90 to 100	—	25 to 60	—	0 to 10	0 to 5	—	—	—	—	—	—
3	50 to 25.0-mm (2 to 1-in.)	—	—	—	100	90 to 100	35 to 70	0 to 15	—	0 to 5	—	—	—	—	—	—
357	50 to 4.75-mm (2-in. to No. 4)	—	—	—	100	95 to 100	—	35 to 70	—	10 to 30	—	0 to 5	—	—	—	—
4	37.5 to 19.0-mm (1½ to ¾-in.)	—	—	—	—	100	90 to 100	20 to 55	0 to 15	—	0 to 5	—	—	—	—	—
467	37.5 to 4.75-mm (1½ to No. 4)	—	—	—	—	100	95 to 100	—	35 to 70	—	10 to 30	0 to 5	—	—	—	—
5	25.0 to 12.5-mm (1 to ½-in.)	—	—	—	—	—	100	90 to 100	20 to 55	0 to 10	0 to 5	—	—	—	—	—
56	25.0 to 9.5-mm (1 to ⅜-in.)	—	—	—	—	—	100	90 to 100	40 to 85	10 to 40	0 to 15	0 to 5	—	—	—	—
57	25.0 to 4.75-mm (1 to No. 4)	—	—	—	—	—	100	95 to 100	—	25 to 60	—	0 to 10	0 to 5	—	—	—
6	19.0 to 9.5-mm (¾ to ⅜-in.)	—	—	—	—	—	—	100	90 to 100	20 to 55	0 to 15	0 to 5	—	—	—	—
67	19.0 to 4.75-mm (¾ to No. 4)	—	—	—	—	—	—	100	90 to 100	—	20 to 55	0 to 10	0 to 5	—	—	—
68	19.0 to 2.36-mm (¾ to No. 8)	—	—	—	—	—	—	100	90 to 100	—	30 to 65	5 to 25	0 to 10	0 to 5	—	—
7	12.5 to 4.75-mm (½ to No. 4)	—	—	—	—	—	—	—	100	90 to 100	40 to 70	0 to 15	0 to 5	—	—	—
78	12.5 to 2.36-mm (½ to No. 8)	—	—	—	—	—	—	—	100	90 to 100	40 to 75	5 to 25	0 to 10	0 to 5	—	—
8	9.5 to 2.36-mm (⅜ to No. 8)	—	—	—	—	—	—	—	—	100	85 to 100	10 to 30	0 to 10	0 to 5	—	—
89	9.5 to 1.18-mm (⅜ to No. 16)	—	—	—	—	—	—	—	—	100	90 to 100	20 to 55	5 to 30	0 to 10	0 to 5	—
9	4.75 to 1.18-mm (No. 4 to No. 16)	—	—	—	—	—	—	—	—	—	100	85 to 100	10 to 40	0 to 10	0 to 5	—
10	4.75-mm (No. 4 to 0)[A]	—	—	—	—	—	—	—	—	—	100	85 to 100	—	—	—	10 to 30

[A] Screenings.

AH. F
4/4

Exploration Location	Depth (feet)	Soil Description	Percent Sodium	Percent Sulfate	Total Available Water Soluble sodium Sulfate (%)
B-5	10-15	Silty sand with gravel	0.07	0.13	0.20
B-8	19-20	Silty sand with gravel	0.07	0.06	0.08
B-101	5-10	Silty sand with gravel	0.17	0.06	0.08
B-102	0-5	Fill – Silty sand with gravel	0.17	0.03	0.05
B-106	0-5	Silty sand with gravel	0.15	0.08	0.12
B-106	29-30	Silty sand with gravel	0.15	0.06	0.08

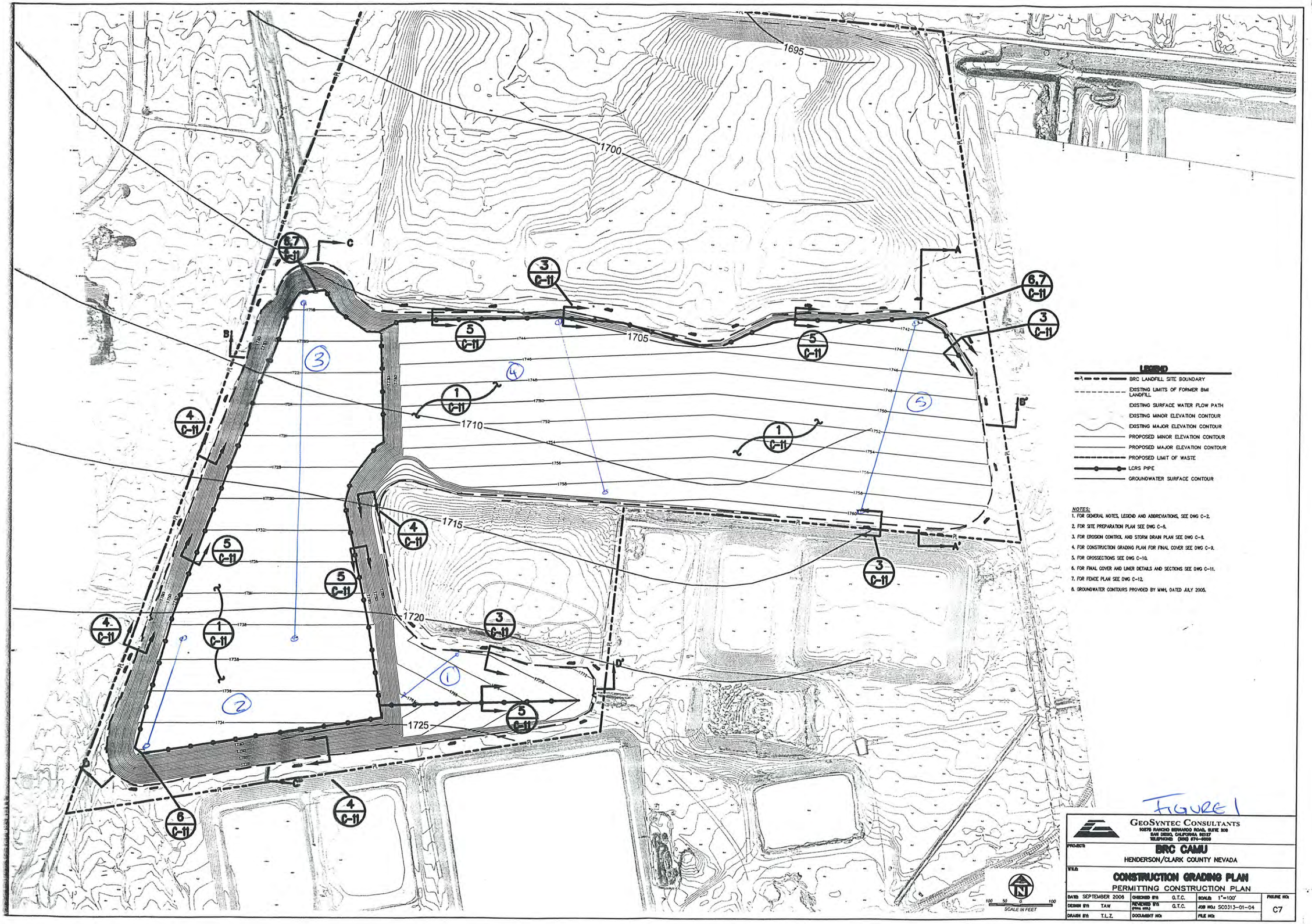
Permeability

Falling head permeability tests were conducted on remolded samples in general accordance with modified ASTM procedure D2434. The soil was compacted in a mold 4.6 inches long and 4.0 inches in diameter to 85 or 90 percent of maximum dry density and at optimum moisture content. A falling head was applied to the sample and the flow of water through the sample was monitored. The permeability was calculated after the flow rate had stabilized. The result of the falling head permeability test is presented in the following table:

Exploration Location	Sample Depth (Feet)	Soil Description	k (cm/s)
B-5	20-25	Silty sand with gravel	5.3×10^{-4}
B-12	10-15	Silty sand with gravel	4.0×10^{-4}
B-102	20-25	Silty sand with gravel	1.0×10^{-4}
B-105	20-25	Well graded sand with silt and gravel	1.2×10^{-3}

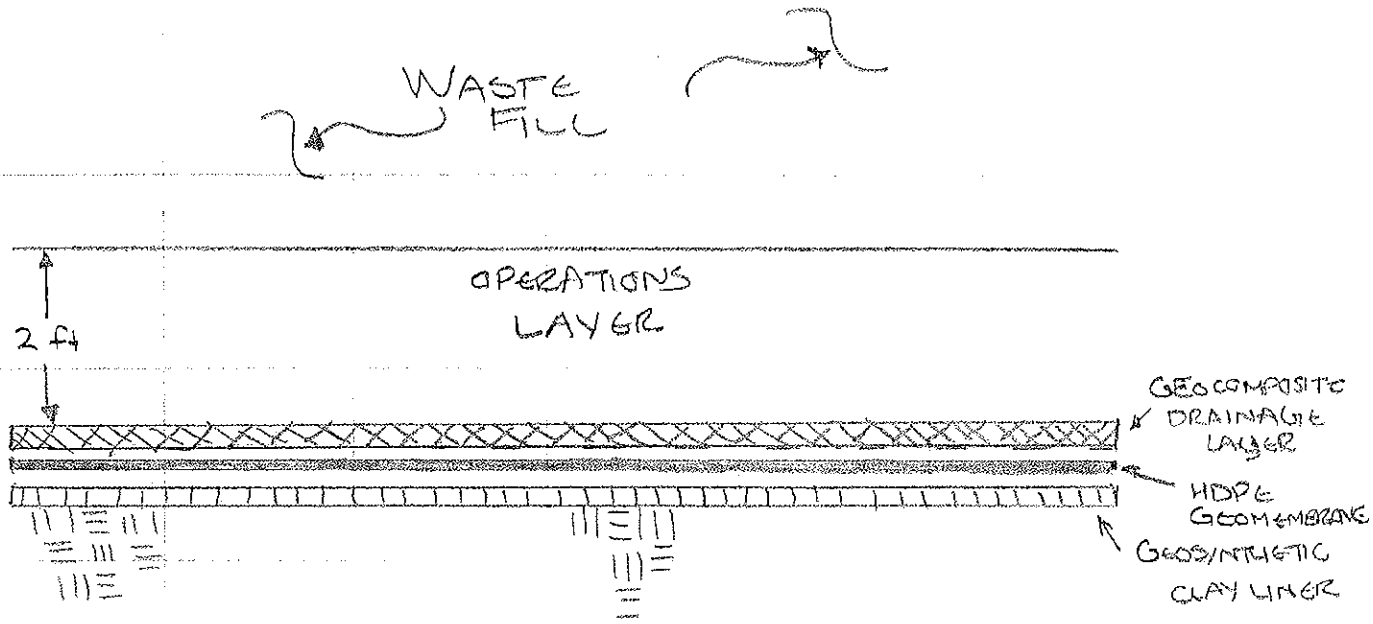
Flexible wall permeameter tests were performed on selected samples by AP Engineering and Testing, Inc according to ASTM D5084. With the exception of one sample (B-105), all tested samples were undisturbed ring samples. The samples were placed in a triaxial machine with a constant confining pressure at the approximate in-place effective stress pressures. Results were generally consistent with the fal-

Attachment G 1/1


1695
1700
1705
1710
1715
1720
1725
LEGEND
BRC LANDFILL SITE BOUNDARY
EXISTING LIMITS OF FORMER BMI LANDFILL
EXISTING SURFACE WATER FLOW PATH
EXISTING MINOR ELEVATION CONTOUR
EXISTING MAJOR ELEVATION CONTOUR
PROPOSED MINOR ELEVATION CONTOUR
PROPOSED MAJOR ELEVATION CONTOUR
PROPOSED LIMIT OF WASTE
LCRS PIPE
GROUNDWATER SURFACE CONTOUR
NOTES:
1. FOR GENERAL NOTES, LEGEND AND ABBREVIATIONS, SEE DWG C-2.
2. FOR SITE PREPARATION PLAN SEE DWG C-8.
3. FOR EROSION CONTROL AND STORM DRAIN PLAN SEE DWG C-8.
4. FOR CONSTRUCTION GRADING PLAN FOR FINAL COVER SEE DWG C-9.
5. FOR CROSSECTIONS SEE DWG C-10.
6. FOR FINAL COVER AND LINER DETAILS AND SECTIONS SEE DWG C-11.
7. FOR FENCE PLAN SEE DWG C-12.
8. GROUNDWATER CONTOURS PROVIDED BY MWH, DATED JULY 2005.
SCALE IN FEET
FIGURE 1
GEOSYNTEC CONSULTANTS
10875 RANCHO BERNARDO ROAD, SUITE 208
SAN DIEGO, CALIFORNIA 92127
TELEPHONE: (858) 674-6000
PROJECT
BRC CAMU
HENDERSON/CLARK COUNTY NEVADA
TITLE
CONSTRUCTION GRADING PLAN
PERMITTING CONSTRUCTION PLAN
DATE SEPTEMBER 2006
CHECKED BY G.T.C.
SCALE 1"=100'
DESIGN BY TAW
REVIEWED BY (PRINC. ENG.) G.T.C.
JOB NO. SC0313-01-04
DRAWN BY T.L.Z.
DOCUMENT NO.
FILE NO.
FIGURE NO. C7

Written by: R. FLYNN Date: 21 / 08 / 06 (DD MM YY) Reviewed by: _____ Date: ___ / ___ / ___ (DD MM YY)

Client: BRC Project: BRC CAMV Project/Proposal No.: SC0313 Task No: 01 - 04



COMPOSITE LINER SYSTEM

NOT TO SCALE

FIGURE 2

Calculation Package D
Pipe Strength

GeoSyntec Consultants

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: Basic Remediation Company

Project: BRC CAMU **Project/Proposal #:** SC0313 **Task #:** 01

Title of Computations: Pipe Strength Calculations

Computations By:
SIGNATURE — DATE 11/3/06
Rebecca Flynn, Staff Engineer
PRINTED NAME AND TITLE

Assumptions and Procedures Checked By (Peer Reviewer):
SIGNATURE — DATE 11/6/06
Keaton Botelho, Staff Engineer
PRINTED NAME AND TITLE

Computations Checked By:
SIGNATURE — DATE 11/3/06
Gregory T. Corcoran, PE / Principal
PRINTED NAME AND TITLE

Computations Backchecked By (Originator):
SIGNATURE — DATE 11/3/06
Rebecca Flynn, Staff Engineer
PRINTED NAME AND TITLE

Approved By (PM or Designate):
SIGNATURE — DATE 11/3/06
Gregory T. Corcoran, PE / Principal
PRINTED NAME AND TITLE

Approval Notes:

Revisions: (Number and Initial All Revisions)

No.	Sheet	Date	By	Checked By	Approval

Written by: Rebecca Flynn Date: 06 / 08 / 21 (YY MM DD) Reviewed by: BTC Date: 06 / 11 / 03 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

PIPE STRENGTH CALCULATIONS
BRC CAMU
HENDERSON, NEVADA

OBJECTIVE

A 4-in diameter HDPE leachate collection pipe and 18-in diameter side slope riser will be constructed at the BRC Corrective Action Management Unit (CAMU) in Henderson, Nevada. The objective of this calculation package is to evaluate the pipe strength performance and size the pipe wall thickness (i.e., determine the SDR).

SITE CONDITIONS

Crushed gravel will be backfilled around the 4-in and 18-in pipes. The maximum height of waste soil placed above the pipes will be 93 ft. Short term construction and long-term conditions will be evaluated.

LOADING CONDITIONS

The following two loading conditions were evaluated:

1. Short-Term Loading: Haul Truck (H-20)

   The ground pressure applied by the haul truck was estimated to be 100 psi as shown in Attachment A, p. 2. Based on the maximum axle load of 18 kips, the total load on the tire is 9 kips. Therefore, the footprint of the tire is approximately 0.63 ft^2 (see Attachment A). During construction, it was assumed that a minimum of 1 ft (0.3 m) of cover soil will separate haul trucks from the leachate collection pipes. Using Boussinesq's solution for a uniformly loaded square area, the assumed vertical pressure on the top of the pipe is 25 psi (see Attachment A).

2. Long-Term: Waste Soil Overburden Pressure

   Post construction, the maximum overburden soil will exist over the pipe at the southwest sump at a total depth of 93 ft (28.3 m). The unit weight is assumed to be 136 pcf. Additional loads from equipment is assumed to be negligible. The vertical pressure is calculated by:

P = 93 ft (136 pcf) /144 in^2/ft^2 = 87.8 psi.

Therefore, the vertical pressure on the top of pipe in the long-term condition is 87.8 psi.

Since the long-term load (#2) is greater than short-term load (#1), only the long-term load (#2) was considered herein.

METHOD OF ANALYSES

Ring deflection, wall buckling, and wall crushing of the pipe were evaluated for the loading conditions. The Spangler's Modified Iowa Formula was used to calculate ring deflection. Recent literature indicates that the Modified Iowa Formula results in conservative values for pipe deformation (Brachman 1998). The actual deflection is likely lower due to the arching effects of soil via pipe deflection that are neglected in the Modified Iowa Formula. The manufacturer's design manual for Driscopipe (Philips 66, 1991) and Koerner's *Designing with Geosynthetics* (Koerner 1998) was used to evaluate wall buckling and wall crushing. The design criteria were based on the manufacturer's design manual for Driscopipe (Philips 66, 1991).

The method of analysis shown below solves directly for the SDR (Equation 2) of the pipe. Since the SDR is a dimensionless parameter, the diameter of the pipe does not need to be known.

ANALYSIS

Evaluating Variables

E' = 3,000 psi for crushed rock (Philips 66 1998)

P = Long-term loading. Soil Load = 93 ft of soil at 136 pcf = 12,648 psf = 87.8 psi
(Assume haul truck loading is negligible)

E = 30,000 psi
Attachment D (Philips 66, 1991) shows that the modulus of elasticity (E) is approximately 30,000 psi for a 100 year design life.

Design by Wall Buckling

Wall buckling is generally the critical failure case for buried pipes. Naturally, this is a starting point for initial values for the SDR.

Written by: Rebecca Flynn Date: 06 / 08 / 21 (YY MM DD) Reviewed by: GTC Date: 06 / 11 / 3 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

The SDR is defined as:

SDR = D/t (Equation 1)

where D= outside diameter of pipe
t = minimum pipe wall thickness

Assume a factor of safety of 2.0 for buckling (Philips 66 1998). Therefore:

$FS = 2.0 = P_{cb}/P_T$ (Equation 2) (Attachment D)

where P_{cb} = critical buckling pressure at top of the pipe, and
P_T = total soil pressure at the top of the pipe = 87.8 psi

Solving Equation 2 for the critical buckling pressure, P_{cb}, yields:

P_{cb} = 175.6 psi

The critical buckling pressure, P_{cb} is defined (Philips 66 1998) as:

$$P_{cb} = 0.8\sqrt{(E')(P_c)}$$ (Equation 3) (Attachment D)

where: P_c = critical collapse pressure
E' = soil modulus = 3,000 psi

The critical collapse pressure can be determined by the following equation:

$$P_c = \frac{2E(t/D)^3(D_{min}/D_{max})^3}{1-\mu^2}$$ (Equation 4)(Attachment D)

where: E = pipe modulus = 30,000 psi
D = outside diameter
t = thickness
$(D_{min}/D_{max}) = 0.95$
μ = Poisson's Ratio = 0.45 for HDPE pipe

Written by: Rebecca Flynn Date: 06 / 08 / 21 (YY MM DD) Reviewed by: EC Date: 06 / 11 / 3 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

Equation 4 can be reduced to the following equation:

$$P_c = \frac{2.15(E)}{SDR^3}$$ (Equation 5) (Attachment D)

Inserting Equation 5 and rearranging, Equation 3 becomes:

$$SDR^3 = 0.64(E')\frac{2.15E}{P_{cb}^{\ 2}}$$ (Equation 6)

By inserting the appropriate value determined above, the following result is obtained:

SDR = 15.9, use 13.5 (13.5 < 15.9, OK)

Check Wall Crushing

Wall crushing occurs when the compressive strength of the pipe is exceeded by the overburden soil pressure. For example, the compressive yield strength for HDPE pipe manufactured by Driscopipe is 1,500 psi (Philips 66, 1998). Assuming a factor of safety of 2.0, the required compressive strength of the pipe becomes:

$FS = 2.0 = 1500 \text{ psi} / S_A$, therefore $S_A = 750$ psi (Equation 7)(Attachment D)

The hoop stress in the pipe is expressed as:

$S_A = (SDR-1)P_T/2$ (Equation 8) (Attachment D)

where: P_T = total external pressure = 87.8 psi

Rearranging, Equation 9 becomes:

$SDR = [2(S_A)/P_T] + 1$ (Equation 9)

Therefore, the design SDR is shown below:

SDR = 18.1 > 13.5 O.K.

Written by: Rebecca Flynn Date: 06 / 08 / 21 (YY MM DD) Reviewed by: ETC Date: 06 / 11 / 3 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

Check Ring Deflection

Ring deflection is the change in the vertical diameter of the pipe as the pipe/aggregate system deforms under the external vertical pressure. Ring deflection can be evaluated using Spangler's Modified Iowa formula and can be expressed as follows (Koerner 1998):

$$\Delta y = \frac{D_L K_b W_c}{(EI / r^3) + 0.061E'}$$ (Equation 10) (Attachment B)

Rearranging Equation 11 to express SDR and the percent pipe deflection directly:

$$\frac{\Delta y}{D} = \frac{D_L K_b P}{(2E) / (3(SDR-1)^3) + 0.061E'}$$ (Equation 11)

where:

Δy	= pipe deflection or change in diameter, in.
D	= pipe diameter, in.
W_c	= prism soil load, lb/in of pipe
P	= prism soil load, psi = 87.8 psi
K	= bedding constant, typically 0.083 (Attachment E)
SDR	= standard dimension ratio (SDR) = 13.5
E	= modulus of elasticity of pipe, 30,000 psi
E'	= modulus of soil reaction, 3,000 psi
D_L	= deflection lag factor, 1.3 (range 1.0 to 1.5)

Solving for Equation 12 for the critical load yields:

$$\frac{\Delta y}{D} = \frac{(1.3)(0.083)(87.8)}{2(30{,}000)/3(13.5-1)^3 + 0.061(3000)} = 4.9\%$$

The maximum allowable ring deflection for SDR 13.5 pipe is approximately 5.1% at 1.5% strain (Attachment D). Therefore, the estimated ring deflection is acceptable.

Written by: Rebecca Flynn Date: 06 / 08 / 21 (YY MM DD) Reviewed by: GR Date: 06 / 11 / 3 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

SUMMARY AND CONCLUSIONS

Based upon these calculations for pipe ring deflection, wall buckling, and wall crushing, an HDPE pipe with an SDR of 13.5 satisfies the design criteria.

The pipe compressive strength and the design methods and criteria were based on the Driscopipe manufacturer's design manual (Philips 66, 1998). These parameters might be slightly different for the specific pipe used at BRC CAMU. However, the factors of safety against wall buckling and wall crushing calculated herein will account of uncertainty or differences in the pipe compressive strength or in the design methods and criteria.

CONSIDERATIONS FOR SPECIFICATIONS

In accordance with the above analyses, the following items should be included in the specifications for construction at the BRC CAMU:

- A pipe with a maximum SDR of 13.5.
- A minimum of 1 ft (0.3 m) of cover soil shall be placed over the pipes before a haul truck is allowed to drive over them.
- Compacted crushed rock shall be placed in the pipe trench.

REFERENCES

Das, B. M. "Principles of Geotechnical Engineering", Third Edition, PWS Publishing, p.236
Attachment A

Yoder E.J., Witczak M.W., Principles of Pavement Design, Second Edition, John Wiley and Sons, In.c, p. 13
Attachment A

Brachman, R.W. I., "Laboratory Investigation of the Effect of Coarse Stone Backfill on the Performance of Leachate Collection Pipe", Geosythetics 99, Atlanta, Georgia, March 1998

Koerner R.B. (1998), "Designing with Geosynthetics", Fourth Edition, Prentice Hall, p.676

Written by: Rebecca Flynn Date: 06 / 08 / 21 (YY MM DD) Reviewed by: ETC Date: 06 / 11 / 3 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

Attachment B

Philips 66 (1991), "Driscopipe Systems Design", 800-527-0062
Attachment C

Philips 66 (1998), "Driscopipe Systems Design", 800-527-0062
Attachment D

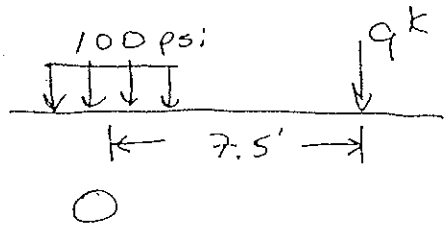
Written by: GLS Date: 00/01/26 (YY MM DD) Reviewed by: MLD GTC (3) 5/10/05 Date: 00/07/03 (YY MM DD)

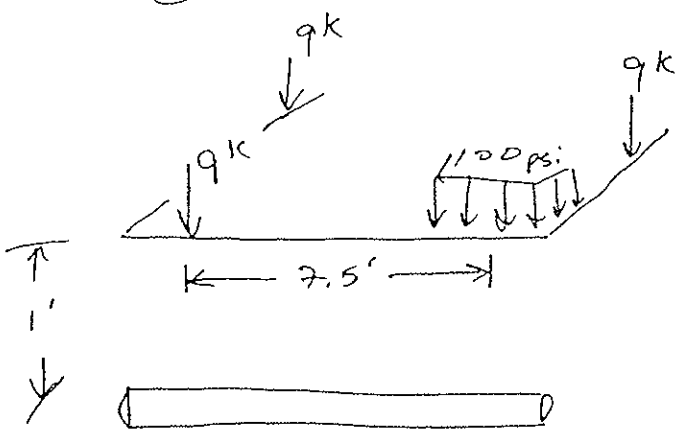
Client: Parsons Project: BRC Landfill Project/Proposal No.: HL0389 Task No.: 01

Haul truck loading (H-20)

- Assumptions: (AASHTO 94)
  - → max single axle load of 18 kip
  - → tire pressure of 100 psi (assumed) 1ft wide tires
  - → truck is 8½ wide

- Distribute Load
  - → assume distributed load of one wheel over pipe
  - → assume other loads are point loads





- Assume 1 ft cover soil

Attachment A

1/4

Written by: GLS Date: 00/02/13 Reviewed by: MJD CTC 5/10/05 Date: 00/07/03

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 02

→ From Das (1994)

Table 7.1, Variation of I_1

Due to shallow depths and large distance to point loads, influence of point load wheels are negligable.

→ From Das (1994)

Evaluate stress increases due to wheel directly above pipe:

- contact pressure of 100 psi
- radius of footprint = $R = \sqrt{\frac{P}{p\pi}} = \left[\frac{9K}{(100)(144)\pi}\right]^{1/2}$

$R = 0.45$ ft

- assume flexible circular footprint (Das, 1994)

$$\Delta p = q\left\{1 - \frac{1}{[(R/z)^2+1]^{3/2}}\right\}$$

$z = 1$ ft, $R = 0.45$ ft, $q = 100$ psi

$$\Delta p = 100\left\{1 - \frac{1}{[(0.45/1)^2+1]^{3/2}}\right\}$$

$\Delta p = 24$ psi

add soil 1 ft = 1310 psf/144 = 0.94 psi

$\boxed{\Delta p = 25 \text{ psi}}$: total external pressure

Attachment A
2/4

GTC (3) 5/10/05 MLD

vertical stress, dp, at point A caused by the load on the elemental area (which may be assumed to be a concentrated load) can be obtained from Eq. (7.11):

$$dp = \frac{3(qr\,dr\,d\alpha)}{2\pi}\frac{z^3}{(r^2+z^2)^{5/2}} \tag{7.24}$$

The increase in the stress at A caused by the entire loaded area can be found by integrating Eq. (7.24), or

$$\Delta p = \int dp = \int_{\alpha=0}^{\alpha=2\pi}\int_{r=0}^{r=R}\frac{3q}{2\pi}\frac{z^3 r}{(r^2+z^2)^{5/2}}\,dr\,d\alpha$$

So

$$\boxed{\Delta p = q\left\{1 - \frac{1}{[(R/z)^2+1]^{3/2}}\right\}} \tag{7.25}$$

The variation of $\Delta p/q$ with z/R as obtained from Eq. (7.25) is given in Table 7.5. A plot of this is also shown in Figure 7.17. The value of Δp decreases rapidly with depth, and, at $z = 5R$, it is about 6% of q, which is the intensity of pressure at the ground surface.

TABLE 7.5 Variation of $\Delta p/q$ with z/R [Eq. (7.25)]

z/R	$\Delta p/q$
0	1
0.02	0.9999
0.05	0.9998
0.10	0.9990
0.2	0.9925
0.4	0.9488
0.5	0.9106
0.8	0.7562
1.0	0.6465
1.5	0.4240
2.0	0.2845
2.5	0.1996
3.0	0.1436
4.0	0.0869
5.0	0.0571

Attachment A
3/4

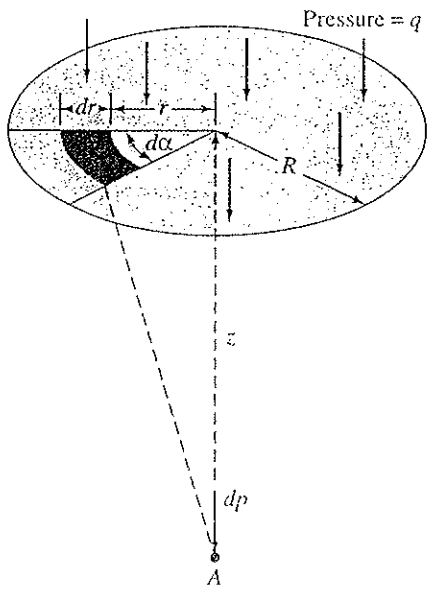
▼ **TABLE 7.4** Values of $\Delta p/q$ [Eq. (7.23)]

	$2z/B$								
$2x/B$	0	0.5	1.0	1.5	2.0	2.5	3.0	4.0	5.0
−3	0	0.0003	0.0018	0.00054	0.0107	0.0170	0.0235	0.0347	0.0422
−2	0	0.0008	0.0053	0.0140	0.0249	0.0356	0.0448	0.0567	0.0616
−1	0	0.0041	0.0217	0.0447	0.0643	0.0777	0.0854	0.0894	0.0858
0	0	0.0748	0.1273	0.1528	0.1592	0.1553	0.1469	0.1273	0.1098
1	0.5	0.4797	0.4092	0.3341	0.2749	0.2309	0.1979	0.1735	0.1241
2	0.5	0.4220	0.3524	0.2952	0.2500	0.2148	0.1872	0.1476	0.1211
3	0	0.0152	0.0622	0.1010	0.1206	0.1268	0.1258	0.1154	0.1026
4	0	0.0019	0.0119	0.0285	0.0457	0.0596	0.0691	0.0775	0.0776
5	0	0.0005	0.0035	0.0097	0.0182	0.0274	0.0358	0.0482	0.0546

7.8 VERTICAL STRESS BELOW THE CENTER OF A UNIFORMLY LOADED CIRCULAR AREA

Using Boussinesq's solution for vertical stress Δp caused by a point load [Eq. (7.11)], one can also develop an expression for the vertical stress below the center of a uniformly loaded flexible circular area.

From Figure 7.16, let the intensity of pressure on the circular area of radius R be equal to q. The total load on the elemental area (shaded in the figure) $= qr\,dr\,d\alpha$. The



▼ **FIGURE 7.16** Vertical stress below the center of a uniformly loaded flexible circular area

Attachment A

TABLE 1.2. Typical Runway Lengths for Several Aircraft and Conditions[a]

Plane Type	Normal Max Temp. of Hottest Month (°F)	Elevation (ft)	Length[b] (ft)
Boeing 707-100	100	Sea level	10,500
Boeing 707-100	75	3000	11,500
Boeing 707-100	75	1000	10,500
Boeing 727	75	1000	7,800
Boeing 747	75	1000	10,500
Douglas DC 9	75	1000	8,000
Convair Cv 880	75	1000	10,500
BAC 1-11	75	1000	7,500

[a] Data from charts in FAA publication (ref. 4).

[b] The lengths shown in the table are relative and are for illustrative purposes only since the required lengths are dependent upon many factors, including effective grade of the runway, setting of the wing flaps, and takeoff weight. Each runway must be analyzed for its own particular conditions and the critical plane using the runway.

In the majority of the problems, circular tire imprints are assumed. Hence the radius of contact is as follows:

$$a = \sqrt{\frac{P}{p\pi}} \qquad A = \frac{P}{p} \tag{1.1}$$

where a = radius of contact
P = total load on the tire
p = tire pressure (assumed to be equal to contact pressure)

For some cases tire imprints as illustrated on Figure 1.8 are used. The relationship between pressure and the geometry of the imprint is as shown on the figure.

DESIGN FACTORS

Pavement design consists of two broad categories: (1) design of the paving mixtures, and (2) structural design of the pavement components. These two design steps must go hand in hand.

The structural design of pavements is basically different from the structural design of bridges and buildings in that the pavement structure lies exposed upon the ground surface and, hence, is greatly influenced by environmental factors. Likewise, a highway, for example, will cross many different soil deposits and it becomes necessary for the design engineer to select in a rational manner a design value representative of the area under question. The strength of soil is affected by many factors, including density, moisture content, soil texture, soil structure, rate of load application, and degree of confinement. In addition, soils

Attachment A
4/4

7.2.2 Deflection Issues

An engineering approach to the quantification of deflection of buried pipelines has been developed by a sequential group of research faculty and students at Iowa State University. Beginning with Marston in the 1920s evaluating rigid conduits (the term used for shallow buried pipes), followed by Spangler in 1950–1970 evaluating flexible conduits, and into the present by Watkins, the group and their colleagues have "written the book" for this type of research [12]. Key issues in the development are the use of arching theory for gravitational force dissipation, the importance of subgrade stability, backfill type, and compaction conditions, and finally the flexibility of the pipe structure itself. Moser [13] presents the following equation, summarizing the Iowa State group's effort for the deflection behavior of flexible (in our case plastic) pipe.

$$\Delta X = \frac{D_L K_b W_c}{(\mathrm{EI}/r^3) + (0.061E')} \cong y \tag{7.17}$$

where

ΔX = horizontal increase in diameter (m),
y = vertical deflection (m),
D_L = deflection lag factor, which varies from 1.0 to 1.5 (dimensionless), 1.5 (conservative)
K_b = bedding constant, which varies from 0.83 to 0.110 (dimensionless), 0.1
W_c = Marston's prism load per unit length of pipe (kN/m) (note that arching is not taken into account in this formula),
E = modulus of elasticity of the pipe material (kPa),
I = moment of inertia of the pipe wall per unit length (m^3),
EI = bedding stiffness of the pipe ring per unit length (kN-m),
r = mean radius of the pipe (m), and
E' = modulus of soil reaction (kPa).

The last term (E') has been the subject of intense discussion and research. Howard [14] of the U.S. Bureau of Reclamation has recommended the values given in Table 7.9, which have relatively wide acceptance.

Eq. (7.17) can also be cast in terms of the laboratory plate loading test with the following result. The equation assumes a bedding constant $K_b = 0.2$ and uses the ring stiffness constant (RSC).

$$\frac{y}{D} = \frac{P(0.1L)}{[14.9(\mathrm{RSC})/D + 0.061E']} \tag{7.18}$$

where

y = vertical deflection (m),
D = inside pipe diameter (m),
P = load on pipe (kPa),
L = deflection lag factor (usually 1.0 to 1.5),
RSC = ring stiffness constant (kN/m), and
E' = modulus of soil reaction (kPa).

Attachment B

1/1

GTC (3) 5/10/05 MSD

Where: S_A = Actual compressive stress, psi
SDR = Standard Dimension Ratio
P_T = External Pressure, psi

Safety Factor = 1500 psi ÷ S_A where 1500 psi is the Compressive Yield Strength of Driscopipe.

Design by Wall Buckling: Local wall buckling is a longitudinal wrinkling of the pipe wall. Tests of *non-pressurized* Driscopipe show that buckling and collapse do not occur when the soil envelope is in full contact with the pipe and is compacted to a dense state. However, it can be forced to occur over the long term in *non-pressurized* pipe if the total external soil pressure, P_t, is allowed to exceed the pipe-soil system's critical buckling pressure, P_{cb}. If $P_t > P_{cb}$, gradual collapse may occur over the long term. A calculated, conservative value for the critical buckling pressure may be obtained by the following approximate formula. All pipe diameters with the same SDR in the same burial situation have the same critical collapse and critical buckling endurance

$$P_{cb} = 0.8\sqrt{E' \times P_c}$$

Where:

P_t = Total vertical soil pressure at the top of the pipe, psi

P_{cb} = Critical buckling soil pressure at the top of the pipe, psi

E' = Soil modulus in psi calculated as the ratio of the vertical soil pressure to vertical soil strain at a specified density

P_C = Hydrostatic, critical-collapse differential pressure, psi

$$P_C = \frac{2E\,(t/D)^3\,(D_{MIN}/D_{MAX})^3}{(1-\mu^2)}$$

$$P_c = \frac{2.32\,E}{(SDR)^3}$$

Where: (D_{MIN}/D_{MAX}) = .95
μ = Poission's Ratio
μ = .45 for Driscopipe
E = stress and time dependent tensile modulus of elasticity, psi

In a direct burial pressurized pipeline, the internal pressure is usually great enough to exceed the external critical-buckling soil pressure. When a pressurized line is to be shut down for a period, wall buckling should be examined.

Design by Wall Buckling Guidelines
Although wall buckling is seldom the limiting factor in the design of a Driscopipe system, a check of non-pressurized pipelines can be made according to the following steps to insure $P_t < P_{cb}$

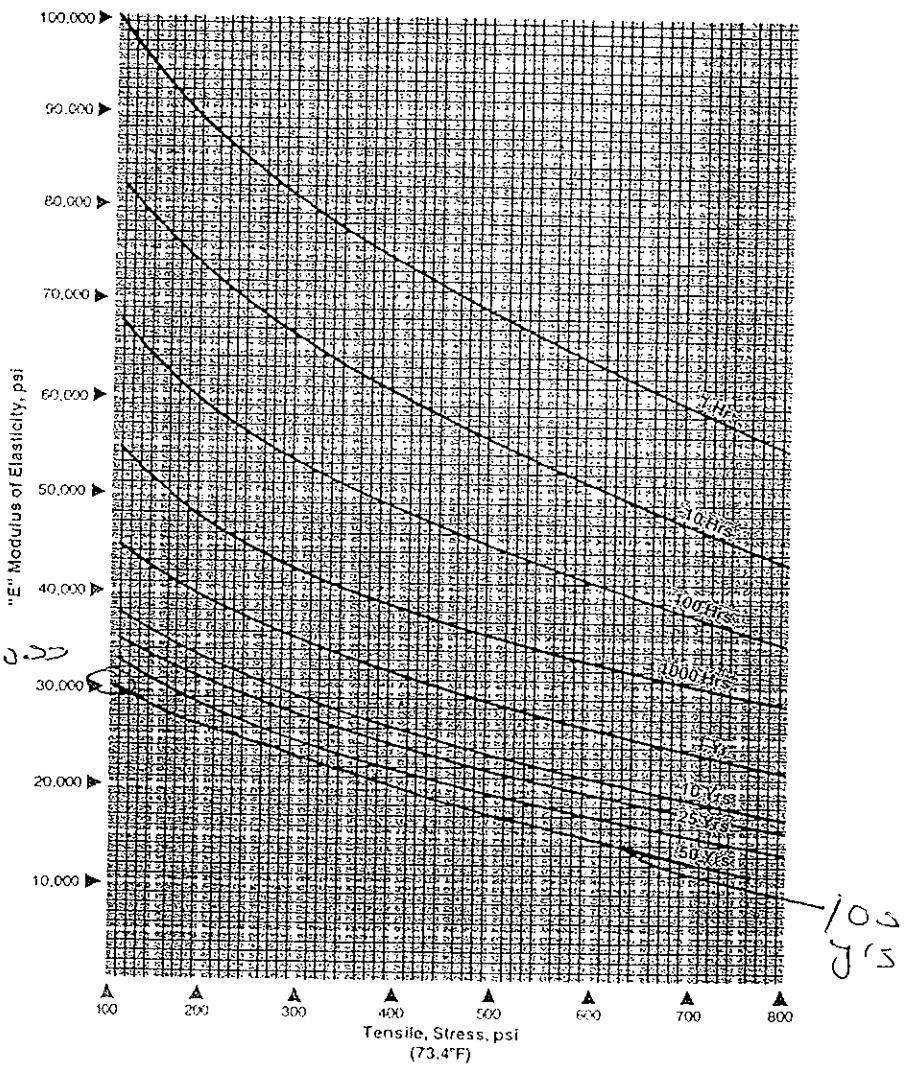
1. Calculate or estimate the total soil pressure, P_t, at the top of the pipe
2. Calculate the stress "S_A" in the pipe wall according to the formula:

$$S_A = \frac{(SDR - 1)\,P_t}{2}$$

3. Based upon the stress "S_A" and the estimated time duration of non-pressurization, use Chart 25 to find the value of the pipe's modulus of elasticity, E, in psi

Chart 25

Time Dependent Modulus of Elasticity for Polyethylene Pipe vs. Stress Intensity (73.4°F)



NOTE: The short term modulus of elasticity of Driscopipe per ASTM D 638 is approximately 100,000 psi. Due to the cold flow (creep) characteristic of the pipe material, this modulus is dependent upon the stress intensity and the time duration of the applied stress.

Attachment C
1/1

GTC (3) 5/10/05 MSD

TABLE 13: VALUE OF E' BASED ON SOIL TYPE (ASTM D2321) AND DEGREE OF COMPACTION

E' (psi) for Degree of Compaction (Standard Proctor Density, %)

	Soil Type of Initial Backfill Material	Loose 70%	Slight (70 - 85%)	Moderate (85- 95%)	High > 95%
I	Manufactured angular, granular materials (Crushed Stone, or rock, broken coral, cinders, etc.)	1,000	3,000	3,000	3,000
II	Coarse grained soils with little or no fines	Not Recommended	1,000	2,000	3,000
III	Coarse grained soils with fines	Not Recommended	Not Recommended	1,000	2,000
IV	Fine Grained Soils	Not Recommended	Not Recommended	Not Recommended	Not Recommended
V	Organic Soils (Peat, Muck, Clay, etc.)	Not Recommended	Not Recommended	Not Recommended	Not Recommended

Note: This summary of ASTM D 2321 is provided for the design engineer's convenience. This specification should be reviewed in detail before specifying burial conditions.

MINIMUM COVER There are no firm rules regarding minimum burial depth. The variables change for each installation, and the designer should check each design for wall crushing, wall buckling, and ring deflection. However, the following guidelines may be helpful.

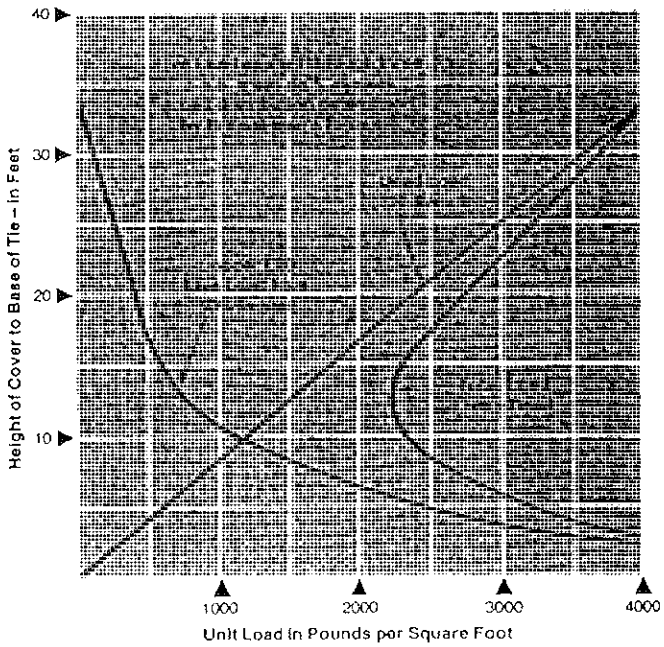
- Consider a burial depth below the local frost line.
- Where there will be no overland traffic, the designer may wish to consider a cover of 18" or one diameter, whichever is greater.
- Where truck traffic may be expected, the designer may wish to consider a burial depth of 36" or one diameter, whichever is greater.
- Where heavy off-the-road truck or locomotive traffic is expected, the designer may wish to consider a minimum cover of 5 feet or more.

CALCULATION OF TOTAL SOIL PRESSURE BY COMPONENTS Proper design of the polyethylene "pipe-soil" system balances the response of the pipe and surrounding soil against the total external soil pressure. Burial design by wall crushing, wall buckling, and ring deflection require the calculation of the total soil pressure, P_T, at the top of the pipe. There are many sources of soil pressure above the pipe. It is helpful to examine the total soil pressure as the sum of its components.

Attachment D
1/6

GTC (3) 5/10/05 MLD

FIGURE 6: COOPER E-80 LIVE LOADING



Note: Cooper E-80 live load assumes 80,000 pounds applied to three 2' x 8' areas on 5' centers such as might be encountered through live loading from a locomotive with three 80,000 pound axle loads.

Source: American Iron and Steel Institute, Washington, DC

APPARENT EXTERNAL PRESSURE DUE TO INTERNAL VACUUM, P_I Vacuum generates a compressive hoop stress in the wall of a pipe and acts to collapse the pipeline. Under vacuum conditions, the value of P_I is positive. P_I is added to the other two external pressure components, P_S and P_L, to obtain the total external pressure, P_T, acting on the pipe. An internal vacuum generates pressure equal to the absolute value of the vacuum. The maximum apparent external pressure due to a vacuum inside the pipe is 14.7 psi (2,117 psf).

BURIAL DESIGN GUIDELINES

The design engineer must select the proper pipe DR and specify the backfill conditions to obtain the desired performance of the "pipe-soil" system.

DESIGN BY WALL CRUSHING Wall crushing occurs when external vertical pressure causes the compressive stress in the pipe wall to exceed the long-term compressive strength of the pipe material. To design for wall crushing, the following check should be made:

$$S_A = \frac{(SDR - 1)}{2} P_T$$

Where:
- S_A = Actual compressive stress, psi
- SDR = Standard Dimension Ratio
- P_T = Total external pressure on the top of the pipe, psi

Safety Factor = 1500 psi /S_A (where 1500 psi is the compressive yield strength of Driscopipe HDPE pipe)

DESIGN BY WALL BUCKLING Local wall buckling is a longitudinal wrinkling of the pipe wall. Buckling can occur over the long term in non-pressurized pipe if the total external soil pressure, P_T, exceeds the pipe-soil system's critical buckling pressure, Pcb . Although wall buckling is seldom the limiting factor in the design of a Driscopipe system, a check of non-pressurized pipelines can be made according to the following steps to insure $P_T < P_{cb}$. All pipe diameters with the same DR in the same burial situation have the same critical collapse and critical buckling endurance.

Attachment D
2/4

GTC (3) 5/10/05 MLD

1. Calculate or estimate the total soil pressure, P_T, at the top of the pipe.

2. Calculate the stress, S_a, in the pipe wall:

$$S_A = \frac{(SDR-1)}{2} P_T$$

3. Based upon the stress, S_a, and the estimated time duration of non-pressurization, find the value of the pipe's modulus of elasticity, E, in psi (approximate value for E is 35,000 psi).

4. Calculate the pipes hydrostatic, critical-collapse differential pressure, P_c

$$P_c = \frac{2E(t/D)^3 (D_{MIN} / D_{MAX})^3}{(1-\mu^2)} \quad \text{or} \quad P_c = \frac{2.32(E)}{SDR^3}$$

$$P_c = \frac{2.15(E)}{SDR^3}$$

Where: $(D_{MIN}/D_{MAX}) = 0.95$
μ = Poission's Ratio = 0.45 for polyethylene pipe
E = stress and time dependent tensile modulus of elasticity, psi
E = 35,000 psi (approximate)
D = Outside Diameter, in.
t = thickness, in.

5 Calculate the soil modulus, E', by plotting the total external soil pressure, P_T, against a specified soil density to derive the soil strain as shown in the example problem below Figure 7.

6. Calculate the critical buckling pressure at the top of the pipe by the formula:

$$P_{cb} = 0.8\sqrt{(E')(P_c)}$$

Where: P_{cb} = Critical buckling soil pressure at the top of the pipe, psi
E' = Soil Modulus, psi
P_c = Hydrostatic critical-collapse differential pressure, psi

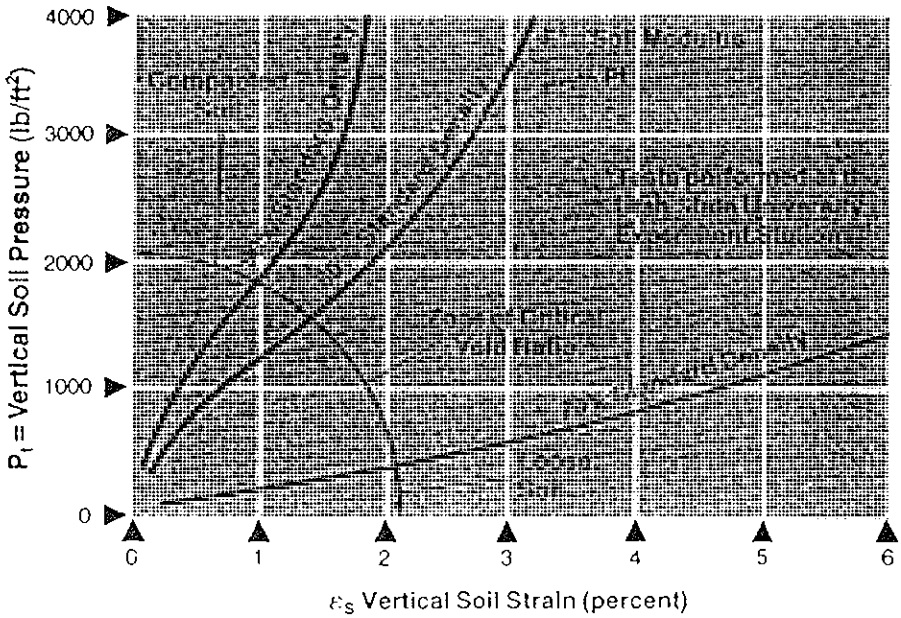
7. Calculate the Safety Factor: SF = P_{cb} / P_T.

8. The above procedures can be reversed to calculate the minimum pipe DR required for a given soil pressure and an estimated soil density.

In a direct burial pressurized pipeline, the internal pressure is usually great enough to exceed the external critical-buckling soil pressure. When a pressurized line is to be shut down for a period, wall buckling should be examined.

Attachment D
3/4

FIGURE 7: PLOT OF VERTICAL STRESS-STRAIN DATA FOR TYPCIAL TRENCH BACKFILL (EXCEPT CLAY) FROM ACTUAL TESTS



Example:
Find: E' @ 2000 psf and 80% density
Formula: $E' = PT/\varepsilon_s$
Calculations: E' = 2000 psf / (0.018 * 144) = 771 psi

Note: The curves shown on this chart are sample curves for a granular soil. If other types of soil are used for backfill such as clay or clay loam, curves should be developed from laboratory test data for the material used. Soil pressures greater than 4000 psf may be extrapolated with the slope of the curve or curves can be generated by testing at higher soil pressures. Probable error of curves is about half the distance between adjacent lines.

Design by Ring Deflection Ring deflection, by definition, is the ratio of the vertical change in diameter to the pipe's original diameter. It is often expressed as a percentage.

Driscopipe HDPE pipe is designed to be "flexible". This assumes the pipe will deflect the same as the vertical compression of the soil around it. Design by ring deflection matches the ability of the pipe to accommodate, without structural distress, the vertical compression of the surrounding soil. Design by ring deflection calculates the vertical soil strain and compares it to the allowable ring deflection of the pipe.

Attachment D
4/4

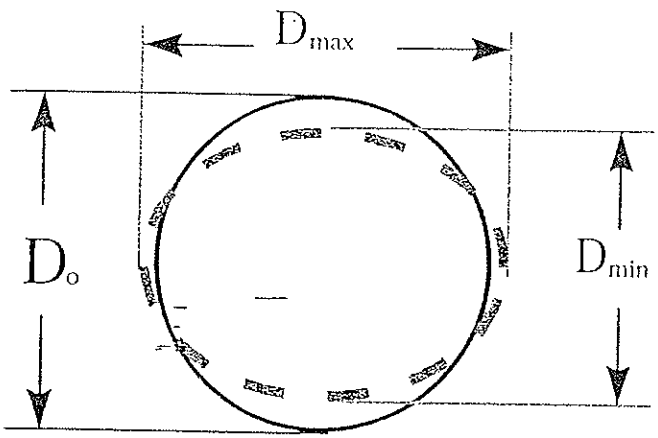
GTC (8) 5/10/05 MLD

TABLE 15: ALLOWABLE RING DEFLECTION OF DRISCOPIPE® POLYETHYLENE PIPE BASED UPON DR

DR	Allowable Ring Deflection
32.5	8.1%
26	6.5%
21	5.2%
19	4.7%
17	4.2%
15.5	3.9%
13.5	3.4%
11	2.7%

The allowable ring deflection of polyethylene pipe is limited to create no more than 1 to 1.5% tangential strain in the outer surface of the pipe wall. As the wall of a pipe becomes thicker (a "lower" DR value), the distance from the neutral axis to the outer surface increases. As a result, less deflection is required to create the allowable tangential strain. Deflection of the pipe-soil system is controlled by proper specification of the backfill compaction.

FIGURE 8: CALCULATING RING DEFLECTION



$$\%\,Ring\,Deflection = \left(1 - \frac{D_{min}}{D_o}\right) \times 100\%$$

The percentage ring deflection based upon strain for a given DR pipe can be calculated as follows:

$$\frac{\Delta Y}{D} = (0.25)(\varepsilon)(SDR)$$

Attachment D
5/6

Where:

	ΔY	= Vertical deflection, in.
	D	= Pipe OD, in.
	ε	= Tangential strain in the surface of the pipe ring, in./in.
	SDR	= Standard Dimension Ratio

Driscopipe recommends limiting tangential surface strain to 0.01. This value is based upon the following criteria:

- Most of the deflection of a flexible pipe occurs within a few days after final backfill is completed. Development of a soil arch over the pipe relieves the pipe of much of the vertical soil load by the arching action of the soil envelope and by the development of soil restraint at the sides of the pipe.
- An allowable strain value of 0.01 will allow for reasonable additional deflection due to disturbance of the backfill by earthquake, fluctuations of the water table, etc.
- An allowable design strain value of 0.01 allows for the normal deviation of temperature encountered during installation.

In summary, a soil density can be specified for the bedding and initial backfill so that total soil pressure at the top of the pipe, P_T, will not cause a given DR pipe to exceed its maximum allowable ring deflection.

Attachment D
60/60

Table 5-6
Support Spacing for Schedule 80 CPVC Pipe

Nominal Pipe Size, mm (in)	Maximum Support Spacing, m (ft) at Various Temperatures					
	23• C (73• F)	38• C (100• F)	49• C (120• F)	60• C (140• F)	71• C (160• F)	82• C (180• F)
25 (1)	1.83 (6.0)	1.83 (6.0)	1.68 (5.5)	1.52 (5.0)	1.07 (3.5)	0.91 (3.0)
40 (1.5)	2.13 (7.0)	1.98 (6.5)	1.83 (6.0)	1.68 (5.5)	1.07 (3.5)	0.91 (3.0)
50 (2)	2.13 (7.0)	2.13 (7.0)	1.98 (6.5)	1.83 (6.0)	1.22 (4.0)	1.07 (3.5)
80 (3)	2.44 (8.0)	2.44 (8.0)	2.29 (7.5)	2.13 (7.0)	1.37 (4.5)	1.22 (4.0)
100 (4)	2 59 (8.5)	2 59 (8.5)	2 59 (8.5)	2.29 (7.5)	1.52 (5.0)	1.37 (4.5)
150 (6)	3.05 (10.0)	2.90 (9.5)	2.74 (9.0)	2.44 (8.0)	1.68 (5.5)	1.52 (5.0)
200 (8)	3.35 (11.0)	3.20 (10.5)	3.05 (10.0)	2.74 (9.0)	1.83 (6.0)	1.68 (5.5)
250 (10)	3.51 (11.5)	3.35 (11.0)	3.20 (10.5)	2.90 (9.5)	1.98 (6.5)	1.83 (6.0)
300 (12)	3.81 (12.5)	3.66 (12.0)	3.51 (11.5)	3.20 (10.5)	2.29 (7.5)	1.98 (6.5)

Note: The above spacing values are based on test data developed by the manufacturer for the specific product and continuous spans. The piping is insulated and is full of liquid that has a specific gravity of 1.0.
Source: Harvel Plastics, Product Bulletin 112/401 (rev. 10/1/95), p. 63.

Table 5-7
Bedding Factor, K_x

Type of Installation	K_x
Shaped bottom with tamped backfill material placed at the sides of the pipe, 95% Proctor density or greater	0.083
Compacted coarse-grained bedding and backfill material placed at the side of the pipe, 70-100% relative density	0.083
Shaped bottom, moderately compacted backfill material placed at the sides of the pipe, 85-95% Proctor density	0.103
Coarse-grained bedding, lightly compacted backfill material placed at the sides of the pipe, 40-70% relative density	0.103
Flat bottom, loose material placed at the sides of the pipe (not recommended); <35% Proctor density, <40% relative density	0.110

Source: Reprinted from Schweitzer, Corrosion-Resistant Piping Systems, p. 49, by courtesy of Marcel Dekker, Inc.

Attachment E

Calculation Package E
Veneer Stability

GeoSyntec Consultants

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: Parsons **Project:** BRC CAMU **Project/Proposal #:** HL0389 **Task #:** 02

Title of Computations: Veneer Stability of Geosynthetic-Lined Slopes

Computations By: SIGNATURE (GS) DATE 3 May 2000
Geoffrey L. Smith / Staff Engineer
PRINTED NAME AND TITLE

Assumptions and Procedures Checked By (Peer Reviewer): SIGNATURE DATE 7/3/00
GREGORY T CORCORAN / PROJ. ENG.
PRINTED NAME AND TITLE

Computations Checked By: SIGNATURE DATE 2 May 2000
Matt Darr Staff Engr.
PRINTED NAME AND TITLE

Computations Backchecked By (Originator): SIGNATURE DATE 3 May 2000
Geoffrey L. Smith / Staff Engineer
PRINTED NAME AND TITLE

Approved By (PM or Designate): SIGNATURE DATE 10 July 2000
Bradford H. Cody / Project Manager
PRINTED NAME AND TITLE

Approval Notes:

Revisions: (Number and Initial All Revisions)

No.	Sheet	Date	By	Checked By	Approval

Written by: Geoff L. Smith GLS Date: 00 / 01 / 26 (YY MM DD) Reviewed by: MLD GTC Date: 00 / 07 / 03 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 04

SLOPE STABILITY EVALUATION
VENEER STABILITY OF GEOSYNTHETIC-SOIL LINED SIDESLOPES

OBJECTIVE

To evaluate the tension developed within the geosynthetic-soil layered sideslope of the BRC Corrective Action Management Unit (CAMU) located in Henderson, Nevada.

METHOD OF ANALYSIS

The stability analysis of the geosynthetic-soil layered systems was carried out using the approach outlined by McKelvey (1994). McKelvey (1994) calculates the tension of a geosynthetic component along a geosynthetic-soil layered sideslope and compares it to the allowable geosynthetic strength to evaluate the overall factor of safety against tension. McKelvey (1994) allows for the consideration of tapered slopes and equipment loads. The calculations herein were performed by a spreadsheet developed by McKelvey that has been verified numerous times, so verification will not be presented herein.

SIDESLOPE LINER SYSTEM

The sideslope liner system (Attachment A) consists of, from top to bottom:

- 2 ft (min) 2.5H:1V tapered operations layer material (10 ft max height),
- a drainage geocomposite;
- ~~a non-woven cushion geotextile;~~ GLS
- a 60-mil (1.5-mm) thick textured high density polyethylene (HDPE) geomembrane;
- a geosynthetic clay liner (GCL); and
- subgrade.

The sideslope inclination is 2.1H:1.0V. The maximum height of the side slope is 30 vertical feet.

Written by: Geoff L. Smith GLS Date: 00 / 01 / 26 (YY MM DD) Reviewed by: MLD GTC Date: 00 / 07 / 03 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 04

MATERIAL SHEAR STRENGTHS

Operations Layer Material and Drainage Aggregate:

The soil materials to be used overlying the side slope liner system will be native materials such as silty sands (SM) for the operations layer. The operations layer material is charaeterized by an internal angle of friction of 31 degrees (Attachment B). Converse reported a maximum dry density of 132 pcf and a optimum water content of 8.7 percent for materials at the site. Therefore, assuming 95% relative compaction, the dry density in the field is approximately 125 pcf. Adding the weight of water, the unit weight is approximately 136 pcf (Attachment B).

For this analysis, a shear strength of ~~31~~ 30 degrees and a unit weight of ~~132~~ 136 pcf will be used for the analyses performed herein.

Geosynthetic interface:

The following values for the interface friction between geosynthetic and soil components of the liner system will be used in this calculation:

Operations Layer to Geocomposite (NWGT side)	25 (Attachment D)
~~Geocomposite (GN side) to Cushion Geotextile~~	~~30 (Attachment D)~~
Cushion Geotextile to Textured HDPE	28 (Attachment E)
Textured HDPE to Dry GCL	18 (Attachment F)
Dry GCL to Subgrade	28 (Attachment F)

The critical loading for the side slope liner system occurs during construction when dozers are placing the ~~drainage aggregate and~~ operations layer materials up the slope. Global stability analyses have been performed to determine the long-term stability of the liner system. Therefore, the GCL component of the liner system was selected to be dry, since hydration will likely occur only after the construction phase is complete, and the normal stress used in obtaining the interface friction will be low (i.e. less than 5 psi).

The minimum shear strength along the geosynthetic interfaces of the sideslope liner system was assumed to occur at the interface of the textured HDPE geomembrane/GCL. A shear strength value of 18 degrees will be used in the tension analysis for the textured HDPE geomembrane/GCL interface as suggested in Attachment F.

Written by: Geoff L. Smith Date: 00 / 01 / 26 (YY MM DD) Reviewed by: MLD GTC Date: 00/07/03 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 04

DESIGN CRITERION

The geosynthetic-soil lined sideslopes are considered interim slopes because they will eventually be buttressed by placement of waste. Due to the limited duration during which the geosynthetic-soil lined slope will exist before it is buttressed by waste, seismic stability analyses were not conducted.

RESULTS AND CONCLUSIONS

The computer output for the analyses are presented in pages 4-~~7~~5. The results suggest the following:

Live Load Case (assuming placement of operations layer with a bulldozer no larger than Caterpillar D6H-LGP dozer in terms of operating weight and ground pressure), the side slope liner system will not be placed into tension.

REFERENCES

Converse (1999), "Preliminary Geotechnical and Geologic Report - Industrial Non-Hazardous Disposal Facility (Converse 1999)", prepared for Basic Management, Inc., October 1999.

Hunt R.E. (1986), *Geotechnical Engineering Techniques and Practices*, McGraw-Hill Book Company.

Koerner, R.M. (1990), *Designing with Geosynthetics*, Third Edition, Prentice Hall, New Jersey.

GeoSyntec Consultants

Page 4

Written By: Geoff Smith Date: 26-Apr-00 Reviewed by: MLD GTC 7/3/00 Dat

Client: Parsons Project: BRC CAMU Project No.:

GeoSyn

Written By:

Client:

Calculated Tension for : BRC CAMU - Side Slope, Final Thickness -Construction loads

Project variables

Cover soil unit weight :	136.00 pcf
Cover soil thickness :	2.00 feet
Cover soil internal angle of friction :	30.00 degrees
Angle of slope (ie nH:1V) :	2.10
Angle of cover (ie nH:1V) :	2.50
Slope height :	10.00 feet
Equipment load :	D6H

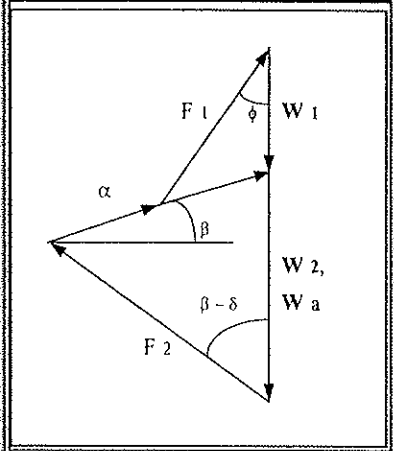
Geosynthetic variables

Minimum friction angle :	18.00 degrees
Load bearing product name :	60 MIL HDPE
Yield tensile strength :	126.00 ppi
Creep factor of safety :	5.00
installation damage factor of safety:	1.20
chemical degradation factor of safety:	1.50
biological degradation factor of safety:	1.00
Break strain factor of safety:	1.00

ANALYSIS OUTPUT

Slope angle:	25.46 degrees
Ramp angle:	21.80 degrees
Resisting force (W1) :	2,390 ppf
Driving force (W2) :	14,776 ppf
Equipment and special loads (Wa) :	6,477 ppf
estimated tension :	**0 ppf**
Geomembrane allowable strength :	168 ppf
Overall Factor of Safety for tension :	**INFINITE OK**

Free body diagram



Notes

1. 60 MIL HDPE assumed to carry load.

2. Minimum interface at GM/GCL

Taper Distances

x' (ft) :	4.00
y' (ft) :	1.60

GeoSyntec Consultants

Written By: Geoff Smith GS Date: 26-Apr-00 Reviewed by: MLD GK Date: 7/3/00

Client: Parsons Project: BRC CAMU Project No.:

Equipment load

PLACEMENT EQUIPMENT:	D6H
operating weight (lbs):	38,605
track width (in):	22.00
ground contact (in^2)	4,564
ground pressure (psi):	8.46
depth (ft):	2.74
ANALYSIS OUTPUT	
Surface stress (q) in psf :	1218.04
Track length in inches :	103.73
Length to width ratio (L/B) :	4.72
Length to depth ratio (N) :	1.58
Width to depth ratio (M) :	0.33
Influence coefficient (Io) :	0.0946
Stress at geosynthetic surface (s) in psf :	460.91
Equivalent track width due to attenuation (B') in feet :	2.98
Driving force of equipment (Wa) in ppf :	6,477
Special load (ppf) :	0

References

1. McKelvey, J.A. and Deutsch, W.L., (1991) "The Effect of Equipment Loading and Tapered Cover Soil Layers on Geosynthetic Lined Landfill Slopes", Proc. 14th Ann. Madison Waste Conference, Madison, WI:UWM, pp 395 - 4

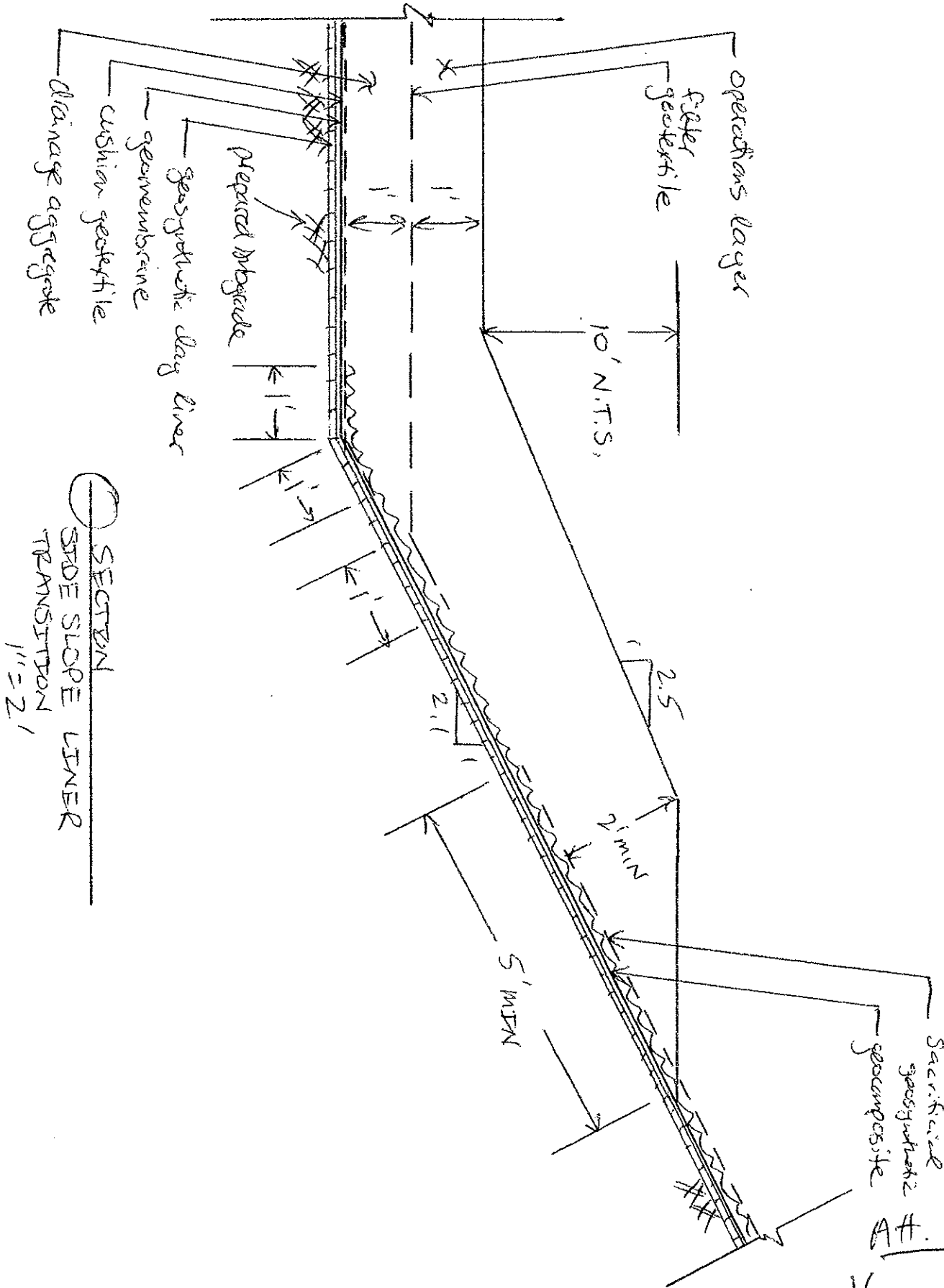
2. McKelvey, J.A. (1994) "Consideration of equipment loadings in geosynthetic lined slope designs", Proc. 8th Intc Conf. of the International Association for Computer Methods and Advances in Geomechanics, Morgantown, WV:Balkema, pp. 1371-1377.

GEOSYNTEC CONSULTANTS

Page ____ of ____

Written by: Geoff Smith Date: 00/04/18 (YY/MM/DD) Reviewed by: MLD GC Date: 00/07/03 (YY/MM/DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HC0398 Task No.: 02



SECTION
SIDE SLOPE LINER TRANSITION
1" = 2'

Att. A

1/1

GCC

Direct Shear Strength

A progressive direct shear test was performed on selected undisturbed samples using a constant strain rate direct shear machine in general accordance with ASTM D3080. The test specimen was trimmed and placed in the shear machine, a specified normal load was applied, and the specimen was sheared until maximum shear strength was developed. After the soil specimen had developed maximum shear resistance under the first normal load, the normal load was removed and the specimen was pushed back to its original undeformed configuration. Another normal load was then applied, and the specimen was sheared a second time. This process was repeated for three different normal loads. Results of the direct shear test are presented on Figures A-62 through A-69 and in the following table:

Exploration Location	Depth (Feet)	Soil Description	Angle of Internal Friction (deg)	Coulomb Cohesion (ksf)
B-4	14-14.5	Silty sand with gravel	31	0.7
B-5	14-15	Silty sand with gravel	43	0.3
B-10	54-54.5	Sandy lean clay	26	0.85
B-12	14-15	Silty sand with gravel	40	0.3
B-101	39-40	Sandy lean clay	26	0.9
B-102	20-25	Silty sand with gravel	37	0.2
B-103	49-50	Sandy lean clay	37	1.0
B-104	10-15	Silty sand with gravel	43	0.1

Chemical Analysis

Chemical tests were performed on a representative soil samples to investigate the potential for soil corrosivity and chemical heave. Atlas Chemical Testing Laboratories, Inc. in Las Vegas performed the chemical analysis for water-soluble sulfates and sodium in general accordance with ASTM D516. The results of the chemical tests are presented on Drawing No. A-70.

Converse Consultants, 1999 MLD

Attachment B, 1/2

© Converse Consultants

shown on Drawing Nos. A-49 through A-56, entitled *Consolidation Test* and are summarized on the following table:

Exploration Location	Depth (feet)	Soil Description	Dry Unit Weight, pcf	Moisture Content, %	Hydrocollapse (percent)*
B-1	29-30	Silty sand with gravel	105	6	3.2
B-8	39-40	Sandy lean clay	57.4	64	0.4
B-8	49-50	Sandy lean clay	69.5	51.1	-0.6
B-10	54-54.5	Sandy lean clay	60.7	67.7	-0.6
B-101	39-40	Sandy lean clay	65.8	45	-0.2
B-101	59-60	Sandy lean clay	73.2	38.3	-0.6
B-102	49-50	Sandy lean clay	67.3	48.7	-0.5
B-105	34-35	Well graded sand with silt and gravel	101	5	0.1

NA: Not available

* A negative sign indicates swell occurred upon inundation with water instead of collapse.

Laboratory Maximum Density

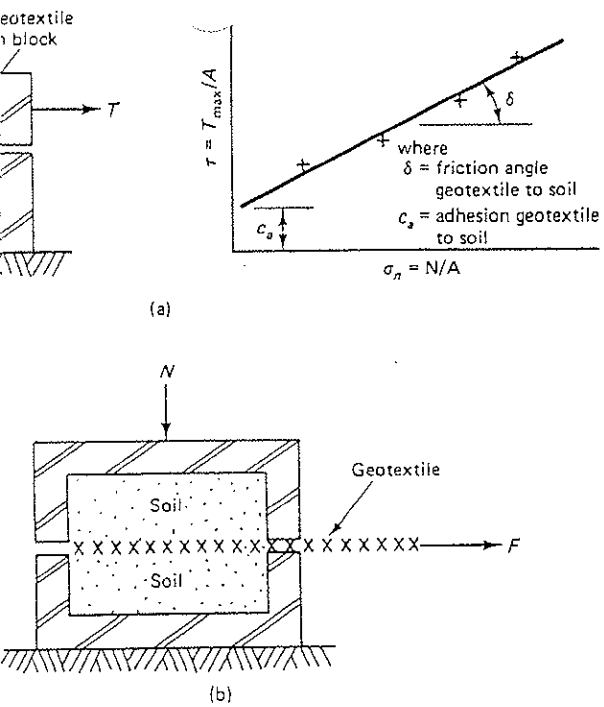
Laboratory maximum density tests were performed on selected samples of the granular soils. The purpose of the test was to define the compaction characteristics of these soils, and to aid in estimating soil shrinkage. The laboratory maximum density test was performed in general accordance with the ASTM D1557 test method. This test procedure uses 25 blow of a 10-pound hammer falling a height of 18 inches on each of five layers of soil in a 1/30 or 1/13 cubic foot cylinder. The test results are presented on Drawing Nos. A-57 through A-61 and in the following table:

Exploration Location	Depth (Feet)	Soil Description	Maximum Dry Unit Weight (pcf)	Optimum Moisture Content (percent) of dry weight)
B-1	20-25	Silty sand with gravel	129.4	8.2
B-5	20-25	Silty sand with gravel	132.1	8.2
B-12	10-15	Silty sand with gravel	129.7	7.9
B-101	5-10	Silty sand with gravel	130.6	8.7
B-105	20-25	Well graded sand with silt and gravel	131.8	7.5

TABLE 3.31
TYPICAL PROPERTIES OF COMPACTED SOILS*

Group symbol	Soil type	Range of maximum dry unit weight, pcf	Range of optimum moisture, %	Typical value of compression: Percent of original height: At 1.4 tsf (20 psi)	At 3.8 tsf (50 psi)	Typical strength characteristics: Cohesion (as compacted), psf	Cohesion (saturated), psf	Effective stress envelope ϕ, degrees	tan ϕ	Typical coefficient of permeability, ft/min	Range of CBR values	Range of subgrade modulus k_s, lb/in³
GW	Well-graded clean gravels, gravel-sand mixtures	125–135	11–8	0.3	0.6	0	0	>38	>0.79	5×10^{-2}	40–80	300–500
GP	Poorly graded clean gravels, gravel-sand mix	115–125	14–11	0.4	0.9	0	0	>37	>0.74	10^{-1}	30–60	250–400
GM	Silty gravels, poorly graded gravel-sand silt	120–135	12–8	0.5	1.1	...	...	>34	>0.67	$>10^{-6}$	20–60	100–400
GC	Clayey gravels, poorly graded gravel-sand-clay	115–130	14–9	0.7	1.6	...	...	>31	>0.60	$>10^{-7}$	20–40	100–300
SW	Well-graded clean sands, gravelly sands	110–130	16–9	0.6	1.2	0	0	38	0.79	$>10^{-3}$	20–40	200–300
SP	Poorly-graded clean sands, sand-gravel mix	100–120	21–12	0.8	1.4	0	0	37	0.74	$>10^{-3}$	10–40	200–300
SM	Silty sands, poorly graded sand-silt mix	110–125	16–11	0.8	1.6	1050	420	34	0.67	5×10^{-5}	10–40	100–300
SM-SC	Sand-silt clay mix with slightly plastic fines	110–130	15–11	0.8	1.4	1050	300	33	0.66	2×10^{-6}	...	
SC	Clayey sands, poorly graded sand-clay mix	105–125	19–11	1.1	2.2	1550	230	31	0.60	5×10^{-7}	5–20	100–300
ML	Inorganic silts and clayey silts	95–120	24–12	0.9	1.7	1400	190	32	0.62	10^{-5}	15 or less	100–200
ML-CL	Mixture of inorganic silt and clay	100–120	22–12	1.0	2.2	1350	460	32	0.62	5×10^{-7}	...	
CL	Inorganic clays of low to medium plasticity	95–120	24–12	1.3	2.5	1800	270	28	0.54	10^{-7}	15 or less	50–200
OL	Organic silts and silt-clays, low plasticity	80–100	33–21	...	...	...	...	...	...	...	5 or less	50–100
MH	Inorganic clayey silts, elastic silts	70–95	40–24	2.0	3.8	1500	420	25	0.47	5×10^{-7}	10 or less	50–100
CH	Inorganic clays of high plasticity	75–105	36–19	2.6	3.9	2150	230	19	0.35	10^{-7}	15 or less	50–150
OH	Organic clays and silty clays	65–100	45–21	...	...	...	...	...	...	...	5 or less	25–100

Hunt, 1986 MLD
Attachment C 1/1



nematic diagrams of test setups for friction and pullout evaluation of ls. (a) Soil-to-fabric friction test and results. (b) Fabric pullout (anchor-

between the fabric and the soil with no further increase in n the test is repeated at different normal stresses, a trend is shear strength parameters can be obtained. Note that these parameters are related to, but not necessarily the same as, the ers. They (the soil parameters) are, however, the conservative fabric parameters. Often an efficiency, as defined below, is of soil shear strength parameters that is mobilized, e.g.,

$$E_c = (c_a/c) \times 100 \tag{2.7}$$

$$E_\phi = (\tan \delta/\tan \phi) \times 100 \tag{2.8}$$

n cohesion,
n friction angle,
f soil to fabric,

c = the cohesion of soil,
δ = the friction angle of soil to fabric, and
ϕ = the friction angle of soil.

Results from such a test setup by Martin, et al. [13], are presented in Table 2.6 for four geotextile types against three different cohesionless soils. Soil-to-fabric friction angles are given, as well as the fabric efficiency versus the soil friction angle by itself as per Equation 2.8. Here it is seen that most geotextiles can mobilize a high percentage of the soil's friction and can be used to advantage in situations requiring this feature. A review and compilation of a number of direct shear tests on various fabrics against different granular soils is given by Richards and Scott [14]. Another review by Williams and Houlihan [15] covers a wider range of soils, including some sands, silts, and mixed soils.

2.2.3.11 Pullout (Anchorage) Tests

Geotextiles are often called upon to provide anchorage for many applications within the reinforcement function. Such anchorage usually has the fabric sandwiched between soil on each side of it. The resistance can be modeled in the laboratory using a pullout test, shown schematically in Figure 2.8b. The pullout resistance is obviously dependent on the normal force applied to the soil surrounding it, which mobilizes shear forces on both sides of the fabric.

Test results by Collios et al. [16] show a relationship of pullout test results to shear test results with some notable exceptions. If the soil particles are smaller than the fabric openings, efficiencies are higher; if not, they can be lower. In all cases, however, pullout test resistances are less than shear test resistances. This is due to the fact that the fabric is taut and exhibits large deformations. This in turn causes the soil particles to reorient themselves into a reduced-shear-strength situation at the soil-fabric interfaces, resulting in lower pullout resistance. The stress state mobilized in this test is a very complex one requiring additional research.

TABLE 2.6 SOIL-TO-FABRIC FRICTION ANGLES AND EFFICIENCIES (IN PARENTHESES) IN COHESIONLESS SOIL

Geotextile type	Manufacturer's designation	Concrete sand ϕ = 30 deg.	Rounded sand ϕ = 28 deg.	Silty sand ϕ = 26 deg.
Woven, monofilament	Polyfilter X	26 deg. (84%)	-	—
Woven, silt film	500X	24 deg. (77%)	24 deg. (84%)	23 deg. (87%)
Nonwoven, melt-bonded	3401	26 deg. (84%)	–	-
Nonwoven, needle-punched	CZ600	30 deg. (100%)	26 deg. (92%)	25 deg. (96%)

Source: After Martin et al. [13]

SLT North America, Inc.

FrictionFlex™ Application Data

SLT's FrictionFlex process provided the industry's first textured liner. It is the only geomembrane texturing process ever to be granted a U.S. Patent. It, in fact, has been awarded two*. In direct contrast to blown-film geomembranes which are textured or made rough by a process which actually erodes the sides of the sheet, the FrictionFlex process is additive. SLT begins with 24-foot wide SLT HyperFlex™ or UltraFlex™ sheet manufactured to the industry's most exacting standards. Only after the sheet passes all QC, is texturing added to one or both sides as required by the application. When the engineer utilizes SLT geomembranes textured by the FrictionFlex process, increased facility design capacity, service life and total revenue potential can be obtained. Containment slopes, vertical expansions and perimeter slopes in closures share the benefits of greater air-space and superior cover stability.

Most importantly, the advantages of FrictionFlex are available without compromise of any performance property or other issue of secure containment. The patented manufacturing process enables SLT to produce a textured liner exhibiting similar mechanical and chemical properties demanded of SLT's premium grades of smooth geomembrane liners, whether HDPE, VLDPE or LDPE.

An added feature of SLT's process is that an edge, 6-to-8 inches wide, is left smooth to aid in welding and field quality control. This allows standard installation equipment and procedures to ensure expedient construction.

The following reflects independent data confirming superior FrictionFlexed liner performance in contact with soils and synthetics:

- Highest coefficient of friction with soils
- Highest coefficient of friction with synthetics
- Premium grade mechanical and chemical properties

SLT Textured Liner Materials				Typical Smooth HDPE
Material	Coefficient of Friction	Adhesion (per square foot)	Average Friction Angle (degrees)	Comparable Friction Angle
Sandy Glacial Till	0.74	27	36	20
Sandy Clay	0.70	65	35	18
Smooth Clay	0.62	39	32	16
Ottawa Sand	0.59	21	30	19
Non-woven Polyester Geotextile	0.54	116	28	11
Non-woven Poly-propylene Geotextile	0.65	133	33	12

NOTE: The above data is approximate. SLT recommends that specific data be developed for all application designs. Shear box testing of the specific geosynthetic and natural components of the composite is necessary to establish an appropriate design basis. SLT will be pleased to provide any necessary material samples for such purposes and invites compararive procedures.

This data is provided for informational purposes only and is not intended as a warranty or guarantee. SLT assumes no liability in connection with the use of this data.

*U.S. Patent No. 4,885,201
5,075,135

For environmental lining solutions...the world comes to SLT.™

SLT NORTH AMERICA, INC.
Subsidiary of SLT Environmental, Inc.
200 S. Trade Center Parkway
Conroe, Texas 77385
(713) 350-1813 FAX (409) 273-2266

SLT Lining Technology GmbH
Pollhornweg 17
D-2102 Hamburg 93
Germany
49-40-751-0060
FAX 49-40-752-1988

SLT Lining Technology (Far East) Pte., Ltd.
182 Tagore Ln.
Singapore 2678
65-459-2466
FAX 65-459-4366

SLT Advanced Lining Technology Pty. Ltd.
5 Regent Crescent
Moorebank, New South Wales
Australia 2170
61-2-821-2977
FAX 61-602-9606

SUMMARY OF BENTOMAT DIRECT SHEAR TEST DATA

Lab[1]	Report Date	Interface Tested[2]	Normal Stresses (psi)	Bentomat Moisture[3]	Shear Rate (in/min)	Peak Friction Angle (deg)	Residual Friction Angle (deg)	Apparent Cohesion (psf)	Comments
J & L	05-30-90	NW/Sand	1 - 2 - 3	Hydrated	0.02	35	Not determined	10	
		NW/Sand *	1 - 2 - 3	Dry *	0.02	28 *	"	85	
		NW/Clay	1 - 2 - 3	Hydrated	0.02	41	"	77	
		NW/Clay	1 - 2 - 3	Dry	0.02	32	"	105	
STS	09-11-90	NW/40-mil Text. HDPE *	35 - 52 - 70	Dry *	0.2	18 *	Not determined	0	
		NW/80-mil Text. HDPE	35 - 52 - 70	Dry	0.2	37	"	0	
		W/80-mil Text. HDPE	35 - 52 - 70	Dry	0.2	24	"	0	
J & L	11-06-90	NW/Sandy soil	2 - 3.5 - 5	Dry	0.02	23	Not determined	119	
GRI	04-18-91	Internal	.5 - 1 - 5 - 10 - 20	Dry	0.035	42	Not determined	288	
		Internal	.1 - .5 - 1 - 5 - 10	Hydrated	0.035	37	"	115	
		Internal	.1 - .5 - 1 - 5 - 10	Hydrated	0.035	39	"	173	Hydrated in leachate
STS	05-28-91	NW/40-mil Text. HDPE	35 - 52 - 70	Hydrated	0.2	20	Not determined	0	
		W/80-mil Text. HDPE	35 - 52 - 70	Hydrated	0.2	19	"	0	
UTA	08-12-91	Internal	6 - 9 - 14 - 19	Hydrated	0.000131	26	Not determined	619	
J & L	09-09-91	W/Soil cover	0.6 - 1.25 - 1.88	Hydrated	0.035	22.5	20.5	55	
		W/Geonet	0.6 - 1.25 - 1.88	Hydrated	0.035	17	16	64	
		NW/2B Stone	0.6 - 1.25 - 1.88	Hydrated	0.035	53	52	10	
TRI	05-06-92	W/60-mil text. VLDPE	2 - 8 - 14	Hydrated	0.04	22	Not determined	113	Limited hydration
		W/60-mil sm. VLDPE	2 - 8 - 14	Hydrated	0.04	15	"	77	"
TRI	11-12-92	W/40-mil text. LLDPE	3.5 - 7 - 14	Hydrated	0.2	25	16.5	230	
TRI	03-16-93	W/Saturated soil	1 - 2 - 3	Hydrated	0.04	24	Not determined	100	Bentomat HS
		W/Dry soil	1 - 2 - 3	Hydrated	0.04	20	"	153	"
		NW/Drainage geocomp.	1 - 2 - 3	Dry	0.04	17	"	20	"

Calculation Package F
Geotextile/Separation/Filtration Requirements

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: Basic Remediation Company

Project: BRC CAMU **Project/Proposal #:** SC0313 **Task #:** 01

Title of Computations: Geotextile Performance Requirements

Computations By:

SIGNATURE — DATE 11/3/06

Rebecca Flynn, Staff Engineer
PRINTED NAME AND TITLE

Assumptions and Procedures Checked By (Peer Reviewer):

SIGNATURE — DATE 11/3/06

Gregory T. Corcoran, PE / Principal
PRINTED NAME AND TITLE

Computations Checked By:

SIGNATURE — DATE 11/3/06

Gregory T. Corcoran, PE / Principal
PRINTED NAME AND TITLE

Computations Backchecked By (Originator):

SIGNATURE — DATE 11/3/06

Rebecca Flynn, Staff Engineer
PRINTED NAME AND TITLE

Approved By (PM or Designate):

SIGNATURE — DATE 11/3/06

Gregory T. Corcoran, PE / Principal
PRINTED NAME AND TITLE

Approval Notes:

Revisions: (Number and Initial All Revisions)

No.	Sheet	Date	By	Checked By	Approval

Written by: Rebecca Flynn Date: 06/09/06 (YY MM DD) Reviewed by: GTC Date: 06/11/03 (YY MM DD)

Client: BRC Project: CAMU Project/Proposal No.: SC0313 Task No.: 01-04

GEOTEXTILE PERFORMANCE REQUIREMENTS
BRC CAMU
HENDERSON, NEVADA

OBJECTIVE

It is proposed that the drainage system for the BRC Corrective Action Management Unit (CAMU) located in Henderson, Nevada include a geonet overlaid by an 8 oz/sy geotextile on the top side of the geonet acting as a filter geotextile. The geotextile must retain the overlying protective soil to minimize impairment to the underlying geocomposite drainage layer material flow properties and have sufficient mechanical properties for durability. This calculation will evaluate the required performance properties of the filter geotextile.

SUMMARY OF ANALYSIS

The calculations suggest:

- that the separation/filtration geotextile overlying the aggregate drainage layer have an AOS less than sieve No. 70 (0.21 mm), a permittivity greater than 0.8 sec^{-1}, a minimum mass per unit area of 6 $oz./yd^2$, and sufficient mechanical strength properties as outlined in federal guidelines; and

- that the separation/filtration geotextile adhered to the geonet layer have an AOS less than sieve No. 70 (0.21 mm), a permittivity greater than 0.6 sec^{-1}, a minimum mass per unit area of 8 $oz./yd^2$, and sufficient mechanical strength properties as outlined in federal guidelines.

SITE CONDITIONS

The liner system consists of, from top to bottom:

- 2 ft. of operations layer material;
- Drainage geocomposite with an 8 oz/sy geotextile bonded to both sides of the geonet;
- a 60-mil (1.5-mm) textured high density polyethylene (HDPE) geomembrane;
- a geosynthetic clay liner (GCL); and
- subgrade.

Written by: Rebecca Flynn Date: 06/09/06 (YY MM DD) Reviewed by: GTC Date: 06/11/3 (YY MM DD)

Client: BRC Project: CAMU Project/Proposal No.: SC0313 Task No.: 01-04

A cross-section of the lining system is presented as Attachment A.

The operations layer material will consist of on-site material, which has been classified as silty sand to well-graded sand (SM, SM-SW according to the Unified Soils Classification System) (Converse Consultants, 1999) (Attachment F).

ANALYSIS

Filtration Requirements: The geotextile will minimize fine particles of the operations layer material from migrating into the geocomposite drainage layer material. Migration of fine particles would have the adverse effect of decreasing the transmissivity of the geocomposite drainage layer.

The filtration requirements for geotextiles can be evaluated using the "Geotextile Filter Design Manual" developed by Luettich et al., (1991) (Attachment B). Page 2 of Attachment B shows a chart in which soil properties are used to evaluate the retention criteria of the geotextile by determining the maximum allowable apparent opening size (AOS or O_{95}).

The soil cover has been classified as silty or clayey sand and well-graded sand. Both of these classifications suggest that less than fifty percent of the material is fine-grained soils (i.e., smaller than the No. 200, or 0.075 mm, sieve size). To be conservative in the calculations herein, the operations layer is assumed to consist of more than 20 percent clay and to be non-dispersive. Therefore, using page 2 of Attachment B,

> **O_{95} < 0.21 mm**, which corresponds to sieve No. 70, meaning that the geotextile apparent opening size (AOS) must be less than a No. 70 sieve size.

Permeability: The following equation can be used to evaluate the minimum allowable geotextile permeability:

$$k_g > i_s k_s$$ (Luettich et al. (1991), Att. B, p. 1)

where: k_g = permeability of geotextile (cm/s)
i_s = hydraulic gradient (dimensionless)
k_s = permeability of the protective soil cover (cm/s)

Written by: Rebecca Flynn Date: 06/09/06 (YY MM DD) Reviewed by: GTC Date: 06/11/03 (YY MM DD)

Client: BRC Project: CAMU Project/Proposal No.: SC0313 Task No.: 01-04

Hydraulic Gradient, i_s: Attachment B, page 3 from Luettich et al. (1991) lists typical hydraulic gradients for various geotextile drainage applications. In this attachment, a hydraulic gradient of 1.5 for landfill LCRS (landfill leachate collection and removal system) applications is recommended.

Soil Permeability, k_s: A permeability of 1.2×10^{-3} cm/s was used based on permeability testing of site specific soils. (Attachment F)

Therefore,

$$k_g > \quad i_s k_s = (1.5)(1.2\text{x}10^{-3})$$
$$k_g > \quad 1.8 \times 10^{-3} \text{ cm/s}$$

Koerner (1994) suggests applying partial factors of safety to the ultimate flow capacity of the geotextile to account for clogging of the geotextile. Using recommendations given in Table 2.13 on p. 160 of Koerner (1994) (Attachment D), the following partial safety values were applied:

soil clogging and blinding:	10 (5 – 10)	creep reduction of voids:	2.0 (1.5 – 2.0)
intrusion into voids:	1.2 (1.0 – 1.2)	chemical clogging:	1.5 (1.2 – 1.5)
biological clogging:	2.0 (2 – 50)		

Therefore,

$$k_g > \quad (1.8 \times 10^{-3})(10)(2)(1.2)(1.5)(2)$$
$$k_g > \quad 0.13 \text{ cm/s}$$

The thickness of 6 oz/yd^2 (205 g/m^2) and 8 oz/yd^2 (273 g/m^2) nonwoven geotextiles are approximately 65 mils (0.165 cm) and 90 mils (0.229 cm), respectively (Amoco technical literature, Attachment E, p. 1). Dividing the permeability by the thickness of the geotextile results in the following permittivity values:

6 oz./SY = 0.78 sec^{-1}
8 oz./SY = 0.57 sec^{-1}

Mechanical Property Requirements: To ensure proper manufacturing and durability of the geotextile, the geotextile should have appropriate strength requirements. Based on guidelines developed by Task Force 25 (see note below) (Attachment C) for mechanical properties of geotextiles used in applications requiring moderate survivability, the geotextile should have the following properties:

Written by: Rebecca Flynn Date: 06/09/06 (YY MM DD) Reviewed by: CTC Date: 06/11/03 (YY MM DD)

Client: BRC Project: CAMU Project/Proposal No.: SC0313 Task No.: 01-04

Property	Criteria
Grab strength	≥ 130 lb.
Puncture strength	≥ 40 lb.
Mullen burst	≥ 210 lb
Trapezoidal tear	≥ 40 lb
Ultraviolet strength retention	≥ 70 %

Note: Task Force 25 consisted of the American Associated of State and Transportation Officials (AASHTO), the American Building Contractors (ABC), and the American Road Builders and Transportation Association (ARBTA).

CONCLUSIONS

In accordance with the above analysis, the geotextile component of the drainage composite or separation/filtration geotextile shall have the following properties:

6 oz/yd^2

Property	Separation/Filtration Criteria
matrix	nonwoven
mass per unit area	6 oz/yd^2 (205 g/m^2)
apparent opening	≤ 0.21 mm (sieve No. 70)
permittivity	≥ 0.8 s^{-1}
grab strength	≥ 130 lb.
puncture strength	≥ 40 lb.
mullen burst	≥ 210 lb.
trapezoidal tear	≥ 40 lb.
ultraviolet strength retention	≥ 70 %

8 oz/yd^2

Property	Separation/Filtration Criteria
matrix	nonwoven
mass per unit area	8 oz/yd^2 (273 g/m^2)

Written by: Rebecca Flynn Date: 06/09/06 (YY MM DD) Reviewed by: GTC Date: 06/11/3 (YY MM DD)

Client: BRC Project: CAMU Project/Proposal No.: SC0313 Task No.: 01-04

apparent opening	≤ 0.21 mm (sieve No. 70)
permittivity	≥ 0.6 s^{-1}
grab strength	≥ 130 lb.
puncture strength	≥ 40 lb.
mullen burst	≥ 210 lb.
trapezoidal tear	≥ 40 lb.
ultraviolet strength retention	≥ 70 %

The following is a partial list of geotextile products that should meet the material requirements.

Amoco Fabrics & Fibers Co., Amoco 4506
Trevira 011/120
Synthetic Industries, Geotex 701

REFERENCES

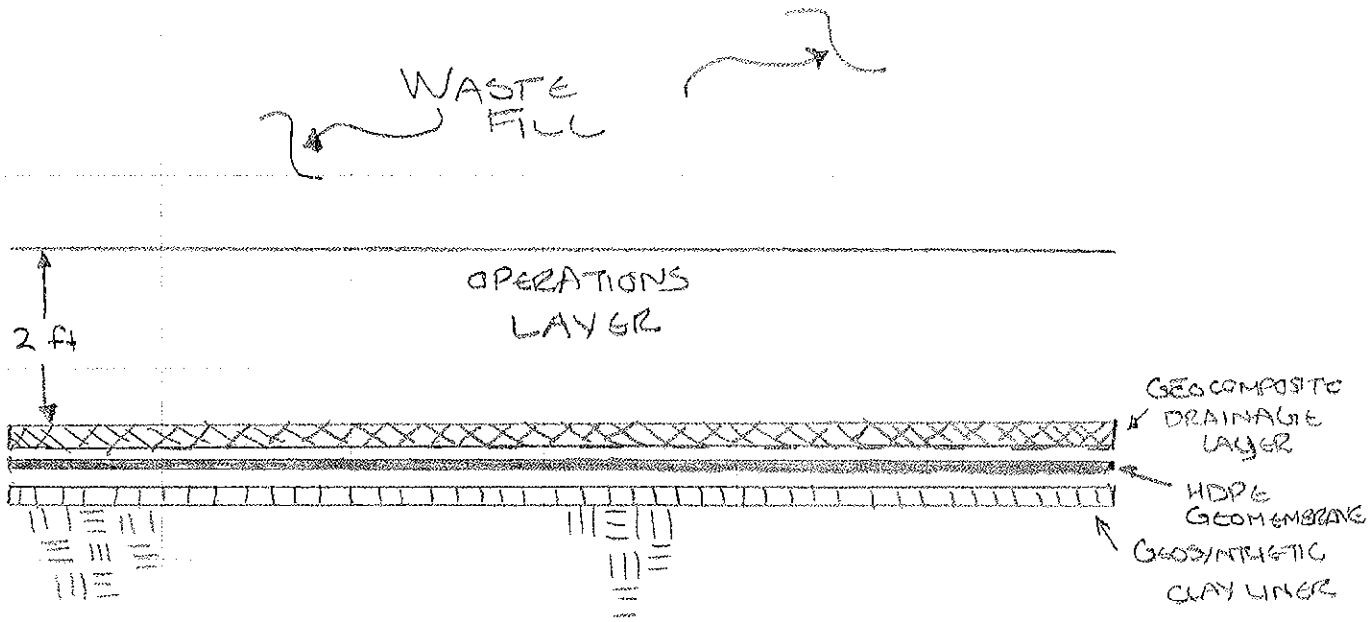
Amoco Fabrics and Fibers Company, Atlanta, Georgia, 404-984-4444

Luettich, S.M., Giroud, J.P., and Bachus, R.C. (1991), "Geotextile Filter Design Manual", report prepared for Nicolon Corporation, Norcross, GA *(Attachment B)*.

Converse Consultants (1999), "Preliminary Geotechnical and Geological Investigation", Prepared for Parsons Engineering Science, Inc., October 1999.

Written by: R. FLYNN Date: 21 / 08 / 06 (DD MM YY) Reviewed by: BTC Date: 06 / 11 / 13 (DD MM YY)

Client: BRC Project: BRC CAMV Project/Proposal No.: SC0313 Task No: 01 - 04



COMPOSITE LINER SYSTEM

ATTACHMENT A 1/1

MW

MLD

GTC

4.2 Define the Hydraulic Gradient for the Application (i_s)

The hydraulic gradient will vary depending on the application of the filter. Anticipated hydraulic gradients for various applications may be estimated using Figure 3.

4.3 Determine the Minimum Allowable Geotextile Permeability (k_g)

After determining the soil hydraulic conductivity and the hydraulic gradient, the following equation can be used to determine the minimum allowable geotextile permeability [Giroud, 1988]:

$$k_g > i_s k_s$$

The hydraulic conductivity (permeability) of the geotextile can be calculated from the permittivity test method ASTM D 4491; this value can often be obtained from the manufacturer's literature as well. The geotextile permeability is defined as the product of the permittivity, ψ, and the geotextile thickness, t_g:

$$k_g > \psi t_g$$

STEP 5. DETERMINE ANTI-CLOGGING REQUIREMENTS

To minimize the risk of clogging, the following criteria should be met:

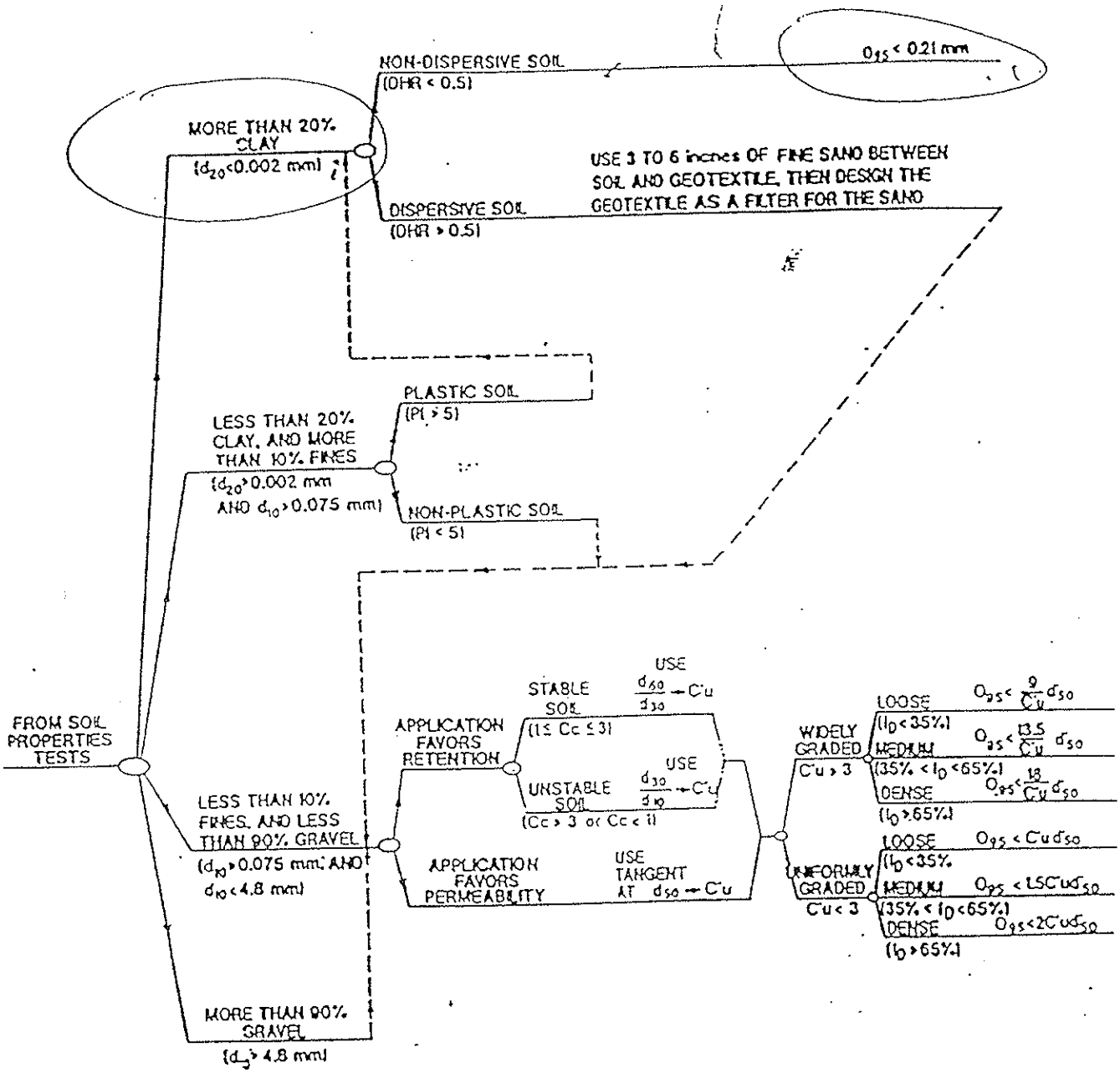
- Use the largest opening size (O_{95}) that satisfies the retention criteria.
- For nonwoven geotextiles, use the largest porosity available, but not less than 30 percent.
- For woven geotextiles, use the largest percent open area available, but not less than 4 percent.

Source: Luettich, S.M. Giroud, J.P. and Bachus R.C (1991) "Geotextile Filter Design Manual" Report prepared for Nicolon Corporation Norcross, GA

ATTACHMENT B

P 2/3

CHART 1
SOIL RETENTION CRITERIA
FOR STEADY-STATE FLOW CONDITIONS



NOTES:

d_x is the particle size of which x percent is smaller

$C'u = \sqrt{\frac{d'_{100}}{d'_0}}$ where: d'_{100} and d'_0 are the extremities of a straight line drawn through the particle-size distribution, as directed above; and d'_{50} is the midpoint of this line.

$Cc = \frac{(d_{30})^2}{d_{60} \times d_{10}}$

I_D is the relative density of the soil

PI is the plasticity index of the soil

DHR is the double-hydrometer ratio of the soil

Portions of this flow chart modified from Giroud (1988)

Source: Luettich, S.M., Giroud, J.P., and Bachus, R.C. (1991) "Geotextile Filter Design Manual" Report prepared for

ATTACHMENT B, 2/3

MN

MLD
GTC

FIGURE 3
TYPICAL HYDRAULIC GRADIENTS[a]

DRAINAGE APPLICATION	TYPICAL HYDRAULIC GRADIENT
STANDARD DEWATERING TRENCH	1.0
VERTICAL WALL DRAIN	1.5
PAVEMENT EDGE DRAIN	1[b]
LANDFILL LCDRS	1.5
LANDFILL LCRS	1.5
LANDFILL SWCRS	1.5
DAMS	10[b]
INLAND CHANNEL PROTECTION	1[b]
SHORELINE PROTECTION	10[b]
LIQUID IMPOUNDMENTS	10[b]

NOTES: (a) Table developed after Giroud, 1988.

(b) Critical applications may require designing with higher gradients than those given.

Attachment B
P. 3/3

Specification for *Survivability*

TABLE C-4 MINIMUM FABRIC PROPERTIES RECOMMENDED FOR FABRIC SURVIVABILITY[a]

Required degree of fabric survivability	Grab strength (lbs.)	Puncture strength[b] (lbs.)	Burst strength[c] (lb./in.^{2})	Trap tear[d] (lbs.)
Low	90	30	145	30
Moderate	130	40	210	40
High	180	75	290	50
Very high	270	110	430	75

(a) All values represent minimum values (i.e., any roll in a lot should meet or exceed the minimum values in this table).

(b) ASTM D751-68, tension testing machine with ring clamp, steel ball replaced with a 5/16-in.-diameter solid steel cylinder with hemispherical tip centered within the ring clamp.

(c) ASTM D751-68, diaphragm test method.

(d) ASTM D1117, either principal direction.

Appendix 2nd Edition
Attachment C 1/1

TABLE C-5 REQUIRED DEGREE OF SI \BILITY AS A FUN
CONDITIONS AND CONSTRUCTION EQ ENT[a]

Subgrade conditions	Construction e: Low ground-pressure equipment (≤4 lb./in.^{2})
Subgrade has been cleared of all obstacles except grass, weeds, leaves, and fine wood debris. Surface is smooth and level such that any shallow depressions and humps do not exceed 6 in. in depth and height. All larger depressions are filled. Alternatively, a smooth working table may be placed.	Low
Subgrade has been cleared of obstacles larger than small to moderate-sized tree limbs and rocks. Tree trunks and stumps should be removed or covered with a partial working table. Depressions and humps should not exceed 18 in. in depth and height. Larger depressions should be filled.	Moderate
Minimal site preparation is required. Trees may be felled, delimbed, and left in place. Stumps should be cut to project not more than 6 in. ± above subgrade. Fabric may be draped directly over tree trunks, stumps, large depressions and humps, holes, steam channels, and large boulders. Items should be removed only if placing the fabric and cover material over them will distort the finished road surface.	High

(a) Recommendations are for 6-12 in. initial lift thickness. For other init
12–18 in: reduce survivability requirement one level
18–24 in.: reduce survivability requirement two levels
>24 in.: reduce survivability requirement three levels
Survivability levels are, in increasing order: low, moderate, high, an
For special construction techniques such as prerutting, increase fabric
Placement of excessive initial cover material thickness may cause be

Source: After Christopher, B., and Holtz, R. D., Federal Highway Ad
Training Manual, Washington, DC.

MG

Table 2.13 Recommended partial factors of safety values for use in Equation 2.25

Application	Various Partial Factors of Safety				
	Soil Clogging and Blinding	Creep Reduction of Voids	Intrusion into Voids	Chemical Clogging	Biological Clogging
Retaining wall filters	2.0 to 4.0	1.5 to 2.0	1.0 to 1.2	1.0 to 1.2	1.0 to 1.3
Underdrain filters	5.0 to 10	1.0 to 1.5	1.0 to 1.2	1.2 to 1.5	2.0 to 4.0
Erosion control filters	2.0 to 10	1.0 to 1.5	1.0 to 1.2	1.0 to 1.2	2.0 to 4.0
Landfill filters	5.0 to 10	1.5 to 2.0	1.0 to 1.2	1.2 to 1.5	2.0 to 50
Gravity drainage	2.0 to 4.0	2.0 to 3.0	1.0 to 1.2	1.2 to 1.5	1.2 to 1.5
Pressure drainage	2.0 to 3.0	2.0 to 3.0	1.0 to 1.2	1.1 to 1.3	1.1 to 1.3

do not serve this function, the other, sometimes primary, function will not be served properly. This should not give the impression that geotextiles as separators always play a secondary role. Many situations call for separation only, and in such cases the geotextiles do serve a significant and worthwhile function.

2.5.1 Overview of Applications

Perhaps the target application that can best illustrate the use of geotextiles as separators is their placement between an underlying reasonably firm soil subgrade and a stone base course, aggregate, or ballast placed above the geotextile. We say "reasonably firm" because it is assumed that the subgrade deformation is not sufficiently large to mobilize uniformly high tensile stress in the geotextile. (The application of geotextiles in unpaved roads on soft soils wherein membrane-type reinforcement is developed is treated later in Section 2.6.) Thus for such a separation function to occur, the geotextile must be placed on the soil subgrade and then have stone placed, spread, and compacted on top of it. A number of scenar can be developed showing what geotextile properties are required for a given situation.

2.5.2 Burst Resistance

Consider a geotextile on a soil subgrade with stone of average particle diameter (d_a) placed above it. If the stone is uniformly sized, there will be voids within it that will be available for the geotextile to enter into. This entry is caused by the simultaneous action of the traffic loads being transmitted to the stone, through the geotextile, and into the underlying soil. The stressed soil then tries to push the geotextile up into the voids within the stone. The situation is shown schematically in Figure 2.26. Giroud [59] provides a formulation for the required geotextile strength which can be adopted for this application.

$$T_{reqd} = \frac{1}{2} p' d_v [f(\epsilon)] \tag{2.26}$$

where T_{reqd} = the required geotextile strength,
p' = the stress at the geotextile's surface, which is less than, or equal to,

Koerner (1994)

ATTACHMENT D 1/1

AMOCO WASTE RELATED GEOTEXTILES

MINIMUM PHYSICAL PROPERTIES
(Minimum Average Roll Values)

Property	Test Method	Units	4504	4506	4508	4510	4512	4516
Unit Weight	ASTM D-3776	Oz./yd.²	4.0	6.0	8.0	10.0	12.0	16.0
Grab Tensile	ASTM D-4632	lbs.	95	150	200	235	275	350
Grab Elongation	ASTM D-4632	%	50	50	50	50	50	50
Mullen Burst	ASTM D-3786	psi	225	350	450	550	650	750
Puncture	ASTM D-4833	lbs.	55	90	130	165	185	220
Trapezoid Tear	ASTM D-4533	lbs.	35	65	80	95	115	130
Apparent Opening Size	ASTM D-4751	US Sieve Number	70	70	100	100	100	100
Permittivity	ASTM D-4491	gal/min/ft² sec⁻¹	100 2.0	90 1.7	80 1.5	70 1.1	60 0.9	50 0.7
Permeability	ASTM D-4491	cm/sec	.2	.2	.2	.2	.2	.2
Thickness	ASTM D-1777	mils	40	65	90	110	130	175
U.V. Resistance	ASTM D-4355[1]	%[2]	70	70	70	70	70	70

1. Fabric conditioned per ASTM D-4355 2. Percent of minimum grab tensile after conditioning

TYPICAL PHYSICAL PROPERTIES

Property	Test Method	Units	4504	4506	4508	4510	4512	4516
Grab Tensile	ASTM D-4632	lbs.	130/115	225/200	275/270	315/310	410/370	510/470
Grab Elongation	ASTM D-4632	%	75	65	65	65	65	65
Mullen Burst	ASTM D-3786	psi	285	410	575	650	825	920
Puncture	ASTM D-4833	lbs	75	120	170	190	210	270
Trapezoid Tear	ASTM D-4533	lbs	60/50	100/80	140/120	160/140	185/155	220/180
Apparent Opening Size	ASTM D-4751	US Sieve Number	70/120	70/140	100/200	100+	100+	100+
Permittivity	ASTM D-4491	gal/min/ft² sec⁻¹	150 3.1	110 2.0	100 1.8	80 1.5	70 1.3	60 1.0
Permeability	ASTM D-4491	cm/sec	.35	.31	.27	.26	.25	.23
Thickness	ASTM D-1777	mils	50	75	115	130	150	195

PACKAGING

Dimensions		4504	4506	4508	4510	4512	4516
Roll Width	ft	15	15	15	15	15	15
Roll Length	ft.	1200	900	600	600	450	300

Amoco Technical Literature Appendix E
404 984-4444 p 1/1
MLD GTC

accuracy or reliability of said information or the performance of any product. All specifications [illegible] provided as information only and in no way modify, amend, enlarge or create any warranty. Nothing contained herein is to be construed as permission or as a recommendation to infringe any patent.

Exploration Location	Depth (feet)	Soil Description	Percent Sodium	Percent Sulfate	Total Available Water Soluble sodium Sulfate (%)
B-5	10-15	Silty sand with gravel	0.07	0.13	0.20
B-8	19-20	Silty sand with gravel	0.07	0.06	0.08
B-101	5-10	Silty sand with gravel	0.17	0.06	0.08
B-102	0-5	Fill – Silty sand with gravel	0.17	0.03	0.05
B-106	0-5	Silty sand with gravel	0.15	0.08	0.12
B-106	29-30	Silty sand with gravel	0.15	0.06	0.08

Permeability

Falling head permeability tests were conducted on remolded samples in general accordance with modified ASTM procedure D2434. The soil was compacted in a mold 4.6 inches long and 4.0 inches in diameter to 85 or 90 percent of maximum dry density and at optimum moisture content. A falling head was applied to the sample and the flow of water through the sample was monitored. The permeability was calculated after the flow rate had stabilized. The result of the falling head permeability test is presented in the following table:

Exploration Location	Sample Depth (Feet)	Soil Description	k (cm/s)
B-5	20-25	Silty sand with gravel	5.3×10^{-4}
B-12	10-15	Silty sand with gravel	4.0×10^{-4}
B-102	20-25	Silty sand with gravel	1.0×10^{-4}
B-105	20-25	Well graded sand with silt and gravel	1.2×10^{-3}

Flexible wall permeameter tests were performed on selected samples by AP Engineering and Testing, Inc according to ASTM D5084. With the exception of one sample (B-105), all tested samples were undisturbed ring samples. The samples were placed in a triaxial machine with a constant confining pressure at the approximate in-place effective stress pressures. Results were generally consistent with the fal-

Calculation Package G
Geotextile Cushion Protection

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: Basic Remediation Company

Project: BRC CAMU **Project/Proposal #:** SC0313 **Task #:** 01

Title of Computations: Geotextile Puncture Protection of Geomembrane

Computations By:
SIGNATURE — DATE 11/3/06
Rebecca Flynn, Staff Engineer
PRINTED NAME AND TITLE

Assumptions and Procedures Checked By (Peer Reviewer):
SIGNATURE — DATE 11/6/06
Keaton Botelho, Staff Engineer
PRINTED NAME AND TITLE

Computations Checked By:
SIGNATURE — DATE 11/3/06
Gregory T. Corcoran, PE / Principal
PRINTED NAME AND TITLE

Computations Backchecked By (Originator):
SIGNATURE — DATE 11/3/06
Rebecca Flynn, Staff Engineer
PRINTED NAME AND TITLE

Approved By (PM or Designate):
SIGNATURE — DATE 11/3/06
Gregory T. Corcoran, PE / Principal
PRINTED NAME AND TITLE

Approval Notes:

Revisions: (Number and Initial All Revisions)

No.	Sheet	Date	By	Checked By	Approval

Written by: Rebecca Flynn Date: 06 / 08 / 21 (YY MM DD) Reviewed by: GTC Date: 06 / 11 / 3 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

GEOTEXTILE PUNCTURE PROTECTION OF GEOMEMBRANE

OBJECTIVE

A composite liner system is proposed for the Corrective Action Maintenance Unit (CAMU) located in Henderson, Nevada. The objective of this calculation is to evaluate the maximum particle size of soil materials adjacent to the geomembrane that will not puncture the geomembrane. Specifically, the evaluation will consider the drainage aggregate overlying the geocomposite and geomembrane components of the liner system and the subgrade underlying the geomembrane and GCL components of the liner system.

SUMMARY OF ANALYSIS

The analysis suggests that the following maximum particle sizes and geotextile mass per unit areas will be required:

Soil Component of Liner	Maximum Particle Size	Minimum Mass Per Unit Area
Subgrade	0.75 in	9 oz./SY (GCL)
Angular Drainage Aggregate	1.00 in	16 oz./SY

SITE CONDITIONS

The composite liner system will be comprised of the following components, from top to bottom (Attachment A):

- 2 ft of operations layer material;
- a geocomposite drainage layer;
- 60-mil (1.5 mm) HDPE geomembrane, textured on both sides;
- a geosynthetic clay liner (GCL); and
- prepared subgrade.

The maximum height of waste to be placed within the lined area is 93 ft overlying the drainage sump in the South Mesa, based on the proposed waste fill plan. (Attachment B)

Written by: Rebecca Flynn Date: 06 / 08 / 21 (YY MM DD) Reviewed by: BTC Date: 06 / 11 / 3 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

- **OVERLYING PRESSURE:**

The overlying pressure can be estimated based on the maximum future fill height of 93 feet. The unit weight of the waste material was selected to be 136 pcf based on modified proctor tests conducted on soil samples from the site that are similar to the waste material to be placed with in the CAMU. The maximum dry density was determined to be 132 pcf at an optimum moisture content of 8.2%. Assuming that the material will be placed at a density less than 95% degree of compaction, the resulting dry density is 125.4 pcf. Adding the weight of the moisture in the soil results in a wet density of approximately 136 pcf. (Attachment C). Therefore, the overlying pressure is estimated as follows:

$$P = (93\ ft)(136\ pcf) = 12{,}648\ psf \text{ or } 606\ kPa$$

ANALYSIS

- **APPROACH – Protected Geomembrane**

Wilson-Fahmy, Narejo, and Koerner have evaluated puncture protection of geomembranes in a series of three papers. These papers are:

1) Wilson-Fahmy, R.F., Narejo, D., and Koerner, R.M (1996) "Puncture Protection of Geomembranes Part I: Theory", Geosynthetics International, Vol. 3, No. 5, pp. 605-628

2) Narejo, D., Koerner, RM. and Wilson-Fahmy, R.F. (1996) "Puncture Protection of Geomembranes Part II: Experimental", Geosynthetics International, Vol. 3, No. 5, pp. 629-653

3) Koerner, R.M., Wilson-Fahmy, R.F. and Narejo, D. (1996) "Puncture Protection of Geomembranes Part III: Examples", Geosynthetics International, Vol. 3, No. 5, pp. 655-675

These papers present an evaluation of geomembrane puncture theory, the results of a laboratory experimental program, and design examples in regards to puncture protection of geomembranes. The design methods and conclusions of these papers were used for the analysis herein.

According to these papers, the important parameters that affect the puncture protection of geomembranes are: overlying pressure, mass per area of the geotextile, and the particle size and shape of the material overlying the geotextile. For the analysis herein, the overlying pressure and the mass per unit area of the geotextile are given, and the maximum particle size is evaluated.

Written by: Rebecca Flynn Date: 06 / 08 / 21 (YY MM DD) Reviewed by: GTC Date: 06 / 11 / 3 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

- **MASS PER UNIT AREA OF GEOTEXTILE**

Two different mass per unit areas will be evaluated. The cushion geotextile overlying the liner system will be 16 oz./SY and the GCL underlying the liner system will have geotextile components with a minimum 9 oz./SY mass per unit area. (Attachment D)

- **SIZING MAXIMUM PARTICLE OF SOIL**

Narejo et al (1996, Attachment E) present the following equation for evaluating geotextile puncture protection of 60 mil (1.5 mm) HDPE geomembrane:

$H^2 = 450\ M_A / P_{allow}$ (Attachment E)

where:

M_A = mass per unit area geotextile (g/m^2)
= 542 (16 oz./SY) and 305 (9 oz./SY) g/m^2

H = cone height (mm), which corresponds to predicted effective protrusion height, which equals one half maximum stone size (Attachment E).

P_{allow} = maximum long term allowable pressure

where: $P_{allow} = P'_{allow}\ (MF_S \times MF_{PD} \times MF_A)(FS_{CR} \times FS_{CBD})$ (Attachment E)

where: MF_S, MF_{PD}, MF_A = modification factors (discussed below)
FS_{CR}, FS_{CBD} = partial factor of safety values (discussed below)

P'_{allow} = allowable pressure based on field conditions
= (FS) ($P_{actual\ field\ pressure}$) (Attachment E)

where: FS = global factor of safety, 3.0 (Attachment E)
$P_{actual\ field\ pressure}$ = 606 kPa
P'_{allow} = (606)(3) = 1,818 kPa

MF_S = shape factor: (Attachment E)
1.0 (assume angular particles)

MF_{PD} packing density: (Attachment E)
0.5 (assume packed stones)

Written by: Rebecca Flynn Date: 06 / 08 / 21 (YY MM DD) Reviewed by: BTC Date: 06 / 11 / 3 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

MF_A	soil arching: 0.75 (assume moderate)	(Attachment E)
FS_{CR}	partial factor of safety for creep 1.5 (see Table 12)	(Attachment E)
FS_{CBD}	partial factor of safety for chemical and biological degradation 1.5 (based on average value)	(Attachment E)

Solving for P_{allow} provides:

P_{allow} = (1,818) (1.0 x 0.5 x 0.75)(1.5 x 1.5)
P_{allow} = 1,534 kPa

Solving for H, the predicted effective protrusion height, provides:

$H^2 = 450\ M_A / P_{allow}$

$H_{cushion} = [(450)(M_A)/(1,534)]^{1/2}$
$M_A = 542\ g/m^2$ = 12.6 mm = 0.50 inches

$H_{GCL} = [(450)(M_A)/(1,534)]^{1/2}$
$M_A = 305\ g/m^2$ = 9.45 mm = 0.37 inches

The predicted effective protrusion height equals one half the maximum stone size. Therefore, the maximum stone size is twice the values listed above.

$M_A = 542\ g/m^2$ = 0.50 inches x 2 = 1.0 inches
$M_A = 305\ g/m^2$ = 0.37 inches x 2 = 0.75 inches

CONCLUSIONS

Assuming the following:

- the particle shape is angular for the drainage aggregate, and
- the approach presented by Wilson-Fahmy, Narejo, and Koerner for evaluating puncture protection of geomembranes is appropriate for the analysis herein,

then, the calculations suggest that THE MAXIMUM PARTICLE SIZE IS 1.0 IN. for a 16 oz/yd^2 geocomposite drainage layer and 0.75 IN. for a GCL with two geotextiles equating to 9 oz/yd^2.

Written by: Rebecca Flynn Date: 06 / 08 / 21 (YY MM DD) Reviewed by: GTC Date: 06 / 11 / 03 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

- **COMPLETE SET OF GEOTEXTILE PROPERTIES**

Typical nonwoven, needlepunched geotextile, when subjected to laboratory testing, should provide the following mechanical property values:

Property	**16 oz./SY Value**
puncture strength	> 240 lb
grab strength	> 390 lb
trapezoidal tear	> 150 lb
ultraviolet strength retention	> 70 %

REFERENCES

Geotechnical Fabrics Report, "2005 Specifiers Guide", Vol 22, No. 9, Dec. 2004.

Koerner, R.M., Wilson-Fahmy, R.F. and Narejo, D. (1996) "Puncture Protection of Geomembranes Part III: Examples", Geosynthetics International, Vol. 3, No. 5, pp. 655-675.

Narejo, D., Koerner, R.M. and Wilson-Fahmy, R.F. (1996) "Puncture Protection of Geomembranes Part II: Experimental", Geosynthetics International, Vol. 3, No. 5, pp. 629-653.

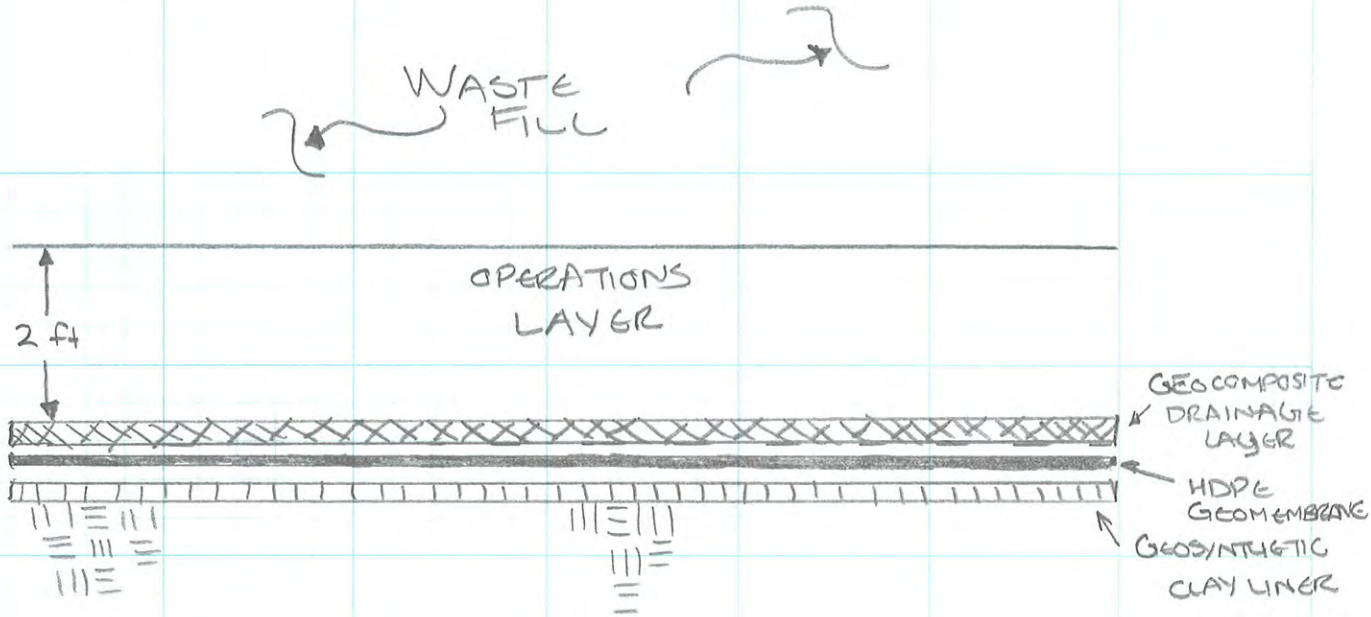
Wilson-Fahmy, R.F., Narejo, D., and Koerner, R.M. (1996) "Puncture Protection of Geomembranes Part I, Theory", Geosynthetics International, Vol. 3, No. 5, pp. 605-628.

GEOSYNTEC CONSULTANTS

Page _____ of _____

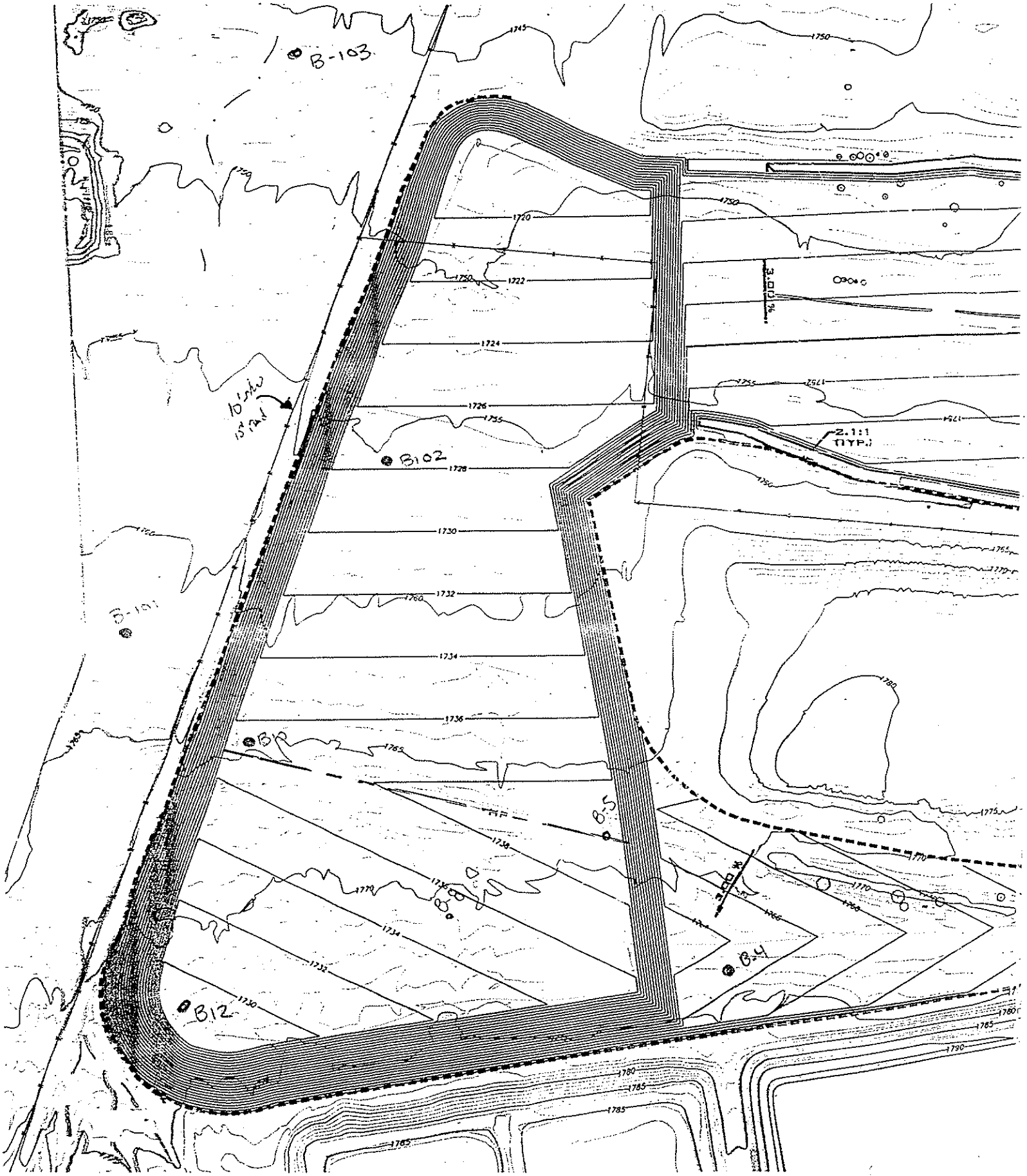
Written by: R. FLYNN Date: 21 / 08 / 06 (DD / MM / YY) Reviewed by: GTC Date: 03 / 11 / 06 (DD / MM / YY)

Client: BRC Project: BRC CAMV Project/Proposal No.: SC0313 Task No: 01 - 04



COMPOSITE LINER SYSTEM

ATTACHMENT A 1/1



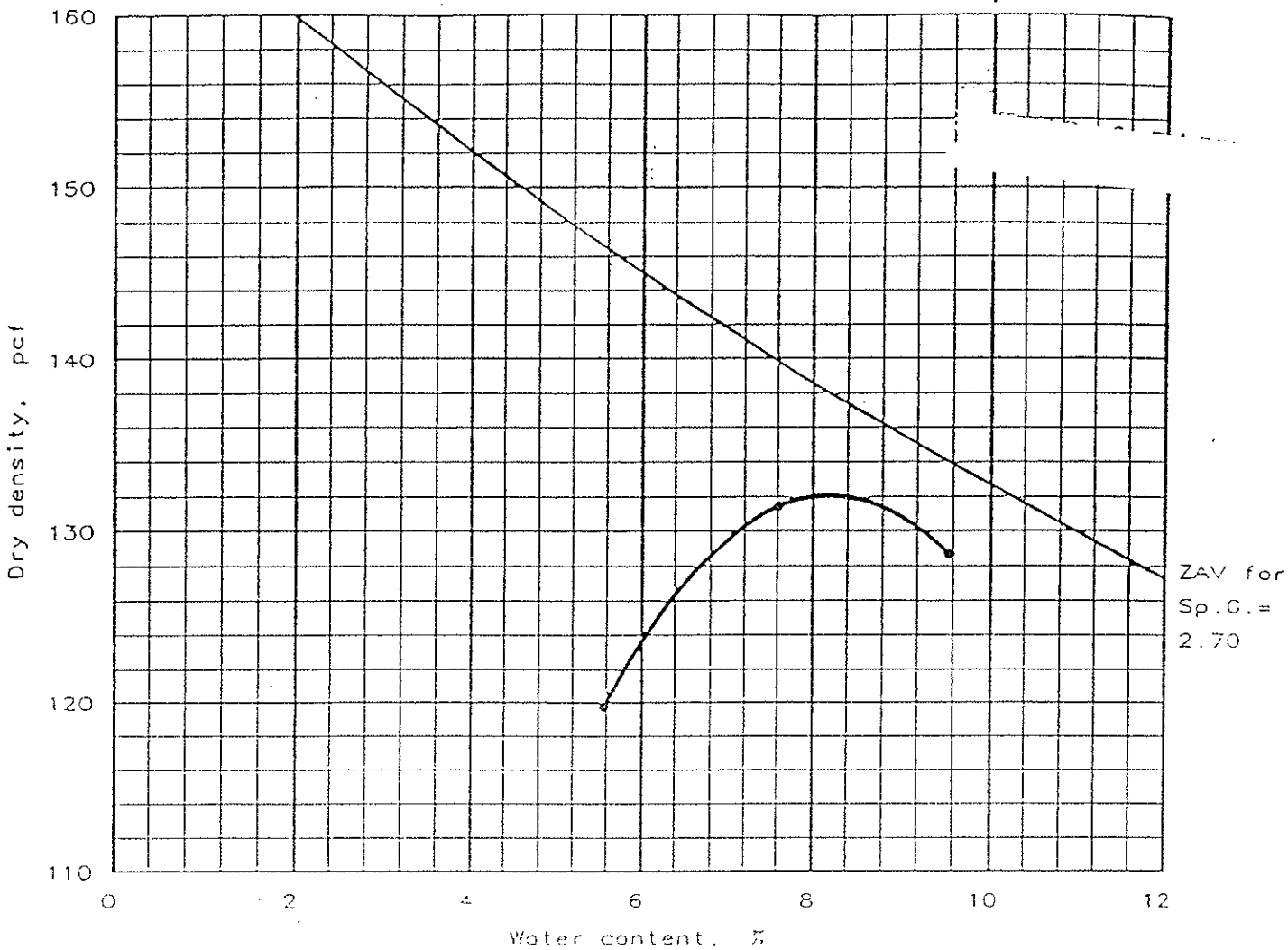
Attachment B

1/1

78 etc

(3) 5/10/05

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 1557-91 Procedure C, Modified

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/4 in	% < No.200
	USCS	AASHTO						
	SM				NV	NP	0 %	19.2 %

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 132.1 pcf Optimum moisture = 8.2 %	Silty Sand with Gravel

Project No.: 99-33437-01

Project: BMI Landfill

Location: B5 @ 20-25'

Date: 10-15-1999

MOISTURE-DENSITY RELATIONSHIP TEST

CONVERSE CONSULTANTS

Fig. No. A-58

ATTACHMENT C, 1/1 MLD

GEOSYNTHETIC CLAY LINERS

Product Name	Bonding Method	GCL Dimensional Properties: Panel Size Roll Width/Length m/m (ft/ft)	GCL Dimensional Properties: Average Roll Weight kg (lb)	GCL Dimensional Properties: Bentonite Mass/Unit Area ASTM D 5993 gm/m² (lb/ft²)	GCL Hydraulic Properties: Flux [1] ASTM D 5887 [2] m³/m²-s	Base Bentonite Properties: Swell Index ASTM D 5890 (min.) ml/2g	Base Bentonite Properties: Fluid Loss ASTM D 5891 ml	GCL Structural Components: Upper Geosynthetic: Type or Structure	GCL Structural Components: Upper Geosynthetic: Weight ASTM D 3776 g/m² (oz/yd²)	GCL Structural Components: Lower Geosynthetic: Type or Structure	GCL Structural Components: Lower Geosynthetic: Weight ASTM D 3776 or Thickness ASTM D 5199 g/m² or mm (oz/yd² or mil)	Manufacturer's Suggested Applications [3]
CETCO											www.cetco.com	
Bentomat ST	needle-punched	4.6/45.7 (15/150)	1180 (2600)	3670 (0.75)	1 x 10⁻⁸	24	18	woven	105 (3.2)	nonwoven	200 (6.0)	LL, LC, SIC
Bentomat SDN	needle-punched	4.4/45.7 (14.5/150)	1200 (2650)	3670 (0.75)	1 x 10⁻⁸	24	18	nonwoven	90 (2.7)	nonwoven	200 (6.0)	LL, LC, SIC
Bentomat DN	needle-punched	4.4/45.7 (14.5/150)	1200 (2650)	3670 (0.75)	1 x 10⁻⁸	24	18	nonwoven	200 (6.0)	nonwoven	200 (6.0)	LL, LC, SIC
Bentomat YSDN	needle-punched	4.4/60.9 (14.5/200)	1180 (2600)	2440 (0.50)	3 x 10⁻⁸	24	18	nonwoven	90 (2.7)	nonwoven	200 (6.0)	LC
Bentomat CL	needlepunched laminated	4.6/45.7 (15/150)	1250 (2750)	3670 (0.75)	1 x 10⁻⁸	24	18	FML/geotextile composite	NA	woven	105 (3.2)	LL, LC, SIC, CL, SIL
Bentomat CLT	needle-punched	4.6/45.7 (15/150)	1340 (2950)	3670 (0.75)	1 x 10⁻⁸	24	18	textured FML/geotextile composite	NA	woven	105 (3.2)	LL, LC, SIC, CL, SIL
Claymax 200R	adhesive	4.6/45.7 (15/150)	1225 (2700)	3670 (0.75)	1 x 10⁻⁸	24	18	nonwoven	75 (2.2)	nonwoven	90 (2.7)	LL, LC, SIC
Claymax [illegible]	adhesive	4.4/[illegible]	[illegible]	[illegible]	1 x 10⁻⁸	24	18	FML/nonwoven composite	NA	nonwoven	75 (2.2)	LL, LC, SIC, CL, SIL

Attachment D 1/2

3/5/10/05

GSE Gundseal Smooth HDPE	adhesive	5.3/61 (17.5/200)	1900 (4200)	3660 (0.75)	$\leq 4 \times 10^{-14}$	24	18	smooth HDPE geomembrane	0.4–2.0 mm (15–80 mil)	spunbonded geotextile	25 (0.75)	all
GSE Gundseal Textured HDPE	adhesive	5.3/55 (17.5/180)	1900 (4200)	3660 (0.75)	$\leq 4 \times 10^{-14}$	24	18	textured HDPE geomembrane	0.75–2.0 mm (30–80 mil)	spunbonded geotextile	25 (0.75)	all
Bentofix EC	needle-punched	4.7/46 (15.5/150)	980 (2160)	3660 (0.75)	1×10^{-5}	24	18	PP nonwoven	100 (3.0)	PP woven	105 (3.1)	all
Bentofix NWL	needle-punched	4.7/46 (15.5/150)	980 (2160)	3660 (0.75)	1×10^{-5}	24	18	PP nonwoven	200 (6.0)	PP nonwoven	200 (6.0)	all
Bentofix NSL	needle-punched	4.7/46 (15.5/150)	980 (2160)	3660 (0.75)	1×10^{-5}	24	18	PP nonwoven	200 (6.0)	PP woven	105 (3.1)	all
Bentofix CNSL	needlepunched, polymer-coated	4.7/46 (15.5/150)	1180 (2600)	3660 (0.75)	$\leq 1 \times 10^{-7}$	24	18	PP FML/nonwoven composite	200 (6.0)	PP woven	105 (3.1)	all

[1] Flux is defined as "Flow rate/unit area" which can be converted to permeability using the equation:
Permeability = flux/hydraulic gradient
[2] Report result at a confining stress of 69 kN/m^2 (10psi) and 34 Kpa (5psi) head pressure

[3] CL = Canal liner
LL = Landfill liner
SIC = Surface impoundment cover
LC = Landfill cover
SIL = Surface impoundment liner
NP = Not provided by manufacturer
NA = Not applicable, per manufacturer

Companies were requested to provide minimum average roll values (MARV). All claims are the responsibility of the manufacturer.

GFR recommends you contact the manufacturers before making any specifying/purchasing decisions.

GEOSYNTHETIC CLAY LINERS

Attachment B31 2/2

5/10/05

ion tile	Failur pressure (kPa)	Applied pressure (% of failure pressure)	Applied pressure (kPa)	Failure time (hours)
e	140	75	100	130
		50	70	170
		25	35	260
/m²	1750*	75	1300	10,000**
/m²	3400*	40	1300	10,000**
e	69	75	52	24
		50	34	42
		25	17	68
m²	320	75	240	140
		50	160	110
		25	80	310
m²	450	85	380	240
		70	310	390
		60	270	1000**
m²	610	75	460	10,000**
e	55	75	41	0.5
		50	28	2.5
		25	14	40
m²	83	75	62	3
		50	41	12
		25	21	200
m²	103	75	77	192
		50	52	1000**
m²	365	75	270	10,000**

ues using Equation 3. **Geomembrane showed signs of yield. † From short term cated cone puncture tests.

ORMULATION

Attachment E

on is presented in this section based on the experimental puncture previous sections. The resulting equations predict the allowable DPE geomembranes both with and without geotextile protection.

odification factors are then applied to correlate the truncated cone actual d conditions. The modification factors consider the stone shape, arr ent and soil arching. All of these modification factors have a magnitude of 1.0 or less since the experiments were conducted on a worst-case basis. Partial factors of safety are then incorporated into the design equations to account for creep and chemical/biological degradation. These partial factors of safety are equal to 1.0 or greater since longer periods of time are typically required for these factors to have an effect. Finally, a global factor of safety is applied to account for uncertainties in the formulation. The above described empirical formulation is presented in a step-by-step manner in order to emphasize the various factors involved.

6.2 Basic Design Equation

The formulation for predicting geomembrane failure pressure, p, is based on Figure 3 where it is seen that for each cone height, the failure pressure varies linearly with respect to the mass per unit area of the geotextile. Note that this failure pressure from the experiments is assumed to be the maximum allowable design pressure with an implied global factor of safety of 1.0. Thus, the maximum allowable pressure can be expressed as follows:

$$p_{allow} = d \times M_A \tag{1}$$

where: p_{allow} = maximum allowable pressure (with an implied factor of safety of 1.0); M_A = mass per unit area of the protection geotextile (g/m²); and d = constant. From Figure 3, it is found that the parameter d can be related to the cone height, H, according to the following equation:

$$d = \frac{450}{H^2} \tag{2}$$

where H is in millimeters.

Combining Equations 1 and 2, the failure pressure can be determined in terms of the cone height and mass per unit area of the protection geotextile as follows (a minimum pressure of 50 kPa is imposed which conservatively corresponds to the failure pressure of the 1.5 mm thick HDPE geomembrane without any protection material):

$$p_{allow} = 450 \frac{M_A}{H^2} \geq 50 \text{ kPa} \tag{3}$$

The accuracy of the above equation is depicted in Figure 6 which shows the relationship between the measured failure pressure and the failure pressure predicted using Equation 3. The data in Figure 6 are for polyester geotextiles made from cont s filaments, and polypropylene geotextiles made of staple fibers. Hence, Equatio plies to essentially all of the polymer and fiber types used in the nonwoven e-punched geotextiles.

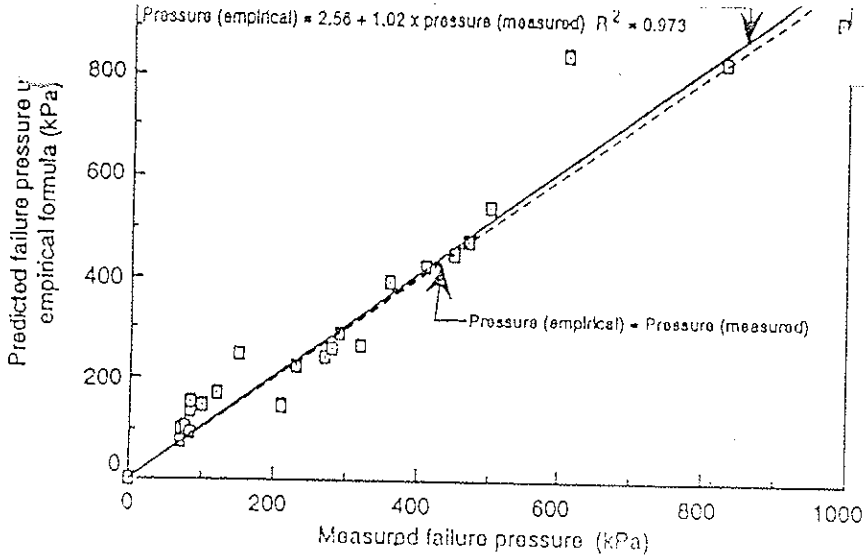


Figure 6. Measured versus empirically predicted failure pressures using Equation 3 for all nonwoven needle-punched geotextiles evaluated with a 1.5 mm thick HDPE geomembrane. Note: R = correlation coefficient.

6.3 Modification Factors

A series of modification factors is now sequentially applied to Equation 3 in order to arrive at a pressure representing field conditions. The modified pressure will be referred to as p'_{allow}.

6.3.1 *Modification Factor for the Protrusion Shape*

It was previously shown that the failure pressure depends on the protrusion shape. Rounded stones gave the highest failure pressure followed by subrounded stones. The lowest failure pressure is associated with angular stones and is approximately equal to the failure pressure of truncated cones. In order to account for the effect of stone shape, a modification factor is introduced into Equation 3 as follows:

$$p'_{allow} = p_{allow}\left(\frac{1}{MF_S}\right) \tag{4}$$

where MF_S is the modification factor for the protrusion shape. Hereafter, p'_{allow} refers to the empirically modified value of p_{allow} as is illustrated in Figure 6.

Based on the analysis of the data presented in Section 5.2.1, the modification factors for different stone shapes are presented in Table 9.

Attachment E 2/5

Stone shape	Modificati
Angular	
Subrounded	
Rounded	

6.3.2 *Modification Factor for Packing Density*

It is shown in Section 5.2.2 that the allowable pressure for higher than for isolated stones. Unfortunately, within the capac device, no failure could be achieved with the packed stones, ar relation with isolated stones could be made. However, using presented in Part I of this series of papers (Wilson-Fahmy et a yield for packed stones ($R_o/H = 2$) could be compared with the p lated stones ($R_o/H = 4$) where R_o is the horizontal distance from brane point of tangency with the protrusion tip to the undeform of tangency with the soil subgrade. The analysis was performed and without protection. Based on the results, a modification fa which provides a conservative estimate of the effect of packing 4 can be rewritten after introducing a modification factor for pac

$$p'_{allow} = p_{allow}\left(\frac{1}{MF_S \times MF_{PD}}\right)$$

where MF_{PD} is the modification factor for packing density. The r sented in Table 10 can be used for isolated protrusions and pack

6.3.3 *Modification Factor for Soil Arching*

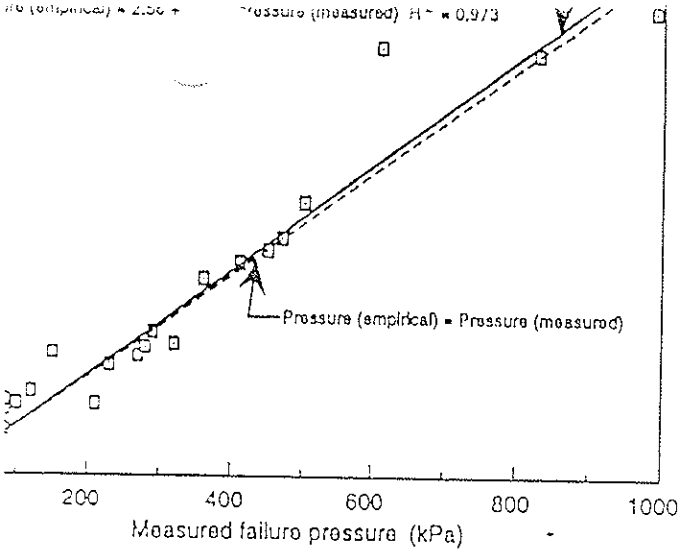
Equation 5 can be further modified as follows to include ing:

$$p'_{allow} = p_{allow}\left(\frac{1}{MF_S \times MF_{PD} \times MF_A}\right)$$

where MF_A is the modification factor for soil arching.

Table 10. Modification factors for packing density.

Protrusion arrangement	Modificati
Isolated protrusions	
Packed stones	



ed versus empirically predicted failure pressures using Equation 3 for all unched geotextiles evaluated with a 1.5 mm thick HDPE geomembrane. ion coefficient.

on Factors

ification factors is now sequentially applied to Equation 3 in order ure representing field conditions. The modified pressure will be re-

n Factor for the Protrusion Shape

shown that the failure pressure depends on the protrusion shape. ve the highest failure pressure followed by subrounded stones. The ure is associated with angular stones and is approximately equal to of truncated cones. In order to account for the effect of stone shape, or is introduced into Equation 3 as follows:

$$p'_{allow} = p_{allow}\left(\frac{1}{MF_S}\right) \tag{4}$$

modification factor for the protrusion shape. Hereafter, p'_{allow} refers modified value of p_{allow} as is illustrated in Figure 6.
ysis of the data presented in Section 5.2.1, the modification factors hapes are presented in Table 9.

Attachment E 3/5

Stone shape	Modification factor, MF_S
Angular	1.00
Subrounded	0.50
Rounded	0.25

6.3.2 *Modification Factor for Packing Density*

It is shown in Section 5.2.2 that the allowable pressure for packed stones is much higher than for isolated stones. Unfortunately, within the capacity of the experimental device, no failure could be achieved with the packed stones, and hence, no direct correlation with isolated stones could be made. However, using the theoretical analysis presented in Part I of this series of papers (Wilson-Fahmy et al. 1996), the pressure at yield for packed stones ($R_o/H = 2$) could be compared with the pressure at yield for isolated stones ($R_o/H = 4$) where R_o is the horizontal distance from a undeformed geomembrane point of tangency with the protrusion tip to the undeformed geomembrane point of tangency with the soil subgrade. The analysis was performed for geomembranes with and without protection. Based on the results, a modification factor of 0.5 is suggested which provides a conservative estimate of the effect of packing density. Thus, Equation 4 can be rewritten after introducing a modification factor for packing density as follows:

$$p'_{allow} = p_{allow}\left(\frac{1}{MF_S \times MF_{PD}}\right) \tag{5}$$

where MF_{PD} is the modification factor for packing density. The modification values presented in Table 10 can be used for isolated protrusions and packed stone arrangements.

6.3.3 *Modification Factor for Soil Arching*

Equation 5 can be further modified as follows to include the effect of soil arching:

$$p'_{allow} = p_{allow}\left(\frac{1}{MF_S \times MF_{PD} \times MF_A}\right) \tag{6}$$

where MF_A is the modification factor for soil arching.

Table 10. Modification factors for packing density.

Protrusion arrangement	Modification factor, MF_{PD}
Isolated protrusions	1.00
Packed stones	0.50

pressure by a factor of six in comparison with hydrostatic loading. This corresp[illegible]s to a [illegible]lication factor of 0.17. It may be noted, however, that the effect of so[illegible]ing o[illegible] pressure at yield may not be as great as the effect on the failure pres[illegible]. The deformations of the geomembrane up to yield may not be large enough to mobilize the soil arching effect; therefore, caution must be exercised when using the data in Table 7 for design. It is recommended that the values in Table 11 be used when soil arching is anticipated.

6.4 Partial Factors of Safety

After introducing the various modification factors (all of which are 1.0 or less), several partial factors of safety should be applied in order to determine the allowable pressure on the geomembrane. The partial factors of safety are equal to 1.0 or greater. Two factors are considered below, a partial factor of safety for long term creep and a partial factor of safety to account for long term chemical/biological degradation of the materials involved.

6.4.1 *Partial Factor of Safety for Creep*

A partial factor of safety for creep is incorporated into Equation 6, and the allowable pressure is now calculated as follows:

$$p'_{allow} = p_{allow}\left(\frac{1}{MF_S \times MF_{PD} \times MF_A}\right)\left(\frac{1}{FS_{CR}}\right) \qquad (7)$$

where FS_{CR} is the partial factor of safety for creep. Based on the creep data presented in Table 8, the recommended partial factors of safety for creep are given in Table 12.

Table 11. Modification factors for soil arching.

Soil arching effect	Modification factor, MF_A
None	1.00
Moderate	0.75
Maximum	0.50

Table 12. Partial factors of safety for creep.

Geotextile mass per unit area (g/m²)	Partial factors of safety for creep			
	Protrusion height (mm)			
	38	25	12	6
No geotextile	N/R	N/R	N/R	>>1.5
270	N/R	N/R	>1.5	1.5
550	N/R	1.5	1.3	1.2
1100	1.3	1.2	1.1	1.0
>1100	~1.2	~1.1	~1.0	1.0

Note: N/R = not recommended.

Attachment E 4/5

low in comparison with the factors of safety found in the literatu[illegible] tiles in tension. This may be explained by f[illegible]t that, in the pu[illegible] membrane and its protection material will c[illegible]rm more to the s[illegible] and hence the unsupported length will decrease with time. It was [illegible] series of papers (Wilson-Fahmy et al. 1996) that for the same app[illegible] mum stress mobilized at the protrusion tip will decrease as the [illegible] creases. Thus, a decrease in stress in the geomembrane and its [illegible] expected with time. Accordingly, a lower factor of safety for cr[illegible] puncture mode in comparison to the stress mode in which the n[illegible] a constant tensile stress.

6.4.2 *Partial Factor of Safety for Chemical/Biological Degraa*

The partial factor of safety against chemical/biological deg[illegible] cluded in Equation 7 as follows:

$$p'_{allow} = p_{allow}\left(\frac{1}{MF_S \times MF_{PD} \times MF_A}\right)\left(\frac{1}{FS_{CR} \times}\right.$$

Although not assessed in this study, the value of FS_{CBD} is felt to [illegible] 2.0 with an average value of 1.5; see Koerner (1994) for discuss[illegible]

6.5 Global Factor of Safety

After determining an allowable pressure that is suitably adj[illegible] factors and partial factors of safety (Equation 8), a global factor [illegible] by dividing the allowable pressure by the required pressure as f[illegible]

$$FS = \frac{p'_{allow}}{p_{reqd}}$$

where: p_{reqd} = maximum stress required on the geomembrane; a[illegible] factor of safety for uncertainties related to site specific conditio[illegible]

It is felt that the global factor of safety should never be less t[illegible] may be used depending on site specific conditions. For example [illegible] should be used in situations where large isolated stones are free[illegible] the subgrade. Also, a tightly installed geomembrane may also [illegible] factor of safety compared to a geomembrane installed with slac[illegible] dification has been included for in situ temperatures different f[illegible] temperature, i.e. ≈ 20°C. More definitive recommendations f[illegible] safety are made in Part III of this series of papers (Koerner et a[illegible]

5/10/95 ③ 30/10/95

...ctor of six in comparison with hydrostatic loading. This corresponds to factor of 0.17 ... be noted, however, that the effect of soil arching e at yield may ... as great as the effect on the failure pressure. The of the geomembrane up to yield may not be large enough to mobilize the fect; therefore, caution must be exercised when using the data in Table : is recommended that the values in Table 11 be used when soil arching

Factors of Safety

icing the various modification factors (all of which are 1.0 or less), sever- s of safety should be applied in order to determine the allowable pressure ibrane. The partial factors of safety are equal to 1.0 or greater. Two fac- ered below, a partial factor of safety for long term creep and a partial fac- account for long term chemical/biological degradation of the materials

Factor of Safety for Creep

or of safety for creep is incorporated into Equation 6, and the allowable calculated as follows:

$$p'_{allow} = p_{allow}\left(\frac{1}{MF_S \times MF_{PD} \times MF_A}\right)\left(\frac{1}{FS_{CR}}\right) \quad (7)$$

he partial factor of safety for creep. Based on the creep data presented recommended partial factors of safety for creep are given in Table 12.

lification factors for soil arching.

Soil arching effect	Modification factor, MF_A
None	1.00
Moderate	0.75
Maximum	0.50

ial factors of safety for creep.

Partial factors of safety for creep			
Protrusion height (mm)			
38	25	12	6
N/R	N/R	N/R	>>1.5
N/R	N/R	>1.5	1.5
N/R	1.5	1.3	1.2
1.3	1.2	1.1	1.0
~1.2	~1.1	~1.0	1.0

ecommended.

Attachment E5/5

...ow in comparison with the factors of safety found in the literature for creep of geotex- s in tension. This may be explained by the fact that, in the puncture ... the geo- membrane and its protection material will conform more to the subgrade ... they creep and hence the unsupported length will decrease with time. It was shown in Part I of this series of papers (Wilson-Fahmy et al. 1996) that for the same applied pressure the maximum stress mobilized at the protrusion tip will decrease as the unsupported length decreases. Thus, a decrease in stress in the geomembrane and its protection material is expected with time. Accordingly, a lower factor of safety for creep is required for the puncture mode in comparison to the stress mode in which the material is subjected to a constant tensile stress.

6.4.2 *Partial Factor of Safety for Chemical/Biological Degradation*

The partial factor of safety against chemical/biological degradation, FS_{CBD}, is included in Equation 7 as follows:

$$p'_{allow} = p_{allow}\left(\frac{1}{MF_S \times MF_{PD} \times MF_A}\right)\left(\frac{1}{FS_{CR} \times FS_{CBD}}\right) \quad (8)$$

Although not assessed in this study, the value of FS_{CBD} is felt to range between 1.0 and 2.0 with an average value of 1.5; see Koerner (1994) for discussion and details.

6.5 Global Factor of Safety

After determining an allowable pressure that is suitably adjusted for modification factors and partial factors of safety (Equation 8), a global factor of safety is determined by dividing the allowable pressure by the required pressure as follows:

$$FS = \frac{p'_{allow}}{p_{reqd}} \quad (9)$$

where: p_{reqd} = maximum stress required on the geomembrane; and FS = desired global factor of safety for uncertainties related to site specific conditions.

It is felt that the global factor of safety should never be less than 3.0. Higher values may be used depending on site specific conditions. For example, a high factor of safety should be used in situations where large isolated stones are frequently encountered on the subgrade. Also, a tightly installed geomembrane may also require a larger global factor of safety compared to a geomembrane installed with slack. Furthermore, no modification has been included for in situ temperatures different from the test procedure temperature, i.e. ≈ 20°C. More definitive recommendations for the global factor of safety are made in Part III of this series of papers (Koerner et al. 1996).

Calculation Package H
Sump Capacity

GeoSyntec Consultants

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: Basic Remediation Company

Project: BRC CAMU **Project/Proposal #:** SC0313 **Task #:** 01

Title of Computations: Sump Capacity

Computations By:

SIGNATURE DATE 11/3/06

Rebecca Flynn, Staff Engineer
PRINTED NAME AND TITLE

Assumptions and Procedures Checked By (Peer Reviewer):

SIGNATURE DATE 11/3/06

Gregory T. Corcoran, PE / Principal
PRINTED NAME AND TITLE

Computations Checked By:

SIGNATURE DATE 11/3/06

Gregory T. Corcoran, PE / Principal
PRINTED NAME AND TITLE

Computations Backchecked By (Originator):

SIGNATURE DATE 11/3/06

Rebecca Flynn, Staff Engineer
PRINTED NAME AND TITLE

Approved By (PM or Designate):

SIGNATURE DATE 11/3/06

Gregory T. Corcoran, PE / Principal
PRINTED NAME AND TITLE

Approval Notes:

Revisions: (Number and Initial All Revisions)

No.	Sheet	Date	By	Checked By	Approval

Written by: Rebecca B. Flynn Date: 08 /31 /06 (MM DD YY) Reviewed by: GTC Date: 11 / 3 /06 (MM DD YY)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 04

SUMP CAPACITY
BRC CAMU
HENDERSON, NEVADA

OBJECTIVE

The objective of this calculation is to evaluate if the sump and leachate aggregate have the capacity to hold the maximum average daily volume (evaluated by the HELP model in the drainage pipe sizing calculation) without exceeding the 12-inch head requirement.

SUMMARY OF ANALYSIS

The HELP model suggest that the maximum, average daily volume collected by the leachate collection system is 231 cubic feet. The capacity of the sump and a "pool" of leachate 1 ft deep within the leachate collection system is 453 ft^3. Therefore, the sump and adjacent drainage geocomposite capacity exceeds the estimated maximum average daily leachate volume from the drainage pipe.

SITE CONDITIONS

The proposed composite liner system will be comprised of the following components, from top to bottom:

- 2 ft of operations layer material;
- a drainage geocomposite;
- 60-mil (1.5 mm) HDPE geomembrane, textured on both sides;
- a geosynthetic clay liner (GCL); and
- prepared subgrade.

The proposed base grading plans are shown on in Figure 1. A berm will be placed around the cells and within the cells to contain and control runoff during construction and during the worst case scenario when the cell contains a small quantity of waste. A sump will be located at the low point of each cell. Each sump will be approximately 10 ft x 10ft x 2 ft deep. The grade of the lining system immediately adjacent to the sumps ranges from 2 to 3%.

The Hydrologic Evaluation of Landfill Performance (HELP) model was used to estimate the peak daily quantity of liquid expected to be generated in the drainage layer during or after a rainfall

Written by: Rebecca B. Flynn Date: 08 /31 /06 (MM DD YY) Reviewed by: BTC Date: 11 / 3 / 06 (MM DD YY)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 04

event. The HELP model is used to evaluate the worst case scenario which occurs *during the period where the cell contains a small quantity of waste*, such that any collected liquid is considered leachate, yet the majority of the cell is empty so the largest quantity of liquid will infiltrate through the operations layer to the drainage layer. The output and assumptions of the HELP analyses are presented in the pipe sizing calculation package. It is assumed that surface runoff will be controlled, therefore this sump capacity calculation package compares the capacity of the sump to the quantity of leachate collected from the drainage layer.

ANALYSIS

Each sump will be approximately 10 ft x 10ft x 2 ft deep (see attachment). The side slopes of the sumps are proposed to be inclined at 2:1 (horizontal:vertical), although the calculation conservatively assumes side slopes of 1:1. The porosity (n) of the drainage aggregate is assumed to be 0.4 (HELP value for gravel). Therefore, the capacity of each sump is:

V_{sump} = [volume of square + volume of triangle around circumference]*porosity
V_{sump} = [10*10*2+(2*2)/2*40]*0.4 = 112 ft^3

Additional storage capacity within the drainage aggregate within the upgradient drainage collection layer is available provided that the leachate level does not exceed 12 inches over the liner (in order to remain compliant with 40 CFR 264.301(c)(2)).

The HELP model runs performed for the pipe sizing calculation indicates the following maximum average daily volumes:

Sump 1	169 ft^3
Sump 2	231 ft^3
Sump 3	65 ft^3

As Sump 2 has the largest peak daily volume of the four sumps, the capacity of the drainage aggregate will be analyzed for this sump. The plan view of Sump 2 is presented in Attachment A. For Sump 2, the slope of the drainage aggregate is assumed to be 2%. Therefore, for a 12-inch height of leachate, the edge of the "pool" of water is located at:

distance from sump = 1 ft / 0.02 = 50 ft.

Written by: Rebecca B. Flynn Date: 08 /31 /06 (MM DD YY) Reviewed by: GC Date: 11/03/06 (MM DD YY)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 04

Based on the topography of Sump 2, the grading from Sump 2 varies from 1 to 2 percent from the sump (Figure 1). Therefore, the 2% slope assumption is conservative.

The limits of the "pool" of water is assumed to have a radius of 50 ft from the sump (i.e., constant 2% slope). Again, this assumption is conservative (see attachment). The area of the "pool" around the sump is approximately 1,963 ft^2 as shown in the attachment. The capacity of this volume of drainage geocomposite and operation layer is approximately 342 ft^3, based on a maximum leachate depth of 12 inches and considering the porosity of the geocomposite and operations layer. Adding the volume within the sump yields a total capacity of 453 ft^3 (112 + 342 ft^3). The geometry for the other sumps is similar to Sump 2, and can be considered adequate to handle the estimated maximum average daily leachate volume.

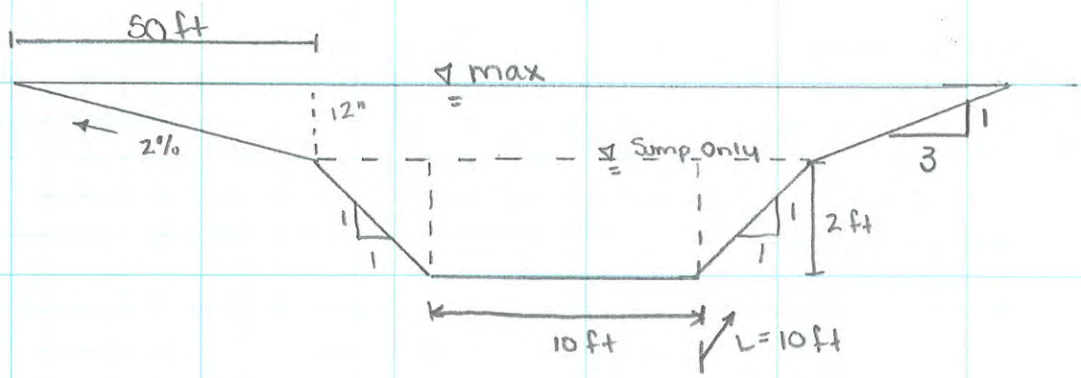
SUMMARY AND CONCLUSIONS

- The sump capacity by itself is 112 ft^3; and
- The capacity of the drainage aggregate sloping at 2% away from the sump without exceeding the 1 ft head requirement is approximately 342 ft^3.
- The capacity of the sump and drainage aggregate far exceeds the maximum average daily volume evaluated from the HELP model (pipe size calculations) without exceeding 12 inches of head on the liner.

Written by: _____ Date: ___/___/___ (DD MM YY) Reviewed by: BTC Date: 3/11/06 (DD MM YY)

Client: _____ Project: _____ Project/Proposal No.: _____ Task No: _____

Elevation - Sump 2



Capacity of sump only = $[10' \times 10' \times 2' + \frac{2' \times 2'}{2} \times 40'] \times 0.4$

(40' = circum.; 0.4 = porosity)

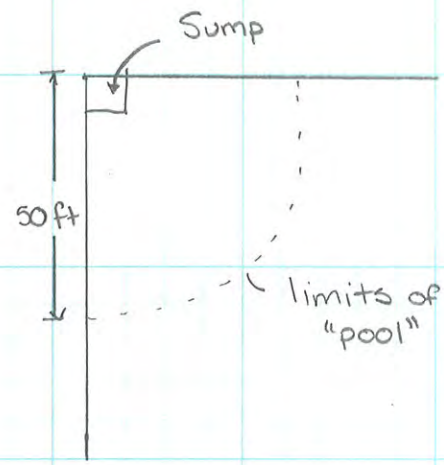
Sump Capacity: 112 ft^3

→ Since average daily flow is 231 ft^3 (HELP model) exceeds capacity, look at influence of overflow (into geocomposite and operations layer) capacity. Max head on liner = 12". See next page.

Written by: _____ Date: ___/___/___ (DD MM YY) Reviewed by: GTC Date: 03/11/06 (DD MM YY)

Client: _____ Project: _____ Project/Proposal No.: _____ Task No: _____

PLAN SUMP 2



To be conservative, and for ease of calculation, assume radius of +1 ft contour to be 50 ft from sump. Also, add volume directly above sump.

The area of the above "pool" is:

$$A = (50\,ft)^2 \pi \; 90/360 = 1963\,ft^2$$

The average depth of the leachate is 6" (mid-point of triangle shown on page 1). Therefore, the volume is:

$$V = (1963\,ft^2)\left[\underbrace{\left(\frac{0.2}{12}\right)(0.8)}_{\text{Geocomposite}} + \underbrace{\left(\frac{6-0.2}{12}\right)(0.3)}_{\text{Operations layer}}\right]$$

(0.2/12: Thickness; 0.8: Porosity; (6−0.2)/12: leachate level; 0.3: Porosity)

$$V = 311\,ft^3$$

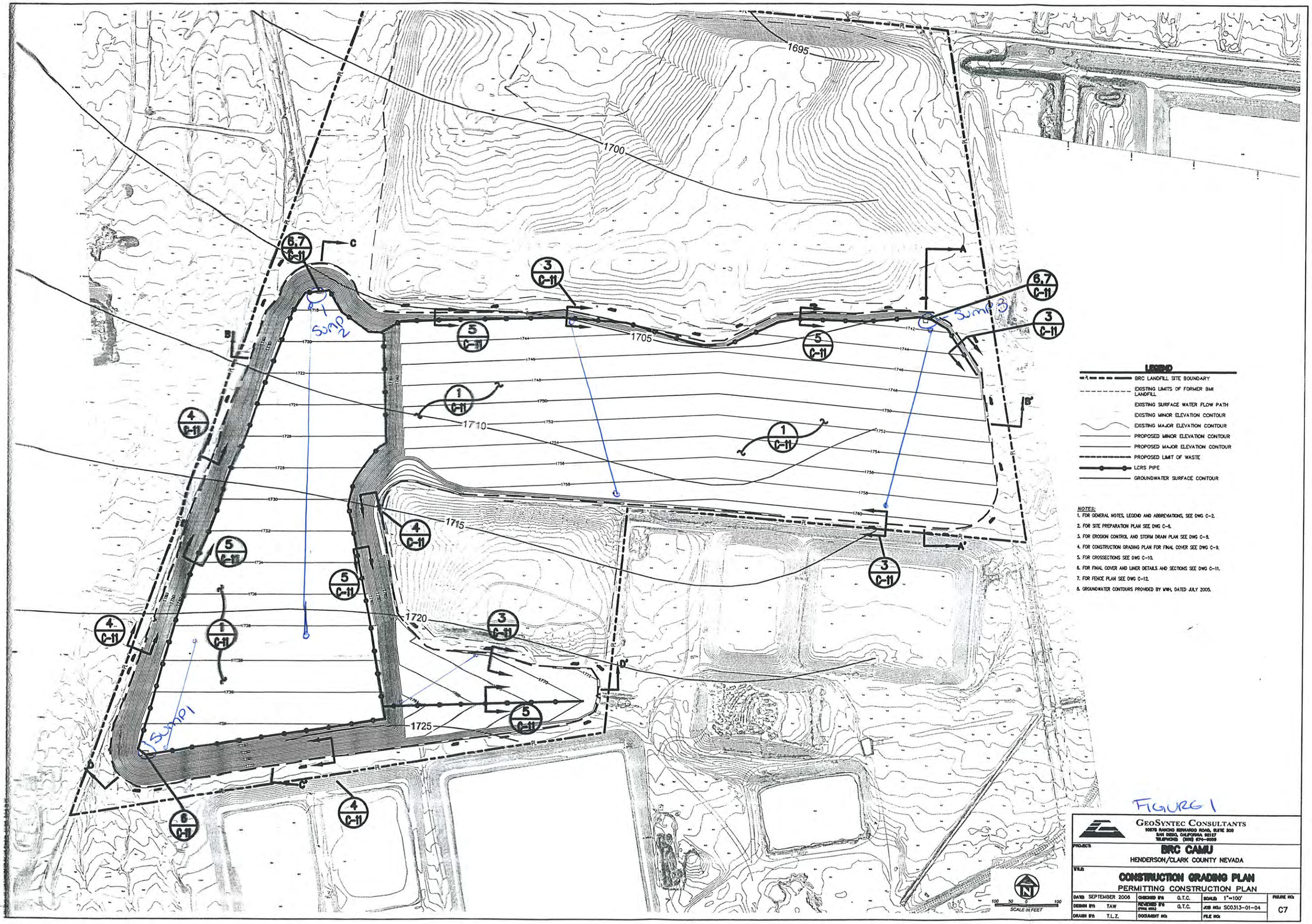
The capacity of the geocomposite and operations layer directly above the sump is:

$$V_S = (\text{length})(\text{width})\left[\left(\frac{0.2}{12}\right)(0.8) + \left(\frac{12-0.2}{12}\right)(0.3)\right]$$

$$V_S = 30.8\,ft^3$$

Total Volume of voids for 1 ft "pool" of leachate is:

$$\underline{342\,ft^3}$$


1695
1700
1705
1710
1715
1720
1725
SUMP 1
SUMP 2
SUMP 3
LEGEND
BRC LANDFILL SITE BOUNDARY
EXISTING LIMITS OF FORMER BMI LANDFILL
EXISTING SURFACE WATER FLOW PATH
EXISTING MINOR ELEVATION CONTOUR
EXISTING MAJOR ELEVATION CONTOUR
PROPOSED MINOR ELEVATION CONTOUR
PROPOSED MAJOR ELEVATION CONTOUR
PROPOSED LIMIT OF WASTE
LCRS PIPE
GROUNDWATER SURFACE CONTOUR
NOTES:
1. FOR GENERAL NOTES, LEGEND AND ABBREVIATIONS, SEE DWG C-2.
2. FOR SITE PREPARATION PLAN SEE DWG C-8.
3. FOR EROSION CONTROL AND STORM DRAIN PLAN SEE DWG C-8.
4. FOR CONSTRUCTION GRADING PLAN FOR FINAL COVER SEE DWG C-9.
5. FOR CROSSECTIONS SEE DWG C-10.
6. FOR FINAL COVER AND LINER DETAILS AND SECTIONS SEE DWG C-11.
7. FOR FENCE PLAN SEE DWG C-12.
8. GROUNDWATER CONTOURS PROVIDED BY WHH, DATED JULY 2005.
SCALE IN FEET
FIGURE 1
GEOSYNTEC CONSULTANTS
10875 RANCHO BERNARDO ROAD, SUITE 200
SAN DIEGO, CALIFORNIA 92127
TELEPHONE: (858) 674-2020
PROJECT:
BRC CAMU
HENDERSON/CLARK COUNTY NEVADA
TITLE:
CONSTRUCTION GRADING PLAN
PERMITTING CONSTRUCTION PLAN
DATE: SEPTEMBER 2006
CHECKED BY: G.T.C.
SCALE: 1"=100'
DESIGN BY: TAW
REVIEWED BY (FINAL ONLY): G.T.C.
JOB NO.: SC0313-01-04
DRAWN BY: T.L.Z.
DOCUMENT NO.:
FILE NO.:
FIGURE NO.: C7

Calculation Package I
Comparison of Flow Between CCL and GCL

GeoSyntec Consultants

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: Parsons **Project:** BRC CAMU **Project/Proposal #:** HL0389 **Task #:** 02

Title of Computations: Comparison of Flow Through Prescriptive CCL and Alternative GCL

Computations By: SIGNATURE — 13 March 2000 DATE

Geoff L. Smith / Staff Engineer
PRINTED NAME AND TITLE

Assumptions and Procedures Checked By (Peer Reviewer): SIGNATURE — 7/3/00 DATE

GREGORY T CORCORAN/PROJ. ENG.
PRINTED NAME AND TITLE

Computations Checked By: SIGNATURE — 26 April 2000 DATE

Matt Darr Staff Eng.
PRINTED NAME AND TITLE

Computations Backchecked By (Originator): SIGNATURE — 3 May 2000 DATE

Geoff L. Smith / Staff Engineer
PRINTED NAME AND TITLE

Approved By (PM or Designate): SIGNATURE — 10 July 2000 DATE

Bradford H. Cody / Project Manager
PRINTED NAME AND TITLE

Approval Notes:

Revisions: (Number and Initial All Revisions)

No.	Sheet	Date	By	Checked By	Approval

Written by: Geoff L. Smith Date: 01/25/00 (MM DD YY) Reviewed by: GTC Date: 07/03/00 (MM DD YY)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 02

COMPARISON OF FLOW THROUGH THE PRESCRIPTIVE COMPOSITE LINER AND A PROPOSED ALTERNATIVE COMPOSITE LINER

OBJECTIVE

Evaluate an alternative composite lining system, consisting of a 60-mil HDPE geomembrane overlying a geosynthetic clay liner (GCL), to demonstrate equivalent or better fluid migration characteristics when compared with the prescriptive composite liner system, consisting of a 60-mil HDPE geomembrane overlying a compacted clay liner (CCL) having a saturated hydraulic conductivity less than 1×10^{-7} cm/s. The method outlined by Giroud, et al. (1997) will be employed to compare the fluid migration characteristics.

SUMMARY OF ANALYSIS

The calculations suggest that the flow rate through the prescriptive composite liner system is approximately 1.64 times greater than the flow rate through the alternative composite liner system. The fluid head on the geomembrane is assumed to be 12 in (305 mm), the maximum allowed as required in regulations 40 CFR §258.40(2).

In terms of limiting flow through the composite liner system, the alternative liner system performs better than the prescriptive liner system.

ANALYSIS

Liquid migration through a composite liner occurs essentially through defects of the geomembrane. According to Giroud, et al. (1997) (see Attachment 1), the rate of liquid migration through a defect in the geomembrane component of a composite liner is given by the following semi-empirical equation:

$$Q = 0.21[1+0.1(h/t)^{0.95}]\, a^{0.1}\ h^{0.9}\ k^{0.74} \qquad \text{Eq. (1)}$$

where:

Q = flow rate through one geomembrane defect, m^3/s
h = head of liquid above the geomembrane, m
t = thickness of soil component of composite liner, m
a = defect area, m^2
k = hydraulic conductivity of the soil component of composite liner, m/s

Using Eq. (1) the ratio between the rate of leachate flow through the prescriptive composite liner system and the alternative composite liner system can be compared as follows (Attachment 1):

$$\frac{q_{compCCL}}{q_{compGCL}} = \left(\frac{k_{CCL}}{k_{GCL}}\right)^{0.74} \frac{1+0.1(h/t_{CCL})^{0.95}}{1+0.1(h/t_{GCL})^{0.95}} \qquad \text{Eq. (2)}$$

where:

$q_{comp\ CCL}$ = unit rate of flow through a composite liner where soil component is a CCL
$q_{comp\ GCL}$ = unit rate of flow through a composite liner where soil component is a GCL

and other terms have previously been defined for Eq. (1).

EVALUATE FLOW THROUGH COMPOSITE LINER SYSTEMS

The values for the parameters in Eq. (2) are discussed below:

Properties of Compacted Clay Liner (CCL):

- $k_{CCL} = 1 \times 10^{-7}$ cm/s (the maximum hydraulic conductivity for the low-permeability soil component of the composite liner prescribed by 40 CFR §258.40(2))
- t_{CCL} = 2 ft (0.6 m) (minimum thickness prescribed by 40 CFR §258.40(2))

Properties of Geosynthetic Clay Liner (GCL):

- $k_{GCL} = 5 \times 10^{-9}$ cm/s (maximum hydraulic conductivity reported in manufacturer's documentation and typically allowed in technical specifications for GCLs)
- t_{GCL} = 0.20 in. (5 mm) (minimum thickness reported in manufacturer's documentation and typically allowed in technical specifications for GCLs)

Head Above Liner, (h):

40 CFR §258.40(2) states that the maximum allowable liquid head on a composite liner is less than 12 in. (305 mm).

Three cases comparing the flow rates through the prescriptive and alternative composite liner systems are evaluated using Eq. (2). The calculation is presented below:

Calculation:

Plugging the above values for Case 1, Eq. (2) becomes as follows:

$$q_{comp\ CCL} / q_{comp\ GCL} = (1 \times 10^{-7} / 5 \times 10^{-9})^{0.74} [(1+0.1(12.0/24.0)^{0.95}) / (1+0.1(12.0/0.20)^{0.95}] = 1.64$$

Thus, for a liquid head of 12.0 in. (305 mm) on the geomembrane, the flow through the prescriptive composite liner system that includes a CCL is 1.64 times greater than the flow through the alternative liner system that includes a GCL instead of a CCL.

SUMMARY AND CONCLUSIONS

- Using the method outlined by Giroud, et al. (1997), the flow rate through the prescriptive liner system (with CCL) was evaluated to be greater than the flow rate through the proposed alternative liner system (with GCL instead of CCL).
- The amount of flow through the prescriptive liner system was evaluated to be 1.64 times greater than flow through the alternative liner system for a leachate head of 12 in. (305 mm).
- In terms of limiting fluid flow through the composite liner system, the alternative liner system performs better than the prescriptive liner system.

REFERENCES

Giroud, J.P., Badu-Tweneboah, K., and Soderman, K.L. (1997), "Comparison of Leachate Flow Through Compacted Clay Liners and Geosynthetic Clay Liners in Landfill Liner Systems," Geosynthetic International, Vol. 4, No. 3-4, pp. 391-431.
(Attachment 1)

ATTACHMENT A
P 1/2

4 FLOW THROUGH COMPOSITE LINERS

4.1 Introduction

As indicated in Section 2.8, GCLs used in landfills are always used as the low-permeability soil component of composite liners. In other words, GCLs used in landfills are always associated with a geomembrane. The cases discussed in Section 3 were only relevant to the extreme design scenario where the geomembrane is ignored, and to other containment structures where GCLs may be used without a geomembrane.

In Section 4, the geomembrane is not ignored and the effectiveness of composite liners constructed with CCLs and GCLs is compared.

4.2 Rate of Leachate Migration Through Composite Liners With CCL and GCL

Development of Equation. As indicated by Giroud and Bonaparte (1989), liquid migration through a composite liner occurs essentially through defects of the geomembrane. According to Giroud (1997), the rate of liquid migration through a defect in the geomembrane component of a composite liner is given by the following semi-empirical equation:

$$\boxed{Q = 0.21\,[1 + 0.1(h/t)^{0.95}]\,a^{0.1}\,h^{0.9}\,k^{0.74}} \tag{51}$$

where: Q = flow rate through one geomembrane defect; h = head of liquid above the geomembrane; t = thickness of the soil component of the composite liner; a = defect area; and k = hydraulic conductivity of the soil component of the composite liner. It is important to note that Equation 51 can only be used with the following units: a (m^2), h (m), t (m), k (m/s).

As discussed in Sections 2.5 and 2.6, there are cases where it is prescribed by regulations, or simply envisioned by design engineers, to place a GCL on a layer of soil with a low hydraulic conductivity such as 1×10^{-8} or 1×10^{-7} m/s. An important conclusion from Section 3, is that, if a GCL is placed on a soil layer (even a soil layer with low permeability), the soil layer has no influence on leachate advective flow and only the GCL should be considered in leachate flow calculations. The same conclusion applies to the soil component of a composite liner. Accordingly, if, in a composite liner, a GCL is placed on a layer of low-permeability soil, only the GCL will be considered in Equation 51.

Using Equation 51, the ratio between the rate of leachate flow through a composite liner with a CCL and a composite liner with a GCL is as follows:

$$\frac{q_{comp\,CCL}}{q_{comp\,GCL}} = \frac{0.21\,N\,[1 + 0.1(h/t_{CCL})^{0.95}]\,a^{0.1}\,h^{0.9}\,k_{CCL}^{0.74}}{0.21\,N\,[1 + 0.1(h/t_{GCL})^{0.95}]\,a^{0.1}\,h^{0.9}\,k_{GCL}^{0.74}} \tag{52}$$

where: $q_{comp\,CCL}$ = unit rate of flow through a composite liner where the soil component is a CCL; $q_{comp\,GCL}$ = unit rate of flow through a composite liner where the soil component is a GCL; t_{CCL} = thickness of the CCL in the composite liner; t_{GCL} = thickness of the GCL

ATTACHMENT A
P 2/2 MW

in the composite liner; and N = number of geomembrane defects per unit area. After simplification, Equation 52 becomes:

$$\frac{q_{comp\ CCL}}{q_{comp\ GCL}} = \left(\frac{k_{CCL}}{k_{GCL}}\right)^{0.74} \frac{1 + 0.1(h/t_{CCL})^{0.95}}{1 + 0.1(h/t_{GCL})^{0.95}} \tag{53}$$

Discussion. It appears that the leachate flow rate ratio expressed by Equation 53 does not depend on the number and the size of defects. Numerical values of $q_{comp\ CCL}/q_{comp\ GCL}$ calculated using Equation 53 are presented in Table 7. It appears that, for leachate heads typically encountered in landfills (i.e. heads smaller than 0.3 m, and generally smaller than 0.1 m), the calculated advective flow control performance of a composite liner which consists of a geomembrane on a GCL is significantly better than the calculated advective flow control performance of the standard composite liner which consists of a geomembrane on the standard CCL (i.e. a CCL with a thickness of 0.6 m and a hydraulic conductivity of 1×10^{-9} m/s). Table 7 also shows that a composite liner with a GCL outperforms the standard composite liner for leachate heads up to approximately 1 to 7 m depending on the GCL hydraulic conductivity; such large heads should be a very rare occurrence in a landfill since they would correspond to a major malfunction of the leachate collection and removal system.

Table 7. Ratio between rates of advective flow through a composite liner including a CCL and a composite liner including a GCL, $q_{comp\ CCL}/q_{comp\ GCL}$.

GCL characteristics: Thickness, t_{GCL} (mm) Hydraulic conductivity, k_{GCL} (m/s)			5 5×10^{-12}	7 1×10^{-11}	9 5×10^{-11}
	(m)	(mm)	$q_{comp\ CCL}/q_{comp\ GCL}$	$q_{comp\ CCL}/q_{comp\ GCL}$	$q_{comp\ CCL}/q_{comp\ GCL}$
Leachate head on top of the liner, h	0	0	50.44	30.20	9.18
	0.01	10	42.36	26.54	8.28
	0.05	50	26.92	18.50	6.14
	0.1	100	18.87	13.66	4.71
	0.3	300	9.01	6.98	2.54
	0.6	600	5.31	4.23	1.58
	1.0		3.59	2.89	1.09
	3.0		1.65	1.35	0.52
	5.0		1.23	1.01	0.39
	7.0		1.04	0.85	0.33
	10		0.90	0.74	0.28
	∞		0.53	0.44	0.17

Notes: The tabulated values of the advective flow rate ratio were calculated using Equation 53 with the following CCL characteristics: thickness, t_{CCL} = 0.6 m; and hydraulic conductivity, $k_{CCL} = 1 \times 10^{-9}$ m/s. (This is the standard CCL defined in Section 2.5.) The characteristics of the GCL are from Table 2.

Calculation Package J
Tension Due to Wind Uplift

GeoSyntec Consultants

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: Parsons **Project:** BRC CAMU **Project/Proposal #:** HL0389 **Task #:** 02

Title of Computations: Geotextile Tension due to Wind Uplift

Computations By:
SIGNATURE — 28 June 2000 DATE
Geoff L. Smith / Staff Engineer
PRINTED NAME AND TITLE

Assumptions and Procedures Checked By (Peer Reviewer):
SIGNATURE — 7/3/00 DATE
GREGORY T CORCORAN / PROJ. ENG.
PRINTED NAME AND TITLE

Computations Checked By:
SIGNATURE — 7/3/00 DATE
GREGORY T. CORCORAN / PROJ. ENG.
PRINTED NAME AND TITLE

Computations Backchecked By (Originator):
SIGNATURE — 28 June 2000 DATE
Geoff L. Smith / Staff Engineer
PRINTED NAME AND TITLE

Approved By (PM or Designate):
SIGNATURE — 10 July 2000 DATE
Bradford H. Cook / Project Manager
PRINTED NAME AND TITLE

Approval Notes:

Revisions: (Number and Initial All Revisions)

No.	Sheet	Date	By	Checked By	Approval

Written by: Geoff L. Smith GN Date: 00 / 01 / 26 (YY MM DD) Reviewed by: GTC Date: 00 / 07 / 03 (YY MM DD)

Client: Parsons Project: BRC Landfill Project/Proposal No.: HL0389 Task No.: 01

GEOTEXTILE TENSION DUE TO WIND UPLIFT
BRC LANDFILL
HENDERSON, NEVADA

OBJECTIVE

Evaluate tension in a woven geotextile due to wind uplift. Use method outlined by Giroud, et al (1995). Tension generated by wind uplift will be compared to the anchor trench capacity and the ultimate strength of the woven geotextile.

SITE CONDITIONS

The side slope liner system considered in the wind uplift calculation consists (from top to bottom) of:

- woven geotextile U.V. protection layer
- geocomposite;
- 60-mil HDPE geomembrane
- GCL

The capacity of the anchor trench is determined in a separate calculation package.

ANALYSIS

The analysis will follow the method outlined by Giroud, et al, in "Uplift of Geomembrane by Wind" (Attachment A). Giroud et al offer the following equation for estimating the effective suction on a geomembrane (Attachment A):

$$S_E = 0.050\lambda V^2 e^{-[1.252E-4]z} - 9.81 M_{GM} \qquad \text{(Equation 1)}$$

where: S_E = effective suction (P_a)
λ = suction factor (dimensionless)
V = wind velocity (km/h)
z = altitude above sea level (m)
M_{GM} = mass per unit area of geomembrane (kg/m^2)

Written by: Geoff L. Smith Date: 00 / 01 / 26 (YY MM DD) Reviewed by: GTC Date: 00 / 07 / 03 (YY MM DD)

Client: Parsons Project: BRC Landfill Project/Proposal No.: HL0389 Task No.: 01

Evaluate Variables

λ Suction factor = 0.85 for the upper third of the slope being considered

V wind velocity = 90 mph = 145 km/h (the peak gust ever recorded after 1961, see Attachment B)

z altitude above sea level (m). A representative elevation for the base side slopes is approximately 1760 ft = 536 m

M_{GM} mass per unit area of geotextile (kg/m^2)
M_{GM} = 0.15 kg/m^2 (Attachment C)

Evaluate Suction

$S_E = (0.05)(0.85)(145)^2 e^{-(1.252E-4)536} - 9.81(0.15) = 834$ Pa

The height of the exposed slope (2.1H:1V) after the first phase of operations layer is placed is 20 vertical feet, so the total length of exposed slope, L, is $L/\sin\beta$ = 46.5 ft = 14.2 m

$S_E L = (821)(14.2) = 11.84$ kN/m

Evaluate Tension

The objective of this case is to evaluate tension in the geomembrane. Assuming the geomembrane stress-strain curve is linear, the tension can be expresses as:

$$T = J\varepsilon$$

where: T = tension
J = stiffness
ε = strain

To evaluate the tension in the geomembrane, the stiffness and stain must be evaluated.

Written by: Geoff L. Smith Date: 00 / 01 / 26 (YY MM DD) Reviewed by: GTC Date: 00 / 07 / 03 (YY MM DD)

Client: Parsons Project: BRC Landfill Project/Proposal No.: HL0389 Task No.: 01

Stiffness, J

For strains typically less than 10 percent, the stress-strain curve for woven geotextiles is approximately linear. Therefore, stiffness can be approximated as:

$$J = ET_{GT}$$

where: E = elastic modulus = 1535 kN/m (Koerner 1994)
T_{GM} = geotextile thickness, approximately 5 mils (Koerner 1994)

$$J = (1535 \text{ MPa})(0.000127 \text{ m}) = 195 \text{ kN/m}$$

Strain, ε

The strain on the woven geotextile induced by wind uplift loading can be estimated using the table by Giroud et al. (Attachment A).

$$\text{For } \frac{J}{S_E L} = \frac{195}{11.84} = 16.7$$

from Table 4, ε = 5.57%

The estimated strain in the woven geotextile is 5.57% percent, so the assumption of a linear stress-strain relationship is valid.

Evaluate tension

$$\mathbf{T} = 195\frac{5.57\%}{100} = \mathbf{10.9\ \ kN/m}$$

GEOTEXTILE ALLOWABLE TENSION

Since the woven geotextile (for U.V. protection) will be subjected to wind uplift forces, the woven geotextile will be designed for tension.

The estimated tensile force imposed on the geomembrane due to wind uplift suction is 14.5 kN/m for a design wind speed of 90 mph (145 kph). To account for uncertainties in the woven geotextile ultimate strength and wind speed, a factor of safety of 1.5 will be employed.

Written by: Geoff L. Smith Date: 00 / 01 / 26 (YY MM DD) Reviewed by: GTC Date: 00 / 07 / 03 (YY MM DD)

Client: Parsons Project: BRC Landfill Project/Proposal No.: HL0389 Task No.: 01

Therefore, the required ultimate strength of the geotextile shall be greater than or equal to 16 kN/m (91 ppi).

CONCLUSIONS

Based on the results herein, the woven geotextile U.V. protection layer shall have a wide width ultimate tensile strength greater than or equal to 16 kN/m (91 ppi).

The capacity of the anchor trench is determined in a separate calculation package.

REFERENCES

Giroud, J.P., Pelte., Bathurst, R.J. (1995), "Uplift of Geomembranes by Wind," Geosynthetic International, Vol. 2, No. 6., pp. 897-952
Attachment A

Western Regional Climate Center, Summary of Las Vegas Climate
www.wrcc.dri.edu
Attachment B

$$T = J\varepsilon \tag{34}$$

where: T = geomembrane tension; J = geomembrane tensile stiffness; and ε = geomembrane strain. The case of geomembranes with a linear tension-strain curve will be further discussed in Section 3.5.

It is important to note that geomembranes that are not reinforced with a fabric, for example PVC and PE geomembranes, have tensile characteristics that are highly dependent on temperature. Extensive data on the influence of temperature on the tensile characteristics of HDPE geomembranes are provided by Giroud (1994). The influence of temperature will be further discussed in Section 3.6.

3.2.3 *Suction Due to Wind*

In the subsequent analysis, the suction applied by the wind is assumed to be uniform over the entire length L. In reality, the suction due to the wind is not uniformly distributed as shown in Figure 4. Therefore, the design engineer using the method presented in this paper must exercise judgment in selecting the value of the length L and the value of the ratio λ defined by Equation 13.

In accordance with the discussions presented in Sections 2.3 and 2.4, the suction that effectively uplifts the geomembrane is:

$$S_e = S - \mu_{GM}\, g \tag{35}$$

where S_e is the "effective suction".

Combining Equations 2, 13 and 35 gives:

$$S_e = \lambda \rho V^2/2 - \mu_{GM}\, g \tag{36}$$

Combining Equations 3 and 36 gives:

$$S_e = \lambda \rho_o (V^2/2) e^{-\rho_o g z/p_o} - \mu_{GM}\, g \tag{37}$$

Using the values of ρ_o and p_o given in Section 2.1 and $g = 9.81$ m/s^2, Equation 37 gives:

- At sea level:

$$S_e = 0.6465 \lambda V^2 - 9.81 \mu_{GM} \tag{38}$$

with S_e(Pa), V(m/s), μ_{GM}(kg/m^2)

$$S_e = 0.050 \lambda V^2 - 9.81 \mu_{GM} \tag{39}$$

with S_e(Pa), V(km/h), μ_{GM}(kg/m^2)

Attachment A 1/3

- At altitude z above sea level:

$$S_e = 0.6465\lambda V^2 e^{-(1.252\times10^{-4})z} - 9.81\mu_{GM} \quad (40)$$

with S_e(Pa), V(m/s), z(m), μ_{GM}(kg/m^2)

$$S_e = 0.050\lambda V^2 e^{-(1.252\times10^{-4})z} - 9.81\mu_{GM} \quad (41)$$

with S_e(Pa), V(km/h), z(m), μ_{GM}(kg/m^2)

3.3 Determination of Geomembrane Tension and Strain

According to Equation 36, the effective suction results from two components: a component due to the wind-generated suction, which is normal to the geomembrane; and a component due to the geomembrane mass per unit area, which is not normal to the geomembrane. The component due to the geomembrane mass per unit area is generally small compared to the component due to the wind-generated suction. Therefore, the effective suction is essentially normal to the geomembrane. Since the effective suction is taken as normal to the geomembrane and has been assumed to be uniformly distributed over the length L of geomembrane, and since the problem is considered to be two-dimensional (see Section 3.2.2), the cross section of the uplifted geomembrane has a circular shape (Figure 9). As a result, the resultant F of the applied effective suction is equal to the effective suction multiplied by the length of chord AB, i.e. L:

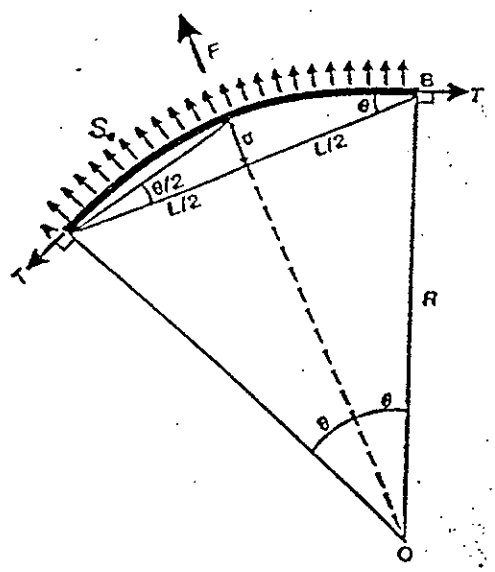


Figure 9. Schematic representation of uplifted geomembrane used for developing equations.

Attachment A
2/3

Table 4. Relationship between the strain of the geomembrane uplifted by the wind and the normalized tensile stiffness of the geomembrane for the case where the geomembrane has a linear tension-strain curve (Equation 57).

ε (%)	$\frac{J}{S_e L}$	ε (%)	$\frac{J}{S_e L}$	ε (%)	$\frac{J}{S_e L}$	ε (%)	$\frac{J}{S_e L}$
0	∞	3.6	31.347	7.2	11.607	10.8	6.607
0.1	6463.688	3.7	30.124	7.3	11.384	10.9	6.525
0.2	2288.342	3.8	28.981	7.4	11.168	11.0	6.443
0.3	1247.294	3.9	27.910	7.5	10.959	11.1	6.365
0.4	811.232	4.0	26.905	7.6	10.757	11.2	6.291
0.5	581.251	4.1	25.960	7.7	10.561	11.3	6.212
0.6	442.767	4.2	25.071	7.8	10.372	11.4	6.138
0.7	351.834	4.3	24.233	7.9	10.189	11.5	6.065
0.8	288.358	4.4	23.442	8.0	10.010	11.6	5.994
0.9	241.983	4.5	22.694	8.1	9.839	11.7	5.925
1.0	206.885	4.6	21.987	8.2	9.671	11.8	5.857
1.1	179.565	4.7	21.316	8.3	9.508	11.9	5.790
1.2	157.804	4.8	20.680	8.4	9.351	12.0	5.724
1.3	140.137	4.9	20.076	8.5	9.198	12.1	5.660
1.4	125.562	5.0	19.502	8.6	9.049	12.2	5.598
1.5	113.368	5.1	18.956	8.7	8.905	12.3	5.537
1.6	103.044	5.2	18.435	8.8	8.765	12.4	5.477
1.7	94.212	5.3	17.939	8.9	8.628	12.5	5.418
1.8	86.586	5.4	17.465	9.0	8.495	12.6	5.359
1.9	79.947	5.5	17.013	9.1	8.365	12.7	5.302
2.0	74.125	5.6	16.580	9.2	8.240	12.8	5.247
2.1	68.985	5.7	16.167	9.3	8.118	12.9	5.192
2.2	64.421	5.8	15.771	9.4	7.998	13.0	5.138
2.3	60.345	5.9	15.392	9.5	7.882	13.1	5.086
2.4	56.688	6.0	15.027	9.6	7.769	13.2	5.035
2.5	53.391	6.1	14.678	9.7	7.658	13.3	4.984
2.6	50.407	6.2	14.342	9.8	7.551	13.4	4.934
2.7	47.696	6.3	14.020	9.9	7.446	13.5	4.885
2.8	45.223	6.4	13.710	10.0	7.344	13.6	4.837
2.9	42.960	6.5	13.412	10.1	7.243	13.7	4.790
3.0	40.885	6.6	13.126	10.2	7.146	13.8	4.743
3.1	38.973	6.7	12.849	10.3	7.051	13.9	4.698
3.2	37.209	6.8	12.582	10.4	6.958	14.0	4.653
3.3	35.577	6.9	12.325	10.5	6.867	14.1	4.609
3.4	34.064	7.0	12.078	10.6	6.779	14.2	4.566
3.5	32.657	7.1	11.838	10.7	6.692	14.3	4.524

ATTACHMENT A
3/3

LAS VEGAS, NEVADA

NB GTC

NORMALS, MEANS, AND EXTREMES

LATITUDE: 36 Deg. 02 Min. N LONGITUDE: 115 Deg. 11 Min. W ELEVATION: FT. GRND 2286 BARO 2179 TIME ZONE: PACEFIC WBAN: 23169

	(a)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
TEMPERATURE (Deg. F)										
Normals										
-Daily Maximum		57.3	63.3	68.8	77.5	87.8	100.3	105.9	103.2	94.7
-Daily Minimum		33.6	38.8	43.8	50.7	60.2	69.4	76.2	74.2	66.2
-Monthly		45.5	51.1	56.3	64.1	74.0	84.9	91.1	88.7	80.5
Extremes										
-Record Highest	47	77	87	91	99	109	115	116	116	113
-Year		1975	1986	1966	1981	1951	1994	1985	1979	1950
-Record Lowest	47	8	16	23	31	40	48	60	56	46
-Year		1963	1989	1971	1975	1964	1993	1987	1968	1965
NORMAL DEGREE DAYS										
Heating (base 65 Deg. F)		605	389	292	143	14	0	0	0	0
Cooling (base 65 Deg. F)		0	0	22	116	293	597	809	735	465
% OF POSSIBLE SUNSHINE	46	77	81	83	87	88	93	88	88	91
MEAN SKY COVER(tenths)										
Sunrise - Sunset	47	4.9	4.8	4.6	3.9	3.5	2.1	2.8	2.5	2.1
MEAN NUMBER OF DAYS:										
Sunrise to Sunset										
-Clear	47	13.6	12.3	13.6	15.6	17.7	22.3	20.1	21.6	22.5
-Partly Cloudy	47	6.3	6.8	8.4	7.7	8.0	5.2	7.5	6.7	5.0
-Cloudy	47	11.1	9.1	9.0	6.8	5.3	2.5	3.4	2.8	2.5
Precipitation										
.01 inches or more	47	3.3	2.8	3.2	1.7	1.4	0.7	2.6	2.8	1.6
Snow, Ice Pellets, Hail										
1.0 inches or more	47	0.3	0.*	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thunderstorms	47	0.*	0.2	0.4	0.5	1.0	1.0	3.9	3.9	1.5
Heavy Fog Visibility										
1/4 mile or less	47	0.3	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.*
Temperature Deg. F										
-Maximum										
90 Deg. F and above	35	0.0	0.0	0.*	3.3	15.1	25.7	30.5	29.9	22.4
32 Deg. F and below	35	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
-Minimum										
32 Deg. F and below	35	11.9	4.2	1.1	0.1	0.0	0.0	0.0	0.0	0.0
0 Deg. F and below	35	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AV. STATION PRES. (mb)	23	942.4	940.7	937.3	935.9	933.9	933.6	934.9	935.5	936.0
RELATIVE HUMIDITY (%)										
Hour 04	35	56	51	46	35	32	25	28	34	33
Hour 10 (Local Time)	35	42	37	31	22	19	15	19	23	22
Hour 16	35	32	27	23	16	14	11	14	17	17
Hour 22	35	50	43	37	26	23	17	22	26	26
PRECIPITATION (in.)										
Water Equivalent										
-Normal		0.48	0.49	0.42	0.21	0.28	0.12	0.35	0.49	0.28
-Maximum Monthly	47	3.00	2.52	4.80	2.44	0.96	0.97	2.48	2.59	1.58
-Year		1995	1993	1992	1965	1969	1990	1984	1957	1963

Attachment B
1/2

Attachment B

-Minimum Monthly	47	T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-Year		1984	1977	1972	1962	1970	1982	1981	1980	1971
-Maximum in 24 hrs	47	1.09	1.30	1.27	0.97	0.83	0.97	1.36	2.59	1.07
-Year		1990	1993	1992	1965	1987	1990	1984	1957	1963
Snow, Ice Pellets, Hail										
-Maximum Monthly	47	16.7	1.4	0.1	T	0.0	0.0	0.0	T	0.0
-Year		1949	1990	1976	1970				1989	
-Maximum in 24 hrs	7 9	.0 6	.9 0	.1 T	0	.0 0	.0 0	.0 T	0	.0 T
-Year		1974	1979	1976	1970				1989	
WIND										
Mean Speed (mph)	47	7.4	8.5	10.2	11.0	11.1	11.1	10.3	9.6	9.0
Prevailing Direction through 1964		W	SW	SW	SW	SW	SW	SW	SW	SW
Fastest Mile										
-Direction(!!)	10	23	23	23	22	32	34	02	14	22
-Speed(mph) Avg. 44 mph		30	50	51	49	53	48	44	40	35
-Year		1987	1989	1989	1988	1991	1989	1994	1989	1989
Peak Gust										
-Direction(!!)	12	SW	NW	NW	W	NW	NE	NE	SE	SW
-Speed(mph) Avg 68	12	54	67	82	69	72	59	71	90	49
-Date		1987	1984	1994	1988	1991	1984	1994	1989	1989

(a) - Length of Record in Years, although individual months may be missing.
0.* or * - The value is between 0.0 and 0.05.
Normals - Based on the 1961 - 1990 record period.
Extremes - Dates are the most recent occurrence.
Wind Dir.- Numerals show tens of degrees clockwise from true north. "00" indicates calm.
Resultant Directions are given to whole degrees.

90 mph

Attachment B
2/2

GEOTEXTILES

Product Name (Structure [1]/ Polymer Type [2])	Mass Per Unit Area ASTM D 5261 g/m² (oz/yd²)	M288 Transportation-Related Applications: Filtration/Hydraulic Properties: Percent Open Area CWO-22125 %	Apparent Opening Size ASTM D 4751 mm (U.S. sieve)	Permittivity ASTM D 4491 sec⁻¹ Flow Rate (FH or CH) [3] l/min/m² (gal/min/ft²)	Physical Properties: Puncture ASTM D 4833 kN (lb)	Trapezoid Tearing Strength ASTM D 4533 kN (lb)	Grab Tensile/ Elongation ASTM D 4632 kN (lb)/%	M288 Survivability Class	M288 Applications [4]	Reinforcement Applications: Wide Width Tensile Properties ASTM D 4595 kN/m (lb/in.): Strength @ 5% Strain [5] MD	Strength @ 5% Strain [5] XD	Ultimate Strength % (T_{ult}) [5],[6] MD	Ultimate Strength % (T_{ult}) [5],[6] XD	Creep Limited Strength ASTM D 5262 [6], [7] kN/m (lb/ft)	T_{allow} GRI GT7 (in sand) [6]	Other Manufacturer's Suggested Applications [8]
Maccaferri Gabions Inc. (cont.)																
MacTex MXF2 (W-SF-PP)	95 (2.9)	<1 [A]	0.850 (20)	0.2/610 (15), FH	0.255 (58)	0.220x0.220 (50x50)	0.445x0.445 (100x100)/15x15	--	S/F	NA	NA	NA	NA	NA	NP	S/F
MacTex MXM10 (W-PP)	200 (5.9)	4 [A]	0.212 (70)	0.28/730 (18), CH	0.535 (120)	0.445x0.310 (100x70)	1.645x1.110 (370x250)/24x24	--	E, F, D	NA	NA	NA	NA	NA	NP	F
MacTex MXM20 (W-PP)	190 (5.7)	11 [A]	0.600 (30)	1.10/4480 (110), CH	0.510 (115)	0.510x0.335 (115x75)	1.845x0.980 (370x220)/25x15	--	E, F, D	NA	NA	NA	NA	NA	NP	E, F, D
MacTex MXW9 (W-SF-PP)	150 (4.5)	<1 [A]	0.425 (40)	0.07/240 (6), FH	0.445 (100)	0.330x0.330 (75x75)	0.890x0.890 (200x200)/15x15	--	SP, ST	8.7 (50)	9.6 (55)	21/9 (120)	21/7 (120)	NA	NP	ST, SP, R
MacTex MXW13 (W-SF-PP)	220 (6.5)	<1 [A]	0.212 (70)	0.06/200 (5), FH	0.555 (125)	0.530x0.530 (120x120)	1.400x1.400 (315x315)/15x15	--	SP, ST	8.7 (50)	10.5 (60)	30.6/10 (175)	30.6/8 (175)	NA	NP	ST, SP, R
Serrot International Inc./Fluid Systems																
Trevira 011/140	136 (4.0)	NA	0.3 (50)	2.01/102 (150)	0.222 (50)	0.178 (40)	0.489 (110)/60	NA	NA	NA	NA	NA	NA	NA	NA	SP, ST, F, A/O, D, E
Trevira 011/120	193 (5.7)	NA	0.21 (70)	1.74/88 (130)	0.356 (80)	0.267 (60)	0.711 (160)/60	NA	NA	NA	NA	NA	NA	NA	NA	SP, ST, F, A/O, D, E

Attachment C

Calculation Package K
Anchorage Capacity

GeoSyntec Consultants

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: Parsons **Project:** BRC CAMU **Project/Proposal #:** HL0389 **Task #:** 02

Title of Computations: Evaluation of Geosynthetic Anchorage Capacity

Computations By:
SIGNATURE — 28 June 2000 DATE
Geoff L. Smith / Staff Engineer
PRINTED NAME AND TITLE

Assumptions and Procedures Checked By (Peer Reviewer):
SIGNATURE — 7/3/00 DATE
GREGORY T CORCORAN / PROJ. ENG.
PRINTED NAME AND TITLE

Computations Checked By:
SIGNATURE — 7/3/00 DATE
GREGORY T. CORCORAN / PROJ. ENG.
PRINTED NAME AND TITLE

Computations Backchecked By (Originator):
SIGNATURE — 28 June 2000 DATE
Geoff L. Smith / Staff Engineer
PRINTED NAME AND TITLE

Approved By (PM or Designate):
SIGNATURE — 10 July 2000 DATE
Bradford H. Cooley / Project Manager
PRINTED NAME AND TITLE

Approval Notes:

Revisions: (Number and Initial All Revisions)

No.	Sheet	Date	By	Checked By	Approval

Written by: Geoff L. Smith Date: 01 / 27/ 00 (MM DD YY) Reviewed by: GTC Date: 07 / 03 / 00 (MM DD YY)

Client: Parsons Project: BRC CAMU Project No.: HL0389 Task No.: 01

EVALUATION OF LINER SYSTEM ANCHOR CAPACITY
BRC CAMU
HENDERSON, NEVADA

OBJECTIVE

The objective of this calculation package is to evaluate the tensile strength capacity for anchorage of the liner system at termination locations of the liner system with respect to wind uplift forces on the U.V. protective woven geotextile. One liner termination detail will be evaluated for the BRC CAMU.

SITE CONDITIONS

The proposed design for the BRC CAMU consists of a trench located a minimum of 3 ft from the crest of the slope. The width and depth of the trench is 2 ft and 2.5 ft, respectively. During the period of wind uplift exposure, there will be a 1 ft (0.3 m) high overburden placed above the anchor trench. The geosynthetic anchorage design is presented in Figure 1.

METHOD OF ANALYSIS

Koerner (1994) presents design equations developed from static equilibrium to evaluate the allowable geosynthetic tension from an anchor trench. The equation considers frictional resistance due to (i) overburden pressures, (ii) anchor trench side slopes, and (iii) base of the anchor trench. The proposed design equation for determination of the allowable geomembrane tension from an anchor trench is:

$$T_{allow} = F_U + F_L + F_{AT\text{-}SIDE1} + F_{AT\text{-}SIDE2} + F_{AT\text{-}BASE1} + F_{AT\text{-}BASE2} \quad (1)$$

Where: T_{allow} = Allowable tensile force in the geotextile;

F_U = Friction force above the geotextile;

F_L = Friction force below the geotextile;

$F_L = q\tan\delta(L_{RO})$

q = surcharge pressure due to soil overburden

Written by: Geoff L. Smith Date: 01 / 27/ 00 (MM DD YY) Reviewed by: GTC Date: 07/03/00 (MM DD YY)

Client: Parsons Project: BRC CAMU Project No.: HL0389 Task No.: 01

δ = minimum friction angle between liner system interfaces and the soil

L_{RO} = Runout length

$F_{AT\text{-}SIDE}$ = Friction force due to the side of the anchor trench;

$F_{AT\text{-}SIDE} = (\sigma_h)_{ave} \tan\delta(d_{AT})$

$(\sigma_h)_{ave}$ = average horizontal stress in the anchor trench = $K_o\sigma_v$

d_{AT} = depth of the anchor trench

K_o = coefficient of earth pressure at rest, = $(1\text{-}\sin\phi)$

σ_v = vertical overburden stress (at average depth of the anchor trench)

$F_{AT\text{-}BASE}$ = Friction force due to the base of the anchor trench;

$F_{AT\text{-}BASE} = q\tan\delta(L_{AT})$

L_{AT} = width of the anchor trench

ANALYSIS

Evaluating Variables

Since tension will develop in the U.V. protective layer (see the calculation package *Tension due to Wind Uplift*), frictional forces of the U.V. protective layer woven geotextile will be mobilized along the geosynthetic and soil interfaces on the side and base of the anchor trench. For the analysis presented herein:

- A friction angle of 8 degrees will be used to represent the friction angle between the geocomposite (non-woven geotextile side) and the woven geotextile. (Attachment 1 presents a typical friction angle between a non-woven geotextile and a *smooth* HDPE sheet as 8 degrees. The interface between a woven geotextile and the non-woven geotextile will be higher due to the slit film and raised surfaces of the woven geotextile. Therefore, it is conservative to assume a friction angle of 8 degrees);

- A friction angle of 26 degrees to represent the soil/ woven geotextile interface. (Attachment 1 presents typical efficiency values between woven and soil interfaces. The typical efficiency is on the order of 85 percent. The anchor trench soil compacted to 90 % modified proctor will have a friction angle on

Written by: Geoff L. Smith Date: 01 / 27/ 00 (MM DD YY) Reviewed by: _____ Date: ___/___/___ (MM DD YY)

Client: Parsons Project: BRC CAMU Project No.: HL0389 Task No.: 01

the order of 30 degrees - see final slope stability calculation package. Therefore, the interface friction angle is $\tan^{-1}(0.85*\tan(30))$=26 deg.).

For determination of the surcharge due to soil overburden, q, and the vertical and horizontal overburden stresses, σ_h and σ_v, a unit weight of overburden soil of 136 pcf was assumed (γ = 136 pcf). For evaluation of the effective horizontal overburden stress based on the coefficient of earth pressure at rest, a friction angle of 30° was assumed for the cover soil.

Analysis

From Equation (1):

$$T_{allow} = F_U + F_L + F_{AT\text{-}SIDE1} + F_{AT\text{-}SIDE2} + F_{AT\text{-}BASE1} + F_{AT\text{-}BASE2}$$

$$F_U = q\tan\delta(L_{RO}) = 1\text{ ft (136 pcf) tan 8°(2 ft)} = 38.2\text{ lb/ft}$$

$$F_L = q\tan\delta(L_{RO}) = 1\text{ ft (136 pcf) tan 26°(2 ft)} = 132.7\text{ lb/ft}$$

$$F_{AT\text{-}SIDE1} = (\sigma_h)_{ave}\tan\delta(d_{AT}) = Ko(\sigma_v)_{ave}\tan\delta(d_{AT}) = (1\text{-}\sin30^\circ)(2.25\text{ ft})(136\text{ pcf})\tan8^\circ(2.5\text{ ft}) = 53.8\text{ lb/ft}$$

$$F_{AT\text{-}SIDE2} = (\sigma_h)_{ave}\tan\delta(d_{AT}) = Ko(\sigma_v)_{ave}\tan\delta(d_{AT}) = (1\text{-}\sin30^\circ)(2.25\text{ ft})(136\text{ pcf})\tan26^\circ(2.5\text{ ft}) = 186\text{ lb/ft}$$

$$F_{AT\text{-}BASE1} = q\tan\delta(L_{AT}) = (3.5\text{ft})(136\text{ pcf})(\tan8^\circ)(2\text{ ft}) = 133.8\text{ lb/ft}$$

Written by: Geoff L. Smith Date: 01 / 27/ 00 (MM DD YY) Reviewed by: GTC Date: 01 / 03 / 00 (MM DD YY)

Client: Parsons Project: BRC CAMU Project No.: HL0389 Task No.: 01

$$F_{AT\text{-}BASE2} = q\tan\delta(L_{AT})$$
$$= (3.5\text{ft})(136\text{ pcf})(\tan 26^{\circ})(2\text{ ft})$$
$$= 464\text{ lb/ft}$$

$$T_{allow} = F_U + F_L + F_{AT\text{-}SIDE1} + F_{AT\text{-}SIDE2} + F_{AT\text{-}BASE1} + F_{AT\text{-}BASE2}$$
$$= 38.2 + 132.7 + 53.8 + 186 + 134 + 464$$
$$\mathbf{T_{allow} = 1{,}008\ lb/ft = 14.7\ kN/m}$$

CONCLUSIONS

The allowable tensile capacity of the anchorage system as calculated herein (as T_{allow}) exceeds the expected wind uplift tensile loads (from the calculation package entitled *Evaluation of Tension due to Wind Uplift*). The expected tensile load due to wind uplift was evaluated to be 10.9 kN/m. Since the design wind speed is the maximum peak gust recorded (90 mph), the required factor of safety against anchorage pullout is greater than 1.0. Therefore, the anchor capacity is adequate.

Based on the methods employed herein, results of analysis indicates that the design anchorage evaluated provides adequate tensile capacity to resist the U.V. protective geotextile tension induced by wind uplift forces.

REFERENCES

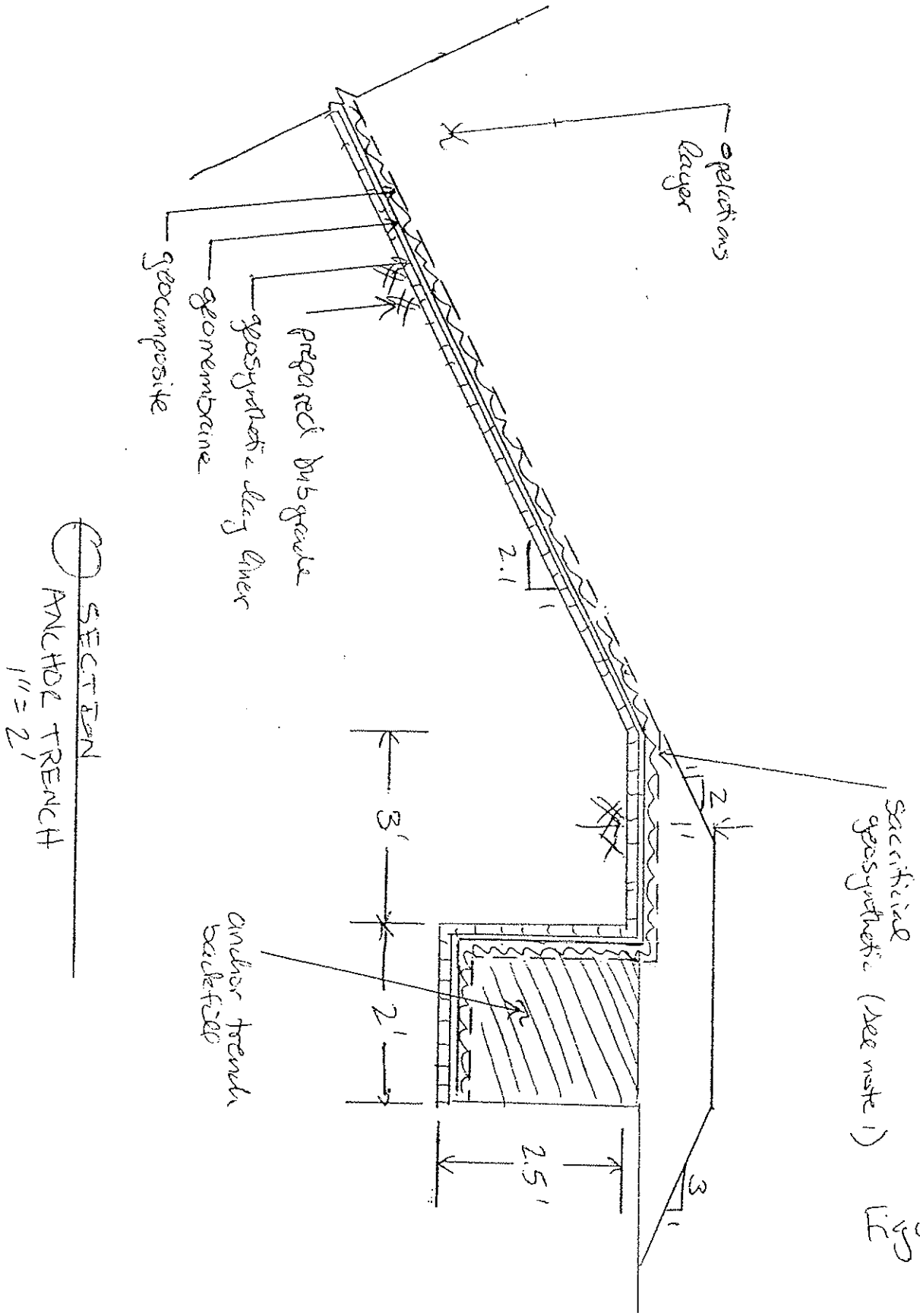
Koerner, R.M. (1994), "*Designing with Geosynthetics*," 3rd Edition., Englewood Cliffs, NJ, Prentice Hall
(Attachment 1)

GEOSYNTEC CONSULTANTS

Page ____ of ____

Written by: MY Date: __/__/__ (YY MM DD) Reviewed by: GTC Date: 00/07/03 (YY MM DD)

Client: ____ Project: ____ Project/Proposal No.: ____ Task No.: ____



SECTION
ANCHOR TRENCH
1" = 2'

Figure 1

Solution: From the design equations just presented,

$$T \cos \beta = 350\ (144)(0.030/12) \cos 18.4$$
$$= 120 \text{ lb./ft.}$$
$$T \sin \beta = 39.8 \text{ lb./ft.}$$
$$q_L = d_{CS}\ \gamma_{CS}$$
$$= (1.0)\ (100)$$
$$= 100 \text{ lb./ft.}^2$$

which, when substituted into Equation 5.27, gives

$$T \cos \beta = q_L \tan \delta\ (L_{RO}) + T \sin \beta \tan \delta$$
$$120 = 100 \tan 20\ (L_{RO}) + 39.8 \tan 20$$
$$120 = 36.4 L_{RO} + 14.5$$
$$L_{RO} = 2.9 \text{ ft.; use } 3.0 \text{ ft.}$$

Note that this value is strongly dependent on the value of mobilized allowable stress used in the analysis. To mobilize the full strength of the geomembrane would require a longer runout length or an anchor trench. This, however, might not be desirable. Pullout, without geomembrane failure, might be a preferable phenomenon. It is a site-specific situation.

The situation with an anchor trench at the end of the runout section is illustrated in Figure 5.31. The configuration requires some important assumptions regarding the state of stress within the anchor trench and its resistance mechanism. To establish static equilibrium, Daniel [41] has suggested using an imaginary and frictionless pulley as shown in Figure 5.31, which allows for the geomembrane to be considered in its continuous form.

$$T_{\text{allow}} = F_U + F_L + 2\ F_{AT} \tag{5.28}$$

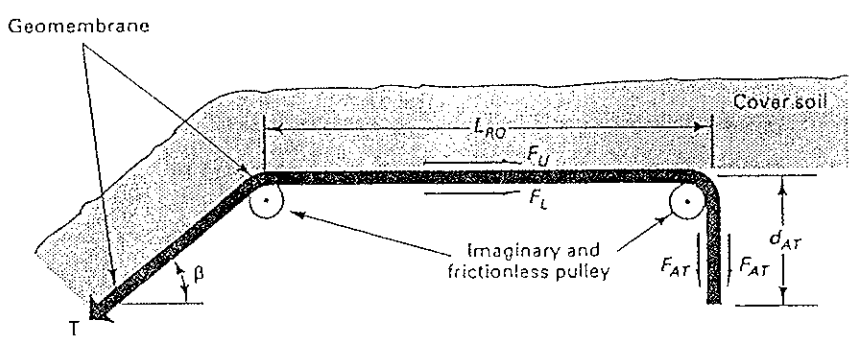


Figure 5.31 Cross section of geomembrane runout section with anchor trench and related stresses and forces involved.

Attachment A 1/3

where $T_{allow} = \sigma_{allow}\, t$, in which
σ_{allow} = the mobilized allowable geomembrane stress = σ_{ult}/FS,
σ_{ult} = the ultimate geomembrane stress (e.g., yield or break),
FS = the factor of safety, and
t = the geomembrane thickness,
F_U = the friction force above geomembrane (assumed to be negligible, since the cover soil probably moves along with the liner as it deforms),
$F_L = q \tan \delta\, (L_{RO})$, in which
q = the surcharge pressure = $d_{CS}\, \gamma_{CS}$,
d_{CS} = the depth of cover soil,
γ_{CS} = the unit weight of cover soil,
δ = the friction angle between geomembrane and soil, and
L_{RO} = (unknown) length of runout, and
$F_{AT} = (\sigma_h)_{ave} \tan \delta\, (d_{AT})$, in which
σ_h = the average horizontal stress in anchor trench = $K_O\, \sigma_V$,
$\sigma_V = \gamma\, H_{ave}$,
γ = the unit weight of backfill soil,
H_{ave} = the average depth of anchor trench (requires an estimate),
$K_O = 1 - \sin \phi$,
ϕ = the angle of shearing resistance of backfill soil, and
d_{AT} = the (unknown) depth of anchor trench.

This situation results in one equation with two unknowns; thus a choice of either L_{RO} or d_{AT} is necessary to calculate the other. As with the previous situation, the factor of safety is placed on the geomembrane force T, which is used as an allowable value (i.e., T_{allow}). An example illustrates the procedure.

Example:

Repeat the previous problem of a 30-mil VLDPE geomembrane of allowable stress 350 lb./in.^{2} on a 3(H) to 1(V) side slope. There is a 12-in. cover soil placed over the geomembrane weighing 100 lb./ft.^{3} (also the unit weight of the backfill soil). The friction angle between the liner and soil is 20 deg. and the soil itself is 30 deg. Determine the required length of runout for a 12-in.-deep anchor trench and for a zero-depth anchor trench to check the preceding example.

Solution: Using the previously developed design equations based on Figure 5.31,

$$T_{allow} = F_U + F_L + 2F_{AT}$$

$$\sigma_{allow}(t) = 0 + q \tan\delta\,(L_{RO}) + 2(K_O \sigma_{V_{ave}}) \tan\delta(d_{AT})$$

$$(350 \times 144)\left(\frac{0.030}{12}\right) = 0 + (1.0)(100) \tan 20(L_{RO}) + 1.5(0.5)(2.0 \times 100) \tan 20(d_{AT})$$

$$126 = 36.4 L_{RO} + 56.6 d_{AT}$$

Attachment A
2/3

GTC

Table 5.7 Friction values and efficiencies (in parentheses) for (a) soil-to-geomembrane, (b) geomembrane-to-geotextile, and (c) soil-to-geotextile combinations*

(a) Soil-to-Geomembrane Friction Angles

	Soil Types		
Geomembrane	*Concrete Sand* (ϕ = 30°)	*Ottawa Sand* (ϕ = 28°)	*Micha Schist Sand* (ϕ = 26°)
EPDM-R	24° (0.77)	20° (0.68)	24° (0.91)
PVC			
Rough	27° (0.88)	—	25° (0.96)
Smooth	25° (0.81)	—	21° (0.79)
CSPE-R	25° (0.81)	21° (0.72)	23° (0.87)
HDPE ~Smooth	18° (0.56)	18° (0.61)	17° (0.63)

(b) Geomembrane-to-Geotextile Friction Angles

	Geomembrane				
		PVC			
Geotextile	*EPDM-R*	*Rough*	*Smooth*	*CSPE-R*	*HDPE*
Nonwoven, needle punched	23°	23°	21°	15°	8°
Nonwoven, heat bonded	18°	20°	18°	21°	11°
Woven, monofilament	17°	11°	10°	9°	6°
Woven, slit film	21°	28°	24°	13°	10°

(c) Soil-to-Geotextile Friction Angles

	Soil Types		
Geotextile	*Concrete Sand* (ϕ = 30°)	*Ottawa Sand* (ϕ = 28°)	*Mica Schist Sand* (ϕ = 26°)
Nonwoven, needle punched	30° (1.00)	26° (0.92)	25° (0.96)
Nonwoven, heat bonded	26° (0.84)	—	—
Woven, monofilament	26° (0.84)	—	—
Woven, slit film	24° (0.77)	24° (0.84)	23° (0.87)

*Efficiency values in parentheses are based on the relationship $E = (\tan \delta)/(\tan \phi)$.

Source: After Martin et al. [14].

The frictional behavior of geomembranes placed on clay soils is of considerable importance in the composite liners of waste landfills. Current requirements are for the clay to have a hydraulic conductivity equal to or less than 2×10^{-7} ft./min. (1×10^{-7} cm/sec.) and for the geomembrane to be placed directly on the clay. While an indication of the shear strength parameters has been investigated (e.g., reference 15), the data are so sensitive to the variables listed previously that site-specific and material-specific tests should always be performed. In such cases, literature values should never be used for final design purposes.

5.1.3.9 Geomembrane Anchorage In certain problem situations a geomembrane might be sandwiched between two materials and then tensioned by an external force. The termination of a geomembrane liner within an anchor trench is such a situation. To simulate this behavior in a laboratory environment, one can use an 8.0-in. (200-mm)-wide geomembrane sandwiched between back-to-back channels.

Attachment A 3/3

Koerner, R.M. (1995), Designing with Geosynthetics, Third Edition, Prentice Hall, N.J.

Calculation Package L
Geocomposite Equivalency Demonstration

GeoSyntec Consultants

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: Parsons **Project:** BRC CAMU **Project/Proposal #:** HL0389 **Task #:** 02

Title of Computations: Drainage Geocomposite Equivalency Demonstration

Computations By:
SIGNATURE — 28 June 2000 DATE
Geoff L. Smith / Staff Engineer
PRINTED NAME AND TITLE

Assumptions and Procedures Checked By (Peer Reviewer):
SIGNATURE — 7/3/00 DATE
GREGORY T CORCORAN / PROJ. ENG.
PRINTED NAME AND TITLE

Computations Checked By:
SIGNATURE — 7/3/00 DATE
GREGORY T. CORCORAN / PROJ. ENG.
PRINTED NAME AND TITLE

Computations Backchecked By (Originator):
SIGNATURE — 28 June 2000 DATE
Geoff L. Smith / Staff Engineer
PRINTED NAME AND TITLE

Approved By (PM or Designate):
SIGNATURE — 10 July 2000 DATE
Bedford H. Cooley / Project Manager
PRINTED NAME AND TITLE

Approval Notes:

Revisions: (Number and Initial All Revisions)

No.	Sheet	Date	By	Checked By	Approval

Written by: Geoff L. Smith GLS Date: 00 / 06 / 28 (YY MM DD) Reviewed by: GTC Date: 00 / 07 / 03 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 02

DRAINAGE COMPOSITE EQUIVALENCY DEMONSTRATION
BRC CAMU
HENDERSON, NEVADA

OBJECTIVE

The objective of this analysis is to evaluate the hydraulic performance of a drainage composite, and compare it to the prescriptive leachate collection layer, consisting of drainage aggregate, within the BRC CAMU. A drainage composite, consisting of two 8 oz/sy nonwoven geotextiles bonded to either side of a geonet, is proposed. This analysis will demonstrate equivalence or performance exceedance of the drainage composite to the prescriptive 1-foot thick (0.3m) aggregate drainage layer. The method of analysis will compare the current transmissivity of the aggregate drainage layer and the equivalent transmissivity of the drainage composite.

SUMMARY OF ANALYSIS

The calculations suggest that a drainage composite having a transmissivity of $6.1*10^{-5}$ m^2/sec, at a maximum stress of 12,000 psf (574 kN/m^2) and a hydraulic gradient of ~~0.02~~ 0.10 GLS, will provide equivalence to the aggregate drainage layer.

METHOD OF ANALYSIS

The analysis was performed using procedures recommended by Koerner (1994). The procedure first evaluates the flow rate (transmissivity) through the aggregate drainage layer, using the basic flow equation described by Darcy, and then calculates the equivalent flow rate (transmissivity) of the drainage composite, and includes appropriate partial factors of safety for geosynthetic materials.

ANALYSIS

This calculation evaluates the flow rate within the drainage composite.

- **FLOW RATE (TRANSMISSIVITY) OF THE AGGREGATE DRAINAGE LAYER**

The maximum flow rate within the leachate collection zone is determined from Darcy's Law by the equation:

$$q = K\,i\,A$$

Written by: Geoff L. Smith GLS Date: 00 / 06 / 28 (YY MM DD) Reviewed by: GTC Date: 00 / 07 / 03 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 02

where:

q = flow rate within the leachate collection layer (m^3/sec)
K = hydraulic conductivity (m/sec)
i = hydraulic gradient (dimensionless)
A = area of flux (m^2)

The following properties will be used for the aggregate drainage layer material.

$K = 1*10^{-2}$ cm/sec = $1*10^{-4}$ m/sec.
i = 0.02 (minimum slope of base liner system)
A= (1 ft * 1 ft) = 1 ft^2 = 0.093 m^2

The hydraulic conductivity is the prescriptive minimum value for the aggregate drainage layer, and the hydraulic gradient is a function of the minimum base slope of the cell. The area of flux is based on the unit thickness of the aggregate drainage layer (1 foot minimum).

Therefore,

$q_{req} = (1*10^{-4}$ m/sec.)(0.02)(0.093 m^2)
$= 1.86*10^{-7}$ m^3/sec

This maximum flow rate through the aggregate drainage layer, is the required flow through the drainage composite (q_{req}).

The allowable flow rate is obtained from laboratory testing for design purposes. This value is determined using appropriate safety factors against the required flow rate. The factor of safety is expressed as the ratio of the allowable flow rate (q_{all}) to the required flow rate (q_{req}).

$$FS = q_{all} / q_{req}$$

Similarly, the factor of safety equation can be expressed as the ratio of allowable to required in plane flow, transmissivity (θ), where the factor of safety equals:

$$FS = \theta_{all} / \theta_{req}$$

Where the transmissivity is calculated by:

$$\theta_{req} = q_{req} / (i*W)$$ (Attachment A)

W = unit width of the drainage layer = 1 ft = 0.3408 m

Therefore,

$$\theta_{req} = \frac{(1.86*10^{-7}\ m^3/sec)}{(0.3048m)(0.02)}$$

$$= 3.05*10^{-5}\ m^2/sec.$$

The transmissivity of the aggregate drainage layer then becomes the minimum required transmissivity (θ_{req}) of the drainage composite.

- **TRANSMISSIVITY OF THE DRAINAGE COMPOSITE**

To ensure that the transmissivity of the proposed drainage composite meets or exceeds the required values over the life of the landfill, the required transmissivity must be increased through the use of appropriate partial factors of safety. These partial factors of safety make the adequate adjustment between the laboratory transmissivity values for drainage composite and actual field conditions.

As seen in Attachment A, Koerner suggests four factors of safety which should be accounted for: the intrusion of the adjacent geotextile into the core of the geonet (FS_{IN}), creep deformation of the geonet (FS_{CR}), factor of safety against chemical clogging of the geonet (FS_{CC}), and factor of safety against biological clogging of the geonet (FS_{BC}). Partial factor of safety values were applied to the geotextile in the filtration geotextile calculation to account for flow through the geotextile component of the drainage composite.

Attachment A shows the ranges for the partial factors of safety. For the purposes of the calculations made, the factors of safety were assumed to be:

FS_{IN} = 1.0 (Accounted for during the testing of the drainage composite)
FS_{CR} = 2.0
FS_{CC} = 1.0 (Accounted for in the Filter Calculation)
FS_{BC} = 1.0 (Accounted for in the Filter Calculation)

The ultimate transmissivity of the drainage composite then becomes:

$$\theta_{ultimate} = \theta_{req} * (\Sigma\ FS)$$

Written by: Geoff L. Smith GS Date: 00 / 06 / 28 (YY MM DD) Reviewed by: GTC Date: 00/07/03 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 02

Σ FS = product of all the partial factors of safety for the site specific conditions

The ultimate transmissivity of the drainage composite is then calculated as:

$$\theta_{geonet} = \theta_{req} * (\Sigma \text{ FS}) = 3.05*10^{-5} \text{ m}^2/\text{sec } [\ 1.0*2.0*1.0*1.0]$$

$$= 6.1*10^{-5} \text{ m}^2/\text{sec}$$

- **MAXIMUM STRESS**

The maximum height of the waste fill is 60 ft (18.3 m). Assuming a unit weight of 136 pcf and a factor of safety of 1.5, this translates to a overburden stress of approximately 12,000 psf (574 kPa).

- CONCLUSIONS

The required transmissivity of the geocomposite shall be $6.1*10^{-5}$ m^2/sec at a maximum stress of 12,000 psf and a gradient of ~~0.02~~. 0.10 GS

REFERENCES

Koerner, R.M. (1994) "Designing with Geosynthetics", 3rd Edition, Prentice Hall, New Jersey *(Attachment A)*

GTC

transportation-related systems, such as roads and walls, the problem does not appear to be too serious. In waste leachate related systems (e.g., landfill leachate collection systems), it might be another story. At the bottom of a landfill, temperatures are high, ample carbon (as a biological food source) is available, and bacteria and fungi could indeed thrive. Whether oxygen is available or not only dictates whether aerobic or anaerobic conditions prevail. No data regarding microorganisms in geonets are presently available, although research is currently ongoing. Procedurally, one must use a high flow rate factor of safety, or have systems designed so that flushing is possible. This area begs for future inquiry.

The last environmental consideration, resistance to light and weather, is not felt to be a serious concern for most situations in which geonets are used. Polyethylene is resistant to weather-related degradation, and carbon black is included in all of the known products. Nevertheless geonets should be covered as soon as possible after placement.

4.1.6 Allowable Flow Rate

As described previously, the essence of the design-by-function concept is the establishment of an adequate global factor of safety. For geonets, where flow rate is the primary function, this takes the following form:

$$FS = \frac{q_{allow}}{q_{req}} \tag{4.3}$$

where FS = the global factor of safety (to handle unknown loading conditions or uncertainties in design methods, etc.),
q_{allow} = the allowable flow rate as obtained from laboratory testing, and
q_{req} = the required flow rate as obtained from design of the actual system.

Alternatively, one could also work from a transmissivity basis to obtain the equivalent relationship.

$$FS = \frac{\theta_{allow}}{\theta_{req}} \tag{4.4}$$

where θ is the transmissivity under similar definitions as above. As described previously, however, it is preferable to design with flow rate rather than transmissivity because of nonlaminar flow conditions in geonets.

Concerning the allowable value, which comes from hydraulic testing of the type just described, one must assess the realism of the test setup in contrast to the actual field system. If it does not model real life adequately, then some adjustments to the laboratory value must be made. This is often the case. Thus the laboratory-

ATTACHMENT A, ~~#4~~ 1/2

GTC

Table 4.2 Recommended preliminary factor of safety values for determining allowable flow rate or transmissivity of geonets

	Partial Factor of Safety Value in Equation 4.5			
Application Area	FS_{IN}	FS_{CR}*	FS_{CC}	FS_{BC}
Sport fields	1.0 to 1.2	1.0 to 1.5	1.0 to 1.2	1.1 to 1.3
Capillary breaks	1.1 to 1.3	1.0 to 1.2	1.1 to 1.5	1.1 to 1.3
Roof and plaza decks	1.2 to 1.4	1.0 to 1.2	1.0 to 1.2	1.1 to 1.3
Retaining walls, seeping rock and soil slopes	1.3 to 1.5	1.2 to 1.4	1.1 to 1.5	1.0 to 1.5
Drainage blankets	1.3 to 1.5	1.2 to 1.4	1.0 to 1.2	1.0 to 1.2
Surface water drains for landfill caps	1.3 to 1.5	1.2 to 1.4	1.0 to 1.2	1.2 to 1.5
Secondary leachate collection (landfills)	1.5 to 2.0	1.4 to 2.0	1.5 to 2.0	1.5 to 2.0
Primary leachate collection (landfills)	1.5 to 2.0	1.4 to 2.0	1.5 to 2.0	1.5 to 2.0 *

*These values assume that the q_{ult} value was obtained using an applied normal pressure of 1.5 to 2 times the field-anticipated maximum value. If not, values must be increased.

done at the proper design load and hydraulic gradient and that this testing yielded a short-term between-rigid-plates value of 1.2 gal./min.-ft.

Solution: Since better information is not known, average values from Table 4.2 are used.

$$q_{allow} = q_{ult}\left[\frac{1}{FS_{IN} \times FS_{CR} \times FS_{CC} \times FS_{BC}}\right] \tag{4.5}$$

$$= 1.2\left[\frac{1}{1.1 \times 1.1 \times 1.1 \times 1.2}\right]$$

$$= 1.2\left[\frac{1}{1.60}\right]$$

$$= 0.75 \text{ gal./min.-ft.}$$

Example:

What is the allowable geonet flow rate to be used in the design of a secondary leachate collection system? Assume that laboratory testing at proper design load and proper hydraulic gradient gave a short-term between-rigid-plates value of 1.2 gal./min.-ft.

Solution: Average values from Table 4.2 are used; however, note the large reduction.

2/2

ATTACHMENT A, ~~#4~~

4.2 DESIGNING FC

This section wi
transportation-r
field.

4.2.1 Theoretic

Design by func

For geonets ser
aforementioned

where q_{allow} = t
q_{requ} = t

As stated prev
saturated condi
flow rate, name
equations 4.1 a

SM 3/14/99

Calculation Package M
Consolidation Analysis of the South Mesa

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: Basic Remediation Company

Project: BRC CAMU **Project/Proposal #:** SC0313 **Task #:** 01

Title of Computations: Consolidation Analysis of South Mesa

Computations By:
SIGNATURE — DATE 11/3/06
Rebecca Flynn, Staff Engineer
PRINTED NAME AND TITLE

Assumptions and Procedures Checked By (Peer Reviewer):
SIGNATURE — DATE 11/6/06
Keaton Botelho, Staff Engineer
PRINTED NAME AND TITLE

Computations Checked By:
SIGNATURE — DATE 11/3/06
Gregory T. Corcoran, PE / Principal
PRINTED NAME AND TITLE

Computations Backchecked By (Originator):
SIGNATURE — DATE 11/3/06
Rebecca Flynn, Staff Engineer
PRINTED NAME AND TITLE

Approved By (PM or Designate):
SIGNATURE — DATE 11/3/06
Gregory T. Corcoran, PE / Principal
PRINTED NAME AND TITLE

Approval Notes:

Revisions: (Number and Initial All Revisions)

No.	Sheet	Date	By	Checked By	Approval

Written by: Rebecca Flynn Date: 06 / 08 / 21 (YY MM DD) Reviewed by: BTC Date: 06 / 11 / 3 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

CONSOLIDATION ANALYSIS OF SOUTH MESA
BRC CAMU
HENDERSON, NEVADA

OBJECTIVE

The objective of this calculation package is to evaluate the consolidation settlement potential of the south mesa at the BRC Corrective Action Management Unit (CAMU) located in Henderson, Nevada. In particular, the amount of differential settlement and strain will be evaluated.

SUMMARY OF ANALYSIS

The calculations suggest that the strain on the liner system due to differential settlement is within tolerable amounts. In addition, the proposed grading plan will accommodate the calculated differential settlement without significant effects on drainage. Since limited information is available regarding the consolidation characteristics of the soil strata, interpretation was required and the analyses were approached on a conservative basis.

SITE BACKGROUND

Native material within the limits of the BRC CAMU consists of alluvial granular soils overlying fine-grained soils. Shear strength parameters for the native soil material were previously estimated and reported in the *Preliminary Geotechnical and Geologic Investigation - Industrial Non-Hazardous Disposal Facility* (Converse 1999). Twelve exploratory borings were conducted by others to depths ranging from 33-ft to 60-ft (Converse 1999). In general, the native materials appear to be consistent between borings. Six consolidation tests were performed on retrieved samples of sandy clay (CL). All samples were inundated with water at 2000 psf. The author has approximated the saturated consolidation curve for the purposes herein. A summary of the consolidation test results as reported by Converse (1999) are presented in Attachment 1.

ANALYSIS

Terzaghi's one-dimensional consolidation theory will be used to evaluate the consolidation potential of the south mesa at the BRC CAMU. The method of analysis to evaluate the maximum differential settlement is to compare the calculated settlement at each boring location.

Written by: Rebecca Flynn Date: 06 / 08 / 21 (YY MM DD) Reviewed by: BRC Date: 06 11 13 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

After the expected settlement is known for each location, the maximum differential settlement and strain can be calculated. The location of each boring is presented in Figure 1. An idealized profile for the borings is presented in Figure 2. The sandy clay (CL) layers are highlighted.

The Casagrande construction method was used to evaluate if the lean clay is normally consolidated and to construct the field consolidation curve. The construction is shown in Attachment 1. The following results are obtained:

Sample	Depth (ft)	Initial e_o	C_c	Liquid Limit (%)	Moisture Content (%)	Present Consolidation Pressure (ksf)	Previous Consolidation Pressure (ksf)
B-8	39.0	1.9	0.55		64	3.71	about 3.7
B-8	49.0	1.41	0.98		51	5.18	about 5.0
B-102	49.0	1.52	0.86	88	49	4.89	about 4.1
B-10	54.0	1.76	0.81		68	5.06	about 4.1
B-101	59.0	1.31	0.52		38	4.88	about 4.4
B-101	39.0	1.55	0.47	105	45	3.7	about 4.0
Avg.		1.58	0.73				

Based on the above results, the lean clay deposit can be categorized as normally consolidated (i.e., the previous consolidation pressure is relatively close to the present consolidation pressure).

The settlement calculations are presented in Attachment 2. The results are summarized below:

Boring	Thickness of CL (ft)	Calculated Settlement (ft)
B-10	22 ft (interbedded layers of SM)	2.54
B-12	24 ft	2.58
B-8	22 ft	2.35
B-102	8 ft	0.92
B-5	10 ft	1.18
B-4	5 ft	0.37

As shown in Figure 1, borings B-4, B-5, B-8, B-10, B-12, and B-102 were considered for this analysis. Borings B-101 and B-103 were not considered because they lie well outside the liner

limits. Settlement was calculated at the aforementioned boring locations (known CL thickness). However, consolidation tests were not necessarily performed at each of these locations. For locations were there was no consolidation data, the average values for e_o and C_c were used. See Attachment 2 for settlement calculations.

The shortest distance between borings and the largest differential settlement will result in the largest strain. This relationship is defined as:

$$\varepsilon = \Delta h/L$$

The maximum differential settlement at the shortest distance was between borings B-4, and boring B-8 (see Figure 1). The distance between the borings is 470 ft. The strain is:

$$\varepsilon = \Delta h/L = (2.35-0.37)/470 = 0.42 \text{ percent.}$$

Assuming a linear differential settlement profile, the calculated strain is well below the typical yield strength of HDPE geomembrane. Typical strain at the yield stress for HDPE geomembrane is approximately 12 percent (Koerner 1994).

CONCLUSIONS

Based on available information and the author's interpretation of the appropriate consolidation curves, the following can be concluded:

- The CL deposit can be characterized as normally consolidated;
- The maximum settlement expected in the south mesa is approximately 2 ft;
- The maximum strain expected in the south mesa is approximately 0.4%
- The liner system and proposed grading can accommodate the expected differential settlement and strain.

REFERENCES

Converse (1999), "Preliminary Geotechnical and Geologic Report - Industrial Non-Hazardous Disposal Facility (Converse 1999)", prepared for Basic Management, Inc., October 1999.

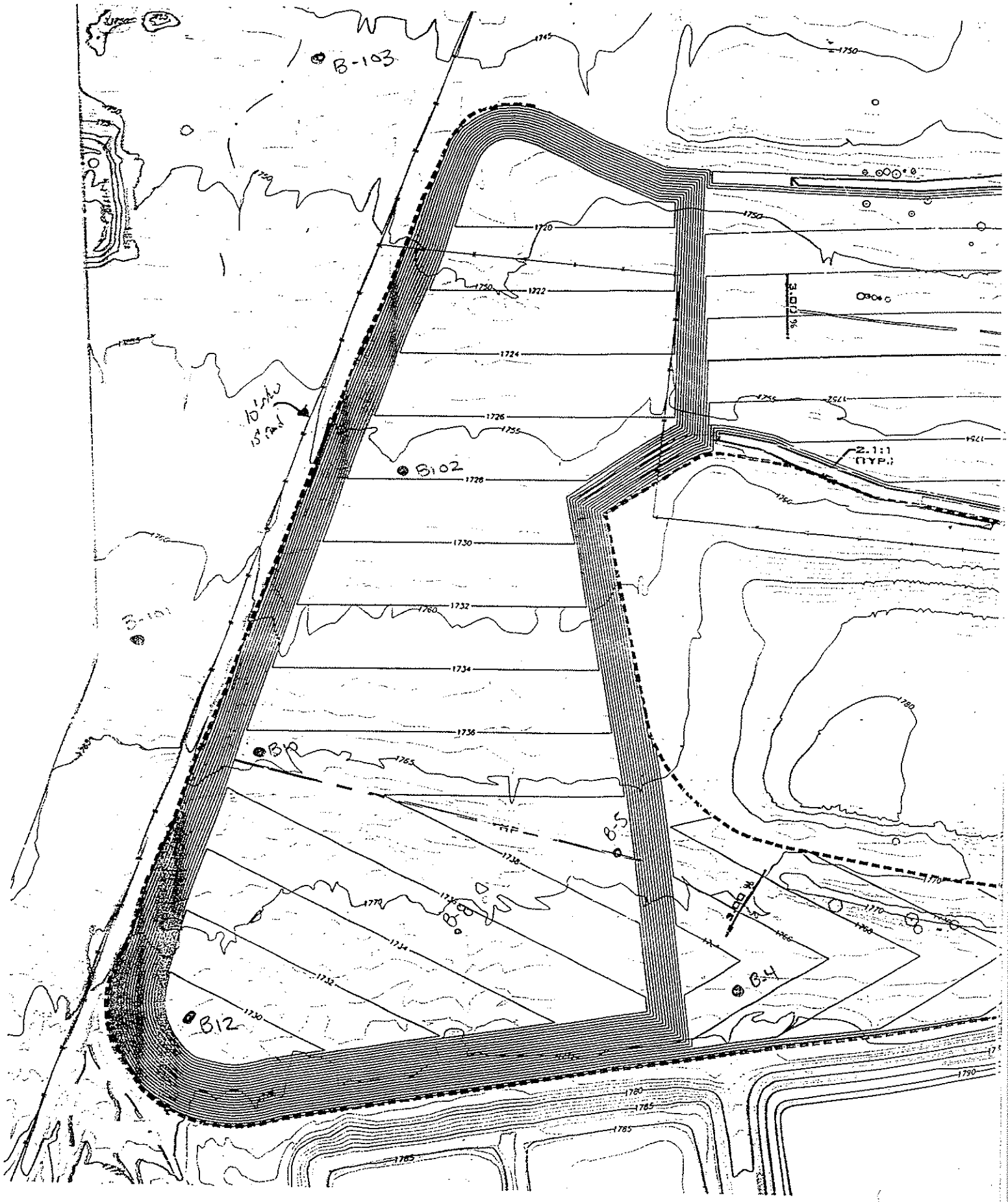

B-103
B-102
B-101
B-10
B-5
B-4
B-12
2:1:1
(TYP.)
10' sidw
15' rad
1720
1722
1724
1726
1728
1730
1732
1734
1736
1738
1740
1742
1744
1746
1750
1755
1760
1765
1770
1780
1785
1790

FIGURE 1

GEOSYNTEC CONSULTANTS

Page _____ of _____

Written by: R. FLYNN Date: 21 / 08 / 06 (DD / MM / YY) Reviewed by: _____ Date: ___ / ___ / ___ (DD / MM / YY)

Client: _____ Project: _____ Project/Proposal No.: _____ Task No: _____

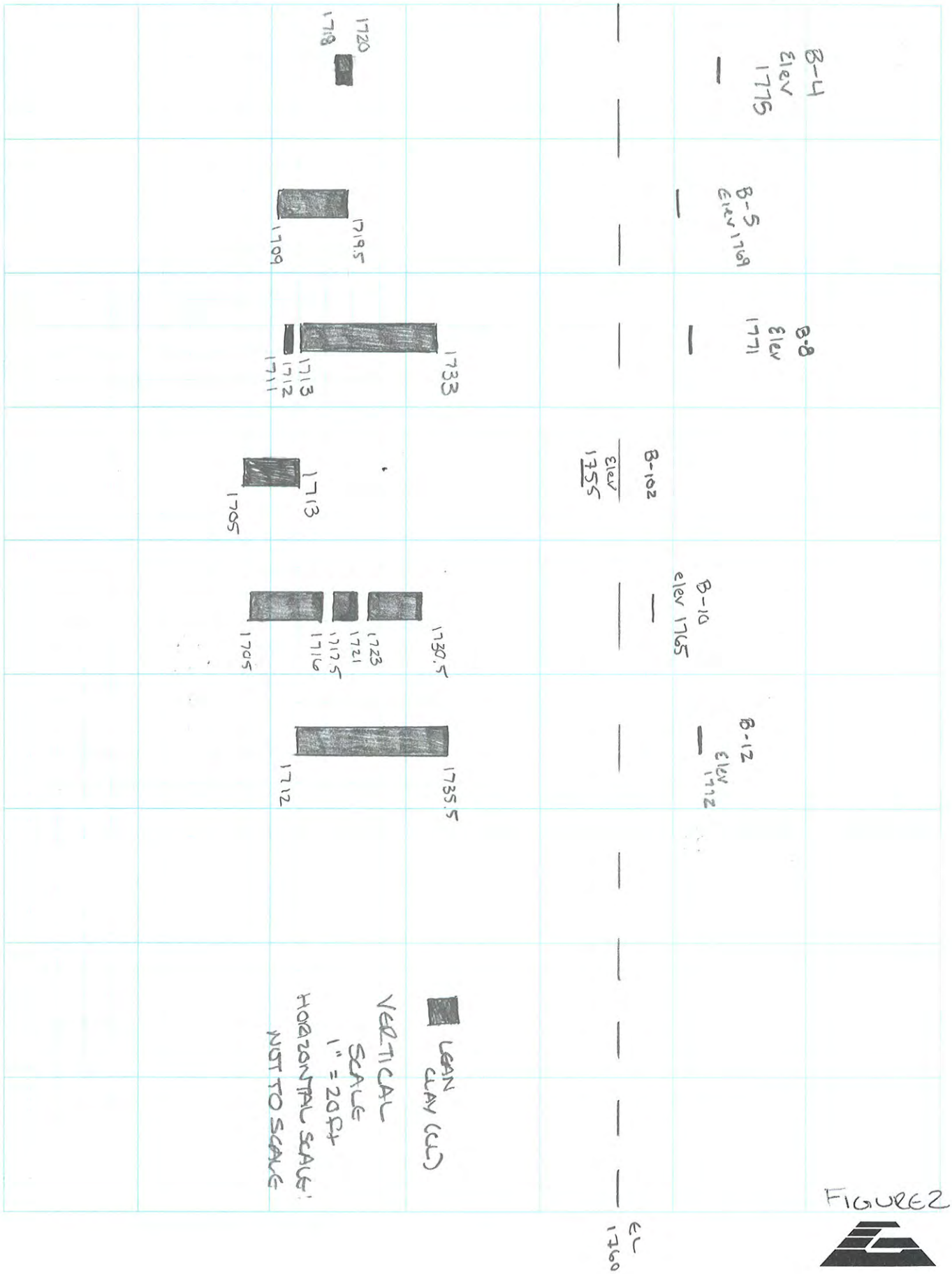
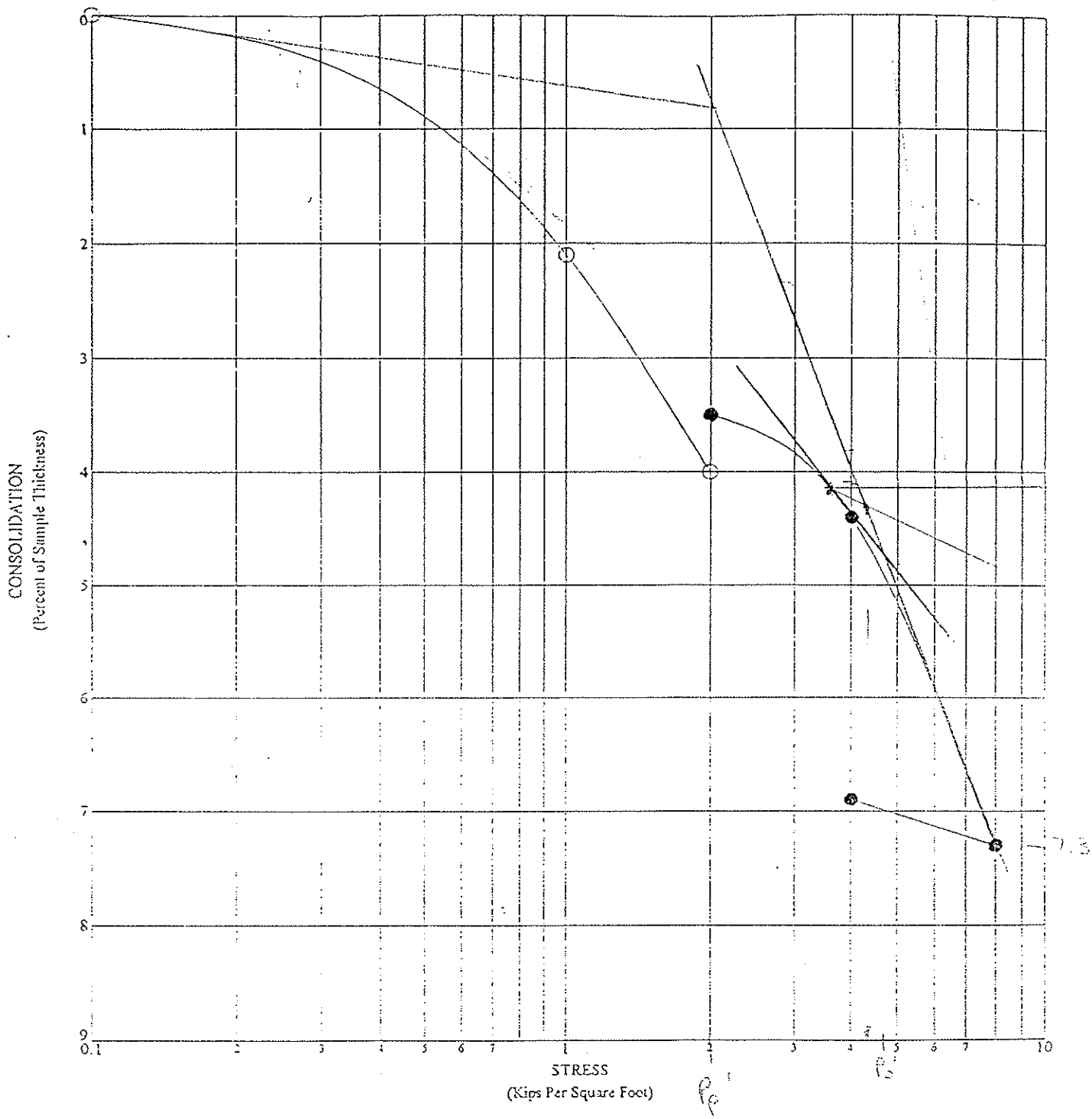


FIGURE 2



BORING NO: B-102 $C_c = 1.52$

DEPTH: 49.0

DESCRIPTION:

DRY DENSITY: 67 PCF

MOISTURE CONTENT: 49%

$C_c = \frac{0.13}{\log(5/4.5)} = 0.56$

Attachment 1

1/6

● READINGS AFTER SATURATION WITH WATER

CONSOLIDATION TEST

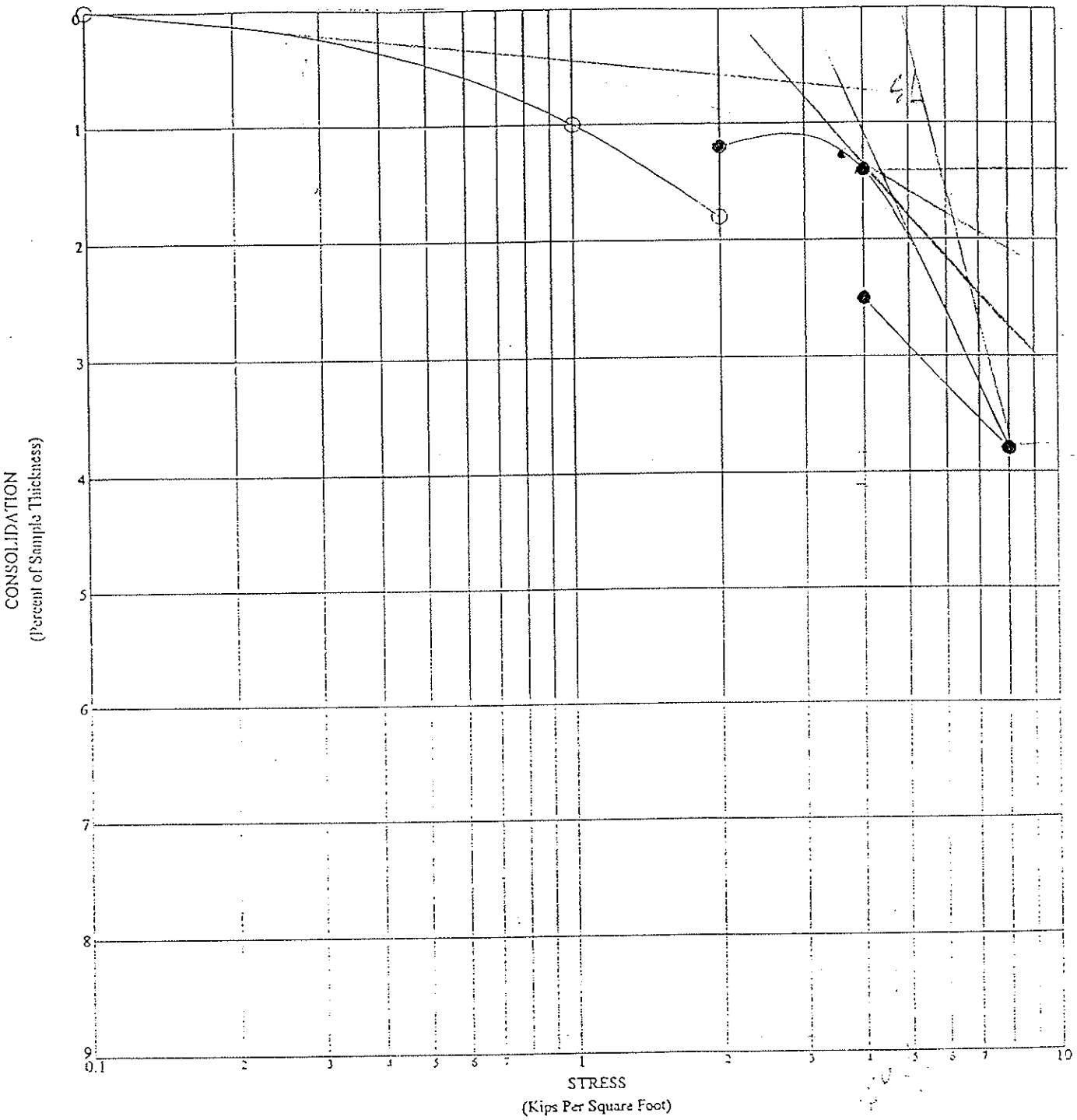
PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION

Project No. 99-33437-01

Converse Consultants

Geotechnical Engineering

Drawing No.



BORING NO: B-101
DEPTH: 59.0
DESCRIPTION: LEAN CLAY
DRY DENSITY: 73 PCF
MOISTURE CONTENT: 38%

Attachment 1
2/6

● READINGS AFTER SATURATION WITH WATER

CONSOLIDATION TEST

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION

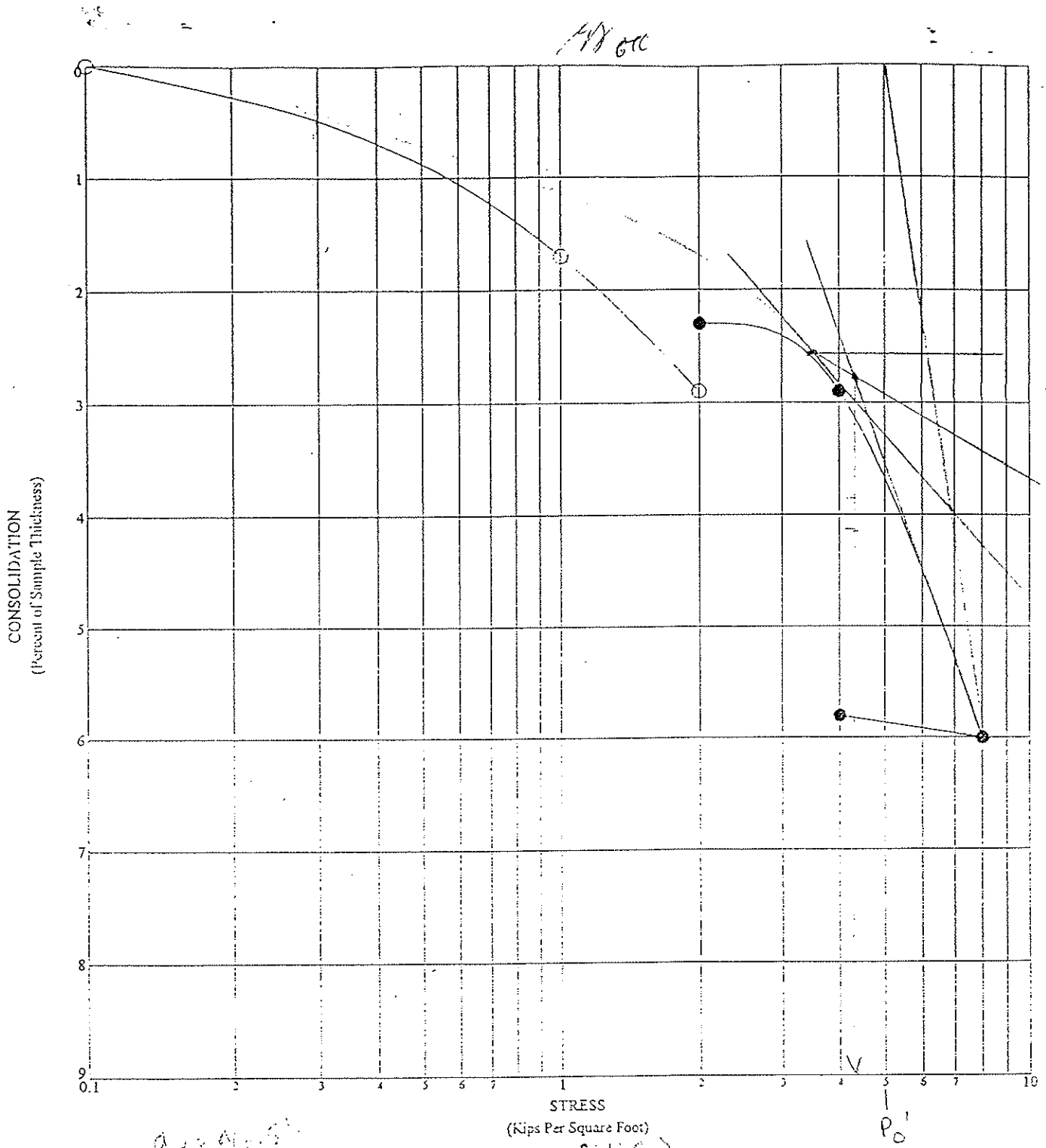
Project No.
99-33437-01

Geotechnical Engineering

Drawing No.

DRAFTED

APPROVED BY ON



DRAFT

PROVIDED BY ON

BORING NO: B-10
DEPTH: 54.0
DESCRIPTION: LEAN CLAY
DRY DENSITY: 61 PCF
MOISTURE CONTENT: 68%

$e_o = 1.70$

$P_o' = 5.0$

$C_c = \frac{\Delta e}{\log \frac{P_o'}{P_o'}} = 0.01$

Attachment 1
3/6

● READINGS AFTER SATURATION WITH WATER

CONSOLIDATION TEST

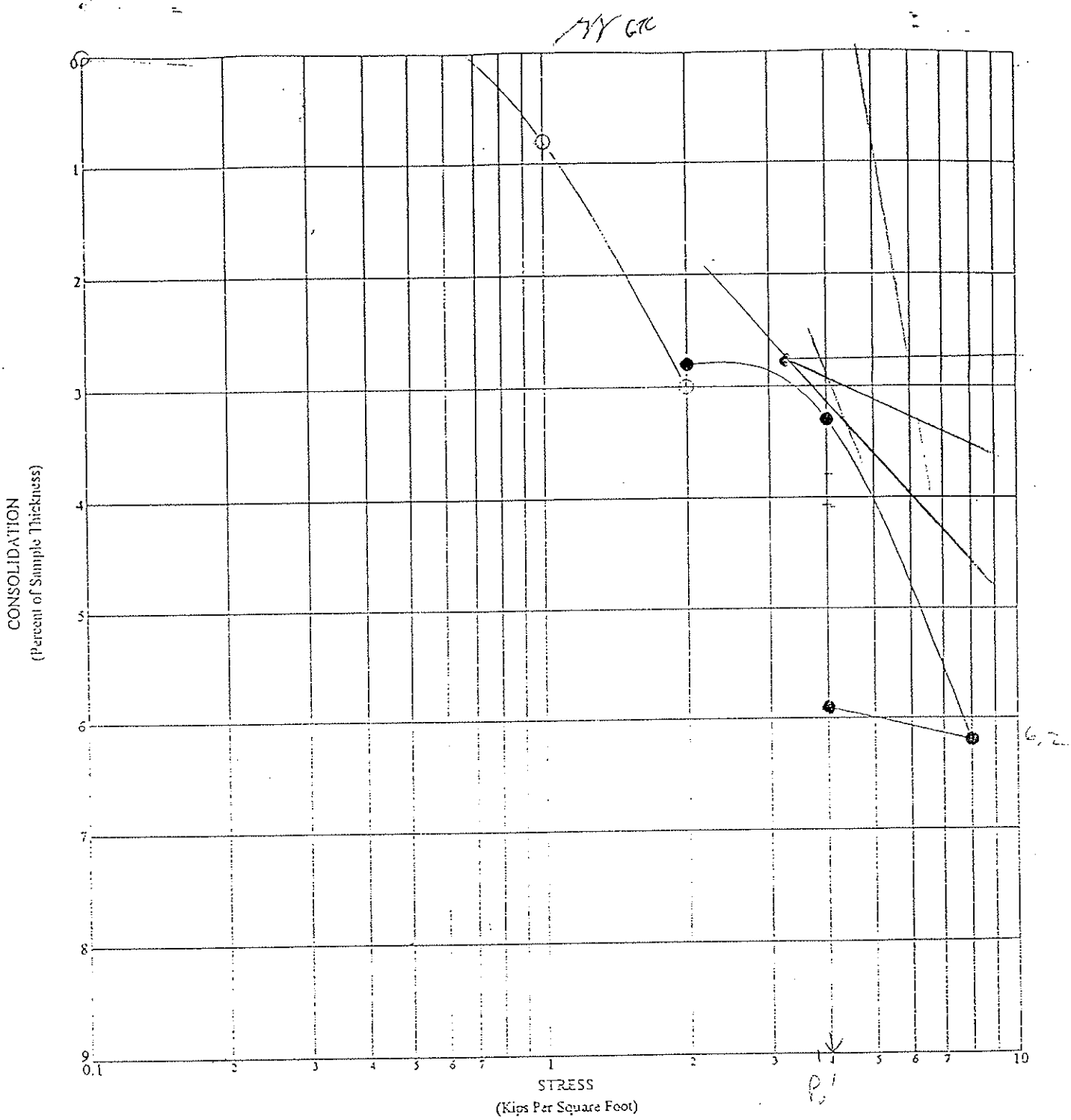
PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION

Project No.
99-33437-01

Converse Consultants

Geotechnical Engineering and Applied Science

Drawing No.



BORING NO: B-101
DEPTH: 39.0
DESCRIPTION: LEAN CLAY
DRY DENSITY: 66 PCF
MOISTURE CONTENT: 45%

Attachment 1
4/6

● READINGS AFTER SATURATION WITH WATER

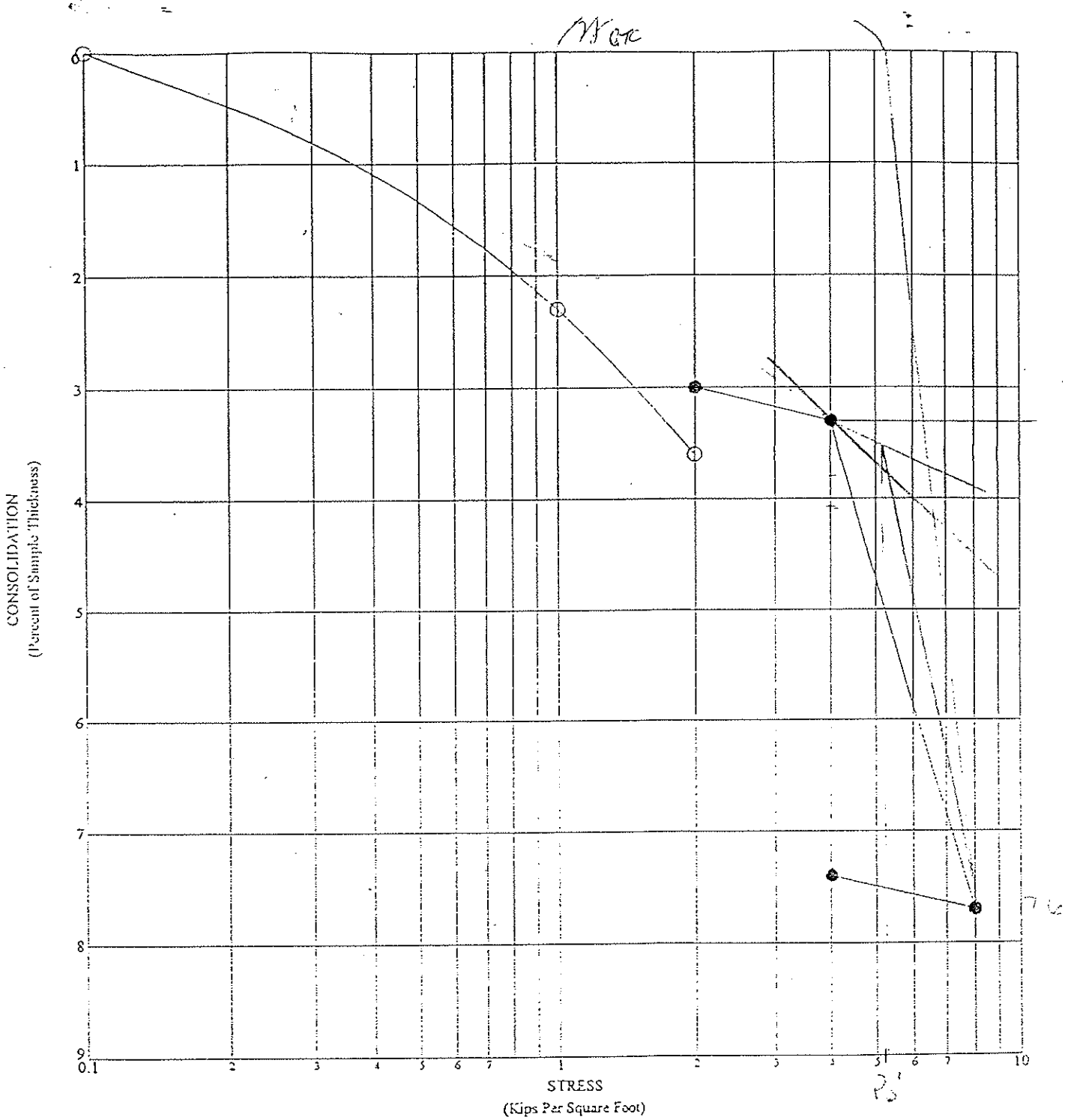
CONSOLIDATION TEST

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION

Project No. 99-33437-01

Geotechnical Engineering

Drawing No.



BORING NO: B- 8
DEPTH: 49.0
DESCRIPTION: LEAN CLAY
DRY DENSITY: 70 PCF
MOISTURE CONTENT: 51%

$G_s = 1.41$

$\Delta e = \frac{\Delta H}{H}(1+e_0) = 0.152$

$P_c' = 5.130$

$C_c = \frac{0.133}{\log(5/5.1)} = 0.94$

Attachment 1
5/6

● READINGS AFTER SATURATION WITH WATER

CONSOLIDATION TEST

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION

Project No. 99-33437-01

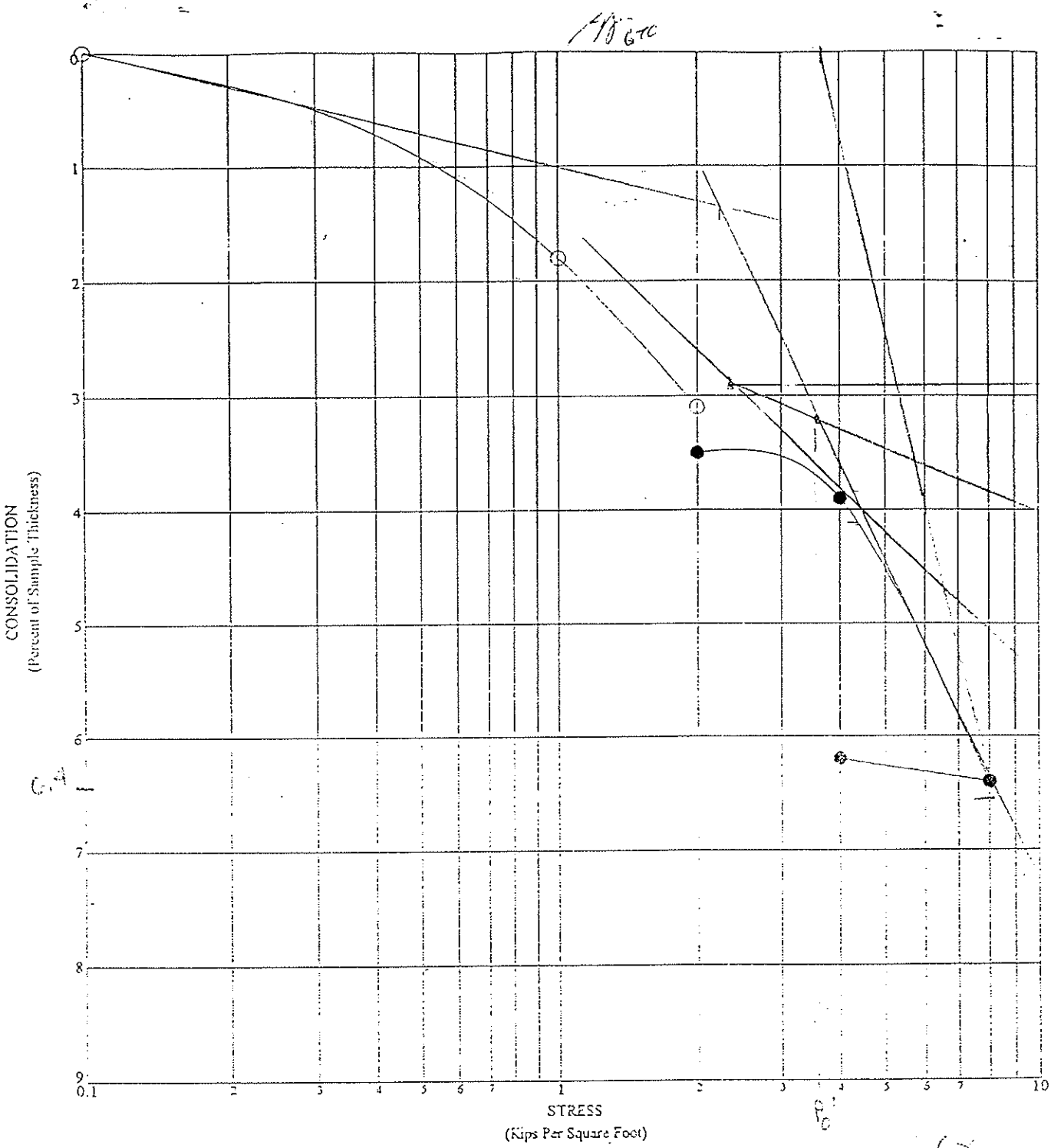
Geotechnical Engineering

Drawing No.

DRAFTED BY OL

APPROVED BY ON

DRAFT



BORING NO: B- 8
DEPTH: 39.0
DESCRIPTION: LEAN CLAY
DRY DENSITY: 58 PCF
MOISTURE CONTENT: 64%

$e_0 = 1.9$

$\gamma_w = 62.4$

$P_0' = 3110$ psf

$C_c = \frac{\Delta e}{\log(P_0'/P_0)} = \frac{0.156}{\log(8/3.1)} = 0.56$

$e_0 = \frac{G_s \gamma_w}{\gamma_d} - 1$

$\Delta e = \frac{S(\Delta e)}{H} = 0.156$

$H = 1''$

● READINGS AFTER SATURATION WITH WATER

CONSOLIDATION TEST

~~Attachment 1~~ 6/6

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION

Project No. 99-33437-01

Geotechnical Engineering

Drawing No.

PROVED BY ON

Written by: R. FLYNN Date: 21 / 08 / 06 (DD MM YY) Reviewed by: GTC Date: 07 / 11 / 06 (DD MM YY)

Client: _____ Project: _____ Project/Proposal No.: _____ Task No: _____

SETTLEMENT ANALYSIS FOR BORING B-102

→ ASSUME LAYER THICKNESS OF 8 ft
O.K THICKNESS FOR ANALYSIS

→ ASSUME $C_c = 0.86$ $e_0 = 1.52$

→ Assume 29 ft excavation of 117 pcf and replace at 136 pcf plus 42 ft of fill at 136 pcf

Therefore, $\Delta p = (29')(136-117) + 42'(136)$
$\Delta p = 6263$

→ Depth of mid-layer at depth = 46'
water table at 43 ft
Therefore,
$P_o' = 43ft\ (117pcf) + (117-62.4)(3ft)$

$P_o' = 5195$

$$S = \frac{C_c}{1+e_0} H \log\left(\frac{P_o' + \Delta p}{P_o'}\right)$$

$$S = \frac{0.86}{1+1.52}(8')\log\left(\frac{5159+6263}{5159}\right)$$

$S = 0.924$ ft = 11.3 inches

.942 GTC

Attachment 2

1/4

Written by: R FLYNN Date: 21 / 08 / 06 (DD MM YY) Reviewed by: _____ Date: ___ / ___ / ___ (DD MM YY)

Client: _____ Project: _____ Project/Proposal No.: _____ Task No: _____

SETTLEMENT ANALYSIS FOR BORING B-5

→ ASSUME LAYER THICKNESS OF 10 ft
Too thick: do analysis for two 5ft layers

→ Assume $C_c = 0.73$ and $e_0 = 1.58$

→ ASSUME 30 ft of excavation and replacement at 136 pcf, plus 70 ft of fill at 136 pcf
Therefore

$$\Delta p = (30)(136-117) + 70(136)$$
$$\Delta p = 10,090$$

→ Depth of mid-layer #1 = 52.5 ft
$$P_o' = 52.5(117) = 6142 \text{ psf}$$

→ Depth of mid-layer #2 = 57.5 ft
$$P_o' = 52 \text{ ft}(117 \text{ pcf}) + (117-62.4)(57.5-52)$$
$$P_o' = 6385 \text{ psf}$$

$$S_1 = \frac{0.73}{1+1.58}(5)\log\left(\frac{6142+10090}{6142}\right)$$

$$S_1 = 0.597 \text{ ft} = 7.17 \text{ inches}$$

$$S_2 = \frac{0.73}{1+1.58}(5)\log\left(\frac{6385+10090}{6385}\right)$$

$$S_2 = 0.582 \text{ ft} = 6.99 \text{ inches}$$

$$S_{TOTAL} = 1.18 \text{ ft} = 14.15 \text{ inches}$$

Attachment 2

Written by: R. FLYNN Date: 21 / 08 / 06 (DD MM YY) Reviewed by: _____ Date: ___ / ___ / ___ (DD MM YY)

Client: _____ Project: _____ Project/Proposal No.: _____ Task No: _____

SETTLEMENT ANALYSIS FOR BORING B-4

→ ASSUME LAYER THICKNESS OF 5 ft

→ Assume $C_c = 0.73$ and $e_0 = 1.58$

→ $S = \frac{C_c}{1+e_0} H \log\left(\frac{P_0 + \Delta p}{P_0}\right)$

→ ASSUME 10 ft of excavation and replace at 136 pcf, plus 38 ft fill at 136 pcf

Therefore $\Delta p = (10)(136-117) + 38(136)$
$\Delta p = 5358$

→ DEPTH AT MID LAYER = 56 ft
WATERTABLE DEPTH AT 54 ft

THEREFORE $P_0' = 54(117 pcf) + 2'(117-62.4)$
$P_0' = 6427$ psf

$S = \frac{0.73}{1+1.58}(5ft) \log\left[\frac{6427 + 5358}{6427}\right]$

$S = 0.373$ ft → 4.5 inches

Attachment 2
3/4

Settlement Analysis for Boring B-8

H	22	ft
w%	51	%
Gs	2.7	
$\gamma_{d,\,max}$	70	pcf
% comp.	100	%
γ	105.7	pcf
e_o	1.406857	
C_c	0.76	
Δp	6668	

Layer	Thickness	Mid-Depth	Po'	Si
1	3	39.5	4621.5	0.367447
2	3	42.5	4972.5	0.349927
3	3	45.5	5323.5	0.334088
4	3	48.5	5674.5	0.319688
5	3	51.5	6025.5	0.306533
6	3	54.5	6376.5	0.294462
7	4	58	6786	0.375428
				2.347574

Settlement Analysis for Boring B-10

H	22	ft
w%	49	%
Gs	2.7	
$\gamma_{d,\,max}$	67	pcf
% comp.	100	%
γ	99.83	pcf
e_o	1.514627	
C_c	0.86	
Δp	6399	
water table	46	

Layer	Thickness	Mid-Depth	Po'	Si
1	3	39.5	4621.5	0.38723
2	3	42.5	4972.5	0.368582
3	3	45.5	5323.5	0.351735
4	3	48.5	5518.5	0.343057
5	3	51.5	5682.3	0.336106
6	3	54.5	5846.1	0.329444
7	4	58.5	6064.5	0.427971
	22			2.544125

Settlement Analysis for Boring B-12

H	24	ft
e_o	1.58	
C_c	0.73	
Δp	7753	

Layer	Thickness	Mid-Depth	Po'	Si
1	4	38	4446	0.496122
2	4	42	4914	0.465433
3	4	46	5382	0.43855
4	4	50	5850	0.414774
5	4	54	6318	0.393572
6	4	58	6786	0.37453
				2.582983

Attachment 2
4/4

Calculation Package N
Consolidation Analysis of the North Mesa

GeoSyntec Consultants

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: Basic Remediation Company

Project: BRC CAMU **Project/Proposal #:** SC0313 **Task #:** 01

Title of Computations: Consolidation Analysis of North Mesa

Computations By:

SIGNATURE DATE 11/3/06

Rebecca Flynn, Staff Engineer
PRINTED NAME AND TITLE

Assumptions and Procedures Checked By (Peer Reviewer):

SIGNATURE DATE 11/3/06

Gregory T. Corcoran, PE / Principal
PRINTED NAME AND TITLE

Computations Checked By:

SIGNATURE DATE 11/3/06

Gregory T. Corcoran, PE / Principal
PRINTED NAME AND TITLE

Computations Backchecked By (Originator):

SIGNATURE DATE 11/3/06

Rebecca Flynn, Staff Engineer
PRINTED NAME AND TITLE

Approved By (PM or Designate):

SIGNATURE DATE 11/3/06

Gregory T. Corcoran, PE / Principal
PRINTED NAME AND TITLE

Approval Notes:

Revisions: (Number and Initial All Revisions)

No.	Sheet	Date	By	Checked By	Approval

Written by: Rebeccca Flynn Date: 06 / 08 / 22 (YY MM DD) Reviewed by: GTC Date: 06 / 11 / 3 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

CONSOLIDATION ANALYSES OF SLIT TRENCHES
BRC CAMU
HENDERSON, NEVADA

OBJECTIVE

The objective of this calculation package is to evaluate the consolidation settlement potential of landfilled waste in the "slit trenches" of the North Mesa at the BRC Corrective Action Management Unit (CAMU) located in Henderson, Nevada. In particular, the amount of differential settlement and potential strain in an overlying geosynthetic liner will be evaluated. Finally, the height of surcharge material to be used in pre-loading the slit-trenches will be calculated.

SUMMARY OF ANALYSES

Since limited information is available regarding the consolidation characteristics of the soil strata, interpretation was required and the analyses were approached on a conservative basis. Should the liner system be constructed overlying the existing, unconsolidated "slit trenches", the calculations suggest that the strain on the liner system due to differential settlement is not within tolerable amounts. The strain on the liner system may be reduced to within tolerable amounts if the trenches are first 'pre-loaded' with approximately 40 feet of surcharge material.

SITE BACKGROUND

Native material within the limits of the BRC CAMU consists of alluvial granular soils overlying fine-grained soils. Shear strength parameters for the native soil material were previously estimated and reported in the *Preliminary Geotechnical and Geologic Investigation - Industrial Non-Hazardous Disposal Facility* (Converse 1999). Twelve exloratorary borings were conducted by others to depths ranging from 33-ft to 60-ft (Converse 1999). In general, the native materials appear to be consistent between borings.

In January 2005, BRC performed a subsurface investigation of the slit trenches, consisting of continuous, split-spoon sampling to determine the depth of landfilled waste. Twenty exploratory borings were advanced to depths ranging from 22-ft to 32-ft (Attachment A). The thickness of landfilled waste ranges between 5-ft to 26-ft, and consists of typical industrial waste and

construction/demolition debris: wood, paper, fabric, plastic, glass, and metal. The width of slit trenches ranges between 20 feet and 76 feet

The design of the proposed North Mesa landfill includes approximately 38-ft of waste and 2-ft of cover soil, resulting in approximately 40-ft of overburden material on the present base grades.

ANALYSIS

Consolidation Settlement

Terzaghi's one-dimensional consolidation theory will be used to evaluate the consolidation potential of the slit trenches of the North Mesa at the BRC CAMU. The method of analysis to evaluate the maximum differential settlement is to compare the calculated settlement at each boring location. After the expected settlement is known for each location, the maximum differential settlement and strain can be calculated.

There are two components to the total settlement calculated by one-dimensional consolidation theory, primary settlement and secondary settlement. The calculation of total consolidation settlement is governed by the following equation:

$$S_T = S_p + S_S$$

Where:

S_p = magnitude of primary consolidation settlement, ft
S_S = magnitude of secondary consolidation settlement, ft

The calculation of primary settlement is governed by the following equation:

$$S_p = C'_c \cdot H \cdot \log\left(\frac{p_o + \Delta p}{p_o}\right)$$ (Attachment B, 1 of 2)

Where:

S_p = magnitude of primary consolidation settlement, ft
C'_c = compression index for the compressible layer (waste) = 0.3
H = initial thickness of compressible layer (waste), ft
p_o = initial overburden pressure on the compressible layer, lb/ft^2
Δp = change in overburden pressure due to loading, lb/ft^2

Written by: Rebeccca Flynn Date: 06 / 08 / 22 (YY MM DD) Reviewed by: GTC Date: 06 / 11 / 3 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

Furthermore:

$$p_o = \frac{H}{2} \cdot \gamma_{waste} + H_{soil,overburden} \cdot \gamma_{soil,overburden}$$

H = initial thickness of compressible layer, ft
γ_{waste} = unit weight of waste = 85 lb/ft^3
$H_{soil,overburden}$ = thickness of soil overburden over waste, ft
$\gamma_{soil,\ overburden}$ = unit weight of soil overburden = 115 lb/ft^3

and $$\Delta p = H_{soil,waste} \cdot \gamma_{soil,waste} + H_{soil,coversystem} \cdot \gamma_{soil,coversystem}$$

$H_{soil,\ waste}$= thickness of waste to be placed in landfill, ft
γ_{waste} = unit weight of waste to be placed in landfill = 136 lb/ft^3
$H_{soil,\ coversystem}$ = thickness of soil in landfill cover system, ft
$\gamma_{soil,\ coversystem}$= unit weight of soil in landfill cover system = 125 lb/ft^3

The calculation of secondary settlement is governed by the following equation:

$$S_S = C'_\alpha \cdot H \cdot \log\left(\frac{t_2}{t_1}\right)$$ (Attachment B, 2 of 2)

Where:

S_S = magnitude of secondary consolidation settlement, ft
C'_α = secondary compression index for the compressible layer (waste) = 0.019
H = initial thickness of compressible layer (waste), ft
t_1 = time at beginning of secondary consolidation = 26 year (assuming waste placement ended in 1980)
t_2 = time at end of consolidation, years = 59 years (t_1 + 30 years post-closure maintenance + 3 years of landfill operation)

The compression index (C_c) and secondary compression index (C'_α) are normally determined through laboratory analyses of samples collected during subsurface investigation. In the absence of such testing, the following calculations use a conservatively high C_c value, as obtained from Deutsch, et al. (Attachment C), and a conservatively high C'_α value, as obtained from Bjarngard, et al. (Attachment D).

Written by: Rebeccca Flynn Date: 06 / 08 / 22 (YY MM DD) Reviewed by: BRC Date: 06 / 11 / 3 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

The consolidation settlement calculations are presented in Attachment E (1 of 3). The results are summarized below:

Location	Initial Waste Thickness (ft)	Total Settlement, S_T (ft)
BS-01	1	0.35
BS-02	6	1.10
BS-03	19	3.53
BS-04	10	1.86
BS-05	18	3.78
BS-06	20	4.46
BS-07	18	3.54
BS-08	12	1.74
BS-09	22	3.82
BS-10	0	0.00
BS-11	24	4.18
BS-12	26	5.42
BS-13	20	4.55
BS-14	26	5.00
BS-15	10	2.76
BS-16	5	0.04
BS-17	22	0.15
BS-18	11	1.24
BS-19	21	1.35
BS-20	8	0.83

Strain Due to Differential Settlement

The differential settlement between the compressible material in a slit trench and the relatively incompressible native material adjacent to the trench will result in strain in the overlying liner system. The maximum strain is assumed to occur at the middle of the trench, at the point of maximum settlement. This relationship is defined as:

$$\varepsilon = \frac{\sqrt{S_T^{\,2} + L^2}}{L} - 1$$

Written by: Rebeccca Flynn Date: 06 / 08 / 22 (YY MM DD) Reviewed by: CTC Date: 06 / 11 / 3 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

Where:

ε = strain in liner system due to differential settlement
L = half the width of the slit trench, ft
S_T = total settlement, ft

The maximum allowable strain in the liner system is selected to be 1% to maintain drainage of the leachate collection system (3%, as constructed) and acceptable for the geomembrane material properties. Those locations that exceed the allowable strain will require "pre-loading" prior to liner placement. The purpose of this "pre-loading" is to achieve consolidation settlement of the waste and minimize settlement induced strain. The required settlement to be achieved by pre-loading is calculated as follows:

$$S_{req} = S_T - \left(\varepsilon_{allow} \cdot L\right)$$

Where:

S_{req} = required settlement, ft
S_T = total settlement, ft
ε_{allow} = maximum allowable strain in liner system = 1%
L = half the width of the slit trench, ft

Written by: Rebeccca Flynn Date: 06 / 08 / 22 (YY MM DD) Reviewed by: OTC Date: 06 / 11 / 3 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

The strain calculations are presented in Attachment E (2 of 3). The results are summarized below:

Location	L (ft)	Strain, ε	S_{req} (ft)
BS-01	20	0.02%	-
BS-02	20	0.15%	-
BS-03	20	1.55%	2.52
BS-04	10	1.72%	0.85
BS-05	10	6.91%	2.77
BS-06	10	9.50%	3.45
BS-07	10	6.08%	2.53
BS-08	10	1.50%	0.73
BS-09	10	7.05%	2.81
BS-10	38	0.00%	-
BS-11	38	0.60%	-
BS-12	20	3.61%	4.41
BS-13	20	2.56%	3.54
BS-14	20	3.08%	3.99
BS-15	20	0.95%	-
BS-16	23	0.00%	-
BS-17	23	0.00%	-
BS-18	23	0.15%	-
BS-19	13	0.54%	-
BS-20	13	0.20%	-

Required Surcharge Height

The surcharge height necessary to preload the slit trenches and obtain the required settlement is calculated by rearranging the equation for primary consolidation settlement (S_P), as below:

$$H_{surch\arg e} = \frac{\left(10^{\left(\frac{S_{req}}{C_c \cdot H}\right)} \cdot p_o\right) - p_o}{\gamma_{surch\arg e}}$$

Written by: Rebeccca Flynn Date: 06 / 08 / 22 (YY MM DD) Reviewed by: [illegible] Date: 06 / 11 / 3 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

Where:

$H_{surcharge}$ = height of surcharge, ft
S_{req} = required settlement, ft
C_c = compression index for the compressible layer (waste) = 0.3
H = initial thickness of compressible layer (waste), ft
p_o = initial overburden pressure on the compressible layer, lb/ft^2
$\gamma_{surcharge}$ = unit weight of surcharge soil = 135 lb/ft^3

The surcharge height calculations are presented in Attachment E (3 of 3). The results are summarized below:

Location	S_{req} (ft)	$H_{surcharge}$ (ft)
BS-01	-	-
BS-02	-	-
BS-03	2.52	23
BS-04	0.85	12
BS-05	2.77	22
BS-06	3.45	24
BS-07	2.53	23
BS-08	0.73	12
BS-09	2.81	24
BS-10	-	-
BS-11	-	-
BS-12	4.41	29
BS-13	3.54	26
BS-14	3.99	28
BS-15	-	-
BS-16	-	-
BS-17	-	-
BS-18	-	-
BS-19	-	-
BS-20	-	-

Thus, it appears that a maximum of 29 feet of surcharge should be placed overlying the slit trenches to minimize the effects of settlement induced strain in the base liner system.

Written by: Rebeccca Flynn Date: 06 / 08 / 22 (YY MM DD) Reviewed by: PC Date: 06 / 11 / 3 (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-04

CONCLUSIONS

Based on available information and the results of these consolidation analyses, the following can be concluded:

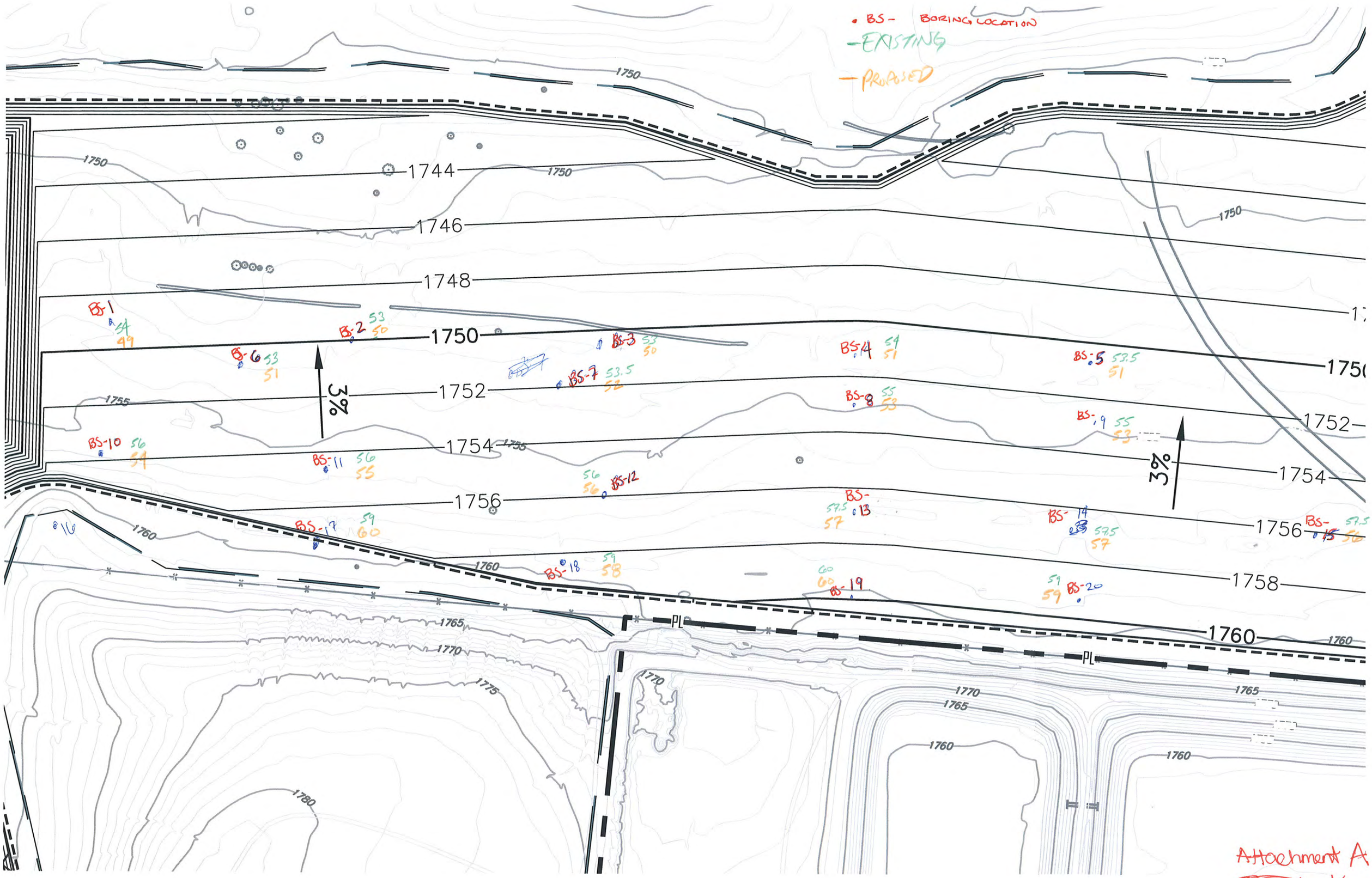
- The maximum differential settlement expected in the slit trenches of the North Mesa is approximately 4.96 ft;
- The height of surcharge required to pre-load the North Mesa is a maximum of 29 ft;
- The maximum strain expected in the slit trenches of the North Mesa, AFTER PRELOADING, is approximately 1% ; and
- The liner system and proposed grading can accommodate the expected differential settlement and strain.

REFERENCES

GeoSyntec (2005), "Permit Application for Class III Landfill, Henderson, Nevada", submitted to Clark County Health District, Las Vegas, Nevada. GeoSyntec Consultants, 2005.

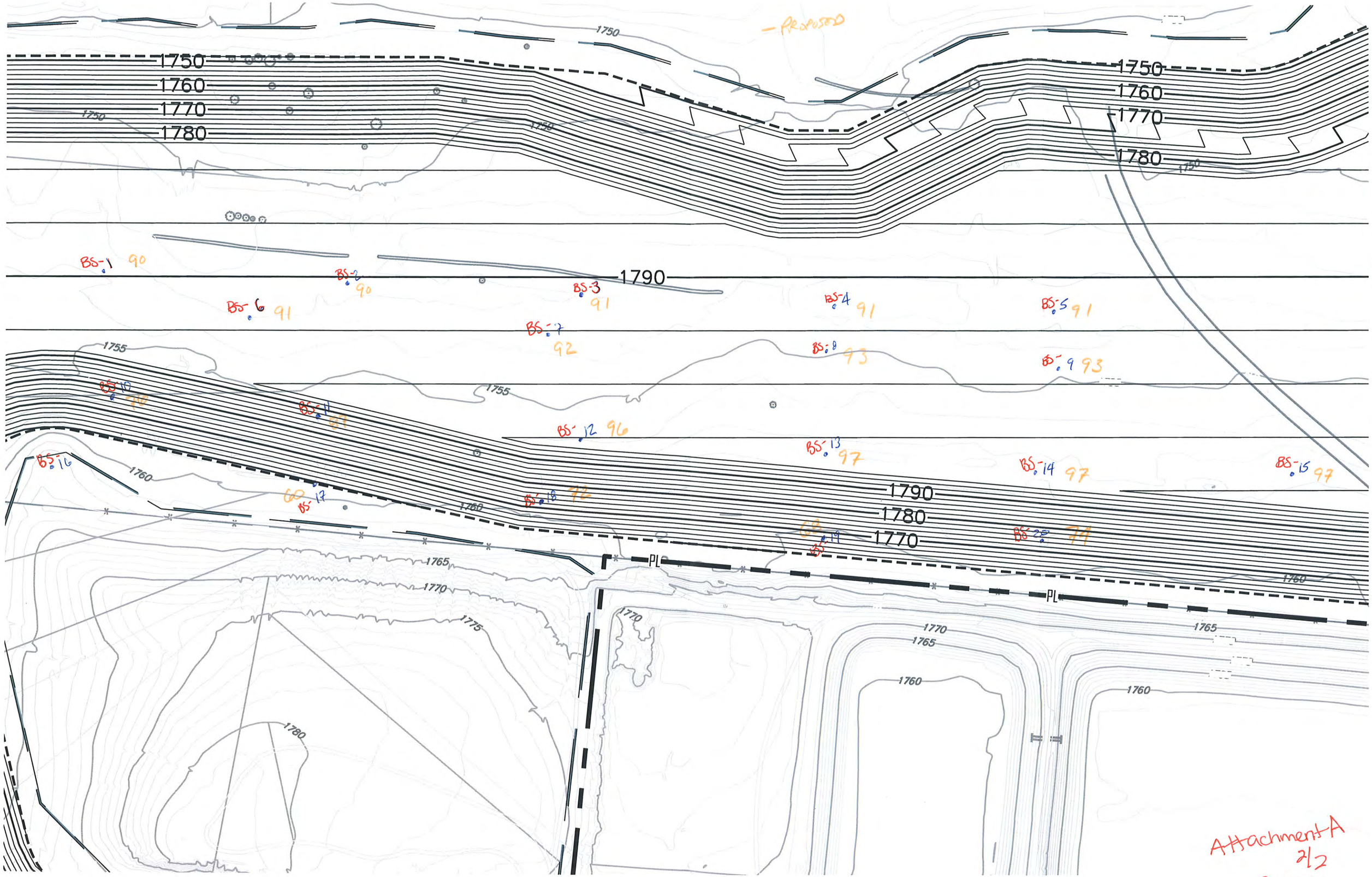
Converse (1999), "Preliminary Geotechnical and Geologic Report - Industrial Non-Hazardous Disposal Facility (Converse 1999)", prepared for Basic Management, Inc., October 1999.

Das, Braja M, (1998), "Principles of Geotechnical Engineering, 4th Edition", PWS Publishing Company, Boston, Massachusetts.



Attachment A

1/3



Attachment A
2/2

E.T.C
6/3/05

where e_O = initial void ratio at volume V_0. Thus, from Eqs. (8.11) through (8.14),

$$\Delta V = SA = \Delta e V_s = \frac{AH}{1 + e_O}\Delta e$$

or

$$S = H\frac{\Delta e}{1 + e_O} \tag{8.15}$$

For normally consolidated clays that exhibit a linear e–log p relationship (see Figure 8.9),

$$\Delta e = C_c[\log (p_O + \Delta p) - \log p_O] \tag{8.16}$$

where C_c = slope of the e–log p plot and is defined as the compression index. Substitution of Eq. (8.16) into Eq. (8.15) gives

$$\boxed{S = \frac{C_c H}{1 + e_O}\log\left(\frac{p_O + \Delta p}{p_O}\right)} \tag{8.17}$$

For a thicker clay layer, it is more accurate if the layer is divided into a number of sublayers and calculations for settlement are made separately for each sublayer. Thus, the total settlement for the entire layer can be given as

$$S = \sum\left[\frac{C_c H_i}{1 + e_O}\log\left(\frac{p_{Oi} + \Delta p_{ai}}{p_{Oi}}\right)\right]$$

where H_i = thickness of sublayer i
p_{Oi} = initial average effective overburden pressure for sublayer i
Δp_{ai} = increase of vertical pressure for sublayer i

In overconsolidated clays (see Figure 8.10), for $p_O + \Delta p \leq p_c$, field e–log p variation will be along the line hj, the slope of which will be approximately equal to that for the laboratory rebound curve. The slope of the rebound curve, C_s, is referred to as the *swell index,* so

$$\Delta e = C_s[\log (p_O + \Delta p) - \log p_O] \tag{8.18}$$

From Eqs. (8.15) and (8.18),

$$\boxed{S = \frac{C_s H}{1 + e_O}\log\left(\frac{p_O + \Delta p}{p_O}\right)} \tag{8.19}$$

If $p_O + \Delta p > p_c$, then

$$\boxed{S = \frac{C_s H}{1 + e_O}\log\frac{p_c}{p_O} + \frac{C_c H}{1 + e_O}\log\left(\frac{p_O + \Delta p}{p_c}\right)} \tag{8.20}$$

Attachment B, 1/2

GTC 6/3/05

The magnitude of the secondary consolidation can be calculated as

$$\boxed{S_s = C'_\alpha H \log\left(\frac{t_2}{t_1}\right)} \tag{8.27}$$

where

$$\boxed{C'_\alpha = \frac{C_\alpha}{1 + e_p}} \tag{8.28}$$

e_p = void ratio at the end of primary consolidation (see Figure 8.18)
H = thickness of clay layer

The general magnitudes of C'_α as observed in various natural deposits are given in Figure 8.19.

Secondary consolidation settlement is more important than primary consolidation in organic and highly compressible inorganic soils. In overconsolidated inorganic clays, the secondary compression index is very small and of less practical significance.

Several factors might affect the magnitude of secondary consolidation, some of which are not clearly understood (Mesri, 1973). The ratio of secondary to primary compression for a given thickness of soil layer depends on the ratio of the stress increment (Δp) to the initial effective stress (p). For small $\Delta p/p$ ratios, the secondary-to-primary compression ratio is larger.

EXAMPLE 8.4

For a normally consolidated clay layer in the field, the following are given:

- thickness of clay layer = 8.5 ft
- Void ratio (e_O) = 0.8
- Compression index (C_c) = 0.28
- Average effective pressure on the clay layer (p_O) = 2650 lb/ft^2
- Δp = 970 lb/ft^2
- Secondary compression index (C_α) = 0.02

What is the total settlement of the clay layer five years after the completion of primary consolidation settlement? (*Note:* Time for completion of primary settlement = 1.5 years.)

Solution From Eq. (8.28),

$$C'_\alpha = \frac{C_\alpha}{1 + e_p}$$

Attachment B 2/2

COFFMAN

GTC
6/3/05

MODELING SETTLEMENTS OF AN EXISTING MUNICIPAL SOLID WASTE LANDFILL SIDESLOPE USING AN EARTHEN SURCHARGE PILE

by

William L. Deutsch, Jr., Ph.D., P.E.
Technical Director
Geotechnical Engineering
Roy F. Weston, Inc.
West Chester, PA

Owen R. Esterly, P.E.
Facility Engineer
Chester County Solid Waste Authority, Lanchester Landfill

and

John Vitale
Assistant Engineer
Roy F. Weston, Inc.
West Chester, PA

INTRODUCTION

The large-scale field study discussed in this paper was completed for the purpose of determining design parameters for potential overfilling of existing landfill sideslopes at the Lanchester Landfill facility in Honey Brook, Pennsylvania. In particular, to maximize future waste disposal quantities at this facility, the Chester County Solid Waste Authority (CCSWA) is proposing to overfill additional municipal solid waste (MSW) within the available air space between the eastern sideslope of their closed Municipal Site Landfill and the adjacent western sideslope of Cell No. 1 of their currently active Area B landfill. In accordance with current Pennsylvania Department of Environmental Resources (DER) MSW landfill lining system regulations, CCSWA must initially install a geosynthetic lining/leachate collection system over the existing landfill sideslope prior to placement of additional waste at this location. The intent of this project was to simulate the total settlements and lateral movements of the existing waste mass when subjected to the additional applied stress of overfilled waste materials. These vertical and lateral movements would allow the maximum strains that these movements would generate within the geosynthetics of an overfill lining system to be calculated. Based on these calculated strains, appropriate geosynthetic reinforcement criteria for the overfill lining system could be developed. The reinforcement would protect the geosynthetic components of this lining system, in particular, the geomembrane, from excessive straining and possible tear resulting from underlying waste settlements.

To complete this study, an earthen surcharge pile, whose maximum height modeled the stress of the proposed overfilled waste, was constructed on the eastern sideslope of the closed Municipal Site Landfill following an initial survey of the topography of this slope.

Attachment C 1/2

GTC 6/9/05

Tabulated values of the independent variables are presented in Table 2 for each of the 64 nodal point locations. These values were subsequently input into Equation 2 in order to calculate the "modified compressibility index" (C′) of the waste. These values are also presented in Table 2 for each of the 64 nodal points.

It is evident from an inspection of Table 2 that the calculated values of C′ define a fairly limited range of values, with the exception of nodal points H1 through H8. In particular, the C′ values for the 56-nodal point database consisting of lines A through G varied from 0.15 to 0.39, averaging 0.22, while the C′ database consisting of H line values varied from 0.66 to 0.98, averaging 0.80. It is clear that the H line values are anomalous. This is believed to be due to the minimal and highly variable surcharge pile thicknesses that existed in the vicinity of the nodal points along the H line resulting from the sloping geometry of the back face of the pile at these locations. As a result, the surcharge loading varies considerably in the vicinity of each H line nodal point location. Therefore, there is significant error in assuming that the load at these nodal point locations can be accurately calculated using Equation 4. Based on the above discussion, it was believed appropriate to disregard the H line C′ values in generating pertinent statistics for this database as discussed in the following paragraph.

The 56-point database was analyzed statistically. A quantitative procedure was used to confirm that the database is normally distributed. The mean ($\bar{x}$), standard deviation (σ), variance (σ^2), and coefficient of variation (C_v) of the database were also calculated. These values are as follows:

$\bar{x} = 0.22$ $\qquad$ $\sigma^2 = 0.0016$

$\sigma = 0.0402$ $\qquad$ $C_v = 10.27\%$

.0402

Based on the properties of a normal distribution, it is known that 97.5% of the database lies below the random variable value of $\bar{x} + 2\sigma$. For this database, this value is equal to 0.22 + 2(0.402) = 0.30. Therefore, it can be concluded that calculation of surcharge load induced MSW settlement using Equation 1 with known values of H_w, $\bar{\sigma}_{o_w}$, and $\Delta\sigma_s$ will yield a conservative estimate of this settlement 97.5% of the time if a value of

$$\boxed{C' = \frac{C_c}{1 + e_o} = 0.30}$$

is used in the equation.

no relevance

II. Analysis Using a Multiple Linear Regression Model

The 56-point database was also analyzed using a multiple linear regression model, in which the dependent variable waste settlement (ΔH_w) was assumed to be a linear function of the independent variables waste thickness (H_w) and applied surcharge loading ($\Delta\sigma_s$). The form of this equation is as follows:

Attachment C, 2/2

GTC
6/3/05

Proceedings
Thirteenth Annual
Madison Waste Conference

Municipal & Industrial Waste

September 19-20, 1990

Department of Engineering Professional Development
University of Wisconsin-Madison
432 N. Lake Street
Madison, WI 53706
(608) 262-2061

These proceedings, and selected previous year proceedings, can be purchased at the above address for $35.

Printed on recycled paper.

Attachment D, 1/3

GTC 6/3/03

SETTLEMENT OF MUNICIPAL SOLID WASTE LANDFILLS

by Anders Bjarngard[1] and Lewis Edgers[2]

Abstract

Landfill settlement data from 24 case histories were collected and analyzed to establish engineering parameters for the prediction of landfill settlement. Several one-dimensional laboratory compression tests were performed to evaluate the load and time dependent compression characteristics of paper. Standard geotechnical engineering parameters were used to describe settlements.

Both the field and laboratory data show large initial settlements, followed by high logarithmic rates of delayed compression. Primary consolidation was generally not observed in the field or laboratory data. The field data suggest two phases of delayed compression, one dominated by mechanical compression and a later phase possibly showing the added effects of decomposition. The delayed (secondary) compression coefficient (C_α) ranged from 0.01 to 0.056 for the laboratory data and from 0.003 to 0.038 for the first phase of the field data. The second phase, at long time periods, showed field values of C_α as large as 0.51.

Introduction

The settlement of landfills is important in a number of ways. Settlement will affect the:

- design of protection systems such as caps, leachate collection and drainage systems.

---

1 Project Engineer, Goldberg-Zoino & Associates, Inc., Newton Upper Falls, Massachusetts.

2 Professor of Civil Engineering, Tufts University, Medford, Massachusetts.

Presented at the Thirteenth Annual Madison Waste Conference, September 19-20, 1990, Department of Engineering Professional Development, University of Wisconsin-Madison.

KUHI F. WE ... LIBRARY ...

Attachment D, 2/3

TABLE 6
COMPARISON OF FIELD AND LABORATORY SETTLEMENT PARAMETERS

	INITIAL SETTLEMENTS %		C_α	
	Avg.	Range	Avg.	Range
Field Case Histories	6.3	3-11.8	0.019 0.125	0.003-0.038 (min) 0.017-0.51 (max)
Laboratory Data	6.4[1] 2.5[2]	3.6-11[1] 0.7-5.4[2]	0.026	0.010-0.056

1. Initial settlements from the first load increment.
2. Initial settlements excluding first load increment.

Conclusions

Settlement of MSW landfills can be large and continue for very long time periods. This settlement is believed to occur due to mechanical compression, ravelling of particles and decomposition of the waste. This paper has reviewed available MSW landfill settlement data, compared these data with the results of one-dimensional laboratory tests on paper specimens, and quantified the measured compressions.

Review of settlement data from MSW landfills has shown little settlement due to primary consolidation. On the other hand, the long-term settlements due to mechanical effects (secondary compression), possible ravelling, piping or collapse, and possible chemical and biological decomposition develop over a long period of time and may become large. They are very difficult to predict because they are highly dependent upon site-specific factors such as moisture, density and composition which are usually not well defined.

The complex time-settlement behavior of landfills has been idealized by separating it into three phases: initial compression; early delayed compression; and late delayed compression. In the first phase, settlements are believed to occur because of rapid compression of the refuse and reduction of the gas voids. In the second phase, settlements are believed to be caused mostly by long-term reorientation, slippage at the particle contacts, and delayed compression of some of the MSW constituents. It is believed that in the third phase, the rate of delayed compression is greatly increased by decomposition. Ravelling may also be a contributing factor to the delayed compression phases.

The following measures of landfill settlement were observed from the case histories:

Basic Remediation Company
Corrective Action Management Unit
Henderson, Nevada

Consolidation Calculation

Material Properties

C_{cr}	0.3	*Note 1*
$C_{\alpha r}$	0.019	*Note 1*
e_o	0	
γ_{waste}	85	pcf
$\gamma_{soil\ overburden}$	115	pcf
$\gamma_{soil\ waste}$	136	pcf
$\gamma_{cover\ system}$	125	pcf

Secondary Consolidation Time

time t_1	26	years
time t_2	59	years

Location	Depth to Waste (ft)	Depth to Native (ft)	Initial Waste Thickness (ft) H_{waste}	Soil Overburden Thickness (ft) $H_{soil\ overburden}$	Initial Overburden Presure (psf) p_0	Waste Soil Thickness (ft) $H_{soil\ waste}$	Cover System Thickness (ft) $H_{cover\ system}$	Change Overburden Pressure (psf) Δp	Primary Settlement (ft) S_P	Secondary Settlement (ft) S_S	Total Settlement (ft) S_T	Approximate Elevations: Existing Grade	Approximate Elevations: Base Liner Grade	Approximate Elevations: Final Cover Grade
MWH - BRC - BS-01	3	4	1	3	388	34	2	4,874	0.34	0.01	0.35	1754.0	1749.0	1790.0
MWH - BRC - BS-02	13	19	6	13	1,750	35	2	5,010	1.06	0.04	1.10	1753.0	1750.0	1790.0
MWH - BRC - BS-03	8	27	19	8	1,728	36	2	5,146	3.42	0.11	3.53	1753.0	1750.0	1791.0
MWH - BRC - BS-04	11	21	10	11	1,690	35	2	5,010	1.80	0.06	1.86	1754.0	1751.0	1791.0
MWH - BRC - BS-05	5	23	18	5	1,340	36	2	5,078	3.68	0.10	3.78	1753.5	1751.0	1791.0
MWH - BRC - BS-06	3	23	20	3	1,195	36	2	5,146	4.35	0.11	4.46	1753.0	1751.0	1791.0
MWH - BRC - BS-07	7	25	18	7	1,570	37	2	5,214	3.44	0.10	3.54	1753.5	1752.0	1792.0
MWH - BRC - BS-08	19	31	12	19	2,695	36	2	5,146	1.67	0.07	1.74	1755.0	1753.0	1793.0
MWH - BRC - BS-09	9	31	22	9	1,970	36	2	5,146	3.69	0.13	3.82	1755.0	1753.0	1793.0
MWH - BRC - BS-10	0	0	0	0	0	18	2	2,698	0.00	0.00	0.00	1756.0	1754.0	1776.0
MWH - BRC - BS-11	5	29	24	5	1,595	29	2	4,194	4.04	0.14	4.18	1756.0	1755.0	1787.0
MWH - BRC - BS-12	3	29	26	3	1,450	38	2	5,418	5.27	0.15	5.42	1756.0	1756.0	1796.0
MWH - BRC - BS-13	3	23	20	3	1,195	38	2	5,350	4.44	0.11	4.55	1757.5	1757.0	1797.0
MWH - BRC - BS-14	5	31	26	5	1,680	38	2	5,350	4.85	0.15	5.00	1757.5	1757.0	1797.0
MWH - BRC - BS-15	3	13	10	3	770	38	2	5,350	2.71	0.05	2.76	1757.5	1756.0	1797.0
MWH - BRC - BS-16	3	8	5	3	558	0	0	0	0.00	0.04	0.04	1762.5	1762.5	1762.5
MWH - BRC - BS-17	3	25	22	3	1,280	0	0	0	0.00	0.15	0.15	1759.0	1760.0	1760.0
MWH - BRC - BS-18	8	19	11	8	1,388	11	2	1,746	1.17	0.07	1.24	1759.0	1758.0	1772.0
MWH - BRC - BS-19	9	30	21	9	1,928	6	2	1,066	1.21	0.14	1.35	1760.0	1760.0	1768.0
MWH - BRC - BS-20	13	21	8	13	1,835	13	2	2,018	0.78	0.05	0.83	1759.0	1759.0	1774.0

Note 1.

C_c' = 0.01 to 0.04, $C_\alpha C$ = 0.001 to 0.006 - low organic waste, C&D - "Settlement Evaluation for Cap Closure Performance", Zamiskie et. Al.

C_c' = 0.30 - MSW - "Modeling Settlements of an Existing MSW Landfill Side Slope Using an Earthen Surcharge Pile", Deutsch et. Al.

C_c' = 0.063, $C_\alpha C$ = 0.019 - MSW LFs - "Settlement of Municipal Waste Landfills", Bjarngard et. Al.

High values selected to reflect the uncompacted nature of the waste materials placed in the "slit trenches".

- input value

Basic Remediation Company
Corrective Action Management Unit
Henderson, Nevada

Strain Calculation				
Maximum Allowable Strain	1.00%			
Location	**Total Settlement (ft) S_T**	**Distance to Native** *Note 1* **(ft) L**	**Strain (%) ε**	**Surcharge Settlement (Required) (ft)**
MWH - BRC - BS-01	0.35	20	0.02%	0.00
MWH - BRC - BS-02	1.10	20	0.15%	0.00
MWH - BRC - BS-03	3.53	20	1.55%	2.52
MWH - BRC - BS-04	1.86	10	1.72%	0.85
MWH - BRC - BS-05	3.78	10	6.91%	2.77
MWH - BRC - BS-06	4.46	10	9.50%	3.45
MWH - BRC - BS-07	3.54	10	6.08%	2.53
MWH - BRC - BS-08	1.74	10	1.50%	0.73
MWH - BRC - BS-09	3.82	10	7.05%	2.81
MWH - BRC - BS-10	0.00	38	0.00%	0.00
MWH - BRC - BS-11	4.18	38	0.60%	0.00
MWH - BRC - BS-12	5.42	20	3.61%	4.41
MWH - BRC - BS-13	4.55	20	2.56%	3.54
MWH - BRC - BS-14	5.00	20	3.08%	3.99
MWH - BRC - BS-15	2.76	20	0.95%	0.00
MWH - BRC - BS-16	0.04	23	0.00%	0.00
MWH - BRC - BS-17	0.15	23	0.00%	0.00
MWH - BRC - BS-18	1.24	23	0.15%	0.00
MWH - BRC - BS-19	1.35	13	0.54%	0.00
MWH - BRC - BS-20	0.83	13	0.20%	0.00

Note 1
Half the width of the "Slit Trench".

- input value

Basic Remediation Company
Corrective Action Management Unit
Henderson, Nevada

Surcharge Height Calculation

Material Properties		
C_{cr}	0.3	*Note 1*
γ_{waste}	85	pcf
$\gamma_{soil\ overburden}$	115	pcf
$\gamma_{surcharge}$	135	pcf

Location	Depth to Waste (ft)	Depth to Native (ft)	Initial Waste Thickness (ft) H_{waste}	Soil Overburden Thickness (ft) $H_{soil\ overburden}$	Initial Overburden Presure (psf) p_0	Settlement Required (ft)	Surcharge Height (ft) $H_{surcharge}$	Minimum Surcharge Elevation
MWH - BRC - BS-01	3	4	1	3	388	0.00	0	1,754
MWH - BRC - BS-02	13	19	6	13	1,750	0.00	0	1,753
MWH - BRC - BS-03	8	27	19	8	1,728	2.52	23	1,776
MWH - BRC - BS-04	11	21	10	11	1,690	0.85	12	1,766
MWH - BRC - BS-05	5	23	18	5	1,340	2.77	22	1,776
MWH - BRC - BS-06	3	23	20	3	1,195	3.45	24	1,777
MWH - BRC - BS-07	7	25	18	7	1,570	2.53	23	1,776
MWH - BRC - BS-08	19	31	12	19	2,695	0.73	12	1,767
MWH - BRC - BS-09	9	31	22	9	1,970	2.81	24	1,779
MWH - BRC - BS-10	0	0	0	0	0	0.00	0	1,756
MWH - BRC - BS-11	5	29	24	5	1,595	0.00	0	1,756
MWH - BRC - BS-12	3	29	26	3	1,450	4.41	29	1,785
MWH - BRC - BS-13	3	23	20	3	1,195	3.54	26	1,783
MWH - BRC - BS-14	5	31	26	5	1,680	3.99	28	1,785
MWH - BRC - BS-15	3	13	10	3	770	0.00	0	1,758
MWH - BRC - BS-16	3	8	5	3	558	0.00	0	1,763
MWH - BRC - BS-17	3	25	22	3	1,280	0.00	0	1,759
MWH - BRC - BS-18	8	19	11	8	1,388	0.00	0	1,759
MWH - BRC - BS-19	9	30	21	9	1,928	0.00	0	1,760
MWH - BRC - BS-20	13	21	8	13	1,835	0.00	0	1,759

- input value

Section 3
Base Liner Construction Quality Assurance Plan

CONSTRUCTION QUALITY ASSURANCE PLAN
FOR THE
CONSTRUCTION OF

BASE LINER SYSTEM
AT
CORRECTIVE ACTION MANAGEMENT UNIT
BASIC REMEDIATION COMPANY
HENDERSON, NEVADA

Prepared for:

Basic Remediation Company
875 West Warm Springs Road
Henderson, Nevada 89015
(702) 567-0400

Prepared by:

GeoSyntec Consultants
11305 Rancho Bernardo Road, Suite 101
San Diego, California 92127
(858) 674-6559

3 November 2006

TABLE OF CONTENTS

1. INTRODUCTION 1

1.1 Terms of Reference 1
1.2 Purpose and Scope of the Construction Quality Assurance Plan 1
1.3 References 2
1.4 Organization of the Construction Quality Assurance Plan 2

2. DEFINITIONS RELATING TO CONSTRUCTION QUALITY ASSURANCE 3

3. PARTIES INVOLVED WITH CONSTRUCTION QUALITY ASSURANCE 4

3.1 Engineer 4
3.2 Project Manager 4
3.3 Contractor 4
3.4 Resin Supplier 5
3.5 Geosynthetics Manufacturer 5
3.6 Geosynthetic Installer 6
3.7 CQA Consultant 7
3.8 Surveyor 8
3.9 CQA Laboratory 8

4. CQA CONSULTANTS PERSONNEL ORGANIZATION AND DUTIES 10

4.1 Overview 10
4.2 CQA Personnel 11
4.2.1 CQA Officer 11
4.2.2 CQA Site Manager 12

5. SITE AND PROJECT CONTROL 14

5.1 Project Coordination Meetings 14
5.1.1 Resolution Meeting 14
5.1.2 Pre-Construction Meeting 15
5.1.3 Progress Meetings 17
5.1.4 Problem or Work Deficiency Meeting 17

6. DOCUMENTATION 18

6.1 Overview 18
6.2 Daily Recordkeeping 18
6.3 Construction Problems and Resolution Data Sheets 20
6.4 Photographic Documentation 21
6.5 Design and/or Specifications Changes 21
6.6 CQA Report 21

7. EARTHWORKS 24

7.1 Introduction 24
7.2 Testing Activities 24
7.2.1 Sample Frequency 25
7.2.2 Sample or Test Location Selection 25
7.3 CQA Monitoring Activities 26
7.3.1 Earthwork 26
7.3.2 Engineered Fill Material 27
7.3.3 Prepared Subgrade 28
7.3.4 Operations Layer Material 28
7.4 Deficiencies 29
7.4.1 Notification 29
7.4.2 Repairs and Re-Testing 29

8. DRAINAGE AGGREGATE 31

8.1 Introduction 31
8.2 Testing Activities 31
8.2.1 Sample Frequency 31
8.2.2 Sample Selection 32
8.3 CQA Monitoring Activities 32
8.3.1 Drainage Aggregate 32
8.4 Deficiencies 33
8.4.1 Notification 33
8.4.2 Repairs and Re-testing 33

9. HIGH DENSITY POLYETHYLENE (HDPE) PIPE AND FITTINGS 34

9.1 Material Requirements 34
9.2 Manufacturer 34
9.2.1 Submittals 34
9.2.2 Identification 34

9.3 Handling and Laying 35
9.4 Joints 35

10. GEOMEMBRANE 37

10.1 General 37
10.2 Geomembrane Material Conformance 37
10.2.1 Introduction 37
10.2.2 Review of Quality Control 38
10.2.3 Conformance Testing 40
10.3 Delivery 40
10.3.1 Transportation and Handling 40
10.3.2 Storage 41
10.4 Geomembrane Installation 41
10.4.1 Introduction 41
10.4.2 Earthwork 41
10.4.3 Geomembrane Placement 42
10.4.4 Field Seaming 46
10.4.5 Defects and Repairs 59
10.4.6 Lining System Acceptance 61

11. GEOTEXTILE 63

11.1 Introduction 63
11.2 Manufacturing 63
11.3 Labeling 64
11.4 Shipment and Storage 64
11.5 Conformance Testing 65
11.5.1 Tests 65
11.5.2 Sampling Procedures 65
11.5.3 Test Results 65
11.5.4 Conformance Sample Failure 65
11.6 Handling and Placement 66
11.7 Seams and Overlaps 67
11.8 Repair 67
11.9 Placement of Soil or Aggregate Materials 68

12. GEOSYNTHETIC CLAY LINER (GCL) 69

12.1 Introduction 69

12.2 Manufacturing 69
12.3 Labeling 70
12.4 Shipment and Storage 70
12.5 Conformance Testing 70
12.5.1 Tests 70
12.5.2 Conformance Sample Failure 71
12.6 GCL Delivery and Storage 72
12.7 GCL Installation 72

13. GEOCOMPOSITE 74

13.1 Introduction 74
13.2 Manufacturing 74
13.3 Labeling 74
13.4 Shipment and Storage 75
13.5 Conformance Testing 75
13.5.1 Tests 75
13.5.2 Sampling Procedures 76
13.5.3 Test Results 76
13.5.4 Conformance Test Failure 76
13.6 Handling and Placement 77
13.7 Drainage composite Seams and Overlaps 78
13.8 Repair 78
13.9 Placement of Soil Materials 79

14. SURVEYING 80

14.1 Survey Control 80
14.2 Precision and Accuracy 80
14.3 Lines and Grades 80
14.4 Frequency and Spacing 81
14.5 Documentation 82

1. INTRODUCTION

1.1 Terms of Reference

GeoSyntec Consultants (GeoSyntec) has prepared this Construction Quality Assurance (CQA) Plan for the construction of the Corrective Action Management Unit (CAMU) Base Liner System for Basic Remediation Company (BRC) located in Henderson, Nevada. Hereinafter, the CAMU construction is referred to as the Project.

This CQA Plan was prepared by Mr. Gregory T. Corcoran, P.E. of GeoSyntec Consultants (GeoSyntec) under the direction of Mr. James A. McKelvey III, P.E. In general accordance with the peer review policies of the firm, Mr. James A. McKelvey III, P.E. of GeoSyntec was responsible for senior peer review of the work presented in this plan.

1.2 Purpose and Scope of the Construction Quality Assurance Plan

The purpose of the CQA Plan is to address the CQA procedures and monitoring requirements for construction of the Project. The CQA Plan is intended to: (i) define the responsibilities of parties involved with the construction; (ii) provide guidance in the proper construction of the major components of the Project; (iii) establish testing protocols; (iv) establish guidelines for construction documentation; and (v) provide the means for assuring that the Project is constructed in conformance to the *Technical Specifications*, permit conditions, applicable regulatory requirements, and *Construction Drawings*.

This CQA Plan addresses the soils and geosynthetic components of the liner system for the project. The soils, geosynthetic, and appurtenant components include engineered fill, prepared subgrade, operations layer material, drainage aggregate, geosynthetic clay liner, geomembrane, geotextile, geocomposite, and polyethylene pipe. It should be emphasized that care and documentation are required in the placement and compaction of the soils and aggregate and in the production and installation of the geosynthetic materials placed during construction. The CQA Plan, therefore, delineates the procedures to be followed for monitoring construction of these materials.

The scope of this CQA Plan includes the CQA of the soil and geosynthetic components of the Project. The CQA monitoring activities during the selection,

evaluation, treatment, placement, and compaction of soils for earthworks, and drainage aggregate are included in the scope of this plan. The CQA protocols applicable to manufacturing, shipping, handling, and installing all geosynthetic materials are also included. However, this CQA Plan does not specifically address either installation specifications or specification of soils and geosynthetic materials as these requirements are addressed in the *Technical Specifications*.

1.3 References

The CQA Plan includes references to test procedures in the latest editions of the American Society for Testing and Materials (ASTM).

1.4 Organization of the Construction Quality Assurance Plan

The remainder of the CQA Plan is organized as follows:

- Section 2 presents definitions relating to CQA;
- Section 3 describes the parties involved with the CQA;
- Section 4 describes the responsibilities of the CQA personnel;
- Section 5 describes site and project control requirements;
- Section 6 presents CQA documentation;
- Section 7 presents CQA of earthworks;
- Section 8 presents CQA of the drainage aggregates;
- Section 9 presents CQA of the pipe and fittings;
- Section 10 presents CQA of the geomembrane;
- Section 11 presents CQA of the geotextile;
- Section 12 presents CQA of the geosynthetic clay liner;
- Section 13 presents CQA of the geocomposite; and
- Section 16 presents CQA surveying.

2. DEFINITIONS RELATING TO CONSTRUCTION QUALITY ASSURANCE

This CQA Plan is devoted to Construction Quality Assurance. In the context of this document, Construction Quality Assurance and Construction Quality Control are defined as follows:

Construction Quality Assurance (CQA) - A planned and systematic pattern of means and actions designed to assure adequate confidence that materials and/or services meet contractual and regulatory requirements and will perform satisfactorily in service.

Construction Quality Control (CQC) - Those actions which provide a means to measure and regulate the characteristics of an item or service in relation to contractual and regulatory requirements.

In the context of this document:

- CQA refers to means and actions employed by the CQA Consultant to assure conformity of the Project "Work" with this CQA Plan, the *Drawings*, and the *Technical Specifications*.

- Construction Quality Control refers to those actions taken by the Contractor, Manufacturer, or Geosynthetic Installer to verify that the materials and the workmanship meet the requirements of this CQA Plan, the *Drawings*, and the *Technical Specifications*. In the case of soil components, CQC is combined with CQA and is provided by the CQA Consultant. In the case of the geosynthetic components and piping of the Work, CQC is provided by the Manufacturer and Geosynthetic Installer and the Contractor. CQA testing of soil, pipe, and geosynthetic components is provided by the CQA Consultant.

3. PARTIES INVOLVED WITH CONSTRUCTION QUALITY ASSURANCE

3.1 Engineer

Responsibilities

The Engineer is responsible for the design, *Drawings*, and *Technical Specifications* for the Project Work. In this CQA Plan, the term "Engineer" refers to Parsons Engineering Science, Inc. (Parsons) and GeoSyntec.

Qualifications

The Engineer of Record shall be a qualified engineer, registered as required by Nevada state regulations. The Engineer should have expertise, which demonstrates significant familiarity with piping, geosynthetics and soils, as appropriate, including design and construction experience related to landfill liner systems.

3.2 Project Manager

Responsibilities

The Project Manager is responsible for implementing the design, and overseeing subcontractors. In this CQA Plan, the term "Project Manager" refers to a qualified BRC employee.

Qualifications

The Project Manager shall be a qualified engineer having familiarity with earthwork construction and installation of geosynthetic materials.

3.3 Contractor

Responsibilities

In this CQA Plan, Contractor refers to an independent party or parties, contracted by the Owner, performing the Work in general accordance with this CQA

Plan, the *Drawings*, and the *Technical Specifications*. The Contractor will be responsible for the installation of the soils and geosynthetic components of the liner system. This work will include excavation, placement and compaction of engineered fill and prepared subgrade, placement of drainage aggregate and native soil (operations layer material), installation and of piping and concrete manhole, installation of temporary erosion control features, and coordination of work with the Geosynthetic Installer and other subcontractors.

The Contractor will be responsible for constructing the liner system and appurtenant components in general accordance with the *Drawings* and complying with the quality control requirements specified in the *Technical Specifications*.

Qualifications

Qualifications of the Contractor are specific to the construction contract. The Contractor should have a demonstrated history of successful earthworks construction and maintain current state and federal licenses as appropriate.

3.4 Resin Supplier

Responsibilities

The Resin Supplier produces and delivers the resin to the Geosynthetics Manufacturer.

Qualifications

Qualifications of the Resin Supplier are specific to the Manufacturer's requirements. The Resin Supplier will have a demonstrated history of providing resin with consistent properties.

3.5 Geosynthetics Manufacturer

Responsibilities

The Manufacturer is responsible for the production of finished material (geomembrane, geotextile, geosynthetic clay liner, geocomposite, pipe, and other specified material) from appropriate raw materials.

Qualifications

The Manufacturer(s) will be able to provide sufficient production capacity and qualified personnel to meet the demands of the project. The Manufacturer(s) must be a well established firm(s) that meet the requirements identified in the *Technical Specifications*.

3.6 Geosynthetic Installer

Responsibilities

The Geosynthetic Installer is responsible for field handling, storage, placement, seaming, loading or anchoring against wind uplift, and other aspects of the geosynthetic material installation. The Geosynthetic Installer may also be responsible for specialized construction tasks (i.e., including construction of anchor trenches for the geosynthetic materials).

Qualifications

The Geosynthetic Installer will be trained and qualified to install the geosynthetic materials of the type specified for this project. The Geosynthetic Installer shall meet the qualification requirements identified in the *Technical Specifications*.

3.7 CQA Consultant

Responsibilities

The CQA Consultant is a party, independent from the Contractor, Manufacturer, and Geosynthetic Installer, who is responsible for observing, testing, and documenting activities related to the CQC and CQA of the earthwork, piping, and the geosynthetic components used in the construction of the Project. The CQA Consultant will also be responsible for issuing a CQA report at the completion of the Project construction, which details the earthworks, piping, and geosynthetic installation activities and associated CQA activities. The CQA report will be signed and sealed by the CQA Officer who will be a Professional Engineer registered in the State of Nevada.

The CQA Consultant will be responsible for obtaining and testing representative samples of all components used in construction of the Project as required by this CQA Plan and *Technical Specifications*. All tests will be conducted in general accordance with ASTM or other applicable state or federal standards. Test results must be submitted to the Project Manager within a reasonable timeframe, which will not impede or delay construction of the Project. The CQA Consultant will be responsible for inspecting all earthwork, piping, and geosynthetic operations to verify that the components are installed in general accordance with this CQA Plan and *Technical Specifications*.

Qualifications

The CQA Consultant is a well established firm specializing in geotechnical and geosynthetic engineering and possess the equipment, personnel, and licenses necessary to conduct the geotechnical and geosynthetic tests required by the project plans and *Technical Specifications*. The CQA Consultant will provide qualified staff for the project, as necessary, which will include, at a minimum, a CQA Officer, and a CQA Site Manager. The CQA Officer will be a professionally licensed engineer as required by Nevada State regulations.

The CQA Consultant will be experienced with earthwork construction and the installation of geosynthetic materials similar to those materials used in construction of the Project. The CQA Consultant will be experienced in the preparation of CQA documentation including CQA Plans, field documentation, field testing procedures,

laboratory testing procedures, construction specifications, construction drawings, and CQA reports.

The CQA Site Manager will be specifically familiar with the construction of earthworks, piping, and the installation of geosynthetic materials and will be trained by the CQA Consultant in the duties of a CQA Site Manager.

3.8 Surveyor

Responsibilities

The Surveyor is a party, independent from the Contractor, Manufacturer, and Geosynthetic Installer, that is responsible for surveying, documenting, and verifying the location of all significant components of the Work. The Surveyor's work is coordinated and employed by the Owner. The Surveyor is responsible for issuing record drawings of the construction.

Qualifications

The Surveyor will be a well established surveying company with at least 3 years experience in the profession of surveying services in the State of Nevada. The Surveyor will be a licensed professional as required by the State of Nevada regulations. The Surveyor shall be fully equipped and experienced in the use of total stations and AutoCAD Version 14. All surveying will be performed under the direct supervision of the Owner.

3.9 CQA Laboratory

Responsibilities

The CQA Laboratory is a party, independent from the Contractor, Manufacturer and Geosynthetic Installer, that is responsible for conducting tests in general accordance with ASTM and other applicable test standards on samples of geosynthetic materials, soil, and in the field and in either an on-site or off-site laboratory.

Qualifications

The CQA Laboratory will have experience in testing soils and geosynthetic materials and will be familiar with ASTM and other applicable test standards. The CQA Laboratory will be capable of providing test results within a maximum of seven days of receipt of samples and will maintain that capability throughout the duration of earthworks construction and geosynthetic materials installation. The CQA Laboratory will also be capable of transmitting geosynthetic destructive test results within 24 hours of receipt of samples and will maintain that capability throughout the duration of geosynthetic material installation.

4. CQA CONSULTANTS PERSONNEL ORGANIZATION AND DUTIES

4.1 Overview

The CQA Officer will provide supervision within the scope of work of the CQA Consultant. The scope of work for the CQA Consultant includes monitoring of construction activities including the following:

- excavation and screening of materials;
- placement and compaction of engineered fill, surcharge prepared subgrade, and operations layer material;
- installation of geotextile;
- installation of geosynthetic clay liner;
- installation of geomembrane;
- installation of drainage aggregate;
- installation of geocomposite;
- installation of cast-in-place concrete; and
- installation of piping.

The duties of the CQA personnel are discussed in the remainder of this section.

4.2 CQA Personnel

For construction of the Project, the CQA Consultant's personnel will include:

- the CQA Officer, who operates from the office of the CQA Consultant and who conducts periodic visits to the site as required; and

- the CQA Site Manager, who is located at the site.

The duties of the CQA Personnel are discussed in the following subsections.

4.2.1 CQA Officer

The CQA Officer shall supervise and be responsible for monitoring and CQA activities relating to the construction of the earthworks, piping, and installation of the geosynthetic materials of the Project. Specifically, the CQA Officer:

- reviews the project design, this CQA Plan, *Drawings*, and *Technical Specifications*;

- reviews other site-specific documentation; unless otherwise agreed, such reviews are for familiarization and for evaluation of constructability only, and hence the CQA Officer and the CQA Consultant assume no responsibility for the liner system design;

- reviews and approves the Geosynthetic Installer's QC Plan;

- attends resolution and/or pre-construction meetings as needed;

- administers the CQA program (i.e., provides supervision of and manages on-site CQA personnel, reviews field reports, and provides engineering review of CQA related activities);

- provides quality control of CQA documentation and conducts site visits;
- reviews the record drawings; and
- with the CQA Site Manager, prepares the CQA report documenting that the project was constructed in general accordance with the Construction Documents.

4.2.2 CQA Site Manager

The CQA Site Manager:

- acts as the on-site representative of the CQA Consultant;
- attends CQA-related meetings (e.g., resolution, pre-construction, daily, weekly (or designates a representative to attend the meeting));
- prepares or oversees the ongoing preparation of the record drawings;
- reviews test results provided by Contractor;
- assigns locations for testing and sampling;
- oversees the collection and shipping of laboratory test samples;
- reviews results of laboratory testing and makes appropriate recommendations;
- reviews the calibration and condition of on-site CQA equipment;
- prepares a daily summary report for the project;
- reviews the Manufacturer's QC documentation;

- reviews the Geosynthetic Installer's personnel Qualifications for conformance with those pre-approved for work on site;

- notes in the daily summary report and reports to the CQA Officer and Project Manager on-site activities that could result in damage to the geosynthetic materials or other completed work;

- reports unresolved deviations from the CQA Plan, *Drawings*, and *Technical Specifications* to the Project Manager; and

- assists with the preparation of the CQA report.

5. SITE AND PROJECT CONTROL

5.1 Project Coordination Meetings

Meetings of key project personnel are necessary to assure a high degree of quality during installation, and promote clear, open channels of communication. Therefore, Project Coordination Meetings are an essential element in the success of the project. Several types of Project Coordination Meetings are described below, including: (i) resolution meetings; (ii) pre-construction meetings; (iii) progress meetings; and (iv) problem or work deficiency meetings.

5.1.1 Resolution Meeting

Following the completion of the design, *Drawings*, and *Technical Specifications* for the project and prior to the start of construction, a Resolution Meeting will be held. This meeting may include the CQA Officer, the CQA Site Manager, the Engineer, and the Project Manager.

The purpose of this meeting is to begin planning for coordination of construction tasks, anticipate installation problems which might cause difficulties and delays in construction, and, above all, present the CQA Plan to the parties involved. It is very important that the criteria regarding testing, repair, and other CQA activities be known and accepted by the parties involved in the work prior to the installation of geosynthetic materials and construction of the soil components for the Project.

The first part of the Resolution Meeting may be devoted to a review of the *Drawings* and *Technical Specifications* for familiarity. This is different from the peer review of the design, including design calculations, which will have been carried out previously.

The Resolution Meeting may include the following activities:

- distribute relevant documents to all parties;
- review critical design details of the project;

- review this CQA Plan;
- review the Drawings and Technical Specifications;
- make appropriate modifications to the design criteria, *Drawings*, and *Technical Specifications* so that the fulfillment of the design specifications or performance standards can be determined through the implementation of the CQA Plan;
- reach a consensus on the quality control procedures, especially on methods of evaluating acceptability of the soils and geosynthetic materials;
- assign the responsibilities of each party;
- establish work area security and health and safety protocol;
- confirm the methods for documenting observations, reporting, and distributing documents and reports; and
- confirm the lines of authority and communication.

The Project Manager will appoint one of the meeting attendees to record the discussions and decisions of the Resolution Meeting. The record of the meeting will be documented by the appointee in the form of meeting minutes, which will be subsequently distributed to all attendees.

5.1.2 Pre-Construction Meeting

A Pre-Construction Meeting will be held at the site prior to construction of the Project. As a minimum, the Pre-Construction Meeting will be attended by the Contractor, the Geosynthetic Installer's Superintendent, the CQA Consultant, the Engineer, and the Project Manager.

Specific items for discussion at the pre-construction meeting include the following:

- appropriate modifications or clarifications to the CQA Plan;
- the Drawings and Technical Specifications;
- the responsibilities of each party;
- lines of authority and communication;
- methods for documenting and reporting, and for distributing documents and reports;
- acceptance and rejection criteria;
- protocols for testing;
- protocols for handling deficiencies, repairs, and re-testing;
- the time schedule for all operations;
- procedures for packaging and storing archive samples;
- panel layout and numbering systems for panels and seams;
- seaming procedures;
- repair procedures; and
- soil stockpiling locations.

The Project Manager will conduct a site tour to observe the current site conditions and to review construction material and equipment storage locations. A person in attendance at the meeting will be appointed by the Project Manager to record the discussions and decisions of the meeting in the form of meeting minutes. Copies of the meeting minutes will be distributed to all attendees.

5.1.3 Progress Meetings

Progress meetings will be held between the CQA Site Manager, the Contractor, Project Manager, and other concerned parties participating in the construction of the project. This meeting will include discussions on the current progress of the project, planned activities for the next week, and revisions to the work plan and/or schedule. The meeting will be documented in meeting minutes prepared by a person designated by the CQA Site Manager at the beginning of the meeting. Within 2 working days of the meeting, draft minutes will be transmitted to representatives of parties in attendance for review and comment. Corrections and/or comments to the draft minutes shall be made within 2 working days of receipt of the draft minutes to be incorporated in the final meeting minutes.

5.1.4 Problem or Work Deficiency Meeting

A special meeting will be held when and if a problem or deficiency is present or likely to occur. The meeting will be attended by the Contractor, the Project Manager, the CQA Site Manager, and other parties as appropriate. If the problem requires a design modification, the Engineer should either be present at, consulted prior to, or notified immediately upon conclusion of this meeting. The purpose of the work deficiency meeting is to define and resolve the problem or work deficiency as follows:

- define and discuss the problem or deficiency;
- review alternative solutions;
- select a suitable solution agreeable to all parties; and
- implement an action plan to resolve the problem or deficiency.

The Project Manager will appoint one attendee to record the discussions and decisions of the meeting. The meeting record will be documented in the form of meeting minutes and copies will be distributed to all affected parties. A copy of the minutes will be retained in facility records.

6. DOCUMENTATION

6.1 Overview

An effective CQA Plan depends largely on recognition of all construction activities that should be monitored and on assigning responsibilities for the monitoring of each activity. This is most effectively accomplished and verified by the documentation of quality assurance activities. The CQA Consultant will document that all quality assurance requirements have been addressed and satisfied.

The CQA Site Manager will provide the Project Manager with signed descriptive remarks, data sheets, and logs to verify that monitoring activities have been carried out. The CQA Site Manager will also maintain, at the job site, a complete file of *Drawings* and *Technical Specifications*, a CQA Plan, checklists, test procedures, daily logs, and other pertinent documents.

6.2 Daily Recordkeeping

Preparation of daily CQA documentation will consist of daily reports prepared by the CQA Site Manager which may include CQA monitoring logs, and testing data sheets. This information may be regularly submitted to and reviewed by the Project Manager.

The CQA Site Manager will prepare daily reports that document the activities observed during each day of activity. The daily reports may include monitoring logs and testing data sheets. At a minimum, these logs and data sheets will include the following information:

- the date, project name, location, and other identification;
- a summary of the weather conditions;
- a summary of locations where construction is occurring;
- equipment and personnel on the project;

- a summary of meetings held and attendees;
- a description of materials used and references of results of testing and documentation;
- identification of deficient work and materials;
- results of re-testing corrected “deficient work;”
- an identifying sheet number for cross referencing and document control;
- descriptions and locations of construction inspected;
- type of construction and inspection performed;
- description of construction procedures and procedures used to evaluate construction;
- a summary of test data and results;
- calibrations or re-calibrations of test equipment and actions taken as a result of re-calibration;
- decisions made regarding acceptance of units of work and/or corrective actions to be taken in instances of substandard testing results;
- a discussion of agreements made between the interested parties which may affect the work; and
- signature of the respective CQA Site Manager.

6.3 Construction Problems and Resolution Data Sheets

Construction Problems and Resolution Data Sheets, to be submitted with the daily reports prepared by the CQA Site Manager, describing special construction situations will be cross-referenced with daily reports, specific observation logs, and testing data sheets and will include the following information, where available:

- an identifying sheet number for cross-referencing and document control;
- a detailed description of the situation or deficiency;
- the location and probable cause of the situation or deficiency;
- how and when the situation or deficiency was found or located;
- documentation of the response to the situation or deficiency;
- final results of responses;
- measures taken to prevent a similar situation from occurring in the future; and
- signature of the CQA Site Manager and a signature indicating concurrence by the Project Manager.

The Project Manager will be made aware of significant recurring nonconformance with the *Drawings*, *Technical Specifications*, or CQA Plan. The cause of the nonconformance will be determined and appropriate changes in procedures or specifications will be recommended. These changes will be submitted to the Engineer for approval. When this type of evaluation is made, the results will be documented and any revision to procedures or specifications will be approved by the Contractor and Engineer.

A summary of supporting data sheets, along with final testing results and the CQA Site Manager's approval of the work, will be required upon completion of construction.

6.4 Photographic Documentation

Photographs will be taken and documented in order to serve as a pictorial record of work progress, problems, and mitigation activities. The basic file will contain color prints. Negatives will also be stored in a separate file in chronological order. These records will be presented to the Project Manager upon completion of the project. Photographic reporting data sheets, where used, will be cross-referenced with observation and testing data sheet(s), and/or construction problem and solution data sheet(s). Photographs used for documentation will be identified with the date, time, and location of the photograph.

6.5 Design and/or Specifications Changes

Design and/or specifications changes may be required during construction. In such cases, the CQA Site Manager will notify the Project Manager. Design and/or specification changes will be made with the written agreement of the Project Manager and the Engineer and will take the form of an addendum to the *Drawings* and *Technical Specifications*.

6.6 CQA Report

At the completion of the Project, the CQA Consultant will submit to the Project Manager the CQA report signed and sealed by the Professional Engineer licensed in the State of Nevada. The CQA report will acknowledge: (i) that the work has been performed in compliance with the *Drawings* and *Technical Specifications*; (ii) physical sampling and testing has been conducted at the appropriate frequencies; and (iii) that the summary document provides the necessary supporting information. At a minimum, this report will include:

- Manufacturers' quality control documentation;

- a summary report describing the CQA activities and indicating compliance with the *Drawings* and *Technical Specifications* which is signed and sealed by the CQA Officer;

- a summary of CQA/CQC testing, including failures, corrective measures, and retest results;

- contractor personnel resumes and qualifications;

- documentation that the geomembrane trial seams were performed in general accordance with the CQA Plan and *Technical Specifications*;

- documentation that field seams were non-destructively tested using a method in general accordance with the applicable test standards;

- documentation that nondestructive testing was monitored by the CQA Consultant, that the CQA Consultant informed the Geosynthetic Installer of any required repairs, and that the CQA Consultant inspected the seaming and patching operations for uniformity and completeness;

- records of sample locations, the name of the individual conducting the tests, and the results of tests;

- record drawings as provided by the Surveyor;

- documentation showing that piping was tested in general accordance with the *Technical Specifications*; and

- daily inspection reports.

The record drawings will include scale drawings depicting the location of the construction and details pertaining to the extent of construction (e.g., depths, plan dimensions, elevations, soil component thicknesses). Base maps required for

development of the record drawings and the record drawings will be prepared by a qualified Professional Land Surveyor registered in the State of Nevada. These documents will be reviewed by the CQA Consultant and included as part of the CQA Report.

7. EARTHWORKS

7.1 Introduction

This section prescribes the CQA activities to be performed to monitor that earthwork components are constructed in general accordance with *Drawings* and *Technical Specifications*. The earthworks construction procedures to be monitored by the CQA Consultant include:

- excavation;
- surcharge placement;
- engineered fill placement;
- anchor trench excavation and backfill;
- subgrade preparation; and
- operations layer material placement.

7.2 Testing Activities

Soil testing will be performed for material qualification, material conformance, and construction quality control (CQC). These three stages of testing are defined as follows:

- Material qualification tests are used to evaluate the conformance of a proposed soil source to the material specifications for qualification of the source prior to construction.

- Soils conformance testing is used to evaluate the conformance of a particular batch of soil from a qualified source to the material specifications prior to installation of the soil.

- CQC tests are performed on completed portions of the earthwork during construction to demonstrate that the placement procedures are resulting in a product that meets or exceeds both material and performance specifications.

The Contractor will be responsible for submitting material qualification test results to the Project Manager and to the CQA Site Manager for review. The CQA Laboratory will perform the conformance testing and CQC testing. Soil testing will be conducted in general accordance with the current versions of the corresponding American Society for Testing and Materials (ASTM) test procedures. The test methods indicated in Table 1 are those that will be used for this testing unless the test methods are updated or revised prior to construction. Revisions to the test methods will be reviewed and approved by the Engineer and the CQA Site Manager prior to their usage.

7.2.1 Sample Frequency

The frequency of soils testing for material qualification will conform to the minimum frequencies presented in Table 2. The frequency of soils testing for material conformance will conform to the minimum frequencies presented in Table 3. The actual frequency of testing required will be increased by the CQA Site Manager as necessary if variability of materials is noted at the site, during adverse conditions, or to isolate failing areas of the construction.

7.2.2 Sample or Test Location Selection

With the exception of qualification samples, sampling locations will be selected by the CQA Site Manager. Conformance samples will be obtained from borrow pits and/or stockpiles of material. The Contractor must plan the work and make soil available for sampling in a timely and organized manner so that the test results can be obtained before the material is installed. The CQA Site Manager must document sample locations so that failing areas can be immediately isolated. The CQA Site Manager will follow standard sampling procedures to obtain representative samples of the proposed soil materials.

CQC sample and test locations will be selected by the CQA Site Manager at the minimum test frequency specified in Table 4. Samples and test locations will generally be selected at random, however a special testing frequency will be used at the discretion of the CQA Site Manager when visual observations of construction performance indicate a potential problem. Additional testing for suspected areas will be considered when:

- rollers slip during rolling operation;

- lift thickness is greater than specified;
- fill is at improper and/or variable moisture content;
- less than specified number of roller passes are made;
- dirt-clogged rollers are used to compact the material;
- rollers may not have used optimum ballast;
- fill materials differ substantially from those specified;
- the degree of compaction is doubtful; and
- as directed by the Project Manager or the CQA Site Manager.

The frequency of testing may also be increased in the following situations:

- adverse weather conditions;
- breakdown of equipment;
- at the start and finish of grading;
- material fails to meet specifications; and
- the work area is reduced.

7.3 CQA Monitoring Activities

7.3.1 Earthwork

The CQA Site Manager will monitor and document the earthworks required for the Project. In general, monitoring the construction for earthwork includes the following activities:

- reviewing documentation of the material qualification test results provided by the Contractor;

- monitoring the prepared subgrade and subgrade surfaces for compliance with the *Technical Specifications* before geosynthetic materials are placed;

- sampling and testing for conformance of the materials to the *Technical Specifications*;

- documenting that the earthwork is constructed using the specified equipment and procedures;

- documenting that the earthwork is constructed to the lines and grades shown on the *Drawings*;

- monitoring that the construction activities do not cause damage to underlying geosynthetic materials;

- quality control testing to determine the acceptability of the work during construction; and

- monitoring the action of the compaction and heavy hauling equipment on the construction surface (i.e., penetration, pumping, cracking, etc.).

The specific activities required for CQA of each of the major soil components of the Liner System are presented in the following sections.

7.3.2 Engineered Fill Material

Monitoring the earthwork for the engineered fill material specifically includes the following:

- reviewing documentation of the qualification and conformance test results;

- monitoring soil for maximum particle size and deleterious materials;

- monitoring the thickness of lifts during placement of the materials;

- monitoring compaction operations; and

- measuring and recording the field density and the field moisture content of the in-place material.

7.3.3 Prepared Subgrade

During construction, the CQA Site Manager will monitor the prepared subgrade to document that the prepared subgrade soil characteristics are consistent with those specified in the *Technical Specifications*. The CQA Site Manager will monitor the construction activities to document that sharp rocks and other undesirable materials are removed and that the subgrade is prepared using the procedures and equipment specified in the *Technical Specifications*.

The upper portion of the subgrade can be damaged by excess moisture (causing softening) or insufficient moisture (causing desiccation and shrinkage). At a minimum, the CQA Site Manager will determine the suitability of the subgrade for geomembrane placement by:

- documenting that the surface is free of sharp rocks, debris and other undesirable materials;
- documenting that the surface is smooth, uniform, and free from desiccation cracks by visually monitoring proof rolling activities; and
- documenting that the subgrade surface meets the lines and grades shown on the *Drawings* by reviewing certified survey results.

7.3.4 Operations Layer Material

The CQA Site Manager will monitor the earthwork of the operations layer material for the following:

- the Contractor's submittals and qualification test results for consistency between the proposed methods and the approved methods;
- the conformance testing of the material and notifying the Contractor of results for compliance with material specifications;
- the thickness of lifts during placement;

- the placement equipment operation on the sideslopes is in general accordance with the *Technical Specifications*;

- the construction procedures to monitor that completed sections of liner and geomembrane are protected from damage; and

- the survey data to monitor that operations layer material is constructed to the proposed lines and grades and to the specified thickness.

7.4 Deficiencies

If a defect is discovered in the earthwork product, the CQA Site Manager will immediately determine the extent and nature of the defect. If the defect is indicated by an unsatisfactory test result, the CQA Site Manager will determine the extent of the deficient area by additional tests, observations, a review of records, or other means that the CQA Site Manager deems appropriate. If the defect is related to adverse site conditions, such as overly wet soils or surface desiccation, the CQA Site Manager will define the limits and nature of the defect.

7.4.1 Notification

After evaluating the extent and nature of a defect, the CQA Site Manager will notify the Project Manager and Contractor and schedule appropriate re-tests when the work deficiency is to be corrected.

7.4.2 Repairs and Re-Testing

At locations where the field testing indicates densities below the requirements of the specification, the failing area will be reworked. The Contractor will correct the deficiency to the satisfaction of the CQA Site Manager. If a project specification criterion cannot be met, or unusual weather conditions hinder work, then the CQA Site Manager will develop and present to the Engineer and/or Project Manager suggested solutions for his approval.

All re-tests recommended by the CQA Site Manager must verify that the defect has been corrected before any additional work is performed by the Contractor in the area of the deficiency. The CQA Site Manager will also verify that installation requirements are met and that submittals are provided.

8. DRAINAGE AGGREGATE

8.1 Introduction

This section prescribes the CQA activities to be performed to monitor that drainage aggregates are constructed in general accordance with *Drawings* and *Technical Specifications*. The drainage aggregates construction procedures to be monitored by the CQA Consultant include drainage aggregate placement.

8.2 Testing Activities

Aggregate testing will be performed for material qualification and material conformance. These two stages of testing are defined as follows:

- Material qualification tests are used to evaluate the conformance of a proposed aggregate source to the material specifications for qualification of the source prior to construction.

- Aggregate conformance testing is used to evaluate the conformance of a particular batch of aggregate from a qualified source to the material specifications prior to installation of the aggregate.

The Contractor will be responsible for submitting material qualification test results to the Project Manager and to the CQA Site Manager for review. The CQA Laboratory will perform the conformance testing and CQC testing. Aggregate testing will be conducted in general accordance with the current versions of the corresponding American Society for Testing and Materials (ASTM) test procedures. The test methods indicated in Table 5 are those that will be used for this testing unless the test methods are updated or revised prior to construction. Revisions to the test methods will be reviewed and approved by the Engineer and the CQA Site Manager prior to their usage.

8.2.1 Sample Frequency

The frequency of aggregate testing for material qualification will conform to the minimum frequencies presented in Table 6. The frequency of aggregate testing for material conformance will conform to the minimum frequencies presented in Table 7.

The actual frequency of testing required will be increased by the CQA Site Manager as necessary if variability of materials is noted at the site, during adverse conditions, or to isolate failing areas of the construction.

8.2.2 Sample Selection

With the exception of qualification samples, sampling locations will be selected by the CQA Site Manager. Conformance samples will be obtained from borrow pits and/or stockpiles of material. The Contractor must plan the work and make aggregate available for sampling in a timely and organized manner so that the test results can be obtained before the material is installed. The CQA Site Manager must document sample locations so that failing areas can be immediately isolated. The CQA Site Manager will follow standard sampling procedures to obtain representative samples of the proposed aggregate materials.

8.3 <u>CQA Monitoring Activities</u>

8.3.1 Drainage Aggregate

The CQA Site Manager will monitor and document the installation of the drainage aggregates. In general, monitoring the installation of the drainage aggregates includes the following activities:

- reviewing documentation of the material qualification test results provided by the Contractor;
- sampling and testing for conformance of the materials to the *Technical Specifications*;
- documenting that the drainage aggregates are installed using the specified equipment and procedures;
- documenting that the drainage aggregates are constructed to the lines and grades shown on the *Drawings*; and

- monitoring that the construction activities do not cause damage to underlying geosynthetic materials.

8.4 Deficiencies

If a defect is discovered in the drainage aggregates, the CQA Site Manager will evaluate the extent and nature of the defect. If the defect is indicated by an unsatisfactory test result, the CQA Site Manager will determine the extent of the deficient area by additional tests, observations, a review of records, or other means that the CQA Site Manager deems appropriate.

8.4.1 Notification

After evaluating the extent and nature of a defect, the CQA Site Manager will notify the Project Manager and Contractor and schedule appropriate re-tests when the work deficiency is to be corrected.

8.4.2 Repairs and Re-testing

The Contractor will correct the deficiency to the satisfaction of the CQA Site Manager. If a project specification criterion cannot be met, or unusual weather conditions hinder work, then the CQA Site Manager will develop and present to the Engineer and/or Project Manager suggested solutions for approval.

All re-tests recommended by the CQA Site Manager must verify that the defect has been corrected before any additional work is performed by the Contractor in the area of the deficiency. The CQA Site Manager will also verify that installation requirements are met and that submittals are provided.

9. HIGH DENSITY POLYETHYLENE (HDPE) PIPE AND FITTINGS

9.1 Material Requirements

HDPE pipe and fittings must conform to the requirements of the *Technical Specifications*. The CQA Consultant will document that the HDPE pipe and fittings meet those requirements through manufacturer's quality control certificates, conformance testing, and visual examination of materials arriving on site.

9.2 Manufacturer

9.2.1 Submittals

Prior to the installation of HDPE pipe, the Manufacturer will provide to the CQA Consultant:

- a properties' sheet including, at a minimum, all specified properties, measured using test methods indicated in the *Technical Specifications*, or equivalent; and

- a certification that property values given in the properties sheet are minimum values and are guaranteed by the Manufacturer.

The CQA Consultant will document that:

- the property values certified by the Manufacturer meet the *Technical Specifications*; and

- the measurements of properties by the Manufacturer are properly documented and that the test methods used are acceptable.

9.2.2 Identification

Prior to shipment, the Manufacturer will provide the Project Manager and the CQA Site Manager with a quality control certificate for each lot/batch of HDPE pipe provided. The quality control certificate will be signed by a responsible party

employed by the Manufacturer, such as the Production Manager. The quality control certificate will include:

- lot/batch numbers and identification; and
- sampling procedures and results of quality control tests.

The CQA Site Manager will:

- document that the quality control certificates have been provided at the specified frequency for all lots/batches of pipe, and that each certificate identifies the pipe lot/batch related to it; and

- review the quality control certificates and document that the certified properties meet the *Technical Specifications*.

9.3 Handling and Laying

Care will be taken during transportation of the pipe such that it will not be cut, kinked, or otherwise damaged.

Ropes, fabric, or rubber-protected slings and straps will be used when handling pipes. Chains, cables, or hooks inserted into the pipe ends will not be used. Two slings spread apart will be used for lifting each length of pipe. Pipe or fittings will not be dropped onto rocky or unprepared ground.

Pipes will be handled and stored in general accordance with the Manufacturer's recommendation. The handling of joined pipe will be in such a manner that the pipe is not damaged by dragging it over sharp and cutting objects. Slings for handling the pipe will not be positioned at butt-fused joints. Sections of the pipes with deep cuts and gauges will be removed and the ends of the pipe rejoined.

9.4 Joints

Lengths of pipe will be assembled into suitable installation lengths by the butt-fusion process. Butt-fusion means the butt-joining of the pipe by softening by heat the aligned faces of the pipe ends in a suitable apparatus and pressing them together under

controlled pressure. This process will be applied by personnel experienced with the process. Certification will be provided that the person performing this work is qualified by experience and instruction in the procedure. All pipe so joined will be made from the same class and type of raw material made by the same raw material supplier.

10. GEOMEMBRANE

10.1 General

This section discusses and outlines the CQA activities to be performed for high density polyethylene (HDPE) geomembrane installation. The CQA Site Manager will review the *Drawings*, and the *Technical Specifications*, and any approved Addenda regarding this material.

10.2 Geomembrane Material Conformance

10.2.1 Introduction

The CQA Site Manager will document that the geomembrane delivered to the site meets the requirements of the *Technical Specifications* prior to installation. The CQA Site Manager will:

- review the manufacturer's submittals for compliance with the *Technical Specifications*;
- document the delivery and proper storage of geomembrane rolls; and
- conduct conformance testing of the rolls before the geomembrane is installed.

The following sections describe the CQA activities required to verify the conformance of geomembrane.

10.2.2 Review of Quality Control

10.2.2.1 Material Properties Certification

The Manufacturer will provide the Project Manager and the CQA Site Manager with the following:

- a properties sheet including, at a minimum, all specified properties, measured using test methods indicated in the *Technical Specifications*, or equivalent;
- the sampling procedure and results of testing; and
- a certification that property values given in the properties sheet are guaranteed by the Manufacturer.

The CQA Site Manager will document that:

- the property values certified by the Manufacturer meet all of the *Technical Specifications*; and
- the measurements of properties by the Manufacturer are properly documented and that the test methods used are acceptable.

10.2.2.2 Resin Certification

The Manufacturer will also provide the Project Manager with the following information concerning the resin used to manufacture the geomembrane:

- the origin (Resin Supplier's name and resin production plant), identification (brand name, lot number), and production date of the resin; and
- the raw material quality control certificates.

The CQA Site Manager will:

- evaluate that the quality control certificates have been provided at the specified frequency, and that the certificate identifies the rolls related to it; and

- review the quality control certificates and evaluate that the certified properties meet the specifications.

10.2.2.3 Geomembrane Roll QC Certification

Prior to shipment, the Manufacturer will provide the Project Manager and the CQA Site Manager with a quality control certificate for every roll of geomembrane provided. The quality control certificate will be signed by a responsible party employed by the Geomembrane Manufacturer, such as the production manager. The quality control certificate will include:

- roll numbers and identification; and

- results of quality control tests - as a minimum, results will be given for thickness, specific gravity, carbon black content, carbon black dispersion, tensile properties, tear resistance, puncture resistance, and single point stress rupture evaluated in general accordance with the methods indicated in the specifications or equivalent methods approved by the Engineer.

The CQA Site Manager will:

- evaluate that the quality control certificates have been provided at the specified frequency, and that the certificate identifies the rolls related to the roll represented by the test results; and

- review the quality control certificates and evaluate that the certified roll properties meet the specifications.

10.2.3 Conformance Testing

Upon delivery of the rolls of geomembrane, the CQA Site Manager will document that the rolls are unloaded and stored on site as required by the *Technical Specifications*. Damage caused by unloading will be documented by the CQA Site Manager and the damaged material will not be installed. The CQA Site Manager shall obtain conformance samples at the specified frequency and forward them to the Geosynthetics CQA Laboratory for testing to monitor conformance to both the *Technical Specifications* and the list of properties certified by the Manufacturer. The test procedures will be as indicated in Table 8. Where optional procedures are noted in the test method, the requirements of the *Technical Specifications* will prevail.

Samples will be taken across the width of the roll and will not include the first linear 3 ft (1 m) of material. Unless otherwise specified, samples will be 3 ft (1 m) long by the roll width. The CQA Site Manager will mark the machine direction on the samples with an arrow along with the date and roll number. The required minimum sampling frequencies are provided in Table 8.

The CQA Site Manager will examine results from laboratory conformance testing and will report any non-conformance to the Project Manager and the Geosynthetic Installer. The procedure prescribed in the *Technical Specifications* will be followed in the event of a failing conformance test.

10.3 <u>Delivery</u>

10.3.1 Transportation and Handling

The CQA Site Manager will document that the transportation and handling does not pose a risk of damage to the geomembrane.

Upon delivery at the site, the Geosynthetic Installer and the CQA Site Manager will conduct a surface observation of the rolls for defects and damage. This

inspection will be conducted without unrolling unless defects or damages are found or suspected. The CQA Site Manager will indicate to the Project Manager:

- rolls, or portions thereof, which should be rejected and removed from the site because they have severe flaws; and

- rolls that include minor repairable flaws.

10.3.2 Storage

The Geosynthetic Installer will be responsible for the storage of the geomembrane on site. The Contractor will provide storage space in a location (or several locations) such that on-site transportation and handling are optimized if possible.

The CQA Site Manager will document that storage of the geomembrane provides adequate protection against sources of damage.

10.4 Geomembrane Installation

10.4.1 Introduction

The CQA Consultant will document that the geomembrane installation is carried out in general accordance with the *Drawings*, *Technical Specifications* and Manufacturer's recommendations.

10.4.2 Earthwork

10.4.2.1 Surface Preparation

The CQA Site Manager will document that:

- a qualified land surveyor has verified lines and grades;

- that the supporting prepared subgrade or subgrade meets the *Technical Specifications* and has been approved; and

- placement of the overlying materials does not damage, create large wrinkles, or induce excessive tensile stress in the underlying geosynthetic materials.

The Geosynthetic Installer will certify in writing that the surface on which the geomembrane will be installed is acceptable. The certificate of acceptance will be given by the Geosynthetic Installer to the Project Manager prior to commencement of geomembrane installation in the area under consideration. The CQA Site Manager will be given a copy of this certificate by the Project Manager.

After the supporting subgrade has been accepted by the Geosynthetic Installer, it will be the Geosynthetic Installer's responsibility to indicate to the Project Manager any change in the supporting soil condition that may require repair work. If the CQA Site Manager concurs with the Geosynthetic Installer, then the Project Manager will document that the supporting soil is repaired.

At any time before and during the geomembrane installation, the CQA Site Manager will indicate to the Project Manager locations that may not provide adequate support to the geomembrane.

10.4.2.2 Geosynthetic Termination

The CQA Site Manager will document that the geosynthetic terminations have been constructed in general accordance with the *Drawings*. Backfilling above the terminations will be conducted in general accordance with the *Technical Specifications*.

10.4.3 Geomembrane Placement

10.4.3.1 Panel Identification

A field panel is the unit area of geomembrane which is to be seamed in the field, i.e., a field panel is a roll or a portion of roll cut in the field. It will be the responsibility of the CQA Site Manager to document that each field panel is given an "identification code" (number or letter- number) consistent with the layout plan. This identification code will be agreed upon by the Project Manager, Geosynthetic Installer and CQA Site Manager. This field panel identification code will be as simple and

logical as possible. Roll numbers established in the manufacturing plant must be traceable to the field panel identification code.

The CQA Site Manager will establish documentation showing correspondence between roll numbers, and field panel identification codes. The field panel identification code will be used for all quality assurance records.

10.4.3.2 Field Panel Placement

Location

The CQA Site Manager will document that field panels are installed at the location indicated in the Geosynthetic Installer's layout plan, as approved or modified by the Engineer.

Installation Schedule

Field panels may be installed using one of the following schedules:

- all field panels are placed prior to field seaming in order to protect the subgrade from erosion by rain;
- field panels are placed one at a time and each field panel is seamed after its placement (in order to minimize the number of unseamed field panels exposed to wind); and
- any combination of the above.

If a decision is reached to place all field panels prior to field seaming, it is usually beneficial to begin at the high point area and proceed toward the low point with "shingle" overlaps to facilitate drainage in the event of precipitation. It is also usually beneficial to proceed in the direction of prevailing winds. Accordingly, an early decision regarding installation scheduling should be made if and only if weather conditions can be predicted with reasonable certainty. Otherwise, scheduling decisions must be made during installation, in general accordance with varying conditions. In any

event, the Geosynthetic Installer is fully responsible for the decision made regarding placement procedures.

The CQA Site Manager will evaluate every change in the schedule proposed by the Geosynthetic Installer and advise the Project Manager on the acceptability of that change. The CQA Site Manager will document that the condition of the supporting soil has not changed detrimentally during installation.

The CQA Site Manager will record the identification code, location, and date of installation of each field panel.

Weather Conditions

Geomembrane placement will not proceed unless otherwise authorized:

- when the ambient temperature is below 40°F or above 104°F;
- when the geomembrane sheet temperature is below 40°F or above 104°F; or
- when wind gusts are in excess of 20 mph.

Geomembrane placement will not be performed during any precipitation, in the presence of excessive moisture (e.g., fog, dew), in an area of ponded water, or in the presence of excessive winds (i.e., wind gusts in excess of 20 mph).

The CQA Site Manager will document that the above conditions are fulfilled. Additionally, the CQA Site Manager will document that the supporting soil has not been damaged by weather conditions. The Geosynthetics Installer will inform the Project Manager if the above conditions are not fulfilled.

Method of Placement

The CQA Site Manager will document the following:

- equipment used does not damage the geomembrane by handling, trafficking, excessive heat, leakage of hydrocarbons or other means;

- the surface underlying the geomembrane has not deteriorated since previous acceptance, and is still acceptable immediately prior to geomembrane placement;

- geosynthetic elements immediately underlying the geomembrane are clean and free of debris;

- personnel working on the geomembrane do not smoke, wear damaging shoes, or engage in other activities which could damage the geomembrane;

- the method used to unroll the panels does not cause scratches or crimps in the geomembrane and does not damage the supporting soil;

- the method used to place the panels minimizes wrinkles (especially differential wrinkles between adjacent panels); and

- adequate temporary loading and/or anchoring (e.g., sand bags, tires), not likely to damage the geomembrane, has been placed to prevent uplift by wind (in case of high winds, continuous loading, e.g., by adjacent sand bags, is recommended along edges of panels to minimize risk of wind flow under the panels).

The CQA Site Manager will inform the Project Manager if the above conditions are not fulfilled.

Damaged panels or portions of damaged panels that have been rejected will be marked and their removal from the work area recorded by the CQA Site Manager. Repairs will be made in general accordance with procedures described in Section 10.4.5.

10.4.4 Field Seaming

This section details CQA procedures to document that seams are properly constructed and tested in general accordance with the Manufacturer's specifications and industry standards.

10.4.4.1 Seam Layout

The Geosynthetic Installer will provide the Project Manager and the CQA Site Manager with a seam layout drawing, i.e., a drawing of the facility to be lined showing all expected seams. The CQA Site Manager will review the seam layout drawing and evaluate that it is consistent with the preliminary geomembrane panel layout. No panels may be seamed in the field without the Project Manager's approval. In addition, panels not specifically shown on the seam layout drawing may be used without the Project Manager's prior approval.

In general, seams should be oriented parallel to the line of maximum slope, i.e., oriented along, not across, the slope. In corners and odd-shaped geometric locations, the number of seams should be minimized. No horizontal seam should be less than 5 ft (1.5 m) from the toe of the slope, or areas of potential stress concentrations, unless otherwise authorized.

A seam numbering system compatible with the panel numbering system will be agreed upon at the Resolution and/or Pre-Construction Meeting.

10.4.4.2 Requirements of Personnel

All personnel performing seaming operations will be qualified by experience or by successfully passing seaming tests, as outlined in the *Technical Specifications*. The most experienced seamer, the "master seamer", will provide direct supervision over less experienced seamers.

The Geosynthetic Installer will provide the Project Manager and the CQA Site Manager with a list of proposed seaming personnel and their experience records. This document will be reviewed by the Project Manager and the Geosynthetics CQA Manager.

10.4.4.3 Seaming Equipment and Products

Approved processes for field seaming are fillet extrusion welding and fusion welding.

Fillet Extrusion Process

The fillet extrusion-welding apparatus will be equipped with gauges giving the temperature in the apparatus.

The Geosynthetic Installer will provide documentation regarding the extrudate to the Project Manager and the CQA Site Manager, and will certify that the extrudate is compatible with the specifications, and in any event is comprised of the same resin as the geomembrane sheeting.

The CQA Site Manager will log apparatus temperatures, ambient temperatures, and geomembrane surface temperatures at appropriate intervals.

The CQA Site Manager will document that:

- the Geosynthetic Installer maintains on site the number of spare operable seaming apparatus decided at the Resolution Meeting;
- equipment used for seaming is not likely to damage the geomembrane;
- the extruder is purged prior to beginning a seam until all heat-degraded extrudate has been removed from the barrel;
- the electric generator is placed on a smooth base such that no damage occurs to the geomembrane;
- a smooth insulating plate or fabric is placed beneath the hot welding apparatus after usage; and

- the geomembrane is protected from damage in heavily trafficked areas.

Fusion Process

The fusion-welding apparatus must be automated vehicular-mounted devices. The fusion-welding apparatus will be equipped with gauges giving the applicable temperatures and pressures.

The CQA Site Manager will log ambient, seaming apparatus, and geomembrane surface temperatures as well as seaming apparatus pressures.

The CQA Site Manager will also document that:

- the Geosynthetic Installer maintains on-site the number of spare operable seaming apparatus decided at the Resolution Meeting;

- equipment used for seaming is not likely to damage the geomembrane;

- for cross seams, the edge of the cross seam is ground to a smooth incline (top and bottom) prior to welding;

- the electric generator is placed on a smooth base such that no damage occurs to the geomembrane;

- a smooth insulating plate or fabric is placed beneath the hot welding apparatus after usage;

- the geomembrane is protected from damage in heavily trafficked areas; and

- a movable protective layer may be used directly below each overlap of geomembrane that is to be seamed to prevent build- up of moisture between the sheets.

10.4.4.4 Seam Preparation

The CQA Site Manager will document that:

- prior to seaming, the seam area is clean and free of moisture, dust, dirt, debris, and foreign material; and

- seams are aligned with the fewest possible number of wrinkles and "fishmouths."

10.4.4.5 Weather Conditions for Seaming

The normally required weather conditions for seaming are as follows unless authorized in writing by the Project Manager:

- seaming will only be approved between ambient temperatures of 40°F (4°C) and 104°F (40°C); and

- seaming will not be approved if sustained wind speed is in excess of 20 mph (32 km/hr).

If the Geosynthetic Installer wishes to use methods that may allow seaming at ambient temperatures below 40°F (4°C) or above 104°F (40°C), the Geosynthetic Installer will demonstrate and certify that such methods produce seams which are entirely equivalent to seams produced within acceptable temperature and wind requirements, and that the overall quality of the geomembrane is not adversely affected.

The CQA Site Manager will document that these seaming conditions are fulfilled and will advise the Project Manager if they are not. The Project Manager will then decide if the installation will be stopped or postponed.

10.4.4.6 Overlapping and Temporary Bonding

The CQA Site Manager will document that:

- the panels of geomembrane have a finished overlap of a minimum of 3 in. (75 mm) for both extrusion and fusion welding;

- no solvent or adhesive bonding material are to be used; and

- the procedure used to temporarily bond adjacent panels together does not damage the geomembrane.

The CQA Site Manager will log appropriate temperatures and conditions, and will log and report to the Project Manager non-compliances.

10.4.4.7 Trial Seams

Trial seams will be made on fragment pieces of geomembrane liner to verify that seaming conditions are adequate. Such trial seams will be made at the beginning of each seaming period, beginning of the day and after lunch, for each seaming apparatus used that day. Also, each seamer will make at least one trial seam each day. Trial seams will be made under the same conditions as actual seams.

Extrusion welded trial seam samples will be at least 3 ft (0.9 m) long by 1 ft (0.3 m) wide (after seaming) with the seam centered lengthwise. Fusion welded trial seam samples will be at least 5 ft (1.5 m) long by 1 ft (0.3 m) wide (after seaming) with the seam centered lengthwise. Seam overlap will be as indicated in Section 10.5.3.6.

Four specimens, each 1 in. (25 mm) wide, will be cut from the trial seam sample by the Geosynthetic Installer. One specimen will be tested for shear strength and three specimens will be tested for peel adhesion using a gauged tensiometer. All specimens tested will exhibit a Film Tear Bond (FTB) and will not fail in the seam. In addition, all specimens will meet or exceed the minimum strength requirements described in the *Technical Specifications*. If any of the four specimens fails, the entire trial seaming operation will be repeated. If any of the four additional specimens fails, the seaming apparatus and seamer will not be approved for production seaming until the deficiencies are corrected and two consecutive trial seam tests achieve the FTB requirements outlined above.

The CQA Site Manager will observe trial seam procedures. Trial seam samples will be assigned a number. The CQA Site Manager, will log the date, time, machine temperature(s), number of the seaming unit, name of the seamer, and pass or fail description for each trial seam sample tested.

10.4.4.8 General Seaming Procedure

Unless otherwise specified, the general seaming procedure used by the Geosynthetic Installer will be as follows:

- Fishmouths or wrinkles at the seam overlaps will be cut along the ridge of the wrinkle in order to achieve a flat overlap. The cut fishmouths or wrinkles will be seamed and any portion where the overlap is inadequate will then be patched with an oval or round patch of the same geomembrane extending a minimum of 6 in. (150 mm) beyond the cut in all directions.

- If seaming operations are carried out at night, adequate illumination will be provided at the Geosynthetic Installer's expense.

- Seaming will extend to the outside edge of panels to be placed in the anchor trench.

The CQA Site Manager will document that the above seaming procedures are followed, and will inform the Project Manager if they are not.

10.4.4.9 Nondestructive Seam Continuity Testing

Concept

The Geosynthetic Installer will non-destructively test field seams over their length using a vacuum test unit, air pressure test (for double fusion seams only), or other approved method. The purpose of nondestructive tests is to check the continuity of seams. It does not provide information on seam strength. Continuity testing will be carried out as the seaming work progresses, not at the completion of field seaming.

The CQA Site Manager will:

- observe continuity testing;
- record location, date, test unit number, name of person conducting the test, and the results of tests; and
- inform the Geosynthetic Installer and Project Manager of required repairs.

The Geosynthetic Installer will complete any required repairs in general accordance with Section 10.4.5.

The CQA Site Manager will:

- observe the repair and re-testing of the repair;
- mark on the geomembrane that the repair has been made; and
- document the results.

The following procedures will apply to locations where seams cannot be non-destructively tested:

All such seams will be cap-stripped with the same geomembrane.

- If the seam is accessible to testing equipment prior to final installation, the seam will be non-destructively tested prior to final installation.
- If the seam cannot be tested prior to final installation, the seaming and cap-stripping operations will be observed by the CQA Site Manager and Geosynthetic Installer for uniformity and completeness.

The seam number, date of observation, name of tester, and outcome of the test or observation will be recorded by the CQA Site Manager.

Vacuum Testing

The equipment will be comprised of the following:

- a vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, port hole or valve assembly, and a vacuum gauge;
- a steel vacuum tank and pump assembly equipped with a pressure controller and pipe connections;
- a rubber pressure/vacuum hose with fittings and connections;
- an approved applicator; and
- a soapy solution.

The following procedures will be followed:

- energize the vacuum pump and reduce the tank pressure to approximately 5 psi (35 kPa) (10 in. of Hg.) gauge;
- wet a strip of geomembrane approximately 12 in. by 48 in. (0.3 m by 1.2 m) with the soapy solution;
- place the box over the wetted area;
- close the bleed valve and open the vacuum valve;
- document that a leak tight seal is created;
- for a period of not less than ten seconds, examine the geomembrane through the viewing window for the presence of leaks indicated by soap bubbles;

- if no leaks appear after ten seconds, close the vacuum valve and open the bleed valve, move the box over the next adjoining area with a minimum 3 in. (75 mm) overlap, and repeat the process;

- areas where soap bubbles appear will be marked and repaired in general accordance with Section 10.4.5 and retested using the vacuum testing method.

Air Pressure Testing (For Double-Track Fusion Seam Only)

The following procedures are applicable to those processes that produce a double seam with an enclosed space.

The equipment will be comprised of the following:

- an air pump (manual or motor driven) equipped with pressure gauge capable of generating and sustaining a pressure of 30 psi (200 kPa) and mounted on a cushion to protect the geomembrane;

- a rubber hose with fittings and connections;

- a sharp hollow needle, or other approved pressure feed device.

The following procedures will be followed:

- seal both ends of the seam to be tested;

- insert needle or other approved pressure feed device into the tunnel created by the fusion weld;

- insert a protective cushion between the air pump and the geomembrane;

- energize the air pump to a pressure of 25 to 30 psi (170 to 204 kPa), close valve, and sustain pressure for not less than 5 minutes;

- if loss of pressure exceeds 3 psi (20 kPa) or does not stabilize, locate faulty area and repair in general accordance with Section 10.4.5;

- cut end of tested seam area, opposite the location of the pressure gauge, after completion of the five minute pressure hold period to verify complete testing of the seam. If the pressure gauge does not indicate a release of pressure, locate blockage of the air channel and retest until entire seam is tested; and

- remove needle or other approved pressure feed device and repair any holes in the geomembrane resulting from the air pressure testing procedure in general accordance with Section 10.4.5.

10.4.4.10 Destructive Testing

Concept

Destructive seam testing will be performed on site and at the independent CQA laboratory in general accordance with the *Drawings* and the *Technical Specifications*. Destructive seam tests will be performed at selected locations. The purpose of these tests is to evaluate seam strength. Seam strength testing will be done as the seaming work progresses, not at the completion of all field seaming.

Location and Frequency

The CQA Site Manager will select locations where seam samples will be cut out for laboratory testing. Those locations will be established as follows.

- The frequency of geomembrane seam testing is a minimum of one destructive sample per 500 feet of weld. The minimum frequency is to be evaluated as an average taken throughout the entire facility.

- A minimum of one test per seaming machine over the duration of the project phase.

- Test locations will be evaluated during seaming at CQA Site Manager's discretion. Selection of such locations may be prompted by suspicion of excess crystallinity, contamination, offset welds, or any other potential cause of imperfect welding.

The Geosynthetic Installer will not be informed in advance of the locations where the seam samples will be taken.

Sampling Procedure

Samples will be cut by the Geosynthetic Installer as the seaming progresses in order to have laboratory test results before the geomembrane is covered by another material. The CQA Site Manager will:

- observe sample cutting;
- assign a number to each sample, and mark it accordingly;
- record sample location on layout drawing; and
- record reason for taking the sample at this location (e.g., statistical routine, suspicious feature of the geomembrane).

Holes in the geomembrane resulting from destructive seam sampling will be immediately repaired in general accordance with repair procedures described in Section 10.4.5. The continuity of the new seams in the repaired area will be tested in general accordance with Section 10.4.4.9.

Size and Distribution of Samples

The destructive sample will be 12 in. (0.3 m) wide by 42 in. (1.1 m) long with the seam centered lengthwise. The sample will be cut into three parts and distributed as follows:

- one portion, measuring 12 in. × 12 in. (0.30 cm × 30 cm), to the Geosynthetic Installer for field testing;

- one portion, measuring 12 in. × 18 in. (30 cm × 45 cm), for CQA Laboratory testing; and

- one portion, measuring 12 in. × 12 in. (30 cm × 30 cm), to the Contractor for archive storage.

Final evaluation of the destructive sample sizes and distribution will be made at the Pre-Construction Meeting.

Field Testing

Field testing will be performed by the Geosynthetic Installer using a gauged tensiometer. Prior to field testing the Geosynthetic Installer shall submit a calibration certificate for gauge tensiometer to the CQA Consultant for review. Calibration must have been performed within one year of use on the current project. Five 1 in. (25 mm) wide strips will be taken for peel. The specimens shall not fail in the seam and shall meet the strength requirements outlined in the *Technical Specifications*. If any field test specimen fails, then the procedures outlined in *Procedures for Destructive Test Failures* of this section will be followed.

The CQA Site Manager will witness field tests and mark samples and portions with their number. The CQA Site Manager will also log the date and time, ambient temperature, number of seaming unit, name of seamer, welding apparatus temperatures and pressures, and pass or fail description.

CQA Laboratory Testing

Destructive test samples will be packaged and shipped, if necessary, under the responsibility of the CQA Site Manager in a manner that will not damage the test sample. The Project Manager will document that packaging and shipping conditions are acceptable. The Project Manager will be responsible for storing the archive samples. This procedure will be outlined at the Resolution Meeting. Samples will be tested by the CQA Laboratory. The CQA Laboratory will be selected by the CQA Site Manager with the concurrence of the Project Manager.

Testing will include “Bonded Seam Strength” and “Peel Adhesion.” The minimum acceptable values to be obtained in these tests are given in the *Technical Specifications*. At least five specimens will be tested for each test method. Specimens will be selected alternately by test from the samples (i.e., peel, shear, peel, shear...). A

passing test will meet the minimum required values in at least four out of five specimens.

The CQA Laboratory will provide test results no more than 24 hours after they receive the samples. The CQA Site Manager will review laboratory test results as soon as they become available, and make appropriate recommendations to the Project Manager.

Geosynthetic Installer's Laboratory Testing

The Geosynthetic Installer's laboratory test results will be presented to the Project Manager and the CQA Site Manager for comments.

Procedures for Destructive Test Failure

The following procedures will apply whenever a sample fails a destructive test, whether that test conducted by the CQA Laboratory, the Geosynthetic Installer's laboratory, or by gauged tensiometer in the field. The Geosynthetic Installer has two options:

- The Geosynthetic Installer can reconstruct the seam between two passed test locations.

- The Geosynthetic Installer can trace the welding path to an intermediate location at 10 ft (3 m) minimum from the point of the failed test in each direction and take a small sample for an additional field test at each location. If these additional samples pass the test, then full laboratory samples are taken. If these laboratory samples pass the tests, then the seam is reconstructed between these locations. If either sample fails, then the process is repeated to establish the zone in which the seam should be reconstructed.

Acceptable seams must be bounded by two locations from which samples passing laboratory destructive tests have been taken. In cases where the failed seam segment exceeds 150 ft (50 m), a destructive sample will be taken from the zone in which the seam has been reconstructed. Repairs will be made in general accordance with Section 10.4.5.

The CQA Site Manager will document actions taken in conjunction with destructive test failures.

10.4.5 Defects and Repairs

This section prescribes CQA activities to document that defects, tears, rips, punctures, damage, or failing seams shall be repaired.

10.4.5.1 Identification

Seams and non-seam areas of the geomembrane will be examined by the CQA Site Manager for identification of defects, holes, blisters, undispersed raw materials and signs of contamination by foreign matter. Because light reflected by the geomembrane helps to detect defects, the surface of the geomembrane will be clean at the time of examination.

10.4.5.2 Evaluation

Each suspect location both in seam and non-seam areas will be non-destructively tested using the methods described in Section 10.4.4.9 as appropriate. Each location that fails the nondestructive testing will be marked by the CQA Site Manager and repaired by the Geosynthetic Installer. Work will not proceed with any materials that will cover locations which have been repaired until laboratory test results with passing values are available.

10.4.5.3 Repair Procedures

Portions of the geomembrane exhibiting a flaw, or failing a destructive or nondestructive test, will be repaired. Several procedures exist for the repair of these areas. The final decision as to the appropriate repair procedure will be at the discretion of the CQA Consultant with input from the Project Manager and Geosynthetic Installer. The procedures available include:

- patching, used to repair large holes, tears, undispersed raw materials, and contamination by foreign matter;

- grinding and re-welding, used to repair small sections of extruded seams;

- spot welding or seaming, used to repair small tears, pinholes, or other minor, localized flaws;

- capping, used to repair large lengths of failed seams;

- removing bad seam and replacing with a strip of new material welded into place (used with large lengths of fusion seams).

In addition, the following provisions will be satisfied:

- surfaces of the geomembrane which are to be repaired will be abraded no more than 20 minutes prior to the repair;

- surfaces must be clean and dry at the time of the repair;

- all seaming equipment used in repairing procedures must be approved;

- the repair procedures, materials, and techniques will be approved in advance by the CQA Consultant with input from the Project Manager and Geosynthetic Installer;

- patches or caps will extend at least 6 in. (150 mm) beyond the edge of the defect, and all corners of patches will be rounded with a radius of at least 3 in. (75 mm); and

- the geomembrane below large caps should be appropriately cut to avoid water or gas collection between the two sheets.

10.4.5.4 Verification of Repairs

Each repair will be numbered and logged. Each repair will be non-destructively tested using the methods described in Section 10.4.4.9 as appropriate.

Repairs that pass the non- destructive test will be taken as an indication of an adequate repair. Large caps may be of sufficient extent to require destructive test sampling, at the discretion of the CQA Site Manager. Failed tests indicate that the repair will be redone and re-tested until a passing test results. The CQA Site Manager will observe all non-destructive testing of repairs and will record the number of each repair, date, and test outcome.

10.4.5.5 Large Wrinkles

When seaming of the geomembrane is completed (or when seaming of a large area of the geomembrane liner is completed) and prior to placing overlying materials, the CQA Site Manager will observe the geomembrane wrinkles. The CQA Site Manager will indicate to the Project Manager which wrinkles should be cut and re-seamed by the Geosynthetic Installer. The seam thus produced will be tested like any other seam.

10.4.6 Lining System Acceptance

The Geosynthetic Installer and the Manufacturer(s) will retain all responsibility for the geosynthetic materials in the liner system until acceptance by the Owner.

The geosynthetic liner system will be accepted by the Owner when:

- the installation is finished;
- verification of the adequacy of all seams and repairs, including associated testing, is complete;
- all documentation of installation is completed including the CQA Site Manager's acceptance report; and
- CQA report, including "as built" drawing(s), sealed by a registered professional engineer has been received by the Project Manager.

The CQA Site Manager will document that installation has proceeded in general accordance with the *Technical Specifications* for the project except as noted to the Project Manager.

11. GEOTEXTILE

11.1 Introduction

This section of the CQA Plan outlines the CQA activities to be performed for the geotextile installation. The CQA Consultant will review the *Drawings*, and the *Technical Specifications*, and any approved addenda or changes.

11.2 Manufacturing

The Manufacturer will provide the Project Manager with a list of guaranteed "minimum average roll value" properties (defined as the mean less two standard deviations), for each type of geotextile to be delivered. The Manufacturer will also provide the Project Manager with a written quality control certification signed by a responsible party employed by the Manufacturer that the materials actually delivered have property "minimum average roll values" which meet or exceed all property values guaranteed for that type of geotextile.

The quality control certificates will include:

- roll identification numbers; and
- results of quality control testing.

The Manufacturer will provide, as a minimum, test results for the following:

- mass per unit area (cushion geotextile only);
- grab strength (cushion and filtration geotextiles only);
- tear strength (cushion and filtration geotextiles only);
- burst strength (cushion and filtration geotextiles only);
- puncture strength (cushion and filtration geotextiles only);
- wide width tensile strength (UV protection geotextile only);
- permittivity (filtration geotextile only); and
- apparent opening size (filtration and UV protection geotextiles only).

Quality control tests must be performed, in general accordance with the test methods specified in Table 9, on geotextile produced for the project. The Manufacturer

will also provide a written certification that the nonwoven, needle-punched geotextiles are continuously inspected and found to be needle-free.

The CQA Site Manager will examine Manufacturer certifications to evaluate that the property values listed on the certifications meet or exceed those specified for the particular type of geotextile and the measurements of properties by the Manufacturer are properly documented, test methods acceptable and the certificates have been provided at the specified frequency properly identifying the rolls related to testing. Deviations will be reported to the Project Manager.

11.3 Labeling

The Manufacturer will identify all rolls of geotextile with the following:

- manufacturer's name;
- product identification;
- lot number;
- roll number; and
- roll dimensions.

The CQA Site Manager will examine rolls upon delivery and deviation from the above requirements will be reported to the Project Manager.

11.4 Shipment and Storage

During shipment and storage, the geotextile will be protected from ultraviolet light exposure, precipitation or other inundation, mud, dirt, dust, puncture, cutting or any other damaging or deleterious conditions. To that effect, geotextile rolls will be shipped and stored in relatively opaque and watertight wrappings.

Protective wrappings will be removed less than one hour prior to unrolling the geotextile. After the wrapping has been removed, a geotextile will not be exposed to sunlight for more than 15 days, except for UV protection geotextile, unless otherwise specified and guaranteed by the Manufacturer.

The CQA Site Manager will observe rolls upon delivery at the site and deviation from the above requirements will be reported to the Project Manager.

11.5 Conformance Testing

11.5.1 Tests

Upon delivery of the rolls of geotextiles, the CQA Site Manager will document that samples are removed and forwarded to the Geosynthetics CQA Laboratory for testing to evaluate conformance to *Technical Specifications*. Required test and testing frequency for the geotextiles are presented in Table 9.

These conformance tests will be performed in general accordance with the test methods specified in the *Technical Specifications*.

11.5.2 Sampling Procedures

Samples will be taken across the width of the roll and will not include the first three feet (linear meter). Unless otherwise specified, samples will be 3 ft (1 m) long by the roll width. The CQA Site Manager will mark the machine direction on the samples with an arrow.

Unless otherwise specified, samples will be taken at a rate as indicated in Table 9 for geotextiles.

11.5.3 Test Results

The CQA Site Manager will examine results from laboratory conformance testing and will report non-conformance to the Project Manager.

11.5.4 Conformance Sample Failure

The following procedure will apply whenever a sample fails a conformance test that is conducted by the CQA Laboratory:

- The Manufacturer will replace every roll of geotextile that is in nonconformance with the *Technical Specifications* with a roll(s) that meets *Technical Specifications*.

- The Geosynthetic Installer will remove conformance samples for testing by the CQA Laboratory from the closest numerical rolls on both sides of the failed roll. These two samples must conform to the *Technical Specifications*. If either of these samples fail, the numerically closest rolls on the side of the failed sample will be tested by the CQA Laboratory. These samples must conform to the *Technical Specifications*. If any of these samples fail, every roll of geotextile on site from this lot and every subsequently delivered roll that is from the same lot must be tested by the CQA Laboratory for conformance to the *Technical Specifications*. This additional conformance testing will be at the expense of the Manufacturer.

The CQA Site Manager will document actions taken in conjunction with conformance test failures.

11.6 Handling and Placement

The Geosynthetic Installer will handle all geotextiles in such a manner as to document they are not damaged in any way, and the following will be complied with:

- On slopes, the geotextiles will be securely anchored in the anchor trench and then rolled down the slope in such a manner as to continually keep the geotextile sheet in tension.

- In the presence of wind, all geotextiles will be weighted with sandbags or the equivalent. Such sandbags will be installed during placement and will remain until replaced with earth cover material.

- Geotextiles will be cut using an approved geotextile cutter only. If in place, special care must be taken to protect other materials from damage, which could be caused by the cutting of the geotextiles.

- The Geosynthetic Installer will take all necessary precautions to prevent damage to underlying layers during placement of the geotextile.

- During placement of geotextiles, care will be taken not to entrap in the geotextile stones, excessive dust, or moisture that could damage the geotextile, generate clogging of drains or filters, or hamper subsequent seaming.

- A visual examination of the geotextile will be carried out over the entire surface, after installation, to document that no potentially harmful foreign objects, such as needles, are present.

The CQA Site Manager will note non-compliance and report it to the Project Manager.

11.7 Seams and Overlaps

All geotextiles will be continuously sewn in accordance with *Technical Specifications*. Geotextiles will be overlapped 6 in. (0.15 m) prior to seaming. No horizontal seams will be allowed on side slopes (i.e. seams will be along, not across, the slope), except as part of a patch.

Sewing will be done using polymeric thread with chemical and ultraviolet resistance properties equal to or exceeding those of the geotextile.

11.8 Repair

Holes or tears in the geotextile will be repaired as follows:

- On slopes: A patch made from the same geotextile will be double seamed into place. Should a tear exceed 10 percent of the width of the roll, that roll will be removed from the slope and replaced.

- Non-slopes: A patch made from the same geotextile will be spot-seamed in place with a minimum of 6 in. (0.60 m) overlap in all directions.

Care will be taken to remove any soil or other material that may have penetrated the torn geotextile.

The CQA Site Manager will observe any repair, note any non-compliance with the above requirements and report them to the Project Manager.

11.9 Placement of Soil or Aggregate Materials

The Contractor will place all soil or aggregate materials located on top of a geotextile, in such a manner as to document:

- no damage of the geotextile;
- minimal slippage of the geotextile on underlying layers; and
- no excess tensile stresses in the geotextile.

Unless otherwise specified by the Engineer, all lifts of soil material will be in conformance with the following guidelines:

Equipment Ground Pressure		**Minimum Loose Lift Thickness**	
Psi	**kPa**	**in.**	**m**
<10	< 68	12	0.30
<20	< 138	24	0.60
>20	> 138	36	0.90

If portions of the geotextile are exposed, the CQA Site Manager will periodically place two (or more, at his discretion) marks on the geotextile 10 ft (3 m) apart along the slope and measure the elongation of the geotextile during the placement of soil. This elongation will be related, by the Engineer, to the tensile stress in the geotextile.

Non-compliance will be noted by the CQA Site Manager and reported to the Project Manager.

12. GEOSYNTHETIC CLAY LINER (GCL)

12.1 Introduction

This section of the CQA Plan outlines the CQA activities to be performed for the geosynthetic clay liner (GCL) installation. The CQA Consultant will review the *Drawings*, and the *Technical Specifications*, and approved addenda or changes.

12.2 Manufacturing

The Manufacturer will provide the Project Manager with a list of guaranteed "minimum average roll value" properties (defined as the mean less two standard deviations), for the GCL to be delivered. The Manufacturer will also provide the Project Manager with a written quality control certification signed by a responsible party employed by the Manufacturer that the materials actually delivered have property "minimum average roll values" which meet or exceed all property values guaranteed for that GCL.

The quality control certificates will include:

- roll identification numbers; and
- results of quality control testing.

The Manufacturer will provide, as a minimum, test results for the following:

- mass per unit area; and
- index flux.

Quality control tests must be performed, in general accordance with the test methods specified in Table 10, on GCL produced for the project.

The CQA Site Manager will examine Manufacturer certifications to verify that the property values listed on the certifications meet or exceed those specified for the GCL and the measurements of properties by the Manufacturer are properly documented, test methods acceptable and the certificates have been provided at the

specified frequency properly identifying the rolls related to testing. Deviations will be reported to the Project Manager.

12.3 Labeling

The Manufacturer will identify all rolls of GCL with the following:

- manufacturer's name;
- product identification;
- lot number;
- roll number; and
- roll dimensions.

The CQA Site Manager will examine rolls upon delivery and deviation from the above requirements will be reported to the Project Manager.

12.4 Shipment and Storage

During shipment and storage, the GCL will be protected from ultraviolet light exposure, precipitation or other inundation, mud, dirt, dust, puncture, cutting or any other damaging or deleterious conditions. To that effect, GCL rolls will be shipped and stored in relatively opaque and watertight wrappings.

The CQA Site Manager will observe rolls upon delivery at the site and any deviation from the above requirements will be reported to the Project Manager.

12.5 Conformance Testing

12.5.1 Tests

CQA personnel will sample the GCL either during production at the manufacturing facility or after delivery to the construction site. The samples will be forwarded to the Geosynthetics CQA Laboratory for testing to assess conformance with the *Technical Specifications*. The test methods and minimum testing frequencies are indicated in Table 10.

Samples will be taken across the width of the roll and will not include the first 3 ft (0.9 m) if the sample is cut on site. Unless otherwise specified, samples will be 3 ft (0.9 m) long by the roll width. The CQA Consultant will mark the machine direction with an arrow and the manufacturer's roll number on each sample.

The CQA Site Manager will examine results from laboratory conformance testing and will report non-conformance to the Project Manager.

12.5.2 Conformance Sample Failure

The following procedure will apply whenever a sample fails a conformance test that is conducted by the CQA Laboratory:

- The Manufacturer will replace every roll of GCL that is in nonconformance with the *Technical Specifications* with a roll(s) that meets *Technical Specifications*.

- The Geosynthetic Installer will remove conformance samples for testing by the CQA Laboratory from the closest numerical rolls on both sides of the failed roll. These two samples must conform to the *Technical Specifications*. If either of these samples fail, the numerically closest rolls on the side of the failed sample will be tested by the CQA Laboratory. These samples must conform to the *Technical Specifications*. If any of these samples fail, every roll of GCL on site from this lot and every subsequently delivered roll that is from the same lot must be tested by the CQA Laboratory for conformance to the *Technical Specifications*. This additional conformance testing will be at the expense of the Manufacturer.

The CQA Site Manager will document actions taken in conjunction with conformance test failures.

12.6 <u>GCL Delivery and Storage</u>

Upon delivery to the site, the CQA Consultant will check the GCL rolls for defects (e.g., tears, holes) and for damage. The CQA Consultant will report to the Project Manager and the Geosynthetics Installer:

- any rolls, or portions thereof, which should be rejected and removed from the site because they have severe flaws; and

- any rolls which include minor repairable flaws.

The GCL rolls delivered to the site will be checked by the CQA Consultant to document that the roll numbers correspond to those on the approved Manufacturer's quality control certificate of compliance.

12.7 GCL Installation

The CQA Consultant will monitor and document that the GCL is installed in general accordance with the *Drawings* and the *Technical Specifications*. The Geosynthetics Installer shall provide the CQA Consultant a certificate of subgrade acceptance prior to the installation of the GCL as outlined in the *Technical Specifications*. The GCL installation activities to be monitored and documented by the CQA Consultant include:

- monitoring that the GCL rolls are stored and handled in a manner which does not result in any damage to the GCL;

- monitoring that the GCL is not exposed to UV radiation for extended periods of time without prior approval;

- monitoring that the GCL are seamed in general accordance with the *Technical Specifications* and the Manufacturer's recommendations;

- monitoring and documenting that the GCL is installed on an approved subgrade, free of debris, protrusions, or uneven surfaces;

- monitoring that the GCL is not installed on a saturated subgrade or standing water and is not exposed such that it is hydrated prior to completion of the construction; and

- monitoring that any damage to the GCL is repaired as outlined in the *Technical Specifications*.

The CQA Site Manager will note non-compliance and report it to the Project Manager.

13. GEOCOMPOSITE

13.1 Introduction

This section of the CQA Plan outlines the CQA activities to be performed for the geocomposite installation. The CQA Consultant will review the *Drawings*, and the *Technical Specifications*, and any approved addenda or changes.

13.2 Manufacturing

The Manufacturer will provide the CQA Consultant with a list of certified "minimum average roll value" properties for the type of geocomposite to be delivered. The Manufacturer will also provide the CQA Consultant with a written certification signed by a responsible representative of the Manufacturer that the geocomposite actually delivered have "minimum average roll values" properties which meet or exceed all certified property values for that type of geocomposite.

The CQA Consultant will examine the Manufacturers' certifications to document that the property values listed on the certifications meet or exceed those specified for the particular type of geocomposite (geotextile and geonet). Deviations will be reported to the Project Manager.

13.3 Labeling

The Manufacturer will identify all rolls of geocomposite with the following:

- Manufacturer's name;
- product identification;
- lot number;
- roll number; and
- roll dimensions.

The CQA Site Manager will examine rolls upon delivery and deviation from the above requirements will be reported to the Project Manager.

13.4 Shipment and Storage

During shipment and storage, the geocomposite will be protected from ultraviolet light exposure, precipitation or other inundation, mud, dirt, dust, puncture, cutting or any other damaging or deleterious conditions. Therefore, geocomposite rolls will be shipped and stored in relatively opaque and watertight wrappings. The CQA Site Manager will observe rolls upon delivery to the site and deviation from the above requirements will be reported to the Project Manager. Damaged rolls will be rejected and replaced.

Wrapping protecting geocomposite rolls will be removed less than one hour prior to unrolling geocomposite before placement. After the wrapping has been removed, geocomposite should not be exposed to sunlight for more than 15 days, unless otherwise approved by the Manufacturer. Approval by the Manufacturer will be a guarantee that the properties of the exposed geotextile will not degrade upon prolonged exposure to such values that would cause the material to not meet the *Technical Specifications*. Any material that is exposed for more than 15 days, which has been approved for prolonged exposure by the Manufacturer, will be tested by the CQA Laboratory to document that the material properties are still in conformance with the *Technical Specifications*. Any material that fails to meet the *Technical Specifications* will be replaced by the Manufacturer.

The CQA Site Manager will observe that geocomposite is free of dirt and dust just before installation. The CQA Site Manager will report the outcome of this observation to the Project Manager, and if the geocomposite is judged dirty or dusty, they will be cleaned by the Geosynthetic Installer prior to installation.

13.5 Conformance Testing

13.5.1 Tests

The geocomposite material will be tested for transmissivity (ASTM D 4716) and for peel strength (ASTM D 413) at the frequencies presented in Table 11.

13.5.2 Sampling Procedures

Upon delivery of the geocomposite rolls, the CQA Site Manager will document that samples are obtained from individual rolls at the frequency specified in this CQA Plan. The geocomposite samples will be forwarded to the CQA Laboratory for testing to evaluate conformance to both the *Technical Specifications* and the list of physical properties certified by the Manufacturer.

Samples will be taken across the width of the roll and will not include the first 3 linear ft (1 linear m). Unless otherwise specified, samples will be 3 ft (1 m) long by the roll width. The CQA Consultant will mark the machine direction on the samples with an arrow.

13.5.3 Test Results

The CQA Site Manager will examine results from laboratory conformance testing and compare results to the *Technical Specifications*. The criteria used to evaluate acceptability are presented in the *Technical Specifications*. The CQA Site Manager will report any nonconformance to the Project Manager.

13.5.4 Conformance Test Failure

The following procedure will apply whenever a sample fails a conformance test that is conducted by the CQA Laboratory:

- The Manufacturer will replace every roll of geocomposite that is in nonconformance with the *Technical Specifications* with a roll that meets specifications.

- The Geosynthetic Installer will remove conformance samples for testing by the CQA Laboratory from the closest numerical rolls on both sides of the failed roll. These two samples must conform to the *Technical Specifications*. If either of these samples fail, the numerically closest rolls on the side of the failed sample that is not tested, will be tested by the CQA Laboratory. These samples must conform to the *Technical Specifications*. If any of these samples fail, every roll of geocomposite on site from this lot and every

subsequently delivered roll that is from the same lot must be tested by the CQA Laboratory for conformance to the *Technical Specifications*.

The CQA Site Manager will document actions taken in conjunction with conformance test failures.

13.6 Handling and Placement

The Geosynthetic Installer will handle all geocomposite in such a manner as to document they are not damaged in any way. The Geosynthetic Installer will comply with the following:

- In the presence of wind, the geocomposite will be weighted with sandbags or the equivalent. Sandbags will be used during installation only and will remain until replaced with the appropriate cover material.

- If in place, special care must be taken to protect other materials from damage, which could be caused by the cutting of the geocomposite.

- The Geosynthetic Installer will take any necessary precautions to prevent damage to underlying layers during placement of the geocomposite.

- During placement of geocomposite, care will be taken to prevent entrapment of dirt or excessive dust that could cause clogging of the drainage system, and/or stones that could damage the adjacent geomembrane. If dirt or excessive dust is entrapped in the geocomposite, it should be cleaned prior to placement of the next material on top of it. In this regard, care should be taken with the handling or sandbags, to prevent rupture or damage of the sandbag.

- A visual examination of the geocomposite will be carried out over the entire surface, after installation to document that no potentially harmful foreign objects are present.

The CQA Site Manager will note noncompliance and report it to the Project Manager.

13.7 Drainage composite Seams and Overlaps

Adjacent geocomposite panels will be joined in general accordance with *Construction Drawings* and *Technical Specifications*. As a minimum, the following requirements will be met:

- Adjacent rolls will be overlapped by at least 4 in. (100 mm).
- Each component of the geocomposite will be secured or seamed to the like component at overlaps.
- The geocomposite overlaps will be secured by tying, in general accordance with the *Technical Specifications*.
- The bottom layers of geotextile will be overlapped.
- The top layers of geotextile will be continuously sewn.

The CQA Consultant will note any noncompliance and report it to the Project Manager.

13.8 Repair

Holes or tears in the geocomposite will be repaired by placing a patch extending 2 ft (0.6 m) beyond edges of the hole or tear. The patch will be secured by tying with approved tying devices every 6 in. (150 mm) through the bottom geotextile and the geonet of the patch, and through the top geotextile and geonet components of the geocomposite needing repair. The top geotextile component of the patch will be heat sealed to the top geotextile of the geocomposite needing repair. If the hole or tear width across the roll is more than 50 percent of the width of the roll, the damaged area will be cut out and the two portions of the geocomposite will be joined in general accordance with Section 13.7.

The CQA Site Manager will observe repairs, note noncompliances with the above requirements and report them to the Project Manager.

13.9 Placement of Soil Materials

The Contractor will place all soil materials located on top of a geocomposite in such a manner as to document:

- the geocomposite and underlying liner materials are not damaged;
- minimal slippage of the geocomposite on underlying layers occurs; and
- no excess tensile stresses occur in the geocomposite.

Unless otherwise specified by the CQA Consultant, lifts of soil material will be in conformance with the *Technical Specifications*. If portions of the geocomposite are exposed, the CQA Consultant will periodically place marks on the geocomposite and the underlying geomembrane and measure the elongation of the geonet during the placement of soil.

Noncompliance will be noted by the CQA Consultant and reported to the Project Manager.

14. SURVEYING

14.1 Survey Control

Survey control will be performed by the Owner as needed. A permanent benchmark will be established for the site(s) in a location convenient for daily tie-in. The vertical and horizontal control for this benchmark will be established within normal land surveying standards.

14.2 Precision and Accuracy

A wide variety of survey equipment is available for the surveying requirements for these projects. The survey instruments used for this work should be sufficiently precise and accurate to meet the needs of the projects. Surveys shall be performed at 2nd order accuracy.

14.3 Lines and Grades

The following surfaces will be surveyed to verify the lines and grades achieved during soil placement and compaction.

- Excavation:
  - original grade surface;
  - completed excavation surface prior to fill placement.
- Engineered Fill:
  - subgrade surface; and
  - finished compacted engineered fill surface.
- Prepared Subgrade:
  - prepared subgrade surface.

The following structures will be surveyed to verify and document the lines and grades achieved during construction of the Project:

- all culverts, inlet, and drop structures;
- ditch bottoms and sideslopes;
- permanent erosion control features;
- geomembrane terminations and selected geomembrane seams, as indicated by the CQA Manager; and
- centerlines of pipes.

14.4 Frequency and Spacing

Surveying should be carried out immediately upon completion of a given installation to facilitate progress and avoid delaying commencement of the next installation. In addition, spot checks during placement and compaction will be necessary to assist the Contractor in compliance with required grades.

At the least the following minimum spacings and locations should be provided for survey points:

- all "flat" surfaces, such as the base of the landfill, with gradients less than 10 percent, should be surveyed on a square grid not wider spaced than 100 ft (30 m);
- on all slopes greater than 10 percent, a square grid not wider than 100 ft (30 m) should be used, but in any case, a line at the crest, midpoint, and toe of the slope should be taken;
- a line of survey points no further than 100 ft (30 m) apart must be taken along any slope break (this will include the inside edge and outside edge of any bench on a slope); and
- a line of survey points no further than 50 ft (15 m) apart must be taken at the invert of pipes or other appurtenances to the liner.

14.5 Documentation

Field survey notes should be retained by the Land Surveyor. The findings from the field surveys should be documented on a set of Survey Record Drawings, which shall be provided to the Engineer in AutoCADD 2000 format or other suitable format as directed by the Owner.

TABLE 1
TEST PROCEDURES FOR THE EVALUATION OF SOILS

TEST METHOD	DESCRIPTION	TEST STANDARD
Laboratory Test Procedures:		
Classification	Classification of Soils	ASTM D 2487
Modified Proctor	Moisture/Density Relationship of Soil (10 lb (4.54 kg) rammer and 18 in. (457 mm) drop)	ASTM D 1557
Hydrometer Analysis	Particle Size Distribution of Fine Fraction of Soils	ASTM D 422
Sieve Analysis	Particle Size Distribution of Coarse Fraction of Soils	ASTM D 422
Field Test Procedures:		
Nuclear Densometer	In Situ Soil Unit Weight In Situ Moisture Content	ASTM D 2922 ASTM D 3017
Sand Cone	In Situ Soil Unit Weight Moisture Content	ASTM D 1556 ASTM D 2216
Drive Cylinder	In Situ Soil Unit Weight Moisture Content	ASTM D 2937 ASTM D 2216

TABLE 2

MINIMUM SOILS TESTING FREQUENCIES FOR MATERIAL QUALIFICATION TESTING

TEST	ENGINEERED FILL
Sieve Analysis	1 per source
Hydrometer Analysis	1 per source
Soil Classification	1 per source
Modified Proctor	1 per source

TABLE 3

MINIMUM SOILS TESTING FREQUENCIES FOR CONFORMANCE TESTING

TEST	ENGINEERED FILL
Sieve Analysis	1 per 10,000 yd^3 (7,646 m^3)
Hydrometer Analysis	1 per 10,000 yd^3 (7,646 m^3)
Soil Classification	1 per 10,000 yd^3 (7,646 m^3)
Modified Proctor	1 per 10,000 yd^3 (7,646 m^3)

TABLE 4

MINIMUM SOIL TESTING FREQUENCIES FOR CONSTRUCTION QUALITY CONTROL

TEST	ENGINEERED FILL
Nuclear densometer	1 per 500 yd^3 (76 m^3)
Sand cone or drive cylinder	1 per 20 nuclear densometer tests

TABLE 5

TEST PROCEDURES FOR THE EVALUATION OF AGGREGATE

TEST METHOD	DESCRIPTION	TEST STANDARD
Sieve Analysis	Particle Size Distribution of Fine and Coarse Aggregates	ASTM C 136
Hydraulic Conductivity (Rigid Wall Permeameter)	Permeability of Aggregates	ASTM D 2434

TABLE 6

MINIMUM AGGREGATE TESTING FREQUENCIES FOR MATERIAL QUALIFICATION TESTING

TEST	DRAINAGE AGGREGATE
Sieve Analysis	1 per source
Hydraulic Conductivity	1 per source

TABLE 7

MINIMUM AGGREGATE TESTING FREQUENCIES FOR CONFORMANCE TESTING

TEST	TEST METHOD	DRAINAGE AGGREGATE
Sieve Analysis	ASTM C 136	1 per 5,000 yd^3 (3,823 m^3)
Hydraulic Conductivity	ASTM D 2434	1 per 10,000 yd^3 (7,646 m^3)

TABLE 8

GEOMEMBRANE CONFORMANCE TESTING REQUIREMENTS

TEST NAME	TEST METHOD	FREQUENCY
Specific Gravity	ASTM D 792 Method A or ASTM D 1505	100,000 ft^2 (9,290 m^2)
Thickness	ASTM D 5994	100,000 ft^2 (9,290 m^2)
Tensile Strength at Yield	ASTM D 638	100,000 ft^2 (9,290 m^2)
Tensile Strength at Break	ASTM D 638	100,000 ft^2 (9,290 m^2)
Elongation at Yield	ASTM D 638	100,000 ft^2 (9,290 m^2)
Elongation at Break	ASTM D 638	100,000 ft^2 (9,290 m^2)
Carbon Black Content	ASTM D 1603	100,000 ft^2 (9,290 m^2)
Carbon Black Dispersion	ASTM D 5596	100,000 ft^2 (9,290 m^2)

TABLE 9

GEOTEXTILE CONFORMANCE TESTING REQUIREMENTS

TEST NAME	TEST METHOD	MINIMUM FREQUENCY CUSHION	MINIMUM FREQUENCY FILTRATION	MINIMUM FREQUENCY UV PROTECTION
Mass per Unit Area	ASTM D 5261	1 test per 200,000 ft^2 (18,580 m^2)	---	---
Grab Strength	ASTM D 4632	1 test per 200,000 ft^2 (18,580 m^2)	1 test per 200,000 ft^2 (18,580 m^2)	---
Puncture Resistance	ASTM D 4833	1 test per 200,000 ft^2 (18,580 m^2)	1 test per 200,000 ft^2 (18,580 m^2)	---
Permittivity	ASTM D 4491	---	1 test per 200,000 ft^2 (18,580 m^2)	---
Apparent Opening Size	ASTM D 4751	---	1 test per 200,000 ft^2 (18,580 m^2)	1 test per 200,000 ft^2 (18,580 m^2)
Wide Width Tensile	ASTM D 4595	---	---	1 test per 200,000 ft^2 (18,580 m^2)

TABLE 10

GCL CONFORMANCE TESTING REQUIREMENTS

TEST NAME	TEST METHOD	MINIMUM FREQUENCY
Mass per Unit Area	ASTM D 3776	100,000 ft^2 (9,290 m2)
Index Flux	ASTM D 5887	400,000 ft^2 (37,160 m^2)
Residual Shear Strength	ASTM D 5321	See Technical Specifications

TABLE 11

GEOCOMPOSITE CONFORMANCE TESTING REQUIREMENTS

TEST NAME	TEST METHOD	MINIMUM FREQUENCY
Peel Strength	ASTM D 413	1 test per 200,000 ft^2 (18,580 m^2)
Hydraulic Transmissivity	ASTM D 4716	1 test per 200,000 ft^2 (18,580 m^2)

Note: Testing will be carried out at a frequency of one per lot or at listed frequency, whichever yields the greater number of samples.

Section 4
Base Liner Technical Specifications

TECHNICAL SPECIFICATIONS
FOR THE
CONSTRUCTION OF

BASE LINER SYSTEM
AT
CORRECTIVE ACTION MANAGEMENT UNIT
BASIC REMEDIATION COMPANY
HENDERSON, NEVADA

Prepared for:

Basic Remediation Company
875 West Warm Springs Road
Henderson, Nevada 89015
(702) 567-0400

Prepared by:

GeoSyntec Consultants
11305 Rancho Bernardo Road, Suite 101
San Diego, California 92127
(858) 674-6559

3 November 2006

TABLE OF CONTENTS

Section 02110	**—**	**Site Clearing**
Section 02200	**—**	**Earthwork**
Section 02225	**—**	**Drainage Aggregate**
Section 02711	**—**	**Polyethylene Pipe**
Section 02770	**—**	**Geomembrane**
Section 02771	**—**	**Geotextile**
Section 02772	**—**	**Geosynthetic Clay Liner**
Section 02773	**—**	**Geocomposite**
Section 02820	**—**	**Chain Link Fence**

SECTION 02110
SITE CLEARING

PART 1 – GENERAL

1.01 Description of Work

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, and equipment necessary to perform all work specified herein and as shown on the Drawings.

B. The Contractor shall remove and dispose of all debris, vegetation, other organic and deleterious material, and other materials not suitable for Engineered fill materials that exist within the designated construction limits.

1.02 Related Sections

Section 02200 — Earthwork

1.03 References

A. Drawings

B. Construction Quality Assurance (CQA) Plan

PART 2 – PRODUCTS

A. Not Used.

PART 3 – EXECUTION

3.01 General

A. The Contractor shall be responsible for all clearing and grubbing operations within the limits of work.

B. All vegetation, debris, deleterious and other organic material not suitable for Engineered fill materials shall be removed completely from within the construction limits.

C. No open burning of combustible materials will be allowed.

D. All materials removed during the clearing and grubbing operations shall be disposed of properly.

E. Prior to site clearing, Contractor shall have implemented erosion control plan.

PART 4 – MEASUREMENT AND PAYMENT

4.01 General

A. Providing for and complying with the requirements set forth in this Section for Clearing and Grubbing will be incidental to earthworks (Section 02200).

B. The following are considered incidental to the Work:

- Mobilization
- Layout survey

END OF SECTION

SECTION 02200
EARTHWORK

PART 1 – GENERAL

1.01 Description of Work

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, equipment, and incidentals necessary to perform all Earthwork. The work shall be carried out as specified herein and in accordance with the Drawings.

B. The Work shall include, but not be limited to excavating, hauling, placing, moisture conditioning, backfilling, compacting, grading, stockpiling, surcharging, and subgrade preparation. Earthwork shall conform to the dimensions, lines, grades and sections shown on the Drawings or as directed by the Engineer.

1.02 Related Sections

Section 02110 — Site Clearing

Section 02771 — Geotextile

Section 02772 — Geosynthetic Clay Liner

Section 02773 — Geocomposite

1.03 References

A. Drawings

B. Construction Quality Assurance (CQA) Plan

C. Latest version of American Society for Testing and Materials (ASTM) standards:

ASTM D 422	Standard Method for Particle-Size Analysis of Soils
ASTM D 1557	Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3))
ASTM D 2216	Standard Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures
ASTM D 2487	Standard Test Method for Classification of Soils for Engineering Purposes
ASTM D 2922	Standard Test Methods for Density of Soil and Soil-Aggregate In-Place by Nuclear Density Methods (Shallow Depth)
ASTM D 3017	Standard Test Method for Water Content of Soil and Rock In-Place by Nuclear Methods (Shallow Depth)

1.04 Submittals

A. The Contractor shall submit to the Engineer a description of equipment and methods proposed for Engineered Fill, Operations Layer, Anchor Trench Backfill, and Prepared Subgrade placement and compaction at least 7 days prior to the start of activities covered by this Section.

B. If the work of this Section is interrupted for reasons other than inclement weather, the Contractor shall notify the Engineer a minimum of 24 hours prior to the resumption of work.

C. The Contractor shall provide the Engineer with sufficient time to perform as-built surveys of the completed excavation, engineered fill, prepared subgrade, and operations layer.

D. If foreign borrow materials are proposed for any earthwork material on this project, the Contractor shall provide the Engineer information regarding the source of the material. In addition, the Contractor shall provide the Engineer an opportunity to obtain the necessary samples for conformance testing, prior to delivery of foreign borrow materials to the site.

1.05 Quality Assurance

A. The Contractor shall ensure that the materials and methods used for Earthwork meet the requirements of the Drawings and this Section. Any material or method that does not conform to these documents, or to alternatives approved in writing by the Engineer will be rejected and shall be repaired or replaced by the Contractor.

B. The Contractor shall be aware of and accommodate all monitoring and field/laboratory conformance testing required by the CQA Plan. This monitoring and testing, including random conformance testing of construction materials and completed work, will be performed by the Engineer. If nonconformances or other deficiencies are found in the materials or completed work, the Contractor will be required to repair the deficiency or replace the deficient materials.

PART 2 – PRODUCTS

2.01 Materials

A. Engineered fill shall consist of relatively homogeneous, natural soils that are free of debris, foreign objects, large rock fragments (greater than 6 inches in maximum dimension), roots, and organics. No materials larger than 6 inches shall be allowed within the Engineered fill. The Engineered fill shall be classified according to the Unified Soil Classification System (per ASTM D 2487) as SC, ML, CL, SM, SW, SP, GW, GP, GM, GC, or combinations of these materials. The Contractor may propose the use of other soil types as Engineered fill, but then such use shall be at the sole discretion of the Engineer.

B. Prepared subgrade is defined as the material directly underlying the geosynthetic liner system which shall meet the requirements listed above for Engineered fill. No materials larger than 3/4 inch shall project or protrude from the surface of the prepared subgrade.

C. Anchor Trench Backfill materials shall meet the requirements listed above for the Engineered fill.

D. Operations Layer materials shall meet the requirements listed above for the Engineered fill, except that the 12 inches of layer material to be placed overlying the geocomposite shall have a maximum particle size of 1 inch.

E. Surcharge materials shall have a minimum wet density, as compacted in place of 135 pounds per cubic foot.

2.02 Equipment

A. The Contractor shall furnish, operate, and maintain compaction equipment as is necessary to produce the required in-place soil density and moisture content.

B. The Contractor shall furnish, operate and maintain tank trucks, pressure distributors, or other equipment designed to apply water uniformly and in controlled quantities to variable surface widths.

C. The Contractor shall furnish, operate, and maintain miscellaneous equipment such as scarifiers or disks, earth excavating equipment, earth hauling equipment, and other equipment, as necessary for Earthwork construction.

PART 3 – EXECUTION

3.01 Familiarization

A. Prior to implementing any of the work in this Section, the Contractor shall become thoroughly familiar with the site, the site conditions, and all portions of the work falling within this and other related Sections.

B. Inspection:

- The Contractor shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the installation of the work specified in this Section may properly commence without adverse impact.

- If the Contractor has any concerns regarding the installed work of other Sections, the Engineer shall be notified in writing prior to commencing work. Failure to notify the Engineer or continuance of the work of this Section will be construed as Contractor's acceptance of the related work of all other Sections.

3.02 Site Preparation

A. The Contractor shall perform clearing and grubbing in accordance with the Drawings and Section 02110 of these Specifications prior to any Earthwork activity.

B. Prior to performing any earthworks on the site, the Contractor shall perform a baseline topographic survey. This survey shall be conducted by a Professional Land Surveyor licensed in the state of Nevada. This survey will serve as the starting point for earthwork quantities, both excavation and fill placement.

3.03 General Excavation

A. The Contractor shall excavate materials to the limits and grades shown on the Drawings.

B. All excavated materials not used for Engineered fill or operations layer shall be stockpiled in an area designated by the Owner in accordance with Part 3.06 of this Section.

C. Excavations in native soil shall not have slopes steeper than 2.1H:1V, unless otherwise approved by the Engineer.

3.04 Anchor Trench Excavation

A. The Contractor shall excavate the anchor trench to the limits and grades shown on the Drawings.

B. All excavated materials not used for Anchor Trench Backfill or Engineered fill shall be stockpiled in an area designated by the Owner in accordance with Part 3.06 of this Section.

3.05 Surcharge

A. The surcharge soil shall be placed and compacted as shown on the drawings.

B. Surcharge shall have slopes no steeper than 1H:1V.

C. Settlement plates shall be installed as shown on the drawings and shall be surveyed on a weekly basis, at a minimum.

D. Surcharge shall be removed once settlement has reached levels differing no more than 5% from previous readings or no more than 0.05 feet.

3.06 Subgrade Surface Preparation

A. The subgrade shall be prepared and made suitable as a foundation for placement and compaction of soil material, where applicable. The subgrade shall be firm and able to support the Contractor's construction equipment without the development of depressions or ruts. In addition, the subgrade shall provide adequate support such that the overlying fill material may be placed and compacted to the specified density.

3.07 Prepared Subgrade

A. The prepared subgrade shall be made suitable as a foundation for placement of the geosynthetic components of the liner system (prepared subgrade). The prepared subgrade shall be firm, meet the requirements outlined in Part 2.01, and be able to support the geosynthetic components of the liner system.

3.08 Stockpiling

A. Soil shall be stockpiled in areas designated by the Owner and shall be free of incompatible soil, clearing, clearing debris, or other objectionable materials.

B. Stockpiles shall be no steeper than 2.1H:1V (Horizontal:Vertical) or other slope approved by the Engineer, graded to drain, sealed by tracking parallel to the slope with a dozer or other means approved by the Engineer, and dressed daily during periods when fill is taken from the stockpile. The Contractor shall employ temporary erosion and sediment control measures (i.e. silt fence) as directed by the Engineer around stockpile areas.

3.09 Engineered Fill And Anchor Trench Backfill

A. The Engineered fill and Anchor Trench Backfill shall be placed to the lines and grades shown on the Drawings.

B. Soil used for the Engineered fill and Anchor Trench Backfill shall meet the requirements of Part 2.01 of this Section.

C. Soil used for the Engineered fill and Anchor Trench Backfill shall be placed in a loose lift that results in a compacted lift thickness of no greater than 12 inches. The maximum permissible pre-compaction soil clod size is 6 inches.

D. Each 12-inch horizontal lift of Engineered fill placed against a slope shall be keyed into the slope a minimum of 3 feet, as measured horizontally from the top of the 12-inch lift.

E. The Contractor shall compact each lift to at least 90 percent of its modified Proctor maximum dry density (ASTM D 1557). The Contractor shall utilize compaction equipment suitable for achieving the soil compaction requirements.

F. During wetting or drying, the material shall be regularly disced or otherwise mixed so that uniform moisture conditions in the appropriate range are obtained.

3.10 Operations Layer

A. Place only when underlying drainage aggregate and filter geotextile or geocomposite installation is complete including all Construction Quality Control (CQC) and CQA work.

B. The subgrade to the operations layer consists of a geotextile or geocomposite. Therefore, the Contractor shall avoid tearing, puncturing, folding, or damaging in any way the filter geotextile or geocomposite geotextile during placement of the operations layer material.

C. Any damage to the geosynthetic liner system which is caused by the Contractor or representatives of the Contractor shall be repaired by the Geosynthetics Installer at the expense of the Contractor.

D. No density requirements are specified for placement of the operations layer material. Operations layer material shall be placed at a moisture content less than the optimum moisture content for the soil.

E. The operations layer material shall be placed out in front of the equipment used to place the operations layer such that the minimum thickness requirements are maintained at all times between the geosynthetic materials and the wheels or tracks of the equipment used to place the operations layer material.

F. Care must be exercised by the operators of tracked equipment to avoid sharp pivoting turns that could displace the operations layer material and result in damage to the liner system.

G. The Contractor shall not push operations layer material down the side slope. All soil materials shall be placed from the toe of slope upward.

H. Equipment used in spreading the operations layer material on top of the geosynthetic liner system shall be restricted to the following maximum allowable equipment ground pressures:

MAXIMUM ALLOWABLE EQUIPMENT GROUND PRESSURE (psi)	INITIAL LIFT THICKNESS OF OVERLYING AGGREGATE (ft)
<20	2.0
>20	3.0

I. The operations layer shall be placed to a maximum vertical height of 10 ft at a slope inclination no steeper than 2.5H:1V as shown on the Drawings.

3.11 Field Testing

A. The minimum frequency and details of quality control testing are provided below. This testing will be performed by the Engineer. The Contractor shall take this testing frequency into account in planning the construction schedule.

1. Engineered fill material quality control testing:

a. particle-size analyses conducted in accordance with ASTM D 422 at a frequency of one test per 10,000 yd^3;

b. soil classification tests conducted in accordance with ASTM D 2487 at a frequency of one test per 10,000 yd^3; and

c. modified Proctor compaction tests conducted in accordance with ASTM D 1557 at a frequency of one test per 10,000 yd^3.

2. The Engineer will perform conformance tests on placed and compacted Engineered fill to evaluate compliance with these Specifications. These tests will include in-situ moisture content and dry density. The frequency and procedures for moisture-density testing are given in the CQA Plan. At a minimum, the dry density and moisture content of the soil will be measured in-situ in accordance with ASTM D 2922 and ASTM D 3017, respectively.

3. A special testing frequency will be used by the Engineer when visual observations of construction performance indicate a potential problem. Additional testing will be considered when:

   a. the rollers slip during rolling operation;
   b. the lift thickness is greater than specified;
   c. the fill is at improper and/or variable moisture content;
   d. fewer than the specified number of roller passes are made;
   e. dirt-clogged rollers are used to compact the material;
   f. the rollers do not have optimum ballast; or
   g. the degree of compaction is doubtful.

4. During construction, the frequency of testing will be increased by the Engineer in the following situations:

   a. adverse weather conditions;
   b. breakdown of equipment;
   c. at the start and finish of grading;
   d. if the material fails to meet specifications; or
   e. the work area is reduced.

B. Defective Areas:

1. If a defective area is discovered in the Earthwork, the Engineer will evaluate the extent and nature of the defect. If the defect is indicated by an unsatisfactory test result, the Engineer will determine the extent of the defective area by additional tests, observations, a review of records, or other means that the Engineer deems appropriate. If the defect is related to adverse site conditions, such as overly wet soils or surface desiccation, the Engineer shall define the limits and nature of the defect.

2. Once the extent and nature of a defect is determined, the Contractor shall correct the deficiency to the satisfaction of the Engineer. The Contractor shall not perform additional work in the area until the Engineer approves the correction of the defect.

3. Additional testing may be performed by the Engineer to verify that the defect has been corrected. This additional testing will be performed before any additional work is allowed in the area of deficiency. The cost of the additional testing shall be borne by the Contractor.

3.12 Survey Control

A. The Contractor shall perform all surveys necessary for construction layout and control.

3.13 Construction Tolerance

A. The Contractor shall perform the Earthwork construction to within ±0.1 ft on areas with a slope less than 10 percent and ±0.2 ft on areas with a slope greater than 10 percent of the grades indicated on the Drawings.

3.14 Protection of Work

A. The Contractor shall use all means necessary to protect completed work of this Section.

B. At the end of each day, the Contractor shall verify that the entire work area is left in a state that promotes drainage of surface water away from the area and from finished work. If threatening weather conditions are forecast, at a minimum, compacted surfaces shall be seal-rolled to protect finished work.

C. In the event of damage to prior work, the Contractor shall make repairs and replacements to the satisfaction of the Engineer.

PART 4 – MEASUREMENT AND PAYMENT

4.01 General

A. Providing for and complying with the requirements set forth in this Section for Excavation will be measured as in-place cubic yards (CY), prior to excavation, and payment will be based on the unit price provided on the Bid Schedule.

B. Providing for and complying with the requirements set forth in this Section for Engineered Fill will be measured as compacted and moisture conditioned in-place cubic yards (CY), and payment will be based on the unit price provided on the Bid Schedule.

C. Providing for and complying with the requirements set forth in this Section for Prepared Subgrade will be measured as square feet (SF), and payment will be based on the unit price provided on the Bid Schedule.

D. Providing for and complying with the requirements set forth in this Section for Anchor Trench Excavation and Backfill will be measured as linear feet (LF), and payment will be based on the unit price provided on the Bid Schedule.

E. Providing for and complying with the requirements set forth in this Section for Operations Layer will be measured as in-place cubic yards (CY), and payment will be based on the unit price provided on the Bid Schedule.

F. Providing for and complying with the requirements set forth in this section for Surcharge will be measured as in-place cubic yards (CY), and payment will be based on the unit price provided on the Bid Schedule.

G. The following are considered incidental to the Work:

- material samples, sampling, and testing.
- layout survey.
- rejected material removal, re-testing, handling, and repair.

- rejected material.
- mobilization.
- Stockpiling.
- settlement plates.
- surcharge removal.

END OF SECTION

SECTION 02225
DRAINAGE AGGREGATE

PART 1 – GENERAL

1.01 Description of Work

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, equipment and incidentals necessary for the installation of drainage aggregate. The work shall be carried out as specified herein and in accordance with the Drawings.

B. The work shall include, but not be limited to, delivery, storage, and placement of drainage aggregate (aggregate).

1.02 Related Sections

Section 02200 — Earthwork

Section 02771 — Geotextile

1.03 References

A. Drawings

B. Construction Quality Assurance (CQA) Plan

C. Latest Version of American Society for Testing and Materials (ASTM) Standards:

ASTM C 33	Standard Specification for Concrete Aggregates
ASTM C 136	Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM D 2434	Standard Test Method for Permeability of Granular Soils (Constant Head)

1.04 Submittals

A. The Contractor shall submit to the Engineer for approval, at least 7 days prior to the start of construction, Certificates of Compliance for proposed aggregate materials. Certificates of Compliance shall include, at a minimum, typical gradation and source of aggregate materials.

B. The Contractor shall submit to the Engineer a list of equipment and technical information for equipment proposed for use in placing the aggregate material in accordance with this Section.

1.05 Quality Assurance

A. The Contractor shall ensure that the materials and methods used for Earthwork meet the requirements of the Drawings and this Section. Any material or method that does not conform to these documents, or to alternatives approved in writing by the Engineer will be rejected and shall be repaired or replaced by the Contractor.

B. The Contractor shall be aware of all monitoring and field/laboratory conformance testing required by the CQA Plan. This monitoring and testing, including random conformance testing of construction materials and completed work, will be performed by the Engineer. If nonconformances or other deficiencies are found in the materials or completed work, the Contractor will be required to repair the deficiency or replace the deficient materials.

PART 2 – PRODUCTS

2.01 Materials

A. Aggregate shall meet the requirements specified in ASTM C-33 and shall have a maximum particle size of 1-inch. Aggregate shall have a minimum permeability of 1 x 10^{-2} cm/sec when tested in accordance with ASTM D 2434.

2.02 Equipment

A. The Contractor shall furnish, operate, and maintain hauling, placing, and grading equipment as necessary for aggregate placement.

PART 3 – EXECUTION

3.01 Familiarization

A. Prior to implementing any of the work in this Section, the Contractor shall become thoroughly familiar with the site, the site conditions, and all portions of the work falling within this and other related Sections.

B. Inspection:

1. The Contractor shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the installation of the work specified in this Section may properly commence without adverse impact.

2. If the Contractor has any concerns regarding the installed work of other Sections, the Engineer shall be notified in writing prior to commencing work. Failure to notify the Engineer or continuance of the work of this Section will be construed as Contractor's acceptance of the related work of all other Sections.

3.02 Placement

A. Place only when underlying geosynthetic installation is complete including all CQC and CQA work.

B. Place to the lines, grades, and dimensions shown on the Drawings.

C. The subgrade to the aggregate consists of a geotextile overlying a geomembrane. The Contractor shall avoid creating large wrinkles (greater than 6-inches high), tearing, puncturing, folding, or damaging in any way the geosynthetic materials during placement of the aggregate material.

D. Any damage to the geosynthetic liner system which is caused by the Contractor or his representatives shall be repaired by the Geosynthetic Installer.

E. No density or moisture requirements are specified for placement of the aggregate material.

F. Equipment used in spreading the aggregate material on top of the geosynthetic liner system shall be restricted to the following maximum allowable equipment ground pressures:

MAXIMUM ALLOWABLE EQUIPMENT GROUND PRESSURE (psi)	INITIAL LIFT THICKNESS OF OVERLYING AGGREGATE (ft)
<10	1.0
<20	2.0
>20	3.0

G. The aggregate material shall be placed out in front of the equipment used to place the aggregate such that the minimum thickness requirements are maintained at all times between the geosynthetic materials and the wheels or tracks of the equipment used to place the aggregate material.

H. All equipment to be used in placing the aggregate material must be approved in writing by the Engineer prior to use. The Contractor shall provide a list of the equipment to be used for placing the aggregate material and the necessary technical information (equipment specifications) on each piece of equipment to be approved at least two working days prior to use.

I. Care must be exercised by the operators of tracked equipment to avoid sharp pivoting turns that could displace the aggregate material and result in damage to the geosynthetic liner system. Care must also be exercised by the operators to avoid the formation of waves greater than 6-inches high in the underlying geosynthetic materials which, when formed and pushed out in front of the leading face of the aggregate material, may grow to such magnitude as to result in a fold in the underlying geosynthetic materials. The Contractor shall place, by backhoe or some other acceptable method, aggregate material on the geosynthetic liner system out in front of the leading face of the aggregate material to trap small waves in the underlying geosynthetic materials and prevent the small waves from combining and growing as the aggregate material is spread. Folds in the underlying geosynthetic materials shall be considered as damage to the liner and must be repaired by the Geosynthetic Installer at the expense of the Contractor.

J. Place filter geotextile overlying aggregate as shown on the Drawings and as specified in Section 02771.

3.03 Field Testing

A. The minimum frequency and details of quality control testing are provided below. This testing will be performed by the Engineer. The Contractor shall take this testing frequency into account in planning the construction schedule.

1. Aggregates quality control testing:

   a. particle-size analyses conducted in accordance with ASTM C-136 at a frequency of one test per 5,000 yd^3;

   b. permeability tests conducted in accordance with ASTM D 2434 at a frequency of one test per 10,000 yd^3.

3.04 Survey Control

A. The Contractor shall perform all surveys necessary for construction layout and control.

3.05 Construction Tolerance

A. The Contractor shall perform the aggregate construction to within +0.1 ft of the thickness indicated on the Drawings.

3.06 Protection Of Work

A. The Contractor shall use all means necessary to protect all work of this Section.

B. In the event of damage, the Contractor shall make repairs and replacements to the satisfaction of the Engineer.

PART 4 – MEASUREMENT AND PAYMENT

4.01 General

A. Providing for and complying with the requirements set forth in this Section for Drainage Aggregate will be measured as in-place cubic yards (CY) and payment will be based on the unit price provided on the Bid Schedule.

B. The following are considered incidental to the Work:

- material samples, sampling, and testing.
- layout survey.
- rejected material.
- rejected material removal, re-testing, handling, and repair.
- mobilization.

END OF SECTION

SECTION 02711
POLYETHYLENE PIPE

PART 1 – GENERAL

1.01 Description of Work

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, and equipment necessary to install perforated and solid wall high density polyethylene (HDPE) pipe and fittings as shown on the Drawings and specified herein.

1.02 Related Sections

Section 02225 — Drainage Aggregate

Section 02774 — Geotextile

1.03 References

A. Drawings

B. Construction Quality Assurance (CQA) Plan

C. Latest Version of American Society for Testing and Materials (ASTM) Standards:

ASTM F 714	Specification for Polyethylene Plastic Pipe (SDR-PR) Based on Outside Diameter
ASTM D 1248	Specification for Polyethylene Plastics Molding and Extrusion
ASTM D 2657	Standard Practice for Heat Fusion Joining of Polyolefin Pipe and Fittings
ASTM D 3035	Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Controlled Outside Diameter
ASTM D 3350	Specification for Polyethylene Plastic Pipe and Fitting Materials

1.04 Definitions

A. Standard Dimensional Ratio (SDR) is defined as the actual outside pipe diameter divided by the wall thickness.

1.05 Submittals

A. The Contractor shall submit, at least 7 days prior to installation of this material, to the Engineer, certificates of compliance for the pipe materials and fittings to be furnished.

B. The Contractor shall submit, at least 7 days prior to installation of this material, to the Engineer, copies of certifications for each operator responsible for welding pipe.

C. The Engineer will supply a surveyor to document the as-built conditions of the piping. The Contractor shall notify and allow the Engineer sufficient time to survey piping prior to backfilling the pipe.

1.06 Quality Assurance

A. The Contractor shall ensure that the materials and methods used for polyethylene pipe meet the requirements of the Drawings and this Section. Any material or method that does not conform to these documents, or to alternatives approved in writing by the Engineer will be rejected and shall be repaired or replaced by the Contractor.

PART 2 – PRODUCTS

2.01 Pipe

A. HDPE pipe sizes shown on the Drawings and specified in this Section reference nominal inside diameter. Pipe size shall be in accordance with ASTM F 714 and ASTM D 3035.

B. Pipe shall be, 4-inch, 6-inch, and 18-inch diameter, and shall be HDPE with a minimum standard dimension ratio (SDR) of 13.5, and have a cell classification of 345434C in accordance with ASTM D 3350.

C. Pipe shall conform to the following requirements:

1. Pipe and fittings shall contain no recycled compound except that generated in the Manufacturer's own plant and from resin of the same specification as the raw material supplier.

2. Pipe and fittings shall be homogeneous throughout and free of visible cracks, holes, foreign inclusions, or other deleterious defects, being uniform in color, capacity, density, and other physical properties.

D. The following information shall be continuously marked on the pipe or spaced at intervals not exceeding 5 feet.

1. Name and/or trademark of the pipe Manufacturer.

2. Nominal pipe size.

3. Standard Dimensional Ratio (SDR).

4. PE 3408.

5. A production code from which the date and place of manufacture can be determined.

PART 3 – EXECUTION

3.01 General

A. When shipping, delivering, and installing pipe, fittings, and accessories, do so to ensure a sound, undamaged installation. Provide adequate storage for all materials and equipment delivered to the job site. Handle and store pipe and fittings in accordance with the Manufacturer's recommendation.

3.02 Placing and Laying Pipe

A. Follow the Manufacturer's recommendations when hauling, unloading, and stringing the pipe.

B. HDPE solid and perforated pipe shall be installed as shown on the Drawings.

C. HDPE pipe shall be inspected for cuts, scratches, or other damages prior to installation. Any pipe showing damage, which in the opinion of the CQA Engineer will affect performance of the pipe, must be removed from the Site. The Contractor shall replace any material found to be defective at no additional cost to the Owner.

D. The Contractor shall place the Trench Backfill material around the polyethylene pipe so as to not deform or otherwise damage the pipe and fittings. Special care shall be taken when placing pipe bedding material beneath the spring-line of the pipe and fittings.

E. The Contractor shall clean out pipe interior, as necessary, to remove debris that may affect performance of pipe.

3.03 Fusion Welding Pipe

A. All pipe fusion shall be performed by the Supplier, or a by fusion operator certified by the Manufacturer.

B. Join the polyethylene pipe by the method of thermal butt fusion, as outlined in ASTM D 2657. Electro-fusion couplings shall not be used. Perform butt-fusion joining of pipe and fittings in accordance with the procedures established by the pipe Manufacturer. Of particular importance is the use of proper interface pressures and heater plate temperatures.

C. Do not perform pipe fusion on wet or excessively dirty pipe or when conditions are unsuitable for the work. Secure open ends of pipe when work is not in progress, so that no water, earth, or other substance will enter the pipe or fittings. Plug, cap, or valve off ends of pipe left for future connections, if any.

D. In order to allow the joining operation to continue in adverse weather conditions, a shelter may be required for the joining machine. Particular caution should be exercised to prevent water from entering the pipe and from coming in contact with the heater plate.

E. Only fully trained personnel will be allowed to perform the fusion, installation, supervision, or inspection of polyethylene fusion joints.

3.04 Construction Tolerance

A. The Contractor shall perform the work to within ±0.1 ft of the grades indicated on the Drawings.

PART 4 – MEASUREMENT AND PAYMENT

4.01 General

A. Providing for and complying with the requirements set forth in this Section for 4-inch HDPE solid wall pipe and fittings will be measured in linear feet (LF), and payment will be based on the unit price provided on the Bid Schedule.

B. Providing for and complying with the requirements set forth in this Section for 4-inch HDPE perforated pipe and fittings will be measured in linear feet (LF), and payment will be based on the unit price provided on the Bid Schedule.

C. Providing for and complying with the requirements set forth in this Section for 6-inch HDPE solid wall pipe and fittings will be measured in linear feet (LF), and payment will be based on the unit price provided on the Bid Schedule.

D. Providing for and complying with the requirements set forth in this Section for 18-inch HDPE perforated and solid wall pipe and fittings will be measured in linear feet (LF), and payment will be based on the unit price provided on the Bid Schedule.

E. Providing for and complying with the requirements set forth in this Section for 4-inch HDPE solid and perforated pipe and fittings for vertical installation in wells will be incidental to Section 02074 for well installation.

F. The following are considered incidental to the Work:

- shipping, handling and storage.
- layout survey.
- mobilization.
- Fittings, and other pipe appurtenances.
- Fusing and Joining.
- rejected material.
- rejected material removal, handling, re-testing, repair, and replacement.
- filtration Geotextile in accordance with Section 02771.
- trench Excavation and Backfill in accordance with Section 02200.

END OF SECTION

SECTION 02770
GEOMEMBRANE

PART 1 – GENERAL

1.01 Description of Work

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, equipment, and incidentals necessary for the installation of textured high-density polyethylene (HDPE) geomembrane, as shown on the Drawings. The work shall be carried out as specified herein and in accordance with Drawings.

B. The work shall include, but not be limited to, delivery, storage, placement, anchorage, and seaming of the geomembrane.

1.02 Related Sections

Section 02771 — Geotextile

Section 02772 — Geosynthetic Clay Liner

Section 02773 — Geocomposite

1.03 References

A. Drawings

B. Construction Quality Assurance (CQA) Plan

C. Latest version of the American Society for Testing and Materials (ASTM) standards:

ASTM D 638	Standard Test Method for Tensile Properties of Plastics
ASTM D 792	Standard Test Methods for Specific Gravity (Relative Density) and Density of Plastics by Displacement
ASTM D 1004	Standard Test Method of Initial Tear Resistance of Plastic Film and Sheeting
ASTM D 1505	Standard Test Methods for Density of Plastics by Density-Gradient Technique
ASTM D 1603	Standard Test Method for Carbon Black in Olefin Plastics
ASTM D 5321	Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method
ASTM D 5397	Test Method for Evaluation of Stress Crack Resistance of Polyolefin Geomembranes Using Notched Constant Tensile Load Test
ASTM D 5596	Recommended Practice for Microscopical Examination of Pigment Dispersion in Plastic Compounds
ASTM D 5641	Practice for Geomembrane Seam Evaluation by Vacuum Chamber

ASTM D 5820	Practice for Pressurized Air Channel Evaluation of Dual Seamed Geomembranes
ASTM D 5994	Standard Test Method for Measuring Core Thickness of Textured Geomembranes
ASTM D 6392	Test Method for Determining the Integrity of Non-reinforced Geomembrane Seams Produced using Thermo-Fusion Methods.

1.04 Qualifications

A. The Geomembrane Manufacturer shall be responsible for the production of geomembrane rolls from resin and shall have sufficient production capacity and qualified personnel to provide material meeting the requirements of this Section and the construction schedule for this project.

B. Geosynthetics Installer:

1. The Geosynthetics Installer shall be responsible and shall provide sufficient resources for field handling, deploying, seaming, temporarily restraining (against wind), and other aspects of the deployment and installation of the geomembrane and other geosynthetic components of the project.

2. The Geosynthetics Installer shall have successfully installed a minimum of 10,000,000 ft^2 of polyethylene geomembrane on previous projects.

3. The installation crew shall have the following experience.

   a. The Superintendent shall have supervised the installation of a minimum of 2,000,000 ft^2 of polyethylene geomembrane on at least five (5) different projects.

   b. At least one seamer shall have experience seaming a minimum of 1,000,000 square feet of polyethylene geomembrane using the same type of seaming apparatus to be used at this site. Seamers with such experience will be designated “master seamers” and shall provide direct supervision over less experienced seamers.

   c. All other seaming personnel shall have seamed at least 100,000 square feet of polyethylene geomembrane using the same type of seaming apparatus to be used at this site. Personnel who have seamed less than 100,000 square feet shall be allowed to seam only under the direct supervision of the master seamer or Superintendent.

1.05 Warranty

A. The Geosynthetic Installer shall furnish the Engineer a 20-year written warranty against defects in materials. Warranty conditions concerning limits of liability will be evaluated by, and must be acceptable to, the Engineer and Owner.

B. The Geosynthetic Installer shall furnish the Engineer with a 1-year written warranty against defects in workmanship. Warranty conditions concerning limits of liability will be evaluated by, and must be acceptable to, the Engineer and Owner.

1.06 Submittals

A. The Geosynthetic Installer shall submit the following documentation on the resin used to manufacture the geomembrane to the Engineer for approval 14 days prior to transporting any geomembrane to the site.

1. Copies of quality control certificates issued by the resin supplier including the production dates and origin of the resin used to manufacture the geomembrane for the project.

2. Results of tests conducted by the Geomembrane Manufacturer to verify the quality of the resin used to manufacture the geomembrane rolls assigned to the project.

3. Certification that no reclaimed polymer is added to the resin during the manufacturing of the geomembrane to be used for this project, or, if recycled polymer is used, the Manufacturer shall submit a certificate signed by the production manager documenting the quantity of recycled material, including a description of the procedure used to measure the quantity of recycled polymer.

B. The Geosynthetic Installer shall submit the following documentation on geomembrane roll production to the Engineer for approval 14 days prior to transporting any geomembrane to the site.

1. Quality control certificates, which shall include:

   a. roll numbers and identification; and

   b. results of quality control tests, including descriptions of the test methods used, outlined in Part 2.02 of this Section.

2. The manufacturer warranty specified in Part 1.05.A of this Section.

C. The Geosynthetic Installer shall submit the following information to the Engineer for approval 14 days prior to mobilization.

1. A drawing showing the installation layout identifying geomembrane panel configurations, dimensions, details, locations of seams, as well as any variance or additional details that deviate from the Drawings. The layout shall be adequate for use as a construction plan and shall include dimensions, details, etc. The layout drawings, as modified and/or approved by the Engineer, shall become part of these Specifications.

2. Installation schedule.

3. Copy of Geosynthetic Installer's letter of approval or license by the Geomembrane Manufacturer.

4. Installation capabilities, including:

   a. information on equipment proposed for this project;
   b. average daily production anticipated for this project; and
   c. quality control procedures.

5. A list of completed facilities for which the installer has installed a minimum of 10,000,000 ft^2 of polyethylene geomembrane, in accordance with Part 1.04 of this Specification. The following information shall be provided for each facility:

   a. the name and purpose of the facility, its location, and dates of installation;
   b. the names of the owner, project manager, and geomembrane manufacturer;

c. name of the supervisor of the installation crew; and
d. thickness and surface area of installed geomembrane.

6. In accordance with Part 1.04, a resume of the Superintendent to be assigned to this project, including dates and duration of employment, shall be submitted at least 7 days prior to beginning geomembrane installation.

7. In accordance with Part 1.04, resumes of all personnel who will perform seaming operations on this project, including dates and duration of employment, shall be submitted at least 7 days prior to beginning geomembrane installation.

D. A Certificate of Calibration less than 12 months old shall be submitted for each field tensiometer prior to installation of any geomembrane.

E. During installation, the Geosynthetic Installer shall be responsible for the timely submission to the Engineer of:

1. Quality control documentation; and

2. Subgrade acceptance certificates, signed by the Geosynthetic Installer, for each area to be covered by geosynthetic materials.

F. Upon completion of the installation, the Geosynthetic Installer shall be responsible for the submission to the Engineer of a warranty from the Geosynthetic Installer as specified in Part 1.05.B of this Section.

G. Upon completion of the installation, the Geosynthetic Installer shall be responsible for the submission to the Engineer of a record drawing showing the location and number of each panel and locations and numbers of destructive tests and repairs.

H. The Geosynthetic Installer shall submit the following documentation on welding rod to the Engineer for approval 14 days prior to transporting welding rod to the site:

1. Quality control documentation, including lot number, welding rod spool number, and results of quality control tests on the welding rod.

1.07 Quality Assurance

A. The Geosynthetic Installer shall ensure that the materials and methods used for installation of the geomembrane meet the requirements of the Drawings and this Section. Any material or method that does not conform to these documents, or to alternatives approved in writing by the Engineer, will be rejected and shall be repaired or replaced by the Geosynthetic Installer.

B. The Geosynthetic Installer shall be aware of and accommodate all monitoring and conformance testing required by the CQA Plan. This monitoring and testing, including random conformance testing of construction materials and completed work, will be performed by the Engineer. If nonconformances or other deficiencies are found in the Geosynthetic Installer's materials or completed work, the Geosynthetic Installer will be required to repair the deficiency or replace the deficient materials.

PART 2 – PRODUCTS

2.01 Geomembrane Properties

A. The Geomembrane Manufacturer shall furnish double-sided, textured geomembrane having properties that comply with the required property values shown in Table 02770-1.

B. In addition to the property values listed in Table 02770-1, the geomembrane shall:

1. Contain a maximum of 1 percent by weight of additives, fillers, or extenders (not including carbon black).

2. Not have striations, pinholes (holes), bubbles, blisters, nodules, undispersed raw materials, or any sign of contamination by foreign matter on the surface or in the interior.

2.02 Manufacturing Quality Control

A. Rolls:

1. The Geomembrane Manufacturer shall continuously monitor geomembrane during the manufacturing process for defects.

2. No geomembrane shall be accepted that exhibits any defects.

3. The Geomembrane Manufacturer shall measure and report the geomembrane thickness at regular intervals along the roll length.

4. No geomembrane shall be accepted that fails to meet the specified thickness.

5. The Geomembrane Manufacturer shall sample and test the geomembrane at a minimum of once every 50,000 ft^2 to demonstrate that its properties conform to the values specified in Table 02770-1. At a minimum, the following tests shall be performed:

Test	Procedure
Thickness	ASTM D 5994
Specific Gravity	ASTM D 792 Method A or ASTM D 1505
Tensile Properties	ASTM D 638
Puncture Resistance	ASTM D 4833
Carbon Black	ASTM D 1603
Carbon Black Dispersion	ASTM D 5596

6. Tests not listed above but listed in Table 02770-1 need not be run at the 1 per 50,000 ft^2 frequency. However, the Geomembrane Manufacturer shall certify that these tests are in compliance with this section and have been performed on a sample that is identical to the geomembrane to be used on this project. The Geosynthetic Installer shall provide the test result documentation to the Engineer.

7. Any geomembrane sample that does not comply with the requirements of this Section will result in rejection of the roll from which the sample was obtained and will not be used for this project.

8. If a geomembrane sample fails to meet the quality control requirements of this Section, the Geomembrane Manufacturer shall sample and test, at the expense of the Manufacturer, rolls manufactured, in the same resin batch, or at the same time, as the failing roll. Sampling and testing of rolls shall continue until a pattern of acceptable test results is established to bound the failed roll(s).

9. Additional testing may be performed at the Geomembrane Manufacturer's discretion and expense, to isolate and more closely identify the non-complying rolls and/or to qualify individual rolls.

B. The Geomembrane Manufacturer shall permit the Engineer to visit the manufacturing plant for project specific visits. If possible, such visits will be prior to or during the manufacturing of the geomembrane rolls for the specific project.

2.03 Labeling

A. Geomembrane rolls shall be labeled with the following information.

1. thickness of the material;
2. length and width of the roll;
3. name of Geomembrane Manufacturer;
4. product identification;
5. lot number; and
6. roll number.

2.04 Transportation, Handling and Storage

A. Handling and care of the geomembrane prior to and following installation at the site shall be the responsibility of the Geosynthetic Installer. The Geosynthetic Installer shall be liable for all damage to the materials incurred prior to final acceptance of the liner system by the Engineer.

B. Geosynthetic Installer shall be responsible for storage of the geomembrane at the site. The geomembrane shall be protected from excessive heat or cold, dirt, puncture, cutting, or other damaging or deleterious conditions. Any additional storage procedures required by the Geomembrane Manufacturer shall be the Geosynthetic Installer's responsibility. Geomembrane rolls shall not be stored or placed in a stack of more than two rolls high.

C. The geomembrane shall be delivered at least 14 days prior to the planned deployment date to allow the Engineer adequate time to perform conformance testing on the geomembrane samples as described in Part 3.05 or this Section. If the Engineer performed a visit to the manufacturing plant and performed the required conformance sampling, geomembrane can be delivered to the site within the 14 days prior to the planned deployment date as long as there is sufficient time for the Engineer to complete the conformance testing and confirm that the rolls shipped to the site are in compliance with this Section.

PART 3 – PART 3 — GEOMEMBRANE INSTALLATION

3.01 Familiarization

A. Prior to implementing any of the work described in this Section, the Geosynthetic Installer shall become thoroughly familiar with all portions of the work falling within this Section.

B. Inspection:

1. The Geosynthetic Installer shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the work of this Section may properly commence without adverse effect.

2. If the Geosynthetic Installer has any concerns regarding the installed work of other Sections, he shall notify the Engineer in writing prior to the start of the work of this Section. Failure to inform the Engineer in writing or installation of the geomembrane

will be construed as the Geosynthetic Installer's acceptance of the related work of all other Sections.

C. A pre-installation meeting shall be held to coordinate the installation of the geomembrane with the installation of other components of the composite liner system.

3.02 Geomembrane Deployment

A. Layout Drawings:

1. The Geosynthetic Installer shall deploy the geomembrane panel in general accordance with the layout drawing specified. The layout drawings must be approved by the Engineer prior to installation of any geomembrane.

B. Field Panel Identification:

1. A geomembrane field panel is a roll or a portion of roll cut in the field.

2. Each field panel shall be given an identification code (number or letter-number). This identification code shall be agreed upon by the Engineer and Geosynthetic Installer.

C. Field Panel Placement:

1. Field panels shall be installed, as approved or modified, at the location and positions indicated on the layout drawings.

2. Field panels shall be placed one at a time, and each field panel shall be seamed immediately after its placement.

3. Geomembrane shall not be placed when the ambient temperature is below 40°F or above 104°F, unless otherwise authorized in writing by the Engineer.

4. Geomembrane shall not be placed during any precipitation, in the presence of excessive moisture (e.g., fog, dew), in an area of ponded water, or in the presence of excessive winds.

5. The Geosynthetic Installer shall ensure that:

a. No vehicular traffic is allowed on the geomembrane.

b. Equipment used does not damage the geomembrane by handling, trafficking, or leakage of hydrocarbons (i.e., fuels).

c. Personnel working on the geomembrane do not smoke, wear damaging shoes, bring glass onto the geomembrane, or engage in other activities that could damage the geomembrane.

d. The method used to unroll the panels does not scratch or crimp the geomembrane and does not damage the supporting soil or geosynthetics.

e. The method used to place the panels minimizes wrinkles (especially differential wrinkles between adjacent panels). The method used to place the panels results in intimate contact with adjacent components.

f. Temporary ballast and/or anchors (e.g., sand bags), not likely to damage the geomembrane, are placed on the geomembrane to prevent wind uplift.

g. The geomembrane is especially protected from damage in heavily trafficked areas.

h. Any rub sheets to facilitate seaming are removed prior to installation of subsequent panels.

6. Any field panel or portion thereof that becomes seriously damaged (torn, twisted, or crimped) shall be replaced with new material. Less serious damage to the geomembrane may be repaired, as approved by the Engineer. Damaged panels or portions of damaged panels that have been rejected shall be removed from the work area.

D. If the Geosynthetic Installer intends to install geomembrane between one hour before sunset and one hour after sunrise, he shall notify the Engineer in writing prior to the start of the work. The Geosynthetic Installer shall indicate additional precautions, which shall be taken during these installation hours. The Geosynthetic Installer shall provide proper illumination for work during this time period.

3.03 Field Seaming

A. Seam Layout:

1. In corners and at odd-shaped geometric locations, the number of field seams shall be minimized. No horizontal seam shall be along a slope with an inclination steeper than 10 percent. Horizontal seams shall be considered as any seam having an alignment exceeding 20 degrees from being perpendicular to the slope contour lines, unless otherwise approved by the Engineer. No seams shall be located in an area of potential stress concentration.

B. Personnel:

1. All personnel performing seaming operations shall be qualified as indicated in Part 1.04 of this Section. No seaming shall be performed unless a “master seamer” is present on-site.

C. Weather Conditions for Seaming:

1. Unless authorized in writing by the Engineer, seaming shall not be attempted at ambient temperatures below 40°F or above 104°F. If the Geosynthetic Installer wishes to use methods that may allow seaming at ambient temperatures below 40°F or above 104°F, he shall use a procedure approved by the Engineer.

2. A meeting will be held with the Geosynthetic Installer and Engineer to establish acceptable installation procedures. In all cases, the geomembrane shall be dry and protected from wind damage.

3. Ambient temperatures shall be measured between 0 to 6 in. above the geomembrane surface.

D. Overlapping:

1. Geomembrane panels shall be sufficiently overlapped for welding and to allow peel tests to be performed on the seam. Any seams that cannot be destructively tested because of insufficient overlap shall be treated as failing seams.

E. Seam Preparation:

1. Prior to seaming, the seam area shall be clean and free of moisture, dust, dirt, debris of any kind, and foreign material.

2. If seam overlap grinding is required, the process shall be completed according to the Geomembrane Manufacturer's instructions within 20 minutes of the seaming operation and in a manner that does not damage the geomembrane. The grind depth shall not exceed ten percent of the geomembrane thickness.

3. Seams shall be aligned with the fewest possible number of wrinkles and “fishmouths.”

F. General Seaming Requirements:

1. Fishmouths or wrinkles at the seam overlaps shall be cut along the ridge of the wrinkle to achieve a flat overlap. The cut fishmouths or wrinkles shall be seamed and any portion where the overlap is insufficient shall be patched with an oval or round patch of geomembrane that extends a minimum of 6 in. beyond the cut in all directions.

2. Any electric generator shall be placed outside the area to be lined or mounted in a manner that protects the geomembrane from damage. The electric generator shall be properly grounded.

G. Seaming Process:

1. Approved processes for field seaming are extrusion welding and fusion welding. Only equipment identified as part of the approved submittal specified in Part 1.06 shall be used.

2. Extrusion Equipment and Procedures:

a. The Geosynthetics Installer shall maintain at least one spare operable seaming apparatus on site.

b. Extrusion welding apparatus shall be equipped with gauges giving the temperature in the apparatus.

c. Prior to beginning a seam, the extruder shall be purged until all heat-degraded extrudate has been removed from the barrel.

d. The Geosynthetics Installer shall provide documentation regarding the welding rod to the Engineer and shall certify that the welding rod is compatible with the specifications.

e. A smooth insulating plate or fabric shall be placed beneath the hot welding apparatus after use.

3. Fusion Equipment and Procedures:

a. The Geosynthetic Installer shall maintain at least one spare operable seaming apparatus on site.

b. Fusion-welding apparatus shall be automated vehicular-mounted devices equipped with gauges giving the applicable temperatures and speed.

c. A smooth insulating plate or fabric shall be placed beneath the hot welding apparatus after use.

H. Trial Seams:

1. Trial seams shall be made on fragment pieces of geomembrane to verify that seaming conditions are adequate. Trial seams shall be conducted on the same material to be installed and under similar field conditions as production seams. Such trial seams shall be made at the beginning of each seaming period, beginning of the day and after lunch, for each seaming apparatus used each day. The trial seam sample shall be a minimum of 5-ft long by 1-ft wide (after seaming) with the seam centered lengthwise for fusion equipment and at least 3-ft long by 1-ft wide for extrusion equipment. Seam overlap shall be as indicated in Part 3.03.D of this Section.

2. Four adjoining coupon specimens, each 1-in. wide, shall be cut from the trial seam sample by the installer using a die cutter to ensure precise 1-in. wide coupons. The coupons shall be tested in peel (outside (fusion only) and inside track) and shear using an electronic readout field tensiometer in accordance with ASTM D 4437, at a strain rate of 2 in./min., and they shall not fail in the seam (i.e., Film Tear Bond (FTB), which is failure in the parent material, is required). The required peel and shear seam strength is listed in Table 02770-2. Ideally, samples shall be conditioned at $23 \pm 2^{o}C$ at a relative humidity of $50 \pm 5\%$ for two hours prior to testing. If test conditions vary from these conditions, a 1-in. wide coupon of the parent geomembrane material (no weld) shall be tested in the same manner as the seam specimens to determine the break strength at this condition.

3. If a coupon specimen fails, the entire operation shall be repeated. If the additional coupon specimen fails, the seaming apparatus and seamer shall not be accepted and shall not be used for seaming until the deficiencies are corrected and two consecutive successful trial seams are achieved.

I. Nondestructive Seam Continuity Testing:

1. The Geosynthetic Installer shall nondestructively test for continuity on all field seams over their full length. Continuity testing shall be carried out as the seaming work progresses, not at the completion of all field seaming. The Geosynthetic Installer shall complete any required repairs in accordance with Part 3.03.K of this Section. The following procedures shall apply:

a. Vacuum testing in accordance with ASTM D 5641.

b. Air pressure testing (for double-track fusion seams only) in accordance with ASTM D 5820 and the following:

i. Energize the air pump to a pressure between 25 and 30 pounds per square inches, close valve, and sustain the pressure for not less than 5 minutes.

ii. If loss of pressure exceeds 3 pounds per square inches, or does not stabilize, locate faulty area and repair in accordance with Part 3.03.K of this Section.

iii. Cut opposite end of air channel from pressure gauge and observe release of pressure to ensure air channel is not blocked.

iv. Remove needle, or other approved pressure feed device, and seal repair in accordance with Part 3.03.K of this Section.

c. Spark testing shall be performed if the seam cannot be tested using other nondestructive methods.

J. Destructive Testing:

1. Destructive seam tests shall be performed on samples collected from selected locations to evaluate seam strength and integrity. Destructive tests shall be carried out as the seaming work progresses, not at the completion of all field seaming.

2. Sampling:

a. Destructive test samples shall be collected at a minimum average frequency of one test location per 500 ft of seam length. Test locations shall be determined during seaming, and may be prompted by suspicion of excess crystallinity, contamination, offset seams, or any other potential cause of imperfect seaming. The Engineer will be responsible for choosing the locations. The Geosynthetic Installer shall not be informed in advance of the locations where the seam samples will be taken. The Engineer reserves the right to increase the sampling frequency.

b. Samples shall be cut by the Geosynthetic Installer at the locations designated by the Engineer as the seaming progresses in order to obtain laboratory test results before the geomembrane is covered by another material. Each sample shall be numbered and the sample number and location identified on the panel layout drawing. All holes in the geomembrane resulting from the destructive seam sampling shall be immediately repaired in accordance with the repair procedures described in Part 3.03.K of this Section. The continuity of the new seams in the repaired areas shall be tested according to Part 3.03.I of this Section.

c. Two strips of dimensions 1-in. wide and 12 in. long with the seam centered parallel to the width shall be taken from either side of the sample location. These samples shall be tested in the field in accordance with Part 3.03.J.3 of this Section. If these samples pass the field test, a laboratory sample shall be taken. The laboratory sample shall be at least 1-ft wide by 3.5-ft long with the seam centered lengthwise. The sample shall be cut into three parts and distributed as follows:

i. One portion 12-in. long to the Geosynthetic Installer.
ii. One portion 18-in. long to the Geosynthetic CQA Laboratory for testing.
iii. One portion 12-in. long to the Engineer for archival storage.

3. Field Testing:

a. The two 1-in. wide strips shall be tested in the field tensiometer in the peel mode. The Engineer has the option to request an additional test in the shear mode. If any field test sample fails to meet the requirements in Table 02770-2, then the procedures outlined in Part 3.03.J.5 of this Section shall be followed.

4. Laboratory Testing:

   a. Testing by the Geosynthetics CQA Laboratory will include “Seam Strength” and “Peel Adhesion” (ASTM D 4437) with the 1-in. wide strip tested at a rate of 2 in./min. At least 5 specimens will be tested for each test method (peel and shear). Four of the five specimens per sample must pass both the shear strength test and peel adhesion test when tested in accordance with ASTM D 4437. The minimum acceptable values to be obtained in these tests are indicated in Table 02770-2. Both inside and outside tracks of the dual track fusion welds shall be tested in peel.

5. Destructive Test Failure:

   a. The following procedures shall apply whenever a sample fails a destructive test, whether the test is conducted by the Geosynthetic CQA's laboratory, the Geosynthetic Installer laboratory, or by a field tensiometer. The Geosynthetic Installer shall have two options:

      i. The Geosynthetic Installer can reconstruct the seam (e.g., remove the old seam and reseam) between any two passed destructive test locations.

      ii. The Geosynthetic Installer can trace the welding path to an intermediate location, a minimum of 10 feet from the location of the failed test (in each direction) and take a small sample for an additional field test at each location. If these additional samples pass the field tests, then full laboratory samples shall be taken. These full laboratory samples shall be tested in accordance with Part 3.03.J.4 of this Section. If these laboratory samples pass the tests, then the seam shall be reconstructed between these locations. If either sample fails, then the process shall be repeated to establish the zone in which the seam should be reconstructed. All acceptable seams must be bounded by two locations from which samples passing laboratory destructive tests have been taken. In cases exceeding 150 ft of reconstructed seam, a sample taken from within the reconstructed zone must pass destructive testing.

   b. Whenever a sample fails, the Engineer may require additional tests for seams that were formed by the same seamer and/or seaming apparatus or seamed during the same time shift.

K. Defects and Repairs:

1. The geomembrane will be inspected before and after seaming for evidence of defects, holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter. The surface of the geomembrane shall be clean at the time of inspection. The geomembrane surface shall be swept or washed by the Installer if surface contamination inhibits inspection.

2. Each suspected location, both in seam and non-seam areas, shall be nondestructively tested using the methods described Part 3.03.I of this Section, as appropriate. Each location that fails nondestructive testing shall be marked by the Engineer and repaired by the Geosynthetic Installer.

3. When seaming of a geomembrane is completed (or when seaming of a large area of a geomembrane is completed) and prior to placing overlying materials, the Engineer shall identify all excessive geomembrane wrinkles. The Geosynthetic Installer shall cut and reseam all wrinkles so identified. The seams thus produced shall be tested like any other seams.

4. Repair Procedures:

   a. Any portion of the geomembrane exhibiting a flaw, or failing a destructive or nondestructive test, shall be repaired by the Geosynthetic Installer. Several repair procedures exist. The final decision as to the appropriate repair procedure shall be agreed upon between the Engineer and the Geosynthetic Installer. The procedures available include:

      i. patching, used to repair holes larger than 1/16 inch, tears, undispersed raw materials, and contamination by foreign matter;

      ii. abrading and reseaming, used to repair small sections of extruded seams;

      iii. spot seaming, used to repair minor, localized flaws;

      iv. capping, used to repair long lengths of failed seams; and

      v. removing bad seam and replacing with a strip of new material seamed into place (used with long lengths of fusion seams).

   b. In addition, the following criteria shall be satisfied:

      i. surfaces of the geomembrane that are to be repaired shall be abraded no more than 20 minutes prior to the repair;

      ii. all surfaces must be clean and dry at the time of repair;

      iii. all seaming equipment used in repair procedures must be approved;

      iv. the repair procedures, materials, and techniques shall be approved in advance, for the specific repair, by the Engineer;

      v. patches or caps shall extend at least 6 in. beyond the edge of the defect, and all corners of patches shall be rounded with a radius of at least 3 in.; and

      vi. the geomembrane below large caps shall be appropriately cut to avoid water or gas collection between the two sheets.

5. Repair Verification:

   a. Each repair shall be nondestructively tested using the methods described in Part 3.03.I of this Section, as appropriate. Repairs that pass the nondestructive test shall be taken as an indication of an adequate repair. Failed tests will require the repair to be redone and retested until a passing test results. At the discretion of the Engineer, destructive testing may be required on large caps.

3.04 Materials In Contact With The Geomembrane

A. The Geosynthetic Installer shall take all necessary precautions to ensure that the geomembrane is not damaged during its installation. During the installation of other components of the liner system by the Contractor, the Contractor shall ensure that the geomembrane is not damaged. Any damage to the geomembrane shall be repaired by the Geosynthetic Installer , at the expense of the Contractor.

B. Soil and aggregate materials shall not be placed over the geomembranes at ambient temperatures below 40°F or above 104°F, unless otherwise specified.

C. All attempts shall be made to minimize wrinkles in the geomembrane.

D. Equipment shall not be driven directly on the geomembrane.

3.05 Conformance Testing

A. Samples of the geomembrane will be removed by the Engineer and sent to a Geosynthetic CQA Laboratory for testing to ensure conformance with the requirements of this Section. The Geosynthetic Installer shall assist the Engineer in obtaining conformance samples. The Geosynthetic Installer and Contractor shall account for this testing in the installation schedule. Only material that meets the requirements of Part 2.02 this Section shall be installed.

B. Samples will be selected by the Engineer in accordance with this Section and with the procedures outlined in the CQA Plan.

C. Samples will be taken at a minimum frequency of one sample per 100,000 ft^2.

D. The Engineer may increase the frequency of sampling in the event that test results do not comply with the requirements of Part 2.02 of this Section.

E. The following tests will be performed by the Engineer:

Test	Test Method
Specific Gravity	ASTM D 792 or D 1505
Thickness	ASTM D 5994
Tensile Properties	ASTM D 638
Carbon Black Content	ASTM D 1603
Carbon Black Dispersion	ASTM D 5596

F. Any geomembrane that is not certified in accordance with Part 1.07.C of this Section, or that conformance testing indicates do not comply with Part 2.02 of this Section, will be rejected. The Geosynthetic Installer shall replace the rejected material with new material.

3.06 Geomembrane Acceptance

A. The Geosynthetic Installer shall retain all ownership and responsibility for the geomembrane until accepted by the Engineer.

B. The geomembrane shall be accepted by the Engineer when:

1. the installation is completed;
2. all documentation is submitted;

3. verification of the adequacy of all field seams and repairs, including associated testing, is complete; and

4. all warranties are submitted.

3.07 Protection of Work

A. The Geosynthetic Installer and Contractor shall use all means necessary to protect all work of this Section.

B. In the event of damage, the Geosynthetic Installer shall make all repairs and replacements necessary, to the satisfaction of the Engineer.

PART 4 – MEASUREMENT AND PAYMENT

4.01 General

A. Providing for a complying with the requirements set forth in this Section for textured HDPE geomembrane will be measured as in-place square feet (SF), including geomembrane in the anchor trench to the limits shown on the Drawings, and payment will be based on the unit price provided on the Bid Schedule.

B. The following are considered incidental to the Work:

- shipping, handling and storage.
- layout survey.
- mobilization.
- rejected material.
- overlaps and seaming.
- rejected material removal, handling, re-testing, and repair.
- temporary anchorage.

TABLE 02770-1
REQUIRED HDPE GEOMEMBRANE PROPERTIES

PROPERTIES	QUALIFIERS	UNITS	SPECIFIED VALUES	TEST METHOD
Physical Properties				
Thickness	Average Minimum	mils mils	60 54	ASTM D 5994
Specific Gravity	Minimum	N/A	.94	ASTM D 792 Method A or ASTM D 1505
Mechanical Properties				
Tensile Properties (each direction)				
1. Tensile (Break) Strength Tensile (Break) Strength 2. Elongation at Break 3. Tensile (Yield) Strength 4. Elongation at Yield	Minimum	lb/in % lb/in %	90 100 126 12	ASTM D 638
Puncture	Minimum	lb	90	ASTM D 4833
Tear Resistance	Minimum	lb	42	ASTM D 1004
Interface Shear Strength	-	-	Note 1	ASTM D 5321
Environmental Properties				
Carbon Black Content	Range	%	2-3	ASTM D 1603
Carbon Black Dispersion	N/A	none	Note 2	ASTM D 5596
Environmental Stress Crack	Minimum	hr	400	ASTM D 5397

Notes: (1) Interface shear strength test(s) shall be performed, by the Engineer, on the composite liner system in accordance with Section 02772 — Geosynthetic Clay Liner.
(2) Minimum 8 of 10 in Categories 1 or 2; 10 in Categories 1, 2, or 3.

TABLE 02770-2
REQUIRED GEOMEMBRANE SEAM PROPERTIES

PROPERTIES	QUALIFIERS	UNITS	SPECIFIED VALUES	TEST METHOD
Shear Strength(1)				
Fusion	minimum	lb/in	120	ASTM D 6392
Extrusion	minimum	lb/in	120	ASTM D 6392
Peel Adhesion				
FTB(2)				
Fusion	minimum	lb/in	91	ASTM D 6392
Extrusion	minimum	lb/in	78	ASTM D 6392

Notes: (1) Also called "Bonded Seam Strength".
(2) FTB = Film Tear Bond means that failure is in the parent material, not the seam. The maximum seam separation is 25 percent of the seam area.

END OF SECTION

SECTION 02771
GEOTEXTILE

PART 1 – GENERAL

1.01 Description of Work

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, equipment, and incidentals necessary for the installation of the geotextile. The work shall be carried out as specified herein and in accordance with the Drawings.

B. The work shall include, but not be limited to, delivery, storage, placement, and seaming of the various geotextile components of the project.

C. Filter geotextile shall be used overlying the drainage aggregate. Cushion geotextile shall be used overlying the geomembrane and underlying the drainage aggregate. A UV protective geotextile shall be used overlying the exposed portions of geosynthetic components of the side slope liner system.

1.02 Related Sections

Section 02200 — Earthwork

Section 02225 — Drainage Aggregate

Section 02770 — Geomembrane

Section 02773 — Geocomposite

1.03 References

A. Drawings

B. Construction Quality Assurance (CQA) Plan

C. Latest version of American Society for Testing and Materials (ASTM) standards:

ASTM D 3786	Standard Test Method for Hydraulic Bursting Strength of Knitted Goods and Nonwoven Fabric-Diaphragm Bursting Strength Test Method
ASTM D 4355	Standard Test Method for Deterioration of Geotextile from Exposure to Ultraviolet Light and Water
ASTM D 4491	Standard Test Method for Water Permeability of Geotextile by Permittivity
ASTM D 4533	Standard Test Method for Trapezoid Tearing Strength of Geotextile
ASTM D 4595	Standard Test Method for Wide Width Tensile Properties of Geosynthetics
ASTM D 4632	Standard Test Method for Breaking Load and Elongation of Geotextile (Grab Method)
ASTM D 4751	Standard Test Method for Determining Apparent Opening Size of a Geotextile

ASTM D 4833 Standard Test Method for Index Puncture Resistance of Geotextile, Geomembranes, and Related Products

ASTM D 5261 Standard Test Method for Measuring Mass Per Unit Area of Geotextile

1.04 Submittals

A. The Geosynthetic Installer shall submit to the Engineer, at least 7 days prior to geotextile delivery, the following information regarding the proposed geotextile:

1. manufacturer and product name;
2. minimum property values of the proposed geotextile and the corresponding test procedures;
3. projected geotextile delivery dates; and
4. list of geotextile roll numbers for rolls to be delivered to the site.

B. At least 7 days prior to geotextile placement, the Geosynthetic Installer shall submit to the Engineer the manufacturing quality control certificates for each roll of geotextile. The certificates shall be signed by responsible parties employed by the geotextile manufacturer (such as the production manager). The quality control certificates shall include:

1. lot, batch, and/or roll numbers and identification; and
2. results of quality control tests, including a description of the test methods used.

1.05 Quality Assurance

A. The Geosynthetic Installer shall ensure that the geotextile and installation methods used meet the requirements of the Drawings and this Section. Any material or method that does not conform to these documents, or to alternatives approved in writing by the Engineer, will be rejected and shall be repaired or replaced by the Geosynthetic Installer.

B. The Geosynthetic Installer shall be aware of all monitoring and conformance testing required by the CQA Plan. This monitoring and testing, including random conformance testing of construction materials and completed work, will be performed by the Engineer. If nonconformances or other deficiencies are found in the Geosynthetic Installer's materials or completed work, the Geosynthetic Installer will be required to repair the deficiency or replace the deficient materials.

PART 2 – PRODUCTS

2.01 Geotextile Properties

A. Geotextile suppliers shall furnish materials in which the "Minimum Average Roll Values", as defined by the Federal Highway Administration (FHWA), meet or exceed the criteria specified in Table 02771-1.

B. The geotextile shall be nonwoven materials, suitable for use in filter/separation and cushion applications and woven geotextile for use as a UV protective layer.

2.02 Manufacturing Quality Control

A. The geotextile shall be manufactured with quality control procedures that meet or exceed generally accepted industry standards.

B. The Geotextile Manufacturer shall sample and test the geotextile to demonstrate that the material conforms to the requirements of these Specifications.

C. Any geotextile sample that does not comply with this Section shall result in rejection of the roll from which the sample was obtained. The Geosynthetic Installer shall replace any rejected rolls.

D. If a geotextile sample fails to meet the quality control requirements of this Section the Geotextile Manufacturer shall sample and test, at the expense of the Manufacturer, rolls manufactured in the same lot, or at the same time, as the failing roll. Sampling and testing of rolls shall continue until a pattern of acceptable test results is established to bound the failed roll(s).

E. Additional sample testing may be performed, at the Geotextile Manufacturer's discretion and expense, to identify more closely any non-complying rolls and/or to qualify individual rolls.

F. Sampling shall, in general, be performed on sacrificial portions of the geotextile material such that repair is not required. The Geotextile Manufacturer shall sample and test the geotextile, at a minimum once every 100,000 ft^2, to demonstrate that the geotextile properties conform to the values specified in Table 02771-1. At a minimum, the following manufacturing quality control tests shall be performed on each type of geotextile:

Test	Procedure	Cushion	Filtration	UV Protective
Mass per unit area	ASTM D 5261	Yes	No	No
Grab strength	ASTM D 4632	Yes	Yes	No
Puncture strength	ASTM D 4833	Yes	Yes	No
Permittivity	ASTM D 4491	No	Yes	No
A.O.S.	ASTM D 4751	No	Yes	Yes
Wide Width Tensile	ASTM D 4595	No	No	Yes

G. The Geotextile Manufacturer shall comply with the certification and submittal requirements of this Section.

2.03 Packing and Labeling

A. Geotextile shall be supplied in rolls wrapped in relatively impermeable and opaque protective covers.

B. Geotextile rolls shall be marked or tagged with the following information:

1. manufacturer's name;
2. product identification;
3. lot or batch number;

4. roll number; and
5. roll dimensions.

2.04 Transportation, Handling, and Storage

A. The Geosynthetic Installer shall be liable for any damage to the materials incurred prior to and during transportation to the site.

B. The geotextile shall be delivered to the site at least 14 days prior to the planned deployment date to allow the Engineer adequate time to perform conformance testing on the geotextile samples as described in Part 3.06 of this Section.

C. Handling, unloading, storage, and care of the geotextile prior to and following installation at the site, is the responsibility of the Geosynthetic Installer. The Geosynthetic Installer shall be liable for any damage to the materials incurred prior to final acceptance by the Engineer.

D. The Geosynthetic Installer shall be responsible for storage of the geotextile at the site.

E. The geotextile shall be protected from sunlight, excessive heat or cold, puncture, or other damaging or deleterious conditions. The geotextile shall be protected from mud, dirt, and dust. Any additional storage procedures required by the geotextile Manufacturer shall be the responsibility of the Geosynthetic Installer.

PART 3 – EXECUTION

3.01 Familiarization

A. Prior to implementing any of the work described in this Section, the Geosynthetic Installer shall become thoroughly familiar with the site, the site conditions, and all portions of the work falling within this Section.

B. Inspection:

1. The Geosynthetic Installer shall carefully inspect the installed work of all other Sections and verify that all such work is complete to the point where the installation of this Section may properly commence without adverse effect.

2. If the Geosynthetic Installer has any concerns regarding the installed work of other Sections or the site, the Engineer shall be notified, in writing, prior to commencing the work. Failure to notify the Engineer or installation of the geotextile will be construed as Geosynthetic Installer’s acceptance of the related work of all other Sections.

3.02 Placement

A. Geotextile installation shall not commence until CQA conformance evaluations, by the Engineer, of previous work are complete, including evaluations of the Contractor's survey results to confirm that the previous work was constructed to the required grades, elevations, and thicknesses. Should the Contractor begin the work of this Section prior to the completion of CQA evaluations, he does so at his own risk. The Contractor shall account for the CQA conformance evaluations in the construction schedule.

B. The Geosynthetic Installer shall handle all geotextile in such a manner as to ensure they are not damaged in any way.

C. The Geosynthetic Installer shall take any necessary precautions to prevent damage to underlying materials during placement of the geotextile.

D. After unwrapping the geotextile from its opaque cover, the filtration and cushion geotextile shall not be left exposed for a period in excess of 15 days unless a longer exposure period is approved in writing by the geotextile manufacturer.

E. The Geosynthetic Installer shall take care not to entrap stones, excessive dust, or moisture in the geotextile during placement.

F. The Geosynthetic Installer shall anchor or weight all geotextile with sandbags, or the equivalent, to prevent wind uplift.

G. The Geosynthetic Installer shall examine the entire geotextile surface after installation to ensure that no foreign objects are present that may damage the geotextile or adjacent layers. The Contractor shall remove any such foreign objects and shall replace any damaged geotextile.

3.03 Seams and Overlaps

A. On slopes steeper than 10 horizontal to 1 vertical, geotextiles shall be continuous down the slope; that is, no horizontal seams are allowed. Horizontal seams shall be considered as any seam having an alignment exceeding 20 degrees from being perpendicular to the slope contour lines, unless otherwise approved by the Engineer.

B. Geotextile shall be continuously sewn (i.e., spot sewing is not allowed) using a “single prayer” seam, with the stitching a minimum of 1.5 inches from the edge of the geotextile. Cushion to filtration geotextile shall be overlapped a minimum of 12 inches.

C. Geotextile shall be sewn with polymeric thread, having similar strength characteristics as the geotextile.

3.04 Repair

A. Any holes or tears in the geotextile shall be repaired using a patch made from the same geotextile. Geotextile patches will be sewn into place no closer than 1 inch from any panel edge. Should any tear exceed 50% of the width of the roll, that roll shall be removed and replaced.

B. Where geosynthetic materials underlie the geotextile being placed, care shall be taken to remove any soil or other material that may have penetrated the torn geotextile.

3.05 Placement of Soil Materials

A. The Contractor shall place soil materials on top of the geotextile in such a manner as to ensure that:

1. the geotextile and the underlying materials are not damaged;
2. minimum slippage occurs between the geotextile and the underlying layers during placement; and
3. excess stresses are not produced in the geotextile.

B. Equipment shall not be driven directly on the geotextile.

C. Unless otherwise approved in writing by the Engineer, all equipment operating on materials overlying the geotextile shall comply with Section 02200 and Section 02225.

3.06 Conformance Testing

A. Samples of the geotextile materials will be removed by the Engineer after the material has been received at the site and sent to a Geosynthetic CQA Laboratory for testing to ensure conformance with the requirements of this Section. This testing will be carried out, in accordance with the CQA Plan, prior to the start of the work of this Section.

B. Samples of each geotextile will be taken, by the Engineer, at a minimum frequency of one sample per 200,000 ft^2.

C. The Engineer may increase the frequency of sampling in the event that test results do not comply with requirements of Part 2.01 of this Section until passing conformance test results are obtained for all material that is received at the site. This additional testing shall be performed at the expense of the Contractor.

D. The following conformance tests will be performed:

Test	Procedure	Cushion	Filtration	UV Protective
Mass per unit area	ASTM D 5261	Yes	No	No
Grab strength	ASTM D 4632	Yes	Yes	No
Puncture strength	ASTM D 4833	Yes	Yes	No
Permittivity	ASTM D 4491	No	Yes	No
A.O.S.	ASTM D 4751	No	Yes	Yes
Wide Width Tensile	ASTM D 4595	No	No	Yes

E. Any geotextile that is not certified in accordance with Part 1.04 of this Section, or that conformance testing results do not comply with Part 2.01 of this Section, will be rejected. The Geosynthetic Installer shall replace the rejected material with new material.

3.07 Protection of Work

A. The Geosynthetic Installer shall use all means necessary to protect all work of this Section.

B. In the event of damage, the Geosynthetic Installer shall make repairs and replacements to the satisfaction of the Engineer at the expense of the Contractor.

PART 4 – MEASUREMENT AND PAYMENT

4.01 General

A. Providing for and complying with the requirements set forth in this Section for Cushion Geotextile will be measured as in-place square feet (SF), including Cushion Geotextile in the anchor trench to the limits shown on the Drawings, and payment will be based on the unit price provided on the Bid Schedule.

B. Providing for and complying with the requirements set forth in this Section for Filtration Geotextile will be measured as in-place square feet (SF), including Filtration Geotextile in the anchor trench to the limits shown on the Drawings, and payment will be based on the unit price provided on the Bid Schedule.

C. Providing for and complying with the requirements set forth in this Section for UV Protection Geotextile will be measured as in-place square feet (SF), including UV Protection Geotextile in the anchor trench to the limits shown on the Drawings, and payment will be based on the unit price provided on the Bid Schedule.

D. The following are considered incidental to the Work:

- shipping, handling and storage.
- layout survey.
- mobilization.
- rejected material.
- overlaps and seaming.
- rejected material removal, handling, re-testing, and repair.
- temporary anchorage.

TABLE 02771-1
REQUIRED PROPERTY VALUES FOR GEOTEXTILE

PROPERTIES	QUALIFIERS	UNITS	CUSHION SPECIFIED VALUES	FILTER SPECIFIED VALUES	UV PROTECTIVE SPECIFIED VALUES	TEST METHOD
Type			Nonwoven	nonwoven	Woven	(-)
Mass per unit area	minimum	oz/yd^2	16	6(1)	-	ASTM D 5261
Filter Requirements						
Apparent opening size (O_{95})	maximum	mm	-	0.21	0.43	ASTM D 4751
Permittivity	minimum	s^{-1}	-	0.8	-	ASTM D 4491
Mechanical Requirements						
Grab strength	minimum	lb	350	130	-	ASTM D 4632
Puncture strength	minimum	lb	155	40	-	ASTM D 4833
Wide Width Tensile Strength	minimum	ppi	-	-	110	ASTM D 4595
Durability						
Ultraviolet Resistance @ 500 hours	minimum	%	70	70	70	ASTM D 4355

Notes: (1) For information purposes only, not a required property.

END OF SECTION

SECTION 02772
GEOSYNTHETIC CLAY LINER

PART 1 – GENERAL

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, equipment, and incidentals necessary for installation of the geosynthetic clay liner (GCL). The work shall be carried out as specified herein and in accordance with the Drawings.

B. The work shall include, but not be limited to, delivery, storage, placement, anchorage, and seaming of the GCL.

1.02 Related Sections

Section 02200 — Earthworks

Section 02770 — Geomembrane

1.03 References

A. Drawings

B. Construction Quality Assurance (CQA) Plan

C. Latest Version American Society of Testing and Materials (ASTM) Standards:

ASTM D 2216	Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures
ASTM D 5321	Determination of the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method
ASTM D 5887	Test Method for Measurement of Index Flux Through Saturated Geosynthetic Clay Liner Specimens using a Flexible Wall Permeameter
ASTM D 5888	Guide for Storage and Handling of Geosynthetic Clay Liners
ASTM D 5890	Test Method for Swell Index of Clay Mineral Component of Geosynthetic Clay Liners
ASTM D 5891	Test Method for Fluid Loss of Clay Component of Geosynthetic Clay Liners
ASTM D 5993	Test Method for Measuring Mass per Unit Area of Geosynthetic Clay Liners

1.04 Qualifications

A. The Manufacturer shall be a well-established firm with more than ten years of experience in the manufacturing of GCL.

B. The Geosynthetic Installer shall install the GCL and shall meet the requirements of Section 02770 and this Section.

1.05 Submittals

A. At least 7 days before transporting any GCL to the site, the Manufacturer shall provide the following documentation to the Engineer for approval.

1. list of material properties, including test method, to which are attached GCL samples.

2. projected delivery dates for this project.

3. Manufacturing quality control certificates for each shift's production, signed by responsible parties employed by the Manufacturer (such as the production manager).

4. The quality control certificates shall include:

   a. roll numbers and identification; and

   b. results of quality control tests, including description of test methods used, outlined in Part 2.01 of this Section.

5. The Manufacturer shall certify that the GCL meets all the properties outlined in 2.01 of this Section.

1.06 Construction Quality Assurance Monitoring

A. The Geosynthetic Installer shall ensure that the materials and methods used for the GCL meet the requirements of the Drawings and this Section. Any material or method that does not conform to these documents, or to alternatives approved in writing by the Engineer, will be rejected and shall be repaired or replaced.

B. The Geosynthetic Installer shall be aware of all monitoring and conformance testing required by the CQA Plan. This monitoring and testing, including random conformance testing of construction materials and completed work, will be performed by the Engineer. If nonconformances or other deficiencies are found in the materials or completed work, the Geosynthetic Installer will be required to repair the deficiency or replace the deficient materials.

PART 2 – PRODUCTS

2.01 Material Properties

A. The flux of the GCL shall be no greater than 1×10^{-8} m^3/m^2-sec, when measured in a flexible wall permeameter in accordance with ASTM D 5887 under an effective confining stress of 5 pounds per square inch.

B. The GCL shall have the following minimum dimensions:

1. the minimum roll width shall be 15 feet; and

2. the liner length shall be long enough to conform with the requirements specified in this Section.

C. The bentonite used to fabricate the GCL shall have at least 90 percent sodium mortmorillonite.

D. The bentonite component of the GCL shall be applied at a minimum concentration of 0.75 pound per square foot, when measured at a water content of less than or equal to 0 percent.

E. The geotextile components of the GCL shall have a minimum combined mass per unit area of 9 oz/yd^2 in accordance with ASTM D 5261.

F. The GCL shall meet the required property values listed in Table 02772-1.

G. The bentonite will be adhered to the backing material(s) in a manner that prevents it from being dislodged when transported, handled, and installed in a manner prescribed by the Manufacturer. The method used to hold the bentonite in place shall not be detrimental to other components of the lining system.

H. An alternative GCL having a textured vapor barrier (i.e., geomembrane) as an integral component of the GCL may be provided. If an alternative GCL is used, the textured HDPE vapor barrier component shall be placed against the prepared subgrade and shall meet the following requirements:

1. have an average thickness of 30-mils in accordance with ASTM D 5994;

2. not have striations, pinholes, or bubbles on the surface or in the interior; and

3. be produced so as to be free of holes, blisters, undispersed raw materials, or any sign of contamination by foreign matter.

2.02 Interface Shear Testing

A. Interface Shear test(s) shall be performed on the proposed geosynthetic and soil components in accordance with ASTM D 5321. Tests shall be performed on several geosythetic interfaces as outlined below.

1. Dry GCL interface - the GCL shall be underlain by prepared subgrade compacted to 90% of the maximum dry density (ASTM D 1557) at the optimum moisture content and overlain by a textured 60-mil HDPE geomembrane, geocomposite, and operations layer material. The geosynthetic components of the liner system shall be allowed to “float” (i.e., not fixed) such that the failure surface can occur between any of the interfaces.

    a. The test shall be performed, under dry conditions, at normal stresses of 1, 3, and 5 psi at a shear rate of no more than 0.04 in./min. (1 mm/min.).

    b. The results of this test shall have a post peak apparent friction angle in excess of 18 degrees.

2. Hydrated GCL interface - the GCL shall be underlain by prepared subgrade compacted to 90% of the maximum dry density (ASTM D 1557) at the optimum moisture content and overlain by a textured 60-mil HDPE geomembrane, geocomposite, and operations layer material. The GCL component of the liner system shall be allowed to “float” (i.e., not fixed) such that the failure surface can occur at the top, bottom, or internal GCL interfaces.

    a. Before shearing, the GCL shall be hydrated under a loading of 240 psf (11 Kpa) for 48 hours. The test shall be performed under saturated conditions, at normal stresses of 20, 40, and 80 psi at a shear rate of no more than 0.04 in./min. (1 mm/min.).

    b. The results of this test shall have a post-peak apparent friction angle in excess of 12 degrees.

3. Hydrated GCL interface - If a GCL containing a geomembrane vapor barrier (i.e. Gundseal) is to be used, one additional shear strength test shall be performed. The GCL shall be underlain by prepared subgrade compacted to 90% of the maximum dry density (ASTM D 1557) at the optimum moisture content and covered by a textured 60 mil HDPE geomembrane, geocomposite, and operations layer material.

   a. The test shall evaluate the interface between the bentonite side of an unhydrated (i.e., dry) GCL containing a geomembrane vapor barrier and a textured 60 mil HDPE geomembrane. The test shall be set up such that the failure occurs between the bentonite component of the GCL and the textured geomembrane. The test shall be performed under dry conditions, at normal stresses of 20, 40, and 80 psi at a shear rate of no more than 0.04 in./min. (1 mm/min.).

   b. The acceptance criterion for the interface between the GCL consisting of a geomembrane vapor barrier component and the overlying geomembrane shall be as follows:

$$\tan^{-1}(0.25 \tan \delta_{hydrated} + 0.75 \tan\delta_{unhydrated}) \geq 12°$$

where $\delta_{hydrated}$ is the post-peak apparent friction angle in degrees determined in test No. 2 and $\delta_{unhydrated}$ is the post-peak apparent friction angle in degrees determined in test No. 3.

2.03 Manufacturing Quality Control

A. The GCL shall be manufactured with quality control procedures that meet or exceed generally accepted industry standards.

B. The Manufacturer shall sample and test the GCL to demonstrate that the material complies with the requirements of this Section.

C. Any GCL sample that does not comply with this Section will result in rejection of the roll from which the sample was obtained. The Manufacturer shall replace any rejected rolls.

D. If a GCL sample fails to meet the quality control requirements of this Section, the Engineer will require that the Manufacturer sample and test, at the expense of the Manufacturer, rolls manufactured in the same lot, or at the same time, as the failing roll. Sampling and testing of rolls shall continue until a pattern of acceptable test results is established to bound the failed roll(s).

E. Additional sample testing may be performed, at the Manufacturer's discretion and expense, to more closely identify any non-complying rolls and/or to qualify individual rolls.

F. Sampling shall, in general, be performed on sacrificial portions of the GCL material such that repair is not required. The Manufacturer shall sample and test the GCL to demonstrate that its properties conform to the requirements stated herein. At a minimum, the following tests shall be performed by the Manufacturer: dry mass per unit area and index flux at frequencies of at least 1 per 50,000 ft^2 and 1 per 200,000 ft^2, respectively.

G. The Manufacturer shall comply with the certification and submittal requirements of this Section.

2.04 Packing and Labeling

A. GCLs shall be supplied in rolls wrapped in impermeable and opaque protective covers.

B. GCLs shall be marked or tagged with the following information:

1. Manufacturer's name;
2. product identification;
3. lot number;
4. roll number; and
5. roll dimensions.

2.05 Transportation, Handling and Storage

A. Handling, storage, and care of the GCL, prior to and following installation, is the responsibility of the Geosynthetic Installer, until final acceptance by the Engineer.

B. The GCL shall be stored and handled in accordance with ASTM D 5888.

C. The Geosynthetic Installer shall be liable for all damage to the materials incurred prior to and during transportation to the site.

D. The GCL shall be on-site at least 14 days prior to the scheduled installation date to allow for completion of conformance testing described in Part 3.08 of this Section.

PART 3 – EXECUTION

3.01 Familiarization

A. Prior to implementing any of the work described in this Section, the Geosynthetic Installer shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the installation of this Section may properly commence without adverse impact.

B. Inspection:

1. The Geosynthetic Installer shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the installation of this Section may properly commence without adverse impact.

2. If the Geosynthetic Installer has any concerns regarding the installed work of other Sections, he should notify the Engineer in writing prior to commencing the work. Failure to notify the Engineer or installation of the GCL will be construed as Geosynthetic Installer's acceptance of the related work of all other Sections.

C. A pre-installation meeting shall be held to coordinate the installation of the GCL with the installation of other components of the lining system.

3.02 Surface Preparation

A. The Geosynthetics Installer shall provide certification in writing that the surface on which the GCL will be installed is acceptable. This certification of acceptance shall be given to the Engineer prior to commencement of geomembrane installation in the area under consideration.

B. Special care shall be taken to maintain the prepared soil surface.

C. No GCL shall be placed onto an area that has been softened by precipitation or that has cracked due to desiccation. The soil surface shall be observed daily to evaluate the effects of desiccation cracking and/or softening on the integrity of the prepared subgrade.

3.03 Crest Anchorage System

A. The anchor trench shall be excavated, prior to GCL placement, to the lines and grades shown on the Drawings.

B. No loose soil shall be allowed in the anchor trench beneath the GCL.

C. The GCL shall be temporarily anchored in the anchor trench until all geosynthetic layers are installed in the anchor trench as shown on the Drawings.

3.04 Handling and Placement

A. The Geosynthetic Installer shall handle all GCL in such a manner that they are not damaged in any way and so that they do not become hydrated prior to, or during, installation.

B. In the presence of wind, all GCLs shall be sufficiently weighted with sandbags to prevent their movement.

C. Any GCL damaged by stones or other foreign objects, or by installation activities, shall be repaired in accordance with Part 3.07 by the Geosynthetic Installer.

D. If an alternative GCL is used, the vapor barrier portion of the GCL shall be installed against the underlying prepared subgrade.

E. The GCL shall not be installed on an excessively moist subgrade or on standing water. The GCL shall be installed in a way that prevents hydration of the GCL prior to completion of construction of the liner system.

F. The GCL shall not be installed during precipitation or other conditions that may cause hydration of the GCL.

G. All hydrated GCL shall be removed and replaced by the Geosynthetic Installer.

3.05 Overlaps

A. On slopes steeper than 10 horizontal to 1 vertical, all GCL shall be continuous down the slope; that is, no horizontal seams shall be allowed on the slope. Horizontal seams shall be considered as any seam having an alignment exceeding 20 degrees from being perpendicular to the slope contour lines, unless otherwise approved by the Engineer.

B. All GCL shall be overlapped in accordance with the Manufacturer’s recommended procedures. As a minimum, along the length (i.e., the sides) of the GCL the overlap shall be 6 inches, and along the width (i.e., the ends) the overlap shall be 12 inches.

3.06 Materials in Contact With the GCL

A. Geomembrane installation shall immediately follow the GCL installation. All GCL that is placed during a day's work shall be covered with geomembrane before the Geosynthetic Installer leaves the site at the end of the day. The edges of GCL placement should be covered each day and protected from hydration due to storm water run-on.

B. Material shall not be placed on a GCL that is hydrated.

C. Installation of other components of the liner system shall be carefully performed to minimize damage to the GCL.

D. Equipment shall not be driven directly on the GCL.

E. Installation of the GCL in appurtenant areas, and connection of the GCL to appurtenances shall be made according to the Drawings. The Geosynthetic Installer shall ensure that the GCL is not damaged while working around the appurtenances.

3.07 Repair

A. Any holes or tears in the GCL shall be repaired by placing a GCL patch over the hole. On slopes steeper than 10 percent, the patch shall overlap the edges of the hole or tear by a minimum of 2 feet in all directions. On slopes 10 percent or flatter, the patch shall overlap the edges of the hole or tear by a minimum of 1 foot in all directions. The patch shall be secured with a water-based adhesive approved by the Manufacturer.

B. Care shall be taken to remove any soil or other material, which may have penetrated the torn GCL.

C. The patch shall not be nailed or stapled.

3.08 Conformance Testing

A. Samples of the GCL will be removed by the Engineer and sent to a Geosynthetic CQA Laboratory for testing to ensure conformance with the requirements of this Section. The Geosynthetic Installer shall assist the Engineer in obtaining conformance samples. The Geosynthetic Installer shall account for this testing in the installation schedule.

B. Samples shall be taken at a minimum frequency rate of one sample per 100,000 square feet.

C. The Engineer may increase the frequency of sampling in the event that test results do not comply with the requirements of Part 2.01 of this Section until passing conformance test results are obtained for all material that is received at the site. This additional testing shall be performed at the expense of the Contractor.

D. As a minimum, the following conformance tests will be performed: mass per unit area and index flux. All tests shall be carried out at a frequency of one sample per 100,000 ft^2 and 400,000 ft^2, respectively. In addition, the Engineer will perform a minimum of two interface shear strength tests in accordance with Part 2.02.

E. Any GCL that is not certified by the Manufacturer in accordance with Part 1.05 of this section or that does not meet the requirements specified in Part 2.01 shall be rejected and replaced by the Geosynthetic Installer.

3.09 Protection of Work

A. The Geosynthetic Installer shall use all means necessary to protect all work of this Section.

B. In the event of damage, the Geosynthetic Installer shall immediately make all repairs and replacements necessary to the approval of the Engineer.

PART 4 – MEASUREMENT AND PAYMENT

A. Providing for a complying with the requirements set forth in this Section for GCL will be measured as in-place square feet (SF), including GCL in the anchor trench to the limits shown on the Drawings, and payment will be based on the unit price provided on the Bid Schedule.

B. The following are considered incidental to the Work:

- shipping, handling and storage.
- overlaps and seaming.
- layout survey.
- mobilization.
- rejected material.
- rejected material removal, handling, re-testing, and repair.
- temporary anchorage.

TABLE 02772-1
REQUIRED GCL PROPERTY VALUES

PROPERTIES	QUALIFIERS	UNITS	SPECIFIED[1] VALUES	TEST METHOD
Liner System Properties				
Interface Shear Strength	minimum	degrees	18° (unhydrated) 12° (hydrated)	ASTM D 5321[2]
GCL Properties				
Bentonite Content[4]	minimum	lb/ft^2	0.75	ASTM D 5993
Bentonite Swell Index	minimum	mL/2g	24	ASTM D 5890
Bentonite Fluid Loss	maximum	mL	18	ASTM D 5891
Hydraulic Flux	minimum	m^3/m^2-s	1×10^{-8}	ASTM D 5887[3]
Moisture Content (Bentonite)	maximum	percent	25	ASTM D 2216

Notes: (1) All values represent minimum average roll values (i.e., any roll in a lot should meet or exceed the values in this table).
(2) Interface shear strength testing shall be performed, by the Engineer, in accordance with Part 2.02 of this Section.
(3) Hydraulic flux testing shall be performed under an effective confining stress of 5 pounds per square inch.
(4) Measured at a moisture content of 0 percent.

END OF SECTION

SECTION 02773
GEOCOMPOSITE

PART 1 – GENERAL

1.01 Description of Work

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, equipment, and incidentals necessary for the installation of the geocomposite. The work shall be carried out as specified herein and in accordance with the Drawings.

B. The work shall include, but not be limited to, delivery, storage, placement, and seaming of the geocomposite.

C. Geocomposite shall be used overlying the geomembrane and underlying the operations layer on the side slopes for the base liner system. Geocomposite shall be used overlying the geomembrane for the final cover liner system.

1.02 Related Sections

Section 02200 — Earthwork

Section 02770 — Geomembrane

Section 02771 — Geotextiles

1.03 References

A. Drawings

B. Construction Quality Assurance (CQA) Plan

C. Latest version of American Society for Testing and Materials (ASTM) standards:

ASTM D 413. Standard Test Method for Rubber Property-Adhesion to Flexible Substrate.

ASTM D 792. Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.

ASTM D 1603. Standard Test Method for Carbon Black in Olefin Plastics.

ASTM D 4491. Standard Test Methods for Water Permeability of Geotextiles by Permittivity.

ASTM D 4533. Standard Test Method for Trapezoid Tearing Strength of Geotextiles.

ASTM D 4632. Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.

ASTM D 4716. Standard Test Method for Constant Head Hydraulic Transmissivity (In-Plane Flow) of Geotextiles and Geotextile Related Products.

ASTM D 4751. Standard Test Method for Determining Apparent Opening Size of a Geotextile.

ASTM D 4833. Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.

ASTM D 5199. Standard Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes.

ASTM D 5261. Standard Test Method for Measuring Mass per Unit Area of Geotextiles.

1.04 Qualifications

A. The manufacturer shall be a well-established firm with more than one year experience in the manufacturing of geocomposite.

B. The Geosynthetic Installer shall install the geocomposite and shall meet the requirements of Section 02770 and this Section.

1.05 Submittals

A. The Geosynthetic Installer shall submit to the Engineer, at least 7 days prior to geocomposite delivery, the following information regarding the proposed geocomposite:

1. manufacturer and product name;
2. minimum property values of the proposed geocomposite and the corresponding test procedures;
3. projected geocomposite delivery dates; and
4. list of geocomposite roll numbers for rolls to be delivered to the site.

B. At least 7 days prior to geocomposite placement, the Geosynthetic Installer shall submit to the Engineer the manufacturing quality control certificates for each roll of geocomposite. The certificates shall be signed by responsible parties employed by the geocomposite manufacturer (such as the production manager). The quality control certificates shall include:

1. lot, batch, and/or roll numbers and identification; and
2. results of quality control tests, including a description of the test methods used.

1.06 Construction Quality Assurance Monitoring

A. The Geosynthetic Installer shall ensure that the geocomposite and installation methods used meet the requirements of the Drawings and this Section. Any material or method that does not conform to these documents, or to alternatives approved in writing by the Engineer, will be rejected and shall be repaired or replaced by the Geosynthetic Installer.

B. The Geosynthetic Installer shall be aware of and accommodate all monitoring and conformance testing required by the CQA Plan. This monitoring and testing, including random conformance testing of construction materials and completed work, will be performed by the Engineer. If nonconformances or other deficiencies are found in the Geosynthetic Installer's materials or completed work, the Geosynthetic Installer will be required to repair the deficiency or replace the deficient materials.

PART 2 – PRODUCTS

2.01 Geocomposite Properties

A. The Geocomposite Manufacturer shall furnish geocomposites having properties that comply with the required property values shown in Table 02773-1. The Geocomposite Manufacturer shall provide results of tests performed using the procedures listed in Table 02773-1, as well as certification that the materials meet or exceed the specified values.

B. Geotextiles will be thermally bonded to both sides of the geonet component of geocomposite material rather than chemically bonded.

C. Geocomposite suppliers shall furnish materials in which the "Minimum Average Roll Values", as defined by the Federal Highway Administration (FHWA), meet or exceed the criteria specified in Table 02773-1.

D. The geocomposite's geotextile components shall be nonwoven materials, suitable for use in filter/separation and cushion applications.

2.02 Manufacturing Quality Control

A. The geocomposite shall be manufactured with quality control procedures that meet or exceed generally accepted industry standards.

B. The geocomposite Manufacturer shall sample and test the geocomposite to demonstrate that the material conforms to the requirements of these Specifications.

C. Any geocomposite sample that does not comply with this Section shall result in rejection of the roll from which the sample was obtained. The Geosynthetic Installer shall replace any rejected rolls.

D. If a geocomposite sample fails to meet the quality control requirements of this Section the geocomposite Manufacturer shall sample and test, at the expense of the Manufacturer, rolls manufactured in the same lot, or at the same time, as the failing roll. Sampling and testing of rolls shall continue until a pattern of acceptable test results is established to bound the failed roll(s).

E. Additional sample testing may be performed, at the geocomposite Manufacturer's discretion and expense, to identify more closely any non-complying rolls and/or to qualify individual rolls.

F. Sampling shall, in general, be performed on sacrificial portions of the geocomposite material such that repair is not required. The Geocomposite Manufacturer shall sample and test the geocomposite, at a minimum once every 100,000 ft^2, to demonstrate that the geocomposite properties conform to the values specified in Table 02773-1. At a minimum, the following manufacturing quality control tests shall be performed on the geotextile component of the geocomposite:

Test	Procedure
Mass per unit area	ASTM D 5261
Grab strength	ASTM D 4632
Puncture strength	ASTM D 4833
Permittivity	ASTM D 4491
A.O.S.	ASTM D 4751

G. At a minimum, the following manufacturing quality control tests shall be performed on the geonet component of the geocomposite:

Test	Procedure
Specific gravity	ASTM D 792
Nominal thickness	ASTM D 5199

H. At a minimum, the following manufacturing quality control tests shall be performed on the geocomposite:

Test	Procedure
Transmissivity	ASTM D 4716
Peel strength	ASTM D 413

I. The geocomposite Manufacturer shall comply with the certification and submittal requirements of this Section.

2.03 Packing and Labeling

A. Geocomposite shall be supplied in rolls wrapped in relatively impermeable and opaque protective covers.

B. Geocomposite rolls shall be marked or tagged with the following information:

1. manufacturer's name;
2. product identification;
3. lot or batch number;
4. roll number; and
5. roll dimensions.

2.04 Transportation, Handling, and Storage

A. The Geosynthetic Installer shall be liable for any damage to the materials incurred prior to and during transportation to the site.

B. The geocomposite shall be delivered to the site at least 14 days prior to the planned deployment date to allow the Engineer adequate time to perform conformance testing on the geocomposite samples as described in Part 3.06 of this Section.

C. Handling, unloading, storage, and care of the geocomposite prior to and following installation at the site, is the responsibility of the Geosynthetic Installer. The Geosynthetic Installer shall be liable for any damage to the materials incurred prior to final acceptance by the Engineer.

D. The Geosynthetic Installer shall be responsible for storage of the geocomposite at the site.

E. The geocomposite shall be protected from sunlight, excessive heat or cold, puncture, or other damaging or deleterious conditions. The geocomposite shall be protected from mud, dirt, and dust. Any additional storage procedures required by the geocomposite Manufacturer shall be the responsibility of the Geosynthetic Installer.

PART 3 – EXECUTION

3.01 Familiarization

A. Prior to implementing any of the work described in this Section, the Geosynthetic Installer shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the installation of this Section may properly commence without adverse impact.

B. Inspection:

1. The Geosynthetic Installer shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the installation of this Section may properly commence without adverse impact.

2. If the Geosynthetic Installer has any concerns regarding the installed work of other Sections, he should notify the Engineer in writing prior to commencing the work. Failure to notify the Engineer or installation of the geocomposite will be construed as Geosynthetic Installer's acceptance of the related work of all other Sections.

C. A pre-installation meeting shall be held to coordinate the installation of the geocomposite with the installation of other components of the lining system.

3.02 Handling and Placement

A. The Geosynthetic Installer shall handle all geocomposite in such a manner that it is not damaged in any way.

B. Install the geocomposite down the slope not across the slope. Place ends into the anchor trenches in such a manner as to continually keep the geocomposite in tension.

C. Precautions shall be taken to prevent damage to underlying layers during placement of the geocomposite.

D. In the presence of wind, all geocomposites shall be sufficiently weighted with sandbags or the equivalent to prevent movement.

E. The geocomposite shall be positioned by hand after being unrolled to minimize wrinkles.

F. Care shall be taken during placement of geocomposites not to entrap dirt or excessive dust in the geocomposite that could cause clogging of the drainage system, and/or stones that could damage the adjacent geomembrane. If dirt or excessive dust is entrapped in the geocomposite, it should be cleaned prior to placement of the next material on top of it. Care shall be exercised when handling sandbags, to prevent rupture or damage of the sandbags.

G. Geocomposites shall only be cut using a hooked utility blade.

H. After unwrapping the geocomposite from its opaque cover, the geocomposite shall not be left exposed for a period in excess of 15 days.

3.03 Overlaps and Seams

A. Geonet Components:

1. The geonet components shall be overlapped a minimum 4 in. along the length. The geonet shall be overlapped by a minimum 1 ft. across the width.

2. Geonet overlaps shall be secured by tying with nylon cable ties. Tying devices shall be white or yellow for easy inspection. Metallic devices shall not be used.

3. Seaming of the geonet shall be performed by wrap-ties at 12-in. centers for end of panels and at 5-ft centers for edge of panel seams.

4. No end-of-panel seams shall be placed on slopes exceeding 10 %.

B. Geotextile Components:

1. The bottom layers of geotextile shall be overlapped. The top layers of geotextiles shall be continuously sewn.

2. Polymeric thread, with chemical resistance properties equal to or exceeding those of the geotextile component, shall be used for all sewing.

3.04 Placement of Overlying Materials

A. All overlying materials shall be placed in such a manner as to ensure that:

1. The geocomposite and underlying materials are not damaged;

2. Minimal slippage occurs between the geocomposite and underlying layers; and

3. Excess tensile stresses are not produced in the geocomposite.

4. Equipment shall not be driven directly on the geocomposite.

5. Unless otherwise approved in writing by the Engineer, all equipment operating on the materials overlying the geotextile shall comply with Section 02200 and Section 02225.

3.05 Conformance Testing

A. Samples of geocomposite will be removed by the Engineer and sent to a Geosynthetic CQA Laboratory for testing to ensure conformance with the requirements of this Section. The Geosynthetic Installer shall assist the Engineer in obtaining conformance samples. The Geosynthetic Installer shall account for this testing in the installation schedule.

B. Samples shall be taken at a minimum frequency rate of one sample per 200,000 square feet.

C. The Engineer may increase the frequency of sampling in the event that test results do not comply with the requirements of Part 2.01 of this Section until passing conformance test results are obtained for all material that is received at the site. This additional testing shall be performed at the expense of the Contractor.

D. As a minimum, transmissivity and peel strength will be performed on each sample.

E. Any geocomposite that is not certified by the Manufacturer in accordance with Part 1.05 of this section or that does not meet the requirements specified in Part 2.01 shall be rejected and replaced by the Geosynthetic Installer.

3.06 Protection of Work

A. The Geosynthetic Installer shall use all means necessary to protect all work of this Section.

B. In the event of damage, the Geosynthetic Installer shall immediately make all repairs and replacements necessary to the approval of the Engineer.

PART 4 – MEASUREMENT AND PAYMENT

A. Providing for a complying with the requirements set forth in this Section for geocomposite will be measured as in-place square feet (SF), including geocomposite in the anchor trench to the limits shown on the Drawings, and payment will be based on the unit price provided on the Bid Schedule.

B. The following are considered incidental to the Work:

- shipping, handling, and storage.
- overlaps and seaming.
- layout survey.
- mobilization.
- rejected material.
- rejected material removal, handling, re-testing, and repair.
- temporary anchorage.

TABLE 02773 - 1

GEOCOMPOSITE PROPERTY VALUES – BASE LINER SYSTEM

PROPERTIES	QUALIFIER	UNITS	SPECIFIED VALUES (1)	TEST METHOD
Geonet Component:				
Specific gravity	Minimum		0.935	ASTM D 792
Carbon black content	Range	%	2 – 3	ASTM D 1603
Nominal thickness	Minimum	mils	200	ASTM D 5199
Geotextile Components:				
Mass per unit area	Minimum	oz/yd^2	8	ASTM D 5261
Filter Requirements				
Apparent opening size	Maximum	mm	0.21 mm	ASTM D 4751
Permittivity	Minimum	1/s	0.6	ASTM D 4491
Mechanical Requirements				
Grab strength	Minimum	lb	190	ASTM D 4632
Puncture strength	Minimum	lb	110	ASTM D 4833
Geocomposite:				
Transmissivity (2)	Minimum	m^2/s	6.1×10^{-5}	ASTM D 4716
Peel Strength	Minimum	gm/in	500	ASTM D 413

Notes:

1. All values except transmissivity represent minimum average roll values (i.e., any roll in a lot should meet or exceed the values in this table).

2. The design transmissivity is the hydraulic transmissivity of the geocomposite measured using water at 68°F ±3°F (20°C ±1.5°C) with a hydraulic gradient of 0.1 under a compressive stress of not less than 12,000 psf (574 kPa). For the test, the geocomposite shall be sandwiched between a layer of operations material and a textured 60-mil HDPE geomembrane. The minimum test duration shall be 24 hours and the report for the test results shall include measurements at intervals over the entire test duration.

END OF SECTION

SECTION 02820
CHAIN LINK FENCE

PART 1 – GENERAL

1.01 Description of Work

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, equipment, and incidentals necessary to construct the Chain Link Fence. The Work shall be performed as specified herein and in accordance with the Drawings.

B. The Work shall include construction of footers, construction of posts, rails, and bracing, placement and securing the fence fabric, construction and installation of swing gates, and all other Work incidental to construction of a completed fence as shown on the Drawings and as described in this Section.

1.02 Related Sections

Section 01025 – Measurement and Payment

Section 01300 – Submittals

Section 01400 – Quality Control

Section 01500 – Construction Facilities

Section 01560 – Temporary Controls

Section 02200 – Earthwork

Section 03400 – Cast-in-Place Concrete

1.03 References

A. Drawings

B. Latest Version of American Society for Testing and Materials (ASTM) Standards:

ASTM A 153	Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A 1043	Standard Specification for Strength and Protective Coatings on Metal Industrial Chain Link Fence Framework

1.04 Delivery, Storage, and Handling

A. Deliver materials to Site in good condition, in unopened packaging, and with labels intact. Inspect materials upon delivery and replace damaged or contaminated materials.

B. Store materials above ground, under cover, in a dry place, and in a manner to prevent damage or staining.

C. Handle materials to prevent damage to surfaces, edges, and ends. Replace damaged materials at no additional cost to the Owner.

1.05 Submittals

A. The Contractor shall submit to the Construction Manager, at least 7 days prior to installation of fence material, certificates of compliance with the fence Manufacturer's specifications and that the material meets or exceeds all internal quality control requirements and the requirements of this Section.

1.06 Quality Assurance

A. The Contractor shall ensure that the materials and methods used for security chain link fence construction meet the requirements of the Manufacturer, the Drawings, and this Section. Any material or method that does not conform to these documents, or to alternatives approved in writing by the Design Engineer will be rejected and shall be repaired or replaced by the Contractor to the satisfaction of the CQA Engineer at the Contractor's expense.

PART 2 – PRODUCTS

2.01 Security Fence Fabric

A. Fence fabric: 2" by 2" mesh size, 11 gauge core size, hot-dip zinc galvanized steel wire.

B. Fence fabric shall be a commercial-grade fence system, as supplied by Master-Halco, or shall be equivalent in core material, metallic-coating material, and all coating processes and strengths.

C. Manufacturer shall warranty the fence materials against defects and deterioration, other than normal wear and tear, for a minimum of 12 years.

D. Fabric selvages shall be twisted (barbed) on the top and knuckled on the bottom.

E. The heights of fabric shall be sufficiently long so that no horizontal splices are required.

2.02 Framework

A. Framework includes all posts and rails.

B. Fencing framework shall be made of tubular galvanized steel pipe that conforms to ASTM F 1043, Group 1a. The framework shall be standard weight, schedule 40 steel pipe, galvanized by the hot-dip method, with a minimum average of 1.8 ounces per square foot of zinc-coated surface.

C. Dimensions of the framework components shall be as shown on the Drawings.

2.03 Footers

A. Post footers shall be made with concrete rated at a minimum of 2,500 pounds per square inch (psi) and shall be constructed to the dimensions as shown on the Drawings.

2.04 Swing Gates

A. Gates frames shall be of the same materials and coatings as for the fence fabric and framework.

B. Dimensions of the gates and gate components shall be as shown on the Drawings.

C. Gate frame members shall be welded at joints for a rigid connection.

D. Contractor shall provide and install the following hardware for each gate:

E. Hinges: provide hinges of type to, size, and material to suit gate size. Hinges shall be non-liftoff type, offset to permit 180 degree gate opening.

F. Latch: exit control lock and cylinder, as shown on the Drawings.

G. Latch rail: steel plate, weld to stiles at interior side of gate to receive and protect latch.

2.05 Hardware

A. Hardware shall include bolts, tension rods, and truss rods.

B. Hardware shall be made of galvanized steel as per ASTM A 153.

C. Bolts shall be 3/16” diameter self drilling hex head TEK screws with flat washers, as manufactured by Hilti, Red Head, or approved.

D. Tension rods shall be stainless steel, in standard lengths to equal full height of fabric, with maximum cross section to suit fabric openings. Provide one tension rod for each gate post and corner post.

E. Truss rods shall be minimum 3/8” diameter threaded, galvanized steel rod and turnbuckle.

2.06 Fittings

A. Fittings include: tension and brace bands, caps, eye tops, rail ends, sleeves, and tie wires.

B. All fittings, except tie wires, shall be hot-dip galvanized steel. Tie wires shall be zinc-coated steel wire.

PART 3 – EXECUTION

3.01 General

A. When shipping, delivering, and installing all fence materials, do so to ensure a sound, undamaged installation. Provide storage for all materials and equipment delivered to the Site that is protective of stored materials. Handle and store materials in accordance with the Manufacturer's recommendations.

B. Prior to installation, examine surfaces designated to receive Work described in the Section for conditions adversely affecting the finished Work. Repair or replace surfaces not meeting tolerances or quality requirements governing substrate construction prior to initiating this Work.

C. Do not begin installation and erection before construction of the concrete secondary containment portion of the Work is complete.

3.02 Installation

A. Install materials in accordance with accepted shop drawings and Manufacturer’s printed instructions.

B. Provide top and intermediate rails as shown on Drawings. Install each as one piece between posts. Offset as necessary to allow for depth of fabric.

C. Place chain link fabric on the outside of the area to enclosed. Secure one end and apply sufficient tension to remove all slack before making attachments elsewhere. Tighten the fabric to provide a smooth uniform appearance, free from sag.

D. Cut fabric by untwisting on picket and attach each span independently at all terminal posts. Install tension rods with bolts and washers at 15" on center.

E. Fasten fabric to all posts, rails, and gate frames with bolts and washers at 15" on center.

F. Gates: install gates plumb, level and secure, for full operation without interference. Adjust hardware for smooth operation and lubricate where necessary. Gates shall open outward form the area to be secured.

G. Clearances: install fencing and gates with a maximum ½" clearance between the perimeter of the fabric and the framing, between the framing and adjacent construction, and between the perimeter of each gate leaf and surrounding construction. Close off gaps exceeding 1/2"at the direction of the Construction Manager.

3.03 Cleaning Up

A. During the progress of the Work, the premises shall be kept free of debris and waste. Upon completion, remove from the Site and dispose of all debris and surplus materials in a lawful manner.

B. At completion of Work, touch up minor damage to all surfaces to the satisfaction of the Construction Manager. Protect completed Work until final acceptance by the Owner.

3.04 Survey

A. The locations of the fence posts shall be surveyed by the Surveyor, and shall be included in the Record Drawings.

PART 4 – MEASUREMENT AND PAYMENT

4.01 General

A. Providing for and complying with the requirements set forth in this Section for chain link fence will be measured as linear feet (LF), and payment will be based on the unit price provided on the Bid Schedule.

B. The following are considered incidental to the Work:

- Submittals.
- Mobilization.
- Quality Control.
- Shipping, handling and storage.
- Footers
- Framework
- Welding.
- Fence fabric
- Gates
- Hardware and fittings
- Clean up
- As-built survey.

END OF SECTION

Section 5
Final Cover Calculation Packages

Section 5
Final Cover Calculation Packages

Calculation Package A
Geocomposite and Pipe Size Calculation

GeoSyntec Consultants

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: Parsons **Project:** BRC CAMU **Project/Proposal #:** HL0389 **Task #:** 04

Title of Computations: Drainage Geocomposite and Pipe Size Requirements

Computations By:
SIGNATURE — DATE: 10 July 2000
Geoff L. Smith / Staff Engineer
PRINTED NAME AND TITLE

Assumptions and Procedures Checked By (Peer Reviewer):
SIGNATURE — DATE: 13 JULY 2000
MICHAEL E. KALINSKI / SR. STAFF ENG.
PRINTED NAME AND TITLE

Computations Checked By:
SIGNATURE — DATE: 7/14/00
GREGORY T CORCORAN / PROJ. ENG.
PRINTED NAME AND TITLE

Computations Backchecked By (Originator):
SIGNATURE — DATE: 7/14/00
Geoff L. Smith / Staff Engineer
PRINTED NAME AND TITLE

Approved By (PM or Designate):
SIGNATURE — DATE: 7/17/2000
Bradford H. Cody / Project Manager
PRINTED NAME AND TITLE

Approval Notes:

Revisions: (Number and Initial All Revisions)

No.	Sheet	Date	By	Checked By	Approval

Written by: Geoff L. Smith Date: 00 / 07 / 10 (YY MM DD) Reviewed by: 7.13.00 GTC Date: 00 / 07 / 14 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 04

DRAINAGE COMPOSITE AND PIPE SIZE REQUIREMENTS
BRC CAMU
HENDERSON, NEVADA

OBJECTIVE

The objective of this analysis is to evaluate the hydraulic performance of a drainage geocomposite and drainage pipe within the final cover system at the BRC Corrective Action Management Unit (CAMU). A drainage pipe is proposed to convey the collected water (from the geocomposite) to perimeter ditches. This calculation will evaluate the required criteria (e.g., transmissivity, pipe diameter) for the geocomposite and pipes.

SUMMARY OF ANALYSIS

The analyses indicate that the ultimate (or laboratory) transmissivity of the drainage composite shall be greater than 1×10^{-3} m^2/sec-m at $\sigma_n = 2000$ psf and $i = 0.10$. The drainage path shall be no longer than 1100 ft. The drainage pipe shall be 6-inch diameter perforated, corrugated polyethylene (CPE) pipe. The interior wall of the pipe shall be smooth.

METHOD OF ANALYSIS

The approach of the analysis is to first select a representative geocomposite from manufacturer data. Then, the ultimate transmissivity of the geocomposite will be evaluated from the manufacturer data. The allowable transmissivity of the geocomposite will be evaluated by reducing the ultimate transmissivity by partial factors of safety to account for field conditions. The allowable transmissivity will be used in an analysis performed using the Hydrological Evaluation of Landfill Performance (HELP) model developed by the EPA. The HELP model was developed to conduct water balance analysis of landfills, cover systems, and solid waste disposal and containment facilities.

Precipitation values used in this analysis are based on the assumed irrigation rates of a potential golf course that may be constructed overlying the final cover system. Based on verbal conversations with golf course landscape managers in Palm Springs, CA, approximately 3.5 inches of water per month is used from September to April and approximately 7 inches during the summer months. This equates to a total of about 56 inches per year. In addition, at the end of the model year, a 3-inch storm was simulated in HELP.

Written by: Geoff L. Smith Date: 00 / 07 / 10 (YY MM DD) Reviewed by: 7/13/00 Date: 00 / 07 / 14 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 04

The maximum drainage length of the geocomposite will be evaluated by varying its value to limit the head on the liner to a value less than the design criterion.

FINAL COVER LINER SYSTEM

The final cover system consists of, from top to bottom:

- 2 ft native material;
- a geocomposite;
- a 60-mil (1.5-mm) thick high density polyethylene (HDPE) geomembrane;
- a geosynthetic clay liner (GCL); and
- prepared subgrade.

The sideslope inclination is 3.0H:1.0V and the top deck area has a minimum grade of 2%. The maximum height of the side slope is 30 vertical feet (Figure 1).

DESIGN CRITERION

The design criteria consists of an allowable liquid head over the geomembrane component of the final cover system for the top deck area and side slopes. The allowable liquid head over the geomembrane for the side slopes is a negligible amount to limit potential sloughing failure of the vegetative cover soil component of the final cover system. The allowable head over the geomembrane for the top deck is less than twelve inches (0.3 m), to minimize unstable areas in the vegetative cover soil.

ANALYSIS

Geocomposite Design

A review of manufacturer literature suggests that an ultimate transmissivity of 1×10^{-3} m^2/sec can be achieved (see Attachment A) under gradients and normal stresses representative of the BRC CAMU final cover.

To ensure that the transmissivity of the proposed drainage composite meets or exceeds the required values over the life of the final cover, the ultimate transmissivity must be reduced through the use of appropriate partial factors of safety. These partial factors of safety

make the adequate adjustment between the laboratory transmissivity values for drainage composite and actual field conditions.

As seen in Attachment B, Koerner suggests four partial factor of safety values that should be accounted for: the intrusion of the adjacent geotextile into the core of the geonet (FS_{IN}), creep deformation of the geonet (FS_{CR}), factor of safety against chemical clogging of the geonet (FS_{CC}), and factor of safety against biological clogging of the geonet (FS_{BC}). Partial factor of safety values were applied to the geotextile in the filtration geotextile calculation to account for flow through the geotextile component of the drainage composite.

Attachment B shows the ranges for the partial factors of safety. For the purposes of this analysis, the following factors of safety values were selected:

$FS_{IN} = 1.0$ (Accounted for during the testing of the drainage composite)
$FS_{CR} = 1.3$
$FS_{CC} = 1.0$ (Surface water)
$FS_{BC} = 1.2$ (Surface water)

The allowable transmissivity of the drainage composite then becomes:

$$\theta_{allowable} = \theta_{ultimate} / (\prod FS)$$

$\prod FS$ = product of all the partial factors of safety for the site specific conditions

The allowable transmissivity of the drainage composite is then calculated as:

$$\theta_{allowable} = \theta_{ultimate} / (\prod FS) = 1 \times 10^{-3}\ m^2/sec\ /\ [\ 1.0*1.3*1.0*1.2]$$

$$= \mathbf{6.4 \times 10^{-4}\ m^2/sec\ at\ \sigma_n = 2000\ psf,\ i = 0.10}$$

The hydraulic conductivity and the thickness of the geocomposite are input for the HELP model to evaluate the maximum drainage distance. The hydraulic conductivity can be translated to transmissivity by using Darcy's Law as shown below:

$q = kiA = ki(t * W) = kti = \theta i$, therefore, for a unit width,
$k = \theta / t$

Written by: Geoff L. Smith GLS Date: 00 / 07 / 10 (YY MM DD) Reviewed by: BHC 7-13-00 GTC Date: 00 / 07 / 14 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 04

The thickness of the geocomposite can be ascertained from manufacturer information. (ATTACHMENT A) The thickness used herein is 225 mils (0.0057 m) for the Gundnet XL-14. Hence, the allowable hydraulic conductivity is 11 cm/sec (6.4×10^{-4} m^2/sec / 0.0057 m * 100) for the geocomposite.

HELP model output is presented in Attachment D. Typical near surficial soils exhibit a permeability of 5.3×10^{-4} cm/sec (Converse 1999) (Attachment C). Input parameters and results from the HELP model are presented below for the top deck area:

K_{veg} (cm/sec)	drainage length (ft)	Gradient (%)	$t_{geocomposite}$ (in)	$k_{geocomposite}$ (cm/sec)	Head on Liner (in)
5.3×10^{-4}	1100	2.0	0.225	11	8.2

Input parameters and results from the HELP model are presented below for the side slope area (Figure 1):

K_{veg} (cm/sec)	drainage length (ft)	Gradient (%)	$t_{geocomposite}$ (in)	$k_{geocomposite}$ (cm/sec)	Head on Liner (in)
5.3×10^{-4}	150	33.3	0.225	11	0.0

Since the head on the side slope liner is negligable, slope stability analyses for the side slope that includes seepage forces are not needed. BHC 7/17/00

Based on the above analyses, the drainage geocomposite and drainage distances meet the design criteria.

Pipe Size Design

A pipe diameter must be chosen for the final cover collection pipes and the downchutes for the final cover drainage system. The pipe is assumed to be a CPE pipe with a smooth wall interior. Figure 1 shows the maximum contributing area that a lateral must collect. This maximum contributing area is 13.2 acres (located in the South Mesa). From the HELP model analyses (Attachment D), the peak daily quantity of water expected to be generated is 926 cubic feet per acre. Assuming that all of this liquid will have to flow through one pipe, the following flow rate can be calculated:

(926 CF/day/acre) * 13.2 acres / (24 hours/day) / (60 min/hour) / (60 sec/min) = 0.14 cfs

Written by: Geoff L. Smith GLS Date: 00 / 07 / 10 (YY MM DD) Reviewed by: MSK 7.13.00 GTC Date: 00 / 07 / 14 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 04

Manning's Equation (Attachment E) can be used to estimate the flow rate in the pipe when flowing full:

$$Q_{full} = (1.486/n)(A)(R)^{2/3}(S)^{1/2}$$

where:
n = Manning's roughness coefficient, 0.012 from product literature (Attachment F)
A = area of pipe
R = hydraulic radius = area/wetting perimeter of the pipe (Attachment E)
S = slope of pipe, assume 0.5%

Assuming a 6-inch diameter corregated pipe flowing half-full, and using literature from ADS (Attachment F), the following values will be used in the above equation:

$r = 3.0$ in (Attachment F)
$A = \pi r^2 = \pi(3/12)^2 = 0.196 \text{ ft}^2$
$R = (0.196) / (2\pi(3/12)) = 0.125$ ft

Placing the above values into the Manning's equation results in the following:

$$Q_{full} = (1.486/0.012)(0.196)(0.125)^{2/3}(0.005)^{1/2}$$

$Q_{full} = 0.43 \text{ cfs} > 0.14$ O.K.

Therefore, a 6-inch nominal diameter pipe is acceptable.

NOTE TO SPECIFICATIONS

The ultimate transmissivity of the drainage composite shall be greater than or equal to 1×10^{-3} m^2/sec at $\sigma_n = 2000$ psf and $i = 0.10$. The drainage path shall be no longer than 1100 ft. The pipe shall be 6-inch diameter perforated corrugated polyethylene pipe with smooth interior wall.

Written by: Geoff L. Smith GLS Date: 00 / 07 / 10 (YY MM DD) Reviewed by: GC Date: 00 / 07 / 14 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 04

REFERENCES

Advanced Drainage Systems, Inc., Product Literature, (614) 457-3051. *(Attachment F)*

Koerner, R.M. (1994) "Designing with Geosynthetics", 3rd Edition, Prentice Hall, New Jersey *(Attachment B)*

Environmental Protection Agency (1994), "The Hydrologic Evaluation of Landfill Performance (HELP) Model," September 1994. *(model ouput presented in Attachment D)*

Converse Consultants (1999), "Preliminary Geotechnical and Geologic Investigation, Industrial Non-Hazardous Disposal Facility, Basic Management Incorporated, Clark County, Nevada," October 27, 1999, Las Vegas, Nevada. *(Attachment C)*

Chow, V.T. (1959) "Open Channel Hydraulics," McGraw-Hill, *(Attachment E)*

Product Description

Gundnet® XL-14 Drainage Media is a net-like product of two overlapping polyethylene strands which transmits fluids in the plane of the net.

Fabri-Net® XL-14 Drainage Composite consists of a geotextile fabric heat bonded to Gundnet® XL-14 Drainage Net on one or both sides.

- Gundnet® XL-14 and Fabri-Net® XL-14 drainage systems are rolled on 6 in. (15 cm) I.D. hollow cores.
- Each Gundnet® XL-14 roll is provided with a sling to aid handling on site.
- Fabri-Net® XL-14 Drainage Composite is wrapped in a protective plastic bag.
- Dimensions and weights are approximate.
- Custom lengths available.

Gundnet® XL-14 Drainage Net and Fabri-Net® XL-14 Drainage Composite

Gundnet® XL-14 Drainage Net and Fabri-Net® XL-14 Drainage Composite replace traditional one foot (0.3 m) thicknesses of drainage sand with typically 100 times the equivalent hydraulic conductivity of the sand drainage layer. They simultaneously add nearly one foot of air space to the project for each drainage layer they replace. Fabri-Net® XL-14 Drainage Composite allows single step deployment where geotextile separation of soils from drainage net is required. Double-sided Fabri-Net® XL-14 Drainage Composite (geotextile heat bonded on both sides) provides tremendous slope stability in combination with textured liner by gripping the geomembrane surface with velcro-like friction.

Standard Roll Dimensions

Gundnet® XL-14

Roll Width	6.5 ft. (2 m)	14 ft. (4.3 m)
Roll Length	100 ft. (30 m)	300 ft. (91 m)
Roll Weight	130 lbs (60 kg)	840 lbs (382 kg)

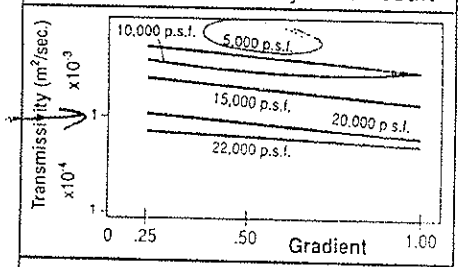
Fabri-Net® XL-14

Roll Width [1]	6.5 ft. (2 m)	14 ft. (4.3 m)
Roll Length [2]	100 ft. (30 m)	200 ft. (61 m)
Roll Weight [2]	194 lbs (88 kg)	835 lbs (380 kg)

[1] Width with geotextile overlap is 7 ft. for 6.5 ft. width and 15 ft. for 14 ft. width.
[2] Value for Fabri-Net® XL-14 double-sided with 6 ounce geotextile only. Bonding geotextile with different weights will change the final roll weight and length.

Material: Gundnet® XL-14
Fluid: Water Temperature: 60°F

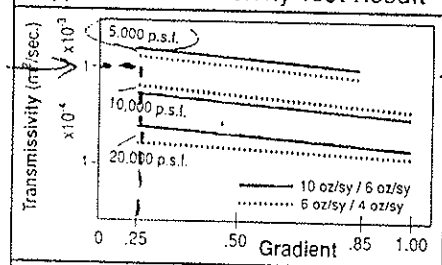
Typical Transmissivity Test Result



Section:
- Upper Load Plate
- Gundline® HD
- Gundnet® XL-14
- Gundline® HD
- Lower Load Plate

Material: Fabri-Net® XL-14
Fluid: Water Temperature: 70°F

Typical Transmissivity Test Result



Section:
- Upper Load Plate
- Sand
- Geotextile
- Gundnet® XL-14
- Geotextile
- Gundline® HD
- Lower Load Plate

Gundle Lining Systems Inc.

Gundle Lining Systems, Inc.
19103 Gundle Road
Houston, Texas 77073 U.S.A.

Phone: (713) 443-8564
Toll Free: (800) 435-2008
Telex: 166657 Gundle Hou
Fax: (713) 875-6010

Attachment A 1/1

© Gundle Lining Systems, Inc. 1994 20MSP1194

printed on recycled paper

7-10-02 MAGIC 7.13-02 GTC

TME CALCS 2/23

Table 4.2 Recommended preliminary factor of safety values for determining allowable flow rate or transmissivity of geonets

	Partial Factor of Safety Value in Equation 4.5			
Application Area	FS_{IN}	FS_{CR}*	FS_{CC}	FS_{BC}
Sport fields	1.0 to 1.2	1.0 to 1.5	1.0 to 1.2	1.1 to 1.3
Capillary breaks	1.1 to 1.3	1.0 to 1.2	1.1 to 1.5	1.1 to 1.3
Roof and plaza decks	1.2 to 1.4	1.0 to 1.2	1.0 to 1.2	1.1 to 1.3
Retaining walls, seeping rock and soil slopes	1.3 to 1.5	1.2 to 1.4	1.1 to 1.5	1.0 to 1.5
Drainage blankets	1.3 to 1.5	1.2 to 1.4	1.0 to 1.2	1.0 to 1.2
Surface water drains for landfill caps	1.3 to 1.5	1.2 to 1.4	1.0 to 1.2	1.2 to 1.5
Secondary leachate collection (landfills)	1.5 to 2.0	1.4 to 2.0	1.5 to 2.0	1.5 to 2.0
Primary leachate collection (landfills)	1.5 to 2.0	1.4 to 2.0	1.5 to 2.0	1.5 to 2.0

*These values assume that the q_{ult} value was obtained using an applied normal pressure of 1.5 to 2 times the field-anticipated maximum value. If not, values must be increased.

done at the proper design load and hydraulic gradient and that this testing yielded a short-term between-rigid-plates value of 1.2 gal./min.-ft.

Solution: Since better information is not known, average values from Table 4.2 are used.

$$q_{allow} = q_{ult}\left[\frac{1}{FS_{IN} \times FS_{CR} \times FS_{CC} \times FS_{BC}}\right] \tag{4.5}$$

$$= 1.2\left[\frac{1}{1.1 \times 1.1 \times 1.1 \times 1.2}\right]$$

$$= 1.2\left[\frac{1}{1.60}\right]$$

$$= 0.75 \text{ gal./min.-ft.}$$

Example:

What is the allowable geonet flow rate to be used in the design of a secondary leachate collection system? Assume that laboratory testing at proper design load and proper hydraulic gradient gave a short-term between-rigid-plates value of 1.2 gal./min.-ft.

Solution: Average values from Table 4.2 are used; however, note the large reduction.

Attachment B

SOURCE Koerner (1994)

1/1

FROM CONVERSE (1999)

Exploration Location	Depth (feet)	Soil Description	Percent Sodium	Percent Sulfate	Total Available Water Soluble sodium Sulfate (%)
B-5	10-15	Silty sand with gravel	0.07	0.13	0.20
B-8	19-20	Silty sand with gravel	0.07	0.06	0.08
B-101	5-10	Silty sand with gravel	0.17	0.06	0.08
B-102	0-5	Fill – Silty sand with gravel	0.17	0.03	0.05
B-106	0-5	Silty sand with gravel	0.15	0.08	0.12
B-106	29-30	Silty sand with gravel	0.15	0.06	0.08

Permeability

Falling head permeability tests were conducted on remolded samples in general accordance with modified ASTM procedure D2434. The soil was compacted in a mold 4.6 inches long and 4.0 inches in diameter to 85 or 90 percent of maximum dry density and at optimum moisture content. A falling head was applied to the sample and the flow of water through the sample was monitored. The permeability was calculated after the flow rate had stabilized. The result of the falling head permeability test is presented in the following table:

Exploration Location	Sample Depth (Feet)	Soil Description	k (cm/s)
B-5	20-25	Silty sand with gravel	5.3×10^{-4}
B-12	10-15	Silty sand with gravel	4.0×10^{-4}
B-102	20-25	Silty sand with gravel	1.0×10^{-4}
B-105	20-25	Well graded sand with silt and gravel	1.2×10^{-3}

Flexible wall permeameter tests were performed on selected samples by AP Engineering and Testing, Inc according to ASTM D5084. With the exception of one sample (B-105), all tested samples were undisturbed ring samples. The samples were placed in a triaxial machine with a constant confining pressure at the approximate in-place effective stress pressures. Results were generally consistent with the fal-

Attachment 1, 1/2

MY 7-13-00 GTC

ling head permeability test results for the granular materials. Laboratory results are presented on Drawing Nos. A-71 through A-76 and summarized below:

Exploration Location	Sample Depth (Feet)	Soil Description	k (cm/s)
B-1	14-15	Silty sand with gravel	1.57×10^{-4}
B-4	24-25	Silty sand with gravel	1.47×10^{-4}
B-8	44-45	Sandy silt	2.90×10^{-5}
B-12	39-39.5	Silty clay	1.76×10^{-7}
B-103	44-45	Silty clay	3.83×10^{-7}
B-105*	30-35	Silty sand	3.05×10^{-4}

* Sample remolded to 85% relative compaction at optimum moisture.

FROM CONVERSE (1999)

Attachment C
2/2

7-13-00 7-13-00 GTC

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:      r:\cawp\gls\help307\DATA44.D4
TEMPERATURE DATA FILE:        r:\cawp\gls\help307\DATA74.D7
SOLAR RADIATION DATA FILE:    r:\cawp\gls\help307\DATA134.D13
EVAPOTRANSPIRATION DATA:      r:\cawp\gls\help307\DATA114.D11
SOIL AND DESIGN DATA FILE:    r:\cawp\gls\help307\DATA104.D10
OUTPUT DATA FILE:             r:\cawp\gls\help307\TEST4.OUT


TIME:  11:11      DATE:    7/10/2000


******************************************************************************

     TITLE:  BRC CAMU, Condition 4
******************************************************************************
```

top deck w/ geocomposite

```
     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   7
          THICKNESS                  =       1.00   INCHES
          POROSITY                   =       0.4730 VOL/VOL
          FIELD CAPACITY             =       0.2220 VOL/VOL
          WILTING POINT              =       0.1040 VOL/VOL
          INITIAL SOIL WATER CONTENT =       0.2494 VOL/VOL
          EFFECTIVE SAT. HYD. COND.  =  0.520000001000E-03 CM/SEC
       NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  1.80
                FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

Att. D

61C

LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	23.00	INCHES
POROSITY	=	0.4730	VOL/VOL
FIELD CAPACITY	=	0.2220	VOL/VOL
WILTING POINT	=	0.1040	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3271	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.530000019000E-03	CM/SEC

LAYER 3

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.22	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.8500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	11.0000000000	CM/SEC
SLOPE	=	2.00	PERCENT
DRAINAGE LENGTH	=	1100.0	FEET

LAYER 4

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	2.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	1.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 5

GTC

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.20	INCHES
POROSITY	=	0.7500	VOL/VOL
FIELD CAPACITY	=	0.7470	VOL/VOL
WILTING POINT	=	0.4000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000003000E-08	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 7 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 1100. FEET.

SCS RUNOFF CURVE NUMBER	=	81.70	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	5.337	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.514	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.872	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	8.113	INCHES
TOTAL INITIAL WATER	=	8.113	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
LAS VEGAS NEVADA

STATION LATITUDE	=	36.08	DEGREES
MAXIMUM LEAF AREA INDEX	=	1.00	
START OF GROWING SEASON (JULIAN DATE)	=	62	
END OF GROWING SEASON (JULIAN DATE)	=	321	
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	9.10	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	39.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	21.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	24.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	36.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA

GIC

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
0.50	0.46	0.41	0.22	0.20	0.09
0.45	0.54	0.32	0.25	0.43	0.32

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
44.60	50.10	55.30	63.50	73.30	83.60
90.30	88.00	80.10	67.60	53.60	45.40

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA
AND STATION LATITUDE = 36.08 DEGREES

****

ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	61.72	224043.187	100.00
RUNOFF	0.845	3066.880	1.37
EVAPOTRANSPIRATION	57.247	207807.844	92.75
DRAINAGE COLLECTED FROM LAYER 3	3.4317	12457.194	5.56
PERC./LEAKAGE THROUGH LAYER 5	0.000008	0.028	0.00
AVG. HEAD ON TOP OF LAYER 4	0.0548		
CHANGE IN WATER STORAGE	0.196	711.629	0.32
SOIL WATER AT START OF YEAR	8.113	29451.367	
SOIL WATER AT END OF YEAR	8.309	30162.996	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00

G-1C

ANNUAL WATER BUDGET BALANCE -0.0001 -0.391 0.00

****

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 1

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.72	3.36	3.72	3.30	3.41	7.20
	7.75	8.05	7.52	3.55	3.60	6.54
STD. DEVIATIONS	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.845
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	2.805	3.292	4.494	3.871	3.646	7.066
	7.823	7.942	6.748	4.260	2.823	2.479
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
LATERAL DRAINAGE COLLECTED FROM LAYER 3						
TOTALS	2.4674	0.5061	0.2495	0.0039	0.0014	0.0008
	0.0001	0.0002	0.0000	0.0004	0.0004	0.2015
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 5						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

6TC

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 4

AVERAGES	0.5174	0.0159	0.0071	0.0001	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.1174
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

****

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 1

	INCHES		CU. FEET	PERCENT
PRECIPITATION	61.72	(0.000)	224043.2	100.00
RUNOFF	0.845	(0.0000)	3066.88	1.369
EVAPOTRANSPIRATION	57.247	(0.0000)	207807.84	92.753
LATERAL DRAINAGE COLLECTED FROM LAYER 3	3.43173	(0.00000)	12457.194	5.56018
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.00001	(0.00000)	0.028	0.00001
AVERAGE HEAD ON TOP OF LAYER 4	0.055	(0.000)		
CHANGE IN WATER STORAGE	0.196	(0.0000)	711.63	0.318

****

AA 7-10-00

GIC

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 1

	(INCHES)	(CU. FT.)
PRECIPITATION	3.00	10890.000
RUNOFF	0.845	3066.8796
DRAINAGE COLLECTED FROM LAYER 3	0.25524	926.53894
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.000002	0.00546
AVERAGE HEAD ON TOP OF LAYER 4	4.490	
MAXIMUM HEAD ON TOP OF LAYER 4	8.210	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	93.9 FEET	
SNOW WATER	0.16	579.4747

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.3497

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1515

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

****

AH. D

6C

****

FINAL WATER STORAGE AT END OF YEAR 1

LAYER	(INCHES)	(VOL/VOL)
1	0.2492	0.2492
2	7.7189	0.3356
3	0.1913	0.8500
4	0.0000	0.0000
5	0.1500	0.7500
SNOW WATER	0.000	

****
****

MM 7-10-00
MSK 7.13.00

MC

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:      r:\cawp\gls\help307\DATA44.D4
TEMPERATURE DATA FILE:        r:\cawp\gls\help307\DATA74.D7
SOLAR RADIATION DATA FILE:    r:\cawp\gls\help307\DATA134.D13
EVAPOTRANSPIRATION DATA:      r:\cawp\gls\help307\DATA114.D11
SOIL AND DESIGN DATA FILE:    r:\cawp\gls\help307\DATA105.D10
OUTPUT DATA FILE:             r:\cawp\gls\help307\TEST5.OUT


TIME:  13:22     DATE:   7/10/2000


******************************************************************************

    TITLE:  BRC CAMU, Condition 5
```

Title Proper

```
******************************************************************************


    NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
             COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                 TYPE 1 - VERTICAL PERCOLATION LAYER
                     MATERIAL TEXTURE NUMBER   7
        THICKNESS                    =      1.00   INCHES
        POROSITY                     =      0.4730 VOL/VOL
        FIELD CAPACITY               =      0.2220 VOL/VOL
        WILTING POINT                =      0.1040 VOL/VOL
        INITIAL SOIL WATER CONTENT   =      0.2892 VOL/VOL
        EFFECTIVE SAT. HYD. COND.    =  0.520000001000E-03 CM/SEC
      NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  1.80
               FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                  LAYER  2
                                  --------

                 TYPE 1 - VERTICAL PERCOLATION LAYER
                     MATERIAL TEXTURE NUMBER   0
        THICKNESS                    =     23.00   INCHES
        POROSITY                     =      0.4730 VOL/VOL
        FIELD CAPACITY               =      0.2220 VOL/VOL
        WILTING POINT                =      0.1040 VOL/VOL
        INITIAL SOIL WATER CONTENT   =      0.2546 VOL/VOL
```

Att. D

EFFECTIVE SAT. HYD. COND. = 0.530000019000E-03 CM/SEC

LAYER 3

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.22	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0158	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	11.0000000000	CM/SEC
SLOPE	=	33.30	PERCENT
DRAINAGE LENGTH	=	150.0	FEET

LAYER 4

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	2.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	1.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 5

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.20	INCHES
POROSITY	=	0.7500	VOL/VOL
FIELD CAPACITY	=	0.7470	VOL/VOL
WILTING POINT	=	0.4000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000003000E-08	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 7 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 33.% AND A SLOPE LENGTH OF 150. FEET.

SCS RUNOFF CURVE NUMBER	=	84.80	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	0.520	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	4.344	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.514	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.872	INCHES

INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	6.298	INCHES
TOTAL INITIAL WATER	=	6.298	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
LAS VEGAS NEVADA

STATION LATITUDE	=	36.08	DEGREES
MAXIMUM LEAF AREA INDEX	=	1.00	
START OF GROWING SEASON (JULIAN DATE)	=	62	
END OF GROWING SEASON (JULIAN DATE)	=	321	
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	9.10	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	39.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	21.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	24.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	36.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
0.50	0.46	0.41	0.22	0.20	0.09
0.45	0.54	0.32	0.25	0.43	0.32

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
44.60	50.10	55.30	63.50	73.30	83.60
90.30	88.00	80.10	67.60	53.60	45.40

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA
AND STATION LATITUDE = 36.08 DEGREES

****

ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	61.72	116502.453	100.00
RUNOFF	0.941	1776.331	1.52
EVAPOTRANSPIRATION	45.182	85284.914	73.20
DRAINAGE COLLECTED FROM LAYER 3	15.2152	28720.299	24.65

6-7C

PERC./LEAKAGE THROUGH LAYER 5	0.000002	0.005	0.00
AVG. HEAD ON TOP OF LAYER 4	0.0003		
CHANGE IN WATER STORAGE	0.382	721.107	0.62
SOIL WATER AT START OF YEAR	6.298	11888.534	
SOIL WATER AT END OF YEAR	6.680	12609.642	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	-0.0001	-0.200	0.00

****

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 1

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.72	3.36	3.72	3.30	3.41	7.20
	7.75	8.05	7.52	3.55	3.60	6.54
STD. DEVIATIONS	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.941
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	2.535	2.748	3.640	3.724	2.661	5.384
	6.433	5.925	4.995	3.087	2.107	1.943
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
LATERAL DRAINAGE COLLECTED FROM LAYER 3						
TOTALS	1.7294	0.7077	0.5946	0.3187	0.5837	1.5292
	1.3191	2.0582	2.4341	0.9180	1.1996	1.8228
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 5						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

6c

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 4

AVERAGES	0.0004	0.0002	0.0002	0.0001	0.0002	0.0004
	0.0003	0.0005	0.0007	0.0002	0.0003	0.0005
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 1

	INCHES		CU. FEET	PERCENT
PRECIPITATION	61.72	(0.000)	116502.5	100.00
RUNOFF	0.941	(0.0000)	1776.33	1.525
EVAPOTRANSPIRATION	45.182	(0.0000)	85284.91	73.204
LATERAL DRAINAGE COLLECTED FROM LAYER 3	15.21525	(0.00000)	28720.299	24.65210
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.00000	(0.00000)	0.005	0.00000
AVERAGE HEAD ON TOP OF LAYER 4	0.000	(0.000)		
CHANGE IN WATER STORAGE	0.382	(0.0000)	721.11	0.619

MM 7-10-02

GTC

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 1

	(INCHES)	(CU. FT.)
PRECIPITATION	3.00	5662.800
RUNOFF	0.941	1776.3307
DRAINAGE COLLECTED FROM LAYER 3	0.16183	305.47559
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.000000	0.00001
AVERAGE HEAD ON TOP OF LAYER 4	0.001	
MAXIMUM HEAD ON TOP OF LAYER 4	0.002	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	0.16	301.3268

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.2709
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1434

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

****

6C

****

FINAL WATER STORAGE AT END OF YEAR 1

LAYER	(INCHES)	(VOL/VOL)
1	0.2881	0.2881
2	6.2395	0.2713
3	0.0027	0.0121
4	0.0000	0.0000
5	0.1500	0.7500
SNOW WATER	0.000	

****
****

CHANNEL DESIGN

MB 7-10-00
MK 7-13-00

CIC.

well-known form

$$V = \frac{1.49}{n} R^{2/3} S^{1/2} \tag{5-6}$$

where V is the mean velocity in fps, R is the hydraulic radius in ft, S is the slope of energy line, and n is the coefficient of roughness, specifically known as *Manning's n*. This formula was developed from seven different formulas, based on Bazin's experimental data, and further verified by 170 observations.[1] Owing to its simplicity of form and to the satis-

---

a linear measure of roughness and $\phi(R/k)$ is a function of R/k. If $\phi(R/k)$ is considered dimensionless, n will have the same dimensions as those of $k^{1/6}$, that is, $L^{1/6}$.

On the other hand, of course, it is equally possible to assume that the numerator of $1.486/n$ can absorb the dimensions of $L^{1/3}T^{-1}$, or that $\phi(R/k)$ involves a dimensional factor, thus leaving no dimensions for n. Some authors, therefore, preferring the simpler choice, consider n a dimensionless coefficient.

It is interesting to note that the conversion of the units for the Manning formula is independent of the dimensions of n, as long as the same value of n is used in both systems of units. If n is assumed dimensionless, then the formula in English units gives the numerical constant $3.2808^{1/3} = 1.486$ since 1 meter = 3.2808 ft. Now, if n is assumed to have the dimensions of $L^{1/6}$, its numerical value in English units must be different from its value in metric units, unless a numerical correction factor is introduced for compensation. Let n be the value in metric units and n' the value in English units. Then, $n' = (3.2808^{1/6})n = 1.2190n$. When the formula is converted from metric to English units, the resulting form takes the numerical constant $3.2808^{1/3+1/6} = 3.2808^{1/2} = 1.811$, since n has the dimensions of $L^{1/6}$. Thus, the resulting equation should be written $V = 1.811R^{2/3}S^{1/2}/n'$. Since the same value of n is used in both systems, the practical form of the formula in the English system is $V = 1.811R^{2/3}S^{1/2}/1.2190n = 1.486R^{2/3}S^{1/2}/n$, which is identical with the formula derived on the assumption that n has no dimensions.

In a search of early literature on hydraulics, the author has failed to find any significant discussion regarding the dimensions of n. It seems that this was not a problem of concern to the forefathers of hydraulics. It is most likely, however, that n was unconsciously taken as dimensionless in the conversion of the Manning formula, because such a conversion, as shown above, is more direct and simpler.

Now, considering the approximations involved in the derivation of the formula and the uncertainty in the value of n, it seems unjustifiable to carry the numerical constant to more than three significant figures. For practical purposes, a value of 1.49 is believed to be sufficiently accurate [16].

Manning mentioned that the simplified form of the formula had been suggested independently by G. H. L. Hagen prior to Manning's own work, according to a statement by Major Cunningham [17]. Hagen's formula was believed to have appeared first in 1876 [7]. It is also known that Philippe-Gaspard Gauckler [18] had an early proposal of the simplified form of Manning's formula in 1868 and that Strickler [19] presented independently the same form of the formula in 1923.

[1] For the derivation of the exponent of R, use was made of Bazin's experimental data on artificial channels [12]. For different shapes and roughnesses, the average value of the exponent was found to vary from 0.6499 to 0.8395. Considering these variations, Manning adopted an approximate value of $\frac{2}{3}$ for the exponent. On the

Attachment E

Chow, V.T. "Open Channel Hydraulics", (1959) McGraw-Hill

1/1

Technical Notes

ADS
ADVANCED DRAINAGE SYSTEMS, INC.

Technical Note 2.109
Re: Flow Capacity
Date: March 1, 1995

It is the intent of this Technical Note to provide current hydraulic performance data for use by the engineering community. A bibliography is included for the engineer's use if further information or guidance is needed.

Manning's "n" values are offered for design purposes based on the best available data assembled from a variety of sources as indicated. Table 1 presents the Manning's "n" values recommended by the A.D.S. engineering staff for use in design.

Table 1
Manning's "n" Value For Design
(Storm & Sanitary Sewer and Culverts)

Pipe Type	"n"
A.D.S. Corrugated Polyethylene Pipe	
3" - 6" Diameter	0.015
8" Diameter	0.016
10" Diameter	0.017
12" - 15" Diameter	0.018
18" - 36" Diameter	0.020
A.D.S. N-12	0.012
Concrete Pipe	0.013
Corrugated Metal Pipe (2 2/3" x 1/2" corrugation)	
Annular	
Plain	0.024
Paved Invert	0.020
Fully Paved (smooth lined)	0.013
Helical	
Plain 15" Diameter	0.013
Plain 18" Diameter	0.015
Plain 24" Diameter	0.018
Plain 36" Diameter	0.021
Spiral-Rib	0.012
Plastic Pipe (SDR, S&D, Etc.)	0.011
Vitrified Clay	0.013

Attachment F

ADS N-12® PRODUCT ORMATION SHEET

Nominal Diameter	Inside Diameter, Average	Outside Diameter, Average	Wall Thickness, Minimum	Pipe Stiffness @ 5% Deflection	Weight lbs./20 ft. (kg./6 m.)	Area in.²/in.	"I" in.⁴/in.	"C" in.
4" (100 mm)	4.10" (104 mm)	4.78" (120 mm)	0.020" (0.50 mm)	50 psi (340 kN/m²)	8.10 lbs. (3.60 kg.)	0.070	0.0014	0.29
6" (150 mm)	6.00" (152 mm)	6.92" (176 mm)	0.020" (0.50 mm)	50 psi (340 kN/m²)	17.00 lbs. (7.71 kg.)	0.107	0.0036	0.25
8" (200 mm)	7.90" (200 mm)	9.11" (233 mm)	0.025" (0.64 mm)	50 psi (340 kN/m²)	30.80 lbs. (13.97 kg.)	0.135	0.0070	0.27
10" (250 mm)	9.90" (251 mm)	11.36" (287 mm)	0.025" (0.64 mm)	50 psi (340 kN/m²)	45.20 lbs. (20.50 kg.)	0.145	0.0110	0.34
12" (300 mm)	12.15" (308 mm)	14.45" (367 mm)	0.035" (0.89 mm)	50 psi (340 kN/m²)	63.80 lbs. (28.96 kg.)	0.188	0.0410	0.53
15" (375 mm)	14.98" (380 mm)	17.57" (448 mm)	0.035" (0.89 mm)	42 psi (290 kN/m²)	92.50 lbs. (42.00 kg.)	0.217	0.0660	0.66
18" (450 mm)	18.07" (459 mm)	21.20" (536 mm)	0.050" (1.27 mm)	40 psi (280 kN/m²)	128.60 lbs. (58.38 kg.)	0.250	0.0890	0.75
24" (600 mm)	24.08" (612 mm)	27.80" (719 mm)	0.050" (1.27 mm)	34 psi (240 kN/m²)	224.60 lbs. (101.97 kg.)	0.338	0.2310	1.07
30" (750 mm)	30.20" (767 mm)	36.07" (917 mm)	0.050" (1.27 mm)	28 psi (190 kN/m²)	308.30 lbs. (139.97 kg.)	0.353	0.4870	0.69
36" (900 mm)	36.20" (919 mm)	42.46" (1073 mm)	0.050" (1.27 mm)	22 psi (150 kN/m²)	361.20 lbs. (163.98 kg.)	0.361	0.5500	0.46
42" (1050 mm)	41.50" (1054 mm)	46.75" (1187 mm)	0.050" (1.27 mm)	19 psi (140 kN/m²)	530.00 lbs. (240.62 kg.)	0.420	0.7400	1.25
48" (1200 mm)	47.55" (1208 mm)	52.70" (1339 mm)	0.050" (1.27 mm)	17 psi (120 kN/m²)	640.00 lbs. (290.56 kg.)	0.420	0.7400	1.25

Date: March 1, 1996

Attachment E 2/2

SOURCE ADS 1996

Calculation Package B
Veneer Stability

GeoSyntec Consultants

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: Basic Remediation Company

Project: BRC CAMU **Project/Proposal #:** SC0313 **Task #:** 01

Title of Computations: Veneer Stability of Geosynthetic – Soil Lined Sideslope

Computations By:
SIGNATURE — DATE 11/6/06
Meghan Lithgow, Staff Engineer
PRINTED NAME AND TITLE

Assumptions and Procedures Checked By (Peer Reviewer):
SIGNATURE — DATE 11/4/06
Gregory T. Corcoran, PE / Principal
PRINTED NAME AND TITLE

Computations Checked By:
SIGNATURE — DATE 11/4/06
Gregory T. Corcoran, PE / Principal
PRINTED NAME AND TITLE

Computations Backchecked By (Originator):
SIGNATURE — DATE 11/6/06
Meghan Lithgow, Staff Engineer
PRINTED NAME AND TITLE

Approved By (PM or Designate):
SIGNATURE — DATE 11/4/06
Gregory T. Corcoran, PE / Principal
PRINTED NAME AND TITLE

Approval Notes:

Revisions: (Number and Initial All Revisions)

No.	Sheet	Date	By	Checked By	Approval

Written by: Meghan Lithgow Date: 09 / 25 / 06 (MM DD YY) Reviewed by: GTC Date: 11 / 4 / 06 (MM DD YY)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 1.2

SLOPE STABILITY EVALUATION
VENEER STABILITY OF GEOSYNTHETIC-SOIL LINED SIDESLOPES
COVER LINER SYSTEM
BRC CAMU

OBJECTIVE

To evaluate the tension developed within the geosynthetic-soil layered sideslopes of the cover liner system of the BRC Corrective Action Management Unit (CAMU) located in Henderson, Nevada.

SUMMARY OF RESULTS

The calculations suggest that a minimum geosynthetic interface friction angle of 20 degrees is required to prevent the development of tension in the geosynthetic components of the side slope liner final cover system. A review of the literature indicates that achieving a friction angle of 20 degrees is obtainable. The critical interface of the geosynthetics is likely the internal friction angle of the GCL.

METHOD OF ANALYSIS

The stability analysis of the geosynthetic-soil layered systems was carried out using the approach outlined by Koerner and Soong [1998] (Attachment F). This approach calculates the driving force of an active soil wedge along a geosynthetic-soil layered sideslope and compares it to the resisting force of the complementary passive soil wedge to evaluate the overall factor of safety against failure. The method presented by Koerner and Soong [1998] allows for the consideration of a uniform depth soil layer and the influence of dynamic equipment loading.

SIDESLOPE LINER SYSTEM

The sideslope liner system consists of, from top to bottom:

- 2 ft (min) cover soil;
- Double-sided geocomposite consisting of geonet sandwiched between two non-woven geotextiles;

Written by: Meghan Lithgow Date: 09 / 25 / 06 (MM DD YY) Reviewed by: GTC Date: 11 / 14 / 06 (MM DD YY)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 1.2

- 60-mil (1.5-mm) textured high density polyethylene (HDPE) geomembrane;
- Geosynthetic clay liner (GCL) consisting of bentonite sandwiched between a top nonwoven geotextile and a bottom woven geotextile needle-punched together
- Prepared subgrade.

The sideslope inclination is 3.0H:1.0V. The maximum height of a side slope is 47 vertical feet, located in the southwest corner of the South Mesa.

MATERIAL SHEAR STRENGTHS

Cover Soil Material:

The soil materials to be used overlying the side slope liner system will be native materials such as silty sands (SM) for the operations layer. Converse reported a maximum dry density of 132 pcf and a optimum water content of 8.7 percent for materials at the site (Attachment A). Therefore, assuming 95% relative compaction, the dry density in the field is approximately 125 pcf. Adding the weight of water, the unit weight is approximately 136 pcf. The cover soil material is characterized by a minimum internal angle of friction of 32 degrees in accordance with NAVFAC and the expected compaction criteria (see *review of reported interface strengths*).

For this analysis, a shear strength of 32 degrees, with 500 psf cohesion, and a unit weight of 136 pcf will be used for the analyses performed herein.

Geosynthetic Interface:

The geosynthetic interface friction angle was varied to evaluate the minimum allowable value to obtain no tension. A literature review was performed to evaluate if the calculated minimum allowable interface friction value is achievable. Adhesion is neglected for the analyses herein.

Written by: Meghan Lithgow Date: 09 / 25 / 06 (MM DD YY) Reviewed by: GR Date: 11 / 4 / 06 (MM DD YY)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 1.2

REVIEW OF REPORTED INTERFACE STRENGTHS IN THE LITERATURE

The following values for the interface friction between the geosynthetic and soil components of the liner system represent values reported in the literature:

Native Material (SM)	32	NAVFAC[1,2], 500 psf cohesion (Attachment B)
Cover Soil to Geocomposite (NWGT side)	29	Koerner[3] (Attachment C)
Geocomposite to Textured HDPE	28	(Professional Experience)
Textured HDPE to Hydrated GCL	20	Bentomat[4] (Attachment D)
Hydrated GCL to Subgrade	22	Bentomat[5] (Attachment D)

1. NAVFAC (1982) lists typical shear strength values for various soils based on 100 percent standard Proctor compaction. Actual construction materials would likely be placed at 90 percent of the modified Proctor compaction. To be conservative, a value of phi = 32 degree was used.

2. Value of friction angle for a silty sand designated under the USCS classification system as a SM. This value is a conservative friction angle estimate as compared to an SC soil, which would yield a greater friction angle.

3. Koerner (1995) suggests that an efficiency of greater than 90 percent for the interface of nonwoven, needle-punched geotextiles to various soils can be achieved. Efficiency values are based on the relationship, Efficiency = tan(interface friction angle)/tan(soil friction angle). The interface friction angle presented herein was calculated using a 90 percent efficiency and the estimated soil friction angle. Adhesion is neglected.

4. Values of residual friction angle reported for interface shear strength between 60 mil textured HDPE geomembrane and woven geotextile side of CETCO Bentomat GCL under hydrated conditions at a shearing rate of 0.04 in/min. Maximum displacement was not reported. Normal stresses of 1.4, 3.5, and 7.0 psi yielded a friction angle of 20.4 degrees.

5. Values of residual friction angle reported for interface shear strength between 60 mil textured HDPE geomembrane and woven geotextile side of CETCO Bentomat GCL under hydrated conditions at a shearing rate of 0.04 in/min. Maximum displacement was not reported. Normal stresses of 1.4, 3.5, and 7.0 psi yielded a friction angle of 22.1 degrees.

DESIGN CRITERION

For the geosynthetic-soil lined side slopes of BRC CAMU final cover system it was desired to evaluate the combination of operations layer soil height, inclination, and equipment loading which would introduce no geosynthetic tension. Subsequently, zero geosynthetic tension was established as the design criterion for veneer stability of the geosynthetic-soil lined side slopes.

Written by: Meghan Lithgow Date: 09 / 25 / 06 (MM DD YY) Reviewed by: GTC Date: 11 / 4 / 06 (MM DD YY)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 1.2

The geosynthetic-soil lined side slopes are considered permanent slopes because they will not eventually be buttressed by placement of waste. In consideration of the significance of no tension in the geosynthetic liner system and consistent with current practice, GeoSyntec will adopt a factor of safety (FS) equal to or greater than 1.5 for slope stability (CASE I, completed cover system). However, the construction of the cover system involves a very short period where the cover soil will be placed by construction equipment moving parallel to the slope, which imparts additional forces parallel to the liner system and may induce geosynthetic tension. Therefore, a factor of safety of 1.1 is established as the stability criterion for this case (CASE II, during construction).

ANALYSIS

CASE I: Veneer Stability on Side Slope

According to the Koerner and Soong approach, a soil veneer on a side slope is stable when the resultant driving force on the passive wedge (E_P) is equal to the resultant resistant force on the active wedge (E_A) (Figure 1). The following equations represent the resultant resistance and active forces, respectively:

$$E_A = \frac{FS(W_A - N_A \cos\beta) - (N_A \tan\delta + C_a)\sin\beta}{\sin\beta(FS)}$$ (Attachment E, 2 of 6)

$$E_P = \frac{C + W_P \tan\phi}{\cos\beta(FS) - \sin\beta\tan\phi}$$ (Attachment E, 2 of 6)

The variables will be defined in a subsequent section.

By setting E_A=E_P, the resulting equation may be arranged in the form of the quadratic equation $ax^2+bx+c=0$. Considering FS as the variable of interest, the resulting equation is as follows:

$$a(FS)^2 + b(FS) + c = 0$$ (Attachment E, 2 of 6)

The factor of safety may be obtained from the solution of the following equation:

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$ (Attachment E, 2 of 6)

Where the constants are defined, as in Attachment E, 6 of 6:

Written by: Meghan Lithgow Date: 09 / 25 / 06 (MM DD YY) Reviewed by: GTC Date: 11 / 4 / 06 (MM DD YY)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 1.2

$$a = (W_A - N_A \cos\beta)\cos\beta \quad (1)$$

$$b = -[(W_A - N_A \cos\beta)\sin\beta \tan\phi + (N_A \tan\delta + C_a)\sin\beta\cos\beta + \sin\beta(C + W_P \tan\phi)] \quad (2)$$

$$c = (N_A \tan\delta + C_a)\sin^2\beta \tan\phi \quad (3)$$

In which the variables are indicated on Figure 1 and defined as follows:

$$C = \frac{c \cdot h}{\sin\beta} \quad (4) \quad \text{(Attachment E, 2 of 6)}$$

$$C_a = c_a\left(L - \frac{h}{\sin\beta}\right) \quad (5) \quad \text{(Attachment E, 2 of 6)}$$

$$W_A = \gamma \cdot h^2\left(\frac{L}{h} - \frac{1}{\sin\beta} - \frac{\tan\beta}{2}\right) \quad (6) \quad \text{(Attachment E, 2 of 6)}$$

$$N_A = W_A \cos\beta \quad (7) \quad \text{(Attachment E, 2 of 6)}$$

$$W_P = \frac{\gamma \cdot h^2}{\sin 2\beta} \quad (8) \quad \text{(Attachment E, 2 of 6)}$$

β = soil slope angle beneath the geomembrane, **18.4°** for 3H:1V slope
δ = minimum interface friction angle of side slope liner system, **20°**
ϕ = friction angle of cover soil, **32°**
γ = unit weight of the cover soil, **136 pcf**
C = cohesive force along the failure plane of the passive wedge
c = cohesion of the cover soil, **500 psf**
C_a = adhesive force between the cover soil of the active wedge and the geomembrane
c_a = adhesion between the cover soil of the active wedge and the geomembrane, **0 psf**
h = thickness of the operations layer, **2 feet**
L = length of slope measured along the geomembrane beneath cover soil, **148.6 feet**
N_A = effective force normal to the failure plane of the active wedge
W_A = total weight of the active wedge
W_P = total weight of the passive wedge

Substituting the variables and solving equations (4)-(8), above:

Written by: Meghan Lithgow Date: 09 / 25 / 06 (MM DD YY) Reviewed by: GTC Date: 11 / 4 / 06 (MM DD YY)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 1.2

$$C = \frac{c \cdot h}{\sin\beta} = \frac{500 \cdot 2}{\sin(18.4)} = \mathbf{3163\ lbs/ft} \quad (4)$$

$$C_a = c_a\left(L - \frac{h}{\sin\beta}\right) = 0\left(148.7 - \frac{2}{\sin 21.8}\right) = \mathbf{0\ lbs/ft} \quad (5)$$

$$W_A = \gamma \cdot h^2\left(\frac{L}{h} - \frac{1}{\sin\beta} - \frac{\tan\beta}{2}\right) = 136 \cdot 2^2\left(\frac{148.7}{2} - \frac{1}{\sin 18.4} - \frac{\tan 18.4}{2}\right) = \mathbf{38{,}627\ lbs/ft} \quad (6)$$

$$N_A = W_A \cos\beta = 38{,}627 \cdot \cos 18.4. = \mathbf{36{,}646\ lbs/ft} \quad (7)$$

$$W_P = \frac{\gamma \cdot h^2}{\sin 2\beta} = \frac{136 \cdot 2^2}{\sin 2 \cdot 18.4} = \mathbf{907\ lbs/ft} \quad (8)$$

Next, substituting the solutions to equations (4)-(8) into equations (1)-(3):

$$a = (38{,}627 - 36{,}646 \cdot \cos 18.4)\cos 18.4 = \mathbf{3{,}663\ lbs/ft} \quad (1)$$

$$\begin{aligned} b = -[&(38{,}627 - 36{,}646 \cos 18.4) \sin 18.4 \tan 32 \\ &+ (36{,}646 \tan 20 + 0) \sin 18.4 \cos 18.4 \\ &+ \sin 18.4\,(3163 + 907 \tan 32) = \mathbf{-5942\ lbs/ft} \end{aligned} \quad (2)$$

$$c = (36{,}646 \cdot \tan 20 + 0)\sin^2 18.4 \cdot \tan 32 = \mathbf{833\ lbs/ft} \quad (3)$$

Finally, inserting the solutions to (1), (2) and (3) and solving the following equation:

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a} = \frac{-(-5942) + \sqrt{(-5942)^2 - 4(3663)(833)}}{2(3663)} = \mathbf{1.47}$$

Therefore, the factor of safety for the veneer stability of the operations layer on a sideslope composite liner system is 1.47. This factor of safety satisfies the stability criterion for permanent slopes of 1.5, as previously described.

CASE II: Veneer Stability during Dynamic Equipment Loading

In consideration of the loading due to soil placement equipment moving on the slope, the following equations represent the resultant resistant and active forces, respectively:

Written by: Meghan Lithgow Date: 09 / 25 / 06 (MM DD YY) Reviewed by: GTC Date: 11 / 4 / 06 (MM DD YY)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 1.2

$$E_A = \frac{FS[(W_A + W_e)\sin\beta + F_e]}{FS} - \frac{[(N_e + N_A)\tan\delta + C_a]}{FS}$$ (Attachment E, 5 of 6)

$$E_P = \frac{C + W_P \tan\phi}{\cos\beta(FS) - \sin\beta\tan\phi}$$ (Attachment E, 6 of 6)

Where the constants are defined, as in Attachment A, 6 of 6:

$$a = [(W_A + W_e)\sin\beta + F_e]\cos\beta \quad (9)$$

$$b = -\{[(N_e + N_A)\tan\delta + C_a]\cos\beta + [(W_A + W_e)\sin\beta + F_e]\sin\beta\tan\phi + (C + W_P\tan\phi)\} \quad (10)$$

$$c = [(N_e + N_A)\tan\delta + C_a]\sin\beta\tan\phi \quad (11)$$

In which the variables are indicated on Figure 1, defined previously and as follows:

$$q = \frac{W_b}{(2 \cdot w \cdot b)}$$ (12) (Attachment E, 3 of 6)

$$W_e = qwI$$ (13) (Attachment E, 3 of 6)

$$F_e = W_e\left(\frac{a}{g}\right)$$ (14) (Attachment E, 5 of 6)

$$N_e = W_e\cos\beta$$ (15) (Attachment E, 5 of 6)

a = acceleration of placement equipment (12km/hr, 2secs), **0.19 g** (Attachment E, 5of 6)
b = width of placement equipment track, **22 inches (D6R XL)** (Attachment F)
F_e = dynamic equipment loading force per unit parallel to slope at geomembrane interface
g = acceleration due to gravity, **32.2 ft/s^2**
I = influence factor at the geomembrane interface, **0.9** (Attachment E, 4 of 6)
N_e = effective equipment force normal to the failure plane of the active wedge
w = length of placement equipment track, **111 inches (D6R XL)** (Attachment F)
W_b = actual weight of the placement equipment, **42,300 lbs (D6R XL)** (Attachment F)
W_e = equivalent equipment force per unit width at the geomembrane interface

Substituting the variables and solving equations (4)-(8) and (12)-(15), above:

$$C = \frac{c \cdot h}{\sin\beta} = \frac{500 \cdot 2}{\sin(18.4)} = \mathbf{3163\ lbs/ft} \quad (4)$$

Written by: Meghan Lithgow Date: 09 / 25 / 06 (MM DD YY) Reviewed by: GTC Date: 11 / 4 / 06 (MM DD YY)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 1.2

$$C_a = c_a\left(L - \frac{h}{\sin\beta}\right) = 0\left(148.7 - \frac{2}{\sin 18.4}\right) = \mathbf{0\ lbs/ft} \quad (5)$$

$$W_A = \gamma \cdot h^2\left(\frac{L}{h} - \frac{1}{\sin\beta} - \frac{\tan\beta}{2}\right) = 136 \cdot 2^2\left(\frac{148.7}{2} - \frac{1}{\sin 18.4} - \frac{\tan 18.4}{2}\right) = \mathbf{38{,}627\ lbs/ft} \quad (6)$$

$$N_A = W_A \cos\beta = 38{,}627 \cdot \cos 18.4 = \mathbf{36{,}646\ lbs/ft} \quad (7)$$

$$W_P = \frac{\gamma \cdot h^2}{\sin 2\beta} = \frac{136 \cdot 2^2}{\sin 2 \cdot 18.4} = \mathbf{907\ lbs/ft} \quad (8)$$

$$q = \frac{W_b}{(2 \cdot w \cdot b)} = \frac{42{,}300}{(2 \cdot 111 \cdot 22)} = 8.66\ \text{psi} = \mathbf{1247\ psf} \quad (12)$$

$$W_e = qwl = 8.66 \cdot 111 \cdot 0.9 = 865\ \text{lbs/in} = \mathbf{10{,}381\ lbs/ft} \quad (13)$$

$$F_e = W_e\left(\frac{a}{g}\right) = 10{,}381\left(\frac{0.19 \cdot 32.2}{32.2}\right) = \mathbf{1{,}972\ lbs/ft} \quad (14)$$

$$N_e = W_e \cos\beta = 10{,}381 \cdot \cos 18.4 = \mathbf{9{,}482\ lbs/ft} \quad (15)$$

Next, substituting the solutions to equations (4)-(12) and (12)-(15) into equations (9)-(11):

$$a = [(38627 + 10381)\sin 18.4 + 1972]\cos 18.4 = \mathbf{16{,}571\ lbs/ft} \quad (9)$$

$$\begin{aligned} b = -\{&[9482 + 36646)\tan 20 + 0]\cos 18.4 \\ &+ [(38627 + 10381)\sin 18.4 + 1972]\sin 18.4 \tan 32 \\ &+ (3163 + 907 \tan 32)\} = \mathbf{-23{,}108\ lbs/ft} \end{aligned} \quad (10)$$

$$c = [(9482 + 36646)\tan 20 + 0]\sin 18.4 \tan 32 = \mathbf{3{,}317\ lbs/ft} \quad (11)$$

Finally, inserting the solutions to (9), (10) and (11) and solving the following equation:

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a} = \frac{-(-23108) + \sqrt{(-23108)^2 - 4(16571)(3317)}}{2(16571)} = \mathbf{1.23}$$

Therefore, the factor of safety for the stability of the operations layer on a sideslope composite liner system considering additional dynamic loading due to placement equipment is 1.23. This factor of safety satisfies the stability criterion for interim slopes of 1.1, as previously described.

Written by: Meghan Lithgow Date: 09 / 25 / 06 (MM DD YY) Reviewed by: GTC Date: 11 / 9 / 06 (MM DD YY)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 1.2

RESULTS AND CONCLUSIONS

The results suggest that the proposed final cover system satisfies the design criteria of no geosynthetic tension development:

Stability Condition	Soil Cover Layer Inclination (H:V)	Equipment Loading	Tension FS
Case I	3.0H:1V	NONE	1.47
Case II	3.0H:1V	CAT-D6H	1.23

Live Load Case (assuming placement of operations layer with a bulldozer no larger than Caterpillar D6R XL dozer in terms of operating weight and ground pressure), the side slope liner system will not be placed into tension.

Results of veneer stability analyses presented herein indicate that an apparent internal friction or interface friction angle (residual) of 20 degrees for any component of the composite liner system is the minimum allowable value providing for a static factor of safety that satisfies that design criteria of no tension in the geosynthetic liner system.

Based on the analyses herein, results of interface shear tests on the actual materials proposed for use in the composite liner system must indicate that the weakest apparent residual friction angle of the composite liner is equal to or greater than 20 degrees.

The results suggest that the following conditions satisfy the design criteria of no geosynthetic tension development:

- 3H:1 V side slopes;
- 2 feet thickness of operations layer soil/leachate collection layer on side slopes, placed to a vertical height of 47 feet;
- 136 pcf unit weight of operations layer soil;
- Minimum shear properties of operations layer soil - 500 psf cohesion and 32° friction angle;
- Minimum shear strength of composite liner system – 0 psf adhesion and 20° friction angle;
- Caterpillar D6R XL used as operations layer placement equipment;
- Acceptable factor of safety for interim slope stability is 1.3 (CASE I); and

- Acceptable factor of safety for dynamically loaded interim slopes is 1.1 (CASE II).

REFERENCES

Caterpillar, Inc., [1998], "Caterpillar Performance Handbook", Caterpillar Publications, Peoria, Illinois, October 1998. *(Attachment F)*

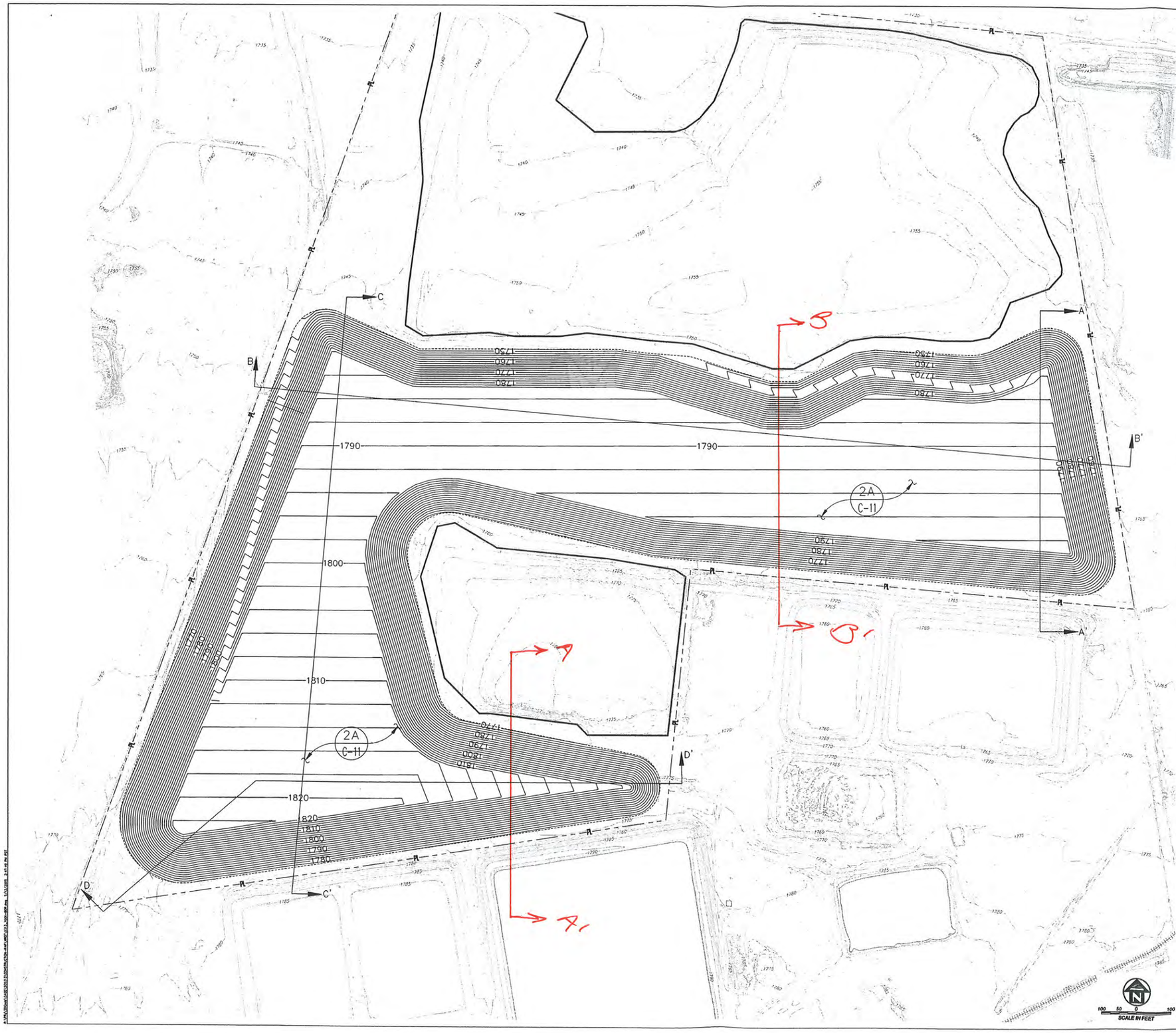
Converse Consultants (1999), "Preliminary Geotechnical and Geologic Investigation, Industrial Non-Hazardous Disposal Facility, Basic Management Incorporated, Clark County, Nevada," October 27, 1999, Las Vegas, Nevada. *(Attachment A)*

Koerner, R. K. and Soong, T.Y., [1998], "Analysis and Design of Veneer Cover Soils", Proceedings of the Sixth International Conference on Geosynthetics, Atlanta, Georgia, Vol. I, 1998. *(Attachment E)*

Koerner, R. M. (1997), "Designing with Geosynthetics," Simon and Schuster / A Viacom Company, Upper Saddle New Jersey, 07458, 1998 *(Attachment C)*

NAVFAC (1982), "Foundations and Earth Structures, Design Manual - 7.2," Department of Navy, Naval Facilities Engineering Command, May 1982 *(Attachment B)*

Bentomat Attachment! (*Attachment D)*



LEGEND

- BRC LANDFILL SITE BOUNDARY
- EXISTING LIMITS OF FORMER BMI LANDFILL
- EXISTING SURFACE WATER FLOW PATH
- EXISTING MINOR ELEVATION CONTOUR
- EXISTING MAJOR ELEVATION CONTOUR
- PROPOSED MINOR EXCAVATION ELEVATION CONTOUR
- 1770 PROPOSED MAJOR EXCAVATION ELEVATION CONTOUR
- PROPOSED LIMITS OF REFUSE

NOTES:

1. FOR GENERAL NOTES, LEGEND AND ABBREVIATIONS, SEE DWG C-2.
2. FOR SITE PREPARATION PLAN SEE DWG C-6.
3. FOR CONSTRUCTION GRADING PLAN SEE DWG C-7.
4. FOR EROSION CONTROL AND STORM DRAIN PLAN SEE DWG C-8.
5. FOR CROSSECTIONS SEE DWG C-10.
6. FOR FINAL COVER AND LINER DETAILS AND SECTIONS SEE DWG C-11
7. FOR FENCE PLAN SEE DWG C-12.

GEOSYNTEC CONSULTANTS
10875 RANCHO BERNARDO ROAD, SUITE 200
SAN DIEGO, CALIFORNIA 92127
TELEPHONE: (858) 674-6559

PROJECT: BRC CAMU
HENDERSON/CLARK COUNTY NEVADA

TITLE: FINAL COVER GRADING PLAN
PERMITTING CONSTRUCTION PLAN

DATE: SEPTEMBER 2006	CHECKED BY: G.T.C	SCALE: 1"=100'	FIGURE NO: C9
DESIGN BY: TAW	REVIEWED BY: (PRIN. MGR.) G.T.C	JOB NO.: SC0313-01-04	
DRAWN BY: T.L.Z.	DOCUMENT NO:	FILE NO:	

Figure 1

shown on Drawing Nos. A-49 through A-56, entitled *Consolidation Test* and are summarized on the following table:

Exploration Location	Depth (Feet)	Soil Description	Dry Unit Weight, pcf	Moisture Content, %	Hydrocollapse (percent)*
B-1	29-30	Silty sand with gravel	105	6	3.2
B-8	39-40	Sandy lean clay	57.4	64	0.4
B-8	49-50	Sandy lean clay	69.5	51.1	-0.6
B-10	54-54.5	Sandy lean clay	60.7	67.7	-0.6
B-101	39-40	Sandy lean clay	65.8	45	-0.2
B-101	59-60	Sandy lean clay	73.2	38.3	-0.6
B-102	49-50	Sandy lean clay	67.3	48.7	-0.5
B-105	34-35	Well graded sand with silt and gravel	101	5	0.1

NA: Not available

* A negative sign indicates swell occurred upon inundation with water instead of collapse.

Laboratory Maximum Density

Laboratory maximum density tests were performed on selected samples of the granular soils. The purpose of the test was to define the compaction characteristics of these soils, and to aid in estimating soil shrinkage. The laboratory maximum density test was performed in general accordance with the ASTM D1557 test method. This test procedure uses 25 blow of a 10-pound hammer falling a height of 18 inches on each of five layers of soil in a 1/30 or 1/13 cubic foot cylinder. The test results are presented on Drawing Nos. A-57 through A-61 and in the following table:

Exploration Location	Depth (Feet)	Soil Description	Maximum Dry Unit Weight (pcf)	Optimum Moisture Content (percent) of dry weight)
B-1	20-25	Silty sand with gravel	129.4	8.2
B-5	20-25	Silty sand with gravel	132.1	8.2
B-12	10-15	Silty sand with gravel	129.7	7.9
B-101	5-10	Silty sand with gravel	130.6	8.7
B-105	20-25	Well graded sand with silt and gravel	131.8	7.5

assume $\gamma_d = 130$ pcf, $w\% = 8\%$

SOURCE: CONVERSE (1999)

Attachment A 1/1

TABLE 1
Typical Properties of Compacted Soils

Group Symbol	Soil Type	Range of Maximum Dry Unit Weight, pcf	Range of Optimum Moisture, Percent	Typical Value of Compression: At 1.4 tsf (20 psi)	Typical Value of Compression: At 3.6 tsf (50 psi)	Typical Strength Characteristics: Cohesion (as compacted) psf	Typical Strength Characteristics: Cohesion (saturated) psf	Typical Strength Characteristics: φ (Effective Stress Envelope Degrees)	Typical Strength Characteristics: Tan φ	Typical Coefficient of Permeability ft./min.	Range of CBR Values	Range of Subgrade Modulus k lbs/cu in.
				Percent of Original Height								
GW	Well graded clean gravels, gravel-sand mixtures.	125 - 135	11 - 8	0.3	0.6	0	0	>38	>0.79	5×10^{-2}	40 - 80	300 - 500
GP	Poorly graded clean gravels, gravel-sand mix	115 - 125	14 - 11	0.4	0.9	0	0	>37	>0.74	10^{-1}	30 - 60	250 - 400
GM	Silty gravels, poorly graded gravel-sand-silt.	120 - 135	12 - 8	0.5	1.1	.....	.....	>34	>0.67	$>10^{-6}$	20 - 60	100 - 400
GC	Clayey gravels, poorly graded gravel-sand-clay.	115 - 130	14 - 9	0.7	1.6	.....	.....	>31	>0.60	$>10^{-7}$	20 - 40	100 - 300
SW	Well graded clean sands, gravelly sands.	110 - 130	16 - 9	0.6	1.2	0	0	38	0.79	$>10^{-3}$	20 - 40	200 - 300
SP	Poorly graded clean sands, sand-gravel mix.	100 - 120	21 - 12	0.8	1.4	0	0	37	0.74	$>10^{-3}$	10 - 40	200 - 300
SM	Silty sands, poorly graded sand-silt mix.	110 - 125	16 - 11	0.8	1.6	1050	420	34	0.67	$5 \times >10^{-5}$	10 - 40	100 - 300
SM-SC	Sand-silt clay mix with slightly plastic fines.	110 - 130	15 - 11	0.8	1.4	1050	300	33	0.66	$2 \times >10^{-6}$	5 - 30	100 - 300
SC	Clayey sands, poorly graded sand-clay-mix.	105 - 125	19 - 11	1.1	2.2	1550	230	31	0.60	$3 \times >10^{-7}$	5 - 20	100 - 300
ML	Inorganic silts and clayey silts.	95 - 120	24 - 12	0.9	1.7	1400	190	32	0.62	$>10^{-5}$	15 or less	100 - 200
ML-CL	Mixture of inorganic silt and clay.	100 - 120	22 - 12	1.0	2.2	1350	460	32	0.62	$5 \times >10^{-7}$	.....	
CL	Inorganic clays of low to medium plasticity.	95 - 120	24 - 12	1.3	2.5	1800	270	28	0.54	$>10^{-7}$	15 or less	50 - 200
OL	Organic silts and silt-clays, low plasticity.	80 - 100	33 - 21	.....	.....	.....	.....	.....	.....	.....	5 or less	50 - 100
MH	Inorganic clayey silts, elastic silts.	70 - 95	40 - 24	2.0	3.8	1500	420	25	0.47	$5 \times >10^{-7}$	10 or less	50 - 100
CH	Inorganic clays of high plasticity	75 - 105	36 - 19	2.6	3.9	2150	230	19	0.35	$>10^{-7}$	15 or less	50 - 150
OH	Organic clays and silty clays	65 - 100	45 - 21	.....	.....	.....	.....	.....	.....	.....	5 or less	25 - 100

Notes:

1. All properties are for condition of "Standard Proctor" maximum density, except values of k and CBR which are for "modified Proctor" maximum density.
2. Typical stength characteristics are for effective strength envelopes and are obtained from USBR data.
3. Compression values are for vertical loading with complete lateral confinement.
4. (>) indicates that typical property is greater than the value shown.
   (..) indicates insufficient data available for an estimate.

SOURCE - NAVFAC (1982) Attachment B 1/1

Page 13 of 66 (3)

Table 5.7 Friction values and efficiencies (in parentheses) for (a) soil-to-geomembrane, (b) geomembrane-to-geotextile, and (c) soil-to-geotextile combinations*

(a) Soil-to-Geomembrane Friction Angles

Geomembrane	Soil Types: Concrete Sand (ϕ = 30°)	Ottawa Sand (ϕ = 28°)	Micha Schist Sand (ϕ = 26°)
EPDM-R	24° (0.77)	20° (0.68)	24° (0.91)
PVC			
Rough	27° (0.88)	—	25° (0.96)
Smooth	25° (0.81)	—	21° (0.79)
CSPE-R	25° (0.81)	21° (0.72)	23° (0.87)
HDPE -Smooth	18° (0.56)	18° (0.61)	17° (0.63)

(b) Geomembrane-to-Geotextile Friction Angles

Geotextile	Geomembrane: EPDM-R	PVC: Rough	PVC: Smooth	CSPE-R	HDPE Smooth
Nonwoven, needle punched	23°	23°	21°	15°	8°
Nonwoven, heat bonded	18°	20°	18°	21°	11°
Woven, monofilament	17°	11°	10°	9°	6°
Woven, slit film	21°	28°	24°	13°	10°

(c) Soil-to-Geotextile Friction Angles

Geotextile	Soil Types: Concrete Sand (ϕ = 30°)	Ottawa Sand (ϕ = 28°)	Mica Schist Sand (ϕ = 26°)
Nonwoven, needle punched	30° (1.00)	26° (0.92)	25° (0.96)
Nonwoven, heat bonded	26° (0.84)	—	—
Woven, monofilament	26° (0.84)	—	—
Woven, slit film	24° (0.77)	24° (0.84)	23° (0.87)

*Efficiency values in parentheses are based on the relationship $E = (\tan \delta)/(\tan \phi)$.

Source: After Martin et al. [14].

The frictional behavior of geomembranes placed
erable importance in the composite liners of waste land
are for the clay to have a hydraulic conductivity equa
ft./min. (1×10^{-7} cm/sec.) and for the geomembrane t
clay. While an indication of the shear strength param
(e.g., reference 15), the data are so sensitive to the var
site-specific and material-specific tests should always b
literature values should never be used for final design

5.1.3.9 Geomembrane Anchorage In certain proble
might be sandwiched between two materials and the
force. The termination of a geomembrane liner within an anchor trench is such a
situation. To simulate this behavior in a laboratory environment, one can use an
8.0-in. (200-mm)-wide geomembrane sandwiched between back-to-back channels.

Jodrey - Koerner (1997)

Attachment C 1/1

SUMMARY OF BENTOMAT DIRECT SHEAR TEST DATA
INTERFACE W/ SOIL

Lab[1]	Report Date	Interface Tested[2]	Normal Stresses (psi)	Bentomat Moisture[3]	Shear Rate (in/min)	Peak Friction Angle (deg)	Residual Friction Angle (deg)[4]	Apparent Peak Cohesion (psf)	Comments
GSC	03-09-95	NW/ Soaked GC Soil	7.5 - 15 - 30	Hydrated	0.04	33	31	385	
CETCO	08-29-95	W/Silty Sand	1 - 2 - 3	Hydrated	0.04	32.3	ND	127	
GSC	03-12-96	NW/ Soaked Soil	2 - 4 - 6	Hydrated	0.04	29	29	70	
STS	05-30-96	NW/Silty Sandy Gravel	0.7 – 2 – 3.5	Hydrated	0.04	28	ND	222	
CETCO	07-08-96	NW/ Sandy Silty Gravel	0.7 - 2.0 - 3.5	Hydrated	0.04	40.4	ND	238	
	07-31-96	W/ Sandy Silty Gravel	0.7 - 2.0 - 3.5	Hydrated	0.04	37.8	ND	194	
AGP	11-08-96	NW/ SC Soil	1.4 - 3.5 - 7.0	Hydrated	0.04	27.8	ND	186	
		W/ SC Soil	1.4 - 3.5 - 7.0	Hydrated	0.04	23.5	22.1	187	
GSC	01-08-97	NW/ Soaked Soils	14 - 40 - 70	Hydrated	0.04	18	18	155	
TRI	09-23-97	NW/ Subbaase Soil	3.5 – 7 – 14	Hydrated	0.001	24.0	20.7	4	
		NW/ Subbase Soil	.35 - .7 – 1.4	Hydrated	0.001	35.5	37.2	88	
GSC	01-22-98	CLS/ SM soil	5 - 25 - 45	Hydrated	0.04	17	13	70	
CETCO	02-10-98	CLS/ SC Soil	0.5 – 1 – 1.5	Hydrated	0.04	9.5	ND	46	
VE	03-03-98	W/ Cover soil	1 - 2.1 – 4.9	Hydrated	0.04	37	33	50	
CETCO	08-11-98	W/ SC soil	2.1 – 4.2 – 6.3	Hydrated	0.04	33.6	35.2	183	
		NW/ Non-Pag Quartz Monzonite Waste	2.1 – 4.2 – 6.3	Hydrated	0.04	39.8	37.5	190	
TRI	09-22-98	NW/ soil	16 – 32 – 73	Hydrated	0.04	17.5	16.8	505	Residual @ 3"
CETCO	11-3-98	CLS/SM soil	0.5 – 1 – 1.5	Hydrated	0.04	27	27	80	
		CLS/SP soil	0.5 – 1 – 1.5	Hydrated	0.04	15.2	15.2	55	
GSC	6-24-00	CLS/drainage soil	139	Hydrated	0.04	24	0	13	Angle w/ origin

ATTACHMENT D 1/2

SUMMARY OF BENTOMAT DIRECT SHEAR TEST DATA
INTERFACE W/ GEOMEMBRANE

Lab[1]	Report Date	Interface Tested[2]	Normal Stresses (psi)	Bentomat Moisture[3]	Shear Rate (in/min)	Peak Friction Angle (deg)	Residual Friction Angle (deg)[4]	Apparent Peak Cohesion (psf)	Comments
GA	09-04-92	W/60-mil sm. HDPE	0.5 - 1 - 2 - 4 - 10	Hydrated	0.02	8	7	0	
		W/60-mil text. HDPE	0.5 - 1 - 2 - 4 - 10	Hydrated	0.02	28	28 / 6	29	bi-modal residual
GSC	12-08-94	W/60-mil text. HDPE	7.5 - 15 - 30	Hydrated	0.04	18	17	175	Diff. membrane manufacturers
		W/60-mil text. HDPE	7.5 - 15 - 30	Hydrated	0.04	16	12	345	
GSC	12-16-94	W/60-mil text. HDPE	1 -3 - 6 - (15)	Hydrated	0.04	25 (19)	10	100	(lower d at 15 psi)
AGP	07-12-95	W/80-mil Text. HDPE	14 - 28 - 69 - 104	Hydrated	0.04	18	8	192	
		W/80-mil Text. HDPE	14 - 28 - 69 - 104	Dry	0.04	30	14	0	
AGP	11-30-95	W/ Text. HDPE	10 - 26 - 38	Dry	0.08	30.2	13.3	0	
GSC	03-12-96	W/ 30 mil PVC	2 - 4 - 6	Hydrated	0.04	17	17	24	
GSC	05-29-96	NW/80mil Text. HDPE	140	Hydrated	0.04	19	5	475	Consol 24 hrs @140 psi
AGP	11-08-96	NW/60mil Text. HDPE	1.4 - 3.5 - 7.0	Hydrated	0.04	34.8	22.7	149	
		W/60 mil Text. HDPE	1.4 - 3.5 - 7.0	Hydrated	0.04	28.8	20.4 *	83	
GSC	01-08-97	NW/60mil Text. HDPE	14 - 40 - 70	Hydrated	0.04	17	9	255	
TRI	4-15-97	NW/60mil Text. HDPE	14 – 28 – 56	Hydrated	0.04	21.9	10.8	722	
Emcon	6-16-97	NW/40mil Text. LLPE	1.0 – 2.0 – 3.5	Hydrated	0.04	32.0	18.5	111	
		NW/40mil Text. LLPE	1.0 – 2.0 – 3.5	Hydrated	0.04	37.5	27.1	118	
TRI	10-15-97	NW/ 60mil Text.HDPE	3.5 – 7 – 14	Hydrated	0.04	20.3	18.6	278	
		NW/ 60mil Text.HDPE	.35 - .7 – 1.4	Hydrated	0.04	36.6	25.8	2	
TRI	12-01-97	NW/60mil Text. HDPE	0.35 – 0.7 – 1.4	Hydrated	0.001	25.6	23.3	54	Residual @ 4"
		NW/60mil Text. HDPE	3.5 – 7 – 14	Hydrated	0.001	23.2	17.8	85	"
Emcon	04-06-98	NW/60mil Text. HDPE	14 – 28 – 70	Hydrated	0.04	24.1	12.2	290	

Eshilor (3) GTC 5/11/01

- The issue of appropriate normal stress is greatly complicated if gas pressures are generated in the underlying waste. These gas pressures will counteract some (or all) of the gravitational stress of the cover soil. The resulting shear strength, and subsequent stability, can be significantly decreased. See Liu et al (1997) for insight into this possibility.
- Shear rates necessary to attain drained conditions (if this is the desired situation) are extremely slow, requiring long testing times.
- Deformations necessary to attain residual strengths require large relative movement of the two respective halves of the shear box. So as not to travel over the edges of the opposing shear box sections, devices should have the lower shear box significantly longer than 300 mm. However, with a lower shear box longer than the upper traveling section, new surface is constantly being added to the shearing plane. This influence is not clear in the material's response or in the subsequent behavior.
- The attainment of a true residual strength is difficult to achieve. ASTM D5321 states that one should "run the test until the applied shear force remains constant with increasing displacement". Many commercially available shear boxes have insufficient travel to reach this condition.
- The ring torsion shearing apparatus is an alternative device to determine true residual strength values, but is not without its own problems. Some outstanding issues are the small specimen size, nonuniform shear rates along the width of the specimen, anisotropic shearing with some geosynthetics and no standardized testing protocol. See Stark and Poeppel (1994) for information and data using this alternative test method.

2.3 Various Types of Loadings

There are a large variety of slope stability problems that may be encountered in analyzing and/or designing final covers of engineered landfills, abandoned dumps and remediation sites as well as leachate collection soils covering geomembranes beneath the waste. Perhaps the most common situation is a uniformly thick cover soil on a geomembrane placed over the soil subgrade at a given and constant slope angle. This "standard" problem will be analyzed in the next section. A variation of this problem will include equipment loads used during placement of cover soil on the geomembrane. This problem will be solved with equipment moving up the slope and then moving down the slope.

Unfortunately, cover soil slides have occurred and it is felt that the majority of the slides have been associated with seepage forces. Indeed, drainage above a geomembrane (or other barrier material) in the cover soil cross section must be accommodated to avoid the possibility of seepage forces. A section will be devoted to this class of slope stability problems.

Lastly, the possibility of seismic forces exists in earthquake prone locations. If an earthquake occurs in the vicinity of an engineered landfill, abandoned dump or remediation site, the seismic wave travels through the solid waste mass reaching the upper surface of the cover. It then decouples from the cover soil materials, producing a horizontal force which must be appropriately analyzed. A section will be devoted to the seismic aspects of cover soil slope analysis as well.

All of the above actions are destabilizing forces tending to cause slope instability. Fortunately, there are a number of actions that can be taken to increase the stability of slopes.

Other than geometrically redesigning the slope with a flatter slope angle or shorter slope length, a designer can add soil mass at the toe of the slope thereby enhancing stability. Both toe berms and tapered soil covers are available options and will be analyzed accordingly. Alternatively, the designer can always use geogrids or high strength geotextiles within the cover soil acting as reinforcement materials. This technique is usually referred to as veneer reinforcement. Cases of both intentional and nonintentional veneer reinforcement will be presented.

Thus it is seen that a number of strategies influence slope stability. Each will be described in the sections to follow. First, the basic gravitational problem will be presented followed by those additional loading situations which tend to decrease slope stability. Second, various actions that can be taken by the designer to increase slope stability will be presented. The summary will contrast the FS-values obtained in the similarly crafted numeric examples.

3 SITUATIONS CAUSING DESTABILIZATION OF SLOPES

This section treats the standard veneer slope stability problem and then superimposes upon it a number of situations, all of which tend to destabilize slopes. Included are gravitational, construction equipment, seepage and seismic forces. Each will be illustrated by a design graph and a numeric example.

3.1 Cover Soil (Gravitational) Forces

Figure 3 illustrates the common situation of a *finite* length, uniformly thick cover soil placed over a liner material at a slope angle "β". It includes a passive wedge at the toe and has a tension crack of the crest. The analysis that follows is after Koerner and Hwu (1991), but comparable analyses are available from Giroud and Beech (1989), McKelvey and Deutsch (1991), Ling and Leshchinsky (1997) and others.

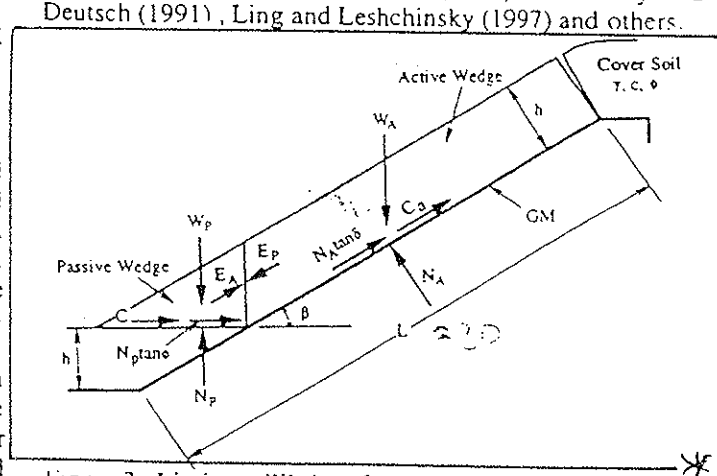


Figure 3. Limit equilibrium forces involved in a finite length slope analysis for a uniformly thick cover soil.

Attachment E 1/6

Eg 5/11/01 ⑤
GTC 5/11/01

The symbols used in Figure 3 are defined below.

W_A = total weight of the active wedge
W_P = total weight of the passive wedge
N_A = effective force normal to the failure plane of the active wedge
N_P = effective force normal to the failure plane of the passive wedge
γ = unit weight of the cover soil
h = thickness of the cover soil
L = length of slope measured along the geomembrane
β = soil slope angle beneath the geomembrane
ϕ = friction angle of the cover soil
δ = interface friction angle between cover soil and geomembrane
C_a = adhesive force between cover soil of the active wedge and the geomembrane
c_a = adhesion between cover soil of the active wedge and the geomembrane
C = cohesive force along the failure plane of the passive wedge
c = cohesion of the cover soil
E_A = interwedge force acting on the active wedge from the passive wedge
E_P = interwedge force acting on the passive wedge from the active wedge
FS = factor of safety against cover soil sliding on the geomembrane

The expression for determining the factor of safety can be derived as follows:

Considering the active wedge,

$$W_A = \gamma h^2\left(\frac{L}{h} - \frac{1}{\sin\beta} - \frac{\tan\beta}{2}\right) \quad (3)$$

$$N_A = W_A \cos\beta \quad (4)$$

$$C_a = c_a\left(L - \frac{h}{\sin\beta}\right) \quad (5)$$

By balancing the forces in the vertical direction, the following formulation results:

$$E_A \sin\beta = W_A - N_A \cos\beta - \frac{N_A \tan\delta + C_a}{FS}\sin\beta \quad (6)$$

Hence the interwedge force acting on the active wedge is:

$$E_A = \frac{(FS)(W_A - N_A\cos\beta) - (N_A\tan\delta + C_a)\sin\beta}{\sin\beta(FS)} \quad (7)$$

The passive wedge can be considered in a similar manner:

$$W_P = \frac{\gamma h^2}{\sin 2\beta} \quad (8)$$

$$N_P = W_P + E_P \sin\beta \quad (9)$$

$$C = \frac{(c)(h)}{\sin\beta} \quad (10)$$

By balancing the forces in the horizontal direction, the following formulation results:

$$E_P \cos\beta = \frac{C + N_P \tan\phi}{FS} \quad (11)$$

Hence the interwedge force acting on the passive wedge is:

$$E_P = \frac{C + W_P \tan\phi}{\cos\beta(FS) - \sin\beta\tan\phi} \quad (12)$$

By setting $E_A = E_P$, the resulting equation can be arranged in the form of the quadratic equation $ax^2 + bx + c = 0$ which in our case, using FS-values, is:

$$a(FS)^2 + b(FS) + c = 0 \quad (13)$$

where

$$a = (W_A - N_A\cos\beta)\cos\beta$$

$$b = -\left[(W_A - N_A\cos\beta)\sin\beta\tan\phi + (N_A\tan\delta + C_a)\sin\beta\cos\beta + \sin\beta(C + W_P\tan\phi)\right]$$

$$c = (N_A\tan\delta + C_a)\sin^2\beta\tan\phi \quad (14)$$

The resulting FS-value is then obtained from the solution of the quadratic equation:

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a} \quad (15)$$

When the calculated FS-value falls below 1.0, sliding of the cover soil on the geomembrane is to be anticipated. Thus a value of greater than 1.0 must be targeted as being the minimum factor of safety. How much greater than 1.0 the FS-value should be, is a design and/or regulatory issue. The issue of minimum allowable FS-values under different conditions will be assessed at the end of the paper. In order to better illustrate the implications of Eqs. 13, 14 and 15, typical design curves for various FS-values as a function of slope angle and interface friction angle are given in Figure 4. Note that the curves are developed specifically for the variables stated in the legend of the figure. Example 1 illustrates the use of the curves in what will be the standard example to which other examples will be compared.

Example 1:
Given a 30 m long slope with a uniformly thick 300 mm cover soil at a unit weight of 18 kN/m³. The soil has a friction angle of 30 deg. and zero cohesion, i.e., it is a sand. The cover soil is placed directly on a geomembrane as shown in Figure 3. Direct shear testing has resulted in a interface friction angle between the cover soil and geomembrane of 22 deg. with zero adhesion. What is the FS-value at a slope angle of 3(H)-to-1(V), i.e., 18.4 deg?

Attachment V 2/6

Solution:

Substituting Eq. 14 into Eq. 15 and solving for the FS-value results in the following which is seen to be in agreement with the curves of Figure 4.

$$\left.\begin{array}{l} a = 14.7\,kN/m \\ b = -21.3\,kN/m \\ c = 3.5\,kN/m \end{array}\right\} FS = 1.25$$

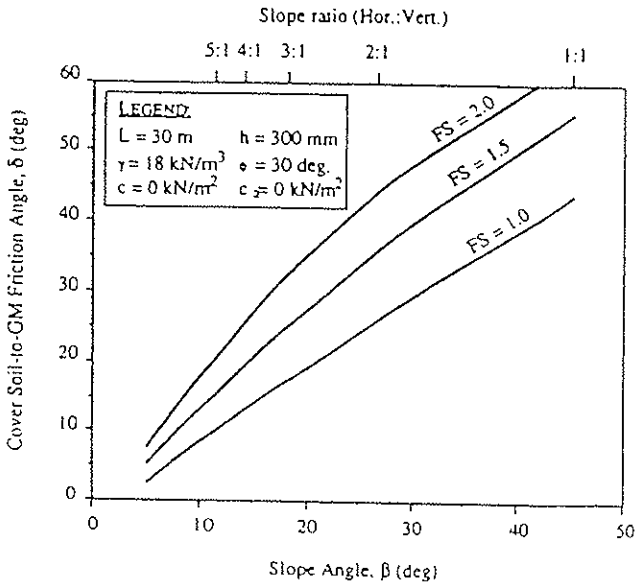


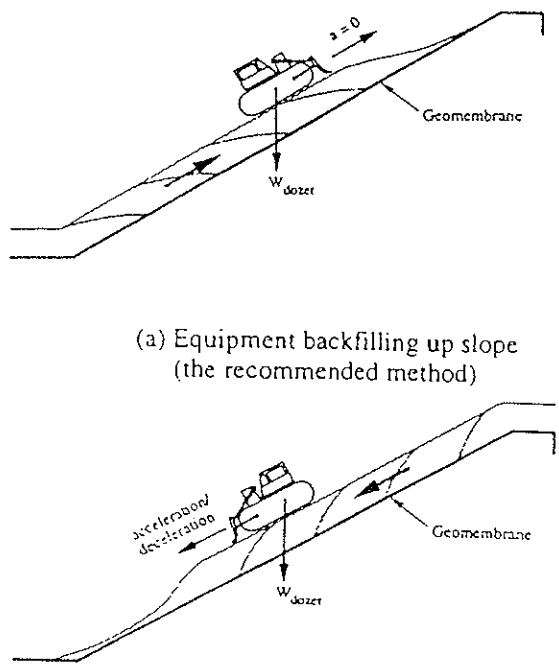
Figure 4. Design curves for stability of uniform thickness cohesionless cover soils on linear failure planes for various global factors-of-safety.

Comment:
In general, this is too low of a value for a final cover soil factor-of-safety and a redesign is necessary. While there are many possible options of changing the geometry of the situation, the example will be revisited later in this section using toe berms, tapered cover soil thickness and veneer reinforcement. Furthermore, this general problem will be used throughout the main body of this paper for comparison purposes to other cover soil slope stability situations.

3.2 Tracked Construction Equipment Forces

The placement of cover soil on a slope with a relatively low shear strength inclusion (like a geomembrane) should always be from the toe upward to the crest. Figure 5a shows the recommended method. In so doing, the gravitational forces of the cover soil and live load of the construction equipment are compacting previously placed soil and working with an ever present passive wedge and stable lower-portion beneath the active wedge. While it is necessary to specify low ground pressure equipment to place the soil, the reduction of the FS-value for this situation of equipment working up the slope will be seen to be relatively small.

For soil placement down the slope, however, a stability analysis cannot rely on toe buttressing and also a dynamic stress should be included in the calculation. These conditions decrease the FS-value and in some cases to a great extent. Figure 5b shows this procedure. Unless absolutely necessary, it is not recommended to place cover soil on a slope in this manner. If it is necessary, the design must consider the unsupported soil mass and the dynamic force of the specific type of construction equipment and its manner of operation.



(a) Equipment backfilling up slope (the recommended method)

(b) Equipment backfilling down slope (method is not recommended)

Figure 5. Construction equipment placing cover soil on slopes containing geosynthetics.

For the first case of a bulldozer pushing cover soil up from the toe of the slope to the crest, the analysis uses the free body diagram of Figure 6a. The analysis uses a specific piece of tracked construction equipment (like a bulldozer characterized by its ground contact pressure) and dissipates this force or stress through the cover soil thickness to the surface of the geomembrane. A Boussinesq analysis is used, see Poulos and Davis (1974). This results in an equipment force per unit width as follows:

$$W_e = q w I \qquad (16)$$

where

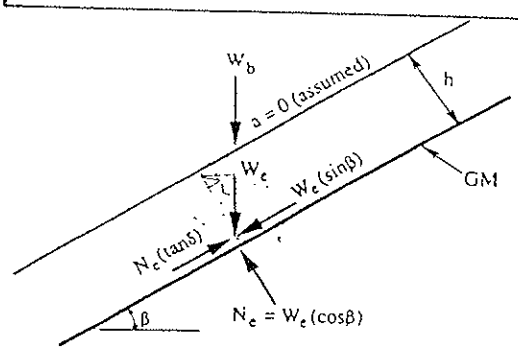
W_e = equivalent equipment force per unit width at the geomembrane interface

$q = W_b / (2 \times w \times b)$

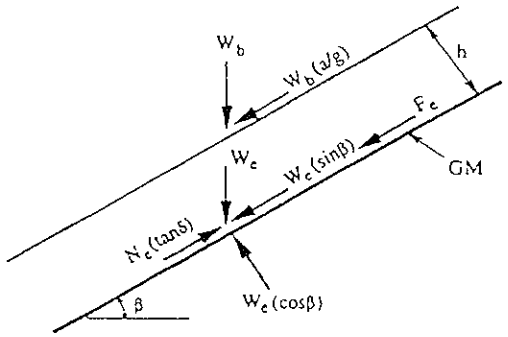
Attachment E 3/6

E 5/11/01 (3)
GTC 5/11/01

W_b = actual weight of equipment (e.g., a bulldozer)
w = length of equipment track
b = width of equipment track
I = influence factor at the geomembrane interface see Figure 7



(a) Equipment moving up slope
(load with no assumed acceleration)



(b) Equipment moving down slope
(load plus acceleration or deceleration)

Figure 6. Additional (to gravitational forces) limit equilibrium forces due to construction equipment moving on cover soil (see Figure 3 for the gravitational soil force to which the above forces are added).

Upon determining the additional equipment force at the cover soil-to-geomembrane interface, the analysis proceeds as described in Section 3.1 for gravitational forces only. In essence, the equipment moving up the slope adds an additional term, W_e, to the W_A-force in Eq. 3. Note, however, that this involves the generation of a resisting force as well. Thus, the net effect of increasing the driving force as well as the resisting force is somewhat neutralized insofar as the resulting FS-value is concerned. It should also be noted that no acceleration/deceleration forces are included in this analysis which is somewhat optimistic. Using these concepts (the same equations used in Section 3.1 are used here), typical design curves for various FS-values as a function of equivalent ground contact equipment pressures and cover soil thicknesses are given in Figure 8. Note that the curves are developed specifically for the variables stated in the legend. Example 2a illustrates the use of the formulation.

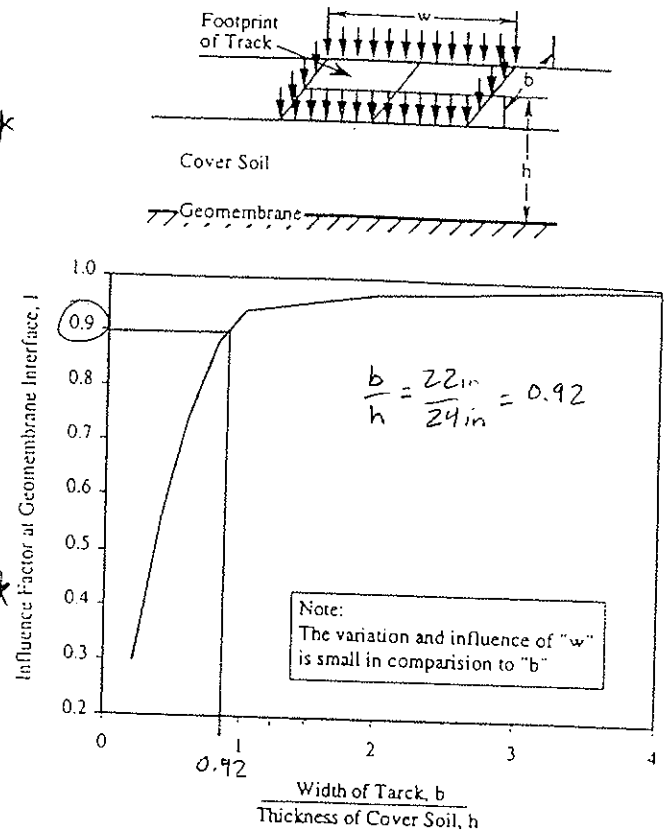


Figure 7. Values of influence factor, "I", for use in Eq. 16 to dissipate surface force of tracked equipment through the cover soil to the geomembrane interface, after Poulos and Davis (1974).

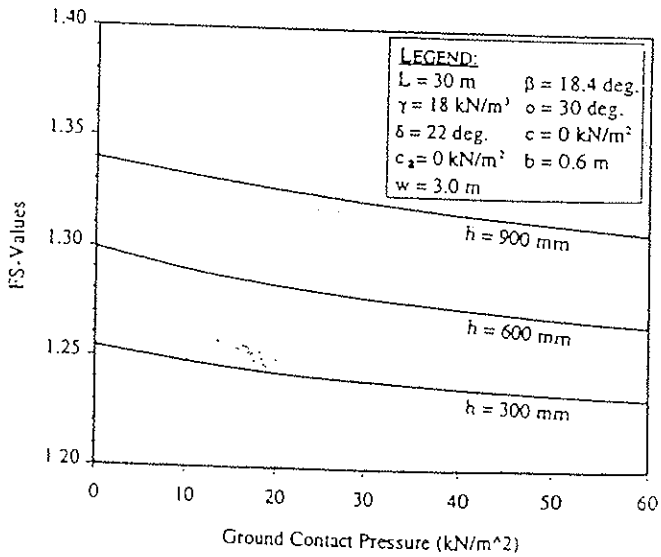


Figure 8. Design curves for stability of different thickness of cover soil for various values of tracked ground contact pressure construction equipment.

Attachment E 4/6

Example 2a:

Given 30 m long slope with uniform cover soil of 300 mm thickness at a unit weight of 18 kN/m^3. The soil has a friction angle of 30 deg. and zero cohesion, i.e., it is a sand. It is placed on the slope using a bulldozer moving from the toe of the slope up to the crest. The bulldozer has a ground pressure of 30 kN/m^2 and tracks that are 3.0 m long and 0.6 m wide. The cover soil to geomembrane friction angle is 22 deg. with zero adhesion. What is the FS-value at a slope angle of 3(H)-to-1(V), i.e., 18.4 deg.

Solution:
This problem follows Example 1 exactly except for the addition of the bulldozer moving up the slope. Using the additional equipment load Eq. 16, substituted into Eqs. 14 and 15 results in the following.

$$\left.\begin{aligned} a &= 73.1\,\text{kN/m} \\ b &= -104.3\,\text{kN/m} \\ c &= 17.0\,\text{kN/m} \end{aligned}\right\} \quad FS = 1.24$$

Comment:
While the resulting FS-value is low, the result is best assessed by comparing it to Example 1, i.e., the same problem except without the bulldozer. It is seen that the FS-value has only decreased from 1.25 to 1.24. Thus, in general, a low ground contact pressure bulldozer placing cover soil up the slope with negligible acceleration/deceleration forces does not significantly decrease the factor-of-safety.

For the <u>second case</u> of a bulldozer pushing cover soil down from the crest of the slope to the toe as shown in Figure 5b, the analysis uses the force diagram of Figure 6b. While the weight of the equipment is treated as just described, the lack of a passive wedge along with an additional force due to acceleration (or deceleration) of the equipment significantly changes the resulting FS-values. This analysis again uses a specific piece of construction equipment operated in a specific manner. It produces a force parallel to the slope equivalent to W_b (a/g), where W_b = the weight of the bulldozer, a = acceleration of the bulldozer and g = acceleration due to gravity. Its magnitude is equipment operator dependent and related to both the equipment speed and time to reach such a speed, see Figure 9. A similar behavior will be seen for deceleration.

The acceleration of the bulldozer, coupled with an influence factor "I" from Figure 7, results in the dynamic force per unit width at the cover soil to geomembrane interface, "F_e". The relationship is as follows:

$$F_e = W_e\left(\frac{a}{g}\right) \qquad (17)$$

where

F_e = dynamic force per unit width parallel to the slope at the geomembrane interface,

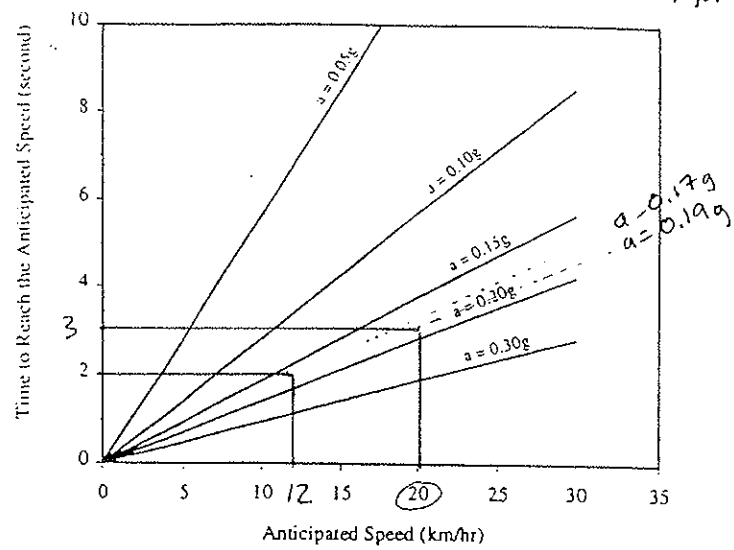


Figure 9. Graphic relationship of construction equipment speed and rise time to obtain equipment acceleration.

W_e = equivalent equipment (bulldozer) force per unit width at geomembrane interface, recall Eq. 16.
β = soil slope angle beneath geomembrane
a = acceleration of the bulldozer
g = acceleration due to gravity

Using these concepts, the new force parallel to the cover soil surface is dissipated through the thickness of the cover soil to the interface of the geomembrane. Again, a Boussinesq analysis is used, see Poulos and Davis (1974). The expression for determining the FS-value can now be derived as follows:

Considering the active wedge, and balancing the forces in the direction parallel to the slope, the following formulation results:

$$E_A + \frac{(N_e + N_A)\tan\delta + C_a}{FS} = (W_A + W_e)\sin\beta + F_e \qquad (18)$$

where

N_e = effective equipment force normal to the failure plane of the active wedge
= $W_e \cos\beta$ (19)

Note that all the other symbols have been previously defined.

The interwedge force acting on the active wedge can down be expressed as:

$$E_A = \frac{(FS)\left[(W_A + W_e)\sin\beta + F_e\right]}{FS} - \frac{\left[(N_e + N_A)\tan\delta + C_a\right]}{FS} \qquad (20)$$

The passive wedge can be treated in a similar manner. The following formulation of the interwedge force acting on the passive wedge results:

Attachment E 5/6

$$E_P = \frac{C + W_P \tan\phi}{\cos\beta(FS) - \sin\beta\tan\phi} \qquad (21)$$

By setting $E_A = E_P$, the following equation can be arranged in the form of Eq. 13 in which the "a", "b" and "c" terms are as follows:

$$a = \left[\left(W_A + W_e\right)\sin\beta + F_e\right]\cos\beta$$

$$b = -\left\{\left[\left(N_e + N_A\right)\tan\delta + C_a\right]\cos\beta + \left[\left(W_A + W_e\right)\sin\beta + F_e\right]\sin\beta\tan\phi + \left(C + W_P\tan\phi\right)\right\}$$

$$c = \left[\left(N_e + N_A\right)\tan\delta + C_a\right]\sin\beta\tan\phi \qquad (22)$$

Finally, the resulting FS-value can be obtained using Eq. 15. Using these concepts, typical design curves for various FS-values as a function of equipment ground contact pressure and equipment acceleration can be developed, see Figure 10. Note that the curves are developed specifically for the variables stated in the legend. Example 2b illustrates the use of the formulation.

Example 2b:

Given a 30 m long slope with uniform cover soil of 300 mm thickness at a unit weight of 18 kN/m^3. The soil has a friction angle of 30 deg. and zero cohesion, i.e., it is a sand. It is placed on the slope using a bulldozer moving from the crest of the slope down to the toe. The bulldozer has a ground contact pressure of 30 kN/m^2 and tracks that are 3.0 m long and 0.6 m wide. The estimated equipment speed is 20 km/hr and the time to reach this speed is 3.0 sec. The cover soil to geomembrane friction angle is 22 deg. with zero adhesion. What is the FS-value at a slope angle of 3(H)-to-1(V), i.e., 18.4 deg.

Solution:

Using the design curves of Figure 10 along with Eqs. 22 substituted into Eq. 15 the solution can be obtained:

- From Figure 9 at 20 km/hr and 3.0 sec. the bulldozer's acceleration is 0.19g.
- From Eq. 22 substituted into Eq. 15 we obtain

$$\left.\begin{aligned} a &= 88.8\,\text{kN/m} \\ b &= -107.3\,\text{kN/m} \\ c &= 17.0\,\text{kN/m} \end{aligned}\right\} \quad FS = 1.03$$

Comment:

This problem solution can now be compared to the previous two examples:

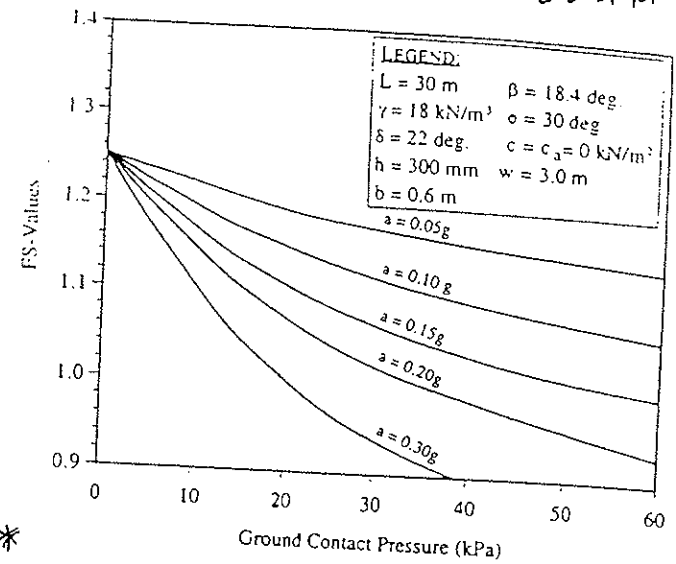


Figure 10. Design curves for stability of different construction equipment ground contact pressure for various equipment accelerations.

Ex. 1:	cover soil alone with no bulldozer loading	FS = 1.25
Ex. 2a:	cover soil plus bulldozer moving up slope	FS = 1.24
Ex. 2b:	cover soil plus bulldozer moving down slope	FS = 1.03

The inherent danger of a bulldozer moving down the slope is readily apparent. Note, that the same result comes about by the bulldozer decelerating instead of accelerating. The sharp breaking action of the bulldozer is arguable the more severe condition due to the extremely short times involved when stopping forward motion. Clearly, only in unavoidable situations should the cover soil placement equipment be allowed to work down the slope. If it is unavoidable, an analysis should be made of the specific stability situation and the construction specifications should reflect the exact conditions made in the design. The maximum allowable weight and ground contact pressure of the equipment should be stated along with suggested operator movement of the cover soil placement operations. Truck traffic on the slopes can also give as high, or even higher, stresses and should be avoided unless adequately designed. Additional detail is given in McKelvey (1994). The issue of access ramps is a unique subset of this example and one which deserves focused attention due to the high loads and decelerations that often occur.

3.3 Consideration of Seepage Forces

The previous sections presented the general problem of slope stability analysis of cover soils placed on slopes under different conditions. The tacit assumption throughout was that either permeable soil or a drainage layer was placed above the barrier layer with adequate flow capacity to efficiently remove permeating water safely way from the cross section. The amount of water to be removed is obviously a site specific situation. Note that in extremely

Attachment E 6/6

5/11/01 GTC 5/11/01

MODEL	D6R		D6R XL		D6R XL (IG)▶		D6R XR	
Flywheel Power	123 kW	165 hp	130 kW	175 hp	138 kW	185 hp	130 kW	175 hp
Operating Weight:*								
Power Shift	18 000 kg	39,700 lb	19 000 kg	41,900 lb	19 780 kg	43,600 lb	18 780 kg	41,400 lb
Direct Drive	18 053 kg**	39,800 lb	—		—		—	
Power Shift Differential Steer	18 200 kg	40,000 lb	19 200 kg	42,300 lb	19 960 kg	44,000 lb	18 910 kg	41,700 lb
Engine Model	3306T		3306T		3306T		3306T	
Rated Engine RPM	1900		1900		1900		1900	
No. of Cylinders	6		6		6		6	
Bore	121 mm	4.75"	121 mm	4.75"	121 mm	4.75"	121 mm	4.75"
Stroke	152 mm	6"	152 mm	6"	152 mm	6"	152 mm	6"
Displacement	10.5 L	638 in³	10.5 L	638 in³	10.5 L	638 in³	10.5 L	638 in³
Track Rollers (Each Side)	6		7		7		7	
Width of Standard Track Shoe	560 mm	1'10"	560 mm	1'10"	762 mm	2'6"	560 mm	1'10"
Length of Track on Ground	2.61 m	8'7"	2.82 m	9'3"	2.82 m	9'3"	2.75 m	9'0"
Ground Contact Area (W/Std. Shoe)	2.92 m²	4523 in²	3.16 m²	4888 in²	4.3 m²	6661 in²	3.08 m²	4771 in²
Track Gauge	1.88 m	6'2"	1.88 m	6'2"	2.03 m	6'8"	1.88 m	6'2"
GENERAL DIMENSIONS:								
Height (Stripped Top)***	2.38 m	7'5"	2.38 m	7'5"	2.38 m	7'5"	2.38 m	7'5"
Height (To Top of ROPS)	3.19 m	10'5"	3.19 m	10'5"	3.19 m	10'5"	3.19 m	10'5"
Height (To Top of Cab ROPS)	3.19 m	10'5"	3.19 m	10'5"	3.19 m	10'5"	3.19 m	10'5"
Height (To Top of ROPS Canopy)	—		—		—		—	
Overall Length (With S Blade)	5.11 m	16'9"	—		—		5.26 m	17'3"
(Without Blade)	4.08 m	13'4"	4.08 m	13'4"	—		4.22 m	13'10"
Width (Over Trunnion)	2.64 m	8'8"	2.64 m	8'8"	2.95 m	9'8"	2.64 m	8'8"
Width (W/O Trunnion — Std. Shoe)	2.44 m	8'0"	2.44 m	8'0"	2.74 m	9'0"	2.44 m	8'0"
Ground Clearance	383 mm	14.8"	383 mm	14.8"	383 mm	14.8"	383 mm	14.8"
Blade Types and Widths:								
Straight	3.35 m	11'0"	—		—		3.36 m	11'0"
Angle	—		—		—		—	
Angle Straight	4.16 m	13'7.8"	4.16 m	13'8"	—		4.16 m	13'8"
Full Angle	3.78 m	12'4.7"	3.78 m	12'5"	—		3.78 m	12'5"
Universal	—		—		—		—	
Semi-U	3.26 m	10'8"	3.26 m	10'8"	3.56 m	11'8"	3.26 m	10'8"
Fuel Tank Refill Capacity	383 L	101 U.S. gal	383 L	101 U.S. gal	383 L	101 U.S. gal	383 L	101 U.S. gal

*Operating Weight includes ROPS canopy, operator, lubricants, coolant, full fuel tank, hydraulic controls and fluid, straight dozer with tilt, horn, back-up alarm, retrieval hitch and front pull hook.

**Japan only.

***Height (stripped top) — without ROPS canopy, exhaust, seat back or other easily removed encumbrances

▶Intermediate Gauge offered as custom product.

Attachment F, 1/1

~~Attachment G~~

Calculation Package C
Cover Liner Sloughing Stability

GeoSyntec Consultants

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: BRC Project: BRC CAMU Project/Proposal #: SC0313 Task #: 01-02

Title of Computations: Slope Stability Evaluation – Sloughing Stability

Computations By: SIGNATURE — DATE: 24 May 2005

Edward M. Zielanski / Project Engineer
PRINTED NAME AND TITLE

Assumptions and Procedures Checked By (Peer Reviewer): SIGNATURE — DATE: 6/3/05

Gregory T. Corcoran / Associate Engineer
PRINTED NAME AND TITLE

Computations Checked By: SIGNATURE — DATE: 6/3/05

Gregory T. Corcoran / Associate Engineer
PRINTED NAME AND TITLE

Computations Backchecked By (Originator): SIGNATURE — DATE: 6/3/05

Edward M. Zielanski / Project Engineer
PRINTED NAME AND TITLE

Approved By (PM or Designate): SIGNATURE — DATE: 6/3/05

Gregory T. Corcoran / Associate Engineer

Approval Notes:

Revisions: (Number and Initial All Revisions)

No.	Sheet	Date	By	Checked By	Approval

Written by: Ed Zielanski (2) Date: 05 / 05 / 24 (YY MM DD) Reviewed by: _____ Date: ___/___/___ (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-02

SLOPE STABILITY EVALUATION
SLOUGHING STABILITY OF GEOSYNTHETIC-SOIL LINED SIDESLOPES
COVER LINER SYSTEM
BRC CAMU

OBJECTIVE

To evaluate the infinite slope stability (i.e., sloughing failure) within the geosynthetic-soil layered sideslopes of the cover liner system of the BRC Corrective Action Management Unit (CAMU) located in Henderson, Nevada.

SUMMARY OF RESULTS

Assuming that no head buildup is expected above the liner, the proposed slope meets the required factor of safety of 1.5. The minimum interface friction angle between the cover soil and geocomposite shall be greater than or equal to 27 degrees. The yield acceleration is 0.15 g.

METHOD OF ANALYSIS

The stability analyses presented herein are based on the principles of an infinite slope failure. The critical failure plane may occur within the cover soil mass or along the geotextile/cover soil interface. The procedure outlined below is based on published data from Thiel and Steward (1993) (Attachment A). The factor of safety, defined as the ratio of resisting shear strength divided by the driving shear stress, is:

$$FS = \frac{S}{\tau} = \frac{c' + \left[h_1\gamma_1 + (h_2 - h_w)\gamma_2 - h_w\gamma_w\right]\tan\phi'}{\left[h_1\gamma_1 + (h_2 - h_w)\gamma_2 + h_w\gamma_{sat}\right]\tan\beta} \qquad \text{(Equation 1)}$$

where:
- h_1 = thickness of topsoil;
- h_2 = thickness of drainage layer;
- h_w = average height of water in drainage layer normal to slope;
- γ_1 = saturated unit weight of topsoil;
- γ_2 = moist unit weight of drainage layer;
- γ_{2sat} = saturated unit weight of drainage layer;
- β = slope angle; and
- ϕ, c' = interface strength parameters.

Written by: Ed Zielanski Date: 05 / 05 / 24 (YY MM DD) Reviewed by: _____ Date: ___/___/___ (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-02

Since the results of the veneer stability calculation package indicate that there will be no tension developed in the geosynthetics, only the stability of the cover soil and interface between the cover soil and drainage composite will be analyzed herein.

The yield acceleration is the horizontal acceleration (in terms of gravity) required for the slope to have a factor of safety of 1.0. Matasovic (1991) (Attachment D) presents a formula to calcualate the yield acceleration for an infinite slope, defined as:

$$k_y = \frac{c/(\gamma z \cos^2 \beta) + \tan\phi[1 - \gamma_w (z - d_w)/(\gamma z)] - \tan\beta}{1 + \tan\beta \tan\phi} \qquad \text{(Equation 2)}$$

where:
k_y = yield acceleration (g)
ϕ = friction angle (deg.)

Since the head on the liner is negligable and the material is cohesionless, Equation 2 becomes:

$$k_y = \frac{\tan\phi - \tan\beta}{1 + \tan\beta \tan\phi} \qquad \text{(Equation 3)}$$

DESIGN CRITERION

For long term conditions, a design criterion is a factor of safety of 1.5.

SIDESLOPE LINER SYSTEM

The sideslope liner system of the cover liner system consists of, from top to bottom:

- 2 ft native material;
- a drainge geocomposite;
- a 60-mil (1.5-mm) thick textured high density polyethylene (HDPE) geomembrane;
- a geosynthetic clay liner (GCL); and
- waste soil fill.

The sideslope inclination is 3.0H:1.0V. The maximum height of a side slope is 42 vertical feet, located in the southwest corner of the South Mesa.

Written by: Ed Zielanski Date: 05 / 05 / 24 (YY MM DD) Reviewed by: _____ Date: ___/___/___ (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-02

MATERIAL SHEAR STRENGTHS

Cover Soil Material:

The soil materials to be used overlying the side slope liner system will be native materials such as silty sands (SM) for the operations layer. Converse reported a maximum dry density of 132 pcf and an optimum water content of 8.7 percent for materials at the site. Therefore, assuming 95% relative compaction, the dry density in the field is approximately 125 pcf. Adding the weight of water, the unit weight is approximately 136 pcf.

NAVFAC (1982) lists typical shear strength values for various soils based on 100 percent standard Proctor compaction (Attachment C). Actual construction materials would likely be placed at 90 percent of the modified Proctor compaction which for the sake of the comparison presented herein roughly corresponds to 95 percent standard Proctor compaction. NAVFAC (1982) lists typical shear strength values for a SM material to be 34 degrees. For the analysis herein, cohesion was neglected. Therefore, the shear strength can be approximately estimated to be 0.95(34 deg) = 32 degrees.

For this analysis, a shear strength of 32 degrees and a unit weight of 136 pcf will be used for the analyses performed herein.

ANALYSIS

Based on HELP model analyses (presented in a separate calculation package titled *Geocomposite and Pipe Size Requirements*), the side slopes will not develop a head on the liner system. In addition, a geocomposite will be used as a drainage layer in the cover liner system. Based on the assumption of a cohesionless material, Equation 1 becomes:

$$FS = \frac{S}{\tau} = \frac{\tan\phi'}{\tan\beta}$$

The design criteria dictates a minimum factor of safety of 1.5 for long term conditions. Therefore, the minimum allowable friction angle (interface or internal) is evaluated as:

$$\varphi = \tan^{-1}(FS\tan\beta)$$
$$\varphi = \tan^{-1}(1.5\tan 18.43) = 27$$

Written by: Ed Zielanski Date: 05 / 05 / 24 (YY MM DD) Reviewed by: _____ Date: ___/___/___ (YY MM DD)

Client: BRC Project: BRC CAMU Project/Proposal No.: SC0313 Task No.: 01-02

To calculate the yield accleration, Equation 3 becomes:

$$k_y = \frac{\tan 27 - 0.333}{1 + (0.333)\tan 27} = 0.15 \text{ g}$$

RESULTS AND CONCLUSIONS

The calculations suggest that the minimum friction angle (interface or internal) of 26.5 degrees will meet the design criteria of a factor of safety equal to 1.5. The yield accleration is evaluated to be 0.15 g. The minimum friction angle should be obtained in the cover soil and the interface between the cover soil and geocomposite interface. A review of current literature suggests that the minimum friction angle can be obtained.

REFERENCES

Koerner, R. M. (1997), "Designing with Geosynthetics," Simon and Schuster / A Viacom Company, Upper Saddle New Jersey, 07458, 1998 *(Attachment B)*

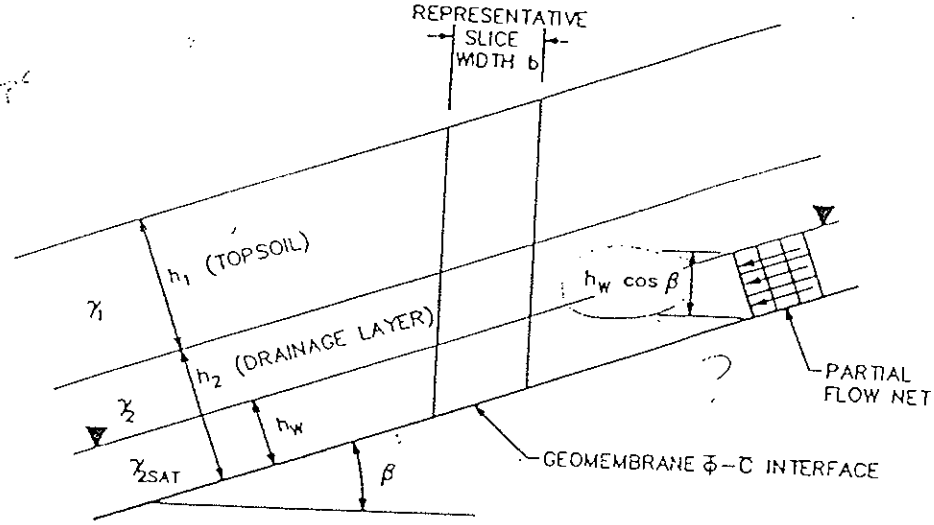
NAVFAC (1982), "Foundations and Earth Structures, Design Manual - 7.2," Department of Navy, Naval Facilities Engineering Command, May 1982 *(Attachment C)*

Thiel, R. S., Stewart, M.G., "Geosynthetic Landfill Cover Design Methodology and Construction Experience in the Pacific Northwest," Proceedings from Geosynthetics 1993, Vancouver, Canada. *(Attachment A)*

[redacted]

MKK 7-13-00
RC 7/27/00 GTC (32)

a) INFINITE SLOPE GEOMETRY AND MATERIAL PARAMETERS



b) FORCES

$W = [h_1 \gamma_1 + (h_2 - h_w)\gamma_2 + h_w \gamma_{2SAT}]\, b/\cos\beta$

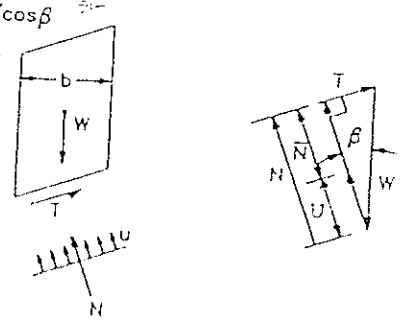
$u = \gamma_w h_w \cos\beta$

$U = ub/\cos\beta = \gamma_w h_w b$

$N = W\cos\beta$

$T = W\sin\beta$

$\bar{N} = N - U$



FREE BODY DIAGRAM FORCE POLYGON

Geometric Parameters: β = slope angle; h_1 = thickness of topsoil; h_2 = thickness of drainage layer; h_w = average height of water in drainage layer normal to slope; b = width of representative slice.

Material Parameters: γ_1 = saturated unit weight of topsoil; γ_2 = moist unit weight of drainage layer; γ_{2SAT} = saturated unit weight of drainage layer; γ_w = unit weight of water; $\bar{\phi}$ = effective friction parameter for shear strength at base of drainage layer; $\bar{c}$ = effective cohesion parameter for shear strength at base of drainage layer.

Forces: u = pore pressure on base of drainage layer; U = uplifting water force; W = total weight of slice; N = total force normal to slope exerted by weight; T = tangential force to slope exerted by weight; $\bar{N}$ = effective normal force.

FIGURE 4. INFINITE SLOPE STABILITY WITH SEEPAGE PARALLEL TO SLOPE (MODIFIED AFTER DUNN ET AL, 1980, p.241)

$$FS = \frac{\bar{c}' + \left[\left[\gamma_1 h_1 + h_2\gamma_2 - h_w\gamma_w\right]\frac{\cos\beta}{\cos\beta}\right]\tan\bar{\phi}}{\left[\gamma_1 h_1 + h_2\gamma_2 - h_w\gamma_w\right]\frac{\sin\beta}{\cos\beta} + \left(\frac{\gamma_w h_w}{\cos\beta}\right)}$$

Attachment A
1/2

SOURCE: THIEL & STEWART (1993)

The effective stress normal to base of the slice, $\bar{\sigma}$, is

$$\bar{\sigma} = \frac{\bar{N}}{b/\cos\beta} = [h_1\gamma_1 + (h_2 - h_w)\gamma_2 + h_w\gamma_{2\,SAT} - h_w\gamma_w]\cos\beta \tag{4}$$

The shear stress exerted tangential to the slice base, τ, is

$$\tau = \frac{T}{b/\cos\beta} = [h_1\gamma_1 + (h_2 - h_w)\gamma_2 + h_w\gamma_{2SAT}]\sin\beta \tag{5}$$

The shear strength at base of the slice, S, is

$$S = \bar{c} + \bar{\sigma}\tan\bar{\phi} \tag{6}$$

The factor of safety, defined as the ratio of the resisting shear strength divided by the driving shear stress, is

$$FS = \frac{S}{\tau} = \frac{\bar{c} + [h_1\gamma_1 + (h_2 - h_w)\gamma_2 + h_w\gamma_{2SAT} - h_w\gamma_w]\tan\bar{\phi}}{[h_1\gamma_1 + (h_2 - h_w)\gamma_2 + h_w\gamma_{2SAT}]\tan\beta} \tag{7}$$

Because the depth of saturation in the drainage layer varies, the FS would vary also. A common procedure is to compute the average FS by using the average water depth in the drainage layer, assumed to be half the maximum water depth (D) used in Equation (2). The method therefore computes an average factor of safety for the slope length between drainage discharge points. Locations upgradient of the average flow depth will have a slightly higher FS, and downgradient locations, a slightly lower FS.

The design methodology would be to compute the FS for a given cover geometry and materials properties using Equation (7), and using one half the maximum water depth (D) used in Equations (2) and (3). If the FS is acceptable, use the maximum drainage discharge spacing (L) computed in Equation (3). If the FS is unacceptably low, reduce the distance (L), recompute the average flow depth (D/2) in the drainage layer, and recompute the FS. Iterate until the FS is acceptable.

Design Example. Given: thickness (h_1) of 1.5 feet (45 cm) of topsoil with a saturated unit weight (γ_1) of 115 pcf (18 KN/m^3) and hydraulic conductivity (k_1) of 2×10^{-4} ft/min (1×10^{-4} cm/sec); thickness (h_2) of 1 foot (30 cm) of drainage layer with moist unit weight (γ_2) of 100 pcf (15.7KN/m^3), saturated unit weight (γ_{2SAT}) of 105 pcf (16.5 KN/m^3) and hydraulic conductivity (k_2) of 0.2 ft/min (0.1 cm/sec); slope angle (β) of 3:1 (18.4 degrees); and interface friction parameter (ϕ) of 30 degrees. Unit weight of water (γ_w) = 62.4 pcf (9.8 KN/m^3).

Find: Maximum allowable spacing (L_{max}) between drainage outlets designed subparallel to slope contours such that the maximum depth (D) of accumulated water in the drainage layer is one foot (30 cm), and a minimum average FS of 1.5 is maintained.

Solution:

$$L_{(max)} = (k_2)\sin(\beta)(D)/(k_1) = 0.2\sin(18.4)(1)/0.0002 = 316\,ft\,(96\,m)$$

$$FS = \frac{[(h_1)(\gamma_1) + (h_2 - D/2)(\gamma_2) + (D/2)(\gamma_{2SAT}) - (D/2)(\gamma_w)]\tan(\phi)}{[(h_1)(\gamma_1) + (h_2 - D/2)(\gamma_2) + (D/2)(\gamma_{2SAT})]\tan(\beta)} \tag{8}$$

$$= \frac{[(1.5)(115) + (1-.5)(100) + (.5)(105) - (.5)(62.4)]\tan(30)}{[(1.5)(115) + (1-.5)(100) + (.5)(105)]\tan(18.43)} = 1.5\ (ok)$$

Factor of Safety. Geotechnical engineers often feel comfortable with a minimum FS of 1.5 for long-term static slope stability conditions. This value originated from dam

MSW 1-13-00
KCF 7/27/00 GTC (2)

Table 5.7 Friction values and efficiencies (in parentheses) for (a) soil-to-geomembrane, (b) geomembrane-to-geotextile, and (c) soil-to-geotextile combinations*

(a) Soil-to-Geomembrane Friction Angles

	Soil Types		
Geomembrane	*Concrete Sand* (ϕ = 30°)	*Ottawa Sand* (ϕ = 28°)	*Micha Schist Sand* (ϕ = 26°)
EPDM-R	24° (0.77)	20° (0.68)	24° (0.91)
PVC			
Rough	27° (0.88)	—	25° (0.96)
Smooth	25° (0.81)	—	21° (0.79)
CSPE-R	25° (0.81)	21° (0.72)	23° (0.87)
HDPE	18° (0.56)	18° (0.61)	17° (0.63)

(b) Geomembrane-to-Geotextile Friction Angles

	Geomembrane				
		PVC			
Geotextile	*EPDM-R*	*Rough*	*Smooth*	*CSPE-R*	*HDPE*
Nonwoven, needle punched	23°	23°	21°	15°	8°
Nonwoven, heat bonded	18°	20°	18°	21°	11°
Woven, monofilament	17°	11°	10°	9°	6°
Woven, slit film	21°	25°	24°	15°	10°

(c) Soil-to-Geotextile Friction Angles

	Soil Types		
Geotextile	*Concrete Sand* (ϕ = 30°)	*Ottawa Sand* (ϕ = 28°)	*Mica Schist Sand* (ϕ = 26°)
Nonwoven, needle punched	30° (1.00)	26° (0.92)	25° (0.96)
Nonwoven, heat bonded	26° (0.84)	—	—
Woven, monofilament	26° (0.84)	—	—
Woven, slit film	24° (0.77)	24° (0.84)	23° (0.87)

*Efficiency values in parentheses are based on the relationship $E = (\tan \delta)/(\tan \phi)$.

Source: After Martin et al. [14].

The frictional behavior of geomembranes placed on clay soils is of considerable importance in the composite liners of waste landfills. Current requirements are for the clay to have a hydraulic conductivity equal to or less than 2×10^{-7} ft./min. (1×10^{-7} cm/sec.) and for the geomembrane to be placed directly on the clay. While an indication of the shear strength parameters has been investigated (e.g., reference 15), the data are so sensitive to the variables listed previously that site-specific and material-specific tests should always be performed. In such cases, literature values should never be used for final design purposes.

5.1.3.9 Geomembrane Anchorage In certain problem situations a geomembrane might be sandwiched between two materials and then tensioned by an external force. The termination of a geomembrane liner within an anchor trench is such a situation. To simulate this behavior in a laboratory environment, one can use an 8.0-in. (200-mm)-wide geomembrane sandwiched between back-to-back channels.

FROM KOERNER (1997) Attachment B 1/1

BLE 1

Typical Properties of Compacted Soils

Group Symbol	Soil Type	Range of Maximum Dry Unit Weight, pcf	Range of Optimum Moisture, Percent	Typical Value of Compression (Percent of Original Height): At 1.4 tsf (20 psi)	At 3.6 tsf (50 psi)	Typical Strength Characteristics: Cohesion (as compacted) psf	Cohesion (saturated) psf	φ (Effective Stress Envelope Degrees)	Tan φ	Typical Coefficient of Permeability ft./min.	Range of CBR Values	Range of Subgrade Modulus k lbs/cu in.
GW	Well graded clean gravels, gravel-sand mixtures.	125 - 135	11 - 8	0.3	0.6	0	0	>38	>0.79	5×10^{-2}	40 - 80	300 - 500
GP	Poorly graded clean gravels, gravel-sand mix	115 - 125	14 - 11	0.4	0.9	0	0	>37	>0.74	10^{-1}	30 - 60	250 - 400
GM	Silty gravels, poorly graded gravel-sand-silt.	120 - 135	12 - 8	0.5	1.1	.....	.....	>34	>0.67	$>10^{-6}$	20 - 60	100 - 400
GC	Clayey gravels, poorly graded gravel-sand-clay.	115 - 130	14 - 9	0.7	1.6	.....	.....	>31	>0.60	$>10^{-7}$	20 - 40	100 - 300
SW	Well graded clean sands, gravelly sands.	110 - 130	16 - 9	0.6	1.2	0	0	38	0.79	$>10^{-3}$	20 - 40	200 - 300
SP	Poorly graded clean sands, sand-gravel mix.	100 - 120	21 - 12	0.8	1.4	0	0	37	0.74	$>10^{-3}$	10 - 40	200 - 300
SM	Silty sands, poorly graded sand-silt mix.	110 - 125	16 - 11	0.8	1.6	1050	420	34	0.67	$5 \times >10^{-5}$	10 - 40	100 - 300
SM-SC	Sand-silt clay mix with slightly plastic fines.	110 - 130	15 - 11	0.8	1.4	1050	300	33	0.66	$2 \times >10^{-6}$	5 - 30	100 - 300
SC	Clayey sands, poorly graded sand-clay-mix.	105 - 125	19 - 11	1.1	2.2	1550	230	31	0.60	$5 \times >10^{-7}$	5 - 20	100 - 300
ML	Inorganic silts and clayey silts.	95 - 120	24 - 12	0.9	1.7	1400	190	32	0.62	$>10^{-5}$	15 or less	100 - 200
ML-CL	Mixture of inorganic silt and clay.	100 - 120	22 - 12	1.0	2.2	1350	460	32	0.62	$5 \times >10^{-7}$	.....	
CL	Inorganic clays of low to medium plasticity.	95 - 120	24 - 12	1.3	2.5	1600	270	28	0.54	$>10^{-7}$	15 or less	50 - 200
OL	Organic silts and silt-clays, low plasticity.	80 - 100	33 - 21	.....	.....	.....	.....	.....	.....	.....	5 or less	50 - 100
MH	Inorganic clayey silts, elastic silts.	70 - 95	40 - 24	2.0	3.8	1500	420	25	0.47	$5 \times >10^{-7}$	10 or less	50 - 100
CH	Inorganic clays of high plasticity	75 - 105	36 - 19	2.6	3.9	2150	230	19	0.35	$>10^{-7}$	15 or less	50 - 150
OH	Organic clays and silty clays	65 - 100	45 - 21	.....	.....	.....	.....	.....	.....	.....	5 or less	25 - 100

Notes:

1. All properties are for condition of "Standard Proctor" maximum density, except values of k and CBR which are for "modified Proctor" maximum density.
2. Typical stength characteristics are for effective strength envelopes and are obtained from USBR data.
3. Compression values are for vertical loading with complete lateral confinement.
4. (>) indicates that typical property is greater than the value shown.
   (..) indicates insufficient data available for an estimate.

NNEFNC

7.2-39

AH. C

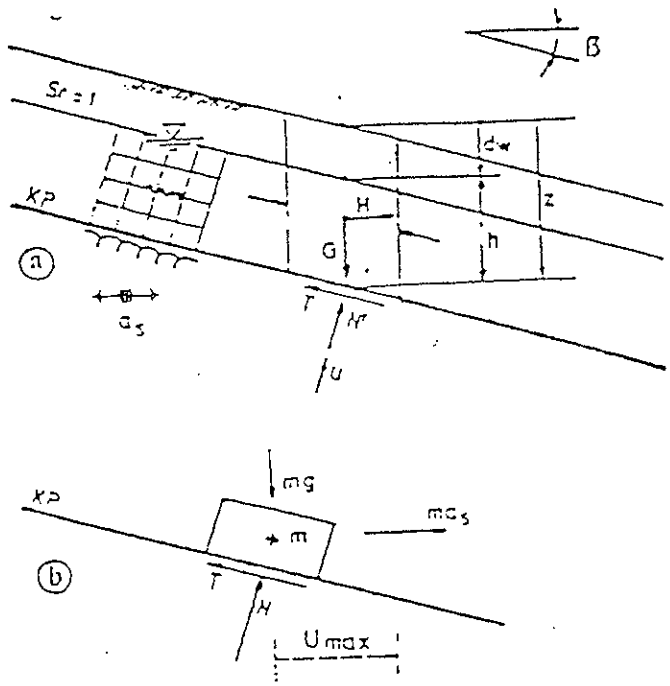
1/1

1/13-OC

KC 7/27/00 GTC

to get estimate of permanent displacement.

KL 4/27/00



- Ground Water Level
- Steady Seepage
- KP - Sliding Surface
- Seismic Exitation
- U_{max} - Permanent Displacement of sliding mass

Fig. 2 Model of an infinite slope

Based on the above assumptions, the principles of limit equilibrium and the notation introduced in Figure 2, the following expression for the factor of safety, F_s, has been derived (Matasovic, 1989):

$$F_s = \frac{c/(\gamma z \cos^2\beta) - \tan\Phi[1 - \gamma_w(z-d_w)/(\gamma z)] - k_s \tan\beta \tan\Phi}{k_s - \tan\beta} \qquad (1)$$

where γ, γ_w, c and Φ are the unit weight of slope material, the unit weight of water, cohesion and the angle of internal friction respectively.

Equation (1) defines the factor of safety for a general case of infinite slope stability. A similar expression, but for stability of cohesionless materials with pore pressure increase due to seismic loading, has been used by Hadj-Hamou and Kavazanjian (1985).

It should be noted that the value of factor of safety calculated by Equation (1) diminishes with depth in cohesive ($c \neq 0$, $\varphi = 0$) materials. Also, since the equation has been set for a case of limit equilibrium when $F_s = 1$, it is assumed that slope will generally resist seismic loading and will be stable if $F_s > 1.0$.

To estimate u_{max}, it is necessary, as a first step, to determine a_c, expressed by the product $k_c g$. The coefficient k_c can be determined iteratively by varying the amount of horizontal force until it reaches the value that gives the $F_s = 1$. However, for the model of infinite slope the coefficient of critical acceleration can be expressed explicitly by inserting $F_s = 1$ in Equation (1) and rearranging the variables:

$$k_c = \frac{c/(\gamma z \cos^2\beta) - \tan\Phi[1 - \gamma_w(z-d_w)/(\gamma z)] - \tan\beta}{1 - \tan\beta \tan\Phi} \qquad (2)$$

For a case without steady state seepage in the slope (if we insert $d_w = z$), Equation (2) becomes the expression for k_c used by Chang et Al. (1984).

REFERENCE: [Matasovic, 1991]

Attachment D

1/1

Calculation Package D
Geotextile Filtration Requirements

GeoSyntec Consultants

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: Parsons **Project:** BRC CAMU **Project/Proposal #:** HL0389 **Task #:** 04

Title of Computations: Geotextile Performance Requirements

Computations By: SIGNATURE — 10 July 2000 DATE

Geoff L. Smith / Staff Engineer
PRINTED NAME AND TITLE

Assumptions and Procedures Checked By (Peer Reviewer): SIGNATURE — 7-13-00 DATE

MICHAEL F. KRUSKI / SR. STAFF ENG.
PRINTED NAME AND TITLE

Computations Checked By: SIGNATURE — 7/14/00 DATE

GREGORY T. GOODMAN
PRINTED NAME AND TITLE

Computations Backchecked By (Originator): SIGNATURE — 7/14/00 DATE

Geoff L. Smith / Staff Engineer
PRINTED NAME AND TITLE

Approved By (PM or Designate): SIGNATURE — 7/17/2000 DATE

Bradford H. Cooley / Project Manager
PRINTED NAME AND TITLE

Approval Notes:

Revisions: (Number and Initial All Revisions)

No.	Sheet	Date	By	Checked By	Approval

Written by: Geoff L. Smith GLS Date: 00 / 07 / 13 (YY MM DD) Reviewed by: MSK 7.13.00 CTC Date: 00 / 07 / 14 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 04

GEOTEXTILE PERFORMANCE REQUIREMENTS
BRC CAMU

OBJECTIVE

It is proposed that the final cover for the BRC Corrective Action Management Unit (CAMU) located in Henderson, Nevada include a drainage geocomposite and a geotextile filter overlying the drainage aggregate. One geotextile bonded to a geonet will be used for the top deck and two geotextiles bonded to a geonet (geocomposite) will be used for the side slopes. The filtration geotextile must retain the overlying protective soil to minimize impairment of the drainage capacity of the underlying geonet or drainage aggregate. This calculation package focuses on the separation/filtration performance of the top geotextile and the required geotextile properties.

SUMMARY OF RESULTS

The calculations suggest that the separation/filtration geotextile must have an AOS less than sieve No. 70 (0.21 mm), a permittivity greater than 0.5 sec^{-1}, a minimum mass per unit area of 6 oz./sy, and sufficient mechanical strength properties as outlined in federal regulations.

SITE CONDITIONS

The final cover system is presented in Attachment F. The final cover system consists of, from top to bottom:

- 2 ft. cover soil;
- geocomposite;
- geomembrane;
- geosynthetic clay liner; and
- subgrade.

The final cover soils will consist of on-site material, which has been classified as silty sand to well-graded sand (SM, SM-SW according to the Unified Soils Classification System) (Converse Consultants, 1999) (Attachment A).

Written by: Geoff L. Smith Date: 00 / 07 / 13 (YY MM DD) Reviewed by: MSK 7-13-00 GTC Date: 00 / 07 / 14 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 04

ANALYSIS

Filtration Requirements: The geotextile will minimize fine particles of the cover soil layer from migrating into the underlying geonet or the underlying drainage aggregate. Migration of fine particles would have the adverse effect of decreasing the transmissivity of the geocomposite or clogging the drainage aggregate.

The filtration requirements for geotextiles can be evaluated using the "Geotextile Filter Design Manual," developed by Luettich et. al. (1991) (Attachment B). Page 2 of Attachment B shows a chart in which soil properties are used to evaluate the retention criteria of the geotextile by determining the maximum allowable apparent opening size (AOS or O_{95}).

The soil cover has been classified as silty or clayey sand and well-graded sand. Both of these classifications suggest that less than fifty percent of the material is fine-grained soils (i.e., smaller than the No. 200 sieve or 0.075 mm, sieve size). To be conservative in the calculations herein, the cover soil is assumed to consist of more than 20 percent clay and to be non-dispersive. Therefore, using Page 2 of Attachment B:

O_{95} < 0.21 mm, which corresponds to sieve No. 70, meaning that the geotextile apparent opening size (AOS) must be less than a No. 70 sieve size.

Permeability: The following equation can be used to evaluate the minimum allowable geotextile permeability:

$$k_g > i_s k_s$$

where: k_g = permeability of geotextile (cm/s)
i_s = hydraulic gradient (dimensionless)
k_s = permeability of the protective soil cover (cm/s)

Hydraulic gradient, i_s: Attachment B, page 3 from Luettich et al. (1991) lists typical hydraulic gradients for various geotextile drainage applications. In this attachment, a hydraulic gradient of 1.5 for landfill cover systems is recommended.

Soil Permeability, k_s: A permeability of 1.2×10^{-3} cm/s was used based on permeability testing of site specific soils (Attachment A).

Therefore,

Written by: Geoff L. Smith GLS Date: 00 / 07 / 13 (YY MM DD) Reviewed by: [illegible] GTC Date: 00 / 07 / 14 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 04

$k_g >$ $i_s k_s = (1.5)(1.2 \times 10^{-3})$
$k_g >$ 1.8×10^{-3} cm/s

Koerner (1994) suggests applying partial factors of safety to the ultimate flow capacity of the geotextile to account for clogging of the geotextile. Using recommendations given in Table 2.13 on p. 160 of Koerner (1994) (Attachment D), the following partial factor of safety values were applied:

soil clogging and blinding	10 (5-10)
intrusion into voids	1.2 (1.0-1.2) (Surface water – minimum)
biological clogging:	2.0 (2.0-4.0) GLS
creep reduction of voids:	1.5 (1.0-1.5)
chemical clogging:	1.2 (1.2-1.5) (Surface water – minimum)

Therefore,

$k_g > (1.8 \times 10^{-3})(10)(1.2)(2.0)(1.5)(1.2)$
$k_g > 0.08$ cm/s

The thickness of a 6 oz/yd^2 (205 g/m^2) geotextile is approximately 65 mils (0.165 cm) (Amoco technical literature, Attachment E, p.1). Dividing the permeability by the thickness of the geotextile results in the following permittivity values:

6 oz/sy = 0.5 sec^{-1}

Mechanical Property Requirements: To ensure proper manufacturing and durability of the geotextile, the geotextile should have appropriate strength requirements. Based on guidelines developed by Task Force 25 (see note below) (Attachment C) for mechanical properties of geotextiles used in applications requiring moderate survivability, the geotextile should have the following properties:

Property	**Criteria**
Grab Strength	≥130 lb
Puncture Protection	≥40 lb
Mullen Burst	≥210 psi
Trapezoidal Tear	≥40 lb
Ultraviolet strength retention	≥70% (typical value for geotextiles)

Written by: Geoff L. Smith Date: 00 / 07 / 13 (YY MM DD) Reviewed by: 7-13-00 GTC Date: 00 / 07 / 14 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 04

Note: Task Force 25 consisted of the American Association of State and Transporation Officials (AASHTO), the American Building Contractors (ABC), and the American Road Builders and Transportation Association (ARBTA).

CONCLUSIONS

In accordance with the above analyses, the top geotextile component of the drainage composite and the filtration geotextile overlying the drainage aggregate shall have the following properties:

Property	Separation/Filtration Criteria
matrix	nonwoven
mass per unit area	6 oz/sy (205 g/m^2)
apparent opening	≤0.21 mm (sieve No. 70)
permittivity	≥0.5 sec^{-1}
grab strength	≥130 lb
puncture strength	≥40 lb
Mullen burst	≥210 psi
trapezoidal tear	≥40 lb
ultraviolet strength reduction	≥70%

The following is a partial list of geotextile products that should meet the material requirements:

Amoco Fabrics & Fibers Co., Amoco 4506
Trevira 011/120
Synthetic Industries, Geotex 701

Written by: Geoff L. Smith Date: 00 / 07 / 13 (YY MM DD) Reviewed by: 7.13.00 GTC Date: 00 / 07 / 19 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 04

REFERENCES

Amoco Fabrics and Fibers Company, Atlanta, Georgia 404-984-4444 *(Attachment E)*

Converse Consultants (1999), "Preliminary Geotechnical and Geologic Investigation, Industrial Non-Hazardous Disposal Facility, Basic Management Incorporated, Clark County, Nevada," October 27, 1999, Las Vegas, Nevada. *(Attachment A)*

Koerner, R. M. (1994), "Designing with Geosynthetics," Prentice Hall, New Jersey, 1994 *(Attachment C, D)*

Luettich, S.M., Giroud, J.P., and Bachus, R.C. (1991), "Geotextile Filter Design Manual," report prepared for Nicolon Corporation, Norcross, GA *(Attachment B)*

Exploration Location	Depth (feet)	Soil Description	Percent Sodium	Percent Sulfate	Total Available Water Soluble sodium Sulfate (%)
B-5	10-15	Silty sand with gravel	0.07	0.13	0.20
B-8	19-20	Silty sand with gravel	0.07	0.06	0.08
B-101	5-10	Silty sand with gravel	0.17	0.06	0.08
B-102	0-5	Fill – Silty sand with gravel	0.17	0.03	0.05
B-106	0-5	Silty sand with gravel	0.15	0.08	0.12
B-106	29-30	Silty sand with gravel	0.15	0.06	0.08

Permeability

Falling head permeability tests were conducted on remolded samples in general accordance with modified ASTM procedure D2434. The soil was compacted in a mold 4.6 inches long and 4.0 inches in diameter to 85 or 90 percent of maximum dry density and at optimum moisture content. A falling head was applied to the sample and the flow of water through the sample was monitored. The permeability was calculated after the flow rate had stabilized. The result of the falling head permeability test is presented in the following table:

Exploration Location	Sample Depth (Feet)	Soil Description	k (cm/s)
B-5	20-25	Silty sand with gravel	5.3×10^{-4}
B-12	10-15	Silty sand with gravel	4.0×10^{-4}
B-102	20-25	Silty sand with gravel	1.0×10^{-4}
B-105	20-25	Well graded sand with silt and gravel	1.2×10^{-3}

Flexible wall permeameter tests were performed on selected samples by AP Engineering and Testing, Inc according to ASTM D5084. With the exception of one sample (B-105), all tested samples were undisturbed ring samples. The samples were placed in a triaxial machine with a constant confining pressure at the approximate in-place effective stress pressures. Results were generally consistent with the fal-

Laverse (1999)

Attachment A

4.2 Define the Hydraulic Gradient for the Application (i_s)

The hydraulic gradient will vary depending on the application of the filter. Anticipated hydraulic gradients for various applications may be estimated using Figure 3.

4.3 Determine the Minimum Allowable Geotextile Permeability (k_g)

After determining the soil hydraulic conductivity and the hydraulic gradient, the following equation can be used to determine the minimum allowable geotextile permeability [Giroud, 1988]:

$$k_g > i_s k_s$$

The hydraulic conductivity (permeability) of the geotextile can be calculated from the permittivity test method ASTM D 4491; this value can often be obtained from the manufacturer's literature as well. The geotextile permeability is defined as the product of the permittivity, ψ, and the geotextile thickness, t_g:

$$k_g > \varphi t_g$$

STEP 5. DETERMINE ANTI-CLOGGING REQUIREMENTS

To minimize the risk of clogging, the following criteria should be met:

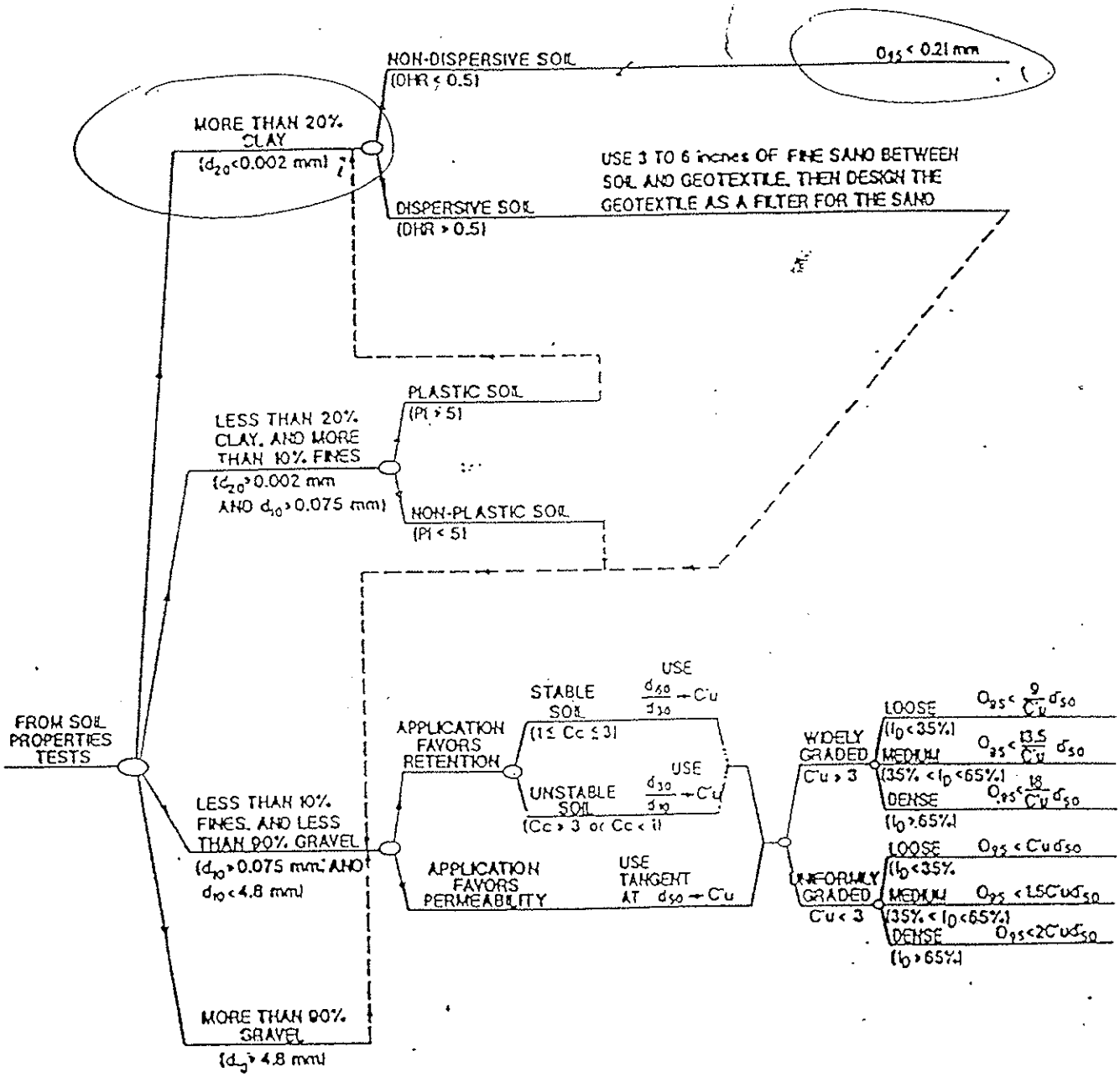
- Use the largest opening size (O_{95}) that satisfies the retention criteria.
- For nonwoven geotextiles, use the largest porosity available, but not less than 30 percent.
- For woven geotextiles, use the largest percent open area available, but not less than 4 percent.

Source: Luettich, S.M. Giroud, J.P. and Bachus R.C (1991) "Geotextile Filter Design Manual" Report prepared for Nicolon Corporation Norcross, GA

ATTACHMENT

P 2/3

CHART 1
SOIL RETENTION CRITERIA
FOR STEADY-STATE FLOW CONDITIONS



NOTES:

d_x is the particle size of which x percent is smaller

$Cu = \sqrt{\frac{d_{100}}{d_0}}$ where: d_{100} and d_0 are the extremities of a straight line drawn through the particle-size distribution, as directed above; and d_{50} is the midpoint of this line.

$Cc = \frac{(d_{30})^2}{d_{60} \times d_{10}}$

I_D is the relative density of the soil

PI is the plasticity index of the soil

DHR is the double-hydrometer ratio of the soil

Portions of this flow chart modified from Giroud (1980)

Source: Luettich, S.M., Giroud, J.P., and Bachus, R.C. (1991) "Geotextile Filter Design

FIGURE 3

TYPICAL HYDRAULIC GRADIENTS[a]

DRAINAGE APPLICATION	TYPICAL HYDRAULIC GRADIENT
STANDARD DEWATERING TRENCH	1.0
VERTICAL WALL DRAIN	1.5
PAVEMENT EDGE DRAIN	1[b]
LANDFILL LCDRS	1.5
~~LANDFILL LCRS~~	1.5
LANDFILL SWCRS	1.5
DAMS	10[b]
INLAND CHANNEL PROTECTION	1[b]
SHORELINE PROTECTION	10[b]
LIQUID IMPOUNDMENTS	10[b]

NOTES: (a) Table developed after Giroud, 1988.

(b) Critical applications may require designing with higher gradients than those given.

Luettich et al. (1991) Attachment B

p. 3/3

Specification for *Survivability*

TABLE C-4 MINIMUM FABRIC PROPERTIES RECOMMENDED FOR FABRIC SURVIVABILITY[a]

Required degree of fabric survivability	Grab strength (lbs.)	Puncture strength[b] (lbs.)	Burst strength[c] (lb./in.^{2})	Trap tear[d] (lbs.)
Low	90	30	145	30
* Moderate	130	40	210	40
High	180	75	290	50
Very high	270	110	430	75

(a) All values represent minimum values (i.e., any roll in a lot should meet or exceed the minimum values in this table).

(b) ASTM D751-68, tension testing machine with ring clamp, steel ball replaced with a 5/16-in.-diameter solid steel cylinder with hemispherical tip centered within the ring clamp.

(c) ASTM D751-68, diaphragm test method.

(d) ASTM D1117, either principal direction.

Korbaek 2nd Edition (1974)

Attachment C 1/1

TABLE C-5 REQUIRED DEGREE OF SI ... ITY AS A FUNC
CONDITIONS AND CONSTRUCTION EQ... ...T[a]

Subgrade conditions	Construction equi: Low ground-pressure equipment (≤4 lb./in.^{2})	N (
Subgrade has been cleared of all obstacles except grass, weeds, leaves, and fine wood debris. Surface is smooth and level such that any shallow depressions and humps do not exceed 6 in. in depth and height. All larger depressions are filled. Alternatively, a smooth working table may be placed.	Low	
Subgrade has been cleared of obstacles larger than small to moderate-sized tree limbs and rocks. Tree trunks and stumps should be removed or covered with a partial working table. Depressions and humps should not exceed 18 in. in depth and height. Larger depressions should be filled.	Moderate	
Minimal site preparation is required. Trees may be felled, delimbed, and left in place. Stumps should be cut to project not more than 6 in. ± above subgrade. Fabric may be draped directly over tree trunks, stumps, large depressions and humps, holes, steam channels, and large boulders. Items should be removed only if placing the fabric and cover material over them will distort the finished road surface.	High	

(a) Recommendations are for 6-12 in. initial lift thickness. For other initial
12–18 in: reduce survivability requirement one level
18–24 in.: reduce survivability requirement two levels
>24 in.: reduce survivability requirement three levels
Survivability levels are, in increasing order: low, moderate, high, and
For special construction techniques such as prerutting, increase fabric s
Placement of excessive initial cover material thickness may cause beari

Source: After Christopher, B., and Holtz, R. D., Federal Highway Admi
Training Manual, Washington, DC.

Table 2.13 Recommended partial factors of safety values for use in Equation 2.25

Application	Various Partial Factors of Safety				
	Soil Clogging and Blinding	*Creep Reduction of Voids*	*Intrusion into Voids*	*Chemical Clogging*	*Biological Clogging*
Retaining wall filters	2.0 to 4.0	1.5 to 2.0	1.0 to 1.2	1.0 to 1.2	1.0 to 1.3
Underdrain filters	5.0 to 10	1.0 to 1.5	1.0 to 1.2	1.2 to 1.5	2.0 to 4.0
Erosion control filters	2.0 to 10	1.0 to 1.5	1.0 to 1.2	1.0 to 1.2	2.0 to 4.0
Landfill filters	5.0 to 10	1.5 to 2.0	1.0 to 1.2	1.2 to 1.5	2.0 to 50
Gravity drainage	2.0 to 4.0	2.0 to 3.0	1.0 to 1.2	1.2 to 1.5	1.2 to 1.5
Pressure drainage	2.0 to 3.0	2.0 to 3.0	1.0 to 1.2	1.1 to 1.3	1.1 to 1.3

do not serve this function, the other, sometimes primary, function will not be served properly. This should not give the impression that geotextiles as separators always play a secondary role. Many situations call for separation only, and in such cases the geotextiles do serve a significant and worthwhile function.

2.5.1 Overview of Applications

Perhaps the target application that can best illustrate the use of geotextiles as separators is their placement between an underlying reasonably firm soil subgrade and a stone base course, aggregate, or ballast placed above the geotextile. We say "reasonably firm" because it is assumed that the subgrade deformation is not sufficiently large to mobilize uniformly high tensile stress in the geotextile. (The application of geotextiles in unpaved roads on soft soils wherein membrane-type reinforcement is developed is treated later in Section 2.6.) Thus for such a separation function to occur, the geotextile must be placed on the soil subgrade and then have stone placed, spread, and compacted on top of it. A number of scenarios can be developed showing what geotextile properties are required for a given situation.

2.5.2 Burst Resistance

Consider a geotextile on a soil subgrade with stone of average particle diameter (d_a) placed above it. If the stone is uniformly sized, there will be voids within it that will be available for the geotextile to enter into. This entry is caused by the simultaneous action of the traffic loads being transmitted to the stone, through the geotextile, and into the underlying soil. The stressed soil then tries to push the geotextile up into the voids within the stone. The situation is shown schematically in Figure 2.26. Giroud [59] provides a formulation for the required geotextile strength which can be adopted for this application.

$$T_{reqd} = \frac{1}{2} p' d_a [f(\epsilon)] \tag{2.26}$$

where T_{reqd} = the required geotextile strength,
p' = the stress at the geotextile's surface, which is less than, or equal to,

Koerner (1994) Attachment D 1/1

MCK 7-13-C

AMOCO WASTE RELATED GEOTEXTILES

MINIMUM PHYSICAL PROPERTIES
(Minimum Average Roll Values)

Property	Test Method	Units	4504	4506	4508	4510	4512	4516
Unit Weight	ASTM D-3776	Oz./yd.²	4.0	6.0	8.0	10.0	12.0	16.0
Grab Tensile	ASTM D-4632	lbs.	95	150	200	235	275	350
Grab Elongation	ASTM D-4632	%	50	50	50	50	50	50
Mullen Burst	ASTM D-3786	psi	225	350	450	550	650	750
Puncture	ASTM D-4833	lbs.	55	90	130	165	185	220
Trapezoid Tear	ASTM D-4533	lbs.	35	65	80	95	115	130
Apparent Opening Size	ASTM D-4751	US Sieve Number	70	70	100	100	100	100
Permittivity	ASTM D-4491	gal/min/ft² sec⁻¹	100 2.0	90 1.7	80 1.5	70 1.1	60 0.9	50 0.7
Permeability	ASTM D-4491	cm/sec	.2	.2	.2	.2	.2	.2
Thickness	ASTM D-1777	mils	40	65	90	110	130	175
U.V. Resistance	ASTM D-4355[1]	%[2]	70	70	70	70	70	70

1. Fabric conditioned per ASTM D-4355 2. Percent of minimum grab tensile after conditioning.

TYPICAL PHYSICAL PROPERTIES

Property	Test Method	Units	4504	4506	4508	4510	4512	4516
Grab Tensile	ASTM D-4632	lbs.	130/115	225/200	275/270	315/310	410/370	510/470
Grab Elongation	ASTM D-4632	%	75	65	65	65	65	65
Mullen Burst	ASTM D-3786	psi	285	410	575	650	825	920
Puncture	ASTM D-4833	lbs.	75	120	170	190	210	270
Trapezoid Tear	ASTM D-4533	lbs.	60/50	100/80	140/120	160/140	185/155	220/190
Apparent Opening Size	ASTM D-4751	US Sieve Number	70/120	70/140	100/200	100+	100+	100+
Permittivity	ASTM D-4491	gal/min/ft² sec⁻¹	150 3.1	110 2.0	100 1.8	80 1.5	70 1.3	60 1.0
Permeability	ASTM D-4491	cm/sec	.35	.31	.27	.26	.25	.23
Thickness	ASTM D-1777	mils	50	75	115	130	150	195

PACKAGING

Dimensions		4504	4506	4508	4510	4512	4516
Roll Width	ft.	15	15	15	15	15	15
Roll Length	ft.	1200	900	600	600	450	300

Amoco Technical Literature — Appendix E Y.
404 984-4441

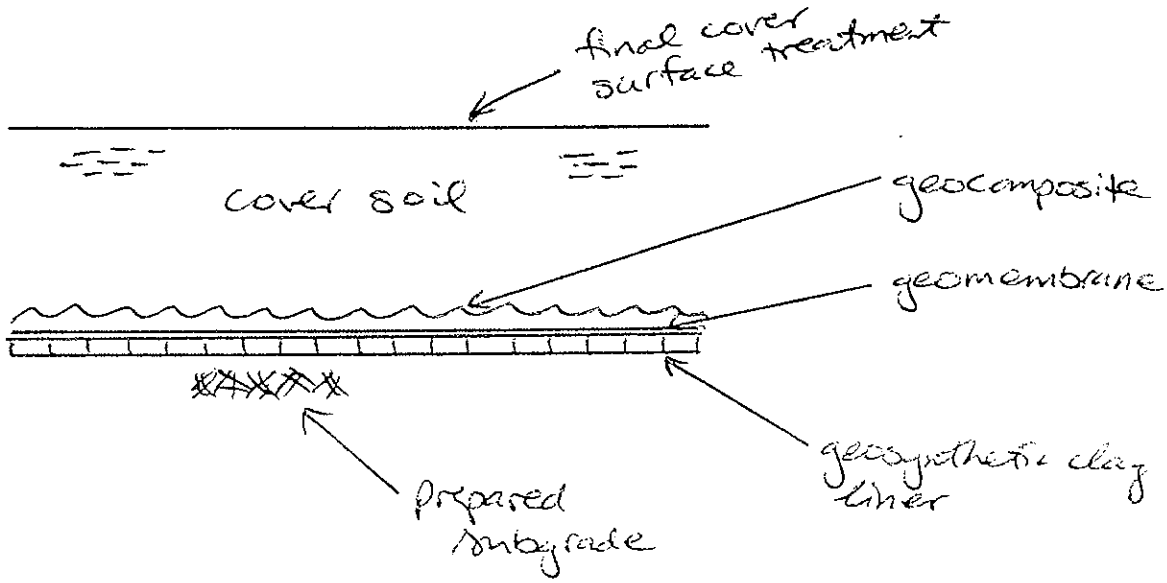
GTC

accuracy or reliability of said information or the performance of any product. Any specifications, properties ... provided as information only and in no way modify, amend, enlarge or create any warranty. Nothing contained herein is to be construed as permission or as a recommendation to infringe any patent.

Written by: GLS Date: 00/07/07 Reviewed by: MK 7-13-00 GTC Date: 00/07/14
YY MM DD YY MM DD

Client: Project: Project/Proposal No.: Task No.:

Final Cover Configuration



SECTION
FINAL COVER

Attachment F
1/1

Calculation Package E
Geotextile Puncture Protection

GeoSyntec Consultants

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: Parsons **Project:** BRC CAMU **Project/Proposal #:** HL0389 **Task #:** 04

Title of Computations: Geotextile Cushion Calculations

Computations By:
SIGNATURE — DATE: 6 July 2000
Geoff L. Smith / Staff Engineer
PRINTED NAME AND TITLE

Assumptions and Procedures Checked By (Peer Reviewer):
SIGNATURE — DATE: 7/11/00
GREGORY T CORCORAN / PROJECT ENG
PRINTED NAME AND TITLE

Computations Checked By:
SIGNATURE — DATE: 7/11/00
GREGORY T CORCORAN / PROJECT ENG
PRINTED NAME AND TITLE

Computations Backchecked By (Originator):
SIGNATURE — DATE: 14 July 2000
Geoff L. Smith / Staff Engineer
PRINTED NAME AND TITLE

Approved By (PM or Designate):
SIGNATURE — DATE: 7/17/2000
Bradford H. Cooley / Project Manager
PRINTED NAME AND TITLE

Approval Notes:

Revisions: (Number and Initial All Revisions)

No.	Sheet	Date	By	Checked By	Approval

Written by: Geoff L. Smith Date: 00 / 07 / 10 (YY MM DD) Reviewed by: Date: 00 / 07 / 11 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 4

GEOTEXTILE PUNCTURE PROTECTION OF GEOMEMBRANE COVER LINER SYSTEM FOR BRC CAMU HENDERSON, NEVADA

OBJECTIVE

A composite final cover liner system is proposed for the Corrective Action Maintenance Unit (CAMU) located in Henderson, Nevada. The objective of this calculation is to evaluate the maximum particle size of soil materials adjacent to the geomembrane that will not puncture the geomembrane. Specifically, the evaluation will consider the gravel component of the local soils (silty sand with gravel, Converse 1999) overlying the cushion geotextile and geomembrane components of the cover liner system and the waste soil underlying the geomembrane and GCL components of the cover liner system.

SUMMARY OF ANALYSIS

The analysis suggests that the following maximum particle sizes and geotextile mass per unit areas will be required:

Soil Component of Liner	Maximum Particle Size	Minimum Mass Per Unit Area
Subgrade	1.5 in	9 oz/yd^2 (GCL)
Silty Sand with Gravel	1.5 in	12 oz./yd^2 (double-sided geocomposite)
Silty Sand with Gravel	1 in	6 oz/yd^2 (single-sided geocomposite)

SITE CONDITIONS

The composite liner system will be comprised of the following components, from top to bottom (Attachment A):

- 2 ft of native soil;
- double-sided geocomposite on side slopes (geonet sandwiched between two 6 oz/yd^2 geotextiles (combined thickness of 12 oz/sy)) OR single-sided geocomposite on top deck (one 6 oz/yd^2 geotextile attached to top of geonet);

- 60-mil (1.5 mm) high-density polyethylene (HDPE) geomembrane;
- a geosynthetic clay liner (GCL) with a combined geotextile mass per unit area of 9 oz/sy; and
- prepared subgrade.

The maximum height of soil to be placed overlying the final cover system is assumed to be 10 ft overlying the geomembrane. This assumes future end-use fill of the area (e.g., golf course fill).

OVERLYING PRESSURE

The unit weight of the cover soil was selected to be 136 pcf based on modified proctor tests conducted on soil samples from the site that are similar to the waste material to be placed as cover soil (Attachment B). The maximum dry density was determined to be 132 pcf at an optimum moisture content of 8.2%. Assuming that the material will be placed at a density less than 95% degree of compaction, the resulting dry density is 125.4 pcf. Adding the weight of the moisture in the soil results in a wet density of approximately 136 pcf.

The following loading conditions was evaluated:

Haul Truck (H-20) Loading

The live load applied by the haul truck was estimated to be 8.7 psi as shown in Attachment D. The dead load consists of the 1.5 ft of cover soil overburden. Therefore the dead load is 1.4 psi (1.5 ft * 136 pcf / 144 psi/psf). The combined load from haul truck (H-20) loading is:

$P = P_{live} + P_{dead} = 8.7 + 1.4 = 10.1$ psi.

Therefore, the vertical pressure on the top of pipe due to H-20 loading is 10.1 psi.

ANALYSIS

APPROACH – Protected Geomembrane

Wilson-Fahmy, Narejo, and Koerner have evaluated puncture protection of geomembranes in a series of three papers. These papers are:

Written by: Geoff L. Smith Date: 00 / 07 / 10 (YY MM DD) Reviewed by: GTC Date: 00 / 07 / 11 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 4

1) Wilson-Fahmy, R.F., Narejo, D., and Koerner, R.M (1996) "Puncture Protection of Geomembranes Part I: Theory", Geosynthetics International, Vol. 3, No. 5, pp. 605-628

2) Narejo, D., Koerner, RM. and Wilson-Fahmy, R.F. (1996) "Puncture Protection of Geomembranes Part II: Experimental", Geosynthetics International, Vol. 3, No. 5, pp. 629-653

3) Koerner, R.M., Wilson-Fahmy, R.F. and Narejo, D. (1996) "Puncture Protection of Geomembranes Part III: Examples", Geosynthetics International, Vol. 3, No. 5, pp. 655-675

These papers present an evaluation of geomembrane puncture theory, the results of a laboratory experimental program, and design examples in regards to puncture protection of geomembranes. The design methods and conclusions of these papers were used for the analysis herein.

According to these papers, the important parameters that affect the puncture protection of geomembranes are: overlying pressure, mass per unit area of the geotextile, and the particle size and shape of the material overlying the geotextile. For the analysis herein, the overlying pressure and the mass per unit area of the geotextile are given, and the maximum particle size is evaluated.

MASS PER UNIT AREA OF GEOTEXTILE

The combined geotextile density overlying the geomembrane will be a minimum of 12 oz/yd^2 (405 g/m^2) on the sides slopes (double-sided geocomposite) and a minimum of 6 oz/yd^2 on the top deck (single-sided geocomposite). The combined geotextile density for the GCL is 9 oz/sy (305 g/m^2).

SIZING MAXIMUM PARTICLE OF SOIL

Narejo et al (1996, Attachment C) present the following equation for evaluating geotextile puncture protection of a 60 mil (1.5 mm) HDPE geomembrane:

$$H^2 = 450\ M_A / P_{allow} \qquad \text{(Attachment C)}$$

Written by: Geoff L. Smith GLS Date: 00 / 07 / 10 (YY MM DD) Reviewed by: GTC Date: 00 / 07 / 11 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 4

where:

M_A = mass per unit area geotextile (g/m^2)
= 405 (12 oz./yd^2 for double sided composite), 305 (9 oz/yd^2 for GCL), and 205 (6 oz./yd^2 single-sided geocomposite);

H = cone height (mm), which corresponds to predicted effective protrusion height, which equals one half maximum stone size (Attachment C).

P_{allow} = maximum allowable pressure = 10.1 psi (

where: P_{allow} = P'_{allow} (MF_S x MF_{PD} x MF_A)(FS_{CR} x FS_{CBD}) (Attachment C)

where: MF_S, MF_{PD}, MF_A = modification factors (discussed below)
FS_{CR}, FS_{CBD} = partial factor of safety values (discussed below)

P'_{allow} = allowable pressure based on field conditions
= (FS) ($P_{actual\ field\ pressure}$)

where: FS = global factor of safety, 3.0
$P_{actual\ field\ pressure}$ = 70 kPa
P'_{allow} = (70)(3) = 210 kPa

MF_S = shape factor:
1.0 (assume angular particles)

MF_{PD} packing density:
1.0 (assume isolated protrusions)

MF_A soil arching:
0.75 (assume moderate)

FS_{CR} partial factor of safety for creep
1.5 (see Table 12)

FS_{CBD} partial factor of safety for chemical and biological degradation
1.5 (based on average value) (Attachment C)

Solving for P_{allow} provides:

Written by: Geoff L. Smith Date: 00 / 07 / 10 (YY MM DD) Reviewed by: GTC Date: 00 / 07 / 11 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 4

P_{allow} = (210) (1.0 x 1.0 x 0.75)(1.5 x 1.5)
P_{allow} = 354 kPa

RESULTS

Solving for H, the predicted effective protrusion height, provides:

$H^2 = 450\ M_A / P_{allow}$

For the three geotextile weights, the following results are:

$H_{cushion} = ((450)(M_A)/(354))^{1/2}$
$M_A = 405\ g/m^2\ (12\ oz/yd^2)$ = 22.7 mm = 0.89 inches

$H_{cushion} = ((450)(M_A)/(354))^{1/2}$
$M_A = 305\ g/m^2\ (9\ oz/yd^2)$ = 19.7 mm = 0.78 inches

$H_{cushion} = ((450)(M_A)/(354))^{1/2}$
$M_A = 205\ g/m^2\ (6\ oz/yd^2)$ = 16.1 mm = 0.64 inches

The predicted effective protrusion height equals one half the maximum stone size. Therefore, the maximum stone size is twice the values listed above.

$M_A = 405\ g/m^2$ = 0.89 inches x 2 = 1.78 inches
$M_A = 305\ g/m^2$ = 0.78 inches x 2 = 1.56 inches
$M_A = 205\ g/m^2$ = 0.64 inches x 2 = 1.28 inches

CONCLUSIONS

Assuming the following:

- the particle shape is angular for the gravel component of the cover soils, and
- the approach presented by Wilson-Fahmy, Narejo, and Koerner for evaluating puncture protection of geomembranes is appropriate for the analysis herein.

then, the calculations suggest that THE MAXIMUM PARTICLE SIZE IS 1.5 IN. for a 12 oz/sy geotextile (combined weight of the double-sided geocomposite) and the 9 oz/sy geotextile

(combined weight for the GCL) and 1 inch for the 6 oz/sy geotextile (single-sided geocomposite).

REFERENCES

Advanced Drainage Systems (ADS) (1994), "ADS Specification Manual", PH: 615-457-3051
Attachment D

Converse Consultants, Inc (1999), *Preliminary Geotechnical and Geologic Investigation, Industrial Non-Hazardous Disposal Facility*, October 1999.
Attachment B

Attachment C:

Koerner, R.M., Wilson-Fahmy, R.F. and Narejo, D. (1996) "Puncture Protection of Geomembranes Part III: Examples", Geosynthetics International, Vol. 3, No. 5, pp. 655-675.

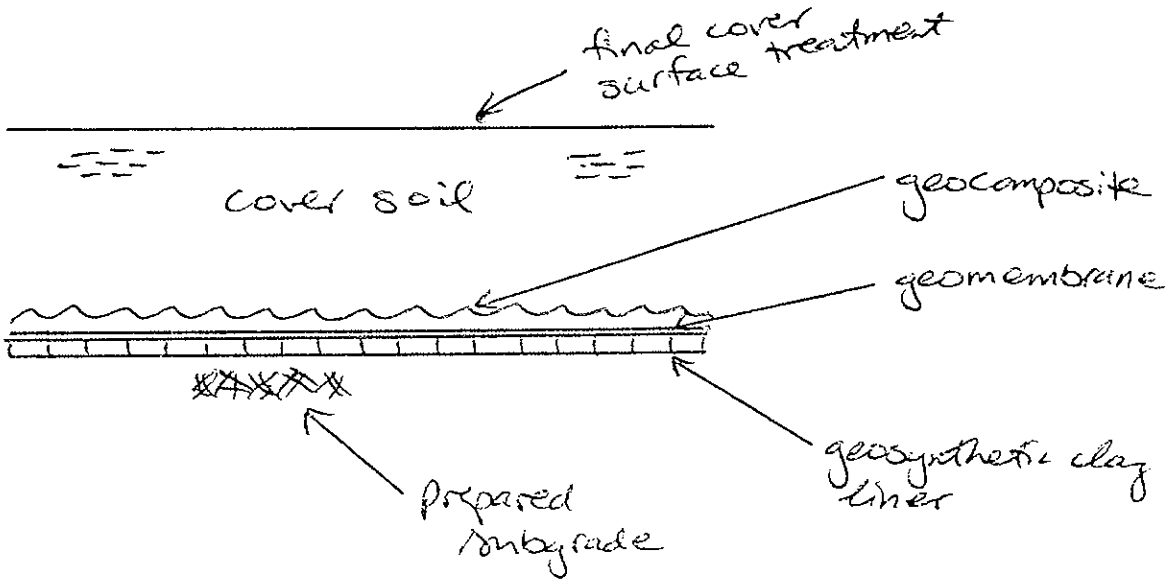
Narejo, D., Koerner, R.M. and Wilson-Fahmy, R.F. (1996) "Puncture Protection of Geomembranes Part II: Experimental", Geosynthetics International, Vol. 3, No. 5, pp. 629-653.

Wilson-Fahmy, R.F., Narejo, D., and Koerner, R.M. (1996) "Puncture Protection of Geomembranes Part I, Theory", Geosynthetics International, Vol. 3, No. 5, pp. 605-628.

Written by: GLS Date: 00/07/07 Reviewed by: GK Date: 00/07/11

Client: ____ Project: ____ Project/Proposal No.: ____ Task No.: ____

Final Cover Configuration



SECTION
FINAL COVER

Attachment A

1/1

shown on Drawing Nos. A-49 through A-56, entitled *Consolidation Test* and are summarized on the following table:

Exploration Location	Depth (feet)	Soil Description	Dry Unit Weight, pcf	Moisture Content, %	Hydrocollapse (percent)*
B-1	29-30	Silty sand with gravel	105	6	3.2
B-8	39-40	Sandy lean clay	57.4	64	0.4
B-8	49-50	Sandy lean clay	69.5	51.1	-0.6
B-10	54-54.5	Sandy lean clay	60.7	67.7	-0.6
B-101	39-40	Sandy lean clay	65.8	45	-0.2
B-101	59-60	Sandy lean clay	73.2	38.3	-0.6
B-102	49-50	Sandy lean clay	67.3	48.7	-0.5
B-105	34-35	Well graded sand with silt and gravel	101	5	0.1

NA: Not available

* A negative sign indicates swell occurred upon inundation with water instead of collapse.

Laboratory Maximum Density

Laboratory maximum density tests were performed on selected samples of the granular soils. The purpose of the test was to define the compaction characteristics of these soils, and to aid in estimating soil shrinkage. The laboratory maximum density test was performed in general accordance with the ASTM D1557 test method. This test procedure uses 25 blow of a 10-pound hammer falling a height of 18 inches on each of five layers of soil in a 1/30 or 1/13 cubic foot cylinder. The test results are presented on Drawing Nos. A-57 through A-61 and in the following table:

Exploration Location	Depth (Feet)	Soil Description	Maximum Dry Unit Weight (pcf)	Optimum Moisture Content (percent) of dry weight)
B-1	20-25	Silty sand with gravel	129.4	8.2
B-5	20-25	Silty sand with gravel	132.1	8.2
B-12	10-15	Silty sand with gravel	129.7	7.9
B-101	5-10	Silty sand with gravel	130.6	8.7
B-105	20-25	Well graded sand with silt and gravel	131.8	7.5

Attachment B

Failure pressure† (kPa)	Applied pressure (% of failure pressure)	Applied pressure (kPa)	Failure time (hours)
140	75	100	130
	50	70	170
	25	35	260
1750*	75	1300	10,000**
3400*	40	1300	10,000**
69	75	52	24
	50	34	42
	25	17	68
320	75	240	140
	50	160	110
	25	80	310
450	85	380	240
	70	310	390
	60	270	1000**
610	75	460	10,000**
55	75	41	0.5
	50	28	2.5
	25	14	40
83	75	62	3
	50	41	12
	25	21	200
103	75	77	192
	50	52	1000**
365	75	270	10,000**

s using Equation 3. **Geomembrane showed signs of yield. † From short term ted cone puncture tests.

RMULATION

on is presented in this section based on the experimental puncture previous sections. The resulting equations predict the allowable DPE geomembranes both with and without geotextile protection.

odification factors are then applied to correlate the truncated cone da actual conditions. The modification factors consider the stone shape, arran t and soil arching. All of these modification factors have a magnitude of 1.0 or le ince the experiments were conducted on a worst-case basis. Partial factors of safety are then incorporated into the design equations to account for creep and chemical/biological degradation. These partial factors of safety are equal to 1.0 or greater since longer periods of time are typically required for these factors to have an effect. Finally, a global factor of safety is applied to account for uncertainties in the formulation. The above described empirical formulation is presented in a step-by-step manner in order to emphasize the various factors involved.

6.2 Basic Design Equation

The formulation for predicting geomembrane failure pressure, p, is based on Figure 3 where it is seen that for each cone height, the failure pressure varies linearly with respect to the mass per unit area of the geotextile. Note that this failure pressure from the experiments is assumed to be the maximum allowable design pressure with an implied global factor of safety of 1.0. Thus, the maximum allowable pressure can be expressed as follows:

$$p_{allow} = d \times M_A \tag{1}$$

where: p_{allow} = maximum allowable pressure (with an implied factor of safety of 1.0); M_A = mass per unit area of the protection geotextile (g/m^2); and d = constant. From Figure 3, it is found that the parameter d can be related to the cone height, H, according to the following equation:

$$d = \frac{450}{H^2} \tag{2}$$

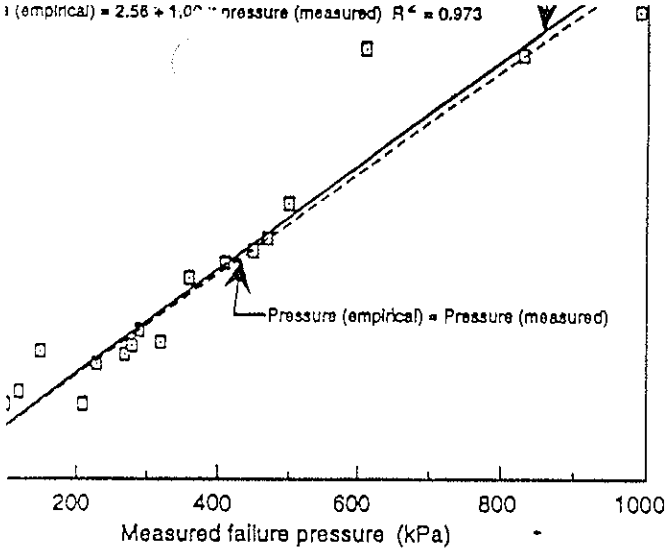
where H is in millimeters.

Combining Equations 1 and 2, the failure pressure can be determined in terms of the cone height and mass per unit area of the protection geotextile as follows (a minimum pressure of 50 kPa is imposed which conservatively corresponds to the failure pressure of the 1.5 mm thick HDPE geomembrane without any protection material):

$$p_{allow} = 450\frac{M_A}{H^2} \geq 50 \text{ kPa} \tag{3}$$

The accuracy of the above equation is depicted in Figure 6 which shows the relationship between the measured failure pressure and the failure pressure predicted using Equation 3. The data in Figure 6 are for polyester geotextiles made from continuous filaments, and polypropylene geotextiles made of staple fibers. Hence, Equation 3 applies to essentially all of the polymer and fiber types used in the nonwoven needle-punched geotextiles.

Attachment C 1/3



d versus empirically predicted failure pressures using Equation 3 for all nched geotextiles evaluated with a 1.5 mm thick HDPE geomembrane. on coefficient.

n Factors

ication factors is now sequentially applied to Equation 3 in order re representing field conditions. The modified pressure will be re-

Factor for the Protrusion Shape

shown that the failure pressure depends on the protrusion shape. e the highest failure pressure followed by subrounded stones. The ire is associated with angular stones and is approximately equal to of truncated cones. In order to account for the effect of stone shape, r is introduced into Equation 3 as follows:

$$p'_{allow} = p_{allow}\left(\frac{1}{MF_S}\right) \tag{4}$$

odification factor for the protrusion shape. Hereafter, p'_{allow} refers odified value of p_{allow} as is illustrated in Figure 6.
sis of the data presented in Section 5.2.1, the modification factors apes are presented in Table 9.

Stone shape	Modification factor, MF_S
Angular	1.00
Subrounded	0.50
Rounded	0.25

6.3.2 *Modification Factor for Packing Density*

It is shown in Section 5.2.2 that the allowable pressure for packed stones is much higher than for isolated stones. Unfortunately, within the capacity of the experimental device, no failure could be achieved with the packed stones, and hence, no direct correlation with isolated stones could be made. However, using the theoretical analysis presented in Part I of this series of papers (Wilson-Fahmy et al. 1996), the pressure at yield for packed stones ($R_o/H = 2$) could be compared with the pressure at yield for isolated stones ($R_o/H = 4$) where R_o is the horizontal distance from a undeformed geomembrane point of tangency with the protrusion tip to the undeformed geomembrane point of tangency with the soil subgrade. The analysis was performed for geomembranes with and without protection. Based on the results, a modification factor of 0.5 is suggested which provides a conservative estimate of the effect of packing density. Thus, Equation 4 can be rewritten after introducing a modification factor for packing density as follows:

$$p'_{allow} = p_{allow}\left(\frac{1}{MF_S \times MF_{PD}}\right) \tag{5}$$

where MF_{PD} is the modification factor for packing density. The modification values presented in Table 10 can be used for isolated protrusions and packed stone arrangements.

6.3.3 *Modification Factor for Soil Arching*

Equation 5 can be further modified as follows to include the effect of soil arching:

$$p'_{allow} = p_{allow}\left(\frac{1}{MF_S \times MF_{PD} \times MF_A}\right) \tag{6}$$

where MF_A is the modification factor for soil arching.

Table 10. Modification factors for packing density.

Protrusion arrangement	Modification factor, MF_{PD}
Isolated protrusions	1.00
Packed stones	0.50

Attachment C
2/3

'actor of 0.17. It be noted, however, that the effect of soil arching at yield may n s great as the effect on the failure pressure. The the geomembra up to yield may not be large enough to mobilize the ct; therefore, caution must be exercised when using the data in Table is recommended that the values in Table 11 be used when soil arching

'actors of Safety

ing the various modification factors (all of which are 1.0 or less), sever- of safety should be applied in order to determine the allowable pressure rane. The partial factors of safety are equal to 1.0 or greater. Two fac- ed below, a partial factor of safety for long term creep and a partial fac- ccount for long term chemical/biological degradation of the materials

'actor of Safety for Creep

r of safety for creep is incorporated into Equation 6, and the allowable calculated as follows:

$$p'_{allow} = p_{allow}\left(\frac{1}{MF_S \times MF_{PD} \times MF_A}\right)\left(\frac{1}{FS_{CR}}\right) \tag{7}$$

e partial factor of safety for creep. Based on the creep data presented ecommended partial factors of safety for creep are given in Table 12.

fication factors for soil arching.

il arching effect	Modification factor, MF_A
None	1.00
Moderate	0.75
Maximum	0.50

al factors of safety for creep.

Partial factors of safety for creep			
Protrusion height (mm)			
38	25	12	6
N/R	N/R	N/R	>>1.5
N/R	N/R	>1.5	1.5
N/R	1.5	1.3	1.2
1.3	1.2	1.1	1.0
~1.2	~1.1	~1.0	1.0

commended.

s in tension. This may be explained by the fact that, in the puncture m the geo- ibrane and its protection material will conform more to the subgrade y creep d hence the unsupported length will decrease with time. It was shown i. I of this series of papers (Wilson-Fahmy et al. 1996) that for the same applied pressure the maximum stress mobilized at the protrusion tip will decrease as the unsupported length decreases. Thus, a decrease in stress in the geomembrane and its protection material is expected with time. Accordingly, a lower factor of safety for creep is required for the puncture mode in comparison to the stress mode in which the material is subjected to a constant tensile stress.

6.4.2 *Partial Factor of Safety for Chemical/Biological Degradation*

The partial factor of safety against chemical/biological degradation, FS_{CBD}, is included in Equation 7 as follows:

$$p'_{allow} = p_{allow}\left(\frac{1}{MF_S \times MF_{PD} \times MF_A}\right)\left(\frac{1}{FS_{CR} \times FS_{CBD}}\right) \tag{8}$$

Although not assessed in this study, the value of FS_{CBD} is felt to range between 1.0 and 2.0 with an average value of 1.5; see Koerner (1994) for discussion and details.

6.5 Global Factor of Safety

After determining an allowable pressure that is suitably adjusted for modification factors and partial factors of safety (Equation 8), a global factor of safety is determined by dividing the allowable pressure by the required pressure as follows:

$$FS = \frac{p'_{allow}}{p_{reqd}} \tag{9}$$

where: p_{reqd} = maximum stress required on the geomembrane; and FS = desired global factor of safety for uncertainties related to site specific conditions.

It is felt that the global factor of safety should never be less than 3.0. Higher values may be used depending on site specific conditions. For example, a high factor of safety should be used in situations where large isolated stones are frequently encountered on the subgrade. Also, a tightly installed geomembrane may also require a larger global factor of safety compared to a geomembrane installed with slack. Furthermore, no modification has been included for in situ temperatures different from the test procedure temperature, i.e. ≈ 20°C. More definitive recommendations for the global factor of safety are made in Part III of this series of papers (Koerner et al. 1996).

Attachment C
3/3

ATTACHMENT E

GTC

Figure 4

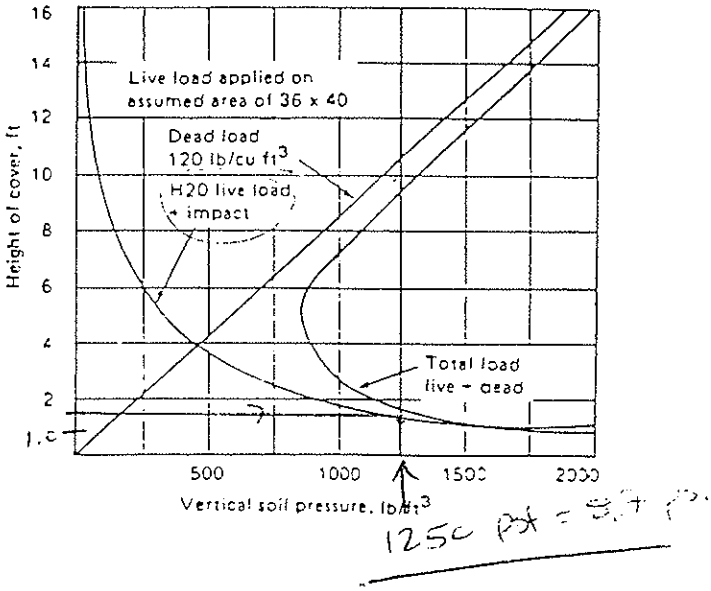


Figure 5

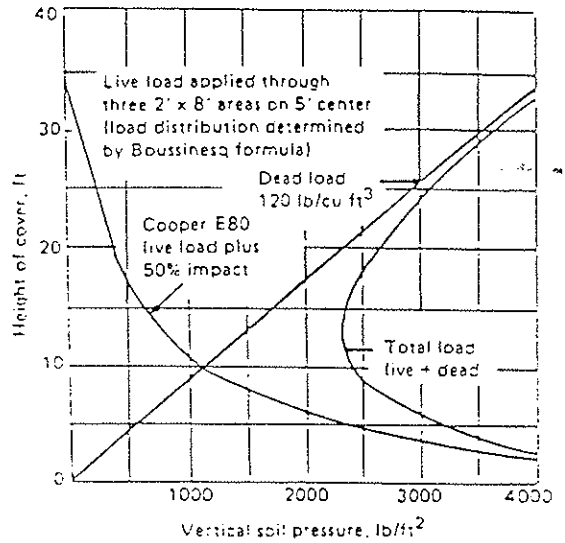
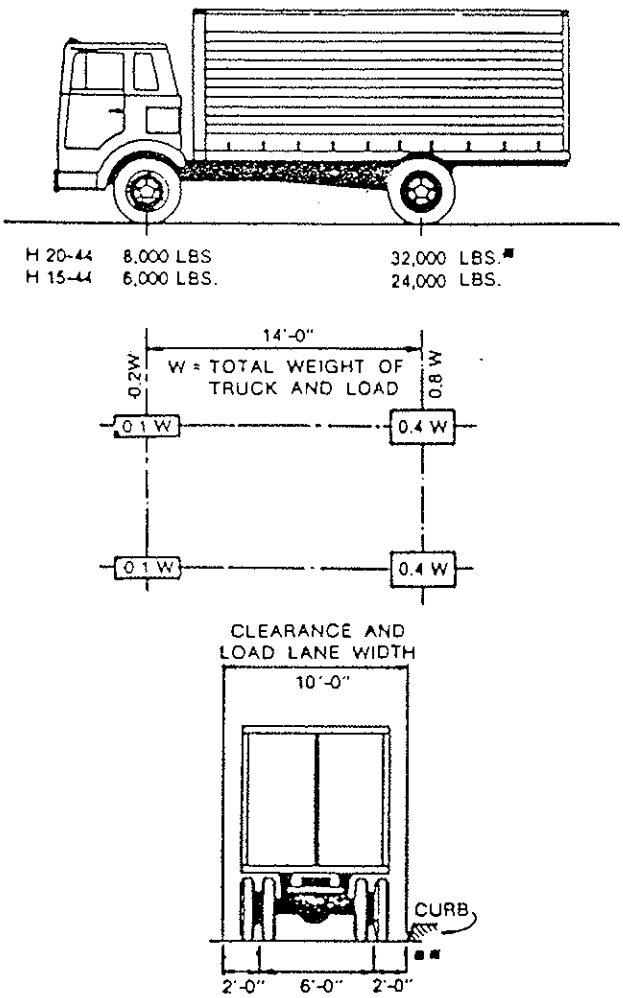
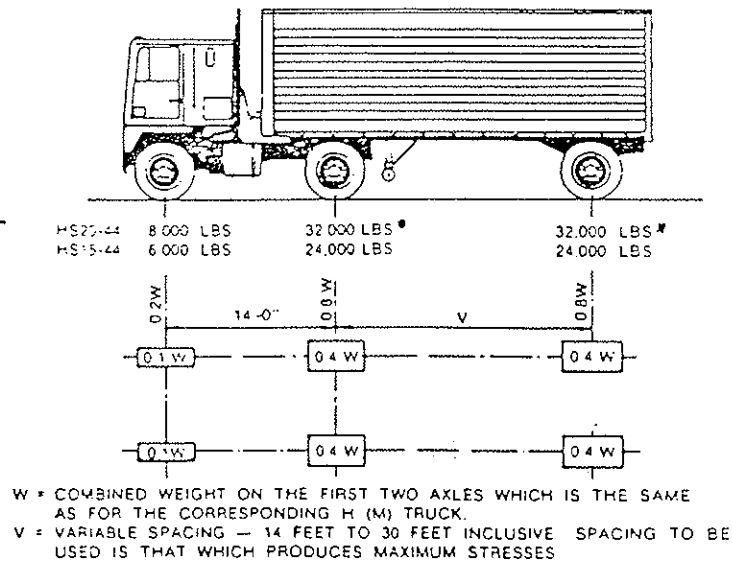


Figure 6





Attachment D
1/1

Calculation Package F
Pipe Strength

GeoSyntec Consultants

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: Parsons **Project:** BRC CAMU **Project/Proposal #:** HL0389 **Task #:** 04

Title of Computations: Pipe Strength Evaluation

Computations By:
SIGNATURE — DATE: 10 July 2000
Geoff L. Smith / Staff Engineer
PRINTED NAME AND TITLE

Assumptions and Procedures Checked By (Peer Reviewer):
SIGNATURE — DATE: 13 JULY 2000
MICHAEL E KALINSKI / SR. STAFF ENG.
PRINTED NAME AND TITLE

Computations Checked By:
SIGNATURE — DATE: 7/14/00
GREGORY T CORCORAN / PROJECT ENG.
PRINTED NAME AND TITLE

Computations Backchecked By (Originator):
SIGNATURE — DATE: 7/14/00
Geoff L. Smith / Staff Engineer
PRINTED NAME AND TITLE

Approved By (PM or Designate):
SIGNATURE — DATE: 7/17/00
Bradford H. Cooley / Project Manager
PRINTED NAME AND TITLE

Approval Notes:

Revisions: (Number and Initial All Revisions)

No.	Sheet	Date	By	Checked By	Approval

Written by: Geoff L. Smith Date: 00 / 07 / 10 (YY MM DD) Reviewed by: 7-13-00 Date: 00 / 07 / 14 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 02

PIPE STRENGTH CALCULATIONS
BRC CAMU
HENDERSON, NEVADA

OBJECTIVE

A 6-in diameter corrugated perforated polyethylene (CPE) pipe will be constructed at the BRC Corrective Action Management Unit (CAMU) in Henderson, Nevada. This pipe will collect and transport the water collected in the geocomposite located above the geomembrane. The objective of this calculation package is to evaluate the pipe strength performance.

SITE CONDITIONS

Crushed gravel will be backfilled around the 6-in pipes. The maximum height of cover soil placed above the pipes will be 1.5-ft.

LOADING CONDITIONS

The following loading condition was evaluated:

Haul Truck (H-20) Loading

The live load applied by the haul truck was estimated to be 8.7 psi as shown in Attachment C, p. 13. The dead load consists of the 1.5 ft of cover soil overburden. Therefore the dead load is 1.4 psi (1.5 ft * 136 pcf / 144 psi/psf). The combined load from haul truck (H-20) loading is:

$P = P_{live} + P_{dead} = 8.7 + 1.4 = 10.1$ psi.

Therefore, the vertical pressure on the top of pipe in the long-term condition is 10.1 psi.

METHOD OF ANALYSES

Ring deflection, wall buckling, and wall crushing of the pipe were evaluated for the loading conditions. The Spangler's Modified Iowa Formula was used to calculate ring deflection. The actual deflection is likely lower due to the arching effects of soil via pipe deflection that are

Written by: Geoff L. Smith Date: 00 / 07 / 10 (YY MM DD) Reviewed by: MSK 7-13-00 GLC Date: 00 / 07 / 14 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 02

neglected in the Modified Iowa Formula. The manufacturer's design manual for ADS corrugated HDPE pipe (ADS, 1994) was used to evaluate wall buckling and wall crushing. The design criteria were based on the manufacturer's design manual for ADS corrugated polyethylene pipe.

ANALYSIS

Evaluating Variables

E' = 1,000 psi for crushed rock, dumped (Attachment C, p. 8/19)

P = Loading of 10.1 psi

EI = pipe stiffness. ADS recommends replacing the pipe EI values with a minimum pipe stiffness value defined as $D^3PS/53.77$ (Attachment C, p. 9/19) where PS = 50 psi for 6-inch diameter pipe at 5% deflection (Attachment C, p. 1/19).

Design by Wall Buckling

Wall buckling is generally the critical failure case for buried pipes. Naturally, this is a starting point. GeoSyntec set the minimum factor of safety for buckling as 2.0.

The critical buckling pressure, P_{cr} is defined (ADS 1994) as:

$$P_{cr} = 2\sqrt{\frac{E'}{1-\nu^2}\left(\frac{D^3PS}{R^3 53.77}\right)}$$ (Equation 1) (Attachment C, p. 10/19)

where:
P_{cr} = critical buckling pressure (psi)
E' = soil modulus = 1,000 psi
ν = Poisson's Ratio = 0.45 for polyethylene pipe (Attachment D)
R = Pipe Radius (in) = 3 in
PS = 50 psi
D = 6 in

Solving Eqn. 4 for P_{cr}, the critical buckling is:

$P_{cr} = 193$ psi

The factor of safety for pipe buckling is defined as:

$FS = P_{cr}/P_T > 2.0$

where P_{cr} = critical buckling pressure at top of the pipe, and
P_T = total soil pressure at the top of the pipe = 10.1 psi

Therefore, the factor of safety for buckling is:

FS = 193 psi / 10.1 psi = 19 > 2.0 O.K.

Check Wall Crushing

The potential for wall crushing under load is checked in the AASHTO design procedure. Wall crushing occurs when the compressive strength of the pipe is exceeded by the overburden soil pressure. The thrust in the wall is calculated as follows:

$T = P * D/2$ (Equation 2) (Attachment C, p. 11/19)

where: T = thrust (lb/ft);
P = design load (psi); and
D = diameter (in).

The design load is 10.1 psi. Therefore, the thrust is evaluated to be:

T = 10.1 psi * 4 in / 2
T = 20.2 lb/in

Using the service load design, the following equation is used to determine the required wall thickness:

$A = T/f_a$

where: A = required wall area (in^2/ft);
T = thrust (lb/ft); and

Written by: Geoff L. Smith GW Date: 00 / 07 / 10 (YY MM DD) Reviewed by: MSC 7-13-00 GTC Date: 00 / 07 / 14 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 02

f_a = allowable minimum compressive strength (psi) divided by a factor of safety of 2.

The compressive yield strength for pipe manufactured by ADS should be limited to 3000 psi (Attachment A, p. 2/3). Assuming a factor of safety of 2.0, the allowable compressive strength of the pipe becomes:

FS = 2.0 = 3000 psi / f_a, therefore f_a = 1500 psi

The required area can then be calculated to be:

A = 50 lb/in / 1500 psi
A = 0.033 in^2 / in

The wall area for 6-inch ADS pipe is 0.107 in^2/in. Therefore, the pipe is sufficient to withstand compressive crushing.

$F.S. = \frac{.107}{.033} = 3.2$ ok.

Written by: Geoff L. Smith Date: 00 / 07 / 10 (YY MM DD) Reviewed by: GTC Date: 00 / 07 / 14 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 02

Check Ring Deflection

Ring deflection is the change in the vertical diameter of the pipe as the pipe/sand system deforms under the external vertical pressure. Ring deflection can be evaluated using Spangler's Modified Iowa Formula formula and can be expressed as follows (ADS 1994):

$$\Delta y = \frac{D_L K_b W_c r^3}{(D^3 PS/53.77) + 0.061 E' r^3}$$ (Equation 3) (Attachment C, p. 9/19)

where:

Δy	= pipe deflection or change in diameter, in.
r	= pipe radius, 3-inch
W_c	= prism soil load, lb/in of pipe, 136 pcf * 1.5 ft = 204 psf = 1.42 psi * 6-in pipe width = 8.5 lb/in of pipe
K_b	= bedding constant, typically 0.1 (Attachment B) (Attachment C, 6/19)
D	= pipe diameter, 6 inches
PS	= pipe stiffness, 50 psi at 5% deflection (Attachment C, 1/19)
E'	= modulus of soil reaction, 1,000 psi (Attachment C, 8/19)
D_L	= deflection lag factor, 1.5 long-term conditions (Attachment B)(Attachment C, 6/19)

Solving for Equation 12 for the critical load yields:

$$\Delta y = \frac{(1.5)(0.1)(8.5)(3^3)}{(6^3)(50)/53.77 + 0.061(1{,}000)(3^3)} = 0.019 \text{ in}$$

Koerner (1994) recommends ring deflections of less than 5 % (Attachment B). The ring deflection for this application is: 0.019-in / 6 in = 0.3 %. Therefore, the ring deflection is acceptable.

SUMMARY AND CONCLUSIONS

Based upon these calculations for pipe ring deflection, wall buckling, and wall crushing, ADS CPE pipe satisfies the design criterion.

Written by: Geoff L. Smith Date: 00 / 07 / 10 (YY MM DD) Reviewed by: MSK 7-13-00 GLC Date: 00 / 07 / 14 (YY MM DD)

Client: Parsons Project: BRC CAMU Project/Proposal No.: HL0389 Task No.: 02

CONSIDERATIONS FOR SPECIFICATIONS

In accordance with the above analyses, the following items should be included in the specifications for construction at the BRC CAMU:

- Pipe shall be corrugated HDPE pipe with a smooth interior wall; and
- A minimum of 1 ft (0.3 m) of cover soil shall be placed over the pipes before a haul truck is allowed to drive over them.

REFERENCES

Advanced Drainage Systems (ADS) (1994), "ADS Specifications Manual", Ph: 614-457-3051
Attachments A and C

Philips 66 (1998), "Driscopipe Systems Design" 800-527-0062
Attachment D

Koerner R.B. (1998), "Designing with Geosynthetics", Fourth Edition, Prentice Hall, p.676
Attachment B

MMSK 7-17-00 GC

Technical Notes

ADS ADVANCED DRAINAGE SYSTEMS, INC.

Technical Note 2.130

Re: Structural Performance of Corrugated PE Pipe Using the Burns and Richard Solution

By: James B. Goddard, Norman E. Kampbell and David P. Kozman

INTRODUCTION

In 1964, Jerome Burns and Ralph Richard presented a break-through paper on the "Attenuation of Stresses for Buried Cylinders" which provided an improved understanding of the stresses around a buried pipe. The analysis is applicable to deeply buried structures where the structure is made from an elastic material and the soil is assumed to be an elastic medium. The circumferential stiffness of the pipe, the bending stiffness of the pipe, and the load transfer between the soil and pipe all influence the loads, in both magnitude and direction (tensile or compression loads). The solution is applicable to any pipe buried in an linearly elastic medium.

The elastic medium parameters are the modulus of elasticity (E′), Poisson's ratio of the soil (μ), the constrained modulus (M′), and the lateral stress ratio (K). These parameters are related by the following equations:

$$M' = \frac{E'(1-\mu)}{(1+\mu)(1-2\mu)} \tag{1}$$

$$K = \frac{\mu}{(1-\mu)} \tag{2}$$

Two additional constants relate to the lateral stress ratio:

$$B = \frac{1}{2}(1+K) = \frac{1}{2}\left(\frac{1}{1-\mu}\right) = \text{symmetrical lateral stress ratio} \tag{3}$$

and

$$C = \frac{1}{2}(1-K) = \frac{1}{2}\left(\frac{1-2\mu}{1-\mu}\right) = \text{antisymmetrical lateral stress ratio} \tag{4}$$

The pipe parameters are the mean radius of the pipe, the circumferential stiffness, and the pipe stiffness (bending stiffness). The circumferential stiffness (or ring compression stiffness) is given by the equation:

M

Attachment A

3300 RIVERSIDE DRIVE COLUMBUS, OH 43221 (614) 457-3051 http://www.ADS-pipe.com

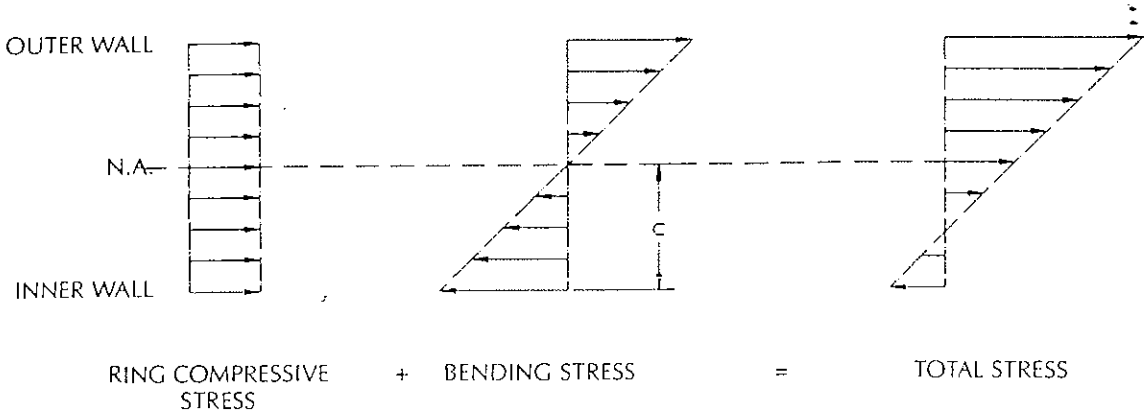


Figure 2: Stress distribution of pipe profile

A great deal can be learned from plots of pipe deflection versus pipe stiffness; moment versus pipe stiffness; thrust versus pipe stiffness; tension versus pipe stiffness ; and compression versus pipe stiffness. As pipe stiffness increases so does the moment, thrust, tension and compression in the pipe wall. All other things remaining constant, as pipe stiffness increases deflection changes very little; it is the soil stiffness that defines deflection performance. Thus it can be said a pipe that is more more compliant is a more structurally capable pipe.

For the design engineer, vertical deflection limits typically will determine the design limits; However, other parameters should also be checked. Circumferential shortening should he limited to less than 2%. Under total stress, inner and outer wall stress should be limited to less than 1,000 psi tensile stress and/or 3,000 psi compressive stress.

SUMMARY

This spreadsheet provides a powerful tool for the design engineer. Installation limits based on deflection, buckling, and circumferential shortening can be selected by the designer, based on his or her experience with pipe installations. It will provide more accurate predictions of pipe performance than the traditional approaches, particularly the "Iowa Formula" for thermoplastic pipes.

The problems with the Iowa Formula:

$$\Delta Y = \frac{W}{\left(EI/R^3 + E'\right)}$$

are:

1. It is assumed that the total stiffness (resistance to deformation) of the soil-pipe interaction system can be estimated by adding the separate stiffnesses of the pipe and the soil. It is far more complicated.
2. The pipe stiffness is a composite of a material stiffness (E) and a geometric stiffness (I/R^3). The soil stiffness (E′) is only a material stiffness.

*MSK 7-13-00 GC

3. The soil stiffness (E′) is empirically arrived at by back calculation of existing installations. This data is from installations with limited cover; typical 25' or less. This makes extrapolations above and beyond the pipes studied vulnerable to error. A single E′ is typically used for a given backfill material and compaction level regardless of depth, which is clearly in error.
4. The load (W) is not truly known. For flexible pipes it is often taken as the Marston load; $W = c_d \gamma B_c B_d$ where c_d is a coefficient dependent upon the depth of burial in the trench, the type of backfill soil, and the nature and extent of a soil arch; typically read from prepared charts. B_c is the OD of the pipe and B_d is the trench width.
5. For viscoelastic materials, like HDPE, the modulus value (E) typically used is based on a test specimen in bending only. There is no consideration of the effect of hoop compression and circumferential shortening; which do effect soil arching and, therefore, soil pressure on the pipe.

The Burns and Richard solution deals with these issues and provides a much more thorough analysis of the pipe response.

Table 1. Predefined MATNAM values and associated soil classes for the overburden dependent model

Young's Modulus (psi) for Overburden Pressures

Soil	MATNAM	5 psi	10 psi	15 psi	20 psi	25 psi	30 psi	40 psi	50 psi	Poisson's Ratio	Density (lb/ft^3)
Granular											
Good	G.GOOD	1,100	1,300	1,500	1,650	1,800	1,900	2,100	2,250	0.30-0.35	110-150
Fair	G.FAIR	550	750	850	1,000	1,100	1,150	1,300	1,400		
Mixed											
Good	M.GOOD	600	850	1,000	1,100	1,200	1,250	1,350	1,450	0.30-0.40	100-140
Fair	M.FAIR	400	550	600	700	750	800	900	900		
Cohesive											
Good	C.GOOD	250	325	375	375	400	400	400	400	0.35-0.40	100-130
Fair	C.FAIR	150	200	225	250	250	250	250	250		

AA

AA. A
3/3

where ΔX = the horizontal deflection or change in diameter, in.,
D_L = the deflection lag factor (varies from 1.0 to 1.5),
K = the bedding constant (varies from 0.83 to 0.110),
W_c = the Marston's prism load per unit length of pipe, lb./in. (note that arching is not taken into account in this formula),
E = the modulus of elasticity of the pipe material, lb./in.^{2},
I = the moment of inertia of the pipe wall per unit length, in.^{4}/in. = in.^{3},
r = the mean radius of the pipe, in., and
E' = the modulus of soil reaction, lb./in.^{2}.

The last mentioned term (E') has been the subject of intense discussion and research. Howard [13] of the U.S. Bureau of Reclamation has recommended the values given in Table 7.6, which have seen relatively wide acceptance.

The preceding equation can also be cast in terms of the laboratory plate loading test with the following result. The equation assumes a bedding constant $K = 0.2$ and uses the ring stiffness constant (RSC).

$$\frac{\Delta y}{d} = \frac{P}{144} \frac{0.1L}{(1.24(RSC)/d + 0.061\ E')} \tag{7.20}$$

where Δy = the vertical pipe deformation (in.),
d = the inside pipe diameter (in.),
P = the load on pipe (lb./ft.^{2}),
L = the deflection lag factor (usually 1.0 to 1.5),
RSC = the ring stiffness constant (lb./ft.), and
E' = the modulus of soil reaction (lb./ft.^{2}).

The ring stiffness constant reflects the sensitivity of the pipe to installation stresses. It is defined in terms of the pipe's deflection resulting from the load applied between parallel plates as per ASTM D2412 (recall Section 7.1.2.1). As described in ASTM F894, RSC is the valued obtained by dividing the parallel plate load in pounds per foot of length by the resulting deflection, in percent, at 3% deflection. Most plastic pipe manufacturers have an empirical formula, along with the necessary tables of their pipe products, for evaluation of RSC values (e.g., see reference 14). The equation also reflects strongly on the type, condition, and placement of backfill both on the sides of the pipe and above it (recall Table 7.6) for values of the modulus of soil reaction (E').

Recognizing the importance of the preceding formulation, several full-scale field and large-scale laboratory trials have been published which give valuable information. Watkins and Reeve [3] have evaluated 15-, 18-, and 24-in. corrugated plastic pipe under standard H-20 truck loadings to determine the minimum cover necessary to prevent pipe damage. They also performed high-pressure, large-scale laboratory tests. Regarding the minimum cover tests, their results showed the response given in Figure 7.9. It can be seen that for a limiting ring deflection of 5% (for this particular pipe), 12 to 15 in. of soil cover is necessary. For the large-scale laboratory tests the setup and typical data were shown in Figure 7.4e.

ADS N-12® PRODUCT FORMATION SHEET

Nominal Diameter	Inside Diameter, Average	Outside Diameter, Average	Wall Thickness, Minimum	Pipe Stiffness @ 5% Deflection	Weight lbs./20 ft. (kg./6 m.)	Area in.²/in.	"I" in.⁴/in.	"C" in.
4" (100 mm)	4.10" (104 mm)	4.78" (120 mm)	0.020" (0.50 mm)	50 psi (340 kN/m²)	8.10 lbs. (3.60 kg.)	0.070	0.0014	0.29
6" (150 mm)	6.00" (152 mm)	6.92" (176 mm)	0.020" (0.50 mm)	50 psi (340 kN/m²)	17.00 lbs. (7.71 kg.)	0.107	0.0036	0.25
8" (200 mm)	7.90" (200 mm)	9.11" (233 mm)	0.025" (0.64 mm)	50 psi (340 kN/m²)	30.80 lbs. (13.97 kg.)	0.135	0.0070	0.27
10" (250 mm)	9.90" (251 mm)	11.36" (287 mm)	0.025" (0.64 mm)	50 psi (340 kN/m²)	45.20 lbs. (20.50 kg.)	0.145	0.0110	0.34
12" (300 mm)	12.15" (308 mm)	14.45" (367 mm)	0.035" (0.89 mm)	50 psi (340 kN/m²)	63.80 lbs. (28.96 kg.)	0.188	0.0410	0.53
15" (375 mm)	14.98" (380 mm)	17.57" (448 mm)	0.035" (0.89 mm)	42 psi (290 kN/m²)	92.50 lbs. (42.00 kg.)	0.217	0.0660	0.66
18" (450 mm)	18.07" (459 mm)	21.20" (536 mm)	0.050" (1.27 mm)	40 psi (280 kN/m²)	128.60 lbs. (58.38 kg.)	0.250	0.0890	0.75
24" (600 mm)	24.08" (612 mm)	27.80" (719 mm)	0.050" (1.27 mm)	34 psi (240 kN/m²)	224.60 lbs. (101.97 kg.)	0.338	0.2310	1.07
30" (750 mm)	30.20" (767 mm)	36.07" (917 mm)	0.050" (1.27 mm)	28 psi (190 kN/m²)	308.30 lbs. (139.97 kg.)	0.353	0.4870	0.69
36" (900 mm)	36.20" (919 mm)	42.46" (1073 mm)	0.050" (1.27 mm)	22 psi (150 kN/m²)	361.20 lbs. (163.98 kg.)	0.361	0.5500	0.46
42" (1050 mm)	41.50" (1054 mm)	46.75" (1187 mm)	0.050" (1.27 mm)	19 psi (140 kN/m²)	530.00 lbs. (240.62 kg.)	0.420	0.7400	1.25
48" (1200 mm)	47.55" (1208 mm)	52.70" (1339 mm)	0.050" (1.27 mm)	17 psi (120 kN/m²)	640.00 lbs. (290.56 kg.)	0.420	0.7400	1.25

Date: March 1, 1996

Attach. C 1/9

Ag

10.4.96 1/13-00 GTC

MMK 1-13-00 GC

Technical Report

ADS
ADVANCED DRAINAGE SYSTEMS, INC.

Technical Report 4.103

Re: Plastic Pipe Design
Date: November 1, 1994
By: J. B. Goddard

Introduction

To most of the engineering profession there was little time spent on underground structure design, particularly small pipe design, in our undergraduate studies. Bridges, large buildings, and pavement design occupied most of our time and our interest. This occured despite the fact that nearly 10% of our transportation construction dollars go for drainage structures. This is particularly interesting since a number of engineering professors have stated that the three most important considerations in pavement design are drainage, drainage, and drainage.

This lack of emphasis in our training is further exacerbated when considering plastic pipe design in that our structural design courses focused on rigid and elastic materials but spent little or no time on viscoelastic materials. A review of my own college texts reveal a total of three pages on viscoelastic properties.

In considering pipe design, generally, pipes are divided into two categories, rigid and flexible. Rigid pipes are defined as those that will not accept deflection without structural distress. Flexible pipes are defined as those that will deflect at least 2% without structural distress. Concrete, clay, and cast iron pipe are examples of rigid pipes. Steel, aluminum and plastic pipes are usually considered flexible. Within those pipes defined as flexible, the metal pipes would be considered elastic and the thermoplastic pipes would be viscoelastic or viscoplastic. Individual pipe types may have different performance limits based on type, material and wall design. The strength to resist wall stresses due to external load is critical for rigid pipe; while for flexible pipe, stiffness is important in resisting deflection and possibly buckling. Wall area may also be a factor to consider in design. For all buried pipe, rigid or flexible, the "structural performance is dependent on soil structure interaction. The type and anticipated behavior of the material beneath the structure, adjacent to the structure, and over the structure must be considered". (From paragraph 17.1.6, AASHTO Standard Specifications for Highway Bridges). Also, "It must be recognized that a buried plastic pipe is a composite structure made up of the plastic ring and the soil envelope, and that both materials play a vital part in the structural design of plastic pipe". (From paragraph 18.1.1, AASHTO Standard Specifications for Highway Bridges). Both these statements apply to rigid or flexible pipe.

Attach. C

2/19

3300 RIVERSIDE DRIVE COLUMBUS, OH 43221 (614) 457-3051 http://www.ADS-pipe.com

MSK 7-13-00 GTC

To put the differences between rigid, elastic, and viscoelastic materials in the simplest possible terms consider the following; the hard candy stick, licorice, and a hershey bar. The hard candy (the rigid structure) shatters if you attempt to bend it, regardless of loading rate. The hershey bar (the elastic structure) flexes under load but returns to shape unless that load exceeds the yield point. Beyond the yield point, the material takes a permanent set or deformation. At some amount of strain, the elastic material fails. The licorice (the viscoelastic material) responds differently depending on the rate at which the load is applied. If the load is applied very rapidly, the strength of the material is quite high. If a much lower load is placed on the licorice, it will slowly elongate. If the elongation is fixed at some constant strain, the licorice will relieve itself of stress. Although helpful in visualizing the differences in these materials,this perspective is inaccurate in that the pipe wall in non-pressure pipe is normally in compression, not tension. Because of that, the tendency is for the pipe wall to compress and thicken under load rather than stretching and thinning (or necking down). The impact of that is to increase cross-sectional or wall area while, at the same time, stress relaxation is taking place. The impact of this is discussed later in the design section.

Design Theory

The proof of any design theory should be how accurately it predicts the point and mode of failure in the product under the anticipated loading conditions. Unfortunately, current non-pressure pipe design procedures do not pass this test, regardless of major pipe types. Rigid pipe practice tends to predict quartering of the pipe as a failure mode when in fact wall shear is more common. Metal pipe design predicts circumferential wall crushing as the failure mode, a phenomenum I have never seen in the field, where localized buckling is a more typical failure mode. In defense of both theories; however, they appear to be generally conservative in that there are few structural failures of standard production pipe supplied by either industry, unless blatantly abused in installation and handling.

The same can generally be said for standard production thermoplastic pipe supplied by the major producers in that there have been few structural failures of these products. Design theory for these products is considerably more confusing, in part because the products represented are only about 30 years old (versus 100 years for steel and antiquity for concrete) and in part because of the variation in wall design and materials (primarily PVC and HDPE).

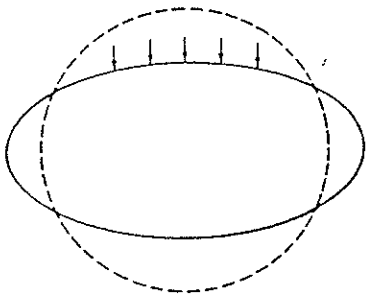
Prior to developing a design procedure, performance limits must be established. Deflection, wall buckling, stress, and strain are normally considered performance limits for flexible pipes.

AM

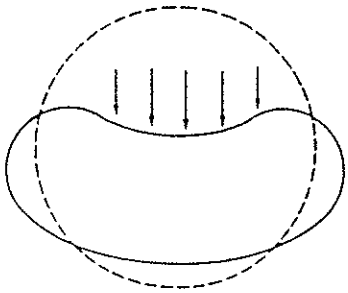
Att. C
3/19

MK 7/13-CC GC

Deflection limits are set to avoid reversal of curvature, limit bending stress and strain, and avoid pipe flattening. Excessive deflection may reduce the flow capacity of the pipe and may cause joint leakage. Deflection of flexible pipe is primarily controlled by the method of installation and the backfill and insitu soil properties.

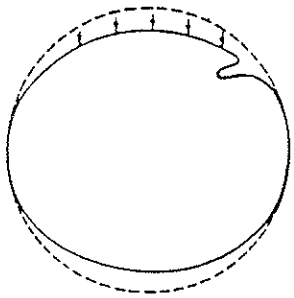


Ring deflection in a flexible pipe



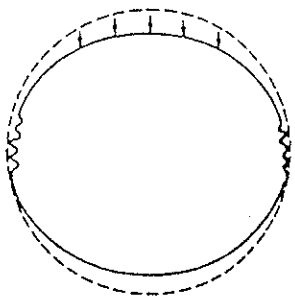
Reversal of curvature due to over-deflection

Wall buckling should be considered. Large diameter flexible pipe design may be governed by buckling, particularly when subjected to high soil pressures in low stiffness soils.



Localized wall buckling

Wall stress in compression can theoretically lead to wall crushing if excessive. If the ring compressive stress is greater than the compressive strength of the wall of the pipe, wall crushing may occur. The viscoelastic properties of thermoplastic material make this mode of failure very unlikely and field and lab tests tend to confirm that view.



Wall crushing at the 3 and 9 o'clock positions

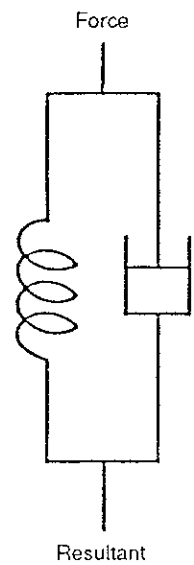
Pipe wall strain, generally in bending should be checked. Typically, these are outer wall fiber strains brought about by excessive deflection or localized deformations. Strain limits for thermoplastic pipe materials are generally assumed to be from 3.5 to 8% depending on wall design and resin used. Note that this is fiber strain, not deflection.

Att. C

4/17

The equations to determine deflections, wall buckling, wall stress, and wall strain were developed primarily for evaluating flexible pipes manufactured from elastic materials and do not adequately reflect the effect of viscoelastic properties; in some cases treating a positive attribute as a negative. Again, using an analogy, the viscoelastic material is treated as a spring and dash pot (or shock absorber) connected in parallel with the spring handling sudden or short term loads and the dash pot responding to long term loads. The effect of this combined response is significant on the soil structure interaction system. (Figure 1)

Figure 1



Design Practice

1. Deflection

Probably the most commonly used formula in plastic pipe design is Spangler's Iowa Deflection Formula. It, at least in some form, is referenced or utilized in the ASCE Plastic Design Manual; by Moser in his textbook, Buried Pipe Design; by Koerner in his textbook, Designing With Geosynthetics; by the Bureau of Reclamation; and by the Environmental Protection Agency. The most common form of the equation is:

$$\Delta x = D_L\,(kWr^3)/(EI + 0.061\,E'r^3) \qquad (1)$$

Where:	Δx	=	Horizontal deflection of the pipe in inches
	D_L	=	Deflection lag factor (usually 1.5)
	k	=	Bedding constant
	W	=	Load per unit length of pipe in lbs/linear inch
	r	=	Pipe radius in inches
	E	=	Modulus of elasticity of pipe material in lbs/in2
	I	=	Moment of inertia of the pipe wall in in4/in
	E'	=	Modulus of soil reactions in lbs/in2

Developed by Dr. Merlin G. Spangler based on work begun in 1927 with rigid and flexible pipes, this built on previous work by Dr. Marston which predicted loads on culverts. The form above is the modified formula developed by Dr. Reynold Watkins based on his work in 1958.

It should be noted that this equation was developed largely from test installations with from 15 to 25 feet of cover.

MSK 7-13-cc

GC

A number of factors in the equation are contentious and deserve explanation:

A. The deflection lag factor (D_L) was included in the equation because Dr. Spangler believed that deflections could increase as much as 30% over a period of 40 years. He recommended a D_L of 1.5 to be conservative. We now know virtually all of the deflection occurs during the first year, therefore a D_L of 1.0 may be used.

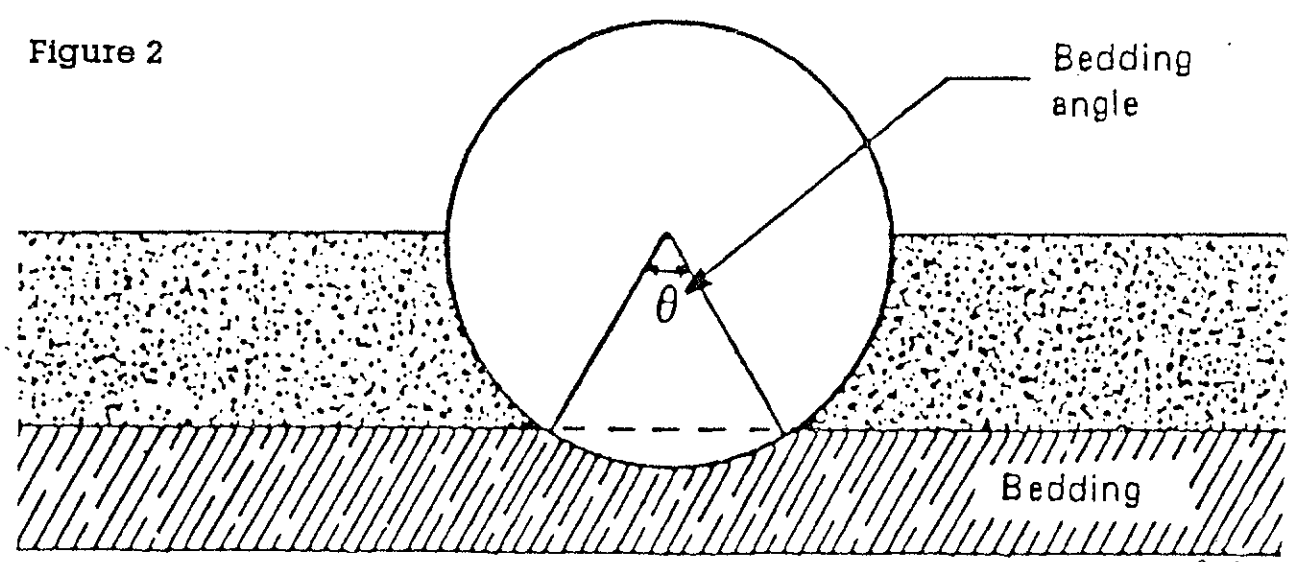
B. The bedding constant (k) is usually assumed to equal 0.1, although, as shown in Table 1, other values may be appropriate for specific installation conditions. A bedding angle (see Figure 2) of 0° would indicate a very firm foundation which would not be recommended for any pipe type.

Table 1

Values of Bedding Constant, K

Bedding angle, degrees	K
0	0.110
30	0.108
45	0.105
60	0.102
90	0.096
120	0.090
180	0.083

Figure 2



Att C.
6/19

C. The load per unit length of pipe (W) is Marston's prism load, which assumes that the entire weight of the vertical prism of soil over the pipe is pressing down on the pipe. For very deep fills, this is probably very conservative in that it assumes no soil arching. This may be unconservative for very shallow cover.

D. The modulus of soil reaction E' has been studied extensively and continues to be a point of contention between rigid and flexible pipe manufacturers. Probably the most used values are those developed by Amster Howard of the U.S. Bureau of Reclamation and shown in Table 2. These values are based on field measurements of flexible pipe installations whose installation conditions were known and then back calculating to find the E' values.

Recent work by Dr. Mike Duncan at V.P.I. indicates that E' varies with depth. When looked upon as a confining pressure, this seems logical. Amster Howard's work limits his E' values to 50 foot or less. Richard Chamber's work published in 1980 showed that E' can be replaced by M_s (constrained soil modulus) in the Iowa Formula. M_s does vary with depth. Dr. Duncan's values are shown in Table 3. These values may be more appropriate than those shown in Table 2.

Values of E' have been given as high as 8,000 psi in very high fills.

Selection of the appropriate E' value is up to the design engineer who must make that decision based on experience and knowledge of the project conditions. Clearly, values less than 400 psi would indicate backfill conditions inappropriate for pipe installation.

AH. C
7/19

7-13-00

Table 2

Average Values of Modulus of Soil Reaction, E'
(For Initial Flexible Pipe Deflection)

Soil type-pipe bedding material (Unified Classification System*)	E' for degree of compaction of bedding, lb/in²			
	Dumped	Slight, < 85% proctor, < 40% relative density	Moderate, 85%-95% proctor, 40%-70% relative density	High > 95% proctor > 70% relative density
Fine-grained soils (LL > 50) † Soils with medium to high plasticity CH, MH, CH-MH	No data available; consult a competent soils engineer; Otherwise use E' = 0			
Fine-grained soils (LL < 50) Soils with medium to no plasticity CL, ML, ML-CL, with less than 25% coarse-grained particles	50	200	400	1000
Fine-grained soils (LL < 50) Soils with medium to no plasticity CL, ML, ML-CL, with more than 25% coarse-grained particles Coarse-grained soils with fines GM, GC, SM, SC contains more than 12% fines	100	400	1000	2000
Coarse-grained soils with little or no fines GW, GP, SW, SP‡ contains less than 12% fines	200	1000	2000	3000
Crushed rock	1000	3000	3000	3000
Accuracy in terms of percentage deflection§	± 2	± 2	± 1	± 0.5

* ASTM Designation D2487, USBR Designation E-3
†LL - liquid limit
‡ Or any borderline soil beginning with one of these symbols (i.e., GM-GC, GC-SC)
§ For ± 1% acuracy and predicted deflection of 3%, actual deflection would be between 2 and 4%

NOTE: Values applicable only for fills less than 50 ft (15 m). Table does not include any safety factor. For use in predicting initial deflections only, appropriate deflection lag factor must be applied for long-term deflections. If bedding falls on the borderline between two compaction categories, select lower E' value or average the two values. Percentage proctor based on laboratory maximum dry density from test standards using about 12,500 ft-lb/ft³ (598,000 J/m¹) (ASTM D698, AASHTO T-99, USBR Designation E-11). 1 lb/in² = 6.9 kN/m².

SOURCE: Amster K. Howard, "Soil Reaction for Buried Flexible Pipe", U.S. Bureau of Reclamation, Denver, Colorado. Reprinted with Permission from American Society of Civil Enginers J. Geotech Eng. Div., January 1977, pp. 33-43.

Att. C
8/19

One variation to the Modified Iowa Formula that can simplify its use is replacing the pipe EI values with a minimum pipe stiffness value as shown below:

$$\Delta x = D_L\ [kWr^3/[(D^3PS/53.77) + (0.061\ E'r^3)]] \qquad (2)$$

Minimum pipe stiffness values are provided in the pipe specification in ASTM and AASHTO.

PS = Pipe stiffness in #/in/in
D = Pipe diameter in inches

One additional design approach intended in part to limit installation deflections and ensure construction survivability is the use of flexibility factor in the AASHTO design procedure. Based on earlier experience with corrugated steel and corrugated aluminum pipe, AASHTO has set a minimum flexibility factor for thermoplastic pipes at 0.095, based on the following formula:

$$FF = D^2/EI \qquad (3)$$

Where:
D = Pipe diameter in inches
E = Modulus of elasticity in PSI
I = Moment of inertia of the pipe wall in in^4/in.

To utilize minimum specified pipe stiffness (PS), this equation becomes:

$$FF = 53.77/(PS \times D) \qquad (4)$$

From this, Table 4 can be generated:

Table 4

Pipe Stiffness For FF = 0.095

Pipe Diameter (in)	Pipe Stiffness (#/in/in)
12	47.17
15	37.73
18	31.44
24	23.58
30	18.87
36	15.72
42	13.48
48	11.79
54	10.48
60	9.43

Att. C
9/19

Considerable experience with pipe sizes 48" and smaller and with stiffness values equal to or greater than those given has shown that these products perform well with good installation procedures. More flexible structures can be successfully installed if special care is exercised.

2. Wall Buckling

Wall buckling can govern design of flexible pipes subjected to high soil pressures, external hydrostatic pressure, or internal vacuum. The more flexible the pipe, the lower the resistance to buckling. Caution should be exercised when considering large diameter pipes or pipes in shallow burial. Buckling equations assume the external pressure is reasonably uniform around the pipe. From Dr. Moser's textbook, the following equation offers a relatively simple equation that has been shown to be conservative for thermoplastic pipe.

$$P_{cr} = 2\sqrt{\frac{E'}{1-v^2}\left(\frac{EI}{R^3}\right)} \qquad (5)$$

Where:

Pcr	=	Critical Buckling Pressure (PSI)
E'	=	Soil Modulus (PSI)
v	=	Poisson's Ratio
E	=	Modulus of Elasticity (Pipe Material) (PSI)
I	=	Moment of Inertia (in_4/in)
R	=	Pipe Radius (in)

AASHTO and ASCE use a somewhat different approach, relying on variations of the AWWA equation. The current AASHTO version is as follows:

$$Pcr = 9.24\ (R/Ap)\sqrt{C_W\ M_S\ EI/0.149R^3} \qquad (6)$$

Where:

R	=	Pipe Radius (in)
M_S	=	Soil Modulus (PSI)
C_W	=	Water Buoyancy Factor = (1 - 0.33 hw/h)
		Where hw = Height of water above top of pipe
		h = Height of ground surface above top of pipe
Ap	=	Pipe Wall area (in^2/in)

For viscoelastic materials, the E value in this equation is normally the long-term E value, either 10 yr or 50 yr.

MSK 7/3-00

GTC

3. Wall Crushing

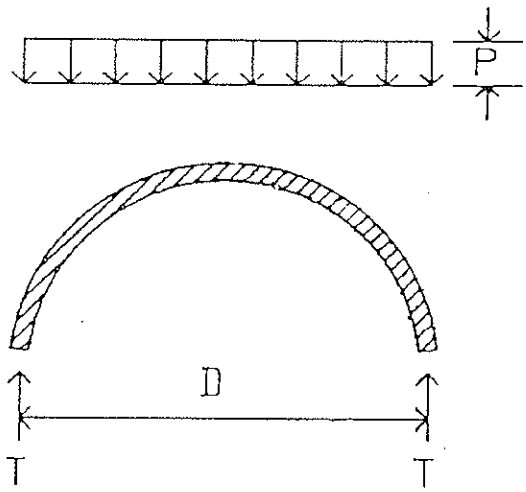
Based on ring compression theory developed for metal pipe, the potential for wall crushing under load is checked in the AASHTO design procedure. According to the AASHTO procedure, this can be addressed in two ways, using service load design or load factor design. Both start by calculating the thrust in the wall as follows:

$$T = P \times D/2 \qquad (7)$$

Where T = Thrust in pounds/foot
P = Design Load in PSI.
D = Diameter in ~~Feet~~ inches

This is represented by the free body diagram in Figure 3.

Figure 3



AH C.
11/19

MSK 7.13-CA

GK

The design load is generally assumed to be the weight of the soil load above the pipe calculated by multiplying the soil density times the height of cover. Any anticipate live load must be added to this dead load. Live loads are given in Table 5 and shown on Figure 4, 5, and 6.

Table 5

Live Loads on Flexible Pipe
(Live Load Transferred to Pipe, lb/in²)

Height of Cover	Highway	Railway	Airports
(FT)	H20	E80	
1	12.50	N.R.	N.R.
2	5.56	26.39	13.14
3	4.17	23.61	12.28
4	2.78	18.40	11.27
5	1.74	16.67	10.09
6	1.39	15.63	8.79
7	1.22	12.15	7.85
8	0.69	11.11	6.93
10	N.S.	7.64	6.08
12	-	5.56	4.76
14	-	4.17	3.06
16	-	3.47	2.29
18	-	2.78	1.91
20	-	2.08	1.53
22	-	1.91	1.14
24	-	1.74	1.05
26	-	1.39	N.S.
28	-	1.04	-
30	-	0.69	-
35	-	N.S.	-
40	-	-	-

Notes: H20 load simulates 20 ton truck traffic and impact.
E80 load simulates 80,000 lb./ft. railway load and impact.
Airport load simulates 180,000 lb. dual tandem gear, 26 inch spacing between tires and 66 inch center-to-center spacing between fore and aft tires under rigid pavement 12" thick plus impact.

N.S.= Not Significant
N.R.= Not Recommended

AH C.
12/19

MSK 7/13-00

GTC

Figure 4

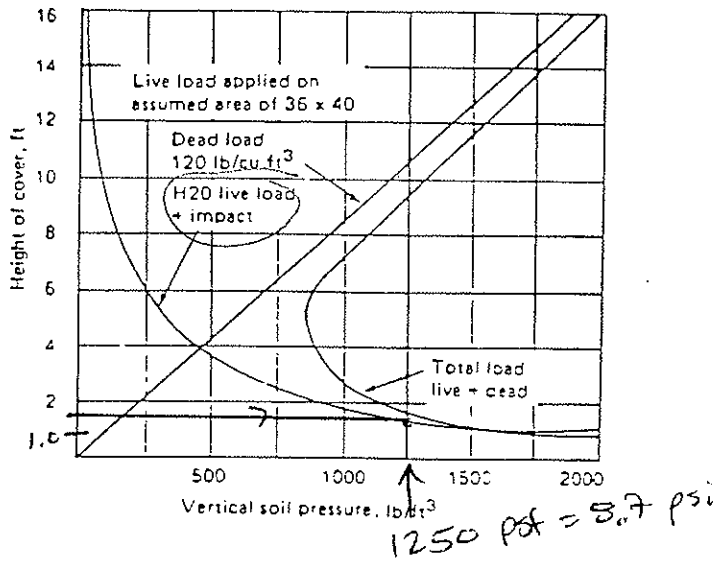


Figure 5

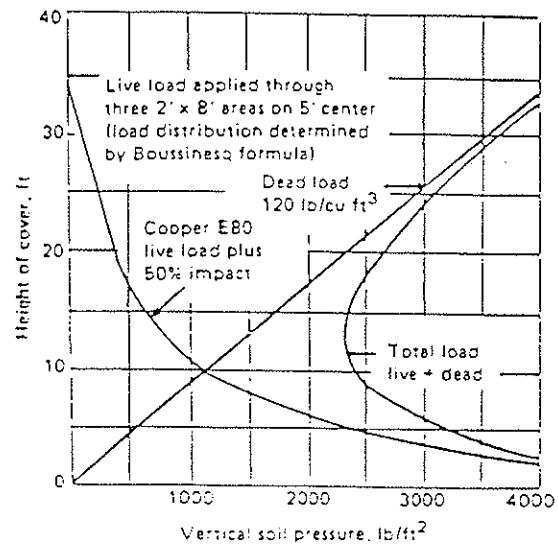
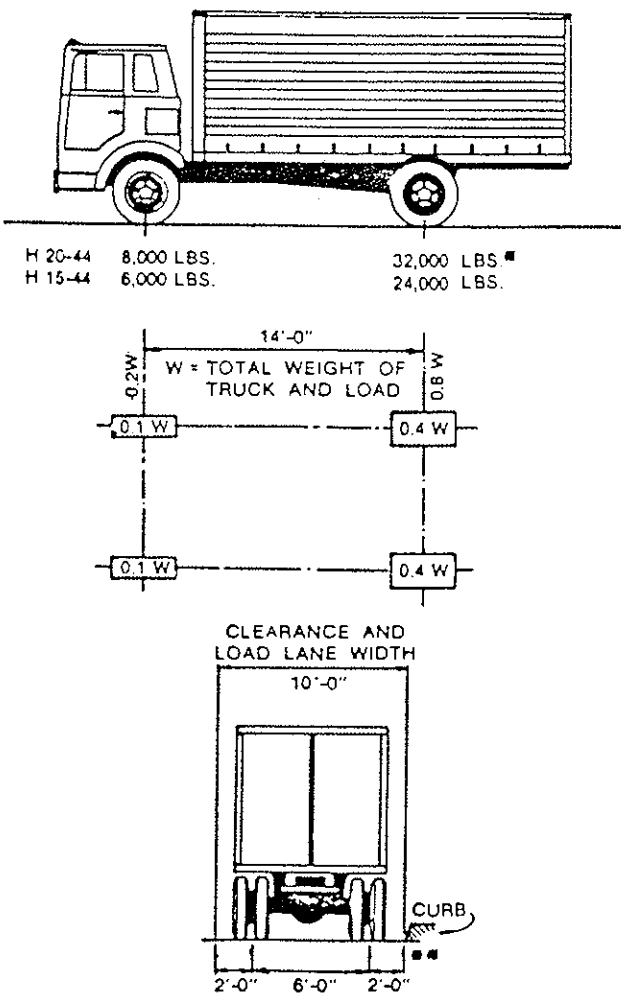
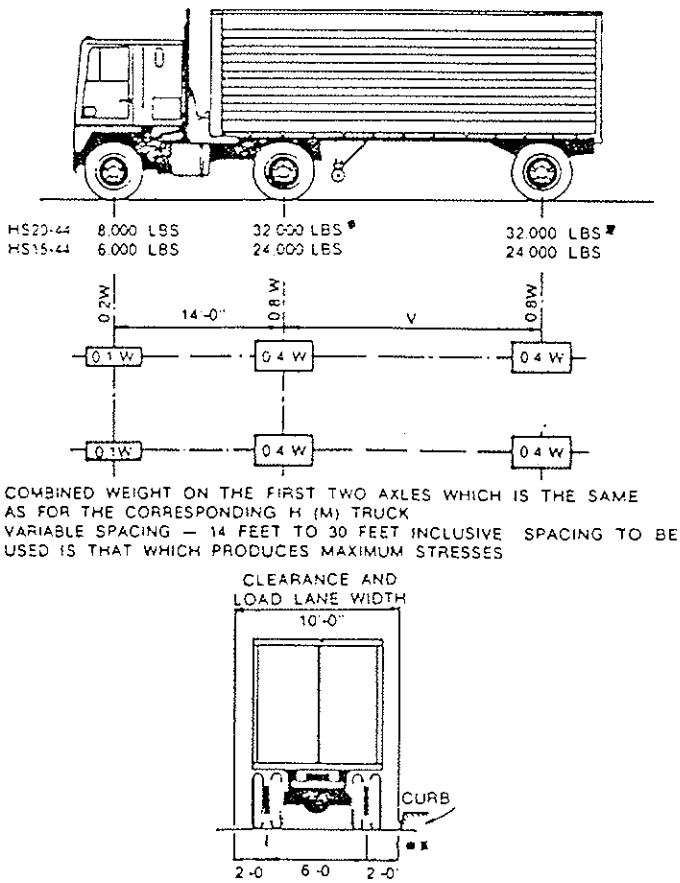


Figure 6





Att. C

13/19

With the wall thrust determined, the required pipe wall area necessary can then be calculated. AASHTO provides two approaches to this, Service Load Design and Load Factor Design. Service Load Design is a working stress method while Load Factor Design is based on ultimate strength principles. Using Service Load Design, the following equation is used to determine required wall area:

$$A = T/fa \qquad (8)$$

Where:	A	=	Required wall area in in^2/ft
	T	=	Thrust in #/ft
	fa	=	Allowable minimum tensile strength in PSI divided by a safety factor of 2

Using Load Factor Design, the following approach is used:

$$A = T_L/\varnothing\ fu \qquad (9)$$

Where:	T_L	=	Load factor modified thrust
	fu	=	Specified minimum tensile strength in PSI
	Ø	=	Capacity modification factor

For flexible conduits, $T_L = T/(1.5 \times 1.3)$, where 1.3 = load factor and 1.5 = beta factor (from section 3, AASHTO Bridge Guide Manual). Phi (Ø) equals 1.0 (from section 18).

This approach has been used successfully with metal pipe for many years. For plastic pipe (viscoelastic), there are a couple of fundamental errors that lead the designer to very conservative designs. The most obvious error is the use of tensile strength values in calculating wall area in compression. At least with the principle resins used in the manufacture of thermoplastic pipe, PVC, and HDPE, the allowable values should be higher in compression.

The second error is that the calculated soil load is still based on the weight of the soil prism over the pipe without any consideration of soil arching, which has been proven in a number of research studies to reduce the load considerably in very deep fills.

The third error is the use of long term material properties rather than initial strength in these calculations. When backfilled with Type I, Type II, or compacted Type III soils, it is appropriate to assume the pipe is subjected to repeated dynamic loads from the successive settling of the soil. Because stresses in the pipe wall relax, design should be based on the instantaneous modulus of elasticity and compressive strength.

4. Pipe wall strain is mostly a post-construction concern. Within the normally specified deflection limitations, allowable outer fiber tensile strains are not a concern. If, however, due to poor installation localized deformations occur, wall strain should be checked. Allowable strains for the resins used for thermoplastic

MSK 7-13-00

GK

pipe are 3.5 to 5% for PVC and 4 to 8% for HDPE. To check bending strain, the following equation should be used:

$$E_b = 6\left(\frac{t}{D}\right)\left(\frac{\Delta Y}{D}\right) \qquad (10)$$

Where:	E_b	=	Bending strain
	t	=	Wall thickness
	D	=	Diameter
	ΔY	=	Vertical deflection

Total circumferential strain may also include (in addition to bending strain) ring compression strain and strain due to Poisson's effect. Ring compression strain is:

$$E_c = P_v D/2tE \qquad (11)$$

Where:	E_c	=	Ring compression strain
	P_v	=	Vertical soil pressure
	E	=	Modulus of elasticity

The contribution to circumferential strain due to the Poisson effect caused by longitudinal strain is:

$$E = -v \times L_S \qquad (12)$$

Where:	E	=	Circumferential Poisson's strain
	v	=	Poisson's ratio
	L_S	=	Longitudinal strain

As noted, these strains are additive. Compressive strains reduce tensile strains.

In order to properly design any plastic pipe, it is necessary to know the section properties of the pipe; including inside and outside diameter, pipe wall area; wall centroid, and moment of inertia. Also, the minimum resin properties including short and long term tensile strength, modulus of elasticity, and compression strength as well as allowable long term strain. These values will be available in the referenced specifications or from the manufacturers.

Installation

As noted in the introduction, design of any buried structure, be it rigid or flexible, depends on the interaction of the pipe structure and the surrounding soil (or backfill). Sound installation practice assures satisfactory structural performance. Fortunately, for thermoplastic pipe, there is an excellent installation specification in ASTM, ASTM D2321, Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications. This specification is particularly helpful in its classification of embedment and backfill materials and its recommendations for

AH. C

15/19

MSK 7-13-00

GK

their use. It also includes guidance as to the compatibility of backfill materials with various soil types, particularly in terms of migration of fines. Minimum compaction levels for different backfill classes are provided and should be followed. These are based on providing an E' (modulus of soil reaction) value of 1,000 psi, as used in the deflection formula (1).

In typical conditions, the minimum trench width is determined by the size of the pipe and the ability to get compaction equipment between the pipe and the trench walls. The minimum trench width should not be less than the outside diameter plus 16 inches or the pipe outside diameter times 1.25 plus 12 inches; whichever is greater. High speed trenchers may enable satisfactory installation of pipe in narrower trenches. Poor insitu soil conditions such as peat, muck, running sands, or expansive clays will require substantially wider backfill as well as deeper foundation and bedding. Trench width and foundation depth should be based on a thorough site investigation.

Other means of trench control through poor insitu soils include wrapping the backfill and bedding material with a geotextile. Particularly severe conditions may require a geonet or geogrid, often in combination with a geotextile.

Bedding, to provide a stable and uniform base for the pipe should be 3 to 4 inches thick. Over rock or unyielding foundations, a minimum of 6" of bedding should be provided.

Backfill in the area up to the springline should be carefully placed and compacted to achieve a minimum E' value of 1,000 psi as detailed in ASTM D2321. A minimum of 12" of backfill should be placed and compacted above the crown of the pipe. It is typical for trenches to be backfilled entirely with Type I or Type II materials when under pavement. (Figure 7)

For pipe up to 48" diameter, and with pipe stiffness equal to or in excess of those required in AASHTO Section 18 (Table 4), a minimum of 12" of compacted cover is required prior to vehicle loadings. For larger or less stiff pipe, additional cover is recommended.

Recent development of flowable, low strength cement or fly ash backfill provides the ability to reduce trench widths and still get adequate backfill support. This can be particularly helpful in municipal street installations. Manufacturer's recommendations should be closely followed.

Flexible pipe should never be installed in a concrete cradle, as done for rigid pipe in a Class A installation. This type of installation could create concentrated forces at the ends of the cradle when the pipe has deformed.

10

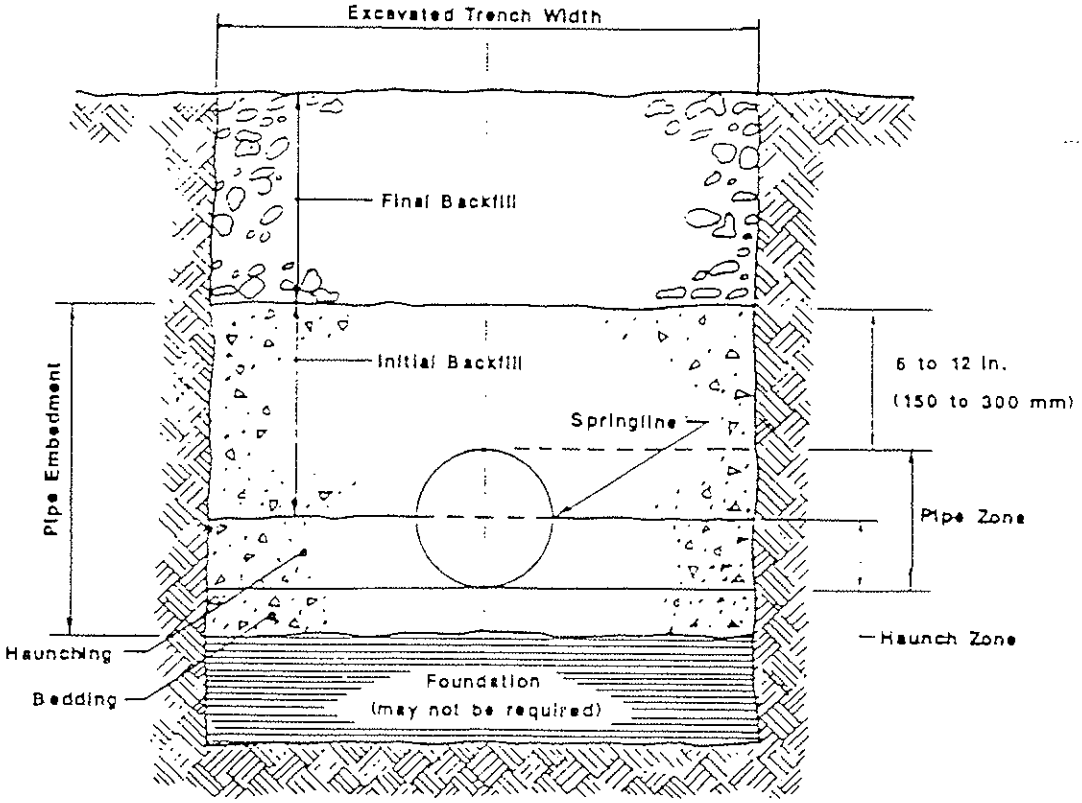
Att. C

16/17

MAS 1C 7.13-CU

GTC

Figure 7



Trench Cross Section

ATT. C
17/19

Research

One way to verify design and installation procedures for any product is to compare research findings with predicted performance. Over the past ten years, there has been a substantial amount of research done by the plastic pipe industry or by users of plastic pipe to verify the existing design procedures or to improve upon them.

A considerable amount of research has been conducted at Utah State University by either Dr. Reynold Watkins or Dr. Al Moser. Much of Dr. Watkins work has involved the large soil cell at U.S.U. to attempt to simulate very large soil pressures on buried pipe. Depending on the specific test, different backfill material and installation practice have been used as well. Based on work done in 1982 (TRR 903) (Figures 8 and 9) and 1990 on corrugated polyethylene pipe, the measured deflections were 1/2 to 2/3 those predicted by the Modified Iowa Formula (1) (Figure 10). At the soil pressures in the test cells in both tests, the resultant wall thrust exceeded that predicted by the AASHTO equations (8 & 9) by a factor of 2 using short-term material values and by a factor of 10 using long term (50 year) material values. In these tests, however, no wall thrust failure occurred, so ultimate wall thrust loads must be greater than those in these tests. These tests also exceeded the predicted wall buckling pressures by approximately 50%. With deflections less than 5% in these tests, wall strain was about 1%, well under the strain limit for HDPE.

In 1987, under the direction of Dr. Ernest Selig, a 24" diameter corrugated polyethylene pipe was installed in a 100' highway fill under I-279 North of Pittsburgh, PA as a test of the pipe's performance under high soil pressures in a realistic installation. Pipe shape and circumference have been monitored along with soil pressure at crown and springline, free field soil strain, and trench strain (pipe & backfill). Under 100 feet of fill, this pipe has shortened vertically 4.3%, with 1.6% of that reflected in circumferential shortening. The actual deflection is therefore only 2.7%. The free field soil strain is 4.2%. Because of the combination of circumferential shortening and deflection, a soil arch has developed over the pipe in the fill reducing the vertical soil pressure at the crown to only 22% of the predicted (by Marsten) soil pressure. Total vertical shortening is 55% of that predicted by the Iowa Formula (1) as deflection. Actual deflection (out of roundness) is only 35% of that predicted by the Iowa Formula. This study demonstrates that the soil arching and the circumferential shortening, which are not taken into consideration in the traditional calculations add a considerable degree of conservatism to the predicted performance values. Using the AASHTO design calculations, this pipe should have failed in wall crushing at about one half of the actual fill height. Dr. Selig has shown that finite element analysis programs, specifically CANDE and SOILCON, can predict the kind of results found in this study.

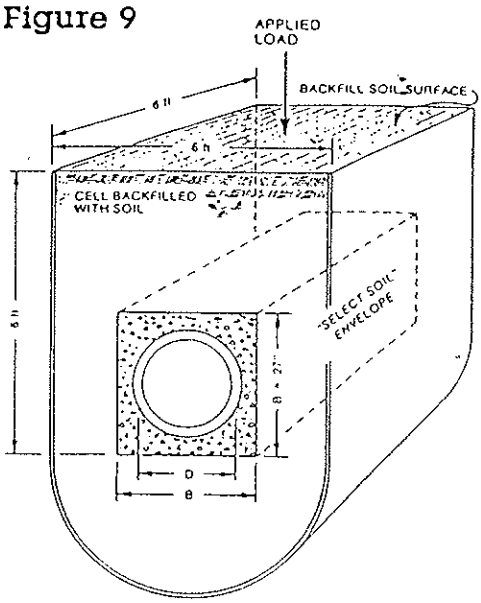
MAK 7-13-00

GTC

Figure 8

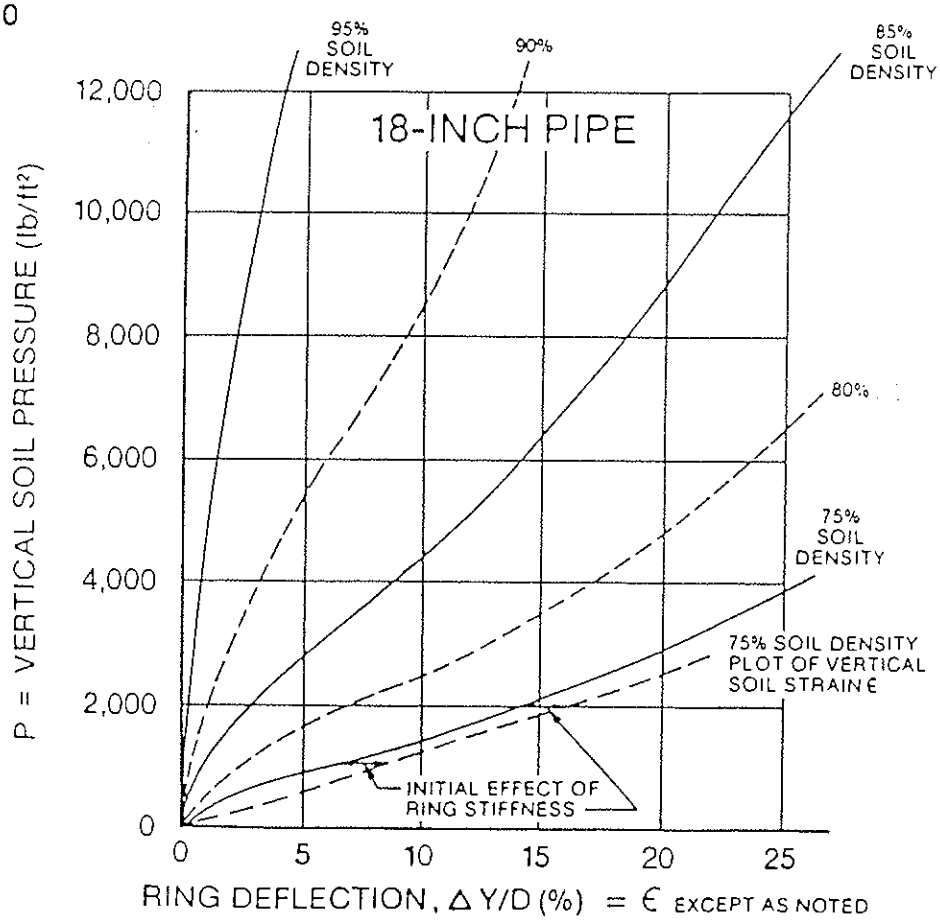
H-20 (32 kip axle load) being applied on 24-inch pipe with cover removed

Figure 9



Sketch of the small Utah State University high vertical soil pressure test cell, showing the setup for testing corrugated plastic pipe. The test can be conducted with or without the "select soil" envelope (gravel).

Figure 10



AH-C
19/17

AB

1. Calculate or estimate the total soil pressure, P_T, at the top of the pipe.

2. Calculate the stress, S_a, in the pipe wall:

$$S_A = \frac{(SDR - 1)}{2} P_T$$

3. Based upon the stress, S_a, and the estimated time duration of non-pressurization, find the value of the pipe's modulus of elasticity, E, in psi (approximate value for E is 35,000 psi).

4. Calculate the pipes hydrostatic, critical-collapse differential pressure, P_c

$$P_C = \frac{2E(t/D)^3 (D_{MIN} / D_{MAX})^3}{(1-\mu^2)} \quad \text{or} \quad P_c = \frac{2.32(E)}{SDR^3}$$

Where:
$(D_{MIN}/D_{MAX}) = 0.95$
μ = Poission's Ratio = 0.45 for polyethylene pipe
E = stress and time dependent tensile modulus of elasticity, psi
E = 35,000 psi (approximate)
D = Outside Diameter, in.
t = thickness, in.

5 Calculate the soil modulus, E', by plotting the total external soil pressure, P_T, against a specified soil density to derive the soil strain as shown in the example problem below Figure 7.

6. Calculate the critical buckling pressure at the top of the pipe by the formula:

$$P_{cb} = 0.8\sqrt{(E')(P_c)}$$

Where:
P_{cb} = Critical buckling soil pressure at the top of the pipe, psi
E' = Soil Modulus, psi
P_c = Hydrostatic critical-collapse differential pressure, psi

7. Calculate the Safety Factor: SF = P_{cb} / P_T.

8. The above procedures can be reversed to calculate the minimum pipe DR required for a given soil pressure and an estimated soil density.

In a direct burial pressurized pipeline, the internal pressure is usually great enough to exceed the external critical-buckling soil pressure. When a pressurized line is to be shut down for a period, wall buckling should be examined.

Attachment D

Calculation Package G
Seismic Performance Evaluation

Calculation Package G-1
Seismic Hazard Evaluation and Evaluation of Design Ground Motions

GeoSyntec Consultants

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: Parsons **Project:** BRC CAMU **Project/Proposal #:** HL 0389 **Task #:** 04

Title of Computations: Seismic Hazard Evaluation and Evaluation of Design Ground Motions

Computations By:
SIGNATURE — DATE: 05-04-2000
Neven Matasovic / Project Engineer
PRINTED NAME AND TITLE

Assumptions and Procedures Checked By (Peer Reviewer):
SIGNATURE — DATE: 07/24/00
Edward Kavazanjian, Jr. / Principal
PRINTED NAME AND TITLE

Computations Checked By:
SIGNATURE — DATE: 5/04/00
Geoffrey L. Smith / Staff Engineer
PRINTED NAME AND TITLE

Computations Backchecked By (Originator):
SIGNATURE — DATE: 07-26-00
Neven Matasovic / Project Engineer
PRINTED NAME AND TITLE

Approved By (PM or Designate):
SIGNATURE — DATE: 07/24/00
Edward Kavazanjian, Jr / Principal
PRINTED NAME AND TITLE

Approval Notes:

Revisions: (Number and Initial All Revisions)

No.	Sheet	Date	By	Checked By	Approval

Written by: Neven Matasovic Date: 05 / 03 / 00 Reviewed by: _____ Date: ___ / ___ / ___ (MM DD YY)

Client: Parsons Project: BRC CAMU Project No.: HL0389 Task No.: 04

SEISMIC HAZARD EVALUATION AND EVALUATION OF DESIGN GROUND MOTIONS BRC CAMU HENDERSON, NEVADA

BACKGROUND AND PURPOSE

The proposed BRC CAMU (BRC site) is located in Henderson, Nevada, approximately 10 miles (16 km) southeast of Las Vegas. The approximate site location is shown on Figure 1. Approximate coordinates of the geometric center of the site are 36.0412 North Latitude and -114.9964 West Longitude.

The purpose of the evaluations documented herein is:

- to estimate Peak Horizontal Ground Acceleration (PHGA) at hypothetical bedrock outcrop at the geometric center of the BRC site; and
- to develop representative ground motions for seismic site response analyses at the site.

EVALUATION OF SEISMIC HAZARD

GeoSyntec evaluated the seismic hazard at the site using the most recent United States Geological Survey (USGS) probabilistic seismic hazard maps [Frankel et al., 1996]. For compliance with the State of Nevada regulations, GeoSyntec considered motions with 2 percent probability of being exceeded in 50 years [2% PE in 50 yrs., which is equivalent to the 10% PE in 250 yrs. used by Algermissen et al., 1990]. The Frankel et al. [1996] maps are accessible via the Internet. In addition to bedrock free-field PHGA values, these maps also provide 5 percent damping elastic Spectral Acceleration (S_a) values for spectral periods of 0.2, 0.3 and 1.0 seconds. This data was used to establish the design free-field PHGA and set limits on the target acceleration response spectrum for design ground motions.

Information obtained from the USGS web site is enclosed in Appendix A. The Frankel et al. [1996] 2% PE in 50 yrs. map values indicate that the free-field bedrock PHGA at the site equals to 0.34 g. The same maps indicate that the 0.2, 0.3 and 1.0 seconds spectral acceleration values for 5 percent spectral damping equal 0.82 g, 0.64 g and 0.21 g, respectively. The map-derived

spectral acceleration values are plotted on Figure 2. The acceleration response spectrum defined by the above cited (spectral) acceleration points is referred to herein as the "target" spectrum and serves as the basis for evaluation of design ground motions for the site, as explained below.

Frankel et al. [1996] also provide limited disaggregated seismic hazard that can be used to establish the design earthquake magnitude. Tabulated disaggregated seismic hazard (contributing earthquake magnitudes) can be obtained from the USGS web site for the major cities in the area. To evaluate the design earthquake magnitude for the BRC CAMU site, GeoSyntec downloaded the disaggregated seismic hazard data for Las Vegas. Information obtained from the USGS web site is enclosed in Appendix A. The disaggregation of the seismic hazard for Las Vegas indicates that a Moment Magnitude (M_w) 6.5 earthquake governs the seismic hazard in the area.

EVALUATION OF DESIGN GROUND MOTIONS

A suite of representative acceleration time histories, time histories which conform to the target acceleration response spectrum and magnitude of the design earthquake, was selected for use in the seismic response analyses. GeoSyntec selected a suite of three time histories that enveloped the target response spectrum using the following methodology: (i) screen the database of acceleration time histories on the basis of earthquake magnitude to select a reduced set of accelerograms; and (ii) plot the acceleration response spectra of the candidate accelerograms against target acceleration response spectrum and select the representative accelerograms for use in design analyses.

Using the above methodology, GeoSyntec selected the following three candidate accelerograms to represent design ground motions at the BRC site:

- The Cholame Shandon Array No. 5 (355 deg) accelerogram, recorded during the M_w 6.3 Parkfield earthquake. The Parkfield earthquake occurred on 27 June 1966 on a strike-slip fault.

- The Superstition Mountain (135 deg) accelerogram, recorded during the M_w 6.5 Imperial Valley earthquake. The Imperial Valley earthquake occurred on 15 October 1979 on a strike-slip fault.

- The Big Bear Lake - Civic Center Grounds (360 deg) accelerogram, recorded during the M_w 6.7 Big Bear earthquake. The Big Bear earthquake occurred on 28 June 1992 on a strike-slip fault.

The acceleration response spectra of the scaled candidate design accelerograms are plotted against the target acceleration response spectrum on Figure 2. Figure 2 indicates that the acceleration response spectra of Cholame Shandon Array No. 5, Superstition Mountain and Big Bear Lake - Civic Center Grounds accelerograms match and exceed the target acceleration response spectrum in the period range of 0.1 to 1.0 seconds, the period range of interest for seismic design considerations at the site. Therefore, the Cholame Shandon Array No. 5, Superstition Mountain and Big Bear Lake - Civic Center Grounds accelerograms scaled to 0.34 g were selected as the representative acceleration time histories for use in seismic site response analyses at the BRC site.

REFERENCES

Algermissen, S.T., Perkins, D.M., Thenhaus, P.C., Hanson, S.L. and Bender, B.L. [1990], "Probabilistic Earthquake Acceleration and Velocity Maps for the United States and Puerto Rico," Miscellaneous Field Studies Map MF-2120, U.S. Geological Survey, Reston, Virginia.

Frankel, F., Mueller, C., Bernhard, T., Perkins, D., Leyendecker, Dickman, N., Hanson, S. and Hopper, M. [1996], "Interim National Hazard Maps: Documentation," *Draft Report*, U.S. Geological Survey, Denver, Colorado.

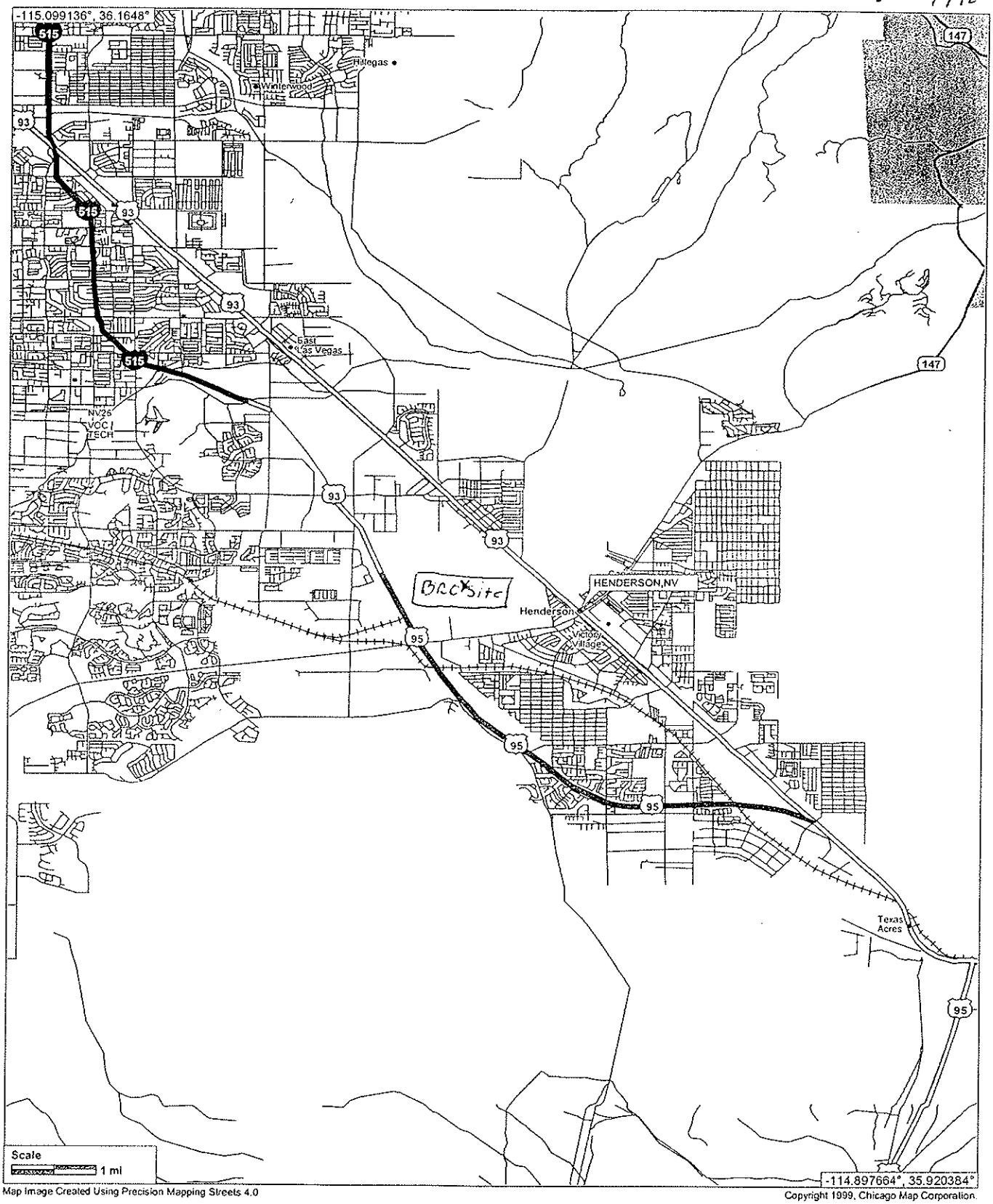
Calc.
MJB

N.M. 05-04-00

Fig. 1

Approximate Site Location

GK 07/24/00
4/12



Map Image Created Using Precision Mapping Streets 4.0

Copyright 1999, Chicago Map Corporation.

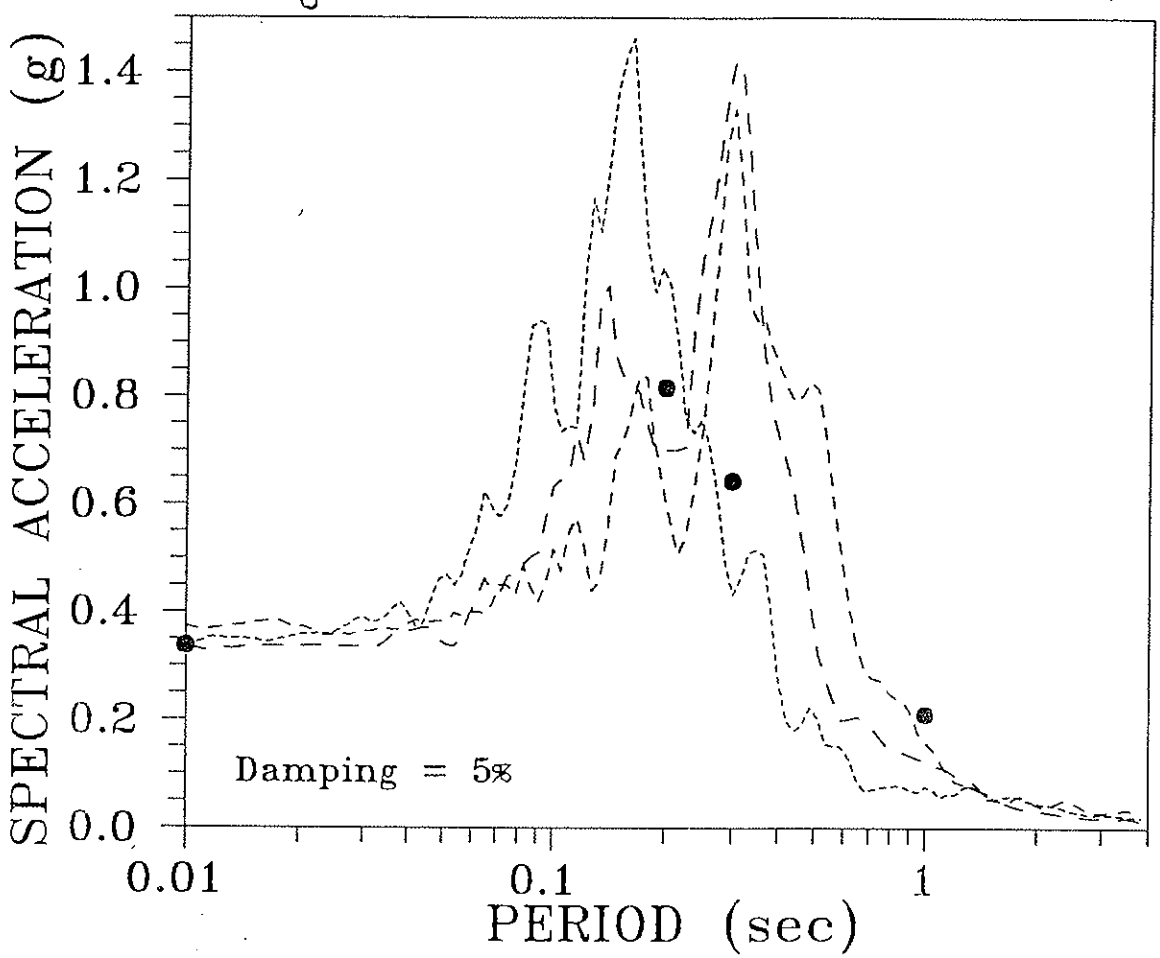
Calc

N.M. 35-04-00

EW: 07/24/00

Fig. 2

5/12



●●●●● Spectral values from USGS web site (2% PE in 50 yrs.)
------- Superstition Mountain Accelerogram (135 deg)
- - - - Cholame Shandon Array No. 5 Accel. (355 deg)
— — Big Bear Lake – Civic Center Grounds (360 deg)

APPENDIX A

SEISMIC HAZARD FOR THE BRC SITE
AND
DISAGGREGATED SEISMIC HAZARD FOR LAS VEGAS
(2% PE IN 50 YEARS)

Calc

N.M. 05-04-00

7/12

USGS

Home Page

Lat/Lon Lookup page

NATIONAL SEISMIC HAZARD MAPPING PROJECT

USGS, Central Region, Geologic Hazards Team
Golden, Colorado

The ground motion values for the requested point:

LOCATION	36.0412 Lat. -114.9964 Long.
DISTANCE TO NEAREST GRID POINT	4.58287299074001 kms
NEAREST GRID POINT	36.00000 Lat. -115.0000 Long.

Probabilistic ground motion values, in %g, at this point are:

	10%PE in 50 yr	5%PE in 50 yr	2%PE in 50 yr
PGA	13.85668	20.33881	33.70004 ✓
0.2 sec SA	31.82535	47.43614	81.64591
0.3 sec SA	27.39132	41.04289	64.31845
1.0 sec SA	8.801240	13.04513	21.02698

The program has detected a zero latitude and has assumed the end of valid input data.

EK 07/24/00

Calc 4/8

11.M. 05-04-00

USGS

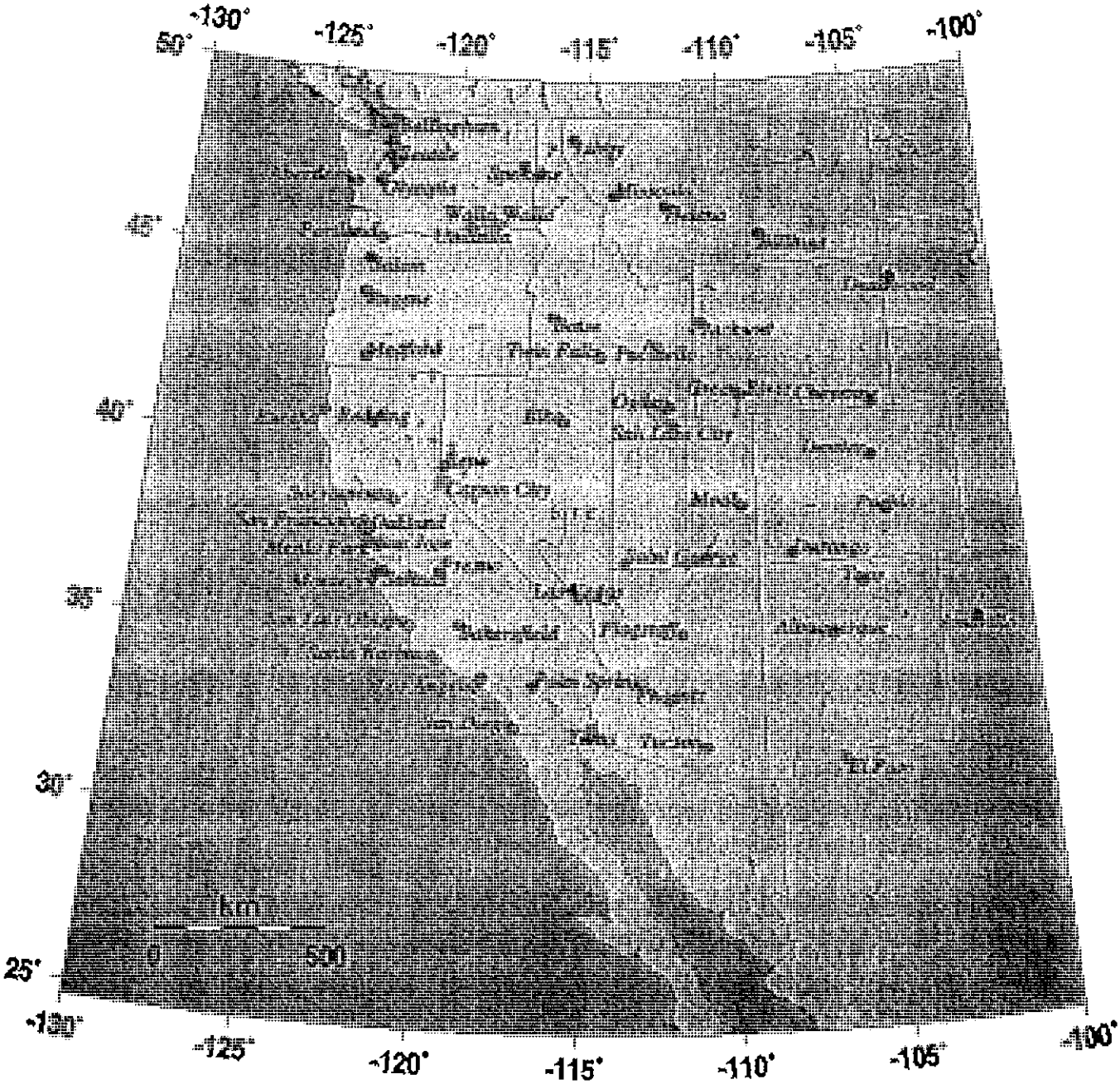
NATIONAL SEISMIC HAZARD MAPPING PROJECT 8/12
Golden, Colorado

EK 07/24/00

Please note that the image map on this page is a client-side image map.
YOU WILL NEED A BROWSER WHICH SUPPORTS CLIENT-SIDE IMAGE MAPS TO USE IT!!!
(such as Netscape Navigator 2.0 or Microsoft Internet Explorer 3.0 or the equivalent)

To obtain the four hazard matrices click on the city (red dot). The entries are per cent contribution to hazard. They will sum to 100 per cent for each matrix.

WUS Cities



Calc
RB

http://geohazards.cr.usgs.gov/eq/deagg/lasvegas.html

N.M. 05-04-00

9/12

EK
07/24/00

Deaggregated Seismic Hazard PE = 2% in 50 years pga
Las_Vegas NV 36.175 deg N 115.136 deg W PGA=0.27640 g

M<=	5.0	5.5	6.0	6.5	7.0	7.5
d<= 25.	0.000	16.873	15.484	47.082	16.578	0.000
50.	0.000	0.101	0.310	0.353	3.037	0.000
75.	0.000	0.003	0.007	0.051	0.064	0.000
100.	0.000	0.000	0.000	0.005	0.010	0.001
125.	0.000	0.000	0.000	0.002	0.005	0.000
150.	0.000	0.000	0.000	0.001	0.019	0.006
175.	0.000	0.000	0.000	0.000	0.002	0.005
200.	0.000	0.000	0.000	0.000	0.001	0.000

Deaggregated Seismic Hazard PE = 2% in 50 years 1hz
Las_Vegas NV 36.175 deg N 115.136 deg W SA= 0.18000 g

M<=	5.0	5.5	6.0	6.5	7.0	7.5
d<= 25.	0.000	3.479	7.223	47.502	19.347	0.000
50.	0.000	0.076	0.318	3.177	15.119	0.000
75.	0.000	0.004	0.022	0.510	1.095	0.000
100.	0.000	0.000	0.001	0.050	0.184	0.037
125.	0.000	0.000	0.000	0.023	0.125	0.000
150.	0.000	0.000	0.000	0.008	0.641	0.389
175.	0.000	0.000	0.000	0.006	0.073	0.413
200.	0.000	0.000	0.000	0.002	0.042	0.076
225.	0.000	0.000	0.000	0.005	0.012	0.000
300.	0.000	0.000	0.000	0.000	0.001	0.000
325.	0.000	0.000	0.000	0.000	0.003	0.000
350.	0.000	0.000	0.000	0.001	0.006	0.000
375.	0.000	0.000	0.000	0.001	0.009	0.000
400.	0.000	0.000	0.000	0.002	0.004	0.000
425.	0.000	0.000	0.000	0.002	0.002	0.000
450.	0.000	0.000	0.000	0.001	0.003	0.000
475.	0.000	0.000	0.000	0.001	0.002	0.000
500.	0.000	0.000	0.000	0.001	0.001	0.000

Deaggregated Seismic Hazard PE = 2% in 50 years 3.33 hz (0.3 s)
Las_Vegas NV 36.175 deg N 115.136 deg W SA= 0.55200 g

M<=	5.0	5.5	6.0	6.5	7.0	7.5
d<= 25.	0.000	10.013	12.605	50.737	17.888	0.000
50.	0.000	0.125	0.256	1.394	6.637	0.000
75.	0.000	0.003	0.008	0.111	0.158	0.000
100.	0.000	0.000	0.000	0.007	0.016	0.002
125.	0.000	0.000	0.000	0.002	0.008	0.000
150.	0.000	0.000	0.000	0.000	0.019	0.004
175.	0.000	0.000	0.000	0.000	0.001	0.003
200.	0.000	0.000	0.000	0.000	0.001	0.000

Deaggregated Seismic Hazard PE = 2% in 50 years 5hz
Las_Vegas NV 36.175 deg N 115.136 deg W SA= 0.62990 g

M<=	5.0	5.5	6.0	6.5	7.0	7.5
d<= 25.	0.000	13.541	14.177	49.428	16.715	0.000
50.	0.000	0.171	0.247	1.004	4.559	0.000
75.	0.000	0.003	0.005	0.061	0.070	0.000
100.	0.000	0.000	0.000	0.003	0.005	0.001
125.	0.000	0.000	0.000	0.001	0.002	0.000
150.	0.000	0.000	0.000	0.000	0.004	0.001

MN

N.A. 05-24-00 10/12

USGS

NATIONAL SEISMIC HAZARD MAPPING PROJECT
Golden, Colorado

EK 07/24/00

LAS VEGAS NV

Hazard matrices

The distance scale on the following two maps is accurate in the east-west direction,
but there is foreshortening in the north-south direction.

Disaggregated Seismic Hazard for 1 second Spectral Acceleration
GIF, PDF, PS
Disaggregated Seismic Hazard for 0.2 second Spectral Acceleration
GIF, PDF, PS

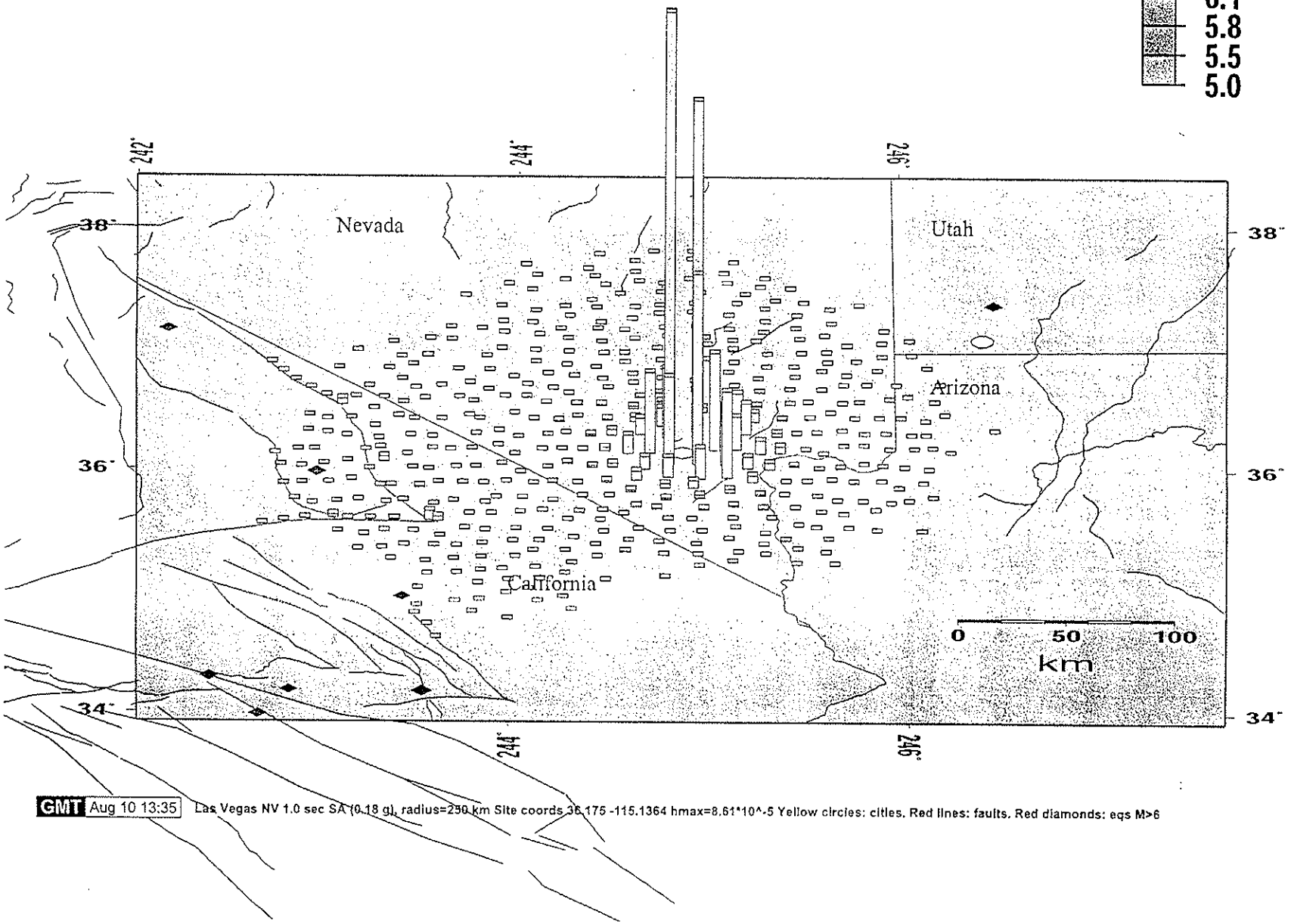
Las Vegas NV Disaggregated Seismic Hazard

for 1 second Spectral Acceleration, 0.18 g

PE = 2% per 50 yr. Hazard radius 250 km, DeltaR=10 km

Mw: Binned average; equal-area bins.

Most hazard from gridded seismicity; Eglington Fault ca. 5%



Calif

EK 07/24/00

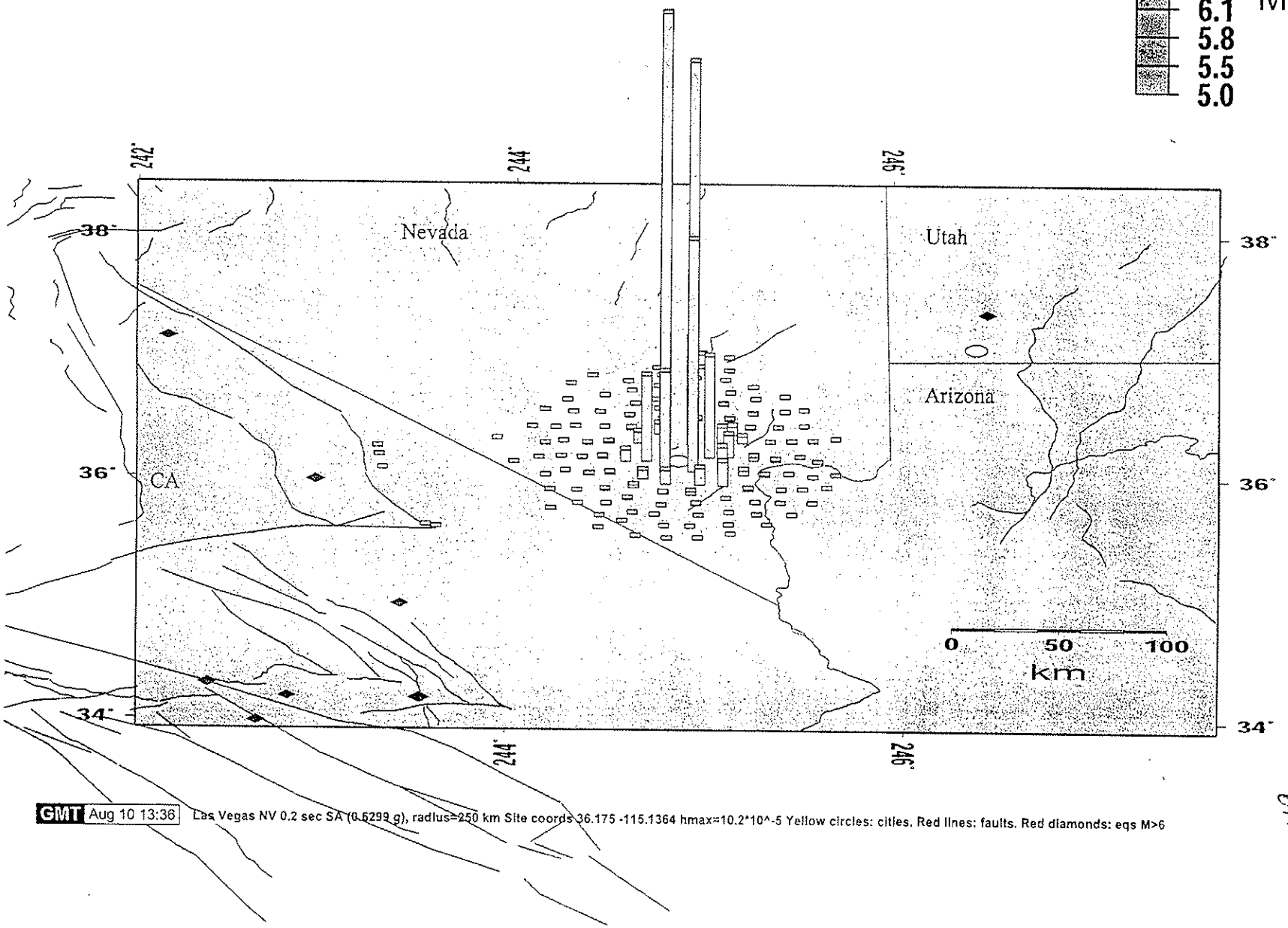
N.M. 05-06-00

11/12

Las Vegas NV Disaggregated Seismic Hazard

for 0.2 second Spectral Acceleration, 0.63 g

PE = 2% per 50 yr. Hazard radius 250 km, DeltaR=10 km
Mw: Binned average; equal-area bins.
Most hazard from gridded seismicity; Eglington Fault ca. 5%



GMT Aug 10 13:36 Las Vegas NV 0.2 sec SA (0.6299 g), radius=250 km Site coords 36.175 -115.1364 hmax=10.2*10^-5 Yellow circles: cities. Red lines: faults. Red diamonds: eqs M>6

Calif Fgs

N.Y. 07-01-00

12/12

EK 07/24/00

Calculation Package G-2
Site Response Analysis

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: Parsons **Project:** BRC CAMU **Project #:** HL0389 **Task #:** 04

Title of Computations: Seismic Site Response Analysis

Computations By:

SIGNATURE — DATE: 26 July 2000

Michael E. Kalinski / Senior Staff Engineer
PRINTED NAME AND TITLE

Assumptions and Procedures Checked By (Peer Reviewer):

SIGNATURE — DATE: 07-26-00

Neven Matasovic / Project Engineer
PRINTED NAME AND TITLE

Computations Checked By:

SIGNATURE — DATE: 7-26-00

Geoff Smith/Staff Engineer
PRINTED NAME AND TITLE

Computations Backchecked By (Originator):

SIGNATURE — DATE: 7-26-2000

Michael E. Kalinski / Senior Staff Engineer
PRINTED NAME AND TITLE

Approved By (PM or Designate):

SIGNATURE — DATE: 07/26/00

Edward Kavazanjian, Jr. / Principal
PRINTED NAME AND TITLE

Approval Notes: _____

Revisions:

No.	Date	Description	Approval

Written by: Michael E. Kalinski Date: 07 / 26 / 00 (MM DD YY) Reviewed by: Date: 07 / 26 / 00 (MM DD YY)

Client: Parsons Project: BRC CAMU Project No.: HL0389 Task No.: 04

PURPOSE

One-dimensional site response analyses were performed for the BRC Landfill in Henderson, Nevada using the SHAKE91 computer program [SHAKE91, 1992]. Analyses were performed to assess the dynamic site response of the compacted landfill to three design earthquake seismograms. This ~~memo~~ calculation package provides the details of the analyses. Synthetic accelerograms for the ground surface derived from these analyses were used in the companion computation package titled "Site-Specific Seismic Deformation Charts."

SUMMARY OF SHAKE91

SHAKE91 is a computer program for conducting an equivalent linear seismic response analysis of a horizontally layered soil deposit [SHAKE91, 1992]. SHAKE91 was originally written in 1972, but has undergone several modifications and revisions to its present form. SHAKE91 performs a frequency-domain analysis of a one-dimensional soil column subjected to earthquake shaking in bedrock at its base. SHAKE91 is based on the assumption that the earthquake is a vertically propagating shear wave.

The three main sets of input parameters for SHAKE91 are 1) information about the soil profile, 2) information about how the dynamic properties of the soil (shear modulus and damping) vary with strain and 3) input ground motion. Information about the soil profile includes layer thickness, small-strain shear modulus (G_{max}) and unit weight. Information about how the dynamic properties of the soil vary with strain are provided using curves of modulus reduction (G/G_{max}) and damping versus shearing strain. Different curves are used for the different types of material (i.e. sand, clay, rock and waste) in the profile. Seismograms recorded at earthquake stations near the site being evaluated are typically used as input ground motion.

To perform the site response analysis, SHAKE91 implements an iterative procedure using an 'equivalent linear' method. In this method, the linear response of the soil column to earthquake shaking is calculated using initial estimates for G_{max} and material damping. The resulting shear strains are plotted against the modulus reduction and damping curves and the dynamic soil properties are adjusted accordingly. The linear response of the soil column is re-calculated using the adjusted parameters. The re-calculated shear strains are used to re-adjust the dynamic soil properties and the linear response of the soil column is calculated again. This procedure is repeated until the difference in dynamic soil properties between iterations is

sufficiently small. The final result is typically expressed in terms of peak accelerations calculated at the surface of the model.

PROBLEM APPROACH

Site response analyses were performed using three seismogram records. Each input record was adjusted to a maximum amplitude of 0.337 g. This value is the predicted peak ground acceleration (PGA) for Las Vegas, Nevada with a 2% probability of occurrence in a 50-year period and is based on probabilistic analysis of available earthquake data by the United States Geological Survey [USGS, 2000]. The three seismograms (Parkfield, Superstition and Big Bear) were selected based on similarities between their response spectra and the target acceleration response spectrum as described in the companion computation package titled "Seismic Hazard Evaluation and Evaluation of Design Ground Motions."

Shear wave velocity and layer thickness data were derived from SASW testing performed by Dr. Barbara Luke at the University of Nevada at Las Vegas on February 25, 2000. SASW testing was performed on native material as shown in Fig. 1. The resulting shear wave velocity data are summarized in Table 1. These data were integrated with soil boring data [Converse Consultants, 1999] to identify units of silty sand (SM), lean clay (CL), waste and bedrock within the profiles. The interpreted shear wave velocity profile is included in Fig. 2 (GeoSyntec, 2000).

Estimated unit weights for the native soil spanned a reasonable range of 120 to 130 pcf. These values were varied according to shear wave velocity. Higher values were assigned to layers with higher shear wave velocities.

For characterizing bedrock, it was assumed that the bedrock material was a hard, competent rock with a relatively high shear wave velocity (7000 ft/s) and high unit weight (140 pcf). These values are comparable to typical values observed in other hard, competent rocks.

Separate modulus reduction and damping curves were used for the materials encountered in the two profiles. Reduction curves for the clay and sand were taken from research performed by Vucetic and Dobry [1991] where the effects of plasticity index on cyclic response were investigated for a wide variety of soil types and studies. To apply the Vucetic and Dobry data to this analysis, the plasticity indices of the silty sand and lean clay were assumed to be 0% and 15%, respectively. Modulus reduction curves corresponding to silty sand were used for the

compacted waste based on the assumption that the compacted waste will be classifiable as a silty sand.

Two SHAKE91 analyses were performed on hypothetical profiles representative of the final design of the new landfill. These profiles, shown in Fig. 3, consist of 1) the existing native material overlain by 30 ft of compacted waste and 2) 60 ft of waste embedded 30 ft into the native soil. For these analyses, shear wave velocities estimated for the native material were modified to account for the effect of increased confining stress on increased shear wave velocity. As shown in Table 2, shear wave velocities of the native material were used, but shear wave velocities less than 800 ft/s were set equal to 800 ft/s to account for the increased confining stress.

← North mesa
← South mesa

To characterize the compacted waste material, shear wave velocities and unit weights of 1000 ft/s and 120 pcf, respectively, were assumed. These are reasonable values for silty sands that are compacted at 90 to 95% of optimum water content, which is the anticipated nature of the compacted waste.

Based on results from SASW testing, the depth to bedrock could not be conclusively estimated. Therefore, three sets of SHAKE91 analyses were performed by varying the thickness of the silty sand layer present at the bottom of the native material profile (Fig. 2). Silty sand layer thicknesses of 50, 100 and 150 ft were used for the analyses.

Corresponding to bedrock either 201, 251, & 301 ft bgs EK
or 231, 281, & 331 ft below top of landfill. EK 07/26/00

RESULTS

Site response analyses were performed for the two scenarios (unembedded and embedded waste) using the procedures described in the previous section. A sample SHAKE91 input file is attached to this memorandum. Peak accelerations at the surface of the landfill and native material are summarized in Table 3. The calculated accelerations are all less than 0.50 g. Embedding the compacted waste causes a minor (less than 10%) reduction in predicted surface accelerations.

Calculated profile periods are summarized in Table 4. Profile periods for modeling with the 150-ft thick bottom soil layer are all greater than 1.09 s. Since this period is longer than the maximum-amplitude period on typical response spectra, it was believed that thicker bottom layers would produce longer periods, less amplification and smaller accelerations. Therefore, modeling with layer thicknesses greater than 150 ft was not considered necessary.

REFERENCES

Converse Consultants, (1999), "Preliminary Geotechnical and Geologic Investigation, Industrial Non-Hazardous Disposal Facility, Basic Management Incorporated, Clark County, Nevada," Converse Project No. 99-33437-01, October 27, 1999, Converse Consultants, Las Vegas, Nevada.

GeoSyntec, (2000), "Preliminary Results of SASW Testing, BRC Landfill, Henderson, Nevada," interoffice memorandum from Michael E. Kalinski to Jay McKelvey, 7 April 2000.

SHAKE91, (1992), "User's Manual for SHAKE91," Center for Geotechnical Modeling, Department of Civil & Environmental Engineering, University of California at Davis.

USGS, (2000), "National Seismic Hazard Mapping Project," USGS, Central Region, Geologic Hazards Team, http://geohazards.cr.usgs.gov/eq/.

Written by: Michael E. Kalinski Date: 07 / 26 / 00 (MM DD YY) Reviewed by: Date: 7 / 26 / 00 (MM DD YY)

Client: Parsons Project: BRC CAMU Project No.: HL0389 Task No.: 04

EK 07/26/00

TABLE 1
SHEAR WAVE VELOCITY PROFILES FROM SASW MEASUREMENTS PERFORMED AT THE BRC LANDFILL, HENDERSON NEVADA

Thickness (ft)	Depth (ft)	Shear Wave Velocity (ft/s)	Material Type
0.98	0.98	426	SM
1.31	2.29	754	SM
10.8	13.09	984	SM
3.28	16.37	1082	SM
16.4	32.77	1279	SM
7.28	40.05	1312	SM
81.9	121.95	1115	CL
29.5	151.45	1246	CL
Half-space	-	1968	SM

Written by: Michael E. Kalinski Date: 07 / 26 / 00 (MM DD YY) Reviewed by: Date: 7 / 26 / 00 (MM DD YY)

Client: Parsons Project: BRC CAMU Project No.: HL0389 Task No.: 04

07/26/00

TABLE 2
SHEAR WAVE VELOCITY PROFILES USED FOR SHAKE91 ANALYSIS
NATIVE MATERIAL WITH 30 FT OF OVERBURDEN WASTE

a) 30 ft waste placed on top of native material

Thickness (ft)	Depth (ft)	Shear Wave Velocity (ft/s)	Material Type
30.00	30.00	1000	compacted waste
0.98	30.98	800	SM
1.31	32.29	800	SM
10.8	43.09	984	SM
3.28	46.37	1082	SM
16.4	62.77	1279	SM
7.28	70.05	1312	SM
81.9	151.95	1115	CL
29.5	181.45	1246	CL
50, 100 or 150	231.45, 281.45 or 331.45	1968	SM
Half-space	-	7000	bedrock

b) 30-ft excavation filled with waste to elevation of 30 ft above native ground surface (60 ft total waste thickness)

Thickness (ft)	Depth (ft)	Shear Wave Velocity (ft/s)	Material Type
30.00	30.00	1000	compacted waste
30.00	60.00	1000	compacted waste
2.77	62.77	1279	SM
7.28	70.05	1312	SM
81.9	151.95	1115	CL
29.5	181.45	1246	CL
50, 100 or 150	231.45, 281.45 or 331.45	1968	SM
Half-space	-	7000	bedrock

TABLE 3
PEAK GROUND SURFACE ACCELERATIONS CALCULATED USING SHAKE91

EK 07/26/00

a) 30 ft Compacted Waste over Native Material

Earthquake	Bottom soil layer = 50 ft thick	Bottom soil layer = 100 ft thick	Bottom soil layer = 150 ft thick
Big Bear	0.47 g	0.50	0.46
Parkfield	0.43	0.47	0.48
Superstition	0.40	0.35	0.31
AVERAGE	**0.43**	**0.44**	**0.42**

b) 60 ft Compacted Waste Embedded into Native Material

Earthquake	Bottom soil layer = 50 ft thick	Bottom soil layer = 100 ft thick	Bottom soil layer = 150 ft thick
Big Bear	0.41 g	0.44	0.41
Parkfield	0.40	0.44	0.42
Superstition	0.38	0.34	0.31
AVERAGE	**0.40**	**0.41**	**0.38**

Written by: Michael E. Kalinski Date: 07 / 26 / 00 (MM DD YY) Reviewed by: Date: 7 / 26 / 00 (MM DD YY)

Client: Parsons Project: BRC CAMU Project No.: HL0389 Task No.: 04

07/26/00

TABLE 4
SOIL PROFILE PERIODS CALCULATED USING SHAKE91

a) 30 ft Compacted Waste Over Native Material

Earthquake	Bottom soil layer = 50 ft thick	Bottom soil layer = 100 ft thick	Bottom soil layer = 150 ft thick
Big Bear	0.95 s	1.10	1.22
Parkfield	0.94	1.05	1.19
Superstition	0.91	1.01	1.09

b) 60 ft Compacted Waste Embedded into Native Material

Earthquake	Bottom soil layer = 50 ft thick	Bottom soil layer = 100 ft thick	Bottom soil layer = 150 ft thick
Big Bear	0.98 s	1.11	1.22
Parkfield	0.95	1.06	1.21
Superstition	0.92	1.01	1.09

Written by: Michael E. Kalinski Date: 07 / 26 / 00 (MM DD YY) Reviewed by: Cole Date: 7 / 26 / 00 (MM DD YY)

Client: Parsons Project: BRC CAMU Project No.: HL0389 Task No.: 04

EK 07/26/00

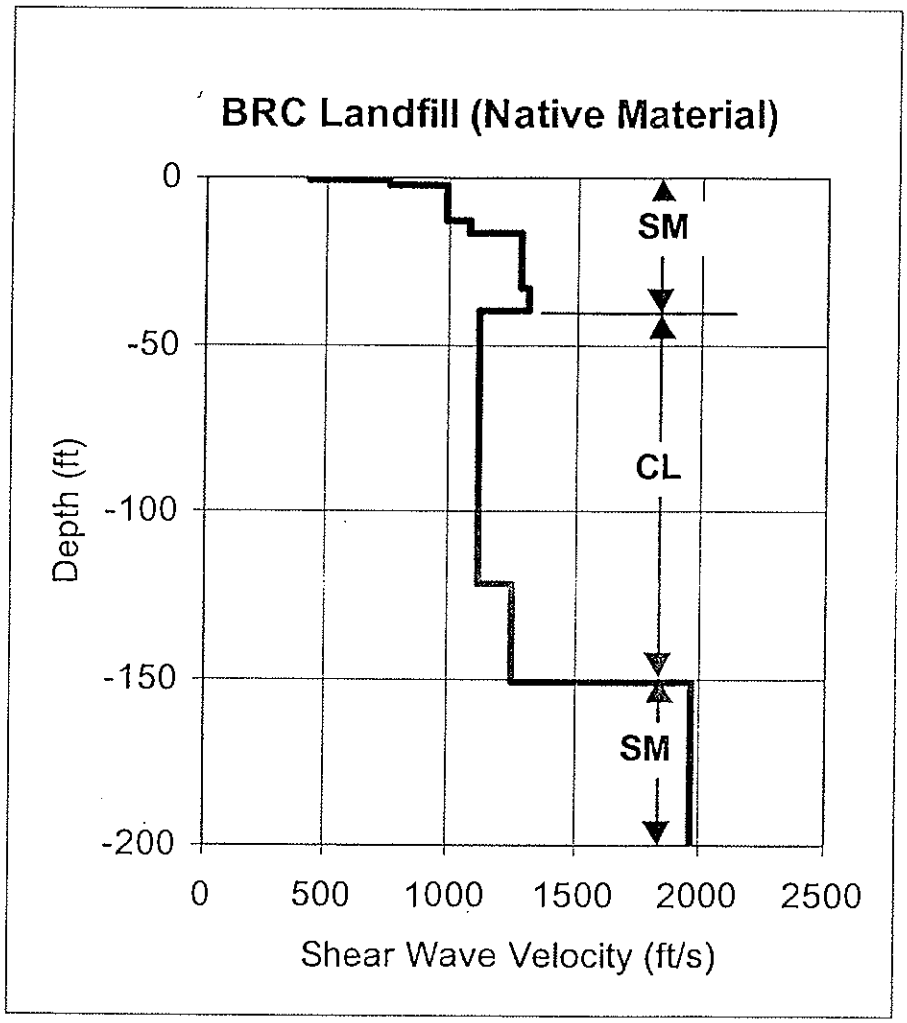


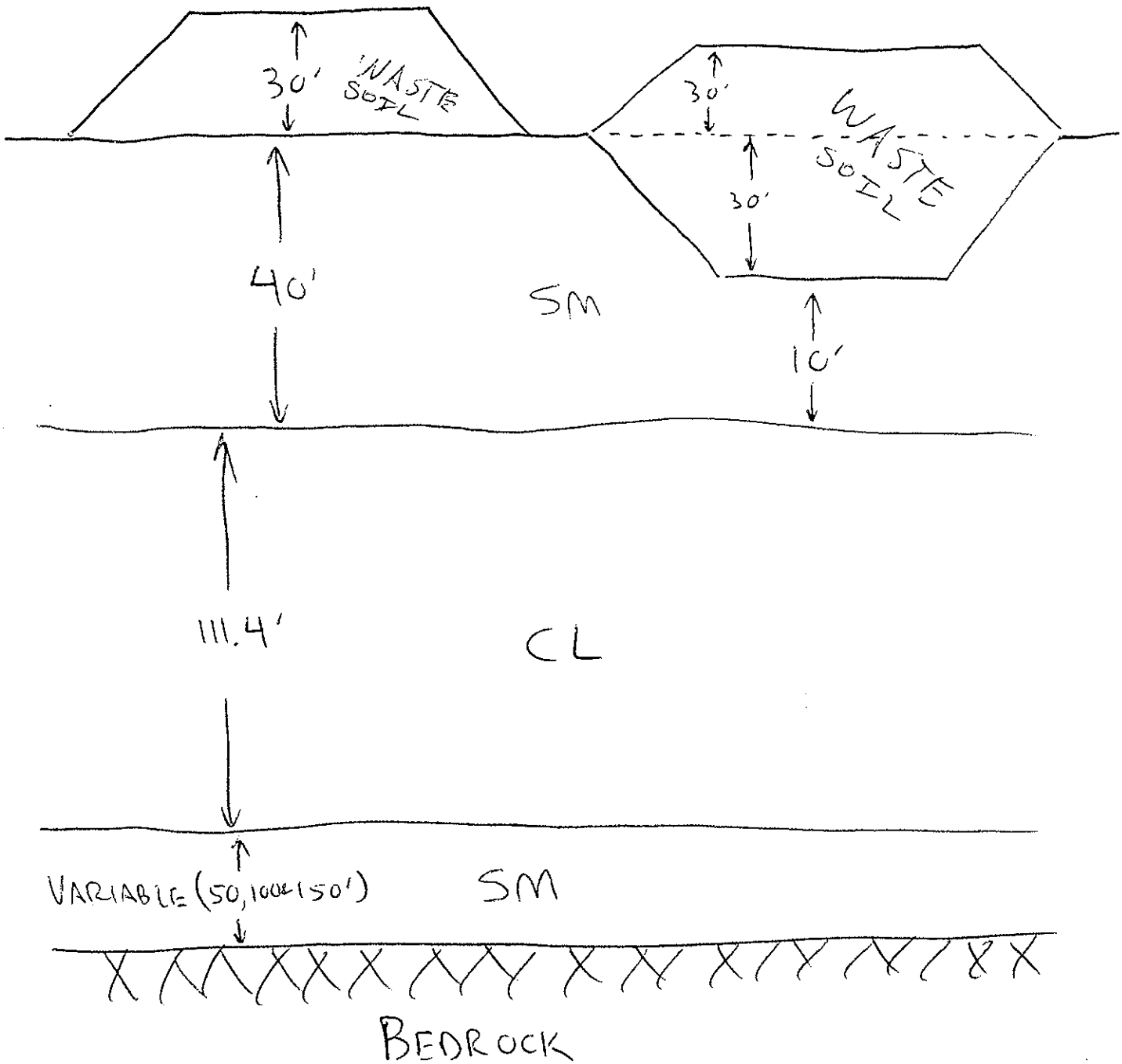
FIGURE 2. SHEAR WAVE VELOCITY PROFILE OF NATIVE MATERIAL FROM SASW DATA

Written by: VMC Date: / / (YY MM DD) Reviewed by: Cale Date: 7 / 26 / 00 (YY MM DD)

Client: Project: Project/Proposal No.: Task No.:

FIG 3 SOIL PROFILES USED FOR NEW COMPACTED LANDFILL.

ESK 07/26/00



Written by: Michael E. Kalinski Date: 07 / 26 / 00 (MM DD YY) Reviewed by: Calle Date: 9 - 20 - 00 (MM DD YY)

Client: Parsons Project: BRC CAMU Project No.: HL0389 Task No.: 04

EK 07/26/00

ATTACHMENT

SAMPLE SHAKE91 INPUT FILE

(Embedded Waste, Big Bear Earthquake, Bottom Soil Layer Thickness = 100 ft)

embedN2

7.26

Calc 1-20-00

14/15

```
option 1 - dynamic soil properties - (max is thirteen):
    1
    3
   10  #1 Modulus for Clay (PI=15) (Vucetic and Dobry, 1991)
    0.0001  0.000316     0.001   0.00316      0.01    0.0316
 0.1     0.316
        1.      3.16
     1.000     1.000     0.995     0.936     0.818     0.640     0
.405     0.210
     0.095     0.034
   10  #1 Damping for Clay (PI=15) (Vucetic and Dobry, 1991)
    0.0001  0.000316     0.001   0.00316      0.01    0.0316
 0.1     0.316
        1.      3.16
      0.85      1.04      1.55      2.58     4.635      7.77     1
1.67    16.085
     20.12     23.17
   10  #2 Modulus for Sand (PI=0) (Vucetic and Dobry, 1991)
   0.0001   0.000316     0.001   0.00316      0.01    0.0316
 0.1     0.316
      1.0      3.16
    1.000     1.000     0.964     0.870     0.712     0.474     0
.253     0.103
    0.028     0.004
    9  #2 Damping for Sand (PI=0) (Vucetic and Dobry, 1991)
   0.0001   0.000316    0.0010    0.0032      0.01    0.0316
 0.1     0.316
      1.0      3.16
     0.85      1.04      1.66     2.999      5.48     10.01     1
5.40     20.23
    23.94     26.17
    8  #3 Modulus for Rock
    0.0001    0.0003     0.001     0.003      0.01      0.03
 0.1       1.0
     1.000     1.000    0.9875    0.9525     0.900     0.810     0
.725     0.550
    5  #3 Damping for Rock
    0.0001     0.001      0.01       0.1       1.0
       0.4       0.8       1.5       3.0       4.6
    3    1    2    3
Option 2 -- Soil Profile
    2
    1    8      Profile embedN2 -- 60 ft waste embedded 30 ft
    1    2          30.00                .010      .120      1000
    2    2          30.00                .010      .120      1000
    3    2           2.77                .010      .125      1279
    4    2           7.28                .010      .125      1312
    5    1           81.9                .020      .125      1115
```

EK

07/26/0

MMK 7-26 Cale 7/26/00 15/15

```
    6    1            29.5                    .020       .125       1246
    7    2           100.0                    .010       .130       1968
    8    3                                    .005       .125       7000
Option 3 -- input motion:
    3
 2000 4096        .01 bigbear.acc                    (8f9.6)
                0.337      50.0    2    8
Option 4 -- sublayer for input motion (within (1) or outcropping (
0):
    4
    8    0
Option 5 -- number of iterations & ratio of avg strain to max stra
in
    5
    0   12        0.6
Option 6 -- sublayers for which accn time histories are computed &
 saved:
    6
    1    2    3    4    5    6    7    8
    1    1    1    1    1    1    1    1
    1    0    0    0    0    0    0    0
Option 7 -- sublayer for which shear stress or strain are computed
 & saved:
    7
    8    1    1      2000          -- stress at top of bedrock
    8    0    1      2000          -- strain at top of bedrock
Option 10 -- compute & save amplification spectrum:
   10
    8    0    1    0      0.25 -- ground surface/rock outcrop
execution will stop when program encounters 0
    0
```

EK 07/26/00

FIG. 1

10/15

CK 07/26/00

Cale 7-26 188

Approximate Boring Locations (... 11/21/90 B.S. NO. 2, FILE # 43701052)

PARSONS ENGINEERING SCIENCE, PASADENA, CAL

JOB NO. 7

Calculation Package G-3
Seismic Deformation Charts

GeoSyntec Consultants

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: Parsons **Project:** BRC CAMU **Project/Proposal #:** HL0389 **Task #:** 04

Title of Computations: Site-Specific Seismic Deformation Charts

Computations By:
SIGNATURE — DATE: ~~25~~ 26 July 2000
Geoff L. Smith / Staff Engineer
PRINTED NAME AND TITLE

Assumptions and Procedures Checked By (Peer Reviewer):
SIGNATURE — DATE: 07-26-00
Neven Matasovic / Project Engineer
PRINTED NAME AND TITLE

Computations Checked By:
SIGNATURE — DATE: 26 JULY 2000
Michael E. Kalinski / Senior Staff Engineer
PRINTED NAME AND TITLE

Computations Backchecked By (Originator):
SIGNATURE — DATE: 7-26-00
Geoff L. Smith / Staff Engineer
PRINTED NAME AND TITLE

Approved By (PM or Designate):
SIGNATURE — DATE: 07/26/00
Edward Kavazanjian, Jr. / Principal
PRINTED NAME AND TITLE

Approval Notes:

Revisions: (Number and Initial All Revisions)

No.	Sheet	Date	By	Checked By	Approval

Written by: Geoff L. Smith GLS Date: 07 / 25 / 00 (MM DD YY) Reviewed by: MRC 7.26 Date: / / (MM DD YY)

Client: Parsons Project: BRC CAMU Project No.: HL0389 Task No.: 04

SITE-SPECIFIC SEISMIC DEFORMATION CHARTS
BRC CAMU
HENDERSON, NEVADA

EK 07/26/00

BACKGROUND AND PURPOSE

The purpose of the analyses documented herein is to develop site-specific seismic deformation charts for the proposed BRC CAMU in Henderson, Nevada. Due to different geometry, the deformation response for the borth North Mesa and the South Mesa were evaluated. The North Mesa is characterized by a 30 ft (10 m) contaminated soil fill placed on native ground. The South Mesa is characterized by a 60 ft (20 m) thick comtaiminated soil fill that is embedded 30 ft (10 m) below native ground surface. The analyses presented herein are based on results documented in a companion calculation package (seismic site response analyses).

METHOD OF ANALYSIS

The site-specific seismic deformation charts were developed using the computer program YSLIP_PM [Yan et al. 1996]. YSLIP_PM is based upon the Newmark [1965] seismic deformation analysis.

The Newmark method assumes a rigid block on a plane. The block base is subjected to earthquake-induced accelerations. YSLIP_PM calculates the permanent displacement of the rigid block from pseudostatically-evaluated yield accelerations and block base accelerations evaluated in a site response analysis.

ANALYSIS

The analysis consisted of inputting site response acceleration time histories generated by SHAKE91 [Idriss and Sun 1992] into YSLIP_PM. Since bedrock is deep below the ground surface, the depth to the bedrock was varied. Depth to bedrock was assumed to be 201, 251, and 301 ft below the ground surface and 231, 281, and 331 feet below the top of the the landfill.

Written by: Geoff L. Smith Date: 07 / 25 / 00 (MM DD YY) Reviewed by: Date: / / (MM DD YY)

Client: Parsons Project: BRC CAMU Project No.: HL0389 Task No.: 04

EK 07/26/00

A suite of three accelerograms were used to represent the conditions at the BRC CAMU. The three accelerograms were:

- The Cholame Shandon Array No. 5 (355 deg.) accelerogram, recorded during the M_w 6.3 Parkfield earthquake. The Parkfield earthquake occurred on 27 June 1996 on a strike-slip fault.

- The Superstition Mountain (135 deg.) accelerogram, recorded during the M_w 6.5 Imperial Valley earthquake. The Imperial Valley earthquake occurred on 15 October 1979 on a strike-slip fault.

- The Big Bear Lake - Civic Center Grounds (360 deg.) accelerogram, recorded during the M_w 6.7 Big Bear earthquake. The Big Bear earthquake occurred on 28 June 1992 on a strike-slip fault.

The three depths to bedrock for each accelerogram for native and landfill site conditions were analyzed to evaluate a suite of site-specific seismic deformation responses.

RESULTS

The results of evaluations documented herein are plotted on the charts shown in Figure 1 (North Mesa characterized by 30 ft high landfill) and Figure 2 (South Mesa characterized by a 60 ft waste soil thickness embedded 30 ft below native ground suface). Inspection of Figures 1 and 2 indicate that the North Mesa displacement response is more critical than the South Mesa, although both ~~locations~~ responses are similar. The results further indicate that the largest seismic displacement response is calculated by applying the Parkfield record to the base of the 331 ft (101 m) high soil (soil/landfill) column.

Written by: Geoff L. Smith Date: 07 / 25 / 00 (MM DD YY) Reviewed by: Date: / / (MM DD YY)

Client: Parsons Project: BRC CAMU Project No.: HL0389 Task No.: 04

EK 07/26/00

REFERENCES

Idriss, I.M., Sun, J. I. (1992), "User's Manual for SHAKE91, A Computer Program for Conducting Equivalent Linear Seismic Response Analyses of Horizontally Layered Soil Deposits," Center for Geotechnical Modeling, Department of Civil and Environmental Engineering, University of California, Davis, California, November 1992.

Newmark, N.M. (1965), "Effects of Earthquakes on Dams and Embankments," Geotechnique, Vol. 15, No. 2, pp. 139-160.

Yan, L., Matasovic, N., and Kavazanjian, E. (1996), "YSLIP_PM - User's Guide," Research Report, GeoSyntec Consultants, Huntington Beach, California

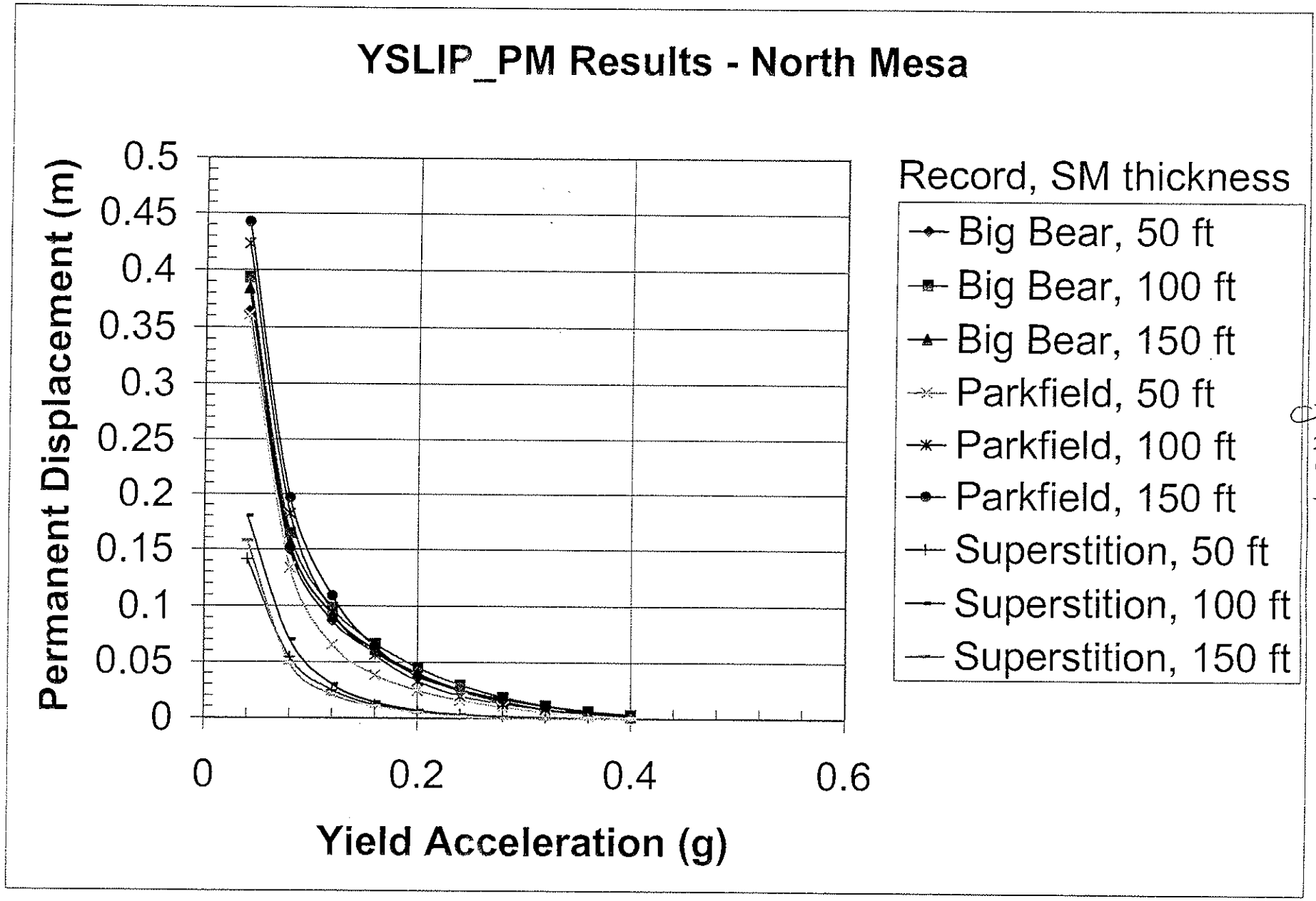


Figure 1

Page 7-7a

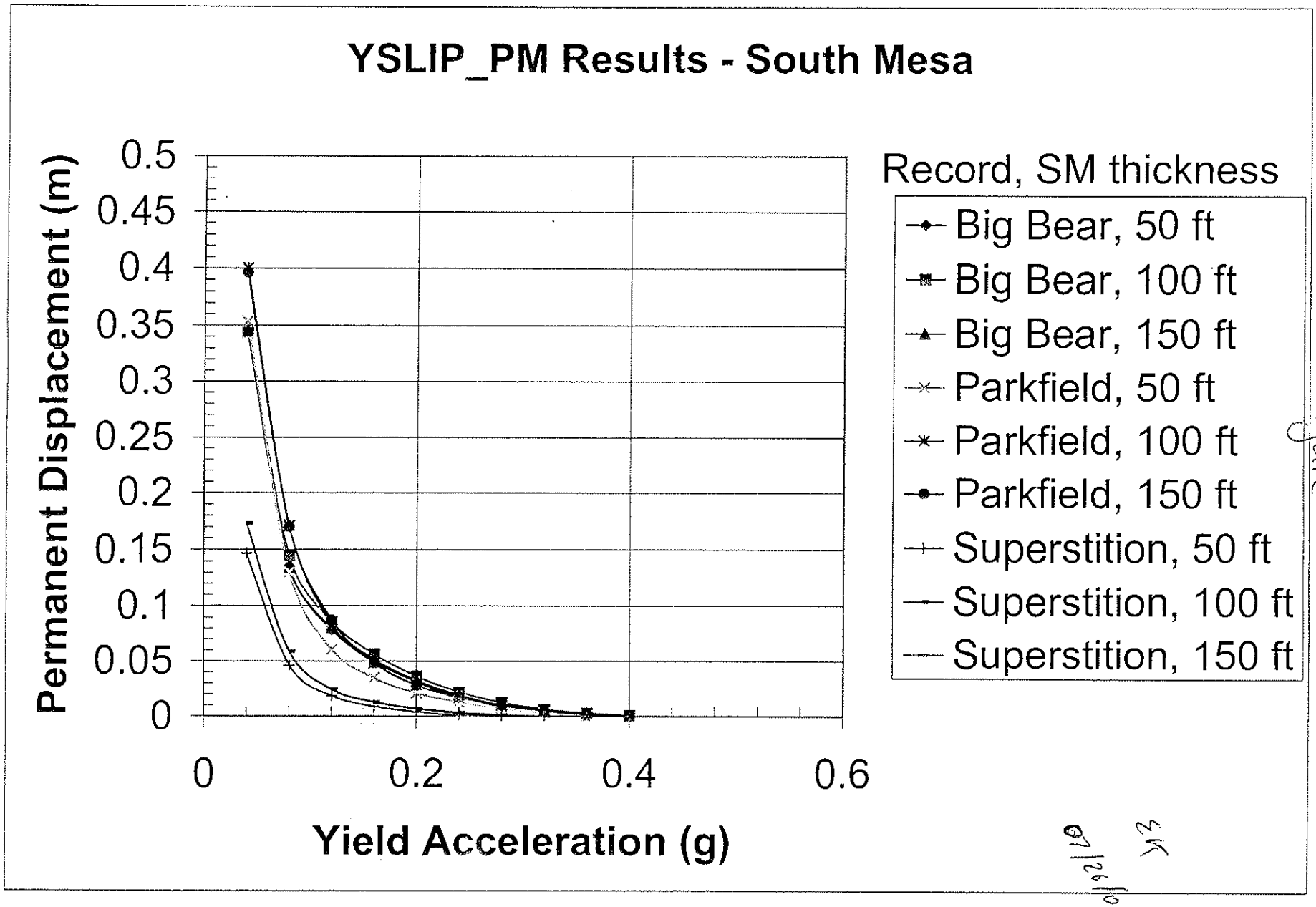


Figure 2

Fig 7-26

07/26/00

EK

SMGK 7-26

```
*********************************************
**                                         **
**                YSLIP_PM                 **
**        (VERSION 2.2, JANUARY 1996)      **
**                                         **
**   A COMPUTER PROGRAM FOR SIMULATION OF  **
**   DYNAMIC BEHAVIOR OF A RIGID BLOCK ON  **
**   AN INCLINED PLANE AND CALCULATION OF  **
**   PERMANENT DISPLACEMENTS OF THE BLOCK  **
**                                         **
**                   BY                    **
**                                         **
**              Liping Yan                 **
**           Neven Matasovic               **
**        Edward Kavazanjian, Jr.          **
**                                         **
*********************************************

***************REPRINT INPUT DATA**************

CARD  1: TITLE
         VARIATION OF Ky/Kh
CARD  2: SUBTITLE
         Parkfield Record 60 ft, SM thickness = 50 ft
CARD  3: KPAR  N     KACC  KCOM   g(m/s/s)  KOUT   KSLIP  KDIR
         0     10    1     1      9.807     0      0      0
CARD  4: Ky(1), ..., Ky(N)
         0.040 0.080 0.120 0.160 0.200 0.240 0.280 0.320 0.360 0.400
CARD  5: YIELD ACCELERATION DEGRADATION DATA
         Ky is constant.
CARD  6: INPUT HORIZONTAL ACC. TIME HISTORY FILE NAME
         p6050.out
CARD  7: NIDH  KREAD    NP      NLINE   DT      APH
         2     2        4096    512     0.02    0.4001
CARD  8: INPUT VERTICAL ACC. TIME HISTORY FILE NAME
         NO Av
CARD  9: NIDV  KREAD    NP      NLINE   DT      APV     TSHIFT
         NO INPUT
CARD 10: FILE NAME FOR OUTPUT OF SLIDING MOTION
         bbl.OUS
CARD 11: FILE NAME FOR OUTPUT OF ABSOLUTE MOTION
         bbl.OUA

MAX. VALUE OF INPUT HORI. ACC. =  .400062
INPUT HORI. ACC. TIMES A FACTOR = 1.000095 TO GET APH =  .400100

*****************RESULTS****************

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .040000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .3310 m/sec
        PERMANENT SLIDING DISPLACEMENT =  .3520 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .4161 m/sec
        PERMANENT SLIDING DISPLACEMENT =  .3537 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .080000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .2446 m/sec
        PERMANENT SLIDING DISPLACEMENT =  .0984 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .3471 m/sec
        PERMANENT SLIDING DISPLACEMENT =  .1303 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .120000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .1719 m/sec
        PERMANENT SLIDING DISPLACEMENT =  .0473 m
```

MAK 7-26

```
*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .2833 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0604 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .160000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1207 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0249 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .2267 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0349 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .200000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0758 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0111 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1724 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0209 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .240000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0421 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0034 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1231 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0128 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .280000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0156 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0008 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0817 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0072 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .320000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0004 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0430 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0032 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .360000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0155 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0008 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .400000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m
```

MSC 7-26

```
**********************************************
**                                          **
**                  YSLIP_PM                **
**          (VERSION 2.2, JANUARY 1996)     **
**                                          **
**   A COMPUTER PROGRAM FOR SIMULATION OF   **
**   DYNAMIC BEHAVIOR OF A RIGID BLOCK ON   **
**   AN INCLINED PLANE AND CALCULATION OF   **
**   PERMANENT DISPLACEMENTS OF THE BLOCK   **
**                                          **
**                    BY                    **
**                                          **
**                Liping Yan                **
**             Neven Matasovic              **
**          Edward Kavazanjian, Jr.         **
**                                          **
**********************************************

***************REPRINT INPUT DATA**************

CARD  1: TITLE
         VARIATION OF Ky/Kh
CARD  2: SUBTITLE
         Parkfield Record 60 ft, SM thickness = 100 ft
CARD  3: KPAR  N     KACC  KCOM   g(m/s/s)  KOUT   KSLIP  KDIR
         0     10    1     1      9.807    0      0      0
CARD  4: Ky(1), ..., Ky(N)
         0.040 0.080 0.120 0.160 0.200 0.240 0.280 0.320 0.360 0.400
CARD  5: YIELD ACCELERATION DEGRADATION DATA
         Ky is constant.
CARD  6: INPUT HORIZONTAL ACC. TIME HISTORY FILE NAME
         p60100.out
CARD  7: NIDH  KREAD   NP      NLINE   DT      APH
         2     2       4096    512     0.02    0.4395
CARD  8: INPUT VERTICAL ACC. TIME HISTORY FILE NAME
         NO Av
CARD  9: NIDV  KREAD   NP      NLINE   DT      APV     TSHIFT
         NO INPUT
CARD 10: FILE NAME FOR OUTPUT OF SLIDING MOTION
         bb1.OUS
CARD 11: FILE NAME FOR OUTPUT OF ABSOLUTE MOTION
         bb1.OUA

MAX. VALUE OF INPUT HORI. ACC. =  .439500
INPUT HORI. ACC. TIMES A FACTOR = 1.000000 TO GET APH =  .439500


*****************RESULTS****************

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .040000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
              MAX. SLIDING VELOCITY =   .3957 m/sec
       PERMANENT SLIDING DISPLACEMENT =   .3981 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
              MAX. SLIDING VELOCITY =   .4384 m/sec
       PERMANENT SLIDING DISPLACEMENT =   .3999 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .080000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
              MAX. SLIDING VELOCITY =   .3226 m/sec
       PERMANENT SLIDING DISPLACEMENT =   .1384 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
              MAX. SLIDING VELOCITY =   .3716 m/sec
       PERMANENT SLIDING DISPLACEMENT =   .1708 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .120000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
              MAX. SLIDING VELOCITY =   .2582 m/sec
       PERMANENT SLIDING DISPLACEMENT =   .0690 m
```

TASK 7-2C

```
*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .3115 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0834 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .160000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1966 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0386 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .2535 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0480 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .200000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1459 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0215 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1977 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0280 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .240000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0982 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0108 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1518 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0163 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .280000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0610 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0050 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1085 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0100 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .320000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0285 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0018 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0676 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0055 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .360000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0076 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0003 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0373 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0024 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .400000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0115 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0006 m
```

MSK 7-2C

```
**********************************************
**                                          **
**                  YSLIP_PM                **
**         (VERSION 2.2, JANUARY 1996)      **
**                                          **
**   A COMPUTER PROGRAM FOR SIMULATION OF   **
**   DYNAMIC BEHAVIOR OF A RIGID BLOCK ON   **
**   AN INCLINED PLANE AND CALCULATION OF   **
**   PERMANENT DISPLACEMENTS OF THE BLOCK   **
**                                          **
**                    BY                    **
**                                          **
**                Liping Yan                **
**             Neven Matasovic              **
**          Edward Kavazanjian, Jr.         **
**                                          **
**********************************************

***************REPRINT INPUT DATA**************

CARD  1: TITLE
         VARIATION OF Ky/Kh
CARD  2: SUBTITLE
         Parkfield Record 60 ft, SM thickness = 150 ft
CARD  3: KPAR  N    KACC  KCOM  g(m/s/s)  KOUT  KSLIP  KDIR
         0     10   1     1     9.807     0     0      0
CARD  4: Ky(1), ..., Ky(N)
         0.040 0.080 0.120 0.160 0.200 0.240 0.280 0.320 0.360 0.400
CARD  5: YIELD ACCELERATION DEGRADATION DATA
         Ky is constant.
CARD  6: INPUT HORIZONTAL ACC. TIME HISTORY FILE NAME
         p60150.out
CARD  7: NIDH  KREAD  NP    NLINE  DT    APH
         2     2      4096  512    0.02  0.4249
CARD  8: INPUT VERTICAL ACC. TIME HISTORY FILE NAME
         NO Av
CARD  9: NIDV  KREAD  NP    NLINE  DT    APV    TSHIFT
         NO INPUT
CARD 10: FILE NAME FOR OUTPUT OF SLIDING MOTION
         bbl.OUS
CARD 11: FILE NAME FOR OUTPUT OF ABSOLUTE MOTION
         bbl.OUA

MAX. VALUE OF INPUT HORI. ACC. =  .424949
INPUT HORI. ACC. TIMES A FACTOR =  .999885 TO GET APH =  .424900


*****************RESULTS****************

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .040000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
              MAX. SLIDING VELOCITY =   .4676 m/sec
       PERMANENT SLIDING DISPLACEMENT =   .3960 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
              MAX. SLIDING VELOCITY =   .4437 m/sec
       PERMANENT SLIDING DISPLACEMENT =   .3740 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .080000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
              MAX. SLIDING VELOCITY =   .3909 m/sec
       PERMANENT SLIDING DISPLACEMENT =   .1531 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
              MAX. SLIDING VELOCITY =   .3734 m/sec
       PERMANENT SLIDING DISPLACEMENT =   .1696 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .120000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
              MAX. SLIDING VELOCITY =   .3212 m/sec
       PERMANENT SLIDING DISPLACEMENT =   .0811 m
```

MGK 7-76

```
*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .3081 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0873 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .160000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .2540 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0457 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .2504 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0476 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .200000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1972 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0281 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1949 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0266 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .240000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1431 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0172 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1433 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0157 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .280000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0978 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0100 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1010 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0093 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .320000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0573 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0049 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0613 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0048 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .360000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0272 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0017 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0295 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0018 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .400000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0053 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0002 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0056 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0002 m
```

MSK 7-26

```
**********************************************
**                                          **
**                YSLIP_PM                  **
**        (VERSION 2.2, JANUARY 1996)       **
**                                          **
**   A COMPUTER PROGRAM FOR SIMULATION OF   **
**   DYNAMIC BEHAVIOR OF A RIGID BLOCK ON   **
**   AN INCLINED PLANE AND CALCULATION OF   **
**   PERMANENT DISPLACEMENTS OF THE BLOCK   **
**                                          **
**                    BY                    **
**                                          **
**               Liping Yan                 **
**             Neven Matasovic              **
**         Edward Kavazanjian, Jr.          **
**                                          **
**********************************************

***************REPRINT INPUT DATA**************

CARD  1: TITLE
         VARIATION OF Ky/Kh
CARD  2: SUBTITLE
         Parkfield Record 30 ft, SM thickness = 50 ft
CARD  3: KPAR  N     KACC  KCOM   g(m/s/s)  KOUT  KSLIP  KDIR
         0     10     1     1     9.807     0     0     0
CARD  4: Ky(1), ..., Ky(N)
         0.040 0.080 0.120 0.160 0.200 0.240 0.280 0.320 0.360 0.400
CARD  5: YIELD ACCELERATION DEGRADATION DATA
         Ky is constant.
CARD  6: INPUT HORIZONTAL ACC. TIME HISTORY FILE NAME
         p3050.out
CARD  7: NIDH  KREAD    NP      NLINE   DT      APH
         2     2        4096    512     0.02    0.4298
CARD  8: INPUT VERTICAL ACC. TIME HISTORY FILE NAME
         NO Av
CARD  9: NIDV  KREAD    NP      NLINE   DT      APV     TSHIFT
         NO INPUT
CARD 10: FILE NAME FOR OUTPUT OF SLIDING MOTION
         bbl.OUS
CARD 11: FILE NAME FOR OUTPUT OF ABSOLUTE MOTION
         bbl.OUA

MAX. VALUE OF INPUT HORI. ACC. =  .429801
INPUT HORI. ACC. TIMES A FACTOR =  .999998 TO GET APH =  .429800


*****************RESULTS****************

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .040000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .3252 m/sec
       PERMANENT SLIDING DISPLACEMENT =   .3609 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .4408 m/sec
       PERMANENT SLIDING DISPLACEMENT =   .3555 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .080000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .2552 m/sec
       PERMANENT SLIDING DISPLACEMENT =   .0970 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .3711 m/sec
       PERMANENT SLIDING DISPLACEMENT =   .1340 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .120000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .1973 m/sec
       PERMANENT SLIDING DISPLACEMENT =   .0509 m
```

MSK 7-26

```
*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .3112 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0656 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .160000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1451 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0291 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .2536 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0387 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .200000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1006 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0151 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1981 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0246 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .240000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0625 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0062 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1495 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0158 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .280000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0323 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0020 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1067 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0098 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .320000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0092 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0004 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0663 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0053 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .360000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0342 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0022 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .400000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0085 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0004 m
```

MGK 7.76

```
**********************************************
**                                          **
**                YSLIP_PM                  **
**        (VERSION 2.2, JANUARY 1996)       **
**                                          **
**   A COMPUTER PROGRAM FOR SIMULATION OF   **
**   DYNAMIC BEHAVIOR OF A RIGID BLOCK ON   **
**   AN INCLINED PLANE AND CALCULATION OF   **
**   PERMANENT DISPLACEMENTS OF THE BLOCK   **
**                                          **
**                   BY                     **
**                                          **
**              Liping Yan                  **
**            Neven Matasovic               **
**        Edward Kavazanjian, Jr.           **
**                                          **
**********************************************

***************REPRINT INPUT DATA**************

CARD  1: TITLE
         VARIATION OF Ky/Kh
CARD  2: SUBTITLE
         Parkfield Record 30 ft, SM thickness = 100 ft
CARD  3: KPAR  N     KACC  KCOM   g(m/s/s)   KOUT   KSLIP  KDIR
         0     10    1     1      9.807     0      0      0
CARD  4: Ky(1), ..., Ky(N)
         0.040 0.080 0.120 0.160 0.200 0.240 0.280 0.320 0.360 0.400
CARD  5: YIELD ACCELERATION DEGRADATION DATA
         Ky is constant.
CARD  6: INPUT HORIZONTAL ACC. TIME HISTORY FILE NAME
         p30100.out
CARD  7: NIDH  KREAD     NP        NLINE     DT        APH
         2     2         4096      512       0.02      0.469
CARD  8: INPUT VERTICAL ACC. TIME HISTORY FILE NAME
         NO Av
CARD  9: NIDV  KREAD     NP        NLINE     DT        APV       TSHIFT
         NO INPUT
CARD 10: FILE NAME FOR OUTPUT OF SLIDING MOTION
         bbl.OUS
CARD 11: FILE NAME FOR OUTPUT OF ABSOLUTE MOTION
         bbl.OUA

MAX. VALUE OF INPUT HORI. ACC. =  .469017
INPUT HORI. ACC. TIMES A FACTOR =  .999964 TO GET APH =  .469000


*****************RESULTS****************

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .040000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .4464 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .4231 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .4670 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .4123 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .080000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .3777 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .1421 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .4022 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .1820 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .120000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .3113 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .0753 m
```

MISK 7.26

```
*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .3420 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0950 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .160000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .2518 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0458 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .2839 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0566 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .200000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1979 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0290 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .2280 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0330 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .240000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1466 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0173 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1799 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0198 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .280000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1053 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0101 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1363 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0128 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .320000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0671 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0054 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0951 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0079 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .360000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0368 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0023 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0583 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0042 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .400000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0127 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0006 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0307 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0017 m
```

MAK 7-26

```
*********************************************
**                                         **
**                YSLIP_PM                 **
**        (VERSION 2.2, JANUARY 1996)      **
**                                         **
**   A COMPUTER PROGRAM FOR SIMULATION OF  **
**   DYNAMIC BEHAVIOR OF A RIGID BLOCK ON  **
**   AN INCLINED PLANE AND CALCULATION OF  **
**   PERMANENT DISPLACEMENTS OF THE BLOCK  **
**                                         **
**                   BY                    **
**                                         **
**              Liping Yan                 **
**           Neven Matasovic               **
**        Edward Kavazanjian, Jr.          **
**                                         **
*********************************************

***************REPRINT INPUT DATA**************

CARD  1: TITLE
         VARIATION OF Ky/Kh
CARD  2: SUBTITLE
         Parkfield Record 30 ft, SM thickness = 150 ft
CARD  3: KPAR  N    KACC  KCOM   g(m/s/s)  KOUT  KSLIP  KDIR
         0     10   1     1      9.807     0     0      0
CARD  4: Ky(1), ..., Ky(N)
         0.040 0.080 0.120 0.160 0.200 0.240 0.280 0.320 0.360 0.400
CARD  5: YIELD ACCELERATION DEGRADATION DATA
         Ky is constant.
CARD  6: INPUT HORIZONTAL ACC. TIME HISTORY FILE NAME
         p30150.out
CARD  7: NIDH  KREAD   NP      NLINE   DT      APH
         2     2       4096    512     0.02    0.4797
CARD  8: INPUT VERTICAL ACC. TIME HISTORY FILE NAME
         NO Av
CARD  9: NIDV  KREAD   NP      NLINE   DT      APV     TSHIFT
         NO INPUT
CARD 10: FILE NAME FOR OUTPUT OF SLIDING MOTION
         bbl.OUS
CARD 11: FILE NAME FOR OUTPUT OF ABSOLUTE MOTION
         bbl.OUA

MAX. VALUE OF INPUT HORI. ACC. =  .479704
INPUT HORI. ACC. TIMES A FACTOR =  .999992 TO GET APH =  .479700


*****************RESULTS****************

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .040000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .5281 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .4422 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .4656 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .4124 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .080000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .4522 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .1726 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .3967 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .1964 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .120000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .3817 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .0971 m
```

Page 7-26

```
*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .3344 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .1090 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .160000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .3180 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0582 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .2744 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0634 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .200000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .2566 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0372 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .2168 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0356 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .240000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .2011 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0255 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1679 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0195 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .280000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1521 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0170 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1232 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0116 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .320000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1055 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0105 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0812 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0067 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .360000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0689 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0057 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0469 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0032 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .400000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0356 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0024 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0196 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0010 m
```

MSK 7-26

```
**********************************************
**                                          **
**                YSLIP_PM                  **
**        (VERSION 2.2, JANUARY 1996)       **
**                                          **
**   A COMPUTER PROGRAM FOR SIMULATION OF   **
**   DYNAMIC BEHAVIOR OF A RIGID BLOCK ON   **
**   AN INCLINED PLANE AND CALCULATION OF   **
**   PERMANENT DISPLACEMENTS OF THE BLOCK   **
**                                          **
**                    BY                    **
**                                          **
**               Liping Yan                 **
**            Neven Matasovic               **
**         Edward Kavazanjian, Jr.          **
**                                          **
**********************************************

***************REPRINT INPUT DATA**************

CARD  1: TITLE
         VARIATION OF Ky/Kh
CARD  2: SUBTITLE
         Superstition 30'- SM layer thickness = 50'
CARD  3: KPAR  N     KACC  KCOM   g(m/s/s)  KOUT   KSLIP  KDIR
         0     10    1     1      9.807     0      0      0
CARD  4: Ky(1), ..., Ky(N)
         0.040 0.080 0.120 0.160 0.200 0.240 0.280 0.320 0.360 0.400
CARD  5: YIELD ACCELERATION DEGRADATION DATA
         Ky is constant.
CARD  6: INPUT HORIZONTAL ACC. TIME HISTORY FILE NAME
         sn3050.out
CARD  7: NIDH  KREAD     NP        NLINE     DT        APH
         2     2         4096      512       0.005     0.4046
CARD  8: INPUT VERTICAL ACC. TIME HISTORY FILE NAME
         NO Av
CARD  9: NIDV  KREAD     NP        NLINE     DT        APV       TSHIFT
         NO INPUT
CARD 10: FILE NAME FOR OUTPUT OF SLIDING MOTION
         bbl.OUS
CARD 11: FILE NAME FOR OUTPUT OF ABSOLUTE MOTION
         bbl.OUA

MAX. VALUE OF INPUT HORI. ACC. =  .404609
INPUT HORI. ACC. TIMES A FACTOR =  .999978 TO GET APH =  .404600


******************RESULTS*****************

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .040000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .2177 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .1389 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .2152 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .1415 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .080000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .1495 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .0532 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .1580 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .0542 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .120000
```

MSK 7-26

```
*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1128 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0207 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1253 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0248 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .160000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0801 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0089 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0980 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0117 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .200000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0518 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0035 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0735 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0060 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .240000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0282 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0013 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0523 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0030 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .280000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0100 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0003 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0338 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0014 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .320000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0184 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0006 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .360000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0068 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0001 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .400000
```

7-26

```
*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
      PERMANENT SLIDING DISPLACEMENT =    .0000 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0001 m/sec
      PERMANENT SLIDING DISPLACEMENT =    .0000 m
```

PMSK 7-26

```
**********************************************
**                                          **
**                YSLIP_PM                  **
**        (VERSION 2.2, JANUARY 1996)       **
**                                          **
**   A COMPUTER PROGRAM FOR SIMULATION OF   **
**   DYNAMIC BEHAVIOR OF A RIGID BLOCK ON   **
**   AN INCLINED PLANE AND CALCULATION OF   **
**   PERMANENT DISPLACEMENTS OF THE BLOCK   **
**                                          **
**                    BY                    **
**                                          **
**               Liping Yan                 **
**             Neven Matasovic              **
**          Edward Kavazanjian, Jr.         **
**                                          **
**********************************************

***************REPRINT INPUT DATA**************

CARD  1: TITLE
         VARIATION OF Ky/Kh
CARD  2: SUBTITLE
         Superstition 30'- SM layer thickness = 100'
CARD  3: KPAR  N     KACC  KCOM   g(m/s/s)  KOUT   KSLIP  KDIR
         0     10    1     1      9.807     0      0      0
CARD  4: Ky(1), ..., Ky(N)
         0.040 0.080 0.120 0.160 0.200 0.240 0.280 0.320 0.360 0.400
CARD  5: YIELD ACCELERATION DEGRADATION DATA
         Ky is constant.
CARD  6: INPUT HORIZONTAL ACC. TIME HISTORY FILE NAME
         sn30100.out
CARD  7: NIDH  KREAD     NP        NLINE     DT       APH
         2     2         4096      512       0.005    0.3467
CARD  8: INPUT VERTICAL ACC. TIME HISTORY FILE NAME
         NO Av
CARD  9: NIDV  KREAD     NP        NLINE     DT       APV       TSHIFT
         NO INPUT
CARD 10: FILE NAME FOR OUTPUT OF SLIDING MOTION
         bbl.OUS
CARD 11: FILE NAME FOR OUTPUT OF ABSOLUTE MOTION
         bbl.OUA

MAX. VALUE OF INPUT HORI. ACC. =  .346668
INPUT HORI. ACC. TIMES A FACTOR = 1.000092 TO GET APH =  .346700


******************RESULTS*****************

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .040000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .2369 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .1598 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .2412 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .1800 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .080000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .1683 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .0592 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .1843 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .0702 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .120000
```

MGK 7-26

```
*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1305 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0235 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1344 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0302 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .160000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0966 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0117 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0946 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0139 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .200000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0667 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0064 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0627 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0066 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .240000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0411 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0029 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0369 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0029 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .280000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0203 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0009 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0172 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0009 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .320000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0050 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0001 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0037 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0001 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .360000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .400000
```

MGK 7-26

```
*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
      PERMANENT SLIDING DISPLACEMENT =    .0000 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
      PERMANENT SLIDING DISPLACEMENT =    .0000 m
```

MSK 7-26

```
**********************************************
**                                          **
**                  YSLIP_PM                **
**          (VERSION 2.2, JANUARY 1996)     **
**                                          **
**    A COMPUTER PROGRAM FOR SIMULATION OF  **
**    DYNAMIC BEHAVIOR OF A RIGID BLOCK ON  **
**    AN INCLINED PLANE AND CALCULATION OF  **
**    PERMANENT DISPLACEMENTS OF THE BLOCK  **
**                                          **
**                     BY                   **
**                                          **
**                Liping Yan                **
**              Neven Matasovic             **
**          Edward Kavazanjian, Jr.         **
**                                          **
**********************************************

***************REPRINT INPUT DATA**************

CARD  1: TITLE
         VARIATION OF Ky/Kh
CARD  2: SUBTITLE
         Superstition 30'- SM layer thickness = 150'
CARD  3: KPAR  N     KACC  KCOM   g(m/s/s)  KOUT   KSLIP  KDIR
         0     10    1     1      9.807     0      0      0
CARD  4: Ky(1), ..., Ky(N)
         0.040 0.080 0.120 0.160 0.200 0.240 0.280 0.320 0.360 0.400
CARD  5: YIELD ACCELERATION DEGRADATION DATA
         Ky is constant.
CARD  6: INPUT HORIZONTAL ACC. TIME HISTORY FILE NAME
         sn30150.out
CARD  7: NIDH  KREAD     NP        NLINE     DT        APH
         2     2         4096      512       0.005     0.3088
CARD  8: INPUT VERTICAL ACC. TIME HISTORY FILE NAME
         NO Av
CARD  9: NIDV  KREAD     NP        NLINE     DT        APV       TSHIFT
         NO INPUT
CARD 10: FILE NAME FOR OUTPUT OF SLIDING MOTION
         bbl.OUS
CARD 11: FILE NAME FOR OUTPUT OF ABSOLUTE MOTION
         bbl.OUA

MAX. VALUE OF INPUT HORI. ACC. =  .308773
INPUT HORI. ACC. TIMES A FACTOR = 1.000087 TO GET APH =  .308800

*****************RESULTS****************

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .040000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .1835 m/sec
       PERMANENT SLIDING DISPLACEMENT =   .1271 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .2060 m/sec
       PERMANENT SLIDING DISPLACEMENT =   .1579 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .080000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .1431 m/sec
       PERMANENT SLIDING DISPLACEMENT =   .0485 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .1518 m/sec
       PERMANENT SLIDING DISPLACEMENT =   .0491 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .120000
```

MSK 7-26

```
*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1064 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0209 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1086 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0180 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .160000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0736 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0102 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0729 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0084 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .200000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0450 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0050 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0437 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0035 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .240000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0212 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0018 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0210 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0011 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .280000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0049 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0002 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0054 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0001 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .320000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .360000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .400000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
```

MAX. SLIDING VELOCITY = .0000 m/sec
PERMANENT SLIDING DISPLACEMENT = .0000 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
MAX. SLIDING VELOCITY = .0000 m/sec
PERMANENT SLIDING DISPLACEMENT = .0000 m

Mark 7-26

```
*********************************************
**                                         **
**                YSLIP_PM                 **
**        (VERSION 2.2, JANUARY 1996)      **
**                                         **
**   A COMPUTER PROGRAM FOR SIMULATION OF  **
**   DYNAMIC BEHAVIOR OF A RIGID BLOCK ON  **
**   AN INCLINED PLANE AND CALCULATION OF  **
**   PERMANENT DISPLACEMENTS OF THE BLOCK  **
**                                         **
**                   BY                    **
**                                         **
**              Liping Yan                 **
**           Neven Matasovic               **
**        Edward Kavazanjian, Jr.          **
**                                         **
*********************************************

***************REPRINT INPUT DATA**************

CARD  1: TITLE
         VARIATION OF Ky/Kh
CARD  2: SUBTITLE
         Superstition 60'- SM layer thickness = 150'
CARD  3: KPAR  N     KACC  KCOM   g(m/s/s)   KOUT   KSLIP  KDIR
         0     10    1     1      9.807     0      0      0
CARD  4: Ky(1), ..., Ky(N)
         0.040 0.080 0.120 0.160 0.200 0.240 0.280 0.320 0.360 0.400
CARD  5: YIELD ACCELERATION DEGRADATION DATA
         Ky is constant.
CARD  6: INPUT HORIZONTAL ACC. TIME HISTORY FILE NAME
         sn60150.out
CARD  7: NIDH  KREAD    NP        NLINE     DT       APH
         2     2        4096      512       0.005    0.3090
CARD  8: INPUT VERTICAL ACC. TIME HISTORY FILE NAME
         NO Av
CARD  9: NIDV  KREAD    NP        NLINE     DT       APV       TSHIFT
         NO INPUT
CARD 10: FILE NAME FOR OUTPUT OF SLIDING MOTION
         bbl.OUS
CARD 11: FILE NAME FOR OUTPUT OF ABSOLUTE MOTION
         bbl.OUA

MAX. VALUE OF INPUT HORI.'ACC. =  .308963
INPUT HORI. ACC. TIMES A FACTOR = 1.000120 TO GET APH =  .309000


*****************RESULTS****************

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .040000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .1797 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .1272 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .1887 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .1468 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .080000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .1401 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .0461 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .1434 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .0446 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .120000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .1044 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .0183 m
```

Wash 7-26

```
*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1044 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0157 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .160000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0726 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0086 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0711 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0069 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .200000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0450 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0037 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0432 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0029 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .240000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0222 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0011 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0210 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0010 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .280000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0054 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0001 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0055 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0001 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .320000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .360000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .400000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m
```

MSC 7.76

```
*********************************************
**                                         **
**                YSLIP_PM                 **
**        (VERSION 2.2, JANUARY 1996)      **
**                                         **
**   A COMPUTER PROGRAM FOR SIMULATION OF  **
**   DYNAMIC BEHAVIOR OF A RIGID BLOCK ON  **
**   AN INCLINED PLANE AND CALCULATION OF  **
**   PERMANENT DISPLACEMENTS OF THE BLOCK  **
**                                         **
**                   BY                    **
**                                         **
**               Liping Yan                **
**            Neven Matasovic              **
**         Edward Kavazanjian, Jr.         **
**                                         **
*********************************************

***************REPRINT INPUT DATA**************

CARD  1: TITLE
         VARIATION OF Ky/Kh
CARD  2: SUBTITLE
         Superstition 60'- SM layer thickness = 100'
CARD  3: KPAR  N    KACC  KCOM  g(m/s/s)  KOUT  KSLIP  KDIR
         0     10   1     1     9.807     0     0     0
CARD  4: Ky(1), ..., Ky(N)
         0.040 0.080 0.120 0.160 0.200 0.240 0.280 0.320 0.360 0.400
CARD  5: YIELD ACCELERATION DEGRADATION DATA
         Ky is constant.
CARD  6: INPUT HORIZONTAL ACC. TIME HISTORY FILE NAME
         sn60100.out
CARD  7: NIDH  KREAD  NP    NLINE  DT     APH
         2     2      4096  512    0.005  0.3379
CARD  8: INPUT VERTICAL ACC. TIME HISTORY FILE NAME
         NO Av
CARD  9: NIDV  KREAD  NP    NLINE  DT     APV    TSHIFT
         NO INPUT
CARD 10: FILE NAME FOR OUTPUT OF SLIDING MOTION
         bbl.OUS
CARD 11: FILE NAME FOR OUTPUT OF ABSOLUTE MOTION
         bbl.OUA

MAX. VALUE OF INPUT HORI. ACC. =  .337891
INPUT HORI. ACC. TIMES A FACTOR = 1.000027 TO GET APH =  .337900


*****************RESULTS****************

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .040000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .2146 m/sec
       PERMANENT SLIDING DISPLACEMENT =   .1509 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .2143 m/sec
       PERMANENT SLIDING DISPLACEMENT =   .1729 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .080000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .1588 m/sec
       PERMANENT SLIDING DISPLACEMENT =   .0550 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .1591 m/sec
       PERMANENT SLIDING DISPLACEMENT =   .0587 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .120000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .1225 m/sec
       PERMANENT SLIDING DISPLACEMENT =   .0243 m
```

MW 9-96

```
*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1170 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0217 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .160000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0901 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0126 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0823 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0102 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .200000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0614 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0066 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0537 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0046 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .240000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0366 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0030 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0302 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0018 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .280000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0168 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0009 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0123 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0004 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .320000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0029 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0001 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0012 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .360000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .400000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m
```

TASK 7-26

```
**********************************************
**                                          **
**                YSLIP_PM                  **
**        (VERSION 2.2, JANUARY 1996)       **
**                                          **
**   A COMPUTER PROGRAM FOR SIMULATION OF   **
**   DYNAMIC BEHAVIOR OF A RIGID BLOCK ON   **
**   AN INCLINED PLANE AND CALCULATION OF   **
**   PERMANENT DISPLACEMENTS OF THE BLOCK   **
**                                          **
**                   BY                     **
**                                          **
**              Liping Yan                  **
**            Neven Matasovic               **
**        Edward Kavazanjian, Jr.           **
**                                          **
**********************************************

***************REPRINT INPUT DATA**************

CARD  1: TITLE
         VARIATION OF Ky/Kh
CARD  2: SUBTITLE
         Superstition 60'- SM layer thickness = 50'
CARD  3: KPAR  N     KACC  KCOM   g(m/s/s)  KOUT   KSLIP  KDIR
         0     10    1     1      9.807     0      0      0
CARD  4: Ky(1), ..., Ky(N)
         0.040 0.080 0.120 0.160 0.200 0.240 0.280 0.320 0.360 0.400
CARD  5: YIELD ACCELERATION DEGRADATION DATA
         Ky is constant.
CARD  6: INPUT HORIZONTAL ACC. TIME HISTORY FILE NAME
         sn6050.out
CARD  7: NIDH  KREAD    NP      NLINE   DT      APH
         2     2        4096    512     0.005   0.3763
CARD  8: INPUT VERTICAL ACC. TIME HISTORY FILE NAME
         NO Av
CARD  9: NIDV  KREAD    NP      NLINE   DT      APV     TSHIFT
         NO INPUT
CARD 10: FILE NAME FOR OUTPUT OF SLIDING MOTION
         bbl.OUS
CARD 11: FILE NAME FOR OUTPUT OF ABSOLUTE MOTION
         bbl.OUA

MAX. VALUE OF INPUT HORI. ACC. =  .376289
INPUT HORI. ACC. TIMES A FACTOR = 1.000029 TO GET APH =  .376300

*****************RESULTS****************

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .040000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .2217 m/sec
        PERMANENT SLIDING DISPLACEMENT =  .1409 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .1932 m/sec
        PERMANENT SLIDING DISPLACEMENT =  .1427 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .080000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .1351 m/sec
        PERMANENT SLIDING DISPLACEMENT =  .0519 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .1526 m/sec
        PERMANENT SLIDING DISPLACEMENT =  .0510 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .120000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .0990 m/sec
        PERMANENT SLIDING DISPLACEMENT =  .0202 m
```

9/15/K 7-26

```
*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1203 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0201 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .160000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0674 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0095 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0917 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0101 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .200000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0403 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0045 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0663 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0051 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .240000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0188 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0014 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0442 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0024 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .280000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0048 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0002 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0257 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0010 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .320000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0112 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0003 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .360000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0016 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .400000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m
```

MSK 7.26

```
**********************************************
**                                          **
**                YSLIP_PM                  **
**        (VERSION 2.2, JANUARY 1996)       **
**                                          **
**   A COMPUTER PROGRAM FOR SIMULATION OF   **
**   DYNAMIC BEHAVIOR OF A RIGID BLOCK ON   **
**   AN INCLINED PLANE AND CALCULATION OF   **
**   PERMANENT DISPLACEMENTS OF THE BLOCK   **
**                                          **
**                   BY                     **
**                                          **
**              Liping Yan                  **
**            Neven Matasovic               **
**        Edward Kavazanjian, Jr.           **
**                                          **
**********************************************

***************REPRINT INPUT DATA**************

CARD  1: TITLE
         VARIATION OF Ky/Kh
CARD  2: SUBTITLE
         Big Bear Record 30' - SM thickness = 100 ft
CARD  3: KPAR  N     KACC  KCOM   g(m/s/s)  KOUT   KSLIP  KDIR
         0     10    1     1      9.807     0      0      0
CARD  4: Ky(I), ..., Ky(N)
         0.040 0.080 0.120 0.160 0.200 0.240 0.280 0.320 0.360 0.400
CARD  5: YIELD ACCELERATION DEGRADATION DATA
         Ky is constant.
CARD  6: INPUT HORIZONTAL ACC. TIME HISTORY FILE NAME
         b30100.out
CARD  7: NIDH  KREAD     NP        NLINE     DT        APH
         2     2         4096      512       0.01      0.4969
CARD  8: INPUT VERTICAL ACC. TIME HISTORY FILE NAME
         NO Av
CARD  9: NIDV  KREAD     NP        NLINE     DT        APV       TSHIFT
         NO INPUT
CARD 10: FILE NAME FOR OUTPUT OF SLIDING MOTION
         bbl.OUS
CARD 11: FILE NAME FOR OUTPUT OF ABSOLUTE MOTION
         bbl.OUA

MAX. VALUE OF INPUT HORI. ACC. =  .496930
INPUT HORI. ACC. TIMES A FACTOR =  .999940 TO GET APH =  .496900


*****************RESULTS****************

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .040000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .5224 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .3651 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .3417 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .3938 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .080000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .4477 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .1647 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .2547 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .1513 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .120000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .3783 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .0984 m
```

MSK 7.26

```
*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1779 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0649 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .160000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .3145 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0665 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1184 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0288 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .200000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .2562 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0452 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0807 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0131 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .240000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .2032 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0297 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0499 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0047 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .280000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1557 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0188 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0249 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0011 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .320000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1136 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0111 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0069 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0002 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .360000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0763 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0061 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .400000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0445 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0029 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m
```

PSK 7.26

```
**********************************************
**                                          **
**                YSLIP_PM                  **
**        (VERSION 2.2, JANUARY 1996)       **
**                                          **
**   A COMPUTER PROGRAM FOR SIMULATION OF   **
**   DYNAMIC BEHAVIOR OF A RIGID BLOCK ON   **
**   AN INCLINED PLANE AND CALCULATION OF   **
**   PERMANENT DISPLACEMENTS OF THE BLOCK   **
**                                          **
**                   BY                     **
**                                          **
**               Liping Yan                 **
**             Neven Matasovic              **
**         Edward Kavazanjian, Jr.          **
**                                          **
**********************************************

***************REPRINT INPUT DATA**************

CARD  1: TITLE
         VARIATION OF Ky/Kh
CARD  2: SUBTITLE
         Big Bear Record 30' - SM thickness = 50 ft
CARD  3: KPAR  N     KACC  KCOM   g(m/s/s)  KOUT   KSLIP  KDIR
         0     10    1     1      9.807     0      0      0
CARD  4: Ky(1), ..., Ky(N)
         0.040 0.080 0.120 0.160 0.200 0.240 0.280 0.320 0.360 0.400
CARD  5: YIELD ACCELERATION DEGRADATION DATA
         Ky is constant.
CARD  6: INPUT HORIZONTAL ACC. TIME HISTORY FILE NAME
         b3050.out
CARD  7: NIDH  KREAD     NP        NLINE     DT        APH
         2     2         4096      512       0.01      0.4652
CARD  8: INPUT VERTICAL ACC. TIME HISTORY FILE NAME
         NO Av
CARD  9: NIDV  KREAD     NP        NLINE     DT        APV       TSHIFT
         NO INPUT
CARD 10: FILE NAME FOR OUTPUT OF SLIDING MOTION
         bbl.OUS
CARD 11: FILE NAME FOR OUTPUT OF ABSOLUTE MOTION
         bbl.OUA

MAX. VALUE OF INPUT HORI. ACC. =  .465208
INPUT HORI. ACC. TIMES A FACTOR =  .999983 TO GET APH =  .465200


*****************RESULTS****************

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .040000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .4741 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .3345 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .3380 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .3638 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .080000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .3983 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .1498 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .2529 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .1481 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .120000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .3309 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .0872 m
```

NSK 7-26

```
*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1761 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0623 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .160000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .2716 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0584 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1094 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0265 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .200000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .2179 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0385 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0562 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0102 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .240000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1688 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0240 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0272 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0027 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .280000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1257 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0141 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0080 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0002 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .320000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0869 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0075 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .360000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0529 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0036 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .400000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0256 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0013 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m
```

MSC 7.26

```
**********************************************
**                                          **
**                YSLIP_PM                  **
**        (VERSION 2.2, JANUARY 1996)       **
**                                          **
**   A COMPUTER PROGRAM FOR SIMULATION OF   **
**   DYNAMIC BEHAVIOR OF A RIGID BLOCK ON   **
**   AN INCLINED PLANE AND CALCULATION OF   **
**   PERMANENT DISPLACEMENTS OF THE BLOCK   **
**                                          **
**                   BY                     **
**                                          **
**               Liping Yan                 **
**            Neven Matasovic               **
**         Edward Kavazanjian, Jr.          **
**                                          **
**********************************************

***************REPRINT INPUT DATA**************

CARD  1: TITLE
         VARIATION OF Ky/Kh
CARD  2: SUBTITLE
         Big Bear Record 30' - SM thickness = 150 ft
CARD  3: KPAR  N     KACC  KCOM   g(m/s/s)  KOUT   KSLIP  KDIR
         0     10     1     1     9.807     0      0      0
CARD  4: Ky(1), ..., Ky(N)
         0.040 0.080 0.120 0.160 0.200 0.240 0.280 0.320 0.360 0.400
CARD  5: YIELD ACCELERATION DEGRADATION DATA
         Ky is constant.
CARD  6: INPUT HORIZONTAL ACC. TIME HISTORY FILE NAME
         b30150.out
CARD  7: NIDH  KREAD    NP      NLINE    DT      APH
         2     2        4096    512      0.01    0.4570
CARD  8: INPUT VERTICAL ACC. TIME HISTORY FILE NAME
         NO Av
CARD  9: NIDV  KREAD    NP      NLINE    DT      APV     TSHIFT
         NO INPUT
CARD 10: FILE NAME FOR OUTPUT OF SLIDING MOTION
         bbl.OUS
CARD 11: FILE NAME FOR OUTPUT OF ABSOLUTE MOTION
         bbl.OUA

MAX. VALUE OF INPUT HORI. ACC. =  .457006
INPUT HORI. ACC. TIMES A FACTOR =  .999987 TO GET APH =  .457000


*****************RESULTS****************

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .040000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .5083 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .3525 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .3590 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .3839 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .080000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .4312 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .1558 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .2764 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .1452 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .120000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .3584 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .0923 m
```

MSK 7.26

```
*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .2026 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0643 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .160000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .2907 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0607 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1370 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0297 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .200000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .2288 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0399 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0818 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0142 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .240000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1734 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0251 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0386 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0053 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .280000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1247 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0149 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0112 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0009 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .320000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0830 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0079 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .360000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0483 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0036 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .400000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0211 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0011 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m
```

HGK 7.96

```
**********************************************
**                                          **
**                YSLIP_PM                  **
**        (VERSION 2.2, JANUARY 1996)       **
**                                          **
**   A COMPUTER PROGRAM FOR SIMULATION OF   **
**   DYNAMIC BEHAVIOR OF A RIGID BLOCK ON   **
**   AN INCLINED PLANE AND CALCULATION OF   **
**   PERMANENT DISPLACEMENTS OF THE BLOCK   **
**                                          **
**                    BY                    **
**                                          **
**               Liping Yan                 **
**             Neven Matasovic              **
**         Edward Kavazanjian, Jr.          **
**                                          **
**********************************************

***************REPRINT INPUT DATA**************

CARD  1: TITLE
         VARIATION OF Ky/Kh
CARD  2: SUBTITLE
         Big Bear Record 60' - SM thickness = 150 ft
CARD  3: KPAR  N    KACC  KCOM  g(m/s/s)  KOUT  KSLIP  KDIR
         0     10   1     1     9.807     0     0      0
CARD  4: Ky(1), ..., Ky(N)
         0.040 0.080 0.120 0.160 0.200 0.240 0.280 0.320 0.360 0.400
CARD  5: YIELD ACCELERATION DEGRADATION DATA
         Ky is constant.
CARD  6: INPUT HORIZONTAL ACC. TIME HISTORY FILE NAME
         b60150.out
CARD  7: NIDH  KREAD  NP    NLINE  DT    APH
         2     2      4096  512    0.01  0.4084
CARD  8: INPUT VERTICAL ACC. TIME HISTORY FILE NAME
         NO Av
CARD  9: NIDV  KREAD  NP    NLINE  DT    APV    TSHIFT
         NO INPUT
CARD 10: FILE NAME FOR OUTPUT OF SLIDING MOTION
         bbl.OUS
CARD 11: FILE NAME FOR OUTPUT OF ABSOLUTE MOTION
         bbl.OUA

MAX. VALUE OF INPUT HORI. ACC. =  .408391
INPUT HORI. ACC. TIMES A FACTOR = 1.000022 TO GET APH =  .408400


*****************RESULTS****************

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .040000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .4684 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .3155 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .3114 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .3454 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .080000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .3884 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .1351 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .2265 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .1202 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .120000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .3136 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .0802 m
```

MK 7.26

```
*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1512 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0485 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .160000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .2451 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0512 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0871 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0185 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .200000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1836 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0321 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0402 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0065 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .240000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1302 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0189 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0142 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0011 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .280000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0853 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0097 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0005 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .320000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0481 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0039 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .360000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0191 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0011 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .400000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0014 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m
```

AMK 7-26

```
**********************************************
**                                          **
**                YSLIP_PM                  **
**        (VERSION 2.2, JANUARY 1996)       **
**                                          **
**   A COMPUTER PROGRAM FOR SIMULATION OF   **
**   DYNAMIC BEHAVIOR OF A RIGID BLOCK ON   **
**   AN INCLINED PLANE AND CALCULATION OF   **
**   PERMANENT DISPLACEMENTS OF THE BLOCK   **
**                                          **
**                    BY                    **
**                                          **
**               Liping Yan                 **
**             Neven Matasovic              **
**          Edward Kavazanjian, Jr.         **
**                                          **
**********************************************

***************REPRINT INPUT DATA**************

CARD  1: TITLE
         VARIATION OF Ky/Kh
CARD  2: SUBTITLE
         Big Bear Record 60' - SM thickness = 100 ft
CARD  3: KPAR  N     KACC  KCOM   g(m/s/s)  KOUT   KSLIP  KDIR
         0     10    1     1      9.807     0      0      0
CARD  4: Ky(1), ..., Ky(N)
         0.040 0.080 0.120 0.160 0.200 0.240 0.280 0.320 0.360 0.400
CARD  5: YIELD ACCELERATION DEGRADATION DATA
         Ky is constant.
CARD  6: INPUT HORIZONTAL ACC. TIME HISTORY FILE NAME
         b60100.out
CARD  7: NIDH  KREAD    NP      NLINE   DT      APH
         2     2        4096    512     0.01    0.4448
CARD  8: INPUT VERTICAL ACC. TIME HISTORY FILE NAME
         NO Av
CARD  9: NIDV  KREAD    NP      NLINE   DT      APV     TSHIFT
         NO INPUT
CARD 10: FILE NAME FOR OUTPUT OF SLIDING MOTION
         bbl.OUS
CARD 11: FILE NAME FOR OUTPUT OF ABSOLUTE MOTION
         bbl.OUA

MAX. VALUE OF INPUT HORI. ACC. =  .444781
INPUT HORI. ACC. TIMES A FACTOR = 1.000043 TO GET APH =  .444800


*****************RESULTS****************

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .040000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .4677 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .3317 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .3117 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .3436 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .080000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .3908 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .1448 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .2199 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .1205 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .120000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .3210 m/sec
        PERMANENT SLIDING DISPLACEMENT =   .0858 m
```

MGK 7.26

```
*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1377 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0488 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .160000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .2595 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0563 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0865 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0180 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .200000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .2044 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0363 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0506 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0049 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .240000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1549 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0220 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0226 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0011 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .280000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1107 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0124 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0043 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0001 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .320000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0727 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0062 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .360000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0405 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0026 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .400000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0153 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0007 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m
```

Tuck 7.26

```
*********************************************
**                                         **
**                YSLIP_PM                 **
**        (VERSION 2.2, JANUARY 1996)      **
**                                         **
**   A COMPUTER PROGRAM FOR SIMULATION OF  **
**   DYNAMIC BEHAVIOR OF A RIGID BLOCK ON  **
**   AN INCLINED PLANE AND CALCULATION OF  **
**   PERMANENT DISPLACEMENTS OF THE BLOCK  **
**                                         **
**                   BY                    **
**                                         **
**              Liping Yan                 **
**            Neven Matasovic              **
**        Edward Kavazanjian, Jr.          **
**                                         **
*********************************************

***************REPRINT INPUT DATA**************

CARD  1: TITLE
         VARIATION OF Ky/Kh
CARD  2: SUBTITLE
         Big Bear Record 60' - SM thickness = 50 ft
CARD  3: KPAR  N    KACC  KCOM  g(m/s/s)  KOUT  KSLIP  KDIR
         0     10   1     1     9.807     0     0      0
CARD  4: Ky(1), ..., Ky(N)
         0.040 0.080 0.120 0.160 0.200 0.240 0.280 0.320 0.360 0.400
CARD  5: YIELD ACCELERATION DEGRADATION DATA
         Ky is constant.
CARD  6: INPUT HORIZONTAL ACC. TIME HISTORY FILE NAME
         b6050.out
CARD  7: NIDH  KREAD  NP    NLINE  DT    APH
         2     2      4096  512    0.01  0.4108
CARD  8: INPUT VERTICAL ACC. TIME HISTORY FILE NAME
         NO Av
CARD  9: NIDV  KREAD  NP    NLINE  DT    APV    TSHIFT
         NO INPUT
CARD 10: FILE NAME FOR OUTPUT OF SLIDING MOTION
         bbl.OUS
CARD 11: FILE NAME FOR OUTPUT OF ABSOLUTE MOTION
         bbl.OUA

MAX. VALUE OF INPUT HORI. ACC. =  .410755
INPUT HORI. ACC. TIMES A FACTOR = 1.000110 TO GET APH =  .410800


*****************RESULTS****************

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .040000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .4468 m/sec
        PERMANENT SLIDING DISPLACEMENT =  .3073 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .3389 m/sec
        PERMANENT SLIDING DISPLACEMENT =  .3441 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .080000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .3635 m/sec
        PERMANENT SLIDING DISPLACEMENT =  .1357 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =   .2567 m/sec
        PERMANENT SLIDING DISPLACEMENT =  .1319 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =   .120000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =   .2871 m/sec
        PERMANENT SLIDING DISPLACEMENT =  .0784 m
```

MGK 7.26

```
*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1816 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0547 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .160000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .2249 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0500 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .1151 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0228 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .200000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1723 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0311 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0598 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0087 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .240000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .1255 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0175 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0232 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0020 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .280000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0841 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0087 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0020 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0001 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .320000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0488 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0036 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .360000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0205 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0011 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

  RESULTS FOR DOWNSLOPE YIELD ACCELERATION (g) =    .400000

*** RUN 1: THE DIRECTION OF Ah IS AS INPUT ***
                MAX. SLIDING VELOCITY =    .0018 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m

*** RUN 2: THE DIRECTION OF Ah IS REVERSED ***
                MAX. SLIDING VELOCITY =    .0000 m/sec
        PERMANENT SLIDING DISPLACEMENT =    .0000 m
```

Calculation Package G-4
Seismically-Induced Permanent Deformations

GeoSyntec Consultants

GEOSYNTEC CONSULTANTS
COMPUTATION COVER SHEET

Client: Parsons **Project:** BRC CAMU **Project/Proposal #:** HL0389 **Task #:** 04

Title of Computations: Evaluation of Seismic-Induced Permanent Deformations

Computations By:
SIGNATURE — DATE: 28 July 2000
Geoff L. Smith / Staff Engineer
PRINTED NAME AND TITLE

Assumptions and Procedures Checked By (Peer Reviewer):
SIGNATURE — DATE: 07-26-00
Neven Matasovic / Project Engineer
PRINTED NAME AND TITLE

Computations Checked By:
SIGNATURE — DATE: 7-26-00
Michael E. Kalinski / Senior Staff Engineer
PRINTED NAME AND TITLE

Computations Backchecked By (Originator):
SIGNATURE — DATE: 7-26-00
Geoff L. Smith / Staff Engineer
PRINTED NAME AND TITLE

Approved By (PM or Designate):
SIGNATURE — DATE: 07/26/00
Edward Kavazanjian, Jr. / Principal
PRINTED NAME AND TITLE

Approval Notes:

Revisions: (Number and Initial All Revisions)

No.	Sheet	Date	By	Checked By	Approval

Written by: Geoff L. Smith Date: 07 / 25 / 00 (MM DD YY) Reviewed by: Date: / / (MM DD YY)

Client: Parsons Project: BRC CAMU Project No.: HL0389 Task No.: 04

EVALUATION OF SEISMICALLY-INDUCED PERMANENT DEFORMATIONS BRC CAMU HENDERSON, NEVADA

PURPOSE

The purpose of the analyses documented herein is to evaluate seismically-induced permanent deformations of the proposed BRC CAMU in Henderson, Nevada. The analyses are based on site-specific seismic deformation charts documented in a companion calculation package (*site-specific seismic deformation charts*).

METHOD OF ANALYSIS

Using the site-specific seismic deformation charts, seismically-induced permanent deformations may be evaluated. The site-specific seismic deformation charts are presented in two figures which represent the expected deformations of the North Mesa area and at the South Mesa area of the proposed landfill (see *site-specific deformation charts* calculation package). The North Mesa site-specific deformation chart shows a larger deformation response than the South Mesa chart. Therefore, for simplicity and conservatism, the North Mesa site-specific deformation chart will be used herein to represent the expected deformations at all locations. Figure 1 presents the North Mesa site-specific deformation chart. The site-specific seismic deformation chart has numerous curves that represent a suite of potential site responses. To be conservative, the curve that indicates the largest seismic deformation is used.

Seismically-induced permanent deformations are evaluated for the following locations:

- side slopes of the final cover;
- top deck of the final cover; and
- base liner.

Written by: Geoff L. Smith Date: 07 / 25 / 00 (MM DD YY) Reviewed by: RKC 7.26 Date: / / (MM DD YY)

Client: Parsons Project: BRC CAMU Project No.: HL0389 Task No.: 04

RK 07/26/00

DESIGN CRITERION

To evaluate seismically-induced permanent deformations at the BRC CAMU site, GeoSyntec established a maximum deformation of 12 in (0.3 m) for final cover slopes and 6 in (150 mm) for the base liner as the design criterion.

YIELD ACCELERATIONS

The yield accelerations presented here in were calculated in the final waste slopes and the final cover stability companion calculation packages. The yield accelerations evaluated from the stability calculations are as follows:

Location	Yield Acceleration
Final Cover Side Slopes	0.15 g
Final Cover Top Deck	>0.15 g
Base Liner	0.10 g

The yield acceleration of the final cover top deck is larger than the final cover side slopes due to the smaller slope inclination (e.g., 2% for the top deck compared to 3H:1V for the side slopes). The smaller slope inclination of the top deck produces a higher factor of safety than the final cover side slopes resulting in larger yield accelerations.

RESULTS

By inputting the yield acceleration into the site-specific deformation charts, the seismically-induced permanent deformations may be evaluated. Based on the site-specific seismic deformation charts, the permanent seismic deformations are estimated to be:

Location	Estimated Permanent Deformation
Final Cover Side Slopes	0.07 m (2.8 in)
Final Cover Top Deck	< 0.07 m (2.8 in)
Base Liner	0.15 m (5.9 in)

Based on the above results, the estimated seismically-induced permanent deformations meet the design criteria.

REFERENCES - COMPANION CALCULATION PACKAGES

- Site-specific Deformation Charts
- Seismic Hazard Evaluation and Design Ground Motions
- Seismic Site Response Analyses
- Slope Stability Evaluation - Final Waste Slopes
- Final Cover Sloughing Stability Calculations

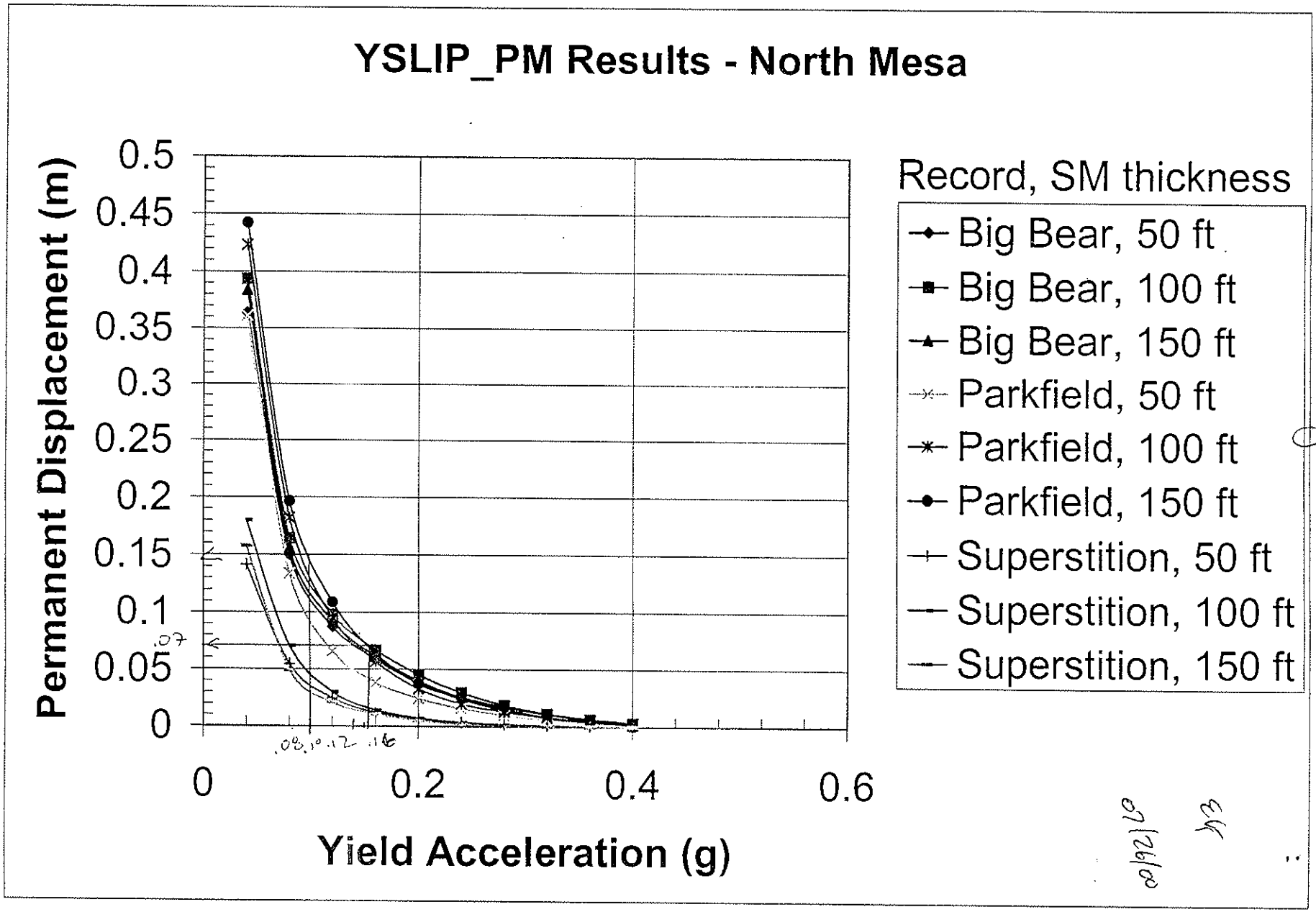


Figure 1

MSC 7.26

EK

09/26/00

Section 6
Final Cover Construction Quality Assurance Plan

CONSTRUCTION QUALITY ASSURANCE PLAN
FOR THE
CONSTRUCTION OF

FINAL COVER SYSTEM
AT
CORRECTIVE ACTION MANAGEMENT UNIT
BASIC REMEDIATION COMPANY
HENDERSON, NEVADA

Prepared for:

Basic Remediation Company
875 West Warm Springs Road
Henderson, Nevada 89015
(702) 567-0400

Prepared by:

GeoSyntec Consultants
11305 Rancho Bernardo Road, Suite 101
San Diego, California 92127
(858) 674-6559

3 November 2006

TABLE OF CONTENTS

1. INTRODUCTION 1

1.1 Terms of Reference 1
1.2 Purpose and Scope of the Construction Quality Assurance Plan 1
1.3 References 2
1.4 Organization of the Construction Quality Assurance Plan 2

2. DEFINITIONS RELATING TO CONSTRUCTION QUALITY ASSURANCE 3

3. PARTIES INVOLVED WITH CONSTRUCTION QUALITY ASSURANCE 4

3.1 Engineer 4
3.2 Project Manager 4
3.3 Contractor 5
3.4 Resin Supplier 5
3.5 Geosynthetics Manufacturer 6
3.6 Geosynthetic Installer 6
3.7 CQA Consultant 7
3.8 Surveyor 8
3.9 CQA Laboratory 9

4. CQA CONSULTANTS PERSONNEL ORGANIZATION AND DUTIES 10

4.1 Overview 10
4.2 CQA Personnel 11
4.2.1 CQA Officer 11
4.2.2 CQA Site Manager 12

5. SITE AND PROJECT CONTROL 14

5.1 Project Coordination Meetings 14
5.1.1 Resolution Meeting 14
5.1.2 Pre-Construction Meeting 15
5.1.3 Progress Meetings 17
5.1.4 Problem or Work Deficiency Meeting 17

6. DOCUMENTATION 18

6.1 Overview 18
6.2 Daily Recordkeeping 18
6.3 Construction Problems and Resolution Data Sheets 19
6.4 Photographic Documentation 21
6.5 Design and/or Specifications Changes 21
6.6 CQA Report 21

7. EARTHWORKS 24

7.1 Introduction 24
7.2 Testing Activities 24
7.2.1 Sample Frequency 25
7.2.2 Sample or Test Location Selection 25
7.3 CQA Monitoring Activities 26
7.3.1 Earthwork 26
7.3.2 Cover Soil Material 27
7.3.3 Prepared Subgrade 28
7.4 Deficiencies 28
7.4.1 Notification 28
7.4.2 Repairs and Re-Testing 29

8. DRAINAGE AGGREGATE 30

8.1 Introduction 30
8.2 Testing Activities 30
8.2.1 Sample Frequency 30
8.2.2 Sample Selection 31
8.3 CQA Monitoring Activities 31
8.3.1 Drainage Aggregate 31
8.4 Deficiencies 32
8.4.1 Notification 32
8.4.2 Repairs and Re-testing 32

9. CORRUGATED POLYETHYLENE (CPE) PIPE AND FITTINGS 33

9.1 Material Requirements 33
9.2 Manufacturer 33
9.2.1 Submittals 33

9.2.2 Identification 33
9.3 Handling and Laying 34
9.4 Joints 35

10. GEOMEMBRANE 36

10.1 General 36
10.2 Geomembrane Material Conformance 36
10.2.1 Introduction 36
10.2.2 Review of Quality Control 37
10.2.3 Conformance Testing 39
10.3 Delivery 39
10.3.1 Transportation and Handling 39
10.3.2 Storage 40
10.4 Geomembrane Installation 40
10.4.1 Introduction 40
10.4.2 Earthwork 40
10.4.3 Geomembrane Placement 41
10.4.4 Field Seaming 45
10.4.5 Defects and Repairs 58
10.4.6 Lining System Acceptance 60

11. GEOTEXTILE 62

11.1 Introduction 62
11.2 Manufacturing 62
11.3 Labeling 63
11.4 Shipment and Storage 63
11.5 Conformance Testing 64
11.5.1 Tests 64
11.5.2 Sampling Procedures 64
11.5.3 Test Results 64
11.5.4 Conformance Sample Failure 65
11.6 Handling and Placement 65
11.7 Seams and Overlaps 66
11.8 Repair 66
11.9 Placement of Soil Materials 67

12. GEOSYNTHETIC CLAY LINER (GCL) 68

12.1 Introduction 68
12.2 Manufacturing 68
12.3 Labeling 69
12.4 Shipment and Storage 69
12.5 Conformance Testing 69
12.5.1 Tests 69
12.5.2 Conformance Sample Failure 70
12.6 GCL Delivery and Storage 71
12.7 GCL Installation 71

13. GEOCOMPOSITE 73

13.1 Introduction 73
13.2 Manufacturing 73
13.3 Labeling 73
13.4 Shipment and Storage 74
13.5 Conformance Testing 74
13.5.1 Tests 74
13.5.2 Sampling Procedures 75
13.5.3 Test Results 75
13.5.4 Conformance Test Failure 75
13.6 Handling and Placement 76
13.7 Geocomposite Seams and Overlaps 77
13.8 Repair 77
13.9 Placement of Soil Materials 78

14. SURVEYING 79

14.1 Survey Control 79
14.2 Precision and Accuracy 79
14.3 Lines and Grades 79
14.4 Frequency and Spacing 80
14.5 Documentation 80

1. INTRODUCTION

1.1 Terms of Reference

GeoSyntec Consultants (GeoSyntec) has prepared this Construction Quality Assurance (CQA) Plan for the construction of the Corrective Action Management Unit (CAMU) Final Cover System for Basic Remediation Company (BRC) located in Henderson, Nevada. Hereinafter, the CAMU construction is referred to as the Project.

This CQA Plan was prepared by Mr. Gregory T. Corcoran, P.E. of GeoSyntec Consultants (GeoSyntec) under the direction of Mr. Brad Cooley, P.E. In general accordance with the peer review policies of the firm, Mr. Brad Cooley, P.E. of GeoSyntec was responsible for senior peer review of the work presented in this plan.

1.2 Purpose and Scope of the Construction Quality Assurance Plan

The purpose of the CQA Plan is to address the CQA procedures and monitoring requirements for construction of the Project. The CQA Plan is intended to: (i) define the responsibilities of parties involved with the construction; (ii) provide guidance in the proper construction of the major components of the Project; (iii) establish testing protocols; (iv) establish guidelines for construction documentation; and (v) provide the means for assuring that the Project is constructed in conformance to the *Technical Specifications*, permit conditions, applicable regulatory requirements, and *Construction Drawings*.

This CQA Plan addresses the soils and geosynthetic components of the final cover system for the project. The soils, geosynthetic, and appurtenant components include cover soil, prepared subgrade, drainage aggregate, geosynthetic clay liner, geomembrane, geotextile, geocomposite, and corrugated polyethylene (CPE) pipe. It should be emphasized that care and documentation are required in the placement and compaction of the soils and aggregate and in the production and installation of the geosynthetic materials placed during construction. The CQA Plan, therefore, delineates the procedures to be followed for monitoring construction of these materials.

The scope of this CQA Plan includes the CQA of the soil and geosynthetic components of the Project. The CQA monitoring activities during the selection, evaluation, treatment, placement, and compaction of soils for earthworks, and drainage aggregate are included in the scope of this plan. The CQA protocols applicable to manufacturing, shipping, handling, and installing all geosynthetic materials are also included. However, this CQA Plan does not specifically address either installation specifications or specification of soils and geosynthetic materials as these requirements are addressed in the *Technical Specifications*.

1.3 References

The CQA Plan includes references to test procedures in the latest editions of the American Society for Testing and Materials (ASTM).

1.4 Organization of the Construction Quality Assurance Plan

The remainder of the CQA Plan is organized as follows:

- Section 2 presents definitions relating to CQA;
- Section 3 describes the parties involved with the CQA;
- Section 4 describes the responsibilities of the CQA personnel;
- Section 5 describes site and project control requirements;
- Section 6 presents CQA documentation;
- Section 7 presents CQA of earthworks;
- Section 8 presents CQA of the drainage aggregates;
- Section 9 presents CQA of the pipe and fittings;
- Section 10 presents CQA of the geomembrane;
- Section 11 presents CQA of the geotextile;
- Section 12 presents CQA of the geosynthetic clay liner;
- Section 13 presents CQA of the geocomposite; and
- Section 14 presents CQA surveying.

2. DEFINITIONS RELATING TO CONSTRUCTION QUALITY ASSURANCE

This CQA Plan is devoted to Construction Quality Assurance. In the context of this document, Construction Quality Assurance and Construction Quality Control are defined as follows:

Construction Quality Assurance (CQA) - A planned and systematic pattern of means and actions designed to assure adequate confidence that materials and/or services meet contractual and regulatory requirements and will perform satisfactorily in service.

Construction Quality Control (CQC) - Those actions which provide a means to measure and regulate the characteristics of an item or service in relation to contractual and regulatory requirements.

In the context of this document:

- CQA refers to means and actions employed by the CQA Consultant to assure conformity of the Project "Work" with this CQA Plan, the *Drawings*, and the *Technical Specifications*.

- Construction Quality Control refers to those actions taken by the Contractor, Manufacturer, or Geosynthetic Installer to verify that the materials and the workmanship meet the requirements of this CQA Plan, the *Drawings*, and the *Technical Specifications*. In the case of soil components, CQC is combined with CQA and is provided by the CQA Consultant. In the case of the geosynthetic components and piping of the Work, CQC is provided by the Manufacturer and Geosynthetic Installer and the Contractor. CQA testing of soil, pipe, and geosynthetic components is provided by the CQA Consultant.

3. PARTIES INVOLVED WITH CONSTRUCTION QUALITY ASSURANCE

3.1 Engineer

Responsibilities

The Engineer is responsible for the design, *Drawings*, and *Technical Specifications* for the Project Work. In this CQA Plan, the term "Engineer" refers to Parsons Engineering Science, Inc. (Parsons) and GeoSyntec.

Qualifications

The Engineer of Record shall be a qualified engineer, registered as required by Nevada state regulations. The Engineer should have expertise, which demonstrates significant familiarity with piping, geosynthetics and soils, as appropriate, including design and construction experience related to landfill liner systems.

3.2 Project Manager

Responsibilities

The Project Manager is responsible for implementing the design, and overseeing subcontractors. In this CQA Plan, the term "Project Manager" refers to a qualified BRC employee.

Qualifications

The Project Manager shall be a qualified engineer having familiarity with earthwork construction and installation of geosynthetic materials.

3.3 Contractor

Responsibilities

In this CQA Plan, Contractor refers to an independent party or parties, contracted by the Owner, performing the Work in general accordance with this CQA Plan, the *Drawings*, and the *Technical Specifications*. The Contractor will be responsible for the installation of the soils and geosynthetic components of the liner system. This work will include excavation, placement and compaction of engineered fill and prepared subgrade, placement of drainage aggregate and native soil (operations layer material), installation and of piping and concrete manhole, installation of temporary erosion control features, and coordination of work with the Geosynthetic Installer and other subcontractors.

The Contractor will be responsible for constructing the liner system and appurtenant components in general accordance with the *Drawings* and complying with the quality control requirements specified in the *Technical Specifications*.

Qualifications

Qualifications of the Contractor are specific to the construction contract. The Contractor should have a demonstrated history of successful earthworks construction and maintain current state and federal licenses as appropriate.

3.4 Resin Supplier

Responsibilities

The Resin Supplier produces and delivers the resin to the Geosynthetics Manufacturer.

Qualifications

Qualifications of the Resin Supplier are specific to the Manufacturer's requirements. The Resin Supplier will have a demonstrated history of providing resin with consistent properties.

3.5 Geosynthetics Manufacturer

Responsibilities

The Manufacturer is responsible for the production of finished material (geomembrane, geotextile, geosynthetic clay liner, geocomposite, pipe, and other specified material) from appropriate raw materials.

Qualifications

The Manufacturer(s) will be able to provide sufficient production capacity and qualified personnel to meet the demands of the project. The Manufacturer(s) must be a well established firm(s) that meet the requirements identified in the *Technical Specifications*.

3.6 Geosynthetic Installer

Responsibilities

The Geosynthetic Installer is responsible for field handling, storage, placement, seaming, loading or anchoring against wind uplift, and other aspects of the geosynthetic material installation. The Geosynthetic Installer may also be responsible for specialized construction tasks (i.e., including construction of anchor trenches for the geosynthetic materials).

Qualifications

The Geosynthetic Installer will be trained and qualified to install the geosynthetic materials of the type specified for this project. The Geosynthetic Installer shall meet the qualification requirements identified in the *Technical Specifications*.

3.7 CQA Consultant

Responsibilities

The CQA Consultant is a party, independent from the Contractor, Manufacturer, and Geosynthetic Installer, who is responsible for observing, testing, and documenting activities related to the CQC and CQA of the earthwork, piping, and the geosynthetic components used in the construction of the Project. The CQA Consultant will also be responsible for issuing a CQA report at the completion of the Project construction, which details the earthworks, piping, and geosynthetic installation activities and associated CQA activities. The CQA report will be signed and sealed by the CQA Officer who will be a Professional Engineer registered in the State of Nevada.

The CQA Consultant will be responsible for obtaining and testing representative samples of all components used in construction of the Project as required by this CQA Plan and *Technical Specifications*. All tests will be conducted in general accordance with ASTM or other applicable state or federal standards. Test results must be submitted to the Project Manager within a reasonable timeframe, which will not impede or delay construction of the Project. The CQA Consultant will be responsible for inspecting all earthwork, piping, and geosynthetic operations to verify that the components are installed in general accordance with this CQA Plan and *Technical Specifications*.

Qualifications

The CQA Consultant is a well established firm specializing in geotechnical and geosynthetic engineering and possess the equipment, personnel, and licenses necessary to conduct the geotechnical and geosynthetic tests required by the project plans and *Technical Specifications*. The CQA Consultant will provide qualified staff

for the project, as necessary, which will include, at a minimum, a CQA Officer, and a CQA Site Manager. The CQA Officer will be a professionally licensed engineer as required by Nevada State regulations.

The CQA Consultant will be experienced with earthwork construction and the installation of geosynthetic materials similar to those materials used in construction of the Project. The CQA Consultant will be experienced in the preparation of CQA documentation including CQA Plans, field documentation, field testing procedures, laboratory testing procedures, construction specifications, construction drawings, and CQA reports.

The CQA Site Manager will be specifically familiar with the construction of earthworks, piping, and the installation of geosynthetic materials and will be trained by the CQA Consultant in the duties of a CQA Site Manager.

3.8 Surveyor

Responsibilities

The Surveyor is a party, independent from the Contractor, Manufacturer, and Geosynthetic Installer, that is responsible for surveying, documenting, and verifying the location of all significant components of the Work. The Surveyor's work is coordinated and employed by the Owner. The Surveyor is responsible for issuing record drawings of the construction.

Qualifications

The Surveyor will be a well established surveying company with at least 3 years experience in the profession of surveying services in the State of Nevada. The Surveyor will be a licensed professional as required by the State of Nevada regulations. The Surveyor shall be fully equipped and experienced in the use of total stations and AutoCAD Version 14. All surveying will be performed under the direct supervision of the Owner.

3.9 CQA Laboratory

Responsibilities

The CQA Laboratory is a party, independent from the Contractor, Manufacturer and Geosynthetic Installer, that is responsible for conducting tests in general accordance with ASTM and other applicable test standards on samples of geosynthetic materials and soil in the field and in either an on-site or off-site laboratory.

Qualifications

The CQA Laboratory will have experience in testing soils and geosynthetic materials and will be familiar with ASTM and other applicable test standards. The CQA Laboratory will be capable of providing test results within a maximum of seven days of receipt of samples and will maintain that capability throughout the duration of earthworks construction and geosynthetic materials installation. The CQA Laboratory will also be capable of transmitting geosynthetic destructive test results within 24 hours of receipt of samples and will maintain that capability throughout the duration of geosynthetic material installation.

4. CQA CONSULTANTS PERSONNEL ORGANIZATION AND DUTIES

4.1 Overview

The CQA Officer will provide supervision within the scope of work of the CQA Consultant. The scope of work for the CQA Consultant includes monitoring of construction activities including the following:

- screening of materials;
- placement and compaction of cover soil and prepared subgrade;
- installation of geotextile;
- installation of geosynthetic clay liner;
- installation of geomembrane;
- installation of drainage aggregate;
- installation of geocomposite; and
- installation of piping.

The duties of the CQA personnel are discussed in the remainder of this section.

4.2 CQA Personnel

For construction of the Project, the CQA Consultant's personnel will include:

- the CQA Officer, who operates from the office of the CQA Consultant and who conducts periodic visits to the site as required; and

- the CQA Site Manager, who is located at the site.

The duties of the CQA Personnel are discussed in the following subsections.

4.2.1 CQA Officer

The CQA Officer shall supervise and be responsible for monitoring and CQA activities relating to the construction of the earthworks, piping, and installation of the geosynthetic materials of the Project. Specifically, the CQA Officer:

- reviews the project design, this CQA Plan, *Drawings*, and *Technical Specifications*;

- reviews other site-specific documentation; unless otherwise agreed, such reviews are for familiarization and for evaluation of constructability only, and hence the CQA Officer and the CQA Consultant assume no responsibility for the liner system design;

- reviews and approves the Geosynthetic Installer's QC Plan;

- attends resolution and/or pre-construction meetings as needed;

- administers the CQA program (i.e., provides supervision of and manages on-site CQA personnel, reviews field reports, and provides engineering review of CQA related activities);

- provides quality control of CQA documentation and conducts site visits;
- reviews the record drawings; and
- with the CQA Site Manager, prepares the CQA report documenting that the project was constructed in general accordance with the Construction Documents.

4.2.2 CQA Site Manager

The CQA Site Manager:

- acts as the on-site representative of the CQA Consultant;
- attends CQA-related meetings (e.g., resolution, pre-construction, daily, weekly (or designates a representative to attend the meeting));
- prepares or oversees the ongoing preparation of the record drawings;
- reviews test results provided by Contractor;
- assigns locations for testing and sampling;
- oversees the collection and shipping of laboratory test samples;
- reviews results of laboratory testing and makes appropriate recommendations;
- reviews the calibration and condition of on-site CQA equipment;
- prepares a daily summary report for the project;
- reviews the Manufacturer's QC documentation;

- reviews the Geosynthetic Installer's personnel Qualifications for conformance with those pre-approved for work on site;

- notes in the daily summary report and reports to the CQA Officer and Project Manager on-site activities that could result in damage to the geosynthetic materials or other completed work;

- reports unresolved deviations from the CQA Plan, *Drawings*, and *Technical Specifications* to the Project Manager; and

- assists with the preparation of the CQA report.

5. SITE AND PROJECT CONTROL

5.1 Project Coordination Meetings

Meetings of key project personnel are necessary to assure a high degree of quality during installation, and promote clear, open channels of communication. Therefore, Project Coordination Meetings are an essential element in the success of the project. Several types of Project Coordination Meetings are described below, including: (i) resolution meetings; (ii) pre-construction meetings; (iii) progress meetings; and (iv) problem or work deficiency meetings.

5.1.1 Resolution Meeting

Following the completion of the design, *Drawings*, and *Technical Specifications* for the project and prior to the start of construction, a Resolution Meeting will be held. This meeting may include the CQA Officer, the CQA Site Manager, the Engineer, and the Project Manager.

The purpose of this meeting is to begin planning for coordination of construction tasks, anticipate installation problems which might cause difficulties and delays in construction, and, above all, present the CQA Plan to the parties involved. It is very important that the criteria regarding testing, repair, and other CQA activities be known and accepted by the parties involved in the work prior to the installation of geosynthetic materials and construction of the soil components for the Project.

The first part of the Resolution Meeting may be devoted to a review of the *Drawings* and *Technical Specifications* for familiarity. This is different from the peer review of the design, including design calculations, which will have been carried out previously.

The Resolution Meeting may include the following activities:

- distribute relevant documents to all parties;
- review critical design details of the project;

- review this CQA Plan;
- review the Drawings and Technical Specifications;
- make appropriate modifications to the design criteria, *Drawings*, and *Technical Specifications* so that the fulfillment of the design specifications or performance standards can be determined through the implementation of the CQA Plan;
- reach a consensus on the quality control procedures, especially on methods of evaluating acceptability of the soils and geosynthetic materials;
- assign the responsibilities of each party;
- establish work area security and health and safety protocol;
- confirm the methods for documenting observations, reporting, and distributing documents and reports; and
- confirm the lines of authority and communication.

The Project Manager will appoint one of the meeting attendees to record the discussions and decisions of the Resolution Meeting. The record of the meeting will be documented by the appointee in the form of meeting minutes, which will be subsequently distributed to all attendees.

5.1.2 Pre-Construction Meeting

A Pre-Construction Meeting will be held at the site prior to construction of the Project. As a minimum, the Pre-Construction Meeting will be attended by the Contractor, the Geosynthetic Installer's Superintendent, the CQA Consultant, the Engineer, and the Project Manager.

Specific items for discussion at the pre-construction meeting include the following:

- appropriate modifications or clarifications to the CQA Plan;
- the Drawings and Technical Specifications;
- the responsibilities of each party;
- lines of authority and communication;
- methods for documenting and reporting, and for distributing documents and reports;
- acceptance and rejection criteria;
- protocols for testing;
- protocols for handling deficiencies, repairs, and re-testing;
- the time schedule for all operations;
- procedures for packaging and storing archive samples;
- panel layout and numbering systems for panels and seams;
- seaming procedures;
- repair procedures; and
- soil stockpiling locations.

The Project Manager will conduct a site tour to observe the current site conditions and to review construction material and equipment storage locations. A person in attendance at the meeting will be appointed by the Project Manager to record

the discussions and decisions of the meeting in the form of meeting minutes. Copies of the meeting minutes will be distributed to all attendees.

5.1.3 Progress Meetings

Progress meetings will be held between the CQA Site Manager, the Contractor, Project Manager, and other concerned parties participating in the construction of the project. This meeting will include discussions on the current progress of the project, planned activities for the next week, and revisions to the work plan and/or schedule. The meeting will be documented in meeting minutes prepared by a person designated by the CQA Site Manager at the beginning of the meeting. Within 2 working days of the meeting, draft minutes will be transmitted to representatives of parties in attendance for review and comment. Corrections and/or comments to the draft minutes shall be made within 2 working days of receipt of the draft minutes to be incorporated in the final meeting minutes.

5.1.4 Problem or Work Deficiency Meeting

A special meeting will be held when and if a problem or deficiency is present or likely to occur. The meeting will be attended by the Contractor, the Project Manager, the CQA Site Manager, and other parties as appropriate. If the problem requires a design modification, the Engineer should either be present at, consulted prior to, or notified immediately upon conclusion of this meeting. The purpose of the work deficiency meeting is to define and resolve the problem or work deficiency as follows:

- define and discuss the problem or deficiency;
- review alternative solutions;
- select a suitable solution agreeable to all parties; and
- implement an action plan to resolve the problem or deficiency.

The Project Manager will appoint one attendee to record the discussions and decisions of the meeting. The meeting record will be documented in the form of meeting minutes and copies will be distributed to all affected parties. A copy of the minutes will be retained in facility records.

6. DOCUMENTATION

6.1 Overview

An effective CQA Plan depends largely on recognition of all construction activities that should be monitored and on assigning responsibilities for the monitoring of each activity. This is most effectively accomplished and verified by the documentation of quality assurance activities. The CQA Consultant will document that all quality assurance requirements have been addressed and satisfied.

The CQA Site Manager will provide the Project Manager with signed descriptive remarks, data sheets, and logs to verify that monitoring activities have been carried out. The CQA Site Manager will also maintain, at the job site, a complete file of *Drawings* and *Technical Specifications*, a CQA Plan, checklists, test procedures, daily logs, and other pertinent documents.

6.2 Daily Recordkeeping

Preparation of daily CQA documentation will consist of daily reports prepared by the CQA Site Manager which may include CQA monitoring logs, and testing data sheets. This information may be regularly submitted to and reviewed by the Project Manager.

The CQA Site Manager will prepare daily reports that document the activities observed during each day of activity. The daily reports may include monitoring logs and testing data sheets. At a minimum, these logs and data sheets will include the following information:

- the date, project name, location, and other identification;
- a summary of the weather conditions;
- a summary of locations where construction is occurring;
- equipment and personnel on the project;

- a summary of meetings held and attendees;
- a description of materials used and references of results of testing and documentation;
- identification of deficient work and materials;
- results of re-testing corrected “deficient work;”
- an identifying sheet number for cross referencing and document control;
- descriptions and locations of construction inspected;
- type of construction and inspection performed;
- description of construction procedures and procedures used to evaluate construction;
- a summary of test data and results;
- calibrations or re-calibrations of test equipment and actions taken as a result of re-calibration;
- decisions made regarding acceptance of units of work and/or corrective actions to be taken in instances of substandard testing results;
- a discussion of agreements made between the interested parties which may affect the work; and
- signature of the respective CQA Site Manager.

6.3 Construction Problems and Resolution Data Sheets

Construction Problems and Resolution Data Sheets, to be submitted with the daily reports prepared by the CQA Site Manager, describing special construction situations will be cross-referenced with daily reports, specific observation logs, and testing data sheets and will include the following information, where available:

- an identifying sheet number for cross-referencing and document control;
- a detailed description of the situation or deficiency;
- the location and probable cause of the situation or deficiency;
- how and when the situation or deficiency was found or located;
- documentation of the response to the situation or deficiency;
- final results of responses;
- measures taken to prevent a similar situation from occurring in the future; and
- signature of the CQA Site Manager and a signature indicating concurrence by the Project Manager.

The Project Manager will be made aware of significant recurring nonconformance with the *Drawings*, *Technical Specifications*, or CQA Plan. The cause of the nonconformance will be determined and appropriate changes in procedures or specifications will be recommended. These changes will be submitted to the Engineer for approval. When this type of evaluation is made, the results will be documented and any revision to procedures or specifications will be approved by the Contractor and Engineer.

A summary of supporting data sheets, along with final testing results and the CQA Site Manager's approval of the work, will be required upon completion of construction.

6.4 Photographic Documentation

Photographs will be taken and documented in order to serve as a pictorial record of work progress, problems, and mitigation activities. The basic file will contain color prints. Negatives will also be stored in a separate file in chronological order. These records will be presented to the Project Manager upon completion of the project. Photographic reporting data sheets, where used, will be cross-referenced with observation and testing data sheet(s), and/or construction problem and solution data sheet(s). Photographs used for documentation will be identified with the date, time, and location of the photograph.

6.5 Design and/or Specifications Changes

Design and/or specifications changes may be required during construction. In such cases, the CQA Site Manager will notify the Project Manager. Design and/or specification changes will be made with the written agreement of the Project Manager and the Engineer and will take the form of an addendum to the *Drawings* and *Technical Specifications*.

6.6 CQA Report

At the completion of the Project, the CQA Consultant will submit to the Project Manager the CQA report signed and sealed by the Professional Engineer licensed in the State of Nevada. The CQA report will acknowledge: (i) that the work has been performed in compliance with the *Drawings* and *Technical Specifications*; (ii) physical sampling and testing has been conducted at the appropriate frequencies; and (iii) that the summary document provides the necessary supporting information. At a minimum, this report will include:

- Manufacturers' quality control documentation;

- a summary report describing the CQA activities and indicating compliance with the *Drawings* and *Technical Specifications* which is signed and sealed by the CQA Officer;

- a summary of CQA/CQC testing, including failures, corrective measures, and retest results;

- contractor personnel resumes and qualifications;

- documentation that the geomembrane trial seams were performed in general accordance with the CQA Plan and *Technical Specifications*;

- documentation that field seams were non-destructively tested using a method in general accordance with the applicable test standards;

- documentation that nondestructive testing was monitored by the CQA Consultant, that the CQA Consultant informed the Geosynthetic Installer of any required repairs, and that the CQA Consultant inspected the seaming and patching operations for uniformity and completeness;

- records of sample locations, the name of the individual conducting the tests, and the results of tests;

- record drawings as provided by the Surveyor;

- documentation showing that piping was tested in general accordance with the *Technical Specifications*; and

- daily inspection reports.

The record drawings will include scale drawings depicting the location of the construction and details pertaining to the extent of construction (e.g., depths, plan dimensions, elevations, soil component thicknesses). Base maps required for development of the record drawings and the record drawings will be prepared by a

qualified Professional Land Surveyor registered in the State of Nevada. These documents will be reviewed by the CQA Consultant and included as part of the CQA Report.

7. EARTHWORKS

7.1 Introduction

This section prescribes the CQA activities to be performed to monitor that earthwork components are constructed in general accordance with *Drawings* and *Technical Specifications*. The earthworks construction procedures to be monitored by the CQA Consultant include:

- cover soil placement;
- anchor trench excavation and backfill; and
- subgrade preparation.

7.2 Testing Activities

Soil testing will be performed for material qualification, material conformance, and construction quality control (CQC). These three stages of testing are defined as follows:

- Material qualification tests are used to evaluate the conformance of a proposed soil source to the material specifications for qualification of the source prior to construction.

- Soils conformance testing is used to evaluate the conformance of a particular batch of soil from a qualified source to the material specifications prior to installation of the soil.

- CQC tests are performed on completed portions of the earthwork during construction to demonstrate that the placement procedures are resulting in a product that meets or exceeds both material and performance specifications.

The Contractor will be responsible for submitting material qualification test results to the Project Manager and to the CQA Site Manager for review. The CQA Laboratory will perform the conformance testing and CQC testing. Soil testing will be

conducted in general accordance with the current versions of the corresponding American Society for Testing and Materials (ASTM) test procedures. The test methods indicated in Table 1 are those that will be used for this testing unless the test methods are updated or revised prior to construction. Revisions to the test methods will be reviewed and approved by the Engineer and the CQA Site Manager prior to their usage.

7.2.1 Sample Frequency

The frequency of soils testing for material qualification will conform to the minimum frequencies presented in Table 2. The frequency of soils testing for material conformance will conform to the minimum frequencies presented in Table 3. The actual frequency of testing required will be increased by the CQA Site Manager as necessary if variability of materials is noted at the site, during adverse conditions, or to isolate failing areas of the construction.

7.2.2 Sample or Test Location Selection

With the exception of qualification samples, sampling locations will be selected by the CQA Site Manager. Conformance samples will be obtained from borrow pits and/or stockpiles of material. The Contractor must plan the work and make soil available for sampling in a timely and organized manner so that the test results can be obtained before the material is installed. The CQA Site Manager must document sample locations so that failing areas can be immediately isolated. The CQA Site Manager will follow standard sampling procedures to obtain representative samples of the proposed soil materials.

CQC sample and test locations will be selected by the CQA Site Manager at the minimum test frequency specified in Table 4. Samples and test locations will generally be selected at random, however a special testing frequency will be used at the discretion of the CQA Site Manager when visual observations of construction performance indicate a potential problem. Additional testing for suspected areas will be considered when:

- rollers slip during rolling operation;
- lift thickness is greater than specified;

- fill is at improper and/or variable moisture content;
- less than specified number of roller passes are made;
- dirt-clogged rollers are used to compact the material;
- rollers may not have used optimum ballast;
- fill materials differ substantially from those specified;
- the degree of compaction is doubtful; and
- as directed by the Project Manager or the CQA Site Manager.

The frequency of testing may also be increased in the following situations:

- adverse weather conditions;
- breakdown of equipment;
- at the start and finish of grading;
- material fails to meet specifications; and
- the work area is reduced.

7.3 CQA Monitoring Activities

7.3.1 Earthwork

The CQA Site Manager will monitor and document the earthworks required for the Project. In general, monitoring the construction for earthwork includes the following activities:

- reviewing documentation of the material qualification test results provided by the Contractor;

- monitoring the prepared subgrade and subgrade surfaces for compliance with the *Technical Specifications* before geosynthetic materials are placed;

- sampling and testing for conformance of the materials to the *Technical Specifications*;

- documenting that the earthwork is constructed using the specified equipment and procedures;

- documenting that the earthwork is constructed to the lines and grades shown on the *Drawings*;

- monitoring that the construction activities do not cause damage to underlying geosynthetic materials;

- quality control testing to determine the acceptability of the work during construction; and

- monitoring the action of the compaction and heavy hauling equipment on the construction surface (i.e., penetration, pumping, cracking, etc.).

The specific activities required for CQA of each of the major soil components of the Final Cover System are presented in the following sections.

7.3.2 Cover Soil Material

Monitoring the earthwork for the cover soil material specifically includes the following:

- reviewing documentation of the qualification and conformance test results;

- monitoring soil for maximum particle size and deleterious materials;

- monitoring the thickness of lifts during placement of the materials;

- monitoring compaction operations; and

- measuring and recording the field density and the field moisture content of the in-place material.

7.3.3 Prepared Subgrade

During construction, the CQA Site Manager will monitor the prepared subgrade to document that the prepared subgrade soil characteristics are consistent with those specified in the *Technical Specifications*. The CQA Site Manager will monitor the construction activities to document that sharp rocks and other undesirable materials are removed and that the subgrade is prepared using the procedures and equipment specified in the *Technical Specifications*.

The upper portion of the subgrade can be damaged by excess moisture (causing softening) or insufficient moisture (causing desiccation and shrinkage). At a minimum, the CQA Site Manager will determine the suitability of the subgrade for geomembrane placement by:

- documenting that the surface is free of sharp rocks, debris and other undesirable materials;
- documenting that the surface is smooth, uniform, and free from desiccation cracks by visually monitoring proof rolling activities; and
- documenting that the subgrade surface meets the lines and grades shown on the *Drawings* by reviewing certified survey results.

7.4 <u>Deficiencies</u>

If a defect is discovered in the earthwork product, the CQA Site Manager will immediately determine the extent and nature of the defect. If the defect is indicated by an unsatisfactory test result, the CQA Site Manager will determine the extent of the deficient area by additional tests, observations, a review of records, or other means that the CQA Site Manager deems appropriate. If the defect is related to adverse site conditions, such as overly wet soils or surface desiccation, the CQA Site Manager will define the limits and nature of the defect.

7.4.1 Notification

After evaluating the extent and nature of a defect, the CQA Site Manager will notify the Project Manager and Contractor and schedule appropriate re-tests when the work deficiency is to be corrected.

7.4.2 Repairs and Re-Testing

At locations where the field testing indicates densities below the requirements of the specification, the failing area will be reworked. The Contractor will correct the deficiency to the satisfaction of the CQA Site Manager. If a project specification criterion cannot be met, or unusual weather conditions hinder work, then the CQA Site Manager will develop and present to the Engineer and/or Project Manager suggested solutions for his approval.

All re-tests recommended by the CQA Site Manager must verify that the defect has been corrected before any additional work is performed by the Contractor in the area of the deficiency. The CQA Site Manager will also verify that installation requirements are met and that submittals are provided.

8. DRAINAGE AGGREGATE

8.1 Introduction

This section prescribes the CQA activities to be performed to monitor that drainage aggregates are constructed in general accordance with *Drawings* and *Technical Specifications*. The drainage aggregates construction procedures to be monitored by the CQA Consultant include drainage aggregate placement.

8.2 Testing Activities

Aggregate testing will be performed for material qualification and material conformance. These two stages of testing are defined as follows:

- Material qualification tests are used to evaluate the conformance of a proposed aggregate source to the material specifications for qualification of the source prior to construction.

- Aggregate conformance testing is used to evaluate the conformance of a particular batch of aggregate from a qualified source to the material specifications prior to installation of the aggregate.

The Contractor will be responsible for submitting material qualification test results to the Project Manager and to the CQA Site Manager for review. The CQA Laboratory will perform the conformance testing and CQC testing. Aggregate testing will be conducted in general accordance with the current versions of the corresponding American Society for Testing and Materials (ASTM) test procedures. The test methods indicated in Table 5 are those that will be used for this testing unless the test methods are updated or revised prior to construction. Revisions to the test methods will be reviewed and approved by the Engineer and the CQA Site Manager prior to their usage.

8.2.1 Sample Frequency

The frequency of aggregate testing for material qualification will conform to the minimum frequencies presented in Table 6. The frequency of aggregate testing for

material conformance will conform to the minimum frequencies presented in Table 7. The actual frequency of testing required will be increased by the CQA Site Manager as necessary if variability of materials is noted at the site, during adverse conditions, or to isolate failing areas of the construction.

8.2.2 Sample Selection

With the exception of qualification samples, sampling locations will be selected by the CQA Site Manager. Conformance samples will be obtained from borrow pits and/or stockpiles of material. The Contractor must plan the work and make aggregate available for sampling in a timely and organized manner so that the test results can be obtained before the material is installed. The CQA Site Manager must document sample locations so that failing areas can be immediately isolated. The CQA Site Manager will follow standard sampling procedures to obtain representative samples of the proposed aggregate materials.

8.3 CQA Monitoring Activities

8.3.1 Drainage Aggregate

The CQA Site Manager will monitor and document the installation of the drainage aggregates. In general, monitoring the installation of the drainage aggregates includes the following activities:

- reviewing documentation of the material qualification test results provided by the Contractor;
- sampling and testing for conformance of the materials to the *Technical Specifications*;
- documenting that the drainage aggregates are installed using the specified equipment and procedures;
- documenting that the drainage aggregates are constructed to the lines and grades shown on the *Drawings*; and

- monitoring that the construction activities do not cause damage to underlying geosynthetic materials.

8.4 Deficiencies

If a defect is discovered in the drainage aggregates, the CQA Site Manager will evaluate the extent and nature of the defect. If the defect is indicated by an unsatisfactory test result, the CQA Site Manager will determine the extent of the deficient area by additional tests, observations, a review of records, or other means that the CQA Site Manager deems appropriate.

8.4.1 Notification

After evaluating the extent and nature of a defect, the CQA Site Manager will notify the Project Manager and Contractor and schedule appropriate re-tests when the work deficiency is to be corrected.

8.4.2 Repairs and Re-testing

The Contractor will correct the deficiency to the satisfaction of the CQA Site Manager. If a project specification criterion cannot be met, or unusual weather conditions hinder work, then the CQA Site Manager will develop and present to the Engineer and/or Project Manager suggested solutions for approval.

All re-tests recommended by the CQA Site Manager must verify that the defect has been corrected before any additional work is performed by the Contractor in the area of the deficiency. The CQA Site Manager will also verify that installation requirements are met and that submittals are provided.

9. CORRUGATED POLYETHYLENE (CPE) PIPE AND FITTINGS

9.1 Material Requirements

CPE pipe and fittings must conform to the requirements of the *Technical Specifications*. The CQA Consultant will document that the CPE pipe and fittings meet those requirements through manufacturer's quality control certificates, conformance testing, and visual examination of materials arriving on site.

9.2 Manufacturer

9.2.1 Submittals

Prior to the installation of CPE pipe, the Manufacturer will provide to the CQA Consultant:

- a properties' sheet including, at a minimum, all specified properties, measured using test methods indicated in the *Technical Specifications*, or equivalent; and

- a certification that property values given in the properties sheet are minimum values and are guaranteed by the Manufacturer.

The CQA Consultant will document that:

- the property values certified by the Manufacturer meet the *Technical Specifications*; and

- the measurements of properties by the Manufacturer are properly documented and that the test methods used are acceptable.

9.2.2 Identification

Prior to shipment, the Manufacturer will provide the Project Manager and the CQA Site Manager with a quality control certificate for each lot/batch of CPE pipe

provided. The quality control certificate will be signed by a responsible party employed by the Manufacturer, such as the Production Manager. The quality control certificate will include:

- lot/batch numbers and identification; and
- sampling procedures and results of quality control tests.

The CQA Site Manager will:

- document that the quality control certificates have been provided at the specified frequency for all lots/batches of pipe, and that each certificate identifies the pipe lot/batch related to it; and

- review the quality control certificates and document that the certified properties meet the *Technical Specifications*.

9.3 Handling and Laying

Care will be taken during transportation of the pipe such that it will not be cut, kinked, or otherwise damaged.

Ropes, fabric, or rubber-protected slings and straps will be used when handling pipes. Chains, cables, or hooks inserted into the pipe ends will not be used. Two slings spread apart will be used for lifting each length of pipe. Pipe or fittings will not be dropped onto rocky or unprepared ground.

Pipes will be handled and stored in general accordance with the Manufacturer's recommendation. The handling of joined pipe will be in such a manner that the pipe is not damaged by dragging it over sharp and cutting objects. Slings for handling the pipe will not be positioned at joints. Sections of the pipes with deep cuts and gauges will be removed and the ends of the pipe rejoined.

9.4 Joints

Lengths of pipe will be assembled into suitable installation lengths by a manufacturer-recommended method.

10. GEOMEMBRANE

10.1 General

This section discusses and outlines the CQA activities to be performed for high density polyethylene (HDPE) geomembrane installation. The CQA Site Manager will review the *Drawings*, and the *Technical Specifications*, and any approved Addenda regarding this material.

10.2 Geomembrane Material Conformance

10.2.1 Introduction

The CQA Site Manager will document that the geomembrane delivered to the site meets the requirements of the *Technical Specifications* prior to installation. The CQA Site Manager will:

- review the manufacturer's submittals for compliance with the *Technical Specifications*;
- document the delivery and proper storage of geomembrane rolls; and
- conduct conformance testing of the rolls before the geomembrane is installed.

The following sections describe the CQA activities required to verify the conformance of geomembrane.

10.2.2 Review of Quality Control

10.2.2.1 Material Properties Certification

The Manufacturer will provide the Project Manager and the CQA Site Manager with the following:

- a properties sheet including, at a minimum, all specified properties, measured using test methods indicated in the *Technical Specifications*, or equivalent;
- the sampling procedure and results of testing; and
- a certification that property values given in the properties sheet are guaranteed by the Manufacturer.

The CQA Site Manager will document that:

- the property values certified by the Manufacturer meet all of the *Technical Specifications*; and
- the measurements of properties by the Manufacturer are properly documented and that the test methods used are acceptable.

10.2.2.2 Resin Certification

The Manufacturer will also provide the Project Manager with the following information concerning the resin used to manufacture the geomembrane:

- the origin (Resin Supplier's name and resin production plant), identification (brand name, lot number), and production date of the resin; and
- the raw material quality control certificates.

The CQA Site Manager will:

- evaluate that the quality control certificates have been provided at the specified frequency, and that the certificate identifies the rolls related to it; and

- review the quality control certificates and evaluate that the certified properties meet the specifications.

10.2.2.3 Geomembrane Roll QC Certification

Prior to shipment, the Manufacturer will provide the Project Manager and the CQA Site Manager with a quality control certificate for every roll of geomembrane provided. The quality control certificate will be signed by a responsible party employed by the Geomembrane Manufacturer, such as the production manager. The quality control certificate will include:

- roll numbers and identification; and

- results of quality control tests - as a minimum, results will be given for thickness, tensile properties, specific gravity, carbon black content, carbon black dispersion, tear resistance, puncture resistance, and single point stress rupture evaluated in general accordance with the methods indicated in the specifications or equivalent methods approved by the Engineer.

The CQA Site Manager will:

- evaluate that the quality control certificates have been provided at the specified frequency, and that the certificate identifies the rolls related to the roll represented by the test results; and

- review the quality control certificates and evaluate that the certified roll properties meet the specifications.

10.2.3 Conformance Testing

Upon delivery of the rolls of geomembrane, the CQA Site Manager will document that the rolls are unloaded and stored on site as required by the *Technical Specifications*. Damage caused by unloading will be documented by the CQA Site Manager and the damaged material will not be installed. The CQA Site Manager shall obtain conformance samples at the specified frequency and forward them to the Geosynthetics CQA Laboratory for testing to monitor conformance to both the *Technical Specifications* and the list of properties certified by the Manufacturer. The test procedures will be as indicated in Table 8. Where optional procedures are noted in the test method, the requirements of the *Technical Specifications* will prevail.

Samples will be taken across the width of the roll and will not include the first linear 3 ft (1 m) of material. Unless otherwise specified, samples will be 3 ft (1 m) long by the roll width. The CQA Site Manager will mark the machine direction on the samples with an arrow along with the date and roll number. The required minimum sampling frequencies are provided in Table 8.

The CQA Site Manager will examine results from laboratory conformance testing and will report any non-conformance to the Project Manager and the Geosynthetic Installer. The procedure prescribed in the *Technical Specifications* will be followed in the event of a failing conformance test.

10.3 <u>Delivery</u>

10.3.1 Transportation and Handling

The CQA Site Manager will document that the transportation and handling does not pose a risk of damage to the geomembrane.

Upon delivery at the site, the Geosynthetic Installer and the CQA Site Manager will conduct a surface observation of the rolls for defects and damage. This

inspection will be conducted without unrolling unless defects or damages are found or suspected. The CQA Site Manager will indicate to the Project Manager:

- rolls, or portions thereof, which should be rejected and removed from the site because they have severe flaws; and
- rolls that include minor repairable flaws.

10.3.2 Storage

The Geosynthetic Installer will be responsible for the storage of the geomembrane on site. The Contractor will provide storage space in a location (or several locations) such that on-site transportation and handling are optimized if possible.

The CQA Site Manager will document that storage of the geomembrane provides adequate protection against sources of damage.

10.4 Geomembrane Installation

10.4.1 Introduction

The CQA Consultant will document that the geomembrane installation is carried out in general accordance with the *Drawings*, *Technical Specifications* and Manufacturer's recommendations.

10.4.2 Earthwork

10.4.2.1 Surface Preparation

The CQA Site Manager will document that:

- a qualified land surveyor has verified lines and grades;

- that the supporting prepared subgrade or subgrade meets the *Technical Specifications* and has been approved; and

- placement of the overlying materials does not damage, create large wrinkles, or induce excessive tensile stress in the underlying geosynthetic materials.

The Geosynthetic Installer will certify in writing that the surface on which the geomembrane will be installed is acceptable. The certificate of acceptance will be given by the Geosynthetic Installer to the Project Manager prior to commencement of geomembrane installation in the area under consideration. The CQA Site Manager will be given a copy of this certificate by the Project Manager.

After the supporting subgrade has been accepted by the Geosynthetic Installer, it will be the Geosynthetic Installer's responsibility to indicate to the Project Manager any change in the supporting soil condition that may require repair work. If the CQA Site Manager concurs with the Geosynthetic Installer, then the Project Manager will document that the supporting soil is repaired.

At any time before and during the geomembrane installation, the CQA Site Manager will indicate to the Project Manager locations that may not provide adequate support to the geomembrane.

10.4.2.2 Geosynthetic Termination

The CQA Site Manager will document that the geosynthetic terminations have been constructed in general accordance with the *Drawings*. Backfilling above the terminations will be conducted in general accordance with the *Technical Specifications*.

10.4.3 Geomembrane Placement

10.4.3.1 Panel Identification

A field panel is the unit area of geomembrane which is to be seamed in the field, i.e., a field panel is a roll or a portion of roll cut in the field. It will be the

responsibility of the CQA Site Manager to document that each field panel is given an "identification code" (number or letter- number) consistent with the layout plan. This identification code will be agreed upon by the Project Manager, Geosynthetic Installer and CQA Site Manager. This field panel identification code will be as simple and logical as possible. Roll numbers established in the manufacturing plant must be traceable to the field panel identification code.

The CQA Site Manager will establish documentation showing correspondence between roll numbers, and field panel identification codes. The field panel identification code will be used for all quality assurance records.

10.4.3.2 Field Panel Placement

Location

The CQA Site Manager will document that field panels are installed at the location indicated in the Geosynthetic Installer's layout plan, as approved or modified by the Engineer.

Installation Schedule

Field panels may be installed using one of the following schedules:

- all field panels are placed prior to field seaming in order to protect the subgrade from erosion by rain;
- field panels are placed one at a time and each field panel is seamed after its placement (in order to minimize the number of unseamed field panels exposed to wind); and
- any combination of the above.

If a decision is reached to place all field panels prior to field seaming, it is usually beneficial to begin at the high point area and proceed toward the low point with "shingle" overlaps to facilitate drainage in the event of precipitation. It is also usually

beneficial to proceed in the direction of prevailing winds. Accordingly, an early decision regarding installation scheduling should be made if and only if weather conditions can be predicted with reasonable certainty. Otherwise, scheduling decisions must be made during installation, in general accordance with varying conditions. In any event, the Geosynthetic Installer is fully responsible for the decision made regarding placement procedures.

The CQA Site Manager will evaluate every change in the schedule proposed by the Geosynthetic Installer and advise the Project Manager on the acceptability of that change. The CQA Site Manager will document that the condition of the supporting soil has not changed detrimentally during installation.

The CQA Site Manager will record the identification code, location, and date of installation of each field panel.

Weather Conditions

Geomembrane placement will not proceed unless otherwise authorized:

- when the ambient temperature is below 40°F or above 104°F;
- when the geomembrane sheet temperature is below 40°F or above 104°F; or
- when wind gusts are in excess of 20 mph.

Geomembrane placement will not be performed during any precipitation, in the presence of excessive moisture (e.g., fog, dew), in an area of ponded water, or in the presence of excessive winds (i.e., wind gusts in excess of 20 mph).

The CQA Site Manager will document that the above conditions are fulfilled. Additionally, the CQA Site Manager will document that the supporting soil has not been damaged by weather conditions. The Geosynthetics Installer will inform the Project Manager if the above conditions are not fulfilled.

Method of Placement

The CQA Site Manager will document the following:

- equipment used does not damage the geomembrane by handling, trafficking, excessive heat, leakage of hydrocarbons or other means;

- the surface underlying the geomembrane has not deteriorated since previous acceptance, and is still acceptable immediately prior to geomembrane placement;

- geosynthetic elements immediately underlying the geomembrane are clean and free of debris;

- personnel working on the geomembrane do not smoke, wear damaging shoes, or engage in other activities which could damage the geomembrane;

- the method used to unroll the panels does not cause scratches or crimps in the geomembrane and does not damage the supporting soil;

- the method used to place the panels minimizes wrinkles (especially differential wrinkles between adjacent panels); and

- adequate temporary loading and/or anchoring (e.g., sand bags, tires), not likely to damage the geomembrane, has been placed to prevent uplift by wind (in case of high winds, continuous loading, e.g., by adjacent sand bags, is recommended along edges of panels to minimize risk of wind flow under the panels).

The CQA Site Manager will inform the Project Manager if the above conditions are not fulfilled.

Damaged panels or portions of damaged panels that have been rejected will be marked and their removal from the work area recorded by the CQA Site Manager. Repairs will be made in general accordance with procedures described in Section 10.4.5.

10.4.4 Field Seaming

This section details CQA procedures to document that seams are properly constructed and tested in general accordance with the Manufacturer's specifications and industry standards.

10.4.4.1 Seam Layout

The Geosynthetic Installer will provide the Project Manager and the CQA Site Manager with a seam layout drawing, i.e., a drawing of the facility to be lined showing all expected seams. The CQA Site Manager will review the seam layout drawing and evaluate that it is consistent with the preliminary geomembrane panel layout. No panels may be seamed in the field without the Project Manager's approval. In addition, panels not specifically shown on the seam layout drawing may be used without the Project Manager's prior approval.

In general, seams should be oriented parallel to the line of maximum slope, i.e., oriented along, not across, the slope. In corners and odd-shaped geometric locations, the number of seams should be minimized. No horizontal seam should be less than 5 ft (1.5 m) from the toe of the slope, or areas of potential stress concentrations, unless otherwise authorized.

A seam numbering system compatible with the panel numbering system will be agreed upon at the Resolution and/or Pre-Construction Meeting.

10.4.4.2 Requirements of Personnel

All personnel performing seaming operations will be qualified by experience or by successfully passing seaming tests, as outlined in the *Technical Specifications*. The most experienced seamer, the "master seamer", will provide direct supervision over less experienced seamers.

The Geosynthetic Installer will provide the Project Manager and the CQA Site Manager with a list of proposed seaming personnel and their experience records. This document will be reviewed by the Project Manager and the Geosynthetics CQA Manager.

10.4.4.3 Seaming Equipment and Products

Approved processes for field seaming are fillet extrusion welding and fusion welding.

Fillet Extrusion Process

The fillet extrusion-welding apparatus will be equipped with gauges giving the temperature in the apparatus.

The Geosynthetic Installer will provide documentation regarding the extrudate to the Project Manager and the CQA Site Manager, and will certify that the extrudate is compatible with the specifications, and in any event is comprised of the same resin as the geomembrane sheeting.

The CQA Site Manager will log apparatus temperatures, ambient temperatures, and geomembrane surface temperatures at appropriate intervals.

The CQA Site Manager will document that:

- the Geosynthetic Installer maintains on site the number of spare operable seaming apparatus decided at the Resolution Meeting;
- equipment used for seaming is not likely to damage the geomembrane;
- the extruder is purged prior to beginning a seam until all heat-degraded extrudate has been removed from the barrel;

- the electric generator is placed on a smooth base such that no damage occurs to the geomembrane;

- a smooth insulating plate or fabric is placed beneath the hot welding apparatus after usage; and

- the geomembrane is protected from damage in heavily trafficked areas.

Fusion Process

The fusion-welding apparatus must be automated vehicular-mounted devices. The fusion-welding apparatus will be equipped with gauges giving the applicable temperatures and pressures.

The CQA Site Manager will log ambient, seaming apparatus, and geomembrane surface temperatures as well as seaming apparatus pressures.

The CQA Site Manager will also document that:

- the Geosynthetic Installer maintains on-site the number of spare operable seaming apparatus decided at the Resolution Meeting;

- equipment used for seaming is not likely to damage the geomembrane;

- for cross seams, the edge of the cross seam is ground to a smooth incline (top and bottom) prior to welding;

- the electric generator is placed on a smooth base such that no damage occurs to the geomembrane;

- a smooth insulating plate or fabric is placed beneath the hot welding apparatus after usage; and

- the geomembrane is protected from damage in heavily trafficked areas.

10.4.4.4 Seam Preparation

The CQA Site Manager will document that:

- prior to seaming, the seam area is clean and free of moisture, dust, dirt, debris, and foreign material; and

- seams are aligned with the fewest possible number of wrinkles and "fishmouths."

10.4.4.5 Weather Conditions for Seaming

The normally required weather conditions for seaming are as follows unless authorized in writing by the Project Manager:

- seaming will only be approved between ambient temperatures of 40°F (4°C) and 104°F (40°C); and

- seaming will not be approved if sustained wind speed is in excess of 20 mph (32 km/hr).

If the Geosynthetic Installer wishes to use methods that may allow seaming at ambient temperatures below 40°F (4°C) or above 104°F (40°C), the Geosynthetic Installer will demonstrate and certify that such methods produce seams which are entirely equivalent to seams produced within acceptable temperature and wind requirements, and that the overall quality of the geomembrane is not adversely affected.

The CQA Site Manager will document that these seaming conditions are fulfilled and will advise the Project Manager if they are not. The Project Manager will then decide if the installation will be stopped or postponed.

10.4.4.6 Overlapping and Temporary Bonding

The CQA Site Manager will document that:

- the panels of geomembrane have a finished overlap of a minimum of 3 in. (75 mm) for both extrusion and fusion welding;
- no solvent or adhesive bonding material are to be used; and
- the procedure used to temporarily bond adjacent panels together does not damage the geomembrane.

The CQA Site Manager will log appropriate temperatures and conditions, and will log and report to the Project Manager non-compliances.

10.4.4.7 Trial Seams

Trial seams will be made on fragment pieces of geomembrane liner to verify that seaming conditions are adequate. Such trial seams will be made at the beginning of each seaming period, beginning of the day and after lunch, for each seaming apparatus used that day. Also, each seamer will make at least one trial seam each day. Trial seams will be made under the same conditions as actual seams.

Extrusion welded trial seam samples will be at least 3 ft (0.9 m) long by 1 ft (0.3 m) wide (after seaming) with the seam centered lengthwise. Fusion welded trial seam samples will be at least 5 ft (1.5 m) long by 1 ft (0.3 m) wide (after seaming) with the seam centered lengthwise. Seam overlap will be as indicated in Section 10.5.3.6.

Four specimens, each 1 in. (25 mm) wide, will be cut from the trial seam sample by the Geosynthetic Installer. One specimen will be tested for shear strength and three specimens will be tested for peel adhesion using a gauged tensiometer. All specimens tested will exhibit a Film Tear Bond (FTB) and will not fail in the seam. In addition, all specimens will meet or exceed the minimum strength requirements described in the *Technical Specifications*. If any of the four specimens fails, the entire trial seaming operation will be repeated. If any of the four additional specimens fails, the seaming apparatus and seamer will not be approved for production seaming until the

deficiencies are corrected and two consecutive trial seam tests achieve the FTB requirements outlined above.

The CQA Site Manager will observe trial seam procedures. Trial seam samples will be assigned a number. The CQA Site Manager, will log the date, time, machine temperature(s), number of the seaming unit, name of the seamer, and pass or fail description for each trial seam sample tested.

10.4.4.8 General Seaming Procedure

Unless otherwise specified, the general seaming procedure used by the Geosynthetic Installer will be as follows:

- Fishmouths or wrinkles at the seam overlaps will be cut along the ridge of the wrinkle in order to achieve a flat overlap. The cut fishmouths or wrinkles will be seamed and any portion where the overlap is inadequate will then be patched with an oval or round patch of the same geomembrane extending a minimum of 6 in. (150 mm) beyond the cut in all directions.

- If seaming operations are carried out at night, adequate illumination will be provided at the Geosynthetic Installer's expense.

- Seaming will extend to the outside edge of panels to be placed in the anchor trench.

The CQA Site Manager will document that the above seaming procedures are followed, and will inform the Project Manager if they are not.

10.4.4.9 Nondestructive Seam Continuity Testing

Concept

The Geosynthetic Installer will non-destructively test field seams over their length using a vacuum test unit, air pressure test (for double fusion seams only), or

other approved method. The purpose of nondestructive tests is to check the continuity of seams. It does not provide information on seam strength. Continuity testing will be carried out as the seaming work progresses, not at the completion of field seaming.

The CQA Site Manager will:

- observe continuity testing;
- record location, date, test unit number, name of person conducting the test, and the results of tests; and
- inform the Geosynthetic Installer and Project Manager of required repairs.

The Geosynthetic Installer will complete any required repairs in general accordance with Section 10.4.5.

The CQA Site Manager will:

- observe the repair and re-testing of the repair;
- mark on the geomembrane that the repair has been made; and
- document the results.

The following procedures will apply to locations where seams cannot be non-destructively tested:

All such seams will be cap-stripped with the same geomembrane.

- If the seam is accessible to testing equipment prior to final installation, the seam will be non-destructively tested prior to final installation.
- If the seam cannot be tested prior to final installation, the seaming and cap-stripping operations will be observed by the CQA Site Manager and Geosynthetic Installer for uniformity and completeness.

The seam number, date of observation, name of tester, and outcome of the test or observation will be recorded by the CQA Site Manager.

Vacuum Testing

The equipment will be comprised of the following:

- a vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, port hole or valve assembly, and a vacuum gauge;
- a steel vacuum tank and pump assembly equipped with a pressure controller and pipe connections;
- a rubber pressure/vacuum hose with fittings and connections;
- an approved applicator; and
- a soapy solution.

The following procedures will be followed:

- energize the vacuum pump and reduce the tank pressure to approximately 5 psi (35 kPa) (10 in. of Hg.) gauge;
- wet a strip of geomembrane approximately 12 in. by 48 in. (0.3 m by 1.2 m) with the soapy solution;
- place the box over the wetted area;
- close the bleed valve and open the vacuum valve;
- document that a leak tight seal is created;

- for a period of not less than ten seconds, examine the geomembrane through the viewing window for the presence of leaks indicated by soap bubbles;

- if no leaks appear after ten seconds, close the vacuum valve and open the bleed valve, move the box over the next adjoining area with a minimum 3 in. (75 mm) overlap, and repeat the process;

- areas where soap bubbles appear will be marked and repaired in general accordance with Section 10.4.5 and retested using the vacuum testing method.

Air Pressure Testing (For Double-Track Fusion Seam Only)

The following procedures are applicable to those processes that produce a double seam with an enclosed space.

The equipment will be comprised of the following:

- an air pump (manual or motor driven) equipped with pressure gauge capable of generating and sustaining a pressure of 30 psi (200 kPa) and mounted on a cushion to protect the geomembrane;

- a rubber hose with fittings and connections;

- a sharp hollow needle, or other approved pressure feed device.

The following procedures will be followed:

- seal both ends of the seam to be tested;

- insert needle or other approved pressure feed device into the tunnel created by the fusion weld;

- insert a protective cushion between the air pump and the geomembrane;

- energize the air pump to a pressure of 25 to 30 psi (170 to 204 kPa), close valve, and sustain pressure for not less than 5 minutes;

- if loss of pressure exceeds 3 psi (20 kPa) or does not stabilize, locate faulty area and repair in general accordance with Section 10.4.5;

- cut end of tested seam area, opposite the location of the pressure gauge, after completion of the five minute pressure hold period to verify complete testing of the seam. If the pressure gauge does not indicate a release of pressure, locate blockage of the air channel and retest until entire seam is tested; and

- remove needle or other approved pressure feed device and repair any holes in the geomembrane resulting from the air pressure testing procedure in general accordance with Section 10.4.5.

10.4.4.10 Destructive Testing

Concept

Destructive seam testing will be performed on site and at the independent CQA laboratory in general accordance with the *Drawings* and the *Technical Specifications*. Destructive seam tests will be performed at selected locations. The purpose of these tests is to evaluate seam strength. Seam strength testing will be done as the seaming work progresses, not at the completion of all field seaming.

Location and Frequency

The CQA Site Manager will select locations where seam samples will be cut out for laboratory testing. Those locations will be established as follows.

- The frequency of geomembrane seam testing is a minimum of one destructive sample per 500 feet of weld. The minimum frequency is to be evaluated as an average taken throughout the entire facility.

- A minimum of one test per seaming machine over the duration of the project phase.

- Test locations will be evaluated during seaming at CQA Site Manager's discretion. Selection of such locations may be prompted by suspicion of excess crystallinity, contamination, offset welds, or any other potential cause of imperfect welding.

The Geosynthetic Installer will not be informed in advance of the locations where the seam samples will be taken.

Sampling Procedure

Samples will be cut by the Geosynthetic Installer as the seaming progresses in order to have laboratory test results before the geomembrane is covered by another material. The CQA Site Manager will:

- observe sample cutting;
- assign a number to each sample, and mark it accordingly;
- record sample location on layout drawing; and
- record reason for taking the sample at this location (e.g., statistical routine, suspicious feature of the geomembrane).

Holes in the geomembrane resulting from destructive seam sampling will be immediately repaired in general accordance with repair procedures described in Section 10.4.5. The continuity of the new seams in the repaired area will be tested in general accordance with Section 10.4.4.9.

Size and Distribution of Samples

The destructive sample will be 12 in. (0.3 m) wide by 42 in. (1.1 m) long with the seam centered lengthwise. The sample will be cut into three parts and distributed as follows:

- one portion, measuring 12 in. × 12 in. (0.30 cm × 30 cm), to the Geosynthetic Installer for field testing;
- one portion, measuring 12 in. × 18 in. (30 cm × 45 cm), for CQA Laboratory testing; and
- one portion, measuring 12 in. × 12 in. (30 cm × 30 cm), to the Contractor for archive storage.

Final evaluation of the destructive sample sizes and distribution will be made at the Pre-Construction Meeting.

Field Testing

Field testing will be performed by the Geosynthetic Installer using a gauged tensiometer. Prior to field testing the Geosynthetic Installer shall submit a calibration certificate for gauge tensiometer to the CQA Consultant for review. Calibration must have been performed within one year of use on the current project. Five 1 in. (25 mm) wide strips will be taken for peel. The specimens shall not fail in the seam and shall meet the strength requirements outlined in the *Technical Specifications*. If any field test specimen fails, then the procedures outlined in *Procedures for Destructive Test Failures* of this section will be followed.

The CQA Site Manager will witness field tests and mark samples and portions with their number. The CQA Site Manager will also log the date and time, ambient temperature, number of seaming unit, name of seamer, welding apparatus temperatures and pressures, and pass or fail description.

CQA Laboratory Testing

Destructive test samples will be packaged and shipped, if necessary, under the responsibility of the CQA Site Manager in a manner that will not damage the test sample. The Project Manager will document that packaging and shipping conditions are acceptable. The Project Manager will be responsible for storing the archive samples. This procedure will be outlined at the Resolution Meeting. Samples will be tested by the CQA Laboratory. The CQA Laboratory will be selected by the CQA Site Manager with the concurrence of the Project Manager.

Testing will include "Bonded Seam Strength" and "Peel Adhesion." The minimum acceptable values to be obtained in these tests are given in the *Technical Specifications*. At least five specimens will be tested for each test method. Specimens will be selected alternately by test from the samples (i.e., peel, shear, peel, shear...). A passing test will meet the minimum required values in at least four out of five specimens.

The CQA Laboratory will provide test results no more than 24 hours after they receive the samples. The CQA Site Manager will review laboratory test results as soon as they become available, and make appropriate recommendations to the Project Manager.

Geosynthetic Installer's Laboratory Testing

The Geosynthetic Installer's laboratory test results will be presented to the Project Manager and the CQA Site Manager for comments.

Procedures for Destructive Test Failure

The following procedures will apply whenever a sample fails a destructive test, whether that test conducted by the CQA Laboratory, the Geosynthetic Installer's laboratory, or by gauged tensiometer in the field. The Geosynthetic Installer has two options:

- The Geosynthetic Installer can reconstruct the seam between two passed test locations.

- The Geosynthetic Installer can trace the welding path to an intermediate location at 10 ft (3 m) minimum from the point of the failed test in each direction and take a small sample for an additional field test at each location. If these additional samples pass the test, then full laboratory samples are taken. If these laboratory samples pass the tests, then the seam is reconstructed between these locations. If either sample fails, then the process is repeated to establish the zone in which the seam should be reconstructed.

Acceptable seams must be bounded by two locations from which samples passing laboratory destructive tests have been taken. In cases where the failed seam segment exceeds 150 ft (50 m), a destructive sample will be taken from the zone in which the seam has been reconstructed. Repairs will be made in general accordance with Section 10.4.5.

The CQA Site Manager will document actions taken in conjunction with destructive test failures.

10.4.5 Defects and Repairs

This section prescribes CQA activities to document that defects, tears, rips, punctures, damage, or failing seams shall be repaired.

10.4.5.1 Identification

Seams and non-seam areas of the geomembrane will be examined by the CQA Site Manager for identification of defects, holes, blisters, undispersed raw materials and signs of contamination by foreign matter. Because light reflected by the geomembrane helps to detect defects, the surface of the geomembrane will be clean at the time of examination.

10.4.5.2 Evaluation

Each suspect location both in seam and non-seam areas will be non-destructively tested using the methods described in Section 10.4.4.9 as appropriate.

Each location that fails the nondestructive testing will be marked by the CQA Site Manager and repaired by the Geosynthetic Installer. Work will not proceed with any materials that will cover locations which have been repaired until laboratory test results with passing values are available.

10.4.5.3 Repair Procedures

Portions of the geomembrane exhibiting a flaw, or failing a destructive or nondestructive test, will be repaired. Several procedures exist for the repair of these areas. The final decision as to the appropriate repair procedure will be at the discretion of the CQA Consultant with input from the Project Manager and Geosynthetic Installer. The procedures available include:

- patching, used to repair large holes, tears, undispersed raw materials, and contamination by foreign matter;
- grinding and re-welding, used to repair small sections of extruded seams;
- spot welding or seaming, used to repair small tears, pinholes, or other minor, localized flaws;
- capping, used to repair large lengths of failed seams;
- removing bad seam and replacing with a strip of new material welded into place (used with large lengths of fusion seams).

In addition, the following provisions will be satisfied:

- surfaces of the geomembrane which are to be repaired will be abraded no more than 20 minutes prior to the repair;
- surfaces must be clean and dry at the time of the repair;

- all seaming equipment used in repairing procedures must be approved;

- the repair procedures, materials, and techniques will be approved in advance by the CQA Consultant with input from the Project Manager and Geosynthetic Installer;

- patches or caps will extend at least 6 in. (150 mm) beyond the edge of the defect, and all corners of patches will be rounded with a radius of at least 3 in. (75 mm); and

- the geomembrane below large caps should be appropriately cut to avoid water or gas collection between the two sheets.

10.4.5.4 Verification of Repairs

Each repair will be numbered and logged. Each repair will be non-destructively tested using the methods described in Section 10.4.4.9 as appropriate. Repairs that pass the non- destructive test will be taken as an indication of an adequate repair. Large caps may be of sufficient extent to require destructive test sampling, at the discretion of the CQA Site Manager. Failed tests indicate that the repair will be redone and re-tested until a passing test results. The CQA Site Manager will observe all non-destructive testing of repairs and will record the number of each repair, date, and test outcome.

10.4.5.5 Large Wrinkles

When seaming of the geomembrane is completed (or when seaming of a large area of the geomembrane liner is completed) and prior to placing overlying materials, the CQA Site Manager will observe the geomembrane wrinkles. The CQA Site Manager will indicate to the Project Manager which wrinkles should be cut and re-seamed by the Geosynthetic Installer. The seam thus produced will be tested like any other seam.

10.4.6 Lining System Acceptance

The Geosynthetic Installer and the Manufacturer(s) will retain all responsibility for the geosynthetic materials in the liner system until acceptance by the Owner.

The geosynthetic liner system will be accepted by the Owner when:

- the installation is finished;
- verification of the adequacy of all seams and repairs, including associated testing, is complete;
- all documentation of installation is completed including the CQA Site Manager's acceptance report; and
- CQA report, including "as built" drawing(s), sealed by a registered professional engineer has been received by the Project Manager.

The CQA Site Manager will document that installation has proceeded in general accordance with the *Technical Specifications* for the project except as noted to the Project Manager.

11. GEOTEXTILE

11.1 Introduction

This section of the CQA Plan outlines the CQA activities to be performed for the geotextile installation. The CQA Consultant will review the *Drawings*, and the *Technical Specifications*, and any approved addenda or changes.

11.2 Manufacturing

The Manufacturer will provide the Project Manager with a list of guaranteed "minimum average roll value" properties (defined as the mean less two standard deviations), for each type of geotextile to be delivered. The Manufacturer will also provide the Project Manager with a written quality control certification signed by a responsible party employed by the Manufacturer that the materials actually delivered have property "minimum average roll values" which meet or exceed all property values guaranteed for that type of geotextile.

The quality control certificates will include:

- roll identification numbers; and
- results of quality control testing.

The Manufacturer will provide, as a minimum, test results for the following:

- grab strength;
- tear strength;
- burst strength;
- puncture strength;
- permittivity; and
- apparent opening size.

Quality control tests must be performed, in general accordance with the test methods specified in Table 9, on geotextile produced for the project. The Manufacturer

will also provide a written certification that the nonwoven, needle-punched geotextiles are continuously inspected and found to be needle-free.

The CQA Site Manager will examine Manufacturer certifications to evaluate that the property values listed on the certifications meet or exceed those specified for the particular type of geotextile and the measurements of properties by the Manufacturer are properly documented, test methods acceptable and the certificates have been provided at the specified frequency properly identifying the rolls related to testing. Deviations will be reported to the Project Manager.

11.3 Labeling

The Manufacturer will identify all rolls of geotextile with the following:

- manufacturer's name;
- product identification;
- lot number;
- roll number; and
- roll dimensions.

The CQA Site Manager will examine rolls upon delivery and deviation from the above requirements will be reported to the Project Manager.

11.4 Shipment and Storage

During shipment and storage, the geotextile will be protected from ultraviolet light exposure, precipitation or other inundation, mud, dirt, dust, puncture, cutting or any other damaging or deleterious conditions. To that effect, geotextile rolls will be shipped and stored in relatively opaque and watertight wrappings.

Protective wrappings will be removed less than one hour prior to unrolling the geotextile. After the wrapping has been removed, a geotextile will not be exposed to sunlight for more than 15 days, except for UV protection geotextile, unless otherwise specified and guaranteed by the Manufacturer.

The CQA Site Manager will observe rolls upon delivery at the site and deviation from the above requirements will be reported to the Project Manager.

11.5 Conformance Testing

11.5.1 Tests

Upon delivery of the rolls of geotextiles, the CQA Site Manager will document that samples are removed and forwarded to the Geosynthetics CQA Laboratory for testing to evaluate conformance to *Technical Specifications*. Required test and testing frequency for the geotextiles are presented in Table 9.

These conformance tests will be performed in general accordance with the test methods specified in the *Technical Specifications*.

11.5.2 Sampling Procedures

Samples will be taken across the width of the roll and will not include the first three feet (linear meter). Unless otherwise specified, samples will be 3 ft (1 m) long by the roll width. The CQA Site Manager will mark the machine direction on the samples with an arrow.

Unless otherwise specified, samples will be taken at a rate as indicated in Table 9 for geotextiles.

11.5.3 Test Results

The CQA Site Manager will examine results from laboratory conformance testing and will report non-conformance to the Project Manager.

11.5.4 Conformance Sample Failure

The following procedure will apply whenever a sample fails a conformance test that is conducted by the CQA Laboratory:

- The Manufacturer will replace every roll of geotextile that is in nonconformance with the *Technical Specifications* with a roll(s) that meets *Technical Specifications*.

- The Geosynthetic Installer will remove conformance samples for testing by the CQA Laboratory from the closest numerical rolls on both sides of the failed roll. These two samples must conform to the *Technical Specifications*. If either of these samples fail, the numerically closest rolls on the side of the failed sample will be tested by the CQA Laboratory. These samples must conform to the *Technical Specifications*. If any of these samples fail, every roll of geotextile on site from this lot and every subsequently delivered roll that is from the same lot must be tested by the CQA Laboratory for conformance to the *Technical Specifications*. This additional conformance testing will be at the expense of the Manufacturer.

The CQA Site Manager will document actions taken in conjunction with conformance test failures.

11.6 <u>Handling and Placement</u>

The Geosynthetic Installer will handle all geotextiles in such a manner as to document they are not damaged in any way, and the following will be complied with:

- In the presence of wind, all geotextiles will be weighted with sandbags or the equivalent. Such sandbags will be installed during placement and will remain until replaced with earth cover material.

- Geotextiles will be cut using an approved geotextile cutter only. If in place, special care must be taken to protect other materials from damage, which could be caused by the cutting of the geotextiles.

- The Geosynthetic Installer will take all necessary precautions to prevent damage to underlying layers during placement of the geotextile.

- During placement of geotextiles, care will be taken not to entrap in the geotextile stones, excessive dust, or moisture that could damage the geotextile, generate clogging of drains or filters, or hamper subsequent seaming.

- A visual examination of the geotextile will be carried out over the entire surface, after installation, to document that no potentially harmful foreign objects, such as needles, are present.

The CQA Site Manager will note non-compliance and report it to the Project Manager.

11.7 Seams and Overlaps

Geotextiles will be overlapped a minimum of 12 in. (0.3 m) prior to seaming.

11.8 Repair

Holes or tears in the geotextile will be repaired as follows:

- A patch made from the same geotextile will be spot-seamed in place with a minimum of 6 in. (0.60 m) overlap in all directions.

Care will be taken to remove any soil or other material that may have penetrated the torn geotextile.

The CQA Site Manager will observe any repair, note any non-compliance with the above requirements and report them to the Project Manager.

11.9 Placement of Soil Materials

The Contractor will place all soil materials located on top of a geotextile, in such a manner as to document:

- no damage of the geotextile;
- minimal slippage of the geotextile on underlying layers; and
- no excess tensile stresses in the geotextile.

Non-compliance will be noted by the CQA Site Manager and reported to the Project Manager.

12. GEOSYNTHETIC CLAY LINER (GCL)

12.1 Introduction

This section of the CQA Plan outlines the CQA activities to be performed for the geosynthetic clay liner (GCL) installation. The CQA Consultant will review the *Drawings*, and the *Technical Specifications*, and approved addenda or changes.

12.2 Manufacturing

The Manufacturer will provide the Project Manager with a list of guaranteed "minimum average roll value" properties (defined as the mean less two standard deviations), for the GCL to be delivered. The Manufacturer will also provide the Project Manager with a written quality control certification signed by a responsible party employed by the Manufacturer that the materials actually delivered have property "minimum average roll values" which meet or exceed all property values guaranteed for that GCL.

The quality control certificates will include:

- roll identification numbers; and
- results of quality control testing.

The Manufacturer will provide, as a minimum, test results for the following:

- mass per unit area; and
- index flux.

Quality control tests must be performed, in general accordance with the test methods specified in Table 10, on GCL produced for the project.

The CQA Site Manager will examine Manufacturer certifications to verify that the property values listed on the certifications meet or exceed those specified for the GCL and the measurements of properties by the Manufacturer are properly documented, test methods acceptable and the certificates have been provided at the

specified frequency properly identifying the rolls related to testing. Deviations will be reported to the Project Manager.

12.3 Labeling

The Manufacturer will identify all rolls of GCL with the following:

- manufacturer's name;
- product identification;
- lot number;
- roll number; and
- roll dimensions.

The CQA Site Manager will examine rolls upon delivery and deviation from the above requirements will be reported to the Project Manager.

12.4 Shipment and Storage

During shipment and storage, the GCL will be protected from ultraviolet light exposure, precipitation or other inundation, mud, dirt, dust, puncture, cutting or any other damaging or deleterious conditions. To that effect, GCL rolls will be shipped and stored in relatively opaque and watertight wrappings.

The CQA Site Manager will observe rolls upon delivery at the site and any deviation from the above requirements will be reported to the Project Manager.

12.5 Conformance Testing

12.5.1 Tests

CQA personnel will sample the GCL either during production at the manufacturing facility or after delivery to the construction site. The samples will be forwarded to the Geosynthetics CQA Laboratory for testing to assess conformance with the *Technical Specifications*. The test methods and minimum testing frequencies are indicated in Table 10.

Samples will be taken across the width of the roll and will not include the first 3 ft (0.9 m) if the sample is cut on site. Unless otherwise specified, samples will be 3 ft (0.9 m) long by the roll width. The CQA Consultant will mark the machine direction with an arrow and the manufacturer's roll number on each sample.

The CQA Site Manager will examine results from laboratory conformance testing and will report non-conformance to the Project Manager.

12.5.2 Conformance Sample Failure

The following procedure will apply whenever a sample fails a conformance test that is conducted by the CQA Laboratory:

- The Manufacturer will replace every roll of GCL that is in nonconformance with the *Technical Specifications* with a roll(s) that meets *Technical Specifications*.

- The Geosynthetic Installer will remove conformance samples for testing by the CQA Laboratory from the closest numerical rolls on both sides of the failed roll. These two samples must conform to the *Technical Specifications*. If either of these samples fail, the numerically closest rolls on the side of the failed sample will be tested by the CQA Laboratory. These samples must conform to the *Technical Specifications*. If any of these samples fail, every roll of GCL on site from this lot and every subsequently delivered roll that is from the same lot must be tested by the CQA Laboratory for conformance to the *Technical Specifications*. This additional conformance testing will be at the expense of the Manufacturer.

The CQA Site Manager will document actions taken in conjunction with conformance test failures.

12.6 GCL Delivery and Storage

Upon delivery to the site, the CQA Consultant will check the GCL rolls for defects (e.g., tears, holes) and for damage. The CQA Consultant will report to the Project Manager and the Geosynthetics Installer:

- any rolls, or portions thereof, which should be rejected and removed from the site because they have severe flaws; and

- any rolls which include minor repairable flaws.

The GCL rolls delivered to the site will be checked by the CQA Consultant to document that the roll numbers correspond to those on the approved Manufacturer's quality control certificate of compliance.

12.7 GCL Installation

The CQA Consultant will monitor and document that the GCL is installed in general accordance with the *Drawings* and the *Technical Specifications*. The Geosynthetics Installer shall provide the CQA Consultant a certificate of subgrade acceptance prior to the installation of the GCL as outlined in the *Technical Specifications*. The GCL installation activities to be monitored and documented by the CQA Consultant include:

- monitoring that the GCL rolls are stored and handled in a manner which does not result in any damage to the GCL;

- monitoring that the GCL is not exposed to UV radiation for extended periods of time without prior approval;

- monitoring that the GCL are seamed in general accordance with the *Technical Specifications* and the Manufacturer's recommendations;

- monitoring and documenting that the GCL is installed on an approved subgrade, free of debris, protrusions, or uneven surfaces;

- monitoring that the GCL is not installed on a saturated subgrade or standing water and is not exposed such that it is hydrated prior to completion of the construction; and

- monitoring that any damage to the GCL is repaired as outlined in the *Technical Specifications*.

The CQA Site Manager will note non-compliance and report it to the Project Manager.

13. GEOCOMPOSITE

13.1 Introduction

This section of the CQA Plan outlines the CQA activities to be performed for the geocomposite installation. The CQA Consultant will review the *Drawings*, and the *Technical Specifications*, and any approved addenda or changes.

13.2 Manufacturing

The Manufacturer will provide the CQA Consultant with a list of certified "minimum average roll value" properties for the type of geocomposite to be delivered. The Manufacturer will also provide the CQA Consultant with a written certification signed by a responsible representative of the Manufacturer that the geocomposite actually delivered have "minimum average roll values" properties which meet or exceed all certified property values for that type of geocomposite.

The CQA Consultant will examine the Manufacturers' certifications to document that the property values listed on the certifications meet or exceed those specified for the particular type of geocomposite (geotextile and geonet). Deviations will be reported to the Project Manager.

13.3 Labeling

The Manufacturer will identify all rolls of geocomposite with the following:

- Manufacturer's name;
- product identification;
- lot number;
- roll number; and
- roll dimensions.

The CQA Site Manager will examine rolls upon delivery and deviation from the above requirements will be reported to the Project Manager.

13.4 Shipment and Storage

During shipment and storage, the geocomposite will be protected from ultraviolet light exposure, precipitation or other inundation, mud, dirt, dust, puncture, cutting or any other damaging or deleterious conditions. Therefore, geocomposite rolls will be shipped and stored in relatively opaque and watertight wrappings. The CQA Site Manager will observe rolls upon delivery to the site and deviation from the above requirements will be reported to the Project Manager. Damaged rolls will be rejected and replaced.

Wrapping protecting geocomposite rolls will be removed less than one hour prior to unrolling geocomposite before placement. After the wrapping has been removed, geocomposite should not be exposed to sunlight for more than 15 days, unless otherwise approved by the Manufacturer. Approval by the Manufacturer will be a guarantee that the properties of the exposed geotextile will not degrade upon prolonged exposure to such values that would cause the material to not meet the *Technical Specifications*. Any material that is exposed for more than 15 days, which has been approved for prolonged exposure by the Manufacturer, will be tested by the CQA Laboratory to document that the material properties are still in conformance with the *Technical Specifications*. Any material that fails to meet the *Technical Specifications* will be replaced by the Manufacturer.

The CQA Site Manager will observe that geocomposite is free of dirt and dust just before installation. The CQA Site Manager will report the outcome of this observation to the Project Manager, and if the geocomposite is judged dirty or dusty, they will be cleaned by the Geosynthetic Installer prior to installation.

13.5 Conformance Testing

13.5.1 Tests

The geocomposite material will be tested for transmissivity (ASTM D 4716) and for peel strength (ASTM D 413) at the frequencies presented in Table 11.

13.5.2 Sampling Procedures

Upon delivery of the geocomposite rolls, the CQA Site Manager will document that samples are obtained from individual rolls at the frequency specified in this CQA Plan. The geocomposite samples will be forwarded to the CQA Laboratory for testing to evaluate conformance to both the *Technical Specifications* and the list of physical properties certified by the Manufacturer.

Samples will be taken across the width of the roll and will not include the first 3 linear ft (1 linear m). Unless otherwise specified, samples will be 3 ft (1 m) long by the roll width. The CQA Consultant will mark the machine direction on the samples with an arrow.

13.5.3 Test Results

The CQA Site Manager will examine results from laboratory conformance testing and compare results to the *Technical Specifications*. The criteria used to evaluate acceptability are presented in the *Technical Specifications*. The CQA Site Manager will report any nonconformance to the Project Manager.

13.5.4 Conformance Test Failure

The following procedure will apply whenever a sample fails a conformance test that is conducted by the CQA Laboratory:

- The Manufacturer will replace every roll of geocomposite that is in nonconformance with the *Technical Specifications* with a roll that meets specifications.

- The Geosynthetic Installer will remove conformance samples for testing by the CQA Laboratory from the closest numerical rolls on both sides of the failed roll. These two samples must conform to the *Technical Specifications*. If either of these samples fail, the numerically closest rolls on the side of the failed sample that is not tested, will be tested by the CQA Laboratory. These samples must

conform to the *Technical Specifications*. If any of these samples fail, every roll of geocomposite on site from this lot and every subsequently delivered roll that is from the same lot must be tested by the CQA Laboratory for conformance to the *Technical Specifications*.

The CQA Site Manager will document actions taken in conjunction with conformance test failures.

13.6 Handling and Placement

The Geosynthetic Installer will handle all geocomposite in such a manner as to document they are not damaged in any way. The Geosynthetic Installer will comply with the following:

- In the presence of wind, the geocomposite will be weighted with sandbags or the equivalent. Sandbags will be used during installation only and will remain until replaced with the appropriate cover material.

- If in place, special care must be taken to protect other materials from damage, which could be caused by the cutting of the geocomposite.

- The Geosynthetic Installer will take any necessary precautions to prevent damage to underlying layers during placement of the geocomposite.

- During placement of geocomposite, care will be taken to prevent entrapment of dirt or excessive dust that could cause clogging of the drainage system, and/or stones that could damage the adjacent geomembrane. If dirt or excessive dust is entrapped in the geocomposite, it should be cleaned prior to placement of the next material on top of it. In this regard, care should be taken with the handling or sandbags, to prevent rupture or damage of the sandbag.

- A visual examination of the geocomposite will be carried out over the entire surface, after installation to document that no potentially harmful foreign objects are present.

The CQA Site Manager will note noncompliance and report it to the Project Manager.

13.7 Geocomposite Seams and Overlaps

Adjacent geocomposite panels will be joined in general accordance with *Construction Drawings* and *Technical Specifications*. As a minimum, the following requirements will be met:

- Adjacent rolls will be overlapped by at least 4 in. (100 mm).
- Each component of the geocomposite will be secured or seamed to the like component at overlaps.
- The geocomposite overlaps will be secured by tying, in general accordance with the *Technical Specifications*.
- The bottom layers of geotextile, if applicable, will be overlapped.
- The top layers of geotextile will be continuously sewn.

The CQA Consultant will note any noncompliance and report it to the Project Manager.

13.8 Repair

Holes or tears in the geocomposite will be repaired by placing a patch extending 2 ft (0.6 m) beyond edges of the hole or tear. The patch will be secured by tying with approved tying devices every 6 in. (150 mm) through the bottom geotextile and the geonet of the patch, and through the top geotextile and geonet components of the geocomposite needing repair. The top geotextile component of the patch will be

heat sealed to the top geotextile of the geocomposite needing repair. If the hole or tear width across the roll is more than 50 percent of the width of the roll, the damaged area will be cut out and the two portions of the geocomposite will be joined in general accordance with Section 13.7.

The CQA Site Manager will observe repairs, note noncompliances with the above requirements and report them to the Project Manager.

13.9 Placement of Soil Materials

The Contractor will place all soil materials located on top of a geocomposite in such a manner as to document:

- the geocomposite and underlying liner materials are not damaged;
- minimal slippage of the geocomposite on underlying layers occurs; and
- no excess tensile stresses occur in the geocomposite.

Unless otherwise specified by the CQA Consultant, lifts of soil material will be in conformance with the *Technical Specifications*. If portions of the geocomposite are exposed, the CQA Consultant will periodically place marks on the geocomposite and the underlying geomembrane and measure the elongation of the geonet during the placement of soil.

Noncompliance will be noted by the CQA Consultant and reported to the Project Manager.

14. SURVEYING

14.1 Survey Control

Survey control will be performed by the Owner as needed. A permanent benchmark will be established for the site(s) in a location convenient for daily tie-in. The vertical and horizontal control for this benchmark will be established within normal land surveying standards.

14.2 Precision and Accuracy

A wide variety of survey equipment is available for the surveying requirements for these projects. The survey instruments used for this work should be sufficiently precise and accurate to meet the needs of the projects. Surveys shall be performed at 2nd order accuracy.

14.3 Lines and Grades

The following surfaces will be surveyed to verify the lines and grades achieved during soil placement and compaction.

- Prepared Subgrade:
  - prepared subgrade surface.
- Cover Soil:
  - finished compacted cover soil surface.

The following structures will be surveyed to verify and document the lines and grades achieved during construction of the Project:

- all culverts, inlet, and drop structures;
- ditch bottoms and sideslopes;
- permanent erosion control features;

- geomembrane terminations and selected geomembrane seams, as indicated by the CQA Manager; and

- centerlines of pipes.

14.4 Frequency and Spacing

Surveying should be carried out immediately upon completion of a given installation to facilitate progress and avoid delaying commencement of the next installation. In addition, spot checks during placement and compaction will be necessary to assist the Contractor in compliance with required grades.

At the least the following minimum spacings and locations should be provided for survey points:

- all "flat" surfaces with gradients less than 10 percent, should be surveyed on a square grid not wider spaced than 100 ft (30 m);

- on all slopes greater than 10 percent, a square grid not wider than 100 ft (30 m) should be used, but in any case, a line at the crest, midpoint, and toe of the slope should be taken;

- a line of survey points no further than 100 ft (30 m) apart must be taken along any slope break (this will include the inside edge and outside edge of any bench on a slope); and

- a line of survey points no further than 50 ft (15 m) apart must be taken at the invert of pipes or other appurtenances to the liner.

14.5 Documentation

Field survey notes should be retained by the Land Surveyor. The findings from the field surveys should be documented on a set of Survey Record Drawings, which shall be provided to the Engineer in AutoCADD V.14 format or other suitable format as directed by the Owner.

TABLE 1
TEST PROCEDURES FOR THE EVALUATION OF SOILS

TEST METHOD	DESCRIPTION	TEST STANDARD
Laboratory Test Procedures:		
Classification	Classification of Soils	ASTM D 2487
Moisture Content	Moisture Content	ASTM D 2216
Modified Proctor	Moisture/Density Relationship of Soil (10 lb (4.54 kg) rammer and 18 in. (457 mm) drop)	ASTM D 1557
Hydrometer Analysis	Particle Size Distribution of Fine Fraction of Soils	ASTM D 422
Sieve Analysis	Particle Size Distribution of Coarse Fraction of Soils	ASTM D 422
Field Test Procedures:		
Nuclear Densometer	In Situ Soil Unit Weight In Situ Moisture Content	ASTM D 2922 ASTM D 3017
Sand Cone	In Situ Soil Unit Weight Moisture Content	ASTM D 1556 ASTM D 2216
Drive Cylinder	In Situ Soil Unit Weight Moisture Content	ASTM D 2937 ASTM D 2216

TABLE 2

MINIMUM SOILS TESTING FREQUENCIES FOR MATERIAL QUALIFICATION TESTING

TEST	ENGINEERED FILL
Moisture Content	1 per source
Sieve Analysis	1 per source
Hydrometer Analysis	1 per source
Soil Classification	1 per source
Modified Proctor	1 per source

TABLE 3

MINIMUM SOILS TESTING FREQUENCIES FOR CONFORMANCE TESTING

TEST	COVER SOIL
Moisture Content	1 per 10,000 yd^3 (7,646 m^3)
Sieve Analysis	1 per 10,000 yd^3 (7,646 m^3)
Hydrometer Analysis	1 per 10,000 yd^3 (7,646 m^3)
Soil Classification	1 per 10,000 yd^3 (7,646 m^3)
Modified Proctor	1 per 10,000 yd^3 (7,646 m^3)

TABLE 4

MINIMUM SOIL TESTING FREQUENCIES FOR CONSTRUCTION QUALITY CONTROL

TEST	ENGINEERED FILL
Nuclear densometer	1 per 750 yd^3
Sand cone or drive cylinder	1 per 20 nuclear densometer tests

Notes: (1) Nuclear densometer testing of the first lift of cover soil placed above the final cover system geosynthetics shall be performed at a depth no greater than 6 in. (i.e., 8-in. deep hole in 12-in. thick cover).

TABLE 5

TEST PROCEDURES FOR THE EVALUATION OF AGGREGATE

TEST METHOD	DESCRIPTION	TEST STANDARD
Sieve Analysis	Particle Size Distribution of Fine and Coarse Aggregates	ASTM C 136
Hydraulic Conductivity (Rigid Wall Permeameter)	Permeability of Aggregates	ASTM D 2434

TABLE 6

MINIMUM AGGREGATE TESTING FREQUENCIES FOR MATERIAL QUALIFICATION TESTING

TEST	DRAINAGE AGGREGATE
Sieve Analysis	1 per source
Hydraulic Conductivity	1 per source

TABLE 7

MINIMUM AGGREGATE TESTING FREQUENCIES FOR CONFORMANCE TESTING

TEST	TEST METHOD	DRAINAGE AGGREGATE
Sieve Analysis	ASTM C 136	1 per 5,000 yd^3 (3,823 m^3)
Hydraulic Conductivity	ASTM D 2434	1 per 10,000 yd^3 (7,646 m^3)

TABLE 8

GEOMEMBRANE CONFORMANCE TESTING REQUIREMENTS

TEST NAME	TEST METHOD	FREQUENCY
Specific Gravity	ASTM D 792 Method A or ASTM D 1505	100,000 ft^2 (9,290 m^2)
Thickness	ASTM D 5994 or ASTM D 5199	100,000 ft^2 (9,290 m^2)
Tensile Strength at Yield	ASTM D 638	100,000 ft^2 (9,290 m^2)
Tensile Strength at Break	ASTM D 638	100,000 ft^2 (9,290 m^2)
Elongation at Yield	ASTM D 638	100,000 ft^2 (9,290 m^2)
Elongation at Break	ASTM D 638	100,000 ft^2 (9,290 m^2)
Carbon Black Content	ASTM D 1603	100,000 ft^2 (9,290 m^2)
Carbon Black Dispersion	ASTM D 5596	100,000 ft^2 (9,290 m^2)

TABLE 9

GEOTEXTILE CONFORMANCE TESTING REQUIREMENTS

TEST NAME	TEST METHOD	MINIMUM FREQUENCY
Grab Strength	ASTM D 4632	1 test per 260,000 ft^2
Puncture Resistance	ASTM D 4833	1 test per 260,000 ft^2
Permittivity	ASTM D 4491	1 test per 260,000 ft^2
Apparent Opening Size	ASTM D 4751	1 test per 260,000 ft^2

TABLE 10

GCL CONFORMANCE TESTING REQUIREMENTS

TEST NAME	TEST METHOD	MINIMUM FREQUENCY
Mass per Unit Area	ASTM D 3776	100,000 ft^2 (9,290 m2)
Index Flux	ASTM D 5084	400,000 ft^2 (37,160 m^2)
Residual Shear Strength	ASTM D 5321	See Technical Specifications

TABLE 11

GEOCOMPOSITE CONFORMANCE TESTING REQUIREMENTS

TEST NAME	TEST METHOD	MINIMUM FREQUENCY
Peel Strength	ASTM D 413	1 test per 200,000 ft^2 (18,580 m^2)
Hydraulic Transmissivity	ASTM D 4716	1 test per 200,000 ft^2 (18,580 m^2)

Note: Testing will be carried out at a frequency of one per lot or at listed frequency, whichever yields the greater number of samples.

Section 7
Final Cover Technical Specifications

TECHNICAL SPECIFICATIONS
FOR THE
CONSTRUCTION OF

FINAL COVER SYSTEM
AT
CORRECTIVE ACTION MANAGEMENT UNIT
BASIC REMEDIATION COMPANY
HENDERSON, NEVADA

Prepared for:

Basic Remediation Company
875 West Warm Springs Road
Henderson, Nevada 89015
(702) 567-0400

Prepared by:

GeoSyntec Consultants
11305 Rancho Bernardo Road, Suite 101
San Diego, California 92127
(858) 674-6559

3 November 2006

TABLE OF CONTENTS

Section 02200	**—**	**Earthwork**
Section 02225	**—**	**Drainage Aggregate**
Section 02711	**—**	**Polyethylene Pipe**
Section 02770	**—**	**Geomembrane**
Section 02771	**—**	**Geotextile**
Section 02772	**—**	**Geosynthetic Clay Liner**
Section 02773	**—**	**Geocomposite**

SECTION 02200
EARTHWORK

PART 1 — GENERAL

1.01 DESCRIPTION OF WORK

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, equipment, and incidentals necessary to perform all Earthwork. The work shall be carried out as specified herein and in accordance with the Drawings.

B. The Work shall include, but not be limited to excavating, hauling, placing, moisture conditioning, backfilling, compacting, grading, and subgrade preparation. Earthwork shall conform to the dimensions, lines, grades and sections shown on the Drawings or as directed by the Engineer.

1.02 RELATED SECTIONS

Section 02772 — Geosynthetic Clay Liner

Section 02773 — Geocomposite

1.03 REFERENCES

A. Drawings.

B. Site Construction Quality Assurance (CQA) Plan.

C. Latest version of American Society for Testing and Materials (ASTM) standards:

ASTM D 422	Standard Method for Particle-Size Analysis of Soils
ASTM D 1557	Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3))
ASTM D 2216	Standard Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures
ASTM D 2487	Standard Test Method for Classification of Soils for Engineering Purposes
ASTM D 2922	Standard Test Methods for Density of Soil and Soil-Aggregate In-Place by Nuclear Density Methods (Shallow Depth)
ASTM D 3017	Standard Test Method for Water Content of Soil and Rock In-Place by Nuclear Methods (Shallow Depth)

1.04 SUBMITTALS

A. The Contractor shall submit to the Engineer a description of equipment and methods proposed for Cover Soil, Anchor Trench Backfill, and Prepared Subgrade placement and compaction at least 7 days prior to the start of activities covered by this Section.

B. If the work of this Section is interrupted for reasons other than inclement weather, the Contractor shall notify the Engineer a minimum of 24 hours prior to the resumption of work.

C. The Contractor shall provide the Engineer with sufficient time to perform as-built surveys of the completed cover soil and prepared subgrade.

D. If foreign borrow materials are proposed for any earthwork material on this project, the Contractor shall provide the Engineer information regarding the source of the material. In addition, the Contractor shall provide the Engineer an opportunity to obtain the necessary samples for conformance testing, prior to delivery of foreign borrow materials to the site.

1.05 QUALITY ASSURANCE

A. The Contractor shall ensure that the materials and methods used for Earthwork meet the requirements of the Drawings and this Section. Any material or method that does not conform to these documents, or to alternatives approved in writing by the Engineer will be rejected and shall be repaired or replaced by the Contractor.

B. The Contractor shall be aware of and accommodate all monitoring and field/laboratory conformance testing required by the CQA Plan. This monitoring and testing, including random conformance testing of construction materials and completed work, will be performed by the Engineer. If nonconformances or other deficiencies are found in the materials or completed work, the Contractor will be required to repair the deficiency or replace the deficient materials.

PART 2 — PRODUCTS

2.01 MATERIALS

A. Cover soil shall consist of relatively homogeneous, natural soils that are free of debris, foreign objects, large rock fragments (greater than 6 inches in maximum dimension), roots, and organics. The first lift of cover soil placed directly overlying the geosynthetic components of the cover system shall have a maximum particle size of 1 inch. The cover soil shall be classified according to the Unified Soil Classification System (per ASTM D 2487) as SC, ML, CL, SM, SW, GW, GM, GC, or combinations of these materials. The Contractor may propose the use of other soil types as cover soil, but then such use shall be at the sole discretion of the Engineer.

B. Prepared subgrade is defined as the material directly underlying the geosynthetic liner system which shall meet the requirements listed above for cover soil. No materials larger than 1.5 inch shall project or protrude from the surface of the prepared subgrade.

C. Anchor Trench Backfill materials shall meet the requirements listed above for the cover soil.

2.02 EQUIPMENT

A. The Contractor shall furnish, operate, and maintain compaction equipment as is necessary to produce the required in-place soil density and moisture content.

B. The Contractor shall furnish, operate and maintain tank trucks, pressure distributors, or other equipment designed to apply water uniformly and in controlled quantities to variable surface widths.

C. The Contractor shall furnish, operate, and maintain miscellaneous equipment such as scarifiers or disks, earth excavating equipment, earth hauling equipment, and other equipment, as necessary for Earthwork construction.

PART 3 — EXECUTION

3.01 FAMILIARIZATION

A. Prior to implementing any of the work in this Section, the Contractor shall become thoroughly familiar with the site, the site conditions, and all portions of the work falling within this and other related Sections.

B. Inspection:

- The Contractor shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the installation of the work specified in this Section may properly commence without adverse impact.

- If the Contractor has any concerns regarding the installed work of other Sections, the Engineer shall be notified in writing prior to commencing work. Failure to notify the Engineer or continuance of the work of this Section will be construed as Contractor's acceptance of the related work of all other Sections.

3.02 SITE PREPARATION

A. Prior to performing any earthworks on the site, the Contractor shall perform a baseline topographic survey. This survey shall be conducted by a Professional Land Surveyor licensed in the state of Nevada. This survey will serve as the starting point for earthwork quantities.

3.03 ANCHOR TRENCH EXCAVATION

A. The Contractor shall excavate the anchor trench to the limits and grades shown on the Drawings.

B. All excavated materials not used for Anchor Trench Backfill or cover soil shall be stockpiled in an area designated by the Owner in accordance with Part 3.06 of this Section.

3.04 SUBGRADE SURFACE PREPARATION

A. The subgrade shall be prepared and made suitable as a foundation for placement and compaction of soil material, where applicable. The subgrade shall be firm and able to support the Contractor's construction equipment without the development of depressions or ruts. In addition, the subgrade shall provide adequate support such that the overlying fill material may be placed and compacted to the specified density.

3.05 PREPARED SUBGRADE

A. The prepared subgrade shall be made suitable as a foundation for placement of the geosynthetic components of the liner system (prepared subgrade). The prepared subgrade shall be firm, meet the requirements outlined in Part 2.01, and be able to support the geosynthetic components of the liner system.

3.06 STOCKPILING

A. Soil shall be stockpiled in areas designated by the Owner and shall be free of incompatible soil, clearing, clearing debris, or other objectionable materials.

B. Stockpiles shall be no steeper than 2.1H:1V (Horizontal:Vertical) or other slope approved by the Engineer, graded to drain, sealed by tracking parallel to the slope with a dozer or other means approved by the Engineer, and dressed daily during periods when fill is taken from the stockpile. The Contractor shall employ temporary erosion and sediment control measures (i.e. silt fence) as directed by the Engineer around stockpile areas.

3.07 ANCHOR TRENCH BACKFILL

A. The Anchor Trench Backfill shall be placed to the lines and grades shown on the Drawings.

B. Soil used for the Anchor Trench Backfill shall meet the requirements of Part 2.01 of this Section.

C. Soil used for the Anchor Trench Backfill shall be placed in a loose lift that results in a compacted lift thickness of no greater than 12 inches. The maximum permissible pre-compaction soil clod size is 6 inches.

D. The Contractor shall compact each lift to at least 90 percent of its modified Proctor maximum dry density (ASTM D 1557). The Contractor shall utilize compaction equipment suitable for achieving the soil compaction requirements.

3.08 COVER SOIL

A. The Cover Soil shall be placed to the lines and grades shown on the Drawings.

B. Soil used for the Cover Soil shall meet the requirements of Part 2.01 of this Section.

C. Place only when underlying geocomposite installation is complete including all Construction Quality Control (CQC) and CQA work.

D. Soil used for the Cover Soil shall be placed in a loose lift that results in a compacted lift thickness of no greater than 12 inches. The maximum permissible pre-compaction soil clod size is 6 inches.

E. During wetting or drying, the material shall be regularly disced or otherwise mixed so that uniform moisture conditions in the appropriate range are obtained.

F. The subgrade to the cover soil layer consists of a geocomposite. Therefore, the Contractor shall avoid tearing, puncturing, folding, or damaging in any way the geocomposite during placement of the cover soil material.

G. Any damage to the geosynthetic liner system which is caused by the Contractor or representatives of the Contractor shall be repaired by the Geosynthetics Installer at the expense of the Contractor.

H. The Contractor shall compact each lift to at least 90 percent of its modified Proctor maximum dry density (ASTM D 1557). The Contractor shall utilize compaction equipment suitable for achieving the soil compaction requirements.

I. The cover soil material shall be placed out in front of the equipment used to place the cover soil such that the minimum thickness requirements are maintained at all times between the geosynthetic materials and the wheels or tracks of the equipment used to place the cover soil material.

J. Care must be exercised by the operators of tracked equipment to avoid sharp pivoting turns that could displace the cover soil material and result in damage to the liner system.

K. The Contractor shall not push cover soil material down the side slope. All soil materials shall be placed from the toe of slope upward.

L. Equipment used in spreading the cover soil material on top of the geosynthetic liner system shall be restricted to the following maximum allowable equipment ground pressures:

MAXIMUM ALLOWABLE EQUIPMENT GROUND PRESSURE (psi)	INITIAL LIFT THICKNESS OF OVERLYING COVER SOIL (ft)
<10	1.0
>20	2.0

3.09 FIELD TESTING

A. The minimum frequency and details of quality control testing are provided below. This testing will be performed by the Engineer. The Contractor shall take this testing frequency into account in planning the construction schedule.

1. Cover Soil material quality control testing:

   a. particle-size analyses conducted in accordance with ASTM D 422 at a frequency of one test per 10,000 yd^3;

   b. moisture content tests conducted in accordance with ASTM D 2216 at a frequency of one test per 10,000 yd^3;

   c. soil classification tests conducted in accordance with ASTM D 2487 at a frequency of one test per 10,000 yd^3; and

   d. modified Proctor compaction tests conducted in accordance with ASTM D 1557 at a frequency of one test per 10,000 yd^3.

2. The Engineer will perform conformance tests on placed and compacted cover soil to evaluate compliance with these Specifications. These tests will include in-situ moisture content and dry density. The frequency and procedures for moisture-density testing are given in the CQA Plan. At a minimum, the dry density and moisture content of the soil will be measured in-situ in accordance with ASTM D 2922 and ASTM D 3017, respectively.

3. A special testing frequency will be used by the Engineer when visual observations of construction performance indicate a potential problem. Additional testing will be considered when:

   a. the rollers slip during rolling operation;

b. the lift thickness is greater than specified;
c. the fill is at improper and/or variable moisture content;
d. fewer than the specified number of roller passes are made;
e. dirt-clogged rollers are used to compact the material;
f. the rollers do not have optimum ballast; or
g. the degree of compaction is doubtful.

4. During construction, the frequency of testing will be increased by the Engineer in the following situations:

a. adverse weather conditions;
b. breakdown of equipment;
c. at the start and finish of grading;
d. if the material fails to meet specifications; or
e. the work area is reduced.

B. Defective Areas:

1. If a defective area is discovered in the Earthwork, the Engineer will evaluate the extent and nature of the defect. If the defect is indicated by an unsatisfactory test result, the Engineer will determine the extent of the defective area by additional tests, observations, a review of records, or other means that the Engineer deems appropriate. If the defect is related to adverse site conditions, such as overly wet soils or surface desiccation, the Engineer shall define the limits and nature of the defect.

2. Once the extent and nature of a defect is determined, the Contractor shall correct the deficiency to the satisfaction of the Engineer. The Contractor shall not perform additional work in the area until the Engineer approves the correction of the defect.

3. Additional testing may be performed by the Engineer to verify that the defect has been corrected. This additional testing will be performed before any additional work is allowed in the area of deficiency. The cost of the additional testing shall be borne by the Contractor.

3.10 SURVEY CONTROL

A. The Contractor shall perform all surveys necessary for construction layout and control.

3.11 CONSTRUCTION TOLERANCE

A. The Contractor shall perform the Earthwork construction to within ±0.1 ft on areas with a slope less than 10 percent and ±0.2 ft on areas with a slope greater than 10 percent of the grades indicated on the Drawings.

3.12 PROTECTION OF WORK

A. The Contractor shall use all means necessary to protect completed work of this Section.

B. At the end of each day, the Contractor shall verify that the entire work area is left in a state that promotes drainage of surface water away from the area and from finished work. If threatening weather conditions are forecast, at a minimum, compacted surfaces shall be seal-rolled to protect finished work.

C. In the event of damage to prior work, the Contractor shall make repairs and replacements to the satisfaction of the Engineer.

PART 4 — MEASUREMENT AND PAYMENT

4.01 GENERAL

A. Providing for and complying with the requirements set forth in this Section for Prepared Subgrade will be measured as square feet (SF), and payment will be based on the unit price provided on the Bid Schedule.

B. Providing for and complying with the requirements set forth in this Section for Anchor Trench Excavation and Backfill will be measured as linear feet (LF), and payment will be based on the unit price provided on the Bid Schedule.

C. Providing for and complying with the requirements set forth in this Section for Cover Soil will be measured as in-place cubic yards (CY), and payment will be based on the unit price provided on the Bid Schedule.

D. The following are considered incidental to the Work:

- material samples, sampling, and testing.
- layout survey.
- rejected material removal, re-testing, handling, and repair.
- rejected material.
- mobilization.

END OF SECTION

SECTION 02225
DRAINAGE AGGREGATE

PART 1 — GENERAL

1.01 DESCRIPTION OF WORK

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, equipment and incidentals necessary for the installation of drainage aggregate. The work shall be carried out as specified herein and in accordance with the Drawings.

B. The work shall include, but not be limited to, delivery, storage, and placement of drainage aggregate (aggregate).

1.02 RELATED SECTIONS

Section 02200 — Earthwork

Section 02771 — Geotextile

1.03 REFERENCES

A. Drawings

B. Site Construction Quality Assurance (CQA) Plan

C. Latest Version of American Society for Testing and Materials (ASTM) Standards:

ASTM C 33	Standard Specification for Concrete Aggregates
ASTM C 136	Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM D 2434	Standard Test Method for Permeability of Granular Soils (Constant Head)

1.04 SUBMITTALS

A. The Contractor shall submit to the Engineer for approval, at least 7 days prior to the start of construction, Certificates of Compliance for proposed aggregate materials. Certificates of Compliance shall include, at a minimum, typical gradation and source of aggregate materials.

1.05 QUALITY ASSURANCE

A. The Contractor shall ensure that the materials and methods used for Earthwork meet the requirements of the Drawings and this Section. Any material or method that does not conform to these documents, or to alternatives approved in writing by the Engineer will be rejected and shall be repaired or replaced by the Contractor.

B. The Contractor shall be aware of and accommodate all monitoring and field/laboratory conformance testing required by the CQA Plan. This monitoring and testing, including random conformance testing of construction materials and completed work, will be performed by the Engineer. If nonconformances or other deficiencies are found in the materials or completed work, the Contractor will be required to repair the deficiency or replace the deficient materials.

PART 2 — PRODUCTS

2.01 MATERIALS

A. Aggregate shall meet the requirements specified in ASTM C-33 and shall have a maximum particle size of 1-inch. Aggregate shall have a minimum permeability of 1×10^{-2} cm/sec when tested in accordance with ASTM D 2434.

2.02 EQUIPMENT

A. The Contractor shall furnish, operate, and maintain hauling, placing, and grading equipment as necessary for aggregate placement.

PART 3 — EXECUTION

3.01 FAMILIARIZATION

A. Prior to implementing any of the work in this Section, the Contractor shall become thoroughly familiar with the site, the site conditions, and all portions of the work falling within this and other related Sections.

B. Inspection:

- The Contractor shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the installation of the work specified in this Section may properly commence without adverse impact.

- If the Contractor has any concerns regarding the installed work of other Sections, the Engineer shall be notified in writing prior to commencing work. Failure to notify the Engineer or continuance of the work of this Section will be construed as Contractor's acceptance of the related work of all other Sections.

3.02 PLACEMENT

A. Place only when underlying geosynthetic and CPE pipe installation is complete including all CQC and CQA work.

B. Place to the lines, grades, and dimensions shown on the Drawings.

C. The subgrade to the aggregate consists of a geocomposite overlying a geomembrane. The Contractor shall avoid creating large wrinkles (greater than 6-inches high), tearing, puncturing, folding, or damaging in any way the geosynthetic materials during placement of the aggregate material.

D. Any damage to the geosynthetic liner system which is caused by the Contractor or his representatives shall be repaired by the Geosynthetic Installer.

E. No density or moisture requirements are specified for placement of the aggregate material.

F. Place filter geotextile overlying aggregate as shown on the Drawings and as specified in Section 02771.

3.03 FIELD TESTING

A. The minimum frequency and details of quality control testing are provided below. This testing will be performed by the Engineer. The Contractor shall take this testing frequency into account in planning the construction schedule.

1. Aggregates quality control testing:

a. particle-size analyses conducted in accordance with ASTM C-136 at a frequency of one test per 5,000 yd^3;

b. permeability tests conducted in accordance with ASTM D 2434 at a frequency of one test per 10,000 yd^3.

3.04 SURVEY CONTROL

A. The Contractor shall perform all surveys necessary for construction layout and control.

3.05 CONSTRUCTION TOLERANCE

A. The Contractor shall perform the aggregate construction to within +0.1 ft of the thickness indicated on the Drawings.

3.06 PROTECTION OF WORK

A. The Contractor shall use all means necessary to protect all work of this Section.

B. In the event of damage, the Contractor shall make repairs and replacements to the satisfaction of the Engineer.

PART 4 — MEASUREMENT AND PAYMENT

4.01 GENERAL

A. Providing for and complying with the requirements set forth in this Section for Drainage Aggregate around CPE pipe will be measured in linear feet (LF), and payment will be based on the unit price provided on the Bid Schedule.

B. Providing for and complying with the requirements set forth in this Section for Drainage Aggregate at geocomposite perimeter termination will be measured in linear feet (LF), and payment will be based on the unit price provided on the Bid Schedule.

C. The following are considered incidental to the Work:

- material samples, sampling, and testing.
- layout survey.
- rejected material.
- rejected material removal, re-testing, handling, and repair.
- mobilization.

END OF SECTION

SECTION 02711
CORRUGATED POLYETHYLENE PIPE

PART 1 — GENERAL

1.01 DESCRIPTION OF WORK

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, and equipment necessary to install perforated and solid wall corrugated polyethylene (CPE) pipe and fittings as shown on the Drawings and specified herein.

1.02 RELATED SECTIONS

Section 02200 — Earthwork

1.03 REFERENCES

A. Drawings

B. Site Construction Quality Assurance (CQA) Plan

C. Latest Version of American Society for Testing and Materials (ASTM) Standards:

ASTM F 405 Standard Specification for Corrugated Polyethylene (CPE) Pipe and Fittings

Latest American Association of State Highway and Transportation Officials (AASHTO) Standards:

AASHTO M252M-96 Corrugated Polyethylene Drainage Pipe

1.04 SUBMITTALS

A. The Contractor shall submit, at least 7 days prior to installation of this material, to the Engineer, certificates of compliance for the pipe materials and fittings to be furnished.

B. The Engineer will supply a surveyor to document the as-built conditions of the piping. The Contractor shall notify and allow the Engineer sufficient time to survey piping prior to backfilling the pipe.

1.05 QUALITY ASSURANCE

A. The Contractor shall ensure that the materials and methods used for corrugated polyethylene pipe meet the requirements of the Drawings and this Section. Any material or method that does not conform to these documents, or to alternatives approved in writing by the Engineer will be rejected and shall be repaired or replaced by the Contractor.

PART 2 — PRODUCTS

2.01 PIPE

A. HDPE pipe sizes shown on the Drawings and specified in this Section reference nominal inside diameter. Pipe material, markings, properties, and size shall be in accordance with AASHTO M252.

B. Pipes shall be corrugated polyethylene pipe with a smooth interior wall, Type SP with Class 2 perforations in accordance with AASHTO M252.

PART 3 — EXECUTION

3.01 GENERAL

A. When shipping, delivering, and installing pipe, fittings, and accessories, do so to ensure a sound, undamaged installation. Provide adequate storage for all materials and equipment delivered to the job site. Handle and store pipe and fittings in accordance with the Manufacturer's recommendation.

3.02 PLACING AND LAYING PIPE

A. Follow the Manufacturer's recommendations when hauling, unloading, and stringing the pipe.

B. Corrugated polyethylene solid and perforated pipe shall be installed as shown on the Drawings.

C. Corrugated polyethylene pipe shall be inspected for cuts, scratches, or other damages prior to installation. Any pipe showing damage, which in the opinion of the Engineer will affect performance of the pipe, must be removed from the site. Replace any material found to be defective.

3.03 CONSTRUCTION TOLERANCE

A. The Contractor shall perform the work to within ±0.1 ft of the grades indicated on the Drawings.

PART 4 — MEASUREMENT AND PAYMENT

4.01 GENERAL

A. Providing for and complying with the requirements set forth in this Section for 6-inch HDPE perforated and solid wall CPE pipe and fittings will be measured in linear feet (LF), and payment will be based on the unit price provided on the Bid Schedule.

B. Providing for and complying with the requirements set forth in this Section for 6-inch HDPE perforated and solid wall CPE pipe and fittings will be measured in linear feet (LF), and payment will be based on the unit price provided on the Bid Schedule.

C. The following are considered incidental to the Work:

- shipping, handling and storage.
- layout survey.
- mobilization.
- rejected material.
- rejected material removal, handling, re-testing, and repair.

END OF SECTION

SECTION 02770
GEOMEMBRANE

PART 1 — GENERAL

1.01 DESCRIPTION OF WORK

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, equipment, and incidentals necessary for the installation of double-sided textured high-density polyethylene (HDPE) and smooth HDPE geomembrane, as shown on the Drawings. The work shall be carried out as specified herein and in accordance with Drawings.

B. The work shall include, but not be limited to, delivery, storage, placement, anchorage, and seaming of the geomembrane.

C. Double-sided textured geomembrane shall be used on the side slopes and smooth geomembrane shall be used on the top deck as shown on the Drawings.

1.02 RELATED SECTIONS

Section 02772 — Geosynthetic Clay Liner

Section 02773 — Geocomposite

1.03 REFERENCES

A. Drawings

B. Site Construction Quality Assurance (CQA) Plan

C. Latest version of the American Society for Testing and Materials (ASTM) standards:

ASTM D 638	Standard Test Method for Tensile Properties of Plastics
ASTM D 792	Standard Test Methods for Specific Gravity (Relative Density) and Density of Plastics by Displacement
ASTM D 1004	Standard Test Method of Initial Tear Resistance of Plastic Film and Sheeting
ASTM D 1505	Standard Test Methods for Density of Plastics by Density-Gradient Technique
ASTM D 1603	Standard Test Method for Carbon Black in Olefin Plastics
ASTM D 4437	Standard Test Methods for Determining the Integrity of Field Seams Used in Joining Flexible Polymeric Geomembranes
ASTM D 5321	Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method
ASTM D 5397	Test Method for Evaluation of Stress Crack Resistance of Polyolefin Geomembranes Using Notched Constant Tensile Load Test

ASTM D 5596 Recommended Practice for Microscopical Examination of Pigment Dispersion in Plastic Compounds

ASTM D 5641 Practice for Geomembrane Seam Evaluation by Vacuum Chamber

ASTM D 5820 Practice for Pressurized Air Channel Evaluation of Dual Seamed Geomembranes

ASTM D 5994 Standard Test Method for Measuring Core Thickness of Textured Geomembranes

1.04 QUALIFICATIONS

A. Geomembrane Manufacturer:

1. The Geomembrane Manufacturer shall be responsible for the production of geomembrane rolls from resin and shall have sufficient production capacity and qualified personnel to provide material meeting the requirements of this Section and the construction schedule for this project.

2. Prequalified Geomembrane Manufacturers include the following:

GSE Lining Technology, Inc.
19103 Gundle Road
Houston, TX 77073
(800) 435-2008

Serrot International, Inc.
125 Cassia Way
Henderson, NV 89014
(800) 237-1777

B. Geosynthetics Installer:

1. The Geosynthetics Installer shall be responsible and shall provide sufficient resources for field handling, deploying, seaming, temporarily restraining (against wind), and other aspects of the deployment and installation of the geomembrane and other geosynthetic components of the project.

2. The Geosynthetics Installer shall have successfully installed a minimum of 2,000,000 ft^2 of polyethylene geomembrane on previous projects.

3. The installation crew shall have the following experience.

a. The Superintendent shall have supervised the installation of a minimum of 2,000,000 ft^2 of polyethylene geomembrane on at least five (5) different projects.

b. At least one seamer shall have experience seaming a minimum of 1,000,000 square feet of polyethylene geomembrane using the same type of seaming apparatus to be used at this site. Seamers with such experience will be designated “master seamers” and shall provide direct supervision over less experienced seamers.

c. All other seaming personnel shall have seamed at least 100,000 square feet of polyethylene geomembrane using the same type of seaming apparatus to be used at this site. Personnel who have seamed less than 100,000 square feet shall be allowed to seam only under the direct supervision of the master seamer or Superintendent.

1.05 WARRANTY

A. The Geosynthetic Installer shall furnish the Engineer a 20-year written warranty against defects in materials. Warranty conditions concerning limits of liability will be evaluated by, and must be acceptable to, the Engineer and Owner.

B. The Geosynthetic Installer shall furnish the Engineer with a 5-year written warranty against defects in workmanship. Warranty conditions concerning limits of liability will be evaluated by, and must be acceptable to, the Engineer and Owner.

1.06 SUBMITTALS

A. The Geosynthetic Installer shall submit the following documentation on the resin used to manufacture the geomembrane to the Engineer for approval 14 days prior to transporting any geomembrane to the site.

1. Copies of quality control certificates issued by the resin supplier including the production dates and origin of the resin used to manufacture the geomembrane for the project.

2. Results of tests conducted by the Geomembrane Manufacturer to verify the quality of the resin used to manufacture the geomembrane rolls assigned to the project.

3. Certification that no reclaimed polymer is added to the resin during the manufacturing of the geomembrane to be used for this project, or, if recycled polymer is used, the Manufacturer shall submit a certificate signed by the production manager documenting the quantity of recycled material, including a description of the procedure used to measure the quantity of recycled polymer.

B. The Geosynthetic Installer shall submit the following documentation on geomembrane roll production to the Engineer for approval 14 days prior to transporting any geomembrane to the site.

1. Quality control certificates, which shall include:

a. roll numbers and identification; and

b. results of quality control tests, including descriptions of the test methods used, outlined in Part 2.02 of this Section.

2. The manufacturer warranty specified in Part 1.05.A of this Section.

C. The Geosynthetic Installer shall submit the following information to the Engineer for approval 14 days prior to mobilization.

1. A drawing showing the installation layout identifying geomembrane panel configurations, dimensions, details, locations of seams, as well as any variance

or additional details that deviate from the Drawings. The layout shall be adequate for use as a construction plan and shall include dimensions, details, etc. The layout drawings, as modified and/or approved by the Engineer, shall become part of these Specifications.

2. Installation schedule.

3. Copy of Geosynthetic Installer's letter of approval or license by the Geomembrane Manufacturer.

4. Installation capabilities, including:

   a. information on equipment proposed for this project;
   b. average daily production anticipated for this project; and
   c. quality control procedures.

5. A list of completed facilities for which the installer has installed a minimum of 2,000,000 ft^2 of polyethylene geomembrane, in accordance with Part 1.04 of this Specification. The following information shall be provided for each facility:

   a. the name and purpose of the facility, its location, and dates of installation;

   b. the names of the owner, project manager, and geomembrane manufacturer;

   c. name of the supervisor of the installation crew; and

   d. thickness and surface area of installed geomembrane.

6. In accordance with Part 1.04, a resume of the Superintendent to be assigned to this project, including dates and duration of employment, shall be submitted at least 7 days prior to beginning geomembrane installation.

7. In accordance with Part 1.04, resumes of all personnel who will perform seaming operations on this project, including dates and duration of employment, shall be submitted at least 7 days prior to beginning geomembrane installation.

D. A Certificate of Calibration less than 12 months old shall be submitted for each field tensiometer prior to installation of any geomembrane.

E. During installation, the Geosynthetic Installer shall be responsible for the timely submission to the Engineer of:

1. Quality control documentation; and

2. Subgrade acceptance certificates, signed by the Geosynthetic Installer, for each area to be covered by geosynthetic materials.

F. Upon completion of the installation, the Geosynthetic Installer shall be responsible for the submission to the Engineer of a warranty from the Geosynthetic Installer as specified in Part 1.05.B of this Section.

G. Upon completion of the installation, the Geosynthetic Installer shall be responsible for the submission to the Engineer of a record drawing showing the location and number of each panel and locations and numbers of destructive tests and repairs.

H. The Geosynthetic Installer shall submit the following documentation on welding rod to the Engineer for approval 14 days prior to transporting welding rod to the site:

1. Quality control documentation, including lot number, welding rod spool number, and results of quality control tests on the welding rod.

1.07 QUALITY ASSURANCE

A. The Geosynthetic Installer shall ensure that the materials and methods used for installation of the geomembrane meet the requirements of the Drawings and this Section. Any material or method that does not conform to these documents, or to alternatives approved in writing by the Engineer, will be rejected and shall be repaired or replaced by the Geosynthetic Installer.

B. The Geosynthetic Installer shall be aware of and accommodate all monitoring and conformance testing required by the CQA Plan. This monitoring and testing, including random conformance testing of construction materials and completed work, will be performed by the Engineer. If nonconformances or other deficiencies are found in the Geosynthetic Installer's materials or completed work, the Geosynthetic Installer will be required to repair the deficiency or replace the deficient materials.

PART 2 — PRODUCTS

2.01 GEOMEMBRANE PROPERTIES

A. The Geomembrane Manufacturer shall furnish double-sided and smooth-textured geomembrane having properties that comply with the required property values shown in Table 02770-1.

B. In addition to the property values listed in Table 02770-1, the geomembrane shall:

1. Contain a maximum of 1 percent by weight of additives, fillers, or extenders (not including carbon black).

2. Not have striations, pinholes (holes), bubbles, blisters, nodules, undispersed raw materials, or any sign of contamination by foreign matter on the surface or in the interior.

2.02 MANUFACTURING QUALITY CONTROL

A. Rolls:

1. The Geomembrane Manufacturer shall continuously monitor geomembrane during the manufacturing process for defects.

2. No geomembrane shall be accepted that exhibits any defects.

3. The Geomembrane Manufacturer shall measure and report the geomembrane thickness at regular intervals along the roll length.

4. No geomembrane shall be accepted that fails to meet the specified thickness.

5. The Geomembrane Manufacturer shall sample and test the geomembrane at a minimum of once every 50,000 ft^2 to demonstrate that its properties conform to the values specified in Table 02770-1. At a minimum, the following tests shall be performed:

Test	Procedure
Thickness	ASTM D 5994
Specific Gravity	ASTM D 792 Method A or ASTM D 1505
Tensile Properties	ASTM D 638
Puncture Resistance	ASTM D 4833
Tear Resistance	ASTM D 1004
Carbon Black	ASTM D 1603
Carbon Black Dispersion	ASTM D 5596

6. Tests not listed above but listed in Table 02770-1 need not be run at the 1 per 50,000 ft^2 frequency. However, the Geomembrane Manufacturer shall certify that these tests are in compliance with this section and have been performed on a sample that is identical to the geomembrane to be used on this project. The Geosynthetic Installer shall provide the test result documentation to the Engineer.

7. Any geomembrane sample that does not comply with the requirements of this Section will result in rejection of the roll from which the sample was obtained and will not be used for this project.

8. If a geomembrane sample fails to meet the quality control requirements of this Section, the Geomembrane Manufacturer shall sample and test, at the expense of the Manufacturer, rolls manufactured, in the same resin batch, or at the same time, as the failing roll. Sampling and testing of rolls shall continue until a pattern of acceptable test results is established to bound the failed roll(s).

9. Additional testing may be performed at the Geomembrane Manufacturer's discretion and expense, to isolate and more closely identify the non-complying rolls and/or to qualify individual rolls.

B. The Geomembrane Manufacturer shall permit the Engineer to visit the manufacturing plant for project specific visits. If possible, such visits will be prior to or during the manufacturing of the geomembrane rolls for the specific project.

2.03 LABELING

A. Geomembrane rolls shall be labeled with the following information.

1. thickness of the material;
2. length and width of the roll;
3. name of Geomembrane Manufacturer;
4. product identification;
5. lot number; and
6. roll number.

2.04 TRANSPORTATION, HANDLING AND STORAGE

A. Handling and care of the geomembrane prior to and following installation at the site shall be the responsibility of the Geosynthetic Installer. The Geosynthetic Installer shall be liable for all damage to the materials incurred prior to final acceptance of the liner system by the Engineer.

B. Geosynthetic Installer shall be responsible for storage of the geomembrane at the site. The geomembrane shall be protected from excessive heat or cold, dirt, puncture, cutting, or other damaging or deleterious conditions. Any additional storage procedures required by the Geomembrane Manufacturer shall be the Geosynthetic Installer's responsibility. Geomembrane rolls shall not be stored or placed in a stack of more than two rolls high.

C. The geomembrane shall be delivered at least 14 days prior to the planned deployment date to allow the Engineer adequate time to perform conformance testing on the geomembrane samples as described in Part 3.05 or this Section. If the Engineer performed a visit to the manufacturing plant and performed the required conformance sampling, geomembrane can be delivered to the site within the 14 days prior to the planned deployment date as long as there is sufficient time for the Engineer to complete the conformance testing and confirm that the rolls shipped to the site are in compliance with this Section.

PART 3 — GEOMEMBRANE INSTALLATION

3.01 FAMILIARIZATION

A. Prior to implementing any of the work described in this Section, the Geosynthetic Installer shall become thoroughly familiar with all portions of the work falling within this Section.

B. Inspection:

1. The Geosynthetic Installer shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the work of this Section may properly commence without adverse effect.

2. If the Geosynthetic Installer has any concerns regarding the installed work of other Sections, he shall notify the Engineer in writing prior to the start of the work of this Section. Failure to inform the Engineer in writing or installation of the geomembrane will be construed as the Geosynthetic Installer's acceptance of the related work of all other Sections.

C. A pre-installation meeting shall be held to coordinate the installation of the geomembrane with the installation of other components of the composite liner system.

3.02 GEOMEMBRANE DEPLOYMENT

A. Layout Drawings:

1. The Geosynthetic Installer shall deploy the geomembrane panel in general accordance with the layout drawing specified. The layout drawings must be approved by the Engineer prior to installation of any geomembrane.

B. Field Panel Identification:

1. A geomembrane field panel is a roll or a portion of roll cut in the field.

2. Each field panel shall be given an identification code (number or letter-number). This identification code shall be agreed upon by the Engineer and Geosynthetic Installer.

C. Field Panel Placement:

1. Field panels shall be installed, as approved or modified, at the location and positions indicated on the layout drawings.

2. Field panels shall be placed one at a time, and each field panel shall be seamed immediately after its placement.

3. Geomembrane shall not be placed when the ambient temperature is below 40°F or above 104°F, unless otherwise authorized in writing by the Engineer.

4. Geomembrane shall not be placed during any precipitation, in the presence of excessive moisture (e.g., fog, dew), in an area of ponded water, or in the presence of excessive winds.

5. The Geosynthetic Installer shall ensure that:

a. No vehicular traffic is allowed on the geomembrane.

b. Equipment used does not damage the geomembrane by handling, trafficking, or leakage of hydrocarbons (i.e., fuels).

c. Personnel working on the geomembrane do not smoke, wear damaging shoes, bring glass onto the geomembrane, or engage in other activities that could damage the geomembrane.

d. The method used to unroll the panels does not scratch or crimp the geomembrane and does not damage the supporting soil or geosynthetics.

e. The method used to place the panels minimizes wrinkles (especially differential wrinkles between adjacent panels). The method used to place the panels results in intimate contact with adjacent components.

f. Temporary ballast and/or anchors (e.g., sand bags), not likely to damage the geomembrane, are placed on the geomembrane to prevent wind uplift.

g. The geomembrane is especially protected from damage in heavily trafficked areas.

h. Any rub sheets to facilitate seaming are removed prior to installation of subsequent panels.

6. Any field panel or portion thereof that becomes seriously damaged (torn, twisted, or crimped) shall be replaced with new material. Less serious damage to the geomembrane may be repaired, as approved by the Engineer. Damaged panels or portions of damaged panels that have been rejected shall be removed from the work area.

D. If the Geosynthetic Installer intends to install geomembrane between one hour before sunset and one hour after sunrise, he shall notify the Engineer in writing prior to the start of the work. The Geosynthetic Installer shall indicate additional precautions, which shall be taken during these installation hours. The Geosynthetic Installer shall provide proper illumination for work during this time period.

3.03 FIELD SEAMING

A. Seam Layout:

1. In corners and at odd-shaped geometric locations, the number of field seams shall be minimized. No horizontal seam shall be along a slope with an inclination steeper than 10 percent. Horizontal seams shall be considered as any seam having an alignment exceeding 20 degrees from being perpendicular to the slope contour lines, unless otherwise approved by the Engineer. No seams shall be located in an area of potential stress concentration.

B. Personnel:

1. All personnel performing seaming operations shall be qualified as indicated in Part 1.04 of this Section. No seaming shall be performed unless a "master seamer" is present on-site.

C. Weather Conditions for Seaming:

1. Unless authorized in writing by the Engineer, seaming shall not be attempted at ambient temperatures below 40°F or above 104°F. If the Geosynthetic Installer wishes to use methods that may allow seaming at ambient temperatures below 40°F or above 104°F, he shall use a procedure approved by the Engineer.

2. A meeting will be held with the Geosynthetic Installer and Engineer to establish acceptable installation procedures. In all cases, the geomembrane shall be dry and protected from wind damage.

3. Ambient temperatures shall be measured between 0 to 6 in. above the geomembrane surface.

D. Overlapping:

1. Geomembrane panels shall be sufficiently overlapped for welding and to allow peel tests to be performed on the seam. Any seams that cannot be destructively tested because of insufficient overlap shall be treated as failing seams.

E. Seam Preparation:

1. Prior to seaming, the seam area shall be clean and free of moisture, dust, dirt, debris of any kind, and foreign material.

2. If seam overlap grinding is required, the process shall be completed according to the Geomembrane Manufacturer's instructions within 20 minutes of the seaming operation and in a manner that does not damage the geomembrane. The grind depth shall not exceed ten percent of the geomembrane thickness.

3. Seams shall be aligned with the fewest possible number of wrinkles and "fishmouths."

F. General Seaming Requirements:

1. Fishmouths or wrinkles at the seam overlaps shall be cut along the ridge of the wrinkle to achieve a flat overlap. The cut fishmouths or wrinkles shall be seamed and any portion where the overlap is insufficient shall be patched with an oval or round patch of geomembrane that extends a minimum of 6 in. beyond the cut in all directions.

2. Any electric generator shall be placed outside the area to be lined or mounted in a manner that protects the geomembrane from damage. The electric generator shall be properly grounded.

G. Seaming Process:

1. Approved processes for field seaming are extrusion welding and fusion welding. Only equipment identified as part of the approved submittal specified in Part 1.06 shall be used.

2. Extrusion Equipment and Procedures:

a. The Geosynthetics Installer shall maintain at least one spare operable seaming apparatus on site.

b. Extrusion welding apparatus shall be equipped with gauges giving the temperature in the apparatus.

c. Prior to beginning a seam, the extruder shall be purged until all heat-degraded extrudate has been removed from the barrel.

d. The Geosynthetics Installer shall provide documentation regarding the welding rod to the Engineer and shall certify that the welding rod is compatible with the specifications.

e. A smooth insulating plate or fabric shall be placed beneath the hot welding apparatus after use.

3. Fusion Equipment and Procedures:

a. The Geosynthetic Installer shall maintain at least one spare operable seaming apparatus on site.

b. Fusion-welding apparatus shall be automated vehicular-mounted devices equipped with gauges giving the applicable temperatures and speed.

c. A smooth insulating plate or fabric shall be placed beneath the hot welding apparatus after use.

H. Trial Seams:

1. Trial seams shall be made on fragment pieces of geomembrane to verify that seaming conditions are adequate. Trial seams shall be conducted on the same material to be installed and under similar field conditions as production seams. Such trial seams shall be made at the beginning of each seaming period, beginning of the day and after lunch, for each seaming apparatus used each day. The trial seam sample shall be a minimum of 5-ft long by 1-ft wide (after seaming) with the seam centered lengthwise for fusion equipment and at least 3-ft long by 1-ft wide for extrusion equipment. Seam overlap shall be as indicated in Part 3.03.D of this Section.

2. Four adjoining coupon specimens, each 1-in. wide, shall be cut from the trial seam sample by the installer using a die cutter to ensure precise 1-in. wide coupons. The coupons shall be tested in peel (outside (fusion only) and inside track) and shear using an electronic readout field tensiometer in accordance with ASTM D 4437, at a strain rate of 2 in./min., and they shall not fail in the seam (i.e., Film Tear Bond (FTB), which is failure in the parent material, is required). The required peel and shear seam strength is listed in Table 02770-2. Ideally, samples shall be conditioned at $23 \pm 2^{o}C$ at a relative humidity of $50 \pm 5\%$ for two hours prior to testing. If test conditions vary from these conditions, a 1-in. wide coupon of the parent geomembrane material (no weld) shall be tested in the same manner as the seam specimens to determine the break strength at this condition.

3. If a coupon specimen fails, the entire operation shall be repeated. If the additional coupon specimen fails, the seaming apparatus and seamer shall not be accepted and shall not be used for seaming until the deficiencies are corrected and two consecutive successful trial seams are achieved.

I. Nondestructive Seam Continuity Testing:

1. The Geosynthetic Installer shall nondestructively test for continuity on all field seams over their full length. Continuity testing shall be carried out as the seaming work progresses, not at the completion of all field seaming. The Geosynthetic Installer shall complete any required repairs in accordance with Part 3.03.K of this Section. The following procedures shall apply:

   a. Vacuum testing in accordance with ASTM D 5641.

   b. Air pressure testing (for double-track fusion seams only) in accordance with ASTM D 5820 and the following:

      i. Energize the air pump to a pressure between 25 and 30 pounds per square inches, close valve, and sustain the pressure for not less than 5 minutes.

      ii. If loss of pressure exceeds 3 pounds per square inches, or does not stabilize, locate faulty area and repair in accordance with Part 3.03.K of this Section.

      iii. Cut opposite end of air channel from pressure gauge and observe release of pressure to ensure air channel is not blocked.

iv. Remove needle, or other approved pressure feed device, and seal repair in accordance with Part 3.03.K of this Section.

c. Spark testing shall be performed if the seam cannot be tested using other nondestructive methods.

J. Destructive Testing:

1. Destructive seam tests shall be performed on samples collected from selected locations to evaluate seam strength and integrity. Destructive tests shall be carried out as the seaming work progresses, not at the completion of all field seaming.

2. Sampling:

a. Destructive test samples shall be collected at a minimum average frequency of one test location per 500 ft of seam length. Test locations shall be determined during seaming, and may be prompted by suspicion of excess crystallinity, contamination, offset seams, or any other potential cause of imperfect seaming. The Engineer will be responsible for choosing the locations. The Geosynthetic Installer shall not be informed in advance of the locations where the seam samples will be taken. The Engineer reserves the right to increase the sampling frequency.

b. Samples shall be cut by the Geosynthetic Installer at the locations designated by the Engineer as the seaming progresses in order to obtain laboratory test results before the geomembrane is covered by another material. Each sample shall be numbered and the sample number and location identified on the panel layout drawing. All holes in the geomembrane resulting from the destructive seam sampling shall be immediately repaired in accordance with the repair procedures described in Part 3.03.K of this Section. The continuity of the new seams in the repaired areas shall be tested according to Part 3.03.I of this Section.

c. Two strips of dimensions 1-in. wide and 12 in. long with the seam centered parallel to the width shall be taken from either side of the sample location. These samples shall be tested in the field in accordance with Part 3.03.J.3 of this Section. If these samples pass the field test, a laboratory sample shall be taken. The laboratory sample shall be at least 1-ft wide by 3.5-ft long with the seam centered lengthwise. The sample shall be cut into three parts and distributed as follows:

i. One portion 12-in. long to the Geosynthetic Installer.

ii. One portion 18-in. long to the Geosynthetic CQA Laboratory for testing.

iii. One portion 12-in. long to the Engineer for archival storage.

3. Field Testing:

The two 1-in. wide strips shall be tested in the field tensiometer in the peel mode. The Engineer has the option to request an additional test in the shear mode. If any field test sample fails to meet the requirements in Table 02770-2, then the procedures outlined in Part 3.03.J.5 of this Section shall be followed.

4. Laboratory Testing:

Testing by the Geosynthetics CQA Laboratory will include "Seam Strength" and "Peel Adhesion" (ASTM D 4437) with the 1-in. wide strip tested at a rate of 2 in./min. At least 5 specimens will be tested for each test method (peel and shear). Four of the five specimens per sample must pass both the shear strength test and peel adhesion test when tested in accordance with ASTM D 4437. The minimum acceptable values to be obtained in these tests are indicated in Table 02770-2. Both inside and outside tracks of the dual track fusion welds shall be tested in peel.

5. Destructive Test Failure:

a. The following procedures shall apply whenever a sample fails a destructive test, whether the test is conducted by the Geosynthetic CQA's laboratory, the Geosynthetic Installer laboratory, or by a field tensiometer. The Geosynthetic Installer shall have two options:

i. The Geosynthetic Installer can reconstruct the seam (e.g., remove the old seam and reseam) between any two passed destructive test locations.

ii. The Geosynthetic Installer can trace the welding path to an intermediate location, a minimum of 10 feet from the location of the failed test (in each direction) and take a small sample for an additional field test at each location. If these additional samples pass the field tests, then full laboratory samples shall be taken. These full laboratory samples shall be tested in accordance with Part 3.03.J.4 of this Section. If these laboratory samples pass the tests, then the seam shall be reconstructed between these locations. If either sample fails, then the process shall be repeated to establish the zone in which the seam should be reconstructed. All acceptable seams must be bounded by two locations from which samples passing laboratory destructive tests have been taken. In cases exceeding 150 ft of reconstructed seam, a sample taken from within the reconstructed zone must pass destructive testing.

b. Whenever a sample fails, the Engineer may require additional tests for seams that were formed by the same seamer and/or seaming apparatus or seamed during the same time shift.

K. Defects and Repairs:

1. The geomembrane will be inspected before and after seaming for evidence of defects, holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter. The surface of the geomembrane shall be clean at the time of inspection. The geomembrane surface shall be swept or washed by the Installer if surface contamination inhibits inspection.

2. Each suspected location, both in seam and non-seam areas, shall be nondestructively tested using the methods described Part 3.03.I of this Section, as appropriate. Each location that fails nondestructive testing shall be marked by the Engineer and repaired by the Geosynthetic Installer.

3. When seaming of a geomembrane is completed (or when seaming of a large area of a geomembrane is completed) and prior to placing overlying materials, the Engineer shall identify all excessive geomembrane wrinkles. The Geosynthetic Installer shall cut and reseam all wrinkles so identified. The seams thus produced shall be tested like any other seams.

4. Repair Procedures:

a. Any portion of the geomembrane exhibiting a flaw, or failing a destructive or nondestructive test, shall be repaired by the Geosynthetic Installer. Several repair procedures exist. The final decision as to the appropriate repair procedure shall be agreed upon between the Engineer and the Geosynthetic Installer. The procedures available include:

i. patching, used to repair holes larger than 1/16 inch, tears, undispersed raw materials, and contamination by foreign matter;

ii. abrading and reseaming, used to repair small sections of extruded seams;

iii. spot seaming, used to repair minor, localized flaws;

iv. capping, used to repair long lengths of failed seams; and

v. removing bad seam and replacing with a strip of new material seamed into place (used with long lengths of fusion seams).

b. In addition, the following criteria shall be satisfied:

i. surfaces of the geomembrane that are to be repaired shall be abraded no more than 20 minutes prior to the repair;

ii. all surfaces must be clean and dry at the time of repair;

iii. all seaming equipment used in repair procedures must be approved;

iv. the repair procedures, materials, and techniques shall be approved in advance, for the specific repair, by the Engineer;

v. patches or caps shall extend at least 6 in. beyond the edge of the defect, and all corners of patches shall be rounded with a radius of at least 3 in.; and

vi. the geomembrane below large caps shall be appropriately cut to avoid water or gas collection between the two sheets.

5. Repair Verification:

a. Each repair shall be nondestructively tested using the methods described in Part 3.03.I of this Section, as appropriate. Repairs that pass the nondestructive test shall be taken as an indication of an adequate repair. Failed tests will require the repair to be redone and retested until a passing test results. At the discretion of the Engineer, destructive testing may be required on large caps.

3.04 MATERIALS IN CONTACT WITH THE GEOMEMBRANE

A. The Geosynthetic Installer shall take all necessary precautions to ensure that the geomembrane is not damaged during its installation. During the installation of other components of the liner system by the Contractor, the Contractor shall ensure that the geomembrane is not damaged. Any damage to the geomembrane shall be repaired by the Geosynthetic Installer , at the expense of the Contractor.

B. Soil and aggregate materials shall not be placed over the geomembranes at ambient temperatures below 40°F or above 104°F, unless otherwise specified.

C. All attempts shall be made to minimize wrinkles in the geomembrane.

D. Equipment shall not be driven directly on the geomembrane.

3.05 CONFORMANCE TESTING

A. Samples of the geomembrane will be removed by the Engineer and sent to a Geosynthetic CQA Laboratory for testing to ensure conformance with the requirements of this Section. The Geosynthetic Installer shall assist the Engineer in obtaining conformance samples. The Geosynthetic Installer and Contractor shall account for this testing in the installation schedule. Only material that meets the requirements of Part 2.02 this Section shall be installed.

B. Samples will be selected by the Engineer in accordance with this Section and with the procedures outlined in the CQA Plan.

C. Samples will be taken at a minimum frequency of one sample per 100,000 ft^2.

D. The Engineer may increase the frequency of sampling in the event that test results do not comply with the requirements of Part 2.02 of this Section.

E. The following tests will be performed by the Engineer:

Test	**Test Method**
Specific Gravity	ASTM D 792 or D 1505
Thickness	ASTM D 5994
Tensile Properties	ASTM D 638
Carbon Black Content	ASTM D 1603
Carbon Black Dispersion	ASTM D 5596

F. Any geomembrane that is not certified in accordance with Part 1.07.C of this Section, or that conformance testing indicates do not comply with Part 2.02 of this Section, will be rejected. The Geosynthetic Installer shall replace the rejected material with new material.

3.06 GEOMEMBRANE ACCEPTANCE

A. The Geosynthetic Installer shall retain all ownership and responsibility for the geomembrane until accepted by the Engineer.

B. The geomembrane shall be accepted by the Engineer when:

1. the installation is completed;

2. all documentation is submitted;

3. verification of the adequacy of all field seams and repairs, including associated testing, is complete; and

4. all warranties are submitted.

3.07 PROTECTION OF WORK

A. The Geosynthetic Installer and Contractor shall use all means necessary to protect all work of this Section.

B. In the event of damage, the Geosynthetic Installer shall make all repairs and replacements necessary, to the satisfaction of the Engineer.

PART 4 — MEASUREMENT AND PAYMENT

4.01 GENERAL

A. Providing for a complying with the requirements set forth in this Section for HDPE geomembrane will be measured as in-place square feet (SF), including geomembrane in the anchor trench to the limits shown on the Drawings, and payment will be based on the unit price provided on the Bid Schedule.

B. The following are considered incidental to the Work:

- shipping, handling and storage.
- layout survey.
- mobilization.
- rejected material.
- overlaps and seaming.
- rejected material removal, handling, re-testing, and repair.
- temporary anchorage.

TABLE 02770-1
REQUIRED HDPE GEOMEMBRANE PROPERTIES

PROPERTIES	QUALIFIERS	UNITS	SPECIFIED VALUES	TEST METHOD
Physical Properties				
Thickness	Average	mils	60	ASTM D 5994 or
	Minimum	mils	54	ASTM D 5199
Specific Gravity	Minimum	N/A	.94	ASTM D 792 Method A or ASTM D 1505
Asperity Height	Minimum	mils	10	GRI GM12
Mechanical Properties				
Tensile Properties (each direction)				
1. Tensile (Break) Strength	Minimum	lb/in	90	ASTM D 638
2. Elongation at Break		%	100	
3. Tensile (Yield) Strength		lb/in	126	
4. Elongation at Yield		%	12	
Puncture	Minimum	lb	90	ASTM D 4833
Tear Resistance	Minimum	lb	42	ASTM D 1004
Interface Shear Strength	-	-	Note 1	ASTM D 5321
Environmental Properties				
Carbon Black Content	Range	%	2-3	ASTM D 1603
Carbon Black Dispersion	N/A	none	Note 2	ASTM D 5596
Environmental Stress Crack	Minimum	hr	400	ASTM D 5397

Notes: (1) Interface shear strength test(s) shall be performed, by the Engineer, on the composite liner system in accordance with Section 02772 — Geosynthetic Clay Liner.
(2) Minimum 9 of 10 in Categories 1 or 2; 10 in Categories 1, 2, or 3.

TABLE 02770-2
REQUIRED GEOMEMBRANE SEAM PROPERTIES

PROPERTIES	QUALIFIERS	UNITS	SPECIFIED VALUES	TEST METHOD
Shear Strength[1]				
Fusion	minimum	lb/in	120	ASTM D 4437
Extrusion	minimum	lb/in	120	ASTM D 4437
Peel Adhesion				
FTB[2]				
Fusion	minimum	lb/in	91	ASTM D 4437
Extrusion	minimum	lb/in	78	ASTM D 4437

Notes: (1) Also called "Bonded Seam Strength".
(2) FTB = Film Tear Bond means that failure is in the parent material, not the seam. The maximum seam separation is 25 percent of the seam area.

END OF SECTION

SECTION 02771
GEOTEXTILE

PART 1 — GENERAL

1.01 DESCRIPTION OF WORK

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, equipment, and incidentals necessary for the installation of the geotextile. The work shall be carried out as specified herein and in accordance with the Drawings.

B. The work shall include, but not be limited to, delivery, storage, placement, and seaming of the various geotextile components of the project.

C. Filter geotextile shall be used overlying the drainage aggregate.

1.02 RELATED SECTIONS

Section 02200 — Earthwork

Section 02225 — Drainage Aggregate

1.03 REFERENCES

A. Drawings

B. Site Construction Quality Assurance (CQA) Plan

C. Latest version of American Society for Testing and Materials (ASTM) standards:

ASTM D 4355	Standard Test Method for Deterioration of Geotextile from Exposure to Ultraviolet Light and Water
ASTM D 4491	Standard Test Method for Water Permeability of Geotextile by Permittivity
ASTM D 4533	Standard Test Method for Trapezoid Tearing Strength of Geotextile
ASTM D 4595	Standard Test Method for Wide Width Tensile Properties of Geosynthetics
ASTM D 4632	Standard Test Method for Breaking Load and Elongation of Geotextile (Grab Method)
ASTM D 4751	Standard Test Method for Determining Apparent Opening Size of a Geotextile
ASTM D 4833	Standard Test Method for Index Puncture Resistance of Geotextile, Geomembranes, and Related Products
ASTM D 5261	Standard Test Method for Measuring Mass Per Unit Area of Geotextile

1.04 SUBMITTALS

A. The Geosynthetic Installer shall submit to the Engineer, at least 7 days prior to geotextile delivery, the following information regarding the proposed geotextile:

1. manufacturer and product name;

2. minimum property values of the proposed geotextile and the corresponding test procedures;

3. projected geotextile delivery dates; and

4. list of geotextile roll numbers for rolls to be delivered to the site.

B. At least 7 days prior to geotextile placement, the Geosynthetic Installer shall submit to the Engineer the manufacturing quality control certificates for each roll of geotextile. The certificates shall be signed by responsible parties employed by the geotextile manufacturer (such as the production manager). The quality control certificates shall include:

1. lot, batch, and/or roll numbers and identification; and

2. results of quality control tests, including a description of the test methods used.

1.05 QUALITY ASSURANCE

A. The Geosynthetic Installer shall ensure that the geotextile and installation methods used meet the requirements of the Drawings and this Section. Any material or method that does not conform to these documents, or to alternatives approved in writing by the Engineer, will be rejected and shall be repaired or replaced by the Geosynthetic Installer.

B. The Geosynthetic Installer shall be aware of and accommodate all monitoring and conformance testing required by the CQA Plan. This monitoring and testing, including random conformance testing of construction materials and completed work, will be performed by the Engineer. If nonconformances or other deficiencies are found in the Geosynthetic Installer's materials or completed work, the Geosynthetic Installer will be required to repair the deficiency or replace the deficient materials.

PART 2 — PRODUCTS

2.01 GEOTEXTILE PROPERTIES

A. Geotextile suppliers shall furnish materials in which the "Minimum Average Roll Values", as defined by the Federal Highway Administration (FHWA), meet or exceed the criteria specified in Table 02771-1.

B. The geotextile shall be nonwoven materials, suitable for use in filter/separation applications.

2.02 MANUFACTURING QUALITY CONTROL

A. The geotextile shall be manufactured with quality control procedures that meet or exceed generally accepted industry standards.

B. The Geotextile Manufacturer shall sample and test the geotextile to demonstrate that the material conforms to the requirements of these Specifications.

C. Any geotextile sample that does not comply with this Section shall result in rejection of the roll from which the sample was obtained. The Geosynthetic Installer shall replace any rejected rolls.

D. If a geotextile sample fails to meet the quality control requirements of this Section the Geotextile Manufacturer shall sample and test, at the expense of the Manufacturer, rolls manufactured in the same lot, or at the same time, as the failing roll. Sampling and testing of rolls shall continue until a pattern of acceptable test results is established to bound the failed roll(s).

E. Additional sample testing may be performed, at the Geotextile Manufacturer's discretion and expense, to identify more closely any non-complying rolls and/or to qualify individual rolls.

F. Sampling shall, in general, be performed on sacrificial portions of the geotextile material such that repair is not required. The Geotextile Manufacturer shall sample and test the geotextile, at a minimum once every 130,000 ft^2, to demonstrate that the geotextile properties conform to the values specified in Table 02771-1. At a minimum, the following manufacturing quality control tests shall be performed on each type of geotextile:

Test	Procedure	Filtration
Grab strength	ASTM D 4632	Yes
Tear strength	ASTM D 4533	Yes
Puncture strength	ASTM D 4833	Yes
Permittivity	ASTM D 4491	Yes
A.O.S.	ASTM D 4751	Yes

G. The Geotextile Manufacturer shall comply with the certification and submittal requirements of this Section.

2.03 PACKING AND LABELING

A. Geotextile shall be supplied in rolls wrapped in relatively impermeable and opaque protective covers.

B. Geotextile rolls shall be marked or tagged with the following information:

1. manufacturer's name;
2. product identification;
3. lot or batch number;
4. roll number; and
5. roll dimensions.

2.04 TRANSPORTATION, HANDLING, AND STORAGE

A. The Geosynthetic Installer shall be liable for any damage to the materials incurred prior to and during transportation to the site.

B. The geotextile shall be delivered to the site at least 14 days prior to the planned deployment date to allow the Engineer adequate time to perform conformance testing on the geotextile samples as described in Part 3.06 of this Section.

C. Handling, unloading, storage, and care of the geotextile prior to and following installation at the site, is the responsibility of the Geosynthetic Installer. The Geosynthetic Installer shall be liable for any damage to the materials incurred prior to final acceptance by the Engineer.

D. The Geosynthetic Installer shall be responsible for storage of the geotextile at the site.

E. The geotextile shall be protected from sunlight, excessive heat or cold, puncture, or other damaging or deleterious conditions. The geotextile shall be protected from mud, dirt, and dust. Any additional storage procedures required by the geotextile Manufacturer shall be the responsibility of the Geosynthetic Installer.

PART 3 — EXECUTION

3.01 FAMILIARIZATION

A. Prior to implementing any of the work described in this Section, the Geosynthetic Installer shall become thoroughly familiar with the site, the site conditions, and all portions of the work falling within this Section.

B. Inspection:

1. The Geosynthetic Installer shall carefully inspect the installed work of all other Sections and verify that all such work is complete to the point where the installation of this Section may properly commence without adverse effect.

2. If the Geosynthetic Installer has any concerns regarding the installed work of other Sections or the site, the Engineer shall be notified, in writing, prior to commencing the work. Failure to notify the Engineer or installation of the geotextile will be construed as Geosynthetic Installer's acceptance of the related work of all other Sections.

3.02 PLACEMENT

A. Geotextile installation shall not commence until CQA conformance evaluations, by the Engineer, of previous work are complete, including evaluations of the Contractor's survey results to confirm that the previous work was constructed to the required grades, elevations, and thicknesses. Should the Contractor begin the work of this Section prior to the completion of CQA evaluations, he does so at his own risk. The Contractor shall account for the CQA conformance evaluations in the construction schedule.

B. The Geosynthetic Installer shall handle all geotextile in such a manner as to ensure they are not damaged in any way.

C. The Geosynthetic Installer shall take any necessary precautions to prevent damage to underlying materials during placement of the geotextile.

D. After unwrapping the geotextile from its opaque cover, the filtration and cushion geotextile shall not be left exposed for a period in excess of 15 days unless a longer exposure period is approved in writing by the geotextile manufacturer.

E. The Geosynthetic Installer shall take care not to entrap stones, excessive dust, or moisture in the geotextile during placement.

F. The Geosynthetic Installer shall anchor or weight all geotextile with sandbags, or the equivalent, to prevent wind uplift.

G. The Geosynthetic Installer shall examine the entire geotextile surface after installation to ensure that no foreign objects are present that may damage the geotextile or adjacent layers. The Contractor shall remove any such foreign objects and shall replace any damaged geotextile.

3.03 SEAMS AND OVERLAPS

A. On slopes steeper than 10 horizontal to 1 vertical, geotextiles shall be continuous down the slope; that is, no horizontal seams are allowed. Horizontal seams shall be considered as any seam having an alignment exceeding 20 degrees from being perpendicular to the slope contour lines, unless otherwise approved by the Engineer.

B. Filtration geotextile shall be overlapped a minimum of 12 inches.

3.04 REPAIR

A. Any holes or tears in the geotextile shall be repaired using a patch made from the same geotextile. Geotextile patches will be sewn into place no closer than 1 inch from any panel edge. Should any tear exceed 50% of the width of the roll, that roll shall be removed and replaced.

B. Where geosynthetic materials underlie the geotextile being placed, care shall be taken to remove any soil or other material that may have penetrated the torn geotextile.

3.05 PLACEMENT OF SOIL MATERIALS

A. The Contractor shall place soil materials on top of the geotextile in such a manner as to ensure that:

1. the geotextile and the underlying materials are not damaged;

2. minimum slippage occurs between the geotextile and the underlying layers during placement; and

3. excess stresses are not produced in the geotextile.

B. Equipment shall not be driven directly on the geotextile.

C. Unless otherwise approved in writing by the Engineer, all equipment operating on materials overlying the geotextile shall comply with Section 02200.

3.06 CONFORMANCE TESTING

A. Samples of the geotextile materials will be removed by the Engineer after the material has been received at the site and sent to a Geosynthetic CQA Laboratory for testing to ensure conformance with the requirements of this Section. This testing will be carried out, in accordance with the CQA Plan, prior to the start of the work of this Section.

B. Samples of each geotextile will be taken, by the Engineer, at a minimum frequency of one sample per 260,000 ft^2.

C. The Engineer may increase the frequency of sampling in the event that test results do not comply with requirements of Part 2.01 of this Section until passing conformance test results are obtained for all material that is received at the site. This additional testing shall be performed at the expense of the Contractor.

D. The following conformance tests will be performed:

Test	Procedure	Filtration
Grab strength	ASTM D 4632	Yes
Puncture strength	ASTM D 4833	Yes
Permittivity	ASTM D 4491	Yes
A.O.S.	ASTM D 4751	Yes

E. Any geotextile that is not certified in accordance with Part 1.04 of this Section, or that conformance testing results do not comply with Part 2.01 of this Section, will be rejected. The Geosynthetic Installer shall replace the rejected material with new material.

3.07 PROTECTION OF WORK

A. The Geosynthetic Installer shall use all means necessary to protect all work of this Section.

B. In the event of damage, the Geosynthetic Installer shall make repairs and replacements to the satisfaction of the Engineer at the expense of the Contractor.

PART 4 — MEASUREMENT AND PAYMENT

4.01 GENERAL

A. Providing for and complying with the requirements set forth in this Section for Filtration Geotextile will be measured as in-place square feet (SF), and payment will be based on the unit price provided on the Bid Schedule.

B. The following are considered incidental to the Work:

- shipping, handling and storage.
- layout survey.
- mobilization.
- rejected material.
- overlaps and seaming.
- rejected material removal, handling, re-testing, and repair.
- temporary anchorage.

TABLE 02771-1
REQUIRED PROPERTY VALUES FOR GEOTEXTILE

PROPERTIES	QUALIFIERS	UNITS	FILTER SPECIFIED VALUES	TEST METHOD
Type			nonwoven	(-)
Mass per unit area	minimum	oz/yd^2	6[1]	ASTM D 5261
Filter Requirements				
Apparent opening size (O_{95})	maximum	mm	0.21	ASTM D 4751
Permittivity	minimum	s^{-1}	0.5	ASTM D 4491
Mechanical Requirements				
Grab strength	minimum	lb	130	ASTM D 4632
Tear strength	minimum	lb	40	ASTM D 4533
Puncture strength	minimum	lb	40	ASTM D 4833
Durability				
Ultraviolet Resistance @ 500 hours	minimum	%	70	ASTM D 4355

Notes: (1) For information purposes only, not a required property.

END OF SECTION

SECTION 02772
GEOSYNTHETIC CLAY LINER

PART 1 — GENERAL

1.01 SCOPE

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, equipment, and incidentals necessary for installation of the geosynthetic clay liner (GCL). The work shall be carried out as specified herein and in accordance with the Drawings.

B. The work shall include, but not be limited to, delivery, storage, placement, anchorage, and seaming of the GCL.

1.02 RELATED SECTIONS

Section 02200 — Earthworks

Section 02770 — Geomembrane

1.03 REFERENCES

A. Drawings

B. Site Construction Quality Assurance (CQA) Plan

C. Latest Version American Society of Testing and Materials (ASTM) Standards:

ASTM D 2216	Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures
ASTM D 5321	Determination of the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method
ASTM D 5887	Test Method for Measurement of Index Flux Through Saturated Geosynthetic Clay Liner Specimens using a Flexible Wall Permeameter
ASTM D 5888	Guide for Storage and Handling of Geosynthetic Clay Liners
ASTM D 5890	Test Method for Swell Index of Clay Mineral Component of Geosynthetic Clay Liners
ASTM D 5891	Test Method for Fluid Loss of Clay Component of Geosynthetic Clay Liners
ASTM D 5993	Test Method for Measuring Mass per Unit Area of Geosynthetic Clay Liners

1.04 QUALIFICATIONS

A. The Manufacturer shall be a well-established firm with more than one year of experience in the manufacturing of GCL.

B. The Geosynthetic Installer shall install the GCL and shall meet the requirements of Section 02770 and this Section.

1.05 SUBMITTALS

A. At least 7 days before transporting any GCL to the site, the Manufacturer shall provide the following documentation to the Engineer for approval.

1. list of material properties, including test method, to which are attached GCL samples.

2. projected delivery dates for this project.

3. Manufacturing quality control certificates for each shift's production, signed by responsible parties employed by the Manufacturer (such as the production manager).

4. The quality control certificates shall include:

a. roll numbers and identification; and

b. results of quality control tests, including description of test methods used, outlined in Part 2.01 of this Section.

5. The Manufacturer shall certify that the GCL meets all the properties outlined in 2.01 of this Section.

1.06 CONSTRUCTION QUALITY ASSURANCE MONITORING

A. The Geosynthetic Installer shall ensure that the materials and methods used for the GCL meet the requirements of the Drawings and this Section. Any material or method that does not conform to these documents, or to alternatives approved in writing by the Engineer, will be rejected and shall be repaired or replaced.

B. The Geosynthetic Installer shall be aware of and accommodate all monitoring and conformance testing required by the CQA Plan. This monitoring and testing, including random conformance testing of construction materials and completed work, will be performed by the Engineer. If nonconformances or other deficiencies are found in the materials or completed work, the Geosynthetic Installer will be required to repair the deficiency or replace the deficient materials.

PART 2 — PRODUCTS

2.01 MATERIAL PROPERTIES

A. The flux of the GCL shall be no greater than 1×10^{-8} m^3/m^2-sec, when measured in a flexible wall permeameter in accordance with ASTM D 5887 under an effective confining stress of 5 pounds per square inch.

B. The GCL shall have the following minimum dimensions:

1. the minimum roll width shall be 15 feet; and

2. the liner length shall be long enough to conform with the requirements specified in this Section.

C. The bentonite used to fabricate the GCL shall have at least 90 percent sodium mortmorillonite.

D. The bentonite component of the GCL shall be applied at a minimum concentration of 0.75 pound per square foot, when measured at a water content of less than or equal to 0 percent.

E. The geotextile components of the GCL shall have a minimum combined mass per unit area of 9 oz/yd^2 in accordance with ASTM D 5261.

F. The GCL shall meet the required property values listed in Table 02772-1.

G. The bentonite will be adhered to the backing material(s) in a manner that prevents it from being dislodged when transported, handled, and installed in a manner prescribed by the Manufacturer. The method used to hold the bentonite in place shall not be detrimental to other components of the lining system.

2.02 INTERFACE SHEAR TESTING

A. Interface Shear test(s) shall be performed on the proposed geosynthetic and soil components in accordance with ASTM D 5321. Tests shall be performed as outlined below.

1. Dry GCL interface - the GCL shall be underlain by prepared subgrade compacted to 90% of the maximum dry density (ASTM D 1557) at the optimum moisture content and overlain by a GCL textured 60-mil HDPE geomembrane, geocomposite, and cover soil. The GCL, geomembrane, and geocomposite components of the liner system shall be allowed to “float” (i.e., not fixed) such that the failure surface can occur at the any of these interfaces.

a. Before shearing, the GCL shall be hydrated under a loading of 120 psf (6 Kpa) for 48 hours. The test shall be performed under saturated conditions, at normal stresses of 1, 2, and 4 psi at a shear rate of no more than 0.04 in./min. (1 mm/min.).

b. The results of this test shall have a post-peak apparent friction angle in excess of 18 degrees.

2.03 MANUFACTURING QUALITY CONTROL

A. The GCL shall be manufactured with quality control procedures that meet or exceed generally accepted industry standards.

B. The Manufacturer shall sample and test the GCL to demonstrate that the material complies with the requirements of this Section.

C. Any GCL sample that does not comply with this Section will result in rejection of the roll from which the sample was obtained. The Manufacturer shall replace any rejected rolls.

D. If a GCL sample fails to meet the quality control requirements of this Section, the Engineer will require that the Manufacturer sample and test, at the expense of the Manufacturer, rolls manufactured in the same lot, or at the same time, as the failing roll. Sampling and testing

of rolls shall continue until a pattern of acceptable test results is established to bound the failed roll(s).

E. Additional sample testing may be performed, at the Manufacturer's discretion and expense, to more closely identify any non-complying rolls and/or to qualify individual rolls.

F. Sampling shall, in general, be performed on sacrificial portions of the GCL material such that repair is not required. The Manufacturer shall sample and test the GCL to demonstrate that its properties conform to the requirements stated herein. At a minimum, the following tests shall be performed by the Manufacturer: dry mass per unit area and index flux at frequencies of at least 1 per 50,000 ft^2 and 1 per 200,000 ft^2, respectively.

G. The Manufacturer shall comply with the certification and submittal requirements of this Section.

2.04 PACKING AND LABELING

A. GCLs shall be supplied in rolls wrapped in impermeable and opaque protective covers.

B. GCLs shall be marked or tagged with the following information:

1. Manufacturer's name;
2. product identification;
3. lot number;
4. roll number; and
5. roll dimensions.

2.05 TRANSPORTATION, HANDLING AND STORAGE

A. Handling, storage, and care of the GCL, prior to and following installation, is the responsibility of the Geosynthetic Installer, until final acceptance by the Engineer.

B. The GCL shall be stored and handled in accordance with ASTM D 5888.

C. The Geosynthetic Installer shall be liable for all damage to the materials incurred prior to and during transportation to the site.

D. The GCL shall be on-site at least 14 days prior to the scheduled installation date to allow for completion of conformance testing described in Part 3.08 of this Section.

PART 3 — EXECUTION

3.01 FAMILIARIZATION

A. Prior to implementing any of the work described in this Section, the Geosynthetic Installer shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the installation of this Section may properly commence without adverse impact.

B. Inspection:

1. The Geosynthetic Installer shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the installation of this Section may properly commence without adverse impact.

2. If the Geosynthetic Installer has any concerns regarding the installed work of other Sections, he should notify the Engineer in writing prior to commencing the work. Failure to notify the Engineer or installation of the GCL will be construed as Geosynthetic Installer's acceptance of the related work of all other Sections.

C. A pre-installation meeting shall be held to coordinate the installation of the GCL with the installation of other components of the lining system.

3.02 SURFACE PREPARATION

A. The Geosynthetics Installer shall provide certification in writing that the surface on which the GCL will be installed is acceptable. This certification of acceptance shall be given to the Engineer prior to commencement of geomembrane installation in the area under consideration.

B. Special care shall be taken to maintain the prepared soil surface.

C. No GCL shall be placed onto an area that has been softened by precipitation or that has cracked due to desiccation. The soil surface shall be observed daily to evaluate the effects of desiccation cracking and/or softening on the integrity of the prepared subgrade.

3.03 CREST ANCHORAGE SYSTEM

A. The anchor trench shall be excavated, prior to GCL placement, to the lines and grades shown on the Drawings.

B. No loose soil shall be allowed in the anchor trench beneath the GCL.

C. The GCL shall be temporarily anchored in the anchor trench until all geosynthetic layers are installed in the anchor trench as shown on the Drawings.

3.04 HANDLING AND PLACEMENT

A. The Geosynthetic Installer shall handle all GCL in such a manner that they are not damaged in any way and so that they do not become hydrated prior to, or during, installation.

B. In the presence of wind, all GCLs shall be sufficiently weighted with sandbags to prevent their movement.

C. Any GCL damaged by stones or other foreign objects, or by installation activities, shall be repaired in accordance with Part 3.07 by the Geosynthetic Installer.

D. If an alternative GCL is used, the vapor barrier portion of the GCL shall be installed against the underlying prepared subgrade.

E. The GCL shall not be installed on an excessively moist subgrade or on standing water. The GCL shall be installed in a way that prevents hydration of the GCL prior to completion of construction of the liner system.

F. The GCL shall not be installed during precipitation or other conditions that may cause hydration of the GCL.

G. All hydrated GCL shall be removed and replaced by the Geosynthetic Installer.

3.05 OVERLAPS

A. On slopes steeper than 10 horizontal to 1 vertical, all GCL shall be continuous down the slope; that is, no horizontal seams shall be allowed on the slope. Horizontal seams shall be considered as any seam having an alignment exceeding 20 degrees from being perpendicular to the slope contour lines, unless otherwise approved by the Engineer.

B. All GCL shall be overlapped in accordance with the Manufacturer's recommended procedures. As a minimum, along the length (i.e., the sides) of the GCL the overlap shall be 6 inches, and along the width (i.e., the ends) the overlap shall be 12 inches.

3.06 MATERIALS IN CONTACT WITH THE GCL

A. Geomembrane installation shall immediately follow the GCL installation. All GCL that is placed during a day's work shall be covered with geomembrane before the Geosynthetic Installer leaves the site at the end of the day. The edges of GCL placement should be covered each day and protected from hydration due to storm water run-on.

B. Material shall not be placed on a GCL that is hydrated.

C. Installation of other components of the liner system shall be carefully performed to minimize damage to the GCL.

D. Equipment shall not be driven directly on the GCL.

E. Installation of the GCL in appurtenant areas, and connection of the GCL to appurtenances shall be made according to the Drawings. The Geosynthetic Installer shall ensure that the GCL is not damaged while working around the appurtenances.

3.07 REPAIR

A. Any holes or tears in the GCL shall be repaired by placing a GCL patch over the hole. On slopes steeper than 10 percent, the patch shall overlap the edges of the hole or tear by a minimum of 2 feet in all directions. On slopes 10 percent or flatter, the patch shall overlap the edges of the hole or tear by a minimum of 1 foot in all directions. The patch shall be secured with a water-based adhesive approved by the Manufacturer.

B. Care shall be taken to remove any soil or other material, which may have penetrated the torn GCL.

C. The patch shall not be nailed or stapled.

3.08 CONFORMANCE TESTING

A. Samples of the GCL will be removed by the Engineer and sent to a Geosynthetic CQA Laboratory for testing to ensure conformance with the requirements of this Section. The Geosynthetic Installer shall assist the Engineer in obtaining conformance samples. The Geosynthetic Installer shall account for this testing in the installation schedule.

B. The Engineer may increase the frequency of sampling in the event that test results do not comply with the requirements of Part 2.01 of this Section until passing conformance test

results are obtained for all material that is received at the site. This additional testing shall be performed at the expense of the Contractor.

C. As a minimum, the following conformance tests will be performed: mass per unit area and index flux. All tests shall be carried out at a frequency of one sample per 100,000 ft^2 and 400,000 ft^2, respectively. In addition, the Engineer will perform a minimum of one interface shear strength test in accordance with Part 2.02.

D. Any GCL that is not certified by the Manufacturer in accordance with Part 1.05 of this section or that does not meet the requirements specified in Part 2.01 shall be rejected and replaced by the Geosynthetic Installer.

3.09 PROTECTION OF WORK

A. The Geosynthetic Installer shall use all means necessary to protect all work of this Section.

B. In the event of damage, the Geosynthetic Installer shall immediately make all repairs and replacements necessary to the approval of the Engineer.

PART 4 — MEASUREMENT AND PAYMENT

A. Providing for a complying with the requirements set forth in this Section for GCL will be measured as in-place square feet (SF), including GCL in the anchor trench to the limits shown on the Drawings, and payment will be based on the unit price provided on the Bid Schedule.

B. The following are considered incidental to the Work:

- shipping, handling and storage.
- overlaps and seaming.
- layout survey.
- mobilization.
- rejected material.
- rejected material removal, handling, re-testing, and repair.
- temporary anchorage.

TABLE 02772-1
REQUIRED GCL PROPERTY VALUES

PROPERTIES	QUALIFIERS	UNITS	SPECIFIED[1] VALUES	TEST METHOD
Liner System Properties				
Interface Shear Strength	minimum	degrees	20°	ASTM D 5321[2]
GCL Properties				
Bentonite Content	minimum	lb/ft^2	0.75	ASTM D 5993
Bentonite Swell Index	minimum	mL/2g	24	ASTM D 5890
Bentonite Fluid Loss	maximum	mL	18	ASTM D 5891
Index Flux	minimum	m^3/m^2-s	1×10^{-8}	ASTM D 5887[3]
Moisture Content (Bentonite)	maximum	percent	25	ASTM D 2216

Notes: (1) All values represent minimum average roll values (i.e., any roll in a lot should meet or exceed the values in this table).
(2) Interface shear strength testing shall be performed, by the Engineer, in accordance with Part 2.02 of this Section.
(3) Hydraulic flux testing shall be performed under an effective confining stress of 5 pounds per square inch.
(4) Measured at a moisture content of 0 percent.

END OF SECTION

SECTION 02773
GEOCOMPOSITE

PART 1 — GENERAL

1.01 DESCRIPTION OF WORK

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, equipment, and incidentals necessary for the installation of the geocomposite. The work shall be carried out as specified herein and in accordance with the Drawings.

B. The work shall include, but not be limited to, delivery, storage, placement, and seaming of the geocomposite.

C. Single-sided geocomposite shall be used overlying the geomembrane and underlying the cover soil on the top deck area of the cover system. Double-sided geocomposite shall be used overlying the geomembrane and underlying the cover soil on the side slopes of the cover system.

1.02 RELATED SECTIONS

Section 02200 — Earthwork

Section 02770 — Geomembrane

1.03 REFERENCES

A. Drawings

B. Site Construction Quality Assurance (CQA) Plan

C. Latest version of American Society for Testing and Materials (ASTM) standards:

1. ASTM D 413. Standard Test Method for Rubber Property-Adhesion to Flexible Substrate.

2. ASTM D 792. Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.

3. ASTM D 1603. Standard Test Method for Carbon Black in Olefin Plastics.

4. ASTM D 4491. Standard Test Methods for Water Permeability of Geotextiles by Permittivity.

5. ASTM D 4533. Standard Test Method for Trapezoid Tearing Strength of Geotextiles.

6. ASTM D 4632. Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.

7. ASTM D 4716. Standard Test Method for Constant Head Hydraulic Transmissivity (In-Plane Flow) of Geotextiles and Geotextile Related Products.

8. ASTM D 4751. Standard Test Method for Determining Apparent Opening Size of a Geotextile.

9. ASTM D 4833. Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.

10. ASTM D 5199. Standard Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes.

11. ASTM D 5261. Standard Test Method for Measuring Mass per Unit Area of Geotextiles.

1.04 QUALIFICATIONS

A. The manufacturer shall be a well-established firm with more than one year experience in the manufacturing of geocomposite.

B. The Geosynthetic Installer shall install the geocomposite and shall meet the requirements of Section 02770 and this Section.

1.05 SUBMITTALS

A. The Geosynthetic Installer shall submit to the Engineer, at least 7 days prior to geocomposite delivery, the following information regarding the proposed geocomposite:

1. manufacturer and product name;

2. minimum property values of the proposed geocomposite and the corresponding test procedures;

3. projected geocomposite delivery dates; and

4. list of geocomposite roll numbers for rolls to be delivered to the site.

B. At least 7 days prior to geocomposite placement, the Geosynthetic Installer shall submit to the Engineer the manufacturing quality control certificates for each roll of geocomposite. The certificates shall be signed by responsible parties employed by the geocomposite manufacturer (such as the production manager). The quality control certificates shall include:

1. lot, batch, and/or roll numbers and identification; and

2. results of quality control tests, including a description of the test methods used.

1.06 CONSTRUCTION QUALITY ASSURANCE MONITORING

A. The Geosynthetic Installer shall ensure that the geocomposite and installation methods used meet the requirements of the Drawings and this Section. Any material or method that does not conform to these documents, or to alternatives approved in writing by the Engineer, will be rejected and shall be repaired or replaced by the Geosynthetic Installer.

B. The Geosynthetic Installer shall be aware of and accommodate all monitoring and conformance testing required by the CQA Plan. This monitoring and testing, including random conformance testing of construction materials and completed work, will be

performed by the Engineer. If nonconformances or other deficiencies are found in the Geosynthetic Installer's materials or completed work, the Geosynthetic Installer will be required to repair the deficiency or replace the deficient materials.

PART 2 — PRODUCTS

2.01 GEOCOMPOSITE PROPERTIES

A. The Geocomposite Manufacturer shall furnish geocomposites having properties that comply with the required property values shown in Table 02773-1. The Geocomposite Manufacturer shall provide results of tests performed using the procedures listed in Table 02773-1, as well as certification that the materials meet or exceed the specified values.

B. Geotextiles will be thermally bonded to one and two sides of the geonet component of geocomposite material rather than chemically bonded.

C. Geocomposite suppliers shall furnish materials in which the "Minimum Average Roll Values", as defined by the Federal Highway Administration (FHWA), meet or exceed the criteria specified in Table 02773-1.

D. The geocomposite's geotextile components shall be nonwoven materials, suitable for use in filter/separation and cushion applications.

2.02 MANUFACTURING QUALITY CONTROL

A. The geocomposite shall be manufactured with quality control procedures that meet or exceed generally accepted industry standards.

B. The geocomposite Manufacturer shall sample and test the geocomposite to demonstrate that the material conforms to the requirements of these Specifications.

C. Any geocomposite sample that does not comply with this Section shall result in rejection of the roll from which the sample was obtained. The Geosynthetic Installer shall replace any rejected rolls.

D. If a geocomposite sample fails to meet the quality control requirements of this Section the geocomposite Manufacturer shall sample and test, at the expense of the Manufacturer, rolls manufactured in the same lot, or at the same time, as the failing roll. Sampling and testing of rolls shall continue until a pattern of acceptable test results is established to bound the failed roll(s).

E. Additional sample testing may be performed, at the geocomposite Manufacturer's discretion and expense, to identify more closely any non-complying rolls and/or to qualify individual rolls.

F. Sampling shall, in general, be performed on sacrificial portions of the geocomposite material such that repair is not required. The Geocomposite Manufacturer shall sample and test the geocomposite, at a minimum once every 100,000 ft^2, to demonstrate that the geocomposite properties conform to the values specified in Table 02773-1. At a minimum, the following manufacturing quality control tests shall be performed on the geotextile component of the geocomposite:

Test	Procedure
Mass per unit area	ASTM D 5261
Grab strength	ASTM D 4632
Tear strength	ASTM D 4533
Puncture strength	ASTM D 4833
Burst Strength	ASTM D 3786
Permittivity	ASTM D 4491
A.O.S.	ASTM D 4751

At a minimum, the following manufacturing quality control tests shall be performed on the geonet component of the geocomposite:

Test	Procedure
Specific gravity	ASTM D 792
Nominal thickness	ASTM D 5199

At a minimum, the following manufacturing quality control tests shall be performed on the geocomposite:

Test	Procedure
Transmissivity	ASTM D 4716
Peel strength	ASTM D 413

G. The geocomposite Manufacturer shall comply with the certification and submittal requirements of this Section.

2.03 PACKING AND LABELING

A. Geocomposite shall be supplied in rolls wrapped in relatively impermeable and opaque protective covers.

B. Geocomposite rolls shall be marked or tagged with the following information:

1. manufacturer's name;
2. product identification;
3. lot or batch number;
4. roll number; and
5. roll dimensions.

2.04 TRANSPORTATION, HANDLING, AND STORAGE

A. The Geosynthetic Installer shall be liable for any damage to the materials incurred prior to and during transportation to the site.

B. The geocomposite shall be delivered to the site at least 14 days prior to the planned deployment date to allow the Engineer adequate time to perform conformance testing on the geocomposite samples as described in Part 3.06 of this Section.

C. Handling, unloading, storage, and care of the geocomposite prior to and following installation at the site, is the responsibility of the Geosynthetic Installer. The Geosynthetic Installer shall be liable for any damage to the materials incurred prior to final acceptance by the Engineer.

D. The Geosynthetic Installer shall be responsible for storage of the geocomposite at the site.

E. The geocomposite shall be protected from sunlight, excessive heat or cold, puncture, or other damaging or deleterious conditions. The geocomposite shall be protected from mud, dirt, and dust. Any additional storage procedures required by the geocomposite Manufacturer shall be the responsibility of the Geosynthetic Installer.

PART 3 — EXECUTION

3.01 FAMILIARIZATION

A. Prior to implementing any of the work described in this Section, the Geosynthetic Installer shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the installation of this Section may properly commence without adverse impact.

B. Inspection:

1. The Geosynthetic Installer shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the installation of this Section may properly commence without adverse impact.

2. If the Geosynthetic Installer has any concerns regarding the installed work of other Sections, he should notify the Engineer in writing prior to commencing the work. Failure to notify the Engineer or installation of the geocomposite will be construed as Geosynthetic Installer's acceptance of the related work of all other Sections.

C. A pre-installation meeting shall be held to coordinate the installation of the geocomposite with the installation of other components of the lining system.

3.02 HANDLING AND PLACEMENT

A. The Geosynthetic Installer shall handle all geocomposite in such a manner that it is not damaged in any way.

B. Install the double-sided geocomposite down the slope not across the slope. Place ends into the anchor trenches in such a manner as to continually keep the geocomposite in tension.

C. Precautions shall be taken to prevent damage to underlying layers during placement of the geocomposite.

D. In the presence of wind, all geocomposites shall be sufficiently weighted with sandbags or the equivalent to prevent movement.

E. The geocomposite shall be positioned by hand after being unrolled to minimize wrinkles.

F. Care shall be taken during placement of geocomposites not to entrap dirt or excessive dust in the geocomposite that could cause clogging of the drainage system, and/or stones that could damage the adjacent geomembrane. If dirt or excessive dust is entrapped in the geocomposite, it should be cleaned prior to placement of the next material on top of it. Care shall be exercised when handling sandbags, to prevent rupture or damage of the sandbags.

G. Geocomposites shall only be cut using a hooked utility blade.

H. After unwrapping the geocomposite from its opaque cover, the geocomposite shall not be left exposed for a period in excess of 15 days.

3.03 OVERLAPS AND SEAMS

A. Geonet Components:

1. The geonet components shall be overlapped a minimum 4 in. along the length. The geonet shall be overlapped by a minimum 1 ft. across the width.

2. Geonet overlaps shall be secured by tying with nylon cable ties. Tying devices shall be white or yellow for easy inspection. Metallic devices shall not be used.

3. Seaming of the geonet shall be performed by wrap-ties at 12-in. centers for end of panels and at 5-ft centers for edge of panel seams.

4. No end-of-panel seams shall be placed on slopes exceeding 10 %.

B. Geotextile Components:

1. The bottom layers of geotextile shall be overlapped, if applicable. The top layers of geotextiles shall be continuously sewn.

2. Polymeric thread, with chemical resistance properties equal to or exceeding those of the geotextile component, shall be used for all sewing.

3.04 PLACEMENT OF OVERLYING MATERIALS

A. All overlying materials shall be placed in such a manner as to ensure that:

1. The geocomposite and underlying materials are not damaged;
2. Minimal slippage occurs between the geocomposite and underlying layers; and
3. Excess tensile stresses are not produced in the geocomposite.

B. Equipment shall not be driven directly on the geocomposite.

C. Unless otherwise approved in writing by the Engineer, all equipment operating on the materials overlying the geotextile shall comply with Section 02200.

3.05 CONFORMANCE TESTING

A. Samples of geocomposite will be removed by the Engineer and sent to a Geosynthetic CQA Laboratory for testing to ensure conformance with the requirements of this Section. The Geosynthetic Installer shall assist the Engineer in obtaining conformance samples. The Geosynthetic Installer shall account for this testing in the installation schedule.

B. Samples shall be taken at a minimum frequency rate of one sample per 200,000 square feet.

C. The Engineer may increase the frequency of sampling in the event that test results do not comply with the requirements of Part 2.01 of this Section until passing conformance test

results are obtained for all material that is received at the site. This additional testing shall be performed at the expense of the Contractor.

D. As a minimum, transmissivity and peel strength will be performed on each sample.

E. Any geocomposite that is not certified by the Manufacturer in accordance with Part 1.05 of this section or that does not meet the requirements specified in Part 2.01 shall be rejected and replaced by the Geosynthetic Installer.

3.06 PROTECTION OF WORK

A. The Geosynthetic Installer shall use all means necessary to protect all work of this Section.

B. In the event of damage, the Geosynthetic Installer shall immediately make all repairs and replacements necessary to the approval of the Engineer.

PART 4 — MEASUREMENT AND PAYMENT

A. Providing for a complying with the requirements set forth in this Section for geocomposite will be measured as in-place square feet (SF), including geocomposite in the anchor trench to the limits shown on the Drawings, and payment will be based on the unit price provided on the Bid Schedule.

B. The following are considered incidental to the Work:

- shipping, handling, and storage.
- overlaps and seaming.
- layout survey.
- mobilization.
- rejected material.
- rejected material removal, handling, re-testing, and repair.
- temporary anchorage.

TABLE 02773 - 1
GEOCOMPOSITE PROPERTY VALUES – FINAL COVER LINER SYSTEM

PROPERTIES	QUALIFIER	UNITS	SPECIFIED VALUES (1)	TEST METHOD
Geonet Component:				
Specific gravity	Minimum		0.935	ASTM D 792
Carbon black content	Range	%	2 – 3	ASTM D 1603
Nominal thickness	Minimum	mils	200	ASTM D 5199
Geotextile Components:				
Mass per unit area	Minimum	oz/yd^2 (g/m^2)	6 (203)	ASTM D 5291
Filter Requirements				
Apparent opening size	Maximum	mm	0_{95} ≈ 0.21 mm	ASTM D 4751
Permittivity	Minimum	1/s	0.5	ASTM D 4491
Mechanical Requirements				
Grab strength	Minimum	lb (N)	130 (578)	ASTM D 4632
Tear strength	Minimum	lb (N)	40 (178)	ASTM D 4533
Puncture strength	Minimum	lb (N)	40 (178)	ASTM D 4833
Geocomposite:				
Transmissivity (2)	Minimum	m^2/s	5×10^{-4}	ASTM D 4716
Peel Strength	Minimum	lb	0.5	ASTM D 413

Notes: (1) All values except transmissivity represent minimum average roll values (i.e., any roll in a lot should meet or exceed the values in this table).

(2) The design transmissivity is the hydraulic transmissivity of the geocomposite measured using water at 68°F ±3°F (20°C ±1.5°C) with a hydraulic gradient of 0.1 under a compressive stress of not less than 2,000 psf (96 kPa). For the test, the geocomposite shall be sandwiched between a layer of cover soil material and a textured 60-mil HDPE geomembrane. The minimum test duration shall be 24 hours and the report for the test results shall include measurements at intervals over the entire test duration.

END OF SECTION

Section 8
Previous Explorations

Converse Consultants
Over 50 Years of Dedication in Geotechnical Engineering and Environmental Sciences

PRELIMINARY GEOTECHNICAL AND GEOLOGIC INVESTIGATION

INDUSTRIAL NON-HAZARDOUS DISPOSAL FACILITY
BASIC MANAGEMENT INCOPORATED
CLARK COUNTY, NEVADA

Prepared for:

Parsons Engineering Science, Inc.
100 West Walnut Street
Pasadena, CA 91124

Converse Project No. 99-33437-01

October 27, 1999

18/69BG

Printed on Recycled Paper

731 Pilot Road, Suite H, Las Vegas, Nevada 89119-4429
Telephone: (702) 269-8336 ♦ Facsimile: (702) 269-8353 ♦ e-mail: postmaster@convrs.com

Converse Consultants
Over 50 Years of Dedication in Geotechnical Engineering and Environmental Sciences

October 27, 1999 99-33437-01

Parsons Engineering Science, Inc.
100 West Walnut Street
Pasadena, CA 91124

Attention: Mr. Jim Goepel

Subject: **Preliminary Geotechnical and Geologic Investigation**
Industrial Non-Hazardous Disposal Facility
Basic Management Incorporated
Clark County, Nevada

Gentlemen:

We are pleased to submit the results of our preliminary geotechnical and geologic investigation conducted for an industrial non-hazardous disposal facility at property owned by Basic Management Incorporated (BMI). The site is located immediately south and west of the operating BMI facility off Lake Mead Drive in Clark County, Nevada and is approximately 20 acres in size. The study was performed in general accordance with our proposal dated August 30, 1999, and your Notice-to-Proceed dated September 1, 1999.

The on-site soils are suitable for use as materials for structural and embankment fills for support of a disposal facility. There do not appear to be adverse geologic or engineering considerations that would severely restrict the development of the proposed facility.

Soils generally consisted of medium dense to very dense granular soils with occasional zones of moderately hard to hard cemented sand and gravel overlying very stiff clay and silts. Groundwater encountered in the borings explored for this project and ranged from 30 to 58 feet be-

Printed on Recycled Paper
731 Pilot Road, Suite H, Las Vegas, Nevada 89119-4429
Telephone: (702) 269-8336 ♦ Facsimile: (702) 269-8353 ♦ e-mail: postmaster@convrs.com

low the ground surface. Cemented soils were encountered at 9 out of 12 boring locations beginning at depths ranging from 7 to 49½ feet below ground surface. Rock excavation techniques may be required for deep cuts.

If you have questions concerning information contained in this report, please contact us at your convenience.

Respectfully submitted,

CONVERSE CONSULTANTS

Algirdas G. Leskys, P.E.
Principal

AGL:MKK:gm
18/69BG

Contents

		Page
1.0	Introduction	1
2.0	Scope of Services	2
3.0	Existing Site Conditions	3
3.1	Site Description	3
3.2	Subsurface	4
4.0	Site Conditions	6
4.1	Topography and Vegetation	6
4.2	Geologic Soil Units	7
5.0	Geologic Conditions	8
5.1	Geologic Setting	8
5.2	Drainage	8
5.3	Geologic and Environmental Hazards Review	8
5.4	Estimated Ground Accelerations	9
6.0	Site Evaluation and Preliminary Recommendations	10
6.1	General	10
6.2	Foundations	12
6.3	Cut Slopes and Fill Embankments	12
6.4	Retaining Walls	13
7.0	Construction Considerations	14
7.1	Site Grading	14

Page

7.2 Excavations 15
7.3 Soil Corrosivity 16
7.4 Final Design Recommendations 16

8.0 Closure 16

References

Drawing Nos. 1 through 3

Appendix A – Field and Laboratory Investigations

1.0 Introduction

This report presents the results of our preliminary geotechnical and geologic investigation performed for development of an industrial non-hazardous disposal facility at property owned by Basic Management Incorporated (BMI). The site is located immediately south and west of the operating BMI facility off Lake Mead Drive in Clark County, Nevada and is approximately 20 acres in size. We understand that BMI desires to excavate the existing near-surface soils at the site to approximate depths of the proposed disposal facility, which will be constructed some time in the future. Ideally, the excavated soils will be suitable as commercial aggregate materials that may be sold.

A vicinity map showing the location of the project within the Las Vegas Valley area is provided on Drawing No. 1. This scope of work included performing geologic mapping, field exploration, and laboratory testing and engineering analyses to provide preliminary geotechnical design criteria for the site. In conjunction with this scope of work, an environmental evaluation was performed to assess the existing residual chemical concentrations of the soils at the site. Results from this work have been submitted under separate cover.

The purposes of this investigation were to: (1) determine the geologic conditions and presence of any hazards or controlling features at the proposed site; (2) define general subsurface conditions at the sites, and delineate or determine, if possible, the presence of any features that might impact location of the project features; and (3) provide preliminary geotechnical design recommendations.

Designs are in the conceptual stage at this time. The specific type of disposal facility, related structures and other details have not been determined. Future studies will be necessary to address liner designs, slope stability, earthwork recommendations and foundation design.

2.0 Scope of Services

The following tasks were included in our scope of services:

1. A geologic and geotechnical reference search was conducted to confirm the geology and soil conditions in the area.

2. A field reconnaissance of the site was performed by our field geologist to determine the presence of geologic features that could have an impact on the project.

3. A field exploration program was conducted which consisted of drilling, logging, and sampling of twelve (12) exploratory borings to depths ranging from 33 to 60 feet. The approximate location of the borings is shown on Drawing No. 2. The location of the borings was determined in the field by PBS&J surveyors at locations requested by Parsons Engineering Science, Inc. Coordinates and elevations of the individual soil boring locations were not available at the time this report was prepared. Summaries of the subsurface conditions encountered are presented on the boring summary sheets, Drawing Nos. A-1 through A-34 presented in Appendix A. Field drilling and investigation procedures are further described in Appendix A. Samples of the subsurface soils were obtained from the borings and were taken to our laboratory for further evaluation and testing.

4. Laboratory tests were conducted on selected soil samples. Tests included solubility, Atterberg limits, grain size analysis, direct shear, moisture/density relationship, chemical analyses, solubility and permeability. Descriptions and results of the laboratory tests are presented in Appendix A.

5. Results of the field exploration and laboratory testing were evaluated and engineering analyses were performed develop appropriate preliminary recommendations for the design and construction of the proposed project.

6. This geotechnical report was prepared to present the findings, conclusions, and preliminary recommendations. Based on the soil boring logs, geologic cross sections were developed which show interpolated subsurface conditions and are presented on Drawing No. 3

3.0 Existing Site Conditions

3.1 Site Description

The site is located on the northwest portion of the Black Mountain Industrial Complex near Lake Mead Drive and Interstate 515. Two potential areas were investigated at the project site and evaluated for the proposed disposal facility. Six borings were drilled in each area.

Area 1 was located north and west of several evaporation ponds and north of the Pioneer Chlor Alkali Plant. The area was rough-graded and relatively level. A drainage ditch was located adjacent and north of Area 1. Several dirt roads crossed this area. Numerous groundwater wells were observed in this area during our site visit; however, they did not appear to be pumping. Access to this area was either through the BMI plant or by a gate accessed from Warm Springs Road. Soil borings B-1, B-4, B-5, B-8, B-10, and B12 were drilled to investigate this area and cross section A-A' developed from this information.

Area 2 was located north and west of Area 1 and nearly paralleled the west and north fence of the BMI property. Area 2 was less disturbed except near dirt roadways. Undeveloped areas generally were covered with desert vegetation and scattered debris at the time of our field investigation. Soil borings B-101 through B-106 were drilled to investigate this area and cross section B-B' shown on Drawing No. 3 was de-

veloped from this information. Only one of the borings (B-102) in Area 2 was located inside the fence of the BMI property.

Based on our investigation, no major subsurface variations were observed at either of the above areas at the site. The soil materials encountered in both areas were found to be of the same type and have the same engineering properties. The following sections present information applicable for both areas.

3.2 Subsurface

Based on results of our subsurface explorations and subsurface explorations performed by others, the subsurface is characterized by alluvial granular soils overlying fine-grained soils, the top of which generally coincides with the groundwater table. The depth of the contact between the granular soil top and the fine-grained soils was encountered from approximately 34 feet to 55 feet below ground surface. The location of this material contact is shown on geologic cross sections A-A' and B-B' on Drawing No. 3.

The granular subsoils generally consisted of medium dense to very dense granular fill and native soils overlying localized zones of moderately hard to hard cemented sand and gravel. The fine-grained soils consisted high plasticity silts and lean clays. Granular fill soils 2 to 14 feet deep were encountered in 10 of the borings. Small boulders and large cobbles were encountered in several of the borings. Cemented soils were not encountered in Boring Nos. 1, 5 and 8 for this investigation. The depths to the cemented soils for the other borings are provided below in Table No. 1.

Table 1 - Depth to and Thickness of Cemented Soils

Boring Location	Depth To Cemented Soils (Ft)	Thickness of Cemented Soils (Ft)	Cemented Soil Description
B-4	39	1	Hard
B-4	48	6	Moderately Hard to Hard

Boring Location	Depth To Cemented Soils (ft)	Thickness of Cemented Soils (ft)	Cemented Soil Description
B-10	14	16	Moderately Hard
B-12	21	2	Hard
B-101	49.5	0.5	Moderately Hard
B-102	7	10.5	Moderately Hard
B-102	38	2	Moderately Hard
B-103	37	5	Moderately Hard
B-104	25	4	Moderately Hard
B-104	40	3.5	Hard
B-105	17	3	Moderately Hard
B-105	38	>2	Hard
B-106	31	>2	Hard

Field and laboratory test results indicate that the native granular soils at the site have a low compressibility, moderate to high internal angles of friction, low potential for gypsum solubility, a low chemical (salt) heave potential, and contain sulfate salts in concentrations considered harmful to normal strength concrete. The fine-grained soils encountered at depth at the site generally were found to be moderately compressible, have a high expansion potential, and have relatively low permeabilities. Ranges of laboratory test results for the soils are summarized in Table No. 2 and the individual test results and procedures are presented in detail in Appendix A.

Table No. 2 - Summary of Laboratory Test Results

*Properties	Range of Results
Solubility	0.0 to 0.6 percent
Laboratory Max Density (ASTM D1557)	129.7 to 132.1 pcf
Optimum Moisture Content D 1557	7.5 to 8.7 percent
Angle of Internal Friction	26 to 43 degrees
Percent Passing the No. 200 Sieve	8 to 20 percent
Permeability (cm/s)	1.2×10^{-3} to 1.7×10^{-7}
Plasticity Index	Nonplastic to 34

*The laboratory tests are described in detail in Appendix A.

Free groundwater was encountered at depths between 30 and 58 feet below ground surface. Groundwater was measured in the borings immediately following drilling and levels may not have stabilized in the boreholes. A summary of the groundwater elevations encountered in the borings, which extended to groundwater is summarized in the following table:

Table 3 - Depth to Groundwater at Time of Drilling

Boring Location	Depth to Groundwater (ft)
B-1	53
B-4	54.5
B-5	52.5
B-8	58
B-10	46.5
B-12	37.5
B-101	42
B-102	43
B-103	42.5
B-104	43.5
B-105	30
B-106	30

4.0 Site Conditions

4.1 Topography and Vegetation

The native topography of the site is characterized by moderately sloping alluvial fans that lie at the base of the McCullough Range. These piedmont surfaces (areas geologically formed at the base of mountains) slope to the north and northeast, and coalesce in several areas near the proposed disposal facility. The relatively flat surfaces of the alluvial fans in the area are sparsely vegetated with creosote bushes, weeds, and other native plants typical of the Mojave Desert. The eastern two-thirds of Area 1 had been rough graded and was relatively level. Vegetation was very sparse in this area.

Several small north to northeast-trending washes cross the fans and the western portion of the site providing drainage for natural storm-water runoff from the uplands to the south. Most of these washes vary in size from about 10 to 20 feet across. The terrain within the washes consist of gentle to moderate bar-and-swale topography with numerous bar deposits of cobbles and gravel.

4.2 Geologic Soil Units

Our mapping has been based upon review of aerial photographs, published geologic and soils maps, site reconnaissance, and field exploration program. Within the general project area, two different geologic soil units were identified for the purposes of this work. The approximate boundary between the two units is the BMI property fence. Geologic descriptions of the units are based on the *Soil Conservation Service* (SCS) of soil classification and are given below:

Caliza Soil

This soil corresponds to *SCS Soil Map Unit 187* and is described as a very deep, well drained, cobbly fine sandy loam with 2 to 8 percent slopes. This soil is formed in alluvium derived from various types of rock and found on inset fan remnants. The subsurface is predominantly very gravelly coarse sand to a depth of 5 feet or more. Permeability is moderately rapid, available water capacity is low, and runoff is medium. The hazard of water erosion is slight, and the hazard of soil blowing is moderate if the surface is disturbed. Intermittent streams form the drainages in this unit. These drainages are subject to rare or occasional periods of high-velocity flooding.

Urban Land

This unit corresponds to *SCS Soil Map Unit 615* and consists of areas covered by asphalt, concrete, and buildings or other urban structures. The entire BMI complex including the undeveloped areas within the fenced property is mapped in this unit.

5.0 Geologic Conditions

5.1 Geologic Setting

The project area is located in the southeastern portion of the Las Vegas Valley, a structural basin of late Mesozoic and Tertiary block faulting origin. The valley is physiographically characteristic of the Basin and Range province. Valley deposits are Tertiary and Quaternary Age unconsolidated sediments derived from the surrounding mountains; the local sources of deposition are the McCullough Range to the south and the River Mountains to the east. Alluvial deposits consisting of gravel, sand, silt, and clay are overlain by lacustrine deposits of sand, silt, and clay in some portions of the valley. The alluvial and lacustrine sediments can be up to 4,000 feet thick in some parts of the valley. Coarse-grained alluvial fan deposits are located near the base of the mountains and grade into and interfinger with fine-grained sand, silt, and clay deposits in the central portion of the valley.

5.2 Drainage

Primary drainage for the valley is toward the southeast along four major wash systems: Las Vegas Wash, Flamingo Wash, Tropicana Wash, and Duck Creek Wash. These four systems consist of a series of channels of varying lengths and depths that originate along alluvial fans at the base of the Spring Mountains. The channels drain the valley to the southeast where they all coalesce into Las Vegas Wash. Several drainages near the proposed disposal facility divert stormwater runoff from the area to Las Vegas Wash and its tributaries.

5.3 Geologic and Environmental Hazards Review

Existing geologic data, including past Converse project files and references from the U.S. Soil Conservation Service, U.S. Geological Survey, Nevada Bureau of Mines and Geology, aerial photographs, and information through the State Universities were reviewed as part of this in-

vestigation. According to our review, two north-trending fault scarps are located approximately ½ mile northwest and southwest of the proposed site. The first is located along the fringe of the McCullough Mountains. The northern terminus of this fault scarp is located approximately 690 feet south of Lake Mead Drive and 1,050 feet west of Interstate 515. The second scarp is located near the vicinity of Gibson Road and American Pacific Drive. No evidence for faulting was observed within the proposed disposal facility site.

The *Subsidence-Related Faults and Fissures of the Las Vegas Valley Map*, published by the *Nevada Bureau of Mines and Geology, Subsidence in Las Vegas Valley 1980-91 Final Project Report*, John W. Bell and Jonathan G. Price, 1991, did not indicate topographic lineations regarded as a subsidence-related (compaction) fault were located near the proposed site. It is generally agreed that subsidence-related faults are not bedrock faults, although their displacement may have been at least partly induced by a seismic event. Others have dated the age of one of these escarpments in the southern part of the valley at about 14,000 to 35,000 years old. Fissures, surface expressions of differential stress resulting from regional and local subsidence due to withdrawal of groundwater, have been localized near subsidence-related faults. The nearest subsidence related faults and fissures are located approximately 2.3 miles northwest of the proposed disposal facility near Whitney Mesa.

The potential for landslides is believed to be low due to the nature and proximity of the topographic highlands to the project area and low precipitation in the region.

5.4 Estimated Ground Accelerations

Las Vegas Valley is located in Seismic Zone 2B as categorized in the Uniform Building Code. Zone 2B represents a low to moderately active seismic area. A regional map published by Algermissen and Perkins (1976) presents the expected peak horizontal ground acceleration for the Las Vegas Valley as approximately 0.1g. This value has a 10 per-

cent chance of being exceeded in a 50-year period. Site specific seismicity model analyses have been performed by Converse on other projects in the Las Vegas Valley. This analysis has typically found the peak horizontal ground acceleration of an event having a 10 percent chance of exceedance during a 100-year design life to range between 0.2g and 0.3g. For an event having a 10 percent chance of exceedance during a 50-year design life, the peak horizontal ground acceleration has ranged between 0.1g and 0.2g. The peak horizontal ground acceleration recommended for the design of the project is 0.15g. Based on our subsurface explorations and well drillers' logs in the area, a soil profile type of S_D per Table 16-J of the 1997 Uniform Building Code should be used for the site.

6.0 Site Evaluation and Preliminary Recommendations

6.1 General

Based on (1) our review of published geologic maps; (2) our geologic site reconnaissance, (3) the results of the preliminary field and laboratory investigations ; and (4) and assuming that the proposed facilities will not be developed to within 8 feet or closer of the fine-grained soils encountered at depth, it is our opinion that from a geotechnical engineering perspective, the site is suitable for support of the proposed disposal facility. We did not identify geologic hazards that would severely restrict development of the proposed disposal facility. Granular native site soils will provide support of the facility with some reworking. Cemented soils were found at shallow to moderate depths in 9 of the 12 borings drilled for this investigation. Based on observed excavation activities performed on other nearby projects, the majority of the soils should be rippable with conventional earthwork equipment, however, deep cuts into fully cemented soil deposits could require rock excavation techniques.

One design consideration will be requirements pertaining to liner permeability as related to the availability of near-surface, low-permeability native soils. As previously mentioned, the subsurface soils are char-

acterized by alluvial granular soils overlying fine-grained soils, the top of which coincides with the groundwater table. The granular soils above the fine-grained soils and groundwater table were tested to have relatively high permeabilities (greater that 1×10^{-5} cm/sec) and are not suitable as potential liner material. Due to regulatory requirements and the subsurface site conditions, development of the site as a disposal facility will probably require placement of either synthetic or non-synthetic (clay) liners. Synthetic liners could include membranes manufactured of high density polyethylene or a similar material. If a clay liner is used, a borrow source containing materials which meet regulatory permeability criteria would need to be identified and investigated. Another possible alternative, which is a combination of the above, is a geosynthetic clay liner which is constructed both of geotextile and/or geomembrane and bentonite. The appropriate regulatory agencies should be contacted during the design process to establish a dialogue as to which liner systems are allowed for the given waste stream and site conditions.

In order to provide geotechnical design recommendations for the proposed project, additional field explorations, laboratory testing, and engineering analyses should be performed. Additional field investigations related to excavatability of the on-site cemented soils may be desirable to perform and could include additional borings at cut areas and seismic refraction tests. After details of the project are finalized and design information is available, specific design recommendations should be developed in the design-level investigation.

The following sections present an engineering evaluation and preliminary considerations for the proposed site and facilities. The preliminary recommendations are for planning and should be confirmed with a final design-level investigation.

6.2 Foundations

Disturbed soils and undocumented fill soils are not considered suitable for the support of structures or retaining walls in the their present condition. It is our opinion that structures may be supported on spread footings founded on a zone of properly placed and compacted structural fill, undisturbed medium dense to very dense granular native soils or on moderately hard to hard cemented soils. Individual footings should not bear on both cemented soils and uncemented soils. Actual bearing materials can be determined after foundation loads and elevations have been determined.

Depending on the type of construction, the proposed structural loads, and the depths of footings, we estimate that the maximum allowable bearing pressures for conventional spread footings will range from 4,000 to 6,000 psf on cemented or non-cemented native granular soils or granular structural fill. Concrete floor slabs may be supported by a 4 to 6 inch layer of processed and compacted granular fill material underlain by structural fill or undisturbed, dense native soils.

6.3 Cut Slopes and Fill Embankments

Cut slopes into medium dense to very dense native granular soils or cemented soils should provide stable slopes on which waste disposal liners may be placed. For any proposed embankments, medium dense to very dense native granular soils or a zone of properly placed and compacted structural fill or cemented soils should provide adequate support for the embankments and disposal facilities after the surface vegetation and organics have been removed and the foundation preparation has been conducted. For embankments, we recommend a homogeneous embankment section consisting of either on-site or import soils. The on-site soils are suitable for use as materials for embankment fill or other structural fills. Fill soils and disturbed native granular soil beneath the embankment sections or any areas which will support liner systems will require scarification, moisture conditioning, and recompaction.

Surfaces of the cut or embankment slopes will need to be adequately protected from erosion due to rainfall and runoff. The stability of the cut or embankment slopes should be analyzed during the final design-level investigation after locations, geometry and heights have been determined. The ranges of cut and embankment slopes given in Table No. 4 may be used for preliminary planning.

Table No. 4 - Slopes for Preliminary Planning

Cut Slope or Embankment Soil Type	Approximate Slope (Horizontal:Vertical)
Sands and Gravels	1½:1 to 2:1

It should be noted that typical slopes on which liners will be constructed are usually not recommended to be steeper than 3:1 (horizontal to vertical). Slopes would need to analyzed on an individual basis with proposed liner types and expected loads for the appropriate maximum steepness in the design-level investigation.

6.4 Retaining Walls

We anticipate that conventional concrete retaining walls may be used for the project. The appropriateness of concrete walls will depend on the height, length, and configuration of the walls. After wall details have been determined, information on different options and approximate costs can be provided in the design-level investigation. Ranges of lateral earth pressures for restrained and unrestrained walls are given in Table 5 below:

Table No. 5 - Lateral Earth Pressures

Wall Type	Lateral Earth Pressures psf/ft
Restrained	38-45
Unrestrained	30-40

The site soils generally contain too high a percentage of fines to be free draining. On-site material may be processed to reduce the silt and clay content and to remove oversize material, to obtain a free draining backfill material. If free draining material is not used, a drainage system will need to be provided or the wall designed to resist hydrostatic forces.

7.0 Construction Considerations

7.1 Site Grading

It is anticipated that site grading will be a large component of development of the site. Site grading should consist of: (1) the removal of existing vegetation, pavements, debris, surface trash and possibly some underground utilities that may be relocated from the site; (2) the undocumented fill, loose or disturbed native soils should be processed and stockpiled for later use as engineered fill; (3) excavating down to medium dense to very dense granular soils or down to expose the underlying cemented soils for support of any foundations; (4) overexcavation and recompaction of the natural soils will be required for the support of any structures; and (5) the exposed native soils will require scarification, moisture conditioning and recompaction prior to placing structural fill in fill areas. Scarification and recompaction can be terminated where cemented soils are exposed. The existing on-site soils should be suitable for use as compacted structural fill. All fill at the site should be considered undocumented unless records of proper placement were prepared and are obtained. All undocumented fill at the site will be unsuitable for support of structures and settlement-sensitive facilities at the site will need to be reworked as structural fill. Rubble and debris resulting from excavating cemented soil deposits should be considered undocumented fill. Contingency plans should be considered for removing small boulders, cobbles, and broken cemented material resulting from excavations of cemented soil from the project site. Boulders, cobbles, and cemented material between 4 and 24 inches in diameter may possibly be used in deep fill where potential

settlement may be tolerated areas if special compaction procedures are used and full-time observation during placement is provided.

There will be shrinkage when excavating and compacting or scarifying and recompacting the non-cemented on-site soils, and swell when excavating and compacting cemented soils. The shrinkage and swell factors provided in Table No. 6 may be used for preliminary planning.

Table No. 6 - Shrinkage and Swell Factors for Preliminary Planning

Soil Type	Estimated Shrinkage (-) or Swell (+) Factor (percent)
Sands and Gravels	5 to 15 (-)
Cemented Soils	0 to 10 (+)

A shrinkage factor of 5 to 15 percent may be used for preliminary planning in areas where the exposed native soils will be compacted to a depth of 6 inches. For final design, the anticipated shrinkage and swell factors for the on-site soils should be determined in the design-level investigation.

7.2 Excavations

Based on observations made during our field explorations, the majority of non-cemented soils should be readily excavatable with conventional earthwork equipment. Partially to fully cemented (moderately hard to hard) soils were encountered during this investigation at depths of 7 to 49½ feet below the existing ground surface. Heavy-duty ripping, heavy-duty backhoe, headache ball, rocksaw, blasting, or Ho-ram should be anticipated for any deep excavations. The Contractor should be aware of the potential for vibrational damage to adjacent or nearby structures when using blasting or heavy impact equipment during removal of the hard cemented materials.

7.3 Soil Corrosivity

Laboratory test results indicate that according to Clark County Building Department standards, soils should be considered moderately to severely corrosive to buried metal and have sulfate levels above that considered harmful to normal strength concrete and soil cement. Consideration should be given to corrosion protection systems for buried metal. The concrete mixture recommendations to accommodate severely corrosive soils should be based on the design-level investigation.

7.4 Final Design Recommendations

Additional design-level investigations will be required, when final facility and structure layouts and dimensions have been determined. Borings should be located within the foot-print of the facilities or structures and laboratory testing should be performed to evaluate the nature and engineering properties of the native subsoils at those locations and, if possible, any potential import materials. It may also be desirable to evaluate the extent and rippability of cemented soils.

8.0 Closure

Our assumptions, conclusions, recommendations, and opinions presented herein are: (1) based upon the geologic site reconnaissance, (2) based upon our evaluation and interpretation of the findings of the preliminary field exploration and laboratory programs, (3) based upon an interpolation of soil conditions between and extrapolation beyond the boring locations, (4) based on our geotechnical experience in the locale, (5) not based on environmental regulatory requirements for disposal facility design and construction and are only based on standard geotechnical engineering considerations (6) subject to confirmation of the conditions encountered during a design-level investigation, and (7) prepared in accordance with generally accepted professional geotechnical engineering principles and practice. We make no other warranty, either express or implied.

It has been our pleasure to serve you on this project. If you have any questions, please contact this office.

Respectfully submitted,

CONVERSE CONSULTANTS

Lorraine Linnert Dunford
Project Geologist

Mike Klein, P.E.
Senior Engineer

Reviewed by:

James L. Werle, P.G.
Principal Geologist

REGISTERED PROFESSIONAL ENGINEER STATE OF NEVADA
MICHAEL K. KLEIN
CIVIL
NO. 11407

10-27-99

MKK:CMK:gm
18/69BG

Encl: Drawing Nos. 1 through 3
Appendix A

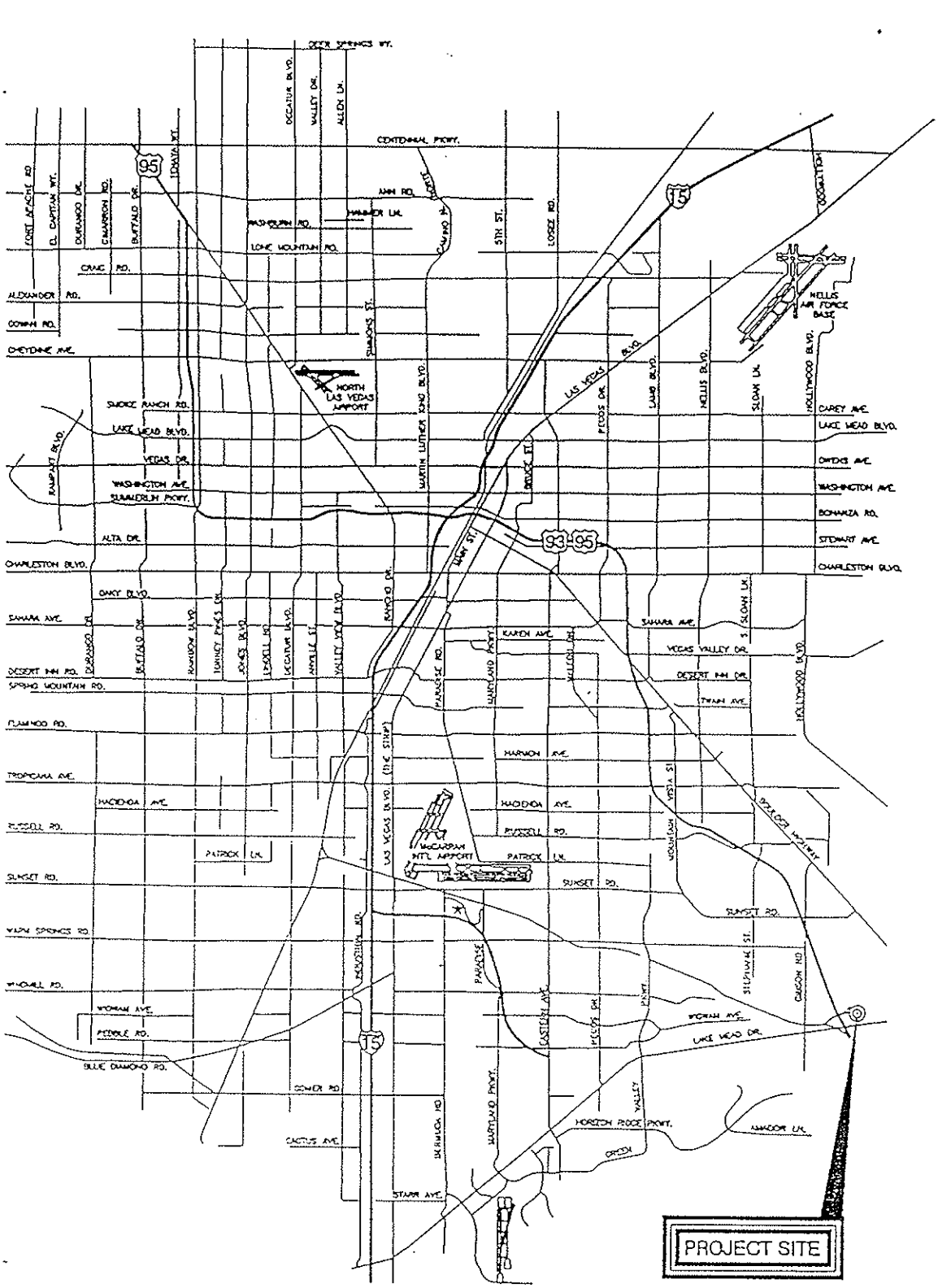
Dist: 3/Addressee

References

Bell, J.W., 1978, *Geologic Constraints Map, Las Vegas SE Folio*, Nevada Bureau of Mines and Geology, Environmental Series, Las Vegas Area.

Bell, J.W. and Price, J.G., 1991, *Subsidence-Related Faults and Fissures of the Las Vegas Valley Map*, Nevada Bureau of Mines and Geology, Subsidence in the Las Vegas Valley 1980-91 Final Project Report.

Soil Conservation Service, 1985, *Soil Survey of Las Vegas Valley Area, Nevada, Part of Clark County*: U.S. Department of Agriculture.



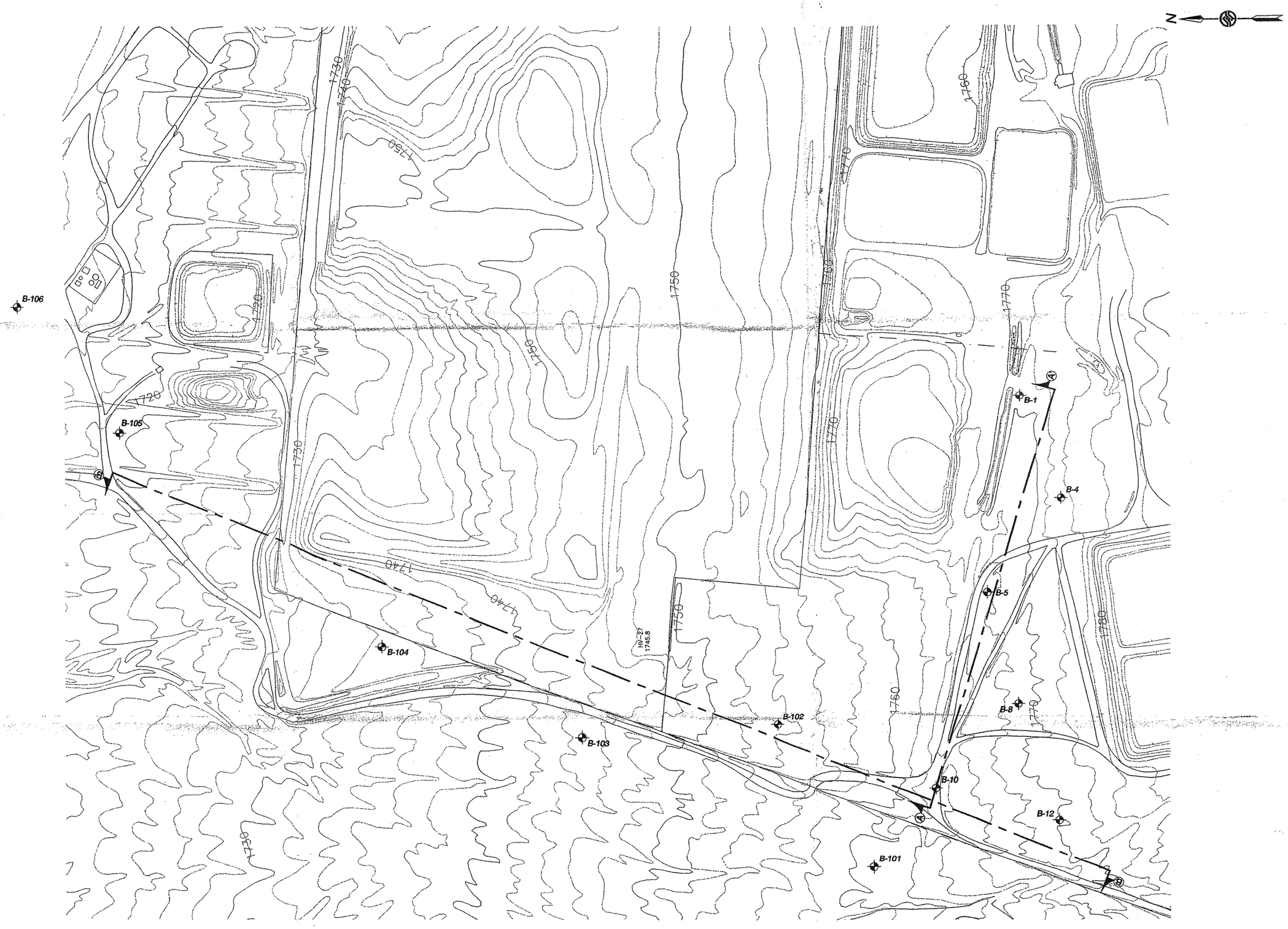
LAS VEGAS VICINITY

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Scale	N.T.S.
Date	10/21/99
Drafted By	CLE
Checked By	MKK
Approved By	
File No.	
Project No.	99-33437-01
Drawing No.	1

CONVERSE CONSULTANTS

Over 50 Years of Dedication in Engineering and Environmental Sciences



GRAPHIC SCALE

100 0 200 400

(In Feet)

EXPLANATION

APPROXIMATE SOIL BORING LOCATION

APPROXIMATE LOCATION OF GEOLOGIC SECTION (See Drawing No. 3)

REF: AutoCAD drawing file "site.dwg", supplied by client

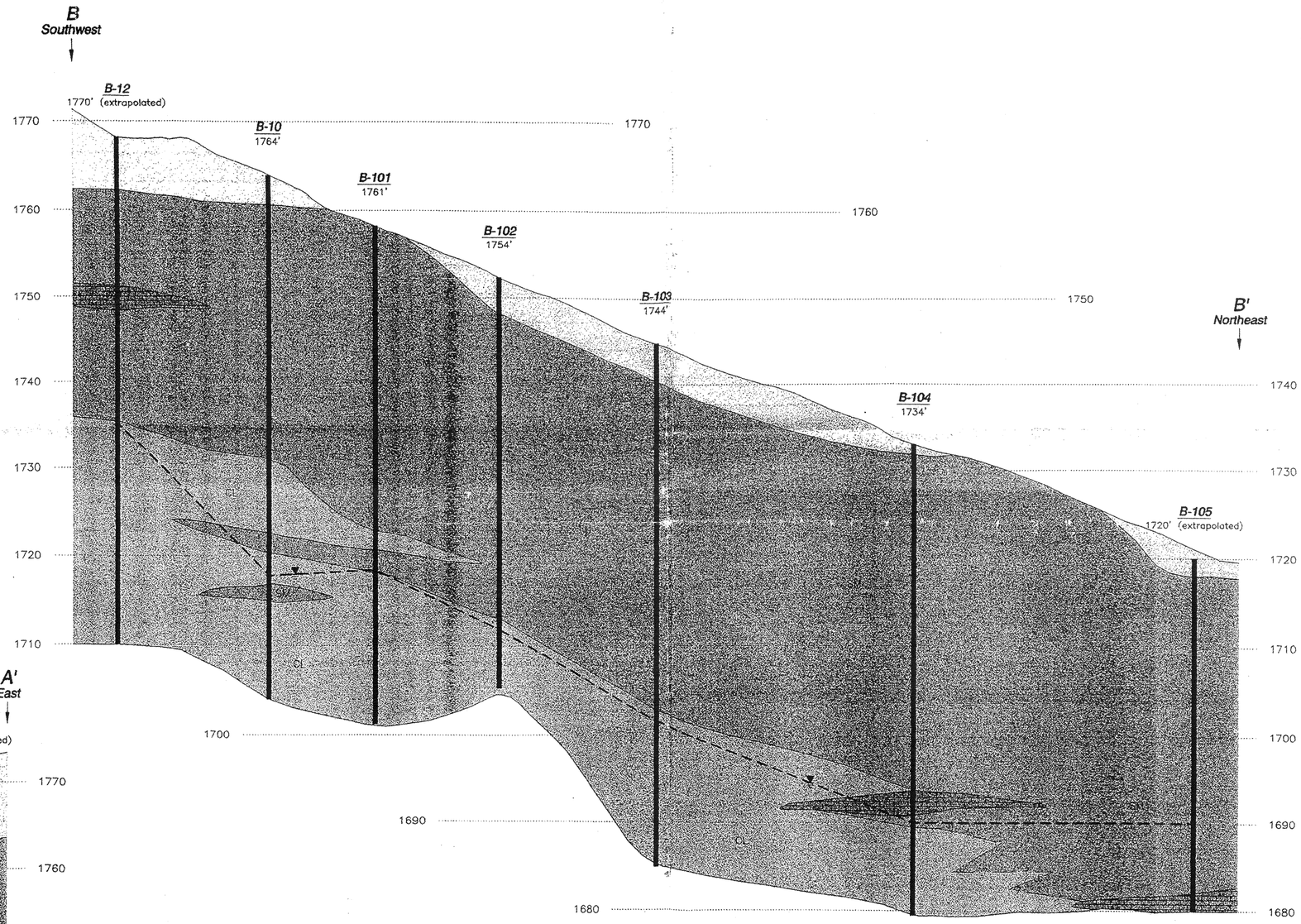
LOCATION OF SUBSURFACE EXPLORATIONS

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Scale	1" = 200'	File No.	43701002
Date	10/21/99	Project No.	99-33437-01
Drafted By	GLE	Drawing No.	2
Checked By	MKK		
Approved By			

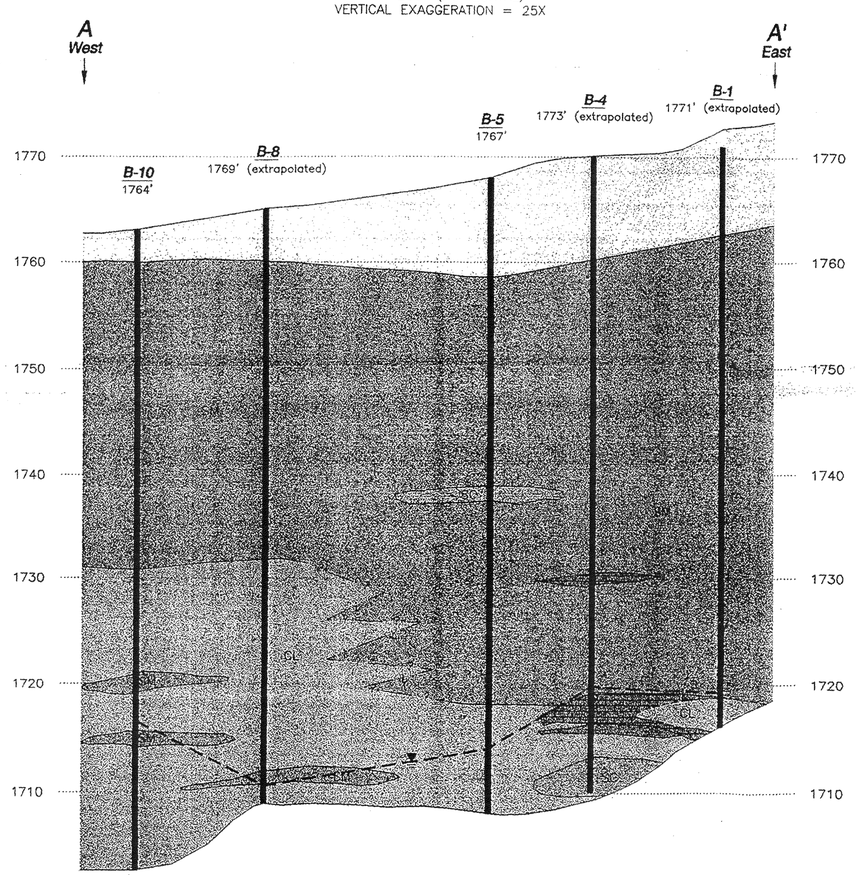
CONVERSE CONSULTANTS

Over 50 Years of Dedication in Engineering and Environmental Sciences



SECTION B-B'

SCALE: 1" = 10' (VERTICAL)
1" = 250' (HORIZONTAL)
VERTICAL EXAGGERATION = 25X



SECTION A-A'

SCALE: 1" = 10' (VERTICAL)
1" = 250' (HORIZONTAL)
VERTICAL EXAGGERATION = 25X

LEGEND

- FILL
- CLAY
- CLAYEY SAND
- SILTY SAND
- SAND
- CEMENTED SAND AND GRAVEL
- APPROXIMATE GROUNDWATER LEVEL MEASURED IMMEDIATELY AFTER DRILLING

NOTE: Ground surface elevations were extrapolated from a topographic map provided by the client. Locations and elevations of the soil borings are approximate. Data concerning subsurface conditions has been obtained at exploration locations only. Actual conditions between explorations may differ from the generalized profiles shown here.

GEOLOGIC SECTIONS

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

CONVERSE CONSULTANTS

Over 50 Years of Dedication in Engineering and Environmental Sciences

Scale	1" = 300'
Date	10/28/99
Drafted By	GLE
Checked By	LLD
Approved By	
File No.	43701003
Project No.	99-33437-01
Drawing No.	3

Field and Laboratory Investigations

Field Investigation

The subsurface soil conditions were explored by drilling 6 borings in each of the two areas (total of 12 for the site) to depths ranging from 33 to 60 feet below ground surface. The approximate locations of the explorations are shown on Drawing No. 2, Locations of Subsurface Explorations. Boring locations were located, surveyed, and staked by PBS&J surveyors, however, at the time this report was prepared this information was not available. Continuous logs of the subsurface conditions as encountered in the explorations were recorded at the time of drilling by a field geologist. The subsurface conditions encountered were visually classified in accordance with the Unified Soil Classification System. Summaries of the subsurface conditions encountered are presented on the boring summary sheets, Drawing Nos. A-1 through A-34. A key to soil symbols and terms is found on Drawing No. A-35. The soil classification system for engineering purposes is further explained on Drawing No. A-36.

Drilling was accomplished with a BK-81 hollow-stem auger drill rig equipped for soil sampling. Relatively undisturbed soil samples were obtained using a 2.42-inch inside diameter Converse sampler driven with a 140-pound hammer free-falling through a distance of 30 inches. Sampler driving resistance, expressed as blows per 12 inches of penetration, is presented on the boring logs at the respective sampling depths. The sampled soil is retained in brass rings 1-inch in height which line the sampler. A representative portion of each sample was retained and carefully sealed in waterproof plastic containers for transport to the geotechnical laboratory. Additional samples were collected in 6-inch high stainless steel sleeves for environmental laboratory analysis. Soils with stains and orders due to potential chemical contamination are noted on the soil boring logs. It should be noted that given the coarse grained materials encountered at the site, undisturbed sample recovery was low. Also, the encountered materials

in the borings classified as boulders could have also been cobble size as well as boulder size particles.

Pocket Penetrometer

At the time of drilling, pocket penetrometer tests (pp) were conducted in the ends of selected brass ring samples of fine-grained soils as they were received from the borings. The purpose of the tests was to give an indication of the unconfined compressive strength in tons per square foot (tsf) or unconfined shear strength in kips per square foot (ksf) of the soil. A Brainard-Kilman S-170 pocket penetrometer was used. The results of the tests are presented in the Field or Laboratory Tests column of the boring logs, Drawing Nos. A-1 through A-34.

Laboratory Investigation

Laboratory tests were conducted on representative soil samples for the purpose of classification, and determination of their physical properties and engineering characteristics. The amount and selection of the types of testing for a given study are based on the geotechnical conditions of the project. Test results are presented in the summary boring logs and in this appendix. A summary of the various laboratory tests conducted by our office for engineering purposes is presented as follows.

The soil samples presently stored in our laboratory will be discarded 30 days after the date of this report, unless this office receives a specific request to retain the samples for a longer period.

Moisture Content and Dry Density

Data obtained from these tests, performed on relatively undisturbed samples obtained from the field and in accordance with ASTM D2435, were used in the classification and correlation of the soils and to provide qualitative information regarding soils strength and compressibility. Test results are presented on the boring logs on Drawing Nos. A-1 through A-34.

Grain Size Distribution

Grain size distribution for soil samples were determined by sieve analysis in accordance with ASTM C136. A sieve analysis is conducted by passing the soil through a number of different sized sieves and measuring the amount of soils retained on each sieve. The test results and grain size distribution curves are presented on Drawing Nos. A-37 through A-48.

Atterberg Limits

The liquid limit, plastic limit and plasticity index of a representative sample of the fine-grained soils were determined to aid in the classification of the soils and in the evaluation of other engineering parameters. The test was performed in general accordance with ASTM test method D4318. The results of the tests are tabulated in the following table:

Exploration Location	Sample Depth, ft.	Liquid Limit, %	Plastic Limit, %	Plasticity Index	Unified Soils Classification
B-1	30-35	NP	NP	NP	SM
B-5	20-25	NP	NP	NP	SM
B-10	30-35	NP	NP	NP	SM
B-12	10-15	NP	NP	NP	SM
B-101	39-40	105	71	34	MH
B-101	54-55	54	44	10	ML
B-102	20-25	NP	NP	NP	SM
B-102	49-50	88	58	30	MH
B-103	30-35	NP	NP	NP	SM
B-104	10-15	NP	NP	NP	SM
B-105	20-25	NP	NP	NP	SW-SM
B-106	0-5	NP	NP	NP	SM

NP = Nonplastic

Solubility

Solubility tests were performed to determine the amount of water-soluble materials (principally gypsum) present in the soil. After drying a soil specimen weighing approximately 150 grams in a 60-degree centigrade oven, about 2 liters of tap water are passed through the specimen. The soil is then oven-dried and the amount of soluble materials lost is calculated based on the original dry weight of the soil. The results of the solubility test are presented in the following table:

Exploration Location	Sample Depth (Feet)	Soil Description	Solubility (% by Unit Weight)
B-4	2-2.5	Fill – Poorly graded sand	0.2
B-5	10-15	Silty sand with gravel	0.6
B-8	19-20	Silty sand with gravel	0.2
B-101	5-10	Silty sand with gravel	0.0
B-102	0-5	Fill - Silty sand with gravel	0.6
B-104	0-5	Silty sand with gravel and cobbles	0.4
B-106	0-5	Silty sand with gravel	0.0

Consolidation

The apparatus used for the consolidation tests is designed to receive a one-inch high brass ring containing an undisturbed soil sample as it comes from the field. Tests were performed in general accordance with ASTM D2435 test method. Loads are applied to the test specimen in several increments, while resulting deformations are recorded at selected time intervals. Porous stones are placed in contact with both ends of the specimen to permit the ready addition or release of water. Samples are initially tested at their field moisture content. After consolidating at the field moisture content with a 2 ksf surcharge load, the specimens are inundated with water. Additional consolidation that occurs with a 2 ksf load after the specimens are inundated with water (hydrocollapse) is measured. Subsequent consolidation with additional loads is measured at the increased moisture content to determine soil behavior under saturated conditions. Results of the tests are

shown on Drawing Nos. A-49 through A-56, entitled *Consolidation Test* and are summarized on the following table:

Exploration Location	Depth (feet)	Soil Description	Dry Unit Weight, pcf	Moisture Content, %	Hydrocollapse (percent)*
B-1	29-30	Silty sand with gravel	105	6	3.2
B-8	39-40	Sandy lean clay	57.4	64	0.4
B-8	49-50	Sandy lean clay	69.5	51.1	-0.6
B-10	54-54.5	Sandy lean clay	60.7	67.7	-0.6
B-101	39-40	Sandy lean clay	65.8	45	-0.2
B-101	59-60	Sandy lean clay	73.2	38.3	-0.6
B-102	49-50	Sandy lean clay	67.3	48.7	-0.5
B-105	34-35	Well graded sand with silt and gravel	101	5	0.1

NA: Not available

* A negative sign indicates swell occurred upon inundation with water instead of collapse.

Laboratory Maximum Density

Laboratory maximum density tests were performed on selected samples of the granular soils. The purpose of the test was to define the compaction characteristics of these soils, and to aid in estimating soil shrinkage. The laboratory maximum density test was performed in general accordance with the ASTM D1557 test method. This test procedure uses 25 blow of a 10-pound hammer falling a height of 18 inches on each of five layers of soil in a 1/30 or 1/13 cubic foot cylinder. The test results are presented on Drawing Nos. A-57 through A-61 and in the following table:

Exploration Location	Depth (Feet)	Soil Description	Maximum Dry Unit Weight (pcf)	Optimum Moisture Content (percent) - of dry weight)
B-1	20-25	Silty sand with gravel	129.4	8.2
B-5	20-25	Silty sand with gravel	132.1	8.2
B-12	10-15	Silty sand with gravel	129.7	7.9
B-101	5-10	Silty sand with gravel	130.6	8.7
B-105	20-25	Well graded sand with silt and gravel	131.8	7.5

Direct Shear Strength

A progressive direct shear test was performed on selected undisturbed samples using a constant strain rate direct shear machine in general accordance with ASTM D3080. The test specimen was trimmed and placed in the shear machine, a specified normal load was applied, and the specimen was sheared until maximum shear strength was developed. After the soil specimen had developed maximum shear resistance under the first normal load, the normal load was removed and the specimen was pushed back to its original undeformed configuration. Another normal load was then applied, and the specimen was sheared a second time. This process was repeated for three different normal loads. Results of the direct shear test are presented on Figures A-62 through A-69 and in the following table:

Exploration Location	Depth (Feet)	Soil Description	Angle of Internal Friction (deg)	Coulomb Cohesion (ksf)
B-4	14-14.5	Silty sand with gravel	31	0.7
B-5	14-15	Silty sand with gravel	43	0.3
B-10	54-54.5	Sandy lean clay	26	0.85
B-12	14-15	Silty sand with gravel	40	0.3
B-101	39-40	Sandy lean clay	26	0.9
B-102	20-25	Silty sand with gravel	37	0.2
B-103	49-50	Sandy lean clay	37	1.0
B-104	10-15	Silty sand with gravel	43	0.1

Chemical Analysis

Chemical tests were performed on a representative soil samples to investigate the potential for soil corrosivity and chemical heave. Atlas Chemical Testing Laboratories, Inc. in Las Vegas performed the chemical analysis for water-soluble sulfates and sodium in general accordance with ASTM D516. The results of the chemical tests are presented on Drawing No. A-70.

Exploration Location	Depth (feet)	Soil Description	Percent Sodium	Percent Sulfate	Total Available Water Soluble sodium Sulfate (%)
B-5	10-15	Silty sand with gravel	0.07	0.13	0.20
B-8	19-20	Silty sand with gravel	0.07	0.06	0.08
B-101	5-10	Silty sand with gravel	0.17	0.06	0.08
B-102	0-5	Fill – Silty sand with gravel	0.17	0.03	0.05
B-106	0-5	Silty sand with gravel	0.15	0.08	0.12
B-106	29-30	Silty sand with gravel	0.15	0.06	0.08

Permeability

Falling head permeability tests were conducted on remolded samples in general accordance with modified ASTM procedure D2434. The soil was compacted in a mold 4.6 inches long and 4.0 inches in diameter to 85 or 90 percent of maximum dry density and at optimum moisture content. A falling head was applied to the sample and the flow of water through the sample was monitored. The permeability was calculated after the flow rate had stabilized. The result of the falling head permeability test is presented in the following table:

Exploration Location	Sample Depth (Feet)	Soil Description	k (cm/s)
B-5	20-25	Silty sand with gravel	5.3×10^{-4}
B-12	10-15	Silty sand with gravel	4.0×10^{-4}
B-102	20-25	Silty sand with gravel	1.0×10^{-4}
B-105	20-25	Well graded sand with silt and gravel	1.2×10^{-3}

Flexible wall permeameter tests were performed on selected samples by AP Engineering and Testing, Inc according to ASTM D5084. With the exception of one sample (B-105), all tested samples were undisturbed ring samples. The samples were placed in a triaxial machine with a constant confining pressure at the approximate in-place effective stress pressures. Results were generally consistent with the fal-

ling head permeability test results for the granular materials. Laboratory results are presented on Drawing Nos. A-71 through A-76 and summarized below:

Exploration Location	Sample Depth (Feet)	Soil Description	k (cm/s)
B-1	14-15	Silty sand with gravel	1.57×10^{-4}
B-4	24-25	Silty sand with gravel	1.47×10^{-4}
B-8	44-45	Sandy silt	2.90×10^{-5}
B-12	39-39.5	Silty clay	1.76×10^{-7}
B-103	44-45	Silty clay	3.83×10^{-7}
B-105*	30-35	Silty sand	3.05×10^{-4}

* Sample remolded to 85% relative compaction at optimum moisture.

Log No. B- 1

Date of Drilling: 9/23/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 53.0

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		FILL: SILTY SAND With Gravel; light brown, dry	▼		21				
2									
4		---moist	▼		26				
			▼		42				
6			▼						
8									
			▼		26		4		
10		SILTY SAND With Gravel (SM): dense, light brown, slightly moist	▼		33				
12									
14			▼		44				K
16									
18		---very dense	▼		35/5"				

End of Exploration at 55.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and Environmental Sciences

Drawing No. A-1

LV-51 8334701 GPJ

Log No. B- 1

Date of Drilling: 9/23/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 53.0

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Samples: Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SILTY SAND With Gravel (SM); dense, light brown, slightly moist			35				
22									G;F
24					35		7	108	
26									
28		---grayish brown							
					35/6"				
30		---very dense			53				A
32									G
34					35/3"				
36									
38		---dense			35/6"				

End of Exploration at 55.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and Environmental Sciences

Drawing No. A-2

LV-B1 9343701 GP

Log No. B- 1

Date of Drilling: 9/23/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 53.0

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Samples: Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SILTY SAND With Gravel (SM); dense, grayish brown, slightly moist	▼		42				
42									
44		—very dense	▼		58/7"				
46									
48									
			▼		35/4"				
50									
52		---wet							
54		SANDY LEAN CLAY (CL); very stiff, dark brown, moist	▼		35/6"				
56									
58									

End of Exploration at 55.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No.
99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and Environmental Sciences

Drawing No.
A-3

Log No. B- 4

Date of Drilling: 9/13/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 54.5

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		FILL: SILTY SAND With Gravel; brown, dry			17				
2		---POORLY GRADED GRAVELLY SAND			45				Sol
4					66/7"		3		
					35/4"				
6									
8									
		---SILTY SAND With Gravel			35/5"				
10					36				
12									
14		SILTY SAND With Gravel (SM); very dense, brown, dry			35/8"		5		DS
16									
18		---dense							
					43				

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY CN

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No.
99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and

Drawing No.

01 93343701 GPJ

Log No. B- 4

Date of Drilling: 9/13/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 54.5

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SILTY SAND With Gravel (SM); very dense, brown, dry			35/2"				
22									
24		--dense			49				K
26									
28									
		---few gravel			35		7	107	
30					42				
32									
34		---with gravel, very dense			35/8"		4		
36									
38		---with boulders							
		CEMENTED SAND AND GRAVEL: hard, brown, dry			20/0"				

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY MD

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and Environmental Sci

Drawing No.

Log No. B- 4

Date of Drilling: 9/13/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 54.5

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Samples: Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SILTY SAND With Gravel (SM); very dense, brown, dry			35/1"				
42									
44		—with boulders			35/0"				
46									
48		---partially cemented, moderately hard							
					35/0"				
50									
		CEMENTED SAND AND GRAVEL; hard, gray, dry							
52									
54		POORLY GRADED SAND (SP); dense, black, moist, very strong odor, heavy staining			44				
		LEAN CLAY (CL); stiff, grayish brown, dry							pp=2.0
56									
		CLAYEY SAND (SC); medium dense, brown, wet							
58									
		---strong odor			23				

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and Environmental Sciences

Drawing No. A-6

Log No. B- 5

Date of Drilling: 9/15/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 52.5

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving WL and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		FILL: SILTY SAND With Gravel; tan, dry			9				
2									
4		---slightly moist			35/5"				
					58				
6									
8		---with cobbles							
		SILTY SAND With Gravel (SM); dense, tan, slightly moist			31		5	115	
10					29				
12									K;Sol; Ch
14					43		4	111	DS
16									
18		---very dense			57/8"				

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and

Drawing No.

B1 93343701 CPJ

Log No. B- 5

Date of Drilling: 9/15/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 52.5

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Samples: Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SILTY SAND With Gravel (SM); dense, tan, slightly moist			32				A
22									G;P;C
24					58/8"				
		---very dense							
26									
28		---brown							
		CLAYEY SAND With Gravel (SC); dense, dark brown, slightly moist			35/5"		6	112	
30					35/6"				
		SILTY SAND With Gravel (SM); dense, black, slightly moist							
32		---dark brown							
34		---very dense			50/3"				
36									
38		---with cobbles			50/6"				

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and

Drawing No.

Log No. B- 5

Date of Drilling: 9/15/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 52.5

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Samples: Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SILTY SAND With Gravel (SM); dense, black, slightly moist			35/6"				
42									
44					35/0"				
46									
48									
					36				
50		SANDY LEAN CLAY With Gravel (CL); very stiff, dark brown, slightly moist							
52									
54		---moist			32				pp=3.0
56									
58					18				

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and

Drawing No.

Log No. B- 8

Date of Drilling: 9/14/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 58.0

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		FILL: SILTY SAND With Gravel; tan, dry			8				
2									
4					28				
					16				
6									
8									
		SILTY SAND With Gravel (SM); very dense, tan, dry			35/8"		2		
10					32				
12									
14					33/6"				
16									
18									
		---dense			38		4		Ch Sol

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and Environmental Sciences

Drawing No. A-10

Log No. B- 8

Date of Drilling: 9/14/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 58.0

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Samples: Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SILTY SAND With Gravel (SM); very dense, tan, dry			60/9"				
22									
24					54/9"		4		
26									
28									
					35/8"				
30					45		4		
32									
34					55				
36									G
38		SANDY LEAN CLAY (CL); very stiff, dark brown, slightly moist							
		---with gravel			30		46	69	

APPROVED BY ON

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and

Drawing No.

1 0334370 1 CPJ

Log No. B- 8

Date of Drilling: 9/14/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 58.0

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Samples: Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SANDY LEAN CLAY With Gravel (CL); very stiff, dark brown, slightly moist	▼		49				
42									
44		—dry	▼		35/8"				K
46									
48									
		---partially cemented, moderately hard, white, dry							
		SANDY LEAN CLAY (CL); very stiff, dark brown, moist	▼		35/10"				pp=3.
50									
52									
54			▼		16		52	71	pp=2.(
56									
58		SILTY SAND (SM); dense, brown, wet							
		SANDY LEAN CLAY (CL); stiff, dark brown, wet	▼		13		51	70	pp=3.(

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery

APPROVED BY ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and

Drawing No. A-12

99 B1 9334370 1 GPJ

Log No. B-10

Date of Drilling: 9/13/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 46.5

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Samples: Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		FILL: SILTY SAND With Gravel; tan, dry			26				
2									
4		SILTY SAND With Gravel (SM); medium dense, tan, slightly moist			25		5		
					20				
6									
8									
		---very dense			39				
10					60/8"				
		---cobbles							
12									
14		---partially cemented, moderately hard			35/1"				
16									
18					35/1"				

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No.
99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and Environmental Sciences

Drawing No.
A-13

Log No. B-10

Date of Drilling: 9/13/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 46.5

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

Depth (ft)	Graphic Log	SUMMARY OF SUBSURFACE CONDITIONS	Samples: Drive	Samples: Bulk	Samples: Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.							
		SILTY SAND With Gravel (SM); partially cemented, moderately hard, tan, slightly moist			35/0"				
22									
24		—with cobbles			35/1"				
26									
28									
					35/0"				
30		SILTY SAND With Gravel and Cobbles (SM); very dense, brown, slightly moist			35/3"				
32									A.G
34		---cobbles and boulders			35/3"				
		LEAN CLAY With Gravel (CL); very stiff, light brown, dry							
36									
38					35/6"				

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and Environmental Sciences

Drawing No. A-14

B1 9334370 GPJ

Log No. B-10

Date of Drilling: 9/13/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 46.5

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		LEAN CLAY (CL); very stiff, light brown, dry	▼▲		35				
42		SILTY SAND With Boulders (SM); very dense, brown, dry							
44		LEAN CLAY With Gravel (CL); stiff, dark brown, moist	▼▲		13				pp=1.2
46									
48		SILTY SAND With Gravel and Caliche Nodules (SM); medium dense, dark brown, moist							
		SANDY LEAN CLAY (CL); very stiff, dark grayish brown, wet	▼▲		30		17	106	
50									
52									
54			▼▲		26		68	60	DS pp=1.5
56									
58			▼▲		16				

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No.
99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and Environmental Sciences

Drawing No.
A-15

99-33437-01 GPJ

Log No. B-12

Date of Drilling: 9/14/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 37.5

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		FILL: SILTY SAND With Gravel; tan, dry							
2					16				
4					25				
					35/4"				
6									
8									
					35/2"				
10		SILTY SAND With Gravel (SM): very dense, tan, dry			35/7"				
12		---cobbles							AGP KDS
14					35/7"		2		
16									
18		---cobbles							
		SILTY SAND With Gravel (SM); very dense, light brown, dry			35/6"				

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and Environmental Sciences

Drawing No. A-16

31 93343701 CPJ

Log No. B-12

Date of Drilling: 9/14/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 37.5

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Description	Samples: Drive	Samples: Bulk	Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SILTY SAND With Gravel (SM); very dense, light brown, dry			35/6"				
22		CEMENTED SAND AND GRAVEL; hard, grayish brown, dry							
		SILTY SAND With Gravel (SM); very dense, tan, dry							
24					35/5"		2		
26									
28									
		---with gypsum, dense			35		3		
30		---with clay			35				
32									
34					28		5		
36									
		SANDY LEAN CLAY (CL); very stiff, dark brown, moist							
38		---slight odor							
					21				K pp=3.0

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and Environmental Sciences

Drawing No. A-17

LV-B1 933437-01.GPJ

Log No. B-12

Date of Drilling: 9/14/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 37.5

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

Depth (ft)	Graphic Log	SUMMARY OF SUBSURFACE CONDITIONS This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.	Samples: Drive	Samples: Bulk	Samples: Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SANDY LEAN CLAY (CL); very stiff, dark brown, moist	▼		44				
42									
44									
		—wet, stiff	▼		15		80	53	pp=1..
46									
48									
			▼		11				
50									
52									
		---with gravel, very stiff							
54			▼		16		31	87	pp=1..
56									
58									
			▼		18				pp=1..

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY GN

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No.
99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and Environmental Sciences

Drawing No.
A-18

Log No. B-101

Date of Drilling: 9/20/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 42.0

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SILTY SAND With Gravel (SM); occasional cobbles, medium dense, tan, slightly moist			11				
2									
4		---dense			35				
					21				
6									G.P. Sol:Ch
8									
					42		4		
10					39				
12									
14					42				
16									
18									
		---very dense			35/1"				

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and Environmental Sciences

Drawing No. A-19

DRAFTED BY GLE
APPROVED BY ON
BK-81 03343701 CPJ

Log No. B-101

Date of Drilling: 9/20/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 42.0

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SILTY SAND With Gravel (SM); occasional cobbles, very dense, tan, slightly moist			55				
22									
24					35/7"		4		
26									
28									
		---dense			35/8"		4		
30					35				
32									
34					35/9"				
36									
38		SANDY LEAN CLAY (CL): very stiff, dark brown, slightly moist			21		52	64	ADS

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No.
99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and Environmental Sciences

Drawing No.
A-20

Log No. B-101

Date of Drilling: 9/20/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 42.0

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
					10				
		SILTY SAND With Gravel (SM); medium dense, grayish brown, dry							
42									
		SANDY LEAN CLAY (CL); stiff, dark brown, moist							
44					11		45	67	
46									
48									
					25				pp=1.5
50		---partially cemented lens, moderately hard, brownish white, wet							
52									
54					11		42	75	A
		---with gravel							
56									
58									
					14		42	74	

APPROVED BY ON

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and Environmental Sciences

Drawing No. A-21

99-33437-01.GPJ

Log No. B-102

Date of Drilling: 9/23/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 43.0

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

Depth (ft)	Graphic Log	SUMMARY OF SUBSURFACE CONDITIONS This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.	Samples: Drive	Samples: Bulk	Samples: Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SILTY SAND With Gravel (SM); very dense, light brown, slightly moist			35/5"				
22									A;G;K; DS
24					35/8"				
		---with cobbles							
26									
28									
					35/4"				
30					35/10"				
32									
34		---dense			35/6"		5		
36									
38		---partially cemented, moderately hard			35/0"				

End of Exploration at 50.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY CEH ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No.
99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and Environmental Sciences

Drawing No.
A-22

99 03343701 GPJ

Log No. B-102

Date of Drilling: 9/23/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 43.0

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Samples: Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SILTY SAND With Gravel (SM); trace clay, very dense, light brown, slightly moist			35/9"				
		---with cobbles							
42		SANDY LEAN CLAY (CL); very stiff, dark brown, moist							
44					28				
46									
48									
		---stiff			13		48	68	A
50									
52									
54									
56									
58									

APPROVED BY ON

End of Exploration at 50.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and Environmental Sciences

Drawing No. A-24

99-33437-01 GPJ

Log No. B-103

Date of Drilling: 9/21/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 42.5

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Samples: Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		FILL: SILTY SAND With Clay; tan, dry			14				
2									
4					14				
		SILTY SAND With Gravel (SM); dense, tan, dry			26				
6		---with cobbles							
8									
					35		4		
10					25				
12									
14					42				
16									
18									
					26		3		

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and Environmental Sciences

Drawing No. A-25

V-01 9333701.GPJ

Log No. B-103

Date of Drilling: 9/21/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 42.5

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Samples: Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SILTY SAND With Gravel (SM); medium dense, tan, dry			24				
22									
24		---with cobbles, very dense			35/5"		3		
26									
28									
					35/0"				
30					59/8"				
32									A.G
34					62/8"				
36									
38		---partially cemented, moderately hard			35/0"				

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and

Drawing No.

LAB 9334370 GPJ

Log No. B-103

Date of Drilling: 9/21/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 42.5

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Samples: Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SILTY SAND With Gravel (SM); partially cemented, moderately hard, tan, dry							
42		SANDY LEAN CLAY (CL); very stiff, dark brown, slightly moist							
44			▼		21				K
		---stiff	◆		13				pp=2.5
46			▲						
48									
			▽		12		88	51	DS
50			△						
52									
54			▽		10				
			△						
56									
58			▽		12				
			△						

End of Exploration at 60.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY GLE ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and Environmental Sciences

Drawing No. A-27

81 93343701.CPJ

Log No. B-104

Date of Drilling: 9/21/99
Driller: D. Wilson
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 43.5

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		FILL: SILTY SAND With Gravel; tan, dry			9				
2		SILTY SAND With Gravel and Cobbles (SM); dense, tan, slightly moist							Sol
4					35/7"		3		
		—very dense			35/3"				
6									
8									
					45				
10					35/6"				
12									A.G.DS
14					55/7"		1		
16									
18									
					35/2"				

End of Exploration at 54.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No.
99-33437-01

Drawing No.
A-28

Converse Consultants

Over 50 Years of Dedication in Engineering and Environmental Sciences

31 03343701 CPJ

Log No. B-104

Date of Drilling: 9/21/99
Driller: D. Wilson
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 43.5

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Samples: Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		CEMENTED SAND AND GRAVEL; hard, tan, dry							
42									
		SILTY SAND (SM); medium dense, gray, wet							
44		SANDY LEAN CLAY (CL); very stiff, dark brown, slightly moist			18				pp=1..
46									
48									
					16				
50									
52									
54									
56									
58									

APPROVED BY ON

End of Exploration at 54.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and

Drawing No. A-20

01 99-33437-01 GPJ

Log No. B-105

Date of Drilling: 9/22/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 30.0

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		FILL: SILTY SAND With Clay and Gravel; tan, dry			6				
2		WELL GRADED SAND With Silt and Gravel (SW-SM); trace clay, dense, tan, slightly moist							
		—with cobbles, very dense							
4					35/4"				
					35/7"				
6									
8									
		---dense			35/8"		5		
10					35/4"				
12									G
14		---very dense			60/9"		4		
16									
		---partially cemented, moderately hard							
18									
					52				

End of Exploration at 40.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and

Drawing No. A-24

Log No. B-105

Date of Drilling: 9/22/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 30.0

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Samples: Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		WELL GRADED SAND With Silt and Gravel (SW-SM); dense, grayish brown, slightly moist			44				
22									A;P;K
24					35/1"				
26									
28									
		---with cobbles			35/3"				
30					35/2"		3		
32									K
34					35		13	122	
36									
38		CEMENTED SAND AND GRAVEL; hard, grayish brown, slightly moist			35/0"				

End of Exploration at 40.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY GN

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and

Drawing No. A-22

99 9334370 1 GPJ

Log No. B-106

Date of Drilling: 9/22/99
Driller: T. High
Logged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 30.0

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SILTY SAND With Gravel (SM); medium dense, grayish brown, dry			23				
2									A;G;Sol; Ch
4		---very dense			35/6"		7	111	
		---tan			52/9"				
6									
8									
					44				
10		---dense			37				
12									
		---very dense							
14					60/11"		5		
16									
18									
					58/7"				

End of Exploration at 33.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

Converse Consultants

Over 50 Years of Dedication in Engineering and

Drawing No. A-33

Log No. B-106

e of Drilling: 9/22/99
er: T. High
ged By: M. Stacy

Location: See Drawing No. 2
Borehole Diameter: 8"
Groundwater Depth (ft): 30.0

Ground Surface Elevation (ft): Not Available
Equipment: BK-81 Hollow Stem Auger
Driving Wt. and Drop: 140#/30"

DRAFTED BY GLE

SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read with the report. This summary applies only at the location and time of the exploration. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplified model of the actual conditions encountered.

Depth (ft)	Graphic Log	Summary of Subsurface Conditions	Samples: Drive	Samples: Bulk	Samples: Blow Count	Drill Rate (sec/ft)	Moisture (%)	Dry Density (lb/cf)	Field or Lab Tests
		SILTY SAND With Gravel (SM); dense, grayish brown, dry			35/2"				
22									
		—with cobbles							
24					35/6"				
26									
28									
					35/8"		15	114	Ch
30		---gray, wet							
		CEMENTED SAND AND GRAVEL; hard, gray, wet							
32									
34									
36									
38									

End of Exploration at 33.0'

Converse Sampler (white symbol=no recovery) SPT Sampler (white symbol=no recovery)

APPROVED BY ON

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Project No. 99-33437-01

Drawing No. A-34

Converse Consultants

Over 50 Years of Dedication in Engineering and Environmental Sciences

99-33437-01.GPJ

KEY TO SOILS SYMBOLS AND TERMS

Terms used in this report for describing soils according to thier texture and grain size distributions are generally in accordance with the UNIFIED SOILS CLASSIFICATION SYSTEM.

TERMS DESCRIBING CONDITION, CONSISTENCY, AND HARDNESS

COARSE GRAINED SOILS (major portion retained on No. 200 sieve) includes cleon gravels, silty or clayey gravels, and silty, clayey, or gravelly sands. Consistency is rated according to relative density, os determined by laboratory tests.

DESCRIPTIVE TERM	RELATIVE DENSITY
very loose	0 to 15%
loose	15 to 40%
medium dense	40 to 70%
dense	70 to 85%
very dense	85 to 100%

FINE GRAINED SOILS (major portion passing No. 200 sieve) includes inorganic and organic silts and clays, gravelly, silty, or sandy clays, and clayey silts. Consistency is rated according to shearing strength as indicated by penetrometer readings or by direct shear tests.

DESCRIPTIVE TERM	SHEAR STRENGTH (ksf)
very soft	less than 0.25
soft	0.25 to 0.50
firm	0.50 to 1.00
stiff	1.00 to 2.00
very stiff	2.00 to 4.00
hard	4.00 and up

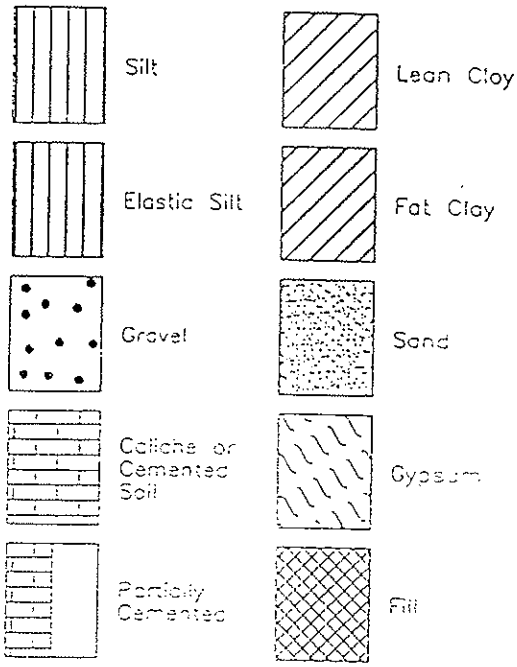
ROCK includes gravels, cobbles, rock, caliche, and bedrock materials. Hardness is relcted to field identification procedures described below.

DESCRIPTIVE TERM	SHEAR STRENGTH (ksf)
soft	can be dug by hand and crushed by fingers
moderately hard	friable, can be gouged deeply with knife and will crumble readily under light hammer blows
hard	knife scratch leaves dust trace and will withstand a few hammer blows before breaking
very hard	scratched with knife with difficulty and is difficult to break with hammer blows

SIZE PROPORTIONS

DESIGNATION	PERCENT BY WEIGHT
trace	0 to 5
few	5 to 10
little	15 to 25
some	30 to 45

SOIL TYPE GRAPHIC KEY



SOIL TYPE GRAPHIC KEY

MOISTURE CONTENT IS INDICATED BY

dry
slightly moist
moist
very moist
wet

LEGEND OF LABORATORY TESTS

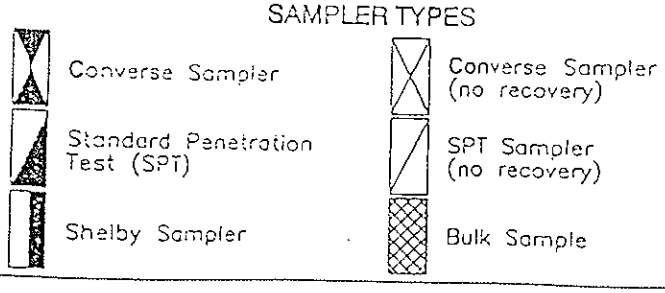
A	Liquid & Plastic Limits	G	Grain	R	Resistivity
C	Consolidation	H	Horticultural Tests	RV	R-Value
Ch	Chemical	K	Permeability	S	Swell
Disp	Dispersion	N	Chemical Heave	Sol	Solubility
DR	Drill Rate	P	Compaction	T	Triaxial
DS	Direct Shear	pp	Unconfined Compressive Strength (tsf)	UU	Unconsolidated, Undrained

GROUNDWATER LEVEL KEY

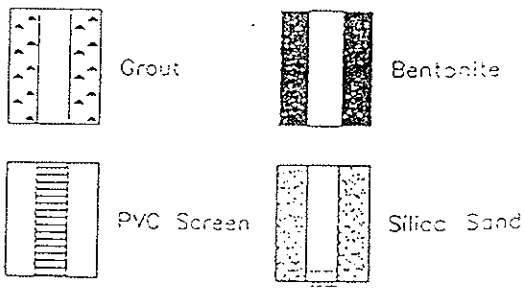
Water level during drilling

Stabilized water level

SAMPLER TYPES



WELL DESIGN GRAPHIC KEY



CONVERSE CONSULTANTS

Over 50 Years of Dedication in Engineering and Environmental Sciences

Drawing No.

A-35

CLASSIFICATION OF SOILS

ASTM Designation: D2487-93
(ASTM version of Unified Soil Classification System)

			Criteria for Assigning Group Symbols and Group Names using Laboratory Tests[a]	Soil Classification Group Symbol	Soil Classification Group Name[b]
COARSE-GRAINED SOILS More than 50% retained on No. 200 sieve	Gravels More than 50% of coarse fraction retained on #4 sieve	Clean Gravels Less than 5% fines[c]	$Cu \geq 4$ and $1 \leq Cc \leq 3$[e]	GW	Well-graded gravel[f]
			$Cu < 4$ and/or $Cc < 1$ or $Cc > 3$[e]	GP	Poorly graded gravel[f]
		Gravels with Fines More than 12% fines[c]	Fines classify as ML or MH	GM	Silty gravel[f,g,h]
			Fines classify as CL or CH	GC	Clayey gravel[f,g,h]
	Sands 50% or more of coarse fraction passes #4 sieve	Clean Sands Less than 5% fines[d]	$Cu \geq 6$ and $1 \leq Cc \leq 3$[e]	SW	Well-graded sand[i]
			$Cu < 6$ and/or $Cc < 1$ or $Cc > 3$[e]	SP	Poorly graded sand[i]
		Sands with Fines More than 12% fines[d]	Fines classify as ML or MH	SM	Silty sand[g,h,i]
			Fines classify as CL or CH	SC	Clayey sand[g,h,i]
FINE-GRAINED SOILS 50% or more passes the No. 200 sieve	Silts and Clays Liquid limit less than 50	Inorganic	PI > 7 and plots on or above "A" line[j]	CL	Lean clay[k,l,m]
			PI < 4 or plots below "A" line[j]	ML	Silt[k,l,m]
		Organic	Liquid limit - oven dried / Liquid limit - not dried < 0.75	OL	Organic clay[k,l,m,n] / Organic silt[k,l,m,o]
	Silts and Clays Liquid limit 50 or more	Inorganic	PI plots on or above "A" line	CH	Fat clay[k,l,m]
			PI plots below "A" line	MH	Elastic silt[k,l,m]
		Organic	Liquid limit - oven dried / Liquid limit - not dried < 0.75	OH	Organic clay[k,l,m,p] / Organic silt[k,l,m,q]
HIGHLY ORGANIC SOILS	Primarily organic matter, dark in color, and organic odor			PT	Peat

a. Based on the material passing the 3-in. (75-mm) sieve.

b. If field sample contained cobbles or boulders, or both, add "with cobbles" or "with boulders", or both to group name.

c. GW-GM well graded gravel with silt
GW-GC well graded gravel with clay
GP-GM poorly graded gravel with silt
GP-GC poorly graded gravel with clay

d. Sands with 5-12% fines require dual symbols:
SW-SM well graded sand with silt
SW-SC well graded sand with clay
SP-SM poorly graded sand with silt
SP-SC poorly graded sand with clay

e. $Cu = \frac{D_{60}}{D_{10}}$ $\quad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$

f. If soil contains ≥ 15% sand, add "with sand" to group name.

g. If fines classify as CL-ML, use dual symbol GC-GM or SC-SM.

h. If fines are organic, add "with organic fines" to group name.

i. If soil contains ≥ 15% gravel, add "with gravel" to group name.

j. If Atterberg limits plot in hatched area, soil is a CL-ML silty clay.

k. If soil contains 15-29% plus No. 200, add "with sand" or "with gravel", whichever is predominant.

l. If soil contains ≥ 30% plus No. 200, predominantly sand, add "sandy" to group name.

m. If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

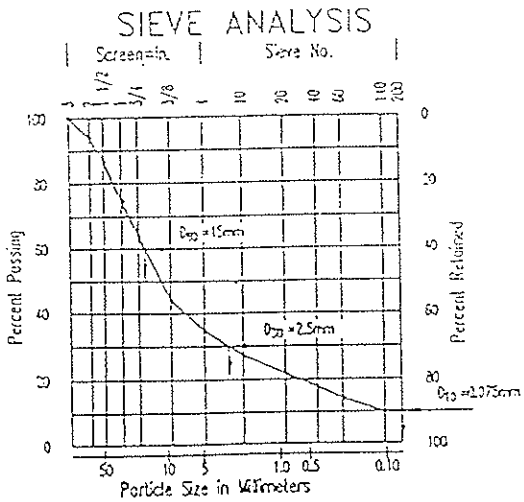
n. PI ≥ 4 and plots on or above "A" line

o. PI < 4 or plots below "A" line

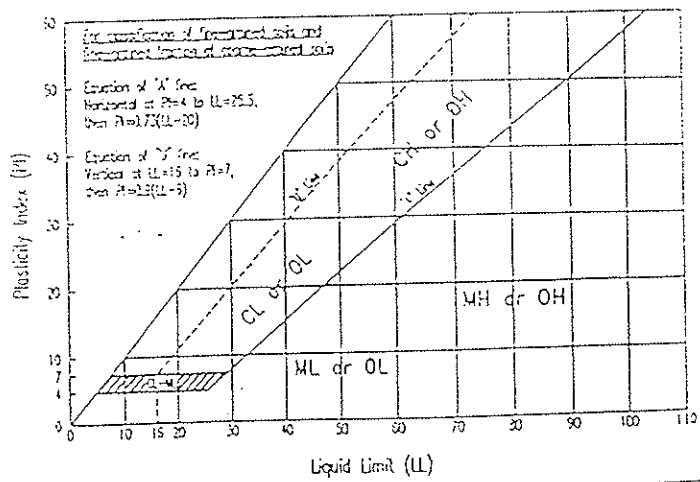
p. PI plots on or above "A" line

q. PI plots below "A" line

SIEVE ANALYSIS



$Cu = \frac{D_{60}}{D_{10}} = \frac{15}{0.075} = 200$ $\quad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}} = \frac{(2.5)^2}{0.075 \times 15} = 5.6$

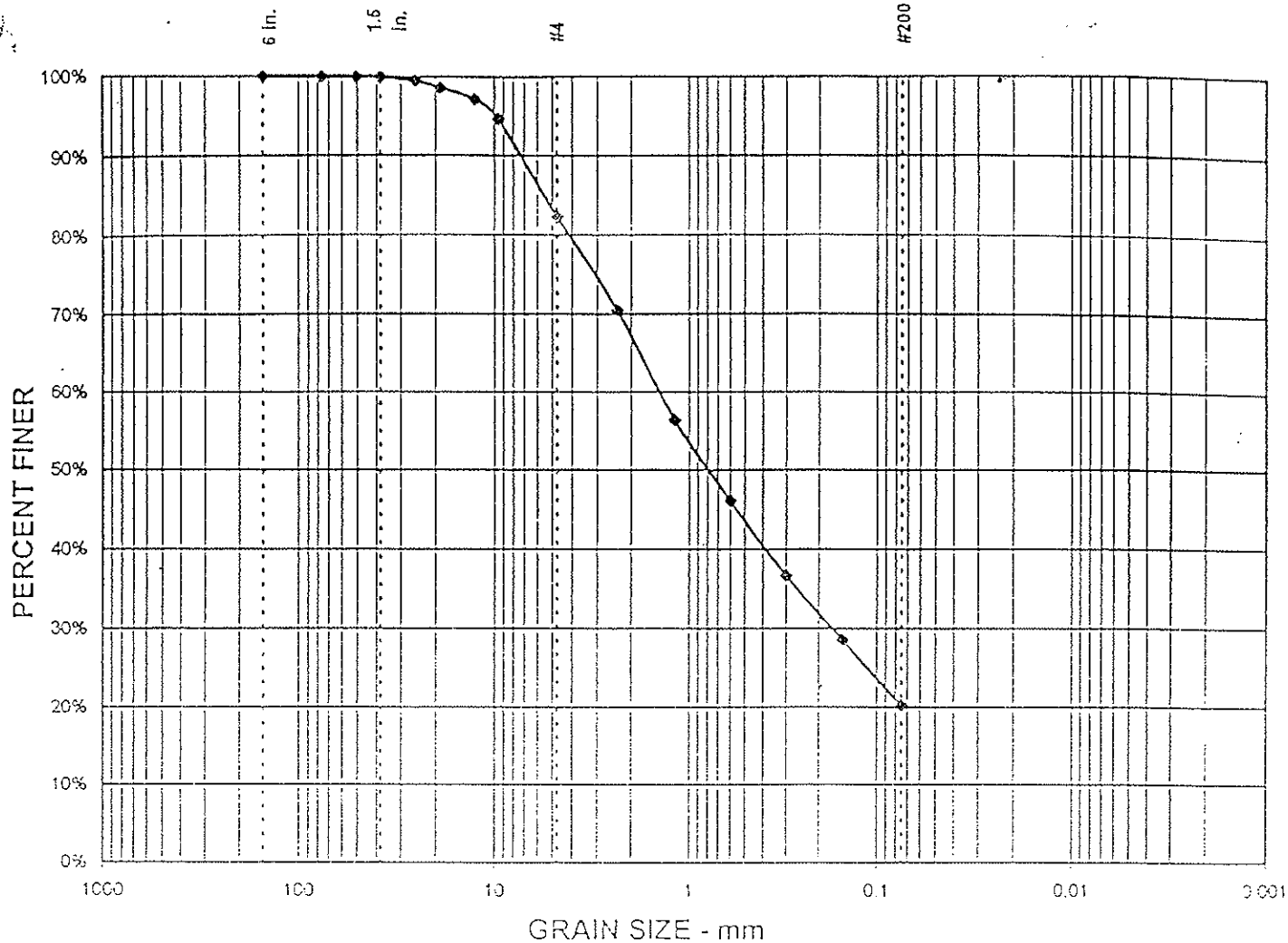


Drawing No.

CONVERSE CONSULTANTS

Over 50 Years of Dedication in Engineering and Environmental Sciences

GRAIN SIZE DISTRIBUTION GRAPH



TEST SUMMARY

% GRAVEL =	18%	D_{85} = 5.5	D_{15} =
% SAND =	62%	D_{50} = 1.4	D_{10} =
% SILT & CLAY =	20%	D_{50} = 0.8	C_u =
		D_{30} = 0.2	C_c =

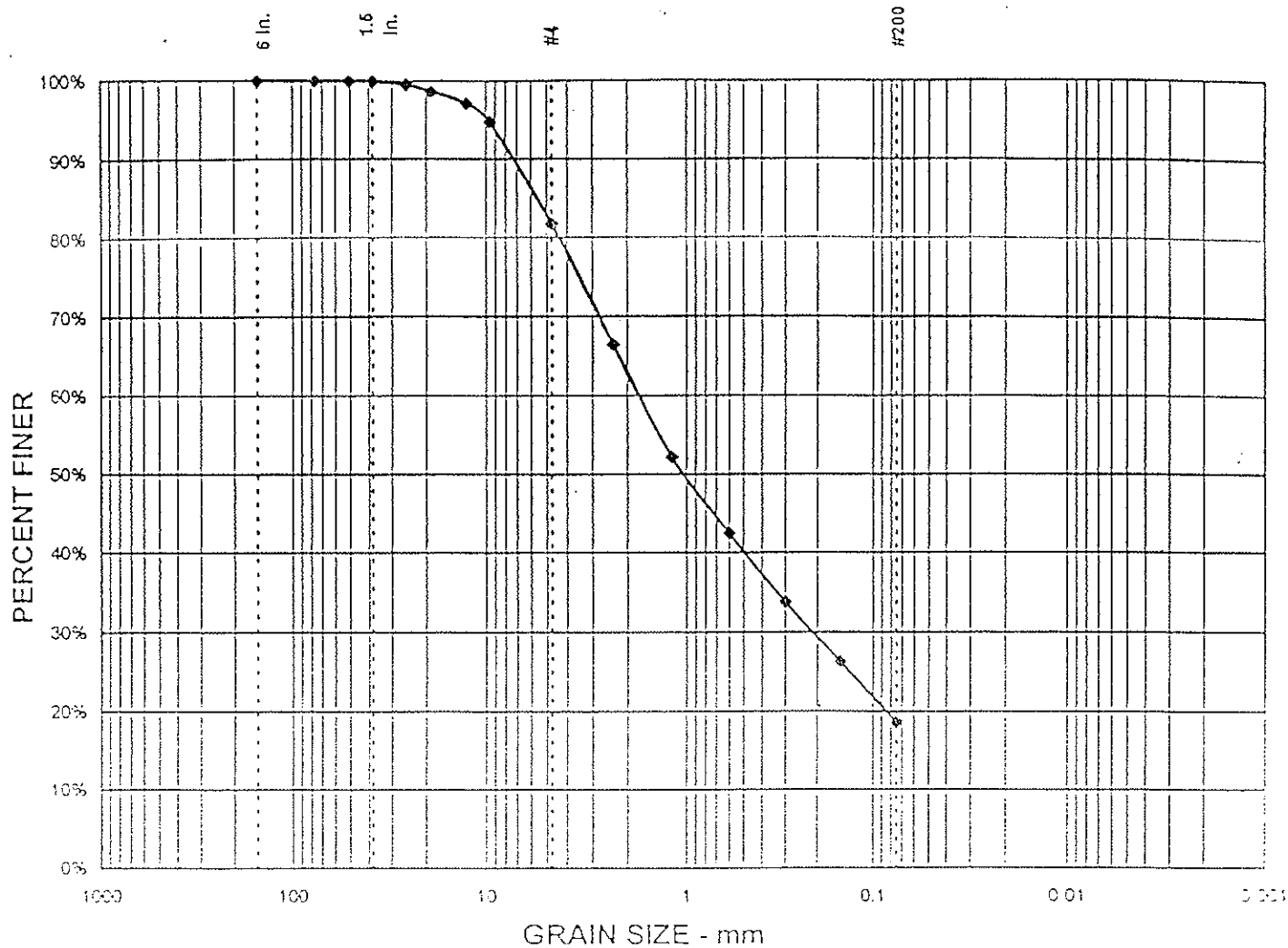
Project No.: 99-33437-01
Project Name: BMI Landfill
Date sampled: Oct 1999
Location: B 1 @ 20-25'
Silty Sand with Gravel

GRAIN SIZE DISTRIBUTION TEST REPORT

CONVERSE CONSULTANTS

Drawing No. A-37

GRAIN SIZE DISTRIBUTION GRAPH



TEST SUMMARY

% GRAVEL =	18%	D_{85} = 5.6	D_{15} =
% SAND =	63%	D_{60} = 1.7	D_{10} =
% SILT & CLAY =	19%	D_{50} = 1.0	C_u =
		D_{30} = 0.2	C_c =

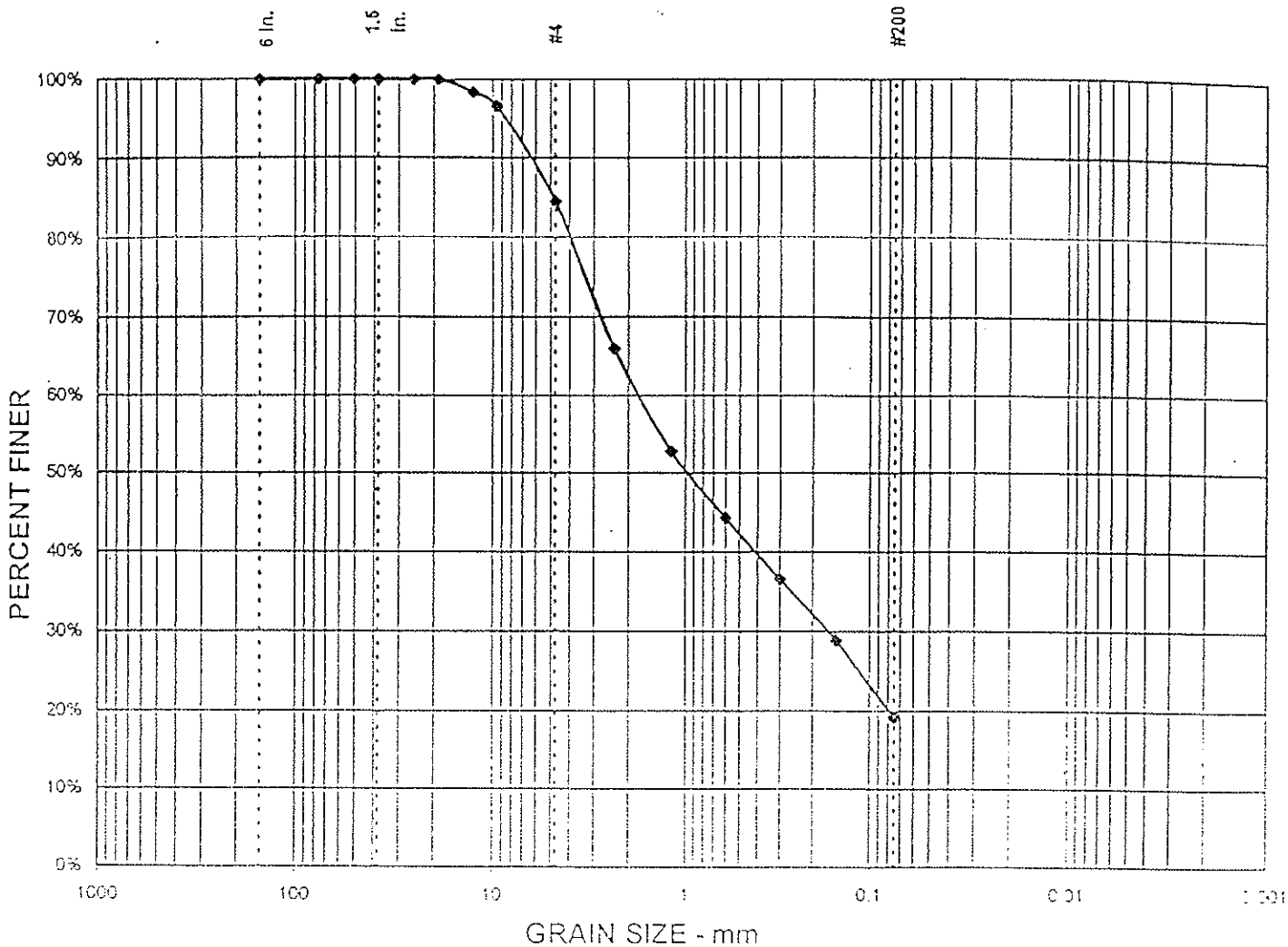
Project No.: 99-33437-01
Project Name: BMI Landfill
Date sampled: Oct 1999
Location: B 1 @ 30-35'
Silty Sand with Gravel

GRAIN SIZE DISTRIBUTION TEST REPORT

CONVERSE CONSULTANTS

Drawing No. A-38

GRAIN SIZE DISTRIBUTION GRAPH



TEST SUMMARY

% GRAVEL =	16%	D_{85} = 4.9	D_{15} =
% SAND =	65%	D_{60} = 1.7	D_{10} =
% SILT & CLAY =	19%	D_{50} = 0.9	C_u =
		D_{30} = 0.2	C_c =

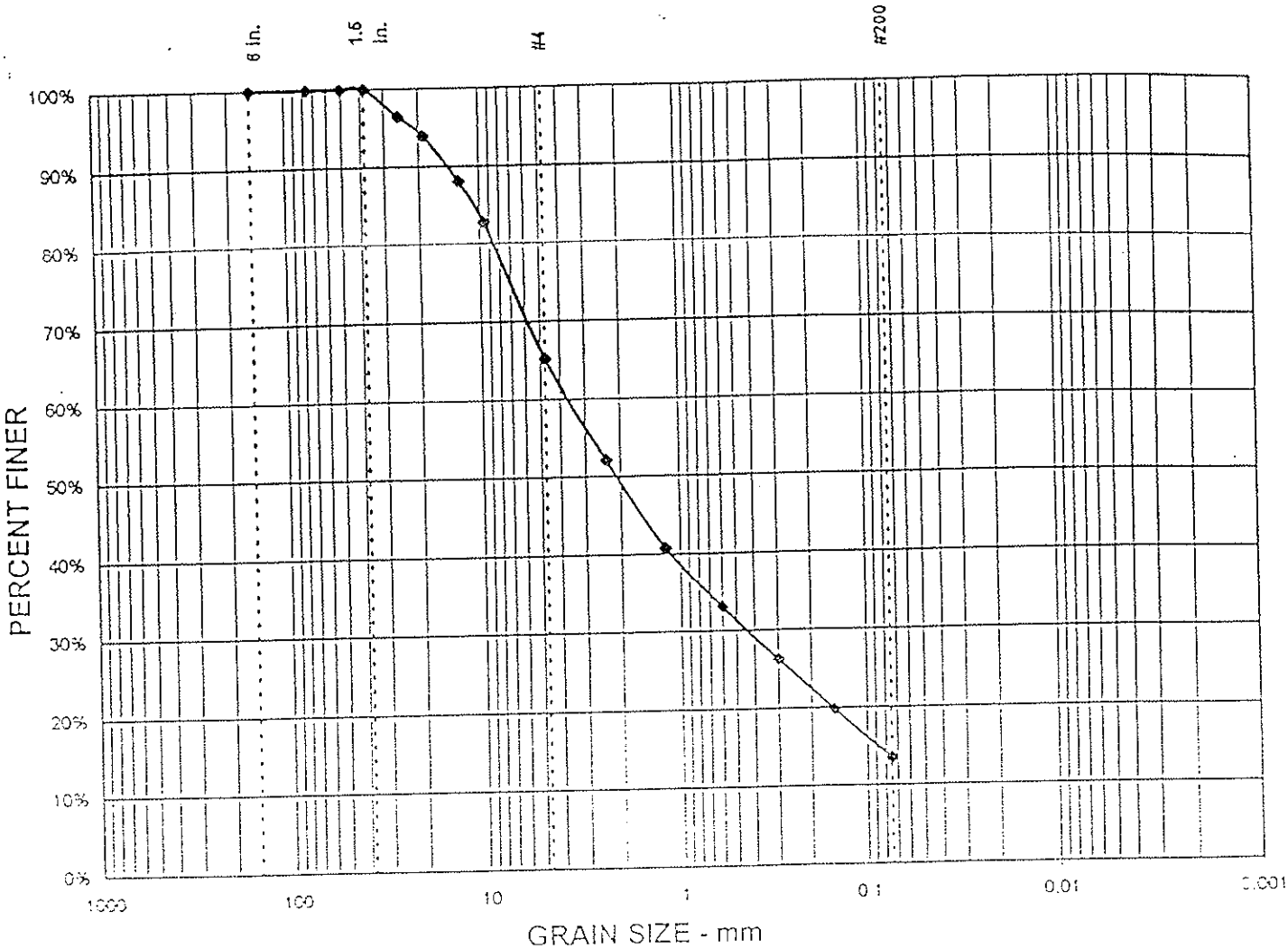
Project No.: 99-33437-01
Project Name: BMI Landfill
Date sampled: Oct 1999
Location: B5 @ 20-25'
Silty Sand with Gravel

GRAIN SIZE DISTRIBUTION TEST REPORT

CONVERSE CONSULTANTS

Drawing No. A-39

GRAIN SIZE DISTRIBUTION GRAPH



TEST SUMMARY

% GRAVEL =	35%	D_{35} = 10.8	D_{15} = 0.1
% SAND =	52%	D_{50} = 3.6	D_{10} =
% SILT & CLAY =	14%	D_{50} = 2.1	C_u =
		D_{30} = 0.4	C_c =

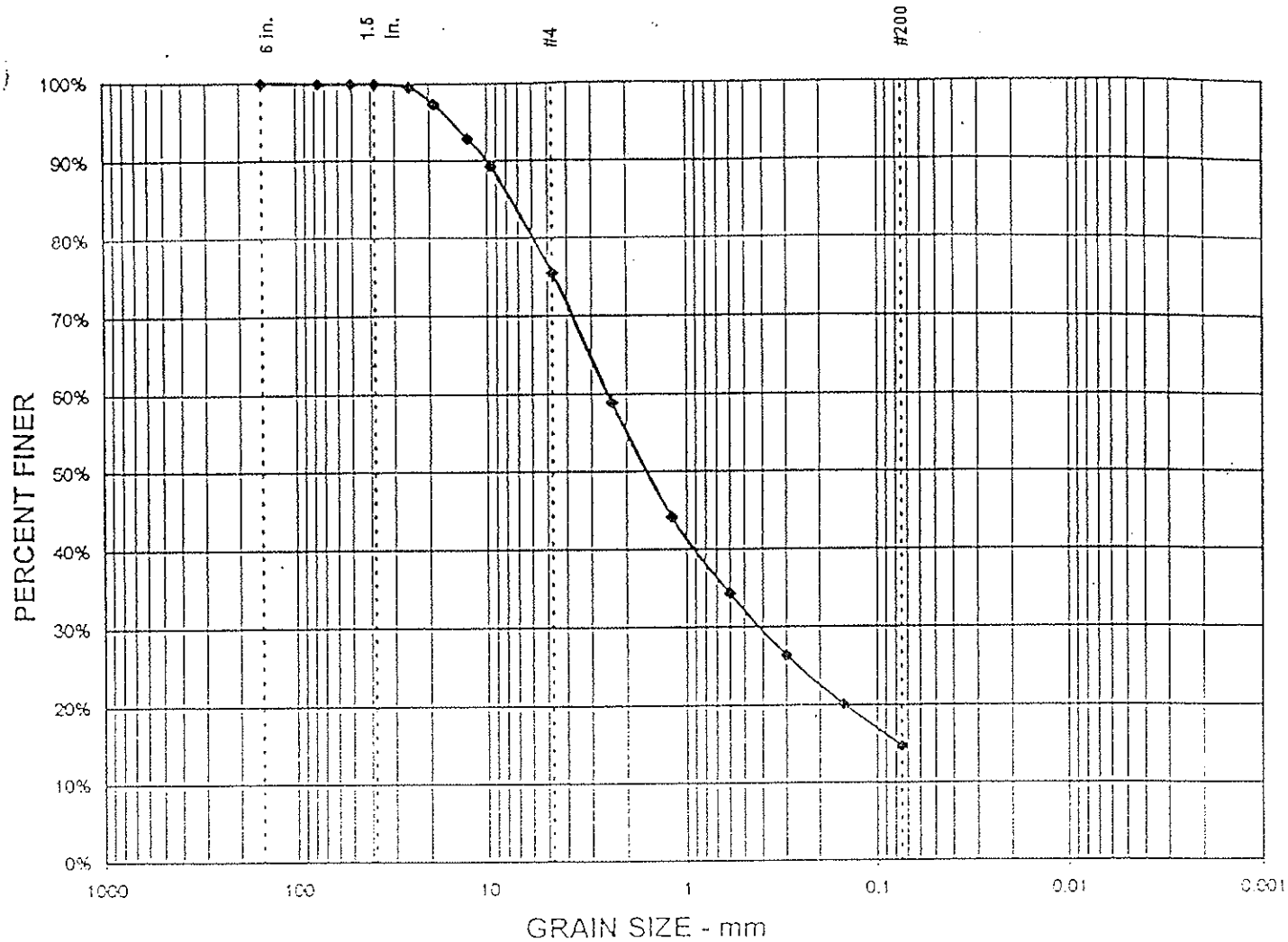
Project No.: 99-33437-01
Project Name: BMI Landfill
Date sampled: Oct 1999
Location: B 8 @ 35-40'
Silty Sand with Gravel

GRAIN SIZE DISTRIBUTION TEST REPORT

CONVERSE CONSULTANTS

Drawing No. A-4

GRAIN SIZE DISTRIBUTION GRAPH



TEST SUMMARY

% GRAVEL =	24%	D_{35} = 7.7	D_{15} = 0.1
% SAND =	61%	D_{50} = 2.5	D_{10} =
% SILT & CLAY =	15%	D_{50} = 1.5	C_u =
		D_{30} = 0.4	C_c =

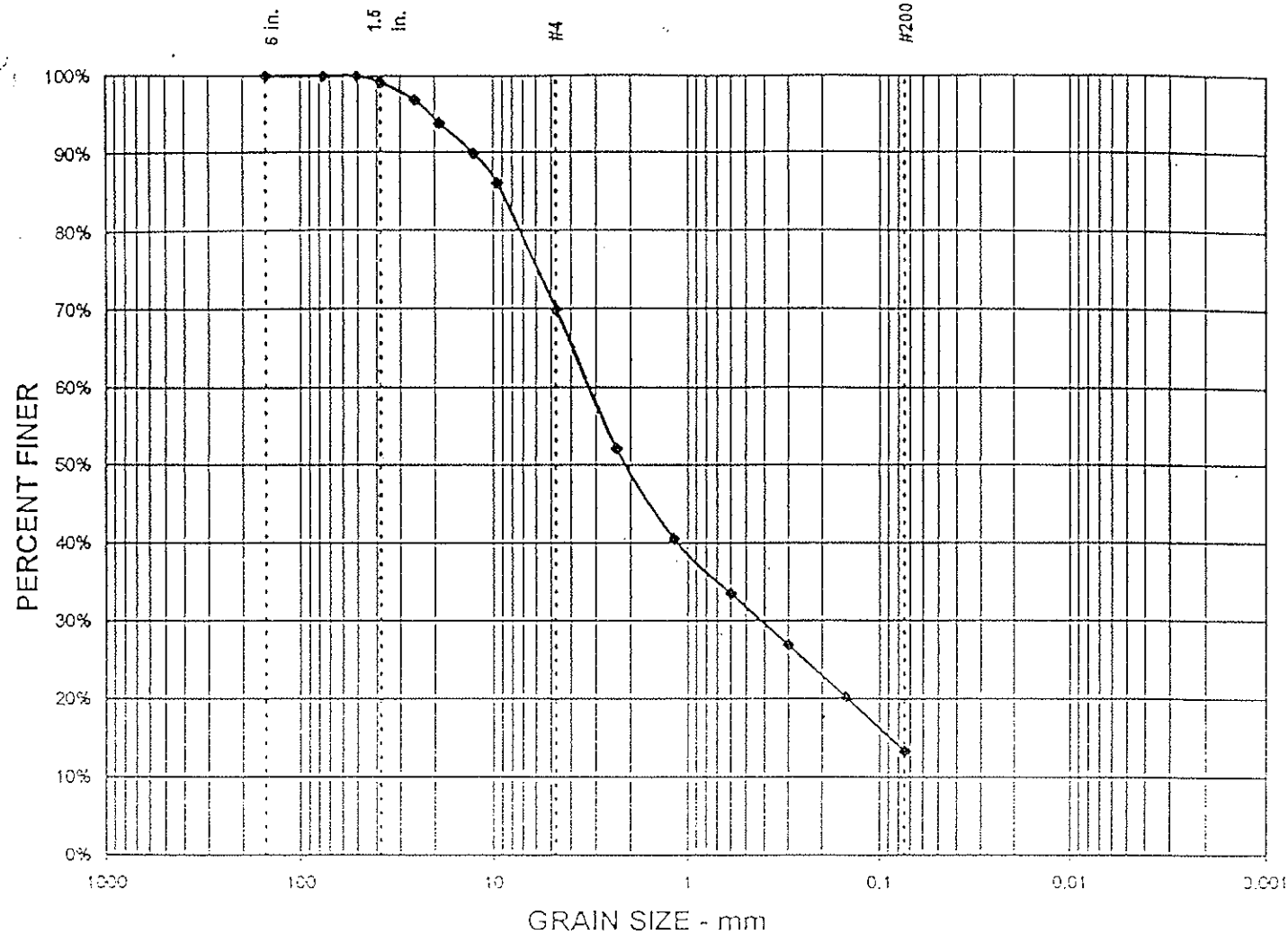
Project No.: 99-33437-01
Project Name: BMI Landfill
Date sampled: Oct 1999
Location: B 10 @ 30-35'
Silty Sand with Gravel

GRAIN SIZE DISTRIBUTION TEST REPORT

CONVERSE CONSULTANTS

Drawing No. A-41

GRAIN SIZE DISTRIBUTION GRAPH



TEST SUMMARY

% GRAVEL =	30%	D_{85} = 9.1	D_{15} = 0.1
% SAND =	57%	D_{60} = 3.2	D_{10} =
% SILT & CLAY =	13%	D_{50} = 2.1	C_u =
		D_{30} = 0.4	C_c =

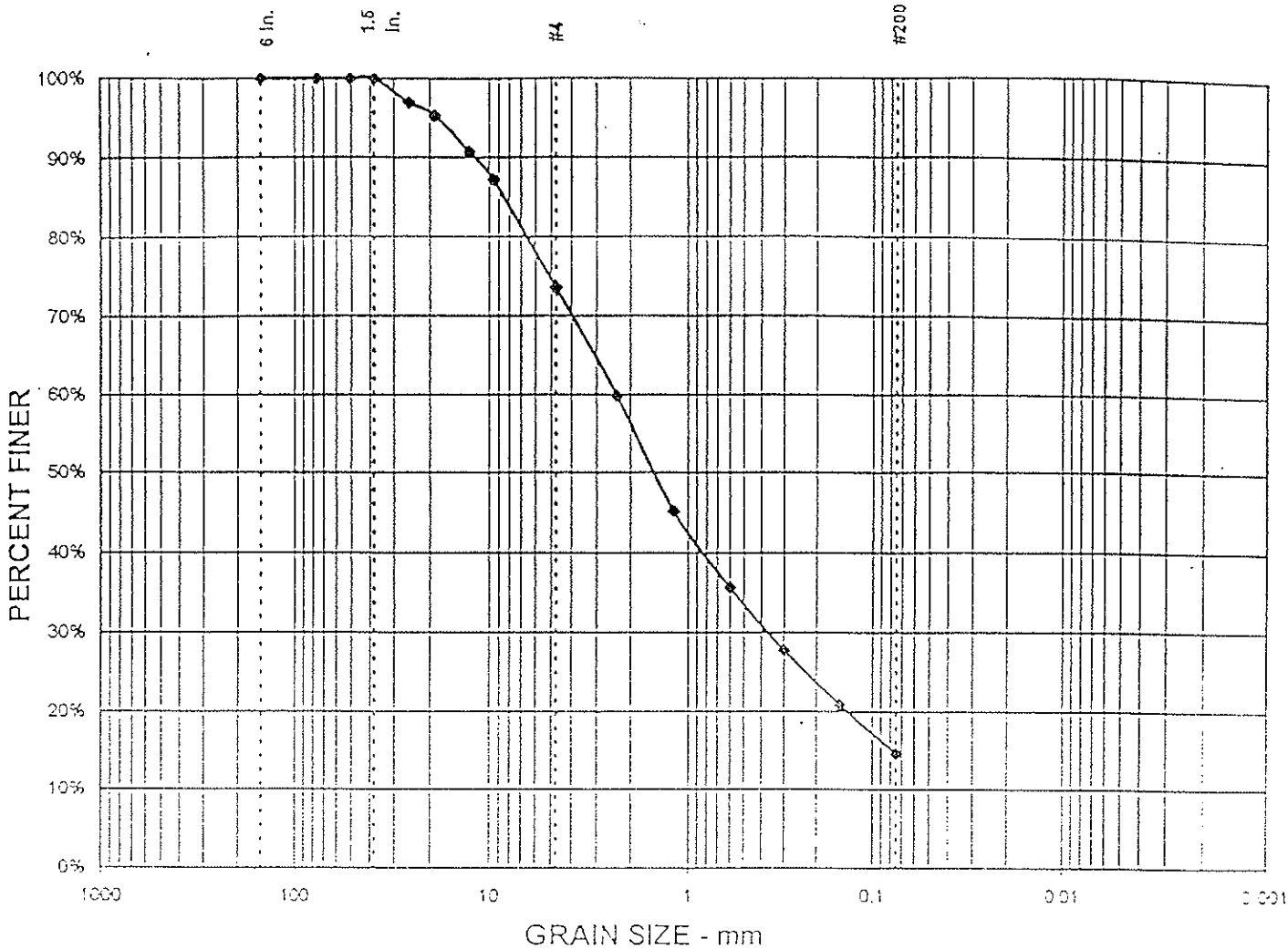
Project No.: 99-33437-01
Project Name: BMI Landfill
Date sampled: 10/01/99
Location: B12 @ 10-15'
Silty Sand with Gravel

GRAIN SIZE DISTRIBUTION TEST REPORT

CONVERSE CONSULTANTS

Drawing No. A-42

GRAIN SIZE DISTRIBUTION GRAPH



TEST SUMMARY

% GRAVEL =	26%	D_{85} = 8.5	D_{15} = 0.1
% SAND =	59%	D_{60} = 2.4	D_{10} =
% SILT & CLAY =	15%	D_{50} = 1.5	C_u =
		D_{30} = 0.4	C_c =

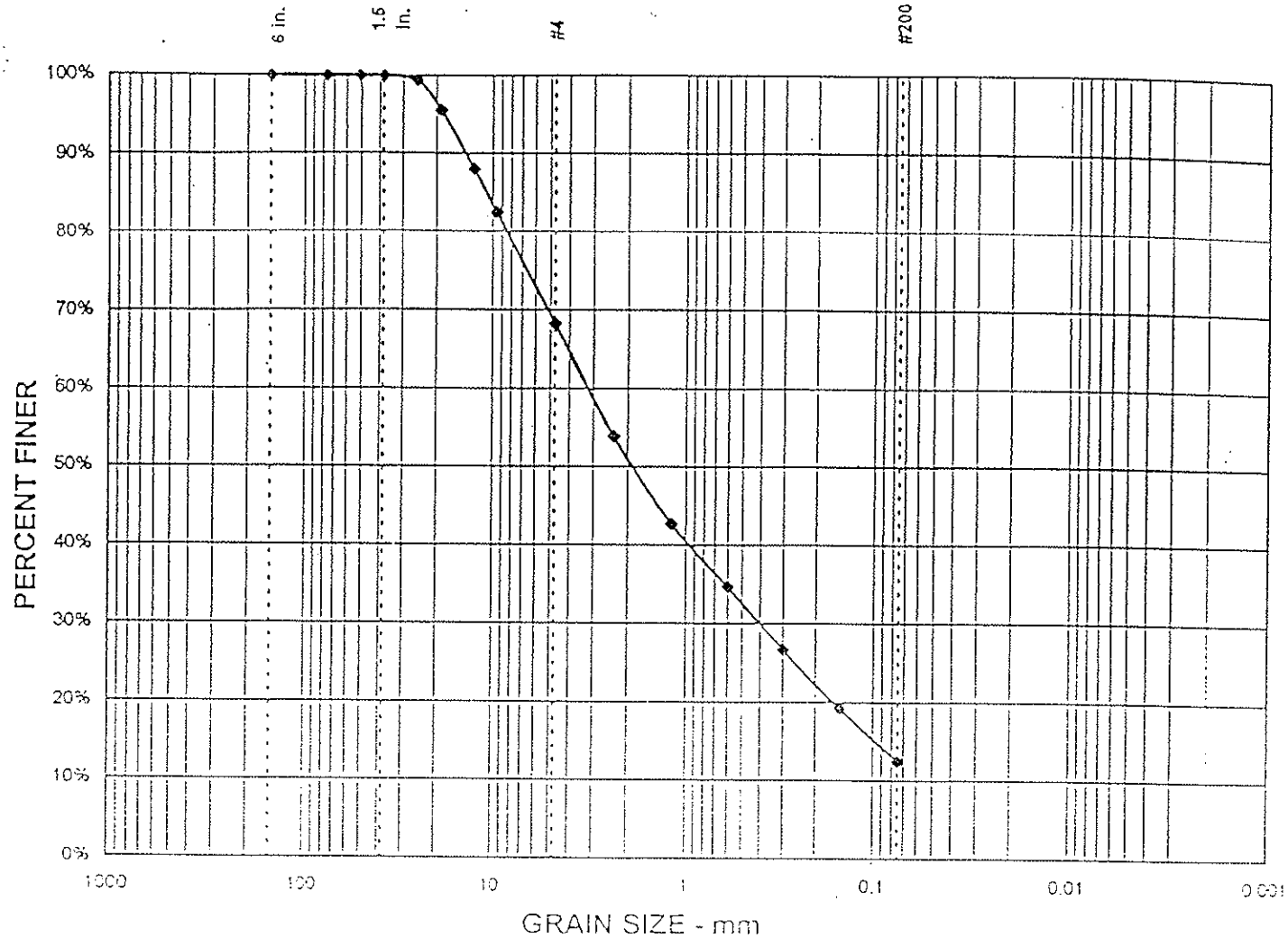
Project No.: 99-33437-01
Project Name: BMI Landfill
Date sampled: Oct 1999
Location: B 101 @ 5-10'
Silty Sand with Gravel

GRAIN SIZE DISTRIBUTION TEST REPORT

CONVERSE CONSULTANTS

Drawing No. A-4

GRAIN SIZE DISTRIBUTION GRAPH



TEST SUMMARY

% GRAVEL =	32%	D_{85} = 10.9	D_{15} = 0.1
% SAND =	56%	D_{60} = 3.2	D_{10} =
% SILT & CLAY =	12%	D_{50} = 1.9	C_u =
		D_{30} = 0.4	C_c =

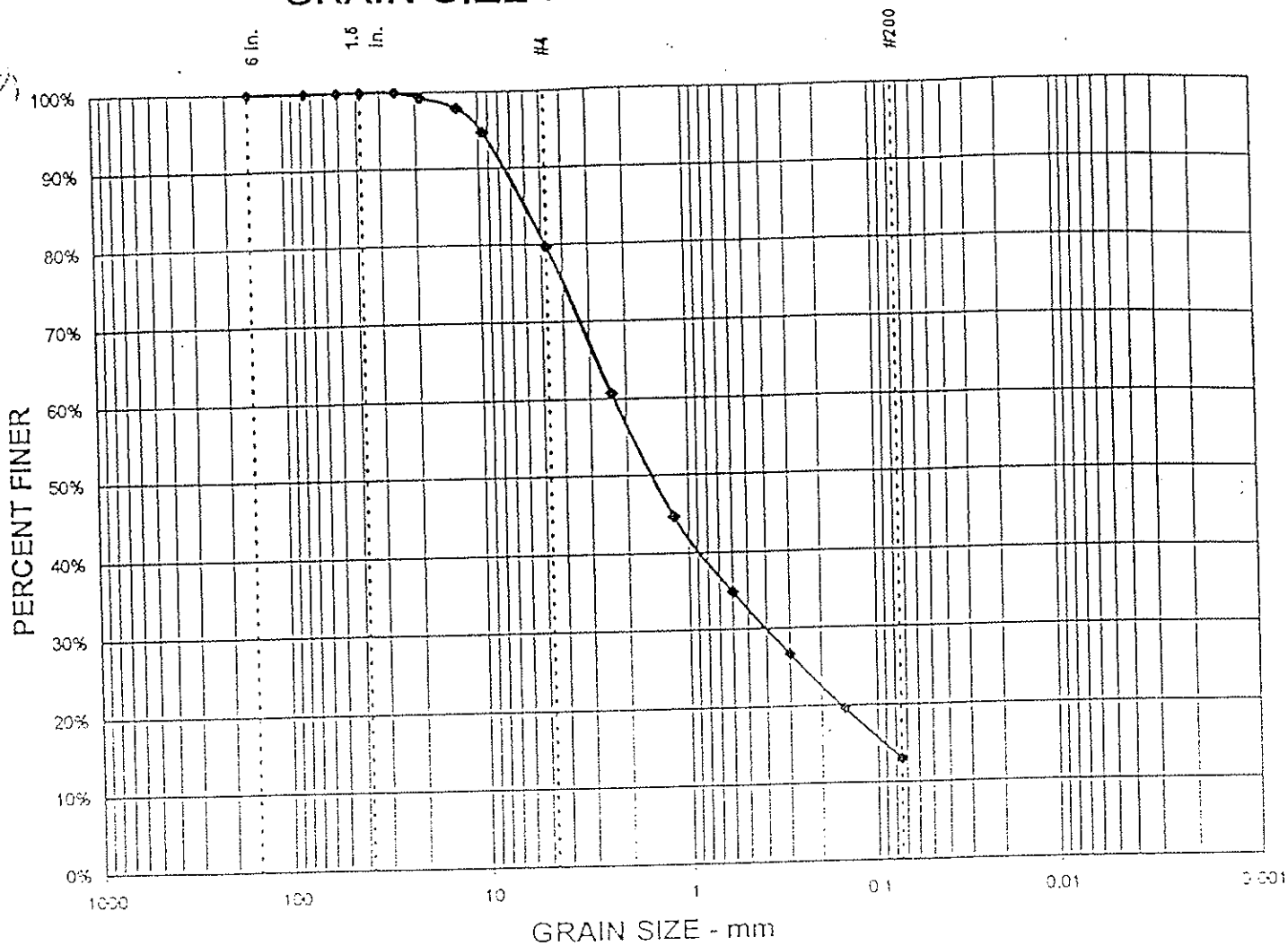
Project No.: 99-33437-01
Project Name: BMI Landfill
Date sampled: Oct 1999
Location: B 102 @ 20-25'
Silty Sand with Gravel

GRAIN SIZE DISTRIBUTION TEST REPORT

CONVERSE CONSULTANTS

Drawing No. A-44

GRAIN SIZE DISTRIBUTION GRAPH



TEST SUMMARY

% GRAVEL =	20%	D_{85} = 6.1	D_{15} = 0.1
% SAND =	67%	D_{60} = 2.3	D_{10} =
% SILT & CLAY =	13%	D_{50} = 1.5	C_u =
		D_{30} = 0.4	C_c =

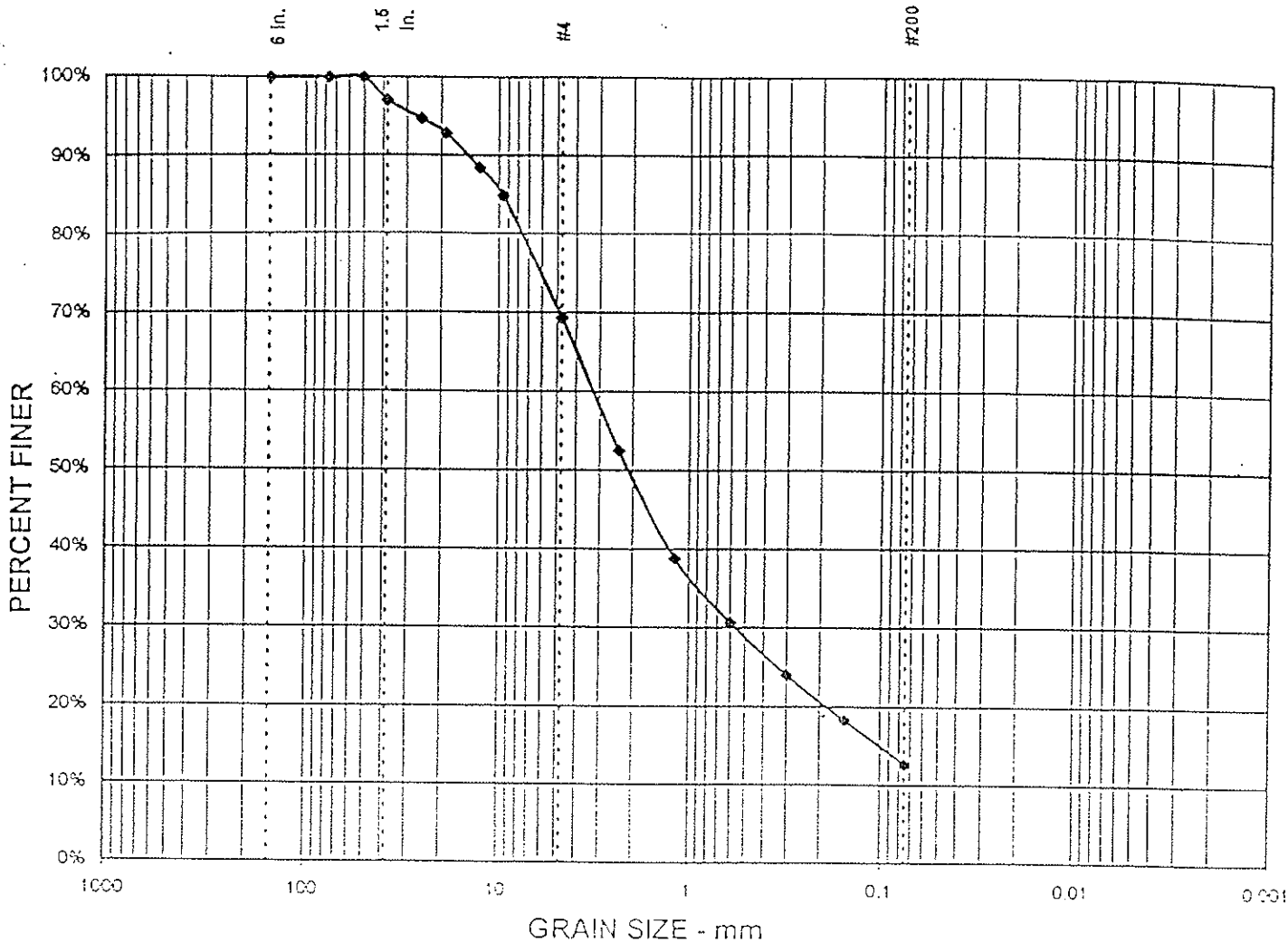
Project No.: 99-33437-01
Project Name: BMI Landfill
Date sampled: Oct 1999
Location: B 103 @ 30-35'
Silty Sand with Gravel

GRAIN SIZE DISTRIBUTION TEST REPORT

CONVERSE CONSULTANTS

Drawing No. A-4

GRAIN SIZE DISTRIBUTION GRAPH



TEST SUMMARY

% GRAVEL =	31%	D_{85} = 9.6	D_{15} = 0.1
% SAND =	57%	D_{60} = 3.2	D_{10} =
% SILT & CLAY =	13%	D_{50} = 2.1	C_u =
		D_{30} = 0.6	C_c =

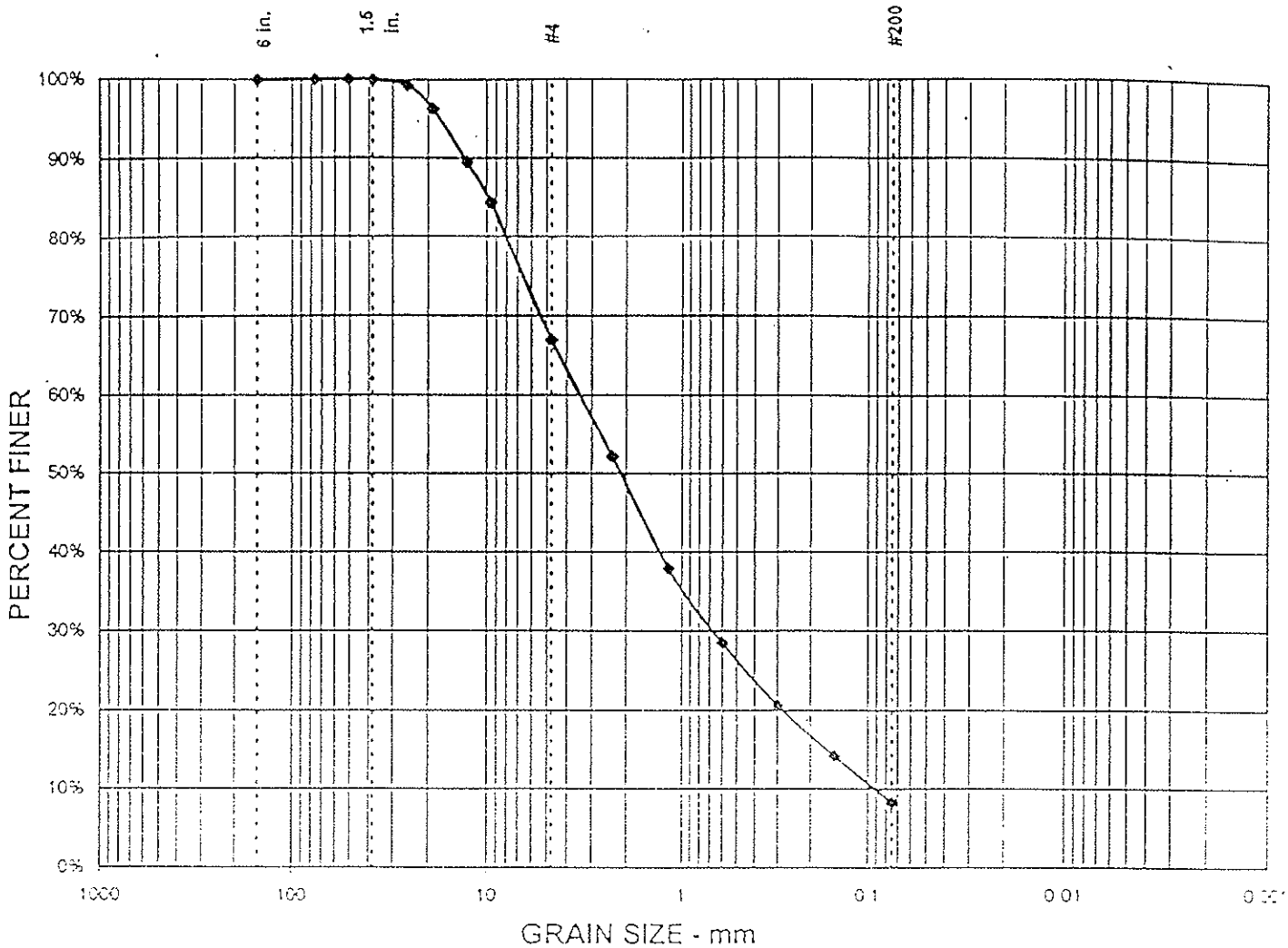
Project No.: 99-33437-01
Project Name: BMI Landfill
Date sampled: Oct 1999
Location: B 104 @ 10-15'
Silty Sand with Gravel

GRAIN SIZE DISTRIBUTION TEST REPORT

CONVERSE CONSULTANTS

Drawing No. A-46

GRAIN SIZE DISTRIBUTION GRAPH



TEST SUMMARY

% GRAVEL =	33%	D_{85} = 9.9	D_{15} = 0.2
% SAND =	59%	D_{60} = 3.4	D_{10} = 0.1
% SILT & CLAY =	8%	D_{50} = 2.1	C_u = 37.4
		D_{30} = 0.7	C_c = 1.4

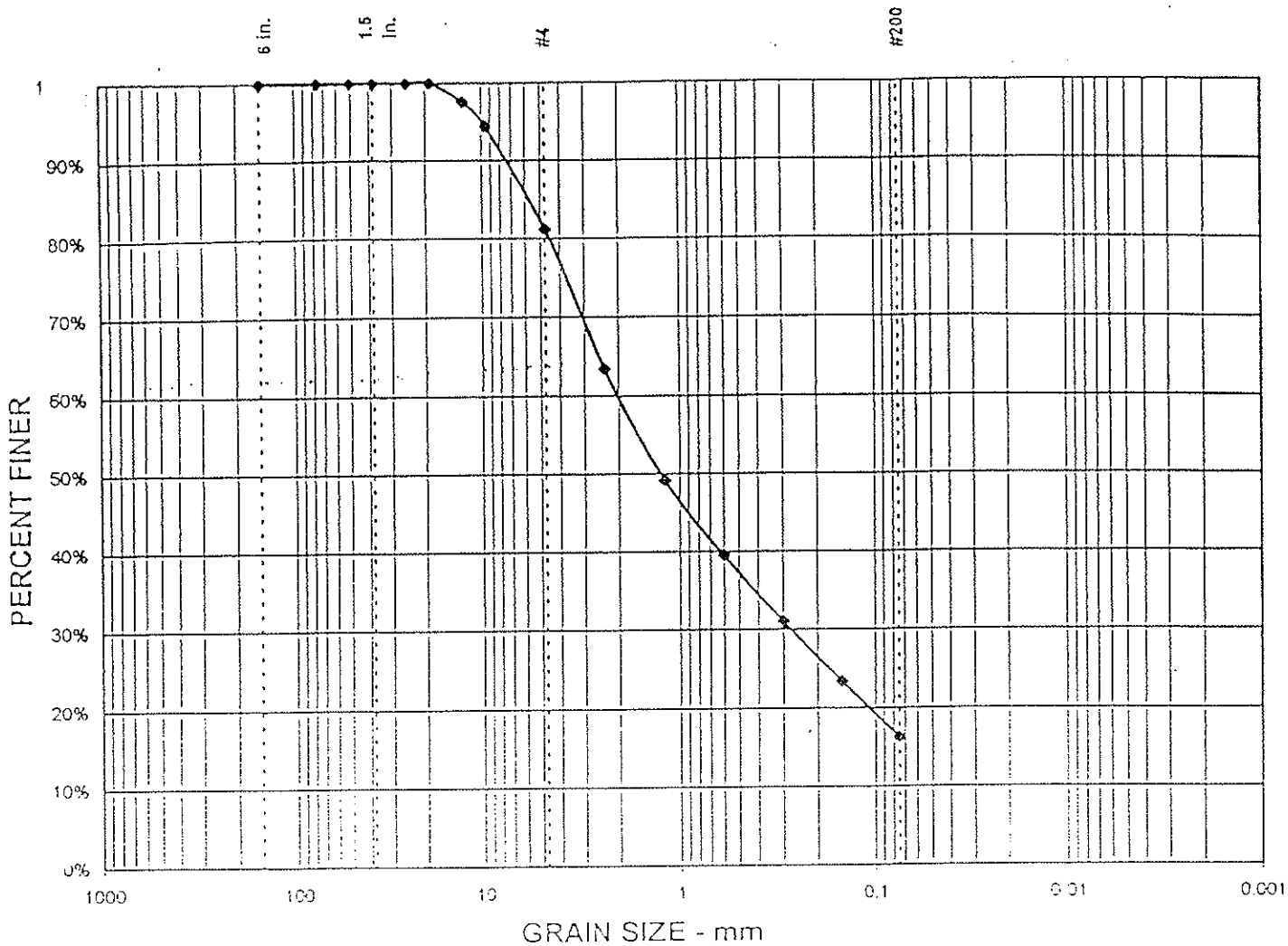
Project No.: 99-33437-01
Project Name: BMI Landfill
Date sampled: Oct 1999
Location: B105 @ 20-25'
Well Graded Sand with Silt & Gravel

GRAIN SIZE DISTRIBUTION TEST REPORT

CONVERSE CONSULTANTS

Drawing No. A-47

GRAIN SIZE DISTRIBUTION GRAPH



TEST SUMMARY

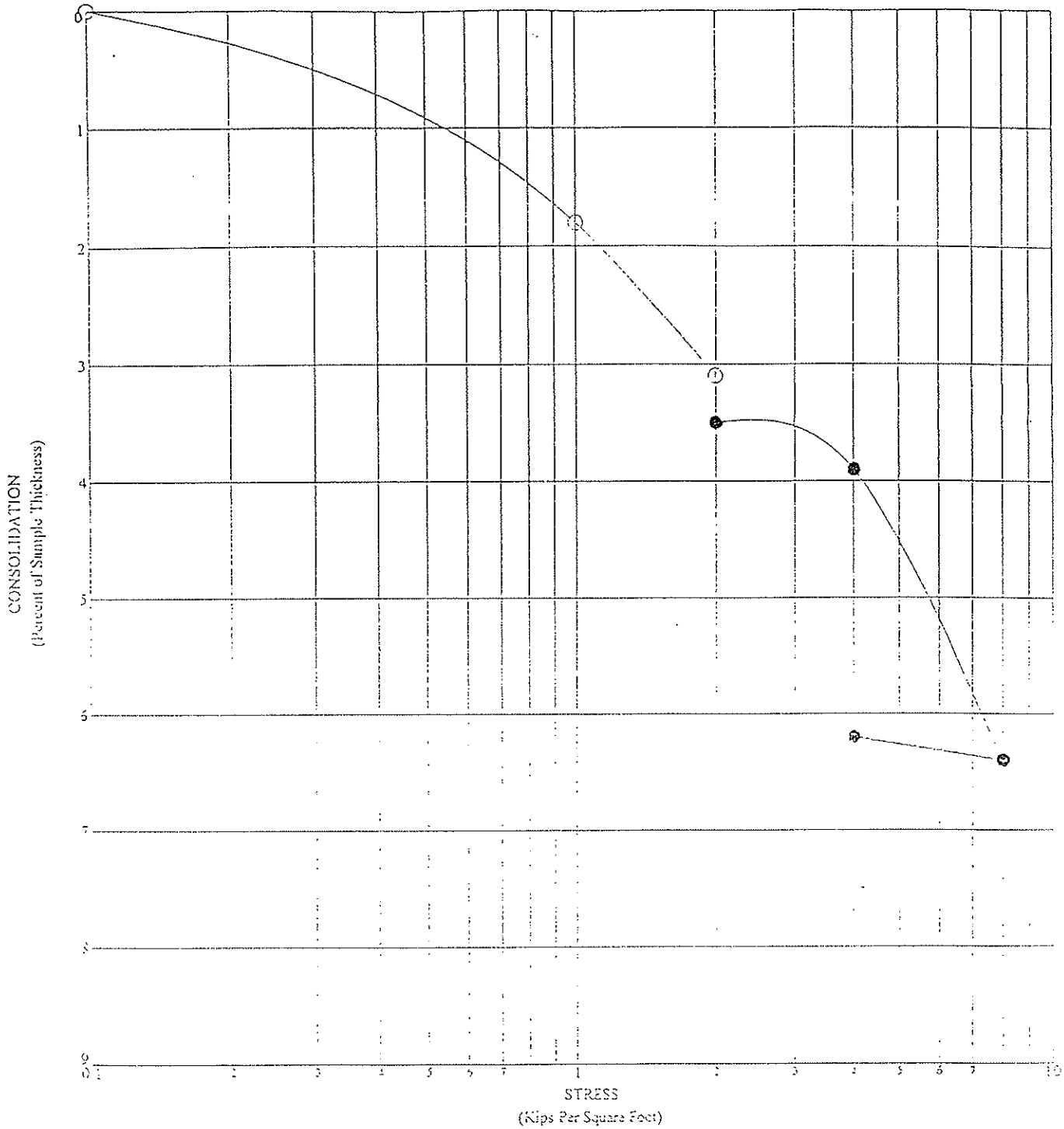
% GRAVEL =	19%	D_{85} = 5.8	D_{15} =
% SAND =	65%	D_{50} = 2.0	D_{10} =
% SILT & CLAY =	16%	D_{50} = 1.2	C_u =
		D_{30} = 0.3	C_c =

Project No.: 99-33437-01
Project Name: BMI Landfill
Date sampled: Oct 1999
Location: B 106 @ 0-5'
Silty Sand with Gravel

GRAIN SIZE DISTRIBUTION TEST REPORT

CONVERSE CONSULTANTS

Drawing No. A-4



BORING NO: B- 8
DEPTH: 39.0
DESCRIPTION: LEAN CLAY
DRY DENSITY: 58 PCF
MOISTURE CONTENT: 64%

● READINGS AFTER SATURATION WITH WATER

CONSOLIDATION TEST

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION

Project No. 99-33437-01

Converse Consultants

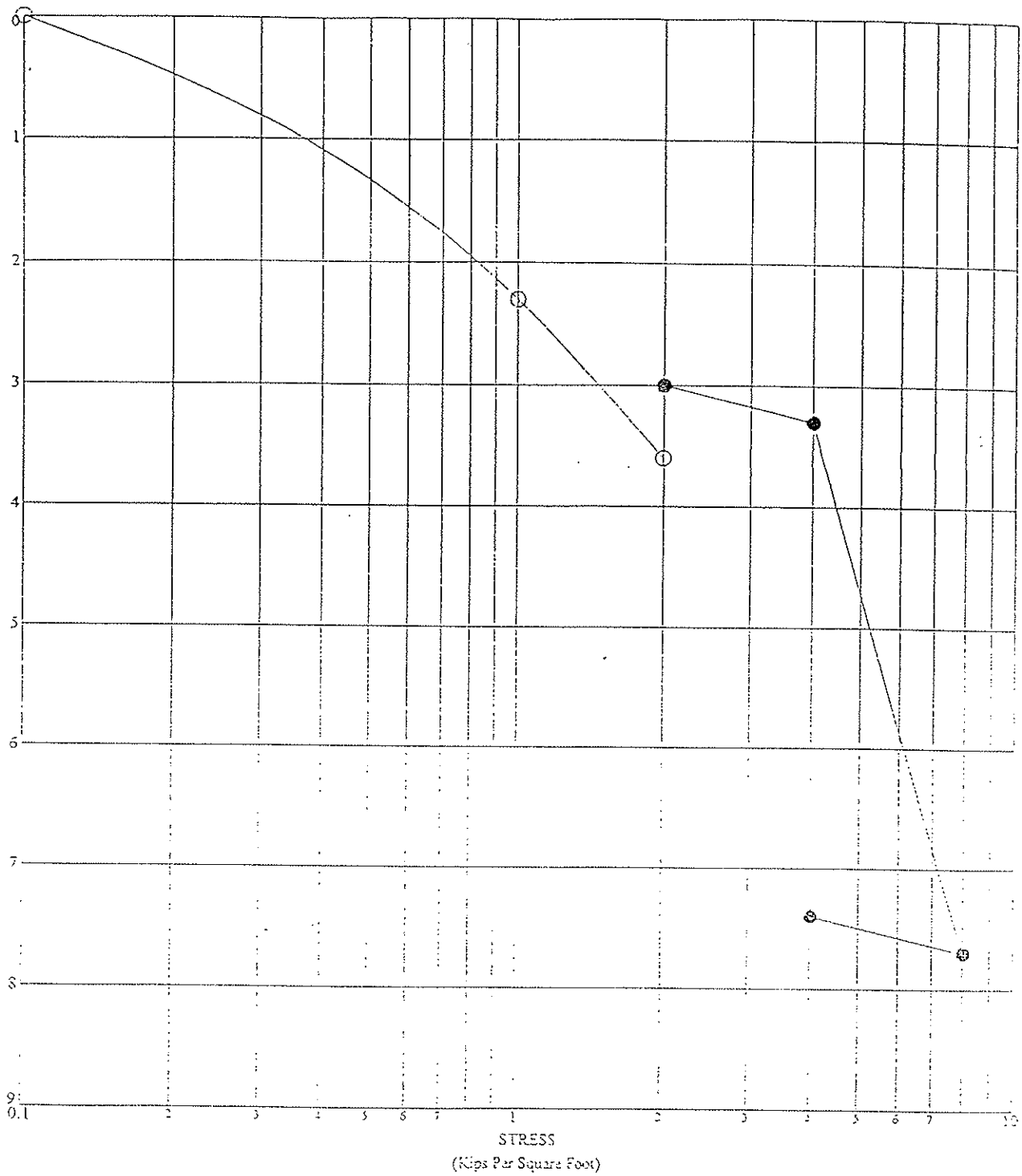
Geotechnical Engineering and Applied Sciences

Drawing No. A-50

DRAFT

APPROVED BY ON

DRAFTED BY GLE



APPROVED BY ON

BORING NO: B- 8
DEPTH: 49.0
DESCRIPTION: LEAN CLAY
DRY DENSITY: 70 PCF
MOISTURE CONTENT: 51 %

● READINGS AFTER SATURATION WITH WATER

CONSOLIDATION TEST

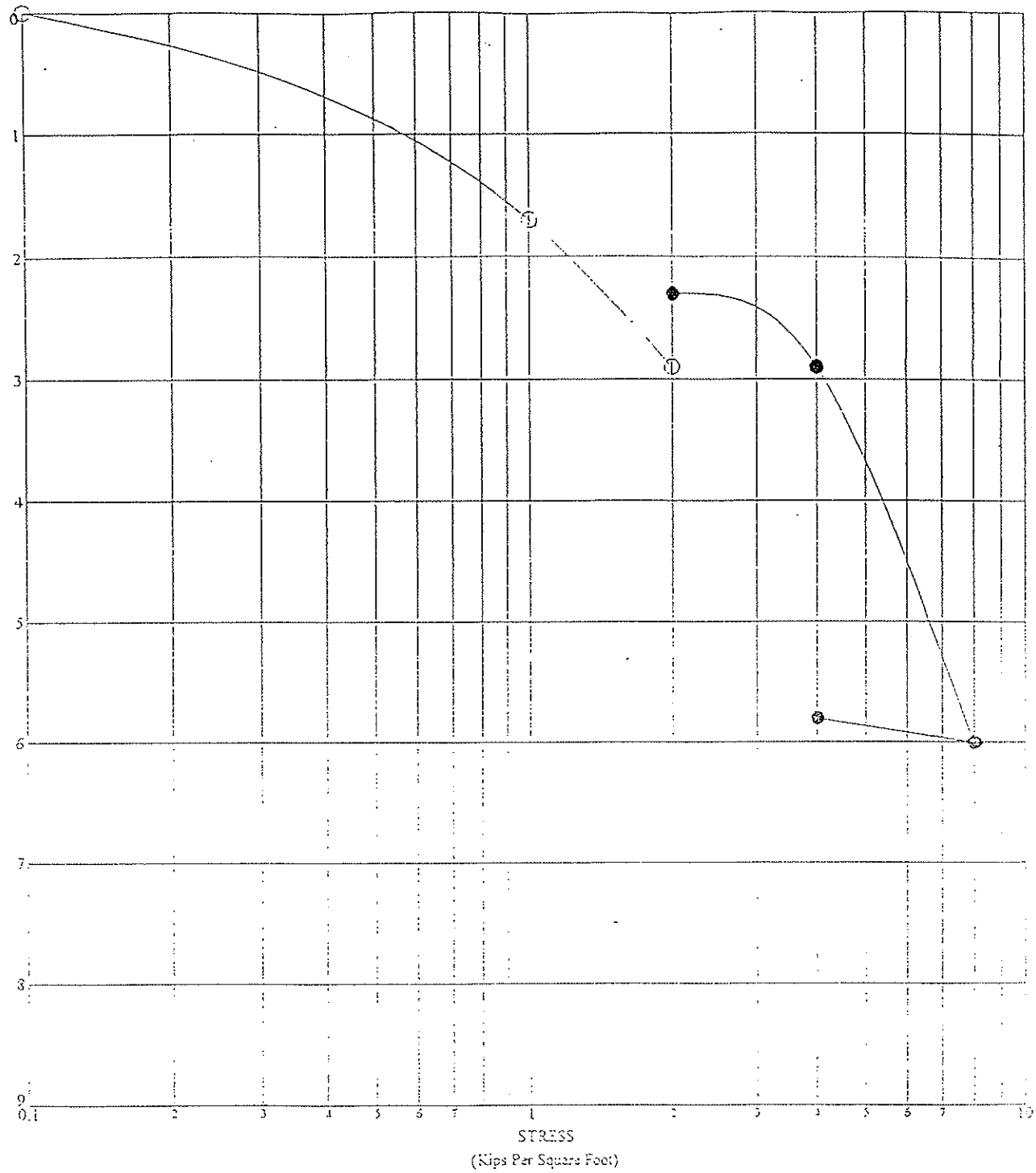
PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION

Project No. 99-33437-01

Converse Consultants

Geotechnical Engineering and Applied Sciences

Drawing No. A-51



BORING NO: B-10- -
DEPTH: 54.0
DESCRIPTION: LEAN CLAY
DRY DENSITY: 61 PCF
MOISTURE CONTENT: 68 %

● READINGS AFTER SATURATION WITH WATER

CONSOLIDATION TEST

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION

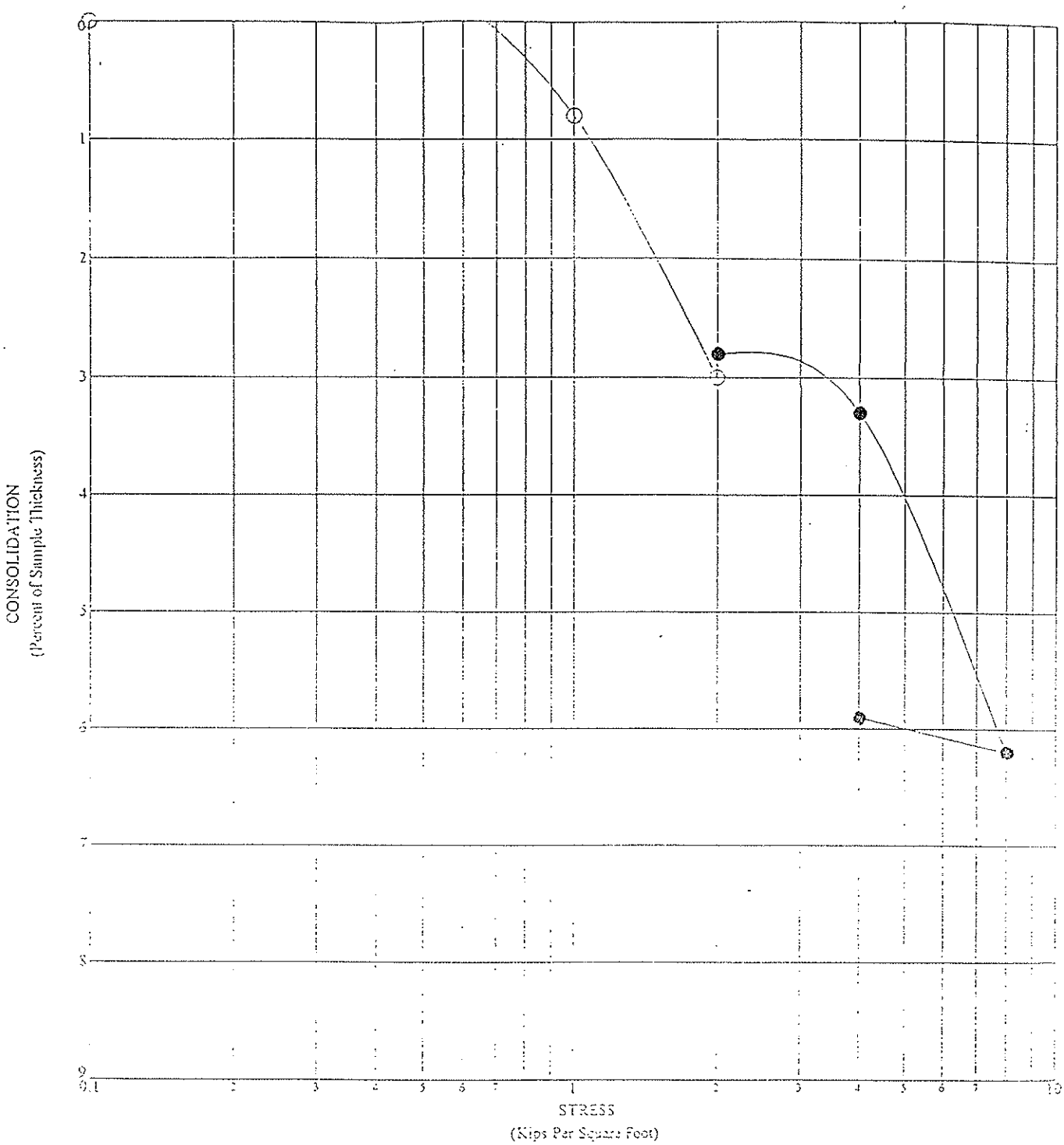
Project No. 99-33437-01

Converse Consultants

Geotechnical Engineering and Applied Sciences

Drawing No. A-52

DRAFTED BY GLE



APPROVED BY ON

BORING NO: B-101
DEPTH: 39.0
DESCRIPTION: LEAN CLAY
DRY DENSITY: 66 PCF
MOISTURE CONTENT: 45%

● READINGS AFTER SATURATION WITH WATER

CONSOLIDATION TEST

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION

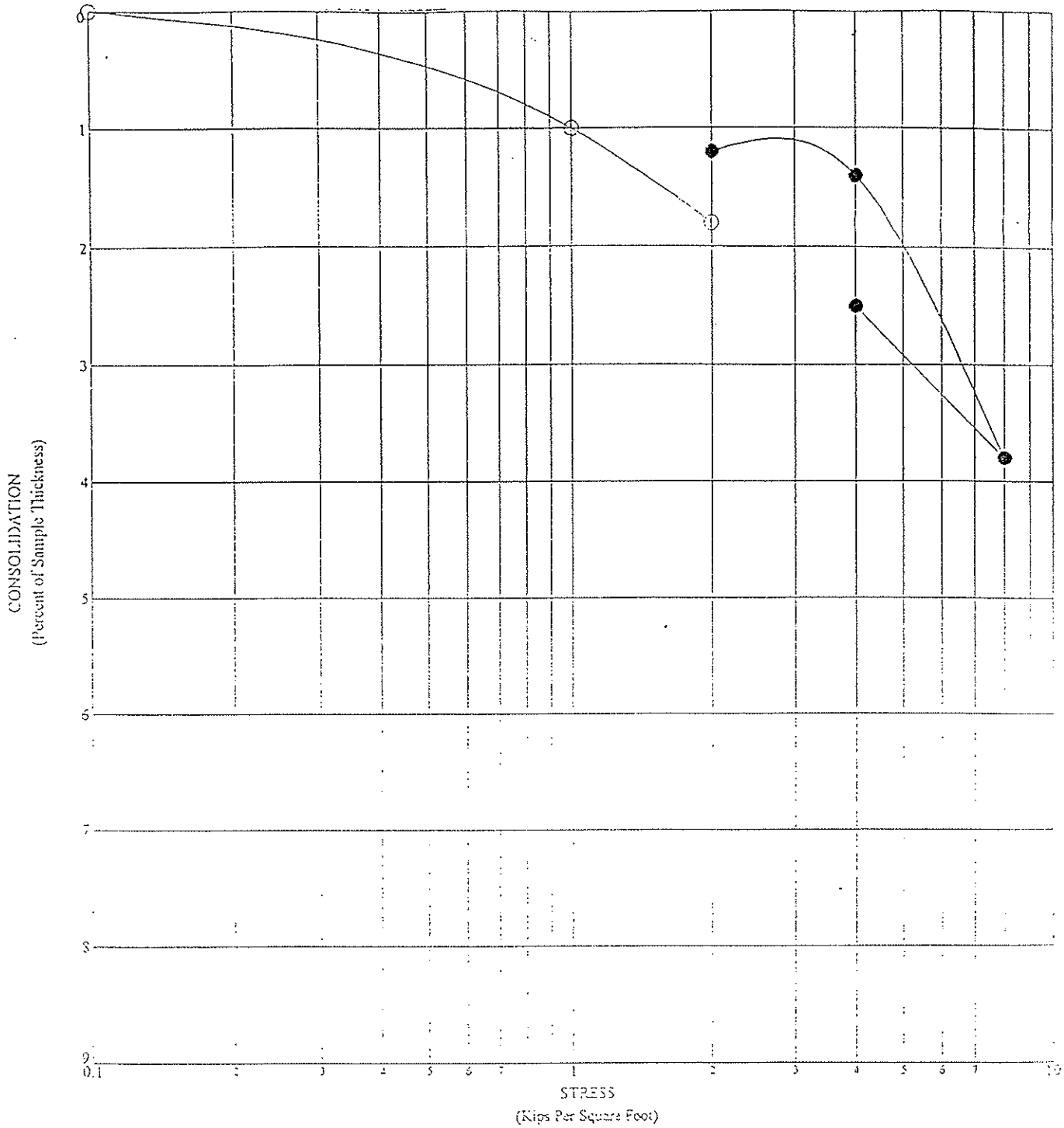
Project No. 99-33437-01

Converse Consultants

Geotechnical Engineering and Applied Sciences

Drawing No. A-53

DRAFTED BY GLE



APPROVED BY ON

BORING NO: B-101
DEPTH: 59.0
DESCRIPTION: LEAN CLAY
DRY DENSITY: 73 PCF
MOISTURE CONTENT: 38%

● READINGS AFTER SATURATION WITH WATER

CONSOLIDATION TEST

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION

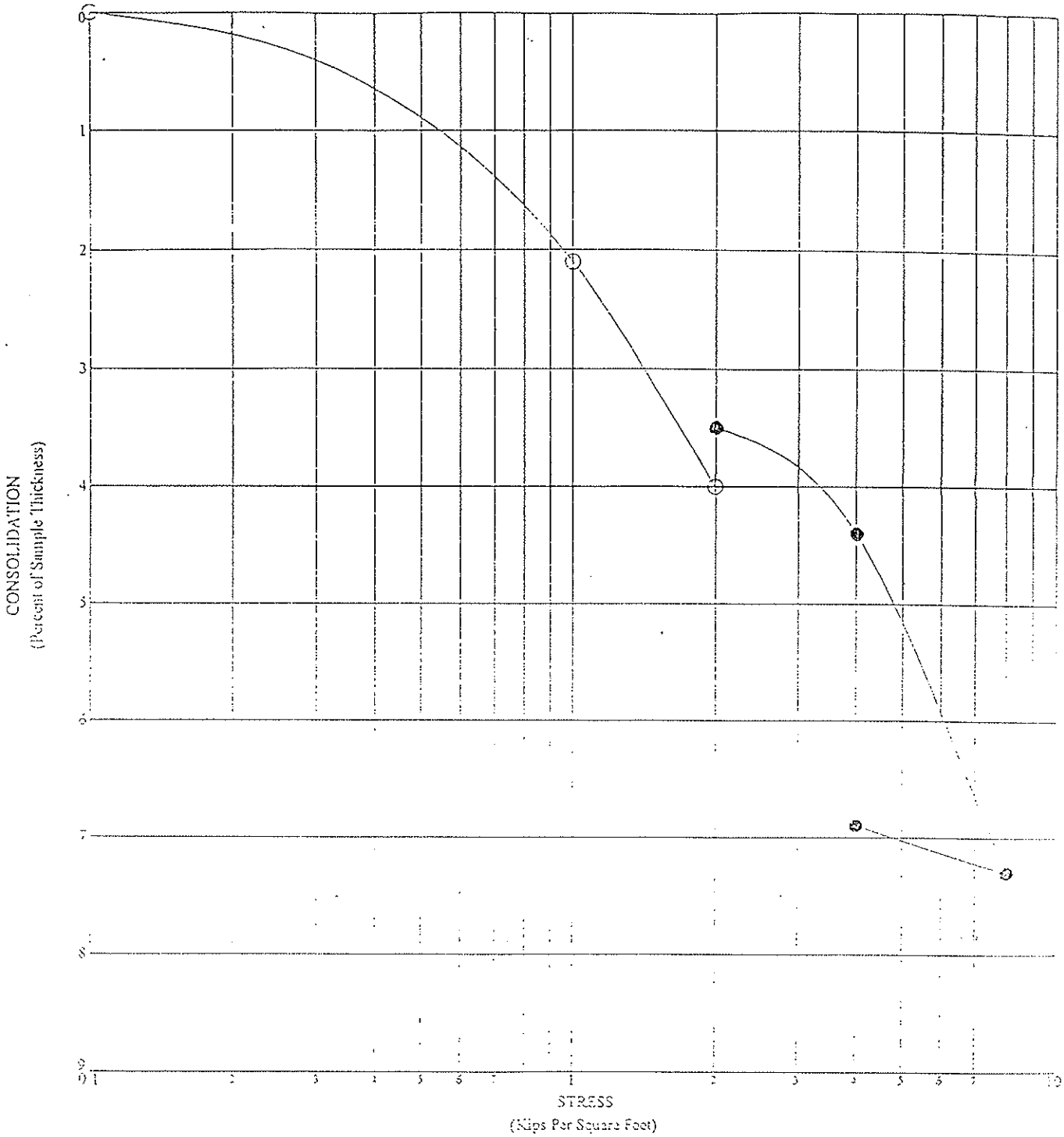
Project No. 99-33437-01

Converse Consultants

Geotechnical Engineering and Applied Sciences

Drawing No. A-54

DRAFTED BY GLE



APPROVED BY ON

BORING NO: B-102
DEPTH: 49.0
DESCRIPTION:
DRY DENSITY: 67 PCF
MOISTURE CONTENT: 49%

● READINGS AFTER SATURATION WITH WATER

CONSOLIDATION TEST

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION

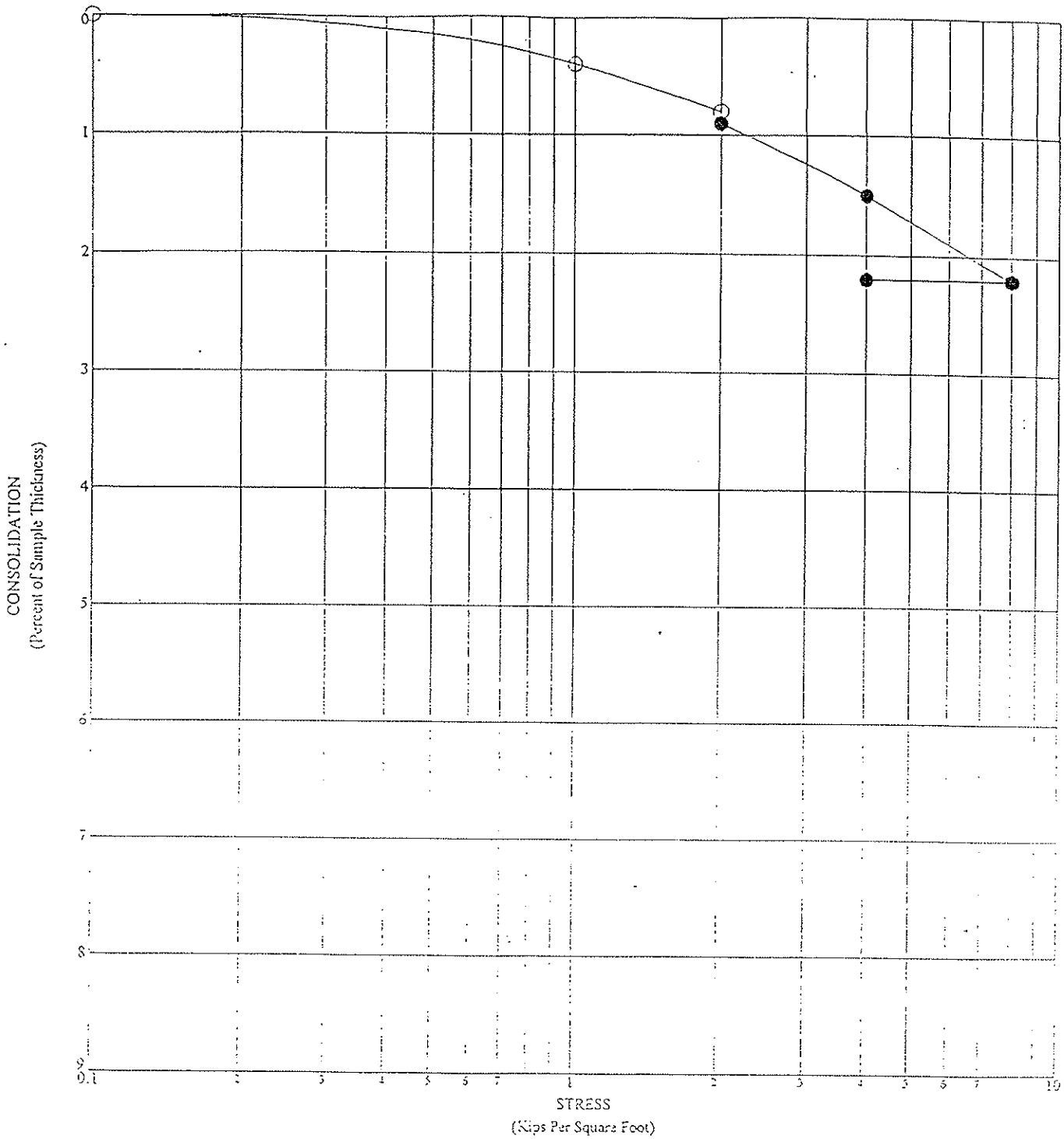
Project No. 99-33437-01

Converse Consultants

Geotechnical Engineering and Applied Sciences

Drawing No. A-55

DRAFTED BY GLE



APPROVED BY ON

BORING NO: B-105
DEPTH: 34.0
DESCRIPTION: SILTY SAND With Gravel
DRY DENSITY:101 PCF
MOISTURE CONTENT: 5 %

⊗ READINGS AFTER SATURATION WITH WATER

CONSOLIDATION TEST

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION

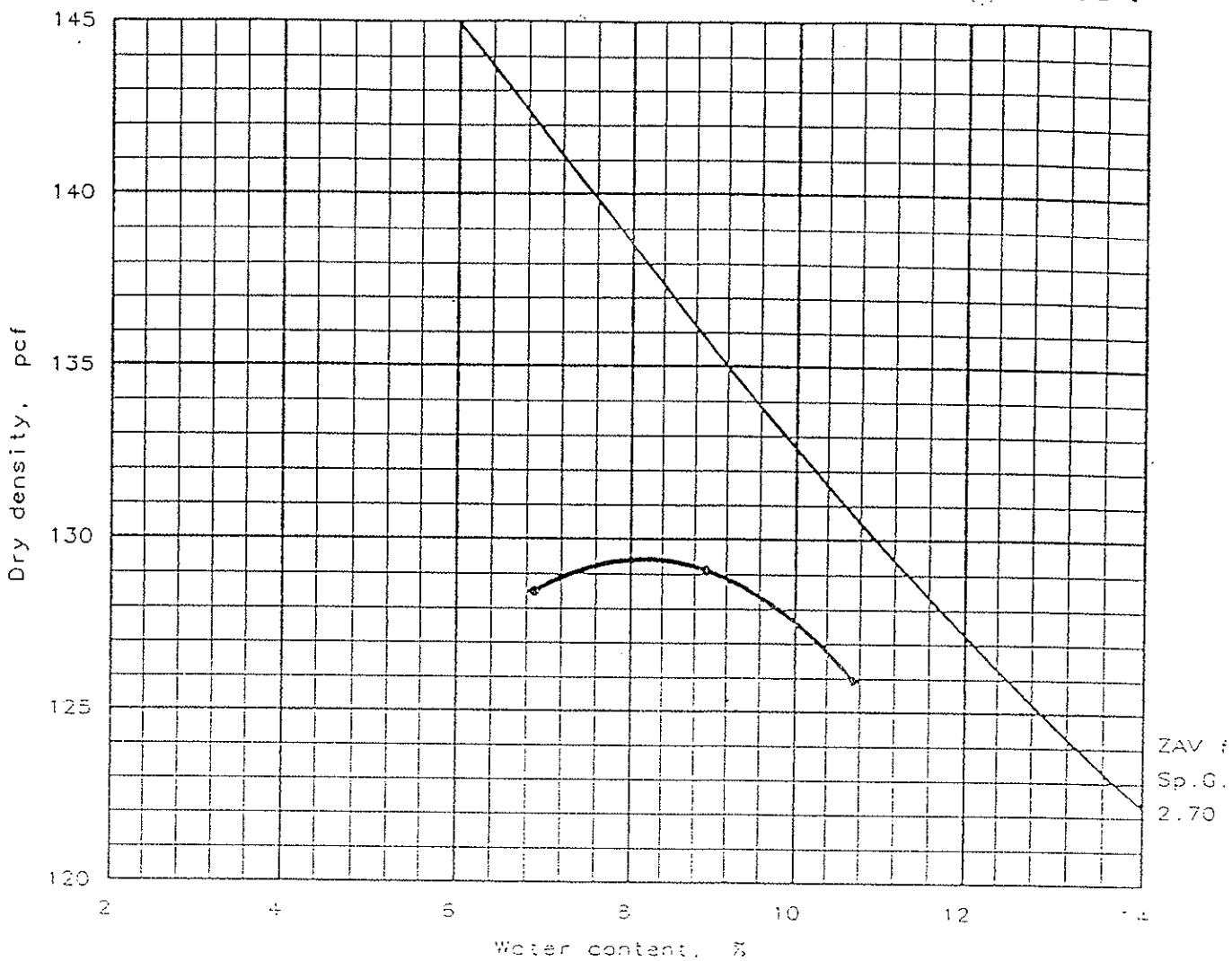
Project No. 99-33437-01

Converse Consultants

Geotechnical Engineering and Applied Sciences

Drawing No. A-56

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 1557-91 Procedure C, Modified

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/4 in	% < No.2
	USCS	AASHTO						
	SM				NV	NP	1.4 %	20.2

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 129.4 pcf Optimum moisture = 8.2 %	Silty Sand with Gravel

Project No.: 99-33437-01

Project: BMI Landfill

Location: B1 @ 20-25'

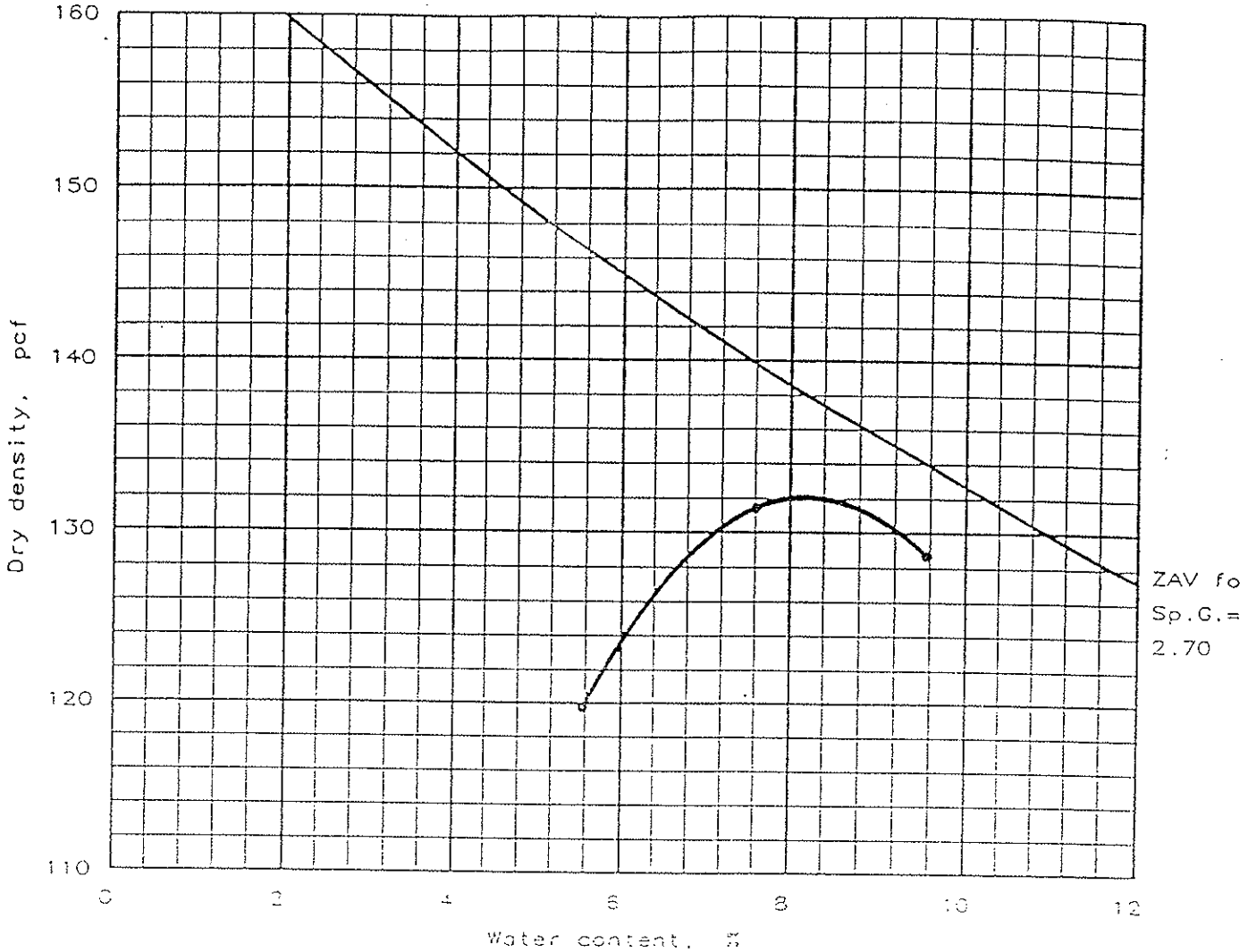
Date: 10-15-1999

MOISTURE-DENSITY RELATIONSHIP TEST

CONVERSE CONSULTANTS

Fig. No. A-57

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 1557-91 Procedure C, Modified

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/4 in	% < No.200
	USCS	AASHTO						
	SM				NV	NP	0 %	19.2 %

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 132.1 pcf Optimum moisture = 8.2 %	Silty Sand with Gravel

Project No.: 99-33437-01

Project: BMI Landfill

Location: B5 @ 20-25'

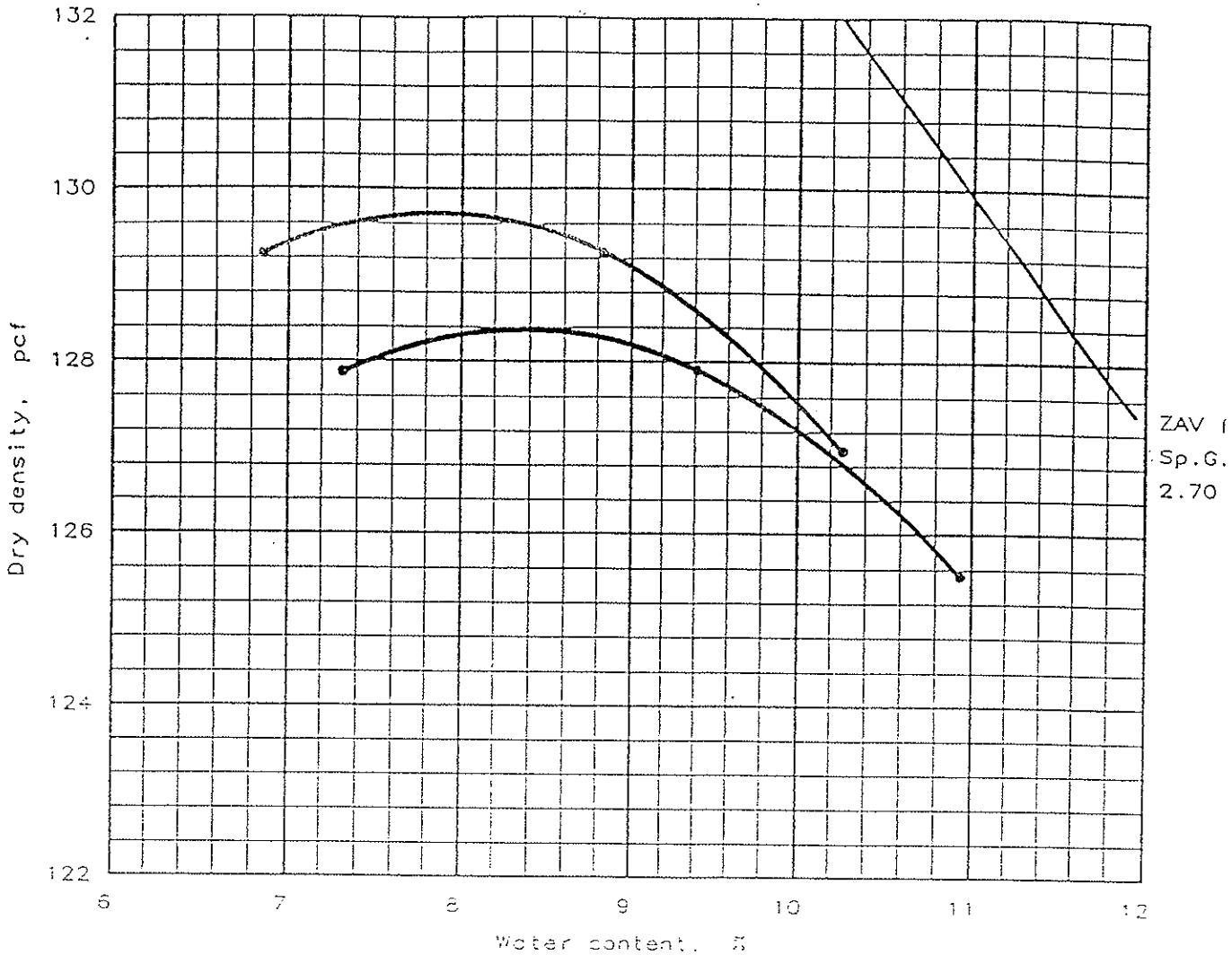
Date: 10-15-1999

MOISTURE-DENSITY RELATIONSHIP TEST

CONVERSE CONSULTANTS

Fig. No. A-58

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 1557-91 Procedure C, Modified

Oversize correction applied to each point

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/4 in	% < No.2
	USCS	AASHTO						
	SM				NV	NP	6.2 %	13.3

ROCK CORRECTED TEST RESULTS	UNCORRECTED	MATERIAL DESCRIPTION
Maximum dry density = 129.7 pcf Optimum moisture = 7.9 %	128.4 pcf 8.4 %	Silty Sand with Gravel

Project No.: 99-33437-01

Project: BMI Landfill

Location: B12 @ 10-15'

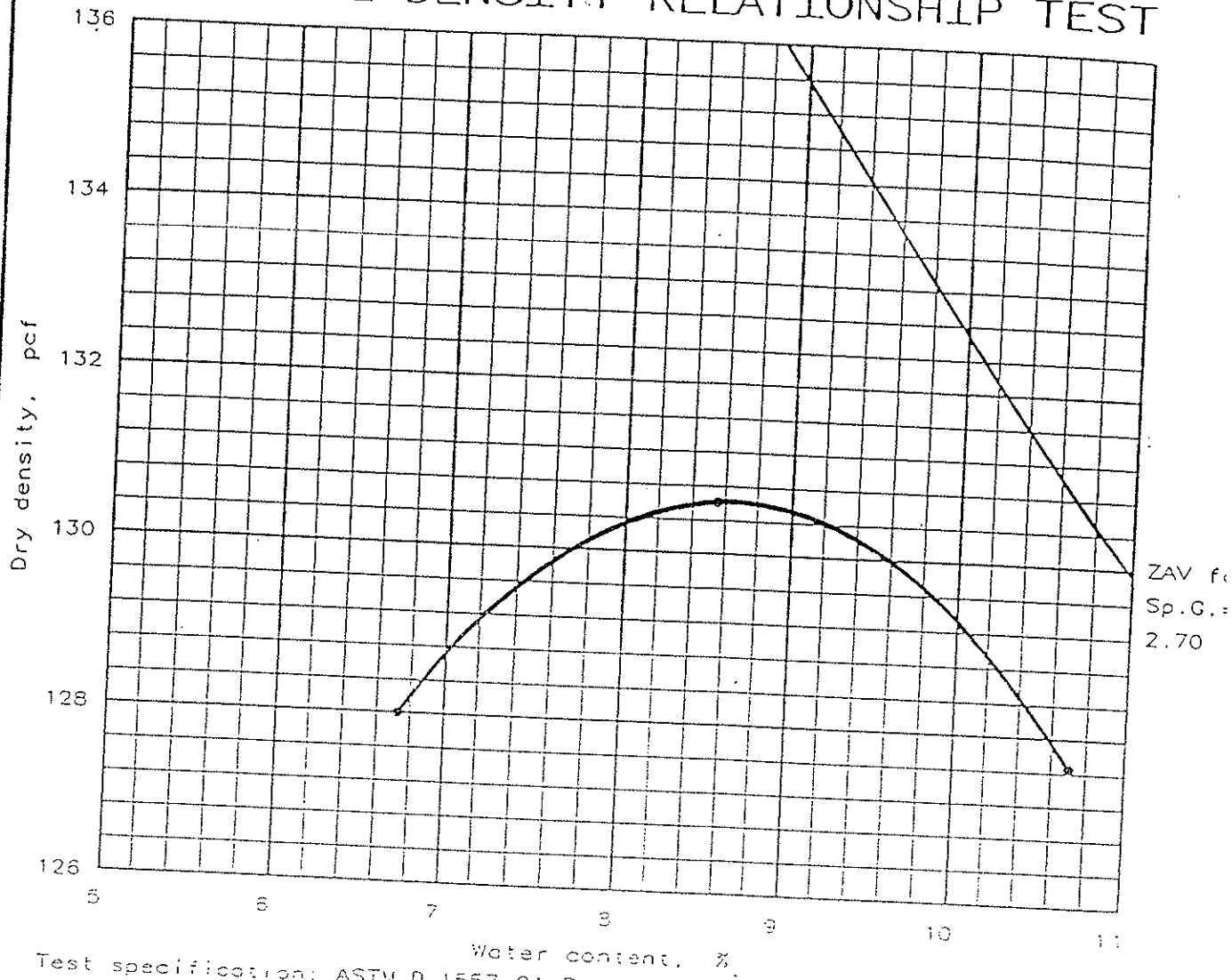
Date: 10-15-1999

MOISTURE-DENSITY RELATIONSHIP TEST

CONVERSE CONSULTANTS

Fig. No. A-59

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 1557-91 Procedure C, Modified

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/4 in	% < No.200
	USCS	AASHTO						
	SM				NV	NP	4.7 %	14.7 %

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 130.6 pcf Optimum moisture = 8.7 %	Silty Sand with Gravel

Project No.: 99-33437-01

Project: BMI Landfill

Location: B 101 @ 5-10'

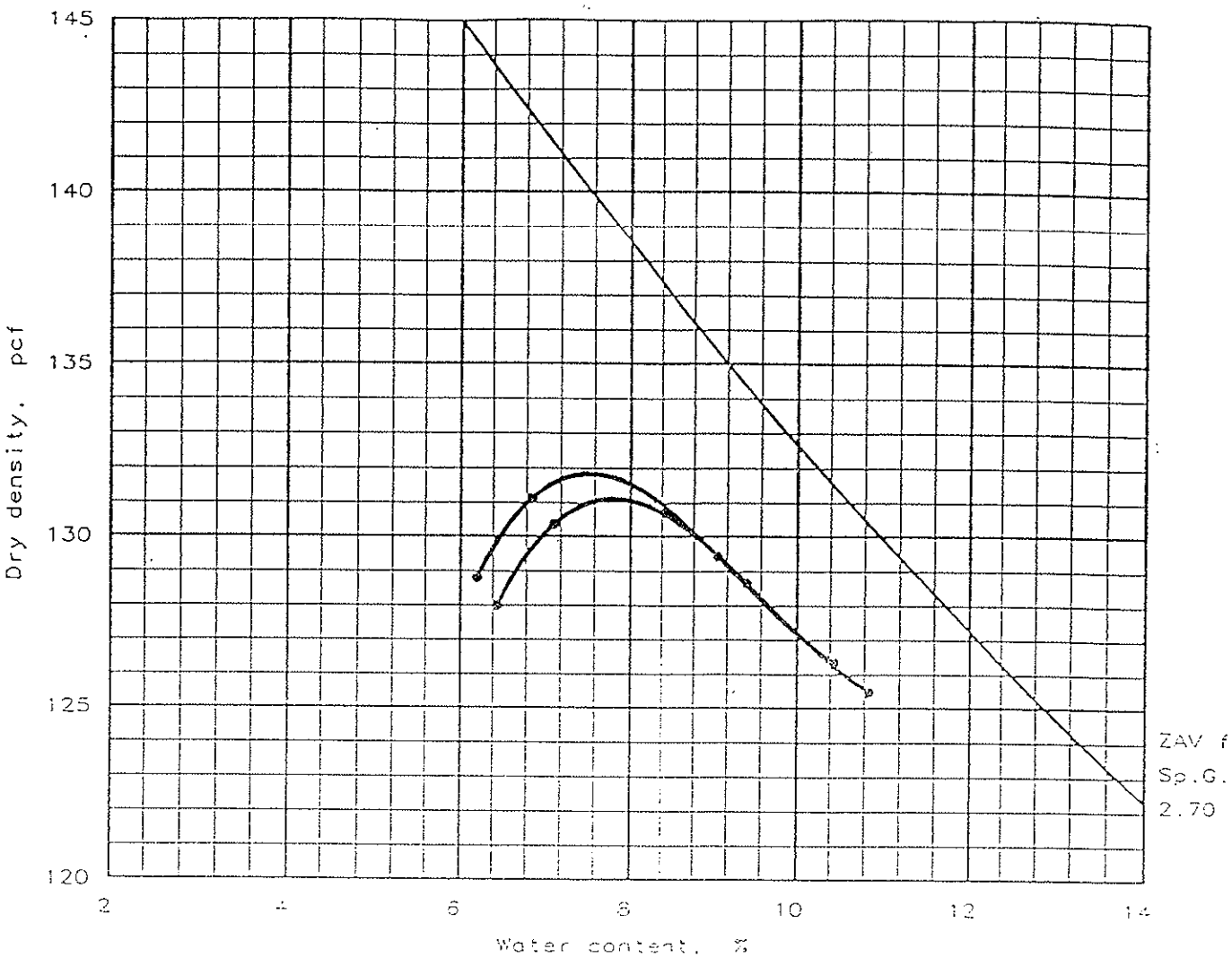
Date: 10-15-1999

MOISTURE-DENSITY RELATIONSHIP TEST

CONVERSE CONSULTANTS

Fig. No. A-60

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 1557-91 Procedure C, Modified

Oversize correction applied to each point

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/4 in	% < No.2
	USCS	AASHTO						
	SW-SM				NV	NP	3.7 %	5.3

ROCK CORRECTED TEST RESULTS	UNCORRECTED	MATERIAL DESCRIPTION
Maximum dry density = 131.8 pcf Optimum moisture = 7.5 %	131.1 pcf 7.8 %	Well Graded Sand with Silt & Gravel

Project No.: 99-33437-01

Project: BMI Landfill

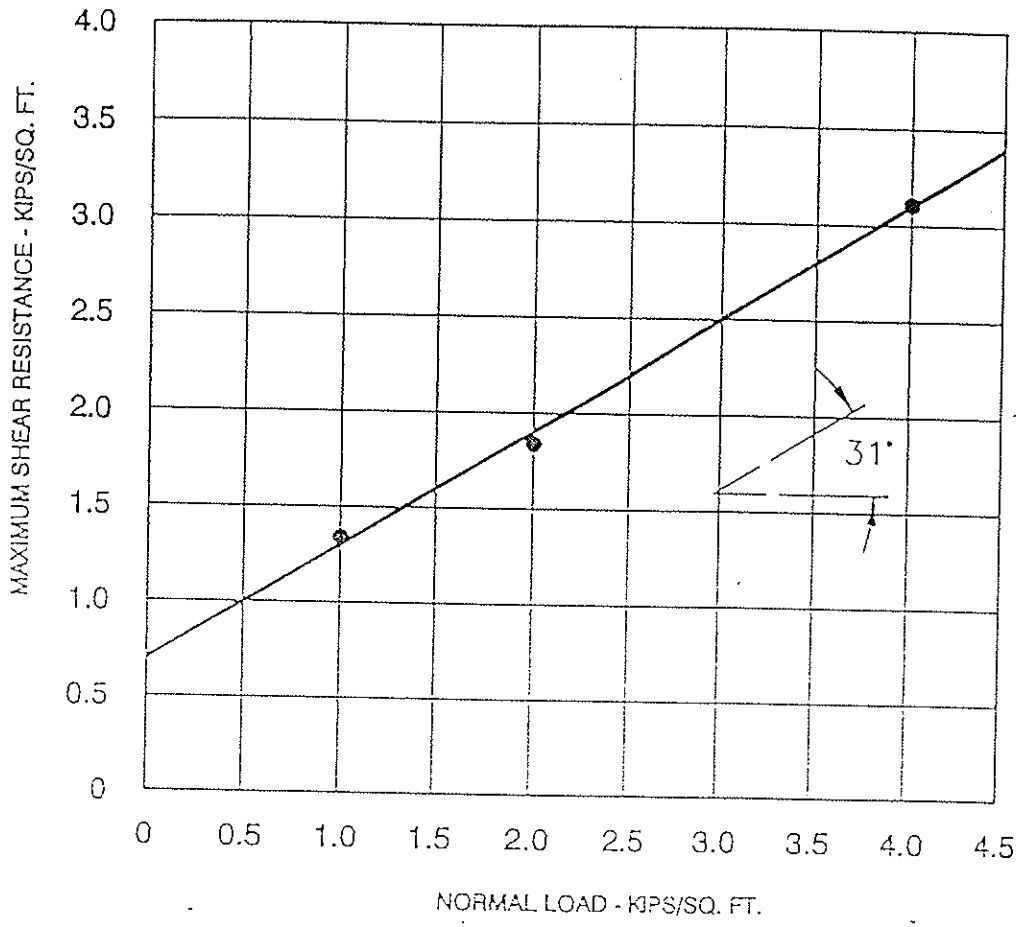
Location: B 105 @ 20-25'

Date: 10-15-1999

MOISTURE-DENSITY RELATIONSHIP TEST

CONVERSE CONSULTANTS

Fig. No. A-61



Exploration Location = B-4

Sample Depth = 14 - 14.5 FT

Angle of Shearing Resistance, Ø = 31°

Cohesion, c = 0.70 KIPS/SQ. FT.

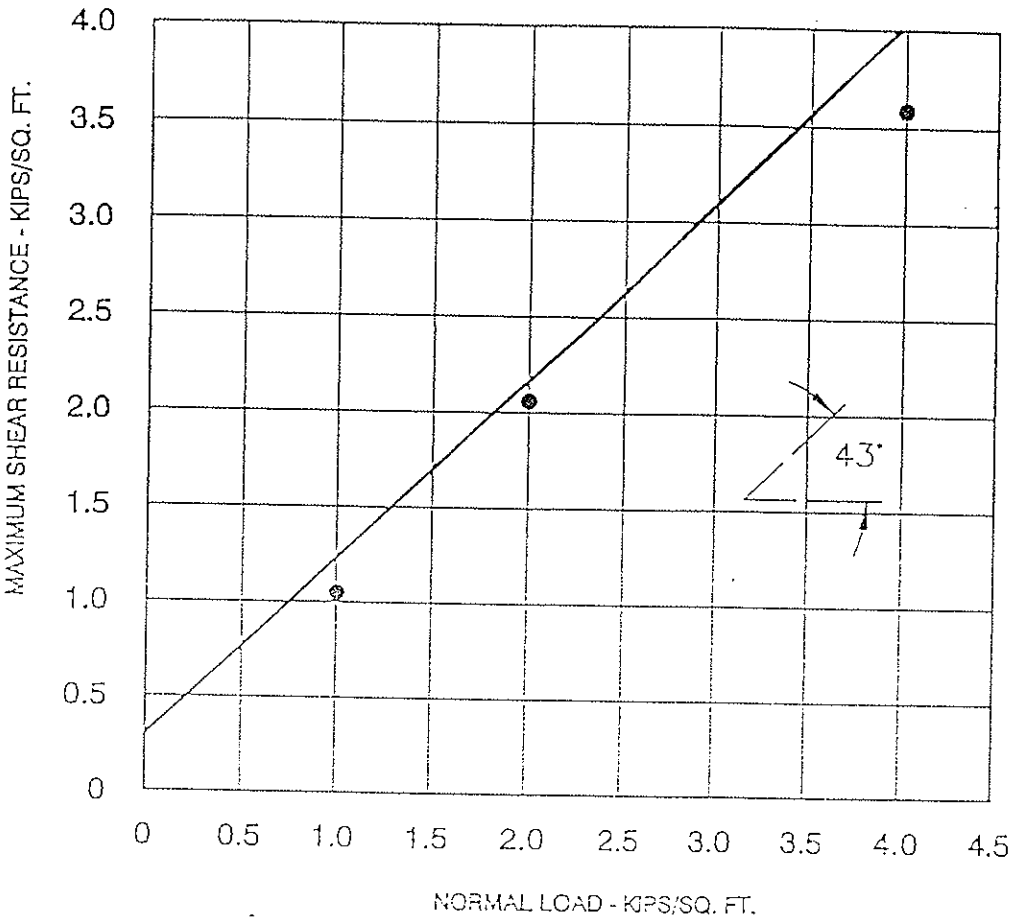
DIRECT SHEAR TEST RESULTS

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Scale	N/A
Date	10/20/99
Drafted By	TGLE
Checked By	MKK
Approved By	
File No.	4370183
Project No.	99-33437-01
Figure No.	A-62

CONVERSE CONSULTANTS

Over 50 Years of Dedication in Engineering and Environmental Sciences



Exploration Location = B-5

Sample Depth = 14 - 15 FT

Angle of Shearing Resistance, Ø = 43°

Cohesion, c = 0.30 KIPS/SQ. FT.

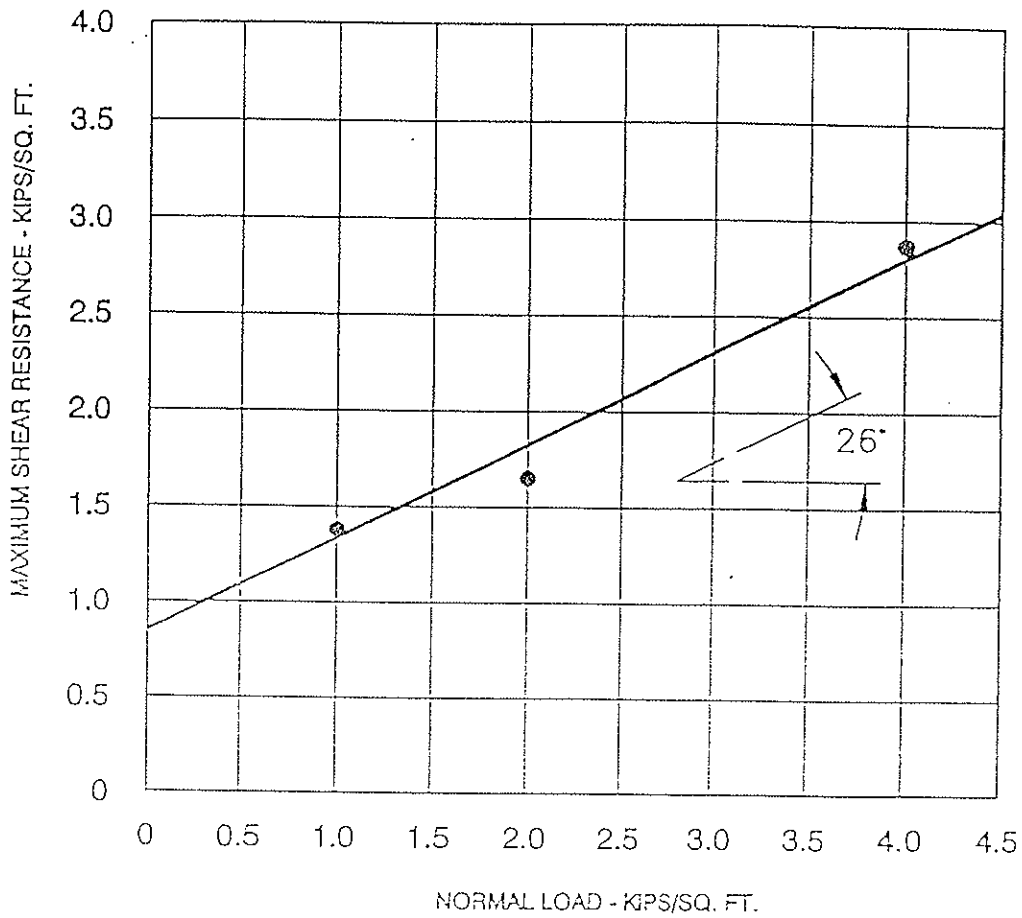
DIRECT SHEAR TEST RESULTS

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Scale	N/A
Date	10/20/99
Drafted By	CLE
Checked By	MKK
Approved By	
File No.	43701353
Project No.	99-33437-01
Figure No.	A-63

CONVERSE CONSULTANTS

Over 50 Years of Dedication in Engineering and Environmental Sciences



Exploration Location = B-10

Sample Depth = 54 - 54.5 FT

Angle of Shearing Resistance, Ø = 26°

Cohesion, c = 0.85 KIPS/SQ. FT.

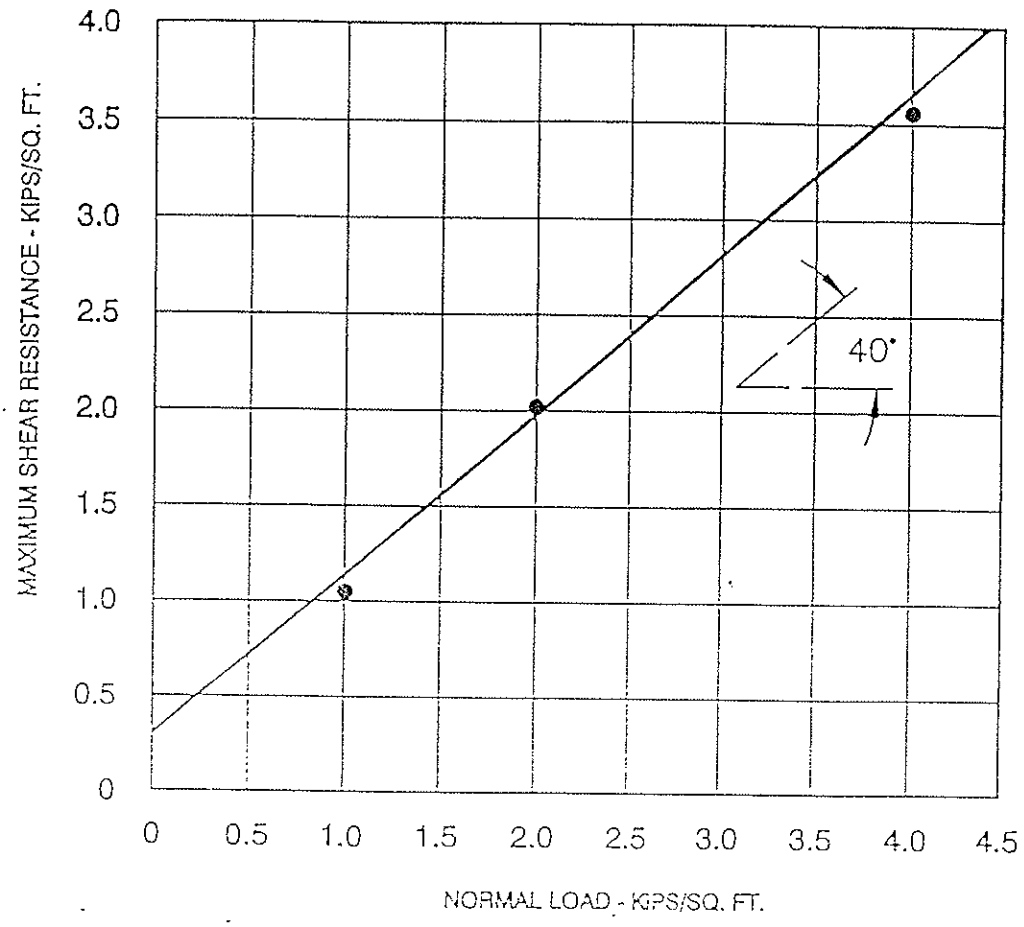
DIRECT SHEAR TEST RESULTS

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Scale	N/A
Date	10/20/99
Drafted By	GLE
Checked By	MKK
Approved By	
File No.	4370185
Project No.	99-33437-0
Figure No.	A-64

CONVERSE CONSULTANTS

Over 50 Years of Dedication in Engineering and Environmental Sciences



Exploration Location = B-12

Sample Depth = 14 - 15 FT

Angle of Shearing Resistance, Ø = 40°

Cohesion, c = 0.30 KIPS/SQ. FT.

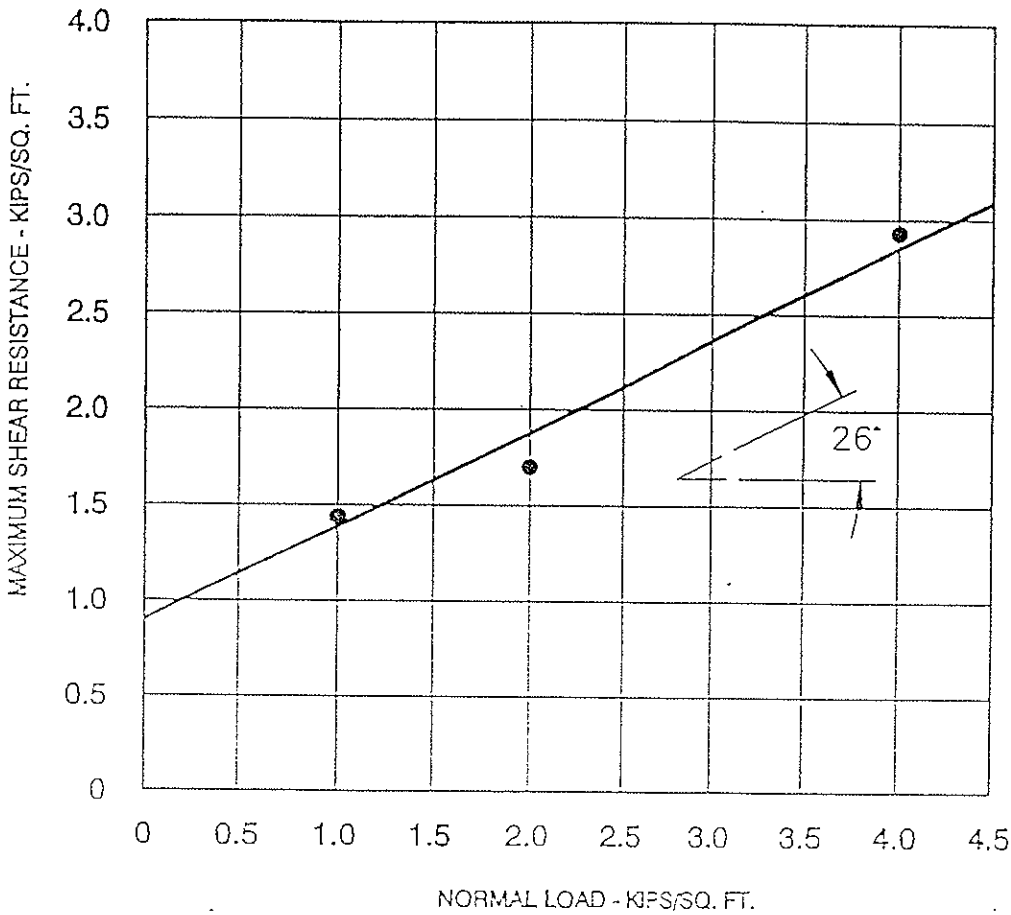
DIRECT SHEAR TEST RESULTS

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Scale	N/A
Date	10/20/99
Drafted By	OLE
Checked By	MKK
Approved By	
File No.	4370185
Project No.	99-33437-0
Figure No.	A-65

CONVERSE CONSULTANTS

Over 50 Years of Dedication in Engineering and Environmental Sciences



Exploration Location = B-101

Sample Depth = 39 - 40 FT

Angle of Shearing Resistance, Ø = 26°

Cohesion, c = 0.90 KIPS/SQ. FT.

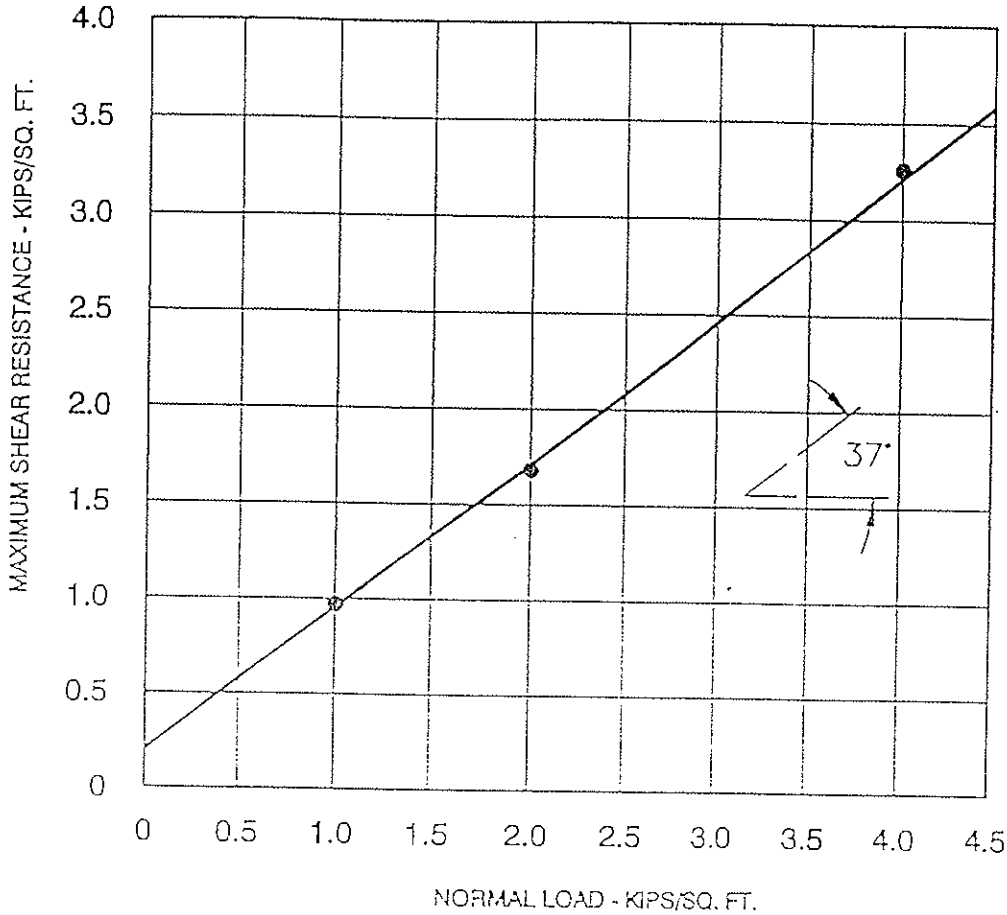
DIRECT SHEAR TEST RESULTS

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Scale	N/A
Date	10/20/99
Drafted By	GLE
Checked By	MKK
Approved By	
File No.	4370185
Project No.	99-33437-0
Figure No.	A-66

CONVERSE CONSULTANTS

Over 50 Years of Dedication in Engineering and Environmental Sciences



Exploration Location = B-102

Sample Depth = 20 - 25 FT

Angle of Shearing Resistance, Ø = 37°

Cohesion, c = 0.20 KIPS/SQ. FT.

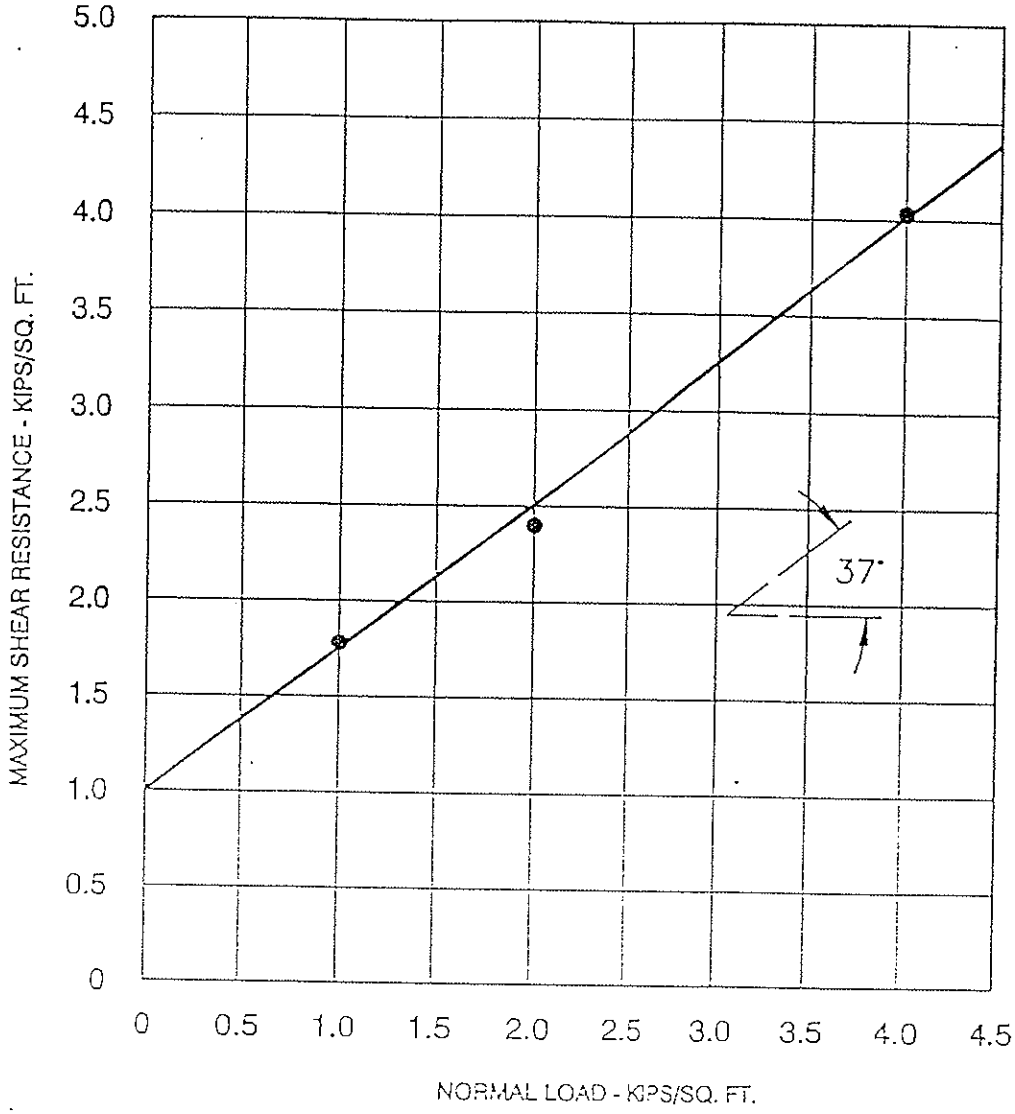
DIRECT SHEAR TEST RESULTS

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Scale	N/A
Date	10/20/99
Drafted By	GLF
Checked By	MKK
Approved By	
File No.	4370186
Project No.	99-33437-0
Figure No.	A-67

CONVERSE CONSULTANTS

Over 50 Years of Dedication in Engineering and Environmental Sciences



Exploration Location = B-103

Sample Depth = 49 - 50 FT

Angle of Shearing Resistance, Ø = 37°

Cohesion, c = 1.00 KIPS/SQ. FT.

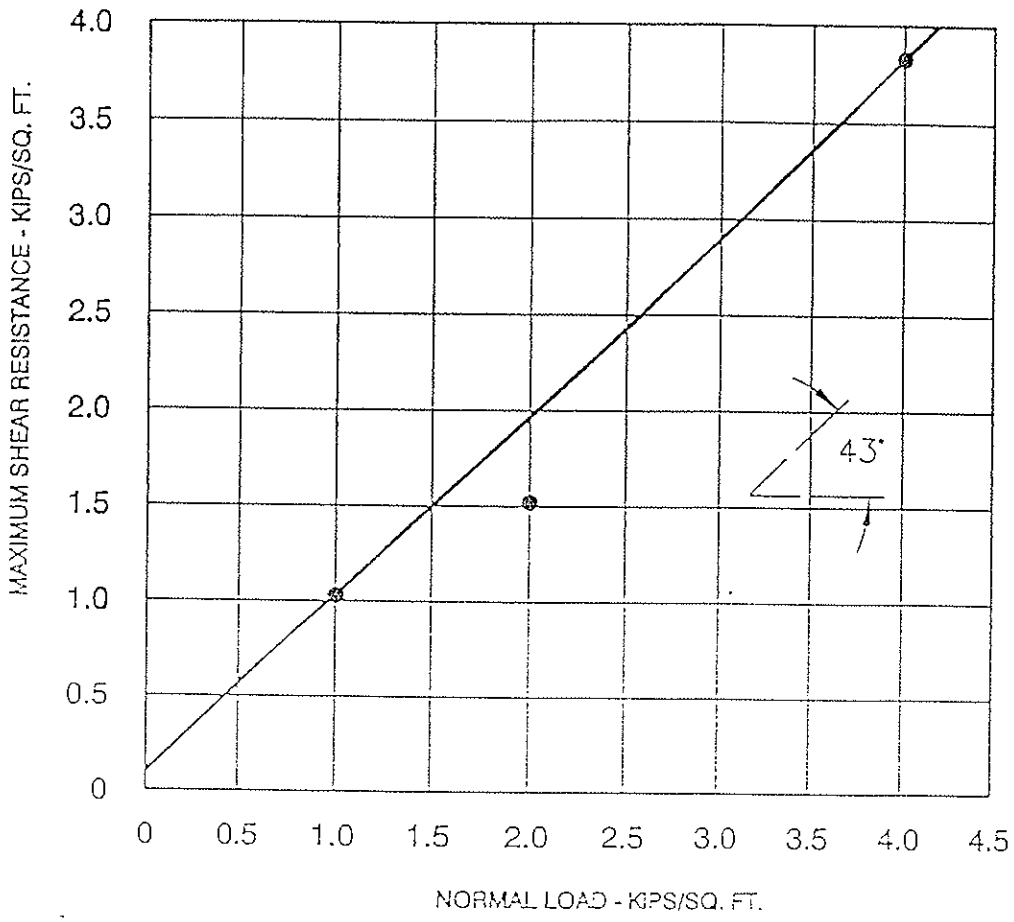
DIRECT SHEAR TEST RESULTS

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Scale	N/A
Date	10/20/99
Drafted By	GLE
Checked By	MKK
Approved By	
File No.	43701359
Project No.	99-33437-01
Figure No.	A-68

CONVERSE CONSULTANTS

Over 50 Years of Dedication in Engineering and Environmental Sciences



Exploration Location = B-104

Sample Depth = 10 - 15 FT

Angle of Shearing Resistance, Ø = 43°

Cohesion, c = 0.10 KIPS/SQ. FT.

DIRECT SHEAR TEST RESULTS

PRELIMINARY GEOLOGIC AND GEOTECHNICAL INVESTIGATION
Basic Management Incorporated
Clark County, Nevada

Scale	N/A
Date	10/20/99
Drafted By	GLE
Checked By	MKK
Approved By	
File No.	4370186
Project No.	99-33437-0
Figure No.	A-69

CONVERSE CONSULTANTS

Over 50 Years of Dedication in Engineering and Environmental Sciences

Atlas Chemical Testing Laboratories

2120 Western Avenue, Suite C-6 • Las Vegas, Nevada 89102
(702) 383-1199 • Fax (702) 383-4983

CHEMICAL
PHYSICAL
FORENSIC

member of
AMERICAN SOCIETY FOR
TESTING MATERIALS

ACT LAB NO: 9218(b) DATE: October 13, 1999

PROJECT NO: 99-33437-01 P.O.: 18154

ANALYZED BY: Robert L. Simmons LAB ID:

WATER SOLUBLE SALT ANALYSIS IN SOIL

1:5 (soil:water) Aqueous Extraction

AWWA 3500-Na D, ASTM D 516

BMI LANDFILL

Sample No.	Location	Depth (Feet)	Sodium (Percent)	Water Soluble Sulfate (SO_4) (Percent)	Total Available Water Soluble Sodium Sulfate(Na_2SO (Percent)
	B-5	10-15	0.07	0.13	0.20
	B-8	19-20	0.07	0.06	0.08
	B-101	5-10	0.17	0.06	0.08
	B-102	0-5	0.17	0.03	0.05
	B-106	0-5	0.15	0.08	0.13
	B-106.	29-30	0.15	0.06	0.08

A-7C

Notes: The results for each constituent denote the percentage of that analyte, at a 1:5 (soil:water) extraction ratio, which is present in the soil. Sodium was determined by flame photometry, sulfate turbidimetrically, and sodium sulfate by calculation.

AP Engineering and Testing, Inc.

GEOTECHNICAL TESTING LABORATORY

FLEXIBLE WALL HYDRAULIC CONDUCTIVITY TEST
ASTM D5084

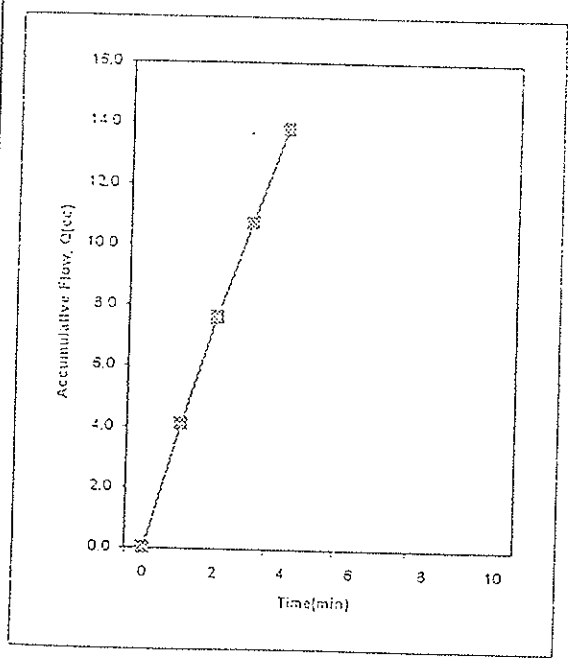
Project Name:	Preliminary Geologic Investigation	Tested by	PS	Date	10/12/99
Project No.:	99-33437-01	Calculated by	SY	Date	10/20/99
Boring No.:	B-1	Checked by	AP	Date	10/20/99
Sample No.:	— Depth: 14-15' feet				
Soil Description:	Olive Brown Silty Sand w/ gravel				
Test Condition:					
	Confining Pressure = 11 PSI				

INITIAL CONDITION OF SPECIMEN

Diameter (d)	2.42	in
Sample Area (A)	4.58	in².
Length (L)	2.48	in
Weight Before	286.60	g
Wet Density	95.97	pcf
Dry Density	91.48	pcf

	Before	After
Container No.		
Wt. Wet Soil+Container(gms)	340.95	361.62
Wt. Dry Soil+Container(gms)	327.35	316.16
Wt. Container (gms)	50.51	50.02
Moisture, (%)	4.91	17.07

TEST RESULTS



Time (min)	Flow Rdg (cm)	Burette Factor	Q (cc)	Head, h (psi)	h/L	Q/t (cc/s)
0	29.2	1	0.0	1.0	11.2	0
1	25.1	1	4.1	1.0	11.2	6.83E-02
2	21.6	1	7.6	1.0	11.2	5.83E-02
3	18.5	1	10.7	1.0	11.2	5.17E-02
4	15.4	1	13.8	1.0	11.2	5.17E-02

Hydraulic Conductivity (cm/sec): 1.57E-04

AP Engineering and Testing, Inc.

GEOTECHNICAL TESTING LABORATORY

FLEXIBLE WALL HYDRAULIC CONDUCTIVITY TEST
ASTM D5084

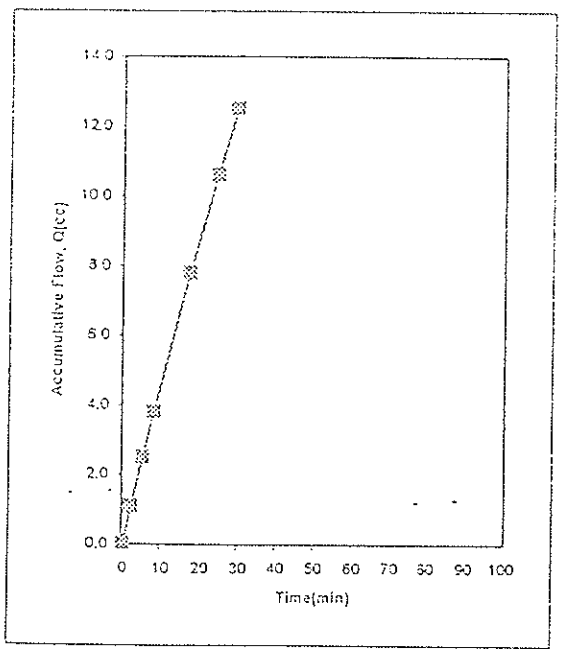
Project Name:	Preliminary Geologic Investigation	Tested by	PS	Date	10/12/99
Project No.:	99-33437-01	Calculated by	SY	Date	10/20/99
Boring No.:	B-8	Checked by	AP	Date	10/20/99
Sample No.:	— Depth: 44-45' feet				
Soil Description:	Lt Olive Brown Sandy Silt				
Test Condition:					
	Confining Pressure = 33 PSI				

INITIAL CONDITION OF SPECIMEN

Diameter (d)	2.42	in
Sample Area (A)	4.58	in²
Length (L)	3.48	in
Weight Before	457.60	g
Wet Density	109.24	pcf
Dry Density	85.69	pcf

	Before	After
Container No.		
Wt. Wet Soil+Container(gms)	248.6	412.7
Wt. Dry Soil+Container(gms)	205.71	323.46
Wt. Container (gms)	49.67	53.72
Moisture, (%)	27.49	33.03

TEST RESULTS



Time (min)	Flow Rdg (cm)	Burette Factor	Q (cc)	Head, h (psi)	h/L	Q/t (cc/s)
0	27.2	1	0.0	1.0	7.95	0
2	26.1	1	1.1	1.0	7.95	9.17E-03
5	24.7	1	2.5	1.0	7.95	7.78E-03
8	23.4	1	3.8	1.0	7.95	7.22E-03
17	19.4	1	7.8	1.0	7.95	7.41E-03
24	16.6	1	10.6	1.0	7.95	6.67E-03
29	14.7	1	12.5	1.0	7.95	6.33E-03
34	12.9	1	14.3	1.0	7.95	6.00E-03

Hydraulic Conductivity (cm/sec): 2.90E-05

AP Engineering and Testing, Inc.

GEOTECHNICAL TESTING LABORATORY

FLEXIBLE WALL HYDRAULIC CONDUCTIVITY TEST
ASTM D5084

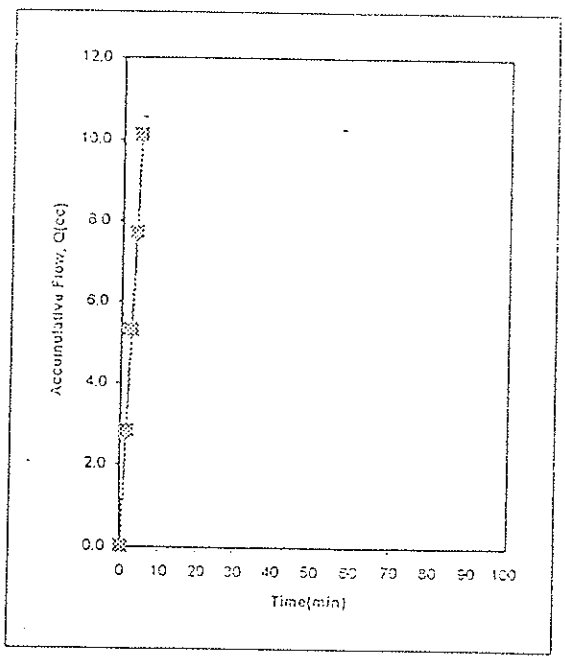
Project Name:	Preliminary Geologic Investigation	Tested by	PS	Date	10/12/99
Project No.:	99-33437-01	Calculated by	SY	Date	10/20/99
Boring No.:	B-4	Checked by	AP	Date	10/20/99
Sample No.:	— Depth: 24-25 feet				
Soil Description:	Lt Olive Brown Silty Sand w/ gravel				
Test Condition:					
	Confining Pressure = 18 PSI				

INITIAL CONDITION OF SPECIMEN

Diameter (d)	2.42	in
Sample Area (A)	4.58	in²
Length (L)	3.00	in
Weight Before	437.24	g
Wet Density	121.20	pcf
Dry Density	114.78	pcf

	Before	After
Container No.		
Wt. Wet Soil+Container(gms)	308.84	421.32
Wt. Dry Soil+Container(gms)	295.15	372.45
Wt. Container (gms)	50.05	49.46
Moisture, (%)	5.59	15.13

TEST RESULTS



Time (min)	Flow Rdg (cm)	Burette Factor	Q (cc)	Head, h (psi)	h/L	Q/t (cc/s)
0	32.6	1	0.0	1.0	9.23	0
1	29.3	1	2.8	1.0	9.23	4.67E-02
2	27.3	1	5.3	1.0	9.23	4.17E-02
3	24.9	1	7.7	1.0	9.23	4.00E-02
4	22.5	1	10.1	1.0	9.23	4.00E-02

Hydraulic Conductivity (cm/sec): 1.47E-04

AP Engineering and Testing, Inc.

GEOTECHNICAL TESTING LABORATORY

FLEXIBLE WALL HYDRAULIC CONDUCTIVITY TEST
ASTM D5084

Project Name: Preliminary Geologic Investigation
Project No.: 99-33437-01
Boring No.: B-12
Sample No.: — Depth: 39-39.5 feet
Soil Description: Yell Brown Silty Clay w/ siltstone
Test Condition:
Confining Pressure = 29 PSI

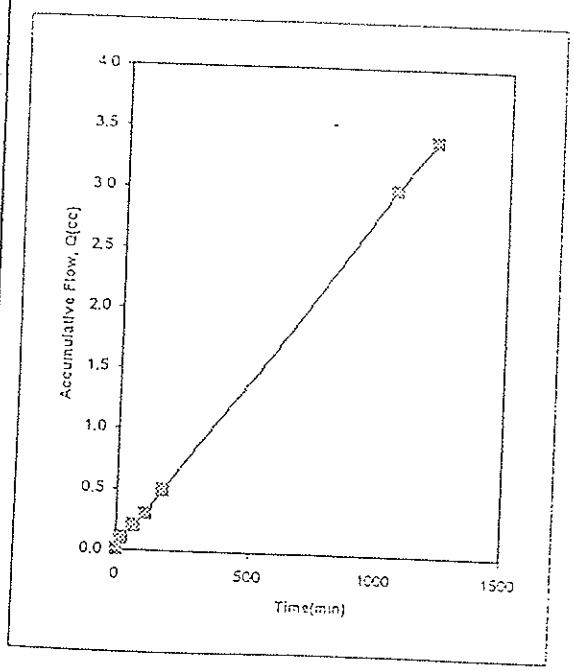
Tested by PS Date 10/14/99
Calculated by SY Date 10/20/99
Checked by AP Date 10/20/99

INITIAL CONDITION OF SPECIMEN

Diameter (d)	2.42	in
Sample Area (A)	4.58	in²
Length (L)	3.00	in
Weight Before	410.32	g
Wet Density	113.73	pcf
Dry Density	86.05	pcf

	Before	After
Container No.		
Wt. Wet Soil+Container(gms)	173.15	470.17
Wt. Dry Soil+Container(gms)	137.46	363.54
Wt. Container (gms)	26.53	50.02
Moisture, (%)	32.17	34.01

TEST RESULTS



Time (min)	Flow Rdg (cm)	Burette Factor	Q (cc)	Head, h (psi)	h/L	Q/t (cc/s)
0	22.3	1	0.0	1.0	9.23	0
19	22.2	1	0.1	1.0	9.23	8.77E-05
63	22.1	1	0.2	1.0	9.23	3.79E-05
109	22.0	1	0.3	1.0	9.23	3.62E-05
171	21.8	1	0.5	1.0	9.23	5.38E-05
1052	19.3	1	3.0	1.0	9.23	4.73E-05
1207	18.9	1	3.4	1.0	9.23	4.30E-05

Hydraulic Conductivity (cm/sec): 1.76E-07

AP Engineering and Testing, Inc.

GEOTECHNICAL TESTING LABORATORY

FLEXIBLE WALL HYDRAULIC CONDUCTIVITY TEST
ASTM D5084

Project Name: Preliminary Geologic Investigation
Project No.: 99-33437-01
Boring No.: B-105
Sample No.: --- Depth: 30-35 feet
Soil Description: Grayish Brown Silty Sand
Test Condition: Remolded to 85 % Relative Compaction @ Opt
Confining Pressure = 23 PSI

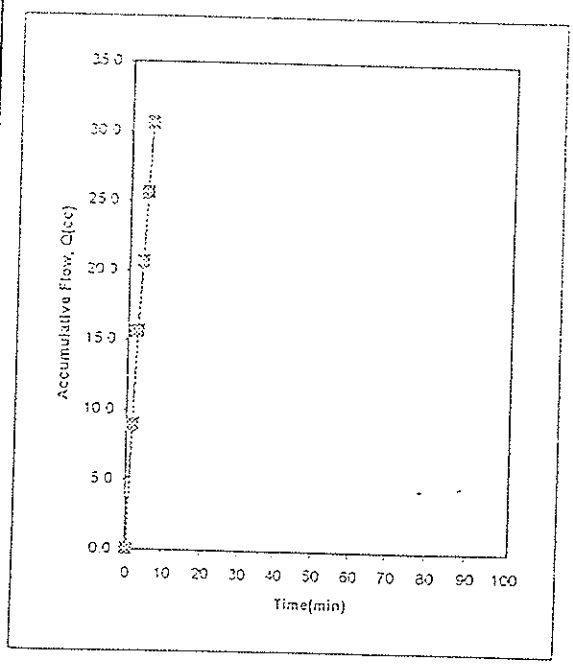
Tested by PS Date 10/14/99
Calculated by SY Date 10/20/99
Checked by AP Date 10/20/99

INITIAL CONDITION OF SPECIMEN

Diameter (d)	2.42	in
Sample Area (A)	4.58	in²
Length (L)	3.00	in
Weight Before	432.56	g
Wet Density	119.90	pcf
Dry Density	112.01	pcf

	Before	After
Container No.		
Wt. Wet Soil+Container(gms)	309.87	317.64
Wt. Dry Soil+Container(gms)	300.27	282.06
Wt. Container (gms)	164.05	49.93
Moisture, (%)	7.05	15.32

TEST RESULTS



Time (min)	Flow Rdg (cm)	Burette Factor	Q (cc)	Head, h (psi)	h/L	Q/t (cc/s)
0	45.3	1	0.0	1.0	9.23	0
1	36.4	1	8.9	1.0	9.23	1.48E-01
2	29.7	1	15.6	1.0	9.23	1.12E-01
3	24.7	1	20.6	1.0	9.23	8.33E-02
4	19.7	1	25.6	1.0	9.23	8.33E-02
5	14.7	1	30.6	1.0	9.23	8.33E-02

Hydraulic Conductivity (cm/sec): 3.05E-04

Log of Boring No. BRC-BS-01

CAMU

Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: HSA
Drilling Equipment: HSA LAR
Drilling Contractor: Water Development Corporation
Driller: James Duke

Borehole Total Depth: 32 ft bgs
Borehole Diameter: 8 in
Well ID: N/A
Depth to Water (ft. bgs): NA ▽

Sample Type: 2.5" Split Spoon
Sample Interval Continuous

Logged By: J. Wiley
Date Started: 01/15/05
Date Completed: 01/15/05

Monitoring Well Construction

Type of Surface Seal:	N/A	**Screen Slot Size:**	N/A
Blank Casing Type/Size:	N/A	**Top of Screen (ft. bgs):**	N/A
Screen Type/Size:	N/A	**Bottom of Screen (ft. bgs):**	N/A
Transition Sand Type:	N/A	**Type of Sand Pack:**	N/A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0							SP: Soil surface. (Odors not being observed due to potential chemical hazards.)	
							SP: @ 3', debris present, grey discolored soil and rubber cord with belt pieces.	
	Grab				0.1		SP: Poorly graded sand, dark greyish brown (10YR4/2), loose to medium dense, moist, fine to coarse subrounded sand and fine gravel, noncemented, no debris. Approximately trace gravel, 5% coarse sand, 85% medium sand and 10% fine sand.	
-10					0.6		Poorly graded sand, light brownish grey (10YR6/2), very dense, moist, fine to coarse, subangular to subrounded sand and fine gravel with increasing volcanics, noncemented silt. Approximately 5% gravel, 5% coarse sand, 65% medium sand, 25% fine sand and trace silt.	
	Grab				1.5		Poorly graded sand, brown (10YR5/3), loose to medium dense, moist, fine to coarse subangular to subrounded snad and fine gravel, no volcanics, noncemented, trace silt. Approximately 5% gravel, 15% coarse sand, 60% medium sand, 20% fine sand, trace silt.	
-20					1.4		Poorly graded sand, brown (10YR5/3), very dense, moist, moist, fine to coarse subangular volcanic sand and fine gravel, noncemented, trace silt. Approximately 5% gravel, 15% coarse sand, 60% medium sand, 20% fine sand, and trace silt.	
	Grab				0.5		Poorly graded sand, brown (10YR5/3) loose to medium dense, moist, fine to coarse subangular to subrounded sand and fine gravel, few volcanics, noncemented, trace silt. Approximately 5% gravel, 15% coarse sand, 60% medium sand, 20% fine sand and trace silt.	
-30					1.9		Poorly graded sand, brown (10YR5/3), very dense, moist, fine to coarse subangular to subrounded volcanic sand, and fine gravel, noncemented, slight solvent odor. Approximately 5% gravel, 15% coarse sand, 60% medium sand, 20% fine sand, and trace silt. Terminated borehole at 32' bgs.	

Log of Boring No. BRC-BS-02

CAMU

Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: HSA
Drilling Equipment: HSA LAR
Drilling Contractor: Water Development Corporation
Driller: James Duke

Borehole Total Depth: 32 ft bgs
Borehole Diameter: 8 in
Well ID: N/A
Depth to Water (ft. bgs): NA ▽

Sample Type: 2.5" Split Spoon
Sample Interval Continuous

Logged By: J. Wiley
Date Started: 01/14/05
Date Completed: 01/14/05

Monitoring Well Construction

Type of Surface Seal:	N/A	**Screen Slot Size:**	N/A
Blank Casing Type/Size:	N/A	**Top of Screen (ft. bgs):**	N/A
Screen Type/Size:	N/A	**Bottom of Screen (ft. bgs):**	N/A
Transition Sand Type:	N/A	**Type of Sand Pack:**	N/A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0							SP: Soil Surface, soil boring located in area of subsidence. (Odors not being observed due to potential chemical hazards.)	
	Grab				0.2		Poorly graded sand, yellowish brown (10YR5/4), loose, moist, fine to coarse, subrounded to rounded sand and fine gravel, noncemented, no debris. Approximately trace gravel, 10% coarse sand, 70% medium sand, 20% fine sand and trace silt.	
-10					0.0		Poorly graded sand, dark yellowish brown (10YR4/4), medium dense, moist, fine to coarse subrounded to rounded sand, and fine gravel, noncemented. Approximately trace gravel, 10% coarse sand, 70% medium sand, 20% fine sand and trace silt.	
	Grab				2.2		SP: Poorly graded sand, brown (10YR5/4), loose to medium dense, moist, fine to coarse subrounded sand and fine gravel, noncemented, minor debris (small paper shreds). Approximately trace gravel, 5% coarse sand, 75% medium sand and 20% fine sand and trace silt.	
					3.2		SP: Debris - wood, fabric, plastic, paper bags, white powder, and wet white chalky substance, strong solvent odor.	
-20							SP: Poorly graded sand, yellowish brown (10YR5/4), dense, moist, fine to coarse subrounded to subangular sand and fine gravel, noncemented, no debris.	
							@ 23' drillers note change in drilling - hard soil.	
	Grab				0.2		Poorly graded sand, brown (10YR5/3), moist, fine to coarse, angular to subrounded sand and fine gravel (includes volcanics), noncemented, no debris, trace silt. Approximately trace gravel, 5% coarse, 65% medium sand, 65% medium sand, 25% fine and 5% silt.	
-30					1.8		Poorly graded sand, brown (10YR5/3), very dense, moist, fine to coarse subanguar sand and fine gravel (including volcanics), noncemented, no debris, trace silt. Approximately trace gravel, trace coarse sand, 50% medium sand, 45% fine sand and 5% silt. Terminated borehole at 32' bgs.	

Log of Boring No. BRC-BS-03

CAMU

Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: HSA
Drilling Equipment: HSA LAR
Drilling Contractor: Water Development Corporation
Driller: James Duke

Borehole Total Depth: 32 ft bgs
Borehole Diameter: 8 in
Well ID: N/A
Depth to Water (ft. bgs): NA ⊻

Sample Type: 2.5" Split Spoon
Sample Interval Continuous

Logged By: J. Wiley
Date Started: 01/12/05
Date Completed: 01/12/05

Monitoring Well Construction

Type of Surface Seal:	N/A	**Screen Slot Size:**	N/A
Blank Casing Type/Size:	N/A	**Top of Screen (ft. bgs):**	N/A
Screen Type/Size:	N/A	**Bottom of Screen (ft. bgs):**	N/A
Transition Sand Type:	N/A	**Type of Sand Pack:**	N/A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0	Grab				0.0		GP: Soil surface; boring located within area of slight subsidence. (Odors not being observed due to potential chemical hazards.) SP: Poorly graded gravel with sand, yellowish brown (10YR5/4), loose, moist, medium to coarse subrounded sand and fine subrounded (pea) gravel, trace fine snad, noncemented. Approximately 60% gravel, 20% coarse sand, 20% medium sand and trace fine sand.	
-10					2.6		SP: Poorly graded sand, yellowish brown (10YR5/4), medium dense, moist, fine to medium subrounded to angular sand and fine subangular gravel, noncemented, debris includes plastic, fabric, concrete chunks, and visqueen. Apporximately 10% gravel, 5% coarse sand, 65% medium sand and 20% fine sand.	
	No Soil				1.0		DEBRIS/COBBLES: @15' cuttings consist mostly of debris - clothing mostly and plastic parts (one reads "janitorial toilet bowl cleaner"), some paper/cardboard, with cobbles up to 2.5" diameter.	
-20					1.5		@19' cannot pound sample - blocked - no recovery. @20' cannot pound sample - no recovery. Drill to 21' and try again. Cuttings consist of debris (paper/cardboard) with some cobbles/coarse gravel.	
-30					1.7		GP: @27' drillers noted that soil way more compacted - likely out of fill. Poorly graded gravel with sand, light yellowish brown (10YR6/4), very dense, moist, fine to coarse subangular sand and fine subangular gravel, trace silt, no debris. Approximately 60% gravel, 15% coarse sand, 15% medium sand, 10% fine sand and trace silt. Terminated borehole at 32' bgs.	

Log of Boring No. BRC-BS-04

CAMU

Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: HSA
Drilling Equipment: HSA LAR
Drilling Contractor: Water Development Corporation
Driller: James Duke

Borehole Total Depth: 32 ft bgs
Borehole Diameter: 8 in
Well ID: N/A
Depth to Water (ft. bgs): NA ▽

Sample Type: 2.5" Split Spoon
Sample Interval Continuous

Logged By: J. Wiley
Date Started: 01/17/05
Date Completed: 01/17/05

Monitoring Well Construction

Type of Surface Seal:	N/A	**Screen Slot Size:**	N/A
Blank Casing Type/Size:	N/A	**Top of Screen (ft. bgs):**	N/A
Screen Type/Size:	N/A	**Bottom of Screen (ft. bgs):**	N/A
Transition Sand Type:	N/A	**Type of Sand Pack:**	N/A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0							SP: Soil surface; soil boring located within subsidence cracks. (Odors not being observed due to potential chemical hazards.)	
	Grab				0.4		Poorly raded sand, dark yellowish brown (10YR4/4), loose to medium dense, moist, fine to coarse subrounded to rounded sand and fine gravel - not volcanic, noncemented, no debris. Approximately trace gravel, 20% coarse sand, 65% medium sand and 15% fine sand.	
-10					0.5		Poorly graded sand, dark yellowish brown (10YR4/4), dense, moist, fine to coarse subrounded to rounded sand and fine gravel - not volcanic, noncemented. Debris begins at 11.5', consists of paper bags and white powder, and wood splinters. Approximately 5% gravel, 20% coarse sand, 60% medium sand and 15% fine sand.	
	Grab				11.3		SP: Poorly graded sand, brown (10YR4/3), medium dense to dense, moist, fine to coarse subrounded to rounded sand and fine gravel - no volcanics, noncemented, paper and plastic debris, wood splinters. Approximately 5% gravel, 20% coarse sand, 60% medium sand and 15% fine sand.	
-20					3.6			
	Grab				12.0		SP: Poorly graded sand, brown (10YR4/3), very dense, moist, fine to coarse angular to subangular volcanic sand and fine gravel, noncemented, no debris. Drillers note change in hardness @ 21'. Cuttings appear to be from 15' - 20' interval - have plastic lid (~4' diameter) debris and trace metal straps. Approximately trace gravel, 10% coarse, 65% medium sand and 25% fine sand.	
-30							Poorly graded sand, brown (10YR4/3), very dense, moist, fine to coarse angular to subangular volcanic sand and fine gravel, noncemented, no debris. Approximately trace gravel, 10% coarse sand, 65% medium sand and 25% fine sand. Terminated borehole at 31' bgs.	

Log of Boring No. BRC-BS-05

CAMU

Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: HSA
Drilling Equipment: HSA LAR
Drilling Contractor: Water Development Corporation
Driller: James Duke

Borehole Total Depth: 32 ft bgs
Borehole Diameter: 8 in
Well ID: N/A
Depth to Water (ft. bgs): NA ▽

Sample Type: 2.5" Split Spoon
Sample Interval Continuous

Logged By: J. Wiley
Date Started: 01/19/05
Date Completed: 01/19/05

Monitoring Well Construction

Type of Surface Seal:	N/A	**Screen Slot Size:**	N/A
Blank Casing Type/Size:	N/A	**Top of Screen (ft. bgs):**	N/A
Screen Type/Size:	N/A	**Bottom of Screen (ft. bgs):**	N/A
Transition Sand Type:	N/A	**Type of Sand Pack:**	N/A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0							SP: Soil surface, boring located within area of subsidence. (Odors not being observed due to potential chemical hazards.) Debris begins @ 5'	
	Grab				0.7		SP: Poorly graded sand, yellowish brown (10YR5/4), loose, moist, fine to coarse sand and fine grained - subrounded to rounded - no volcanics, noncemented. Debris includes wood, metal, cobbles, and plastic. Approximately trace gravel, trace coarse sand, 70% medium sand and 30% fine sand.	
-10					4.3		Poorly graded sand, yellowish brown (10YR5/4), dense, moist, fine to coarse subrounded to rounded sand and fine gravel - no volcanics, noncemented, debris includes mostly wood, some plastic, metal, and white chalky material. Approximately 5% gravel, 10% coarse sand, 75% medium sand and 10% fine sand.	
	Grab				21.0		Poorly graded sand, brown (10YR4/3), loose to dense, moist, fine to coarse subangular to subrounded sand and fine gravel, no volcanics, noncemented, little debris, paper (small shreds). Approximately trace gravel, 5% coarse sand, 65% medium sand and 30% fine sand.	
-20					19.0		Poorly graded sand, dark grayish brown (10YR4/2), very dense, moist, fine to coarse subangular to subrounded sand and fine gravel, no volcanics, noncemented, debris includes wood, plastic lined paper bags with white chalky material, metal and newspaper. Approximately trace gravel, 5% coarse sand, 65% medium sand and 30% fine sand.	
	Grab				5.2		SP: Poorly graded sand, yellowish brown (10YR5/4), loose to dense, moist, fine to coarse angular to rounded sand and fine gravel - some volcanics, noncemented, no debris, trace silt. Approximately trace gravel, 5% coarse sand, 60% medium sand, 35% fine sand and trace silt.	
-30					0.4		Poorly graded sand, yellowish brown (10YR5/4), very dense, moist, fine to coarse angular to subangular sand and fine gravel - volcanic, noncemented, no debris. Approximately trace gravel, 5% coarse sand, 60% medium sand, 35% fine sand and trace silt. Terminated borehole at 32' bgs.	

Log of Boring No. BRC-BS-06
CAMU
Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: HSA
Drilling Equipment: HSA LAR
Drilling Contractor: Water Development Corporation
Driller: James Duke

Borehole Total Depth: 32 ft bgs
Borehole Diameter: 8 in
Well ID: N/A
Depth to Water (ft. bgs): NA ▽

Sample Type: 2.5" Split Spoon
Sample Interval Continuous

Logged By: J. Wiley
Date Started: 01/14/05
Date Completed: 01/14/05

Monitoring Well Construction

Type of Surface Seal:	N/A	**Screen Slot Size:**	N/A
Blank Casing Type/Size:	N/A	**Top of Screen (ft. bgs):**	N/A
Screen Type/Size:	N/A	**Bottom of Screen (ft. bgs):**	N/A
Transition Sand Type:	N/A	**Type of Sand Pack:**	N/A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0							SP: Soil surface. (Odors not being observed due to potential chemical hazards.) Poorly graded sand, brown (10YR4/3), loose, moist, fine to coarse subrounded to rounded sand and fine grained, noncemented. Approximately 5% gravel, 10% coarse sand, 65% medium sand and 20% fine sand.	
	Grab				30.6		SP: Begin debris at 3' bgs. wood, solvent odor. Poorly graded sand, brown (10YR4/3) loose to medium dense, moist, fine to coarse subrounded to rounded sand and fine gravel, noncemented, solvent odor, debris includes wood. Approximately trace gravel, 10% coarse sand 70% medium sand and 20% fine sand.	
-10					4.0		Poorly graded sand, brown (10YR4/3), dense, moist, fine to coarse subangular to subrounded sand, and trace fine gravel, noncemented, strong solvent odor, very little wood debris. Approximately trace gravel, 5% coarse sand, 75% medium sand and 20% fine sand.	
							@12' increased debris: wood, fabric, plastic, solvent odor.	
	Grab				15.0		Poorly graded sand, dark yellowish brown (10YR4/4), loose to medium dense, fine to coarse subrounded sand and fine gravel, noncemented, debris includes fabric with plastic and wood, solvent odor.	
-20					1.0		Poorly graded sand, dark yellowish brown (10YR4/4), dense, fine to coarse, subangular sand and fine gravel, noncemented, solvent odor. Approximately 5% gravel, 5% coarse sand, 50% medium sand, 40% fine sand and trace silt.	
	Grab				35.1		SP: Poorly graded sand, dark yellowish brown (10YR4/4), loose to medium dense, fine to coarse subangular sand and fine gravel, noncemented, solvent odor, no debris. Approximately 10% gravel, 5% coarse sand, 55% medium sand, 30% fine sand and trace silt.	
-30					0.8		Poorly graded sand, brown (10YR5/3), very dense, moist, fine to coarse volcanic sand (angular to subangular) and fine gravel, noncemented, no debris. Approximately trace gravel, 5% coarse snad 55% medium sand and 40% fine sand.	
							Terminated borehole at 32' bgs.	

Log of Boring No. BRC-BS-07

CAMU

Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: HSA
Drilling Equipment: HSA LAR
Drilling Contractor: Water Development Corporation
Driller: James Duke

Borehole Total Depth: 32 ft bgs
Borehole Diameter: 8 in
Well ID: N/A
Depth to Water (ft. bgs): NA ▽

Sample Type: 2.5" Split Spoon
Sample Interval Continuous

Logged By: J. Wiley
Date Started: 01/11/05
Date Completed: 01/11/05

Monitoring Well Construction

Type of Surface Seal:	N/A	**Screen Slot Size:**	N/A
Blank Casing Type/Size:	N/A	**Top of Screen (ft. bgs):**	N/A
Screen Type/Size:	N/A	**Bottom of Screen (ft. bgs):**	N/A
Transition Sand Type:	N/A	**Type of Sand Pack:**	N/A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0	Grab						SP: Soil surface; boring located adjacent to deep (3') area of subsidence, and is in line of subsidence areas. (Odors not being observed due to potential chemical hazards.) Poorly graded sand with gravel, yellowish brown (10YR5/4), loose, moist, fine to coarse subrounded to angular sand and fine angular gravel (fill), noncemented. Approximately 15% gravel, 10% coarse sand, 55% medium sand, 20% fine sand and trace silt.	
-10					1.1		DEBRIS: Debris-fabric (black) and plastic chunks (white to grey). Poor recovery.	
							SP: Poorly graded sand with gravel, pale brown (10YR6/3), moist, medium dense, fine to coarse subrounded to angular sand and fine subangular gravel, noncemented. Approximately 15% gravel, 20% coarse sand, 50% medium sand, 15% fine sand and trace silt.	
							SP: No recovery from cuttings due to fabric material caught in auger - likely debris in this interval.	
-20					0.1		SP: Poorly graded sand with gravel, pale brown (10YR6/3), moist, very dense, fine to coarse subrounded to angular sand and fine subangular gravel, noncemented, trace cobbles, has black fabric fragments. Approximately 15% gravel, 10% coarse sand, 45% medium sand, 30% fine sand and trace silt.	
	Grab						Poorly graded sand with gravel, brown (10YR5/3), moist, fine to coarse subrounded to subangular sand and subangular gravel, noncemented. Approximately 15% gravel, 5% coarse sand, 40% medium sand, 40% fine sand and trace silt.	
-30					3.0		Poorly graded sand with gravel, brown (10YR5/3), very dense, moist, fine to coarse subrounded to subangular sand and fine subangular gravel, noncemented, no fabric observed, drillers observed harder drilling after 25'. Approximately 15% gravel, 5% coarse sand, 40% medium sand, 40% fine sand and trace silt.	
							Terminated borehole at 32' bgs.	

Log of Boring No. BRC-BS-08

CAMU

Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: HSA
Drilling Equipment: HSA LAR
Drilling Contractor: Water Development Corporation
Driller: Ignacio Gutierrez

Borehole Total Depth: 32 ft bgs
Borehole Diameter: 8 in
Well ID: N/A
Depth to Water (ft. bgs): NA ⊻

Sample Type: 2.5" Split Spoon
Sample Interval Continuous

Logged By: J. Wiley
Date Started: 01/18/05
Date Completed: 01/18/05

Monitoring Well Construction

Type of Surface Seal:	N/A	**Screen Slot Size:**	N/A
Blank Casing Type/Size:	N/A	**Top of Screen (ft. bgs):**	N/A
Screen Type/Size:	N/A	**Bottom of Screen (ft. bgs):**	N/A
Transition Sand Type:	N/A	**Type of Sand Pack:**	N/A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0							SP: Soil surface, boring located in slight depression area. (Odors not being observed due to potential chemical hazards.)	
	Grab				-6.5		Poorly graded sand, dark yellowish brown (10YR4/4), loose to dense, fine to coarse subrounded to rounded sand and fine gravel - no volcanics, trace silt, noncemented. Approximately 5% gravel, 5% coarse sand, 75% medium sand, 15% fine sand and trace silt.	
-10					16.2		Poorly graded sand, brown (10YR4/3), dense, moist, fine to coarse angular to subangular volcanic sand and fine gravel plus nonvolcanics, noncemented, solvent odor, grains have slight coating (dark brown), oily.	
	Grab				57.2		Poorly graded sand, very dark grayish brown, dense, fine to coarse angular to subangular volcanic sand and fine gravel, noncemented, oily coating (dark brown), solvent odor. Approximately trace gravel, 10% coarse sand, 70% medium sand and 20% fine sand.	
-20					1361		SP: Poorly graded sand, brown (10YR4/3), dense, moist, fine to coarse, subangular to subrounded sand and fine gravel - some volcanic. Thick oily residue covers grains. Has sheen when washed, strong solvent odor, weakly cemented from residues. Fill begins at ~19', consisting of wood fragments and white powder and paper bags - strong solvent odor. From 20'-25' soil is oily coated, difficult to wash grains - heavy sheen, some loose oil/sludge between grains.	
	Grab				1140		GP: Poorly graded gravel, very dark grey (10YR3/1), loose to dense, moist, fine to medium sand, fine gravel, heavy oily residue on grains, sheen when washed, strong solvent odor, traces of wood splinters, areas of pure sludge between grains. Approximately 80% gravel, 10% coarse sand, 5% medium sand and 5% fine sand.	
-30					2900		Poorly graded sand, dark brown (7.5YR3/4), very dense, fine to coarse angular to subangular volcanic sand and fine gravel, trace silt, noncemented sheen when washing grains. Approximately trace gravel, 10% coarse sand, 70% medium sand, 20% fine sand and trace silt. Terminated borehole at 31.5' bgs.	

Log of Boring No. BRC-BS-09

CAMU

Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: HSA
Drilling Equipment: HSA LAR
Drilling Contractor: Water Development Corporation
Driller: Ignacio Gutierrez

Borehole Total Depth: 32 ft bgs
Borehole Diameter: 8 in
Well ID: N/A
Depth to Water (ft. bgs): NA ⊻

Sample Type: 2.5" Split Spoon
Sample Interval Continuous

Logged By: J. Wiley
Date Started: 01/19/05
Date Completed: 01/19/05

Monitoring Well Construction

Type of Surface Seal:	N/A	**Screen Slot Size:**	N/A
Blank Casing Type/Size:	N/A	**Top of Screen (ft. bgs):**	N/A
Screen Type/Size:	N/A	**Bottom of Screen (ft. bgs):**	N/A
Transition Sand Type:	N/A	**Type of Sand Pack:**	N/A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0							SP: Soil surface, boring located within slight depression area. (Odors not being observed due to potential chemical hazards.)	
	Grab				2.1		Poorly graded sand, brown (10YR5/3), loose, moist, fine to coarse subrounded to rounded sand and fine gravel - no volcanic, noncemented, no debris. Approximately trace gravel 5% coarse sand, 70% medium sand and 25% fine sand. Trash begins at 9' bgs.	
-10					9.8		SP: Poorly graded sand as at 5', layered between debris - gray and white speckled cement/concrete - like material. Approximately trace gravel, 5% coarse sand, 70% medium sand and 25% fine sand. Drillers noted a change in drilling at ~16'.	
	Grab				5.2		Poorly graded sand, brown (10YR4/3), dense, moist, fine to coarse sand and fine gravel - subrounded to rounded, no volcanics, noncemented. Debris includes wood, fabric and plastic. Approximately trace gravel, trace coarse sand, 80% medium sand and 20% fine sand.	
-20					4.2		Poorly graded sand, dark gray (10YR4/1), dense, moist fine to coarse subrounded to rounded sand and fine gravel, noncemented, debris includes glass, paper and white chalky material, plastic bottles. Approximately trace gravel, trace coarse sand, 80% medium sand and 20% fine sand.	
	Grab				9.7		Poorly graded sand, brown (10R4/3), dense, moist, fine to coarse subangular to rounded sand and fine gravel, noncemented, debris including glass and paper, some metal. Approximately 10% gravel, 20% coarse sand, 50% medium sand and 20% fine sand.	
-30					7.4		Poorly graded sand, brown (10YR5/3), very dense, fine to coarse subangular to angular sand and fine gravel - volcanic, noncemented, no debris. Approximately 10% gravel, 20% coarse sand, 50% medium sand and 20% fine sand. Terminated borehole at 32' bgs.	

Log of Boring No. BRC-BS-10
CAMU
Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: HSA
Drilling Equipment: HSA LAR
Drilling Contractor: Water Development Corporation
Driller: James Duke

Borehole Total Depth: 22 ft bgs
Borehole Diameter: 8 in
Well ID: N/A
Depth to Water (ft. bgs): NA ⊻

Sample Type: 2.5" Split Spoon
Sample Interval Continuous

Logged By: J. Wiley
Date Started: 01/15/05
Date Completed: 01/15/05

Monitoring Well Construction

Type of Surface Seal:	N/A	**Screen Slot Size:**	N/A
Blank Casing Type/Size:	N/A	**Top of Screen (ft. bgs):**	N/A
Screen Type/Size:	N/A	**Bottom of Screen (ft. bgs):**	N/A
Transition Sand Type:	N/A	**Type of Sand Pack:**	N/A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0							SP: Soil surface - soil boring apears to be in possible slightly subsided area. (Odors not being observed due to potential chemical hazards.)	
	Grab				13.6		Poorly graded sand, brown (10YR4/3), loose to medium dense, fine to coarse, subrounded to rounded sand and fine gravel, no volcanics, trace silt, noncemented, no debris. Approximately 5% gravel, 5% coarse sand, 80% medium sand, 10% fine sand and trace silt.	
-10					3.5		Poorly graded sand, yellowish brown (10YR5/4), very dense, moist, fine to coarse subangular volcanic sand and fine gravel, noncemented, no odor, no debris. Approximately 5% gravel, 10% coarse sand, 60% medium sand and 25% fine sand.	
	Grab				4.1		Poorly graded sand, yellowish brown (10YR5/4), medium dense, moist, fine to coarse angular to subrounded sand and fine gravel including some volcanics, noncemented, trace silt. Approximately 5% gravel, 10% coarse sand, 65% medium sand, 10% fine sand and trace silt.	
-20							Poorly graded sand, yellowish brown (10YR5/4), very dense, moist, fine to coarse angular to subangular volcanic sand and fine gravel, noncemented. Aproximately 5% gravel, 15% coarse sand, 60% medium sand and 20% fine sand.	
							Terminate borehole at 22' due to no debris encountered. Fill material ended by 9'.	

Log of Boring No. BRC-BS-11
CAMU
Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: HSA
Drilling Equipment: HSA LAR
Drilling Contractor: Water Development Corporation
Driller: James Duke

Borehole Total Depth: 32 ft bgs
Borehole Diameter: 8 in
Well ID: N/A
Depth to Water (ft. bgs): NA ▽

Sample Type: 2.5" Split Spoon
Sample Interval Continuous

Logged By: J. Wiley
Date Started: 01/13/05
Date Completed: 01/13/05

Monitoring Well Construction

Type of Surface Seal:	N/A	**Screen Slot Size:**	N/A
Blank Casing Type/Size:	N/A	**Top of Screen (ft. bgs):**	N/A
Screen Type/Size:	N/A	**Bottom of Screen (ft. bgs):**	N/A
Transition Sand Type:	N/A	**Type of Sand Pack:**	N/A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0							SP: Soil surface. Poorly graded sand, yellowish brown (10YR5/4), loose, moist, fine to medium subangular to subrounded sand, trace subangular to subrounded gravel, trace silt, noncemented. Approximately trace gravel, 10% coarse sand, 60% medium sand, 30% fine sand and trace silt.	
	Grab				0.5		@ 5' bgs, debris encountered consisting of fabric and cobbles.	
-10							Poorly graded sand, yellowish brown (10YR5/4), loose, moist, fine to medium subangular to subrounded sand trace fine grained, trace silt, noncemented from 10-10.5' bgs, black fine material and gravel debris. Approximately trace gravel, 10% coarse sand, 60% medium sand, 30% fine sand and trace silt.	
	Grab				9.0		Poorly graded sand, very dark grayish brown (2.5Y3/2), loose, moist, fine to coarse subangular to subrounded sand, fine subrounded gravel, noncemented. Approximately 5% gravel, 5% coarse sand, 30% medium sand and 60% fine sand.	
-20					42.5		Poorly graded sand, brown (10YR5/3), medium dense, moist, fine to medium sand and fine gravel (as at 15'), noncemented, with paper debris and solvent odor. Approximately 10% gravel, 5% coarse, 25% medium sand and 60% fine sand.	
							@ 23', mostly debris-cobbles, wood, paper (receipts, paper pads), fabric, minor amounts of metal and plastic, paper bags, strong odor (solvent).	
							Drillers hit hard soil at 29.5' bgs.	
-30					70 0.2		Poorly graded sand, yellowish brown 10YR5/4), very dense, moist, fine to coarse sand, subangular to subrounded volcanic, trace gravel, noncemented. Approximately trace gravel, 5% coarse sand, 50% medium sand, 45% fine sand and trace silt. Borehole terminated @ 32 ft bgs.	

Log of Boring No. BRC-BS-12
CAMU
Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: HSA
Drilling Equipment: HSA LAR
Drilling Contractor: Water Development Corporation
Driller: James Duke

Borehole Total Depth: 32 ft bgs
Borehole Diameter: 8 in
Well ID: N/A
Depth to Water (ft. bgs): NA ▽

Sample Type: 2.5" Split Spoon
Sample Interval Continuous

Logged By: J. Wiley
Date Started: 01/12/05
Date Completed: 01/12/05

Monitoring Well Construction

Type of Surface Seal:	N/A	**Screen Slot Size:**	N/A
Blank Casing Type/Size:	N/A	**Top of Screen (ft. bgs):**	N/A
Screen Type/Size:	N/A	**Bottom of Screen (ft. bgs):**	N/A
Transition Sand Type:	N/A	**Type of Sand Pack:**	N/A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0							SP: Soil surface; boring located within area of slight subsidence. (Odors not being observed due to potential chemical hazards.)	
	Grab						Debris encountered - plastic lined paper bag pieces.	
					1.0		Poorly graded sand, brown (10YR4/3), loose, moist, fine to coarse subangular to subrounded sand and subrounded fine gravel, trace silt, noncemented, few paper and plastic debris fragments. Approximately 5% gravel, 20% coarse sand, 55% medium sand, 20% fine sand and trace silt.	
-10					7.6		Poorly graded sand, brown (10YR4/3), very dense, moist, fine to coarse, subrounded sand and subrounded fine gravel, trace silt, noncemented debris including paper, plastic and white cement fragments. Approximately 5% gravel, 10% coarse sand, 65% medium sand, 20% fine sand and trace silt.	
	Grab				7.0		Poorly graded sand, brown (10YR4/3), moist, fine to coarse subrounded sand and fine subrounded gravel, noncemented, paper and plastic debris. Approximately 5% gravel, 10% coarse sand, 65% medium sand, 20% fine sand and trace silt.	
							@18' bgs, increase in plastic lined paper bag remnants - writing on them reads "Montrose ODT".	
-20					0.6		Poorly graded sand, yellowish brown (10YR5/4), moist, dense, fine to coarse, subrounded sand and fine subrounded gravel, noncemented, paper and plastic debris. Approcimately 5% gravel, 15% coarse sand, 65% medium sand, 15% fine sand and trace silt.	
	Grab				11.7		Poorly graded sand, yellowish brown (10YR5/4), moist, fine to coarse subrounded sand and fine subrounded gravel, noncemented, small ammounts of paper and plastic. Approximately 5% gravel, 5% coarse sand, 60% medium sand, 30% fine sand and trace silt.	
-30					1.5		Poorly graded sand with gravel, yellowish brown (10YR5/4), moist, fine to coarse subrounded sand and fine subangular to angular gravel, noncemented, no debris. Approximately 15% gravel, 5% coarse sand, 40% medium sand and 40% fine sand.	
							Terminate borehole at 32' bgs.	

Log of Boring No. BRC-BS-13

CAMU

Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: HSA
Drilling Equipment: CME-75/HSA LAR
Drilling Contractor: Water Development Corporation
Driller: Ignacio Gutierrez

Borehole Total Depth: 31 ft bgs
Borehole Diameter: 8 in
Well ID: N/A
Depth to Water (ft. bgs): NA ▽

Sample Type: 2.5" Split Spoon
Sample Interval Continuous

Logged By: J. Wiley
Date Started: 01/18/05
Date Completed: 01/18/05

Monitoring Well Construction

Type of Surface Seal:	N/A	**Screen Slot Size:**	N/A
Blank Casing Type/Size:	N/A	**Top of Screen (ft. bgs):**	N/A
Screen Type/Size:	N/A	**Bottom of Screen (ft. bgs):**	N/A
Transition Sand Type:	N/A	**Type of Sand Pack:**	N/A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0	Grab				22		SP: Soil surface, boring located in area of subsidence. Poorly graded sand, yellowish brown (10YR5/4), loose to dense, fine to coarse subrounded to rounded sand and fine gravel, no volcanics, noncemented, trace debris, consisting of glass shards (very little). Approximately trace gravel, 10% coarse sand, 70% medium sand, 20% fine sand and trace silt.	
-10					29.1		At 9' bgs, debris begins, consisting of visqueen and rope. Poorly graded sand, brown (10YR4/3), yellowish brown (10YR5/4), medium dense, moist, fine to coarse subrounded sand and fine gravel, very few volcanics, noncemented, small layer of black (burned) paper bags. Approximately trace gravel, 10% coarse sand, 70% medium sand 20% fine sand and trace silt.	
	Grab				85.6		Poorly graded sand, dark grayish brown (10YR4/2), loose, fine to coarse subrounded to rounded sand and fine gravel, few volcanics, noncemented, abundant debris, entire paper (plastic lined) bags of lime (~80%) and DDT (~20%), solvent odor (flowery). Approximately trace gravel, 5% coarse sand, 65% medium sand, 30% fine sand and trace silt.	
-20					53.1		Entire bags of lime (~80%) and DDT (~20%) with very little sand mixed in, loose trash, solvent odor (flowery). Approximately trace gravel, 5% coarse sand, 65% medium sand, 30% fine sand, and trace silt.	
							Drillers indicated change of drilling at 23', out of trash zone.	
	Grab				0.4		Poorly graded sand, brown (7.5YR5/3), loose to dense, moist, fine to coarse subangular sand and fine gravel, increased volcanics, noncemented. Approximately trace gravel, 10% coarse sand, 60% medium sand, 30% fine sand and trace silt.	
							Poorly graded sand, light yellowish brown (10YR 6/4), very dense, moist, fine to coarse angular to subrounded volcanic sand and fine gravel, noncemented, trace silt. Approximately trace gravel, 5% coarse sand, 55% medium sand, 40% fine sand and trace silt.	
-30					1.1		Terminate borehole at 31' bgs.	

Log of Boring No. BRC-BS-14

CAMU

Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: HSA
Drilling Equipment: CME-75/HSA LAR
Drilling Contractor: Water Development Corporation
Driller: Ignacio Gutierrez

Borehole Total Depth: 31.5 ft bgs
Borehole Diameter: 8 in
Well ID: N/A
Depth to Water (ft. bgs): NA ▽

Sample Type: 2.5" Split Spoon
Sample Interval Continuous

Logged By: J. Wiley
Date Started: 01/19/05
Date Completed: 01/19/05

Monitoring Well Construction

Type of Surface Seal:	N/A	**Screen Slot Size:**	N/A
Blank Casing Type/Size:	N/A	**Top of Screen (ft. bgs):**	N/A
Screen Type/Size:	N/A	**Bottom of Screen (ft. bgs):**	N/A
Transition Sand Type:	N/A	**Type of Sand Pack:**	N/A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0							SP: Soi surface, boring located with in slight depression area. Poorly graded sand, strong brown (7.5YR4/6), loose, moist, fine to coarse subrounded to rounded sand, no volcanics, noncemented.	
	Grab				0.2		Debris begins at ~5' bgs: fabric, paper bags and plastic.	
-10					11.7		Poorly graded sand, strong brown (7.5YR4/6), dense, moist, fine to coarse subrounded to rounded sand, no volcanics, with trace medium sand size angular red brick fragments, noncemented, debris including paper and burned wood fragments, with some plastic. Approximately 5% gravel, 5% coarse sand 80% medium sand and 10% fine sand.	
	Grab				9.3		Poorly graded sand, very dark gray (7.5YR3/1), loose to dense, moist, fine to coarse subangular to rounded sand (some consisting of red brick fragments), fine gravel, noncemented, debris consists of plastic, paper, wood splinters and fabric. Approximately 5% gravel, 5% coarse sand, 70% medium sand and 20% fine sand.	
-20					13.2		Poorly graded sand, very dark gray (7.5YR3/1), very dense, moist, fine to course subangular to rounded sand (some consisting of red brick fragments), fine gravel and few cobbles, noncemented, debris is paper, plastic, fabric, and wood. Approximately 5% gravel, 5% coarse sand, 70% medium sand and 20% fine sand.	
	Grab				6.1		Poorly graded sand, very dark gray (7.5YR3/1), loose to dense, moist, fine to coarse subangular to rounded sand and fine gravel (with red brick fragments), noncemented, debris is paper and plastic. Approximately 5% gravel, 10% coarse sand, 60% medium sand and 25% fine sand.	
-30					0.4		Poorly graded sand, brown (7.5YR5/4), very dense, moist, fine to coarse angular to subangular volcanic sand and fine gravel, noncemented, no debris, drillers also noted a change in drilling. Approximately trace gravel, 5% coarse sand, 55% medium sand and 40% fine sand.	
							Terminatel boring at 31.5' bgs.	

Log of Boring No. BRC-BS-15

CAMU

Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: HSA
Drilling Equipment: CME-75/HSA LAR
Drilling Contractor: Water Development Corporation
Driller: Ignacio Gutierrez

Borehole Total Depth: 32 ft bgs
Borehole Diameter: 8 in
Well ID: N/A
Depth to Water (ft. bgs): NA ▽

Sample Type: 2.5" Split Spoon
Sample Interval Continuous

Logged By: J. Wiley
Date Started: 01/19/05
Date Completed: 01/19/05

Monitoring Well Construction

Type of Surface Seal:	N/A	**Screen Slot Size:**	N/A
Blank Casing Type/Size:	N/A	**Top of Screen (ft. bgs):**	N/A
Screen Type/Size:	N/A	**Bottom of Screen (ft. bgs):**	N/A
Transition Sand Type:	N/A	**Type of Sand Pack:**	N/A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0							SP: Soil surface located approximately 10' east of sunken pit from trench (moved from origional location, which was ~30' east of current).	
	Grab				1.5		Poorly graded sand, dark grayish brown (10YR4/2), moist, loose, fine to coarse subangular to rounded sand and fine gravel, few cobbles, debris includes wood, glass and cobbles coated in black residue. Approximately 10% gravel, 10% coarse sand, 60% medium sand and 20% fine sand.	
-10					0.8		Poorly graded sand, brown (10YR5/3), dense, moist, fine to coarse, angular to subangular sand and fine gravel, few volcanics, debris includes few wood splinters and paper (from bags). Approximately trace gravel, 5% coarse sand, 65% medium sand, 30% fine sand and trace silt.	
	Grab				0.3		Poorly graded sand, yellowish brown (10YR5/4), dense, moist, fine to coarse angular to subrounded sand and fine gravel, no volcanics, noncemented, no debris, trace silt, slight solvent odor. Approximately trace gravel, 5% coarse sand, 65% medium sand, 30% fine sand and trace silt.	
-20					0.4		Poorly graded sand, yellowish brown (10YR5/4), medium dense, moist, fine to coarse angular to subrounded sand and fine gravel, abundant volcanics, noncemented, no debris, trace silt, slight solvent odor. Approximately trace gravel, 5% coarse sand, 55% medium sand, 40% fine sand and trace silt.	
	Grab				1.3		Poorly graded sand, as at 15', no debris, medium dense, slight solvent odor. Approximatley trace gravel, 5% coarse sand, 65% medium sand, 30% fine sand and trace silt.	
-30					0.1		Poorly graded sand, yellowish brown (10YR5/4), very dense, moist, fine to coarse angular to subangular sand and fine gravel, volcanic areas of weak to moderate cementation, trace silt, no debris, slight solvent odor. Approximately trace gravel, 5% coarse sand, 55% medium sand, 40% fine sand and trace silt.	
							Terminate borehole at 32' bgs.	

Log of Boring No. BRC-BS-16
CAMU
Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: HSA
Drilling Equipment: CME-75/HSA LAR
Drilling Contractor: Water Development Corporation
Driller: James Duke

Borehole Total Depth: 32 ft bgs
Borehole Diameter: 8 in
Well ID: N/A
Depth to Water (ft. bgs): NA ▽

Sample Type: 2.5" Split Spoon
Sample Interval Continuous

Logged By: J. Wiley
Date Started: 01/15/05
Date Completed: 01/15/05

Monitoring Well Construction

Type of Surface Seal:	N/A	**Screen Slot Size:**	N/A
Blank Casing Type/Size:	N/A	**Top of Screen (ft. bgs):**	N/A
Screen Type/Size:	N/A	**Bottom of Screen (ft. bgs):**	N/A
Transition Sand Type:	N/A	**Type of Sand Pack:**	N/A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0							SP: Soil surface soil boring in a hill.	
							Debris begins at surface, consists of white powdery/chalky substance mixed with soil fill.	
	Grab				94.3		Poorly graded sand, grayish brown (10YR5/2), loose, fine to coarse subrounded to rounded sand and fine gravel, not volcanic, noncemented, solvent odor, with traces of debris - white chalky pieces and wood splinters. Approximately trace gravel, 20% coarse sand, 70% medium sand and 10% fine sand.	
-10					92.5		Poorly graded sand, brown (10YR5/3), medium dense, fine to coarse angular to subrounded sand and fine gravel - volcanic, strong solvent odor. Approximately 5% gravel, 15% coarse sand, 60% medium sand, 20% fine sand and trace silt.	
	Grab				2773		SP (as at 10'), very strong solvent odor (flowery smell). Approximately 5% gravel, 15% coarse sand, 60% medium sand, 20% fine sand and trace silt.	
-20					30.1		Poorly graded sand, yellowish brown (10YR5/4), fine to coarse subangular volcanic sand and fine gravel, noncemented, strong solvent odor. Approximately 5% gravel, 5% coarse sand, 70% medium sand and 20% fine sand.	
	Grab				NM		Poorly graded sand, yellowish brown (10YR5/4), fine to coarse subangular to rounded sand and fine gravel - some volcanic, noncemented, strong solvent odor. Approximately trace gravel, 20% coarse sand, 70% medium sand and 10% fine sand.	
-30					213		Poorly graded sand, yellowish brown (10YR5/4), fine to coarse angular to subangular sand and fine gravel- volcanic, noncemented, no odor, trace silt. Approximately 5% gravel, 5% coarse sand, 70% medium sand, 20% fine sand and trace silt.	
					6.3		Terminate borehole at 32' bgs.	

Log of Boring No. BRC-BS-17
CAMU
Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: HSA
Drilling Equipment: CME-75/HSA LAR
Drilling Contractor: Water Development Corporation
Driller: James Duke

Borehole Total Depth: 32 ft bgs
Borehole Diameter: 8 in
Well ID: N/A
Depth to Water (ft. bgs): NA ▽

Sample Type: 2.5" Split Spoon
Sample Interval Continuous

Logged By: J. Wiley
Date Started: 01/13/05
Date Completed: 01/13/05

Monitoring Well Construction

Type of Surface Seal:	N/A	**Screen Slot Size:**	N/A
Blank Casing Type/Size:	N/A	**Top of Screen (ft. bgs):**	N/A
Screen Type/Size:	N/A	**Bottom of Screen (ft. bgs):**	N/A
Transition Sand Type:	N/A	**Type of Sand Pack:**	N/A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0							SP: Soil surface, boring located with in area of subsidence.	
	Grab				NM		Poorly graded sand with gravel, pale brown (10YR6/3), loose, moist, fine to coarse subrounded to rounded sand and fine rounded gravel, noncemented, contains debris consisting of plastic-lined paper bags and wood. Approximately 20% gravel, 10% coarse sand, 50% medium sand and 20% fine sand.	
							@9' bgs, wood chunks.	
							DEBRIS: @ 9.75'-10' bgs, black powder (fine to fine end of medium sand size) carbon(?).	
-10							SP: Poorly graded sand with gravel, brown (10YR5/3), very dense, moist, fine to coarse subangular to subrounded sand and fine subrounded gravel, noncemented. Approximately 15% gravel, 10% coarse sand, 55% medium sand and 20% fine sand.	
							@13' bgs, debris includes plastic lined paper bags and black fine gravel sized debris.	
					20.4		Poorly graded sand, brown (10YR4/3), very dense, moist, fine to coarse subangular to subrounded sand and fine angular gravel sized black fragments. trace cobbles up to 2.5" long. Approximately 5% gravel, 10% coarse sand, 50% medium sand and 35% fine sand.	
-20							@ 21' bgs, drillers noted change in drilling to harder soil.	
					200		@ 22' bgs, color change to dark reddish brown (5YR2.5/2), strong odor.	
	Grab				238		Poorly graded sand, dark brown (7.5YR3/2), moist, fine to coarse subangular to subrounded sand and subangular fine gravel, noncemented, strong odor, no debris.	
					12.4		Poorly graded sand, brown (7.5YR 5/3), very dense, moist, fine to coarse subangular to subrounded sand and fine subangular to subrounded gravel, noncemented, strong odor. Approximately 5% gravel, 5% coarse sand, 40% medium sand and 40% fine sand.	
-30					345		Terminate borehole at 32' bgs.	

Log of Boring No. BRC-BS-18

CAMU

Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: HSA
Drilling Equipment: CME-75/HSA LAR
Drilling Contractor: Water Development Corporation
Driller: James Duke

Borehole Total Depth: 32 ft bgs
Borehole Diameter: 8 in
Well ID: N/A
Depth to Water (ft. bgs): NA ⊻

Sample Type: 2.5" Split Spoon
Sample Interval Continuous

Logged By: J. Wiley
Date Started: 01/13/05
Date Completed: 01/13/05

Monitoring Well Construction

Type of Surface Seal:	N/A	**Screen Slot Size:**	N/A
Blank Casing Type/Size:	N/A	**Top of Screen (ft. bgs):**	N/A
Screen Type/Size:	N/A	**Bottom of Screen (ft. bgs):**	N/A
Transition Sand Type:	N/A	**Type of Sand Pack:**	N/A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0							SP: Soil surface, boring located within area of subsidence.	
	Grab				2.6		Poorly graded sand with gravel, dark grayish brown (10YR4/2), medium dense to loose, fine to coarse subrounded to rounded sand and subrounded fine gravel, noncemented. Approximately 15% gravel, 40% coarse snad 40% medium sand, 5% fine sand and trace silt.	
-10					1.5		Poorly graded sand, light gray (10YR7/2), dense, moist, fine to medium subangular sand and fine subangular gravel, noncemented, containing debris - mostly rusted metal pipe fragments and small amounts of insullation material (fiberglass or asbestos). Approximately 5% gravel, 35% medium sand and 60% fine sand.	
					1.2		Poorly graded sand, light gray (10YR7/2), medium dense, moist, fine to medium subangular sand and fine subangular gravel, noncemented, coantains rusted metal pipe fragments and small amounts of insulation attached. Approximately 5% gravel, 35% medium sand and 60% fine sand.	
-20					0.2		Poorly graded sand, dark yellowish brown (10YR4/4), medium dense, moist, fine to coarse subangular to subrounded sand and fine subangular gravel, no debris observed. Approximately 5% gravel, 5% coarse sand, 50% medium sand, 40% fine sand and trace silt.	
	Grab				38.5		GP: Poorly graded gravel with sand, brown (10YR4/3), medium dense to loose, moist, fine to coarse subrounded sand and fine subrounded to rounded gravel, noncemented, debris includes fabric with cobbles. Approximately 55% gravel, 10% coarse sand, 30% medium sand and 5% fine sand.	
							SP: Poorly graded sand, brown (10YR4/3), very dense, moist, fine to medium subangular to subrounded sand and subangular gravel, noncemented, no debris, trace silt. Approximately 10% gravel, 10% coarse sand, 50% medium sand, 30% fine sand and trace silt. At 26' bgs, drilling in hard soil - drillers think we are out of fill.	
-30					5.7		Terminate boring at 32' bgs.	

Log of Boring No. BRC-BS-19
CAMU
Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: HSA
Drilling Equipment: CME-75/HSA LAR
Drilling Contractor: Water Development Corporation
Driller: Ignacio Gutierrez

Borehole Total Depth: 31.5 ft bgs
Borehole Diameter: 8 in
Well ID: N/A
Depth to Water (ft. bgs): NA ⊻

Sample Type: 2.5" Split Spoon
Sample Interval Continuous

Logged By: J. Wiley
Date Started: 01/18/05
Date Completed: 01/18/05

Monitoring Well Construction

Type of Surface Seal:	N/A	**Screen Slot Size:**	N/A
Blank Casing Type/Size:	N/A	**Top of Screen (ft. bgs):**	N/A
Screen Type/Size:	N/A	**Bottom of Screen (ft. bgs):**	N/A
Transition Sand Type:	N/A	**Type of Sand Pack:**	N/A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0							SP: Soil surface, boring located in area of subsidence.	
	Grab				0.5		Poorly graded sand, brown (7.5YR4/3), loose to dense, moist, fine to coarse subangular to subrounded, sand and fine gravel - no volcanics, noncemented, trace silt. Approximately trace gravel, 5% coarse sand, 55% medium sand, 40% fine sand and trace silt.	
-10					1.3		Poorly graded sand, brown (10YR4/3), moist, fine to coarse subangular to subrounded sand and fine gravel - no volcanics, noncemented, debris consists of white chalky powder. Approximately trace gravel, 5% coarse sand, 55% medium sand and 40% fine sand. At 9.5' bgs debris begins - consists of white powdery/chalky chunks of material from plastic lined paper bags.	
	Grab				0.7		Poorly graded sand, grayish brown (10YR5/2), loose to dense, moist, fine to coarse subangular to rounded sand and fine gravel - no volcanics, some cobbles, noncemented. Approximately 10% gravel, 15% coarse sand, 70% medium sand and 5% fine sand. From 15'-20', few bags - lime.	
-20					0.6		Poorly graded sand, yellowish brown (10YR5/4), dense, moist, fine to coarse subangular to rounded sand and fine gravel - few volcanics, noncemented, debris includes wood splinters and lime bags. Approximately 5% gravel, 15% coarse sand, 70% medium sand and 10% fine sand.	
	Grab				43.5		Poorly graded sand, yellowish brown (10YR5/4), loose to dense, moist, fine to coarse subangular to subrounded sand and fine gravel, few cobbles, no volcanics, noncemented, debris includes gravel fill, wood splinters and traces of white chalky substance. Approximately 5% gravel, 15% coarse sand, 70% medium sand and 10% fine sand.	
-30					12.5		Poorly graded sand , brown (10YR5/3), very dense, moist, fine to coarse angular to subangular sand and fine gravel - volcanic, noncemented, no debris. Approximately trace gravel, 5% coarse sand, 70% medium sand, 25% fine sand and trace silt. Terminate borehole at 31.5' bgs.	

Log of Boring No. BRC-BS-20

CAMU

Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: HSA
Drilling Equipment: CME-75/HSA LAR
Drilling Contractor: Water Development Corporation
Driller: Ignacio Gutierrez

Borehole Total Depth: 31 ft bgs
Borehole Diameter: 8 in
Well ID: N/A
Depth to Water (ft. bgs): NA ⊻

Sample Type: 2.5" Split Spoon
Sample Interval Continuous

Logged By: J. Wiley
Date Started: 01/18/05
Date Completed: 01/18/05

Monitoring Well Construction

Type of Surface Seal:	N/A	**Screen Slot Size:**	N/A
Blank Casing Type/Size:	N/A	**Top of Screen (ft. bgs):**	N/A
Screen Type/Size:	N/A	**Bottom of Screen (ft. bgs):**	N/A
Transition Sand Type:	N/A	**Type of Sand Pack:**	N/A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0							SP: Soil surface, boring located in area of subsidence.	
	Grab				0.2		Poorly graded sand, dark yellowish brown (10YR4/4), loose to dense, moist, fine to coarse subangular to subrounded sand and fine gravel - no volcanics, noncemented, no debris, trace silt. Approximately trace gravel, 5% coarse sand, 65% medium sand, 30% fine sand and trace silt.	
-10					1.7		Poorly graded sand, dark yellowish brown (10YR4/4), dense, moist, fine to coarse subangular to subrounded sand and fine gravel - few volcanics, noncemented, trace silt, no debris.	
	Grab				21.0		Poorly graded sand, dark yellowish brwon (10YR4/4), loose, fine to coarse subangular to rounded sand and fine gravel - no volcanics, noncemented, debris consists of DDT and lime bags, solvent odor (flowery). Approximately 5% gravel, 10% coarse sand, 75% medium sand and 10% fine sand.	
							@ 19', plastic debris and paper bags (DDT and lime) with SP.	
-20					22.0		CL: Sandy lean clay, olive yellow (2.5Y6/6), soft, wet, fine sand and trace medium sand, noncemented, medium plasticity, petroleum hydrocarbon odor, clay was found in sampler shoe and stuck to outside of sampler. Approximately trace medium sand, 30% fine sand and 70% clay.	
							SP	
	Grab				21.0		@ 25' Pooly graded sand as at 15', no debris. Drillers noted change of drilling at 20.5'.	
-30					0.4		Poorly graded sand, brown (10YR5/3), very dense, moist, fine to coarse angular to subangular volcanic and fine gravel, weak cementation, no debris. Approximately trace gravel, 5% coarse sand, 80% medium sand and 15% fine sand. Terminate borehole at 31' bgs.	

Log of Boring No. BW-8B

BMI Landfill CAMU Investigation

Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: Rotary Sonic
Drilling Equipment: GEFCO
Drilling Contractor: Water Development Corporation
Driller: Mike Wilkerson

Borehole Total Depth: 75 ft bgs
Borehole Diameter: 7 5/8" O.D. Casing / 7 7/8" O.D. Bit
Well ID: GW-AA-BW-08A
Depth to Water (ft. bgs): 50' bgs ⊻

Sample Type: N/A
Sample Interval Continuous

Logged By: A. Norris
Date Started: 03/15/05
Date Completed: 03/15/05

Monitoring Well Construction

Type of Surface Seal:	Bentonite-Grout	**Screen Slot Size:**	0.010 in
Blank Casing Type/Size:	4" Sch 80 PVC	**Top of Screen (ft. bgs):**	37.5 ft bgs
Screen Type/Size:	4" Sch 80 PVC	**Bottom of Screen (ft. bgs):**	57.5 ft bgs
Transition Sand Type:	N/A	**Type of Sand Pack:**	#2/12

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0					0.0		SM: Silty sand with gravel, moist, (fill).	Locking Monument Well Box Surrounded by Concrete slab and Traffic Ballards
					0.0			
							Silty sand with gravel, moist to dry, trace local debris (wood fragments, plastic) (fill).	
					0.0			
					0.0		Silty sand with gravel, dry, trace local debris (plastic, wood, metal fragments) (fill). Note: soils @ 0' to 12' bgs essentially same as logged a BW-8A. See boring log BW-8A for details.	
-10								Cement Backfill
					0.0			
					0.0		Silty sand with gravel, dry.	
					0.0			
								4" Blank PVC Riser Pipe
					0.0		Silty sand with gravel, dry. Note: soils @12' to 20" bgs essentially same as logged @ BW-8A. See boring log BW-8A for details.	
					0.0			
-20					0.0		Silty sand with gravel, dry.	
					0.0		Silty sand with gravel, dry.	
					0.0			Cement Backfill

BMI Landfill CAMU Investigation

Henderson, Nevada

Basic Remediation COMPANY

Log of Boring No. BW-8B

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
					0.0		Silty sand with gravel, dry. Note: soils @ 20' to 30' bgs essentailly same as logged @ BW-8A. See boring log BW-8A for details.	
-30				■	0.0		Silty sand with gravel, dry.	Bentonite Seal
					0.0		Silty sand with gravel, dry.	
					0.0			#2/12 Sand Pack
					0.0		Silty sand with gravel, dry. Note: soils @ 30' to 40' bgs essentially same as logged @ BW-8A. See boring log BW-8A for details.	
-40					0.0			4" 0.010 Slot PVC screen
					0.0		Silty sand with gravel, dry.	
					0.0			
					0.0		Silty sand with gravel, dry.	
					0.0		Silty sand with gravel, dry to moist. Note: soils @ 40' to 50' bgs essentially same as logged @ BW-8A. See boring log BW-8A for details.	
-50				■	0.0		Silty sand with gravel, wet @ 50' to 57' bgs.	
					0.0		Silty sand with gravel, wet.	
					0.0			
					0.0		GW: Well graded gravel, multicolored, wet, subangular to subrounded fine to coarse volcanic gravel (up to 3" long). Approximately 100% gravel.	Threaded PVC Well Base Cap
					0.0		ML: Silt with sand, light brownish gray (10YR6/2), moist to wet, nonplastic to low plasticity fines, subangular to subrounded sand. Approximately 15% fine sand, 85% silt and trace clay.	
-60					0.0		CALICHE: Caliche, strongly cemented. Silty sand with gravel, white (10YR8/1), dry.	
					0.0			
					0.0			

BMI Landfill CAMU Investigation

Henderson, Nevada

Basic Remediation COMPANY

Log of Boring No. BW-8B

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
					5.5		ML: Clayey silt, yellowish brown (10YR5/4), moist, very low to low plasticity fines. Approximately 5% fine sand, 80% silt and 15% clay.	Basal Bentonite Seal
					14.2		Clayey silt, yellowish brown (10YR5/4), moist, very low to low plasticity fines. Approximately 85% silt and 15% clay.	
					3.0		Silt with sand, yellowish brown (10YR5/4), moist, nonplastic to very low plasticity fines, subangular to subrounded sand. Approximately 15% fine sand, 85% silt and trace clay.	
-70					8.2		Clayey silt, yellowish brown (10YR5/4). moist, very low to low plasticity fines. Approximately 85% silt and 15% clay.	
					28.7		Clayey silt, light yellowish brown (10YR6/4), moist, very low to low plasticity fines. Approximately 85% silt and 15% clay.	
					2.0			
					1.0			
					3.0		Bottom of hole @ 75' bgs.	
					0.0			

Log of Boring No. BW-8C

BMI Landfill CAMU Investigation

Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: Rotary Sonic
Drilling Equipment: GEFCO
Drilling Contractor: Water Development Corporation
Driller: Mike Wilkerson

Borehole Total Depth: 75 ft bgs
Borehole Diameter: 7 5/8" O.D. Casing / 7 7/8" O.D. Bit
Well ID: GW-AA-BW-08B
Depth to Water (ft. bgs): 47' bgs ⊻

Sample Type: N/A
Sample Interval Continuous

Logged By: A. Norris
Date Started: 03/16/05
Date Completed: 03/16/05

Monitoring Well Construction

Type of Surface Seal:	Bentonite-Grout	**Screen Slot Size:**	0.010 in
Blank Casing Type/Size:	4" Sch 80 PVC	**Top of Screen (ft. bgs):**	43 ft bgs
Screen Type/Size:	4" Sch 80 PVC	**Bottom of Screen (ft. bgs):**	63 ft bgs
Transition Sand Type:	N/A	**Type of Sand Pack:**	#2/12

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0					0.0		SM: Silty sand with gravel, dry.	Locking monument well box with concrete apron and ballards
					0.0		Silty sand with gravel, dry.	Cement Bentonite Grout
					0.0		Silty sand with gravel, dry. Note: Soils @ 0' to 10' bgs essentially same a logged @ BW-8A. See boring log BW-8A for details.	
-10					0.0			4" Blank PVC Riser Pipe
					0.0		Silty sand with gravel, dry.	
					0.0		Silty sand with gravel, dry, trace fill material, (wood fragments).	
					0.0		Note: Soil encountered @ 10' to 20' bgs essentially same as logged @ BW-8A. See boring log BW-8A for details.	
-20					0.0		Silty sand with gravel, dry.	
					0.0		Silty sand with gravel, dry.	

BMI Landfill CAMU Investigation

Henderson, Nevada

Basic Remediation COMPANY

Log of Boring No. BW-8C

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
							Silty sand with gravel, dry.	Cement Bentonite Grout
							Note: Soil encountered @ 20' to 30' bgs essentially same as logged @ BW-8A. See boring log BW-8A for details.	
-30					0.0		Silty sand with gravel, dry.	
					0.0		Silty sand with gravel, dry.	
					0.0		Silty sand with gravel, dry.	Bentonite seal
					0.0		Note: soils encountered @ 30' to 40' bgs essentially same as logged @ BW-8A. See boring log BW-8A for details.	
-40					0.0		Silty sand with gravel, dry.	#2/12 Sand Pack
					0.0		Silty sand with gravel, dry. Note: Soils encountered @ 40' to 47' bgs essentially same as logged @ BW-8A. See boring log BW-8A for details.	4" 0.010 Slot PVC screen
					3.6		Silty sand with gravel, grayish brown (10YR5/2), wet, subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 1.5" long). Approximately 15% gravel, 15% coarse sand, 30%medium sand, 25% fine sand and 15% silt.	
-50					4.0			
					6.2		ML: Silt with sand, light brownish gray (10YR6/2), dry to moist, nonplastic to low plasticity silt, subangular to subrounded sand. Approximately 15% fine sand and 85% silt.	
					113		SM: Silty sand with gravel, light grey (10YR6/1), dry, subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 1" long), weakly to strongly cemented. Approximately 15% gravel, 15% coarse sand, 30% medium sand, 25% fine sand, 15% silt.	
					22.6			
					3.5		CALICHE: Caliche: strongly cemented. Silty sand with gravel, white (10YR8/1), dry.	
					4.5		SM: Silty sand with gravel, gray (10YR5/1), wet, subangular to subrounded sand, nonplastic silt, subangular to subrouneded fine to coarse volcanic gravel (up to 1.5" long). Approximately 15% gravel, 15% coarse sand, 35% medium sand, 20% fine sand, 15% silt.	
					3.2			
					0.0		ML: Silt with sand, light brownish gray (10YR6/2), dry, nonplastic to very low plasticity silt, subangular to subrounded sand. Approximately 15% fine sand and 85% silt.	
					2.0			#2/12 Sand Pack
-60							CALICHE: Caliche: strongly cemented. Silty sand with gravel, white (10YR8/1), dry.	
					3.3		ML: Clayey silt, yellowish brown (10YR5/4), moist, very low to low plasticity fines, trace subangular to subrounded sand. Approximately 5% fine sand, 80% silt and 15% clay.	

BMI Landfill CAMU Investigation

Henderson, Nevada

Basic Remediation COMPANY

Log of Boring No. BW-8C

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
					3.8		Clayey silt, brown (7.5YR5/4), moist, very low to low plasticity fines, stiff. Approximately 85% silt and 15% clay.	Threaded PVC Well Base Cap
					2.3			
					16.1			
					14.4			
					65.3		Clayey silt, brown (7.5YR5/4) moist, very low to low plasticity fines, stiff. Approximately 85% fine sand and 15% silt.	
					2.9			
-70	Grab				77.2			
					104		Silt, pale brown (10YR6/3), moist, nonplastic to very low plasticity silt. Approximately 5% fine sand and 95% silt. (Sample BRC-BW-08C-70 collected).	Basal Bentonite Seal
					10.9			
					6.4			
					3.4			
					15.1		Bottom of hole @ 75' bgs.	

Log of Boring No. BW-10A

BMI Landfill CAMU Investigation

Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: Rotary Sonic
Drilling Equipment: GEFCO
Drilling Contractor: Water Development Corporation
Driller: Mike Wilkerson

Borehole Total Depth: 80 ft bgs
Borehole Diameter: 7 5/8" O.D. Casing / 7 7/8" O.D. Bit
Well ID: GW-MCF-BW-10
Depth to Water (ft. bgs): 60.0 ft bgs ▽

Sample Type: 2" Split Spoon
Sample Interval Continuous

Logged By: A. Norris
Date Started: 03/23/05
Date Completed: 03/23/05

Monitoring Well Construction

Type of Surface Seal:	Bentonite-Grout	**Screen Slot Size:**	0.010 in
Blank Casing Type/Size:	4" Sch 80 PVC	**Top of Screen (ft. bgs):**	57 ft bgs
Screen Type/Size:	4" Sch 80 PVC	**Bottom of Screen (ft. bgs):**	72 ft bgs
Transition Sand Type:	N/A	**Type of Sand Pack:**	#2/12 sand

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0					0.0		SM: Silty sand with gravel, brown (7.5YR5/4), dry to moist, subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 3" long), locally partly indurated to weakly cemented. Approximately 20% gravel, 15% coarse sand, 15% medium sand, 30% fine sand and 20% silt. (Sample BRC-BW-10A-0 collected).	Locking monument well box with concrete apron and ballards
					0.0		Silty sand with gravel, brown (7.5YR5/4), dry to moist, subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 3" long), locally partly indurated to weakly cemented. Approximately 20% gravel, 15% coarse sand, 15% medium sand, 35% fine sand and 15% silt.	Cement Bentonite Grout
					0.0			
					0.0		Silty sand with gravel, light brown (7.5YR6/3), dry, subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 2.5" long). Approximately 20% gravel, 15% coarse sand 10% medium sand, 40% fine sand and 15% silt.	
-10					0.0			4" Blank PVC Riser Pipe
					0.0		Silty sand with gravel, brown (7.5YR 5/3) dry subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 3" long). Approximately 20% gravel, 15% coarse sand, 15% medium sand, 35% fine sand and 15% silt.	
					0.0		Silty sand, light brown (7.5YR6/4), dry, subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 3" long). Approximately 20% gravel, 15% coarse sand, 15% medium sand, 30% fine sand and 20% silt. (Sample BRC-BW-10A-18 collected).	
					0.0			
-20					0.0		Silty sand with gravel, pale brown (10YR6/3), dry, angular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 1.5" long), locally partly indurated to weakly cemented. Approximately 20% gravel, 15% coarse sand, 15% medium sand, 30% fine sand and 20% silt.	
					0.0		Silty sand, light brownish gray (10YR6/2), dry, subangular to subrounded sand,nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 3" long), locally partly indurated to weakly cemented.	

BMI Landfill CAMU Investigation

Henderson, Nevada

Basic Remediation COMPANY

Log of Boring No. BW-10A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
					0.0		Silty sand with gravel, light brown (7.5YR6/3), dry, subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 1" long), locally partly indurated to weakly cemented. Approximately 15% gravel, 15% coarse sand, 15% medium sand, 35% fine sand and 20% silt.	
					0.0			
-30					0.0		Silty sand with gravel, yellowish brown (10YR5/4), dry, subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 3" long), locally partly indurated to weakly cemented. Approximtaely 20% gravel, 15% coarse sand, 15% medium sand, 35% fine sand and 15% silt. (Sample BRC-BW-10A-30 collected).	Cement Bentonite Grout
					0.0			
					0.0		Silty sand with gravel, yellowish brown (10YR5/4), dry, subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 3" long), locally partly indurated to weakly cemented. Approximately 20% gravel, 15% coarse sand, 15% medium sand, 35% fine sand and 15% silt.	
					0.0			
-40					0.0		ML: Silt with sand, strong brown (7.5YR5/6), moist, nonplastic silt, subangular to subrounded sand. Approximately 15% fine sand and 85% silt.	
					0.0		Silt with sand, brown (7.5YR5/4), moist, nonplastic silt, subangular to subrounded sand. Approximately trace medium sand, 20% fine sand and 80% silt.	
					0.0		Silt with sand, strong brown (7.5YR5/6), moist, nonplastic silt, subangular to subrounded sand. Approximtaely 15% fine sand and 85% silt.	
					0.0		Silt with sand, strong brown (7.5YR5/6), moist, nonplastic to low plasticity fines, subangular to subrounded sand. Approximately 15% fine sand, 80% silt and 5% clay.	
-50					0.0		Clayey silt, brown (10YR5/4), moist, very low to low plasticity fines, stiff. Approximately 5% fine sand, 80% silt and 15% clay. (Sample BRC-BW-10A-50 collected).	Bentonite seal
					0.0		Silt with clay, light olive brown (5Y6/2), moist, very low to low plasticity fines, stiff. Approximately 90% silt and 10% clay.	
					0.0		Silt with clay, brwon (10YR5/3), moist, very low to low plasticity fines, stiff. Approximately 90% silt and 10% clay.	#2/12 Sand Pack
					0.0			4" 0.010 Slot PVC screen
-60					0.0		Becomes wet @ 60' to 64' bgs. Silt with sand, brown (7.5YR5/4), wet, nonplastic to low plasticity fines, subangular to subrounded sand. Approximatley 5% medium sand, 20% fine sand, 70% silt and 5% clay.	4" 0.010 Slot PVC screen

BMI Landfill CAMU Investigation

Henderson, Nevada

Basic Remediation COMPANY

Log of Boring No. BW-10A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
					0.0		Clayey silt, brown (7.5YR5/4), moist, very low to low plasticity fines, stiff, trace subangular to subrounded sand. Approximately 5% fine sand, 80% silt and 15% clay.	#2/12 Sand Pack
					0.0			
							Clayey silt, brown (7.5YR5/4), moist, very low to low plasticity fines, stiff. Approximately 80% silt and 20% clay.	
					0.0			
-70								
					0.0		Clayey silt, brown (7.5YR5/4), moist, very low to low plasticity fines, stiff. Approximately 85% silt and 15% clay.	Threaded PVC Well Base Cap
								Basal Bentonite Seal
					0.0		Clayey silt, strong brown (7.5YR5/6), moist, very low to low plasticity fines, stiff. Approximately 80% silt and 20% clay.	
					0.0			
-80								

Log of Boring No. BW-11A

BMI Landfill CAMU Investigation

Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: Rotary Sonic
Drilling Equipment: GEFCO
Drilling Contractor: Water Development Corporation
Driller: Mike Wilkerson

Borehole Total Depth: 80 ft bgs
Borehole Diameter: 7 5/8" O.D. Casing / 7 7/8" O.D. Bit
Well ID: GW-MCF-BW-11
Depth to Water (ft. bgs): 60' bgs ▽

Sample Type: 2" Split Spoon
Sample Interval Continuous

Logged By: A. Norris
Date Started: 03/22/05
Date Completed: 03/22/05

Monitoring Well Construction

Type of Surface Seal:	Bentonite-Grout	**Screen Slot Size:**	0.010 in
Blank Casing Type/Size:	4" Sch 80 PVC	**Top of Screen (ft. bgs):**	57 ft bgs
Screen Type/Size:	4" Sch 80 PVC	**Bottom of Screen (ft. bgs):**	72 ft bgs
Transition Sand Type:	N/A	**Type of Sand Pack:**	#2/12

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0					0.0		SM: Silty sand with gravel, yellowish brown (10YR5/4), dry to moist, subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 2" long). Approximately 15% gravel, 10% coarse sand, 15% medium sand 45% fine sand and 15% silt. (Sample BRC-BW-11A-0 collected).	Locking monument well box with concrete apron and ballards
					0.0			
					0.0		Silty sand with gravel, yellowish brown (10YR5/4), dry to moist, subangular to subrounded sand, nonplastic to very low plasticity silt, subangular to subrounded fine to coarse volcanic gravel (up to 2" long). Approximately 15% gravel, 10% coarse sand, 15% medium sand, 40% fine sand and 20% silt.	
					2.0			
					1.8			
					2.0			Cement Bentonite Grout
					4.0		Silty sand with gravel, brown (7.5YR5/4), dry to moist, subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 2" long). Approximately 20% gravel, 15% coarse sand, 15% medium sand, 35% fine sand and 15% silt.	
					3.7			
					4.1			
					4.7			
-10					14.2		Silty sand with gravel, brown (7.5YR5/4), dry to moist, subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 2.5" long). Approximately 15% gravel, 10% coarse sand 15% medium sand, 45% fine sand and 15% silt.	4" Blank PVC Riser Pipe
					9.1			
					25.3			
					17.7		Silty sand with gravel, brown (7.5YR5/4), dry to moist, subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 1" long). Approximately 15% gravel, 10% coarse sand, 15% medium sand, 45% fine sand and 15% silt.	
					22.5			
					20.9			
					19.3		Silty sand with gravel, pale brown (10YR6/3), dry, subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 2.5" long), locally partly indurated. Approximately 20% gravel, 15% coarse sand, 15% medium sand, 30% fine sand and 20% silt. (Sample BRC-BW-11A-18 collected).	
					53.5			
					54.3			
-20					30.9		Silty sand with gravel, brown (7.5YR5/3), dry, subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 3" long). locally partly indurated to weakly cemented. Approximately 20% gravel, 15% coarse sand, 15% medium sand, 35% fine sand and 15% silt.	
					14.7			
					57.0			
					49.3			
					59.1		Silty sand with gravel, light brown (7.5YR6/3), dry subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 2" long), locally partly indurated to weakly cemented. Approximately 15% gravel, 15% coarse sand, 15% medium sand, 35% fine sand and 20% silt.	
					118			
					50.0			

BMI Landfill CAMU Investigation

Henderson, Nevada

Basic Remediation COMPANY

Log of Boring No. BW-11A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
					46.7		Silty sand with gravel, light brown (7.5YR6/4), dry subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 1" long), locally partly indurated to weakly cemented. Approximately 15% gravel, 10% coarse sand, 10% medium sand, 50% fine sand and 15% silt.	
					44.3			
					46.8			
-30					100		(Sample BRC-BW-11A-30 collected).	
					29.2			
					60.8		Silty sand with gravel, brown (7.5YR5/4), dry, subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 2" long). Approximately 20% gravel, 15% coarse sand 15% medium sand, 35% fine sand and 15% silt.	
					41.1			
					45.2			
					27.2		Silty sand with gravel, brown (7.5YR5/3), dry, subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 3" long). Approximately 20% gravel, 15% coarse sand, 15% medium sand, 35% fine sand and 15% silt.	Cement Bentonite Grout
					25.7			
					14.6			
					10.0		Silty sand with gravel, gray (10YR6/2), dry, subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 3" long), locally partly indurated to weakly cemented, trace local volcanic cobbles (up to 4" long). Approximately 20% gravel, 15% coarse sand, 15% medium sand, 35% fine sand and 15% silt.	
-40					5.7		CALICHE: Caliche: strongly cemented. Silty sand, white (10YR8/1), dry.	
					22.6		SM: Silty sand, light gray (10YR7/2), dry, subangular to subrounded sand, nonplastic silt, locally weakly to strongly cemented. Approximately 5% coarse sand, 15% medium sand, 60% fine sand and 20% silt.	
					22.5			
					38.4			
					0.0			
					0.0		Silty sand, very pale brown (10YR8/2), dry, subangular to subrounded sand, nonplastic silt, locally partly indurated to weakly cemented. Approximately 5% gravel, 5% coarse sand, 10% medium sand, 60% fine sand and 20% silt.	
					0.0			
					0.0			
					0.0		Silty sand, brown (10YR5/3), dry, subangular to subrounded sand, nonplastic silt, locally weakly to strongly cemented. Approximately 5% gravel, 5% coarse sand, 10% medium sand, 60% fine sand and 20% silt.	
	Grab				0.0		(Sample BRC-BW-11A-49 collected).	
-50					12.2			Bentonite seal
					0.0			
					0.0		ML: Clayey silt, brown (7.5YR5/4), moist, very low to low plasticity fines, stiff. Approximately 80% silt and 20% clay.	
					0.0			
					0.0			
					0.0		Clayey silt, brown (7.5YR5/4), moist, very low to low plasticity fines, stiff to very stiff. Approximately 80% silt and 20% clay.	#2/12 Sand Pack
					0.0			
					0.0			
					0.0			
					0.0			
-60	Grab				0.0		Silt with sand, brown (7.5YR5/4), wet, nonplastic to low plasticity fines, subangular to subrounded sand. Approximately trace medium sand, 20% fine sand, 80% silt and trace clay. (Sample BRC-BW-11A-60 collected). Becomes wet @ 60' to 61.5' bgs.	4" 0.010 Slot PVC screen
					0.0			

BMI Landfill CAMU Investigation

Henderson, Nevada

Basic Remediation COMPANY

Log of Boring No. BW-11A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
					0.0			
					0.0			
					0.0			
					0.0		Clayey silt, yellowish brown (10YR5/4), moist, very low to low plasticity fines, stiff. Approximately trace fine sand, 85% silt and 15% clay.	#2/12 Sand Pack
					0.0			
					0.0			
					0.0			4" 0.010 Slot PVC screen
					0.0			
-70					0.0		Clayey silt, brown (7.5YR5/4), moist, very low to low plasticity fines, stiff. Approximately trace fine sand, 85% silt and 15% clay.	
					0.0			
					0.0			Threaded PVC Well Base Cap
					0.0		(Sample BRC-BW-11A-73 collected).	
					0.0		Clayey silt, brown (7.5YR5/4), very low to low plasticity fines, stiff to very stiff. Approximately trace fine sand, 85% silt and 15% clay.	Basal Bentonite Seal
					0.0			
					0.0		Clayey silt, brown (7.5YR5/4), moist, very low to low plasticity fines, stiff. Approximately 85% silt and 15% clay.	
					0.0			
					0.0			
					0.0		Bottom of hole @ 80' bgs.	Native Backfill
-80								

Log of Boring No. BW-12A
BMI Landfill CAMU Investigation
Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: Rotary Sonic
Drilling Equipment: GEFCO
Drilling Contractor: Water Development Corporation
Driller: Mike Wilkerson

Borehole Total Depth: 131.5 ft bgs
Borehole Diameter: 7 5/8" O.D. Casing / 7 7/8" O.D. Bit
Well ID: N/A
Depth to Water (ft. bgs): 68' bgs ▽

Sample Type: 2" Split Spoon
Sample Interval Continuous

Logged By: M. Manwaring
Date Started: 03/25/05
Date Completed: 03/26/05

Monitoring Well Construction

Type of Surface Seal:	N/A	**Screen Slot Size:**	N/A
Blank Casing Type/Size:	N/A	**Top of Screen (ft. bgs):**	N/A
Screen Type/Size:	N/A	**Bottom of Screen (ft. bgs):**	N/A
Transition Sand Type:	N/A	**Type of Sand Pack:**	N/A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0					0.0		SM: Silty sand with gravel, dark yellowish brown (10YR4/4), dry to slightly moist, sand and gravel is subrounded to subangular (volcanic coarse material), soil may be fill. Approximately 15% gravel, 15% coarse sand, 20% medium sand, 30% fine sand, 20% silt and trace clay. (Sample BRC-BW-12A-0 collected).	No Well
					0.0		Silty sand, yellowish brown (10YR5/6), slightly moist, as above. Approximately 5% gravel, 15% coarse sand, 25% medium sand, 35% fine sand, 20% silt and trace clay.	
					0.0			
					0.0		Silty sand with gravel, light yellowish brown (10YR6/4), dry, gravel and coarse sand material is likely volcanic, material is slightly cemented (the fine sand and silt sizes). Approximately 20% gravel, 20% coarse sand, 15% medium sand, 30% fine sand, 15% silt and trace clay.	
					1.6			
-10					0.4		Silty sand, brown (7.5YR5/4), dry, subrounded to subangular. Approximately 10% gravel, 15% coarse sand, 25% medium sand, 20% fine sand, 30% silt and trace clay.	
					0.0			
					0.4			
					0.8		Silty sand with gravel, light brown (7.5YR6/3), dry gravel is likely volcanic, subrounded to subangular (gravel is up to 2"-3" diameter). Approximately 15% gravel, 15% coarse sand, 20% medium sand, 25% fine sand, 25% silt and trace clay. (Sample BRC-BW-12A-18 collected).	
					0.0			
					0.4			
-20					0.7		Silty sand, brown (7.5YR5/4), dry, some coarse gravels (2"-3" diameter), subrounded to subangular, slight odor, loose. Approximately 10% gravel, 5% coarse, 15% medium, 30% fine sand, 30% silt and trace clay.	
					1.7		Silty sand with clay and gravel, dark yellowish brown (10YR4/4), abundant coarse angular to subangular gravel (3/4"-1" diameter), dry, slight odor, when wetted soil has low to medium plasticity. Approximately 20% gravel, 5% coarse sand, 10% medium sand, 25% fine sand, 30% silt and 10% clay.	

BMI Landfill CAMU Investigation

Henderson, Nevada

Basic Remediation COMPANY

Log of Boring No. BW-12A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
					0.3		Silty sand with clay, dry, brown (7.5YR5/4), low to medium plasticity (when wetted), no odor. Approximately 10% gravel, 5% coarse sand, 10% medium sand, 25% fine sand, 35% silt and 15% trace clay. (Sample BRC-BW-12A-30 collected).	
-30					0.3			
					0.4		SM: Silty sand with clay, brown (7.5YR5/4), dry to slightly moist, loose, low plasticity. Approximately 10% gravel, 5% coarse sand, 10% medium sand, 25% fine sand, 35% silt and 15% clay.	
					1.1			
					0.3		SM: Silty sand, dark yellowish brown (10YR4/4), slightly moist, loose, some subrounded to subangular sand and gravel, low plasticity. Approximately 10% gravel, 5% coarse sand, 15% medium sand, 35% fine sand, 30% silt and 5% clay.	
-40					0.0		SM: Silty sand, grayish brown (10YR5/2), dry, loose, abundant broken rock, gravel and coarse sand crushed rock. Approximately 10% gravel, 10% coarse sand, 15% medium sand, 25% fine sand, 30% silt and 10% clay.	
					0.0		Silty sand with gravel, silt with abundant coarse sand and gravels, angular to subangular, dry matrix, light grayish brown (10YR6/2), rock color varies. Approximately 20% gravel, 15% coarse sand, 20% medium sand, 20% fine sand, 15% silt and 5% clay.	
					0.3			
					0.0		Same as above to 50' bgs, brechia-volcanics (rock)	
-50							(Sample BRC-BW-12A-50 collected)	
					0.0			
					0.6		Silty sand with gravel, grayish brown (10YR5/2), dry to slighty moist, (below 52' bgs), slight odor. Approximately 20% gravel, 5% coarse sand, 10% medium sand, 25% fine sand, 30% silt and 10% clay.	
					4.6			
					4.2		SM: Silty sand with clay, gray (5Y5/1), with gravels (subangular to angular) moist, slight odor, trace clay. Approximately 10% gravel, 10% coarse sand, 5% medium sand, 30% fine sand, 30% silt and 15% clay.	
					8.5		ML: Clayey silt with sand and gravel, as above, grayish brown (10YR5/2). Approximately 25% gravel, 10% coarse sand, 5% medium sand, 20% fine sand, 25% silt and 15% clay.	
-60					2.0		Clayey silt with sand, strong brown (7.5YR5/6), moist, to very moist, slight odor, trace light gray silt size lenses and gravels, firm to stiff, low plasticity. Approximately 5% gravel, trace coarse sand, 20% fine sand, 55% silt and 20% clay.	

BMI Landfill CAMU Investigation

Henderson, Nevada

Basic Remediation COMPANY

Log of Boring No. BW-12A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
					1.9			
					1.6			
							Clayey silt with sand. Approximately 5% gravel, 20% fine sand, 55% silt and 20% clay.	
					0.6		Silt with clay, trace gravel, brown (7.5YR4/4), wet to very moist, medium plasticity no odor, firm (stiff and moist, not wet below 70').	
-70					1.1			
					0.5			
					0.4		Clayey silt with sand, brown (7.5YR5/4), moist, as above, low to medium plasticity. Approximately trace gravel, 20% fine sand, 65% silt and 15% clay. Silt, wet zone (74'-74.5'), brown, with clay, medium plasticity.	
					1.6			
					2.6		Silt with clay, light gray (10YR7/2), very moist to wet, low plasticity fines. Approximately 10% gravel, 5% fine sand, 75% silt and 10% clay.	
					2.8		Clayey silt with sand, very moist to moist. Approximately trace gravel, 15% fine sand, 65% silt and 15% clay.	
-80					0.4			
							No recovery. Likely soft clayey silt.	
-90								

BMI Landfill CAMU Investigation

Henderson, Nevada

Basic Remediation COMPANY

Log of Boring No. BW-12A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
							No recovery. Likely soft clayey silt.	
-100								
-110								
					0.0		Clayey silt with trace angular gravel, brown (7.5YR5/4), trace angular gravel, very moist to saturated (not wet), stiff, low to medium plasticity, trace light brown to pale brown silt size/sand size gypsum crystals, (no odor). Approximately trace gravel, trace fine sand, 60% silt and 40% clay.	
-120					0.0			
					0.0		Clayey silt, yellowish brown (10YR5/4), trace angular gravel and sand size fractured rock fragments (gypsum), firm to stiff (some very stiff), medium to low plasticity, saturated to very moist (not wet), no odor. Approximately trace gravel, 70% silt and 30% clay.	
					0.0			
					0.0		Clayey silt, strong brown (7.5YR5/6), medium plasticity, stiff, saturated trace gypsum nodules. Approximately 70% silt and 30% clay.	
-130							End borehole at 130'bgs at 3-26-05.	

Log of Boring No. BW-12B
BMI Landfill CAMU Investigation
Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: Rotary Sonic
Drilling Equipment: GEFCO
Drilling Contractor: Water Development Corporation
Driller: Mike Wilkerson

Borehole Total Depth: 200 ft bgs
Borehole Diameter: 7 5/8" O.D. Casing / 7 7/8" O.D. Bit
Well ID: GW-AA-BW-12
Depth to Water (ft. bgs): 59.5 ft bgs ▽

Sample Type: N/A
Sample Interval Continuous

Logged By: A. Norris
Date Started: 02/13/05
Date Completed: 02/15/05

Monitoring Well Construction

Type of Surface Seal:	Bentonite-Grout	**Screen Slot Size:**	0.010 in
Blank Casing Type/Size:	4" Sch 80 PVC	**Top of Screen (ft. bgs):**	49 ft bgs
Screen Type/Size:	4" Sch 80 PVC	**Bottom of Screen (ft. bgs):**	69 ft bgs
Transition Sand Type:	N/A	**Type of Sand Pack:**	#2/12 sand

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0					0.0		SM: Silty sand with gravel, dark yellowish brown (10YR4/4), moist, subangular to surounded sand, nonplastic to very low plasticity silt, fine to coarse subangular to subrounded volcanic gravel (up to 3" long), locally partly indurated to weakly cemented, trace local volcanic cobbles. Approximately 15% gravel, 15% coarse sand, 20% medium sand, 30% fine sand and 20% silt.	Locking monument well box with concrete apron and ballards
					0.0			
					0.0		Silty sand with gravel, yellowish brown (10YR5/4), moist, subangular to subrounded sand, nonplastic silt, fine to coarse subangular to subrounded volcanic gravel (up to 3" long), locally partly indurated to weakly cemented. Approximately 15% gravel, 15% coarse sand, 25% medium sand, 30% fine sand and 15% silt.	Cement Bentonite Grout
					0.0		Silty sand with gravel, pale brown (10YR6/3), dry, subangular to subrounded sand, nonplastic silt, fine to coarse subangular to subrounded volcanic gravel (up to 3" long), locally partly indurated to weakly cemented. Approximately 15% gravel, 15% coarse sand, 20% medium sand, 35% fine sand and 15% silt.	
-10					0.0		Silty sand with gravel, pale brown (10YR6/3), dry, subangular to subrounded sand, nonplastic silt, fine to coarse subangular to subrounded volcanic gravel (up to 3" long). Approximately 15% gravel, 10% coarse sand, 20% medium sand, 40% fine sand and 15% silt.	4" Blank PVC Riser Pipe
					0.0		Silty sand with gravel, light yellowish brown (10YR6/4), dry, subangular to subrounded sand, nonplastic silt, fine to coarse subangular to subrounded volcanic gravel (up to 2" long). Approximately 15% gravel, 15% coarse sand, 25% medium sand, 30% fine sand and 15% silt.	
					0.0		Silty sand with gravel, light yellowish brown (10YR6/4), dry, subangular to subrounded sand, nonplastic silt, fine to coarse subangular to subrounded volcanic gravel (up to 2" long). Approximately 15% gravel, 15% coarse sand, 15% medium sand, 40% fine sand and 15% silt.	
-20					0.0		Silty sand with gravel, pale brown (10YR6/3), dry, subangular to subrounded sand, nonplastic silt, fine to coarse subangular to subrounded volcanic gravel (up to 2" long). Approximately 15% gravel, 15% coarse sand, 20% medium sand, 35% fine sand and 15% silt.	
					0.0		Silty sand with gravel, pale brown (10YR6/3), dry, subangular to subrounded sand, nonplastic silt, fine to coarse subangular to subrounded volcanic gravel (up to 3" long). Some local volcanic cobbles (up to 4" long). Approximately 20% gravel, 10% coarse sand, 20% medium sand, 35% fine sand and 15% silt.	

BMI Landfill CAMU Investigation

Henderson, Nevada

Basic Remediation COMPANY

Log of Boring No. BW-12B

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
					0.0		Silty sand with gravel, pale brown (10YR6/3), dry, angular to subrounded sand, nonplastic silt, fine to coarse angular to subrounded volcanic gravel (up to 1.5" long), locally partly indurated to weakly cemented. Approximately 40% gravel, 15% coarse sand, 15% medium sand, 15% fine sand and 15% silt.	
-30					0.0		Silty sand with gravel, very pale brown (10YR7/3), dry, subangular to subrounded sand, nonplastic silt, fine to coarse angular to subrounded volcanic gravel (up to 1" long), locally partly indurated to weakly cemented. Approximately 15% gravel, 15% coarse sand, 20% medium sand, 35% fine sand and 15% silt.	Cement Bentonite Grout
					0.0		Silty sand with gravel, very pale brown (10YR7/3), dry, angular to subrounded sand, nonplastic silt, fine to coarse sngular to subrounded volcanic gravel (up to 2" long), locally partly indurated to weakly cemented. Approximately 15% gravel, 15% coarse sand, 20% medium sand, 35% fine sand and 15% silt.	
					0.0			
-40					0.0		Silty sand with gravel, brown (10YR5/3), dry, angular to subrounded sand, nonplastic silt, fine to coarse angular to subrounded volcanic gravel (up to 1" long), locally partly indurated to weakly cemented. Approximately 15% gravel. 10% coarse sand, 20% medium sand, 35% fine sand and 20% silt.	Bentonite seal
					0.0		Silty sand with gravel, light brownish gray (10YR6/2), dry, subangular to subrounded sand, nonplastic silt, fine to coarse subangular to subrounded volcanic gravel (up to 1.5" long). Approximately 15% gravel, 15% coarse sand, 15% medium sand, 40% fine sand and 15% silt.	
					0.0			#2/12 Sand Pack
-50					0.0		Silty sand with gravel, light brownish gray (10YR6/2), dry, subangular to subrounded sand, fine to coarse subangular to subrounded volcanic gravel (up to 1.5" long) locally partly indurated to weakly cemented. Approximately 20% gravel, 10% coarse sand, 15% medium sand, 40% fine sand and 15% silt.	
					0.0			4" 0.010 Slot PVC screen
					0.0		Silty sand with gravel, light brownish gray (10YR6/2), dry, angular to subrounded sand, nonplastic silt, fine to coarse angular to subrounded volanic gravel (up to 3" long), locally partly indurated to weakly cemented. Some local volcanic cobbles. Approximtely 15% gravel, 10% coarse sand, 30% medium sand, 30% fine sand, and 15% silt.	
					1.0			
					2.0		Becomes wet and black (2.5Y2.5/1) @ 59.5' bgs to 60' bgs.	
-60					11.6		ML: Clayey silt, yellowish brown (10YR5/4), moist, stiff, nonplastic to low plasticity fines. Approximately trace fine sand, 80% silt and 20% clay.	#2/12 Sand Pack

BMI Landfill CAMU Investigation

Henderson, Nevada

Basic Remediation COMPANY

Log of Boring No. BW-12B

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
					1.3		Clayey silt, yellowish brown (10YR5/4), moist, stiff, nonplastic to low plasticity fines. Approximtely trace fine sand, 85% silt and 15% clay.	
					6.6			4" 0.010 Slot PVC screen
					0.0		Clayey silt, light gray (10YR7/2), moist, stiff to very stiff, low plasticity fines. Approximately trace fine sand, 65% silt and 35% clay.	Threaded PVC Well Base Cap
-70								
					0.0		Becomes yellowish brown (10YR5/4) @ 71' bgs.	
							Clayey silt, yellowish brown (10YR5/4), moist, stiff, nonplastic to low plasticity fines. Approximately trace fine sand, 85% silt and 15% clay.	
					0.0			
							Clayey silt, yellowish bown (10YR5/4), moist, stiff, nonplastic to low plasticity fines, locally partly indurated. Approximately 5% fine sand, 80% silt and 15% clay.	Basal Bentonite Seal
					0.0			
-80					0.0		Clayey silt, yellowish brown (10YR5/4), moist, stiff, very low to low plasticity fines. Approximately 75% silt and 25% clay.	
					0.0			
							Clayey silt, yellowish brown (10YR5/4), moist, stiff, very low to low plasticity fines, subangular to subrounded sand. Approximately 5% fine sand, 70% silt and 25% clay.	
					0.0			
					0.0			
-90							Clayey silt, yellowish brown (10YR5/4), moist, stiff, very low to low plasticity fines, subangular to subrounded sand. Approximately trace medium sand, 5% fine sand, 75% silt and 20% clay.	
					0.0			
							Clayey silt, yellowish brown (10YR5/4), moist, stiff, very low to low plasticity fines. Approximately trace fine sand, 85% silt and 15% clay.	
					0.0			

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
							Clayey silt, yellowish brown (10YR5/4), moist, stiff, very low to low plasticity fines. Approximately 80% silt and 20% clay.	
					0.0			
-100					0.0		Clayey silt, yellowish brown (10YR5/4), moist, stiff, very low to low plasticity fines. Approximately 80% silt and 20% clay.	
					0.0			
					0.0			
							Clayey silt, yellowish brown (10YR5/4), moist, stiff, very low to low plasticity fines. Approximately 80% silt and 20% clay.	
					0.0			
					0.0		Clayey silt, light yellowish brown (10YR6/4), moist, stiff to very stiff, nonplastic to low plasticity fines. Approximately trace fine sand, 85% silt and 15% clay.	
-110								Basal Bentonite Seal
					0.0		Clayey silt, yellowish brown (10YR5/4), moist, stiff, very low to low plasticity fines. Approximately 80% silt and 20% clay.	
					0.0		Clayey silt, strong brown (7.5YR5/6), moist, very low to low plasticity fines. Approximately trace fine sand, 80% silt and 20% clay.	
					0.0		Clayey silt, brown (7.5YR5/4), moist, very low to low plasticity fines, trace subangular to subrounded sand. Approximately 5% fine sand 75% silt and 20% clay.	
-120								
					1.0		Clayey silt with sand, brown (7.5YR5/4), wet, nonplastic to low plasticity fines, subangular to subrounded sand. Note: wet zone @ 120' to 130.5' bgs. Approximately trace medium sand, 15% fine sand, 70% silt and 15% clay.	
	Chemical				1.0		(Sample BRC-BW-12B-122 collected). Saturated Soil.	
							Clayey silt with sand, brown (7.5YR5/4), wet, nonplastic to low plasticity fines, subangular to subrounded sand. Approximtely 15% fine sand, 70% silt and 15% clay.	
					1.0			
					1.0			
-130							Clayey silt, brown (7.5YR5/4), wet, nonplastic to low plasticity fines, trace subangular to subrounded sand. Becomes moist @ 130.5' bgs. Approximately 5% fine sand, 75% silt and 20% clay.	
					0.0			
							Clayey silt, brown (7.5YR5/4), moist, very low to low plasticity fines, medium stiff to stiff.	

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
							Approximately trace fine sand, 80% silt and 20% clay.	
					0.0		Clayey silt, brown (7.5YR5/4), moist, stiff, very low to low plasticity fines. Approximately trace fine sand, 80% silt and 20% clay.	
					0.0		Clayey silt, brown (7.5YR5/4), moist, stiff to very stiff, very low to low plasticity fines. Approximately trace fine sand, 80% silt and 20% clay.	
					0.0			
-140					0.0		Clayey silt, brown (7.5YR5/4), moist, very stiff, low plasticity fines, some local silty clay seams. Approximately 60% silt and 40% clay.	
					0.0			
							Clayey silt, yellowish brown (10YR5/4), moist, very stiff, nonplastic to low plasticity fines. Approximately trace fine sand, 70% silt and 30% clay.	Basal Bentonite Seal
					0.0			
					0.0		Clayey silt, yellowish brown (10YR5/4), moist, very stiff, nonplastic to low plasticity fines. Approximately trace fine sand, 85% silt and 15% clay.	
-150								
					0.0			
							Clayey silt, yellowish brown (10YR5/4), moist, very stiff, nonplastic to low plasticity fines. Approximately 85% silt and 15% clay.	
					0.0			
							Clayey silt, yellowish brown (10YR5/4), moist, very stiff, nonplastic to low plasticity fines. Approximately 85% silt and 15% clay.	
					0.0			
-160					0.0		Clayey silt, brown (7.5YR5/4), moist, stiff, very low to low plasticity fines. Approximately 65% silt and 35% clay.	
					0.0			
							Clayey silt, brown (7.5YR5/4), moist, stiff, very low to low plasticity fines. Approximately 70% silt and 30% clay.	
					0.0			

BMI Landfill CAMU Investigation

Henderson, Nevada

Basic Remediation COMPANY

Log of Boring No. BW-12B

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
					0.0		Clayey silt, brown (7.5YR5/4), moist, stiff, very low to low plasticity fines. Approximately 75% silt and 25% clay.	
-170								
					0.0		Clayey silt, yellowish brown (10YR5/4), moist, stiff, very low to low plasticity fines. Approximately 80% silt and 20% clay.	
					0.0		Clayey silt, yellowish brown (10YR5/4), moist, stiff to very stiff, very low to low plasticity fines. Approximately trace fine sand, 80% silt and 20% clay.	
					0.0		Clayey silt, yellowish brown (10YR5/4), moist, very stiff, nonplastic to low plasticity fines. Approximately 80% silt and 20% clay.	
-180					0.0			Basal Bentonite Seal
							Clayey silt, brown (7.5YR5/4), moist, stiff, very low to low plasticity fines. Approximately 70% silt and 30% clay.	
					0.0			
							Clayey silt, brown (7.5YR5/4), moist, stiff, very low to low plasticity fines. Approximately 65% silt and 35% clay.	
					0.0			
							Clayey silt, yellowish brown (10YR5/4), moist, stiff to very stiff, nonplastic to low plasticity fines, trace local cementation. Approximately trace fine sand 85% silt and 15% clay.	
					0.0			
-190							Clayey silt, yellowish brown (10YR5/4), moist, stiff, very low to low plasticity fines. Approximately 70% silt and 30%.	
					0.0		Clayey silt, yellowish brown (10YR5/4), moist, stiff to very stiff, nonplastic to low plasticity fines. Approximately 75% silt and 25% clay.	
					0.0		Clayey silt, brown (7.5YR5/4), moist, very stiff, nonplastic to low plasticity fines, trace subangular to subrounded sand, trace local cementation. Approximately trace medium sand, 5% fine sand, 80% silt and 15% clay.	
					0.0		Clayey silt, yellowish brown (10YR5/4), moist, very stiff, nonplastic to low plasticity fines, trace local cementation. Approximately trace fine sand, 80% silt and 20% clay. Bottom of hole @ 200' bgs.	
-200							End Borehole @ 200 ft bgs.	

Log of Boring No. BW-13A

BMI Landfill CAMU Investigation

Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: Rotary Sonic
Drilling Equipment: GEFCO
Drilling Contractor: Water Development Corporation
Driller: Mike Wilkerson

Borehole Total Depth: 86.5 ft bgs
Borehole Diameter: 7 5/8" O.D. Casing / 7 7/8" O.D. Bit
Well ID: GW-MCF-BW-13
Depth to Water (ft. bgs): 29' bgs ▽

Sample Type: 2" Split Spoon
Sample Interval Continuous

Logged By: M. Manwaring
Date Started: 03/27/05
Date Completed: 03/28/05

Monitoring Well Construction

Type of Surface Seal:	Bentonite-Grout	**Screen Slot Size:**	0.010 in
Blank Casing Type/Size:	4" Sch 80 PVC	**Top of Screen (ft. bgs):**	59 ft bgs
Screen Type/Size:	4" Sch 80 PVC	**Bottom of Screen (ft. bgs):**	69 ft bgs
Transition Sand Type:	N/A	**Type of Sand Pack:**	#2/12

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0					0.4		SM: Silty sand with gravel, dark grayish brown (10YR4/2), silghtly moist to dry, loose, (0"-2" asphalt), hand auger to 3' (refusal in cobbles/gravels begin rotosonic - slowly to 10' bgs), fill to about 4' bgs/road base). Approximately 15% gravel, 10% coarse sand, 20% medium sand, 40% fine sand and 15% silt. (Sample BRC-BW-13A-0 collected).	Flush mount well box with concrete apron
					0.2		Silty sand with gravel, dark yellowish brown (10YR3/4), dry to slightly moist, angular, becoming angular volcanic rock below 7' bgs. (gray to strong brown). Approximately 15% gravel, 10% coarse sand, 15% medium sand, 30% fine sand, 30% silt and trace clay. Approximately 10% gravel, 15% coarse sand, 20% medium sand, 25% fine sand, 30% silt and trace clay.	Cement Bentonite Grout
-10							COBBLES: Cobbles/Boulders, gray (7.5YR5/1), vessicular volcanic rock, drill bit crushed rock into fine silt size, dry. Approximately 100% cobbles and boulders.	4" Blank PVC Riser Pipe
					0.0		SM: Silty sand with gravel, yellowish brown (10YR5/4), gravels are angular to subangular volcanics (up to 2"-3" diameter). Approximately 25% gravel, 5% coarse sand, 15% medium sand, 25% fine sand, 30% silt and trace clay.	Bentonite seal
					0.0			
					0.0		Silty sand with gravel, brown (10YR5/3), subangular to angular (broken) gravels (volcanics). Approximately 20% gravel, 5% coarse sand, 15% medium sand, 30% fine sand, 30% silt and trace clay.	#2/12 Sand Pack
-20					0.0			
					0.0		GP-GM: Gravel with silt and sand, large gravels and silty sand, large subangular to subrounded, dry, gray (10YR5/1-6/1), when cobbles cored, broken material silty and angular gravel. Approximately 75% gravel and cobbles, 5% coarse sand, 10% fine sand and 10% silt.	
					0.0		Silty gravel with sand, gray (10YR6/1), subangular to angular (broken) moist at 27' bgs, increased silt and fine sand, wet, at 29' bgs (casing to 30') [water lever meter indicates water to 27'8" bgs]. Approximately 60% gravel, 20% fine sand, 20% silt and trace clay. Becomming	4" 0.010 Slot PVC screen

BMI Landfill CAMU Investigation

Henderson, Nevada

Basic Remediation COMPANY

Log of Boring No. BW-13A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
							moist at 25' bgs.	
					0.4		SM: Silty sand with gravel, very moist, lenses of medium sand, very moist to wet, brown (10YR4/3), gravel is subangular to angular, firm. Approximately 20% gravel, 15% coarse sand, 10% medium sand, 20% fine sand, 30% silt and 5% clay.	
					1.8		Approximately 20% gravel, 5% coarse sand, 15% medium sand 30% fine sand, 30% silt and trace clay. (Sample BRC-BW-13A-30 collected).	
-30					2.1			4" 0.010 Slot PVC screen
					0.0			
					NR			
					NR		ML/SM: Sandy silt with gravel, brown (7.5YR4/3), very moist, increased fines (silt and clay), driller had trouble holding samples from ~30' - 36' in corebarrel. Approximately 10% gravel, 5% coarse sand, 15% medium sand, 20% fine sand, 40% silt and 10% clay.	#2/12 Sand Pack
					1.6			Threaded PVC Well Base Cap
-40					2.8		Sandy silt with clay, several thin (<0.3") fine to medium sand lenses, dark yellowish brown (10YR4/4), trace silty gypsum, small gravel are angular volcanics. Approximately 10% gravel, 5% coarse sand, 10% medium sand, 25% fine sand, 40% silt and 10% clay.	
					7.5			
					29			
					44			Basal Bentonite Seal
					6.9		ML: Sandy silt with clay, subangular to subrounded, trace thin (0.3" - 0.5"), fine to medium sand lenses (subrounded volcanic sands), very moist (not wet) but saturated, no odors. Approximately 5% gravel, 5% coarse sand, 10% medium sand, 20% fine sand, 50% silt and 10% clay.	
-50							(Casing advanced to 50' bgs).	
							Sandy silt with clay, brown silt (7.5YR4/4), most pronounced at 51.5' - 52.5', very moist to saturated (wet), silt is firm, sand is loose, trace clay, low to medium plasticity, some local sand lenses (<1" thick). Approximately trace gravel, 5% coarse sand, 10% medium sand, 20% fine sand, 55% silt and 10% clay. (Sample BRC-BW-13A-53 collected).	
							Clayey silt with sand, brown (7.5YR4/3), medium plasticity, saturated (wet 56' - 57' bgs). Approximately trace gravel, 15% fine sand, 65% silt and 20% clay.	
					0.5			
							Silt with clay, gravel and sand, (chert/gypsum?), brocken by corebarrel, moist. Approximately 15% gravel, 10% medium sand, 15% fine sand, 55% silt and 10% clay.	
-60					0.3		Clayey silt, strong brown (7.5YR5/6), medium plasticity clay, becomes wet @ 60' - 63' bgs, slightly firm. Approximately 10% gravel, 10% fine sand, 60% silt and 20% clay.	

BMI Landfill CAMU Investigation

Henderson, Nevada

Basic Remediation COMPANY

Log of Boring No. BW-13A

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
					0.0		Clayey silt with gravel, brown (7.5YR5/4), moist to very moist, (saturated not wet), low plasticity, firm to stiff, some gypsum content. Approximately 15% gravel, 10% fine sand, 60% silt and 15% clay.	
					0.0		Silt with clay and gravel, yellowish brown (10YR5/4), moist, firm. Approxiamtely 15% gravel, 75% silt and 10% clay.	
					0.0		Silt, brown (7.5YR5/4), low plasticity, firm to stiff, some gypsum content. Approximately 10% gravel, 10% fine sand, 75% silt and 5% clay.	
-70					0.0			
					0.0		Clayey silt with gravel, brown (7.5YR5/4). Approximately 15% gravel, 10% fine sand, 60% silt and 15% clay.	
					0.0		Clayey silt, sand and trace gravels, (gypsum fragments), angular to subangular, firm to stiff, moist (not wet), low plasticity. Approximately 5% gravel, 10% fine sand, 70% silt and 15% clay.	
					0.0		Clayey silt, trace gravel size gypsum fragments, (angular) visible crystals on some fragments firm to stiff, low plasticity, moist. Approximately trace gravel, 10% fine sand, 75% silt and 15% clay.	
					0.0			
-80					0.0		Clayey silt, brown (7.5YR5/3), moist, low plasticity, firm to stiff. Approximately 5% fine gravel, 5% medium sand, 10% fine sand, 65% silt and 15% clay. (Casing to 80' bgs)	
					0.0		Clayey silt, trace angular gravel size rocks (gypsum), moist, firm/stiff. Approximately 5% gravel, 10% fine sand, 70% silt and 15% clay. (Sample BRC-BW-13A-85 collected). Bottom of hole @ 86.5 ft bgs.	

Log of Boring No. BW-13B

BMI Landfill CAMU Investigation

Henderson, Nevada

Basic Remediation COMPANY

Drilling Method: Rotary Sonic
Drilling Equipment: GEFCO
Drilling Contractor: Water Development Corporation
Driller: Mike Wilkerson

Borehole Total Depth: 60 ft bgs
Borehole Diameter: 7 5/8" O.D. Casing / 7 7/8" O.D. Bit
Well ID: GW-AA-BW-13
Depth to Water (ft. bgs): 29' bgs ▽

Sample Type: N/A
Sample Interval Continuous

Logged By: A. Norris
Date Started: 03/29/05
Date Completed: 03/30/05

Monitoring Well Construction

Type of Surface Seal:	Bentonite-Grout	**Screen Slot Size:**	0.010 in
Blank Casing Type/Size:	4" Sch 80 PVC	**Top of Screen (ft. bgs):**	18 ft bgs
Screen Type/Size:	4" Sch 80 PVC	**Bottom of Screen (ft. bgs):**	38 ft bgs
Transition Sand Type:	N/A	**Type of Sand Pack:**	#2/12

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
0					0.0		SM: Silty sand with gravel, dark yellowish brown (10YR4/4), moist to dry, subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 2" long), locally partly indurated to weakly cemented. Approximately 20% gravel, 15% coarse sand, 15% medium sand, 30% fine sand and 20% silt. Note: Asphalt pavement (5" thick) @ ground surface.	Locking monument well box with concrete apron and ballards
					0.0		Silty sand with gravel, dark yellowish brown (10YR4/4), dry to moist, subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 3" long), locally partly indurated to weakly cemented, trace local volcanic cobbles (up to 4" long). Approximately 35% gravel, 10% coarse sand, 10% medium sand, 30% fine sand and 15% silt.	Cement Bentonite Grout
					0.0			
					0.0		Silty sand with gravel, brown (10YR5/3), dry, subangular to surounded sand, nonplastic silt, subangular to subronded fine to coarse volcanic gravel (up to 3" long), locally partly indurated to weakly cemented. Approximately 30% gravel, 10% coarse sand, 10% medium sand, 30% fine sand and 20% silt.	
-10					0.0			4" Blank PVC Riser Pipe
					0.0		Silty sand with gravel, light brownish gray (10YR6/2), dry, subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 3" long), some local volcanic cobbles (up to 5" long). Approximately 30% gravel, 15% coarse sand, 10% medium sand, 30% fine sand and 15% silt.	Bentonite seal
					0.0			
					0.0		Silty sand with gravel, dark grayish (10YR4/2), dry to moist, subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 3" long), trace local volcanic cobbles (up to 5" long). Approximatley 30% gravel, 15% coarse sand, 10% medium sand, 25% fine sand and 20% silt. Becomes yellowish brown (10YR5/4) @ 17' bgs.	
					0.0			
					0.0		ML: Silt with sand, brown (10YR4/3), moist, nonplastic to very low plasticity silt, subangular to subrounded sand. Approximately 5% medium sand, 15% fine sand and 80% silt.	#2/12 Sand Pack
-20					0.0		SM: Silty sand with gravel, light brownish gray (10YR6/2), moist, subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 2" long), locally partly indurated to weakly cemented. Approximately 20% gravel, 15% coarse sand, 15% medium sand, 35% fine sand and 15% silt.	
					0.0		Silty sand with gravel, light brownish gray (10YR6/2), moist, subangular to subrounded sand, nonplastic silt, subangular to subrounded fine to coarse volcanic gravel (up to 2" long), locally partly indurated to weakly cemented, trace local strong cementation. Approximately 20% gravel,	4" 0.010 Slot PVC screen

BMI Landfill CAMU Investigation

Henderson, Nevada

Basic Remediation COMPANY

Log of Boring No. BW-13B

Depth Elevation (MSLD)	Sample Type	Sample Interval	Sample Recovery (feet)	Sample Retained for Analysis	PID	Lithology	Soil Description	Well Construction
					0.0		15% coarse sand, 10% medium sand, 25% fine sand and 30% silt.	
-30					0.0		Silty sand with gravel, light brownish gray (10YR6/2), wet, subangular to subrounded sand, nonplastic to very low plasticity silt, fine to coarse subangular to subrounded volcanic gravel (up to 3" long), locally partly indurated to weakly cemented, trace local volcanic cobbles (up to 5" long). Approximately 20% gravel, 10% coarse sand, 10% medium sand, 35% fine sand and 25% silt. First water @ 29' bgs.	4" 0.010 Slot PVC screen
					0.0		Silty sand with gravel, brown (7.5YR5/2), wet, subangular to subrounded sand, nonplastic to very low plasticity silt, subangular to subrounded fine to coarse volcanic gravel (up to 2" long), locally cemented. Approximately 15% gravel, 10% coarse sand, 10% medium sand, 40% fine sand and 25% silt.	
					0.0		ML: Silt with sand, pink (7.5YR7/3), moist, nonplastic to very low plasticity silt, subangular to subrounded sand, very stiff to hard. Approximately 20% fine sand and 80% silt.	#2/12 Sand Pack
					0.0 0.0		Silt wit clay, brown (7.5YR5/4), moist, very low to low plasticity fines, subangular to subrounded sand, stiff. Approximately 10% fine sand, 80% silt and 10% clay.	Threaded PVC Well Base Cap
-40					0.0		Silt with clay, brown (7.5YR5/4), moist, very low to low plasticity fines, subangular to subrounded sand, stiff. Approximately 10% fine sand, 80% silt and 10% clay.	
					0.0		Silt with clay and sand, brown (7.5YR5/4), moist, very low to low plasticity fines, subangular to subrounded sand, very stiff. Approximately 5% gravel, 5% coarse sand 5% medium sand, 10% fine sand, 65% silt and 10% clay.	Basal Bentonite Seal
					0.0		Clayey silt, brown (7.5YR5/4), moist, very low to low plasticity fines, very stiff. Approximately 5% fine sand, 80% silt and 15% clay.	
-50					0.0		Clayey silt, strong brown (7.5YR5/6), moist, very low to low plasticity fines, stiff. Approximately 80% silt and 20% clay.	
					0.0 0.0		Clayey silt, brown (7.5YR5/4), moist, very low to low plasticity fines, stiff to very stiff. Approximately 85% silt and 15% clay.	
					0.0		Clayey silt, brown (7.5YR5/4), moist, very low to low plasticity fines, stiff, subangular to subrounded sand. Approximately 5% coarse sand, 5% medium sand, 5% fine sand, 70% silt and 15% clay. 1" thick Sandy silt seam @59' bgs. Wet seam bound above and below by moist clayey silt. Seam: Approximately 40% fine to coarse sand and 60% silt. 59.1' to 60' bgs: Clayey silt. brown (7.5YR5/4), moist, very low to low plasticity fines, stiff. Approximtaely 80% silt and 20% clay.	
-60					0.0		Bottom of hole @ 60' bgs.	