March 13, 2014

Geotechnical
Environmental
Water Resources
Ecological

Mr. Michael Friend, P.E.
Staff Engineer III
Special Projects Branch
Bureau of Corrective Actions
Nevada Division of Environmental Protection
2030 E. Flamingo Road, Suite 230
Las Vegas, Nevada 89119-0818

Re: Titanium Metals Corporation
Henderson, Nevada Facility
NDEP Facility ID # 000537
Responses to NDEP Comments Transmitted by E-mail Dated March 7, 2014 Regarding the Document Titled: "Draft TIMET Soil Management Plan-Slurry Wall/Northern Property", dated February 24, 2014

Dear Mr. Friend:

Titanium Metals Corporation (TIMET) is in receipt of the Department's e-mail communication dated March 7, 2014 presenting comments on the above-captioned submittal. Responses to these comments are attached.

If you have any questions regarding this submittal, please do not hesitate to contact the undersigned at (716) 204-7158 (email: kmcintosh@geiconsultants.com) or Mr. Richard Pfarrer of TIMET at (702) 566-4453 (email: Richard.Pfarrer@Timet.com).

Sincerely,

GEI Consultants, Inc., P.C.

Kelly R. McIntosh, Ph.D., EM-2199 (exp. 9/24/15)
Senior Consultant

cc: Richard Pfarrer – TIMET, hard copy and electronic copy
Michael Ruetten – GEI, electronic copy
JD Dotchin, Nevada Division of Environmental Protection, Las Vegas, Nevada, electronic copy
Stephen F. Tyahla, PE

GEI Consultants, Inc., P.C.
90B John Muir Drive, Suite 104, Amherst, NY 14228
716.204.7154

JURAT

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.

For the services provided and attested to with this Jurat including preparation of the responses to comments attached to this letter.

GEI CONSULTANTS, INC., P.C.

Kelly R. McIntosh
Senior Consultant
Nevada Certified Environmental Manager
EM No. 2199; Expires September 24, 2015

Date Signed: March 13, 2014

Titanium Metals Corporation
Henderson, Nevada Facility
NDEP Facility ID # 000537
Preliminary Responses to NDEP Comments Transmitted by E-mail Dated March 7, 2014 Regarding the Document Titled: "Draft TIMET Soil Management Plan-Slurry Wall/Northern Property" dated February 24, 2014

NDEP Comment 1, General Comments:

a. TIMET should provide the Construction Quality Assurance (CQA) Plan for the project.

TIMET Response: A CQA Manual has been prepared (Attachment A). The CQA Manual encompasses other site activities (i.e. pond installations and Crystallizer foundation construction) in addition to this project.

b. TIMET should provide the Technical Specifications for the project stamped by an Engineer registered in the State of Nevada.

TIMET Response: See Attachment B for technical specifications for the GCL, a gradation for the NDOT Type II gravel and Nevada Power Sand. The slurry wall construction documents address the earthwork activities associated with moving soil to a smooth and uniform grade. A copy of the proposed earthwork section is also attached.

c. TIMET should provide all design work and calculations for the project stamped by an Engineer registered in the State of Nevada.

TIMET Response: Calculations and specifications included with this response are stamped by an Engineer registered in the State of Nevada.

d. As was mentioned in the February 27th meeting, NDEP will require an O&M plan for the cover system.

TIMET Response: TIMET will provide an O&M Manual for the soil cover with the construction documentation report. The manual will address inspection of the cover and repairs (as necessary). The main focus of the O&M Manual will be to maintain ditch alignment and prevent long term exposure of the GCL. This manual will be separate from the O&M manual for the groundwater extraction system.

e. All impacted stormwater will be required to be kept onsite and is not allowed to come in contact with the new cover system as it is being constructed.

TIMET Response: A stormwater management plan will be developed by the contractor. A copy will be provided to NDEP prior to construction. Stormwater will not be allowed to leave the site unless from a clean cover area.

f. All visually impacted material encountered should be properly removed offsite. If any large quantities of visually impacted materials are found or if visually impacted material is found outside the project limits, TIMET is to contact NDEP immediately for guidance.

TIMET Response: Visually impacted soils will be managed in the same manner as implemented during the slurry wall and utility project. NDEP will be contacted if large quantities of visibly impacted soils are found or if visually impacted soils are identified outside of the proposed grading limits.

NDEP Comment 2: Section 1.1, item 1, Prevent erosion, TIMET should provide the hydrology and rip-rap sizing calculations for review.

TIMET Response: Hydrological analysis was performed in the Drainage Study and approved by the appropriate local agencies. A copy of the channel calculations and riprap sizing is provided in Attachment C.

NDEP Comment 3: Section 1.1, item 3, Limit infiltration, TIMET should define this term and provide the supporting calculations. In relation, the leaching pathway was not discussed in this document, however the leaching potential will determine the minimum performance goals for the infiltration rate of the cover system if TIMET is to eliminate/reduce the leaching pathway of contaminants.

TIMET Response: The use of a GCL in the cover cross section will reduce infiltration to a value less than would occur into the existing onsite soils (hydraulic conductivity likely on the order of $1x10^{-2}$ to $1x10^{-3}$ cm/sec). While infiltration will be limited to some degree by the GCL, it is not the primary function of the layer. The immediate purpose is to prevent erosion and direct contact while achieving the site grades in accordance with the approved grading plan (which was necessary in order to obtain permission to build the slurry wall).

The Conceptual Site Model (CSM) will address exposure pathways involving the covered soil including potential leaching to groundwater.

NDEP Comment 4: Section 3.1.1:

a. **Geosynthetic Clay Liner, TIMET should provide the supporting slope stability calculations for review. Please also clarify how the GCL placed on the prepared subgrade will minimize construction damage.**

TIMET Response: Calculations for the placement of cover soil and rip rap on the proposed pond slopes are provided in Attachment D. The specifications and CQA Manual discuss subgrade inspection during the GCL placement. GCL placement will be determined by the installer to match the requirement to minimize subgrade rutting.

b. **6 inch minimum Sand Cover Layer, TIMET should provide the supporting calculations including the transmissivity of the specified sand that supports the design premise, the confining stress of the sand for restricting bentonite swell, the anticipated hydration range of the GCL to be maintained and the support that the sand will dry to the full depth of the soil. Please also specify how the 6-inch sand layer will be placed.**

TIMET Response: It is not the intent of the cover sand to provide a horizontal drainage function. While a clean sand has been specified above the GCL, there is not a permeability or transmissivity requirement for this layer. The potential for horizontal drainage has been accounted for with the installation of a small depression at the toe of pond slopes and adjacent to the groundwater transmission line. These features are intended to control seepage from the sand. The specification for the sand is provided in Attachment B and placement observation requirements are addressed in the CQA manual.

c. **6 inch minimum Gravel or Wear Surface, TIMET should provide the supporting calculations that the six inches and twelve to fifteen inches of gravel material overlying the six inches of sand, respectively, will be sufficient to avoid compression of the bentonite layer of the GCL from vehicular traffic both during construction and during long term maintenance considering maximum anticipated moisture content of the bentonite. Please also specify how the gravel materials will be placed.**

TIMET Response: GCL is typically delivered at a moisture content that is below the level where squeeze-out of the bentonite is a problem. Given the local climate and the specifications that do not allow placement in the rain, the potential for bentonite pumping is minimized. The maintenance traffic will be limited to the access road proposed along the groundwater extraction pipe alignment. The calculation for normal maintenance vehicles is provided in Attachment E. In other covered areas, it is anticipated that normal vehicle traffic will be limited to small golf carts and Cushmans used by maintenance staff at TIMET and these can drive directly on the GCL so a 12-inch separation is safe. The final location of the maintenance road will be decided during the final site grading. Access by large construction vehicles in a repeated pattern is addressed in the specifications and will be included in the O&M plan.

d. **Bullet list on page 7, TIMET should provide support that the GCL will strengthen the subgrade for road areas to minimize rutting and regarding hydration of the bentonite over time and potential of mineral replacement, TIMET should provide supporting documentation for anticipated long term hydraulic conductivity of the bentonite component of the GCL as it relates to the design premise.**

TIMET Response: The use of a GCL which includes two layers of geotextiles that are needled together will provide subgrade reinforcement, however it is anticipated that bentonite displacement will occur in some areas. Therefore, no calculations are provided to document GCL anticipated performance from a hydraulic conductivity perspective. While 12-inches of cover soil is less than the pressure to prevent any and all bentonite swell, it is sufficient to constrain the GCL between the cover sand and subgrade soils.

NDEP Comment 5: Section 3.1.2, TIMET should confirm soil placement specifications to quantify a "firm soil condition." Please clarify the GCL placement specification including but not limited to required subgrade condition prior to GCL placement and granular/powdered bentonite placement in overlapping GCL seams.

TIMET Response: The GCL specifications are included in Attachment B. The overlaps are addressed in the specifications.

NDEP Comment 6: Figure 6, TIMET will need to further investigate hexavalent chromium exceedance at P-B-10.

TIMET Response: P-B-10 is located within the south CSD Pond and is not covered by the Soil Management Plan. This result will be addressed in the CSM

NDEP Comment 7: Appendix A:

a. **There appears to be no sub-surface samples in Area #6, the Boneyard / Proposed Pond GW-1. Are PP-B-1 and PP-B-2 sample points or just geotechnical investigations? This is a data gap that should be addressed before the proposed pond is installed.**

TIMET Response: This area is not known or suspected to have had past chemical releases and the results of the surface soil samples collected do not suggest otherwise. However, PP-B-1 and PP-B-2 were drilled to collect subsurface soil samples. Two samples were collected from PP-B-1 (from 0 to 4 feet and 11 to 13 feet bgs) and two samples were collected from PP-B-2 (from 0 to 4 feet and 7 to 15 feet bgs). Samples were analyzed for anions, metals and radionuclides. Preliminary analytical results are attached (Attachment F). No visibly impacted soils were observed in these borings. TIMET believes this does not constitute a data gap.

b. There appears to be no sub-surface samples in Area 9, the WCF-3 and future waste water process equipment pads. This is a data gap that should be addressed before the pads and ponds are installed. (I have attached the 2007 deliverable and NDEP letter for the NFA of the *Sort and Blend Plant Footprint* that can give some guidance on sampling in these areas.)

TIMET Response: TIMET will install a soil boring in Area 9 following the same procedures, sampling intervals and analyses as presented in the 2007 Sort and Blend Footprint Deliverable.

c. Some of the samples appear to be composite samples taken over a range depth primarily for waste characterization and not for the CSM. TIMET may need to fill in data gaps for these areas and other areas after the CSM submitted and reviewed.

TIMET Response: While there may be data gaps identified as the CSM is completed, the composite samples obtained along the slurry wall alignment were not for the purposes of the CSM and are unlikely to represent a data gap.

d. Some of the sub-surface samples do not include everything that was sampled at the surface or in other areas. For example, the mystery ditch sub-surface samples do not include VOCs or PCBs/Dioxins. Without the final CSM report, NDEP cannot comment on whether this is acceptable or not. This could very likely be potential data gaps for those areas.

TIMET Response: TIMET does not disagree that it may be appropriate to preemptively collect subsurface samples from the Mystery Ditch. TIMET will install a soil boring and collect a sample from the interval from 5 to 10 feet bgs with analyses for PCB congeners, dioxins and VOCs. In addition a subsurface soil sample (5 to 10 feet bgs) will be obtained in the Northern Storage Area from the location of NS-SS-1 and analyzed for PCBs/dioxin.

NDEP Comment 8: Drawings C-1:

a. Some of the sides of the existing ponds (HP-1 and HP-6) appear to be outside of the proposed cover. Does TIMET have plans for eliminating exposure to those potential impacted soils in the berms of the ponds and preventing stormwater erosion and impacted stormwater run-off? Our immediate concerns are where exposed berms are upgradient of the proposed clean cover system and stormwater could transport impacted sediment/water onto the new clean cover system.

TIMET Response: The intent of Area 7 is to address the full extent of the west and north side of the ponds. The only item that is outstanding on this side is the portion of NERT site that may drain towards

TIMET and the 48-inch pipe. The south side of HP-1 will be filled with the construction of the WCF-3 pond and the crystallizer. The area between the south limits of HP-6 and the J-2 landfill is being designed as part of the J-2 landfill permit modification and the crystallizer project, this area will drain to the east.

b. Is there a reason the area east of Area 8 is not being covered? Where will the drainage from this area go?

TIMET Response: The area east of Area 8 is outside of the TIMET fence and was not identified as a PSA in previous reports. This area has historically been used for truck staging after the construction of Gate 9. TIMET is evaluating the use of Water Street asphalt regrind in this area to cover the existing soil. The majority of this area drains to the north and east.

c. How is the drainage from the landfill area managed? Will there be any run-off from the landfill to the clean cover system?

TIMET Response: The historic S-18 and J-2 landfill were covered with soil and have an erosion prevention material applied in non-traffic areas. The preliminary plans are being prepared for the construction of a 60-mil HDPE geomembrane and soil cover for the historic areas. The active portion of the J-2 landfill is permitted by the Southern Nevada Health District and the contact water from this portion is directed to the runoff storage area on the west end of cell 3. Cell 1 is covered with an erosion prevention material and drawings are being prepared for the final cover construction on this portion. Therefore, the final cover construction and proper operation of the landfill will prevent any potentially impacted runoff from reaching the new cover areas.

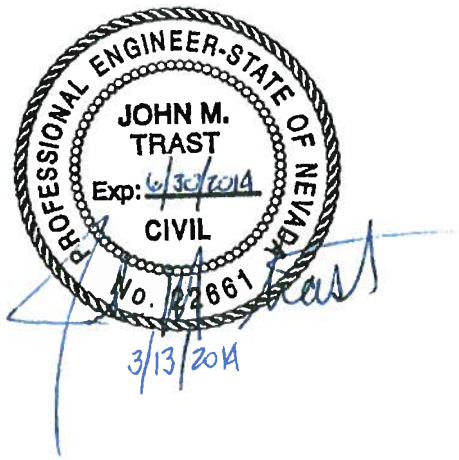
Attachment A

Construction Quality Assurance (CQA) Plan

TIMET
Henderson, NV

CONSTRUCTION QUALITY ASSURANCE MANUAL

TIMET HENDERSON FACILITY



Contents

1.0 Introduction

1.1 Project Description

This Construction Quality Assurance (CQA) Plan was prepared specifically for the landfill, ponds and remediation-related projects located at the TIMET facility in Henderson, Nevada.

The following liner configuration is typical of the ponds: (in ascending order):

1. Structural fill for construction of perimeter berms
2. 60 mil HDPE Secondary Geomembrane
3. 200 mil Geonet
4. 60 mil HDPE Primary Geomembrane

Pond construction activities, which are covered in this CQA Plan, consist of:

1. Site preparation activities (installing erosion controls and locating and protecting utilities and other existing structures)
2. Surface water conveyance system installation
3. Sub-grade preparation
4. Geomembrane installation
5. Geotextile cushion installation
6. Geonet installation
7. Leak detection sump and pipe installation 8) conveyance pipe

Landfill construction is anticipated to include excavation of a new cell, placement of base geosynthetics, and final cover construction. The specific layer will be designed in the permit modification package and are anticipated to include many of the components in this site manual.

The Soil Management Plan for the site includes the construction of a geosynthetic clay liner (GCL) as a marker and clean cover soils. This manual address the GCL and the cover soil placement.

Purpose and Scope

This CQA Plan was prepared to provide written construction oversight guidance to confirm that the construction activities and completed project comply with the Technical Specifications, Project Drawings, and applicable permit requirements. The CQA Plan summarizes methods, procedures, and frequency of observation and testing activities to document proper installation.

2.0 Organization, Responsibility, and Authority

2.1 Overview

The principal organizations involved in this project include the regulatory agency, Owner, Engineer, Geosynthetic Manufacturer, Earthwork Contractor, Installer, and CQA Technician. The roles and responsibilities of the principal organizations are discussed in the following subsections. A project directory will be prepared at the completion of bidding.

2.2 Regulatory Agency

The regulatory agency representatives for the ponds will be defined at the start of each construction sequence.

2.3 Owner

The site Owner is Titanium Metals Corporation further referred to as "the Owner" who is responsible for operating the facility and is responsible for submittals to the regulatory agency.

2.4 Engineer of Record

The Engineer of Record further referred to as "Engineer" will be responsible for approving and making any necessary design changes, reviewing and approving/rejecting the Earthwork Contractor's submittals, coordinating surveys and CQA Technician's reports and photographs, providing recommendations of material/workmanship to the Owner, and preparing the Construction Documentation Report and Drawings.

2.5 Geosynthetic Manufacturer

The Geosynthetic Manufacturer is responsible for production of the geosynthetic lining components outlined in this CQA manual. In addition, the Manufacturer is responsible for the condition of the geosynthetic until the material is accepted by the Engineer upon delivery. The Manufacturer will produce a consistent product meeting the technical specifications set forth by the manufacturer. Moreover, The Manufacturer will provide quality control documentation for the products produced as specified in this CQA manual.

2.6 Earthwork Contractor

The Earthwork Contractor is ultimately responsible for construction of the ponds structural berms, preparing final surface of sub-grade and excavations for the ponds and the landfill in strict accordance with the design criteria, Project Drawings, and Technical Specifications and for using the necessary construction procedures and techniques; specifically:

- Excavation to approved grade elevations and slopes
- Installation and maintenance of temporary and permanent erosion control measures
- Structural fill
- Anchor trench excavation, backfill and compaction

- Placement of cover soils over geosynthetics
- Construction of necessary site access roads.

Furthermore, the Earthwork Contractor is responsible for surface water management within the project limits until geosynthetics are placed. The Earthwork Contractor is also responsible for coordinating, supervising, and overseeing subcontractors, as needed, to perform construction-related activities.

2.7 Installer

The Installer will be responsible for the delivery, storage, deployment, quality control, and seaming of the geosynthetic components.

2.8 CQA Technician

The CQA Technician is retained by the Owner. The CQA Technician will perform construction inspection responsibilities to confirm construction compliance with the Technical Specifications and Project Drawings by observation, testing verification, and documentation activities. The CQA Technician is responsible for soil inspection, testing, and geosynthetic installation observation to document that the work meets the requirements of the Technical Specifications and Project Drawings. The CQA Technician will be responsible for confirming construction compliance with the Technical Specifications by performing material testing. The Engineer will supervise the CQA Technician(s) during the project.

3.0 Communications

3.1 Overview

A pre-construction meeting, weekly progress meetings, monthly project review meetings, geomembrane pre-installation meeting, and a final inspection meeting will take place on site, unless otherwise announced. The Earthwork Contractor, Installer, subcontractor (as necessary), CQA Technician, and Engineer will attend these meetings. The regulatory agency representative is invited to attend these meetings, however, attendance is optional. These meetings are discussed in the following subsections.

Minutes for all the project meetings will be documented, maintained, and transmitted by the Engineer (unless otherwise noted) to the principal project participants attending each meeting and to those who will be affected by the decisions.

3.2 Pre-Construction Meeting

A pre-construction meeting will be held prior to commencement of construction activities at the work site. The Earthwork Contractor will contact the Engineer of Record at least five working days prior to the anticipated commencement of construction to schedule the pre-construction meeting. The Earthwork Contractor will submit all required submittals prior to project commencement and prior to scheduling the meeting. The pre-construction meeting will be conducted by the Engineer and will be attended by those personnel listed in Section 3.1, including a representative of the Installer. The purpose of this meeting will be to:

- Exchange the following information: business addresses, phone numbers, fax numbers, email addresses, and pager numbers of the Owner, regulatory agency, Engineer, CQA Technician, Installer, and pertinent personnel for the Earthwork Contractor.
- Resolve any uncertainties following the award of the construction contract.
- Review work scope.
- Conduct a site walkover and inspection.
- Discuss the Earthwork Contractor's overall construction schedule and anticipated work hours.
- Discuss project administration.
- Review status of submittals required to be transmitted.
- Discuss any appropriate design modifications.
- Discuss the Earthwork Contractor's Surface Water and Dust Management Plan.
- Discuss the schedule and procedures of the geomembrane installation.
- Schedule weekly progress meetings.
- Discuss Owner's emergency notification and operating practices for emergency situations.
- Review project methods, site security, and safety.
- Determine a regular day of the week and time of day for weekly progress meetings.

3.3 Weekly Progress Meetings

A progress meeting may be held weekly or as desired by Owner. The day of the week and time of day will be determined and agreed upon by all parties at the pre-construction meeting. Changes to the regularly scheduled meeting time will be announced during the previous week's meeting. The meeting will be conducted by the Earthwork Contractor. The purpose of the meetings will be to:

- Review coordination of work.
- Review schedule to expedite the work.
- Review the previous week's activities and accomplishments.
- Review the work location and activities for the week.
- Review the status of the Earthwork Contractor's submittals.
- Review the Earthwork Contractor's progress report for the prior week.
- Identify the Earthwork Contractor's personnel and equipment assignments for the week.
- Discuss any existing or potential construction problems and their respective corrective actions.

3.4 Special Meetings

Special meetings may be called at the discretion of the Owner or the Engineer to resolve problems or other project-related issues.

3.5 Geosynthetics Pre-Installation Meeting

A meeting will be held to discuss the details of the proposed design and installation of the geosynthetics. The Earthwork Contractor will contact the Engineer to schedule the meeting a minimum of one working day in advance of the start of the geosynthetics installation. The Earthwork Contractor, Installer (including the project foreman), Owner, Engineer, and CQA Technician will attend the meeting.

3.6 Final Inspection Meeting

Upon completion of construction activities, a final inspection meeting may be conducted by the Engineer and attended by the Installer and the Earthwork Contractor. The meeting will be scheduled when:

1. The Earthwork Contractor has submitted written certification to the Engineer and the Owner that the Contract Documents have been reviewed
2. The work has been inspected
3. The work is substantially complete in accordance with Contract Documents
4. The work is ready for the Engineer's inspection. The final inspection may consist of a walkthrough inspection of the project site to determine whether the project is complete and consistent with the Contract Documents. Any outstanding construction items discovered during the inspection will be identified and noted on a punch list for the Earthwork Contractor to complete.

4.0 Geosynthetic Manufacturer

All Geosynthetic materials including the geomembrane, geonet and geotextile will be manufactured by GSE Environmental or equal. No substitutes will be used unless requested and approved in writing from the Owner and Engineer.

- Each geomembrane, geonet and geotextile roll will be marked by the manufacturer with the following information (on a durable gummed label or equivalent):
  - Name of manufacturer.
  - Product type and identification number (if any).
  - Panel length and width.
  - Nominal product thickness.
  - Identification number.

4.1 Geomembrane

See Appendix A for Material Specification Sheet

4.2 Geonet

See Appendix A for Material Specification Sheet

4.3 Geotextile

See Appendix A for Material Specification Sheet

4.4 Geosynthetic Clay Liner

See Appendix A for material Specification Sheet.

5.0 Construction Submittals, Inspection, and Testing

5.1 Overview

This Section outlines the work inspections, confirmations, audits, and evaluations of material and workmanship necessary to determine and document the construction quality for the major construction activities listed below:

- Submittals prior to project commencement
- Site preparation and erosion control installation
- Sub-grade preparation
- Structural fill placement and compaction
- Geosynthetic installation
- Geosynthetic testing
- Cover Material Placement
- Project closeout

The CQA activities will provide assurance that the construction was performed as specified in the Project Drawings and Technical Specifications.

5.2 Earthwork

5.2.1 Construction Submittals

The Earthwork Contractor will perform the following activities prior to project commencement, unless otherwise requested in writing by the Earthwork Contractor and approved in writing by the Engineer:

- Report any discrepancies between the existing conditions, project drawings, and actual site conditions to the Engineer and Owner.
- Submit the site superintendent/foreman names and phone numbers to the Engineer and Owner.
- Submit an overall construction schedule to the Owner and Engineer within five working days of the date of the contract award.
- Submit a project-specific Health and Safety Plan to the Engineer and Owner.
- Submit the construction commencement date to the Owner and Engineer five working days prior to project commencement.
- Submit a Surface Water and Dust Management Plan to the Engineer and Owner.
- Submit the imported soil source names and addresses to the Engineer and Owner.
- Submit the cushion geotextile manufacturers' and Installers' names, addresses and experience lists to the Engineer and Owner.
- Submit the pipe product data to the Engineer and Owner.

- Communicate with the Engineer, CQA Technician, and/or Owner regarding any pertinent issues.

5.2.2 Site Preparation and Erosion Control

The Earthwork Contractor will perform the following activities in accordance with Technical Specifications and Project Drawings:

- Submit Material Safety Data Sheets (MSDS) for chemical products to be used on site to the Engineer and Owner prior to those bringing chemicals on site
- Review locations of existing site utilities prior to beginning work
- Review and verify that all survey benchmarks and control makers are acceptable
- Construct and maintain erosion control measures
- Locate and protect all utilities, monitoring wells, leachate collection system, , and other structures
- Communicate with the Engineer, CQA Technician, and/or Owner regarding any pertinent issues

5.2.3 Sub-grade Preparation

The Earthwork Contractor will be responsible for preparing the sub-grade soil for structural fill for berm construction. Specifically, the following activities will be performed in accordance with Technical Specifications and Project Drawings:

- Excavate, grade, and compact the sub-grade as stated in the Geotechnical Report and Project Drawings.
- Perform Dust Control and Surface Water Control Measures to satisfaction of Engineer and/or Owner.
- Notify the Engineer and Owner in writing 48 hours prior to sub-grade completion.
- Communicate with the Engineer, Owner, and/or CQA Technician regarding any pertinent issues.

The Engineer will perform the following activities:

- Monitor construction progress.
- Review, approve/reject, and log project submittals.
- Review the CQA Technician daily logs and photographs.
- Survey the sub-grade surface, as specified in Technical Specifications.
- Notify the Earthwork Contractor and Owner of areas to be adjusted or approved grades.
- Communicate with the Owner, CQA Technician, and/or Earthwork Contractor regarding any pertinent issues.

5.3 Geosynthetic Installation

5.3.1 Pre-Installation Notifications and Submittals

Installation Contractor will provide the following notifications and submittals to the Engineer and Owner prior to starting any geosynthetic installation.

Notifications

- Notify Engineer and Owner in writing of any discrepancies between the existing conditions, project drawings, and actual site conditions.

Submittals Concerning Material Manufacturer

- Submit the resin quality control tests for resin used in manufacturing geomembrane and geonet materials.
- Submit the reclaimed polymer statement.
- Submit the production information for the geomembrane, geonet, GCL, and geotextile.
- Submit the geomembrane, geonet GCL,and geotextile quality control certificate for each roll and quality control test results to the Engineer prior to delivery of the first geosynthetic shipment.
- Submit certificate that extrudate to be used is comprised of same resin as geomembrane to be used.

Submittals Concerning Installer Qualifications

- Submit a project-specific Health and Safety Plan.
- Submit the (geomembrane, geonet, GCL, and geotextile) Installers' names and experience lists.
- Submit the site superintendent/foreman name(s) and phone numbers.

Submittals Concerning Site Construction and Material Installation

- Submit the installation panel layout diagram for the geomembrane.
- Submit documentation for the seaming apparatus to be used on site for the geomembrane.
- Submit pipe boot data.
- Submit the construction commencement date five working days prior to project commencement.
- Submit an overall construction schedule within five working days of the date of the contract award.
- Submit list of seaming devices with identification numbers.
- Submit calibration sheet of shear and peel testing (tensiometer) equipment.

5.3.2 Pre- Installation Submittal Reviews and Acceptance

Installation Contractor will not proceed with any phase of the installation until all pre-construction submittals have been reviewed and accepted by the Engineer and Owner. Installation contractor will correct and re-submit any rejected submittals within 24 hours of rejection notification.

5.3.3 During Installation Notifications, Submittals & Testing

Installation Contractor will perform and provide notifications, submittals and testing results for the following list to the QCA Technician, Engineer and Owner after material delivery and during the installation of the Geosynthetic.

Identification, Sampling, Storage and Transportation

- Assist in obtaining roll tags for each roll prior to usage.
- Obtain samples of the geomembrane, geonet, GCL, and geotextile upon delivery if required for QA testing.
- Inspect the Geomembrane, geonet, GCL, and geotextile rolls once they have arrived at the jobsite. In the event the rolls are damaged, the Installer will provide the CQA Technician with a complete assessment of the extent of damage, and suggested repair methods approved by the manufacturer within 24 hours of time of the inspection and prior to installation. Damaged material will be replaced as directed by the Engineer/Owner.
- Unloading or transfer of the geomembrane, geonet, GCL, and geotextile rolls from one location to another will be done using procedures and equipment that prevent damage to the rolls.
- The geosynthetic material rolls will be stored to ensure that they are adequately protected from the following:
    - Equipment
    - Strong oxidizing chemicals, acids, or bases
    - Flames, including welding spark
    - Ambient temperatures in excess of 160°F
    - Dust and mud
    - Inclement weather
- Whenever possible, a 6 inch minimum airspace will be provided between the rolls and will not be stacked.
- Prior to installation, inspect the surface of each roll for defects and damage, along with the Engineer.

Installation

- Submit Installer daily logs every Monday morning by 9:00am basis during all material placements to the Owner.
- Submit copies of signed Sub-Grade Acceptance Certificates on a daily basis when geosynthetic is deployed.
- Notify CQA Technician when changes in supporting soil conditions occur that may require repair work after the supporting soil is accepted by the Installer.

- Take the following precautions while installing the geomembrane:
    - Equipment used does not damage the geomembrane by handling, excessive heat, high winds, leakage of hydrocarbons, or by any other means
    - Personnel working on the geomembrane will not smoke, wear damaging shoes, clothing, or engage in other activities that could damage the geomembrane
    - The method used to deploy the geomembrane does not cause scratches, scuffs, or crimps in the geomembrane and does not damage the sub-grade.
    - The method used to place the panels minimizes wrinkles.
    - Provide adequate temporary loading or anchoring (continuously placed, if necessary), which will not damage the geomembrane and will be placed to prevent uplift by wind.
    - Direct contact by equipment or tools with the geomembrane will be minimized. The geomembrane will be protected by geotextiles, extra geomembrane rub sheets, or other suitable materials in areas where excessive traffic may be expected. No contact with the geomembrane by heavy construction equipment or motor vehicles with tire pressures exceeding 5 pounds per square inch (psi) will be allowed.
- Designate each roll or blanket with a panel number that is consistent with layout plan and as negotiated in the pre-construction meeting.

Seam Testing

- Test geomembrane seams under the observation of the CQA Technician in accordance with Technical Specifications.
- Maintain and use equipment and personnel at the site to perform testing of test seams. Test seams will be made each day in accordance with Technical Specifications prior to commencing field seaming.
- Test production seams continuously in accordance with Technical Specifications using non-destructive techniques under the observation of the CQA Technician.
- Perform the following destructive seam tests on an average of every 500 linear feet of production seam (locations of the tests will be selected by the CQA Technician, and sufficient samples will be obtained to provide one sample to the Owner, one sample to the CQA Technician for laboratory testing, and one sample to be retained by the Installer for field testing). A bounding sample on each side of the laboratory sample will be tested in the field for three peel and three shear specimens each.
    - Peel Tests Specimens:
        - Fusion Seams - The inside and outside tracks of specimen will meet the minimum requirements outlined in Appendix A for ultimate strength and Film Tearing Bond (FTB).
        - Extrusion Seams - Specimens will meet minimum requirements outlined in Appendix A for ultimate strength and FTB
    - Shear Tests Specimens:
        - Fusion Seams - specimens must achieve the minimum required in Appendix A and have an FTB

    - Extrusion Seams - specimens must achieve the minimum required in Appendix A and have an FTB
- Perform field destructive tests on the end of the seam for 100 foot or longer seams, one peel, and one shear as defined in Table 2 of Appendix A.
- Repair damaged and sample coupon area in the geomembrane.

Panel Leak Testing

- After deployment and seaming, Installer shall perform leak testing of geomembrane in accordance with ASTM D-7240
- Installer shall demonstrate equipment to show working order and identification of a defect. Documentation of wipe speed and distance equipment can be off of the geomembrane will be documented
- Installer well perform leak test and demonstrate maximum coverage of geomembrane
- Defects will be labeled and reported
- Installer shall submit documentation statement of tested area on a daily basis
- Traffic on tested areas shall be minimized after approvals

Submittals

- After installation, submit the following to the Engineer and CQA Technician:
    - Construction Drawing (include details and locations of the connection to the existing geomembrane liner, anchor trench, panel layout, and repairs).
    - Copy of materials and installation warranty, covering both for a period of two years from date of substantial completion.
- Communicate with the Engineer, Owner, and/or CQA Technician regarding any pertinent issues

6.0 Owner Responsibilities

6.1 Overview

The Owner will perform the following activities:

- Provide access to project site.
- Monitor submittals and submittal review process.
- Inform Contractor, Installer, Engineer, and CQA Technician of site specific health and safety requirements.
- Communicate with Earthwork Contractor, CQA Technician, and/or Engineer regarding any pertinent issues.

7.0 Engineer Responsibilities

7.1 Overview

Review and Approve/Reject

- All CQA Technician's daily logs, photographs and submittals
- All Installer submittals.
- All Earthwork Contractor submittals
- All soil and geomembrane testing data.

Performed Activities

- Notify the Owner in writing of the identities and qualifications of all the contractors involved in the geosynthetic construction. The following minimum information will be included, if available, for pre-construction report:
    - Identification of polymers and admixtures, quality control for the raw material, fabrication methods, quality control of the geomembrane panels delivered to the site, sources of resin, panel fabricators, and specific factory seaming method with detailed description of the process will also be identified.
    - Quality control for transporting and storing the geomembrane rolls.
    - An experience record of the Installer to show projects completed within the last five years, including: name, address, phone number of contact, type of application, and acreage completed.
    - The proposed equipment to be used in geomembrane installation, including: machinery used in panel deployment, soil cover placement, and geomembrane seaming and testing. Operating temperature and speed of seaming will also be identified.
    - Quality control for factory and field seams, including: identification of the destructive and nondestructive testing equipment with standards which define field seam failure and frequency of calibration of the testing equipment.
- Notify the Owner prior to geomembrane installation of the time and date of the start of geomembrane installation.
- Prior to commencing installation, Engineer will submit Installer's panel layout to Owner. The layout plan will include the following:
    - Size and configuration of all panels to be assembled in the field with a panel identification scheme.
    - General location and type of all factory and field seams.
    - Construction detail for all geomembrane-related work, including but not limited to:
        - Minimum panel overlap.
        - Temporary panel anchoring methods.
        - Plan for covering geomembrane with traffic routing shown.

- Monitor all construction progress
- Accept the geomembrane liner when:
    - Written certification letter, including record drawings, are received by the Owner and Engineer.
    - Installation is complete.
    - Documentation of installation is completed, including the CQA Technician's final report.
    - Verification of adequacy of field seams and repairs, including associated testing, is complete.
- Communicate with the Owner, CQA Technician, and/or Installer regarding any pertinent issues.
- Notify the Installer and CQA Technician of areas to be adjusted or approved areas.

8.0 CQA Technician Duties

8.1 Overview

The CQA Technician will perform the following communication, observations and documenting activities pertaining to each phase of construction:

8.1.1 General Communication

Verbal

- Verbally communicate with the Owner, Engineer, and/or Installer regarding any pertinent issues
- Verbally communicate the results for each field seam sample to the Engineer within one working day after the samples have been tested. Any uncertainty of the results will be addressed at that time by the Engineer. The Engineer will determine final acceptability of the seam
- Inform the Installer and Engineer when the weather conditions are questionable and may not be in conformance with the Technical Specifications. The Engineer will determine if the weather conditions are acceptable

Written

- Submit daily reports and photographs to Engineer by 7:00 am for the previous day
- Provide Earthwork Contractor written certification of completion to geomembrane installation
- Provide hard copy of destructive seam test results to owner and installer

8.1.2 Observations and Documentation

8.1.2.1 Earthwork

- Perform the following as required in the Technical Specification and Project Drawings:
  - Dry density and as-placed moisture content will be determined on an approximate 100 foot grid pattern for each 1 foot thickness of fill placed. The grid pattern will be offset on each subsequent layer of tests. Additionally, a minimum of two (2) density and moisture content tests for each 1 foot thickness of structural fill placed will be performed to fully define the degree of soil compaction obtained in confined areas where equipment movement is hindered or hand compaction is necessary.
  - One moisture-density curve will be developed for every 5,000 cubic yards (cyd) or less of structural fill placed and for each major soil type utilized. At least five points will be established for each curve. A representative sample for every 5,000 cyd or less of fill will be analyzed for grain size distribution and for Atterberg limits. If apparent changes in soil quality are observed during fill placement, a one-point Proctor analysis will be utilized to verify the applicability of previously analyzed moisture-density curves.
- Density and moisture content test during each 12" lift of structural fill per Table 1.
- Collect structural fill samples at the frequency required in the Technical Specifications.

- Observe and document the condition of the final lift of structural fill prior to geomembrane installation. Document presence of coarse gravel or cobbles present at surface of fill after rolling that may damage geomembrane.
- Perform the following for anchor trenches:
    - Prior to installation of the geosynthetics in the anchor trench, document that the trench is free of standing water and that the trench has been constructed according to the Technical Specifications and the Project Drawings.
    - Observe the backfilling of the anchor trenches for conformance with Technical Specifications. Any discrepancies will be reported to the Installer and/or Earthwork Contractor for correction.
- Monitor construction progress
- Log Earthwork Contractor submittals
- Review and approve/reject the Earthwork Contractor submittals.
- Communicate with Owner, Engineer, and/or Earthwork Contractor regarding any pertinent issues

8.1.2.2 Pre-Installation of Geosynthetic

- Document on-site storage areas conditions prior to material arrival
- Prior to deployment, inspect the surface of each roll for defects and damage, along with the Installer (defected or damaged rolls or portions of rolls, as well as those without identification labeling, will be rejected and removed from the site and replaced with new rolls)
- Obtain samples from the Installer upon delivery of the geosynthetics to the site at the frequency stated in the Technical Specifications
- Observe and document that the handling equipment used on the site is industry standard and conforms to the geosynthetic manufacturer's recommendations and intent
- Obtain the roll tags from the Installer
- Check delivered material for proper labeling with the Installer
- Observe and document on-site storage of the geosynthetics is as specified in Technical Specifications

8.1.2.3 Geomembrane Installation

8.1.2.3.1 Obtain and Document the following

- Weather conditions during installation
- All project submittals
- Production seam samples from the Installer for archiving (assign a number to the archive sample and mark the sample with the number. Also, log the date, seam number, approximate location in the seam, and field test pass-or-fail description, if applicable).
- All production seam field test procedures conducted by the Installer.
- The successful test seam samples from the Installer for archiving.

- Test seam samples from the Installer for the laboratory destructive testing.

8.1.2.3.2 Observe and Document the following

- General Placement and Installation
    - The method used to unroll the panels and observations of scratches or crimps in the Geosynthetic materials, and damage to the underlying soil layer resulting from the unrolling method.
    - The Geosynthetic rolls which have repairable minor flaws according to the Technical Specifications.
    - Any miss-handling or storage of the Geosynthetic materials
    - Equipment used on and for the installation of the Geosynthetic materials
    - The method used to place the panels to minimize wrinkles.
    - The actions taken to protect the geomembranes during installation
    - The identification code, location, and date of installation of each panel and record on a field drawing
    - For damage panels after placement and before seaming is initiated and inform the Installer which panels or portions of panels, will be rejected, repaired, or accepted. Damaged panels or portions of damaged panels which have been rejected will be marked and their removal from the work area recorded by the CQA Technician. Repairs will be made by the Installer according to Technical Specifications.
- Seaming (Trial Testing)
    - The Installer while performing trial test seams and assign a number and mark the test seam samples (in addition, log the date, hour, ambient temperature, number of seaming unit, name of operator, and pass-or-fail description).
    - Perform the following during non-destructive seam continuity testing:
        - Any discrepancies with the Project Specification will be reported to the Engineer and the Installer.
        - Record the seam number, date of observation, name of tester, and outcome of the test or observation.
        - Document locations where the seam cannot be non-destructively tested after final placement, and visually inspect the seam.
        - Inform the Installer of any required repairs. The Installer will complete any required repairs in accordance with the Technical Specifications.
        - If repair work is performed, observe the repair and the testing of the repair. In addition, mark on the geomembrane that the repair has been made, and document the results.
    - Select the locations for destructive seam testing to be performed by the Installer (the tests will be performed on an average of no greater than 500 linear feet). Follow the procedures listed and outlined in Technical Specifications for destructive test failure.

- Seaming (Production)
  - The seam area for cleanliness and absence of moisture, dust, dirt, debris of any kind, and foreign material.
  - Conformance of seam overlap with Technical Specifications.
  - Seams are aligned to prevent wrinkles and "fish-mouths."
  - The seaming techniques for the prevailing weather conditions are being employed in conformance with Technical Specifications. If adverse weather conditions do occur, the CQA Technician will notify the Installer as to whether or not to seam for the day.
  - Equipment.
    - The Installer maintains on site at least two each of the following operable spare apparatus: extrusion welder, fusion welder, and generator.
    - The extruder is purged prior to beginning a seam or repair until the heat-degraded extradite has been removed from the barrel.
    - The geomembrane is protected from damage in heavy traffic areas.
    - The Installer's calibration records for welding apparatus temperature gauges.
    - Apparatus temperature and ambient temperature at appropriate intervals.
  - The CQA Technician may perform additional testing to verify that the geomembrane seams meet the Technical Specifications.

Verify and Document

- All rejected rolls of material, or portions thereof, have been removed from the site.
- The panel locations are placed according to the Installer's shop drawings, as approved or modified at the pre-construction meeting. Any discrepancies in panel locations will be documented and reported to the Owner.
- The fill surface each day of the geomembrane installation to evaluate desiccation cracking and report desiccation to the Earthwork Contractor for repair.
- The geomembrane seam strength requirements are achieved as listed in Tables 2 in Appendix A.
- The geomembrane thickness is in conformance with Technical Specifications. Five thickness readings will be taken for every roll. Readings will be taken across the width at any point where the panel has been cut. Any non-conformance will be reported to the Installer for correction
- Ship final destructive seam samples to laboratory for testing and report results

8.1.2.4 Geosynthetic Clay Liner Installation

8.1.2.4.1 Obtain and Document the following

- Weather conditions during installation
- All project submittals

- Subgrade soil surface acceptance forms

8.1.2.4.2 Observe and Document the following

- General Placement and Installation
    - The method used to unroll the panels and observations of scratches or crimps in the Geosynthetic materials, and damage to the underlying soil layer resulting from the unrolling method.
    - The Geosynthetic rolls which have repairable minor flaws according to the Technical Specifications.
    - Any miss-handling or storage of the Geosynthetic materials
    - Equipment used on and for the installation of the Geosynthetic materials
    - The method used to place the panels to minimize wrinkles.
    - The actions taken to protect the geomembranes during installation
    - For damage panels after placement inform the installer which panels or portions of panels, will be rejected, repaired, or accepted. Damaged panels or portions of damaged panels which have been rejected will be marked and their removal from the work area recorded by the CQA Technician. Repairs will be made by the Installer according to Technical Specifications.
- Seaming
    - The Installer or contractor shall provide powdered bentonite for overlaps.

9.0 Documentation

9.1 Overview

Documentation for this project will per performed by the QCA Technician with the required assistance and information provided by the Grading Contractor and Geosynthetic Installation Contractor. Documentation will include daily field reports, photo logs, and final construction documentation. These elements are discussed in the following subsections.

9.2 Daily Field Reports

All observations, relevant discussions with on-site personnel, measurements, and meetings will be documented in the Daily Field Reports and Supplements by the CQA Technician. At a minimum, the following will be recorded each construction day (see attached forms in Appendix B):

General Information

- Date, project name, location, and other identification.
- Weather conditions.
- Significant changes in the weather, as well as when the change occurred.
- When and where work was performed.
- What equipment, methods, and materials were used to perform the work.
- Estimated quantities of materials used or delivered to the site.
- Reports on any meetings held and their result (Engineer to complete meeting minutes).
- Modifications/deviations from the approved Technical Specifications and this CQA Plan.
- Site visits by the Owner or Engineer.
- Name of person making the observations or measurements or documenting the meeting and their signature.
- In addition, the CQA Technician will document the date and duration each person performs CQA activities. This includes the Engineer and CQA Technician as well as the Owner.
- Observe and document (daily logs and photographs) the placement and testing of the geomembrane. At a minimum, the following information will be documented:
- Amount and location of geosynthetics placed. Changes from the fabrication plan will be noted.
- Identification of the panel numbers for the geomembrane panels installed.
- Location of field seams, patches, and repairs.
- Result of geomembrane test seams.
- Results of geomembrane nondestructive seam repair testing.
- Location of and reason for repairs made and results of the non-destructive testing of those repairs.

- Location of samples taken for destructive testing.
- Calibrations or recalibrations of test equipment action taken as a result of recalibration.

9.3 Photographic Log

Photographic reporting will be used to document construction progress, construction activities, construction problems, and remedial actions. Photographs will be taken by CQA Technician. These photographs will serve as a pictorial record of work progress, problems, and corrective measures.

At a minimum, photographs will be taken before, during, and after the following major construction phases:

- Date, time, place, and unique identification of photographs
- Site preparation and erosion control installation
- Sub-grade preparation including Structural fill placement and compaction
- Cushion geotextile installation
- 60 mil HDPE Secondary Geomembrane installation
- Granular drainage layer placement at leak detection sump
- Geonet installation
- 60 mil HDPE Secondary Geomembrane installation
- GCL installation
- Seaming procedures and equipment
- At least 10 photos during any testing (grading and Geosynthetic installation)
- Unforeseen problems and resulting activities
- At a minimum, photographs will be taken to document any accidents, unusual conditions, material testing, location of stockpiled materials, and post-construction site and vicinity conditions

All photographs will be logged in a field book. Digital photographs will be copied to CDs for backup storage archive. A unique identification number of the photo and photo log in which the photo was recorded in.

- Name of photographer.
- Date and time the photo was taken.
- Where the photo was taken from.
- The photo significance.

The photographs and photo logs will be kept in a protective file (i.e. photo album or digital file) in chronological order. The file will contain color prints. Photographic records will be updated weekly for review by Engineer.

9.4 Construction Documentation Report

Upon completion of the Project, the Engineer will submit to the Owner a Construction Documentation Report.

The report will document all aspects of construction and will be prepared for:

- The initial site preparation
- The Sub-grade construction activities including final grade elevations and test results
- The installation of all geosynthetic materials and test results
- The report will include a Certification Statement
- Project submittals, submittal review and approved documents
- Photographic Log
- Communicate with Earthwork Contractor, Installer, Owner, and/or CQA Technician regarding any pertinent issues
- Final as built construction drawings

Appendix A
Tables

Table 1 - Fill Testing Summary

Test	Test Method	Sample/Test Frequency	Acceptance Criteria
Nuclear Density(1)(2)	ASTM D 6938	1 per 100 foot-grid* (minimum 5 per acre per 1 foot thickness of fill)	Min. 90% of Modified Proctor
Moisture Content(1)(2)	ASTM D 6938	1 per 100 foot grid* (minimum 5 per acre per 1 foot thickness of fill)	Wet of optimum when possible to reduce dust

NOTES: * Location as selected by CQA Technician.

(1) Dry density and as-placed moisture content will be determined on an approximate 100 foot grid pattern for each 1 foot thickness of fill placed. The grid pattern will be offset on each subsequent layer of tests. Additionally, a minimum of two density and moisture content tests will be performed for each 1 foot thickness of fill placed in confined areas where equipment movement is hindered or hand compaction is necessary.

(2) Locations will be determined in the field

Table 2 – 60 mil HDPE Production Seam Requirements

Type of Seam	Peel Requirements GRI-GM 19	Shear Requirements GRI-GM 19
Fusion	Four out of five specimens must achieve: 1. 91 ppi minimum tensile strength at yield for fusion welds of 60 mil sheet, 2. FTB with no greater separation than 25% of the width of the track, and 3. The fifth specimen must achieve 80% of the above passing strength requirement or 73 ppi.	Four out of five specimens must achieve: 1. 120 ppi minimum tensile strength at yield, and 2. FTB with 25% or less incursion as a percentage of the track. 3. The fifth specimen must achieve 80% of the above passing strength requirement or 96 ppi.
Extrusion	Four out of five specimens must achieve: 1. 78 ppi minimum tensile strength at yield for extrusion welds of 60 mil sheet, 2. FTB with 25% or less incursion as a percentage of total weld area, and 3. The fifth specimen must achieve 80% of the above passing strength requirement or 62 ppi.	Four out of five specimens must achieve: 1. 120 ppi minimum tensile strength at yield, and 2. FTB with 25% or less incursion as a percentage of the weld area. 3. The fifth specimen must achieve 80% of the above passing strength requirement or 96 ppi.
NOTE: FTB = Film Tearing Bond: A failure in the ductile mode of one of the bonded sheets by tearing prior to complete separation of the bonded area. (As defined in NSF Standard 54-1993).		

Table 3 – 60 mil HDPE Smooth & Textured Leak Location Geomembrane Properties

Test Properties	Test Method	Testing Frequency (minimum)	60 mil Test Values	
			Textured	Smooth
Thickness (min. ave.)	D 5199		Nom. (-5%)	60 mil
• Lowest individual for 8 out of 10 values	or	Per roll	-10%	–
• Lowest individual for any of the 10 values	D 5994		-15%	-10%
Asperity Height (min. ave.) (1)	D 7466	every 2nd roll (2)	18 mil	–
Density (min. ave)	D 1505	200,000 lb	0.940 g/cc	0.940 g/cc
Tensile Properties (min. ave.) (3)	D 6693	200,000 lb		
• Yield strength	Type IV		126 lb/in.	126 lb/in.
• Break strength			90 lb/in.	228 lb/in.
• Yield elongation			12%	12%
• Break elongation			100%	700%
Tear Resistance (min. ave)	D 1004	45,000 lb	42 lb	42 lb
Puncture Resistance (min. ave.)	D 4833	45,000 lb	90 lb	108 lb
Stress Crack Resistance (4)	D 5397	Per GRI-GM 10	300 hr.	300 hr.
Carbon Black Content (range)	D 1603 (5)	20,000 lb	2.0-3.0%	2.0-3.0%
Carbon Black Dispersion	D 5596	45,000 lb	Note (6)	Note (6)
Oxidative Induction Time (OIT) (min. ave.) (7)		20,000 lb		
(a) Standard OIT	D 3895		100 min.	100 min.
(b) High Pressure OIT	D 5885		400 min	400 min
Oven Aging at 85°C (7), (8)	D 5721	per formulation		
(a) Standard OIT (min. ave.) retained after 90 days	D 3895		55%	55%
(b) High Pressure OIT (min. ave.) retained after 90 days	D5885		80%	80%
UV Resistance (9)	GM 11	per formulation		
(a) Standard OIT (min. ave.)	D 3895		N.R. (10)	N.R. (10)
(b) High Pressure OIT (min. ave) retained after 1,600 hrs (11)	D5885		50%	50%

Notes:

1. Of 10 readings; 8 out of 10 must be ≥ 13 mils, and lowest individual reading must be ≥ 10 mils; also see Note 6.
2. Alternate the measurement side for double sided textured sheet.
3. Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction.
   - Yield elongation is calculated using a gage length of 1.3 inches
   - Break elongation is calculated using a gage length of 2.0 inches
4. P-NCTL test is not appropriate for testing geomembranes with textured or irregular rough surfaces. Test should be conducted on smooth edges of textured rolls or on smooth sheets made from the same formulation as being used for the textured sheet materials. The yield stress used to calculate the applied load for the SP-NCTL test should be the manufacturer's mean value via MQC testing.
5. Other methods such as D 4218 (muffle furnace) or microwave methods are acceptable if an appropriate correlation to D 1603 (tube furnace) can be established.
6. Carbon black dispersion (only near spherical agglomerates) for 10 different views: 9 in Categories 1 or 2 and 1 in Category 3.
7. The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.
8. It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response
9. The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.
10. Not recommended since the high temperature of the std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.
11. UV resistance is based on percent retained regardless of the original HP-OIT value.

Table 4 – Geonet Properties

Test Properties	Test Method	Testing Frequency (minimum)	Minimum Average Roll Values (200 mil)
Thickness, mil [3]	ASTM D 5199	1/50,000 ft^2	200
Transmissivity [2], (gal/min/ft)	ASTM D 4716	1/540,000 ft^2	9.6
Density, g/cm^3	ASTM D 1505	1/50,000 ft^2	0.94
Tensile Strength (MD), lb/in	ASTM D 7179	1/50,000 ft^2	45
Carbon Black Content, %	ASTM D 4118	1/50,000 ft^2	2.0

Notes:
1. Geonet thickness is nominal value
2. Gradient of 0.1 normal load of 10,000 psf, water at 70° F, between steel plates for 15 minutes.
3. Roll widths and lengths have a tolerance of ±1%

Table 5 – Cushion Geotextile Properties

Test Properties [1]	Test Method	Testing Frequency (minimum)	Minimum Average Roll Values (12 oz)
AASHTO M288 Class	N/A	N/A	>>1
Mass Per Unit Area, oz/yd^2	ASTM D 5261	90,000 ft^2	12
Grab Tensile Strength, lb	ASTM D 4632	90,000 ft^2	320
Grab Elongation, %	ASTM D 4632	90,000 ft^2	50
GBR Puncture Strength, lb	ASTM D 6241	90,000 ft^2	925
Trapezoidal Tear Strength, lb	ASTM D 4533	90,000 ft^2	125
Apparent Opening Size, Sieve No.	ASTM D 4751	540,000 ft^2	100
Permittivity, sec^{-1}	ASTM D 4491	540,000 ft^2	0.80
Water Flow Rate, gpm / ft^2	ASTM D 4491	540,000 ft^2	60
UV Resistance % retained after 500 hours	ASTM D 4355	Per Formulation	70

Notes:
1. The property values listed are in weaker principal direction. All values listed are minimum average roll values except apparent opening size in (mm) is a maximum average roll value and UV is a typical value.

Table 6 – Geosynthetic Clay Liner Properties

GEOSYNTHETIC CLAY LINER		
Property	**Method**	**Value**
Index Flux	ASTM D 5887	1×10^{-8} m^3/m^2-sec.maximum
Mass Per Unit Area		
1. Bentonite Content	ASTM D 5993	0.75 lb/ft^2 dry weight minimum
2. Geotextile Upper Layer (nonwoven)	ASTM D 5261	6.0 oz/yd^2 minimum
3. Geotextile Lower Layer (nonwoven)	ASTM D 5261	6.0 oz/yd^2 minimum
Swell Index	ASTM D 5890	24 ml/2 g minimum
Moisture Content	ASTM D 4643	12% maximum

Appendix B
Field Forms

Sub-Grade Surface Acceptance Log

Geosynthetic Inventory Check List Log

Geomembrane Panel Placement Log

Geomembrane Trial Seam Weld Log

Geomembrane Production Seam Log

Geomembrane Destructive Test Log

Geomembrane Non-Destructive Log – Air Test

Spark Test Log

Attachment B

Technical Specifications for Geosynthetic Clay Liner

Technical Specifications for Earthwork

SECTION 02200

EARTHWORK

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Placement and grading of the subgrade soils.

B. Providing, placing, and compacting of soils, gravel, and rip rap over the GCL..

1.02 RELATED SECTIONS

A. Geosynthetic Clay Liner (GCL), Section 02413.

1.03 SUBMITTALS

A. Soil Materials: Submit 75-lb samples and results of recent (within previous month) testing laboratory grain size analyses for imported soils, material must conform to the specified gradations or characteristics as specified herein.

B. Chemical analysis confirming the proposed fill is not contaminated prior to importing soil onto site. **Please note, this testing may takes a much as 6-8 weeks to complete, so please plan accordingly to avoid construction delays.**

C. A report from a testing laboratory verifying that imported material is asbestos-free.

1.04 EXISTING CONDITIONS

A. Site Information:

1. Soil and grades at the site for this project area are the result of the installation of the slurrywall and the groundwater extraction system. The material movement from the associated construction zones may not be complete at the start of the subgrade finishing and GCL deployment..
2. The Contractor may perform additional test borings and other explorations at no cost to Owner.

B. Existing Utilities:

1. Locate existing underground utilities in areas of work. Provide adequate means of support and protection during earthwork operations. This includes groundwater wells and benchmarks.
2. Should uncharted, or incorrectly charted, piping or other utilities be encountered during excavation, consult utility owner immediately for directions. Cooperate with Owner and utility companies in keeping respective services and facilities in operation. Repair damaged utilities to satisfaction of utility owner.
3. Do not interrupt existing utilities serving facilities occupied and used by Owner or others during occupied hours, except when permitted in writing by Owner and then only after acceptable temporary utility services have been provided.
4. Provide minimum of 48-hour notice to Owner, and receive written notice to proceed before interrupting any utility.

C. Existing Extraction Wells: Identify, mark, and protect existing ground water extraction wells located within the work zone.

1.05 LAYOUT AND GRADES

A. Lay out all needed lines and grades not presently established at the site in accordance with the Contract Documents. Establish permanent benchmarks by employment of a registered land surveyor or professional civil engineer. Maintain all established bounds and benchmarks and replace any that are destroyed or disturbed. Bring any deviations from the locations and elevations indicated on the Drawings to the attention of the Engineer immediately.

B. Verify all existing ground surface elevations within the contract limits.

PART 2 - PRODUCTS

2.01 SOIL MATERIALS

A. General Backfill to create subgrades: Backfill material is available onsite from the designated source areas. This material shall be used to create the proposed subgrades. Any additional offsite fill shall be approved by the Owner before hauling starts.

B. Nevada Power Sand: Clean natural sand or a mixture of sands that meet the following gradation or as approved by the Engineer:

Sieve Sizes	Percent Passing by Mass
3/8 inch	100
No. 4	90-100
No. 50	10-40
No. 200	0-7

C Required Analytical: provide at least one representative composite sample for every 25,000 cubic yards of imported clean material brought to the site: Required analytical parameters list is as follows:

Parameters	Analytical Methods
Ions (bromide, bromine, chloride, chlorine (soluble), chlorite, fluoride, nitrate, nitrite, orthophosphate, and sulfate)	EPA 300.0/300.1
Perchlorate	EPA 314.0
RCRA 8 Metals	EPA 6020/6010B
Organochlorine Pesticides	EPA 8081A
Semi-volilate Organic Compounds	EPA 8270C
Asbestos Analyses by PLM	EPA Method 600/R-93/116 Section 2.3

D. Type II Class B Aggregate: Clean natural gravel that meets the following gradation and quality of aggregate required by Nevada DOT.

Sieve Sizes	Percent Passing by Mass
1 inch	100
¾ inch	90-100

No. 4	35-65
No. 200	2-10

E. Rip Rap: Rip rap shall be class 150 nevada department of transportation class or equal approved by Engineer.

2.02 USE OF SOIL MATERIALS

A. Use Nevada Power Sand directly above the GCL except on the pond slopes. Thickness shall not be less than 6-inches.

B. Use Type II Class B aggregate on top of the GCL on pond slopes to provide base for rip rap and on top of the Nevada Power Sand in all other areas.

PART 3 - EXECUTION

3.01 GENERAL

A. Prepare subgrade for the GCL placement in accordance with the lines and grades shown on the Drawings.

B. Protect existing structures, utilities, sidewalks, pavements, and other facilities not designated for removal from damage by equipment, settlement, undermining, washout, and other hazards created by earthwork operations.

C. Perform excavation work in compliance with OSHA guidelines and regulations.

3.02 DEWATERING

A. Off-site dewatering is prohibited until clean cover is completed and approved

3.05 TESTING FOR COMPACTION

A. Compact soil to not less than the following percentages of maximum dry density determined in accordance with ASTM D1557, Method C. Compact soil using the lift thicknesses indicated.

1. Subgrade: compact to greater than 85 % modified Proctor, ASTM D-1557, maximum dry density and provide smooth uniform surface free of debris and ruts.
2. Nevada Power Sand: compact to greater than 85% modified Proctor, ASTM D 1557.
3. Type II Class B aggregate: compact to a smooth grade that does leave ruts greater than 2-inches.

3.06 PLACEMENT

A. Place acceptable soil material in layers to required grade elevations for each area identified on the drawings.

B. Place soils in methods that will not damage subgrade and GCL:

1. Do not place fill on surfaces that are saturated, soft or muddy.
2. Place fill in level, uniform layers.

3.07 GRADING

A. Uniformly grade areas within limits of grading under this section including adjacent transition areas. Smooth finished surface within specified tolerances, compact with uniform levels or slopes between points where elevations are indicated, or between such points and existing grades.

3.08 FIELD QUALITY CONTROL

A. CONTRACTOR shall correct deficiencies to meet Contract Documents. If specification criteria cannot be met, or unusual weather conditions hinder work, CONTRACTOR shall develop and suggest solutions to ENGINEER for approval.

B. CONTRACTOR shall schedule appropriate retests when defect has been corrected. Retests by ENGINEER shall verify that defect has been corrected before any additional WORK is performed by CONTRACTOR in area of deficiency.

3.09 FIELD QUALITY ASSURANCE

A. Quality assurance testing during construction: Allow ENGINEER to test and observe subgrades and backfill layers before further construction work is performed.

B. If, in opinion of ENGINEER based on testing and observation, fills have been placed below specified percent compaction, provide additional compaction at no additional expense.

3.10 QUALITY ASSURANCE TESTING

A. Quality assurance testing of granular materials shall be performed to document material used on site. The following tests shall be conducted:

1. Particle size analysis (ASTM D 1140, D 422) at a rate of one per 10,000 cubic yards of in-place material
2. Moisture density relationship ASTM D 1557 Method C at a rate of 1 test per 10,000 cubic yards of in-place material.
3. Density of testing of subgrade and fill material at a rate of 1 test per acre per lift of soil placed.

B. Fill materials not in conformance shall be removed and replaced at no cost to the OWNER.

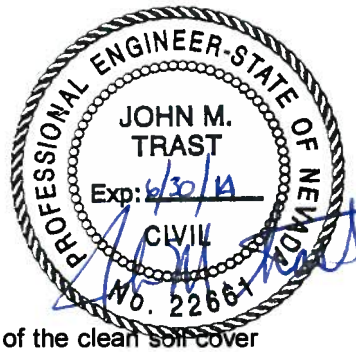
3.09 PROTECTION AND REPAIR

A. Protect newly graded areas from traffic and erosion. Keep free of trash and debris.

B. Repair and reestablish grades in settled, eroded, and rutted areas to specified tolerances.

C. Where completed compacted areas are disturbed by subsequent construction operations or adverse weather, scarify surface, reshape, and compact to required percent compaction prior to further construction.

END OF SECTION



SECTION 02413

GEOSYNTHETIC CLAY LINER (GCL)

PART 1 - GENERAL

1.01 SUMMARY

A. GCL meeting the following specifications shall be installed as part of the clean soil cover system. Installer shall furnish all labor, materials, tools, supervision, transportation, and equipment for proper handling and installation over the area shown on the Drawings. Sufficient material for full coverage, overlaps, and waste shall be provided.

1.02 REFERENCES

A. American Society for Testing and Materials (ASTM), current edition.

1.03 SUBMITTALS

A. Pre-installation: Submit prior to GCL delivery.

1. Identification of bentonite used for production of GCL.

2. Results of quality control tests conducted by GCL Manufacturer to verify that bentonite supplied met GCL Manufacturer's specifications.

3. Written certification that minimum values given in Specifications are guaranteed by Manufacturer.

4. Quality control certificates, signed by responsible party employed by Manufacturer. Each quality control certificate shall include roll identification numbers, testing procedures, and results of quality control tests. These quality control tests shall be performed in accordance with test methods for at least every 100,000 lb for moisture content and swell index, and once per 40,000 ft^2 for mass per unit area. Index flux tests shall be performed in accordance with test methods for at least every 100,000 ft^2 of GCL produced. At minimum, results shall be submitted for:

   a. Moisture content (ASTM D 4643 or D 2216)
   b. Index flux (ASTM D 5887)
   c. Swell index (ASTM D 5890)
   d. Mass per unit area (ASTM D 5993)

5. Verification that needle punched non-woven geotextiles have been inspected continuously for broken needles.

6. Quality control certificates shall be delivered to ENGINEER prior to off- loading of the material on site.

B. Installation: Submit as installation proceeds:

1. Quality control documentation recorded during installation.

B. GCL Properties:

GEOSYNTHETIC CLAY LINER		
Property	**Method**	**Value**
Index Flux	ASTM D 5887	1×10^{-8} m^3/m^2-sec.maximum
Mass Per Unit Area		
1. Bentonite Content	ASTM D 5993	0.75 lb/ft^2 dry weight minimum
2. Geotextile Upper Layer (nonwoven)	ASTM D 5261	6.0 oz/yd^2 minimum
3. Geotextile Lower Layer (nonwoven)	ASTM D 5261	6.0 oz/yd^2 minimum
Swell Index	ASTM D 5890	24 ml/2 g minimum
Moisture Content	ASTM D 4643	12% maximum

PART 3 - EXECUTION

3.01 EXAMINATION

A. Ensure supporting soil surface for GCL is below 100% saturation and free of debris or materials that could damage rolls.

B. The subgrade shall be free of all angular stones protruding from the surface greater than 0.5 inch. Rounded stones or stones not protruding from the surface shall be less than 1.5 inches in greatest dimension.

3.02 QUALITY ASSURANCE SAMPLING

A. CONTRACTOR shall make rolls available and assist ENGINEER in obtaining material inventory and material samples.

B. OWNER reserves the right to sample and test delivered material for conformance to specifications.

C. Material not meeting specification shall be rejected and removed from site at CONTRACTOR's expense. Retesting at CONTRACTOR's expense may be performed to limit rejection to specific rolls.

3.03 INSTALLATION

A. Overlap GCL seams minimum of 6 inches on edge seams and minimum of 24 inches on end seams or as otherwise specified by the manufacturer.

B. Overlap GCL panels to create a "shingle effect" such that water sheds over seams in the direction of flow.

C. Do not deploy more GCL in one day than can be covered by end of that day.

D. Repair perforations or cuts in GCL with additional GCL layer extending 1-foot from edge of perforation or cut in each direction or as otherwise specified by the manufacturer.

E. Handle rolls to minimize loss of bentonite along edges during deployment.

F. Remove GCL exposed to moisture and prematurely hydrated prior to placement of overlying material and replace with new GCL. Bentonite soft enough to displace when walked on shall be considered hydrated.

G. The installer is responsible for repair of areas of premature hydration of GCL until final acceptance by the OWNER.

H. GCL shall not be installed during precipitation, high wind, or other conditions that may hydrate or damage the GCL.

I. Horizontal seams are not allowed on slopes steeper than 10% unless INSTALLER provides an installation plan for ENGINEER's approval that describes anchoring and transfer of shear.

J. Supplemental bentonite, if required by the manufacturer, shall be applied at a rate of 0.25 pound per linear foot of seam.

3.04 GCL PROTECTION

A. Materials placed on top of GCL shall comply with following:

1. GCL and underlying materials are not damaged.
2. Minimum slippage of GCL on underlying layers occurs.
3. No excess tensile stress occurs in GCL.

B. At no time shall vehicles or equipment be allowed to drive directly on top of the GCL unless approved by ENGINEER.

C. Place soil over GCL using LGP equipment with less than 5 psi ground contact pressure. Maintain a minimum of 12" between surface of GCL and tracks of LGP equipment at all times.

D. All other vehicles that are not LGP equipment shall maintain a minimum of 3 feet of soil between GCL and tracks or tires of vehicle or equipment.

END SECTION

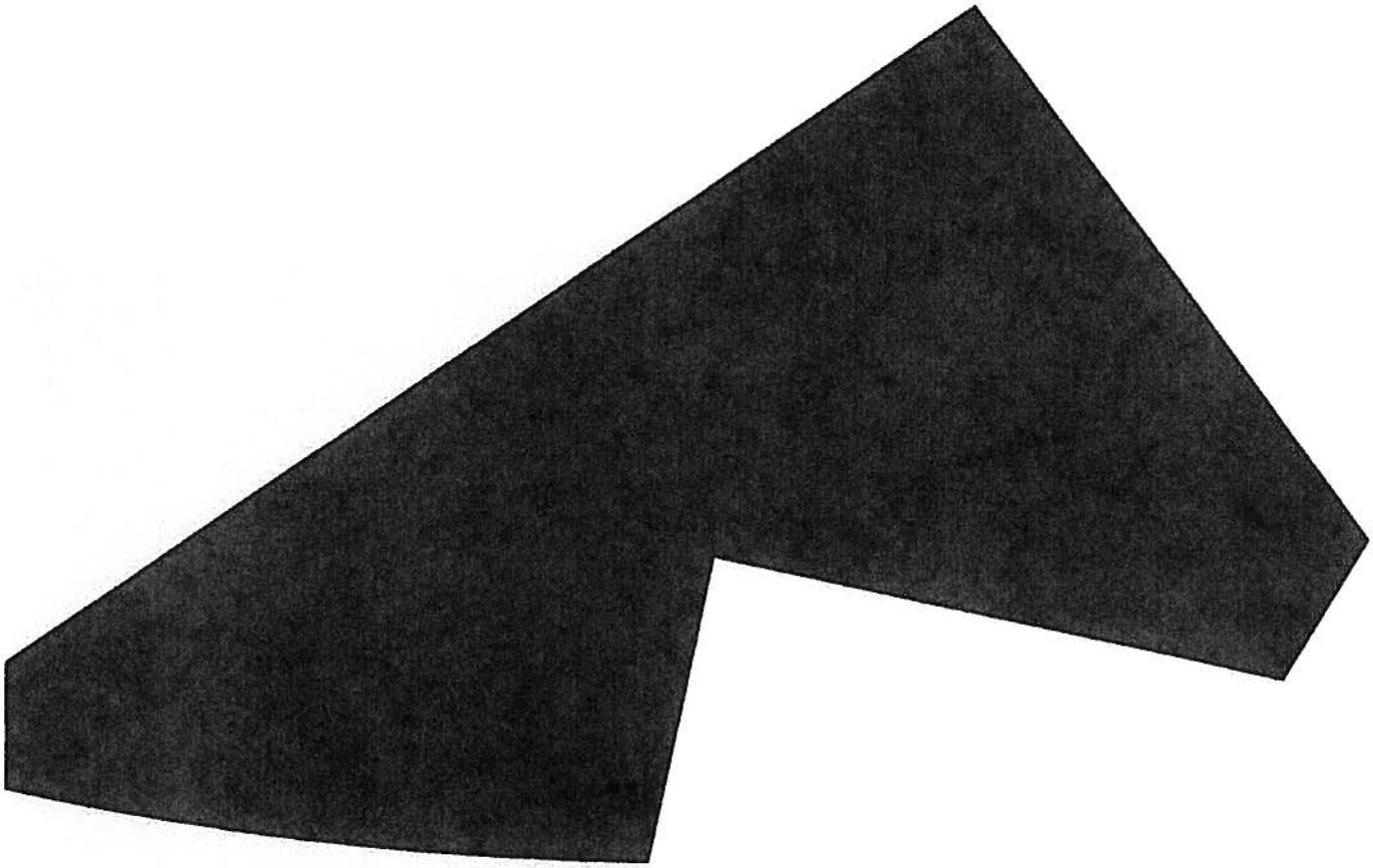
Attachment C

Channel Calculations and Riprap Sizing

Addendum No. 1 to the Technical Drainage Study for TIMET Site Remediation

October 21, 2013

ATKINS



Plan Design Enable

WEST CHANNEL

RIPRAP CALCULATIONS

RIPRAP CALCULATION

For Channel Lining

Project: West Channel

Riprap D_{50}

Equation 734 (CCRFCD HCDDM) $D_{50} = [V(S^{0.17})/3(Ss-1)]^2$

S_S = specific gravity	2.65		
V = velocity	6.76	ft/s	10 ft/s Max
S = slope	0.02	ft/ft	
$D_{50} = [V(S^{0.17})/3(Ss-1)]^2$	0.49	ft	
	5.9	in	

RIPRAP CALCULATION

RCB Outlet Protection

Project: 5' x 3' RCB at West Channel - Downstream Riprap

If the flow is supercritical use H_a for H:

Equation 763 (CCRFCD HCDDM) $H_a = 1/2\ (H+Y_n)$

Y_n = normal depth of supercritical flow in the culvert (from Flowmaster or WSPG)	1.27	ft
H = height of box	3	ft
H_a = average depth at supercritical flow	2.14	ft
$Q/WH^{1.5}$ =	4.43	

If $Q/WH^{1.5} \geq 4.0$ use:

Equation 761b (CCRFCD HCDDM)

$$d_{50} = H \times 0.0019 \times [(Q/WH^{1.5})^{2.5} / (Y_t/H)^2]$$

Riprap d_{50}

H = height of box culvert	2.14	ft
W = width of box culvert	5	ft
Q = design discharge	115	cfs
Y_t = tailwater depth ; if unknown use $Y_t = H \times 0.4$	1.4	ft
d_{50} = rock size	1.392	ft
	16.7	in

RIPRAP LENGTH OF PROTECTION

Project: 5' x 3' RCB at West Channel - Downstream Riprap

Riprap Pad Length

Equation 764 (CCRFCD HCDDM)

$$L = \left(\frac{1}{2\tan\theta}\right)\left[\left(\frac{A_t}{Y_t}\right) - D\right]$$

$[1/(2\tan\theta)]$	= expansion angle of culvert flow (from Figure 714 or 715)	6.5	
Q_{100}	= Discharge	115	cfs
A_t	= area of flow at allowable velocity = Q/V V = 15.59 ft/s	7.76	ft^2
Y_t	= tailwater depth ; if unknown use Y_t = D x 0.4	1.5	ft
D	= diameter of RCP or width of RCB	5	ft
L	= Length of protection	1	ft

Check:
If Equation 764 yields an unreasonable result, use the following:
(Per section 707.4.3 CCRFCD Design Manual)

For RCB if $Q/WH^{1.5} \leq 8.0$ then;	1.2857	
For RCP if $Q/D^{2.5} \leq 6.0$ then;	2.06	
L $\geq$ 3H or 3D	15	ft min
OR		
L $\leq$ 10H or 10D	50	ft max

EAST CHANNEL

RIPRAP CALCULATIONS

RIPRAP CALCULATION

For Channel Lining

Project: East 3+00_2.0Slope

Riprap D_{50}

Equation 734 (CCRFCD HCDDM) $D_{50} = [V(S^{0.17})/3(Ss-1)]^2$

S_S = specific gravity	2.65		
V = velocity	8.21	ft/s	10 ft/s Max
S = slope	0.02	ft/ft	
$D_{50} = [V(S^{0.17})/3(Ss-1)]^2$	0.73	ft	
	8.7	in	

9" d50 riprap provided
from STA 5+06 to downstream end of riprap

RIPRAP CALCULATION

For Channel Lining

Project: East 5+06 to 10+57

Riprap D_{50}

Equation 734 (CCRFCD HCDDM) $D_{50} = [V(S^{0.17})/3(Ss-1)]^2$

S_S = specific gravity	2.65		
V = velocity	6	ft/s	10 ft/s Max
S = slope	0.02	ft/ft	
$D_{50} = [V(S^{0.17})/3(Ss-1)]^2$	0.39	ft	
	4.7	in	

8" d50 riprap provided

RIPRAP CALCULATION

For Channel Lining

Project: East_10+57 to 12+09 2%Slope

Riprap D_{50}

Equation 734 (CCRFCD HCDDM) $D_{50} = [V(S^{0.17})/3(Ss-1)]^2$

S_S = specific gravity	2.65		
V = velocity	5.66	ft/s	10 ft/s Max
S = slope	0.02	ft/ft	
$D_{50} = [V(S^{0.17})/3(Ss-1)]^2$	0.35	ft	
	4.1	in	

8" d50 riprap provided

RIPRAP CALCULATION

For Channel Lining

Project: East_12+09 to 12+83 4%Slope

Riprap D_{50}

Equation 734 (CCRFCD HCDDM) $D_{50} = [V(S^{0.17})/3(Ss-1)]^2$

S_S = specific gravity	2.65		
V = velocity	5.59	ft/s	10 ft/s Max
S = slope	0.02	ft/ft	
$D_{50} = [V(S^{0.17})/3(Ss-1)]^2$	0.34	ft	
	4.0	in	

8" d50 riprap provided

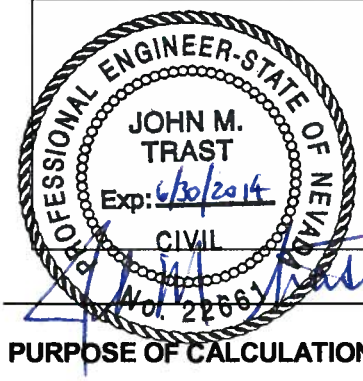
Attachment D

Slope Stability Calculations

GEI Consultants

Calculation Cover Sheet

GEI Project	TIMET	
GEI Project Number	1323080	
	By: Karl Krueger	Date: 2/27/2014
	Checked By: Mark Vannieuwenhoven	Date: 2/28/2014
	Approved By: John Trast	Date: 3/10/2014



PURPOSE OF CALCULATIONS

The TIMET ponds are designed with outer sideslopes ranging from 2.5H:1V to 3.0H:1V, with a maximum vertical rise of approximately 20 feet. The sideslope is to be protected with a GCL, a layer of bedding stone, and a layer of riprap. This analysis evaluates the stability of the sideslope protection system during placement of the bedding stone layer, as well as long term stability of the sideslope protection system.

METHOD

The slope was analyzed as an infinite slope. Slope failure would occur as a plane sliding along a critical interface. The potential sliding interfaces are between the GCL and the bedding stone, and between the bedding stone and riprap. A design factor of safety of 1.5 is used for long-term steady state conditions. 1.3 is used for peak strength analysis under short-term equipment loading during construction. 1.0 is used for residual strength analysis under short-term loading. These factors of safety are considered appropriate based on experience of common geotechnical engineering practice.

For the short-term equipment loading condition, a CAT D5K LGP bulldozer was evaluated. The weight of the equipment is assumed to be 21,266 pounds. It is assumed that the bulldozer will place the bedding stone layer only. It is assumed that riprap will be placed using a long reach excavator. This results in no equipment loading on the slope during riprap placement. Therefore the critical construction time is during placement of the bedding stone layer.

RESULTS

The minimum required friction angle for each of the design conditions is presented in the following table:

	2.5H:1V	3.0H:1V
	Required ϕ	Required ϕ
Peak Strength With Equipment Loading (FS=1.3)	31	26
Long-Term (FS=1.5)	31	26
Residual Strength With Equipment Loading (FS=1.0)	25	21

Alternatively, the minimum required shear strength for each of the design conditions is presented in the following table:

	2.5H:1V	3.0H:1V
	Required Shear Strength (psf)	Required Shear Strength (psf)
Peak Strength With Equipment Loading (FS=1.3)	79	61
Long-Term (FS=1.5)	37	31
Residual Strength With Equipment Loading (FS=1.0)	60	47

A GCL with nonwoven geotextile on both sides, such as Bentomat DN, GSE BentoLiner NWL, or equivalent, should generally have a higher interface friction with soil than a GCL with a woven or slit film geotextile on one side. It is recommended that a GCL with nonwoven geotextile on both sides be used to provide a greater factor of safety against veneer stability.

Interface and internal shear strength test results should be performed at the time of construction, and should be reviewed by a qualified engineer to determine if the material is equivalent to the stated values in the tables above.

Slope Stability of Slope Protection System

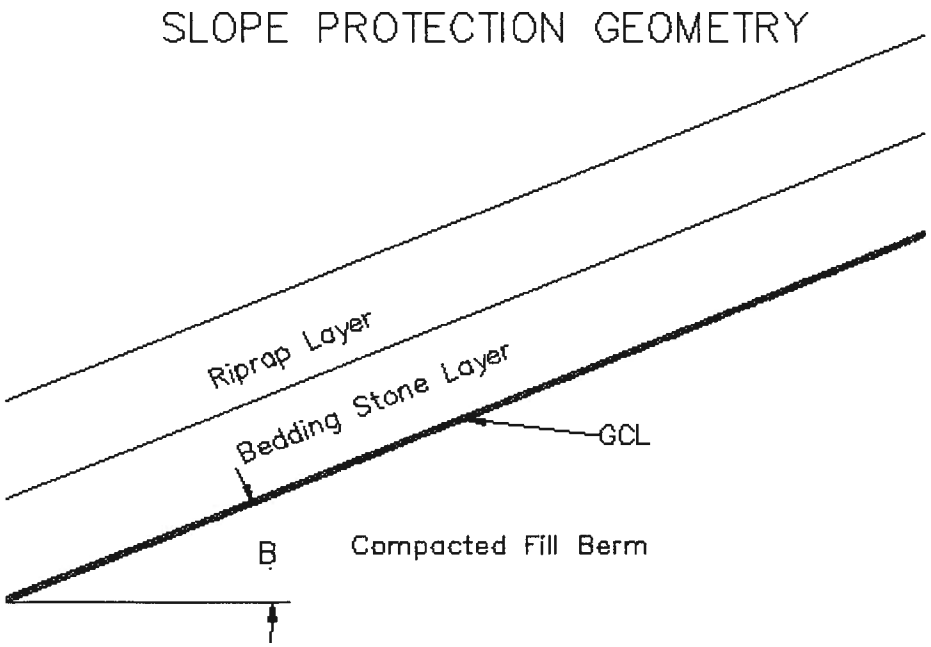
Unknown units for Mathcad Program

$$pcf := \frac{lb}{ft^3} \qquad psf := \frac{lb}{ft^2} \qquad psi := \frac{lb}{in^2} \qquad R := \theta \cdot \frac{\pi}{180}$$

Slope Protection Stability Analysis

The TIMET Ponds are designed with a 2.5H:1V outer sideslopes with a maximum vertical rise of approximately 20 feet. The sideslope stability is dependent on the shear strength developed from the interface friction of the slope protection components. The critical time for stabiity of the slope is during construction, when equipment is placing bedding stone over the GCL. The different layers of the slope protection system consist of, from bottom to top, a compacted granular fill berm, a GCL, a 0.5-foot bedding stone layer, and a riprap layer. This analysis evaluates the stability of the slope protection system during placement of the bedding stone layer.

Profile



The slope of the system is 2.5H:1V, resulting in an angle of approximately 22 degrees

$\beta := 22\text{deg}$ $\beta = 0.384 \cdot \text{rad}$

The maximum height of the berm is approximately 20 feet, resulting in a slope length of approximately 54 feet.

$L_s := 54\text{ft}$

Material Properties:

The compacted fill has an assumed internal angle of friction, ϕ_{fill}, of 35 degrees, and a cohesion of 0.

The bedding stone layer has an assumed unit weight, γ_{stone}, of 130 pcf, an internal friction angle, ϕ_{stone}, of 32 degrees, and a cohesion of 0.

The riprap layer has an assumed unit weight, γ_{rip}, of 130 pcf, an internal friction angle, ϕ_{rip}, of 35 degrees, and a cohesion of 0.

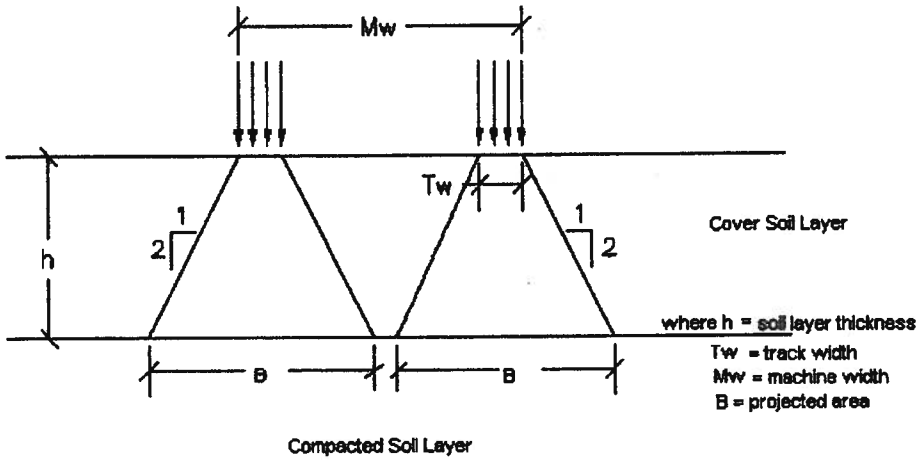
$\phi_{fill} := 35\text{deg}$

$\gamma_{stone} := 130\text{pcf}$ $\phi_{stone} := 32\text{deg}$

$\gamma_{rip} := 130\text{pcf}$ $\phi_{rip} := 35\text{deg}$

Design Vehicle Loading Condition

The weight of the vehicle is projected onto the surface of the GCL as shown below:



For the vehicle loading condition, the use of a CAT D5K2 bulldozer will be evaluated.

The weight of the vehicle on the slope surface is assumed to be 21,266 pounds for a CAT D5K LGP bulldozer. The projected imprint area onto the surface of the GCL is calculated as:

$$B := T_w + 2 \cdot P_w$$

where T_w = width of the track
P_w = extra width projected through layer thickness

$h := 0.5\text{ft}$ $\quad P_w := \frac{h}{2}$

$T_w := 2.16\text{ft}$ $\quad P_w = 0.25 \cdot \text{ft}$

$B := T_w + 2P_w$ $\quad B = 2.66 \cdot \text{ft}$

The line load due to the projected vehicle weight is aassumed to be applied to the entire slope. The weight of the vehicle on the GCL surface is:

$$W_{eq} := 21266\text{lb}$$

$$W_{line} := \frac{W_{eq}}{2B}$$

$$W_{line} = 3.997 \times 10^3 \cdot \frac{\text{lb}}{\text{ft}}$$

Analysis:

The sideslope stability analysis assumes that the slope is infinite. Slope failure would occur as a plane sliding along a critical interface.

A design factor of safety of 1.5 is used for long term steady state conditions, 1.3 is used for peak strength analysis under equipment loading, and 1.0 for residual strength under equipment loading (Duncan, 1987). These factors of safety are considered appropriate based on experience of common geotechnical practice.

For an infinite slope, the factor of safety is the ratio of resisting forces to driving forces. The equation is shown below.

$$FS := \frac{F_R}{F_D}$$

where F_R = Resisting Forces
F_D = Driving Forces

The driving forces for the static condition are:

$$F_D := W \cdot \sin(\beta)$$

$$F_D := \gamma_{stone} \cdot h \cdot L_s \cdot \sin(\beta)$$

Where W = weight of cover soils
γ = unit weight of cover soils
h = thickness of cover soil
L = length of slope
β = angle of the slope

$$F_D = 1.315 \times 10^3 \cdot \frac{lb}{ft}$$

Taking into consideration the weight of the bulldozer, the driving force during construction (F_{Ddozer}) is:

$$F_{Ddozer} := W_{line} \cdot \sin(\beta)$$

$$F_{Ddozer} = 1.497 \times 10^3 \cdot \frac{lb}{ft}$$

To account for the additional force due to braking, the driving force due to the dozer is increased by 30%

$$F_{Dbraking} := F_{Ddozer} \cdot 1.3$$

$$F_{Dbraking} = 1.947 \times 10^3 \cdot \frac{lb}{ft}$$

The total driving force is calculated as:

$$F_{Dtotal} := F_D + F_{Dbraking}$$

$$F_{Dtotal} = 3.262 \times 10^3 \cdot \frac{lb}{ft}$$

The resisting forces are:

$$F_R := F_S + F_G + F_B + F_{Dozer}$$

where F_S = friction resistance force of soil
F_G = tensile strength of GCL
F_B = soil buttressing force

The friction resistance force is defined as:

$$F_S := \left[\left(\gamma_{stone} \cdot h \cdot L_s\right) \cdot \cos(\beta)\right] \cdot \tan\left(\phi_{min}\right)$$

The minimum required friction angle (ϕ_{min}) will be solved for.

The soil buttressing force is defined as:

$$F_B := \frac{\cos\left(\phi_{stone}\right)}{\cos\left(\phi_{stone} + \beta\right)} \cdot \left(\frac{\gamma_{stone} \cdot h^2}{\sin(2 \cdot \beta)} \cdot \tan\left(\phi_{stone}\right)\right)$$

$$F_B \rightarrow \frac{32.5 \cdot lb \cdot \cos(32 \cdot deg) \cdot \tan(32 \cdot deg)}{ft \cdot \cos(54 \cdot deg) \cdot \sin(44 \cdot deg)} \qquad F_B = 42 \cdot \frac{lb}{ft}$$

The buttressing force is negligible, so it will not be included in the total resisting force.

$$F_B \equiv 0 \frac{lb}{ft}$$

No tensile strength for the geosynthetics was included to allow for the GCL to be installed in a relaxed condition.

$$F_G := 0 \frac{lb}{ft}$$

The weight of the bulldozer serves as an additional resisting force, by contributing additional normal force to the friction component.

$$F_{Rdozer} := W_{line} \cdot \cos(\beta) \cdot \tan\left(\phi_{min}\right)$$

The minimum required friction angle (ϕ_{min}) will be solved for.

For peak strength with equipment loading, use FS=1.3 for short term loading:

The required minimum friction angle for the liner system can be found by solving the factor of safety equation. Using a factor of safety of 1.3 for maximum strength evaluation, the required friction angle is:

$$FS := \frac{F_{Rtotal}}{F_{Dtotal}} \qquad FS_1 := 1.3 \qquad 1.3 := \frac{F_S + F_{Rdozer}}{F_{Dtotal}}$$

$$T_{\phi min1} := \frac{1.3 \cdot F_{Dtotal}}{\gamma_{stone} \cdot h \cdot L_s \cdot \cos(\beta) + W_{line} \cdot \cos(\beta)}$$

$$T_{\phi min1} = 0.609$$

$$\phi_{min1} := \operatorname{atan}\left(T_{\phi min1}\right)$$

$$\phi_{min1} = 31.3 \cdot deg$$

Alternatively, the minimum peak shear strength required is:

$$S_{min1} := 1.3 \cdot \frac{F_{Dtotal}}{L_s} \quad S_{min1} = 78.5 \cdot psf$$

For peak strength WITHOUT equipment loading, use FS=1.5 for long term conditions:

$$T_{\phi min2} := \frac{1.5 \cdot F_D}{\gamma_{stone} \cdot h \cdot L_s \cdot \cos(\beta)}$$

$$T_{\phi min2} = 0.606$$

$$\phi_{min2} := \operatorname{atan}\left(T_{\phi min2}\right)$$

$$\phi_{min2} = 31.2 \cdot deg$$

Alternatively, the minimum peak shear strength required is:

$$S_{min2} := 1.5 \cdot \frac{F_D}{L_s} \qquad S_{min2} = 36.5 \cdot psf$$

The required minimum friction angle for peak strength conditions is 31 degrees, or alternatively the minimum required peak shear strength is 79 psf.

For residual strength, with equipment loading, use FS=1.0:

$$FS_{res} := \frac{F_{Rtotal}}{F_{Dtotal}} \qquad FS_{res} := 1.0 \qquad 1.0 := \frac{F_S + F_{Rdozer}}{F_{Dtotal}}$$

$$T_{\phi res} := \frac{1.0 \cdot F_{Dtotal}}{\gamma_{stone} \cdot h \cdot L_s \cdot \cos(\beta) + W_{line} \cdot \cos(\beta)}$$

$$T_{\phi res} = 0.469$$

$$\phi_{res} := \operatorname{atan}\left(T_{\phi res}\right)$$

$$\phi_{res} = 25.1 \cdot \text{deg}$$

Alternatively, the minimum peak shear strength required is:

$$S_{res} := 1.0 \cdot \frac{F_{Dtotal}}{L_s} \qquad S_{res} = 60.4 \cdot \text{psf}$$

The required minimum friction angle for residual strength conditions is 25 degrees, or alternatively the minimum required peak shear strength is 60 psf.

Recommendations:

A GCL with nonwoven geotextile on both sides, such as Bentomat DN, GSE BentoLiner NWL, or equivalent, will generally have a higher interface friction with soil than a GCL with a woven or slit film on one side. It is recommended that a GCL with nonwoven geotextile on both sides be used to provide a greater factor of safety against veneer stability.

Interface and internal shear strength test results performed at the time of construction should be reviewed by a qualified engineer to determine if equivalent to the stated values.

References:

Duncan, J.M. Buchigani, A.Land DeWet, M. "An Engineering Manual for Slope Stability Studies," Department of Civil Engineering, Virginia Polytechnic Institute and State University. 1987.

Gilbert, R.B. "Peak Versus Residual Strength for Waste Containment Systems," Proceedings of the 15th GRI Conference on Hot Topics in Geosynthetics II. December 2001.

Theil, R.S. "Peak Vs. Residual Shear Strength for Bottom Liner Stability Analysis," Proceedings of the 15th GRI Conference on Hot Topics in Geosynthetics II. December 2001.

Slope Stability of Slope Protection System

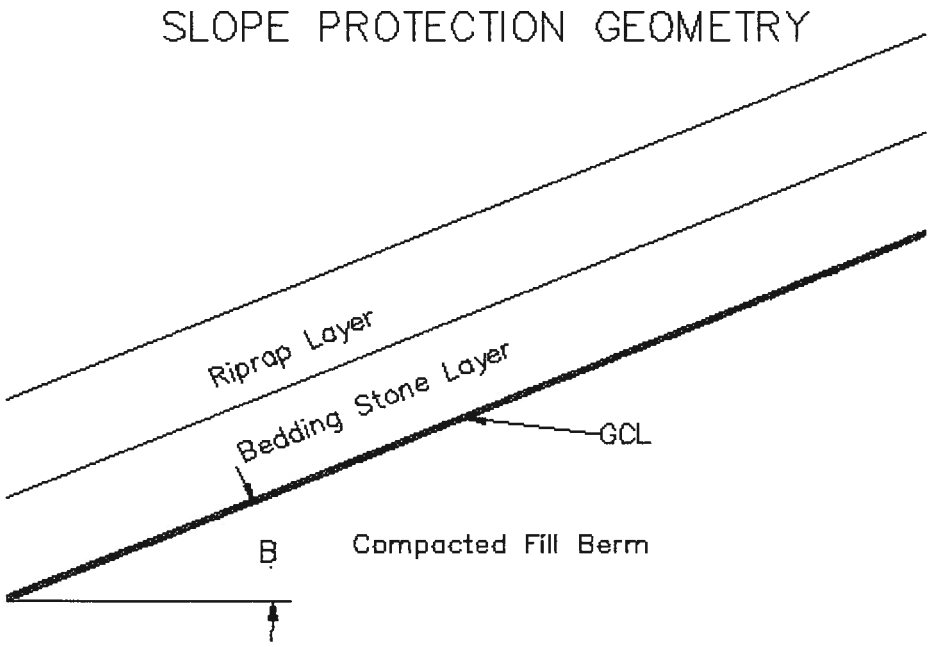
Unknown units for Mathcad Program

$$pcf := \frac{lb}{ft^3} \qquad psf := \frac{lb}{ft^2} \qquad psi := \frac{lb}{in^2} \qquad R := \theta \cdot \frac{\pi}{180}$$

Slope Protection Stability Analysis

The TIMET Ponds are designed with a 3.0:1V outer sideslopes with a maximum vertical rise of approximately 20 feet. The sideslope stability is dependent on the shear strength developed from the interface friction of the slope protection components. The critical time for stabiity of the slope is during construction, when equipment is placing bedding stone over the GCL. The different layers of the slope protection system consist of, from bottom to top, a compacted granular fill berm, a GCL, a 0.5-foot bedding stone layer, and a riprap layer. This analysis evaluates the stability of the slope protection system during placement of the bedding stone layer.

Profile



The slope of the system is 3.0H:1V, resulting in an angle of approximately 18.4 degrees

$\beta := 18.4\text{deg} \qquad \beta = 0.321 \cdot \text{rad}$

The maximum height of the berm is approximately 20 feet, resulting in a slope length of approximately 63 feet.

$L_s := 63\text{ft}$

Material Properties:

The compacted fill has an assumed internal angle of friction, ϕ_{fill}, of 35 degrees, and a cohesion of 0.

The bedding stone layer has an assumed unit weight, γ_{stone}, of 130 pcf, an internal friction angle, ϕ_{stone}, of 32 degrees, and a cohesion of 0.

The riprap layer has an assumed unit weight, γ_{rip}, of 130 pcf, an internal friction angle, ϕ_{rip}, of 35 degrees, and a cohesion of 0.

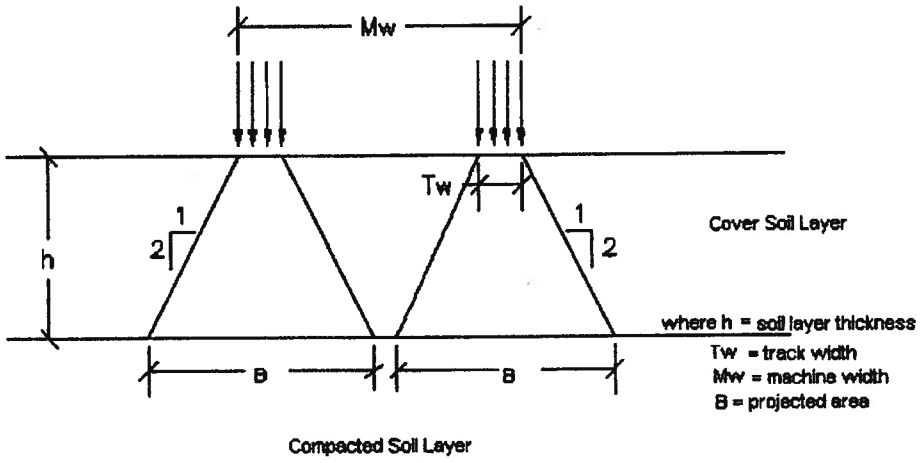
$\phi_{fill} := 35\text{deg}$

$\gamma_{stone} := 130\text{pcf} \qquad \phi_{stone} := 32\text{deg}$

$\gamma_{rip} := 130\text{pcf} \qquad \phi_{rip} := 35\text{deg}$

Design Vehicle Loading Condition

The weight of the vehicle is projected onto the surface of the GCL as shown below:



For the vehicle loading condition, the use of a CAT D5K LGP bulldozer will be evaluated.

The weight of the vehicle on the slope surface is assumed to be 21,266 pounds for a CAT D5K LGP bulldozer. The projected imprint area onto the surface of the GCL is calculated as:

$$B := T_w + 2 \cdot P_w$$

where T_w = width of the track
P_w = extra width projected through layer thickness

$h := 0.5\text{ft}$ $\quad P_w := \frac{h}{2}$

$T_w := 2.16\text{ft}$ $\quad P_w = 0.25 \cdot \text{ft}$

$B := T_w + 2P_w$ $\quad B = 2.66 \cdot \text{ft}$

The line load due to the projected vehicle weight is aassumed to be applied to the entire slope. The weight of the vehicle on the GCL surface is:

$$W_{eq} := 21266\text{lb}$$

$$W_{line} := \frac{W_{eq}}{2B}$$

$$W_{line} = 3.997 \times 10^3 \cdot \frac{\text{lb}}{\text{ft}}$$

Analysis:

The sideslope stability analysis assumes that the slope is infinite. Slope failure would occur as a plane sliding along a critical interface.

A design factor of safety of 1.5 is used for long term steady state conditions, 1.3 is used for peak strength analysis under equipment loading, and 1.0 for residual strength under equipment loading (Duncan, 1987). These factors of safety are considered appropriate based on experience of common geotechnical practice.

For an infinite slope, the factor of safety is the ratio of resisting forces to driving forces. The equation is shown below.

$$FS := \frac{F_R}{F_D}$$

where F_R = Resisting Forces
F_D = Driving Forces

The driving forces for the static condition are:

$$F_D := W \cdot \sin(\beta)$$

$$F_D := \gamma_{stone} \cdot h \cdot L_s \cdot \sin(\beta)$$

Where W = weight of cover soils
γ = unit weight of cover soils
h = thickness of cover soil
L = length of slope
β = angle of the slope

$$F_D = 1.293 \times 10^3 \cdot \frac{lb}{ft}$$

Taking into consideration the weight of the bulldozer, the driving force during construction (F_{Ddozer}) is:

$$F_{Ddozer} := W_{line} \cdot \sin(\beta)$$

$$F_{Ddozer} = 1.262 \times 10^3 \cdot \frac{lb}{ft}$$

To account for the additional force due to braking, the driving force due to the dozer is increased by 30%

$$F_{Dbraking} := F_{Ddozer} \cdot 1.3$$

$$F_{Dbraking} = 1.64 \times 10^3 \cdot \frac{lb}{ft}$$

The total driving force is calculated as:

$$F_{Dtotal} := F_D + F_{Dbraking}$$

$$F_{Dtotal} = 2.933 \times 10^3 \cdot \frac{lb}{ft}$$

The resisting forces are:

$$F_R := F_S + F_G + F_B + F_{Dozer}$$

where F_S = friction resistance force of soil
F_G = tensile strength of GCL
F_B = soil buttressing force

The friction resistance force is defined as:

$$F_S := \left[\left(\gamma_{stone} \cdot h \cdot L_s\right) \cdot \cos(\beta)\right] \cdot \tan\left(\phi_{min}\right)$$

The minimum required friction angle (ϕ_{min}) will be solved for.

The soil buttressing force is defined as:

$$F_B := \frac{\cos\left(\phi_{stone}\right)}{\cos\left(\phi_{stone} + \beta\right)} \cdot \left(\frac{\gamma_{stone} \cdot h^2}{\sin(2 \cdot \beta)} \cdot \tan\left(\phi_{stone}\right)\right)$$

$$F_B \rightarrow \frac{32.5 \cdot lb \cdot \cos(32 \cdot deg) \cdot \tan(32 \cdot deg)}{ft \cdot \cos(50.4 \cdot deg) \cdot \sin(36.8 \cdot deg)} \qquad F_B = 45 \cdot \frac{lb}{ft}$$

The buttressing force is negligible, so it will not be included in the total resisting force.

$$F_B \equiv 0 \frac{lb}{ft}$$

No tensile strength for the geosynthetics was included to allow for the GCL to be installed in a relaxed condition.

$$F_G := 0 \frac{lb}{ft}$$

The weight of the bulldozer serves as an additional resisting force, by contributing additional normal force to the friction component.

$$F_{Rdozer} := W_{line} \cdot \cos(\beta) \cdot \tan\left(\phi_{min}\right)$$

The minimum required friction angle (ϕ_{min}) will be solved for.

For peak strength with equipment loading, use FS=1.3 for short term loading:

The required minimum friction angle for the liner system can be found by solving the factor of safety equation. Using a factor of safety of 1.3 for maximum strength evaluation, the required friction angle is:

$$FS := \frac{F_{Rtotal}}{F_{Dtotal}} \qquad FS_1 := 1.3 \qquad 1.3 := \frac{F_S + F_{Rdozer}}{F_{Dtotal}}$$

$$T_{\phi min1} := \frac{1.3 \cdot F_{Dtotal}}{\gamma_{stone} \cdot h \cdot L_s \cdot \cos(\beta) + W_{line} \cdot \cos(\beta)}$$

$$T_{\phi min1} = 0.497$$

$$\phi_{min1} := \operatorname{atan}\left(T_{\phi min1}\right)$$

$$\phi_{min1} = 26.4 \cdot \text{deg}$$

Alternatively, the minimum peak shear strength required is:

$$S_{min1} := 1.3 \cdot \frac{F_{Dtotal}}{L_s} \quad S_{min1} = 60.5 \cdot \text{psf}$$

For peak strength WITHOUT equipment loading, use FS=1.5 for long term conditions:

$$T_{\phi min2} := \frac{1.5 \cdot F_D}{\gamma_{stone} \cdot h \cdot L_s \cdot \cos(\beta)}$$

$$T_{\phi min2} = 0.499$$

$$\phi_{min2} := \operatorname{atan}\left(T_{\phi min2}\right)$$

$$\phi_{min2} = 26.5 \cdot \text{deg}$$

Alternatively, the minimum peak shear strength required is:

$$S_{min2} := 1.5 \cdot \frac{F_D}{L_s} \qquad S_{min2} = 30.8 \cdot \text{psf}$$

The required minimum friction angle for peak strength conditions is 27 degrees, or alternatively the minimum required peak shear strength is 61 psf.

For residual strength, with equipment loading, use FS=1.0:

$$FS_{res} := \frac{F_{Rtotal}}{F_{Dtotal}} \qquad FS_{res} := 1.0 \qquad 1.0 := \frac{F_S + F_{Rdozer}}{F_{Dtotal}}$$

$$T_{\phi res} := \frac{1.0 \cdot F_{Dtotal}}{\gamma_{stone} \cdot h \cdot L_s \cdot \cos(\beta) + W_{line} \cdot \cos(\beta)}$$

$$T_{\phi res} = 0.382$$

$$\phi_{res} := \operatorname{atan}\left(T_{\phi res}\right)$$

$$\phi_{res} = 20.9 \cdot \text{deg}$$

Alternatively, the minimum peak shear strength required is:

$$S_{res} := 1.0 \cdot \frac{F_{Dtotal}}{L_s} \qquad S_{res} = 46.6 \cdot \text{psf}$$

The required minimum friction angle for residual strength conditions is 21 degrees, or alternatively the minimum required peak shear strength is 47 psf.

Recommendations:

A GCL with nonwoven geotextile on both sides, such as Bentomat DN, GSE BentoLiner NWL, or equivalent, will generally have a higher interface friction with soil than a GCL with a woven or slit film on one side. It is recommended that a GCL with nonwoven geotextile on both sides be used to provide a greater factor of safety against veneer stability.

Interface and internal shear strength test results performed at the time of construction should be reviewed by a qualified engineer to determine if equivalent to the stated values.

References:

Duncan, J.M. Buchigani, A.Land DeWet, M. "An Engineering Manual for Slope Stability Studies," Department of Civil Engineering, Virginia Polytechnic Institute and State University. 1987.

Gilbert, R.B. "Peak Versus Residual Strength for Waste Containment Systems," Proceedings of the 15th GRI Conference on Hot Topics in Geosynthetics II. December 2001.

Theil, R.S. "Peak Vs. Residual Shear Strength for Bottom Liner Stability Analysis," Proceedings of the 15th GRI Conference on Hot Topics in Geosynthetics II. December 2001.

Attachment E

Calculations for Road Design

GEI Consultants

Calculation Cover Sheet

GEI Project	TIMET	
GEI Project Number	1323080	
	By: Karl Krueger	Date: 3/10/2014
	Checked By: Mike Ruetten	Date: 3/11/2014
	Approved By: John Trast	Date: 3/11/2014

PROFESSIONAL ENGINEER-STATE OF NEVADA
JOHN M. TRAST
Exp: 6/30/14
CIVIL
No. 12664

PURPOSE OF CALCULATIONS

The TIMET access roads are to be constructed over a GCL. The purpose of the calculation was to check rutting to determine the extent of damage possible to the GCL

METHOD

The AASHTO Design Chart Procedure was followed to check for rutting in the gravel road.

RESULTS

It was determined that the likely rutting of the road would not exceed 1.5 inches over the service life of the road. Rutting of the GCL was expected to be significantly less than 1.5 inches, because it is covered by 12 inches of gravel, a nonwoven geotextile, and 6 inches of sand.

GEI Consultants

Project	1323080	Page	1 of 2
Client	TIMET	By	KMK Date 3/10/14
Subject	New Road Rutting	Checked	Date 3/11/14
		Approved	Date 3/11/14

Determine the estimated rut depth of the proposed gravel road.

Assumptions: Follow AASHTO Design Chart Procedure

- Design Cross Section:

6" Type 2 Gravel

10 oz/sy NWGT

6" Type 2 Gravel

6" Sand

GCL

Sand CBR=10

- Total 18-kip ESAL Repetitions - W_{18} = 25,000 (entire service life)
  - Wet Season 4 months 25,000 (4/12) = 8333
  - Dry Season 8 months 25,000 (8/12) = 16,667
- Base CBR = 10 (Sand) Gravel

$M_{R(wet)}$ = 6,000 $M_{R(wet)}$ = 8,000

$M_{R(dry)}$ = 10,000 $M_{R(dry)}$ = 20,000

Trial Gravel Thickness = 12 in

Season	Sand M_R	Gravel M_R	ESALs	Serviceability Criteria $\Delta PSI = 2.5$ Allowable	Seasonal Damage	Rutting $RD = 1.5$ in Allowable	Seasonal Dam
Wet	6,000	8,000	8,333	60,000	0.13	10,000	0.83
Dry	10,000	20,000	16,667	400,000	0.04	50,000	0.33
			25,000	Total Damage 0.17		Total Rutting	1.16

GEI Consultants

Client TIMET	Project 1323080	Page 2 of 2
Subject New Road Rutting	By KMK	Date 3/10/14
	Checked	Date 3/11/14
	Approved	Date 3/11/14

- Based on the AASHTO Design Chart Procedure, after approximately 25,000 ESALs, the rutting in the surface of the road will be approximately 1.5 inches. Rutting deformation at the GCL (18" below the surface) is expected to be considerably less than 1.5 inches.

- The addition of a 10 oz/sy NWGT in the road section will act to significantly improve road serviceability and reduce rutting.

- In conclusion, rutting deformation of the GCL is expected to be significantly less than 1.5 inches.

Attachment F

Analytical results for PP-B-1 and PP-B-2

				Location	PP-B-1	PP-B-1	PP-B-2	PP-B-2
				Sample Name	PP-B-1 0-4	PP-B-1 11-13	PP-B-2 0-4	PP-B-2 7-15
				Start Depth	0	11	0	7
				End Depth	4	13	4	15
				Depth Units	ft	ft	ft	ft
				Sample Date	12/12/2013	12/12/2013	12/12/2013	12/12/2013
				Parent Sample				
Method	Chemical Name	Units	CAS No.	NDEP Industrial Outdoor Worker BCL				
EPA 300.0	Chloride	mg/Kg	16887-00-6		90 J	290 J	2100 J-	1300 J
EPA 300.0	Nitrate as Nitrogen	mg/Kg	14797-55-8	100000	0.22 J-	2.1 J-	11 J-	5.3 J-
EPA 300.0	Sulfate	mg/Kg	14808-79-8		36 J-	24 J-	470 J-	740 J-

				Location	PP-B-1	PP-B-1	PP-B-2	PP-B-2
				Sample Name	PP-B-1 0-4	PP-B-1 11-13	PP-B-2 0-4	PP-B-2 7-15
				Start Depth	0	11	0	7
				End Depth	4	13	4	15
				Depth Units	ft	ft	ft	ft
				Sample Date	12/12/2013	12/12/2013	12/12/2013	12/12/2013
				Parent Sample				
Method	Chemical Name	Units	CAS No.	NDEP Industrial Outdoor Worker BCL				
SW 6010C	Aluminum	mg/Kg	7429-90-5	100000	6400	9200	10000	9900
SW 6010C	Antimony	mg/Kg	7440-36-0	454	3.3 UJ-	3.4 UJ-	3.2 UJ-	3.3 UJ-
SW 6010C	Barium	mg/Kg	7440-39-3	100000	97 J+	200	180	170
SW 6010C	Beryllium	mg/Kg	7440-41-7	2230	0.86 UJ-	0.9 UJ-	0.85 UJ-	0.87 UJ-
SW 6010C	Cadmium	mg/Kg	7440-43-9	1110	0.51 U	0.54 U	0.5 U	0.52 U
SW 6010C	Calcium	mg/Kg	7440-70-2		22000 J+	21000 J+	24000 J+	29000 J+
SW 6010C	Chromium	mg/Kg	7440-47-3	234	7 J+	13 J+	12 J+	12 J+
SW 6010C	Cobalt	mg/Kg	7440-48-4	337	6.3 J	7.6 J	10 J	7.2 J
SW 6010C	Copper	mg/Kg	7440-50-8	42200	12 J	14	58	15
SW 6010C	Iron	mg/Kg	7439-89-6	100000	7800	13000	16000	13000
SW 6010C	Lead	mg/Kg	7439-92-1	800	7.6 J+	8.7 J+	12 J+	9 J+
SW 6010C	Magnesium	mg/Kg	7439-95-4	100000	6400 J	8000 J	12000 J	9900 J
SW 6010C	Manganese	mg/Kg	7439-96-5	24900	330 J-	290 J-	500 J-	310 J-
SW 6010C	Nickel	mg/Kg	7440-02-0	21800	13 J	15 J	19 J	15 J
SW 6010C	Potassium	mg/Kg	7440-09-7		3400 U	3600 U	3400 U	3500 U
SW 6010C	Selenium	mg/Kg	7782-49-2	5680	1.5 UJ-	1.5 UJ-	1.5 UJ-	1.5 UJ-
SW 6010C	Silver	mg/Kg	7440-22-4	5680	1.2 U	1.3 U	1.2 U	1.2 U
SW 6010C	Sodium	mg/Kg	7440-23-5		730 J	690 J	2600 J+	2400 J+
SW 6010C	Titanium	mg/Kg	7440-32-6	100000	440	630	630	660
SW 6010C	Vanadium	mg/Kg	7440-62-2	5680	23 J	35 J-	38 J-	35 J-
SW 6010C	Zinc	mg/Kg	7440-66-6	100000	28 J+	33 J+	40 J+	35 J+
SW 6020A	Arsenic	mg/Kg	7440-38-2	283	3.3 J	5.9	4.6 J	5.4
SW 6020A	Niobium	mg/Kg	7440-03-1	114	2.9 J	2 UJ-	1.9 J	2 UJ-
SW 6020A	Thallium	mg/Kg	7440-28-0	74.9	0.78 U	0.81 U	0.77 U	0.78 U
SW 6020A	Uranium	mg/Kg	7440-61-1	3400	0.62	1.6	1.1	1.3
SW 7471B	Mercury	mg/Kg	7439-97-6	182	0.02 J	0.026 J	0.021 J	0.02 J

				Location	PP-B-1	PP-B-1	PP-B-2	PP-B-2
				Sample Name	PP-B-1 0-4	PP-B-1 11-13	PP-B-2 0-4	PP-B-2 7-15
				Start Depth	0	11	0	7
				End Depth	4	13	4	15
				Depth Units	ft	ft	ft	ft
				Sample Date	12/12/2013	12/12/2013	12/12/2013	12/12/2013
				Parent Sample				
Method	Chemical Name	Units	CAS No.	NDEP Industrial Outdoor Worker BCL				
A-01-R	Thorium	pCi/g	7440-29-1		1.74	1.78	1.41	1.78
A-01-R	Thorium-228	pCi/g	14274-82-9	**0.025**	**2.16 ^^^**	**1.86 ^^^**	**1.71 ^^^**	**1.91 ^^^**
A-01-R	Thorium-230	pCi/g	14269-63-7	8.3	1.5	1.2	1.11	1.39
A-01-R	Uranium-234	pCi/g	13966-29-5	110	1.1	1.38	1.15	1
A-01-R	Uranium-235	pCi/g	15117-96-1	0.35	0.107	0.103	0.0464	0.0751 U
A-01-R	Uranium-238	pci/g	U-238	1.4	1.13	1.08	1.27	1
EPA 900	GROSS ALPHA	pCi/g	12587-46-1		24.9	25.1	19.5	25.2
EPA 900	GROSS BETA	pCi/g	12587-47-2		29.2	26.2	25	27.3
EPA 901.1	Actinium-228	pCi/g	14331-83-0		1.58	1.82	0.948	2.02
EPA 901.1	Bismuth-210M	pCi/g	378253-41-9		0.107 U	0.116 U	0.171 U	0.149 U
EPA 901.1	Bismuth-212	pCi/g	14913-49-6		2.05	1.1 U	1.68 U	1.3
EPA 901.1	Bismuth-214	pCi/g	14733-03-0		1.12	1.08	1.06	0.908
EPA 901.1	Cesium-134	pCi/g	13967-70-9		0.231 U	0.242 U	0.106 U	0.104 U
EPA 901.1	Cesium-137	pCi/g	10045-97-3		0.122 U	0.0861 U	0.158 U	0.127 U
EPA 901.1	Cobalt-57	pCi/g	13981-50-5		0.0536 U	0.062 U	0.0822 U	0.0746 U
EPA 901.1	Cobalt-60	pCi/g	10198-40-0		0.115 U	0.0887 U	0.202 U	0.127 U
EPA 901.1	Lead-212	pCi/g	15092-94-1		1.77	1.83	1.6	1.91
EPA 901.1	Lead-214	pCi/g	15067-28-4		1.17	1.27	1.36	1.16
EPA 901.1	Potassium-40	pCi/g	13966-00-2		25.8	23.7	21.6	23.7
EPA 901.1	Protactinium-231	pCi/g	14331-85-2		2.52 U	2.31 U	4.41 U	3.17 U
EPA 901.1	Protactinium-234m	pCi/g	15100-28-4		0.299 U	0.259 U	0.336 U	0.342 U
EPA 901.1	Radium-224	pCi/g	13233-32-4		1.84 U	2.04 U	2.72	2.09
EPA 901.1	Thallium-208	pCi/g	14913-50-9		0.579	0.632	0.677	0.668
EPA 901.1	Thorium-227	pCi/g	15623-47-9		1.57 U	0.454 U	0.64 U	2.12 U
EPA 901.1	Thorium-234	pCi/g	15065-10-8		1.53 U	2.25 U	2.91 U	2.14 U
EPA 903	Radium-226	pCi/g	13982-63-3	**0.023**	**1.12 ^^^**	**1.06 ^^^**	**1.1 ^^^**	**0.914 ^^^**
EPA 904	Radium-228	pCi/g	15262-20-1	**0.041**	**1.53 ^^^**	**1.18 ^^^**	**1.26 ^^^**	**1.16 ^^^**