GROUNDWATER PROTECTION EVALUATION PLAN

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Proposed Jungo Disposal Site

Revision 1

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Table of Contents

1.0 INTRODUCTION 1
2.0 ENVIRONMENTAL CONTROLS 2
2.1 Prescriptive Landfill Construction Standard 2
2.2 Proposed JDS Landfill Construction Design 2
2.3 Evaluation of Double Liner System Leachate Leakage Control Efficiency 4
3.0 INTERIM GROUNDWATER MONITORING PROGRAM 6
3.1 Site Geology 6
3.2 Site Hydrogeology 7
3.3 Initial Landfill Development 7
3.4 Interim Groundwater Monitoring Wells 8
4.0 LANDFILL PERFORMANCE REVIEW 10
5.0 CLOSING 11
6.0 REFERENCES 12

List of Figures

Figure 1 – Proposed Liner System
Figure 2 – Proposed Monitoring Well Locations
Figure 3 – Angled Boring Cross Section

Appendices

Appendix A– Landfill Performance Review Report Outline

1.0 INTRODUCTION

Golder Associates Inc. (Golder) is submitting this Groundwater Protection Evaluation Plan for the Jungo Disposal Site located in Humboldt County California. The Jungo Disposal Site (JDS) is a proposed Class I Landfill located in the Desert Valley Basin approximately 30 miles west of Winnemucca, Nevada. The landfill is located on a 634-acre parcel that consists of Section 7 of Township 35N (T35N), Range 33E (R33E). The landfill has a disposal footprint that will encompass 562-acres with an estimated life of approximately 95 years.

Golder, on behalf of Jungo Land and Investments, Inc. (JLII), has prepared and submitted a Report of Design (April 2010), Plan of Operations (May 2009) including a Monitoring Plan (updated April 2010), and Design Drawings (May 2009, revised April 2010) for the development of the Jungo Disposal Site.

As described in the Report of Design (April 2010), the site is underlain by a thick sequence of alluvial sediments. Groundwater occurs at a depth of approximately 60 feet below ground surface (bgs) and approximately 25 feet below the base of the liner system at its closest point.

Section 444.678(9) of the Nevada Administrative Code (NAC) states that Class I sites shall not be located within 100 feet of the uppermost aquifer unless approved by the solid waste management authority (Nevada Division of Environmental Protection (NDEP)). NDEP can approve landfills with less than 100 feet of separation between wastes and groundwater if NDEP considers the proposed environmental controls appropriate for preventing contamination of groundwater.

The JDS design provides environmental controls that fulfill the prescriptive requirements and incorporates a monitoring system that will provide an early, effective evaluation of the design. The purpose of this plan is to provide a means to assess the performance of the JDS environmental controls, and if necessary, implement design changes to ensure protection of groundwater quality.

The objectives of this plan are to demonstrate how JDS will:

- Provide early confirmation during the initial site operations that the constructed liner system is adequately preventing migration of waste constituents to groundwater
- Evaluate the effectiveness of the liner system and implement modifications as may be appropriate to provide adequate groundwater protection through the operational life and postclosure period of the landfill

The following sections of this report present (1) a comparison of the prescriptive landfill liner system and the proposed liner system for the JDS, (2) the additional environmental controls proposed for the JDS that will reduce the potential for leakage from the landfill, (3) an evaluation of the efficiency of the double liner system to control leachate leakage, and (4) an interim groundwater monitoring system capable of early detection of landfill leakage.

2.0 ENVIRONMENTAL CONTROLS

The JDS will be constructed with a lining system and environmental controls appropriate to ensure protection of groundwater quality. The lining system and environmental controls will be more robust than the prescriptive landfill construction standards. The following provides a summary of the prescriptive construction standard and the proposed JDS construction and environmental controls.

2.1 Prescriptive Landfill Construction Standard

The prescriptive standard (NAC Section 444.681) for landfill liner construction includes a composite liner and a system for the collection of leachate which is designed and constructed to maintain less than a 30-centimeter depth of leachate over the liner. The composite liner must have an upper component consisting of a flexible membrane liner of at least 30 mils (60 mils if comprised of high density polyethylene) and a lower component consisting of a layer of compacted soil that is at least 2 feet with a hydraulic conductivity of no more than $1x10^{-7}$ centimeters per second (cm/s).

2.2 Proposed JDS Landfill Construction Design

The JDS is designed with more robust, additional environmental controls compared to the minimum prescriptive standard. The additional environmental controls provide for additional waste containment layers, reduced potential for leakage, more efficient leachate controls limiting leachate accumulation on the liner, and early and more efficient landfill gas controls.

The environmental controls for the Jungo Disposal Site (JDS) consist of the following elements:

- A **double-liner system** with primary and secondary leachate collection
- A **high capacity leachate collection and removal system** (LCRS) on top of a composite liner system. The high capacity system will limit maximum leachate build-up to a fraction of an inch and thereby reduce the leakage potential of leachate.
- **Additional gas control system piping** that will be incorporated in the LCRS system. This allows the potential to develop a vacuum on top of the liner to minimize the potential for the migration of landfill gas through the liner.
- **Early operation of landfill gas controls**. Early operation means that landfill gas controls will be operated once landfill gas is generated in sufficient volumes for collection and disposal instead of waiting for the landfill gas generation to reach air emissions thresholds, which is the typical standard of practice..
- **An operations soil layer** to protect the liner system from damage due to equipment or sharp debris in the refuse.

In addition to the environmental controls listed above, an interim groundwater monitoring system will be installed that will allow for early detection of any leakage to groundwater below the site.

The double-liner system is comprised of the following components from top to bottom on the floor of the landfill (see Figure 1):

- 2-foot thick operations soil layer;

- 1-foot thick gravel blanket for the primary LCRS with a permeability of 1 cm/s or greater;
- central leachate collection piping within each module to provide redundant leachate removal capacity;
- 16-oz geotextile cushion;
- 60-mil high-density polyethylene (HDPE) primary geomembrane;
- 2-foot thick compacted low-permeability soil liner with a permeability (k) less than or equal to $1x10^{-7}$ cm/s;
- A secondary geocomposite drainage layer for the secondary LCRS; and
- A 60-mil high-density polyethylene (HDPE) secondary geomembrane

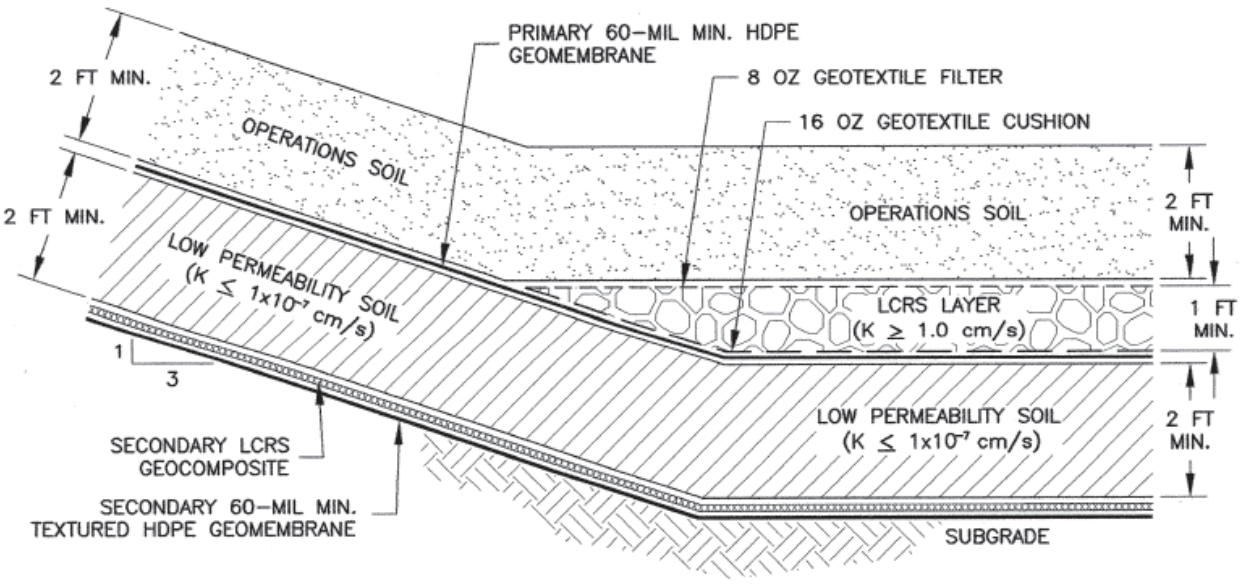

Figure 1 - Proposed Landfill Liner System Detail

On the side-slopes, the base liner system is comprised of the following components from top to bottom:

- 2-foot thick operations soil layer;
- Geocomposite drainage layer (geonet with geotextile heat-bonded to both sides) for the LCRS;
- 60-mil HDPE primary geomembrane;
- 2-foot thick compacted low-permeability soil liner ($k \leq 1x10^{-7}$ cm/s).
- A secondary geocomposite drainage layer for the secondary LCRS; and
- A 60-mil high-density polyethylene (HDPE) secondary geomembrane

In predicting the ability of the proposed environmental controls to protect groundwater, the following factors were considered:

- The threat to groundwater resulting from the generation of landfill gas and leachate. In dry climates, such as the Jungo Disposal Site, landfill gas generally poses the more significant threat than leachate due to limited leachate volumes that are generated. Golder's experience suggests that landfill sites with an average annual rainfall of less than 10-inches/year can expect to produce an average of less than 20 gallons/acre/day (gpad) of leachate. The JDS receives approximately 8 inches of annual precipitation.
- Upon closure, the final cover becomes another containment system that further minimizes the potential for leachate to impact groundwater. Bonaparte et al. (2002) show that landfills closed with low-permeability cover systems, as proposed for the JDS, reduce leachate generation to approximately 10 percent of the operational leachate generation rate within 4 years following closure. Within 9 years, the leachate generation rate is negligible.
- Landfill gas controls can be modified relatively easily to enhance gas collection and control if necessary by adding more collection wells or adjusting vacuum pressures for individual wells.
- The leakage potential through a geomembrane defect in a composite liner is approximately proportional to the depth of leachate over the geomembrane defect (Giroud, 1997). The proposed high capacity leachate collection system minimizes leachate depth on the liner, and therefore, minimizes leakage potential.

2.3 Evaluation of Double Liner System Leachate Leakage Control Efficiency

Although Golder considers landfill gas to be of primary concern with respect to groundwater quality impacts, the potential of leachate migration is often perceived to be the primary concern. Golder's modeling of potential leakage through a single, composite clay liner predicted no measurable leakage through that liner system (Report of Design, 2010). Therefore, similar modeling of leakage potential through the proposed double liner system also would be negligible.

The above leachate leakage modeling results are a reasonable performance expectation for the Jungo Disposal Site. However, the modeling relies on a number of assumptions including the quality of the liner installation. Measurements of liquids collected in secondary leachate collection systems provide another point of comparison of how modern landfill liners actually perform. Bonaparte et al. (2002) present measured leakage rates for primary liners at 187 double-lined cells located at 54 landfills in the United States. This study quantified the leakage performance of the liner systems in terms of efficiencies. Efficiency was defined as the volume of liquids collected in the primary LCRS divided by the total of the liquids collected in the primary LCRS and secondary LCRS layers. An efficiency of 100 percent represents no leakage.

Single geomembrane liners (no underlying clay layer) were observed to have an average efficiency of 90 percent. The determination of the efficiency of single, geomembrane/clay composite liners (CCLs) was not definitive due to consolidation of the clay liner. Clay consolidation "squeezes" water from clay due to increased normal stresses imposed by the overlying wastes. The presence of the relatively impermeable geomembrane at the top of the clay liner means that clay consolidation water is released to the underlying secondary collection layer and therefore masks any potential leakage volumes.

Although the efficiencies of CCLs were not definitive, the performance of CCLs is expected to be comparable to that of composite geomembrane/geosynthetic clay liners (GCLs). An average efficiency of 99.96% was measured for 28 cells constructed with composite GCLs, which are generally considered to be an equivalent alternative liner system to CCLs. Composite GCLs simply substitute a manufactured, approximately 1/4-inch thick layer of bentonite bounded by geotextiles in place of a two-foot thick compacted clay soil. GCLs are installed relatively dry and do not release pore water during consolidation allowing for a more accurate estimate of the liner efficiency. As an initial estimate, Golder considers it reasonable to assume that a single, composite CCL liner will have a similar average efficiency of 99.96%.

Although leakage through a full double liner was not measured, a reasonable estimate for the JDS double liner system can be made by combining the estimated efficiency of a single-composite liner (99.96%) with that of a single geomembrane liner system (90%). The resulting combined efficiency of the JDS liner system is expected to be on the order of 99.996 percent. Assuming an average leachate production rate of 20 gpad for JDS, the resulting leakage potential is less than 0.0008 gpad, which is effectively a negligible rate.

The implementation of enhanced CQA measures, such geoelectric leak surveys, will result in above average liner performance and provide a means for ensuring that the constructed liner system performs as intended.

3.0 INTERIM GROUNDWATER MONITORING PROGRAM

An interim groundwater monitoring program to provide early groundwater detection monitoring during the initial 10 years of landfill operation is presented below. The interim program includes the installation of groundwater monitoring wells directly below the proposed landfill leachate sumps (Figure 2). The installation of monitoring wells directly below the initial leachate sumps will provide monitoring points capable of detecting a leachate release from the landfill within a reasonable amount of time (the initial 10-year operation of the landfill). The following sections review the site conditions, geology and hydrogeology, and the proposed interim monitoring well locations and construction.

3.1 Site Geology

An initial site characterization program was completed to evaluate the site-specific geologic and hydrogeologic conditions. This initial characterization program consisted of the completion of five borings to depths of 100 to 145 feet below ground surface (bgs).

The five borings were completed using hollow-stem auger drilling methods under the observation of a Golder engineer who logged the soil samples and recorded groundwater conditions. Soil samples were classified in accordance with Golder technical procedures and the Unified Soil Classification System. The four borings located near the corners of the property were converted into groundwater monitoring wells (MW-1 through MW-4). The boring completed in the middle of the site was abandoned by backfilling the boring annulus with a cement-bentonite grout.

The site is underlain by interbedded sands, silts, and clays. Five primary soil sequences were identified. Figure 2 illustrates the subsurface lithology to a depth of 100 to 145 feet bgs, which is summarized below:

- **Upper Silty Sands**. The uppermost soils are predominately silty fine sands with occasional thin lenses of silt. These soils occur at the ground surface and extend to depths of approximately 35 to 40 feet bgs.
- **Upper Silty Clays and Clayey Silts**. A 10- to 18-foot thick layer of primarily silty clay and clayey silt underlies the uppermost silty sands.
- **Middle Sand and Silty Sand**. At a depth of 55 to 60 feet bgs, the borings encountered predominately sands that are interbedded with silty sands and thin lenses of silts and silty clays. This soil zone was observed to be 18 to 30 feet thick.
- **Lower Clay and Clayey Silt**. A 12- to 20-foot thick clay layer was first encountered at a depth of 70 to 80 feet bgs. The upper portion of this layer is generally comprised of highly plastic and compressible clay, while the lower portion consists of low to moderately plastic clay.
- **Lower Sand and Silty Sand**. The deepest boring penetrated the lower clay and clayey silt zone at a depth of 115 feet and encountered interbedded sands, silty sands, and thin lenses of silt to the full depth of the boring at 145 feet.

3.2 Site Hydrogeology

Groundwater was first encountered in the 18 to 30-feet thick middle sand/silty sand layer at a depth of approximately 60 feet below ground surface. The overlying 10- to 18-feet thick upper silty clay to clayey silt layer occurs between the base of the landfill and the sand/silty sand water-bearing zone.

Quarterly depth-to-water measurements have been taken in the site wells since their installation in January 2007. These measurements indicate that groundwater occurs at elevations similar to those recorded in the initial soil borings. Therefore, first-encountered groundwater occurs under unconfined, water-table conditions, consistent with the regional hydrogeologic model.

Regional studies have shown water levels in the basin have decreased, and in the area of the site have declined approximately 10 feet over the past 30 years. Current depth to groundwater at the site is approximately 60 feet bgs. Therefore, assuming a return to 1975 groundwater levels, the highest anticipated groundwater levels at the site are estimated to be approximately 50 feet bgs.

Based on groundwater elevations measured in the site wells, groundwater flows toward the southwest, consistent with the regional groundwater flow direction (Berger, 1995). The gradient is estimated to be 0.0003.

Rising head slug tests were conducted in each site well to determine the hydraulic conductivity of the middle sand and silty sand layer. With these data, hydraulic conductivities were calculated for each well. The geometric mean of the four individual well hydraulic conductivities was calculated to be 1.2×10^{-4} centimeters per second (cm/sec). The estimated effective porosity of the sand to silty sand is 0.30. The groundwater flow velocity calculated using the above parameters is less than 1 foot per year.

The four groundwater monitoring wells, which comprise the current monitoring network (MW-1 through MW-4), are located at the four corners of the site boundaries. Groundwater samples collected from these wells, prior to construction of the Facility, are providing background groundwater quality data, both upgradient of the proposed Facility site and at the downgradient boundary of the site. Once waste placement commences, well MW-2 will be designated as a hydraulically-upgradient background well.

3.3 Initial Landfill Development

The initial landfill module development includes module 5 (located in the northeast corner of the site and the adjacent northern portion of module 4. The modules will be constructed in phases, starting with the northern portion of module 5, followed by the northern portion of module 4. Module construction will then proceed to the south in module 5 and then module 4.

The landfill liner system design includes a high capacity (high permeability), blanket LCRS that is designed to collect leachate while minimizing leachate head build-up on the liner. The maximum leachate head on the liner is estimated to be only a fraction of one-inch. The leakage potential of a liner system is

reduced by decreasing the potential head build-up on the liner system. The modules are graded to drain toward the north, with leachate collected within each module conveyed to a 2-foot deep, gravel filled sump measuring approximately 40 feet by 40 feet in plan area. Liquids will be extracted from each sump through a riser pipe using either submersible pumps or a pneumatic pump system. The leachate sumps for modules 4 and 5 are located along the northern module boundary (Figure 2). There will be one leachate sump per module.

3.4 Interim Groundwater Monitoring Wells

A leachate sump is the most likely location for landfill leakage, due to the flow of leachate toward the sump and the accumulation of leachate in the sump. Locating groundwater monitoring wells downgradient of each leachate sump is the proposed groundwater monitoring approach for the site (Plan of Operations, Appendix D (April 2010)). The downgradient western edge of the initial landfill modules is approximately 600 feet downgradient of the leachate sumps. Given the relatively slow groundwater flow velocity (less than 1 foot per year), a substantial amount of time could pass before leakage from one of these sumps reached a groundwater monitoring well placed at the downgradient edge of the initial modules.

To minimize the time required for a potential leak from the initial landfill module leachate sumps to be detected, interim groundwater monitoring wells will be installed as close as possible to the leachate sumps. The interim groundwater monitoring wells will be installed in angled boreholes below and immediately downgradient of the sumps for modules 4 and 5 (see Figure 2 for proposed well locations). The borings for each well will be drilled using rotary drilling equipment inclined at approximately 30 degrees from horizontal. The borings will extend to a length of approximately 150 feet and will terminate at a depth of approximately 10 vertical feet below the groundwater table (see Figure 3 for cross section showing proposed well construction). The monitoring wells will be constructed with 2- or 4-inch diameter flush-threaded PVC pipe, with 20 feet of machine-slotted well screen and a threaded end cap at the bottom. Well centralizers will be placed at 10- to 20-foot intervals to maintain the well casing off the sides of the boreholes. Sand filter pack will be placed adjacent to the well screens and extend up the lower 30 feet of the borehole. A 5-foot thick bentonite seal will be placed above the sand pack and hydrated with clean water. The remaining portion of the borehole will be filled with cement grout. A locking protective well box will be installed in concrete at the ground surface and a cap will be placed at the upper end of the well casing.

The monitoring wells may be installed to match the phased module development; the first well will be installed adjacent to the leachate sump for module 5 and prior to waste placement within the module. The second well may be installed at the same time, or later, when module 4 is constructed.

The monitoring wells will be sampled on a semi-annual schedule as described in the Monitoring Plan (Plan of Operations, Appendix D). The analytical results will be evaluated and reported as described in the Monitoring Plan.

4.0 LANDFILL PERFORMANCE REVIEW

Two comprehensive landfill performance reviews will be completed to confirm the existing landfill design and operations plans, and if necessary, make appropriate changes to ensure protection of groundwater. The performance reviews will occur at the end of the construction sequences shown in Drawings 11 and 12 of Volume II, which correspond to the development sequences that are currently estimated to occur after 10 and 25 years of operations, respectively.

The landfill performance review at the completion of each development sequence will be summarized in a report submitted to NDEP for review and approval. Appendix A presents the minimum report outline, which will address the following:

- Review the landfill operational practices and training programs
- Review the landfill design
- Review the environmental monitoring program including groundwater, landfill gas, and surface water
- Review the base settlement monitoring program
- Evaluate the environmental and base settlement monitoring data to determine the effectiveness of landfill design, landfill operational practices, and the monitoring programs to adequately protect groundwater
- Provide recommendations regarding whether changes to the landfill design, landfill operational practices, and/or monitoring programs are warranted. Depending on the results of the evaluations, these recommendations may include more stringent environmental controls or reduced environmental controls, or changes to monitoring programs to modify the frequency, type, location and/or length of monitoring.

Changes to the landfill design, landfill operational practices, and/or monitoring programs would be completed only after receiving NDEP approval.

The monitoring programs will be ongoing throughout operations of the landfill. In the event that the monitoring programs indicate that the landfill wastes are impacting groundwater prior to the completion of the above landfill performance reviews (or following the completion of the landfill performance reviews). JLII will complete an evaluation of the source of the impacts and implement appropriate corrective actions with consultation and approval by NDEP. Depending on the results of the evaluation, corrective actions could include, but not be limited to, improved landfill gas collection, enhanced liner design for future cells, and/or early closure of a portion of the landfill.

5.0 CLOSING

The proposed Jungo Disposal Site liner system, enhanced leachate controls, and landfill gas collection approach significantly exceed the minimum controls necessary to ensure groundwater protection from wastes. These environmental controls are designed to prevent releases from the landfill, thereby protecting underlying groundwater. In addition to these preventative engineered controls, an interim groundwater monitoring plan is proposed to provide an early evaluation of the performance of the landfill environmental controls. This interim program, which provides an early evaluation of landfill environmental controls creates a mechanism for evaluation and potential subsequent revision of the landfill construction design. Should any design revisions be needed, they would be implemented over the remaining life of the landfill.

Sincerely,

GOLDER ASSOCIATES INC.

Kris Johnson
Senior Consultant

Kenneth G. Haskell
Practice Leader/Principal

6.0 REFERENCES

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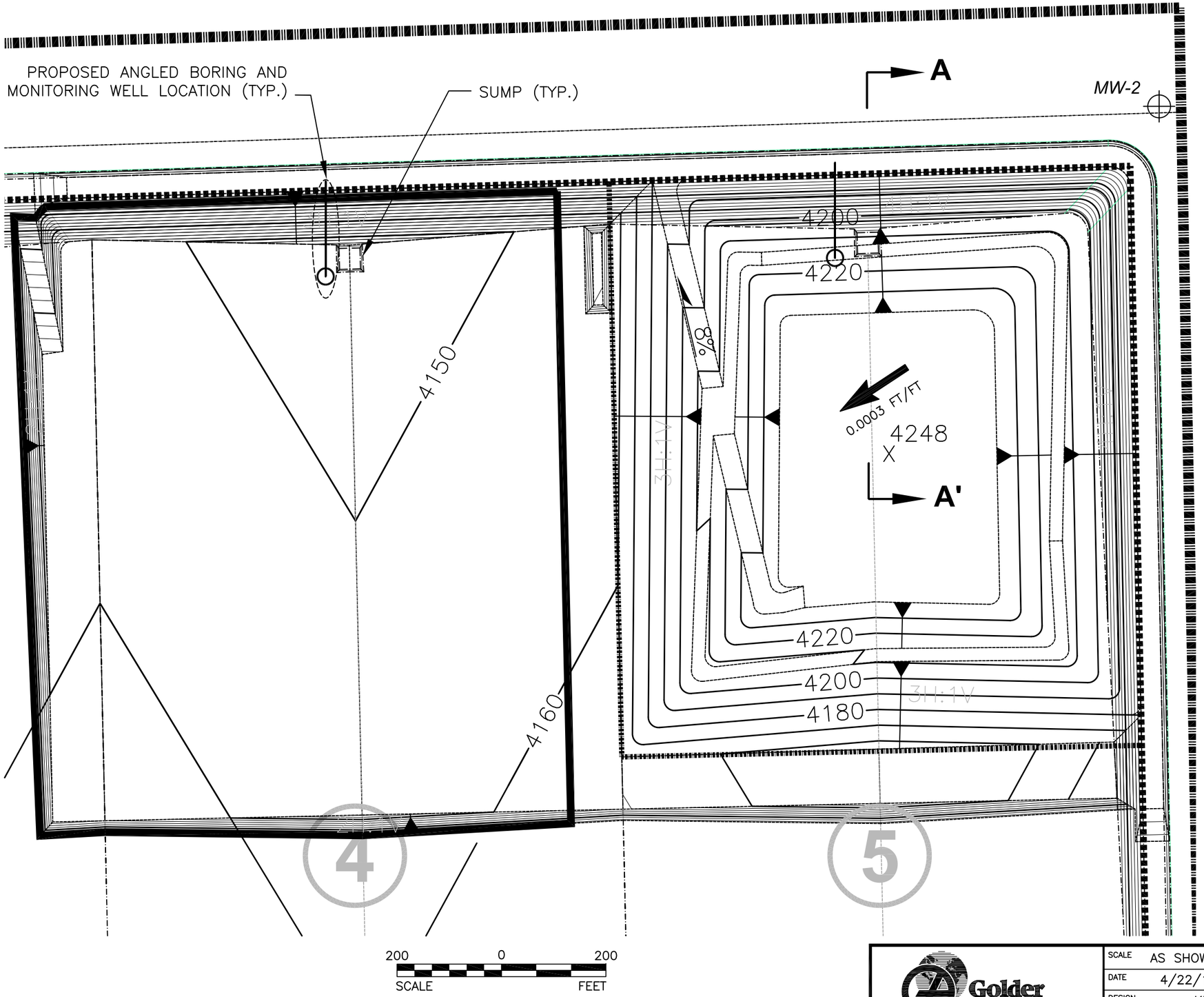
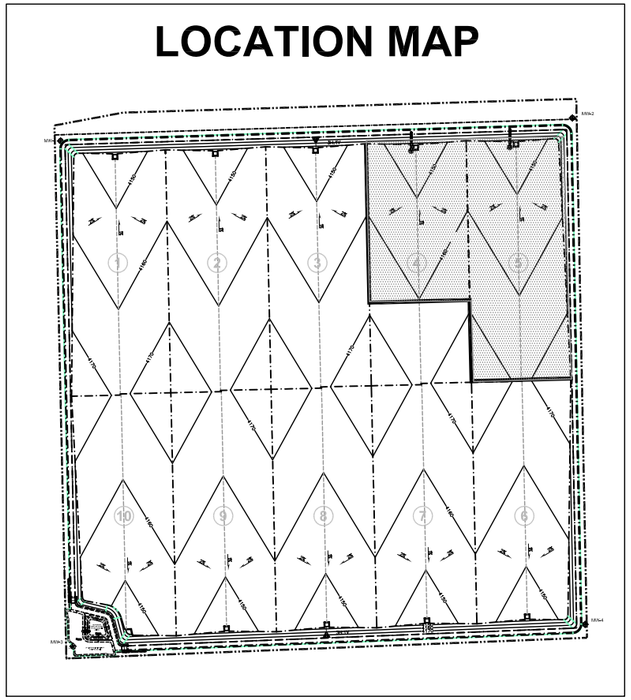
FIGURES



LOCATION MAP



1500 0 1500
SCALE FEET

0.0003 FT/FT APPROXIMATE DIRECTION OF GROUNDWATER FLOW SHOWING GRADIENT

EXISTING MONITORING WELL

Golder Associates
Sunnyvale, California

FILE No.	063–7079–100	SCALE	AS SHOWN
		DATE	4/22/10
		DESIGN	KHJ
		CADD	KMM
		CHECK	KHJ
PROJECT No. 063–7079–100	REV. 0	REVIEW	

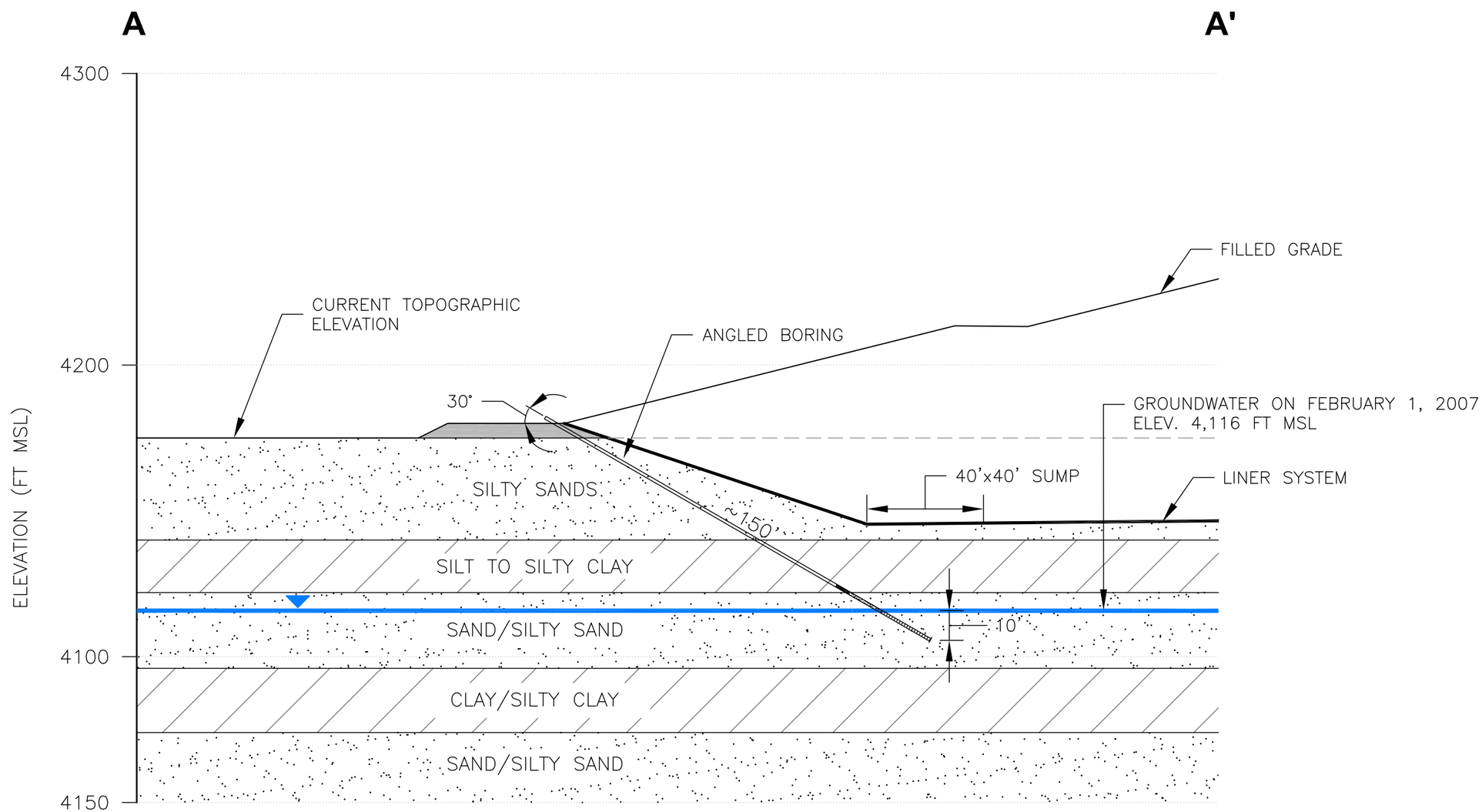
TITLE

PROPOSED MONITORING WELL LOCATIONS

JUNGO ROAD - WINNEMUCA, NV

FIGURE 2

Drawing file: Angled Boring Locations.dwg Apr 28, 2010 – 3:26pm



40 0 40
SCALE FEET

Golder Associates
Sunnyvale, California

FILE No.	063-7079-100	SCALE	AS SHOWN
PROJECT No.	063-7079-100	DATE	4/22/10
REV.	0	DESIGN	KHJ
		CADD	KMM
		CHECK	KHJ
		REVIEW	

TITLE

CROSS SECTION OF ANGLED BORING

JUNGO ROAD - WINNEMUCCA, NV

FIGURE 3

Drawing file: Angle bore X-Sec.dwg Apr 28, 2010 - 3:23pm

APPENDIX A
LANDFILL PERFORMANCE REVIEW REPORT OUTLINE

APPENDIX A

LANDFILL PERFORMANCE REVIEW REPORT OUTLINE

1. Introduction
   - 1.1 Overview
   - 1.2 Purpose and Objectives

2. Review of Operational Practices That Provide Additional Groundwater Protection
   - 2.1 Waste Screening
   - 2.2 Waste Handling and Placement
   - 2.3 Waste Cover Materials
   - 2.4 Training Programs

3. Environmental Monitoring Program
   - 3.1 Review of Environmental Monitoring Program
   - 3.2 Review of Environmental Monitoring Data
     - 3.2.1 Interim Downgradient Groundwater Wells
     - 3.3.2 Interim Groundwater Wells Below Sump
     - 3.3.3 Perimeter Groundwater Wells
     - 3.3.4 Landfill Gas Monitoring
     - 3.3.5 Surface Water Monitoring
     - 3.3.6 Leachate Monitoring
   - 3.3 Compare Actual Leachate Generation Rates vs Predicted Leachate Rates
   - 3.4 Conclusions
   - 3.5 Recommendations

4. Settlement Monitoring Program
   - 4.1 Review of Monitoring Program
   - 4.2 Review of Monitoring Data
   - 4.3 Compare Actual Settlement vs Predicted Settlement
   - 4.4 Conclusions
   - 4.5 Recommendations

5. Overall Design Confirmation
   - 5.1 Effectiveness of Overall Landfill Design and Operation
   - 5.2 Recommended Changes to the Design and Operation
   - 5.3 Recommended Changes to Monitoring Programs