ENGINEERING AND DESIGN REPORT

B-18 CLASS I LANDFILL PHASE III EXPANSION AND FINAL CLOSURE

KETTLEMAN HILLS FACILITY
KETTLEMAN CITY, CALIFORNIA

Prepared for:
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November 2008
Revision 1: February 2010
Revision 2: August 2011
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1.0 INTRODUCTION

1.1 Purpose of Report and Background Information

This report provides engineering data and analyses to support the Construction Drawings (Drawings), the Technical Specifications (Specifications), and the Construction Quality Assurance (CQA) Plans for Landfill Unit B-18 (B-18) at the Kettleman Hills Facility (KHF) in Kettleman City, Kings County, California. B-18 is located in the southeast portion of the KHF, as shown on Figure 1.1 and on the Site Location Map portion of Sheet T-1[1] in Appendix A.1.2

B-18 is an existing active Class I/II landfill that has been accepting waste continually since 1992. The existing B-18 landfill was constructed in two phases (Phases I and II), both of which were completed in the early 1990s. The design of Phases I and II of B-18 was completed by Environmental Solutions, Inc. (ESI) and was presented in the original Engineering and Design Report for B-18 (ESI, 1990a)[2].

Chemical Waste Management, Inc. (CWM), the owner and operator of B-18, wishes to construct Phase III to expand B-18 to provide additional waste capacity. Hence, this report has been prepared to supersede and serve as an updated revision to the original ESI (1990a) Engineering and Design Report for B-18. The updates contained in this report pertain primarily to the proposed Phase III expansion of B-18 and to the revised final closure design for B-18. The contents of the original ESI (1990a) Engineering and Design Report have been preserved herein - as appropriate - such that this report should be used as a stand-alone reference for the entirety of the Landfill B-18 engineering and design.

Reduced-size copies of the Drawings for Phases I through III and final closure are included in Appendix A. The Specifications and CQA Plan for Phases I and II of B-18 were prepared as a separate document by ESI (1990b). The Specifications and CQA Plans for Phase III and final closure are included in Appendices O and P, respectively.

1.2 Landfill B-18 Design

As described in Section 1.1, ESI (1990a) designed the existing Phases I and II of B-18 while Golder Associates Inc. (Golder) designed the proposed Phase III expansion and the revised final closure configuration. Golder's design of Phase III and the final closure of B-18 is based largely on the design of the existing B-18 Phases I and II completed by ESI (1990a).

The design of B-18 described in this report follows the master plan for the KHF, including the approved Kings County Conditional Use Permit (CUP) requirements. A Subsequent Environmental Impact Report (SEIR) has been prepared in accordance with the California Environmental Quality Act (CEQA). The SEIR is currently under review and certification of the SEIR will be required prior to construction of B-18 Phase III. The B-18 design generally follows procedures used for prior KHF

[1] The term "Sheet" refers to the specific page of the Drawings in Appendix A
[2] References are provided in Section 6

waste management units (WMU) for land disposal and complies with the following regulatory documents:

- United States Environmental Protection Agency (USEPA) Draft Minimum Technology Guidance on Double Liner Systems (USEPA, 1985)[3].
- USEPA Resource Conservation and Recovery Act (RCRA) Hazardous Waste Facility Permit, Part B (USEPA, 1990)[4].
- USEPA PCB regulations for Chemical Waste Landfills, Code of Federal Regulations, Title 40, Section 761.75.
- California Department of Toxic Substances Control (DTSC) Hazardous Waste Facility (Part B) Permit (DTSC, 2003).
- DTSC Environmental Health Standards for the Management of Hazardous Waste, Title 22, Division 4.5 of the California Code of Regulations (CCR).
- California Regional Water Quality Control Board (RWQCB), Central Valley Region, Waste Discharge Requirements No. 98-058 (RWQCB, 1998).
- California State Water Resources Control Board and RWQCBs, Discharges of Hazardous Waste to Land, Title 23, Division 3, Chapter 15 of the CCR.
- Kings County Conditional Use Permit (CUP) No. 1412, Administrative Approval Nos. 90-23 and 90-24 for the B-18 Landfill Phases I and II (Kings County, 1990).
- Kings County CUP No. 05-10 (application under review).

The primary differences between the B-18 design and the design of prior (i.e., pre-1990) KHF landfill units are the use of textured high density polyethylene (HDPE) geomembrane and the avoidance of operating waste slopes directly on the base liner system. These changes improve stability conditions throughout the operating period. These design concepts were initiated in Phase I and continue through Phase III and Closure.

Key aspects of the B-18 design are:

- The facility is developed in three phases (see Sheet 2 in Appendix A.1 and Sheet C-3 in Appendix A.2). Phase I is located on the west side of the existing landfill and was constructed in 1990 thru 1992 (ECS, 1992f). Phase II is located on the east side of the existing landfill and was constructed in 1992 thru 1993 (GCS, 1993h). Phase III will include a vertical expansion primarily over the western half (approximately) of the existing landfill as well as a lateral expansion up the existing rock cut slope along the west side of the landfill. Phase III is anticipated to be constructed in 2010/2011 and operational in 2010/2011.

[3] This reference is applicable only to Phases I and II.
[4] This reference is applicable only to Phases I and II.

- Phases I and II each have two independent sump areas for leachate collection, detection, and removal. No other sumps will be installed for Phase III since only sideslope liner systems will be constructed for this phase. The existing portions of each phase draining to the separate sumps are designated as Areas IA and IB for Phase I and Areas IIA and IIB for Phase II. The Phase III sideslope liner will drain to all four of the existing Areas (IA, IB, IIA, and IIB).

- The source of clay for the existing Phase I and Phase II liners was from an overburden claystone stratum (herein referred to as Stratum 18-8) that was excavated from the Phase II footprint. The primary source of clay for the Phase III liner is anticipated to be from the Landfill Unit B-17 excavation. The clay borrowing and preparation procedures that were used for Phases I and II as well as the procedures to be used for Phase III are described in Section 4.6.

1.3 Report Organization

This report is organized into the following sections that provide detailed descriptions and background information for the design of B-18:

- Section 2.0 – Site Description;
- Section 3.0 – Geotechnical Investigations;
- Section 4.0 – Landfill B-18 Description;
- Section 5.0 – Engineering Analyses; and
- Section 6.0 – References.

Supporting information on the B-18 engineering and design is provided in the following appendices to this report:

- Appendix A – Construction Drawings;
- Appendix B – Boring Logs;
- Appendix C – Trench and Test Pit Logs;
- Appendix D – Laboratory Data;
- Appendix E – Clay Liner Test Pad Data;
- Appendix F – Liner System Material Data;
- Appendix G – Settlement Analyses;
- Appendix H – Stability Analyses;
- Appendix I – Soil Erosion Analyses;

- Appendix J – Surface Water Drainage Analyses;
- Appendix K – LCRS Analyses;
- Appendix L – Riser Pipe Analyses;
- Appendix M – Cover Infiltration Analyses;
- Appendix N – Frost and Biotic Protection Evaluation;
- Appendix O – Technical Specifications; and
- Appendix P – CQA Plan.

2.0 SITE DESCRIPTION

2.1 General

This section describes the general location of B-18 as well as its pre-development and existing conditions. Sections 2.2 and 2.3 describe the current and pre-development B-18 site conditions, respectively. Sections 2.4 to 2.6 provide brief descriptions of the B-18 site's geologic, seismic, and hydrogeologic conditions, respectively.

2.2 Current Site Layout and Conditions

The KHF is located approximately midway between San Francisco and Los Angeles (see the Regional Location Map on Sheet T-1 in Appendix A.1) along the western edge of the San Joaquin Valley in central California. The KHF property consists of approximately 1,600 acres that occupies 2.5 Sections (1/2 of Section 33 and all of Section 34, R18E, T22S, and all of Section 3, R18E, T23S, Mount Diablo Base and Meridian). Landfill B-18 is located in the southeast portion of the KHF (see Figure 1.1) and currently has a footprint area of approximately 53 acres. The proposed final footprint area of B-18 will be approximately 68 acres.

Figure 1.1 shows the KHF in relation to the west side of the San Joaquin Valley floor. The KHF is located in the Kettleman Hills, approximately four miles from the valley's edge. The existing ground surface elevations (USGS Datum) at the KHF range from approximately 750 to 1,010 feet above mean sea level, making the KHF approximately 600 feet higher than the adjacent portion of the valley floor. The most recent (March 28, 2008) topographic survey of the KHF indicates that, as of March 28, 2008, the top deck waste elevations of B-18 range between 885 and 905 feet above mean sea level (see Sheet C-2 in Appendix A.2).

Access to the KHF is from State Route 41 and Interstate 5, located along the west side of the San Joaquin Valley as shown on Figure 1.1. The entrance to the KHF is approximately three miles west of Interstate 5 and 60 miles northeast of San Luis Obispo, California. Within the KHF, access to the B-18 area is through the existing Guard Station at the Main Gate, northwestward past Landfill Unit B-15, westward along the road that is south of Surface Impoundment P-9, and southward past Surface Impoundments P-10 and P-11 and past the Final Stabilization Unit (FSU), which is located immediately north of B-18 (see Sheet C-1 in Appendix A.2). Waste trucks currently enter at the northwest corner of the B-18 area; as waste elevations increase, the trucks will use the western access road and closure cover access road as shown on Sheet C-4 in Appendix A.2.

The layout of the existing Phases I and II of B-18 was based on the August 1990 CUP Facilities Boundary during the original design of B-18 (see Sheet 2 in Appendix A.1). Physical constraints for the Phases I and II areas included the following:

- The existing FSU facility to the north of Phase I.
- The existing KHF truck access road surface water control basin located along the northeast portion of Phase II.
- The requirement for a B-18 surface water containment basin (referred to as the Northeast Containment Basin herein) near the northeast corner of Phase II. This surface water basin was constructed as part of Phase II in 1992 thru 1993 and is shown on Sheet 2 in Appendix A.1.

The layout of Phase III of B-18 was developed based on the proposed modified CUP Facility Boundary the three above-mentioned physical constraints, and the following additional physical constraints:

- The existing Phases I and II geometry.
- The requirement for a second surface water containment basin (referred to as the South Containment Basin herein) to the south of B-18, as shown on Sheet C-3 in Appendix A.2.

The clean soil stockpile from the Phases I and II excavation is located outside of the immediate B-18 area as shown on Sheet C-1 in Appendix A.2. The "B-17 Borrow Area," within the boundary of Landfill B-17, to the northwest of B-18 is used for clay borrow and processing activities, but is primarily utilized as the source of daily and final cover soil.

No major KHF utilities are located within the B-18 area. Power for the existing light poles that surround B-18 and for the B-18 leachate control pumps is currently provided from an electrical transformer located along the north side of B-18 (see Sheet C-2 in Appendix A.2). For the Phase III construction, this electrical transformer will be removed and relocated to the north. The existing lighting system that surrounds B-18 is no longer required and will be removed during the Phase III construction.

2.3 Pre-Development Site Conditions

Figure 2.1 shows the B-18 site topography prior to the construction of B-18. This area was defined by a central, east/northeast-draining dry wash (i.e., swale) flanked on either side by several roughly northwest-trending ridge spurs. A former elongated, northeast-facing ridge slope formed the southwest boundary between Phases I and II and was used to develop these phases. In the Phase I area, two former tributary swales drained (northwest and southeast, respectively) along the toe of this slope into the former central swale. Another former swale drained northward through the south portion of the Phase II area, joining the former central swale near the northeast corner of the B-18 area. Typical relief between the former swales and adjacent ridge tops varied up to about 100 feet; however, the long ridge that currently borders B-18 on its southwest side rises over 250 feet above the lower portion of the former central swale. Former slopes in the B-18 footprint were gentle to moderate, ranging from nearly flat up to inclinations of about 3H:1V (horizontal:vertical). Locally steep (2H:1V) former slopes occurred on the east/northeast side of the former ridge spur in the south-central portion of B-18.

2.4 Geologic Conditions

Geologic conditions at the KHF are well-documented in the many studies completed for previous site activities. In general, subsurface conditions are relatively straightforward and consistent in comparison with other sites in California.

Figure 2.2 shows the general geologic conditions in the vicinity of the KHF, based on the work of Woodring, et al. (1940). The KHF is located along the southwest limb of North Dome, which is a broad northwest-trending anticline that forms the north portion of the Kettleman Hills. The bedrock in the vicinity of B-18 mainly consists of the stratigraphically lowest units of the Upper and Lower San Joaquin Formation, which are comprised of discrete beds of sandstone, siltstone, and claystone. The prevailing strike of these beds in the KHF area is about N45°W, with dips ranging from 25° to 35° southwest.

Figure 2.3 summarizes the geologic conditions at the KHF based on data from a variety of prior investigations. The most important characteristic of the site geology with respect to the B-18 site investigation program (Section 3) was the continuity and uniformity of the bedrock strata. Of special importance was the thick claystone stratum which passes through the western portion of the B-18 Phase II area. This material served as the clay source for the Phases I and II liner. Additionally, for the Phase III area, the dip of the bedrock strata is to the southwest, representing the most favorable bedding orientation for stability of the excavation.

Neither Figure 2.2 nor 2.3 indicates the existence of faults within the KHF, which would disrupt the general bedrock strike and dip trends and/or the continuity of the individual sandstone, siltstone, and claystone strata. Two studies by Roger Foott and Associates (1990a and 1990b) concluded that there is no surface or recent (i.e., Holocene) faulting in the B-18 area. This conclusion was corroborated by geologic mapping of the completed landfill subgrades during the construction of Phases I and II (Golder, 1992; GCS, 1993b).

2.5 Design Ground Motions

2.5.1 General

CCR Titles 22 and 23 require Class I landfills to be designed and maintained to withstand the Maximum Credible Earthquake (MCE) event. Hence, the design ground motions used in the analyses of B-18 were based on the MCE event(s), as described in the following two sections.

2.5.2 Ground Motions Used in the Original Design

In the original design of B-18, ESI (1990a) used the MCE event and associated ground motion parameters that had been developed by Golder (1988). The Golder (1988) MCE event for the KHF corresponded to a moment magnitude (M_w) 7.0 earthquake occurring at a depth of 10 km below the site on the Ramp Thrust Kettleman Hills North Dome segment of the blind Ramp Thrust Faults. The deterministic peak horizontal ground acceleration (PHGA) associated with this MCE event was calculated to be 0.43g (Golder, 1988), where g is the acceleration due to gravity.

2.5.3 Ground Motions Used in the Current Design

Hushmand Associates, Inc. (HAI), under subcontract to Golder, updated the design ground motions for the KHF as part of the current B-18 design. Appendix H.5 contains HAI's slope stability report that explains the methods used to develop the updated design ground motions. HAI performed deterministic seismic hazard analyses to evaluate the MCE ground motions for the controlling near-field and far-field events using a variety of state-of-the-practice attenuation relationships. Based on their analyses, HAI has developed the following deterministic MCE ground motion parameters for the KHF that were used in the current design of B-18:

- *Near-Field Event:* The controlling near-field MCE event is considered to be a M_w 7 earthquake occurring 10 km from the site on the Ramp Thrust Kettleman Hills North Dome segment. The PHGA associated with this event was calculated to be 0.62g.

- *Far-Field Event:* The controlling far-field MCE event is considered to be a M_w 8 earthquake occurring 35 km from the site on the San Andreas Fault. The PHGA associated with this event was calculated to be 0.16g.

2.6 Hydrogeology

Groundwater conditions are extensively monitored at several existing monitoring wells located throughout the KHF site. Sheet C-2, C-3 and C-4 in Appendix A.2 shows the locations of monitoring wells in the vicinity of B-18. Recent data from these wells indicate that the depth to groundwater is about 250 feet below the bottom of the existing B-18 base liner system. No shallow perched groundwater or perennial springs are known to occur in the B-18 area.

Because groundwater conditions do not affect the design or construction of B-18, an extensive evaluation of hydrogeology is not provided in this report. A report by EMCON (1986) contains a detailed description of the hydrogeological conditions at the KHF. The current Groundwater Monitoring Plan for the KHF was prepared by Geosyntec (2001).

3.0 GEOTECHNICAL INVESTIGATIONS

3.1 General

This section describes the geotechnical field and laboratory investigations previously undertaken by ESI and others to characterize the B-18 subsurface conditions and to evaluate soil and rock properties necessary for the geotechnical design of B-18. No additional field or laboratory investigations were performed by Golder in the preparation of this report. Field and laboratory testing on the proposed clay source for Phase III of B-18 was performed by Geosyntec (2008), as discussed in Section 3.2.2.

Section 3.2 describes the main field investigation activities associated with the design of B-18 and the evaluation of on-site claystone for use in the B-18 liner construction. Section 3.3 summarizes the subsurface conditions for B-18 based on the results of the geotechnical investigations. Section 3.4 describes the procedures used to select the soil and rock samples for laboratory testing in order to evaluate the required geotechnical design parameters. Results of the laboratory tests, including prior KHF data not directly associated with the design of B-18, are discussed in Section 3.5.

3.2 Field Investigations

3.2.1 Geotechnical Exploration Program

The locations of geotechnical field exploration activities are shown in plan view on Figure 3.1 and in sectional views on Figure 3.2. The field explorations were undertaken in several phases designed to verify the anticipated site geologic characteristics and to obtain representative soil and rock samples.

The initial phase of B-18 field exploration activities was conducted from February 20 through 27, 1990, and consisted of the following:

- Excavating long dozer trenches DT-A to DT-F to observe the thickness of colluvium, identify stratum contacts, and measure the strike and dip of rock discontinuities/bedding. These dozer trenches were generally between about 3 and 10 feet deep.

- Excavating test pits TP-l through TP-21 to penetrate colluvium at the base of the dozer trenches and to observe soil and rock conditions throughout the B-18 area. These test pits were generally about 6 to 18 feet deep.

Several disturbed bulk samples of representative colluvium and rock materials were collected for general laboratory analyses during this initial program.

The second phase of B-18 field exploration activities was conducted from March 12 through 23, 1990, and consisted of the following:

- Drilling nine geotechnical borings (L18-A through L18-I) to further verify the depth of contacts between individual rock strata and to collect relatively undisturbed samples of the rock materials to be encountered during excavation and/or to be used as embankment borrow material. These borings were advanced to depths ranging between approximately 18.5 and 89 feet below ground surface.

- Excavating test pits TP-22 through TP-28 to confirm colluvium thicknesses and characteristics of bedrock strata at locations between the borings. These test pits were excavated to depths of approximately 5.5 to 13.5 feet.

Table 3.1 summarizes the purpose for and key information about each boring. The borings were drilled using a Pitcher Barrel rig so that core samples could be recovered at the various intervals shown in Table 3.1. A total of 65 Pitcher Barrel samples of bedrock and 6 drive samples of colluvium were collected from the initial borings (L18-A through L18-I).

Data from the two initial field exploration phases were used to develop the preliminary versions of the geologic cross sections shown in Figure 3.2. Existing monitoring well logs were also reviewed to confirm interpretations of rock strike and dip. These data consistently verified the relatively uniform site conditions and indicated that site characterization for the purposes of the B-18 design was complete. However, it was concluded that additional clay samples were required to complete the characterization of Stratum 18-8 for use as the onsite clay source for the Phases I and II liner.

Therefore, the third and final phase of B-18 field exploration activities was conducted from May 8 through 11, 1990, and consisted of the following:

- Drilling boring L18-J to penetrate the entire Stratum 18-8 (clay borrow source) thickness to confirm uniformity of the claystone throughout this stratum. Sampling was accomplished by collecting approximately 2.5 feet of relatively undisturbed sample for each 5 feet of penetration. This boring was drilled to a depth of approximately 172.5 feet below ground surface.

- Drilling boring L18-K through the entire thickness of Stratum 18-9 and into the underlying Stratum 18-8. Stratum 18-9 was excavated concurrently with the Stratum 18-8 claystone during the construction of Phases I and II. This boring was also sampled by collecting approximately 2.5 feet of relatively undisturbed sample for each 5-foot penetration interval. This boring was drilled to a depth of approximately 97.5 feet below ground surface.

- Excavating test pits TP-29 through TP-43 to obtain larger bag samples of materials from Strata 18-8, 18-9, 18-10, 18-11, 18-12, and 18-13. These larger samples were used to evaluate properties of compacted borrow materials that could be mixed with the clay. These test pits were excavated to depths of approximately 3.5 to 16 feet.

Appendix B contains the logs of the above-described borings. Logs of the dozer trenches and test pits are included in Appendix C.

The information contained in Table 3.2 demonstrates that the colluvium and rock strata of interest to the design of B-18 have been adequately investigated by the above-described field exploration activities. Table 3.2 also includes the existing and previous monitoring wells which pass/passed through each geologic stratum underlying B-18.

Supplemental geologic field investigations were undertaken by Roger Foott and Associates (1990a and 1990b) to evaluate the potential for recent faulting in the vicinity of B-18. The findings of these investigations are discussed in Section 3.3.2.

3.2.2 Clay Liner Test Pads

In 1991, a clay liner test pad was constructed to evaluate the B-18 Phases I and II clay borrow source (i.e., Stratum 18-8). A sealed double-ring infiltrometer (SDRI) test was conducted on this test pad. Results of the SDRI test confirmed that the Stratum 18-8 clay source met the permeability requirements under actual field conditions. The construction of the 1991 clay liner test pad and the SDRI testing are discussed in detail in the test fill and infiltrometer report by ESI (1992), which is provided in Appendix E.1. CQA testing of the clay liner material during construction of Phases I and II of B-18 (ECS, 1992a, 1992b, and 1992d; GCS, 1993a, 1993d, and 1993f) verified the results of the SDRI test and indicated that the as-built clay liners for Phases I and II have permeabilities that do not exceed the specified maximum of 1×10^{-7} cm/s.

The clay source for the Phase III liner is anticipated to be the on-site Pecten Claystone stratum that lies along the eastern boundary of Landfill Unit B-17 (see Sheet C-1 in Appendix A.2). Geosyntec (2008) performed laboratory testing on samples of this stratum of Pecten Claystone. Results of Geosyntec's laboratory tests indicate that the Pecten Claystone stratum is a suitable clay borrow source for the Phase III liner. The Geosyntec (2008) report on the Pecten Claystone testing is summarized in Table 3.13 and presented in Appendix E.2. A clay liner test pad consisting of Pecten Claystone was constructed in July 2008. A SDRI test was conducted by Geosyntec (2008a) on this test pad to further evaluate the Pecten Claystone and validate its use as the clay borrow source for the Phase III liner. The SDRI test report was completed in December 2008 and is presented in Appendix E.3. The report concludes the Pecten clay is suitable for Phase III clay liner.

3.3 Site Subsurface Conditions

3.3.1 Surficial Soils

The majority of the B-18 site was blanketed with colluvial soils prior to its development. These deposits consisted of low to moderately plastic, silty and/or sandy clays and very fine-grained clayey sands. The colluvium was generally stiff to very stiff and dry to slightly damp when encountered during the field explorations. Occasional laminated lenses of fine-grained sand, probably representative of intermittent alluvial deposits within the colluvium, were encountered in some swale areas. The colluvium varied in thickness from less than 1 foot along the uppermost ridge slopes to over 18 feet within the swales, as shown in Figure 3.2. Considerable variation in the thickness of colluvium beneath uniform slopes was indicative of differential weathering of the underlying San Joaquin Formation bedrock and surficial soil compaction.

During the Phases I and II construction, the colluvium was excavated from the vast majority of foundation areas within the B-18 footprint due to its shallow depths. The only areas where colluvium was left in place were at the crest of the 2H:1V slope along the western boundary of Phase I. The colluvium that remained in these areas was less than 5 feet thick (GCS, 1993h). Areas where colluvium remained above landfill cut slopes outside of the waste footprint (e.g., the steep northeast facing slope above the southwestern edge of B-18) were graded to control soil erosion and/or sloughing.

Prior to the development of B-18, minor portions of the B-18 footprint were covered with fill. The northern portion of the Phase I area included the toe of a fill slope associated with the FSU construction. Several small fills in the Phase II area were apparently associated with drilling pads and a former access road that traversed the area. These fill materials were removed during the Phases I and II excavations.

3.3.2 Bedrock Lithology, Structure, and Stratigraphy

The San Joaquin Formation underlying B-18 is similar to the other portions of this formation found throughout the KHF area. The San Joaquin Formation consists of three major lithologic units: sandstone, siltstone, and claystone. Principal variants include silty sandstone and sandy siltstone. These units of the San Joaquin Formation were relatively easy to excavate using conventional earthmoving equipment (e.g., scrapers and dozers) during the Phases I and II construction. The physical characteristics of each of the discrete lithologic units, as well as qualities common to the overall San Joaquin Formation, are:

- *Sandstone:* Beds of both clean and silty sandstone occur within the B-18 area. The sandstones are variably white, gray, tan, and orange-brown. They are typically slightly weathered, soft, friable, very fine- to fine-grained, thick-bedded, and uncemented to weakly cemented. Occasional thin beds are moderately- to well-cemented. Numerous veins of gypsum and thin, orange interbeds of hard, cemented, iron-rich material occur along bedding planes and joints within the sandstones, as well as within the other lithologic units. The sandstone excavations generated fine, loose, clean, and silty sand. Several fossiliferous, well-cemented sandstone beds (including "Trachycardium" and "Mya") occur at various stratigraphic positions within the B-18 area, as shown on Figures 2.3, 3.1, and 3.2. These fossil beds are generally excavated as hard, gravel- to boulder-sized blocks.

- *Siltstone:* The siltstone units within the B-18 area are of variable character and include siltstone, sandy siltstone, and occasionally clayey siltstone. Each siltstone type is typically slightly weathered, soft, and laminated to thin-bedded. The siltstones vary from non- to low-plastic materials. Atterberg limits of selected samples, visually classified as siltstone, indicate that some "siltstones" consist of silty clays that plot just above the A-line on the plasticity chart. The siltstones are usually light brown or gray. Excavation of siltstone generates thin, angular fragments or slabs ranging from about 1/2 inch to 1 foot in largest dimension.

- *Claystone:* The claystone is usually either light gray, gray-brown, or dark olive-gray. It is typically slightly weathered, soft, laminated to thin-bedded, highly plastic, and frequently exhibits pronounced slickensides (striations) along glossy or waxy-appearing fracture and bedding surfaces. Dozer excavation of the claystone opposite the direction of dip yielded generally uniform, angular gravel-sized fragments, while excavation in the direction of dip yielded gravel- and larger-sized blocks and slabs in the range of 12 to 18 inches in maximum size. The largest slabs of claystone generated during the initial excavation tended to break down after repeated passes with the dozer.

The prevailing structural characteristic of the bedrock is its consistent bedding, which trends generally N30°W to N50°W and dips about 24 to 45°SW throughout the B-18 area (Golder, 1992; GCS, 1993b). Most measured joints dip steeper than the bedding and trend both across and generally parallel to the bedding (bedding and joint attitudes are shown on Figure 3.2). As shown on the cross sections in Figure 3.2, the cut slopes required for the Phases I and II construction were excavated shallower than the bedding plane angles to prevent adverse daylight conditions (e.g., along generally southwest-facing cut slopes).

Anomalous and contorted bedding (measured at N55°E, 73°SE) was encountered in dozer trench DT-C (Figure 3.1) within the thick Stratum 18-8 claystone. The length of the dozer trench characterized by this feature was logged as trench T-3 (see Appendix C). A detailed examination of the geologic units along this portion of DT-C suggest that the anomalous bedding was a result of old, intraformational deformation (e.g., localized folding, faulting, or slumping). The colluvium that overlaid this feature appeared undisturbed and displayed no evidence of offset or displacement that would be indicative of recent slope instability or faulting. Excavations for the construction of Phases I and II confirmed that the contorted bedding observed in DT-C was a localized, anomalous feature.

Contorted beds of cemented sandstone, appearing to be folded or compressed in a down-dip direction, were encountered immediately beneath colluvial soils in dozer trench DT-B (Figure 3.1). The contorted bedding is apparently related to settlement of the near-surface, cemented bedrock following erosion or animal burrowing of underlying, softer, uncemented sandstone (refer to the log of trench T-1 in Appendix C). The disturbed, near-surface bedrock was removed during the excavations for Phases I and II.

Stratigraphically, the San Joaquin Formation beds underlying B-18 have been grouped into a sequence of 13 stratigraphic units. Each unit is defined according to either a discrete lithology or a distinctive interbedding of various lithologic units. The units are designated 18-1 through 18-13, from northeast (oldest) units to southwest (youngest) units. The approximate contacts of these units are depicted in plan on Figure 3.1 and in profile on Figure 3.2. The stratigraphy shown in Figures 3.1 and 3.2 was based on the results of the dozer trenching, exploration drilling, air photo analysis, mapping of cut exposures prior to the development of B-18, and excavation of test pits. Comparisons were also made with logs of existing and previous monitoring wells in the B-18 area. In general, the geologic conditions in the B-18 area were found to be straightforward and consistent. Geologic mapping of the B-18 subgrades performed during the construction of Phases I and II revealed 15 units within the Phase I area (Golder, 1992) and 26 units within the Phase II area (GCS, 1993b). The results of this mapping confirmed the general geologic conditions shown on Figures 3.1 and 3.2 with the only significant discrepancies being local adjustments of some of the contact locations.

Geologic field investigations undertaken by Roger Foott and Associates (1990a and 1990b) indicated that recent (i.e., Holocene) faulting has not occurred in the vicinity of B-18. Additionally, geologic mapping of the completed B-18 subgrades during the construction of Phases I and II did not reveal any evidence of recent faulting (Golder, 1992; GCS, 1993b).

3.4 Laboratory Investigations

3.4.1 Sample and Testing Selection Process

This section describes the approach for selecting appropriate geotechnical laboratory tests to evaluate the necessary geotechnical design parameters and to establish geochemical background data for the on-site materials.

Initially, the large amount of existing geotechnical data available from pre-1990 KHF landfill designs was evaluated to assess the usefulness of this data for the B-18 design. Also, index property tests were initially conducted on many of the B-18 samples for comparison with properties of materials previously tested and to characterize the range of material types which may be important for design. Representative samples for strength, consolidation, compaction, shrink/swell, permeability, and geochemical testing were selected based on the results of index property tests, past data, and the importance of specific strata to the design analyses.

3.4.2 Prior (Pre-1990) Geotechnical Data

The most pertinent pre-1990 KHF geotechnical data used in the design of B-18 is summarized in Table 3.3 and is based on the results of investigations reported for the following activities:

- The design of Phases II and III of Landfill Unit B-19 (Donohue and Associates, 1988a);
- The slope failure investigation for Phase IA of Landfill Unit B-19 (Seed et al., 1988); and
- Generic investigations of closure alternatives for various landfills at the KHF (Golder, 1988b, 1989c, and 1989a).

Table 3.3 also summarizes reported properties from published literature and vendor data on geosynthetic liner interface testing.

3.4.3 Laboratory Testing for Landfill Design

Tables 3.4 and 3.5 summarize the B-18 geotechnical laboratory testing program and show the samples collected from the borings and test pits/trenches, respectively. An “X” is provided in each table to indicate the types of tests conducted on each sample. The analysis methods used for the various tests are summarized in Table 3.6.

A large number of index tests were initially conducted to evaluate the consistency of characteristics for the various rock and soil types. The index tests performed on a particular sample were selected based on the type of material. For example, plasticity index testing was conducted only on fine-grained claystone or siltstone samples. Index property comparisons were then used to select representative samples to be tested for the various engineering properties (e.g., compaction, strength, settlement, permeability).

Tests that were conducted under conditions to simulate the B-18 site-specific conditions are indicated by the footnotes in Tables 3.4 and 3.5. These included:

- Conducting unconsolidated undrained (UU) triaxial tests at confining pressures ranging between 4 and 16 kips per square foot (ksf) to represent the anticipated range of overburden pressures due to the weight of the overlying waste.
- Conducting most of the clay permeability tests at a dry unit weight equal to 90 percent of the Modified Proctor (ASTM D1557) maximum dry density and at water contents ranging from 2 to 6 percent above the optimum moisture content to represent clay liner material that has been compacted in accordance with the Specifications.

All of the compaction tests except two were conducted using the Modified Proctor procedures (ASTM D1557), which are specified for the B-18 construction. Standard Proctor procedures (ASTM D698) were conducted on one sandstone sample from Boring L18-K and one claystone sample from test pit TP-37 for comparison purposes only.

Table 3.4 also shows that background geochemistry was analyzed for three rock samples (one each from borings L18-A, L18-C, and L18-F) representing a range of the claystone, siltstone, and sandstone. The geochemical analyses conducted are listed in Table 3.6. These are the same background analyses conducted for prior KHF landfill investigations.

3.4.4 Special Testing of the Phases I and II Clay Borrow Material

Plasticity and unit weight/water content tests were conducted on 15 samples of Stratum 18-8 claystone collected from Boring L18-J to assess the uniformity of the claystone. Hydrometer tests were then conducted on five of the 15 samples that were considered representative of the range of conditions in the stratum to compare grain size characteristics. Shrinkage tests were conducted on four of the five samples to quantify the clay shrink/swell characteristics. Plasticity index and hydrometer tests were also conducted on shallow claystone samples from dozer trenches DT-A and DT-C and from test pits TP-36, TP-38, and TP-40 to provide a comparison of conditions derived from the shallow weathered rock.

Modified Proctor (ASTM D1557) compaction tests were conducted on three “pure” claystone composites of borehole samples to determine their water content-dry density relationship. Permeability tests were also performed on each of these three Modified Proctor composite samples using material compacted at approximately 90 percent relative compaction and water contents ranging from 0 to 2 percent above optimum. Unconsolidated-undrained (UU) triaxial and consolidation tests were conducted on one Modified Proctor test sample from dozer trench DT-A that was considered to be representative of the clay material.

The above-described tests on “pure” claystone samples provided conservative characteristics of strength and consolidation parameters for the clay materials. In order to assess the potential for mixing the claystone with other rock materials, an additional series of tests was conducted on mixtures of claystone from Stratum 18-8 and sandstone/siltstone from the adjacent Stratum 18-9. Mix ratios of 70:30 and 50:50 (claystone:sandstone/siltstone) percent were used.

Long-term leachate compatibility testing for the B-18 clay was not conducted in light of the results of an extensive testing program by EMCON (1989) using on-site claystone materials. That program included soil/waste compatibility tests performed consistent with the California Administrative Code, Title 23, Chapter 3, Subchapter 15, Section 2541(b) and (c); the United States Environmental Protection Agency (USEPA) regulations in 40 CFR 270.17(b)(1), 270.21(b)(1), 264.22l(a)(1), and 264.301(a)(1)(i); and the Resource Conservation and Recovery Act (RCRA) Method 9100.

The EMCON (1989) compatibility tests showed no significant increase in clay permeability after displacing two volumes of pore water with a representative leachate obtained from another hazardous waste site operated by CWM EMCON (1989) therefore concluded that the leachate did not have a significant effect on the permeability of the clay. EMCON (1989) also considered this conclusion to be consistent with findings reported by others in published literature, which indicate that dilute organic liquids do not adversely affect the permeability of clay soils.

3.5 Laboratory Testing Results

3.5.1 General

This section summarizes the B-18-specific laboratory testing results in the following order:

1. Index properties.
2. Compaction tests.
3. Strength tests.
4. Permeability tests.
5. Consolidation tests.
6. Shrink/swell potential tests.
7. Geochemical analyses.

The complete laboratory test results and supporting information are presented in Appendices D and E.

The laboratory test results described in this section were performed prior to the development of B-18 and provided the necessary information that guided the B-18 design. CQA reports prepared for the Phases I and II construction (see Section 4.1) contain additional laboratory and field test results that were performed as part of the Phases I and II CQA program. These CQA test results generally confirmed that the actual properties of the various as-built materials met or exceeded the material properties that were assumed during design. Hence, no attempt has been made to fully incorporate the CQA test data into the discussions in this report. Rather, CQA test results are only mentioned herein when deemed appropriate to reinforce an earlier assumption or finding. More recent testing, Geosyntec 2008a and b, has been conducted on proposed clay liner materials. Test results indicate the clay liner is similar to that used for Phase I and II and it will be suitable for use as a clay liner in Phase III. Test results that are included in Appendix E.2 and E.3 are summarized herein.

3.5.2 Index Property Tests

Plasticity index tests (i.e., Atterberg limits tests) were performed on claystone samples from Strata 18-2 through 18-5, 18-7, 18-8 (the clay borrow source for Phases I and II), 18-9, 18-10, and 18-12. Table 3.7 summarizes the plasticity index data and indicates that the majority of the claystone is classified as high-plasticity clay (CH) having a liquid limit ranging from about 55 to 90 and a plasticity index ranging from about 30 to 60. One sample from Stratum 18-8 and several samples from other fine-grained strata were classified as low-plasticity clay (CL). These materials have a liquid limit ranging from about 30 to 49 and a plasticity index ranging from about 6 to 29. In addition, one of the plasticity index tests performed on a minor claystone/siltstone sample of Stratum 18-3 showed the characteristics of a low plasticity silt (ML).

Figure 3.3 shows a plasticity chart with plotted data points for the majority of the Stratum 18-8 samples that were tested. It can be seen from this figure that the Stratum 18-8 claystone material consistently lies in the CH (i.e., high-plasticity clay) range. Additional plasticity charts containing plotted data for the other strata that were tested are included in Appendix D.1.

Table 3.8 summarizes the tests performed to evaluate the percentage of material passing the U.S. No. 200 sieve (i.e., fine-grained silt and clay) for the various samples tested. The colluvial soil samples generally have a fairly high percentage (about 33 to 81 percent) of fine-grained materials. This variation apparently relates to the origin of the colluvial materials with the highest percentage of fines being derived from siltstone or claystone. The data in Table 3.8 for sandstone shows a relatively low percentage of fines that ranges from about 11 to 37 percent. Clayey and silty sandstone samples showed the largest variation of percent fines (from about 21 to 73 percent) which reflects the varying amount of fine-grained laminations in these samples.

Figure 3.4 presents the grain size envelopes obtained from sieve analyses on sandstone samples from Stratum 18-9 and hydrometer tests on claystones from Stratum 18-8. Individual test results for samples from these strata and other rock units are included in Appendix D.2. These results further show the relative uniformity of the various rock types at B-18. The sandstones have relatively uniform grain sizes that fall mostly in the 4 to 0.1 millimeter diameter range. The percentage fines in the sandstones is approximately 10 to 40 percent. The claystone is well-graded with at least 80 percent fines and about 5 to 30 percent of the particles being smaller than 0.001 millimeters. The clay-size fraction (particles with a diameter less than 0.002 millimeters) varies between about 12 and 40 percent.

Natural moisture contents and dry densities for samples tested are presented on the boring logs in Appendix B. Typically, the sandstone materials have a natural moisture content varying between about 8 and 20 percent and a natural dry density varying between about 95 and 121 pounds per cubic foot (pcf). The claystone material's natural moisture content typically varies between about 15 and 30 percent and its dry density range is approximately 90 to 105 pcf.

Figure 3.5 contains a plot showing the relationship of the natural water content to the Atterberg limits for claystone samples from Stratum 18-8. This relationship is useful for qualitatively evaluating the compressibility and strength behavior of the claystone. The data in Figure 3.5 show that the natural water content of the Stratum 18-8 claystone is typically less than or roughly equal to its plastic limit. This condition is indicative of a material with relatively low compressibility and high strength. The importance of this condition is that it allowed the settlements of the B-18 foundation to be calculated based on the theory of elasticity. Other interesting features that can be seen from Figure 3.5 are the following:

- The natural water content of the Stratum 18-8 claystone is relatively close to its optimum moisture content as determined from Modified Proctor compaction tests (see Section 3.5.3); and
- The Stratum 18-8 claystone plasticity characteristics are relatively uniform throughout its entire depth, although a lower-plasticity zone was encountered in the 70- to 90-foot depth range.
- Recent testing on the proposed clay liner material, summarized in Table 3.13, indicates the plasticity index data of the claystone is generally classified as high-plasticity clay (CH) having a liquid limit ranging from about 58 to 105 and a plasticity index ranging from about 29 to 72. The fines content of the claystone ranged from 76 percent to nearly 100 percent. This is consistent with clay liner materials used for Phases I and II.

3.5.3 Compaction Tests

Table 3.9 summarizes the results of compaction tests conducted on a variety of composited samples and on individual bag samples from test pit TP-42 and dozer trenches DT-A and DT-C. With the exception of composite Samples No. 4 and No. 11, all of the tests were performed using the Modified Proctor test method (ASTM D1557), which is the method that was specified for the Phases I and II construction (ESI, 1990b) and is specified for the Phase III and final closure construction (see Appendix O). The Standard Proctor test method (ASTM D698) was utilized for Samples No. 4 and No. 11 in order to assess the differences in densities resulting from the use of a lower compactive energy (the Modified Proctor method utilizes an energy of 56,000 foot-pounds per cubic foot as compared to an energy of only 12,400 foot-pounds per cubic foot for the Standard Proctor method). Individual plots for the Modified and Standard Proctor tests are provided in Appendices D.3 and D.4, respectively.

The Modified Proctor compaction data indicate that the optimum water content for the claystone is on the order of 21 to 25 percent and the corresponding maximum dry density is approximately 96 to 104 pcf. As the percentage of sandstone increases, the optimum moisture content is expected to decrease and the maximum dry density to increase. The recent testing by Geosyntec, presented in Appendix E.2, indicates lower optimum moisture contents and higher maximum dry density than previous testing. The optimum moisture content and maximum dry density ranged from 12.5 to 20.1 percent and 105.5 to 122.0 pcf, respectively. These variations are not significant and do not necessarily indicate a change in the clay quality.

The compaction tests using the Standard Proctor method indicate that the claystone's optimum water content for this lower compactive energy increases to about 30 percent while the maximum dry density decreases to below 90 pcf. A similar amount of change was also observed for the mixture of sandstone and claystone tested.

3.5.4 Strength Tests on Relatively Undisturbed Samples

Strength properties of the in-situ rock materials that form the sidewalls of the majority of B-18 were evaluated by the following two types of tests:

1. Unconsolidated–undrained (UU) triaxial compression tests performed on relatively undisturbed samples of silty sandstone and claystone as summarized in Appendix D.5. These tests allowed failure to occur on the weakest plane in the sample and provided representative data for evaluating the stability of slopes in which failure along bedding planes may occur.

2. Direct shear tests performed on relatively undisturbed samples of sandstone and claystone, as summarized in Figure 3.6 and Appendix D.8. The direct shear samples were oriented such that failure occurred across bedding planes. These test results were then used for the stability evaluation of slopes which are not parallel or nearly parallel to the bedding.

Figure 3.6 also includes direct shear test data from the previous B-19 Phases II and III investigation (Golder, 1988b) for comparison.

The in-situ rock strengths along bedding planes obtained from the UU triaxial tests were consistently higher than the minimum strengths obtained for similar conditions for the design of B-19 Phases II and III (Golder, 1988b). Therefore, in order to be conservative for B-18 cut slopes in the west-facing direction, it was concluded that the appropriate rock strength along bedding planes should be represented by a friction angle (ϕ) = 36 degrees and a cohesion intercept (c) = 0, as recommended by Golder (1988b).

As shown on Figure 3.6, the shear strength parameters for evaluating slope stability for crossbed conditions was evaluated to be ϕ = 40 degrees and c = 800 pounds per square foot (psf). As can be seen in Figure 3.6, these strength parameters provide an approximately lower-bound limit of the direct shear test data conducted for the B-18 and B-19 (Golder, 1988b) investigations.

3.5.5 Strength Tests on Remolded Samples

The following two types of tests were performed to evaluate the strength of the clay liner for use in assessing the stability of B-18 at different times throughout its life:

1. UU triaxial compression tests were conducted on remolded sandstone and claystone samples to provide strength parameters to assess landfill stability for short-term conditions (i.e., prior to significant clay liner consolidation occurring due to the weight of the overlying waste).

2. Consolidated–undrained (CU) triaxial compression tests were conducted on remolded claystone samples for use in evaluating the long-term stability of B-18 (i.e., after the clay liner consolidation is essentially complete).

The results of the UU and CU triaxial tests are included in Appendices D.6 and D.7, respectively.

The UU triaxial test results indicate that the short-term strength of the clay liner can be represented by ϕ = 8 degrees and c = 3,600 psf. After consolidation is essentially complete, the clay liner is significantly stronger and can be represented by ϕ = 15 degrees and c = 1,500 psf.

CU triaxial compression tests conducted on silty sandstone materials from Stratum 18-9 indicate that the shear strength of these materials when compacted to 95 percent relative compaction can be represented by ϕ = 30 degrees and c = 3,000 psf. These strength parameters are considered appropriate for evaluating the stability of structural fill and embankments constructed from low plasticity borrow materials.

3.5.6 Permeability Tests

The five permeability tests summarized in Table 3.10 were conducted on clay samples derived from the Stratum 18-8 claystone. These tests show that the anticipated permeability under laboratory conditions varies between about 2×10^{-8} and 2×10^{-9} cm/s. For comparison, the field SDRI test performed by ESI (1992) indicated that the permeability of a clay liner constructed of Stratum 18-8 claystone is on the order of approximately 5×10^{-8} cm/s.

The laboratory permeability tests were conducted under a variety of conditions to evaluate the degree to which the particle size and weathering of the claystone may affect its permeability. The first two tests in Table 3.10 were conducted using a maximum particle size of 3/8-inches in the Proctor mold. Although small with respect to field compaction equipment, the 3/8-inch particle size is relatively large for small-scale laboratory permeability tests. The second two tests in Table 3.10 were conducted using a 1/4-inch maximum particle size, which corresponds to the ASTM procedures. The final test in Table 3.10 was designed to simulate the field conditions anticipated for B-18. This test was conducted by allowing the material to weather over a two-week period and without controlling the particle size. This procedure best represents the conditions which are realized in the field as the clay borrow material is mixed, worked, stockpiled, and recovered with wetting operations at various times during these activities. Experience from the Phases I and II construction indicates that adequate permeabilities are realized if a maximum particle size of 1 to 2 inches is maintained.

Recent permeability tests, Geosyntec 2008, indicate the proposed clay liner material has a permeability of less than 1 x 10^{-7} cm/sec. The tests show that the anticipated permeability under laboratory conditions varies between about 9 x 10^{-8} and 4 x 10^{-9} cm/s, and 4.2 x 10^{-8} cm/s based on the field SDRI (see Appendix E.2 and E.3).

3.5.7 Consolidation Tests

Consolidation tests were conducted on two samples of the Stratum 18-8 clay that were compacted to conditions similar to those specified for construction. These tests provided information for:

- Estimating the amount of settlement that will occur in the clay liners as a result of the waste loading; and
- Estimating the rate at which pore pressures will dissipate from the clay liner in order to evaluate if there is a potential for excess pore pressure build-up.

The two consolidation tests showed similar compressive stress versus void ratio relationships. The results of the consolidation tests are included in Appendix D.9.

3.5.8 Shrink/Swell Potential Tests

Tables 3.11 and 3.12 summarize the shrink/swell test results for relatively undisturbed and remolded Stratum 18-8 claystone samples, respectively. The test results for the relatively undisturbed samples in Table 3.11 indicate that the in-situ claystone has low to moderate swell potential under low confining pressures. At high confining pressures, such as those on the base liner system, the swelling potential of the claystone is considered negligible based on the test results in Table 3.11.

The data in Table 3.12 shows that remolded Stratum 18-8 clay has a moderate to high swelling potential under low confining pressures. This indicates that it is important to keep the clay liner materials wet after placement and prior to deployment of the overlying geosynthetics in order to prevent significant desiccation cracking. Appropriate steps were taken to prevent excessive drying of the clay liner during the Phases I and II construction. Similar preventative procedures are specified for the Phase III clay liner construction (see Appendix O.1).

3.5.9 Geochemical Tests

Background geochemical analyses were conducted on representative claystone, siltstone, and sandstone samples prior to the development of B-18. These test results are presented in Appendix D.10.

Additional geochemical analyses were performed on seven bedrock samples collected from the B-18 excavations during the construction of Phases I and II (Golder, 1992; GCS, 1993b). The results of these tests were consistent with the typical natural background composition (in terms of analytes and concentrations) of the San Joaquin Formation bedrock.

3.6 Method 9090 (Liner/Leachate Compatibility Testing

As a condition of the Hazardous Waste Facility Permit (DTSC, 2003) "the Permittee shall test all components of landfill liners for waste/leachate compatibility using EPA Method 9090 or other more appropriate methods approved by DTSC. The liner components include seamed portions of 60-mil [HDPE], [HDPE] geomembrane material, [HDPE] geonet, geotextiles fabric, graded gravel used as drainage material, and [HDPE] piping used in the leachate collection systems."

For Landfill B-18 Phases I and II, leachate samples from an on-site hazardous waste landfill were used to test compatibility with the liner components. The following reports were submitted to the agencies, confirming the acceptability of the materials:

- Chemical Compatibility Testing of National Seal 60 mil Geomembrane with Kettleman Hills Waste Leachate, Soltex Resin, NSC#CO2A, Final Report (TRI/Environmental, Inc., October 14, 1991)
- Leachate Compatibility of Geosynthetic Materials – Kettleman Hills Facility, Final Report (J&L Testing Company, November 4, 1991)
- Geotechnical Laboratory Test Results Aggregate/Leachate Compatibility Testing, Kettleman Hills Facility, (J&L Testing Company, November 7, 1991)
- NSC 60 mil Textured HDPE Chemical Compatibility Testing EPA Method 9090 – Kettleman Hills Facility, (J&L Testing Company, September 8, 1992)

The materials that were tested in 1991 and 1992 (during the B-18 construction) by J&L Testing Company included:

Gundle XL-14 Geonet
NSC PN-3000 Geonet
Trevira 1125 Geotextile
Gundle 60mil HDPE Geomembrane
Gundle 60mil Textured HDPE Geomembrane (New Resin)
NSC 60 mil Textured HDPE Geomembrane (1992 testing)
PVC Pipe
HDPE Pipe
LCRS Gravel

Testing was conducted in accordance with the Test Protocol and Methodology for Compatibility Testing (CWMI, May 31, 1988, revised August 31, 1989). This Test Protocol was approved with the issuance of EPA Permit Modification #2 and DTSC Permit Modification #1. Results of the testing indicate that the liner components, when exposed to leachate, would function satisfactorily and had no adverse cumulative effect on the physical and/or engineering properties.

Phase III will utilize similar materials for the construction of the liner components. The previous test results as well as industry-wide testing of liner materials with leachate (see Appendix F, Attachment 3), indicate that the proposed materials will function without adverse effect due to the exposure to leachate. Based on these data, no additional compatibility testing is proposed for materials to be used in the construction of Phase III. As allowed by the Hazardous Waste Facility Permit, the "existing test data from similar studies, and manufacturer supplied specifications [may be] used as an alternative [to testing]."

4.0 LANDFILL B-18 DESCRIPTION

4.1 General

This section describes the B-18 design configuration, the key elements of B-18, and the supporting reasoning for the B-18 design.

B-18 development includes the following three phases:

- Phase I, which was constructed from October 1990 to February 1992 and has a footprint area of approximately 21 acres as shown on Sheet 2 in Appendix A.1.
- Phase II, which was constructed from August 1992 to November 1993 and has a footprint area of approximately 32 acres as shown on Sheet 2 in Appendix A.1.
- Phase III, which is anticipated to be constructed in 2012 and will have a footprint area of approximately 13.8 acres as shown on Sheet C-3 in Appendix A.2.

The landfill components and construction procedures for the three phases and final closure of B-18 are described in the following documents:

1. The Drawings for Phases I and II provided in Appendix A.1. It is noted that the original final closure design of B-18 shown on the Drawings in Appendix A.1 is superseded by the final closure design shown on the Drawings in Appendix A.2 and discussed herein.
2. The Drawings for Phase III and final closure provided in Appendix A.2.
3. The Specifications and CQA Plan for Phases I and II (ESI, 1990b).
4. The Specifications for Phase III and final closure contained in Appendices O.1 and O.2, respectively.
5. The CQA Plans for Phase III and final closure presented in Appendices P.1 and P.2, respectively.
6. The CQA Reports prepared for Phase I, which consist of the following:
    a. Volume 1 – Subgrade Geologic Mapping Report (Golder, 1992).
    b. Volume 2 – Clay Liner Source Report (ECS, 1992a).
    c. Volume 3 – Secondary Clay Liner Construction Report (ECS, 1992b).
    d. Volume 4 – Secondary HDPE Liner and Leachate Collection System Construction Report (ECS, 1992c).
    e. Volume 5 – Primary Clay Liner Construction Report (ECS, 1992d).

f. Volume 6 – Primary HDPE Liner and Leachate Collection System Construction Report (ECS, 1992e).

g. Volume 7 – Summary Construction Observation Report (ECS, 1992f).

h. Volume 8 – Operational Features Report (ECS, 1992g).

i. Volume 9 – Design Changes and Design Clarifications Report (ECS, 1992h).

7. The CQA Reports prepared for Phase II, which consist of the following:

   a. Volume 1 – Clay Liner Source Report (GCS, 1993a).

   b. Volume 2 – Subgrade Geologic Mapping Report (GCS, 1993b).

   c. Volume 3 – Excavation and Structural Fill Placement Construction Report (GCS, 1993c).

   d. Volume 4 – Secondary Clay Liner Construction Report (GCS, 1993d).

   e. Volume 5 – Secondary and Vadose HDPE Liner and Leachate Collection System Construction Report (GCS, 1993e).

   f. Volume 6 – Primary Clay Liner Construction Report (GCS, 1993f).

   g. Volume 7 – Primary HDPE Liner and Leachate Collection System Construction Report (GCS, 1993g).

   h. Volume 8 – Summary Construction Observation Report (GCS, 1993h).

   i. Volume 9 – Operational Features Report (GCS, 1993i).

An overview of the existing Phases I and II of B-18 is provided on the following sheets in Appendix A.1:

- Sheet 2 shows the Phases I and II areas and the former stockpile areas that were used for temporary storage of excavated materials during the construction of Phases I and II.

- Sheet 3 shows the Phase I subgrade elevations and the initial Phases I and II clay borrow area configuration in the Stratum 18-8 claystone described in Section 3 (see Figures 3.1 and 3.2).

- Sheet 7 generally shows how the Phases I and II clay borrow area was expanded after completion of Phase I but prior to the construction of Phase II. However, the grades shown on Sheet 7 were adjusted such that overexcavation below the Phase II subgrade was avoided.

- Sheet 8 shows the interim closure of Phase I and the Phase II subgrade elevations.

An overview of the proposed Phase III and final closure of B-18 is provided on the following sheets in Appendix A.2:

- Sheet C-1 and C-2 show the existing conditions of the B-18 area (as of March 28, 2008) and the location of the Phase III clay borrow area (borrow is within Landfill B-17).
- Sheet C-3 shows the subgrade elevations for all of B-18.
- Sheet C-4 illustrates the configuration of the B-18 closure cover final development grades (including benches, drainage, and access roads) for B-18.
- Sheets C-5 and C-6 show critical cross sections that further detail the development of B-18
- Sheet C-7 provides critical details for the liner cross section, liner termination, liner tie-in, and other items required for development of B-18.
- Sheet C-8 provides critical details for the extension of the existing leachate riser system as well as development of a replacement leachate riser and tank station.
- Sheet C-9 provides details to convey drainage into the new southern retention basin.
- Sheet C-10 provides additional drainage bench details and the final cover profile.

Detailed descriptions of the B-18 design are provided in the following sections:

- Section 4.2 – Phase I;
- Section 4.3 – Phase II;
- Section 4.4 – Phase III;
- Section 4.5 – Final Closure;
- Section 4.6 – Clay Borrow Operations;
- Section 4.7 – Liner Systems;
- Section 4.8 – Leachate Collection and Recovery Systems;
- Section 4.9 – Surface Water Control; and
- Section 4.10 – Utilities.

4.2 Phase I

Phase I comprises the western 40 percent (approximately) of the existing B-18 area (see Sheets 2 to 6 in Appendix A.1). Phase I of B-18 was configured so that:

- Disposed wastes are located within the 1990 CUP Facilities Boundary (Kings County, 1990).
- The number of boundary curves, which complicate excavation and liner construction, were minimized.
- Approximately 1,000,000 cubic yards of waste (including daily cover) were disposed of in Phase I.
- The waste is adequately stable under the operating and interim fill conditions.

The north, south, and west sides of Phase I form the originally-planned ultimate B-18 limits and were constructed as the final waste containment boundary. However, the proposed Phase III expansion will extend the ultimate limits of B-18 such that the Phase I area will be bordered by Phase III along the full length of its north, south, and west sides. The entire east side of Phase I is bordered by Phase II. Prior to the construction of Phase II, the east boundary of Phase I consisted of a berm (the Phase I/II Berm) that rises approximately 40 to 45 feet above the landfill base (see Sheets 3 and 8 in Appendix A.1). The Phase I/II Berm allowed waste to be filled in horizontal lifts in Phase I without having a laterally-unsupported waste slope on the Phase I base liner system. This minimized the risk of slope instability during Phase I disposal operations. The Phase I/II Berm is a permanent feature of the B-18 floor.

Almost all of Phase I is within excavated rock of the San Joaquin Formation. The only significant areas that required structural fill during the construction of Phase I were along the B-18 Perimeter Road near the northwest and southwest corners of B-18, as shown on Sheet 3A and in Section A-3A/15 on Sheet 15 in Appendix A.1.

The former access route into the Phase I area during its initial filling is illustrated on Sheet 5 in Appendix A.1. The main waste truck access included the following segments:

- Entering B-18 near the northwest corner of Phase I.
- Proceeding southward along the northern two–thirds (approximately) of the B-18 Perimeter Road on the west side of B-18.
- Proceeding down the 35-foot-wide access ramp on the west, south, and east Phase I waste area slopes. Special liner and road construction details for this access ramp are discussed in Section 4.7.3.3.

The Phase I waste area access ramp discussed above was aligned to intersect the top of the Phase I/II Berm near the southeast corner of Phase I. This allowed operations personnel to move landfill equipment and daily soil cover into the Phase I waste area along a temporary road on top of the Phase I/II Berm without impacting the main waste truck access. The appropriate manner for handling site traffic was refined on an on-going basis as operational experience was gained.

The existing B-18 Perimeter Road (see Section A-3,8/15 on Sheet 15 and Section A on Sheet 17 in Appendix A.1) is typically set back approximately 20 feet from the waste disposal limit to allow for the future construction of the final closure cover (Section 4.5). This separation is wider at two locations along the western portion of the B-18 Perimeter Road to accommodate the leachate collection and recovery system (LCRS) riser pads.

The base of Phase I is subdivided into two separate leachate collection zones that are referred to as Areas IA and IB, as shown on Sheets 2 through 5 in Appendix A.1. These areas are sloped toward two separate leachate sumps. This arrangement reduces the flow length for leachate to be collected as compared to an arrangement with only one sump at either end of the Phase I base. The sump areas are described in Section 4.8.

Waste was placed in nearly level, 10-foot-thick lifts across the entire Phase I area. This filling method avoided the condition of having interim waste slopes that were supported directly on the liner system. The interim waste surface was sloped slightly toward the north to allow for collection of surface water at a single location away from the waste fill access ramp.

Sheet 6 in Appendix A.1 shows the Phase I Intermediate Closure configuration that provided approximately 1,000,000 cubic yards of initial airspace in the Phase I area. The intermediate closure was primarily an operational condition to allow time for the then newly constructed Phase II to be filled to an elevation above the Phase I/II berm. Design considerations for this intermediate fill plan consisted of the following:

- A maximum waste elevation of approximately 810 feet to provide the 1,000,000 cubic yards of airspace.
- The east-facing intermediate closure slope was configured to provide adequate stability against a potential wedge failure occurring along the liner system. This stability consideration is discussed in Section 5.3.4.
- The south-facing intermediate closure slope was configured such that the access ramp to the Phase I waste area was maintained to provide access into the Phase II disposal area.
- The north-facing intermediate closure slope was provided to avoid having any laterally-unsupported portion of the waste fill directly on the liner system.

The Phase I Intermediate Closure top deck included a run-off collection sump to temporarily collect direct rainfall run-off from the top deck area. Control of this run-off is described in Section 4.9.3.

Once the Phase I Intermediate Closure elevations were reached, the flatter portions of the intermediate closure slopes (i.e., the top deck slopes) were temporarily covered by a nominal soil foundation layer and an overlying temporary 40-mil HDPE geomembrane for infiltration control. The temporary run-off collection sump in the top deck area was also lined with a 40-mil HDPE geomembrane to minimize infiltration during the infrequent periods when surface water was temporarily retained in this sump. The sideslope portions of the Phase I Intermediate Closure area were covered with soil as shown in Section A-6/23 on Sheet 23 in Appendix A.1 to provide stability and infiltration control. This soil was recovered and used for daily cover when waste disposal in the Phase I area resumed. Additionally, the 40-mil HDPE geomembrane was removed prior to covering the interim Phase I top deck with additional waste.

4.3 Phase II

Phase II comprises the eastern 60 percent (approximately) of the existing B-18 area (see Sheets 2, 8, 9, and 10 in Appendix A.1). This area encompasses the initial Phases I and II clay borrow area (excavated during the Phase I construction), the Phases I and II clay mixing area shown on the Drawings in Appendix A.1, and the Phase II clay borrow area expansion shown on Sheet 7 in Appendix A.1 (excavated prior to the construction of Phase II). Phase II of B-18 was configured so that:

- Disposed wastes are located within the 1990 CUP Facilities Boundary (Kings County, 1990).
- The number of boundary curves, which complicate construction, were minimized.
- The waste is adequately stable under the operating and interim fill conditions.

The eastern portion of Phase II was located to allow for the construction of the Northeast Containment Basin (see Sheet C-2 and C-3 in Appendix A.2).

Most of the Phase II area was also formed by excavation into rock of the San Joaquin Formation. A fill embankment was constructed along the eastern portion of Phase II where the former main natural drainage channel formed a low spot in the B-18 perimeter (see Figure 2.1). This fill embankment contains waste on its western (Phase II) side and forms the western sideslope of the Northeast Containment Basin on its eastern side. A cross-section of this embankment is shown in Section A-8/23 on Sheet 23 in Appendix A.1. Fill was also placed along the southern portion of the B-18 Perimeter Road (see Section D-8/15 on Sheet 15 in Appendix A.1) and to form the remaining upper sideslopes of the Northeast Containment Basin.

Waste truck access into Phase II occurred along the previously-described (see Section 4.2) access route into Phase I. This was accomplished by extending the Phase I access ramp across the Phase I/II Berm and then constructing an access ramp down the southern Phase II sideslope, as shown on Sheet 9 in Appendix A.1. This access ramp was 44 feet wide (see Section A on Sheet 16A in Appendix A.1) to provide adequate room for waste truck and operations equipment traffic.

As with Phase I, the existing B-18 Perimeter Road (see Section A-3,8/15 on Sheet 15 and Section A on Sheet 17 in Appendix A.1) is typically set back approximately 20 feet from the Phase II waste disposal limit to allow for the future construction of the final closure cover (Section 4.5). This separation is wider at two locations along the northeastern and southeastern portions of the B-18 Perimeter Road to accommodate the Phase II LCRS riser pads.

Phase II is also provided with two separated sumps (see Sheets 8, 9, and 10 in Appendix A.1) serving areas designated as Areas IIA and IIB. These sumps are located to optimize drainage distances within the Phase II LCRS and to provide access for the leachate pump and storage facilities along the Phase II perimeter.

Waste placement in the Phase II area also occurred in nearly level lifts to avoid laterally-unsupported slopes against the liner system. A slight slope on the waste surface was maintained toward one or two low areas during filling to allow for collection of direct rainfall run-off in the Phase II area. Procedures that were used for handling this run-off are described in Section 4.9.5.

When the waste elevation in Phase II reached the Phase I/II berm height, the entire existing B-18 Landfill began operating as a single contiguous disposal area.

4.4 Phase III

The proposed Phase III vertical and lateral expansion of B-18 will increase the footprint area of the landfill by approximately 14 acres. Most of the lateral expansion area will be along the existing western, northwestern, and southern edges of B-18. Sheet C-3 in Appendix A.2 shows the limit of the existing B-18 liner system and the limit of the Phase III expansion area. Phase III of B-18 is configured so that:

- Disposed wastes are located within the modified CUP Facilities Boundary.
- The number of boundary curves, which complicate construction, will be minimized.
- The maximum waste elevation is increased from 965 feet to 1,018 feet, which provides B-18 with a total airspace of approximately 15,700,000 cubic yards. Of this total airspace capacity (volume between base grades and final grades which includes lining and final cover systems), the expansion of B-18 accounts for approximately 5,000,000 cubic yards of airspace.
- The waste is adequately stable under the operating, interim, and final fill conditions.

Construction of the Phase III liner system will be completed in one continuous construction sequence in accordance with the certified EIR. However, to facilitate early use of a portion of the expansion area, KHF will submit a CQA certification report for the 3.5-acre Phase IIIA area in the northwestern portion of the Phase III expansion area. Once approval from the regulatory agencies is obtained, the site will begin placement of waste within the approved Phase IIIA limits. Construction of the Phase IIIB liner system will continue and would be expected to be completed within 6 months of the initiation of waste placement in Phase IIIA. A separate CQA certification report will be prepared and submitted for Phase IIIB.

The configuration of the Phase IIIA waste fill is shown on Sheet C-4A in Appendix A.2. As can be seen on Sheet C-4A, the waste placement in Phase IIIA will involve filling to final design grades along the north, east, and west portions of the landfill. The south limit of waste in Phase IIIA will terminate in a 2H:1V interim waste fill slope. A lined temporary stormwater containment berm will be provided a minimum of 10 feet from the toe of the Phase IIIA interim waste slope as shown in Detail 1 on Sheet C-4A. This temporary berm will prevent stormwater run-off from the 24-hour PMP storm event from leaving the Phase IIIA area and will also prevent stormwater run-on from entering the Phase IIIA area from the south, as discussed in Sections 5.5.5 and 5.5.4, respectively. The Phase IIIA area will not involve the construction of any leachate controls; the temporary stormwater containment berm will also serve to contain leachate and direct this leachate to the adjacent Phase IA leachate collection system.

The southern limits of Phase III are located to allow for the construction of a second surface water run-off containment basin for B-18, herein referred to as the South Containment Basin, which will be built during the construction of Phase IIIB. The layout of Phase III and the South Containment Basin also allows two of the existing groundwater monitoring wells along the south side of B-18 (K-51 and K-32R) to be protected during the construction of Phase III. Monitoring well K-68 will be extended due to soil fill placement in the vicinity of this well.

The Phase III expansion will involve the construction of an additional sideslope liner system only (i.e., no additional base liner will be installed). Most of the Phase III sideslope liner will be constructed over either the existing B-18 Perimeter Road or the existing rock cut slopes located above the existing B-18 Perimeter Road. The existing rock cut slope will be regraded to the proposed design subgrade for Phase III. A fill embankment will be required along much of the southern and southeastern boundary of the Phase III limits to build this area up to the design subgrade elevations. This fill embankment will contain the waste on its northern (Phase III) side and will form the northern sideslope of the South Containment Basin on its southern side. A cross-section of this embankment is shown in Section D on Sheet C-5 in Appendix A.2.

Waste truck access into the Phase III disposal area will be initially through the existing entry point into B-18 at its northwest corner. Access to B-18 will eventually be relocated to the west side perimeter access road as the waste fill is extended above the surrounding topography.

The new B-18 Perimeter Road (see Sheet C-3 and C-4 in Appendix A.2) will typically be set back a minimum of 20 feet from the Phase III waste disposal limit to allow for the future construction of the final closure cover (Section 4.5). This separation will be wider at the locations of the three LCRS riser pads (the riser pads for Areas IA, IB, and IIB) that will be relocated up to the new B-18 Perimeter Road during the Phase III construction.

Phase III will not include any additional floor areas. Hence, no new LCRS sumps will be constructed as part of Phase III. Depending upon where leachate originates within Phase III, it will flow to one of the four existing sumps (IA, IB, IIA, and IIB).

Similar to Phases I and II, waste will be placed in the Phase III area in nearly level lifts to avoid laterally-unsupported slopes against the liner system. A slight waste surface slope will be maintained toward one or two low areas during operations to allow for collection of direct rainfall run-off in the Phase III area. Procedures that will be used for handling this run-off are described in Section 4.9.7.

4.5 Final Closure

Sheet C-4 in Appendix A.2 shows the proposed B-18 final closure configuration, which is based on the following parameters:

- Overall closure slope inclinations of 4H:1V.
- Approximately 25-foot wide benches at maximum vertical intervals of 50 feet.
- Approximately 3.5H:1V slope inclinations between the individual benches.

Access to each final cover bench and the top deck will be provided by either the new B-18 Perimeter Road or the Cover Access Road that will run up the west sideslope of B-18 at the approximate location shown on Sheet C-4 in Appendix A.2. This Cover Access Road will be developed during operations to haul waste onto the above-grade disposal areas.

The final cover benches will be sloped to direct surface water flow to the Cover Access Road and/or the new B-18 Perimeter Road. The longitudinal slope of the benches will generally be about 2 percent to control flow velocities and to allow adjustment for differential settlement of the waste. The Cover Access Road and the new B-18 Perimeter Road will both be sloped at about 8 percent in most locations.

Each final cover bench will be configured as a trapezoidal drainage ditch to provide the necessary capacity to adequately convey surface water flows resulting from the 6-hour Probable Maximum Precipitation (PMP) storm event. The 6-hour PMP is used to design conveyance structures (e.g. channels) since the rainfall intensity is greater than the 24-hour PMP, and is therefore conservative. The Cover Access Road will be configured with a lined V-ditch to convey surface water flows from the 100-year 24-hour storm event. In the event of the 6-hour PMP storm event, the flow will be contained within the road width.

In accordance with the current Hazardous Waste Facility Permit for the KHF (DTSC, 2003), the final cover system for B-18 will consist of the following components (from bottom to top):

- Intermediate soil cover (minimum of 1 foot) over the last lift of waste.
- A foundation layer consisting of a minimum of 1 foot of compacted soil having a maximum permeability of $1x10^{-5}$ cm/s.
- 40-mil textured HDPE geomembrane.
- A 12 oz/sy nonwoven geotextile.
- A minimum 2.5-foot-thick vegetative cover soil layer. The top surface of the vegetative cover soil layer will be vegetated with plants having shallow root depths. Seed types for the final cover vegetation are provided in Section 02924 of the final closure Specifications in Appendix O.2.

The portions of the geomembrane located under the Cover Access Road and benches will be sloped at a minimum of 2 percent toward the outside of the landfill so that any water in the geotextile drainage layer can flow toward the toe of the cover system around the perimeter of the landfill.

Detail 4 on Sheet C-7 in Appendix A.2 shows the typical perimeter detail of how the final cover system will be terminated and toed out onto the B-18 Perimeter Road. The HDPE geomembrane and geotextile of the cover system will be terminated approximately 5-feet out beyond the limit of the foundation layer.

In accordance with 22 CCR 66264.111 and 66264.310, B-18 has been designed to be closed in a manner that will:

- Minimize the need for further maintenance;
- Control, minimize or eliminate, to the extent necessary, to protect human health and the environment, post-closure escape of hazardous waste, hazardous constituents, leachate, contaminated rainfall or run-off, or waste decomposition products to groundwater, surface water or the atmosphere;
- Prevent the downward entry of water into the closed landfill throughout a period of at least 100 years;
- Promote drainage;
- Accommodate settling and subsidence so that the cover's integrity is maintained; and

- Accommodate lateral and vertical shear forces generated by the MCE.

After waste acceptance ceases in B-18, the intermediate cover/foundation layer will be graded per the final closure grading plan, as shown on Sheet C-4. A 40 mil HDPE geomembrane, geotextiles and vegetative cover will be constructed over the foundation layer. The entire cover will be vegetated for erosion control. The final cover has been designed to avoid ponding, control run-off, minimize erosion and withstand the MCE event. Therefore the cover will function with minimum maintenance. The base liner and closure cover will provide barriers to protect human health and the environment.

Post-closure inspections will be performed and post-closure maintenance will occur in accordance with the Hazardous Waste Facility Permit (DTSC, 2003).

4.6 Clay Borrow Operations

4.6.1 Phases I and II

The initial Phases I and II clay borrow area excavation was completed during the Phase I excavation as shown on Sheet 3 in Appendix A.1. Sheet 7 in Appendix A.1 shows how the Phases I and II clay borrow area was extended toward the southeast before the Phase II construction began. The cross-sections on Figure 3.2 illustrate how the area was excavated to borrow clay from the thick Stratum 18-8 claystone in the Phase II footprint.

The west-facing sideslope of the clay borrow area was excavated along the rock's dip as the claystone was recovered down to the underlying stratum. This sideslope had an inclination of approximately 25 to 30 degrees on average. The other sideslopes of the clay borrow area cut across bedding planes and were inclined at 2H:1V.

A bench was provided around the initial borrow area (see Sheet 3 in Appendix A.1) at an elevation of approximately 720 feet. This bench was used to anchor the 40-mil HDPE geomembrane (see Section B on Sheet 13 in Appendix A.1) in the bottom of the borrow area. This lined area served as an interim containment basin for run-off from the Phase I access roads.

Sheet 3 in Appendix A.1 also shows how the eastern portion of the Phase II area was initially graded to create a relatively flat clay mixing area. KHF construction crews prepared the claystone in this area to achieve the required engineering properties for clay liner material. The clay preparation procedures used for the Phases I and II construction included the following activities:

- Ripping and excavation of the claystone in a manner that reduced the friable material to relatively small particle sizes;
- Mechanical breakdown of the excavated material to further reduce particle sizes; and
- Moisture conditioning of the clay liner material on mixing tables.

The clay liner test pad described in Appendix E.1 was constructed of Stratum 18-8 clay from the Phases I and II borrow source. This clay liner test pad program demonstrated that the Stratum 18-8 clay was suitable for use as clay liner material under field conditions.

4.6.2 Phase III

The Phase III clay borrow area will be located adjacent and north of Landfill Unit B-17 (i.e., northwest of B-18), as shown on Sheet C-1 in Appendix A.2. This clay borrow source consists of a thick bed of the Pecten Claystone (see Appendix E.2). The contractor will be responsible for excavating and processing all of the required clay liner material for Phase III. Excavation and processing of the Pecten Claystone may be performed as part of the construction of various phases of Landfill B-17. KHF personnel will instruct the contractor on the appropriate excavation configurations to be used when mining the Pecten Claystone from the borrow area.

Sheet C-1 in Appendix A.2 also shows the designated clay mixing area that will be used by the contractor to process and prepare the clay liner material. This mixing area will be located adjacent to the clay borrow area (i.e., northwest of B-18). The final clay preparation procedures, to be determined by the contractor, may include combinations of the following activities:

- Ripping and excavation of the claystone in a manner that reduces the friable material to relatively small particle sizes;
- Crushing of the excavated material to further reduce particle sizes;
- Blending different portions of the claystone by the use of a pugmill or discing the material in lifts; and
- Pre-wetting stockpiled clay material with fresh water and/or a weak dispersant solution to accelerate weathering prior to re-excavation of the stockpiled clay.

A clay liner test pad was constructed from the Pecten Claystone material at the end of July 2008. The SDRI test report was completed in December 2008 (Geosyntec, 2008a). This clay liner test pad program verified the adequacy of the clay material from the Phase III borrow source when placed and compacted under actual field conditions. Based on laboratory testing and the SDRI test by Geosyntec (see Appendices E.2 and E.3), the Pecten Claystone material meets the requirements for use as clay liner. Additional pre-construction testing will be performed to confirm materials used for the construction meet the specified properties.

For Phase III, the compacted clay liner will be constructed using the same specifications as were used for the Phases I and II clay liner (see Section 4.7.2.1). Similar construction equipment will be used to compact the Phase III clay liner as was used to construct the Phases I and II clay liner test pad.

4.7 Liner Systems

4.7.1 General

Liner system details and sections for Phases I and II are shown on Sheets 16 through 22A in Appendix A.1. The Phase III and final closure liner system details and sections are shown on Sheets C-7 through C-10 in Appendix A.2. The B-18 liner configurations are generally the same as those successfully used for prior KHF disposal WMUs. The primary modifications to the B-18 liner system design compared to KHF landfills designed prior to 1990 are:

- The use of textured HDPE geomembranes throughout B-18 and the use of geocomposites and geotextiles on the sideslope areas to improve the stability of B-18.

- The use of protective liner material on the B-18 sideslopes to provide temporary ultraviolet protection to the underlying geotextile component of the geocomposite. This protective liner is removed as the operations layer soil is periodically extended up the slope in advance of the waste mass.

Each of the basic liner systems used in B-18 are described in Section 4.7.2. Special liner construction details (e.g., anchor trenches) are described in Section 4.7.3. Appendix F.1 contains data sheets that list representative properties of the geosynthetic materials used in the construction of Phases I and II. Similarly, Appendix F.2 contains data sheets that list typical properties of the geosynthetic materials that will be used in the construction of Phase III and the final cover. The CQA reports for Phases I and II contain detailed information on the properties of the existing B-18 liner systems.

4.7.2 Liner System Configurations

4.7.2.1 Base Liner

The existing base (i.e., floor) areas of B-18 were each graded to drain toward a sump where leachate is monitored and collected in the three separate zones (primary, secondary, and vadose) described in Section 4.8. The entire base of each of the four areas (IA, IB, IIA, and IIB) was graded at 2 percent toward a central flow line. The central flow line in each area was sloped at 2.4 percent toward that area's respective collection sump. No new base area will be constructed for Phase III.

Detail 2 on Sheet 16 in Appendix A.1 shows the general B-18 base liner system configuration, which consists of the following components (from top to bottom):

- A 2-foot-thick (minimum) base soil operations layer. This operations layer was constructed from on-site granular material with a maximum particle size of 6 inches. The purpose of this layer was to provide a working surface for waste trucks and landfill equipment while protecting the underlying liner system components.

- A 1-foot-thick (minimum) primary LCRS consisting of the following components (from top to bottom):

  An 8 oz/sy nonwoven geotextile (Trevira 1125) to function as a filter below the operations layer soil.

  A 12-inch-thick (minimum) drainage gravel layer. A single-sided geocomposite filter/drainage layer consisting of an 8 oz/sy nonwoven geotextile (Trevira 1125) thermally-bonded to one side of a Polynet 3000 geonet. The geocomposite was placed with the geotextile facing up.

  An 8 oz/sy nonwoven geotextile (Trevira 1125) to provide increased interface shear strength.

- A composite primary liner consisting of the following components (from top to bottom):

  A 60-mil textured HDPE geomembrane.

A 1.5-foot-thick (minimum) layer of compacted clay having a maximum permeability of 1 x 10^{-7} cm/s.

- A secondary LCRS consisting of the following components (from top to bottom):

  A 16-oz/sy nonwoven geotextile (Trevira 1155) to function as a filter below the primary clay liner.

  An approximately 12-inch-thick layer of drainage gravel.

  A single-sided geocomposite filter/drainage layer consisting of a 16-oz/sy nonwoven geotextile (Trevira 1155) thermally-bonded to one side of a Polynet 3000 geonet. The geocomposite was placed with the geotextile facing up.

  An 80-foot-wide layer of Polynet 3000 geonet centered along the entire secondary LCRS flow line above the vadose trench.

  A 16-oz/sy nonwoven geotextile (Trevira 1155) to provide increased interface shear strength.

- A composite secondary liner consisting of the following components (from top to bottom):

  A 60-mil textured HDPE geomembrane.

  A 3.5-foot-thick (minimum) layer of compacted clay having a maximum permeability of 1x10-7 cm/s.

- A prepared subgrade that was graded smooth and proof-rolled to assure that soft or loose zones did not exist.

Both of the clay liners (primary and secondary) were placed in 8-inch-thick (maximum) loose lifts before compaction. The Phases I and II Specifications (ESI, 1990b) required the clay to be compacted to a dry density of at least 90 percent of its Modified Proctor maximum dry density (ASTM D1557) at a water content wet of optimum (ASTM D1557). During the Phase I construction, the clay liner placement specifications were modified to allow the compacted clay's dry density and moisture content to lie within the window defined by the following four points on a moisture-dry density plot:

- Two (2) percent above the optimum moisture content for a dry density equal to 90 percent of the Modified Proctor maximum dry density.

- Five (5) percent above the optimum moisture content for a dry density equal to 90 percent of the Modified Proctor maximum dry density.

- One (1) percent above the optimum moisture content for a dry density equal to 98 percent of the Modified Proctor maximum dry density.

- Three (3) percent above the optimum moisture content for a dry density equal to 97 percent of the Modified Proctor maximum dry density.

This window, which allowed a lower water content for higher compactive efforts, was established to:

- Assure that both the required strength and permeability characteristics of the clay were achieved; and

- Provide the flexibility needed for controlling the clay's moisture content in an arid environment.

It should be noted that an allowance was made for up to 20 percent of the clay moisture-density test results to be slightly outside the above-described compaction window by ±0.5 percent for moisture content and -0.5 percent for relative compaction as long as the average of all acceptable tests for the day fell within the compaction window. The above-described compaction window (along with the allowance for outliers) was used for both the Phases I and II clay liner construction and was formally documented in two design change letters prepared by ESI and contained in the CQA reports for Phases I and II (ECS, 1992h; GCS, 1993h). Copies of both of these ESI letters are included in Appendix E.4.

4.7.2.2 Vadose Zone Trench

Section C on Sheet 16 in Appendix A.1 shows the 12-foot-wide vadose trench that is located directly below the secondary clay liner and along the flow line of the LCRS. Key elements of the vadose trench are:

- An 80-mil smooth HDPE geomembrane, which extends approximately 2.5 feet beyond both sides of the trench; and

- A 1-foot-thick layer of drainage gravel wrapped in a 16-oz/sy nonwoven geotextile (Trevira 1155).

4.7.2.3 Phases I and II Sideslope Liner

Detail 1 on Sheet 16 in Appendix A.1 shows the typical existing Phases I and II sideslope liner system configuration. This system includes each basic component of the base liner system except the drainage gravel layers and the primary clay liner, none of which are required due to the relatively steep inclination of the sideslope liner system and the resulting rapid drainage of any liquids in the LCRS. The Phases I and II sideslope liner system consists of the following components (from top to bottom):

- A 2-foot-thick (minimum) soil operations layer to protect the liner system from the disposal operations. A 1-inch maximum particle size criterion was established for the slope operations layer because this material was placed directly against the geosynthetic layers. The slope operations layer was placed in increments at least 3 feet but not more than 10 feet above the rising waste level.

- A temporary protective liner to protect the underlying geotextile component of the geocomposite from ultraviolet light prior to placement of the operations layer. This protective liner consisted of white 40-mil smooth HDPE geomembrane and was removed as the operations layer was placed.

- A primary LCRS consisting of a single-sided geocomposite underlain by an 8 oz/sy nonwoven geotextile (Trevira 1125). The single-sided geocomposite consisted of an 8 oz/sy nonwoven geotextile (Trevira 1125) thermally-bonded to a Polynet 3000 geonet and was placed with the geotextile facing up. In construction of Phase II the components were combined in a double-sided geocomposite.

- A primary liner consisting of a 60-mil textured HDPE geomembrane.

- A secondary LCRS consisting of a single-sided geocomposite underlain by an 8 oz/sy nonwoven geotextile (Trevira 1125). The single-sided geocomposite consisted of an 8 oz/sy nonwoven geotextile (Trevira 1125) thermally-bonded to a Polynet 3000 geonet and was placed with the geotextile facing up. In construction of Phase II the components were combined in a double-sided geocomposite.

- A composite secondary liner that is the same as that used in the base liner system and consists of the following components (from top to bottom):

  A 60-mil textured HDPE geomembrane.

  A 3.5-foot-thick (minimum) layer of compacted clay having a maximum permeability of 1×10^{-7} cm/s.

- The sideslope subgrade that was prepared differently than the subgrade for the base liner in order to increase stability of the clay liner. The sloped subgrade surface was scarified to a depth of approximately 4 inches as the clay liner was placed to create a rough interface between these two soil layers.

4.7.2.4 Phase III Sideslope Liner

Detail 1 on Sheet C-7 in Appendix A.2 shows the typical Phase III sideslope liner system configuration. This system is the same as the existing sideslope liner system for Phases I and II except the secondary clay liner will have a minimum thickness of 3 feet instead of 3.5 feet and double-sided geocomposites will be used instead of single-sided geocomposites with an underlying geotextile. The Phase III sideslope liner system will consist of the following components (from top to bottom):

- A 2-foot-thick (minimum) soil operations layer with a 1-inch maximum particle size criterion. The slope operations layer will be placed in increments at least 3 feet but not more than 10 feet above the rising waste level.

- Prior to the placement of the 2-foot-thick operations layer on the slope, a temporary 40 mil thick white HDPE protective liner will be installed. The protective liner will be removed as the operations layer is placed.

- A primary LCRS consisting of a double-sided geocomposite.

- A primary liner consisting of a 60-mil textured HDPE geomembrane.

- A secondary LCRS consisting of a double-sided geocomposite.

- A composite secondary liner consisting of the following components (from top to bottom):

  A 60-mil textured HDPE geomembrane.

  A 3-foot-thick (minimum) layer of compacted clay having a maximum permeability of 1 x 10^{-7} cm/s.

- A prepared subgrade that will be scarified to a depth of approximately 4 inches as the clay liner is placed to create a rough interface between these two soil layers.

4.7.2.5 Base to Sideslope Liner Transition

Details 4 and 5 on Sheet 16 in Appendix A.1 show how geotextiles were wrapped around the ends of the drainage gravel and clay layers where the existing base and sideslope liner systems meet. Since there will be no connection between the new Phase III side slope liner and any of the base liner areas of Phases I and II, this does not apply to construction of the Phase III area.

4.7.2.6 Final Cover Liner

The final closure cover liner system for B-18 will be similar to the final cover liner system approved in the Part B Permit and which has been used for closure of several other WMUs at KHF. The final closure cover liner system is described in Section 4.5.

4.7.3 Special Liner Details

4.7.3.1 Sideslope Liner Anchor Trenches

Detail 3 on Sheet 16 in Appendix A.1 shows the typical existing sideslope liner system anchor trench around the perimeter of the existing landfill. The primary requirements of the anchor trench are to prevent the geosynthetic components of the liner system from being pulled down the slope and to minimize the potential for surface water to enter the LCRSs. A vertical separation of 0.5 feet was maintained between the individual geosynthetic components in the anchor trench to provide soil friction against each of these geosynthetics. A 3-foot-tall soil berm was installed above the anchor trench to increase the frictional resistance on the geosynthetic components and to control surface water drainage.

The construction of Phase III will result in some of the existing anchor trenches being removed, as shown in Detail 5 on Sheet C-7 in Appendix A.2. The new anchor trenches for the Phase III sideslope liner system will typically have the configuration shown in Detail 2 on Sheet C-7 in Appendix A.2. The new anchor trenches will be configured similar to the existing anchor trenches except that the 0.5-foot vertical separation between geosynthetic components in the anchor trench is not required and the depth and width of the Phase III anchor trench are slightly less than that of the existing anchor trench.

The final closure cover system will be installed above the perimeter anchor trench as shown in Detail 4 on Sheet C-7 in Appendix A.2. This detail was described in Section 4.5.

4.7.3.2 Temporary Phase I/II Transition Anchors

The B-18 liner system was temporarily terminated along the eastern edge of Phase I prior to the construction of Phase II. During the construction of Phase II, the Phases I and II liner systems were spliced together at the following locations:

- Along the top of the Phase I/II Berm.
- Along the north and south sideslopes above the Phase I/II Berm.

Section B-5,15,23/17 on Sheet 17 in Appendix A.1 shows the temporary liner system configuration at the top of the Phase I/II Berm at the end of the Phase I construction. The temporary anchor trench at the Phase I/II Berm was relatively far from the slope (12 feet) to provide room for the splicing of the Phases I and II liner systems. Also, the portion of the liner system on top of the Phase I/II Berm was sloped 2 percent toward Phase I to assure that leachate ponding did not occur. A small soil berm was constructed on top of the temporary anchor trench to increase frictional resistance of the geosynthetics, control surface water drainage, and provide a foundation for the temporary lights as shown in Section B on Sheet 23 in Appendix A.1.

The procedure that was used to splice the Phases I and II liner systems at the Phase I/II Berm included the following steps:

- The temporary small soil berm, drainage ditches, and light poles were removed.
- The liner system was cut a minimum of 3 feet back (i.e., toward Phase I) from the temporary anchor trench and then this anchor trench was removed.
- The east side of the Phase I/II Berm was graded to match the base of the existing clay liner while maintaining the 2 percent slope toward Phase I.
- The existing 4-foot-thick secondary clay liner on top of the Phase I/II Berm was extended to connect with the clay liner on the west sideslope of Phase II.
- Each individual geosynthetic component was spliced at the cut location, resulting in a continuous liner system over the top of the Phase I/II Berm as shown in Section B-9,10/17 on Sheet 17 in Appendix A.1.

Section B-4,5/16 on Sheet 16 in Appendix A.1 shows the temporary anchoring procedure that was used for the Phase I/II transition on the south and north sideslopes above the Phase I/II Berm. The temporary anchors at these locations were different than those at the tops of the sideslopes since there are no significant liner stresses acting perpendicular to the anchoring. The temporary edge of the Phase I sideslope liner was anchored by:

- Securing approximately 6 feet of the secondary 60-mil HDPE geomembrane beneath 2 feet of compacted clay. Clay was used to provide increased erosion resistance on the slope.
- Cutting and welding the primary 60-mil HDPE geomembrane and temporary protective liner to the secondary 60-mil HDPE geomembrane above the temporary

anchor trench. The geocomposites and geotextiles were also cut to end just inside these welds.

Section B-4,5/16 on Sheet 16 in Appendix A.1 also shows how clay was used to contain a temporary 18-inch diameter corrugated metal pipe (CMP) on the southside slope only. This pipe was used to convey surface water run-off from the B-18 Perimeter Road to the temporary drainage ditch along the top of the Phase I/II Berm.

The splicing of the Phases I and II liner systems on the north and south sideslopes was similar to that described above for the liner system splice at the top of Phase I/II Berm. Section B-9,10/16 on Sheet 16 in Appendix A.1 shows how the Phases I and II sideslope liner systems were spliced together.

4.7.3.3 Phases I and II Access Ramp Liner

Section D-4,5/17 on Sheet 17 in Appendix A.1 shows a typical cross-section through the 35-foot-wide access ramp along the Phase I sideslopes. Key aspects of the design of this access ramp are:

- Both the primary and secondary LCRSs were sloped 2 percent toward the landfill to promote drainage without the need for water to flow the entire length of the ramp.
- An extra layer of 16 oz/sy nonwoven geotextile (Trevira 1155) was placed over the primary LCRS geocomposite to provide added cushioning under traffic loading.
- Three feet of operations layer soil (1-inch maximum particle size) was placed above the extra 16 oz/sy geotextile to further protect the liner system. The operations layer was also extended at least 10 feet up the sideslope areas adjacent to the access ramp to avoid the potential for traffic to accidentally drive onto the liner system.
- The roadway was finished with 1 foot of Class 2 aggregate base to provide all-weather access. Note that this aggregate base layer was used instead of the 4-inch-thick asphalt pavement shown in Section D-4,5/17 on Sheet 17 in Appendix A.1.

A special detail to weld the secondary 60-mil HDPE geomembrane was provided to facilitate continuous access along the ramp during construction and to minimize the potential for the liner to lift off of the ramp before the other materials and operations layer were placed. This was accomplished by anchoring the secondary HDPE geomembrane from the bottom sideslope in a trench about 15 feet from the toe of the upper sideslope. This 15-foot zone was then used for access until the upper sideslope portion of the secondary HDPE geomembrane was installed.

Section A on Sheet 16A in Appendix A.1 shows the arrangement of the Phase II access ramp. This ramp into the Phase II area was 44 feet wide to provide adequate space for the waste trucks and landfill equipment. The special liner details and protection details for the Phase II access ramp were similar to those described above for the Phase I access ramp.

4.8 Leachate Collection and Recovery System (LCRS)

4.8.1 General

The main features of the B-18 LCRS are the collection sumps where leachate is detected and removed. Phases I and II have two sumps each (see Sheets 5 and 10 in Appendix A.1), which subdivide these phases into Areas IA and IB and Areas IIA and IIB, respectively. Phase III will utilize the existing sumps for Phases I and II and, therefore, no additional sumps will be installed.

Phase IIIA will be constructed such that leachate from Phase IIIA will be able to flow directly into the Phase IA LCRS. No interim control measures, except a temporary lined containment berm at the edge of Phase IIIA/IIIB (see Sheet C-4A in Appendix A.2) will be required. Stormwater contained on the north side of this temporary berm (i.e., between the berm and the Phase IIIA waste mass) will be treated as leachate and will be handled in the same manner as leachate that is collected in the existing B-18 leachate storage tanks (located on the concrete riser pads). The temporary berm has been sized such that stormwater run-off from the 24-hour PMP event will be fully contained on the north side of the berm with greater than 1 foot of freeboard.

The layout of the sumps in Areas IA and IB are shown on Sheet 18 in Appendix A.1. The layout of the sumps for Areas IIA and IIB are shown on Sheet 18A in Appendix A.1. Representative cross-sections through the sumps are provided on Sheets 19, 19A, 20, 20A, 22, and 22A in Appendix A.1. Sheet 21 in Appendix A.1 provides typical details for the vertical riser pipe that was installed at each of the four primary sump locations. Sheets 22 and 22A in Appendix A.1 also show details for the existing four riser pads (one riser pad is above each sump) that enable the removal and handling of the leachate. Of the four existing riser pads, three of them (the pads for Areas IA, IB, and IIB) will be removed during the construction of Phase III to allow for the expansion of the B-18 waste footprint in these areas. Three new riser pads will be constructed during Phase IIIB as replacements for the three pads to be removed as shown on Sheet C-3 in Appendix A.2. Typical details for the new riser pads to be constructed during Phase III are shown on Sheet C-8 in Appendix A.2. These new riser pads will be very similar to the existing ones.

Each B-18 sump includes the following three leachate (or leak detection) collection and recovery zones (from top to bottom):

- The primary LCRS, which collects liquids that have infiltrated through the overlying waste and operations layer. The design of the primary LCRS is based on providing adequate pump capacity so that the liquids level in each sump will not exceed the height of that sump, which is taken to be the elevation of the landfill base at the sump perimeter.

- The secondary LCRS, which is typically not expected to be affected by liquids infiltration but drains consolidation water from the overlying clay liner and any seepage that may pass through leaks in the primary liner system.

- The vadose zone collection system, which is located in a 12-foot-wide trench below the secondary liner system. The purpose of this zone is to detect any seepage through leaks in the secondary liner system. Some clay consolidation water may also be collected in the vadose zone as increasing amounts of waste are placed within B-18.

Each of the four sump areas is located so that leachate pumps are lowered into the respective gravel collection zones through sideslope riser pipes. The primary LCRS design also includes a vertical riser pipe in each sump area that is extended upward in segments as the surrounding waste is placed. Details of the individual systems are described in the following three subsections.

4.8.2 Primary LCRS

The maximum operating liquid level for each of the four primary LCRSs is 1 foot above the top of each sump, where the top of a sump corresponds to the lowest point where the 5H:1V sump sideslope meets the toe of the landfill sideslope. The liquid level in each sump is currently maintained as low as possible using a pump, which is lowered to the sump through an existing 8-inch diameter steel riser pipe that lies on a 60-mil HDPE rub sheet (see Section A on Sheet 22 in Appendix A.1). The bottom portion of this riser pipe consists of Type 304 stainless steel to resist corrosion. Above the level of normal liquids exposure, the existing riser pipe is carbon steel that is double-wrapped to protect against corrosion. During the Phase III construction, the primary sideslope riser pipes in Areas IA, IB, and IIB will be extended up the new Phase III sideslopes by connecting a 10-inch diameter HDPE pipe to the existing 8" diameter steel pipe as shown in Detail 3 on Sheet C-8 in Appendix A.2. The existing pumps and controls will be replaced with a system capable of reaching the extended length of the riser and providing a pumping capacity that will maintain the liquid level below the allowable limit.

At each sump, the primary leachate pump is lowered through the sideslope riser pipe into a 4-foot by 8-foot by 1.5-foot-deep gravel-filled pumping zone. This arrangement maximizes the pumping effectiveness of the system. Pumping is controlled manually as required. The pumping need is determined by a water level control bubbler system or equivalent system that provides liquid level sensing at the top of the riser pipe when sufficient liquids for pumping exist in the sump.

As shown in Section A and Detail 1 on Sheet 18 in Appendix A.1, the bottom of each sideslope riser pipe is connected to a perforated collection tee that is also made of stainless steel. This tee lies on and against 2-inch-thick HDPE flatstock to protect the primary liner system from impact and pipe movements as the pumps are operated and periodically removed for maintenance and repair.

Historically (January 2001 to December 2007), the primary LCRS has removed an average of 360 gallons per day from the 4 sumps. During this period, the peak flow in a primary LCRS sump was 98,000 gallons (Phase IB) during January 2006, or 3,300 gallons per day. The volume of liquids removed during Phase III waste placement and after closure is expected to remain the same or diminish after closure.

In addition to the sideslope riser pipes, each of the four sumps has a redundant vertical riser pipe that can also be used to pump leachate from the primary LCRS. Each of the four vertical riser pipes is extended upward in about 10-foot increments as the level of the surrounding waste rises. The design of the vertical riser pipes includes several features, shown on Sheet 21 in Appendix A.1, to control the drag loads transmitted to the pipe as the surrounding waste settles. These features include the following:

- The bottom 7 feet (approximately) consists of perforated, 18-inch diameter stainless steel pipe founded in the small pumping sump adjacent to the perforated tee for the sideslope riser pipe. This bottom pipe telescopes into the main vertical riser pipe through a concrete footing such that drag loads are not transmitted to the pumping area.

- The main 24-inch diameter carbon steel vertical riser pipe is surrounded by a thin-walled corrugated HDPE pipe. This corrugated pipe, which is very flexible in the longitudinal direction, deforms as the adjacent wastes settle, thereby reducing the potential for large drag loads to act on the steel vertical riser pipe.

- A 6-foot by 6-foot reinforced concrete footing provides support for the 24-inch diameter carbon steel pipe and any drag loads that may act on the steel pipe.

The corrugated HDPE pipe has a diameter of 30 inches to provide an annular space for lateral deformation to occur around the 24-inch steel pipe. Spacers were provided inside the corrugated pipe to keep the riser pipe alignment nearly vertical at the time of its initial installation.

As shown in Detail 6 on Sheet C-7 in Appendix A.2, slip connections will be installed in the Area IA and IB vertical risers due to the increased height of waste that will be placed over these areas during the Phase III expansion. These slip connections will be placed at an elevation of between 900 and 910 feet and will reduce the potential drag loads transmitted to the existing 24-inch diameter vertical riser pipes. Analysis of the existing concrete pad at the base of the liner to withstand the additional vertical force related to the expansion was performed and is contained in Appendix L. As shown, the existing pads can satisfactorily carry the additional load related to the extended risers and the down-drag forces related to waste settlement.

Initially, a backup 350 gpm, 20 horsepower submersible pump was installed through each vertical riser pipe and into the primary pumping sump. However, these backup pumps were never used and are no longer provided since they presented difficulties when extending the vertical riser pipes. In the future, backup pumps can be provided through the vertical risers on an as-needed basis.

During the Phase III construction, there will be a period of approximately 6 months between the demolition of the existing LCRS riser pads and the installation of the new riser pads. The primary LCRS will continue to be monitored on a daily basis for liquid level and liquids will be removed in accordance with site protocol during this period by placing pumps down the existing vertical riser pipes (which will not be disturbed during the Phase III construction) and/or by placing pumps down the sideslope risers that will be cut off at the existing riser pads. As the sideslope risers are extended, but before the new riser pads are constructed, a wye fitting will be installed in each sideslope pipe close to the locations of the demolished riser pads (i.e., near the bottom of Phase III). Pumps and level monitoring equipment can be inserted through the wye and then lowered down the sideslope riser. Once the new riser pads are completed, the wyes will be removed and the sideslope risers repaired at those locations.

4.8.3 Secondary LCRS

The existing secondary LCRS is provided with two 8-inch diameter sideslope riser pipes as shown in Section A-18/19 and Detail 2 on Sheet 19 in Appendix A.1 and in Section C-18/20 on Sheet 20 in Appendix A.1. The bottom portion of one of these pipes is Type 304 stainless steel connected to a perforated stainless steel tee. The portion of this existing pipe above the level of normal liquids exposure is double-wrapped carbon steel. The other riser pipe is SDR 8.3 HDPE pipe for its entire length. During the Phase III construction, the secondary sideslope riser pipes in Areas IA, IB, and IIB will be extended up the new Phase III sideslopes. The existing HDPE riser pipe will be extended by splicing to a similar diameter pipe while the existing steel riser pipe will be extended by splicing to a 10-inch diameter HDPE pipe as shown in Detail 3 on Sheet C-8 in Appendix A.2.

A 4-foot by 4-foot by 1.5-foot-deep pumping zone was provided for the secondary LCRS. The perforated tee lies on and against a 2-inch-thick HDPE flatstock to protect the underlying HDPE geomembrane. The HDPE riser pipe terminates against the tee.

Both secondary sideslope riser pipes are sized to contain a pump and a bubbler liquid level control gauge. However, the current operating configuration has the pump in the steel riser pipe and the level control gauge in the HDPE riser pipe.

Historically (January 2001 to December 2007), there has been very little liquid in the secondary LCRS, averaging less than 10 gallons per day from B-18 sumps. Peak flow in the secondary LCRS approached 150 gallons per day in January 2006. This peak resulted from damage to the primary liner system that allowed rainfall to enter the secondary LCRS. The damage was subsequently repaired and leachate volumes have reduced to zero since March 2007.

The existing pumps and controls will be replaced with a system capable of reaching the extended length of the riser and providing a pumping capacity that will maintain the liquid level below the allowable limit. The maximum operating liquid level is 1 foot above the top of each secondary LCRS sump.

During the Phase III construction, there will be a period of approximately 6 months between the demolition of the existing LCRS riser pads and the installation of the new riser pads. The secondary LCRS will continue to be monitored on a daily basis for liquid level and liquids will be removed in accordance with site protocol during this period by placing pumps down the sideslope risers that will be cut off at the existing riser pads. As the sideslope risers are extended, but before the new riser pads are constructed, a wye fitting will be installed in each sideslope pipe close to the locations of the demolished riser pads (i.e., near the bottom of Phase III). Pumps can be inserted through the wye and then lowered down the sideslope riser. Once the new riser pads are completed, the wyes will be removed and the sideslope risers repaired at those locations.

4.8.4 Vadose Zone Collection System

Section B-18A/19A on Sheet 19A in Appendix A.1 shows the configuration of the existing sideslope riser pipe used for pumping liquids from the vadose zone collection sump. A single 8-inch diameter pipe is provided since only a small volume of liquids (e.g., clay liner consolidation water) was expected to be removed from this sump. Historic (January 2001 to December 2010) LCRS pumping data indicate no liquids have been removed from the vadose LCRS. The bottom portion of the vadose riser pipe is stainless steel. During the Phase III construction, the vadose sideslope riser pipes in Areas IA, IB, and IIB will be extended up the new Phase III sideslopes by splicing a 10-inch diameter HDPE pipe to the existing steel pipe as shown in Detail 3 on Sheet C-8 in Appendix A.2.

A 4-foot by 4-foot by 1.5-foot-deep pumping zone is provided below the main 12-foot-wide vadose trench in the sump areas. The 80-mil smooth HDPE geomembrane at the bottom of the main vadose trench extends below the pumping sump to provide continuous containment. Two-inch-thick HDPE flatstock was provided as impact protection above the 80-mil geomembrane.

A pump is currently installed through the vadose sideslope riser pipe and into the vadose sump. A bubbler level control device is also provided through the 8-inch pipe. The maximum operating liquid level is 1 foot above the top of the vadose trench at each sump. During the period of January 2001 to December 2007 no liquids have been detected in the vadose sumps.

The existing pumps and controls will be replaced with a system capable of reaching the extended length of the riser and providing a pumping capacity that will maintain the liquid level below the allowable limit.

During the Phase III construction, there will be a period of approximately 6 months between the demolition of the existing LCRS riser pads and the installation of the new riser pads. Since no liquids have been detected in the vadose zone in the last 10 years, monitoring of the three vadose sumps whose riser pads are to be removed will be suspended for the duration of the Phase III construction. Once the new riser pads are constructed, monitoring of the vadose zones will resume.

4.8.5 Leachate Storage

The following discussion of the leachate tank system provides information peripheral to the permitted unit's design, but supports the operational needs for understanding. Sheets 22 and 22A in Appendix A.1 show the existing top-of-slope riser pads above each sump area where liquids from the three (primary, secondary, and vadose) collection zones are handled. Flows from each pumping zone are monitored individually by a totalizer on each of the four (one primary, two secondary, and one vadose) pump discharge pipes. These pipes are then individually discharged into the top portion of a 6,000-gallon, double-walled, HDPE tank.

The double-walled tank is provided with a centrifugal pump for transferring liquids into vacuum trucks. The removed liquids are treated in on-site treatment facilities located away from B-18.

A curbed concrete slab (i.e., a concrete riser pad) is provided at each pump collection and storage tank area to contain any spilled liquids. A collection sump is provided in each concrete slab for removal of spilled liquids or rainwater.

As discussed in Section 4.8.1, three of the existing concrete riser pads (the pads for Areas IA, IB, and IIB) will be removed during the construction of Phase III. Three new riser pads will be constructed as replacements for the three pads to be removed. These new riser pads will be very similar to the existing ones and it is anticipated that the existing HDPE tanks and appurtenances will be salvaged and re-used for the new system or replaced with similar components.

4.9 Surface Water Control

The B-18 design includes surface water control features for the following conditions described in the indicated sections:

- Section 4.9.1 - Offsite Diversion of Run-on
- Section 4.9.2 - Active Area Run-off Control for Phase I Operations
- Section 4.9.3 - Phase I Direct Rainfall Control
- Section 4.9.4 - Active Area Run-off Control for Phase II Operations
- Section 4.9.5 - Phase II Direct Rainfall Control
- Section 4.9.6 - Run-off Control During the Above Grade Filling Period
- Section 4.9.7 - Phase III Direct Rainfall Control
- Section 4.9.8 - Run-off Control at Closure

Run-on is surface water that originates outside of the B-18 limits and it can therefore be discharged into natural stream channels. Active area run-off is surface water that flows from roads used for waste truck and/or landfill equipment access or from portions of the landfill with intermediate cover. This run-off does not come into direct contract with the waste disposal area.

The primary surface water design criteria for B-18 are the following:

- Precipitation falling directly into the disposal area must be contained within the waste prism. Resulting ponding on the waste surface must be managed as stipulated in the existing KHF permits.

- Active area run-off must be contained in surface water retention (i.e., containment) basins.

The permanent surface water controls that are used for conveying peak flows are designed based on rainfall intensity and duration relationships for the PMP storm event. The 24-hour PMP rainfall event for the site is 10.3 inches as reported by the National Oceanic and Atmospheric Administration (NOAA, 1998). The original design of B-18 (ESI, 1990a), used a 24-hour PMP storm event for the site of 7.4 inches, based on data from the California Department of Water Resources (CDWR, 1976). The CDWR used a statistical method, based on historic rainfall data, to determine the PMP rainfall depth. The CDWR no longer publishes data pertaining to PMP events as they apparently now defer to the PMP data provided by NOAA. The NOAA value is “theoretically, the greatest depth of precipitation for a given duration that is physically possible over a given storm area at a particular geographical location at a certain time of the year.” Hence, the current design PMP storm event of 10.3 inches has increased substantially from the 7.4 inches used in the original design.

4.9.1 Off-site Diversion of Run-On

Sheets 5 and 10 in Appendix A.1 show the existing configuration for diverting run-on away from the B-18 area. This is accomplished by providing run-on collection ditches outside of the entire existing B-18 Perimeter Road that are capable of diverting run-on from the PMP storm event. These run-on collection ditches begin near the northwest corner of Phase I. One of these ditches diverts run-on flows along the outside of the B-18 Perimeter Road along the north side of the existing landfill. The other ditch diverts run-on flows along the outside of the B-18 Perimeter Road along the west and south sides of the existing landfill. These V-shaped run-on collection ditches are 5-feet-wide, earthen, and vary in depth from one to three feet. Sheets 5 and 10 in Appendix A.1 show the locations where changes in the depths of these ditches occur.

A buried culvert is used to convey flows from the southern-most run-on collection ditch under the B-18 Stockpile access road. This culvert is a 24-inch diameter corrugated metal pipe (CMP) that is capable of conveying the 25-year storm event. Larger storms can be safely conveyed over a swale at this road intersection. This swale is graded to maintain the entire surface water flow from the PMP storm event in the run-on collection ditch system.

Upon the completion of the Phase I construction (Sheet 5 in Appendix A.1), the run-on collection ditches were discharged into the natural drainage channel at the northeast corner of the B-18 area, near the limit of the Phases I and II clay mixing area. Upon the completion of Phase II (Sheet 10 in Appendix A.1), the run-on collection ditches were directed to an existing culvert under the KHF main access road. That culvert is capable of conveying flows from most of the storms that may be expected to occur during the B-18 operations. Surface water from large, infrequent storms is allowed to flow across the KHF main access road with no potential for drainage to the existing waste disposal areas.

The final elements of the existing run-on collection ditch system are smaller V-ditches (brow ditches) along the tops of the existing B-18 Perimeter Road cuts. These brow ditches divert run-on from the natural hill slopes into drop inlets that discharge into the collection ditches that run along the outside

of the B-18 Perimeter Road. Due to the relatively steep slopes along the tops of these road cuts, the brow ditches are lined with asphalt to reduce erosion. The locations of the brow ditches and drop inlets are shown on Sheets 5 and 10 in Appendix A.1.

During the Phase III construction, most of the existing collection ditches along the outside edge of the existing B-18 Perimeter Road as well as the smaller brow ditches at the tops of the existing B-18 Perimeter Road cuts on the north, south, and west sides of B-18 will be removed and relocated to accommodate the expanded landfill footprint. The new collection ditches and brow ditches generally have a similar or increased capacity design as those of the existing ditches and they will be located along the outside edge of the new B-18 Perimeter Road (collection ditches) and at the tops of the cuts along the new B-18 Perimeter Road (brow ditches), as shown on Sheet C-3 in Appendix A.2. The permanent stormwater controls for B-18 are designed to convey the design PMP storm event. To be conservative, the stormwater controls were designed to convey the flow of the 6-hour PMP. The 6-hour PMP has a higher rainfall intensity and therefore greater peak flow than the 24-hour PMP event. During a PMP storm event, the drainage channels will reach capacity and some flows extend into the roadway. This design approach maintains reasonable size channels that convey a majority of storm events, however, flows from the PMP are controlled within the roadway assuming trafficable conditions would not need to be maintained during such an event.

During operation of Phase IIIA (while Phase IIIB is being constructed), there will be no potential for stormwater run-on into Phase IIIA from the adjacent portion of Phase IIIB due to the presence of the lined temporary Phase IIIA stormwater containment berm that will be constructed along the Phases IIIA-IIIB interface (see Detail 1 on Sheet C-4A in Appendix A.2). The top of this berm will be approximately 8 feet higher than the nearby high point on the Phase IIIB “bench liner” area, meaning that stormwater run-on from Phase IIIB will flow to the existing Northeast Containment Basin before it could overtop the temporary Phase IIIA berm. It is estimated that a maximum of approximately 2 feet of stormwater run-on could accumulate on the south side of the temporary Phase IIIA berm; this stormwater would be clean and would therefore be pumped by site personnel to just south of the nearby high point, where it could then flow to the Northeast Containment Basin. Once Phase IIIB is completed, the need for conveying stormwater run-on will be eliminated.

4.9.2 Active Area Run-Off Control for Phase I Operations

Sheets 5 and 6 in Appendix A.1 shows how surface water run-off from active areas for the PMP storm event was controlled during the Phase I disposal operations. The main aspects of this control were:

- Active area roads were sloped inward to a ditch system that was separate from the run-on ditch system described in Section 4.9.1.
- The active area run-off was directed to a lined retention basin located in the bottom of the initial clay borrow pit.

The west and south portions of the B-18 Perimeter Road adjacent to Phase I slope inward to an asphalt-lined V-ditch as shown in Section A-3,8/15 on Sheet 15 in Appendix A.1. This ditch flows in the south and east direction to a former culvert inlet on the south portion of the B-18 Perimeter Road approximately 12.5 feet beyond the limit of the sideslope liner system for Phase I. The former culvert was an 18-inch diameter CMP that dropped down the south sideslope (see Section B-4,5/16 on Sheet 16 in Appendix A.1) and into an 18-inch diameter, concrete-encased CMP culvert beneath the entrance of the Phase I/II Berm road to the Phase I access ramp. This culvert then discharged into a V-ditch (see Section B-5,15,23/17 on Sheet 17 in Appendix A.1) that flowed along the west side of the Phase I/II Berm to a drop inlet. This drop inlet discharged into a 30-inch diameter CMP that passed beneath the Phase I/II Berm crest and down its eastern embankment slope and into the lined basin in the clay borrow pit. The V-ditch and culvert also collected run-off from the road on top of the Phase I/II Berm, which sloped at two percent toward the west for its entire length.

An additional concrete-encased, 12-inch diameter CMP culvert was provided where the Phase I access ramp met the west portion of the existing B-18 Perimeter Road. This culvert drained the small flow from the northern part of this portion of the B-18 Perimeter Road and was concrete-encased to support waste truck traffic.

The north portion of the B-18 Perimeter Road adjacent to Phase I and the access road around the top of the initial clay borrow pit were also considered to have active area run-off because of the daily cover and landfill equipment that used these roads. Hence, these roads were also sloped toward an inside ditch that conveyed surface water flows to an 18-inch diameter CMP culvert along the southeast corner of the initial clay pit slope.

The clay pit retention basin was lined with 40-mil HDPE geomembrane from a bench at an elevation of 720 feet to its base at an elevation of 680 feet. Although not normally required for retention basins of this type, the liner was provided to avoid saturation of the clay borrow area because this area would later form part of Phase II floor. The retention basin and its liner system were completely removed when Phase II was constructed. The capacity of this temporary containment basin was sufficient to contain the 24-hour PMP run-off from the areas discussed above. Section A on Sheet 13 in Appendix A.1 shows a cross-section through this retention basin.

4.9.3 Phase I Direct Rainfall Control

The control of direct rainfall into the Phase I disposal area consisted of sloping the waste surface toward a low spot where the collected surface water was removed by vacuum trucks (or other appropriate means) and transported to the appropriate storage, treatment, and/or disposal facilities.

The amount of water that was handled by vacuum trucks was reduced by installing slope gutters on the temporary liner portions of the slopes. Water collected in these gutters drained into a clean tank and was then pumped into the run-on collection ditch system discussed in Section 4.9.1.

Initially, the low spot on the waste surface was located in the northern portion of Phase I to minimize interference with traffic at the Phase I access ramp. As the waste level in Phase I rose, the low spot was moved to best suit operational conditions. Once the waste height rose above the top of the Phase I/II Berm, it was necessary to keep the low spot away from the east-facing Phase I waste slope to avoid localized instability of this slope.

4.9.4 Active Area Run-Off Control for Phase II Operations

Sheet 10 in Appendix A.1 shows the configuration that was used for containing active area run-off during the Phase II operations. The collection system for this period consisted of an extension of the

Phase I ditches located along the inside of the B-18 Perimeter Road as described in Section 4.9.2. These ditches sloped toward the east-northeast portion of Phase II and conveyed run-off into the lined Northeast Containment Basin that was constructed in conjunction with Phase II. This basin is sized to contain run-off from both the existing B-18 Perimeter Road and from waste slopes with interim cover that are located above the level of the existing B-18 Perimeter Road. Surface water from the inside ditches flows into either of two culverts (one culvert is a 30-inch diameter CMP while the other culvert is a 24-inch diameter CMP) at the eastern portion of the B-18 Perimeter Road above the Northeast Containment Basin. These culverts discharge into asphalt-lined swales in the corners of the Northeast Containment Basin. For very large storms, the roadway profile above the culverts is depressed to direct flows across the road and into the asphalt-lined containment basin swales.

4.9.5 Phase II Direct Rainfall Control

Direct rainfall into the Phase II waste disposal area was handled using procedures similar to those described in Section 4.9.3 for the Phase I operations.

4.9.6 Run-Off Control During the Above Grade Filling Period

Currently, the B-18 waste mass is in the above grade filling period. As the waste mass rose above the level of the existing B-18 Perimeter Road, rainfall run-off began to be handled in the following two ways:

- The top deck area, where waste disposal is ongoing, is graded to direct surface water toward a low spot (with temporary earthen berms, as needed) where the collected surface water is removed as discussed for the Phase I and II areas in Sections 4.9.3 and 4.9.5, respectively.

- Surface water from sloped areas with interim cover is handled as run-off water. This run-off is collected from the sideslopes of the existing landfill and conveyed into the inside B-18 Perimeter Road ditches, which ultimately direct the run-off into the Northeast Containment Basin.

The asphalt-paved ditches on the inside of the existing B-18 Perimeter Road contain run-off from storms with recurrence intervals less than 100 years (based on original design storm event). During larger storms and up to the PMP event, the flow may extend outside of these paved ditches but is maintained within the larger channel formed by the inward-sloping perimeter road. Flows up to the PMP storm condition are currently directed into the Northeast Containment Basin. During operations within Phase IIIA (while Phase IIIB is still being constructed), stormwater run-off from the north, east, and west facing Phase IIIA waste slopes will be diverted to the Northeast Containment Basin. A temporary lined containment berm will be constructed at the interface of Phases IIIA and IIIB (see Sheet C-4A in Appendix A.2) to provide containment of stormwater run-off from the lower portions of the south-facing temporary Phase IIIA waste slope. This temporary berm has been sized to contain the entire run-off volume generated by the 24-hour PMP event (while maintaining a freeboard of greater than 1 foot); this run-off will be contained on the north side of the temporary berm. Therefore, no pumping will be required to prevent the overtopping of the temporary berm. Site personnel will treat the stormwater run-off contained on the north side of the temporary berm as leachate. Accordingly, the impounded stormwater run-off will be pumped into tanker trucks and transported to the appropriate on-site facility for treatment as leachate.

The Phase III expansion of B-18 will involve the construction of a new B-18 Perimeter Road around most of the landfill. Similar to the existing configuration, the new B-18 Perimeter Road will be sloped inward toward the landfill during the above grade filling period. Also, asphalt or shotcrete-lined V-ditches will run along the entire inside edge of the new B-18 Perimeter Road to convey run-off to containment basins in a similar manner as is currently done.

Due to the change in the PMP storm event (see the discussion at the beginning of Section 4.9) and the increased landfill area after the construction of Phase III, a second stormwater basin, the South Containment Basin, will be required to provide adequate run-off storage capacity for the PMP storm event after Phase III is completed. The new South Containment Basin will be constructed as part of the Phase IIIB expansion as shown on Sheet C-3 in Appendix A.2. The surface water flow patterns around the expanded landfill will be such that all run-off will be directed to and contained in the South and Northeast Containment Basins.

4.9.7 Phase III Direct Rainfall Control

Direct rainfall into the Phase III waste disposal area will be handled using procedures similar to those described in Section 4.9.3 for the Phase I operations.

4.9.8 Run-Off Control at Closure

The surface water drainage capacities of the final benches, Cover Access Road, and the new B-18 Perimeter Road are designed to be capable of conveying the 6-hour PMP storm water run-off without damage to the landfill. This storm water flow will drain to either the existing Northeast Containment Basin or the new South Containment Basin, as shown on Sheet C-4 in Appendix A.2. The stormwater containment basins are designed to contain the runoff from the 24-hour PMP storm event. After site closure, the basins may be modified to release the stormwater run-off in a controlled manner.

4.10 Utilities

The existing utilities for B-18 consist of the following:

- A perimeter lighting system that currently serves the existing B-18 Perimeter Road and that formerly served the waste disposal area before the waste mass grew to its current level above the lights.

- Electrical power to operate the various leachate control pumps and the perimeter lighting system.

As part of the B-18 Phases I and II construction, permanent lighting fixtures were placed around the entire existing B-18 Perimeter Road as illustrated in Section A-5,10/23 on Sheet 23 in Appendix A.1. However, this existing lighting system is no longer needed and it will be removed as part of the Phase III construction.

Power for the existing lighting system and leachate pumps is provided by an electrical transformer located along the northern boundary of B-18, as shown on Sheet C-2 in Appendix A.2. During the Phase III construction, this transformer will be removed and relocated to allow for the construction of the Phase III expansion.

5.0 ENGINEERING ANALYSES

5.1 General

This section describes the engineering analyses that were performed to support the design of B-18. The B-18 analyses are discussed in Sections 5.2 through 5.9 with calculations provided in Appendices G through N for Settlement, Stability, Cover Soil Erosion, Surface water drainage, leachate collection and removal, riser pipes, cover infiltration, and frost and biotic protection, respectively.

5.2 Settlement Analyses

5.2.1 Conditions Evaluated

The following four settlement conditions were analyzed for B-18:

1. The elastic settlement of the landfill's foundation to assess the minimum slope of the LCRSs. Ideally, the post-settlement slopes of the LCRSs should be maintained at 2 percent or greater.
2. Evaluation of the degree of consolidation of the primary and secondary clay liners at interim and final closure to assign appropriate strength properties for these materials for use in the stability analyses.
3. Estimation of the magnitude of settlements of the primary and secondary clay liners to assure that adequate thicknesses (i.e., 3 feet or more) will be maintained after compression and consolidation of the liners are completed.
4. Estimation of the post-closure waste settlements to assure positive drainage of the cover, benches, and the Cover Access Road.

The settlement calculations are provided in Appendix G and described in the following sections.

5.2.2 Foundation Settlement

The rock strata beneath B-18 have and will continue to settle in an approximately elastic manner as each layer of waste is placed. Therefore, essentially all of the foundation settlement is anticipated to occur prior to closure and, hence, foundation settlement will not be a factor with regard to the closure cover configuration or drainage control. The foundation settlement will, however, result in slope changes at the base of the landfill that will impact the LCRS. These settlements will not cause abrupt changes on the base (e.g., large differential settlements over short distances), but they could potentially reduce the slopes of the LCRS to below the desired minimum of 2 percent. A minimum LCRS slope of 2 percent is desired to assure positive leachate drainage to the sumps.

The foundation settlement estimates presented in Appendix G.1 were calculated using Boussinesq's stress distribution theory in conjunction with the elastic properties of the foundation materials. Elastic properties of the claystone and siltstone were conservatively considered to be the same and were estimated based on the measured plasticity index and strength characteristics of the undisturbed claystone samples using the procedure described by Duncan and Buchignani (1976). The elastic modulus and Poisson's ratio of these fine-grained rocks were estimated to be 6,000 ksf and 0.38, respectively. The sandstone was assumed to be incompressible since information obtained from the boring logs and laboratory test data indicate that deformation of the coarse-grained rock strata (i.e., sandstone) would be negligible in comparison to that of the claystone and siltstone.

In Appendix G.1, landfill base settlement profiles are estimated for four representative cross-sections through the waste mass to evaluate both the total and differential settlements. The total estimated settlements range up to about 15 inches. According to the computed settlements, the resulting slope of the base of the landfill will be greater than 2 percent. Hence, it is concluded that the LCRS will remain sloped at a minimum of 2 percent.

5.2.3 Degree of Consolidation of Clay Liners

Calculations of the time rate of consolidation of the clay liners due to placement of the overlying waste are provided in Appendix G.2. These calculations were carried out in order to evaluate the appropriate clay strength parameters for use in the stability analyses. Shortly after clay liner construction, UU triaxial strength parameters are appropriate. After "complete" consolidation (i.e., an average degree of consolidation greater than about 95 percent) of the clay due to the weight of the overlying waste has occurred, CU triaxial strength parameters are appropriate. The selection of clay strength parameters to assess stability at a certain stage of waste disposal is based on the expected degree of consolidation of the clay liner at that particular time.

The clay liners will be continually consolidating during waste placement such that the undrained shear strength of the clay liners will be continually increasing. Based on the consolidation test data for compacted (remolded) clay discussed in Section 3.5.7, it is estimated that the average degree of consolidation for both the primary and secondary clay liners will be greater than 95 percent by the time the final closure cover is installed. Therefore, the undrained shear strength of the clay liners for long-term, post-closure conditions should be based on its fully-consolidated strength as evaluated from the CU triaxial tests.

Another calculation was performed to evaluate the degree of consolidation of the clay liners when the Phase I Intermediate Closure was completed about two years after initial clay liner construction. This calculation shows that approximately 30 percent of clay consolidation will have occurred at that time, resulting in a modest gain in strength. To be conservative, the UU triaxial test data were used in the stability analyses for the Phase I Intermediate Closure condition. Also, because all of the excess porewater pressures were not dissipated at that time, the friction angle (ϕ) portion of the UU triaxial test data was not relied upon in the Phase I Intermediate Closure stability evaluation.

5.2.4 Magnitude of Clay Liner Consolidation

The clay liner consolidation calculations in Appendix G.3 were performed to estimate the clay liner thickness reductions once "complete" consolidation of the clay had occurred under the weight of the overlying waste mass. Calculations are provided for the following:

1. A primary and secondary clay liner thickness of 1.5 feet and 3.5 feet, respectively, at the landfill base and a maximum waste thickness of about 300 feet (compared to a maximum waste thickness of 230 feet without Phase III).

2. A clay liner thickness of 5 feet beneath the vertical riser pipe, where additional load will be applied to the clay liner by the vertical riser pipe foundation (see Section 5.7).

The calculations show that the maximum consolidation settlement of the primary and secondary clay liners at the landfill base will be approximately 0.1 and 0.3 feet, respectively, under loading from 300 feet of waste (similar to the result for Phase I and II). Therefore, it is concluded that the primary and secondary clay liner's required minimum thickness of 1 and 3 feet, respectively, will be maintained after consolidation settlement is complete.

The maximum primary and secondary clay liner settlements beneath the vertical riser pipe foundation were calculated to be about 0.4 and 0.7 feet, respectively, under loading from 300 feet of waste. These magnitudes of settlement are acceptable because the original clay liner thicknesses in this area were about 3 and 5 feet for the primary and secondary clay liners, respectively.

5.2.5 Post-Closure Waste Settlement

Appendix G.4 contains the post-closure waste settlement calculations that were performed in order to assess the minimum closure cover slopes for positive drainage. It was assumed that the primary consolidation of waste material will fully occur during waste placement. Therefore, the post-closure waste settlements were estimated based on the fo1lowing factors:

- Crushing of disposed drums and the related settlements due to:

  Closure of void spaces in the drums within the waste mass; and

  Consolidation of loosely-placed materials in the drums.

- Secondary consolidation (or creep) settlement of the main, soil-like waste matrix.

It is anticipated that settlement of waste within B-18 will be less than prior WMUs at the KHF because of more restrictive disposal regulations, especially since a significant portion of the waste has been and will continue to be solidified prior to disposal. The waste settlement estimates discussed below do not fully account for these changes and are therefore considered to be conservative.

The waste settlement calculations were based on KHF's estimate that 15 percent of the waste volume within B-18 consists of drums that are distributed randomly throughout the waste. The drums are conservatively assumed to contain 10 percent voids and the wastes within the drums were calculated to consolidate an additional 30 percent. Long-term creep settlement of the waste was estimated based on characteristics for normally-consolidated soft to medium stiff clay.

By analyzing representative cross-sections through the entire B-18 waste mass, it is estimated that the post-closure waste settlements will vary from approximately zero at the edge of the landfill to a maximum of about 27 feet where the waste thickness is greatest. On the basis of the calculations in Appendix G.4, it is concluded that the proposed final cover grades shown on Sheet C-4 in Appendix A.2 will be adequate to assure appropriate drainage after waste settlement is complete.

It is recommended that survey monuments be monitored at areas with interim cover on the landfill sideslopes once these areas are filled to their final elevation. As this settlement data is obtained, it may be appropriate to re-evaluate whether or not a portion of the primary settlement may occur during the post-closure period and to re-assess the final cover grading plan.

5.3 Stability Analyses

5.3.1 General

Appendix H includes static and seismic slope stability analyses for the conditions discussed in the following sections:

- Section 5.3.2 - Temporary Rock Cut Slopes;
- Section 5.3.3 - Compacted Fill Slopes;
- Section 5.3.4 - Temporary Phase I Intermediate Fill Slopes;
- Section 5.3.5 - Temporary Phase IIIA Intermediate Fill Slope; and
- Section 5.3.6 - Final Closure Conditions.

Table 5.1 summarizes the shear strength and unit weight parameters assigned to each of the materials and material interfaces modeled in the stability analyses. The right-hand column in Table 5.1 identifies the data sources for these parameters, which include the site-specific laboratory testing discussed in Section 3, prior KHF landfill investigations, and published data and information.

Table 5.2 summarizes the results of the stability analyses and lists the criteria used to evaluate acceptability. For static conditions, the minimum acceptable factor of safety is considered to be 1.5. This criterion was satisfied for all of the critical conditions analyzed. For seismic conditions, acceptability is evaluated based on a design displacement during the MCE event (see Section 2.5.1). A maximum design displacement of 6 inches was established for all cases where the failure plane could intersect the base liner system, based on the recommendations of Seed and Bonaparte (1992). This minimizes the potential for large displacements that could potentially disrupt the HDPE geomembrane/clay composite liner or the LCRS. As shown in Table 5.2, the estimated displacement for most of the cases considered is less than 1 inch for the applicable MCE event.

The following seismic displacements during the MCE event were considered maximum acceptable values for locations where permanent liner systems are not affected:

- A 6-inch seismic displacement for the Northeast Containment Basin embankment, primarily to minimize the potential of overall embankment instability occurring.
- A 12-inch displacement entirely within the waste mass for the Phase I intermediate fill slope because it is temporary and regrading improvements could easily be made without exposing the underlying liner systems.
- A 12-inch displacement would be allowable for the geotextile/HDPE geomembrane and vegetative cover soil/geotextile interfaces of the final cover system. This maximum displacement minimizes the potential for damage to the HDPE geomembrane and any resulting near-surface cracking could be repaired relatively easily.

The static factors of safety were calculated using:

1. The STABL5 computer program, developed by Purdue University (1986), for the stability analyses performed during the original design of B-18 (ESI, 1990a).
2. The computer program GSTABL7 version 2.003, developed by Gregory Geotechnical Software, for the stability analyses performed for the current design.

Displacement estimates for the seismic conditions were calculated using the following procedures:

1. Newmark (1965), as modified by Franklin and Chang (1977), for temporary rock cut slopes, compacted fill slopes, and the Phase I intermediate waste fill conditions. A conservative velocity-to-acceleration ratio of 30 was used for the Newmark and Franklin and Chang methods for these cases, based on measured velocity/acceleration ratios published by Donovan (1983). The maximum acceleration of the waste mass for these cases was assumed to be 80 percent of the PHGA, based on comparisons with site response analyses performed by Woodward-Clyde (1987) for the OII Landfill in Monterey Park, California. However, no attenuation was allowed for very shallow potential failure surfaces because the lower portions of the slide mass were close to the ground surface.
2. Makdisi and Seed (1978), which is based on the Newmark (1965) method, for the final closure configuration. In order to evaluate the average acceleration time histories of the critical slide mass, two-dimensional dynamic finite element analyses were performed using the computer program QUAD4M (Hudson et al., 1994).
3. Bray et al. (1998) for the final cover veneer stability analyses. Two-dimensional site response analyses were also performed for this case using QUAD4M to evaluate the average acceleration of the cover system.

The PHGAs corresponding to the MCE events (near-field and far-field) used in the current design are discussed in Section 2.5.3. These PHGAs and MCEs were used in the stability analyses of the final closure configuration and in the cover veneer analyses. During the original design of B-18 (ESI, 1990a), a single MCE event was considered, as discussed in Section 2.5.2. This MCE event and its associated PHGA differ from those used in the current design due to advances in geotechnical earthquake engineering since the time of the original design. The temporary rock cut slopes, compacted fill slopes, and Phase I intermediate waste fill conditions were not re-analyzed for the current design since these conditions no longer exist due to the placement of overlying waste. The rock cut slope on the west side of B-18 will be flattened and will be more stable than the current configuration. Hence, the computed seismic displacements for these conditions correspond to the MCE event from the original design (ESI, 1990a), as discussed in Section 2.5.2.

5.3.2 Temporary Rock Cut Slopes

Appendix H.2 provides stability analyses for the two rock cut slope conditions illustrated in Figure 5.1. East-, south-, and north-facing slopes were excavated at a 2H:1V inclination across bedding planes. West-facing slopes, which were in the general direction of the weaker bedding planes, were excavated at a shallower 3H:1V inclination. Table 5.2 shows that the static factors of safety for these two conditions are 2.4 and 2.2 for the 2H:1V and 3H:1V slopes, respectively. Table 5.2 also shows that essentially no displacement of either slope configuration is anticipated during the original design's MCE event (Section 2.5.2). Therefore, the designed temporary rock cut slopes were adequate for both the static and seismic criteria for Phases I and II and are considered to be adequate for the comparatively minor proposed Phase III temporary rock cut slopes.

5.3.3 Compacted Fill Slopes

Phases I and II of B-18 were formed primarily by excavation into rock and there were no large fill embankments required. A relatively small fill embankment was necessary in the former natural drainage area at the northeast edge of Phase II. This fill embankment forms a portion of the eastern Phase II sideslope and also forms one of the sideslopes for the Northeast Containment Basin. A cross-section through this embankment is shown in Section A-8/23 on Sheet 23 in Appendix A.1. Stability analyses were performed for this fill embankment.

Table 5.2 shows that the Phase II/Northeast Containment Basin fill embankment is satisfactory for both static and seismic conditions. The static factor of safety for this embankment is 2.2 and essentially no displacement was projected for this slope during the original design's MCE event (Section 2.5.2). Appendix H.3 contains the detailed stability computations for this condition.

Phase III will require some relatively small fill embankments along the south side of the existing landfill. The slopes of these fill embankments will have inclinations equal to or less than those of the existing Phase II/Northeast Containment Basin fill embankment. Based on the stability analysis results for the Phase II/Northeast Containment Basin fill embankment, the proposed fill embankments for Phase III are considered to be adequately stable for both the static and seismic conditions.

5.3.4 Temporary Phase I Intermediate Fill Slopes

The typical configuration of the temporary Phase I intermediate waste fill slopes is shown in Section A-6/23 on Sheet 23 in Appendix A.1. This slope condition existed from the time that initial filling of Phase I was completed until the Phase II area was filled to the top of the Phase I/II Berm. This temporary waste slope was constructed at the relatively steep 1.5H:1V inclination because the stability analyses showed that the factor of safety along the critical liner interface is higher when the waste slope is steeper due to the added frictional resistance along the toe portion of the potential sliding wedge.

Appendix H.4 presents the detailed results of the stability analyses conducted for the Phase I intermediate fill slopes. Figure 5.2 illustrates the various potential failure mechanisms considered for the Phase I temporary fill slopes. The most important potential sliding mechanism (Cases A1 and A2 in Figure 5.2) involved shearing through the waste, along the base liner of the landfill, and up the lined Phase I/II Berm sideslope, resulting in a wedge-shaped slide mass. This mechanism is critical because the liner interface strengths are much lower than those of the underlying foundation or the overlying waste materials. Also, a failure at this location could damage the liner and LCRSs. Figure 5.2 shows the following two potential shear surfaces for this sliding mechanism:

- Case Al: A shear surface that would occur entirely along the liner interface, including at the intersection of the landfill base and the Phase I/II Berm sideslope.

- Case A2: A shear surface that would include an approximately 50-foot-long diagonal shear zone through the waste near the base/berm intersection to simulate a circular failure surface across that intersection angle.

The results in Table 5.2 for these cases show a static factor of safety of at least 2.5 and essentially no displacement during the original design's MCE event (Section 2.5.2). These results are acceptable for this important stability condition.

The potential for a shallow circular failure (Case B in Figure 5.2) to occur through the intermediate fill slope without intersecting the liner system was an additional consideration for the Phase I temporary waste slope. This condition was less important than Cases Al or A2 because, if some movement were to occur along the potential sliding surface, the underlying liner system would not be damaged. Table 5.2 shows that the static factor of safety for Case B is approximately 1.5 and the estimated displacement for the original design's MCE event (Section 2.5.2) is about half an inch. These results are based on shallow waste strength parameters of ϕ = 27 degrees and c = 300 psf as compared to ϕ = 31 degrees and c = 0 used for deeper zones of the landfill. Use of the cohesionless waste strength parameters would result in a lower static factor of safety (approximately 1.3) for very shallow potential failure surfaces. However, it is reasonable to assume that the waste will have a small degree of cohesion. Therefore, the factor of safety and estimated MCE displacement discussed above were considered to be appropriate and the intermediate slope was acceptable for this temporary and non-critical condition.

During the preliminary stability analyses, calculations were also performed to evaluate whether a failure could potentially occur along the entire Phase I liner interface (i.e., along the west sideslope, the landfill base, and the Phase I/II Berm sideslope). The factor of safety for this condition was found to be much higher than for the Cases A1 and A2 conditions.

Finally, because of prior experience at the KHF, an evaluation was made as to whether or not it would be appropriate to analyze the Phase I intermediate fill slope for a three-dimensional potential failure surface. However, because of the designed configuration, it was concluded that such an analysis was not necessary. Phase I was purposely configured to avoid three-dimensional driving forces that were significantly different than those realized for the two-dimensional (Cases Al and A2) condition. Therefore, the factor of safety for a three-dimensional case would essentially be the same as the acceptable values for the two-dimensional cases discussed above.

5.3.5 Temporary Phase IIIA Intermediate Fill Slope

The configuration of the temporary Phase IIIA intermediate waste fill slope is shown on Sheet C-4A in Appendix A.2. As can been seen on Sheet C-4A, the Phase IIIA interim waste slope is a south-facing, 2H:1V slope that contains an approximately 30-foot wide bench to allow for access to the landfill during waste placement operations. This interim slope condition will exist for only a short time, if at all, as it is anticipated that no more than 6 months of waste will be placed in Phase IIIA before waste placement in Phase IIIB begins. After waste placement in Phase IIIB commences, the interim Phase IIIA waste slope will be covered with waste relatively quickly. The north, east, and west facing Phase IIIA waste slopes will be built to the final cover grades (i.e., 3.5H:1V inclination between benches); therefore, these waste slopes were analyzed as part of the final closure configuration (Section 5.3.6).

Appendix H.4 presents the detailed results of the stability analyses conducted for the south-facing 2H:1V Phase IIIA intermediate fill slope. Due to its temporary nature, only static stability analyses were conducted for the Phase IIIA intermediate waste slope. Also, as can be seen in Appendix H.4, the shear strength parameters of the Phase IIIA liner system were assumed to lie between its peak and residual values since the slope will be temporary and the portion of the Phase IIIA liner modeled in the stability analyses will be graded at only 10 percent, thereby making it similar to a base liner from a shear strength standpoint.

Figure 5.3 illustrates the potential failure mechanism considered for the south-facing 2H:1V Phase IIIA temporary fill slope. This critical potential sliding mechanism involves shearing down through the waste and then along the Phase IIIA liner toward the toe of the south-facing 2H:1V temporary waste slope, resulting in a wedge-shaped slide mass. This mechanism is critical because the liner interface shear strength is much lower than that of the underlying foundation or the overlying waste materials. The result in Table 5.2 for this interim case indicates a static factor of safety of 1.5, which is considered acceptable for this temporary condition.

The potential for a shallow circular failure to occur through the south-facing 2H:1V Phase IIIA intermediate fill slope without intersecting the liner system was not performed since analyses for the Phase I temporary waste slopes indicated that a temporary waste fill slope inclined at 1.5H:1V would be adequately stable (Section 5.3.4) with respect to this potential sliding mechanism. Since the Phase IIIA intermediate waste fill slope will be inclined at 2H:1V, it will be expected to be more stable than the Phase I temporary waste slopes were. In addition, the Phase I temporary waste slopes were observed to perform well after their construction, which further demonstrates that the 2H:1V Phase IIIA intermediate fill slope should be adequately stable with respect to a circular failure entirely through waste.

5.3.6 Final Closure Conditions

The three potential failure scenarios of importance for the final closure configuration, as shown conceptually on Figure 5.3, are:

- Displacement of the final cover system on the 3.5H:1V sideslopes between benches.
- A large wedge failure through the waste and along the base and perimeter sideslope liner systems.
- A circular failure entirely through the waste.

The stability analyses for the final closure conditions were performed by HAI, under subcontract to Golder, as part of the current design. Appendix H.5 contains HAI's slope stability report while the results of HAI's stability analyses are summarized in Table 5.2 and discussed in the following paragraphs.

The weakest interface in the B-18 final cover system is the nonwoven geotextile/40-mil textured HDPE geomembrane interface. Large seismic displacements at this interface could result in a tensile failure of the HDPE geomembrane. The current state-of-practice is to generally limit seismic displacements of the cover system to less than about 12 inches. Table 5.2 shows that the static factor of safety for veneer-type sliding of the cover system along the geotextile/HDPE geomembrane interface is 1.6, which is well above the allowable 1.5. The estimated seismic displacement along this interface was calculated to be about 2.7 inches for the updated MCE event (Section 2.5.3). Hence, the final cover system of B-18 is considered to be adequately stable under the design static and seismic loading. Minor repairs to the cover system may be required if the seismic displacement of the cover system exceeds about 2 to 3 inches.

In order to evaluate a deep, wedge-shaped failure mechanism (along the base liner) for the final closure condition, HAI evaluated 6 representative cross-sections (A-A' to F-F') through B-18. The locations of these 6 cross-sections are shown in Appendix H.5. For each cross-section, multiple sliding mechanisms were considered.

HAI reviewed the interface shear strength test data for B-18 to determine the weakest interface for each phase of construction. The original design report for B-18 (ESI, 1990) assumed the most critical interface would be located at the interface of the textured geomembrane and the geonet side of the geocomposite. The interface was found to have a residual friction angle of 9 degrees and 800 psf adhesion. However, during construction of Phase II, a bonded geotextile was included below the geocomposite to increase the shear strength of the liner system (i.e., a geocomposite with geotextiles heat bonded to both sides of the geonet was used during construction). Therefore, the lower shear strength properties used for the Phase I side slope liner were based on a different critical interface in the liner system. Based on the URS 2005 report, archived samples of the existing Phase II liner system components were recovered from storage and tested for interface shear strength. Two shear tests were performed on multiple components that represented all of the possible interfaces in the existing B-18 Phase II liner systems. Tests performed on these "sandwich-like" specimens of the Phase II liner system demonstrated that failure occurred along the clay/textured geomembrane interface in one test and the clay/geotextile interface in the other test. The results of these tests yielded a peak interface friction angle of 20 degrees with an adhesion of approximately 1,900 psf, and a residual interface friction angle of 19 degrees with approximately 1,800 psf adhesion. For the stability analysis the adhesion was conservatively considered to be 0 psf.

It should be noted that failure in a liner system occurs along the interface with the lowest peak shear strength. Therefore, the weakest interface in the liner system is the interface with the lowest peak strength. Based on the direct shear testing performed by SGI Testing Services, LLC (2003) on the archived Phase II liner system materials (see Appendix A of the URS 2005 report), the lowest peak shear strength is along either the textured geomembrane/compacted clay liner interface or the geotextile/compacted clay interface (peak friction angle of 20 degrees). Even though the clay liner has a lower residual friction angle of 13 degrees with lower adhesion (SGI, 2003), the higher internal peak shear strength of the clay (26 degrees) in comparison with the two above-mentioned interfaces (20 degrees) results in detrimental shear displacements occurring along either of the two geosynthetic liner/clay interfaces and not within the clay liner itself. The "sandwich-like" specimen tests presented in the URS 2005 report demonstrated this.

To confirm the friction angles for the B-18 Phase III liner system, similar "conformance" testing was completed on stock materials from geosynthetic manufacturer's that will supply materials for the Phase III expansion. Based on the testing conducted by Precision Geosynthetic Laboratories (results included in Appendix H.5), the weakest interface is the geocomposite to textured HDPE geomembrane. The measured peak friction angle was approximately 28 degrees with a residual friction angle of 12 degrees. For the stability analysis, the 12 degree residual friction angle was used for the Phase III expansion area. The initial stability report by HAI assumed that the friction angle for Phase III would be similar to Phase II. Based on the recent testing, HAI lowered the Phase III friction angle. An addendum to the original report is included in Appendix H.5 to address the stability analysis using the lower strength values.

Using the above interface shear strengths, Sections D-D' and F-F' were found to be the most critical of the 6 cross-sections considered since their potential failure mechanisms had the lowest static factor of safety and lowest yield accelerations. HAI therefore performed two-dimensional site response analyses (using QUAD4M) and seismic displacement analyses for sections D-D' and F-F'. In the two-dimensional response analyses, four different input ground motion time histories were used to provide a range of anticipated waste mass accelerations (both from the near-field and far-field events). The results of the seismic displacement analyses performed for section D-D' and F-F' indicate that, under the updated MCE ground motions (Section 2.5.3), the maximum seismic displacements will be less than I inch. Therefore, the overall final landfill configuration is considered to be adequately stable with respect to deep, wedge-shaped failure mechanisms.

The last closure configuration condition analyzed was a circular failure entirely through the waste. Section D-D' contained the critical circular shear surface. As can be seen on Table 5.2, the calculated static factor of safety for this case was 2.2 and the seismic displacement during the updated MCE event (Section 2.5.3) is anticipated to be less than 12 inch. Hence, the final landfill configuration is considered to be acceptable with regards to static and seismic stability of circular shear surfaces through the waste.

Finally, the need for a three-dimensional stability analysis for the final landfill configuration was not deemed necessary since no conceivable three-dimensional movements could be hypothesized that would lead to significantly lower factors of safety than those for the two-dimensional cases discussed above.

5.4 Cover Soil Erosion

Appendix I contains the analyses performed to assess the erosion rate of the B-18 vegetative cover soil layer based on the planned vegetation, slope steepness, slope length, and climatological conditions. The soil erosion analyses were performed using the computer program RUSLE2 (NRCS, 2004), which uses the Revised Universal Soil Loss Equation (RUSLE) along with the appropriate site-specific parameters listed above to calculate the potential soil erosion loss in tons per acre per year.

The results of the soil erosion analyses indicate a maximum cover soil erosion rate of about 1 ton per acre per year for the typical 3.5H:1V closure slopes between benches. This maximum rate is approximately half of the maximum allowable rate of 2 tons per acre per year suggested by the USEPA (1989). This cover soil erosion rate assumes that vegetation is established on the final cover. If no vegetation (i.e., bare ground) is assumed, the calculated cover soil erosion rate is about 9 tons per acre per year. Hence, it will be important to establish and maintain an acceptable amount of vegetation on the B-18 final cover to control soil erosion losses. As such, a specification for revegetation of the final landfill slopes is provided for in Appendix O.

5.5 Surface Water Drainage

5.5.1 General

The surface water analyses presented in Appendix J are divided into sections that address the following requirements:

- The general hydrology and design criteria.
- Phases I and II run-on control.
- Phases I and II run-off control.
- Phase III run-on control.
- Phase III run-off control.

- Closure drainage control.

The B-18 surface water drainage control systems are described in Section 4.9. As discussed in Section 4.9, run-on control refers to the collection and off-site diversion of surface water that has originated outside of the B-18 limits and, therefore, has not been affected by the active disposal area. Run-off control refers to the collection of surface water from roads used for waste truck or landfill equipment access and from portions of the waste area with intermediate cover. This run-off does not come into direct contact with the waste disposal area, but it will be retained on-site in accordance with the KHF permitting requirements.

The basic surface water drainage control design criteria for B-18 are:

- Hydraulic structures should be capable of conveying the 6-hour PMP storm event that is considered to have maximum intensities based on the rainfall-duration curve data shown Appendix J. Culverts may be designed for flows as low as those from the 25-year storm event as long as water overtopping the culvert is contained within a drainage control system that has been designed for the peak PMP discharge.

- All run-off containment basins, except the temporary one for the Phase I intermediate condition, are designed for the 24-hour PMP event, which is 10.3 inches of rainfall (NOAA, 1998). It is noted that during the original design of B-18 (ESI, 1990a), the 24-hour PMP event used in the analyses was only 7.4 inches based on the available data at that time (CDWR, 1976). The temporary Phase I intermediate basin was required only during the Phase II construction period and was designed for the 25-year, 24-hour storm.

- During the original design of B-18 (ESI, 1990a), peak storm run-offs were calculated using the rational method for small watersheds along with run-off coefficients of 0.40 for natural areas, 0.90 for roads, and 0.60 for interior cover areas. Volume requirements for the former and existing containment basins were also based on these run-off coefficients. These methods and parameters are applicable for the Phases I and II run-on and run-off calculations presented in Appendices J.2 and J.3.

- For the current design, peak storm run-offs were calculated using the computer program HEC-HMS version 3.1.0, developed by the United States Army Corps of Engineers. In the HEC-HMS analyses, an SCS curve number of 81 was used to model the final cover soil and areas surrounding B-18, except a SCS curve number of 74 was used for the natural terrain west of B-18. The volume requirement for the proposed South Containment Basin was based on the design flows calculated from the HEC-HMS analyses. These methods and parameters are applicable for the closure drainage control calculations presented in Appendix J.4.

- In the original B-18 design (ESI, 1990a), Manning's roughness coefficients used in the design of ditches and culverts were 0.013 for smooth asphalt, 0.018 for earth channels (which extend onto roadway slopes), and 0.019 for CMP. In the current design for the closure condition, the following Manning's roughness coefficients (i.e., "n" values) were used:

Channel Lining	Manning's n for Stability	Manning's n for Capacity
Grass	0.030	0.035
Turf Reinforcement Mat	0.030	0.035
Rip-rap	0.035	0.040
Asphalt or Shotcrete	0.016	0.016

5.5.2 Phases I and II Run-On Control

Figure 5.5 shows individual water shed areas that contribute run-on flow to the diversion ditches located along the outside edge of the B-18 Perimeter Road. These ditches intercept the run-on and direct it away from the B-18 active area. Table 5.3 summarizes the previously calculated maximum flows for Phase I and II during the PMP event at key locations along the diversion ditch system and shows the estimated peak flow in comparison with the ditch capacity. In each case, the asphalt-lined ditch is capable of containing the design flow.

A 24-inch diameter CMP runs beneath the B-18 stockpile access road to convey the computed 25-year peak flow. The roadway above the culvert is graded as a swale to convey higher flows for the PMP event, across the road and into a natural drainage channel at the toe of the B-18 Perimeter Road fill slope, which eventually discharges back into the asphalt V-ditch system.

5.5.3 Phases I and II Run-Off Control

Table 5.4 summarizes previously calculated run-off conditions for Phase I and II at each of the hydraulic structures required to convey the PMP run-off from roads used for waste truck or landfill equipment access. In each case, the ditch or culvert capacity exceeds the appropriate estimated peak flow.

Table 5.5 compares the capacity of the former temporary Phase I containment basin and the Northeast Containment Basin (see Sheets 5 and 10, respectively, in Appendix A.1) with the estimated run-off volumes from the respective design storms. The capacity shown for the temporary Phase I containment basin in the clay borrow pit is for a height to the top of the lined area. Freeboard is not required for this basin because the basin could not be overtopped above the clay pit walls which extend high above the lined area.

The Phase I Intermediate Closure basin was on the top of a liner that was installed to prevent infiltration into the waste. This containment basin was sized only for run-off from the interim closure slope. This basin was only required until the Phase II construction was completed.

The capacity for the Northeast Containment Basin is based on allowance for a 2-foot freeboard because embankment overtopping could occur at this location.

5.5.4 Phase III Run-on Control

Run-on control during Phase III will be performed in a similar manner as it has historically been performed during Phase I and II with the use of ditches on the outside of the perimeter road as well as brow ditches at the top of cut slopes. Figure 5.5 shows individual water shed areas that contribute run-on flow for Phase III and at Closure to the diversion ditches located along the outside edge of the B-18 Perimeter Road. These ditches intercept the run-on and direct it away from the B-18 active area. The run-on areas have decreased in size compared to Phases I and II; however, the run-on control ditches have remained the same size. To avoid ponding around the southeast side of B-18 some additional fill is added to provide positive drainage from localized low points. Buried 18-inch diameter HDPE solid wall pipe is to be installed below the B-18 south berm to provide drainage of two localized low points. The drainage pipe is maintained outside the limits of the landfill.

The permanent stormwater run-on controls, such as the brow ditches, within the Phase IIIA watershed will be constructed as part of Phase IIIA. During the subsequent placement of waste in Phase IIIA (while Phase IIIB is being constructed), a temporary lined stormwater containment berm will be utilized to prevent stormwater run-on from contacting the Phase IIIA waste. The configuration of this temporary lined containment berm is shown on Sheet C-4A in Appendix A.2. The top of this berm will be approximately 8 feet higher than the nearby high point on the Phase IIIB “bench floor”; therefore, overtopping of this berm by stormwater run-on from the south will not occur. If necessary, portable pumps will be used by site personnel to convey the clean ponded stormwater run-on retained on the south side of the temporary berm to just south of the nearby high point on the Phase IIIB “bench floor,” where it can then gravity flow to the Northeast Containment Basin. A maximum of approximately 2 feet of stormwater could pool against the south side of the temporary berm. However, it should be noted that only small amounts of stormwater are anticipated since Phase IIIB is planned to be constructed during the dry season and, once Phase IIIB is completed, run-on control between Phase IIIA and Phase IIIB will no longer be required.

5.5.5 Phase III Run-Off Control

Run-off control during Phase III operations will be very similar to the current operations. The existing B-18 waste fill is above the existing perimeter road and capable of diverting flows to the Northeast Containment Basin. Initially Phase III waste will be placed in the “valley” formed by the existing waste and the Phase III lined slope. Active areas will control run-off with soil berms to keep stormwater from reaching the basin. Areas covered with interim soil cover will drain within the “valley” to the Northeast Containment Basin. In the event of a PMP prior to the Phase III waste fill reaching the elevation of the perimeter road, where run-off can be diverted to the South Containment Basin, active pumping from the Northeast Containment Basin to the South Containment Basin would be required to maintain adequate capacity.

Appendix J.4, Table 4 summarizes run-off conditions at each of the hydraulic structures required to convey the PMP run-off. In each case, the ditch capacity exceeds the appropriate estimated peak flow.

Table 5.5 compares the capacity of the Northeast Containment Basin and South Containment Basin (see Sheets C-3 and C-4 in Appendix A.2) with the estimated run-off volumes from the 24-hour PMP design storm. Sufficient on-site storage capacity exists to contain all run-off within the basins, however, some active pumping during the 24-hour PMP storm will be required (approximately 1 acre foot) from the northeast basin to the south basin.

The permanent stormwater run-off controls, such as the perimeter channels, within the Phase IIIA watershed will be constructed as part of Phase IIIA. During subsequent placement of waste in Phase IIIA (while Phase IIIB is being constructed), a temporary lined stormwater containment berm will be utilized to contain stormwater flowing off of the south-facing Phase IIIA temporary waste fill slope. This temporary berm will be 10 feet tall (see Sheet C-4A in Appendix A.2). As shown in the Phase IIIA hydrology calculations in Appendix J.3, the basin that will be formed on the north side of this berm will have sufficient capacity to contain the entire run-off volume generated by the 24-hour PMP event while maintaining a freeboard of greater than 1 foot. Stormwater run-off that is impounded on the north side of the temporary berm will be considered leachate and will be managed in an appropriate manner by site personnel (i.e., through the use of portable pumps to convey the stormwater into tanker trucks for transportation to an on-site treatment facility). Stormwater run-off from the north, east, and west facing waste slopes of Phase IIIA will flow to the Northeast Containment Basin. It should be noted that only small amounts of stormwater are anticipated for this temporary case as Phase IIIB is planned to be constructed during the dry season and, once Phase IIIB is completed, run-off control between Phase IIIA and Phase IIIB will no longer be required.

As described in the Phase IIIA hydrology calculations in Appendix J.3, during the construction of Phase III (i.e., before the South Containment Basin is constructed), the existing Northeast Containment Basin will not have sufficient capacity to contain the stormwater volume generated by the 24-hour PMP event. Specifically, there will be approximately 14 acre-feet of water that will have to be conveyed from the Northeast Containment Basin to the site's existing East Retention Basin (located approximately 2,000 feet north of the Northeast Containment Basin, as shown on Sheet C-1 in Appendix A.2). A 21-inch orifice outlet device will be set 3 feet below the top of the existing embankment of the Northeast Containment Basin. Water will flow through this orifice and into a pipeline (preliminarily sized at 21-inch inside diameter) that will convey this overflow by gravity to the East Retention Basin. During the Phase III construction, the orifice outlet device and gravity flow pipeline will prevent the overtopping of the existing Northeast Containment Basin during the 24-hour PMP event.

5.5.6 Closure Drainage

At closure, the trapezoidal earthen ditches along benches and the Cover Access Road are designed to convey the flow from the 6-hour PMP event as shown in Appendix J, Table 4. As previously discussed, the 6-hour PMP event has a higher rainfall intensity than the 24-hour PMP and is therefore more conservative for sizing the conveyance structures. Conveyance of surface water from the cover and the adjacent areas will occur along the final B-18 Perimeter Road, which will be graded to slope into the closure cover as shown in Detail 4 on Sheet C-7 in Appendix A.2. The peak surface water run-off generated by the 24-hour PMP event will be contained in either the Northeast Containment Basin or the South Containment Basin.

5.6 Leachate Collection and Removal

In accordance with USEPA guidance for landfill geosynthetic designs (USEPA, 1987), Appendix K includes the following calculations to support the design of the B-18 LCRS:

- The capacity of the primary LCRS at each area to transmit the mean annual precipitation during the operating period.
- The capacity of the primary LCRS at each sump to convey significantly greater volumes of leachate than historically measured without the build-up of 12 inches of hydrostatic head on the base liner system.
- The suitability of the geotextile to act as a filter between the base operations layer and the primary LCRS drainage gravel layer.

The calculations are based on the conservative assumption that, during operations, all rainfall will percolate through the waste and into the primary LCRS.

The calculations show that the transmissivity of the existing Trevira 1125/Polynet 3000 geocomposite drainage layer used on the sideslopes will have a transmissivity greater than that required to convey the mean annual precipitation considering the maximum waste overburden pressure of nearly 25,000 psf.

The transmissivity of the existing base geocomposite is approximately equal to that required to convey the mean annual precipitation drainage case. However, considerable redundant capacity is provided by the 12 inches of drainage gravel above the base geocomposite in the primary LCRS. The base portion of the secondary LCRS also includes a redundant, 12-inch-thick drainage gravel layer. Furthermore, a geonet layer was provided for a width of 80 feet above the vadose trench to provide drainage in this area.

Filter calculations for the geotextile between the base operations layer and the primary LCRS drainage gravel indicate that the existing Trevira 1125 geotextile is adequate.

Historic records (January 2001 to December 2007) indicate that the primary LCRS generates an average of 360 gallons per day for all four sumps. This volume is significantly less than the 36,000 gallon per day system capacity.

The secondary LCRS, has averaged 10 gallons per day over the period of January 2001 to December 2007. Peak flows have approached 150 gallons per day. Recent monitoring has indicated that no liquids are being collected in the secondary LCRS. The Response Action Plan (RAP) (SEC Donohue 1992a) determined that the Action Leakage Rate (ALR) for each sump ranged from 1,250 to 3,500 gallons per day. These values have a minimum calculated safety factor of 3. Liquids collected in the secondary LCRS have not approached the ALR. The current ALRs remain valid for the proposed expansion since the limiting factor was the length of geocomposite at the toe of slope and this length remains unchanged, conservative transmissivity values are used in the calculations.

The vadose zone collection system has not collected any liquids during the period January 2001 to December 2007. The Vadose Zone Response Plan (SEC Donohue 1992b) allows from 3.5 to 6.6 gallons per day to be collected in the vadose sumps based on a de minimus leakage rate of 20 gallons per acre per day. The vadose system will not be modified by the proposed expansion: therefore, the allowable leakage rates remain valid.

In the event leakage in the secondary or vadose collection systems exceeds the ALR, then appropriate actions in accordance with the RAP will be implemented.

5.7 Riser Pipe Designs

Appendix L includes the engineering calculations performed to support the following riser pipe requirements:

- Design of the main 24-inch diameter steel vertical riser pipe and its foundation, located about 6.5 feet above the primary liner system in the sump area, as illustrated in Section B on Sheet 21 in Appendix A.1.
- Provision of adequate crushing strength for the lower 18-inch diameter stainless steel vertical riser pipe that is approximately 7 feet long and is located immediately below the 24-inch diameter steel vertical riser pipe.

- Assurance that the pressure exerted by the main vertical riser pipe foundation will not create a bearing capacity failure in the underlying clay liners.

- Evaluation of the stresses and deflections in the bottom portions of the sideslope riser pipes.

As shown in Section B on Sheet 21 in Appendix A.1, the main vertical riser pipe will be placed inside of a larger, 30-inch diameter corrugated HDPE pipe to avoid the development of high drag loads on the 24-inch diameter steel pipe. The corrugated pipe will not develop significant vertical stresses because it will readily deflect in an accordion-like manner in the longitudinal direction as the surrounding waste settles. The corrugated pipe will be held away from the steel pipe with flexible spacers at about 10-foot centers to avoid long sections where the two pipes would otherwise be in continuous contact. To be conservative, the calculations assume that a contact area of 10 percent of the total contact area between the two pipes develops and that it is capable of transferring drag loads to the inner steel pipe. In addition, significant factors of safety are provided for each of the key components of the system to minimize the potential for large deformation of the riser pipe to occur.

The 6-foot by 6-foot by 1.5-foot-thick reinforced concrete foundation for the main riser pipe was designed to spread any load on the pipe over a sufficient area so that there is a high factor of safety against potential bearing capacity deformations of the underlying clay liner. This is accomplished because the minimum bearing capacity factor of safety is estimated to be between 7 and 10 when using a conservative estimate of the strength of the clay liner. A slip connection has been included in the riser pipe at approximately elevation 900 ft-MSL to reduce the load on the foundation. The loads above the slip connection will be transferred within the waste.

Compression loading on the lower stainless steel pipe is calculated considering at-rest pressures resulting from the main riser pipe foundation loading. The factor of safety against crushing is greater than 5, which is considered appropriately conservative for this system.

Finally, calculations of deflection for the lower portions of the sideslope riser pipes show that:

- The carbon and stainless steel pipe deflections will be on the order of 0.1 inches, which is relatively small with regard to the allowable deflections for these pipes.

- The maximum deflection of the 8-inch diameter HDPE SDR 8.3 pipe is estimated to be on the order of 20 to 30 percent of its diameter.

Although the deflection of the HDPE pipe is higher than would normally be desirable, it is considered to be acceptable because this pipe is included as a second (i.e., redundant) system for pumping from the secondary LCRS. From an operations viewpoint, it was determined that it would be better to have these two redundant types of pipes to minimize the potential for pump access loss because of material deterioration.

5.8 Cover Infiltration

Appendix M includes calculations similar to those performed to support the design of the currently-permitted final closure cover system for B-18 (DTSC, 2003). These calculations were performed using the updated computer program HELP version 3.07 (Schroeder et al., 1994) to estimate the amount of infiltration through and head on the final cover system. The infiltration analyses were conducted by assuming the following parameters:

- The vegetative cover soil layer is 2.5-feet-thick with a permeability of 2 x 10^{-4} cm/s, based on past experience with this type of material at the KHF.

- The HELP program's default climate data for Fresno, California and Bakersfield, California were used to model the climatological conditions at the KHF. Use of Fresno climate is a conservative assumption since Fresno receives approximately 50 percent more rainfall annually than the KHF, based on historic precipitation data.

- The HDPE geomembrane will have 0.50 holes per acre resulting from manufacturer's flaws (where each hole has a 1 mm diameter), 1.0 hole per acre resulting from installation defects (where each hole has an area of 1 cm^2), and "excellent" placement quality.

- The nonwoven geotextile component of the final cover system has an in-plane permeability of 0.25 to 0.40 cm/s.

- The foundation layer has a permeability of 1 x 10^{-5} cm/sec

- The slope of the final cover system is 25 percent (i.e., 4H:1V).

Based on the above assumptions, the results of the HELP analyses indicate that a maximum head of about 3 to 4 inches will develop on the geomembrane during extended rainy seasons (similar to Fresno) and that acceptably low infiltration rates will occur through the HDPE geomembrane. Since a head of only 3 to 4 inches on the geomembrane is not anticipated to compromise the stability of the final cover system, the permitted final cover system is considered adequate for B-18. Additionally, the permitted cover system has been used to close other facilities at KHF since 1994 without failure or apparent build up of liquids within the cover.

5.9 Frost and Biotic Protection

The effects of frost penetration on the B-18 final closure cover were evaluated. Appendix N.1 provides two maps that each show estimated depths of frost penetration for the United States. Both of these maps indicate that the maximum depth of frost penetration at the KHF is less than 6 inches. Past experience and observations at the KHF corroborate this finding. Hence, any frost penetration that occurs is anticipated to be confined to the uppermost portions of the 2.5-foot-thick vegetative cover soil layer and should not present a significant potential to deteriorate the cover system or to cause special maintenance requirements.

The effects of burrowing animals on the B-18 final cover system were also evaluated. Information presented in Appendix N.2 indicates that burrowing animals will be confined to the vegetative cover soil layer due to the presence of the underlying HDPE geomembrane. Past experience at the KHF indicates that HDPE geomembranes are effective barriers to burrowing animals. Hence, the performance of the B-18 final cover is not expected to be impacted by burrowing animals.

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TABLES

TABLE 3.1

KEY BORING INFORMATION

BORING	NORTHING EASTING	GROUND ELEVATION (Feet) TOTAL DEPTH	SAMPLE NUMBER (Mode)(1)	SAMPLE DEPTH (Feet)	STRATIGRAPHIC UNIT DESCRIPTION(2)	STRATIGRAPHIC UNIT NUMBER	RECOVERY (%)	PURPOSE
L18-A	8,943	856	S-1 (PB)	5 - 6.1	ss	18-10	91	• Obtain samples of Unit 18-10. This unit occurs at the toe of the western cut slope and bottom of excavation, Phase I/II (See Sections 8 and 14). Unit 18-10 also occurs at toe and middle section of eastern cut slope at Section 18.
	840	38.7	S-2 (PB)	10 - 12.5	cs/ss	18-10	84	
			S-3 (PB)	17-19.5	cs/ss	18-10	96	
			S-4 (PB)	25-27.5	silty ss	18-10	100	
			S-5 (PB)	33-35.5	silty ss w/cs	18-10	88	
			S-6 (PB)	37-38.7	silty ss w/cs	18-10	88	
L18-B	8,755	861	S-1 (PB)	6-8.5	cs	18-12	92	• Determine depth to top of silty ss (Unit 18-11). • Obtain samples of Unit 18-12. This unit occurs near the toe of western cut slope, Phase I/II (See Sections 14+00 and 18+00). • Obtain samples of Unit 18-11. This unit occurs at toe of western cut slope - See Sections 14+00 and 18+00.
	860	39.5	S-2 (PB)	11.5-14	silty ss	18-11	96	
			S-3 (PB)	20-22.5	ss	18-11	64	
			S-4 (PB)	28-30.5	ss w/cs/slt	18-11	88	
			S-5 (PB)	37-39.5	ss	18-11	80	
L18-C	8,623	754	B-1 (DR)	6-7.5	colluvium (cl)	Qc	87	• Determine colluvium thickness. • Obtain samples of ss, slt (Unit 18-7). This unit occurs at bottom of excavation, Phase III/IV (See Sections 14+00 and 18+00) and at toe of western in-dipping cut slope, Phases III & IV (See Section 14+00).
	2,120	89	B-2 (DR)	12-13.5	colluvium (cl)	Qc	53	
			S-1 (PB)	15-17.3	slt	18-7	91	
			S-2 (PB)	20-22.5	slt	18-7	92	
			S-3 (PB)	25-27.5	slt	18-7	88	
			S-4 (PB)	33-35	cs/slt	18-7	95	
			S-5 (PB)	41-43.1	silty ss	18-7	95	
			S-6 (PB)	48-50.1	slt clayey slt	18-7	90	
			S-7 (PB)	56-58	slt	18-7	90	
			S-8 (PB)	64-66.3	clayey slt	18-7	78	
			S-9 (PB)	72-74.3	ss, silty ss	18-7	100	
			S-10 (PB)	80-82	slt/cs	18-7	95	
			S-11 (PB)	87-89	slt	18-7	85	
L18-D	8,785	740	B-1 (DR)	5-6.5	colluvium	--	87	• Determine colluvium thickness. • Clarify contact of Units 18-4 and 18-3. • Clarify contact of Units 18-4 and 18-5. • Obtain samples of these units. • Units 18-4 and 18-5 occur at eastern out-dipping cut slope, Phase III and IV (See Sections 14+00 and 18+00).
	2,480	86	B-2 (DR)	10-11.5	colluvium	--	100	
			B-3 (Bag)	14	colluvium	--	--	
			S-1 (PB)	15-17.3	silty ss	18-5	78	
			S-2 (PB)	22-24.3	slt	18-5	96	
			S-3 (PB)	29-31.5	cs/slt	18-4	80	
			S-4 (PB)	36-38.5	cs/slt	18-4	92	
			S-5 (PB)	44-46.5	cs	18-4	60	
			S-6 (PB)	52-54.3	cs	18-4	65	
			S-7 (PB)	60-62.5	cs/slt	18-4	48	
			S-8 (PB)	68-70.5	cs	18-4	56	
			S-9 (PB)	76-78.5	silty ss	18-3	32	
			S-10 (PB)	81-83.5	silty ss	18-3	36	
			S-11 (PB)	83.5-86	silty ss	18-3	68	
L18-E	8,895	727	B-1 (DR)	5-6.5	colluvium (cl)	--	87	• Determine colluvium thickness. • Clarify contact of Units 18-2 and 18-3. • Obtain samples of colluvium Units 18-3 and 18-2. These units may serve as foundation materials or run-off retention berms or larger berm for Phase III & IV configuration.
	2,670	62.5	S-1 (PB)	16-12.5	colluvium (cl)	--	68	
			S-2 (PB)	15-17.5	ss	18-3	84	
			S-3 (PB)	20-22.5	ss	18-3	56	
			S-4 (PB)	28-30.2	ss	18-3	86	
			S-5 (PB)	35-37.5	sandy slt	18-3	88	
			S-6 (PB)	43-45	sandy slt	18-3	80	
			S-7 (PB)	51-53	cs	18-2	95	
			S-8 (PB)	60-62.5	sandy cs	18-2	96	

(1) PB = Pitcher Barrel; DR = Drive Sampler
(2) cs = Claystone; ss = Sandstone; slt = Siltstone

TABLE 3.1

KEY BORING INFORMATION
(Continued)

BORING	NORTHING EASTING	GROUND ELEVATION (Feet) TOTAL DEPTH	SAMPLE NUMBER (Mode)(1)	SAMPLE DEPTH (Feet)	STRATIGRAPHIC UNIT DESCRIPTION(2)	STRATIGRAPHIC UNIT NUMBER	RECOVERY (%)	PURPOSE
L18-F	8,930	821	S-1 (PB)	6-8.5	cs	18-8	100	• Obtain samples of Unit 18-8 (clay). This unit occurs in eastern out-dipping cut slope, Phase I/II (See Section 8+00).
	1,538	58.5	S-2 (PB)	16-18.5	cs	18-8	88	
			S-3 (PB)	26-28.5	cs	18-8	92	
			S-4 (PB)	36-38.5	cs	18-8	76	
			S-5 (PB)	46-48.1	cs	18-8	100	
			S-6 (PB)	56-58.5	cs	18-8	84	
L18-G	7,500	853	S-1 (PB)	6-8.5	ss	18-13	56	• Obtain samples of Units 18-13 and 18-12. Unit 18-13 (sandstone) comprises the western cut slope, Phase I/II. Unit 18-12 (claystone) occurs near the toe of the cut slope, Phase I/II, at Section 18+00.
	1,914	77.5	S-2 (PB)	14-16.5	ss	18-13	56	
			S-3 (PB)	22-23.7	ss	18-13	88	
			S-4 (PB)	30-32	ss	18-13	60	
			S-5 (PB)	40-41.3	ss	18-13	92	
			S-6 (PB)	45-47.5	cs	18-12	60	
			S-7 (PB)	50-51.8	cs	18-12	72	
			S-8 (PB)	60-62.5	cs	18-12	40	
			S-9 (PB)	65-67	cs	18-12	70	
			S-10 (PB)	75-77.5	ss	18-12	32	
L18-H	8,065	865	S-1 (PB)	6-8.5	cs	18-10	72	• Obtain samples of Unit 18-10 underlying the fossil bed. This unit occurs at out-dipping cut slope, eastern side, Phase I/II (see Sections 14+00 and 18+00). In Section 8+00 Unit 18-10 occurs at bottom of excavation.
	2,055	57.5	S-2 (PB)	15-17.5	silty ss	18-10	76	
			S-3 (PB)	25-27.5	cs with sand	18-10	68	
			S-4 (PB)	35-37.5	cs	18-10	92	
			S-5 (PB)	45-47.5	silty ss	18-10	96	
			S-6 (PB)	55-57.5	cs with sand	18-10	48	
L18-I	8,022	766	B-1 (DR)	6-7.5	colluvium (cl)	--	87	• Determine colluvium thickness.
	2,415	18.5	S-1 (PB)	12-13.8	colluvium (cl)	--	78	• Obtain sample of Unit 18-8 (claystone).
			S-2 (PB)	16-18.5	cs	18-8	92	
L18-J	228,390	820	S-1 (PB)	5 - 7.5	cs	18-8	68	• Obtain samples of Unit 18-8. This unit will be used as liner material
	1,701,985	172.5	S-2 (PB)	10 - 12.5	cs	18-8	88	• The primary purpose is to evaluate the continuity of the claystone and to determine the existence and thickness of thin sandstone strata as coted on the log of Monitoring Well K-8.
			S-3 (PB)	15 - 17.5	cs	18-8	88	
			S-4 (PB)	20 - 22	cs/ss	18-8	75	
			S-5 (PB)	25 - 27.5	cs	18-8	76	
			S-6 (PB)	30 - 32.5	cs	18-8	96	
			S-7 (PB)	35 - 37.5	cs	18-8	100	
			S-8 (PB)	40 - 42.5	cs	18-8	72	
			S-9 (PB)	45 - 47.5	cs	18-8	92	
			S-10 (PB)	50 - 52.5	cs	18-8	92	
			S-11 (PB)	55 - 57.5	cs	18-8	92	
			S-12 (PB)	60 - 62.5	cs	18-8	96	
			S-13 (PB)	65 - 67.5	cs	18-8	84	
			S-14 (PB)	70 - 72.5	cs	18-8	88	
			S-15 (PB)	75 - 77.5	cs	18-8	100	
			S-16 (PB)	80 - 82.5	cs	18-8	96	
			S-17 (PB)	85 - 87.5	cs	18-8	88	
			S-18 (PB)	90 - 92.5	cs	18-8	84	
			S-19 (PB)	95 - 97.5	cs/ss	18-8	32	
			S-20 (PB)	100 - 101.5	cs	18-8	60	
			S-21 (PB)	105 - 107.5	cs	18-8	100	
			S-22 (PB)	110 - 112.5	cs	18-8	100	
			S-23 (PB)	115 - 117.5	cs	18-8	96	
			S-24 (PB)	120 - 122.5	cs	18-8	100	
			S-25 (PB)	125 - 127.5	cs	18-8	96	

(1) PB = Pitcher Barrel; DR = Drive Sampler
(2) cs = Claystone; ss = Sandstone; slt = Siltstone

TABLE 3.1

KEY BORING INFORMATION
(Continued)

BORING	NORTHING EASTING	GROUND ELEVATION (Feet) TOTAL DEPTH	SAMPLE NUMBER (Mode)(1)	SAMPLE DEPTH (Feet)	STRATIGRAPHIC UNIT DESCRIPTION(2)	STRATIGRAPHIC UNIT NUMBER	RECOVERY (%)	PURPOSE
L18-J (Cont.)			S-26 (PB)	130 - 132.8	cs	18-8	100	
			S-27 (PB)	135 - 137.5	cs	18-8	100	
			S-28 (PB)	140 - 142.5	cs	18-8	100	
			S-29 (PB)	145 - 147.5	cs	18-8	100	
			S-30 (PB)	150 - 152.5	cs	18-8	100	
			S-31 (PB)	155 - 157.5	cs	18-8	100	
			S-32 (PB)	160 - 162.5	cs	18-8	100	
			S-33 (PB)	165 - 167.5	slt	18-7	92	
			S-34 (PB)	170 - 172.5	ss	18-7	88	
L18-K	228,390	804	S-1 (PB)	5 - 7.5	ss	18-9	88	• Obtain samples of Unit 18-9. This strata will be excavated concurrently with the claystone in order to develop the clay borrow pit.
	1,701,722	97.5	S-2 (PB)	10 - 12.5	silty ss	18-9	92	• Samples from this boring will be utilized for various combinations of claystone to determine the potential for mixing of the two rock types as they are excavated from the borrow pit.
			S-3 (PB)	15 - 17.5	silty ss	18-9	100	
			S-4 (PB)	20 - 22.5	silty ss	18-9	60	
			S-5 (PB)	25 - 27.5	ss	18-9	96	
			S-6 (PB)	30 - 32.5	sandy slt	18-9	100	
			S-7 (PB)	35 - 37.2	silty ss	18-9	86	
			S-8 (PB)	40 - 42.5	silty ss	18-9	92	
			S-9 (PB)	45 - 47	slt	18-9	95	
			S-10 (PB)	50 - 52.5	sandy slt	18-9	88	
			S-11 (PB)	55 - 57.5	sandy slt	18-9	68	
			S-12 (PB)	60 - 62.5	sandy slt	18-9	56	
			S-13 (PB)	65 - 67.2	ss	18-9	86	
			S-14 (PB)	70 - 72.5	silty ss	18-9	100	
			S-15 (PB)	75 - 76.8	silty ss	18-9	94	
			S-16 (PB)	80 - 82.3	ss	18-9	52	
			S-17 (PB)	85 - 87.5	cs	18-8	88	
			S-18 (PB)	90 - 92.5	cs	18-8	100	
			S-19 (PB)	95 - 97.5	cs	18-8	100	

(1) PB = Pitcher Barrel; DR = Drive Sampler
(2) cs = Claystone; ss = Sandstone; slt = Siltstone

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TABLE 3.2

MATRIX OF INVESTIGATION ACTIVITY VS. ROCK STRUCTURE

	INVESTIGATION ACTIVITY			
STRATIGRAPHIC UNIT	TEST TRENCHES	TEST PITS	BORINGS	EXISTING AND PREVIOUS MONITORING WELLS
Colluvium	All Test Trenches	All Test Pits	L18-C, L18-D, L18-E, L18-1	–
18-1	–	–	–	K-19, K-29
18-2	–	–	L18-E	K-19, K-29
18-3	–	–	L18-D, L18-E	K2, K-19
18-4	DT-E	–	L18-D	K-1, K-2, K-26
18-5	DT-E	–	L18-D	K-1, K-2, K-26, K-38
18-6	DT-E	–	–	K-1, K-2, K-26, K-38
18-7	DT-B, DT-E, T-1, T-2	TP-5, TP-6, TP-20, TP-21, TP-28	L18-C, L18-F	K-1, K-2, K-8, K-26, K-32, K-38
18-8	DT-A, DT-B, DT-C, T-3	TP-1, TP-6, TP-7, TP-8, TP-9, TP-27, TP-36, TP-37, TP-38, TP-39, TP-40, TP-41	L18-F, L18-1 , L18-J	K-8, K-32, K-33, K-38
18-9	DT-A, DT-D	TP-1, TP-2, TP-3, TP-4, TP-26, TP-42, TP-43	L18-K	K-8, K-33
18-10	DT-A, DT-D	TP-4, TP-12, TP-13, TP-18, TP-29, TP-35, TP-35A	L18-A, L18-H	K-8, K-33
18-11	DT-A, DT-D	TP-11, TP-19, TP-25, TP-30	L18-B	K-8, K-18, K-33
18-12	DT-A, DT-D	TP-10, TP-16, TP-17, TP-31, TP-34	L18-B, L18-G	K-21, K-33
18-13	DT-A, DT-D, DT-F	TP-14, TP-15, TP-22, TP-23, TP-24, TP-32, TP-33	L18-G	K-18, K-21, K-33
18-14	–	–	–	K-18, K-21

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TABLE 3.3

GEOTECHNICAL PARAMETERS FROM PRIOR INVESTIGATIONS

PARAMETER		PHASES II & III B-19 LANDFILL DESIGN			SEED, RAYMOND B. ET AL. INVESTIGATION OF PHASE I B-19 LANDFILL FAILURE	GENERIC EVALUATIONS OF KHF LANDFILL CLOSURES	EMPIRICAL OR MEASURED DATA FROM PUBLISHED LITERATURE	
I. STRENGTH PROPERTIES								
SANDSTONE Cross-bed Strength (In-dipping)	C (psf)	800[1]						
	Ø (Degrees)	40						
Anisotropic Strength (Out-dipping)	C (psf)	--						
	Ø (Degrees)	--						
SILTSTONE Cross-bed Strength (In-dipping)	C (psf)	800[1]						
	Ø (Degrees)	40						
Anisotropic Strength (Out-dipping)	C (psf)	0[1]						
	Ø (Degrees)	36						
CLAYSTONE Cross-bed Strength (In-dipping)	C (psf)	800[1]						
	Ø (Degrees)	40						
Anisotropic Strength (Out-dipping)	C (psf)	0[1]						
	Ø (Degrees)	36						
COMPACTED FILL	C (psf)	600[1]	400	500[2]				
	Ø (Degrees)	26	38	31				
CLAY LINER	C (psf)				2,200[5]	1300 (peak)[6], 600 (residual)		
	Ø (Degrees)							
WASTE	Unit Weight (pcf)	85[3]	85[3]	110[3]				
	C (psf)	700	0	0		31[6]		
	Ø (Degrees)	0	27	28				
LINER SYSTEM INTERFACES Waste/Protective Soil	Ø (Degrees)	--			>>8°	31[6]		
Protective Soil/Geotextile	Ø (Degrees)	--			>>8°			
Geotextile/Granular Layer	Ø (Degrees)	--			>>8°	>30		
Geotextile/Geonet	Ø (Degrees)	--			>12 (Residual)			
HDPE/Geonet - Smooth HDPE	Ø (Degrees)	--			8.5 (Residual)			
- Textured HDPE	Ø (Degrees)	--			--		23[8]	
HDPE/Compacted Clay - Smooth HDPE	Ø (Degrees)	--			0	11[6]	17[9]	
	τ (psf)	--			900	0	--	
- Textured HDPE	Ø (Degrees)	--			--		26[9]	27[4]
	τ (psf)	--			--		0	0
Compacted Clay/Geotextile.	Ø (Degrees)	--			24 (Residual)			

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(1) See Footnotes next page.

TABLE 3.3

GEOTECHNICAL PARAMETERS FROM PRIOR INVESTIGATIONS (Continued)

PARAMETER		PHASES II & III B-19 LANDFILL DESIGN	SEED, RAYMOND B. ET AL. INVESTIGATION OF PHASE I B-19 LANDFILL FAILURE	GENERIC EVALUATIONS OF KHF LANDFILL CLOSURES	EMPIRICAL OR MEASURED DATA FROM PUBLISHED LITERATURE
HDPE/Geotextile - Smooth HDPE	Ø (Degrees)	--	8° (Residual)	9 [6]	9 [9]
- Textured HDPE	Ø (Degrees)	--	--		32[9]
HDPE/Soil - Smooth HDPE	Ø (Degrees)	--	--		18,18,26,23,15,21,15
- Textured HDPE	Ø (Degrees)		--		29.8,34,33,35,29,27, 26,25,35
HDPE/Geocomposite - Smooth HDPE	Ø (Degrees)	--			11°, 16.6
- Textured HDPE	Ø (Degrees)				42°, 38.5 [10]
II. CONSOLIDATION PROPERTIES					
SANDSTONE	E (KSF)	--			
Recompression Ratio (Percent) [1]		0			
SILTSTONE	e_o	.74			
	E (KSF)	--			$(250\text{-}500)(\sigma_1 - \sigma_3)_f$ [11]
Recompression Ratio (Percent) [1]		1.4			
CLAYSTONE	e_o	.93			
	E (KSF)	--			$(250\text{-}500)(\sigma_1 - \sigma_3)_f$ [11]
Recompression Ratio (Percent) [1]		1.4			
COMPACTED FILL Typical Value of Compression (percent of original height)					4 [7]
CLAY LINER	e_o		.82, .83, .87		
Second Compression Index				.005 to .03	
Cv (Ft2/Yr)			2		
WASTE Typical Value of Compression (percent or original height)				10,14.5 [6]	
Second Compression Index					.1 to .4 [7], .09 [12]

(1) Donohue 1988, Appendix F.
(2) EMCON (Pond P-9 levees). Reference 3.
(3) Donohue 1988, Appendix F, Figure V-9.
(4) Koerner, 1986.
(5) Seed, et al., 1988)
(6) Golder, 1988c.
(7) Navy, 1982.
(8) SLT, Friction Flex.
(9) Gundle, 1988a.
(10) Gundle, 1988c.
(11) Winterkorn et al., 1975.
(12) Yen, et al., 1975.
(13) Gundle, 1987.

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TABLE 3.4

LABORATORY TESTS OF BORING SAMPLES

BORING NO.	SAMPLE TYPE	SAMPLE NO.	SAMPLE DEPTH (Feet)	STRATIGRAPHIC UNIT	MATERIAL TYPE	INDEX PROPERTIES: VISUAL CLASSIFICATION	PLASTICITY INDEX	PERCENT PASSING NO. 200	SIEVE ANALYSIS/ HYDROMETER (8)	UNIT WEIGHT/ WATER CONTENT	SPECIFIC GRAVITY	COMPACTION PROPERTIES: STANDARD PROCTOR	MODIFIED PROCTOR	STRENGTH: UNCONSOLIDATED(7) UNDRAINED (UU) TRIAXIAL	CONSOLIDATED UNDRAINED (CU) TRIAXIAL	CONSOLIDATED DRAINED (CD) TRIAXIAL (10)	UNSATURATED DIRECT SHEAR (1)	EXTRUDES FOR MIX	MISC.: PERMEABILITY	CONSOLIDATION	SHRINK/SWELL POTENTIAL	GEOCHEMISTRY	REMARKS
L18-A	PB	S-1	5-6.1	18-10	SS	X			X														
	PB	S-2	10-12.5	18-10	CS																		
	PB	S-3	17-19.5	18-10	CS/SS	X		X		X													
	PB	S-4	25-27.5	18-10	SS	X		X															
	PB	S-5	33-33.5	18-10	SS																	X	
	PB	S-6	37-38.7	18-10	SS	X		X		X													
L18-B	PB	S-1	6-8.5	18-12	CS	X	X		X	X													
	PB	S-2	11.5-14	18-11	SS																		
	PB	S-3	20-22.5	18-11	SS	X				X				X (1 pt.)			X (3 pts.)						
	PB	S-4	28-30.5	18-11	CS/SLT																		
	PB	S-5	37-39.5	18-11	SS	X			X	X				X (2 pts.)			X						
L18-C	DR	B-1	6-7.5	Qc	cl	X	X			X													
	DR	B-2	12-13.5	Qc	cl																		
	PB	S-1	15-17.3	18-7	SLT	X	X		X	X													
	PB	S-2	20-22.5	18-7	SLT																	X	
	PB	S-3	25-27.5	18-7	SLT	X	X			X													
	PB	S-4	33-35	18-7	CS/SLT																		
	PB	S-5	41-43.1	18-7	SS	X				X													
	PB	S-6	48-50.1	18-7	SLT									X (1 pt.)									
	PB	S-7	56-58	18-7	SLT	X	X		X								X (3 pts.)						
	PB	S-8	64-66.3	18-7	SLT									X (2 pts.)									
	PB	S-9	72-74.3	18-7	SS	X				X													
	PB	S-10	80-82	18-7	SLT/CS																		
	PB	S-11	87-89	18-7	SLT	X	X			X													
L18-D	DR	B-1	5-6.5	Qc	cl																		
	DR	B-2	10-11.5	Qc	cl	X	X		X														
	PB	S-1	15-12.3	18-5	SS																		
	PB	S-2	22-24.3	18-5	SLT	X	X		X					X (2 pts.)			X						
	PB	S-3	29-31.5	18-4	CS/SLT									X (1 pt.)									
	PB	S-4	36-38.5	18-4	CS/SLT	X				X													
	PB	S-5	44-46.5	18-4	CS																		
	PB	S-6	52-54.3	18-4	CS	X	X			X													
	PB	S-7	60-62.5	18-4	CS/SLT																		
	PB	S-8	68-70.5	18-4	CS																		
	PB	S-9	76-78.5	18-3	SS																		
	PB	S-10	81-83.5	18-3	SS	X		X		X													
	PB	S-11	83.5-86	18-3	SS																		
L18-E	DR	B-1	5-6.5	Qc	cl																		
	PB	S-1	10-12.5	Qc	cl	X				X													
	PB	S-2	15-17.5	18-3	SS	X		X															
	PB	S-3	20-22.5	18-3	SS																		
	PB	S-4	28-30.2	18-3	SS																		
	PB	S-5	35-37.5	18-3	SLT/CS																		
	PB	S-6	43-45	18-3	SLT	X	X			X													
	PB	S-7	51-53	18-2	CS																		
	PB	S-8	60-62.5	18-2	CS/SLT	X	X			X													
L18-F	PB	S-1	6-8.5	18-8	CS	X																X	
	PB	S-2	16-18.5	18-8	CS																		
	PB	S-3	26-28.5	18-8	CS	X	X		X	X													
	PB	S-4	36-38.5	18-8	CS																		
	PB	S-5	46-48.1	18-8	CS									X (1 pt.)									
	PB	S-6	56-58.5	18-8	CS	X	X		X					X (2 pts.)			X						
L18-G	PB	S-1	6-8.5	18-13	SS	X		X		X													
	PB	S-2	14-16.5	18-13	SS																		
	PB	S-3	22-23.7	18-13	SS																		
	PB	S-4	30-32	18-13	SS									X (2 pts.)									
	PB	S-5	40-41.3	18-13	SS	X		X						X (1 pt.)									
	PB	S-6	45-47.5	8-12	CS									X (2 pts.)									
	PB	S-7	50-51.8	8-12	CS	X	X		X					X (1 pt.)									
	PB	S-8	60-62.5	8-12	CS																		
	PB	S-9	65-67	8-12	CS	X	X		X	X													
	PB	S-10	75-77.5	8-12	SS/CS																		
L18-H	PB	S-1	6-8.5	18-10	CS	X	X			X													
	PB	S-2	15-17.5	18-10	SS/CS	X		X		X													
	PB	S-3	25-27.5	18-10	CS																		
	PB	S-4	35-37.5	18-10	CS	X	X			X													
	PB	S-5	45-47.5	18-10	SS																		
	PB	S-6	55-57.5	18-10	CS	X	X			X													
L18-I	DR	B-1	6-7.5	Qc	cl																		
	PB	S-1	12-13.8	Qc	cl																		
	PB	S-2	16-18.5	18-8	CS	X	X		X	X													
TEST TOTALS FOR INITIAL BORINGS						35	20	8	13	30	–		–	6 (Series)			4		–		–	3	
ANTICIPATED TESTS FOR NEW BORINGS B18-J AND B18-K					(Sheet 2)	21	16	5	5	19	2		9	–			–		9		11	–	

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PB = Pitcher Barrel
DR = Drive Sample
Qc = Colluvium
CS = Claystone
SLT = Siltstone

TABLE 3.4

LABORATORY TESTS OF BORING SAMPLES (Continued)

BORING NO.	SAMPLE TYPE	SAMPLE NO.	SAMPLE DEPTH (Feet)	STRATIGRAPHIC UNIT	MATERIAL TYPE	INDEX PROPERTIES: VISUAL CLASSIFICATION	INDEX PROPERTIES: PLASTICITY INDEX	INDEX PROPERTIES: PERCENT PASSING NO. 200	INDEX PROPERTIES: SIEVE ANALYSIS/ HYDROMETER (9)	INDEX PROPERTIES: UNIT WEIGHT/ WATER CONTENT	INDEX PROPERTIES: SPECIFIC GRAVITY	COMPACTION PROPERTIES: STANDARD PROCTOR	COMPACTION PROPERTIES: MODIFIED PROCTOR	STRENGTH: UNCONSOLIDATED UNDRAINED (UU) TRIAXIAL (1)	STRENGTH: CONSOLIDATED UNDRAINED (CU) TRIAXIAL	STRENGTH: CONSOLIDATED DRAINED (CD) TRIAXIAL	STRENGTH: UNSATURATED DIRECT SHEAR (2)	STRENGTH: EXTRUDE FOR MIX	MISC.: PERMEABILITY	MISC.: CONSOLIDATION	MISC.: SHRINK/SWELL POTENTIAL	GEOCHEMISTRY	REMARKS
L18-J	BB	S-1	5-7.5	18-8	CS	X	X		X	X								X			X		
	PB	S-2	10-12.5	18-8	CS													X					
	PB	S-3	15-17.5	18-8	CS	X	X			X								X					
	PB	S-4	20-22	18-8	CS/SS																		
	PB	S-5	25-27.5	18-8	CS	X	X			X								X					
	PB	S-6	30-32.5	18-8	CS													X					
	PB	S-7	35-37.5	18-8	CS	X	X		X	X	X		X (3)					X	X (3)		X		
	PB	S-8	40-42.5	18-8	CS																		
	PB	S-9	45-47.5	18-8	CS	X	X			X								X					
	PB	S-10	50-52.5	18-8	CS													X					
	PB	S-11	55-57.5	18-8	CS	X	X			X								X					
	PB	S-12	60-62.5	18-8	CS													X					
	PB	S-13	65-67.5	18-8	CS	X	X			X								X					
	PB	S-14	70-72.5	18-8	CS													X					
	PB	S-15	75-77.5	18-8	CS	X	X		X	X			X (4)					X	X (4)				
	PB	S-16	80-82.5	18-8	CS																		
	PB	S-17	85-87.5	18-8	CS	X	X			X													
	PB	S-18	90-92.5	18-8	CS																		
	PB	S-19	95-97.5	18-8	CS/SS																		
	PB	S-20	100-101.5	18-8	CS	X				X													
	PB	S-21	105-107.5	18-8	CS																		
	PB	S-22	110-112.5	18-8	CS	X	X			X								X					
	PB	S-23	115-117.5	18-8	CS																		
	PB	S-24	120-122.5	18-8	CS	X	X		X	X								X			X		
	PB	S-25	125-127.5	18-8	CS																		
	PB	S-26	130-132.8	18-8	CS	X	X			X			X (5)					X	X (5)				
	PB	S-27	135-137.5	18-8	CS																		
	PB	S-28	140-142.5	18-8	CS	X	X			X								X					
	PB	S-29	145-147.5	18-8	CS																		
	PB	S-30	150-152.5	18-8	CS	X	X			X													
	PB	S-31	155-157.5	18-8	CS																		
	PB	S-32	160-162.5	18-8	CS	X	X		X	X											X		
	PB	S-33	165-167.5	18-7	SLT																		
	PB	S-34	170-172.5	18-7	SS																		
L18-K	PB	S-1	5-7.5	18-9	SS	X		X										X					
	PB	S-2	10-12.5	18-9	SS					X								X					
	PB	S-3	15-17.5	18-9	SS													X					
	PB	S-4	20-22.5	18-9	SS	X		X										X					
	PB	S-5	25-27.5	18-9	SS						X	X	X (6)					X	X (6)		X (6)		
	PB	S-6	30-32.5	18-9	SLT													X					
	PB	S-7	35-37.5	18-9	SS													X					
	PB	S-8	40-42.5	18-9	SS	X		X										X					
	PB	S-9	45-47	18-9	SLT													X					
	PB	S-10	50-52.5	18-9	SLT								X (7)					X	X (7)		X (7)		
	PB	S-11	55-57.5	18-9	SLT													X					
	PB	S-12	60-62.5	18-9	SLT													X					
	PB	S-13	65-67.5	18-9	SS	X		X										X					
	PB	S-14	70-72.5	18-9	SS													X					
	PB	S-15	75-76.8	18-9	SS								X (8)					X	X (8)		X (8)		
	PB	S-16	80-82.3	18-9	SS	X	X																
	PB	S-17	85-87.5	18-8	CS																		
	PB	S-18	90-92.5	18-8	CS																		
	PB	S-19	95-97.5	18-8	CS																		
TEST TOTALS FOR L18-J AND L18-K						21	16	5	5	19	2		9	-			-		9		10	-	
TEST TOTAL ALL BORINGS						56	36	13	18	49	2		9	4			4		9		10	3	

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(1) σu = 4, 8, 16 K.S.F.
(2) σn = 4, 8, 12 K.S.F.
(3) Composite from samples S-1, S-2, S-3, S-5, S-6, and S-7 (pure claystone). Permeability at 90% relative compaction and optimum moisture content.
(4) Composite from samples S-9, S-10, S-11, S-12, S-13, S-14, and S-15 (pure claystone). Permeability at 90% relative compaction and 2% above optimum moisture content.
(5) Composite from samples S-22, S-24, S-26, S-28, and S-30 (pure claystone). Permeability at 90% relative compaction and optimum moisture content.
(6) Composite from samples S-1 through S-5 (sandstone). Run two series by mixing with claystone samples from Boring L18-J, at 30% and 70% sandstone (by weight). Permeability at 90% relative compaction and 2% above optimum moisture content.
(7) Composite from samples S-6 through S-10 (sandstone/siltstone). Run two series by mixing with claystone samples from Boring L18-J at 30% and 70% sandstone/siltstone (by weight). Permeability at 90% relative compaction and 2% above optimum moisture content.
(8) Composite from samples S-11 through S-15 (siltstone/sandstone). Run two series by mixing with claystone samples from Boring L18-J at 30% and 70% siltstone (by weight). Permeability at 90% relative compaction and 2% above optimum moisture content.
(9) Sieve analysis if percentage passing No. 200 sieve is less than 40%. Hydrometer analysis if greater than 40%.

TABLE 3.5

LABORATORY TESTS OF TEST PIT SAMPLES

							INDEX PROPERTIES					COMPACTION PROPERTIES		STRENGTH		MISCELLANEOUS		
NUMBER	TEST PIT NO.	SAMPLE TYPE	SAMPLE NO.	SAMPLE DEPTH (Feet)	STRATIGRAPHIC UNIT	MATERIAL TYPE	VISUAL CLASSIFICATION	PLASTICITY INDEX	PERCENT PASSING NO. 200	SIEVE ANALYSIS/ (7) HYDROMETER	SPECIFIC GRAVITY	MODIFIED PROCTOR	STANDARD PROCTOR	UNCONSOLIDATED UNDRAINED (UU) TRIAXIAL	CONSOLIDATED UNDRAINED (CU) TRIAXIAL	PERMEABILITY	CONSOLIDATION (8)	SHRINK/SWELL POTENTIAL
1	DT-A	Sack	1	5	Colluvium	cl												
2	DT-A	Sack	2	5	18-8	CS	X	X		X		X		X (1)(2)	X	X (2)	X (3)(5)	X (2)
3	DT-C	Sack	2		Colluvium	cl												
4	DT-C	Sack	1	8	18-8	CS	X	X		X		X			X	X (2)	X (3)(5)	X (2)
5	TP-1	Sack	B-1	7	18-9	SS	X			X		X						
6	TP-2	Sack	B-1	10	Colluvium	cl	X		X (6)									
7	TP-3	Sack	B-1	15	Colluvium	cl												
8	TP-7	Sack	B-1	10	Colluvium	cl												
9	TP-8	Sack	B-1	7	Colluvium	cl	X		X (6)									
10	TP-11	Sack	B-1	7	Colluvium	S/C	X		X									
11	TP-13	Sack	B-1	4	Colluvium	cl	X		X									
12	TP-15	Sack	B-1	7	Colluvium	S/C												
13	TP-17	Sack	B-1	8	Colluvium	cl												
14	TP-18	Sack	B-1	2	Colluvium	cl	X		X (6)									
15	TP-18	Sack	B-2	12	Colluvium	C/S												
16	TP-23	Sack	B-1	0-4	Colluvium	S/M	X		X (6)									
17	TP-25	Sack	B-1	0-7	Colluvium	SC/S/M	X		X (6)			X (6)				X (6)		X (6)
18	TP-26	Sack	B-1	0-10.5	Colluvium	S/C	X		X (6)									
19	TP-27	Sack	B-1	0-12	Colluvium	S/C	X		X (6)									
20	TP-28	Sack	B-1	0-12.5	Colluvium	S/C												
21	TP-28	Sack	B-2	12.5-13.5	18-7	CS/SLT												
TEST TOTALS FOR INITIAL TEST PITS							12	2	9	3	3	4		2 (Series)		3	2	3
ANTICIPATED TESTS FOR TEST PITS TP-29 THROUGH TP-43							4	4	--	3	--	--		--		--	--	--

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TABLE 3.5

LABORATORY TESTS OF TEST PIT SAMPLES (Continued)

						INDEX PROPERTIES						COMPACTION PROPERTIES		STRENGTH		MISCELLANEOUS		
NUMBER	TEST PIT NO.	SAMPLE TYPE	SAMPLE NO.	SAMPLE DEPTH (Feet)	STRATIGRAPHIC UNIT	MATERIAL TYPE	VISUAL CLASSIFICATION	PLASTICITY INDEX	PERCENT PASSING NO. 200	SIEVE ANALYSIS/(7) HYDROMETER	SPECIFIC GRAVITY	MODIFIED PROCTOR	STANDARD PROCTOR	UNCONSOLIDATED UNDRAINED (UU) TRIAXIAL	CONSOLIDATED UNDRAINED (CU) TRIAXIAL	PERMEABILITY	CONSOLIDATION (8)	SHRINK/SWELL POTENTIAL
22	TP-29	Sack	B-1	4-6.5	18-10	CS												
23	TP-30	Sack	B-1	7	18-11	SS/CS												
24	TP-31	Sack	B-1	3.5	18-12	CS	X	X										
25	TP-32	Sack	B-1	5	18-13	SS												
26	TP-33	Sack	B-1	8	18-13	SS												
27	TP-34	Sack	B-1	4	18-12	CS												
28	TP-35A	Sack	B-1	7	18-10	SS												
29	TP-36	Sack	B-1	4	18-8	CS	X	X		X								
30	TP-37	Sack	B-1	6	18-8	CS							X					
31	TP-38	Sack	B-1	9	18-8	CS	X	X		X								
32	TP-39	Sack	B-1	10	18-8	CS												
33	TP-40	Sack	B-1	3	18-8	CS	X	X		X								
34	TP-41	Sack	B-1	3.5	18-8	CS												
35	TP-42	Sack	B-1	6	18-9	SS	X			X	X	X		X				
36	TP-43	Sack	B-1	6	18-9	SS/SLT												
TEST TOTALS TP29 THROUGH TP-43							4	4	--	3	--	--		--	--		--	--
TEST TOTALS ALL TEST PITS							16	6	9	6		3		4	2 (Series)	3	2	3

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NOTES:

(1) σ_3 = 4, 8, 12 k.s.f.
(2) Sample at 90% relative compaction and optimum moisture content.
(3) If permeability criteria is satisfied, sample at 90% relative compaction and optimum moisture content.
(4) Sample at 95% relative compaction at optimum moisture content.
(5) Loading sequence: 0.5, 1, 2, 4, 8, 16, 32 k.s.f.
(6) Based on the percentage passing no. 200 test results prepare a composite sample using the three samples with smaller percentage of fines. Run compaction, permeability and shrink/swell potential at 90% relative compaction and optimum moisture content. Mixing with claystone samples will be considered upon review of preliminary results.
(7) Sieve analysis if percentage passing no. 200 sieve is less than 40%. Hydrometer analysis if greater than 40%.
(8) Time readings requested.

TABLE 3.6

GEOTECHNICAL/GEOCHEMICAL ANALYSIS METHODS

TYPE OF TEST	STANDARD
Geotechnical	
Moisture Content	ASTM D2216-80
Liquid and Plastic Limits	ASTM D4318-84
Shrinkage Limit	ASTM D427-83
Grain Size Analysis	ASTM D422-63
Specific Gravity	ASTM D854-83
Moisture Density Relations:	
• (Modified Proctor)	ASTM D1557-78, Method A
• (Standard Proctor)	ASTM D698-78, Method A
Direct Shear	ASTM D3080-72
Unconsolidated Undrained Triaxial	Corps of Engineers EM 1110-2-1906
Hydraulic Conductivity	Corps of Engineers EM 1110-2-1906
Background Geochemistry	
Priority Pollutants:	
• Volatile Organics	EPA 8240
• Semi-Volatile Organics	EPA 8270
• Pesticides	EPA 8080
California Regulated Metals	CCR Title 22 Section 66699
Total Organic Carbon	EPA 9060
Specific Conductance	EPA 9050
pH	EPA 9045
Nitrate	EPA 9200
Sulfate	EPA 9035
Cyanide	EPA 9010
Chloride	EPA 9250

TABLE 3.7

SUMMARY OF PLASTICITY INDEX DATA BY STRATIGRAPHIC UNIT

STRATIGRAPHIC UNIT	BORING NO.	SAMPLE NO.	DEPTH (ft.)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USC SYMBOL
COLLUVIUM	L18-C	B-1	6.0 - 7.5	35	19	CL
COLLUVIUM	L18-D	B-2	10.0 - 11.5	29	13	CL
18-2	L18-E	S-8	60.0 - 62.5	53	32	CH
18-3	L18-E	S-6	43.0 - 45.0	32	6	ML
18-4	L18-D	S-6	52.0 - 54.3	67	42	CH
18-5	L18-D	S-2	22.0 - 24.3	49	29	CL/CH
18-7	L18-C	S-1	15.0 - 17.3	38	17	CL
18-7	L18-C	S-3	25.0 - 27.5	46	23	CL
18-7	L18-C	S-7	56.0 - 58.0	60	36	CH
18-7	L18-C	S-11	87.0 - 89.0	41	17	CL
18-9	L18-K	S-10	80.0 - 82.3	30	11	CL
18-10	L18-H	S-1	6.0 - 8.5	81	50	CH
18-10	L18-H	S-4	35.0 - 37.5	78	51	CH
18-10	L18-H	S-6	55.0 - 57.5	71	49	CH
18-12	L18-B	S-1	6.0 - 8.5	64	36	CH
18-12	L18-G	S-7	50.0 - 51.8	78	49	CH
18-12	L18-G	S-9	65.0 - 67.0	60	36	CH
18-12	TP-31	B-1	3.5	70	49	CH
18-8	L18-F	S-1	6.0 - 8.5	78	55	CH
18-8	L18-F	S-3	26.0 - 28.5	69	57	CH
18-8	L18-F	S-6	56.0 - 58.5	59	39	CH
18-8	L18-I	S-2	16.0 - 18.5	58	36	CH
18-8	L18-J	S-1	5.0 - 7.5	55	30	CH
18-8	L18-J	S-3	15.0 - 17.5	67	41	CH
18-8	L18-J	S-5	25.0 - 27.5	79	50	CH
18-8	L18-J	S-7	35.0 - 37.5	64	40	CH
18-8	L18-J	S-9	45.0 - 47.5	74	49	CH
18-8	L18-J	S-11	55.0 - 57.5	69	46	CH
18-8	L18-J	S-13	65.0 - 67.5	74	50	CH
18-8	L18-J	S-15	75.0 - 77.5	33	17	CL
18-8	L18-J	S-17	85.0 - 87.5	56	38	CH
18-8	L18-J	S-22	110.0 - 112.5	71	47	CH
18-8	L18-J	S-24	120.0 - 122.5	70	42	CH
18-8	L18-J	S-26	130.0 - 132.8	88	60	CH
18-8	L18-J	S-28	140.0 - 142.5	85	53	CH
18-8	L18-J	S-30	150.0 - 152.5	88	62	CH
18-8	L18-J	S-32	160.0 - 162.5	55	30	CH

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TABLE 3.8

PERCENT PASSING NO. 200 SIEVE

STRATIGRAPHIC UNIT	MATERIAL TYPE	BORING/ TEST PIT NO.	SAMPLE NO.	DEPTH (ft.)	PERCENT PASSING NO. 200 SIEVE
Colluvium	Soil	TP-2	B-1	10	57
Colluvium	Soil	TP-8	B-1	7	81
Colluvium	Soil	TP-11	B-1	7	39
Colluvium	Soil	TP-13	B-1	4	48
Colluvium	Soil	TP-18	B-1	2	58
Colluvium	Soil	TP-23	B-1	0-4	33
Colluvium	Soil	TP-25	B-1	0-7	57
Colluvium	Soil	TP-26	B-1	0-10.5	52
Colluvium	Soil	TP-27	B-1	0-12	69
18-3	ss/slt	L18-D	S-10	81-83.5	24
18-3	ss	L18-E	S-2	15-17.5	24
18-9	ss	L18-K	S-1	5-7.5	11
18-9	ss/slt	L18-K	S-4	20-22.5	26
18-9	ss/slt	L18-K	S-8	40-42.5	21
18-9	ss	L18-K	S-13	65-67.5	19
18-10	slt/cs	L18-A	S-3	17-19.5	55
18-10	ss/slt	L18-A	S-4	25-27.5	73
18-10	cs/ss	L18-A	S-6	37-38.7	47
18-10	ss	L-18H	S-2	15-17.5	37
18-13	ss	L18-G	S-1	6-8.5	11
18-13	ss	L18-G	S-5	40-41.3	11

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TABLE 3.9

COMPACTION TEST RESULTS (MODIFIED PROCTOR, ASTM D1557-78)

BORING NO./ TEST PIT NO.	COMPOSITE SAMPLE NO.	MATERIAL TYPE	SAMPLE PREPARATION	OPTIMUM MOISTURE CONTENT (%)	MAXIMUM DRY DENSITY (PCF)
1. Modified Proctor Test (ASTM D1557-78)					
L18-J	No. 1	Claystone	S-1, S-2, S-3, S-5, and S-6	22.8	98.7
L18-J	No. 2	Claystone	S-9, S-10, S-11, S-12, S-14, and S-15	21.7	100.7
L18-J	No. 3	Claystone	S-22, S-24, S-26, S-28, and S-30	24.9	96.2
L18-J/L18-K	No. 4	30% Sandstone/ 70% Claystone	S-1 through S-5, Boring L18-14 plus claystone from Boring L18-J	20.8	104.9
L18-J/L18-K	No. 5	50% Sandstone/ 50% Claystone	S-1 through S-5, Boring L18-K plus claystone from Boring L18-J	19.6	106.6
L18-J/L18-K	No. 6	30% Sandstone/ 70% Claystone	S-6 through S-10, Boring L18-K plus claystone from Boring L18-J	21.9	102.9
L18-J/L18-K	No. 7	50% Sandstone/ 50% Claystone	S-6 through S-10, Boring L18-K plus claystone from Boring L18-J	20.4	103.7
L18-J/L18-K	No. 8	30% Sandstone/ 70% Claystone	S-11 through S-15, Boring L18-K plus claystone from Boring L18-J	19.8	104.0
L18-J/L18-K	No. 9	50% Sandstone/ 50% Claystone	S-11 through S-15, Boring L18-K plus claystone from Boring L18-J	19.4	104.8
TP-11, TP-25, TP-26	No. 10	Colluvium (Silty Clay)	Mixture from all test pits	12.3	123.3
TP-42, B-1	—	Sandstone	—	15.0	114.8
DT-A, B-2	—	Claystone	—	21.5	104.2
DT-C, B-1	—	Claystone	—	23.5	99.0
2. Standard Proctor, ASTM D698					
TP-36, TP-37, TP-38	No. 11	Claystone	Mixture from all test pits	29.7*	87.7*
L18-J/L18-K	No. 4	30% Sandstone/ 70% Claystone	S-1 through S-5, Boring L18-K plus claystone from Boring L18-J	27.0*	94.2*

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TABLE 3.10

SUMMARY OF PERMEABILITY TESTS

TEST PIT/BORING NO.	COMPOSITE SAMPLE NO.	MATERIAL TYPE	STRATIGRAPHIC UNIT	OPTIMUM MOISTURE CONTENT (%)	MAXIMUM DRY DENSITY (PCF)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS	PERMEABILITY TEST: MOLD SIZE (INCHES)	MAXIMUM PARTICLE SIZE (INCHES)	INITIAL WATER CONTENT (%)	INITIAL DRY DENSITY (PCF)	INITIAL RELATIVE COMPACTION (%)	FINAL WATER CONTENT (%)	FINAL DRY DENSITY	FINAL RELATIVE COMPACTION	CONFINING PRESSURE (psi)	GRADIENT	K (cm/sec)
L18-J	2	Claystone	18-8	21.7	100.7	63	40	CH	2.5	3/8	22.4	91.6	91	33.6	90.1	89	40	41.2	2.0×10^{-8}
DT-A, B-2	--	Claystone	18-8	21.5	104.2	82	54	CH	2.5	3/8	24.0	93.3	90	29.5	96.4	93	40	82.4	1.9×10^{-9}
TP-36, TP-37, TP-38	11	Claystone	18-8	23.5	99.0	76	45	CH	4	1/4	28.7	89.4	90	33.2	90.4	91	40	82.4	4.1×10^{-9}
TP-36, TP-37, TP-38	11	Claystone	18-8	23.5	99.0	76	45	CH	4	1/4	28.6	89.5	90	33.7	89.7	91	40	82.4	5.0×10^{-9}
L18-J, S-21	--	Claystone	18-8	24.9	99.0	76	45	CH	4	(1)	31.2	89.3	90	34.4	88.5	89	40	82.4	2.1×10^{-8}

(1) Weathered by repeated wetting and drying for two weeks. Maximum particle size resulted from the weathering process only.

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TABLE 3.11

SUMMARY OF SWELL TEST RESULTS (UNDISTURBED SAMPLES)

BORING NO.	SAMPLE NO.	SAMPLE DEPTH (ft.)	STRATI-GRAPHIC UNIT	MATERIAL TYPE	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	NATURAL		APPLIED PRESSURE (PSF)	SWELL[1] (%)
							WATER CONTENT (%)	DRY DENSITY (PCF)		
18-J 18-J	S-1 S-1	5.0 - 7.5 5.0 - 7.5	18-8 18-8	Claystone Claystone	55 55	30 30	23.4 20.6	87.7 89.6	600 12,000	4.0 -1.0
18-J 18-J	S-7 S-7	35.0 - 37.5 35.0 - 37.5	18-8 18-8	Claystone Claystone	64 64	24 24	25.0 26.5	96.0 93.9	600 12,000	1.8 0.7
18-J 18-J	S-24 S-24	120.0 - 122.5 120.0 - 122.5	18-8 18-8	Claystone Claystone	70 70	42 42	29.4 29.7	93.2 94.0	600 12,000	1.6 0.7
18-J 18-J	S-32 S-32	160.0 - 162.5 160.0 - 162.5	18-8 18-8	Claystone Claystone	55 55	30 30	21.2 20.6	96.7 97.6	600 12,000	0.4 -0.4

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(1) As a percent of the sample height after application of the pressure.

TABLE 3.12

SUMMARY OF SWELL TEST RESULTS (REMOLDED SAMPLES)

BORING/ TEST PIT NO.	COMPOSITE SAMPLE NO.	MATERIAL TYPE	STRATI-GRAPHIC UNIT	SAMPLE PREPARATION	OPTIMUM MOISTURE CONTENT (%)	MAXIMUM DRY DENSITY (PCF)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS	INITIAL WATER CONTENT (%)	INITIAL DRY DENSITY (PCF)	INITIAL RELATIVE COMPACTION (%)	APPLIED PRESSURE (PSF)	SWELL[1] %
DT-A, B-2	--	Claystone	18-8	--	21.5	104.2	82	54	CH	24.3	93.1	89	0	22.0
	--	Claystone	18-8	--	21.5	104.2	82	54	CH	24.1	93.1	89	1,200	7.1
	--	Claystone	18-8	--	21.5	104.2	82	54	CH	27.3	93.1	89	6,000	1.0
DT-C, B-1	--	Claystone	18-8	--	23.5	99.0	76	45	CH	26.0	88.7	90	0	12.9
	--	Claystone	18-8	--	23.5	99.0	76	45	CH	25.6	88.8	90	1,200	3.7
		Claystone	18-8	--	23.5	99.0	76	45	CH	28.1	89.4	90	5,000	1.0
L18-J/L18-K	4	30% Sandstone/ 70% Claystone	18-9/18-8	S-1 through S-5. Boring L18-K plus claystone from Boring L18-J.	20.8	104.9	--	--	CL	23.3	94.1	90	0	9.7
	4	30% Sandstone/ 70% Claystone	18-9/18-8	S-1 through S-5. Boring L18-K plus claystone from Boring L18-J.	20.8	104.9	--	--	CL	23.0	94.2	90	1,200	2.7
L18-J/L18-K	6	30% Sandstone/ 70% Claystone	18-9/18-8	S-6 through S-10 Boring L18-K plus claystone from Boring L18-J.	21.9	102.9	--	--	CL	24.3	92.3	90	0	11.8
	6	30% Sandstone/ 70% Claystone	18-9/18-8	S-6 through S-10 Boring L18-K plus claystone from Boring L18-J.	21.9	102.9	--	--	CL	24.2	92.3	90	1,200	3.2
L18-J/L18-K	8	30% Sandstone/ 70% Claystone	18-9/18-8	S-11 through S-15 Boring L18-K plus claystone from Boring L18-J.	19.8	104.0	--	--		22.1	93.4	90	0	13.4
	8	30% Sandstone/ 70% Claystone	18-9/18-8	S-11 through S-15 Boring L18-K plus claystone from Boring L18-J.	19.8	104.0	--	--		21.5	93.8	90	1,200	3.9
TP-11, TP-25, TP-26	10	Colluvium (silty clay)	--	Mixture from all test pits.	12.3	123.3	--	--	CL	14.9	110.3	89	0	4.5
	10	Colluvium (silty clay)	--	Mixture from all test pits.	12.3	123.3	--	--		15.0	110.3	89	1,200	0.2

(1) As a percent of the sample height after application of pressure.

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TABLE 3.13

GEOTECHNICAL LABORATORY TEST RESULTS ON PECTEN CLAYSTONE

Source: Geosyntec (2008)

Boring ID	Sample ID	Depth (ft)		USCS	As-Received Conditions		Sieve	Atterberg Limits			Laboratory Compaction		Hydraulic Conductivit	
		From	To		Moisture Content (D2216) (%)	Dry Density (pcf)	Fines (%)	LL (%)	PL (%)	PI (%)	Maximum Dry Density (pcf)	Optimum Moisture (%)	(cm/s)	Test Conditions (MC, RC)
CS-1	1-2	10.5	12	CH - Fat Clay	16.0		92.2	100	35	65			7.0E-08	+2, 90%*
CS-1	1-3	15	16.5											
CS-1	1-4	20	21.5	CH - Fat Clay	18.5	100.6	96.0	88	32	56				
CA-1A	Bulk 1A-1	0	5	CH - Fat Clay with Sand	12.4		76.0	55	21	34	122	12.5	7.4E-09, 9.2E-09	+3, 92%, +3, 89%
CA-1A	1A-2	10.5	12		19.3	100.3								
CA-1A	1A-3	16	16.5	MH - Elastic Silt	20.3		98.1	97	44	53				
CA-1A	1A-5	25	26.5	CH - Fat Clay	20.9	98.6	93.3	105	41	64			6.2E-08	+2, 90%*
CA-1A	1A-6	30	31.5	MH - Elastic Silt	23.1		89.6	89	39	50			9.6E-08	+2, 90%*
CA-1A	1A-7	35	36.5											
CA-1A	1A-8	40	41.5	CH - Fat Clay	21.2		89.5	78	31	47				
CA-1A	1A-9	45	46.5	CH - Fat Clay	24.4	98.2	87.7	82	35	47				
CA-1A	1A-11	55	56.5	CH - Fat Clay with Sand	18.6	95.8	84.2	58	29	29				
CA-1A	1A-13	65	66	SC - Clayey Sand	3.4		17.4							
CS-2	Bulk 2-1	0	5	CH - Fat Clay	14.1		96.3	104	36	68	113.1	15.6	3.7E-09	+3, 92%
CS-2	Bulk 2-2	6.5	10.5											
CS-2	2-2	10.5	12	CH - Fat Clay	16.5	106.4	95.2	100	34	66				
CS-2	2-4	20	21.5	CH - Fat Clay	21.0		95.3	92	39	53			8.6E-08	+2, 90%*
CS-2	2-7	35	36.5	CH - Fat Clay	21.0	100.6	89.8	93	33	60				
CS-2	2-9	45	46.5	CH - Fat Clay	24.7	99.7	98.6	104	37	67				
CS-2	2-11	55	56.5	CH - Fat Clay	24.0		96.7	82	33	49			8.2E-08	+2, 90%*
CS-2	2-13	65	66	CH - Fat Clay	25.1		98.4	112	40	72			1.7E-08	+2, 90%*
CS-2	2-14	70	71.5			97.7								
CS-2	2-16	80	81.5	CH - Fat Clay	25.4		91.1	129	41	88			5.3E-08	+2, 90%*
CS-2	2-17	85	86.5											
TP-1	TP1-1	9	10	CH - Fat Clay	20.8		93.0	100	37	63	109.9	17.8	1.1E-08	+3, 92%
TP-2	TP2-1	0	8	CH - Fat Clay	14.6		97.8	92	31	61	111.7	16.2	5.0E-09	+3, 92%
TP-3	TP3-1	11	12	CH - Fat Clay	21.9		91.1	102	35	67	108.2	17.4	6.5E-09	+3, 92%
TP-4	TP4-1	9	10	CH - Fat Clay	17.0		88.5	93	34	59	105.5	20.1	1.4E-08 4.5E-08	+3, 92%

Note: *Samples collected with a California type sampler tested for hydraulic conductivity were compacted at 90% relative compaction of the maximum dry density of similar materials from the test pad construction of Landfill B-18 Phases 1A/1B (Environmental Construction Services, 1991).

TABLE 5.1

MATERIAL AND INTERFACE PROPERTIES USED FOR STABILITY CALCULATIONS

Material or Interface	Material/Interface Properties			Source/Remarks
	Total Unit Weight (pcf)	**Cohesion Intercept, c (psf)**	**Friction Angle, ϕ (degrees)**	
Used by ESI (1990a) for the analysis of temporary rock cut slopes, compacted fill slopes, and temporary Phase I intermediate fill slopes:				
Hazardous Waste and Operations Layer (Shallow Sliding)	115	300	27	conservative parameters due to lack of site-specific testing
Hazardous Waste and Operations Layer (Deep Sliding)	115	0	31	Golder (1989a), conservative
Bedrock (Cross Bedding Strength)	130	800	40	Donohue & Associates (1988) and direct shear test results in Appendix D.8
Bedrock (Along Bedding Strength)	130	0	36	Donohue & Associates (1988) and UU triaxial test results in Appendix D.5
Structural Fill	125	2,000	30	UU triaxial test results on compacted sandstone in Appendix D.5
Clay Liner and Clay Liner/Textured HDPE Geomembrane Interface (Long Term)	125	1,150	20	CU triaxial test results on compacted claystone in Appendix D.7
Clay Liner and Clay Liner/Textured HDPE Geomembrane Interface (Short Term or Low Confining Stress)	125	3,600	0	UU triaxial test results on compacted claystone in Appendix D.6
Textured HDPE Geomembrane/Geonet Interface	-	0	15	Gundle (1987a) and Geosyntec (1988)
Geonet/Geotextile (Heat Bonded) Interface	-	0	>30	Fluid Systems, Inc. (Appendix F)
Geotextile/Drainage Gravel Interface	-	0	>21	expected to be stronger than the geotextile/clay liner interface
Geotextile/Clay Liner Interface	-	0	21	Golder (1990b)
Textured HDPE Geomembrane/Geocomposite Interface	-	0	24	Golder (1990b)
Geocomposite/Drainage Gravel Interface	-	0	>21	expected to be stronger than the geotextile/clay liner interface
Geotextile/Operations Layer Interface (Shallow Sliding)	-	300	27	the strength of the operations layer controls
Geotextile/Operations Layer Interface (Deep Sliding)	-	0	31	the strength of the operations layer controls
Used by HAI (Appendix H.4) for the analysis of the temporary Phase IIIA intermediate fill slope:				
Hazardous Waste	115	0	31	ESI (1990a), Rust E&I (1998), URS (2005)
Bedrock	150	800	40	ESI (1990a), Rust E&I (1998), URS (2005)
Phase IIIA Liner Interface	-	0	22	HAI (Appendix H.4)

TABLE 5.1 (continued)

MATERIAL AND INTERFACE PROPERTIES USED FOR STABILITY CALCULATIONS

Material or Interface	Material/Interface Properties			Source/Remarks
	Total Unit Weight (pcf)	Cohesion Intercept, c (psf)	Friction Angle, ϕ (degrees)	
Used by HAI (Appendix H.5) for the analysis of the final closure configuration:				
Hazardous Waste	115	0	31	ESI (1990a), Rust E&I (1998), URS (2005)
Clay Liner	115	1,150	20	ESI (1990a), Rust E&I (1998), URS (2005)
Bedrock	150	800	40	ESI (1990a), Rust E&I (1998), URS (2005)
Phase I Bottom Liner Interface	-	0	17	ESI (1990a), Rust E&I (1998), URS (2005)
Phase I Sideslope Liner Interface	-	800	9	ESI (1990a), Rust E&I (1998), URS (2005)
Phase II Bottom Liner Interface	-	0	19	ESI (1990a), Rust E&I (1998), URS (2005)
Phase II Sideslope Liner Interface	-	0	19	ESI (1990a), Rust E&I (1998), URS (2005)
Phase III Liner Interface	-	0	12	HAI (Appendix H.5)
Vegetative Cover Soil/Geotextile Interface	110	100	21	HAI (Appendix H.5)
Geotextile/40-mil Textured HDPE Geomembrane Interface	110	0	25	HAI (Appendix H.5), conservative based on site-specific direct shear laboratory testing
40-mil Textured HDPE Geomembrane/Foundation Layer Interface	110	0	28	HAI (Appendix H.5)
Foundation Layer/Hazardous Waste Interface	110	0	31	HAI (Appendix H.5)

TABLE 5.2

SUMMARY OF SLOPE STABILITY ANALYSES

Case[1]	Static Factor of Safety[2]	Seismic Stability	
		Allowable Design Displacement for the MCE (inches)	Estimated Displacement for the MCE (inches)
Temporary Rock Cut Slopes (see Figure 5.1 and Appendix H.2):			
2H:1V Slopes Across Bedding Planes	2.4	1	0
3H:1V Slopes Subparallel to Bedding Planes	2.2	1	<0.1
Compacted Fill Slopes (see Appendix H.3):			
Northeast Containment Basin Embankment	2.2	3	0
Temporary Phase I Intermediate Fill Slopes (see Figure 5.2 and Appendix H.4):			
Wedge Sliding Along Landfill Base and Phase I/II Berm Slope	2.5	6	<0.1
Circular Sliding Entirely Through Waste	1.5	12	0.5
Temporary Phase IIIA Intermediate Fill Slope (see Figure 5.3 and Appendix H.4):			
Wedge Sliding Along Phase IIIA Liner System	1.5	N/A	N/A
Final Closure Configuration (see Figure 5.3 and Appendix H.5):			
3.5H:1V Cover Slopes Between Benches (i.e., Veneer Stability)	1.6	12	2.7
Wedge Sliding Along Base and Sideslope of Landfill	2.3	6	<1
Circular Sliding Entirely Through Waste	2.2	12	<12

Notes:

1. Several scenarios were analyzed for most of the cases but only the critical values (i.e., lowest factors of safety and highest seismic displacements) for each case are shown. See Appendix H for complete results.
2. The minimum acceptable static factor of safety is considered to be 1.5.
3. N/A = not analyzed.

TABLE 5.3

PERIMETER RUN-ON DIVERSION DITCH FLOW AND CAPACITY SUMMARY

DITCH LOCATION	ASPHALT V-DITCH DIMENSIONS		MINIMUM DITCH SLOPE (%)	PMP FLOW ESTIMATE (cfs)	DITCH CAPACITY (cfs)
	WIDTH (feet)	DEPTH (minimum)			
Phase I Area (see Sheet 5 in Appendix A.1)					
Brow Ditches	2	1	5.6	8.5	13.5
North Portion of West Perimeter Road	5	1	0.6	10.4	13.3
South Portion of West Perimeter Road	5	3	0.6	61.5	64.6
South Perimeter Road to South Borrow Pit Road	5	2	8.3	121.5	139.6
West Portion of North Perimeter Road	5	1.25	1.0	24.0	24.3
East Portion of North Perimeter Road	5	1.0	8.0	26.4	48.5
Phase II Area (see Sheet 10 in Appendix A.1)					
North Portion of South Perimeter Road	5	2.5	3.6	121.5	124.8

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TABLE 5.4

ACTIVE ROAD RUN-OFF CONTROL SUMMARY

STRUCTURE	STRUCTURE DESCRIPTION	MINIMUM SLOPE (%)	ESTIMATED FLOW (cfs)		FLOW CAPACITY (cfs)
			25-YEAR STORM	PMP	
I. **Phase I** (see Sheet 5 in Appendix A.1)					
Inside Perimeter Road V-ditch	5-feet wide x 1.25-feet deep	0.6	N/A	14.4	18.8
Concrete-enclosed CMP pipe along West Perimeter Road at access ramp.	12-inch diameter	0.6	2	N/A	4.7
CMP culvert down south landfill slope to the Phase I/II Berm.	18-inch diameter	50	N/A	14.4	15.1
Concrete-encased CMP pipe at Phase I/II Berm Access Road.	18-inch diameter	0.5	3.9	N/A	4.8
Top of Phase I/II Berm V-Ditch.	5-feet wide x 1.25-foot deep	0.5	N/A	14.4	17.2
CMP culvert beneath Phase I/II Berm crest toward the clay pit retention basin.	30-inch diameter	0.5	N/A	15.6	33.8
Corrugated pipe at top of Phase I/II Berm to convey run-off into the clay pit containment basin.	30-inch diameter	50	N/A	15.6	33.8
Corrugated pipe to convey run-off from North Bench Road into the clay pit.	18-inch diameter	50	N/A	7.8	8.5
II. **Phase II** (see Sheet 10 in Appendix A.1)					
CMP culverts to convey run-off from Bench Road to northeast containment basin at the following locations:					
- End of South Bench Road	30-inch diameter	0.5	N/A	21.0	33.9
- End of North Bench Road	24-inch diameter	0.5	N/A	11.2	21.3

N/A = Not Applicable

89-977 (8/14/90)

TABLE 5.5

CONTAINMENT BASIN CAPACITY SUMMARY

Basin	Estimated 24-hour PMP Run-off Volume (acre-feet)	Basin Capacity (acre-feet)
Temporary Basins:		
Phase I Containment Basin (see Sheet 6 in Appendix A.1)	8	33
Phase I Intermediate Closure Basin (see Sheet 6 in Appendix A.1)	5	5
Permanent Basins:		
Northeast Containment Basin (see Sheet C-3 in Appendix A.2)	34*	33
South Containment Basin (see Sheet C-3 in Appendix A.2)	32	48

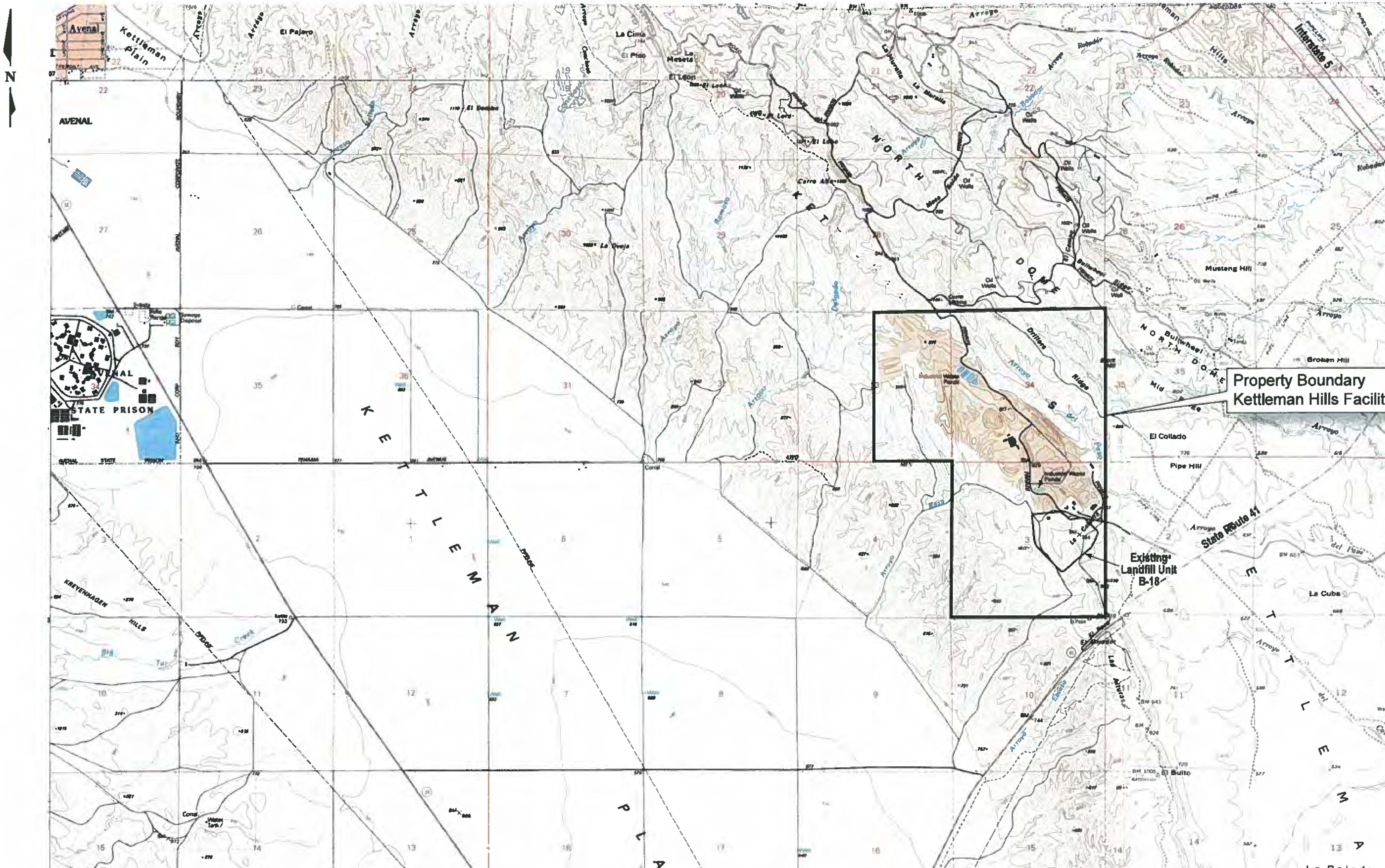
*will require pumping to South Containment Basin to maintain full containment of run-off

TABLE 5.6

FINAL CLOSURE RUN-OFF CONTROL SUMMARY

Structure	Dimensions		Minimum Slope (%)	Estimated Peak PMP Flow (cfs)	Maximum Flow Depth (feet)
	Bottom Width (feet)	Depth (feet)			
Final Drainage Benches (see Detail 2 on Sheet C-10 in Appendix A.2): trapezoidal, earthen	12	2	2	51	0.8
Cover Access Road (see Detail 5 on Sheet C-10 in Appendix A.2): Asphalt-Lined V-Ditch + Earthen Road	43.5	2 to 3.5	8	104	1.6
New B-18 Perimeter Road (see Detail 4 on Sheet C-7 in Appendix A.2): Asphalt-Lined Trapezoidal Ditch + Earthen Road + Earthen V-Ditch/2-Foot-Tall Earthen Berm)	37	2 to 3.5	1.4	270	2.9

FIGURES



Source: USGS La Cima (1978), Las Viejos (1981), Kettleman City (1981) and Kettleman Plain (1994)1:24,00 Scale Topographic Maps.

0 0.5 Scale in Miles | 0 1 Scale in Kilometers

FIGURE 1.1
SITE VICINITY MAP
WM/LANDFILL UNIT B-18 KETTLEMAN HILLS FACILITY/CA

083918870000fig1.1.ai | Mod: 08/12/08 | JDD

Golder Associates

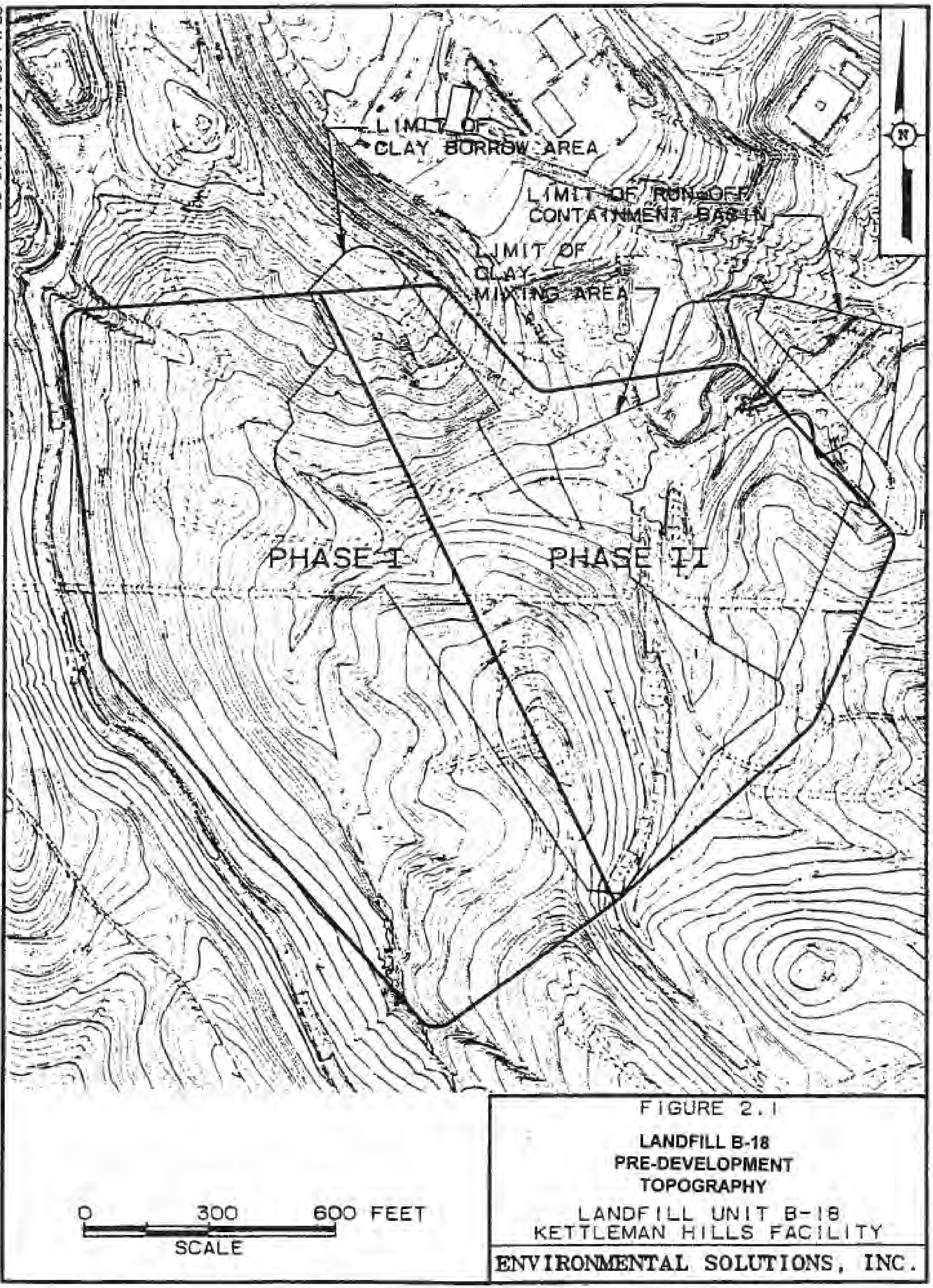
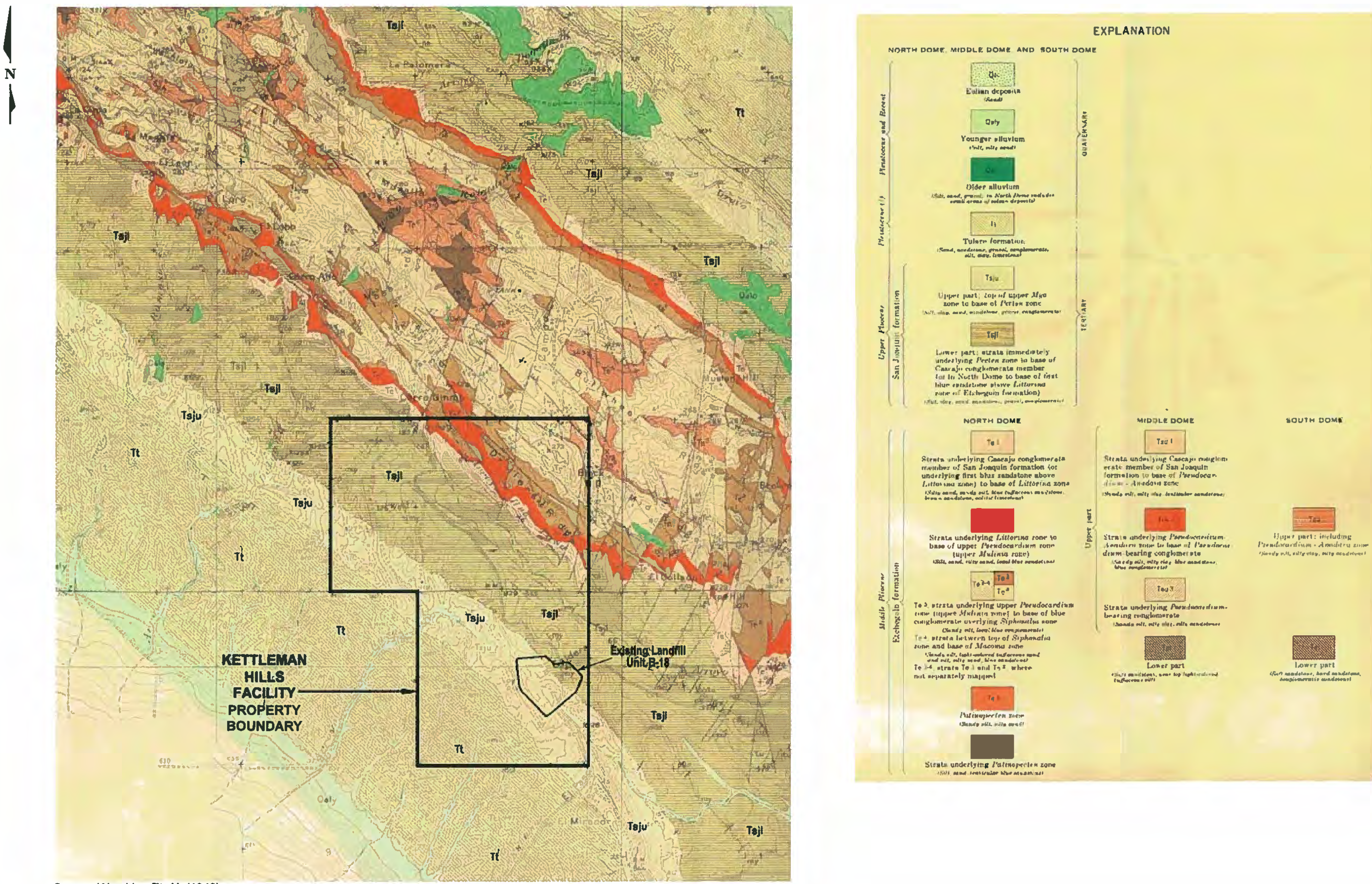


FIGURE 2.1

LANDFILL B-18
PRE-DEVELOPMENT
TOPOGRAPHY

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.



Source: Woodring Et. Al. (1940)

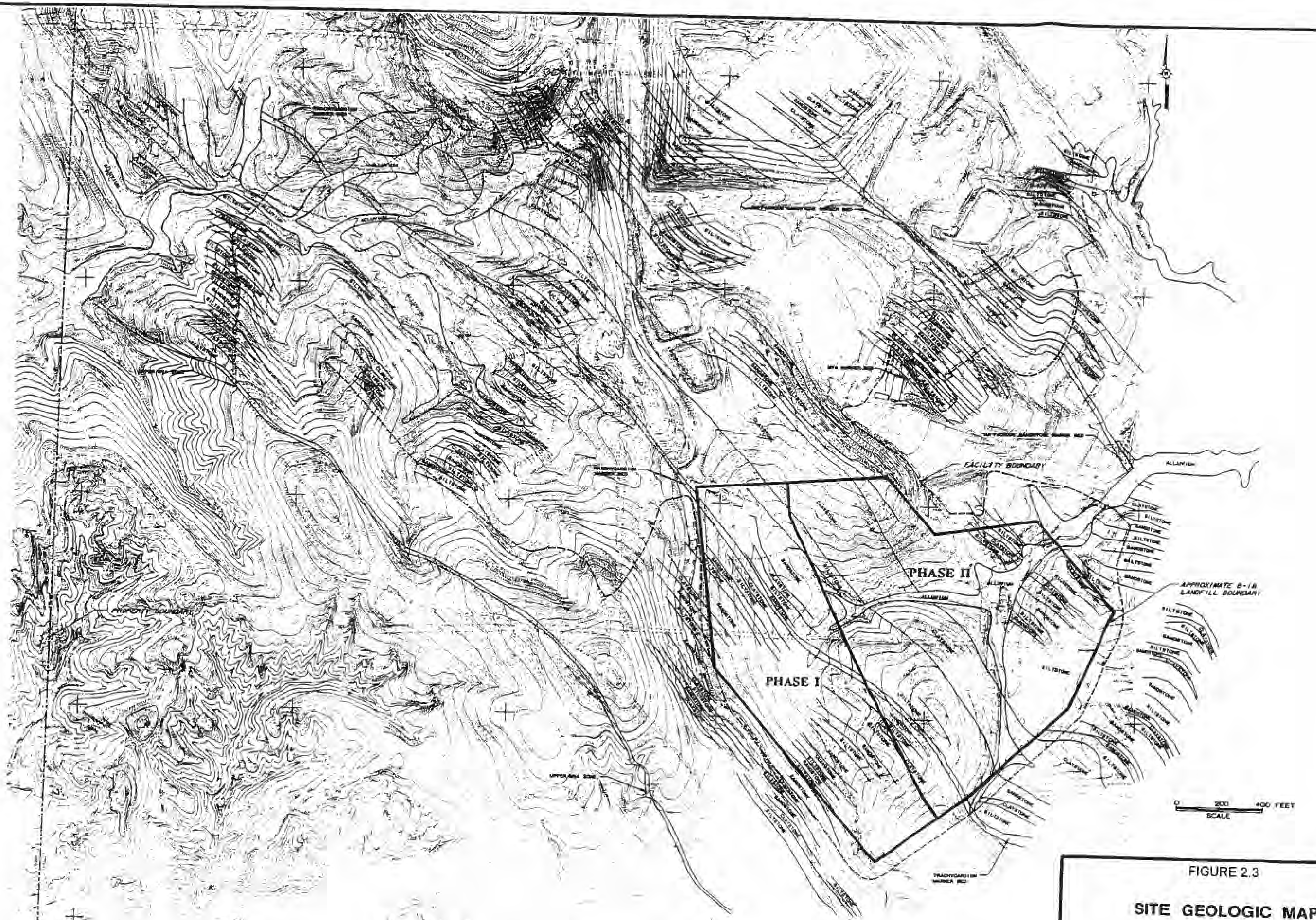
0 0.5
Scale in Miles

FIGURE **2.2**
AREA GEOLOGIC MAP
WM/LANDFILL UNIT B-18 KETTLEMAN HILLS FACILITY/CA

083918870000fig2.2.ai | Mod: 08/12/08 | JDD

Golder Associates

89-977 DR REV. 6/8/90



REFERENCE: THIS GEOLOGIC MAP IS BASED ON FIELD WORK DONE BY EMCON, DAMES AND MOORE, GOLDER ASSOCIATES AND ROGER FOOTT ASSOCIATES.

FIGURE 2.3

SITE GEOLOGIC MAP

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.

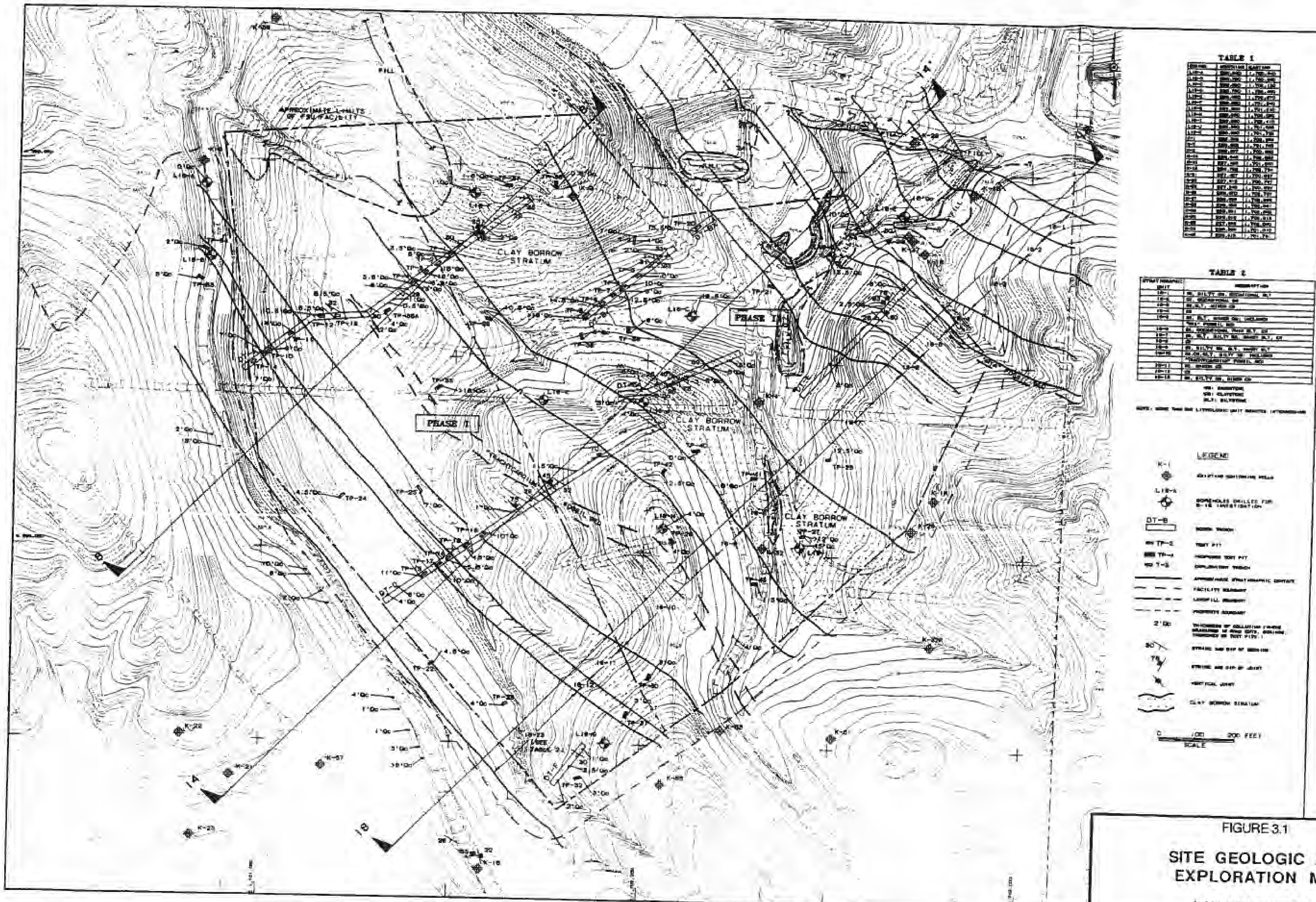
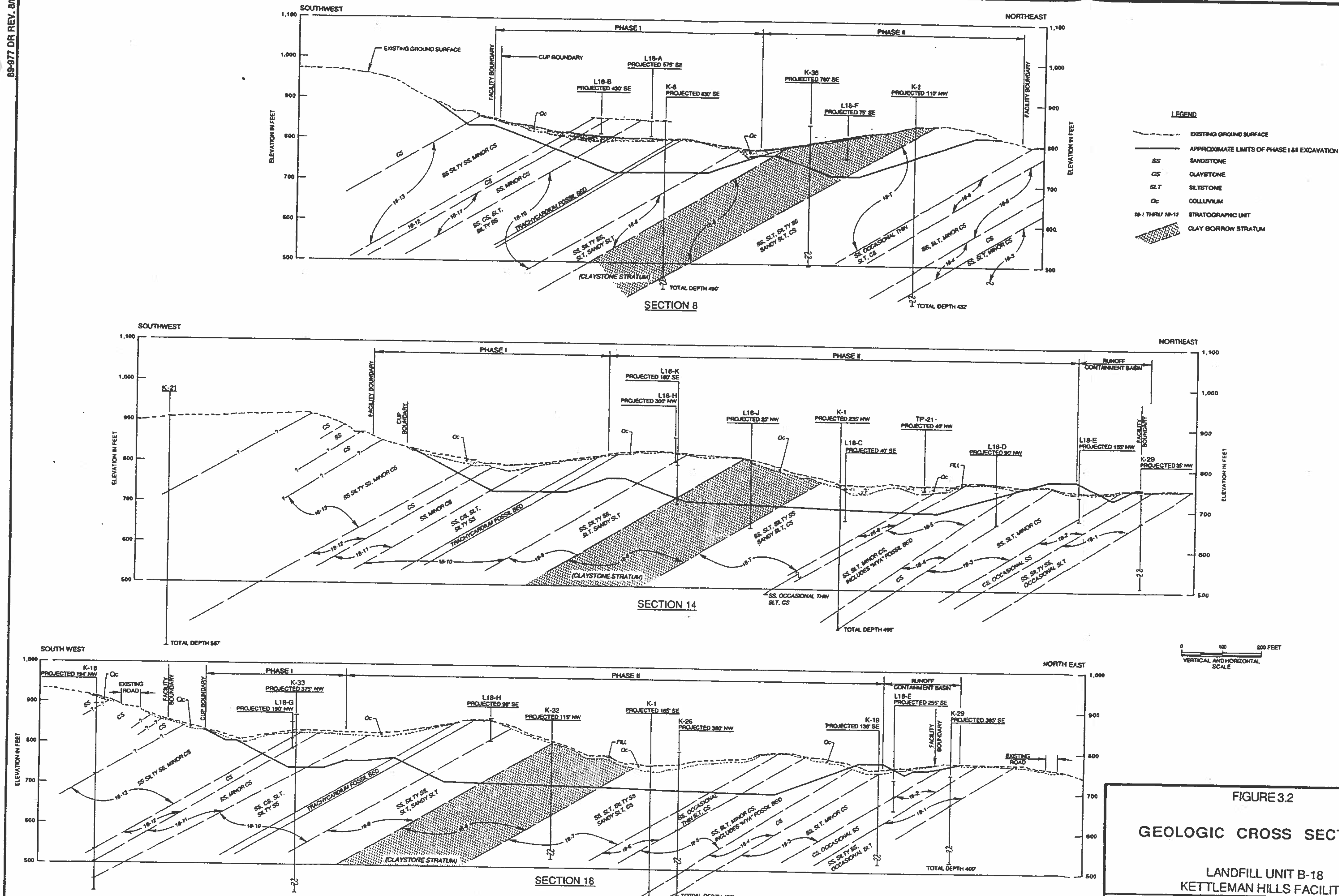


FIGURE 3.1

SITE GEOLOGIC AND EXPLORATION MAP

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.



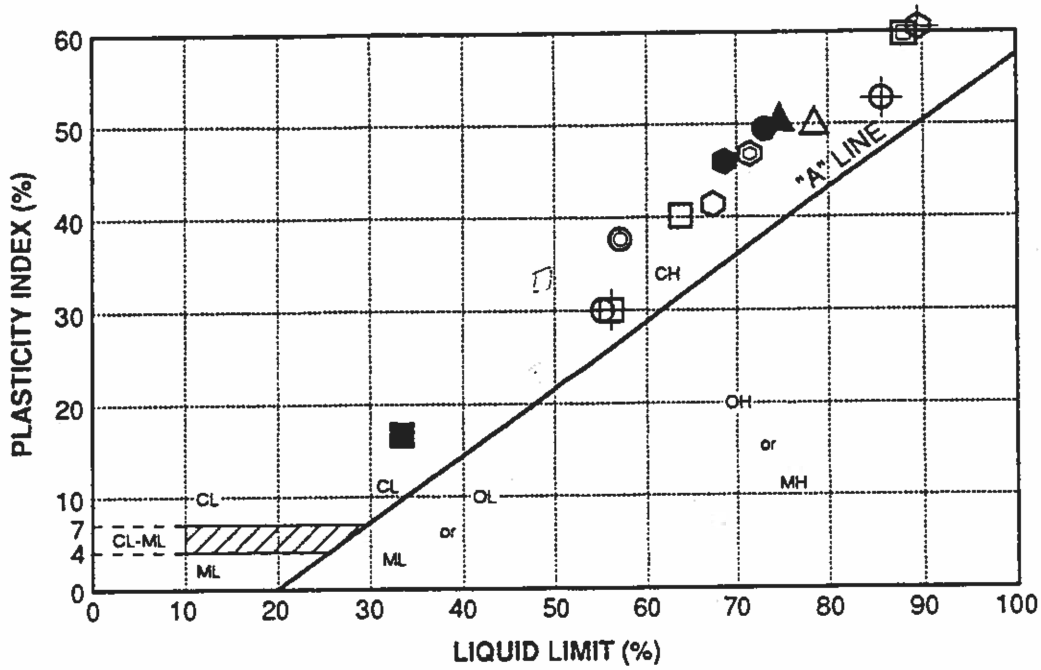
89-877 DR REV. 8/8/90

FIGURE 3.2

GEOLOGIC CROSS SECTIONS

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.



SYMBOL	STRATIGRAPHIC UNIT	BORING NO.	SAMPLE NO.	DEPTH (FT.)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USC SYMBOL
○	18-8	L18-J	S-1	5.0 - 7.5	55	30	CH
⬡	18-8	L18-J	S-3	15.0 - 17.5	67	41	CH
△	18-8	L18-J	S-5	25.0 - 27.5	79	50	CH
□	18-8	L18-J	S-7	35.0 - 37.5	64	40	CH
●	18-8	L18-J	S-9	45.0 - 47.5	74	49	CH
⬢	18-8	L18-J	S-11	55.0 - 57.5	69	46	CH
▲	18-8	L18-J	S-13	65.0 - 67.5	74	50	CH
■	18-8	L18-J	S-15	75.0 - 77.5	33	17	CL
◎	18-8	L18-J	S-17	85.0 - 87.5	56	38	CH
⬡ (double)	18-8	L18-J	S-22	110.0-112.5	71	47	CH
△ (double)	18-8	L18-J	S-24	120.0-122.5	70	42	CH
□ (double)	18-8	L18-J	S-26	130.0-132.8	88	60	CH
⊕	18-8	L18-J	S-28	140.0-142.5	85	53	CH
⬡ with crosshair	18-8	L18-J	S-30	150.0-152.5	88	62	CH
□ with crosshair	18-8	L18-J	S-32	160.0-162.5	55	30	CH

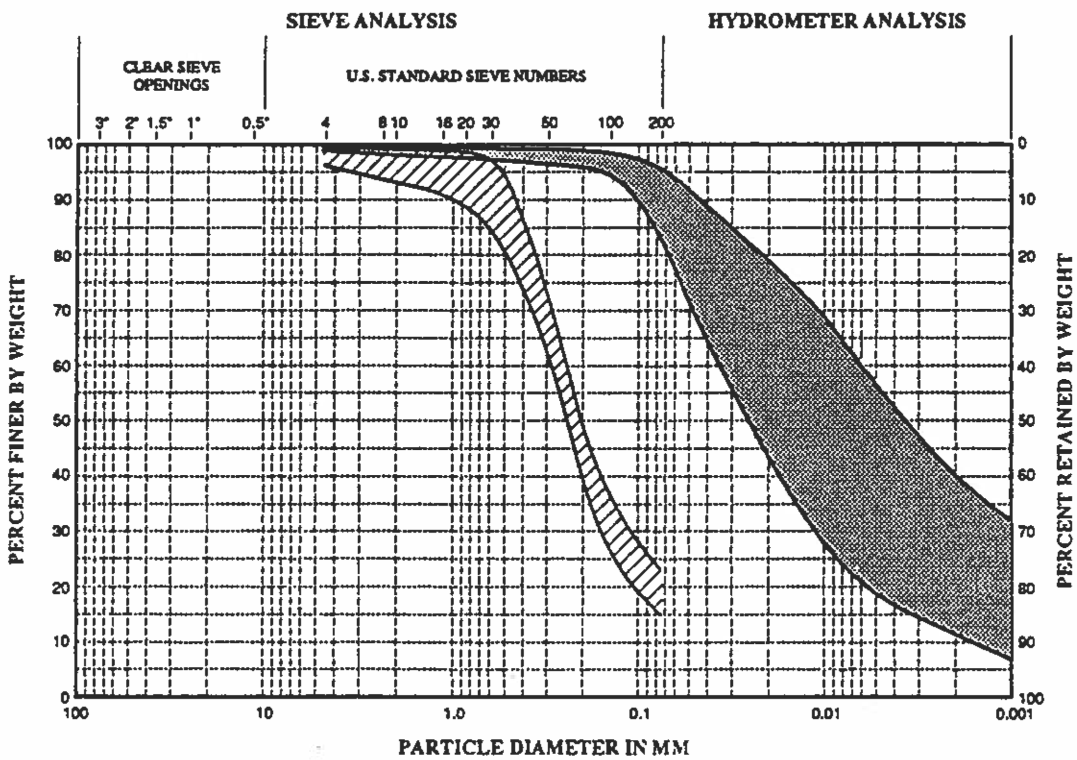
FIGURE 3.3

PLASTICITY CHART
STRATIGRAPHIC UNIT 18-8

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.

89-977DR/Fig 3.4/GrSiCuEn REV. 8/14/90



COBBLES	GRAVEL		SAND			SILT AND CLAY FRACTION
	coarse	fine	coarse	medium	fine	

LEGEND

CLAYSTONE

SANDSTONE

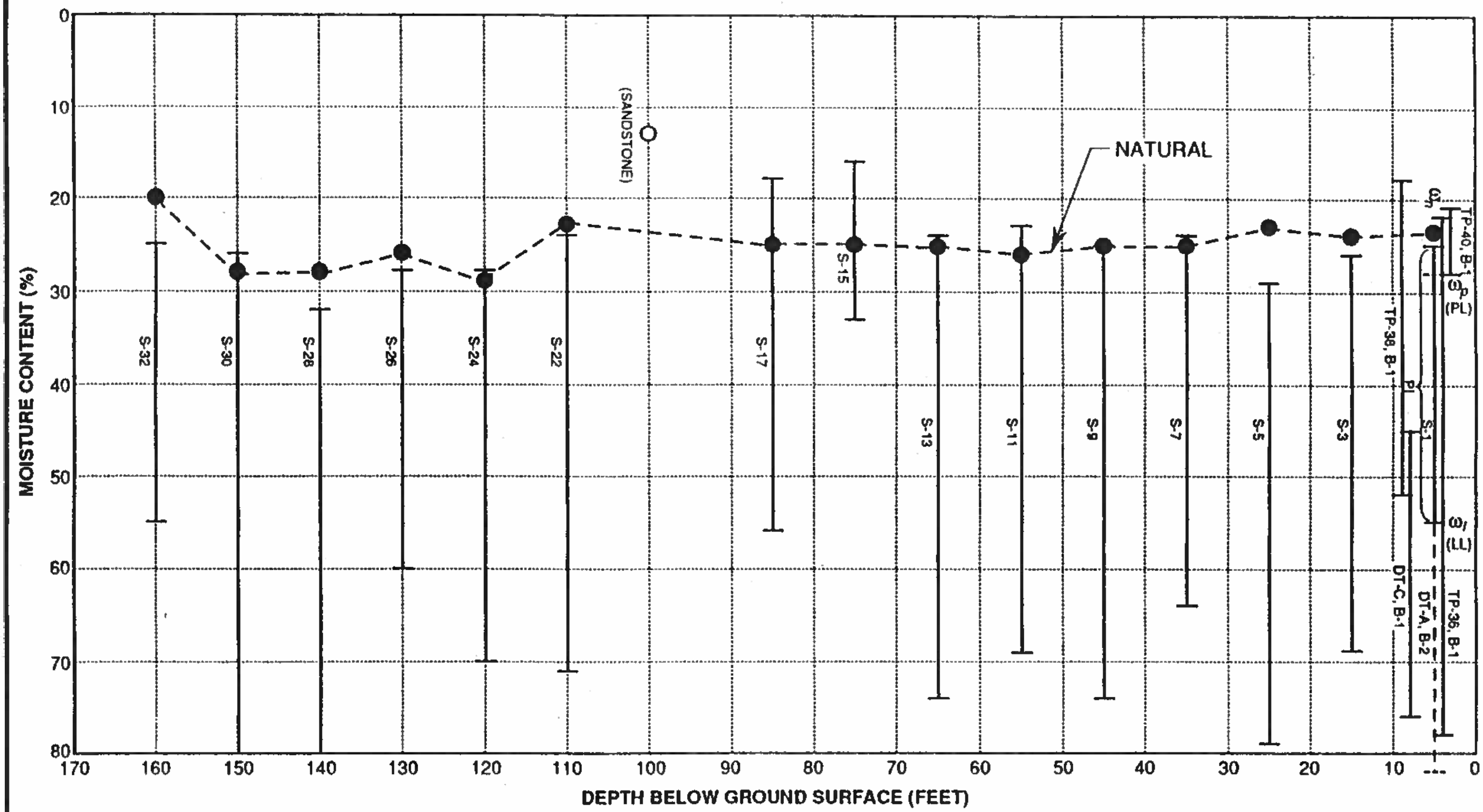
FIGURE 3.4

GRAIN SIZE CURVE ENVELOPES

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.

89-977DR/Fig 3.5/MaWaSoV. REV. 8/6/90

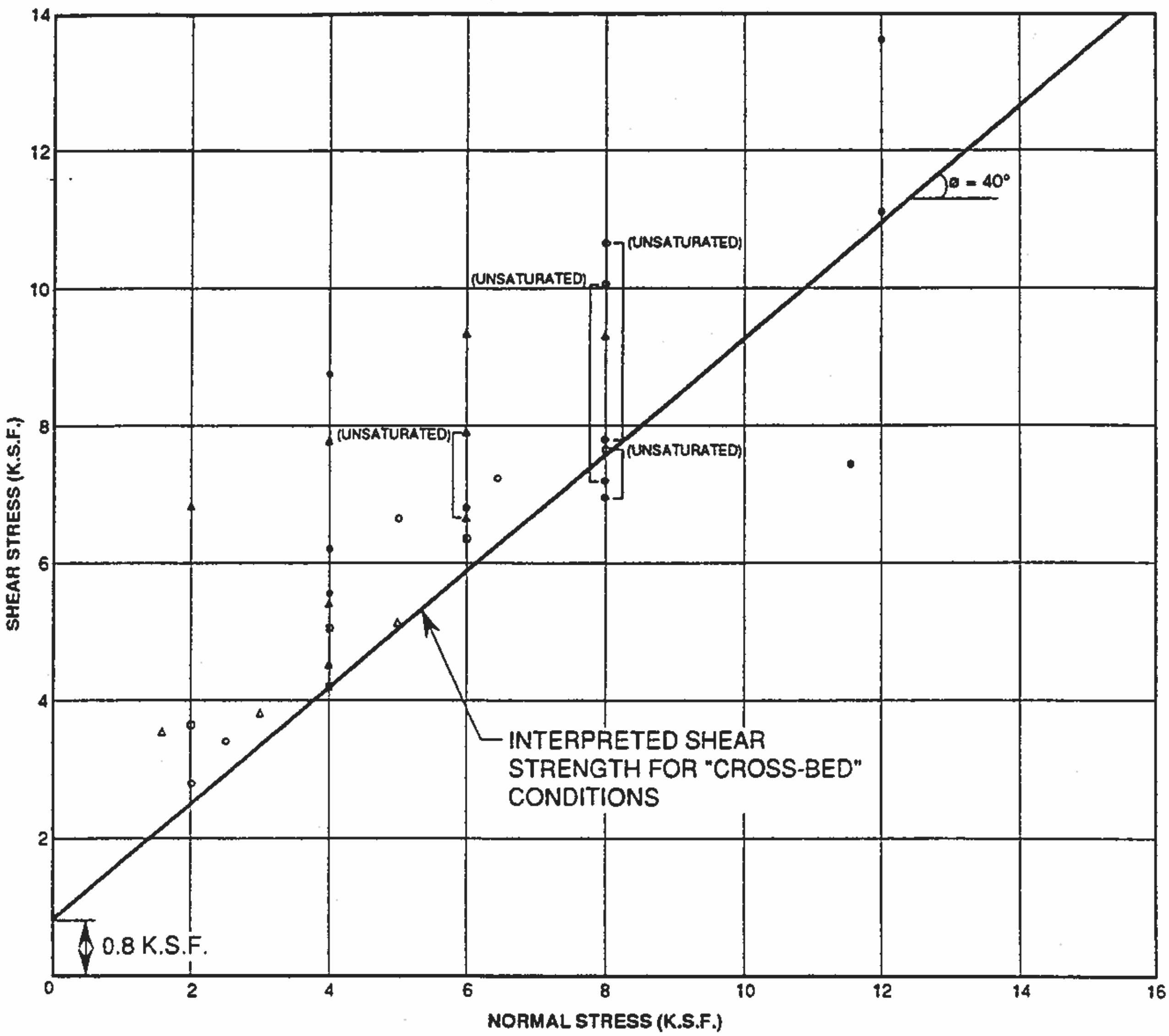


LEGEND

SHALLOW TEST PIT SAMPLE

FIGURE 3.5
MATERIAL WATER CONTENT
VS.
PLASTICITY INDEX
STRATUM 18-8
LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.



CURRENT INVESTIGATION (B-18, PHASES I & II)

- ▲ L18-B, S-3 @20-22.5' (SANDSTONE)
- • L18-C, S-7 @56-58' (CLAYSTONE)
  L18-D, S-2 @22-24.5' (CLAYSTONE)
  L18-F, S-6 @56-58.5' (CLAYSTONE)

PREVIOUS INVESTIGATION (B-19, PHASES II & III)

- ○ CLAYSTONE - DIRECT SHEAR
- □ SILTSTONE - DIRECT SHEAR
- △ SANDSTONE - DIRECT SHEAR

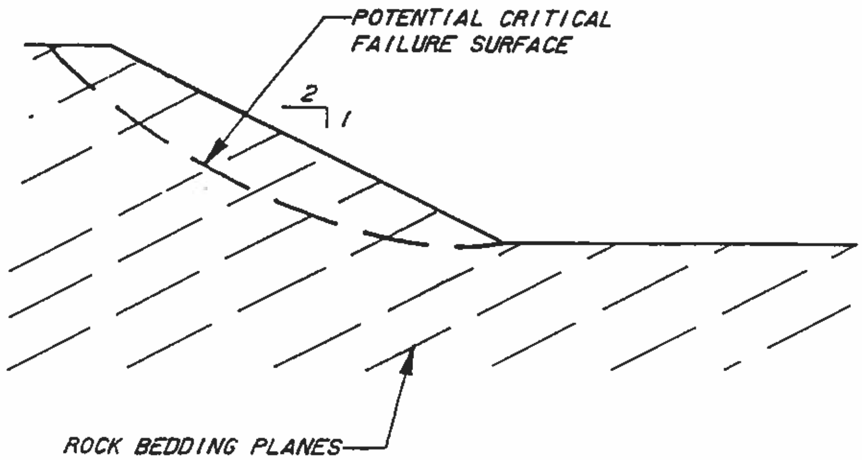
FIGURE 3.6

SUMMARY
DIRECT SHEAR TEST RESULTS

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.

89-977DR-01 REV.8/14/90



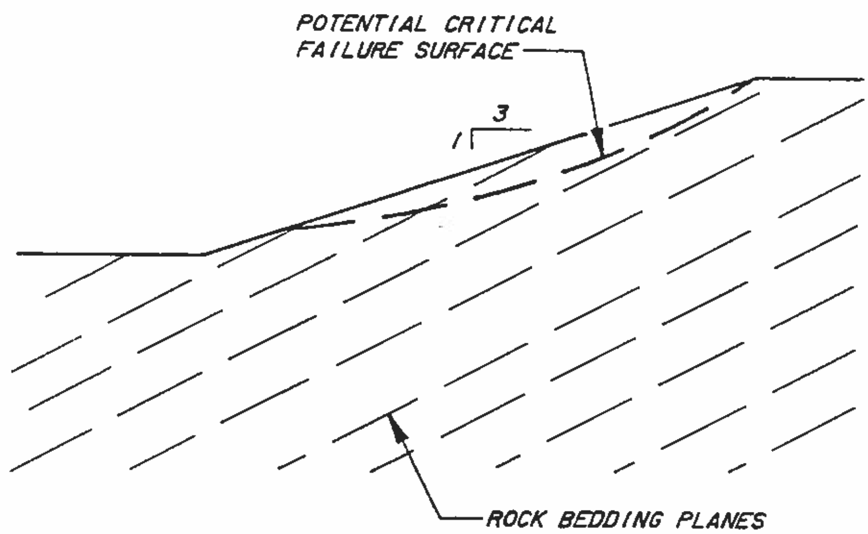
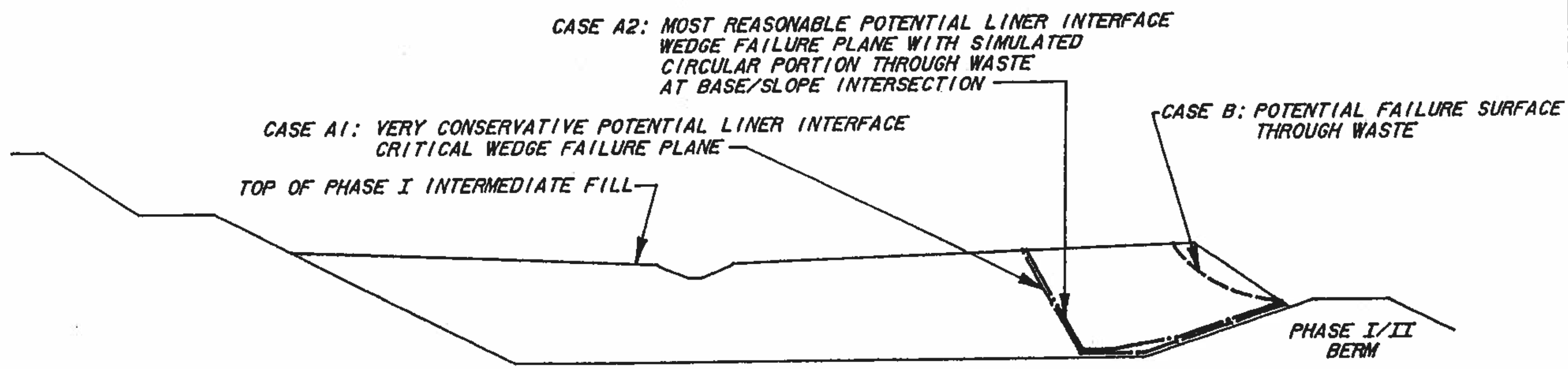


FIGURE 5.1

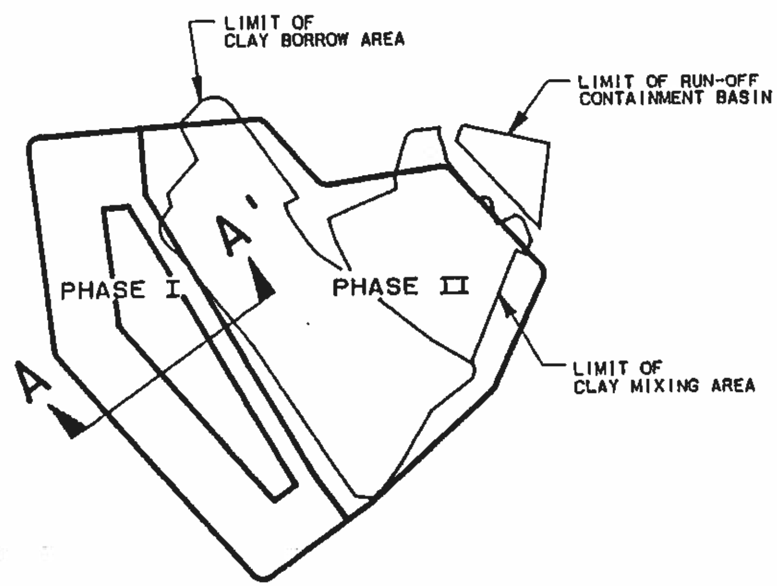
STABILITY CONSIDERATIONS FOR ROCK CUT SLOPES

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.



SECTION A-A'



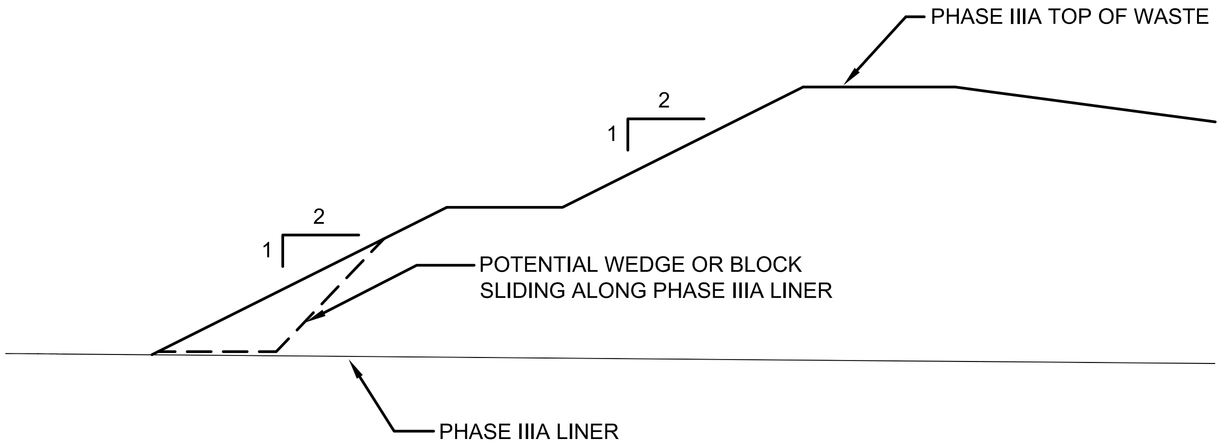
KEY PLAN

FIGURE 5.2

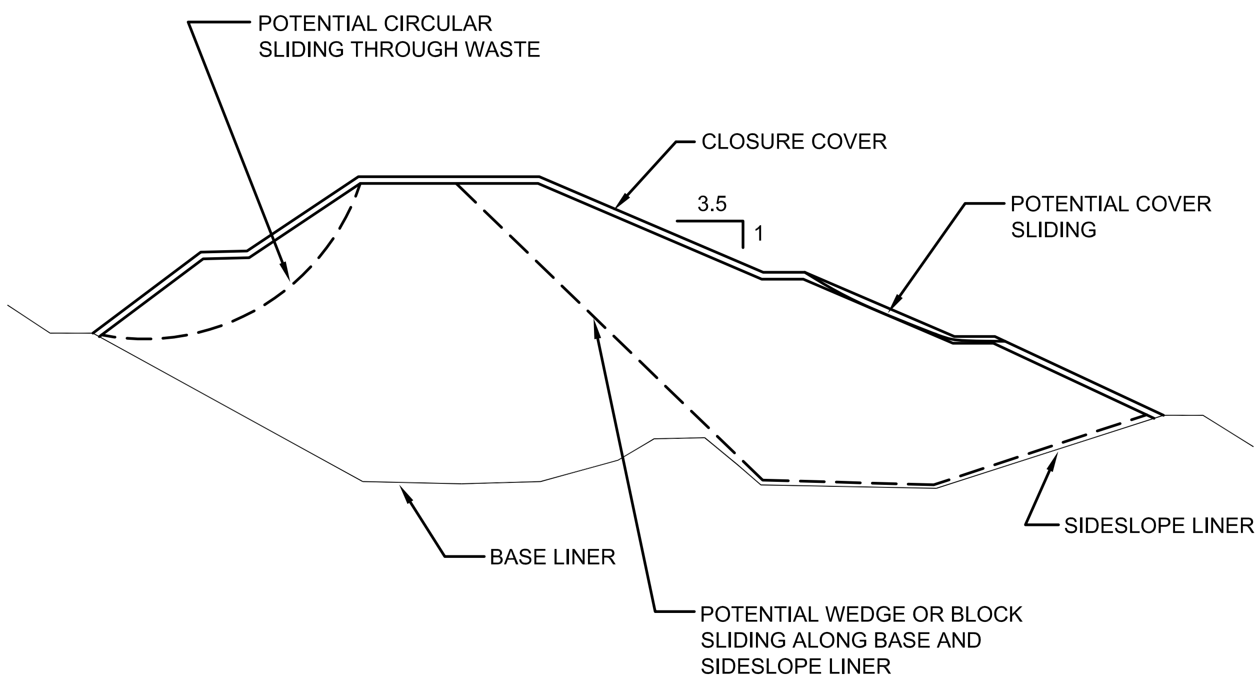
STABILITY CONSIDERATIONS FOR PHASE I INTERMEDIATE FILL SLOPE

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.



A. PHASE IIIA INTERMEDIATE FILL SLOPE



B. FINAL CLOSURE

FIGURE 5.3

POTENTIAL SLIDING MECHANISMS FOR PHASE IIIA INTERMEDIATE FILL SLOPE AND FINAL CLOSURE

Golder Associates
Irvine, California

PROJECT No.083-91887 FILE No. 08391887 5.3 CADD KJK DATE 05/02/11

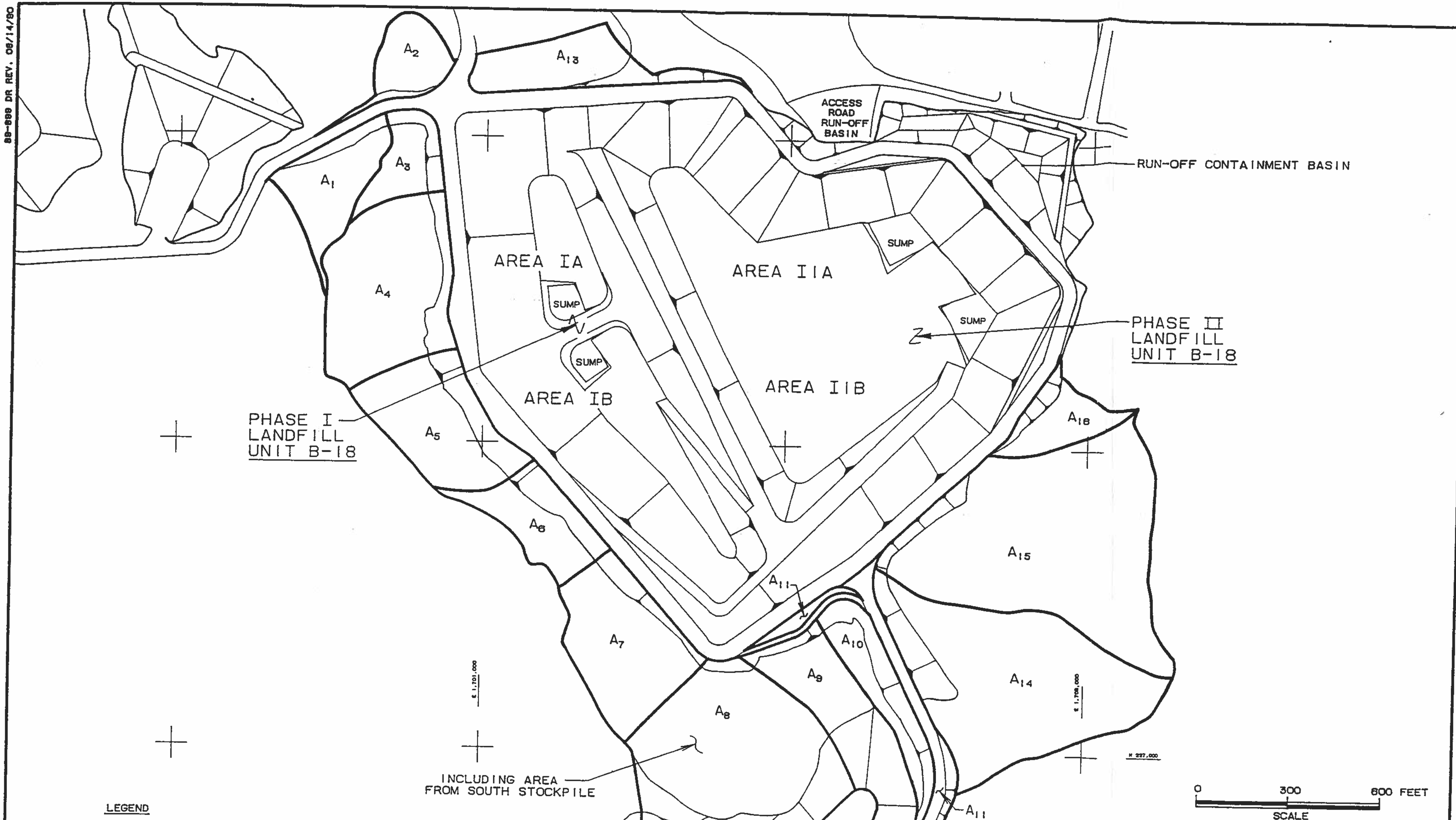
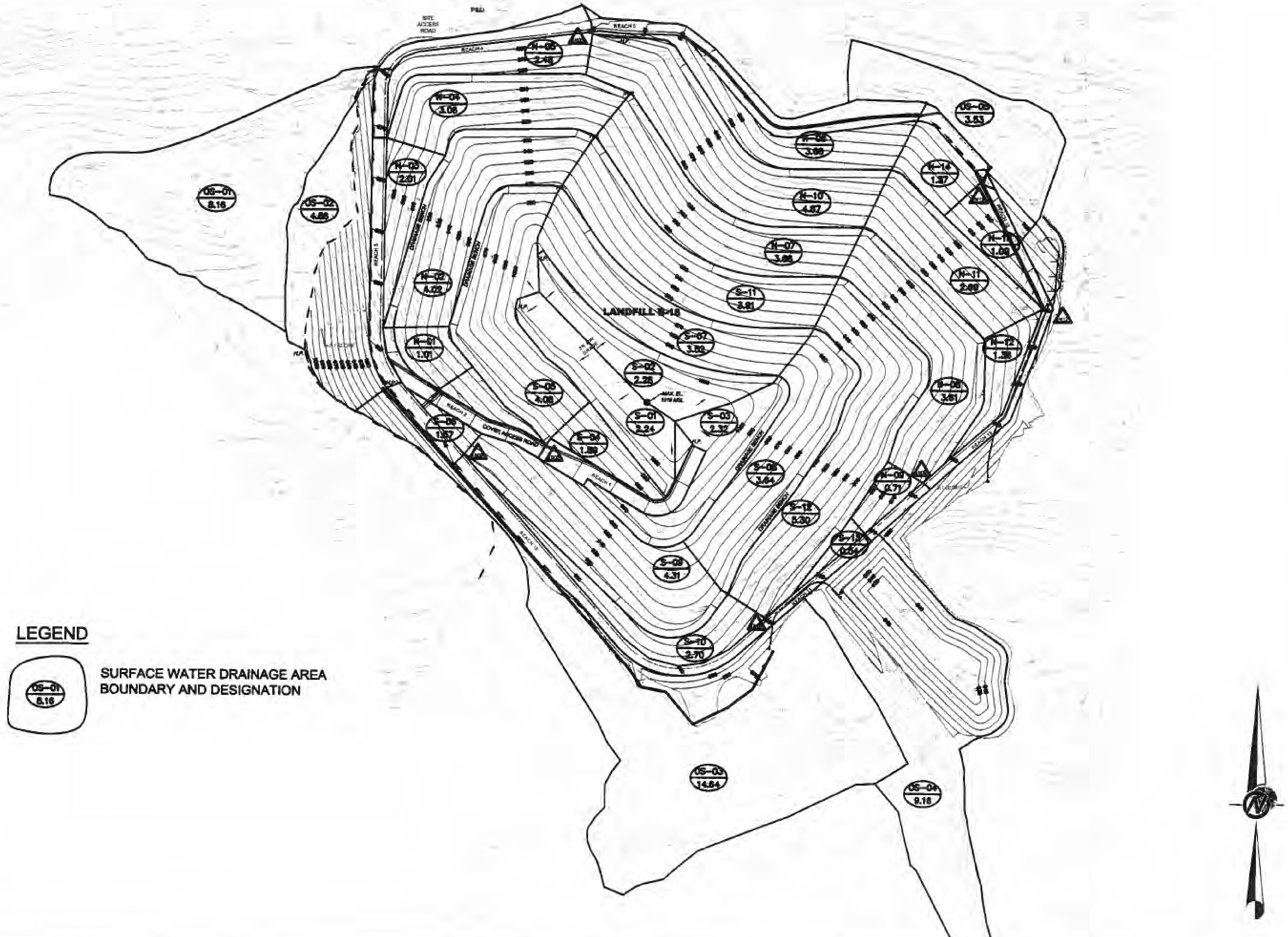


FIGURE 5.4

SURFACE WATER DRAINAGE AREA MAP FOR PHASES I AND II

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS INC.



Golder Associates
IRVINE, CALIFORNIA

PROJECT
KETTLEMAN HILLS FACILITY
LANDFILL UNIT B-18
KETTLEMAN CITY, CALIFORNIA

TITLE
SURFACE WATER DRAINAGE AREA MAP FOR PHASE III AND FINAL CLOSURE

PROJECT No. 083-91887		
FILE No. 08391887A001		
REV. A	SCALE	1"=300'
DESIGN	PM	10/31/08
CADD	PM	10/31/08
CHECK	RH	11/4/08
REVIEW	SGS	11/4/08

FIGURE 5.5

APPENDIX A
CONSTRUCTION DRAWINGS

APPENDIX A.1	**PHASES I AND II DRAWINGS**
APPENDIX A.2	**PHASE III AND FINAL CLOSURE DRAWINGS**

APPENDIX A.1
PHASES I AND II DRAWINGS

CONSTRUCTION DRAWINGS
LANDFILL UNIT B-18
PHASES I AND II
AND
FINAL CLOSURE

KETTLEMAN HILLS FACILITY

KINGS COUNTY, CALIFORNIA

PREPARED FOR:

CHEMICAL WASTE MANAGEMENT, INC. - (CWMI)

PREPARED BY:

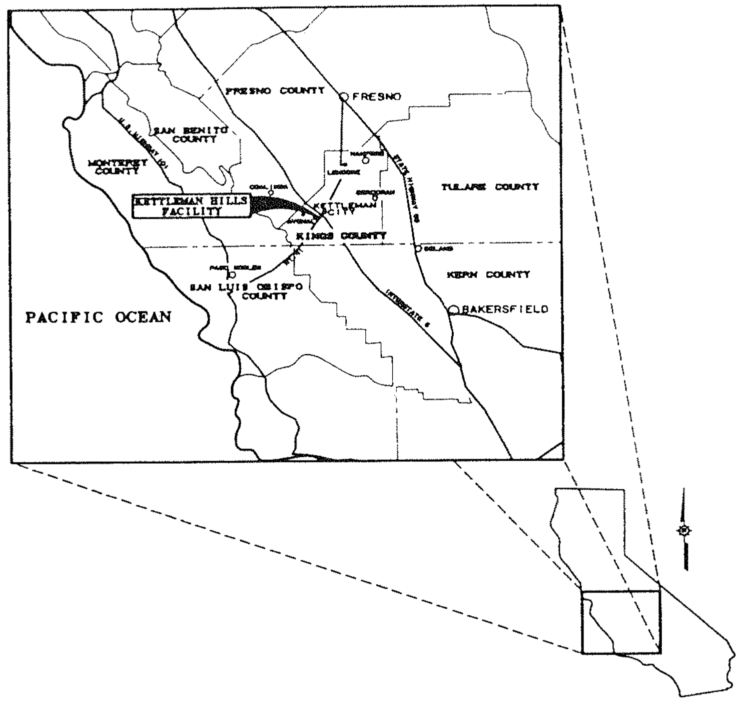
ENVIRONMENTAL SOLUTIONS, INC.

JANUARY, 1991

REGISTERED PROFESSIONAL ENGINEER
RICHARD D. ELLISON
NO. 39298
EXP. 12-31-93
CIVIL
STATE OF CALIFORNIA

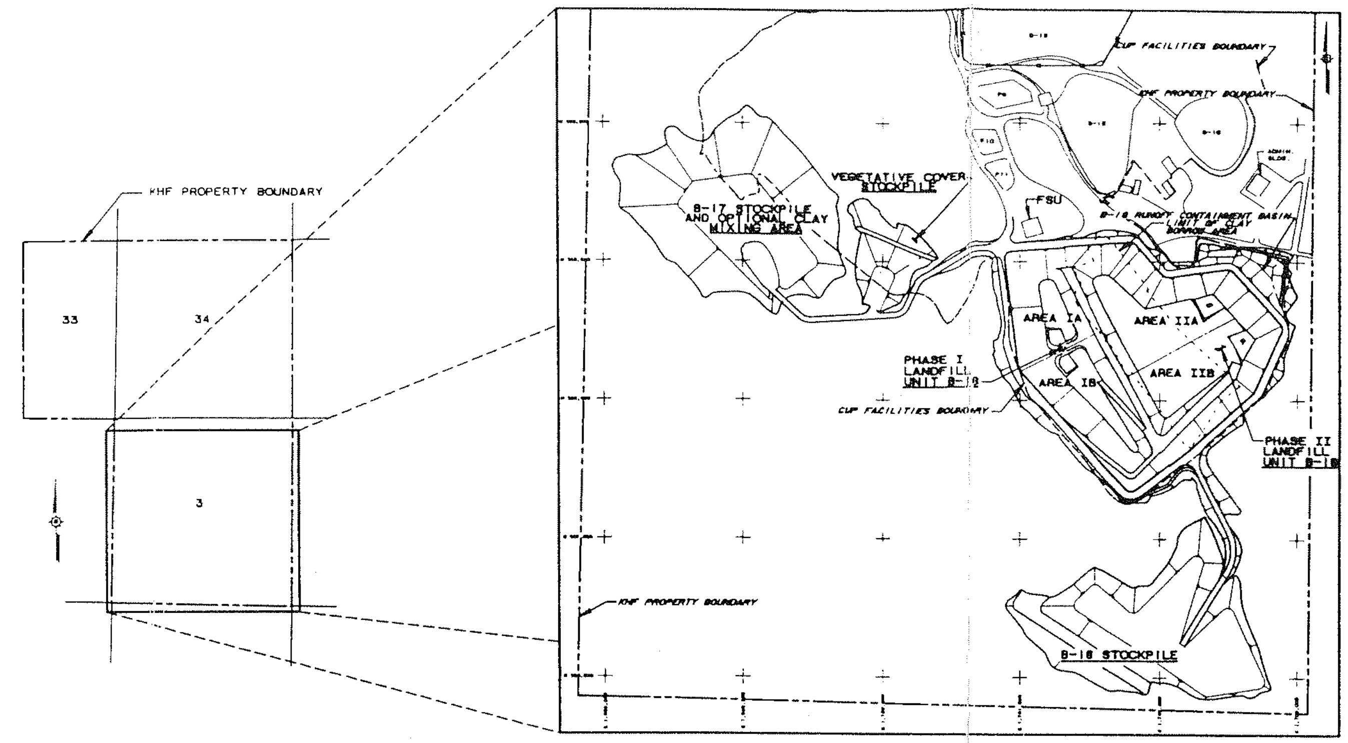
REVISED ISSUE FOR
PHASE II CONSTRUCTION
(JANUARY 29, 1993)

1090



REGIONAL LOCATION MAP

0 30 60 MILES
SCALE



SITE LOCATION MAP

0 600 1200 FEET
SCALE

LEGEND

GENERAL LINES

- KHF PROPERTY BOUNDARY
- MAIN TOPIC OF DRAWING
- SUBTOPIC OF DRAWING
- CENTER LINE
- HIDDEN LINE
- FLOW LINE
- EXISTING GRADE
- WORK DONE BY OTHERS
- 10 FOOT CONTOUR LINE
- 2 FOOT CONTOUR LINE
- 30+20.00 STATION

MISCELLANEOUS

- N. 229,071.00 / E. 1,700,885.00 / EL. 846.0 — CONTROL POINT
- FENCE
- TOP / TOE — SLOPE
- POINT OF INTERSECTION
- CURVE INDENTIFICATION
- CONTROL POINT

KEY

- SECTION (ALPHA) OR DETAIL (NUMERIC) IDENTIFICATION
- SHEET NO. WHERE SECTION OR DETAIL IS SHOWN
- SHEET NO. WHERE SECTION OR DETAIL IS CALLED OUT

MONITORING WELL TYPES

- K-1 — EXISTING MONITORING WELLS TO BE MAINTAINED AND PROTECTED AS REQUIRED
- K-2 I — EXISTING MONITORING WELLS TO BE DECOMMISIONED DURING PHASE I
- K-18 II — EXISTING MONITORING WELLS TO BE DECOMMISIONED DURING PHASE II
- K-81 — PROPOSED MONITORING WELLS

GEOSYNTHETIC LINER TYPES

- HDPE
- GEOTEXTILE
- GEONET
- GEOCOMPOSITES

FILL PATTERNS

- GENERAL FILL
- STRUCTURAL FILL
- COMPACTED CLAY
- GRAVEL
- CONCRETE
- SAND
- WASTE
- NATURAL GRADE

ABBREVIATIONS

A.C.	ASPHALT CONCRETE
ADMIN.	ADMINISTRATION
APPROX.	APPROXIMATE
C	CUT
℄	CENTER LINE
CMP	CORRUGATED METAL PIPE
CWMI	CHEMICAL WASTE MANAGEMENT, INC.
DIA.	DIAMETER
E.	EASTING
EL.	ELEVATION
F	FILL
FSU	FINAL STABILIZATION UNIT
HDPE	HIGH DENSITY POLYETHYLENE
HPFL	HIGH POINT IN FLOW LINE
KHF	KETTLEMAN HILLS FACILITY
L	LENGTH
LPFL	LOW POINT IN FLOW LINE
LT.	LEFT
MIN.	MINIMUM
N.	NORTHING
N.T.S.	NOT TO SCALE
P.C.	POINT OF CURVATURE
P.I.	POINT OF INTERSECTION
P.T.	POINT OF TANGENCY
R	RADIUS
RT.	RIGHT
T	TANGENCY
TYP.	TYPICAL
Δ	INTERNAL ANGLE
Ø	DIAMETER

INDEX OF DRAWINGS

SHEET NO.	ESI FILE NO.	TITLE
1	D-89977-FD001	INDEX, LEGEND AND GENERAL NOTES
2A	D-89977-FD002	PHASE I EXCAVATION PROJECT PLAN
2	D-89977-FD002	PROJECT PLAN
3A	D-89977-FD003	PHASE I CONSTRUCTION SEQUENCE PLAN
3	D-89977-FD003	PHASE I EXCAVATION AND SITE PREPARATION PLAN
4	D-89977-FD004	PHASE I TOP OF SECONDARY LINER
5	D-89977-FD005	PHASE I TOP OF PRIMARY LINER
6	D-89977-FD006	PHASE I INTERMEDIATE WASTE FILL PLAN
7	D-89977-FD007	CLAY BORROW PIT EXPANSION PLAN
8	D-89977-FD008	PHASE II EXCAVATION AND SITE PREPARATION PLAN
9	D-89977-FD009	PHASE II TOP OF SECONDARY LINER
10	D-89977-FD010	PHASE II TOP OF PRIMARY LINER
11	D-89977-FD011	PHASE I AND II FINAL CLOSURE PLAN
12	D-89977-FD012	GRADING DETAILS
13	D-89977-FD013	GRADING DETAILS
14	D-89977-FD014	GRADING DETAILS
15	D-89977-FD015	CROSS SECTIONS
16	D-89977-FD016	LINER DETAILS AND SECTIONS
17	D-89977-FD017	LINER DETAILS AND SECTIONS
18	D-89977-FD018	TYPICAL SUMP PLAN
18A	D-89977-SU018	TYPICAL SUMP PLAN
18	D-89977-FD019	SUMP AND RISER DETAILS
20	D-89977-FD020	SUMP AND RISER DETAILS
21	D-89977-FD021	SUMP AND RISER DETAILS
22	D-89977-FD022	SUMP AND RISER DETAILS
23	D-89977-FD023	MISCELLANEOUS CROSS SECTIONS
24	D-89977-FD024	DRAINAGE DETAILS
25	D-89977-FD025	SURVEY CONTROL

GENERAL NOTES

1. THESE DRAWINGS AND THE SPECIFICATIONS SHOULD BE USED TOGETHER. IF A DIFFERENCE OCCURS, THE CWMI PROJECT MANAGER SHALL DETERMINE WHICH TAKES PRECEDENCE.
2. THE B-18 LANDFILL CONSTRUCTION WILL OCCUR WITHIN AREAS APPROVED BY VARIOUS GOVERNMENT AGENCIES. NO WORK SHALL OCCUR OUTSIDE OF THE CONSTRUCTION AREAS SHOWN ON THE DRAWINGS WITHOUT SPECIFIC APPROVAL OF THE CWMI PROJECT MANAGER.
3. PRIOR TO COMMENCING ANY CUT OR FILL, OR IN ANY WAY DISTURBING THE EXISTING LAND CONTOURS, CONTRACTOR SHALL VERIFY THE ACCURACY OF THE CONTOUR ELEVATIONS SHOWN IN THE DRAWINGS.

REV	DATE	DESCRIPTION	DRAWN BY	CHK'D BY
3	7/28/91	ISSUED FOR PHASE II CONSTRUCTION	KJK	KKP
2	1/02/91	ISSUED FOR CONSTRUCTION	KJK	KKP
1	9/24/90	ISSUED FOR BID	MD	KKP
0	7/31/90	ISSUED FOR PERMITTING	KAB	KKP

DRAWN BY K. J. Kavi — DESIGNED BY [signature] — APPROVED BY RDE

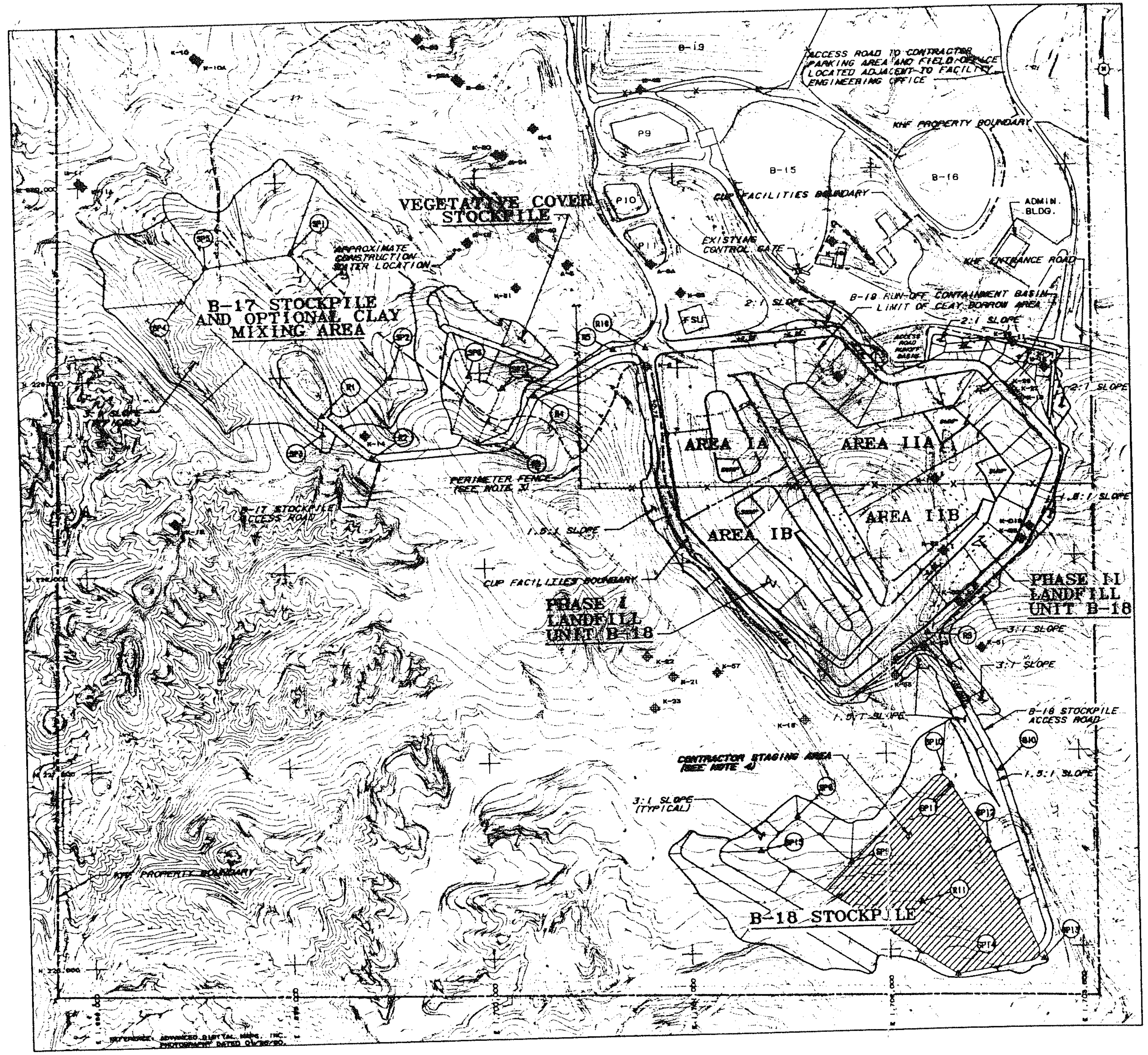
REGISTERED PROFESSIONAL ENGINEER — TERRY K. PARKINSON — No. 41021 — Exp. 3-31-95 — CIVIL — STATE OF CALIFORNIA

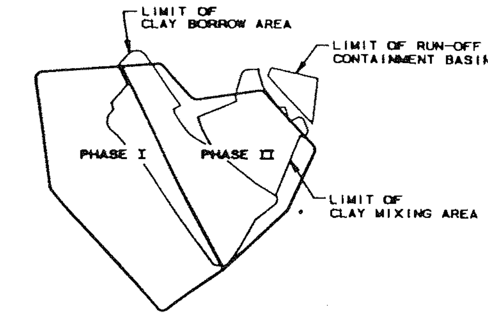
CONSTRUCTION DRAWINGS
LANDFILL UNIT B-18
CWMI-KETTLEMAN HILLS FACILITY
KINGS COUNTY CALIFORNIA

TITLE: INDEX, LEGEND AND GENERAL NOTES

ENVIRONMENTAL SOLUTIONS, INC.

JOB NO.	ESI FILE NUMBER	REVISION
89-977	D-89977-FD001	3
SCALE	CWMI FILE NUMBER	SHEET
AS NOTED	89-03-304.2.1	1





KEY PLAN

MONITORING WELL LOCATIONS

WELL	SYMBOL*	NORTHING	EASTING
A-5	◆	229555.82	1700456.62
A-6A	◆	229531.79	1700882.00
K-1	◆	228398.11	1702295.51
K-2	◆	228821.99	1701793.44
K-5	◆	230247.04	1700301.74
K-8	◆	229987.57	1700832.82
K-10	◆	230837.82	1698600.98
K-10A	◆	230823.02	1698620.82
K-11	◆	230023.23	1698006.78
K-11A	◆	230005.93	1698025.24
K-13	◆	229655.76	1699941.96
K-14	◆	228678.71	1699405.58
K-15	◆	228282.68	1699455.82
K-16	◆	228948.07	1702852.02
K-18	◆	227169.58	1701580.97
K-19	◆	228792.09	1702724.07
K-21	◆	227406.85	1700927.31
K-22	◆	227512.80	1700797.53
K-23	◆	227248.07	1700828.99
K-24	◆	230114.22	1700144.78
K-25	◆	230507.23	1699923.07
K-25A	◆	230493.36	1699937.96
K-26	◆	228070.27	1702707.95
K-27	◆	228825.41	1702893.15
K-28	◆	228838.02	1702881.13
K-29	◆	229080.76	1702889.34
K-30	◆	230115.92	1700113.44
K-31	◆	229418.24	1700178.96
K-32	◆	228018.07	1702313.81
K-33	◆	227398.12	1702060.82
K-38	◆	229369.60	1701010.81
K-40	◆	229687.86	1700284.82
K-46	◆	230843.24	1699397.02
K-48	◆	230432.92	1700853.00
K-49	◆	229612.11	1701781.68
K-50	◆	230719.43	1699730.73
K-51	◆	227530.00	1702510.00
K-53	◆	227543.00	1702215.00
K-57	◆	227435.00	1701165.00
K-01R	◆	228150.00	1702765.00
K-32R	◆	227770.00	1702400.00

* SEE NOTE 2

STOCKPILE AND ACCESS ROAD CONSTRUCTION SURVEY CONTROL POINTS OF INTERSECTION

POINT OF INTERSECTION	NORTHING	EASTING	ELEVATION
P.I.-R1	228798.97	1698205.55	960.0
P.I.-R2	228574.32	1699448.32	940.0
P.I.-R3	228821.64	1700157.41	840.0
P.I.-R4	228873.80	1700272.07	920.0
P.I.-R5	229100.83	1700676.77	861.0
P.I.-R9	227613.22	1702234.86	830.0
P.I.-R10	228906.66	1702588.41	890.0
P.I.-R11	226238.16	1702174.36	952.4
P.I.-R18	229105.63	1700842.12	847.0
P.I.-SP1	229639.65	1698068.21	952.2
P.I.-SP2	228984.60	1699553.23	980.4
P.I.-SP3	228702.65	1699207.26	980.4
P.I.-SP4	229400.92	1698513.68	950.5
P.I.-SP5	229573.26	1698640.43	950.0
P.I.-SP6	228984.50	1699848.74	950.0
P.I.-SP7	228917.80	1700108.96	950.0
P.I.-SP8	226690.14	1701545.22	952.4
P.I.-SP9	226448.63	1701808.85	952.1
P.I.-SP10	226918.64	1702295.90	958.5
P.I.-SP11	226831.48	1702536.27	958.2
P.I.-SP12	226541.09	1702519.15	956.9
P.I.-SP13	225935.86	1702788.64	954.3
P.I.-SP14	225666.12	1702346.97	950.0
P.I.-SP15	226518.41	1701359.42	950.0

NOTES

1. SEE SHEET 1 FOR LEGEND AND GENERAL NOTES.
2. SEE LEGENO ON SHEET 1 FOR MONITORING WELL SYMBOLS.
3. EXISTING PERIMETER FENCE WILL BE EXTENDED TO ENCLOSE THE B-18 LANDFILL AREA INTO THE KHF ACTIVE FACILITY AREA.
4. LOCATION APPROXIMATE. FINAL LOCATION TO BE DETERMINED BY OWNER.

0 300 600 FEET
SCALE

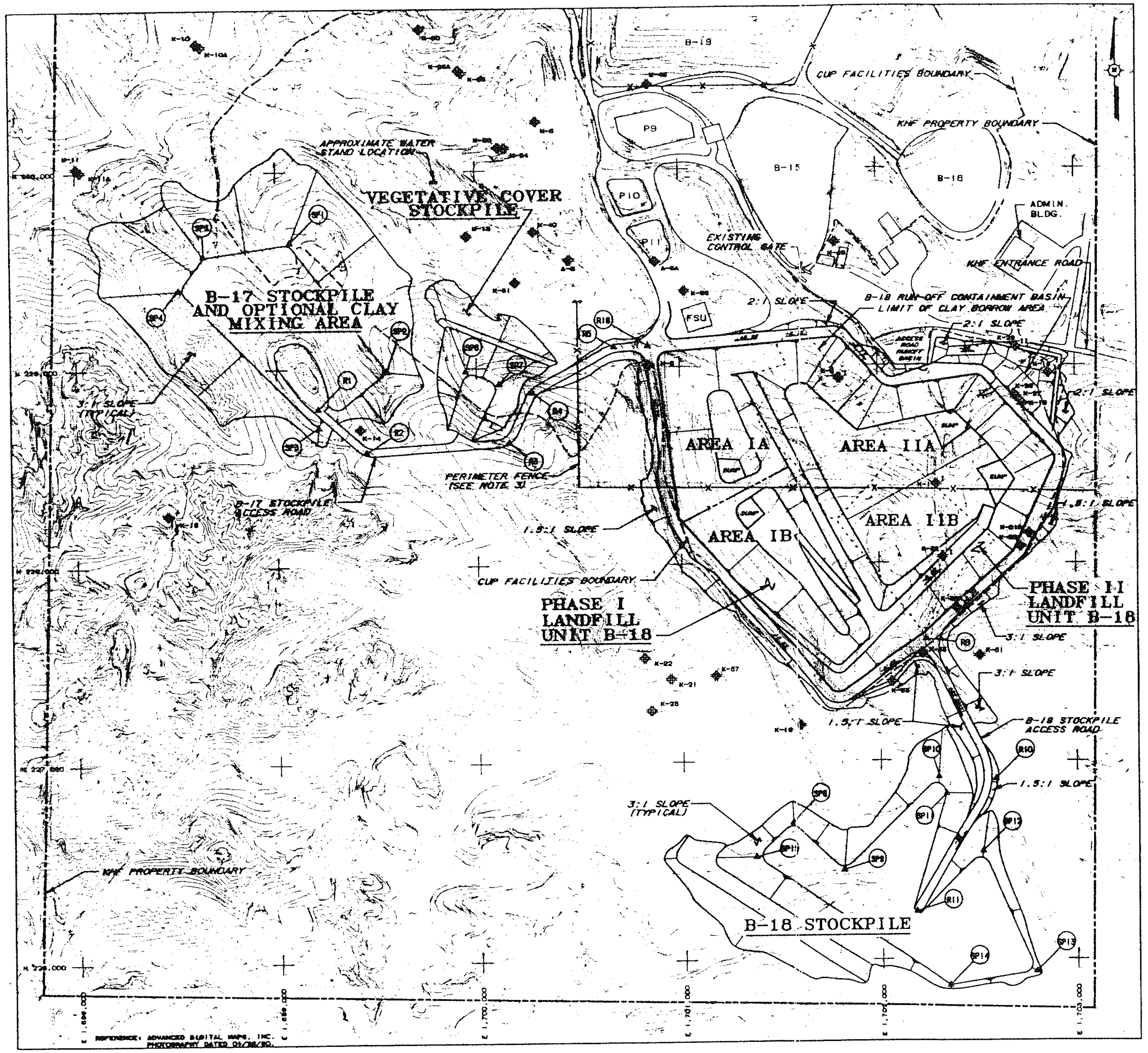
REV	DATE	DESCRIPTION	DRAWN BY	CHK'D BY
3	3/7/91	MODIFIED CONTRACATOR STAGING AREA	KJK	
2	1/2/91	ISSUED FOR CONSTRUCTION	KJK	
1	9/24/90	ISSUED FOR BID	MD	
0	7/31/90	ISSUED FOR PERMITTING	KAB	

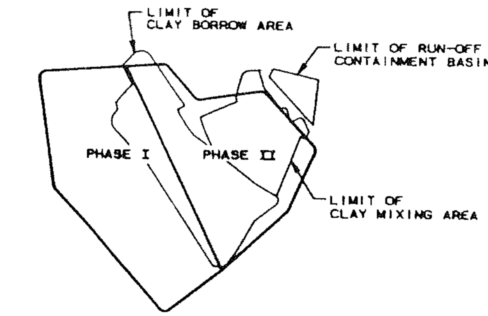
LANDFILL UNIT B-18
CONSTRUCTION PLANS
CWMI-KETTLEMAN HILLS FACILITY
KINGS COUNTY CALIFORNIA

PHASE I EXCAVATION
PROJECT PLAN

ENVIRONMENTAL SOLUTIONS, INC.

JOB NO.	ESI FILE NUMBER	REVISION
89-977	D-89977-EX002	3
SCALE: 1"=300'	CWMI FILE NUMBER: 89-03-304.2.1	SHEET: 2A





KEY PLAN

MONITORING WELL LOCATIONS

WELL	SYMBOL*	NORTHING	EASTING
A-5	◆	229555.02	1700456.82
A-6A	◆	229531.79	1700882.00
K-1	◆	228398.11	1702295.51
K-2	◆	228921.29	1701793.44
K-5	◆	230247.04	1700301.74
K-6	◆	228997.57	1700632.92
K-10	◆	230637.32	1698600.98
K-10A	◆	230623.02	1698620.82
K-11	◆	230023.23	1698006.76
K-11A	◆	230005.93	1698025.24
K-13	◆	229655.76	1699941.96
K-14	◆	228678.71	1699405.58
K-15	◆	228262.98	1698455.62
K-16	◆	228948.07	1702652.02
K-18	◆	227169.58	1701580.97
K-19	◆	228792.09	1702724.07
K-21	◆	227406.65	1700927.31
K-22	◆	227512.60	1700797.53
K-23	◆	227248.07	1700628.99
K-24	◆	230114.22	1700144.79
K-25	◆	230507.23	1699923.07
K-25A	◆	230493.36	1699937.98
K-26	◆	228070.27	1702707.95
K-27	◆	228625.41	1702693.15
K-28	◆	228638.02	1702681.13
K-29	◆	229080.76	1702689.34
K-30	◆	230115.52	1700113.44
K-31	◆	229416.24	1700178.96
K-32	◆	228018.07	1702313.81
K-33	◆	227398.12	1702060.82
K-36	◆	229369.30	1701010.81
K-40	◆	229687.26	1700264.62
K-46	◆	230643.24	1699397.02
K-48	◆	230432.92	1700653.00
K-49	◆	229812.11	1701781.68
K-50	◆	230719.43	1699730.73
K-51	◆	227530.00	1702510.00
K-53	◆	227543.00	1702215.00
K-57	◆	227435.00	1701165.00
K-01R	◆	228150.00	1702765.00
K-32R	◆	227770.00	1702400.00

* SEE NOTE 2

STOCKPILE AND ACCESS ROAD CONSTRUCTION SURVEY CONTROL POINTS OF INTERSECTION

POINT OF INTERSECTION	NORTHING	EASTING	ELEVATION
P.I.-R1	228796.97	1699205.55	960.0
P.I.-R2	228574.32	1699448.32	940.0
P.I.-R3	228621.64	1700157.41	940.0
P.I.-R4	228873.80	1700272.07	920.0
P.I.-R5	229100.83	1700676.77	861.0
P.I.-R9	227613.22	1702254.86	830.0
P.I.-R10	226906.66	1702588.41	890.0
P.I.-R11	226238.18	1702174.36	952.4
P.I.-R18	229105.63	1700642.12	847.0
P.I.-SP1	229639.65	1699068.21	952.2
P.I.-SP2	228984.60	1699553.23	960.4
P.I.-SP3	228702.65	1699207.26	960.4
P.I.-SP4	229400.92	1698513.68	950.5
P.I.-SP5	228573.26	1699640.43	950.0
P.I.-SP6	228984.50	1699948.74	950.0
P.I.-SP7	228917.80	1700106.96	950.0
P.I.-SP8	226690.14	1701545.22	952.4
P.I.-SP9	226448.63	1701808.85	952.1
P.I.-SP10	226916.64	1702295.90	958.5
P.I.-SP11	226631.46	1702336.27	958.2
P.I.-SP12	226541.09	1702519.15	956.9
P.I.-SP13	225835.66	1702786.64	954.3
P.I.-SP14	225866.12	1702346.97	950.0
P.I.-SP15	226518.41	1701359.42	950.0

REGISTERED PROFESSIONAL ENGINEER
TERRY K. PARKINSON
No. 41021
Exp. MAR 31 1991
CIVIL
STATE OF CALIFORNIA

NOTES

1. SEE SHEET 1 FOR LEGEND AND GENERAL NOTES.
2. SEE LEGEND ON SHEET 1 FOR MONITORING WELL SYMBOLS.
3. EXISTING PERIMETER FENCE WILL BE EXTENDED TO ENCLOSE THE B-18 LANDFILL AREA INTO THE KHF ACTIVE FACILITY AREA.

0 300 600 FEET
SCALE

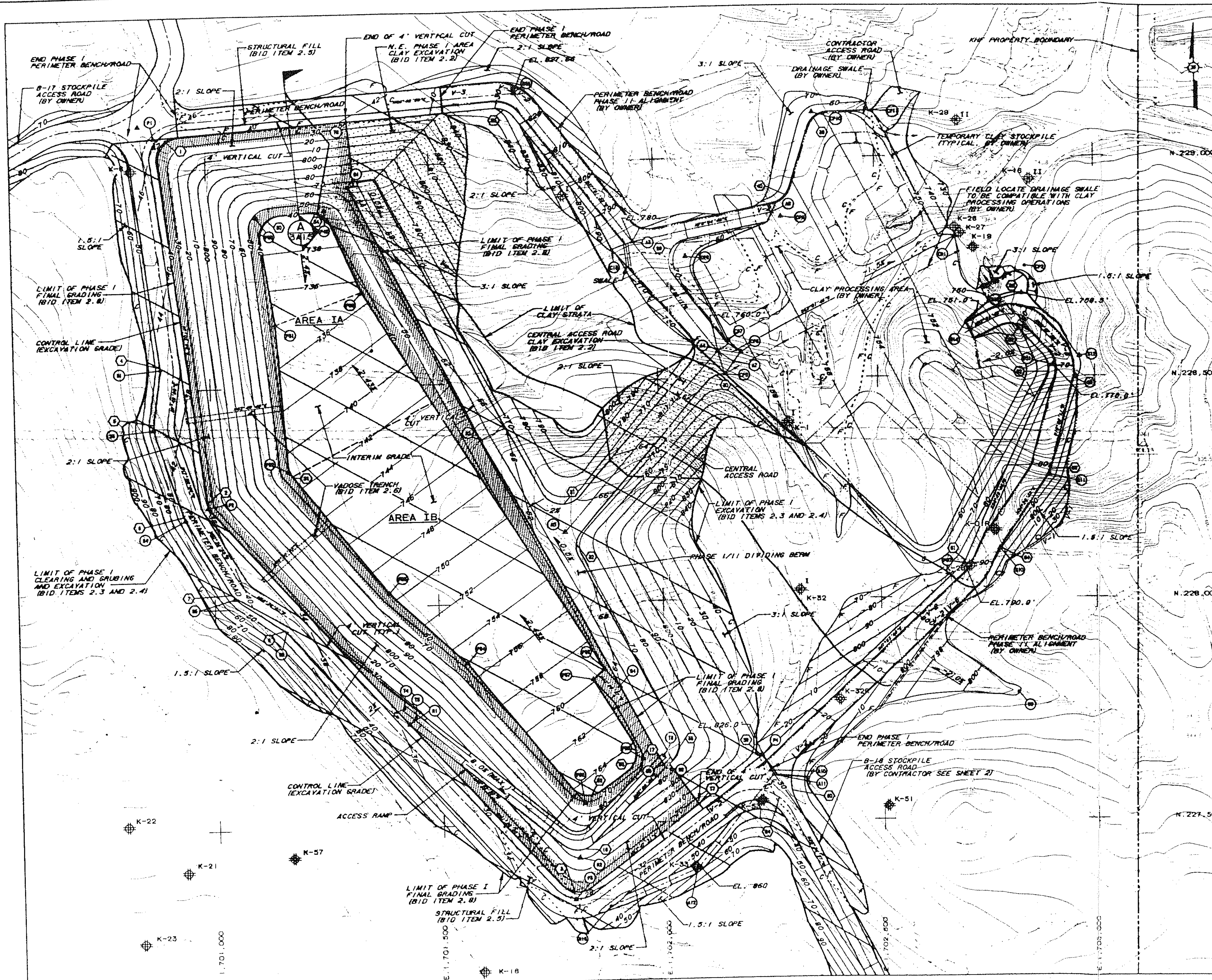
REV	DATE	DESCRIPTION	DRAWN BY	CHK'D BY
2	1/2/91	ISSUED FOR CONSTRUCTION	KJK	
0	7/31/90	ISSUED FOR PERMITTING	KAB	

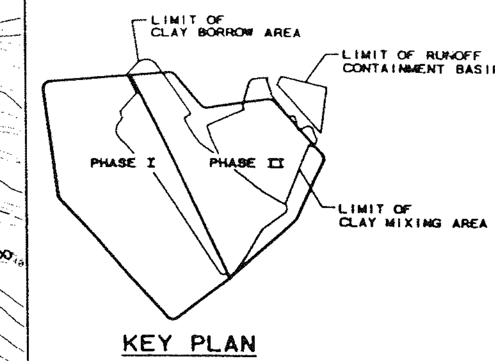
LANDFILL UNIT B-18
CONSTRUCTION PLANS
CWMI-KETTLEMAN HILLS FACILITY
KINGS COUNTY CALIFORNIA

PHASE I EXCAVATION
PROJECT PLAN

ENVIRONMENTAL SOLUTIONS, INC.

JOB NO.	ESI FILE NUMBER	REVISION
89-977	D-89977-FD002	2
SCALE		SHEET
1" = 300'	89-03-304.2.1	2





KEY PLAN

POINTS OF INTERSECTION			
POINT	NORTHING	EASTING	ELEV.
P30	228,665.87	1,701,110.82	740.0
P31	228,542.41	1,701,148.12	754.1
P32	228,305.14	1,701,172.12	740.8
P33	[illegible]	1,701,885.72	745.5
P34	227,885.76	1,701,885.16	755.1
P35	227,844.87	1,701,816.74	755.6
P36	227,842.40	1,701,846.84	755.5
P37	227,894.10	1,701,867.68	755.5
P38	227,947.84	1,701,862.76	755.5
P39	228,715.08	1,701,846.80	765.4
P40	228,660.82	1,701,383.84	740.0
P50	228,074.71	1,702,882.89	780.0
P51	228,338.88	1,702,800.67	770.0
S10	228,106.84	1,702,774.88	788.5
S11	228,376.87	1,702,658.76	781.5
S12	228,544.82	1,702,864.82	735.6
S13	228,462.88	1,702,851.48	758.6
S14	228,822.84	1,702,765.85	781.5
A3A	228,158.74	1,701,661.18	627.7

CURVE DATA						
CURVE NO.	LOCATION OF P.I.		Δ	R	L	T
	NORTHING	EASTING				
30	228,665.87	1,701,110.82	89°55'55"	50.00	61.87	38.86
31	228,305.14	1,701,172.12	34°56'04"	50.00	30.61	15.28
32	227,844.87	1,701,816.74	87°53'56"	50.00	76.71	48.30
33	227,842.40	1,701,846.84	85°14'07"	50.00	74.38	46.01
34	228,665.82	1,701,383.64	72°07'30"	50.00	62.98	36.41
59	228,646.16	1,702,217.87	6°54'31"	45.00	5.14	2.57
60	228,610.75	1,702,236.06	74°27'36"	100.00	125.87	76.89
61	228,074.71	1,702,882.89	28°03'18"	45.00	30.64	16.16
62	228,338.89	1,702,800.67	67°47'05"	45.00	55.62	32.49
63	228,651.38	1,701,621.63	74°00'45"	65.00	83.98	48.99
64	228,106.84	1,702,774.88	6°38'48"	80.00	8.42	4.22
65	228,375.87	1,702,656.76	18°02'21"	110.00	35.26	18.45
66	228,544.82	1,702,864.02	86°25'48"	110.00	112.11	81.47
67	228,158.74	1,701,661.18	58°34'38"	45.00	45.46	27.00

NOTES

1. SEE SHEET 1 FOR LEGEND AND GENERAL NOTES.
2. SEE SHEET 3 FOR CROSS SECTION AND DETAIL PLAN CALLOUTS.
3. SEE SHEET 5 FOR DRAINAGE PLAN AND DETAIL PLAN CALLOUTS. (BID ITEM 2.7)

REGISTERED PROFESSIONAL ENGINEER
TERRY K. PARKIN
No. 41021
Exp. MAR 3 1 1995
CIVIL
STATE OF CALIFORNIA

0 100 200 FEET
SCALE

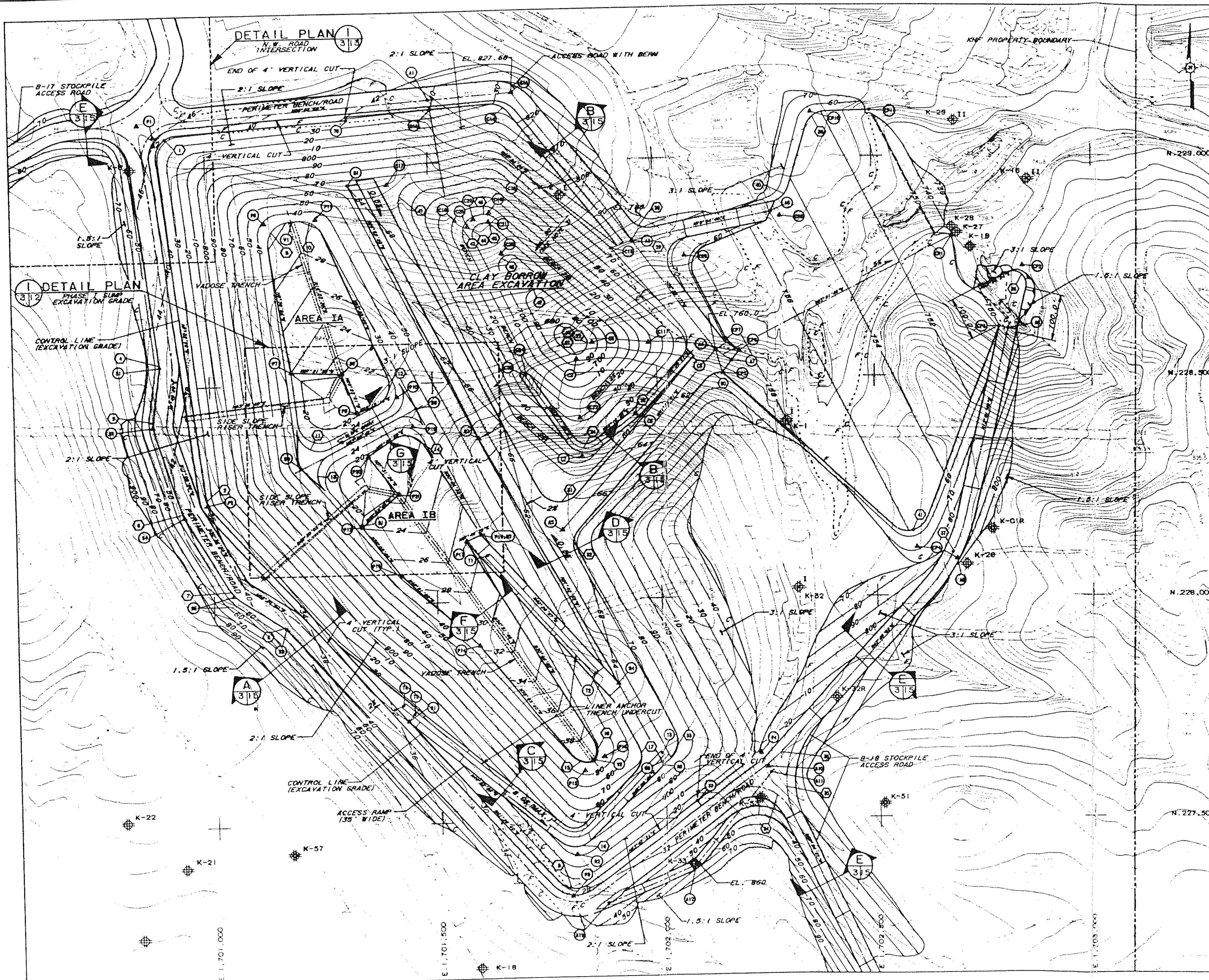
2	01/08/91	ISSUED FOR CONSTRUCTION	KJK	TKP
B	9/24/90	ISSUED FOR BID	KJK	TKP
A	8/31/90	ISSUED FOR COMMENTS	KJK	TKP

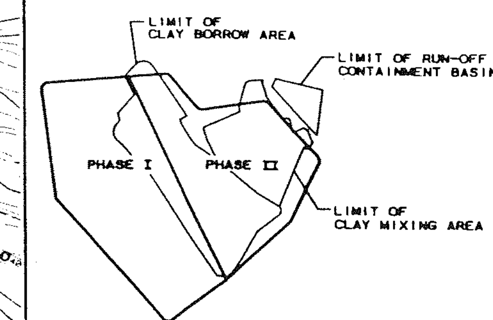
LANDFILL UNIT B-18
CONSTRUCTION PLANS
CWMI-KETTLEMAN HILLS FACILITY
KINGS COUNTY CALIFORNIA

PHASE I
CONSTRUCTION SEQUENCE PLAN

ENVIRONMENTAL SOLUTIONS, INC.

89-977	D-89977-EX003	2
1"=100'	89-03-304.2.1	3A





KEY PLAN

REGISTERED PROFESSIONAL ENGINEER
No. 41021
Exp. 3 1
CIVIL
STATE OF CALIFORNIA

NOTES

1. SEE SHEET 1 FOR LEGEND AND GENERAL NOTES.
2. TRANSITION FROM PERIMETER BENCH/ROAD (SECTION A, 3,15) TO ACCESS ROAD WITH BERM (SECTION B,3,15).
3. THE EAST SLOPE OF THE CLAY PIT EXCAVATION MAY BE VARIED TO CONFORM TO THE BASE OF THE CLAYSTONE STRATUM.
4. SEE SHEET 25 FOR SURVEY CONTROL.

0 100 200 FEET
SCALE

REV	DATE	DESCRIPTION	DRAWN BY	CHK'D BY
2	01/02/91	ISSUED FOR CONSTRUCTION	RVH	KKP
1	9/24/90	ISSUED FOR BIDDING	KJK	KKP
0	7/31/90	ISSUED FOR PERMITTING	KJK	KKP

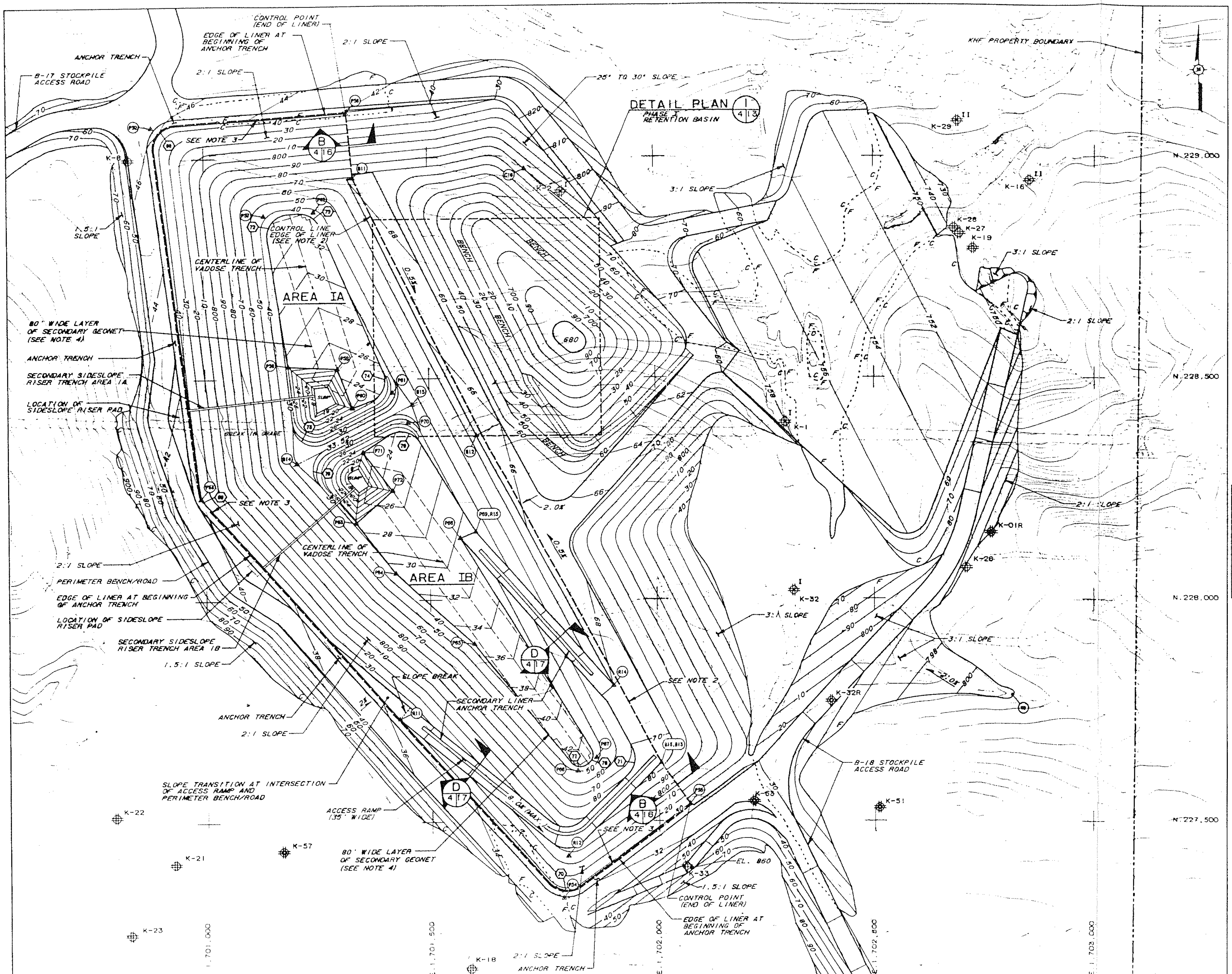
DRAWN BY: KJKarl CHECKED BY: K. Parkinson APPROVED BY: RDE

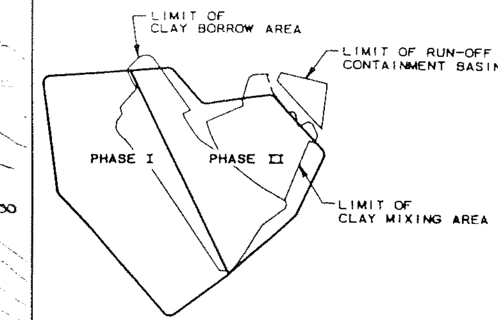
LANDFILL UNIT B-18
CONSTRUCTION PLANS
CWMI-KETTLEMAN HILLS FACILITY
KINGS COUNTY CALIFORNIA

TITLE
PHASE I EXCAVATION AND SITE PREPARATION PLAN

ENVIRONMENTAL SOLUTIONS, INC.

JOB NO.	FILE NUMBER	REVISION
89-977	D-89977-FD003	2
SCALE 1"=100'	89-03-304.2.1	SHEET 3





KEY PLAN

POINTS OF INTERSECTION			
POINT	NORTHING	EASTING	ELEV.
P52	229,071.00	1,700,865.00	846.0
P53	228,280.00	1,700,969.00	840.0
P54	227,328.00	1,701,785.00	832.0
P55	227,587.98	1,702,071.85	830.7
P56	228,101.11	1,701,321.09	841.8
P57	228,869.34	1,701,130.87	784.7
P58	228,326.21	1,701,182.76	727.6
P59	228,323.08	1,701,283.84	724.3
P60	228,434.14	1,701,326.88	722.4
P61	228,466.34	1,701,417.46	724.4
P62	228,877.80	1,701,242.44	784.0
P63	228,174.47	1,701,333.55	727.4
P64	228,060.27	1,701,422.87	780.7
P65	227,900.33	1,701,564.10	735.2
P66	227,613.24	1,701,818.90	743.3
P67	227,843.56	1,701,860.47	743.3
P68	228,138.32	1,701,365.82	780.3
P69	228,155.86	1,701,399.46	781.2
P70	228,400.56	1,701,452.80	724.7
P71	228,334.27	1,701,349.89	722.2
P72	228,246.96	1,701,418.93	724.8
B11	228,947.47	1,701,334.87	768.2
B12	228,371.18	1,701,802.28	764.8
B13	227,630.63	1,702,004.76	773.5
B14	228,309.12	1,701,201.76	733.5
B15	228,441.06	1,701,481.82	733.5
R11	227,731.37	1,701,429.30	685.5
R12	227,422.13	1,701,788.16	787.1
R13	227,630.63	1,702,004.76	773.5
R14	227,805.27	1,701,888.30	768.0
R15	228,153.86	1,701,399.46	731.2

CURVE DATA						
CURVE NO.	LOCATION OF P.I. NORTHING	LOCATION OF P.I. EASTING	Δ	R	L	T
68	229,071.00	1,700,865.00	93°05'58"	50.00	81.24	52.78
69	228,230.00	1,700,969.00	34°22'42"	50.00	29.81	15.28
70	227,328.00	1,701,785.00	84°46'46"	50.00	73.98	45.64
71	227,631.97	1,701,956.61	72°43'17"	50.00	63.46	36.81
72	228,869.34	1,701,130.87	94°18'45"	50.00	82.30	53.81
73	228,320.17	1,701,194.54	115°25'56"	50.00	100.70	78.09
74	228,466.34	1,701,417.46	92°27'56"	50.00	80.69	52.20
75	228,877.80	1,701,242.44	71°11'28"	50.00	62.13	35.79
76	228,309.12	1,701,201.76	109°10'55"	50.00	95.28	70.33
77	227,843.56	1,701,860.47	98°02'22"	25.00	38.41	24.16
78	228,138.32	1,701,365.82	84°36'39"	25.00	36.93	22.76
79	228,400.56	1,701,452.80	92°06'11"	50.00	80.37	51.87

NOTES

1. SEE SHEET 1 FOR LEGEND AND GENERAL NOTES.
2. THE EAST SIDE SECONDARY LINER CONTROL LINE IS THE EDGE OF THE LINER AT THE BEGINNING OF THE ANCHOR TRENCH.
3. THE NORTH, SOUTH AND WEST SECONDARY LINER CONTROL LINE IS THE TOP OF THE SLOPE.
4. TAPER WIDTH OF GEONET AS REQUIRED TO REMAIN WITHIN THE BOTTOM AREA.

REGISTERED PROFESSIONAL ENGINEER — TERRY K. PARKINSON — No. 41021 — Exp. MAR 31 1991 — CIVIL — STATE OF CALIFORNIA

0 100 200 FEET
SCALE

REV	DATE	DESCRIPTION	DRAWN BY	CHK'D BY
2	01/02/91	ISSUED FOR CONSTRUCTION	KJK	KKP
1	8/24/90	ISSUED FOR BID	MD	KKP
0	7/31/90	ISSUED FOR PERMITTING	KJK	KKP

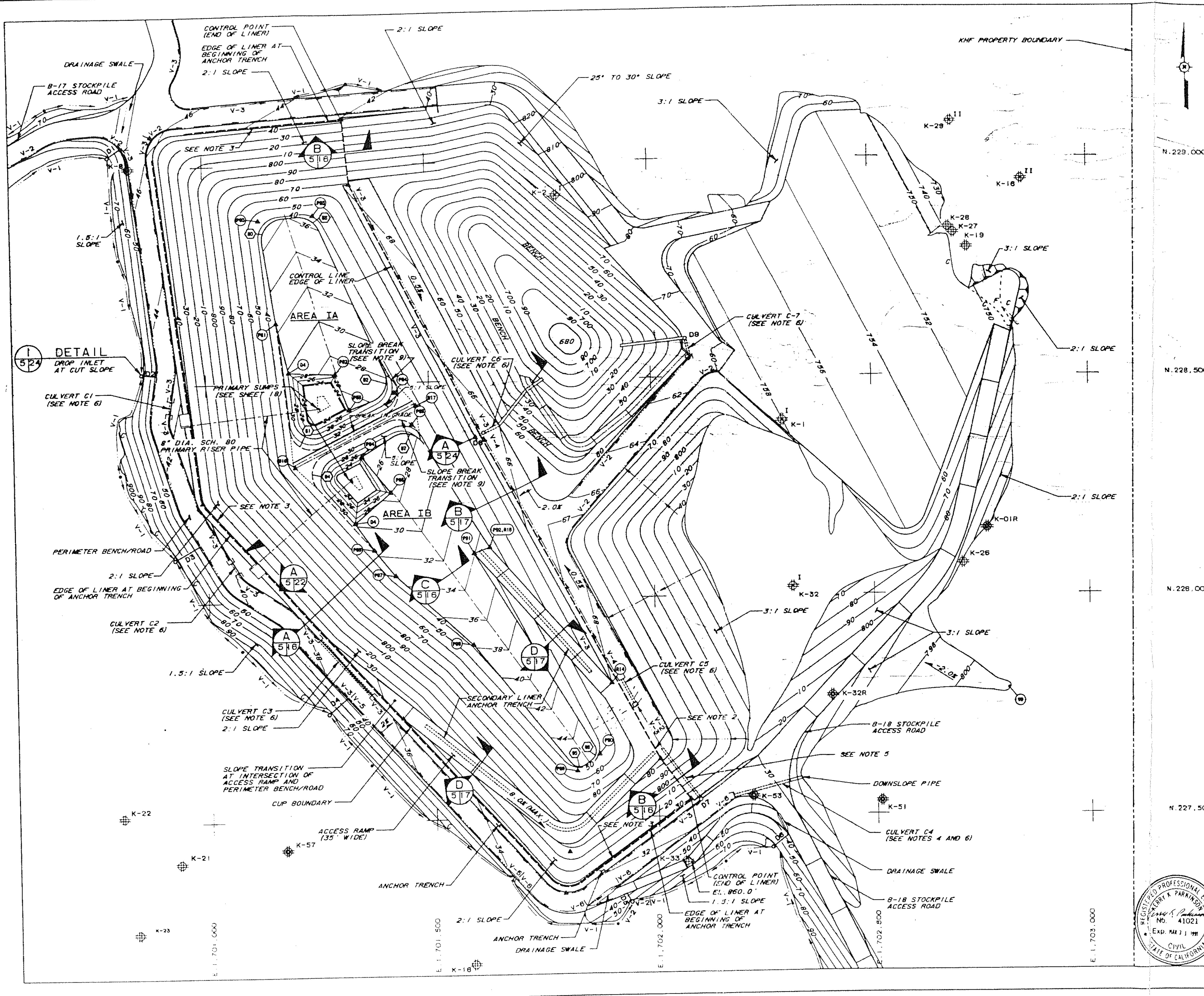
DRAWN BY [signature] CHECKED BY K. Parkinson APPROVED BY [signature]

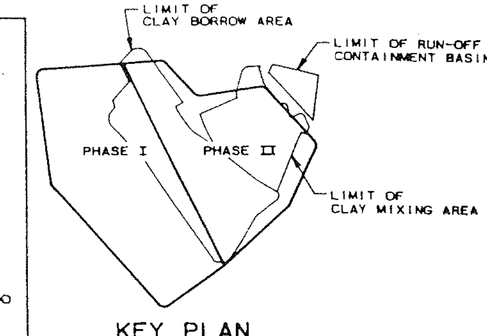
LANDFILL UNIT B-18
CONSTRUCTION PLANS
CWMI-KETTLEMAN HILLS FACILITY
KINGS COUNTY CALIFORNIA

TITLE
PHASE I
TOP OF SECONDARY LINER

ENVIRONMENTAL SOLUTIONS, INC.

JOB NO.	ESI FILE NUMBER	REVISION
89-977	D-89977-FD004	2
SCALE	CWMI FILE NUMBER	SHEET
1"=100'	89-03-304.2.1	4





KEY PLAN

CULVERT SCHEDULE[6]

NO.	DIA. (IN.)	LENGTH (FT.)
C1	12	30
C2	12	30
C3	12	170
C4	24	155*
C5	18	60
C6	30	170*
C7	12	50*

V-DITCH SCHEDULE

TYPE	WIDTH (W)	DEPTH (H)
V-1	2	1
V-2	5	1
V-3	5	1.5
V-4	5	2
V-5	5	2.5
V-6	5	3
V-7	5	1.25

DROP INLET SCHEDULE

NO.	DEPTH D (FT.)	DIA. (IN.)[7]	OUTLET PIPE[8] DIA. (IN.)	OUTLET PIPE LENGTH (FT.)*
D1	4	36	12	36
D2	4	36	24	42
D3	4	36	18	72
D4	4	36	12	60
D5	4	72	2@24	55 EA.
D6	4	36	18	50
D7	4	72	18	145
D8	5	72	30	170
D9	4	36	18	140

* NOTE: LENGTH IS APPROXIMATE. ACTUAL LENGTH WILL BE DETERMINED AT COMPLETION OF GRADING. LENGTH INCLUDES DOWNSLOPE PIPE

POINTS OF INTERSECTION

POINT	NORTHING	EASTING	ELEV.
P80	228,874.32	1,700,985.00	757.5
P81	228,324.98	1,701,188.38	729.8
P82	228,520.10	1,701,281.59	727.0
P83	228,457.98	1,701,322.06	724.8
P84	228,476.08	1,701,422.85	727.2
P85	228,884.32	1,701,246.42	788.8
P86	228,115.77	1,701,372.87	728.8
P87	228,081.20	1,701,412.48	788.2
P88	227,880.75	1,701,584.98	788.0
P89	227,806.98	1,701,818.02	748.2
P90	227,843.58	1,701,868.41	748.1
P91	228,106.71	1,701,884.58	783.8
P92	228,118.57	1,701,828.88	784.8
P93	228,402.78	1,701,480.84	728.4
P94	228,380.20	1,701,346.21	724.8
P95	228,347.54	1,701,844.21	727.4
S16	228,308.14	1,701,186.74	785.0
S17	228,445.68	1,701,470.04	785.0
R18	228,118.57	1,701,828.88	784.8

CURVE DATA

CURVE NO.	LOCATION OF P.I. NORTHING	LOCATION OF P.I. EASTING	Δ	R	L	T
80	228,874.32	1,700,985.00	84°01'25"	50.00	82.05	58.84
81	228,322.32	1,701,185.30	110°38'55"	50.00	98.57	72.30
82	228,478.06	1,701,422.83	92°27'38"	50.00	80.88	82.20
83	228,884.32	1,701,246.42	71°26'48"	50.00	82.38	38.88
84	228,308.18	1,701,207.58	108°45'44"	50.00	80.35	68.72
86	227,806.86	1,701,818.02	98°12'12"	25.00	38.46	24.28
88	227,843.58	1,701,868.41	84°28'38"	25.00	38.86	22.70
87	228,402.78	1,701,480.64	92°08'08"	50.00	80.87	51.87

NOTES

1. SEE SHEET 1 FOR LEGEND AND GENERAL NOTES.
2. THE EAST SIDE PRIMARY LINER CONTROL LINE IS THE EDGE OF THE LINER AT THE BEGINNING OF THE ANCHOR TRENCH.
3. THE NORTH, SOUTH AND WEST PRIMARY LINER CONTROL LINE IS THE TOP OF THE SLOPE.
4. FOR CLAY PROCESSING AREA DRAINAGE SEE SHEET 3A.
5. EXTEND 18" DIA. PIPE 20 FEET BEYOND TOE OF SLOPE. TOE OF SLOPE
6. DUE TO SHALLOW BURIAL DEPTH CULVERT BACKFILL SHALL BE CONCRETE. PROVIDE 6 INCHES OF COVER MINIMUM.
7. ALL DROP INLETS SHALL BE OF 12 GAGE THICKNESS
8. ALL CULVERTS AND OUTLETS SHALL BE OF 18 GAGE THICKNESS
9. BLEND 5:1 TO 3:1 SLOPE BREAK INTO LANDFILL BOTTOM TO CREATE SMOOTH TRANSITION

0 100 200 FEET
SCALE

REV	DATE	DESCRIPTION	DRAWN BY	APP'D BY
3	7/26/91	REMOVED SECTION B:5:24	KJK	KKP
2	01/02/91	ISSUED FOR CONSTRUCTION	KJK	KKP
1	9/24/90	ISSUED FOR BID	MD	KKP
0	7/31/90	ISSUED FOR PERMITTING	KJK	KKP

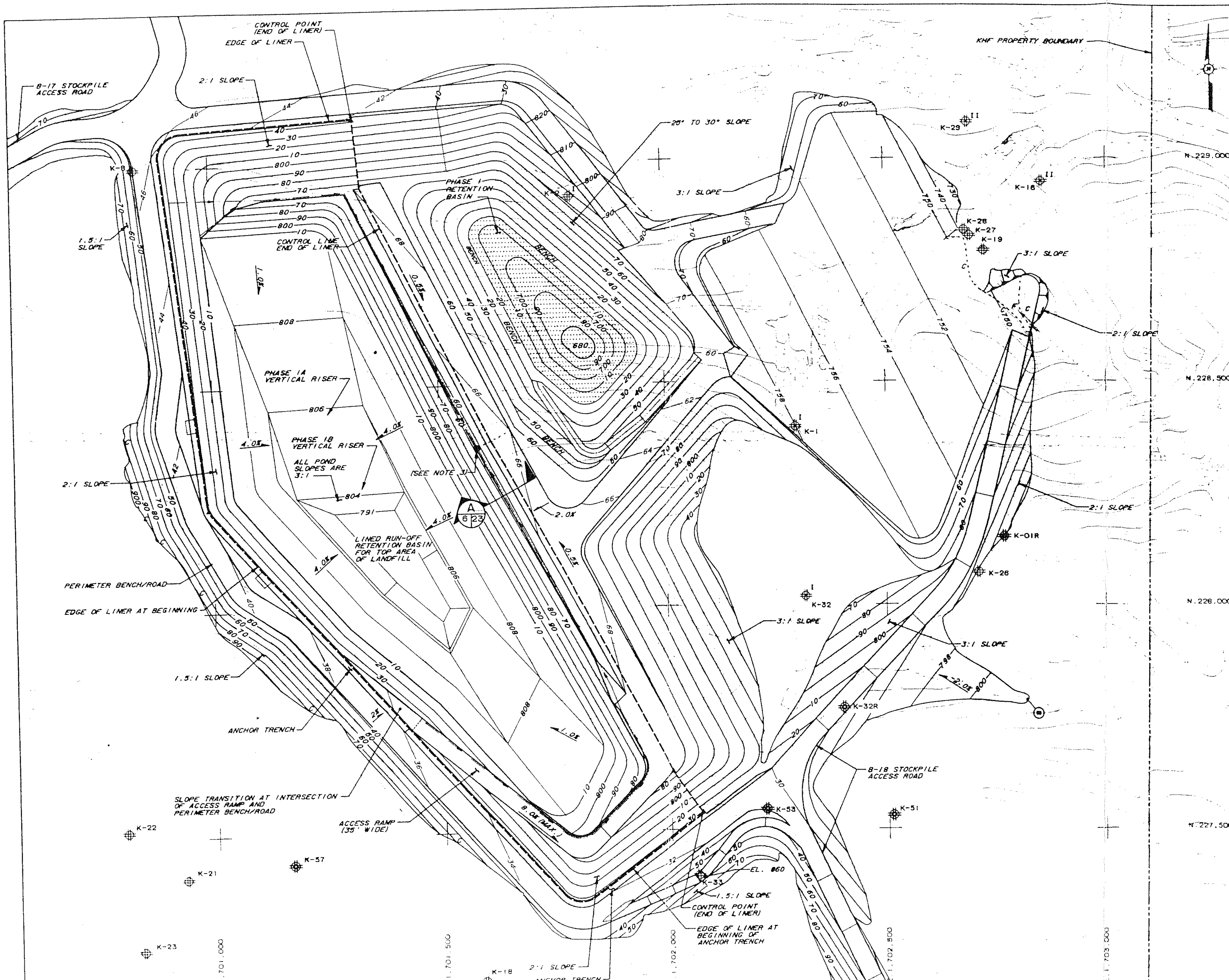
DRAWN BY [signature] DESIGNED BY [signature] APPROVED BY KDE

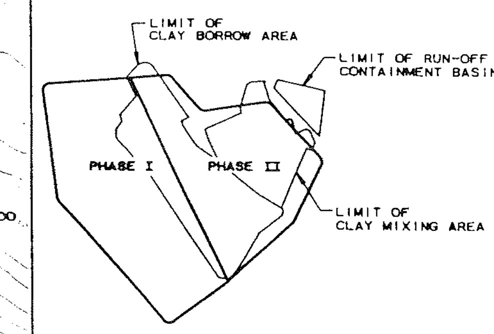
LANDFILL UNIT B-18
CONSTRUCTION PLANS
CWMI-KETTLEMAN HILLS FACILITY
KINGS COUNTY CALIFORNIA

TITLE
PHASE I
TOP OF PRIMARY LINER

ENVIRONMENTAL SOLUTIONS, INC.

JOB NO.	ESI FILE NUMBER	REVISION
89-977	D-89977-FD005	3
SCALE	CWMI FILE NUMBER	SHEET
1" = 100'	89-03-304.2.1	5





KEY PLAN

REGISTERED PROFESSIONAL ENGINEER KERRY K. PARKINSON No. 41021 Exp. MAR 31 1991 CIVIL STATE OF CALIFORNIA

NOTES

1. SEE SHEET 1 FOR LEGEND AND GENERAL NOTES.
2. SEE SHEET 5 FOR DRAINAGE CONTROL.
3. RUN-OFF FROM LANDFILL SLOPES SHALL BE DETAINED IN A TEMPORARY POND FORMED AT THE THE LANDFILL TOE OR PUMPED TO THE PHASE I RETENTION BASIN AT THE OPTION OF THE OWNER.

0 100 200 FEET
SCALE

REV	DATE	DESCRIPTION	DRAWN BY	CHK'D BY
2	01/02/91	ISSUED FOR CONSTRUCTION	RVH	KKP
0	7/31/90	ISSUED FOR PERMITTING	KJK	KKP

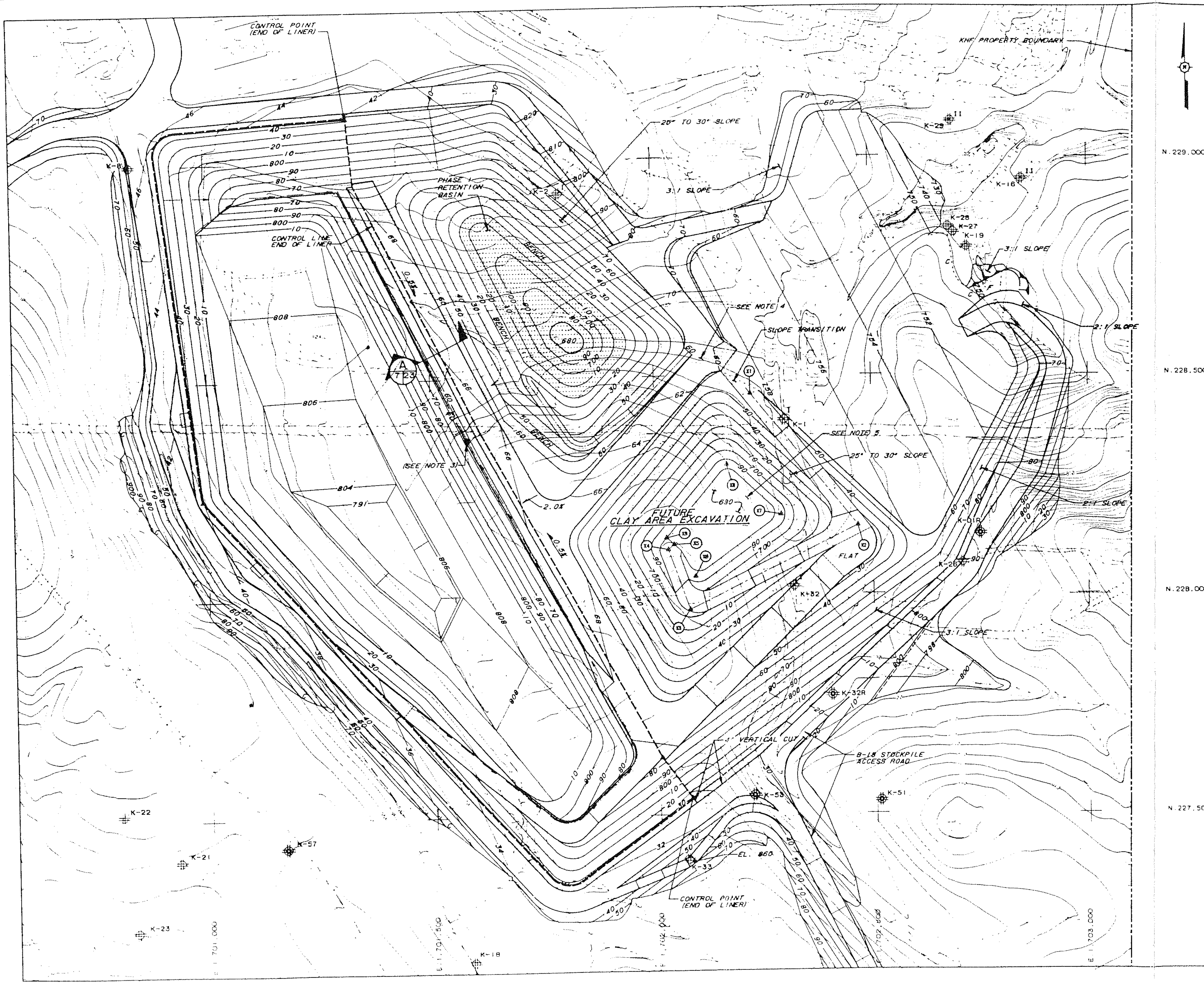
DRAWN BY KOKodi CHECKED BY K. Parkinson APPROVED BY RDE

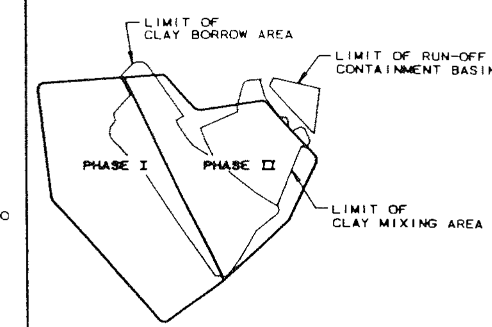
LANDFILL UNIT B-18
CONSTRUCTION PLANS
CWMI-KETTLEMAN HILLS FACILITY
KINGS COUNTY CALIFORNIA

PHASE I
INTERMEDIATE WASTE FILL PLAN

ENVIRONMENTAL SOLUTIONS, INC.

JOB NO.	ESI FILE NUMBER	REVISION
89-977	D-89977-FD006	2
SCALE 1"=100'	CWMI FILE NUMBER 89-03-304.2.1	SHEET 6





KEY PLAN

POINTS OF INTERSECTION			
POINT	NORTHING	EASTING	ELEV.
X1	228,456.06	1,702,218.70	788.1
X2	228,186.35	1,701,488.25	782.0
X3	227,988.98	1,702,074.43	687.3
X4	228,104.15	1,702,027.00	682.1
X5	228,115.42	1,702,040.01	660.0
X6	228,042.44	1,702,087.43	660.0
X7	228,161.51	1,702,288.38	660.0
X8	228,287.00	1,702,182.41	660.0
X9	228,180.92	1,702,028.52	660.0

REGISTERED PROFESSIONAL ENGINEER KERRY K. PARKINSON No. 41021 Exp. 3-31-95 CIVIL STATE OF CALIFORNIA

NOTES

1. SEE SHEET 1 FOR LEGEND AND GENERAL NOTES.
2. SEE SHEET 5 FOR DRAINAGE CONTROL.
3. RUN-OFF FROM LANDFILL SLOPES SHALL BE DETAINED IN A TEMPORARY POND FORMED AT THE THE LANDFILL TOE OR PUMPED TO THE PHASE I RETENTION BASIN AT THE OPTION OF THE OWNER.
4. THE BERM SEPARATING THE PHASE I RETENTION BASIN AND THE FUTURE CLAY AREA EXCAVATION MAY BE EXCAVATED AT THE OPTION OF THE OWNER.
5. THE BOTTOM OF THE FUTURE CLAY EXCAVATION AREA IS LOWER THAN THE EXCAVATION DESIGN GRADE FOR PHASE II (SEE SHEET 8). AT THE OPTION OF THE OWNER THE CLAY EXCAVATION GRADE MAY BE RAISED TO PREVENT THE USE OF BACKFILL AT THE BOTTOM.

0 100 200 FEET
SCALE

REV	DATE	DESCRIPTION	DRAWN BY	CHK'D BY
2	7/26/91	ISSUED FOR PHASE II CONSTRUCTION	KJK	KKP
0	7/31/90	ISSUED FOR PERMITTING	KJK	KKP

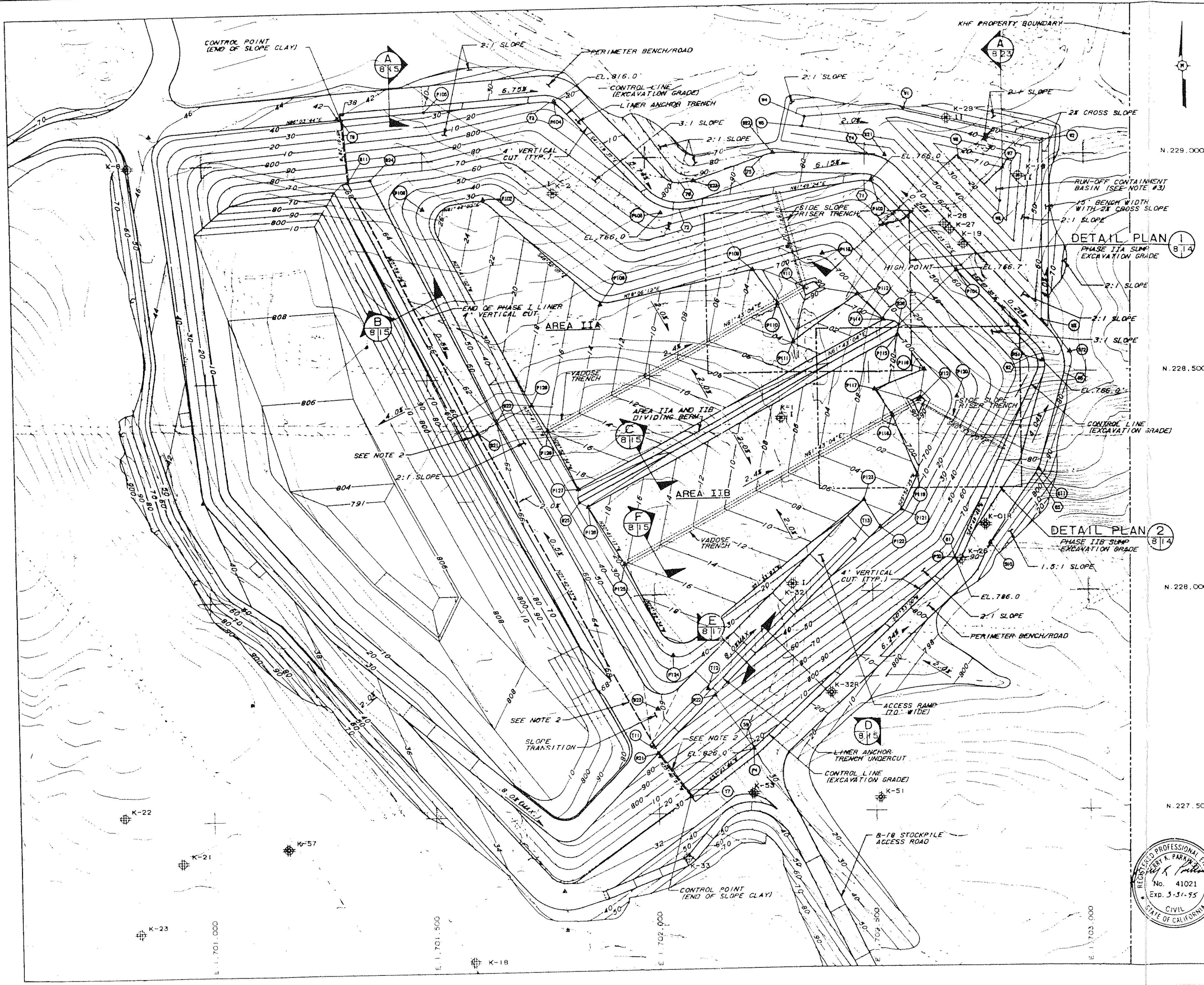
DRAWN BY K. J. Kavli — DESIGNED BY K. Parkinson — APPROVED BY [illegible]

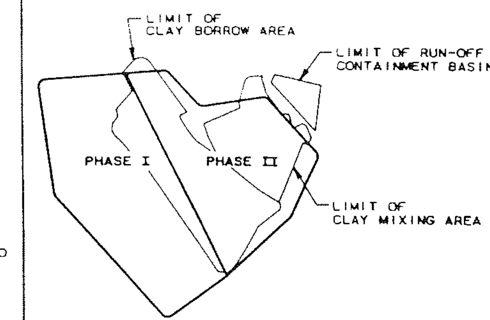
LANDFILL UNIT B-18
CONSTRUCTION PLANS
CWMI-KETTLEMAN HILLS FACILITY
KINGS COUNTY CALIFORNIA

TITLE
CLAY BORROW PIT
EXPANSION PLAN

ENVIRONMENTAL SOLUTIONS, INC.

JOB NO.	ESI FILE NUMBER	REVISION
89-977	D-89977-FD007	2
SCALE	CWMI FILE NUMBER	SHEET
1"=100'	89-03-304.2.1	7





KEY PLAN

POINTS OF INTERSECTION			
POINT	NORTHING	EASTING	ELEV.
P101	228,731.97	1,702,868.03	766.7
P102	228,941.90	1,702,515.80	766.0
P103	228,872.47	1,702,082.38	786.8
P104	229,134.14	1,701,802.28	816.0
P105	229,113.91	1,701,806.47	806.0
P106	228,868.48	1,701,466.81	727.7
P107	228,810.79	1,701,886.51	722.4
P108	228,865.54	1,701,865.27	713.8
P109	228,738.06	1,702,238.47	708.8
P110	228,660.45	1,702,293.34	701.7
P111	228,572.06	1,702,326.86	708.8
P112	228,679.61	1,702,477.38	699.0
P113	228,778.60	1,702,869.67	700.0
P114	228,620.82	1,702,537.03	700.0
P115	228,585.63	1,702,569.13	700.0
P116	228,505.19	1,702,628.10	697.7
P117	228,461.26	1,702,512.63	701.0
P118	228,402.79	1,702,553.42	699.3
P119	228,264.30	1,702,608.65	702.7
P120	228,443.26	1,702,708.72	700.0
P121	228,186.06	1,702,570.96	706.4
P122	228,161.82	1,702,539.86	706.5
P123	228,224.46	1,702,504.13	705.8
P124	227,852.95	1,702,086.20	721.1
P125	228,086.89	1,701,928.11	718.4
P126	228,199.07	1,701,850.67	720.0
P127	228,240.03	1,701,836.53	720.0
P128	228,379.32	1,701,770.65	715.8
P129	228,434.97	1,701,728.26	717.6
B21	228,376.60	1,701,812.88	761.0
B22	228,396.37	1,701,856.00	762.0
B23*	227,738.69	1,702,002.37	——
B24	228,960.36	1,701,362.00	765.1
B25	228,212.65	1,701,838.30	725.7
B26	228,806.01	1,702,572.73	706.0
R21	227,836.31	1,702,000.75	795.3
R22	227,766.18	1,702,130.86	790.6
S21	228,877.37	1,702,546.46	766.5*
S22	229,006.28	1,702,288.85	794.8
S23	228,944.03	1,702,107.17	795.7
T11	227,853.06	1,701,985.62	765.3
T12	227,783.14	1,702,115.94	748.6
T13	228,118.05	1,702,460.85	710.2
W1	229,103.81	1,702,581.20	752.0
W2	229,081.44	1,702,906.02	752.0
W3	228,617.26	1,702,900.46	766.6
W4	229,066.63	1,702,366.70	750.0
W5	229,064.38	1,702,380.46	730.0
W6	228,966.67	1,702,717.57	710.0
W7	228,366.02	1,702,817.02	710.0
W8	228,869.08	1,702,808.43	710.0

*-COORDINATES AND ELEVATIONS SHALL BE DETERMINED FROM PHASE I AS-BUILT SURVEY.

CURVE DATA						
CURVE NO.	LOCATION OF P.I. NORTHING	LOCATION OF P.I. EASTING	Δ	R	L	T
71	228,941.90	1,702,515.80	55°47'24"	48.80	46.46	26.36
72	228,872.47	1,702,082.38	56°50'58"	110.20	108.34	59.65
73	229,134.14	1,701,802.29	52°37'24"	49.80	45.74	24.63
74	228,987.37	1,702,546.46	45°51'01"	110.00	88.06	46.52
75	229,006.26	1,702,288.85	20°19'02"	110.00	39.01	19.71
76	228,944.03	1,702,107.17	10°22'39"	50.00	9.06	4.54

NOTES

1. SEE SHEET 1 FOR LEGEND AND GENERAL NOTES.
2. REMOVE EXISTING DRAINAGE STRUCTURES AND TRANSPORT TO STORAGE AREA AS DIRECTED BY THE OWNER. BACKFILL EXCAVATIONS WITH CLAY AS SPECIFIED FOR CLAY LINER.
3. FIELD LOCATE SUMP AS APPROVED BY OWNER.

0 100 200 FEET
SCALE

REGISTERED PROFESSIONAL ENGINEER
KERRY K. PARKINSON
No. 41021
Exp. 3-31-95
CIVIL
STATE OF CALIFORNIA

REV	DATE	DESCRIPTION	DRAWN BY	CHK'D BY
2	7/26/91	ISSUED FOR PHASE II CONSTRUCTION	KJK	KKP
0	7/31/90	ISSUED FOR PERMITTING	KJK	KKP

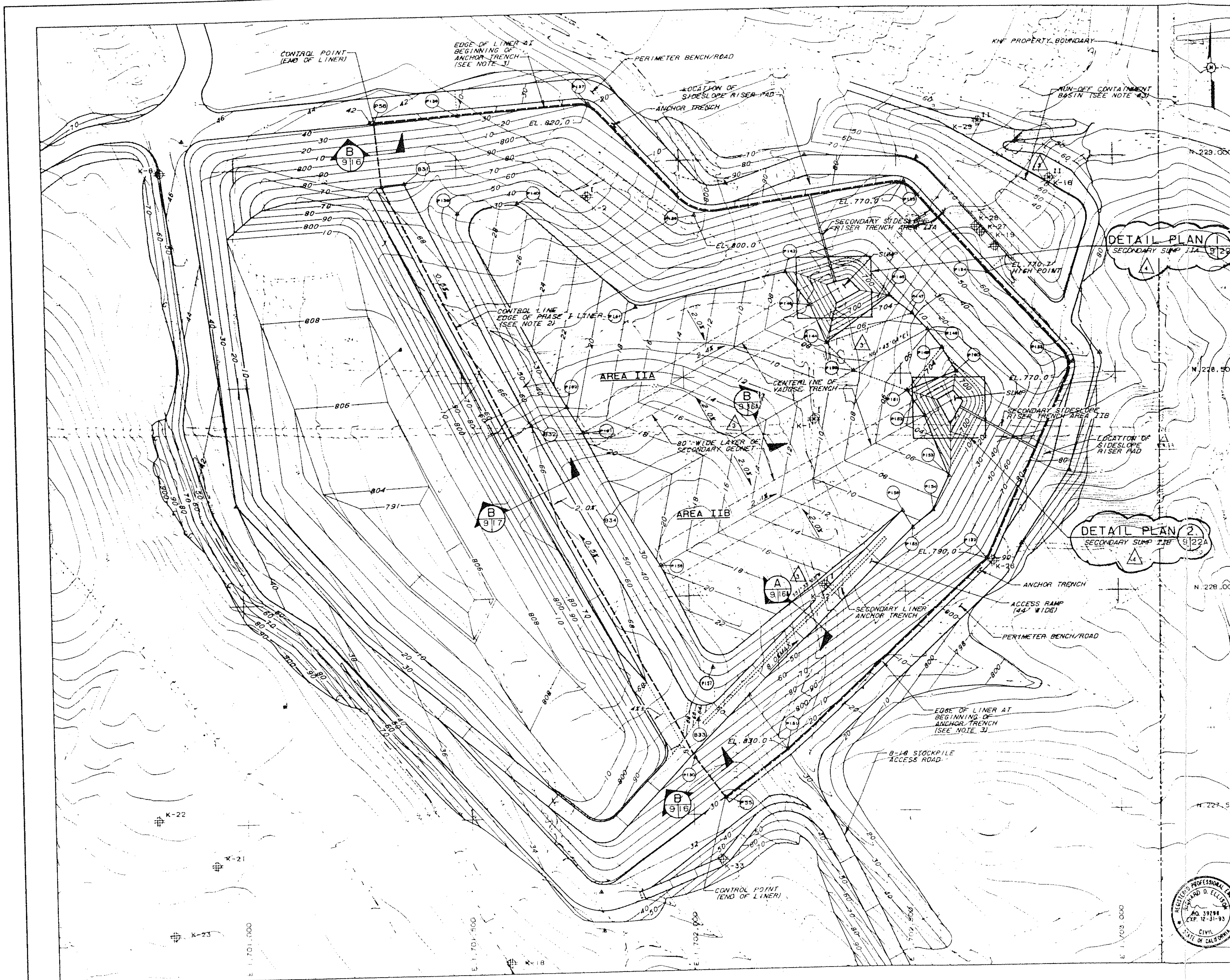
DRAWN BY K. J. Kayli CHECKED BY K. Parkinson APPROVED BY RVE

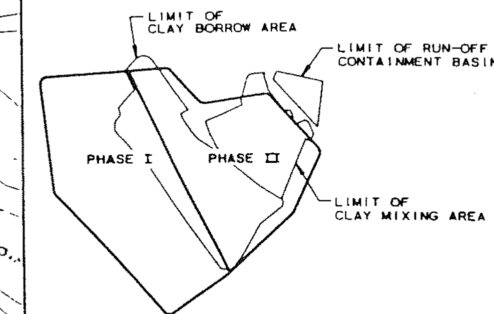
LANDFILL UNIT B-18
CONSTRUCTION PLANS
CWMI-KETTLEMAN HILLS FACILITY
KINGS COUNTY CALIFORNIA

TITLE
PHASE II EXCAVATION
AND
SITE PREPARATION PLAN

ENVIRONMENTAL SOLUTIONS, INC.

JOB NO.	ESI FILE NUMBER	REVISION
89-977	D-89977-FD008	2
SCALE	CWMI FILE NUMBER	SHEET
1"=100'	89-03-304.2.1	8





KEY PLAN

POINTS OF INTERSECTION			
POINT	NORTHING	EASTING	ELEV.
P55	227,537.86	1,702,071.85	830.7
P56	229,100.93	1,701,318.37	841.8
P130	227,830.63	1,702,004.78	773.5
P131	227,845.00	1,702,218.00	830.0
P132	228,074.59	1,702,693.16	780.0
P133	228,524.03	1,702,801.11	770.0
P134	228,732.11	1,702,707.35	770.7
P135	228,942.11	1,702,515.86	770.0
P136	228,872.66	1,702,082.47	800.0
P137	229,134.35	1,701,802.37	820.0
P138	229,118.91	1,701,308.47	840.0
P139	228,895.91	1,701,496.73	730.9
P140	228,907.71	1,701,686.98	726.8
P141	228,864.66	1,701,895.36	717.4
P142	228,737.39	1,702,240.48	707.8
P143	228,660.56	1,702,293.72	705.2
P144	228,572.67	1,702,326.67	707.3
P145	228,679.70	1,702,476.66	702.5
P146	228,627.52	1,702,528.79	703.4
P147	228,636.98	1,702,528.18	705.5
P148	228,801.65	1,702,564.65	708.2
P149	228,559.75	1,702,587.73	704.4
P150	228,504.75	1,702,629.02	701.2
P151	228,461.10	1,702,513.43	704.4
P152	228,402.96	1,702,553.77	702.6
P153	228,265.72	1,701,808.67	708.2
P154	228,186.65	1,702,570.31	709.6
P155	228,146.51	1,702,520.43	711.1
P156	228,185.43	1,702,497.68	709.7
P157	227,885.50	1,702,050.47	733.0
P158	228,071.16	1,701,937.10	719.6
P159	228,307.51	1,702,369.87	706.5
P160	228,244.34	1,701,837.29	722.6
P161	228,379.74	1,701,771.61	719.4
P162	228,439.08	1,701,736.40	720.8
831*	----	----	---
832*	----	----	---
833*	----	----	---
834	228,218.85	1,701,849.96	723.2
835	228,806.43	1,702,571.22	709.0

*-COORDINATES AND ELEVATIONS SHALL BE DETERMINED FROM PHASE I AS-BUILT SURVEY.

NOTES

1. SEE SHEET 1 FOR LEGEND AND GENERAL NOTES.
2. THE WEST SIDE SECONDARY LINER CONTROL LINE IS THE EDGE OF LINER AT THE BEGINNING OF THE ANCHOR TRENCH.
3. THE NORTH, SOUTH AND EAST SECONDARY LINER CONTROL LINE IS THE TOP OF THE SLOPE.

0 100 200 FEET
SCALE

REV	DATE	DESCRIPTION	DRAWN BY	CHK'D BY
4	10/02/93	REVISED CALL OUTS FOR SUMPS AND RISERS	GGI	[signature]
3	1/29/93	ACCESS ROAD WIDTH REDUCED TO 44' ELIMINATED PHASE II A-B DIVIDING BERM ADDED TYPICAL SECTIONS A-9/18A, B-9/18A MODIFIED GRADING IN SUMP AREA MODIFIED SURVEY CONTROL TO REFLECT ABOVE CHANGES	GGI	
2	7/26/91	ISSUED FOR PHASE II CONSTRUCTION	KJK	
0	7/31/90	ISSUED FOR PERMITTING	KJK	

DRAWN BY | CHECKED BY | APPROVED BY

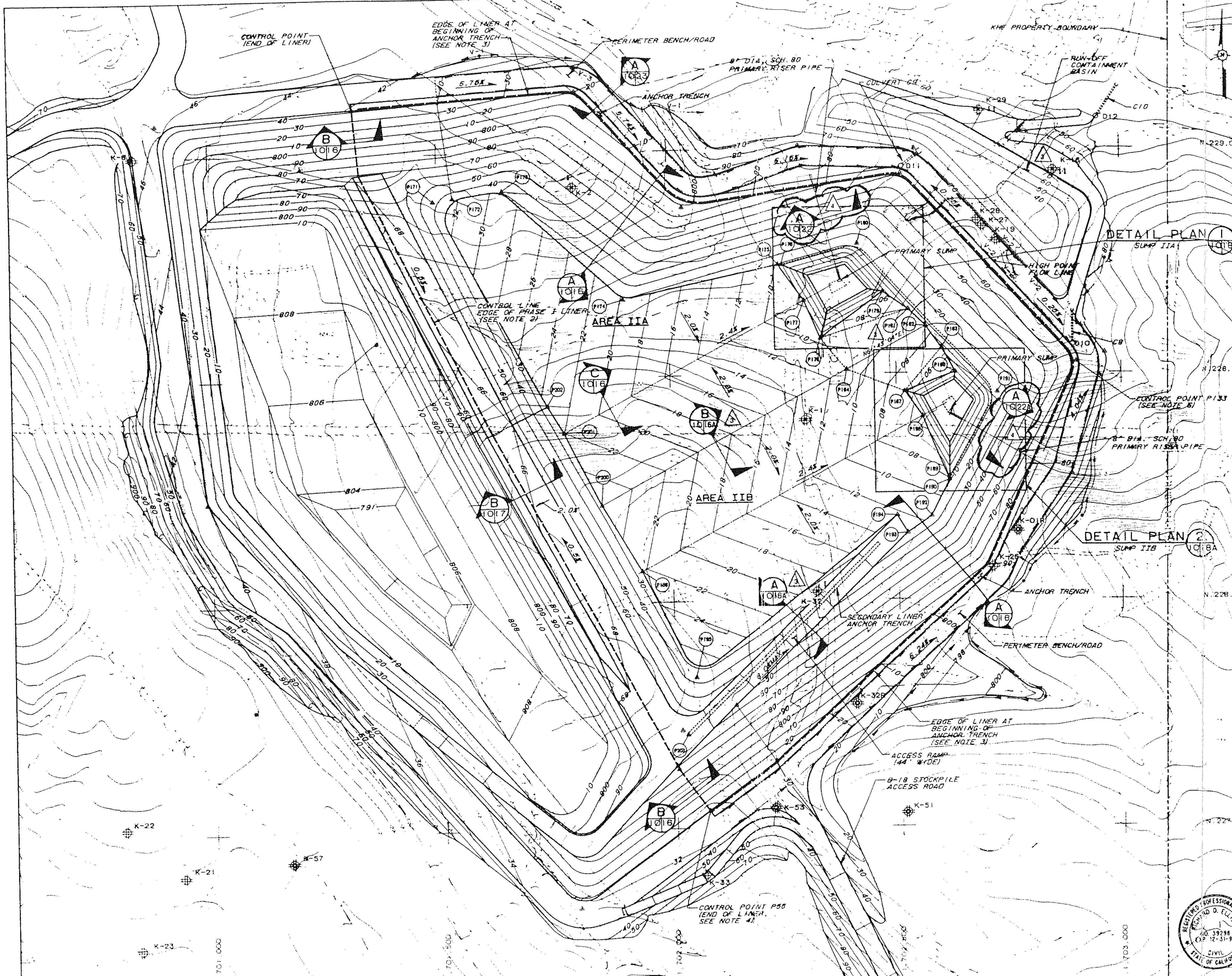
LANDFILL UNIT B-18
CONSTRUCTION PLANS
CWMI-KETTLEMAN HILLS FACILITY
KINGS COUNTY CALIFORNIA

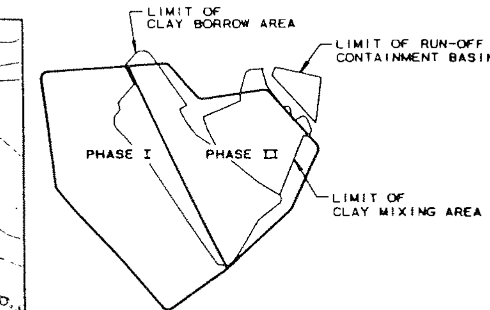
TITLE
PHASE II
TOP OF SECONDARY LINER

ENVIRONMENTAL SOLUTIONS, INC.

JOB NO.	ESI FILE NUMBER	REVISION
89-977	D-89977-FD009	4
SCALE	CWMI FILE NUMBER	SHEET
1"=100'	89-03-304.2.1	9

REGISTERED PROFESSIONAL ENGINEER RICHARD D. ELLISON No. 39298 EXP. 12-31-93 CIVIL STATE OF CALIFORNIA





KEY PLAN

POINTS OF INTERSECTION			
POINT	NORTHING	EASTING	ELEV.
P171	228,894.08	1,701,481.72	758.7
P172	228,900.38	1,701,554.36	782.4
P173	228,915.75	1,701,640.80	720.2
P174	228,870.79	1,701,898.35	718.8
P175	228,742.72	1,702,240.77	709.8
P176	228,742.04	1,702,248.75	708.4
P177	228,662.08	1,702,288.70	707.6
P178	228,577.87	1,702,380.48	708.6
P179	228,880.45	1,702,472.58	706.0
P180	228,787.83	1,702,418.72	---
P181	228,840.86	1,702,528.22	708.0
P182	228,803.49	1,702,588.15	708.8
P183	228,554.31	1,702,588.81	708.8
P184	228,508.28	1,702,388.15	711.0
P185	228,588.85	1,702,584.78	708.1
P186	228,501.24	1,702,628.48	708.7
P187	228,459.84	1,702,518.28	708.8
P188	228,404.48	1,702,558.57	706.3
P189	228,285.06	1,702,618.50	708.4
P190	228,263.24	1,702,618.08	708.7
P191	228,456.48	1,702,721.58	---
P192	228,163.11	1,702,574.20	711.5
P193	228,148.51	1,702,520.48	713.2
P194	228,185.43	1,702,487.88	712.8
P195	227,832.74	1,702,048.88	788.4
P196	228,088.70	1,701,982.48	722.3
P197	228,203.42	1,701,852.58	725.8
P198	228,211.28	1,701,887.08	730.5
P199	228,224.07	1,701,882.50	729.5
P200	228,215.70	1,701,845.85	725.8
P201	228,377.13	1,701,787.05	722.0
P202	228,438.70	1,701,731.70	728.5
P203	227,708.52	1,702,028.24	---

CULVERT SCHEDULE[5]

NO.	DIA. (IN.)	LENGTH (FT.)
C8	30	70
C9	24	40
C10	18	90

DROP INLET SCHEDULE[4]

NO.	DEPTH D (FT.)	DIA. (IN.)
D10	4	30
D11	4	24
D12	4	18

V-DITCH SCHEDULE

TYPE	WIDTH (W)	DEPTH (H)
V-1	2	1
V-2	5	1
V-3	5	1.5
V-4	5	2
V-5	5	2.5
V-6	5	3
V-7	5	1.25

NOTES

1. SEE SHEET 1 FOR LEGEND AND GENERAL NOTES.
2. THE WEST SIDE SECONDARY LINER CONTROL LINE IS THE EDGE OF LINER AT THE BEGINNING OF THE ANCHOR TRENCH.
3. THE NORTH, SOUTH AND EAST SECONDARY LINER CONTROL LINE IS THE TOP OF THE SLOPE.
4. ALL DROP INLETS SHALL BE OF 12 GAGE THICKNESS.
5. ALL CULVERTS AND OUTLETS SHALL BE OF 16 GAGE THICKNESS.
6. THE DRAINAGE FROM CONTROL POIINT P55 TO CONTROL POINT P133 IS NOT A PART OF PHASE II CONSTRUCTION.

0 100 200 FEET
SCALE

REV	DATE	DESCRIPTION	DRAWN BY	CHK'D BY
4	10/02/93	REVISED CALL OUTS FOR SUMPS AND RISERS	GGI	
3	1/29/93	ACCESS ROAD WIDTH REDUCED TO 44' ELIMINATED PHASE IIA-B DIVIDING BERM ADDED TYPICAL SECTIONS A-10/16A, B-10/16A MODIFIED GRADING IN SUMP AREA MODIFIED SURVEY CONTROL TO REFLECT ABOVE CHANGES	GGI	
2	7/26/91	ISSUED FOR PHASE II CONSTRUCTION	KJK	
0	7/31/90	ISSUED FOR PERMITTING	KJK	

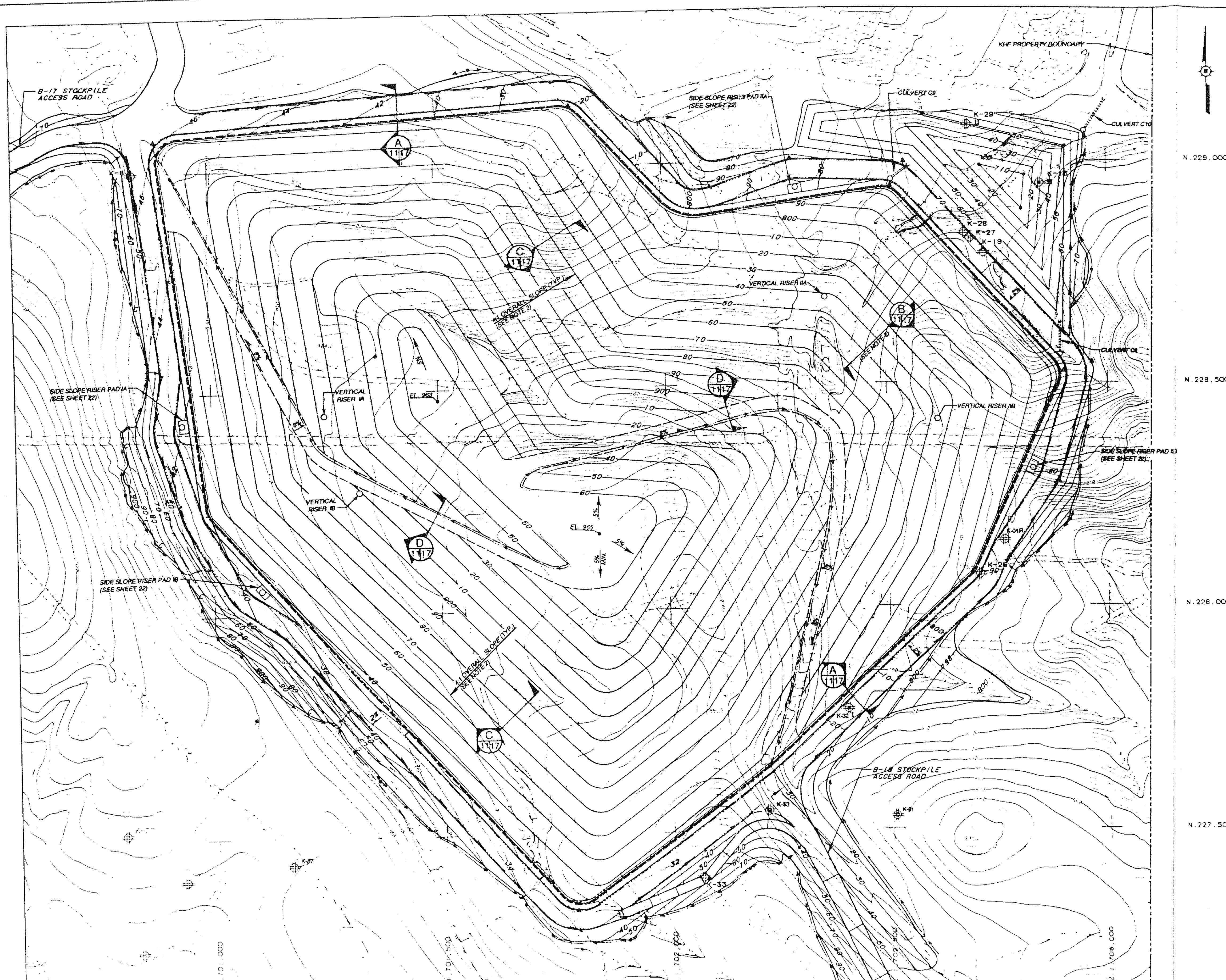
DRAWN BY | CHECKED BY | APPROVED BY

LANDFILL UNIT B-18
CONSTRUCTION PLANS
CWMI-KETTLEMAN HILLS FACILITY
KINGS COUNTY CALIFORNIA

TITLE
PHASE II
TOP OF PRIMARY LINER

ENVIRONMENTAL SOLUTIONS, INC.

JOB NO.	ESI FILE NUMBER	REVISION
89-877	D-89977-FD010	4
SCALE	CWMI FILE NUMBER	SHEET
1"=100'	89-03-304.2.1	10



REGISTERED PROFESSIONAL ENGINEER
KERRY K. PARKINSON
No. 41021
Exp. 3-31-95
CIVIL
STATE OF CALIFORNIA

NOTES

1. SEE SHEET 1 FOR LEGEND AND GENERAL NOTES.
2. BENCHES WILL BE PROVIDED AT APPROXIMATELY 50-FOOT INTERVALS AS SHOWN ON SECTION B, SHEET 17. SLOPES BETWEEN BENCHES WILL HAVE A SLOPE OF APPROXIMATELY 3.6:1. THE BENCHES WILL SLOPE AT 3% TO CONTROL DRAINAGE.

0 100 200 FEET
SCALE

REV	DATE	DESCRIPTION	DRAWN BY	CHK'D BY
2	7/26/91	ISSUED FOR PHASE II CONSTRUCTION	KJK	KKP
0	7/31/90	ISSUED FOR PERMITTING	MD	KKP

DRAWN BY M. D. CHECKED BY K. Parkinson APPROVED BY KDE

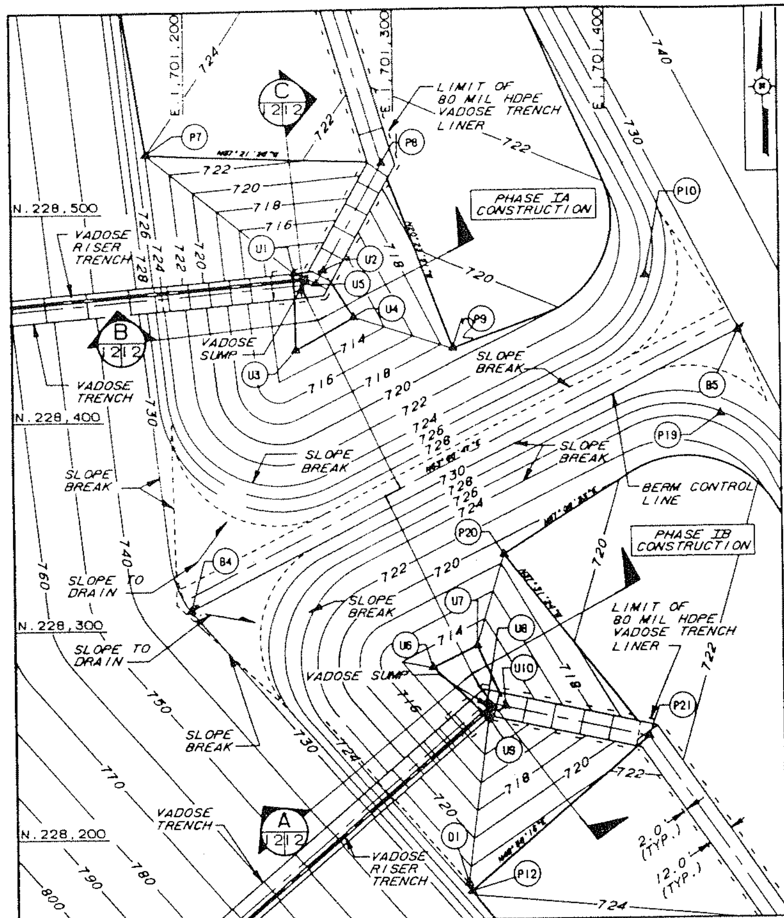
LANDFILL UNIT B-18
CONSTRUCTION PLANS
CWMI-KETTLEMAN HILLS FACILITY

KINGS COUNTY CALIFORNIA

PHASE I AND II
FINAL CLOSURE PLAN

ENVIRONMENTAL SOLUTIONS, INC.

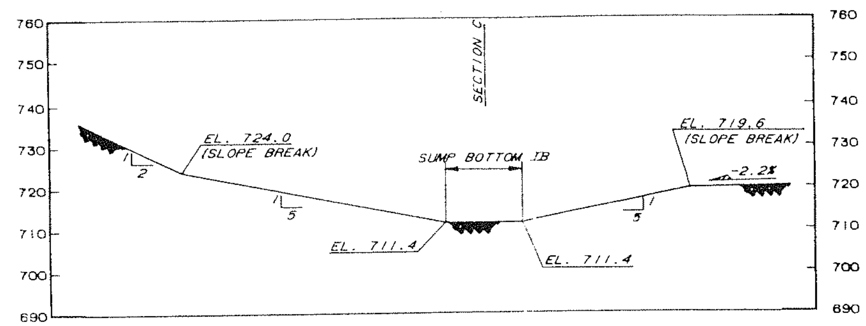
JOB NO.	ESI FILE NUMBER	REVISION
89-977	D-89977-FD011	2
SCALE 1"=100'	CWMI FILE NUMBER 89-03-304.2.1	SHEET 11



DETAIL PLAN (1/3 12)

PHASE I SUMPS

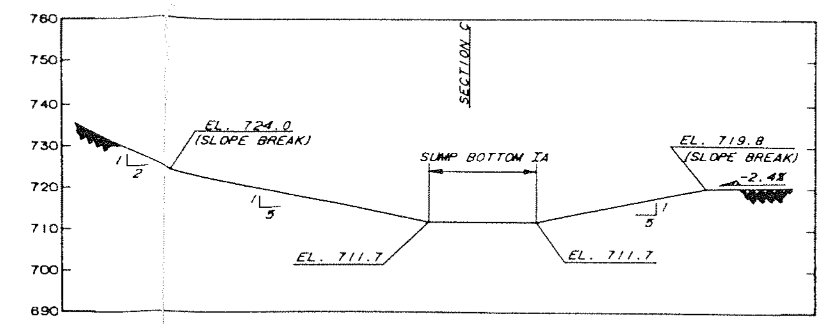
0 40 80 FEET SCALE



SECTION (A/12 12)

TRANSVERSE SECTION SUMP IB

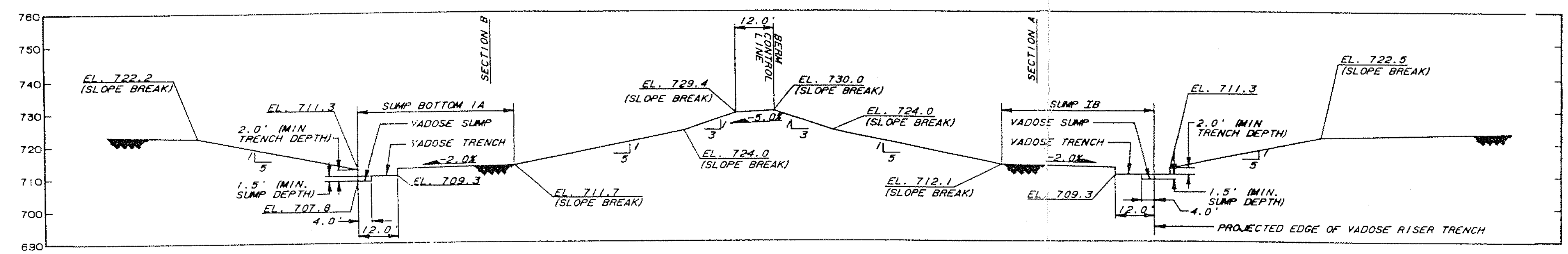
0 20 40 FEET SCALE



SECTION (B/12 12)

TRANSVERSE SECTION SUMP IA

0 20 40 FEET SCALE

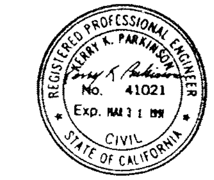


SECTION (C/12 12)

LONGITUDINAL SECTION SUMPS IA AND IB

0 20 40 FEET SCALE

SURVEY CONTROL			
STATION	COORDINATE N	COORDINATE E	ELEVATION
P7	228,528.63	1,701,181.87	724.0
P8	228,523.45	1,701,294.07	721.0
U1	228,471.09	1,701,252.04	711.3
U2	228,472.29	1,701,265.72	709.8
U3	228,433.91	1,701,252.12	712.0
U4	228,449.49	1,701,279.94	711.8
U5	228,465.95	1,701,262.13	709.3
P9	228,433.98	1,701,327.34	718.8
B4	228,309.28	1,701,200.98	730.0
P20	228,334.73	1,701,350.02	718.6
U6	228,280.84	1,701,316.10	712.1
U7	228,291.11	1,701,337.20	712.0
U8	228,263.86	1,701,341.50	709.3
U9	228,256.60	1,701,342.26	711.3
U10	228,261.96	1,701,350.04	709.8
P21	228,246.92	1,701,417.46	721.4
P12	228,173.47	1,701,333.28	724.0
P10	228,468.26	1,701,418.16	725.3
P19	228,401.18	1,701,452.95	726.0
B5	228,441.75	1,701,462.05	730.0
D1	228,177.31	1,701,331.96	723.2



NOTES:

1) ELEVATIONS SHOWN ARE PHASE I EXCAVATION.

REV	DATE	DESCRIPTION	DRAWN BY	CHK'D BY
2	01/08/91	ISSUED FOR CONSTRUCTION	RYH	KKP
1	08/24/90	ISSUED FOR BID	RYH	KKP
0	07/31/90	ISSUED FOR PERMITTING	MD	KKP

DRAWN BY R.V.HYNING CHECKED BY K. Parkinson APPROVED BY RDE

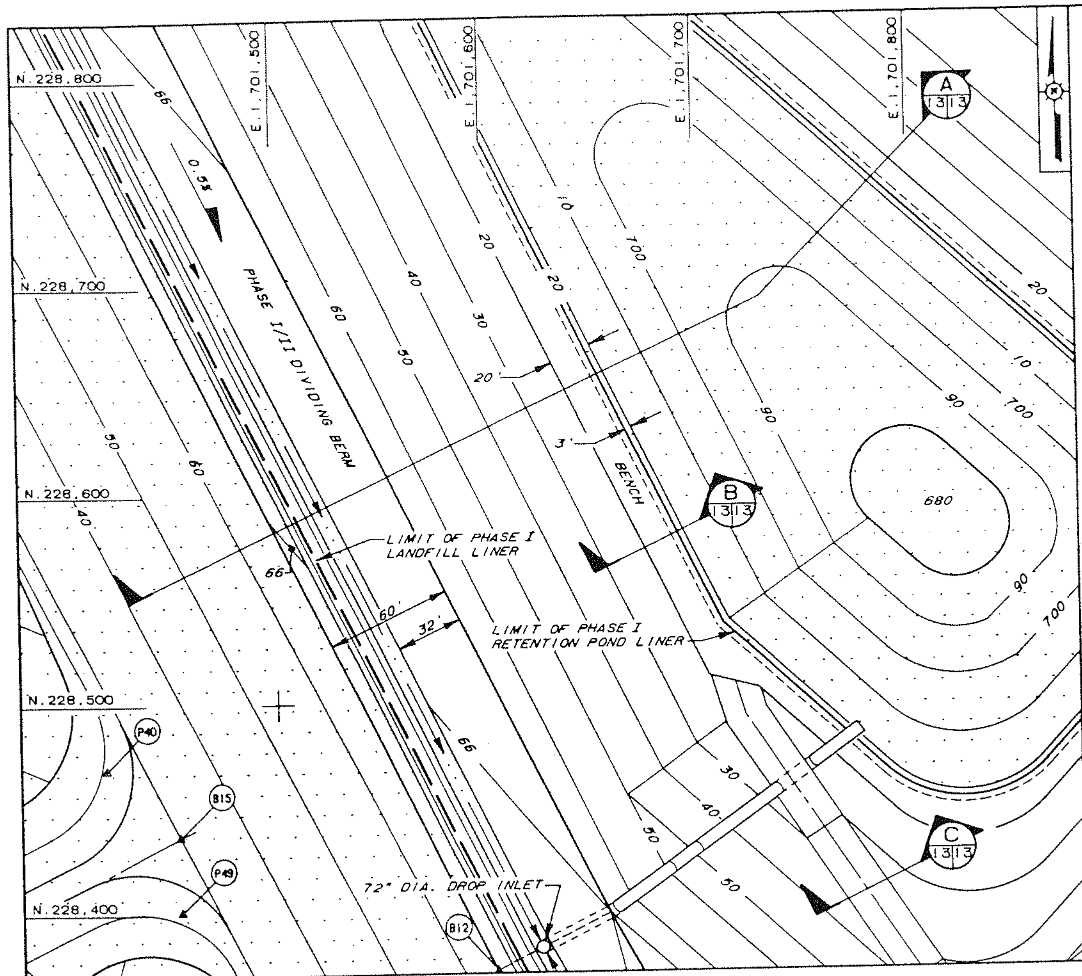
LANDFILL UNIT B-18
CONSTRUCTION PLANS
CWMI-KETTLEMAN HILLS FACILITY
KINGS COUNTY CALIFORNIA

TITLE

GRADING DETAILS

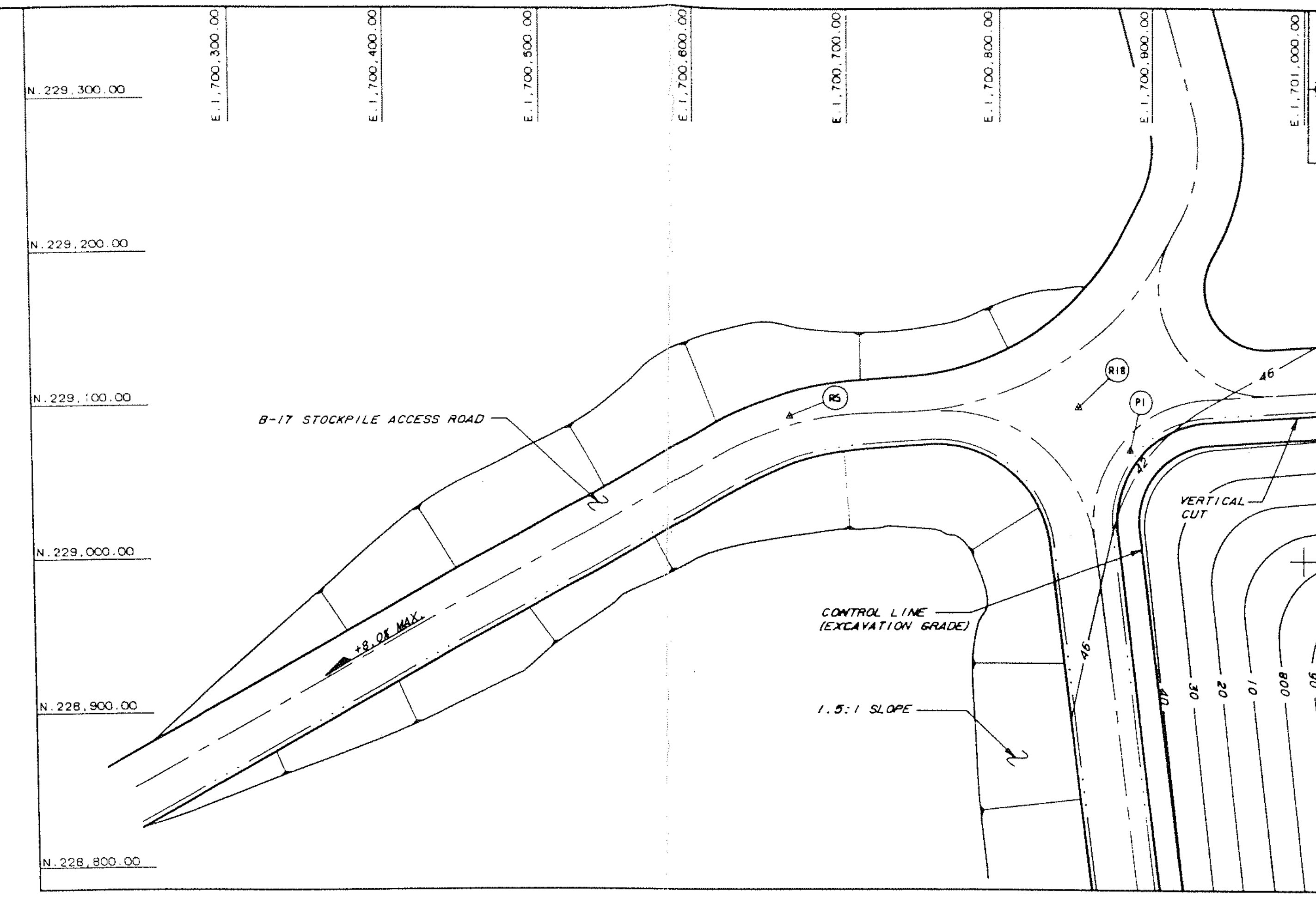
ENVIRONMENTAL SOLUTIONS, INC.

JOB NO.	EST FILE NUMBER	REVISION
89-977	D-89977-FD012	2
SCALE	CWMI FILE NUMBER	SHEET
AS NOTED	89-03-304.2.1	12



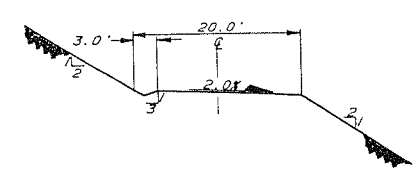
DETAIL PLAN (1/413)
PHASE I RETENTION BASIN

0 40 80 FEET SCALE



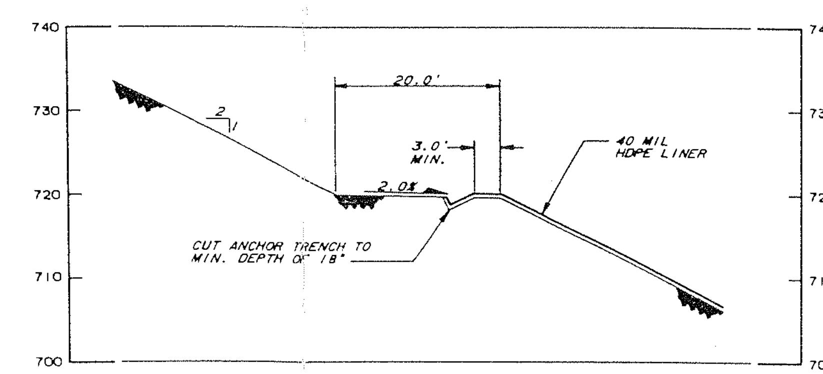
DETAIL PLAN (1/313)
N.W. ROAD INTERSECTION

0 50 100 FEET SCALE



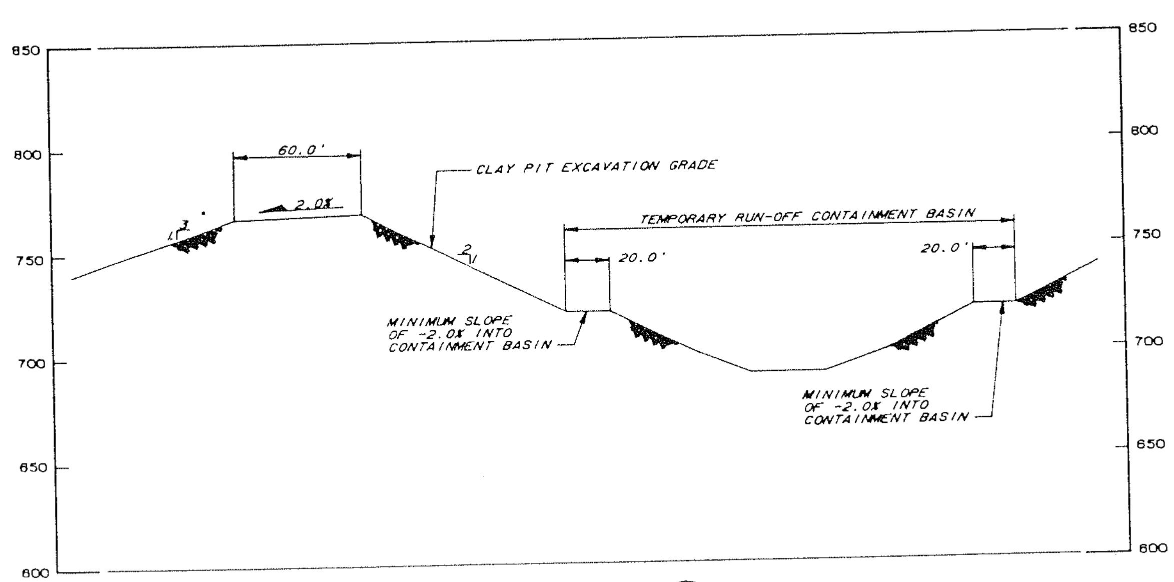
SECTION (C/313)
RETENTION BASIN ACCESS ROAD

0 10 20 FEET SCALE



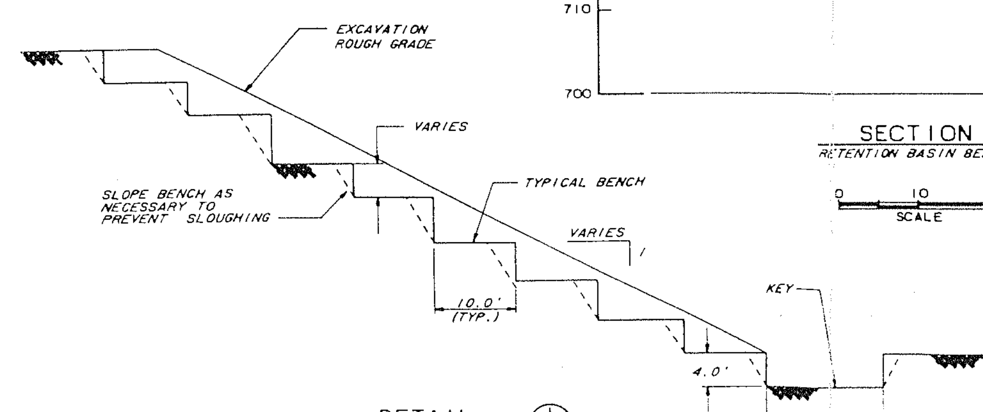
SECTION (B/313)
RETENTION BASIN BENCH

0 10 20 FEET SCALE



SECTION (A/313)
PHASE I BERM FILL RETENTION BASIN EXCAVATION GRADE

0 40 80 FEET SCALE



DETAIL (1/313)
TYPICAL STRUCTURAL FILL FOUNDATION BENCHING

0 10 20 FEET SCALE

REGISTERED PROFESSIONAL ENGINEER
TERRY K. PARKINSON
No. 41021
Exp. MAR 31 1991
CIVIL
STATE OF CALIFORNIA

NOTE
1. SEE SHEET 1 FOR LEGEND AND GENERAL NOTES

2	1/2/91	ISSUED FOR CONSTRUCTION	RVH	KKP
0	1/31/90	ISSUED FOR PERMITTING	MD	KKP

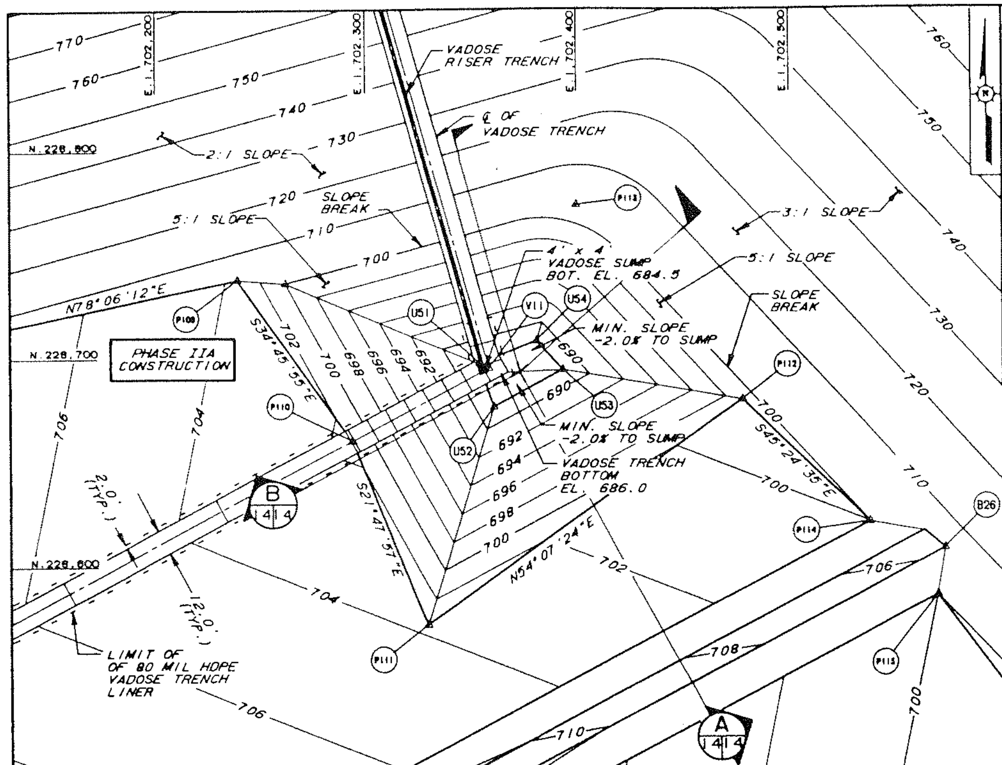
DRAWN BY RVH CHECKED BY K. Parkinson APPROVED BY RDE

LANDFILL UNIT B-18
CONSTRUCTION PLANS
CWMI-KETTLEMAN HILLS FACILITY
KINGS COUNTY CALIFORNIA

GRADING DETAILS

ENVIRONMENTAL SOLUTIONS, INC.

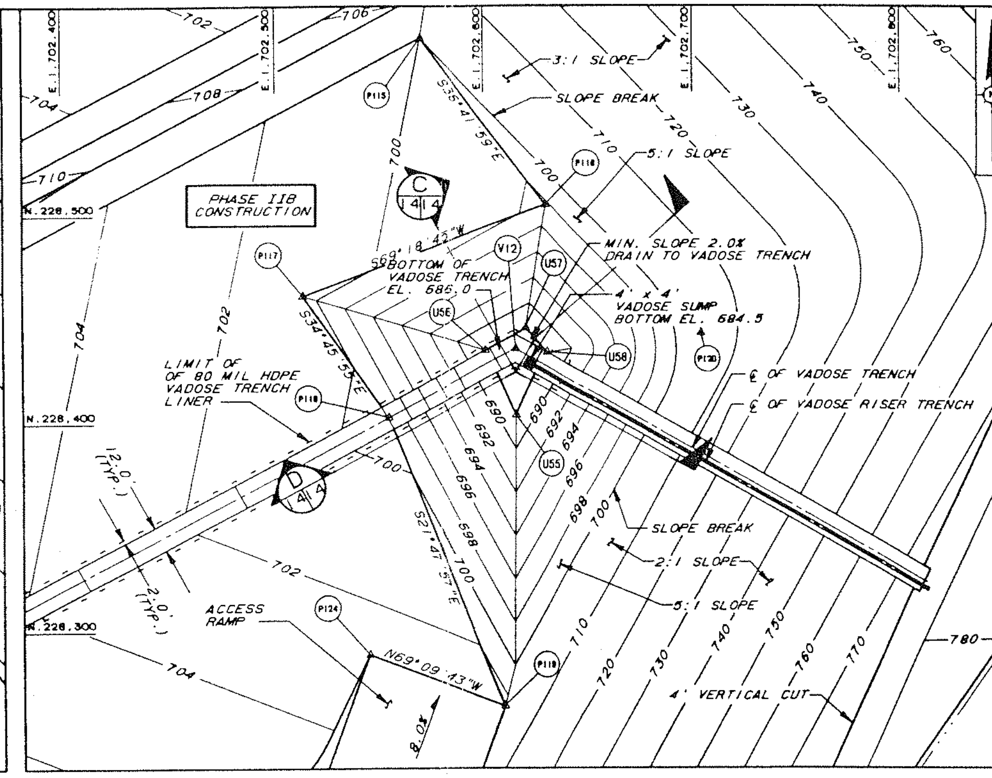
89-977	D-89977-FD013	2
AS NOTED	89-03-304.2.1	13



DETAIL PLAN (1/8|14)

PHASE IIA SUMP EXCAVATION GRADE

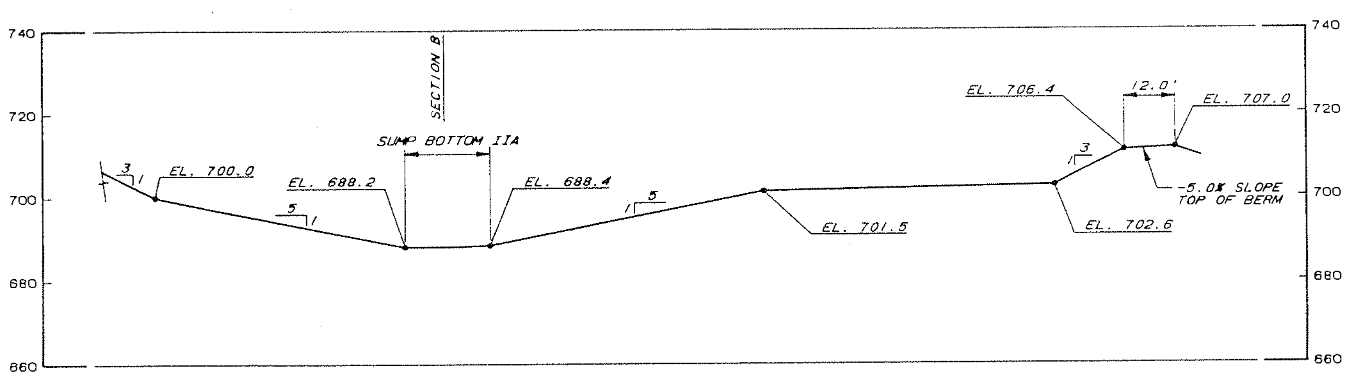
0 40 80 FEET
SCALE



DETAIL PLAN (2/8|14)

PHASE IIB SUMP EXCAVATION GRADE

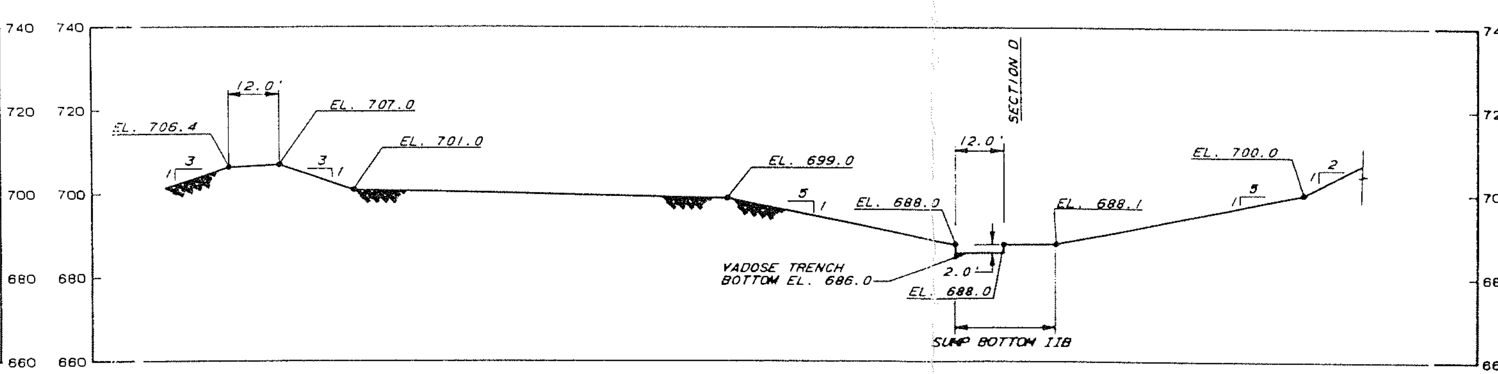
0 40 80 FEET
SCALE



SECTION (A/14|14)

SUMP IIA

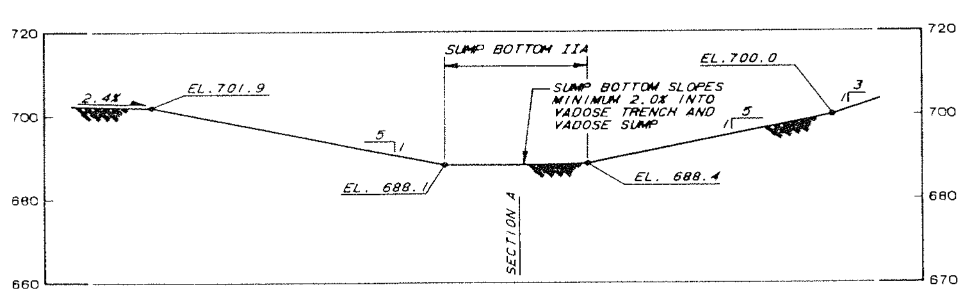
0 20 40 FEET
SCALE



SECTION (C/14)

SUMP IIB

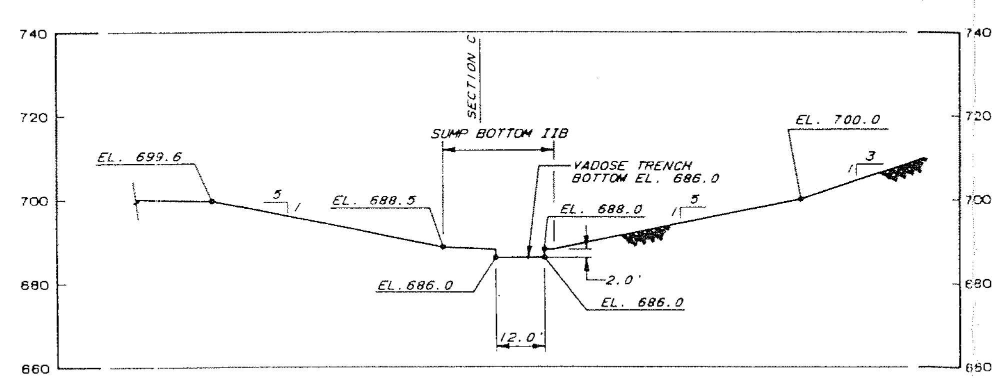
0 20 40 FEET
SCALE



SECTION (B/14|14)

SUMP IIA

0 20 40 FEET
SCALE



SECTION (D/14|14)

SUMP IIB

0 20 40 FEET
SCALE

SURVEY CONTROL			
STATION	COORDINATE		ELEVATION
	N	E	
U51	228,694.65	1,702,353.30	688.0
U52	228,676.57	1,702,360.08	688.4
U53	228,694.30	1,702,393.04	688.4
U54	228,708.34	1,702,380.42	688.4
U55	228,403.94	1,702,614.92	688.5
U56	228,434.94	1,702,600.51	688.0
U57	228,445.83	1,702,619.52	688.1
U58	228,434.21	1,702,629.71	688.0
V11	228,695.14	1,702,357.83	686.0
V12	228,435.78	1,702,614.73	686.0
P109	228,738.06	1,702,239.47	703.8
P110	228,660.45	1,702,293.34	700.0
P111	228,572.06	1,702,328.89	703.9
P112	228,679.61	1,702,477.39	699.0
P113	228,773.60	1,702,399.67	700.0
P114	228,620.82	1,702,537.03	700.0
P115	228,585.63	1,702,569.13	700.0
P116	228,505.19	1,702,629.10	697.7
P117	228,461.28	1,702,512.83	701.0
P118	228,402.79	1,702,553.42	698.5
P119	228,264.20	1,702,608.85	702.8
P120	228,443.26	1,702,703.72	700.0
P124	228,289.03	1,702,543.82	702.8
B26	228,808.01	1,702,572.75	708.0

NOTES:

1. ELEVATIONS CALLED OUT IN SECTION MAY ONLY APPLY ALONG THAT SECTION LINE; CHECK AGAINST PLAN.
2. THE LIMIT OF SUMPS IIA AND IIB ARE DEFINED BY THE 5:1 SLOPE BREAK. EVERYTHING DOWNSLOPE OF THE SLOPE BREAK IS TO BE CONSIDERED SUMP IIA OR IIB AS APPROPRIATE

REGISTERED PROFESSIONAL ENGINEER TERRY K. PARKINSON No. 41021 Exp. 3-31-95 CIVIL STATE OF CALIFORNIA

REV	DATE	DESCRIPTION	DRAWN BY	CHK'D BY
2	7/26/91	ISSUED FOR PHASE II CONSTRUCTION	RVH	[illegible]
0	7/31/90	ISSUED FOR PERMITTING	KJK	TKP

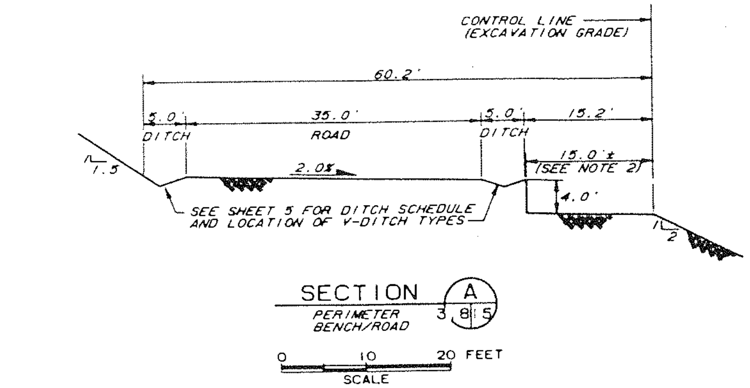
DRAWN BY K.J.Kavli CHECKED BY T. Parkinson APPROVED BY RQE

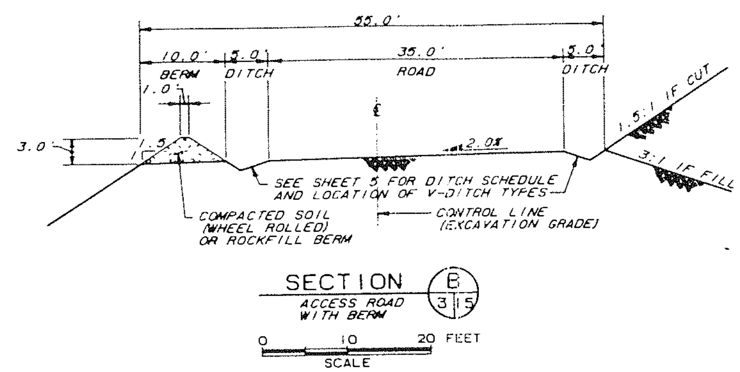
LANDFILL UNIT B-18
CONSTRUCTION PLANS
CWMI-KETTLEMAN HILLS FACILITY
KINGS COUNTY CALIFORNIA

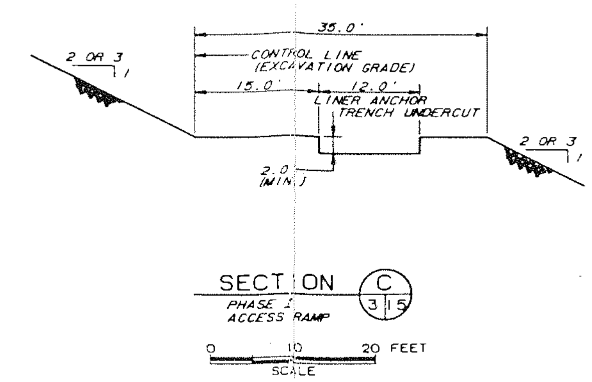
TITLE: GRADING DETAILS

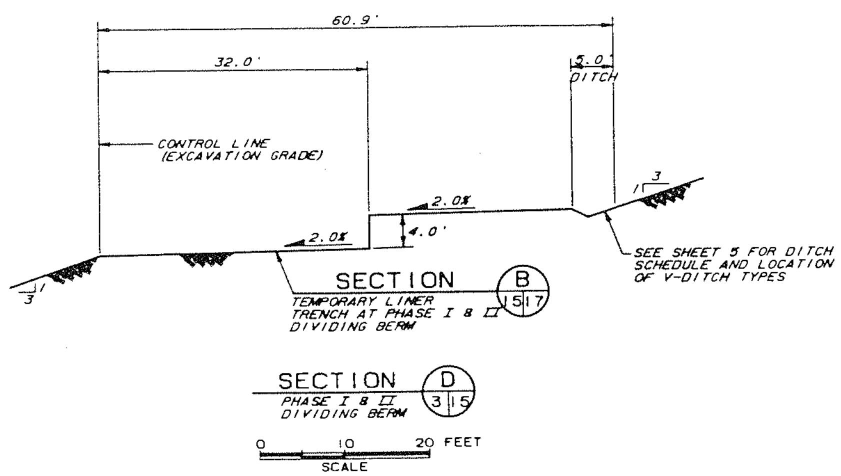
ENVIRONMENTAL SOLUTIONS, INC.

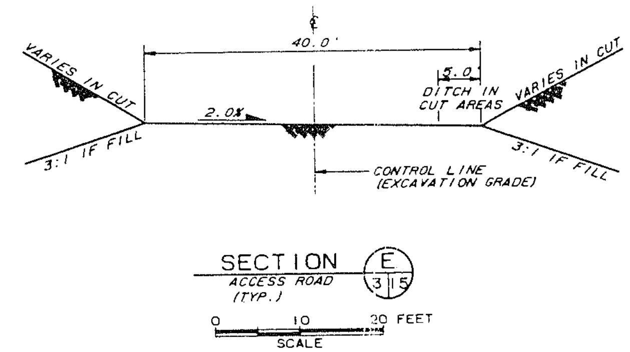
JOB NO.	ESI FILE NUMBER	REVISION
89-977	D-89977-014	2
SCALE	CWMI FILE NUMBER	SHEET
AS SHOWN	89-03-304.2.1	14

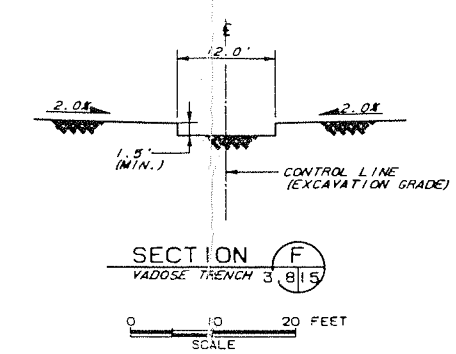


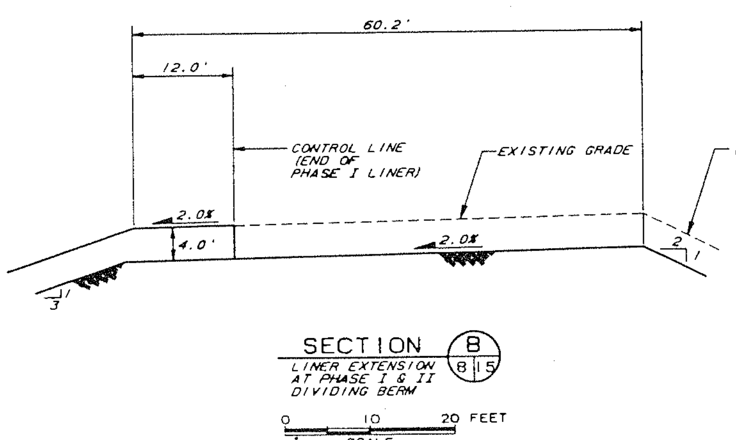


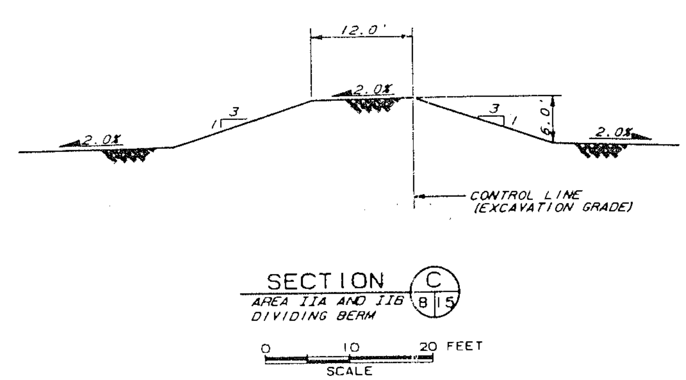


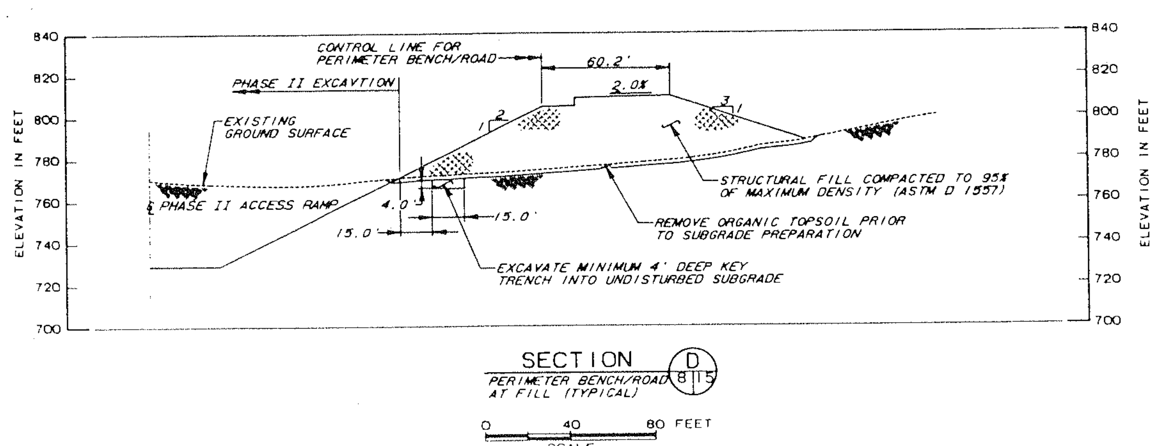


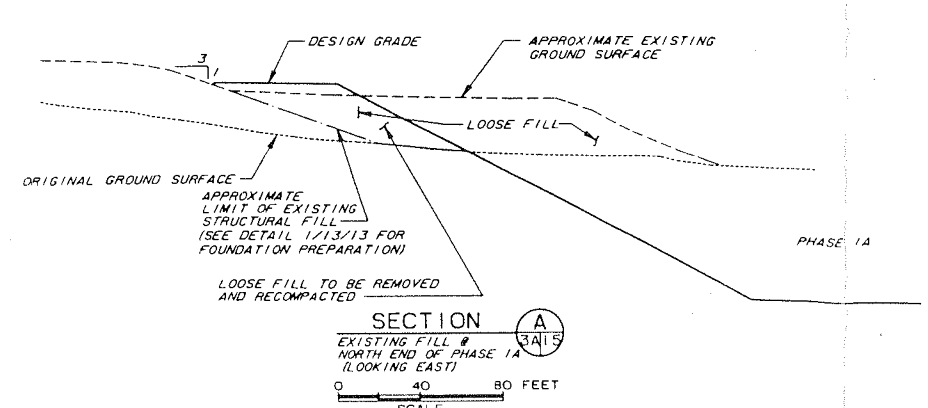












REGISTERED PROFESSIONAL ENGINEER — TERRY K. PARKINSON — No. 41021 — Exp. 3-31-95 — CIVIL — STATE OF CALIFORNIA

NOTES

1. SEE SHEET 1 FOR LEGEND AND GENERAL NOTES.
2. SEE DETAIL 3,16,16 FOR COMPLETED ANCHOR TRENCH DETAILS. WIDTH OF TOP LINER TRENCH EXCAVATION MAY BE VARIED TO SUIT EXCAVATION AND BACKFILLING EQUIPMENT.
3. REMOVE THE MATERIAL TO 3.5 FEET BELOW ORIGINAL DESIGN GRADE TO ALLOW FOR PLACEMENT OF PHASE II LINER.

0 10 20 FEET
SCALE

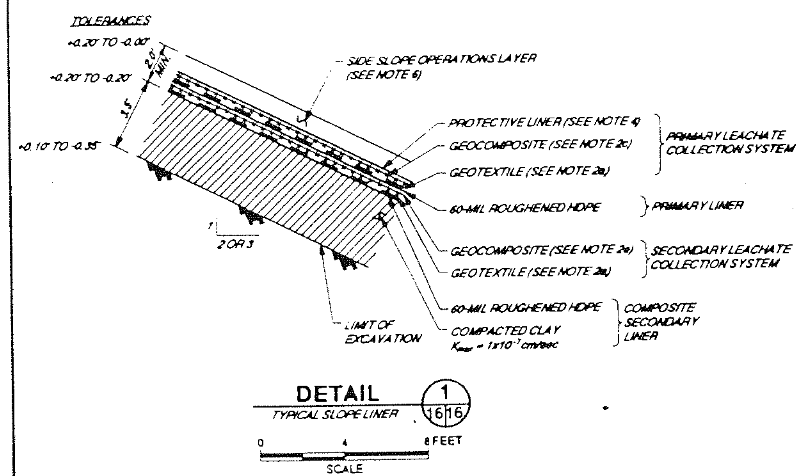
3	7/26/91	ISSUED FOR PHASE II CONSTRUCTION	KJK	TKP
2	5/24/91	ISSUED FOR CONSTRUCTION	KJK	TKP
1	9/24/90	ISSUED FOR BID	KJK	TKP
0	7/31/90	ISSUED FOR PERMITTING	KAB	TKP

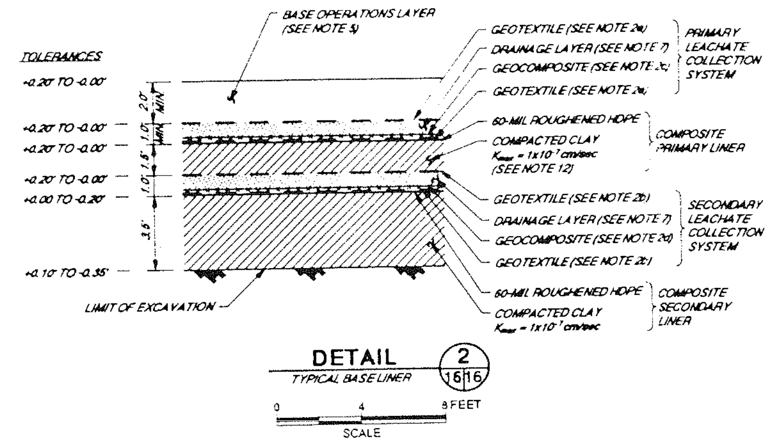
LANDFILL UNIT B-18
CONSTRUCTION PLANS
CWMI-KETTLEMAN HILLS FACILITY
KINGS COUNTY CALIFORNIA

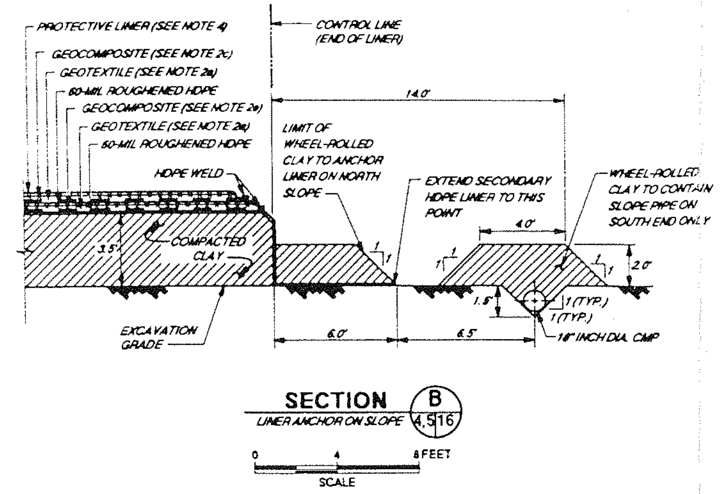
CROSS SECTIONS

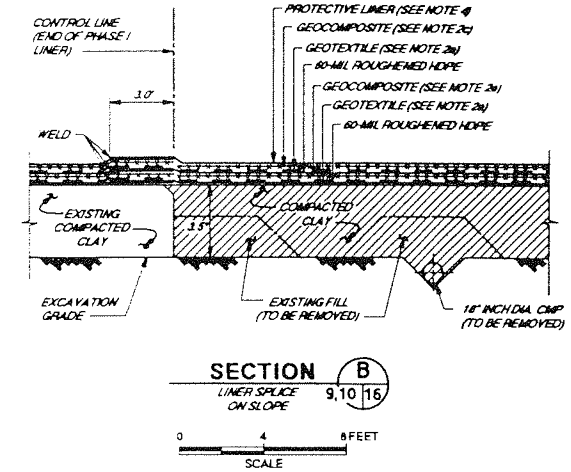
ENVIRONMENTAL SOLUTIONS, INC.

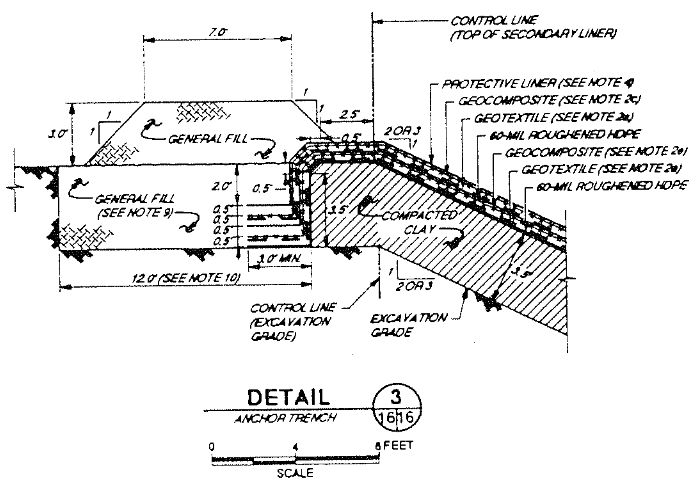
89-877	D-89977-FD015	3
1"=10'	89-03-304.2.1	15

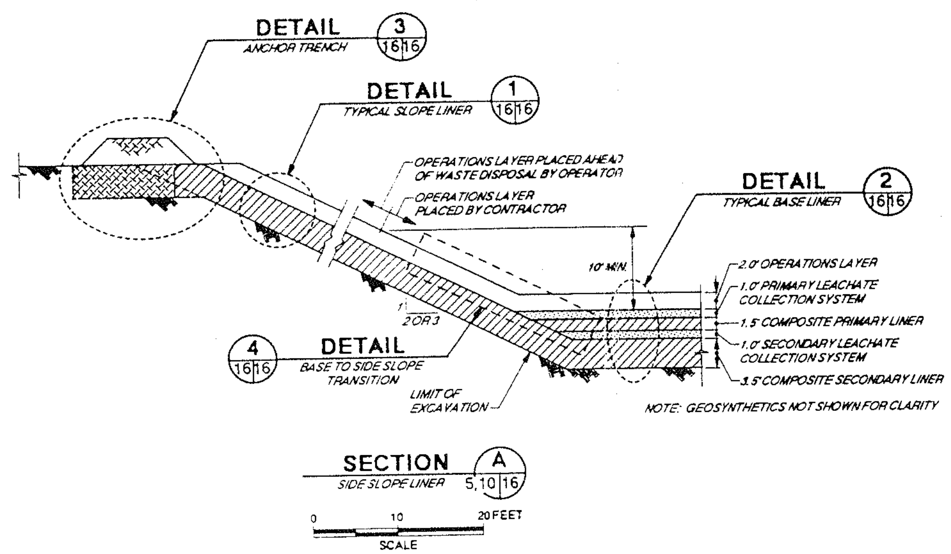


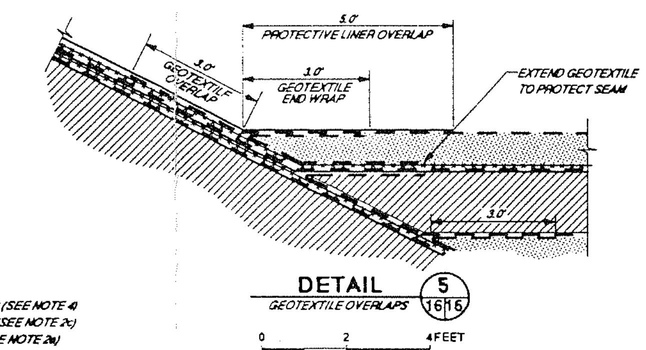


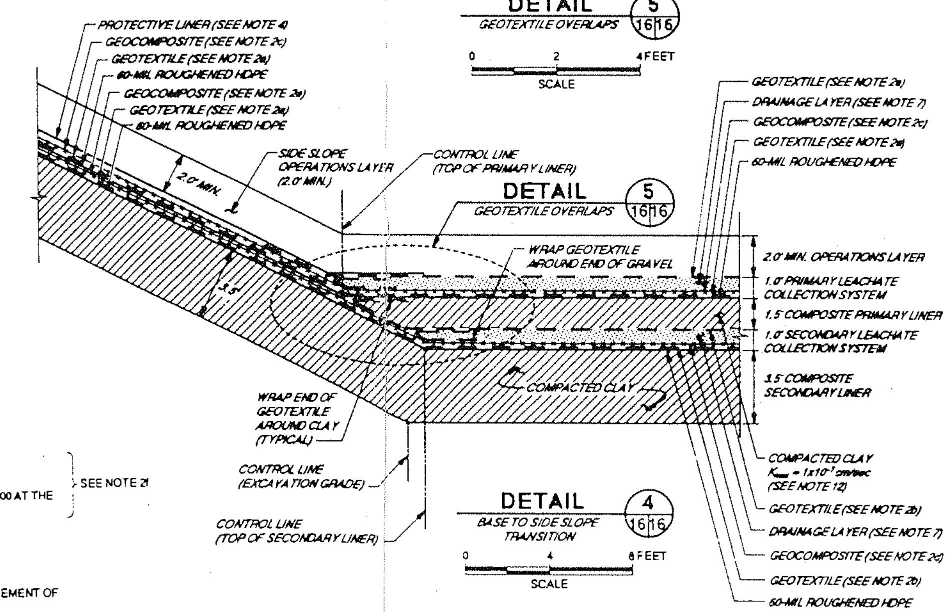


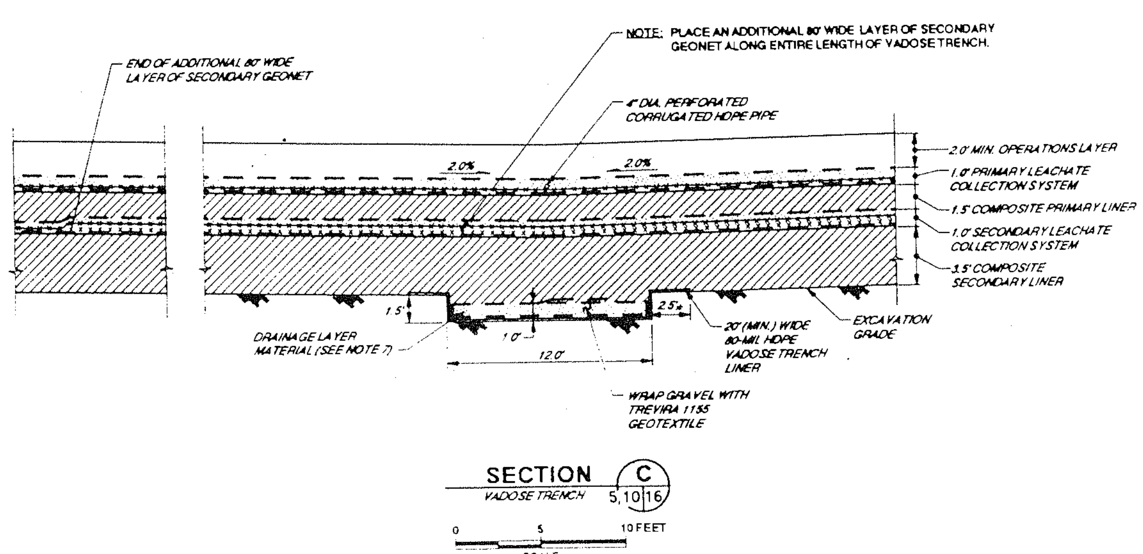












NOTES

1. SEE SHEET 1 FOR LEGEND AND GENERAL NOTES.

2a. GEOTEXTILE SHALL BE TREVIRA 1125 OR EQUAL.
2b. GEOTEXTILE SHALL BE TREVIRA 1155 OR EQUAL.
2c. GEOCOMPOSITE SHALL BE TREVIRA 1125 HEAT BONDED TO POLYNET 3000. } SEE NOTE 2f
2d. GEOCOMPOSITE SHALL BE TREVIRA 1155 HEAT BONDED TO POLYNET 3000.
2e. GEOCOMPOSITE SHALL BE TREVIRA 1125 OR 1155 HEAT BONDED TO POLYNET 3000 AT THE OPTION OF THE OWNER.
2f. GEOTEXTILE SHALL ALWAYS BE FACING UP.

3. GEONET SHALL BE POLYNET 3000 OR EQUAL.

4. PROTECTIVE LINER SHALL BE REMOVED BY OPERATIONS STAFF PRIOR TO PLACEMENT OF OPERATIONS LAYER.

5. BASE OPERATIONS LAYER SHALL CONSIST OF SOILS EXCAVATED FROM ONSITE SOURCES. SOIL PARTICLE SIZE SHALL HAVE MAXIMUM DIAMETER OF 6 INCHES.

6. SIDE SLOPE OPERATIONS LAYER SHALL CONSIST OF SOILS EXCAVATED FROM ONSITE SOURCES. SOIL PARTICLE SIZE SHALL HAVE MAXIMUM DIAMETER OF 1 INCH.

7. DRAINAGE LAYER MATERIAL SHALL CONSIST OF A SUB-ANGULAR TO ROUNDED WASHED GRAVEL MEETING THE GRADATION REQUIREMENTS SPECIFIED IN SECTION 02924 OF THE SPECIFICATIONS.

8. LINER SYSTEM SCALES ARE EXAGGERATED FOR CLARITY.

9. ANCHOR TRENCH BACKFILL SHALL BE PLACED WITH RUBBER TIRE COMPACTION AND MOISTURE CONDITIONING.

10. WIDTH MAY VARY TO FIT CONSTRUCTION EQUIPMENT REQUIREMENTS.

11. THE PROTECTIVE LINER SHALL BE SUITABLE TO PREVENT THE OPERATIONS LAYER FROM CLOGGING THE SECONDARY LEACHATE CONTROL SYSTEM.

12. THE BOTTOM 12" OF PRIMARY CLAY LINER SHALL BE CONSTRUCTED IN ONE LIFT TO PROTECT UNDERLYING GEOSYNTHETIC LINER SYSTEM. THE UPPER 12" WILL HAVE A PERMEABILITY OF K_{max} = 10^{-7} cm/sec.

REGISTERED PROFESSIONAL ENGINEER — No. 41021 — Exp. 3-31-95 — CIVIL — STATE OF CALIFORNIA

REV	DATE	DESCRIPTION	DRAWN BY	CHK'D BY
3	7/26/91	ISSUED FOR PHASE II CONSTRUCTION AND GOETEXTILE MODIFICATION	DVD	KKP
2	1/02/91	ISSUED FOR CONSTRUCTION	DVD	KKP
0	7/31/90	ISSUED FOR PERMITTING	DVD	KKP

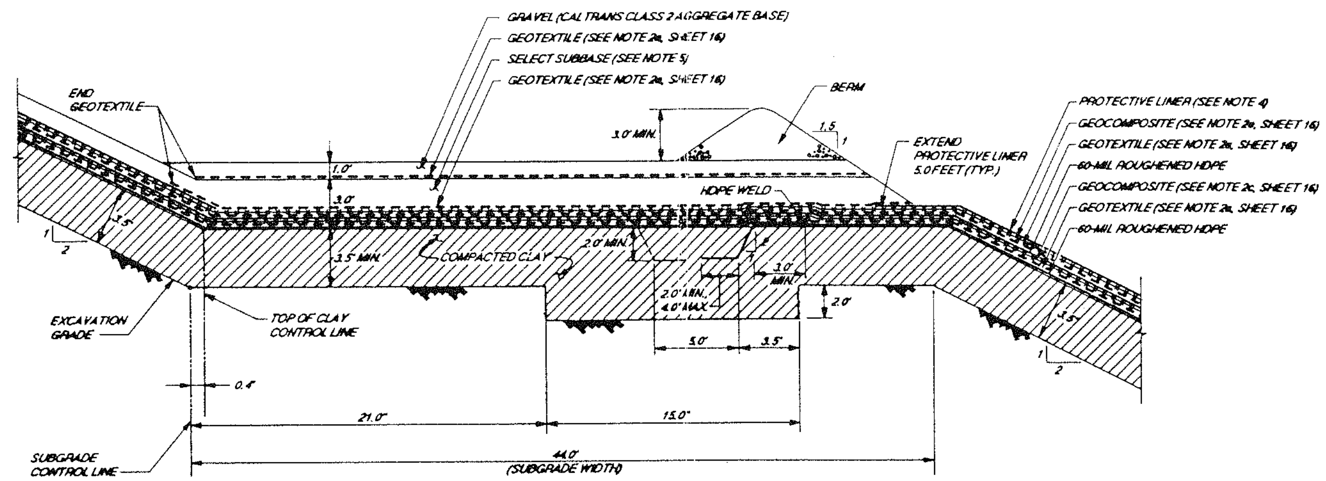
DRAWN BY: [signature] CHECKED BY: [signature] APPROVED BY: RDE

LANDFILL UNIT B-18
CONSTRUCTION PLANS
CWMI-KETTLEMAN HILLS FACILITY
KINGS COUNTY CALIFORNIA

TITLE: LINER DETAILS AND SECTIONS

ENVIRONMENTAL SOLUTIONS, INC.

JOB NO.	ESI FILE NUMBER	REVISION
89-977	D-89977-FD016	3
SCALE	CWMI FILE NUMBER	SHEET
AS NOTED	89-03-304.2.1	16

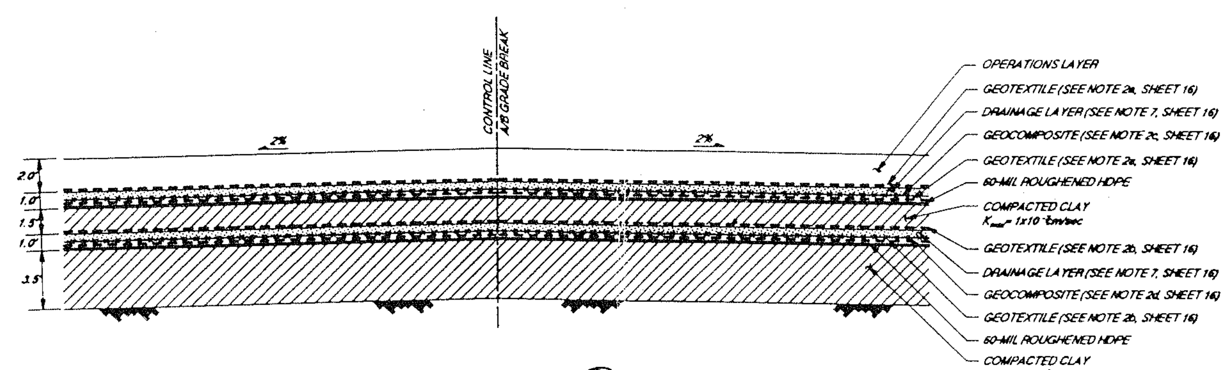


SECTION (A) 9,10/16A

PHASE II ACCESS RAMP

0 5 10 FEET

SCALE



SECTION (B) 9,10/16A

PHASE IIA/IIB DIVISION

0 5 10 FEET

SCALE

NOTES:

1. SEE SHEET 1 FOR LEGEND AND GENERAL NOTES.
2. SEE SHEET 16 FOR GEOSYNTHETIC MATERIAL NOTES.
3. REMOVE PROTECTIVE LINER AS WASTE IS ADVANCED UP THE SLOPE.
4. LINER ELEMENT THICKNESSES AND SPACING EXAGGERATED FOR CLARITY.
5. SELECT SUBBASE SHALL BE ONSITE MATERIAL WITH A MAXIMUM PARTICLE SIZE LESS THAN 1", CLASSIFIED AS SW OR SM (BY THE UNIFIED SOIL CLASSIFICATION SYSTEM), AND SHALL CONFORM TO THE FOLLOWING GRADATION:

SIEVE SIZE	PERCENT PASSING SIEVE
1"	100
NO. 4	70-100
NO. 10	40-90
NO. 40	20-60
NO. 200	0-20

THE MATERIAL SHALL BE SUBANGULAR AND SHALL ALSO CONFORM TO THE FOLLOWING REQUIREMENTS:

TEST	TEST METHOD NO.	REQUIREMENT
R-VALUE[1]	CALIF 301	60 (MIN.)
SAND EQUIVALENT	CALIF 217	20 (MIN.)

UPPER TWO FEET OF SELECT SUBBASE SHALL BE COMPACTED TO 90% OF MAXIMUM DRY DENSITY PER ASTM D1557.

[1] R-VALUE REQUIREMENT MAY BE WAIVED IF MATERIAL HAS AN SE ≥ 30.

REGISTERED PROFESSIONAL ENGINEER RICHARD D. ELLISON NO. 39296 EXP. 12-31-93 CIVIL STATE OF CALIFORNIA

REV	DATE	DESCRIPTION	DRAWN BY	CHK'D BY
1	1/29/93	ADDED NEW SECTIONS A-9,10/16A, B-9,10/16A	GGI	

DRAWN BY | CHECKED BY | APPROVED BY

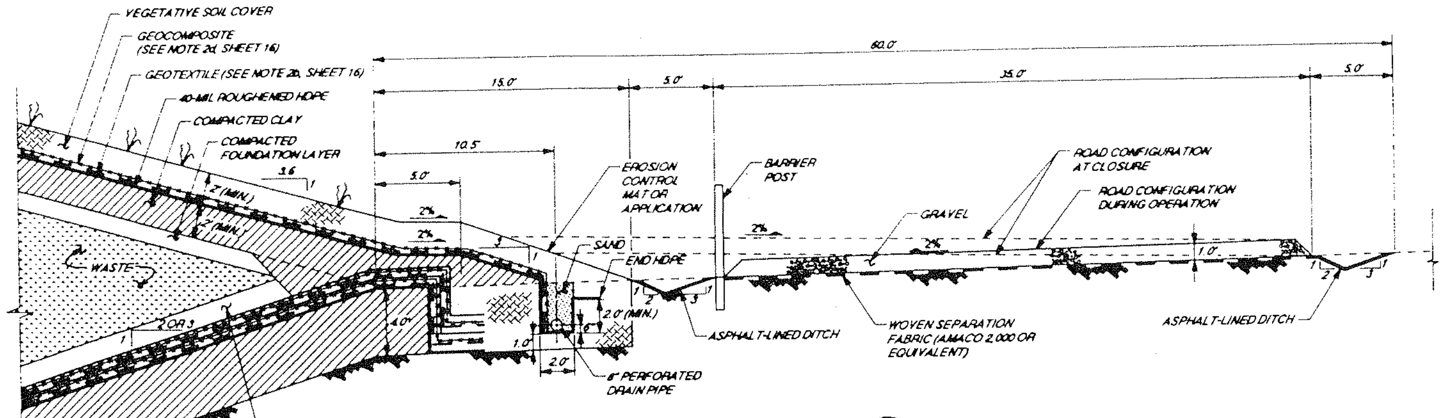
LANDFILL UNIT B-18
CONSTRUCTION PLANS
CWMI-KETTLEMAN HILLS FACILITY
KINGS COUNTY CALIFORNIA

TITLE

PHASE II
LINER DETAILS AND SECTIONS

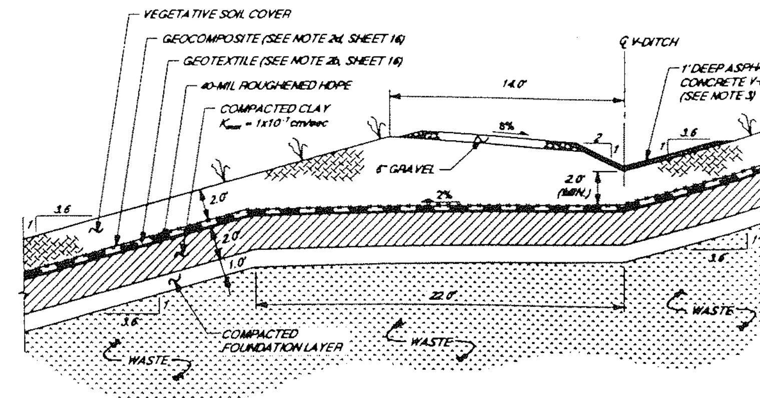
ENVIRONMENTAL SOLUTIONS, INC.

JOB NO.	ESI FILE NUMBER	REVISION
89-977	D-89977-016A	1
SCALE	CWMI FILE NUMBER	SHEET
AS SHOWN	89-03-304.2.1	16A



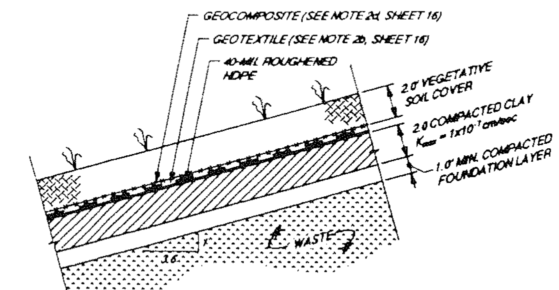
SECTION A
CLOSURE EDGE DETAIL 11|17

SCALE 0 5 10 FEET



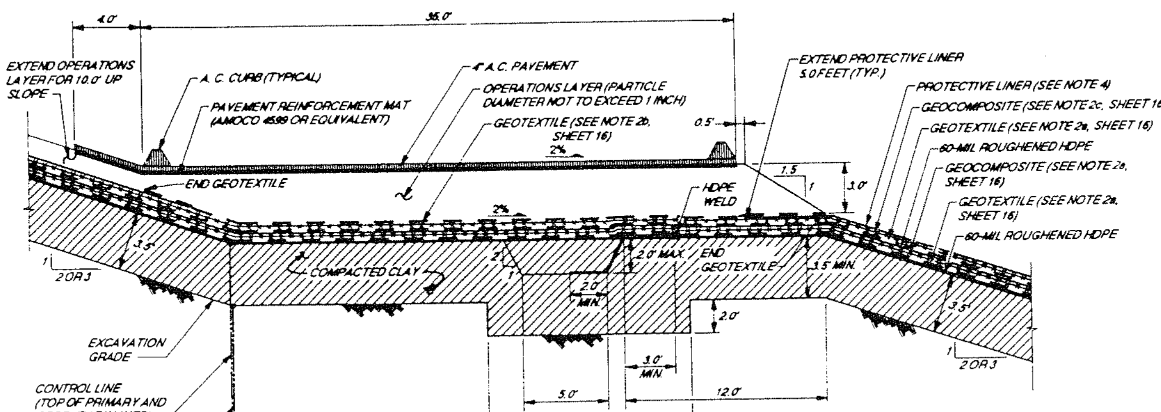
SECTION B
TYPICAL COVER (AT BENCH) 11|17

SCALE 0 5 10 FEET



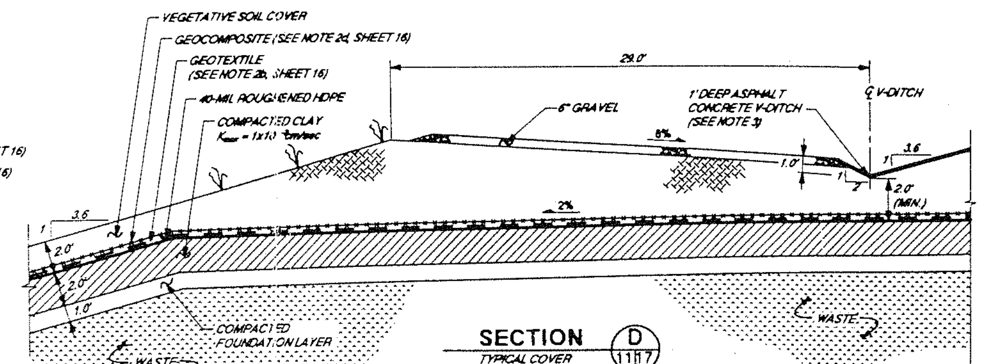
SECTION C
TYPICAL COVER (AT SLOPE) 11|17

SCALE 0 5 10 FEET



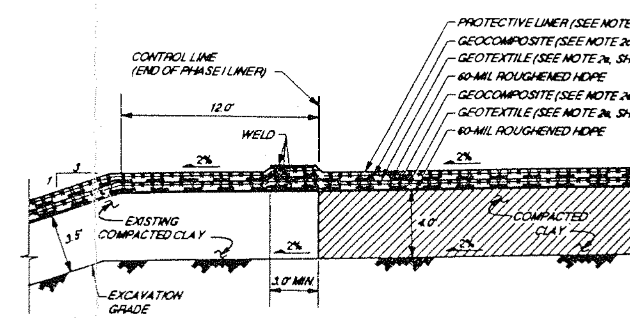
SECTION D
ACCESS RAMP 4,5|17

SCALE 0 5 10 FEET



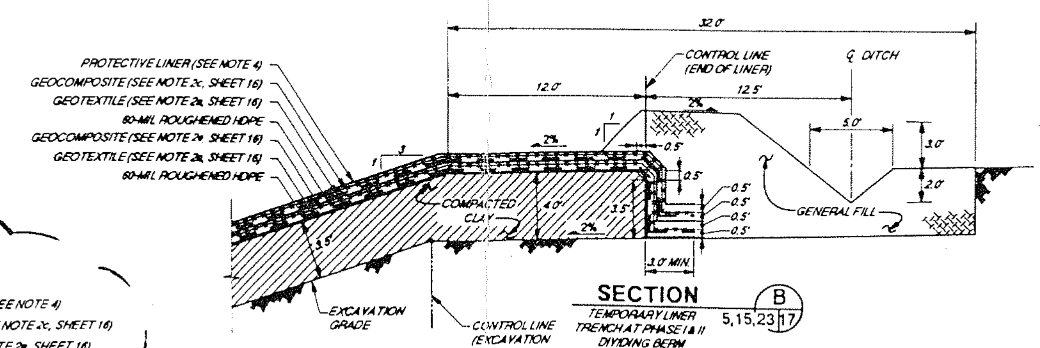
SECTION D
TYPICAL COVER (ACCESS ROAD) 11|17

SCALE 0 5 10 FEET



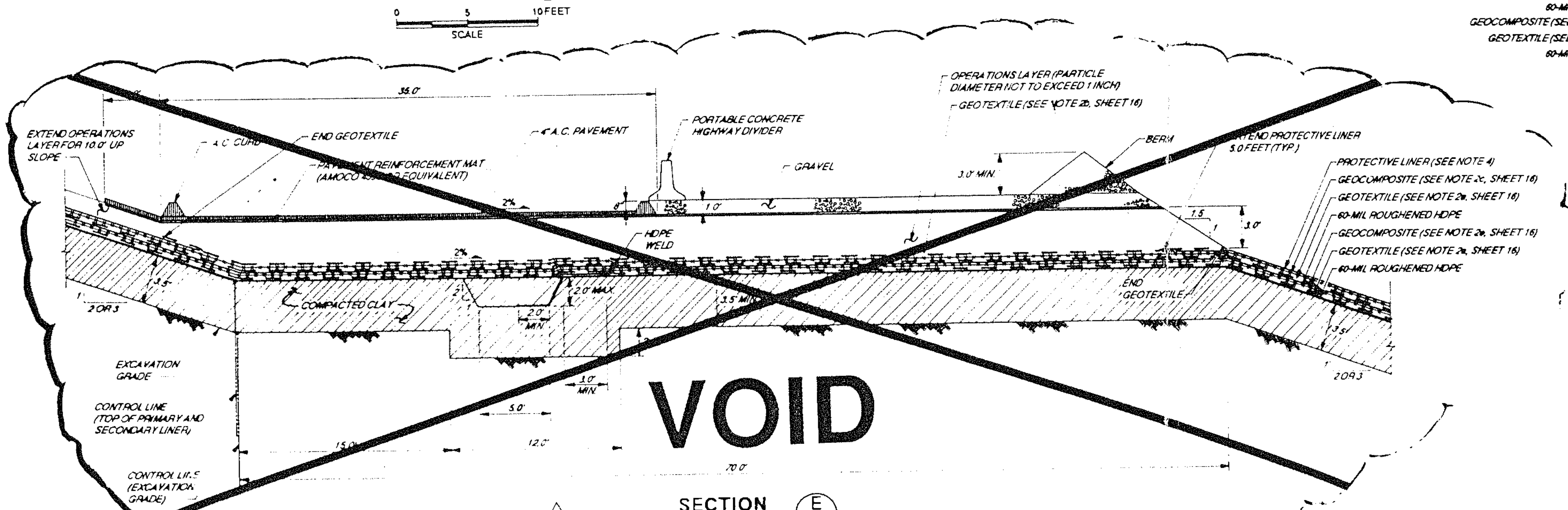
SECTION B
LINER SPLICE AT PHASE I & II DIVIDING BERM 9,10|17

SCALE 0 5 10 FEET



SECTION B
TEMPORARY LINER TRENCH AT PHASE I & II DIVIDING BERM 5,15,23|17

SCALE 0 5 10 FEET



SECTION E
PHASE II ACCESS RAMP 9,10|17

SCALE 0 5 10 FEET

NOTES

1. SEE SHEET 1 FOR LEGEND AND GENERAL NOTES.
2. SEE SHEET 16 FOR GEOSYNTHETIC MATERIAL NOTES.
3. EXTEND PAVEMENT UP SLOPE TO THE SAME ELEVATION AS THE OUTSIDE EDGE OF THE BENCH.
4. PROTECTIVE LINER IS REMOVED AS WASTE IS ADVANCED UP THE SLOPE.

REGISTERED PROFESSIONAL ENGINEER RICHARD D. ELLISON NO. 39298 EXP. 12-31-93 CIVIL STATE OF CALIFORNIA

REV	DATE	DESCRIPTION	DRAWN BY	CHECKED BY
5	1/25/93	VOID ON SECTION E-9,10/17	GGI	
4	10/22/92	REDUCED ACCESS ROAD WIDTH TO 44'; ELIMINATED PHASE II A-B DIVIDING BERM; REVISED DETENTION BASIN	KJK	
3	7/26/91	ISSUED FOR PHASE II CONSTRUCTION AND GOETEXTILE MODIFICATION	DVD	KKP
2	1/02/91	ISSUED FOR CONSTRUCTION	DVD	KKP
0	7/31/90	ISSUED FOR PERMITTING	DVD	KKP

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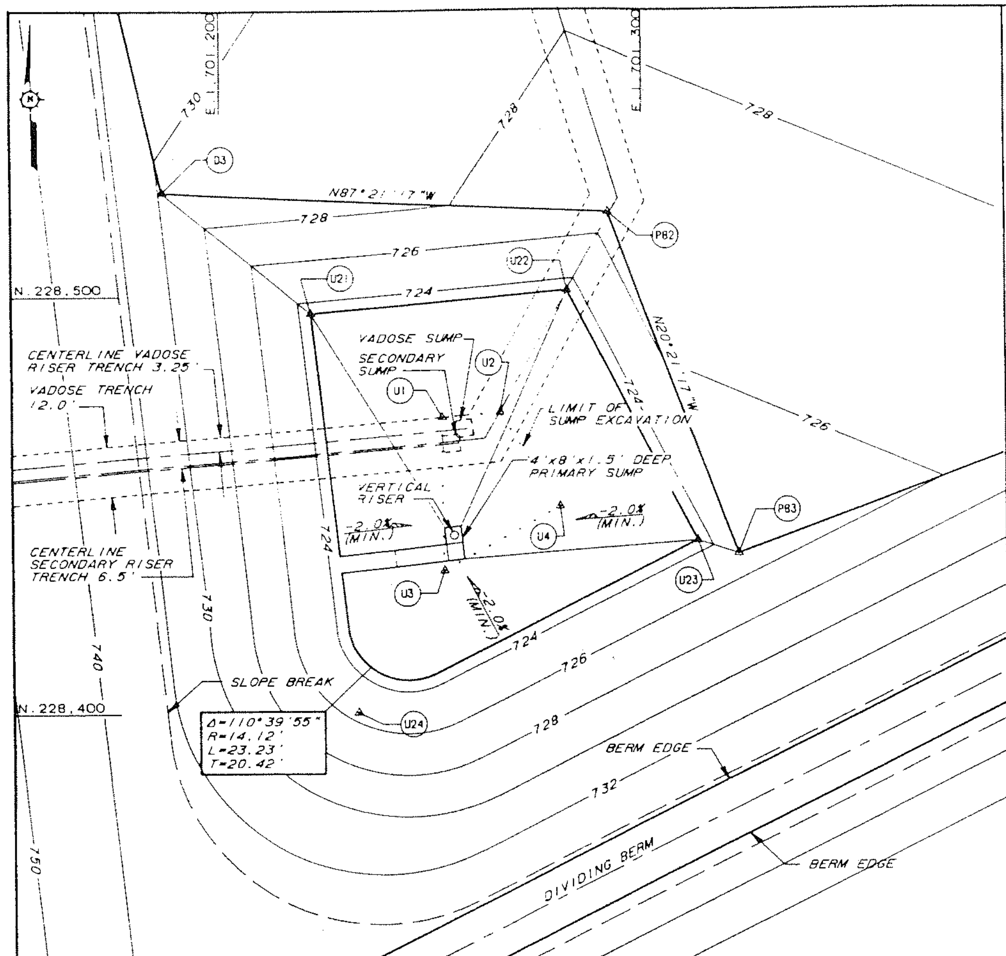
CONSTRUCTION PLANS
CWMI-KETTLEMAN HILLS FACILITY
KINGS COUNTY CALIFORNIA

LINER DETAILS AND SECTIONS

ENVIRONMENTAL SOLUTIONS, INC.

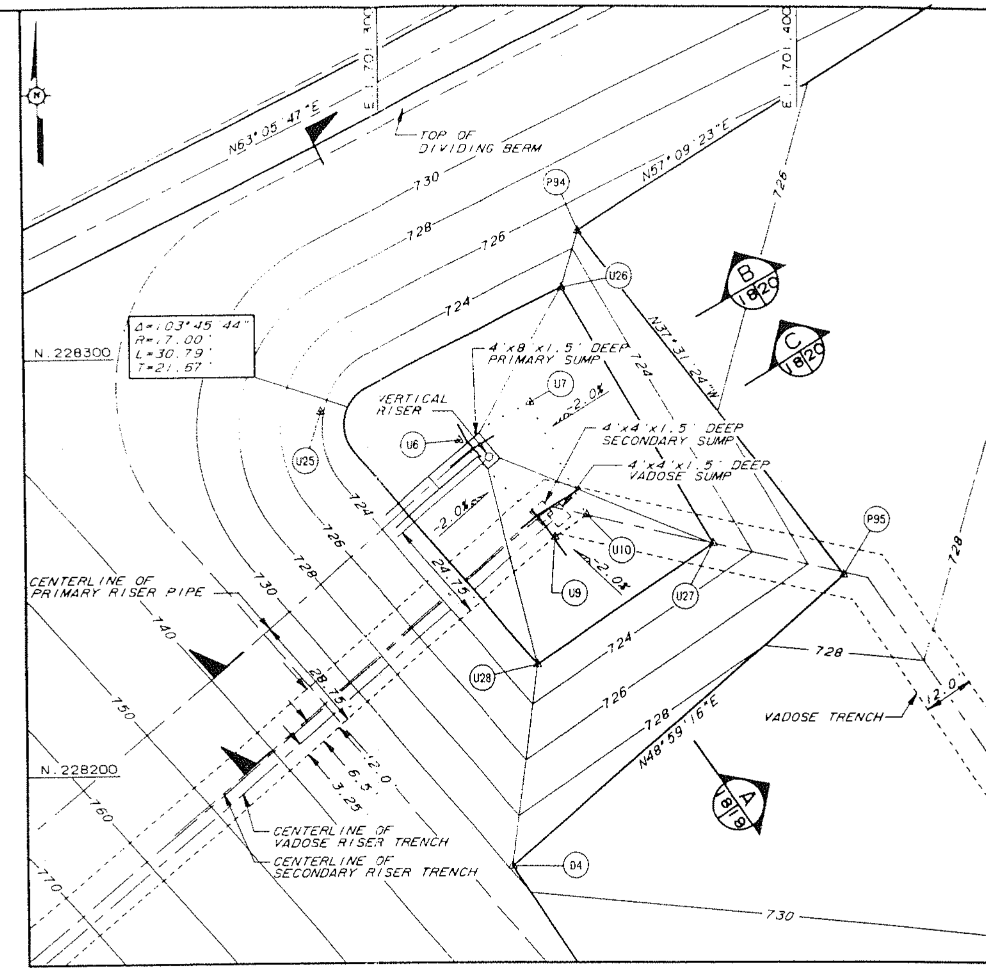
89-977 | D-89977-FD017 | 4
AS NOTED | 89-03-304.2.1 | 17



DETAIL PLAN 1 (5|18)

SUMP 1A

0 20 40 FEET
SCALE



DETAIL PLAN 2 (5|18)

SUMP 1B

0 20 40 FEET
SCALE

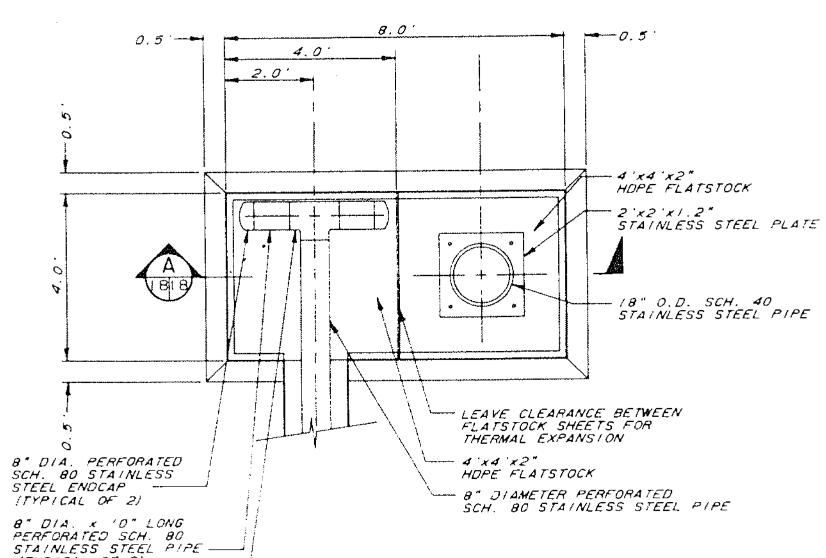
STATION	COORDINATE N	COORDINATE E	ELEVATION
U1*	228,471.09	1,701,252.04	711.3
U2*	228,472.29	1,701,265.72	709.8
U3*	228,433.91	1,701,252.12	712.0
U4*	228,449.49	1,701,279.94	711.8
U6*	228,280.84	1,701,316.10	712.1
U7*	228,291.11	1,701,337.20	712.0
U9*	228,256.60	1,701,342.26	711.3
U10*	228,261.96	1,701,350.04	709.8
D3	228,524.96	1,701,186.33	729.8
P82	228,520.10	1,701,291.59	727.0
P83	228,437.99	1,701,322.05	724.9
U21	228,496.10	1,701,221.53	723.4
U22	228,501.43	1,701,281.90	723.4
U23	228,441.14	1,701,312.42	723.4
U24	228,397.52	1,701,237.60	723.4
P94	228,330.20	1,701,348.21	724.6
P95	228,247.54	1,701,411.69	727.4
D4	228,177.86	1,701,331.56	729.8
U25	228,286.89	1,701,285.64	723.4
U26	228,316.61	1,701,344.21	723.4
U27	228,255.24	1,701,380.13	723.4
U28	228,226.14	1,701,337.84	723.4

Table: SURVEY CONTROL

* CONTROL POINTS FROM EXCAVATION GRADE

STATION	COORDINATE N	COORDINATE E	ELEVATION
U11	228,480.16	1,701,240.95	716.9
U12	228,482.87	1,701,271.59	716.9
U13	228,427.50	1,701,246.79	716.9
U14	228,448.86	1,701,288.81	716.9
U15	228,282.45	1,701,307.99	716.9
U16	228,298.35	1,701,339.35	716.9
U17	228,259.23	1,701,362.22	716.9
U18	228,244.41	1,701,340.68	716.9

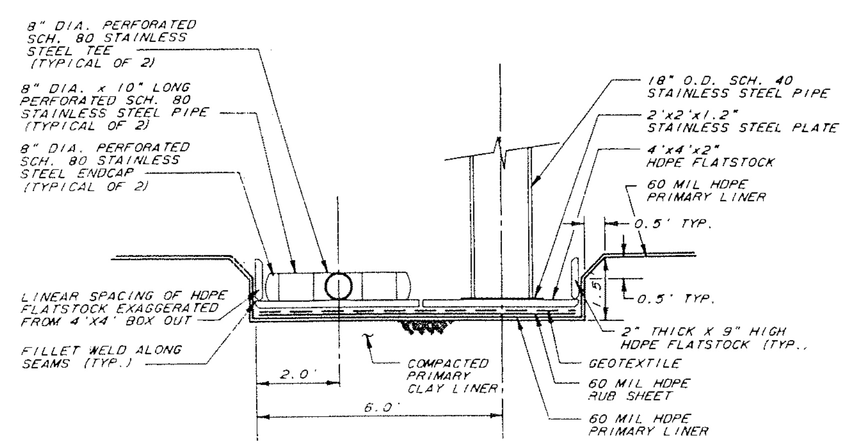
Table: SURVEY CONTROL SECONDARY LINER (SEE NOTE 2)



DETAIL 1 (18,20A|18)

PRIMARY SUMP WITH SLOPE AND VERTICAL RISER

0 2 4 FEET
SCALE



SECTION A (18|18)

PRIMARY SUMP WITH SLOPE AND VERTICAL RISER

0 2 4 FEET
SCALE

NOTES:

1. ELEVATIONS SHOWN ARE TOP OF PRIMARY LINER.
2. SURVEY CONTROL GIVEN IN THE LOWER SURVEY CONTROL TABLE ARE CONTROL ELEVATIONS FOR THE TOP OF SECONDARY LINER. THE POINTS GIVEN ARE FOR THE BOTTOM OF SUMPS 1A AND 1B RESPECTIVELY.

REGISTERED PROFESSIONAL ENGINEER RICHARD D. ELLISON No. 39298 EXP. 12-31-93 CIVIL STATE OF CALIFORNIA

REV	DATE	DESCRIPTION	DRAWN BY	CHK'D BY
3	1/29/93	MODIFIED CALLOUT FOR DETAIL 1-18/18 CLARIFIED DIMENSIONS OF HDPE SUMP & CHAMFER	GGI	
2	1/2/91	ISSUED FOR CONSTRUCTION	RVH	
0	7/31/90	ISSUED FOR PERMITTING	RVH	

DRAWN BY | CHECKED BY | APPROVED BY

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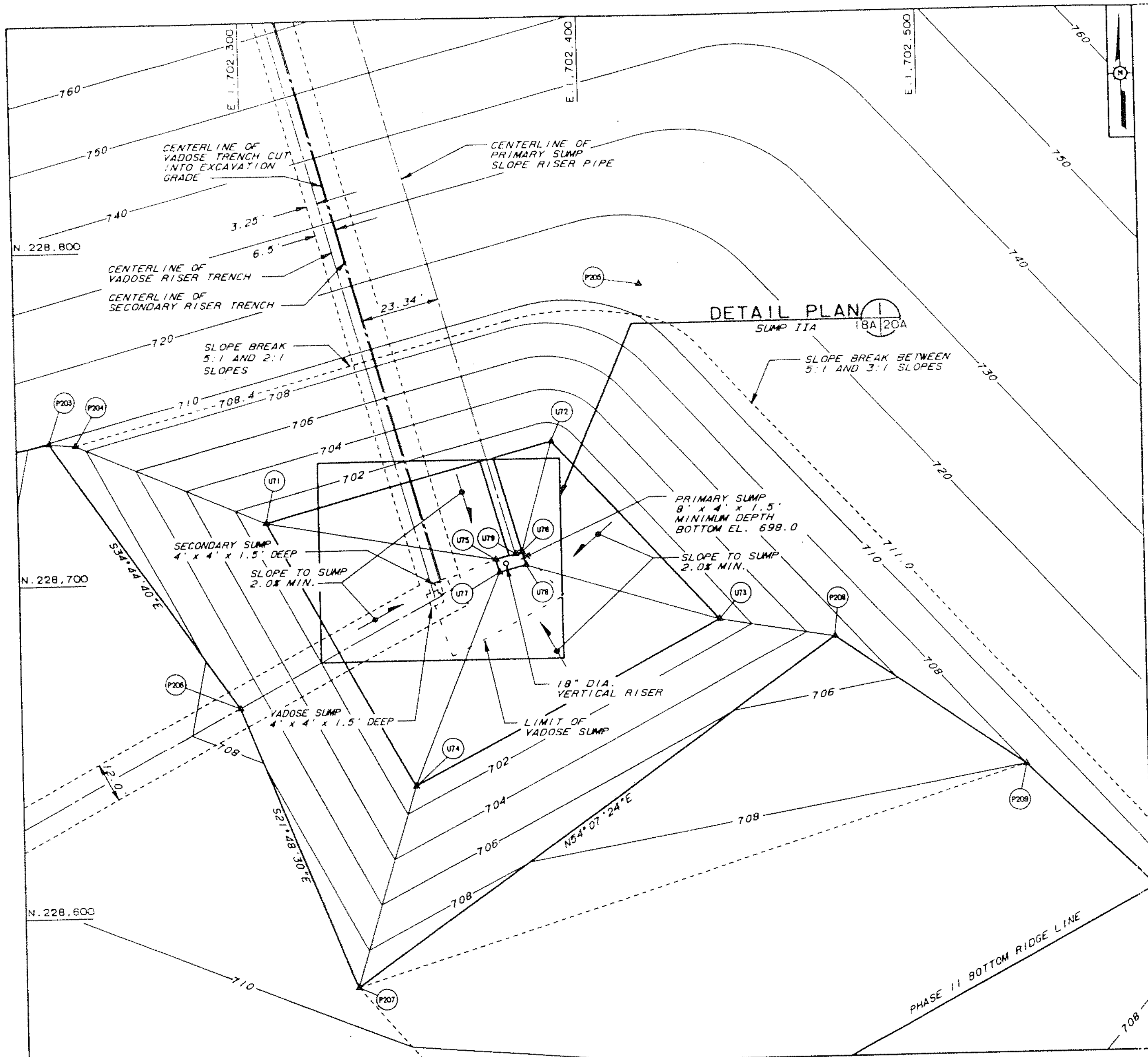
CONSTRUCTION PLANS
CWMI-KETTLEMAN HILLS FACILITY
KINGS COUNTY CALIFORNIA

TITLE: TYPICAL SUMP PLANS

ENVIRONMENTAL SOLUTIONS, INC.

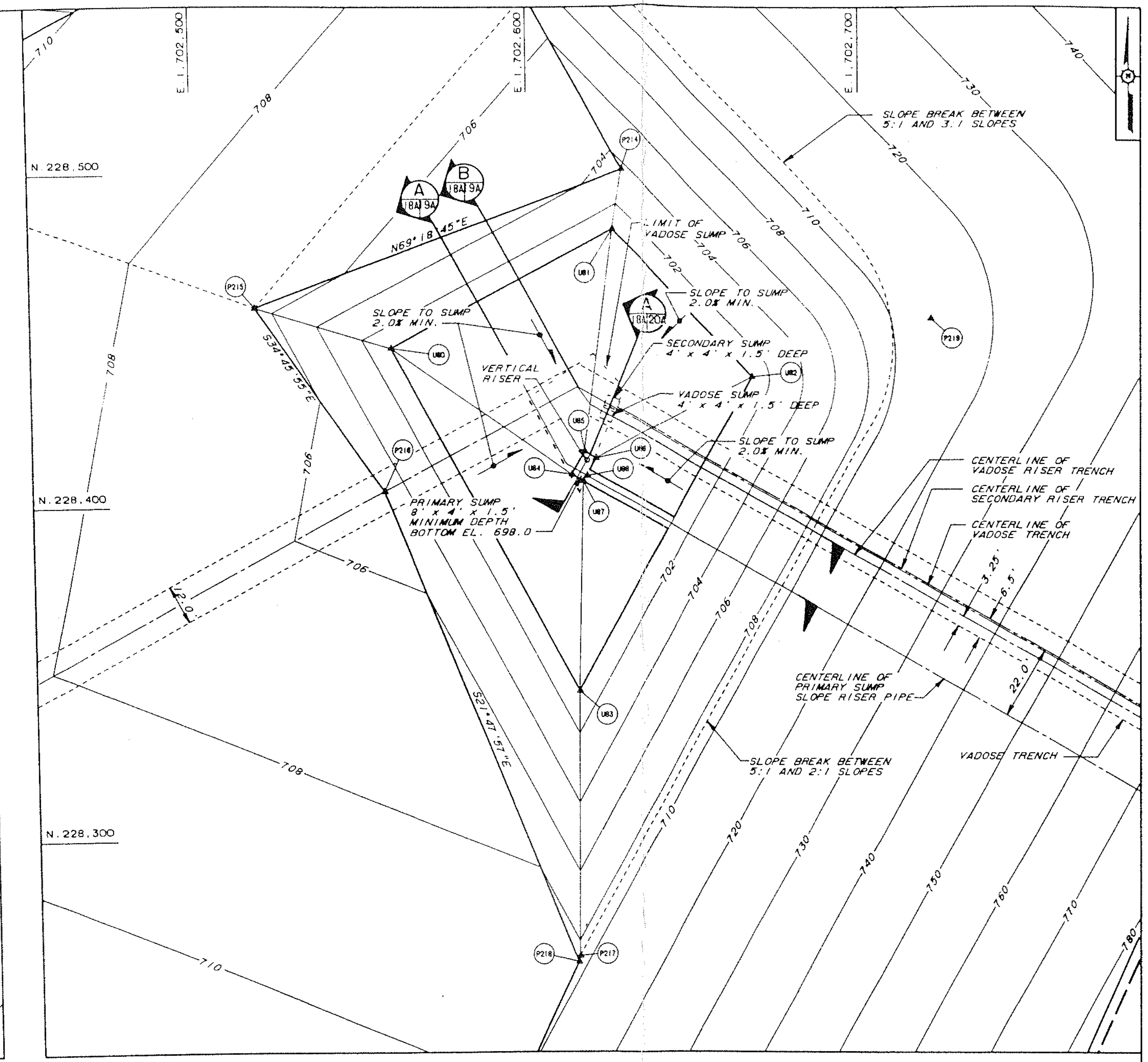
JOB NO.	ESI FILE NUMBER	REVISION
89-977	D-89977-FD018	3
SCALE	CWMI FILE NUMBER	SHEET
NONE	89-030304.2.1	18



DETAIL PLAN 1 (10/18A)

SUMP IIA

0 20 40 FEET
SCALE



DETAIL PLAN 2 (10/18A)

SUMP IIB

0 20 40 FEET
SCALE

SURVEY CONTROL

STATION	COORDINATE N	COORDINATE E	ELEVATION
P203	228,742.72	1,702,240.77	709.8
P204	228,742.04	1,702,248.75	708.4
P205	228,787.63	1,702,416.72	---
P206	228,662.09	1,702,296.70	707.6
P207	228,577.67	1,702,330.48	709.6
P208	228,680.45	1,702,472.58	705.0
P209	228,640.86	1,702,528.22	708.0
P214	228,501.24	1,702,628.46	703.7
P215	228,459.64	1,702,518.29	706.8
P216	228,404.49	1,702,556.57	705.3
P217	228,265.05	1,702,613.50	708.4
P218	228,263.24	1,702,613.06	708.7
P219	228,456.48	1,702,721.58	---
U71	228,717.66	1,702,305.45	700.8
U72	228,740.62	1,702,389.91	700.8
U73	228,686.35	1,702,438.70	700.8
U74	228,637.78	1,702,348.43	700.8
U75	228,705.42	1,702,373.01	699.5
U76	228,707.51	1,702,380.73	699.5
U77	228,701.55	1,702,374.05	699.5
U78	228,703.65	1,702,381.78	699.5
U79	228,706.99	1,702,378.80	698.0
U80	228,447.43	1,702,558.94	700.8
U81	228,483.28	1,702,625.56	700.8
U82	228,438.84	1,702,667.57	700.8
U83	228,344.51	1,702,614.31	700.8
U84	228,409.42	1,702,612.62	699.5
U85	228,416.39	1,702,616.56	699.5
U86	228,414.42	1,702,620.04	699.5
U87	228,407.45	1,702,616.11	699.5
U88	228,409.09	1,702,617.28	698.0

CONTROL POINTS U75-U78 ARE EDGE OF CLAY, BUT DO NOT ACCOUNT FOR BEVELED EDGES

SURVEY CONTROL*

STATION	COORDINATE N	COORDINATE E	ELEVATION
U61	228,705.89	1,702,332.84	694.0
U62	228,719.71	1,702,383.76	694.0
U63	228,691.50	1,702,409.16	694.0
U64	228,662.89	1,702,355.97	694.0
U65	228,439.89	1,702,584.05	694.0
U66	228,460.22	1,702,621.84	694.0
U67	228,436.04	1,702,644.70	694.0
U68	228,382.91	1,702,614.70	694.0

*-STATIONS U61-U68 ARE SECONDARY LINER CONTROL POINTS AND RELATE TO CONTROL POINTS U71-U74 AND U81-U84.

NOTES:

1. SECTIONS SHOWN ON SHEET 19A & 20A ARE TYPICAL OF BOTH SUMPS. PLAN VIEW DIMENSIONS TAKE PRECEDENCE OVER DIMENSIONS FOUND ON TYPICAL SECTION VIEWS.

REGISTERED PROFESSIONAL ENGINEER RICHARD D. ELLISON NO. 39298 EXP. 12-31-93 CIVIL STATE OF CALIFORNIA

REV	DATE	DESCRIPTION	DRAWN BY	CHK'D BY
3	1/29/93	MODIFIED GRADING PER CWMI MODIFIED SURVEY CONTROL ADDED CALLOUTS FOR DETAIL PLAN 1-18A/20A AND SECTIONS A-18A/19A, B-18A/19A, A-18A/20A	GGI	
2	7/26/91	ISSUED FOR PHASE II CONSTRUCTION	RVH	

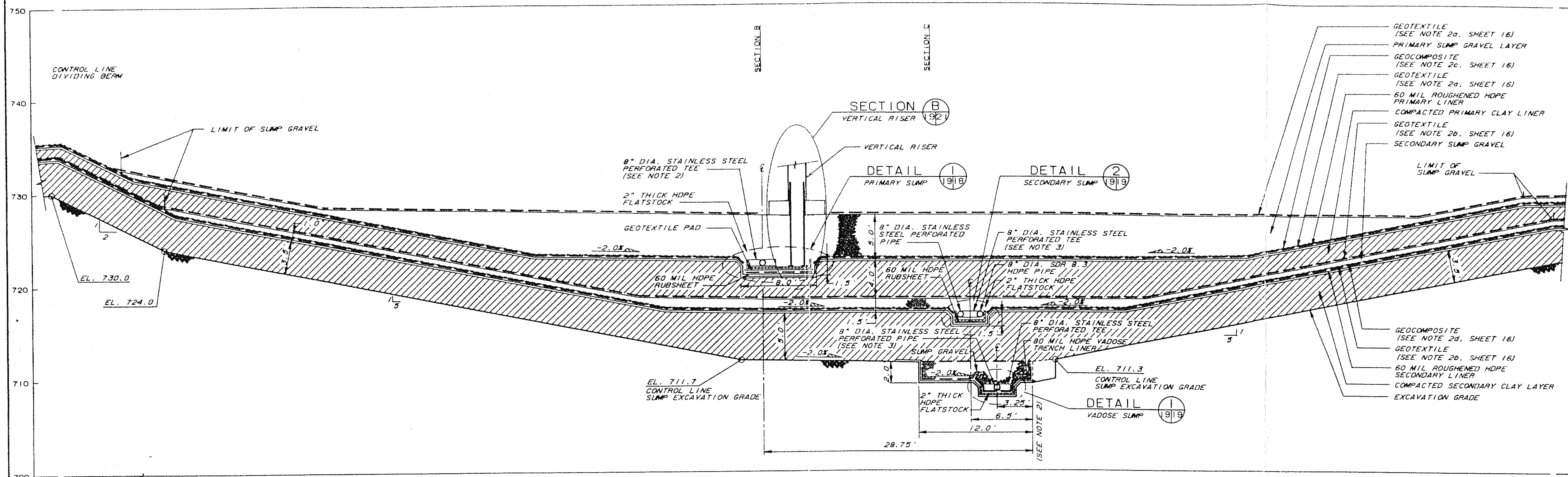
DRAWN BY | CHECKED BY | APPROVED BY

LANDFILL UNIT B-18
CONSTRUCTION PLANS
CWMI-KETTLEMAN HILLS FACILITY
KINGS COUNTY CALIFORNIA

TITLE
PHASE II PRIMARY SUMP GRADING DETAILS

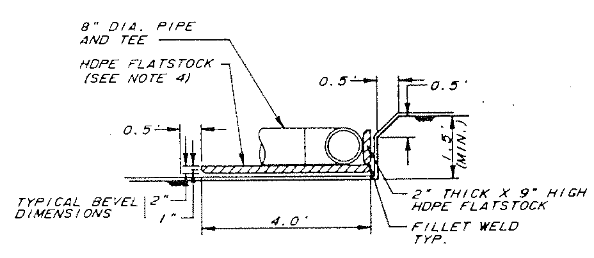
ENVIRONMENTAL SOLUTIONS, INC.

JOB NO.	ESI FILE NUMBER	REVISION
89-977	D-89977-SU018	3
SCALE	CWMI FILE NUMBER	SHEET
AS NOTED	89-03-304.2.1	18A

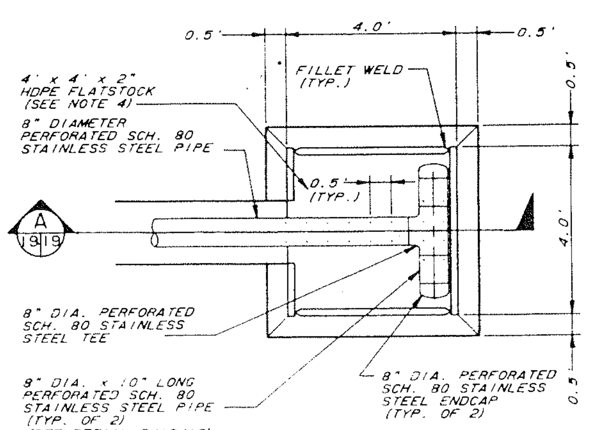


SECTION A
SUMP 18 COMBINED SECTION 18|19

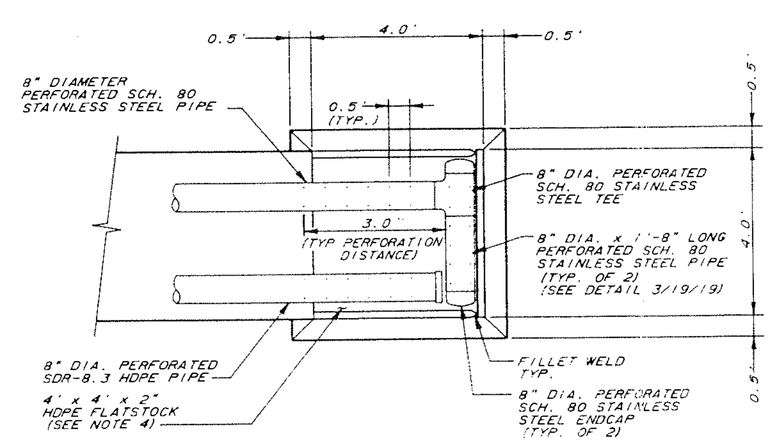
0 5 10 FEET SCALE



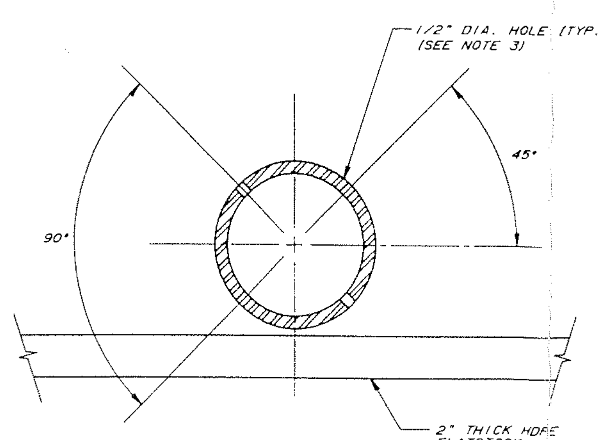
SECTION A 19|19
VADOSE SUMP DETAIL
N.T.S.



DETAIL 1 19,20A|19
VADOSE SUMP DETAIL
N.T.S.



DETAIL 2 19|19
SECONDARY SUMP
N.T.S.



DETAIL 3 19|19
PIPE PERFORATION
N.T.S.

1. SEE SHEET 1 FOR LEGEND AND GENERAL NOTES.
2. THE DIMENSIONS FOR THE SUMP CENTERLINES AND TRENCH WIDTHS ARE CONTROLLED BY THE SUMP EXCAVATION GRADE CONTROL LINES. THESE DIMENSIONS ARE TO BE LAID OUT AT THE CORNER WHERE THE VADOSE TRENCH AND SUMP EXCAVATION COINCIDE (SEE SHEET 18).
3. SIDE SLOPE RISER PIPE PERFORATIONS SHALL BE 1/2" DIAMETER HOLES EVENLY SPACED ALONG THE BOTTOM 3' OF THE RISER PIPE EVERY 6" IN THE LONGITUDINAL DIRECTION. THE PERFORATIONS SHALL BE SEPERATED BY 90 DEGREES IN THE TRANSVERSE DIRECTION. WRAP THE PERFORATED SECTION WITH TWO LAYERS OF GEONET.
4. LAP DRAINAGE LAYER GEOCOMPOSITE OVER HDPE FLATSTOCK SIDEWALLS A MINIMUM OF 6 INCHES.

REV	DATE	DESCRIPTION	DRAWN BY	CHK'D BY
3	1/29/93	ADDED NOTE 4 CLARIFIED SUMP HDPE BOX	GGI	
2	01/02/91	ISSUED FOR CONSTRUCTION	RVH	
0	7/31/90	ISSUED FOR PERMITTING	RVH	

DRAWN BY | CHECKED BY | APPROVED BY

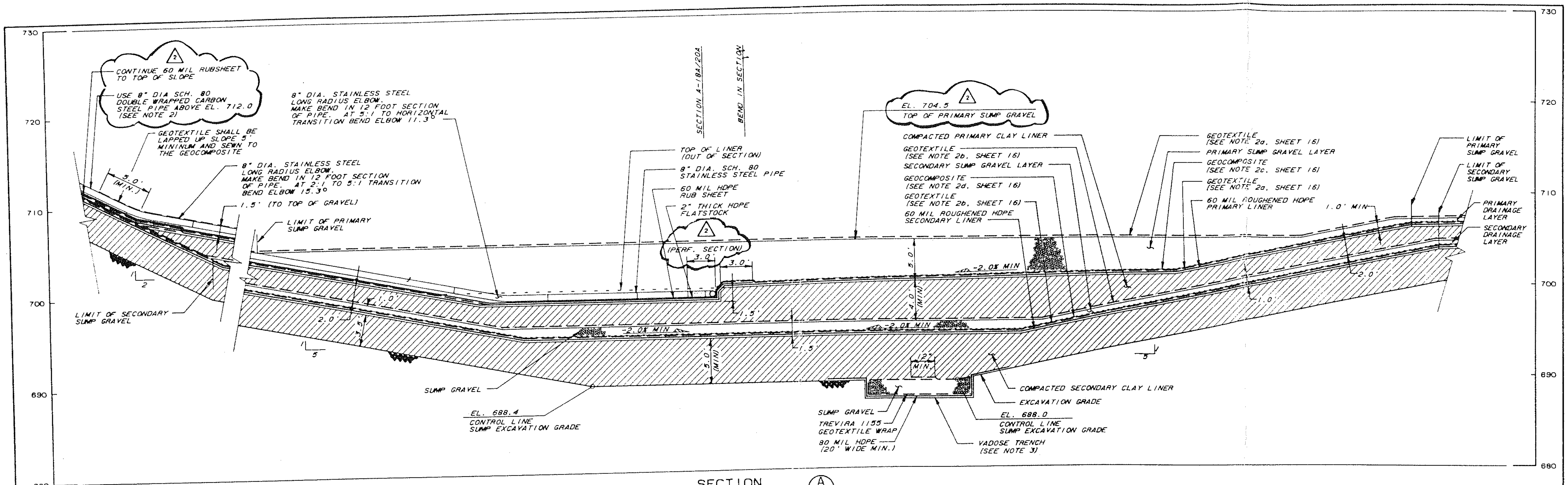
LANDFILL UNIT B-18
CONSTRUCTION PLANS
CWMI-KETTLEMAN HILLS FACILITY
KINGS COUNTY CALIFORNIA

TITLE: SUMP AND RISER DETAILS

ENVIRONMENTAL SOLUTIONS, INC.

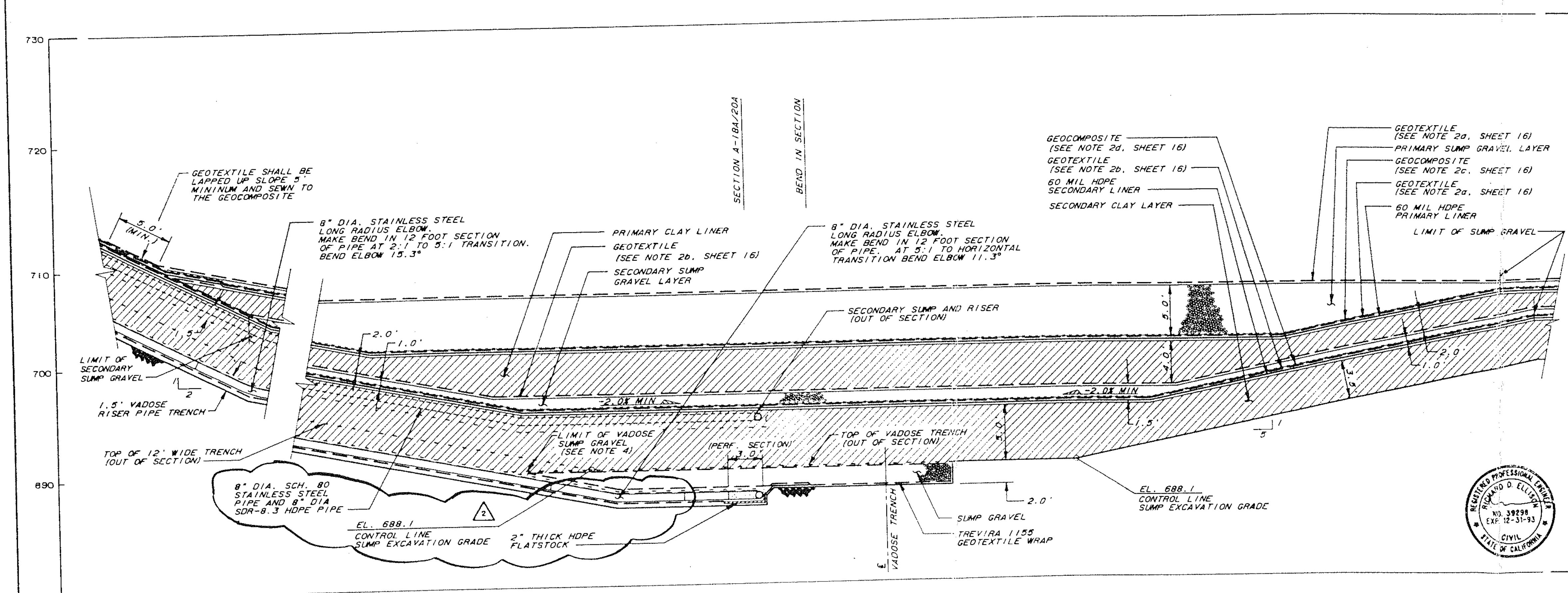
REGISTERED PROFESSIONAL ENGINEER RICHARD D. ELLISON NO. 39298 EXP 12-31-93 CIVIL STATE OF CALIFORNIA

JOB NO. 89-977	ESI FILE NUMBER D-89977-FD019	REVISION 3
SCALE AS NOTED	CWMI FILE NUMBER 89-03-304.1.2	SHEET 19



SECTION (A / 18A 19A)

TYPICAL PHASE II PRIMARY SUMP AND SIDESLOPE RISER



SECTION (B / 18A 19A)

TYPICAL PHASE II VADOSE SUMP AND SIDESLOPE RISER

NOTES:

1. SEE SHEET 1 FOR LEGEND AND GENERAL NOTES.
2. WRAP CARBON STEEL PIPE WITH TWO LAYERS OF TAPECOAT OR APPROVED EQUAL.
3. DUE TO BEND IN SECTION THE VADOSE TRENCH & PRIMARY SUMP RISER TRENCH ARE SHOWN OUT OF PLANE WITH RESPECT TO EACH OTHER.
4. VADOSE SUMP GRAVEL TERMINATES BY FEATHERING INTO 5:1 SLOPE INSIDE THE VADOSE SUMP RISER PIPE RUNS.

0 5 10 FEET
SCALE

REV	DATE	DESCRIPTION	DRAWN BY	CHK'D BY
2	10/02/93	REVISED NOTES FOR PHASE II RISERS AND SUMPS	GGI	
1	1/29/93	ADDED SECTIONS A-18A/19A, B-18A/19A	GGI	

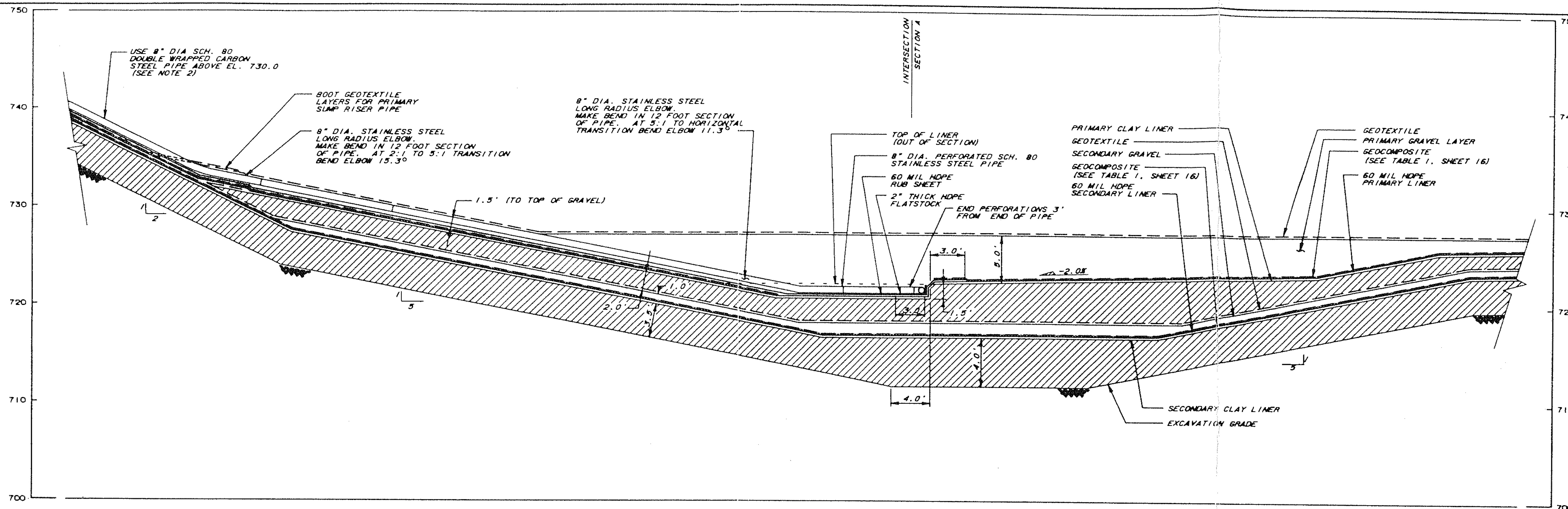
REGISTERED PROFESSIONAL ENGINEER RICHARD D. ELLISON No. 39298 EXP. 12-31-93 CIVIL STATE OF CALIFORNIA

LANDFILL UNIT B-18
CONSTRUCTION PLANS
CWMI-KETTLEMAN HILLS FACILITY
KINGS COUNTY CALIFORNIA

PHASE II
SUMP AND RISER DETAILS

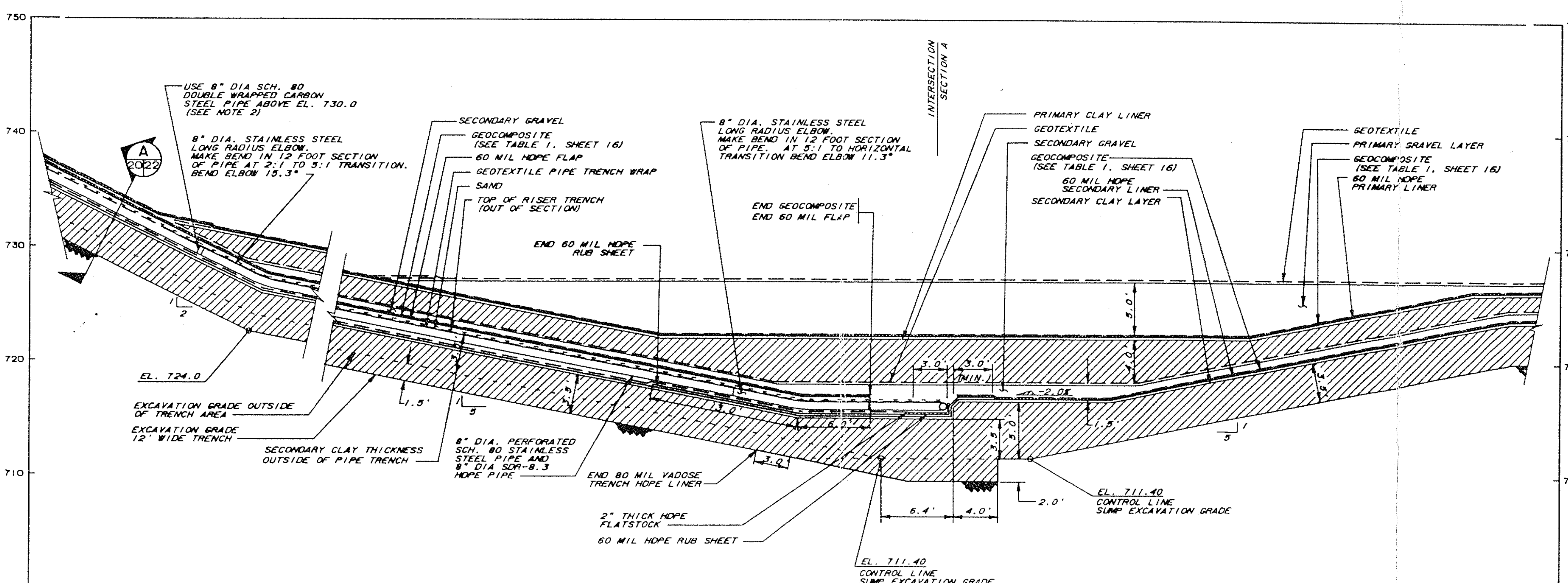
ENVIRONMENTAL SOLUTIONS, INC.

JOB NO.	DWG FILE NAME	REVISION
89-977	D-89977-SU019	2
SCALE 1"=5'	89-03-304.2.1	SHEET 19A



SECTION (B / 18 20)

PRIMARY SUMP AND RISER



SECTION (C / 18 20)

SECONDARY SUMP AND RISER AT PIPE TRENCH

NOTES:

1. SEE SHEET 1 FOR LEGEND AND GENERAL NOTES.
2. WRAP CARBON STEEL PIPE WITH TWO LAYERS OF TAPECOAT OR APPROVED EQUAL.

REGISTERED PROFESSIONAL ENGINEER — TERRY K. PARKINSON — No. 41021 — Exp. MAR 31 1991 — CIVIL — STATE OF CALIFORNIA

0 5 10 FEET
SCALE

2	3/7/91	ISSUED FOR CONSTRUCTION	RVH	KKP
0	7/11/90	ISSUED FOR PERMITTING	RVH	KKP
REV	DATE	DESCRIPTION	BY	CHK'D BY

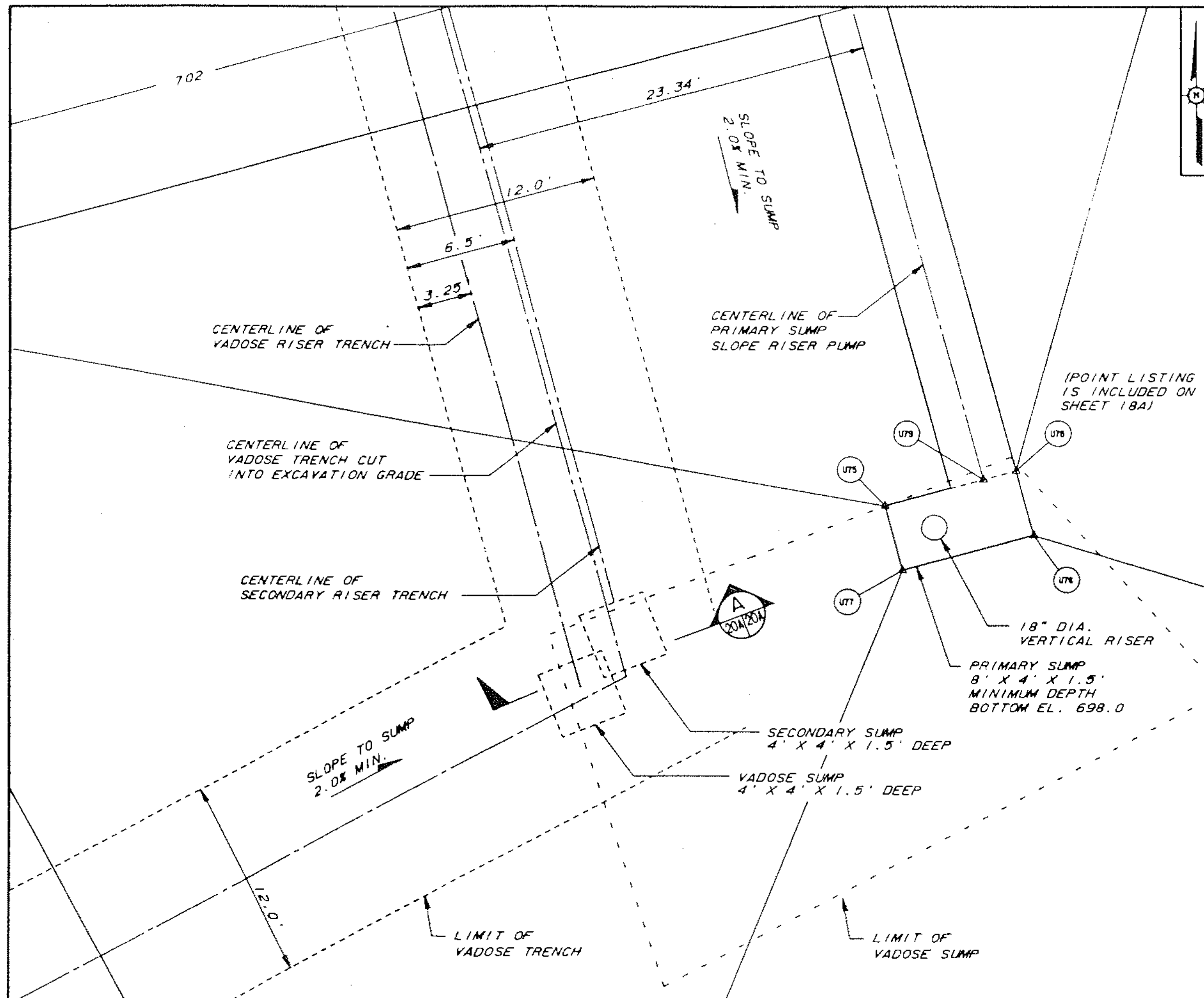
DRAWN BY R.V.HYNINA — CHECKED BY K. Parkinson — APPROVED BY ROE

LANDFILL UNIT B-18
CONSTRUCTION PLANS
CWMI-KETTLEMAN HILLS FACILITY
KINGS COUNTY — CALIFORNIA

SUMP AND RISER DETAILS

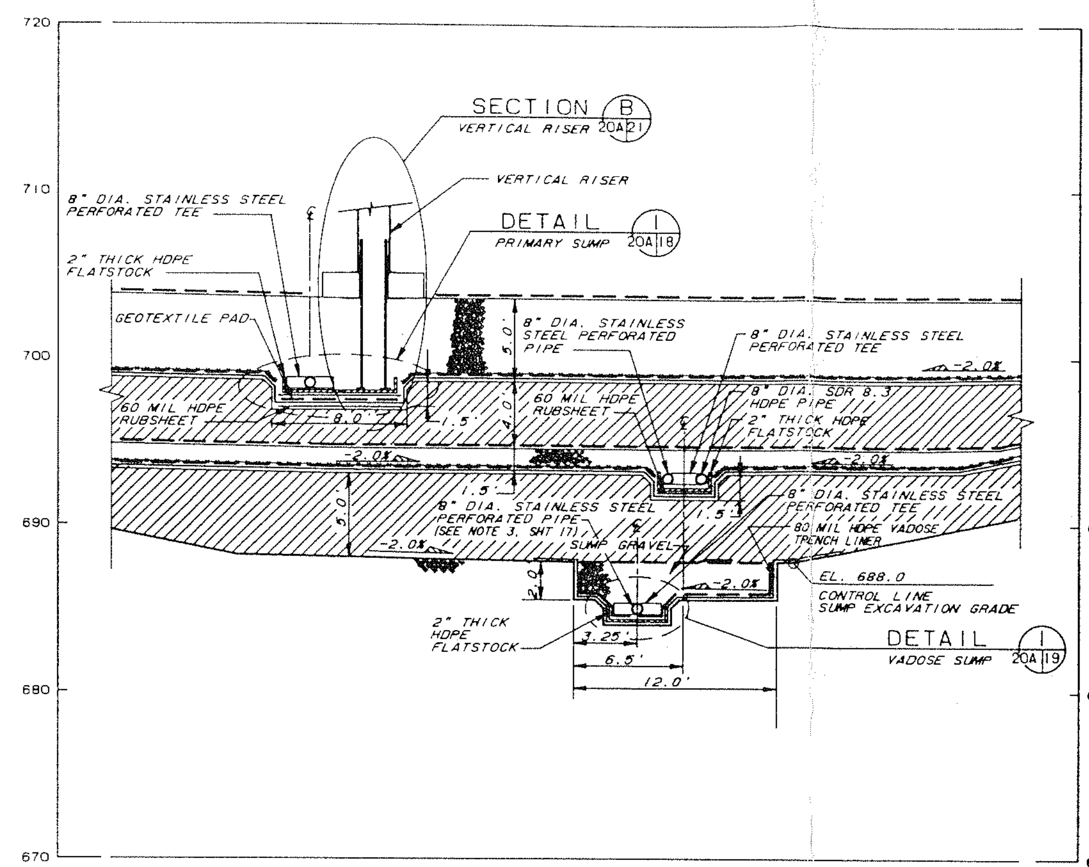
ENVIRONMENTAL SOLUTIONS, INC.

JOB NO.	FILE NUMBER	REVISION
89-977	D-89977-FD020	2
SCALE 1"=5'	89-03-304.2.1	SHEET 20



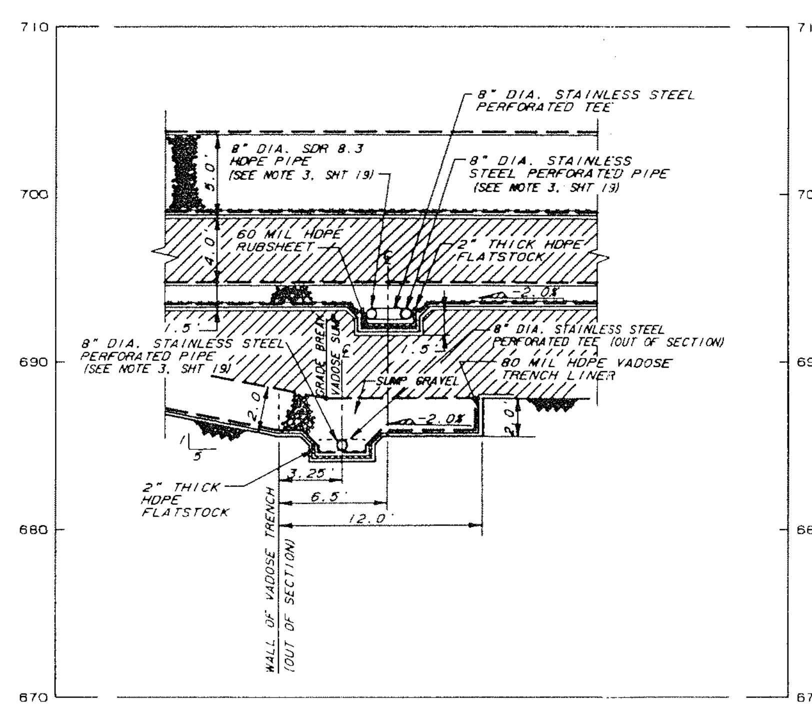
DETAIL PLAN 1 18A 20A
PHASE IIA SUMP
TOP OF PRIMARY LINER

0 5 10 FEET
SCALE



SECTION A 18A 20A
SUMP IIB

0 5 10 FEET
SCALE



SECTION A 20A 20A
SUMP IIA

0 5 10 FEET
SCALE

REV	DATE	DESCRIPTION	DRAWN BY	CHK'D BY
1	1/25/93	ADDED DETAIL PLAN 1-18A/20A AND SECTIONS A-18A/20A, A-20A/20A	GG/	

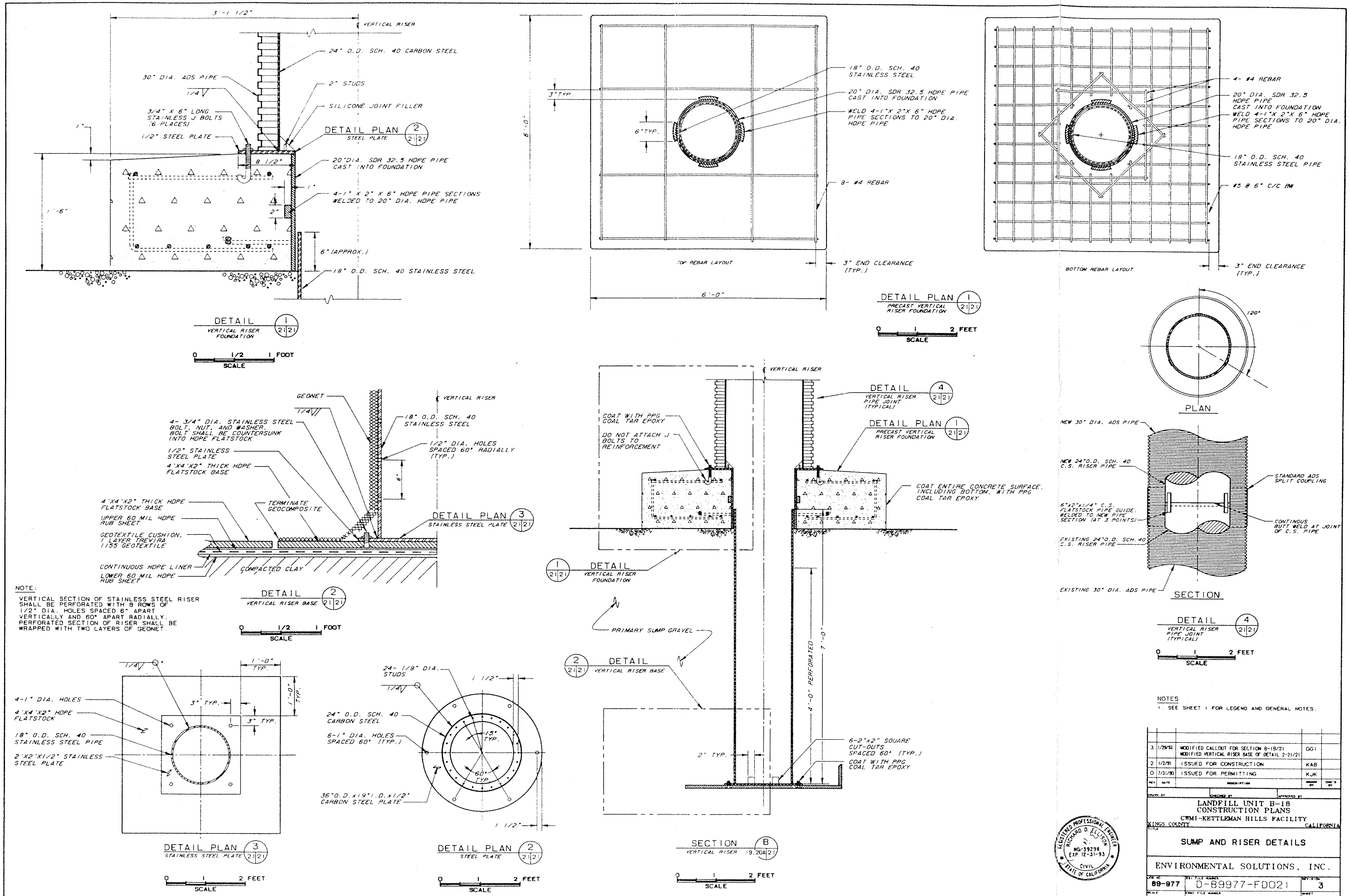
LANDFILL UNIT B-18
CONSTRUCTION PLANS
CWMI-KETTLEMAN HILLS FACILITY
KINGS COUNTY CALIFORNIA

PHASE II
SUMP AND RISER DETAILS

ENVIRONMENTAL SOLUTIONS, INC.

JOB NO.	DWG. FILE NUMBER	REVISION
89-977	D-89977-SU020	1
SCALE	COMP. FILE NUMBER	SHEET
AS SHOWN	89-03-304.2.1	20A

REGISTERED PROFESSIONAL ENGINEER RICHARD D. ELLISON NO. 39298 EXP. 12-31-93 CIVIL STATE OF CALIFORNIA



NOTES

1. SEE SHEET 1 FOR LEGEND AND GENERAL NOTES.

REV	DATE	DESCRIPTION	DRAWN BY	CHK'D BY
3	1/29/93	MODIFIED CALLOUT FOR SECTION B-19/21 MODIFIED VERTICAL RISER BASE OF DETAIL 2-21/21	GGI	
2	1/2/91	ISSUED FOR CONSTRUCTION	KAB	
0	7/31/90	ISSUED FOR PERMITTING	KJK	

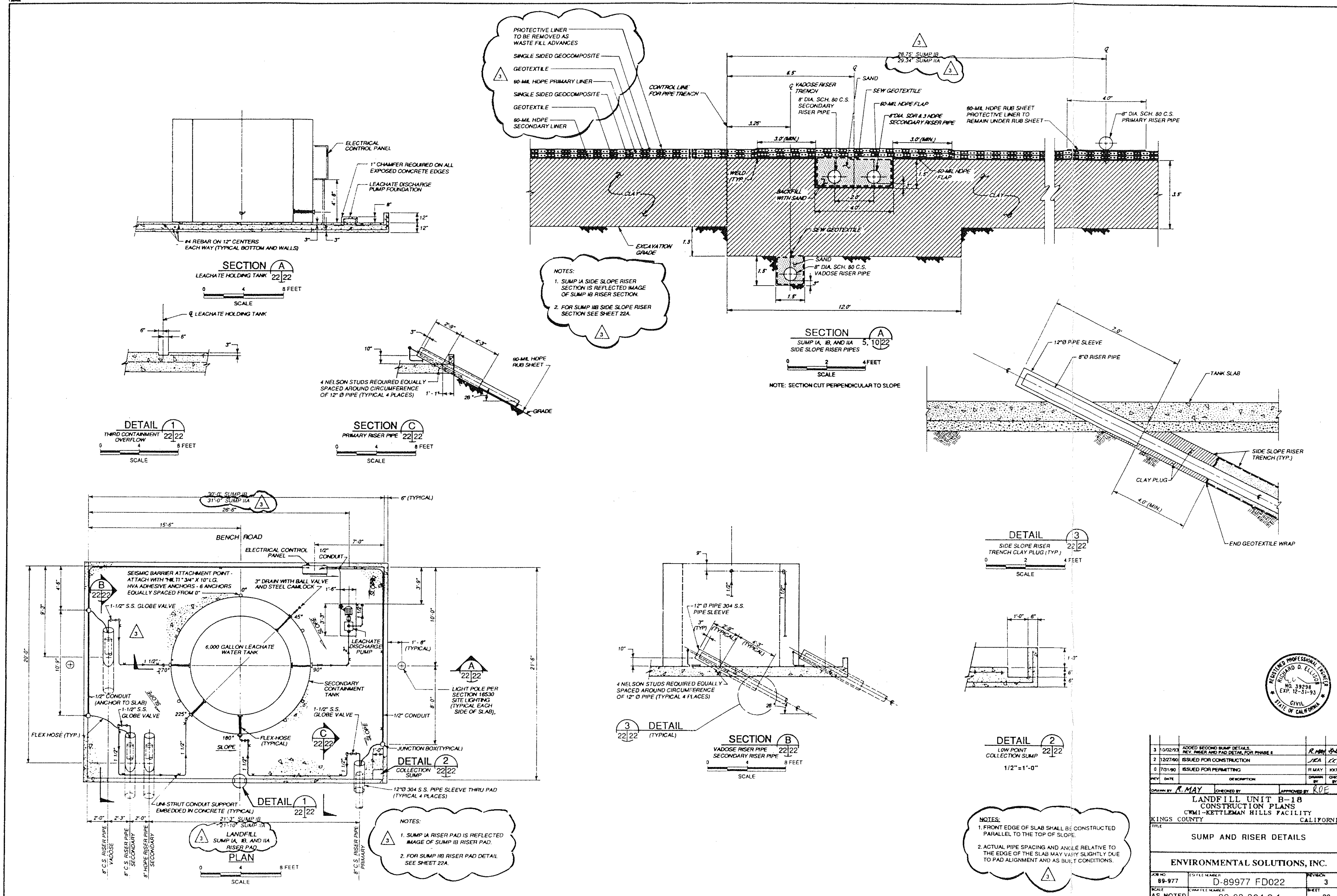
DRAWN BY | CHECKED BY | APPROVED BY

LANDFILL UNIT B-18
CONSTRUCTION PLANS
CWMI-KETTLEMAN HILLS FACILITY
KINGS COUNTY CALIFORNIA

TITLE: SUMP AND RISER DETAILS

ENVIRONMENTAL SOLUTIONS, INC.

JOB NO.	ESI FILE NUMBER	REVISION
89-977	D-89977-FD021	3
SCALE	CWMI FILE NUMBER	SHEET
AS NOTED	89-03-304.2.1	21



REV	DATE	DESCRIPTION	DRAWN BY	CHK'D BY
3	10/02/93	ADDED SECOND SUMP DETAILS, REV. RISER AND PAD DETAIL FOR PHASE II	R.MAY	RAD
2	12/27/90	ISSUED FOR CONSTRUCTION	JEA	KKP
0	7/31/90	ISSUED FOR PERMITTING	R.MAY	KKP

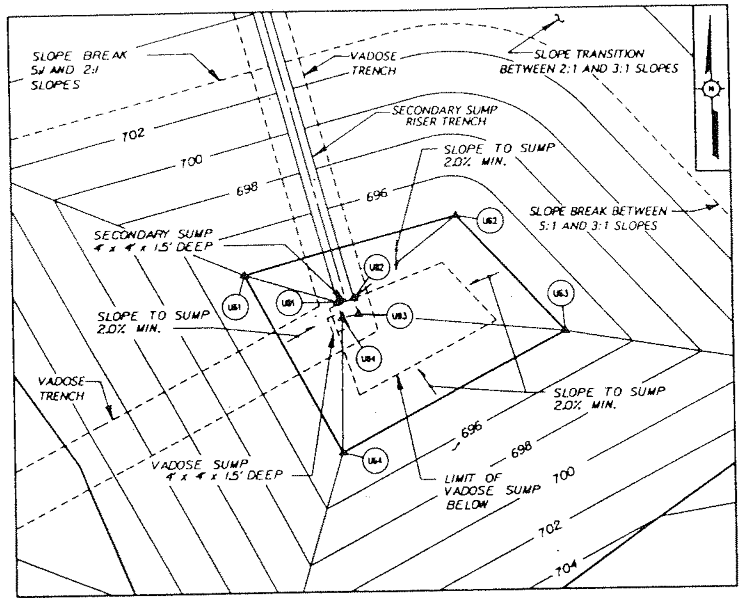
DRAWN BY R. MAY CHECKED BY APPROVED BY RDE

LANDFILL UNIT B-18
CONSTRUCTION PLANS
CWMI-KETTLEMAN HILLS FACILITY
KINGS COUNTY CALIFORNIA

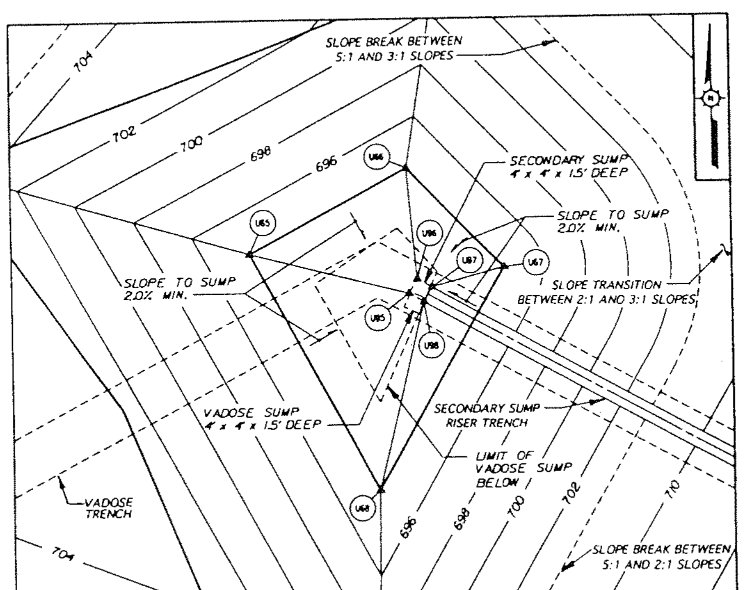
TITLE: SUMP AND RISER DETAILS

ENVIRONMENTAL SOLUTIONS, INC.

JOB NO. 89-977 | FILE NUMBER D-89977 FD022 | REVISION 3
SCALE AS NOTED | DRAWING NUMBER 89-03-304.2.1 | SHEET 22



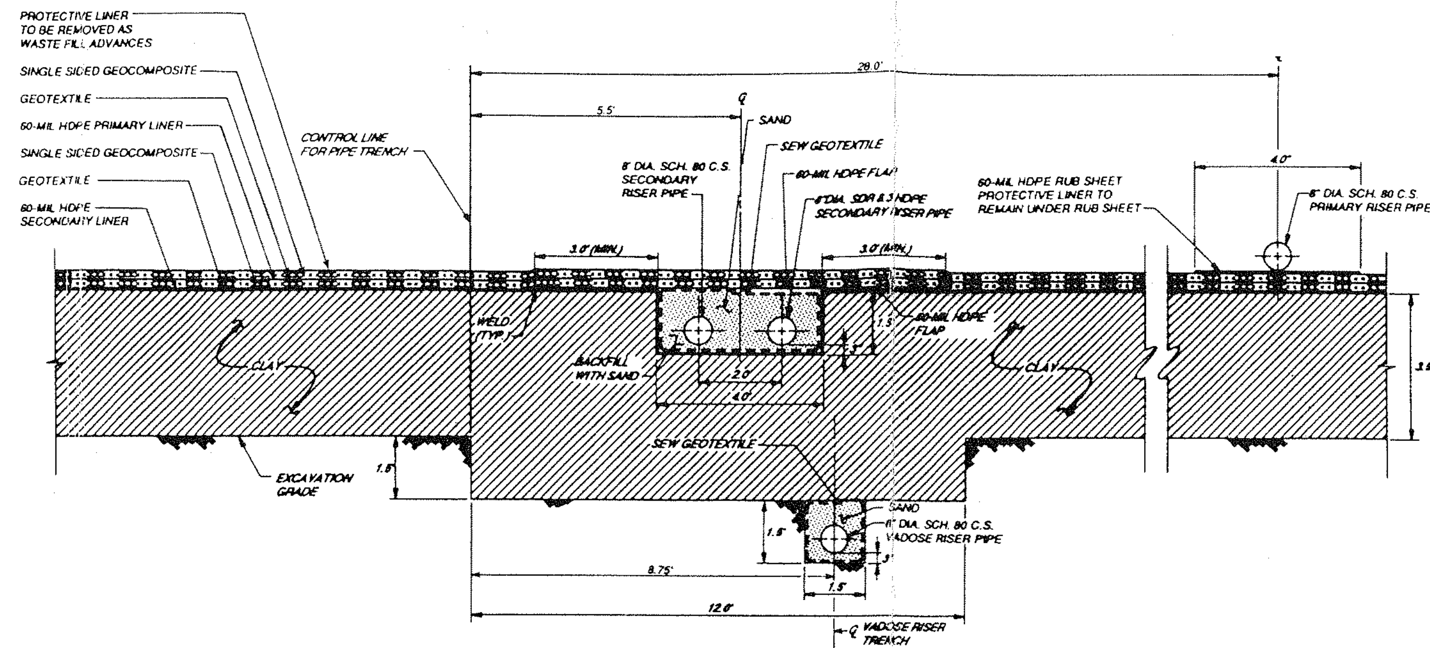
DETAIL PLAN 1 / 9 | 22A
SECONDARY SUMP IIA
0 20 40 FEET
SCALE



DETAIL PLAN 2 / 9 | 22A
SECONDARY SUMP IIB
0 20 40 FEET
SCALE

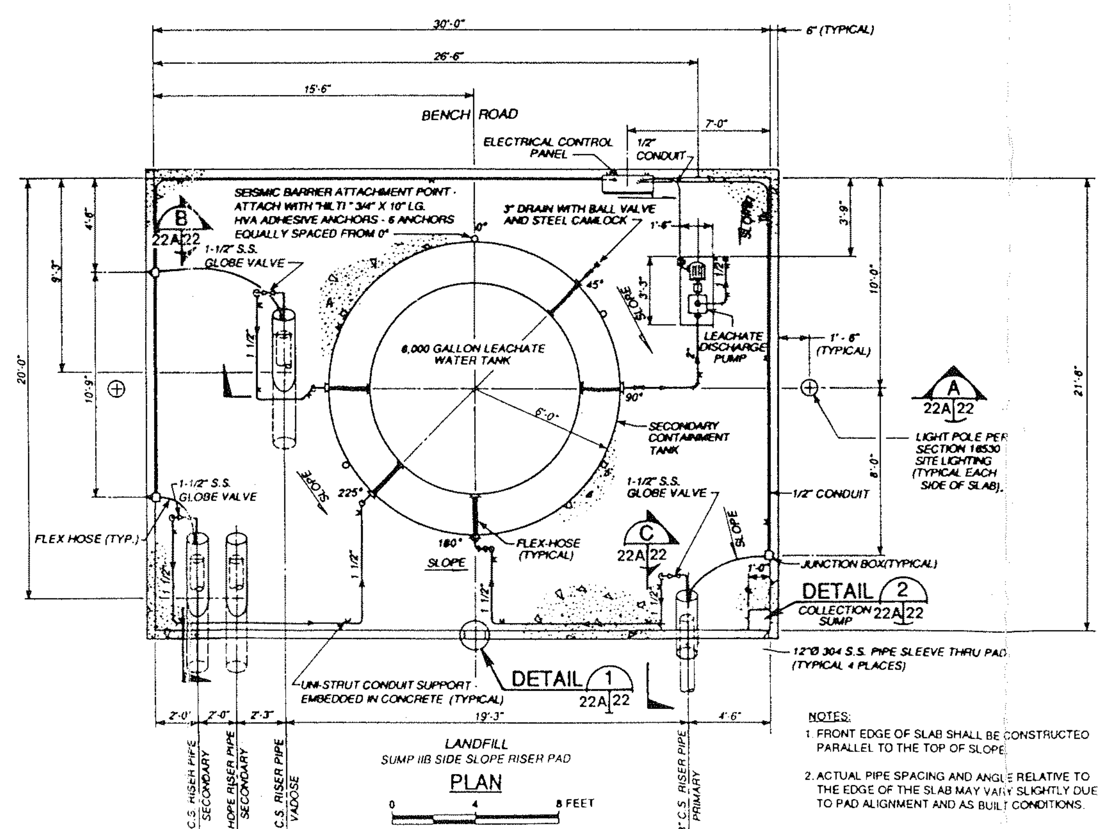
STATION	COORDINATE N	COORDINATE E	ELEVATION
U61	228,705.89	1,702,332.84	694.0
U62	228,719.71	1,702,383.76	694.0
U63	228,691.50	1,702,409.16	694.0
U64	228,662.89	1,702,355.97	694.0
U65	228,439.89	1,702,584.05	694.0
U66	228,460.22	1,702,621.84	694.0
U67	228,436.04	1,702,644.70	694.0
U68	228,382.91	1,702,614.70	694.0
U91	228,699.06	1,702,355.21	693.0
U92	228,700.10	1,702,359.07	693.0
U93	228,696.24	1,702,360.12	693.0
U94	228,695.20	1,702,356.26	693.0
U95	228,429.86	1,702,622.17	693.0
U96	228,433.34	1,702,624.13	693.0
U97	228,431.37	1,702,627.62	693.0
U98	228,427.89	1,702,625.65	693.0

SURVEY CONTROL



SECTION A / 10 | 22A
SUMP IIB SIDE SLOPE RISER PIPES
0 2 4 FEET
SCALE

NOTE: SECTION CUT PERPENDICULAR TO SLOPE



LANDFILL
SUMP IIB SIDE SLOPE RISER PAD
PLAN
0 4 8 FEET
SCALE

NOTES:
1. FRONT EDGE OF SLAB SHALL BE CONSTRUCTED PARALLEL TO THE TOP OF SLOPE.
2. ACTUAL PIPE SPACING AND ANGLE RELATIVE TO THE EDGE OF THE SLAB MAY VARY SLIGHTLY DUE TO PAD ALIGNMENT AND AS BUILT CONDITIONS.

REGISTERED PROFESSIONAL ENGINEER RICHARD O. ELLISON NO. 39298 EXP. 12-31-93 CIVIL STATE OF CALIFORNIA

REV	DATE	DESCRIPTION	DRAWN BY	CHK'D BY
1	10/02/93	ISSUED FOR CONSTRUCTION	GGI	[signature]
0	7/16/93	ISSUED FOR CLIENT REVIEW	R. MAY	[signature]

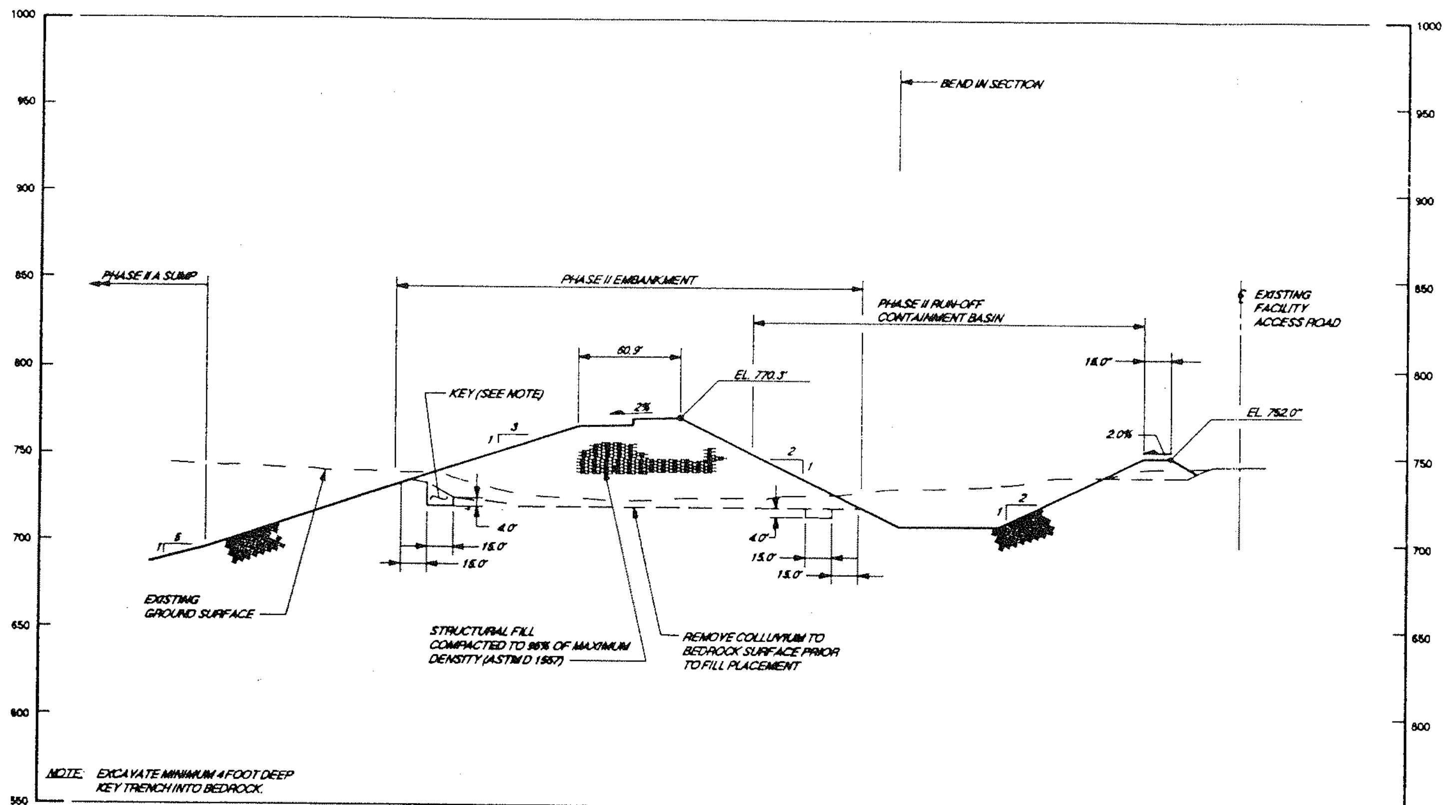
DRAWN BY R. MAY — CHECKED BY [signature] — APPROVED BY

CONSTRUCTION DRAWINGS
LANDFILL UNIT B-18
CWMI-KETTLEMAN HILLS FACILITY
KINGS COUNTY CALIFORNIA

PHASE II SUMPS AND CELL IIB
SIDE SLOPE RISER DETAILS

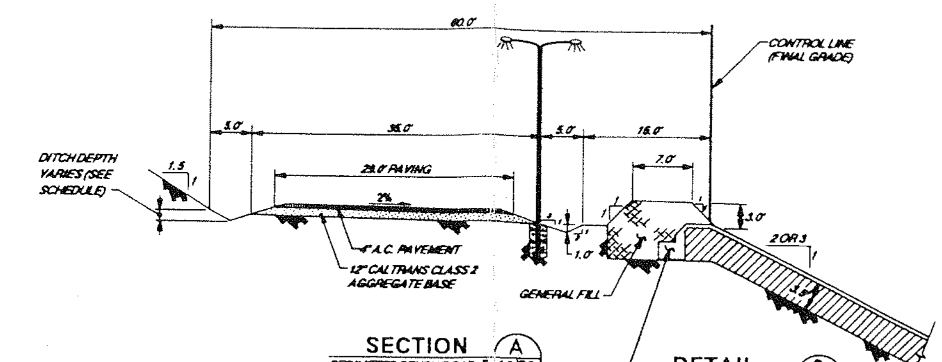
ENVIRONMENTAL SOLUTIONS, INC.

JOB NO.	ESI FILE NUMBER	REVISION
89-977	D-89977-FD022A	1
SCALE	CWMI FILE NUMBER	SHEET
AS NOTED	89-03-304.2.1	22A



SECTION A 8|23
PHASE II EMBANKMENT AND RETENTION BASIN

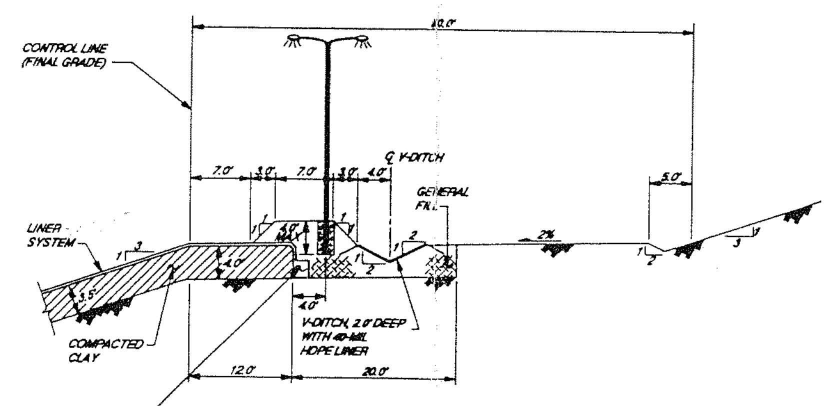
0 50 100 FEET
SCALE



SECTION A 5,10|23
PERIMETER BENCH/ROAD

DETAIL 3 23|16
ANCHOR TRENCH ARRANGEMENT

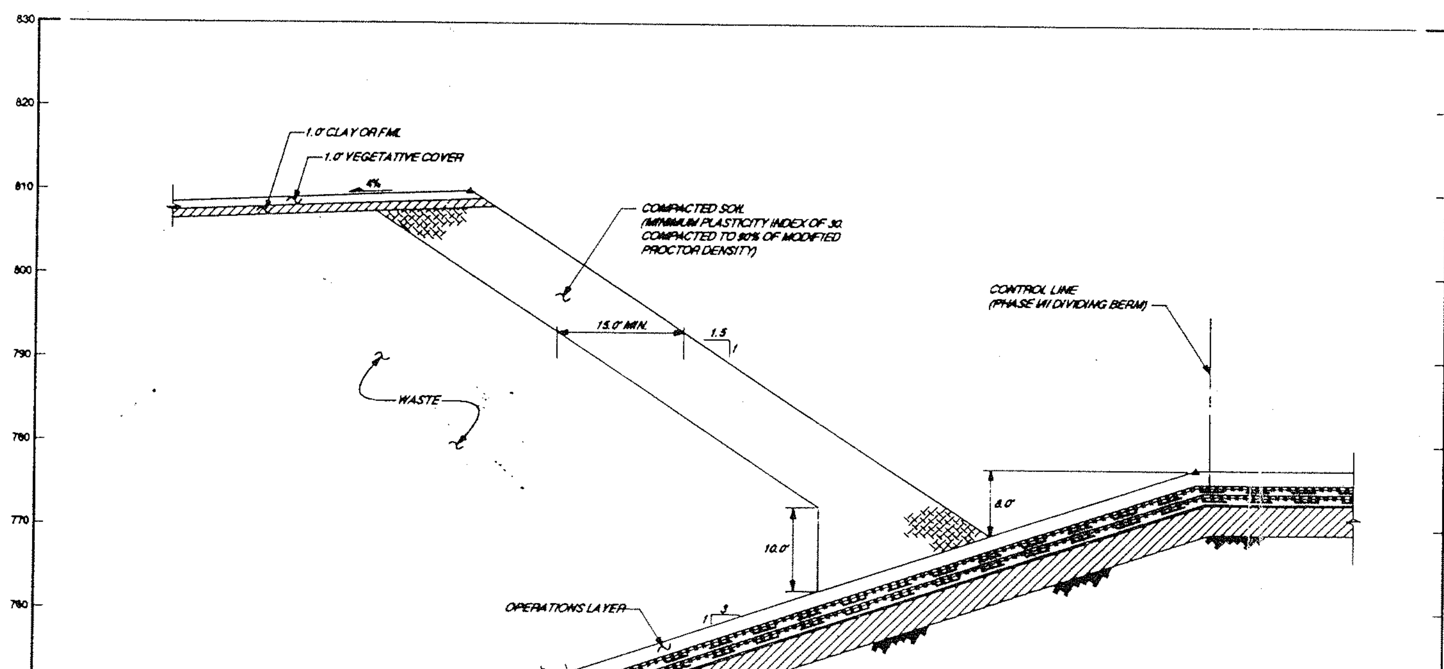
0 10 20 FEET
SCALE



SECTION B 23|17
TEMPORARY LINER TRENCH AT PHASE I & II DIVIDING BERM

SECTION B 5|23
PHASE I & II DIVIDING BERM

0 10 20 FEET
SCALE



SECTION A 6|23
PHASE I INTERIM SLOPE CONFIGURATION

0 10 20 FEET
SCALE

NOTES

1. SEE SHEET 1 FOR LEGEND AND GENERAL NOTES.

REV	DATE	DESCRIPTION	DRAWN BY	CHK'D BY
3	7/26/91	ISSUED FOR PHASE II CONSTRUCTION	SOP	KKP
2	1/2/91	ISSUED FOR CONSRUCTION	SOP	KKP
0	7/31/90	ISSUED FOR PERMITTING	DVD	KKP

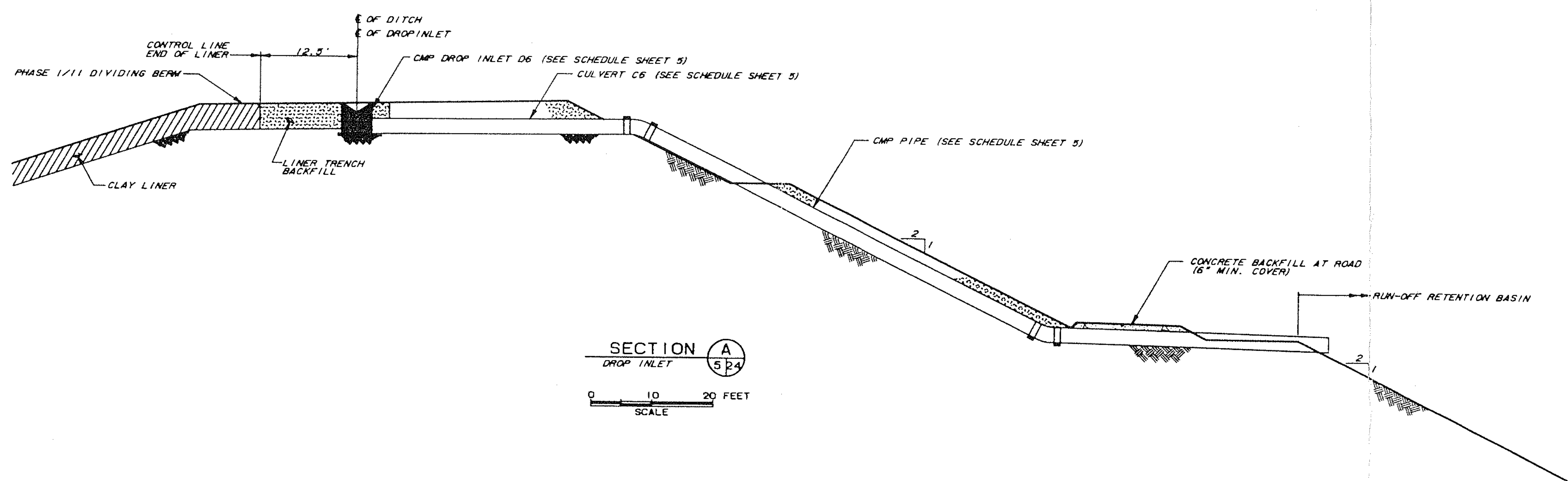
DRAWN BY K. J. Kauri CHECKED BY K. Parkinson APPROVED BY

CONSTRUCTION DRAWINGS
LANDFILL UNIT B-18
CWMI-KETTLEMAN HILLS FACILITY
KINGS COUNTY CALIFORNIA

MISCELLANOUS CROSS SECTIONS

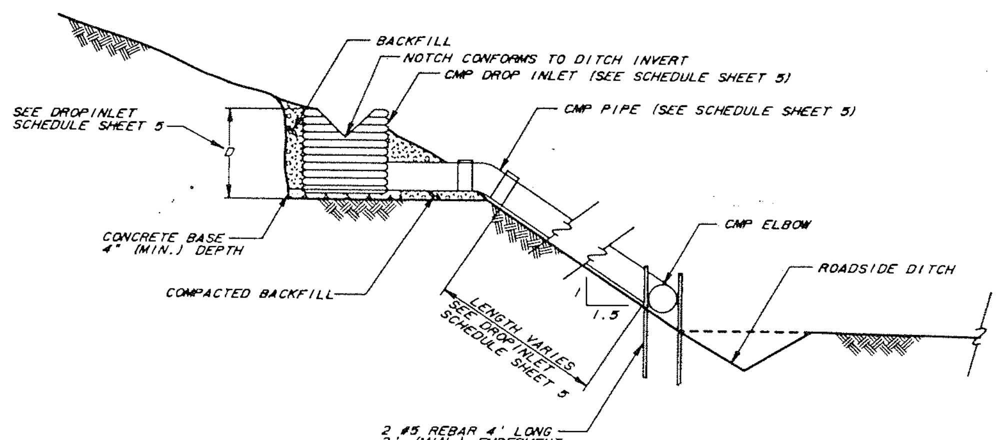
ENVIRONMENTAL SOLUTIONS, INC.

JOB NO.	ESI FILE NUMBER	REVISION
89-977	D-89977-FD023	3
SCALE	CWMI FILE NUMBER	SHEET
AS NOTED	89-03-304.2.1	23



SECTION (A / 5 24)
DROP INLET

0 10 20 FEET
SCALE



DETAIL (1 / 5 24)
DROP INLET AT
CUT SLOPE (TYP.)

0 3 6 FEET
SCALE

REGISTERED PROFESSIONAL ENGINEER
KERRY K. PARKINSON
No. 41021
Exp. MAR 31 1991
CIVIL
STATE OF CALIFORNIA

REV	DATE	DESCRIPTION	DRAWN BY	CHK'D BY
2	1/2/91	ISSUED FOR CONSTRUCTION	KAB	KKP
1	9/24/90	ISSUED FOR BID	KAB	KKP

DRAWN BY K. Barac DESIGNED BY K. Parkinson APPROVED BY RDE

LANDFILL UNIT B-18
CONSTRUCTION PLANS
CWMI-KETTLEMAN HILLS FACILITY
KINGS COUNTY CALIFORNIA

TITLE: DRAINAGE DETAILS

ENVIRONMENTAL SOLUTIONS, INC.

JOB NO.	ESI FILE NUMBER	REVISION
89-977	D-89977-FD024	2
SCALE	CWMI FILE NUMBER	SHEET
AS NOTED	89-03-304.2.1	24

SURVEY CONTROL FOR PHASE I EXCAVATION AND BACKFILL PLAN (SHEET 3)

POINTS OF INTERSECTION

POINT	DESCRIPTION	NORTHING	EASTING	ELEV.
P1	N.W. CORNER TOP PHASE I EXCAVATION	229,070.82	1,700,885.22	846.0
P2	WEST SIDE TOP PHASE I EXCAVATION	228,230.09	1,700,969.19	840.0
P3	S.W. CORNER TOP PHASE I EXCAVATION	227,328.27	1,701,785.03	832.0
P4	S.E.CORNER TOP PHASE I EXCAVATION	227,648.16	1,702,217.87	830.0
P5	N.E.CORNER TOP PHASE I EXCAVATION	229,111.91	1,701,480.39	840.0
P6	N.W. TOE AREA IA	228,868.31	1,701,130.21	731.2
P7	N.W. TOP AREA IA SUMP	228,528.63	1,701,181.87	724.0
P8	N.E. TOP AREA IA SUMP	228,523.45	1,701,294.07	721.0
P9	S.E. TOP AREA IA SUMP	228,433.96	1,701,327.34	718.8
P10	S.E. TOE AREA	228,468.26	1,701,418.16	720.9
P11	N.E. TOE AREA IA	228,878.30	1,701,243.74	730.5
P12	S.W. TOP AREA 1B SUMP	228,171.96	1,701,331.26	724.0
P13	WEST TOE AREA IB	228,073.11	1,701,408.66	726.8
P14	WEST TOE AREA IB	227,893.85	1,701,598.08	731.8
P15	S.W. TOE AREA IB	227,612.06	1,701,818.73	740.8
P16	S.E. TOE AREA IB	227,643.16	1,701,861.42	739.9
P17	EAST TOE AREA IB AT RAMP	228,136.68	1,701,567.80	726.9
P18	EAST TOE AREA IB AT RAMP	228,151.00	1,701,801.75	727.7
P19	N.E. TOE AREA 1B	228,401.18	1,701,452.95	721.2
P20	N.E. TOP AREA 1B SUMP	228,334.73	1,701,350.02	718.6
P21	S.E. TOP AREA IB SUMP	228,246.92	1,701,417.46	721.4
S3	OUTSIDE EDGE BENCH/ROAD	228,409.54	1,700,870.78	843.3
S4	OUTSIDE EDGE BENCH/ROAD	228,202.72	1,700,937.81	841.2
S5	OUTSIDE EDGE BENCH/ROAD	228,023.07	1,701,044.08	840.6
R1	WEST END ACCESS RAMP	227,731.37	1,701,429.30	831.6
R2	S.W. CORNER ACCESS RAMP	227,422.13	1,701,794.16	793.2
R3	S.E. CORNER ACCESS RAMP	227,821.09	1,701,995.23	770.7
R4	EAST SIDE ACCESS RAMP	227,806.27	1,701,896.93	764.0
R5	EAST SIDE ACCESS RAMP	228,151.00	1,701,801.75	727.7

POINT	DESCRIPTION	NORTHING	EASTING	ELEV.
A2	℄ NORTH ACCESS ROAD	229,268.42	1,701,606.92	856.2
A3	℄ NORTH ACCESS ROAD AND CLAY PROCESS ACCESS ROAD	228,812.74	1,701,950.62	780.0
A4	℄ NORTH ACCESS ROAD AND CLAY PROCESS ACCESS ROAD	228,560.82	1,702,136.83	760.0
A6	℄ END NORTH ACCESS ROAD	228,158.44	1,701,781.74	767.4
A8	℄ SOUTH ACCESS ROAD	228,082.19	1,702,685.06	790.0
A10	℄ SOUTH ACCESS ROAD	227,610.79	1,702,236.06	830.0
A12	℄ WELL ACCESS ROAD	227,399.04	1,702,065.83	860.0
B2	L.P.F.L.(1) PHASE I/II BENCH	228,370.78	1,701,601.48	760.8
C1	N.W. TOE CLAY PIT	228,733.64	1,701,619.96	660.0
C2	S.W. TOE CLAY PIT	228,545.82	1,701,821.36	660.0
C3	S.E. TOE CLAY PIT	228,583.21	1,701,856.25	660.0
C4	N.E. TOE CLAY PIT	228,771.02	1,701,654.84	660.0
C6	℄ CLAY PIT ROAD	228,419.26	1,701,950.01	758.5
C7	℄ CLAY PIT ROAD	228,325.50	1,701,829.06	748.9
C9	N.W. CORNER BENCH	228,726.96	1,701,486.56	720.0
C10	N.E. CORNER BENCH	228,896.66	1,701,642.93	720.0
C11	S.E. CORNER BENCH	228,580.09	1,701,982.41	720.0
C12	S.W. CORNER BENCH	228,412.40	1,701,826.04	720.0
C14	INSIDE EDGE N.E. CORNER 780 BENCH	229,064.74	1,701,615.07	779.8
CP4	S.E. CORNER CLAY PROCESS AREA	228,109.13	1,702,593.00	756.0
CP5	WEST SIDE CLAY PROCESS AREA	228,508.82	1,702,152.99	759.2
CP6	WEST SIDE CLAY PROCESS AREA	228,557.56	1,702,191.17	758.3
CP7	WEST SIDE CLAY PROCESS AREA	228,584.17	1,702,182.29	758.5
CP8	WEST SIDE CLAY PROCESS AREA	228,776.69	1,702,070.19	758.4
CP9	WEST SIDE CLAY PROCESS AREA	228,864.14	1,702,209.41	754.3
CP10	NORTH SIDE CLAY PROCESS AREA	229,100.48	1,702,363.31	752.3

CONTROL POINTS

POINT	DESCRIPTION	NORTHING	EASTING	ELEV.
A1	℄ NORTH ACCESS ROAD	229,141.05	1,701,463.93	841.0
A6	℄ END CLAY PROCESS AREA ROAD	228,874.23	1,702,269.34	755.1
A7	℄ END CLAY PROCESS AREA ROAD	228,535.81	1,702,174.20	758.7
A8	℄ END SOUTH ACCESS ROAD	228,605.82	1,702,806.25	750.0
A11	℄ END WELL ACCESS ROAD	227,600.43	1,702,241.26	**
A13	℄ END WELL ACCESS ROAD	227,311.50	1,701,864.04	**
*B1	NORTH END PHASE I/II BENCH	228,852.51	1,701,317.87	764.0
B3	SOUTH END PHASE I/II BENCH	227,628.41	1,701,991.39	66 ±
*B4	WEST END SUMP DIVIDING BERM	228,306.29	1,701,199.02	730.0
B5	EAST END SUMP DIVIDING BERM	228,441.75	1,701,462.05	730.0
C5	℄ CLAY PIT ROAD	228,554.36	1,702,081.13	760.0
*C8	℄ CLAY PIT ROAD AT BENCH	228,507.82	1,701,710.34	720.0
C13	INSIDE EDGE END 780 BENCH	228,796.26	1,701,902.96	779.6
*C15	INSIDE EDGE END 780 BENCH	228,980.66	1,701,545.96	779.6
CP1	CONTROL POINT CLAY PROCESS GRADING	228,817.15	1,702,661.52	750.0
CP2	CLAY PROCESS ACCESS ROAD	228,746.35	1,702,839.52	750.0
CP3	EAST SIDE CLAY PROCESS AREA	228,610.32	1,702,786.77	750.0
CP11	NORTH SIDE CLAY PROCESS AREA	229,104.44	1,702,497.92	750.5
S1	OUTSIDE EDGE BENCH/ROAD	228,545.75	1,700,889.50	843.5
S2	OUTSIDE EDGE BENCH/ROAD	227,946.98	1,701,158.74	839.0
T1	END RAMP LINER TRENCH	228,103.67	1,701,614.80	729.3
T2	END RAMP LINER TRENCH	227,832.45	1,701,848.36	758.0
T3	END RAMP LINER TRENCH	227,648.13	1,701,992.58	787.3
T4	END RAMP LINER TRENCH	227,767.96	1,701,418.47	831.8±
*T5	SLOPE BREAK IN LINER TRENCH	227,747.43	1,701,442.83	831.6
*T6	END TOP LINER TRENCH	229,100.93	1,701,318.44	837.9
*T7	END TOP LINER TRENCH	227,538.02	1,702,071.53	821.6
V1	START AREA 1A VADOSE TRENCH	228,871.27	1,701,190.75	728.2
V2	START AREA IIA VADOSE TRENCH	227,636.62	1,701,837.36	737.7

CURVE DATA

CURVE NO.	DESCRIPTION	LOCATION OF P.I. NORTHING	LOCATION OF P.I. EASTING	D	R	L	T
1	N.W. CORNER TOP PHASE I EXCAVATION	229,070.82	1,700,885.22	93°05'58"	49.80'	80.92'	52.57'
2	WEST SIDE TOP PHASE I EXCAVATION	228,230.09	1,700,969.19	34°22'42"	49.80'	29.88'	15.41'
3	S.W. CORNER TOP PHASE I EXCAVATION	227,328.27	1,701,785.03	84°46'48"	49.80'	73.69'	45.46'
4	OUTSIDE EDGE BENCH/ROAD	228,545.75	1,700,889.50	14°52'26"	50.00'	12.98'	6.53'
5	OUTSIDE EDGE BENCH/ROAD	228,409.54	1,700,870.78	25°48'23"	110.00'	49.54'	25.20'
6	OUTSIDE EDGE BENCH/ROAD	228,202.72	1,700,937.81	12°38'04"	110.00'	24.19'	12.15'
7	OUTSIDE EDGE BENCH/ROAD	228,023.07	1,701,044.08	25°50'51"	110.00'	49.62'	25.24'
8	OUTSIDE EDGE BENCH/ROAD	227,946.98	1,701,158.74	15°00'10"	50.00'	13.09'	6.58'
9	N.W. TOE AREA IA	228,868.31	1,701,130.21	96°30'07"	50.00'	84.21'	56.02'
10	N.E. TOE AREA IA	228,876.30	1,701,243.74	61°33'34"	50.00'	53.72'	29.78'
11	S.W. TOP DIVIDING BERM AREA IA	228,306.29	1,701,199.02	115°48'46"	50.00'	101.06'	79.75'
12	S.E. TOE AREA IA	228,468.26	1,701,418.16	92°27'50"	50.00'	80.88'	52.28'
13	N.W. TOP DIVIDING BERM AREA IB	228,306.29	1,701,199.02	109°10'55"	50.00'	95.28'	70.33'
14	N.E. TOE AREA IB	228,401.18	1,701,452.95	92°06'05"	50.00'	80.37'	51.87'
15	S.W.TOE AREA IB	227,625.57	1,701,806.15	63°49'04"	50.00'	55.69'	31.13'
16	S.E. TOE AREA IB	227,657.27	1,701,853.03	60°24'37"	50.00'	52.72'	29.11'
17	INSIDE EDGE ACCESS RAMP	227,631.97	1,701,956.61	72°43'17"	50.00'	63.46'	36.81'
18	OUTSIDE EDGE ACCESS RAMP	227,422.13	1,701,796.16	85°06'54"	50.00'	74.28'	46.01'
19	N.W. TOE CLAY PIT	228,733.64	1,701,619.96	90°00'00"	25.00'	39.27'	25.00'
20	N.E. TOE CLAY PIT	228,771.02	1,701,654.84	90°00'00"	25.00'	39.27'	25.00'
21	S.W. TOE CLAY PIT	228,545.32	1,701,821.36	90°00'00"	25.00'	39.27'	25.00'
22	S.E. TOE CLAY PIT	228,583.21	1,701,856.25	90°00'00"	25.00'	39.27'	25.00'
23	℄ CLAY PIT ROAD	228,419.26	1,701,950.01	8°03'34"	50.00'	7.03'	3.52'
24	℄ CLAY PIT ROAD	228,325.50	1,701,829.06	94°38'12"	40.00'	66.05'	43.35'
25	℄ N.E. CORNER 780 BENCH	229,064.74	1,701,615.07	90°00'00"	50.00'	78.54'	50.00'
26	℄ NORTH ACCESS ROAD	229,111.91	1,701,480.39	37°44'41"	112.00'	73.78'	38.29'
27	℄ NORTH ACCESS ROAD	229,268.42	1,701,606.92	73°17'51"	77.50'	126.05'	84.09'
28	EDGE ACCESS ROAD	228,836.32	1,701,967.28	63°53'36"	50.00'	55.76'	31.18'
29	EDGE ACCESS ROAD	228,800.68	1,701,983.72	115°33'06"	50.00'	100.84'	79.32'
30	EDGE ACCESS ROAD	228,510.34	1,702,128.69	51°54'40"	50.00'	45.30'	24.34'
31	EDGE ACCESS ROAD	228,184.53	1,701,798.08	110°51'46"	50.00'	96.75'	72.56'
32	EDGE ACCESS ROAD	228,132.42	1,701,795.46	69°08'14"	50.00'	60.33'	34.46'
33	S.E. CORNER PHASE I/II BENCH	227,666.17	1,702,040.33	72°43'18"	50.00'	63.46'	36.81'
34	℄ ACCESS ROAD	227,618.30	1,702,232.32	99°37'31"	100.00'	173.88'	118.38'
35	℄ ACCESS ROAD	227,613.22	1,702,234.86	70°24'50"	200.00'	245.79'	141.12'
36	℄ ACCESS ROAD	227,636.57	1,702,257.26	9°57'39"	400.00'	69.54'	34.86'
37	℄ ACCESS ROAD	228,082.19	1,702,685.06	30°48'04"	400.00'	215.03'	110.18'
38	EAST SIDE CLAY PROCESS AREA	228,761.39	1,702,862.78	130°00'03"	30.00'	68.07'	64.34'
39	NORTH SIDE CLAY PROCESS AREA	229,100.49	1,702,363.31	70°57'28"	50.00'	61.92'	35.64'
40	WEST SIDE CLAY PROCESS AREA	228,900.37	1,702,300.83	45°39'56"	50.00'	39.86'	21.05'
41	SOUTH SIDE CLAY PROCESS AREA	228,109.13	1,702,593.00	111°06'10"	50.00'	96.98'	72.94'

89-977 (8/24/90)

(1) L.P.F.L. - LOW POINT OF FLOW LINE

* LOCATION GIVEN IN TABLE SUPERSEDES THE LOCATION ON THE DRAWING.

** MATCH GRADE AT PERIMETER BENCH/ROAD

REGISTERED PROFESSIONAL ENGINEER
TERRY K. PARKINSON
No. 41021
Exp. MAR 31 1991
CIVIL
STATE OF CALIFORNIA

NO.	DATE	DESCRIPTION	DRAWN BY	APPR. BY
2	1/2/91	ISSUED FOR CONSTRUCTION	J.A.	
1	9/24/90	ISSUED FOR BID	RVH	
0	7/31/90	ISSUED FOR PERMITTING	MD	KKP

LANDFILL UNIT B-18
CONSTRUCTION PLANS
CWMI-KETTLEMAN HILLS FACILITY
KINGS COUNTY — CALIFORNIA

SURVEY CONTROL

ENVIRONMENTAL SOLUTIONS, INC.

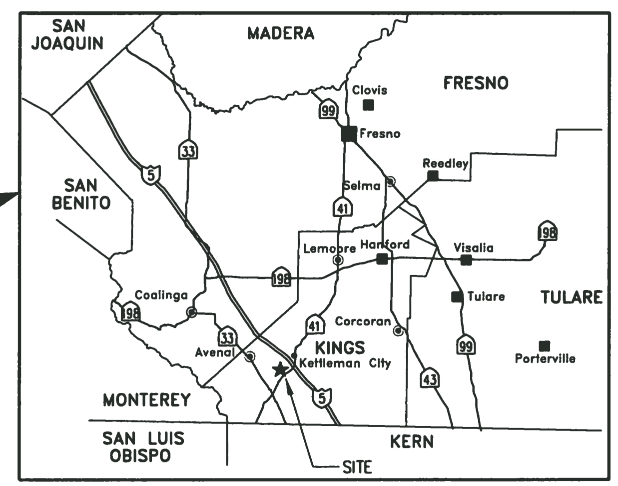
JOB NO.	FILE NUMBER	REVISION
89-977	D-89977-FD025	2
SCALE		SHEET
AS NOTED	89-03-304.1.2	25

APPENDIX A.2
PHASE III AND FINAL CLOSURE DRAWINGS

CONSTRUCTION DRAWINGS FOR THE B-18 CLASS I LANDFILL PHASE III EXPANSION AND FINAL CLOSURE

KETTLEMAN HILLS FACILITY
KINGS COUNTY, CALIFORNIA
NOVEMBER 2008

PREPARED FOR:
CHEMICAL WASTE MANAGEMENT



SHEET INDEX

GENERAL NOTES

1. THESE DRAWINGS AND SPECIFICATIONS SHALL BE USED TOGETHER. IF A DIFFERENCE OCCURS, THE CWM PROJECT MANAGER SHALL DETERMINE WHICH TAKES PRECEDENCE.
2. THE LANDFILL B-18 CONSTRUCTION WILL OCCUR WITHIN AREAS APPROVED BY VARIOUS GOVERNMENT AGENCIES. NO WORK SHALL OCCUR OUTSIDE OF THE CONSTRUCTION AREAS SHOWN ON THE DRAWINGS WITHOUT SPECIFIC APPROVAL OF THE CWM PROJECT MANAGER
3. PRIOR TO COMMENCING ANY CUT OR FILL, OR IN ANY WAY DISTURBING THE EXISTING LAND CONTOURS, CONTRACTOR SHALL VERIFY THE ACCURACY OF THE CONTOUR ELEVATIONS SHOWN IN THE DRAWINGS.

LEGEND

- STRUCTURAL FILL
- GENERAL FILL
- COMPACTED CLAY LINER
- RIP-RAP
- CONCRETE
- OPERATIONS LAYER
- SUBGRADE
- HDPE GEOMEMBRANE
- GEOTEXTILE
- GEOCOMPOSITE
- PROPERTY LINE
- 10' CONTOUR
- 2' CONTOUR
- FLOWLINE
- LIMIT OF GRADING

ABBREVIATIONS

A.C.	ASPHALT CONCRETE
C	CENTER LINE
CMP	CORRUGATED METAL PIPE
CWM	CHEMICAL WASTE MANAGEMENT
EL	ELEVATION
HDPE	HIGH DENSITY POLYETHYLENE
H.P.	HIGH POINT
MIN.	MINIMUM
TYP.	TYPICAL
Ø	DIAMETER

KEY

A — SECTION (ALPHA) OR DETAIL (NUMERIC) IDENTIFICATION
C-4 — SHEET NO. WHERE SECTION OR DETAIL IS CALLED OUT
C-5 — SHEET NO. WHERE SECTION OR DETAIL IS SHOWN

PLANS PREPARED UNDER THE SUPERVISION OF:

REGISTERED PROFESSIONAL ENGINEER RYAN HILLMAN C 71988 CIVIL STATE OF CALIFORNIA

8-29-11

RE-ISSUED FOR PERMITTING

REV	DATE	DESCRIPTION	DESIGN	DRAWN	REVIEW
A	9/16/2008	ISSUED FOR PERMITTING MEETING	KJK	KJK	SGS
B	11/04/2008	ISSUED FOR PERMITTING	KJK	KJK	SGS
C	5/2/2011	RE-ISSUED FOR PERMITTING	KJK	KJK	RH

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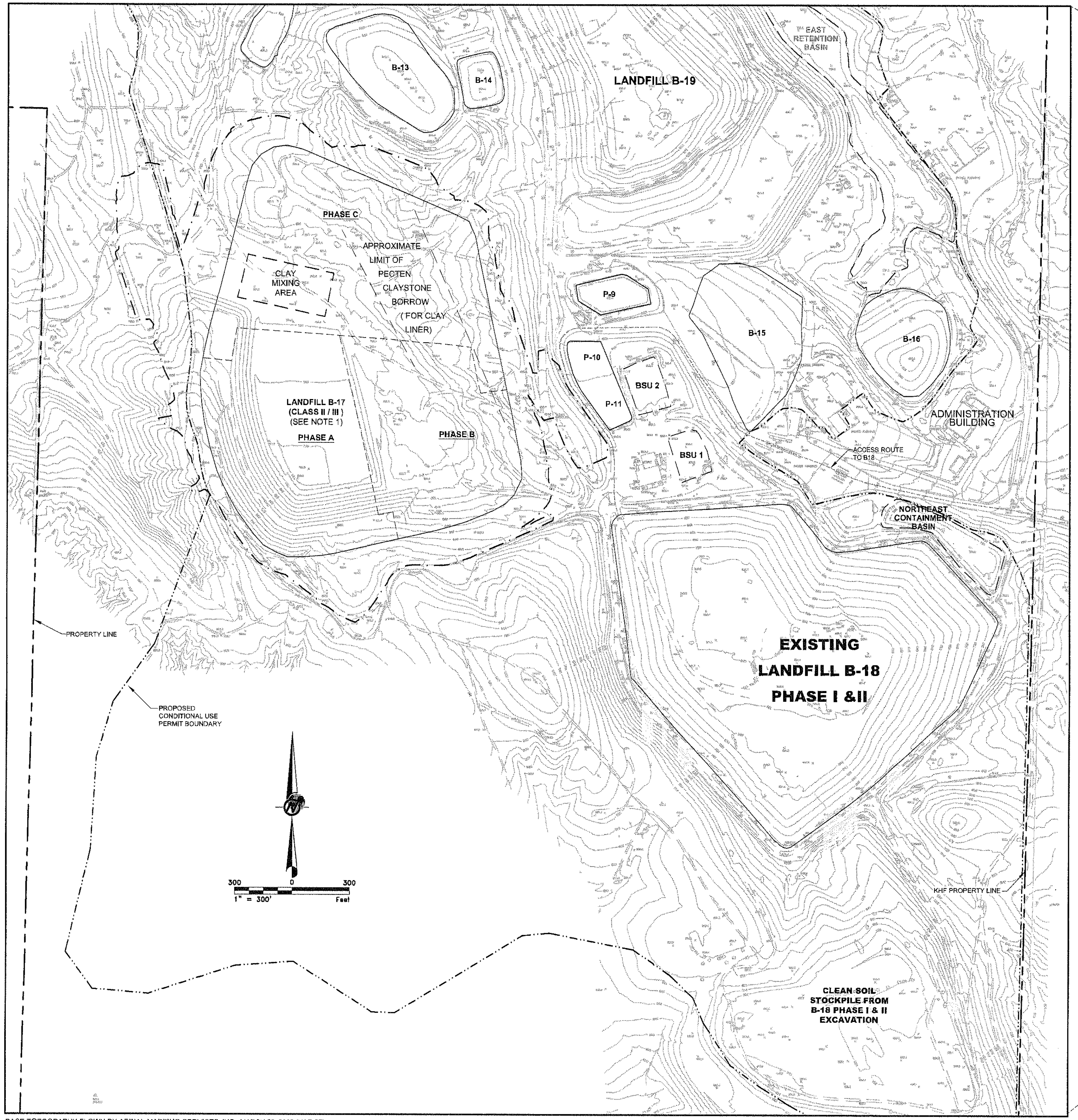
(559) 386-9711

B-18 CLASS I LANDFILL PHASE III EXPANSION AND FINAL CLOSURE

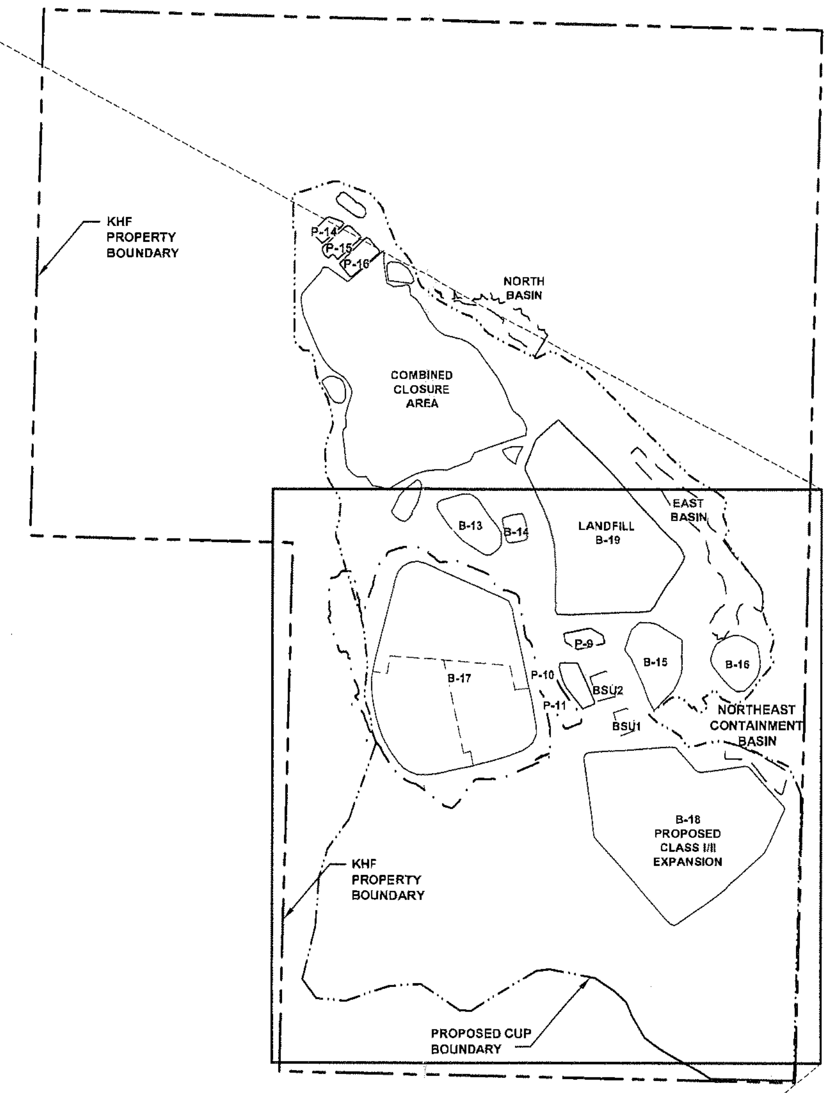
TITLE SHEET

SHEET NUMBER

T-1



BASE TOPOGRAPHY FLOWN BY AERIAL MAPPING SERVICES, INC., MARCH 28, 2008 (NAD 27).



NOTE

1. SOIL EXCAVATED FROM WITHIN LANDFILL B-17 MAY BE UTILIZED FOR STRUCTURAL FILL, CLAY LINER, OPERATIONS LAYER, DAILY COVER AND/OR FINAL COVER.

REV	DATE	DESCRIPTION	DESIGN	DRAWN	REVIEW
A	9/16/2008	ISSUED FOR PERMITTING MEETING	KJK	KJK	SGS
B	11/04/2008	ISSUED FOR PERMITTING	KJK	KJK	SGS

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B-18 CLASS I LANDFILL PHASE III EXPANSION AND FINAL CLOSURE

SITE PLAN

PLANS PREPARED UNDER THE SUPERVISION OF:

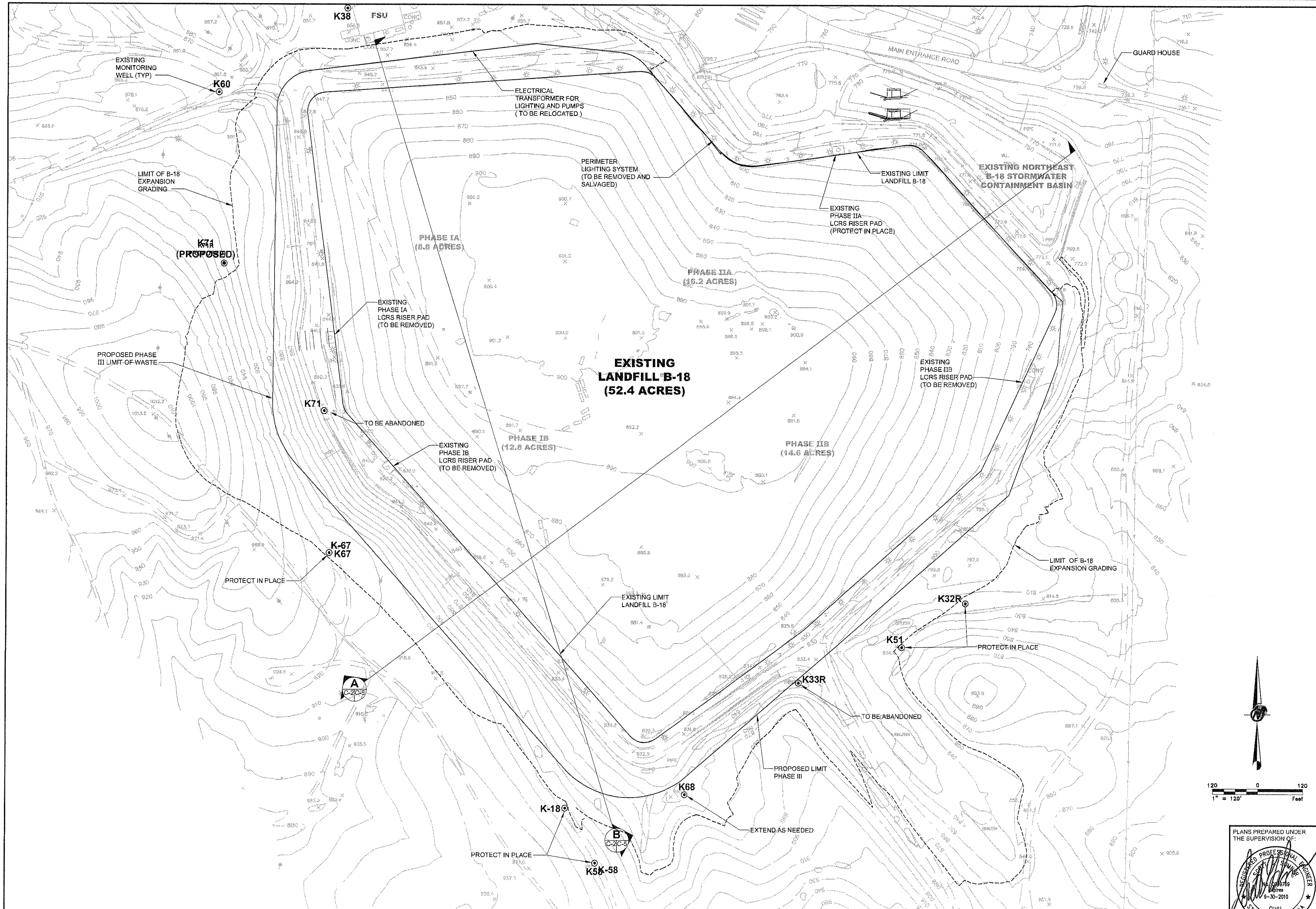
REGISTERED PROFESSIONAL ENGINEER
SCOTT G. SOMMER
Expires 9-30-2010
CIVIL
STATE OF CALIFORNIA

ISSUED FOR PERMITTING

SHEET NUMBER

C-1

2 OF 11 SHEETS



BASE TOPOGRAPHY FLOWN BY AERIAL MAPPING SERVICES, INC., MARCH 28, 2008 (NAD 27).

ISSUED FOR PERMITTING

REV	DATE	DESCRIPTION	DESIGN	DRAWN	REVIEW
A	6/4/2008	ISSUED FOR MEETING	KJK	KJK	SGS
B	9/15/2008	ISSUED FOR PERMITTING MEETING	KJK	KJK	SGS
C	11/04/2008	ISSUED FOR PERMITTING	KJK	KJK	SGS

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B-18 CLASS I LANDFILL PHASE III EXPANSION AND FINAL COVER

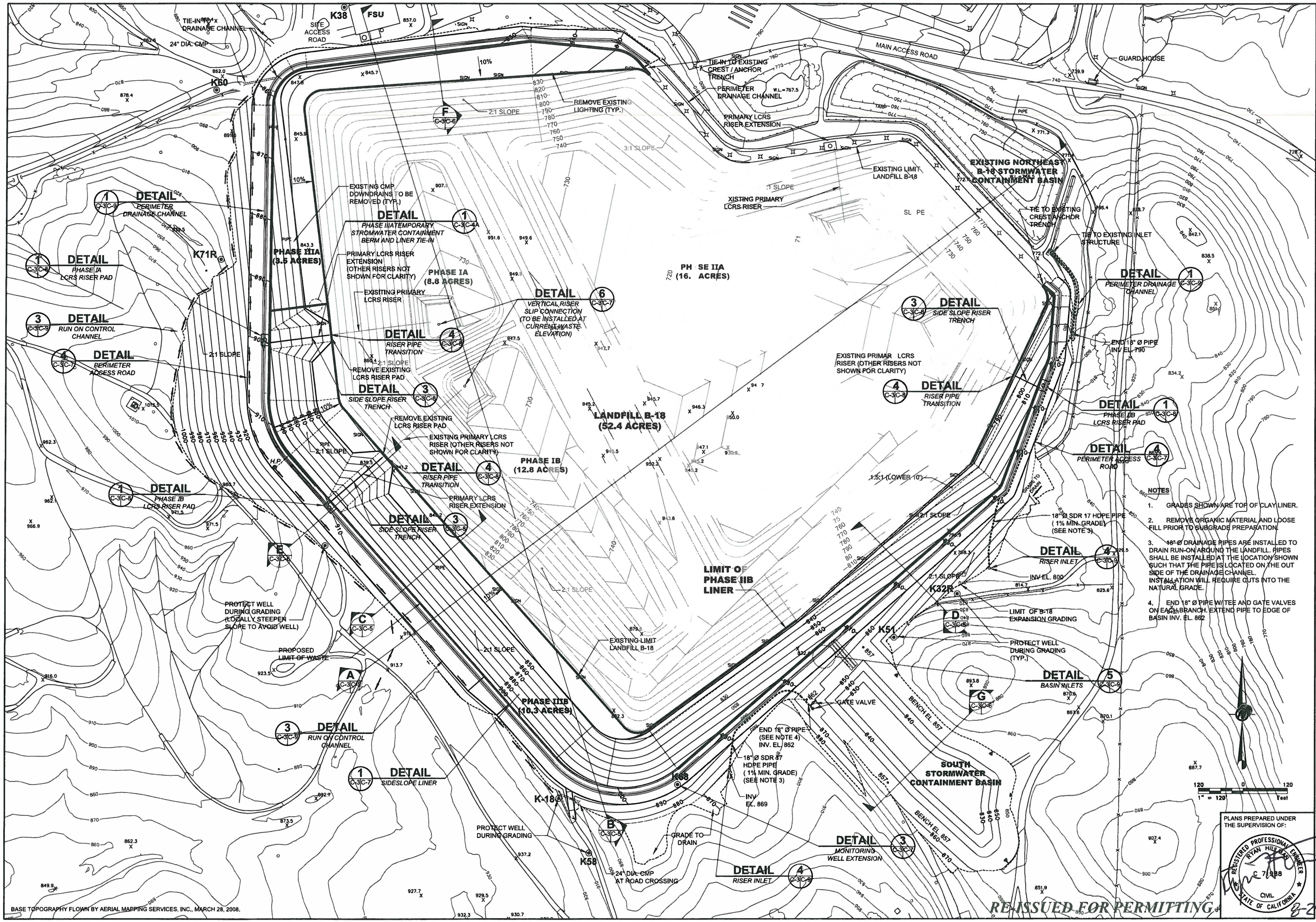
EXISTING CONDITIONS (AS OF MARCH 28, 2008)

PLANS PREPARED UNDER THE SUPERVISION OF:

SHEET NUMBER

C-2

3 OF 11 SHEETS



NOTES

1. GRADES SHOWN ARE TOP OF CLAY LINER.
2. REMOVE ORGANIC MATERIAL AND LOOSE FILL PRIOR TO SUBGRADE PREPARATION.
3. 18" Ø DRAINAGE PIPES ARE INSTALLED TO DRAIN RUN-ON AROUND THE LANDFILL. PIPES SHALL BE INSTALLED AT THE LOCATION SHOWN SUCH THAT THE PIPE IS LOCATED ON THE OUT SIDE OF THE DRAINAGE CHANNEL. INSTALLATION WILL REQUIRE CUTS INTO THE NATURAL GRADE.
4. END 18" Ø PIPE W/ TEE AND GATE VALVES ON EACH BRANCH. EXTEND PIPE TO EDGE OF BASIN INV. EL. 862

REV	DATE	DESCRIPTION	DESIGN	DRAWN	REVIEW
A	9/16/2008	ISSUED FOR PERMITTING MEETING	KJK	KJK	SGS
B	11/04/2008	ISSUED FOR PERMITTING	KJK	KJK	SGS
C	8/10/2011	RE-ISSUED FOR PERMITTING	KJK	KJK	RH

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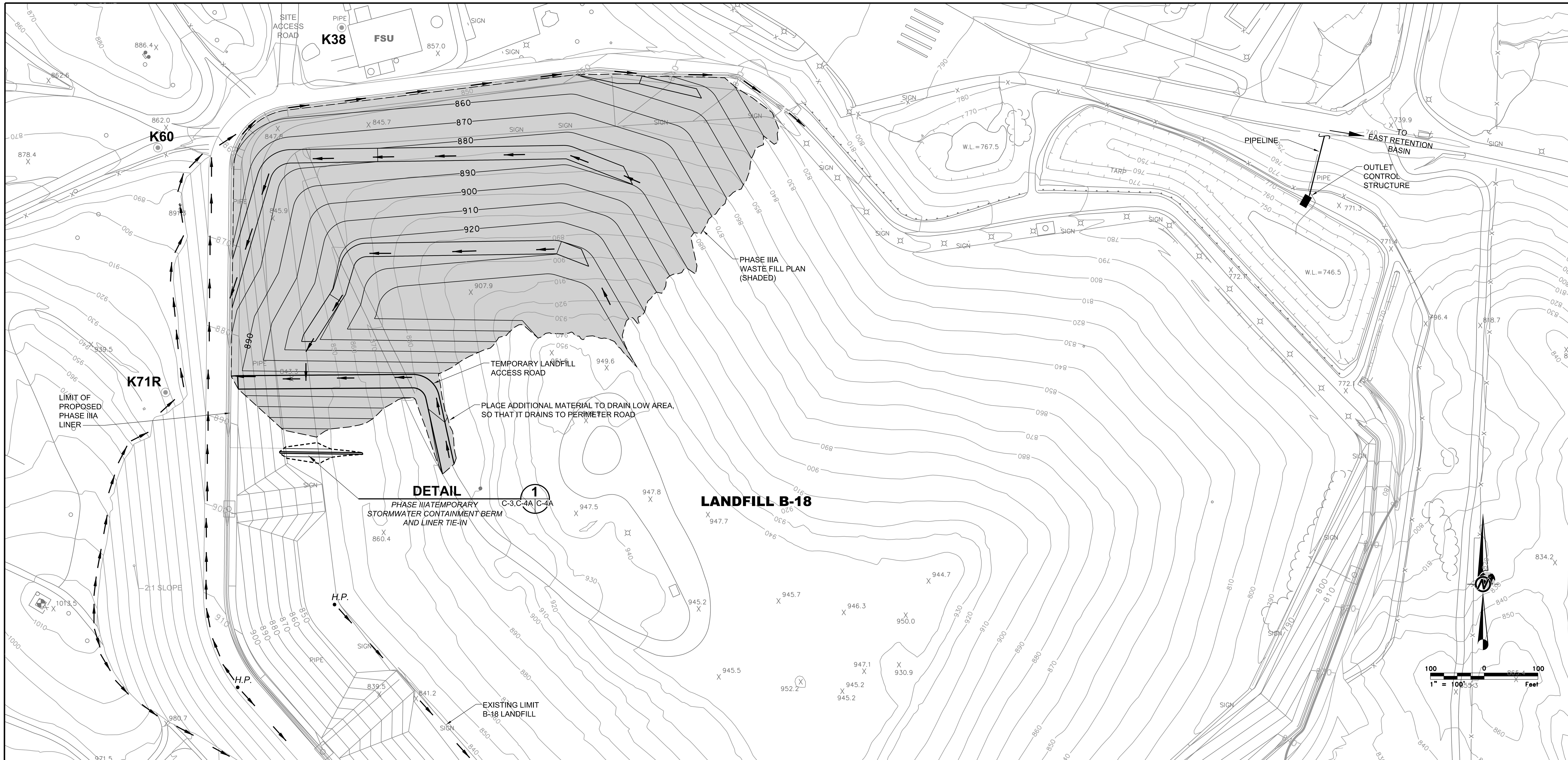
B-18 CLASS I LANDFILL PHASE III EXPANSION AND FINAL CLOSURE

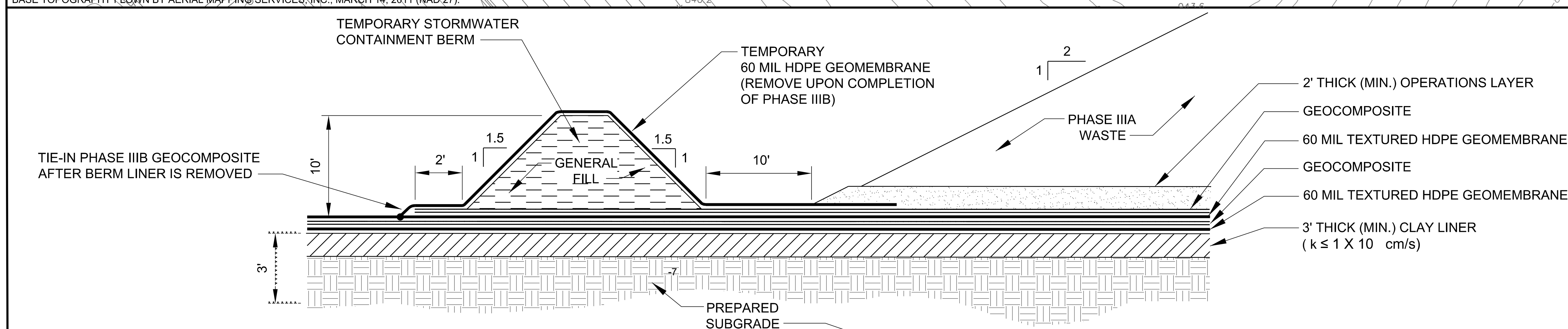
BASE LINER PLAN

PLANS PREPARED UNDER THE SUPERVISION OF:
REGISTERED PROFESSIONAL ENGINEER RYAN HILLMAN C 71888 CIVIL STATE OF CALIFORNIA
8-25-11

RE-ISSUED FOR PERMITTING

SHEET NUMBER
C-3
4 OF 11 SHEETS





DETAIL 1

C-3, C-4A | C-4A

PHASE IIIATEMPORARY STORMWATER CONTAINMENT BERM AND LINER TIE-IN

NOT TO SCALE

NOTES:

1. GRADES SHOWN FOR PHASE IIIA (EXCEPT TEMPORARY WASTE SLOPE)ARE TO TOP OF FINAL COVER.
2. PHASE IIIB GRADING SHOWN AS TOP OF PROPOSED LINER.
3. SOIL BERMS ON DRAINAGE BENCH, COVER ACCESS ROAD AND SOUTH PERIMETER ROAD NOT SHOWN FOR CLARITY.

RE-ISSUED FOR PERMITTING

PLANS PREPARED UNDER THE SUPERVISION OF:

REGISTERED PROFESSIONAL ENGINEER RYAN HILL C 71988 CIVIL STATE OF CALIFORNIA

REV	DATE	DESCRIPTION	DESIGN	DRAWN	REVIEW
C	8/10/2011	RE-ISSUED FOR PERMITTING	KJK	KJK	RH

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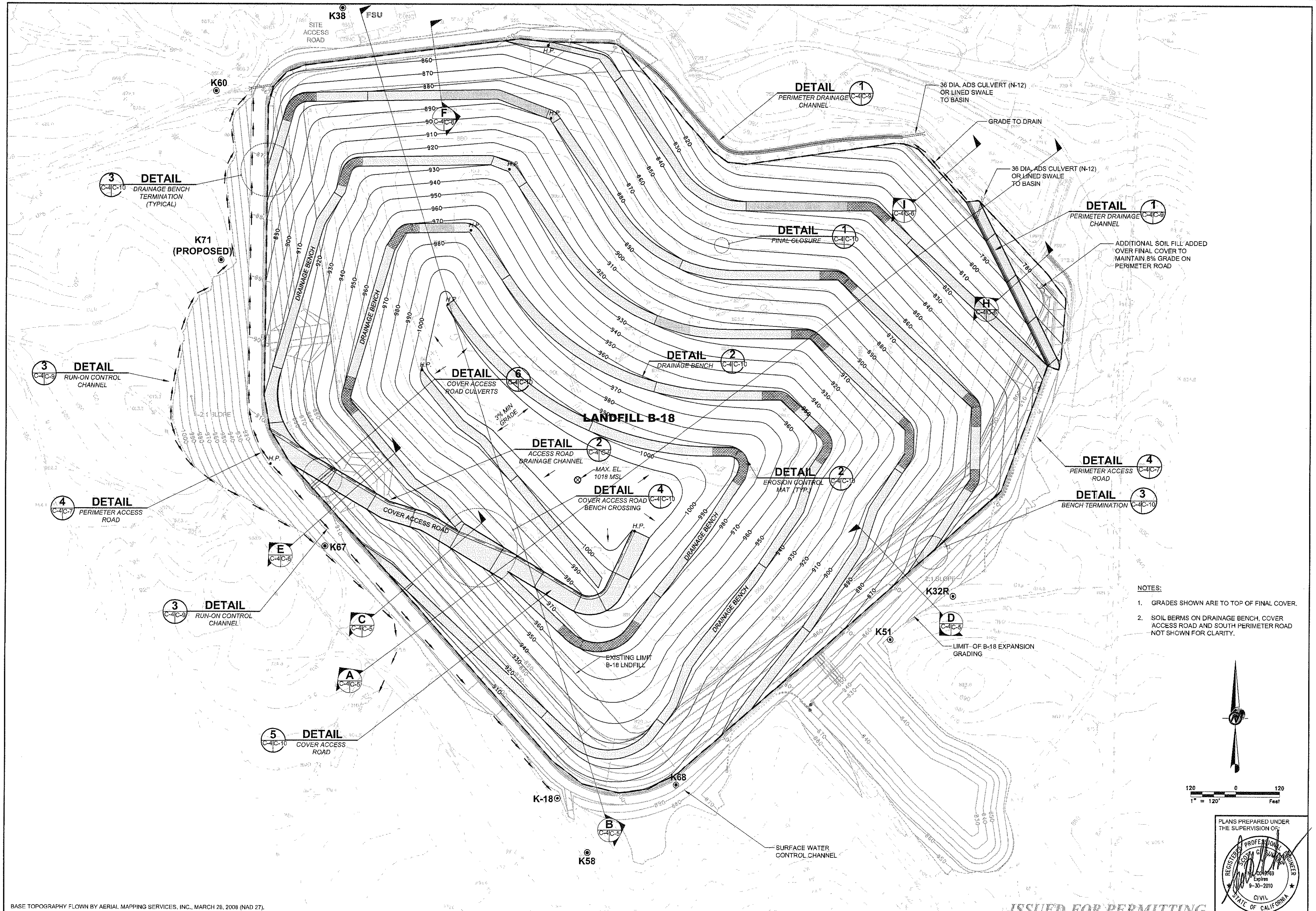
B-18 CLASS I LANDFILL PHASE III EXPANSION AND FINAL CLOSURE

PHASE IIIA FILL PLAN

SHEET NUMBER

C-4A



NOTES:

1. GRADES SHOWN ARE TO TOP OF FINAL COVER.
2. SOIL BERMS ON DRAINAGE BENCH, COVER ACCESS ROAD AND SOUTH PERIMETER ROAD NOT SHOWN FOR CLARITY.

BASE TOPOGRAPHY FLOWN BY AERIAL MAPPING SERVICES, INC., MARCH 26, 2008 (NAD 27).

PLANS PREPARED UNDER THE SUPERVISION OF:

ISSUED FOR PERMITTING

REV	DATE	DESCRIPTION	DESIGN	DRAWN	REVIEW
A	9/16/2008	ISSUED FOR PERMITTING MEETING	KJK	KJK	SGS
B	11/04/2008	ISSUED FOR PERMITTING	KJK	KJK	SGS

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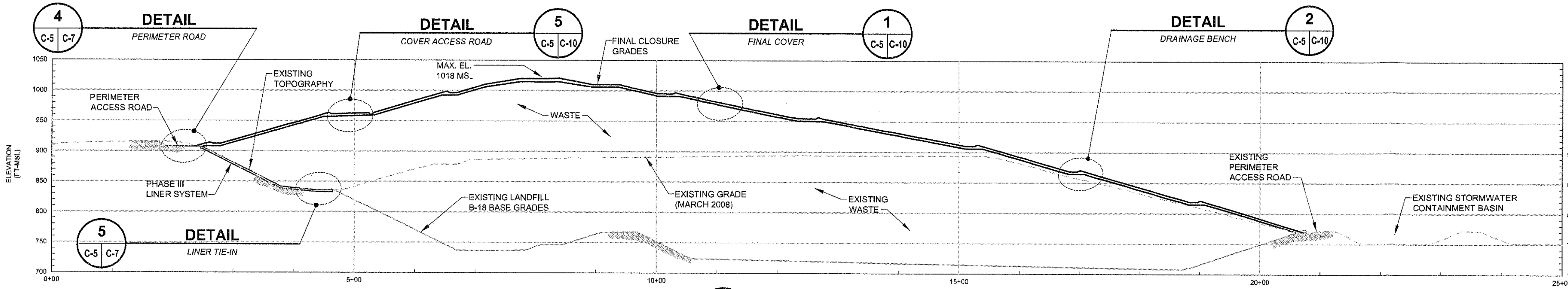
B-18 CLASS I LANDFILL
PHASE III EPANSION AND FINAL CLOSURE

FINAL CLOSURE PLAN

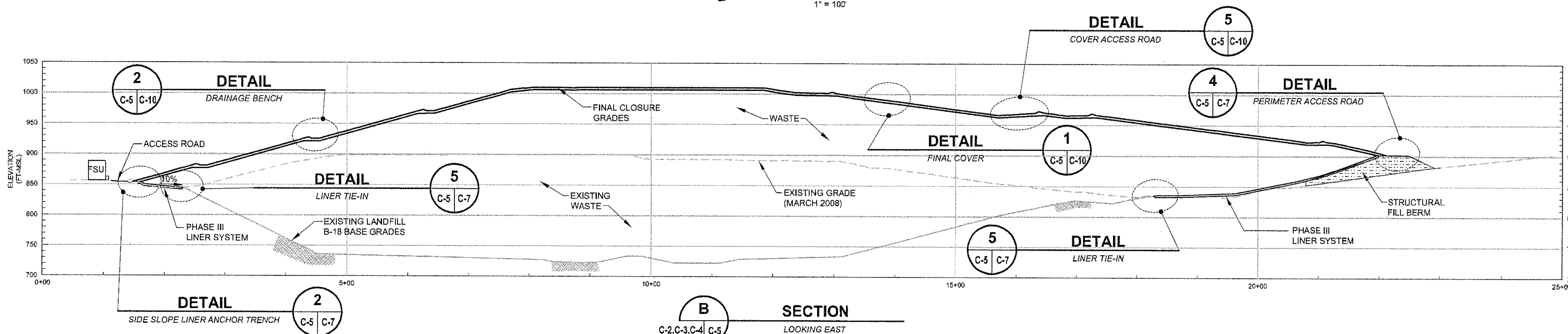
SHEET NUMBER

C-4

5 OF 11 SHEETS

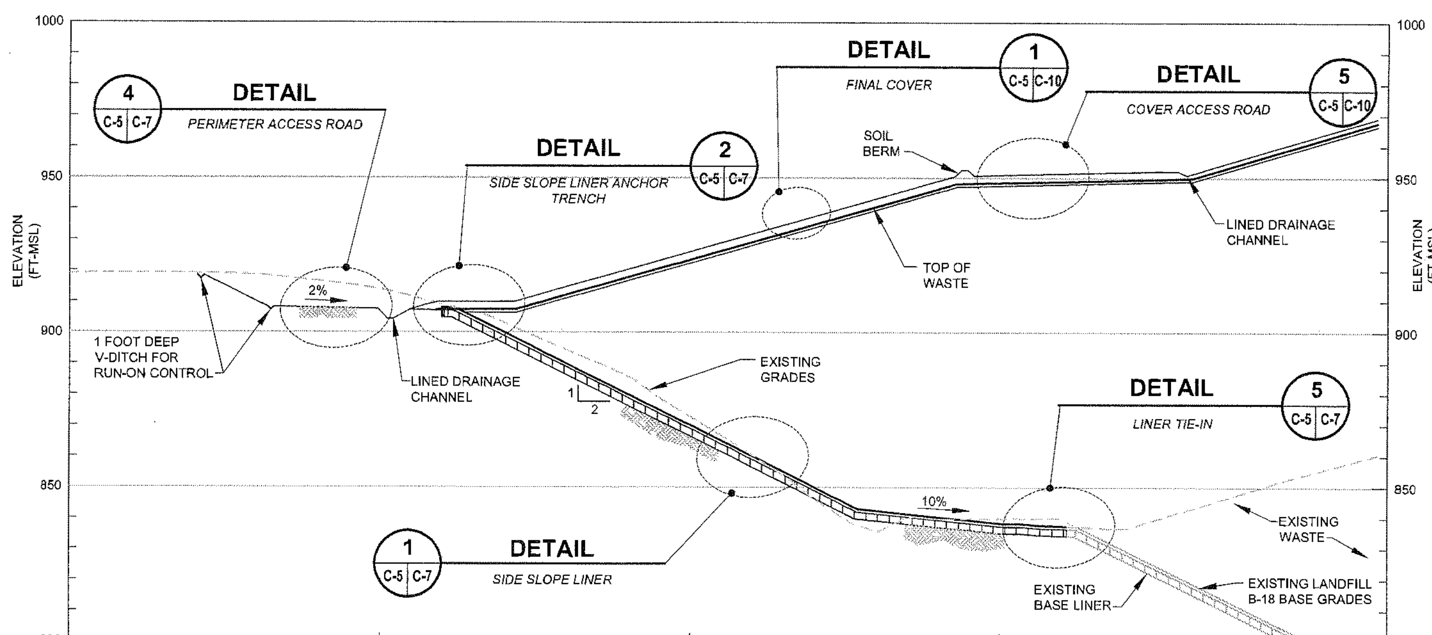


SECTION A (C-2,C-3,C-4 / C-5)
LOOKING NORTH
1" = 100'

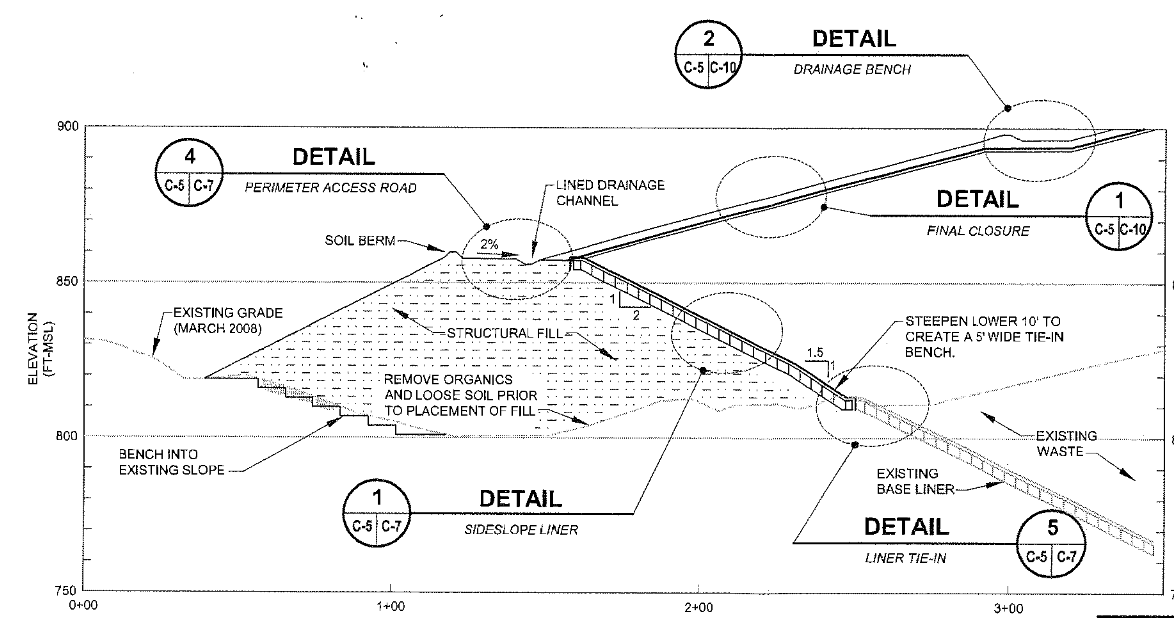


DETAIL 2 (C-5 / C-7)
SIDE SLOPE LINER ANCHOR TRENCH

SECTION B (C-2,C-3,C-4 / C-5)
LOOKING EAST
1" = 100'



SECTION C (C-3,C-4 / C-5)
LOOKING NORTH
PHASE III WESTERN SIDE
1" = 30'



SECTION D (C-3,C-4 / C-5)
LOOKING SOUTH WEST
PHASE III SOUTHERN BERM
1" = 30'

PLANS PREPARED UNDER THE SUPERVISION OF:

REGISTERED PROFESSIONAL ENGINEER, C046789, Expires 9-30-2010, CIVIL, STATE OF CALIFORNIA

ISSUED FOR PERMITTING

REV	DATE	DESCRIPTION	DESIGN	DRAWN	REVIEW
A	9/16/2008	ISSUED FOR PERMITTING MEETING	KJK	KJK	SGS
B	11/04/2008	ISSUED FOR PERMITTING	KJK	KJK	SGS

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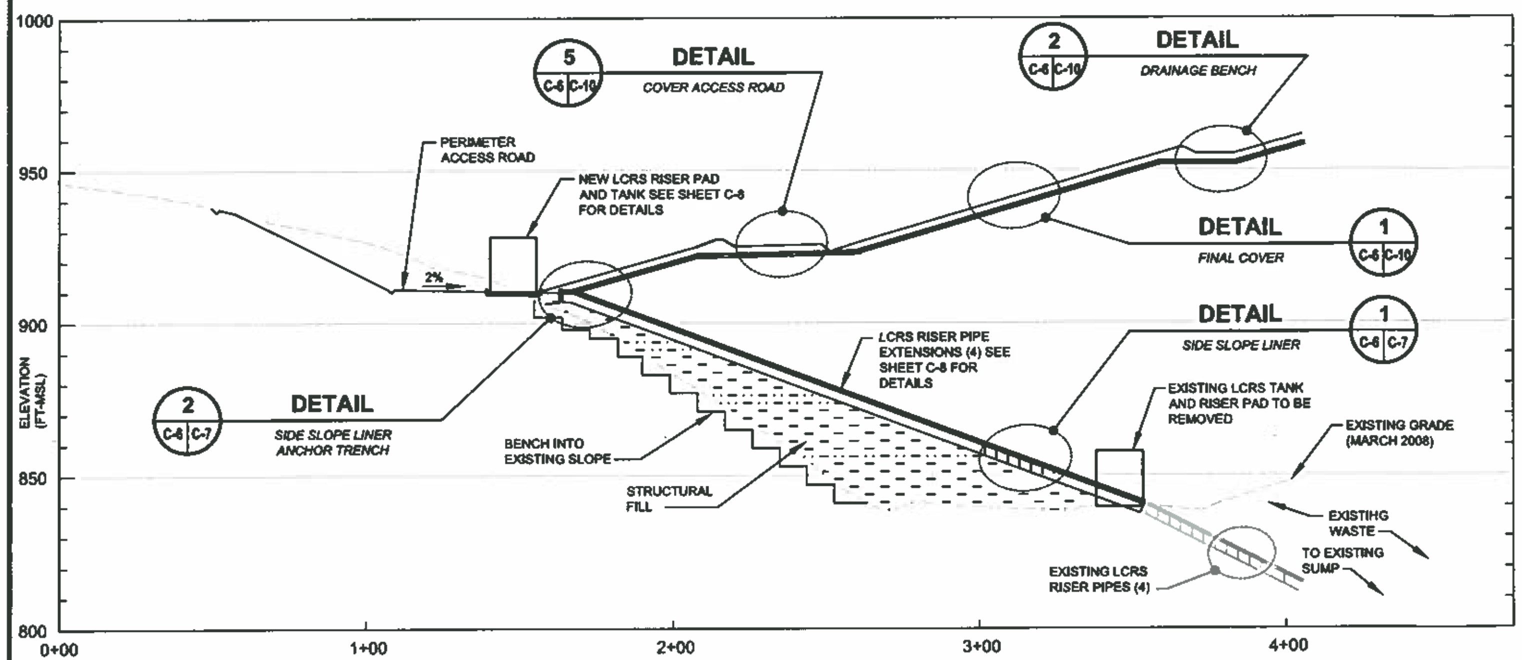
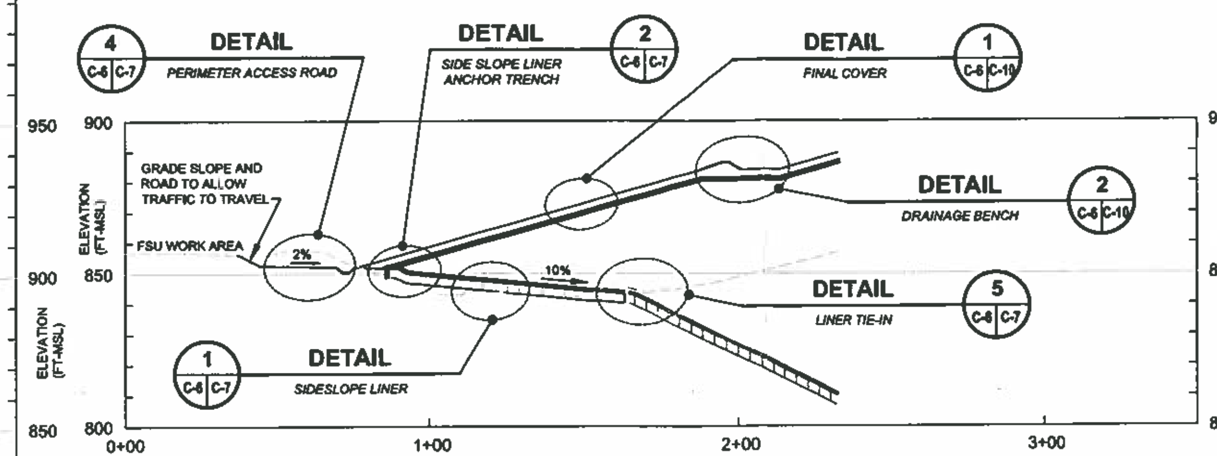
(559) 386-9711

B-18 CLASS I LANDFILL
PHASE III EXPANSION AND FINAL CLOSURE
CROSS SECTIONS A TO D

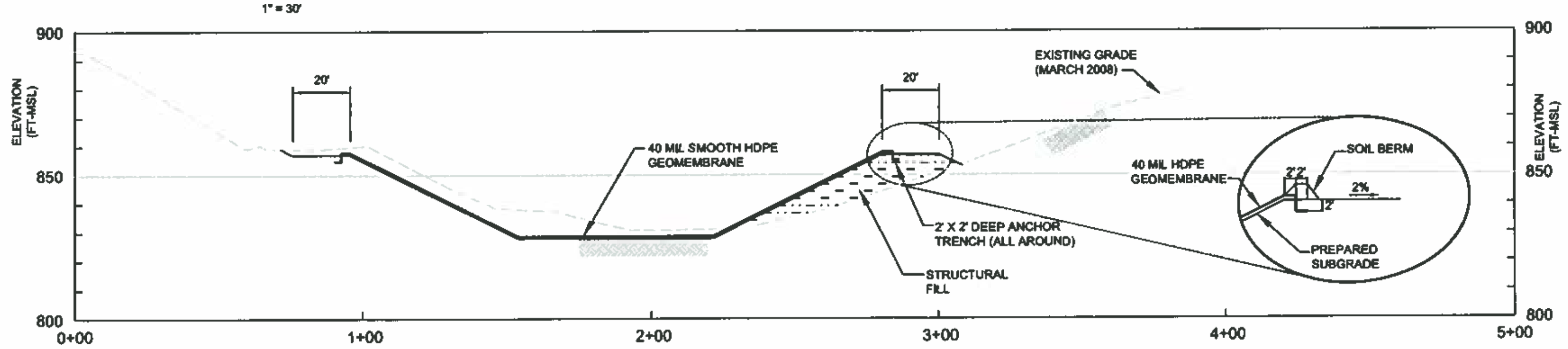
SHEET NUMBER
C-5
6 OF 11 SHEETS



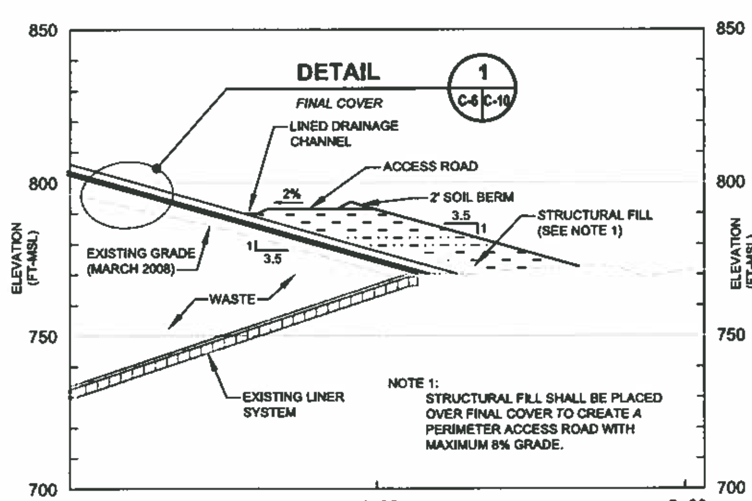
SECTION E (C-3, C-4 | C-6)
LOOKING NORTH
LCRS RISER PIPES
1" = 30'



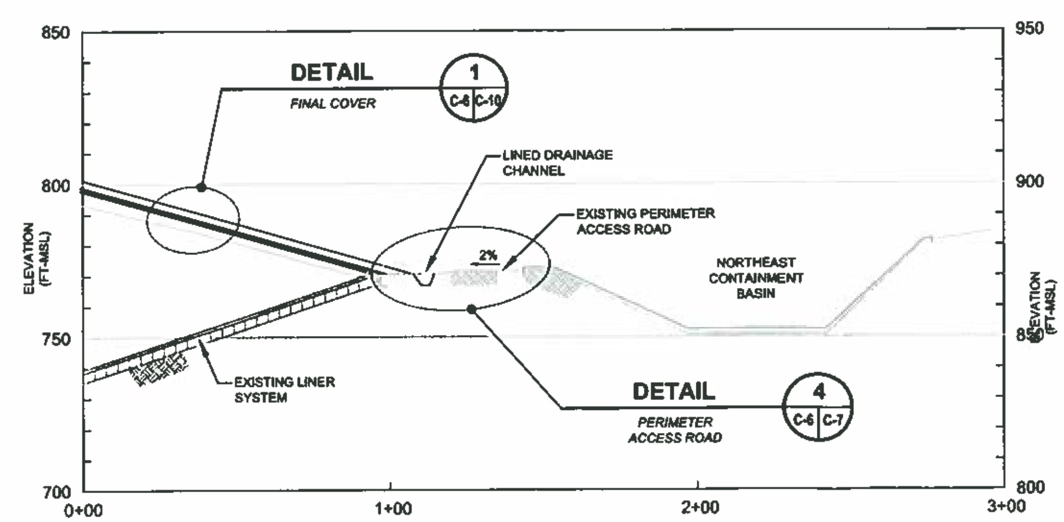
SECTION F (C-3, C-4 | C-6)
LOOKING EAST
PHASE III NORTH SIDE
1" = 30'



SECTION G (C-3 | C-6)
LOOKING NORTH
SOUTH STORMWATER CONTAINMENT BASIN
1" = 30'



SECTION H (C-4 | C-6)
LOOKING NORTH
NORTHEAST ACCESS ROAD
1" = 30'



SECTION I (C-4 | C-6)
LOOKING NORTH
EXISTING NORTHEAST PERIMETER ROAD AND STORMWATER CONTAINMENT BASIN
1" = 30'

ISSUED FOR PERMITTING

PLANS PREPARED UNDER THE SUPERVISION OF:
(Registered Professional Engineer seal, State of California, Civil)

REV	DATE	DESCRIPTION	DESIGN	DRAWN	REVIEW
A	9/18/2008	ISSUED FOR PERMITTING MEETING	KJK	KJK	BGS
B	11/04/2008	ISSUED FOR PERMITTING	KJK	KJK	BGS
C	FEB 2010	REVISED PER RWQCB/DTSC COMMENTS	KJK	KJK	BGS

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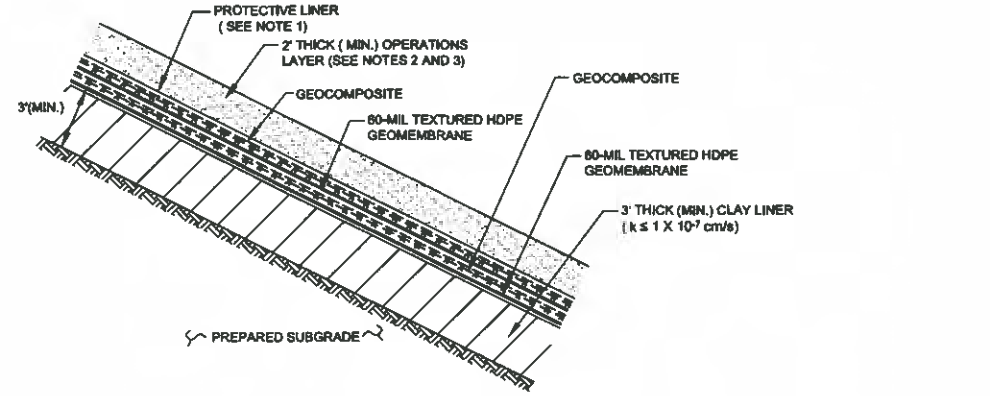
B-18 CLASS I LANDFILL PHASE III EXPANSION AND FINAL CLOSURE

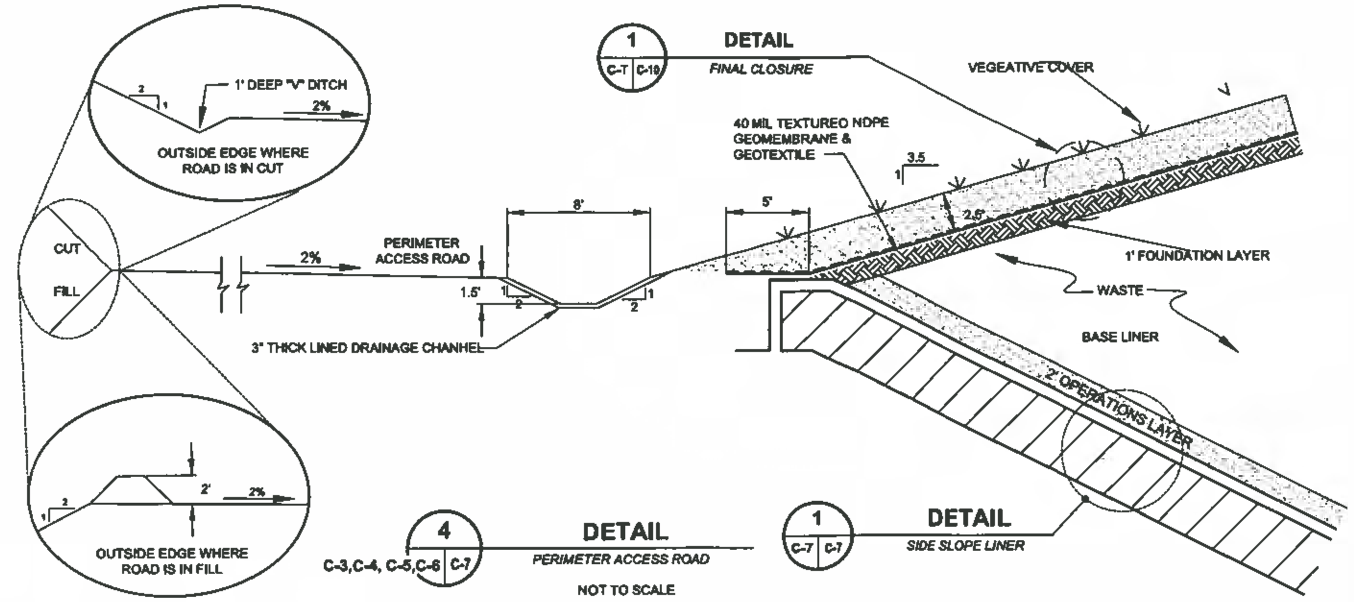
CROSS SECTIONS E TO I

SHEET NUMBER
C-6
7 OF 11 SHEETS



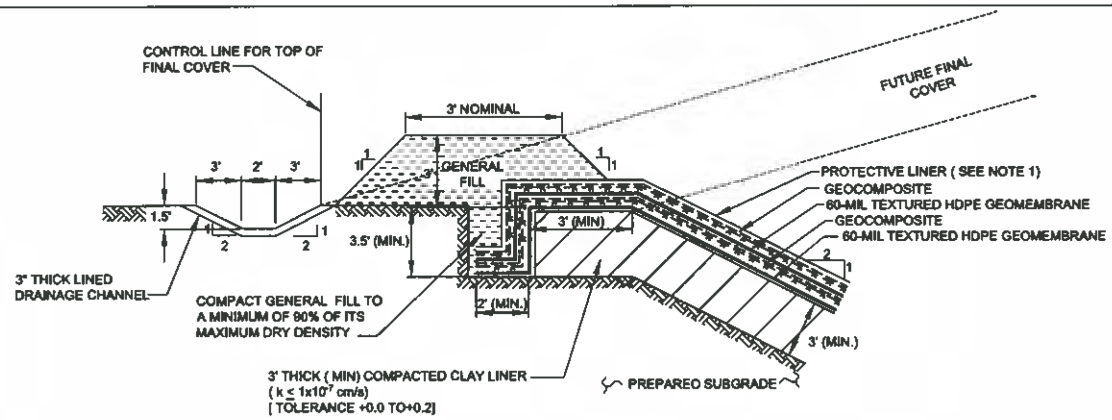
NOTE
1. NO HORIZONTAL SEAMS SHALL BE ALLOWED ON GRADES STEEPER THAN 12% OR WITHIN 3 FEET OF THE CREST OR TOE OF SLOPES. A HORIZONTAL SEAM IS DEFINED AS MORE THAN HALF OF THE PANEL WIDTH.
2. PROTECTIVE LINER SHALL BE COVERED BY OPERATIONS LAYER FOR A DISTANCE OF 3 FEET. PROTECTIVE LINER SHALL BE REMOVED BY LANDFILL PERSONNEL PRIOR TO PLACEMENT OF ADDITIONAL OPERATIONS LAYER.
3. OPERATIONS LAYER SHALL CONSIST OF SOILS EXCAVATED FROM ONSITE SOURCES. SOIL PARTICLE SIZE SHALL HAVE A MAXIMUM DIAMETER OF 1 INCH.
4. CONTRACTOR TO PLACE OPERATIONS LAYER 15' VERTICALLY UP THE SLOPE. CWM WILL PLACE REMAINING OPERATIONS SOIL AS WASTE MATERIALS ARE PLACED.

DETAIL 1 (C-3, C-5, C-6, C-7 / C-7)
SIDESLOPE LINER
NOT TO SCALE



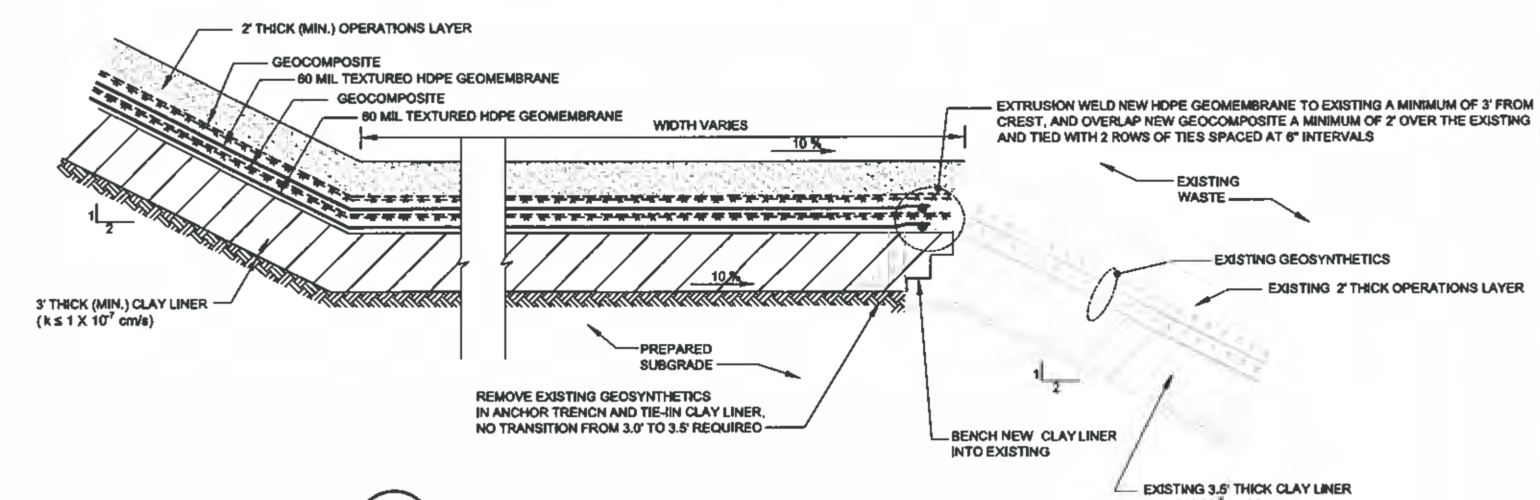
DETAIL 4 (C-3, C-4, C-5, C-6 / C-7)
PERIMETER ACCESS ROAD
NOT TO SCALE

DETAIL 1 (C-7 / C-7)
SIDE SLOPE LINER



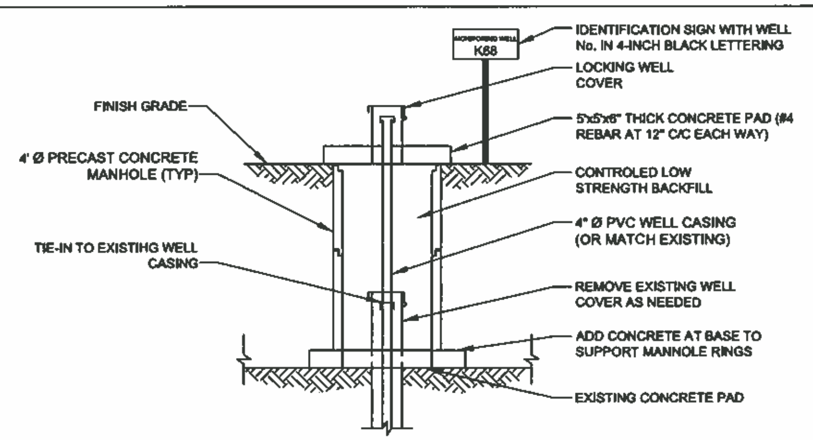
NOTE
1. PROTECTIVE LINER SHALL BE REMOVED BY LANDFILL PERSONNEL PRIOR TO PLACEMENT OF OPERATIONS LAYER.

DETAIL 2 (C-5, C-6 / C-7)
SIDESLOPE LINER ANCHOR TRENCH
NOT TO SCALE



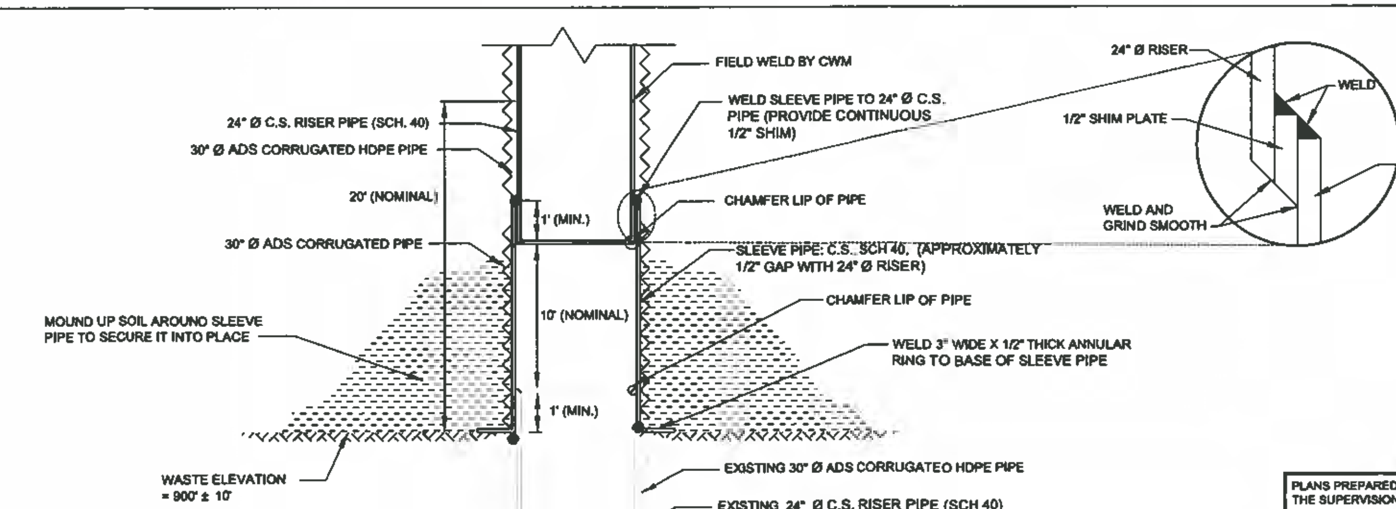
DETAIL 5 (C-5, C-6 / C-7)
LINER TIE-IN
NOT TO SCALE

NOTE:
1. CONTRACTOR TO REMOVE SOIL TO EXPOSE EXISTING LINER SYSTEM.



DETAIL 3 (C-3 / C-7)
MONITORING WELL EXTENSION
NOT TO SCALE

NOTE
1. CONTRACTOR TO EXTEND WELL AND ADD MANHOLE SECTION IN MAXIMUM 8 FOOT INCREMENTS. CONTROLLED LOW STRENGTH BACK FILL TO BE ADDED ONCE EACH 8' WELL EXTENSION IS COMPLETE.



NOTE
1. THIS DETAIL PERTAINS ONLY TO VERTICAL RISERS IA AND IB
2. INITIAL SECTION TO BE INSTALLED BY CONTRACTOR SHALL BE 20' IN LENGTH.
3. ADDITIONAL SECTIONS OF 24" Ø RISER TO BE INSTALLED BY CWM AS WASTE PLACEMENT PROGRESSES.

DETAIL 6 (C-3 / C-7)
VERTICAL RISER SLIP CONNECTION
NOT TO SCALE

ISSUED FOR PERMITTING

PLANS PREPARED UNDER THE SUPERVISION OF:
REGISTERED PROFESSIONAL ENGINEER — CIVIL — STATE OF CALIFORNIA

REV	DATE	DESCRIPTION	DESIGN	DRAWN	REVIEW
A	8/19/2008	ISSUED FOR PERMITTING MEETING	KJK	KJK	SGS
B	11/26/2008	ISSUED FOR PERMITTING	KJK	KJK	SGS
C	FEB 2010	REVISED PER RWQCB/DTSC COMMENTS	KJK	KJK	SGS

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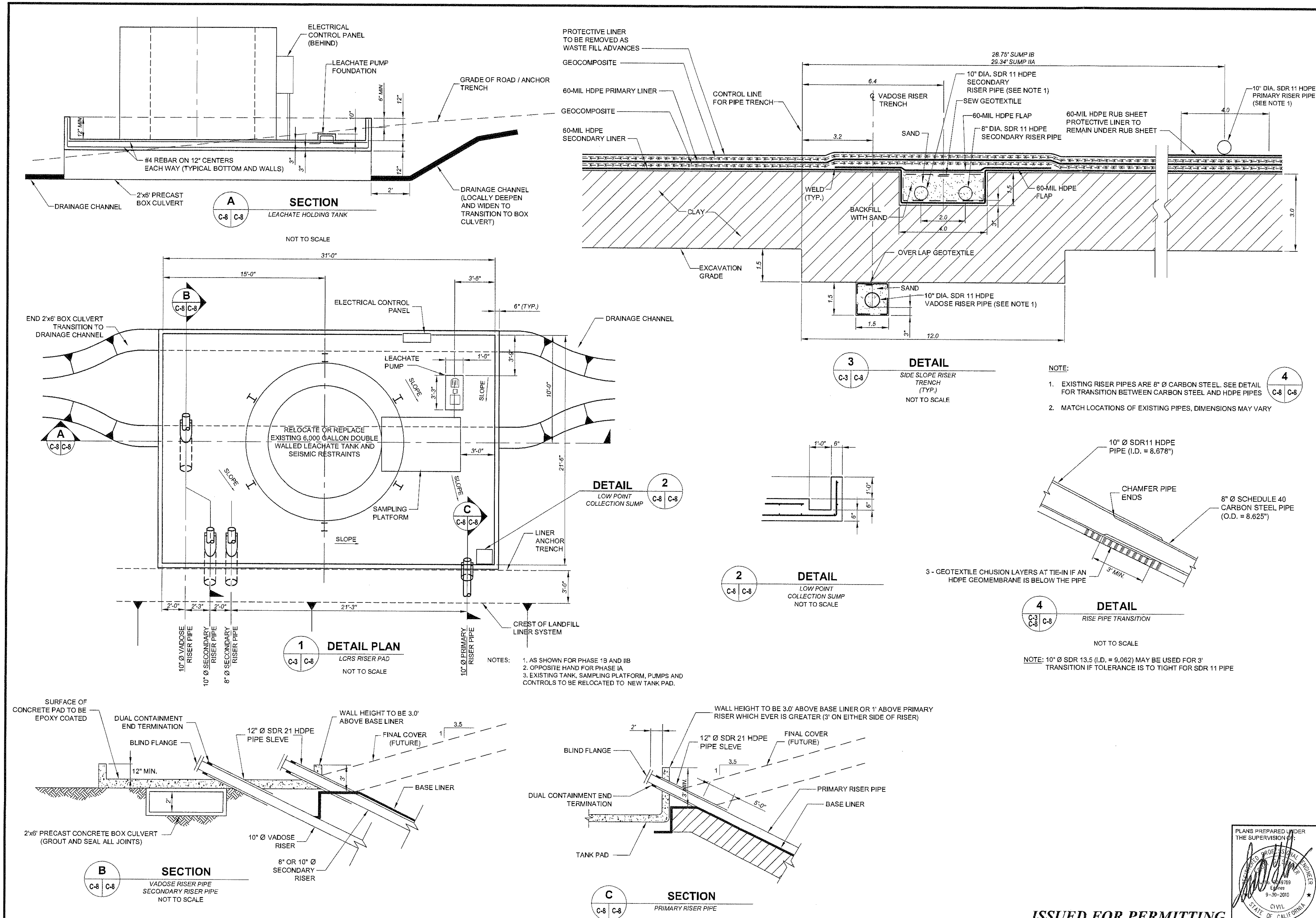
B-18 CLASS I LANDFILL PHASE III EXPANSION AND FINAL CLOSURE
PHASE III BASE LINER CONSTRUCTION DETAILS

SHEET NUMBER
C-7
8 OF 11 SHEETS



REV	DATE	DESCRIPTION	DESIGN	DRAWN	REVIEW
A	9/16/2008	ISSUED FOR PERMITTING MEETING	KJK	KJK	SGS
A	11/04/2008	ISSUED FOR PERMITTING	KJK	KJK	SGS

Golder Associates
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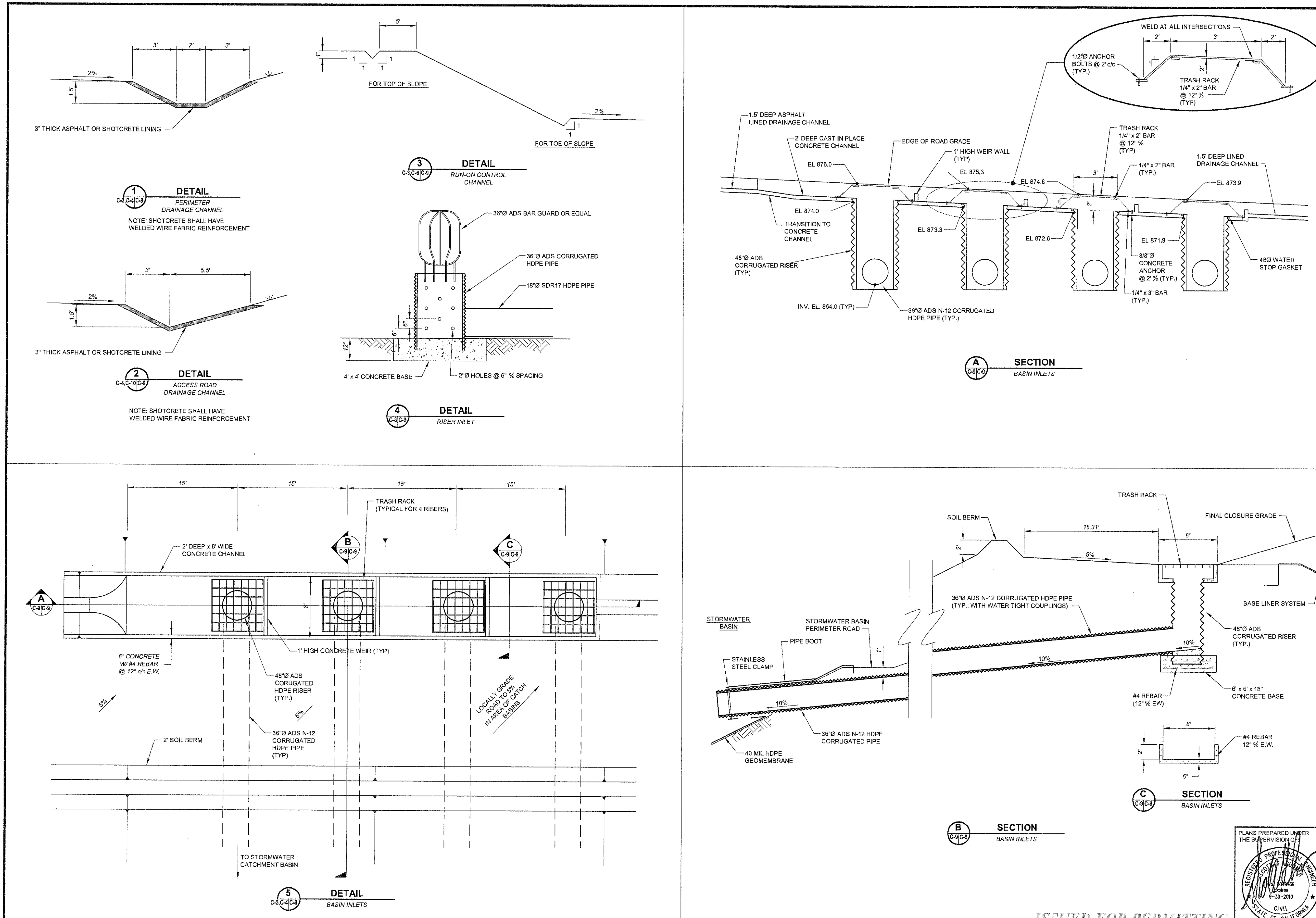
CHEMICAL WASTE MANAGEMENT KETTLEMAN HILLS FACILITY
35251 OLD SKYLINE ROAD
KETTLEMAN CITY, CALIFORNIA 93239
(559) 386-9711

B-18 CLASS I LANDFILL PHASE III EXPANSION AND FINAL CLOSURE

PHASE III LCRS SYSTEM DETAILS

PLANS PREPARED UNDER THE SUPERVISION OF:

SHEET NUMBER
C-8
9 OF 11 SHEETS



REV	DATE	DESCRIPTION	DESIGN	DRAWN	REVIEW
A	9/16/2008	ISSUED FOR PERMITTING MEETING	KJK	KJK	SGS
B	11/04/2008	ISSUED FOR PERMITTING	KJK	KJK	SGS

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KETTLEMAN CITY, CALIFORNIA 93239
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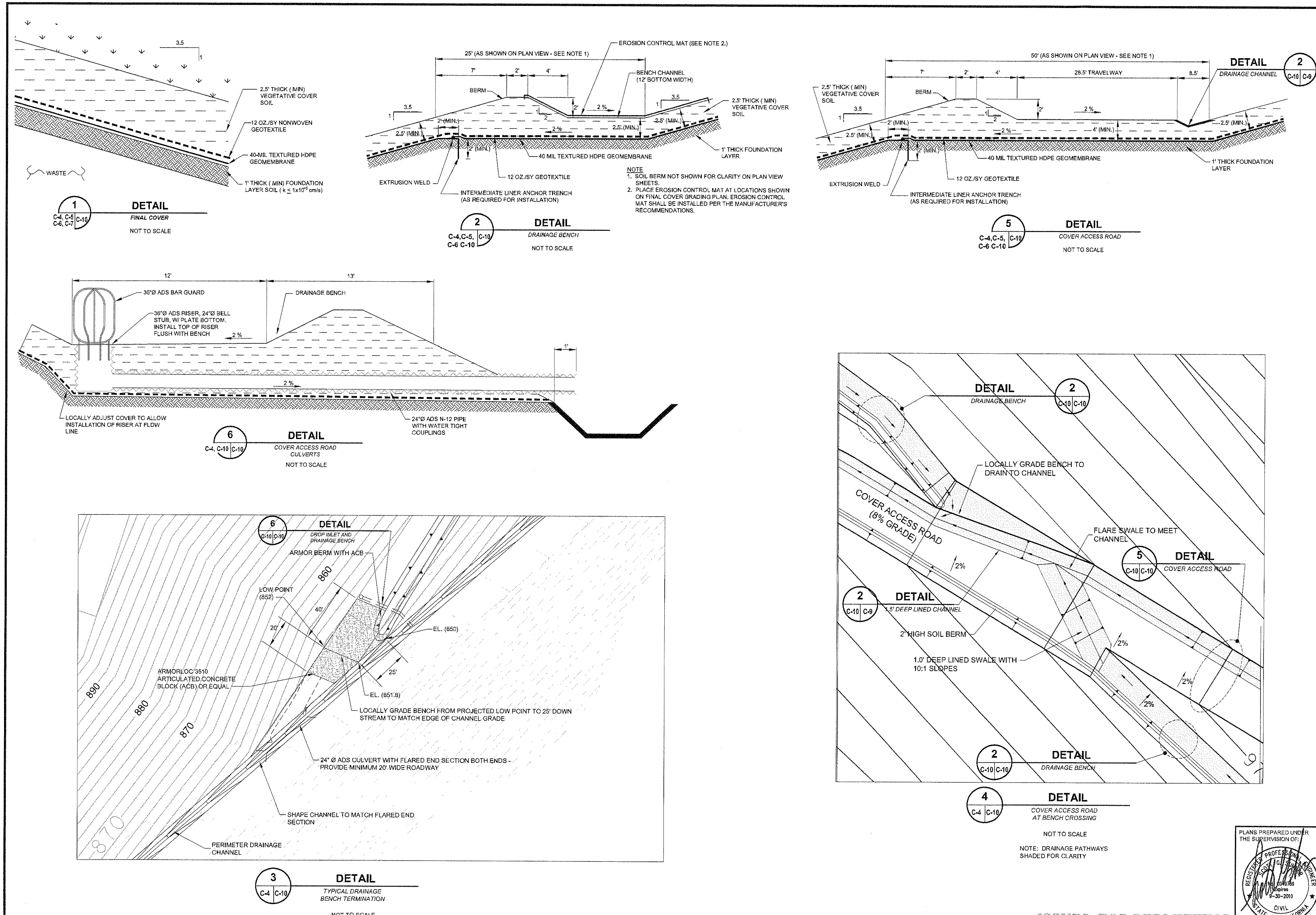
B-18 CLASS I LANDFILL PHASE III EXPANSION AND FINAL COVER

DRAINAGE DETAILS

SHEET NUMBER
C-9
10 OF 11 SHEETS



PLANS PREPARED UNDER THE SUPERVISION OF:

ISSUED FOR PERMITTING

REV	DATE	DESCRIPTION	DESIGN	DRAWN	REVIEW
A	9/16/2008	ISSUED FOR PERMITTING MEETING	KJK	KJK	SGS
B	11/04/2008	ISSUED FOR PERMITTING	KJK	KJK	SGS

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B-18 CLASS I LANDFILL
PHASE III EXPANSION AND FINAL CLOSURE

CLOSURE DETAILS

SHEET NUMBER

C-10

11 OF 11 SHEETS

APPENDIX B
BORING LOGS

LOG OF BORING L18-A

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF		
BORING NUMBER: L18-A	ELEVATION: 856'	DATE	
COORDINATES: N. 228,940 E. 1,700,840	BORING DIA.: 5"	STARTED	COMPLETED
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE	3/12/90	3/12/90
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL	PAGE: 1 OF 3	

LEGEND

SANDS — SANDSTONE (ss)
SILTS — SILTSTONE (slt)
CLAYS — CLAYSTONE (cs)

PB - Pitcher Barrel
DR - Drive Ring Sample
CHEM - Chemical Test
PI - Atterberg Limits Test
COMP - Compaction Test
DIR - Direct Shear Test
TX - Triaxial Test

PER - Permeability Test
SW - Swelling Test
SI - Sieve Analysis Test
%200 - Percentage Passing
HYD - Hydrometer Test
SG - Specific Gravity Test

DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PER FOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
0–4.5					cs		SAN JOAQUIN FORMATION CLAYSTONE/SANDSTONE, gray, light brown, gray brown, orange claystone; interbedded claystone/sandstone, laminated, soft, weak			
4.5–6	PB	S-1	300 - 400	1.0/1.1	ss		- predominantly claystone from 0' - 0.5' - sandstone at 4.5'	18	98	
6–15					cs/ss		- gray claystone, orange-tan silty sandstone (interbedded)			
10–12.5	PB	S-2	250	2.1/2.5			- orange claystone laminae, sandstone - tan, light brown sandstone, very fine, clean - light brown, gray brown, orange claystone, lesser gray claystone, sandstone from 12.5' to 17'			

REV. 8/10/90

LOG OF BORING L18-A

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF		
BORING NUMBER: L18-A	ELEVATION: 856'	DATE	
COORDINATES: N. 228,940 E. 1,700,840	BORING DIA.: 5"	STARTED	COMPLETED
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE	3/12/90	3/12/90
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL	PAGE: 2 OF 3	

DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PER FOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
16					cs/ ss					
17	PB	S-3	250	2.4 / 2.5	ss		- clean, very fine sandstone			
18			300		slt/cs		- interbedded siltstone/claystone, laminated	16	102	%200
19					ss/ cs		- interbedded sandstone/claystone, laminated to very thin bedded			
20							- fine, clean, sandstone, tan with gray claystone lamination			
21							- red, hard cemented sandstone			
22										
23										
24					ss/ slt					
25							- very fine, silty sandstone, light brown			
26	PB	S-4	350	2.5 / 2.5			- silty sandstone, sandy siltstone	20		%200
27							- very fine, silty sandstone, light brown with minor claystone pocket/lamination			
28										
29										
30					ss/ cs					
31										
32										
33										
34	PB	S-5	350	2.2 / 2.5						CHEM
35							- claystone with sandstone			

LOG OF BORING L18-A

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF		
BORING NUMBER: L18-A	ELEVATION: 856'	DATE	
COORDINATES: N. 228,940 E. 1,700,840	BORING DIA.: 5"	STARTED	COMPLETED
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE	3/12/90	3/12/90
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL	PAGE: 3 OF 3	

DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PER FOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
36					ss/ cs		- very fine silty sandstone with claystone laminations			
37					cs		- claystone with interbedded sandstone laminae			
38	PB	S-6		1.5 / 1.7	ss		- silty sandstone with claystone laminae	15	102	%200

- TOTAL DEPTH = 38.7'
- NO GROUND WATER ENCOUNTERED
- BACKFILLED WITH CEMENT GROUT VIA TREMIE

LOG OF BORING L18-B

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF		
BORING NUMBER: L18-B	ELEVATION: 861'	DATE	
COORDINATES: N. 228,750 E. 1,700,860	BORING DIA.: 5"	STARTED	COMPLETED
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE	3/13/90	3/13/90
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL	PAGE: 1 OF 3	

LEGEND

SANDS · SILTS · CLAYS · SANDSTONE (ss) · SILTSTONE (slt) · CLAYSTONE (cs)

PB - Pitcher Barrel
DR - Drive Ring Sample
CHEM - Chemical Test
PI - Atterberg Limits Test
COMP - Compaction Test
DIR - Direct Shear Test
TX - Triaxial Test

PER - Permeability Test
SW - Swelling Test
SI - Sieve Analysis Test
%200 - Percentage Passing
HYD - Hydrometer Test
SG - Specific Gravity Test

DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PER FOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
0–6					cs		SAN JOAQUIN FORMATION CLAYSTONE, gray, highly plastic, minor very fine sand, occasional sandstone pockets (bioturbation), laminae			
6–8.5	PB	S-1		2.3/2.5			- silty claystone, high plasticity, some sandstone modules and bedding - gray claystone, minor very fine sand at 8.3'	22	96	PI-HYD
11–11.5					ss		SILTY SANDSTONE, tan, light brown, mottled orange, very fine grained			
11.5–14	PB	S-2		2.4/2.5						
15										

REV. 8/10/90

LOG OF BORING L18-B

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF		
BORING NUMBER: L18-B	ELEVATION: 861'	DATE	
COORDINATES: N. 228,750 E. 1,700,860	BORING DIA.: 5"	STARTED	COMPLETED
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE	3/13/90	3/13/90
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL	PAGE: 2 OF 3	

DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PER FOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
15–18.5					ss (silty)					
18.5–26.5					ss		SANDSTONE, tan, mottled orange, very fine to medium grained, clean (<10% fines), occasional cemented claystone laminae, orange			
20–22.5	PB	S-3		1.6/2.5				16	107	TX DIR
26.5–35					ss, w/ cs/slt		SANDSTONE with interbedded CLAYSTONE/ SILTSTONE, predominantly tan, light brown sandstone (very fine grained), lesser gray claystone, clayey siltstone interbeds			
28–30.5	PB	S-4		2.2/2.5						
30.2							- very fine sandstone at 30.2'			
35										

LOG OF BORING L18-B

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF		
BORING NUMBER: L18-B	ELEVATION: 861'	DATE	
COORDINATES: N. 228,750 E. 1,700,860	BORING DIA.: 5"	STARTED	COMPLETED
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE	3/13/90	3/13/90
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL	PAGE: 3 OF 3	

DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PER FOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
36							SANDSTONE, tan, fine to medium grained, clean			
37										
38	PB	S-5		2.0/2.5	SS			14	106	%200
39										

- TOTAL DEPTH = 39.5'
- NO GROUND WATER ENCOUNTERED
- BACKFILLED WITH CEMENT GROUT VIA TREMIE

LOG OF BORING L18-C

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF		
BORING NUMBER: L18-C	ELEVATION: 754'	DATE	
COORDINATES: N. 228,620 E. 1,702,120	BORING DIA.: 5"	STARTED	COMPLETED
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE	3/13/90	3/14/90
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL	PAGE: 1 OF 5	

LEGEND

SANDS — SILTS — CLAYS — SANDSTONE (ss) — SILTSTONE (slt) — CLAYSTONE (cs)

PB - Pitcher Barrel
DR - Drive Ring Sample
CHEM - Chemical Test
PI - Atterberg Limits Test
COMP - Compaction Test
DIR - Direct Shear Test
TX - Triaxial Test

PER - Permeability Test
SW - Swelling Test
SI - Sieve Analysis Test
%200 - Percentage Passing
HYD - Hydrometer Test
SG - Specific Gravity Test

DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PER FOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
0–6					cl		COLLUVIUM SANDY CLAY, light brown, damp (to 7.5'), low to moderate plasticity, 20 to 40% very fine grained sand.			
6–7.5	DR	B-1	15	1.3/1.5	cl		- very stiff from 6' to 7.5'			PI
12–13.5	DR	B-2	17	.8/15	sp		- 1"/2 thick, clean, very fine grained sand lens.			
13.5–15					cl		- very stiff from 12' to 13.5'			

REV. 8/10/90

LOG OF BORING L18-C

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF
BORING NUMBER: L18-C	ELEVATION: 754' / DATE
COORDINATES: N. 228,620 E. 1,702,120	BORING DIA.: 5" / STARTED / COMPLETED
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE / 3/13/90 / 3/14/90
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL / PAGE: 2 OF 5

DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PER FOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
15-17	PB	S-1		2.1/2.3	cl			23	100	PI HYD
17-20					slt		SAN JOAQUIN FORMATION SILTSTONE, gray - brown, mottled orange, non - plastic, occasional gray claystone laminae, (Iron oxide stained.)			
20-22.5	PB	S-2		2.3/2.5			- bedding @ ~ 20° @ 16' - siltstone, non-plastic, trace of very fine grained sand.			CHM
25-27.5	PB	S-3		2.2/2.5	slt cs		- silty claystone - clayey siltstone, moderate plasticity at 26'	14	102	PI
27.2					slt		- siltstone at 27.2'			
28.5-33					cs/slt		CLAYSTONE/SILTSTONE, gray claystone, light gray-brown, clayey siltstone, inter bedded, laminated.			
33-35	PB	S-4		1.9/2.0						

LOG OF BORING L18-C

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF
BORING NUMBER: L18-C	ELEVATION: 754'
COORDINATES: N. 228,620 E. 1,702,120	BORING DIA.: 5"
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL

DATE STARTED	DATE COMPLETED
3/13/90	3/14/90

PAGE: 3 OF 5

DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PER FOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
36										
37					SS		SANDSTONE, SILTY SANDSTONE, light brown, very fine to fine grained			
42	PB	S-5		2.0/2.1			- silty sandstone, light brown, very fine grained.	12	102	
49	PB	S-6		1.9/2.1	slt, cs		SANDSTONE, CLAYSTONE, gray brown, gray, interbedded (laminated-thin bedded), occasional sandstone interbeds.			
52							- gray siltstone, non-plastic at 49.9'			
55										

LOG OF BORING L18-C

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF		
BORING NUMBER: L18-C	ELEVATION: 754'	DATE	
COORDINATES: N. 228,620 E. 1,702,120	BORING DIA.: 5"	STARTED	COMPLETED
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE	3/13/90	3/14/90
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL	PAGE: 4 OF 5	

DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PER FOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
56–58	PB	S-7		1.8/2.0	cs, ss, cs					PI, HYD, TX, DIR
58–64					slt; slt, cs					
64–66.5	PB	S-8		1.8/2.3			- gray brown, clayey siltstone with very thin gray claystone laminae, orange (iron oxide stained)			TX
72–74.5	PB	S-9		2.3/2.3	ss		SANDSTONE, SILTY SANDSTONE, light brown, very fine grained, 10 to 20% fines.	8	10.5	
75										

LOG OF BORING L18-C

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF	
BORING NUMBER: L18-C	ELEVATION: 754'	DATE
COORDINATES: N. 228,620 E. 1,702,120	BORING DIA.: 5"	STARTED / COMPLETED
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE	3/13/90 / 3/14/90
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL	PAGE: 5 OF 5

DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PER FOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
76										
77										
78					slt		SILTSTONE, light brown, minor sand, occasional claystone interbeds, claystone with moderate plasticity	14	106	%200
79										
80										
81	PB	S-10		1.9/2.0						
82					slt/cs		- siltstone/claystone (interbedded.)			
83										
84										
85										
86										
87										PI
88	PB	S-11		1.7/2.0	cs		- sandy, silty claystone with moderate plasticity.	12	106	
					slt		- sandy siltstone.			

TOTAL DEPTH 89'
NO GROUNDWATER ENCOUNTERED
BACKFILLED WITH CEMENT GROUT VIA TREMIE

LOG OF BORING L18-D

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF		
BORING NUMBER: L18-D	ELEVATION: 740'	DATE	
COORDINATES: N. 228,780 E. 1,702,480	BORING DIA.: 5"	STARTED	COMPLETED
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE	3/14/90	3/15/90
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL	PAGE: 1 OF 5	

LEGEND

SANDS — SILTS — CLAYS — SANDSTONE (ss) — SILTSTONE (slt) — CLAYSTONE (cs)

PB - Pitcher Barrel
DR - Drive Ring Sample
CHEM - Chemical Test
PI - Atterberg Limits Test
COMP - Compaction Test
DIR - Direct Shear Test
TX - Triaxial Test

PER - Permeability Test
SW - Swelling Test
SI - Sieve Analysis Test
%200 - Percentage Passing
HYD - Hydrometer Test
SG - Specific Gravity Test

DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PER FOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
0					gc		FILL - sandy, clayey gravel			
1							COLLUVIUM Sandy clay, light brown; dry (to 5' deep), low plasticity, stiff 30 to 40% very fine sand.			
5–6	DR	B-1	11	1.3/1.5	cl					
10–11	DR	B-2	11	1.5/1.5				19		PI HYD
14–15	B	B-3	(BAG)		slt/ss		SAN JOAQUIN FORMATION CEMENTED SILTSTONE-SANDSTONE WITH FOSSILS (MYA BED), orange, brown, hard, strong			

REV. 8/10/90

LOG OF BORING L18-D

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF
BORING NUMBER: L18-D	ELEVATION: 740'
COORDINATES: N. 228,780 E. 1,702,480	BORING DIA.: 5"
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL

DATE	
STARTED	COMPLETED
3/14/90	3/15/90

DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PER FOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
16	PB	S-1		1.8/2.3	slt		SANDY SILTSTONE, SILTSTONE, tan, light brown, mottled orange, low plasticity			
23	PB	S-2		2.2/2.3	slt		- siltstone, trace very fine sand, tan, mottled orange at 24'	19	95	PI HYD TX DIR
25					cs/slt		CLAYSTONE/SILTSTONE, gray, brown, orange interbedded, laminated, high plasticity claystone, low plasticity siltstone			
30	PB	S-3		2.0/2.5	cs/slt			19	100	

Depth scale: 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35

LOG OF BORING L18-D

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF		
BORING NUMBER: L18-D	ELEVATION: 740'	DATE	
COORDINATES: N. 228,780 E. 1,702,480	BORING DIA.: 5"	STARTED	COMPLETED
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE	3/14/90	3/15/90
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL	PAGE: 3 OF 5	

DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PER FOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
36–38	PB	S-4		2.3/2.5			- yellow brown silty claystone moderate plasticity	20	100	
44–46	PB	S-5		1.5/2.5			- gray brown claystone, orange			
52–54	PB	S-6		1.5/2.3			- dark olive, gray claystone, moderate to high plasticity striated slick surfaces, very thin sand lamination	25	101	PI
55										

LOG OF BORING L18-D

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF		
BORING NUMBER: L18-D	ELEVATION: 740'	DATE	
COORDINATES: N. 228,780 E. 1,702,480	BORING DIA.: 5"	STARTED	COMPLETED
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE	3/14/90	3/15/90
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL	PAGE: 4 OF 5	

DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PER FOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
56										
57										
58										
59										
60										
61	PB	S-7		1.2/2.5			- interbedded claystone/siltstone and very fine grained sandstone			
62										
63										
64										
65										
66										
67										
68										
69	PB	S-8		1.4/2.5			- gray claystone			
70										
71										
72										
73										
74					slt/ss		SILTSTONE, SILTY SANDSTONE, tan, light brown, orange mottling/layering			
75										

LOG OF BORING L18-D

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF		
BORING NUMBER: L18-D	ELEVATION: 740'	DATE	
COORDINATES: N. 228,780 E. 1,702,480	BORING DIA.: 5"	STARTED	COMPLETED
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE	3/14/90	3/15/90
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL	PAGE: 5 OF 5	

DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PER FOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
							- nonplastic siltstone, silty sandstone, interbedded/laminated, occasional claystone laminae			
76										
77	PB	S-9		0.8/2.5			- tan, silty sandstone, fine/orange, cemented siltstone at 77'			
78										
79										
80										
81					slt					
82	PB	S-10		0.9/2.5			- tan, silty sandstone, orange siltstone with fossils (clam shell) at 81.9'	16	109	%200
83										
84										
85	PB	S-11		1.7/2.5			- very fine silty sandstone, tan, brown, mottled orange (bioturbation)			

- TOTAL DEPTH = 86'
- NO GROUND WATER ENCOUNTERED
- BACKFILLED WITH CEMENT GROUT VIA TREMIE

LOG OF BORING L18-E

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF		
BORING NUMBER: L18-E	ELEVATION: 727'	DATE	
COORDINATES: N. 228,890 E. 1,702,670	BORING DIA.: 5"	STARTED	COMPLETED
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE	3/19/90	3/20/90
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL	PAGE: 1 OF 4	

LEGEND

SANDS	SANDSTONE (ss)	PB - Pitcher Barrel	PER - Permeability Test
SILTS	SILTSTONE (slt)	DR - Drive Ring Sample	SW - Swelling Test
CLAYS	CLAYSTONE (cs)	CHEM - Chemical Test	SI - Sieve Analysis Test
		PI - Atterberg Limits Test	%200 - Percentage Passing
		COMP - Compaction Test	HYD - Hydrometer Test
		DIR - Direct Shear Test	SG - Specific Gravity Test
		TX - Triaxial Test	

DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PER FOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
0–5					cl		COLLUVIUM SANDY CLAY, light brown, dry, low to moderate plasticity, 10 to 40% very fine grained sand. Numerous thin interbeds/laminae of sand (sp), probably intermittent alluvial deposits			
5–6.5	DR	B-1	19	1.3/1.5	cl		- very stiff			
6.5–10					cl		- numerous cemented sandstone fragments (hard, orange brown, to 1/2" Ø), occasional gray claystone fragments from 8' to 13'			
10–12.5	PB	S-1		1.7/2.5	cl		- cemented sandstone fragments - very stiff to hard, light brown sandy clay with claystone fragments, moderate plasticity	16	106	
13–15					ss		SAN JOAQUIN FORMATION SANDSTONE, tan, very fine to fine, occasional siltstone, claystone laminae, occasional orange			

REV. 8/10/90

LOG OF BORING L18-E

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF		
BORING NUMBER: L18-E	ELEVATION: 727'	DATE	
COORDINATES: N. 228,890 E. 1,702,670	BORING DIA.: 5"	STARTED	COMPLETED
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE	3/19/90	3/20/90
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL	PAGE: 2 OF 4	

DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PER FOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
16	PB	S-2		2.1/2.5	ss		- cemented laminae - tan, fine sandstone, clean, with minor claystone laminae at 19'	12		%200
21	PB	S-3		1.4/2.5	ss		- very fine silty sandstone at 21'			
29	PB	S-4		1.9/2.2	ss		- very fine to fine sandstone (sp-sm) at 30'			
30–34					cs/slt		CLAYSTONE/SILTSTONE, gray brown, with orange laminae			
34–35					slt/cs		SILTSTONE, SANDY SILTSTONE, CLAYSTONE predominantly siltstone, sandy siltstone			

LOG OF BORING L18-E

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF
BORING NUMBER: L18-E	ELEVATION: 727'
COORDINATES: N. 228,890 E. 1,702,670	BORING DIA.: 5"
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL

DATE STARTED	DATE COMPLETED
3/19/90	3/20/90

PAGE: 3 OF 4

DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PER FOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
35–37	PB	S-5		2.2/2.5			with claystone interbeds, laminae - tan, sandy siltstone, interbedded with brown claystone, laminated at 37'			
43–45	PB	S-6		1.6/2.0			- yellow brown sandy siltstone, nonplastic at 44'	14	102	PI
47					CS		CLAYSTONE, gray, gray brown, highly plastic, occasional sandstone pockets (bioturbation), laminae			
51–53	PB	S-7		1.9/2.0			- gray brown claystone, highly plastic, with orange laminae at 52'			
55										

LOG OF BORING L18-E

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF		
BORING NUMBER: L18-E	ELEVATION: 727'	DATE	
COORDINATES: N. 228,890 E. 1,702,670	BORING DIA.: 5"	STARTED	COMPLETED
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE	3/19/90	3/120/90
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL	PAGE: 4 OF 4	

DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PER FOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
56										
57										
58										
59										
60										
61	PB	S-8		2.4/2.5				28	95	PI
62							- gray sandy claystone, mottled orange (sand in pockets - bioturbation) at 62'			

- TOTAL DEPTH = 62.5'
- NO GROUND WATER ENCOUNTERED
- BACKFILLED WITH CEMENT GROUT VIA TREMIE

LOG OF BORING L18-F

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF		
BORING NUMBER: L18-F	ELEVATION: 821'	DATE	
COORDINATES: N. 228,930 E. 1,701,540	BORING DIA.: 5"	STARTED	COMPLETED
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE	3/20/90	3/21/90
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL	PAGE: 1 OF 4	

LEGEND

SANDS — SANDSTONE (ss)
SILTS — SILTSTONE (slt)
CLAYS — CLAYSTONE (cs)

PB - Pitcher Barrel
DR - Drive Ring Sample
CHEM - Chemical Test
PI - Atterberg Limits Test
COMP - Compaction Test
DIR - Direct Shear Test
TX - Triaxial Test

PER - Permeability Test
SW - Swelling Test
SI - Sieve Analysis Test
%200 - Percentage Passing
HYD - Hydrometer Test
SG - Specific Gravity Test

DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PER FOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
0–5							SAN JOAQUIN FORMATION CLAYSTONE, gray, brown with orange laminae, slightly weathered, soft, weak, laminated to thin bedded, occasional very fine sand laminae, occasional siltstone interbeds/laminae; highly plastic			
6–8.5	PB	S-1		2.5/2.5	cs		- olive brown, silty claystone, moderate to high plasticity	20	103	PI HYD
9–15										

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LOG OF BORING L18-F

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF		
BORING NUMBER: L18-F	ELEVATION: 821'	DATE	
COORDINATES: N. 228,930 E. 1,701,540	BORING DIA.: 5"	STARTED	COMPLETED
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE	3/20/90	3/21/90
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL	PAGE: 2 OF 4	

DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PER FOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
16–18.5	PB	S-2		2.2/2.5			- gray claystone with orange (iron oxide stained) bedding surfaces, laminated at 18'			
26–28.5	PB	S-3		2.4/2.6			- laminated at 28' silty claystone	29	93	PI HYD
35										

LOG OF BORING L18-F

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF
BORING NUMBER: L18-F	ELEVATION: 821' — DATE
COORDINATES: N. 228,930 E. 1,701,540	BORING DIA.: 5" — STARTED: 3/20/90 — COMPLETED: 3/21/90
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL — PAGE: 3 OF 4

DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PER FOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
36–38.5	PB	S-4		1.9/2.5			- laminated claystone at 38'			
46–48	PB	S-5		2.1/2.1			- laminated, brown/gray claystone with 1/4" thick tan, very fine sandstone lamination at 48'	26	95	
55										

LOG OF BORING L18-F

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF		
BORING NUMBER: L18-F	ELEVATION: 821'	DATE	
COORDINATES: N. 228,930 E. 1,701,540	BORING DIA.: 5"	STARTED	COMPLETED
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE	3/20/90	3/21/90
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL	PAGE: 4 OF 4	

DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PER FOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
56										PI
57	PB	S-6		2.1/2.5			- gray claystone, highly plastic with 1/2" thick orange (iron oxide cemented) sandstone lamination and several sandy bioturbation pockets	26	95	HYD TX DIR
58										

- TOTAL DEPTH = 58.5'
- NO GROUND WATER ENCOUNTERED
- BACKFILLED WITH CEMENT GROUT VIA TREMIE

LOG OF BORING L18-G

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF		
BORING NUMBER: L18-G	ELEVATION: 853'	DATE	
COORDINATES: N. 227,500 E. 1,701,910	BORING DIA.: 5"	STARTED	COMPLETED
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE	3/21/90	3/22/90
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL	PAGE: 1 OF 5	

LEGEND

SANDS	SANDSTONE (ss)	PB - Pitcher Barrel	PER - Permeability Test
SILTS	SILTSTONE (slt)	DR - Drive Ring Sample	SW - Swelling Test
CLAYS	CLAYSTONE (cs)	CHEM - Chemical Test	SI - Sieve Analysis Test
		PI - Atterberg Limits Test	%200 - Percentage Passing
		COMP - Compaction Test	HYD - Hydrometer Test
		DIR - Direct Shear Test	SG - Specific Gravity Test
		TX - Triaxial Test	

DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PER FOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
0–5					ss (silty)		SAN JOAQUIN FORMATION SILTY SANDSTONE, tan-gray, mottled orange, very fine, weakly cemented, occasional claystone laminae, bioturbation, occasional fossils (description based on access road cut exposure adjacent to the boring)			
5–15					ss		SANDSTONE, tan very fine to fine, clean, occasional iron oxide cemented sandstone laminae, interbeds (orange reddish brown), occasional silty sandstone interbeds, occasional iron oxide cemented siltstone laminae	9	107	%200
6–8.5	PB	S-1		1.4/2.5						
14–15	PB	S-2		1.4/2.5			- very fine, light brown, clean sandstone			

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LOG OF BORING L18-G

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF		
BORING NUMBER: L18-G	ELEVATION: 853'	DATE	
COORDINATES: N. 227,500 E. 1,701,910	BORING DIA.: 5"	STARTED	COMPLETED
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE	3/21/90	3/22/90
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL	PAGE: 2 OF 5	

DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PER FOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
16	PB	S-2		1.4/2.5						
17										
18										
19										
20										
21										
22										
23	PB	S-3		1.5/1.7			- very fine, clean sandstone			
24										
25										
26										
27										
28										
29										
30										
31	PB	S-4		1.2/2.0			- very fine, clean sandstone, 1/4" thick iron oxide cemented clay lamination (orange)			
32										
33										
34										
35										

LOG OF BORING L18-G

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF	
BORING NUMBER: L18-G	ELEVATION: 853'	DATE
COORDINATES: N. 227,500 E. 1,701,910	BORING DIA.: 5"	STARTED / COMPLETED
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE	3/21/90 / 3/22/90
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL	PAGE: 3 OF 5

DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PER FOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
36										
37										
38										
39										
40	PB	S-5		1.2/1.3			- very fine to fine clean sandstone			%200 TX
41										
42										
43					CS		CLAYSTONE, dark gray, highly plastic			
44										
45	PB	S-6		1.5/2.5			- gray claystone, highly plastic	30	91	
46										
47										
48										
49										
50	PB	S-7		1.3/1.8			- dark gray claystone, highly plastic, gypsum clots, striated slick surfaces	29	92	PI TX HYD
51										
52										
53										
54										
55										

LOG OF BORING L18-G

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF
BORING NUMBER: L18-G	ELEVATION: 853'
COORDINATES: N. 227,500 E. 1,701,910	BORING DIA.: 5"
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL

DATE STARTED	DATE COMPLETED
3/21/90	3/22/90

PAGE: 4 OF 5

DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PER FOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
56–60										
60–62.5	PB	S-8		1.0/2.5			- gray claystone with sandy pockets (bioturbation)			
62.5–65										
65–67	PB	S-9		1.4/2.0			- gray claystone, high plasticity with silt-sand filled pockets (bioturbation)	27	95	PI HYD
67–70										
70–75					SS		SANDSTONE, SILTY SANDSTONE, tan very fine, occasional silty sandstone pockets, occasional claystone laminae			

LOG OF BORING L18-G

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF	
BORING NUMBER: L18-G	ELEVATION: 853'	DATE
COORDINATES: N. 227,500 E. 1,701,910	BORING DIA.: 5"	STARTED / COMPLETED
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE	3/21/90 / 3/22/90
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL	PAGE: 5 OF 5

DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PER FOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
76 77	PB	S-10		0.8 / 2.5			- clean sandstone with silty sandstone pockets and brown claystone lamination			

- TOTAL DEPTH = 77.5'
- NO GROUND WATER ENCOUNTERED
- BACKFILLED WITH CEMENT GROUT VIA TREMIE

LOG OF BORING L18-H

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF	
BORING NUMBER: L18-H	ELEVATION: 865'	DATE
COORDINATES: N. 228,060 E. 1,702,050	BORING DIA.: 5"	STARTED: 3/22/90 COMPLETED: 3/22/90
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE	
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL	PAGE: 1 OF 4

LEGEND

SANDS — SANDSTONE (ss)
SILTS — SILTSTONE (slt)
CLAYS — CLAYSTONE (cs)

PB - Pitcher Barrel
DR - Drive Ring Sample
CHEM - Chemical Test
PI - Atterberg Limits Test
COMP - Compaction Test
DIR - Direct Shear Test
TX - Triaxial Test

PER - Permeability Test
SW - Swelling Test
SI - Sieve Analysis Test
%200 - Percentage Passing
HYD - Hydrometer Test
SG - Specific Gravity Test

DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PER FOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
0					cl		FILL, sandy clay (drilling pad)			
0.5–5					cl		COLLUVIUM SANDY CLAY, light brown, dry, low plasticity			
5–9	PB (6–8.5)	S-1		1.8/2.5	cs		SAN JOAQUIN FORMATION CLAYSTONE, gray, highly plastic, occasional thin sandstone interbeds laminae - gray highly plastic silty claystone	29	89	PI
9–15					ss		SANDSTONE - SILTY SANDSTONE			

REV. 8/10/90

LOG OF BORING L18-H

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF
BORING NUMBER: L18-H	ELEVATION: 865' / DATE
COORDINATES: N. 228,060 E. 1,702,050	BORING DIA.: 5" / STARTED / COMPLETED
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE / 3/22/90 / 3/22/90
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL / PAGE: 2 OF 4

DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PER FOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
16–17	PB	S-2		1.9/2.5			- yellowish brown silty sandstone, non to weakly cemented with gray claystone layer	15	108	%200
17–29					cs		CLAYSTONE, gray, highly plastic, occasional siltstone, sandstone interbeds/laminae			
25–27.5	PB	S-3		1.7/2.5			- gray claystone with sand filled pocket			
29–31					slt		- siltstone, nonplastic, minor very fine sand			
31–35					cs					

LOG OF BORING L18-H

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF		
BORING NUMBER: L18-H	ELEVATION: 865'	DATE	
COORDINATES: N. 228,060 E. 1,702,050	BORING DIA.: 5"	STARTED	COMPLETED
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE	3/22/90	3/22/90
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL	PAGE: 3 OF 4	

DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PER FOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
36	PB	S-4		2.3/2.5			- gray claystone, highly plastic, laminated with thin interbedded sandstone	26	95	PI
41					SS		SILTY SANDSTONE, tan-brown, very fine, occasional claystone pockets, laminae, 30 to 40% fine			
45							- abundant claystone bioturbation (clay filled pockets) from 45' to 46'			
46	PB	S-5		2.4/2.5						
48					CS		CLAYSTONE, gray, highly plastic, occasional thin sandstone interbeds, laminae			
55										

LOG OF BORING L18-H

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF
BORING NUMBER: L18-H	ELEVATION: 865'
COORDINATES: N. 228,060 E. 1,702,050	BORING DIA.: 5"
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL

DATE STARTED	DATE COMPLETED
3/22/90	3/22/90

DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PER FOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
56	PB	S-6		1.2/2.5			- gray claystone with sand filled pockets (bioturbation)	25	96	PI
57										

- TOTAL DEPTH = 57.5'
- NO GROUND WATER ENCOUNTERED
- BACKFILLED WITH CEMENT GROUT VIA TREMIE

LOG OF BORING L18-I

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF		
BORING NUMBER: L18-I	ELEVATION: 766'	DATE	
COORDINATES: N. 228,020 E. 1,702,410	BORING DIA.: 5"	STARTED	COMPLETED
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE	3/23/90	3/23/90
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL	PAGE: 1 OF 2	

LEGEND

SANDS	SANDSTONE (ss)	PB - Pitcher Barrel	PER - Permeability Test
SILTS	SILTSTONE (slt)	DR - Drive Ring Sample	SW - Swelling Test
CLAYS	CLAYSTONE (cs)	CHEM - Chemical Test	SI - Sieve Analysis Test
		PI - Atterberg Limits Test	%200 - Percentage Passing
		COMP - Compaction Test	HYD - Hydrometer Test
		DIR - Direct Shear Test	SG - Specific Gravity Test
		TX - Triaxial Test	

DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PER FOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
0–6							COLLUVIUM SILTY CLAY, light brown, dry (to 13') low to moderate plasticity, minor very fine sand, occasional root voids (pin-holes), minor caliche			
6–7.5	DR	B-1	35	1.3/1.5	cl		- hard - occasional hard, gray claystone fragments (detrital) to 1/2" Ø, from 7' to 10'			
12–13.5	PB	S-1		1.4/1.8			- sandy clay, light brown, dry, low to moderate plasticity, 20 to 40% very fine sand, occasional claystone fragments			
15										

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LOG OF BORING L18-I

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF		
BORING NUMBER: L18-I	ELEVATION: 766'	DATE	
COORDINATES: N. 228,020 E. 1,702,410	BORING DIA.: 5"	STARTED	COMPLETED
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE	3/23/90	3/23/90
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL	PAGE: 2 OF 2	

DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PER FOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
							SAN JOAQUIN FORMATION			
16 17 18	PB	S-2		2.3/2.5	CS		CLAYSTONE, gray, highly plastic, includes brown laminae, occasional siltstone, very fine sand laminae - laminated claystone/siltstone with very fine sand laminae	19	92	PI HYD

- TOTAL DEPTH = 18.5'
- NO GROUND WATER ENCOUNTERED
- BACKFILLED WITH CEMENT GROUT VIA TREMIE

LOG OF BORING L18-J

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF		
BORING NUMBER: L18-J	ELEVATION: 820'	DATE	
COORDINATES: N. 228,390 E. 1,701,985	BORING DIA.: 5"	STARTED	COMPLETED
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE	5/8/90	5/9/90
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL	PAGE: 1 OF 9	

LEGEND

SANDS	SANDSTONE (ss)	PB - Pitcher Barrel	PER - Permeability Test
SILTS	SILTSTONE (slt)	DR - Drive Ring Sample	SW - Swelling Test
CLAYS	CLAYSTONE (cs)	CHEM - Chemical Test	SI - Sieve Analysis Test
		PI - Atterberg Limits Test	%200 - Percentage Passing
		COMP - Compaction Test	HYD - Hydrometer Test
		DIR - Direct Shear Test	SG - Specific Gravity Test
		TX - Triaxial Test	

DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PER FOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
0					cl		FILL, sandy clay to clayey sand			
0.5–5					cs		SAN JOAQUIN FORMATION CLAYSTONE, gray, brown, highly plastic, occasional thin sandstone/siltstone interbeds and laminae			
5–7.5	PB	S-1		1.7/2.5	cs		- gray, dark brown silty claystone interbedded sandstone, minor silt pockets, faint orange mottling	24	92	PI HYD SW
10–12.5	PB	S-2		2.2/2.5	cs		- dark brown claystone, 1/8" thick gypsum layer (along bedding?)			
15										

REV. 8/10/90

LOG OF BORING L18-J

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF		
BORING NUMBER: L18-J	ELEVATION: 820	DATE	
COORDINATES: N. 228,390 E. 1,701,985	BORING DIA.: 5"	STARTED	COMPLETED
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE	5/8/90	5/9/90
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL	PAGE: 2 OF 9	

DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PER FOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
							- 70° joint filled with 1/4" thick gypsum vein			
16	PB	S-3		2.2/2.5				24	92	PI
17							- gray, brown silty claystone interbedded sandstone, minor orange mottling			
18										
19										
20										
21	PB	S-4		1.5/2.0	ss		- orange, cemented sandstone, fine grained			
22										
23										
24										
25										
26	PB	S-5		1.9/2.5			- bedding at 25°	24	99	PI
27							- gray dark brown claystone interbedded sandstone			
28										
29					cs					
30										
31	PB	S-6		2.4/2.5						
32							- gray, brown claystone, laminated very thin- orange (iron oxide) stain along bedding (at 30°), 1/4" thick gypsum vein along joint (across bedding)			
33										
34										
35										

LOG OF BORING L18-J

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF	
BORING NUMBER: L18-J	ELEVATION: 820'	DATE
COORDINATES: N. 228,390 E. 1,701,985	BORING DIA.: 5"	STARTED / COMPLETED
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE	5/8/90 / 5/9/90
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL	PAGE: 3 OF 9

DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PER FOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
35–37	PB	S-7		2.5/2.5			- 1/2" thick gypsum vein, at 10° dip	25	98	PI HYD COMP SG PER SW
37–40							- laminated claystone, gray, brown, thin interbedded sandstone - bedding at 30° dip			
40–42.5	PB	S-8		1.8/2.5			- gray brown claystone, minor orange mottling, silt and sand pockets (bioturbation?)			
42.5–45										
45–47.5	PB	S-9		2.3/2.5			- gray claystone, laminated, thin iron oxide stain bedding, near vertical joint with 1/8" thick gypsum vein, sandstone lenses	25	97	PI
47.5–50										
50–52.5	PB	S-10		2.3/2.5			- brown-gray claystone			
52.5–55										

LOG OF BORING L18-J

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF	
BORING NUMBER: L18-J	ELEVATION: 820'	DATE
COORDINATES: N. 228,390 E. 1,701,985	BORING DIA.: 5"	STARTED / COMPLETED
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE	5/8/90 / 5/9/90
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL	PAGE: 4 OF 9

DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PER FOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
56	PB	S-11		2.3/2.5			- gray, orange claystone, laminated, thin interbedded sandstone lens	26	99	PI
57										
58										
59										
60										
61	PB	S-12		2.4/2.5			- gray claystone, laminated			
62										
63										
64										
65										
66	PB	S-13		2.1/2.5			- bedding attitude rotates ~ 90° (NE to NW) at 66'	25	100	PI
67							- dark gray claystone, thin interbedded sandstone			
68										
69										
70										
71	PB	S-14		2.2/2.5			- dark brown-gray claystone			
72										
73										
74										
75										

LOG OF BORING L18-J

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF		
BORING NUMBER: L18-J	ELEVATION: 820'	DATE	
COORDINATES: N. 228,390 E. 1,701,985	BORING DIA.: 5"	STARTED	COMPLETED
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE	5/8/90	5/9/90
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL	PAGE: 5 OF 9	

DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PER FOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
76–77	PB	S-15		2.5/2.5			- gray, brown, minor orange claystone, thin interbedded sandstone	25	94	PI HYD COMP PER
78										
79										
80–82	PB	S-16		2.4/2.5			- blue gray claystone with occasional sand pockets (bioturbation?)			
83										
84										
85–87	PB	S-17		2.2/2.5			- gray brown claystone with sand pockets or thin sand interbed	25	99	PI
88										
89										
90–92	PB	S-18		2.1/2.5			- gray, orange claystone with large sand pockets or sandstone interbeds			
93										
94										CHEM
95							- claystone with sandstone			

LOG OF BORING L18-J

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF		
BORING NUMBER: L18-J	ELEVATION: 820'	DATE	
COORDINATES: N. 228,390 E. 1,701,985	BORING DIA.: 5"	STARTED	COMPLETED
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE	5/8/90	5/9/90
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL	PAGE: 6 OF 9	

DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PER FOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
96	PB	S-19		0.8/2.5	ss		- intermittent sandstone from a 95.5' to 105' - cemented sandstone			
97										
98										
99										
100										
101	PB	S-20		0.9/1.5	ss/cs		- very fine silty sandstone, noncemented, mottled, tan/orange	13	121	
102										
103										
104										
105										
106	PB	S-21		2.5/2.5			- dark gray claystone			
107										
108										
109										
110					cs					
111	PB	S-22		2.5/2.5				23	103	PI
112							- dark gray claystone, thin interbedded sandstone, 1/4" sandstone lens			
113										
114										
115										

LOG OF BORING L18-J

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF		
BORING NUMBER: L18-J	ELEVATION: 820'	DATE	
COORDINATES: N. 228,390 E. 1,701,985	BORING DIA.: 5"	STARTED	COMPLETED
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE	5/8/90	5/9/90
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL	PAGE: 7 OF 9	

DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PER FOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
116–117	PB	S-23		2.4/2.5			- dark gray claystone			
118–120										
120–122	PB	S-24		2.5/2.5			- dark gray claystone, thin interbedded sandstone	29	96	PI HYD SW
123–125										
125–127	PB	S-25		2.4/2.5			- dark gray claystone			
128–130										
130–132	PB	S-26		2.8/2.8			- dark gray claystone, thin interbedded sandstone	26	97	PI COMP PER
133–135										

LOG OF BORING L18-J

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF
BORING NUMBER: L18-J	ELEVATION: 820'
COORDINATES: N. 228,390 E. 1,701,985	BORING DIA.: 5"
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL

DATE STARTED	DATE COMPLETED
5/8/90	5/9/90

DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PER FOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
136–137	PB	S-27		2.5/2.5			- dark gray claystone			
140–142	PB	S-28		2.5/2.5			- dark gray claystone, thin interbedded sandstone	28	93	PI
145–147	PB	S-29		2.5/2.5			- dark gray claystone			
150–152	PB	S-30		2.5/2.5			- dark gray claystone, thin interbedded sandstone	28	96	PI
155										

LOG OF BORING L18-J

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF		
BORING NUMBER: L18-J	ELEVATION: 820'	DATE	
COORDINATES: N. 228,390 E. 1,701,985	BORING DIA.: 5"	STARTED	COMPLETED
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE	5/8/90	5/9/90
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL	PAGE: 9 OF 9	

DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PER FOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
156–157	PB	S-31		2.5/2.5			- dark gray claystone - harder (slower drilling)			
158										
159										
160–162	PB	S-32		2.5/2.5			- silty	20	104	PI HYD SW
162–165					SS		SILTY SANDSTONE, tan, very fine, noncemented			
165–167	PB	S-33		2.3/2.5	slt		SILTSTONE, light brown, gray, mottled orange, nonplastic			
168										
169–172					SS		SANDSTONE, SILTY SANDSTONE, orange brown, very fine grained, noncemented			
170–172.5	PB	S-34		2.2/2.5						
172.5					cs		CLAYSTONE, dark brown, black, highly plastic			

- TOTAL DEPTH = 172.5'
- NO GROUND WATER ENCOUNTERED
- BACKFILLED WITH CEMENT GROUT VIA TREMIE

LOG OF BORING L18-K

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF
BORING NUMBER: L18-K	ELEVATION: 804'
COORDINATES: N. 228,390 E. 1,701,722	BORING DIA.: 5"
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL

DATE STARTED	DATE COMPLETED
5/9/90	5/10/90

PAGE: 1 OF 6

LEGEND

SANDS, SILTS, CLAYS, SANDSTONE (ss), SILTSTONE (slt), CLAYSTONE (cs)

PB - Pitcher Barrel
DR - Drive Ring Sample
CHEM - Chemical Test
PI - Atterberg Limits Test
COMP - Compaction Test
DIR - Direct Shear Test
TX - Triaxial Test

PER - Permeability Test
SW - Swelling Test
SI - Sieve Analysis Test
%200 - Percentage Passing
HYD - Hydrometer Test
SG - Specific Gravity Test

DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PER FOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
0					cl		FILL, sandy, clay			
1–4					ss		SAN JOAQUIN FORMATION SANDSTONE, SILTY SANDSTONE, occasional sandy siltstone, tan, light brown, orange brown, typically very fine, non to weakly cemented			
5–7.5	PB	S-1		2.2/2.5	ss		- very fine sandstone, tan, mottled orange			%200
10–12.5	PB	S-2		2.3/2.5	ss		- tan, silty sandstone, very fine, minor claystone fragments, weakly cemented			
15										

REV. 8/10/90

LOG OF BORING L18-K

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF		
BORING NUMBER: L18-K	ELEVATION: 840'	DATE	
COORDINATES: N. 228,390 E. 1,701,722	BORING DIA.: 5"	STARTED	COMPLETED
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE	5/9/90	5/10/90
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL	PAGE: 2 OF 6	

DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PERFOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
16–17	PB	S-3		2.5/2.5			- tan, silty sandstone, very fine			
18–19										
20–22	PB	S-4		1.5/2.5			- tan, silty sandstone with orange brown siltstone interbed/pockets			%200
23–24										
25–27	PB	S-5		2.4/2.5			- clean sandstone with silty sandstone, sandy siltstone interbeds (or pockets)			SG COMP PER SW
28–29										
30–32	PB	S-6		2.5/2.5			- tan, sandy siltstone, mottled orange with minor gray claystone pocket (bioturbation)			
33–35										

LOG OF BORING L18-K

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF
BORING NUMBER: L18-K	ELEVATION: 804'
COORDINATES: N. 228,390 E. 1,701,722	BORING DIA.: 5"
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL

DATE	
STARTED	COMPLETED
5/9/90	5/10/90

PAGE: 3 OF 6

DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PER FOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
36–37	PB	S-7		1.9/2.2			- light brown, silty sandstone, very fine			
40–42	PB	S-8		2.3/2.5			- light brown, orange brown silty sandstone, very fine			%200
45–47	PB	S-9		1.9/2.0			- light brown siltstone - sandy siltstone			
50–52	PB	S-10		2.2/2.5	slt		- sandy siltstone with claystone pockets (or interbeds)			COMP PER SW
55										

LOG OF BORING L18-K

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF		
BORING NUMBER: L18-K	ELEVATION: 804'	DATE	
COORDINATES: N. 228,390 E. 1,701,722	BORING DIA.: 5"	STARTED	COMPLETED
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE	5/9/90	5/10/90
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL	PAGE: 4 OF 6	

DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PER FOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
56–57	PB	S-11		1.7/2.5			- tan to light brown silty sandstone, sandy siltstone, very fine grained			
60–62	PB	S-12		1.4/2.5			- light brown siltstone - sandy siltstone, minor white gypsum			
65					SS					
65–67	PB	S-13		1.9/2.2			- cemented sandstone - light brown sandstone, silty sandstone, very fine grained, moderate to well cemented, mottled dark brown (carbonacesus?), few shells at 67'			%200
70–72	PB	S-14		2.5/2.5			- orange brown silty sandstone, very fine, noncemented			
75										

LOG OF BORING L18-K

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF
BORING NUMBER: L18-K	ELEVATION: 804'
COORDINATES: N. 228,390 E. 1,701,722	BORING DIA.: 5"
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL

DATE STARTED	DATE COMPLETED
5/9/90	5/10/90

PAGE: 5 OF 6

DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PER FOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
76–77	PB	S-15		1.7/1.8			- orange brown silty sandstone, very fine			COMP PER SW
80–82	PB	S-16		1.2/2.3			- cemented from 80' to 82'			%200 PI
82–83					CS		CLAYSTONE, gray, brown, highly plastic, faint orange mottling			
85–87	PB	S-17		2.2/2.5			- dark gray claystone			
90–92	PB	S-18		2.5/2.5			- dark gray claystone			
95										

LOG OF BORING L18-K

PROJECT NUMBER: 89-977	PROJECT NAME: B-18 LANDFILL, KHF		
BORING NUMBER: L18-K	ELEVATION: 740'	DATE	
COORDINATES: N. 228,780 E. 1,702,480	BORING DIA.: 5"	STARTED	COMPLETED
DRILLING METHODS: MUD ROTARY	WATER DEPTH: NONE	3/14/90	3/15/90
ENG/GEO: R. HARLAN (WAHLER ASSOCIATES)	CHECKED BY: J. BADEL	PAGE: 6 OF 6	

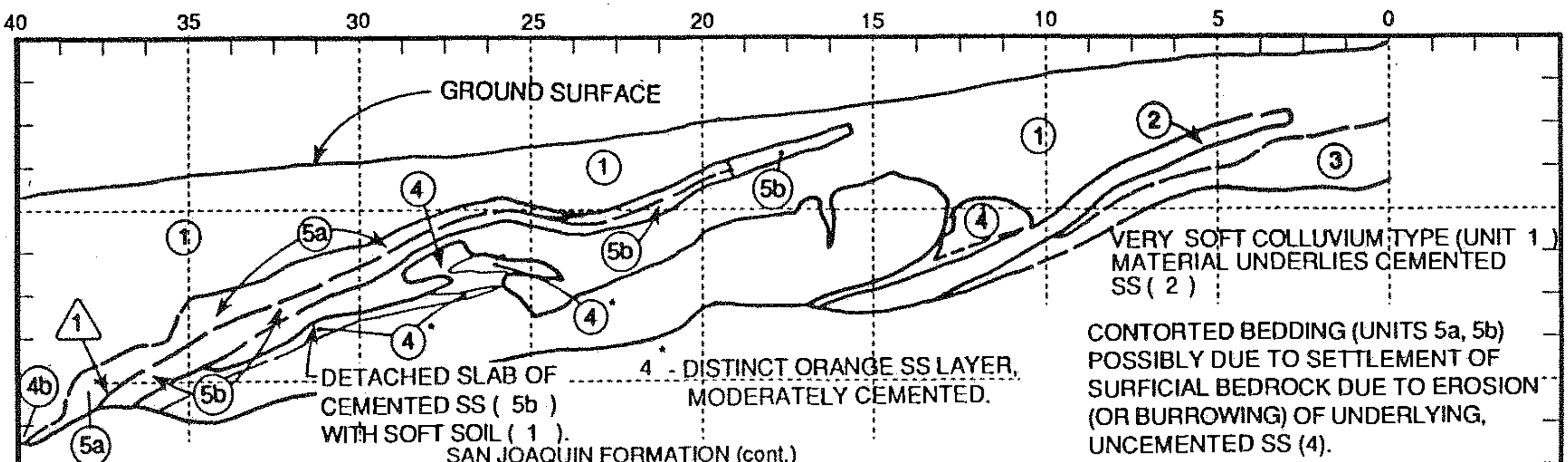
DEPTH IN FEET	SAMPLE TYPE	SAMPLE NO.	RESISTANCE (BLOWS PER FOOT)	RECOVERY	USCS/ROCK TYPE	PROFILE	DESCRIPTION	MOISTURE CONTENT %	DRY DENSITY (pcf)	OTHER TESTS
96 97	PB	S-19		2.5/2.5			- dark gray claystone			

- TOTAL DEPTH = 97.5'
- NO GROUND WATER ENCOUNTERED
- BACKFILLED WITH CEMENT GROUT VIA TREMIE

APPENDIX C
TRENCH AND TEST PIT LOGS

TRENCH NO. T-1

EQUIPMENT: DOZER		LOCATION: SEE FIGURE 2.3 - SITE GEOLOGIC MAP			SHEET 1 OF 2				
BEARING: N50°E		NOTES: LOG OF PORTION OF NORTH WALL OF DOZER CUT DT-B			DATE 7/21/90				
					FIELD ENGINEER: R. H. (WAHLER)				
UNITS			SAMPLE NO.	LAB TESTS	STRUCTURE				
DEPTH	NO.	DESCRIPTION			NO.	STRIKE	DIP	TYPE	
		COLLUVIUM			△1	N42°W	33°SW	bedding on unit (5b)	
	(1)	SANDY CLAY (cl, occasional sc): Light brown, dry-damp; low plasticity; 10-40% very fine sand; typically contains root voids. Unit (1) type-material which occursbeneath disturbed unit (3), and units (2) & (4) are very soft, easily gouged with fingers. Occasional clayey sand, very fine, loose (sc); occasional charcoal.							
		SAN JOAQUIN FORMATION							
	(2)	SANDSTONE (SS): Tan-light brown; well-cemented (hard); moderately strong; underlain by.							
	(3)	SANDSTONE (SS): White-tan, minor orange mottling: Very thick bedded (little discernable bedding). Very fine; non-weakly cemented; soft; friable (easily crumbled to loose soil with fingers.							



SAN JOAQUIN FORMATION (cont.)

(4) SANDSTONE (SS): Very similar to (3); white-tan with orange mottling, banding along bedding; soft; friable; thick-very thick bedded. Excavates as loose, fine sand (sp-sm). Contains numerous in-filled voids, cracks (filled with (1)), possibly partially due to burrowing, at and near contact with overlying units.

(4b) Same as (4), but stratigraphically up-section (above (5a) & (5b)).

(5a) SANDSTONE (SS): Tan-yellowish brown; moderately cemented; soft; weak.

(5b) SANDSTONE (SS): Orange-brown, well-cemented; hard; moderately strong.

NOTE: Contorted bedding (units (5a), (5b)) possibly due to settlement of surficial bedrock due to erosion (or burrowing) of underlying, uncemented ss ((4)).

REV. 8/14/90

CLIENT CHEMICAL WASTE MANAGEMENT, INC.

PROJECT NO. 89-977

LOCATION KETTLEMAN, CALIFORNIA

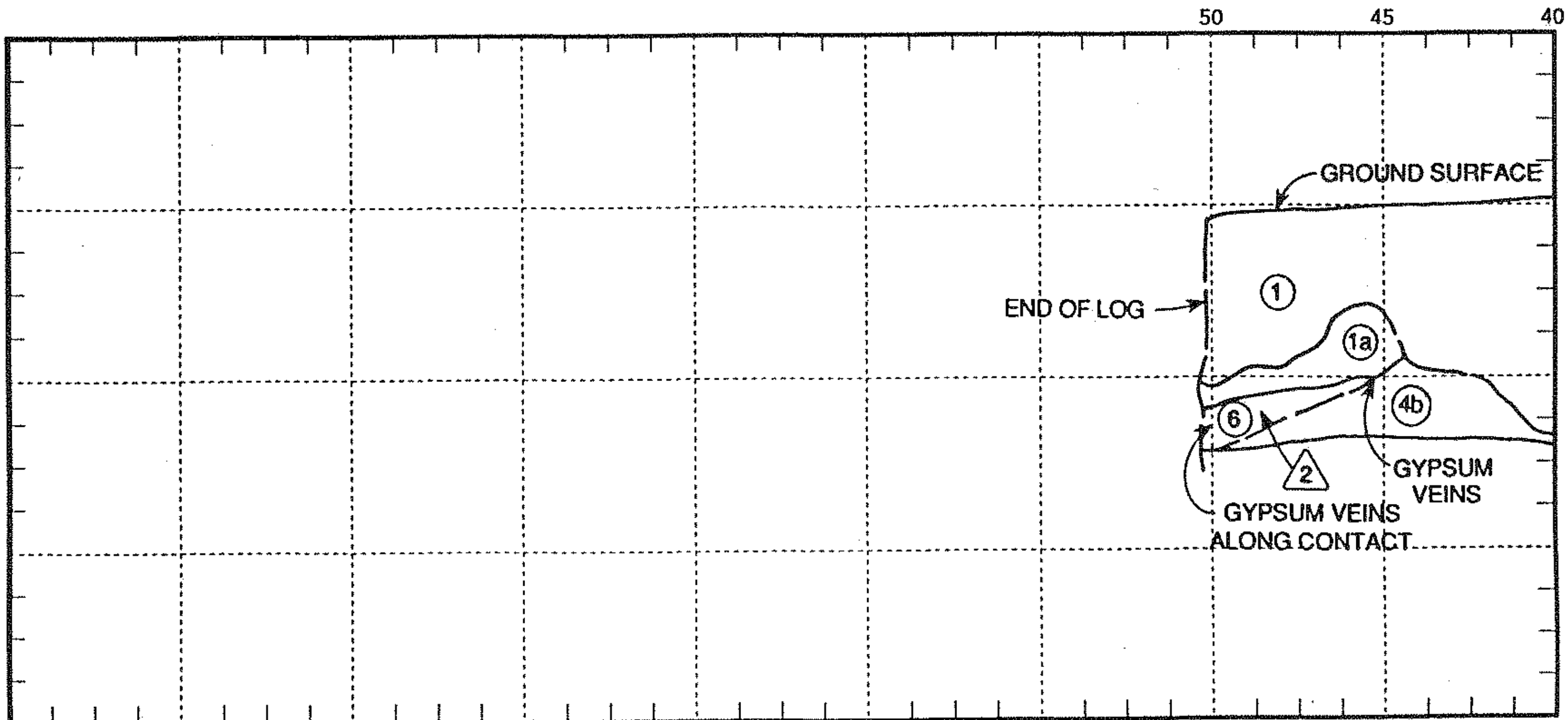
TRENCH NO. T-1 (cont.)

SHEET 2 OF 2
DATE 2/21/90

EQUIPMENT: DOZER	LOCATION: SEE FIGURE 2.3 - SITE GEOLOGIC MAP
BEARING: N50°E	NOTES: LOG OF PORTION OF NORTH WALL OF DOZER CUT DT-B

FIELD ENGINEER: R. H. (WAHLER)

UNITS					STRUCTURE			
DEPTH	NO.	DESCRIPTION	SAMPLE NO.	LAB TESTS	NO.	STRIKE	DIP	TYPE
		SAN JOAQUIN FORMATION (cont.)						
	(6)	SILTY SANDSTONE: Tan-gray; very fine; soft; friable to weak; laminated-thin bedded; 30-40% fines (sm); some siltstone-sandy siltstone interbeds.			△2	N43°W	31°SW	bedding
		COLLUVIUM (?)*						
	(1a)	SANDY CLAY: Gray-light brown; abundant white mottling (precipitate/gypsum?); appears very stiff; moderate plasticity; possibly severely weathered San Joaquin Formation?						



REV. 8/14/90

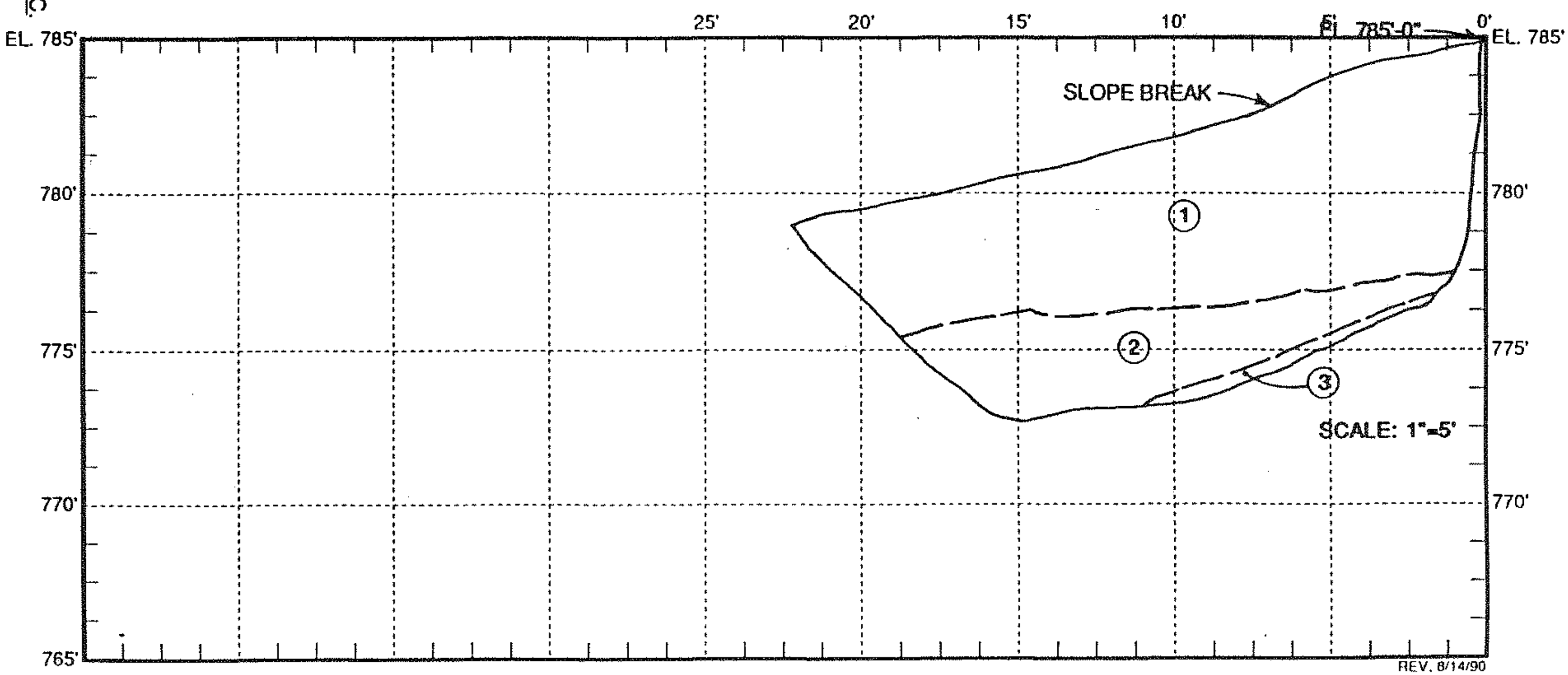
CLIENT CHEMICAL WASTE MANAGEMENT, INC.
PROJECT NO. 89-977
LOCATION KETTLEMAN, CALIFORNIA

TRENCH NO. T-2

SHEET 1 OF 1

DATE 2/27/90

EQUIPMENT: DOZER		LOCATION: SEE FIGURE 2.3 - SITE GEOLOGIC MAP						
BEARING: N4°E		NOTES:			FIELD ENGINEER: R. H. (WAHLER)			
UNITS			SAMPLE NO.	LAB TESTS	STRUCTURE			
DEPTH	NO.	DESCRIPTION			NO.	STRIKE	DIP	TYPE
		COLLUVIUM						
	①	SANDY CLAY (CL): Light brown; dry-slighty damp; low-moderate plasticity; 10-40% very fine sand; excavates easily.						
		SAN JOAQUIN FORMATION						
	②	SANDSTONE (SS): White-tan; very fine; non-weakly cemented; excavates with moderate difficulty; very dense.						
	③	CEMENTED SANDSTONE/SILTSTONE (SS/SLT): Orange-brown; moderately hard; moderately strong; excavates with difficulty; appears planar.						



CLIENT CHEMICAL WASTE MANAGEMENT, INC.

PROJECT NO. 89-977

LOCATION KETTLEMAN, CALIFORNIA

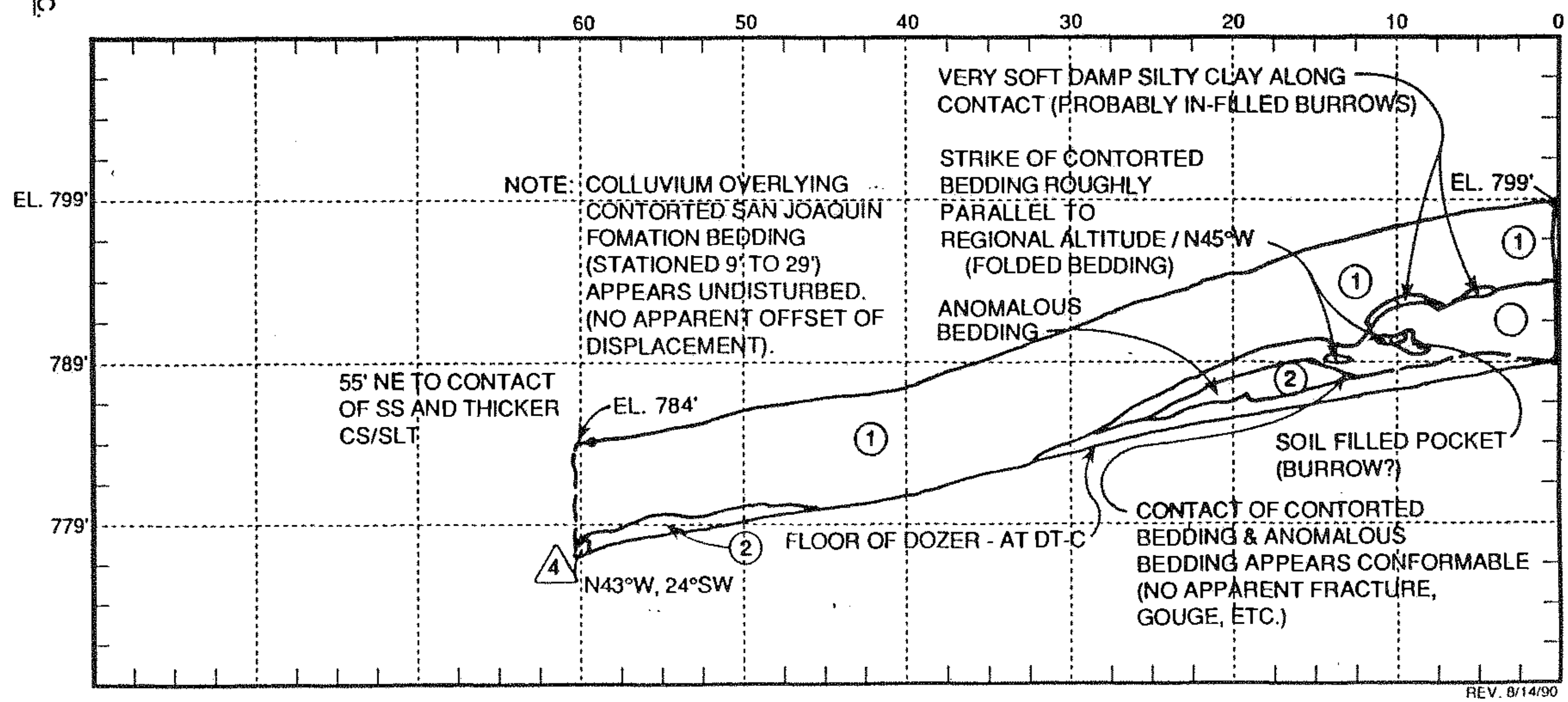
TRENCH NO. T-3

SHEET 1 OF 1
DATE 3/23/90

EQUIPMENT: DOZER	LOCATION: SEE FIGURE 2.3 - SITE GEOLOGIC MAP	FIELD ENGINEER: R. H. (WAHLER)
BEARING: S72°W	NOTES:	

DEPTH	NO.	DESCRIPTION	SAMPLE NO.	LAB TESTS
		COLLUVIUM		
	①	SANDY CLAY (SC): Light brown; dry; low-moderate plasticity; 20-40% very fine sand; numerous root voids (pin-hole); caliche along root voids & soil fractures (dessication cracks); very stiff to hard.		
		SAN JOAQUIN FORMATION		
	②	CLAYSTONE (C/ST): Gray/brown; severly weathered to about 1' below contact with ①; slightly weathered at depth. soft; weak; laminated to thin bedded; occasional siltstone; very fine sandstone laminae.		

STRUCTURE NO.	STRIKE	DIP	TYPE
△1	N46°W	26°SW	bedding
△2	N55°W	73°SW	bedding
△3	N68°W	40°SW	bedding
△4	N43°W	24°SW	bedding



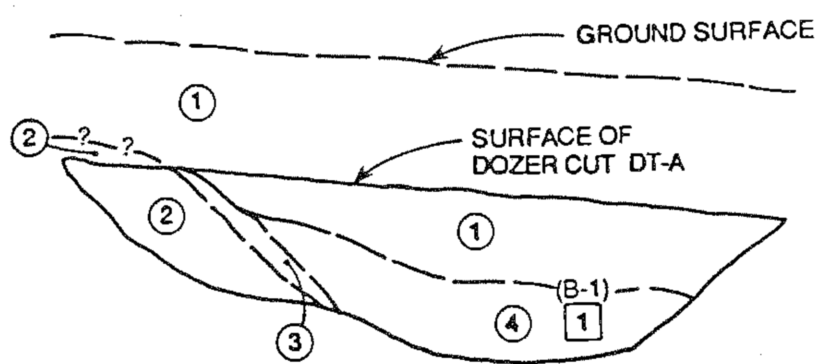
REV. 8/14/90

CLIENT CHEMICAL WASTE MANAGEMENT, INC.
PROJECT NO. 89-977
LOCATION KETTLEMAN, CALIFORNIA

TEST PIT NO. TP-1

SHEET 1 OF 1	LOCATION: SEE FIGURE 2.3 - SITE GEOLOGIC MAP		BEARING: S53°W
RIG: CAT 426 BACKHOE	PIT WIDTH: 24"	DATE 2/20/90	LOGGED BY: R. H. (WAHLER)

TEST PIT NO.	DEPTH INTERVAL	SOIL TYPE	WATER DEPTH	MATERIAL DESCRIPTION EXCAVATION CHARACTERISTICS	SAMPLE NUMBER	SAMPLE DEPTH
				COLLUVIUM		
TP-1	0-~6'		NONE	(1) SANDY CLAY (cl): Light brown; dry -damp; low-moderate plasticity; 20-40% very fine sand; numerous root voids; occasional white precipitate (gypsum?); stiff; excavates easily.		
				SAN JOAQUIN FORMATION		
				(2) CLAYEY SILTSTONE/CLAYSTONE (SLT/CS): Light brown mottled orange (siltstone); moderate-dark gray (claystone), interbeded; laminated to thin bedded; slightly weathered; soft; weak; excavates with moderate difficulty; 1/4" to 1" thick slabs of hard clay (up to 6"dia.).		
				(3) CEMENTED SANDSTONE (SS): White/tan, some orange, brown mottling; fine to coarse sand; moderately hard; moderately strong; slightly weathered.		
				(4) SANDSTONE (SS): Tan/white, mottled orange; slightly weathered; very fine; 5-30% fines (sp-sm); very thick bedded; soft; friable; excavates with slight difficulty.	[1] B-1	~7'



REV. 8/14/90

CLIENT CHEMICAL WASTE MANAGEMENT, INC.

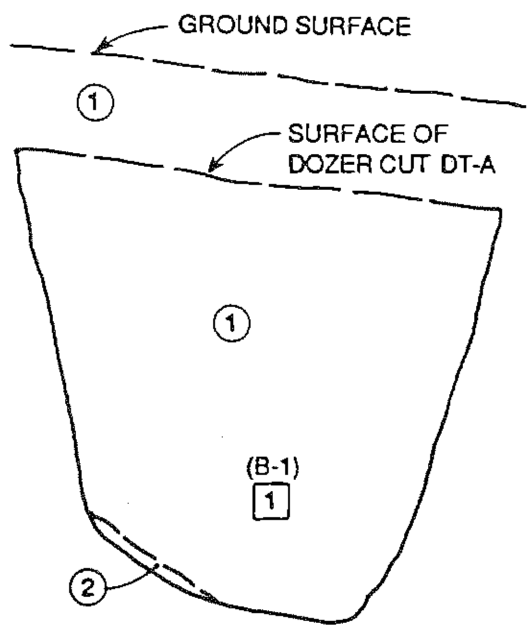
PROJECT NO. 89-977

LOCATION KETTLEMAN, CALIFORNIA

TEST PIT NO. TP-2

SHEET 1 OF 1	LOCATION: SEE FIGURE 2.3 - SITE GEOLOGIC MAP		BEARING: S50°W
RIG: CAT 426 BACKHOE	PIT WIDTH: 24"	DATE: 2/20/90	LOGGED BY: R. H. (WAHLER)

TEST PIT NO.	DEPTH INTERVAL	SOIL TYPE	WATER DEPTH	MATERIAL DESCRIPTION EXCAVATION CHARACTERISTICS	SAMPLE NUMBER	SAMPLE DEPTH
TP-2	0'--15'		NONE	COLLUVIUM (1) SANDY CLAY (cl): Light brown; dry-damp; low-moderate plasticity; 20-40% very fine sand; numerouw root voids; occasional white precipitate (gypsum?); stiff; excavates easily. SAN JOAQUIN FORMATION (2) SANDSTONE (SS): Tan/white; faint orange mottling; slightly weathered; soft friable; excavates with slight difficulty; very fine grained.		



SCALE: 1"=5'

REV. 8/14/90

CLIENT CHEMICAL WASTE MANAGEMENT, INC.

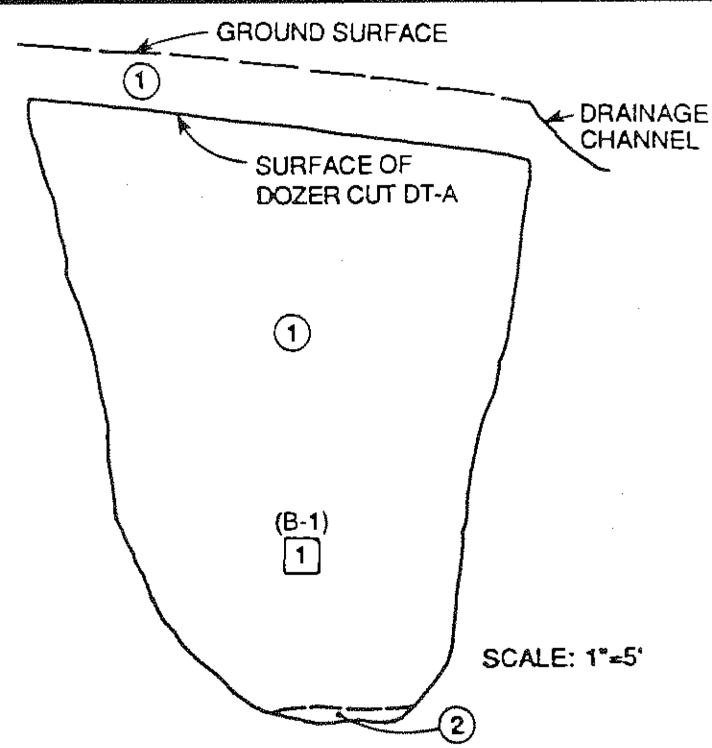
PROJECT NO. 89-977

LOCATION KETTLEMAN, CALIFORNIA

TEST PIT NO. TP-3

SHEET 1 OF 1	LOCATION: SEE FIGURE 2.3 - SITE GEOLOGIC MAP		BEARING: S55°W
RIG: CAT 426 BACKHOE	PIT WIDTH: 24"	DATE: 2/20/90	LOGGED BY: R.H. (WAHLER)

TEST PIT NO.	DEPTH INTERVAL	SOIL TYPE	WATER DEPTH	MATERIAL DESCRIPTION EXCAVATION CHARACTERISTICS	SAMPLE NUMBER	SAMPLE DEPTH
TP-3	0'-~18'		NONE	COLLUVIUM (1) SANDY CLAY (cl): Light brown; damp; low-moderate plasticity; 10-20% very fine sand, occasional lenses of fine, clayey sand; 10-40% fines; stiff; excavates easily. SAN JOAQUIN FORMATION (2) SANDSTONE (SS): Tan, stained white (precipitation/gypsum?); some orange mottling; soft; friable; very fine.	[1] B-1	~15'



REV. 8/14/90

CLIENT CHEMICAL WASTE MANAGEMENT, INC.

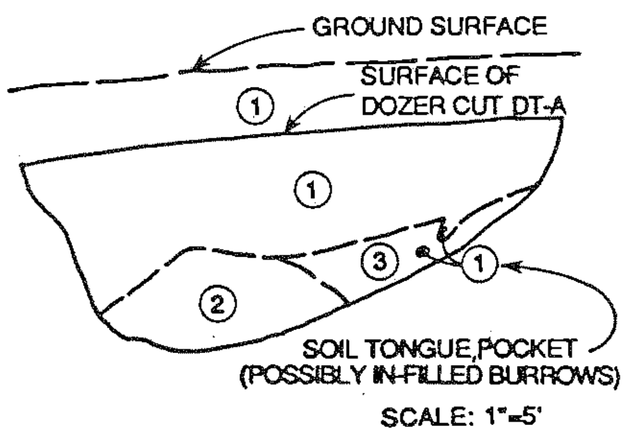
PROJECT NO. 89-977

LOCATION KETTLEMAN, CALIFORNIA

TEST PIT NO. TP-4

SHEET 1 OF 1	LOCATION: SEE FIGURE 2.3 - SITE GEOLOGIC MAP		BEARING: S53°W
RIG: CAT 426 BACKHOE	PIT WIDTH: 24"	DATE: 2/20/90	LOGGED BY: R. H. (WAHLER)

TEST PIT NO.	DEPTH INTERVAL	SOIL TYPE	WATER DEPTH	MATERIAL DESCRIPTION EXCAVATION CHARACTERISTICS	SAMPLE NUMBER	SAMPLE DEPTH
TP-4	0'-~6.5'@ NE end 0-~3.5'@ SW end (Thickens to NE towards channel)		NONE	<u>COLLUVIUM</u> (1) SANDY CLAY (cl): Light brown; dry-damp; low-moderate plasticity; 10-40% very fine sand; appears firm-stiff; excavates easily. <u>SAN JOAQUIN FORMATION</u> (2) SANDSTONE (SS): Tan/white, minor orange mottling; very fine; 5-30% fines; soft; friable; slightly weatered; very thick bedded. Excavates with slight difficulty. (3) CLAYSTONE (CS): Gray, mottled white (gypsum?); slightly weathered; laminated to very thin bedded; soft; weak; occastional fossils; sand content varies along laminae and in-filled pockets (bioturbation). Excavates with slight difficulty as hard, angular chunks of clay up to ~2" dia.		



REV. 8/14/90

CLIENT CHEMICAL WASTE MANAGEMENT, INC.

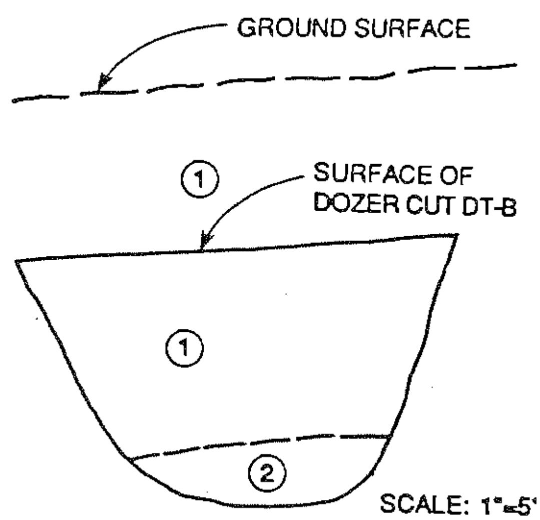
PROJECT NO. 89-977

LOCATION KETTLEMAN, CALIFORNIA

TEST PIT NO. TP-5

SHEET 1 OF 1	LOCATION: SEE FIGURE 2.3 - SITE GEOLOGIC MAP		BEARING: N50°E
RIG: CAT 426 BACKHOE	PIT WIDTH: 24"	DATE: 2/21/90	LOGGED BY: R. H. (WAHLER)

TEST PIT NO.	DEPTH INTERVAL	SOIL TYPE	WATER DEPTH	MATERIAL DESCRIPTION EXCAVATION CHARACTERISTICS	SAMPLE NUMBER	SAMPLE DEPTH
TP-5	0'-10'		NONE	COLLUVIUM ① SANDY CLAY (cl): Light brown; dry-slightly damp; 30-40% very fine sand; low plasticity appears firm; excavates easily.		
	10'-11.5'			SAN JOAQUIN FORMATION ② SANDSTONE (SS): Light gray; very fine; 20-40% non-plastic fines; soft; friable; excavates with slight difficulty as loose soil to ~3"dia. chunks (easily broken by hand).		



REV. 8/14/90

CLIENT CHEMICAL WASTE MANAGEMENT, INC.

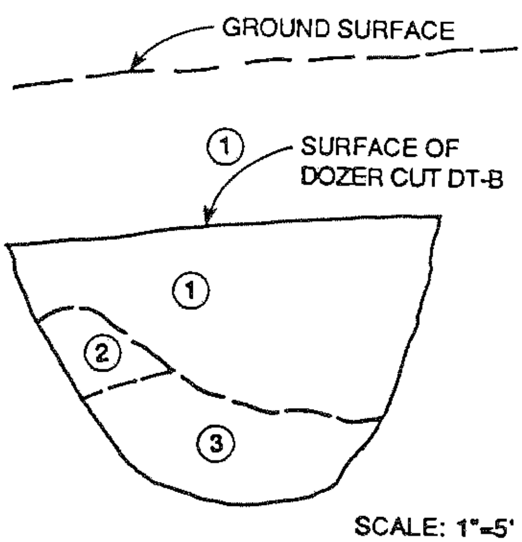
PROJECT NO. 89-977

LOCATION KETTLEMAN, CALIFORNIA

TEST PIT NO. TP-6

SHEET 1 OF 1	LOCATION: SEE FIGURE 2.3 - SITE GEOLOGIC MAP		BEARING: N38°E
RIG: CAT 426 BACKHOE	PIT WIDTH: 24"	DATE: 2/21/90	LOGGED BY: R. H. (WAHLER)

TEST PIT NO.	DEPTH INTERVAL	SOIL TYPE	WATER DEPTH	MATERIAL DESCRIPTION EXCAVATION CHARACTERISTICS	SAMPLE NUMBER	SAMPLE DEPTH
TP-6	varies (see sketch)		NONE	COLLUVIUM (1) SANDY CLAY (cl): Light brown; damp; 10-40% very fine sand; low-moderate plasticity; excavates easily; numerous root voids; occasional concentrations of precipitate along root voids (white stringers). SAN JOAQUIN FORMATION (2) CLAYSTONE (CS): Dark gray; some orange laminae; damp (moderate-severely weathered); soft, friable. (3) SILTSTONE/SANDY SILTSTONE (SLT): Tan with orange laminae; slightly weathered; laminated-very thin bedded; soft; excavates with slight difficulty as chunks up to ~2"dia. (can be broken by hand with some difficulty).		



REV. 8/14/90

CLIENT CHEMICAL WASTE MANAGEMENT, INC.

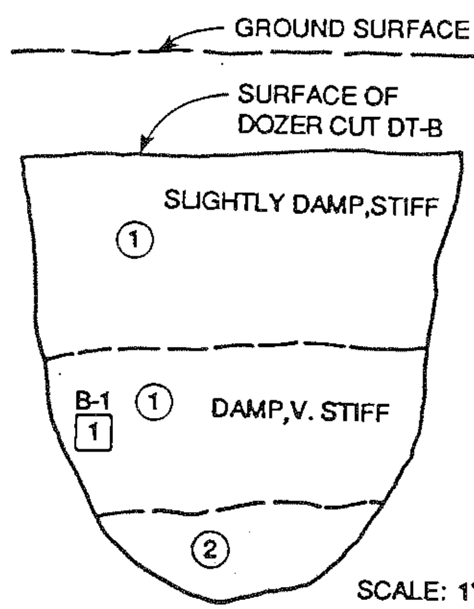
PROJECT NO. 89-977

LOCATION KETTLEMAN, CALIFORNIA

TEST PIT NO. TP-7

SHEET 1 OF 1	LOCATION: SEE FIGURE 2.3 - SITE GEOLOGIC MAP		BEARING: N36°E
RIG: CAT 426 BACKHOE	PIT WIDTH: 24"	DATE: 2/22/90	LOGGED BY: R. H. (WAHLER)

TEST PIT NO.	DEPTH INTERVAL	SOIL TYPE	WATER DEPTH	MATERIAL DESCRIPTION EXCAVATION CHARACTERISTICS	SAMPLE NUMBER	SAMPLE DEPTH
TP-7	0'-12.5'		NONE	COLLUVIUM (1) SANDY CLAY (cl): Light brown; dry-slightly damp; low-moderate plasticity; 10-40% very fine sand; numerous root voids; occasional precipitation(gypsum?) stringers; excavates easily; stiff. 8-12.5' - medium brown; excavates with moderate difficulty, very stiff, damp; moderate plasticity; generally less sand content (10-20%); occasional gray claystone fragments to 1/2"dia.	[1] B-1	~110'
	12.5'-15'			SAN JOAQUIN FORMATION (2) CLAYSTONE (CS): Dark gray with occasional orange banding (Fe-stain along bedding); slightly weathered; laminated to thin bedded; soft; weak; occasional very fine sand laminae; highly plastic; excavates with slight difficulty as ~1/2" to 3"dia. slabs (up to~1" thick) of hard clay.		



SCALE: 1"=5'

REV. 8/14/90

CLIENT CHEMICAL WASTE MANAGEMENT, INC.

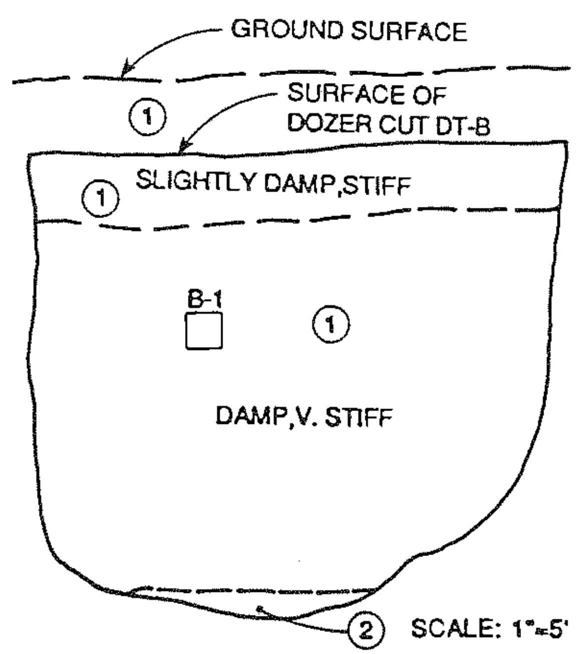
PROJECT NO. 89-977

LOCATION KETTLEMAN, CALIFORNIA

TEST PIT NO. TP-8

SHEET 1 OF 1	LOCATION: SEE FIGURE 2.3 - SITE GEOLOGIC MAP		BEARING: N41°E
RIG: CAT 426 BACKHOE	PIT WIDTH: 24"	DATE: 2/22/90	LOGGED BY: R. H. (WAHLER)

TEST PIT NO.	DEPTH INTERVAL	SOIL TYPE	WATER DEPTH	MATERIAL DESCRIPTION EXCAVATION CHARACTERISTICS	SAMPLE NUMBER	SAMPLE DEPTH
TP-8	0'-14.5'		none	COLLUVIUM (1) SANDY CLAY (cl): Light brown; dry-slightly damp; low-moderate plasticity; 10-40% very fine sand; excavates slightly difficultly; stiff; root voids. brown; damp; moderately plastic; excavates with moderate difficulty; occasional white precipitate (gypsum?); rare slickensides (striated slick surfaces noted @ ~9',11'); minor black organic material from ~4' to 14.5'. Occasional gray claystone fragments from ~10' to 14.5' (increased fragments from ~14' to 14.5').	[1] B-1	7'
	14.5'-15'			SAN JOAQUIN FORMATION (2) CLAYSTONE (CS): Dark gray; some orange banding;soft; weak; highly plastic; laminated - very thin bedded.		



REV. 8/14/90

CLIENT CHEMICAL WASTE MANAGEMENT, INC.

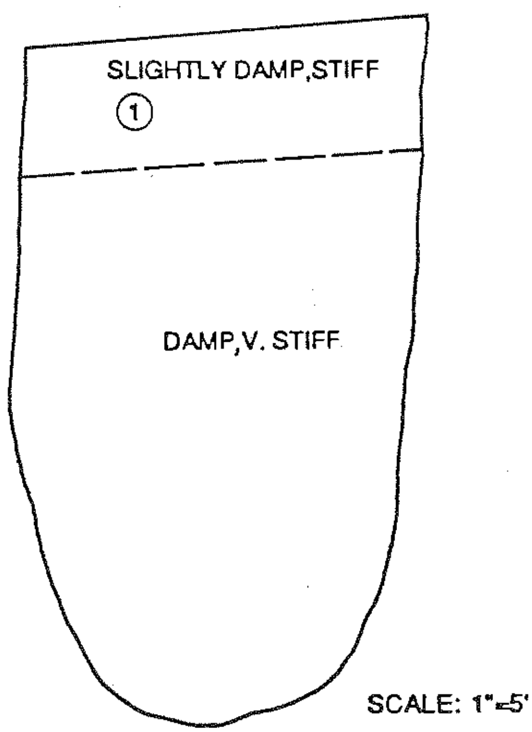
PROJECT NO. 89-977

LOCATION KETTLEMAN, CALIFORNIA

TEST PIT NO. TP-9

SHEET 1 OF 1	LOCATION: SEE FIGURE 2.3 - SITE GEOLOGIC MAP		BEARING: N41°E
RIG: CAT 426 BACKHOE	PIT WIDTH: 24"	DATE: 2/22/90	LOGGED BY: R. H. (WAHLER)

TEST PIT NO.	DEPTH INTERVAL	SOIL TYPE	WATER DEPTH	MATERIAL DESCRIPTION EXCAVATION CHARACTERISTICS	SAMPLE NUMBER	SAMPLE DEPTH
TP-9	0'-18'		NONE	COLLUVIUM (1) SANDY CLAY (cl): Light brown; slightylyt damp; low-moderate plasticity; root voids. moderate brown; damp; moderately plastic; numerous fine, clayey sand and clean sand laminae (intermittent alluvial deposits); excavates with moderate difficulty (very stiff). NOTE: Unable to reach bedrock (colluvium > 18' deep). Test pit located at floor of DT-B		



REV. 8/14/90

CLIENT CHEMICAL WASTE MANAGEMENT, INC.

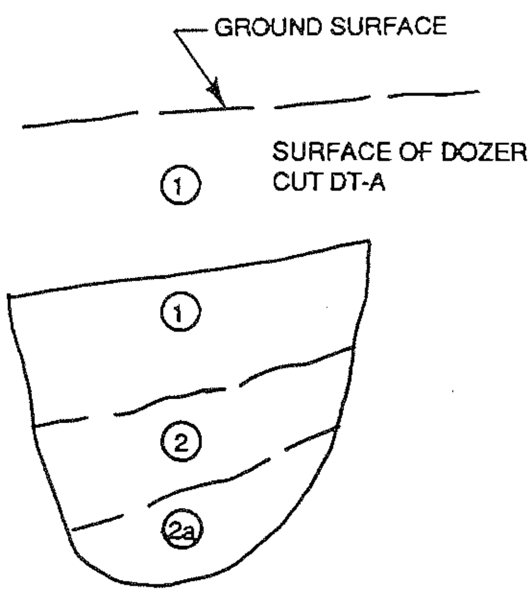
PROJECT NO. 89-977

LOCATION KETTLEMAN, CALIFORNIA

TEST PIT NO. TP-10

SHEET 1 OF 1	LOCATION: SEE FIGURE 2.3 - SITE GEOLOGIC MAP		BEARING: S56°W
RIG: CAT 426 BACKHOE	PIT WIDTH: 24"	DATE: 2/22/90	LOGGED BY: R. H. (WAHLER)

TEST PIT NO.	DEPTH INTERVAL	SOIL TYPE	WATER DEPTH	MATERIAL DESCRIPTION EXCAVATION CHARACTERISTICS	SAMPLE NUMBER	SAMPLE DEPTH
				COLLUVIUM		
TP-10	0 - 7'		NONE	(1) CLAYEY SAND, SANDY CLAY (cl,sc): Light brown: dry to damp (moisture content increases with depth); varies from (sc) to (cl), 30-70% fines; medium dense/stiff (very stiff, damp @ depth). Excavates with slight difficulty. Mottled white (gypsum?).		
				SAN JOAQUIN FORMATION		
	7' - 9'			(2) CLAYSTONE (CS): Gray; severely weathered; soft; plastic.		
	9' - 12.5'			(2a) CLAYSTONE (CS): Dark gray; severely weathered; soft; weak; excavates with moderate difficulty; thick-very thick bedded (bedding not apparent); excavates as ~1/2" to 3" chunks of hard CH.		



SCALE: 1" = 5'

REV. 8/14/90

CLIENT CHEMICAL WASTE MANAGEMENT, INC.

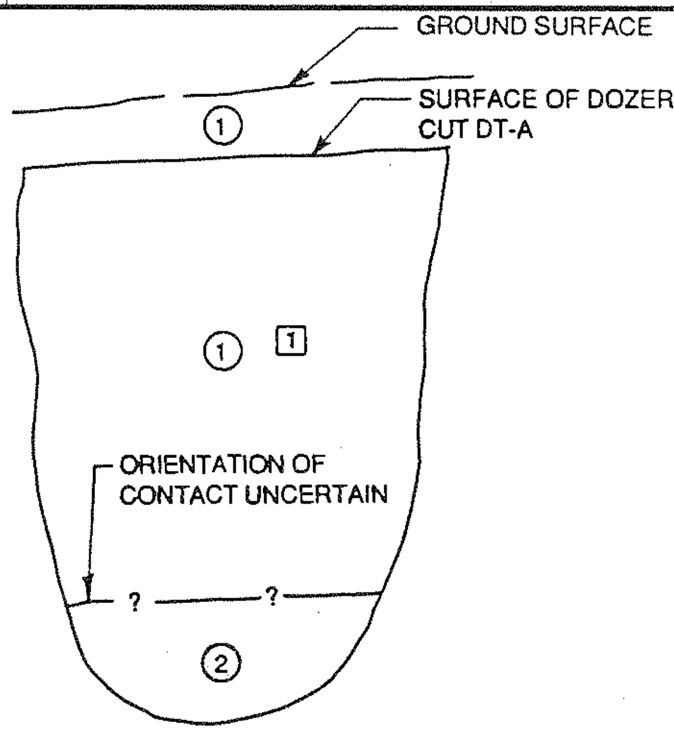
PROJECT NO. 89-977

LOCATION KETTLEMAN, CALIFORNIA

TEST PIT NO. TP-11

SHEET 1 OF 1	LOCATION: SEE FIGURE 2.3 - SITE GEOLOGIC MAP		BEARING: S51°W
RIG: CAT 426 BACKHOE	PIT WIDTH: 24"	DATE: 2/21/90	LOGGED BY: R. H. (WAHLER)

TEST PIT NO.	DEPTH INTERVAL	SOIL TYPE	WATER DEPTH	MATERIAL DESCRIPTION EXCAVATION CHARACTERISTICS	SAMPLE NUMBER	SAMPLE DEPTH
				COLLUVIUM		
TP-11	0 - 14'		NONE	(1) CLAYEY SAND (sc): Light brown; dry-damp; very fine; 20-40% fines; excavates easily; appears loose near surface to medium dense, dense with depth; grades into cleaner sand (10-20% fines) and sandy clay (30-40% very fine sand); moderate white precipitate.		
				9' - 14': Excavates with moderate difficulty (dense); abundant white precipitate (gypsum).	[1] B-1	~7'
				13' - 14': Includes white, tubular chunks of hard, cemented sandstone, at random orientations.		
				SAN JOAQUIN FORMATION		
	14' - 17.5'			(2) INTERBEDDED CLAYSTONE/SANDSTONE (CS/SS): Dark gray claystone, highly plastic, soft, weak; tan-gray, very fine sandstone with minor orange mottling; soft, friable; both materials SS non-weakly cemented, laminated - thin bedded (planer chunks up to ~3" thick): Severly weathered claystone, plastic, @ contact (14'-~14.5')		



SCALE: 1" = 5'

REV. 8/14/90

CLIENT CHEMICAL WASTE MANAGEMENT, INC.

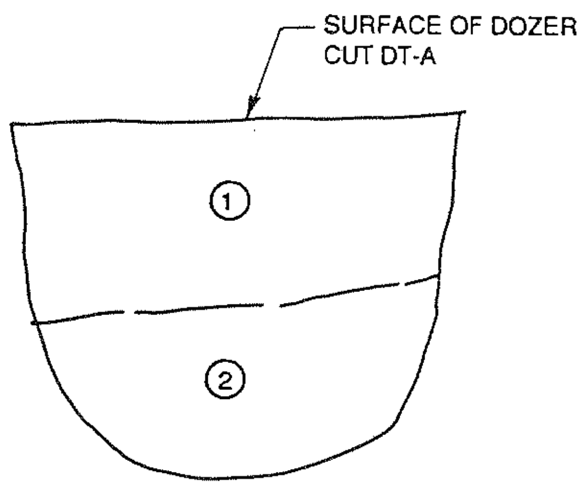
PROJECT NO. 89-977

LOCATION KETTLEMAN, CALIFORNIA

TEST PIT NO. TP-12

SHEET 1 OF 1	LOCATION: SEE FIGURE 2.3 - SITE GEOLOGIC MAP	BEARING: N67°W
RIG: CAT 426 BACKHOE	PIT WIDTH: 24" DATE: 2/22/90	LOGGED BY: R. H. (WAHLER)

TEST PIT NO.	DEPTH INTERVAL	SOIL TYPE	WATER DEPTH	MATERIAL DESCRIPTION EXCAVATION CHARACTERISTICS	SAMPLE NUMBER	SAMPLE DEPTH
TP-12	0 - 10.5'			COLLUVIUM (1) SANDY CLAY (cl occasional SC): Dry-slightly damp to ~5'; damp below ~5'; low plasticity; 30-40% very fine sand; occasional grades to clayey sand; appears loose to ~5' (excavates with moderate difficulty below 5'); variable white precipitate.		
	10.5' - 15.5'			SAN JOAQUIN FORMATION (2) INTERBEDDED CLAYEY SILTSTONE, CLAYSTONE, SANDSTONE: (SLT/CS/SS): Clayey siltstone-brown; claystone-gray; sandstone-tan; entire unit laminated-thin bedded; non-weakly cemented very fine SS; predominately clayey siltstone/claystone (SS ~25% of unit).		



SCALE: 1" = 5'

REV. 8/14/90

CLIENT CHEMICAL WASTE MANAGEMENT, INC.

PROJECT NO. 89-977

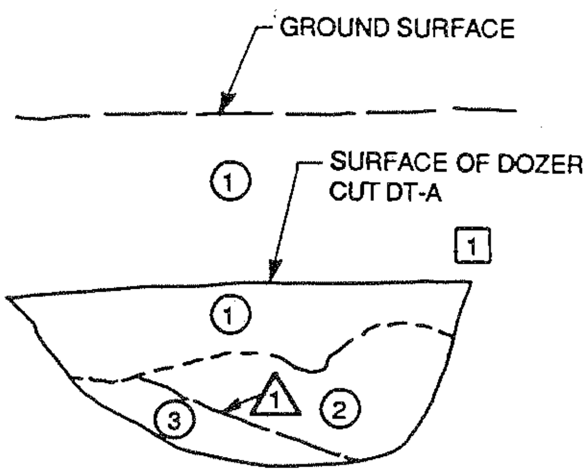
LOCATION KETTLEMAN, CALIFORNIA

TEST PIT NO. TP-13

BEDDING △1: N47°, 32°SW

SHEET 1 OF 1	LOCATION: SEE FIGURE 2.3 - SITE GEOLOGIC MAP		BEARING: S83°W
RIG: CAT 426 BACKHOE	PIT WIDTH: 24"	DATE: 2/22/90	LOGGED BY: R. H. (WAHLER)

TEST PIT NO.	DEPTH INTERVAL	SOIL TYPE	WATER DEPTH	MATERIAL DESCRIPTION EXCAVATION CHARACTERISTICS	SAMPLE NUMBER	SAMPLE DEPTH
TP-13	0 - 6.5'			COLLUVIUM (1) SANDY CLAY (cl): Light brown; dry to ~5'; damp below ~5'; low-moderate plasticity; variable white precipitate; root voids; stiff to ~5'; very stiff below 5'; 30-40% very fine sand.		
	6.5' - 11.5'			SAN JOAQUIN FORMATION (2) CLAYSTONE (CS): Dark, gray; laminated; lesser brown, clayey siltstone laminae; some orange stain along bedding; abundant gypsum @ contact with (1); soft; weak. (3) SILTY SANDSTONE (SLT/SS): Tan-light brown; very fine; thick-very thick bedded (bedding not discernible); non-weakly cemented; soft; friable.	[1] B-1	~4'



REV. 8/14/90

CLIENT CHEMICAL WASTE MANAGEMENT, INC.

PROJECT NO. 89-977

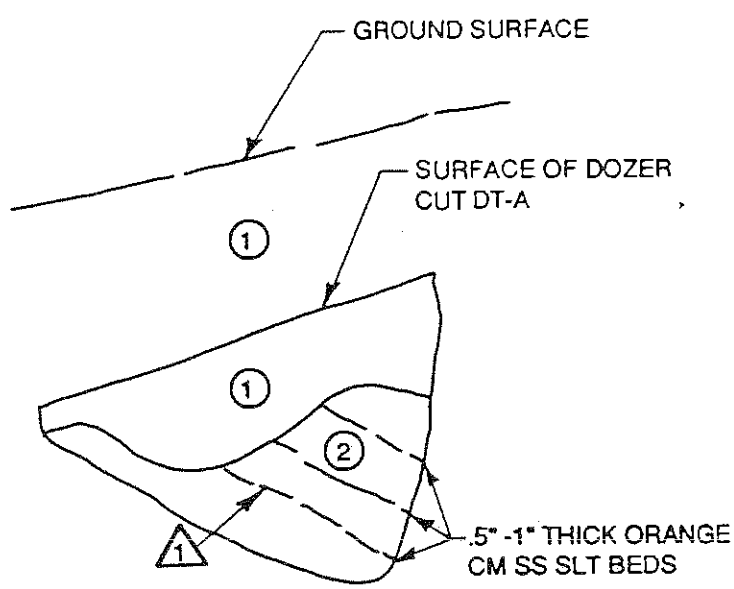
LOCATION KETTLEMAN, CALIFORNIA

TEST PIT NO. TP-14

BEDDING △1: N48°, 33°SW

SHEET 1 OF 1	LOCATION: SEE FIGURE 2.3 - SITE GEOLOGIC MAP		BEARING: S51°W
RIG: CAT 426 BACKHOE	PIT WIDTH: 24"	DATE: 2/22/90	LOGGED BY: R. H. (WAHLER)

TEST PIT NO.	DEPTH INTERVAL	SOIL TYPE	WATER DEPTH	MATERIAL DESCRIPTION EXCAVATION CHARACTERISTICS	SAMPLE NUMBER	SAMPLE DEPTH
				COLLUVIUM		
TP-14	0 - ~7'			(1) CLAYEY SAND (sc): Light brown; dry; very loose-loose; very fine; 20-40% fines; excavates easily.		
				SAN JOAQUIN FORMATION		
	7' - ~12'			(2) SANDSTONE (SS): Tan-white; thin-medium bedding;(dense) friable: non-cemented (easily crumbled with fingers); excavates with slight difficulty.		



SCALE: 1" = 5'

REV. 8/14/90

CLIENT CHEMICAL WASTE MANAGEMENT, INC.

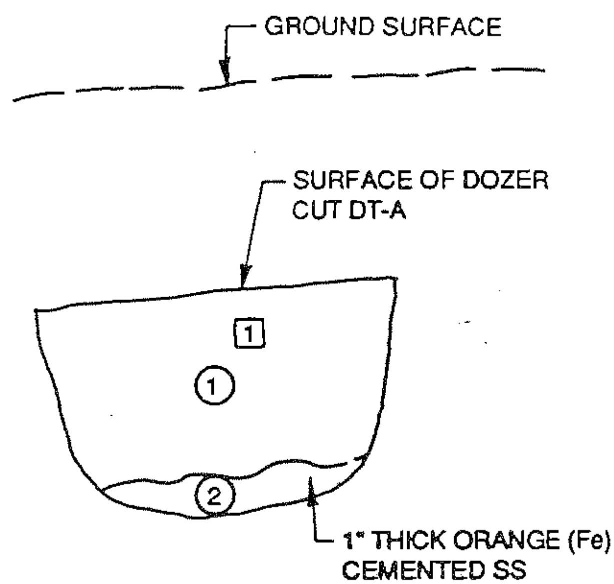
PROJECT NO. 89-977

LOCATION KETTLEMAN, CALIFORNIA

TEST PIT NO. TP-15

SHEET 1 OF 1	LOCATION: SEE FIGURE 2.3 - SITE GEOLOGIC MAP		BEARING: S54°W
RIG: CAT 426 BACKHOE	PIT WIDTH: 36"	DATE: 2/27/90	LOGGED BY: R. H. (WAHLER)

TEST PIT NO.	DEPTH INTERVAL	SOIL TYPE	WATER DEPTH	MATERIAL DESCRIPTION EXCAVATION CHARACTERISTICS	SAMPLE	
					NUMBER	DEPTH
TP-15	0 - 11'			COLLUVIUM (1) CLAYEY SAND (sc occasional cl): Light brown; slightly damp; very fine; 20-40% fines; occasional grades to sandy clay; 30-40% very fine sand; excavates easily; appears medium dense; occasional white mottling (precipitate/gypsum?); numerous root voids.	[1] B-1	~7'
	11' - 12'			SAN JOAQUIN FORMATION (2) SANDSTONE (SS): Tan-white; soft; friable; very fine; very thick bedded; excavates with slight difficulty; occasionally thin (up to ~1" thick) cemented layers. Excavates as loose, fine sand (sp).		



REV. 8/14/90

CLIENT CHEMICAL WASTE MANAGEMENT, INC.

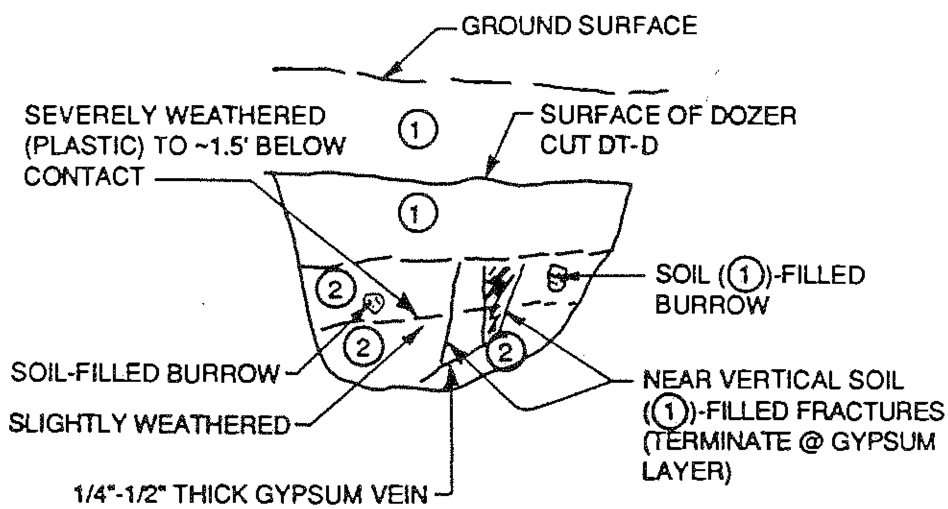
PROJECT NO. 89-977

LOCATION KETTLEMAN, CALIFORNIA

TEST PIT NO. TP-16

SHEET 1 OF 1	LOCATION: SEE FIGURE 2.3 - SITE GEOLOGIC MAP		BEARING: N54°E
RIG: CAT 426 BACKHOE	PIT WIDTH: 36"	DATE: 2/27/90	LOGGED BY: R. H. (WAHLER)

TEST PIT NO.	DEPTH INTERVAL	SOIL TYPE	WATER DEPTH	MATERIAL DESCRIPTION EXCAVATION CHARACTERISTICS	SAMPLE NUMBER	SAMPLE DEPTH
				COLLUVIUM		
TP-16	0 - 5.5'			(1) SANDY CLAY (cl): Light brown; damp; low plasticity; 30-40% very fine sand; appears very stiff ; excavates easily; root vords; variable white mottling (gypsum(?) stringers along root vords and soil fractures).		
				SAN JOAQUIN FORMATION		
	5.5' - 8.5'			(2) CLAYSTONE (CS): Moderate-dark gray; severely weathered to ~1.5' below contact (slightly weathered at greater depth); soft; weak (plastic where severely weathered); excavates with slight difficulty; laminated to very thin bedded.		



SCALE: 1" = 5'

REV. 8/14/90

CLIENT CHEMICAL WASTE MANAGEMENT, INC.

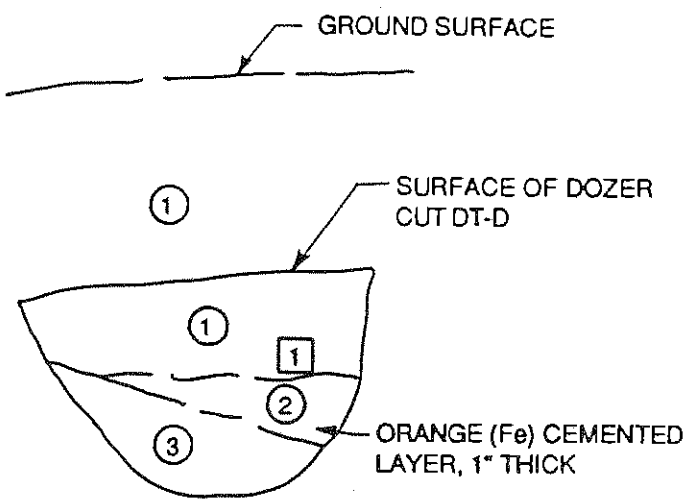
PROJECT NO. 89-977

LOCATION KETTLEMAN, CALIFORNIA

TEST PIT NO. TP-17

SHEET 1 OF 1	LOCATION: SEE FIGURE 2.3 - SITE GEOLOGIC MAP		BEARING: S44°E
RIG: CAT 426 BACKHOE	PIT WIDTH: 36"	DATE: 2/27/90	LOGGED BY: R. H. (WAHLER)

TEST PIT NO.	DEPTH INTERVAL	SOIL TYPE	WATER DEPTH	MATERIAL DESCRIPTION EXCAVATION CHARACTERISTICS	SAMPLE NUMBER	SAMPLE DEPTH
				COLLUVIUM		
TP-17	0 - 8'			(1) SANDY CLAY (cl): Light moderate brown; slightly damp-damp; low plasticity; 30-40% very fine sand; numerous root voids; white precipitate; excavates with ease - slight difficulty; appears very stiff.	[1] B-1	~8'
				SAN JOAQUIN FORMATION		
	8' - 10'			(2) SAND-CLAYEY SAND (SP-SC): Tan-light brown; very fine; 5-15% fines; resembles (probably derived from) San Joaquin Formation sandstone immediately upslope (SW); includes gray claystone fragments to 1/2" dia.		
	10' - 11.5'			(3) CLAYSTONE (CS): Dark gray; laminated to thin bedded, soft; weak; highly plastic.		



REV. 8/14/90

CLIENT CHEMICAL WASTE MANAGEMENT, INC.

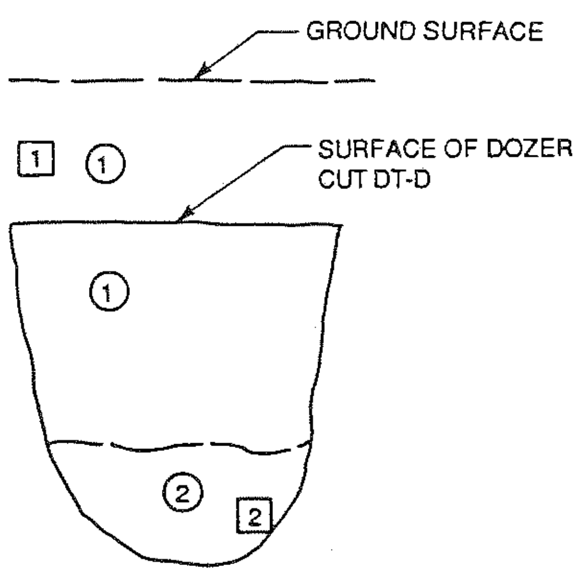
PROJECT NO. 89-977

LOCATION KETTLEMAN, CALIFORNIA

TEST PIT NO. TP-18

SHEET 1 OF 1	LOCATION: SEE FIGURE 2.3 - SITE GEOLOGIC MAP		BEARING: S44°E
RIG: CAT 426 BACKHOE	PIT WIDTH: 36"	DATE: 2/27/90	LOGGED BY: R. H. (WAHLER)

TEST PIT NO.	DEPTH INTERVAL	SOIL TYPE	WATER DEPTH	MATERIAL DESCRIPTION EXCAVATION CHARACTERISTICS	SAMPLE NUMBER	SAMPLE DEPTH
				COLLUVIUM		
TP-18	0 - 10'			(1) SANDY CLAY (cl): Light moderate brown; slightly damp; low-moderate plasticity; 10-40% very fine, sand; stiff-very stiff; excavates with slight difficulty; variable white precipitate.	[1] B-1	~2' (sample from n-opposite wall of dozer cut)
				SAN JOAQUIN FORMATION		
	10' - 13.5'			(2) CLAYSTONE (CS): Dark gray; soft; weak; laminated-thin bedded; highly plastic; slickensides; numerous very fine sandstone, siltstone laminae (up to ~1/2" thick).	[2] B-2	~12'



REV. 8/14/90

CLIENT CHEMICAL WASTE MANAGEMENT, INC.

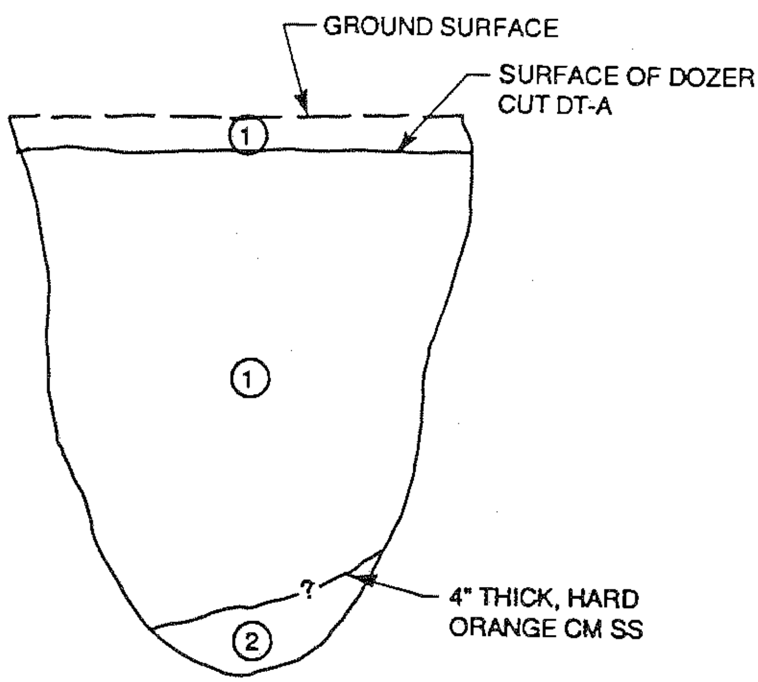
PROJECT NO. 89-977

LOCATION KETTLEMAN, CALIFORNIA

TEST PIT NO. TP-19

SHEET 1 OF 1	LOCATION: SEE FIGURE 2.3 - SITE GEOLOGIC MAP		BEARING: S55°W
RIG: CAT 426 BACKHOE	PIT WIDTH: 36"	DATE: 2/27/90	LOGGED BY: R. H. (WAHLER)

TEST PIT NO.	DEPTH INTERVAL	SOIL TYPE	WATER DEPTH	MATERIAL DESCRIPTION EXCAVATION CHARACTERISTICS	SAMPLE NUMBER	SAMPLE DEPTH
				COLLUVIUM		
TP-19	0 - ~13' (see sketch)			(1) SANDY CLAY, CLAYEY SAND (cl,SC): Light brown; slightly damp; variable cl,SC; cl: low plasticity, 10-40% very fine sand; SC: very fine, 10-40% fines: excavates easily to ~8'; slightly difficult excavation below ~8'. Occasional laminated sand/silt, SP/ML-cl (old alluvium deposits).		
				SAN JOAQUIN FORMATION		
	13' - 15'			(2) INTERBEDDED SANDSTONE/CLAYSTONE (CS/SS): Sandstone: Tan, mottled orange; very fine; bioturbation; soft, friable; claystone: Dark gray; highly plastic; excacates with slight difficulty.		



SCALE: 1" = 5'

REV. 8/14/90

CLIENT CHEMICAL WASTE MANAGEMENT, INC.

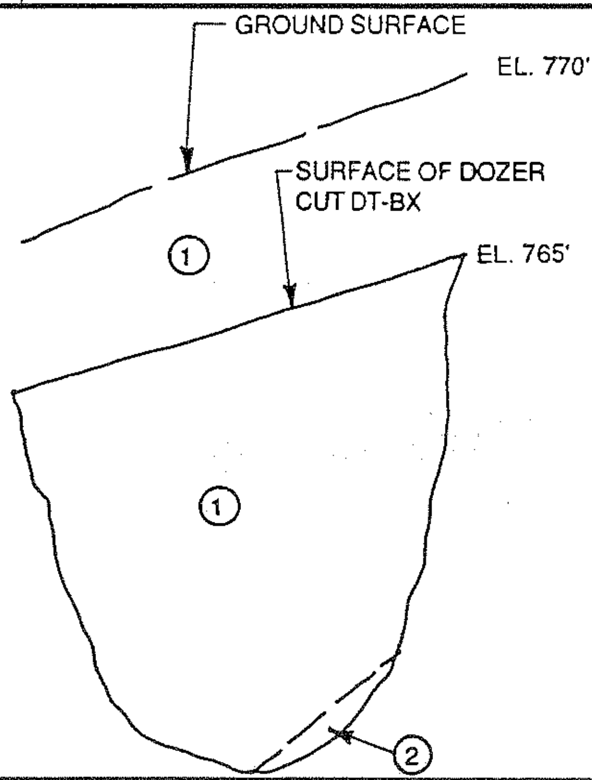
PROJECT NO. 89-977

LOCATION KETTLEMAN, CALIFORNIA

TEST PIT NO. TP-20

SHEET 1 OF 1	LOCATION: SEE FIGURE 2.3 - SITE GEOLOGIC MAP		BEARING: S53°W
RIG: CAT 426 BACKHOE	PIT WIDTH: 36"	DATE: 2/27/90	LOGGED BY: R. H. (WAHLER)

TEST PIT NO.	DEPTH INTERVAL	SOIL TYPE	WATER DEPTH	MATERIAL DESCRIPTION EXCAVATION CHARACTERISTICS	SAMPLE NUMBER	SAMPLE DEPTH
				COLLUVIUM		
TP-20	0 - 15.5'			(1) SANDY CLAY(cl): Light brown; dry-damp low-moderate plasticity; 10-40% very fine sand; excavates easily.		
				SAN JOAQUIN FORMATION		
	15.5' - 16'			(2) CLAYEY SILTSTONE (SLT): Light gray-brown; slighty plastic; soft; friable.		



REV. 8/14/90

CLIENT CHEMICAL WASTE MANAGEMENT, INC.

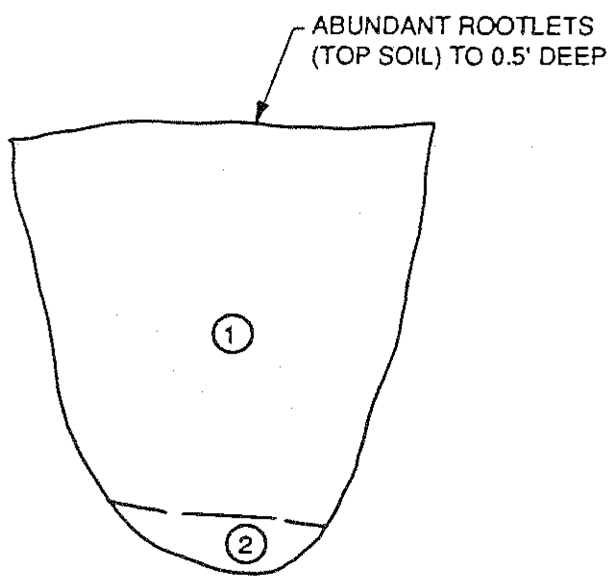
PROJECT NO. 89-977

LOCATION KETTLEMAN, CALIFORNIA

TEST PIT NO. TP-21

SHEET 1 OF 1	LOCATION: SEE FIGURE 2.3 - SITE GEOLOGIC MAP		BEARING: N72°W
RIG: CAT 426 BACKHOE	PIT WIDTH: 36"	DATE: 2/27/90	LOGGED BY: R. H. (WAHLER)

TEST PIT NO.	DEPTH INTERVAL	SOIL TYPE	WATER DEPTH	MATERIAL DESCRIPTION EXCAVATION CHARACTERISTICS	SAMPLE NUMBER	SAMPLE DEPTH
				COLLUVIUM		
TP-21	0 - 11'			(1) SANDY CLAY (cl): Light brown; slightly damp-damp; low-moderate plasticity; 10-30% very fine sand; stiff (excavates with slight difficulty).		
				SAN JOAQUIN FORMATION		
	11' - 12.5'			(2) CLAYEY SILTSTONE (SLT): Light gray; soft; friable to weak; low-moderate plasticity; laminated; fragments can be crumbled by fingers with moderate effort.		



SCALE: 1" = 5'

REV. 8/14/90

CLIENT CHEMICAL WASTE MANAGEMENT, INC.

PROJECT NO. 89-977

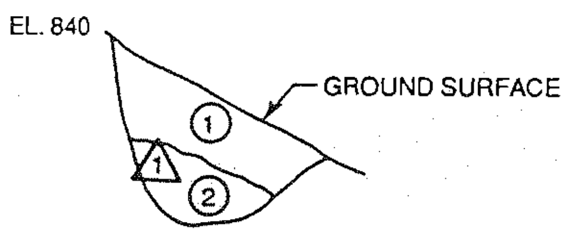
LOCATION KETTLEMAN, CALIFORNIA

TEST PIT NO. TP-22

BEDDING ⚠1: N50°W, 28°SW

SHEET 1 OF 1	LOCATION: SEE FIGURE 2.3 - SITE GEOLOGIC MAP		BEARING:
RIG: CAT 426 BACKHOE	PIT WIDTH: 30"	DATE: 3/19/90	LOGGED BY: A. S. B. (WAHLER)

TEST PIT NO.	DEPTH INTERVAL	SOIL TYPE	WATER DEPTH	MATERIAL DESCRIPTION EXCAVATION CHARACTERISTICS	SAMPLE NUMBER	SAMPLE DEPTH
				COLLUVIUM		
TP-22	0 - 4.5'			(1) SANDY CLAY to CLAYEY SAND (cl-sc): Moderate brown; fine sand; about 25% slightly plastic to low plastic fines; loose; dry.		
				SAN JOAQUIN FORMATION		
	4.5' - 8'			(2) SANDSTONE (SS): Brownish gray; fine to medium sand; ~5-10% silt; streaks of gypsum; loose to medium dense; dry; 4" thick cemented, hard reddish sandstone at 6.5'.		



SCALE: 1" = 5'

REV. 8/14/90

CLIENT CHEMICAL WASTE MANAGEMENT, INC.

PROJECT NO. 89-977

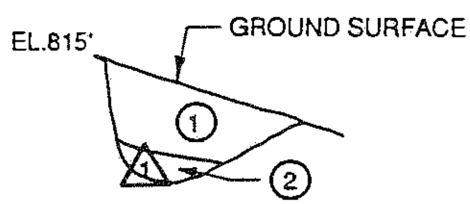
LOCATION KETTLEMAN, CALIFORNIA

TEST PIT NO. TP-23

STRIKE △1: N40°W, 31°SW DIP

SHEET 1 OF 1	LOCATION: SEE FIGURE 2.3 - SITE GEOLOGIC MAP		BEARING:
RIG: CAT 426 BACKHOE	PIT WIDTH: 30"	DATE: 3/19/90	LOGGED BY: A. S. B. (WAHLER)

TEST PIT NO.	DEPTH INTERVAL	SOIL TYPE	WATER DEPTH	MATERIAL DESCRIPTION EXCAVATION CHARACTERISTICS	SAMPLE NUMBER	SAMPLE DEPTH
				COLLUVIUM		
TP-23	0 - 4'			(1) SILTY SAND (sm): Moderate brown; fine sand; 15-20% slightly plastic to low plastic fines; dry.	B-1	
				SAN JOAQUIN FORMATION		
	4' - 5.5'			(2) INTERBEDDED CLAYSTONE and SILTSTONE (CS/SLT): Laminated to thinly bedded; olive-gray with yellow-orange to yellow-brown staining; thin (1/8") sand laminae.		



SCALE: 1" = 5'

REV. 8/14/90

CLIENT CHEMICAL WASTE MANAGEMENT, INC.

PROJECT NO. 89-977

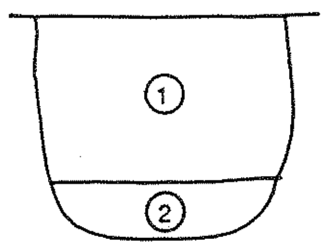
LOCATION KETTLEMAN, CALIFORNIA

TEST PIT NO. TP-24

STRIKE ⚠: N40°W, 31°SW DIP

SHEET 1 OF 1	LOCATION: SEE FIGURE 2.3 - SITE GEOLOGY MAP			BEARING:	
RIG: CAT 426 BACKHOE	PIT WIDTH: 30"	DATE: 3/19/90		LOGGED BY: A. S. B. (WAHLER)	

TEST PIT NO.	DEPTH INTERVAL	SOIL TYPE	WATER DEPTH	MATERIAL DESCRIPTION EXCAVATION CHARACTERISTICS	SAMPLE NUMBER	SAMPLE DEPTH
				COLLUVIUM		
TP-24	0 - 4.5'			(1) CLAYEY SAND (sm): Moderate brown; 15-20% non-plastic fines; fine sand; loose; dry.		
				SAN JOAQUIN FORMATION		
	4.5' - 6.0'			(2) SANDSTONE (SS): Light gray with yellow-brown streaks; fine sand; weakly cemented; old borrow holes in sandstone at contact (filled in with silty sand Qc) included "wavey" lenses of olive-gray claystone in sandstone).		



SCALE: 1"=5'

REV. 8/14/90

CLIENT CHEMICAL WASTE MANAGEMENT, INC.

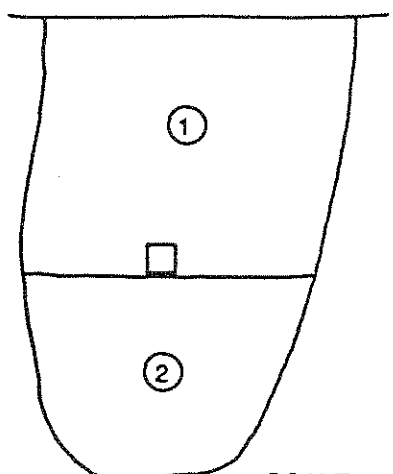
PROJECT NO. 89-977

LOCATION KETTLEMAN, CALIFORNIA

TEST PIT NO. TP-25

SHEET 1 OF 1	LOCATION: SEE FIGURE 2.3 - SITE GEOLOGIC MAP		BEARING:
RIG: CAT 426 BACKHOE	PIT WIDTH: 30"	DATE: 3/19/90	LOGGED BY: A. S. B. (WAHLER)

TEST PIT NO.	DEPTH INTERVAL	SOIL TYPE	WATER DEPTH	MATERIAL DESCRIPTION EXCAVATION CHARACTERISTICS	SAMPLE NUMBER	SAMPLE DEPTH
				COLLUVIUM		
TP-25	0 - 7'			(1) CLAYEY to SILTY SAND (sc-sm): Moderate brown; fine to very fine sand; pockets of sandy clay; ~20-25% slightly plastic fines.	B-1	0-7'
				SAN JOAQUIN FORMATION		
	7' - 12.5'			(2) INTERBEDDED CLAYSTONE/SANDSTONE (CS/SS): Thinly bedded; bioturbation; olive-gray.		



SCALE: 1"=5'

REV. 8/14/90

CLIENT CHEMICAL WASTE MANAGEMENT, INC.

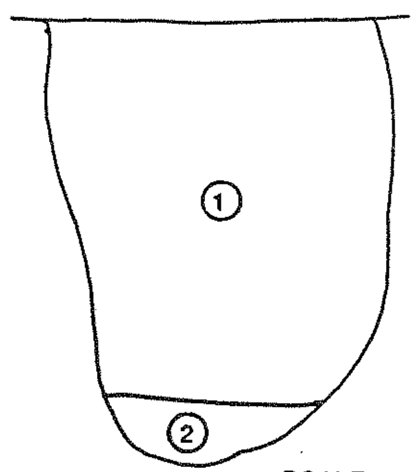
PROJECT NO. 89-977

LOCATION KETTLEMAN, CALIFORNIA

TEST PIT NO. TP-26

SHEET 1 OF 1	LOCATION: SEE FIGURE 2.3 - SITE GEOLOGIC MAP		BEARING:
RIG: CAT 426 BACKHOE	PIT WIDTH: 30"	DATE: 3/19/90	LOGGED BY: A. S. B. (WAHLER)

TEST PIT NO.	DEPTH INTERVAL	SOIL TYPE	WATER DEPTH	MATERIAL DESCRIPTION EXCAVATION CHARACTERISTICS	SAMPLE NUMBER	SAMPLE DEPTH
				COLLUVIUM		
TP-26	0 - 10.5'			(1) CLAYEY SAND (sc): Moderate yellow-brown; fine to very fine sand; slightly to low plastic fines; dry; loose to moderately dense.	B-1	0-10.5'
				SAN JOAQUIN FORMATION		
	10.5' - 12'			(2) SANDSTONE (SS): Moderate yellow-brown mottled with yellow-orange stains.		



SCALE: 1"=5'

REV. 8/14/90

CLIENT CHEMICAL WASTE MANAGEMENT, INC.

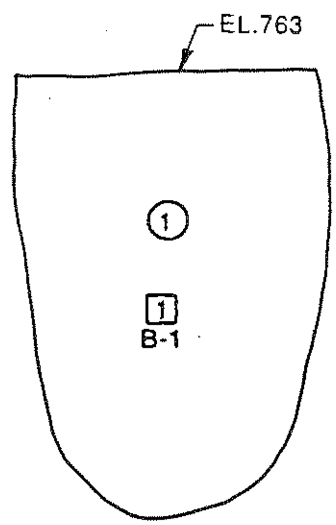
PROJECT NO. 89-977

LOCATION KETTLEMAN, CALIFORNIA

TEST PIT NO. TP-27

SHEET 1 OF 1	LOCATION: SEE FIGURE 2.3 - SITE GEOLOGIC MAP		BEARING:
RIG: CAT 426 BACKHOE	PIT WIDTH: 30"	DATE: 3/19/90	LOGGED BY: A. S. B. (WAHLER)

TEST PIT NO.	DEPTH INTERVAL	SOIL TYPE	WATER DEPTH	MATERIAL DESCRIPTION EXCAVATION CHARACTERISTICS	SAMPLE NUMBER	SAMPLE DEPTH
TP-27	0 - 12'			COLLUVIUM (1) SANDY CLAY (cl): Moderate yellow-brown; fine to very fine sand; low to moderate plastic fines; compact; dry; stiff.	B-1	0-12'



SCALE: 1" = 5'

REV. 8/14/90

CLIENT CHEMICAL WASTE MANAGEMENT, INC.

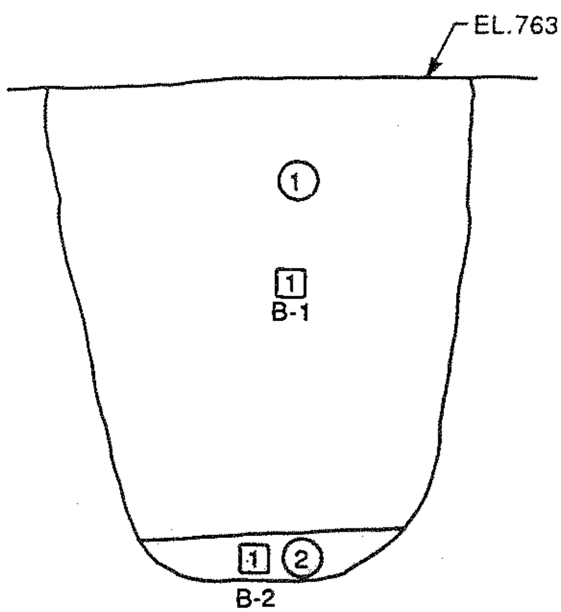
PROJECT NO. 89-977

LOCATION KETTLEMAN, CALIFORNIA

TEST PIT NO. TP-28

SHEET 1 OF 1	LOCATION: SEE FIGURE 2.3 - SITE GEOLOGIC MAP		BEARING:
RIG: CAT 426 BACKHOE	PIT WIDTH: 30"	DATE: 3/19/90	LOGGED BY: A. S. B. (WAHLER)

TEST PIT NO.	DEPTH INTERVAL	SOIL TYPE	WATER DEPTH	MATERIAL DESCRIPTION EXCAVATION CHARACTERISTICS	SAMPLE NUMBER	SAMPLE DEPTH
				COLLUVIUM		
TP-28	0 - 12.5'			(1) CLAYEY SAND (sc): Moderate yellow-brown; fine to very fine sand; ~25-30% slightly to low plastic fines; medium dense; dry.	B-1	0-12.5'
				SAN JOAQUIN FORMATION		
	12.5'-13.5'			(2) INTERBEDDED CLAYSTONE/SILTSTONE (CS/SLT): Light brownish gray; with yellow-orange laminates; thinly bedded.	B-2	12.5'-13.5'



REV. 8/14/90

CLIENT CHEMICAL WASTE MANAGEMENT, INC.

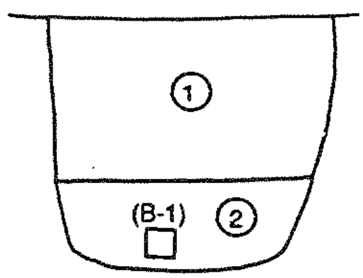
PROJECT NO. 89-977

LOCATION KETTLEMAN, CALIFORNIA

TEST PIT NO. TP-29

SHEET 1 OF 1	LOCATION: SEE FIGURE 2.3 - SITE GEOLOGIC MAP		BEARING:
RIG: CAT 426 BACKHOE	PIT WIDTH: 24"	DATE: 5/10/90	LOGGED BY: R. H. (WAHLER)

TEST PIT NO.	DEPTH INTERVAL	SOIL TYPE	WATER DEPTH	MATERIAL DESCRIPTION EXCAVATION CHARACTERISTICS	SAMPLE NUMBER	SAMPLE DEPTH
				COLLUVIUM		
TP-29	0 - 4'			(1) SILTY CLAY (cl)		
				SAN JOAQUIN FORMATION		
	4' - 6.5'			(2) Unit 18-10 CLAYSTONE (CS): Gray; highly plastic; excavates as angular; gravel to cobble-sized chunks of highly plastic, hard clay; chunk size increases with depth. NOTE: Claystone is only one lithologic member of Unit 18-10 (interbedded SS,CS, SLT, SILTY SS).	B-1	4-6.5' (composite)



SCALE: 1"=5'

REV. 8/14/90

CLIENT CHEMICAL WASTE MANAGEMENT, INC.

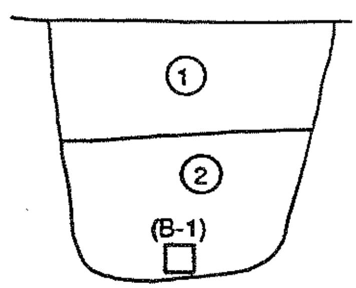
PROJECT NO. 89-977

LOCATION KETTLEMAN, CALIFORNIA

TEST PIT NO. TP-30

SHEET 1 OF 1	LOCATION: SEE FIGURE 2.3 - SITE GEOLOGIC MAP		BEARING:
RIG: CAT 426 BACKHOE	PIT WIDTH: 24"	DATE: 5/10/90	LOGGED BY: R. H. (WAHLER)

TEST PIT NO.	DEPTH INTERVAL	SOIL TYPE	WATER DEPTH	MATERIAL DESCRIPTION EXCAVATION CHARACTERISTICS	SAMPLE NUMBER	SAMPLE DEPTH
				COLLUVIUM		
TP-30	0 - 3'			(1) SANDY CLAY (cl)		
				SAN JOAQUIN FORMATION		
	3' - 7'			(2) Unit 18-11 INTERBEDDED SANDSTONE/CLAYSTONE (SS/CS): Tan, very fine, clean sandstone (excavates as loose SP) with lesser, interbedded gray claystone (thin beds up to 1.5" thick, highly plastic; excavating as angular chunks up to ~3" dia. hard clay). NOTE: Unit 18-11 is predominately clean SS.	B-1	~7'



SCALE: 1"=5'

REV. 8/14/90

CLIENT CHEMICAL WASTE MANAGEMENT, INC.

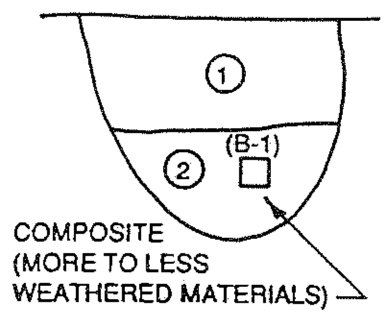
PROJECT NO. 89-977

LOCATION KETTLEMAN, CALIFORNIA

TEST PIT NO. TP-31

SHEET 1 OF 1	LOCATION: SEE FIGURE 2.3 - SITE GEOLOGIC MAP		BEARING:
RIG: CAT 426 BACKHOE	PIT WIDTH: 24"	DATE: 5/10/90	LOGGED BY: R. H. (WAHLER)

TEST PIT NO.	DEPTH INTERVAL	SOIL TYPE	WATER DEPTH	MATERIAL DESCRIPTION EXCAVATION CHARACTERISTICS	SAMPLE NUMBER	SAMPLE DEPTH
TP-31	0 - 3'			COLLUVIUM ① SANDY CLAY (cl): Moderate-dark brown; moderate plasticity; very stiff to hard.		
	3' - 6'			SAN JOAQUIN FORMATION ② Unit 18-12 CLAYSTONE (CS): Gray; highly plastic; moderate to severely weathered to ~3.5'; fresh-slightly weathered below 3.5' (size of excavated blocks increases with depth and with decreased weathering); excavates as hard, angular, gravel to cobble-sized blocks.	B-1	3'-6' composite



SCALE: 1"=5'

REV. 8/14/90

CLIENT CHEMICAL WASTE MANAGEMENT, INC.

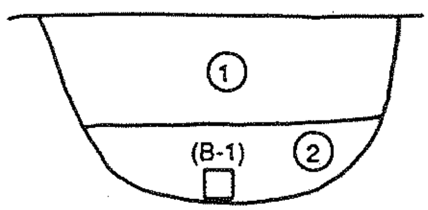
PROJECT NO. 89-977

LOCATION KETTLEMAN, CALIFORNIA

TEST PIT NO. TP-32

SHEET 1 OF 1	LOCATION: SEE FIGURE 2.3 - SITE GEOLOGIC MAP		BEARING:
RIG: CAT 426 BACKHOE	PIT WIDTH: 24"	DATE: 5/10/90	LOGGED BY: R. H. (WAHLER)

TEST PIT NO.	DEPTH INTERVAL	SOIL TYPE	WATER DEPTH	MATERIAL DESCRIPTION EXCAVATION CHARACTERISTICS	SAMPLE NUMBER	SAMPLE DEPTH
				COLLUVIUM		
TP-32	0 - 3'			(1) CLAYEY SAND (SC)		
				SAN JOAQUIN FORMATION		
	3' - 5'			(2) Unit 18-13 SANDSTONE (SS): Tan-white; occasional gypsum/caliche (thin, white cemented layers, up to ~.5" thick); excavates as clean, very fine sand (loose SP).	B-1	~5'



SCALE: 1"=5'

REV. 8/14/90

CLIENT CHEMICAL WASTE MANAGEMENT, INC.

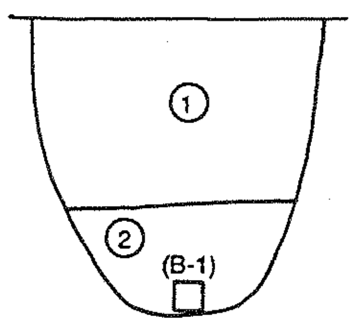
PROJECT NO. 89-977

LOCATION KETTLEMAN, CALIFORNIA

TEST PIT NO. TP-33

SHEET 1 OF 1	LOCATION: SEE FIGURE 2.3 - SITE GEOLOGIC MAP		BEARING:
RIG: CAT 426 BACKHOE	PIT WIDTH: 24"	DATE: 5/10/90	LOGGED BY: R. H. (WAHLER)

TEST PIT NO.	DEPTH INTERVAL	SOIL TYPE	WATER DEPTH	MATERIAL DESCRIPTION EXCAVATION CHARACTERISTICS	SAMPLE NUMBER	SAMPLE DEPTH
				COLLUVIUM		
TP-33	0 - 5'			(1) SANDY CLAY (cl)		
				SAN JOAQUIN FORMATION		
	5' - 8'			(2) Unit 18-13 SANDSTONE (SS): Tan, some orange mottling; excavates as clean, very fine to fine sand (loose SP); non-cemented with occasional thin cemented beds (up to ~2' thick)	B-1	~8'



SCALE: 1"=5'

REV. 8/14/90

CLIENT CHEMICAL WASTE MANAGEMENT, INC.

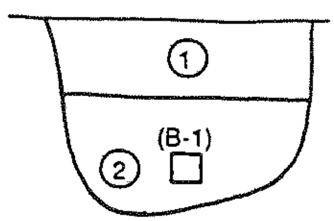
PROJECT NO. 89-977

LOCATION KETTLEMAN, CALIFORNIA

TEST PIT NO. TP-34

SHEET 1 OF 1	LOCATION: SEE FIGURE 2.3 - SITE GEOLOGIC MAP		BEARING:
RIG: CAT 426 BACKHOE	PIT WIDTH: 24"	DATE: 5/10/90	LOGGED BY: R. H. (WAHLER)

TEST PIT NO.	DEPTH INTERVAL	SOIL TYPE	WATER DEPTH	MATERIAL DESCRIPTION EXCAVATION CHARACTERISTICS	SAMPLE NUMBER	SAMPLE DEPTH
				COLLUVIUM		
TP-34	0 - 2'			(1) SANDY CLAY (cl)		
				SAN JOAQUIN FORMATION		
	2' - 5'			(2) Unit 18-12 CLAYSTONE (CS): Gray; moderate to severely weathered to 3'; slightly weathered below 3'; excavates as angular gravel to boulder sized blocks of hard claystone. Blocks become larger (up to 1') below the weathered zone.	B-1	~4'



SCALE: 1"=5'

REV. 8/14/90

CLIENT CHEMICAL WASTE MANAGEMENT, INC.

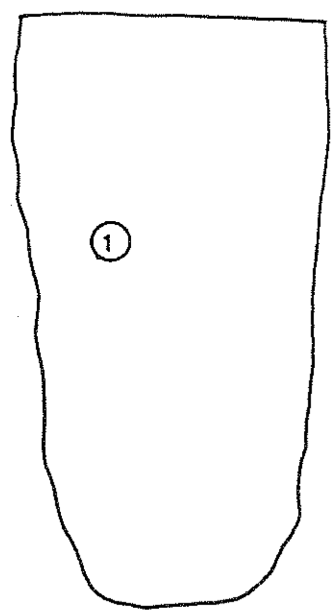
PROJECT NO. 89-977

LOCATION KETTLEMAN, CALIFORNIA

TEST PIT NO. TP-35

SHEET 1 OF 1	LOCATION: SEE FIGURE 2.3 - SITE GEOLOGIC MAP		BEARING:
RIG: CAT 426 BACKHOE	PIT WIDTH: 24"	DATE: 5/11/90	LOGGED BY: R. H. (WAHLER)

TEST PIT NO.	DEPTH INTERVAL	SOIL TYPE	WATER DEPTH	MATERIAL DESCRIPTION EXCAVATION CHARACTERISTICS	SAMPLE NUMBER	SAMPLE DEPTH
				COLLUVIUM		
TP-35	0 - >16'			(1) SILTY CLAY, SANDY CLAY, CLAYEY SAND (cl, sc)		



REV. 8/14/90

CLIENT CHEMICAL WASTE MANAGEMENT, INC.

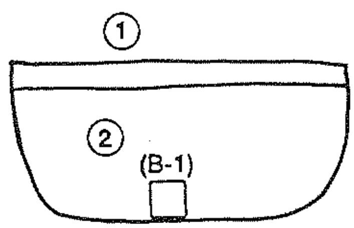
PROJECT NO. 89-977

LOCATION KETTLEMAN, CALIFORNIA

TEST PIT NO. TP-36

SHEET 1 OF 1	LOCATION: SEE FIGURE 2.3 - SITE GEOLOGIC MAP		BEARING:
RIG: CAT 426 BACKHOE	PIT WIDTH: 24"	DATE: 5/10-5/11/90	LOGGED BY: R. H. (WAHLER)

TEST PIT NO.	DEPTH INTERVAL	SOIL TYPE	WATER DEPTH	MATERIAL DESCRIPTION EXCAVATION CHARACTERISTICS	SAMPLE NUMBER	SAMPLE DEPTH
				COLLUVIUM		
TP-36	0 - .5'			(1) SANDY CLAY (cl)		
				SAN JOAQUIN FORMATION		
	.5' - 4'			(2) Unit 18-8 CLAYSTONE (CS): Gray, orange-brown; moderate to severely weathered to 1.5'; fresh, slightly weathered below 1.5'; excavates as angular, gravel to boulder-sized blocks & slabs of hard CH.	B-1	~4'



REV. 8/14/90

CLIENT CHEMICAL WASTE MANAGEMENT, INC.

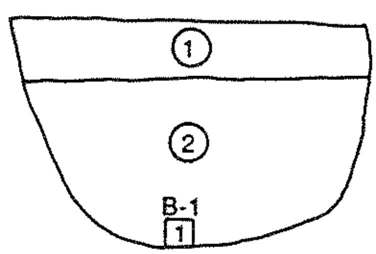
PROJECT NO. 89-977

LOCATION KETTLEMAN, CALIFORNIA

TEST PIT NO. TP-37

SHEET 1 OF 1	LOCATION: SEE FIGURE 2.3 - SITE GEOLOGIC MAP		BEARING:
RIG: CAT 426 BACKHOE	PIT WIDTH: 24"	DATE: 5/10-5/11/90	LOGGED BY: R. H. (WAHLER)

TEST PIT NO.	DEPTH INTERVAL	SOIL TYPE	WATER DEPTH	MATERIAL DESCRIPTION EXCAVATION CHARACTERISTICS	SAMPLE NUMBER	SAMPLE DEPTH
				COLLUVIUM		
TP-37	0 - 1.5'			(1) SANDY CLAY (cl)		
				SAN JOAQUIN FORMATION		
	1.5' - 6'			(2) Unit 18-8 CLAYSTONE (CS): Gray, orange-brown; laminated to thin bedded cl; moderate-severely weathered to 2.5'; fresh-slightly weathered below 2.5'; excavates as angular, gravel to boulder-sized blocks and slabs of hard CH (below 2.5').	B-1	~6'



SCALE: 1" = 5'

REV. 8/14/90

CLIENT CHEMICAL WASTE MANAGEMENT, INC.

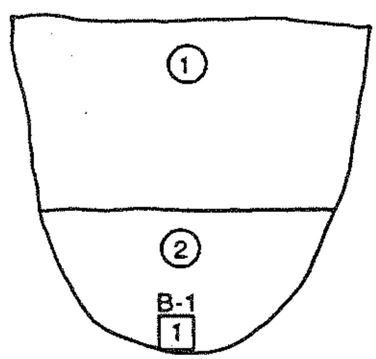
PROJECT NO. 89-977

LOCATION KETTLEMAN, CALIFORNIA

TEST PIT NO. TP-38

SHEET 1 OF 1	LOCATION: SEE FIGURE 2.3 - SITE GEOLOGIC MAP		BEARING:
RIG: CAT 426 BACKHOE	PIT WIDTH: 24"	DATE: 5/11/90	LOGGED BY: R. H. (WAHLER)

TEST PIT NO.	DEPTH INTERVAL	SOIL TYPE	WATER DEPTH	MATERIAL DESCRIPTION EXCAVATION CHARACTERISTICS	SAMPLE NUMBER	SAMPLE DEPTH
				COLLUVIUM		
TP-38	0 - 5'			(1) SANDY CLAY (cl)		
				SAN JOAQUIN FORMATION		
	5' - 9'			(2) Unit 18-8 CLAYSTONE (CS): Gray, orange-brown, light brown; laminated to thin bedded; occasional sand laminae (very minor); excavates as gravel-cobble-sized blocks.		



REV. 8/14/90

CLIENT CHEMICAL WASTE MANAGEMENT, INC.

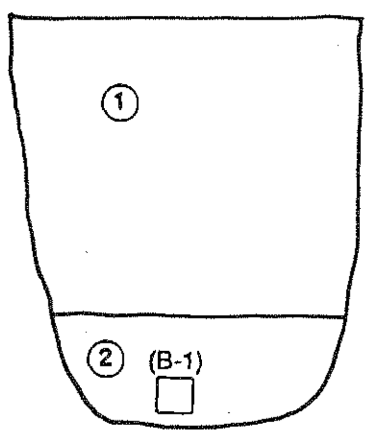
PROJECT NO. 89-977

LOCATION KETTLEMAN, CALIFORNIA

TEST PIT NO. TP-39

SHEET 1 OF 1	LOCATION: SEE FIGURE 2.3 - SITE GEOLOGIC MAP		BEARING:
RIG: CAT 426 BACKHOE	PIT WIDTH: 24"	DATE: 5/11/90	LOGGED BY: R. H. (WAHLER)

TEST PIT NO.	DEPTH INTERVAL	SOIL TYPE	WATER DEPTH	MATERIAL DESCRIPTION EXCAVATION CHARACTERISTICS	SAMPLE NUMBER	SAMPLE DEPTH
				COLLUVIUM		
TP-39	0 - 8'			(1) SANDY CLAY (cl)		
				SAN JOAQUIN FORMATION		
	8' - 11'			(2) Unit 18-8 CLAYSTONE (CS): Gray, highly plastic; hard, excavates as angular; gravel to cobble-sized blocks with 6" dia.; minor sand laminae.		



REV. 8/14/90

CLIENT CHEMICAL WASTE MANAGEMENT, INC.

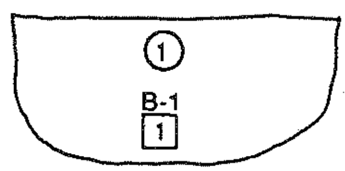
PROJECT NO. 89-977

LOCATION KETTLEMAN, CALIFORNIA

TEST PIT NO. TP-40

SHEET 1 OF 1	LOCATION: SEE FIGURE 2.3 - SITE GEOLOGIC MAP		BEARING:
RIG: CAT 426 BACKHOE	PIT WIDTH: 24"	DATE: 5/11/90	LOGGED BY: R. H. (WAHLER)

TEST PIT NO.	DEPTH INTERVAL	SOIL TYPE	WATER DEPTH	MATERIAL DESCRIPTION EXCAVATION CHARACTERISTICS	SAMPLE NUMBER	SAMPLE DEPTH
				<u>SAN JOAQUIN FORMATION</u>		
TP-40	0 - 4'			(1) Unit 18-8 CLAYSTONE (CS): Gray, brown, occasional orange; highly plastic; includes .5' thick cemented sandstone bed at 3'; laminated to thin bedded; excavates as gravel to cobble-sized slabs and blocks. NOTE: Excavated in cut slope.	B-1	~3'



SCALE: 1" = 5'

REV. 8/14/90

CLIENT CHEMICAL WASTE MANAGEMENT, INC.

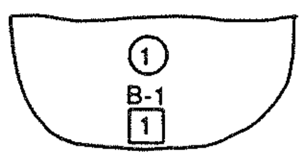
PROJECT NO. 89-977

LOCATION KETTLEMAN, CALIFORNIA

TEST PIT NO. TP-41

SHEET 1 OF 1	LOCATION: SEE FIGURE 2.3 - SITE GEOLOGIC MAP		BEARING:
RIG: CAT 426 BACKHOE	PIT WIDTH: 24"	DATE: 5/11/90	LOGGED BY: R. H. (WAHLER)

TEST PIT NO.	DEPTH INTERVAL	SOIL TYPE	WATER DEPTH	MATERIAL DESCRIPTION EXCAVATION CHARACTERISTICS	SAMPLE NUMBER	SAMPLE DEPTH
				SAN JOAQUIN FORMATION		
TP-41	0 - 3.5'			(1) Unit 18-8 CLAYSTONE (CS): Moderate brown - gray-brown, occasional orange laminae; highly plastic; excavates as gravel-cobble-sized chunks (to ~5"); minor very fine sand laminae. NOTE: Excavated in cut slope.	B-1	~3.5'



SCALE: 1" = 5'

REV. 8/14/90

CLIENT CHEMICAL WASTE MANAGEMENT, INC.

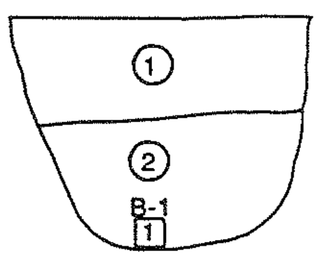
PROJECT NO. 89-977

LOCATION KETTLEMAN, CALIFORNIA

TEST PIT NO. TP-42

SHEET 1 OF 1	LOCATION: SEE FIGURE 2.3 - SITE GEOLOGIC MAP		BEARING:
RIG: CAT 426 BACKHOE	PIT WIDTH: 24"	DATE: 5/10-5/11/90	LOGGED BY: R. H. (WAHLER)

TEST PIT NO.	DEPTH INTERVAL	SOIL TYPE	WATER DEPTH	MATERIAL DESCRIPTION EXCAVATION CHARACTERISTICS	SAMPLE NUMBER	SAMPLE DEPTH
TP-42	0 - 2.5'			COLLUVIUM ① SANDY CLAY (cl)		
	2.5' - 6'			SAN JOAQUIN FORMATION ② Unit 18-9 SANDSTONE-SILTY SANDSTONE (SS): Tan, light brown, mottled orange; very fine; 5-20% fines; excavates as loose sand (SP-SM) or as friable chunks (easily crushed by hand).	B-1	~6'



SCALE: 1" = 5'

REV. 8/14/90

CLIENT CHEMICAL WASTE MANAGEMENT, INC.

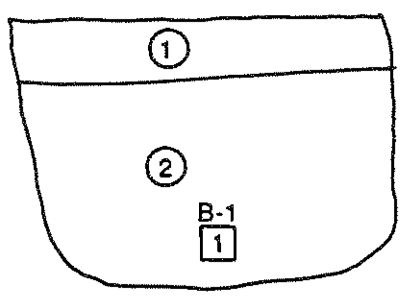
PROJECT NO. 89-977

LOCATION KETTLEMAN, CALIFORNIA

TEST PIT NO. TP-43

SHEET 1 OF 1	LOCATION: SEE FIGURE 2.3 - SITE GEOLOGIC MAP		BEARING:
RIG: CAT 426 BACKHOE	PIT WIDTH: 24"	DATE: 5/10-5/11/90	LOGGED BY: R. H. (WAHLER)

TEST PIT NO.	DEPTH INTERVAL	SOIL TYPE	WATER DEPTH	MATERIAL DESCRIPTION EXCAVATION CHARACTERISTICS	SAMPLE NUMBER	SAMPLE DEPTH
				COLLUVIUM		
TP-43	0 - 1.5'			(1) SANDY CLAY (cl)		
				SAN JOAQUIN FORMATION		
	1.5' - 7'			(2) Unit 18-9 SILTY SANDSTONE-SANDY SILTSTONE (SS/SLT): Light brown, mottled orange; very fine sand; excavates as friable (easily powdered by hand) chunks and loose soil (SM-ML) contains numerous pockets of gray, brown claystone (CH) - bioturbation.	B-1	~6'



SCALE: 1" = 5'

REV. 8/14/90

CLIENT CHEMICAL WASTE MANAGEMENT, INC.

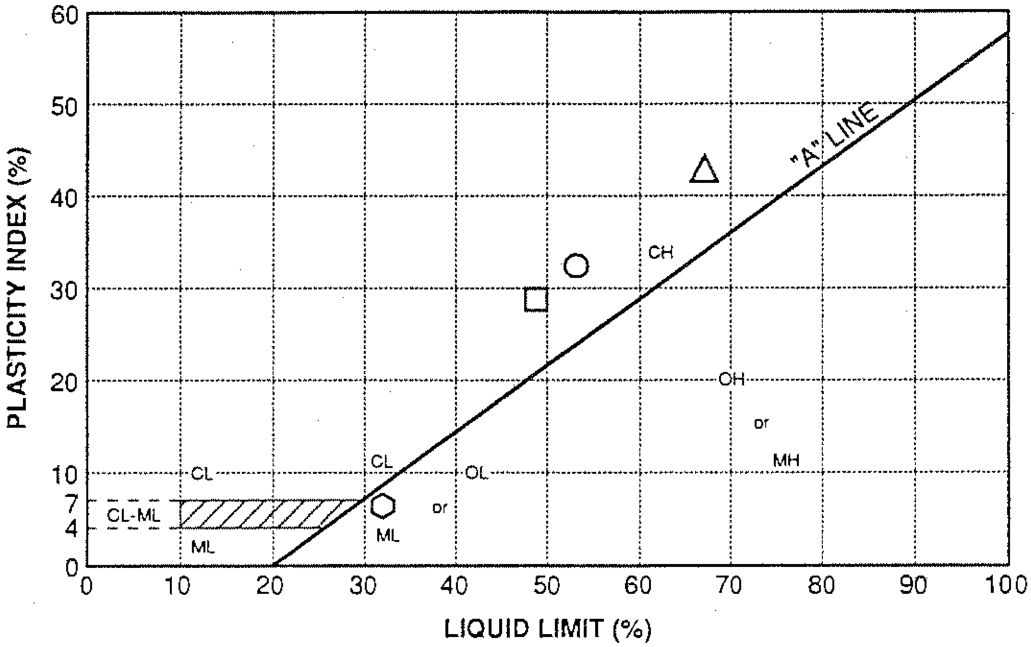
PROJECT NO. 89-977

LOCATION KETTLEMAN, CALIFORNIA

APPENDIX D
LABORATORY DATA

APPENDIX D.1	PLASTICITY CHARTS
APPENDIX D.2	GRAIN SIZE DISTRIBUTIONS
APPENDIX D.3	MODIFIED PROCTOR COMPACTION TESTS
APPENDIX D.4	STANDARD PROCTOR COMPACTION TESTS
APPENDIX D.5	UU TRIAXIAL COMPRESSION TESTS (UNDISTURBED SAMPLES)
APPENDIX D.6	UU TRIAXIAL COMPRESSION TESTS (REMOLDED SAMPLES)
APPENDIX D.7	CU TRIAXIAL COMPRESSION TESTS
APPENDIX D.8	SUMMARY OF DIRECT SHEAR TESTS
APPENDIX D.9	CONSOLIDATION TESTS
APPENDIX D.10	GEOCHEMICAL TESTS

APPENDIX D.1
PLASTICITY CHARTS



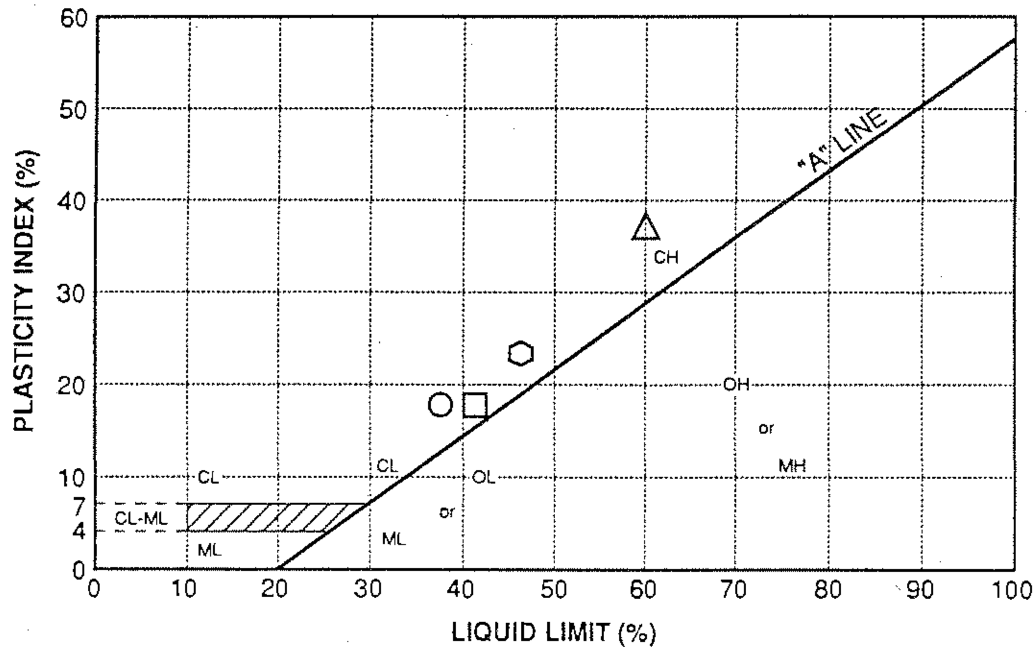
SYMBOL	STRATIGRAPHIC UNIT	BORING NO.	SAMPLE NO.	DEPTH (FT.)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USC SYMBOL
○	18-2	L18-E	S-8	60.0 - 62.5	53	32	CH
⬡	18-3	L18-E	S-6	43.0 - 45.0	32	6	ML
△	18-4	L18-D	S-6	52.0 - 54.3	67	42	CH
□	18-5	L18-D	S-2	22.0 - 24.3	49	29	CL/CH

FIGURE D.1.1

PLASTICITY CHART
STRATIGRAPHIC UNITS
18-2 THROUGH 18-5

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.



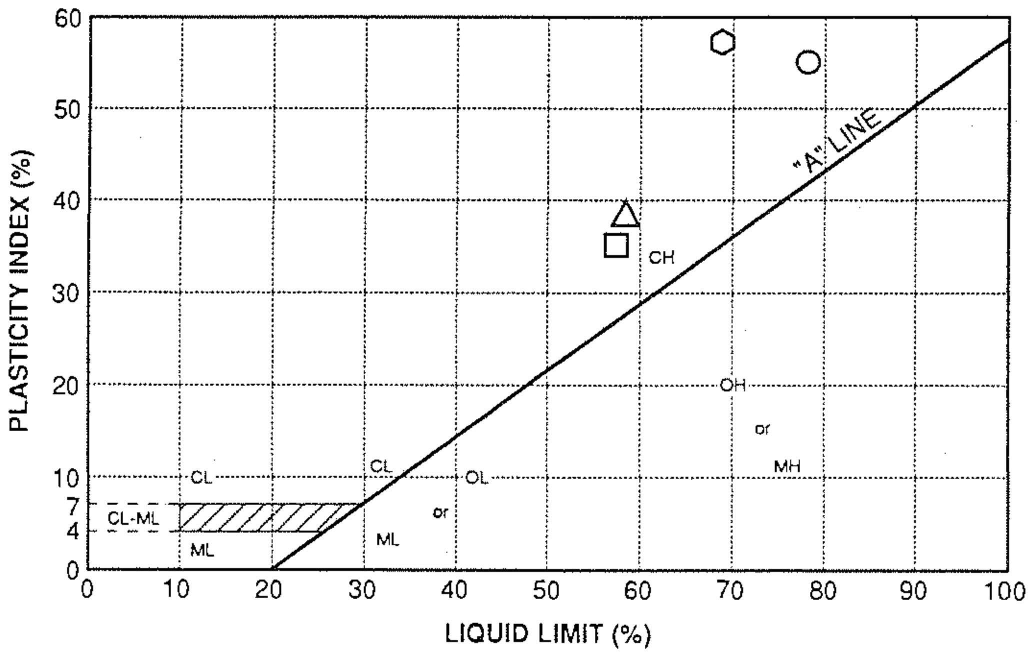
SYMBOL	STRATIGRAPHIC UNIT	BORING NO.	SAMPLE NO.	DEPTH (FT.)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USC SYMBOL
○	18-7	L18-C	S-1	15.0 - 17.3	38	17	CL
⬡	18-7	L18-C	S-3	25.0 - 27.5	46	23	CL
△	18-7	L18-C	S-7	56.0 - 58.0	60	36	CH
□	18-7	L18-C	S-11	87.0 - 89.0	41	17	CL

FIGURE D.1.2

PLASTICITY CHART
STRATIGRAPHIC UNIT 18-7

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.



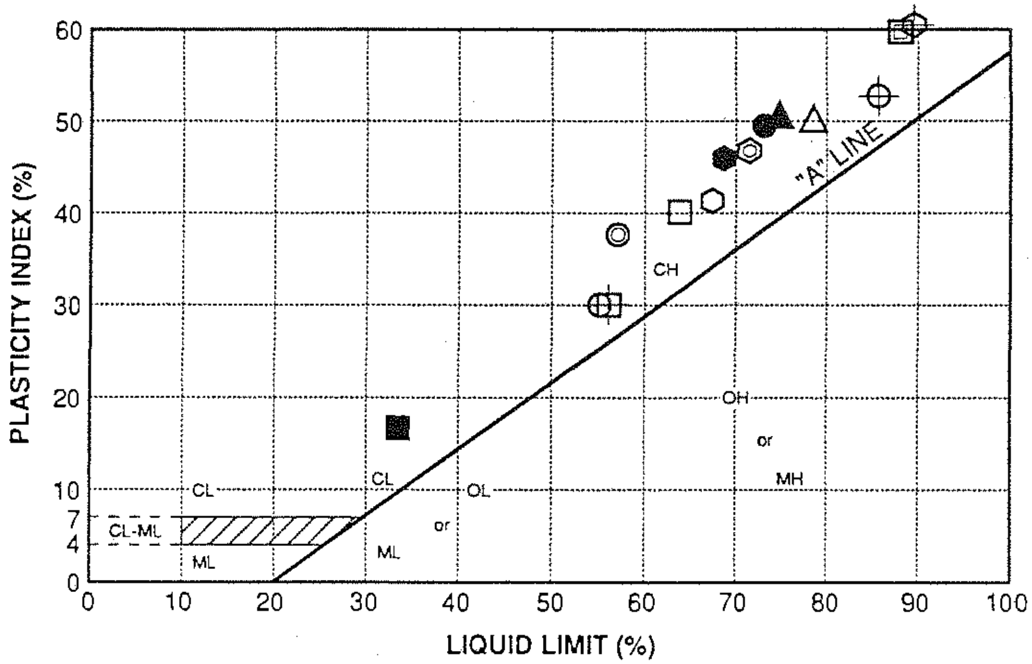
SYMBOL	STRATIGRAPHIC UNIT	BORING NO.	SAMPLE NO.	DEPTH (FT.)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USC SYMBOL
○	18-8	L18-F	S-1	6.0 - 8.5	78	55	CH
⬡	18-8	L18-F	S-3	26.0 - 28.5	69	57	CH
△	18-8	L18-F	S-6	56.0 - 58.5	59	39	CH
□	18-8	L18-I	S-2	16.0 - 18.5	58	36	CH

FIGURE D.1.3

PLASTICITY CHART
STRATIGRAPHIC UNIT 18-8

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.



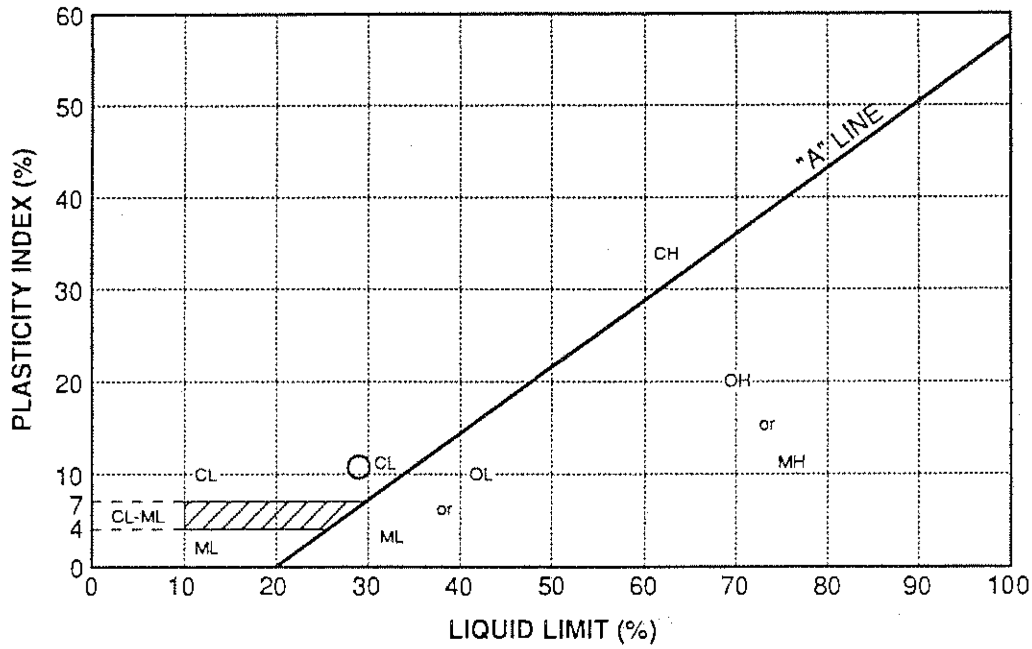
SYMBOL	STRATIGRAPHIC UNIT	BORING NO.	SAMPLE NO.	DEPTH (FT.)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USC SYMBOL
○	18-8	L18-J	S-1	5.0 - 7.5	55	30	CH
⬡	18-8	L18-J	S-3	15.0 - 17.5	67	41	CH
△	18-8	L18-J	S-5	25.0 - 27.5	79	50	CH
□	18-8	L18-J	S-7	35.0 - 37.5	64	40	CH
●	18-8	L18-J	S-9	45.0 - 47.5	74	49	CH
⬢	18-8	L18-J	S-11	55.0 - 57.5	69	46	CH
▲	18-8	L18-J	S-13	65.0 - 67.5	74	50	CH
■	18-8	L18-J	S-15	75.0 - 77.5	33	17	CL
◎	18-8	L18-J	S-17	85.0 - 87.5	56	38	CH
⬡ (double)	18-8	L18-J	S-22	110.0-112.5	71	47	CH
△ (double)	18-8	L18-J	S-24	120.0-122.5	70	42	CH
□ (double)	18-8	L18-J	S-26	130.0-132.8	88	60	CH
⊕	18-8	L18-J	S-28	140.0-142.5	85	53	CH
⊕	18-8	L18-J	S-30	150.0-152.5	88	62	CH
⊞	18-8	L18-J	S-32	160.0-162.5	55	30	CH

FIGURE D.1.4

PLASTICITY CHART
STRATIGRAPHIC UNIT 18-8

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.



SYMBOL	STRATIGRAPHIC UNIT	BORING NO.	SAMPLE NO.	DEPTH (FT.)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USC SYMBOL
○	18-9	18-K	S-10	80.0 - 82.3	30	11	CL

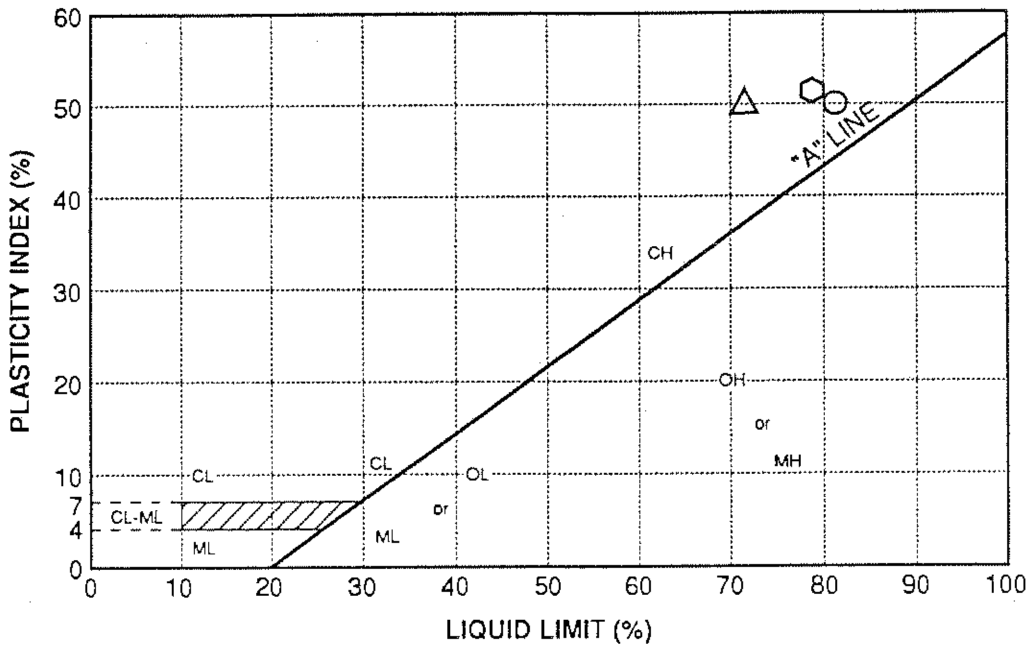
FIGURE D.1.5

PLASTICITY CHART
STRATIGRAPHIC UNIT 18-9

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.

89-97LTR/Fig D.1.6/PICh/U18-10 REV. 8/7/90



SYMBOL	STRATIGRAPHIC UNIT	BORING NO.	SAMPLE NO.	DEPTH (FT.)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USC SYMBOL
○	18-10	L18-H	S-1	6.0 - 8.5	81	50	CH
⬡	18-10	L18-H	S-4	35.0 - 37.5	78	51	CH
△	18-10	L18-H	S-6	55.0 - 57.5	71	49	CH

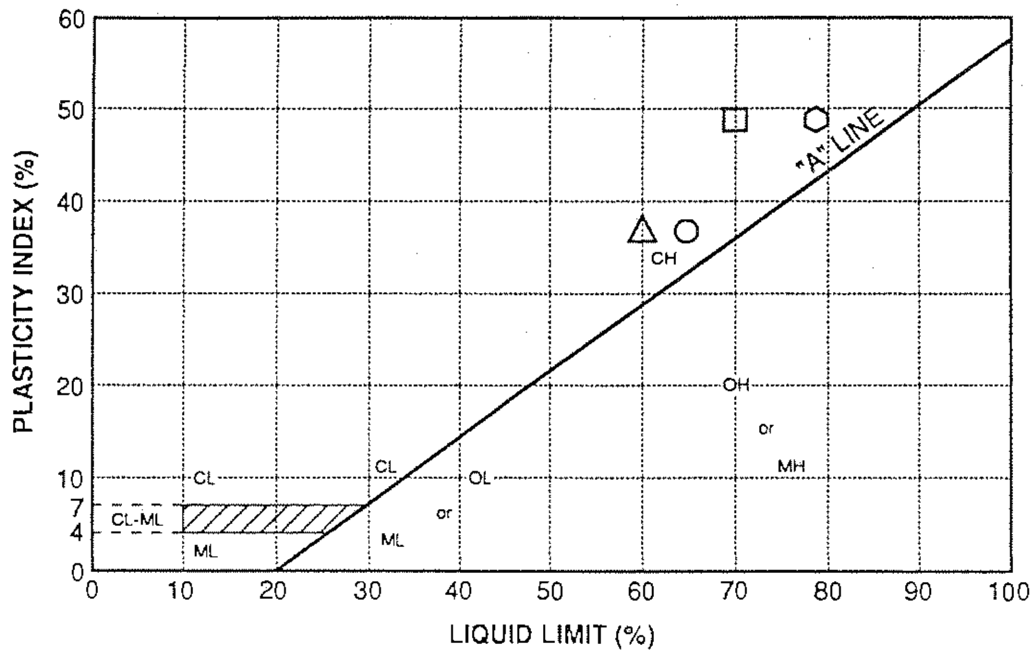
FIGURE D.1.6

PLASTICITY CHART
STRATIGRAPHIC UNIT 18-10

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.

89-97LTR/Fig D.1.7/PlCh/U18-12 REV. 8/7/90



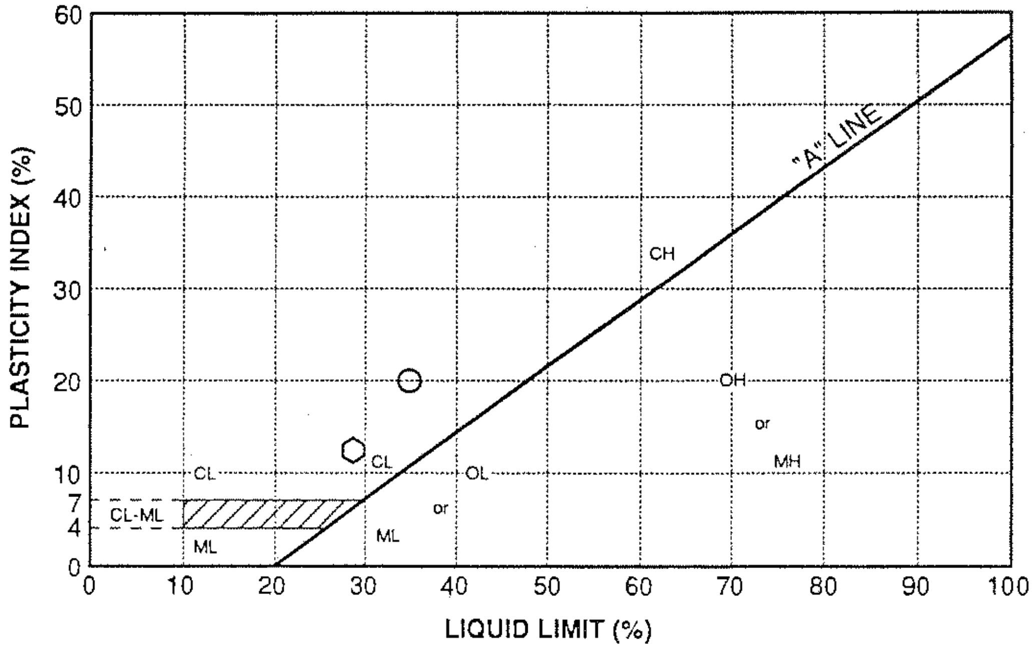
SYMBOL	STRATIGRAPHIC UNIT	BORING NO.	SAMPLE NO.	DEPTH (FT.)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USC SYMBOL
○	18-12	L18-B	S-1	6.0 - 8.5	64	36	CH
⬡	18-12	L18-G	S-7	50.0 - 51.8	78	49	CH
△	18-12	L18-G	S-9	65.0 - 67.0	60	36	CH
□	18-12	TP-31	B-1	3.5	70	49	CH

FIGURE D.1.7

PLASTICITY CHART
STRATIGRAPHIC UNIT 18-12

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.



SYMBOL	STRATIGRAPHIC UNIT	BORING NO.	SAMPLE NO.	DEPTH (FT.)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USC SYMBOL
○	COLLUVIUM	L18-C	B-1	6.0 - 7.5	35	19	CL
⬡	COLLUVIUM	L18-D	B-2	10.0 - 11.5	29	13	CL

FIGURE D.1.8

PLASTICITY CHART
COLLUVIUM

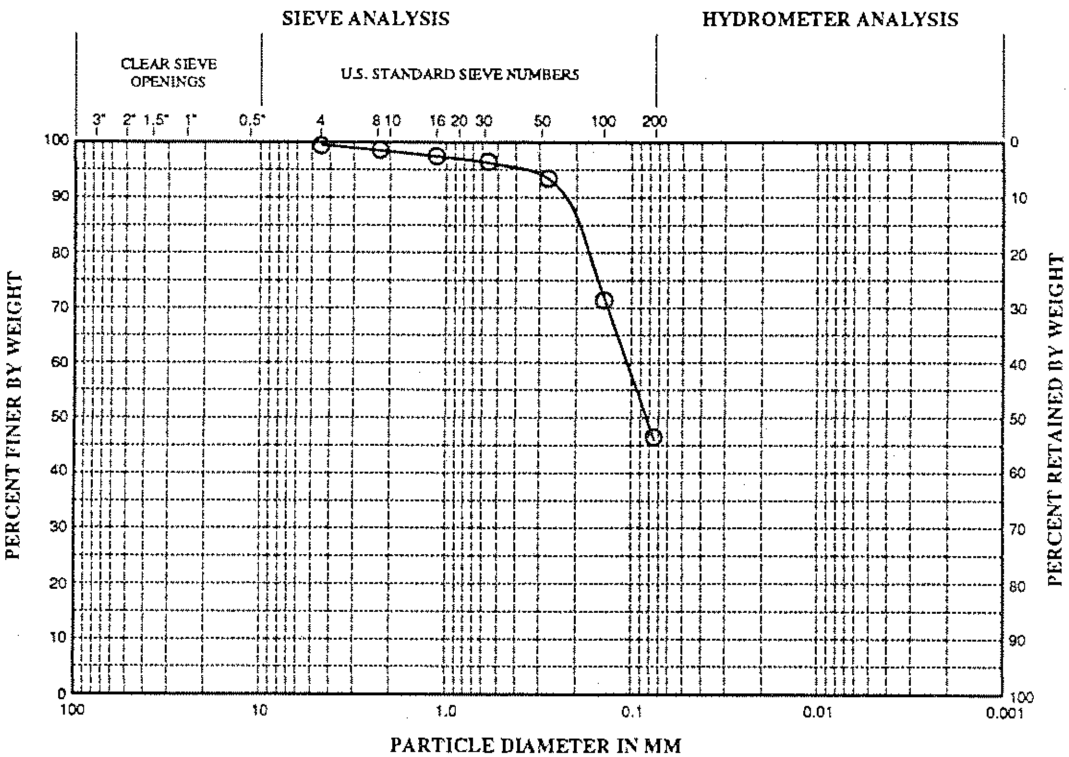
LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.

APPENDIX D.2
GRAIN SIZE DISTRIBUTIONS

89-977/Fig D.2.1/G/SID/Co REV. 8/7/90

SYMBOL	BORING	DEPTH (ft.)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	STRATIGRAPHIC UNIT	MATERIAL TYPE	USCS
o———o	L18-D	10.0 - 11.5	29	13	Colluvium	Clayey Sand	SC



<table>
<tr><td rowspan="2">COBBLES</td><td colspan="2">GRAVEL</td><td colspan="3">SAND</td><td rowspan="2">SILT AND CLAY FRACTION</td></tr>
<tr><td>coarse</td><td>fine</td><td>coarse</td><td>medium</td><td>fine</td></tr>
</table>

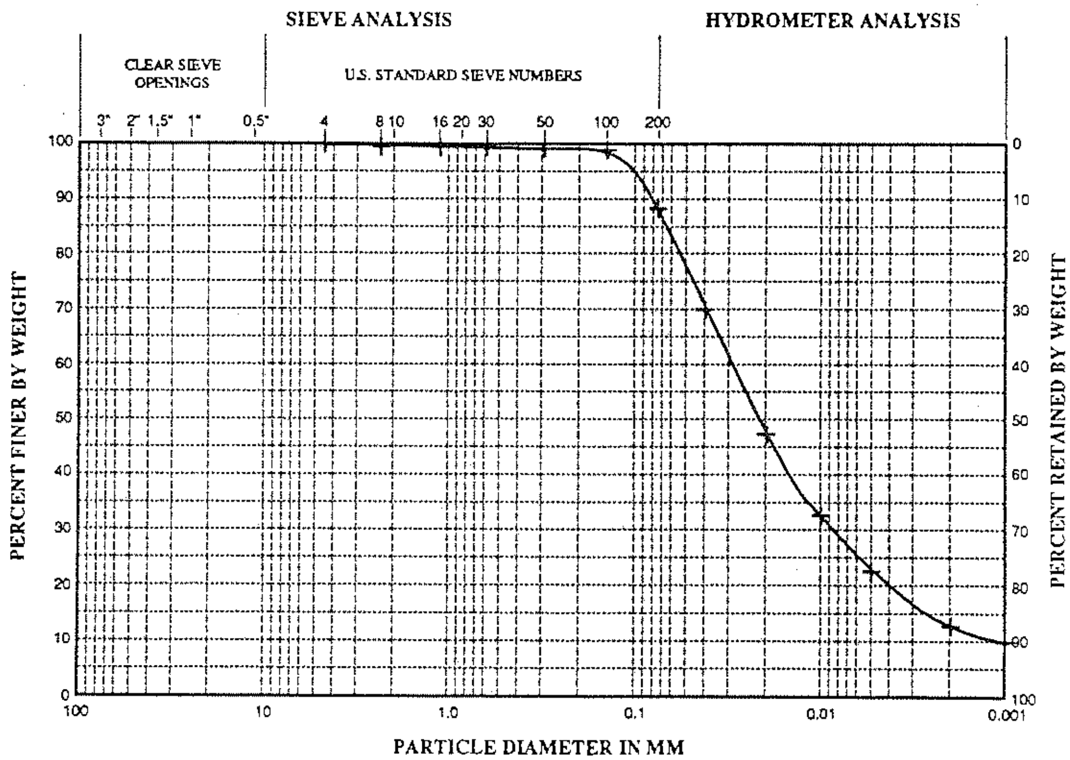
FIGURE D.2.1

GRAIN SIZE DISTRIBUTION COLLUVIUM

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.

SYMBOL	BORING	DEPTH (ft.)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	STRATIGRAPHIC UNIT	MATERIAL TYPE	USCS
+——+	L18-D	22.0-24.3	49	29	18-5	Claystone	CL-CH



COBBLES	GRAVEL		SAND			SILT AND CLAY FRACTION
	coarse	fine	coarse	medium	fine	

FIGURE D.2.2

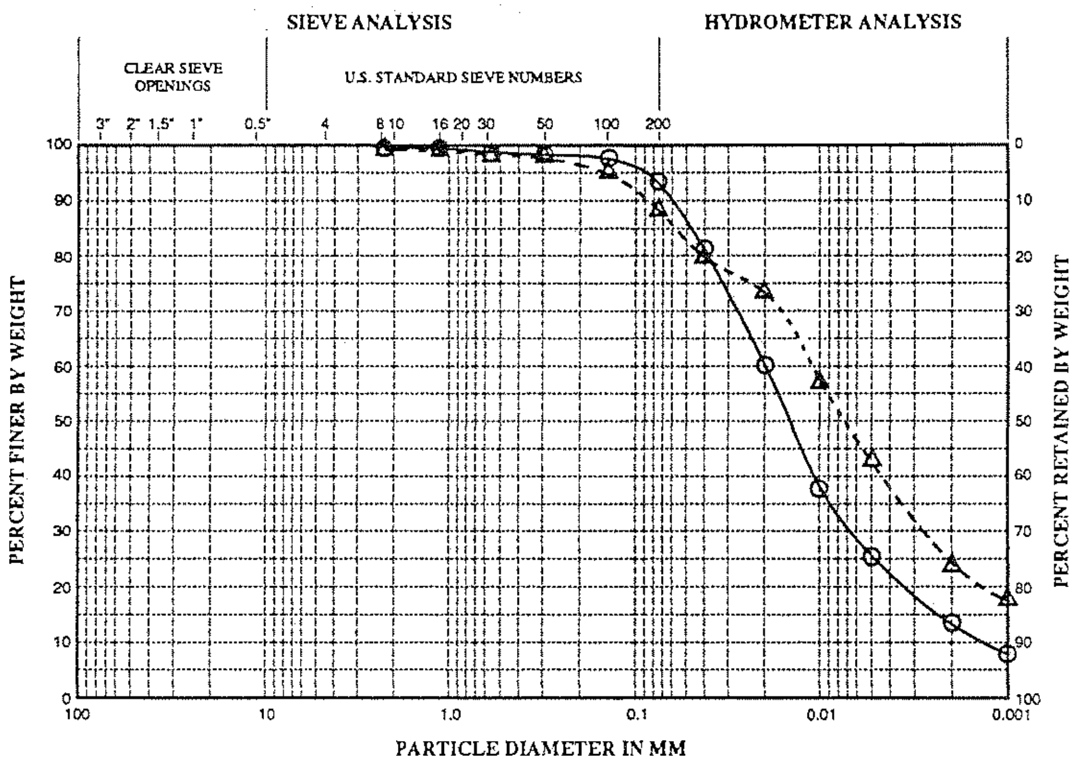
GRAIN SIZE DISTRIBUTION STRATIGRAPHIC UNIT 18-5

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.

89-977/Fig D.2.3/G/SID/U18-7 REV. 8/14/90

SYMBOL	BORING	DEPTH (ft.)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	STRATIGRAPHIC UNIT	MATERIAL TYPE	USCS
o———o	L18-C	15.0-17.3	38	17	18-7	Claystone	CH
Δ- - - -Δ	L18-C	56.0-58.0	60	36	18-7	Claystone	CH



COBBLES	GRAVEL		SAND			SILT AND CLAY FRACTION
	coarse	fine	coarse	medium	fine	

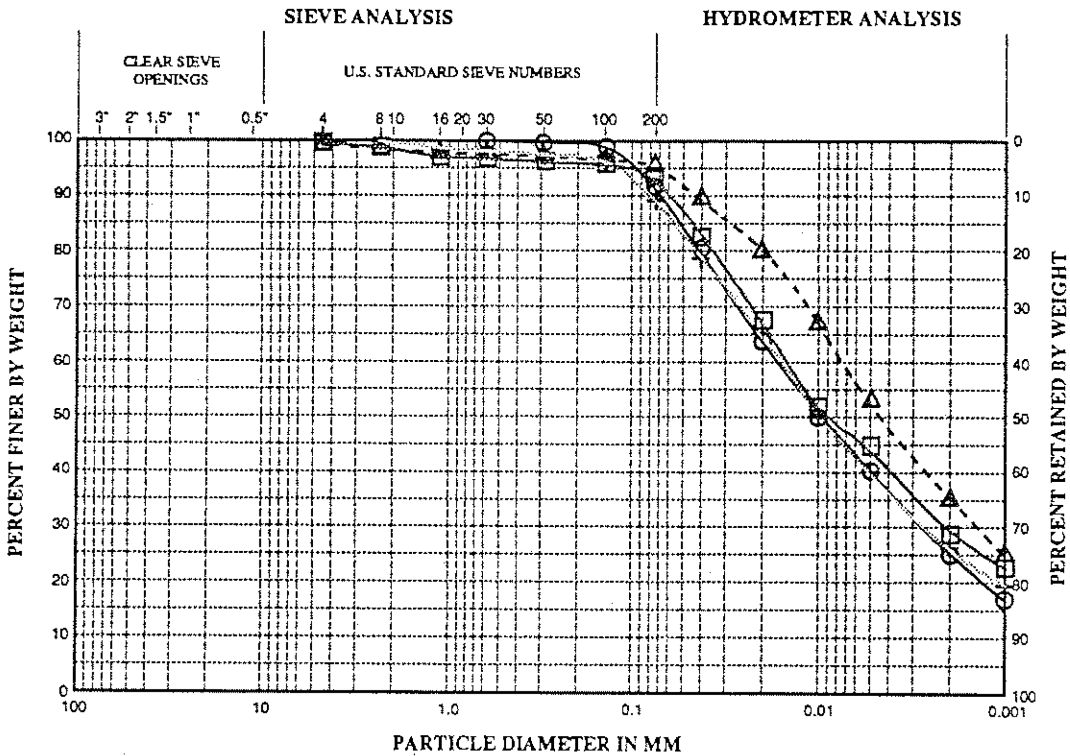
FIGURE D.2.3

GRAIN SIZE DISTRIBUTION STRATIGRAPHIC UNIT 18-7

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.

SYMBOL	BORING	DEPTH (ft.)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	STRATIGRAPHIC UNIT	MATERIAL TYPE	USCS
o———o	L18-I	16.0-18.5	58	36	18-8	Claystone	CH
Δ- - - -Δ	L18-F	6.0-8.5	78	55	18-8	Claystone	CH
□———□	L18-F	26.0-28.5	59	47	18-8	Claystone	CH
+·········+	L18-F	56.0-58.5	59	39	18-8	Claystone	CH



COBBLES	GRAVEL		SAND			SILT AND CLAY FRACTION
	coarse	fine	coarse	medium	fine	

FIGURE D.2.4

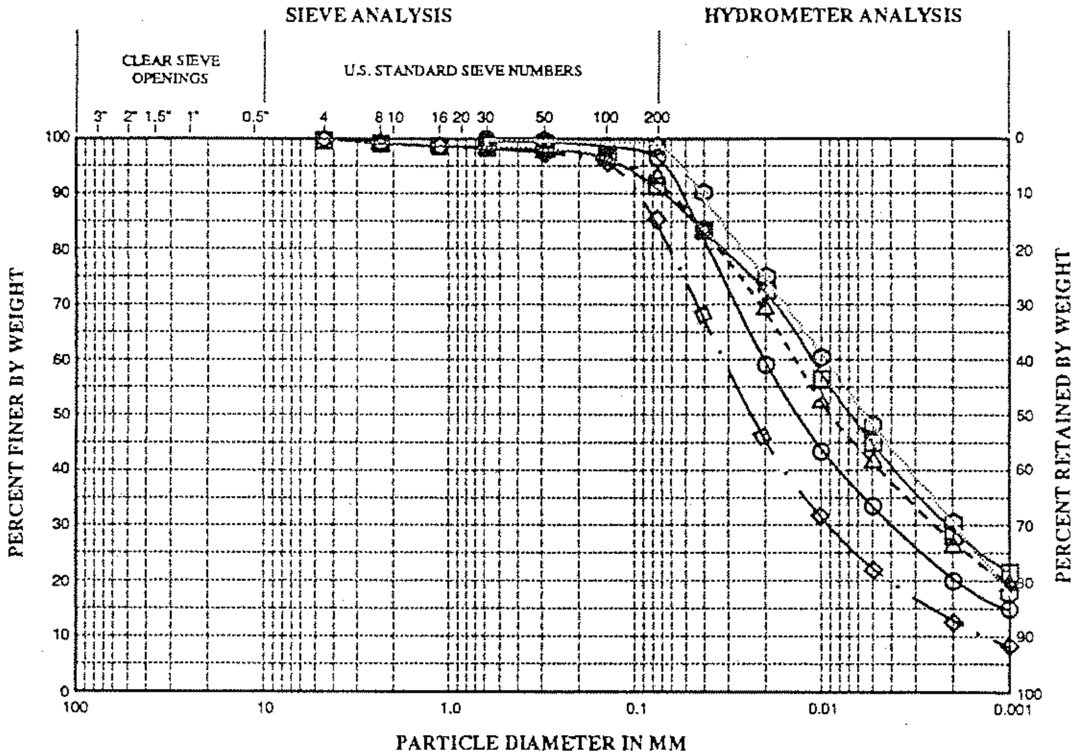
GRAIN SIZE DISTRIBUTION STRATIGRAPHIC UNIT 18-8

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.

89-977/Fig D.2.5/G/SID/U18-8/2 REV. 8/14/90

SYMBOL	BORING	DEPTH (ft.)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	STRATIGRAPHIC UNIT	MATERIAL TYPE	USCS
O———O	L18-J	5-7.5	55	30	18-8	Claystone	CH
△- - - -△	L18-J	35-37.5	64	40	18-8	Claystone	CH
□———□	L18-J	75-77.5	33	17	18-8	Claystone	CH
O·········O	L18-J	120-122.5	70	42	18-8	Claystone	CH
◇— · —◇	L18-J	160-162.5	55	30	18-8	Claystone	CH



COBBLES	GRAVEL		SAND			SILT AND CLAY FRACTION
	coarse	fine	coarse	medium	fine	

FIGURE D.2.5

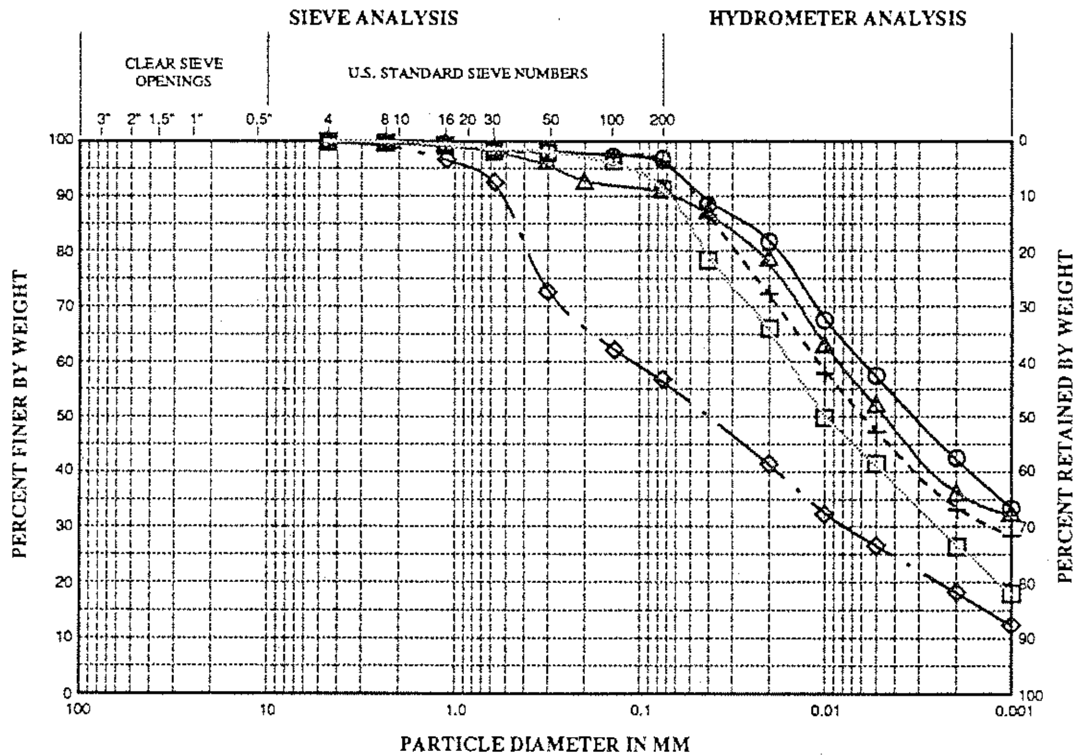
GRAIN SIZE DISTRIBUTION
STRATIGRAPHIC UNIT 18-8

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.

89-977/Fig D.2.6/GrSIDI/U18-8/3 REV. 8/14/90

SYMBOL	TEST PIT	DEPTH (ft.)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	STRATIGRAPHIC UNIT	MATERIAL TYPE	USCS
O———O	DT-A,B-2	5.0	82	54	18-8	Claystone	CH
+- - - - - -+	DT-C,B-1	8.0	78	56	18-8	Claystone	CH
△———△	TP-36,B-1	4.0	78	56	18-8	Claystone	CH
□··········□	TP-38,B-1	9.0	52	34	18-8	Claystone	CH
◇— · —◇	TP-40,B-1	3.0	28	7	18-8	Claystone	CH



COBBLES	GRAVEL		SAND			SILT AND CLAY FRACTION
	coarse	fine	coarse	medium	fine	

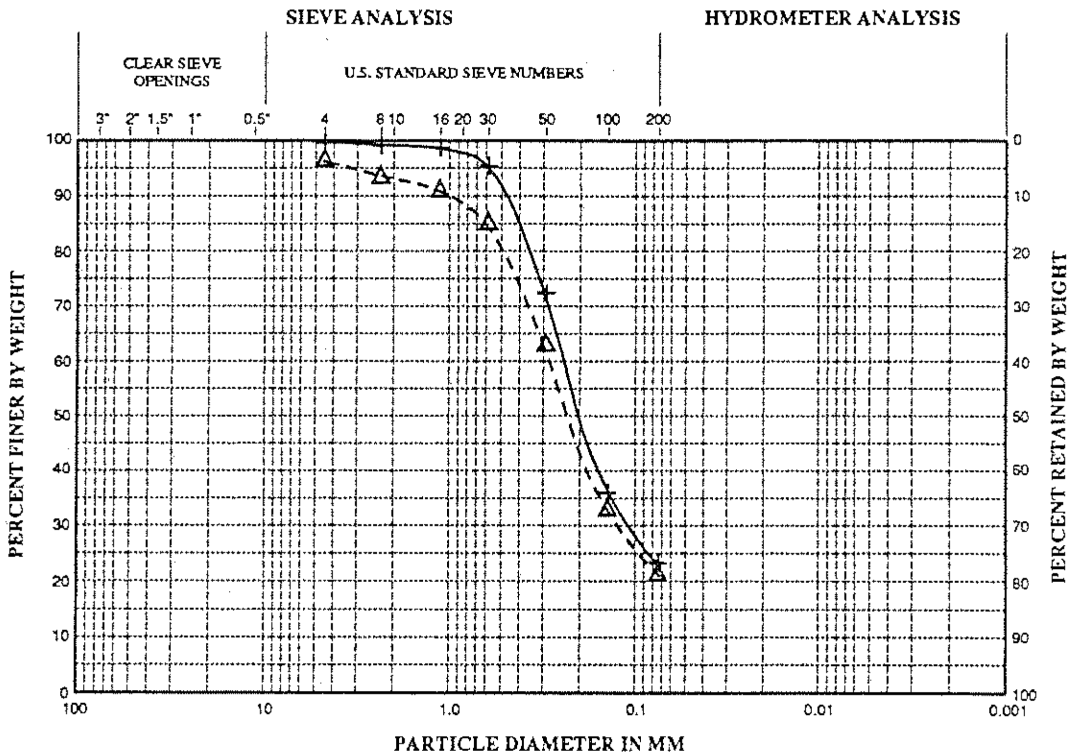
FIGURE D.2.6

GRAIN SIZE DISTRIBUTION STRATIGRAPHIC UNIT 18-8

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.

SYMBOL	TEST PIT TYPE	DEPTH (ft.)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	STRATIGRAPHIC UNIT	MATERIAL TYPE	USCS
+———+	TP-1, B-1	7.0	--	--	18-9	Sandstone	SM
Δ- - - -Δ	TP-42, B-1	6.0	--	--	18-9	Sandstone	SM



COBBLES	GRAVEL		SAND			SILT AND CLAY FRACTION
	coarse	fine	coarse	medium	fine	

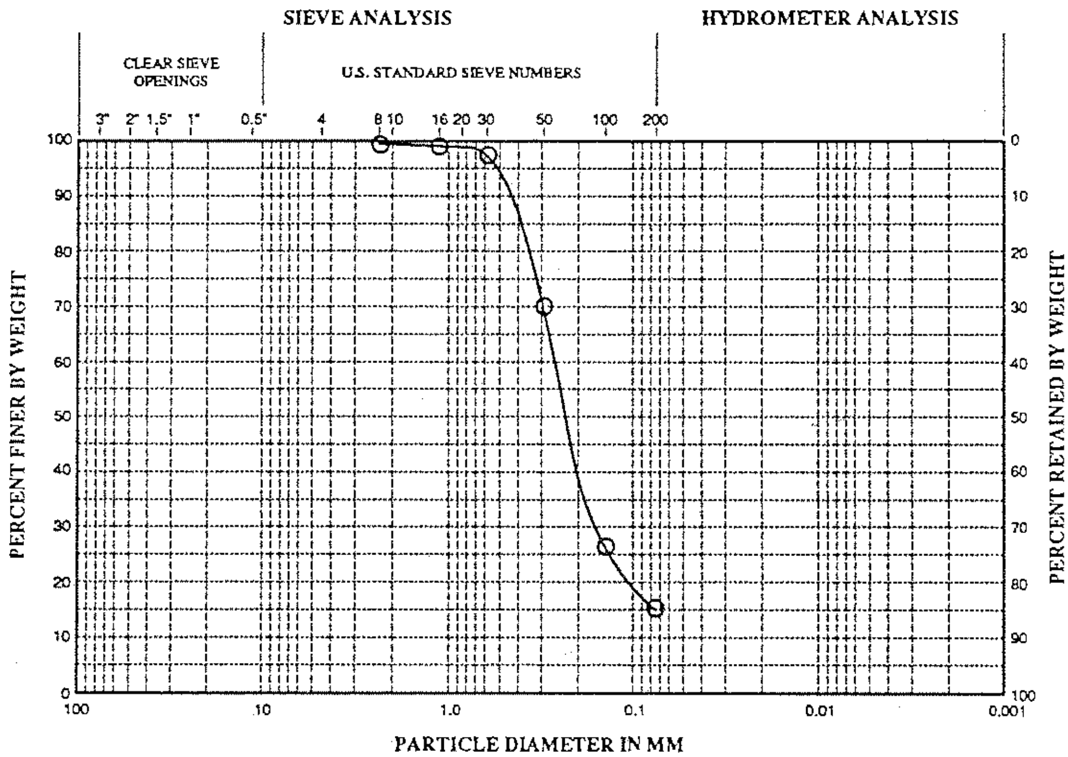
FIGURE D.2.7

GRAIN SIZE DISTRIBUTION
STRATIGRAPHIC UNIT 18-9

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.

SYMBOL	BORING	DEPTH (ft.)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	STRATIGRAPHIC UNIT	MATERIAL TYPE	USCS
o——o	L18-B	37.0-39.5	--	--	18-11	Sandstone	SM



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<tr><td rowspan="2">COBBLES</td><td colspan="2">GRAVEL</td><td colspan="3">SAND</td><td rowspan="2">SILT AND CLAY FRACTION</td></tr>
<tr><td>coarse</td><td>fine</td><td>coarse</td><td>medium</td><td>fine</td></tr>
</table>

FIGURE D.2.8

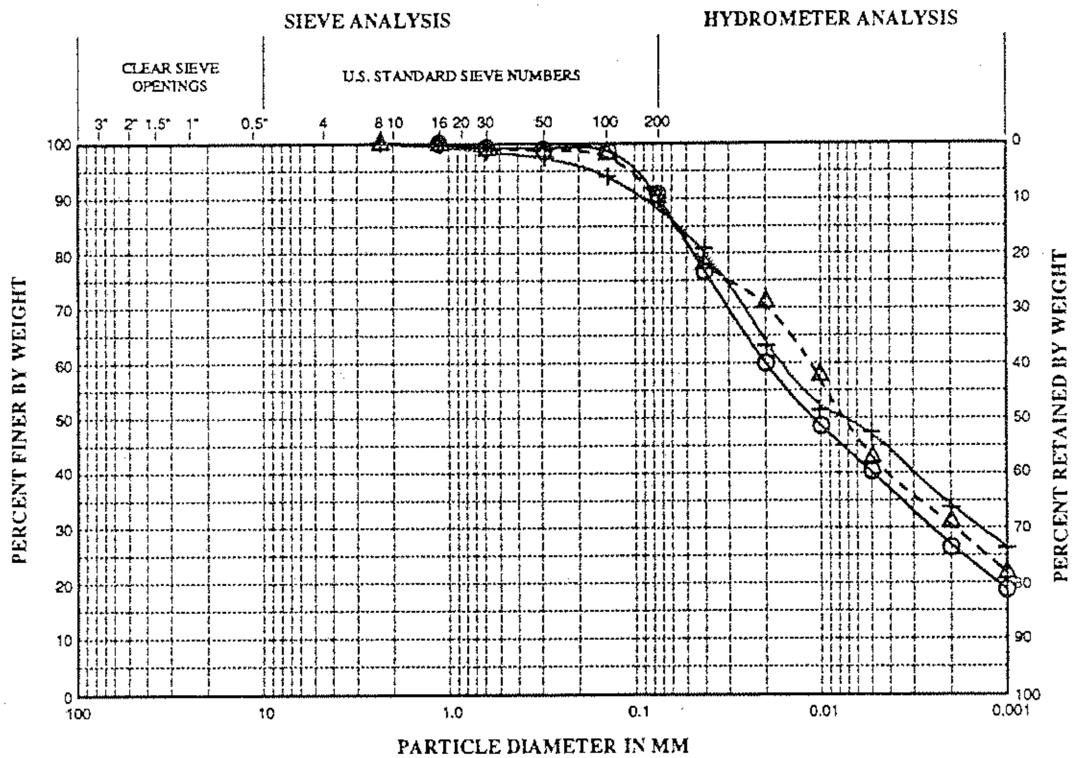
GRAIN SIZE DISTRIBUTION
STRATIGRAPHIC UNIT 18-11

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.

89-977/Fig D.2.9/GrSIDI/U18-12 REV. 8/14/90

SYMBOL	BORING	DEPTH (ft.)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	STRATIGRAPHIC UNIT	MATERIAL TYPE	USCS
o———o	L18-B	6.0-8.5	64	36	18-12	Claystone	CH
Δ- - - -Δ	L18-G	50.0-51.8	78	44	18-12	Claystone	CH
+———+	L18-G	65.0-67.0	60	36	18-12	Claystone	CH



COBBLES	GRAVEL		SAND			SILT AND CLAY FRACTION
	coarse	fine	coarse	medium	fine	

FIGURE D.2.9

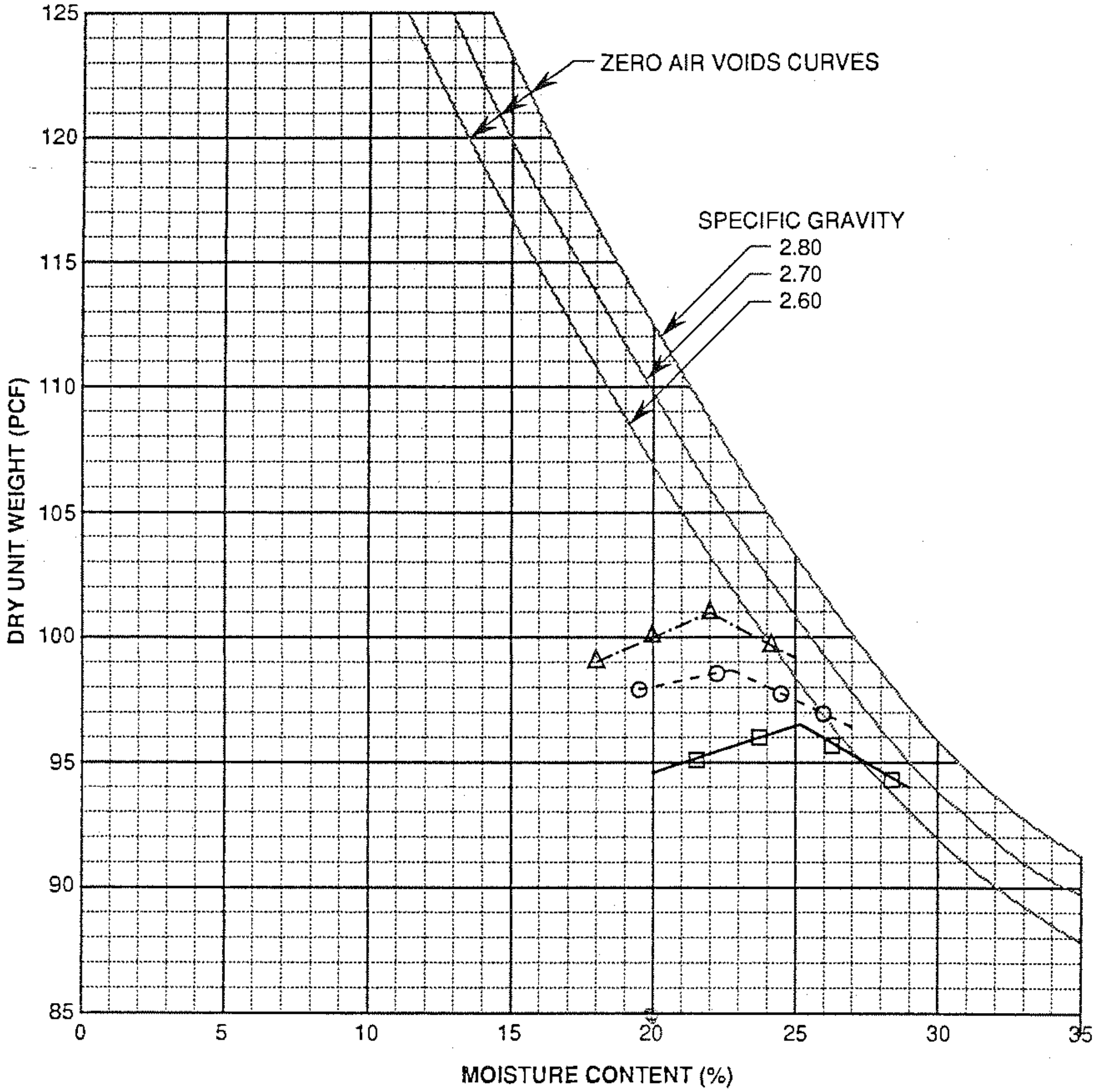
GRAIN SIZE DISTRIBUTION
STRATIGRAPHIC UNIT 18-12

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.

APPENDIX D.3
MODIFIED PROCTOR COMPACTION TESTS

89-97LTR/Fig D.3.1/MoPrTe REV. 8/7/90



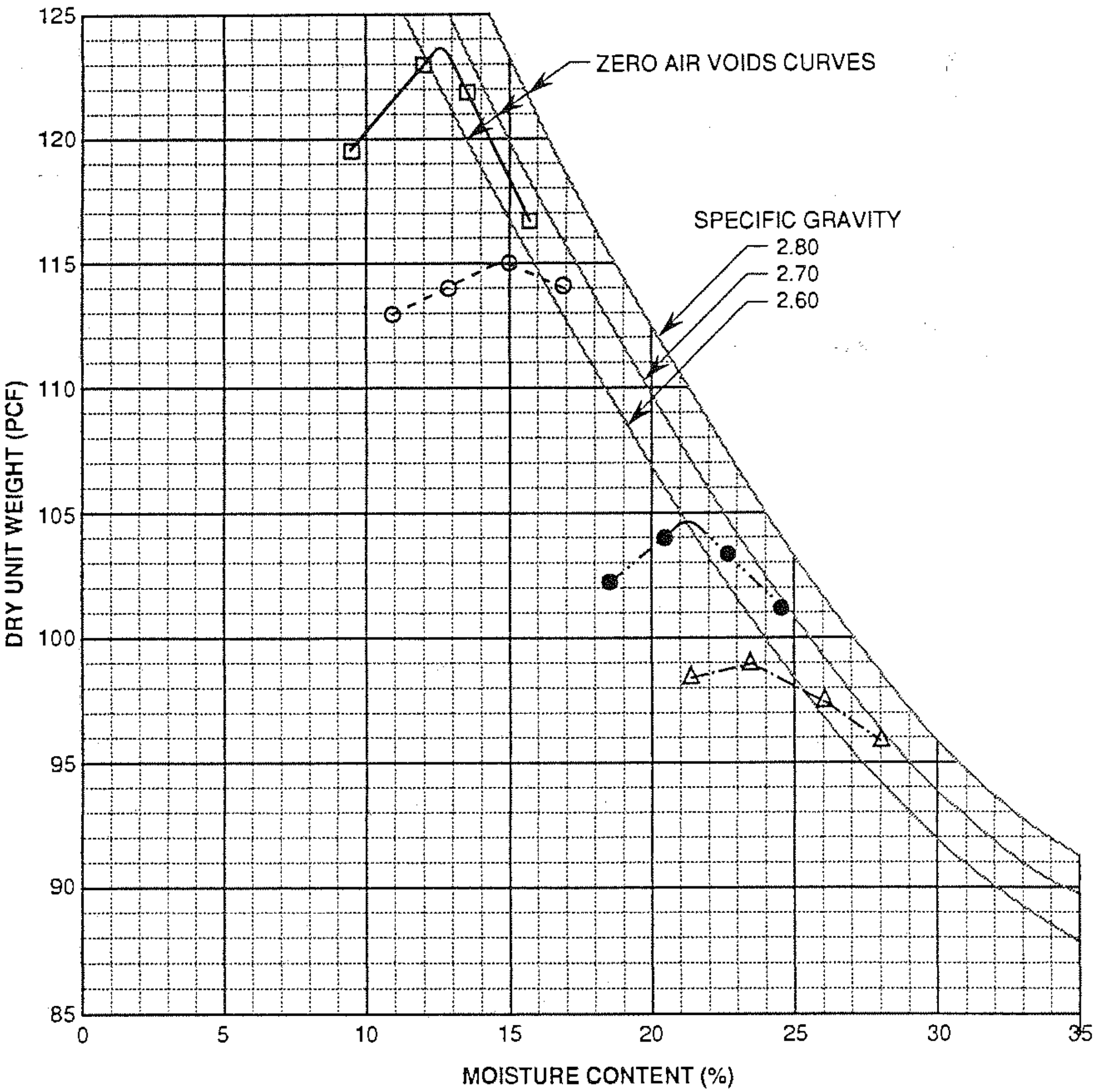
SUMMARY OF COMPACTION TEST RESULTS			
SYMBOL	○	△	□
SAMPLE NO.	COMP. NO. 1	COMP. NO. 2	COMP. NO. 3
MATERIAL TYPE	CLAYSTONE	CLAYSTONE	CLAYSTONE
TEST METHOD	ASTM D1557, METHOD 78A		
MAXIMUM DRY DENSITY (PCF)	98.7	100.7	96.2
OPTIMUM MOISTURE CONTENT (%)	22.8	21.7	24.9
LIQUID LIMIT	67	63	76
PLASTICITY INDEX	40	40	50
SPECIFIC GRAVITY	2.79	2.79	2.79
UNIFIED SOILS CLASSIFICATION	CH	CH	CH

FIGURE D.3.1

MODIFIED PROCTOR TESTS

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.



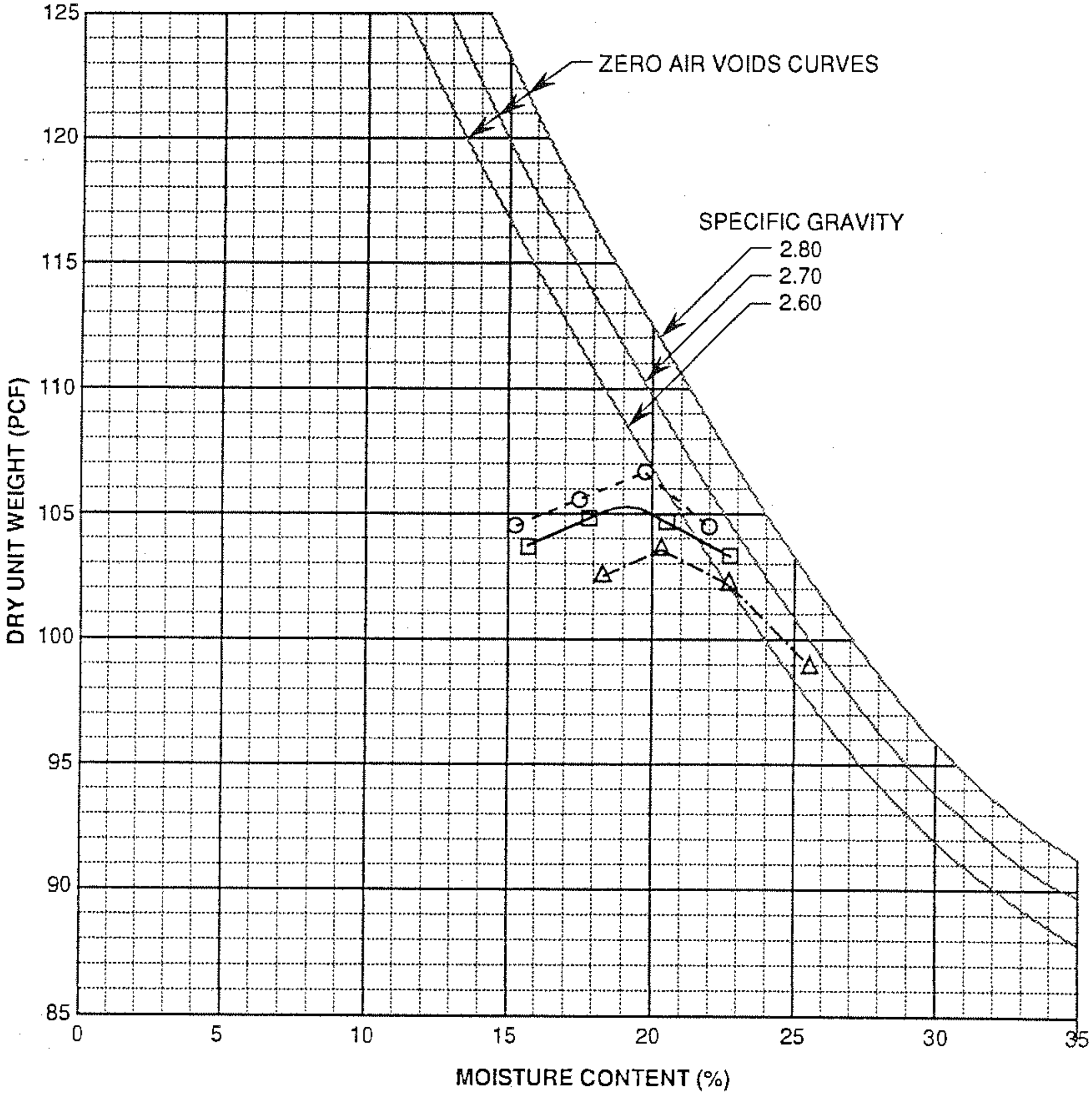
SUMMARY OF COMPACTION TEST RESULTS				
SYMBOL	○	△	□	●
SAMPLE NO.	TP-42, B-1	DT-C, B-1	COMP. NO. 10	DT-A, B-2
MATERIAL TYPE	SANDSTONE	CLAYSTONE	COLLUVIUM	CLAYSTONE
TEST METHOD	ASTM D1557, METHOD 78A			
MAXIMUM DRY DENSITY (PCF)	114.8	99.0	123.3	104.2
OPTIMUM MOISTURE CONTENT (%)	15.0	23.5	12.3	21.5
LIQUID LIMIT	--	76	--	82
PLASTICITY INDEX	--	45	--	54
SPECIFIC GRAVITY	2.8	2.8	2.7	2.7
UNIFIED SOILS CLASSIFICATION	SM	CL	SC	CH

FIGURE D.3.2

MODIFIED PROCTOR TESTS

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.



SUMMARY OF COMPACTION TEST RESULTS			
SYMBOL	○	△	□
SAMPLE NO.	COMP. NO. 5	COMP NO. 7	COMP. NO. 9
MATERIAL TYPE	50% cs/50% ss	50% cs/50% ss	50% cs/50% ss
TEST METHOD	ASTM D1557, METHOD 78A		
MAXIMUM DRY DENSITY (PCF)	106.6	103.7	105.3
OPTIMUM MOISTURE CONTENT (%)	19.8	20.3	19.0
LIQUID LIMIT	--	--	--
PLASTICITY INDEX	--	--	--
SPECIFIC GRAVITY	2.75	2.75	2.75
UNIFIED SOILS CLASSIFICATION	CL	CL	CL

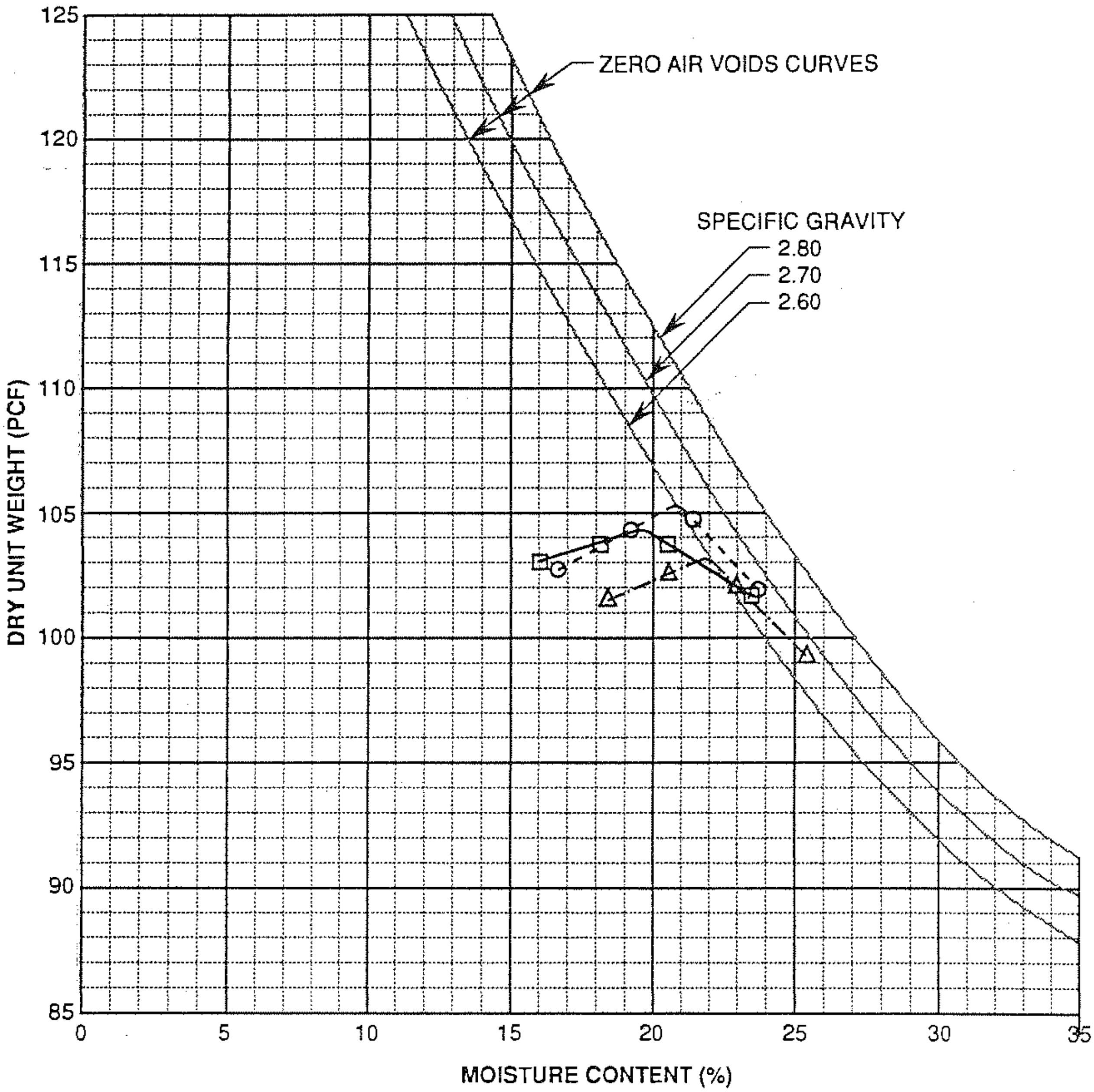
FIGURE D.3.3

MODIFIED PROCTOR TESTS

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.

89-97LTR/Fig D.3.4/MoPr re REV. 8/7/90



SUMMARY OF COMPACTION TEST RESULTS			
SYMBOL	○	△	□
SAMPLE NO.	COMP. NO. 4	COMP. NO. 6	COMP. NO. 8
MATERIAL TYPE	70% cs/30% ss	70% cs/30% ss	70% cs/30% ss
TEST METHOD	ASTM D1557, METHOD 78A		
MAXIMUM DRY DENSITY (PCF)	104.9	102.9	104.0
OPTIMUM MOISTURE CONTENT (%)	20.8	21.9	19.8
LIQUID LIMIT	--	--	--
PLASTICITY INDEX	--	--	--
SPECIFIC GRAVITY	2.7	2.7	2.7
UNIFIED SOILS CLASSIFICATION	CL	CL	CL

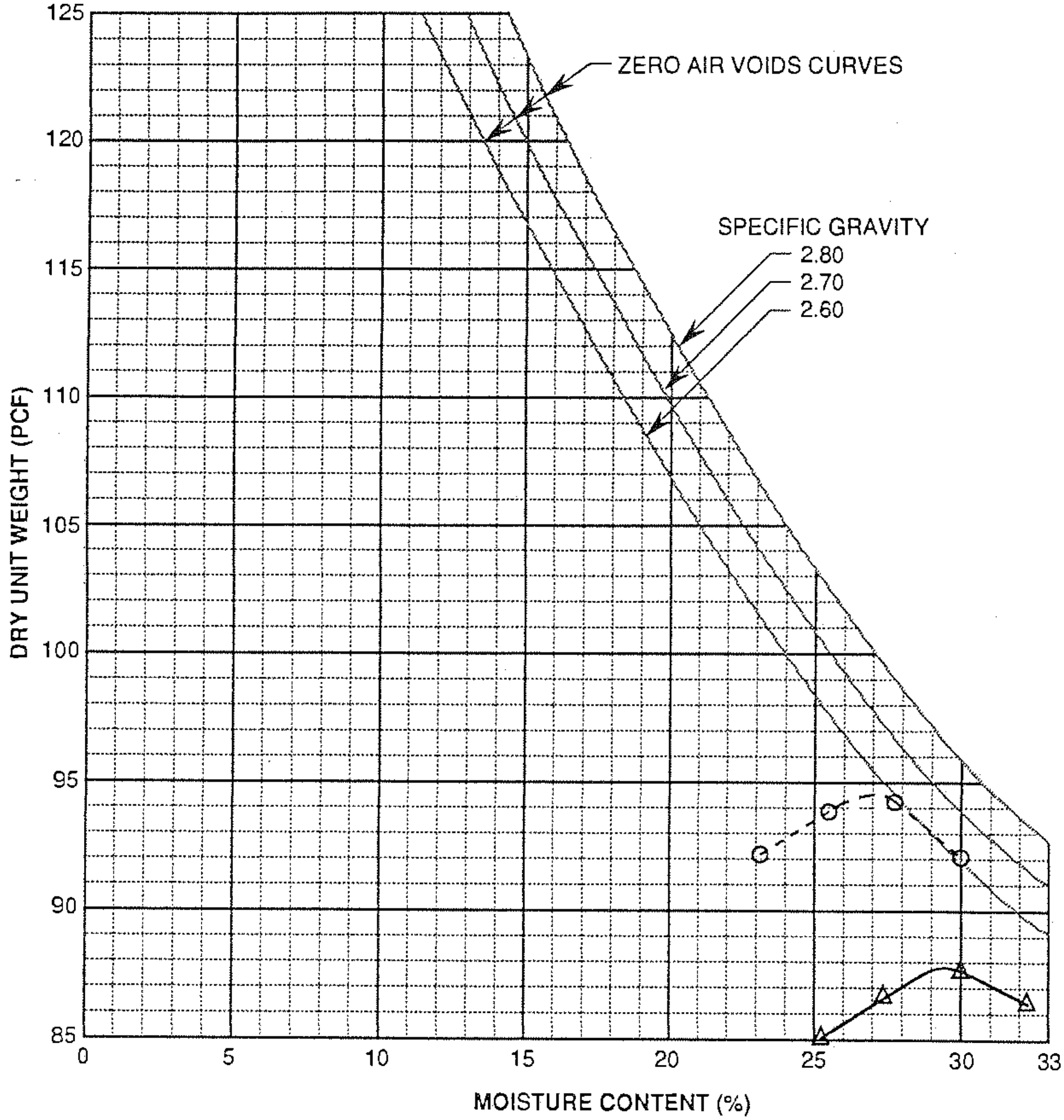
FIGURE D.3.4

MODIFIED PROCTOR TESTS

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.

APPENDIX D.4
STANDARD PROCTOR COMPACTION TESTS



SUMMARY OF COMPACTION TEST RESULTS		
SYMBOL	O	Δ
SAMPLE NO.	COMP. NO. 1	COMP. NO. 11
MATERIAL TYPE	70% cs/30% ss	CLAYSTONE
TEST METHOD	ASTM D698 (STANDARD PROCTOR)	
MAXIMUM DRY DENSITY (PCF)	94.2	87.7
OPTIMUM MOISTURE CONTENT (%)	27.0	29.7
LIQUID LIMIT	--	76
PLASTICITY INDEX	--	45
SPECIFIC GRAVITY	2.8	2.8
UNIFIED SOILS CLASSIFICATION	CL	CH

FIGURE D.4.1

STANDARD PROCTOR TESTS

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.

APPENDIX D.5

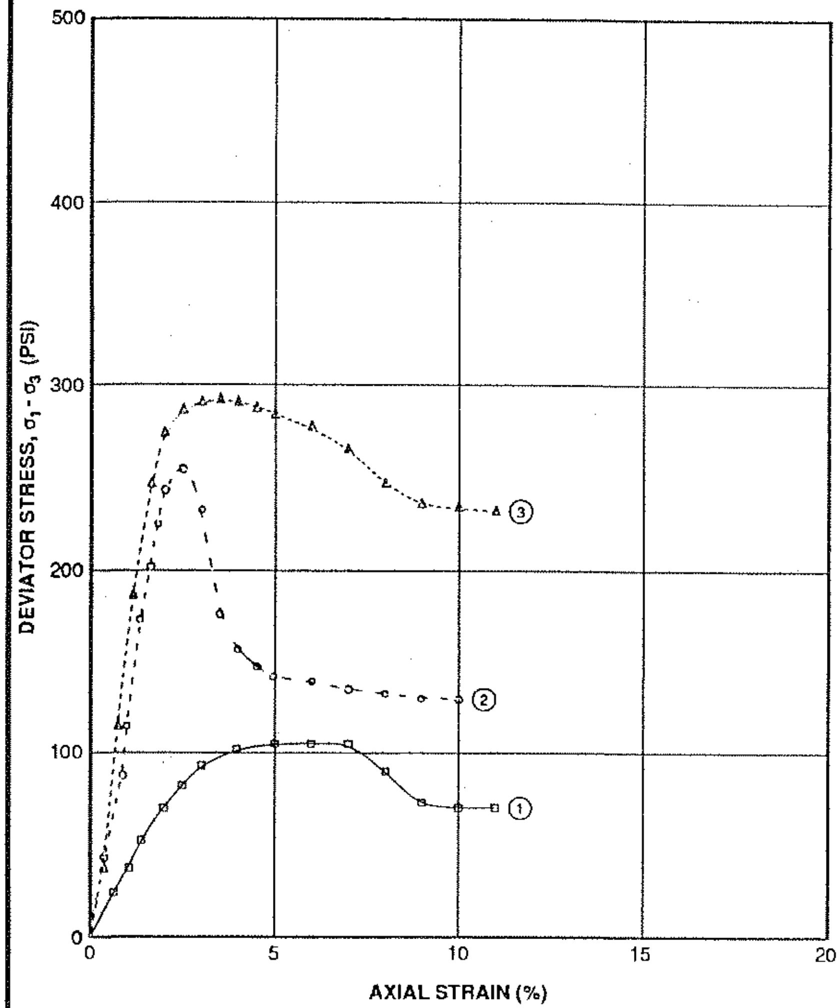
UU TRIAXIAL COMPRESSION TESTS (UNDISTURBED SAMPLES)

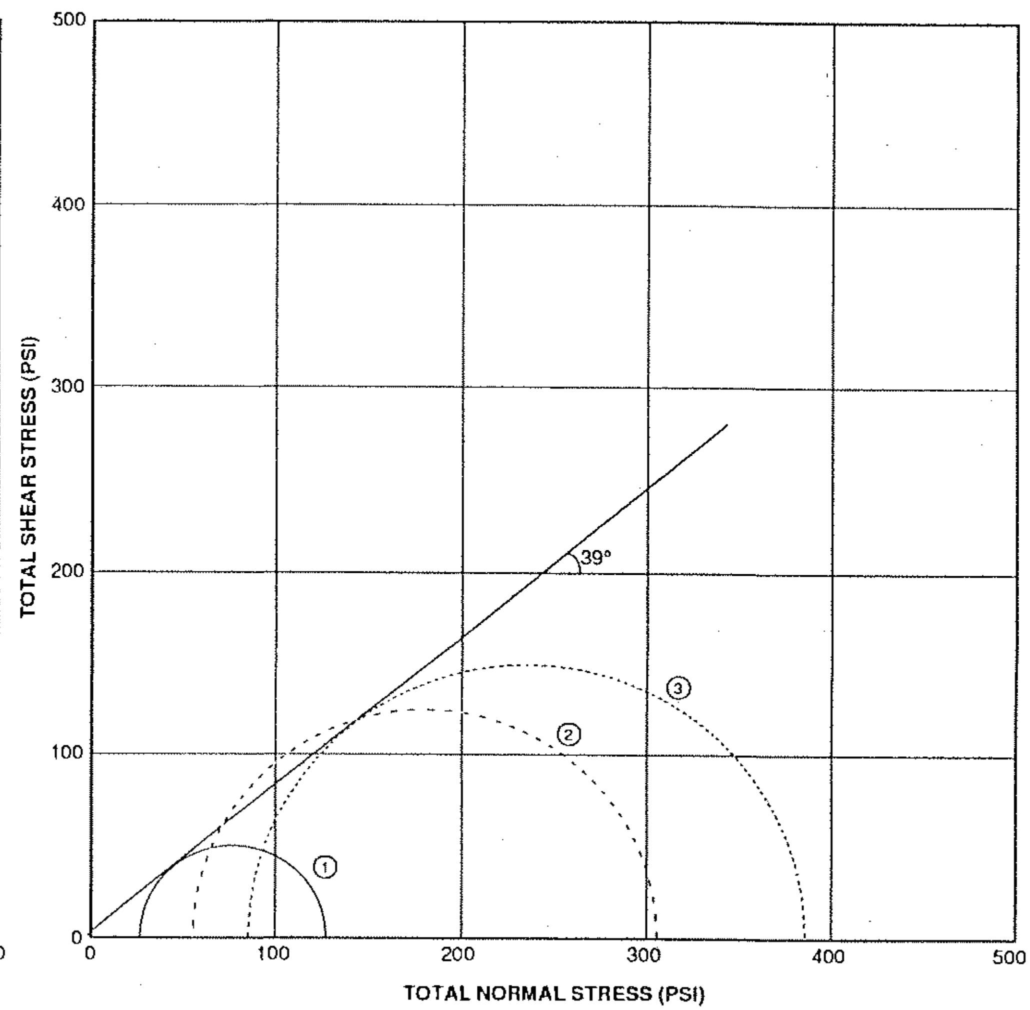
TABLE D.5.1

SUMMARY OF UNCONSOLIDATED UNDRAINED (UU) TRIAXIAL TEST (UNDISTURBED SAMPLES)

BORING NO.	SAMPLE NO.	SAMPLE DEPTH (FT)	STRATIGRAPHIC UNIT	MATERIAL TYPE	NATURAL		CONFINING PRESSURE (PSI)	DEVIATOR STRESS			
					WATER CONTENT (%)	DRY DENSITY (PCF)		PEAK (PSI)	STRAIN (%)	RESIDUAL (PSI)	STRAIN (%)
L18-B	S-3	20.0 - 22.5	18-11	Sandstone	20	101.0	27.8	106.4	6	71.1	11
L18-B	S-5	37.0 - 39.5	18-11	Sandstone	18	101.1	55.6	255.6	8	130.3	10
L18-B	S-5	37.0 - 39.5	18-11	Sandstone	13	102.9	83.3	291.7	4	231.4	11
L18-C	S-8	64.0 - 66.3	18-7	Claystone	22	98.5	27.8	142.7	4	81.4	10
L18-C	S-6	48.0 - 50.1	18-7	Claystone	19	102.8	55.6	221.2	4	142.9	10
L18-C	S-8	64.0 - 66.3	18-7	Claystone	19	105.0	83.3	179.7	4	124.6	10
L18-D	S-2	22.0 - 24.3	18-5	Claystone	19	95.1	27.8	143.8	3	101.9	8
L18-D	S-3	29.0 - 31.5	18-5	Claystone	19	100.4	55.6	214.0	5	144.8	10
L18-D	S-2	22.0 - 24.3	18-5	Claystone	17	93.0	83.3	254.1	5	232.0	10
L18-F	S-6	56.0 - 58.5	18-8	Claystone	26	95.0	27.8	182.2	2	73.6	8
L18-F	S-5	46.0 - 48.1	18-8	Claystone	26	94.9	55.6	163.3	2	65.1	7
L18-F	S-6	56.0 - 58.5	18-8	Claystone	29	88.3	83.3	123.9	3	72.7	7
L18-G	S-4	30.0 - 32.0	18-13	Sandstone	16	101.5	27.8	135.5	3	82.1	10
L18-G	S-5	40.0 - 41.3	18-13	Sandstone	12	101.5	55.6	235.6	4	176.1	10
L18-G	S-4	30.0 - 32.0	18-13	Sandstone	14	101.0	83.3	270.8	4	215.4	12.5
L18-G	S-6	45.0 - 47.5	18-12	Claystone	30	91.3	27.8	130.6	2	53.1	7
L18-G	S-7	50.0 - 51.8	18-12	Claystone	28	91.8	55.6	95.4	2	78.3	5
L18-G	S-6	45.0 - 47.5	18-12	Claystone	29	92.7	83.3	144.3	2	72.7	7

89-977 (8/7/90)





SPECIMEN NO.	SAMPLE NO.	DEPTH (FEET)	INITIAL STATE		CONFINING PRESSURE (PSI)	DEVIATOR STRESS AT FAILURE (PSI)	STRAIN AT FAILURE (%)	STRATIGRAPHIC UNIT	MATERIAL TYPE
			ω (%)	γ_d (PCF)					
①	S-3	20.0-22.5	19.6	101.0	27.8	106.4	6.0	18-11	UNDISTURBED SANDSTONE
②	S-5	37.0-39.5	17.9	101.1	55.6	255.6	2.5		
③	S-5	37.0-39.5	13.2	102.9	83.3	291.7	3.5		

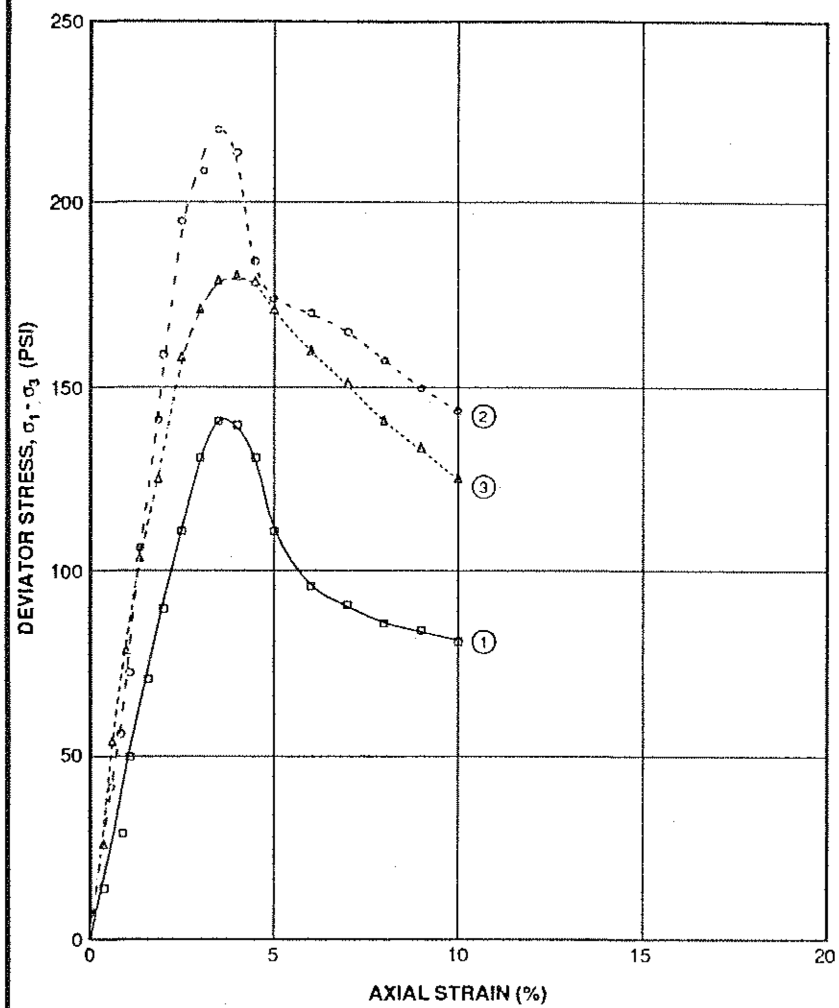
FIGURE D.5.1

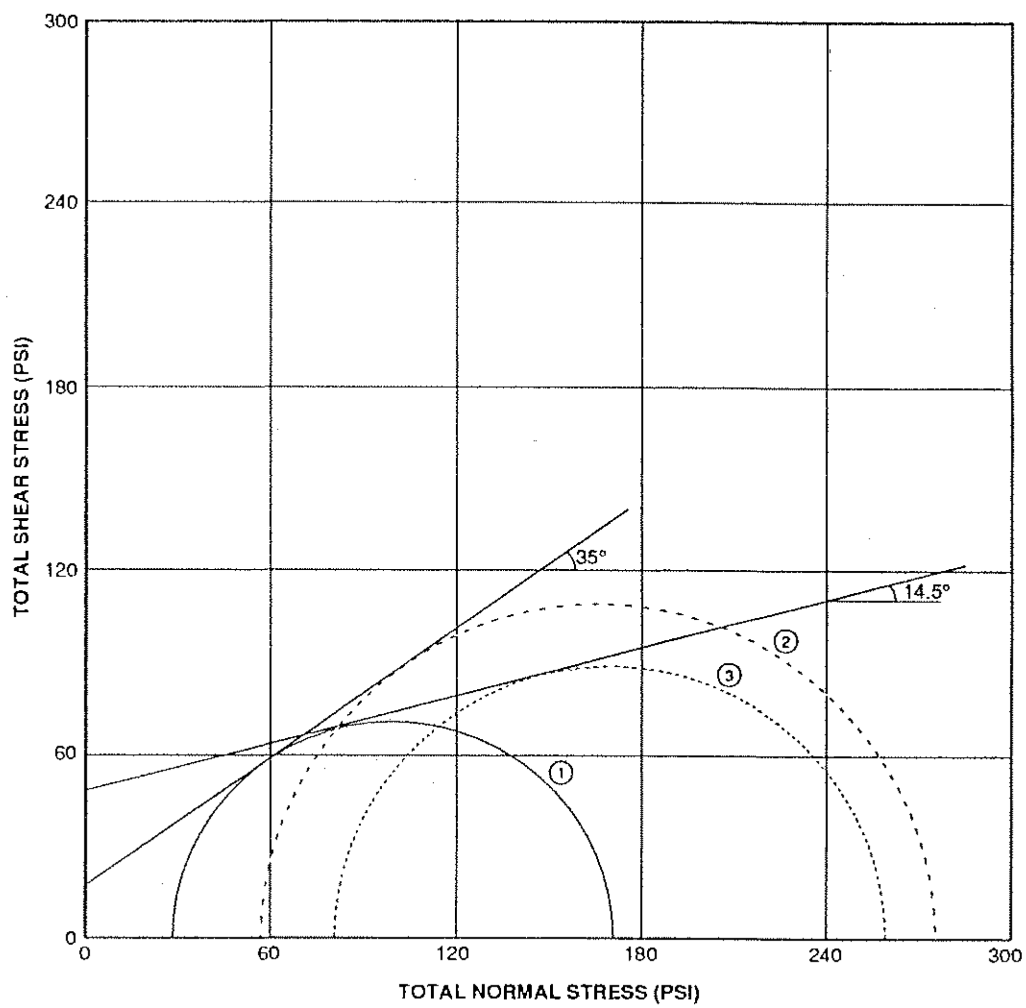
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST RESULTS BORING NO. L18-B

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.

89-977DR/Fig D.5.2/L18-C REV. 8/7/90





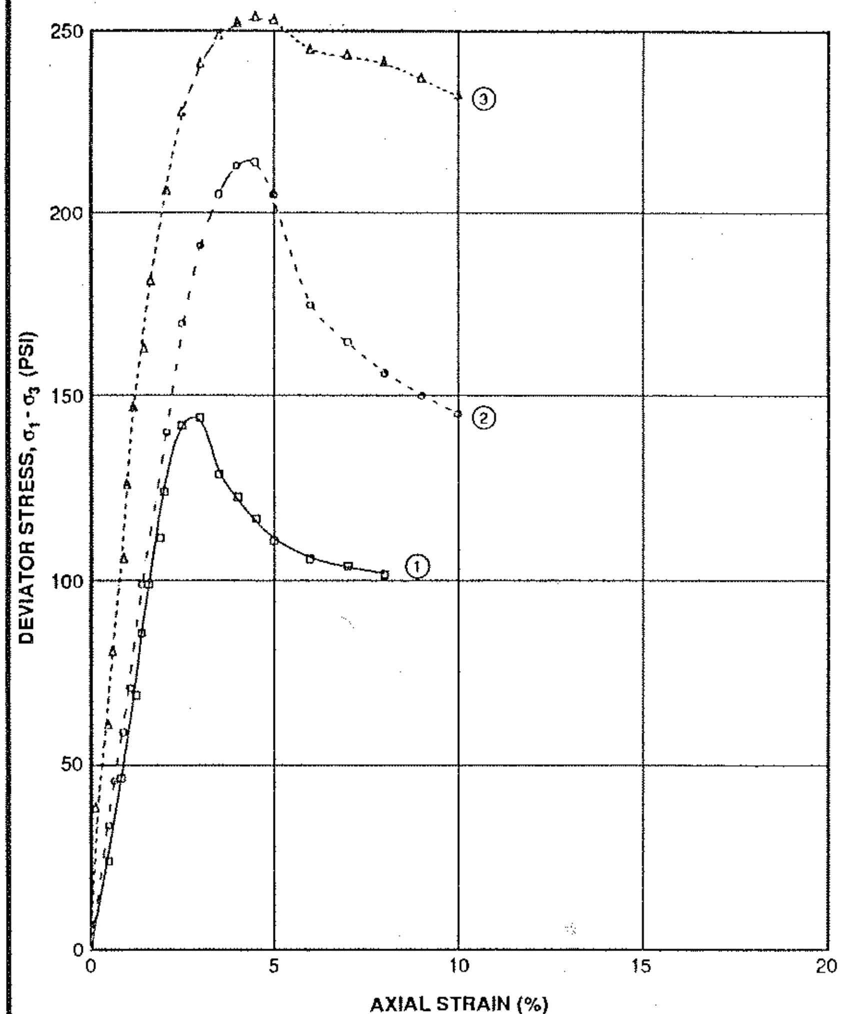
SPECIMEN NO.	SAMPLE NO.	DEPTH (FEET)	INITIAL STATE ω (%)	INITIAL STATE γ_d (PCF)	CONFINING PRESSURE (PSI)	DEVIATOR STRESS AT FAILURE (PSI)	STRAIN AT FAILURE (%)	STRATIGRAPHIC UNIT	MATERIAL TYPE
①	S-8	64.0 - 66.3	21.7	98.5	27.8	142.7	3.5	18-7	UNDISTURBED SILTY CLAYSTONE
②	S-6	48.0 - 50.1	18.7	102.8	55.6	221.2	3.5		
③	S-8	64.0 - 66.3	19.3	105.0	83.3	179.7	4.0		

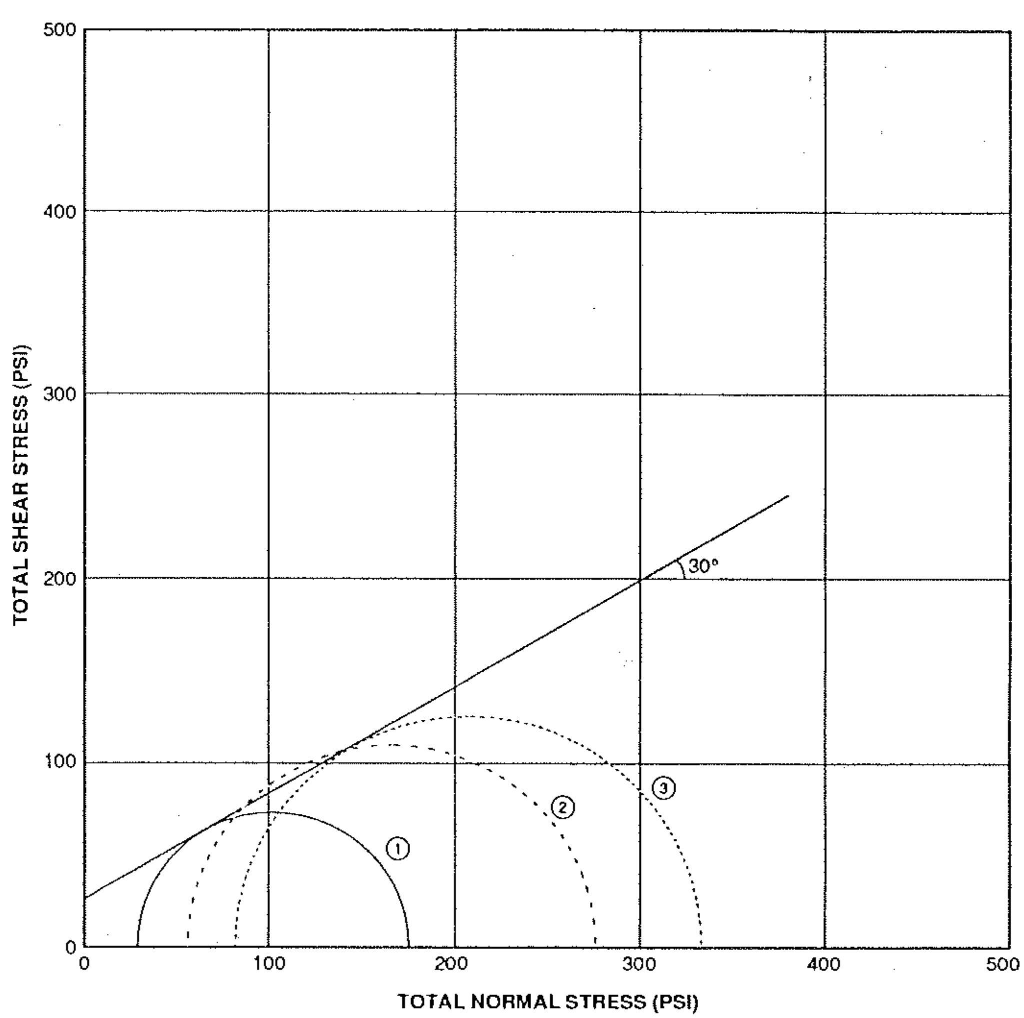
FIGURE D.5.2

UNCONSOLIDATED UNDRAINED TRIAXIAL TEST RESULTS BORING NO. L18-C

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.





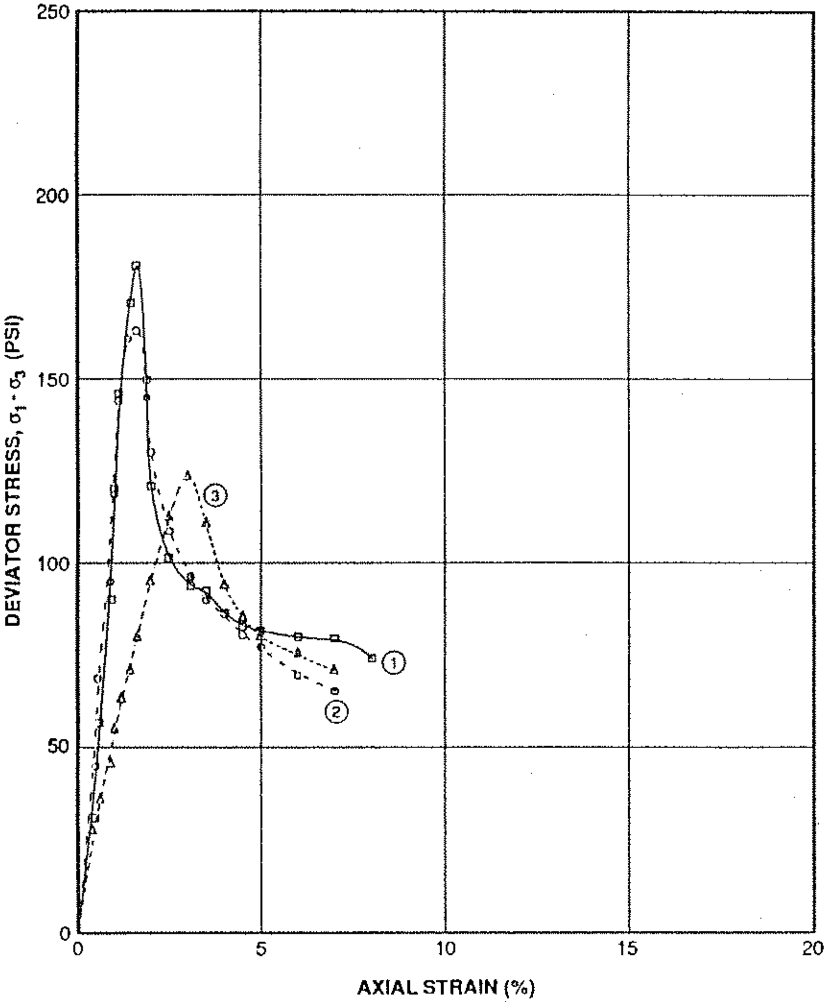
SPECIMEN NO.	SAMPLE NO.	DEPTH (FEET)	INITIAL STATE ω (%)	INITIAL STATE γ_d (PCF)	CONFINING PRESSURE (PSI)	DEVIATOR STRESS AT FAILURE (PSI)	STRAIN AT FAILURE (%)	STRATIGRAPHIC UNIT	MATERIAL TYPE
①	S-2	22.0 - 24.3	18.6	95.1	27.8	143.8	3.0	18-5	UNDISTURBED CLAYSTONE
②	S-3	29.0 - 31.5	19.1	100.4	55.6	214.0	4.5		
③	S-2	22.0 - 24.3	17.4	93.0	83.3	254.1	4.5		

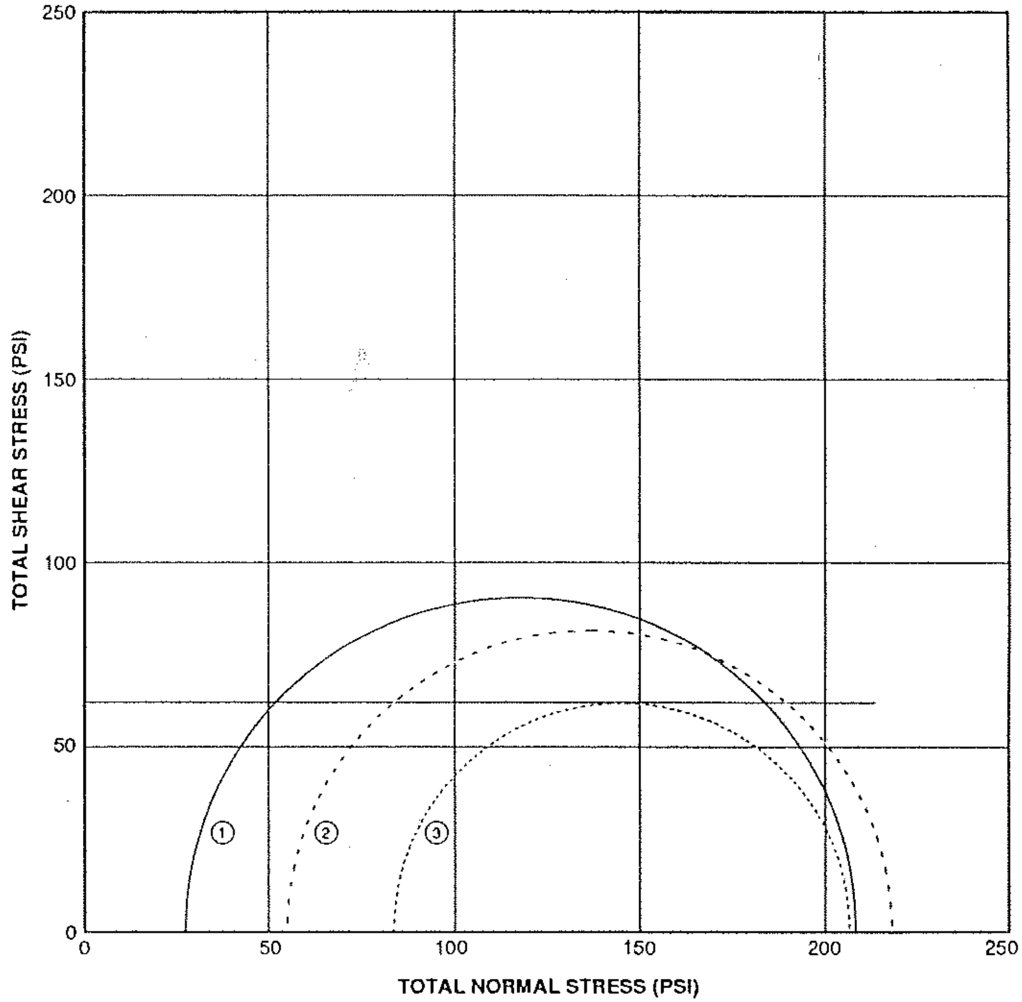
FIGURE D.5.3

UNCONSOLIDATED UNDRAINED TRIAXIAL TEST RESULTS BORING NO. L18-D

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.





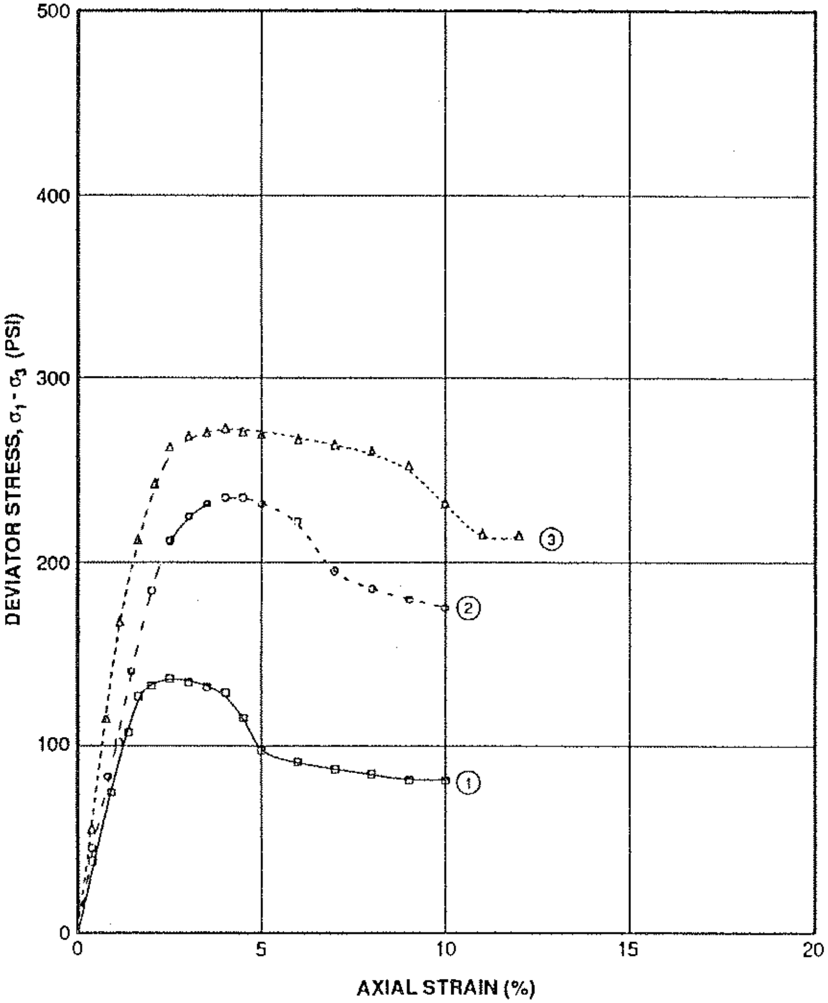
SPECIMEN NO.	SAMPLE NO.	DEPTH (FEET)	INITIAL STATE ω (%)	INITIAL STATE γ_d (PCF)	CONFINING PRESSURE (PSI)	DEVIATOR STRESS AT FAILURE (PSI)	STRAIN AT FAILURE (%)	STRATIGRAPHIC UNIT	MATERIAL TYPE
①	S-6	56.0 - 58.5	25.9	95.0	27.8	182.2	1.6	18-8	UNDISTURBED CLAYSTONE
②	S-5	46.0 - 48.1	25.6	94.9	55.6	163.3	1.6		
③	S-6	56.0 - 58.5	28.8	88.3	83.3	123.9	3.0		

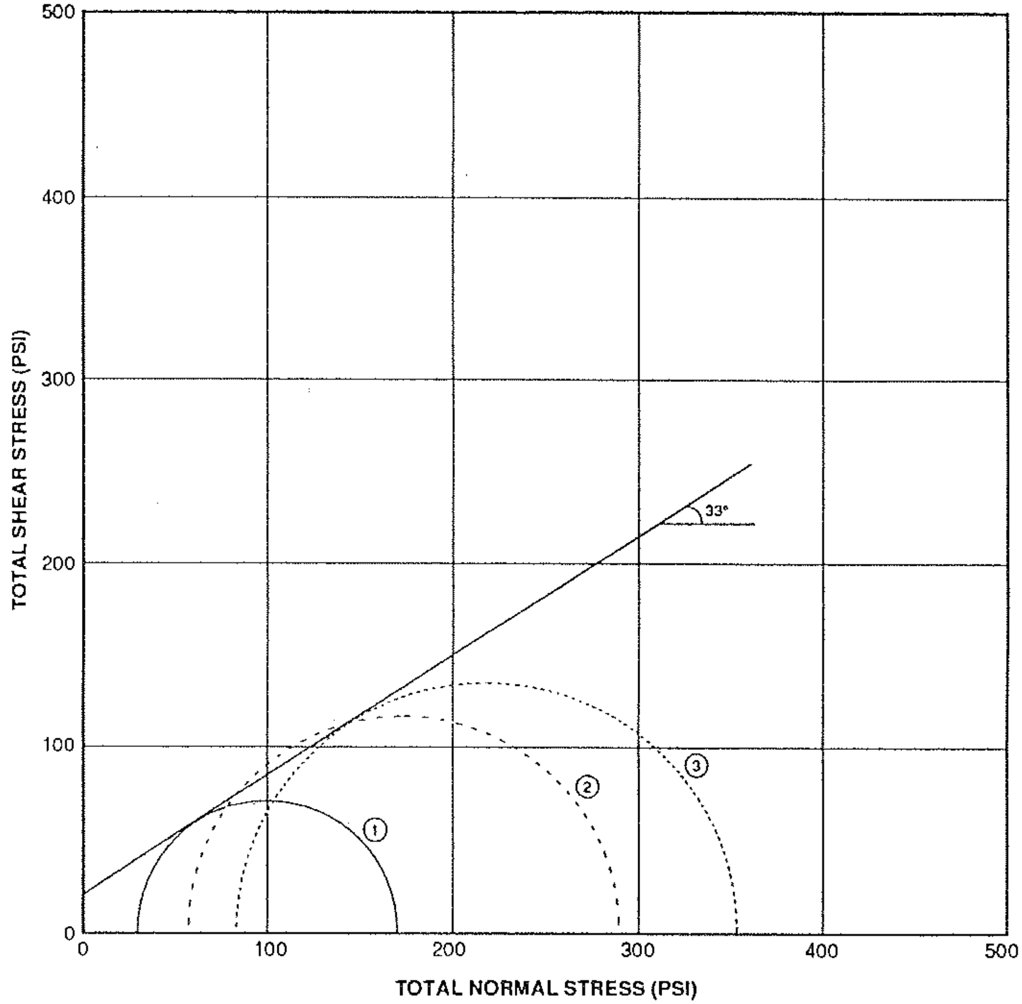
FIGURE D.5.4

UNCONSOLIDATED UNDRAINED TRIAXIAL TEST RESULTS
BORING NO. L18-F

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.





SPECIMEN NO.	SAMPLE NO.	DEPTH (FEET)	INITIAL STATE ω (%)	INITIAL STATE γ_d (PCF)	CONFINING PRESSURE (PSI)	DEVIATOR STRESS AT FAILURE (PSI)	STRAIN AT FAILURE (%)	STRATIGRAPHIC UNIT	MATERIAL TYPE
①	S-4	30.0 - 32.0	16.2	101.5	27.8	135.5	2.5	18-13	UNDISTURBED SANDSTONE
②	S-5	40.0 - 41.3	12.1	101.5	55.6	235.6	4.0		
③	S-4	30.0 - 32.0	14.3	101.0	83.3	270.8	4.0		

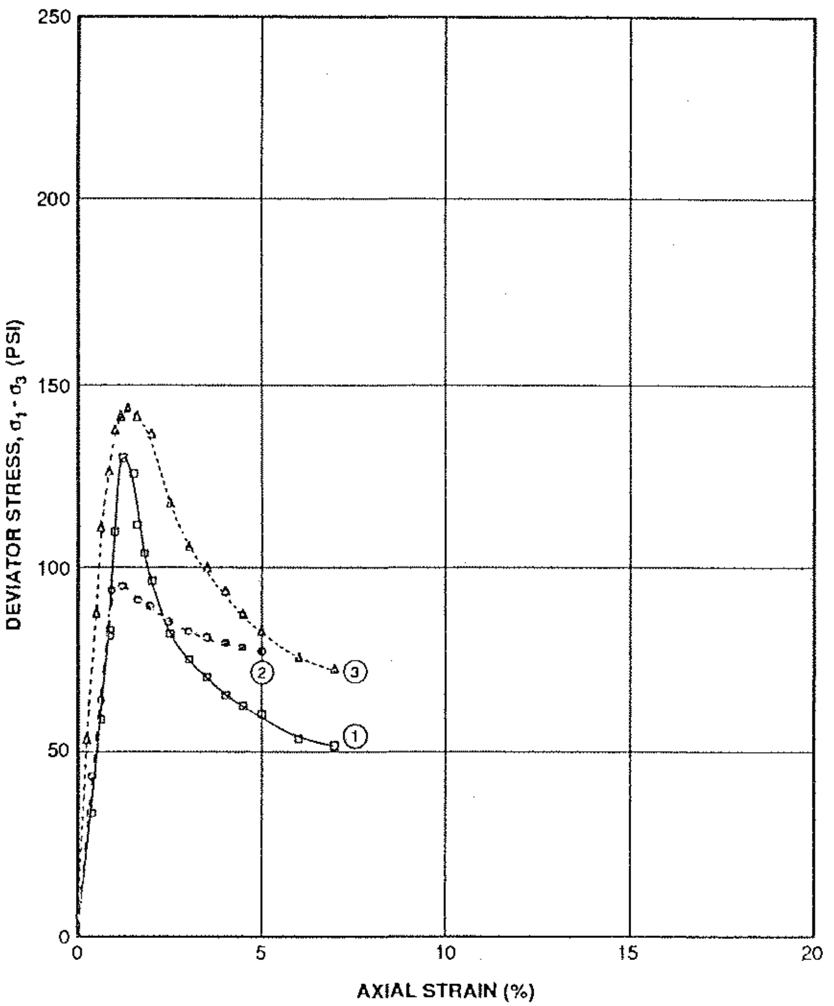
FIGURE D.5.5

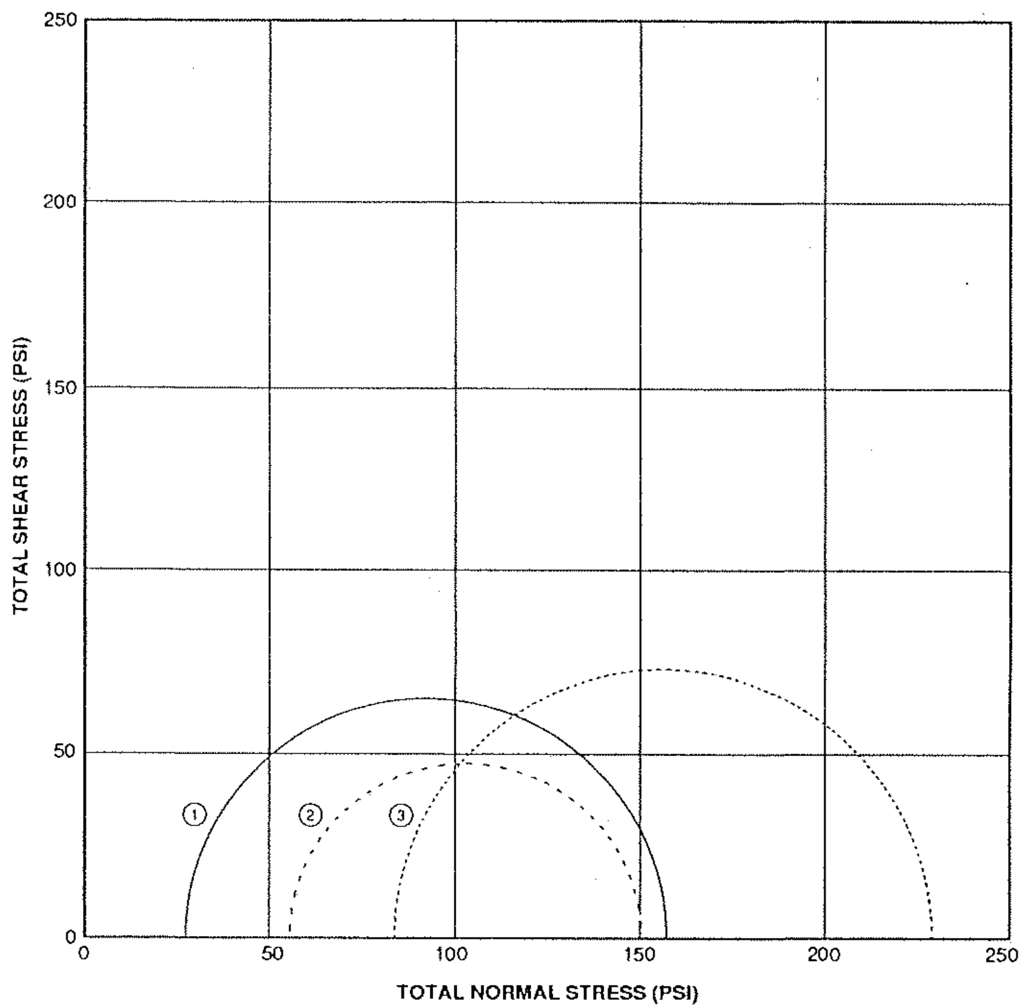
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST RESULTS BORING NO. L18-G

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.

89-977DR/Fig D.5.6/L18-G/[illegible] 8/7/90





SPECIMEN NO.	SAMPLE NO.	DEPTH (FEET)	INITIAL STATE ω (%)	INITIAL STATE γ_d (PCF)	CONFINING PRESSURE (PSI)	DEVIATOR STRESS AT FAILURE (PSI)	STRAIN AT FAILURE (%)	STRATIGRAPHIC UNIT	MATERIAL TYPE
①	S-6	45.0 - 47.5	29.8	91.3	27.8	130.6	1.2	18-12	UNDISTURBED CLAYSTONE
②	S-7	50.0 - 51.8	28.4	91.8	55.6	95.4	1.2		
③	S-6	45.0 - 47.5	29.4	92.7	83.3	144.3	1.4		

FIGURE D.5.6

UNCONSOLIDATED UNDRAINED TRIAXIAL TEST RESULTS BORING NO. L18-G

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.

APPENDIX D.6

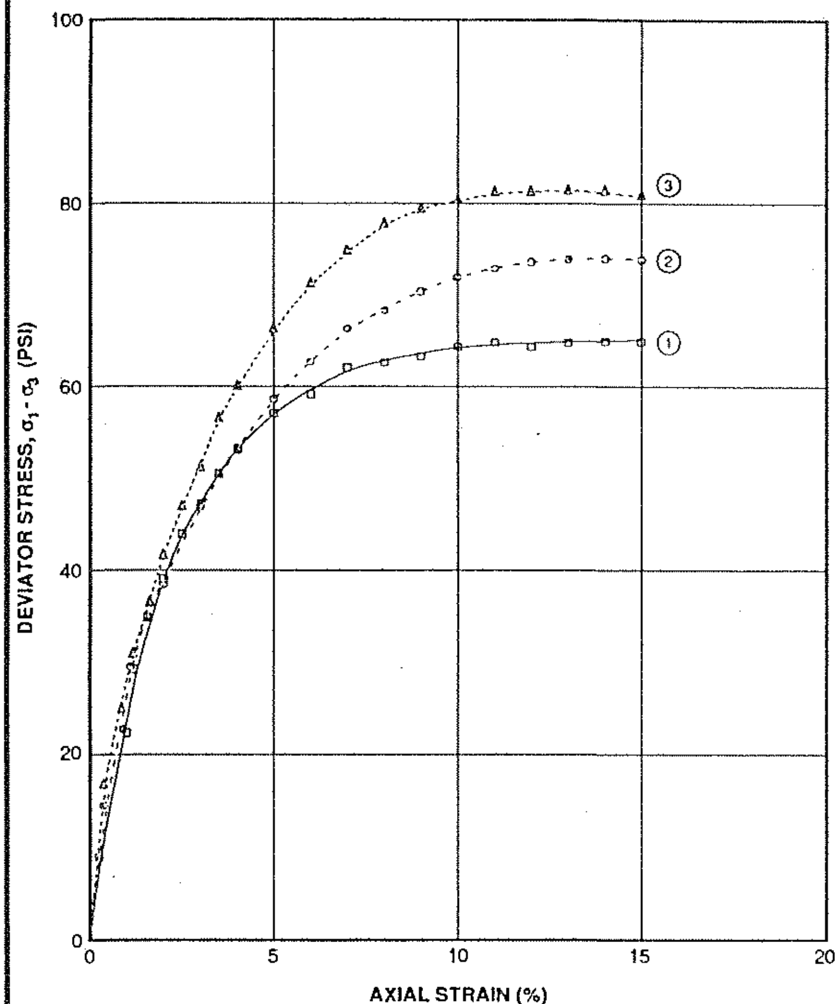
UU TRIAXIAL COMPRESSION TESTS (REMOLDED SAMPLES)

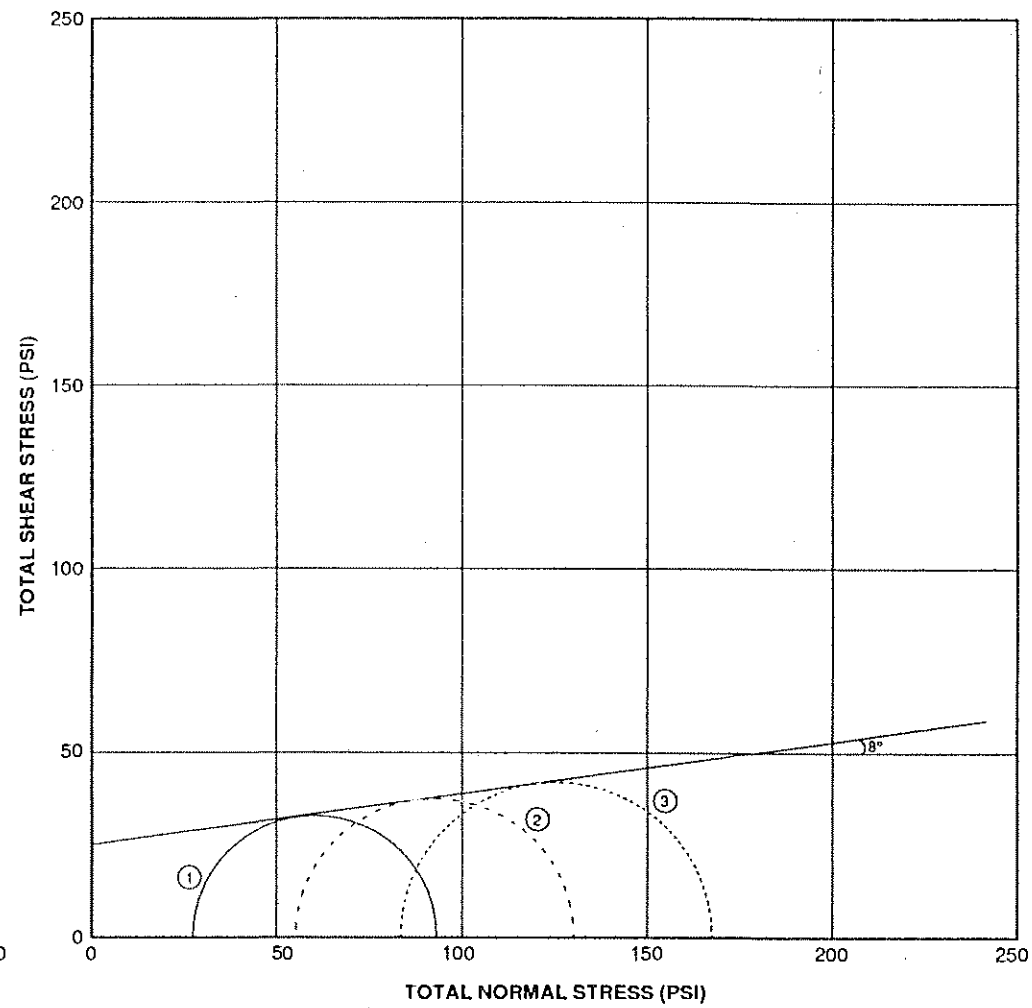
TABLE D.6.1

SUMMARY OF UNCONSOLIDATED UNDRAINED (UU) TRIAXIAL TEST (REMOLDED SAMPLES)

TEST PIT NO.	SAMPLE NO.	SAMPLE DEPTH (FT)	STRATIGRAPHIC UNIT	MATERIAL TYPE	INITIAL STATE		CONFINING PRESSURE (PSI)	DEVIATOR STRESS			
					WATER CONTENT (%)	DRY DENSITY (PCF)		PEAK (PSI)	STRAIN (%)	RESIDUAL (PSI)	STRAIN (%)
DT-A	B-2	5	18-8	Claystone compacted to 90% relative compaction (Modified Proctor) and 5% above optimum.	26.7	93.4	27.8	65.3	14	65.1	15
DT-A	B-2	5	18-8		26.5	93.7	55.6	74.1	14	74.0	15
DT-A	B-2	5	18-8		26.6	93.7	88.3	81.3	13	80.8	15
TP-42	B-1	6	18-9	Sandstone compacted to 95% relative compaction (Modified Proctor) at optimum.	14.9	108.7	27.8	127.2	4	108.0	10
TP-42	B-1	6	18-9		14.8	109.0	55.6	186.8	6	179.0	12
TP-42	B-1	6	18-9		14.8	109.0	83.3	244.6	8	201.9	15

89-977 (8/7/90)





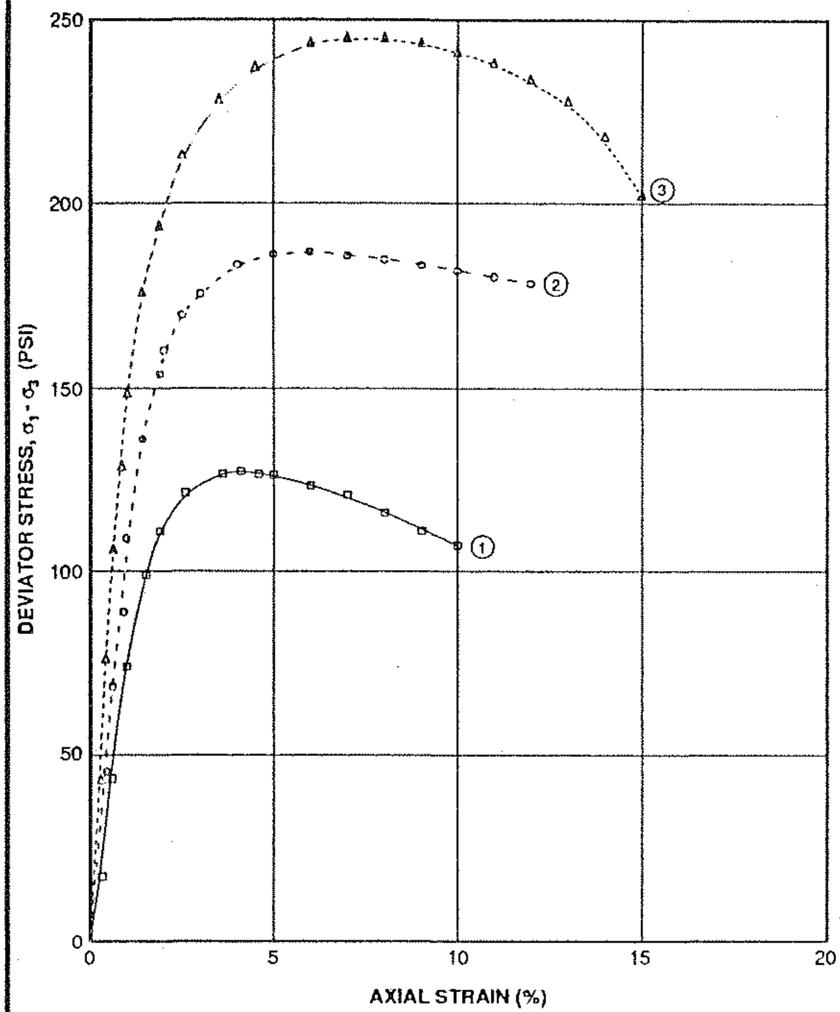
SPECIMEN NO.	SAMPLE NO.	DEPTH (FEET)	INITIAL STATE ω (%)	INITIAL STATE γ_d (PCF)	CONFINING PRESSURE (PSI)	DEVIATOR STRESS AT FAILURE (PSI)	STRAIN AT FAILURE (%)	STRATIGRAPHIC UNIT	MATERIAL TYPE
①	B-2	5	26.7	93.4	27.8	65.3	14.0	18-8	CLAYSTONE COMPACTED TO 90% RELATIVE COMPACTION, 5% ABOVE OPTIMUM (MODIFIED PROCTOR)
②	B-2	5	26.5	93.7	55.6	74.1	14.0		
③	B-2	5	26.6	93.7	83.3	81.3	13.0		

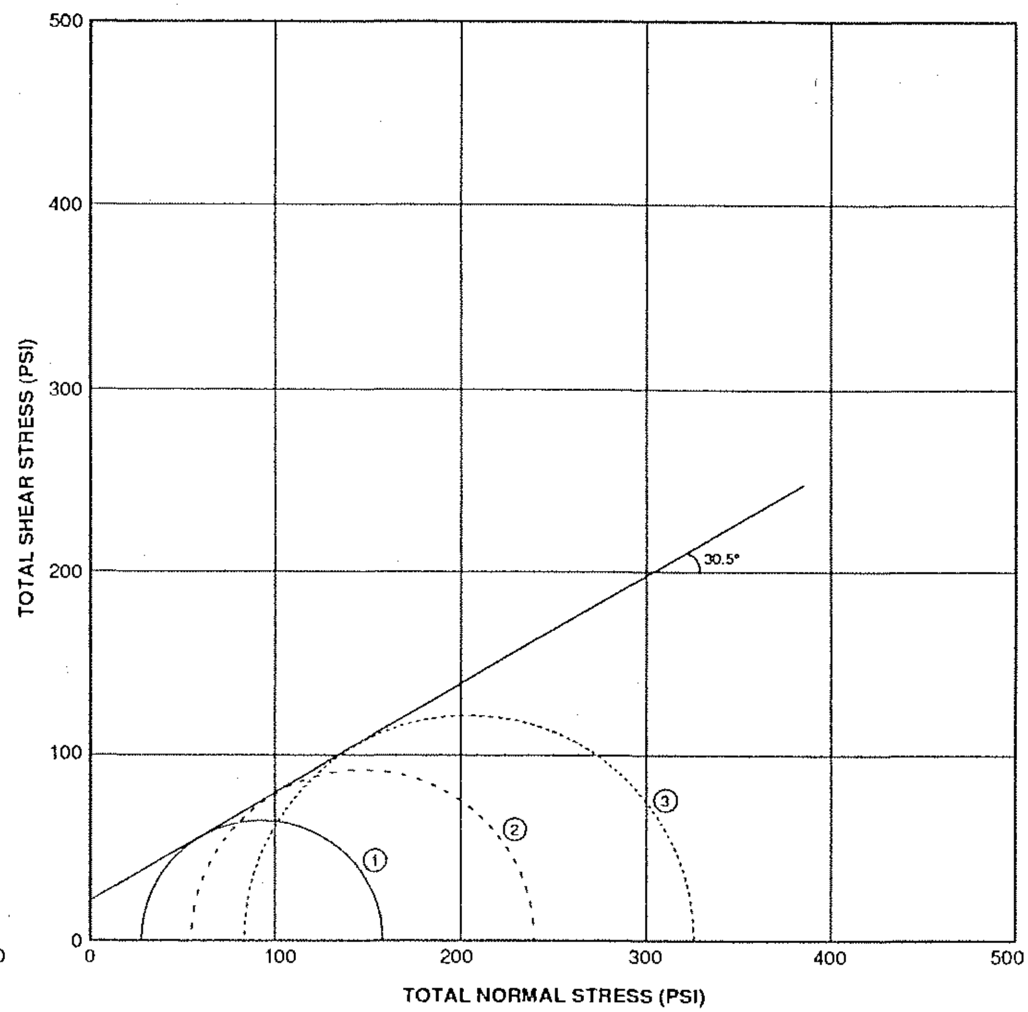
FIGURE D.6.1

UNCONSOLIDATED UNDRAINED TRIAXIAL TEST RESULTS TEST PIT NO. DT-A

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.





SPECIMEN NO.	SAMPLE NO.	DEPTH (FEET)	INITIAL STATE		CONFINING PRESSURE (PSI)	DEVIATOR STRESS AT FAILURE (PSI)	STRAIN AT FAILURE (%)	STRATIGRAPHIC UNIT	MATERIAL TYPE
			ω (%)	γ_d (PCF)					
①	B-1	6	14.9	108.7	27.8	127.2	4.0	18-9	SANDSTONE COMPACTED TO 95% RELATIVE COMPACTION (MODIFIED PROCTOR AT OPTIMUM MOISTURE CONTENT)
②	B-1	6	14.8	109.0	55.6	186.8	6.0		
③	B-1	6	14.8	109.0	83.3	244.6	8.0		

FIGURE D.6.2

UNCONSOLIDATED UNDRAINED TRIAXIAL TEST RESULTS BOREHOLE NO. TP-42

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.

APPENDIX D.7
CU TRIAXIAL COMPRESSION TESTS

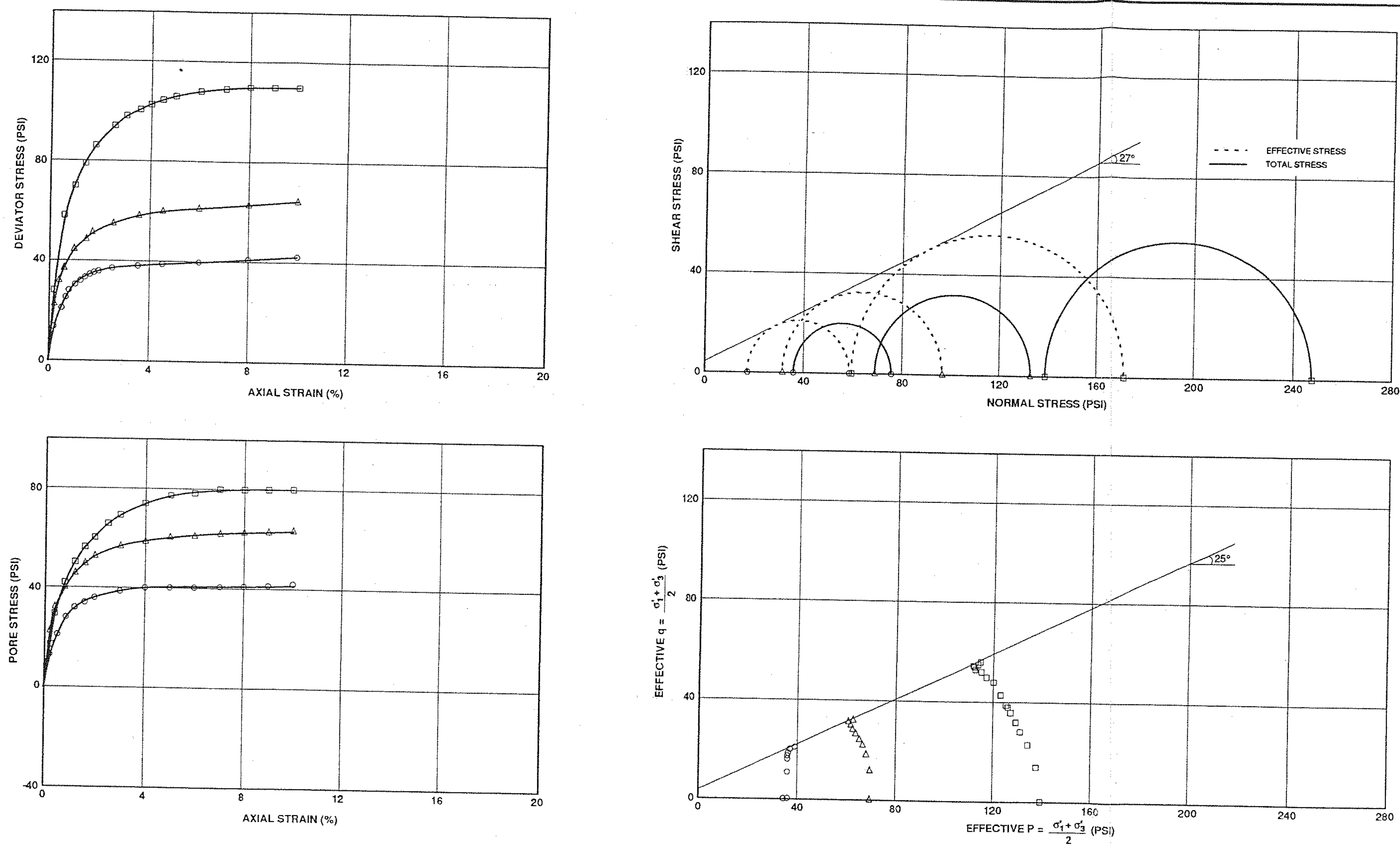
TABLE D.7.1

SUMMARY OF CONSOLIDATED UNDRAINED (CU) TRIAXIAL TEST (REMOLDED SAMPLES)

TEST PIT NO.	SAMPLE NO.	SAMPLE DEPTH (ft)	STRATI-GRAPHIC UNIT	MATERIAL TYPE	INITIAL STATE		CONFINING PRESSURE (PSI)	DEVIATOR STRESS		STRAIN RATE (%/Hour)
					WATER CONTENT (%)	DRY DENSITY (PCF)		PEAK (PSI)	STRAIN (%)	
DT-A	B-2	5	18-8	Claystone compacted to 90% relative compaction (Modified Proctor) and 5% above optimum.	26.4	93.8	34.7	42.38	5.01	3.87
DT-A	B-2	5	18-8		26.3	94.0	69.4	64.76	3.02	3.89
DT-A	B-2	5	18-8		26.7	93.6	138.9	97.44	8.99	3.97
DT-C	B-1	8	18-8	Claystone compacted to 90% relative compaction (Modified Proctor) at 5% above optimum.	28.2	89.1	34.7	40.18	6.0	3.90
DT-C	B-1	8	18-8		28.2	89.3	69.4	62.73	7.99	3.91
DT-C	B-1	8	18-8		28.2	89.3	138.9	108.75	6.97	3.95

89-977 (8/14/90)

89-977DR/Fig/CoUnTrCoTe/1 REV. 8/13/90



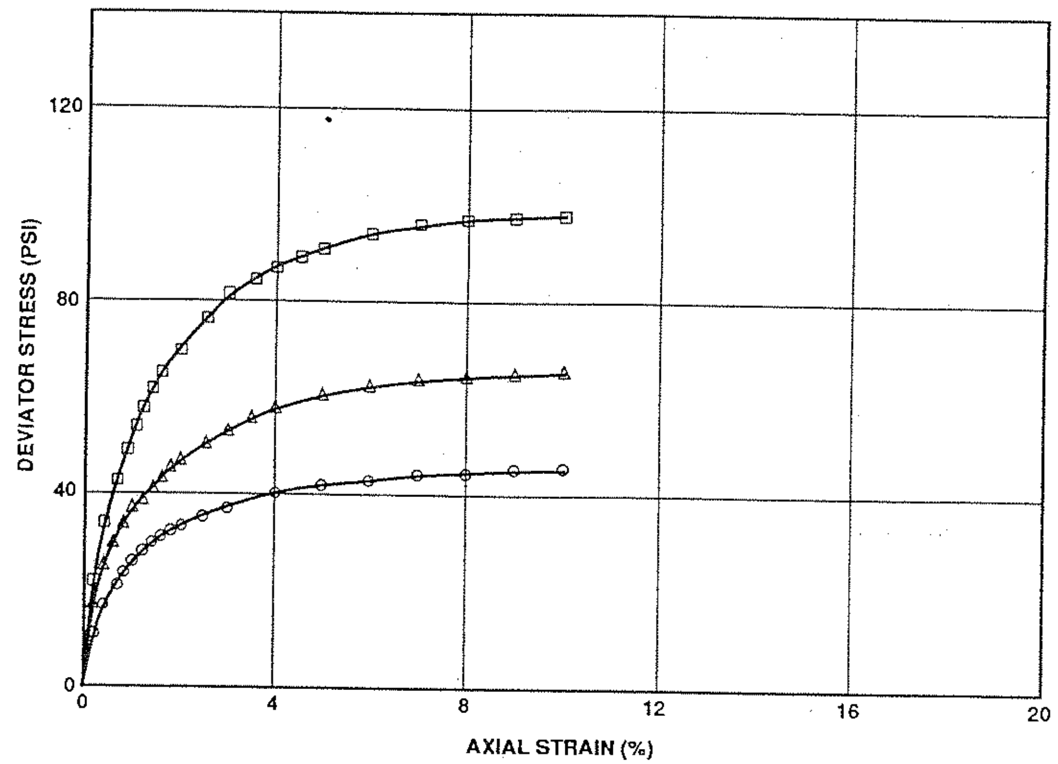
SYMBOL	BORING/ SAMPLE NO.	SPECIMEN NO.	DEPTH (FEET)	SAMPLE TYPE	SOIL TYPE	INITIAL STATE			FINAL STATE			EFFECTIVE CONFINING PRESSURE (PSI)	BACK PRESSURE (PSI)	FAILURE		STRAIN RATE (%/hr)
						γ_d (PCF)	ω (%)	SATURATION (%)	γ_d (PCF)	ω (%)	SATURATION (%)			DEV. STRESS (PSI)	STRAIN (%)	
○	DT-C, B-1	1	8	CLAYSTONE COMPACTED TO 90% RELATIVE COMPACTION (MODIFIED PROCTOR) AND 5% ABOVE OPTIMUM	CLAYSTONE	89.1	28.2	82.6	89.5	33.9	100.00	34.7	50.0	40.18	6.0	3.90
△	DT-C, B-1	2	8		CLAYSTONE	89.3	28.2	82.9	92.0	32.0	100.00	69.4	50.0	62.73	7.99	3.91
□	DT-C, B-1	3	8		CLAYSTONE	89.3	28.2	82.9	95.7	29.4	100.00	138.9	50.0	108.85	6.97	3.95

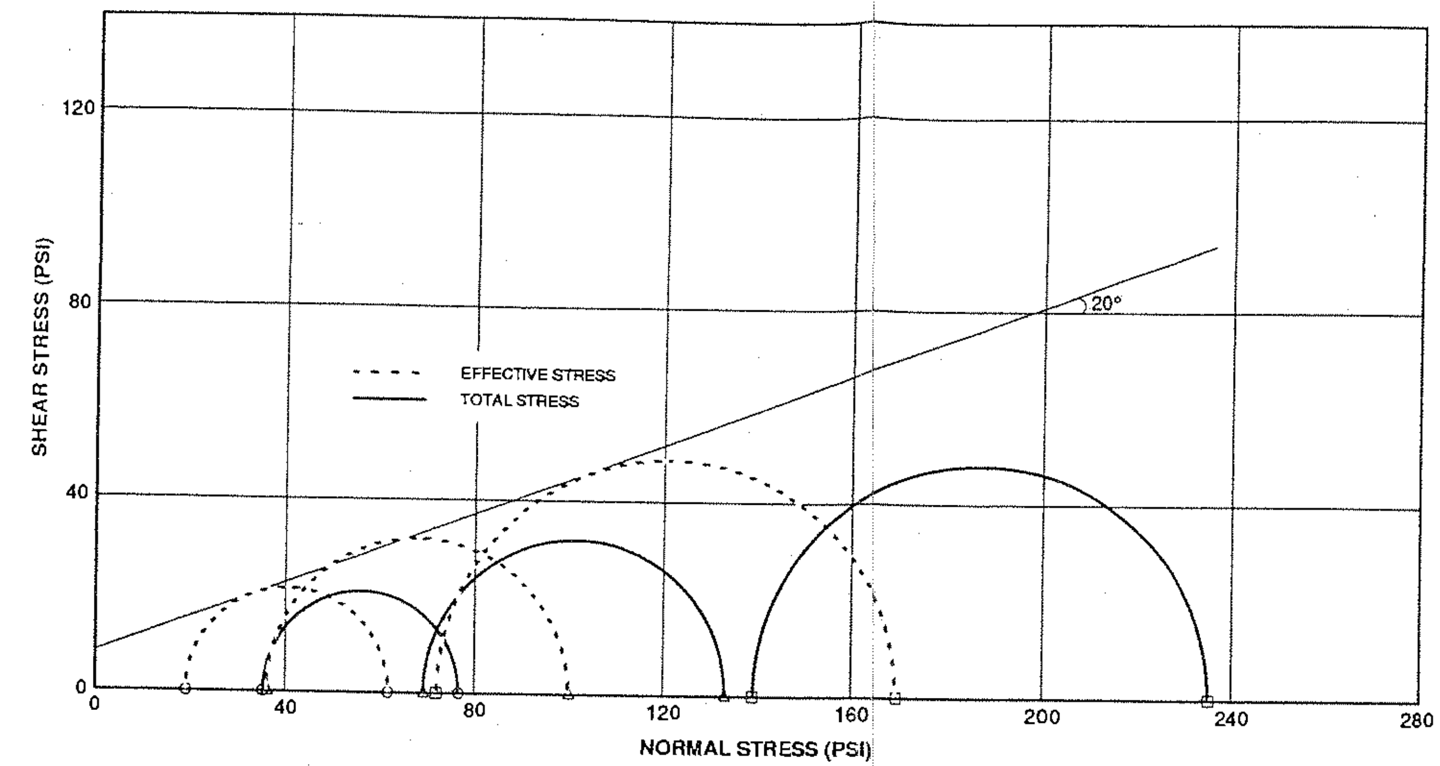
FIGURE D.7-2

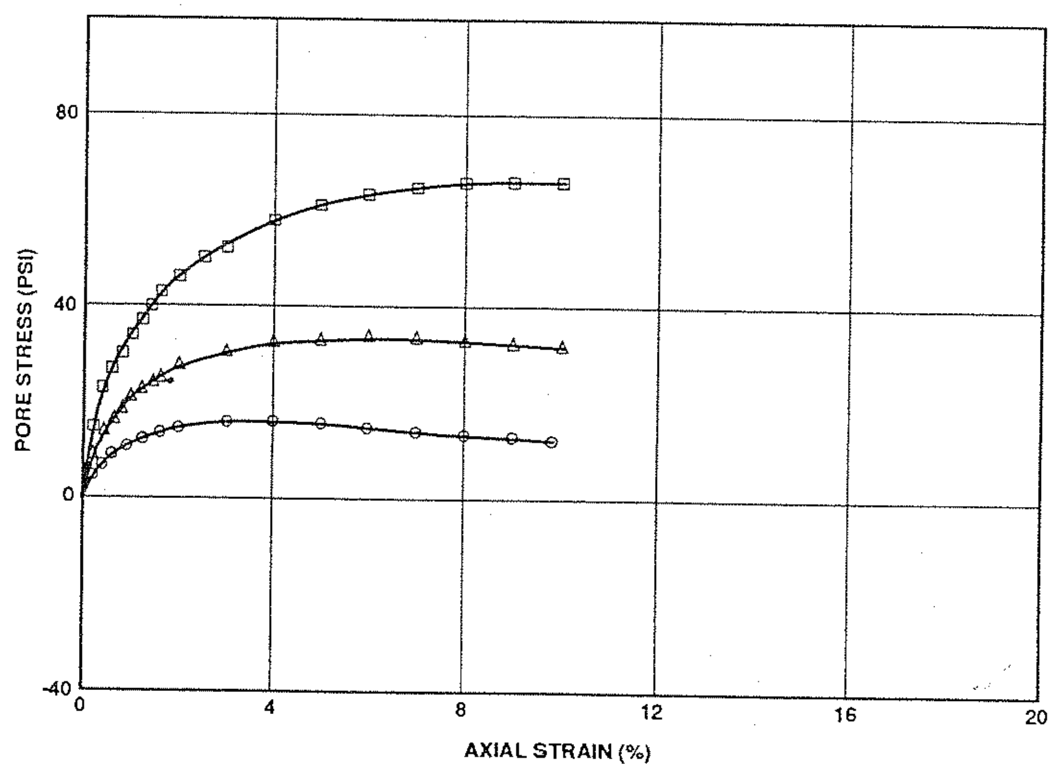
CONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION TEST RESULTS

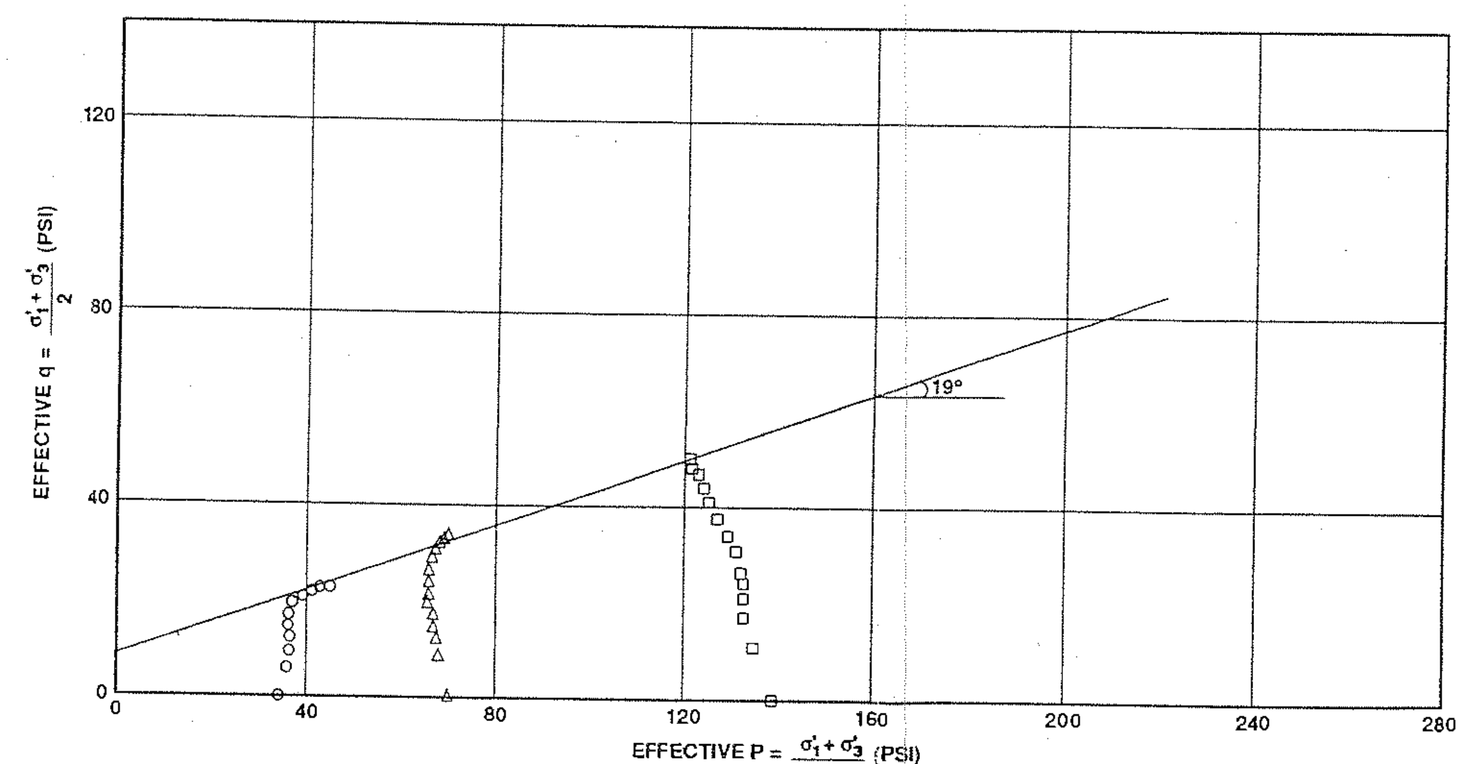
LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.









SYMBOL	BORING/ SAMPLE NO.	SPECIMEN NO.	DEPTH (FEET)	SAMPLE TYPE	SOIL TYPE	INITIAL STATE			FINAL STATE			EFFECTIVE CONFINING PRESSURE (PSI)	BACK PRESSURE (PSI)	FAILURE		STRAIN RATE (%/hr)
						γ_d (PCF)	ω (%)	SATURATION (%)	γ_d (PCF)	ω (%)	SATURATION (%)			DEV. STRESS (PSI)	STRAIN (%)	
○	DT-A, B-2	1	5	CLAYSTONE COMPACTED TO 90% RELATIVE COMPACTION (MODIFIED PROCTOR) AND 5% ABOVE OPTIMUM	CLAYSTONE	93.8	26.4	84.5	94.0	31.1	100.00	34.7	50.0	42.38	5.01	3.87
△	DT-A, B-2	2	5		CLAYSTONE	94.0	26.3	84.2	95.8	29.9	100.00	69.4	50.0	64.76	8.02	3.89
□	DT-A, B-2	3	5		CLAYSTONE	93.6	26.7	85.0	98.7	28.0	100.00	138.9	50.0	97.44	8.99	3.97

FIGURE D.7-3

CONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION TEST RESULTS

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.

APPENDIX D.8

SUMMARY OF DIRECT SHEAR TESTS

TABLE D.8.1

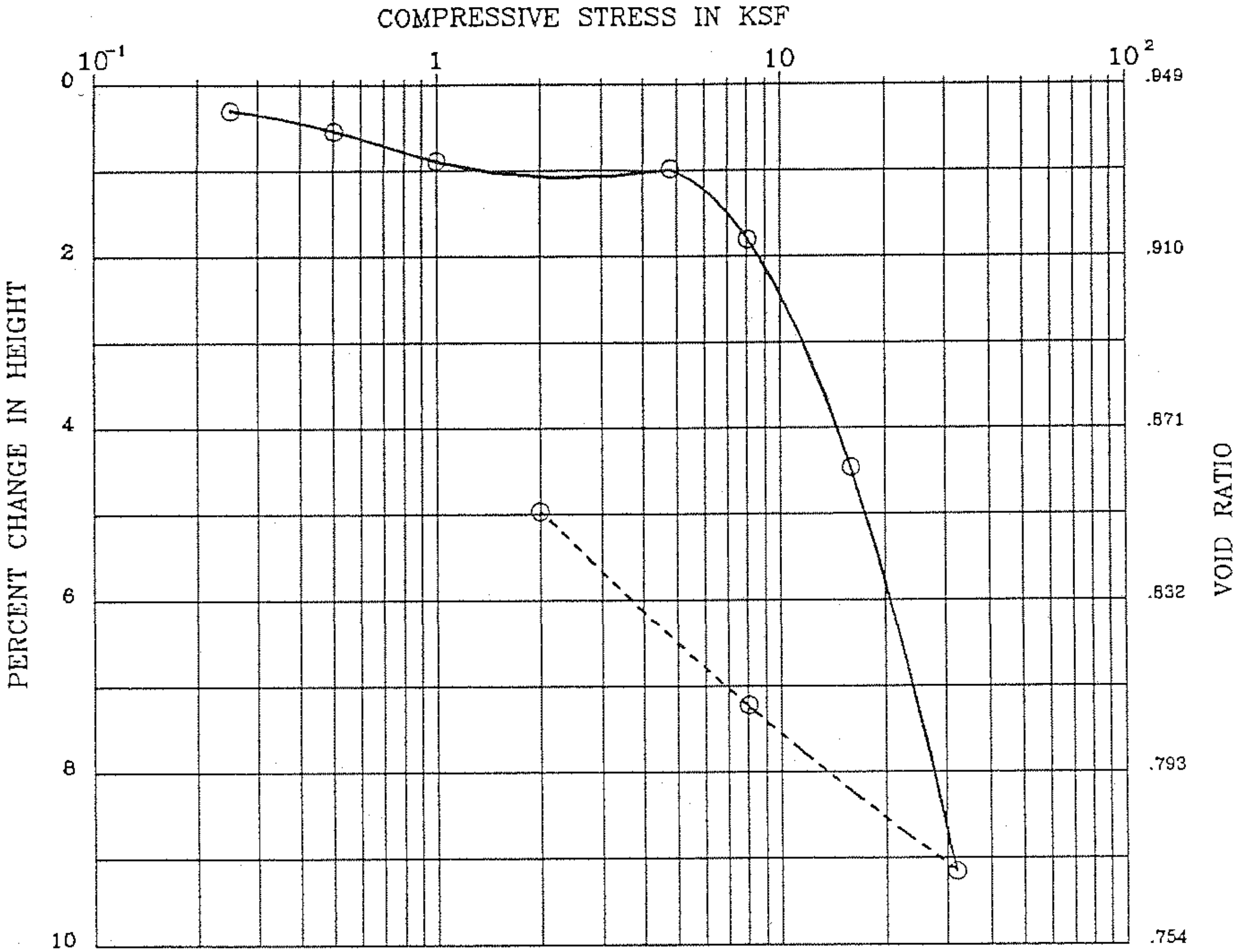
SUMMARY OF DIRECT SHEAR TEST RESULTS

BORING NO.	SAMPLE NO.	SAMPLE DEPTH (FT)	STRATIGRAPHIC UNIT	MATERIAL TYPE	NATURAL		NORMAL LOAD (PSF)	SHEAR STRESS (PSF)			
					WATER CONTENT (%)	DRY DENSITY (PCF)		PEAK (PSF)	STRAIN (%)	RESIDUAL (PSF)	STRAIN (%)
L18-B	S-3	20.0 - 22.5	18-11	Sandstone	18	96.8	4,000	5,377	7	3,253	16
L18-B	S-3	20.0 - 22.5	18-11	Sandstone	20	98.5	6,000	6,676	7	4,546	17
L18-B	S-3	20.0 - 22.5	18-11	Sandstone	20	98.3	8,000	9,297	7	5,653	14
L18-B	S-5	37.0 - 39.5	18-11	Sandstone	12	98.8	6,000*	7,908	5	6,228	17
L18-C	S-7	56.0 - 58.0	18-7	Claystone	21	103.4	4,000	6,161	6	5,377	17
L18-C	S-7	56.0 - 58.0	18-7	Claystone	26	98.5	8,000	7,146	4	5,287	17
L18-C	S-7	56.0 - 58.0	18-7	Claystone	27	96.0	11,500	7,371	3	4,234	17
L18-C	S-8	64.0 - 66.3	18-7	Claystone	21	100.3	8,000*	10,104	5	6,273	14
L18-D	S-2	22.0 - 24.5	18-5	Claystone	14	96.2	4,000	5,579	5	3,405	17
L18-D	S-2	22.0 - 24.5	18-5	Claystone	19	97.6	8,000	7,729	6	5,422	17
L18-D	S-2	22.0 - 24.5	18-5	Claystone	21	97.2	12,000	11,045	7	6,037	17
L18-D	S-2	22.0 - 24.5	18-5	Claystone	17	99.5	8,000*	10,908	6	9,947	14
L18-F	S-6	56.0 - 58.5	18-8	Claystone	26	94.8	4,000	8,715	5	3,562	17
L18-F	S-6	56.0 - 58.5	18-8	Claystone	32	87.7	8,000	6,900	7	4,951	17
L18-F	S-6	56.0 - 58.5	18-8	Claystone	29	92.0	12,000	13,532	6	4,862	17
L18-F	S-6	56.0 - 58.5	18-8	Claystone	30	91.7	8,000	7,729	4	4,010	14

89-977 (8/7/90)

* Unsaturated

APPENDIX D.9
CONSOLIDATION TESTS



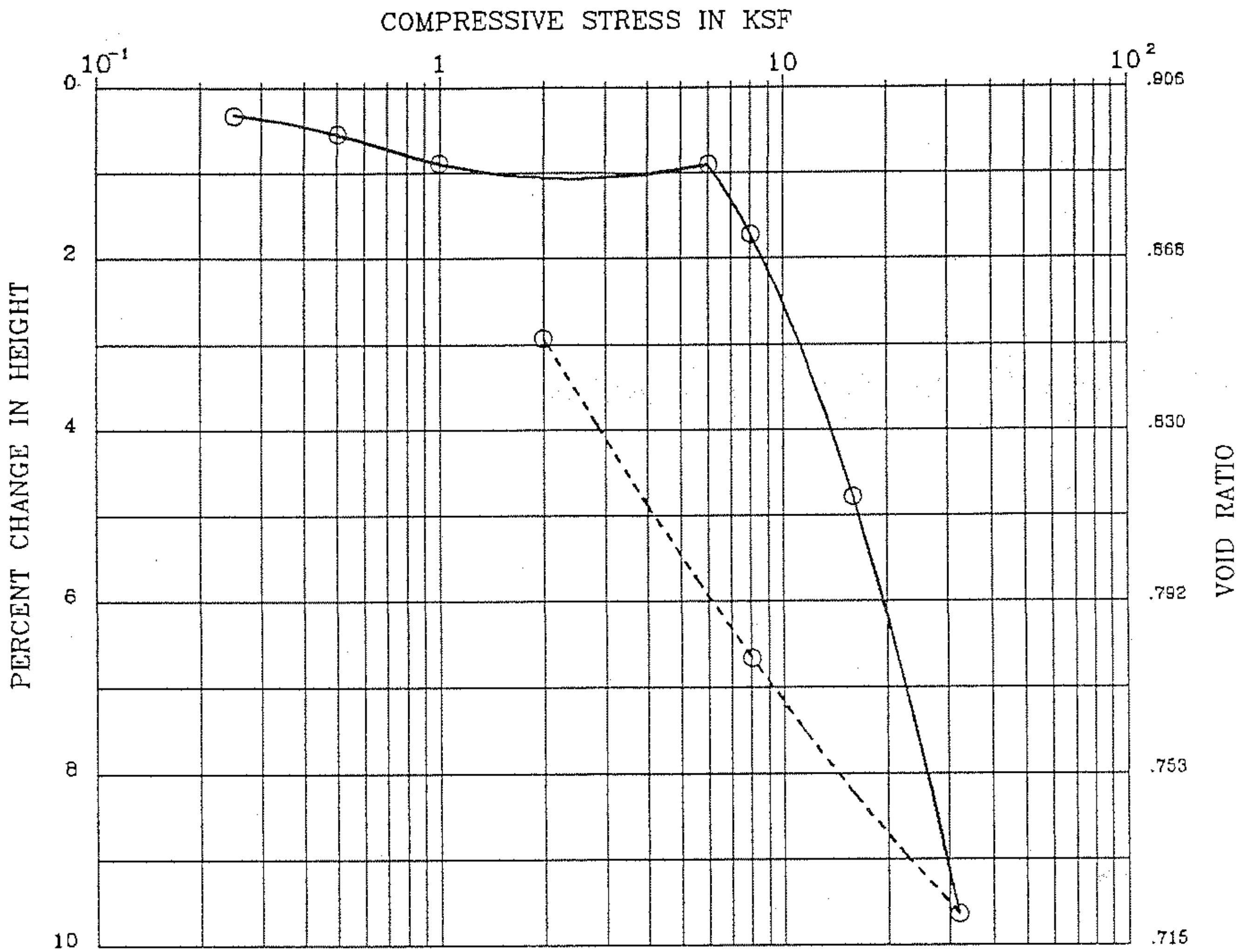
BORING : DT-C, B-1
DEPTH (ft) : 8
SPEC. GRAVITY : 2.79

DESCRIPTION : silty CLAYSTONE, yellow brn (CH)
LIQUID LIMIT : 76
PLASTIC LIMIT : 45

	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	PERCENT SATURATION	VOID RATIO
INITIAL	28.1	89.4	83	.949
FINAL	30.5	94.1	100	.852

Remark : July 1990

Project ESK-101A	Kettleman
Wahler Associates	CONSOLIDATION TEST Figure No.



BORING	: DT-A, B-2		DESCRIPTION	:	silty CLAYSTONE, yellow brn (CH)
DEPTH (ft)	: 5		LIQUID LIMIT	:	82
SPEC. GRAVITY	: 2.84		PLASTIC LIMIT	:	54

	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	PERCENT SATURATION	VOID RATIO
INITIAL	27.3	93.1	86	.906
FINAL	29.9	95.9	100	.851

Remark : July 1990

Project ESK-101A	Kettleman	
Wahler Associates	CONSOLIDATION TEST	Figure No.

APPENDIX D.10
GEOCHEMICAL TESTS

Analytical Report

LOG NO: A90-06-087

Received: 15 JUN 90
Reported: 29 JUN 90

Mr. Julio Badel
Environmental Solutions,Inc.
21 Technology Drive
Irvine, California 92718

Project: 89-977

REPORT OF ANALYTICAL RESULTS

LOG NO	SAMPLE DESCRIPTION, SOIL SAMPLES	DATE SAMPLED
06-087-1	L18-A S-5	28 MAY 90
06-087-2	L18-C S-2	28 MAY 90
06-087-3	L18-F S-1	28 MAY 90

PARAMETER	06-087-1	06-087-2	06-087-3
Antimony, mg/kg	<0.2	<0.2	<0.2
Arsenic, mg/kg	6.8	9.9	11
Barium, mg/kg	15	27	17
Beryllium, mg/kg	<0.02	<0.02	<0.02
Cadmium, mg/kg	<0.06	<0.06	<0.06
Chromium, mg/kg	42	55	42
Cobalt, mg/kg	10	13	9.0
Copper, mg/kg	15	30	25
Lead, mg/kg	1.0	<0.8	<0.8
Mercury, mg/kg	<0.3	<0.3	<0.3
Molybdenum, mg/kg	<0.08	<0.08	<0.08
Nickel, mg/kg	55	88	56
Selenium, mg/kg	<0.4	<0.4	<0.4
Silver, mg/kg	<0.02	<0.02	<0.02
Thallium, mg/kg	31	42	36
Vanadium, mg/kg	23	34	20
Zinc, mg/kg	51	58	58
Cyanide, mg/kg	<0.5	<0.5	<0.5
Nitrate + Nitrite (as NO3), mg/kg	6	120	24
Total Organic Carbon, mg/kg	800	1900	870
Specific Conductance, umhos/cm	1500	3300	40000
pH, Units	8.4	7.4	7.2
Chloride, mg/kg	11	68	170
Sulfate, mg/kg	360	1800	28000
Nitric Acid Digestion, Date	06/22/90	06/22/90	06/22/90

Analytical Report

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Reported: 29 JUN 90

Mr. Julio Badel
Environmental Solutions,Inc.
21 Technology Drive
Irvine, California 92718

Project: 89-977

REPORT OF ANALYTICAL RESULTS

LOG NO	SAMPLE DESCRIPTION, SOIL SAMPLES	DATE SAMPLED
06-087-1	L18-A S-5	28 MAY 90
06-087-2	L18-C S-2	28 MAY 90
06-087-3	L18-F S-1	28 MAY 90

PARAMETER	06-087-1	06-087-2	06-087-3
B/N,A Ext.Pri.Poll. (EPA-8270)			
Date Analyzed	06/21/90	06/21/90	06.21.90
Date Extracted	06/20/90	06/20/90	06.20.90
Dilution Factor, Times	1	1	1
1,2,4-Trichlorobenzene, mg/kg	<0.3	<0.3	<0.3
1,2-Dichlorobenzene, mg/kg	<0.3	<0.3	<0.3
1,2-Diphenylhydrazine, mg/kg	<0.3	<0.3	<0.3
1,3-Dichlorobenzene, mg/kg	<0.3	<0.3	<0.3
1,4-Dichlorobenzene, mg/kg	<0.3	<0.3	<0.3
2,4,5-Trichlorophenol, mg/kg	<0.3	<0.3	<0.3
2,4,6-Trichlorophenol, mg/kg	<0.3	<0.3	<0.3
2,4-Dichlorophenol, mg/kg	<0.3	<0.3	<0.3
2,4-Dimethylphenol, mg/kg	<0.3	<0.3	<0.3
2,4-Dinitrophenol, mg/kg	<0.8	<0.8	<0.8
2,4-Dinitrotoluene, mg/kg	<0.3	<0.3	<0.3
2,6-Dinitrotoluene, mg/kg	<0.3	<0.3	<0.3
2-Chloronaphthalene, mg/kg	<0.3	<0.3	<0.3
2-Chlorophenol, mg/kg	<0.3	<0.3	<0.3
2-Methyl-4,6-dinitrophenol, mg/kg	<2	<2	<2
2-Methylnaphthalene, mg/kg	<0.3	<0.3	<0.3
2-Methylphenol, mg/kg	<0.3	<0.3	<0.3
2-Nitroaniline, mg/kg	<2	<2	<2
2-Nitrophenol, mg/kg	<0.3	<0.3	<0.3
3,3'-Dichlorobenzidine, mg/kg	<0.3	<0.3	<0.3
3-Nitroaniline, mg/kg	<2	<2	<2

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B C Analytical

Analytical Report

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Mr. Julio Badel
Environmental Solutions,Inc.
21 Technology Drive
Irvine, California 92718

Project: 89-977

REPORT OF ANALYTICAL RESULTS

LOG NO	SAMPLE DESCRIPTION, SOIL SAMPLES	DATE SAMPLED
06-087-1	L18-A S-5	28 MAY 90
06-087-2	L18-C S-2	28 MAY 90
06-087-3	L18-F S-1	28 MAY 90

PARAMETER	06-087-1	06-087-2	06-087-3
4-Bromophenylphenylether, mg/kg	<0.3	<0.3	<0.3
4-Chloro-3-methylphenol, mg/kg	<0.3	<0.3	<0.3
4-Chloroaniline, mg/kg	<0.6	<0.6	<0.6
4-Chlorophenylphenylether, mg/kg	<0.3	<0.3	<0.3
4-Methylphenol, mg/kg	<0.3	<0.3	<0.3
4-Nitroaniline, mg/kg	<2	<2	<2
4-Nitrophenol, mg/kg	<0.8	<0.8	<0.8
Acenaphthene, mg/kg	<0.3	<0.3	<0.3
Acenaphthylene, mg/kg	<0.3	<0.3	<0.3
Aniline, mg/kg	<0.6	<0.6	<0.6
Anthracene, mg/kg	<0.3	<0.3	<0.3
Benzidine, mg/kg	<1	<1	<1
Benzo(a)anthracene, mg/kg	<0.3	<0.3	<0.3
Benzo(a)pyrene, mg/kg	<0.3	<0.3	<0.3
Benzo(b)fluoranthene, mg/kg	<0.3	<0.3	<0.3
Benzo(g,h,i)perylene, mg/kg	<0.3	<0.3	<0.3
Benzo(k)fluoranthene, mg/kg	<0.3	<0.3	<0.3
Benzyl Alcohol, mg/kg	<0.6	<0.6	<0.6
Benzoic acid, mg/kg	<2	<2	<2
Butylbenzylphthalate, mg/kg	<0.3	<0.3	<0.3
Chrysene, mg/kg	<0.3	<0.3	<0.3
Di-n-octylphthalate, mg/kg	<0.3	<0.3	<0.3
Dibenzo(a,h)anthracene, mg/kg	<0.3	<0.3	<0.3
Dibenzofuran, mg/kg	<0.3	<0.3	<0.3
Dibutylphthalate, mg/kg	<2	<2	<2

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BCA *B C Analytical*

Analytical Report

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Mr. Julio Badel
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21 Technology Drive
Irvine, California 92718

Project: 89-977

REPORT OF ANALYTICAL RESULTS

LOG NO	SAMPLE DESCRIPTION, SOIL SAMPLES	DATE SAMPLED
06-087-1	L18-A S-5	28 MAY 90
06-087-2	L18-C S-2	28 MAY 90
06-087-3	L18-F S-1	28 MAY 90

PARAMETER	06-087-1	06-087-2	06-087-3
Diethylphthalate, mg/kg	<0.3	<0.3	<0.3
Dimethylphthalate, mg/kg	<0.8	<0.8	<0.8
Fluoranthene, mg/kg	<0.3	<0.3	<0.3
Fluorene, mg/kg	<0.3	<0.3	<0.3
Hexachlorobenzene, mg/kg	<0.3	<0.3	<0.3
Hexachlorobutadiene, mg/kg	<0.3	<0.3	<0.3
Hexachlorocyclopentadiene, mg/kg	<0.3	<0.3	<0.3
Hexachloroethane, mg/kg	<0.3	<0.3	<0.3
Indeno(1,2,3-c,d)pyrene, mg/kg	<0.3	<0.3	<0.3
Isophorone, mg/kg	<0.3	<0.3	<0.3
N-Nitrosodimethylamine, mg/kg	<2	<2	<2
N-Nitrosodiphenylamine, mg/kg	<0.3	<0.3	<0.3
N-Nitrosodi-n-propylamine, mg/kg	<1	<1	<1
Nitrobenzene, mg/kg	<0.3	<0.3	<0.3
Naphthalene, mg/kg	<0.3	<0.3	<0.3
Phenanthrene, mg/kg	<0.3	<0.3	<0.3
Phenol, mg/kg	<0.3	<0.3	<0.3
Pentachlorophenol, mg/kg	<0.3	<0.3	<0.3
Pyrene, mg/kg	<0.3	<0.3	<0.3
Bis(2-chloroethoxy)methane, mg/kg	<0.3	<0.3	<0.3
Bis(2-chloroethyl)ether, mg/kg	<0.3	<0.3	<0.3
Bis(2-chloroisopropyl)ether, mg/kg	<0.3	<0.3	<0.3
Bis(2-ethylhexyl)phthalate, mg/kg	<0.3	0.4	<0.3

Semi-Quantified Results **

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BCA *B C Analytical*

Analytical Report

LOG NO: A90-06-087

Received: 15 JUN 90
Reported: 29 JUN 90

Mr. Julio Badel
Environmental Solutions,Inc.
21 Technology Drive
Irvine, California 92718

Project: 89-977

REPORT OF ANALYTICAL RESULTS

LOG NO	SAMPLE DESCRIPTION, SOIL SAMPLES	DATE SAMPLED
06-087-1	L18-A S-5	28 MAY 90
06-087-2	L18-C S-2	28 MAY 90
06-087-3	L18-F S-1	28 MAY 90

PARAMETER	06-087-1	06-087-2	06-087-3
A C21 Hydrocarbon, mg/kg	2	---	---
A C22 Hydrocarbon, mg/kg	4	---	---
A C27 Hydrocarbon, mg/kg	10	---	---
Heptacosane, mg/kg	2	---	---

** Quantification based upon comparison of total ion count of the compound with that of the nearest internal standard.

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06-087-2	L18-C S-2	28 MAY 90
06-087-3	L18-F S-1	28 MAY 90

PARAMETER	06-087-1	06-087-2	06-087-3
Pesticides/PCBs (EPA 8080)			
Date Analyzed	06/22/90	06/22/90	06/22/90
Date Extracted	06/21/90	06/21/90	06/21/90
Dilution Factor, Times	1	1	1
Aldrin, mg/kg	<0.001	<0.001	<0.001
Chlordane, mg/kg	<0.01	<0.01	<0.01
p,p'-DDD, mg/kg	<0.001	<0.001	<0.001
p,p'-DDE, mg/kg	<0.001	<0.001	<0.001
p,p'-DDT, mg/kg	<0.002	<0.002	<0.001
Dieldrin, mg/kg	<0.001	<0.001	<0.001
Endosulfan I, mg/kg	<0.001	<0.001	<0.001
Endosulfan II, mg/kg	<0.002	<0.002	<0.002
Endosulfan Sulfate, mg/kg	<0.002	<0.002	<0.002
Endrin, mg/kg	<0.002	<0.002	<0.002
Endrin Aldehyde, mg/kg	<0.001	<0.001	<0.001
Heptachlor epoxide, mg/kg	<0.001	<0.001	<0.001
Heptachlor, mg/kg	<0.001	<0.001	<0.001
Methoxychlor, mg/kg	<0.007	<0.007	<0.007
Aroclor 1016, mg/kg	<0.02	<0.02	<0.02
Aroclor 1221, mg/kg	<0.02	<0.02	<0.02
Aroclor 1232, mg/kg	<0.02	<0.02	<0.02
Aroclor 1242, mg/kg	<0.02	<0.02	<0.02
Aroclor 1248, mg/kg	<0.02	<0.02	<0.02
Aroclor 1254, mg/kg	<0.02	<0.02	<0.02
Aroclor 1260, mg/kg	<0.02	<0.02	<0.02

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06-087-2	L18-C S-2	28 MAY 90
06-087-3	L18-F S-1	28 MAY 90

PARAMETER	06-087-1	06-087-2	06-087-3
Aroclor 1262, mg/kg	<0.02	<0.02	<0.02
Toxaphene, mg/kg	<0.02	<0.02	<0.02
BHC, alpha isomer, mg/kg	<0.001	<0.001	<0.001
BHC, beta isomer, mg/kg	<0.001	<0.001	<0.001
BHC, delta isomer, mg/kg	<0.001	<0.001	<0.001
BHC, gamma isomer (Lindane), mg/kg	<0.001	<0.001	<0.001

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06-087-1	L18-A S-5	28 MAY 90
06-087-2	L18-C S-2	28 MAY 90
06-087-3	L18-F S-1	28 MAY 90

PARAMETER	06-087-1	06-087-2	06-087-3
Vol.Pri.Poll. (EPA-8240)			
Date Analyzed	06/22/90	06/21/90	06/21/90
Date Extracted	06/22/90	06/21/90	06/21/90
Dilution Factor, Times	1	1	1
Tetrachloroethylene, ug/kg	<5	<5	<5
1,1,1-Trichloroethane, ug/kg	<5	<5	<5
1,1,2,2-Tetrachloroethane, ug/kg	<5	<5	<5
1,1,2-Trichloroethane, ug/kg	<5	<5	<5
1,1-Dichloroethane, ug/kg	<5	<5	<5
1,1-Dichloroethene, ug/kg	<5	<5	<5
1,2-Dichloroethane, ug/kg	<5	<5	<5
1,2-Dichlorobenzene, ug/kg	<5	<5	<5
1,2-Dichloropropane, ug/kg	<5	<5	<5
1,3-Dichlorobenzene, ug/kg	<5	<5	<5
1,4-Dichlorobenzene, ug/kg	<5	<5	<5
2-Chloroethylvinylether, ug/kg	<5	<5	<5
2-Hexanone, ug/kg	<50	<50	<50
Acetone, ug/kg	<50	<50	<50
Acrolein, ug/kg	<100	<100	<100
Acrylonitrile, ug/kg	<100	<100	<100
Bromodichloromethane, ug/kg	<5	<5	<5
Benzene, ug/kg	<5	<5	<5
Bromomethane, ug/kg	<5	<5	<5
Bromoform, ug/kg	<5	<5	<5
Chlorobenzene, ug/kg	<5	<5	<5

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06-087-2	L18-C S-2	28 MAY 90
06-087-3	L18-F S-1	28 MAY 90

PARAMETER	06-087-1	06-087-2	06-087-3
Carbon Tetrachloride, ug/kg	<5	<5	<5
Chloroethane, ug/kg	<5	<5	<5
Chloroform, ug/kg	<5	<5	<5
Chloromethane, ug/kg	<10	<10	<10
Carbon Disulfide, ug/kg	<10	<10	<10
Dibromochloromethane, ug/kg	<5	<5	<5
Ethylbenzene, ug/kg	<5	<5	<5
Freon 113, ug/kg	<5	<5	<5
Methyl ethyl ketone, ug/kg	<50	<50	<50
Methyl isobutyl ketone, ug/kg	<25	<25	<25
Methylene chloride, ug/kg	<5	<5	<5
Styrene, ug/kg	<5	<5	<5
Trichloroethene, ug/kg	<5	<5	<5
Trichlorofluoromethane, ug/kg	<5	<5	<5
Toluene, ug/kg	<5	<5	<5
Vinyl acetate, ug/kg	<25	<25	<25
Vinyl chloride, ug/kg	<5	<5	<5
Total Xylene Isomers, ug/kg	<25	<25	<25
cis-1,3-Dichloropropene, ug/kg	<5	<5	<5
trans-1,2-Dichloroethene, ug/kg	<5	<5	<5
trans-1,3-Dichloropropene, ug/kg	<5	<5	<5
Other Vol.Pri.Poll. (EPA-8240)	---	---	---

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Mr. Julio Badel
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21 Technology Drive
Irvine, California 92718

Project: 89-977

REPORT OF ANALYTICAL RESULTS

The detection limit for p,p'-DDT on samples A90-06-087 -1 and -2 "L18-A S-5 and L18-C S-2" analyzed by EPA-8080 was elevated to 0.002 mg/kg. This was due to trace level contamination which carried over from the extraction of a sample containing high levels of p,p'-DDT.
-- G. Havalias 06/22/90

Based on historical data,the bis(2-ethylhexyl)phthalate found in the samples on the EPA-8270 analysis could have been introduced as a random laboratory contamination.
-- G. Havalias 06/29/90

Edward Wilson, Laboratory Manager

APPENDIX E
CLAY LINER TEST PAD DATA

APPENDIX E.1	PHASES I AND II TEST PAD REPORT
APPENDIX E.2	PHASE III CLAY SOURCE TESTING REPORT
APPENDIX E.3	CLAY STOCKPILE AND TEST PAD REPORT
APPENDIX E.4	PHASES I AND II CLAY LINER COMPACTION SPECIFICATIONS

APPENDIX E.1
PHASES I AND II TEST PAD REPORT

89-977

TEST FILL AND INFILTROMETER TEST RESULTS

LANDFILL UNIT B-18
PHASES I AND II AND FINAL CLOSURE

Prepared For:

CHEMICAL WASTE MANAGEMENT, INC. (CWMI)

January 23, 1992

ENVIRONMENTAL SOLUTIONS, INC.

ENVIRONMENTAL SOLUTIONS, INC.

January 23, 1992

Project No. 89-977

Mr. Robert Henry
Project Manager
Chemical Waste Management, Inc.
35251 Old Skyline Road
Kettleman City, California 93239

<u>Transmittal</u>
<u>Test Fill and Infiltrometer Test Results Report</u>
<u>Landfill Unit B-18</u>
<u>Phases I and II and Final Closure</u>
<u>Kettleman Hills Facility</u>
<u>Kings County, California</u>

Dear Mr. Henry:

Enclosed are 15 copies of the report entitled *Test Fill and Infiltrometer Test Results, Landfill Unit B-18, Phases I and II and Final Closure.*

Field measured permeabilities coupled with laboratory permeability tests indicate that the claystone used for the test fill and proposed for use as the liner/cap provides an adequate low permeability soil layer for the B-18 Landfill, Phases I and II and Final Closure.

We will be pleased to provide any clarifications necessary in response to reviews by the agencies or your staff.

Very truly yours,

Kerry K. Parkinson, P.E.
Civil Engineer (License No. 41021)

KKP:hs
Enclosures

cc: Dick Ellison
Ken Floom
Julio Badel

REGISTERED PROFESSIONAL ENGINEER
KERRY K. PARKINSON
No. 41021
Exp. 3-31-91
CIVIL
STATE OF CALIFORNIA

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All Environmental Solutions, Inc. letterhead
and second sheet are recycled paper.

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1.0 INTRODUCTION

1. This report presents the Sealed Double Ring Infiltrometer (SDRI) test results and the geotechnical data associated with the construction of the test fill at the Kettleman Hills Facility (see Figure 1). The purposes of the test fill were to model placement and compaction procedures for the construction of the B-18 Landfill clay liner/cap and to verify that these procedures will achieve the specified compaction and permeability criteria.

2. The objective of the SDRI test is to evaluate the saturated, vertical permeability of the clay liner material to verify that it meets the specification for permeability of less than or equal to 1×10^{-7} cm/sec and to assess if laboratory permeability values are comparable to field permeabilities. In this report, the terms permeability and hydraulic conductivity are used interchangeably.

3. The methods used to construct the test fill including field and laboratory testing, are presented in Chapter 2.0. The design and installation of the infiltrometer are described in Chapter 3.0. The theory and data analyses are presented in Chapter 4.0. The results of the test, analyses and conclusions are presented in Chapter 5.0. References are included in Chapter 6.0.

2.0 CONSTRUCTION OF THE TEST FILL

1. The test fill was constructed between January 22 and February 1, 1991, at the location shown in Figure 2. The test fill plan, cross section, and detail are presented in Figure 3.

2. Material used as fill consisted of onsite clay hauled from the B-18 Clay Processing Area. Moisture conditioning in conjunction with weathering and particle size reduction were performed in the Clay Processing Area prior to hauling and placement. The procedures used for processing and construction of the test fill are considered similar to those that would be used for the B-18 Landfill.

3. The clay was originally derived from the Stratum 18-8 (claystone) previously characterized during the design phase (see Section 3.5 of the *Engineering and Design Report, Landfill Unit B-18,* August, 1990 [Environmental Solutions, Inc., 1990a]) as a suitable clay source for clay liner construction.

2.1 SUBGRADE PREPARATION

1. The area within the test fill was initially cleared of vegetation and loose soil. The surface soils were then graded to form a smooth, firm subgrade surface. Finally, a drainage system consisting of geonet (Polynet 3000) and a layer of geotextile (Trevira 1155) was placed over the subgrade as shown in Figure 3.

2.2 EQUIPMENT

1. In order to simulate clay liner/cap construction conditions for Phases I and II and Final Closure, the test fill was constructed using equipment similar to that which would be used during the B-18 Landfill bottom and final closure liner/cap construction. The equipment used and their respective functions are listed in Table 1.

2.3 CONSTRUCTION SEQUENCE

1. Initially, a 1-foot thick base lift of clay was placed and compacted to provide protection for the geonet/geotextile drainage system. Then, each of the five lifts comprising the test fill was constructed according to the following steps:
   - Moisture conditioning, weathering, and particle size reduction were performed in the B-18 Clay Processing Area to meet the revised specification from the *Construction Specifications and Quality Assurance Plan, Landfill Unit B-18, Phases I and II, and Final Closure*, which specifies the following:
     - Moisture Content: Within the range defined by the area formed by connecting the following points for the Modified Proctor Compaction curve:
       - 2 to 5 percent above the optimum moisture content for a density equal to 90 percent of the maximum Modified Proctor density.
       - 3 percent above the optimum moisture content at 97 percent of the maximum Modified Proctor density.
       - 1 percent above the optimum moisture content at 98 percent of the maximum Modified Proctor density.
   - This criterion, which allows a lower water content for higher compactive efforts, was established to: (1) assure that both the required strength and permeability characteristics are realized; and (2) provide flexibility for the contractor and CQA engineer to work with a range of water contents without having a clay which is either too wet or dry. This flexibility is desirable in hot, dry areas where exact water content is difficult to control. This specification is represented by the area designated as "Specified Window" in Figure 4.

- The moisture conditioned clay was hauled to the test fill area by a scraper and unloaded in loose lifts approximately 8 inches thick. A motor grader was utilized to smooth the uneven lifts and to maintain a 2 percent slope in the longitudinal direction.
- After the entire test fill area was covered with a loose lift of clay, a Caterpillar 825C compactor made four passes for each lift. Compacted lift thicknesses were approximately 6 inches. Four passes were determined during the initial testing to achieve approximately the minimum specified density of 90 percent of Modified Proctor maximum dry density. The infiltrometer test was performed on a fill compacted near the lower, acceptable dry density to assure that the permeability criteria ($\approx 10^{-7}$ cm/sec) could be achieved for the more conservative, lower density.
- Each lift was tested to verify the as-built moisture content and density.

2.4 FIELD AND LABORATORY TESTING

1. Field and laboratory tests were conducted on the test fill to evaluate if the construction equipment and procedures would meet the specifications for compaction and permeability of the clay liner.

2. These tests were performed in accordance with the procedures and frequencies outlined in the following documents:
   - Appendix E (Test Fill and Infiltrometer Test Plan) of the *Engineering and Design Report, Landfill Unit B-18, Phases I and II, and Final Closure* (Environmental Solutions, Inc., 1990a).
   - *Construction Specifications and Quality Assurance Plan, Landfill Unit B-18*, Phases I and II, and Final Closure (Environmental Solutions, Inc., 1990b).

2.4.1 FIELD TESTS

1. Initially, the first lift had to be constructed several times until the procedure to achieve the required water content and density was developed. After the appropriate procedure was developed, the moisture density specifications were achieved for the majority of tests.

2. Field density (compaction) tests, consisting of a minimum of two nuclear density tests and one sand cone density test for each lift, were conducted at the locations shown in Figure 3. The compaction test results within the tested zone are shown in Figure 4.

3. The majority of the density tests fall within the lower portion of the specified moisture-density window. Also, except for point 18(5) the tests are within or very close to the specified range. Because point 18(5) has a lower density, its effects on the results, if any, would be in the conservative direction.

2.4.2 LABORATORY TESTS

1. Laboratory tests were conducted on soil samples recovered in six thin-walled Shelby tube samplers collected after the construction of the test fill. These tests include:
   - Atterberg Limits
   - Grain Size Analyses
   - One-Dimensional Swell Test
   - Permeability

   The Shelby Tube sample locations are shown in Figure 3.

2. Atterberg Limits test results are presented in Figure 5. The material consistently had a plasticity in the CH (highly plastic clay) range with liquid limits varying between 65 and 79 percent, and a plasticity index between 44 and 55 percent.

3. Figure 6 shows the grain size distribution determined from the hydrometer tests for the six samples. These data show the relative uniformity of the clay with 80 percent or greater of the soil by weight passing the No. 200 sieve.

4. Appendix A provides a summary table of the One-Dimensional Swell tests. These results indicate that the compacted clay has a high potential to swell with an average swell of 16.5 percent under low confining pressure (70 psf, average value).

5. Laboratory permeability test results are shown in Figure 7 as a function of the initial moisture content. These tests indicate that under laboratory conditions (with applied consolidation pressures from 2.2 ksf to 6.2 ksf to prevent swelling) measured permeability values varied from 1.5 x 10^{-8} cm/sec to 2.8 x 10^{-10} cm/sec. These values, in conjunction with the infiltrometer test results discussed below, provide the basis to conclude that the clay used for the construction of the test fill adequately meets the permeability criterion of 10^{-7} cm/sec or less.

3.0 INFILTROMETER (SDRI) TEST

1. An SDRI, developed by Trautwein Soil Testing Equipment of Houston, Texas, was used to assess the in situ permeability of the test fill constructed with onsite clay which is to be used for the B-18 Landfill clay liner. Eight tensiometer probes were installed around the inner ring to measure the soil suction. The SDRI test layout is shown in Figure 3. The schematic of the infiltrometer test model is presented in Figure 8. The theory and analysis of the test are described in Section 4.0. A summary of the SDRI system installation and data collection is presented in the following sections.

3.1 SDRI DESCRIPTION

1. The SDRI consists of two rings: a fiberglass, 5-feet by 5-feet ring (inner ring) which is positioned in the center of a second aluminum 12-feet by 12-feet ring (outer ring) as shown in Figure 8. The inner ring is sealed over the top to avoid evaporation losses. Both rings are filled with water, and the loss of water from the inner ring is measured periodically. This water loss is the sum of the flow due to infiltration (Qi), filling of pore space due to swelling of the clay (Qs), and volumetric changes of water within the inner ring due to temperature variations. The water head in the inner and outer ring is maintained at a constant level slightly above the top of the inner ring.

3.2 SITE PREPARATION AND INSTALLATION

1. The surface of the test fill was prepared for the installation of the SDRI by using a motor grader and a smooth drum roller to level and smooth the upper lift. The entire test fill area was lightly sprayed with water and covered with a black plastic tarp to prevent cracking.

2. The outer ring was positioned on the tarp and its outline was marked on the tarp to locate the trenches for the ring. The outer ring trench was cut with a Ditch Witch Series 1420 to a depth of 18 inches. The inner ring was positioned in the center of the outer ring and its outline was marked. The 5-inch-deep trench for the inner ring was cut by hand using small tools.

3. The outer ring trench was sealed with bentonite pellets surrounding the ring at the bottom and vertical sides. The trench for the inner ring was grouted with viscous Volclay grout.

4. After the installation of both rings was completed, a topographic survey was made to establish the original horizontal and vertical positions of the test fill surface including selected points on and around the inner ring. The primary purpose of the survey was to monitor the amount of swelling during the test.

5. The outer ring was flooded until the inner ring was slightly submerged, then the inner ring was partially filled through one plastic tube while air was removed through a second tube connected to the highest point of the cover. Then, the outer ring was filled to its final depth and the inner ring was topped off. Finally, plastic bags for measuring water flow within the inner ring were installed, and the test commenced.

3.3 DATA COLLECTION

1. The volume change of water within the flexible bag (shown in Figure 3) was indicative of the volume of water infiltrating through (the volume of water lost) the inner ring. The volume change was determined by calculating the change in the weight of the bag over a known time period (usually once per day). During the early days of the test, several bags of water were needed to account for higher flow rates due to minor surface desiccation cracking. The infiltration flow rates stabilized after several days. SDRI field data sheets are presented in Appendix B.

4.0 THEORY

1. The objective of the infiltrometer test is to measure the saturated permeability of the clay material for the B-18 Landfill under very low confining stresses. The test is performed by measuring the seepage of water through saturated soil.

2. In addition to being driven by the hydraulic gradient caused by the ponded water, seepage of water into the test fill also occurs due to high capillary suction of the partially saturated clay, as opposed to fully saturated conditions associated with laboratory tests. Performance of the field tests must also account for swelling of the clay at low confining stresses, which decreases the compacted density and increases permeability, as opposed to laboratory testing when higher confining stresses preclude swelling of the clay.

3. The saturated permeability is computed using a form of Darcy's Law which includes terms for the total hydraulic gradient. The governing equation that describes the infiltration of water through the compacted clay is developed below, based on the terms and sign convention shown in Figure 8[(1)]:

$$q = -K\frac{\Delta h}{\Delta L} \qquad (1)$$

where:

q = Infiltration rate per unit area and time (L/T)

K = Saturated permeability (L/T)

$\frac{\Delta h}{\Delta L}$ = Total hydraulic gradient (L/L)

Δh = $h_1 - h_2$

ΔL = $z_1 - z_2$

h = Total head

h = $z + \bar{\phi}$

z = Elevation head

$\bar{\phi}$ = Pressure head (due to hydraulic head or soil suction/tension)

In Figure 8, substituting for Δh and ΔL, yields the equation:

$$q = -K\left[\frac{(z_1 + \bar{\phi}_1) - (z_2 + \bar{\phi}_2)}{(z_1 - z_2)}\right] \qquad (2)$$

For any given wetting front, $L_f = z_1 - z_2$. Substituting this into Equation (2), the infiltration rate at any wetting front is calculated as:

$$q = -K\left[\frac{\bar{\phi}_1}{L_f} - \frac{\bar{\phi}_2}{L_f} + 1\right] \qquad (3)$$

4. As shown in Figure 8, at Point 1 the pressure head is equal to the depth of water in the outer ring, D_f, with soil suction/tension equal to zero, i.e., the soil is saturated. At this point, the pressure head, $Df = \bar{\phi}_1$. Also, since the clay fill is unsaturated below the wetting front, the in situ pressure head at Point 2 will be equal to the soil suction and negative in sign convention, and can be designated simply as $\bar{\phi}$, i.e., $\bar{\phi} = -\bar{\phi}_2$. Substituting into Equation 3:

$$q = -K\left[\frac{D_f}{L_f} + \frac{\bar{\phi}}{L_f} + 1\right] \qquad (4)$$

5. Equation 4 is time dependent. That is, the infiltration flow rate per unit area (q) and the depth of the wetting front (L_f) are interrelated and vary with time. As the wetting front advances,

---

(1) The minus sign indicates that the flow is in the negative Z-direction (downward).

Equation 4 can be rearranged to calculate permeability at various wetting front depths, determined by tensiometer measurements, as follows:

$$K = -\frac{q}{1 + \frac{D_f}{L_f} + \frac{\bar{\varphi}}{L_f}} \quad (5)$$

The length of the wetting front (L_f) is known by noting the depth to which tensiometers indicate moisture content increases. The depth of flooding (D_f) is taken as an average value of readings measured during the test. The soil suction ($\bar{\varphi}$) is set equal to the stabilized or weighted soil tension value, measured prior to the passage of the wetting front, and is dependent on the shape of the suction versus time plot. The infiltration rate (q) is determined by weighing the flexible bag periodically to determine the volume of water lost.

6. The measured volume of water lost is corrected to account for swelling of the soil and temperature changes. The total water lost is the sum of the following:

- $Q = Q_i + Q_s + Q_t$ (6)
- Q = measured water loss
- Q_i = flow due to infiltration
- Q_s = flow due to swell
- Q_t = flow due to temperature changes (considered to be insignificant)

7. The infiltration rate per unit area (q) is:

$$q = \frac{Q_i}{A} = \frac{Q - Q_s - Q_t}{A} = \frac{Q - Q_s}{A} \quad (7)$$

A close estimate of Q_s can be obtained by assuming that any volume change that occurs is due to vertical swelling and that the additional volume generated by the swelling is water filling the soil pores. Based on these two assumptions:

$$Q_s = \Delta s \times A \quad (8)$$

where:

Δs = amount of swelling (as surveyed) at the time the water front passes a given tensiometer

A = area of inner ring

A plot of total water lost versus time is used to determine the total flow (Q) at the time the wetting front passes the tensiometer.

8. The test procedure and analysis methodology described above is based on the following assumptions:
   - Darcy's Law applies.
   - A sharp wetting front exists between the saturated soil and the unsaturated soil.
   - The measured water loss from the flexible bag represents the water lost due primarily to infiltration through the inner ring, and soil swelling. Changes due to temperature variations are not significant.
   - The test fill is homogeneous and isotropic.
   - Flow through the inner ring is vertically downward.
   - Any volume change that occurs is vertical.
   - The wetting front under the outer ring reaches a given depth L_f at the same time as the wetting front under the inner ring.

9. The first assumption that Darcy's Law applies is valid due to the fact that the ground water flow is laminar when the wetting front reaches the tensiometer tip. The second assumption of a sharp wetting front is valid early during the test. At later times a transition zone between the saturated and partially-saturated soil is likely to exist.

10. The assumption concerning the measured water loss is based on the fact that the inner ring is completely purged of air; additional volume generated by swelling is water filling the soil pores, and water temperature variations are relatively small due to measuring flow volumes at similar times each day of the test. Considering that the fill was placed under controlled conditions, the assumptions that the test fill is homogeneous and isotropic is appropriate.

11. The assumption that any volume change that occurs is vertical is based on the very low magnitude of the confining stresses in the upper 18 inches of the test fill. There are practically no constraints for vertical swelling.

12. The assumption of vertical flow through the inner ring is based on the fact that an equal head is maintained between the inner and outer ring, and as a result the only driving force is vertically downward. This basis, in effect, also assumes that the wetting fronts for the inner and outer rings advance at the same rate, which would eliminate the possibility of soil suction causing lateral movement.

13. The last assumption is necessary due to the fact that the sealed inner ring apparatus precludes the installation of soil tensiometers under the inner ring to monitor the advance of the wetting front within the inner ring.

5.0 SDRI TEST RESULTS AND CONCLUSIONS

1. The infiltrometer test was conducted over a period of approximately two months to evaluate the permeability of the upper 18 inches of test fill. Based on the tensiometer readings (Figures 9 and 10), the wetting front (zone of saturation) reached depths of 12 and 18 inches in about 18 and 53 days, respectively. The tensiometers installed at a depth of 6 inches were damaged by wind and consequently no readings were taken at this depth as originally intended.

2. Figure 11 presents the accumulated total water flow, Q, as a function of time. The initial flow rate over the time interval of 0 to 5,000 minutes was about two times the average flow rate that occurred during saturation of the top 12 inches. This higher flow rate was likely due to water filling small surface cracks/voids. This condition was accounted for in determining the rate of flow.

3. Table 2 summarizes the survey data indicating the swell of the test fill soil, when the wetting front had reached 12 and 18 inches, respectively. Table 2 also shows the calculated flow due to swell (Qs) for these periods.

4. The suction pressure for both sets of tensiometers (Figures 9 and 10) was approximately 70 centibars, or 280 inches of water pressure.

5. The results of the infiltrometer test using Equation 5 are summarized in Table 3. The field measured permeabilities for both the 0- to 12-inches and 0- to 18-inches increments are less than 1×10^{-7} cm/sec. Based on these results, coupled with the laboratory permeability tests, it is concluded that the claystone, used for the test fill and proposed for use as the liner/cap, provides an adequate low permeability soil layer for the B-18 Landfill.

6. The test fill results are one to two orders of magnitude higher than laboratory permeabilities. These differences are expected and are primarily due to the unrestrained swelling of the clay which occurs during field testing (Chen and Yamamoto, 1987). The low hydraulic conductivity measured in the laboratory is a function of the consolidation pressure used in the test to prevent swelling. This consolidation pressure simulates the effect of the waste fill overburden on the clay liner. The SDRI test is more indicative of the stress condition for the cover system (very low confining stresses).

6.0 REFERENCES

Chen, Hsien W. and Leonard O. Yamamoto. *Permeability Tests for Hazardous Waste Management Unit Clay Liners, Proceedings of Geotechnical and Geohydrologic Aspects of Waste Management;* 1987.

Environmental Solutions, Inc., 1990a. *Engineering and Design Report, Landfill Unit B-18, Phases I and II and Final Closure, Kettleman Hills Facility, Kings County, California,* August 1990.

Environmental Solutions, Inc., 1990b. *Construction Specifications and Quality Assurance Plan, Landfill Unit B-18, Phases I and II and Final Closure, Kettleman Hills Facility, Kings County, California*, September 24, 1990.

Golder Associates. *Test Fill and Infiltrometer Test Results, Landfill B-19, Phase IA, Kettleman Hills Facility, Kettleman City, California*, January 1987.

Trautwein Soil Testing Equipment. *Installation and Operating Instruction for the Sealed-Double Ring Infiltrometer*, March 1989.

TABLE 1

EQUIPMENT UTILIZED IN THE TEST FILL CONSTRUCTION

EQUIPMENT	FUNCTION
Caterpillar D8N Dozer	Grading test fill
Caterpillar 14G Motor Grader	Grading test fill; scarifying previous lifts
Caterpillar 631E Scraper	Hauling clay from B-18 Clay Processing Area
Caterpillar 825C Compactor	Compacting lifts;
Ingersoll-Rand SP-56 Smooth Drum Roller	Dressing test fill
Water Truck	Moisture conditioning

89-977 (1/23/92/hs)

TABLE 2

ESTIMATE OF SWELL FLOW VOLUME

TEST INTERVAL	AVERAGE SURVEYED VERTICAL SWELLING (ft)	AREA OF TEST (ft^2)	SWELL FLOW VOLUME (cc)
0 to 12 inches	0.17	25	120,300
0 to 18 inches	0.20	25	141,600

89-977 (1/9/92/mg)

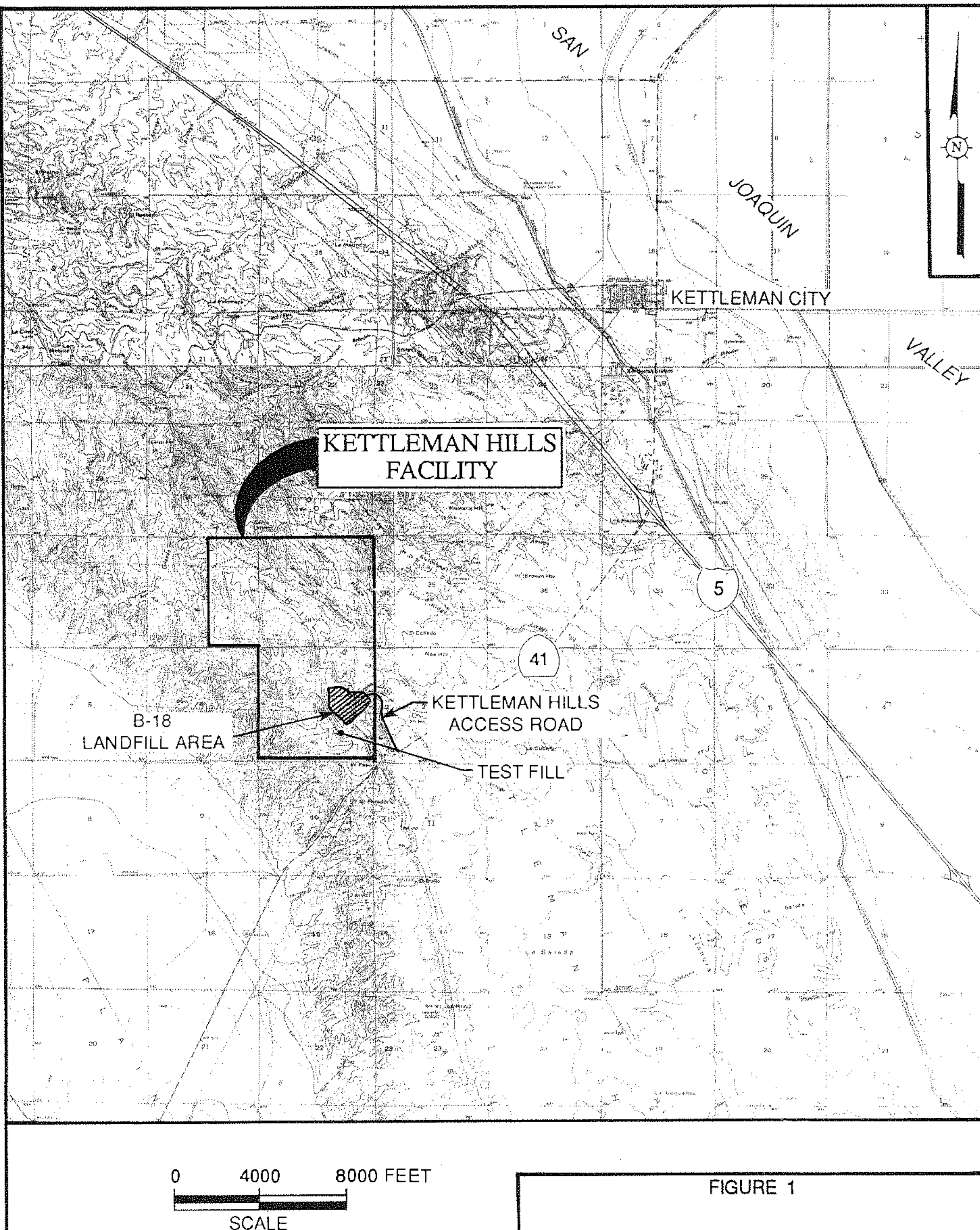
TABLE 3

INFILTROMETER TEST RESULTS

TEST INTERVAL	CUMULATIVE WATER LOSS Q (cc)	FLOW DUE TO SWELL Q_s (cc)	FLOW DUE TO INFILTRATION Q_i (cc)	INFILTRATION RATE PER UNIT AREA q (cm/sec)	DEPTH OF WATER IN OUTSIDE RING D_f (in)	DEPTH OF WETTED FRONT L_f (in)	SUCTION PRESSURE φ (in of H_2O)	$K = -\frac{q}{1 + \frac{D_f}{L_f} + \frac{\Phi}{L_f}}$ (cm/sec)
DEPTH: 0 to 12 INCHES Tensiometers: TN-2, TN-3, TN-6, TN-7 Total Swelling: 1.98 inches % of Swelling - Field: 17.0 % of Swelling - Lab: 16.5	180,000	120,300	59,700	1.3×10^{-6}	15	12	280	5.1×10^{-8}
DEPTH: 0 to 18 INCHES Tensiometers: TN-4, TN-5 Total Swelling: 2.40 inches % of Swelling - Field: 13.3 % of Swelling - Lab: 16.5	280,000	141,600	140,400	1.20×10^{-6}	15	18	280	6.9×10^{-8}

89-977 (1/9/92/mg)

89-977 TFITR REV. 5/7/91



REFERENCE: USGS 7.5 MINUTE TOPOGRAPHIC MAP OF LA CIMA, DATED 1963, PHOTOREVISED 1971, LOS VIEJOS, DATED 1954, PHOTOREVISED 1981, KETTLEMAN CITY, DATED 1963, PHOTOREVISED 1981, AND KETTLEMAN PLAIN, CALIFORNIA, DATED 1953, PHOTOINSPECTED 1978.

FIGURE 1

SITE VICINITY MAP

LANDFILL UNIT B-18
KETTLEMAN HILLLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.

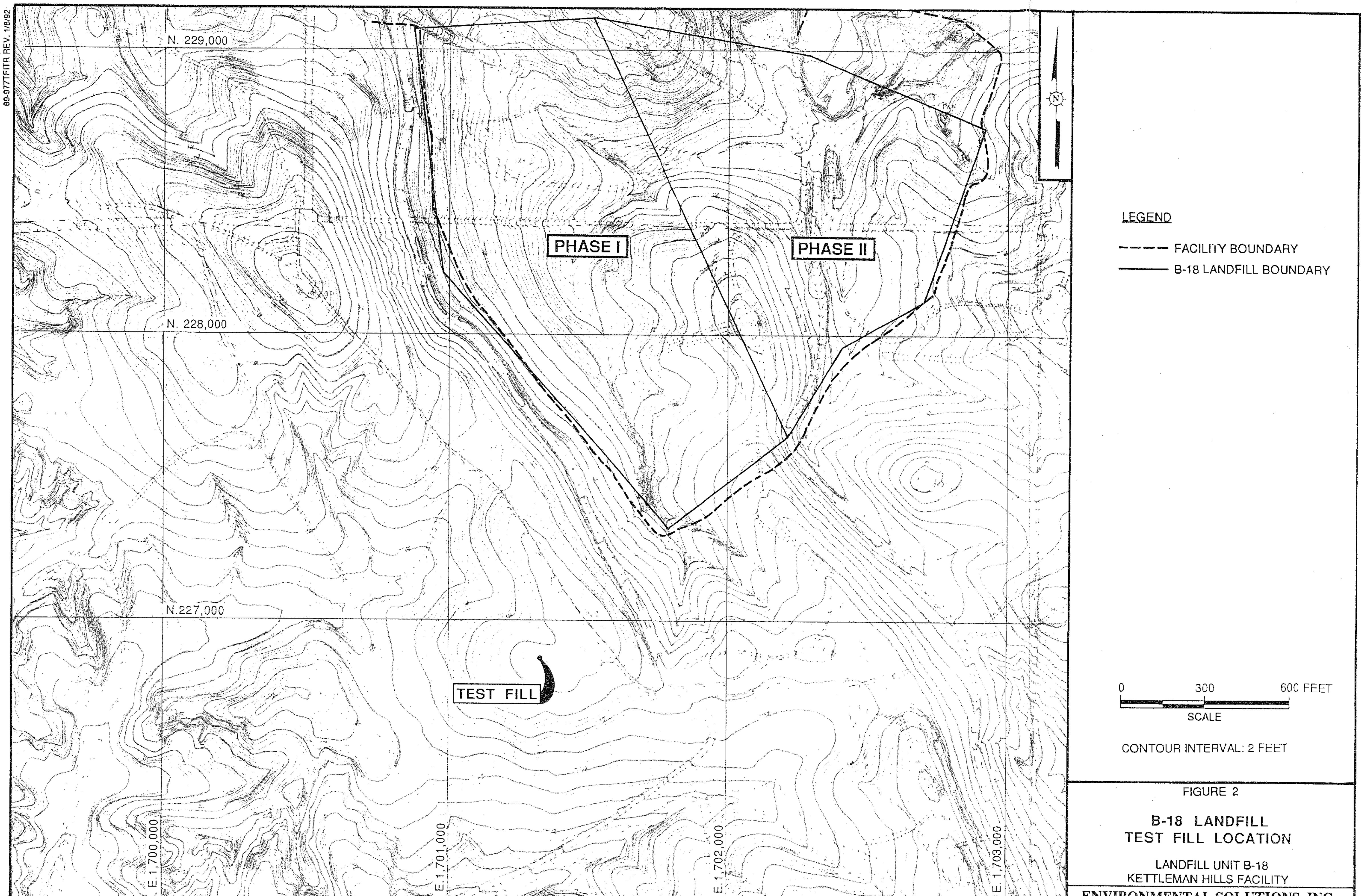


FIGURE 2

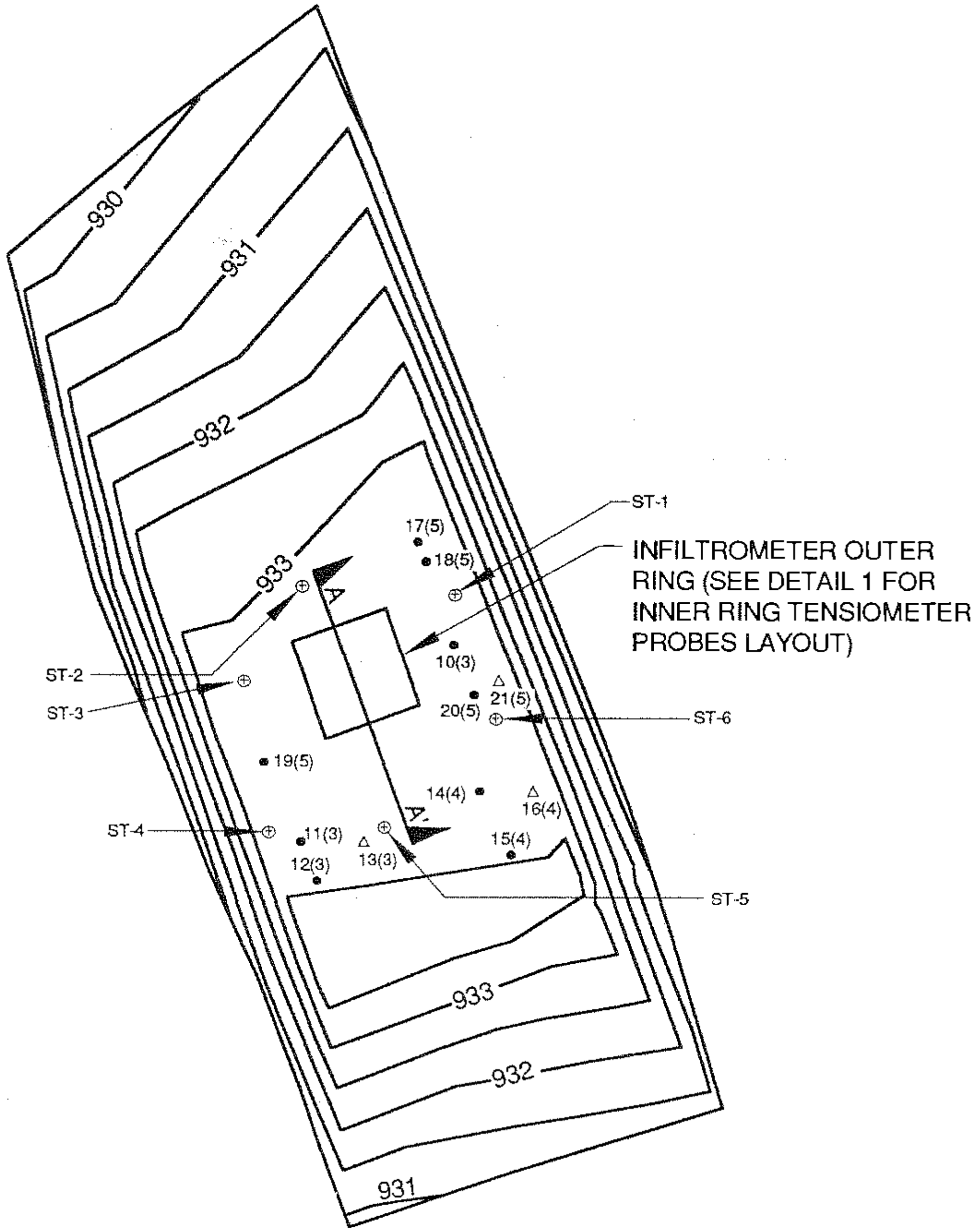
B-18 LANDFILL TEST FILL LOCATION

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.

89-977TFITR REV. 1/8/92

89-977/TFITR-01 REV. 1/22/92



TEST FILL PLAN

0 20 40 FEET

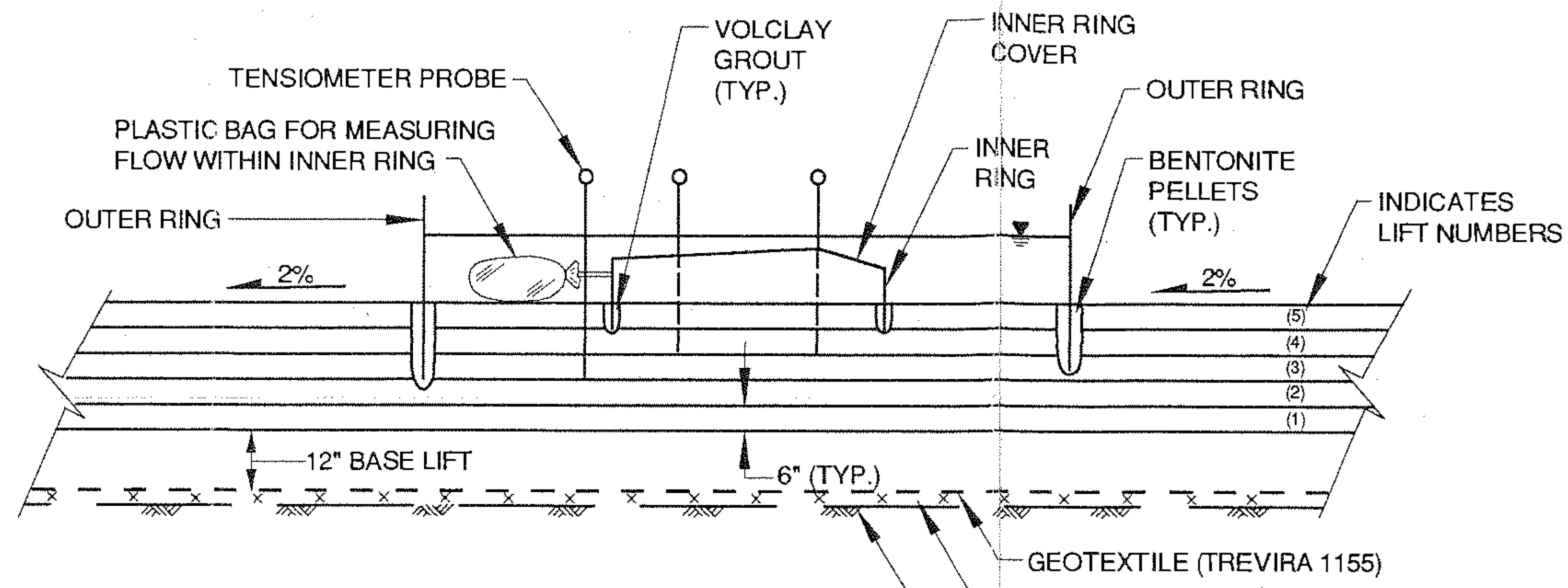
SCALE

LEGEND

4(5) • NUCLEAR DENSITY TEST LOCATION
LIFT NUMBER
TEST NUMBER

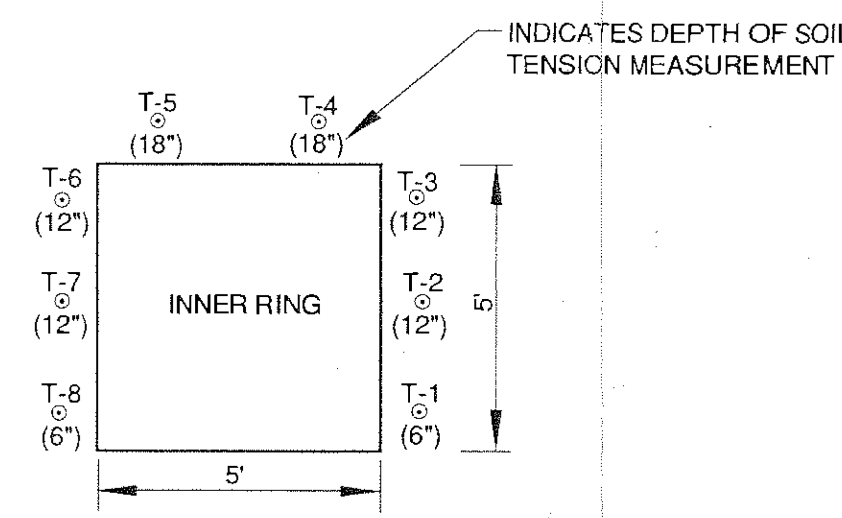
7(3) △ SAND CONE DENSITY TEST LOCATION
LIFT NUMBER
TEST NUMBER

ST-6 ⊕ SHELBY TUBE SAMPLE LOCATION AND NUMBER



SECTION A-A'

NOT TO SCALE



DETAIL 1

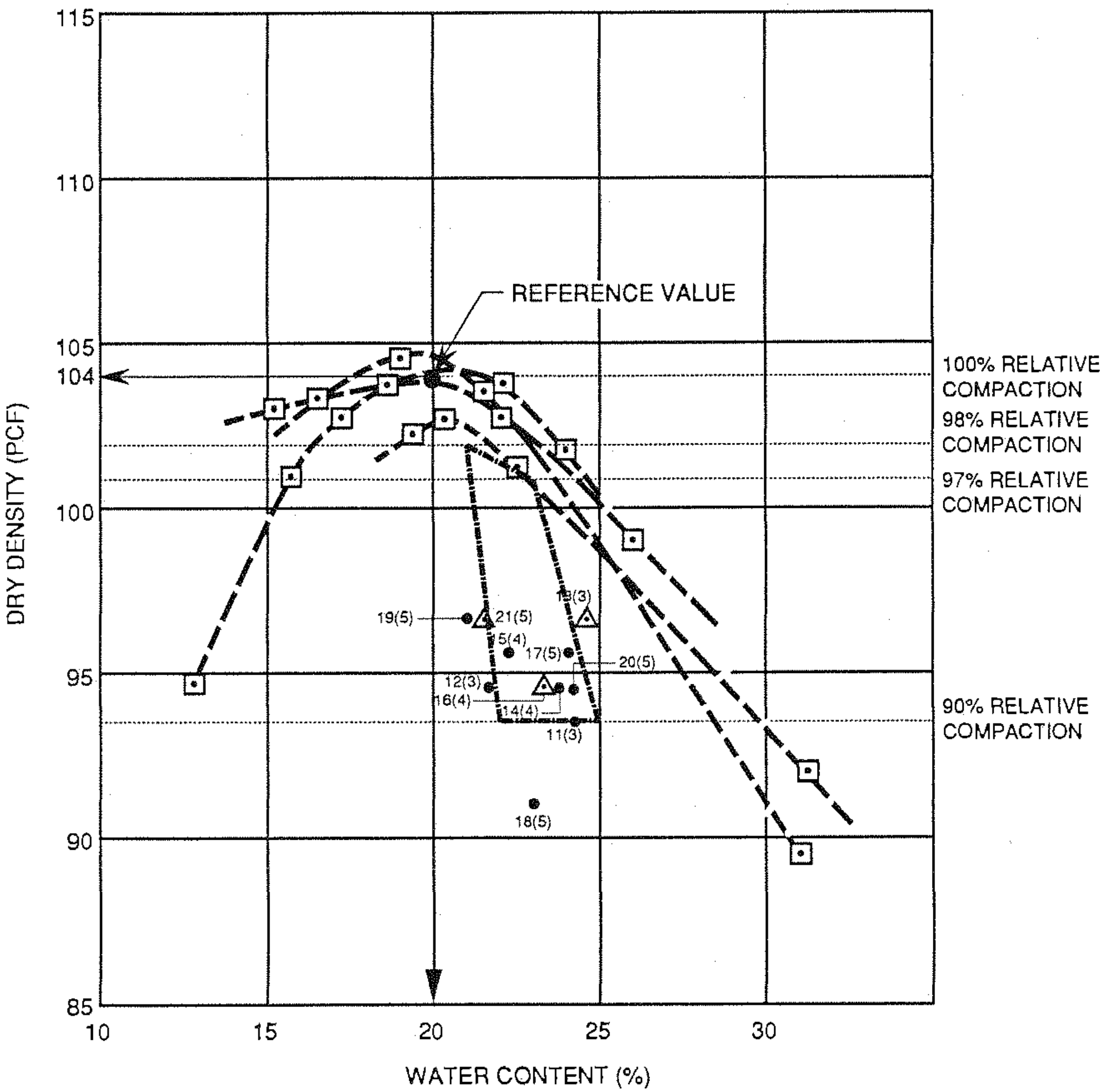
TENSIOMETER PROBES LAYOUT

FIGURE 3

TEST FILL PLAN, CROSS SECTION AND DETAIL

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.



LEGEND

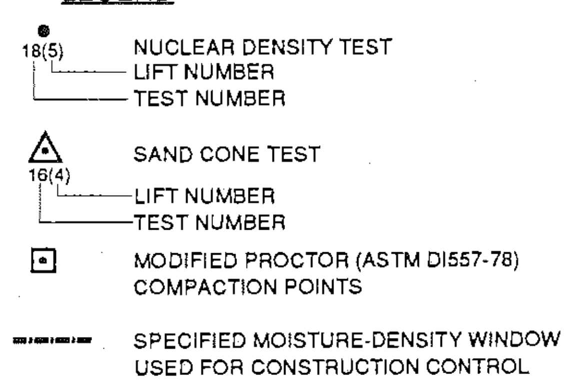
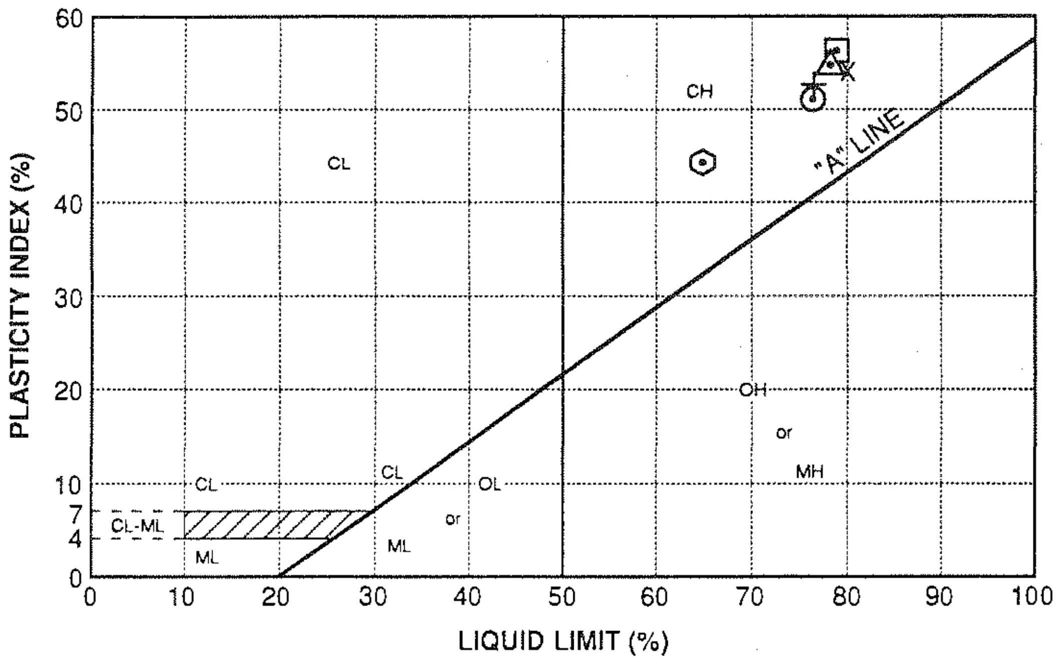


FIGURE 4

COMPACTION DATA
TEST FILL

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.



SYMBOL	SHELBY TUBE NO.	LIQUID LIMIT(%)	PLASTICITY INDEX (%)	SOIL TYPE (USCS SOIL CLASSIFICATION)
◬	ST-1	78	54	OLIVE CLAY (CH)
⊙	ST-2	76	51	OLIVE CLAY (CH)
X	ST-3	79	54	OLIVE CLAY (CH)
⊡	ST-4	79	55	OLIVE CLAY (CH)
+	ST-5	76	52	OLIVE CLAY (CH)
⬡	ST-6	65	44	OLIVE CLAY (CH)

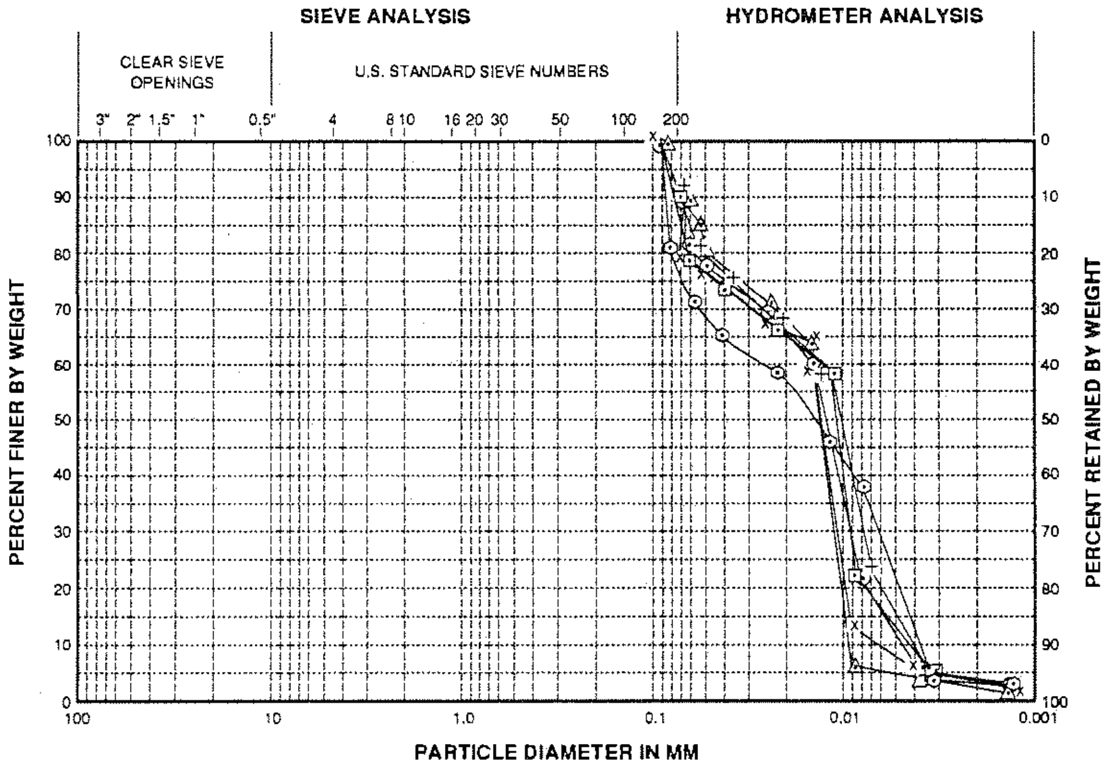
FIGURE 5

ATTERBERG LIMIT TEST FILL SOIL

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.

SYMBOL	SAMPLE NO.	LIQUID LIMIT(%)	PLASTICITY INDEX (%)	SOIL TYPE
△ (dotted triangle)	ST-1	78	54	OLIVE CLAY (CH)
⊙	ST-2	76	51	OLIVE CLAY (CH)
X	ST-3	79	54	OLIVE CLAY (CH)
⊡	ST-4	79	55	OLIVE CLAY (CH)
+	ST-5	76	52	OLIVE CLAY (CH)
⬡ (dotted hexagon)	ST-6	65	44	OLIVE CLAY (CH)



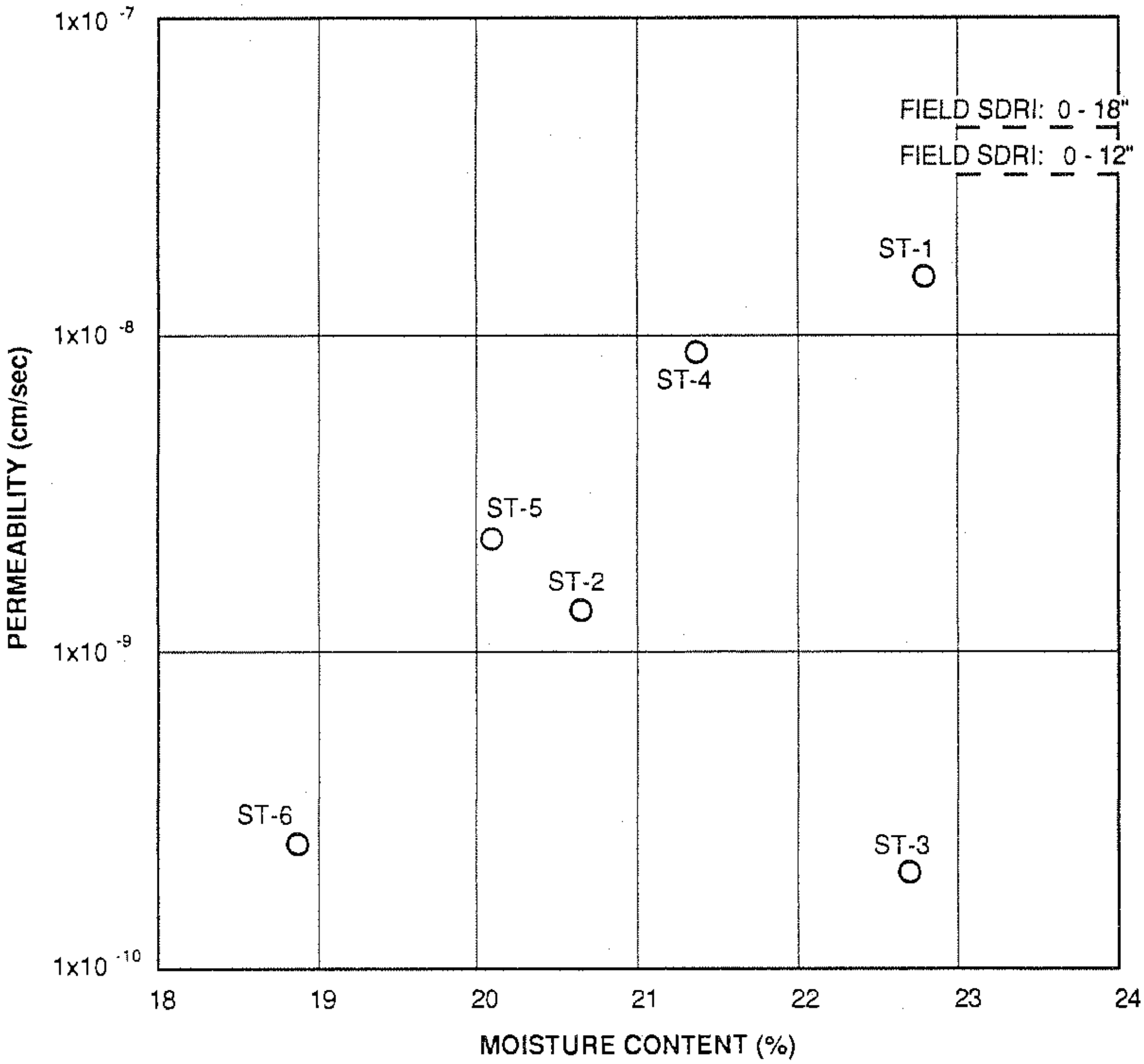
COBBLES	GRAVEL		SAND			SILT AND CLAY FRACTION
	coarse	fine	coarse	medium	fine	

FIGURE 6

GRAIN SIZE DISTRIBUTION
TEST FILL SOIL

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.



LEGEND

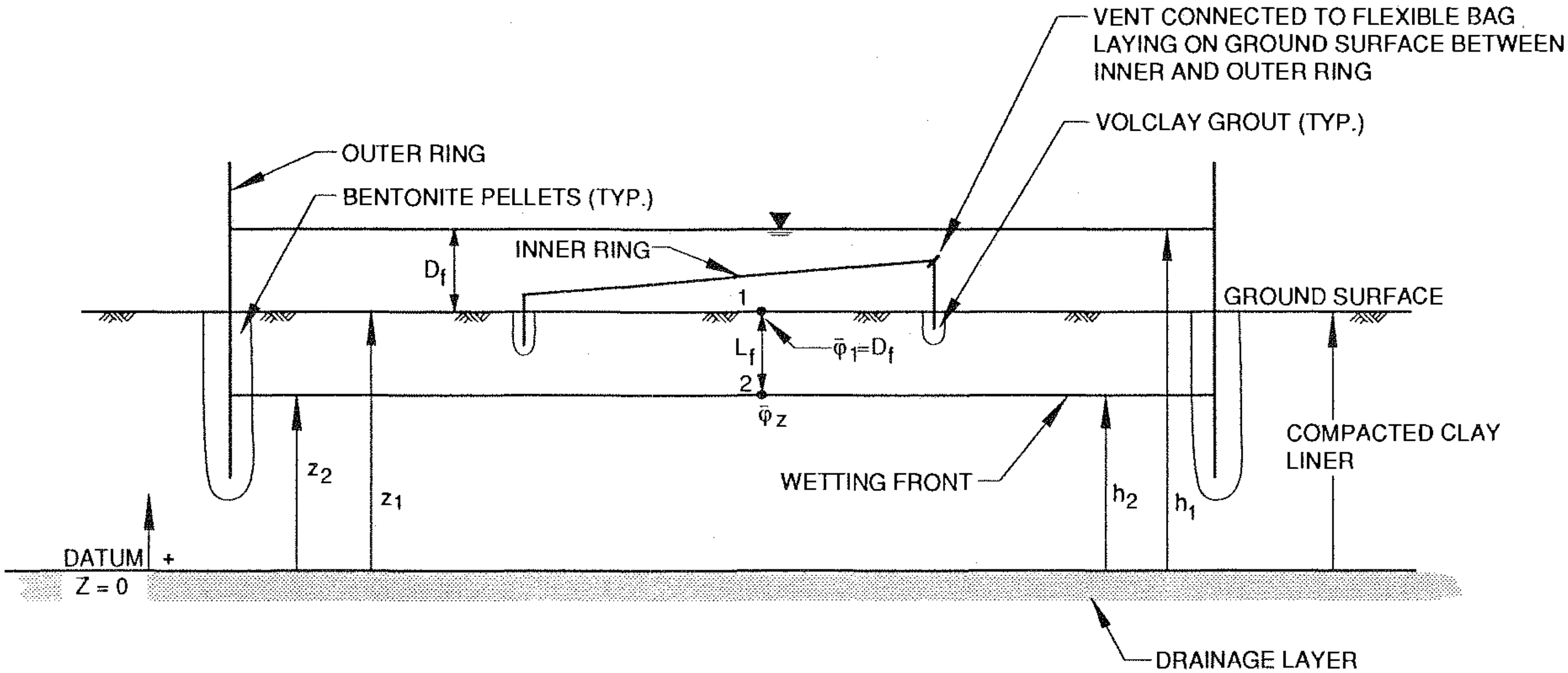
ST-2
O LABORATORY PERMEABILITY AND SAMPLE NUMBER

FIGURE 7

LABORATORY PERMEABILITY VERSUS WATER CONTENT

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.



NOT TO SCALE

FIGURE 8

SCHEMATIC OF INFILTROMETER TEST MODEL

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.

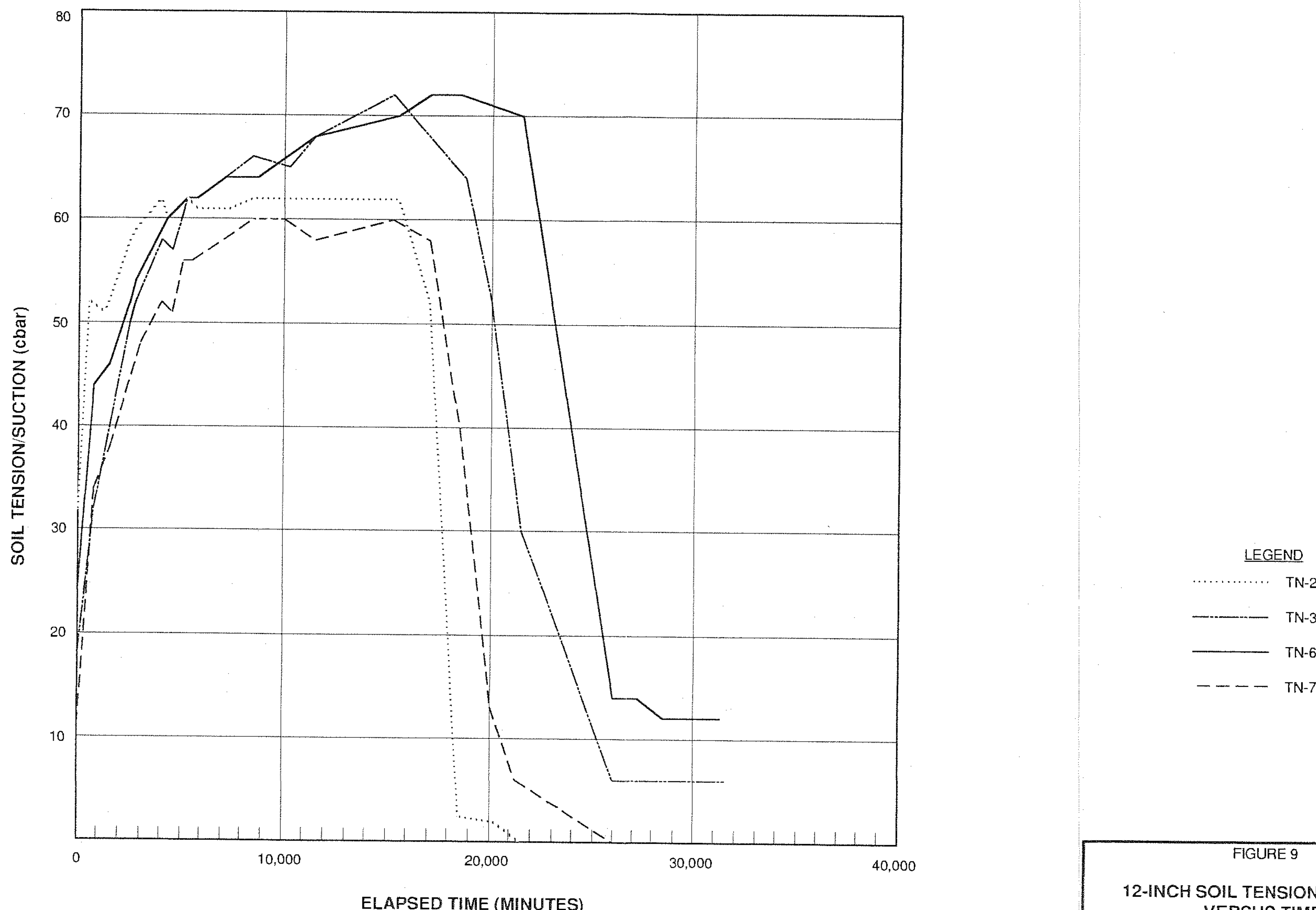


FIGURE 9

12-INCH SOIL TENSION/SUCTION VERSUS TIME

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.

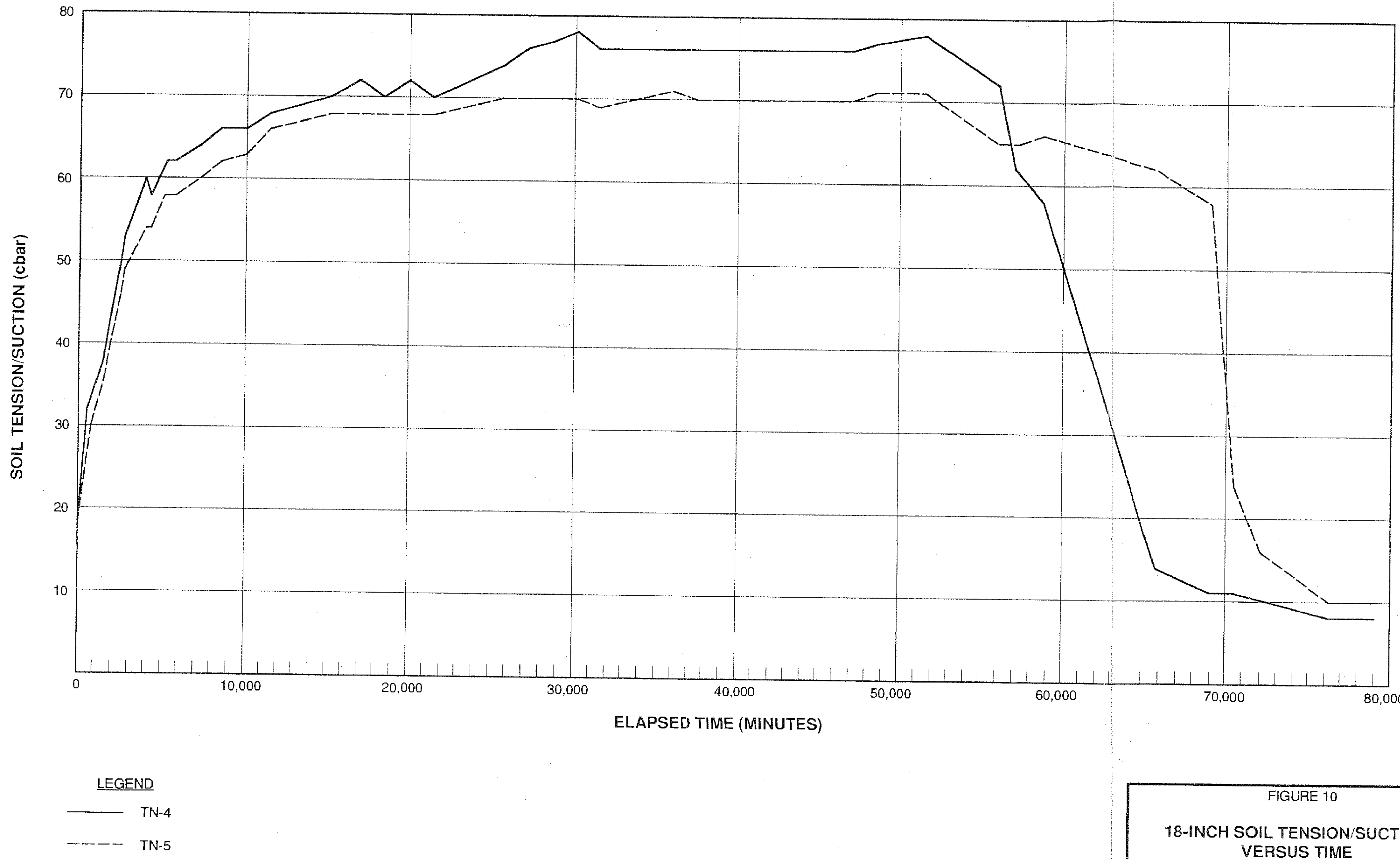
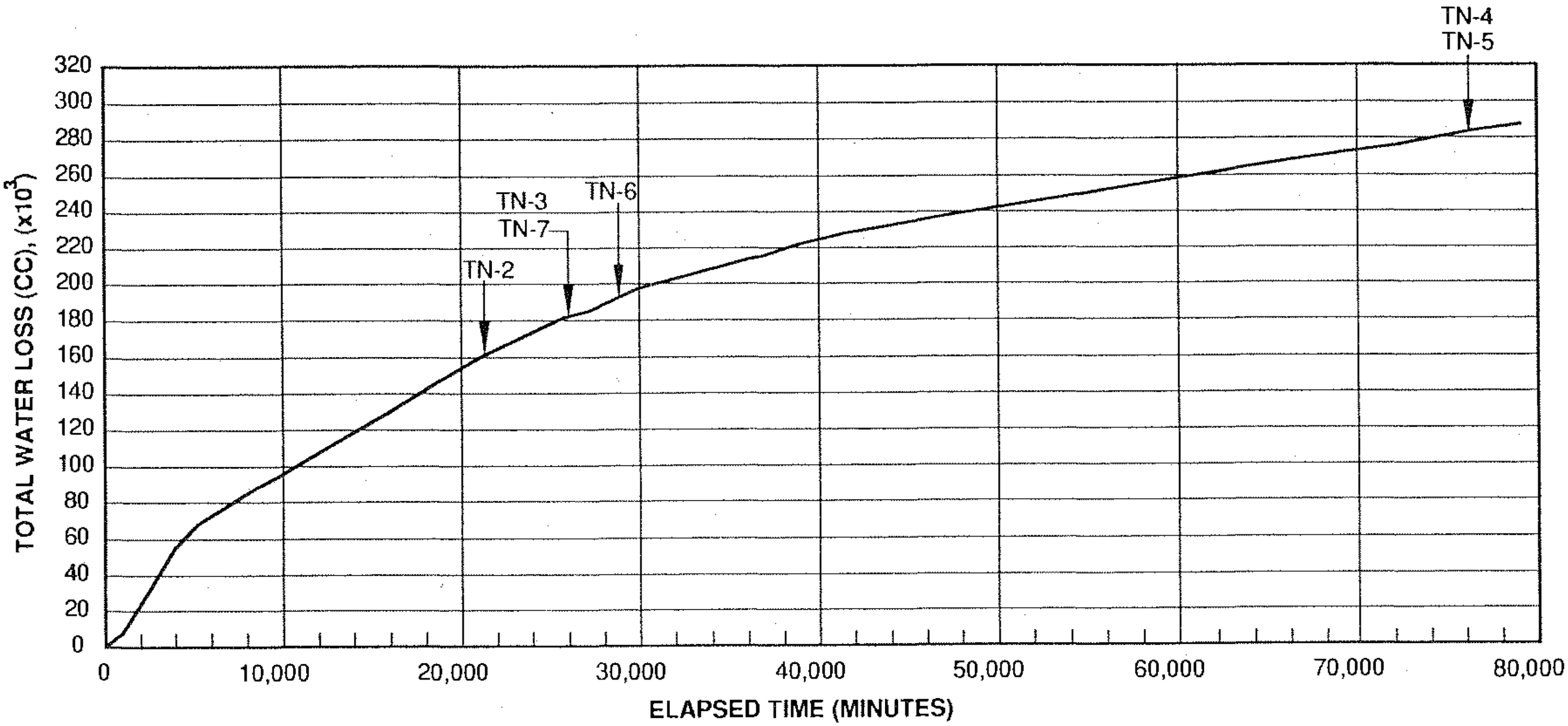


FIGURE 10

18-INCH SOIL TENSION/SUCTION VERSUS TIME

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.



LEGEND

TN-2 ↓ THE TIME WHEN THE TENSIOMETER INDICATED A SATURATED SOIL CONDITION EXISTED.

FIGURE 11

INFILTRATION VERSUS TIME

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.

APPENDIX A

ONE-DIMENSIONAL SWELL TEST RESULTS

ONE DIMENTIONAL SWELL TEST

ASTM 4546-85

Project Name: B-18 Landfill
Project No.: 89-977H
Tested By: GH Date: 03/08/91
Input Checked By: GH Date: 03/13/91
Reviewed By: [signature] Date: 4/5/91

Vertical Stress (psi):	0.470	0.467	0.467	0.468	0.465	0.464
Frame No.:	1	2	3	4	5	6
Sample No.:	ST-1	ST-2	ST-3	ST-4	ST-5	ST-6
Depth (ft):	---	---	---	---	---	---
Liquid Limit (LL):	78	76	79	79	76	65
Plasticity Index (PI):	54	51	54	55	52	44

WATER CONTENT	Trim	Final	Trim	Final	Trim	Final	Trim	Final	Trim	Final	Trim	Final
Wet Wt.+Tare (gm):	219.35	309.43	284.96	316.34	175.14	264.93	150.53	294.07	143.39	271.65	208.92	315.20
Dry Wt.+Tare (gm):	194.56	253.75	248.23	261.60	158.94	211.22	140.33	238.76	133.51	219.52	187.15	262.55
Wt. of Tare (gm):	92.08	114.49	91.99	126.32	89.76	76.62	90.16	105.23	92.18	81.31	89.82	115.62
Moisture Content (%):	24.19	39.98	23.51	40.46	23.42	39.90	20.33	41.42	23.91	37.72	22.37	35.83

DENSITY AND SATURATION	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final
Wet Soil+Tare (gm):	1141.40	309.43	1130.70	316.34	1132.40	264.93	1131.00	294.07	1140.20	271.65	1148.70	315.20
Ring/Tare (gm):	967.30	114.49	962.60	126.32	966.20	76.62	969.00	105.23	969.30	81.31	970.80	115.62
Wet Soil (gm):	174.10	194.94	168.10	190.02	166.20	188.31	162.00	188.84	170.90	190.34	177.90	199.58
Moisture Content (%):	25.02	39.98	24.26	40.46	23.48	39.90	21.32	41.42	23.65	37.72	21.08	35.83
Dry Soil (gm):	139.26	139.26	135.28	135.28	134.60	134.60	133.53	133.53	138.21	138.21	146.93	146.93
Length of Sample (in):	0.8750	1.0323	0.8750	1.0270	0.8750	1.0035	0.8750	1.0291	0.8750	0.9995	0.8750	1.0243
Diameter of Sample (in):	2.870	2.870	2.870	2.870	2.870	2.870	2.870	2.870	2.870	2.870	2.870	2.870
Volume of Sample (c.c.):	92.760	109.436	92.760	108.874	92.760	106.383	92.760	109.097	92.760	105.959	92.760	108.588
Wet Density (PCF):	117.1	111.2	113.1	108.9	111.8	110.5	109.0	108.0	115.0	112.1	119.7	114.7
Dry Density (PCF):	93.7	79.4	91.0	77.5	90.5	79.0	89.8	76.4	93.0	81.4	98.8	84.4
Specific Gravity :	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70
Volume of Solids (%):	55.60	47.13	54.01	46.02	53.74	46.86	53.32	45.33	55.18	48.31	58.67	50.11
Volume of Liquid (%):	37.56	50.88	35.38	50.28	34.07	50.49	30.69	50.70	35.24	49.20	33.39	48.49
Volume of Air (%):	6.84	1.99	10.60	3.70	12.19	2.65	15.99	3.97	9.57	2.49	7.95	1.40
Deg.of Saturation (%):	84.60	96.24	76.94	93.14	73.65	95.01	65.74	92.74	78.64	95.18	80.77	97.20

SUMMARY	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final
Moisture Content (%):	25.02	39.98	24.26	40.46	23.48	39.90	21.32	41.42	23.65	37.72	21.08	35.83
Dry Density (PCF):	93.7	79.4	91.0	77.5	90.5	79.0	89.8	76.4	93.0	81.4	98.8	84.4
Deg.of Saturation (%):	84.60	96.24	76.94	93.14	73.65	95.01	65.74	92.74	78.64	95.18	80.77	97.20
Final Swell (%):	17.98		17.37		14.69		17.61		14.23		17.06	

Note: 1. Specific gravity is assumed. 2. Demineralized water used.

APPENDIX B

SDRI FIELD DATA SHEETS

Chemical Waste Management, Inc.
Post Office Box 471
Kettleman City, California 93239
209 386-9711

TRANSMITTAL LETTER

To Environmental Solutions, Inc
21 Technology Drive
Irvine, CA 92718

ATTN: Julio Badel

Date 3/28/91
Project No. 89-03

Sent by

☒ Mail
☐ Air Freight
☐ Hand Carried

☐ Under Separate Cover
☐ Enclosed

Quantity	Item	Description
4	B-18 TestCell Field Data Sheets	(2) Originals (2) Copies

Remarks

Per Vien Perez

①

Initial 3'

	STATION I-1		INFILTROMETER READINGS								SWELL DATA			
	DATE	FIELD ENGR	WATER TEMP.	WATER DEPTH	INITIAL TIME	FINAL TIME	TIME INTERVAL	INITIAL WT OF BAG (GRAMS)	FINAL WT OF BAG (GRAMS)	CHANGE IN WT (GRAMS)	NW CORNER Δh	NE CORNER Δh	SE CORNER Δh	SW CORNER Δh
TH	1/31/91	VOP/JB	13°C	15'	1637	(2/1) Ø745	15.1	3711 #5	133		3.Ø	3.Ø	3.Ø	3.Ø
								3758 #2	137	7199				
FR	2/1/91	VOP/JB	11°C	15"	Ø745	(2/1) 1615	8.5	3749 #6	1Ø3		3.5	3.Ø	3.5	3.6
								3923 #4	132	7437				
FR	2/1/91	VOP/RAG	13°	15"	1615	(2/2) Ø845	16.6	4234 #12	151					
								4269 #11	155					
								3842 #1	12Ø					
								3939 #3	125	15733				
SAT	2/2/91	VOP	11°C	15"	Ø850	154Ø	6.9	13ØØ #9	129		2.9	2.94	2.98	2.9
								1315 #10	12Ø					
								395Ø #2	212					
								3943 #5	17Ø	9877				
SAT	2/2/91	VOP	11°C	15"	1545	(2/3) Ø945	18.1	4198 #6	345		2.9	2.94	2.98	2.9
								42Ø1 #4	265					
								4246 #3	321					
								4Ø86 #1	314	15486				
SUN	2/3/91	VOP		15"	Ø95Ø	(2/3) 1535	5.9	1421 #8	1243		2.89	2.92	2.97	2.9
								1362 #10	1116					
								4164 #11	248Ø					
								4339 #12	2512	3935				

JOB NO. 89-Ø3 PROJECT B-18 Infiltrometer

INFILTROMETER FIELD DATA

Cond... F... 932.92 ② 5ll

	STATION I-1		INFILTROMETER READINGS								SWELL DATA			
	DATE	FIELD ENGR	WATER TEMP.	WATER DEPTH	INITIAL TIME	FINAL TIME	TIME INTERVAL	INITIAL WT OF BAG (GRAMS)	FINAL WT OF BAG (GRAMS)	CHANGE IN WT (GRAMS)	NW CORNER Δh	NE CORNER Δh	SE CORNER Δh	SW CORNER Δh
SUN	2/3/91	VOP	13°C	15"	1540	(2/4) 0705	15.5	4506 #3	2200		936.03	936.11	936.38	936.24
								4161 #5	1935					
								4158 #2	2890					
								4202 #6	1754	8248				
MON	2/4/91	VOP	11°C	15"	0710	(2/4) 1640	9.5	1421 #8	1217		2.88	2.92	2.96	2.9
								1400 #9	1119					
								4377 #1	2248					
								4113 #4	2384	4343				
MON	2/4/91	VOP	14°C	15"	1643	(2/5) 1550	23.2	4160 #5	1912		2.88	2.92	2.96	2.9
								4421 #6	2292					
								4308 #11	1295					
								4084 #12	1949	7448				
TUE	2/5/91	VOP	15°C	15"	1555	(2/6) 1430	22.7	1379 #9	677					
								1367 #10	947					
								3993 #2	924					
								4694 #3	1155	7730				
WED	2/6/91	VOP	14°C	15"	1435	(2/7) 1600	25.4	1416 #8	1167		2.74	2.81	2.75	2.75
						1600		4372 #1	2530					
						1600		4263 #4	1623					
						1600		4195 #6	1463	7483				

JOB NO. 89-03 PROJECT B-18 Infiltrometer

INFILTROMETER FIELD DATA

	STATION I-1		INFILTROMETER READINGS								SWELL DATA			
	DATE	FIELD ENGR	WATER TEMP.	WATER DEPTH	INITIAL TIME	FINAL TIME	TIME INTERVAL	INITIAL WT OF BAG (GRAMS)	FINAL WT OF BAG (GRAMS)	CHANGE IN WT (GRAMS)	NW CORNER Δh	NE CORNER Δh	SE CORNER Δh	SW CORNER Δh
TH	2/7/91	VOP	19.6°C	15"	1600	(2-8) 1625	24.5	14Ø2 #9	1Ø49					
					1600			4288 #12	1337					
					1600			4599 #5	2Ø59					
					1600			4826 #11	149Ø	9175				
FR	2/8/91	VOP	16.Ø°C	14.9"	163Ø	(2-11) Ø827	64.1	4269 #2	456		2.74	2.73	2.78	2.76
								4571 #4	387					
								4439 #1	459					
								4725 #3	457					
								4224 #6	4Ø1					
								1492 #8	252	213Ø8				
MO	2/11/91	VOP	12°C	14.9"	Ø834	2-12 1145	27.2	1311 #1Ø	1068		2.74	2.73	2.79	2.76
								4421 #12	762					
								4627 #11	1083					
								437Ø #5	903	1Ø913	2.84	2.73	2.88	2.75
TUE	2/12/91	VOP	19.4°C	14.8"	1150	(2-13) 14Ø7	26.3	4363 #1	1Ø3Ø					
								4327 #6	1Ø48					
								41ØØ #2	1587					
								1418 #8	1Ø77	9466				

JOB NO. 89-Ø3 PROJECT B-18 Infiltrometer

INFILTROMETER FIELD DATA

	STATION I-1		INFILTROMETER READINGS								SWELL DATA			
	DATE	FIELD ENGR	WATER TEMP.	WATER DEPTH	INITIAL TIME	FINAL TIME	TIME INTERVAL	INITIAL WT OF BAG (GRAMS)	FINAL WT OF BAG (GRAMS)	CHANGE IN WT (GRAMS)	NW CORNER Δh	NE CORNER Δh	SE CORNER Δh	SW CORNER Δh
WED	2/13/91	VOP	16°C	14.8"	1407	(2-14) 1442	24.6	1366 #9	951		2.72	2.73	2.8	2.73
								4304 #11	904					
								4722 #4	1981					
								4973 #3	2900	8626				
TH	2/14/91	VOP	16.0°C	14.75"	1442	(2-15) 1430	23.8	4367 #1	1338		2.71	2.73	2.82	2.69
								4725 #5	1536					
								1398 #8	1124					
								1347 #10	1123	6716				
FR	2/15/91	VOP	16°C	14.75"	1430	(2-18) 1450	72.3	4803 #4	1189		2.64	2.6	2.79	2.57
								4617 #3	1874					
								5060 #11	1046					
								5481 #12	1246					
								4531 #6	2100					
								4504 #2	2115	9,426				
MON ✱	2/18/91	VOP	14°C	13.8"	1450	(2-19) 1516	24.4	1414 #8	1212		–	–	–	–
								1386 #10	1109					
								4771 #5	2476					
								4747 #1	1622	5899				

✱ Wind pull down wires, unable to measure swell data

JOB NO. 89-03 PROJECT B-18 Landfill Infiltrometer

INFILTROMETER FIELD DATA

	STATION I-1		INFILTROMETER READINGS								SWELL DATA			
	DATE	FIELD ENGR	WATER TEMP.	WATER DEPTH	INITIAL TIME	FINAL TIME	TIME INTERVAL	INITIAL WT OF BAG (GRAMS)	FINAL WT OF BAG (GRAMS)	CHANGE IN WT (GRAMS)	NW CORNER Δh	NE CORNER Δh	SE CORNER Δh	SW CORNER Δh
TUE	2/19/91	VOP	16°C	13.8"	1510	(2-20) 1351	22.6	4537 #6	2997		-	-	-	-
								5056 #11	1264	5332				
WED	2/20/91	VOP	16°C	14.8"	1351	(2-21) 1450	25.0	4734 #5	2535		-	-	-	-
								4586 #1	1911	4874				
TH	2/21/91	VOP	16°C	14.75"	1450	(2-22) 1425	23.6	4940 #11	1736					
								4561 #6	2881	4884	1.44	1.48	1.45	1.42
FR	2/22/91	VOP	16°C	14.5"	1425	(2-25) 1700	74.6	4503 #1	1371					
								4920 #5	2104		1.44	1.48	1.45	1.42
								4679 #4	1984					
								4942 #3	2251					
								1459 #8	1075					
								1442 #9	1151	12029				
MON	2/25/91	VOP	15°C	14.0"	1700	(2-26) 1555	22.9	4713 #12	1802		1.43	1.46	1.45	1.40
								4351 #2	3384	3878				
TUE	2/26/91	VOP	15°C	16.0"	1555	(2-27) 1515	23.3	1322 #10	1174		1.42	1.46	1.45	1.40
								4520 #6	1996	3346				
WED	2/27/91	VOP	13°C	16.0"	1515	(3-1) 1100	43.8	4814 #4	1500		1.42	1.46	1.45	1.40
								4567 #1	1536	6345				

JOB NO. 89-03 PROJECT B-18 INFILTROMETER

INFILTROMETER FIELD DATA

(6)

STATION I-1		INFILTROMETER READINGS								SWELL DATA			
DATE	FIELD ENGR	WATER TEMP.	WATER DEPTH	INITIAL TIME	FINAL TIME	TIME INTERVAL	INITIAL WT OF BAG (GRAMS)	FINAL WT OF BAG (GRAMS)	CHANGE IN WT (GRAMS)	NW CORNER Δh	NE CORNER Δh	SE CORNER Δh	SW CORNER Δh
3/1/91	VOP	13°C	16.0"	1100	(3-5) 1010	95.2	4368 #6	1010		1.42	1.46	1.45	1.40
							4982 #3	993					
							5012 #2	797					
							1376 #10	930	12008				
3/5/91	VOP	12°C	16.0"	1010	(3-6) 1041	24.5	4511 #2	3299		1.41	1.46	1.45	1.40
							5166 #11	2525	3853				
3/6/91	VOP	12°C	15.0"	1041	(3-8) 900	46.3	4565 #5	869		1.41	1.44	1.43	1.39
							1425 #9	987	4134				
3/8/91	VOP	11°C	14.9"	900	(3-8) 1330	78.5	1457 #8	671		1.40	1.42	1.41	1.39
					1530		4511 #4	705					
							4136 #1	772	7956				
3/11/91	RA	11°C	14.2"	1530	(3-13) 11.05	43.6	4474 2	1840		16.2	15.8	15.4	16.0
							4569 11	2330	4873				
3/13/91	RA	11°C	14.2"	1105	(3-18) 1330	122.4	4000 4	570		wires broke			
							3848 1	581	6697				
3/18/91	RA	10°C	14.3"	1330	(3-20) 1405	48.6	4459 11	1196		wires broke			
				1330			3937 2	2091	5109	swell data measured			
3/20/91	RA/VP	11°C	15"	1405	(3-22) 1540	49.6	4167 #6	1811 #6		by Topographic			
							4989 #12	1322 #6	6023	survey			

JOB NO. 89-03 PROJECT B-18 Testfill

INFILTROMETER FIELD DATA

STATION I-1

DATE	FIELD ENGR	INFILTROMETER READINGS: WATER TEMP.	WATER DEPTH	INITIAL TIME	FINAL TIME	TIME INTERVAL	INITIAL WT OF BAG (GRAMS)	FINAL WT OF BAG (GRAMS)	CHANGE IN WT (GRAMS)	SWELL DATA: NW CORNER Δh	NE CORNER Δh	SE CORNER Δh	SW CORNER Δh
3/22/91	TC/VP	13°C	15"	5:40	(3-25) 16:15	72.5	4504 #5	1107 #5					
							4504 #3	1413 #3	6487	wires broke			
3/25/91	TC/VP	13°C	15"	16:15	(3-27) 1435	46.4	4392 #7	944 #7					
							4417 #2	934 #2	3914	swell data measured			
3/27/91	TC/VP	12°C	14.5"	1435			4451 #5			by Topographic survey			
							4377 #3						

JOB NO. 89-03 PROJECT B-18 INFILTROMETER

INFILTROMETER FIELD DATA

+ Probe

	STATION I-1				TENSIOMETER READINGS (CENTIBARS)								
					6"	12"	12"	18"	18"	12"	12"	6"	
	DATE	TIME	FIELD ENGR	ATM. PRESSURE (IN. Hg)	1	2	3	4	5	6	7	8	
c	1/31/91	1641	VOP/JB		34	3Ø	18	18	18	24	11	16	
1	2/1/91	Ø75Ø	VOP/JB		45	54	32	32	3Ø	44	34	2Ø	
1	2/1/91	1617	VOP/RAG		45	51	4Ø	38	36	46	38	15	
2	2/2/91	Ø855	VOP	29 41	5Ø	58	5Ø	5Ø	46	52	46	—*	
2	2/2/91	135Ø	VOP		51	59	52	53	49	54	48	—	
3	2/3/91	1ØØØ	VOP		4	62	58	6Ø	54	59	52	—	
3	2/3/91	155Ø	VOP		4	6Ø	57	58	54	6Ø	51	—	
4	2/4/91	Ø717	VOP		2	62	62	62	58	62	56	—	
4	2/4/91	1645	VOP		3	61	62	62	58	62	56	=	
5	2/5/91	16Ø5	VOP		4	61	64	64	6Ø	64	58		
6	2/6/91	1442	VOP		4	62	66	66	62	64	6Ø		
7	2/7/91	1611	RG/RA		4	62	66	66	63	66	6Ø		
8	2/8/91	164Ø	VOP		4	62	68	68	66	68	58		
11	2/11/91	Ø836	VOP		2	62	72	7Ø	68	7Ø	6Ø		
12	2-12-91	1150	RG		4	52	68	72	68	72	58		
13	2/13/91	1429	VOP		3	2	64	7Ø	68	72	40		
14	2/14/91	1453	VOP		4	2	52	72	68	71	13		
⊛	2/15/91	1448	VOP		4	Ø	3Ø	7Ø	68	7Ø	6		
	2/18/91	1455	VOP		—*	Ø	6	74	7Ø	14	Ø		
	2/19/91	1528	VOP		—	Ø	6	76	7Ø	14	Ø		
	2/20/91	1551	VOP		—	Ø	6	77	7Ø	12	Ø		
	2/21/91	15ØØ	VOP		-	Ø	6	78	7Ø	12	Ø		
	2/22/91	1458	VOP		—	Ø	6	76	69	12	Ø		
	2/25/91	17Ø5	VOP		-	Ø	6	76	71	1Ø	Ø		
	2/26/91	16Ø2	VOP		-	Ø	6	76	7Ø	1Ø	Ø		
	2/27/91	152Ø	VOP		—	Ø	6	76	7Ø	1Ø	Ø		
	3/1/91	11Ø5	VOP		—	Ø	6	76	7Ø	1Ø	Ø		
	3/5/91	1Ø12	VOP		—	Ø	6	76	7Ø	9	Ø		
	3/6/91	1Ø51	VOP		—	Ø	4	77	71	8	Ø		
	3/8/91	914	VOP		—	Ø	2	78	71	8	Ø		

⊛ Refilled

JOB NO. 89-Ø3

PROJECT B-18 Infiltrometer

TENSIOMETER FIELD DATA

STATION I-1

TENSIOMETER READINGS (CENTIBARS)

DATE	TIME	FIELD ENGR	ATM. PRESSURE (IN. Hg)	1	2	3	4	5	6	7	8
3/11/91	1155	RA	29.45	—	0	3	72	65	6	8	0
3/12/91	1050	RA	29.52	—	0	6	62	65	7	6	0
3/13/91	1100	RA	29.27	—	0	2	58	66	5	4	0
3/18/91	0930	RA	29.21	—	0	2	14	62	4	2	0
3/20/91	14ØØ	RA/VP		—	Ø	2	11	58	4	2	Ø
3/21/91	1345	RA/VP		—	Ø	2	11	24	4	2	Ø
3/22/91	15:24	VP/TC		—	Ø	2	10	16	4	2	Ø
3/25/91	16:ØØ	TC/VP		—	Ø	2	8	1Ø	4	2	Ø
3/27/91	1435	TC/VP		—	Ø	2	8	1Ø	4	2	Ø

JOB NO. 89-Ø3

PROJECT B-18 Testfill

TENSIOMETER FIELD DATA

APPENDIX E.2
PHASE III CLAY SOURCE TESTING REPORT

Geosyntec consultants

3990 Old Town Avenue
Suite B-101
San Diego, CA 92110

PH 619.297.1530
FAX 619.297.1532

www.geosyntec.com

11 February 2008

Rodney Walter
Waste Management, Inc.
5903 Spring Blossom Street
Bakersfield, California 93313

Subject: Clay Source Testing: Summary of Field and Laboratory Test Results
Kettleman Hills Facility
Kettleman City, California

Dear Rodney:

Geosyntec Consultants (Geosyntec) is pleased to provide Waste Management, Inc. (WMI) with the results of our recent investigation of a proposed clay source at the Kettleman Hills Facility (KHF), located in Kings County, California. The Pecten Claystone, a clay layer located in the San Joaquin Formation on the eastern boundary of Landfill B-17 has been identified as a potential clay source for use in the liner system of the proposed Class I/II (hazardous waste) Landfill B-18 expansion (see Figure 1). Clay from this clay layer has been used for clay liners on site successfully in the past. Based on discussions with you and a review of preliminary designs for the expansion of Landfill B-18, we understand approximately 35,000 cubic yards (cy) of clay material will be needed for the first phase of the Landfill B-18 expansion.

PROJECT DESCRIPTION

The Code of Federal Regulations Part 264 (Subtitle C) and the California Code of Regulations (CCR) Titles 23 and 22 have the following requirements for the clay liner component of a hazardous waste landfill:

- The compacted soil material shall have a hydraulic conductivity of no more than $1 x 10^{-7}$ centimeters per second (cm/s),

- The clay liner shall consist of materials with at least 30 percent of the material, by weight, passing a No. 200 U.S. Standard sieve, and
- The materials shall be fine-grained soils with a significant clay content and without organic matter, in the "SC" (clayey sand), "CL" (clay, sandy or silty clay), or "CH" (clay, sandy clay) classes of the Unified Soil Classification System.

The purpose of our investigation was to evaluate whether the earthen material in the proposed clay source meets the requirements stated above and to determine the geographic extent of these materials. Our scope for this phase of work included performing a field investigation to evaluate the limit of the claystone material and collect samples, laboratory testing, and preparation of this letter report. We have also prepared plans, specifications and construction quality assurance recommendations for construction of a test pad; these documents have been provided under separate cover.

REVIEW OF EXISTING DOCUMENTATION

We have reviewed existing borings performed by others in the general vicinity of the proposed clay source. Copies of relevant and available borings in the vicinity are included in Attachment 1. We have also reviewed the following documents summarizing laboratory and field testing of clay materials used at the site in the past:

- Environmental Construction Services, Inc.., 1991, "Clay Source Report, Landfill B-18, Phase IA and IB, Kettleman Hills Faciltiy, Kettleman City, California," dated 25 November 1991.
- Environmental Solutions, Inc., 1990 "Engineering and Design Report, Landfill Unit B-18, Phases I and II and Final Closure, Kettleman Hills Facility, Kings County, California," dated August 1990.
- Environmental Solutions, Inc., 1992, "Test Fill and Infiltrometer Test Results, Landfill Unit B-18, Phases I and II and Final Closure," dated 23 January 1992.
- Golder Construction Services, 1993, "Construction Reports for Landfill B-18, Phase IIA and IIB, Volume I – Clay Source Report, Kettleman Hills Facility, Kettleman City, California," dated May 1993.

FIELD INVESTIGATION

Our field investigation was performed at the site by Layne Christensen Company on 27 November and 28 November 2008. Three borings (CS-1, CS-1A, and CS-2) were advanced to depths ranging from 21 feet to 91 feet using the hollow stem auger (HSA) drilling method. The borings were sampled at approximately 5 foot intervals with a California sampler; bulk samples of soil cuttings were also collected. Locations of the borings are shown on Figure 1. Four test pits were also excavated to depths ranging from 10 to 12 feet by KHF staff. The borings and test pits were sampled and logged in accordance with the Unified Soil Classification System by an engineer from our firm. Boring and test pit logs are provided in Attachment 2.

LABORATORY TESTING

Samples from the borings and test pits were collected and returned to our office for review. Based on a review of the boring logs and samples, laboratory tests were assigned and select soil samples were delivered to Excel Geotechnical Testing, Inc. for laboratory testing. Potential clay source material was tested for the plasticity characteristics, grain size analyses, compaction, and permeability. Results of these tests are summarized in Table 1 and are presented in Attachment 3. Laboratory testing was performed in general accordance with American Society for Testing and Materials (ASTM) standards. Hydraulic conductivity tests performed on samples collected with a California sampler were based on maximum dry density results of similar clay materials from the test pad construction for Landfill B-18 Phase I/II (Environmental Construction Services, Inc., 1991); the actual degree of relative compaction may vary for these samples. During hydraulic conductivity testing of these samples, under a confinement of 5 pounds per square inch (psi), significant swelling was noted. This suggests that the Pecten claystone materials may be considered highly expansive.

CONCLUSIONS

Based on our field investigation and a review of previous work at the site, the Pecten Claystone ranges in depth from a few feet (at the northeastern boundary) to more than 90 feet deep at the western boundary of the clay layer. The clay layer is estimated to dip to the southwest at approximately 32 degrees. The surface of this clay layer may be expected to be weathered and may contain some disturbance due to previous grading at the site in some areas.

Based on a review of the available data and the results of our field and laboratory tests, the proposed clay source is generally classified as fat clay (CH) with approximately 90 percent of material passing the No. 200 sieve. Based on preliminary laboratory testing, the laboratory hydraulic conductivity of the compacted clay is on the order of $5x10^{-9}$ cm/s to $1x10^{-8}$ cm/s when compacted to a minimum relative compaction of approximately 92 percent and at least two percent wet of the optimum moisture content. The proposed material is anticipated to generally meet the state and federal requirements for a compacted clay liner and to be suitable for use in the construction of the expansion of Landfill B-18. However, field hydraulic conductivity and laboratory hydraulic conductivity can often vary by more than an order of magnitude. Results of the test pad Sealed Double Ring Infiltrometer test, which will be performed during construction of landfill B-17 Phase A1 on material excavated from the Pecten Claystone, will provide more conclusive results on the in-situ hydraulic conductivity of the proposed material. Specifications, drawings, and construction quality assurance testing recommendations for the test pad construction have been provided under separate cover.

We appreciate the opportunity to work on this project. If you have any questions, please call Jane Soule at 619.297.1530 x 208.

Sincerely,

Jane W. Soule

Jane W. Soule, R.C.E. 59815
Project Engineer

REGISTERED PROFESSIONAL ENGINEER
JANE W. SOULE
C59815
EXP. 12/31/09
CIVIL
STATE OF CALIFORNIA

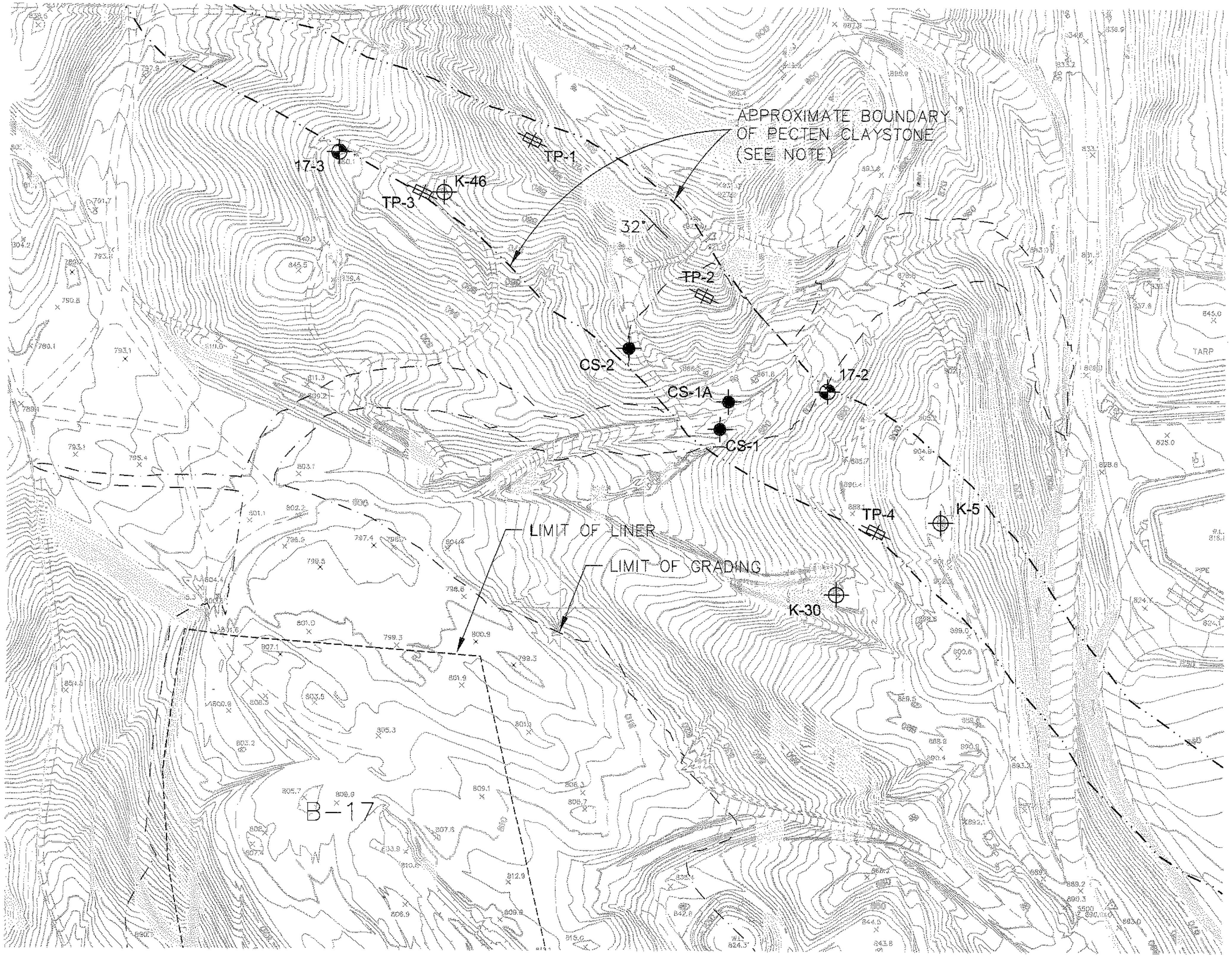
Attachments:

- Table 1: Summary of Geotechnical Laboratory Test Results
- Figure 1: Site Plan
- Attachment 1: Previous Investigations
- Attachment 2: Current Field Investigation
- Attachment 3: Laboratory Test Results

TABLE 1
SUMMARY OF GEOTECHNICAL LABORATORY TEST RESULTS
CLAY SOURCE EVALUATION - PECTEN CLAYSTONE
KETTLEMAN HILLS FACILITY, KETTLEMAN CITY, CALIFORNIA

Boring ID	Sample ID	Depth (ft)		USCS	As-Received Conditions		Sieve	Atterberg Limits			Laboratory Compaction		Hydraulic Conductivity	
		From	To		Moisture Content (D2216) (%)	Dry Density (pcf)	Fines (%)	LL (%)	PL (%)	PI (%)	Maximum Dry Density (pcf)	Optimum Moisture (%)	(cm/s)	Test Conditions (MC, RC)
CS-1	1-2	10.5	12	CH - Fat Clay	16.0		92.2	100	35	65			7.0E-08	+2, 90%*
CS-1	1-3	15	16.5											
CS-1	1-4	20	21.5	CH - Fat Clay	18.5	100.6	96.0	88	32	56				
CA-1A	Bulk 1A-1	0	5	CH - Fat Clay with Sand	12.4		76.0	55	21	34	122	12.5	7.4E-09, 9.2E-09	+3, 92%, +3, 89%
CA-1A	1A-2	10.5	12		19.3	100.3								
CA-1A	1A-3	16	16.5	MH - Elastic Silt	20.3		98.1	97	44	53				
CA-1A	1A-5	25	26.5	CH - Fat Clay	20.9	98.6	93.3	105	41	64			6.2E-08	+2, 90%*
CA-1A	1A-6	30	31.5	MH - Elastic Silt	23.1		89.6	89	39	50			9.6E-08	+2, 90%*
CA-1A	1A-7	35	36.5											
CA-1A	1A-8	40	41.5	CH - Fat Clay	21.2		89.5	78	31	47				
CA-1A	1A-9	45	46.5	CH - Fat Clay	24.4	98.2	87.7	82	35	47				
CA-1A	1A-11	55	56.5	CH - Fat Clay with Sand	18.6	95.8	84.2	58	29	29				
CA-1A	1A-13	65	66	SC - Clayey Sand	3.4		17.4							
CS-2	Bulk 2-1	0	5	CH - Fat Clay	14.1		96.3	104	36	68	113.1	15.6	3.7E-09	+3, 92%
CS-2	Bulk 2-2	6.5	10.5											
CS-2	2-2	10.5	12	CH - Fat Clay	16.5	106.4	95.2	100	34	66				
CS-2	2-4	20	21.5	CH - Fat Clay	21.0		95.3	92	39	53			8.6E-08	+2, 90%*
CS-2	2-7	35	36.5	CH - Fat Clay	21.0	100.6	89.8	93	33	60				
CS-2	2-9	45	46.5	CH - Fat Clay	24.7	99.7	98.6	104	37	67				
CS-2	2-11	55	56.5	CH - Fat Clay	24.0		96.7	82	33	49			8.2E-08	+2, 90%*
CS-2	2-13	65	66	CH - Fat Clay	25.1		98.4	112	40	72			1.7E-08	+2, 90%*
CS-2	2-14	70	71.5			97.7								
CS-2	2-16	80	81.5	CH - Fat Clay	25.4		91.1	129	41	88			5.3E-08	+2, 90%*
CS-2	2-17	85	86.5											
TP-1	TP1-1	9	10	CH - Fat Clay	20.8		93.0	100	37	63	109.9	17.8	1.1E-08	+3, 92%
TP-2	TP2-1	0	8	CH - Fat Clay	14.6		97.8	92	31	61	111.7	16.2	5.0E-09	+3, 92%
TP-3	TP3-1	11	12	CH - Fat Clay	21.9		91.1	102	35	67	108.2	17.4	6.5E-09	+3, 92%
TP-4	TP4-1	9	10	CH - Fat Clay	17.0		88.5	93	34	59	105.5	20.1	1.4E-08 4.5E-08	+3, 92%

Note: *Samples collected with a California type sampler tested for hydraulic conductivity were compacted at 90% relative compaction of the maximum dry density of similar materials from the test pad construction of Landfill B-18 Phases 1A/1B (Environmental Construction Services, 1991).



LEGEND:

- BORING, CURRENT INVESTIGATION
- TEST PIT, CURRENT INVESTIGATION
- BORING, URS (2003)
- BORING EMCON (1985)
- APPROXIMATE LIMITS OF PECTEN CLAYSTONE
- B-17 LIMIT OF GRADING
- B-17 LIMIT OF LINER

N

200 100 0 200

SCALE IN FEET

NOTE:

PECTEN CLAYSTONE LIMITS BASED ON MAPPING BY URS (2003).

SITE PLAN
LANDFILL B-17
KETTLEMAN HILLS FACILITY

Geosyntec consultants

DATE:	JAN 08	FIGURE
PROJECT NO.	SC0478	1

P:\CAD\SC0386 KMAN B-17 CON\figures\location of pecten claystone.dwg

Attachment 1: Previous Investigations

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224-01.36

BY JK/SW DATE 6/1/84 - 6/14/84

BORING NO. K-5

SURFACE ELEV. 900' MSL

CLASSIFICATION DATA			FIELD DATA						
% Fines (-No.200)	Liquid Limit	Plasticity Index		Compressive Stength (TSF)	Penetration (Blows/Ft)	Depth in Ft.	Ground Water Levels	Samples	DESCRIPTION
						0–20			Interlayered Light olive-brown (2.5Y 5/4) clayey SILTSTONE and silty CLAYSTONE; lithified (gypsum layers in top 20 feet)

REMARKS.

EMCON

PLATE A-18

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224-01.36

BY JK/SW DATE 6/1/84 - 6/14/84

BORING NO. K-5

SURFACE ELEV. 900'MSL

CLASSIFICATION DATA			FIELD DATA						DESCRIPTION
% Fines (-No.200)	Liquid Limit	Plasticity Index		Compressive Strength (TSF)	Penetration (Blows/Ft.)	Depth in Ft.	Ground Water Levels	Samples	
									Interlayered light olive-brown (2.5Y 5/4) clayey SILTSTONE and silty CLAYSTONE; lithified
						25			
						30			
						35			
						40			

REMARKS

EMCON

PLATE A-19

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224-01.36

BY JK/SW DATE 6/1/84 - 6/14/84

BORING NO. K-5

SURFACE ELEV. 900'MSL

% Fines (-No.200)	Liquid Limit	Plasticity Index	Core Re-Covery	Compressive Strength (TSF)	Penetration (Blows/Ft.)	Depth in Ft.	Ground Water Levels	Samples	DESCRIPTION
			4'					1	Light olive-brown (2.5Y 5/4) CLAYSTONE with reddish-yellow (7.5YR 6/8) 1/4-inch claystone layers; occasional light gray (10YR 7/1) fine sandstone lenses cemented with gypsum
						45			
									Light olive-brown (2.5Y 5/4) very fine, silty SANDSTONE
									Light olive-brown (2.5Y 5/4) silty CLAYSTONE
			2'					2	Light olive-brown (2.5Y 5/4) very fine, silty SANDSTONE; loose
						50			
						55			(olive-yellow (2.5Y 6/6))
									Light olive-brown, (2.5Y 5/4) silty CLAYSTONE
						60			

REMARKS:

EMCON ASSOCIATES

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224-01.36
BY JK/SW DATE 6/1/84 - 6/14/84

BORING NO. K-5
SURFACE ELEV. 900'MSL

CLASSIFICATION DATA			FIELD DATA			Depth in Ft.	Ground Water Levels	Samples	DESCRIPTION
% Fines (-No 200)	Liquid Limit	Plasticity Index		Compressive Strength (TSF)	Penetration (Blows/Ft.)				
									Olive-brown (2.5Y 5/4) clayey - sandy SILTSTONE
						65			Light olive-brown (2.5Y 5/4) CLAYSTONE
						70			Light olive-brown (2.5Y 5/4) silty SANDSTONE
						75			Light olive-brown (2.5Y 5/4) CLAYSTONE
						80			Olive-brown (2.5Y 5/4) clayey-silty, very fine SANDSTONE

REMARKS:

EMCON

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224-01.36

BY JK/SW DATE 6/1/84 - 6/14/84

BORING NO. K-5

SURFACE ELEV. 900' MSL

CLASSIFICATION DATA			FIELD DATA			Depth in Ft.	Ground Water Levels	Samples	DESCRIPTION
% Fines (-No.200)	Liquid Limit	Plasticity Index	Core Recovery	Compressive Strength (TSF)	Penetration (Blows/Ft.)				
									(gypsum at 83 feet)
									Grayish-brown (2.5Y 5/2) CLAYSTONE
						85			
									Thinly interlayered grayish-brown (2.5Y 5/2) CLAYSTONE and light olive-brown (2.5Y 5/4) SILTSTONE
						90			
			5'					3	Grayish-brown (2.5Y 5/2) to light olive-brown (2.5Y 5/4) CLAYSTONE with silty partings
									Thinly interlayered grayish-brown (2.5Y 5/2) CLAYSTONE and light olive-brown (2.5Y 5/4) SILTSTONE
						95			Light olive-brown (2.5Y 5/4) clayey SILTSTONE; woody fossils
									Light olive-brown (2.5Y 5/4) CLAYSTONE with occasional silty partings
			2'0"					4	
									Light olive-brown (2.5Y 5/4) silty, fine SANDSTONE; loose
						100			

REMARKS

EMCON ASSOCIATES

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224-01.36 BORING NO. K-5

BY JK/SW DATE 6/1/84 - 6/14/84 SURFACE ELEV. 900' MSL

CLASSIFICATION DATA			FIELD DATA						
% Fines (-No.200)	Liquid Limit	Plasticity Index		Compressive Strength (TSF)	Penetration (Blows/Ft.)	Depth in Ft.	Ground Water Levels	Samples	DESCRIPTION
									Gray (N5) CLAYSTONE
						105			
									Light olive-brown (2.5Y 5/4) very fine silty SANDSTONE
						110			Interlayered light olive-brown (2.5Y 5/4) SILTSTONE and gray (N5) CLAYSTONE
									Light olive-brown (2.5Y 5/4) very fine silty SANDSTONE
						115			
						120			

REMARKS:

EMCON

PLATE A-23

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224-01.36

BY JK/SW DATE 6/1/84 - 6/14/84

BORING NO. K-5

SURFACE ELEV. 900'MSL

CLASSIFICATION DATA			FIELD DATA						
% Fines (-No.200)	Liquid Limit	Plasticity Index		Compressive Stength (TSF)	Penetration (Blows/Ft.)	Depth in Ft.	Ground Water Levels	Samples	DESCRIPTION
									Gray (N5) CLAYSTONE
						125			
									Light olive-brown (2.5Y 5/4) very fine silty SANDSTONE
									Interlyered light olive-brown (2.5Y 5/4) SILTSTONE and gray (N5) CLAYSTONE
						130			Light olive-brown (2.5Y 5/4) fine SANDSTONE; poorly graded
									Gray (N6) CLAYSTONE
						135			Light olive-gray (2.5Y 5/4) sandy SILTSTONE
									Gray (N6) CLAYSTONE
						140			

REMARKS:

EMCON ASSOCIATES

PLATE A-24

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224-01.35 | BORING NO. K-5

BY JK/SW DATE 6/1/84 - 6/14/84 | SURFACE ELEV. 900'MSL

CLASSIFICATION DATA			FIELD DATA			Depth in Ft.	Ground Water Levels	Samples	DESCRIPTION
% Fines (-No.200)	Liquid Limit	Plasticity Index	Core Re-Covery	Compressive Strength (TSF)	Penetration (Blows/Ft.)				
									Gray (N6) CLAYSTONE
									Interlayered light olive-brown (2.5Y 5/4) CLAYSTONE and very fine SANDSTONE
			4'						Light olive-brown (2.5Y 5/6) silty, fine SANDSTONE
									Light olive-brown (2.5Y 5/4) CLAYSTONE
						145			Light olive-brown (2.5Y 5/4) slightly silty, fine SANDSTONE; poorly graded (woody fossils at 145 feet) (loose from 146 feet to 148 1/2 feet)
			1'6"						
						150			Interlayered light olive-brown (2.5Y 5/4) very fine sandy SILTSTONE and CLAYSTONE
						155			
									Light olive-brown (2.5Y 5/4) slightly silty, fine to medium SANDSTONE; well graded
						160			

REMARKS:

EMCON

PLATE A-25

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224-01.36 | BORING NO. K-5

BY JK/SW DATE 6/1/84 - 6/14/84 | SURFACE ELEV. 900'MSL

CLASSIFICATION DATA			FIELD DATA						
% Fines (-No.200)	Liquid Limit	Plasticity Index		Compressive Strength (TSF)	Penetration (Blows/Ft.)	Depth in Ft.	Ground Water Levels	Samples	DESCRIPTION
									Light olive-brown (2.5Y 5/4) slightly silty, fine to medium SANDSTONE
						165			Light olive-brown (2.5Y 5/4) sandy SILTSTONE
									Light olive-brown (2.5Y 5/4) silty, fine to medium SANDSTONE
						170			Light olive-brown (2.5Y 5/4) CLAYSTONE
									Light olive-brown (2.5Y 5/4) very silty, very fine SANDSTONE
						175			Interlayered light olive-brown (2.5Y 5/4) very fine, silty SANDSTONE and sandy SILTSTONE
						180			

REMARKS:

EMCON ASSOCIATES

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224-01.36
BY JK/SW   DATE 6/1/84 - 6/14/84

BORING NO. K-5
SURFACE ELEV. 900' MSL

CLASSIFICATION DATA			FIELD DATA						
% Fines (-No.200)	Liquid Limit	Plasticity Index	Core Re-Covery	Compressive Strength (TSF)	Penetration (Blows/Ft.)	Depth In Ft.	Ground Water Levels	Samples	DESCRIPTION
									Interlayered light olive-brown (2.5Y 5/4) very fine, silty SANDSTONE and sandy SILTSTONE
						185			(light olive brown (2.5Y 5/6))
						190			Light olive-brown (2.5Y 5/4) very fine, silty SANDSTONE; very well graded (1-inch clay stringer at 190.5 feet)
			5'						Interlayered light olive-brown (2.5Y 5/4) SILTSTONE and grayish-brown (2.5Y 5/2) CLAYSTONE
						195			Grayish-brown (2.5Y 5/2) CLAYSTONE with silty partings; iron staining present (olive-gray (5Y 4/2); woody fragments at 196 feet) (dark olive-gray (N4); no silty partings)
			5'						
						200			(olive-gray (5Y 4/2) with silty partings)

REMARKS:

emcon associates

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224-01.36
BY JK/SW DATE 6/1/84 - 6/14/84

BORING NO. K-5
SURFACE ELEV. 900'MSL

CLASSIFICATION DATA			FIELD DATA						
% Fines (-No.200)	Liquid Limit	Plasticity Index		Compressive Strength (TSF)	Penetration (Blows/Ft.)	Depth in Ft.	Ground Water Levels	Samples	DESCRIPTION
									Light olive-gray (5Y 6/2) silty SANDSTONE with occasional dark gray (N4) claystone stringers
						205			
									Dark gray (N4) CLAYSTONE
						210			
						215			
									Interlayered light olive-grey (5Y 6/2) silty, fine to medium SANDSTONE and SILTSTONE
						220			

REMARKS:

emcon

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224-01.36 | BORING NO. K-5
BY JK/SW DATE 6/1/84 - 6/14/84 | SURFACE ELEV. 900' MSL

CLASSIFICATION DATA			FIELD DATA						
% Fines (-No.200)	Liquid Limit	Plasticity Index		Compressive Strength (TSF)	Penetration (Blows/Ft.)	Depth in Ft.	Ground Water Levels	Samples	DESCRIPTION
									Interlayered light olive-gray (5Y 6/2) silty, fine to medium SANDSTONE and SILTSTONE
						225			
						230			Blue gray (N6) CLAYSTONE with silty partings
						235			
									Tan to light gray silty, very fine SANDSTONE
						240			

REMARKS:

EMCON ASSOCIATES

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224-01.36 BORING NO. K-5

BY JK/SW DATE 6/1/84 - 6/14/84 SURFACE ELEV. 900' MSL

CLASSIFICATION DATA			FIELD DATA						
% Fines (-No.200)	Liquid Limit	Plasticity Index	Core Re-Covery	Compressive Strength (TSF)	Penetration (Blows/Ft.)	Depth in Ft.	Ground Water Levels	Samples	DESCRIPTION
									Tan to light gray silty, fine SANDSTONE
			5'					9	Olive-brown (2.5Y 5/4) CLAYSTONE with orange and dark gray (N5) bands; silty to very fine sandy partings; black organics present (dark gray (N5))
						245			
									Tan to buff SILTSTONE
			5'					10	Medium gray (N6) CLAYSTONE with occasional limonite staining (slickensides at 249.5 feet)
						250			Olive-gray (5Y 5/2) silty, very fine SANDSTONE with silty layers
						255			
						260			

REMARKS:

EMCON ASSOCIATES

PLATE A-30

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224-01.36
BY JK/SW DATE 6/1/84- 6/14/84

BORING NO. K-5
SURFACE ELEV. 900'MSL

CLASSIFICATION DATA			FIELD DATA							
% Fines (No.200)	Liquid Limit	Plasticity Index		Compressive Strength (TSF)	Penetration (Blows/Ft.)	Depth in Ft.	Ground Water Levels	Samples		DESCRIPTION
										Blue gray (N6) silty CLAYSTONE with silty partings
						265				
						270				
						275				
						280				

REMARKS

PLATE A-31

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224-01.36 BORING NO. K-5

BY JK/SW DATE 6/1/84 - 6/14/84 SURFACE ELEV. 900' MSL

CLASSIFICATION DATA			FIELD DATA			Depth in Ft.	Ground Water Levels	Samples	DESCRIPTION
% Fines (-No.200)	Liquid Limit	Plasticity Index	Core Re-Covery	Compressive Strength (TSF)	Penetration (Blows/Ft.)				
									Olive-gray (5Y 6/2) silty, very fine SANDSTONE with blue gray (N5) claystone stringers
						285			Olive-gray (5Y 6/2) SILTSTONE
						290			Light gray to tan silty, fine to medium SANDSTONE
			5'					11	Brown gray (2.5Y 5/2) CLAYSTONE with occasional orange and drk gray (N4) thin beds; very fine sandy silt partings present
						295			(medium gray (N5), very silty)
		5'						12	(very silty with abundant silt partings)
									(fine sandy partings)
						300			

REMARKS:

EMCON ASSOCIATES

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224-01.36 BORING NO. K-5

BY JK/SW DATE 6/1/84 - 6/14/84 SURFACE ELEV. 900'MSL

CLASSIFICATION DATA			FIELD DATA						
% Fines (-No.200)	Liquid Limit	Plasticity Index		Compressive Strength (TSF)	Penetration (Blows/Ft.)	Depth in Ft.	Ground Water Levels	Samples	DESCRIPTION
									Blue gray (N6) silty CLAYSTONE
						305			(decrease of silt)
						310			
									Light olive (5Y 6/2) slightly silty, fine SANDSTONE with thin blue gray (N6) claystone layers
						315			
						320			

REMARKS:

EMCON ASSOCIATES

PLATE A-33

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224-01.36

BY JK/SW DATE 6/1/84 - 6/14/84

BORING NO. K-5

SURFACE ELEV. 900' MSL

CLASSIFICATION DATA			FIELD DATA			Depth in Ft.	Ground Water Levels	Samples	DESCRIPTION
% Fines (-No.200)	Liquid Limit	Plasticity Index		Compressive Strength (TSF)	Penetration (Blows/Ft.)				
									Light olive (5Y 6/2) slightly silty, fine SANDSTONE with thin blue gray (N5) claystone layers
						325			
						330			
						335			(very silty)
						340			(fine to medium grained and light gray (5Y 6/1))

REMARKS:

EMCON

PLATE A-34

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224-01.36 BORING NO. K-5

BY JK/SW DATE 6/1/84 - 6/14/84 SURFACE ELEV. 900' MSL

CLASSIFICATION DATA			FIELD DATA			Depth in Ft.	Ground Water Levels	Samples	DESCRIPTION
% Fines (-No.200)	Liquid Limit	Plasticity Index	Core Re-Covery	Compressive Stength (TSF)	Penetration (Blows/ Ft.)				
									Orange-brown (7.5YR 7/8) sandy CLAYSTONE
									Tan to light gray (10YR 5/6) silty, fine to medium SANDSTONE
			5'					13	
									(1/2-inch clayey layer)
						345			
									(1/2-inch clayey layer) (orange brown (7.5YR 7/8), clayey stringers from 346 feet to 349 feet)
			4'					14	
						350			
								15	
									(olive-gray (5y 5/2) with occasional siltstone lenses)
						355			
						360			(orange brown (7.5YR 7/8))

REMARKS.

EMCON ASSOCIATES

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224-01.36

BY JK/SW DATE 6/1/84 - 6/14/84

BORING NO. K-5

SURFACE ELEV. 900' MSL

CLASSIFICATION DATA			FIELD DATA			Depth in Ft.	Ground Water Levels	Samples	DESCRIPTION
% Fines (-No.200)	Liquid Limit	Plasticity Index		Compressive Strength (TSF)	Penetration (Blows/Ft.)				
									Orange brown (7.5YR 7/8) slightly silty, fine to medium SANDSTONE
						365			
						370			
						375			
						380			

REMARKS:

EMCON ASSOCIATES

LOG OF EXPLORATORY BORING

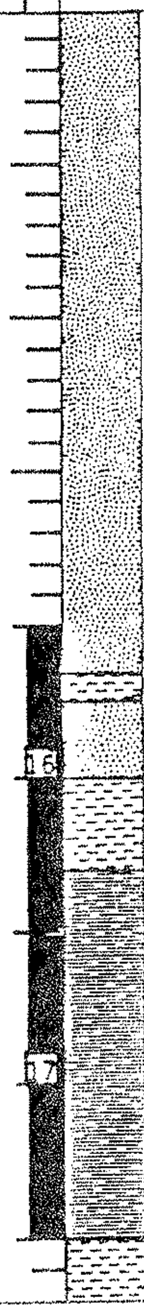
PROJECT NUMBER 224-01.36

BY JK/SW DATE 6/1/84 - 6/14/84

BORING NO. K-5

SURFACE ELEV. 900' MSL

CLASSIFICATION DATA			FIELD DATA			Depth in Ft.	Ground Water Levels	Samples	DESCRIPTION
% Fines (-No.200)	Liquid Limit	Plasticity Index	Core Re-Covery	Compressive Strength (TSF)	Penetration (Blows/Ft.)				
						385			Gray to tan slightly silty, fine to medium SANDSTONE
						390			Olive-gray (2.5Y 5/2) fine sandy SILTSTONE
			4'6"					16	Gray to tan slightly silty, fine to medium SANDSTONE
									Banded light olive-gray, black and orange clayey SILTSTONE with very fine sandy partings
						395			Dark gray (N5) CLAYSTONE with abundant very fine sandy silt partings
			3'0"					17	
						400			



REMARKS:

EMCON ASSOCIATES

PLATE A-37

LOG OF EXPLORATORY BORING

PROJECT NUMBER 244-01.36 BORING NO.K-5

BY JK/SW DATE 6/1/84 - 6/14/84 SURFACE ELEV.900' MSL

CLASSIFICATION DATA			FIELD DATA						
% Fines (-No.200)	Liquid Limit	Plasticity Index		Compressive Strength (TSF)	Penetration (Blows/Ft.)	Depth in Ft.	Ground Water Levels	Samples	DESCRIPTION
									Blue gray (N6) fine sandy SILTSTONE
									(very sandy)
						405			Blue gray (N6) silty fine to medium SANDSTONE
									Blue gray (N6) CLAYSTONE
						410			
						415			(very sandy)
						420			

REMARKS.

EMCON

LOG OF EXPLORATORY BORING

PROJECT NUMBER 244-01.36 BORING NO. K-5

BY JK/SW DATE 6/1/84 - 6/14/84 SURFACE ELEV. 900' MSL

CLASSIFICATION DATA			FIELD DATA						
% Fines (-No.200)	Liquid Limit	Plasticity Index		Compressive Strength (TSF)	Penetration (Blows/Ft.)	Depth in Ft.	Ground Water Levels	Samples	DESCRIPTION
									Blue gray (N6) sandy CLAYSTONE
						425			(decrease of sand
									(increase of sand)
						430			
						435			(very silty)
						440			

REMARKS.

EMCON ASSOCIATES

PLATE A-39

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224-01.36
BY JK/SW DATE 6/1/84 - 6/14/84

BORING NO. K-5
SURFACE ELEV. 900' MSL

CLASSIFICATION DATA			FIELD DATA						
% Fines (-No. 200)	Liquid Limit	Plasticity Index	Core Re-Covery	Compressive Strength (TSF)	Penetration (Blows/Ft.)	Depth in Ft.	Ground Water Levels	Samples	DESCRIPTION
									Dark to medium gray (N5) CLAYSTONE with tight gray very fine sandy - silty partings; black organics present
			5'					18	(very silty partings)
									(1-inch sandy layer) (very silty)
						445	▼		(blue gray (N6))
									Blue gray (N6) silty, fine SANDSTONE with shell fragments
			5'					19	Blue gray (N6) sandy-clayey SILTSTONE; very moist
									Blue gray (N6) silty CLAYSTONE with very fine sandy-silty partings
						450			
									Blue gray (N6) very fine sandy SILTSTONE
						455			
									Dark gray (N6) silty CLAYSTONE with light gray (N7) very fine sandy - silty partings
						460			

REMARKS

EMCON

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224-01.36

BY JK/SW DATE 6/1/84 - 6/14/84

BORING NO. K-5

SURFACE ELEV. 900'MSL

CLASSIFICATION DATA			FIELD DATA						
% Fines (-No.200)	Liquid Limit	Plasticity Index		Compressive Strength (TSF)	Penetration (Blows/Ft.)	Depth in Ft.	Ground Water Levels	Samples	DESCRIPTION
5									Dark gray (N6) silty CLAYSTONE with light gray (N7) very fine sandy - silty partings
						465			Interlayered dark gray (N6) CLAYSTONE and SILTSTONE
						470			Dark gray (N6) silty CLAYSTONE with light gray (N7) very fine sandy-silty partings
						475			
						480			

REMARKS.

EMCON ASSOCIATES

PLATE A-41

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224-01.36 BORING NO. K-5

BY JK/SW DATE 6/1/84 - 6/14/84 SURFACE ELEV. 900' MSL

CLASSIFICATION DATA			FIELD DATA						
% Fines (- No.200)	Liquid Limit	Plasticity Index	Core Re-Covery	Compressive Stength (TSF)	Penetration (Blows/Ft.)	Depth in Ft.	Ground Water Levels	Samples	DESCRIPTION
									Dark gary (N6) silty CLAYSTONE with light gray (N7) very fine sandy - silty partings
						485	▽		Dark gray (N4) very silty - clayey very fine SANDSTONE; black organics at 485 1/4 feet
			2'8"					20	
									(black organics at 488 1/4 feet)
						490			
			0'					21	
						495			
			2'					22	
									Dark gray (N4) very fine, silty SANDSTONE with very thin organic stringers
			1'3"			500		23	

REMARKS.

EMCON ASSOCIATES

PLATE A-4

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224-01.36 BORING NO. K-5

BY JK/SW DATE 6/1/84 - 6/14/84 SURFACE ELEV. 900'MSL

CLASSIFICATION DATA			FIELD DATA						
% Fines (-No.200)	Liquid Limit	Plasticity Index	Core Re-Covery	Compressive Stength (TSF)	Penatration (Blows/Ft.)	Depth in Ft.	Ground Water Levels	Samples	DESCRIPTION
			1'3"					23	
									Dark gray (5Y 4/1) CLAYSTONE with very fine, very silty sandy stringers
			3'			505		24	Dark gray (N4) slightly silty, fine SANDSTONE with occasional claystone stringers
			1'						Log below a depth of 508 feet obtained from adjacent borehole. Claystone at 496 feet on column below corresponds to claystone at 503 feet on above column.
						510			
						515			
						520			

REMARKS:

EMCON

PLATE A-43

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224-01.36 BORING NO. K-5

BY JK DATE 6/12/84 SURFACE ELEV. -

CLASSIFICATION DATA			FIELD DATA						
% Fines (-No.200)	Liquid Limit	Plasticity Index	Core Re-Covery	Compressive Strength (TSF)	Penetration (Blows/Ft.)	Depth in Ft.	Ground Water Levels	Samples	DESCRIPTION
			2'					25	Dark gray (5Y 4/1) CLAYSTONE with occasional sandy stringers
			0'			500		26	Dark gray (5Y 4/1) CLAYSTONE with very fine silty sandstone stringers
			1'					27	Dark gray (5Y 4/1) fine silty SANDSTONE with occasional clay stringers; very loose Dark gray (5Y 4/1) CLAYSTONE with 1/4-inch stringers
			2'			505		28	Dark gray (5Y 4/1) silty, very fine SANDSTONE with clay stringers
			4'			510		29	(3-inches with very hard caliche cement) (fine grained)
			3'			515		30	Interlayered dark gray clayey - silty, fine SANDSTONE and CLAYSTONE with abundant organics and shell fragments

REMARKS:

EMCON

PLATE A-44

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224-01.36 BORING NO. K-5

BY JK DATE 6/12/84 SURFACE ELEV. -

CLASSIFICATION DATA			FIELD DATA						
% Fines (-No.200)	Liquid Limit	Plasticity Index	Core Re-Covery	Compressive Stength (TSF)	Penetration (Blows/Ft.)	Depth in Ft.	Ground Water Levels	Samples	DESCRIPTION
			5'					30	Dark gray (5Y 4/1) very fine, very silty SANDSTONE with frequent claystone stringers
									Dark gray (5Y 4/1) CLAYSTONE with occasional sandy partings
			5'			520		31	
									BOTTOM OF BORING
						525			

REMARKS:

EMCON

PLATE A-4

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224-56.17 | BORING NO. K-30

PROJECT NAME Kettleman Hills | PAGE 1 OF 24

BY CW DATE 7/21 - 7/24/85 | SURFACE ELEV. 878.0' M.S.L.

TORVANE (TSF)	POCKET PENETROMETER (TSF)	PENETRATION (Blows/Ft.)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHOGRAPHIC COLUMN	DESCRIPTION
				0		ML	SANDY SILTSTONE, fill.
				8		SS	SILTY SANDSTONE; yellowish gray (5Y, 7/2); 40% silt; very fine grained; moderately graded; minor siltstone laminae; calcareously cemented; moderately indurated; dry.
				10	Ⓑ		
				20			

REMARKS Well K-30 was drilled with air-rotary drilling equipment to a total depth of 480 feet. The borehole was converted to a groundwater monitoring well (see Completion Diagram).

Ⓑ denotes a bag sample.

EMCON ASSOCIATES

PLATE

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224-56.17
PROJECT NAME Kettleman Hills
BY CW DATE 7/21 - 7/24/85

BORING NO. K-30
PAGE 2 OF
SURFACE ELEV. 878.0' M.S.L.

TORVANE (TSF)	POCKET PENETROMETER (TSF)	PENETRATION (Blows/Ft.)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHOGRAPHIC COLUMN	DESCRIPTION
				20	Ⓑ	SS	SILTY SANDSTONE (continued). 20% disseminated silt.
				25			
				30	Ⓑ	SS/SLST	change of color to dusky yellow (5Y,6/4); <15% silt; very fine- to fine-grained; arkosic(?); poorly graded.
				35			SANDSTONE and SILTSTONE interbedded, 2:1. sandstone: dusky yellow (5Y, 6/4). siltstone: light olive-gray (5Y, 5/2); poorly developed bedding.
				40			

REMARKS

EMCON ASSOCIATES

PLATE

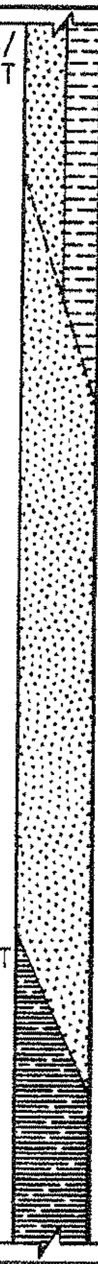
LOG OF EXPLORATORY BORING

PROJECT NUMBER 224-56.17 | BORING NO. K-30

PROJECT NAME Kettleman Hills | PAGE 3 OF 24

BY CW DATE 7/21 - 7/24/85 | SURFACE ELEV. 878.0' M.S.L.

TORVANE (TSF)	POCKET PENETROMETER (TSF)	PENETRATION (Blows/Ft.)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHOGRAPHIC COLUMN	DESCRIPTION
				40	Ⓑ	SS/ SLST	SANDSTONE and SILTSTONE interbedded (continued).
						SS	
				45			
							SANDSTONE.
				50	Ⓑ		
				55		CLST	
							SILTY CLAYSTONE; light olive-gray (5Y, 5/2); 20-30% silt; limonitic partings; poorly indurated; slightly damp.
				60			



REMARKS

EMCON ASSOCIATES

PLATE

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224-56.17 BORING NO. K-30

PROJECT NAME Kettleman Hills PAGE 4 OF

BY CW DATE 7/21 - 7/24/85 SURFACE ELEV. 878.0' M.S.L.

TORVANE (TSF)	POCKET PENETROMETER (TSF)	PENETRATION (Blows/Ft.)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHOGRAPHIC COLUMN	DESCRIPTION
				60	Ⓑ	CLST	SILTY CLAYSTONE (continued).
				65			change of color to dark gray (N3).
				70	Ⓑ		15% disseminated silt; massive.
				75			gypsum viens.
				80			

REMARKS Began water injection at 80 feet.

EMCON ASSOCIATES

PLATE

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224-56.17 BORING NO. K-30

PROJECT NAME Kettleman Hills

BY CW DATE 7/21 - 7/24/85 SURFACE ELEV. 878.0' M.S.L.

TORVANE (TSF)	POCKET PENETROMETER (TSF)	PENETRATION (Blows/Ft.)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHOGRAPHIC COLUMN	DESCRIPTION
				80	(B)	CLST	SILTY CLAYSTONE (continued). change of color to medium dark gray (N4); <10% silt.
				85			
				90	(B)		0.5"-thick beds; slightly fissile; black organic material to 100'.
				95			
				100			

REMARKS

EMCON ASSOCIATES

PLATE

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224-56.17 BORING NO. K-30

PROJECT NAME Kettleman Hills PAGE 6 OF

BY CW DATE 7/21 - 7/24/85 SURFACE ELEV. 878.0' M.S.L.

TORVANE (TSF)	POCKET PENETROMETER (TSF)	PENETRATION (Blows/Ft.)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHOGRAPHIC COLUMN	DESCRIPTION
				100	B	CLST	SILTY CLAYSTONE (continued).
				105			
				110	B		minor yellowish gray (5Y, 7/2) siltstone stringers.
				115			
				120			

REMARKS

EMCON ASSOCIATES

PLATE

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224-56.17
PROJECT NAME Kettleman Hills
BY CW DATE 7/21 - 7/24/85

BORING NO. K-30

SURFACE ELEV. 878.0' M.S.L.

TORVANE (TSF)	POCKET PENETROMETER (TSF)	PENETRATION (Blows/Ft.)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHOGRAPHIC COLUMN	DESCRIPTION
				120	B	CLST	SILTY CLAYSTONE (continued).
				125			
				130	B		*Pecten* (?) shell fragments.
				135			
				140			

REMARKS

EMCON ASSOCIATES

PLATE

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224-56.17

PROJECT NAME Kettleman Hills

BY CW DATE 7/21 - 7/24/85

BORING NO. K-30

PAGE 8 OF

SURFACE ELEV. 878.0' M.S.L.

TORVANE (TSF)	POCKET PENETROMETER (TSF)	PENETRATION (Blows/Ft.)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHOGRAPHIC COLUMN	DESCRIPTION
				140	Ⓑ	CLST	SILTY CLAYSTONE (continued). minor organic material; 1 shell fragment.
				145			
				150	Ⓑ		fine sandstone partings; organic rich.
				155			
							change of color to light olive-gray (5Y, 5/2); 20% fine disseminated sand; moderately fissile; gypsum stringers; minor fossils; minor limonitic sandstone pebbles; poorly indurated.
				160			

REMARKS

EMCON ASSOCIATES

PLATE

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224-56.17 — BORING NO. K-30

PROJECT NAME Kettleman Hills — PAGE 9 OF 24

BY CW DATE 7/21 - 7/24/85 — SURFACE ELEV. 878.0' M.S.L.

TORVANE (TSF)	POCKET PENETROMETER (TSF)	PENETRATION (Blows/Ft.)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHOGRAPHIC COLUMN	DESCRIPTION
				160	(B)	CLST	SILTY CLAYSTONE (continued).
				165			
				170	(B)		
						CLST /SLST	
				175			
							CLAYSTONE and SANDY SILTSTONE interbedded, 2:1. claystone: medium dark gray (N4); sandstone partings. siltstone: light olive-gray (5Y, 6/2); 20-30% very fine sand; minor very limonitic, moderately indurated, fine sandstone laminae.
				180			

REMARKS

EMCON ASSOCIATES

PLATE

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224-56.17 | BORING NO. K-30

PROJECT NAME Kettleman Hills | PAGE 10 OF

BY CW DATE 7/21 - 7/24/85 | SURFACE ELEV. 878.0' M.S.L.

TORVANE (TSF)	POCKET PENETRO-METER (TSF)	PENETRATION (Blows/Ft.)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHO-GRAPHIC COLUMN	DESCRIPTION
				180	(B)	CLST/ SLST	CLAYSTONE and SANDY SILTSTONE interbedded (continued).
				185			
							very poor cuttings return.
				190	(B)		
				195			
				200			

REMARKS

EMCON ASSOCIATES

PLATE

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224-56.17 BORING NO. K-30

PROJECT NAME Kettleman Hills

BY CW DATE 7/21 - 7/24/85 SURFACE ELEV. 878.0' M.S.L.

TORVANE (TSF)	POCKET PENETROMETER (TSF)	PENETRATION (Blows/Ft.)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHOGRAPHIC COLUMN	DESCRIPTION
				200	B	CLST /SLST	CLAYSTONE and SANDY SILTSTONE interbedded (continued). CLST:SLST = 1:1. increase of disseminated sand within the siltstone portion.
						SS	
				205			
							SILTY SANDSTONE; dusky yellow (5Y, 6/4); very fine- to fine-grained; quartzose; moderately graded; claystone laminae; limonitic staining.
				210	B		
							change of color to dark yellowish orange (10YR, 6/6); 40% silt; fine grained; quartzose; iron-oxide cement; abundant organics; poorly indurated.
				215			
				220			

REMARKS

EMCON ASSOCIATES

PLATE

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224-56.17

PROJECT NAME Kettleman Hills

BY CW DATE 7/21 - 7/24/85

BORING NO. K-30

PAGE 12 OF

SURFACE ELEV. 878.0' M.S.L.

TORVANE (TSF)	POCKET PENETROMETER (TSF)	PENETRATION (Blows/Ft.)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHOGRAPHIC COLUMN	DESCRIPTION
				220	Ⓡ	SS	SILTY SANDSTONE (continued).
				225		SLST/SS	
							SILTSTONE and SANDSTONE interbedded, 2:1. siltstone: light olive-gray (5Y, 5/2); < ½"-thick beds; fissile; limonitic partings. sandstone: dark yellowish orange (10YR, 6/6).
				230	Ⓡ		
				235			
				240			

REMARKS

EMCON ASSOCIATES

PLATE

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224-56.17 BORING NO. K-30

PROJECT NAME Kettleman Hills

BY CW DATE 7/21 - 7/24/85 SURFACE ELEV. 878.0' M.S.L.

TORVANE (TSF)	POCKET PENETROMETER (TSF)	PENETRATION (Blows/Ft.)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHOGRAPHIC COLUMN	DESCRIPTION
				240	B	SLST /SS	SILTSTONE and SANDSTONE interbedded (continued).
				245			
				250	B		
				255			
				260			

REMARKS

EMCON ASSOCIATES

PLATE

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224-56.17
PROJECT NAME Kettleman Hills
BY CW DATE 7/21 - 7/24/85

BORING NO. K-30
PAGE 14 OF
SURFACE ELEV. 878.0' M.S.L.

TORVANE (TSF)	POCKET PENETROMETER (TSF)	PENETRATION (Blows/Ft.)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHOGRAPHIC COLUMN	DESCRIPTION
				260	Ⓑ	SLST /SS	SILTSTONE AND SANDSTONE interbedded (continued). @ 260': organic interbeds(?).
						SS	
				265			
							SANDSTONE; dusky yellow (5Y, 6/4); 20% silt; fine grained; quartzose; moderately graded; gypsum stringers; organics; moderately indurated; harder drilling.
				270	Ⓑ		
				275			
				280			

REMARKS

EMCON ASSOCIATES

PLATE

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224-56.17 | BORING NO. K-30

PROJECT NAME Kettleman Hills | PAGE 15 OF 24

BY CW DATE 7/21 - 7/24/85 | SURFACE ELEV. 878.0' M.S.L.

TORVANE (TSF)	POCKET PENETRO-METER (TSF)	PENETRA-TION (Blows/Ft.)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHO-GRAPHIC COLUMN	DESCRIPTION
				280	Ⓑ	SS	SANDSTONE (continued).
				285			
							30% siltstone interbeds.
				290	Ⓑ		
				295		SS/ SLST	
							SILTY SANDSTONE and SILTSTONE interbedded (continued on next page).
				300			

REMARKS

EMCON ASSOCIATES

PLATE

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224-56.17

BORING NO. K-30

PROJECT NAME Kettleman Hills

PAGE 16 OF

BY CW DATE 7/21 - 7/24/85

SURFACE ELEV. 878.0' M.S.L.

TORVANE (TSF)	POCKET PENETRO-METER (TSF)	PENETRATION (Blows/Ft.)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHO-GRAPHIC COLUMN	DESCRIPTION
				300	Ⓑ	SS/ SLST	SILTY SANDSTONE and SILTSTONE interbedded. silty sandstone: light olive-brown (5Y, 5/6); very fine grained; quartzose. siltstone: light olive-brown (5Y, 5/6); thinly bedded; sandstone partings; fissile.
				305			
				310	Ⓑ		
						CLST /SLST	CLAYSTONE and SILTSTONE interbedded, 1:1. claystone: medium dark gray (N4); fissile; poorly indurated. siltstone: light olive-brown (5Y, 5/6); fine to very fine sandstone partings; fissile; poorly indurated.
				315			
				320			

REMARKS

EMCON ASSOCIATES

PLATE

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224-56.17 BORING NO. K-30

PROJECT NAME Kettleman Hills PAGE 17 OF 24

BY CW DATE 7/21 - 7/24/85 SURFACE ELEV. 878.0' M.S.L.

TORVANE (TSF)	POCKET PENETROMETER (TSF)	PENETRATION (Blows/Ft.)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHOGRAPHIC COLUMN	DESCRIPTION
				320	B	CLST /SLST	CLAYSTONE and SILTSTONE interbedded (continued).
				325			
				330	B		siltstone portion becomes sandy; limonitic staining.
				335			gypsum stringers.
				340			

REMARKS

EMCON ASSOCIATES

PLATE

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224-56.17
PROJECT NAME Kettleman Hills
BY CW DATE 7/21 - 7/24/85

BORING NO. K-30
PAGE 18 OF
SURFACE ELEV. 878.0' M.S.L.

TORVANE (TSF)	POCKET PENETRO-METER (TSF)	PENETRATION (Blows/Ft.)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHOGRAPHIC COLUMN	DESCRIPTION
				340	B	CLST /SLST	CLAYSTONE and SILTSTONE interbedded (continued). CLST:SLST = 7:3.
				345			
				350	B		
						CLST	
				355			SILTY CLAYSTONE; medium dark gray (N4); 15-20% light olive-brown (5Y, 5/6) siltstone interbeds; moderately fissile; poorly indurated.
				360			

REMARKS

EMCON ASSOCIATES

PLATE

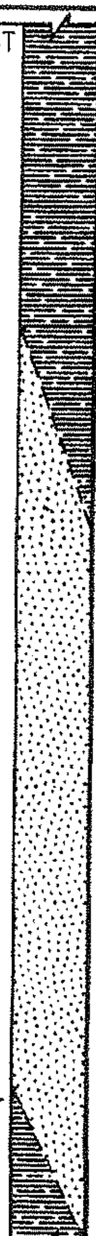
LOG OF EXPLORATORY BORING

PROJECT NUMBER 224-56.17 BORING NO. K-30

PROJECT NAME Kettleman Hills PAGE 19 OF 24

BY CW DATE 7/21 - 7/24/85 SURFACE ELEV. 878.0' M.S.L.

TORVANE (TSF)	POCKET PENETROMETER (TSF)	PENETRATION (Blows/Ft.)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHOGRAPHIC COLUMN	DESCRIPTION
				360	B	CLST	SILTY CLAYSTONE (continued).
				365		SS	
							SILTY SANDSTONE; moderate yellowish brown (10YR, 5/4); 30-40% silt; very fine- to fine-grained; arkosic; limonitic cementation; moderately indurated.
				370	B		
				375			
						CLST	
				380			CLAYSTONE (continued on next page).



REMARKS

EMCON ASSOCIATES

PLATE

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224-56.17

PROJECT NAME Kettleman Hills

BY CW DATE 7/21 - 7/24/85

BORING NO. K-30

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SURFACE ELEV. 878.0' M.S.L.

TORVANE (TSF)	POCKET PENETRO-METER (TSF)	PENETRATION (Blows/Ft.)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHO-GRAPHIC COLUMN	DESCRIPTION
				380	Ⓑ	CLST	CLAYSTONE; medium dark gray (N4); no silt-stone beds; organic material.
				385			
				390	Ⓑ		occasional moderate yellowish brown (10YR, 5/4); limonitic, very fine, silty sandstone interbeds.
				395			
				400			

REMARKS

EMCON ASSOCIATES

PLATE

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224-56.17
PROJECT NAME Kettleman Hills
BY CW DATE 7/21 - 7/24/85

BORING NO. K-30

SURFACE ELEV. 878.0' M.S.L.

TORVANE (TSF)	POCKET PENETROMETER (TSF)	PENETRATION (Blows/Ft.)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHOGRAPHIC COLUMN	DESCRIPTION
				400	(B)	CLST	CLAYSTONE (continued). 10% moderate yellowish brown (10YR, 5/4) siltstone interbeds.
				405			
						CLST /SS	SILTY CLAYSTONE and SANDSTONE interbedded. silty claystone: medium dark gray (N4). sandstone: moderate yellowish brown (10YR, 5/4); very fine grained; limonitic staining.
				410	(B)		
						CLST	CLAYSTONE; dark greenish gray (5GY, 4/1); slightly fissile; slickensides(?); shell fragments; minor organic material.
				415			
				420			

REMARKS

EMCON ASSOCIATES

PLATE

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224-56.17

PROJECT NAME Kettleman Hills

BY CW DATE 7/21 - 7/24/85

BORING NO. K-30

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SURFACE ELEV. 878.0' M.S.L.

TORVANE (TSF)	POCKET PENETRO-METER (TSF)	PENETRATION (Blows/Ft.)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHO-GRAPHIC COLUMN	DESCRIPTION
				420	(B)	CLST	CLAYSTONE (continued).
				425			
				430	(B)		minor very silty claystone interbeds; abundant organic material.
			▼	435			
			▽	440			

REMARKS

EMCON ASSOCIATES

PLATE

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224-56.17 BORING NO. K-30

PROJECT NAME Kettleman Hills PAGE 23 OF 24

BY CW DATE 7/21 - 7/24/85 SURFACE ELEV. 878.0' M.S.L.

TORVANE (TSF)	POCKET PENETROMETER (TSF)	PENETRATION (Blows/Ft.)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHOGRAPHIC COLUMN	DESCRIPTION
				440		SS	SANDSTONE; dark gray (N3); no clay or silt; fine- to medium-grained; quartzose; mafics; poorly graded; subrounded to well rounded; friable; wet(?).
			Rec. 0.0'	445			
			Rec. 0.0'	450			
			Rec. 0.0'	455			@ 455': color change to medium dark gray to dark gray (N4 to N3); <5% silt; quartzose; 10% lithics; rounded; massive; moderately to poorly indurated.
			CORE BOX 1 Rec. 5.0'	460			

REMARKS The borehole was continuously cored from 440- to 480-feet.

EMCON ASSOCIATES

PLATE

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224-56.17
PROJECT NAME Kettleman Hills
BY CW DATE 7/21 - 7/24/85

BORING NO. K-30
PAGE 24 OF
SURFACE ELEV. 878.0' M.S.L.

TORVANE (TSF)	POCKET PENETROMETER (TSF)	PENETRATION (Blows/Ft.)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHOGRAPHIC COLUMN	DESCRIPTION
			CORE BOX 2 Rec. 4.5'	460		SS	SANDSTONE (continued). @ 461': <10% disseminated silt. @ 464'-465': friable.
			CORE BOX 3 Rec. 5.0'	465			@ 466': 42° dip. @ 466.5': change of grain size to fine. @ 469'-469.5': 0.5"-thick siltstone interbeds deposited every 0.5".
			CORE BOX 4 Rec. 5.0'	470			@ 472': <5% disseminated silt and cl[illegible] fine- to medium-grained; quartzose; 20% lithics; siltstone laminae deposited every 0.5'; poorly indurated. @ 474.5'-475': friable. @ 475': change of grain size to medium to very fine; moderately to poorly graded; massive. @ 476'-477.5': unit becomes a silty sandstone to a sandy siltstone with 50% disseminated silt; very fine grained
			CORE BOX 5 Rec. 5.0'	475		SLST	SILTSTONE; medium dark gray (N4); 10-20% sandstone interbeds; 0.25"- to 0.5"-thick beds; organic laminae; poorly indurated. @ 477.5'-478.5': no sand; massive. @ 478.5': <25% very fine sandstone laminae; <30° dip.
				480			TERMINATED BORING AT 480 FEET.

REMARKS

EMCON ASSOCIATES

PLATE

MONITORING WELL K-30

LOKI 2

NORTHING: 230115.9
EASTING: 1700113.4

Well Construction Data[2]			Date Measured
TOC (TOSP) Elevation[3]:	878.83	ft. MSL	96-Apr-01
Ground Surface Elevation	877.7	ft. MSL	87-Nov-22
TOTAL WELL DEPTH:	465	ft. BGS.	87-Nov-22
TOTAL BOREHOLE DEPTH:	480	ft. BGS.	87-Nov-22
easured Depth to Top of Sand Pack:	421	ft. BGS.	87-Nov-22 457.83
Measured Depth to Top of Screen:	435	ft. BGS.	87-Nov-22 445.??
Measured Depth to Pump Intake[4]:	457.8	ft. BGS.	87-Nov-22
Measured Depth to Water:	433.40	ft. BTOC	96-Dec-01

Well Deviation Calculations[1]

Measurement	True Vertical Depth	Ref.	True Vertical Elevation	Ref.
WELL TD:	463.45	ft. BGS.	414.20	ft. MSL
Top of Sand :	419.92	ft. BGS.	457.73	ft. MSL
Top of Screen :	433.61	ft. BGS.	444.04	ft. MSL
Pump Intake :	455.66	ft. BGS.	421.99	ft. MSL
GW Measurement:	432.03	ft. BTOC	446.80	ft. MSL

Well Deviation Survey Results

Measured Depth (ft.)	Course Length (ft.)	Drift/Deviation Angle (°)	Vertical Course (ft.)	True Vertical Depth (ft.)	True Elevation (MSL)
0	0	0.0	0	0	877.65
25	25	0.2	25.0	25.0	852.65
50	25	0.6	25.0	50.0	827.65
75	25	1.1	25.0	75.0	802.66
100	25	1.8	25.0	100.0	777.67
125	25	2.6	25.0	125.0	752.69
150	25	3.6	25.0	149.9	727.74
175	25	3.2	25.0	174.9	702.78
200	25	2.9	25.0	199.8	677.81
225	25	3.4	25.0	224.8	652.86
250	25	3.9	24.9	249.7	627.92
275	25	4.9	24.9	274.6	603.01
300	25	4.2	24.9	299.6	578.07
325	25	5.7	24.9	324.5	553.20
350	25	6.0	24.9	349.3	528.34
375	25	6.4	24.8	374.2	503.49
400	25	5.9	24.9	399.0	478.62
425	25	8.8	24.7	423.7	453.92
450	25	6.7	24.8	448.6	429.09
462	12	5.1	12.0	460.5	417.14

Date Installed: 85-Jul-24
Well Deviation Survey Date: 85-Jul-29

Notes: 1. True Vertical Depth and True Vertical Elevation calculations based on closest previous deviation measurement (i.e. for 460', use deviation measured at 450')
2. Well Construction Data from Emcon, (1985) and site records.
3. TOC elevations & GW Measurements provided by R. Reed, CWMI
4. Pump Intake Depth = Pump depth-(TOC-GSE).

WELENCO, INC. 4817 DISTRICT BLVD. BAKERSFIELD, CA 93309

SURVEY DATA SHEET

COMPANY EMCON ASSOCIATES ADDRESS 90 ARCHER ST., SAN JOSE, CA 95112 7-29-85

WELL #K-30 (CASED HOLE) FIELD KETTLEMAN HILLS COUNTY KINGS STATE CA

ASURED PTH	COURSE LENGTH	DEVIATION ANGLE	VERTICAL DEPTH COURSE	VERTICAL DEPTH TOTAL	COURSE DEVIA-TION	DIRECTION OF DEVIATION	COURSE LATITUDE NORTH	COURSE LATITUDE SOUTH	COURSE DEPARTURE EAST	COURSE DEPARTURE WEST	TOTAL LATITUDE NORTH	TOTAL LATITUDE SOUTH	TOTAL DEPARTURE EAST	TOTAL DEPARTURE WEST
0.0	0.0	0.2	0.0	0.0	0.0	N 36 E	-	-	-	-	-	-	-	-
25.0	25.0	0.2	25.0	25.0	0.1	N 54 E	0.1	-	0.1	-	-	-	-	-
50.0	25.0	0.6	25.0	50.0	0.3	N 61 E	0.1	-	0.2	-	0.1	-	0.1	-
75.0	25.0	1.1	25.0	75.0	0.5	N 66 E	0.2	-	0.4	-	0.2	-	0.3	-
00.0	25.0	1.8	25.0	100.0	0.8	N 76 E	0.2	-	0.8	-	0.4	-	0.7	-
25.0	25.0	2.6	25.0	125.0	1.1	N 68 E	0.4	-	1.1	-	0.6	-	1.5	-
50.0	25.0	3.6	25.0	149.9	1.6	N 72 E	0.5	-	1.5	-	1.0	-	2.6	-
75.0	25.0	3.2	25.0	174.9	1.4	N 71 E	0.5	-	1.3	-	1.5	-	4.0	-
00.0	25.0	2.9	25.0	199.8	1.3	N 71 E	0.4	-	1.2	-	1.9	-	5.4	-
25.0	25.0	3.4	25.0	224.8	1.5	N 69 E	0.5	-	1.4	-	2.3	-	6.6	-
50.0	25.0	3.9	24.9	249.7	1.7	N 70 E	0.6	-	1.6	-	2.9	-	7.9	-
75.0	25.0	4.9	24.9	274.6	2.1	N 68 E	0.8	-	2.0	-	3.5	-	9.5	-
00.0	25.0	4.2	24.9	299.6	1.8	N 74 E	0.5	-	1.8	-	4.3	-	11.5	-
25.0	25.0	5.7	24.9	324.5	2.5	N 73 E	0.7	-	2.4	-	4.8	-	13.3	-
50.0	25.0	6.0	24.9	349.3	2.6	N 72 E	0.8	-	2.5	-	5.5	-	15.7	-
5.0	25.0	6.4	24.9	374.2	2.8	N 73 E	0.8	-	2.7	-	6.3	-	18.1	-
0.0	25.0	5.9	24.9	399.0	2.6	N 71 E	0.8	-	2.4	-	7.1	-	20.8	-
5.0	25.0	8.8	24.7	423.7	3.8	N 72 E	1.2	-	3.6	-	7.9	-	23.2	-
0.0	25.0	6.7	24.8	448.6	2.9	N 72 E	0.9	-	2.8	-	9.1	-	26.9	-
2.0	12.0	5.1	12.0	460.5	1.1	N 70 E	0.4	-	1.0	-	10.0	-	29.6	-
											10.4	-	30.7	-
				CLOSURE:			32.4	FT.	N 70°	E				
				TOTAL VERTICAL DEPTH:			460.5	FT.						
				BEARING:			70°							

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224 - 56.33
PROJECT NAME Kettleman Hills
BY MAC, BB DATE 10/9 - 10/10/85

BORING NO. K-46(RD-2)
PAGE 1 OF
SURFACE ELEV. 871.30' M.S.L.

TORVANE (TSF)	POCKET PENETRO-METER (TSF)	PENETRATION (Blows/Ft.)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHOGRAPHIC COLUMN	DESCRIPTION
				0		CLST	SILTY CLAYSTONE; grayish olive (10Y,4/2); 30% silt; 10% very fine sandstone laminae with limonitic staining. 10' with gypsum viening; very poorly indurated.
				5			
				10	(B)		
				15			
				20			

REMARKS Borings K-46 and K-46(RD-1) were plugged and abandoned as a result of swollen claystone beds blocking the passage of PVC casing. Well K-46(RD-2) was located 65 feet east of K-46(RD-1). K-46(RD-2) was drilled with air-rotary drilling equipment to a total depth of 461 feet. During the completion procedures mud-rotary drilling methods were employed. The borehole was converted to a ground-water monitoring well (see Completion Diagram).

PLATE

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BORING NO. K-46(RD-2
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SURFACE ELEV. 871.30' M.S.L.

TORVANE (TSF)	POCKET PENETROMETER (TSF)	PENETRATION (Blows/Ft.)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHOGRAPHIC COLUMN	DESCRIPTION
				20	(B)	CLST	SILTY CLAYSTONE (Continued). 20% disseminated silt.
				25			
				30	(B)		occasional gypsum stringers.
				35			
				40			

REMARKS (B) denotes bag sample.
Began water injection at 32 feet.

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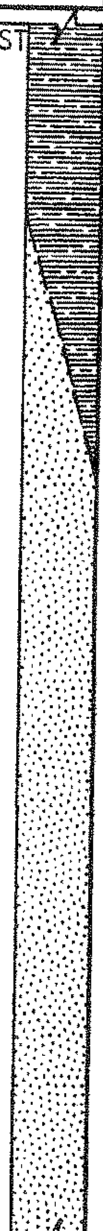
SURFACE ELEV. 871.30' M.S.L.

TORVANE (TSF)	POCKET PENETROMETER (TSF)	PENETRATION (Blows/Ft.)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHOGRAPHIC COLUMN	DESCRIPTION
				40	(B)	CLST	SILTY CLAYSTONE (Continued).
						SS	
				45			
							SANDSTONE; moderate olive-brown (5Y,4/4); 5% silt; very fine-to fine-grained; quartzose; lithic; minor cementatio friable to poorly indurated.
				50	(B)		
				55			
				60			increase of black mica content.



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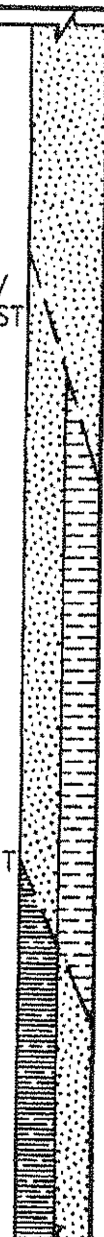
BORING NO. K-46(RD.2

SURFACE ELEV. 871.30' M.S.L.

TORVANE (TSF)	POCKET PENETROMETER (TSF)	PENETRATION (Blows/Ft.)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHOGRAPHIC COLUMN	DESCRIPTION
				60	(B)	SS	SANDSTONE (Continued).
				65		SS/SLST	SANDSTONE and SILTSTONE interbedded, 3:2. sandstone: light olive-brown (5Y, 5/6). siltstone: light olive-brown (5Y, 5/6).
				70	(B)		
				75		CLST/SS	CLAYSTONE and SANDSTONE interbedded, 13:7 claystone: light olive-brown (5Y, 5/6). sandstone: light olive-brown (5Y, 5/6). very fine grained.
				80			



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SURFACE ELEV. 871.30' M.S.L.

TORVANE (TSF)	POCKET PENETROMETER (TSF)	PENETRATION (Blows/Ft.)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHOGRAPHIC COLUMN	DESCRIPTION
				80	(B)	CLST/SS	CLAYSTONE and SANDSTONE interbedded (Continued).
				85			
				90	(B)	CLST	CLAYSTONE, light olive-gray (5Y, 5/2).
				95		SS	SANDSTONE (Continued on next page).
				100			

REMARKS

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SURFACE ELEV. 871.30' M.S.L.

TORVANE (TSF)	POCKET PENETROMETER (TSF)	PENETRATION (Blows/Ft.)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHOGRAPHIC COLUMN	DESCRIPTION
				100	(B)	SS	SANDSTONE; light olive-brown (5Y, 5/6); 10% silt; fine grained; 15% medium and coarse; 15-20% claystone laminae; minor medium to coarse, dark lithics.
				105			
				110	(B)		20% disseminated silt; 5-10% claystone.
				115		SS/ SLST	SANDSTONE and SILTSTONE interbedded, 7:3. sandstone: light olive-brown (5Y, 5/6) fine-to medium-grained; quartzose; abundant pelecypod(?) shell fragments; bone(?) fragments. siltstone: olive (10Y, 5/2).
				120			

REMARKS

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SURFACE ELEV. 871.30' M.S.L.

TORVANE (TSF)	POCKET PENETROMETER (TSF)	PENETRATION (Blows/Ft.)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHOGRAPHIC COLUMN	DESCRIPTION
				120	(B)	SS/ SLST	SANDSTONE and SILTSTONE interbedded (Continued). siltstone comprises the major portion of the unit.
				125			
						CLST	CLAYSTONE; moderate olive-brown (5Y, 4/
				130	(B)		
				135			
				140			

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SURFACE ELEV. 871.30' M.S.L.

TORVANE (TSF)	POCKET PENETRO-METER (TSF)	PENETRATION (Blows/Ft.)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHOGRAPHIC COLUMN	DESCRIPTION
				140	(B)	CLST	CLAYSTONE (Continued).
				145			
				150	(B)		
				155		SLST	
							SILTSTONE; olive (10Y, 5/2).
				160			

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SURFACE ELEV. 871.30' M.S.L.

TORVANE (TSF)	POCKET PENETROMETER (TSF)	PENETRATION (Blows/Ft.)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHOGRAPHIC COLUMN	DESCRIPTION
				160	(B)	SLST	SILTSTONE (Continued).
				165			
				170	(B)		
				175		SLST/ SS	SILTSTONE and SANDSTONE interbedded. siltstone: olive (10Y, 5/2). sandstone: olive (10Y, 5/2); fine-to medium-grained.
				180			

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SURFACE ELEV. 871.30' M.S.L.

TORVANE (TSF)	POCKET PENETROMETER (TSF)	PENETRATION (Blows/Ft.)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHOGRAPHIC COLUMN	DESCRIPTION
				180	(B)	SLST /SS	SILTSTONE and SANDSTONE interbedded (Continued).
				185		SLST	
							SANDY SILTSTONE; olive (10Y, 5/2).
				190	(B)		
				195			
				200			

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SURFACE ELEV. 871.30' M.S.L.

TORVANE (TSF)	POCKET PENETROMETER (TSF)	PENETRATION (Blows/Ft.)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHOGRAPHIC COLUMN	DESCRIPTION
				200	B	SLST	SANDY SILTSTONE (Continued).
				205			
				210	B		
				215			
				220			

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SURFACE ELEV. 871.30' M.S.L.

TORVANE (TSF)	POCKET PENETROMETER (TSF)	PENETRATION (Blows/Ft.)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHOGRAPHIC COLUMN	DESCRIPTION
				220	(B)	SLST	SANDY SILTSTONE (Continued).
				225		SS	SILTY SANDSTONE; light olive-brown (5Y, 5/6); 20% silt; fine-to medium-grained; quartzose; lithic; poorly graded.
				230	(B)		
				235		SLST	
				240			SILTSTONE; grayish olive (10Y, 4/2); <5% very fine sand; occasional limonitic staining.

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SURFACE ELEV. 871.30' M.S.L.

TORVANE (TSF)	POCKET PENETROMETER (TSF)	PENETRATION (Blows/Ft.)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHOGRAPHIC COLUMN	DESCRIPTION
				240	(B)	SLST	SILTSTONE (Continued).
				245		CLST/SLST	
							CLAYSTONE and SILTSTONE interbedded. 10% limonitic, very fine sandstone laminae.
				250	(B)		
				255			
				260			

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SURFACE ELEV. 871.30' M.S.L.

TORVANE (TSF)	POCKET PENETROMETER (TSF)	PENETRATION (Blows/Ft.)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHOGRAPHIC COLUMN	DESCRIPTION
				260	B	CLST /SLST	CLAYSTONE and SILTSTONE interbedded (Continued).
						CLST /SS	CLAYSTONE and SANDSTONE interbedded.
				265			
				270	B		
						SS/ SLST	SANDSTONE and SILTSTONE interbedded, 3:2. sandstone: light olive-brown (5Y, 5/6); fine-to medium- grained; quartzose; lithic. siltstone: grayish olive (10Y, 4/2).
				275			
				280			

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SURFACE ELEV. 871.30' M.S.L.

TORVANE (TSF)	POCKET PENETROMETER (TSF)	PENETRATION (Blows/Ft.)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHOGRAPHIC COLUMN	DESCRIPTION
				280	(B)	SS/ SLST	SANDSTONE and SILTSTONE interbedded (Continued).
				285		SLST/ CLST	
							SILTSTONE and CLAYSTONE interbedded, 3:2. siltstone: light olive-gray (5Y, 5/2). claystone: greenish black (5GY, 2/1).
				290	(B)		
							harder drilling.
				295			
				300			

REMARKS

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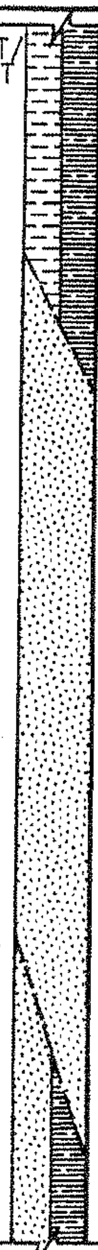
SURFACE ELEV. 871.30' M.S.L.

TORVANE (TSF)	POCKET PENETROMETER (TSF)	PENETRATION (Blows/Ft.)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHOGRAPHIC COLUMN	DESCRIPTION
				300	(B)	SLST/ CLST	SILTSTONE and CLAYSTONE interbedded (Continued).
				305		SS	CLAYEY SANDSTONE; light olive-brown (5Y, 5/6); 20-25% clay; very fine grained; quartzose; poorly graded.
				310	(B)		
				315		SS/ CLST	SANDSTONE and CLAYSTONE interbedded. sandstone: light olive-brown (5Y, 5/6).
				320			



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SURFACE ELEV. 871.30' M.S.L.

TORVANE (TSF)	POCKET PENETRO-METER (TSF)	PENETRA-TION (Blows/Ft.)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHO-GRAPHIC COLUMN	DESCRIPTION
				320	(B)	SS/ CLST	SANDSTONE and CLAYSTONE interbedded (Continued).
						CLST	CLAYSTONE; greenish black (5G, 2/1); 10-15% siltstone laminae; 5% very fine sandstone laminae.
				325			
				330	(B)		
				335			
				340			

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SURFACE ELEV. 871.30' M.S.L.

TORVANE (TSF)	POCKET PENETRO-METER (TSF)	PENETRATION (Blows/Ft.)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHOGRAPHIC COLUMN	DESCRIPTION
				340	(B)	CLST	CLAYSTONE (Continued).
						SS	CLAYEY SANDSTONE; light olive-brown (5Y, 4/4); 15% clay; very fine grained; poorly graded; 10% claystone laminae.
						CLST	
				345			
							CLAYSTONE; dark greenish gray (5G, 4/1); 15-20% grayish olive (10Y, 4/2) and yellowish brown (5Y, 5/4) siltstone interbeds.
				350	(B)		
				355			
				360			

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SURFACE ELEV. 871.30' M.S.L.

TORVANE (TSF)	POCKET PENETROMETER (TSF)	PENETRATION (Blows/Ft.)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHOGRAPHIC COLUMN	DESCRIPTION
				360	B	CLST	CLAYSTONE (Continued).
				365			
				370	B		
				375		SS/ CLST	SANDSTONE and CLAYSTONE interbedded, 1:1. sandstone: light olive-brown (5Y,5/4); very fine-to fine-grained; micaceous; poorly graded. claystone: dark greenish gray (5G, 4/1).
				380			

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SURFACE ELEV. 871.30' M.S.L.

TORVANE (TSF)	POCKET PENETROMETER (TSF)	PENETRATION (Blows/Ft.)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHOGRAPHIC COLUMN	DESCRIPTION
				380	(B)	SS/ CLST	SANDSTONE and CLAYSTONE interbedded (Continued).
						CLST	
				385			
							CLAYSTONE; dark greenish gray (5G, 4/1); 5% sand; 10% sandstone laminae; 15-20% siltstone laminae; black organic laminae; pyrite nodules; occasional gypsum veins.
				390	(B)		
							harder drilling.
				395			
				400			

REMARKS

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SURFACE ELEV. 871.30' M.S.L.

TORVANE (TSF)	POCKET PENETROMETER (TSF)	PENETRATION (Blows/Ft.)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHOGRAPHIC COLUMN	DESCRIPTION
				400	(B)	CLST	CLAYSTONE (Continued).
				405			harder drilling.
				410	(B)		harder drilling.
				415			
							harder drilling.
				420			

REMARKS

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SURFACE ELEV. 871.30' M.S.L.

TORVANE (TSF)	POCKET PENETROMETER (TSF)	PENETRATION (Blows/Ft.)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHOGRAPHIC COLUMN	DESCRIPTION
			CORE BOX 1 REC. 5.0'	420		CLST	CLAYSTONE (Continued). @ 420': color change to greenish black (5GY, 2/1); 40% fine to medium, quartzose, 50% lithics, moderate to well graded, angular to subangular sand. moderately bioturbated; minor slickensides; abundant Mya; poorly indurated; damp.
						SLST	SANDY SILTSTONE; dark greenish gray (5G, 4/1); 20% very fine sand.
						SLST /SS	SILTSTONE and SANDSTONE interbedded, 1:1. siltstone: dark greenish gray (5G, 4/1) very thinly laminated; well indurated. sandstone: medium light gray (N6); very fine grained; very thinly laminated.
			CORE BOX 2 ▼ REC. 5.0'	425			
			CORE BOX 3 REC. 5.0'	430			@ 431.5': SLST:SS = 7:3. siltstone: medium dark gray (N4); poorly indurated. sandstone: medium gray (N5); occasional oraganic fragments; rare pyrite nodules. @ 433'. brownish black (5YR, 2/1) to black (N1) organic laminae.
			CORE BOX 4 REC. 4.5'	435			@ 440'-442': low degree of slumping.
				440			

REMARKS The borehole was continuously cored from 420 - to 461 - feet.

EMCON ASSOCIATES

PLATE

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224 - 56.33
PROJECT NAME Kettleman Hills
BY MAC, BB DATE 10/9 - 10/10/85

BORING NO. K-46(RD-2
PAGE 23 OF
SURFACE ELEV. 871.30' M.S.L.

TORVANE (TSF)	POCKET PENETROMETER (TSF)	PENETRATION (Blows/Ft.)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHOGRAPHIC COLUMN	DESCRIPTION
			CORE BOX 5 REC. 5.0' ∇	440		SLST/SS	SILTSTONE and SANDSTONE interbedded (Continued). @ 441': decrease of sandstone portion.
						SS	CLAYEY SANDSTONE; dark greenish gray (5GY, 4/1); <20% clay; medium-to coarse-grained; quartzose; moderate to well graded; subangular to subrounded; massive; occasional cement, calcareous; poorly indurated; moist. @ 445': harder drilling.
			CORE BOX 6 REC. 5.0'	445	Ⓟ Ⓟ		@ 449'-450': minor sandy claystone interbeds.
			CORE BOX 7 REC. 5.0'	450			@ 451'-452' occasional organic laminae and fragments. @ 452.5': change of grain size to fine to medium.
			CORE BOX 8 REC. 5.0'	455	Ⓟ		@ 455': very poorly indurated; minor friable sandstone. @ 456': 1.0"-thick siltstone interbeds.
				460	Ⓟ Ⓟ	SLST	SILTSTONE; dark greenish gray (5GY, 4/1). very fine silty sandstone to sandy siltstone interbeds with 60% silt and clay; organic laminae. @ 459.5': 10% silty sandstone to sandy siltstone interbeds.

REMARKS Ⓟ denotes a 5-to 6-inch preserved sample.

EMCON ASSOCIATES

PLATE

LOG OF EXPLORATORY BORING

PROJECT NUMBER 224 - 56.33
PROJECT NAME Kettleman Hills
BY MAC, BB DATE 10/9 - 10/10/85

BORING NO. K-46(RD-2)

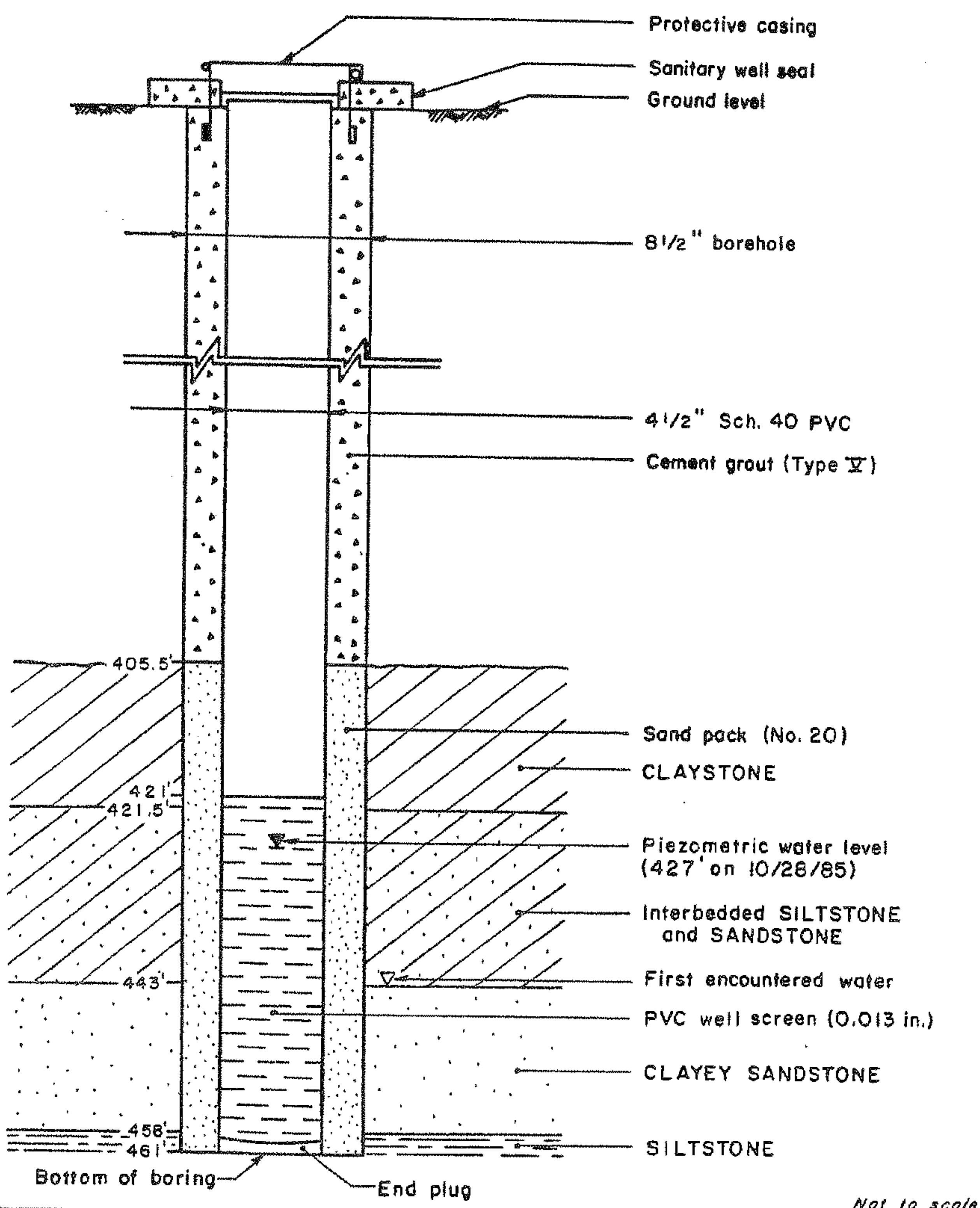
SURFACE ELEV. 871.30' M.S.L.

TORVANE (TSF)	POCKET PENETROMETER (TSF)	PENETRATION (Blows/Ft.)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHOGRAPHIC COLUMN	DESCRIPTION
				460		SLST	SILTSTONE (Continued).
							TERMINATED BORING AT 461'.
				465			
				470			
				475			
				480			

REMARKS

EMCON ASSOCIATES

PLATE



EMCON Associates
San Jose, California

CHEMICAL WASTE MANAGEMENT, INC.
KETTLEMAN HILLS FACILITY
KINGS COUNTY, CALIFORNIA

K-46 (RD-2) WELL COMPLETION DIAGRAM

FIGURE

PROJECT NO.
224-56.33

Project: Kettleman Hills Facility Expansion Project Location: Kettleman City, California Project Number: 27644618.10006	Log of Boring 17-2 Sheet 1 of 10

Date(s) Drilled	10/30/02 - 11/4/02	Logged By	M. McKenzie	Checked By (Date)	M. Hatch
Drilling Method	Air Rotary	Drill Bit Size/Type	5" cutting bit	Total Depth Drilled (feet)	150.0
Drill Rig Type	TH-60	Drilling Contractor	PC Exploration	Approximate Surface Elevation	868
Groundwater Level	Not encountered	Location		Inclination from Horizontal/Bearing	90°
Borehole Completion	Bentonite grout			Hammer Data	NA

Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type	Number	Blows /12 in	Recovery, inches	Drill Time [Rate, ft/hr]	FIELD NOTE AND LAB TES
868	0								HIGHLY SAN JOAQUIN FORMATION Dense, moist, light brown becoming brown, sandy SILT (ML), highly weathered						
	1														
866	2														
	3														
864	4														
	5										1	34		1640	MC=14, SA(90)
862	6														
	7														
860	8								SAN JOAQUIN FORMATION Silty CLAYSTONE (CH), olive brown, soft, highly to moderately weathered grading to clayey SILTSTONE (ML) locally						
	9														
858	10										2	65		1648	MC=16
	11														
856	12														
	13														

Project: Kettleman Hills Facility Expansion
Project Location: Kettleman City, California
Project Number: 27644618.10006

Log of Boring 17-2

Elevation, feet	Depth, feet	Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Type	Number	Blows /12 in	Recovery, inches	Drill Time [Rate, ft/hr]	FIELD NOTES AND LAB TESTS
	13														
854	14														
	15										3			1655	MC=7
852	16											100			
	17														
850	18										4				MC=6, WA(32)
	19											50/5"			
848	20								Silty to clayey SANDSTONE (SM/SC) and sandy SILTSTONE (ML), light olive gray, interbedded, soft, highly to moderately weathered					0727	
	21														
846	22	1	1	40										[60]	
	23														
844	24								CLAYSTONE (CL), grayish brown with reddish brown mottled zones, laminated					0732	
	25				2									0735	
842	26				1										
	27	2	1	100	0									[60]	
840	28				0				Silty sandstone, gray		5				DD=106, UC(21
	29														

Report: GEO_CORE+SOIL_17B; File: 2764461.GPJ; 1/22/2003 17-2

Elevation, feet	Depth, feet	Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Type	Number	Blows /12 in	Recovery, inches	Drill Time [Rate, ft/hr]	FIELD NOTE AND LAB TE
	29				0										
838	30													0740 / 0744	
	31								Silty sandstone						
836	32													[60]	
		3	1	80					Silty SANDSTONE (SM), light grayish brown, soft, highly to moderately weathered						
	33														
834	34														
	35								Sandy SILTSTONE (ML), brownish gray to olive gray with reddish brown zones, highly weathered locally					0749	
832	36								1: 25-30°, B, Vn, Sd, Su, Pl, S						
			1		2										
	37									☒	5A				
		4		76	1										
830	38													[60]	
					1										
	39														
828	40													0758 / 0805	
					1				1: 30°, B, Vn, Cl, Su, Pl, S						
	41								Silty sandstone						
					1										
826	42														
		5	2	100	2									[43]	
	43								Lighter color						
					1										
824	44														
					0										
	45													0812	

Elevation, feet	Depth, feet	Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Type	Number	Blows /12 in	Recovery, inches	Drill Time [Rate, ft/hr]	FIELD NOTES AND LAB TESTS
	45				0									0816	
822	46				1				1: 30°, B, Vn, Cl, Su, Pl, Sr						
	47	6	2	86	0				Silty SANDSTONE (SM), light brownish gray, soft, moderately weathered					[60]	
820	48				0										
	49														
818	50				0									0821 / 0826	
	51		2		1				Slightly darker color						
816	52	7		86	3 / 2				1: 30°, B, Vn, Sd, Su, Pl, S	X	6			[100]	MC=7
	53								2: 30°, B, VN, Cl, Su, Pl, S SILTSTONE (ML), brownish gray, soft, highly to moderately weathered, laminated and thinly bedded with sandstone layers						
814	54		3												
	55				2				1: 30°, B, Vn, CL, Su, Pl, S					0829 / 0835	
812	56				0					X	7				MC=17
	57	8	3	80	2				2: 30°, B, Mw, Sd, Fi, Pl, S, 1/2" sandstone layer					[50]	
810	58				2										
	59														
808	60				0									0841 / 0851	
	61														

Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type	Number	Blows /12 in	Recovery, inches	Drill Time [Rate, ft/hr]	FIELD NOTES AND LAB TESTS
	61				0										
806	62	9	3	76	0									[100]	
	63				0				Silty SANDSTONE (SM), olive gray, soft, highly weathered						
804	64													0854	
	65				0				Silty SANDSTONE (SM), light brownish gray, soft, moderately weathered					0859	
802	66														
	67	10	3	16			NR							[100]	
800	68														
	69													0902	
798	70				0									0907	
	71		3		0										
796	72	11		50	0									[100]	
	73						NR								
794	74													0910	
	75				0				CLAYSTONE (CL), brownish gray, soft, laminated with lesser sandstone 1: 30°, B, Vn, Sd, Su, Pl, Sr					0913	
792	76				1										
	77														

Project: Kettleman Hills Facility Expansion Project Location: Kettleman City, California Project Number: 27644618.10006	Log of Boring 17-2 Sheet 6 of 10

Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type	Number	Blows /12 in	Recovery, inches	Drill Time [Rate, ft/hr]	FIELD NOT AND LAB TE
	77	12		90	2									[43]	
790	78		3		2					X	6				SA(93)
	79		4		1									0920	
788	80				0				Silty SANDSTONE (SM), gray, soft, moderately weathered					0929	
	81				0										
786	82	13	4	100	0									[50]	
	83				1				1: 30°, B, Vn, Sd, Su, Pl, S						
784	84				0									0935	
	85				0									0941	
782	86				0										
	87	14	4	80	0									[43]	
780	88				0										
	89						NR							0948	
778	90				0									0952	
	91		4		0				Sandy SILTSTONE (ML), gray, moderately soft to soft, moderately weathered						
776	92	15		60	0									[43]	
	93														

Elevation, feet	Depth, feet	Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing	Number	Lithology	MATERIAL DESCRIPTION	Soil Samples Type	Number	Blows /12 in	Recovery, inches	Drill Time [Rate, ft/hr]	FIELD NOTES AND LAB TESTS
	93															
774	94		4				NR									
	95														0959	
			4		0					Sandy SILTSTONE (ML), olive gray with iron staining, moderately soft, moderately weathered						
772	96		5													
					2											
	97	16		42	1											
770	98						NR									
	99															
768	100				0					Olive brown SILTSTONE (ML), moderately soft, moderately weathered						
	101				0											
766	102		5							Silty CLAYSTONE (CL), dark gray, moderately soft						
		17		100	0											
	103										☒	9				
					0											
764	104									Gray SILTSTONE (ML)					1019	
	105									Silty SANDSTONE (SM), reddish brown, soft, friable, thinly bedded and laminated					1024	
762	106															
	107	NR	NR	NR											[100]	
760	108															
	109															

Elevation, feet	Depth, feet	Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	MATERIAL DESCRIPTION	Soil Samples Type	Number	Blows /12 in	Recovery, inches	Drill Time [Rate, ft/hr]	FIELD NOT AND LAB TE
	109													
758	110	19	5	80	0			Silty SANDSTONE (SM), light olive brown, moderately soft					1027 / 1031	
	111				0									
756	112				4			1: 30°, B, Vn, Sd, Su, Pl, S					[60]	
	113				3			Sandy SILTSTONE (ML), gray, moderately soft to soft	X	10				
754	114													
	115	20	5	30	2								1036 / 1042	
752	116				1			1: 25-30°, B, Vn, Sd, Su, Pl, Sr						
								Silty SANDSTONE (SM), brownish gray, moderately soft, moderately weathered						
	117												[75]	
750	118						NR							
	119													
748	120	21	6	80	2			CLAYSTONE (CH), brownish gray, laminated and thinly bedded					1046 / 1030	
	121				2			1: 30°, B, Vn, Cl, Su, Pl, S						
746	122				3				X	11			[75]	WA(99)
	123													
744	124						NR	Silty SANDSTONE (SM), light gray, soft, friable						
	125												1034	

Elevation, feet	Depth, feet	Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Soil Samples: Type	Number	Blows /12 in	Recovery, inches	Drill Time [Rate, ft/hr]	FIELD NOTES AND LAB TESTS
	125													1039	
-742	126		6												
	127	22		0										[43]	
-740	128														
	129														
-738	130				2									1046 / 1050	
	131				4				1: 20°, B, Vn, Sd, Su, Pl, Sr						
-736	132	23	6	80	3					X	12			[75]	
	133				3										
-734	134						NR								
	135				0				Siltstone, olive brown / Silty SANDSTONE (SM), light brownish gray, moderately soft					1054 / 1059	
-732	136				0										
	137	24	6	40										[43]	
-730	138						NR								
	139														
-728	140													1106 / 1116	
	141														

Project: Kettleman Hills Facility Expansion Project Location: Kettleman City, California Project Number: 27644618.10006	Log of Boring 17-2 Sheet 10 of 10

Elevation, feet	Depth, feet	ROCK CORE Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES Type	Number	Blows /12 in	Recovery, inches	Drill Time [Rate, ft/hr]	FIELD NOT AND LAB TE
	141								CLAYSTONE (CL), olive brown, moderately soft, moderately to slightly weathered						
726	142	25	6	70										[50]	
	143								Silty SANDSTONE (SM), light grayish brown, moderately soft, slightly weathered						
724	144						NR								
	145													1122 1131	
722	146														
	147	26		0										[75]	
720	148														
	149														
718	150								Bottom of Boring at 150 feet					1135	
	151														
716	152														
	153														
714	154														
	155														
712	156														
	157														

Project: Kettleman Hills Facility Expansion **Project Location:** Kettleman City, California **Project Number:** 27644618.10006	**Log of Boring 17-3** Sheet 1 of 9

Date(s) Drilled	10/29/02	Logged By	M. McKenzie	Checked By (Date)	M. Hatch
Drilling Method	Air Rotary	Drill Bit Size/Type	5" cutting bit	Total Depth Drilled (feet)	140.0
Drill Rig Type	TH-60	Drilling Contractor	PC Exploration	Approximate Surface Elevation	852
Groundwater Level	Not encountered	Location		Inclination from Horizontal/Bearing	90°
Borehole Completion	Bentonite grout			Hammer Data	NA

Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type	Number	Blows /12 in	Recovery, inches	Drill Time [Rate, ft/hr]	FIELD NOTE AND LAB TES
852	0								HIGHLY WEATHERED SAN JOAQUIN FORMATION Silty SANDSTONE (SM), dense, moist, light brown						
	1														
850	2														
	3														
848	4														
	5										1				
846	6											33			
	7														
844	8														
	9								SAN JOAQUIN FORMATION CLAYSTONE (CH), gray, laminated and thinly bedded with siltstone and sandstone layers						
842	10										2				MC=22, WA(77)
	11											48			
840	12														
	13														

Project: Kettleman Hills Facility Expansion
Project Location: Kettleman City, California
Project Number: 27644618.10006

Log of Boring 17-3

Elevation, feet	Depth, feet	Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	MATERIAL DESCRIPTION	Sample Type	Sample Number	Blows /12 in	Recovery, inches	Drill Time [Rate, ft/hr]	FIELD NOTES AND LAB TESTS
	13													
838	14													
	15									3				
836	16										56			
	17													
834	18													
	19									4	66			
								Sandstone						
832	20							CLAYSTONE (CH), olive gray, laminated					0740	
					0									
	21				1									
830	22							1: 30°, B, Vn, Fe, Su, Pl, S						
		1	1	50	1			Silty SANDSTONE (SM), gray, weakly cemented, moderately soft					[100]	
	23				--									
828	24				--		NR							
	25												0743	
					4			CLAYSTONE (CH), dark olive gray, thinly bedded and laminated with silt and sand laminations 1: 30°, B, Vn, Sd, Su, Pl, S					0750	
826	26				5			2: 30°, B, N, Gy, Fi, Pl, Sr						
	27							3: 42°, J, N30E 4: J horizontal, manganese		5				
		2	1	90	3			Increasing silt, with sand laminations, light color					[75]	
824	28				-									
					5									
	29													

Project: Kettleman Hills Facility Expansion
Project Location: Kettleman City, California
Project Number: 27644618.10006

Log of Boring 17-3

Elevation, feet	Depth, feet	Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Type	Number	Blows /12 in	Recovery, inches	Drill Time [Rate, ft/hr]	FIELD NOTES AND LAB TESTS
	29–30				5				Silty CLAYSTONE (CH) grading to SILTSTONE (ML), light olive gray 3: 30°, B, Vn, Cl, Su, Pl, S					0754	
822	30–31				6				1: 60°, Jn, Vn, Cl, Su, Pl, S					0758	
	31–32				6				2: 30°, B, Vn, Cl, Su, Pl, S	X	6				WA(98), LL=83, PI=49
820	32–33	3	1	98	3									[43]	
	33–34				1				3: 30°, B, Vn, Sd, Su, Pl, R Silty sandstone, brown, moderately soft						
818	34–35				1				4: 30°, B, N, Gy, Fi, Pl, R Claystone, dark gray 1: 30°, B, N, Gy, Fe, Pl, R					0805	
	35–36				5				CLAYSTONE (CH), dark olive gray, thinly bedded and laminated, sandstone laminations, decreased silt 2: 30°, B, Vn, Fc, Su, Pl, S					0815	
816	36–37				6				3: 60°, Sh, Vn, Fe, Su, Pl, S						
	37–38	4	2	95	5					X	7			[43]	
814	38–39				6				Increased sand laminations						
	39–40				7		NR		4: 30°, B, Vn, Sd, Su, Pl, Sr					0822	
812	40–41				>15				Darker color, waxy claystone 1: 20-25°, B, Vn, Cl, Su, Pl, Sr 2: 25-30°, B, N, Gy, Fi, Pl, R					0831	
	41–42				6										
810	42–43	5	2	100	5					X	8			[43]	WA(99), LL=78, PI=48
	43–44				3										
808	44–45				7									0838	

Project: Kettleman Hills Facility Expansion Project Location: Kettleman City, California Project Number: 27644618.10006	# Log of Boring 17-3

Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type	Number	Blows /12 in.	Recovery, inches	Drill Time [Rate, ft/hr]	FIELD NOTE AND LAB TES
	45	6	2	100	6				1: 30°, B, Vn, Sd, Su, Pl, Sr					0844	
806	46				5				2: 30°, B, Mw, Gy, Fi, Pl, Sr						
	47				4									[43]	
804	48				6				3: 90°, J, Mw, Mn&Gy&Fe, Fi&Pa, Pl, S, N45E						
	49				3									0851	
802	50	7	3	98	6				1: 30°, B, VN, Ct, Su, Pl, S 2: 30°, B, N, Gy, Fi, Pl, Sr Very dark gray					0856	
	51				5										
800	52				5									[75]	
	53				3					X	9				
798	54				5				3: 30°, B, N, Sd, Fi, Pl, R					0900	
	55	8	3	100	2									0906	
796	56				4				Becomes dark brown 2: 40°, B, N, Gy, Fi, Pl, S						
	57				3				3: 30°, B, Vn, Sd, Su, Pl, S					[60]	
794	58				3										
	59				2									0911	
792	60				3				1: 30°, B, Mw, SE, Fi, Pl, R 2: 75°, J, Mw, Gy, Fi, Pl, Sr 1/2" thick N40W 75 NE					0920	
	61														

Project: Kettleman Hills Facility Expansion Project Location: Kettleman City, California Project Number: 27644618.10006	Log of Boring 17-3 Sheet 5 of 9

Elevation, feet	Depth, feet	Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Soil Samples Type	Number	Blows /12 in	Recovery, inches	Drill Time [Rate, ft/hr]	FIELD NOTES AND LAB TEST
	61	9	3	100	3				Becomes dark gray						
790	62				2				3: 30°, B, Mw, Gy, Fi, Pl, S	X	10			[75]	WA(94)
	63				2										
788	64		4		0									0924	
	65	10	4	100	0									0931	
786	66				3				1: 30°, B, N, Gy, Fi, Pl, S 2: 30°, B, Vn, Cl, Su, Pl, S						
	67				1				Increased waxy claystone 3: 60°, J/Sh, waxy surface, clay gypsum, iron 1/32" thick	X	11			[60]	
784	68				2				Increased sandstone laminations and thin layers, and waxy clay layers						
	69				7									0936	
782	70	11	4	100	1				Silty CLAYSTONE (CL), gray 1: 30°, B, Vn, Cl, Su, Pl, S					0944	
	71				3				2: 30°, B, N, Gy, Fi, Pl, S						
780	72				3				With sandstone layers to 1/2" thick					[100]	
	73				1										
778	74				1									0947	
	75				2				Siltstone	X	12			0952	
776	76				0				1: 30°, B,Vn, Sd, Su, Pl, Sr						
	77														

Elevation, feet	Depth, feet	Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Soil Samples Type	Number	Blows /12 in	Recovery, inches	Drill Time [Rate, ft/hr]	FIELD NOTES AND LAB TEST
	93				1				Grades to silty SANDSTONE (SM)						
758	94														
	95													1050 / 1058	
756	96									X	15				
	97	16	5	80										[60]	
754	98														
	99						NR							1100	
752	100								Sandy SILTSTONE (ML), light olive gray, moderately soft					1110	
	101		5		7				1: 30°, B, Vn, Cl, Su, Pl, S 2: 60°, B,N, Gy, Fl, Wa, Sr 3: 40°, N, N, Gy, Fi, Pl, Sr						
750	102	17	6		1										
	103				4					X	16			[75]	UC(151), DD=103
748	104				1									1114	
	105				0				Sandy CLAYSTONE (CL)< gray, moist, moderately soft					1122	
746	106				0					X	17				WA(75)
	107	18	6	76	0									[75]	
744	108				0				Silty SANDSTONE (SM), light gray to light brown, moderately soft, moderately weathered						
	109														

Project: Kettleman Hills Facility Expansion
Project Location: Kettleman City, California
Project Number: 27644618.10006

Log of Boring 17-3

Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type	Number	Blows /12 in	Recovery, inches	Drill Time [Rate, ft/hr]	FIELD NOTES AND LAB TESTS
	109				0									1126	
742	110	19	6	24			NR							1132	
740	112													[43]	
738	114								CLAYSTONE (CH), gray, moderately soft, moderately to slightly weathered					1139	
	115	20	6	80	1									1143	
736	116				4				1: 30°, B, Vn, Cl, Su, Pl, Sr	☒	18				
									Dark gray color						
	117				0									[60]	
734	118				2				Olive gray, silty CLAYSTONE (CH)						
	119						NR							1148	
732	120	21	6	80	0									1152	
	121		7		2				1: 30°, B, W, Fe, Fi, Pl, Sr						
730	122				4				2: 30°, B, Vn, Cl, Su, Pl, S	☒	19			[50]	
	123				0				Silty SANDSTONE (SM), olive gray, moderately soft						
728	124						NR							1158	
	125														

URS

Elevation, feet	Depth, feet	Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Type	Number	Blows /12 in	Recovery, inches	Drill Time [Rate, ft/hr]	FIELD NOTES AND LAB TESTS
	125				0									1203	
-726	126								Silty fine SANDSTONE (SM) with fine sandy siltstone layers 1: 30°, B, Vn, Sd, Su, Pl, Sr						
	127				2										
		22	7	60	1				Silty SANDSTONE (SM), olive gray, friable	X	20			[75]	
-724	128														
	129						NR							1207	
-722	130				0				Silty CLAYSTONE (CH), dark gray, moderately soft, slightly weathered					1210	
	131				0					X	21				
-720	132								1: 30°, B, Vn, Cl, Su, Pl, Sr						
		23	7	50	1				Silty SANDSTONE (SM), light olive gray, slightly weathered					[37]	
	133						NR								
-718	134													1218	
	135				0									1223	
-716	136				2				1: 20°, B, Vn, Sd, Su, Pl, Sr						
	137								Fine SANDSTONE (SP), light olive gray						
		24	7	48										[60]	
-714	138						NR								
	139													1228	
-712	140								Bottom of Boring at 140 feet						
	141														

Geosyntec
consultants

Attachment 2: Current Field Investigation

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PROJECT Kettleman Hills Facility
PROJECT LOCATION Kettleman City
PROJECT NUMBER SC0458-01

KEY SHEET - CLASSIFICATIONS AND SYMBOLS

GS FORM: KEY 09/99

EMPIRICAL CORRELATIONS WITH STANDARD PENETRATION RESISTANCE N VALUES *

FINE GRAINED SOILS

N VALUE * (BLOWS/FT)	CONSISTENCY	UNCONFINED COMPRESSIVE STRENGTH (TONS/SQ FT)
0 - 2	VERY SOFT	<0.25
3 - 4	SOFT	0.25 - 0.50
5 - 8	FIRM	0.50 - 1.00
9 - 15	STIFF	1.00 - 2.00
16 - 30	VERY STIFF	2.00 - 4.00
31 - 50	HARD	>4.00
>50	VERY HARD	

COARSE GRAINED SOILS

N VALUE * (BLOWS/FT)	RELATIVE DENSITY
0 - 4	VERY LOOSE
5 - 10	LOOSE
11 - 30	MEDIUM DENSE
31 - 50	DENSE
>50	VERY DENSE

* ASTM D 1586; NUMBER OF BLOWS OF 140 POUND HAMMER FALLING 30 INCHES TO DRIVE A 2 IN. O.D., 1.4 IN. I.D. SAMPLER ONE FOOT.

UNIFIED SOIL CLASSIFICATION AND SYMBOL CHART

MAJOR DIVISIONS			SYMBOLS	DESCRIPTIONS
COARSE GRAINED SOILS MORE THAN 50% OF MATERIAL COARSER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO.4 SIEVE	CLEAN GRAVELS LITTLE OR NO FINES	GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
			GP	POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES APPRECIABLE AMOUNT OF FINES	GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES
			GC	CLAYEY GRAVELS, GRAVEL -SAND-CLAY MIXTURES
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING NO.4 SIEVE	CLEAN SANDS LITTLE OR NO FINES	SW	WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
			SP	POORLY GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
		SANDS WITH FINES APPRECIABLE AMOUNT OF FINES	SM	SILTY SANDS, SAND-SILT MIXTURES
			SC	CLAYEY SANDS, SAND-CLAY MIXTURES
FINE GRAINED SOILS MORE THAN 50% OF MATERIAL FINER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50	ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
			CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
			OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50	MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS, ELASTIC SILT
			CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
			OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS			PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENT

NOTE: DUAL SYMBOLS USED FOR BORDERLINE CLASSIFICATIONS

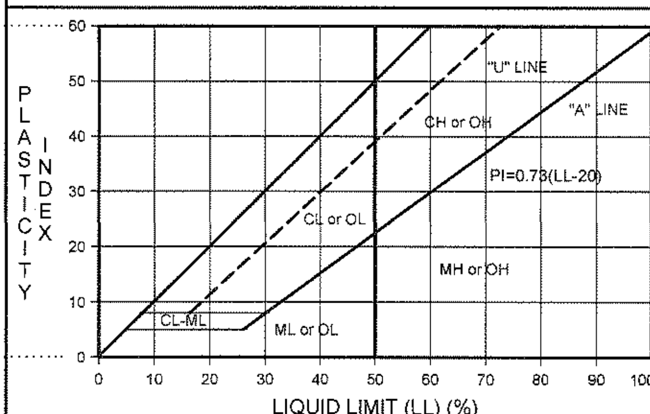
PARTICLE SIZE IDENTIFICATION

BOULDERS	>300 mm
COBBLES	75 - 300 mm
GRAVEL: COARSE	19.0 - 75 mm
GRAVEL: FINE	4.75 - 19 mm
SAND: COARSE	2.00 - 4.75 mm
SAND: MEDIUM	0.425 - 2.00 mm
SAND: FINE	0.075 - 0.425 mm
SILT	0.075 - 0.002 mm
CLAY	<0.002 mm

WELL GRADED - HAVING WIDE RANGE OF GRAIN SIZES AND APPRECIABLE AMOUNTS OF ALL INTERMEDIATE PARTICLE SIZES

POORLY GRADED - PREDOMINANTLY ONE GRAIN SIZE, OR HAVING A RANGE OF SIZES WITH SOME INTERMEDIATE SIZES MISSING

PLASTICITY CHART



OTHER MATERIAL SYMBOLS

Siltstone	Sand
Sandstone	Silt
Siltstone/Claystone	Silty Sand
Claystone	Evaporite
Shale	Artificial Fill
Siltstone/Sandstone	Debris Fill
Conglomerate	Asphalt
Granitic	Concrete

WELL SYMBOLS

- HYDRATED BENTONITE CHIPS
- BENTONITE CEMENT GROUT
- FILTER PACK
- CONCRETE
- NATIVE/ SLOUGH
- CENTRAL-IZER

SAMPLER AND OTHER SYMBOLS

- BULK SAMPLE
- CORE SAMPLE
- GRAB SAMPLE
- HAND AUGER
- DRIVE SAMPLE
- GROUNDWATER SAMPLE

- ∇ Water Level at Time Drilling, or as Shown
- ▼ Static Water Level
- MSL: Mean Sea Level
- AGS: Above Ground Surface
- BGS: Below Ground Surface
- BTOC: Below Top of Casing
- HSA: Hollow Stem Auger

Geosyntec consultants

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GS FORM: BORE 1/99

BOREHOLE RECORD

BORING CS-1A **SHEET** 1 **OF** 3
START DATE Nov 26, 07 **ELEVATION** 855 FT MSL
FINISH DATE Nov 27, 07
PROJECT Kettleman Hills Facility
LOCATION Kettleman City
PROJECT NUMBER SC0458-01

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	ELEVATION (ft)	SAMPLES NUMBER	TYPE	BLOW COUNTS	% RECOVERY	PID READING	TIME	COMMENTS
0	**SAN JOAQUIN FORMATION** Dense, moist, light yellowish brown (2.5Y 6/4), FAT CLAY (CH) with fine to very fine sand			BULK 1A-1						Bulk Sample from 0-5'
1			854							
2			853							
3			852							
4			851							
5			850	1A-1		8/11/20				
6			849							
7			848	BULK 1A-2						
8	Hard, moist, light gray (2.5Y 7/1) to very dark grayish brown (2.5Y 3/2), mottled coloring, FAT CLAY [CH], with thin interbedded laminations of very fine sand, contains iron oxide stain and is cemented locally.		847							
9			846							Bulk Sample from 5-10'
10			845							
11			844	1A-2		10/31/43				
12			843							
13			842							
14			841							
15	Becomes SILTY CLAY		840	1A-3		25/50/50				
16			839							
17			838							
18			837							
19			836							
20			835	1A-4		22/50/5"				
21			834							
22			833							
23			832							
24			831							
25	Calcite infilling, increase in silt and fine sand [ML], becomes pale yellow (2.5Y 7/4)		830	1A-5		16/34/39				
26			829							
27			828							
28			827							
29			826							
30			825	1A-6		61/50/5"				
31	Hard, moist, dark gray (2.5Y 4/1), FAT CLAY [CH], with thin laminations of iron oxide stained silty fine sand.		824							
32			823							

CONTRACTOR Layne Christensen **NORTHING**
EQUIPMENT CME-95 **EASTING**
DRILL MTHD Hollow Stem Auger **ANGLE** Vertical
DIAMETER 8" **BEARING** ------
LOGGER K. Botelho **REVIEWER** A. Greene **PRINTED** Jan 30, 08

REMARKS: Located about 50' south and 10' west of K-25

COORDINATE SYSTEM:

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

BORING LOG NO WELL (STEVE) NO SIG SC0458.GPJ GEOSNTEC.GDT 1/30/08

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GS FORM: BORE 1/99

BOREHOLE RECORD

BORING CS-1A

START DATE Nov 26, 07
ELEVATION 855 FT MSL
FINISH DATE Nov 27, 07
PROJECT Kettleman Hills Facility
LOCATION Kettleman City
PROJECT NUMBER SC0458-01

DEPTH (ft)	MATERIAL DESCRIPTION	ELEVATION (ft)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOW COUNTS	SAMPLES: % RECOVERY	SAMPLES: PID READING	TIME	COMMENTS
33		822							
34		821							
35	Contains manganese staining locally	820	1A-7		12/26/50/5"				
36		819							
37		818							
38		817							
39		816							
40		815	1A-8		17/46/50/4"				
41		814							
42		813							
43		812							
44		811							
45	Decease in sandy interbeds	810	1A-9		12/38/50/4"				
46		809							
47		808							End for the day @16:30 resume drilling following day 11/27/2007 @ 6:30
48		807							
49		806							
50		805	1A-10		22/56/50/3"				
51		804							
52		803							
53		802							
54		801							
55	Becomes yellowish brown (2.5Y 6/2), FAT CLAY [CH] with sand	800	1A-11		32/50/5"				
56		799							
57		798							
58	Very dense, moist, light yellowish brown (2.5Y 6/2), clayey fine SAND [SC]	797							Drilling indicates change at 58'
59		796							
60		795	1A-12		50/50/1"				
61		794							
62	Decrease in silt	793							
63		792							
64		791							

CONTRACTOR Layne Christensen
EQUIPMENT CME-95
DRILL MTHD Hollow Stem Auger
DIAMETER 8"
LOGGER K. Botelho REVIEWER A. Greene
NORTHING
EASTING
ANGLE Vertical
BEARING ------
PRINTED Jan 30, 08

REMARKS: Located about 50' south and 10' west of K-25

COORDINATE SYSTEM:

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

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GS FORM: BORE 1/99

BOREHOLE RECORD

BORING **CS-1A** SHEET 3 OF 3
START DATE Nov 26, 07 ELEVATION 855 FT MSL
FINISH DATE Nov 27, 07
PROJECT Kettleman Hills Facility
LOCATION Kettleman City
PROJECT NUMBER SC0458-01

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	ELEVATION (ft)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOW COUNTS	SAMPLES: % RECOVERY	SAMPLES: PID READING	TIME	COMMENTS
65	Very dense, moist, light yellowish brown (2.5Y 6/2), fine poorly graded SAND [SP] with trace silt		790	1A-13		44/120/4"				Poor recovery added sand catcher to sampler
66			789			110/5"				
	Total Depth = 66.5 ft bgs.									

CONTRACTOR Layne Christensen
EQUIPMENT CME-95
DRILL MTHD Hollow Stem Auger
DIAMETER 8"
LOGGER K. Botelho REVIEWER A. Greene
NORTHING
EASTING
ANGLE Vertical
BEARING -----
PRINTED Jan 30, 08

REMARKS: Located about 50' south and 10' west of K-25

COORDINATE SYSTEM:

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

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GS FORM: BORE 1/99

BOREHOLE RECORD

BORING CS-1 SHEET 1 OF 1
START DATE Nov 26, 07 ELEVATION 845 FT MSL
FINISH DATE Nov 26, 07
PROJECT Kettleman Hills Facility
LOCATION Kettleman City
PROJECT NUMBER SC0458-01

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	ELEVATION (ft)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOW COUNTS	SAMPLES: % RECOVERY	SAMPLES: PID READING	TIME	COMMENTS
	SAN JOAQUIN FORMATION			BULK 1-1						
1	Soft, moist, light yelowish brown (2.5Y 6/4), FAT CLAY [CH] with trace very fine sand, medium plastic.		844							Bulk Sample from 0-5'
2			843							
3			842							
4			841							
5	Becomes hard		840	1-1		20/14/24				
6			839							
7			838	BULK 1-2						
8	Becomes pale yellow to grayish brown (2.5Y 7/3-5/2), with iron oxide stain and calcite locally, contains fine poorly graded sand laminations.		837							
9			836							
10			835							Bulk Sample from 5-10'
11	Increase in moisture and slight color change to light olive brown (2.5Y 5/4) Becomes cemented		834	1-2		17/44/50/5"				
12			833							
13			832							
14			831							
15			830	1-3		6/38/50/5"				
16			829							
17			828							
18			827							
19			826							
20			825	1-4		8/40/50/5"				
21			824							
	Total Depth = 21.5 ft bgs.									

CONTRACTOR Layne Christensen
EQUIPMENT CME-95
DRILL MTHD Hollow Stem Auger
DIAMETER 8"
LOGGER K. Botelho REVIEWER A. Greene
NORTHING
EASTING
ANGLE Vertical
BEARING ------
PRINTED Jan 30, 08

REMARKS: Located about 85' south and 15' west of K-25

COORDINATE SYSTEM:

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

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GS FORM: BORE 1/99

BOREHOLE RECORD

BORING CS-2
START DATE Nov 27, 07 ELEVATION 875 FT MSL
FINISH DATE Nov 27, 07
PROJECT Kettleman Hills Facility
LOCATION Kettleman City
PROJECT NUMBER SC0458-01

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	ELEVATION (ft)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOW COUNTS	SAMPLES % RECOVERY	SAMPLES PID READING	TIME	COMMENTS
0	**SAN JOAQUIN FORMATION** Hard, moist, grayish brown (2.5Y 5/2), and bluish black (GLEY2 2.5/10B), FAT CLAY [CH], medium to high plasticity, mottled, iron oxide staining.			BULK 2-1						
1			874							Highly cemented for the first foot of drilling Bulk Sample from 0-5'
2			873							
3			872							
4			871							
5			870	2-1		22/42/20				
6			869							
7			868	BULK 2-2						
8			867							
9			866							Bulk Sample from 5-10'
10	Contains very thin layers of pale yellow (2.5Y 7/3), fine sandy silt layers, cemented, laminations apprear to be at angles of about 30°		865							
11			864	2-2		20/35/40				
12			863							
13			862							
14			861							
15			860	2-3		17/28/50				
16			859							
17			858							
18			857							
19			856							
20	Becomes very dark gray (2.5Y 3/1), decrease in laminations		855	2-4		16/27/50/4"				
21			854							
22			853							
23			852							
24			851							
25			850	2-5		17/35/50/2"				
26			849							
27			848							
28			847							
29			846							
30	Contains calcite infilling locally		845	2-6		24/50/5"				
31			844							
32			843							

CONTRACTOR Layne Christensen
EQUIPMENT CME-95
DRILL MTHD Hollow Stem Auger
DIAMETER 8"
LOGGER K. Botelho REVIEWER A. Greene
NORTHING
EASTING
ANGLE Vertical
BEARING ------
PRINTED Jan 30, 08

REMARKS: Located about 10' east and 160' south of K-25

COORDINATE SYSTEM:

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

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GS FORM: BORE 1/99

BOREHOLE RECORD

BORING CS-2
START DATE Nov 27, 07 **ELEVATION** 875 FT MSL
FINISH DATE Nov 27, 07
PROJECT Kettleman Hills Facility
LOCATION Kettleman City
PROJECT NUMBER SC0458-01

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	ELEVATION (ft)	SAMPLES NUMBER	TYPE	BLOW COUNTS	% RECOVERY	PID READING	TIME	COMMENTS
33			842							
34			841							
35			840	2-7		27/50/50/4"				
36			839							
37			838							
38			837							
39			836							
40	Increase in laminations, conatins interbedded silt lenses [CH/MH]		835	2-8		38/50/5"				
41			834							
42			833							
43			832							
44	Hard, moist, very dark grayish brown (2.5Y 3/2), FAT CLAY [CH], medium to high plasticity, with pale yellow silty laminations, contains calcite infilling and both managnese and iron oxide staining locally.		831							
45			830	2-9		13/37/50/4"				
46			829							
47			828							
48			827							
49	Increasing laminations of pale yellow sandy silt and occasionally fine silty sand.		826							
50			825	2-10		19/50/5"				
51			824							
52			823							
53			822							
54			821							
55			820	2-11		11/33/50/4"				
56			819							
57			818							
58			817							
59	Becomes dark gray (GLEY1 4/N)		816							
60			815	2-12		26/50/4"				
61			814							
62			813							
63			812							
64			811							

CONTRACTOR Layne Christensen **NORTHING**
EQUIPMENT CME-95 **EASTING**
DRILL MTHD Hollow Stem Auger **ANGLE** Vertical
DIAMETER 8" **BEARING** ------
LOGGER K. Botelho **REVIEWER** A. Greene **PRINTED** Jan 30, 08

REMARKS: Located about 10' east and 160' south of K-25

COORDINATE SYSTEM:

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

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GS FORM: BORE 1/99

BOREHOLE RECORD

BORING CS-2
START DATE Nov 27, 07 ELEVATION 875 FT MSL
FINISH DATE Nov 27, 07
PROJECT Kettleman Hills Facility
LOCATION Kettleman City
PROJECT NUMBER SC0458-01

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	ELEVATION (ft)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOW COUNTS	SAMPLES: % RECOVERY	SAMPLES: PID READING	TIME	COMMENTS
65	Decrease in laminations		810	2-13		23/37/50/4"				
66			809							
67			808							
68			807							
69			806							
70	Becomes moist, dark gray (GLEY1 4/N), CLAY [CH], medium to high plasticity, laminated with light gray (GLEY1 2/N) fine sandy silt.		805	2-14		8/20/50/5"				
71			804							
72			803							
73			802							
74			801							
75	Contains trace pale yellow silty sand laminations		800	2-15		27/40/50/2"				
76			799							
77			798							
78			797							
79			796							
80			795	2-16		15/50/50/4"				
81	Becomes dark grayish brown (2.5Y 4/2) to olive yellow (2.5Y 6/6), FAT CLAY [CH], fissured.		794							
82			793							
83			792							
84			791							
85	Returns to dark gray (2.5Y 4/1), FAT CLAY [CH]		790	2-17		28/50/5"				
86			789							
87			788							
88			787							
89			786							
90	Very dense, moist, light gray (2.5Y 7/1), fine clayey SAND [SC].		785	2-18		34/50/1"				
91	Total Depth = 91 ft bgs.		784							

CONTRACTOR Layne Christensen
EQUIPMENT CME-95
DRILL MTHD Hollow Stem Auger
DIAMETER 8"
LOGGER K. Botelho REVIEWER A. Greene
NORTHING
EASTING
ANGLE Vertical
BEARING ------
PRINTED Jan 30, 08

REMARKS: Located about 10' east and 160' south of K-25

COORDINATE SYSTEM:

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

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GS FORM: BORE 1/99

BOREHOLE RECORD

BORING TP-1 SHEET 1 OF 1
START DATE Nov 27, 07 ELEVATION 900 FT MSL
FINISH DATE Nov 27, 07
PROJECT Kettleman Hills Facility
LOCATION Kettleman City
PROJECT NUMBER SC0458-01

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	ELEVATION (ft)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOW COUNTS	SAMPLES % RECOVERY	SAMPLES PID READING	TIME	COMMENTS
0	**SAN JOAQUIN FORMATION** Hard, moist, light yellowish brown (2.5Y 6/4), with occasional orange coloring, FAT CLAY(CH), medium plasticity			BULK TP1-1						
1			899							
2			898							
3	Becomes pale yellow to orange, cemented		897							
4			896							
5	Becomes dark gray		895							
6			894							
7			893							
8	Dense, moist, light to dark gray, fine clayey sand with silt (SC)		892							Excavation indicates soil becomes harder
9			891	BULK TP1-2						
10	Total Depth = 10 ft bgs.		890							

CONTRACTOR Waste Management
EQUIPMENT CME-95
DRILL MTHD Back Hoe Test Pit
DIAMETER 3' x 8'
LOGGER K. Botelho REVIEWER A. Greene
NORTHING
EASTING
ANGLE Vertical
BEARING ------
PRINTED Jan 30, 08

REMARKS: Located about 50' east of K-46 and 120' north of K-46

COORDINATE SYSTEM:

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
10875 Rancho Bernardo Rd, Suite 200
San Diego, CA 92127
Tel: (858) 674-6559
Fax: (858) 674-6586

GS FORM: BORE 1/99

BOREHOLE RECORD

BORING TP-2 SHEET 1 OF 1
START DATE Nov 27, 07 ELEVATION 900 FT MSL
FINISH DATE Nov 27, 07
PROJECT Kettleman Hills Facility
LOCATION Kettleman City
PROJECT NUMBER SC0458-01

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	ELEVATION (ft)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOW COUNTS	SAMPLES % RECOVERY	SAMPLES PID READING	TIME	COMMENTS
	SAN JOAQUIN FORMATION Hard, moist, light yellowish brown (2.5Y 6/4), FAT CLAY(CH), medium plasticity									
1			899							Fissured from 1 to 5 feet
2	with pale yellow to orange colorations		898							
3	Becomes cemented		897							
4			896							
5	Appearance of white mineral occasionally along side walls of test pit		895							
6			894							
7			893							
8			892							
9	Becomes light gray, highly cemented		891	BULK TP2-1						
10	Total Depth = 10 ft bgs.		890							

CONTRACTOR Waste Management NORTHING
EQUIPMENT CME-95 EASTING
DRILL MTHD Back Hoe Test Pit ANGLE Vertical
DIAMETER 3' x 10' BEARING ------
LOGGER K. Botelho REVIEWER A. Greene PRINTED Jan 30, 08

REMARKS: Located about 150' east of K-50 and 20' north

COORDINATE SYSTEM:
SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

Geosyntec consultants
10875 Rancho Bernardo Rd, Suite 200
San Diego, CA 92127
Tel: (858) 674-6559
Fax: (858) 674-6586

GS FORM: BORE 1/99

BOREHOLE RECORD

BORING TP-3 — SHEET 1 OF 1
START DATE Nov 27, 07 — ELEVATION 870 FT MSL
FINISH DATE Nov 27, 07
PROJECT Kettleman Hills Facility
LOCATION Kettleman City
PROJECT NUMBER SC0458-01

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	ELEVATION (ft)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOW COUNTS	SAMPLES: % RECOVERY	SAMPLES: PID READING	TIME	COMMENTS
	SAN JOAQUIN FORMATION Hard, moist, light yellowish brown (2.5Y 6/4), FAT CLAY (CH), medium to high plasticity									
1			869							
2			868							
3			867							
4	Orange coloration		866							
5			865							
6			864							
7			863							
8	Becomes more cemented		862							
9			861							
10			860							
11			859	BULK TP3-1						
12	Total Depth = 12 ft bgs.		858							

CONTRACTOR Waste Management — NORTHING
EQUIPMENT CME-95 — EASTING
DRILL MTHD Back Hoe Test Pit — ANGLE Vertical
DIAMETER 3' x 8' — BEARING ------
LOGGER K. Botelho — REVIEWER A. Greene — PRINTED Jan 30, 08

REMARKS: Located about 30' west of K-46 and 20' north

COORDINATE SYSTEM:

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

BORING LOG NO WELL (STEVE) NO SIG SC0458.GPJ GEOSNTEC.GDT 1/30/08

Geosyntec consultants
10875 Rancho Bernardo Rd, Suite 200
San Diego, CA 92127
Tel: (858) 674-6559
Fax: (858) 674-6586

GS FORM: BORE 1/99

BOREHOLE RECORD

BORING TP-4 SHEET 1 OF 1
START DATE Nov 27, 07 ELEVATION 895 FT MSL
FINISH DATE Nov 27, 07
PROJECT Kettleman Hills Facility
LOCATION Kettleman City
PROJECT NUMBER SC0458-01

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	ELEVATION (ft)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOW COUNTS	SAMPLES: % RECOVERY	SAMPLES: PID READING	TIME	COMMENTS
0	**SAN JOAQUIN FORMATION** Hard, moist, light yellowish brown (2.5Y 6/4), FAT CLAY (CH) with yellowish to brown discolorations, highly cemented		895							
1			894							side walls appear fissured
2			893							
3			892							
4			891							
5	Becomes light grayish brown		890							
6			889							
7			888							
8			887							
9			886	BULK TP4-1						
10	Total Depth = 10 ft bgs.		885							

CONTRACTOR Waste Management
EQUIPMENT CME-95
DRILL MTHD Back Hoe Test Pit
DIAMETER 3' x 10'
LOGGER K. Botelho REVIEWER A. Greene
NORTHING
EASTING
ANGLE Vertical
BEARING ------
PRINTED Jan 30, 08

REMARKS:

COORDINATE SYSTEM:

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

BORING LOG NO WELL (STEVE) NO SIG SC0458.GPJ GEOSNTEC.GDT 1/30/08

Geosyntec consultants

Attachment 3: Laboratory Test Results

Excel Geotechnical Testing, Inc.
"Excellence in Testing"
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

Test Results Summary

Project Name: KHF Clay Source Evaluation
Client Name: Geosyntec

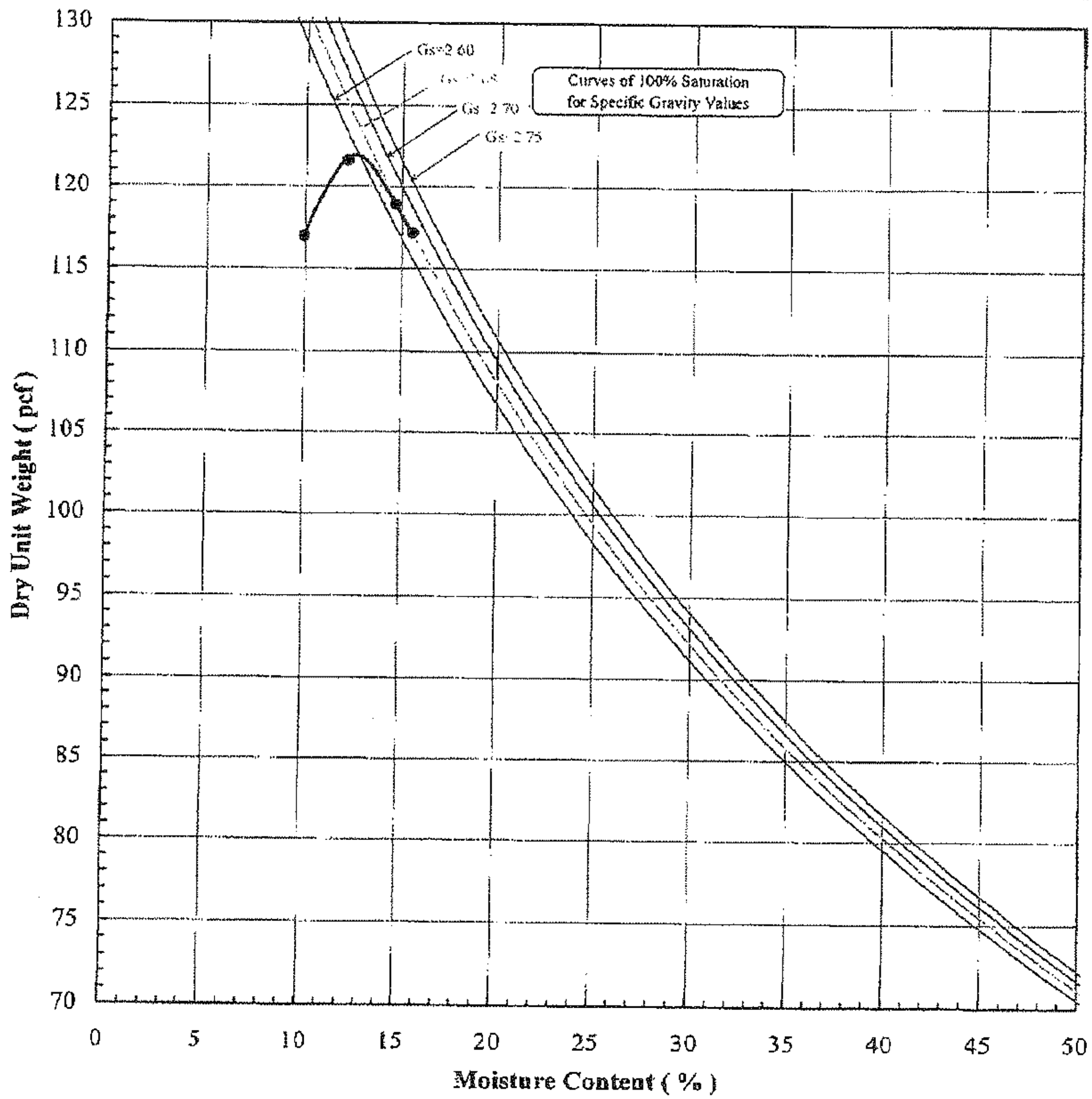
Index Test Results

Sample Information		Test Information						Remarks
Site ID (-)	Lab. No. (-)	As Rec'd Moisture Content (%)	As Rec'd Dry Unit Weight (PCF)	Grain Size Analyses: Gravel Content (%)	Grain Size Analyses: Sand Content (%)	Grain Size Analyses: Fines Content (%)	Engineering Classification (-)	
CS-1-4	I072	18.5	100.6					
CS-1A-2	L074	19.3	100.3					
CS-1A-5	L077	20.9	98.6					
CS-1A-9	L081	24.4	98.2					
CS-1A-11	L083	18.6	95.8					
CS-2-2	L087	16.5	106.4					
CS-2-7	L092	21.0	100.6					
CS-2-9	L094	24.7	99.7					
CS-2-14	L098	25.1	97.7					

Excel Geotechnical Testing, Inc.
"Excellence in Testing"
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

Project Name: KHF Clay Source Evaluation
Project No: 289
Client Sample ID: CS-1A
Lab Sample No: L103

ASTM D 1557 **COMPACTION MOISTURE-DENSITY RELATIONSHIP** Modified - Method B



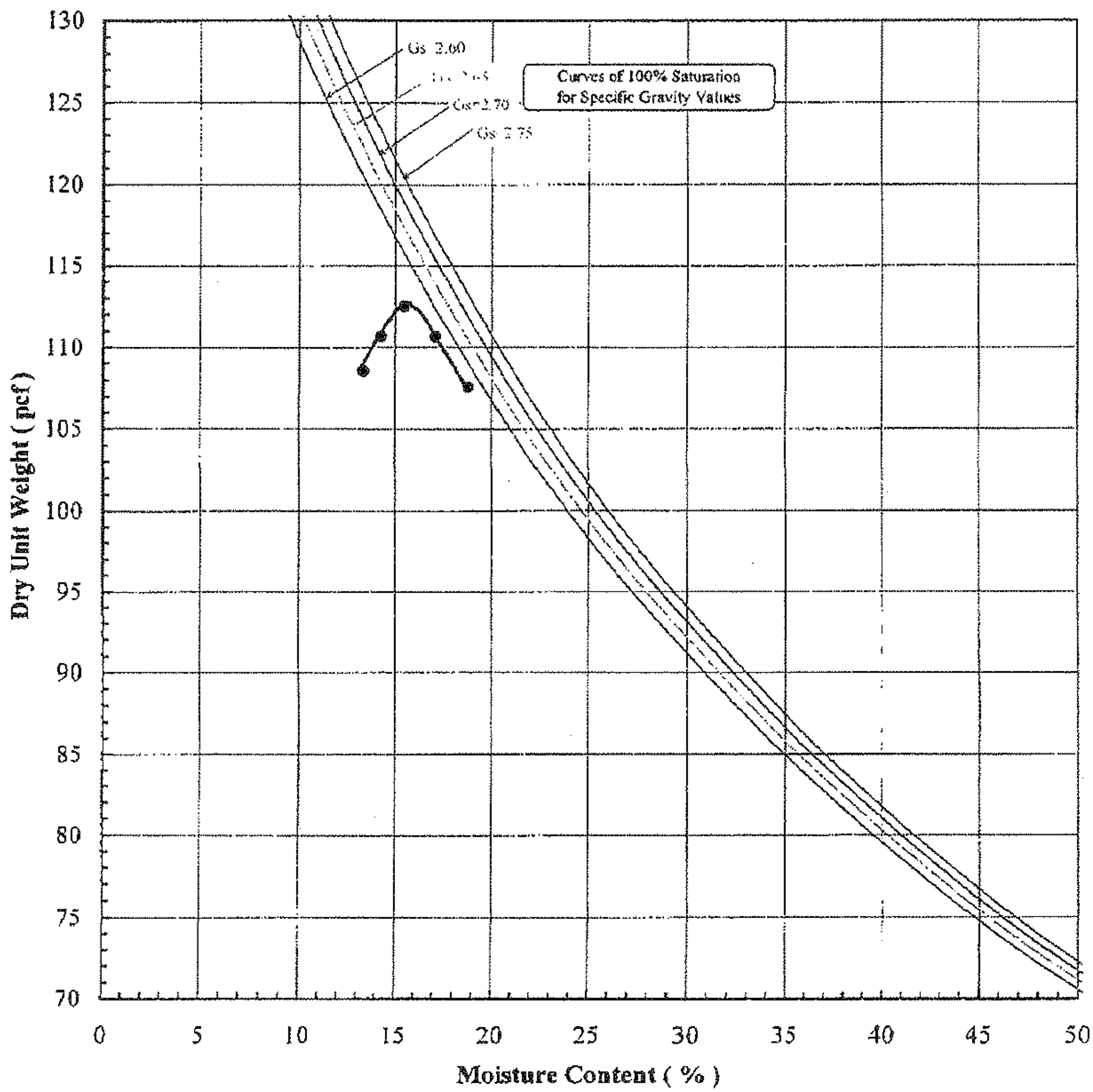
Client/Site Sample ID.	Lab Sample No:	Maximum Dry Unit Weight (pcf)	Optimum Moisture Content (%)	Remarks
CS-1A	L103	122.0	12.5	

Note(s):

Excel Geotechnical Testing, Inc.
"Excellence in Testing"
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

Project Name:	KHF Clay Source Evaluation
Project No:	289
Client Sample ID:	CS-2
Lab Sample No:	L104

ASTM D 1557 **COMPACTION MOISTURE-DENSITY RELATIONSHIP** Modified - Method B



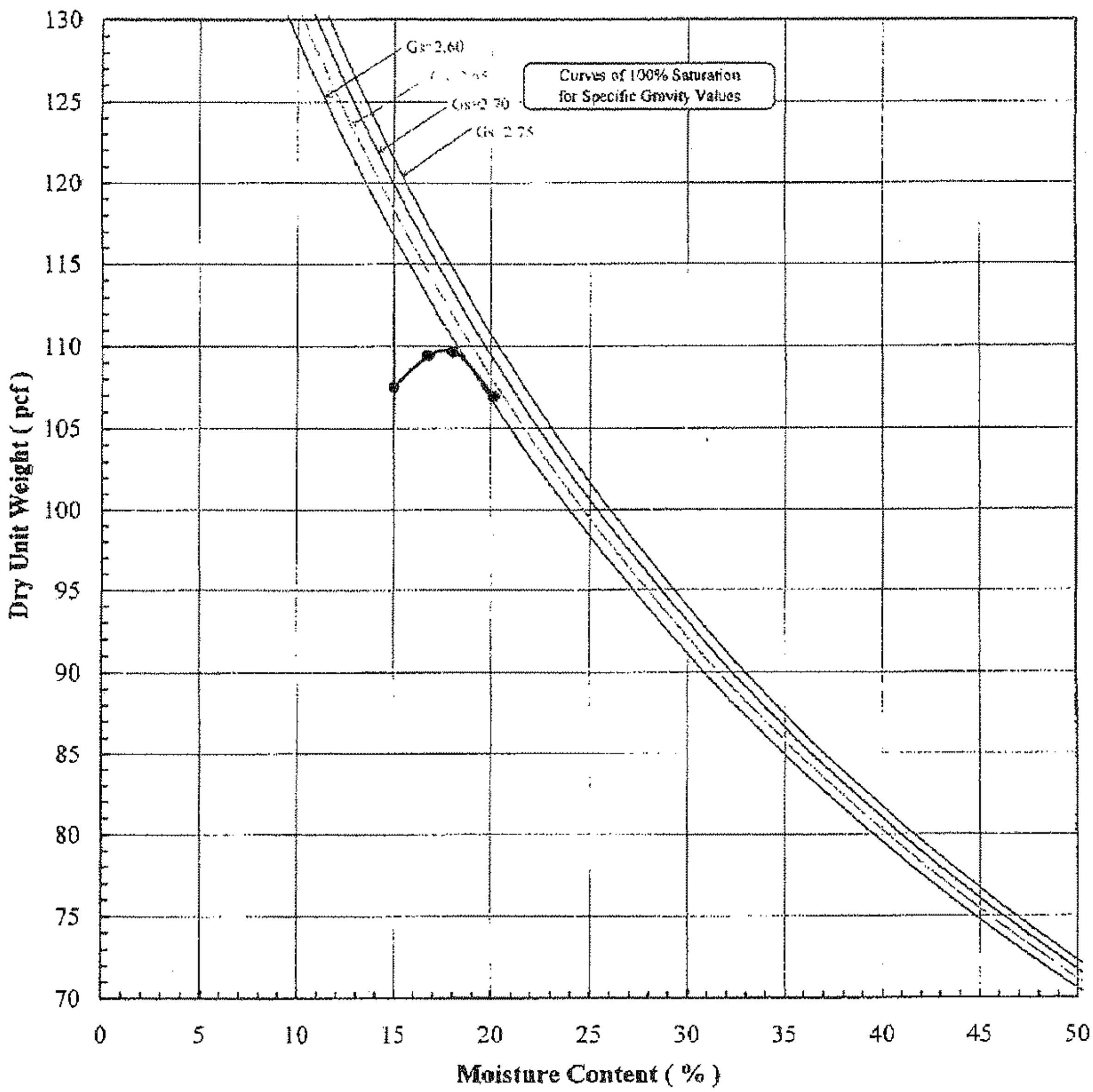
Client/Site Sample ID.	Lab Sample No:	Maximum Dry Unit Weight (pcf)	Optimum Moisture Content (%)	Remarks
CS-2	L104	113.1	15.6	

Note(s):

Excel Geotechnical Testing, Inc.
"Excellence in Testing"
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

Project Name: KHF Clay Source Evaluation
Project No: 289
Client Sample ID: TP-1
Lab Sample No: L105

ASTM D 1557 **COMPACTION MOISTURE-DENSITY RELATIONSHIP** Modified - Method B



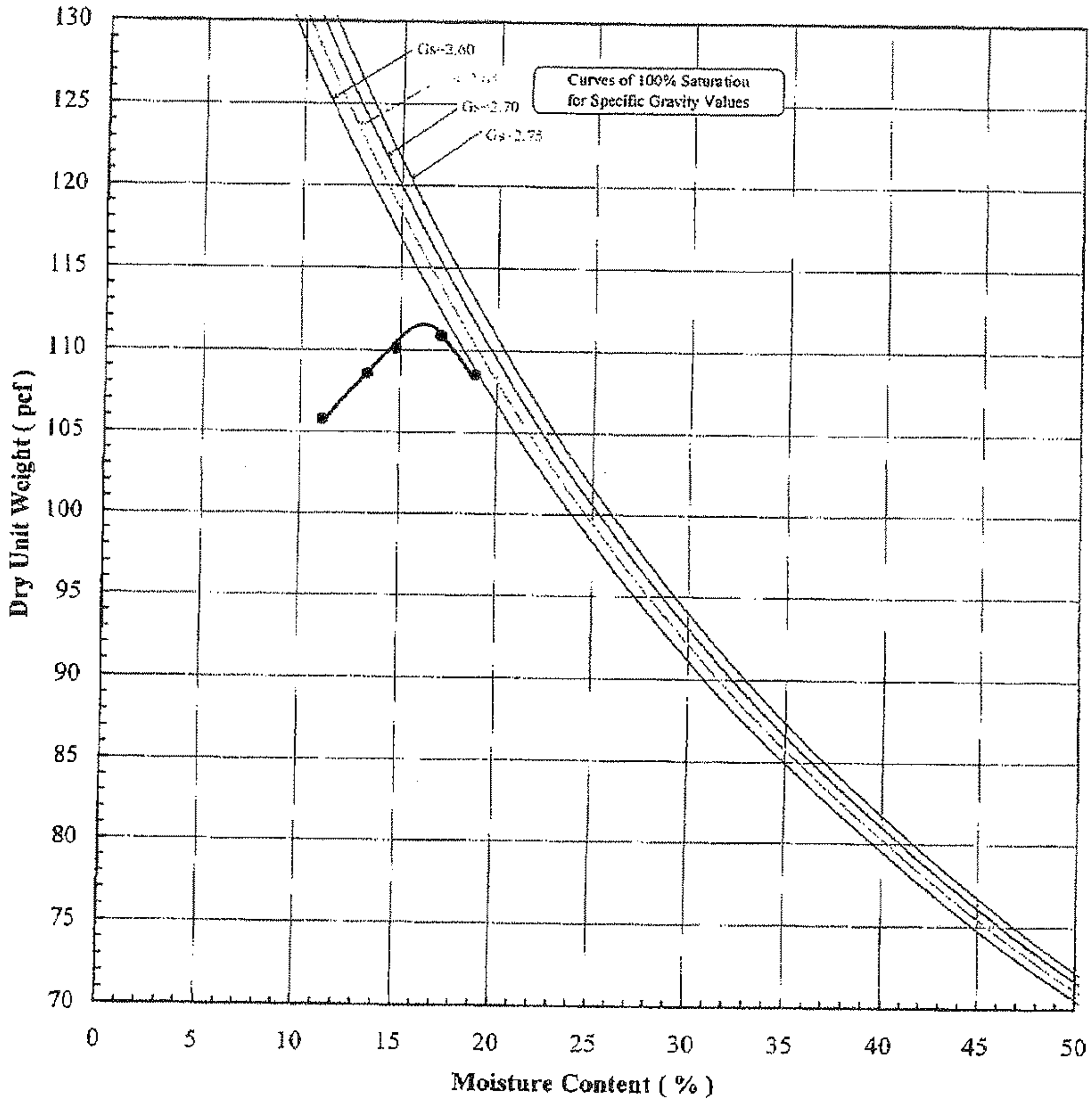
Client/Site Sample ID.	Lab Sample No:	Maximum Dry Unit Weight (pcf)	Optimum Moisture Content (%)	Remarks
TP-1	L105	109.9	17.8	

Note(s):

Excel Geotechnical Testing, inc.
"Excellence in Testing"
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

Project Name:	KHF Clay Source Evaluation
Project No:	289
Client Sample ID:	TP-2
Lab Sample No:	L106

ASTM D 1557 **COMPACTION MOISTURE-DENSITY RELATIONSHIP** Modified - Method B



Client/Site Sample ID.	Lab Sample No:	Maximum Dry Unit Weight (pcf)	Optimum Moisture Content (%)	Remarks
TP-2	L106	111.7	16.2	

Note(s):

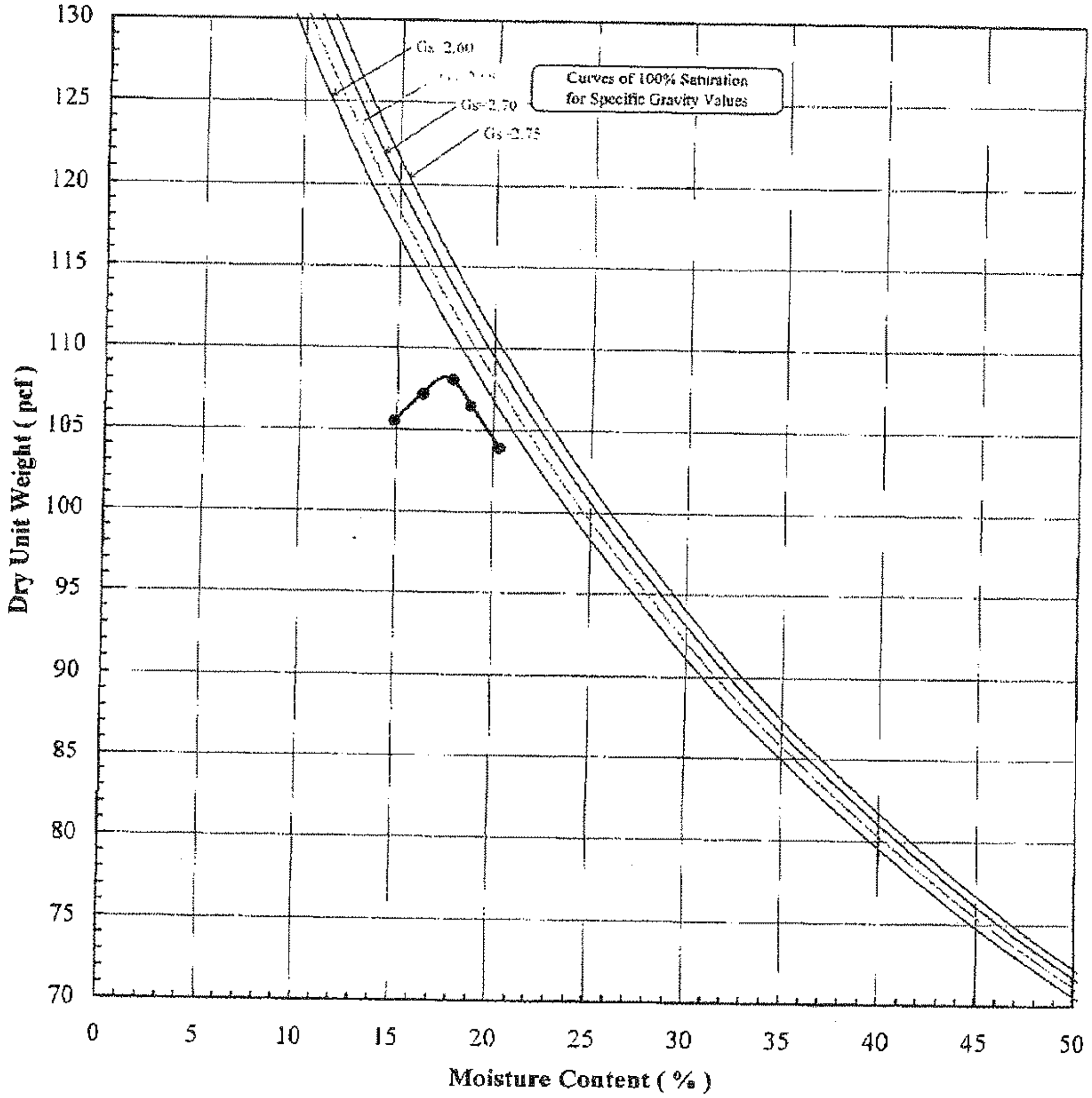
Excel Geotechnical Testing, Inc.
"Excellence in Testing"
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

Project Name: KHF Clay Source Evaluation
Project No: 289
Client Sample ID: TP-3
Lab Sample No: L107

ASTM D 1557

COMPACTION MOISTURE-DENSITY RELATIONSHIP

Modified - Method B



Client/Site Sample ID.	Lab Sample No:	Maximum Dry Unit Weight (pcf)	Optimum Moisture Content (%)	Remarks
TP-3	L107	108.2	17.4	

Note(s):

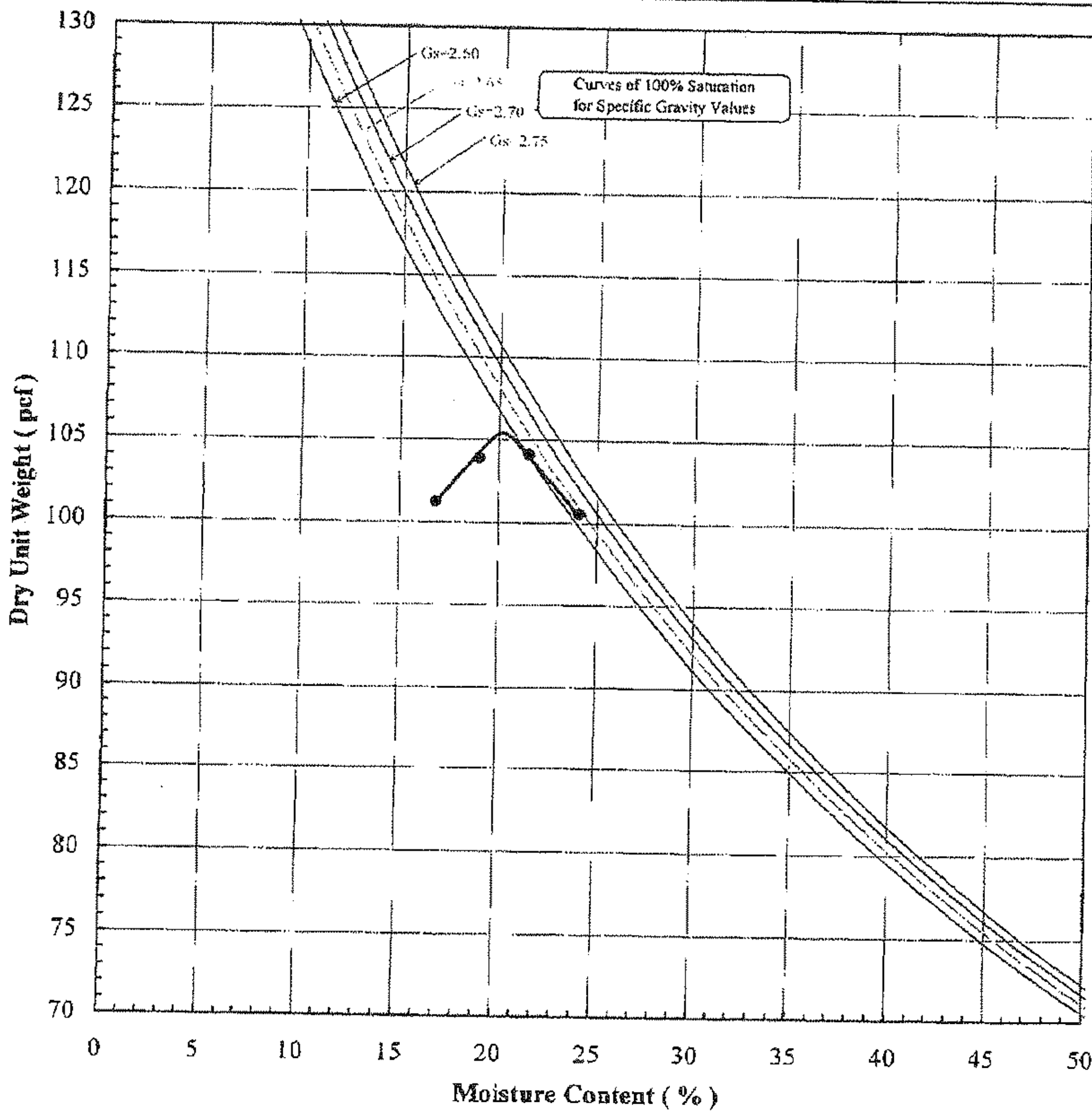
Excel Geotechnical Testing, Inc.
"Excellence In Testing"
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

Project Name:	KHF Clay Source Evaluation
Project No:	289
Client Sample ID:	TP-4
Lab Sample No:	L108

ASTM D 1557

COMPACTION MOISTURE-DENSITY RELATIONSHIP

Modified - Method B



Client/Site Sample ID.	Lab Sample No:	Maximum Dry Unit Weight (pcf)	Optimum Moisture Content (%)	Remarks
TP-4	L108	105.5	20.1	

Note(s):

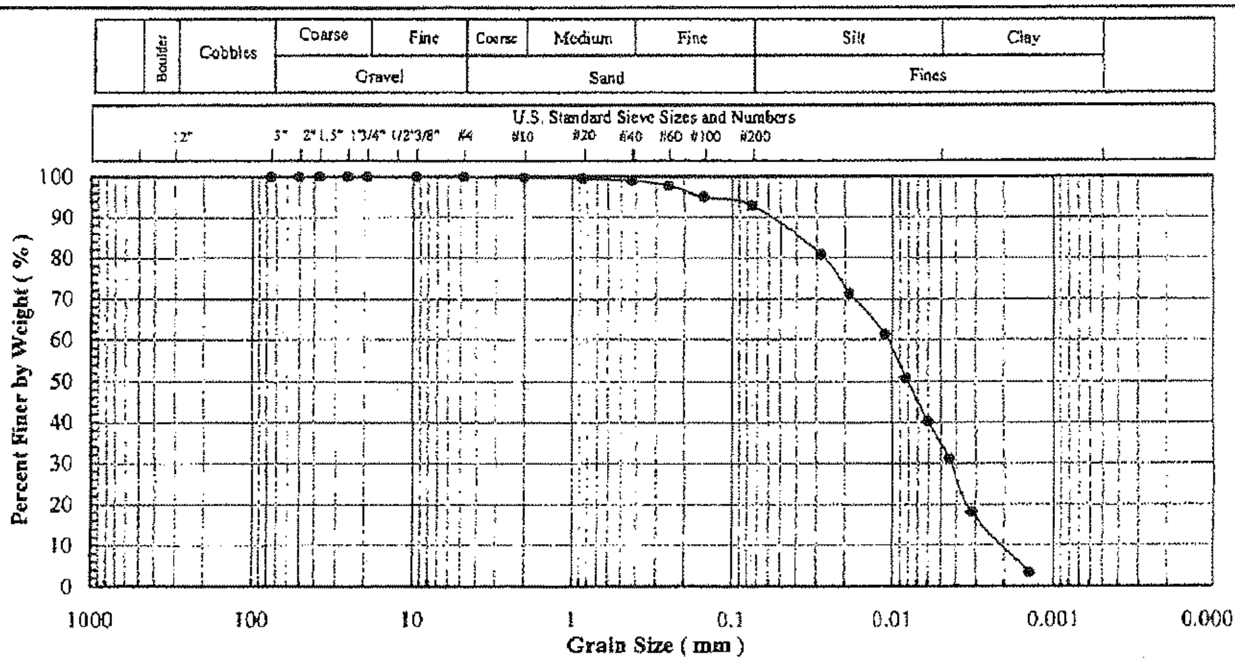
Excel Geotechnical Testing, Inc.
"Excellence in Testing"
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

Project Name:	KHF Clay Source Evaluation
Project No:	289
Client Sample ID:	TP-1
Lab Sample No:	L105

ASTM C 136, D 422, D 854, D 1140, D 2216, D 2487, D 4318

SOIL INDEX PROPERTIES

Grain Size, Spec. Gravity, Moist. Cont. Eng. Classification, Atterberg Limits



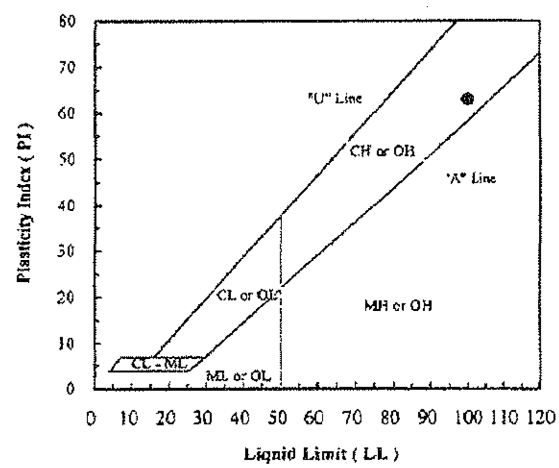
Sieve No.	Size (mm)	% Finer
3"	75	100.0
2"	50	100.0
1.5"	37.5	100.0
1"	25	100.0
3/4"	19	100.0
3/8"	9.5	100.0
#4	4.75	100.0
#10	2.00	99.8
#20	0.850	99.6
#40	0.425	99.1
#60	0.250	97.8
#100	0.150	95.1
#200	0.075	93.0

Specific Gravity (-):	2.65

Hydrometer Particle Diameter (mm)	% Finer
0.0262	80.8
0.0111	61.4
0.0060	40.2
0.0032	18.0
0.0014	3.5

Gravel (%):	
Sand (%):	7.0
Fines (%):	93.0
Silt (%):	58.5
Clay (%):	34.5

Coeff. Unif. (Cu):	
Coeff. Curv. (Cc):	



Client Sample ID.	Lab Sample No:	Moisture Content (%)	Fines Content < No. 200 (%)	Atterberg Limits LL (-)	PL (-)	PI (-)	Engineering Classification
TP-1	L105	20.8	93.0	100	37	63	CH - Fat clay

Note(s):

An assumed specific gravity of 2.65 was used when analyzing the hydrometer test results.

Hydrometer soil specimen conglomerated and formed a cloudy substance which settled to the lower portion of the test tube (i.e., the test results may be questionable).

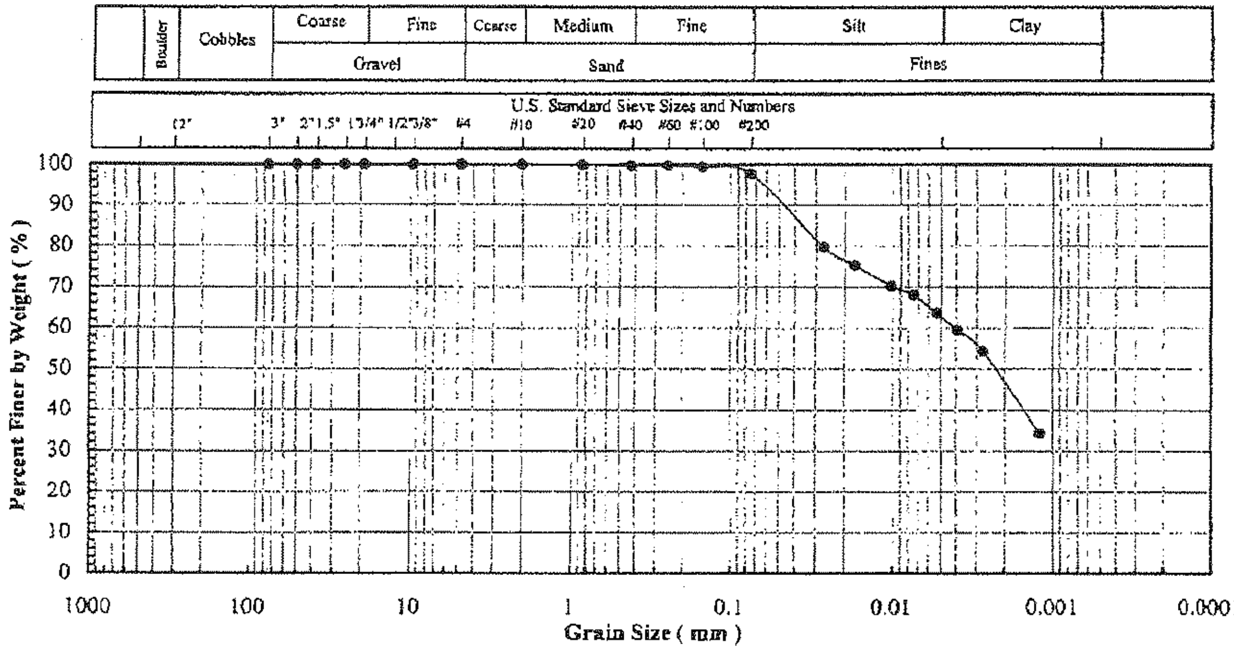
Excel Geotechnical Testing, Inc.
"Excellence in Testing"
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

Project Name:	KHF Clay Source Evaluation
Project No:	289
Client Sample ID:	TP-2
Lab Sample No:	L106

ASTM C 136, D 422, D 854, D 1140, D 2216, D 2487, D 4318

SOIL INDEX PROPERTIES

Grain Size, Spec. Gravity, Moist. Cont, Eng. Classification, Atterberg Limits



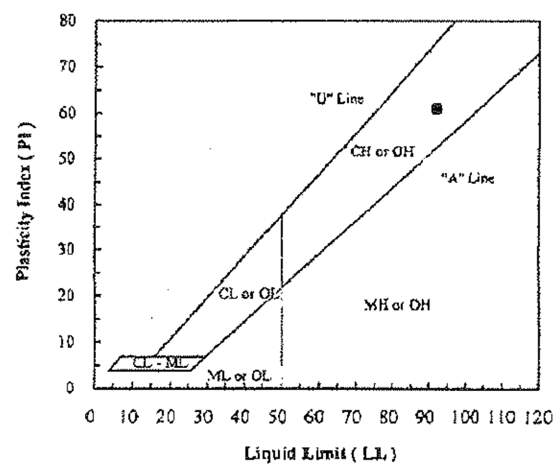
Sieve No.	Size (mm)	% Finer
3"	75	100.0
2"	50	100.0
1.5"	37.5	100.0
1"	25	100.0
3/4"	19	100.0
3/8"	9.5	100.0
#4	4.75	100.0
#10	2.00	100.0
#20	0.850	99.9
#40	0.425	99.8
#60	0.250	99.8
#100	0.150	99.4
#200	0.075	97.8

Specific Gravity (-):	2.65

Hydrometer Particle Diameter (mm)	% Finer
0.0268	79.7
0.0102	70.3
0.0053	63.7
0.0027	54.3
0.0012	34.4

Gravel (%):	
Sand (%):	2.2
Fines (%):	97.8
Silt (%):	35.0
Clay (%):	62.8

Coeff. Unif. (Cu):	
Coeff. Curv. (Cc):	



Client Sample ID.	Lab Sample No:	Moisture Content (%)	Fines Content < No. 200 (%)	Atterberg Limits LL (-)	PL (-)	PI (-)	Engineering Classification
TP-2	L106	14.6	97.8	92	31	61	CH - Fat clay

Note(s):

An assumed specific gravity of 2.65 was used when analyzing the hydrometer test results.

Hydrometer soil specimen conglomerated and formed a cloudy substance which settled to the lower portion of the test tube (i.e., the test results may be questionable).

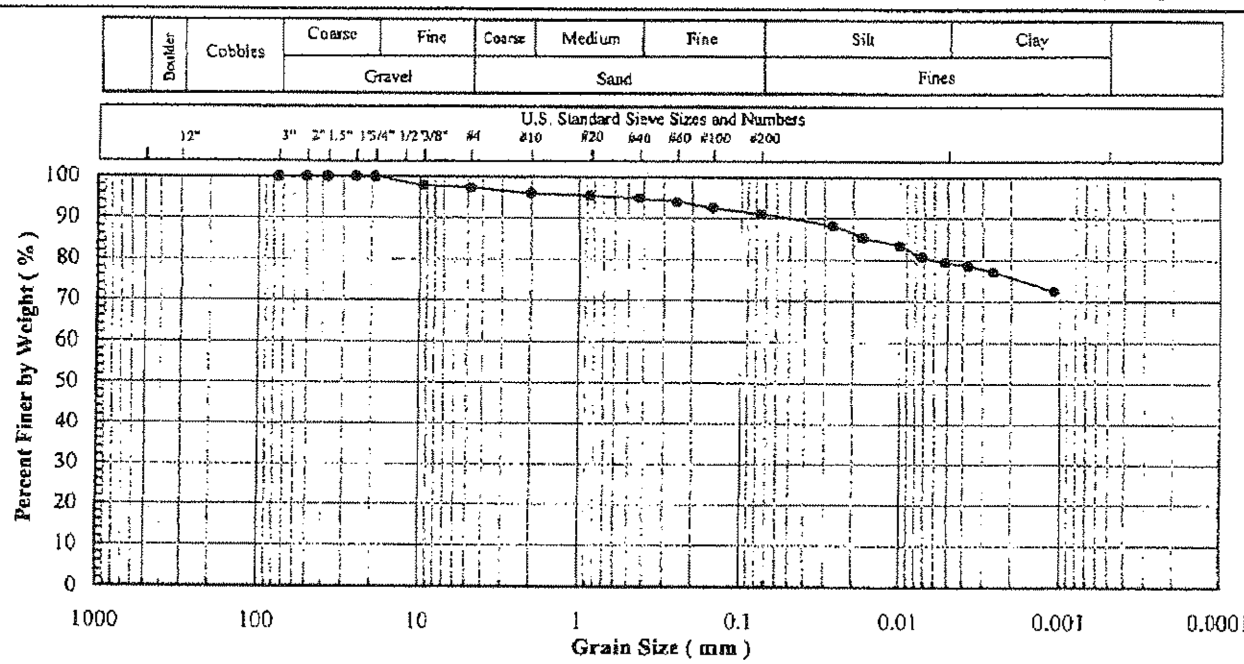
Excel Geotechnical Testing, Inc.
"Excellence in Testing"
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

Project Name:	KHF Clay Source Evaluation
Project No:	289
Client Sample ID:	TP-3
Lab Sample No:	L107

ASTM C 136, D 422, D 854, D 1140, D 2216, D 2487, D 4318

SOIL INDEX PROPERTIES

Grain Size, Spec. Gravity, Moist. Cont., Eng. Classification, Atterberg Limits



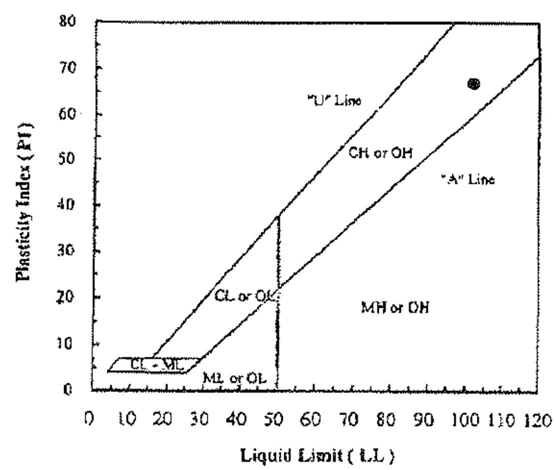
Sieve No.	Size (mm)	% Finer
3"	75	100.0
2"	50	100.0
1.5"	37.5	100.0
1"	25	100.0
3/4"	19	100.0
3/8"	9.5	97.9
#4	4.75	97.3
#10	2.00	96.0
#20	0.850	95.4
#40	0.425	94.8
#60	0.250	93.9
#100	0.150	92.5
#200	0.075	91.1

Specific Gravity (-):	2.65

Hydrometer Particle Diameter (mm)	% Finer
0.0270	88.2
0.0101	83.5
0.0052	79.5
0.0026	77.1
0.0011	72.4

Gravel (%):	2.7
Sand (%):	6.2
Fines (%):	91.1
Silt (%):	11.7
Clay (%):	79.4

Coeff. Unif. (Cu):	
Coeff. Curv. (Cc):	



Client Sample ID.	Lab Sample No:	Moisture Content (%)	Fines Content < No. 200 (%)	Atterberg Limits LL (-)	PL (-)	PI (-)	Engineering Classification
TP-3	L107	21.9	91.1	102	35	67	CH - Fat clay

Note(s):

An assumed specific gravity of 2.65 was used when analyzing the hydrometer test results.

Hydrometer soil specimen conglomerated and formed a cloudy substance which settled to the lower portion of the test tube (i.e., the test results may be questionable).

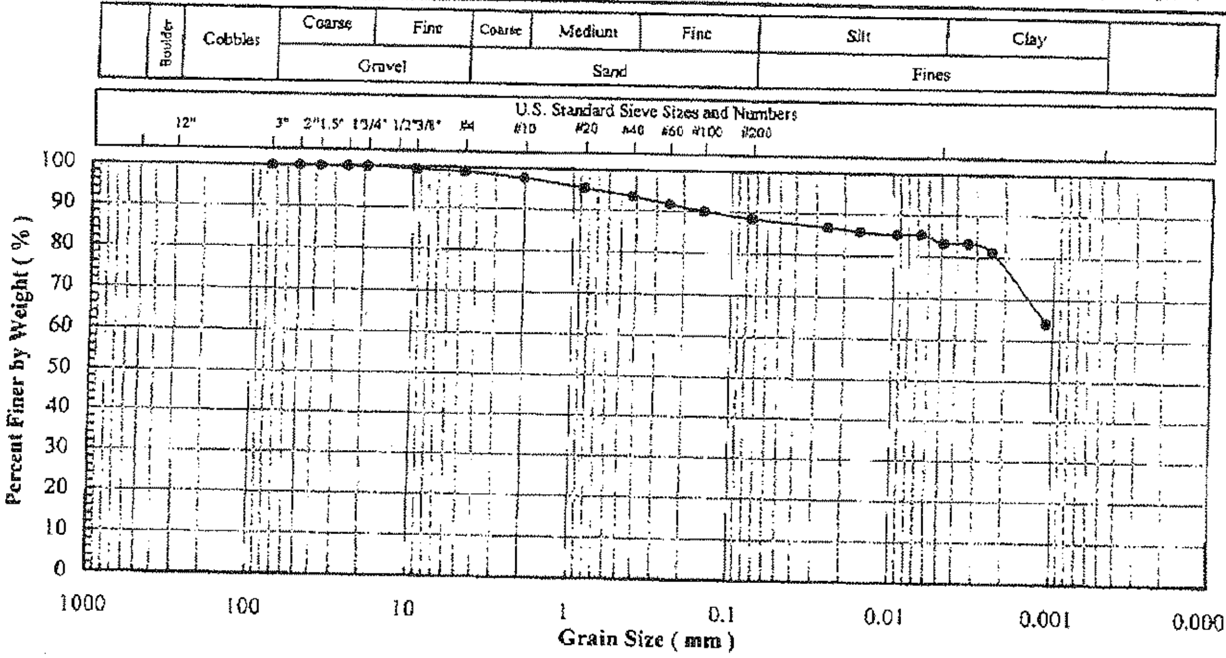
Excel Geotechnical Testing, Inc.
"Excellence in Testing"
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

Project Name:	KHF Clay Source Evaluation
Project No:	289
Client Sample ID:	TP-4
Lab Sample No:	L108

ASTM C 136, D 422, D 854, D 1140, D 2216, D 2487, D 4318

SOIL INDEX PROPERTIES

Grain Size, Spec. Gravity, Moist. Cont., Eng. Classification, Atterberg Limits



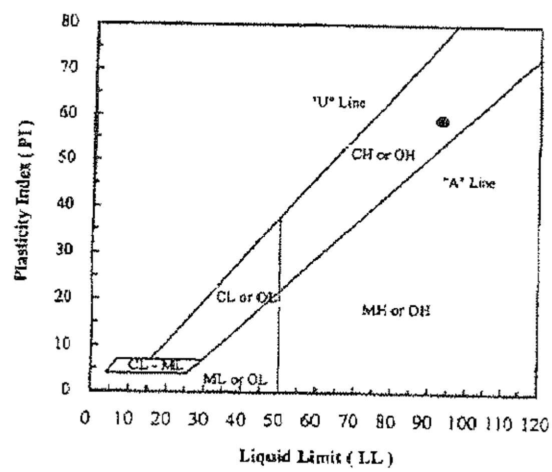
Sieve No.	Size (mm)	% Finer
3"	75	100.0
2"	50	100.0
1.5"	37.5	100.0
1"	25	100.0
3/4"	19	100.0
3/8"	9.5	99.4
#4	4.75	99.0
#10	2.00	97.6
#20	0.850	95.4
#40	0.425	93.6
#60	0.250	91.7
#100	0.150	90.1
#200	0.075	88.5

Specific Gravity (-):	2.65

Hydrometer Particle Diameter (mm)	% Finer
0.0256	86.6
0.0095	85.1
0.0048	83.2
0.0024	81.2
0.0011	64.1

Gravel (%):	1.0
Sand (%):	10.5
Fines (%):	88.5
Silt (%):	5.3
Clay (%):	83.2

Coeff. Unif. (Cu):	
Coeff. Curv. (Cc):	



Client Sample ID.	Lab Sample No:	Moisture Content (%)	Fines Content < No. 200 (%)	Atterberg Limits LL (-)	PL (-)	PI (-)	Engineering Classification
TP-4	L108	17.0	88.5	93	34	59	CH - Fat clay

Note(s):

An assumed specific gravity of 2.65 was used when analyzing the hydrometer test results.

Hydrometer soil specimen conglomerated and formed a cloudy substance which settled to the lower portion of the test tube (i.e., the test results may be questionable).

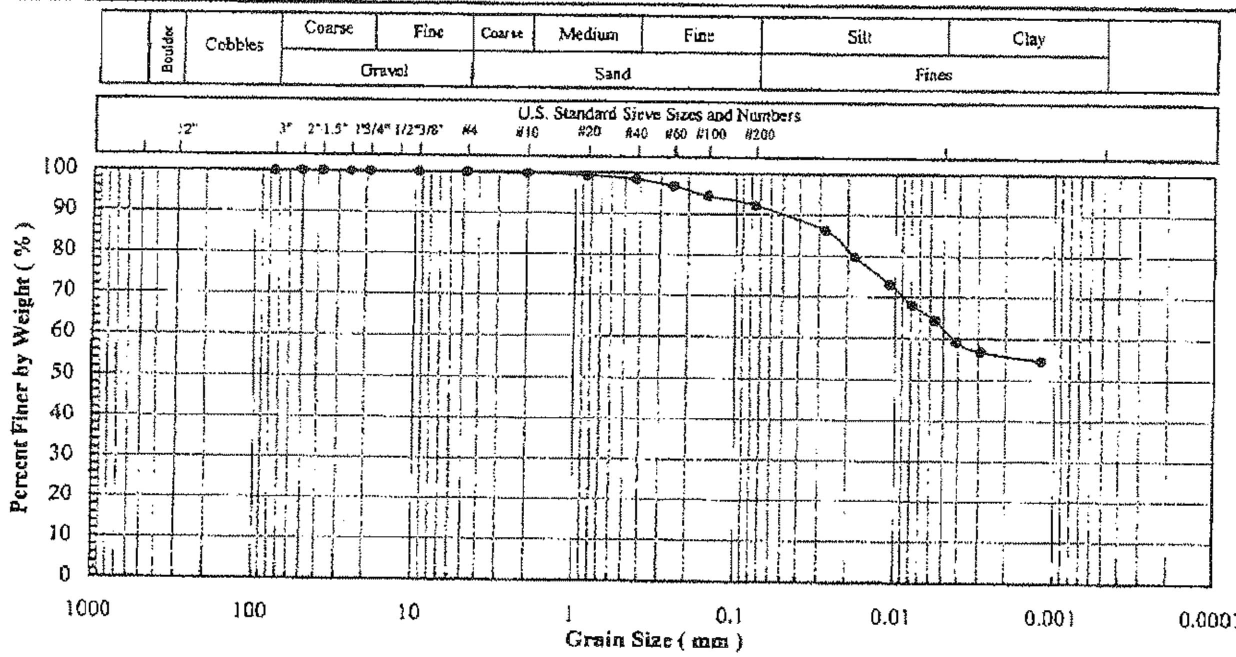
Excel Geotechnical Testing, Inc.
"Excellence in Testing"
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

Project Name:	KHF Clay Source Evaluation
Project No:	289
Client Sample ID:	CS-1-2 & CS-1-3
Lab Sample No:	L070 & L071

ASTM C 136, D 422, D 854, D 3180, D 2216, D 2487, D 4318

SOIL INDEX PROPERTIES

Grain Size, Spec. Gravity, Moist. Cont., Eng. Classification, Atterberg Limits



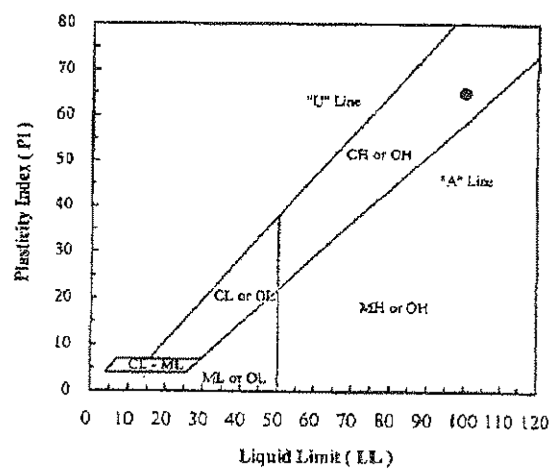
Sieve No.	Size (mm)	% Finer
3"	75	100.0
2"	50	100.0
1.5"	37.5	100.0
1"	25	100.0
3/4"	19	100.0
3/8"	9.5	100.0
#4	4.75	100.0
#10	2.00	99.7
#20	0.850	99.3
#40	0.425	98.4
#60	0.250	96.8
#100	0.150	94.5
#200	0.075	92.2

Specific Gravity (-):	2.65

Hydrometer Particle Diameter (mm)	% Finer
0.0275	86.2
0.0108	73.1
0.0056	64.4
0.0029	56.9
0.0012	54.7

Gravel (%):	
Sand (%):	7.8
Fines (%):	92.2
Silt (%):	29.9
Clay (%):	62.3

Coeff. Unif. (Cu):	
Coeff. Curv. (Cc):	



Client Sample ID.	Lab Sample No:	Moisture Content (%)	Fines Content < No. 200 (%)	Atterberg Limits LL (-)	PL (-)	PI (-)	Engineering Classification
CS-1-2 & CS-1-3	L070 & L071	16.0	92.2	100	35	65	CH - Fat clay

Note(s):

An assumed specific gravity of 2.65 was used when analyzing the hydrometer test results.

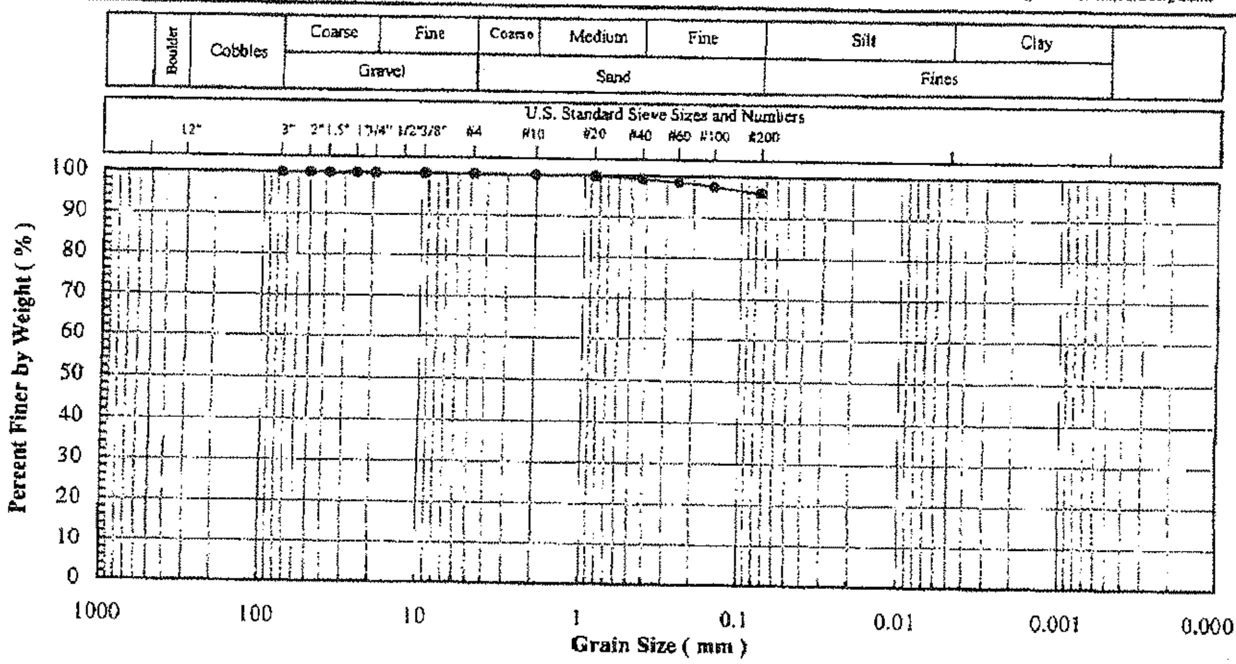
Excel Geotechnical Testing, Inc.
"Excellence in Testing"
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

Project Name:	KHF Clay Source Evaluation
Project No:	289
Client Sample ID:	CS-1-4
Lab Sample No:	L072

ASTM C 136, D 422, D 854, D 1140, D2216, D 2487, D4318

SOIL INDEX PROPERTIES

Grain Size, Spec. Gravity, Moist. Content, Eng. Classification, Atterberg Limits



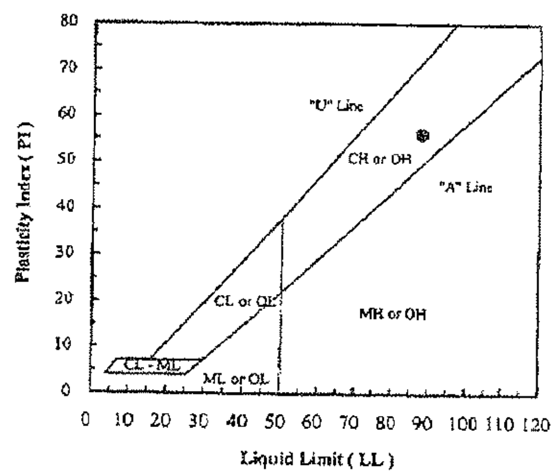
Sieve No.	Size (mm)	% Finer
3"	75	100.0
2"	50	100.0
1.5"	37.5	100.0
1"	25	100.0
3/4"	19	100.0
3/8"	9.5	100.0
#4	4.75	100.0
#10	2.00	99.9
#20	0.850	99.8
#40	0.425	99.2
#60	0.250	98.5
#100	0.150	97.5
#200	0.075	96.0

Specific Gravity (-):	

Hydrometer Particle Diameter (mm)	% Finer

Gravel (%):	
Sand (%):	4.0
Fines (%):	96.0
Silt (%):	
Clay (%):	

Coeff. Unif. (Cu):	
Coeff. Curv. (Cc):	



Client Sample ID.	Lab Sample No:	Moisture Content (%)	Fines Content < No. 200 (%)	Atterberg Limits LL (-)	PL (-)	PI (-)	Engineering Classification
CS-1-4	L072	18.5	96.0	88	32	56	CH - Fat clay

Note(s):

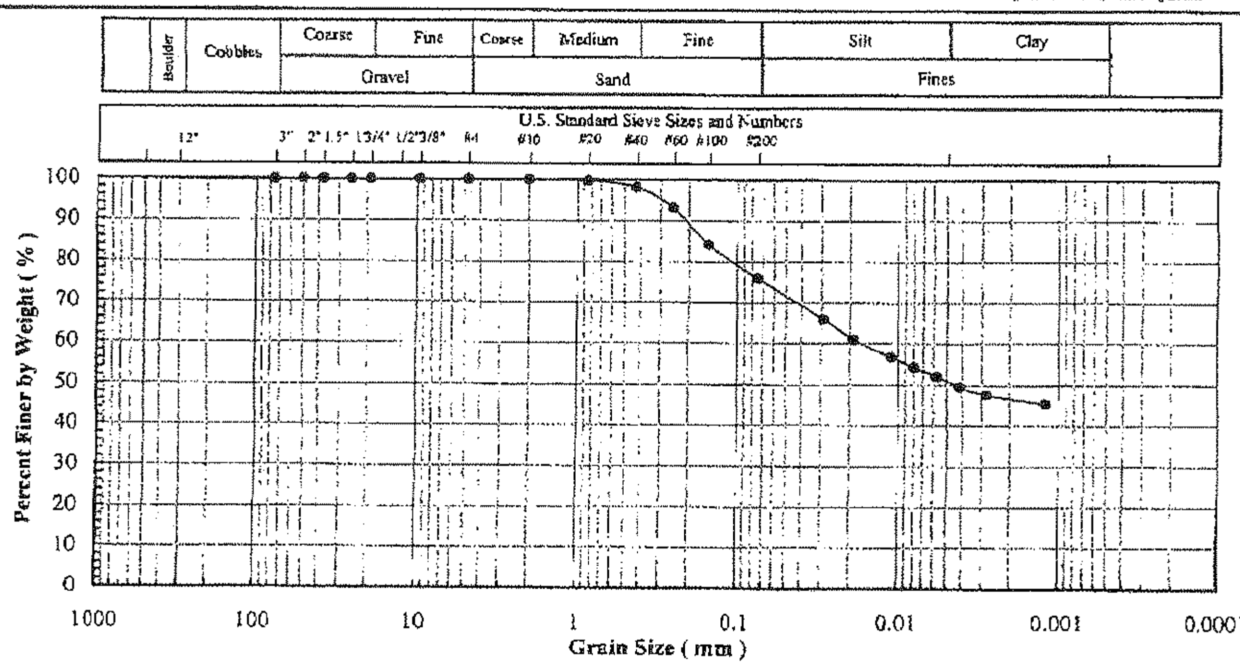
Excel Geotechnical Testing, Inc.
"Excellence in Testing"
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

Project Name:	KHF Clay Source Evaluation
Project No:	289
Client Sample ID:	CS-1A
Lab Sample No:	L103

ASTM C 136, D 422, D 854, D 1140, D 2216, D 2487, D 4318

SOIL INDEX PROPERTIES

Grain Size, Spec. Gravity, Moist. Cont, Eng. Classification, Atterberg Limits



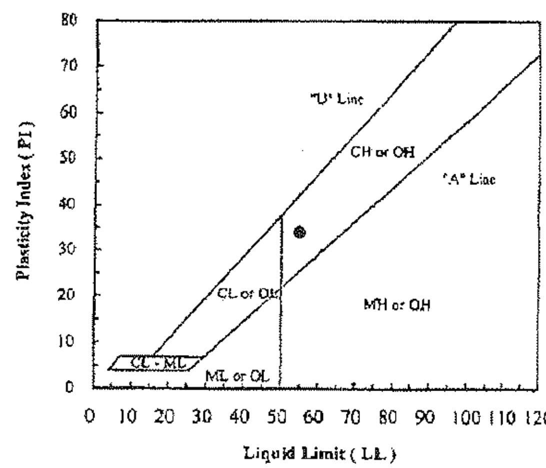
Sieve No.	Size (mm)	% Finer
3"	75	100.0
2"	50	100.0
1.5"	37.5	100.0
1"	25	100.0
3/4"	19	100.0
3/8"	9.5	100.0
#4	4.75	100.0
#10	2.00	100.0
#20	0.850	99.7
#40	0.425	98.2
#60	0.250	93.2
#100	0.150	84.2
#200	0.075	76.0

Specific Gravity (-):	2.65

Hydrometer Particle Diameter (mm)	% Finer
0.0292	65.9
0.0110	56.8
0.0057	52.1
0.0028	47.6
0.0012	45.4

Gravel (%):	
Sand (%):	24.0
Fines (%):	76.0
Silt (%):	25.0
Clay (%):	51.0

Coeff. Unif. (Cu):	
Coeff. Curv. (Cc):	



Client Sample ID.	Lab Sample No:	Moisture Content (%)	Fines Content < No. 200 (%)	Atterberg Limits LL (-)	PL (-)	PI (-)	Engineering Classification
CS-1A	L103	12.4	76.0	55	21	34	CH - Fat clay with sand

Note(s):

An assumed specific gravity of 2.65 was used when analyzing the hydrometer test results.

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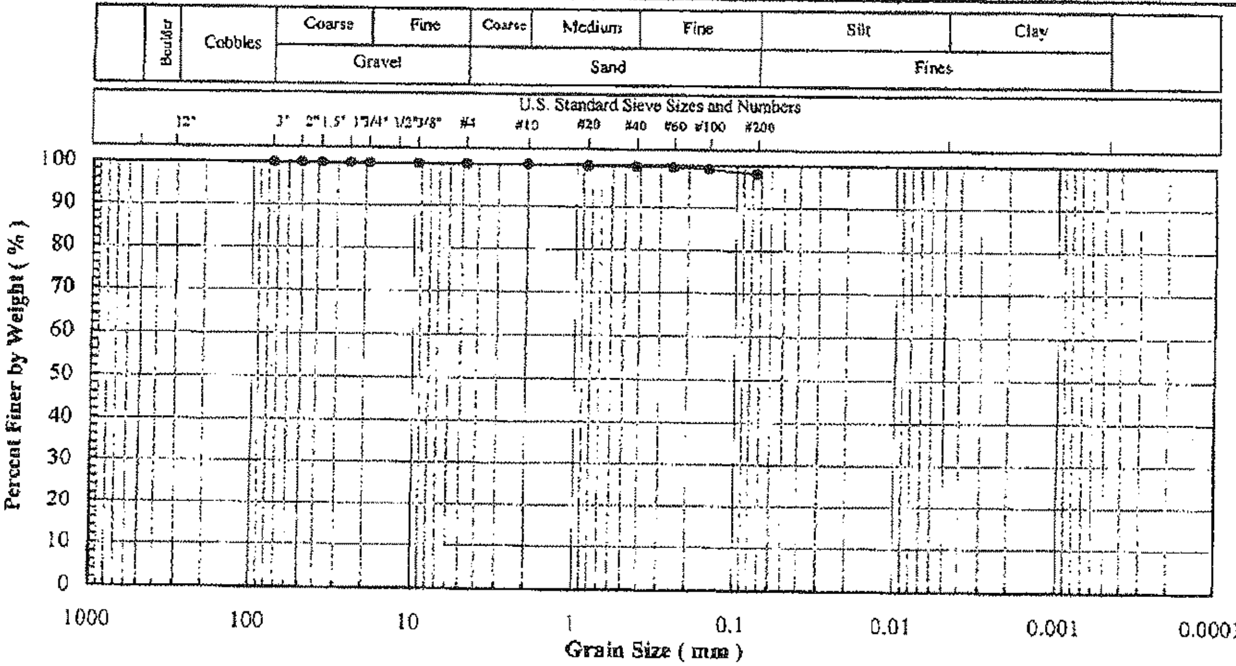
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

Project Name:	KHF Clay Source Evaluation
Project No:	289
Client Sample ID:	CS-1A-3
Lab Sample No:	L075

ASTM C 136, D 422, D 854, D 1140, D2216, D 2487, D4318

SOIL INDEX PROPERTIES

Grain Size, Spec. Gravity, Moist. Content, Eng. Classification, Atterberg Limits



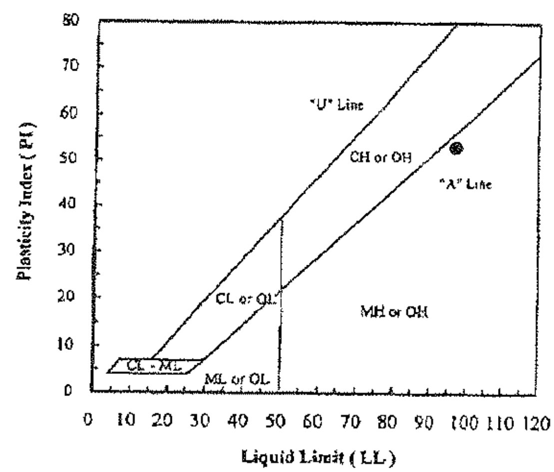
Sieve No.	Size (mm)	% Finer
3"	75	100.0
2"	50	100.0
1.5"	37.5	100.0
1"	25	100.0
3/4"	19	100.0
3/8"	9.5	100.0
#4	4.75	100.0
#10	2.00	100.0
#20	0.850	99.8
#40	0.425	99.6
#60	0.250	99.5
#100	0.150	99.2
#200	0.075	98.1

Specific Gravity (-):	

Hydrometer Particle Diameter (mm)	% Finer

Gravel (%):	
Sand (%):	1.9
Fines (%):	98.1
Silt (%):	
Clay (%):	

Coeff. Unif. (Cu):	
Coeff. Curv. (Cc):	



Client Sample ID.	Lab Sample No:	Moisture Content (%)	Fines Content < No. 200 (%)	Atterberg Limits LL (-)	PL (-)	PI (-)	Engineering Classification
CS-1A-3	L075	20.3	98.1	97	44	53	MH - Elastic silt

Note(s):

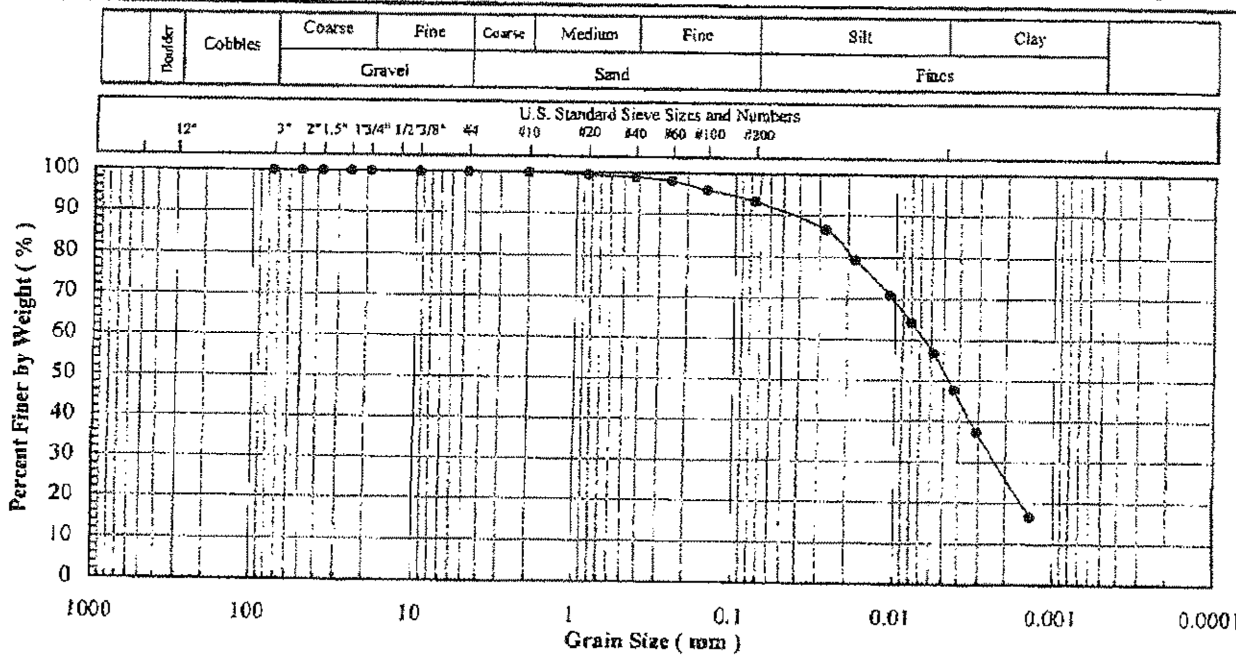
Excel Geotechnical Testing, Inc.
"Excellence in Testing"
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

Project Name:	KHF Clay Source Evaluation
Project No:	289
Client Sample ID:	CS-1A-5
Lab Sample No:	L077

ASTM C136, D 422, D 854, D 1140, D 2216, D 2487, D 4318

SOIL INDEX PROPERTIES

Grain Size, Spec. Gravity, Moist. Cont., Eng. Classification, Atterberg Limits



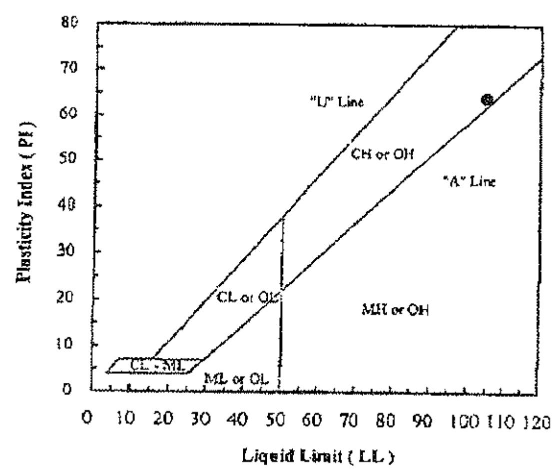
Sieve No.	Size (mm)	% Finer
3"	75	100.0
2"	50	100.0
1.5"	37.5	100.0
1"	25	100.0
3/4"	19	100.0
3/8"	9.5	100.0
#4	4.75	100.0
#10	2.00	100.0
#20	0.850	99.5
#40	0.425	98.9
#60	0.250	98.1
#100	0.150	95.9
#200	0.075	93.3

Specific Gravity (-):	2.65

Hydrometer Particle Diameter (mm)	% Finer
0.0275	86.6
0.0109	70.9
0.0058	56.8
0.0031	37.3
0.0014	16.6

Gravel (%):	
Sand (%):	6.7
Fines (%):	93.3
Silt (%):	41.3
Clay (%):	52.0

Coeff. Unif. (Cu):	
Coeff. Curv. (Cc):	



Client Sample ID.	Lab Sample No:	Moisture Content (%)	Fines Content < No. 200 (%)	Atterberg Limits LL (-)	PL (-)	PI (-)	Engineering Classification
CS-1A-5	L077	20.9	93.3	105	41	64	CH - Fat clay

Note(s):

An assumed specific gravity of 2.65 was used when analyzing the hydrometer test results.

Excel Geotechnical Testing, Inc.
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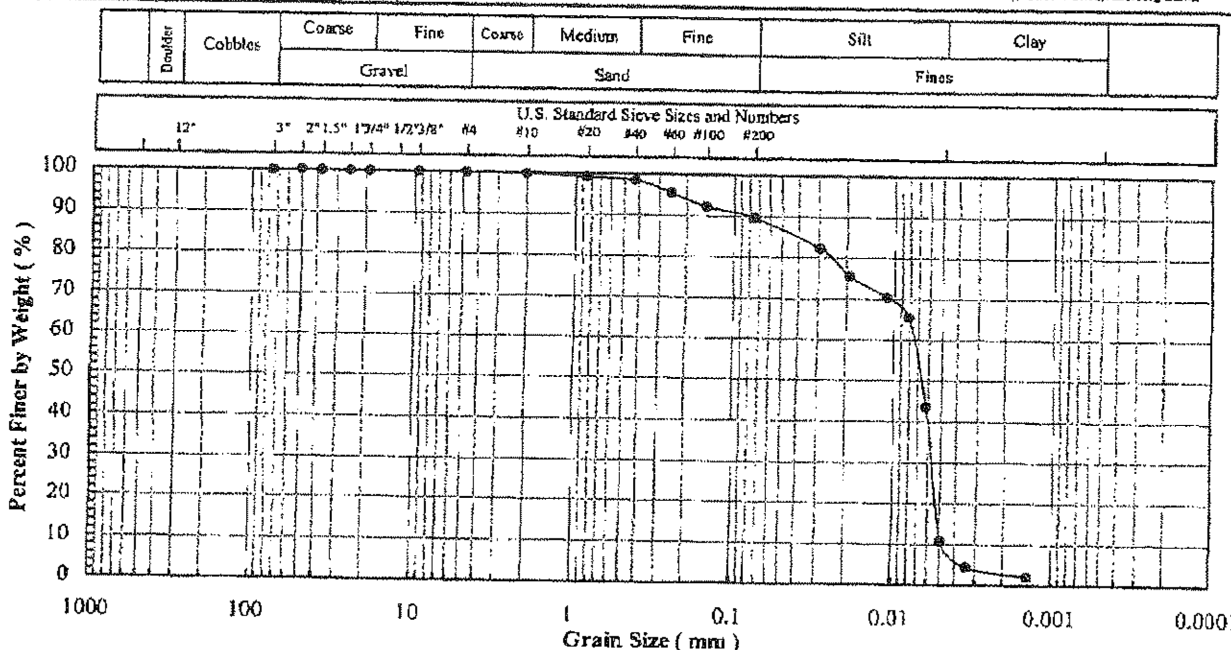
Project Name:	KHF Clay Source Evaluation
Project No:	289
Client Sample ID:	CS-1A-6 & CS-1A-7
Lab Sample No:	L078 & L079

ASTM C 136, D 422, D 854, D 1140, D 2216, D 2487, D 4318

SOIL INDEX PROPERTIES

Grain Size, Spec. Gravity, Moist. Cont., Eng. Classification, Atterberg Limits



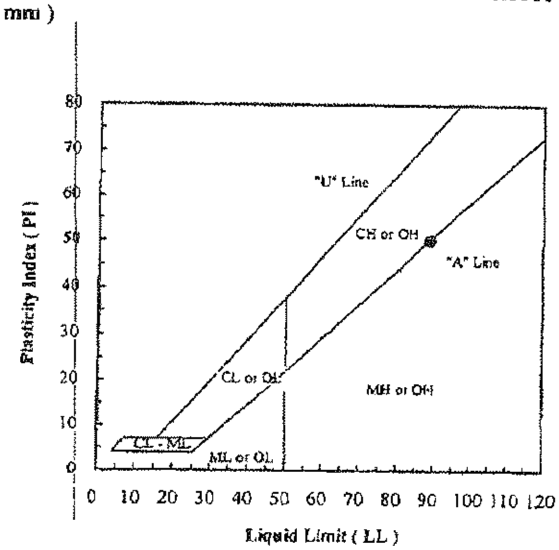
Sieve No.	Size (mm)	% Finer
3"	75	100.0
2"	50	100.0
1.5"	37.5	100.0
1"	25	100.0
3/4"	19	100.0
3/8"	9.5	100.0
#4	4.75	100.0
#10	2.00	99.8
#20	0.850	99.2
#40	0.425	98.4
#60	0.250	95.6
#100	0.150	92.3
#200	0.075	89.6

Specific Gravity (-):	2.65

Hydrometer Particle Diameter (mm)	% Finer
0.0293	82.2
0.0112	70.4
0.0062	43.7
0.0034	4.5
0.0014	2.1

Gravel (%):	
Sand (%):	10.4
Fines (%):	89.6
Silt (%):	76.3
Clay (%):	13.3

Coeff. Unif. (Cu):	
Coeff. Curv. (Cc):	



Client Sample ID.	Lab Sample No:	Moisture Content (%)	Fines Content < No. 200 (%)	Atterberg Limits LL (-)	PL (-)	PI (-)	Engineering Classification
CS-1A-6 & CS-1A-7	L078 & L079	23.1	89.6	89	39	50	MH - Elastic silt

Note(s):

An assumed specific gravity of 2.65 was used when analyzing the hydrometer test results.

Hydrometer soil specimen conglomerated and formed a cloudy substance which settled to the lower portion of the test tube (i.e., the test results may be questionable).

Excel Geotechnical Testing, Inc.
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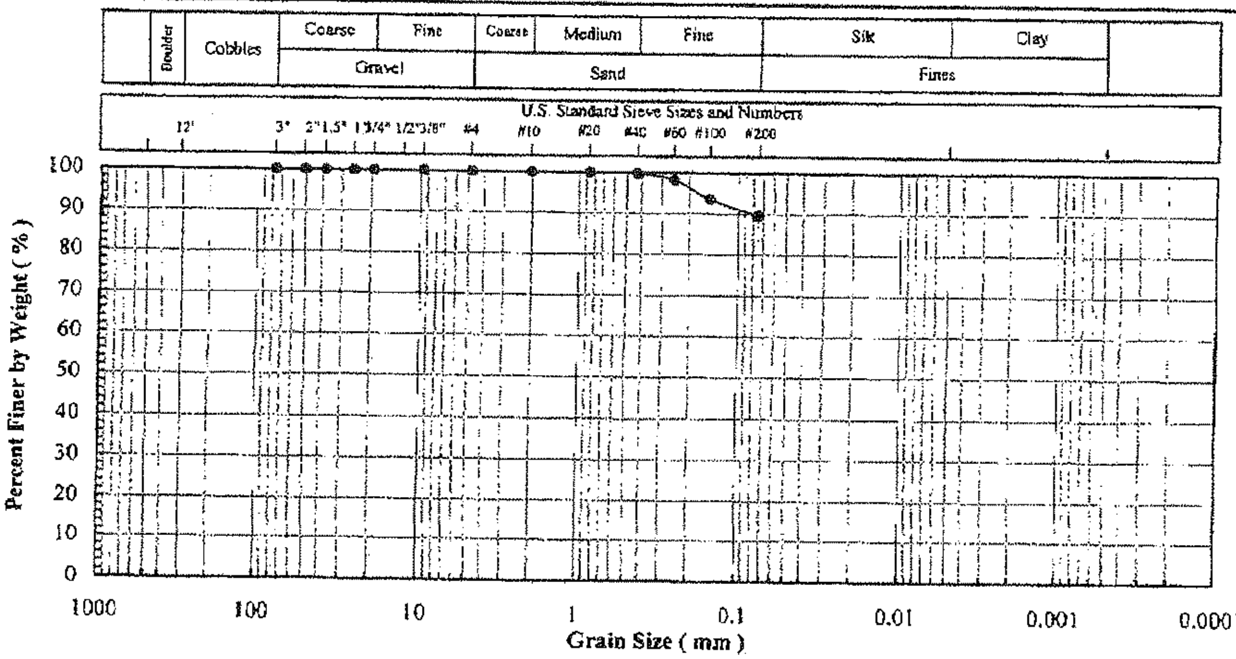
Tel: (770) 650 1666 Fax: (770) 650 5786

Project Name:	KHF Clay Source Evaluation
Project No:	289
Client Sample ID:	CS-1A-8
Lab Sample No:	L080

ASTM C 136, D 422, D 854, D 1140, D2216, D 2487, D4318

SOIL INDEX PROPERTIES

Grain Size, Spec. Gravity, Moist. Content, Eng. Classification, Atterberg Limits



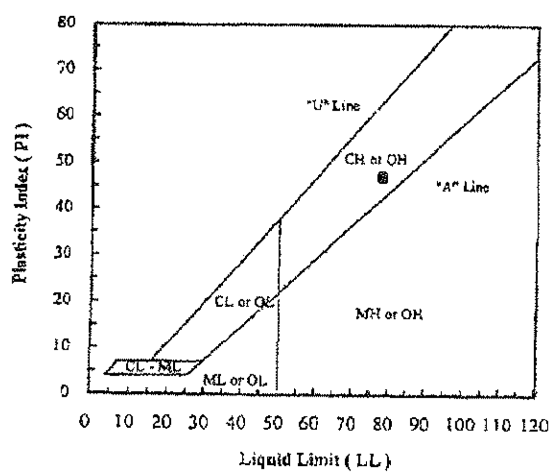
Sieve No.	Size (mm)	% Finer
3"	75	100.0
2"	50	100.0
1.5"	37.5	100.0
1"	25	100.0
3/4"	19	100.0
3/8"	9.5	100.0
#4	4.75	100.0
#10	2.00	100.0
#20	0.850	100.0
#40	0.425	99.8
#60	0.250	98.3
#100	0.150	93.5
#200	0.075	89.5

Specific Gravity (-):	

Hydrometer Particle Diameter (mm)	% Finer

Gravel (%):	
Sand (%):	10.5
Fines (%):	89.5
Silt (%):	
Clay (%):	

Coeff. Unif. (Cu):	
Coeff. Curv. (Cc):	



Client Sample ID.	Lab Sample No:	Moisture Content (%)	Fines Content < No. 200 (%)	Atterberg Limits LL (-)	PL (-)	PI (-)	Engineering Classification
CS-1A-8	L080	21.2	89.5	78	31	47	CH - Fat clay

Note(s):

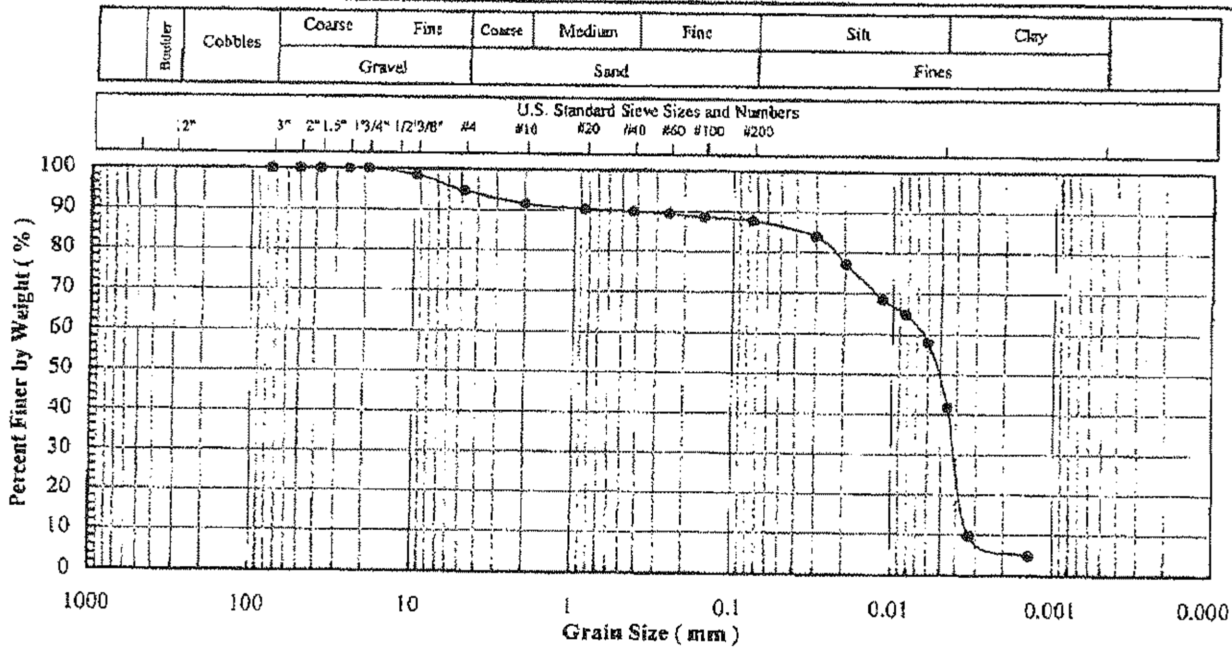
Excel Geotechnical Testing, Inc.
"Excellence in Testing"
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 660 1666 Fax: (770) 650 5786

Project Name:	KHF Clay Source Evaluation
Project No:	289
Client Sample ID:	CS-1A-9
Lab Sample No:	L081

ASTM C 136, D 422, D 854, D 1140, D 2216, D 2487, D 4318

SOIL INDEX PROPERTIES

Grain Size, Spec. Gravity, Moist. Cont., Sup. Classification, Atterberg Limits



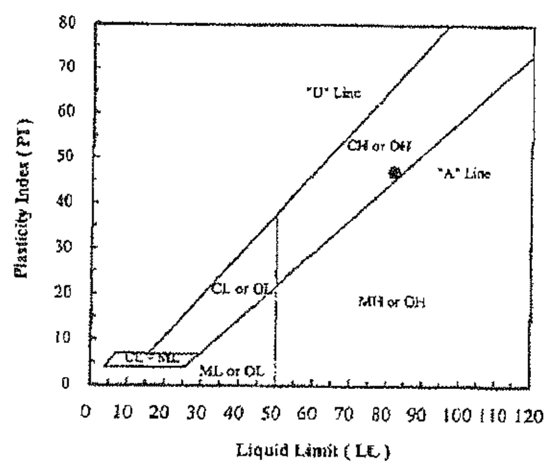
Sieve No.	Size (mm)	% Finer
3"	75	100.0
2"	50	100.0
1.5"	37.5	100.0
1"	25	100.0
3/4"	19	100.0
3/8"	9.5	98.5
#4	4.75	94.6
#10	2.00	91.5
#20	0.850	90.4
#40	0.425	89.9
#60	0.250	89.4
#100	0.150	88.6
#200	0.075	87.7

Specific Gravity (-):	2.65

Hydrometer Particle Diameter (mm)	% Finer
0.0302	84.0
0.0116	68.5
0.0060	58.0
0.0033	9.7
0.0014	4.9

Gravel (%):	5.4
Sand (%):	6.9
Fines (%):	87.7
Silt (%):	40.5
Clay (%):	47.2

Coeff. Unif. (Cu):	
Coeff. Curv. (Cc):	



Client Sample ID.	Lab Sample No:	Moisture Content (%)	Fines Content < No. 200 (%)	Atterberg Limits LL (-)	PL (-)	PI (-)	Engineering Classification
CS-1A-9	L081	24.4	87.7	82	35	47	CH - Fat clay

Note(s):

An assumed specific gravity of 2.65 was used when analyzing the hydrometer test results.

Hydrometer soil specimen conglomerated and formed a cloudy substance which settled to the lower portion of the test tube (i.e., the test results may be questionable).

Excel Geotechnical Testing, Inc.
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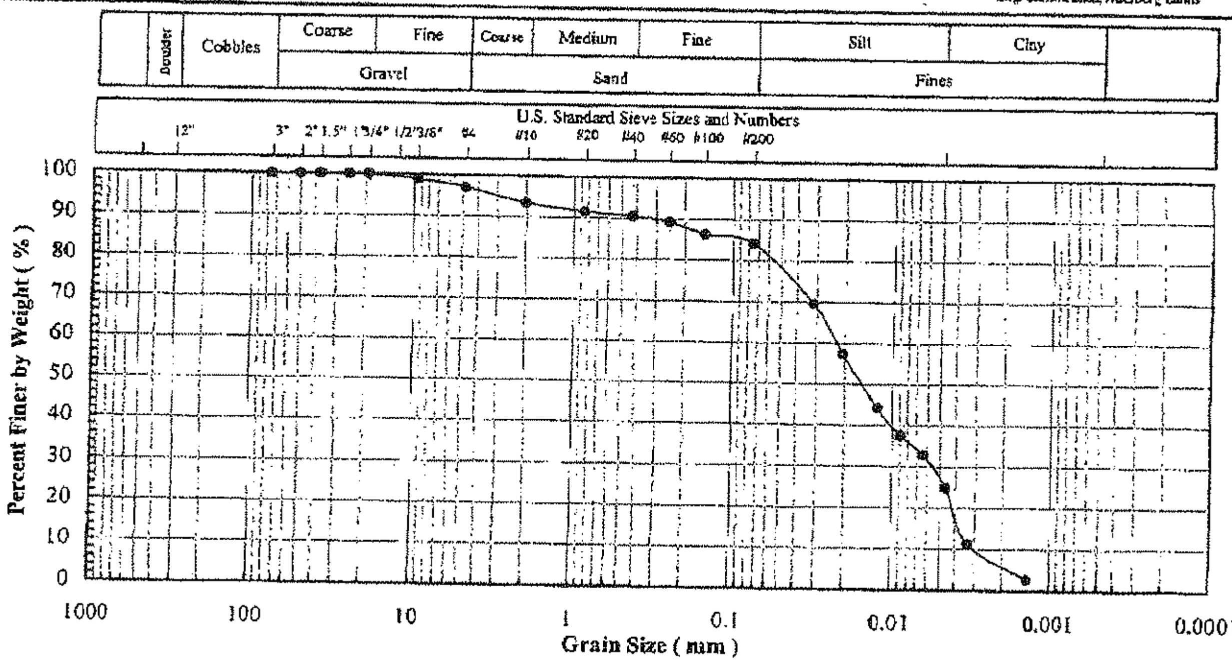
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

Project Name:	KHF Clay Source Evaluation
Project No:	289
Client Sample ID:	CS-1A-11
Lab Sample No:	L083

ASTM C 136, D 422, D 854, D 1140, D 2216, D 2487, D 4318

SOIL INDEX PROPERTIES

Grain Size, Spec. Gravity, Moist. Cont, Eng. Classification, Atterberg Limits



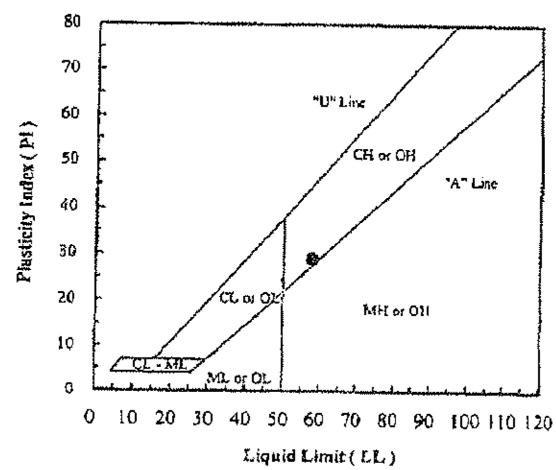
Sieve No.	Size (mm)	% Finer
3"	75	100.0
2"	50	100.0
1.5"	37.5	100.0
1"	25	100.0
3/4"	19	100.0
3/8"	9.5	98.9
#4	4.75	96.9
#10	2.00	93.5
#20	0.850	91.5
#40	0.425	90.5
#60	0.250	89.2
#100	0.150	86.3
#200	0.075	84.2

Specific Gravity (-):	2.65

Hydrometer Particle Diameter (mm)	% Finer
0.0314	69.5
0.0124	44.2
0.0064	32.9
0.0033	11.2
0.0014	2.8

Gravel (%):	3.1
Sand (%):	12.7
Fines (%):	84.2
Silt (%):	57.5
Clay (%):	26.7

Coeff. Unif. (Cu):	
Coeff. Curv. (Cc):	



Client Sample ID.	Lab Sample No:	Moisture Content (%)	Fines Content < No. 200 (%)	Atterberg Limits LL (-)	PL (-)	PI (-)	Engineering Classification
CS-1A-11	L083	18.6	84.2	58	29	29	CH - Fat clay with sand

Note(s).

An assumed specific gravity of 2.65 was used when analyzing the hydrometer test results.

Excel Geotechnical Testing, Inc.
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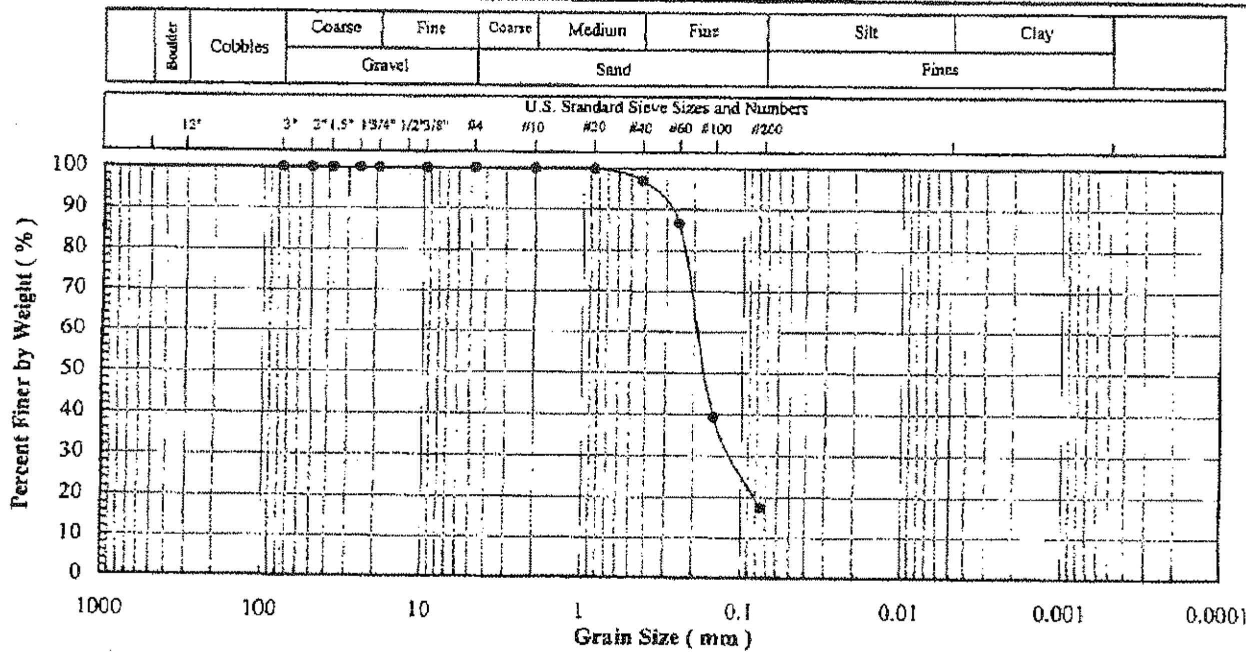
Project Name:	KHF Clay Source Evaluation
Project No:	289
Client Sample ID:	CS-1A-13
Lab Sample No:	L085

ASTM C 136, D 422, D 854, D 1140, D2216, D 2487, D4318

SOIL INDEX PROPERTIES

Grain Size, Spec. Gravity, Moist. Content, Eng. Classification, Atterberg Limits



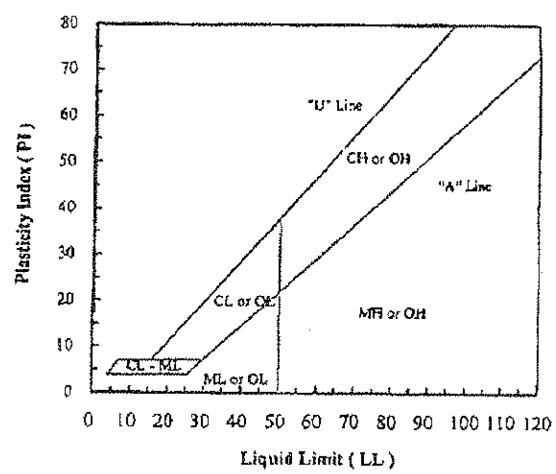
Sieve No.	Size (mm)	% Finer
3"	75	100.0
2"	50	100.0
1.5"	37.5	100.0
1"	25	100.0
3/4"	19	100.0
3/8"	9.5	100.0
#4	4.75	100.0
#10	2.00	100.0
#20	0.850	99.9
#40	0.425	97.1
#60	0.250	86.7
#100	0.150	39.4
#200	0.075	17.4

Specific Gravity (-):	

Hydrometer Particle Diameter (mm)	% Finer

Gravel (%):	
Sand (%):	82.6
Fines (%):	17.4
Silt (%):	
Clay (%):	

Coeff. Unif. (Cu):	
Coeff. Curv. (Cc):	



Client Sample ID.	Lab Sample No:	Moisture Content (%)	Fines Content < No. 200 (%)	Atterberg Limits LL (-)	PL (-)	PI (-)	Engineering Classification
CS-1A-13	L085	3.4	17.4				

Note(s):

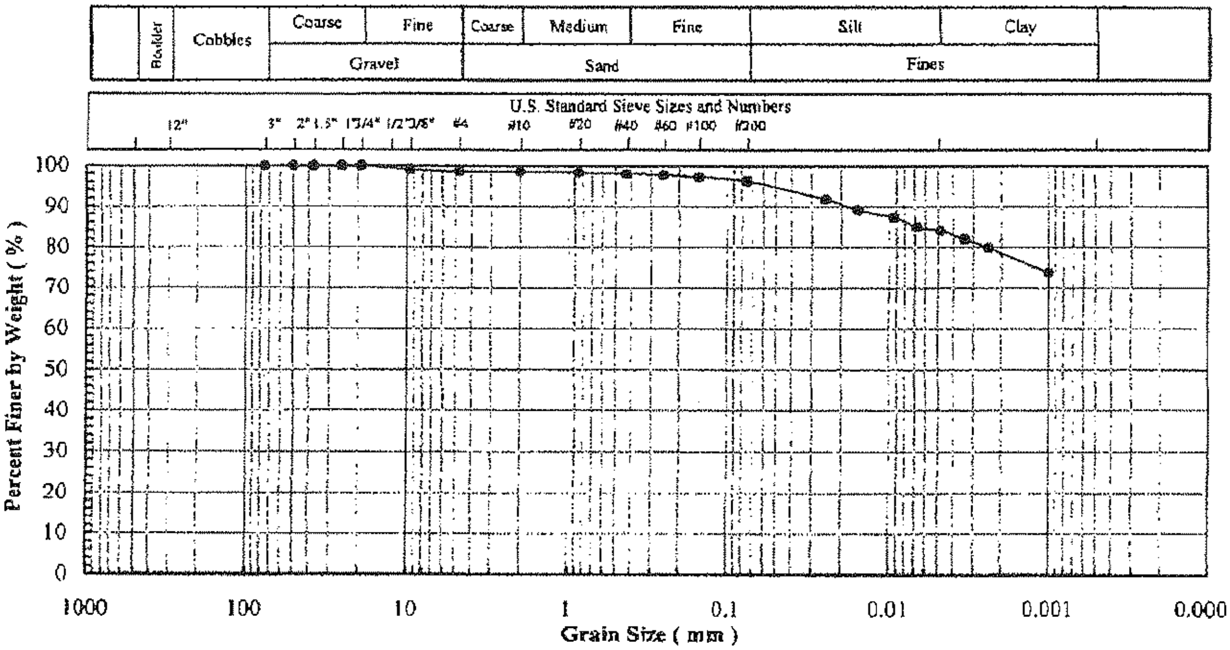
Excel Geotechnical Testing, Inc.
"Excellence in Testing"
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

Project Name:	KHF Clay Source Evaluation
Project No:	289
Client Sample ID:	CS-2
Lab Sample No:	L104

ASTM C 136, D 422, D 854, D 1140, D 2216, D 2487, D 4318

SOIL INDEX PROPERTIES

Grain Size, Spec. Gravity, Moist. Cont., Eng. Classification, Atterberg Limits



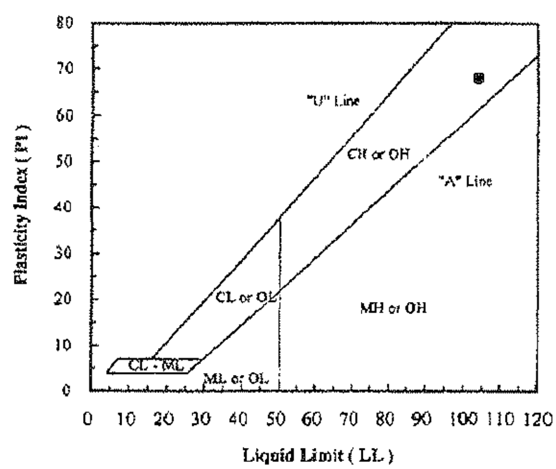
Sieve No.	Size (mm)	% Finer
3"	75	100.0
2"	50	100.0
1.5"	37.5	100.0
1"	25	100.0
3/4"	19	100.0
3/8"	9.5	99.1
#4	4.75	98.6
#10	2.00	98.6
#20	0.850	98.4
#40	0.425	98.1
#60	0.250	97.8
#100	0.150	97.3
#200	0.075	96.3

Specific Gravity (-):	2.65

Hydrometer Particle Diameter (mm)	% Finer
0.0247	91.8
0.0093	87.4
0.0048	84.1
0.0024	80.0
0.0010	73.8

Gravel (%):	1.4
Sand (%):	2.3
Fines (%):	96.3
Silt (%):	11.9
Clay (%):	84.4

Coeff. Unif. (Cu):	
Coeff. Curv. (Cc):	



Client Sample ID.	Lab Sample No:	Moisture Content (%)	Fines Content < No. 200 (%)	Atterberg Limits LL (-)	PL (-)	PI (-)	Engineering Classification
CS-2	L104	14.1	96.3	104	36	68	CH - Fat clay

Note(s):

An assumed specific gravity of 2.65 was used when analyzing the hydrometer test results.

Hydrometer soil specimen conglomerated and formed a cloudy substance which settled to the lower portion of the test tube (i.e., the test results may be questionable).

Excel Geotechnical Testing, Inc.
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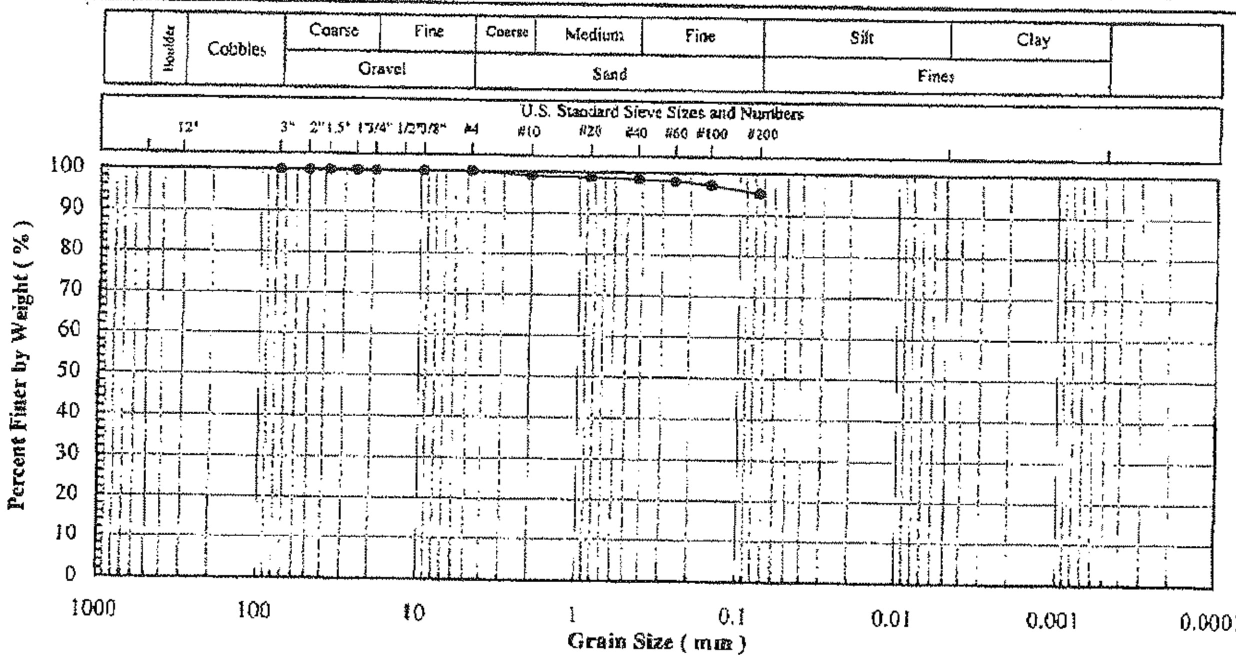
Tel: (770) 650 1666 Fax: (770) 650 5786

Project Name:	KHF Clay Source Evaluation
Project No:	289
Client Sample ID:	CS-2-2
Lab Sample No:	L087

ASTM C 136, D 422, D 854, D 1140, D2216, D 2487, D4318

SOIL INDEX PROPERTIES

Grain Size, Spec. Gravity, Moist. Content, Eng. Classification, Atterberg Limits



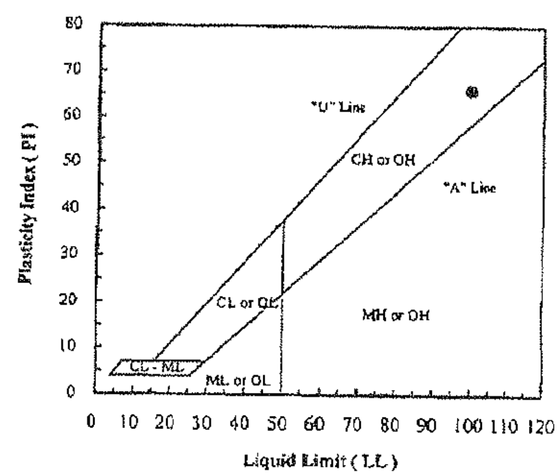
Sieve No.	Size (mm)	% Finer
3"	75	100.0
2"	50	100.0
1.5"	37.5	100.0
1"	25	100.0
3/4"	19	100.0
3/8"	9.5	100.0
#4	4.75	100.0
#10	2.00	99.1
#20	0.850	98.8
#40	0.425	98.4
#60	0.250	98.0
#100	0.150	97.1
#200	0.075	95.2

Specific Gravity (-):	

Hydrometer Particle Diameter (mm)	% Finer

Gravel (%):	
Sand (%):	4.8
Fines (%):	95.2
Silt (%):	
Clay (%):	

Coeff. Unif. (Cu):	
Coeff. Curv. (Cc):	



Client Sample ID.	Lab Sample No:	Moisture Content (%)	Fines Content < No. 200 (%)	Atterberg Limits LL (-)	PL (-)	PI (-)	Engineering Classification
CS-2-2	L087	16.5	95.2	100	34	66	CH - Fat clay

Note(s):

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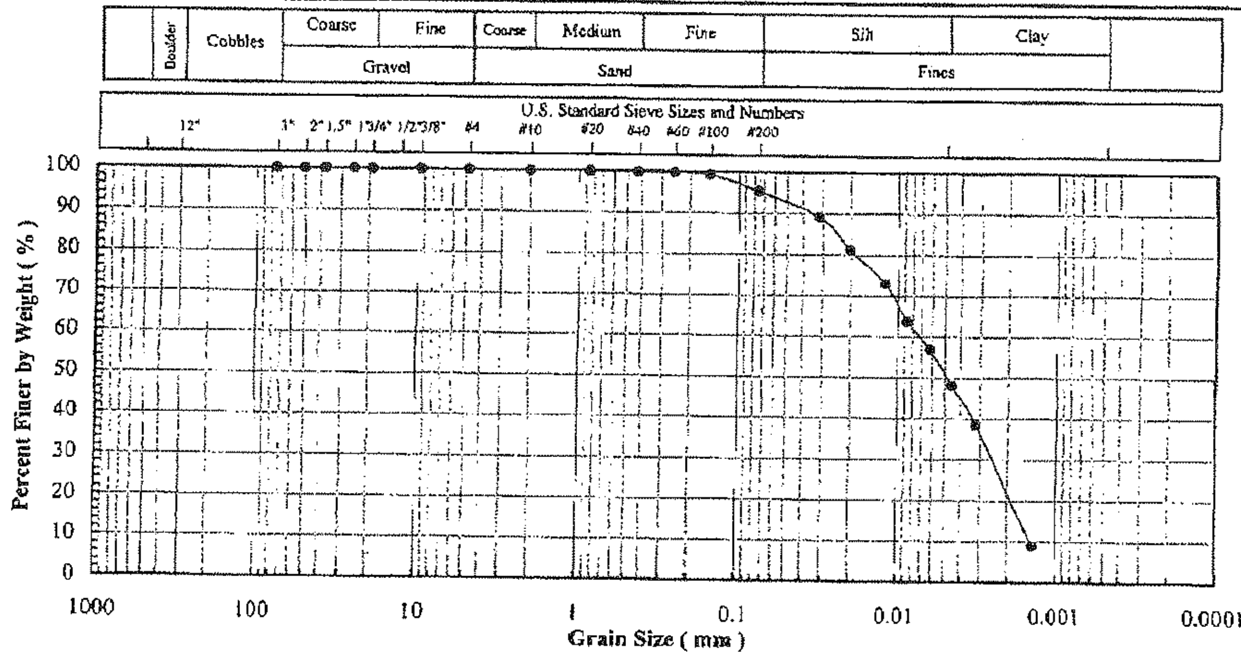
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

Project Name:	KHF Clay Source Evaluation
Project No:	289
Client Sample ID:	CS-2-4
Lab Sample No:	L089

ASTM C 136, D 422, D 854, D 1140, D 2216, D 2487, D 4318

SOIL INDEX PROPERTIES

Grain Size, Spec. Gravity, Moist. Cont., Eng. Classification, Atterberg Limits



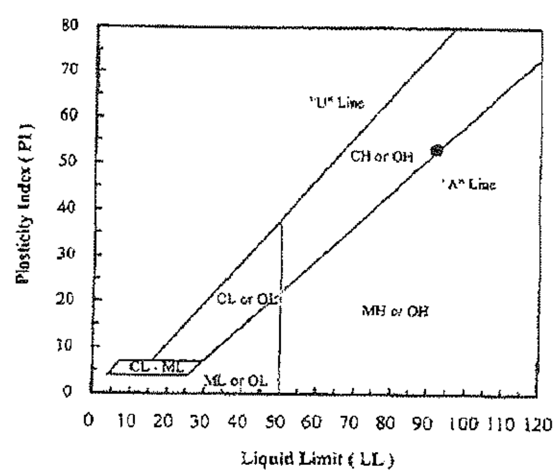
Sieve No.	Size (mm)	% Finer
3"	75	100.0
2"	50	100.0
1.5"	37.5	100.0
1"	25	100.0
3/4"	19	100.0
3/8"	9.5	100.0
#4	4.75	100.0
#10	2.00	99.9
#20	0.850	99.9
#40	0.425	99.8
#60	0.250	99.7
#100	0.150	99.3
#200	0.075	95.3

Specific Gravity (-):	2.65

Hydrometer Particle Diameter (mm)	% Finer
0.0316	89.2
0.0120	73.0
0.0062	56.8
0.0032	38.6
0.0014	8.9

Gravel (%):	
Sand (%):	4.7
Fines (%):	95.3
Silt (%):	44.7
Clay (%):	50.6

Coeff. Unif. (Cu):	
Coeff. Curv. (Cc):	



Client Sample ID.	Lab Sample No:	Moisture Content (%)	Fines Content < No. 200 (%)	Atterberg Limits LL (-)	PL (-)	PI (-)	Engineering Classification
CS-2-4	L089	21.0	95.3	92	39	53	CH - Fat clay

Note(s):

An assumed specific gravity of 2.65 was used when analyzing the hydrometer test results.

Hydrometer soil specimen conglomerated and formed a cloudy substance which settled to the lower portion of the test tube (i.e., the test results may be questionable).

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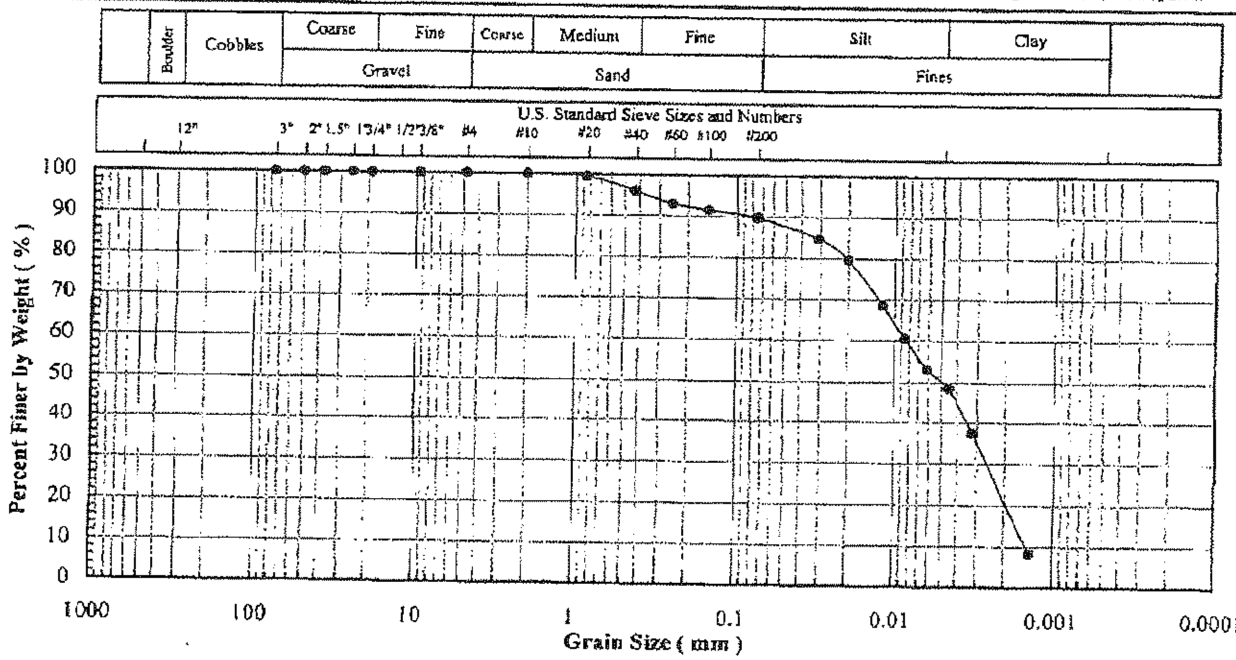
Project Name:	KHF Clay Source Evaluation
Project No:	289
Client Sample ID:	CS-2-7
Lab Sample No:	L092

ASTM C 136, D 422, D 854, D 1140, D 2216, D 2487, D 4318

SOIL INDEX PROPERTIES

Grain Size, Spec. Gravity, Moist. Cont., Eng. Classification, Atterberg Limits



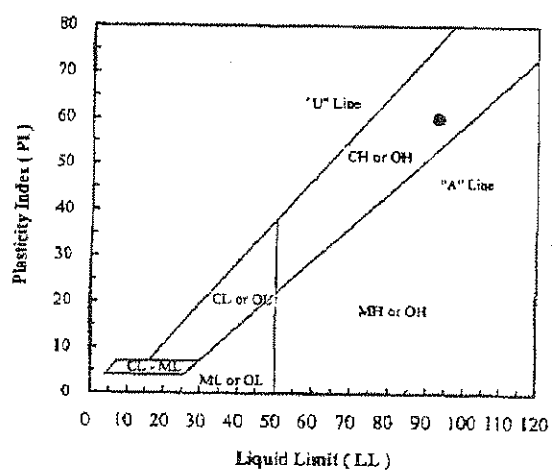
Sieve No.	Size (mm)	% Finer
3"	75	100.0
2"	50	100.0
1.5"	37.5	100.0
1"	25	100.0
3/4"	19	100.0
3/8"	9.5	100.0
#4	4.75	100.0
#10	2.00	99.9
#20	0.850	99.4
#40	0.425	95.9
#60	0.250	92.9
#100	0.150	91.5
#200	0.075	89.8

Specific Gravity (-):	2.63

Hydrometer Particle Diameter (mm)	% Finer
0.0311	84.7
0.0119	68.5
0.0062	53.2
0.0032	37.5
0.0014	8.3

Gravel (%):	
Sand (%):	10.2
Fines (%):	89.8
Silt (%):	39.8
Clay (%):	50.0

Coeff. Unif. (Cu):	
Coeff. Curv. (Cc):	



Client Sample ID.	Lab Sample No:	Moisture Content (%)	Fines Content < No. 200 (%)	Atterberg Limits LL (-)	PL (-)	PI (-)	Engineering Classification
CS-2-7	L092	21.0	89.8	93	33	60	CH - Fat clay

Note(s):

An assumed specific gravity of 2.65 was used when analyzing the hydrometer test results.

Hydrometer soil specimen conglomerated and formed a cloudy substance which settled to the lower portion of the test tube (i.e., the test results may be questionable).

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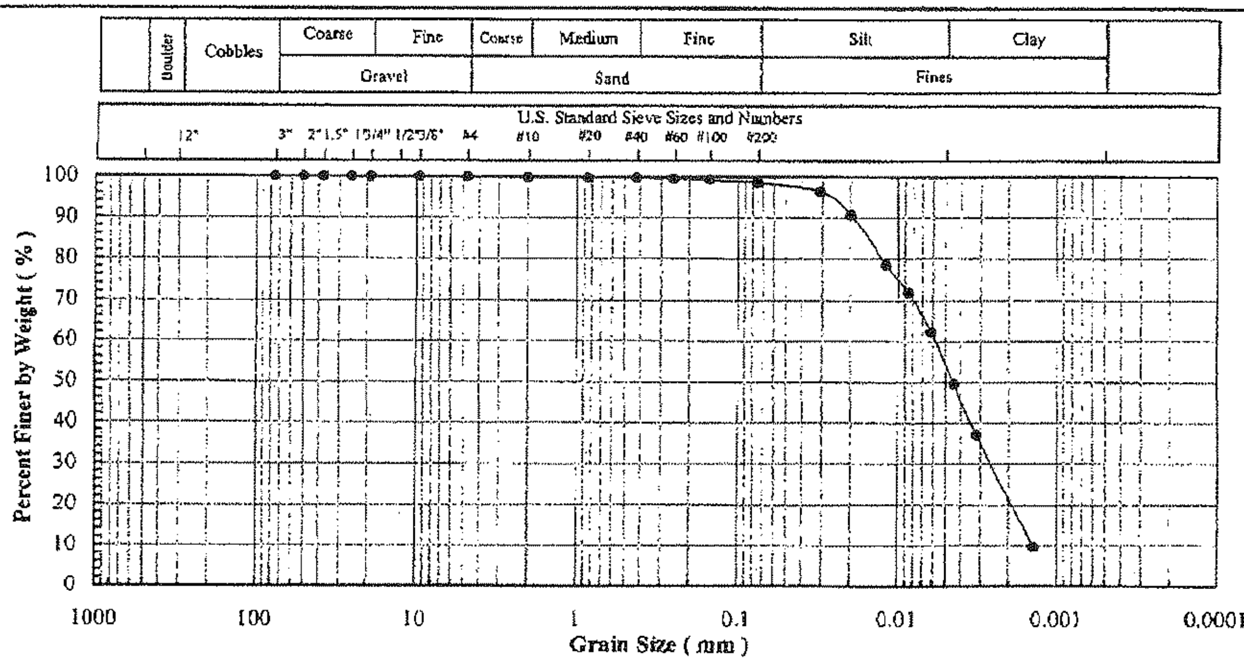
Project Name:	KHF Clay Source Evaluation
Project No:	289
Client Sample ID:	CS-2-9
Lab Sample No:	L094

ASTM C 136, D 422, D 854, D 2140, D 2216, D 2487, D 4318

SOIL INDEX PROPERTIES

Grain Size, Spec. Gravity, Moist. Cont., Eng. Classification, Atterberg Limits



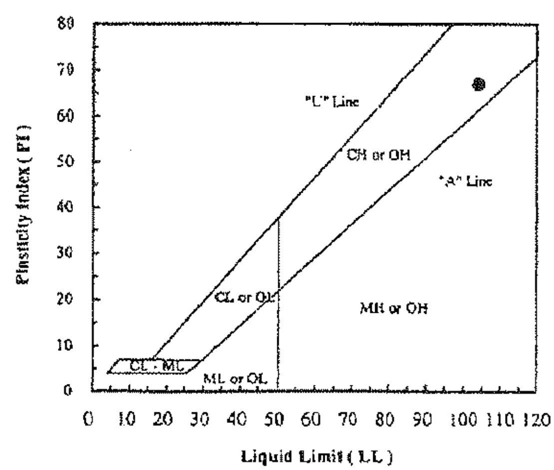
Sieve No.	Size (mm)	% Finer
3"	75	100.0
2"	50	100.0
1.5"	37.5	100.0
1"	25	100.0
3/4"	19	100.0
3/8"	9.5	100.0
#4	4.75	99.9
#10	2.00	99.8
#20	0.850	99.7
#40	0.425	99.7
#60	0.250	99.5
#100	0.150	99.3
#200	0.075	98.6

Specific Gravity (-):	2.65

Hydrometer Particle Diameter (mm)	% Finer
0.0309	96.4
0.0118	78.5
0.0061	62.2
0.0032	37.2
0.0014	9.7

Gravel (%):	0.1
Sand (%):	1.3
Fines (%):	98.6
Silt (%):	44.6
Clay (%):	54.0

Coeff. Unif. (Cu):	
Coeff. Curv. (Cc):	



Client Sample ID.	Lab Sample No:	Moisture Content (%)	Fines Content < No. 200 (%)	Atterberg Limits LL (-)	PL (-)	PI (-)	Engineering Classification
CS-2-9	L094	24.7	98.6	104	37	67	CH - Fat clay

Note(s):

An assumed specific gravity of 2.65 was used when analyzing the hydrometer test results.

Hydrometer soil specimen conglomerated and formed a cloudy substance which settled to the lower portion of the test tube (i.e., the test results may be questionable).

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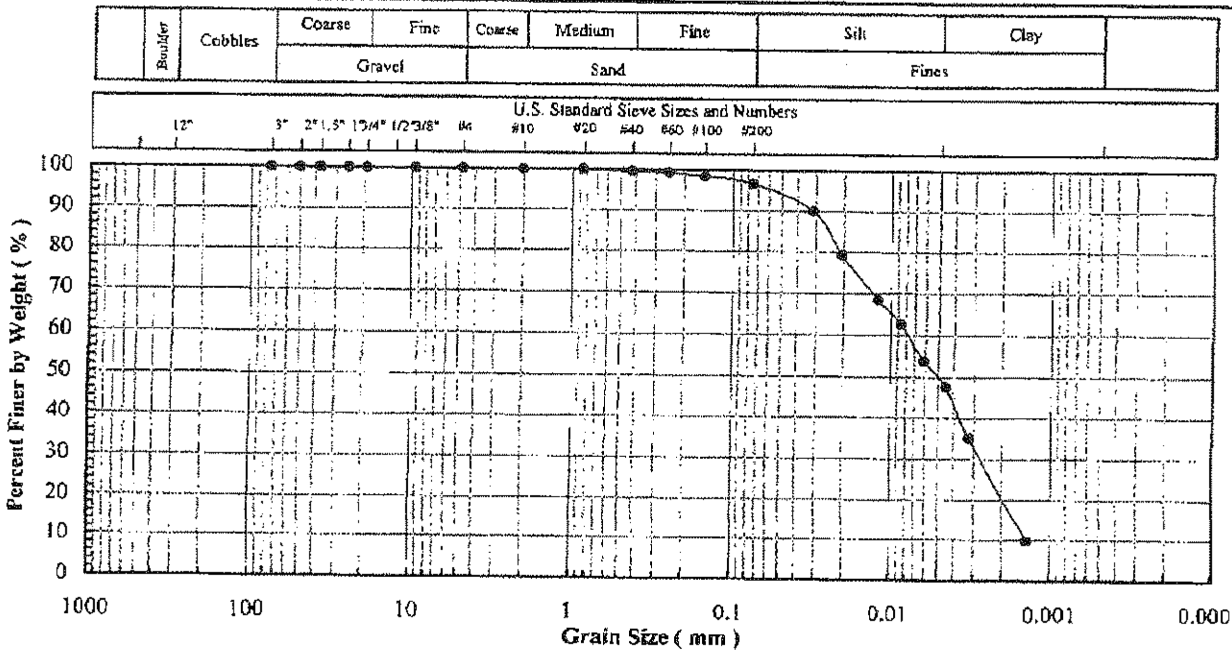
Project Name:	KHF Clay Source Evaluation
Project No:	289
Client Sample ID:	CS-2-11
Lab Sample No:	L095

ASTM C 136, D 422, D 854, D 1140, D 2216, D 2487, D 4318

SOIL INDEX PROPERTIES

Grain Size, Spec. Gravity, Moist. Cont., Eng. Classification, Atterberg Limits



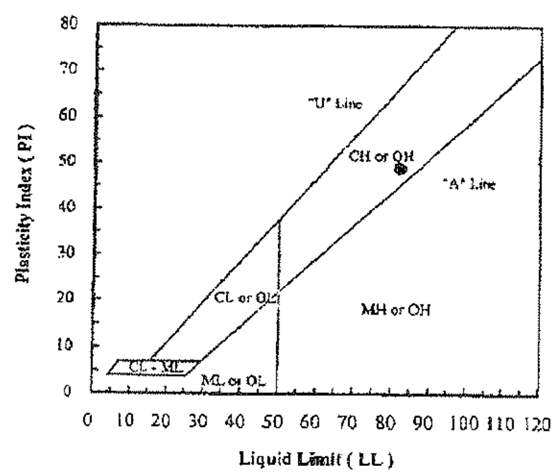
Sieve No.	Size (mm)	% Finer
3"	75	100.0
2"	50	100.0
1.5"	37.5	100.0
1"	25	100.0
3/4"	19	100.0
3/8"	9.5	100.0
#4	4.75	100.0
#10	2.00	99.9
#20	0.850	99.9
#40	0.425	99.6
#60	0.250	99.2
#100	0.150	98.5
#200	0.075	96.7

Specific Gravity (-):	2.65

Hydrometer Particle Diameter (mm)	% Finer
0.0315	90.1
0.0121	68.4
0.0062	53.9
0.0032	35.2
0.0014	9.8

Gravel (%):	
Sand (%):	3.3
Fines (%):	96.7
Silt (%):	47.2
Clay (%):	49.5

Coeff. Unif. (Cu):	
Coeff. Curv. (Cc):	



Client Sample ID.	Lab Sample No:	Moisture Content (%)	Fines Content < No. 200 (%)	Atterberg Limits LL (-)	PL (-)	PI (-)	Engineering Classification
CS-2-11	L095	24.0	96.7	82	33	49	CH - Fat clay

Note(s):

An assumed specific gravity of 2.65 was used when analyzing the hydrometer test results.

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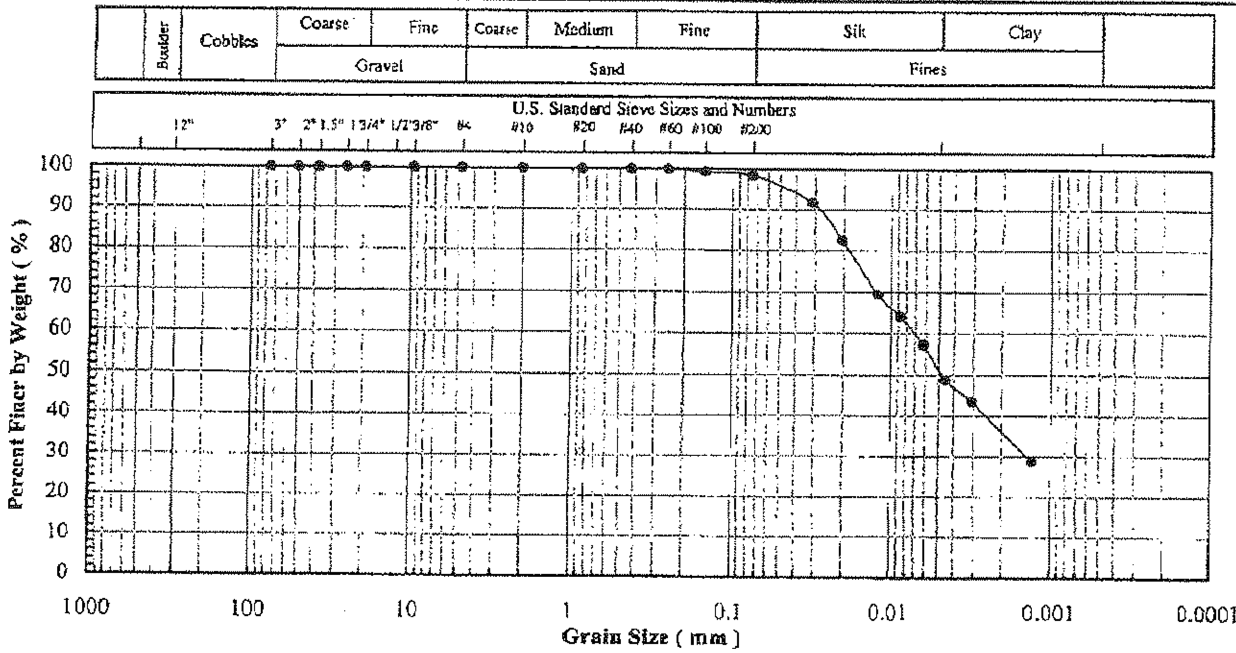
Project Name:	KHF Clay Source Evaluation
Project No:	289
Client Sample ID:	CS-2-13 & CS-2-14
Lab Sample No:	L097 & L098

ASTM C 136, D 422, D 854, D 1140, D 2216, D 2487, D 4318

SOIL INDEX PROPERTIES

Grain Size, Spec. Gravity, Moist. Cont, Eng. Classification, Atterberg Limits



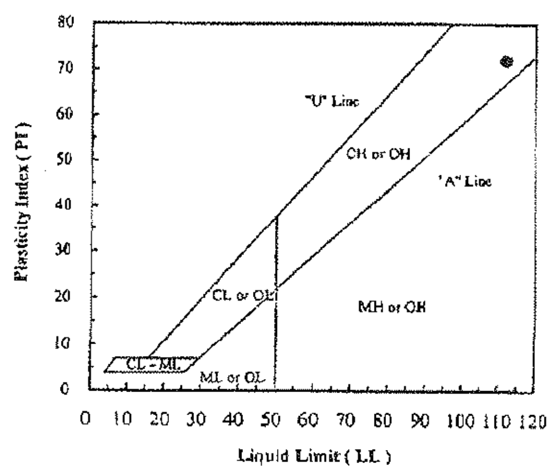
Sieve No.	Size (mm)	% Finer
3"	75	100.0
2"	50	100.0
1.5"	37.5	100.0
1"	25	100.0
3/4"	19	100.0
3/8"	9.5	100.0
#4	4.75	100.0
#10	2.00	100.0
#20	0.850	99.9
#40	0.425	99.9
#60	0.250	99.9
#100	0.150	99.3
#200	0.075	98.4

Specific Gravity (-):	2.65

Hydrometer Particle Diameter (mm)	% Finer
0.0315	91.8
0.0121	69.3
0.0062	57.2
0.0031	43.6
0.0013	28.9

Gravel (%):	
Sand (%):	1.6
Fines (%):	98.4
Silt (%):	47.1
Clay (%):	51.3

Coeff. Unif. (Cu):	
Coeff. Curv. (Cc):	



Client Sample ID.	Lab Sample No:	Moisture Content (%)	Fines Content < No. 200 (%)	Atterberg Limits LL (-)	PL (-)	PI (-)	Engineering Classification
CS-2-13 & CS-2-14	L097 & L098	25.1	98.4	112	40	72	CH - Fat clay

Note(s):

An assumed specific gravity of 2.65 was used when analyzing the hydrometer test results.

Hydrometer soil specimen conglomerated and formed a cloudy substance which settled to the lower portion of the test tube (i.e., the test results may be questionable)

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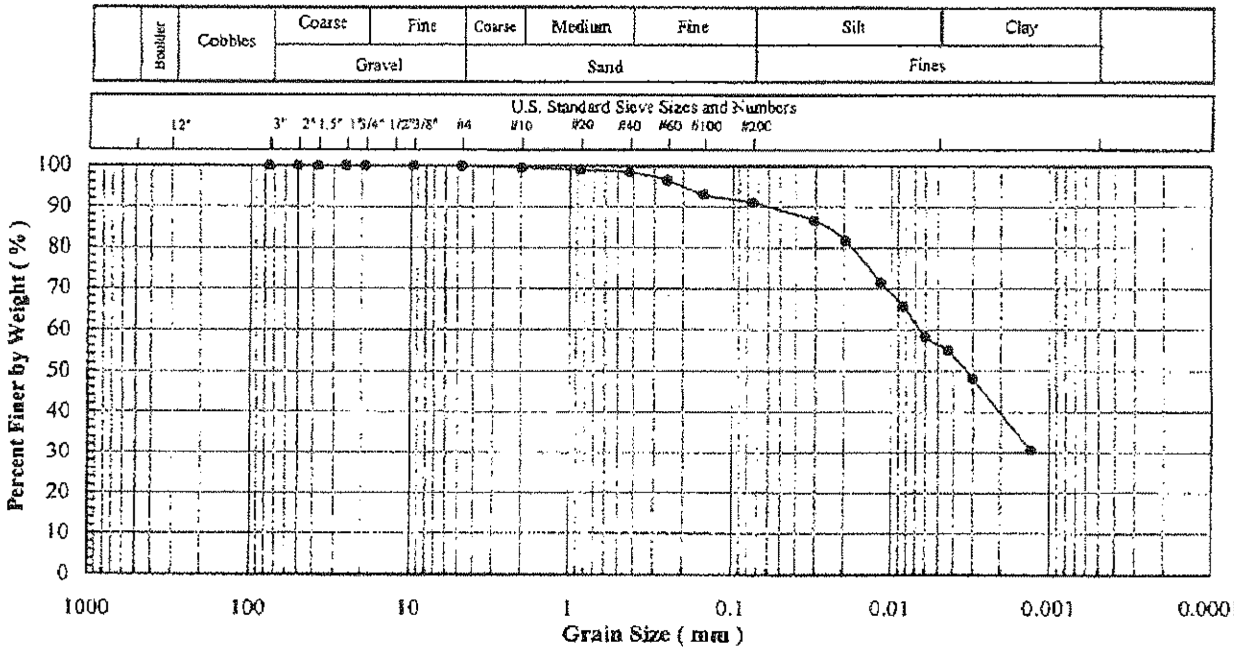
Project Name:	KHF Clay Source Evaluation
Project No:	289
Client Sample ID:	CS-2-16 & CS-2-17
Lab Sample No:	L100 & L101

ASTM C 136, D 422, D 854, D 1140, D 2216, D 2487, D 4318

SOIL INDEX PROPERTIES

Grain Size, Spec. Gravity, Moist. Cont, Eng. Classification, Atterberg Limits



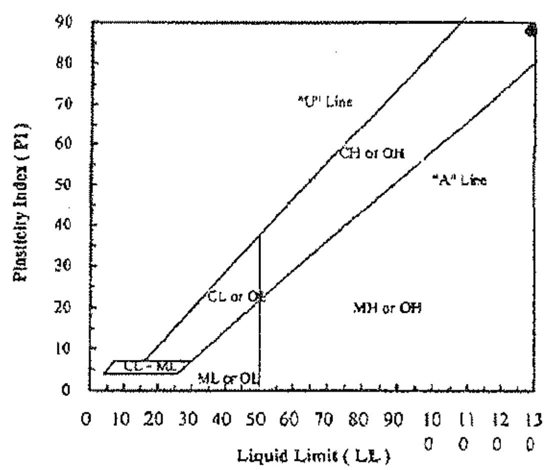
Sieve No.	Size (mm)	% Finer
3"	75	100.0
2"	50	100.0
1.5"	37.5	100.0
1"	25	100.0
3/4"	19	100.0
3/8"	9.5	100.0
#4	4.75	100.0
#10	2.00	99.6
#20	0.850	99.1
#40	0.425	98.4
#60	0.250	96.4
#100	0.150	93.1
#200	0.075	91.1

Specific Gravity (-):	2.65

Hydrometer Particle Diameter (mm)	% Finer
0.0307	86.6
0.0116	71.5
0.0060	58.4
0.0030	48.2
0.0013	30.7

Gravel (%):	
Sand (%):	8.9
Fines (%):	91.1
Silt (%):	34.7
Clay (%):	56.4

Coeff. Unif. (Cu):	
Coeff. Curv. (Cc):	



Client Sample ID.	Lab Sample No:	Moisture Content (%)	Fines Content < No. 200 (%)	Atterberg Limits LL (-)	PL (-)	PI (-)	Engineering Classification
CS-2-16 & CS-2-17	L100 & L101	25.4	91.1	129	41	88	CH - Fat Clay

Note(s):

An assumed specific gravity of 2.65 was used when analyzing the hydrometer test results.

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FLEXIBLE WALL PERMEABILITY TEST [1]

ASTM D5084 *

Project Name:	KHF Clay Source Evaluation
Project Number:	289
Client Name:	Geosyntec Consultants
Site Sample ID:	CS-1A
Lab Sample Number:	L103
Material Type:	Soil
Specified Value (cm/sec):	NA
Date Test Started:	12/21/2007

Remolded Specimen	Proctor [5] Compaction		Specimen Initial Conditions [6]		Test Conditions					Hydraulic Conductivity
	Max. DUW	Opt. MC	Dry Unit Weight	Moisture Content	Cell Press.	Back Press.	Consolid. Press.	Permeant Liquid [7]	Average Gradient	
(-)	(pcf)	(%)	(pcf)	(%)	(psi)	(psi)	(psi)	(-)	(-)	(cm/s)
Notes 2 , 3 & 4	122.0	12.5	108.0	15.4	75.0	70.0	5.0	DTW	6	9.2E-9

88.5%

Notes:

1. Method C. "Falling-Head, Increasing-Tailwater" test procedures were followed during the testing.
2. All particles larger than 3/8 inch, if any, were discarded when forming the remolded specimen.
3. Remolded specimen was formed by tamping the soil in one-centimeter-thick layers.
4. Remolded specimen approximately 2.87 inches in diameter and 2.36 inches in height.
5. Maximum Dry Unit Weight (DUW) and Optimum Moisture Content (MC) based on Modified Proctor Compaction Test (ASTM D 1557).
6. Based on the target values of 89% of the maximum dry unit weight and the optimum moisture content plus 3%.
7. Type of permeant liquid: DTW = Deaired Tap Water, DDI = Deaired Deionized Water

* Deviations:
Laboratory temperature at 22±3 °C.
Test specimen final conditions are not presented.

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FLEXIBLE WALL PERMEABILITY TEST [1]
ASTM D5084 *

Project Name:	KHF Clay Source Evaluation
Project Number:	289
Client Name:	Geosyntec Consultants
Site Sample ID:	CS-1A
Lab Sample Number:	L103
Material Type:	Soil
Specified Value (cm/sec):	NA
Date Test Started:	12/21/2007

Remolded Specimen	Proctor [5] Compaction		Specimen Initial Conditions [6]		Test Conditions					Hydraulic Conductivity
	Max. DUW	Opt. MC	Dry Unit Weight	Moisture Content	Cell Press.	Back Press.	Consolid. Press.	Permeant Liquid [7]	Average Gradient	
(-)	(pcf)	(%)	(pcf)	(%)	(psi)	(psi)	(psi)	(-)	(-)	(cm/s)
Notes 2 , 3 & 4	122.0	12.5	112.4	15.4	75.0	70.0	5.0	DTW	6	7.4E-9

92.1%

Notes:

1. Method C, "Falling-Head, Increasing-Tailwater" test procedures were followed during the testing.
2. All particles larger than 3/8 inch, if any, were discarded when forming the remolded specimen.
3. Remolded specimen was formed by tamping the soil in one-centimeter-thick layers.
4. Remolded specimen approximately 2.87 inches in diameter and 2.36 inches in height.
5. Maximum Dry Unit Weight (DUW) and Optimum Moisture Content (MC) based on Modified Proctor Compaction Test (ASTM D 1557).
6. Based on the target values of 92% of the maximum dry unit weight and the optimum moisture content plus 3%.
7. Type of permeant liquid: DTW = Deaired Tap Water, DDI = Deaired Deionized Water

* Deviations.
Laboratory temperature at 22±3 °C.
Test specimen final conditions are not presented

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FLEXIBLE WALL PERMEABILITY TEST [1]

ASTM D5084 *

Project Name:	KHF Clay Source Evaluation
Project Number:	289
Client Name:	Geosyntec Consultants
Site Sample ID:	CS-2
Lab Sample Number:	L104
Material Type:	Soil
Specified Value (cm/sec):	NA
Date Test Started:	12/21/2007

Remolded Specimen	Proctor [5] Compaction		Specimen Initial Conditions [6]		Test Conditions					Hydraulic Conductivity
	Max. DUW	Opt. MC	Dry Unit Weight	Moisture Content	Cell Press.	Back Press.	Consolid. Press.	Permeant Liquid [7]	Average Gradient	
(-)	(pcf)	(%)	(pcf)	(%)	(psi)	(psi)	(psi)	(-)	(-)	(cm/s)
Notes 2 , 3 & 4	113.1	15.6	104.0	18.5	75.0	70.0	5.0	DTW	12	3.7E-9

92%

Notes:

1. Method C, "Falling-Head, Increasing-Tailwater" test procedures were followed during the testing.
2. All particles larger than 3/8 inch, if any, were discarded when forming the remolded specimen.
3. Remolded specimen was formed by tamping the soil in one-centimeter-thick layers.
4. Remolded specimen approximately 2.87 inches in diameter and 2.36 inches in height.
5. Maximum Dry Unit Weight (DUW) and Optimum Moisture Content (MC) based on Modified Proctor Compaction Test (ASTM D 1557).
6. Based on the target values of 92% of the maximum dry unit weight and the optimum moisture content plus 3%.
7. Type of permeant liquid: DTW = Deaired Tap Water, DDI = Deaired Deionized Water

* Deviations:
Laboratory temperature at 22±3 °C.
Test specimen final conditions are not presented.

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FLEXIBLE WALL PERMEABILITY TEST [1]

ASTM D5084 *

Project Name:	KHF Clay Source Evaluation
Project Number:	289
Client Name:	Geosyntec Consultants
Site Sample ID:	TP-1
Lab Sample Number:	L105
Material Type:	Soil
Specified Value (cm/sec):	NA
Date Test Started:	12/21/2007

Remolded Specimen	Proctor [5] Compaction		Specimen Initial Conditions [6]		Test Conditions					Hydraulic Conductivity
	Max. DUW	Opt. MC	Dry Unit Weight	Moisture Content	Cell Press.	Back Press.	Consolid. Press.	Permeant Liquid [7]	Average Gradient	
(-)	(pcf)	(%)	(pcf)	(%)	(psi)	(psi)	(psi)	(-)	(-)	(cm/s)
Notes 2 , 3 & 4	109.9	17.8	101.0	20.7	75.0	70.0	5.0	DTW	4	1.1E-8

Notes:

1. Method C, "Falling-Head, Increasing-Tailwater" test procedures were followed during the testing.
2. All particles larger than 3/8 inch, if any, were discarded when forming the remolded specimen.
3. Remolded specimen was formed by tamping the soil in one-centimeter-thick layers.
4. Remolded specimen approximately 2.87 inches in diameter and 2.36 inches in height.
5. Maximum Dry Unit Weight (DUW) and Optimum Moisture Content (MC) based on Modified Proctor Compaction Test (ASTM D 1557).
6. Based on the target values of 92% of the maximum dry unit weight and the optimum moisture content plus 3%.
7. Type of permeant liquid: DTW = Deaired Tap Water, DDI = Deaired Deionized Water

* Deviations:

Laboratory temperature at 22±3 °C.

Test specimen final conditions are not presented.

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FLEXIBLE WALL PERMEABILITY TEST [1]

ASTM D5084 *

Project Name:	KHF Clay Source Evaluation
Project Number:	289
Client Name:	Geosyntec Consultants
Site Sample ID:	TP-2
Lab Sample Number:	L106
Material Type:	Soil
Specified Value (cm/sec):	NA
Date Test Started:	12/21/2007

Remolded Specimen	Proctor [5] Compaction		Specimen Initial Conditions [6]		Test Conditions					Hydraulic Conductivity
	Max. DUW	Opt. MC	Dry Unit Weight	Moisture Content	Cell Press.	Back Press.	Consolid. Press.	Permeant Liquid [7]	Average Gradient	
(-)	(pcf)	(%)	(pcf)	(%)	(psi)	(psi)	(psi)	(-)	(-)	(cm/s)
Notes 2 , 3 & 4	111.7	16.2	102.8	19.1	75.0	70.0	5.0	DTW	9	5.0E-9

Notes:

1. Method C, "Falling-Head, Increasing-Tailwater" test procedures were followed during the testing.
2. All particles larger than 3/8 inch, if any, were discarded when forming the remolded specimen.
3. Remolded specimen was formed by tamping the soil in one-centimeter-thick layers.
4. Remolded specimen approximately 2.87 inches in diameter and 2.36 inches in height.
5. Maximum Dry Unit Weight (DUW) and Optimum Moisture Content (MC) based on Modified Proctor Compaction Test (ASTM D 1557).
6. Based on the target values of 92% of the maximum dry unit weight and the optimum moisture content plus 3%.
7. Type of permeant liquid: DTW = Deaired Tap Water, DDI = Deaired Deionized Water

* Deviations:
Laboratory temperature at 22±3 °C.
Test specimen final conditions are not presented.

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FLEXIBLE WALL PERMEABILITY TEST [1]

ASTM D5084 *

Project Name:	KHF Clay Source Evaluation
Project Number:	289
Client Name:	Geosyntec Consultants
Site Sample ID:	TP-3
Lab Sample Number:	L107
Material Type:	Soil
Specified Value (cm/sec):	NA
Date Test Started:	12/21/2007

Remolded Specimen	Proctor [5] Compaction		Specimen Initial Conditions [6]		Test Conditions					Hydraulic Conductivity
	Max. DUW	Opt. MC	Dry Unit Weight	Moisture Content	Cell Press.	Back Press.	Consolid. Press.	Permeant Liquid [7]	Average Gradient	
(-)	(pcf)	(%)	(pcf)	(%)	(psi)	(psi)	(psi)	(-)	(-)	(cm/s)
Notes 2 , 3 & 4	108.2	17.4	99.0	20.2	75.0	70.0	5.0	DTW	8	6.5E-9

Notes:

1. Method C. "Falling-Head, Increasing-Tailwater" test procedures were followed during the testing.
2. All particles larger than 3/8 inch, if any, were discarded when forming the remolded specimen.
3. Remolded specimen was formed by tamping the soil in one-centimeter-thick layers.
4. Remolded specimen approximately 2.87 inches in diameter and 2.36 inches in height.
5. Maximum Dry Unit Weight (DUW) and Optimum Moisture Content (MC) based on Modified Proctor Compaction Test (ASTM D 1557).
6. Based on the target values of 92% of the maximum dry unit weight and the optimum moisture content plus 3%.
7. Type of permeant liquid: DTW = Deaired Tap Water, DDI = Deaired Deionized Water

* Deviations:

Laboratory temperature at 22±3 °C.

Test specimen final conditions are not presented.

Excel Geotechnical Testing, Inc.
"Excellence in Testing"
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

FLEXIBLE WALL PERMEABILITY TEST [1]

ASTM D5084 *

Project Name:	KHF Clay Source Evaluation
Project Number:	289
Client Name:	Geosyntec Consultants
Site Sample ID:	TP-4
Lab Sample Number:	L108
Material Type:	Soil
Specified Value (cm/sec):	NA
Date Test Started:	12/21/2007

Remolded Specimen	Proctor [5] Compaction		Specimen Initial Conditions [6]		Test Conditions					Hydraulic Conductivity
	Max. DUW	Opt. MC	Dry Unit Weight	Moisture Content	Cell Press.	Back Press.	Consolid. Press.	Permeant Liquid [7]	Average Gradient	
(-)	(pcf)	(%)	(pcf)	(%)	(psi)	(psi)	(psi)	(-)	(-)	(cm/s)
Notes 2 , 3 & 4	105.5	20.1	97.1	22.9	75.0	70.0	5.0	DTW	4	1.4E-8

Notes:

1. Method C, "Falling-Head, Increasing-Tailwater" test procedures were followed during the testing.
2. All particles larger than 3/8 inch, if any, were discarded when forming the remolded specimen.
3. Remolded specimen was formed by tamping the soil in one-centimeter-thick layers.
4. Remolded specimen approximately 2.87 inches in diameter and 2.36 inches in height.
5. Maximum Dry Unit Weight (DUW) and Optimum Moisture Content (MC) based on Modified Proctor Compaction Test (ASTM D 1557).
6. Based on the target values of 92% of the maximum dry unit weight and the optimum moisture content plus 3%.
7. Type of permeant liquid: DTW = Deaired Tap Water, DDI = Deaired Deionized Water

* Deviations:
Laboratory temperature at 22±3 °C
Test specimen final conditions are not presented.

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941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

FLEXIBLE WALL PERMEABILITY TEST [1]

ASTM D5084 *

Project Name:	KHF Clay Source Evaluation
Project Number:	289
Client Name:	Geosyntec Consultants
Site Sample ID:	CS1-2 & CS1-3
Lab Sample Number:	L070 & L071
Material Type:	Soil
Specified Value (cm/sec):	NA
Date Test Started:	1/23/2008

Remolded Specimen	Proctor [5] Compaction		Specimen Initial Conditions [6]		Test Conditions					Hydraulic Conductivity
	Max. DUW	Opt. MC	Dry Unit Weight	Moisture Content	Cell Press.	Back Press.	Consolid. Press.	Permeant Liquid [7]	Average Gradient	
(-)	(pcf)	(%)	(pcf)	(%)	(psi)	(psi)	(psi)	(-)	(-)	(cm/s)
Notes 2 , 3 & 4	104.0	20.0	93.6	21.9	75.0	70.0	5.0	DTW	14	7.0E-8

Notes:

1. Method C, "Falling-Head, Increasing-Tailwater" test procedures were followed during the testing.
2. All particles larger than 3/8 inch, if any, were discarded when forming the remolded specimen.
3. Remolded specimen was formed by tamping the soil in one-centimeter-thick layers.
4. Remolded specimen approximately 2.87 inches in diameter and 2.36 inches in height.
5. Assumed Maximum Dry Unit Weight (DUW) and Optimum Moisture Content (MC) based on Modified Proctor Compaction Test (ASTM D 1557).
6. Based on the target values of 90% of the maximum dry unit weight and the optimum moisture content plus 2%.
7. Type of permeant liquid: DTW = Deaired Tap Water, DDI = Deaired Deionized Water

* Deviations:

Laboratory temperature at 22±3 °C.

Test specimen final conditions are not presented.

Excel Geotechnical Testing, Inc.
"Excellence in Testing"
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

FLEXIBLE WALL PERMEABILITY TEST (1)

ASTM D5084 *

Project Name:	KHF Clay Source Evaluation
Project Number:	289
Client Name:	Geosyntec Consultants
Site Sample ID:	CS1A-5
Lab Sample Number:	L077
Material Type:	Soil
Specified Value (cm/sec):	NA
Date Test Started:	1/23/2008

Remolded Specimen	Proctor (5) Compaction		Specimen Initial Conditions (6)		Test Conditions					Hydraulic Conductivity
	Max. DUW	Opt. MC	Dry Unit Weight	Moisture Content	Cell Press.	Back Press.	Consolid. Press.	Permeant Liquid (7)	Average Gradient	
(-)	(pcf)	(%)	(pcf)	(%)	(psi)	(psi)	(psi)	(-)	(-)	(cm/s)
Notes 2 , 3 & 4	104.0	20.0	93.4	21.9	75.0	70.0	5.0	DTW	18	6.2E-8

Notes:

1. Method C, "Falling-Head, Increasing-Tailwater" test procedures were followed during the testing.
2. All particles larger than 3/8 inch, if any, were discarded when forming the remolded specimen.
3. Remolded specimen was formed by tamping the soil in one-centimeter-thick layers.
4. Remolded specimen approximately 2.87 inches in diameter and 2.36 inches in height.
5. Assumed Maximum Dry Unit Weight (DUW) and Optimum Moisture Content (MC) based on Modified Proctor Compaction Test (ASTM D 1557).
6. Based on the target values of 90% of the maximum dry unit weight and the optimum moisture content plus 2%.
7. Type of permeant liquid: DTW = Deaired Tap Water, DDI = Deaired Deionized Water

* Deviations:
Laboratory temperature at 22±3 °C.
Test specimen final conditions are not presented.

Excel Geotechnical Testing, Inc.
"Excellence in Testing"
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

FLEXIBLE WALL PERMEABILITY TEST (1)

ASTM D5084 *

Project Name:	KHF Clay Source Evaluation
Project Number:	289
Client Name:	Geosyntec Consultants
Site Sample ID:	CS1A-6 & CS1A-7
Lab Sample Number:	L078 & L079
Material Type:	Soil
Specified Value (cm/sec):	NA
Date Test Started:	1/22/2008

Remolded Specimen	Proctor (5) Compaction		Specimen Initial Conditions (6)		Test Conditions					Hydraulic Conductivity
	Max. DUW	Opt. MC	Dry Unit Weight	Moisture Content	Cell Press.	Back Press.	Consolid. Press.	Permeant Liquid (7)	Average Gradient	
(-)	(pcf)	(%)	(pcf)	(%)	(psi)	(psi)	(psi)	(-)	(-)	(cm/s)
Notes 2 , 3 & 4	104.0	20.0	93.5	21.9	75.0	70.0	5.0	DTW	15	9.6E-8

Notes:

1. Method C, "Falling-Head, Increasing-Tailwater" test procedures were followed during the testing.
2. All particles larger than 3/8 inch, if any, were discarded when forming the remolded specimen.
3. Remolded specimen was formed by tamping the soil in one-centimeter-thick layers.
4. Remolded specimen approximately 2.87 inches in diameter and 2.36 inches in height.
5. Assumed Maximum Dry Unit Weight (DUW) and Optimum Moisture Content (MC) based on Modified Proctor Compaction Test (ASTM D 1557).
6. Based on the target values of 90% of the maximum dry unit weight and the optimum moisture content plus 2%.
7. Type of permeant liquid: DTW = Deaired Tap Water, DDI = Deaired Deionized Water

* Deviations:

Laboratory temperature at 22±3 °C.

Test specimen final conditions are not presented.

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"Excellence in Testing"
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

FLEXIBLE WALL PERMEABILITY TEST (1)

ASTM D5084 *

Project Name:	KHF Clay Source Evaluation
Project Number:	289
Client Name:	Geosyntec Consultants
Site Sample ID:	CS2-4
Lab Sample Number:	L089
Material Type:	Soil
Specified Value (cm/sec):	NA
Date Test Started:	1/22/2008

Remolded Specimen	Proctor (5) Compaction		Specimen Initial Conditions (6)		Test Conditions					Hydraulic Conductivity
	Max. DUW	Opt. MC	Dry Unit Weight	Moisture Content	Cell Press.	Back Press.	Consolid. Press.	Permeant Liquid (7)	Average Gradient	
(-)	(pcf)	(%)	(pcf)	(%)	(psi)	(psi)	(psi)	(-)	(-)	(cm/s)
Notes 2 , 3 & 4	104.0	20.0	93.6	21.9	75.0	70.0	5.0	DTW	16	8.6E-8

Notes:

1. Method C, "Falling-Head, Increasing-Tailwater" test procedures were followed during the testing.
2. All particles larger than 3/8 inch, if any. were discarded when forming the remolded specimen.
3. Remolded specimen was formed by tamping the soil in one-centimeter-thick layers.
4. Remolded specimen approximately 2.87 inches in diameter and 2.36 inches in height.
5. Assumed Maximum Dry Unit Weight (DUW) and Optimum Moisture Content (MC) based on Modified Proctor Compaction Test (ASTM D 1557).
6. Based on the target values of 90% of the maximum dry unit weight and the optimum moisture content plus 2%.
7. Type of permeant liquid: DTW = Deaired Tap Water, DDI = Deaired Deionized Water

* Deviations:
Laboratory temperature at 22±3 °C.
Test specimen final conditions are not presented.

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941 Forrest Street, Roswell, Georgia 30075
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FLEXIBLE WALL PERMEABILITY TEST (1)
ASTM D5084 *

Project Name:	KHF Clay Source Evaluation
Project Number:	289
Client Name:	Geosyntec Consultants
Site Sample ID:	CS2-11
Lab Sample Number:	L095
Material Type:	Soil
Specified Value (cm/sec):	NA
Date Test Started:	1/22/2008

Remolded Specimen	Proctor (5) Compaction		Specimen Initial Conditions (6)		Test Conditions					Hydraulic Conductivity
	Max. DUW	Opt. MC	Dry Unit Weight	Moisture Content	Cell Press.	Back Press.	Consolid. Press.	Permeant Liquid (7)	Average Gradient	
(-)	(pcf)	(%)	(pcf)	(%)	(psi)	(psi)	(psi)	(-)	(-)	(cm/s)
Notes 2 , 3 & 4	104.0	20.0	93.5	21.8	75.0	70.0	5.0	DTW	18	8.2E-8

Notes:

1. Method C, "Falling-Head, Increasing-Tailwater" test procedures were followed during the testing.
2. All particles larger than 3/8 inch, if any, were discarded when forming the remolded specimen.
3. Remolded specimen was formed by tamping the soil in one-centimeter-thick layers.
4. Remolded specimen approximately 2.87 inches in diameter and 2.36 inches in height.
5. Assumed Maximum Dry Unit Weight (DUW) and Optimum Moisture Content (MC) based on Modified Proctor Compaction Test (ASTM D 1557).
6. Based on the target values of 90% of the maximum dry unit weight and the optimum moisture content plus 2%.
7. Type of permeant liquid: DTW = Deaired Tap Water, DDI = Deaired Deionized Water

* Deviations:

Laboratory temperature at 22±3 °C.
Test specimen final conditions are not presented.

Excel Geotechnical Testing, Inc.
"Excellence in Testing"
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

FLEXIBLE WALL PERMEABILITY TEST (1)
ASTM D5084 *

Project Name:	KHF Clay Source Evaluation
Project Number:	289
Client Name:	Geosyntec Consultants
Site Sample ID:	CS2-13 & CS2-14
Lab Sample Number:	L097 & L098
Material Type:	Soil
Specified Value (cm/sec):	NA
Date Test Started:	1/22/2008

Remolded Specimen	Proctor (5) Compaction		Specimen Initial Conditions (6)		Test Conditions					Hydraulic Conductivity
	Max. DUW	Opt. MC	Dry Unit Weight	Moisture Content	Cell Press.	Back Press.	Consolid. Press.	Permeant Liquid (7)	Average Gradient	
(-)	(pcf)	(%)	(pcf)	(%)	(psi)	(psi)	(psi)	(-)	(-)	(cm/s)
Notes 2 , 3 & 4	104.0	20.0	93.4	22.0	75.0	70.0	5.0	DTW	16	1.7E-8

Notes:

1. Method C, "Falling-Head, Increasing-Tailwater" test procedures were followed during the testing.
2. All particles larger than 3/8 inch, if any, were discarded when forming the remolded specimen.
3. Remolded specimen was formed by tamping the soil in one-centimeter-thick layers.
4. Remolded specimen approximately 2.87 inches in diameter and 2.36 inches in height.
5. Assumed Maximum Dry Unit Weight (DUW) and Optimum Moisture Content (MC) based on Modified Proctor Compaction Test (ASTM D 1557).
6. Based on the target values of 90% of the maximum dry unit weight and the optimum moisture content plus 2%.
7. Type of permeant liquid: DTW = Deaired Tap Water, DDI = Deaired Deionized Water

* Deviations:
Laboratory temperature at 22±3 °C.
Test specimen final conditions are not presented.

Excel Geotechnical Testing, Inc.
"Excellence in Testing"
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

FLEXIBLE WALL PERMEABILITY TEST (1)

ASTM D5084 *

Project Name:	KHF Clay Source Evaluation
Project Number:	289
Client Name:	Geosyntec Consultants
Site Sample ID:	CS2-16 & CS2-17
Lab Sample Number:	L100 & L101
Material Type:	Soil
Specified Value (cm/sec):	NA
Date Test Started:	1/22/2008

Remolded Specimen	Proctor (5) Compaction		Specimen Initial Conditions (6)		Test Conditions					Hydraulic Conductivity
	Max. DUW	Opt. MC	Dry Unit Weight	Moisture Content	Cell Press.	Back Press.	Consolid. Press.	Permeant Liquid (7)	Average Gradient	
(-)	(pcf)	(%)	(pcf)	(%)	(psi)	(psi)	(psi)	(-)	(-)	(cm/s)
Notes 2 , 3 & 4	104.0	20.0	93.5	21.9	75.0	70.0	5.0	DTW	15	5.3E-8

Notes:

1. Method C, "Falling-Head, Increasing-Tailwater" test procedures were followed during the testing.
2. All particles larger than 3/8 inch, if any, were discarded when forming the remolded specimen.
3. Remolded specimen was formed by tamping the soil in one-centimeter-thick layers.
4. Remolded specimen approximately 2.87 inches in diameter and 2.36 inches in height. Modified 1557
5. Maximum Dry Unit Weight (DUW) and Optimum Moisture Content (MC) based on Standard Proctor Compaction Test (ASTM D698).
6. Based on the target values of 95% of the maximum dry unit weight and the optimum moisture content plus 2%. 90
7. Type of permeant liquid: DTW = Deaired Tap Water, DDI = Deaired Deionized Water

* Deviations:

Laboratory temperature at 22±3 °C.

Test specimen final conditions are not presented.

APPENDIX E.3
CLAY STOCKPILE AND TEST PAD REPORT

WASTE MANAGEMENT, INC.

Prepared for

Chemical Waste Management, Inc.
35251 Old Skyline Road
Kettleman City, CA 92139

CLAY STOCKPILE AND TEST PAD REPORT

KETTLEMAN HILLS FACILITY
KINGS COUNTY, CALIFORNIA

Prepared by

Geosyntec consultants

engineers | scientists | innovators

3990 Old Town Avenue, Suite B101
San Diego, California 92110

Project Number SC0472

December 2008

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Geosyntec consultants

CLAY STOCKPILE AND TEST PAD REPORT
KETTLEMAN HILLS FACILITY
KINGS COUNTY, CALIFORNIA

I certify that this document and attachments presented in this report are accurate and complete. This report was prepared by the staff of Geosyntec Consultants under my supervision to ensure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who are directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate and complete.

Jane Soule (signature)
Jane Soule
California Professional Civil Engineer No. 59815

10/20/09
Date

REGISTERED PROFESSIONAL ENGINEER
JANE W. SOULE
C 59815
EXP 12/31/09
CIVIL
STATE OF CALIFORNIA

1. INTRODUCTION

1.1 Terms of Reference

This report presents the results of the clay stockpile and test pad evaluation for Chemical Waste Management, Inc. (CWMI) at the Kettleman Hills Facility in Kings County, California. This report was prepared by Ms. Jane Soule, G.E., and has been reviewed by Mr. Michael J. Minch, G.E., of Geosyntec Consultants, Inc. (Geosyntec), in accordance with the peer review policies of the firm.

1.2 Project Description

The Kettleman Hills Facility is approximately 1,600 acres with approximately 474 acres within the active operation area. The site is located in Kings County, California and is owned and operated by CWMI. Three waste management units are currently permitted and operated at the site, Landfill B-17 (Class II/III), Landfill B-19 (II/III) and Landfill B-18 (Class I/II). The planned expansion of Landfill B-18 will require construction of compacted clay liner (CCL) meeting the requirements of Subtitle C of Title 40 of the Code of Federal Requirements (CFR) §264.301 and California Code of Regulations (CCR), Title 23 §2541. These regulations specify that the CCL meet the following requirements:

- an in-situ (field) hydraulic conductivity no greater than $1x10^{-7}$ centimeters per second (cm/s);
- at least 30 percent of the material, by weight, shall pass a No. 200 U.S. Standard Sieve (0.075 mm); and
- be fine grained soil with a significant clay content without organic matter, in the "SC" (clayey sand), "CL" (clay, sandy or silty clay) or "CH" (clay, sandy clay) classes of the Unified Soil Classification System (USCS).

An onsite clay source was identified on the eastern boundaries of the Landfill B-17 project area (see Figure 1). The potential clay source is part of the Pecten claystone which has been used as a CCL for previous hazardous landfill liner construction projects at the site and has been demonstrated to meet the regulatory requirements. Previous clay investigations and testing programs on the Pecten claystone are summarized in the following reports:

- Environmental Construction Services (ECS), 1991, "Clay Source Report, Landfill B-18, Phases IA and IB, Kettleman Hills Facility, Kettleman City, California, Prepared for Chemical Waste Management, Inc., 25 November 1991.

- Environmental Solutions, Inc. (ESI), 1992, "Test Fill and Infiltrometer Test Results, Landfill B-18 Phases I and II and Final Closure," Prepared for Chemical Waste Management, Inc., 23 January 1992.

- Golder Construction Services (GSC), 1993, "Landfill B-18, Phases IIA and IIB Construction Reports Volume 1 – Clay Liner Source Report," Prepared for Chemical Waste Management, Inc., May 1993.

.These previous investigations are summarized in Section 2 of this report.

During the recent construction of Landfill B-17 Phase A1, approximately 24,000 cubic yards (cy) of soil from the Pecten claystone located northeast of Landfill B-17 Phase A1 was excavated and stockpiled for future use in construction of a CCL for the proposed Landfill B-18 expansion. Material from the stockpile was used to construct a test pad for field hydraulic conductivity testing. The requirements of the test pad construction are summarized in the project specifications Section 02220 (Geosyntec, 2007, see Appendix A-1). Construction quality assurance (CQA) testing requirements for the clay stockpile and test pad are summarized in the CQA Plan, Addendum 1 (Geosyntec, 2008, see Appendix A-2). Appendix B contains photographic documentation detailing activities during test pad construction and testing.

1.3 Purpose and Scope of Work

The purpose of this report is to document the method and equipment used during construction of the test pad as a minimum basis for future construction, that the test pad was constructed in accordance with the project specifications, and to evaluate whether the soil from the identified clay source meets the regulatory requirements for a CCL. Geosyntec's scope of work included the following tasks:

- Visual observation and laboratory testing of the clay excavation and stockpiling;
- Observing and documenting construction of the test pad;
- Performing in-place density and moisture content testing of the clay test pad;
- Laboratory testing of the clay test pad; and
- Providing, installing, and monitoring a sealed double-ring infiltrometer (SDRI) test on the clay test pad.

Geosyntec's services also included preparation of this CQA report summarizing the results of field observations and laboratory data.

2. PREVIOUS ONSITE CLAY EVALUATIONS

Previous clay source evaluations have been performed at the Kettleman Hills Facility for CCLs in Landfill B-18. Geosyntec has reviewed available reports on these activities. A summary of these reports is provided below.

Material was excavated onsite from the Pecten claystone for use in the Phase I and II clay liner for Landfill B-18. Field and laboratory testing from a SDRI test, site source evaluation and liner construction was reviewed (ESI, 1992; ECS, 1991; and GSC, 1993). These reports indicate that the clay material used in construction of the Phase I and II compacted clay liners had the following properties:

- Unified Soil Classification System description as a fat clay (CH) with an average of more than 80 percent or greater passing the No. 200 sieve (ranging from 48-94 percent);
- High swell potential (ESI reported an average swell of 16.5 percent under a low confining pressure);
- Average Liquid Limit (LL) of approximately 76 (ranging from 35 to 90) and an average Plasticity Index (PI) of approximately 55 (ranging from 18 to 68);
- Laboratory hydraulic conductivity ranging from approximately 2×10^{-10} centimeters/second (cm/s) to 2×10^{-7} cm/s with an average on the order of 8×10^{-9} cm/s.

These reports indicate that the Pecten claystone material, when compacted to greater than 90 percent of the maximum dry density per ASTM D1557 at a moisture content between +2% and +5% of the optimum moisture content, has a laboratory and field hydraulic conductivity less than 1×10^{-7} cm/s.

3. CLAY STOCKPILE

3.1 General

Clay material was excavated and stockpiled during July and August 2008 by Wood Brothers, Inc., (WBI). The clay material was excavated from the Pecten claystone located northeast of the Landfill B-17 area (see Figure 1). An engineering geologist from Geosyntec identified the limits of the claystone in the field with WBI prior to excavation. WBI stockpiled the low-permeability soil north of Landfill B-17 Phase A1 as approved by CWMI. Geosyntec monitored the excavation and performed conformance tests on the low-permeability soil as described in the following sections.

3.2 Stockpile Activities – CQA Monitoring

Geosyntec monitored that the borrow and stockpile areas were cleared and grubbed prior to excavation. Geosyntec personnel documented the activities during the clay soil excavation and stockpiling, and observed that material placed in the clay stockpile did not contain significant quantities of sandy soils or other unsuitable material.

3.3 Clay Stockpile Pre-Construction Activities – CQA Testing

The project specifications (Appendix A-1) require that the material to be placed in the clay stockpile meet the following specifications:

- Free of debris, rocks, gravel greater than 1 inch in any direction and other deleterious material;
- At least 30 percent of the material, by weight, shall pass the No. 200 sieve;
- Be classified as CL, SC, or CH in accordance with ASTM D2487; and
- Have a compacted field hydraulic conductivity of less than or equal to 1×10^{-7} cm/sec[1].

As the soil was excavated, Geosyntec collected representative samples and shipped them to Excel Geotechnical Testing (Excel) for laboratory testing in accordance with the CQA Plan. The following CQA tests were performed, at a minimum frequency of 1

[1] Field hydraulic conductivity of soils was evaluated using the SDRI (see Section 5).

per 5,000 cubic yards (cy), to evaluate compliance of the clay stockpile with the requirements specified for the clay source material:

- Moisture-Density Relationship (ASTM D 1557);
- Sieve Analysis (ASTM D 422);
- Atterberg Limits (ASTM D 4318);
- Classification (ASTM D 2487); and
- Hydraulic Conductivity (ASTM D 5084), remolded sample.

The required testing frequencies are presented in Table 2.

The moisture-density relationship (modified Proctor) testing results (ASTM D 1557), documented in Appendix C-1, indicate that the low-permeability soil had a maximum dry unit weight ranging from approximately 106 to 120 pcf with an optimum moisture content varying from approximately 13 to 18 percent.

Atterberg limits (ASTM D 4318) testing performed on the clay stockpile is documented in Appendix C-1. Results of this testing indicate a Liquid Limit (LL) varying from 61 to 110 percent and a Plasticity Index (PI) ranging from 38 to 69 percent. The sieve analysis (ASTM D 422) test results indicate that the low-permeability soil had a fines content ranging from 74 to 94 percent. These tests cited above indicate that the soil is classified as fat clay (CH) according to ASTM D 2487 soil classifications.

As required by the technical specification, Geosyntec obtained bulk samples of the clay stockpile at the specified frequency for hydraulic conductivity testing (ASTM D 5084). The samples were compacted to a minimum of 92 percent relative compaction with moisture contents ranging from 2 to 5 percent wet of the optimum moisture content. Hydraulic conductivity test results ranged from 2×10^{-8} to 9×10^{-8} cm/s. The hydraulic conductivity test results are presented in Appendix C-1.

4. CLAY TEST PAD CONSTRUCTION

4.1 Overview

CQA testing was performed during the construction of the clay test pad by using methods and frequencies specified in the Project Documents, as presented in Table 2. Laboratory and field test results performed on the clay stockpile and test pad are included in Appendix C. Appendix B contains photographic documentation detailing activities during test pad construction and testing.

4.2 Clay Liner Test Pad Construction

4.2.1 General

The construction of the clay test pad began on 28 July 2008 and was completed on 7 August 2008. The test pad was constructed approximately 50 feet wide by 50 feet long and consisted of six 6-in lifts. Observations and testing conducted on the clay liner test pad by Geosyntec are described in the following sections. SDRI testing is described in Section 5.

4.2.2 Test Pad Construction

Geosyntec CQA personnel continuously monitored activities performed prior to and during construction of the clay test pad. CQA monitoring activities performed during clay test pad construction included monitoring of processed material placement, measurement of lift thickness, documentation of the number of passes performed by compaction equipment, and a visual assessment of incoming soil. The following sections describe construction test pad.

4.2.2.1 Site Preparation

Prior to construction of the test pad, the area was cleared and grubbed. The subgrade was then proof-rolled to eliminate soft zones, irregularities, and abrupt changes in grade. The subgrade was graded to slope a grade of approximately 2 to 3 percent to provide positive drainage.

4.2.2.2 Stockpile Material Processing

WBI moisture conditioned the clay in the stockpile prior to placement in lifts for the test pad. Moisture conditioning typically included applying water to the surface with a water truck. Due to cementation in the formational soil, significant quantities of oversize particles were present in the stockpile. Further, due to the high plasticity of the clay material, significant clods were present upon wetting. The material was processed in the stockpile to reduce particle/clod size by mixing using a tractor with a rotary disc and a bushog[2]. In addition, one to three laborers were present to manually remove oversize particles.

4.2.2.3 In-situ Material Processing, Placement and Compaction

Soil was transported to the test pad area from the adjacent stockpile area with paddlewheel scrapers. The test pad was constructed in six lifts, each with a compacted lift height of no greater than 6 inches. Loose lift thickness was on the order of 8 inches. Moisture was added periodically with a water truck to maintain the clay's moisture content.

Each lift was compacted with approximately 16 passes using a Rex 3-35 pad foot compactor (specification sheet for compactor is provided in Appendix B-2). After placement and compaction of each lift, a series of field density test were conducted to measure the soil density and compaction (See Section 4.2.3). In order to improve the bonding between layers, the surface of each lift was scarified and wetted with the disc and bushog prior to placement of a new lift.

The surface of the test fill was graded level with a motor grader, and rolled with two passes of a single drum smooth roller. The test pad was covered in an additional lift of clay and visqueen to minimize desiccation until installation of the SDRI was initiated. The visqueen and additional lift were removed prior to construction of the SDRI.

4.2.3 Test Pad Construction – CQA Testing

Compaction and moisture content specifications for the clay test pad are as follows:

> "The clay shall be compacted to at least 92 percent relative compaction. The moisture content shall be uniform and shall be 2% to 5% wet of optimum moisture content."

CQA testing was conducted on the clay test pad to control the amount of moisture in the fill, monitor the effectiveness of the compaction procedures, and to evaluate the properties of the low-permeability soil. Geosyntec performed the following tests during and after the construction of the clay test pad:

- Nuclear Density and Water Content (ASTM D 6938);
- Moisture-Density Relationship (ASTM D 1557);

[2] A bushog is typically used in agricultural applications to clear weeds between rows.

- Sieve Analysis (ASTM D 422);
- Thin-wall, Drive Tube Density (ASTM D 2937);
- Atterberg Limits (AST D4318);
- Hydraulic Conductivity (ASTM D 5084); and
- SDRI (ASTM D 5093) (described in Section 4.4.3.4).

The required frequencies and the number of tests taken during construction of the clay test pad are listed in Table 2.

In-place field density/moisture was monitored by the nuclear gauge (ASTM D 6938) and the drive cylinder test (ASTM D 2937). Areas with failing moisture content or compaction tests were reworked or replaced. Holes from nuclear gauge or drive cylinder testing were filled with powdered bentonite.

Results obtained from the nuclear density gauge indicated that the low-permeability soil was compacted with an average moisture content of 21 percent and an average relative compaction of 94 percent. Drive cylinder test and in-place density/moisture test results are included in Appendices C-1 and C-2, respectively.

Saturated hydraulic conductivity was measured by laboratory flexible wall permeability testing (ASTM D 5084). Samples were obtained by using thin wall tubing and sent to Excel for testing. Saturated hydraulic conductivity measured in the laboratory ranged from 3×10^{-9} to 1×10^{-8} cm/s. The hydraulic conductivity test results performed on the clay test pad are summarized in Table C-3 of Appendix C-1.

5. SDRI TESTING

5.1 Overview

A SDRI test (ASTM D-5093) was performed to evaluate the field hydraulic conductivity of the clay test pad and to provide a correlation between field and laboratory hydraulic conductivity.

The SDRI test provides a direct measurement of the vertical, one-dimensional, infiltration rate of water through soil at very low confining stresses. The SDRI apparatus includes a 2-ft square inner ring and a 6-ft square outer ring. This large size allows for the testing of both micro (i.e., inter-granular) and macro (i.e., through discontinuities) effects on the infiltration rate of liquid flow through a soil layer. The infiltration rate (**q**) is defined as the quantity of liquid entering a porous material per unit area per unit time. The hydraulic conductivity (**k**), which is not a direct measurement from this test, is defined as the flux of liquid per unit hydraulic gradient. Derivation of equations relating infiltration rate to hydraulic conductivity is provided in Section 5.4.

5.2 Site Preparation and Equipment Installation

The SDRI was installed by Geosyntec personnel on 12 August 2008. The SDRI test apparatus consists of an open-air, square shaped, metal outer ring and a covered, square shaped, fiberglass inner ring. The outer ring measures 6 ft on a side, and 3 ft high. The inner ring measures 2 ft on each side and 10-inches high at its peak. The outer ring was embedded in a bentonite chip filled trench to an average depth of 18 in. The inner ring was embedded in a bentonite grout filled trench to an average depth of about 3 in. Both the inner and the outer rings were then filled with water. The outer ring was filled with water to a depth of approximately 12 to 13 in., completely submerging the inner ring. A flexible bag was attached to the inner ring with flexible Tygon tubing and barbed nylon hose fittings. The infiltration rate was measured for the 4 ft^2 section of the test pad soil directly underlying the inner ring. During the test, the outer ring served only as a water reservoir for inducing a uniform hydraulic head and a flow boundary to produce one-dimensional vertical flow beneath the inner ring. Floating panels of insulation were placed in the water reservoir to reduce evaporation. This insulation also minimized changes in water temperature. The SDRI set up is shown schematically in Figure 2.

Water-filled flexible bags were attached to the inlet port of the inner ring. The flexible bags were submerged underwater in the outer ring reservoir. This allowed the hydraulic head on the inner ring to equalize with that of the outer ring without flow between the two rings. Flow into the inner ring was measured over discrete time intervals by measuring the change in mass of the bags. The SDRI was installed 12 August 2008 and data was collected between 13 August and 13 October 2008, when the test was terminated and the equipment was removed.

5.3 Data Collection

Geosyntec personnel collected the SDRI data during the majority of the testing period however, CWMI personnel collected data while Geosyntec was not on-site and supplied the data to Geosyntec. The data recorded included the following:

- Outer Ring Water Depth (**D_f**) - measured using a stationary scale as the depth of standing water in the outer ring,

- Water Temperature (**T**) - measured with a thermometer as the water temperature in the outer ring,

- Depth to the Inner Ring (**H_s**) – measured depth from a point on the top of the inner ring to a stationary string hung across the outer ring. This measurement evaluates swelling of the clay in test area.

- Inner Ring Infiltration (**M_i-M_f**) - measured as the difference between initial and final weight of the water in the flexible bags for a given period of time, and

- Soil Moisture Content (**MC**) - measured after completion of the test for the soil column beneath the inner ring; the profile of MC vs. depth was used to estimate the depth of the wetting front.

5.3.1 Outer Ring Water Depth (D_f)

The water depth in the outer ring (**D_f**) was recorded using a ruler fixed to the outer ring. The ring was filled up to 12.1 to 13.8 in. above the test fill pad surface. The depth of water was used to estimate the total hydraulic head to induce flow. Table 3 presents the measured outer ring water depths.

5.3.2 Water Temperature (T)

The temperature of the water (**T**) was measured with a thermometer placed in the outer ring reservoir. Temperature was measured to estimate the effects of thermal expansion and contraction of the water on the infiltration rate. Water within the inner ring could expand and contract slightly with changes in temperature. As the water cools, it contracts and more water is pulled out of the flexible bags and into the space within the inner ring; as the water warms, it expands and is pushed out of the ring into the bag. The density of water is non-linearly related to its temperature. Table 3 also presents the measured water temperatures.

Based on the field measurements, the temperature changes are considered negligible between initial and final readings. Therefore, the space within the inner ring above the test section remained relatively constant between these readings.

5.3.3 Depth to Inner Ring (H_s)

The depth to the inner ring (**H_s**) was recorded using a ruler measuring the distance between a point on the top of the inner ring to a stationary string fastened across the outer ring. This value corresponds to the height of swell of the clay in the test area. Total swell was estimated to be greater than 3.5 inches. Table 3 presents the measured outer ring water depths.

5.3.4 Inner Ring Infiltration (M_i-M_f)

Flexible bags were used to measure the volume of water infiltrating through the test section underlying the inner ring. The inner ring infiltration data were collected by the following procedure for each time interval:

- flexible bags were filled with water and their valves were closed. The exterior of the bags were then dried and weighed to the nearest tenth of a gram (**M_i**);
- each bag was submerged in the outer ring with the valves still closed;
- each time interval for infiltration monitoring was started by attaching the flexible bags to the inner ring inlet tube connected to the lower flow port and the valves opened; the date and time was recorded;
- each time interval for infiltration was ended by closing the valve on the flexible bag, disconnecting the bag from the inner ring inlet tubing, and recording the date and time;
- the use of multiple bags allowed for the beginning of one interval to be concurrent with the end of the previous interval as a full bag was swapped out for partially emptied bag;
- the flexible tubing was secured so that it remained submerged; and

- the flexible bags were removed from the outer ring reservoir, dried, and weighed to the nearest tenth of a gram (M_f);

The volume of water infiltrating the test section during a particular time interval was computed by subtracting the final bag mass from the initial bag mass (i.e., M_f-M_i). Table 3 presents the measured masses of the bags.

5.3.5 Soil Moisture Content (MC)

At the end of the test, the soil moisture profile was evaluated by taking soil samples from below the inner ring. The water from within the inner and outer rings was first evacuated and the inner ring removed to allow sampling of the test section soil.

Soil samples were obtained by cutting 6-in by 6-in block samples with 0.1 foot and 0.2 foot thicknesses down to a maximum depth of 2 feet (24 inches) below the surface. Each 0.1 ft or 0.2 ft. interval was placed in a sealed plastic bag to preserve the in-situ moisture content. The soil moisture content was tested in the laboratory in accordance with ASTM D 2216. Results of the moisture content tests are discussed in Section 5.5.2 and are presented in Appendix D.

5.4 Theory

The seepage of water into the test area is driven by the hydraulic gradient caused by the ponded water and high capillary suction of the partially saturated clay (as opposed to fully saturated conditions associated with laboratory tests).

The saturated hydraulic conductivity can be computed using a form of Darcy's Law which includes terms for the total hydraulic gradient. The governing equation that describes the infiltration of water through the compacted clay is developed below, based on the terms and sign convention in Figure 2.

$$q = -ki = -k\frac{\Delta h}{\Delta L} \tag{1}$$

Where,
q = infiltration rate per unit area and time (L/T)
k = saturated hydraulic conductivity (L/T)
$\frac{\Delta h}{\Delta L}$ = total hydraulic gradient (L/L), or i
$\Delta h = h_1 - h_2$
$\Delta L = z_1 - z_2$
h = Total Head
$h = z + \varphi$
z = elevation head

φ = pressure head due to hydraulic head or soil suction/tension

$$q = -k\left[\frac{(z_1+\varphi_1)-(z_2+\varphi_2)}{(z_1-z_2)}\right] \tag{2}$$

For any given wetting front, $L_f = z_1 - z_2$. Substituting this into Equation (2), the infiltration rate at any wetting front is calculated as:

$$q = -k\left[\frac{\varphi_1}{L_f} - \frac{\varphi_2}{L_f} + 1\right] \tag{3}$$

As shown in Figure 2, at Point 1, the pressure head is equal to the depth of water in the outer ring, D_f, with soil suction/tension equal to zero (i.e., the soil is saturated). At Point 1, the pressure head is $D_f = \varphi_1$. Also, since the clay fill is unsaturated below the wetting front, the in situ pressure head at Point 2 will be equal to the soil suction and negative in sign convention, and can be designated simply at φ, i.e., $\varphi = -\varphi_2$. Substituting into Equation (3):

$$q = -k\left[\frac{D_f}{L_f} + \frac{\varphi}{L_f} + 1\right] \tag{4}$$

Equation (4) is time dependent. That is, the infiltration flow rate per unit area (q) and the depth of the wetting front (**L_f**) are interrelated and vary with time. As the wetting front advances, Equation 4 can be rearranged to calculate hydraulic conductivity as the infiltration rate appears to stabilize from daily readings:

$$k = -\frac{q}{\frac{D_f}{L_f} + \frac{\varphi}{L_f} + 1} \tag{5}$$

Equation 5 was used to calculate the hydraulic conductivity of the compacted clay liner. Results of the test are presented below in Section 5.5.

5.5 Results

5.5.1 Infiltration Rate

The infiltration rate per unit area (q) is calculated as the total water lost during a measured time increment. The calculated infiltration rate (q) is presented in Table 3. The infiltration rate at the end of the test was measured at 8×10^{-7} cm/s and was observed to generally decrease over time (see Figure 3).

5.5.2 Wetting Front

The conventional method to estimate the depth to the wetting front (**D_f**) at the end of the test requires obtaining moisture content samples along a vertical column of soil below the inner ring. The moisture profile with depth is then compared against the saturation line and the original moisture content to estimate the depth of the wetting front.

Geosyntec collected moisture samples at 0.1 to 0.2 feet increments along two moisture columns. Figure 4 presents a plot of this moisture content versus depth. As shown in Figure 4, the moisture content decreases with depth as would be expected when significant swelling of the clay occurs[3]. Based on the results of the moisture content testing and visual observation of the soil upon excavation[4], the wetting front (**L_f**) is estimated to be approximately 1.4 feet (17 inches). At a depth of approximately 1.9 feet (23 inches), the moisture content of the soil beneath the inner ring is equivalent to the as-compacted conditions. The soil between depths of 1.4 feet and 1.9 feet represent an area where increased moisture content, but not saturated, due to soil suction.

5.5.3 Soil Suction

Soil suction was not directly measured as part of this field work. However, lysimeters installed as part of the SDRI constructed for development of Phase I/II of Landfill B-18 (ESI, 1992) measured a soil suction of 280 inches of pressure with tensiometers in unsaturated soil below the SDRI inner ring.

Geosyntec developed a soil-moisture characteristic curve for the soil at the wetting front, relating the volumetric water content of the soil to the suction head, using the van Genuchten function (van Genuchten, 1980). The van Genuchten curve-fitting parameters used in the function were back-calculated from the water retention parameters recommended in the Hydraulic Evaluation of Landfill Performance (HELP) model documentation (Schroeder et al. 1994) for moderately compacted clays of high plasticity. Based on the moisture content measured in the laboratory for the soil just below the wetting front, the soil-moisture characteristic curve results in an unsaturated soil suction of approximately 33 feet (396 inches). This value is on the same order of magnitude with the suction pressures measured in the field during previous

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[3] Moisture content at saturation is a function of the dry density of the soil (i.e., the volume of void space). As soil swells and becomes less dense, the volume of void increases, thereby increasing the moisture content at saturation.

[4] Free water was observed in the voids of the soil matrix to a depth of approximately 1.4 feet. From approximately 1.4 feet to 1.9 feet, the material was softened and visually wetter. At a depth of approximately 1.9 feet and below, the soil was hard visually similar to areas outside the SDRI area.

investigations. For use in these calculations, Geosyntec has assumed a soil suction of 280 inches (23 feet) consistent with that previously monitored at the site.

5.5.4 Hydraulic Conductivity

Using Equation 5, the hydraulic conductivity is calculated using the data from the last testing interval, as follows:

$$k = -\frac{q}{\frac{D_f}{L_f} + \frac{\varphi}{L_f} + 1} = \frac{7.6x\ 10^{-7}\ cm/s}{\frac{12.5}{17} + \frac{280}{17} + 1} = 4.2x10^{-8} cm/s$$

The results of this test indicate that the field hydraulic conductivity of the Pecten claystone, when compacted to the specifications presented in Appendix A, meet the hydraulic conductivity requirements of a compacted clay liner as outlined in Section 1.2.

5.5.5 Laboratory Data and Comparison to Field Data

As discussed in Section 4.2.3, Geosyntec tested the hydraulic conductivity of 10 samples collected using 3-inch diameter thin-wall Shelby tubes from the test pad area. These samples were tested at a minimum confining pressure of 2 psi. The average hydraulic conductivity of the laboratory testing on the test pad samples is approximately 5.1 x 10^{-9} cm/s (see Appendix C).

The field test results are approximately one order of magnitude higher than laboratory results. These differences are expected and may be attributed to the unrestrained swelling of the clay which occurs during field testing when compared to laboratory results which have small consolidation pressures preventing some of the swelling. The low hydraulic conductivity measured in the laboratory is a function of the consolidation pressure used in the test to prevent swelling.

By comparing laboratory and field hydraulic conductivity testing, the following correlation factor (CF_k) is calculated:

$$CF_k = \frac{k_{field}}{k_{lab}} = \frac{4.2x10^{-8} cm/s}{5.1x10^{-9} cm/s} = 8.2$$

Therefore, during future construction a correlation factor of 8.2 should be applied against laboratory test results to estimate field hydraulic conductivity of the CCL.

6. SUMMARY AND CONCLUSIONS

Excavation and stockpiling of clay from the Pecten Claystone, as well as test pad construction, was performed in general accordance with the requirements presented in Appendix A. The excavated clay was classified as a fat clay (CH) with more than 30 percent of the material, by weight, passing the No. 200 sieve. This material, when tested in the both the laboratory and field, has a hydraulic conductivity no greater than $1x10^{-7}$ cm/s. Therefore, this material meets the requirements of a CCL as defined by 40 CFR §264.301 and CCR Title 23 §2541. Further, this material is similar to the material previously used as CCL for Landfill B-18 at the Kettleman Hills Facility (see Table 4).

During future construction a correlation factor of 8.2 should be applied against laboratory test results to estimate field hydraulic conductivity of the CCL.

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TABLE 1
CLAY STOCKPILE TESTING FREQUENCIES

Test	ASTM Standard	Required Frequency	Number of Tests	Actual Frequency[1]
Moisture-Density Relationship	ASTM D 1557	1 per 5,000 CY	7	1 per 3,371 CY
Sieve Analysis	ASTM D 422	1 per 5,000 CY	7	1 per 3,371 CY
Atterberg Limits	ASTM D 4318	1 per 5,000 CY	7	1 per 3,371 CY
Hydraulic Conductivity	ASTM D 5094	1 per 5,000 CY	7	1 per 3,371 CY

Notes
1. Based on approximately 23,600 cy of clay material stockpiled.

TABLE 2
CLAY TEST PAD TESTING FREQUENCIES

Test	ASTM Standard	Required Number of Tests	Number of Tests
Bulk Samples:			
Moisture-Density Relationship	ASTM D 1557	3	3
In-Situ Density/Moisture:			
Nuclear Density	ASTM 6938	5 per lift	40 (min 5 per lift)
Shelby Tube Samples:			
Sieve Analysis	ASTM D 422	6	6
Density	ASTM D 2937	6	10
Atterberg Limits	ASTM D 4318	6	10
Hydraulic Conductivity	ASTM D 5094	6	10

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TABLE 3
SDRI MEASUREMENTS

Date	Time	Water Level, Df (in)	Water Temp. (°F)	Rain?	Inner Ring Height, Hs (in)	Initial (full) Bag Mass (grams)		Final (empty) Bag Mass (grams)		Elapsed Time (hours)	Flow Q (cm^3/s)	Infiltration Rate q (cm/s)
8/13/2008	8:00	12.75	76	N		1485.1	0					
8/14/2008	8:04	12.75	80	N		1618.7	0	175.6	0	24.07		
8/14/2008	12:54	12.75	82	N		2023.3	1865.1	179	0	28.90		
8/15/2008	8:34	12.75	84	N	9.8	0	1885.1	?	1703.1	48.57		
8/16/2008	7:40	12.63	84	N	9.6	2167.8	2049.5	203.9	189.3	71.67		
8/17/2008	8:50	12.50	86	N	9.4	1914.6	1834.5	256.2	854.7	96.83	0.0343	9.2E-06
8/18/2008	8:27	12.44	84	N	9.2	2272.4	1944.1	462.8	548.9	120.45	0.0322	8.7E-06
8/19/2008	7:55	12.38	83	N	9.0	2110.8	1740.5	638.7	958.9	143.92	0.0310	8.3E-06
8/20/2008	8:07	12.25	81	N	8.8	1848.3	1852.2	1600.7	318.2	168.12	0.0222	6.0E-06
8/21/2008	8:10	12.25	82	N	8.6	2099.7	2137.4	621.8	1581	192.17	0.0173	4.7E-06
8/22/2008	8:03	12.38	82	N	8.5	2031	2056.7	2012.4	940.7	216.05	0.0149	4.0E-06
8/23/2008	8:18	12.25	82	N	8.4	2014.8	2074	1169.2	1666.4	240.30	0.0143	3.9E-06
8/25/2008	8:32	12.13	84	N	8.3	1984.6	1998.5	393.9	1554.6	288.53	0.01233	3.3E-06
8/26/2008	7:02	13.25	84	N	8.2	1956.3	1978	1126.4	1784.4	311.03	0.01324	3.6E-06
8/27/2008	8:09	13.13	84	N	8.1	2035	2032.4	1070.2	1802.9	336.15	0.01174	3.2E-06
8/29/2008	8:12	13	86	N	7.9	2027.3		2079.2	1204.6	384.20	0.00453	*See Note
8/30/2008	8:49	12.9375	88	N	7.8	2018.6		968.3		408.82	0.01195	3.2E-06
8/31/2008	8:37	12.9375	86	N	7.7	2057.4	1804.4	1076.2		432.62	0.01100	3.0E-06
9/2/2008	8:57	12.75	80	N	7.6	2088.4		907.9	748.1	480.95	0.013	3.4E-06
9/3/2008	9:11	12.628	80	N	7.5	2078.2		1027.9		505.18	0.012	3.3E-06
9/4/2008	8:15	12.5	81	N	7.5	2119.4		1191.4		528.25	0.011	2.9E-06
9/5/2008	9:05	13.8	82	N	7.4	2220.5	2297.6	1131.3		553.08	0.011	3.0E-06
9/8/2008	8:30	13.7	85	N	7.2	2098.5		2013.2	909	624.50	0.00621	1.7E-06
9/9/2008	8:30	13.5	84	N	7.2	2227.8				648.50		
9/10/2008	8:35	13.5	82	N	7.1	2226.6		1625.7		672.58	0.00694	1.9E-06
9/11/2008	8:25	13.1	80	N	7.1	4262.8	2329.8	1761.4		696.42	0.005	1.5E-06
9/15/2008	10:10	13.313	82	N	7	2246.4		3730.2	1466	794.17	0.004	1.1E-06

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TABLE 3
SDRI MEASUREMENTS

Date	Time	Water Level, Df (in)	Water Temp. (°F)	Rain?	Inner Ring Height, Hs (in)	Initial (full) Bag Mass (grams)		Final (empty) Bag Mass (grams)		Elapsed Time (hours)	Flow Q (cm^3/s)	Infiltration Rate q (cm/s)
9/16/2008	8:20	13.25	82	N	6.9	2142.4		1788.2		816.33	0.006	1.5E-06
9/17/2008	8:35	13.125	82	N	6.9	2175.8		1718.9		840.58	0.005	1.3E-06
9/18/2008	8:06	13	79	N	6.9	2045.3		1760.4		864.10	0.005	1.3E-06
9/19/2008	8:37	13	78	N	6.9	1946.9		1663.9		888.62	0.004	1.2E-06
9/22/2008	8:31	12.75	76	N	6.8	1970		1087.7		960.52	0.003	8.9E-07
9/23/2008	8:28	12.6875	75	N	6.8	1984.6		1666.9		984.47	0.004	9.5E-07
9/24/2008	8:33	12.625	76	N	6.8	1722.2		1596.5		1008.55	0.004	1.2E-06
9/25/2008	8:10	12.375	78	N	6.7	1590.1		1498.8		1032.17	0.003	7.1E-07
9/26/2008	8:20	12.25	78	N	6.6	1498.1	1756.2	1281.2		1056.33	0.004	9.6E-07
9/29/2008	9:00	13.375	82	N	6.6	2293.3		1157.2	1410.2	1129.00	0.003	7.1E-07
9/30/2008	9:30	12.25	80	N	6.6	2284.8		1951.2		1153.50	0.004	1.0E-06
10/1/2008	9:10	12.25	82	N	6.6	2305.4		2269.8		1177.17	0.000	4.7E-08
10/2/2008	8:45	13.25	80	N	6.6	2212.1		1968.3		1200.75	0.004	1.1E-06
10/3/2008	9:30	13.25	77	N	6.5	2166.4	2237.1	1759		1225.50	0.005	1.4E-06
10/6/2008	9:50	13	72	N	6.5	2303.2		2161.3	1587.9	1297.83	0.003	6.8E-07
10/7/2008	8:25	13	72	N	6.4	2219.1		2161		1320.42	0.002	4.7E-07
10/8/2008	11:00	12.875	74	N	6.4	2164.5		1958.5		1347.00	0.003	7.3E-07
10/9/2008	10:30	12.75	72	N	6.4	2159.3		1731		1370.50	0.005	1.4E-06
10/10/2008	9:30	12.50	68	N	6.4	2297.5	2184.9	1810.1		1393.50	0.004	1.1E-06
10/13/2008	9:01	12.5	61	N	6.3			1915.6	1837.6	1465.02	0.003	7.6E-07

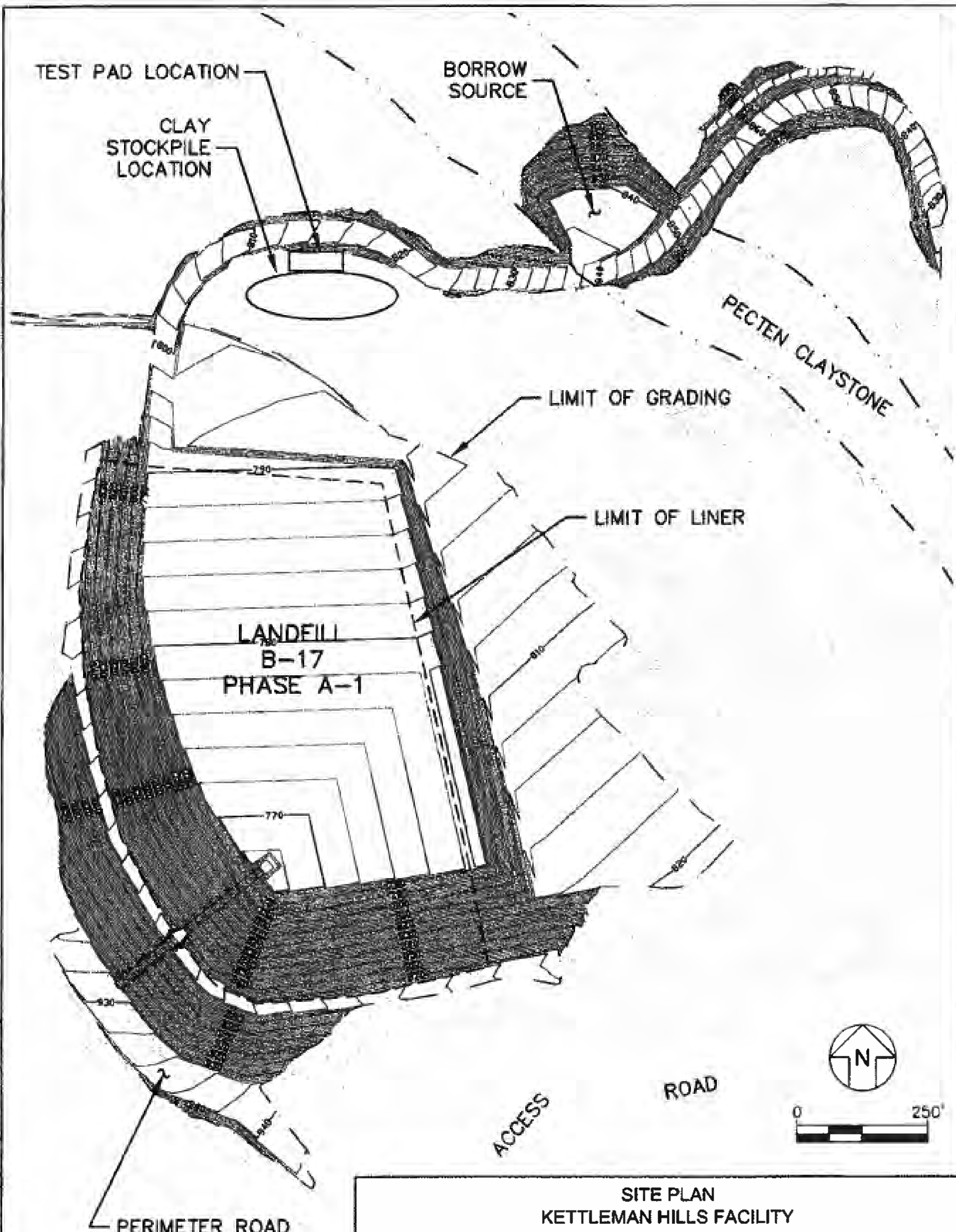
* Field data from 8/28/08 unclear. No bag weights recorded. Data not used.

=Empty bag, data not used

TABLE 4
COMPARISON OF CURRENT AND PREVIOUS LABORATORY TEST RESULTS OF PECTEN CLAYSTONE

	Soil Classification	Percent Passing No. 200 Sieve[1] (%)	LL/PI (%)[2]	Laboratory Hydraulic Conductivity[1] (cm/s)
Current Investigation	CH	89 (74 – 94)	93/64	3×10^{-8} (9×10^{-8} to 3×10^{-9})
Previous Landfill B-18 CCL Testing[3]	CH	>80 (48 - 94)	76/55	8×10^{-9} (2×10^{-7} to 2×10^{-10})

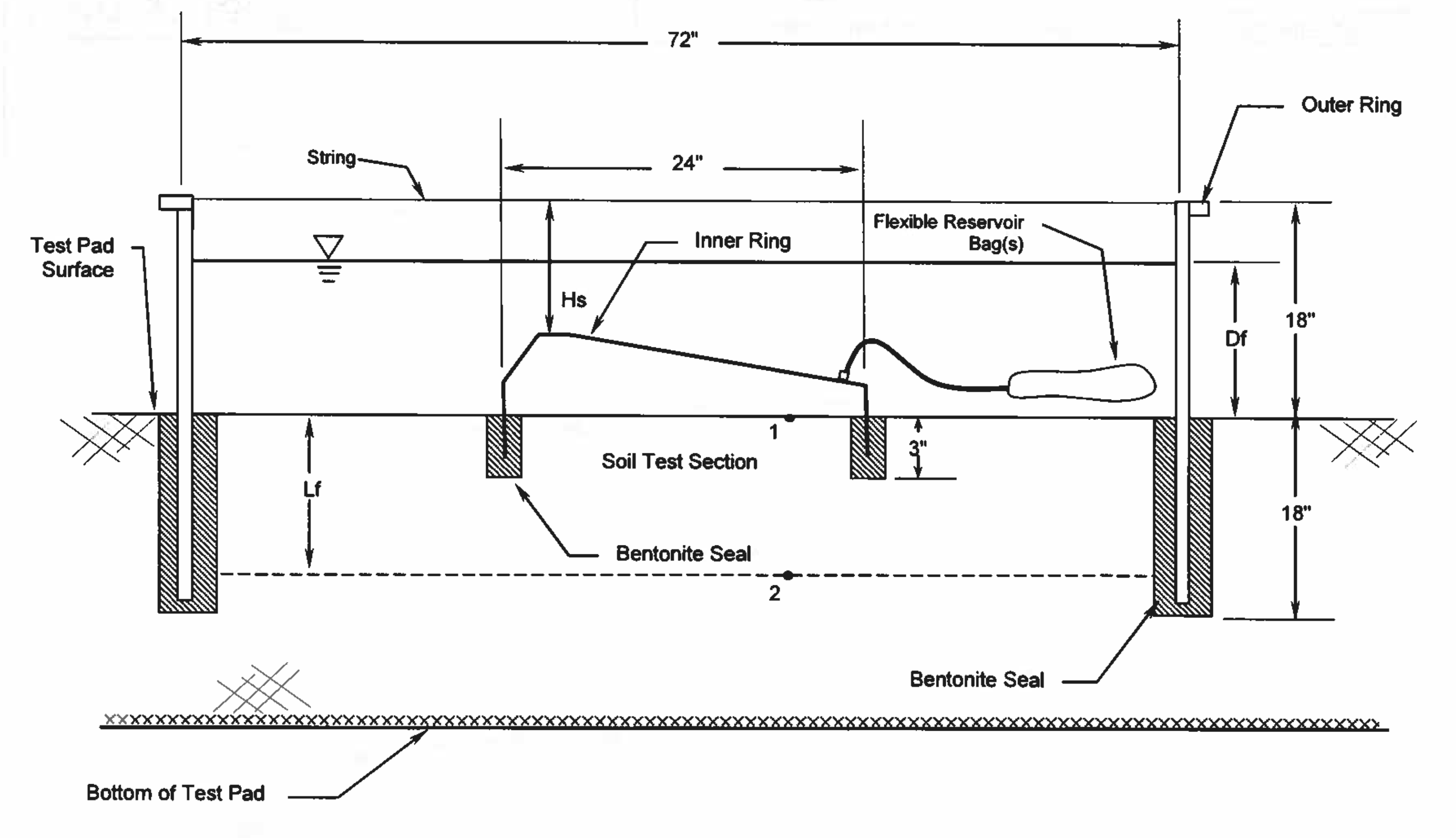
Notes:
1. First value reported is approximate average test results. Values in parentheses are ranges of data results.
2. Values reported are approximate averages.
3. Based on ECS (1991), ESI (1992), and GSC (1993).



SITE PLAN
KETTLEMAN HILLS FACILITY
KINGS COUNTY, CALIFORNIA

Geosyntec consultants	DATE: NOV 08	FIGURE
	PROJECT NO. SC0472	1

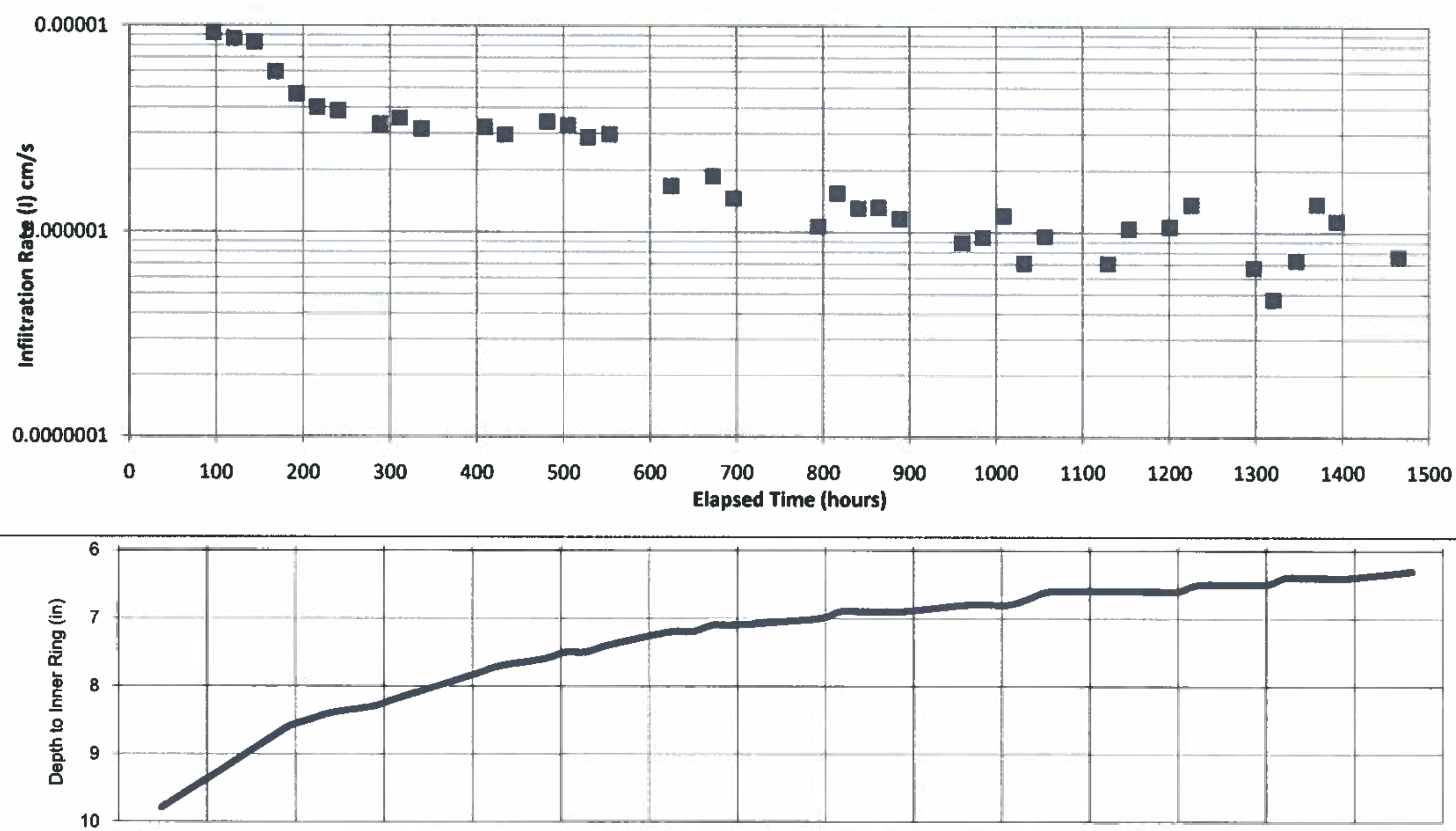
P:\CAD\SC0472 Kman\figures\17 A1 site plan.dwg



Geosyntec consultants

SDRI Test Setup
Kettleman Hills Facility
Kings County, California

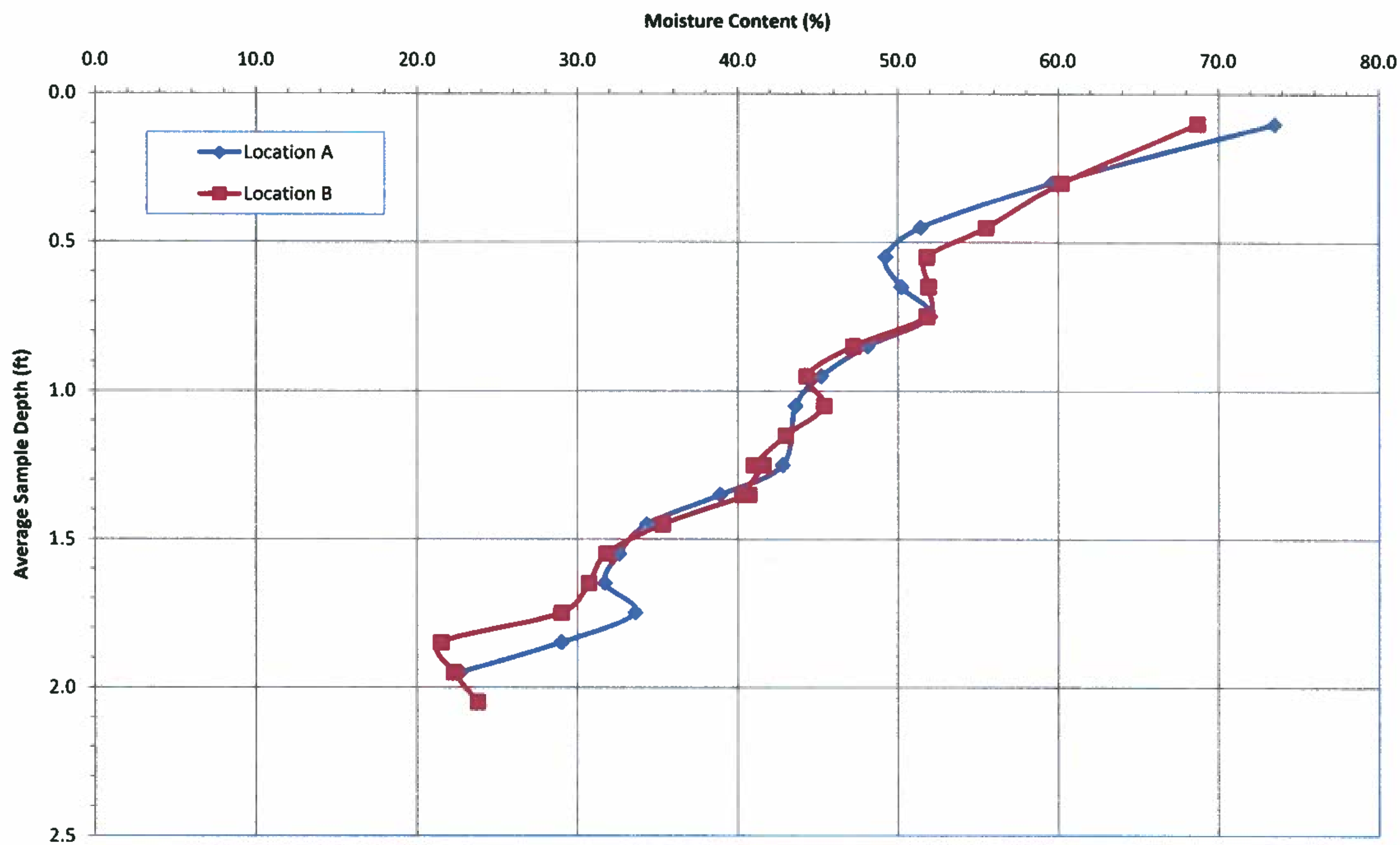
FIGURE NO.	2
PROJECT NO.	SC0472
DATE:	17-Dec-08



Geosyntec consultants

Infiltration Rate and Recorded Swell
Kettleman Hills Facility
Kings County, California

FIGURE NO.	**3**
PROJECT NO.	SC0472
DATE:	25-Nov-08



Geosyntec consultants	Moisture Content versus Depth below SDRI Inner Ring Kettleman Hills Facility Kings County, California	FIGURE NO. 4 PROJECT NO. SC0472 DATE: 25-Nov-08

APPENDIX A
PROJECT DOCUMENTS

APPENDIX A-1
Project Specifications – Section 02220

SECTION 02220

COMPACTED CLAY LINER

PART 1 – GENERAL

1.1 SCOPE OF WORK

A. Furnishing all labor, materials, tools, supervision, transportation, and installation equipment necessary for the construction of the Compacted Clay Liner (CCL) test pad, as specified herein, as shown on the Construction Drawings and in accordance with the Construction Quality Assurance (CQA) Plan.

B. Earthwork Contractor shall construct the CCL test pad to the elevations, lines, grades, and dimensions as shown on the Plans and described in the Specifications, unless otherwise directed by the Engineer.

C. Earthwork Contractor shall use clay from the source(s) selected by the owner.

D. The clay borrow source may contain some debris and oversize particles. The Earthwork Contractor shall remove large and easily recognizable debris. This debris must be removed prior to clay placement. Debris removal is considered part of the cost of clay placement.

1.2 RELATED SECTIONS

A. Section 02200 - Earthwork

1.3 REFERENCES

A. ASTM D422 - Standard Test Method for Particle Size Analysis of Soils

B. ASTM D854 - Standard Test Methods for Specific Gravity of Soils

C. ASTM D1140 - Standard Test Methods for Amount of Material in Soils Finer than the No. 200 Sieve.

D. ASTM D1556 - Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.

E. ASTM D1557 - Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort

F. ASTM D1587 - Standard Practice for Thin-Walled Tube Geotechnical Sampling of Soils

G. ASTM D2216 - Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures.

H. ASTM D2434 - Standard Test Method for Permeability of Granular Soils (Constant Head).

I. ASTM D2487 - Standard Test Method for Classification of Soils for Engineering Purposes.

J. ASTM D2922 - Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).

K. ASTM D3017 - Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).

L. ASTM D4318 - Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

M. ASTM D5084 - Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.

N. ASTM D5093 - Standard Test Method for Field Measurement of Infiltration Rate Using a Double-Ring Infiltrometer with a Sealed Inner Ring

O. Landfill B-17 Phase A1, Kettleman Hills Facility, Construction Quality Assurance Plan (CQA Plan).

1.4 QUALITY ASSURANCE

A. Construction Quality Assurance (CQA) monitoring shall be the responsibility of the Owner or Owner's Representative in accordance with the approved CQA Plan.

B. Quality control testing associated with filling and compaction operations shall be performed by the Owner or Owner's Representative in compliance with the CQA Plan and this Specification. The Contractor shall assist the Owner or Owner's Representative in obtaining clay samples at the frequencies provided in the CQA Plan.

C. Contractor shall provide labor, materials (granular bentonite), and equipment (chain trencher) necessary for the installation of the QA Monitor supplied Sealed Double Ring Infiltrometer equipment in accordance with ASTM D5093.

D. Earthwork Contractor shall give advance notice of at least 24 hours to the Owner or Owner's Representative when ready for compaction testing and inspection.

PART 2 – PRODUCTS

2.1 CLAY

A. Clay at the borrow source may not meet the contract specification for moisture content. Drying and/or wetting of this material may be required prior to placement.

B. Clay shall be free of debris, rocks, gravel greater than 1 inch in any direction, and other deleterious material.

C. At least 30 percent of the material, by weight, shall pass the No. 200 sieve.

D. Acceptable soils are those meeting the requirements of ASTM D 2487 for CL, SC, or CH with a compacted field permeability of less than or equal to $1 x 10^{-7}$ cm/sec.

2.3 EQUIPMENT

A. Provide equipment to excavate and transport clay from borrow source to test pad area.

B. Compaction equipment shall be of suitable mechanical type and adequate to obtain the densities specified, and shall provide satisfactory breakdown of materials to form a dense fill. Flooding or jetting methods of compaction shall not be used.

C. Locations inaccessible to heavy equipment shall be compacted by means of manually controlled pneumatic or vibrating tampers or by approved equivalent methods to achieve specified densities.

D. Compaction equipment shall be operated in strict accordance with the manufacturer's instructions and recommendations. Equipment shall be maintained in such condition that it shall deliver the manufacturer's rated compactive effort. If inadequate relative compaction is obtained, the Earthwork Contractor shall provide larger and/or different types of additional equipment at no additional cost. Hand-operated equipment shall be capable of achieving the specified densities.

E. Operate compaction equipment in strict accordance with the manufacturer's instructions and recommendations. If inadequate densities are obtained, provide larger and/or different types of additional equipment at no cost to the Owner.

F. Provide water application equipment free of leaks and equipped with a distributor bar or other accepted device to ensure uniform application.

G. Provide processing equipment suitable for providing a material that has a uniform moisture content.

H. On-site water source shall be made available for the EARTHWORK CONTRACTOR for the work included in this Section. The water source is located approximately 1.25 miles north of the project area and shall be identified in the pre-bid meeting at the site.

PART 3 – EXECUTION

3.1 GENERAL

The Earthwork Contractor shall:

A. Verify that the survey control system is installed and properly protected from construction operations prior to all earthwork, including clay placement.

B. Fill and compact all holes and other depressions prior to placement of clay.

C. Maintain surface of clay at minimum 2 percent grades for drainage.

D. Material incorporated into clay, determined by the Owner or Owner's Representative to be in violation of Specification requirements, shall be removed by the Earthwork Contractor at the Earthwork Contractor's expense.

3.2 TEST PAD CONSTRUCTION

A. Fill and compact all holes and other depressions prior to placement of clay.

B. Test pad area shall be cleared and grubbed.

C. Construct a test pad on the prepared subgrade. Surface of the test pad subgrade shall be proof-rolled to eliminate soft zones, irregularities, and abrupt changes in grade. Slope the finished subgrade surface at a grade of approximately 2 to 3 percent. No standing water or excessive moisture is allowed to accumulate on the surface of the subgrade.

D. The test pad shall be 50 feet long, 50 feet wide, and 3.5 feet deep. Some of the techniques to be monitored include: moisture conditioning, clod removal, scarification between lifts, number of equipment passes, lift thicknesses, and compactive effort.

E. The Earthwork Contractor will be responsible for verification that material that does not meet the Specifications is removed from the clay prior to placement.

F. Material incorporated into clay, determined by the Owner or Owner's Representative to be in violation of Specification requirements, shall be removed by the Earthwork Contractor at the Earthwork Contractor's expense.

G. Contractor shall breakdown claystone materials as necessary to meet maximum particle size requirements.

H. The clay material shall be compacted to at least 92 percent relative compaction. The moisture content shall be uniform and shall be 2% to 5% wet of the optimum moisture content.

I. Clay material shall be compacted in lifts with a compacted thickness of no greater than 6 inches.

J. Maintain surface of clay at minimum 2 percent grades for drainage.

K. Earthwork Contractor shall take adequate measurements to prevent moisture loss from the CCL.

L. Placement of successive clay layers shall not begin until the Owner or Owner's Representative has accepted the previous layer. Any damage to the previous layer or deterioration subsequent to acceptance shall be repaired by the Earthwork Contractor to the satisfaction of the Owner or Owner's Representative at the expense of the Earthwork Contractor.

M. Earthwork Contractor shall scarify the top of each lift and correct moisture content prior to placement of overlying lift.

N. Clay shall not be placed and compacted if the ambient air temperature drops below 32°F.

O. Earthwork Contractor shall seal the last and uppermost layer of CCL, after achieving the compaction requirements, with two passes of a single drum smooth roller.

P. Where test results indicate that the lift thickness, maximum particle size, in-place density/moisture content and or permeability of any portion of the clay does not meet the specified requirements, that particular portion shall be re-tested by the Owner or Owner's Representative and/or re-worked or replaced by the Earthwork Contractor at his expense until the required condition has been attained and the resulting product meets or exceeds the Specification requirements. No additional fill shall be placed over an area until the existing fill has been tested horizontally and vertically and determined by the Owner or Owner's Representative to meet the Compacted Clay Liner Specifications of this document.

Q. Assist the QA Monitor in obtaining cylinder push samples of the test fill per ASTM D1587 for laboratory permeability testing. These samples will be used to correlate field to laboratory permeability results.

R. Provide equipment and personnel to assist the QA Monitor in installing the Double Ring Infiltrometer per ASTM D 5093. The Infiltrometer has a 6-foot square outer ring and a 2-foot square inner ring. It is assumed that the assistance will require two laborers for one working day. Equipment needed includes:

a. grout mixer
b. 20 50-lb bags of bentonite grout (Volclay or similar)
c. wheelbarrow and shovels for placing grout in trenches
d. 1200 gallons of potable water for test

S. Keep personnel and equipment away from test area while test in running (estimated to be six weeks).

3.3 FIELD QUALITY CONTROL

A. The minimum frequency and details of quality assurance testing are provided in the CQA Plan. The Earthwork Contractor shall be aware of all field quality assurance requirements and activities, and shall incorporate these into his schedule.

B. All test holes, pits or other perforations resulting from testing of soils shall be filled with soil compacted to the satisfaction of the Owner or Owner's Representative.

C. If a defective area is discovered in the earthwork, the Owner or Owner's Representative will determine the extent and nature of the defect by performing additional tests, observations, a review of records, or other means that the Owner or Owner's Representative deems appropriate.

D. After the Owner or Owner's Representative determines the extent and nature of a defect, the Earthwork Contractor shall correct the deficiency at his expense to the satisfaction of the Owner or Owner's Representative.

E. Additional testing will be performed to verify that the defect has been corrected before the Earthwork Contractor performs any additional work in the area of the deficiency.

F. The Owner or Owner's Representative will determine in-place density and moisture content by any one or combination of the following methods: ASTM D1556, D2922, D2216, D3017, or other methods selected by the Owner or Owner's Representative. The Earthwork Contractor shall cooperate with this testing work by leveling small test areas designated by the Owner or Owner's

Representative. Backfilling of test areas shall be at Earthwork Contractor's sole expense. The frequency and location of testing shall be determined solely by the Owner or Owner's Representative. The Owner or Owner's Representative may test any lift of fill at any time, location, or elevation.

****END OF SECTION 02220****

APPENDIX A-1
CQA Plan – Addendum 1

LANDFILL B-17 PHASE A1
KETTLEMAN HILLS FACILITY
CONSTRUCTION QUALITY ASSURANCE PLAN

ADDENDUM NO. 1

1.1 Clay Liner Excavation

- ❑ Monitor that limits of borrow area are staked before work.
- ❑ Monitor that borrow area is cleared and grubbed prior to excavation.
- ❑ Visually observe excavated material for consistency with specifications.
- ❑ Monitor that upper 2 vertical feet of excavated material and material not meeting clay material specifications is stockpiled in general fill stockpile.
- ❑ Sample excavated material at a frequency of one sample per 5,000 cy of material excavated and perform the following laboratory tests:
  - ❑ Moisture-Density Relationship (ASTM D1557)
  - ❑ Sieve Analysis (ASTM D422)
  - ❑ Atterberg Limits (ASTM D4318)
  - ❑ Hydraulic Conductivity (ASTM D5094), remolded sample, compacted at a minimum of 90% relative compaction and at +2% optimum moisture content per ASTM D1557, at confining stress of 2 psi.

1.2 Clay Liner Test Pad

A compacted clay test pad will be constructed to evaluate the excavated material's performance as a compacted clay liner with a maximum hydraulic conductivity of $1x10^{-7}$ cm/sec.

- ❑ Monitor that limits of borrow area are staked before work.
- ❑ Determine correlation between number of passes with compaction equipment and relative density.
- ❑ Document equipment used to construct test pad.
- ❑ Monitor that clay material meets the particle size requirements in the project specifications (1-inch maximum).
- ❑ Monitor that material is placed in lifts with a compacted thickness no greater than 6 inches.
- ❑ Monitor that moisture content is uniform and meets the project specifications.

- Document number of passes for each lift.
- Perform nuclear density tests (ASTM D2922 and D3017) at a frequency of five tests per lift being placed.
- Collect a minimum of three bulk samples to be tested for Moisture-Density Relationship (ASTM D1557)
- Collect a minimum of six in-situ samples using thin-wall samplers (Shelby Tubes) from the completed compacted clay to be tested for the following:
  - Sieve Analysis (ASTM D422)
  - Density (ASTM D2937)
  - Atterberg Limits (ASTM D4318)
  - Hydraulic Conductivity (ASTM D5094)

APPENDIX B
CONSTRUCTION DOCUMENTATION

APPENDIX B-1
Photo Log

Photo No.:	1	**Date:**	07-31-08
Photographer:	David Williams		
Subject:	Preparing to perform FDT on clay test pad		
Project:	Kettleman Hills Facility	**City/State:**	Kings County, California

Photo No.:	2	**Date:**	07-31-08
Photographer:	David Williams		
Subject:	Documenting FDT on clay test pad		
Project:	Kettleman Hills Facility	**City/State:**	Kings County, California

Photo No.:	3	**Date:**	08-07-08
Photographer:	Jane Soule		
Subject:	Compaction of clay test pad with REX 3-35		
Project:	Kettleman Hills Facility	**City/State:**	Kings County, California

Photo No.:	4	**Date:**	08-07-08
Photographer:	Jane Soule		
Subject:	Preparing to take Shelby tube samples on final clay test pad lift		
Project:	Kettleman Hills Facility	**City/State:**	Kings County, California

Photo No.:	5	Date:	08-12-08
Photographer:	David Williams		
Subject:	Removal of visqueen layer used to maintain moisture of clay test pad prior to SDRI installation		
Project:	Kettleman Hills Facility	City/State:	Kings County, California

Photo No.:	6	Date:	08-12-08
Photographer:	David Williams		
Subject:	SDRI Installation, cutting trench for inner ring		
Project:	Kettleman Hills Facility	City/State:	Kings County, California

Photo No.:	7	Date:	08-12-08
Photographer:	David Williams		
Subject:	SDRI Installation, inner ring in place		
Project:	Kettleman Hills Facility	City/State:	Kings County, California

Photo No.:	8	Date:	08-12-08
Photographer:	David Williams		
Subject:	SDRI Installation, filling outer ring with water		
Project:	Kettleman Hills Facility	City/State:	Kings County, California

Photo No.:	9	**Date:**	08-12-08
Photographer:	David Williams		
Subject:	SDRI installation complete		
Project:	Kettleman Hills Facility	**City/State:**	Kings County, California

Photo No.:	10	**Date:**	08-27-08
Photographer:	Jane Soule		
Subject:	SDRI during monitoring with insulating cover.		
Project:	Kettleman Hills Facility	**City/State:**	Kings County, California

Photo No.:	11	**Date:**	10-13-08
Photographer:	Jane Soule		
Subject:	SDRI Setup, showing measurement of depth of water & thermometer, string used to evaluate swell (depth to top of inner ring).		
Project:	Kettleman Hills Facility	**City/State:**	Kings County, California

Photo No.:	12	**Date:**	10-13-08
Photographer:	Jane Soule		
Subject:	Edge of outer ring, showing extensive swell of clay (beyond that of bentonite installed along seam), after draining of water.		
Project:	Kettleman Hills Facility	**City/State:**	Kings County, California

Photo No.:	13	**Date:**	10-13-08
Photographer:	Jane Soule		
Subject:	SDRI removal, stakes placed on ground surfaces to show extent of swell (approximately 5 – 6 inches)		
Project:	Kettleman Hills Facility	**City/State:**	Kings County, California

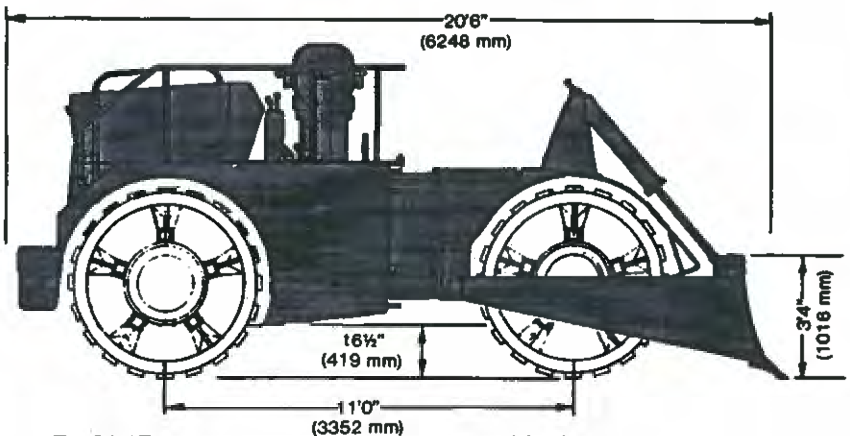
Photo No.:	14	**Date:**	10-13-08
Photographer:	Jane Soule		
Subject:	Excavation of trench around SDRI for removal		
Project:	Kettleman Hills Facility Landfill B-17, Phase A1	**City/State:**	Kings County, California

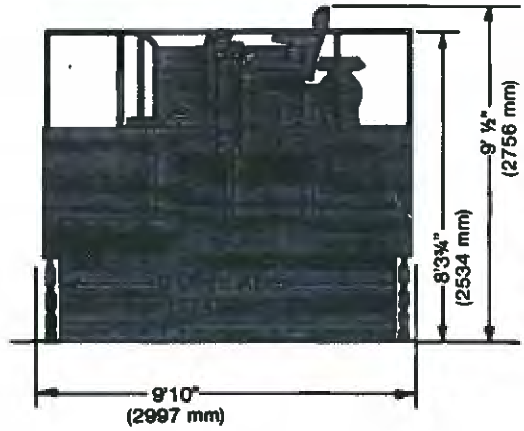
Photo No.:	15	**Date:**	10-13-08
Photographer:	Mike Minch		
Subject:	Sampling of soil for moisture content testing from inner ring area		
Project:	Kettleman Hills Facility	**City/State:**	Kings County, California

Photo No.:	16	Date:	10-13-08
Photographer:	Jane Soule		
Subject:	Excavated trench within inner ring area, significant moisture evident to depth of 1.3 - 1.4 feet, increase in moisture from as-compacted condition evident to depth of 1.8 to 1.9 feet.		
Project:	Kettleman Hills Facility	City/State:	Kings County, California

APPENDIX B-2
Compaction Equipment Specification Sheet

REX MODEL 3-35 PACTOR SPECIFICATIONS





ENGINE
Model 6V53 Detroit Diesel, 185 H.P. @ 2500 RPM, variable speed governor, 22" (559 mm) blower type fan, two stage dry type replaceable element air cleaner with service indicator, fuel and oil filters.

TRANSMISSION AND TORQUE CONVERTER
Clark C-28000 series 3-speed forward and reverse power shift matched to a Clark C-270 series converter. Speeds: 1st-3.75; 2nd-7.25; 3rd-10.5.

DRIVE
3-Wheel configuration for effective full width compaction and stability, all wheels drive. No Spin front differential; Mechanical driveline with heavy duty universals.

AXLES AND WHEELS
Clark 33810 series heavy duty axles front and wear. Wheels: Open ring segmented pad type, 3" x 5" (76.2 mm x 127 mm) pads with raker bars.

STEERING
Articulated front steer actuated by two hydraulic rams. Inside turning radius: 11'3" (3429 mm); Outside turning radius: 22'6" (6858 mm).

BRAKES
Hydraulically operated, multiple disc service brakes running in oil. Mechanically operated multiple disc parking brake.

SHOCK PROTECTION AND SHIELDING
Rear axle is shock absorber mounted. All wheels equipped with rubber cushions mounted between outer ring and inner ring to reduce shock and eliminate metal-to-metal contact. Fenders, guards, and railings designed for maximum operator protection. Engine compartment protected by heavy gauge hood which opens fully with spring assist.

BLADE
9' Wide. Large full width blade. Hydraulically operated with up, down, and float positions. Blade raise above grade: 34" (864 mm); Blade down below grade: 4" (102 mm).

ELECTRICAL
12 Volt system, 62 amp alternator, voltage regulator, starter, emergency and service shutoff.

HYDRAULICS
A fully filtered system with service indicator, gear type pump, and spool valves.

LIGHTS
Two front, two rear.

GAUGES
Ammeter, engine oil pressure, transmission temperature and pressure, water temperature, hour meter, fuel, air cleaner service indicator, and tachometer.

OPERATOR CONTROLS & POSITIONING
Side facing, four way adjustable seating for full visibility front and rear. Travel direction and range and blade positioning hand controls. Braking and travel speed pedal controls. All located for operator comfort.

Operating weight less ROPS . . . 36,000# (16330 KG)
Operating weight with ROPS . . . 37,500# (17010 KG)

COMPACTIVE EFFORT
343 PSI (24.11 KG/cm²)

CAPACITIES
Fuel 125 gal. (473 liters), hydraulic system 55 gal. (208 liters), cooling system 13 gal. (49 liters), transmission and torque converter 8.5 gal. (32 liters), engine crankcase 4 gal. (15 liters), wheel ends 16 pts. (7.5 liters) ea., differential 34 pts. (16 liters) ea.

OPTIONS
1. Enclosed cab with built in ROPS, windshield wipers, front and rear tinted glass, dome light, lockable doors
2. Open ROPS
3. Heater and defroster fan
4. Air conditioning
5. Cold weather starting kit

NOTE: We reserve the right to amend these specifications at any time without notice.
The only warranty applicable is our standard written warranty. We make no other warranty, expressed or implied.

REXWORKS

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(213) 944-8061

APPENDIX C
CLAY STOCKPILE AND TEST PAD RESULTS

APPENDIX C-1
Laboratory Test Summary Table and Results

TABLE C-1
SUMMARY OF GEOTECHNICAL LABORATORY TEST RESULTS
CLAY SOURCE TESTING - PECTEN CLAYSTONE
KETTLEMAN HILLS FACILITY, KINGS COUNTY, CALIFORNIA

Site Sample No.	Date Sampled	Source	Atterberg Limits			Soil Classification (ASTM D 2487)	Fines Content		Laboratory		Permeability (ASTM D5084)		
			LL	PL	PI		% < # 200 Sieve	Natural Moisture Content	Maximum Dry Density	Optimum Moisture	Dry Unit Weight	Moisture Content	Hydraulic Conductivity
			%	%				%	lb/ft^3	%	lb/ft^3	%	cm/s
CL-1	07/16/08	Clay stockpile	95	33	62	CH	87.4	15.3	111.0	17.3	99.1	19.1	9.3E-08
CL-2	07/24/08	Clay stockpile	61	23	38	CH	73.8	8.1	119.7	12.5	107.6	14.7	6.3E-08
CL-3	07/24/08	Clay stockpile	110	41	69	CH	93.5	22.6	106.0	18.0	96.9	20.1	4.0E-08
CL-4	07/27/08	Clay stockpile	88	27	61	CH	90.7	12.4	111.9	15.4	103.0	17.2	4.9E-08
CL-5	07/27/08	Clay test pad							113.6	16.0			
CL-6	07/31/08	Clay test pad	92	21	71						105.6	18.4	5.3E-09
CL-7	07/31/08	Clay test pad	90	23	67						100.0	20.6	3.6E-09
CL-8	07/31/08	Clay test pad	88	27	61						103.1	20.9	1.0E-08
CL-9	07/31/08	Clay test pad	88	29	59						104.6	21.2	3.1E-09
CL-10	08/03/08	Clay test pad							113.1	17.9			
CL-11	08/03/08	Clay stockpile	94	30	64	CH	89.8	16.2	112.8	16.6	103.5	18.3	2.3E-08
CL-12	08/04/08	Test Pad / FDT 5						20.4					
CL-13	08/04/08	Test Pad / FDT 8						18.9					
CL-14	08/04/08	Test Pad / FDT 14						20.6					
CL-15	08/07/08	Clay test pad							110.0	17.4			
CL-16	08/07/08	Clay test pad	98	31	67	CH	89.5	19.2			103.3	19.2	9.0E-09
CL-17	08/07/08	Clay test pad	99	30	69	CH	87.8	18.4			109.4	17.7	2.6E-09
CL-18	08/07/08	Clay test pad	95	27	68	CH	90.3	18.7			105.1	19.5	5.8E-09
CL-19	08/07/08	Clay test pad	98	32	66	CH	91.2	17.7			109.0	18.3	4.4E-09
CL-20	08/07/08	Clay test pad	95	28	67	CH	93.6	20			109.3	18.0	4.7E-09
CL-21	08/07/08	Clay test pad	103	29	74	CH	91.4	18.5			108.4	18.7	2.7E-09
CL-22	08/08/08	Clay stockpile	98	32	66	CH	87.2	15.7	107.4	18.1	98.7	20.3	5.8E-08
CL-23	08/11/08	Clay stockpile	89	27	62	CH	85.8	9.9	112.1	15.2	103.0	17.4	6.4E-08

Average:	93	29	64		89	17	112	16	104	19	2.6E-08
Max:	110	41	74		94	23	120	18	109	21	9.3E-08
Min:	61	21	38		74	8	106	13	97	15	2.6E-09

FDT = Field Density Test
L = Lift Number

TABLE C-2
SUMMARY OF GEOTECHNICAL LABORATORY TEST RESULTS - STOCKPILE SAMPLES
CLAY SOURCE TESTING - PECTEN CLAYSTONE
KETTLEMAN HILLS FACILITY, KINGS COUNTY, CALIFORNIA

Site Sample No.	Date Sampled	Source	Atterberg Limits			Soil Classification (ASTM D 2487)	Fines Content		Laboratory		Permeability (ASTM D5084)		
			LL	PL	PI		% < # 200 Sieve	Natural Moisture Content	Maximum Dry Density	Optimum Moisture	Dry Unit Weight	Moisture Content	Hydraulic Conductivity
			%	%				%	lb/ft^3	%	lb/ft^3	%	cm/s
CL-1	07/16/08	Clay stockpile	95	33	62	CH	87.4	15.3	111.0	17.3	99.1	19.1	9.3E-08
CL-2	07/24/08	Clay stockpile	61	23	38	CH	73.8	8.1	119.7	12.5	107.6	14.7	6.3E-08
CL-3	07/24/08	Clay stockpile	110	41	69	CH	93.5	22.6	106.0	18.0	96.9	20.1	4.0E-08
CL-4	07/27/08	Clay stockpile	88	27	61	CH	90.7	12.4	111.9	15.4	103.0	17.2	4.9E-08
CL-11	08/03/08	Clay stockpile	94	30	64	CH	89.8	16.2	112.8	16.6	103.5	18.3	2.3E-08
CL-22	08/08/08	Clay stockpile	98	32	66	CH	87.2	15.7	107.4	18.1	98.7	20.3	5.8E-08
CL-23	08/11/08	Clay stockpile	89	27	62	CH	85.8	9.9	112.1	15.2	103.0	17.4	6.4E-08

Average:	91	30	60		87	14	112	16	102	18	5.6E-08
Max:	110	41	69		94	23	120	18	108	20	9.3E-08
Min:	61	23	38		74	8	106	13	97	15	2.3E-08

TABLE C-3
SUMMARY OF GEOTECHNICAL LABORATORY TEST RESULTS - TEST PAD SAMPLES
CLAY SOURCE TESTING - PECTEN CLAYSTONE
KETTLEMAN HILLS FACILITY, KINGS COUNTY, CALIFORNIA

Site Sample No.	Date Sampled	Source	Atterberg Limits			Soil Classification (ASTM D 2487)	Fines Content		Laboratory		Permeability (ASTM D5084)		
			LL	PL	PI		% < # 200 Sieve	Natural Moisture Content	Maximum Dry Density	Optimum Moisture	Dry Unit Weight	Moisture Content	Hydraulic Conductivity
			%	%				%	lb/ft^3	%	lb/ft^3	%	cm/s
CL-5	07/27/08	Clay test pad							113.6	16.0			
CL-6	07/31/08	Clay test pad	92	21	71						105.6	18.4	5.3E-09
CL-7	07/31/08	Clay test pad	90	23	67						100.0	20.6	3.6E-09
CL-8	07/31/08	Clay test pad	88	27	61						103.1	20.9	1.0E-08
CL-9	07/31/08	Clay test pad	88	29	59						104.6	21.2	3.1E-09
CL-10	08/03/08	Clay test pad							113.1	17.9			
CL-12	08/04/08	Test Pad / FDT 5						20.4					
CL-13	08/04/08	Test Pad / FDT 8						18.9					
CL-14	08/04/08	Test Pad / FDT 14						20.6					
CL-15	08/07/08	Clay test pad							110.0	17.4			
CL-16	08/07/08	Clay test pad	98	31	67	CH	89.5	19.2			103.3	19.2	9.0E-09
CL-17	08/07/08	Clay test pad	99	30	69	CH	87.8	18.4			109.4	17.7	2.6E-09
CL-18	08/07/08	Clay test pad	95	27	68	CH	90.3	18.7			105.1	19.5	5.8E-09
CL-19	08/07/08	Clay test pad	98	32	66	CH	91.2	17.7			109.0	18.3	4.4E-09
CL-20	08/07/08	Clay test pad	95	28	67	CH	93.6	20			109.3	18.0	4.7E-09
CL-21	08/07/08	Clay test pad	103	29	74	CH	91.4	18.5			108.4	18.7	2.7E-09
		Average:	95	28	67		91	19	112	17	106	19	5.1E-09
		Max:	103	32	74		94	21	114	18	109	21	1.0E-08
		Min:	88	21	59		88	18	110	16	100	18	2.6E-09

FDT = Field Density Test
L = Lift Number

GEOMETRIC MEAN 5.35×10^{-9}

Geosyntec consultants

WASTE MANAGEMENT

SOIL SAMPLE LOG

PROJECT: Kettleman Hills Landfill

LOCATION: Kettleman City, CA.

DESCRIPTION: Cell B17, Phase A1 Clay test pad

PROJECT NO.: SC0472 TASK NO.: 03/1

YEAR: 2008

	SITE SAMPLE NO.	LAB SAMPLE NO.	VISUAL DESCRIPTION	SOURCE (LOCATION/DEPTH)	MATERIAL TYPE	DATE SAMPLED (day/mo)	TEST METHODS ASTM	QA ID
7	CL-1		Brownish grey clay	Clay stockpile	Clay liner soil			
8	CL-2					16/7	D422, 4318, 1557, 5084	JD
9	CL-3					24/7		JD
11	CL-4					24/7		JD
12	CL 5					27/7		JD
22	CL 6			Clay test pad/L-2		27/7	D1557	DW
23	CL 7			Clay test pad/lift 3		31/7	D 5084	DW
24	CL 8							JD
25	CL 9							JD
26	CL 10			Clay test pad / L-4				JD
27	CL 11		Brownish grey clay	Clay stock pile		3/8	D1557	DW
28	CL 12			Test pad/L-4/FDT 5		3/8	D422, 1557, 4318, 5084	DW
29	CL 13			Test pad/L-4/FDT 8		4/8	D2216	DW
30	CL 14			Test pad/L-5/FDT 14				DW
31	CL 15			Clay test pad / L-6				DW
32	CL 16			Clay test pad / L-7		7/8	D 1557	DW
33	CL 17					7/8	D5084	JD
34	CL 18							
35	CL 19							
36	CL 20							
37	CL 21							

NOTES:

CHECKED BY:

Geosyntec consultants

WASTE MANAGEMENT

SOIL SAMPLE LOG

PROJECT: Kettleman Hills Landfill

LOCATION: Kettleman City, CA.

DESCRIPTION: Cell B17, Phase A1 Clay test pad

PROJECT NO.: SC0472 TASK NO.: 03/1

YEAR: 2008

	SITE SAMPLE NO.	LAB SAMPLE NO.	VISUAL DESCRIPTION	SOURCE (LOCATION/DEPTH)	MATERIAL TYPE	DATE SAMPLED (day/mo)	TEST METHODS	QA ID
38	CL-22		Brown/grey clay	Clay stockpile	Clay liner soil	8/8	D1557, 422, 4318, 5084	DCO
41	CL-23		↓	Clay stockpile	↓	11/8	1557, 422, 4318, 5084	DCJ

NOTES:

Soil Sample Log

CHECKED BY:

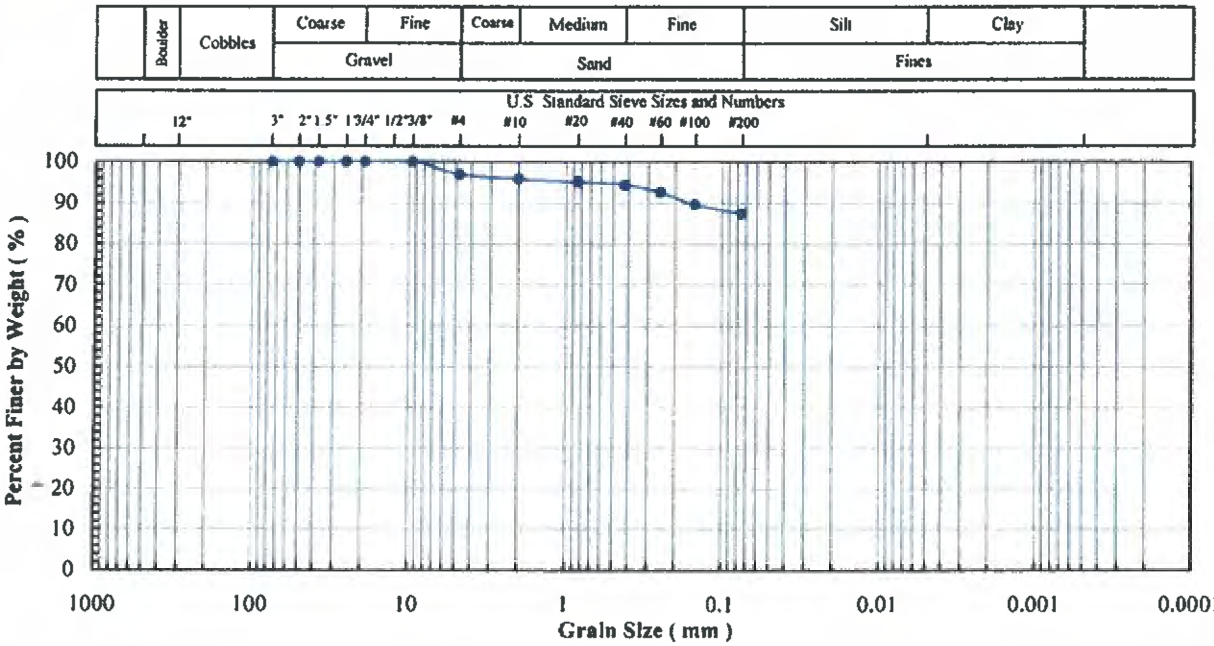
Excel Geotechnical Testing, Inc.
"Excellence in Testing"
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

Project Name:	Kettleman B-17 Landfill
Project No:	309
Client Sample ID:	CL-01
Lab Sample No:	G115

ASTM C 136, D 422, D 854, D 1140, D2216, D 2487, D4318

SOIL INDEX PROPERTIES

Grain Size, Spec. Gravity, Moist. Content, Eng. Classification, Atterberg Limits



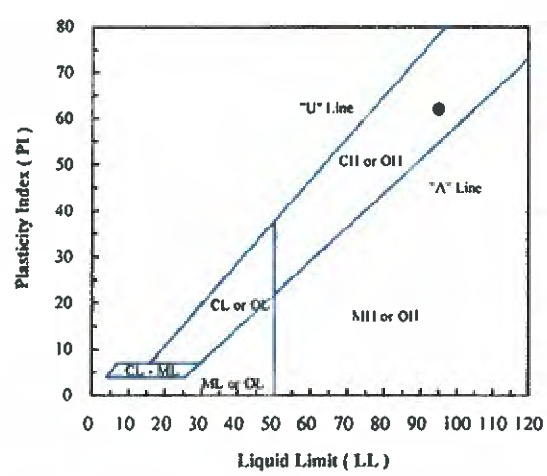
Sieve No.	Size (mm)	% Finer
3"	75	100.0
2"	50	100.0
1.5"	37.5	100.0
1"	25	100.0
3/4"	19	100.0
3/8"	9.5	100.0
#4	4.75	97.0
#10	2.00	95.9
#20	0.850	95.2
#40	0.425	94.4
#60	0.250	92.6
#100	0.150	89.6
#200	0.075	87.4

Specific Gravity (-):	

Hydrometer Particle Diameter (mm)	% Finer

Gravel (%):	3.0
Sand (%):	9.6
Fines (%):	87.4
Silt (%):	
Clay (%):	

Coeff. Unif. (Cu):	
Coeff. Curv. (Cc):	



Client Sample ID.	Lab Sample No:	Moisture Content (%)	Fines Content < No. 200 (%)	Atterberg Limits LL (-)	PL (-)	PI (-)	Engineering Classification
CL-01	G115	15.3	87.4	95	33	62	CH - Fat clay

Note(s):

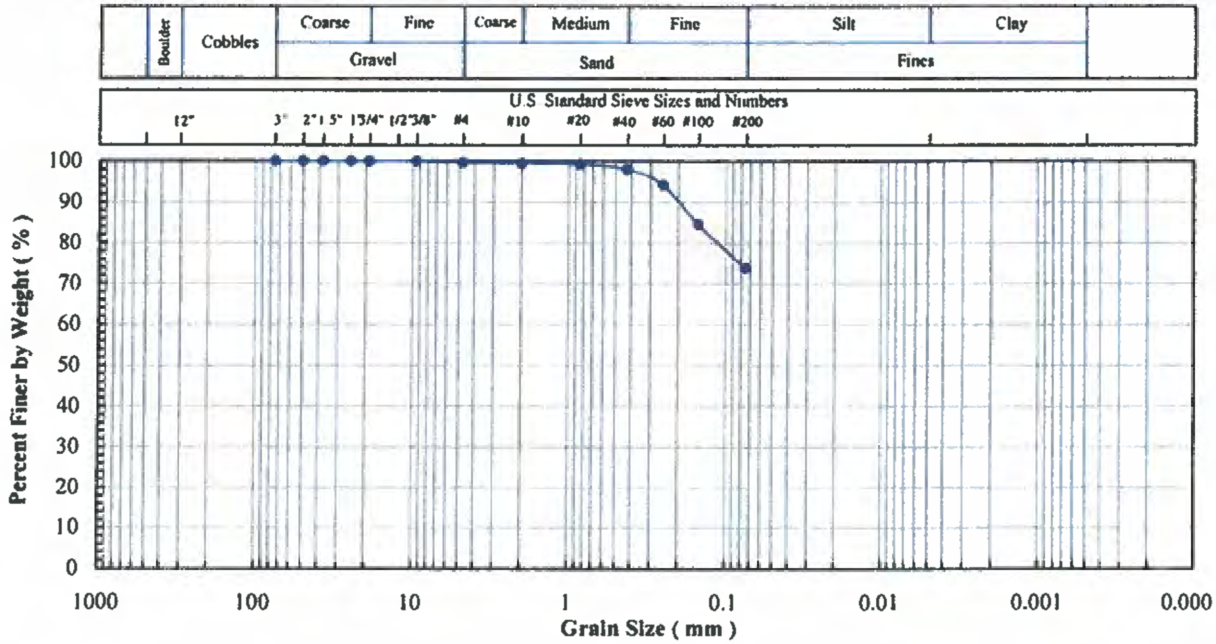
Excel Geotechnical Testing, Inc.
"Excellence In Testing"
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

Project Name:	Kettleman B-17 Landfill
Project No:	309
Client Sample ID:	CL-02
Lab Sample No:	G124

ASTM C 136, D 422, D 854, D 1140, D2216, D 2487, D4318

SOIL INDEX PROPERTIES

Grain Size, Spec. Gravity, Moist. Content, Eng. Classification, Atterberg Limits



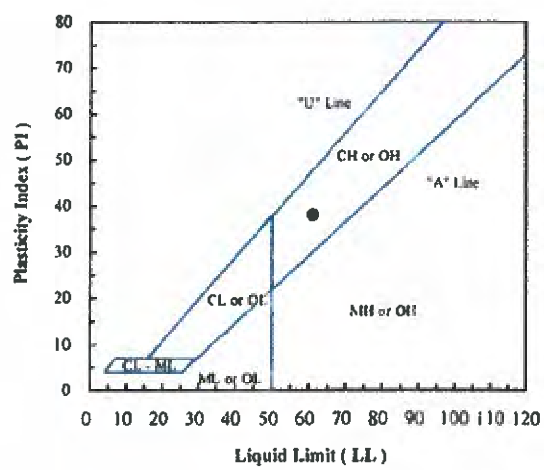
Sieve No.	Size (mm)	% Finer
3"	75	100.0
2"	50	100.0
1.5"	37.5	100.0
1"	25	100.0
3/4"	19	100.0
3/8"	9.5	100.0
#4	4.75	99.6
#10	2.00	99.4
#20	0.850	99.2
#40	0.425	98.0
#60	0.250	94.3
#100	0.150	84.6
#200	0.075	73.8

Specific Gravity (-):	

Hydrometer Particle Diameter (mm)	% Finer

Gravel (%):	0.4
Sand (%):	25.8
Fines (%):	73.8
Silt (%):	
Clay (%):	

Coeff. Unif. (Cu):	
Coeff. Curv. (Cc):	



Client Sample ID.	Lab Sample No:	Moisture Content (%)	Fines Content < No. 200 (%)	Atterberg Limits LL (-)	PL (-)	PI (-)	Engineering Classification
CL-02	G124	8.1	73.8	61	23	38	CH - Fat clay with sand

Note(s):

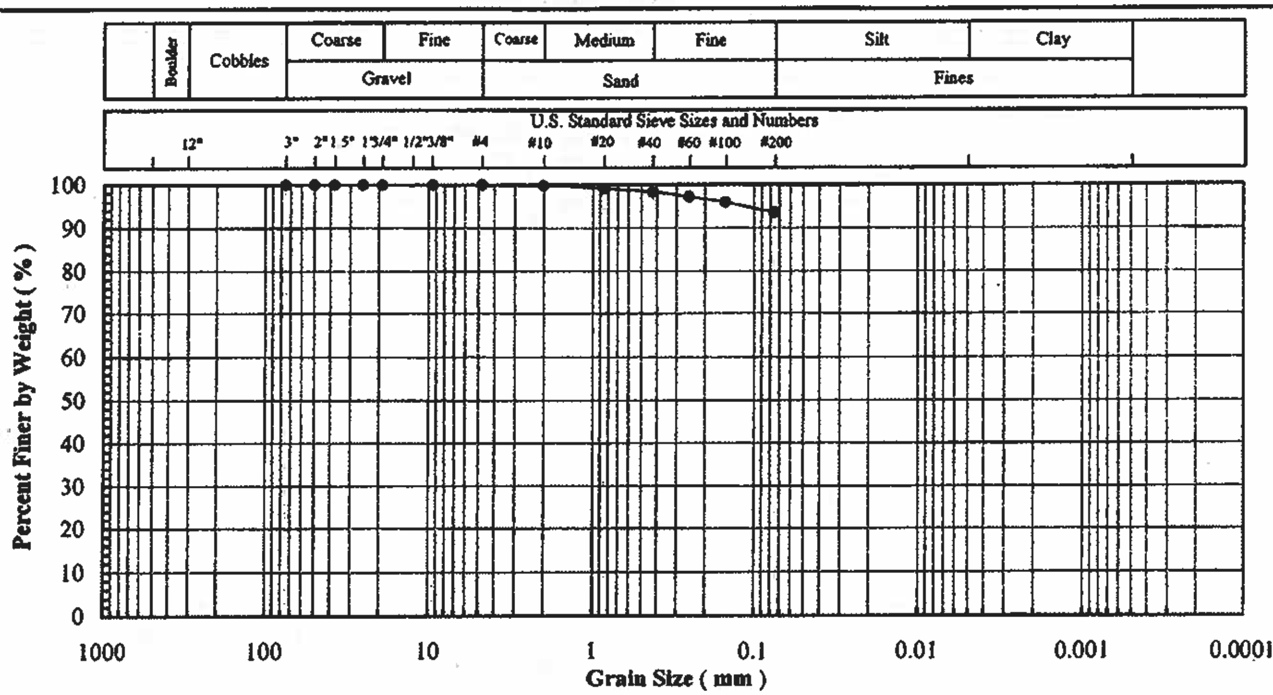
Excel Geotechnical Testing, Inc.
"Excellence in Testing"
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

Project Name:	Kettleman B-17 Landfill
Project No:	309
Client Sample ID:	CL-03
Lab Sample No:	G147

ASTM C 136, D 422, D 854, D 1140, D2216, D 2487, D4318

SOIL INDEX PROPERTIES

Grain Size, Spec. Gravity, Moist. Content, Eng. Classification, Atterberg Limits



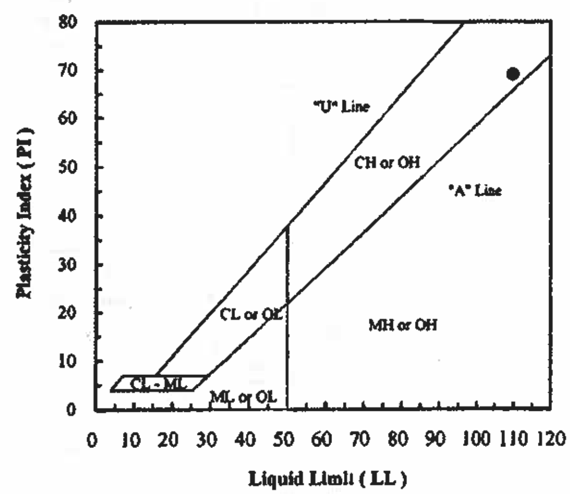
Sieve No.	Size (mm)	% Finer
3"	75	100.0
2"	50	100.0
1.5"	37.5	100.0
1"	25	100.0
3/4"	19	100.0
3/8"	9.5	100.0
#4	4.75	100.0
#10	2.00	99.8
#20	0.850	99.1
#40	0.425	98.3
#60	0.250	97.2
#100	0.150	95.9
#200	0.075	93.5

Specific Gravity (-):	

Hydrometer Particle Diameter (mm)	% Finer

Gravel (%):	
Sand (%):	6.5
Fines (%):	93.5
Silt (%):	
Clay (%):	

Coeff. Unif. (Cu):	
Coeff. Curv. (Cc):	



Client Sample ID.	Lab Sample No:	Moisture Content (%)	Fines Content < No. 200 (%)	Atterberg Limits LL (-)	PL (-)	PI (-)	Engineering Classification
CL-03	G147	22.6	93.5	110	41	69	CH - Fat clay

Note(s):

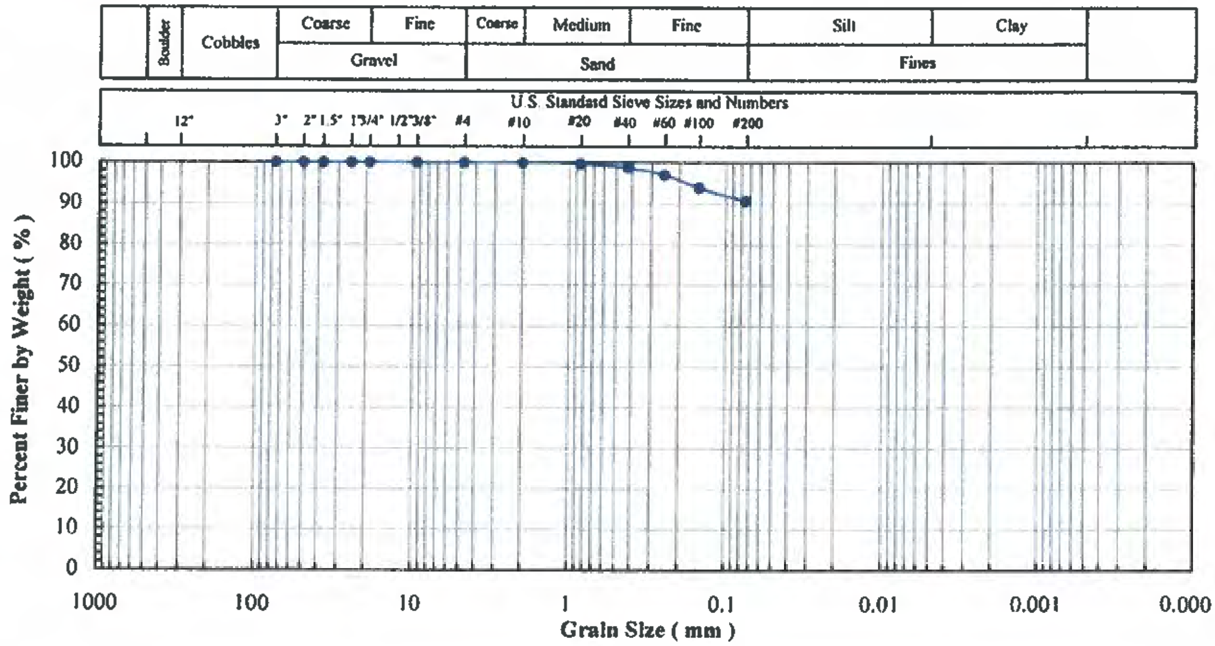
Excel Geotechnical Testing, Inc.
"Excellence in Testing"
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

Project Name:	Kettleman B-17 Landfill
Project No:	309
Client Sample ID:	CL-04
Lab Sample No:	G166

ASTM C 136, D 422, D 854, D 1140, D2216, D 2487, D4318

SOIL INDEX PROPERTIES

Grain Size, Spec. Gravity, Moist. Content, Eng. Classification, Atterberg Limits



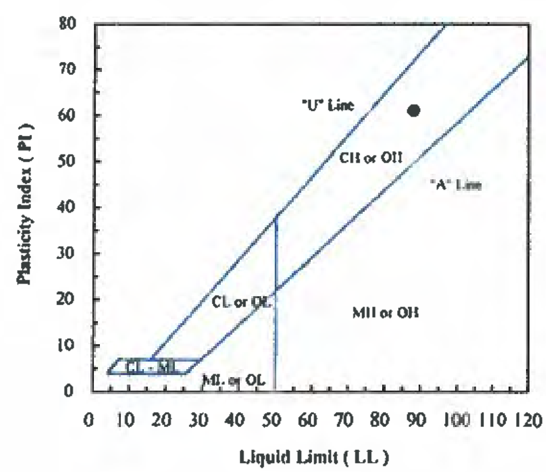
Sieve No.	Size (mm)	% Finer
3"	75	100.0
2"	50	100.0
1.5"	37.5	100.0
1"	25	100.0
3/4"	19	100.0
3/8"	9.5	100.0
#4	4.75	100.0
#10	2.00	99.9
#20	0.850	99.7
#40	0.425	98.8
#60	0.250	97.1
#100	0.150	94.0
#200	0.075	90.7

Specific Gravity (-):	

Hydrometer Particle Diameter (mm)	% Finer

Gravel (%):	
Sand (%):	9.3
Fines (%):	90.7
Silt (%):	
Clay (%):	

Coeff. Unif. (Cu):	
Coeff. Curv. (Cc):	



Client Sample ID.	Lab Sample No:	Moisture Content (%)	Fines Content < No. 200 (%)	Atterberg Limits LL (-)	PL (-)	PI (-)	Engineering Classification
CL-04	G166	12.4	90.7	88	27	61	CH - Fat clay

Note(s):

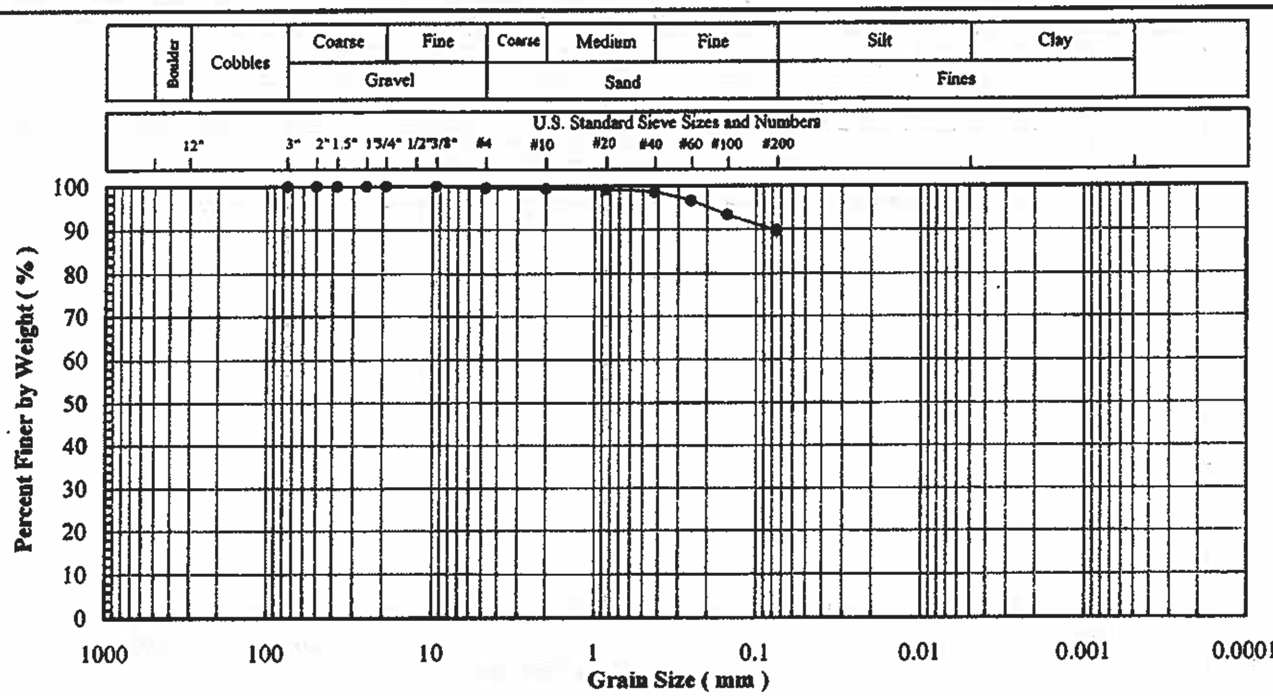
Excel Geotechnical Testing, Inc.
"Excellence in Testing"
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

Project Name:	Kettleman B-17 Landfill
Project No:	309
Client Sample ID:	CL-11
Lab Sample No:	H043

ASTM C 136, D 422, D 854, D 1140, D2216, D 2487, D4318

SOIL INDEX PROPERTIES

Grain Size, Spec. Gravity, Moist. Content, Eng. Classification, Atterberg Limits



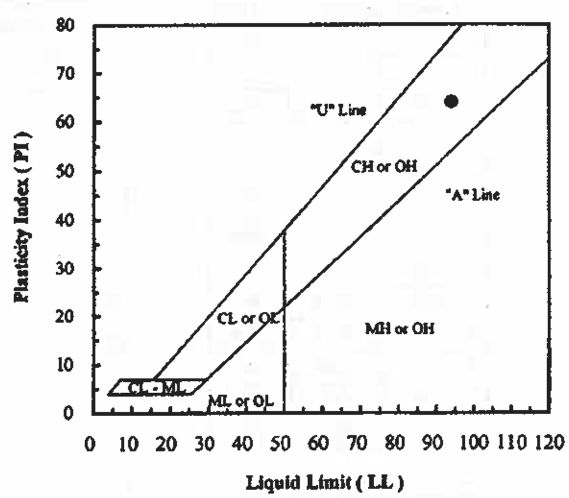
Sieve No.	Size (mm)	% Finer
3"	75	100.0
2"	50	100.0
1.5"	37.5	100.0
1"	25	100.0
3/4"	19	100.0
3/8"	9.5	100.0
#4	4.75	99.6
#10	2.00	99.4
#20	0.850	99.2
#40	0.425	98.6
#60	0.250	96.6
#100	0.150	93.4
#200	0.075	89.8

Specific Gravity (-):	

Hydrometer Particle Diameter (mm)	% Finer

Gravel (%):	0.4
Sand (%):	9.8
Fines (%):	89.8
Silt (%):	
Clay (%):	

Coeff. Unif. (Cu):	
Coeff. Curv. (Cc):	



Client Sample ID.	Lab Sample No:	Moisture Content (%)	Fines Content < No. 200 (%)	Atterberg Limits LL (-)	PL (-)	PI (-)	Engineering Classification
CL-11	H043	16.2	89.8	94	30	64	CH - Fat clay

Note(s):

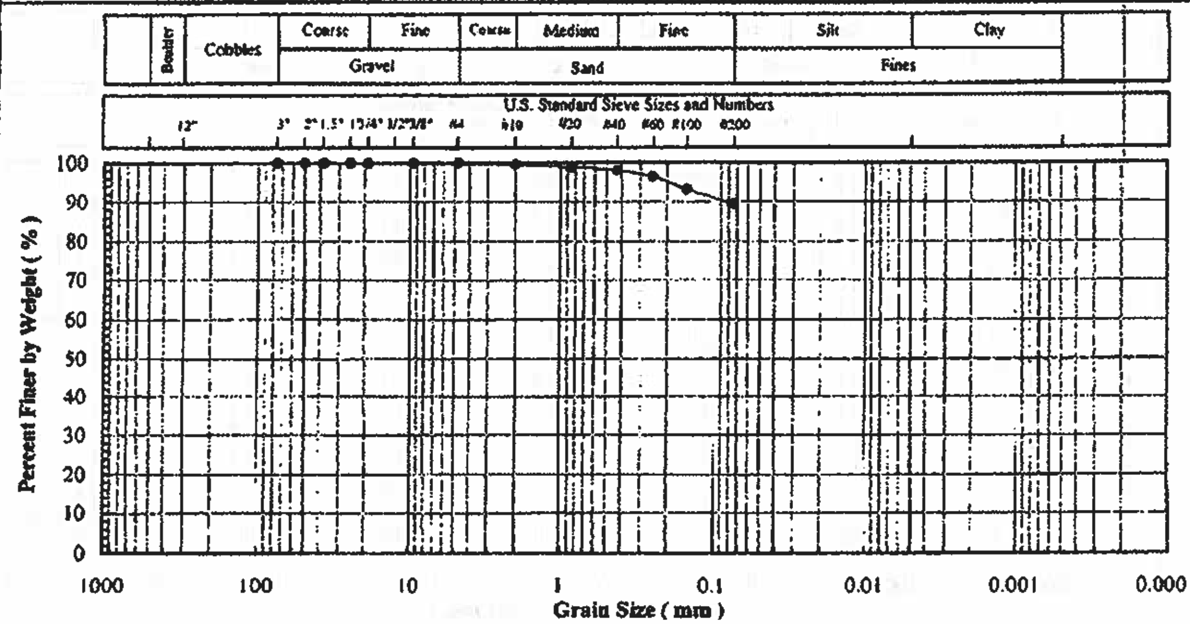
Excel Geotechnical Testing, Inc.
"Excellence in Testing"
941 Forrest Street, Roswell, Georgia 30076
Tel: (770) 660 1666 Fax: (770) 660 5786

Project Name:	Kettleman B-17 Landfill
Project No:	309
Client Sample ID:	CL-16
Lab Sample No:	H051

ASTM C 136, D 421, D 854, D 1140, D2216, D 2487, D4318

SOIL INDEX PROPERTIES

Grain Size, Spec. Gravity, Moist. Content, Eng. Classification, Atterberg Limits



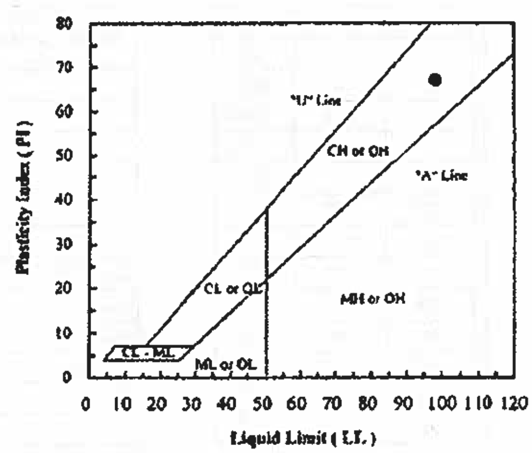
Sieve No.	Size (mm)	% Finer
3"	75	100.0
2"	50	100.0
1.5"	37.5	100.0
1"	25	100.0
3/4"	19	100.0
3/8"	9.5	100.0
#4	4.75	100.0
#10	2.00	99.6
#20	0.850	98.9
#40	0.425	98.1
#60	0.250	96.4
#100	0.150	93.3
#200	0.075	89.5

Specific Gravity (-):	

Hydrometer Particle Diameter (mm)	% Finer

Gravel (%):	
Sand (%):	10.5
Fines (%):	89.5
Silt (%):	
Clay (%):	

Coeff. Unif. (Cu):	
Coeff. Curv. (Cc):	



Client Sample ID.	Lab Sample No:	Moisture Content (%)	Fines Content < No. 200 (%)	Atterberg Limits LL (-)	PL (-)	PI (-)	Engineering Classification
CL-16	H051	19.2	89.5	98	31	67	CH - Fat clay

Note(s):

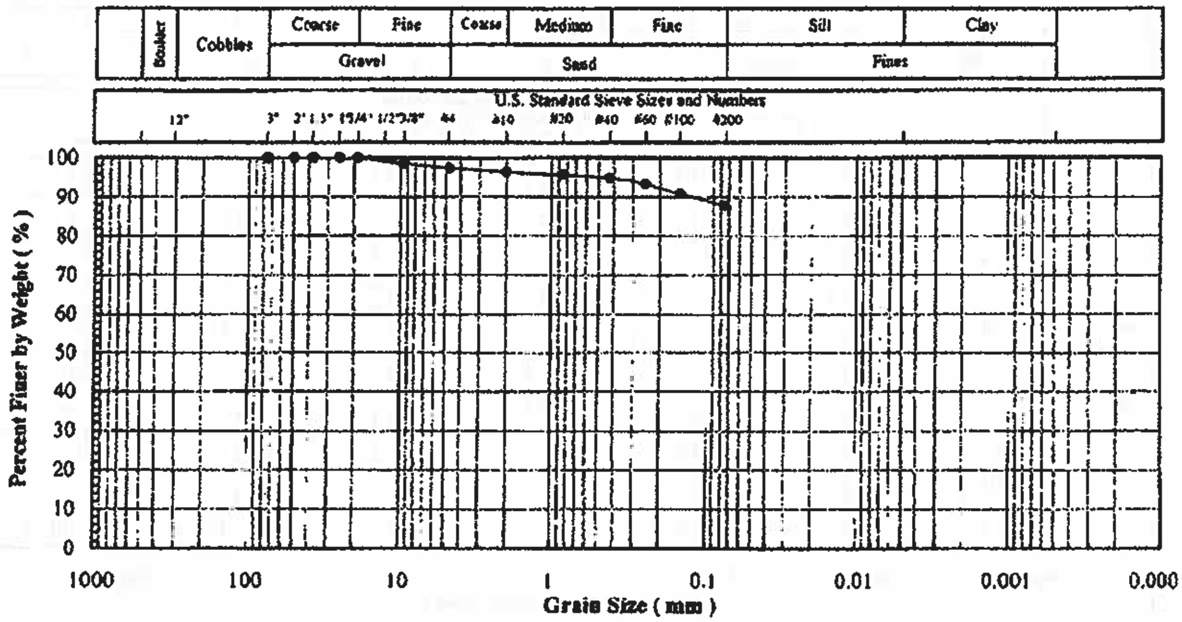
Excel Geotechnical Testing, Inc.
"Excellence In Testing"
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

Project Name:	Kettleman B-17 Landfill
Project No:	309
Client Sample ID:	CL-17
Lab Sample No:	H053

ASTM C136, D 422, D 854, D 1140, D2216, D 2487, D4318

SOIL INDEX PROPERTIES

Grain Size, Spec. Gravity, Moist. Content, Eng. Classification, Atterberg Limits



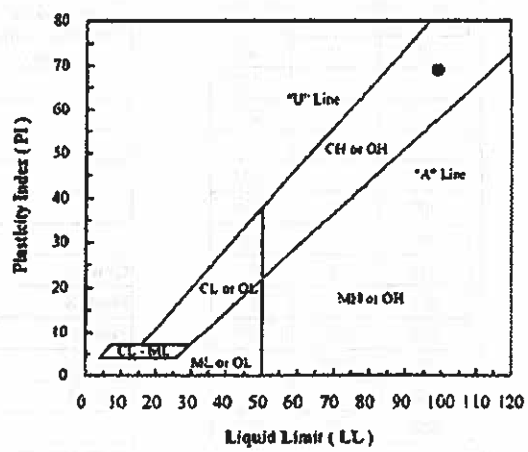
Sieve No.	Size (mm)	% Finer
3"	75	100.0
2"	50	100.0
1.5"	37.5	100.0
1"	25	100.0
3/4"	19	100.0
3/8"	9.5	98.6
#4	4.75	97.4
#10	2.00	96.5
#20	0.850	95.6
#40	0.425	94.9
#60	0.250	93.4
#100	0.150	90.9
#200	0.075	87.8

Specific Gravity (-):	

Hydrometer Particle Diameter (mm)	% Finer

Gravel (%):	2.6
Sand (%):	9.6
Fines (%):	87.8
Silt (%):	
Clay (%):	

Coeff. Unif. (Cu):	
Coeff. Curv. (Cc):	



Client Sample ID.	Lab Sample No:	Moisture Content (%)	Fines Content < No. 200 (%)	Atterberg Limits LL (-)	PL (-)	PI (-)	Engineering Classification
CL-17	H053	18.4	87.8	99	30	69	CH - Fat clay

Note(s):

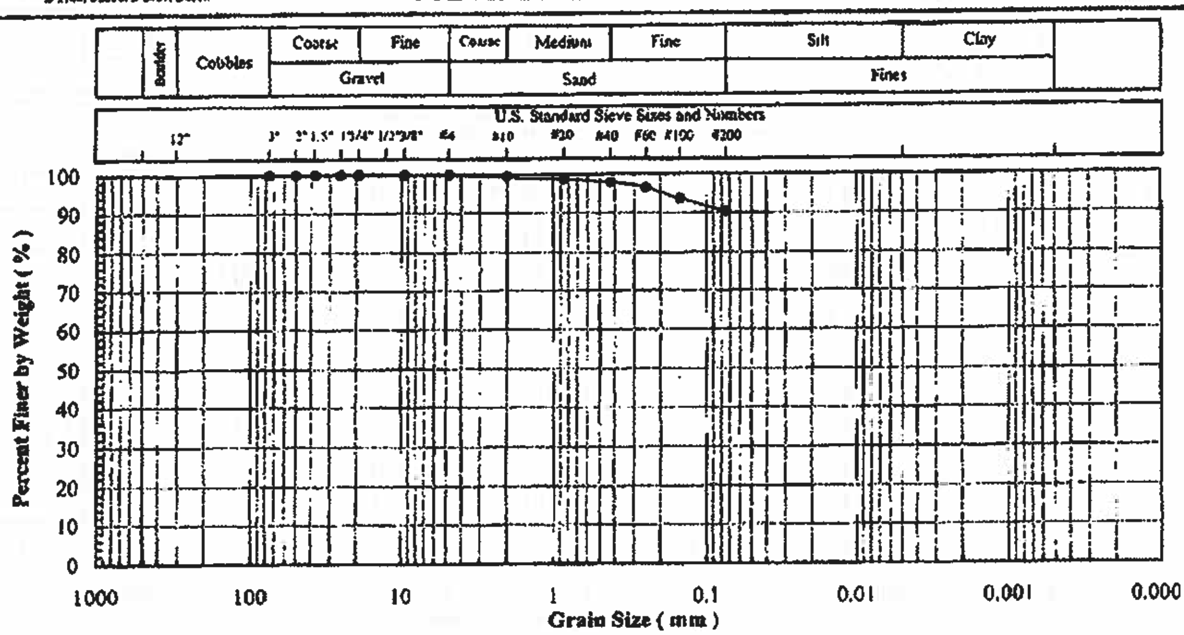
Excel Geotechnical Testing, Inc.
"Excellence in Testing"
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

Project Name:	Kettleman B-17 Landfill
Project No:	309
Client Sample ID:	CL-18
Lab Sample No:	H055

ASTM C 136, D 422, D 854, D 1140, D2216, D 2487, D4318

SOIL INDEX PROPERTIES

Grain Size, Spec. Gravity, Mois. Content, Eng. Classification, Atterberg Limits



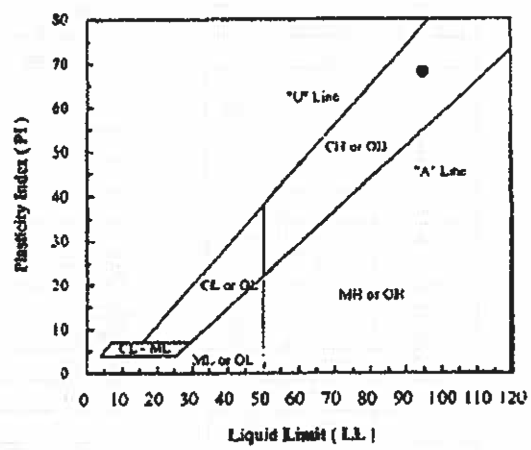
Sieve No.	Size (mm)	% Finer
3"	75	100.0
2"	50	100.0
1.5"	37.5	100.0
1"	25	100.0
3/4"	19	100.0
3/8"	9.5	100.0
#4	4.75	100.0
#10	2.00	99.4
#20	0.850	98.7
#40	0.425	97.9
#60	0.250	96.4
#100	0.150	93.6
#200	0.075	90.3

Specific Gravity (-):	

Hydrometer Particle Diameter (mm)	% Finer

Gravel (%):	
Sand (%):	9.7
Fines (%):	90.3
Silt (%):	
Clay (%):	

Coeff. Unif. (Cu):	
Coeff. Curv. (Cc):	



Client Sample ID.	Lab Sample No:	Moisture Content (%)	Fines Content < No. 200 (%)	Atterberg Limits LL (-)	PL (-)	PI (-)	Engineering Classification
CL-18	H055	18.7	90.3	95	27	68	CH - Fat clay

Note(s)

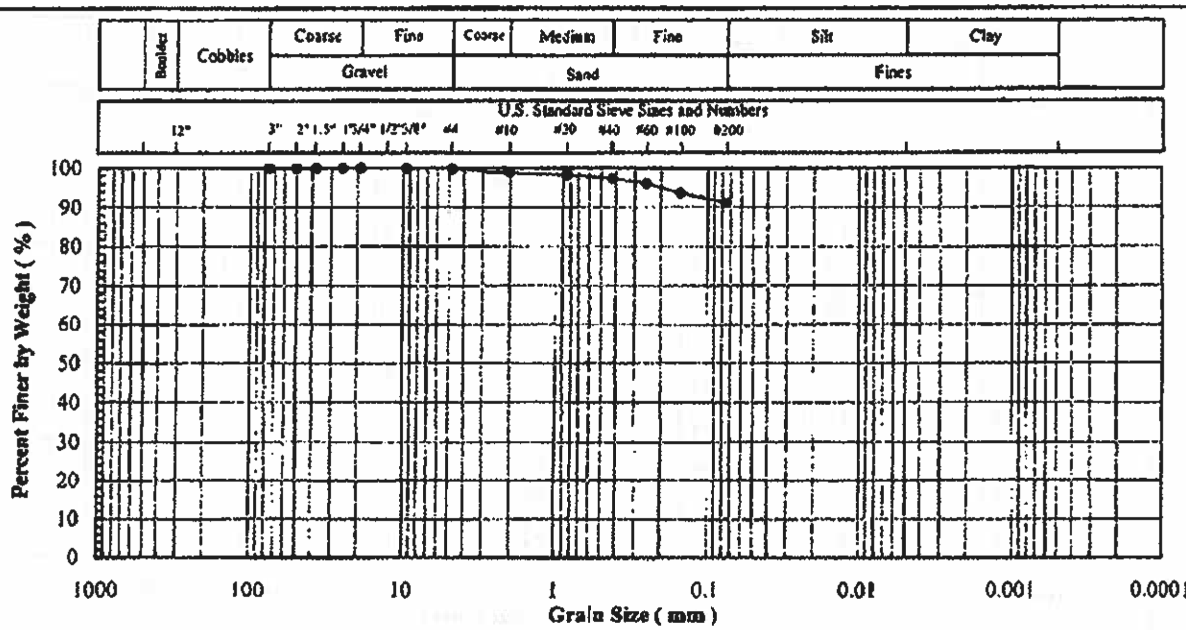
Excel Geotechnical Testing, Inc.
"*Excellence in Testing*"
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

Project Name: Kettleman B-17 Landfill
Project No: 309
Client Sample ID: CL-19
Lab Sample No: H057

ASTM C 136, D 422, D 854, D 1140, D2216, D 2487, D4318

SOIL INDEX PROPERTIES

GrainSize, Spec. Gravity, Moist. Content, Eng. Classification, Atterberg Limits



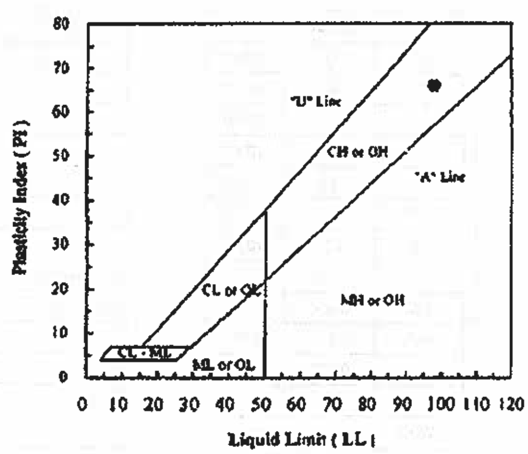
Sieve No.	Size (mm)	% Finer
3"	75	100.0
2"	50	100.0
1.5"	37.5	100.0
1"	25	100.0
3/4"	19	100.0
3/8"	9.5	100.0
#4	4.75	99.8
#10	2.00	98.9
#20	0.850	98.2
#40	0.425	97.3
#60	0.250	96.0
#100	0.150	93.7
#200	0.075	91.2

Specific Gravity (-):	

Hydrometer Particle Diameter (mm)	% Finer

Gravel (%):	0.2
Sand (%):	8.6
Fines (%):	91.2
Silt (%):	
Clay (%):	

Coeff. Unif. (Cu):	
Coeff. Curv. (Cc):	



Client Sample ID.	Lab Sample No:	Moisture Content (%)	Fines Content < No. 200 (%)	Atterberg Limits LL (-)	PL (-)	PI (-)	Engineering Classification
CL-19	H057	17.7	91.2	98	32	66	CH - Fat clay

Note(s):

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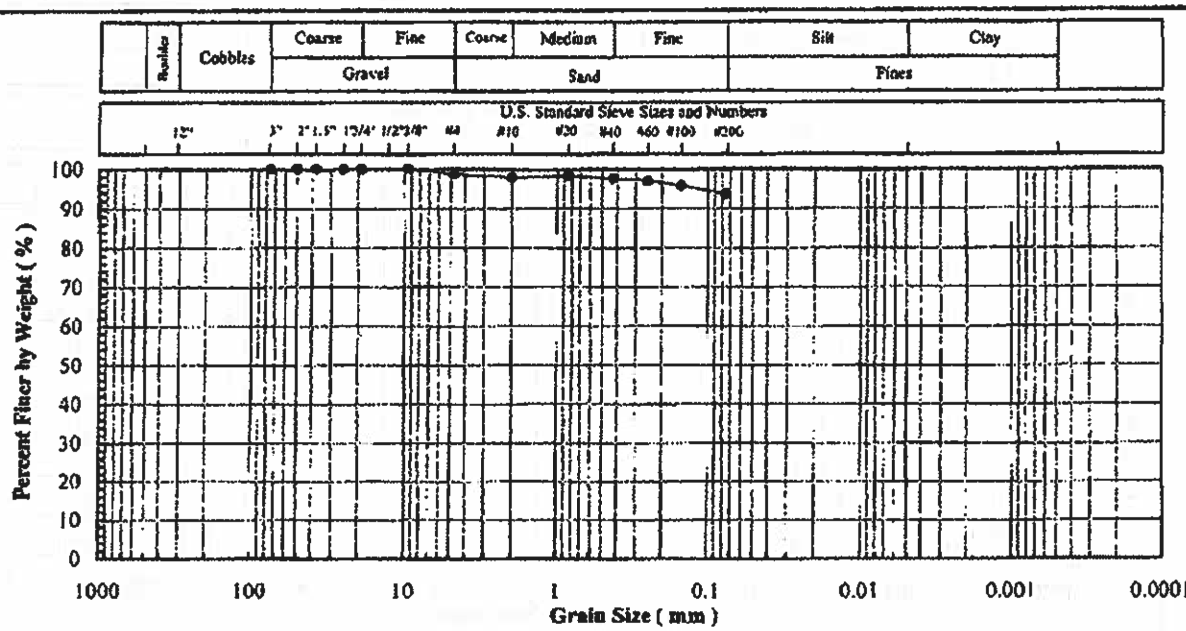
Tel: (770) 650 1666 Fax: (770) 650 5786

Project Name:	Kettleman B-17 Landfill
Project No:	309
Client Sample ID:	CL-20
Lab Sample No:	H058

ASTM C 136, D 422, D 854, D 1140, D 2216, D 2487, D 4318

SOIL INDEX PROPERTIES

Grain Size, Spec. Gravity, Moist. Content, Eng. Classification, Atterberg Limits



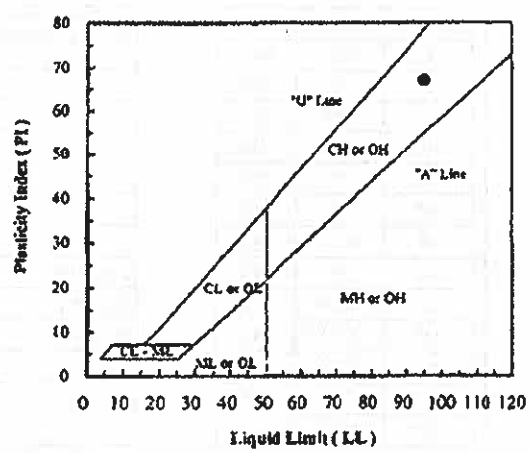
Sieve No.	Size (mm)	% Finer
3"	75	100.0
2"	50	100.0
1.5"	37.5	100.0
1"	25	100.0
3/4"	19	100.0
3/8"	9.5	100.0
#4	4.75	98.7
#10	2.00	97.9
#20	0.850	98.3
#40	0.425	97.6
#60	0.250	97.0
#100	0.150	95.8
#200	0.075	93.6

Specific Gravity (-):	

Hydrometer Particle Diameter (mm)	% Finer

Gravel (%):	1.3
Sand (%):	5.1
Fines (%):	93.6
Silt (%):	
Clay (%):	

Coeff. Unif. (Cu):	
Coeff. Curv. (Cc):	



Client Sample ID.	Lab Sample No:	Moisture Content (%)	Fines Content < No. 200 (%)	Atterberg Limits LL (-)	PL (-)	PI (-)	Engineering Classification
CL-20	H058	20.0	93.6	95	28	67	CH - Fat clay

Note(s):

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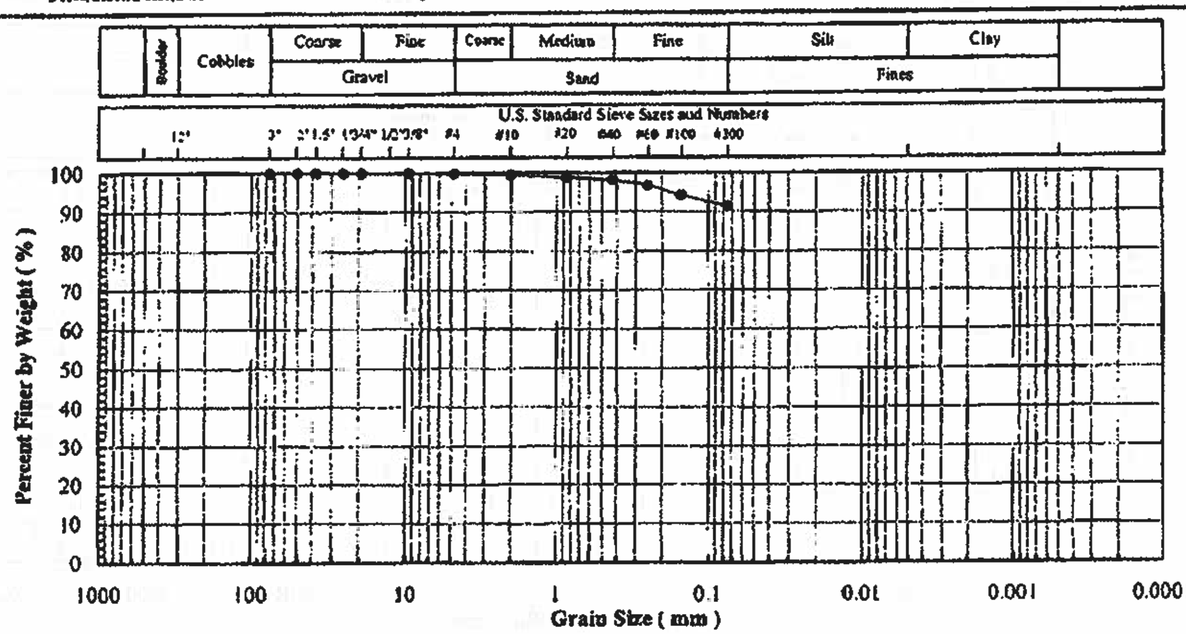
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

Project Name:	Kettleman B-17 Landfill
Project No:	309
Client Sample ID.	CL-21
Lab Sample No:	H061

ASTM C 136, D 422, D 854, D 2140, D2216, D 2487, D4318

SOIL INDEX PROPERTIES

Grain Size, Spec. Gravity, Moist. Content, Eng. Classification, Atterberg Limits



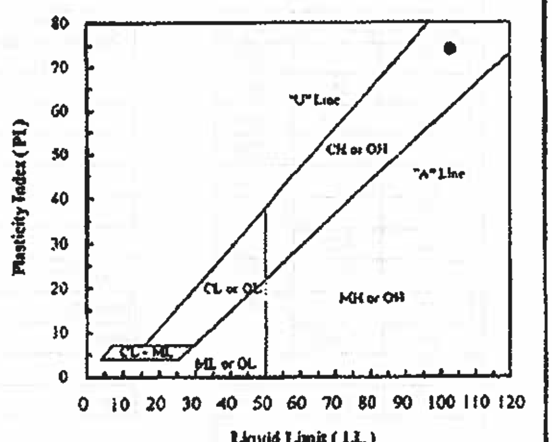
Sieve No.	Size (mm)	% Finer
3"	75	100.0
2"	50	100.0
1.5"	37.5	100.0
1"	25	100.0
3/4"	19	100.0
3/8"	9.5	100.0
#4	4.75	99.8
#10	2.00	99.4
#20	0.850	98.8
#40	0.425	98.1
#60	0.250	96.7
#100	0.150	94.2
#200	0.075	91.4

Specific Gravity (-):	

Hydrometer Particle Diameter (mm)	% Finer

Gravel (%):	0.2
Sand (%):	8.4
Fines (%):	91.4
Silt (%):	
Clay (%):	

Coeff. Unif. (Cu):	
Coeff. Curv. (Cc):	



Client Sample ID.	Lab Sample No:	Moisture Content (%)	Fines Content < No. 200 (%)	Atterberg Limits LL (-)	PL (-)	PI (-)	Engineering Classification
CL-21	H061	18.5	91.4	103	29	74	CH - Fat clay

Note(s):

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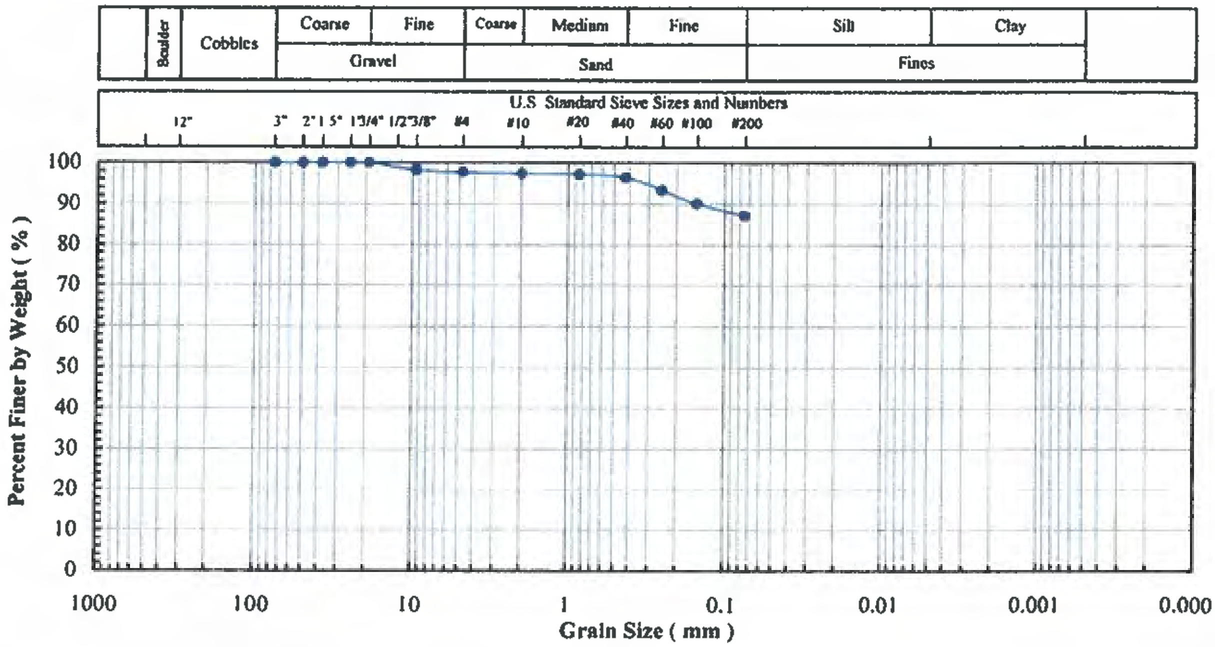
Project Name:	Kettleman B-17 Landfill
Project No:	309
Client Sample ID:	CL-22
Lab Sample No:	H078

ASTM C 136, D 422, D 854, D 1140, D2216, D 3487, D4318

SOIL INDEX PROPERTIES

Grain Size, Spec. Gravity, Moist. Content, Eng. Classification, Atterberg Limits



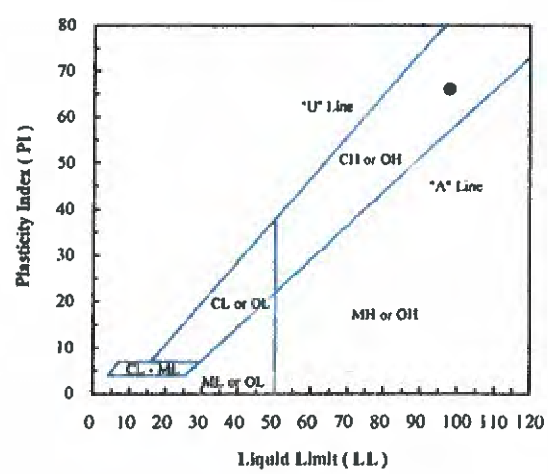
Sieve No.	Size (mm)	% Finer
3"	75	100 0
2"	50	100.0
1.5"	37 5	100.0
1"	25	100.0
3/4"	19	100.0
3/8"	9.5	98.3
#4	4.75	97.8
#10	2.00	97.4
#20	0.850	97.3
#40	0.425	96.5
#60	0.250	93.5
#100	0.150	90.1
#200	0.075	87.2

Specific Gravity (-):	

Hydrometer Particle Diameter (mm)	% Finer

Gravel (%):	2.2
Sand (%):	10.6
Fines (%):	87.2
Silt (%):	
Clay (%):	

Coeff. Unif. (Cu):	
Coeff. Curv. (Cc):	



Client Sample ID.	Lab Sample No:	Moisture Content (%)	Fines Content < No. 200 (%)	Atterberg Limits LL (-)	PL (-)	PI (-)	Engineering Classification
CL-22	H078	15.7	87.2	98	32	66	CH - Fat clay

Note(s):

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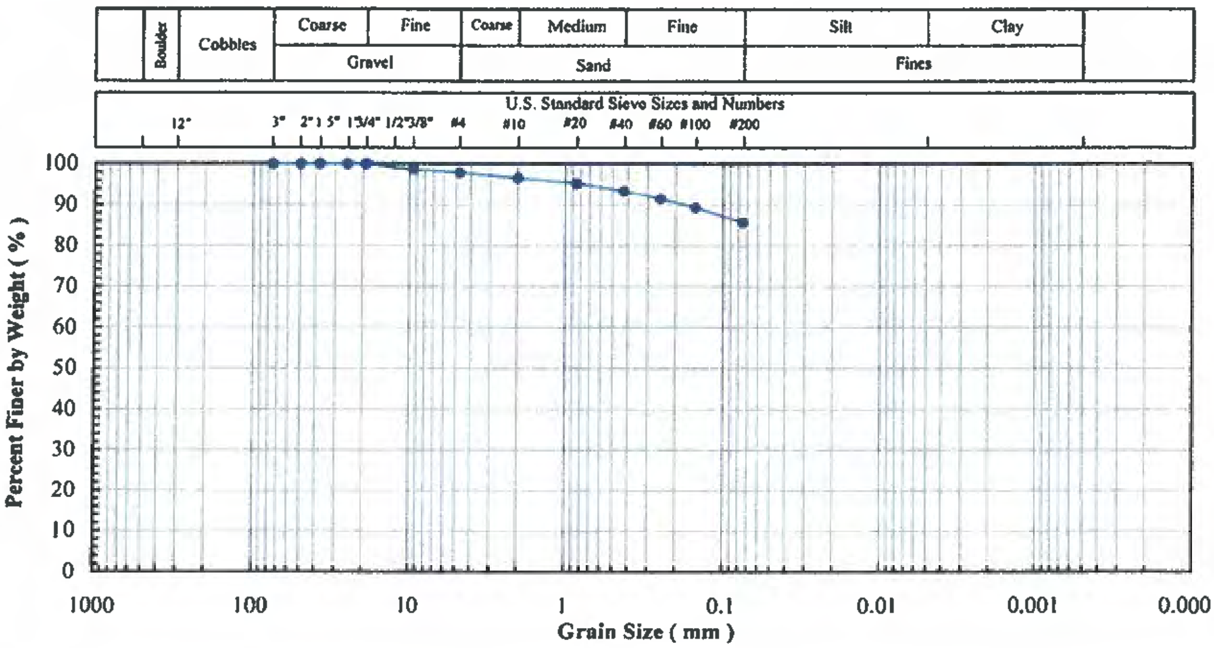
Tel: (770) 650 1666 Fax: (770) 650 5786

Project Name:	Kettleman B-17 Landfill
Project No:	309
Client Sample ID:	CL-23
Lab Sample No:	H080

ASTM C 136, D 422, D 854, D 1140, D2216, D 2487, D4318

SOIL INDEX PROPERTIES

Grain Size, Spec. Gravity, Moist. Content, Eng. Classification, Atterberg Limits



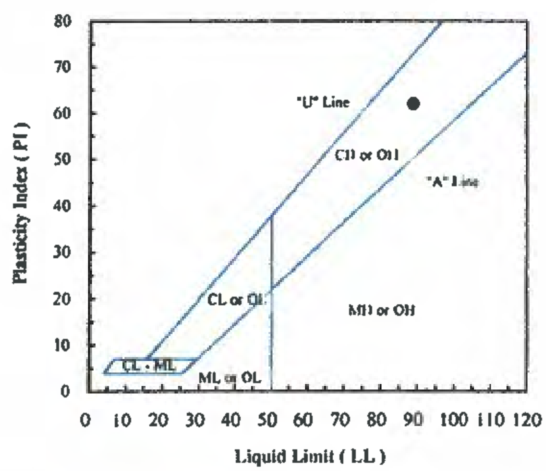
Sieve No.	Size (mm)	% Finer
3"	75	100.0
2"	50	100.0
1.5"	37.5	100.0
1"	25	100.0
3/4"	19	100.0
3/8"	9.5	98.7
#4	4.75	97.9
#10	2.00	96.6
#20	0.850	95.3
#40	0.425	93.4
#60	0.250	91.6
#100	0.150	89.4
#200	0.075	85.8

Specific Gravity (-):	

Hydrometer Particle Diameter (mm)	% Finer

Gravel (%):	2.1
Sand (%):	12.1
Fines (%):	85.8
Silt (%):	
Clay (%):	

Coeff. Unif. (Cu):	
Coeff. Curv. (Cc):	



Client Sample ID.	Lab Sample No:	Moisture Content (%)	Fines Content < No. 200 (%)	Atterberg Limits LL (-)	PL (-)	PI (-)	Engineering Classification
CL-23	H080	9.9	85.8	89	27	62	CH - Fat clay

Note(s):

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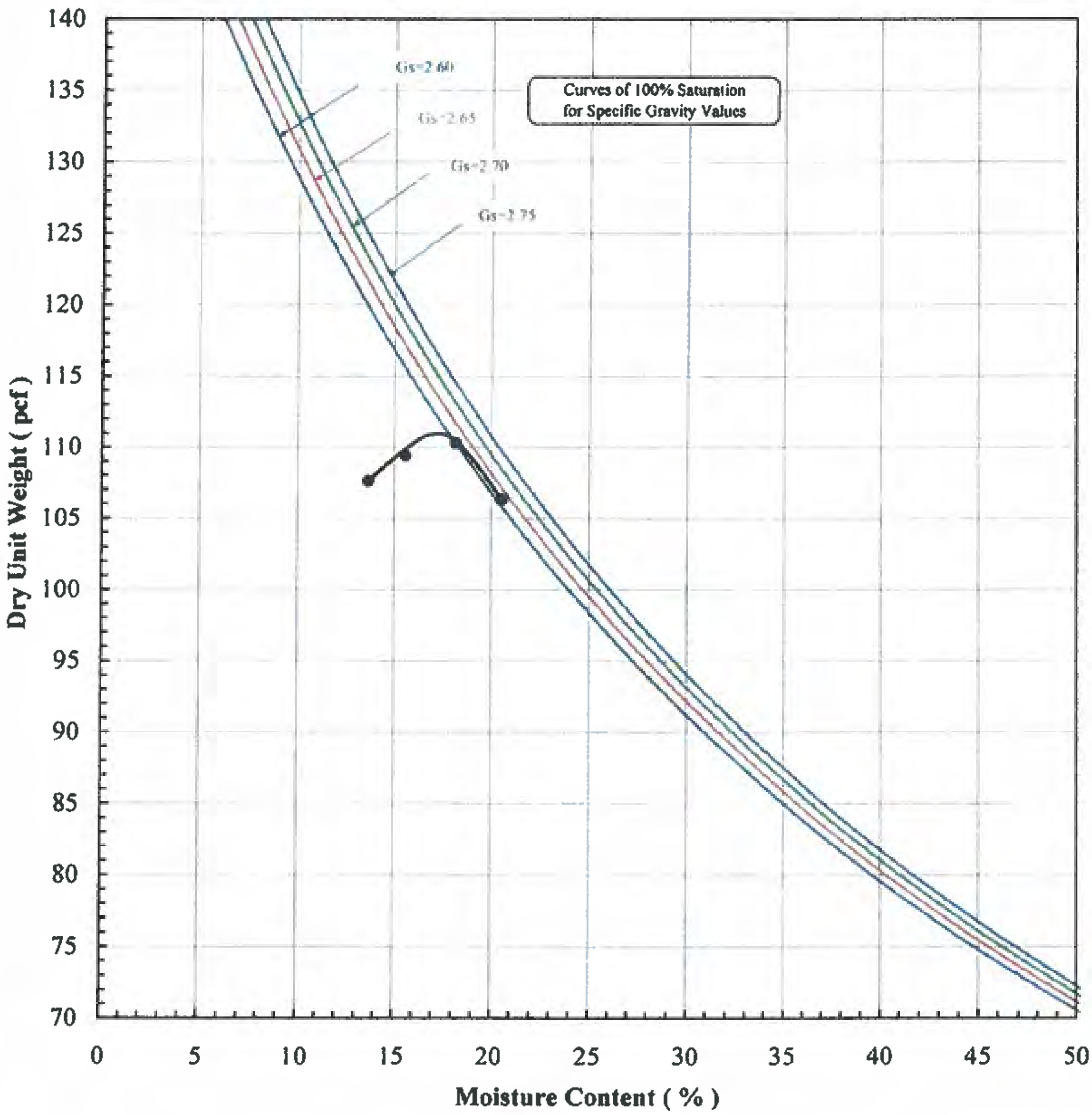
Tel: (770) 650 1666 Fax: (770) 650 5786

Project Name:	Kettleman B-17 Landfill
Project No:	309
Client Sample ID:	CL-01
Lab Sample No:	G115

ASTM D 1557 **COMPACTION MOISTURE-DENSITY RELATIONSHIP** Modified - Method B



Client/Site Sample ID.	Lab Sample No:	Maximum Dry Unit Weight (pcf)	Optimum Moisture Content (%)	Remarks
CL-01	G115	111.0	17.3	

Note(s):

Project Name:	Kettleman B-17 Landfill
Project No:	309
Client Sample ID:	CL-02
Lab Sample No:	G124

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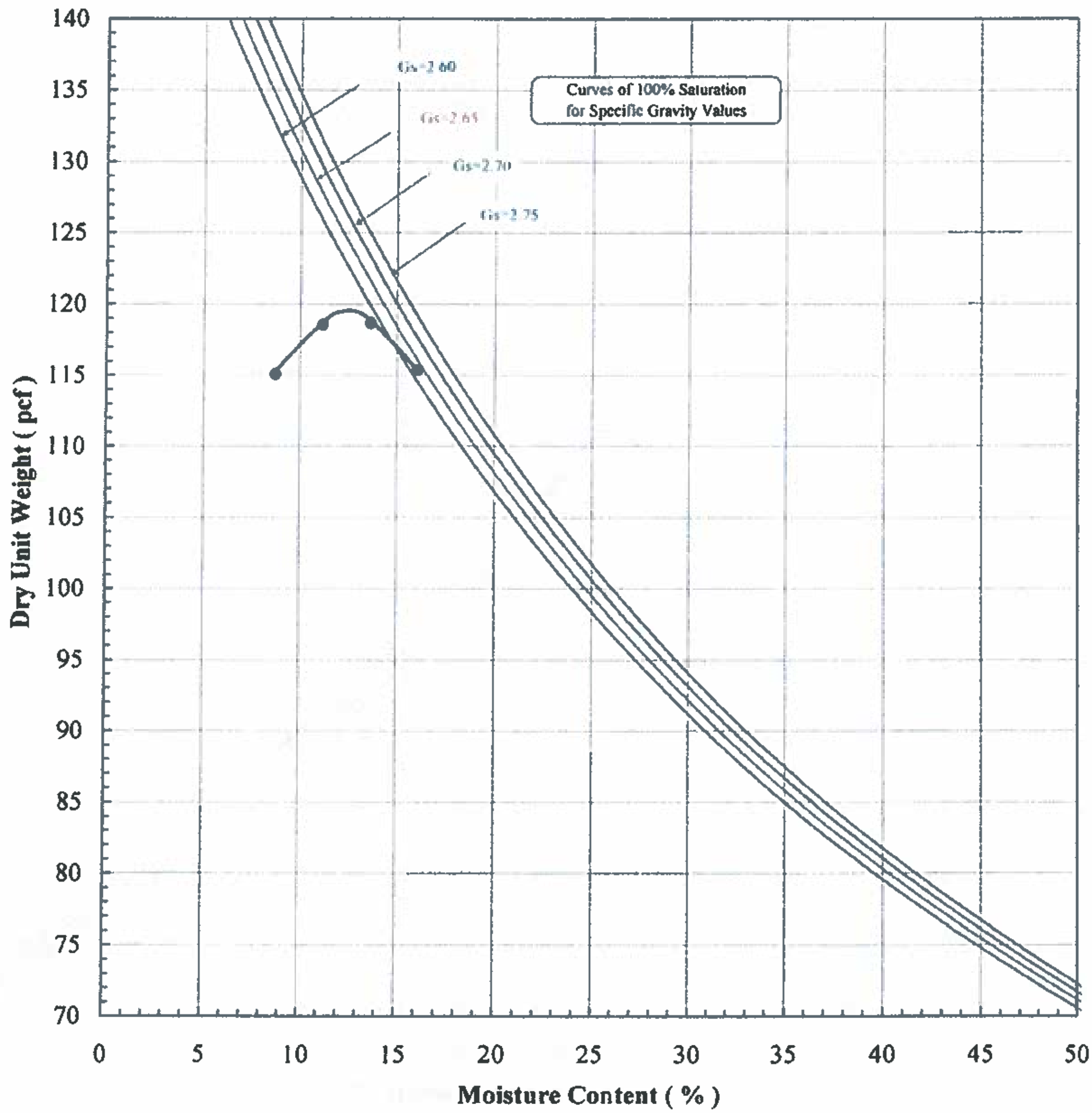
ASTM D 1557 **COMPACTION MOISTURE-DENSITY RELATIONSHIP** Modified - Method B



Client/Site Sample ID.	Lab Sample No:	Maximum Dry Unit Weight (pcf)	Optimum Moisture Content (%)	Remarks
CL-02	G124	119.7	12.5	

Note(s):

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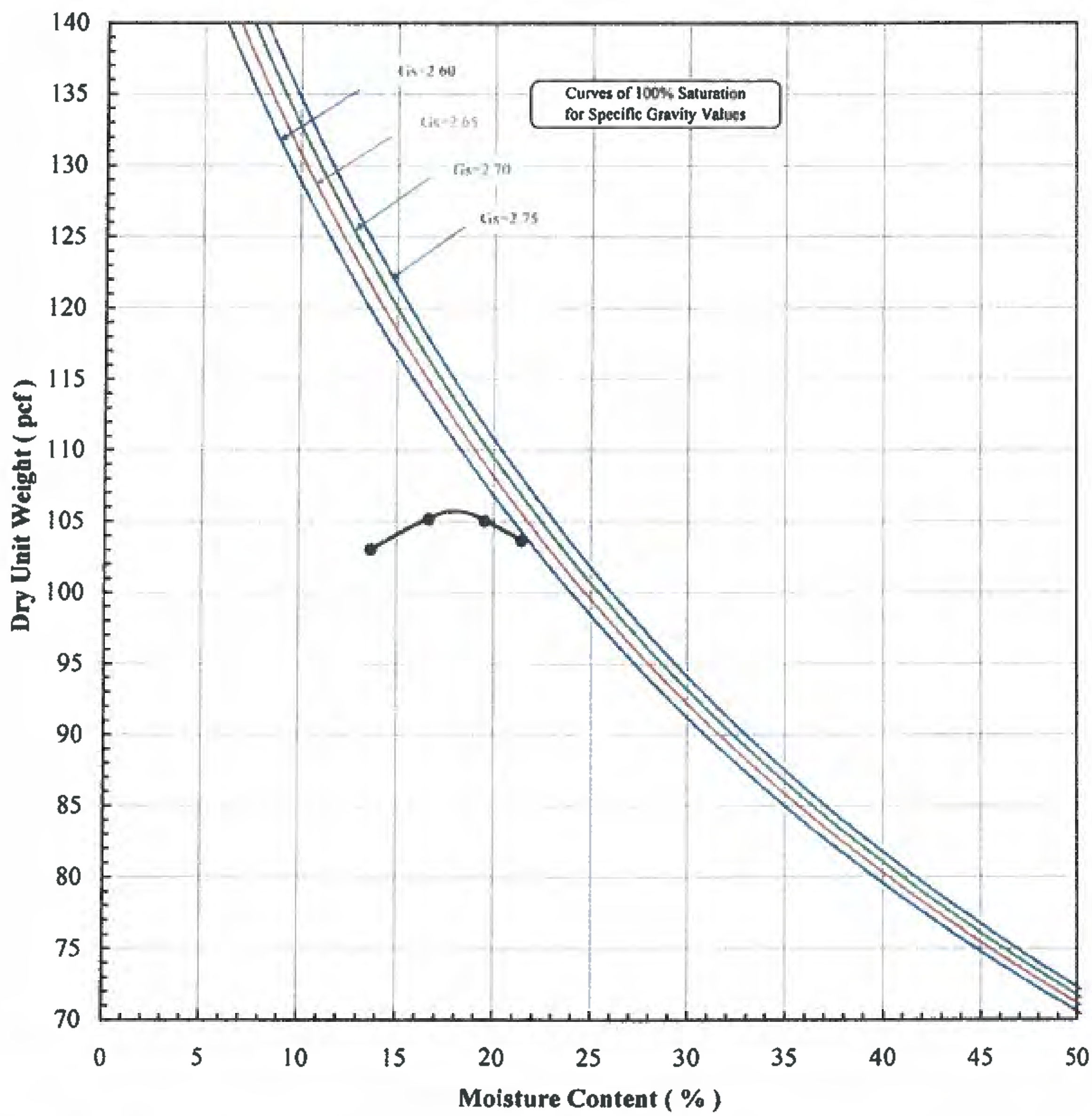
Tel: (770) 650 1666 Fax: (770) 650 5786

Project Name:	Kettleman B-17 Landfill
Project No:	309
Client Sample ID.	CL-03
Lab Sample No:	G147

ASTM D 1557

COMPACTION MOISTURE-DENSITY RELATIONSHIP

Modified - Method B



Client/Site Sample ID.	Lab Sample No:	Maximum Dry Unit Weight (pcf)	Optimum Moisture Content (%)	Remarks
CL-03	G147	106.0	18.0	

Note(s):

Excel Geotechnical Testing, Inc.
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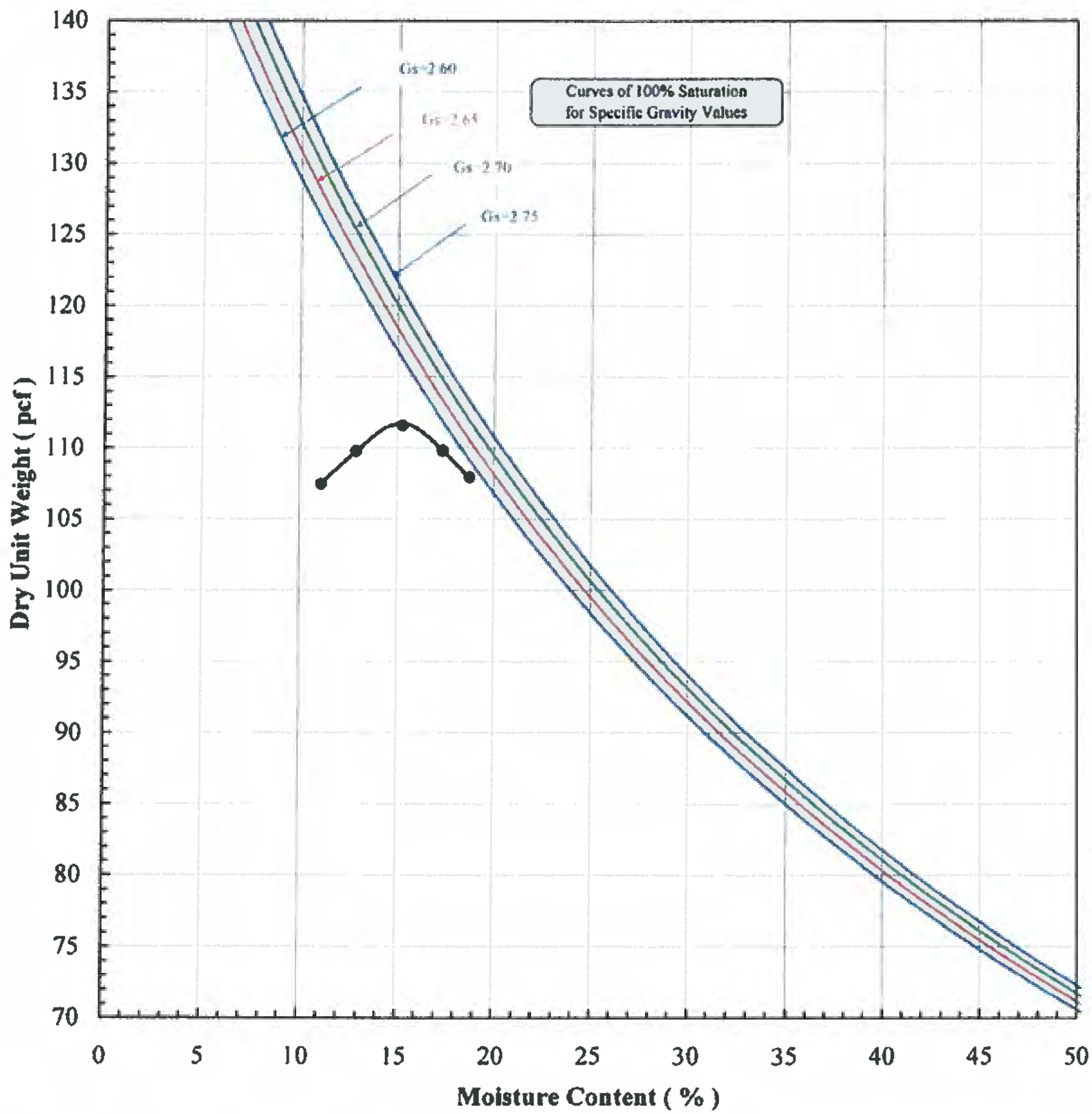
Tel: (770) 650 1666 Fax: (770) 650 5786

Project Name: Kettleman B-17 Landfill
Project No: 309
Client Sample ID: CL-04
Lab Sample No: G166

ASTM D 1557 **COMPACTION MOISTURE-DENSITY RELATIONSHIP** Modified - Method B

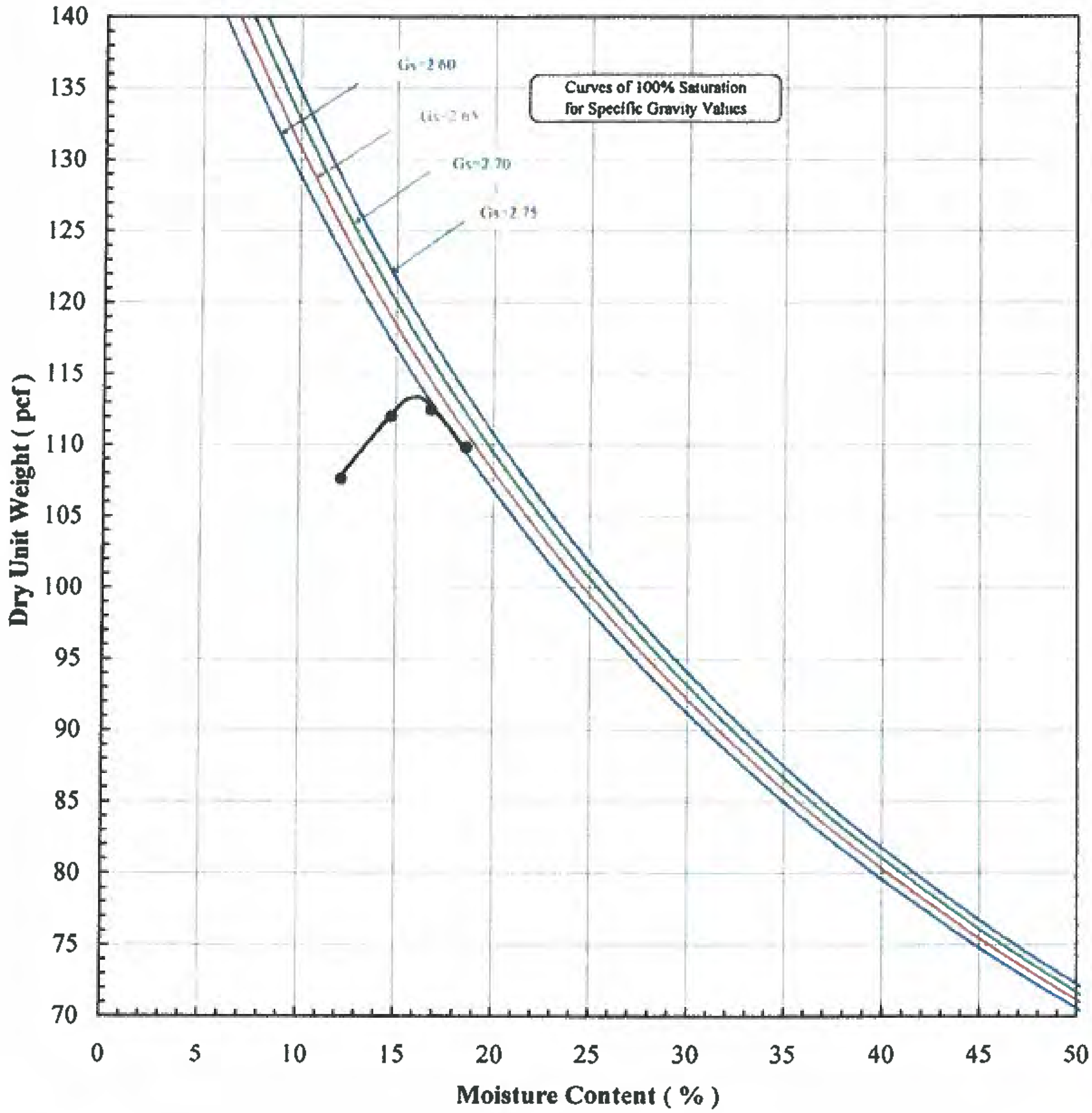


Client/Site Sample ID.	Lab Sample No:	Maximum Dry Unit Weight (pcf)	Optimum Moisture Content (%)	Remarks
CL-04	G166	111.9	15.4	

Note(s):

Excel Geotechnical Testing, Inc. *"Excellence in Testing"* 941 Forrest Street, Roswell, Georgia 30075 Tel: (770) 650 1666 Fax: (770) 650 5786	**Project Name:** Kettleman B-17 Landfill **Project No:** 309 **Client Sample ID:** CL-05 **Lab Sample No:** G167

ASTM D 1557 **COMPACTION MOISTURE-DENSITY RELATIONSHIP** Modified - Method B



Client/Site Sample ID.	Lab Sample No:	Maximum Dry Unit Weight (pcf)	Optimum Moisture Content (%)	Remarks
CL-05	G167	113.6	16.0	

Note(s):

Excel Geotechnical Testing, Inc.
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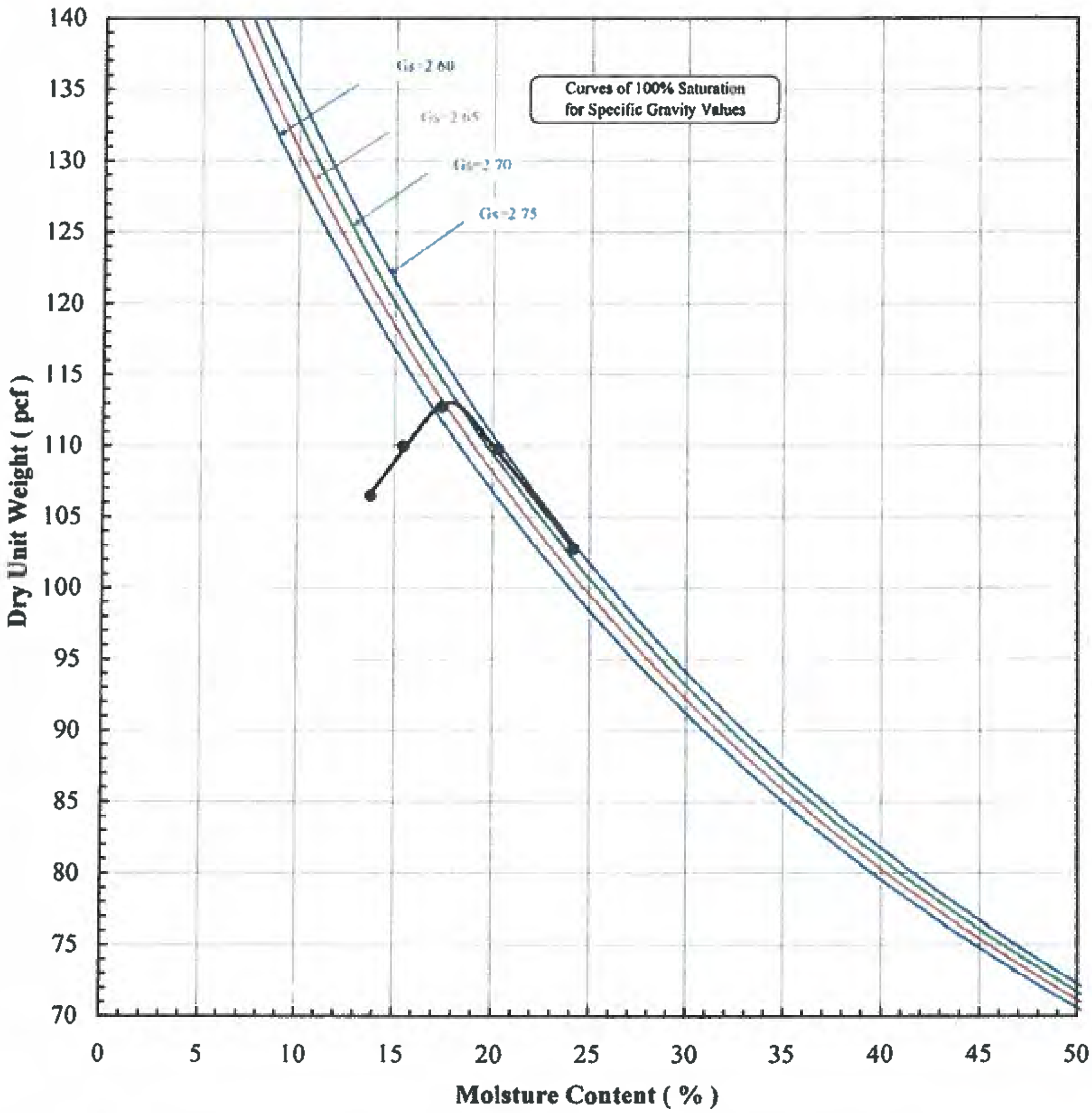
Project Name:	Kettleman B-17 Landfill
Project No:	309
Client Sample ID:	CL-10
Lab Sample No:	H042

ASTM D 1557 **COMPACTION MOISTURE-DENSITY RELATIONSHIP** Modified - Method B



Client/Site Sample ID.	Lab Sample No:	Maximum Dry Unit Weight (pcf)	Optimum Moisture Content (%)	Remarks
CL-10	H042	113.1	17.9	

Note(s):

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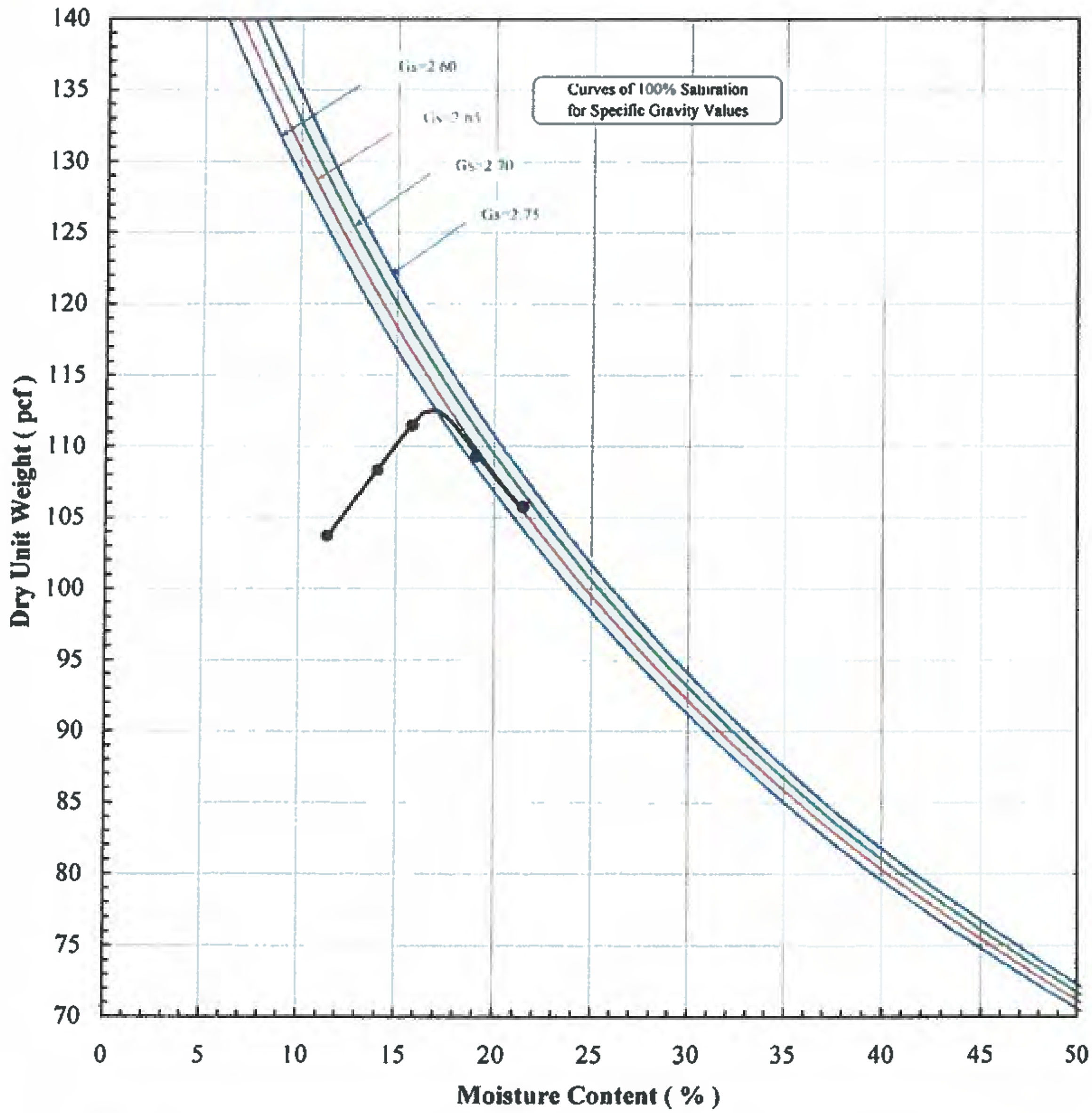
Project Name: Kettleman B-17 Landfill
Project No: 309
Client Sample ID: CL-11
Lab Sample No: H043

ASTM D 1557 **COMPACTION MOISTURE-DENSITY RELATIONSHIP** Modified - Method B



Client/Site Sample ID.	Lab Sample No:	Maximum Dry Unit Weight (pcf)	Optimum Moisture Content (%)	Remarks
CL-11	H043	112.8	16.6	

Note(s):

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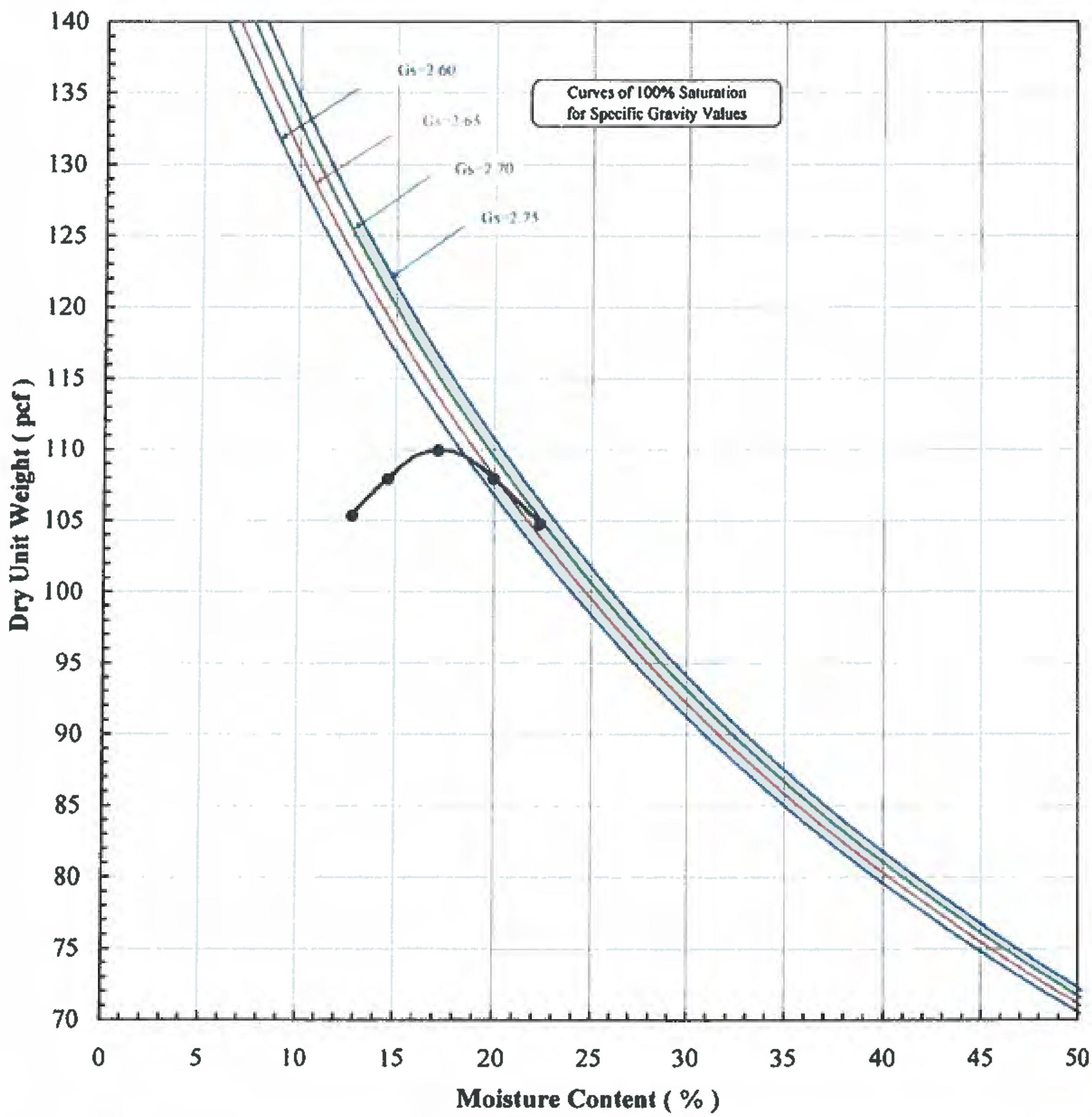
Project Name:	Kettleman B-17 Landfill
Project No:	309
Client Sample ID:	CL-15
Lab Sample No:	H065

ASTM D 1557 **COMPACTION MOISTURE-DENSITY RELATIONSHIP** Modified - Method B



Client/Site Sample ID.	Lab Sample No:	Maximum Dry Unit Weight (pcf)	Optimum Moisture Content (%)	Remarks
CL-15	H065	110.0	17.4	

Note(s):

Excel Geotechnical Testing, Inc.
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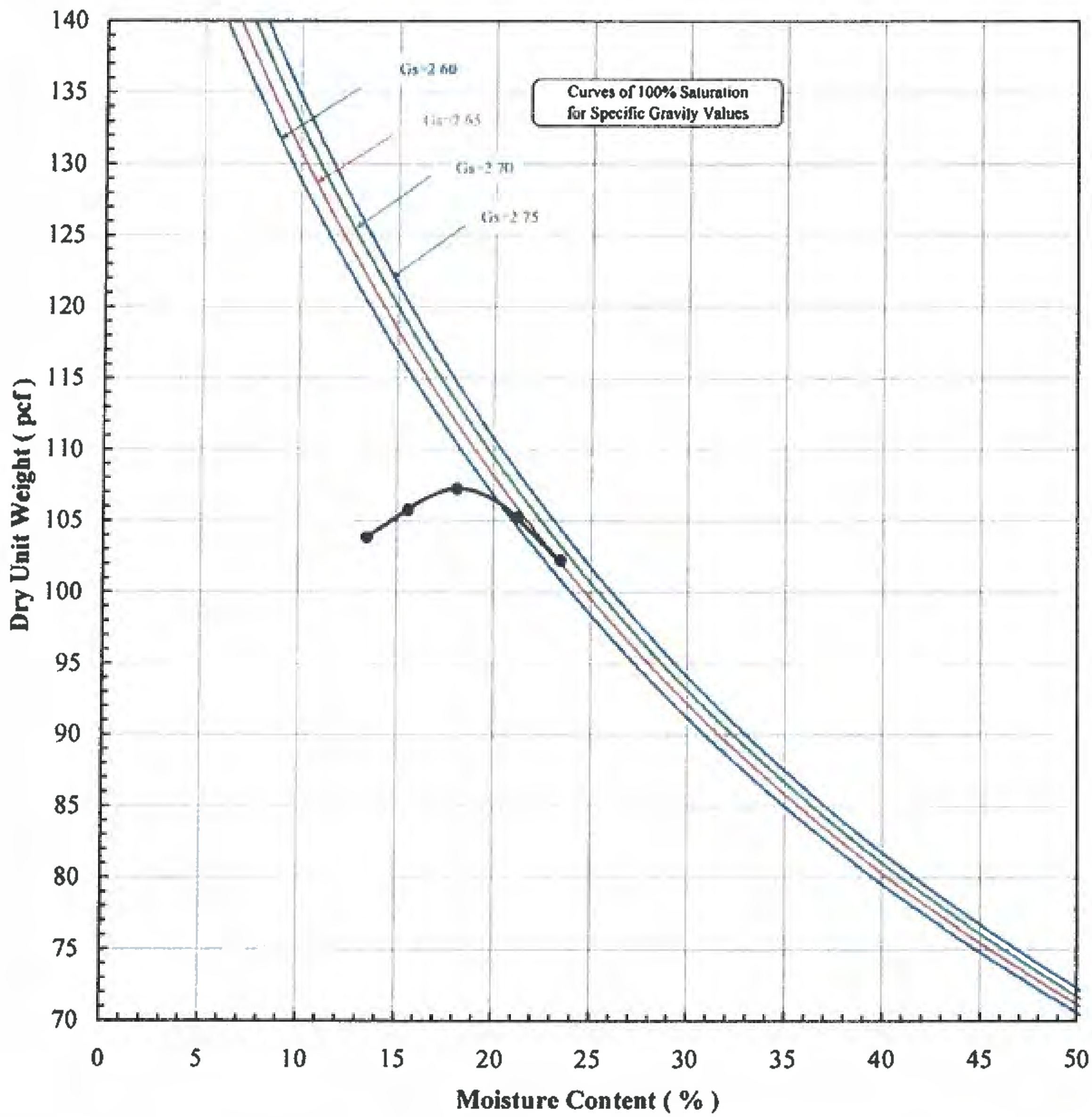
Tel: (770) 650 1686 Fax: (770) 650 5786

Project Name:	Kettleman B-17 Landfill
Project No:	309
Client Sample ID:	CL-22
Lab Sample No:	H078

ASTM D 1557 **COMPACTION MOISTURE-DENSITY RELATIONSHIP** Modified - Method B



Client/Site Sample ID.	Lab Sample No:	Maximum Dry Unit Weight (pcf)	Optimum Moisture Content (%)	Remarks
CL-22	H078	107.4	18.1	

Note(s):

Excel Geotechnical Testing, Inc.
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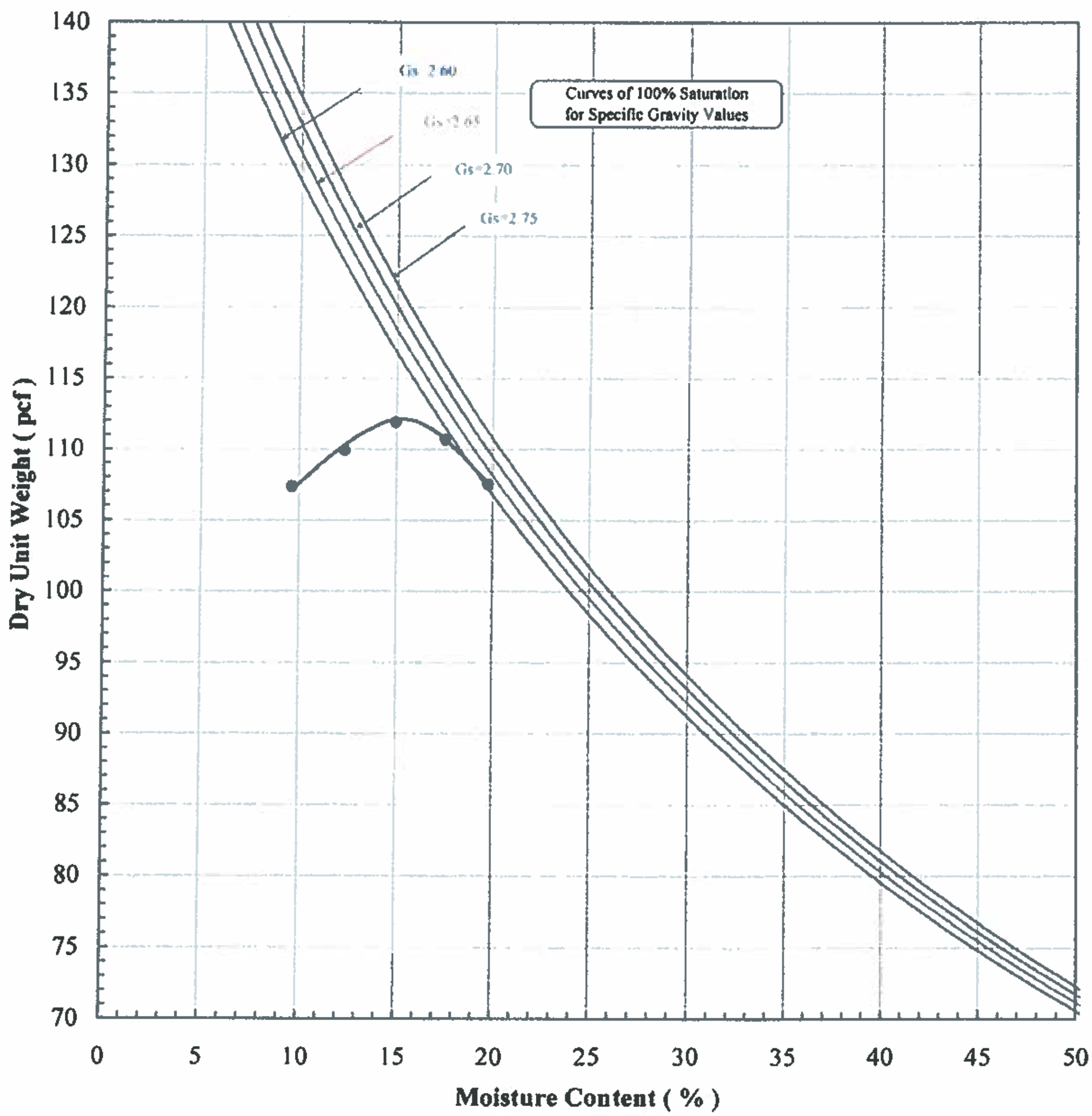
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

Project Name:	Kettleman B-17 Landfill
Project No:	309
Client Sample ID:	CL-23
Lab Sample No:	H080

ASTM D 1557 **COMPACTION MOISTURE-DENSITY RELATIONSHIP** Modified - Method B



Client/Site Sample ID.	Lab Sample No:	Maximum Dry Unit Weight (pcf)	Optimum Moisture Content (%)	Remarks
CL-23	H080	112.1	15.2	

Note(s):

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FLEXIBLE WALL PERMEABILITY TEST (1)

ASTM D5084 *

Project Name:	Kettleman B-17 Landfill
Project Number:	309
Client Name:	Geosyntec Consultants
Site Sample ID:	CL-01
Lab Sample Number:	G115
Material Type:	Soil
Specified Value (cm/sec):	NA
Date Test Started:	7/27/2008

Remolded Specimen	Proctor (5) Compaction		Specimen Initial Conditions (6)		Test Conditions					Hydraulic Conductivity
	Max. DUW	Opt. MC	Dry Unit Weight	Moisture Content	Cell Press.	Back Press.	Consolid. Press.	Permeant Liquid (7)	Average Gradient	
(-)	(pcf)	(%)	(pcf)	(%)	(psi)	(psi)	(psi)	(-)	(-)	(cm/s)
Notes 2 , 3 & 4	110.0	17.3	99.1	19.1	72.0	70.0	2.0	DTW	12	9.3E-8

Notes:

1. Method C, "Falling-Head, Increasing-Tailwater" test procedures were followed during the testing.
2. All particles larger than 3/8 inch, if any, were discarded when forming the remolded specimen.
3. Remolded specimen was formed by tamping the soil in one-centimeter-thick layers.
4. Remolded specimen approximately 2.87 inches in diameter and 2.36 inches in height.
5. Maximum Dry Unit Weight (DUW) and Optimum Moisture Content (MC) based on Modified Proctor Compaction Test (ASTM D 1557).
6. Based on the target values of 90% of the maximum dry unit weight and the optimum moisture content plus 2%.
7. Type of permeant liquid: DTW = Deaired Tap Water, DDI = Deaired Deionized Water

* Deviations:

Laboratory temperature at 22±3 °C.
Test specimen final conditions are not presented.

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FLEXIBLE WALL PERMEABILITY TEST [(1)]

ASTM D5084 *

Project Name:	Kettleman B-17 Landfill
Project Number:	309
Client Name:	Geosyntec Consultants
Site Sample ID:	CL-02
Lab Sample Number:	G124
Material Type:	Soil
Specified Value (cm/sec):	NA
Date Test Started:	7/27/2008

Remolded Specimen	Proctor [(5)] Compaction		Specimen Initial Conditions [(6)]		Test Conditions					Hydraulic Conductivity
	Max. DUW	Opt. MC	Dry Unit Weight	Moisture Content	Cell Press.	Back Press.	Consolid. Press.	Permeant Liquid [(7)]	Average Gradient	
(-)	(pcf)	(%)	(pcf)	(%)	(psi)	(psi)	(psi)	(-)	(-)	(cm/s)
Notes 2 , 3 & 4	119.7	12.5	107.6	14.7	72.0	70.0	2.0	DTW	14	6.3E-8

Notes:

1. Method C, "Falling-Head, Increasing-Tailwater" test procedures were followed during the testing.
2. All particles larger than 3/8 inch, if any, were discarded when forming the remolded specimen.
3. Remolded specimen was formed by tamping the soil in one-centimeter-thick layers.
4. Remolded specimen approximately 2.87 inches in diameter and 2.36 inches in height.
5. Maximum Dry Unit Weight (DUW) and Optimum Moisture Content (MC) based on Modified Proctor Compaction Test (ASTM D 1557).
6. Based on the target values of 90% of the maximum dry unit weight and the optimum moisture content plus 2%.
7. Type of permeant liquid: DTW = Deaired Tap Water, DDI = Deaired Deionized Water

* Deviations:

Laboratory temperature at 22±3 °C.

Test specimen final conditions are not presented.

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FLEXIBLE WALL PERMEABILITY TEST [1]

ASTM D5084 *

Project Name:	Kettleman B-17 Landfill
Project Number:	309
Client Name:	Geosyntec Consultants
Site Sample ID:	CL-03
Lab Sample Number:	G147
Material Type:	Soil
Specified Value (cm/sec):	NA
Date Test Started:	8/01/2008

Remolded Specimen	Proctor [5] Compaction		Specimen Initial Conditions [6]		Test Conditions					Hydraulic Conductivity
	Max. DUW	Opt. MC	Dry Unit Weight	Moisture Content	Cell Press.	Back Press.	Consolid. Press.	Permeant Liquid [7]	Average Gradient	
(-)	(pcf)	(%)	(pcf)	(%)	(psi)	(psi)	(psi)	(-)	(-)	(cm/s)
Notes 2 , 3 & 4	106.0	18.0	96.9	20.1	72.0	70.0	2.0	DTW	14	4.0E-8

Notes:

1. Method C, "Falling-Head, Increasing-Tailwater" test procedures were followed during the testing.
2. All particles larger than 3/8 inch, if any, were discarded when forming the remolded specimen.
3. Remolded specimen was formed by tamping the soil in one-centimeter-thick layers.
4. Remolded specimen approximately 2.87 inches in diameter and 2.36 inches in height.
5. Maximum Dry Unit Weight (DUW) and Optimum Moisture Content (MC) based on Modified Proctor Compaction Test (ASTM D 1557).
6. Based on the target values of 92% of the maximum dry unit weight and the optimum moisture content plus 2%.
7. Type of permeant liquid: DTW = Deaired Tap Water, DDI = Deaired Deionized Water

* Deviations:

Laboratory temperature at 22±3 °C.

Test specimen final conditions are not presented.

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Tel: (770) 650 1666 Fax: (770) 650 5786

FLEXIBLE WALL PERMEABILITY TEST [1]
ASTM D5084 *

Project Name:	Kettleman B-17 Landfill
Project Number:	309
Client Name:	Geosyntec Consultants
Site Sample ID:	CL-04
Lab Sample Number:	G166
Material Type:	Soil
Specified Value (cm/sec):	NA
Date Test Started:	8/02/2008

Remolded Specimen	Proctor [5] Compaction		Specimen Initial Conditions [6]		Test Conditions					Hydraulic Conductivity
	Max. DUW	Opt. MC	Dry Unit Weight	Moisture Content	Cell Press.	Back Press.	Consolid. Press.	Permeant Liquid [7]	Average Gradient	
(-)	(pcf)	(%)	(pcf)	(%)	(psi)	(psi)	(psi)	(-)	(-)	(cm/s)
Notes 2 , 3 & 4	111.9	15.4	103.0	17.2	72.0	70.0	2.0	DTW	16	4.9E-8

Notes:

1. Method C, "Falling-Head, Increasing-Tailwater" test procedures were followed during the testing.
2. All particles larger than 3/8 inch, if any, were discarded when forming the remolded specimen.
3. Remolded specimen was formed by tamping the soil in one-centimeter-thick layers.
4. Remolded specimen approximately 2.87 inches in diameter and 2.36 inches in height.
5. Maximum Dry Unit Weight (DUW) and Optimum Moisture Content (MC) based on Modified Proctor Compaction Test (ASTM D 1557).
6. Based on the target values of 92% of the maximum dry unit weight and the optimum moisture content plus 2%.
7. Type of permeant liquid: DTW = Deaired Tap Water, DDI = Deaired Deionized Water

* Deviations:

Laboratory temperature at 22±3 °C.
Test specimen final conditions are not presented.

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Tel: (770) 650 1666 Fax: (770) 650 5786

FLEXIBLE WALL PERMEABILITY TEST (1)

ASTM D 5084 *

Project Name:	Kettleman B-17 Landfill
Project Number:	309
Client Name:	Geosyntec Consultants
Site Sample ID:	CL-06
Lab Sample Number:	H021
Material Type:	Soil
Specified Value (cm/sec):	NA
Date Test Started:	8/04/2008

Specimen	Test Specimen Initial Condition					Test Conditions					Hydraulic
	Spec.	Spec.	Spec.	Dry Unit	Moisture	Cell	Back	Consolid.	Permeant	Average	Conductivity
No.	Prep. (2)	Length	Diameter	Weight	Content	Press.	Press.	Press.	Liquid (3)	Gradient	
	(-)	(cm)	(cm)	(pcf)	(%)	(psi)	(psi)	(psi)	(-)	(-)	(cm/s)
1	ST	5.67	7.21	105.6	18.4	72.0	70.0	2.0	DTW	13	5.3E-9

Atterberg Test Results (LL, PL, PI) - ASTM D 4318: 92 | 21 | 71

Notes:

1. Method C, "Falling-Head, Increasing-Tailwater" test procedures were followed during the testing.
2. Specimen preparation: ST = Shelby Tube, R = Remolded, B = Block Sample.
3. Type of permeant liquid: DTW = Deaired Tap Water, DDI = Deaired Deionized Water

* Deviations:

Laboratory temperature at 22±3 °C.
Test specimen final conditions are not presented.

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FLEXIBLE WALL PERMEABILITY TEST [1]

ASTM D 5084 *

Project Name:	Kettleman B-17 Landfill
Project Number:	309
Client Name:	Geosyntec Consultants
Site Sample ID:	CL-07
Lab Sample Number:	H023
Material Type:	Soil
Specified Value (cm/sec):	NA
Date Test Started:	8/04/2008

Specimen	Test Specimen Initial Condition					Test Conditions					Hydraulic
No.	Spec. Prep. [2] (-)	Spec. Length (cm)	Spec. Diameter (cm)	Dry Unit Weight (pcf)	Moisture Content (%)	Cell Press. (psi)	Back Press. (psi)	Consolid. Press. (psi)	Permeant Liquid [3] (-)	Average Gradient (-)	Conductivity (cm/s)
1	ST	5.68	7.26	100.0	20.6	72.0	70.0	2.0	DTW	15	3.6E-9

Atterberg Test Results (LL, PL, PI) - ASTM D 4318: | 90 | 23 | 67 |

Notes:

1. Method C, "Falling-Head, Increasing-Tailwater" test procedures were followed during the testing.
2. Specimen preparation: ST = Shelby Tube, R = Remolded, B = Block Sample.
3. Type of permeant liquid: DTW = Deaired Tap Water, DDI = Deaired Deionized Water

* Deviations:

Laboratory temperature at 22±3 °C.

Test specimen final conditions are not presented.

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FLEXIBLE WALL PERMEABILITY TEST [1]

ASTM D 5084 *

Project Name:	Kettleman B-17 Landfill
Project Number:	309
Client Name:	Geosyntec Consultants
Site Sample ID:	CL-08
Lab Sample Number:	H025
Material Type:	Soil
Specified Value (cm/sec):	1.0E-7
Date Test Started:	8/04/2008

Specimen	Test Specimen Initial Condition					Test Conditions					Hydraulic
No.	Spec. Prep. [2] (-)	Spec. Length (cm)	Spec. Diameter (cm)	Dry Unit Weight (pcf)	Moisture Content (%)	Cell Press. (psi)	Back Press. (psi)	Consolid. Press. (psi)	Permeant Liquid [3] (-)	Average Gradient (-)	Conductivity (cm/s)
1	ST	5.63	7.20	103.1	20.9	72.0	70.0	2.0	DTW	9	1.0E-8

Atterberg Test Results (LL, PL, PI) - ASTM D 4318: 88 | 27 | 61

Notes:

1. Method C, "Falling-Head, Increasing-Tailwater" test procedures were followed during the testing.
2. Specimen preparation: ST = Shelby Tube, R = Remolded, B = Block Sample.
3. Type of permeant liquid: DTW = Deaired Tap Water, DDI = Deaired Deionized Water

* Deviations:

Laboratory temperature at 22±3 °C.
Test specimen final conditions are not presented.

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FLEXIBLE WALL PERMEABILITY TEST [1]

ASTM D 5084 *

Project Name:	Kettleman B-17 Landfill
Project Number:	309
Client Name:	Geosyntec Consultants
Site Sample ID:	CL-09
Lab Sample Number:	H027
Material Type:	Soil
Specified Value (cm/sec):	NA
Date Test Started:	8/04/2008

Specimen	Test Specimen Initial Condition					Test Conditions					Hydraulic
No.	Spec. Prep. [2] (-)	Spec. Length (cm)	Spec. Diameter (cm)	Dry Unit Weight (pcf)	Moisture Content (%)	Cell Press. (psi)	Back Press. (psi)	Consolid. Press. (psi)	Permeant Liquid [3] (-)	Average Gradient (-)	Conductivity (cm/s)
1	ST	5.64	7.18	104.6	21.2	72.0	70.0	2.0	DTW	16	3.1E-9

Atterberg Test Results (LL, PL, PI) - ASTM D 4318: 88 | 29 | 59

Notes:

1. Method C, "Falling-Head, Increasing-Tailwater" test procedures were followed during the testing.
2. Specimen preparation: ST = Shelby Tube, R = Remolded, B = Block Sample.
3. Type of permeant liquid: DTW = Deaired Tap Water, DDI = Deaired Deionized Water

* Deviations:

Laboratory temperature at 22±3 °C.
Test specimen final conditions are not presented.

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FLEXIBLE WALL PERMEABILITY TEST (1)

ASTM D5084 *

Project Name:	Kettleman B-17 Landfill
Project Number:	309
Client Name:	Geosyntec Consultants
Site Sample ID:	CL-11
Lab Sample Number:	H043
Material Type:	Soil
Specified Value (cm/sec):	NA
Date Test Started:	8/16/2008

Remolded Specimen	Proctor (5) Compaction		Specimen Initial Conditions (6)		Test Conditions					Hydraulic Conductivity
	Max. DUW	Opt. MC	Dry Unit Weight	Moisture Content	Cell Press.	Back Press.	Consolid. Press.	Permeant Liquid (7)	Average Gradient	
(-)	(pcf)	(%)	(pcf)	(%)	(psi)	(psi)	(psi)	(-)	(-)	(cm/s)
Notes 2 , 3 & 4	112.8	16.6	103.5	18.3	72.0	70.0	2.0	DTW	8	2.3E-8

Notes:

1. Method C, "Falling-Head, Increasing-Tailwater" test procedures were followed during the testing.
2. All particles larger than 3/8 inch, if any, were discarded when forming the remolded specimen.
3. Remolded specimen was formed by tamping the soil in one-centimeter-thick layers.
4. Remolded specimen approximately 2.87 inches in diameter and 2.36 inches in height.
5. Maximum Dry Unit Weight (DUW) and Optimum Moisture Content (MC) based on Modified Proctor Compaction Test (ASTM D 1557).
6. Based on the target values of 92% of the maximum dry unit weight and the optimum moisture content plus 2%.
7. Type of permeant liquid: DTW = Deaired Tap Water, DDI = Deaired Deionized Water

* Deviations:

Laboratory temperature at 22±3 °C.

Test specimen final conditions are not presented.

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FLEXIBLE WALL PERMEABILITY TEST [1]
ASTM D 5084 *

Project Name:	Kettleman B-17 Landfill
Project Number:	309
Client Name:	Geosyntec Consultants
Site Sample ID:	CL-16
Lab Sample Number:	H050
Material Type:	Soil
Specified Value (cm/sec):	NA
Date Test Started:	8/09/2008

Specimen	Test Specimen Initial Condition					Test Conditions					Hydraulic
No.	Spec. Prep. [2] (-)	Spec. Length (cm)	Spec. Diameter (cm)	Dry Unit Weight (pcf)	Moisture Content (%)	Cell Press. (psi)	Back Press. (psi)	Consolid. Press. (psi)	Permeant Liquid [3] (-)	Average Gradient (-)	Conductivity (cm/s)
1	ST	5.70	7.10	103.3	19.2	72.0	70.0	2.0	DTW	13	9.0E-9

Atterberg Test Results (LL, PL, PI) - ASTM D 4318: 98 | 31 | 67

Notes:

1. Method C, "Falling-Head, Increasing-Tailwater" test procedures were followed during the testing.
2. Specimen preparation: ST = Shelby Tube, R = Remolded, B = Block Sample.
3. Type of permeant liquid: DTW = Deaired Tap Water, DDI = Deaired Deionized Water

* Deviations:
Laboratory temperature at 22±3 °C.
Test specimen final conditions are not presented.

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FLEXIBLE WALL PERMEABILITY TEST (1)

ASTM D 5084 *

Project Name:	Kettleman B-17 Landfill
Project Number:	309
Client Name:	Geosyntec Consultants
Site Sample ID:	CL-17
Lab Sample Number:	H052
Material Type:	Soil
Specified Value (cm/sec):	NA
Date Test Started:	8/09/2008

Specimen	Test Specimen Initial Condition					Test Conditions					Hydraulic
No.	Spec. Prep. (2) (-)	Spec. Length (cm)	Spec. Diameter (cm)	Dry Unit Weight (pcf)	Moisture Content (%)	Cell Press. (psi)	Back Press. (psi)	Consolid. Press. (psi)	Permeant Liquid (3) (-)	Average Gradient (-)	Conductivity (cm/s)
1	ST	5.66	7.16	109.4	17.7	72.0	70.0	2.0	DTW	16	2.6E-9

Atterberg Test Results (LL, PL, PI) - ASTM D 4318: 99 | 30 | 69

Notes:

1. Method C, "Falling-Head, Increasing-Tailwater" test procedures were followed during the testing.
2. Specimen preparation: ST = Shelby Tube, R = Remolded, B = Block Sample.
3. Type of permeant liquid: DTW = Deaired Tap Water, DDI = Deaired Deionized Water

* Deviations:

Laboratory temperature at 22±3 °C.

Test specimen final conditions are not presented.

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FLEXIBLE WALL PERMEABILITY TEST (1)

ASTM D 5084 *

Project Name:	Kettleman B-17 Landfill
Project Number:	309
Client Name:	Geosyntec Consultants
Site Sample ID:	CL-18
Lab Sample Number:	H054
Material Type:	Soil
Specified Value (cm/sec):	NA
Date Test Started:	8/09/2008

Specimen	Test Specimen Initial Condition					Test Conditions					Hydraulic
No.	Spec. Prep. (2)	Spec. Length	Spec. Diameter	Dry Unit Weight	Moisture Content	Cell Press.	Back Press.	Consolid. Press.	Permeant Liquid (3)	Average Gradient	Conductivity
	(-)	(cm)	(cm)	(pcf)	(%)	(psi)	(psi)	(psi)	(-)	(-)	(cm/s)
1	ST	5.69	7.07	105.1	19.5	72.0	70.0	2.0	DTW	14	5.8E-9

Atterberg Test Results (LL, PL, PI) - ASTM D 4318: 95 | 27 | 68

Notes:

1. Method C, "Falling-Head, Increasing-Tailwater" test procedures were followed during the testing.
2. Specimen preparation: ST = Shelby Tube, R = Remolded, B = Block Sample.
3. Type of permeant liquid: DTW = Deaired Tap Water, DDI = Deaired Deionized Water

* Deviations:
Laboratory temperature at 22±3 °C.
Test specimen final conditions are not presented.

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FLEXIBLE WALL PERMEABILITY TEST (1)

ASTM D 5084 *

Project Name:	Kettleman B-17 Landfill
Project Number:	309
Client Name:	Geosyntec Consultants
Site Sample ID:	CL-19
Lab Sample Number:	H056
Material Type:	Soil
Specified Value (cm/sec):	NA
Date Test Started:	8/09/2008

Specimen	Test Specimen Initial Condition					Test Conditions					Hydraulic
No.	Spec. Prep. (2) (-)	Spec. Length (cm)	Spec. Diameter (cm)	Dry Unit Weight (pcf)	Moisture Content (%)	Cell Press. (psi)	Back Press. (psi)	Consolid. Press. (psi)	Permeant Liquid (3) (-)	Average Gradient (-)	Conductivity (cm/s)
1	ST	5.71	7.15	109.0	18.3	72.0	70.0	2.0	DTW	14	4.4E-9

Atterberg Test Results (LL, PL, PI) - ASTM D 4318: 98 | 32 | 66

Notes:

1. Method C, "Falling-Head, Increasing-Tailwater" test procedures were followed during the testing.
2. Specimen preparation: ST = Shelby Tube, R = Remolded, B = Block Sample.
3. Type of permeant liquid: DTW = Deaired Tap Water, DDI = Deaired Deionized Water

* Deviations:

Laboratory temperature at 22±3 °C.
Test specimen final conditions are not presented.

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FLEXIBLE WALL PERMEABILITY TEST [1]

ASTM D 5084 *

Project Name:	Kettleman B-17 Landfill
Project Number:	309
Client Name:	Geosyntec Consultants
Site Sample ID:	CL-20
Lab Sample Number:	H059
Material Type:	Soil
Specified Value (cm/sec):	NA
Date Test Started:	8/09/2008

Specimen	Test Specimen Initial Condition					Test Conditions					Hydraulic
No.	Spec. Prep. [2] (-)	Spec. Length (cm)	Spec. Diameter (cm)	Dry Unit Weight (pcf)	Moisture Content (%)	Cell Press. (psi)	Back Press. (psi)	Consolid. Press. (psi)	Permeant Liquid [3] (-)	Average Gradient (-)	Conductivity (cm/s)
1	ST	5.63	7.19	109.3	18.0	72.0	70.0	2.0	DTW	14	4.7E-9

Atterberg Test Results (LL, PL, PI) - ASTM D 4318: 95 | 28 | 67

Notes:

1. Method C, "Falling-Head, Increasing-Tailwater" test procedures were followed during the testing.
2. Specimen preparation: ST = Shelby Tube, R = Remolded, B = Block Sample.
3. Type of permeant liquid: DTW = Deaired Tap Water, DDI = Deaired Deionized Water

* Deviations:

Laboratory temperature at 22±3 °C.

Test specimen final conditions are not presented.

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FLEXIBLE WALL PERMEABILITY TEST (1)

ASTM D 5084 *

Project Name:	Kettleman B-17 Landfill
Project Number:	309
Client Name:	Geosyntec Consultants
Site Sample ID:	CL-21
Lab Sample Number:	H060
Material Type:	Soil
Specified Value (cm/sec):	NA
Date Test Started:	8/09/2008

Specimen	Test Specimen Initial Condition					Test Conditions					Hydraulic
No.	Spec. Prep. (2) (-)	Spec. Length (cm)	Spec. Diameter (cm)	Dry Unit Weight (pcf)	Moisture Content (%)	Cell Press. (psi)	Back Press. (psi)	Consolid. Press. (psi)	Permeant Liquid (3) (-)	Average Gradient (-)	Conductivity (cm/s)
1	ST	5.62	7.24	108.4	18.7	72.0	70.0	2.0	DTW	15	2.7E-9

Atterberg Test Results (LL, PL, PI) - ASTM D 4318: 103 | 29 | 74

Notes:

1. Method C, "Falling-Head, Increasing-Tailwater" test procedures were followed during the testing.
2. Specimen preparation: ST = Shelby Tube, R = Remolded, B = Block Sample.
3. Type of permeant liquid: DTW = Deaired Tap Water, DDI = Deaired Deionized Water

* Deviations:
Laboratory temperature at 22±3 °C.
Test specimen final conditions are not presented.

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FLEXIBLE WALL PERMEABILITY TEST (1)

ASTM D5084 *

Project Name:	Kettleman B-17 Landfill
Project Number:	309
Client Name:	Geosyntec Consultants
Site Sample ID:	CL-22
Lab Sample Number:	H078
Material Type:	Soil
Specified Value (cm/sec):	NA
Date Test Started:	8/22/2008

Remolded Specimen	Proctor (5) Compaction		Specimen Initial Conditions (6)		Test Conditions					Hydraulic Conductivity
	Max. DUW	Opt. MC	Dry Unit Weight	Moisture Content	Cell Press.	Back Press.	Consolid. Press.	Permeant Liquid (7)	Average Gradient	
(-)	(pcf)	(%)	(pcf)	(%)	(psi)	(psi)	(psi)	(-)	(-)	(cm/s)
Notes 2, 3 & 4	107.4	18.1	98.7	20.3	72.0	70.0	2.0	DTW	14	5.8E-8

Notes:

1. Method C, "Falling-Head, Increasing-Tailwater" test procedures were followed during the testing.
2. All particles larger than 3/8 inch, if any, were discarded when forming the remolded specimen.
3. Remolded specimen was formed by tamping the soil in one-centimeter-thick layers.
4. Remolded specimen approximately 2.87 inches in diameter and 2.36 inches in height.
5. Maximum Dry Unit Weight (DUW) and Optimum Moisture Content (MC) based on Modified Proctor Compaction Test (ASTM D 1557).
6. Based on the target values of 92% of the maximum dry unit weight and the optimum moisture content plus 2%.
7. Type of permeant liquid: DTW = Deaired Tap Water, DDI = Deaired Deionized Water

* Deviations:
Laboratory temperature at 22±3 °C.
Test specimen final conditions are not presented.

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FLEXIBLE WALL PERMEABILITY TEST (1)

ASTM D5084 *

Project Name:	Kettleman B-17 Landfill
Project Number:	309
Client Name:	Geosyntec Consultants
Site Sample ID:	CL-23
Lab Sample Number:	H080
Material Type:	Soil
Specified Value (cm/sec):	NA
Date Test Started:	8/22/2008

Remolded Specimen	Proctor (5) Compaction		Specimen Initial Conditions (6)		Test Conditions					Hydraulic Conductivity
	Max. DUW	Opt. MC	Dry Unit Weight	Moisture Content	Cell Press.	Back Press.	Consolid. Press.	Permeant Liquid (7)	Average Gradient	
(-)	(pcf)	(%)	(pcf)	(%)	(psi)	(psi)	(psi)	(-)	(-)	(cm/s)
Notes 2 , 3 & 4	112.1	15.2	103.0	17.4	72.0	70.0	2.0	DTW	13	6.4E-8

Notes:

1. Method C, "Falling-Head, Increasing-Tailwater" test procedures were followed during the testing.
2. All particles larger than 3/8 inch, if any, were discarded when forming the remolded specimen.
3. Remolded specimen was formed by tamping the soil in one-centimeter-thick layers.
4. Remolded specimen approximately 2.87 inches in diameter and 2.36 inches in height.
5. Maximum Dry Unit Weight (DUW) and Optimum Moisture Content (MC) based on Modified Proctor Compaction Test (ASTM D 1557).
6. Based on the target values of 92% of the maximum dry unit weight and the optimum moisture content plus 2%.
7. Type of permeant liquid: DTW = Deaired Tap Water, DDI = Deaired Deionized Water

* Deviations:

Laboratory temperature at 22±3 °C.

Test specimen final conditions are not presented.

APPENDIX C-2
Test Pad Compaction Test Results

Geosyntec consultants

SUMMARY OF FIELD DENSITY TEST

PROJECT: Kettleman Hills Facility - Clay Source Evaluation — PROJECT NO.: SC0472
LOCATION: Kings County, CA — TASK NO.: 1
CONTRACTOR: Wood Brothers, Inc. — DATE:

SPECIFICATION REQUIREMENTS

SOURCE: On-site clay

% COMPACTION: 92% — MOISTURE RANGE: 19.3% to 22.3% and 18.0% to 21.0% (Samples 61-76)

NUCLEAR GAUGE TYPE: Troxler 3440 A — NUCLEAR GAUGE SERIAL NO.: 20202

DATE OF TEST (day/mo)	TEST NO.	TEST LOCATION	LAB RESULTS: SAMPLE NO.	LAB RESULTS: MAX UNIT WT (pcf)	LAB RESULTS: O.M.C. (%)	TYPE OF TEST: ASTM D-2922	TYPE OF TEST: ASTM D-1556	FIELD TEST RESULTS: DEPTH/ELEV (ft)	FIELD TEST RESULTS: WET UNIT WT (pcf)	FIELD TEST RESULTS: DRY UNIT WT (pcf)	FIELD TEST RESULTS: F.M.C. (%)	PERCENT COMPACT (%)	PASS/ FAIL	RETEST NO	QA ID
29/7	11	B-2 0-6"	CL-1	111.0	17.3			0.5	125.3	100.8	24.4	90.8	Fail	17	JD
29/7	12	B-4 0-6"	CL-1	111.0	17.3			0.5	125.2	102.1	22.7	92.0	Pass*	--	JD
29/7	13	C-3 0-6"	CL-1	111.0	17.3			0.5	125.0	103.8	21.4	93.5	Pass	--	JD
29/7	14	D-4 0-6"	CL-1	111.0	17.3			0.5	123.1	98.6	25.6	88.3	Fail	18	JD
29/7	15	E-2 0-6"	CL-1	111.0	17.3			0.5	125.5	102.7	22.2	92.5	Pass	--	JD
29/7	16	D-4 0-6"	CL-1	111.0	17.3			0.5	123.8	100.9	22.7	90.9	Fail	18	JD
29/7	17	B-2 0-6"	CL-1	111.0	17.3			0.5	123.1	100.1	22.9	90.2	Fail	19	JD
29/7	18	D-4 0-6"	CL-1	111.0	17.3			0.5	125.6	103.3	21.6	93.0	Pass	--	JD
29/7	19	B-2 0-6"	CL-1	111.0	17.3			0.5	123.3	99.9	23.4	90.0	Fail	20	ID
29/7	20	B-2 0-6"	CL-1	111.0	17.3			0.5	122.5	102.4	19.6	92.3	Pass	--	JD
30/7	21	D-5 6" - 12"	CL-1	111.0	17.3			0.5	121.7	101.5	19.9	91.4	Fail	27	JD
30/7	22	C-2 6" - 12"	CL-1	111.0	17.3			0.5	123.3	101.2	21.8	91.2	Fail	30	JD
30/7	23	B-2 6" - 12"	CL-1	111.0	17.3			0.5	123.2	101.6	21.2	91.5	Fail	28	JD
30/7	24	B-4 6" - 12"	CL-1	111.0	17.3			0.5	117.7	97.3	20.9	87.7	Fail	29	JD
30/7	25	D-4 6" - 12"	CL-1	111.0	17.3			0.5	114.4	97.8	23.2	88.1	Fail	26	JD
30/7	26	D-4 6" - 12"	CL-1	111.0	17.3			0.5	127.5	106.2	20.0	95.7	Pass	--	JD
30/7	27	E-5 6" - 12"	CL-1	111.0	17.3			0.5	124.0	102.8	20.6	92.6	Pass	--	JD
30/7	28	B-2 6" - 12"	CL-1	111.0	17.3			0.5	124.0	102.5	20.9	92.4	Pass	--	JD
30/7	29	B-4 6" - 12"	CL-1	111.0	17.3			0.5	129.7	103.1	20.9	92.9	Pass	--	JD
30/7	30	C-2 6" - 12"	CL-1	111.0	17.3			0.5	125.3	103.4	21.2	93.1	Pass	--	JD
30/7	31	D-5 12" - 18"	CL-1	111.0	17.3			0.5	124.6	102.9	20.5	92.7	Pass	--	JD
30/7	32	B-4 12" - 18"	CL-1	111.0	17.3			0.5	125.2	103.2	21.3	93.0	Pass	--	JD
30/7	33	D-2 12" - 18"	CL-1	111.0	17.3			0.5	125.2	103.8	20.6	93.5	Pass	--	JD
30/7	34	A-5 12" - 18"	CL-1	111.0	17.3			0.5	125.3	102.5	22.2	92.4	Pass	--	JD
30/7	35	B-2 12" - 18"	CL-1	111.0	17.3			0.5	127.0	107.5	18.1	96.9	Fail	NR	JD
30/7	36	C-3 18" - 24"	CL-1	111.0	17.3			0.5	123.8	101.0	22.6	91.0	Fail	37	JD
30/7	37	C-3 18" - 24"	CL-1	111.0	17.3			0.5	124.8	102.0	22.4	91.9	Fail	57	JD
30/7	38	D-3 18" - 24"	CL-1	111.0	17.3			0.5	125.6	102.6	21.8	92.4	Pass	--	JD
30/7	39	E-5 12" - 18"	CL-1	111.0	17.3			0.5	120.9	97.8	23.7	88.1	Fail	45	JD
30/7	40	E-3 12" - 18"	CL-1	111.0	17.3			0.5	123.8	101.0	22.6	91.0	Fail	42	JD
30/7	41	C-2 12" - 18"	CL-1	111.0	17.3			0.5	124.7	102.8	21.4	92.6	Pass	--	JD
30/7	42	E-3 12" - 18"	CL-1	111.0	17.3			0.5	125.3	102.2	22.9	92.1	Fail	46	JD
30/7	43	C-4 12" - 18"	CL-1	111.0	17.3			0.5	127.4	104.2	21.8	93.9	Pass	--	JD
30/7	44	B-4 12" - 18"	CL-1	111.0	17.3			0.5	126.4	103.6	22.0	93.4	Pass	--	JD
31/7	45	E-5 12" - 18"	CL-1	111.0	17.3			0.5	120.9	97.8	23.7	88.1	Fail	51	JD
31/7	46	E-3 12" - 18"	CL-1	111.0	17.3			0.5	123.8	101.0	22.6	91.0	Fail	48	JD
31/7	47	C-2 12" - 18"	CL-1	111.0	17.3			0.5	124.7	102.8	21.4	92.6	Pass	--	JD
31/7	48	E-3 12" - 18"	CL-1	111.0	17.3			0.5	125.3	102.2	22.9	92.1	Pass*	--	JD
31/7	49	C-4 12" - 18"	CL-1	111.0	17.3			0.5	127.4	104.2	21.8	93.9	Pass	--	JD
31/7	50	B-4 12" - 18"	CL-1	111.0	17.3			0.5	126.4	103.6	22.0	93.4	Pass	--	JD
01/8	51	E-5 12" - 18"	CL-1	111.0	17.3			0.5	120.9	97.8	23.7	88.1	Fail	--	JD
01/8	52	E-3 12" - 18"	CL-1	111.0	17.3			0.5	123.8	101.0	22.6	91.0	Fail	54	JD
01/8	53	C-2 12" - 18"	CL-1	111.0	17.3			0.5	124.7	102.8	21.4	92.6	Pass	--	JD
01/8	54	E-3 12" - 18"	CL-1	111.0	17.3			0.5	125.3	102.2	22.9	92.1	Pass*	--	JD
01/8	55	C-4 12" - 18"	CL-1	111.0	17.3			0.5	127.4	104.2	21.8	93.9	Pass	--	JD
01/8	56	B-4 12" - 18"	CL-1	111.0	17.3			0.5	126.4	103.6	22.0	93.4	Pass	--	JD
04/08	57	C-3 18" - 24"	CL-1	111.0	17.3			0.5	125.3	101.0	24.9	91.0	Fail	58	JD
04/08	58	C-3 18" - 34"	CL-1	111.0	17.3			0.5	126.2	102.0	23.7	91.9	Fail	63	JD
05/08	61	D-4 18" - 24"	CL-5	113.6	16.0			0.5	128.2	105.9	23.7	93.3	Fail	NR	JD
05/08	62	D-2 18" - 24"	CL-5	111.0	17.3			0.5	125.5	104.3	22.6	94.0	Pass**	--	JD
05/08	63	C-3 18" - 24"	CL-5	113.6	16.0			0.5	128.2	106.0	21.4	93.3	Pass	--	JD
05/08	64	B-4 18" - 24"	CL-5	113.6	16.0			0.5	127.5	105.9	22.9	93.2	Pass*	--	ID
05/08	65	B-2 18" - 24"	CL-5	113.6	16.0			0.5	127.0	105.3	21.8	92.7	Pass	--	JD
07/08	66	C-3 24" - 30"	CL-5	113.6	16.0			0.5	126.7	104.8	20.9	92.3	Pass	--	JD
07/08	67	B-4 24" - 30"	CL-5	113.6	16.0			0.5	124.5	104.9	19.6	92.4	Pass	--	JD
07/08	68	C-2 24" - 30"	CL-5	113.6	16.0			0.5	127.2	106.2	19.8	93.5	Pass	--	JD
07/08	69	A-1 24" - 30"	CL-5	113.6	16.0			0.5	125.0	105.4	18.6	92.8	Pass	--	JD
07/08	70	E-5 24" - 30"	CL-5	113.6	16.0			0.5	126.4	105.1	20.3	92.4	Pass	--	JD

DATE OF TEST (day/mo)	TEST NO.	TEST LOCATION		LAB RESULTS: SAMPLE NO.	MAX UNIT WT (pcf)	O.M.C. (%)	TYPE OF TEST: ASTM D-2922	ASTM D-1556	FIELD TEST RESULTS: DEPTH/ELEV (ft)	WET UNIT WT (pcf)	DRY UNIT WT (pcf)	F.M.C. (%)	PERCENT COMPACT (%)	PASS/ FAIL	RETEST NO.	QA ID
07/08	71	D-4	30" - 36"	CL-5	113.6	16.0			0.5	130.4	109.9	18.6	96.8	Pass	--	JD
07/08	72	B-4	30" - 36"	CL-5	113.6	16.0			0.5	126.4	105.5	20.0	92.8	Pass	--	JD
07/08	73	C-3	30" - 36"	CL-5	113.6	16.0			0.5	126.8	104.1	21.4	91.6	Fail	NR	JD
07/08	74	D-2	30" - 36"	CL-5	113.6	16.0			0.5	127.9	107.3	19.2	94.4	Pass	--	JD
07/08	75	A-2	30" - 36"	CL-5	113.6	16.0			0.5	127.6	106.0	20.5	93.3	Pass	--	JD
07/08	76	D-4	30" - 36"	CL-5	113.6	16.0			0.5	127.5	106.8	19.4	94.1	Pass	--	JD

Tests 1-9: First lift was removed after significant failing tests.
Tests 59 and 60 were not recorded due to nuclear gauge malfunction.
Re-test of FDT 51 not recorded

Pass* Moisture content was outside of range, but FDT was passed by Engineer.
Pass ** Previous proctor used for this test.
NR No Retest

Figure C-1: Location of Passing Field Density Tests
Clay Testpad
Kettleman Hills Facility, Kings County, California

Lift 1 - 0 to 6"

	1	2	3	4	5
A					
B		X		X	
C			X		
D				X	
E		X			

Lift 2 - 6 to 12 "

	1	2	3	4	5
A					
B		X		X	
C		X			
D				X	
E					X

Lift 3 - 12 to 18"

	1	2	3	4	5
A					X
B				XXXX	
C		XXX		XXX	
D		X			X
E			XX		

Lift 4 - 18 to 24"

	1	2	3	4	5
A					
B		X		X	
C			X		
D		X	X		
E					

Lift 5 - 24 to 30"

	1	2	3	4	5
A	X				
B				X	
C		X	X		
D					
E					X

Lift 6 - 30 to 36"

	1	2	3	4	5
A		X			
B				X	
C					
D		X		XX	
E					

Note: Each box represents approximately 10 ft x 10 ft in the field
X' represents a passing field density test

APPENDIX D
SDRI Test Results

Excel Geotechnical Testing, Inc.
"Excellence in Testing"
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

Test Results Summary

Project Name: Kettleman B-17 Landfill

Client Name: Geosyntec

Index Test Results

Sample Information				Test Information						Remarks
Site ID	Depth (ft)		Lab. No.	Moisture Content ASTM D 2216	Fines Content ASTM D 1140	Attreberg Limits ASTM D 4318			Soil Class. ASTM D 2487	
	Top	Bottom				LL	PL	PI		
(-)			(-)	(%)	(%)	(-)	(-)	(-)	(-)	
A	0.0	0.2	J079	73.5						
A	0.2	0.4	J080	59.6						
A	0.4	0.5	J081	51.4						
A	0.5	0.6	J082	49.2						
A	0.6	0.7	J083	50.2						
A	0.7	0.8	J084	52.0						
A	0.8	0.9	J085	48.1						
A	0.9	1.0	J086	45.2						
A	1.0	1.1	J087	43.6						
A	1.2	1.3	J089	42.8						
A	1.3	1.4	J090	38.9						
A	1.4	1.5	J091	34.3						
A	1.5	1.6	J092	32.6						
A	1.6	1.7	J093	31.7						
A	1.7	1.8	J094	33.6						
A	1.8	1.9	J095	29.0						
A	1.9	2.0	J096	22.7						

Excel Geotechnical Testing, Inc.
"Excellence in Testing"
941 Forrest Street, Roswell, Georgia 30075
Tel: (770) 650 1666 Fax: (770) 650 5786

Test Results Summary

Project Name: Kettleman B-17 Landfill

Client Name: Geosyntec

Index Test Results

Sample Information				Test Information						Remarks
Site ID	Depth (ft)		Lab. No.	Moisture Content ASTM D 2216	Fines Content ASTM D 1140	Atterberg Limits ASTM D 4318			Soil Class. ASTM D 2487	
	Top	Bottom				LL	PL	PI		
(-)			(-)	(%)	(%)	(-)	(-)	(-)	(-)	
B	0.0	0.2	J097	68.7						
B	0.2	0.4	J098	60.2						
B	0.4	0.5	J099	55.5						
B	0.5	0.6	J100	51.8						
B	0.6	0.7	J101	51.9						
B	0.7	0.8	J102	51.8						
B	0.8	0.9	J103	47.2						
B	0.9	1.0	J104	44.3						
B	1.0	1.1	J105	45.4						
B	1.1	1.2	J106	43.0						
B-1	1.2	1.3	J107	41.0						
B-2	1.2	1.3	J108	41.6						
B-1	1.3	1.4	J109	40.3						
B-2	1.3	1.4	J110	40.7						
B	1.4	1.5	J111	35.3						
B	1.5	1.6	J112	31.8						
B	1.6	1.7	J113	30.7						
B	1.7	1.8	J114	29.0						
B	1.8	1.9	J115	21.5						
B	1.9	2.0	J116	22.3						
B	2.0	2.1	J117	23.8						

APPENDIX E.4

PHASES I AND II CLAY LINER COMPACTION SPECIFICATIONS

Design Change Form

KETTLEMAN HILLS FACILITY
LANDFILL B-18

Number: 3

Date: May 29, 1991 Engineer: Kerry K. Parkinson

Location/Reference of Change: Construction Specifications and Quality Assurance Plan, Landfill Unit B-18, Phases I/II and Final Closure. Page 02924-6, Section B, Item d, which specifies the following:

d. Minimum Moisture Content: Within the range defined by the area formed by connecting the following points for the Modified Proctor Compaction curve.

- 3 to 5 percent above the optimum moisture content for a density equal to 90 percent of the maximum Modified Proctor density.
- 0 to 3 percent above the optimum moisture content for a density equal to 95 percent of the maximum Modified Proctor density.

Change: Change Section B, Item d, to the following:

d. Moisture Content: Within the range defined by the area formed by connecting the following points for the Modified Proctor Compaction curve.

- 2 to 5 percent above the optimum moisture content for a density equal to 90 percent of the maximum Modified Proctor density.
- 3 percent above the optimum moisture content at 97 percent of the maximum Modified Proctor density.
- 1 percent above the optimum moisture content at 98 percent of the maximum Modified Proctor density.

APPROVAL FROM DESIGNER

Date: 5/29/91 Engineer: Kerry K Parkinson

Time: P.M.

Type of Correspondence: Letter dated May 31, 1991 by ESI

ACKNOWLEDGEMENT FROM OWNER

Date: 6-5-91 Engineer: [signature]

Environmental Construction Services

CC: CWM-KETTLEMAN

9037031\34387

ENVIRONMENTAL SOLUTIONS, INC.

May 31, 1991

Project No. 89-977I

Mr. Scott Brown
Engineering and Construction Manager
Chemical Waste Management, Inc.
35251 Old Skyline Road
Kettleman City, California 93239

Revised Compaction Relationships
Clay Liner Material from
B-18 Clay Processing Area
Landfill Unit B-18
Kettleman Hills Facility

Dear Mr. Brown:

Pursuant to your request we have reevaluated the compaction specification for the Phase I clay liner construction at Landfill Unit B-18. This evaluation is based on compaction data from the testfill construction and interface testing program collected over the last six months. Additionally, we have reviewed the field density test results from the initial 10,000 cubic yards of clay liner placement.

The original specification from the Construction Specifications and Quality Assurance Plan, Landfill Unit B-18, Phases I and II, and Final Closure (Page 02924-6, Section B, Item d) specifies the following:

- Minimum Moisture Content: Within the range defined by the area formed by connecting the following points for the Modified Proctor Compaction curve.
  - 3 to 5 percent above the optimum moisture content for a density equal to 90 percent of the maximum Modified Proctor density.
  - 0 to 3 percent above the optimum moisture content for a density equal to 95 percent of the maximum Modified Proctor density.

This criterion, which allows a lower water content for higher compactive efforts, is established to: (1) assure that both the required strength and permeability characteristics are realized; and (2) provide flexibility for the contractor and CQA engineer to work with a range of water contents without having a clay which is too wet or dry, or too close to saturation. This flexibility is desirable in hot dry areas where exact water content is difficult to control. This specification is represented by the area designated as "Original Specification" in Figure 1, attached.

To further facilitate construction control of water content and quality assurance/quality control activities during clay liner placement, the moisture-density relationship graph is being changed to that shown by the "Revised Specification" in Figure 1. The revised moisture-density window is defined by the area encompassed by connecting the following water content density points:

- 2 percent above the optimum moisture content for a density equal to 90 percent of the maximum Modified Proctor density.
- 5 percent above the optimum moisture content for a density equal to 90 percent of the maximum Modified Proctor density.
- 3 percent above the optimum moisture content at 97 percent of the maximum Modified Proctor density.
- 1 percent above the optimum moisture content at 98 percent of the maximum Modified Proctor density.

The majority of material placed in the initial 10,000 cubic yards of clay liner is within the revised specification range. Test results indicate that a portion of the initial clay liner placement was at higher densities and moisture contents than the specification range. Due to the relatively low volume, minor deviation from the specification, and discontinuous placement of the material outside of this range, no planes of weakness or other detrimental features have been developed. Consequently, the clay liner placed to date is acceptable.

Please call us if you need further information regarding this material.

Very truly yours,

Kerry K Parkinson

Kerry K. Parkinson, P.E.
Civil Engineer

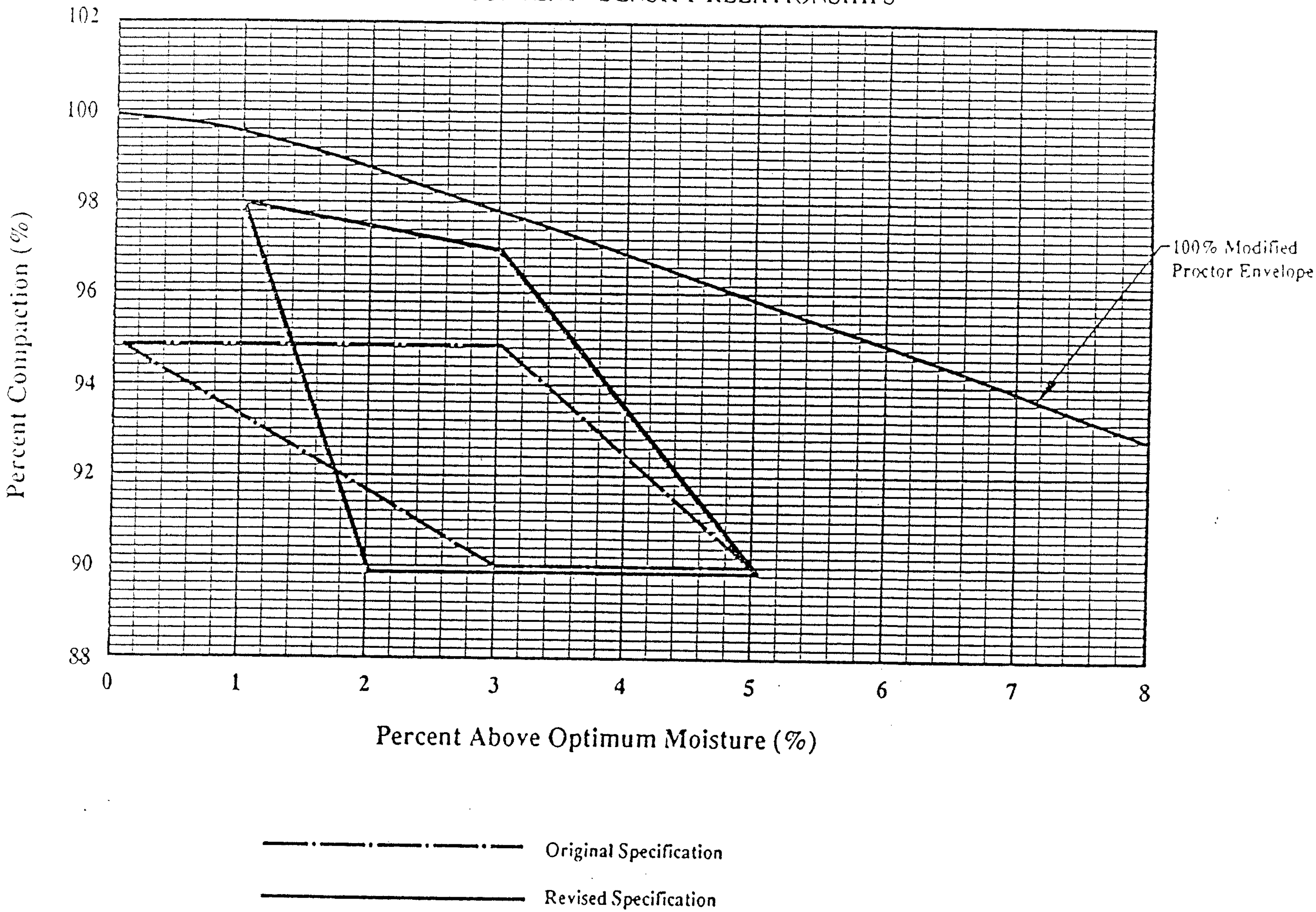
KKP:RDE:dk
Attachments

cc: Bob Henry
Richard Ellison
Miro Knezevic

FIGURE 1

LANDFILL UNIT B-18 PHASE I

WATER CONTENT - DENSITY RELATIONSHIPS



Design Change Form

KETTLEMAN HILLS FACILITY
LANDFILL B-18

Number: 3 Modified

Date: June 28, 1991

Originating Engineer: Kerry K. Parkinson

Location/Reference of Change: Construction Specifications and Quality Assurance Plan, Landfill Unit B-18, Phases I/II and Final Closure. Page 02924-6, Section B, Item d, which specifies the following:

d. Minimum Moisture Content: Within the range defined by the area formed by connecting the following points for the Modified Proctor Compaction curve.

- 3 to 5 percent above the optimum moisture content for a density equal to 90 percent of the maximum Modified Proctor density.
- 0 to 3 percent above the optimum moisture content for a density equal to 95 percent of the maximum Modified Proctor density.

Change: Change Section B, Item d, to the following:

d. Moisture Content: Within the range defined by the area formed by connecting the following points for the Modified Proctor Compaction curve.

- 2 percent above the optimum moisture content for a density equal to 90 percent of the maximum Modified Proctor density.
- 5 percent above the optimum moisture content for a density equal to 90 percent of the maximum Modified Proctor density.
- 3 percent above the optimum moisture content at 97 percent of the maximum Modified Proctor density.
- 1 percent above the optimum moisture content at 98 percent of the maximum Modified Proctor density.

The following tolerance criteria has been established for clay compaction at the B-18 Landfill:

- Twenty percent of the tests per equipment spread per day may be outside the specified moisture-density window by the following amount:
  - Moisture Content ±0.5%
  - Percent Compaction -0.5%
- So long as the average of all acceptable tests for that equipment spread per day falls within the moisture-density window.

APPROVAL FROM DESIGNER

Date: 6/28/91

Engineer: Kerry K Parkinson

Time: P.M.

Type of Correspondence:

ACKNOWLEDGEMENT FROM OWNER

Date: 7/3/91

Engineer: [illegible signature]

Environmental Construction Services

CC: CWM-KETTLEMAN

9037031\34387

ENVIRONMENTAL SOLUTIONS, INC.

June 28, 1991

Project No. 89-9771

Mr. Scott Brown
Engineering and Construction Manager
Chemical Waste Management, Inc.
35251 Old Skyline Road
Kettleman City, California 93239

Moisture-Density Tolerance Criteria
Clay Liner Material
Landfill Unit B-18
Kettleman Hills Facility

Dear Mr. Brown:

The purpose of this letter is to document the compaction test tolerance criteria established during our site visit on June 18, 1991. The tolerance criteria was developed based on our discussions with the CQA engineer and your staff, and review of the clay compaction results being realized. Those discussions and data indicated that a small percentage of tests were being considered as failures, even though they were just outside of the moisture-density window provided in our May 31, 1991, letter.

Your staff and the CQA Engineer requested that consideration be given to enlarging the window, if possible, without affecting necessary engineering properties of the material. We concluded that the window should not be changed without additional laboratory testing and analyses. However, it was also concluded that it would be acceptable for a small percentage of tests to lie just outside of the window, so long as average conditions were well within the basic criteria. This arrangement assures that the contractor continues to prepare and place the clay in a manner which provides the desired results, but also eliminates schedule delays and operational disruptions when the criteria is only occasionally missed by a small amount.

Accordingly, the following tolerance criteria, illustrated in the enclosed revision to Figure 1, has been established for clay compaction at the B-18 Landfill:

- Twenty percent of the tests per equipment spread per day may be outside the specified moisture-density window by the following amount:
  - Moisture Content ± 0.5%
  - Percent Compaction - 0.5%
- So long as the average of all acceptable tests for that equipment spread per day falls within the moisture-density window.

Please call us if you require additional information regarding this matter.

Very truly yours,

Kerry K Parkinson

Kerry K. Parkinson, P.E.
Civil Engineer

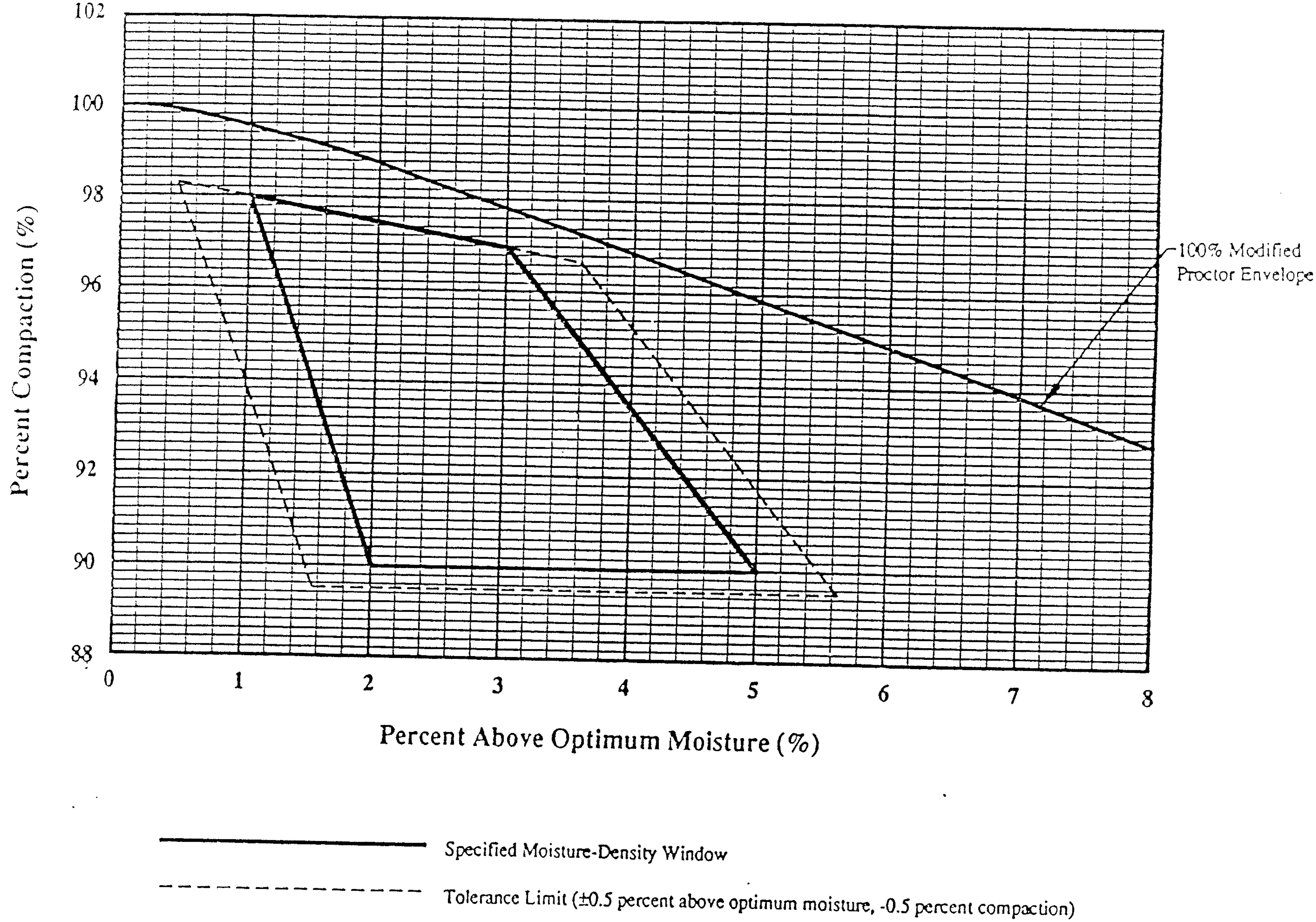
KKP:hd
Enclosure

cc: Bob Henry
Richard Ellison
Miro Knezevic

FIGURE 1

LANDFILL UNIT B-18 PHASE I

WATER CONTENT - DENSITY RELATIONSHIPS
(REVISED JUNE 28, 1991)



APPENDIX F
LINER SYSTEM MATERIAL DATA

Objective:
To provide data on the existing and proposed geosynthetic liner system materials for Landfill B-18.

Given:
Existing B-18 Liner Systems:
The existing (Phases I and II) B-18 base and sideslope liner systems contain the following geosynthetic components:

- 60-mil textured high-density polyethylene (HDPE) geomembrane;
- 80-mil smooth HDPE geomembrane;
- 8-ounce/square yard (oz/sy) nonwoven geotextile;
- 16-oz/sy nonwoven geotextile; and
- 200-mil geonet.

Product data sheets for the above-listed existing geosynthetic components of the B-18 liner systems were provided by ESI (1990). Copies of these product data sheets are provided in Attachment #1.

Proposed B-18 Liner Systems:
The proposed B-18 expansion area sideslope liner system contains the following geosynthetic components:

- 60-mil textured HDPE geomembrane;
- 16-oz/sy nonwoven geotextile; and
- geocomposite.

The proposed B-18 final closure cover system contains the following geosynthetic components:

- 40-mil textured HDPE geomembrane; and
- 12-oz/sy nonwoven geotextile.

Product data sheets that contain typical specified properties for the above-listed proposed geosynthetic components of the B-18 sideslope liner and cover systems are provided in Attachment #2. The data sheets provided in Attachment #2 were obtained from the Agru America, GSE Lining Technology, Inc. (GSE), Polyflex and Scaps. Inclusion of these data sheets does not imply that these materials will be used exclusively for the proposed B-18 expansion and/or final closure. However, the actual geosynthetics used for the B-18 expansion and final closure are anticipated to have properties that are very similar to or the same as those given in Attachment #2. Attachment #3 provides EPA 9090 test results for products similar to the proposed liner materials. Results of the testing, similar to previous site specific testing, indicate the products are compatible with leachate. No additional EPA 9090 testing is proposed.

Reference:

Environmental Solutions, Inc. (ESI), "Engineering and Design Report, Landfill Unit B-18, Phases I and II and Final Closure, Kettleman Hills Facility, Kings County, California," August 1990.

ATTACHMENT #1
LINER SYSTEM MATERIAL DATA

NSC

NATIONAL SEAL COMPANY

SUGGESTED THICKNESS SPECIFICATIONS

Thickness shall be measured in accordance with ASTM D 1593, paragraph 9.1.3 and ASTM D 751. The minimum average roll thickness shall be as specified with no individual thickness measurement on the sheet falling more than 5% below the specified value.

SPECIFIED THICKNESS	MINIMUM AVERAGE ROLL VALUE	MINIMUM THICKNESS ALLOWED
40 mil	40 mil	38 mil
60 mil	60 mil	57 mil
80 mil	80 mil	76 mil
100 mil	100 mil	95 mil

04/89

NSC

NATIONAL SEAL COMPANY
ROLLSTOCK SPECIFICATIONS

I. RESIN SPECIFICATION:

NSC will use Union Carbide or Soltex resin or the equivalent.

Each lot of resin will be analyzed by National Seal Company's Laboratory as follows:

SPECIFICATION	TEST METHOD
Density	ASTM D 1505
Carbon Black Content	ASTM D 1603
Melt Flow Index	ASTM D 1238
Moisture Content	

II. SHEET SPECIFICATION:

Gauge	±5%
Width	15' Nominal
Carbon Black	2% to 3%
Appearance	smooth surface, minimal haze.

III. QUALITY ASSURANCE and TESTING:

1. Sheet appearance will be monitored continuously by production personnel and at least once per hour by a member of our Laboratory.

2. Sheet thickness will be continuously monitored by automatic gauging equipment located on the extruder.

3. Production will hold sheet thickness to within ±3% whenever possible. ±5% is our advertised tolerance.

4. National Seal Company's Laboratory will perform the following tests every 10,000 pounds of material produced:

SPECIFICATION	TEST METHOD
Tensile Properties	ASTM D 638
Carbon Black Dispersion	ASTM D 3015
Thickness	ASTM D 1593
Dimensional Stability	ASTM D 1204

See National Seal Company's Quality Control Manual for full listing of the tests which our Laboratory can perform. Please contact your sales representative for a pricing.

04/89

HIGH DENSITY POLYETHYLENE | HDPE-40 MIL

PHYSICAL PROPERTIES

ALL PROPERTIES MEET OR EXCEED NSF STANDARD 54 SPECIFICATIONS FOR HDPE

PROPERTY	UNITS	TEST METHOD	VALUE
GAUGE OF MATERIAL	MILS	ASTM D 1593	40 (± 5%)
SPECIFIC GRAVITY, MINIMUM		ASTM D 792 A	0.94
MINIMUM TENSILE PROPERTIES		ASTM D 638	
TENSILE STRENGTH AT YIELD	PSI		2200
TENSILE STRENGTH AT BREAK	PSI		3800
ELONGATION AT YIELD	%		13
ELONGATION AT BREAK	%		600
MODULUS OF ELASTICITY	PSI		80,000
TEAR RESISTANCE, MINIMUM	PPI	ASTM D 1004	700
LOW TEMP. BRITTLENESS	DEG C.	ASTM D 746 B	−75° C.
SOIL BURIAL RESISTANCE MAX. CHANGE	%	ASTM D 3083[1]	
TENSILE STRENGTH AT YIELD			10
TENSILE STRENGTH AT BREAK			10
ELONGATION AT YIELD			10
ELONGATION AT BREAK			10
MODULUS OF ELASTICITY			10
ENVIRONMENTAL STRESS CRACK RES.	HRS.	ASTM D 1693[1]	1500
CARBON BLACK CONTENT	%	ASTM D 1603	2-3
CARBON BLACK DISPERSION	RATING	ASTM D 3015	A-2
MELT INDEX, CONDITION E, MAXIMUM	g/10m	ASTM D 1238	1.0
PUNCTURE RESISTANCE	LBS	FTMS 101, 2065	60
WATER VAPOR TRANSMISSION	g/M^2 hr.	ASTM E 96	0.008
HYDROSTATIC RESISTANCE	PSI	ASTM D 751 A	300

NATIONAL SEAL SEAMING PROPERTIES

BONDED SEAM STRENGTH, MINIMUM	PPI	ASTM D 3083[1]	80 & FTB[2]
SEAM PEEL ADHESION, MINIMUM	PPI	ASTM D 413[1]	60 & FTB[2]
SOIL BURIAL RESISTANCE		ASTM D 3083[1]	
BONDED SEAM STRENGTH, MAX. CHANGE	%		−10
SEAM PEEL ADHESION			FTB[2]

1. AS MODIFIED IN NSF STANDARD NUMBER 54.

2. FILM TEARING BOND.

NSC NATIONAL SEAL COMPANY

1255 MONMOUTH BLVD..
GALESBURG, IL 61401
800/323-3820
309/343-3418
309/343-1536 FAX

HIGH DENSITY POLYETHYLENE | HDPE-60 MIL

PHYSICAL PROPERTIES

ALL PROPERTIES MEET OR EXCEED NSF STANDARD 54 SPECIFICATIONS FOR HDPE

PROPERTY	UNITS	TEST METHOD	VALUE
GAUGE OF MATERIAL	MILS	ASTM D 1593	60 (± 5%)
SPECIFIC GRAVITY, MINIMUM		ASTM D 792 A	0.94
MINIMUM TENSILE PROPERTIES		ASTM D 638	
TENSILE STRENGTH AT YIELD	PSI		2200
TENSILE STRENGTH AT BREAK	PSI		3800
ELONGATION AT YIELD	%		13
ELONGATION AT BREAK	%		600
MODULUS OF ELASTICITY	PSI		80,000
TEAR RESISTANCE, MINIMUM	PPI	ASTM D 1004	700
LOW TEMP. BRITTLENESS	DEG C.	ASTM D 746 B	−75° C.
SOIL BURIAL RESISTANCE MAX. CHANGE	%	ASTM D 3083[1]	
TENSILE STRENGTH AT YIELD			10
TENSILE STRENGTH AT BREAK			10
ELONGATION AT YIELD			10
ELONGATION AT BREAK			10
MODULUS OF ELASTICITY			10
ENVIRONMENTAL STRESS CRACK RES.	HRS.	ASTM D 1693[1]	1500
CARBON BLACK CONTENT	%	ASTM D 1603	2-3
CARBON BLACK DISPERSION	RATING	ASTM D 3015	A-2
MELT INDEX, CONDITION E, MAXIMUM	g/10m	ASTM D 1238	1.0
PUNCTURE RESISTANCE	LBS	FTMS 101, 2065	90
WATER VAPOR TRANSMISSION	g/M^2 hr.	ASTM E 96	0.005
HYDROSTATIC RESISTANCE	PSI	ASTM D 751 A	450

NATIONAL SEAL SEAMING PROPERTIES

BONDED SEAM STRENGTH, MINIMUM	PPI	ASTM D 3083[1]	120 & FTB[2]
SEAM PEEL ADHESION, MINIMUM	PPI	ASTM D 413[1]	90 & FTB[2]
SOIL BURIAL RESISTANCE		ASTM D 3083[1]	
BONDED SEAM STRENGTH, MAX. CHANGE	%		−10
SEAM PEEL ADHESION			FTB[2]

1. AS MODIFIED IN NSF STANDARD NUMBER 54.

2. FILM TEARING BOND.

NSC NATIONAL SEAL COMPANY

1255 MONMOUTH BLVD.
GALESBURG, IL 61401
800/323-3820
309/343-3418
309/343-1536 FAX

HIGH DENSITY POLYETHYLENE | HDPE-80 MIL

PHYSICAL PROPERTIES

ALL PROPERTIES MEET OR EXCEED NSF STANDARD 54 SPECIFICATIONS FOR HDPE

PROPERTY	UNITS	TEST METHOD	VALUE
GAUGE OF MATERIAL	MILS	ASTM D 1593	80 (± 5%)
SPECIFIC GRAVITY, MINIMUM		ASTM D 792 A	0.94
MINIMUM TENSILE PROPERTIES		ASTM D 638	
TENSILE STRENGTH AT YIELD	PSI		2200
TENSILE STRENGTH AT BREAK	PSI		3800
ELONGATION AT YIELD	%		13
ELONGATION AT BREAK	%		600
MODULUS OF ELASTICITY	PSI		80,000
TEAR RESISTANCE, MINIMUM	PPI	ASTM D 1004	700
LOW TEMP. BRITTLENESS	DEG C.	ASTM D 746 B	−75° C.
SOIL BURIAL RESISTANCE MAX. CHANGE	%	ASTM D 3083[1]	
TENSILE STRENGTH AT YIELD			10
TENSILE STRENGTH AT BREAK			10
ELONGATION AT YIELD			10
ELONGATION AT BREAK			10
MODULUS OF ELASTICITY			10
ENVIRONMENTAL STRESS CRACK RES.	HRS.	ASTM D 1693[1]	1500
CARBON BLACK CONTENT	%	ASTM D 1603	2-3
CARBON BLACK DISPERSION	RATING	ASTM D 3015	A-2
MELT INDEX, CONDITION E, MAXIMUM	g/10m	ASTM D 1238	1.0
PUNCTURE RESISTANCE	LBS	FTMS 101, 2065	110
WATER VAPOR TRANSMISSION	g/M^2 hr.	ASTM E 96	0.004
HYDROSTATIC RESISTANCE	PSI	ASTM D 751 A	600

NATIONAL SEAL SEAMING PROPERTIES

BONDED SEAM STRENGTH, MINIMUM	PPI	ASTM D 3083[1]	160 & FTB[2]
SEAM PEEL ADHESION, MINIMUM	PPI	ASTM D 413[1]	120 & FTB[2]
SOIL BURIAL RESISTANCE		ASTM D 3083[1]	
BONDED SEAM STRENGTH, MAX. CHANGE	%		−10
SEAM PEEL ADHESION			FTB[2]

1. AS MODIFIED IN NSF STANDARD NUMBER 54.

2. FILM TEARING BOND.

NSC NATIONAL SEAL COMPANY

1255 MONMOUTH BLVD..
GALESBURG, IL 61401
800/323-3820
309/343-3418
309/343-1536 FAX

HIGH DENSITY POLYETHYLENE | HDPE-100 MIL

PHYSICAL PROPERTIES

ALL PROPERTIES MEET OR EXCEED NSF STANDARD 54 SPECIFICATIONS FOR HDPE

PROPERTY	UNITS	TEST METHOD	VALUE
GAUGE OF MATERIAL	MILS	ASTM D 1593	100 (± 5%)
SPECIFIC GRAVITY, MINIMUM		ASTM D 792 A	0.94
MINIMUM TENSILE PROPERTIES		ASTM D 638	
TENSILE STRENGTH AT YIELD	PSI		2200
TENSILE STRENGTH AT BREAK	PSI		3800
ELONGATION AT YIELD	%		13
ELONGATION AT BREAK	%		600
MODULUS OF ELASTICITY	PSI		80,000
TEAR RESISTANCE, MINIMUM	PPI	ASTM D 1004	700
LOW TEMP. BRITTLENESS	DEG C.	ASTM D 746 B	−75° C.
SOIL BURIAL RESISTANCE MAX. CHANGE	%	ASTM D 3083[1]	
TENSILE STRENGTH AT YIELD			10
TENSILE STRENGTH AT BREAK			10
ELONGATION AT YIELD			10
ELONGATION AT BREAK			10
MODULUS OF ELASTICITY			10
ENVIRONMENTAL STRESS CRACK RES.	HRS.	ASTM D 1693[1]	1500
CARBON BLACK CONTENT	%	ASTM D 1603	2-3
CARBON BLACK DISPERSION	RATING	ASTM D 3015	A-2
MELT INDEX, CONDITION E, MAXIMUM	g/10m	ASTM D 1238	1.0
PUNCTURE RESISTANCE	LBS	FTMS 101, 2065	130
WATER VAPOR TRANSMISSION	g/M^2 hr.	ASTM E 96	0.003
HYDROSTATIC RESISTANCE	PSI	ASTM D 751 A	750

NATIONAL SEAL SEAMING PROPERTIES

BONDED SEAM STRENGTH, MINIMUM	PPI	ASTM D 3083[1]	200 & FTB[2]
SEAM PEEL ADHESION, MINIMUM	PPI	ASTM D 413[1]	150 & FTB[2]
SOIL BURIAL RESISTANCE		ASTM D 3083[1]	
BONDED SEAM STRENGTH, MAX. CHANGE	%		−10
SEAM PEEL ADHESION			FTB[2]

1. AS MODIFIED IN NSF STANDARD NUMBER 54.

2. FILM TEARING BOND.

NSC NATIONAL SEAL COMPANY

1255 MONMOUTH BLVD.,
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800/323-3820
309/343-3418
309/343-1536 FAX

Trevira® Spunbonds are highly needled nonwoven engineering fabrics with excellent tensile properties, high filtration potential and outstanding permeability.

Trevira® Spunbond Type 11 products are 100% continuous filament polyester nonwoven needlepunched engineering fabrics. They deliver a combination of advantages unmatched by any other spunbonded geotextiles. They're resistant to freeze-thaw, soil chemicals and ultraviolet light exposure.

Trevira® Spunbonds are excellent where the requirement is (1) tensile reinforcement, (2) planar flow, (3) filtration, and (4) separation. For example, in roadways, railbeds, drainage systems, pondliners, retaining walls. And much more. Trevira® Spunbonds are extraordinary engineering fabrics.

TYPICAL PHYSICAL PROPERTIES OF TREVIRA® TYPE 11 PRODUCTS

Fabric Property	Unit	Test Method	1112	1114	1120	1125	1135	1145	1155
Fabric Weight	oz/yd²	ASTM D-3776	3.6	4.2	6.0	7.4	10.5	13.5	16.2
Thickness, t	mils	ASTM D-1777	60	65	90	110	150	175	210
Grab Strength (MD/CD)[1]	lbs	ASTM D-4632	110/90	135/110	205/175	270/225	390/330	500/425	625/560
Grab Elongation (MD/CD)	%	ASTM D-4632	70/85	70/85	75/85	75/85	75/85	90/95	90/95
Trapezoid Tear Strength (MD/CD)	lbs	ASTM D-4533	50/40	60/50	80/75	105/95	135/120	175/170	205/200
Puncture Resistance (5/16" hemispherical tip)	lbs	ASTM D-3787	50	60	90	115	155	175	240
Mullen Burst Strength	psi	ASTM D-3786	180	210	315	390	550	625	840
Water Flow Rate (5 cm. hd.)	gpm/ft²	ASTM D-4491	200	200	170	150	110	90	70
Permittivity, Ψ	sec^{-1}	ASTM D-4491	2.72	2.72	2.31	1.77	1.50	1.22	0.95
Permeability, k	cm/sec	$K = \Psi t$	0.41	0.45	0.53	0.49	0.57	0.54	0.51
AOS	Sieve Size mm	ASTM D-4751	70-100 .210-.149	70-100 .210-.149	70-100 .210-.149	70-120 .210-.125	70-120 .210-.125	100-140 .149-.105	100-170 .149-.088
Standard Roll Widths[2]	ft		12.5 and 15.0						
Standard Roll Length[2]	ft		400	400	300	300	300	300	300

[1] MD = Machine Direction, CD = Cross Machine Direction.

[2] Other width and length rolls are available upon request.

MINIMUM AVERAGE ROLL VALUES (WEAKEST PRINCIPAL DIRECTION) OF TREVIRA® TYPE 11 PRODUCTS

Fabric Property	Unit	Test Method	1112	1114	1120	1125	1135	1145	1155
Fabric Weight	oz/yd²	ASTM D-3776	3.4	4.0	5.7	7.1	10.0	13.0	16.0
Thickness, t	mils	ASTM D-1777	50	55	80	100	135	160	200
Grab Strength	lbs	ASTM D-4632	80	100	155	200	290	375	500
Grab Elongation	%	ASTM D-4632	60	60	65	60	65	65	65
Trapezoid Tear Strength	lbs	ASTM D-4533	30	40	60	75	100	140	170
Puncture Resistance (5/16" hemispherical tip)	lbs	ASTM D-3787	35	45	75	95	130	155	200
Mullen Burst Strength	psi	ASTM D-3786	160	190	285	360	500	575	765
Water Flow Rate[3] (5 cm. hd.)	gpm/ft²	ASTM D-4491	170	170	140	100	80	60	40
Permittivity Ψ [3]	sec^{-1}	ASTM D-4491	2.31	2.31	1.90	1.36	1.09	0.82	0.54
Permeability, k[3]	cm/sec	$K = \Psi t$	0.29	0.32	0.39	0.35	0.37	0.33	0.27
AOS[3]	Sieve Size mm	ASTM D-4751	70 .210	70 .210	70 .210	70 .210	70 .210	100 .149	100 .149

[3] AOS "minimum average roll value" is a measure of the *largest* opening size in the fabric.

TREVIRA

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Spunbond Business Group
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Hoechst

TREVIRA® Spunbond Engineering Fabric Geotextile Selection Guide

INTRODUCTION

Designers, owners, and contractors are now forced to choose from a multitude of geosynthetic products. The December 1987 issue of "Geotechnical Fabrics Report"[1] listed 26 manufacturers or suppliers of geotextiles, and each supplier had several different products listed. When geonets, geogrids, and geocomposites are included, the list becomes very lengthy.

This brochure will only discuss geotextiles and will provide data to assist the specifier or user in selecting the proper fabric(s) for their application. Most data will be presented in a generic format; however, TREVIRA® Spunbond will be used to illustrate some of the presentation.

Polyester or Polypropylene?

Almost all geotextiles available in the United States are manufactured from either polyester or polypropylene. Both polymers are synthetic "man-made" materials, but they display significantly different physical properties. Table 1 lists important characteristics for both polymers expressed as actual test results or as "excellent, good, fair, and poor".

As Table 1 illustrates, polyester and polypropylene display important differences in physical properties. These differences should always be considered when selecting geotextiles for any application.

Woven or Nonwoven?

Woven geotextiles can be placed in two general categories by manufacturing method — Slit Film and Filament. All woven fabrics display high strength/low

Table 1

CHARACTERISTICS

	Polyester	*Polypropylene*
Melting Point	478-490°F	320-350°F
UV Resistance	Excellent	Poor (Unstabilized) Fair-Excellent (Stabilized)
Creep Resistance	Excellent	Fair
Low Temperature (below 32°F) Workability	Excellent	Fair-Poor
Biological Resistance	Excellent	Excellent
Chemical Resistance*	Good	Good
Specific Gravity	1.36	0.9

*Chemical resistance is difficult to generalize. Both polyester and polypropylene are unaffected by most chemicals, particularly in the concentrations commonly found in soil. However, if the fabric is being used in a waste containment facility or tank farm, and will therefore be exposed to higher concentrations, specific compatibility data should be requested from the geotextile manufacturers. If this data is unavailable, which is often the case with leachates, compatibility testing is suggested.

Figure 1

LOAD-ELONGATION CURVE (MD)

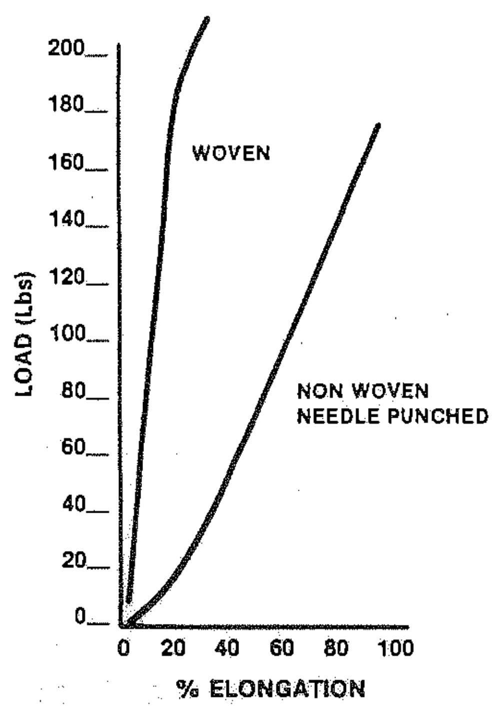


Table 2

INDEX TESTS

PHYSICAL PROPERTY	TEST PROCEDURE
1) Weight	per ASTM D-3776
2) Thickness	per ASTM D-1777
3) Grab Strength	per ASTM D-4632
4) Grab Elongation	per ASTM D-4632
5) Trapezoid Tear Strength	per ASTM D-4533
6) Puncture Strength (modified) (this test is currently being balloted at ASTM for approval of a 5/16" flat tip with 1/32" x 45° chamfer)	per ASTM D-3787
7) Mullen Burst Strength	per ASTM D-3786
8) Permittivity	per ASTM D-4491
9) Apparent Opening Size (AOS)	per ASTM D-4751

"Typical" and "minimum average roll" results are listed on the TREVIRA® Spunbond sample cards.

Hoechst Celanese Corporation also routinely performs or has independent testing labs perform the following index and design tests:

PHYSICAL PROPERTY	TEST PROCEDURE
1) Ultraviolet Degradation	per ASTM D-4355
2) Transmissivity — fabric and fabric-net or fabric-core (Depending on boundary conditions, this test can be used as an index or design test.)	per ASTM D-4716
3) Abrasion Resistance	ASTM is currently balloting on an Abrasion Testing procedure utilizing the SBS (Sliding Block/Sandpaper Abrasion Test.)
4) Wide Width Tensile Test — This test is actually a design test but can be used for comparing fabrics.	per ASTM-4595
5) Friction Testing per the direct shear method — This test may be used as an index or design test.	This test is currently being balloted at ASTM.
6) Gradient Ratio Test — This test may be used as an index or design test.	This test is currently being balloted at ASTM.
7) Chemical Compatibility — This test may be used as an index or design test.	ASTM is currently working on this testing procedure.
8) Creep — This test may be used as an index or design test.	This test is currently being balloted at ASTM.

Table 3

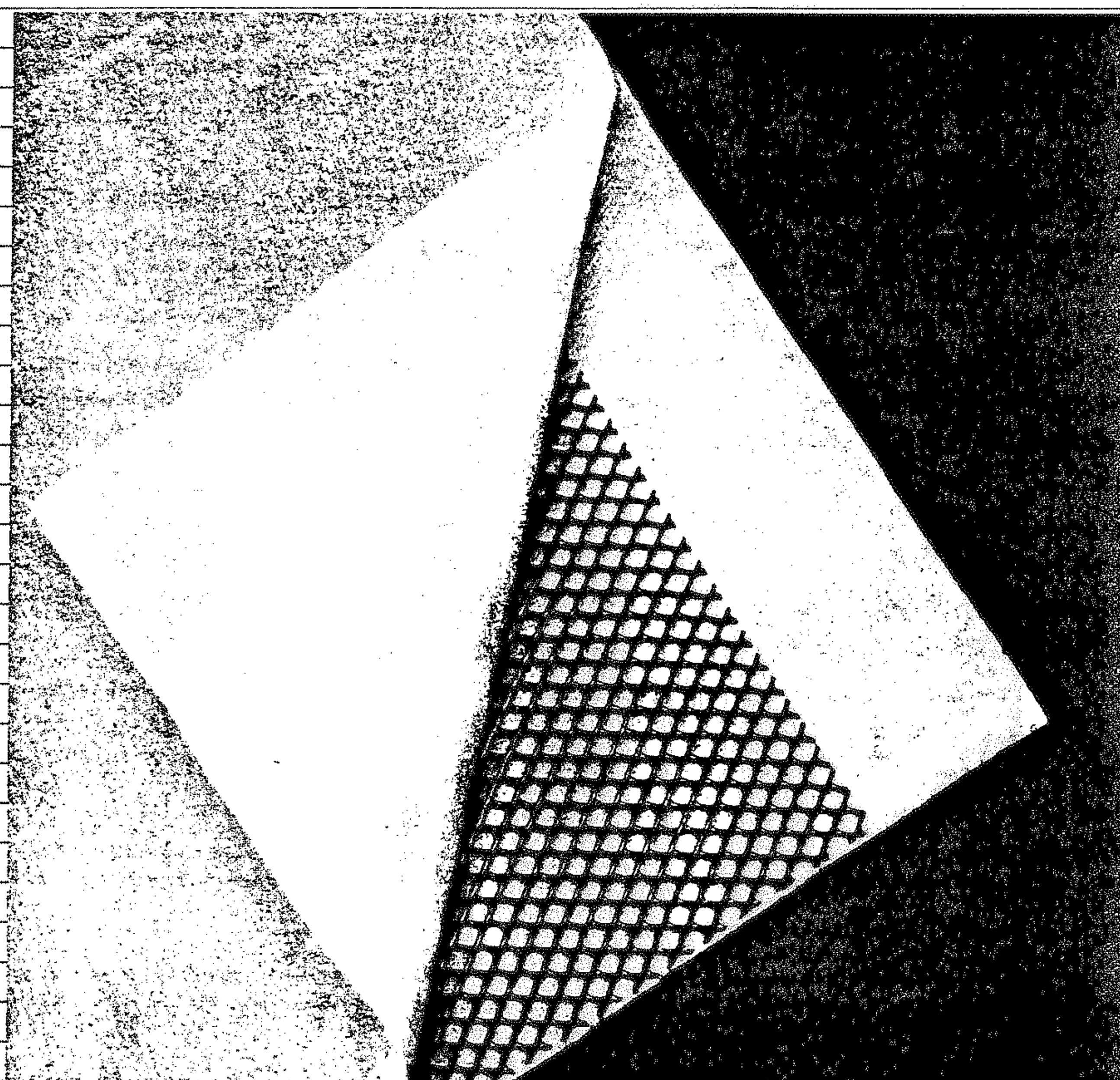
PHYSICAL PROPERTIES FOR PERFORMANCE

APPLICATION	FABRIC FUNCTION	IMPORTANT GEOTEXTILE PHYSICAL PROPERTY for PERFORMANCE
1. Drainage • Underdrains • Recharge drains • Structure drains	Filtration Separation	• Permittivity • Coefficient of Permeability • AOS • Resistance to Clogging or Blinding (Gradient Ratio Test or Long-Term Soil-Fabric Filtration Test) • Trapezoid Tear Strength • Puncture Strength
2. Erosion Protection • Rip rap slope protection • Gabion bank protection	Filtration Separation	• Permittivity • Coefficient of Permeebility • AOS • Resistance to Clogging or Blinding • Friction Angle (Direct Shear Test) • Puncture Strength • Trapezoid Tear Strength • Mullen Burst Strength
3. Stabilization • Aggregate roads and yards • Paved roads and parking lots • Railroad tracks	Separation Reinforcement Filtration Planar Transport	• Grab Tensile Strength • Mullen Burst Strength • Trapezoid Tear Strength • Puncture Strength • Permittivity • Transmissivity • Abrasion Resistance • Friction Angle (Direct Shear Test)
4. Soil Reinforcement • "Wrap around" walls • Reinforced slopes • Embankments over weak foundations	Reinforcement	• Wide Width Tensile Strength • Secant Modulus (confined) • Direct Shear or Pull Out Friction Angle
5. Lining Systems		
• Gas Relief Layer	Planar transport	• Transmissivity
• Cushion Layer	Separation Reinforcement	• Mullen Burst Strength • Puncture Strength • Trapezoid Tear Strength
• Leachate Collection Systems	Filtration Separation Planar Transport	• Permittivity • Coefficient of Permeability • AOS • Resistance to Clogging and Blinding • Friction Angle (Direct Shear Test) • Transmissivity (if fabric is used as the drain)
6. Asphalt Pavement • Asphalt Overlay • Chip Seal • Full depth asphalt	Waterproofing (after absorbing tack coat) Reinforcement	• Asphalt Retention/Absorption • Shrinkage Tempereture

PSI

TEX-NET™

The Composite Drainage System



Solid and Hazardous Waste Containment Drainage

Primary Leachate Collection

TEX-NET, a composite of a drainage net and one or two layers of geotextile fabric, can provide a desired planar flow of liquids down the steep slopes of the walls and across the floor of waste containments to collection standpipes. The fabric acts as a filter to keep soil or fines from inhibiting any planar flow of leachate through the drainage net. It also acts as a cushion protecting the liner from damage. By having the fabric heat-laminated to the net, superior frictional resistance is achieved. Shear tests of TEX-NET with clayey soils indicate realistic friction angles in excess of 30°.

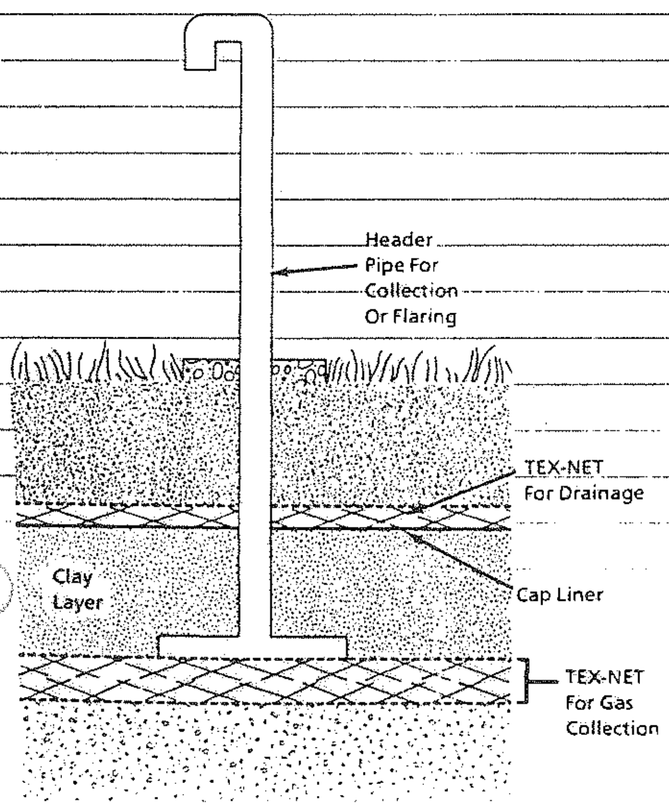
Landfill Cap

There are two applications of TEX-NET in a typical landfill cap. One, as the medium to drain surface water off the geomembrane cap...and two, under the landfill cap as a gas collector. TEX-NET with a geotextile on one side only is ideal for installation over the cap. TEX-NET with fabric on both sides is suggested for under the cap to reduce generated gas buildup. Gases will flow along the grid as freely as fluids.

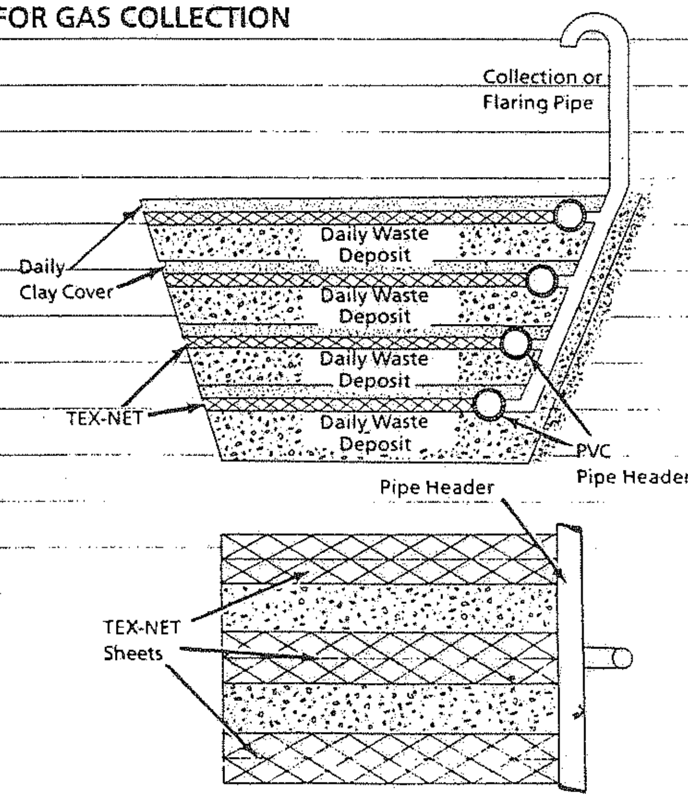
Gas Collection Within The Landfill

TEX-NET works very well in the collection and release of methane and other gases commonly generated in solid waste landfills. Strips of double-faced TEX-NET, if appropriately positioned throughout the refuse, will collect generated gas and direct its flow toward manifold pipes and onto the surface for collection and use, or flaring.

TEX-NET IN A LANDFILL CAP



TEX-NET WITHIN LANDFILL FOR GAS COLLECTION



FSI

FLUID SYSTEMS, INC.

POLY-NET®

TRANSMISSIVITY – CHARTS

513/771-5656
800/346-9107
FAX - 513/771-4844

32 Triangle Park Drive
Suite 3201
Cincinnati, Ohio 45246

FSI FLUID SYSTEMS, INC.

POLY-NET™

PN-4000 FOR CLAY LINED FACILITIES
PN-3000 CN — "CAP-NET"

SPECIFICATION	PN-4000	PN-3000 CN
ROLL LENGTH (MAXIMUM) (FT.)	300	300
ROLL WIDTH (+ 1 in.—0 in.) (FT.)	6.9	6.9
THICKNESS (IN.)	.300	.200
S.F. IN ROLL	2025	2025
WEIGHT PER ROLL (LBS.)	500	233
WEIGHT PER S.F.	.245	.115

*Available to Lengths of 400 Feet

PROPERTY	PN-4000	PN-3000 CN
RAW MATERIAL (ALL DOMESTIC)	POLYETHYLENE (VIRGIN MATERIAL)	POLYETHYLENE (VIRGIN MATERIAL)
MANUFACTURING	FOAMED + EXTRUDED	FOAMED + EXTRUDED
COLOR	BLACK	BLACK
CARBON BLACK	2%	2%
DENSITY & POLYMER (g/cm^3)	.936	.936
MELT INDEX (g/10 MIN)	1.10	1.10
TENSILE STRENGTH (LBS./IN.) (MACH. DIRECTION)	58	24
TENSILE STRENGTH (LBS./IN.) (TRANS. DIRECTION)	33	11
ELONGATION TO BREAK (MACH. DIRECTION)	175%	180%
ELONGATION TO BREAK (TRANS. DIRECTION	165%	150%
POROSITY	.81-.84	.81-.84
U.V. RESISTANCE	STABLE	STABLE
TRANSMISSIVITY	— SEE TABLES —	— SEE TABLES —

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POLY-NET IS PROUDLY MANUFACTURED IN THE U.S.

32 Triangle Park Drive
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NSC

POLYNET PN-3000

PRODUCT DESCRIPTION

PN-3000 is a profiled geonet manufactured by extruding two sets of polyethylene strands to form a diamond shape. The resulting net provides superior planar water flow, is inert to biological and naturally encountered chemicals, alkalies, and acids and is resistant to UV light exposure. Polynet PN-3000 conforms to the property values listed below.

PROPERTY	METHOD	UNITS	QUALIFIER	VALUE
Roll Length	-	ft	Normal	300
Roll Width	-	ft	Normal	7.54
Thickness	ASTM D1777	inches	Range	0.220 ± 0.022
Area per Roll	-	ft^2	Normal	2262
Weight per Roll	-	lbs	Normal	407
Weight per Square Foot	ASTM D3776 (option C)	lbs/ft^2	Range	0.180 ± 0.018
Carbon Black Content	ASTM D1603	percent	Range	2.5 ± 0.5
Polymer Density	ASTM D1505	g/cm^3	Range	0.937 ± 0.002
Melt Flow Index	ASTM D1238 (condition E)	g/10 min.	Maximum	1.0
Tensile Strength (Machine Direction)	ASTM D1682 (modified)	ppi	Range	50 ± 10
Transmissivity[1] (gradient = 1.0 at 15,000 psf)	ASTM D4716	M^2/sec	Minimum	1×10^{-3}

1 Measured between two steel plates one hour after application of the confining pressure. Values may vary based on transmissivity specimen dimensions and specific laboratory.

9/27/88

NSC

POLYNET PN-3000-CN

PRODUCT DESCRIPTION

PN-3000 CN is a foamed profiled geonet manufactured by extruding two sets of polyethylene strands to form a diamond shape. The resulting net provides superior planar water flow, is inert to biological and naturally encountered chemicals, alkalies, and acids and is resistant to UV light exposure. Polynet PN-3000-CN conforms to the property values listed below.

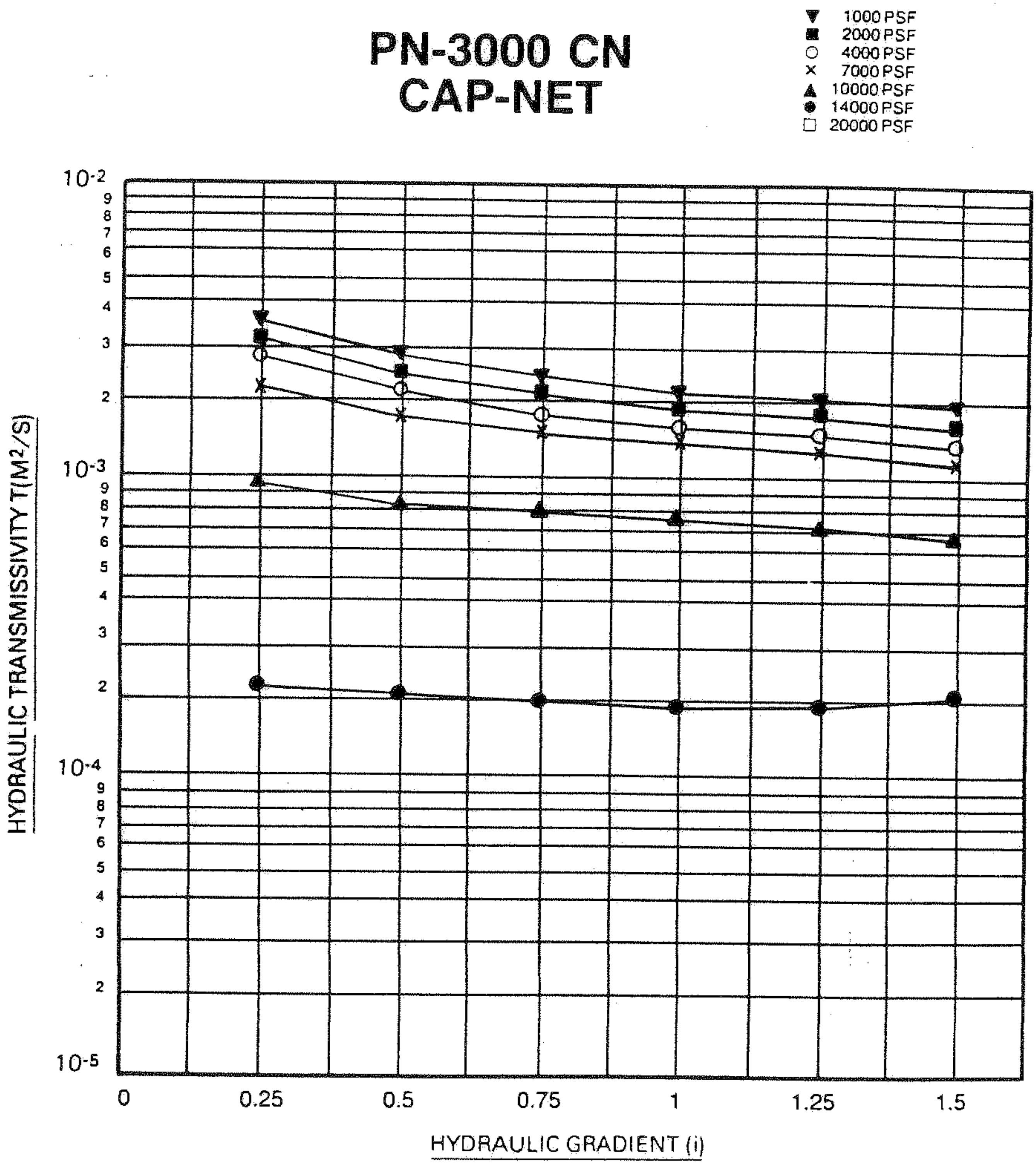
PROPERTY	METHOD	UNITS	QUALIFIER	VALUE
Roll Length	-	ft	Normal	300
Roll Width	-	ft	Normal	7.54
Thickness	ASTM D1777	inches	Range	0.220 ± 0.022
Area per Roll	-	ft^2	Normal	2262
Weight per Roll	-	lbs	Normal	260
Weight per Square Foot	ASTM D3776 (option C)	lbs/ft^2	Range	0.115 ± 0.011
Carbon Black Content	ASTM D1603	percent	Range	2.5 ± 0.5
Polymer Density	ASTM D1505	g/cm^3	Range	0.937 ± 0.002
Melt Flow Index	ASTM D1238 (condition E)	g/10 min.	Maximum	1.0
Tensile Strength (Machine Direction)	ASTM D1682 (modified)	ppi	Range	28 ± 10
Transmissivity[1] (gradient = 1.0 at 4,000 psf)	ASTM D4716	M^2/sec	Minimum	$1 X 10^{-3}$

1 Measured between two steel plates one hour after application of the confining pressure. Values may vary based on transmissivity specimen dimensions and specific laboratory.

9/27/88

POLY-NET ™ TRANSMISSIVITY	INSTALLATION METHOD LEAK DETECTION HDPE LINER/POLY-NET/HDPE LINER	HYDRAULIC PRESSURE

PN-3000 CN
CAP-NET



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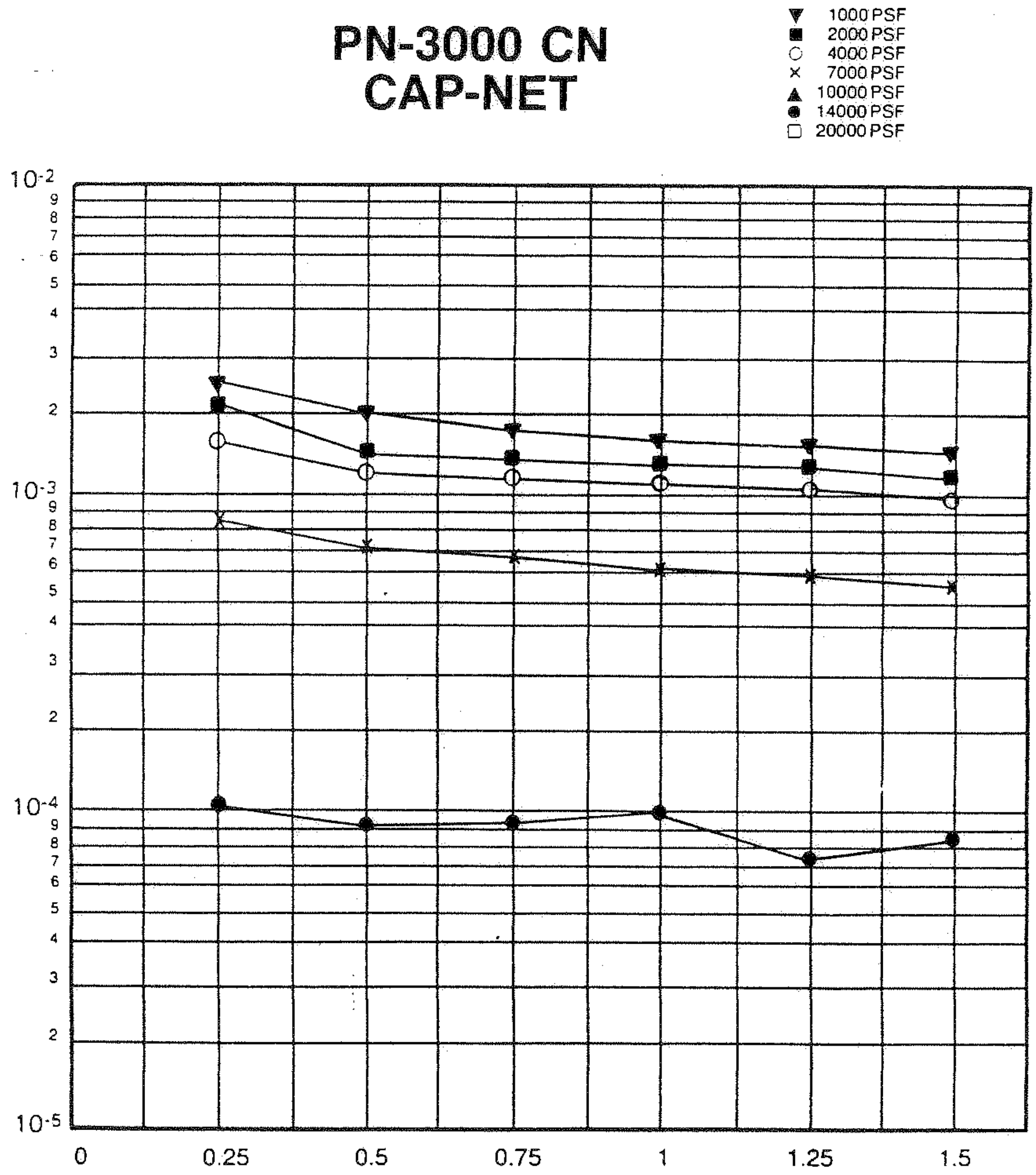
POLY-NET™ TRANSMISSIVITY	INSTALLATION METHOD	HYDRAULIC PRESSURE
	LEACHATE COLLECTION CLAY SUBGRADE · GEOTEXTILE POLY-NET/HDPE LINER	

PN-3000 CN
CAP-NET



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POLY-NET™ TRANSMISSIVITY	INSTALLATION METHOD	HYDRAULIC PRESSURE
	CLAYSUBGRADE/GEOTEXTILE/ POLY-NET/GEOTEXTILE/CLAY SUBGRADE	

LEACHATE COLLECTION FOR CLAY LINED FACILITY

PN-4000

SANDWICHED BETWEEN GEOTEXTILES

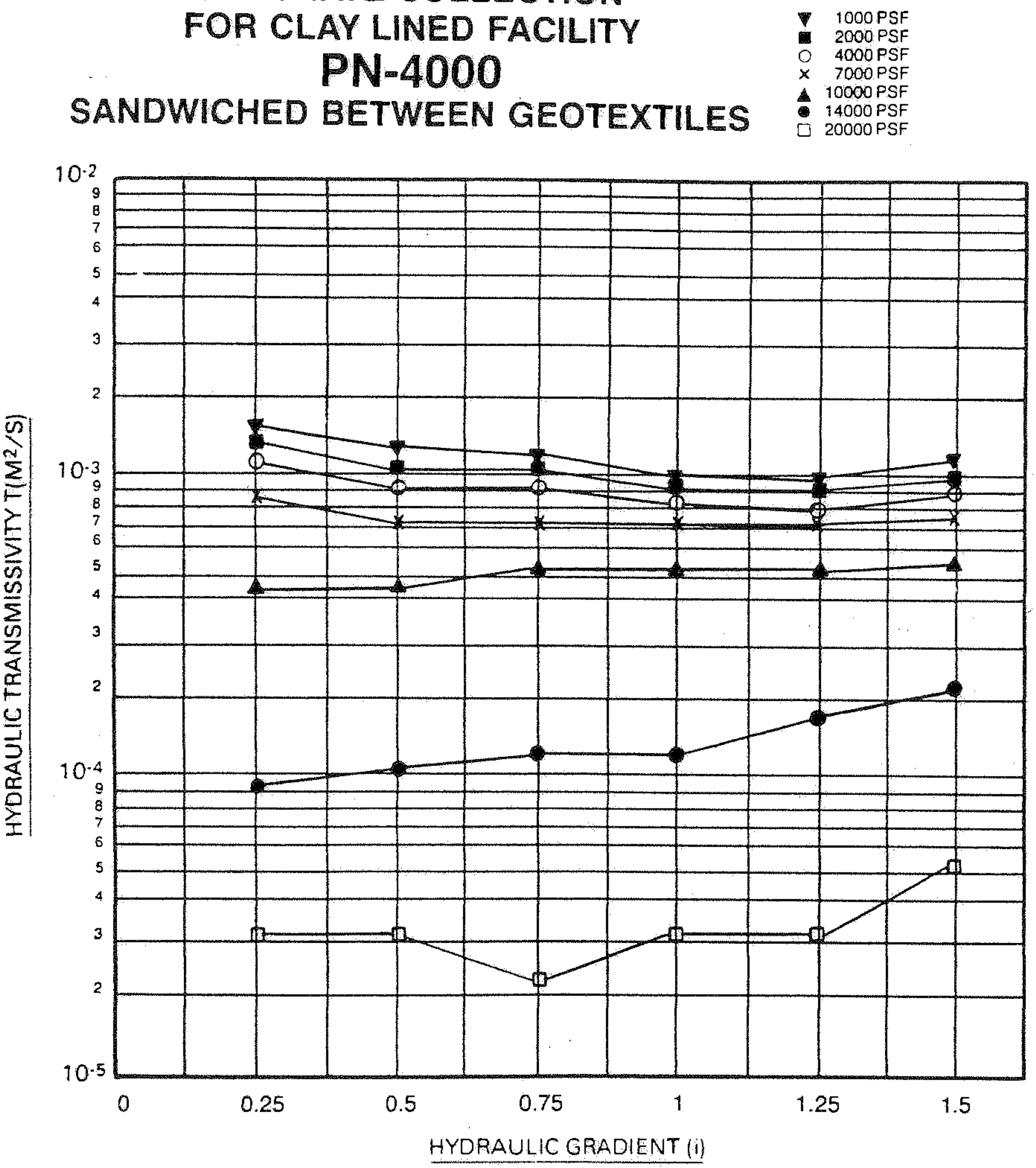

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TABLE 5. HYDRAULIC TRANSMISSIVTTY (M^2/SEC X 10^{-3})
PN4000 GEONET

GRADIENT = 0.25

Specimen	5,000 psf	10,000 psf	15,000 psf	20,000 psf	25,000 psf
1.	3.67	2.16	1.07	0.43	0.17
2.	4.54	3.02	1.27	0.58	0.19
3.	4.54	3.07	1.34	0.63	0.18
Avg:	4.25	2.75	1.23	0.55	0.18
SD:	0.50	0.51	0.14	0.10	0.01

GRADIENT = 0.50

Specimen	5,000 psf	10,000 psf	15,000 psf	20,000 psf	25,000 psf
1.	2.56	1.65	0.78	0.30	0.13
2.	3.05	2.09	1.04	0.46	0.17
3.	2.94	2.05	1.08	0.46	0.18
Avg:	2.85	1.93	0.97	0.41	0.16
SD:	0.26	0.24	0.16	0.09	0.03

GRADIENT = 0.75

Specimen	5,000 psf	10,000 psf	15,000 psf	20,000 psf	25,000 psf
1.	2.01	1.36	0.67	0.25	0.11
2.	2.69	1.74	0.85	0.37	0.13
3.	2.66	1.78	0.86	0.38	0.14
Avg:	2.45	1.63	0.79	0.33	0.13
SD:	0.38	0.23	0.11	0.07	0.02

2×10^{-2}

GRADIENT = 1.0

Specimen	5,000 psf	10,000 psf	15,000 psf	20,000 psf	25,000 psf
1.	1.83	1.22	0.57	0.22	0.10
2.	2.23	1.56	0.75	0.34	0.13
3.	2.26	1.49	0.76	0.34	0.13
Avg:	2.11	1.42	0.69	0.30	0.12
SD:	0.24	0.18	0.11	0.07	0.02

TABLE 3. HYDRAULIC TRANSMISSIVITY (M^2/SEC X 10^{-3})
PN3000 GEONET

GRADIENT = 0.25

Specimen	5,000 psf	10,000 psf	15,000 psf	20,000 psf	25,000 psf
1.	2.85	2.19	1.84	1.37	0.31
2.	2.13	2.81	2.29	1.45	0.80
3.	3.04	2.46	2.08	1.03	0.52
Avg:	2.67	2.49	2.07	1.28	0.54
SD:	0.48	0.31	0.23	0.22	0.25

GRADIENT = 0.50

Specimen	5,000 psf	10,000 psf	15,000 psf	20,000 psf	25,000 psf
1.	2.21	1.84	1.44	0.92	0.26
2.	1.78	2.09	1.72	1.20	0.59
3.	2.23	1.97	1.45	0.78	0.38
Avg:	2.07	1.97	1.54	0.97	0.41
SD:	0.25	0.13	0.16	0.21	0.17

GRADIENT = 0.75

Specimen	5,000 psf	10,000 psf	15,000 psf	20,000 psf	25,000 psf
1.	2.02	1.47	1.11	0.88	0.23
2.	1.61	1.72	1.44	1.04	0.54
3.	1.81	1.68	1.24	0.64	0.33
Avg:	1.81	1.62	1.26	0.85	0.37
SD:	0.21	0.13	0.17	0.20	0.16

GRADIENT = 1.0

Specimen	5,000 psf	10,000 psf	15,000 psf	20,000 psf	25,000 psf
1.	1.75	1.46	1.20	0.81	0.22
2.	1.35	1.51	1.26	0.94	0.49
3.	1.56	1.47	1.10	0.58	0.30
Avg:	1.55	1.48	1.19	0.78	0.34
SD:	0.20	0.03	0.08	0.18	0.14

TABLE 3. HYDRAULIC TRANSMISSIVITY (M^2/Sec X 10^{-3})
SOIL/TREVIRA 1120/PN3000 GEONET/TREVIRA 1120/SOIL

GRADIENT = 0.25

Specimen	5,000 psf	10,000 psf	15,000 psf	20,000 psf	25,000 psf
1.	0.41	0.16	0.07	0.04	0.02
2.	0.42	0.17	0.08	0.05	0.04
3.	0.48	0.23	0.14	0.11	0.09
Avg:	0.44	0.19	0.10	0.07	0.05
SD:	0.04	0.04	0.04	0.04	0.04

GRADIENT = 0.50

Specimen	5,000 psf	10,000 psf	15,000 psf	20,000 psf	25,000 psf
1.	0.36	0.14	0.08	0.03	0.02
2.	0.37	0.14	0.08	0.04	0.03
3.	0.40	0.18	0.11	0.07	0.06
Avg:	0.38	0.15	0.09	0.05	0.04
SD:	0.02	0.02	0.02	0.02	0.02

GRADIENT = 0.75

Specimen	5,000 psf	10,000 psf	15,000 psf	20,000 psf	25,000 psf
1.	0.32	0.14	0.06	0.04	0.03
2.	0.32	0.14	0.06	0.05	0.03
3.	0.35	0.16	0.08	0.06	0.05
Avg:	0.33	0.15	0.07	0.05	0.04
SD:	0.02	0.01	0.01	0.01	0.01

GRADIENT = 1.0

Specimen	5,000 psf	10,000 psf	15,000 psf	20,000 psf	25,000 psf
1.	0.26	0.12	0.05	0.03	0.03
2.	0.26	0.12	0.06	0.04	0.03
3.	0.29	0.14	0.07	0.05	0.04
Avg:	0.27	0.13	0.06	0.04	0.03
SD:	0.02	0.01	0.01	0.01	0.01

TABLE 5. HYDRAULIC TRANSMISSIVITY (M^2/Sec X 10^{-3})
SOIL/TREVIRA 1120/PN4000 GEONET/TREVIRA 1120/SOIL

GRADIENT = 0.25

Specimen	5,000 psf	10,000 psf	15,000 psf	20,000 psf	25,000 psf
1.	0.63	0.17	0.03	0.00	0.00
2.	0.66	0.19	0.05	0.02	0.02
3.	0.76	0.29	0.15	0.11	0.11
Avg:	0.68	0.22	0.08	0.04	0.04
SD:	0.07	0.06	0.06	0.06	0.06

GRADIENT = 0.50

Specimen	5,000 psf	10,000 psf	15,000 psf	20,000 psf	25,000 psf
1.	0.62	0.18	0.02	0.00	0.00
2.	0.64	0.19	0.03	0.01	0.01
3.	0.71	0.24	0.08	0.06	0.05
Avg:	0.66	0.20	0.04	0.02	0.02
SD:	0.05	0.03	0.03	0.03	0.03

GRADIENT = 0.75

Specimen	5,000 psf	10,000 psf	15,000 psf	20,000 psf	25,000 psf
1.	0.51	0.15	0.02	0.00	0.00
2.	0.53	0.16	0.03	0.01	0.01
3.	0.59	0.20	0.06	0.04	0.04
Avg:	0.54	0.17	0.04	0.02	0.02
SD:	0.04	0.03	0.02	0.02	0.02

GRADIENT = 1.0

Specimen	5,000 psf	10,000 psf	15,000 psf	20,000 psf	25,000 psf
1.	0.46	0.13	0.02	0.01	0.00
2.	0.47	0.13	0.03	0.02	0.01
3.	0.53	0.16	0.05	0.04	0.03
Avg:	0.49	0.14	0.03	0.02	0.01
SD:	0.04	0.02	0.02	0.02	0.02

ATTACHMENT #2
LINER SYSTEM MATERIAL DATA

High Density Polyethylene Micro Spike® Liner

Product Data

Property	Test Method	Values				
Thickness, nominal (mm)		30 (.75)	40 (1.0)	60 (1.5)	80 (2.0)	100 (2.5)
Thickness (min. ave.), mil (mm)	ASTM D5994*	29 (.71)	38 (.95)	57 (1.43)	76 (1.90)	95 (2.38)
Thickness (lowest indiv. for 8 of 10 spec.), mil (mm)	ASTM D5994*	27 (.68)	36 (.90)	54 (1.35)	72 (1.80)	90 (2.25)
Thickness (lowest indiv. for 1 of 10 spec.), mil (mm)	ASTM D5994*	26 (.64)	34 (.85)	51 (1.28)	68 (1.70)	85 (2.13)
*The thickness values may be changed due to project specifications (i.e., absolute minimum thickness)						
Asperity Height (min. ave.), mil (mm)	GRI GM12	16 (.41)	16 (.41)	16 (.41)	16 (.41)	16 (.41)
Density, g/cc, minimum	ASTM D792, Method B	0.94	0.94	0.94	0.94	0.94
Tensile Properties (ave. both directions)	ASTM D6693, Type IV					
Strength @ Yield (min. ave.), lb/in width (N/mm)	2 in/minute	66 (11.6)	88 (15.4)	132 (23.1)	176 (30.8)	220 (38.5)
Elongation @ Yield (min. ave.), % (GL=1.3in)	5 specimens in each direction	13	13	13	13	13
Strength @ Break (min. ave.), lb/in width (N/mm)		66 (11.6)	88 (15.4)	132 (23.1)	176 (30.8)	220 (38.5)
Elongation @ Break (min. ave.), % (GL=2.0in)		350	350	350	350	350
Tear Resistance (min. ave.), lbs. (N)	ASTM D1004	23 (102)	30 (133)	45 (200)	60 (267)	72 (320)
Puncture Resistance (min. ave.), lbs. (N)	ASTM D4833	60 (267)	90 (400)	120 (534)	150 (667)	180 (801)
Carbon Black Content (range in %)	ASTM D4218	2 - 3	2 - 3	2 - 3	2 - 3	2 - 3
Carbon Black Dispersion (Category)	ASTM D5596	Only near spherical agglomerates for 10 views: 9 views in Cat. 1 or 2, and 1 view in Cat. 3				
Stress Crack Resistance (Single Point NCTL), hours	ASTM D5397, Appendix	300	300	300	300	300
Oxidative Induction Time, minutes	ASTM D3895, 200°C, 1 atm O_2	≥100	≥100	≥100	≥100	≥100
Melt Flow Index, g/10 minutes	ASTM D1238, 190°C, 2.16kg	≤1.0	≤1.0	≤1.0	≤1.0	≤1.0
Oven Aging with HP OIT, (% retained after 90 days)	ASTM D5721 / ASTM D5885, 150°C, 500psi O_2	80	80	80	80	80
UV Resistance	GRI GM11	20hr. Cycle @ 75°C/4 hr. dark condensation @ 60°C				
with HP OIT, (% retained after 1600 hours)	ASTM D5885, 150°C, 500psi O_2	50	50	50	50	50

These product specifications meet or exceed GRI's GM13

Supply Information (Standard Roll Dimensions)

Thickness mil	Thickness mm	Width ft	Width m	Length ft	Length m	Area (approx.) ft²	Area (approx.) m²	Weight (average) lbs	Weight (average) kg
30	.75	23	7	600.1	182.9	13,782	1,280	3,325	1,510
40	1.0	23	7	600.1	182.9	13,782	1,280	3,325	1,510
60	1.5	23	7	410.1	125	9,419	875	3,356	1,522
80	2.0	23	7	328.1	100	7,535	700	3,306	1,500
100	2.5	23	7	246.1	75	5,651	525	3,167	1,436

Notes:

All rolls are supplied with two slings. All rolls are wound on a 6 inch core. Special roll lengths are available on request.

All information, recommendations and suggestions appearing in this literature concerning the use of our products are based upon tests and data believed to be reliable; however, it is the users responsibility to determine the suitability for their own use of the products described herein. Since the actual use by others is beyond our control, no guarantee or warranty of any kind, expressed or implied, is made by Agru/America as to the effects of such use or the results to be obtained, nor does Agru/America assume any liability in connection herewith. Any statement made herein may not be absolutely complete since additional information may be necessary or desirable when particular or exceptional conditions or circumstances exist or because of applicable laws or government regulations. Nothing herein is to be construed as permission or as a recommendation to infringe any patent.

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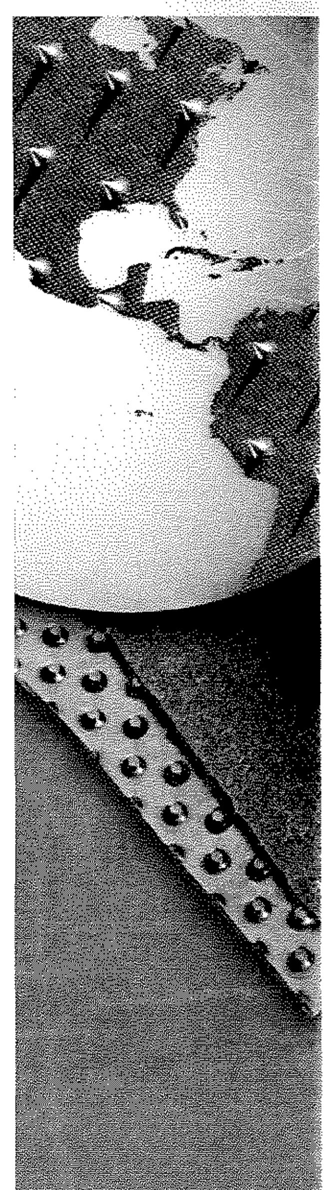
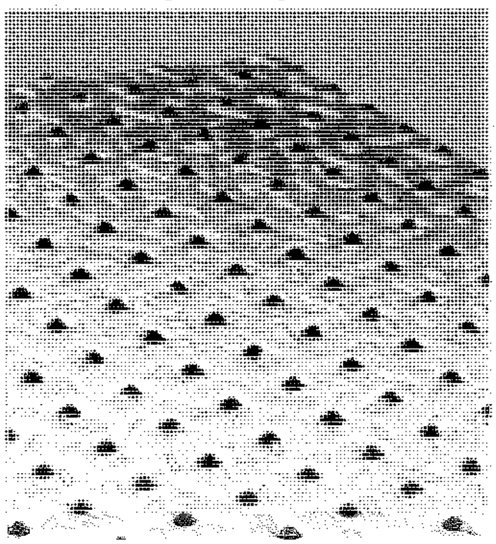
Micro Spike® Textured Geomembrane

Applications for HDPE and LLDPE Micro Spike®, textured geomembranes include projects where slope stability is critical. Micro Spike® is the only HDPE or LLDPE geomembrane that exhibits reproducible texture and friction angle values with the highest interface surface friction values in the industry.

Agru America's structured Geomembranes are produced on state-of-the-art equipment using a flat die-cast extrusion manufacturing process as opposed to blown film extrusion. Agru America is the only manufacturer of structured and embossed Geomembranes in North America.



Micro Spike® surface texture



Comparative properties for Design Consideration

Blown film co-extruded textured surfaces vs. Micro Spike® structured surfaces

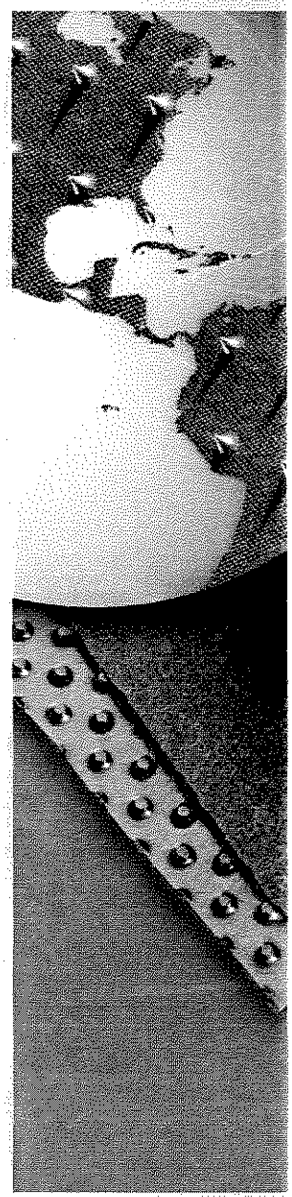
Design Consideration	Blown film co-extruded	Micro Spike® structured
Consistent core thickness	no	yes
Consistent surface texture	no	yes
Consistent asperity height	no	yes
Consistent interface friction	no	yes
Affect on mechanical properties	yes	no
Affect on stress crack potential	yes	no
Affect on multiaxial stress-strain	yes	no
Reduction in CQA program costs (less testing required)	no	yes

The calendared structured liner manufacturing process allows production of the only textured liner with a consistent core thickness, resulting in unchanged mechanical properties from that of smooth sheet. The consistent surface structuring or texture gives Micro Spike® Geomembranes reproducible friction angle values with efficiencies of over 95%.

Representative Large Scale Interface Shear Values
*cap loading conditions (ASTM 5321)**

Soil/Micro Spike® Surface	P	LD
Coarse Sand	34°	34°
Glacial Till	37°	32°
Silty Sand	35°	28°
Non Woven GT	32°	17°

*SGI Testing Services, Atlanta



Micro Spike® geomembranes are manufactured to meet or exceed current industry standards including GRI GM 13 (HDPE) and GRI GM 17 (LLDPE) test values, frequency of testing and functional requirements. Micro Spike® textured Geomembranes have smooth edges to allow for high quality thermal fusion welding between adjacent sheets. All Agru Geomembrane material is rolled on plastic pipe cores to ensure ease of installation without damage to the roll material.

Micro Spike® textured HDPE and LLDPE geomembrane has a decided advantage over blown film textured geomembrane:

Reliability: Micro Spike's® reproducible friction angles gives the design engineer the confidence that he has designed a system that will be built to meet or exceed the project design requirements.

Cost Savings: Micro Spike® is competitively priced with value added advantages including consistent core thickness and texture which reduces the on-site Quality Control and third party Quality Assurance costs.

Consistent Material: The structured "Micro Spikes" are totally integrated with the Geomembrane.

High Interface shear: Exceptional shear resistance between soil and geotextile components allows flexibility and stability during protective cover material placement. The textured asperity height is not only consistent but higher than competitive textured products.

Why specify or use anything else!

Agru has over 20 years experience with Geomembranes and 50 years experience with Thermoplastic Extrusion
Agru offers a wide range of concrete protective liners (Sure Grip), pipe fittings and semi-finished materials.

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Product Data Sheet

GSE HD Textured Geomembranes

GSE HD Textured is the textured version of GSE HD. It is a high quality, high density polyethylene (HDPE) geomembrane with one or two coextruded, textured surfaces, and consisting of appraximately 97.5% polyethylene, 2.5% carbon black and trace amaunts of antioxidants and heat stabilizers; no other additives, fillers or extenders are used. The resin used is specially formulated, virgin polyethylene and is designed specifically for flexible geomembrane applications. GSE HD Textured has excellent resistance to UV radiotion and is suitable for exposed conditions. This product allows projects with greater slopes to be designed since frictional charocteristics are enhanced. *These product specifications meet or exceed GRI GM13.*

Product Specifications

TESTED PROPERTY	TEST METHOD	FREQUENCY	MINIMUM VALUE				
Product Code			HDT 030G000	HDT 040G000	HDT 060G000	HDT 080G000	HDT 100G000
Thickness, (minimum average) mil (mm)	ASTM D 5994	every roll	29 (0.73)	38 (0.96)	57 (1.45)	76 (1.93)	95 (2.41)
Lowest individual for 8 out of 10 values			27 (0.69)	36 (0.91)	54 (1.40)	72 (1.80)	90 (2.30)
Lowest individual for any of the 10 values			26 (0.66)	34 (0.86)	51 (1.30)	68 (1.73)	85 (2.16)
Density, g/cm³	ASTM D 1505	200,000 lb	0.94	0.94	0.94	0.94	0.94
Tensile Properties (each direction)[1]	ASTM D 6693, Type IV	20,000 lb					
Strength at Break, lb/in-width (N/mm)	Dumbell, 2 ipm		45 (8)	60 (11)	90 (16)	120(21)	150 (27)
Strength at Yield, lb/in-width (N/mm)			63 (11)	84 (15)	126 (22)	168 (29)	210 (37)
Elongation at Break, %	G.L. = 2.0 in (51 mm)		100	100	100	100	100
Elongation at Yield, %	G.L. = 1.3 in (33 mm)		12	12	12	12	12
Tear Resistance, lb (N)	ASTM D 1004	45,000 lb	21 (93)	28 (125)	42 (187)	56 (249)	70 (311)
Puncture Resistance, lb (N)	ASTM D 4833	45,000 lb	45 (200)	60 (267)	90 (400)	120 (534)	150 (667)
Carbon Black Content, %	ASTM D 1603*/4218	20,000 lb	2.0	2.0	2.0	2.0	2.0
Carbon Black Dispersion	ASTM D 5596	45,000 lb	+Note 1	+Note 1	+Note 1	+Note 1	+Note 1
Asperity Height	GRI GM 12	second roll	+Note 2	+Note 2	+Note 2	+Note 2	+Note 2
Notched Constant Tensile Load[2], hr	ASTM D 5397, Appendix	200,000 lb	300	300	300	300	300
REFERENCE PROPERTY	**TEST METHOD**	**FREQUENCY**	**NOMINAL VALUE**				
Oxidative Induction Time, min	ASTM D 3895, 200° C; O_2, 1 atm	200,000 lb	>100	>100	>100	>100	>100
Roll Length[3] (approximate), ft (m)	Standard Textured		830 (253)	700 (213)	520 (158)	400 (122)	330 (101)
Roll Width[3], ft (m)			22.5 (6.9)	22.5 (6.9)	22.5 (6.9)	22.5 (6.9)	22.5 (6.9)
Roll Area, ft² (m²)			18,674 (1,735)	15,750 (1,463)	11,700 (1,087)	9,000 (836)	7,425 (690)

NOTES:

- +Note 1: Dispersion only applies to near spherical agglomerates. 9 of 10 views shall be Category 1 or 2. No more than 1 view from Category 3.
- +Note 2: 10 mil average. 8 of 10 readings ≥7 mils. Lowest individual ≥ 5 mils.
- GSE HD Standard Textured is available in rolls weighing about 4,000 lb (1,800 kg).
- [1]The combination of stress concentrations due to coextrusion texture geometry and the small specimen size results in large variation of test results. Therefore, these tensile properties are minimum average values.
- [2]NCTL for HD Textured is conducted on representative smooth membrane samples.
- All GSE geomembranes have dimensional stability of ±2% when tested with ASTM D 1204 and LTB of <-77° C when tested with ASTM D 746.
- [3]Roll lengths and widths have a tolerance of ± 1%.
- *Modified.

DS006 HDtext R01/08/08

This information is provided for reference purposes only and is not intended as a warranty or guarantee. GSE assumes no liability in connection with the use of this information. Please check with GSE for current, standard minimum quality assurance procedures and specifications.

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Asia Pacific	GSE Lining Technology Company Limited	Bangkok, Thailand		66.2.937.0091	Fax: 66.2.937.0097
Europe & Africa	GSE Lining Technology GmbH	Hamburg, Germany		49.40.767420	Fax: 49.40.7674234
Middle East	GSE Lining Technology-Egypt	The 6th of October City, Egypt		20.2.828.8888	Fax: 20.2.828.8889

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GSE

Product Data Sheet

GSE STANDARD PRODUCTS

GSE HD Geomembranes

GSE HD is a smooth, high quality, high density polyethylene (HDPE) geomembrane produced from specially formulated, virgin polyethylene resin. This polyethylene resin is designed specifically for flexible geomembrane applications. It contains approximately 97.5% polyethylene, 2.5% carbon black and trace amounts of antioxidants and heat stabilizers; no other additives, fillers or extenders are used. GSE HD has outstanding chemical resistance, mechanical properties, environmental stress crack resistance, dimensional stability and thermal aging characteristics. GSE HD has excellent resistance to UV radiation and is suitable for exposed conditions. *These product specifications meet or exceed GRI GM13.*

Product Specifications

TESTED PROPERTY	TEST METHOD	FREQUENCY	MINIMUM VALUE				
Product Code			HDE 030A000	HDE 040A000	HDE 060A000	HDE 080A000	HDE 100A000
Thickness, (minimum average) mil (mm)	ASTM D 5199	every roll	30 (0.75)	40 (1.00)	60 (1.50)	80 (2.00)	100 (2.50)
Lowest individual reading (-10%)			27 (0.69)	36 (0.91)	54 (1.40)	72 (1.80)	90 (2.30)
Density, g/cm³	ASTM D 1505	200,000 lb	0.94	0.94	0.94	0.94	0.94
Tensile Properties (each direction)	ASTM D 6693, Type IV	20,000 lb					
Strength at Break, lb/in-width (N/mm)	Dumbell, 2 ipm		114 (20)	152 (27)	228 (40)	304 (53)	380 (67)
Strength at Yield, lb/in-width (N/mm)			63 (11)	84 (15)	126 (22)	168 (29)	210 (37)
Elongation at Break, %	G.L. 2.0 in (51 mm)		700	700	700	700	700
Elongation at Yield, %	G.L. 1.3 in (33 mm)		12	12	12	12	12
Tear Resistance, lb (N)	ASTM D 1004	45,000 lb	21 (93)	28 (125)	42 (187)	56 (249)	70 (311)
Puncture Resistance, lb (N)	ASTM D 4833	45,000 lb	54 (240)	72 (320)	108 (480)	144 (640)	180 (800)
Carbon Black Content, %	ASTM D 1603*/4218	20,000 lb	2.0	2.0	2.0	2.0	2.0
Carbon Black Dispersion	ASTM D 5596	45,000 lb	+Note 1	+Note 1	+Note 1	+Note 1	+Note 1
Notched Constant Tensile Load, hr	ASTM D 5397, Appendix	200,000 lb	300	300	300	300	300
REFERENCE PROPERTY	**TEST METHOD**	**FREQUENCY**	**NOMINAL VALUE**				
Oxidative Induction Time, min	ASTM D 3895, 200° C; O_2, 1 atm	200,000 lb	>100	>100	>100	>100	>100
Roll Length[(1)] (approximate), ft (m)			1,120 (341)	870 (265)	560 (171)	430 (131)	340 (104)
Roll Width[(1)], ft (m)			22.5 (6.9)	22.5 (6.9)	22.5 (6.9)	22.5 (6.9)	22.5 (6.9)
Roll Area, ft² (m²)			25,200 (2,341)	19,575 (1,819)	12,600 (1,171)	9,675 (899)	7,650 (711)

NOTES:

- +Note 1: Dispersion only applies to near spherical agglomerates. 9 of 10 views shall be Category 1 or 2. No more than 1 view from Category 3.
- GSE HD is available in rolls weighing about 3,900 lb (1,769 kg)
- All GSE geomembranes have dimensional stability of ±2% when tested with ASTM D 1204 and LTB of <-77° C when tested with ASTM D 746.
- [(1)]Roll lengths and widths have a tolerance of ± 1%.
- *Modified.

DS005 HD R01/07/08

North America	GSE Lining Technology, Inc.	Houston, Texas	800.435.2008	281.443.8564	Fax: 281.230.6739
South America	GSE Lining Technology Chile S.A.	Santiago, Chile		56.2.595.4200	Fax: 56.2.595.4290
Asia Pacific	GSE Lining Technology Company Limited	Bangkok, Thailand		66.2.937.0091	Fax: 66.2.937.0097
Europe & Africa	GSE Lining Technology GmbH	Hamburg, Germany		49.40.767420	Fax: 49.40.7674234
Middle East	GSE Lining Technology-Egypt	The 6th of October City, Egypt		20.2.828.8888	Fax: 20.2.828.8889

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GSE

Product Data Sheet

GSE STANDARD PRODUCTS

GSE Nonwoven Geotextiles

GSE Nonwoven Geotextiles is a family of polypropylene, staple fiber, nonwoven, needlepunched geotextiles. Manufactured using an advanced manufacturing and quality system, these products are the most uniform and consistent nonwoven, needlepunched geotextile currently available in the industry. GSE combines a fiber selection and approval system with in-line quality control and a state-of-the-art laboratory to ensure that every roll shipped meets customer specifications. The company has performed extensive performance testing to evaluate suitability of its nonwovens for various applications. GSE Nonwoven Geotextiles are available in a range of weights to meet your specific project needs. *These product specifications meet or exceed GRI GT12, GRI GT13 and AASHTO M288.*

Product Specifications

TESTED PROPERTY	TEST METHOD	FREQUENCY	NW4	NW6	NW8	NW10	NW12	NW16
Product Code			GEO 0408002	GEO 0608002	GEO 0808002	GEO 1008002	GEO 1208002	GEO 1608002
AASHTO M288 Class			3	2	1	>1	>>1	>>>1
Mass per Unit Area, oz/yd² (g/m²)	ASTM D 5261	90,000 ft²	4 (135)	6 (200)	8 (270)	10 (335)	12 (405)	16 (540)
Grab Tensile Strength, lb (N)	ASTM D 4632	90,000 ft²	120 (530)	170 (755)	220 (975)	260 (1,155)	320 (1,420)	390 (1,735)
Grab Elongation, %	ASTM D 4632	90,000 ft²	50	50	50	50	50	50
Puncture Strength, lb (N)	ASTM D 4833	90,000 ft²	60 (265)	90 (395)	120 (525)	165 (725)	190 (835)	240 (1,055)
Trapezoidal Tear Strength, lb (N)	ASTM D 4533	90,000 ft²	50 (220)	70 (310)	95 (420)	100 (445)	125 (555)	150 (665)
Apparent Opening Size, Sieve No. (mm)	ASTM D 4751	540,000 ft²	70 (0.212)	70 (0.212)	80 (0.180)	100 (0.150)	100 (0.150)	100 (0.150)
Permittivity, sec⁻¹	ASTM D 4491	540,000 ft²	1.50	1.50	1.50	1.20	0.80	0.70
Permeability, cm/sec	ASTM D 4491	540,000 ft²	0.22	0.30	0.30	0.30	0.29	0.27
Water Flow Rate, gpm/ft² (l/min/m²)	ASTM D 4491	540,000 ft²	120 (4,885)	110 (4,480)	110 (4,480)	85 (3,460)	60 (2,440)	50 (2,035)
UV Resistance (% retained after 500 hours)	ASTM D 4355	per formulation	70	70	70	70	70	70
Roll Length[1], ft (m)			600 (182)	600 (182)	600 (182)	300 (91)	300 (91)	300 (91)
Roll Width[1], ft (m)			15 (4.6)	15 (4.6)	15 (4.6)	15 (4.6)	15 (4.6)	15 (4.6)
Roll Area, ft² (m²)			9,000 (836)	9,000 (836)	9,000 (836)	4,500 (418)	4,500 (418)	4,500 (418)

NOTES:

- The property values listed are in weaker principal direction. All values listed are Minimum Average Roll Values (MARV) except apparent opening size in mm and UV resistance. Apparent opening size (mm) is a Maximum Average Roll Value. UV is a typical value.
- [1]Roll lengths and widths have a tolerance of ±1%.

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Europe & Africa	GSE Lining Technology GmbH	Hamburg, Germany		49.40.767420	Fax: 49.40.7674234
Middle East	GSE Lining Technology-Egypt	The 6th of October City, Egypt		20.2.828.8888	Fax: 20.2.828.8889

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Product Data Sheet

GSE FabriNet Geocomposites (Double-Sided)

GSE FabriNet geocomposite consists of GSE HyperNet geonet heat-laminated on both sides with a GSE nonwoven needlepunched geotextile. GSE HyperNet is a 200 mil thick geonet manufactured from a premium grade high density polyethylene resin. For the purpose of lamination to geonets, GSE nonwoven needlepunched geotextiles are available in mass per unit area range of 6 oz/yd² (200 g/m²) to 16 oz/yd² (540 g/m²). GSE FabriNet geocomposites are designed and formulated to perform drainage function under a range of anticipated site loads, gradients and boundary conditions. Index properties for the product are provided in the table below. Please contact GSE for further information regarding performance under site-specific conditions.

Product Specifications

TESTED PROPERTY	TEST METHOD	FREQUENCY	MINIMUM AVERAGE ROLL VALUE[a]		
Geocomposite			6 oz/yd²	8 oz/yd²	10 oz/yd²
Product Code			F42060060S	F42080080S	F42100100S
Transmissivity[b], gal/min/ft (m²/sec)	ASTM D 4716	1/540,000 ft²	0.48 (1 x 10⁻⁴)	0.48 (1 x 10⁻⁴)	0.43 (9 x 10⁻⁵)
Ply Adhesion, lb/in (g/cm)	ASTM D 7005	1/50,000 ft²	1.0 (178)	1.0 (178)	1.0 (178)
Roll Width[c], ft (m)			14.5 (4.4)	14.5 (4.4)	14.5 (4.4)
Roll Length[c], ft (m)			230 (70.1)	200 (60.9)	190 (58.0)
Roll Area, ft² (m²)			3,335 (310)	2,900 (269)	2,755 (256)
Geonet core[d]					
Transmissivity,[b] gal/min/ft (m²/sec)	ASTM D 4716		9.66 (2 x 10⁻³)	9.66 (2 x 10⁻³)	9.66 (2 x 10⁻³)
Thickness, mil (mm)	ASTM D 5199	1/50,000 ft²	200 (5)	200 (5)	200 (5)
Density, g/cm³	ASTM D 1505	1/50,000 ft²	0.94	0.94	0.94
Tensile Strength (MD), lb/in (N/mm)	ASTM D 5035	1/50,000 ft²	45 (7.9)	45 (7.9)	45 (7.9)
Carbon Black Content, %	ASTM D 1603*/4218	1/50,000 ft²	2.0	2.0	2.0
Geotextile (prior to lamination)[d,e]					
Mass per Unit Area, oz/yd² (g/m²)	ASTM D 5261	1/90,000 ft²	6 (200)	8 (270)	10 (335)
Grab Tensile, lb (N)	ASTM D 4632	1/90,000 ft²	170 (755)	220 (975)	260 (1,155)
Puncture Strength, lb (N)	ASTM D 4833	1/90,000 ft²	90 (395)	120 (525)	165 (725)
AOS, US sieve (mm)	ASTM D 4751	1/540,000 ft²	70 (0.212)	80 (0.180)	100 (0.150)
Permittivity, (sec⁻¹)	ASTM D 4491	1/540,000 ft²	1.5	1.5	1.2
Flow Rate, gpm/ft² (lpm/m²)	ASTM D 4491	1/540,000 ft²	110 (4,480)	110 (4,480)	85 (3,460)
UV Resistance, % retained	ASTM D 4355 (after 500 hours)	once per formulation	70	70	70

NOTES:

- [a]These are MARV values that are based on the cumulative results of specimens tested and determined by GSE. AOS in mm is a maximum average roll value.
- [b]Gradient of 0.1, normal load of 10,000 psf, water at 70° F between steel plates for 15 minutes.
- [c]Roll widths and lengths have a tolerance of ±1%.
- [d]Component properties prior to lamination.
- [e]Refer to geotextile product data sheet for additional specifications.
- *Modified.

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POLY-FLEX, INC.

An Engineering Approach to Groundwater Protection

REFERENCE MANUAL

POLY-FLEX
POLYETHYLENE GEOMEMBRANES

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VI DRAINAGE NET AND GEOCOMPOSITE MANUFACTURING QUALITY CONTROL & QUALITY ASSURANCE

POLY-FLEX
POLYETHYLENE GEOMEMBRANES

Poly-Flex Liner Specifications

POLY-FLEX HDPE & LLDPE LINER SPECIFICATIONS

1. GENERAL REQUIREMENTS

1.1 Scope

The following describes parameters for the manufacture, supply, and installation of Poly-Flex polyethylene geomembranes. All procedures, operations, and methods shall be in strict accordance with the engineer's specifications, plans, and drawings.

1.2 Qualifications of Contractor Work Activities

1.2.1 Manufacturing

The manufacturer shall have at least five (5) years continuous experience in manufacturing polyethylene geomembrane and/or experience totaling 10,000,000 square feet of manufactured polyethylene geomembrane.

1.2.2 Installation

The installation contractor shall be the manufacturer or a dealer trained to install the manufacturer's geomembrane.

Installation shall be performed under the constant direction of a field installation supervisor who shall remain on site and be responsible, throughout the liner installation, for liner layout, seaming, testing, repairs, and all other activities by the Installer. The field installation supervisor shall have installed or supervised the installation of a minimum of 2,000,000 square feet of polyethylene geomembrane. Seaming shall be performed under the direction of a master seamer (who may also be the field installation supervisor) who has seamed a minimum of 2,000,000 square feet of polyethylene geomembrane, using the same type of seaming apparatus specified for this project. The field installation supervisor and/or master seamer shall be present whenever seaming is performed.

1.3 Submittals

1.3.1 Manufacturer

The manufacturer shall provide the following information:

A. Submittals with Bid Documents

1. List of material properties.
2. Manufacturing quality control program.

B. Submittals After Contract Award, Prior to Liner Installation

1. Copy of quality control certificates issued by the resin supplier.
2. Copy of quality control certificates for the geomembranes in conformance with Section 2.4.3.

1.3.2 Installation Contractor

The installer shall provide the following written information:

A. Submittals With Bid Documents

A list of completed facilities, totaling a minimum of 2,000,000 square feet, for which the installer has installed polyethylene geomembrane. For each installation, the following information shall be provided:

a. Name and purpose of facility, location, and date of installation.

b. Name of owner, design engineer, manufacturer, and name and telephone number of contact at the facility who can discuss the project.

c. Thickness and quantity of the installed geomembrane.

B. Submittals by Successful Bidder Prior to Commencement of Installation

1. Proposed installation panel layout.
2. Resume(s) of the field installation supervisor and master seamer.

1.4 Meeting

A daily meeting shall be held at the work area just prior to commencement of the work to discuss work activities. The earthwork contractor, the liner installer and the inspector shall be present.

1.5 Warranty

A written Warranty shall be obtained from the manufacturer (for material) and the installation contractor (for workmanship). These documents shall warrant both the quality of the material and workmanship for a specified duration of time.

2. MATERIAL SPECIFICATIONS

2.1 Materials

1. The geomembrane shall be High-Density Polyethylene (HDPE) or Linear Low Density Polyethylene (LLDPE).
2. Gasket material shall be neoprene, closed cell medium, 1/4-inch thick, 2 inches wide with adhesive on one side, or other compatible gasket materials as required.
3. Metal battens or banding and hardware shall be stainless steel.
4. Water cut-off mastic shall be Neoprene Flashing Cement as supplied by Poly-Flex, Inc., or as required.
5. Sealant shall be General Electric Silicone, RTV 103, or equivalent.

2.2 Geomembrane Raw Materials

The geomembrane shall be manufactured of polyethylene resins produced in the United States and shall be compounded and manufactured specifically for the intended purpose. The resin manufacturer shall certify each lot for the following properties.

The natural polyethylene resin without the carbon black shall meet the following requirements:

Property	Test Method	HDPE Requirements	LLDPE Requirements
Density, g/cc	ASTM D 1505 or ASTM D 792	0.935 - 0.940	0.915 - 0.926
Melt Index, g/10 min.	ASTM D 1238	<0.4	<0.6

2.3 Rolls

The geomembrane shall be a minimum 23.0 ft seamless width, as manufactured by Poly-Flex, Inc. (2000 W. Marshall Dr., Grand Prairie, TX 75051, 888-765-9359). Carbon black shall be added to the resin if the resin is not compounded for ultra-violet resistance.

The surface of the smooth geomembrane shall not have striations, roughness, pinholes, or bubbles.

The geomembrane shall be supplied in rolls. Labels on each roll shall identify the thickness of the material, the length and width of the roll, lot and roll numbers, and name of manufacturer.

The geomembrane rolls shall meet the following specifications:

SMOOTH HDPE GEOMEMBRANE ENGLISH UNITS

Minimum Average Values

Property	Test Method	30 mil	40 mil	60 mil	80 mil	100 mil
Thickness, mils	ASTM D 5199					
minimum average		30	40	60	80	100
lowest individual reading		27	36	54	72	90
Sheet Density, g/cc	ASTM D 1505/D 792	0.940	0.940	0.940	0.940	0.940
Tensile Properties[1]	ASTM D 6693					
1. Yield Strength, lb/in		63	84	126	168	210
2. Break Strength, lb/in		114	152	228	304	380
3. Yield Elongation, %		12	12	12	12	12
4. Break Elongation, %		700	700	700	700	700
Tear Resistance, lb	ASTM D 1004	21	28	42	56	70
Puncture Resistance, lb	ASTM D 4833	54	72	108	144	180
Stress Crack Resistance[2], hrs	ASTM D 5397 (App.)	300	300	300	300	300
Carbon Black Content[3], %	ASTM D 1603	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0
Carbon Black Dispersion	ASTM D 5596			–Note 4–		
Oxidative Induction Time (OIT) Standard OIT, minutes	ASTM D 3895	100	100	100	100	100
Oven Aging at 85°C	ASTM D 5721					
High Pressure OIT - % retained after 90 days	ASTM D 5885	80	80	80	80	80
UV Resistance[5]	GRI GM11					
High Pressure OIT[6] - % retained after 1600 hrs	ASTM D 5885	50	50	50	50	50
Seam Properties	ASTM D 6392 (@ 2 in/min)					
1. Shear Strength, lb/in		57	80	120	160	200
2. Peel Strength, lb/in - Hot Wedge		45	60	91	121	151
- Extrusion Fillet		39	52	78	104	130
Roll Dimensions						
1. Width (feet):		23	23	23	23	23
2. Length (feet)		1000	750	500	375	300
3. Area (square feet):		23,000	17,250	11,500	8,625	6,900
4. Gross weight (pounds, approx.)		3,470	3,470	3,470	3,470	3,470

1 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 gauge length of 1.3 inches; Break elongation is calculated using a gauge length of 2.0 inches.
2 The yield stress used to calculate the applied load for the SP-NCTL test should be the mean value via MQC testing.
3 Other methods such as ASTM D 4218 or microwave methods are acceptable if an appropriate correlation can be established.
4 Carbon black dispersion for 10 different views: Nine in Categories 1 and 2 with one allowed in Category 3.
5 The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.
6 UV resistance is based on percent retained value regardless of the original HP-OIT value.

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POLY-FLEX
POLYETHYLENE GEOMEMBRANES

SMOOTH HDPE GEOMEMBRANE METRIC UNITS

Property	Test Method	0.75 mm	1.00 mm	1.50 mm	2.00 mm	2.50 mm
		Minimum Average Values				
Thickness, microns	ASTM D 5199					
minimum average		750	1,000	1,500	2,000	2,500
lowest individual reading		675	900	1,350	1,800	2,250
Sheet Density, g/cc	ASTM D 1505/D 792	0.940	0.940	0.940	0.940	0.940
Tensile Properties[1]	ASTM D 6693					
1. Yield Strength, kN/m		11	15	22	29	37
2. Break Strength, kN/m		20	27	40	53	67
3. Yield Elongation, %		12	12	12	12	12
4. Break Elongation, %		700	700	700	700	700
Tear Resistance, N	ASTM D 1004	93	125	187	249	311
Puncture Resistance, N	ASTM D 4833	240	320	480	640	800
Stress Crack Resistance[2], hrs	ASTM D 5397 (App.)	300	300	300	300	300
Carbon Black Content[3], %	ASTM D 1603	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0
Carbon Black Dispersion	ASTM D 5596			–Note 4–		
Oxidative Induction Time (OIT)						
Standard OIT, minutes	ASTM D 3895	100	100	100	100	100
Oven Aging at 85°C	ASTM D 5721					
High Pressure OIT - % retained after 90 days	ASTM D 5885	80	80	80	80	80
UV Resistance[5]	GRI GM11					
High Pressure OIT[6] - % retained after 1600 hrs	ASTM D 5885	50	50	50	50	50
Seam Properties	ASTM D 6392 (@ 5 cm/min)					
1. Shear Strength, kN/m		10	14	21	28	35
2. Peel Strength, kN/m - Hot Wedge		7.9	10.5	15.9	21.2	26.4
- Extrusion Fillet		6.8	9.1	13.6	18.2	22.8
Roll Dimensions						
1. Width (meters):		7	7	7	7	7
2. Length (meters)		304.9	228.7	152.4	114.3	91.5
3. Area (square meters):		2,137	1,603	1,068	801	641
4. Gross weight (kilograms, approx.)		1,574	1,574	1,574	1,574	1,574

1 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 gauge length of 33 mm; Break elongation is calculated using a gauge length of 50 mm.
2 The yield stress used to calculate the applied load for the SP-NCTL test should be the mean value via MQC testing.
3 Other methods such as ASTM D 4218 or microwave methods are acceptable if an appropriate correlation can be established.
4 Carbon black dispersion for 10 different views: Nine in Categories 1 and 2 with one allowed in Category 3.
5 The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.
6 UV resistance is based on percent retained value regardless of the original HP-OIT value.

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TEXTURED HDPE GEOMEMBRANE ENGLISH UNITS

POLY-FLEX
POLYETHYLENE GEOMEMBRANES

Property	Test Method	40 mil	60 mil	80 mil	100 mil
		Minimum Average Values			
Thickness, mils	ASTM D 5994				
minimum average		38	57	76	95
lowest individual of 8 of 10 readings		36	54	72	90
lowest individual of 10 readings		34	51	68	85
Asperity Height[1], mils	GRI GM12	10	10	10	10
Sheet Density, g/cc	ASTM D 1505/D 792	0.940	0.940	0.940	0.940
Tensile Properties[2]	ASTM D 6693				
1. Yield Strength, lb/in		84	126	168	210
2. Break Strength, lb/in		60	90	120	150
3. Yield Elongation, %		12	12	12	12
4. Break Elongation, %		100	100	100	100
Tear Resistance, lb	ASTM D 1004	28	42	56	70
Puncture Resistance, lb	ASTM D 4833	60	90	120	150
Stress Crack Resistance[3], hrs	ASTM D 5397 (App.)	300	300	300	300
Carbon Black Content[4], %	ASTM D 1603	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0
Carbon Black Dispersion	ASTM D 5596		–Note 5–		
Oxidative Induction Time (OIT)					
Standard OIT, minutes	ASTM D 3895	100	100	100	100
Oven Aging at 85°C	ASTM D 5721				
High Pressure OIT - % retained after 90 days	ASTM D 5885	80	80	80	80
UV Resistance[6]	GRI GM11				
High Pressure OIT[7] - % retained after 1600 hrs	ASTM D 5885	50	50	50	50
Seam Properties	ASTM D 6392 (@ 2 in/min)				
1. Shear Strength, lb/in		80	120	160	200
2. Peel Strength, lb/in - Hot Wedge		60	91	121	151
- Extrusion Fillet		52	78	104	130
Roll Dimensions					
1. Width (feet):		23	23	23	23
2. Length (feet)		750	500	375	300
3. Area (square feet):		17,250	11,500	8,625	6,900
4. Gross weight (pounds, approx.)		3,500	3,500	3,470	3,470

1 Of 10 readings; 8 must be ≥ 7 mils and lowest individual reading must be ≥ 5 mils.
2 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 gauge length of 1.3 inches; Break elongation is calculated using a gauge length of 2.0 inches.
3 The yield stress used to calculate the applied load for the SP-NCTL test should be the mean value via MQC testing.
4 Other methods such as ASTM D 4218 or microwave methods are acceptable if an appropriate correlation can be established.
5 Carbon black dispersion for 10 different views: Nine in Categories 1 and 2 with one allowed in Category 3.
6 The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.
7 UV resistance is based on percent retained value regardless of the original HP-OIT value.

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POLY-FLEX POLYETHYLENE GEOMEMBRANES

TEXTURED HDPE GEOMEMBRANE METRIC UNITS

Property	Test Method	Minimum Average Values 1.00 mm	1.50 mm	2.00 mm	2.50 mm
Thickness, microns	ASTM D 5994				
minimum average		950	1,425	1,900	2,375
lowest individual of 8 of 10 readings		900	1,350	1,800	2,250
lowest individual of 10 readings		850	1,275	1,700	2,125
Asperity Height[1], microns	GRI GM12	250	250	250	250
Sheet Density, g/cc	ASTM D 1505/D 792	0.940	0.940	0.940	0.940
Tensile Properties[2]	ASTM D 6693				
1. Yield Strength, kN/m		15	22	29	37
2. Break Strength, kN/m		11	16	21	26
3. Yield Elongation, %		12	12	12	12
4. Break Elongation, %		100	100	100	100
Tear Resistance, N	ASTM D 1004	125	187	249	311
Puncture Resistance, N	ASTM D 4833	267	400	534	667
Stress Crack Resistance[3], hrs	ASTM D 5397 (App.)	300	300	300	300
Carbon Black Content[4], %	ASTM D 1603	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0
Carbon Black Dispersion	ASTM D 5596	–Note 5–			
Oxidative Induction Time (OIT) Standard OIT, minutes	ASTM D 3895	100	100	100	100
Oven Aging at 85°C High Pressure OIT - % retained after 90 days	ASTM D 5721 ASTM D 5885	80	80	80	80
UV Resistance[6] High Pressure OIT[7] - % retained after 1600 hrs	GRI GM11 ASTM D 5885	50	50	50	50
Seam Properties	ASTM D 6392 (@ 5 cm/min)				
1. Shear Strength, kN/m		14	24	28	35
2. Peel Strength, kN/m - Hot Wedge		10.5	15.9	21.2	26.4
- Extrusion Fillet		9.1	13.6	18.2	22.8
Roll Dimensions					
1. Width (meters):		7	7	7	7
2. Length (meters):		228.7	152.4	114.3	91.5
3. Area (square meters):		1,603	1,068	801	641
4. Gross weight (kilograms, approx):		1,588	1,588	1,574	1,574

1 Of 10 readings; 8 must be ≥ 180 microns and lowest individual reading must be ≥ 130 microns.
2 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 gauge length of 33 mm; Break elongation is calculated using a gauge length of 50 mm.
3 The yield stress used to calculate the applied load for the SP-NCTL test should be the mean value via MQC testing.
4 Other methods such as ASTM D 4218 or microwave methods are acceptable if an appropriate correlation can be established.
5 Carbon black dispersion for 10 different views: Nine in Categories 1 and 2 with one allowed in Category 3.
6 The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.
7 UV resistance is based on percent retained value regardless of the original HP-OIT value.

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SMOOTH LLDPE GEOMEMBRANE ENGLISH UNITS

POLY-FLEX POLYETHYLENE GEOMEMBRANES

Property	Test Method	Minimum Average Values 30 Mil	40 Mil	60 Mil	80 Mil
Thickness, mils	ASTM D 5199				
minimum average		30	40	60	80
lowest individual reading		27	36	54	72
Sheet Density, g/cc (max.)	ASTM D 1505/D 792	0.939	0.939	0.939	0.939
Tensile Properties[1]	ASTM D 6693				
1. Break Strength, lb/in		114	152	228	304
2. Break Elongation, %		800	800	800	800
2% Modulus, lb/in² (max.)	ASTM D 5323	60,000	60,000	60,000	60,000
Tear Resistance, lb	ASTM D 1004	16	22	33	44
Puncture Resistance, lb	ASTM D 4833	42	56	84	112
Axi-Symetric Break Strain, %	ASTM D 5617	30	30	30	30
Carbon Black Content[2], %	ASTM D 1603	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0
Carbon Black Dispersion	ASTM D 5596	–Note 3–			
Oxidative Induction Time (OIT) Standard OIT, minutes	ASTM D 3895	100	100	100	100
Oven Aging at 85°C High Pressure OIT - % retained after 90 days	ASTM D 5721 ASTM D 5885	60	60	60	60
UV Resistance[4] High Pressure OIT[5] - % retained after 1600 hrs	GRI GM11 ASTM D 5885	35	35	35	35
Seam Properties	ASTM D 6392 (@ 2 in/min)				
1. Shear Strength, lb/in		45	60	90	120
2. Peel Strength, lb/in - Hot Wedge		38	50	75	100
- Extrusion Fillet		34	44	66	88
Roll Dimensions					
1. Width (feet):		23	23	23	23
2. Length (feet):		1,000	750	500	375
3. Area (square feet):		23,000	17,250	11,500	8,625
4. Gross weight (pounds, approx.):		3,435	3,435	3,435	3,435

1 Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction. Break elongation is calculated using a gauge length of 2.0 inches.
2 Other methods such as ASTM D 4218 or microwave methods are acceptable if an appropriate correlation can be established.
3 Carbon black dispersion for 10 different views: Nine in Categories 1 and 2 with one allowed in Category 3.
4 The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.
5 UV resistance is based on percent retained value regardless of the original HP-OIT value.

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POLY-FLEX
POLYETHYLENE GEOMEMBRANES

SMOOTH LLDPE GEOMEMBRANE METRIC UNITS

Property	Test Method	Minimum Average Values 0.75 mm	1.00 mm	1.50 mm	2.00 mm
Thickness, microns	ASTM D 5199				
minimum average		750	1,000	1,500	2,000
lowest individual reading		675	900	1,350	1,800
Sheet Density, g/cc (max.)	ASTM D 1505/D 792	0.939	0.939	0.939	0.939
Tensile Properties[1]	ASTM D 6693				
1. Break Strength, kN/m		20	27	40	53
2. Break Elongation, %		800	800	800	800
2% Modulus, MPa (max.)	ASTM D 5323	414	414	414	414
Tear Resistance, N	ASTM D 1004	70	100	150	200
Puncture Resistance, N	ASTM D 4833	190	250	370	500
Axi-Symetric Break Strain, %	ASTM D 5617	30	30	30	30
Carbon Black Content[2], %	ASTM D 1603	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0
Carbon Black Dispersion	ASTM D 5596	--Note 3--			
Oxidative Induction Time (OIT) Standard OIT, minutes	ASTM D 3895	100	100	100	100
Oven Aging at 85°C	ASTM D 5721				
High Pressure OIT - % retained after 90 days	ASTM D 5885	60	60	60	60
UV Resistance[4]	GRI GM11				
High Pressure OIT[5] - % retained after 1600 hrs	ASTM D 5885	35	35	35	35
Seam Properties	ASTM D 6392 (@ 5 cm/min)				
1. Shear Strength, kN/m		7.9	10.5	15.8	21.0
2. Peel Strength, kN/m - Hot Wedge		6.6	8.7	13.1	17.5
- Extrusion Fillet		5.9	7.7	11.5	15.4
Roll Dimensions					
1. Width (meters):		7	7	7	7
2. Length (meters):		304.9	228.7	152.4	114.3
3. Area (square meters):		2,137	1,603	1,068	801
4. Gross weight (kilograms, approx.):		1,558	1,558	1,558	1,558

1 Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction. Break elongation is calculated using a gauge length of 50 mm
2 Other methods such as ASTM D 4218 or microwave methods are acceptable if an appropriate correlation can be established.
3 Carbon black dispersion for 10 different views: Nine in Categories 1 and 2 with one allowed in Category 3.
4 The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.
5 UV resistance is based on percent retained value regardless of the original HP-OIT value.
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TEXTURED LLDPE GEOMEMBRANE ENGLISH UNITS

POLY-FLEX
POLYETHYLENE GEOMEMBRANES

Property	Test Method	Minimum Average Values 40 Mil	60 Mil	80 Mil
Thickness, mils	ASTM D 5994			
minimum average		38	57	76
lowest individual of 8 of 10 readings		36	54	72
lowest individual of 10 readings		34	51	68
Asperity Height[1], mils	GRI GM12	10	10	10
Sheet Density, g/cc (max.)	ASTM D 1505/D 792	0.939	0.939	0.939
Tensile Properties[2]	ASTM D 6693			
1. Break Strength, lb/in		60	90	120
2. Break Elongation, %		250	250	250
2% Modulus, lb/in^2 (max.)	ASTM D 5323	60,000	60,000	60,000
Tear Resistance, lb	ASTM D 1004	22	33	44
Puncture Resistance, lb	ASTM D 4833	44	66	88
Axi-Symetric Break Strain, %	ASTM D 5617	30	30	30
Carbon Black Content[3], %	ASTM D 1603	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0
Carbon Black Dispersion	ASTM D 5596		--Note 4--	
Oxidative Induction Time (OIT) Standard OIT, minutes	ASTM D 3895	100	100	100
Oven Aging at 85°C	ASTM D 5721			
High Pressure OIT - % retained after 90 days	ASTM D 5885	60	60	60
UV Resistance[5]	GRI GM11			
High Pressure OIT[6] - % retained after 1600 hrs	ASTM D 5885	35	35	35
Seam Properties	ASTM D 6392 (@ 2 in/min)			
1. Shear Strength, lb/in		60	90	120
2. Peel Strength, lb/in - Hot Wedge		50	75	100
- Extrusion Fillet		44	66	88
Roll Dimensions				
1. Width (feet):		23	23	23
2. Length (feet):		750	500	375
3. Area (square feet):		17,250	11,500	8,625
4. Gross weight (pounds, approx.):		3,465	3,465	3,435

1 Of 10 readings: 8 must be ≥ 7 mils and lowest individual reading must be ≥ 5 mils.
2 Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction. Break elongation is calculated using a gauge length of 2.0 inches.
3 Other methods such as ASTM D 4218 or microwave methods are acceptable if an appropriate correlation can be established.
4 Carbon black dispersion for 10 different views: Nine in Categories 1 and 2 with one allowed in Category 3.
5 The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.
6 UV resistance is based on percent retained value regardless of the original HP-OIT value.
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POLY-FLEX POLYETHYLENE GEOMEMBRANES

TEXTURED LLDPE GEOMEMBRANE METRIC UNITS

Property	Test Method	Minimum Average Values 1.00 mm	1.50 mm	2.00 mm
Thickness, microns	ASTM D 5994			
minimum average		950	1,425	1,900
lowest individual of 8 of 10 readings		900	1,350	1,800
lowest individual of 10 readings		850	1,275	1,700
Asperity Height[1], microns	GRI GM12	250	250	250
Sheet Density, g/cc (max.)	ASTM D 1505/D 792	0.939	0.939	0.939
Tensile Properties[2]	ASTM D 6693			
1. Break Strength, kN/m		11	16	21
2. Break Elongation, %		250	250	250
2% Modulus, MPa (max.)	ASTM D 5323	414	414	414
Tear Resistance, N	ASTM D 1004	100	150	200
Puncture Resistance, N	ASTM D 4833	200	300	400
Axi-Symetric Break Strain, %	ASTM D 5617	30	30	30
Carbon Black Content[3], %	ASTM D 1603	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0
Carbon Black Dispersion	ASTM D 5596		–Note 4–	
Oxidative Induction Time (OIT) Standard OIT, minutes	ASTM D 3895	100	100	100
Oven Aging at 85°C	ASTM D 5721			
High Pressure OIT - % retained after 90 days	ASTM D 5885	60	60	60
UV Resistance[5]	GRI GM11			
High Pressure OIT[6] - % retained after 1600 hrs	ASTM D 5885	35	35	35
Seam Properties	ASTM D 6392 (@ 5 cm/min)			
1. Shear Strength, kN/m		10.5	15.8	21.0
2. Peel Strength, kN/m - Hot Wedge		8.7	13.1	17.5
- Extrusion Fillet		5.9	7.7	11.5
Roll Dimensions				
1. Width (meters):		7	7	7
2. Length (meters):		228.7	152.4	114.3
3. Area (square meters):		1,603	1,068	801
4. Gross weight (kilograms, approx.):		1,572	1,572	1,558

1 Of 10 readings; 8 must be ≥ 180 microns and lowest individual reading must be ≥ 130 microns.
2 Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction. Break elongation is calculated using a gauge length of 50 mm.
3 Other methods such as ASTM D 4218 or microwave methods are acceptable if an appropriate correlation can be established.
4 Carbon black dispersion for 10 different views: Nine in Categories 1 and 2 with one allowed in Category 3.
5 The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.
6 UV resistance is based on percent retained value regardless of the original HP-OIT value.

POLY-FLEX POLYETHYLENE GEOMEMBRANES

2.4 Quality Control Specifications

2.4.1 Raw Materials

A. Resin

All resins for use in geomembrane must pass a candidate pre-approval process before being eligible for use. Each incoming railcar shall be sampled with the following testing performed and compared to the manufacturer's specifications:

1. Density: ASTM D 1505.
2. Melt Index: ASTM D 1238.
3. Oxidative Induction Time (OIT): ASTM D 3895.

B. Additives

All incoming materials are to be tested and approved prior to use with the following testing performed and compared to the manufacturer's specifications:

1. Carbon Black Content: ASTM D 1603.
2. Oxidative Induction Time (OIT): ASTM D 3895.

2.4.2 Finished Product: During Production

A. Inspection

Performed on each roll during manufacturing.

1. Appearance

Sheet surface appearance shall be monitored for flaws.

2. Thickness

A full width sample shall be cut from the end of each roll for thickness measurement.

B. Roll Identification

Four tags per roll shall be used.

1. Outside the core.
2. On the core plug.
3. On the roll surface.
4. On the production roll sample.

C. Out-of-Spec. Material

Any roll not meeting the specification for any of the above inspections shall be separated from other rolls and placed on hold.

2.4.3 Manufacturer's Quality Control & Quality Assurance Testing

A. Sampling

Full width samples shall be taken as retains from the end of each roll to the manufacturer's laboratory.

B. Testing

The geomembrane quality control testing shall meet the following frequency requirements:

Property	Test Method	Testing Frequency (min.)
Thickness (smooth sheet) (textured sheet)	ASTM D 5199 ASTM D 5994	per roll
Asperity Height (textured sheet only) Alternate the measurement side for double-sided textured sheet.	GRI GM12	every second roll
Sheet Density	ASTM D 1505/D 792	200,000 lb (90,000 kg)
Tensile Properties 1. Yield Strength (HDPE only) 2. Break Strength 3. Yield Elongation (HDPE only) 4. Break Elongation	ASTM D 6693	20,000 lb (9,000 kg)
2% Modulus (LLDPE only)	ASTM D 5323	per each formulation
Tear Resistance	ASTM D 1004	45,000 lb (20,000 kg)
Puncture Resistance	ASTM D 4833	45,000 lb (20,000 kg)
Axi-Symetric Break Strain (LLDPE only)	ASTM D 5617	per each formulation
Stress Crack Resistance (HDPE only)	ASTM D 5397 (App.)	per GRI GM10
Carbon Black Content	ASTM D 1603	20,000 lb (9,000 kg)
Carbon Black Dispersion	ASTM D 5596	45,000 lb (20,000 kg)
Oxidative Induction Time (OIT) Standard OIT	ASTM D 3895	200,000 lb (90,000 kg)
Oven Aging at 85°C High Pressure OIT	ASTM D 5721 ASTM D 5885	per each formulation
UV Resistance High Pressure OIT	GRI GM11 ASTM D 5885	per each formulation

C. Welding Rod

A sample of welding rod shall be tested at a frequency of once per 25 rolls of welding rod. The following tests shall be performed on the sample:

1. Diameter — ASTM D 5199
2. Density — ASTM D 1505
3. Melt Index — ASTM D 1238
4. Carbon Black Content — ASTM D 1603

D. Reporting

Results from the testing shall be reviewed by the quality control manager. The test data shall then be transferred to the product data file for roll certification. Material that does not meet specifications shall be identified and placed on hold.

3. GEOMEMBRANE INSTALLATION

3.1 Materials Logistics

3.1.1 Transportation and On-site Storage

The geomembrane rolls shall be shipped by flatbed trailer to the job site. The geomembrane shall be stored so as to be protected from puncture, dirt, grease, moisture and excessive heat. Damaged material shall be stored separately for repair or replacement. The rolls shall be stored on a prepared smooth surface (not wooden pallets) and should not be stacked more than two rolls high.

3.2 Earthwork

3.2.1 General

The owner or his representative (soil quality assurance inspector) shall inspect the subgrade preparation. Prior to liner installation the subgrade shall be compacted in accordance with the project specifications. Weak or compressible areas which cannot be satisfactorily compacted should be removed and replaced with properly compacted fill. All surfaces to be lined shall be smooth and free of all foreign and organic material, sharp objects, or debris of any kind. The subgrade shall provide a firm, unyielding foundation with no sharp changes or abrupt breaks in grade. Standing water or excessive moisture shall not be allowed.

The installer, on a daily basis, shall approve the surface on which the geomembrane will be installed. After the supporting soil surface has been approved, it shall be the installer's responsibility to indicate to the inspector any changes to its condition that may require repair work.

3.2.2 Anchor Trench

The anchor trench shall be excavated to the line, grade, and width shown on the project construction drawings, prior to liner system placement. Slightly rounded corners shall be provided in the trench to avoid sharp bends in the geomembrane.

3.3 Method of Placement

The rolls shall be deployed using a spreader bar assembly attached to a loader bucket or by other methods approved by the project engineer.

The installer shall be responsible for the following:

1. Equipment or tools shall not damage the geomembrane during handling, transportation and deployment.
2. Personnel working on the geomembrane shall not smoke or wear damaging shoes.
3. The method used to unroll the panels shall not cause scratches or crimps in the geomembrane and shall not damage the supporting soil.
4. Adequate loading (e.g., sand bags or similar items that will not damage the geomembrane) shall be placed to prevent uplift by wind (in case of high winds, continuous loading is recommended along edges of panels to minimize risk of wind flow under the panels).

3.3.1 Weather Conditions

Geomembrane deployment shall proceed between ambient temperatures of 32° F and 104° F. Placement can proceed below 32° F only after it has been verified by the inspector that the material can be seamed according to the specification. Geomembrane placement shall not be done during any precipitation, in the presence of excessive moisture (e.g., fog, rain, dew) or in the presence of excessive winds, as determined by the installation supervisor.

3.4 Field Seaming

Approved seaming processes are fusion and extrusion welding. On side slopes, seams shall be oriented in the general direction of maximum slope, i.e., oriented down, not across the slope. In corners and odd-shaped geometric locations, the number of field seams shall be minimized.

No base T-seam shall be closer than 5 feet from the toe of the slope. Seams shall be aligned with the least possible number of wrinkles and "fishmouths." If a fishmouth or wrinkle is found, it shall be relieved and cap-stripped.

3.4.1 Seam Overlap

Geomembrane panels must have a finished minimum overlap of 4 inches for fusion welding and 6 inches for extrusion welding.

Cleaning solvents may not be used unless the product is approved by the liner manufacturer.

3.4.2 Test Seams

Field test seams shall be conducted on the liner to verify that seaming conditions are satisfactory. Test seams shall be conducted at the beginning of each seaming period and at least once every 4 hours, for each seaming apparatus and personnel used that day.

All test seams shall be made in contact with the subgrade. Welding rod used for extrusion welding shall have the same properties as the resin used to manufacture the geomembrane. The test seam samples shall be 10 feet long for fusion welding and 3 feet long for extrusion welding with the seam centered lengthwise. Three specimens shall be cut from each end of the test seams by the inspector. The inspector shall use a tensiometer to test 3 specimens for shear and 3 specimens for peel. Each specimen shall be one inch wide with a grip separation of 4 inches plus the width of the seam. The seam shall be centered between the clamps. The rate of grip separation shall be 2 inches per minute.

3.4.3 Assessment of Seam Test Results

For both smooth and textured seams the strength of two out of three 1.0 inch (25 mm) wide strip specimens should meet or exceed values given in this specification. The third must meet or exceed 80% of the given values. The shear percent elongation should exceed 50%. The assumed gauge length is considered to he the unseamed sheet material on either side of the welded area. Elongation measurements should be omitted for field testing. In addition, the peel separation should not exceed 25% based on the proportion of area of separated bond to the area of the original bonding. Regarding the locus-of-break patterns of the different seaming methods in shear and peel, the following are unacceptable break codes per their description in the ASTM D 6392. In this regard, SIP is an acceptable break code.

Unacceptable Break Codes

Hot Wedge: AD and AD-BRK > 25%

Extrusion Fillet: AD1, AD2 and AD-Weld (unless strength is achieved)

3.4.4 Non-Destructive Seam Testing

The Installer shall non-destructively test all field seams over their full length.

A. Vacuum Box Testing

Equipment for testing extrusion seams shall be comprised of the following:

1. A vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft rubber gasket attached to the bottom, port hole or valve assembly, and a vacuum gauge.
2. Soapy solution in a plastic bucket with a mop.

The following procedures shall be followed by the installer:

1. Excess sheet overlap shall be trimmed away.
2. Wet a strip of geomembrane approximately 12 inches wide by the length of box with the soapy solution.
3. Place the box over the wetted area and compress.
4. Create a vacuum of 3 - 5 psig.
5. Ensure that a leak-tight seal is created.
6. For a period of approximately 10 seconds, examine the geomembrane through the viewing window for the presence of animated soap bubbles.

7. If no animated bubbles appear after 10 seconds, close the vacuum valve and open the bleed valve, move the box over the next adjoining area with a minimum 3 inches overlap and repeat the process.
8. All areas where animated soap bubbles appear shall be marked, repaired and then retested.

The following procedures shall apply to locations where seams cannot be non-destructively tested.

1. If the seam is accessible to testing equipment prior to final installation, the seam shall be non-destructively tested prior to final installation.
2. If the seam cannot be tested prior to final installation, the seams shall be spark tested according to the spark tester manufacturer's procedures.

B. Air Pressure Testing (For Double Fusion Seams Only)

Equipment for testing double fusion seams shall be comprised of the following:

1. An air pump equipped with pressure gauge capable of generating and sustaining a pressure between 25 and 30 psi.
2. A pressure gauge equipped with a sharp hollow needle.

The following procedures shall be followed by the installer:

1. Seal one end of the seam to be tested.
2. Insert needle or other approved pressure feed device through the sealed end of the channel created by the double wedge fusion weld.
3. Energize the air pump to verify the unobstructed passage of air through the channel.
4. Seal the other end of the channel.
5. Energize the air pump to a pressure between 25 and 30 psi, close valve, allow 2 minutes for the injected air to come to equilibrium in the channel, and sustain pressure for approximately 5 minutes.
6. If loss of pressure exceeds 4 psi, or pressure does not stabilize, locate faulty area, repair and retest.
7. If pressure does not drop below the acceptable value after five minutes, cut the air channel open at the opposite end from the pressure gauge. The air channel should deflate immediately indicating that the entire length of the seam has been tested.

3.4.5 Destructive Seam Testing

Destructive seam testing should be minimized to preserve the integrity of the liner. The installer shall provide the inspector with one destructive test sample per project specifications (usually once per 500 feet of seam length) from a location specified by the inspector.

A. Sampling Procedure

In order to obtain test results prior to completion of liner installation, samples shall be cut by the installer as the seaming progresses. The installer shall also record the date, location, and pass or fail description. All holes in the geomembrane resulting from obtaining the seam samples shall be immediately patched and vacuum tested.

B. Size and Disposition of Samples

The samples shall be 12 inches wide by 36 inches long with the seam centered lengthwise. The sample shall be cut into three equal-length pieces, one to be given to the inspector, one to be given to the owner and one to the installer.

C. Field Laboratory Testing

The inspector shall test ten 1-inch wide specimens from his sample, five specimens for shear strength and five for peel strength.

D. Independent Laboratory Testing

The owner, at his discretion and expense, may send seam samples to a laboratory for testing. The test method and procedures to be used by the independent laboratory shall be the same as used in field testing.

E. Procedures for Destructive Test Failure

The following procedures shall apply whenever a sample fails the field destructive test:

1. The installer shall cap strip the seam between the failed location and any passed test locations.
2. The installer can retrace the welding path to an intermediate location (usually 10 feet from the location of the failed test), and take a sample for an additional field test. If this test passes, then the seam shall be cap stripped between that location and the original failed location. If the test fails, then the process is repeated.
3. Over the length of seam failure, the installer shall either cut out the old seam, reposition the panel and reseam, or add a cap strip.

3.4.6 Defects and Repairs

All seams and non-seam areas of the geomembrane shall be inspected by the inspector for defects, holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter. The surface of the geomembrane shall be clean at the time of inspection.

A. Evaluation

Each suspect location in seam and non-seam areas shall be non-destructively tested as appropriate in the presence of the inspector. Each location that fails the non-destructive testing shall be marked by the inspector, and repaired accordingly.

B. Repair Procedures

1. Defective seams shall be cap stripped or replaced.
2. Small holes shall be repaired by extrusion welding a bead of extrudate over the hole. If the hole is larger than 1/4 inch, it shall be patched.
3. Tears shall be repaired by patching. If the tear is on a slope or an area susceptible to stress and has a sharp end it must be rounded prior to patching.
4. Blisters, large cuts and undispersed raw materials shall be repaired by patches.

5. Patches shall be completed by extrusion welding. The weld area shall be ground no more than 10 minutes prior to welding. No more than 10% of the thickness shall be removed by grinding. Welding shall commence where the grinding started and must overlap the previous seam by at least 2 inches. Reseaming over an existing seam without regrinding shall not be permitted. The welding shall restart by grinding the existing seam and rewelding a new seam.

   Patches shall be round or oval in shape, made of the same geomembrane, and extend a minimum of 6 inches beyond the edge of defects.

C. **Verification of Repairs**

Each repair shall be non-destructively tested. Repairs that pass the non-destructive test shall be taken as an indication of an adequate repair. Failed tests indicate that the repair shall be repeated and retested until passing test results are achieved.

The inspector shall keep daily documentation of all non-destructive and destructive testing. This documentation shall identify all seams that initially failed the test and include evidence that these seams were repaired and successfully retested.

3.5 Cover Material and Backfilling of Anchor Trench

The geomembrane shall be covered as soon as possible. The covering operation shall not damage the geomembrane. The cover soil material shall be free of foreign and organic material, sharp objects, or debris of any kind, which could potentially damage the geomembrane. No construction equipment or machinery shall operate directly on the geomembrane. The use of lightweight machinery (i.e., generator, etc.) with low ground pressure is allowed.

The anchor trench shall be backfilled by the earthwork contractor. Trench backfill material shall be placed and compacted in accordance with the project specifications.

Care shall be taken when backfilling the trenches to prevent any damage to the geomembrane. If damage occurs, it shall be repaired prior to backfilling.

3.6 Geomembrane Acceptance

The installer shall retain all ownership and responsibility for the geomembrane until accepted by the owner.

Final acceptance is when all of the following conditions are met:

1. Installation is finished.
2. Verification of the adequacy of all field seams and repairs, including associated testing, is complete.

INHERENT PROPERTIES OF POLYETHYLENE LINERS

The properties listed in the table below are primarily inherent on the resin type used to produce the liner or are directly proportional to the thickness of the liner and less dependent on the manufacturing method. Therefore, these properties will not change from roll to roll or even lot to lot. Hence, they should not be included as part of routine quality control testing. The exception to this is Oxidative Induction Time. This test is a measurement of the amount of anti-oxidant added to the resin to produce the finished sheet. This test can function both as a performance test and a quality control test. As a quality control test it is desirable to run the test at high temperatures to keep the test duration short. This test is routinely run at the time of manufacture. As a performance test it is desirable to run the test at lower temperatures. Testing at lower temperatures cannot be done for quality control purposes.

The information given below is based on nominal values. Individual test results may vary from these values depending upon the reproducibility of the test.

NOMINAL PROPERTIES

TEST DESCRIPTION	TEST METHOD	UNITS	HDPE	LLDPE
Modulus of Elasticity	ASTM D 6693	lb/in^2	110,000	45,000
Secant Modulus	ASTM D 5323	lb/in^2	60,000	45,000
Volatile Loss	ASTM D 1203	%	0.1	0.1
Dimensional Stability	ASTM D 1204	%	+/- 0.5	+/- 1.0
Water Absorption (24 hr @ 23 °C)	ASTM D 570	% change	0.1	0.1
Coefficient of Linear Thermal Expansion	ASTM D 696	(cm/cm • °c)	1.2 x 10-4	1.4 x 10-4
Moisture Vapor Transmission Rate (100 °F and 100% relative humidity)	ASTM E 96	g/m^2·day		
		100 mil	0.17	—
		80 mil	0.20	0.25
		60 mil	0.26	0.33
		40 mil	0.39	0.45
		30 mil	0.50	0.57
Low Temperature Brittleness	ASTM D 746	°F	<-112	<-112
Oxidative Induction Time	ASTM D 3895	minutes @ 200 °C	100	100
		minutes @ 150 °C	2000	2000
Multi-Axial Tension	ASTM D 5617	stress, lb/in^2	2200	1500
		strain, %	18	40+
Melt Index	ASTM D 1238	g/10 minutes	0.20	0.20

POLY•FLEX
POLYETHYLENE GEOMEMBRANES

Drainage Net & Geocomposite

POLY•FLEX DRAINAGE NET & GEOCOMPOSITE SPECIFICATIONS

POLY•FLEX DRAINAGE NET & GEOCOMPOSITE SPECIFICATIONS

1. GENERAL REQUIREMENTS

1.1 Scope

The following describes parameters for the manufacture, supply, and installation of Poly-Flex Drainage Net and Geocomposites.

1.2 Qualifications

The drainage net manufacturer shall have successfully manufactured 5,000,000 square feet of polyethylene drainage net.

1.3 Submittals

The manufacturer shall provide the following information:

A. List of material properties.

B. Quality control certificate for the drainage net, geotextile, and geocomposite rolls, upon request.

2. MATERIAL SPECIFICATIONS

2.1 Materials

2.1.1 Drainage Net

The drainage net shall be manufactured by extruding two sets of polyethylene strands to form a three dimensional structure to provide for planar flow. The drainage net shall be manufactured of polyethylene resin produced in the United States and compounded and manufactured specifically for the intended application. The natural polyethylene resin without the carbon black shall meet the following requirements:

Property	Test Method	Requirements
Density, g/cc	ASTM D 1505 or ASTM D 792	0.945 - 0.955
Melt Index, g/10 min.	ASTM D 1238	< 1.0

The drainage net shall be supplied in rolls 14 feet wide, as manufactured by Poly-Flex, Inc. (2000 W. Marshall Dr., Grand Prairie, Texas 75051). Labels on each roll shall identify the thickness of the material, the width and length of the roll, roll number, and name of the manufacturer. The drainage net rolls shall meet the requirements in this specification.

2.1.2 Geotextile

The geotextile shall be a non-woven, needle punched polyester or polypropylene fabric manufactured in the United States for the specific application. The geotextile rolls shall be 15 feet wide and shall meet the requirements in this specification.

2.1.3 Geocomposite

The geocomposite shall consist of the Poly-Flex HDPE drainage net heat bonded to one layer or sandwiched between two layers of geotextile to create a single-sided or double-sided geocomposite. The geocomposite shall be 13.5 feet wide. The geotextiles shall extend a minimum of 6 inches beyond the edges of drainage net on both sides of the geocomposite roll. The geotextile shall not be bonded to the drainage net within 6 inches from the edges of the rolls.

The drainage net and geocomposite rolls shall meet the following specifications:

HDPE DRAINAGE NET ENGLISH UNITS

Property	Test Method	Minimum Average Values GN-200	GN-250
Thickness	ASTM D 5199	200 mils	250 mils
Density, min.	ASTM D 1505	0.940 g/cc	0.940 g/cc
Carbon Black Content	ASTM D 1603	1.5 - 3.0%	1.5 - 3.0%
Tensile Strength, (Peak, MD)	ASTM D 7179	45 lb/in	60 lb/in
Transmissivity, (MD) metal plate/net/metal plate hydraulic gradient, i = 1 normal pressure = 10,000 lb/ft² seat time = 15 minutes	ASTM D 4716	5.0 gal/min-ft	7.2 gal/min-ft
Roll Dimensions 1. Roll Width		14 ft	14 ft
2. Roll Length		325 ft	275 ft
3. Roll Area		4550 ft²	3850 ft²

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POLY-FLEX
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HDPE DRAINAGE NET
METRIC UNITS

Property	Test Method	Minimum Average Values GN-200	GN-250
Thickness	ASTM D 5199	5.1 mm	6.3 mm
Density, min.	ASTM D 1505	0.940 g/cc	0.940 g/cc
Carbon Black Content	ASTM D 1603	1.5 - 3.0%	1.5 - 3.0%
Tensile Strength (Peak, MD)	ASTM D 7179	7.9 kN/m	10.5 kN/m
Transmissivity, (MD) metal plate/net/metal plate hydraulic gradient, i = 1 normal pressure = 480 kPa seat time = 15 minutes	ASTM D 4716	1.0×10^{-3} m^2/sec (62 l/min-m)	1.5×10^{-3} m^2/sec (89 l/min-m)
Roll Dimensions			
1. Roll Width		4.27 m	4.27 m
2. Roll Length		99.0 m	83.8 m
3. Roll Area		422.7 m^2	357.7 m^2

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SINGLE-SIDED GEOCOMPOSITES
ENGLISH UNITS

POLY-FLEX
POLYETHYLENE GEOMEMBRANES

Property	Test Method	Minimum Average Values GC-06S-2.0	GC-08S-2.0	GC-06S-2.5	GC-08S-2.5
GEOCOMPOSITE PROPERTIES					
Transmissivity, (MD), gal/min-ft metal plate/geocomposite/metal plate hydraulic gradient, i = 1 normal pressure = 10,000 lb/ft² seat time = 15 minutes	ASTM D 4716	1.2 (2.5×10^{-4} m^2/sec)	1.0 (2×10^{-4} m^2/sec)	2.4 (5×10^{-4} m^2/sec)	1.4 (2.9×10^{-4} m^2/sec)
Ply Adhesion, lb/in	ASTM D 7005	1	1	1	1
Roll Dimensions					
1. Width, ft		13.5	13.5	13.5	13.5
2. Length, ft		300	250	225	175
COMPONENT PROPERTIES					
Geonet					
Thickness, mil	ASTM D 5199	200	200	250	250
Density, min., g/cc	ASTM D 1505	0.940	0.940	0.940	0.940
Carbon Black Content, %	ASTM D 1603	1.5 - 3.0	1.5 - 3.0	1.5 - 3.0	1.5 - 3.0
Tensile Strength, (Peak, MD), lb/in	ASTM D 7179	45	45	60	60
Transmissivity, (MD), gal/min-ft metal plate/net/metal plate hydraulic gradient, i = 1 normal pressure = 10,000 lb/ft² seat time = 15 minutes	ASTM D 4716	5.0 (1.0×10^{-3} m^2/sec)	5.0 (1.0×10^{-3} m^2/sec)	7.2 (1.5×10^{-3} m^2/sec)	7.2 (1.5×10^{-3} m^2/sec)
Geotextile					
Unit Weight, oz/yd²	ASTM D 5261	6	8	6	8
Grab Strength, lb	ASTM D 4632	160	220	160	220
Grab Elongation, %	ASTM D 4632	50	50	50	50
Tear Strength, lb	ASTM D 4533	65	80	65	80
Puncture Strength, lb	ASTM D 4833	90	120	90	120
Permittivity, sec^{-1}	ASTM D 4491	1.3	1.3	1.3	1.3
AOS, MaxARV	ASTM D 4751	70 sieve	80 sieve	70 sieve	80 sieve
UV Stability, % ret. (500 hr.)	ASTM D 4355	70	70	70	70

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POLY-FLEX POLYETHYLENE GEOMEMBRANES

SINGLE-SIDED GEOCOMPOSITES METRIC UNITS

GEOCOMPOSITE PROPERTIES		Minimum Average Values			
Property	Test Method	GC-06S-2.0	GC-08S-2.0	GC-06S-2.5	GC-08S-2.5
Transmissivity, (MD), m^2/sec	ASTM D 4716	2.5×10^{-4}	2.0×10^{-4}	5.0×10^{-4}	2.9×10^{-4}
metal plate/geocomposite/metal plate		(15 l/min·m)	(12 l/min·m)	(30 l/min·m)	(17 l/min·m)
hydraulic gradient, i = 1					
normal pressure = 480 kPa					
seat time = 15 minutes					
Ply Adhesion, kN/m	ASTM D 7005	0.17	0.17	0.17	0.17
Roll Dimensions					
1. Roll Width, m		4.1	4.1	4.1	4.1
2. Roll Length, m		91.4	76.2	68.6	53.4

COMPONENT PROPERTIES

Geonet					
Thickness, mm	ASTM D 5199	5.1	5.1	6.3	6.3
Density, min., g/cc	ASTM D 1505	0.940	0.940	0.940	0.940
Carbon Black Content, %	ASTM D 1603	1.5 - 3.0	1.5 - 3.0	1.5 - 3.0	1.5 - 3.0
Tensile Strength, (Peak, MD), kN/m	ASTM D 7179	7.9	7.9	10.5	10.5
Transmissivity, (MD), m^2/sec	ASTM D 4716	1.0×10^{-3}	1.0×10^{-3}	1.5×10^{-3}	1.5×10^{-3}
metal plate/net/metal plate		(62 l/min·m)	(62 l/min·m)	(89 l/min·m)	(89 l/min·m)
hydraulic gradient, i = 1					
normal pressure = 480 kPa					
seat time = 15 minutes					
Geotextile					
Unit Weight, g/m^2	ASTM D 5261	203	271	203	271
Grab Strength, N	ASTM D 4632	712	979	712	979
Grab Elongation, %	ASTM D 4632	50	50	50	50
Tear Strength, N	ASTM D 4533	289	356	289	356
Puncture Strength, N	ASTM D 4833	400	534	400	534
Permittivity, sec^{-1}	ASTM D 4491	1.3	1.3	1.3	1.3
AOS, MaxARV, mm	ASTM D 4751	0.212	0.180	0.212	0.180
UV Stability, % ret. (500 hr.)	ASTM D 4355	70	70	70	70

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DOUBLE-SIDED GEOCOMPOSITES ENGLISH UNITS

POLY-FLEX POLYETHYLENE GEOMEMBRANES

GEOCOMPOSITE PROPERTIES		Minimum Average Values			
Property	Test Method	GC-06D-2.0	GC-08D-2.0	GC-06D-2.5	GC-08D-2.5
Transmissivity, (MD), gal/min·ft	ASTM D 4716	0.4	0.2	1.0	0.5
metal plate/geocomposite/metal plate		(0.8×10^{-4} m^2/sec)	(4.0×10^{-5} m^2/sec)	(2.0×10^{-4} m^2/sec)	(1.0×10^{-4} m^2/sec)
hydraulic gradient, i = 1					
normal pressure = 10,000 lb/ft^2					
seat time = 15 minutes					
Ply Adhesion, lb/in	ASTM D 7005	1	1	1	1
Roll Dimensions					
1. Roll Width, ft		13.5	13.5	13.5	13.5
2. Roll Length, ft		250	200	175	150

COMPONENT PROPERTIES

Geonet					
Thickness, mil	ASTM D 5199	200	200	250	250
Density, min., g/cc	ASTM D 1505	0.940	0.940	0.940	0.940
Carbon Black Content, %	ASTM D 1603	1.5 - 3.0	1.5 - 3.0	1.5 - 3.0	1.5 - 3.0
Tensile Strength, (Peak, MD), lb/in	ASTM D 7179	45	45	60	60
Transmissivity, (MD), gal/min·ft	ASTM D 4716	5.0	5.0	7.2	7.2
metal plate/net/metal plate		(1.0×10^{-3} m^2/sec)	(1.0×10^{-3} m^2/sec)	(1.5×10^{-3} m^2/sec)	(1.5×10^{-3} m^2/sec)
hydraulic gradient, i = 1					
normal pressure = 10,000 lb/ft^2					
seat time = 15 minutes					
Geotextile					
Unit Weight, oz/yd^2	ASTM D 5261	6	8	6	8
Grab Strength, lb	ASTM D 4632	160	220	160	220
Grab Elongation, %	ASTM D 4632	50	50	50	50
Tear Strength, lb	ASTM D 4533	65	80	65	80
Puncture Strength, lb	ASTM D 4833	90	120	90	120
Permittivity, sec^{-1}	ASTM D 4491	1.3	1.3	1.3	1.3
AOS, MaxARV	ASTM D 4751	70 sieve	80 sieve	70 sieve	80 sieve
UV Stability, % ret. (500 hr.)	ASTM D 4355	70	70	70	70

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POLYETHYLENE GEOMEMBRANES

DOUBLE-SIDED GEOCOMPOSITES METRIC UNITS

GEOCOMPOSITE PROPERTIES — Minimum Average Values

Property	Test Method	GC-06D-2.0	GC-08D-2.0	GC-06D-2.5	GC-08D-2.5
Transmissivity, (MD), m^2/sec	ASTM D 4716	0.8 x 10^{-4}	4.0 x 10^{-5}	2.0 x 10^{-4}	1.0 x 10^{-4}
metal plate/geocomposite/metal plate		(5.0 l/min-m)	(2.5 l/min-m)	(12 l/min-m)	(6.2 l/min-m)
hydraulic gradient, i = 1					
normal pressure = 480 kPa					
seat time = 15 minutes					
Ply Adhesion, kN/m	ASTM D 7005	0.17	0.17	0.17	0.17
Roll Dimensions					
1. Roll Width, m		4.1	4.1	4.1	4.1
2. Roll Length, m		76.2	61	53.4	45.7

COMPONENT PROPERTIES

Property	Test Method	GC-06D-2.0	GC-08D-2.0	GC-06D-2.5	GC-08D-2.5
Geonet					
Thickness, mm	ASTM D 5199	5.1	5.1	6.3	6.3
Density, min., g/cc	ASTM D 1505	0.940	0.940	0.940	0.940
Carbon Black Content, %	ASTM D 1603	1.5 - 3.0	1.5 - 3.0	1.5 - 3.0	1.5 - 3.0
Tensile Strength, (Peak, MD), kN/m	ASTM D 7179	7.9	7.9	10.5	10.5
Transmissivity, (MD), m^2/sec	ASTM D 4716	1.0 x 10^{-3}	1.0 x 10^{-3}	1.5 x 10^{-3}	1.5 x 10^{-3}
metal plate/net/metal plate		(62 l/min-m)	(62 l/min-m)	(89 l/min-m)	(89 l/min-m)
hydraulic gradient, i = 1					
normal pressure = 480 kPa					
seat time = 15 minutes					
Geotextile					
Unit Weight, g/m²	ASTM D 5261	203	271	203	271
Grab Strength, N	ASTM D 4632	712	979	712	979
Grab Elongation, %	ASTM D 4632	50	50	50	50
Tear Strength, N	ASTM D 4533	289	356	289	356
Puncture Strength, N	ASTM D 4833	400	534	400	534
Permittivity, sec^{-1}	ASTM D 4491	1.3	1.3	1.3	1.3
AOS, MaxARV, mm	ASTM D 4751	0.212	0.180	0.212	0.180
UV Stability, % ret. (500 hr.)	ASTM D 4355	70	70	70	70

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POLY•FLEX DRAINAGE NET & GEOCOMPOSITE SPECIFICATION

POLY-FLEX
POLYETHYLENE GEOMEMBRANES

2.2 Manufacturer's Quality Control Testing

The Drainage Net shall be tested by its manufacturer once every 50,000 square feet for listed properties, except the transmissivity, which shall be tested once every 100,000 square feet.

The geotextile shall be tested by its manufacturer once every 100,000 square feet, except for AOS and Permittivity, which shall be tested once every 500,000 square feet and UV stability, which shall be per manufacturer historical date.

The geocomposite shall be tested by its manufacturer once every 100,000 square feet for the listed properties.

Any rolls not meeting the requirements of the specification shall be rejected. The manufacturer shall prepare a quality control report to be submitted to the project engineer upon request.

3. INSTALLATION

3.1 Transportation and On-site Storage

The drainage net and geocomposite rolls shall be wrapped in a plastic cover. The drainage net and geocomposite rolls shall be shipped to the job site in a manner not to damage the rolls.

3.2 Method of Placement

The subgrade shall be free of foreign and organic material, sharp objects, or debris of any kind, which could potentially damage the geocomposite. The rolls shall be deployed using a spreader bar assembly attached to a loader bucket or by other methods approved by the project engineer. On side slopes, the rolls shall be deployed in the general direction of the maximum slope. The deployment equipment shall not damage the underlying subgrade or geosynthetics. A smooth rub sheet may be needed for installation of the geocomposite over a textured geomembrane. The rub sheet is placed between the geocomposite and the textured geomembrane to prevent damage to geocomposite during positioning. The rub sheet is removed after deployment. Drainage net and geocomposite shall be placed and secured in an anchor trench as shown on the project drawings. Sandbags shall be placed on leading edges of the panels to prevent wind uplift. An extra layer of drainage net or geocomposite may be required at the intersection of any two sideslopes to cover the area where the panels are staggered.

3.3 Field Seaming

Drainage net panels shall be overlapped by a minimum of 2 inches. Non-black plastic ties shall be used at 5-foot intervals in the direction of the roll length and at 2-foot intervals across the end of the panel to tie the drainage net panels. Metallic ties shall not be allowed. On slopes, the spacing of ties across the roll end shall be 6 inches. The geotextile flaps of the adjacent panels shall be heat-bonded or sewn on all sides in accordance with the project specification.

3.4 Cover Material

The drainage net and geocomposite shall be covered as soon as possible. The covering operation shall not damage the drainage net or the geocomposite. The cover soil material shall be free of foreign and organic material, sharp objects, or debris of any kind, which could potentially damage the geocomposite. No construction equipment or machinery shall operate directly on the geocomposite. The use of lightweight machinery (i.e., generator, etc.) with low ground pressure is allowed.

3.5 Repairs

All panels shall be inspected for damage. Any damaged area shall be repaired by a patch of the same material extending one foot beyond the edges of the damaged area.

POLY-FLEX
POLYETHYLENE GEOMEMBRANES

POLY-FLEX POLYETHYLENE EMBED CHANNEL SPECIFICATION

Polyethylene
Embed Channel

GENERAL

1.1 Scope

The following describes parameters for the manufacture, supply, and installation of Poly-Flex High Density Polyethylene Embed Channel (PEC). All procedures, operations, and methods shall be in strict accordance with the engineer's specifications and drawings.

1.2 References

American Society for Testing and Materials

1.3 Submittals

1. The manufacturer shall maintain test records of the resins used to manufacture the PEC. This record shall be made available to the Engineer upon request.
2. The contractor shall submit shop drawings showing the exact location and installation procedures.
3. At the engineer's request, sample(s) of PEC shall be submitted.

1.4 Manufacturer's Quality Control Testing

All resins for use in PEC must pass the Poly-Flex raw material specifications before being eligible for use. Each lot shall be sampled and tested in the Poly-Flex, Inc. laboratory. The tests shall include density, melt index, and carbon black content. All additives and concentrates must pass Poly-Flex specifications.

PRODUCT

2.1 Product

The PEC shall be manufactured by Poly-Flex, Inc. The raw material shall be made of polyethylene resins manufactured in the United States. Carbon black shall be added to the resin if the resin is not precompounded for ultra-violet resistance. The final product shall meet the following values:

Density:	ASTM D1505	≥ 0.940 g/cc
Melt Index:	ASTM D1238	≤ 0.4 g/10 minutes
Carbon Black Content:	ASTM D1603	2% - 3%
Tensile Strength at Yield:	ASTM D6693	2,100 lb/in^2
Dimensions:	As shown on the drawing on page 35.	
Weight:	0.45 lb/ft	
Length:	5 ft and 10 ft	

2.2 Shipment and Storage

PEC shall be shipped in a manner not to be damaged by packaging or handling and shall be stored in a clean environment.

INSTALLATION

PEC can be nailed to wooden forms or pushed or vibrated into poured concrete. A 3-inch clearance is recommended from concrete edges or corners.

3.1 Installation in concrete forms

PEC shall be installed inside the concrete forms in accordance with the shop drawings prior to pouring concrete. Place PEC in the designated locations with the surface of PEC in contact with the form. PEC shall be secured to the wooden forms by means of nails driven from the inside of PEC into the forms (see Step 1 drawing). All exposed nails shall be clipped at the surface of PEC after removal of the forms (see Step 2 drawing).

3.2 Fabrication

PEC can be prefabricated into frames and vibrated into freshly poured concrete. Small air vent holes shall be drilled in approximately 3-foot intervals in the surface of PEC prior to its placement into fresh concrete.

Butt welded connections are made by extrusion welding the back side of the 3.5-inch surface and the outside of the legs. Backup HDPE plates are sometimes used behind the surface to be butt welded to reinforce the connection. A very flat extrusion weld bead is then placed on the 3.5-inch surface. PEC can also be butt welded similar to HDPE pipe welding techniques (See Figure 1). The two pieces (A & B) to be welded are laid on a flat surface. Each piece is held in contact with the "welding mirror" (C) for approximately 45 seconds until a melt bead (D) forms at the mirror; the mirror is removed (E) and the pieces are pushed together (F) fusing the molten plastic. This process gives a full perimeter weld of the PEC. Care must be exercised to assure alignment of the channels after the weld. This method can also be used for miter joints.

It is necessary to prevent gaps or repair gaps caused by thermal contraction or improper placement of the PEC. The liner-to-PEC connection will not be water tight unless the PECs are properly joined at their ends. Other PEC installation details are available from Poly-Flex, Inc.

3.3 Seaming

All seaming shall be done in accordance with the Poly-Flex extrusion seaming procedures, as outlined in this manual, and by experienced technicians who are qualified by Poly-Flex, Inc. to seam Poly-Flex liners.

The following steps shall be followed prior to welding Poly-Flex liners to the PEC:

1. Remove cement paste, form oils, curing compound or other contaminants from the surface of PEC. The 3.5-inch wide surface shall be clean and dry. The welding surfaces of the PEC can be taped prior to its installation. The tape is removed after the concrete is hardened to expose the clean surfaces of PEC for welding.
2. Use a hot air gun to tack liner to PEC in a straight line in the center of the PEC surface.
3. A grinder with 80-grit disc shall be used to remove the surface contamination and oxidation from the welding surface area prior to the extrusion welding. Place the extrudate on the center line (see Step 3 drawing). All air vent or nail holes shall also be ground and covered with the extrudate.

All seams shall be non-destructively tested, whenever possible, by using a vacuum box apparatus if the PEC connection is designed to be waterproof.

Since destructive seam testing is not possible, it is very important that seaming be done by qualified technicians.

POLYFLEX
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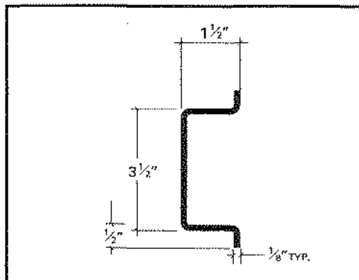
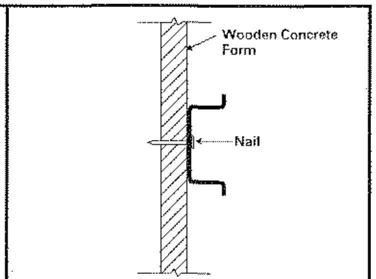
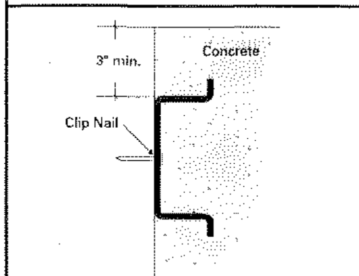
POLYETHYLENE EMBED CHANNEL SPECIFICATION



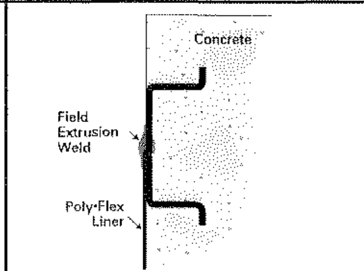
POLYETHYLENE EMBED CHANNEL (PEC)



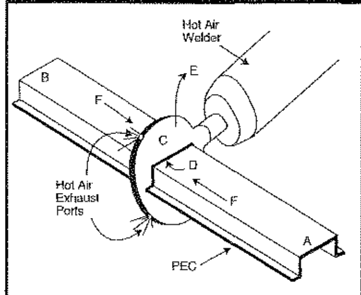
STEP 1. ATTACH PEC TO WOODEN FORM



STEP 2. PEC IN CONCRETE

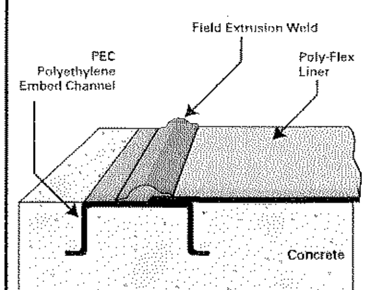


STEP 3. WELD LINER TO PEC



"Welding Mirror" is a PTFE-coated Leister accessory for butt welding polyethylene and polypropylene profiles.

FIGURE 1



POLY-FLEX
POLYETHYLENE GEOMEMBRANES

CHEMICAL RESISTANCE INFORMATION

CHEMICAL COMPATIBILITY OF POLY-FLEX LINERS

Chemical compatibility or resistance, as applied to geomembranes, is a relative term. Actual compatibility would mean that one material dissolves in the other such as alcohol in water or grease in gasoline. An example of incompatibility would be oil and water. In liners it is undesirable to have the chemicals dissolve in the liner, hence the term compatibility is the reverse of what is normally meant in the chemical industry. In the strictest sense and from a laboratory perspective, chemical compatibility, as the term applies to this industry, would imply that the chemical has no effect on the liner. On the other hand, from an engineering perspective, chemical compatibility means that a liner survives the exposure to a given chemical even though the chemical could have some effect on the performance of the liner, but not enough to cause failure. Therefore, one must understand and define chemical compatibility for a specific project.

Generally polyethylene is effected by chemicals in one of three ways.

1. No effect—This means that the chemical in question and the polyethylene do not interact. The polyethylene does not gain (lose) weight or swell, and the physical properties are not significantly altered.
2. Oxidizes (cross linking)—Chemicals classed as oxidizing agents cause the polyethylene molecules to cross link and cause irreversible changes to the physical properties of the liner. Basically they make the liner brittle.
3. Plasticizes—Chemicals in this classification are soluble in the polyethylene structure. They do not change the structure of the polyethylene itself but act as a plasticizer. In doing so, the liner experiences weight gain of 3-15%, may swell by up to 10%, and has measurable changes in physical properties (e.g. the tensile strength at yield may decrease by up to 20%). Even under these conditions the liner maintains its integrity and is not breached by liquids, provided the liner has not been subjected to any stress. These effects are reversible once the chemicals are removed and the liner has time to dry out.

Aside from the effect that chemicals have on a liner is the issue of vapor permeation through the liner. Vapor permeation is molecular diffusion of chemicals through the liner. Vapor transmission for a given chemical is dependent primarily on liner type, contact time, chemical solubility, temperature, thickness, and concentration gradient, but not on hydraulic head or pressure. Transmission through the liner can occur in as little as 1-2 days. Normally, a small amount of chemical is transmitted. Generally HDPE has the lowest permeation rate of the liners that are commercially available.

As stated above chemical compatibility is a relative term. For example, the use of HDPE as a primary containment of chlorinated hydrocarbons at a concentration of 100% may not be recommended, but it may be acceptable at 0.1% concentration for a limited time period or may be acceptable for secondary containment. Factors that go into assessment of chemical compatibility are type of chemical(s), concentration, temperature and the type of application. No hard and fast rules are available to make decisions on chemical compatibility. Even the EPA 9090 test is just a method to generate data so that an opinion on chemical compatibility can be more reliably reached.

A simplified table on chemical resistance is provided to act as a screening process for chemical containment applications.

CHEMICAL CLASS	CHEMICAL EFFECT	PRIMARY CONTAINMENT (LONG TERM CONTACT) HDPE	PRIMARY CONTAINMENT (LONG TERM CONTACT) LLDPE	SECONDARY CONTAINMENT (SHORT TERM CONTACT) HDPE	SECONDARY CONTAINMENT (SHORT TERM CONTACT) LLDPE
CARBOXYLIC ACID	1				
- Unsubstituted (e.g. Acetic acid)		B	C	A	C
- Substituted (e.g. Lactic acid)		A	B	A	A
- Aromatic (e.g. Benzoic Acid)		A	B	A	A
ALDEHYDES	3				
- Aliphatic (e.g. Acetaldehyde)		B	C	B	C
- Hetrocyclic (e.g. Furfural)		C	C	B	C
AMINE	3				
- Primary (e.g. Ethylamine)		B	C	B	C
- Secondary (e.g. Diethylamine)		C	C	B	C
- Aromatic (e.g. Aniline)		B	C	B	C
CYANIDES (e.g. Sodium Cyanide)	1	A	A	A	A
ESTER (e.g. Ethyl acetate)	3	B	C	B	C
ETHER (e.g. Ethyl ether)		C	C	B	C
HYDROCARBONS	3				
- Aliphatic (e.g. Hexane)		C	C	B	C
- Aromatic (e.g. Benzene)		C	C	B	C
- Mixed (e.g. Crude oil)		C	C	B	C
HALOGENATED HYDROCARBONS	3				
- Aliphatic (e.g. Dichloroethane) +A4		C	C	B	C
- Aromatic (e.g. Chlorobenzene)		C	C	B	C
ALCOHOLS	1				
- Aliphatic (e.g. Ethyl alcohol)		A	A	A	A
- Aromatic (e.g. Phenol)		A	C	A	B
INORGANIC ACID					
- Non-oxidizers (e.g. Hydrochloric acid)	1	A	A	A	A
- Oxidizers (e.g. Nitric Acid)	2	C	C	B	C
INORGANIC BASES (e.g. Sodium hydroxide)	1	A	A	A	A
SALTS (e.g. Calcium chloride)	1	A	A	A	A
METALS (e.g. Cadmium)	1	A	A	A	A
KETONES (e.g. Methyl ethyl ketone)	3	C	C	B	C
OXIDIZERS (e.g. Hydrogen peroxide)	2	C	C	C	C

Chemical Effect (see discussion on Chemical Resistance)

1. No Effect—Most chemicals of this class have no or minor effect.
2. Oxidizer—Chemicals of this class will cause irreversible degradation.
3. Plasticizer—Chemicals of this class will cause a reversible change in physical properties.

Chart Rating

A. Most chemicals of this class have little or no effect on the liner.
Recommended regardless of concentration or temperature (below 150° F).

B. Chemicals of this class will affect the liner to various degrees.
Recommendations are based on the specific chemical, concentration and temperature.
Consult with Poly-Flex, Inc.

C. Chemicals of this class at high concentrations will have significant effect on the physical properties of the liner.
Generally not recommended but may be acceptable at low concentrations and with special design considerations.
Consult with Poly-Flex, Inc.

The data in this table is provided for informational purposes only and is not intended as a warranty or guarantee. Poly-Flex, Inc. assumes no responsibility in connection with the use of this data. Consult with Poly-Flex, Inc. for specific chemical resistance information and liner selection.

POLYFLEX
POLYETHYLENE GEOMEMBRANES

GEOMEMBRANE MANUFACTURING QUALITY CONTROL & QUALITY ASSURANCE

Geomembrane
Manufacturing QC/QA

1. DEFINITIONS

Manufacturing Quality Control (MQC) is a planned system of routine inspections that is used to directly monitor and control the quality of a material.

Manufacturing Quality Assurance (MQA) is independent of the MQC and includes inspections, verifications, audits, and evaluations of materials and workmanship necessary to determine and document the quality of a material.

2. MANUFACTURING QUALITY CONTROL AND QUALITY ASSURANCE PROGRAM

2.1 Raw Material

Poly-Flex, Inc.'s quality control and quality assurance for HDPE and LLDPE geomembrane manufacturing starts with the testing of the raw materials. The resin manufacturers provide documentation confirming that the raw materials comply with Poly-Flex, Inc. specifications.

Resin manufacturers report the following properties with each resin shipment:

Density	This property is a measure of unit weight and is an indicator of the degree of crystallinity. It can be related to the material's chemical resistance, rigidity, permeability, tensile strength, and deformation characteristics.
Melt Index	This property is an indication of the molecular weight and rheological properties of the polymer and can be related to the processability.
Carbon Black Content (pre-compounded only)	The carbon black content is an important property to ensure protection against ultraviolet radiation. The raw materials may be pre-compounded with the carbon black. However, if resins are not pre-compounded, Poly-Flex, Inc. will supplement them with the appropriate quantity of carbon black before manufacturing liner.

2.1.1 Geomembrane Material Railcar Acceptance

All resins, additives and concentrates used in Poly-Flex geomembranes must have their physical integrity validated before they can be released into the production material stream. All incoming railcars are sampled; incoming materials not delivered by railcar are statistically sampled. Upon verification of the resin compliance with the specifications, the resin is pumped from the railcar into the silos dedicated to the production of the geomembrane.

1. Resin samples are taken from each of the four payload compartments in an incoming railcar.
2. Resin samples are sent to the laboratory. Using state of the art equipment, highly trained Quality Assurance personnel test the resin to ensure that it meets the specifications for producing Poly-Flex geomembranes. The following tests are performed and compared against Poly-Flex specifications:

Property	Resins	Additives & Concentrates
Density (ASTM D 1505)	•	
Melt Index (ASTM D 1238)	•	
Carbon Black Content (ASTM D 1603)		•
Oxidative Induction Time (ASTM D 3895)	•	•

3. After meeting production specifications, the resin is pumped from its railcar into a silo dedicated to that material.
4. Off-spec material is returned to the vendor.

Applicable Test Methods

American Society for Testing and Materials (ASTM)

ASTM D 792	Specific gravity (relative density) and density of plastics by displacement
ASTM D 1004	Initial tear resistance of plastic sheeting
ASTM D 1238	Flow rates of thermoplastics by extrusion plastometers
ASTM D 1505	Density of plastics by the Density-Gradient technique
ASTM D 1603	Carbon black in olefin plastics
ASTM D 1898	Sampling of plastics
ASTM D 3895	Test method for oxidative induction time of polyolefins by thermal analysis
ASTM D 4833	Index Puncture Resistance of geotextiles, geomembranes and related products
ASTM D 5199	Test method for measuring nominal thickness of geotextiles and geomembrane
ASTM D 5323	Determination of 2% secant modulus for polyethylene geomembranes
ASTM D 5397	Procedure to perform a single point notched constant tensile load - Appendix (SP-NCTL) test
ASTM D 5596	Test method for microscopic evaluation of the dispersion of carbon black in polyolefin geosynthetics
ASTM D 5617	Multi-axial tension test for geosynthetics
ASTM D 5721	Practice for air-oven aging of polyolefin geomembranes
ASTM D 5885	Test method for oxidative induction time of polyolefin geosynthetics by high pressure differential scanning calorimetry
ASTM D 5994	Test method for measuring the core thickness of textured geomembranes
ASTM D 6392	Determining the integrity of nonreinforced geomembrane seams produced using thermo-fusing methods
ASTM D 6693	Determining tensile properties of nonreinforced polyethylene and nonreinforced flexible polypropylene geomembranes

Geosynthetic Research Institute (GRI) Standards

GM 10	Specification for the stress crack resistance of geomembrane sheet
GM 11	Accelerated weathering of geomembranes using a florescent UVA-condensation exposure device
GM 12	Measurement of the asperity height of textured geomembranes using a depth gauge

Addendum to Test Procedures

The following are modifications or clarifications to test procedures.

1. Specifications are based on the average of Machine Direction (MD) and Cross Direction (XMD) values.
2. Specimens shall be taken uniformly across the width of the sheet as stated in ASTM D 1898.

3. MANUFACTURING

3.1 Blown Sheet Process

Polyethylene resin is pumped directly from storage silos or from totes on the floor to hoppers above the extruder.

Hoppers feed resin into the extruder. The resin is beated to the melting point in the extruder barrel. It is conveyed through the barrel by the rotation of a specially designed screw which, in conjunction with heating elements along the barrel, provides consistency to produce a molten polymer stream.

The molten material is forced through a screen pack, which act as a final filter for impurities or contaminants, and up through a die. It extrudes from the circular die as a film tube ("bubble"), pulled vertically by a set of nip rollers located at the top of a cooling tower. An IBC (Internal Bubble Cooling) unit, part of the extruder, maintains consistent bubble diameter. Material gauge is monitored and maintained by a computer system which controls the operation of the extruder.

At the top of the tower the bubble passes through a collapsing frame and is pulled through the nip rollers. The material is directed back toward the ground, and continues cooling as it approaches a winding machine. Before being taken up by the winder, the tube is split and spread to its deployable width. The winder rolls the finished geomembrane onto a specially made heavy-duty core.

3.2 Process Quality Control

Poly-Flex geomembranes are manufactured via the blown sheet process. This is a continuous process. The key elements to successfully producing a high-quality liner is to maintain consistency in both the raw material and the process. As described above, raw material consistency is established in the laboratory when the resin is initially received. Consistency during the processing is assured by an on-line quality control monitor. This representative of the quality department has been specially trained to monitor the process and the liners during the manufacturing process.

The extrusion process starts with the verification of the formulation. This is done at the beginning of each order or blend change by the extrusion manager and then is continuously monitored by the on-line quality control representative.

The process conditions during manufacturing have been optimized for each resin formulation. These conditions are kept in a log book which is available to the line operator. These process conditions must be maintained throughout the production run. Any variation of process parameters from the set point range recorded on the process log book are immediately reported to the production supervisor by the on-line quality control representative. If the variation exceeds the control range, the quality control representative places the material being produced on hold. Materials are placed on hold until the process is brought under control.

The on-line quality monitor can also place material on hold if the material has any visual defect (holes, water spots, or scratches) or dimensional abnormalities (width, length, and thickness).

All materials placed on hold will be further inspected and tested. If the material passes specification and is approved by the quality control manager and/or production manager, the material will then be released into stock. If the material fails to pass specification or does not get approval of either the quality control manager or production manager then the material will be reclassified or scrapped. In either case it cannot be sold as a prime Poly-Flex geomembrane.

Poly-Flex geomembranes are continuously monitored for pinholes during the manufacturing process by spark testing equipment. The spark tester unit is a perpetual monitor of any holes that could surface in the sheet. The spark tester monitors the entire layflat width of the sheet as it is being manufactured. The detector operates from a 120 V AC power supply. The 120 volts are transformed to a higher voltage that ranges from 0-24 kilovolts. The electrode is made up of a long semiconductor blanket that is positioned to lay over the sheet as it passes over a steel roller prior to final winding. A grounding conductor is connected to the roller with a return line to the controller. If a hole passes under the electrically charged blanket, the voltage will arc to the steel roller and the detection system will sense the voltage drop, thus triggering an audible alarm and shutting down the winder. Twice per shift, the quality control technician tests the spark tester by introducing a 1/32" pinhole in the sheet. This hole is at the end of a roll after the scheduled footage has been achieved. The winder continues to run until the hole is detected. Once the hole is detected, the alarm sounds and the winder shuts down. The quality control. technician restarts the winder and cuts out the entire layflat area of the pinhole.

After a roll of material has been produced it is labeled and a retain is cut for laboratory evaluation.

3.3 Roll Labeling

Three labels are affixed to each roll, as described below:

1. One label on the outside of the core.
2. One label on the core plug.
3. One label on the roll surface.

An additional label is attached to the laboratory sample.

3.4 Storage, Staging and Shipping of Geomembrane Rolls

Finished rolls (verified and labeled) are moved to the storage area using a specially designed cart and remain in storage until a Purchase Order is received. Rolls selected for shipment are moved to a staging area, where they are held for a truck. Before loading the order for shipment, all documentation is checked against the information on the roll labels. Rolls are lifted and moved using a loading arm equipped with rigging and hooks. Fork-lifting machinery are never to be used to lift or move geomembrane rolls.

3.5 Laboratory Quality Control & Quality Assurance

Based on the philosophy that quality cannot be inspected into a product and that a consistent raw material and a consistent process will yield a consistent liner, laboratory testing of Poly-Flex geomembrane is provided primarily for roll certification.

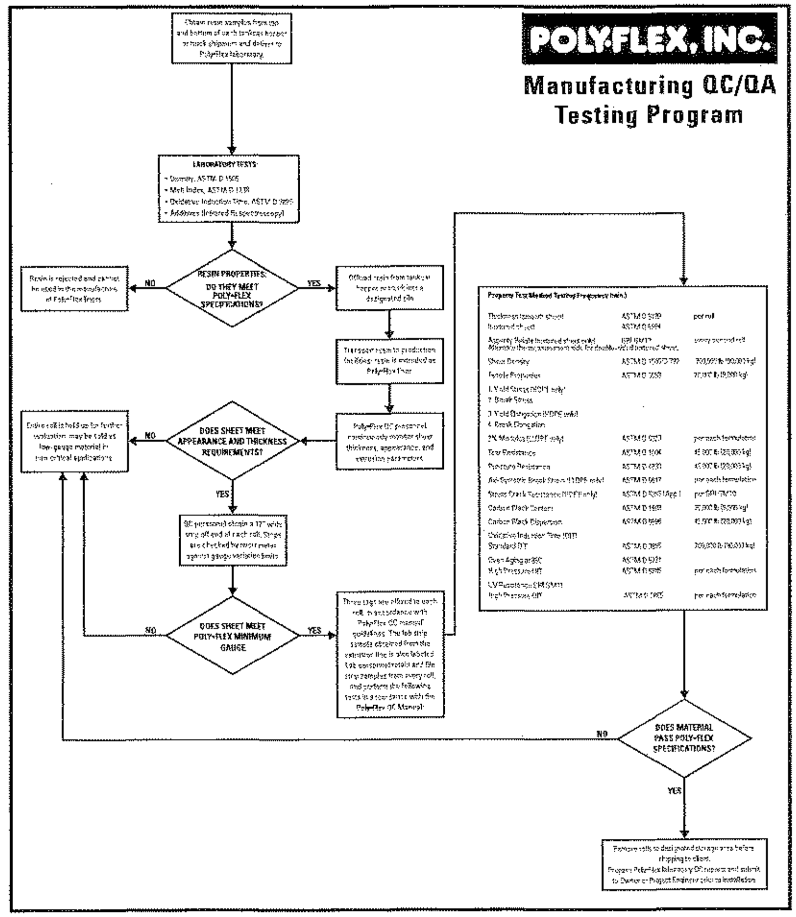
A retain from each roll is provided for the laboratory. Testing is conducted on the retains as indicated below.

Property	Test Method	Testing Frequency (min.)
Thickness (smooth sheet) (textured sheet)	ASTM D 5199 ASTM D 5994	per roll
Asperity Height (textured sheet only) Alternate the measurement side for double-sided textured sheet.	GRI GM12	every second roll
Sheet Density	ASTM D 1505/D 792	200,000 lb (90,000 kg)
Tensile Properties 1. Yield Strength (HDPE only) 2. Break Strength 3. Yield Elongation (HDPE only) 4. Break Elongation	ASTM D 6693	20,000 lb (9,000 kg)
2% Modulus (LLDPE only)	ASTM D 5323	per each formulation
Tear Resistance	ASTM D 1004	45,000 lb (20,000 kg)
Puncture Resistance	ASTM D 4833	45,000 lb (20,000 kg)
Axi-Symetric Break Strain (LLDPE only)	ASTM D 5617	per each formulation
Stress Crack Resistance (HDPE only)	ASTM D 5397 (App.)	per GRI GM10
Carbon Black Content	ASTM D 1603	20,000 lb (9,000 kg)
Carbon Black Dispersion	ASTM D 5596	45,000 lb (20,000 kg)
Oxidative Induction Time (OIT) Standard OIT	ASTM D 3895	200,000 lb (90,000 kg)
Oven Aging at 85°C High Pressure OIT	ASTM D 5721 ASTM D 5885	per each formulation
UV Resistance High Pressure OIT	GRI GM11 ASTM D 5885	per each formulation

After the testing has been completed, the data is reviewed by the quality control manager. If any rolls do not meet specifications, additional testing is conducted on that roll. If the roll still does not meet specifications the production manager is notified and the roll is placed on hold.

After the data has been reviewed it is entered into a product file which is used for roll certification.

4. MANUFACTURING QUALITY CONTROL PROGRAM FLOW CHART



5. PAPER FLOW FORMS

5.1 Product Quality Report

This report documents the raw material manufacturer's test results for the physical properties of the incoming resin. Each incoming shipment to Poly-Flex is accompanied by such a report. A copy of this report is sent to the engineer/client with the finished product.

Chevron Phillips

CoA Date: 12/08/2003

Certificate of Analysis

Shipped To: POLY AMERICA
2000 W. MARSHALL
GRAND PRAIRIE TX 75051
USA

Recipient: Dee Averitte
Fax: 1-972-337-7407

CPC Delivery #: 86514756
PO #: 163697
Weight: 180200 LB
Ship Date: 12/05/2003
Package: BULK
Mode: Hopper Car
Car #: PSPX005774

Product:
MARLEX POLYETHYLENE K203 BULK

Lot Number: 9131212

Property	Test Method	Value	Unit
Melt Index	ASTM D1238	0.180	g/10mi
HLMI Flow Rate	ASTM D1238	14.90	g/10mi
Density	ASTM D1505	0.9230	g/cm3
Production Date		12/02/03	

The data set forth herein have been carefully compiled by Chevron Phillips Chemical Company LP. **However, there is no warranty of any kind, either expressed or implied, applicable to its use and the user assumes all risk and liability in connection therewith.**

Jackie Edwards
Certification Systems Specialist

For CoA questions contact Peter Schatman at 713-289-4799

Page 1 of 1

5.2 Railcar Resin Report

This report is used by Poly-Flex's laboratory to document results of tests performed on incoming raw material. These results are checked against Poly-Flex's raw material specifications and the Product Quality Report issued by the material manufacturer.

RAILCAR RESIN REPORT

BUY INFORMATION

Railcar #: PSPX 5798
Vendor: ChevronPhilli
Type: GHDPE
Description: Prime Poly-Flex HDPE
Pressure: High: Low:

CAR CAPACITY

Measurements:
Weight: 185,400

Release Information

Comments:

LABORATORY TESTING REPORT

Comments: Prime HDPE Geomembrane

PUMPING INFORMATION

Time Started | Time Finished

Comments:

5.3 Quality Control Report

This report is sent to the engineer/client as Poly-Flex, Inc's standard quality control report. It documents the property values of the specific rolls shipped to a project.

CERTIFICATION SHEET

PROJECT NO: ____________ DATE: ____________

TRIP NO: ____________ ORDER NO: ____________

CERTIFIED BY: ____________

POLY-FLEX, INC.
2000 W. Marshall Drive
Grand Prairie, Texas 75051

TEST DESCRIPTION		THICKNESS	CARBON BLACK	TEAR	PUNCTURE	TENSILE@ YIELD	ELONG @ YIELD	TENSILE@ BREAK	ELONG @ BREAK	CAR. BLK. DISPERSION	DENSITY	NCTL
ASTM METHOD		D5199	D1603	D1004	D4833	D6693	D6693	D6693	D6693	D5596	D1505	D5397
(modifications)		min/avg										Appendix
UNITS		mils	%	lb	lb	lb/in	%	lb/in	%		g/cc	hours
SPECIFICATION												
ROLL NUMBER	BLEND											

5.4 Hold Tag

During production, any roll found to be defective is tagged and immediately removed. The roll will not be released for shipment, but it will be studied to determine the cause of the defect.

HOLD

FOR QUALITY DEPARTMENT EVALUATION.
DO NOT SEND THIS MATERIAL TO WAREHOUSE.

DATE ____________ SHIFT ____________

TIME ____________ FILM LINE ____________

QA INSP ____________ ROLL NO. ____________

PRODUCT CODE ____________

REASON PRODUCT BEING HELD ____________

QUALITY DEPARTMENT ASSESSMENT

DATE ____________

AUTHORIZATION ____________

______ RELEASE

______ SCRAP

INSTRUCTIONS ____________

POLY-FLEX
POLYETHYLENE GEOMEMBRANES

DRAINAGE NET AND GEOCOMPOSITE MANUFACTURING QUALITY CONTROL & QUALITY ASSURANCE

Net/Geocomposite Manufacturing QC/QA

1. MANUFACTURING QUALITY CONTROL AND QUALITY ASSURANCE

This section describes the manufacturing quality control and quality assurance for Poly-Flex drainage net and geocomposite products.

1.1 Applicable Test Methods

American Society for Testing and Materials (ASTM)

ASTM D 1505	Density of plastics by the density-gradient technique
ASTM D 1603	Carbon black in olefin plastics
ASTM D 4355	Deterioration of geotextiles by exposure to light, moisture and heat in Xenon Arc type apparatus
ASTM D 4491	Water permeability of geotextiles by the permittivity method
ASTM D 4533	Trapezoid tearing strength of geotextiles
ASTM D 4632	Breaking load and elongation of geotextiles (grab method)
ASTM D 4716	Determining the (in-plane) flow rate per unit width and hydraulic transmissivity of geosynthetics using constant head
ASTM D 4751	Determining apparent opening size of geotextiles
ASTM D 4833	Index puncture resistance of geotextiles, geomembranes, and related products
ASTM D 5199	Measuring nominal thickness of geotextiles and geomembranes
ASTM D 5261	Measuring mass per unit area of geotextiles
ASTM D 7005	Determining the bond strength ply adhesion of geocomposites
ASTM D 7179	Determining geonet breaking force

2. RAW MATERIAL

All resins, additives and concentrates used in Poly-Flex drainage net must meet Poly-Flex specifications before being released into the production material stream. Resin samples are taken from each incoming railcar. The resin density, melt index and carbon black content (for precompounded resins) are determined in the Poly-Flex laboratory. Upon verification of the resin compliance with the specifications, the resin is pumped from its railcar into a silo dedicated to production of the drainage net.

3. MANUFACTURING

3.1 Drainage Net

Poly-Flex drainage net consists of approximately 97% polyethylene, 1.5 to 3.0% carbon black, and other additives. The drainage net is continuously monitored during the manufacturing process. The key element to successfully manufacturing high quality drainage nets is to maintain consistency in both the raw material and the process. Raw material consistency is established in the laboratory when the resin is initially received and tested. An on-line quality control monitor establishes consistency during the processing. This representative of the quality department has been specially trained to monitor the process and the products during the manufacturing process. The on-line quality monitor can place material on hold if the material has any visual defects or dimensional abnormalities. All materials placed on hold will be further inspected and tested. If the material passes specification and is approved by the quality control manager and/or production manager, the material will then be released into stock. If the material fails to pass the specification or does not get approval of the quality control manager or production manager then the material will be reclassified or scrapped. In either case it cannot be sold as a prime Poly-Flex drainage net.

3.2 Drainage Net/Geotextile Geocomposite

Poly-Flex geocomposites consist of a geotextile bonded to one or both sides of the Poly-Flex drainage net. All geotextiles must meet the specifications before being eligible for production of geocomposites. Poly-Flex utilizes a heat bonding process to laminate the geotextile to the drainage net. An on-line quality control monitor establishes consistency during the processing. This representative of the quality department has been specially trained to monitor the process and the products during the lamination process. The on-line quality monitor can place material on hold if the material has any visual defects or dimensional abnormalities. All materials placed on hold will be further inspected and tested. If the material passes specification and is approved by the quality control manager and/or production manager, the material will then be released into stock. If the material fails to pass the specification or does not get approval of the quality control manager or production manager then the material will be reclassified or scrapped. In either case it cannot be sold as a prime Poly-Flex geocomposite.

3.3 Roll Labeling

Three labels are affixed to each roll as described below:

1. One label on the inside of the core.
2. One label on the face on the roll.
3. One label on the end of the roll.

An additional label is attached to the laboratory sample.

3.4 Storage, Staging and Shipping of Drainage Net and Geocomposite Rolls

All drainage net and geocomposite rolls are stretch wrapped prior to moving them to the storage area. Before shipment, all documentation is checked against the information on the roll labels. A full truckload consists of 24 rolls of drainage net and/or geocomposite material.

3.5 Laboratory Testing Program

3.5.1. Drainage Net

A 15 inch wide sample is cut across the width of every 10th roll and brought to the Poly-Flex laboratory for testing. The sample is checked for visual defects and then tested according to the following:

Property	Test Method	Testing Frequency
Thickness	ASTM D 5199	50,000 sf
Density	ASTM D 1505	50,000 sf
Carbon Black Content	ASTM D 1603	50,000 sf
Tensile Strength	ASTM D 7179	50,000 sf
Transmissivity[1]	ASTM D 4716	100,000 sf

The laboratory manager reviews all test results to insure the product meets the specification. Any roll that does not meet the specification is immediately reported to the on-line quality control manager and the roll(s) is placed on hold for further evaluation.

3.5.2. Geotextile

The manufacturer of the geotextile shall submit quality control test results for the geotextile rolls. The rolls must meet the specifications before they are accepted for production of geocomposites.

The geotextile manufacturer shall perform the following tests:

Property	Test Method	Testing Frequency
Unit Weight	ASTM D 5261	100,000 sf
Grab Strength	ASTM D 4632	100,000 sf
Grab Elongation	ASTM D 4632	100,000 sf
Tear Strength	ASTM D 4533	100,000 sf
Puncture Resistance	ASTM D 4833	100,000 sf
Permittivity	ASTM D 4491	500,000 sf
AOS	ASTM D 4751	500,000 sf
UV Stability	ASTM D 4355	Manufacturer Historical Data

3.5.3. Geocomposite

A 15 inch wide sample is cut across the width of every 20th roll and brought to the Poly-Flex laboratory for testing. The sample is checked for visual defects and then tested according to the following:

Property	Test Method	Testing Frequency
Transmissivity[1]	ASTM D 4716	100,000 sf
Ply Adhesion	ASTM D 7005	100,000 sf

1. Transmissivity test is performed with the drainage net or the geocomposite between two metal plates at a hydraulic gradient of 1.0 and a normal pressure of 10,000 psf (480 kPa). The seating time is 15 minutes.

The laboratory manager reviews all test results to ensure the product meets the specification. Any roll that does not meet the specification is immediately reported to the on-line quality control manager and the roll(s) is placed on hold for further evaluation.

3.6 Quality Control Report

The following reports are sent to the engineer/client as Poly-Flex, Inc.'s standard quality control reports. They document the property values of the specific rolls shipped to the project.

3.6.1 Drainage Net Certification Sheet

CERTIFICATION SHEET — **POLY-FLEX, INC.**
2000 W. Marshall Drive
Grand Prairie, Texas 75051

PROJECT NO: ______ DATE: ______
TRIP NO: ______ ORDER NO: ______
CERTIFIED BY: ______

TEST DESCRIPTION	THICKNESS	DENSITY	CARBON BLACK	PEAK TENSILE STRENGTH (MD)	TRANSMISSIVITY (MD)
ASTM METHOD	D5199	D1505	D1603	D7179	D4716
(modifications)	avg				
UNITS	mils	g/cc	%	lb/in	m²/s
SPECIFICATION					
ROLL NUMBER					

3.6.2 Geocomposite Certification Sheet

CERTIFICATION SHEET

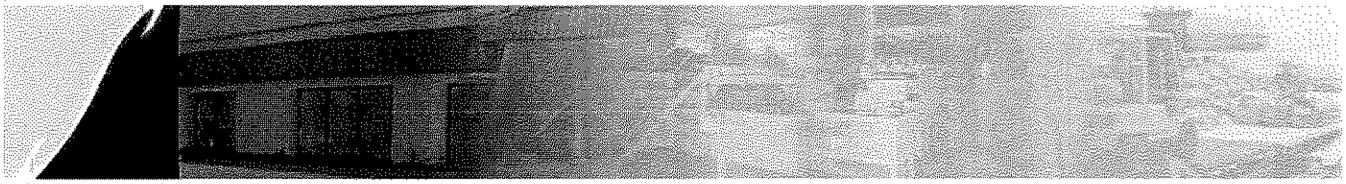
PROJECT NO: ____________ DATE: ____________
TRIP NO: ____________ ORDER NO: ____________
CERTIFIED BY: ____________

POLY-FLEX, INC.
2000 W. Marshall Drive
Grand Prairie, Texas 75051

TEST DESCRIPTION				TRANSMISSIVITY (MD)	PLY ADHESION	
ASTM METHOD				D 4716	D 7005	
(modifications)					TOP	BOTTOM
UNITS				m^2/s	lb/in	lb/in
SPECIFICATION						
COMPOSITE ROLL NUMBER	GEONET ROLL NUMBER	GEOTEXTILE TOP	GEOTEXTILE BOTTOM			

POLY-FLEX, INC.
2000 West Marshall Drive
Grand Prairie, Texas 75051
888-POLYFLX (888-765-9359)
972-337-7113 Fax 972-337-7233
www.poly-flex.com

PN [illegible]-074-0010-Pol Man. [illegible]



SKAPS Industries • 335 Athena Dr • Athens • GA 30601 • USA

DRAINAGE NET

SKAPS TRANSNET™ HDPE GEOCOMPOSITE WITH 220 MIL GEONET

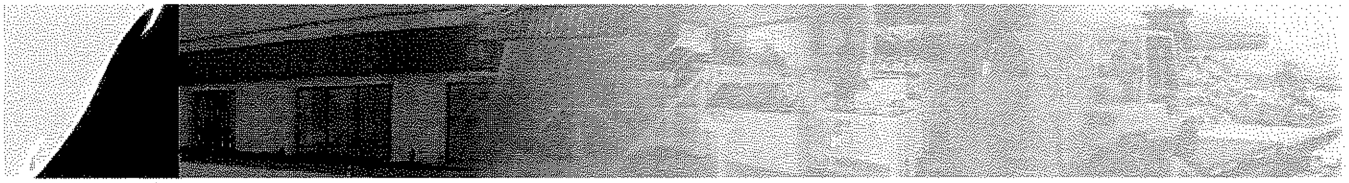
SKAPS TRANSNET™ GeoComposite consists of SKAPS GeoNet made from HDPE resin with non-woven polypropylene GeoTextile fabric heat bonded on both sides of GeoNet.

Property	Test Method	Unit	Required Value			Qualifier
			with 6 oz.	with 8 oz.	with 10 oz.	
GeoNet						
Mass per unit area	ASTM D 5261	lb/ft^2	0.17	0.17	0.17	Minimum
Thickness	ASTM D 5199	mil	220±20	220±20	220±20	Range
Carbon Black	ASTM D 4218	%	2 to 3	2 to 3	2 to 3	Range
Tensile Strength	ASTM D 5035	lb/in	45	45	45	Minimum
Melt Flow	ASTM D 1238[3]	g/10 min	1	1	1	Maximum
Density	ASTM D 1505	g/cm^3	0.94	0.94	0.94	Minimum
Transmissivity1	ASTM D 4716	m^2/sec	$1x10^{-3}$	$1x10^{-3}$	$1x10^{-3}$	MARV2
Composite						
Ply Adhesion (Minimum)	GRI GC7	m^2/sec	0.5	0.5	0.5	MARV
Ply Adhesion (Average)	GRI GC7	lb/in	1	1	1	MARV
Transmissivity[1a]	ASTM D 4716	m2/sec	$2.75x10^{-4}$	$2.25x10^{-4}$	$2.0x10^{-4}$	MARV
GeoTextile						
Fabric Weight	ASTM D 5261	oz/yd^2	6	8	10.0	MARV
Grab Strength	ASTM D 4632	lb	150	225	270	MARV
Grab Elongation	ASTM D 4632	%	50	50	50	MARV
Tear Strength	ASTM D 4533	lb	60	90	100	MARV
Puncture Resistance	ASTM D 4833	gpm/ft^2	95	130	165	MARV
Mullen Burst	ASTM D 3786[4]	psi	325	450	550	MARV
Water Flow Rate	ASTM D 4491	gpm/ft^2	125	100	75	MARV
Permittivity	ASTM D 4491	sec^{-1}	1.63	1.26	0.94	MARV
Permeability	ASTM D 4491	cm/sec	0.48	0.3	0.30	MARV
AOS	ASTM D 4751	US Sieve	70	80	100	MARV

Notes:

1. Transmissivity measured using water at 21 ± 2°C (70 ± 4°F) with a gradient of 1.0 and a confining pressure of 15000 psf between steel plates after 15 minutes. Values may vary between individual labs.

   [1a] Transmissivity measured using water at 21 ± 2°C (70 ± 4°F) with a gradient of 0.1 and a confining pressure of 10000 psf between steel plates after 15 minutes. Values may vary between individual labs.
2. MARV is statistically defined as mean minus two standard deviations and it is the value which is exceeded by 97.5% of all the test data.
3. Condition 190/2.16
4. Modified



SKAPS Industries • 335 Athena Dr • Athens • GA 30601 • USA

SKAPS GT-112
Nonwoven Geotextiles

SKAPS **GT-112** is a needle-punched nonwoven geotextile made of 100% polypropylene staple fibers, which are formed into a random network for dimensional stability. SKAPS GT-112 resists ultraviolet deterioration, rotting, biological degradation, naturally encountered basics and acids. Polypropylene is stable within a pH range of 2 to 13. SKAPS GT-112 conforms to the physical values listed below:

:: Go Back ::

PROPERTY	TEST METHOD	UNIT	M.A.R.V. (Minimum Average Roll Value)
Weight (Typical)	ASTM D5261	oz/yd^2 (g/m^2)	12.0 (407)
Grab Tensile	ASTM D4632	lbs (kN)	300 (1.33)
Grab Elongation	ASTM D4632	%	50
Trapezoid Tear Strength	ASTM D4533	lbs (kN)	115 (0.511)
Puncture Resistance	ASTM D4833	lbs (kN)	180 (0.80)
Mullen Burst	ASTM D3786	psi (kPa)	600 (4134)
Permittivity*	ASTM D4491	sec^{-1}	1.0
Water Flow*	ASTM D4491	gpm/ft^2 ($l/min/m^2$)	75 (3055)
A.O.S.*	ASTM D4751	U.S. Sieve (mm)	100 (0.150)
U.V. Resistance	ASTM D4355	%/hrs	70/500

* At the time of manufacturing. Handling, storage, and shipping may change these properties.

PACKAGING	
Roll Dimension (W x L) - Ft	12.5 x 360 / 15 x 300
Square Yards per Roll	500
Estimated Roll Weight - lbs	375

* At the time of manufacturing. Handling may change these properties.

This information is provided for reference purposes only and is not intended as a warranty or guarantee. SKAPS assumes no liability in connection with the use of this information.

ATTACHMENT #3
EPA 9090 LABORATORY TESTING ON LINER SYSTEM MATERIALS

TRI/ENVIRONMENTAL, INC.
A Texas Research International Company

May 30, 1997

Mr. Paul Barker
AGRU/America, Inc.
300 West Davis, Suite 520
Conroe, Texas 77305

Dear Mr. Barker:

TRI/Environmental, Inc. (TRI) is pleased to present this 120 Day Final Report for geosynthetic chemical compatibility studies via EPA Method performed on AGRU smooth 60 mil HDPE geomembrane.

TRI thanks AGRU/America for the opportunity to work on this project. Please call me if you have any questions or require any additional information.

Respectfully submitted,

Martin D. Nelson

Martin D. Nelson
Project Manager: Geosynthetic Technologies

cc: Mr. Sam R. Allen
Program Manager

FOREWORD

The testing reported herein is based upon accepted industry practice as well as the test method listed. TRI/Environmental Inc. (TRI) neither accepts responsibility for nor makes claim as to the final use and purpose of the materials tested.

Tests were performed under laboratory conditions and not under actual usage conditions. TRI can give no conclusions as to the serviceability, life expectancy or general durability of the products tested when used in a lining and/or leachate collection system.

A 120 Day Final Report:

Laboratory Testing of Geosynthetics
for Waste Containment
EPA Method 9090

May 1997

Submitted to:
AGRU/America, Inc.
300 West Davis, Suite 520
Conroe, Texas 77305

Attn: **Mr. Paul Barker**

Submitted by:

TRI/Environmental, Inc.
9063 Bee Caves Rd.
Austin, Texas 78733

1.0 INTRODUCTION

This report describes the work performed by TRI/Environmental, Inc. (TRI) to determine the chemical compatibility of one geomembrane product with one waste leachate. The objective was to determine the resistance of the geomembrane to changes caused by exposure to leachate. Changes in physical and mechanical properties were measured after exposure to the leachate at 23°C and 50°C for 30, 60, 90 and 120 days. Exposures were performed in accordance with the exposure regimen specified in United States Environmental Protection Agency (EPA) Method 9090A.

Methods, results and discussion are provided in the sections which follow. Test results are provided in the Tables of Results which accompany this report.

2.0 METHODS

2.1 Materials

The material selected for evaluation in this chemical compatibility study was 60 mil smooth High Density Polyethylene (HDPE) geomembrane manufactured by Agru/America, Inc. Roll #638571 was provided by Agru/America.

2.2 Leachate

The exposure leachate used during the testing was a synthetic municipal solid waste (MSW) leachate. TRI generated the synthetic municipal waste leachate by spiking a quantity of actual MSW leachate (secured from the NENT Landfill in Hong Kong) with various chemical constituents as required by the Pennsylvania Department of Environmental Regulation (PADER). Spiking was accomplished using standard solutions used for instrument calibration for organics and salts used for the inorganics. Spiking was performed to assure a minimum concentration as defined by the PADER requirements. The exposure media met all requirements as defined by PADER.

After spiking, the leachate, contained in a fifty-five gallon drum, was stirred for twenty four hours and allowed to settle. Leachate was then transferred to exposure cells for chemical resistance testing.

2.3 Exposure Conditions

Geomembrane specimens were exposed to the waste leachate following the specifications of EPA Method 9090A as they relate to exposure to waste fluids. The tanks used for these exposures were maintained at 23 ± 2°C and 50 ± 2°C throughout the 120-day exposure period. Tanks were constructed from chemically resistant glass, fitted with stirrers and heated with a circulating hot water heat exchanger system. The 50°C tanks were sealed with a lid, and a reflux condenser was installed to minimize loss of volatile leachate components.

2.4 Testing Procedures

Table 2 lists tests performed on the geomembrane. The number of test replicates was doubled for baseline determinations on unexposed material.

Table 2. Tests performed on geomembranes

Test or Physical Property	Method	Number of replicate specimens
Dimensions and weight	EPA 9090	3 readings
Hardness	ASTM D 2240 D scale	5
Volatiles and Extractables	EPA SW 870 Appendix III	2
Specific Gravity	ASTM D 792	3
Tensile Properties	ASTM D 638	3
Modulus of Elasticity	ASTM D 882 Tangential Modulus	3
Hydrostatic Resistance	ASTM D 751 Method A	3
Tear Strength	ASTM D 1004	3
Puncture Resistance	FTMS 101C Method 2065	3
Environmental Stress Crack Resistance	ASTM D 1693	2

Where appropriate testing was performed in both the machine and transverse directions.

3.0 Results and Discussion

Test results are presented in the Test Results section which is included with this report. Test results are presented in tabular form as well as graphical form.

In considering these results, it must be determined through engineering judgment whether observed differences in the value of test results measured before and after immersion are due to product variability, unidentified factors relating to the test procedure, or leachate interaction with the products. Any significant chemical interaction with leachate would be expected to result in degradation trends which are consistent across the various properties being evaluated, and not isolated to one set of test results only. However, with each type of material there may be specific properties which are highly sensitive to leachate-induced effects. These factors must be considered in evaluating the various test results for a given product.

Also of critical importance is the issue of product variability. With geomembranes, a range of physical and mechanical index test values covering 15% or more of the average is not uncommon. This can be traced to variability inherent in the product, and the randomness associated with the onset of failure under the specified testing conditions. However, in chemical compatibility testing the statistical sampling of a broad range of manufactured product is not possible. Therefore, the small size of the sample population tested at each time point must be taken into consideration. The criteria to be applied in evaluating data measured before and after leachate immersion should be that property changes, if observed, are consistent and so great that product variability and experimental factors can be ruled out.

In this report, standard deviations (STD) are reported for most measurements involving three or more replicate specimens. In statistics, the standard deviation is defined as root of the mean squared deviations of individual test results about the mean value. The standard deviation is a quantitative measure of variability within a group of measurements.

One related measure of variability observed within a sample set, relative to the magnitude of the mean value itself, is the *coefficient of variation or variance* (COV). The coefficient of variance is defined as the standard deviation divided by the mean associated with a group of specimens, and may be expressed as a percentage. The COV provides an indication of what proportion of the mean value may be attributable to random experimental factors or product variability. It is useful to consider apparent changes in property values ~~against the~~ criterion of COV since observed changes which fall below the COV may not be significant. This approach was used in preparing the tables in the next sections.

The term *range* refers to the difference between the extreme highest and lowest points within a group of measured values. Considering range as a percentage of the mean values provides another measure of variability within a dataset.

In the tables, the high and low extremes for percentage change in mean values are listed for comparison against COV and range as a percentage of mean from the baseline sample group. The high and low percentage changes are the extremes from data measured at 30, 60, 90 and 120 days.

Agru/America 60 mil smooth HDPE Geomembrane

Table 3 illustrates the range of variability in baseline data compared with some of the observed changes in average test values measured after immersion for the HDPE geomembrane.

Table 3. Baseline coefficients of variation and range of percentage change results for Agru/America 60 mil HDPE Geomembrane (mechanical properties testing only)

Test	Baseline COV (%)*	Baseline Range as % of Mean*	High Observed % Change	Low Observed % Change
Stress @ yield (MD)	3	8	+5	-6
Elongation @ yield (MD)	5	12	+20	+1
Stress @ break (MD)	5	14	+14	-13
Elongation @ break (MD)	4	11	+8	-18
Tangential Modulus (MD)	4	12	+9	-6
Tear Strength (MD)	2	6	+4	-2
Puncture Resistance	2	6	+8	0
Hydrostatic Resistance	2	5	+4	0

* Note that the greatest baseline change for the four exposure periods was reported.

4.0 CONCLUSION

Changes in certain measured physical and mechanical properties were noted for the geomembrane. However, the observed changes were random and are believed to be the effects of product variability and experimental factors. In the opinion of the authors, the data, considered together, support the conclusion that observed changes were not caused by exposure to the test leachate.

TRI/Environmental, Inc. is pleased to have been selected to participate in this project. We trust that the information provided in this report meets your requirements for technical documentation of this chemical compatibility study. Please do not hesitate to call if you have any questions or require any additional information.

Respectfully submitted,

Sam R. Allen
Program Manager
Geosynthetics Technologies

TRI/Environmental, Inc.

TRI GEOSYNTHETICS SERVICES DIVISION
PaDEP Leachate Analysis
Testing performed by TRI/Environmental, Inc.

Analysis: March 02-27, 1999

Analytes	LOQ (ug/L)	Blank (ug/L)	PaDEP Synthetic Leachate (ug/L)
Organics: SW 846 Methods 624, 625, 608			
Acenaphthene	10	ND	113
Acenaphthylene	25	ND	67
Anthracene	10	ND	52
Benzene	10	ND	811
Benzo(a)anthracene	10	ND	28
Benzo(a)pyrene	10	ND	52
Benzo(ghi)perylene	10	ND	45
Benzo(k)flouranthene	50	ND	33
3,4-benzofluoranthene	25	ND	49
Chrysene	10	ND	52
Dibenzo(a,h)anthracene	10	ND	48
Ethyl benzene	10	ND	2600
Fluoranthene	10	ND	54
Fluorene	10	ND	52
Indeno(1,2,3,c,d)pyrene	50	ND	63
Naphthalene	10	ND	288
Phenanthrene	10	ND	65
Pyrene	10	ND	45
Styrene	10	ND	170
Toluene	10	ND	15000
Xylenes	10	ND	280
PCBs	10	ND	ND
Aldrin	10	ND	ND
1,2-Dichlorobenzene	10	ND	1200
1,4-Dichlorobenzene	10	ND	700
Hexachlorobenzene	10	ND	300
Pentachlorobenzene	10	ND	170
Trichlorobenzene**	50	ND	160
Tetrachlorobenzene**	10	ND	150
2-chloronaphthalene	10	ND	100
Chlorobenzene	10	ND	19000
4,4-DDT	10	ND	ND
4,4-DDE	50	ND	ND
4,4-DDD	10	ND	ND

TRI GEOSYNTHETICS SERVICES DIVISION
PaDEP Leachate Analysis
Testing performed by TRI/Environmental, Inc.

Analysis: March 02-27, 1999 Analytes	LOQ (ug/L)	Blank (ug/L)	PaDEP Synthetic Leachate (ug/L)
Organics: SW 846 Methods 624, 625, 608 (Continued)			
Heptane	10	ND	70
Hexane	10	ND	70
Octane	10	ND	60
Bromoform	10	ND	1200
Carbon tetrachloride	25	ND	500
Chlorodibromomethane	10	ND	30
Chloroethane	10	ND	1000
Chloroform	10	ND	6800
Dichlorobromomethane	10	ND	140
Dichlorodifluoromethane	30	ND	600
1,1-Dichloroethane	50	ND	10300
1,2-Dichloroethane	25	ND	16050
Dichloropropane	10	ND	1300
cis-Dichloroethene	10	ND	350
trans-Dichloroethene	40	ND	700
Ethylene dichloride *12DCA	10	ND	ND
Hexachloroethane	10	ND	600
Methyl bromide	50	ND	120
Methyl chloride	10	ND	120
Methylene chloride	50	ND	12000
Tetrachloroethene	50	ND	700
Tetrachloroethane**	50	ND	800
1,1,1-Trichloroethane	10	ND	900
1,1,2-Trichloroethane	10	ND	500
Trichloroethene	10	ND	800
Trichlorofluoromethane	10	ND	75
Vinyl chloride	10	ND	185

TRI GEOSYNTHETICS SERVICES DIVISION
PaDEP Leachate Analysis
Testing performed by TRI/Environmental, Inc.

Analysis: March 02-27, 1999

Analytes	LOQ (ug/L)	Blank (ug/L)	PaDEP Synthetic Leachate (ug/L)
Organics: SW 846 Methods 624, 625, 608 (Continued)			
Acrolein	10	ND	345
Acrylonitrile	25	ND	45
Acetone	10	ND	15000
Amyl acetate	10	ND	70
Benzidine	10	ND	70
Butyl alcohol**	10	ND	220
Bis(2-chloroethoxy)methane	10	ND	32
Bis(2-chloroethoxy)ether	50	ND	70
Bis(2-chloroisopropyl)ether	25	ND	70
Bis(2-ethylhexyl)phthalate	10	ND	900
4-bromophenyl phenyl ether	10	ND	60
Butyl benzyl phthalate	10	ND	200
cresol**	10	ND	425
Chlordane	10	ND	ND
alpha-BHC	50	ND	ND
beta-BHC	10	ND	ND
gamma-BHC	10	ND	ND
delta-BHC	10	ND	ND
Dieldrin	10	ND	ND
Dichlorobenzidine	10	ND	100
Diethyl phthalate	10	ND	30
Dibutyl phthalate	10	ND	70
Dimethyl phthalate	10	ND	70
Isobutyl alcohol	10	ND	12000
Isopropyl alcohol	10	ND	200
Methyl alcohol	10	ND	160
2-chloroethyl vinyl ether	10	ND	700
2-chlorophenol	50	ND	1400
Dichlorophenol**	10	ND	1300
Dimethyl phenol**	10	ND	50
Dinitro-o-cresol	10	ND	60
Dinitrophenol**	10	ND	60
Dinitrotoluene**	10	ND	100
Diphenylhydrazine	10	ND	50
Ethyl acetate	10	ND	110
Ethyl ether	10	ND	100
Ethyl alcohol	10	ND	25000
Endosulfan	10	ND	50
Endrin	10	ND	19

TRI GEOSYNTHETICS SERVICES DIVISION
PaDEP Leachate Analysis
Testing performed by TRI/Environmental, Inc.

Analysis: March 02-27, 1999 Analytes	LOQ (ug/L)	Blank (ug/L)	PaDEP Synthetic Leachate (ug/L)
Organics: SW 846 Methods 624, 625, 608 (Continued)			
Formaldehyde	10	ND	ND
Heptachlor	50	ND	ND
Hexachlorocyclopentadiene	10	ND	80
Haxachlorobutadiene	10	ND	500
Isophorone	10	ND	6000
Methyl ethyl ketone	10	ND	13500
Methyl isobutyl ketone	10	ND	750
Nitrophenol**	10	ND	20
N-nitrosodimethylamine	10	ND	120
N-nitrosodi-n-propylamine	10	ND	120
Nitrobenzene	10	ND	600
Pentachlorophenol	10	ND	450
Phenol	10	ND	15000
Pyridine	10	ND	700
Toluene	50	ND	1260
Toxophene	50	ND	300
Trichlorophenol**	10	ND	400
2,4,5-TP	10	ND	50
METALS (EPA Method 200 Series)			(mg/L)
Aluminum (202.1)	1	ND	15
Antimony (204.1)	1	ND	20
Arsenic (206.2)	1	ND	5
Barium (208.1)	1	ND	120
Beryllium (210.1)	1	ND	2
Boron (212.3)	1	ND	15
Cadmium (213.1)	1	ND	15
Chromium (218.1)	1	ND	10
Copper (220.1)	1	ND	10
Iron (236.1)	1	ND	800
Lead (239.1)	1	ND	10
Manganese (243.1)	1	ND	1000
Mercury (245.1)	1	ND	ND
Molybdenum (246.1)	1	ND	5
Nickel (249.1)	1	ND	ND
Silver (272.1)	1	ND	8
Selenium (270.2)	1	ND	ND
Tin (282.1)	1	ND	ND
Titanium (283.1)	1	ND	ND
Thallium (279.1)	1	ND	ND
Zinc (289.1)	1	ND	25
CONVENTIONALS (EPA Methods)			(mg/L)
Oil and Grease (413.1)	20	ND	500
Total petroleum hydrocarbons (418.1)	10	ND	9000
Ammonia-nitrogen (350.2)	50	ND	600
Cyanide (335.2)	15	ND	ND
Flouride (340.1-340.2)	15	ND	500
Chloride (325.3)	10	ND	8000
Nitrate (353.3)	1	ND	3
Nitrite (353.3)	1	ND	ND
Sulfate (375.4)	1	ND	250
TDS	1	ND	13400
pH	NA	ND	7.2

TRI GEOSYNTHETICS SERVICES DIVISION
PaDEP Leachate Analysis
Testing performed by TRI/Environmental, Inc.

QUALITY ASSURANCE REPORT

Analysis: March 02-27, 1999 Analytes	Blank (ug/L)	PaDEP Synthetic Leachate (ug/L)
Surrogate Recoveries		
1,2-Dichloroethane-d4	156%	124%
Toluene-d8	100%	95%
Bromofluorobenzene	117%	73%
Trifluorotoluene	120%	113%
2-Fluorophenol (Acid Surr)	110%	110%
Phenol-d6 (Acid Surr)	98%	123%
Nitrobenzene-d5 (BN Surr)	68%	74%
2-Fluorobiphenyl (BN Surr)	124%	102%
2,4,6-Tribomophenol (Acid Surr)	92%	76%
p-Terphenyl-d14 (BN Surr)	90%	96%

Compounds	Matrix Spike	Matrix Spike Dup
Phenol	17%	32%
2-Chlorophenol	30%	89%
1,4-Dichlorobenzene	26%	97%
N-Nitroso-Di-N-Propylamine	69%	105%
1,2,4-Trichlorobenzene	39%	86%
4-Chloro-3-Methylphenol	83%	100%
Acenaphthene	88%	120%
4-Nitrophenol	17%	13%
2,4-Dinitrotoluene	72%	96%
Pentachlorophenol	71%	73%
Pyrene	88%	118%
METALS		
Arsenic	90%	87%
Barium	98%	101%
Cadmium	92%	93%
Chromium	84%	86%
Lead	79%	80%
Mercury	94%	98%
Selenium	82%	89%
Silver		

A Final Report:

Laboratory Testing of Geomembrane for Waste Containment EPA Method 9090A

October 1999

Submitted to:

Poly-Flex Inc.
2000 W. Marshall Drive
Grand Prairie, Texas 75051

Attn: **Mr. Lou Jacobsen**

Submitted by:

TRI/Environmental, Inc.
9063 Bee Caves Rd.
Austin, Texas 78733

TRI/ENVIRONMENTAL, INC.
A Texas Research International Company

October 24, 1999

Mr. Lou Jaconsen
Poly-Flex, Inc.
2000 W. Marshall Drive
Grand Prairie, Texas 75051

Dear Mr. Jacobsen:

TRI/Environmental, Inc. (TRI) is pleased to present this Final Report for geomembrane chemical compatibility studies via EPA Method 9090A.

TRI thanks Poly-Flex, Inc. for the opportunity to participate in this project and trusts this report fully documents all testing performed. Please call me if you have any questions or require any additional information.

Respectfully submitted,

Sam R. Allen

Sam R. Allen
Vice President and Division Manager
Geosynthetic Services

9063 Bee Caves Road • Austin, TX 78733-6201 • (512) 263-2101 • FAX (512) 263-2558

1.0 INTRODUCTION

This report describes the work performed by TRI/Environmental, Inc. (TRI) to determine the chemical compatibility of one geomembrane product with one waste leachate. The objective was to determine the resistance of the geomembrane to changes caused by exposure to leachate. Changes in physical and mechanical properties were measured after exposure to the leachate at 23°C and 50°C for 30, 60, 90 and 120 days. Exposures were performed in accordance with the exposure regimen specified in United States Environmental Protection Agency (EPA) Method 9090A.

Methods, results and discussion are provided in the sections which follow. Test results are provided in the Tables of Results which accompany this report.

2.0 METHODS

2.1 Materials

The material selected for evaluation in this chemical compatibility study was 60 mil smooth high density polyethylene (HDPE) geomembrane manufactured by PolyFlex, Inc..

2.2 Leachate

The exposure leachate used during the testing was a synthetic municipal solid waste (MSW) leachate. TRI generated the synthetic municipal waste leachate by spiking a quantity of actual MSW leachate (secured from the NENT Landfill in Hong Kong) with various chemical constituents as required by the Pennsylvania Department of Environmental Regulation (PADER). Spiking was accomplished using standard solutions used for instrument calibration for organics and salts used for the inorganics. Spiking was performed to assure a minimum concentration as defined by the PADER requirements. The exposure media met all requirements as defined by PADER.

After spiking, the leachate, contained in a fifty-five gallon drum, was stirred for twenty four hours and allowed to settle. Leachate was then transferred to exposure cells for chemical resistance testing.

2.3 Exposure Conditions

Geomembrane specimens were exposed to the waste leachate following the specifications of EPA Method 9090A as they relate to exposure to waste fluids. The tanks used for these exposures were maintained at 23 ± 2°C and 50 ± 2°C throughout the 120-day exposure period. Tanks were constructed from chemically resistant glass, fitted with stirrers and heated with a circulating hot water heat exchanger system. The 50°C tanks were sealed with a lid, and a reflux condenser was installed to minimize loss of volatile leachate components.

2.4 Testing Procedures

Table 1 lists tests performed on the geomembrane. The number of test replicates was doubled for baseline determinations on unexposed material.

Table 1. Tests performed on geomembranes

Test or Physical Property	Method	Number of replicate specimens
Dimensions and weight	EPA 9090	3 readings
Hardness	ASTM D 2240 D scale	5
Volatiles and Extractables	EPA SW 870 Appendix III	2
Specific Gravity	ASTM D 792	3
Tensile Properties	ASTM D 638	3
Modulus of Elasticity	ASTM D 882 Tangential Modulus	3
Hydrostatic Resistance	ASTM D 751 Method A	3
Tear Strength	ASTM D 1004	3
Puncture Resistance	FTMS 101C Method 2065	3
Environmental Stress Crack Resistance	ASTM D 1693	2

Where appropriate testing was performed in both the machine and transverse directions.

3.0 Results and Discussion

Test results are presented in the Test Results section which is included with this report. Test results are presented in tabular form as well as graphical form.

In considering these results, it must be determined through engineering judgment whether observed differences in the value of test results measured before and after immersion are due to product variability, unidentified factors relating to the test procedure, or leachate interaction with the products. Any significant chemical interaction with leachate would be expected to result in degradation trends which are consistent across the various properties being evaluated, and not isolated to one set of test results only. However, with each type of material there may be specific properties which are highly sensitive to leachate-induced effects. These factors must be considered in evaluating the various test results for a given product.

Also of critical importance is the issue of product variability. With geomembranes, a range of physical and mechanical index test values covering 15% or more of the average is not uncommon. This can be traced to variability inherent in the product, and the randomness associated with the onset of failure under the specified testing conditions. However, in chemical compatibility testing the statistical sampling of a broad range of manufactured product is not possible. Therefore, the small size of the sample population tested at each time point must be taken into consideration. The criteria to be applied in evaluating data measured before and after leachate immersion should be that property changes, if observed, are consistent and so great that product variability and experimental factors can be ruled out.

In this report, standard deviations (STD) are reported for most measurements involving three or more replicate specimens. In statistics, the standard deviation is defined as root of the mean squared deviations of individual test results about the mean value. The standard deviation is a quantitative measure of variability within a group of measurements.

One related measure of variability observed within a sample set, relative to the magnitude of the mean value itself, is the *coefficient of variation or variance* (COV). The coefficient of variance is defined as the standard deviation divided by the mean associated with a group of specimens, and may be expressed as a percentage. The COV provides an indication of what proportion of the mean value may be attributable to random experimental factors or product variability. It is useful to consider apparent changes in property values against the criterion of COV since observed changes which fall below the COV may not be significant. This approach was used in preparing the tables in the next sections.

The term *range* refers to the difference between the extreme highest and lowest points within a group of measured values. Considering range as a percentage of the mean values provides another measure of variability within a dataset.

In the tables, the high and low extremes for percentage change in mean values are listed for comparison against COV and range as a percentage of mean from the baseline sample group. The high and low percentage changes are the extremes from data measured at 30, 60, 90 and 120 days.

Poly-Flex 60 mil smooth HDPE Geomembrane

Table 2 illustrates the range of variability in baseline data compared with some of the observed changes in average test values measured after immersion for the HDPE geomembrane.

Table 2. Baseline coefficients of variation and range of percentage change results for PolyFlex 60 mil HDPE Geomembrane (mechanical properties testing only)

Test	Baseline COV (%)*	Baseline Range as % of Mean*	High Observed % Change	Low Observed % Change
Stress @ yield (MD)	2	5	+5	1
Elongation @ yield (MD)	2	6	+6	-1
Stress @ break (MD)	6	16	+7	-1
Elongation @ break (MD)	6	22	+4	-4
Tangential Modulus (MD)	13	33	+7	-9
Tear Strength (MD)	2	6	+1	-2
Puncture Resistance	2	4	+4	-3
Hydrostatic Resistance	1	3	+1	-3

* Note that the greatest baseline change for the four exposure periods was reported.

4.0 CONCLUSION

Changes in certain measured physical and mechanical properties were noted for the geomembrane. However, the observed changes were random and are believed to be the effects of product variability and experimental factors. In the opinion of the authors, the data, considered together, support the conclusion that observed changes were not caused by exposure to the test leachate.

TRI/Environmental, Inc. is pleased to have been selected to participate in this project. We trust that the information provided in this report meets your requirements for technical documentation of this chemical compatibility study. Please do not hesitate to call if you have any questions or require any additional information.

Respectfully submitted,

Sam R. Allen

Sam R. Allen
Vice President and Division Manager
Geosynthetics Technologies

TRI/Environmental, Inc.

FOREWORD

The testing reported herein is based upon accepted industry practice as well as the test method listed. TRI/Environmental Inc. (TRI) neither accepts responsibility for nor makes claim as to the final use and purpose of the materials tested.

Tests were performed under laboratory conditions and not under actual usage conditions. TRI can give no conclusions as to the serviceability, life expectancy or general durability of the products tested when used in a lining and/or leachate collection system.

EPA METHOD 9090A TEST RESULTS

GEOSYNTHETIC DIMENSIONS

TABLE OF CHEMICAL COMPATIBILITY TEST RESULTS
Exposure to PADER Waste Leachate
Dimensional Stability Data

; Date: October, 1999

Exposure Time and Temperature

SCA
Quality Review

Test Parameters	Temp.	Baseline	30 Day Exposed	% Change	Baseline	60 Day Exposed	% Change	Baseline	90 Day Exposed	% Change	Baseline	120 Day Exposed	% Change
POLYFLEX GEOMEMBRANE: 60 mil HDPE													
Thickness (mils)	23C	58	59	1.7	61	61	0.0	58	58	0.0	65	64	-1.5
	50C	61	61	0.0	61	61	0.0	61	61	0.0	61	61	0.0
Length (inches)	23C	10.03	10.02	-0.1	10.04	10.04	0.0	10.04	10.04	0.0	10.02	10.01	-0.1
	50C	10.02	10.02	0.0	10.00	10.00	0.0	10.01	10.01	0.0	10.01	10.00	-0.1
Width (inches)	23C	8.02	8.01	-0.1	8.00	8.00	0.0	8.02	8.02	0.0	8.01	8.01	0.0
	50C	8.01	8.01	0.0	8.00	8.00	0.0	8.01	8.01	0.0	8.00	8.00	0.0
Mass (g)	23C	71.98	72.06	0.1	76.34	76.81	0.6	72.65	72.89	0.3	79.39	79.62	0.3
	50C	76.29	76.39	0.1	75.03	75.26	0.3	75.69	75.91	0.3	76.43	76.82	0.5

EPA METHOD 9090A TEST

POLY-FLEX 60 mil SMOOTH HDPE GEOMEMBRANE

TABLE OF CHEMICAL COMPATIBILITY TEST RESULTS
Exposure to PADER Waste Leachate

Report Date: October 1999

Exposure Time and Temperature

Test Parameters	30 Day			60 Day			90 Day			120 Day		
	Baseline	23C	50C	Baseline	23C	50C	Baseline	23C	50C	Baseline	23C	50C
POLYFLEX GEOMEMBRANE: 60 mil HDPE												
Tensile Properties:	2597	2619	2675	2656	2662	2752	2454	2582	2524	2629	2717	2514
Tensile Stress @ Yield (psi)	2625	2754	2693	2610	2777	2698	2476	2422	2478	2652	2624	2768
ASTM D638	2561	2573	2666	2505	2583	2685	2365	2447	2511	2711	2639	2771
Machine Direction	2673			2590			2402			2674		
	2593			2570			2380			2617		
	2537			2522			2419			2540		
Average	2598	2649	2678	2576	2667	2705	2416	2484	2504	2637	2660	2684
STD	44	77	11	61	67	36	39	70	20	53	41	120
Coefficient of Variation	2	3	0	2	3	1	2	3	1	2	2	4
% Change		2	3		4	5		3	4		1	2
Tensile Properties:	4639	4622	4508	3611	4737	4266	4619	4674	4808	4915	4773	4190
Tensile Strength @ Break (psi)	4454	4411	4614	3921	4456	4705	4529	4765	4789	4650	4438	4822
ASTM D638	3942	4215	4355	4781	4022	4193	4470	4497	4760	4034	4603	4720
Machine Direction	4638			3767			4377			5055		
	4672			4964			4510			4295		
	4520			4912			4374			4864		
Average	4478	4416	4492	4328	4405	4389	4460	4645	4786	4636	4605	4577
STD	251	166	106	569	294	226	86	111	20	360	137	277
Coefficient of Variation	6	4	2	13	7	5	2	2	0	8	3	6
% Change		-1	0		2	1		4	7		-1	-1
nsile Properties:	13.8	13.8	13.8	13.1	13.4	13.0	13.4	14.0	14.2	13.1	13.6	13.6
ongation @ Yield (%)	13.8	13.6	13.6	14.0	14.0	13.0	12.8	13.6	14.0	13.3	13.6	13.6
ASTM D638	12.9	13.1	12.9	12.7	13.4	14.2	12.3	13.8	14.0	13.1	12.7	13.6
Machine Direction	13.8			14.0			13.5			13.6		
	13.8			12.5			13.6			13.6		
	13.4			14.2			14.1			12.9		
Average	13.6	13.6	13.5	13.4	13.6	13.4	13.3	13.8	14.1	13.3	13.3	13.6
STD	0.3	0.3	0.4	0.7	0.3	0.6	0.6	0.2	0.1	0.3	0.4	0.0
Coefficient of Variation	2	2	3	5	2	4	5	1	1	2	3	0
% Change		-0	-1		1	-0		4	6		0	2

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TABLE OF CHEMICAL COMPATIBILITY TEST RESULTS
Exposure to PADER Waste Leachate

Report Date: October 1999

Exposure Time and Temperature

Test Parameters	30 Day Baseline	30 Day 23C	30 Day 50C	60 Day Baseline	60 Day 23C	60 Day 50C	90 Day Baseline	90 Day 23C	90 Day 50C	120 Day Baseline	120 Day 23C	120 Day 50C
POLYFLEX GEOMEMBRANE: 60 mil HDPE												
Tensile Properties:	605	594	609	479	630	564	638	609	625	632	599	581
Elongation @ Break (%)	602	585	612	528	598	594	697	616	637	623	556	611
ASTM D638	532	559	650	620	523	565	616	655	627	519	598	598
Machine Direction	603			516			596			644		
	599			638			614			568		
	664			642			689			619		
Average	601	579	624	571	584	574	642	627	630	601	584	597
STD	38	15	19	65	45	14	38	20	5	44	20	12
Coefficient of Variation	6	3	3	11	8	2	6	3	1	7	3	2
% Change		-4	4		2	1		-2	-2		-3	-1
Tensile Properties:	875	600	600	575	700	625	730	690	670	690	630	665
Set after Break (%)	684	580	620	670	670	680	720	710	740	700	575	695
ASTM D638	642	580	685	680	580	660	720	760	680	595	700	660
Machine Direction	681			610			720			720		
	605			700			750			720		
	465			750			740			680		
Average	625	587	635	664	650	655	730	720	697	684	635	673
STD	77	9	36	57	51	23	12	29	31	42	51	15
Coefficient of Variation	12	2	6	9	8	3	2	4	4	6	8	2
% Change		-6	2		-2	-1		-1	-5		-7	-2
Tensile Properties:	2113	2122	2152	2161	2091	2115	1959	2155	2140	2176	2187	2030
Tensile Stress @ 100% Elongation (psi)	2112	2130	2144	2130	2030	2150	1960	2198	2031	2153	2129	2240
ASTM D638	2112	2111	2187	2122	2051	2123	1978	1896	2152	2204	2175	2307
Machine Direction	2236			2092			1985			2210		
	2132			2138			1983			2147		
	2065			2150			2013			2135		
Average	2128	2121	2164	2132	2057	2129	1983	2083	2108	2171	2164	2192
STD	52	8	16	22	25	15	18	133	54	28	25	118
Coefficient of Variation	2	0	1	1	1	1	1	6	3	1	1	5
% Change		-0	2		-4	-0		5	6		-0	1
Tensile Properties:	2151	2158	2164	2251	2107	2217	2049	2219	2177	2271	2233	2097
Tensile Stress @ 200% Elongation (psi)	2144	2171	2188	2246	1933	2148	2132	2193	2089	2214	2164	2318
ASTM D638	2130	2135	2190	2208	2084	2193	2110	1989	2140	2309	2176	2275
Machine Direction	2252			2183			2119			2220		
	2165			2244			2111			2188		
	2107			2144			1929			2170		
Average	2160	2155	2161	2213	2041	2166	2075	2137	2135	2229	2191	2230
STD	49	15	12	39	77	29	70	98	36	48	30	96
Coefficient of Variation	2	1	1	2	4	1	3	5	2	2	1	4
% Change		-0	1		-8	-1		3	3		-2	0

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TABLE OF CHEMICAL COMPATIBILITY TEST RESULTS
Exposure to PADER Waste Leachate

Report Date: October 1999

Exposure Time and Temperature

Test Parameters	30 Day Baseline	30 Day 23C	30 Day 50C	60 Day Baseline	60 Day 23C	60 Day 50C	90 Day Baseline	90 Day 23C	90 Day 50C	120 Day Baseline	120 Day 23C	120 Day 50C
POLYFLEX GEOMEMBRANE: 60 mil HDPE												
Tensile Properties:	2758	2638	2801	2590	2801	2731	2804	2819	2876	2763	2788	2819
Tensile Stress @ Yield (psi)	2711	2743	2788	2874	2752	2767	2736	2767	2901	2786	2765	2861
ASTM D638	2763	2730	2822	2706	2760	2775	2665	2814	2853	2745	2832	2870
Transverse Direction	2775			2712			2702			2798		
	2835			2685			2579			2778		
	2713			2673			2631			2679		
Average	2759	2704	2804	2707	2774	2758	2686	2800	2877	2758	2805	2850
STD	42	47	14	85	19	19	73	23	20	39	19	22
Coefficient of Variation	2	2	0	3	1	1	3	1	1	1	1	1
% Change		-2	2		3	2		4	7		2	3
Tensile Properties:	4428	4745	4179	4862	5168	4106	4824	4381	4079	4547	4850	4328
Tensile Strength @ Break (psi)	4020	4238	3744	5015	4844	4529	4676	5198	4810	4385	4534	4702
ASTM D638	4512	4827	5018	4927	4597	5084	5002	4341	5176	4358	4456	4924
Transverse Direction	4108			3750			4307			4495		
	4797			4554			5012			4022		
	4142			4997			4441			4849		
Average	4335	4537	4314	4688	4870	4573	4710	4640	4688	4443	4613	4651
STD	271	217	529	446	234	400	266	395	456	247	170	246
Coefficient of Variation	6	5	12	10	5	9	6	9	10	6	4	5
% Change		5	-0		4	-2		-1	-0		4	5
Tensile Properties:	12.1	12.7	12.9	12.5	11.9	12.7	12.4	11.9	12.5	12.9	12.3	12.7
Elongation @ Yield (%)	12.9	11.5	12.9	12.5	11.9	12.5	12.5	12.7	12.5	12.1	12.1	12.1
ASTM D638	12.9	12.1	12.3	12.6	12.5	12.5	12.6	12.5	12.3	12.3	12.7	13.6
Transverse Direction	12.9			12.5			12.5			12.9		
	12.9			12.5			12.6			13.2		
	12.7			12.5			12.5			12.7		
Average	12.7	12.1	12.7	12.5	12.1	12.6	12.5	12.4	12.4	12.7	12.4	12.8
STD	0.3	0.5	0.3	0.0	0.3	0.1	0.1	0.3	0.1	0.4	0.2	0.6
Coefficient of Variation	2	4	2	0	2	1	1	3	1	3	2	5
% Change		-5	-0		-3	1		-1	-1		-2	1
Tensile Properties:	668	689	677	695	692	592	656	619	557	626	660	612
Elongation @ Break (%)	675	697	641	680	653	618	654	722	668	603	624	640
ASTM D638	663	636	696	703	732	694	635	618	704	603	611	598
Transverse Direction	672			680			694			620		
	634			655			625			563		
	693			730			633			580		
Average	666	674	671	691	692	635	650	653	643	616	632	617
STD	18	27	23	23	32	43	23	49	63	35	21	17
Coefficient of Variation	3	4	3	3	5	7	4	7	10	6	3	3
% Change		1	1		0	-8		1	-1		3	0

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TABLE OF CHEMICAL COMPATIBILITY TEST RESULTS
Exposure to PADER Waste Leachate

Report Date: October 1999

Exposure Time and Temperature

Test Parameters	Baseline	30 Day 23C	30 Day 50C	60 Day Baseline	60 Day 23C	60 Day 50C	90 Day Baseline	90 Day 23C	90 Day 50C	120 Day Baseline	120 Day 23C	120 Day 50C
POLYFLEX GEOMEMBRANE: 60 mil HDPE												
Tensile Properties:	632	625	630	780	800	740	750	670	640	710	720	645
Set after Break (%)	664	650	640	750	700	700	740	770	740	830	670	690
ASTM D638	641	660	675	780	770	730	740	720	780	680	680	740
Transverse Direction	635			710			770			695		
	615			740			750			660		
	646			800			710			740		
Average	639	645	648	760	757	723	743	720	720	686	690	692
STD	15	15	19	30	42	17	18	41	59	35	22	39
Coefficient of Variation	2	2	3	4	6	2	2	6	8	5	3	6
% Change		1	1		-0	-5		-3	-3		1	1
Tensile Properties:	1964	1970	1919	1906	1993	1917	1923	1956	2013	1963	1999	1997
Tensile Stress @ 100% Elongation (psi)	1929	1979	1963	1948	2002	2026	1902	1928	2006	1995	2011	2079
ASTM D638	2003	1949	2021	1907	1952	1995	1824	1957	1871	1978	1994	1992
Transverse Direction	1964			1915			1932			1963		
	2074			1888			1845			2000		
	1972			1863			1929			1954		
Average	1984	1966	1968	1908	1982	1979	1893	1947	1997	1976	2001	2023
STD	46	13	42	21	22	46	43	13	18	17	7	40
Coefficient of Variation	2	1	2	1	1	2	2	1	1	1	0	2
% Change		-1	-1		4	4		3	6		1	2
Tensile Properties:	2076	2022	1977	1972	2088	2033	1968	1988	2075	2024	2026	2144
Tensile Stress @ 200% Elongation (psi)	1996	2095	2174	2068	2069	2160	1906	1973	2018	2129	2149	2122
ASTM D638	2033	1979	2046	1952	1970	2014	1861	1956	1985	2146	2123	2148
Transverse Direction	2072			2056			1966			2049		
	2232			1941			1694			2114		
	2021			1907			1929			1975		
Average	2072	2032	2066	1983	2042	2069	1921	1972	2026	2073	2099	2137
STD	77	48	82	59	52	65	38	13	37	62	53	11
Coefficient of Variation	4	2	4	3	3	3	2	1	2	3	3	1
% Change		-2	-0		3	4		3	5		1	3
Modulus of Elasticity:	124744	91394	103164	81704	71107	78795	79633	67663	73895	124744	106123	103176
Tangential (psi)	104279	103855	87868	78006	77275	71089	65292	83822	76812	104279	99124	110352
ASTM D882	117219	93445	130990	86535	74467	81924	69526	82388	77912	117219	103275	99878
Machine Direction	90144			77189			73605			90144		
	96237			75676			78201			96237		
	98765			72165			69619			98766		
Average	105232	96231	107347	78713	74283	77269	72646	77958	76205	105232	102841	104502
STD	13234	6681	21860	4558	2521	4553	5059	7303	1695	12081	2874	4338
Coefficient of Variation	13	7	20	6	3	6	7	9	2	11	3	4
% Change		-9	2		-6	-2		7	5		-2	-1

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TABLE OF CHEMICAL COMPATIBILITY TEST RESULTS
Exposure to PADER Waste Leachate

Report Date: October 1999

Exposure Time and Temperature

Test Parameters	30 Day Baseline	30 Day 23C	30 Day 50C	60 Day Baseline	60 Day 23C	60 Day 50C	90 Day Baseline	90 Day 23C	90 Day 50C	120 Day Baseline	120 Day 23C	120 Day 50C
POLYFLEX GEOMEMBRANE: 60 mil HDPE												
Modulus of Elasticity:	132588	133256	116768	86098	72302	75135	70206	82564	94042	132568	135318	150382
Tangential (psi)	139879	126438	126450	84982	88681	94898	67874	73789	66801	139879	144267	129457
ASTM D882	127699	121269	112879	77760	81039	85404	76071	90021	85349	161236	145930	146805
Transverse Direction	122310			77047			78012			156135		
	123564			85623			79633			163050		
	129848			95784			81637			129848		
Average	129311	126994	119365	84716	80867	85145	75239	82125	82064	147119	141838	142215
STD	6438	6003	8104	6527	6684	8069	4849	6634	11361	13520	4660	9138
Coefficient of Variation	5	5	7	8	8	9	6	8	14	9	3	6
% Change		-2	-8		-5	1		9	9		-4	-3
Indentation Hardness:	61	61	62	63	-62	63	65	64	62	62	63	64
Reading	60	61	62	62	62	62	65	63	64	63	64	63
ASTM D2240	61	62	63	62	62	62	65	63	63	63	63	63
(with TYPE D DUROMETER)	62			64			63			63		
	62			63			63			62		
	62			62			64			63		
Average	61	61	62	63	62	62	64	63	63	63	63	63
STD	1	1	1	1	0	0	1	0	1	0	0	0
Coefficient of Variation	1	1	1	1	0	1	1	1	1	1	1	1
% Change		0	2		-1	-1		-1	-2		1	1
cific Gravity:	0.949	0.950	0.950	0.950	0.948	0.949	0.950	0.949	0.950	0.949	0.949	0.949
Specific Gravity (grams/cu.cm)	0.949	0.949	0.950	0.950	0.949	0.950	0.949	0.948	0.948	0.949	0.948	0.949
ASTM D792, Method A	0.950	0.950	0.950	0.948	0.949	0.947	0.948	0.948	0.948	0.949	0.949	0.949
	0.951			0.948			0.949			0.949		
	0.949			0.948			0.949			0.948		
	0.950			0.947			0.948			0.950		
Average	0.950	0.950	0.950	0.949	0.949	0.949	0.949	0.948	0.949	0.949	0.949	0.949
STD	0.001	0.001	0.000	0.001	0.000	0.001	0.001	0.000	0.001	0.001	0.000	0.000
Coefficient of Variation	0.086	0.061	0.000	0.118	0.050	0.131	0.072	0.050	0.099	0.061	0.050	0.000
% Change		0.00	0.04		0.02	0.02		-0.05	-0.02		-0.04	0.00
Environmental Stress Crack Resistance:												
ASTM D1693, Condition B												
Machine Direction (% Failed)	N/A	0	0	N/A	0	0	N/A	0	0	N/A	0	0
Transverse Direction (% Failed)	N/A	0	0	N/A	0	0	N/A	0	0	N/A	0	0

SET 10·24·99
Quality Review/Date

TABLE OF CHEMICAL COMPATIBILITY TEST RESULTS
Exposure to PADER Waste Leachate

Report Date: October 1999

Exposure Time and Temperature

	30 Day			60 Day			90 Day			120 Day		
Test Parameters	Baseline	23C	50C	Baseline	23C	50C	Baseline	23C	50C	Baseline	23C	50C
POLYFLEX GEOMEMBRANE: 60 mil HDPE												
Puncture Resistance:	91	90	95	86	93	95	87	89	91	88	91	92
Load @ Rupture (lbs)	91	91	94	89	92	94	89	86	90	92	92	96
FTMS 101C Method 2065	92	92	93	91	89	94	87	88	90	97	89	97
	93			92			94			96		
	93			93			90			96		
	89			94			91					
Average	92	91	94	91	91	94	90	88	90	94	91	95
STD	1	1	1	3	2	0	2	1	0	3	1	2
Coefficient of Variation	2	1	1	3	2	0	3	1	1	4	1	2
% Change		-1	3		1	4		-2	1		-3	1
Volatiles and Extractables:	-0.05	-0.05	-0.03	-0.03	0.00	-0.10	-0.05	-0.15	-0.05	0.03	-0.05	0.00
Diameter Change (%)	-0.05	-0.08	0.03	0.00	-0.05	-0.08	0.03	0.00	-0.05	-0.05	-0.03	-0.05
SW 870 - Appendix III-D	0.00			-0.10			-0.05			-0.05		
Machine Direction	0.00			-0.08			-0.20			0.00		
Average	-0.03	-0.07	0.00	-0.05	-0.03	-0.09	-0.07	-0.06	-0.05	-0.02	-0.04	-0.03
STD	0.03	0.02	0.03	0.04	0.03	0.01	0.08	0.08	0.00	0.03	0.01	-100
Volatiles and Extractables:	0.28	0.18	0.15	0.10	0.13	0.20	0.15	0.25	0.10	0.18	0.20	0.08
Diameter Change (%)	0.08	0.23	0.18	0.15	0.05	0.13	0.00	0.03	0.18	0.18	0.18	0.10
SW 870 - Appendix III-D	0.23			0.03			0.13			0.03		
Transverse Direction	0.05			0.25			0.38			0.73		
Average	0.16	0.21	0.17	0.13	0.09	0.17	0.17	0.14	0.14	0.28	0.19	0.09
STD	0.10	0.02	0.02	0.06	0.04	0.04	0.14	0.11	0.04	0.27	0.01	0.01
Volatiles and Extractables:	0.07	0.06	0.10	0.06	0.07	0.08	0.05	0.07	0.08	0.05	0.05	0.08
% Volatiles	0.07	0.08	0.08	0.09	0.08	0.08	0.06	0.08	0.07	0.05	0.05	0.05
SW 870 - Appendix III-D	0.08			0.07			0.04			0.05		
	0.08			0.07			0.04			0.05		
Average	0.08	0.07	0.09	0.07	0.08	0.08	0.05	0.08	0.08	0.05	0.05	0.08
STD	0.00	0.01	0.01	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01
Volatiles and Extractables:	0.21	0.21	0.22	0.20	0.21	0.25	0.28	0.22	0.22	0.21	0.22	0.22
% Extractables	0.20	0.22	0.21	0.22	0.19	0.18	0.25	0.21	0.22	0.19	0.21	0.22
SW 870 - Appendix III-D	0.20			0.20			0.31			0.22		
	0.21			0.18			0.32			0.20		
Average	0.21	0.22	0.22	0.20	0.20	0.22	0.29	0.22	0.22	0.21	0.22	0.22
STD	0.00	0.01	0.01	0.01	0.01	0.04	0.03	0.01	0.00	0.01	0.01	0.00

SPA 10·24·99
Quality Review/Date

TABLE OF CHEMICAL COMPATIBILITY TEST RESULTS
Exposure to PADER Waste Leachate

Report Date: October 1999

Exposure Time and Temperature

Test Parameters	Baseline	30 Day 23C	30 Day 50C	60 Day Baseline	60 Day 23C	60 Day 50C	90 Day Baseline	90 Day 23C	90 Day 50C	120 Day Baseline	120 Day 23C	120 Day 50C
POLYFLEX GEOMEMBRANE: 60 mil HDPE												
Tear Resistance:	55	54	54	55	53	53	57	55	55	55	54	56
Tear Resistance (lbs)	54	54	54	53	54	52	55	55	54	55	53	54
ASTM D1004	54	52	55	54	54	55	55	57	55	53	53	53
Machine Direction	54			52			57			54		
	52			52			54			54		
	55			53			57			57		
Average	54	53	54	53	54	53	56	56	55	55	53	54
STD	1	1	1	1	0	1	1	1	0	1	0	1
Coefficient of Variation	2	2	1	2	1	2	2	2	1	2	1	2
% Change		-1	1		1	0		-0	-2		-2	-1
Tear Resistance:	51	54	53	52	55	51	51	51	51	51	53	53
Tear Resistance (lbs)	50	54	51	52	51	51	53	51	51	50	53	52
ASTM D1004	51	51	52	50	54	55	53	59	52	50	52	52
Transverse Direction	50			46			56			50		
	49			48			55			50		
	54			48			54			52		
Average	51	53	52	49	53	52	54	54	51	51	53	52
STD	2	2	1	2	2	2	2	4	0	1	0	0
Coefficient of Variation	3	3	2	4	3	4	3	7	1	2	1	1
% Change		4	2		8	6		0	-4		4	4
Hydrostatic Resistance:	490	495	500	500	495	500	500	495	495	500	495	505
Load @ Rupture (psi)	500	510	510	490	495	490	515	505	495	495	510	505
ASTM D751	505	500	500	505	490	490	520	490	495	510	500	500
	500			510			515			490		
	495			495			505			500		
	500						510			500		
Average	498	502	503	500	493	493	511	497	495	499	502	503
STD	5	8	6	7	2	5	7	6	0	6	6	2
Coefficient of Variation	1	2	1	1	0	1	1	1	0	1	1	0
% Change		1	1		-1	-1		-3	-3		1	1

SR4 10·24·99
Quality Review/Date

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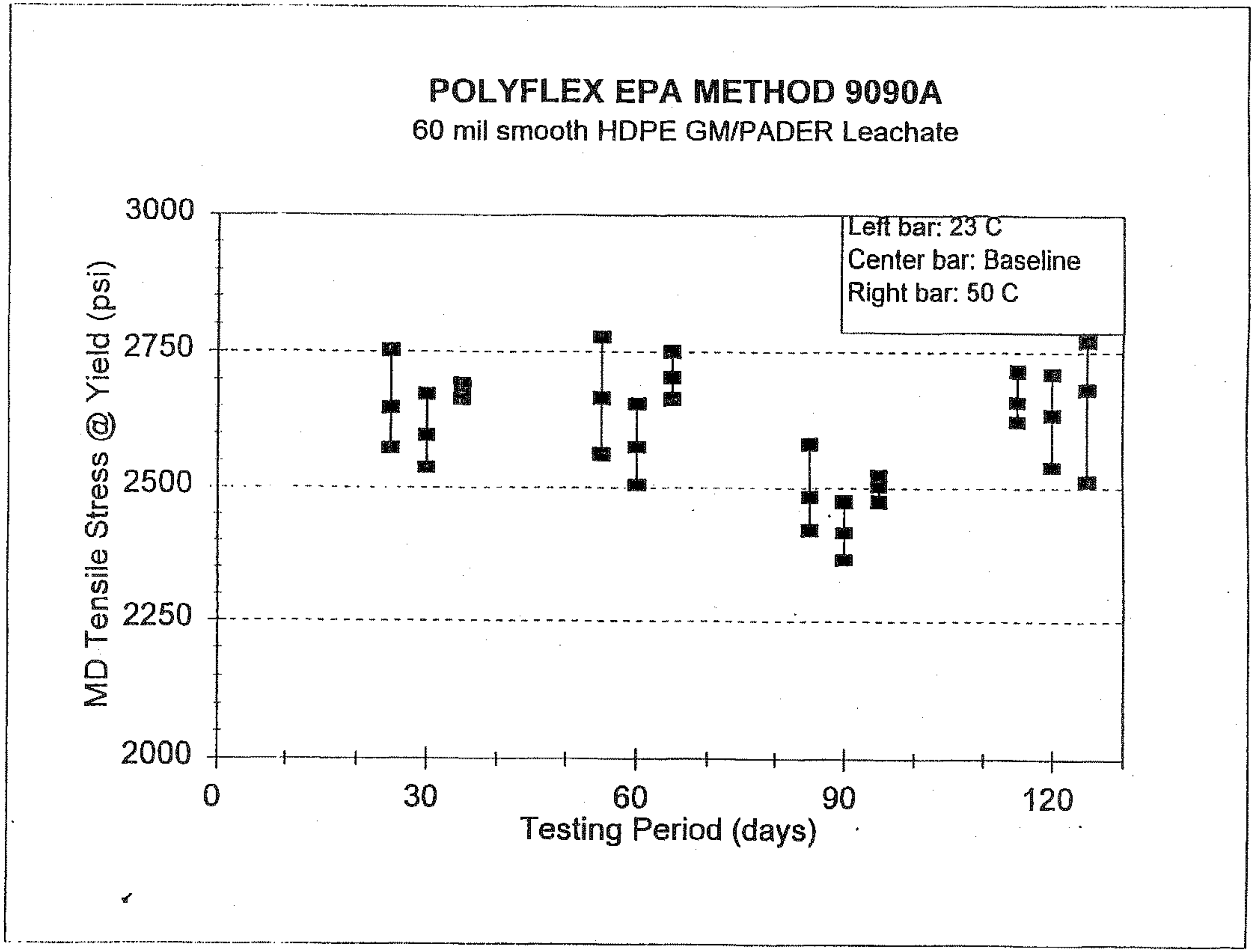

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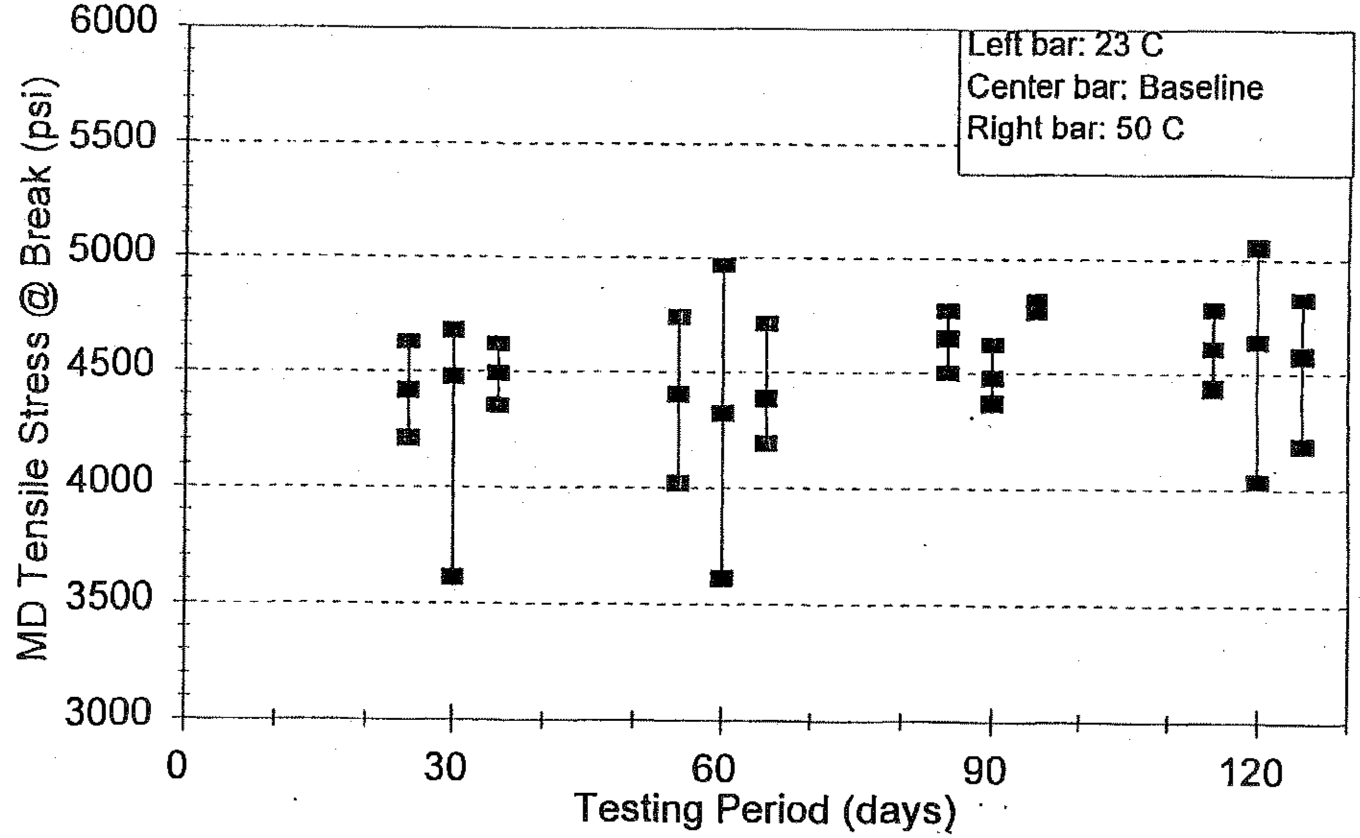
POLYFLEX EPA METHOD 9090A

60 mil smooth HDPE GM/PADER Leachate



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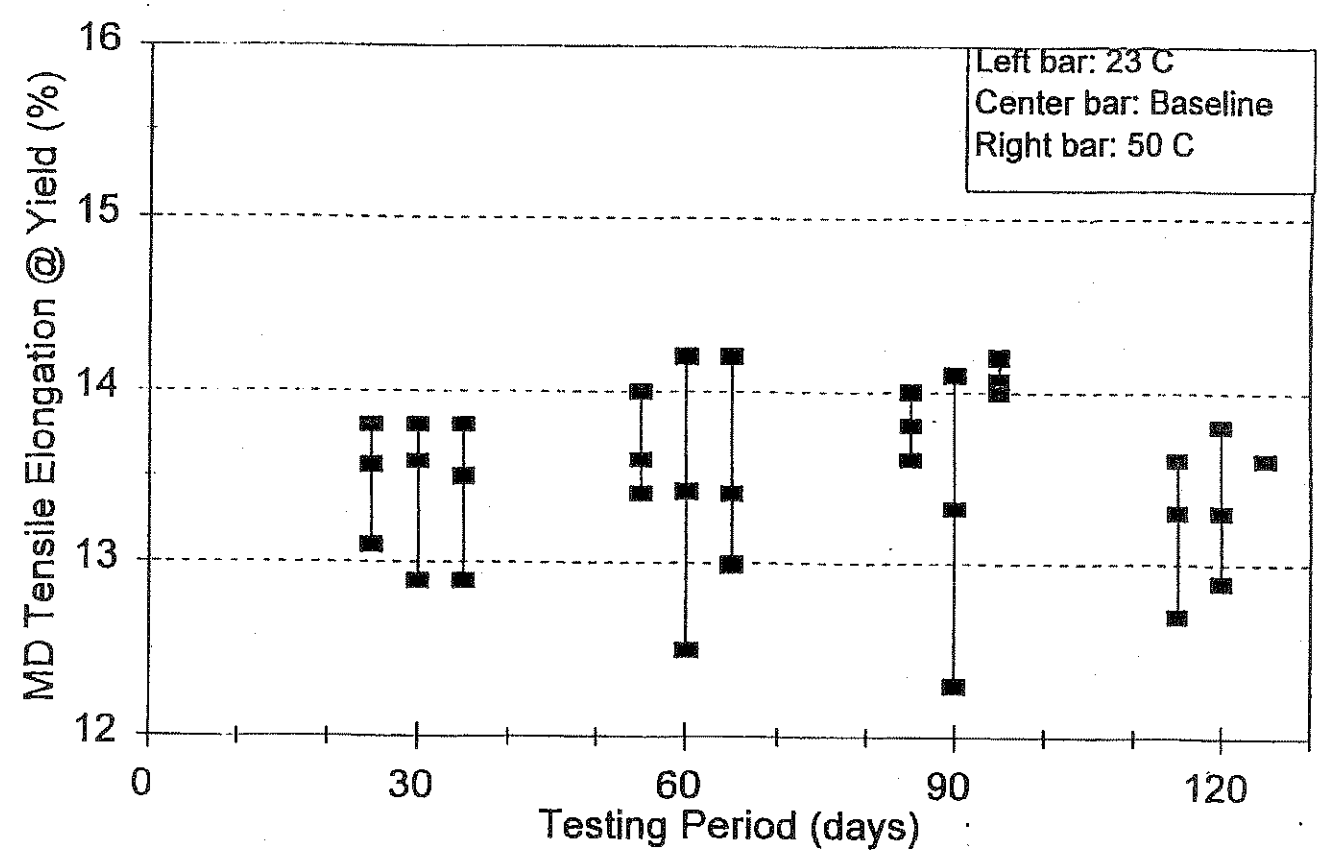
POLYFLEX EPA METHOD 9090A

60 mil smooth HDPE GM/PADER Leachate



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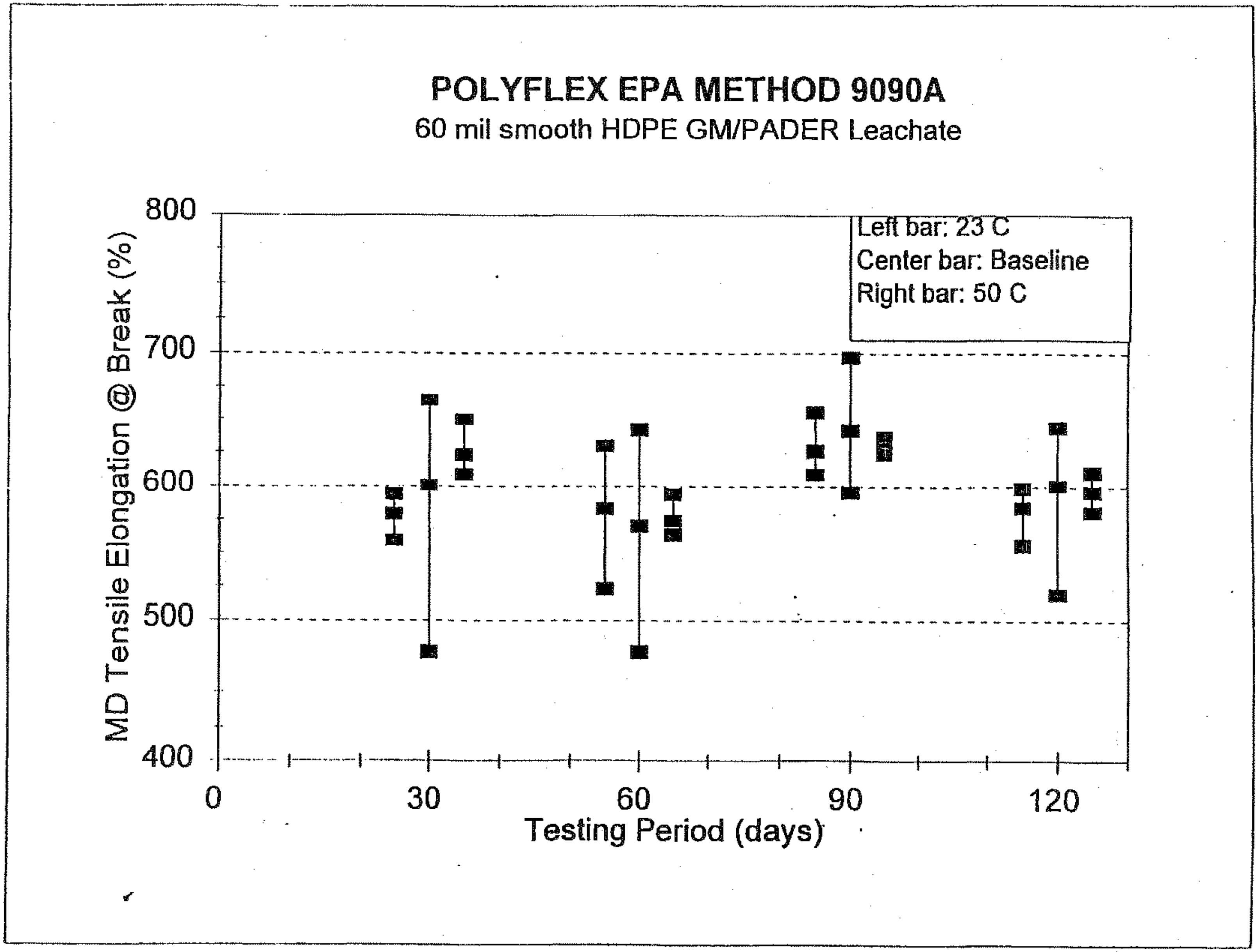

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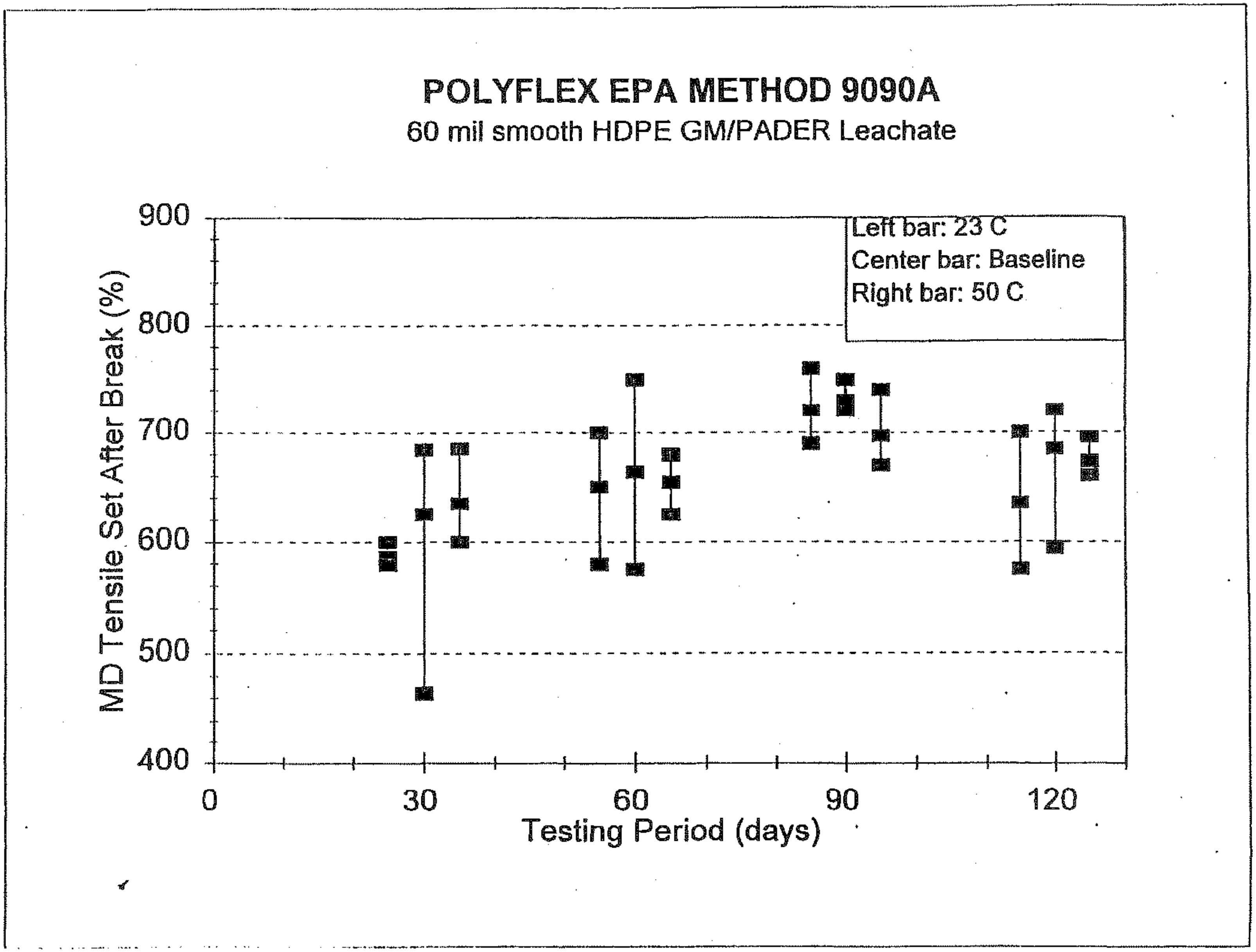

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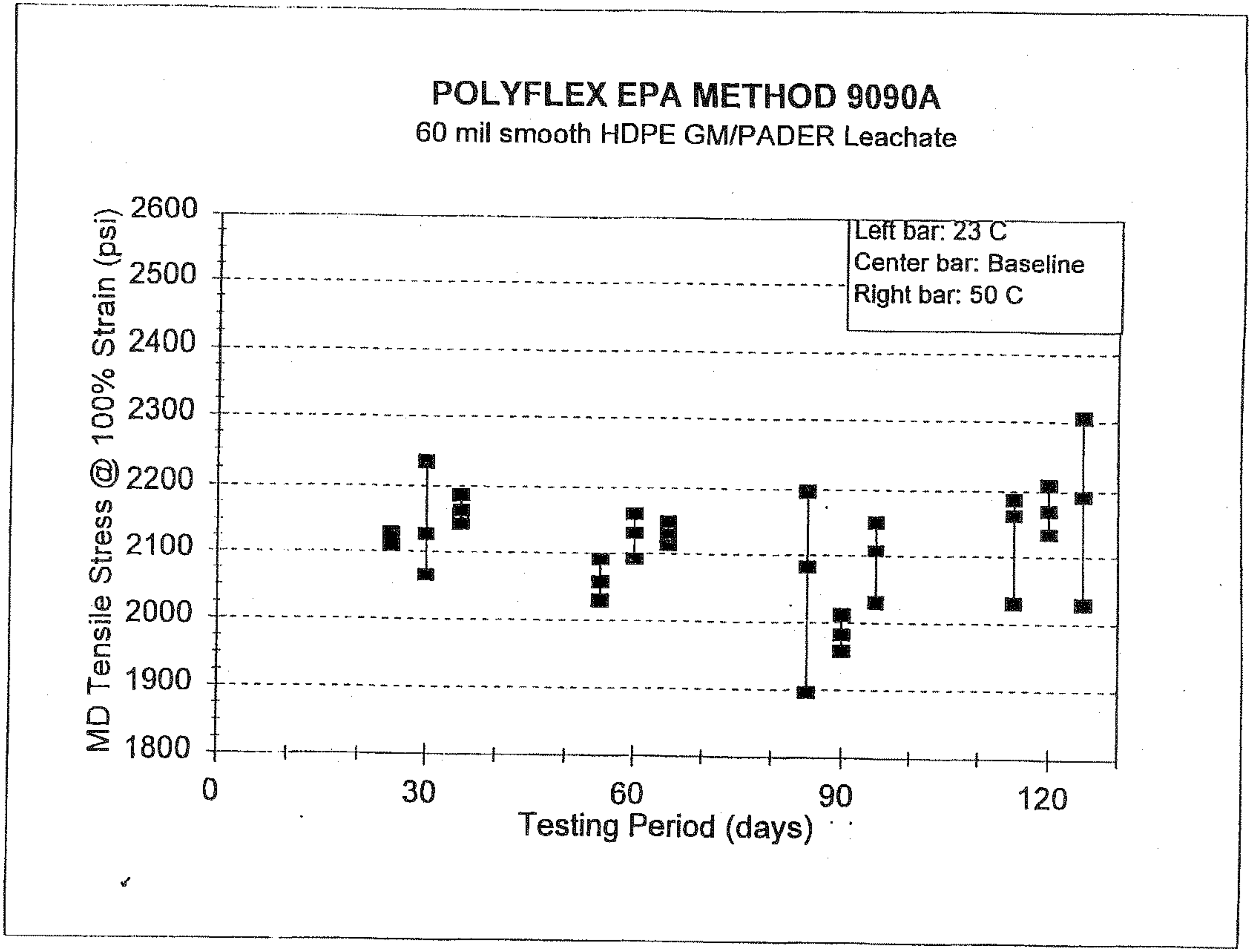

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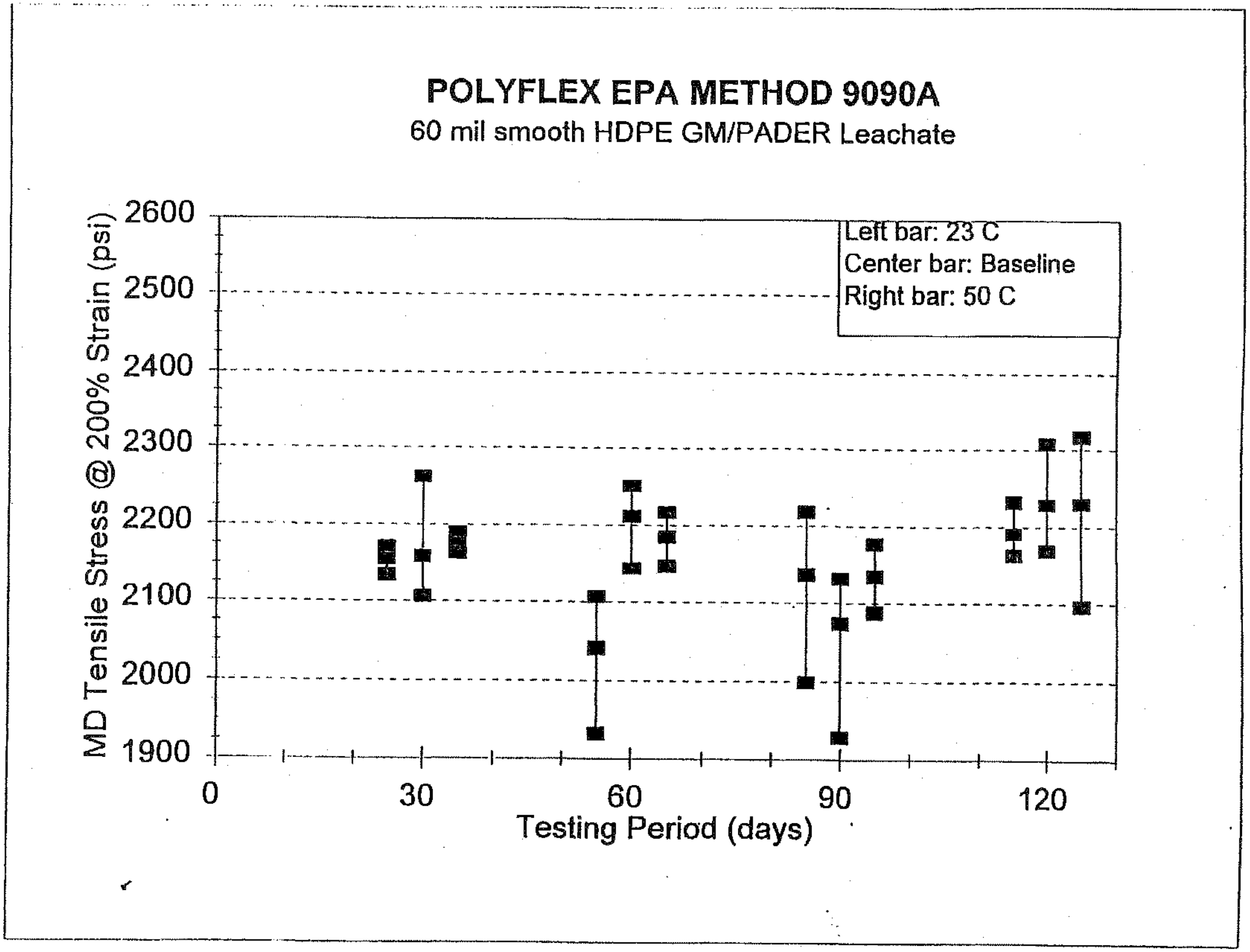

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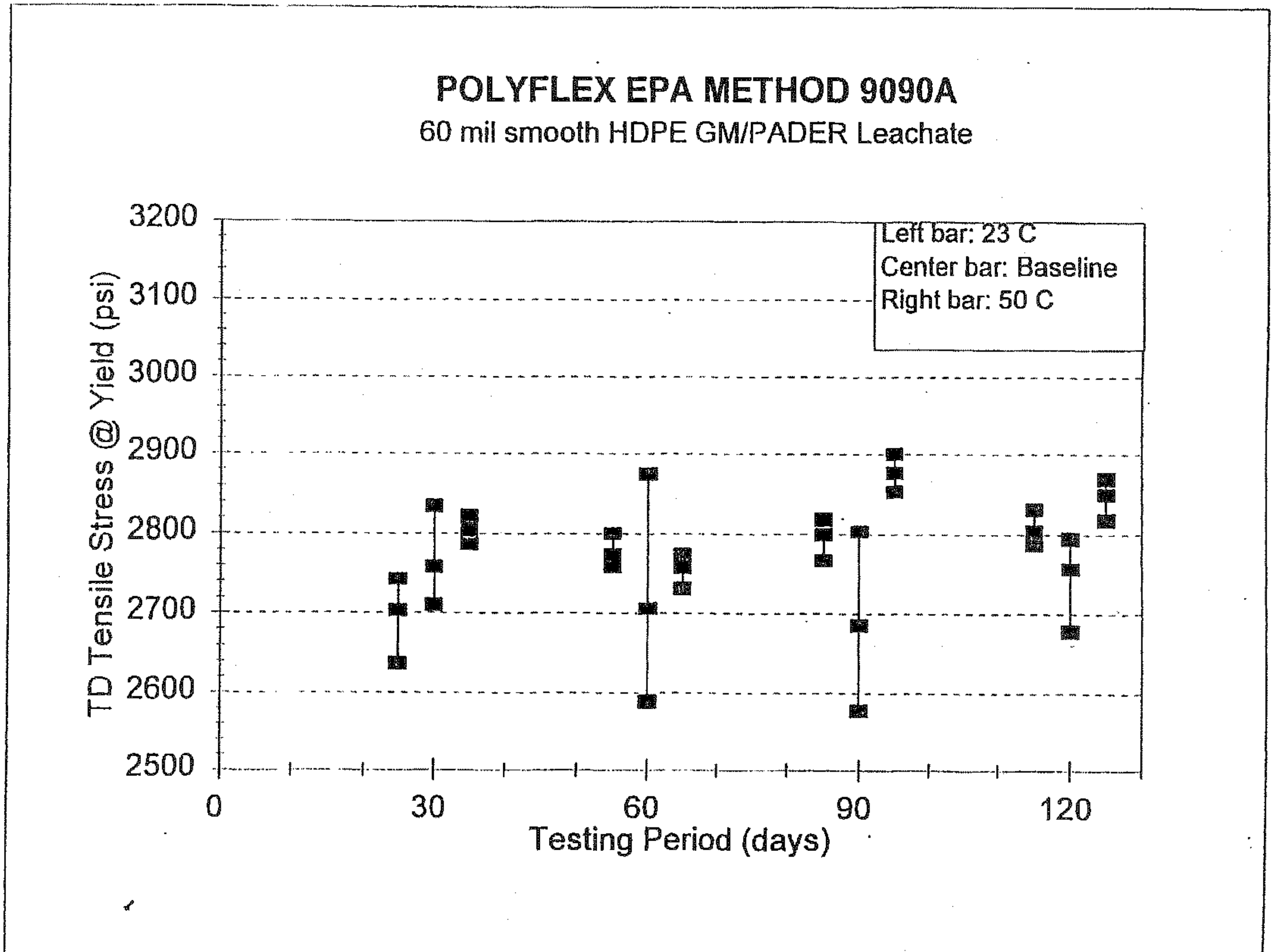
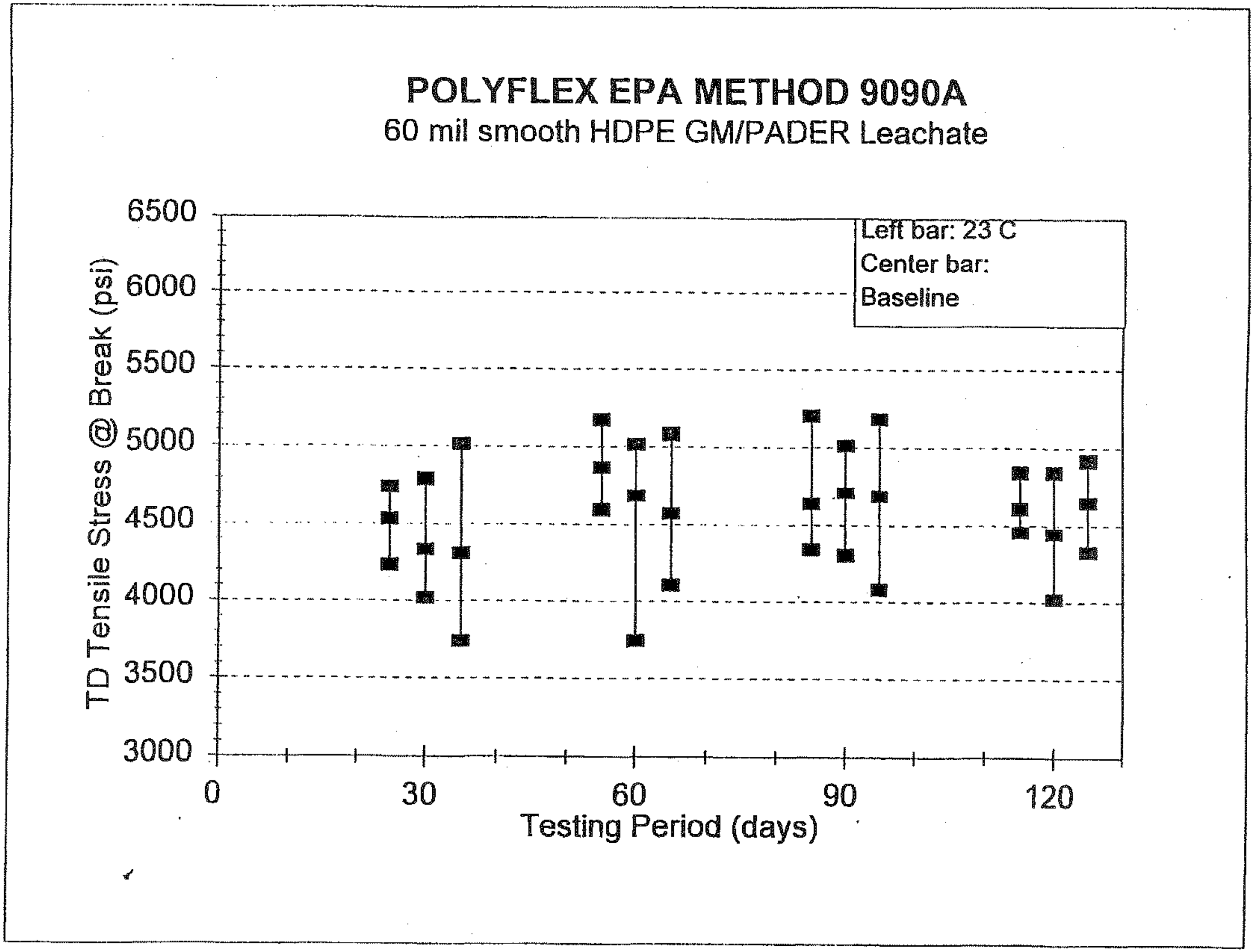

POLYFLEX EPA METHOD 9090A
60 mil smooth HDPE GM/PADER Leachate
TD Tensile Stress @ Yield (psi)
3200
3100
3000
2900
2800
2700
2600
2500
0
30
60
90
120
Testing Period (days)
Left bar: 23 C
Center bar: Baseline
Right bar: 50 C



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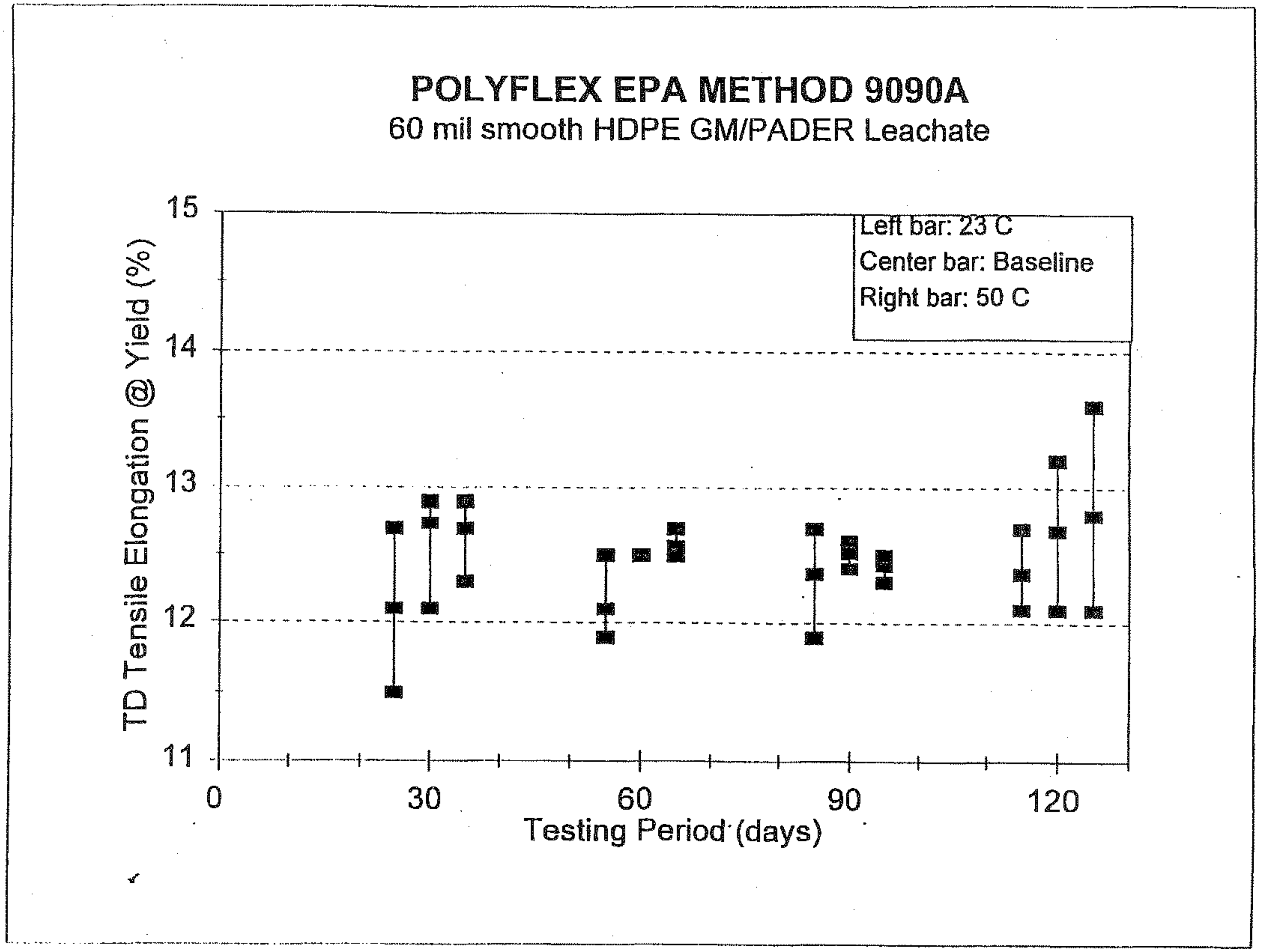

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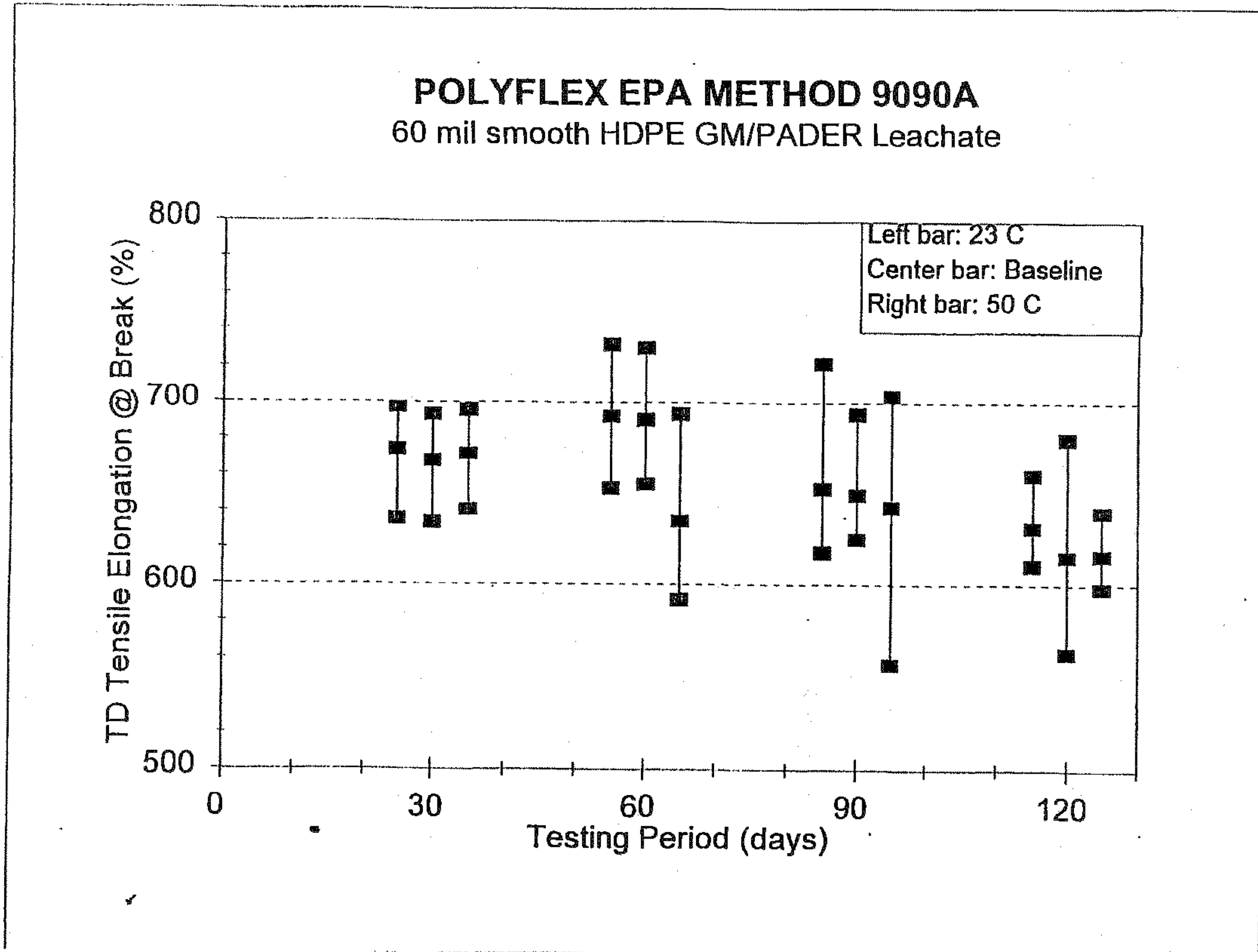

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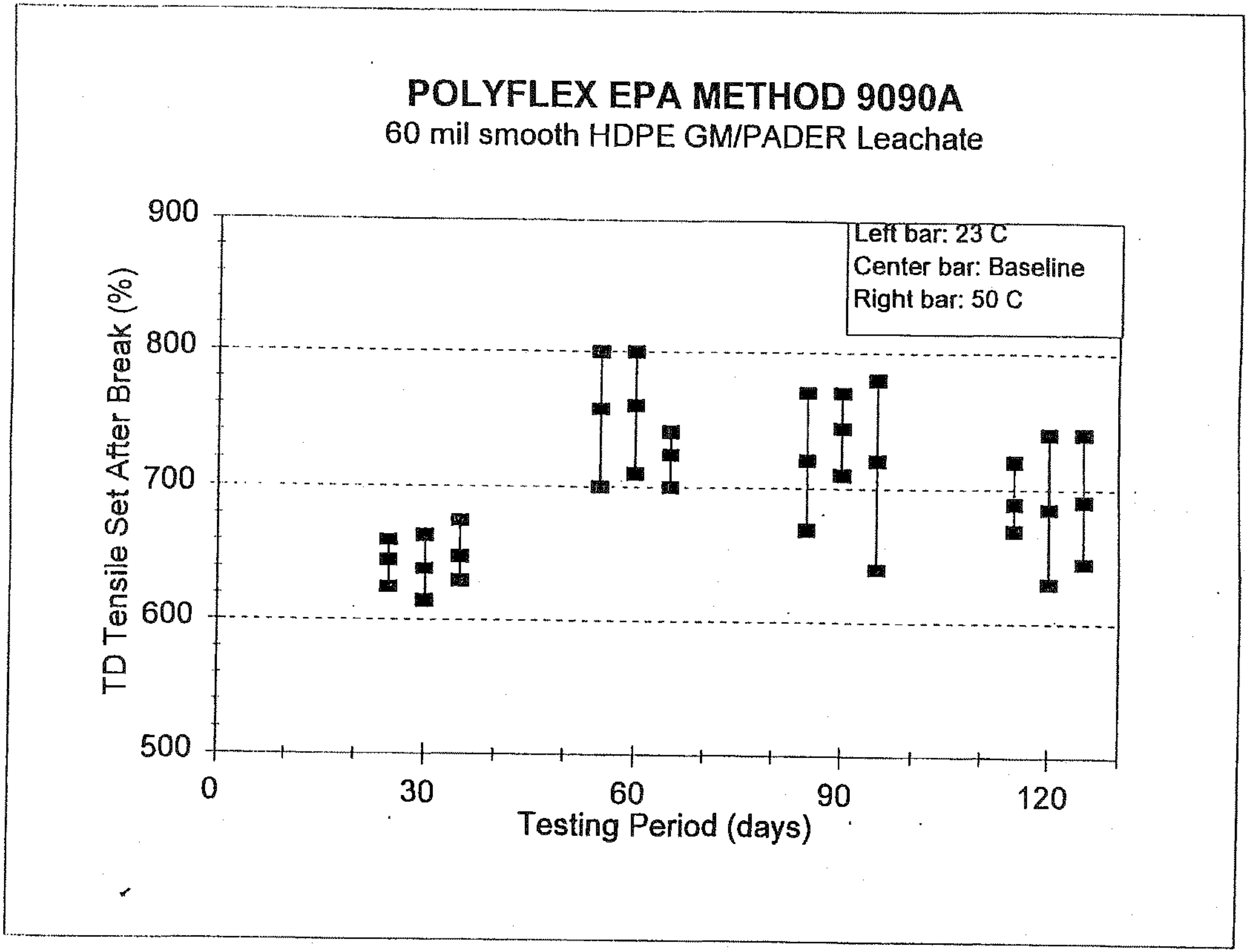

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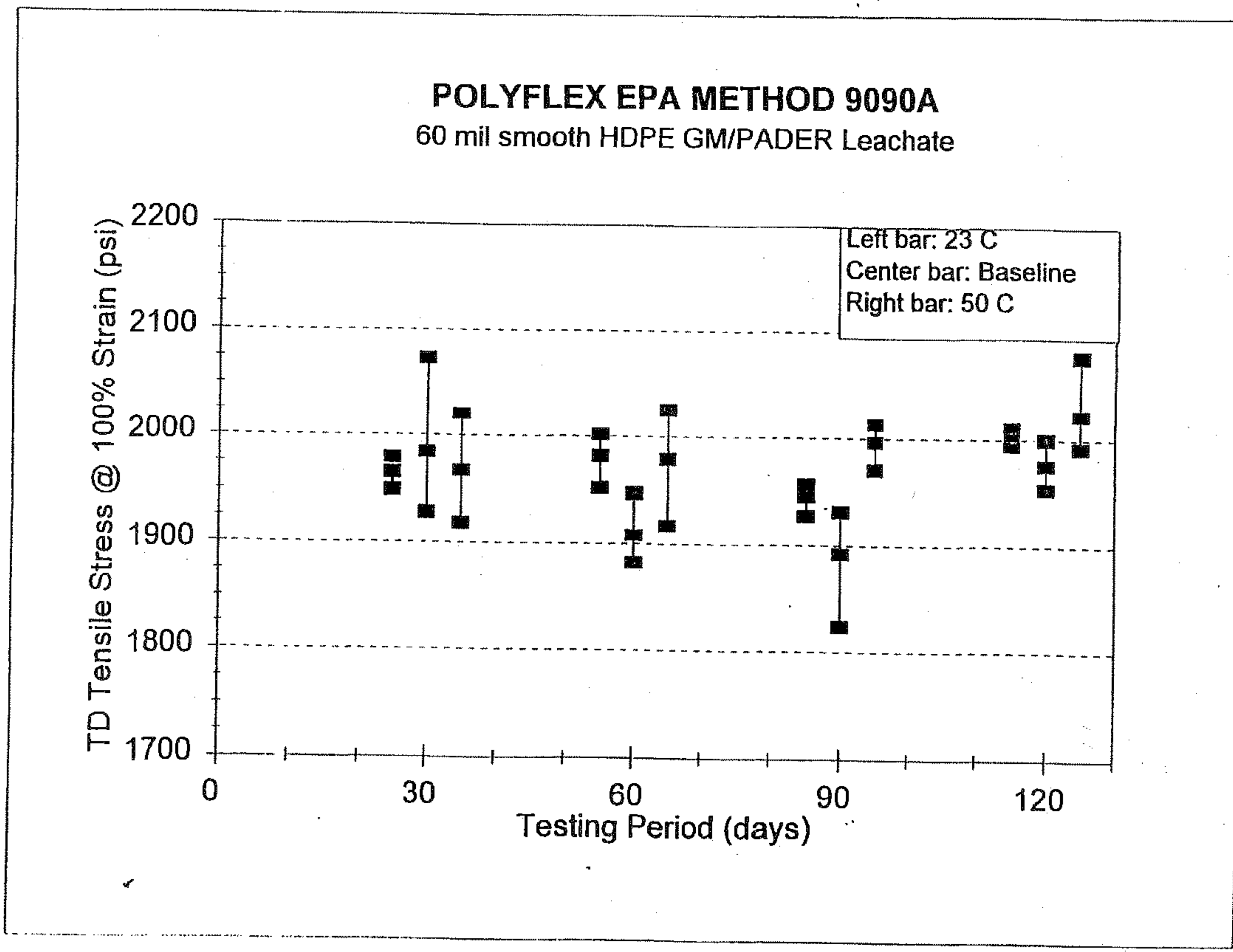

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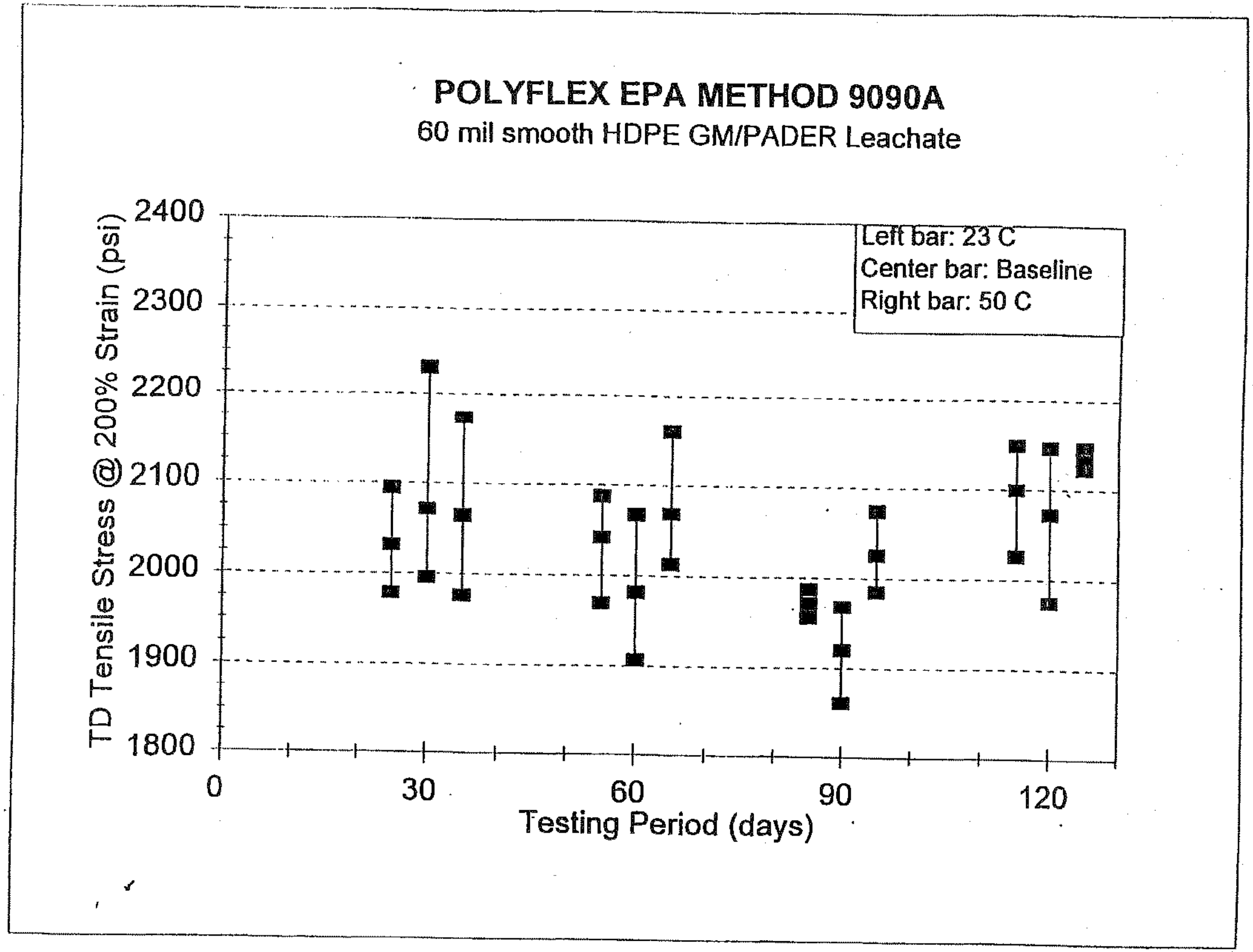

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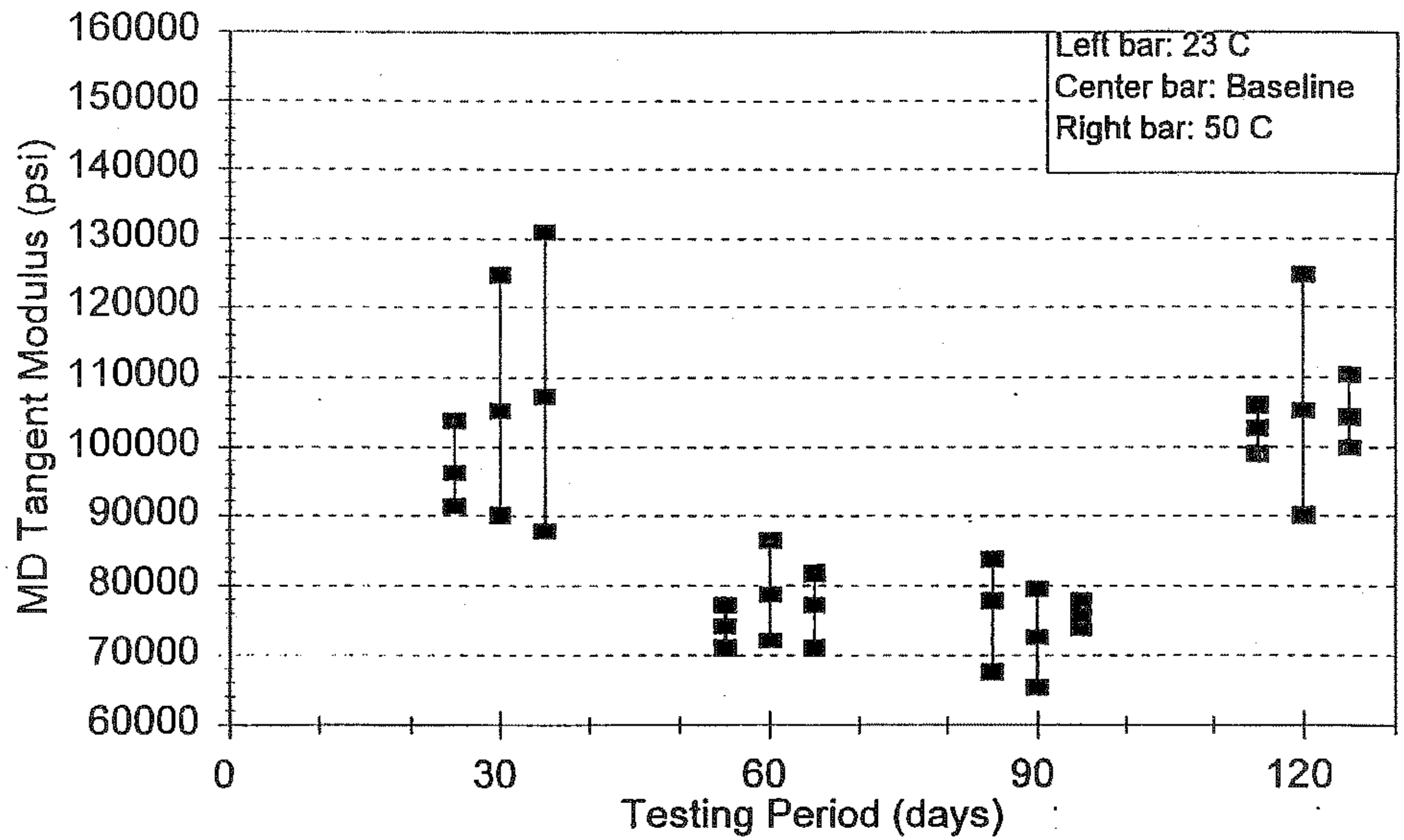
POLYFLEX EPA METHOD 9090A

60 mil HDPE GM/PADER Leachate



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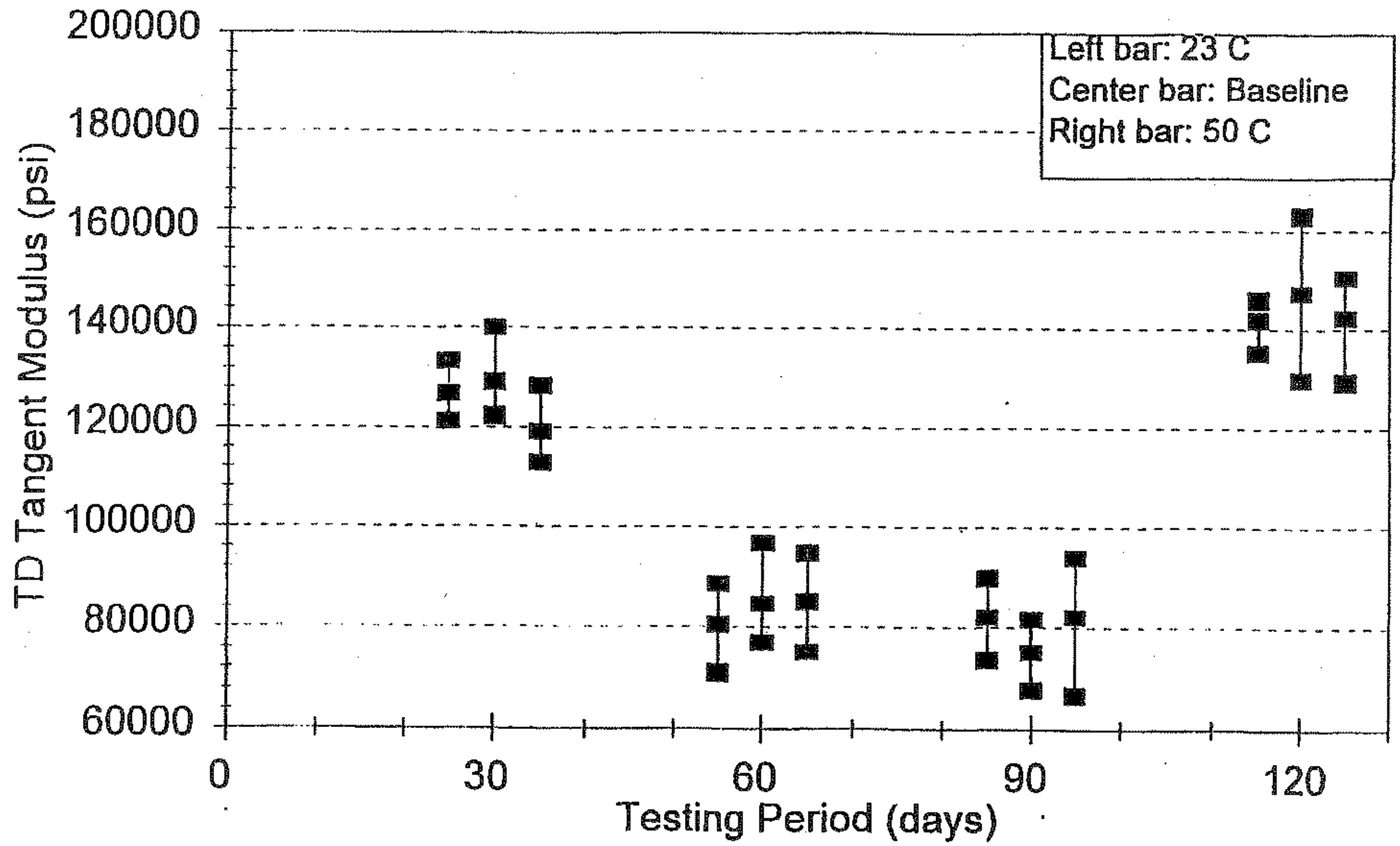
POLYFLEX EPA METHOD 9090A

60 mil HDPE GM/PADER Leachate



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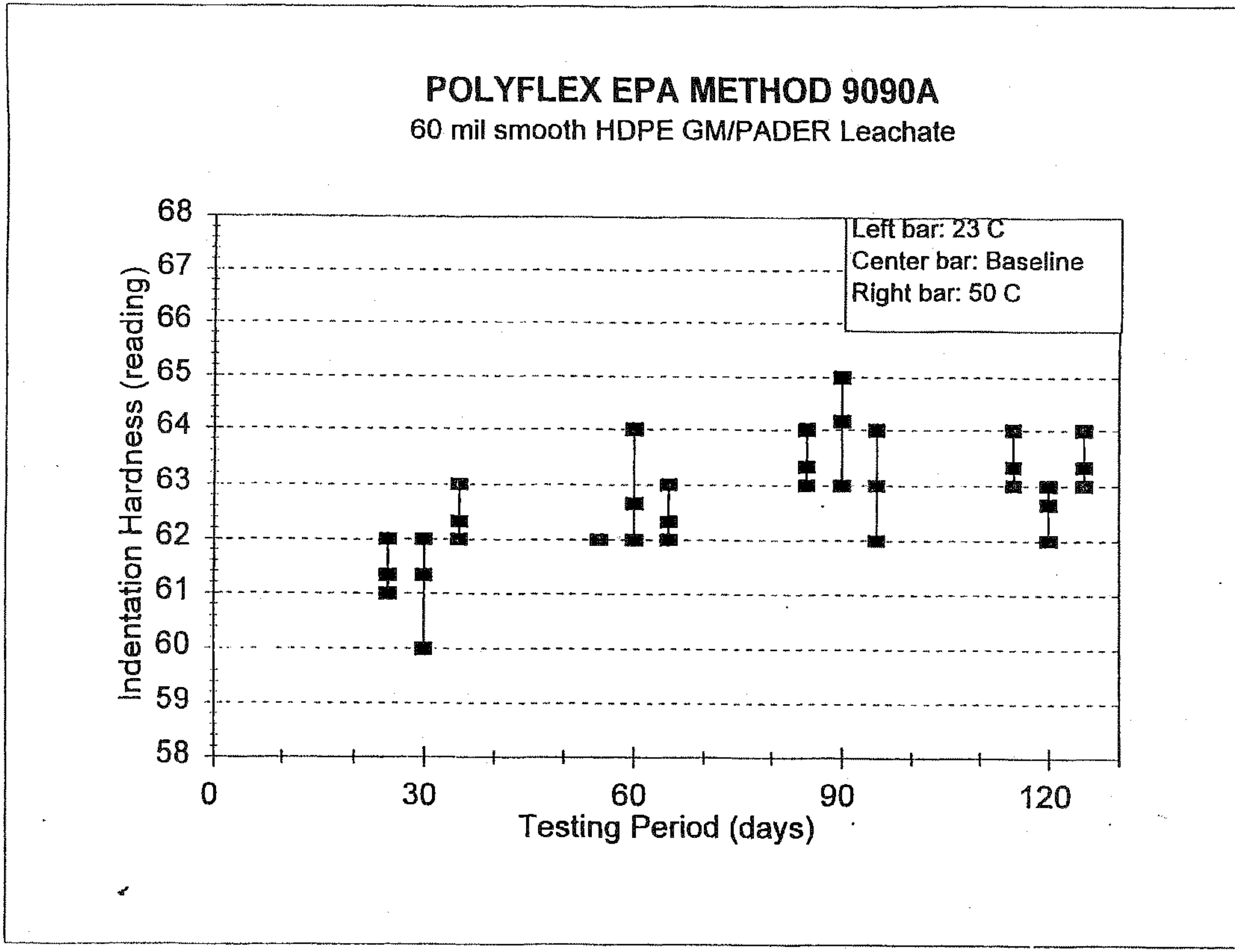

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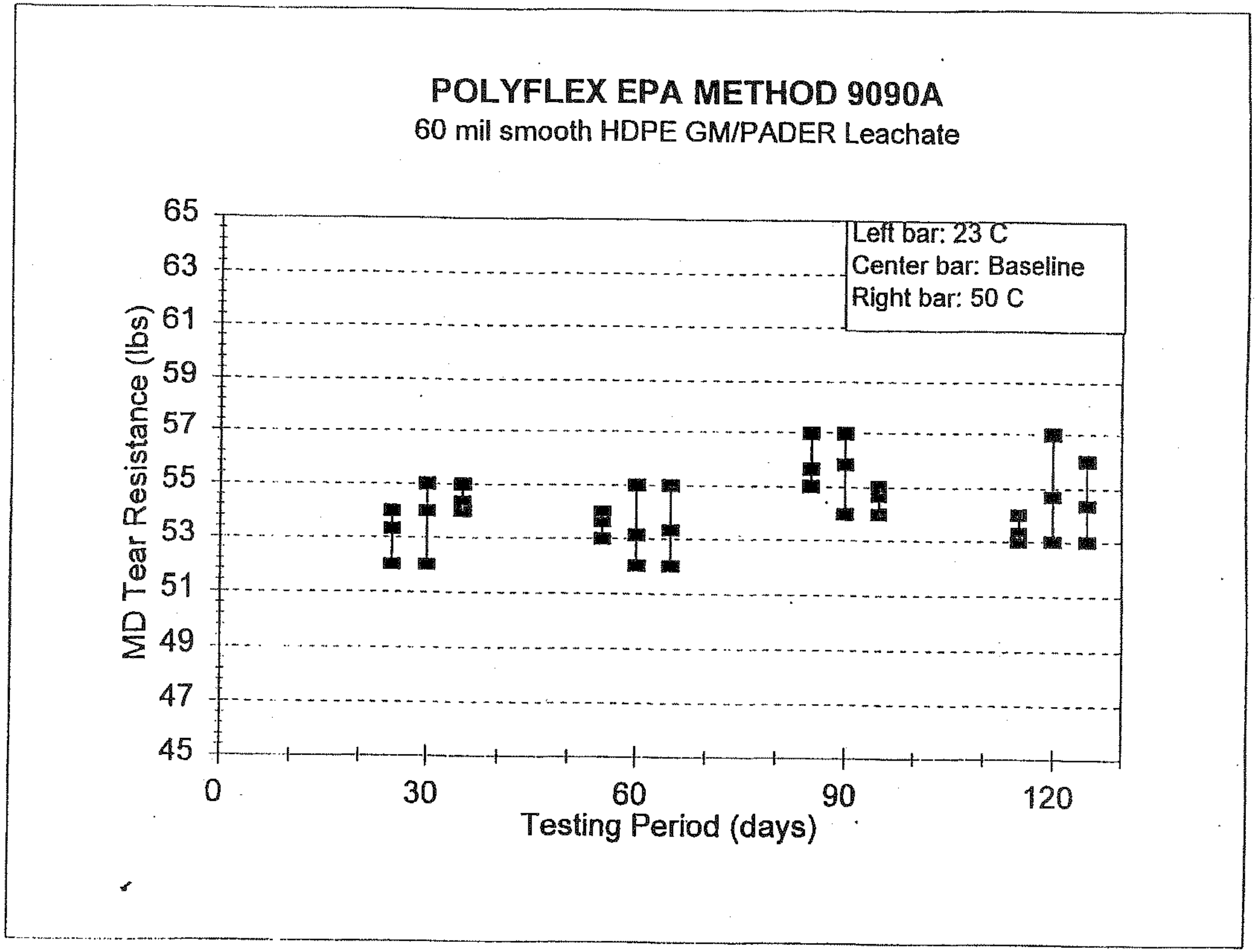

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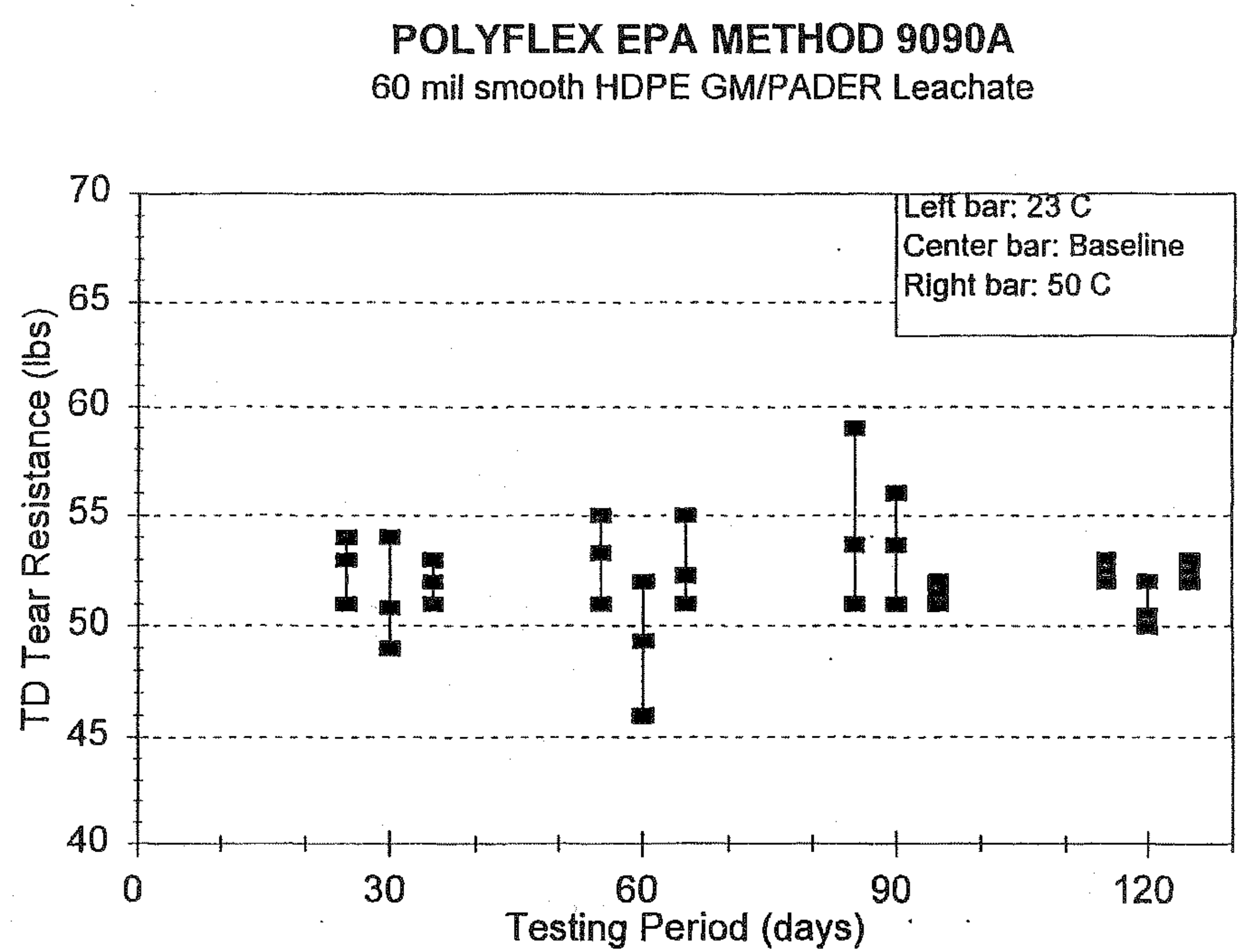

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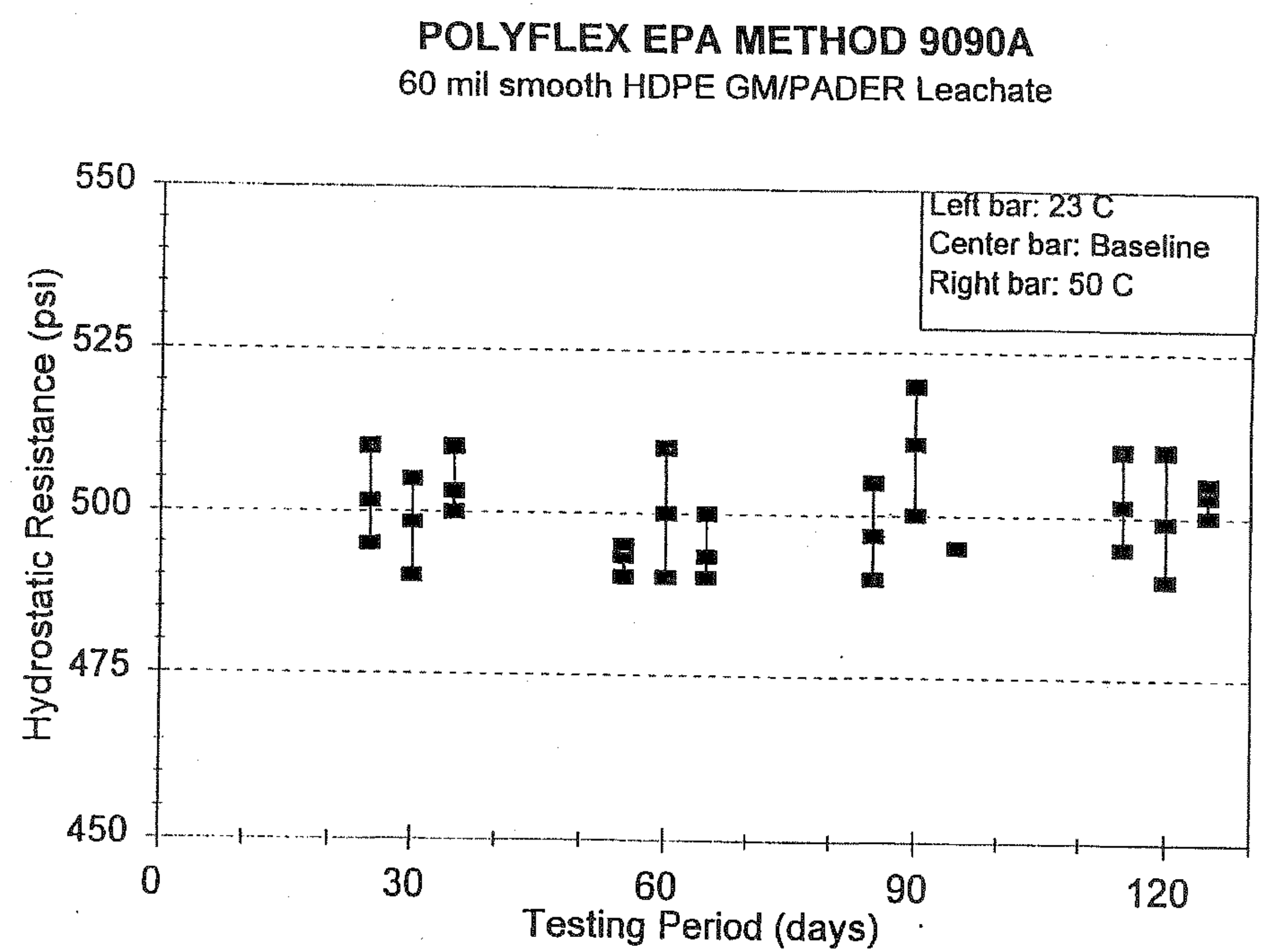


Client: POLYFLEX, File: 770-poly.wb1

A Final Report:

Laboratory Testing of SKAPS Industries HDPE Geonet EPA Method 9090A

January 2003

Submitted to:

SKAPS Industries
571 Industrial Parkway
Commerce, GA 30529

Attn: **Mr. Perry Vyas**

Submitted by:

TRI/Environmental, Inc.
9063 Bee Caves Rd.
Austin, Texas 78733

TRI/ENVIRONMENTAL, INC.
A Texas Research International Company

January 10, 2003

Mr. Perry Vyas
SKAPS Industries
571 Industrial Parkway
Commerce, GA 30529

Dear Mr. Vyas:

TRI/Environmental, Inc. (TRI) is pleased to present this Final Report for a geonet chemical compatibility study performed in general accordance with EPA Method 9090A.

TRI is very pleased to be of service to SKAPS Industries. Please call me if you have any questions or require any additional information.

Respectfully submitted,

Sam R. Allen

Sam R. Allen
Vice President and Division Manager
Geosynthetic Services Division

9063 Bee Caves Road, Austin, TX 78733 / 512 263 2101 / fax: 512 263 2558

FOREWORD

The testing reported herein is based upon accepted industry practice as well as the test method listed. TRI/Environmental Inc. (TRI) neither accepts responsibility for nor makes claim as to the final use and purpose of the materials tested.

Tests were performed under laboratory conditions and not under actual usage conditions. TRI can give no conclusions as to the serviceability, life expectancy or general durability of the products tested when used in a lining and/or leachate collection system.

1.0 INTRODUCTION

This report describes the work performed by TRI/Environmental, Inc. (TRI) to determine the chemical compatibility of one HDPE geonet product with one waste leachate. The objective was to determine the resistance of the geonet to changes caused by exposure to leachate. Changes in physical, mechanical and hydraulic properties were measured after exposure to the leachate at 23°C and 50°C for 30, 60, 90 and 120 days. Exposures were performed in accordance with the exposure regimen specified in United States Environmental Protection Agency (EPA) Method 9090A.

All samples were logged in and all testing performed under TRI log number E2173-46-05. Methods, results and discussion are provided in the sections which follow. Test results are provided in the Tables of Results which accompany this report.

2.0 METHODS

2.1 Materials

The material selected for evaluation in this chemical compatibility study was Skaps Industries HDPE biplaner geonet.

2.2 Leachate

The waste leachate used was supplied by TRI and was a synthetic MSW leachate approximating the PaDER leachate recipe.

2.3 Exposure Conditions

Geonet specimens were exposed to the waste leachate following the specifications of EPA Method 9090A as they relate to exposure to waste fluids. The tanks used for these exposures were maintained at 23 ± 2°C and 50 ± 2°C throughout the 120-day exposure period. Tanks were constructed from chemically resistant glass fitted with stirrers. The 50°C tanks were heated with a circulating hot water heat exchanger system. They were also sealed with a lid, and a reflux condenser was installed to minimize loss of volatile leachate components.

2.4 Testing Procedures

Table 1 lists tests performed on the geonet. The number of test replicates was doubled for baseline determinations on unexposed material.

Table 1. Tests performed on Skaps Industries HDPE Geonet		
Test or Physical Property	**Method**	**Number of replicate specimens**
Dimensions and weight	EPA 9090	2 readings
Strip Tensile Strength	ASTM D 5035	3 MD & TD readings
Strip Tensile Elongation	ASTM D 5035	3 MD & TD readings
Compressive Strength	ASTM D 1621	3 readings
Transmissivity	ASTM D 4716	3 readings
CBR Puncture	ASTM D 6241	3 readings
Volatiles and Extractables	SW870 - Appendix III-D	2 readings

3.0 RESULTS AND DISCUSSION

Test results are presented in the Test Results section which is included with this report. Test results are presented in tabular form as well as graphical form.

In considering these results, it must be determined through engineering judgment whether observed differences in the value of test results measured before and after immersion are due to product variability, unidentified factors relating to the test procedure, or leachate interaction with the product. Any significant chemical interaction with leachate would be expected to result in degradation trends which are consistent across the various properties being evaluated, and not isolated to one set of test results only. However, with each type of material there may be specific properties which are highly sensitive to leachate-induced effects. These factors must be considered in evaluating the various test results for a given product.

Also of critical importance is the issue of product variability. With HDPE geonets, a range of physical and mechanical index test values covering 20% or more of the average is not uncommon. This can be traced to variability inherent in the product, and the randomness associated with the onset of failure under the specified testing conditions. However, in chemical compatibility testing the statistical sampling of a broad range of manufactured product is not possible. Therefore, the small size of the sample population tested at each time point must be taken into consideration. The criteria to be applied in evaluating data measured before and after leachate immersion should be that property changes, if observed, are consistent and so great that product variability and experimental factors can be ruled out.

In this report, standard deviations (STD) are reported for measurements involving three or more replicate specimens. In statistics, the standard deviation is defined as root of the mean squared deviations of individual test results about the mean value. The standard deviation is a quantitative measure of variability within a group of measurements.

One related measure of variability observed within a sample set, relative to the magnitude of the mean value itself, is the *coefficient of variation or variance* (COV). The coefficient of variance is defined as the standard deviation divided by the mean associated with a group of specimens, and may be expressed as a percentage. The COV provides an indication of what proportion of the mean value may be attributable to random experimental factors or product variability. It is useful to consider apparent changes in property values against the criterion of COV since observed changes which fall below the COV may not be significant. This approach was used in preparing the tables in the next section.

The term *range* refers to the difference between the extreme highest and lowest points within a group of measured values. Considering range as a percentage of the mean values provides another measure of variability within a dataset.

In the tables, the high and low extremes for percentage change in mean values are listed for comparison against COV and range as a percentage of mean from the baseline sample group. The high and low percentage changes are the extremes from data measured at 30, 60, 90 and 120 days.

Skaps Industries HDPE Biplaner Geonet

Table 2 illustrates the range of variability in baseline data compared with some of the observed changes in average test values measured after immersion for the geonet.

Table 2. Baseline coefficients of variation and range of percentage change results

Test	Baseline COV (%)*	Baseline Range as % of Mean*	High Observed % Change	Low Observed % Change
Strip Tensile Strength (MD)	7	17	9	-9
Strip Tensile Elongation @ Maximum Load (MD)	6	18	9	-8
Compressive Strength	6	17	4	-6
Transmissivity	2.18	6.63	-0.17	-9.54
CBR Puncture	7	20	9	-9

4.0 CONCLUSION

Changes in certain measured physical and mechanical properties were noted for the geonet. However, the observed variances were random and are believed to be the effects of product variability and experimental factors. In the opinion of the authors, the data, considered together, support the conclusion that observed variances were not caused by exposure to the test leachate.

TRI/Environmental, Inc. is pleased to have been selected to participate in this project. We trust that the information provided in this report meets your requirements for technical documentation of this chemical compatibility study. Please do not hesitate to call if you have any questions or require any additional information.

Respectfully submitted,

Sam R. Allen

Sam R. Allen
Vice President and Division Manager
Geosynthetic Services Division

TRI/Environmental, Inc.

APPENDIX:

EPA METHOD 9090A TEST RESULTS

SKAPS INDUSTRIES HDPE GEONET TEST RESULTS

Dimensions

TRI LOG NUMBER: E2173-46-05

TABLE OF CHEMICAL COMPATIBILITY TEST RESULTS
Client: Skaps Industries

Report Date: January 2003
TRI Log Number: E2173-46-05

Exposure Time and Temperature

Test Paremeters	Temp.	30 Day Baseline	30 Day Exposed	30 Day % Change	60 Day Baseline	60 Day Exposed	60 Day % Change	90 Day Baseline	90 Day Exposed	90 Day % Change	120 Day Baseline	120 Day Exposed	120 Day % Change

GEONET: HDPE GEONET EXPOSED TO PADER MSW SYNTHETIC LEACHATE

Test Paremeters	Temp.	30 Day Baseline	30 Day Exposed	30 Day % Change	60 Day Baseline	60 Day Exposed	60 Day % Change	90 Day Baseline	90 Day Exposed	90 Day % Change	120 Day Baseline	120 Day Exposed	120 Day % Change
Thickness (mils)	23C	224	228	1.8	234	234	0.0	230	230	0.0	228	228	0.0
	50C	232	232	0.0	228	229	0.4	230	231	0.4	229	229	0.0
Length (inches)	23C	6.00	6.00	0.0	6.00	5.85	-2.5	6.00	5.96	-0.7	6.02	6.01	-0.2
	50C	6.00	5.83	-2.8	6.00	5.89	-1.8	6.00	6.00	0.0	5.99	6.00	0.2
Width (inches)	23C	4.04	4.06	0.5	4.01	4.02	0.2	4.01	4.04	0.7	4.02	4.04	0.5
	50C	4.02	4.02	0.0	4.01	4.01	0.0	4.03	4.03	0.0	4.03	4.01	-0.5
Mass (g)	23C	14.91	14.92	0.1	15.46	15.47	0.1	15.30	15.31	0.1	15.23	15.25	0.1
	50C	17.06	17.06	0.0	16.86	16.86	0.0	17.05	17.05	0.0	14.93	14.93	0.0

EPA METHOD 9090A TEST RESULTS

SKAPS INDUSTRIES HDPE GEONET TEST RESULTS

TRI LOG NUMBER: E2173-46-05

NOTE ON TEST RESULTS

This section includes generated test data provided in both tabular and graphical form. Each graph is represented by a series of "I" beam plots. Each "I" beam represents a single test population and illustrates the high and low value as the end points, and the mean as a central box on the beam.

At each testing period, two "I" beams are shown. The left beam represents the 23°C exposed specimens while the right beam represents the 50°C specimens. The initial "I" beam represents the baseline or unexposed test specimens.

TABLE OF CHEMICAL COMPATIBILITY TEST RESULTS
Client: Skaps Industries

Report Date: January 2003
TRI Log Number: E2173-46-05

Test Parameters	Baseline	30 Day 23C	30 Day 50C	60 Day 23C	60 Day 50C	90 Day 23C	90 Day 50C	120 Day 23C	120 Day 50C
		Exposure Time and Temperature							

GEONET: HDPE GEONET EXPOSED TO PaDER MSW SYNTHETIC LEACHATE

Test Parameters	Baseline	30 Day 23C	30 Day 50C	60 Day 23C	60 Day 50C	90 Day 23C	90 Day 50C	120 Day 23C	120 Day 50C
Strip Tensile Properties:	143	158	173	130	167	131	166	168	133
Maximum Strength (lbs)	167	144	162	153	152	167	148	165	150
ASTM D5035	153	151	147	149	173	126	157	172	144
Machine Direction	150								
	170								
	144								
Average	155	151	161	144	164	141	157	168	142
STD	11	6	11	10	9	18	7	3	7
Coefficient of Variation	7	4	7	7	5	13	5	2	5
% Change		-2	4	-7	6	-9	2	9	-8
Strip Tensile Properties:	33	34	35	30	35	35	31	35	33
Elongation @ Max. Strength (%)	36	28	32	35	42	34	33	36	28
ASTM D5035	35	33	24	32	31	31	35	33	31
Machine Direction	30								
	31								
	33								
Average	33	32	30	32	36	33	33	35	31
STD	2	3	5	2	5	2	2	1	2
Coefficient of Variation	6	8	15	6	13	5	5	4	7
% Change		-4	-8	-2	9	1	0	5	-7

TABLE OF CHEMICAL COMPATIBILITY TEST RESULTS
Client: Skaps Industries

Report Date: January 2003
TRI Log Number: E2173-46-05

		Exposure Time and Temperature							
		30 Day		60 Day		90 Day		120 Day	
Test Parameters	Baseline	23C	50C	23C	50C	23C	50C	23C	50C

GEONET: HDPE GEONET EXPOSED TO PaDER MSW SYNTHETIC LEACHATE

Strip Tensile Properties:	56	55	60	57	49	59	53	60	47
Maximum Strength (lbs)	57	53	59	57	56	54	53	61	59
ASTM D5035	64	51	60	56	62	51	52	58	56
Transverse Direction	57								
	51								
	53								
Average	56	53	60	57	56	55	53	60	54
STD	4	2	0	0	5	3	0	1	5
Coefficient of Variation	7	3	1	1	10	6	1	2	9
% Change		-6	6	1	-1	-3	-7	6	-4
Strip Tensile Properties:	129	171	163	151	169	148	155	135	165
Elongation @ Max. Strength (%)	172	160	139	159	157	141	168	147	177
ASTM D5035	153	115	133	160	189	149	167	149	148
Transverse Direction	133								
	151								
	149								
Average	148	149	145	157	172	146	163	144	163
STD	14	24	13	4	13	4	6	6	12
Coefficient of Variation	10	16	9	3	8	2	4	4	7
% Change		1	-2	6	16	-1	10	-3	10

TABLE OF CHEMICAL COMPATIBILITY TEST RESULTS
Client: Skaps Industries

Report Date: January 2003
TRI Log Number: E2173-46-05

Test Parameters	Baseline	30 Day 23C	30 Day 50C	60 Day 23C	60 Day 50C	90 Day 23C	90 Day 50C	120 Day 23C	120 Day 50C
		Exposure Time and Temperature							
GEONET: HDPE GEONET EXPOSED TO PaDER MSW SYNTHETIC LEACHATE									
Compressive Strength:	35951	36083	33732	25141	34508	39672	33045	35164	31349
Strength at Rib Layover (psf)	35677	31833	39106	40149	23798	32742	32879	34119	33234
ASTM D1621	38252	34801	31922	37048	42045	37877	39494	40486	36492
	36837								
	32100								
	33888								
Average	35451	34239	34920	34113	33450	36764	35139	36590	33692
STD	1989	1780	3051	6469	7487	2937	3080	2788	2124
Coefficient of Variation	6	5	9	19	22	8	9	8	6
% Change		-3	-1	-4	-6	4	-1	3	-5
Transmissivity:	1.96E-03	1.88E-03	1.91E-03	1.77E-03	1.94E-03	1.87E-03	1.90E-03	1.96E-03	1.90E-03
(m2/sec)	1.95E-03	1.88E-03	1.89E-03	1.76E-03	1.91E-03	1.84E-03	1.93E-03	1.96E-03	1.96E-03
ASTM D4716	2.01E-03	1.89E-03	1.94E-03	1.78E-03	1.84E-03	1.82E-03	1.95E-03	1.94E-03	1.89E-03
	1.94E-03								
	2.00E-03								
	1.88E-03								
Average	1.96E-03	1.88E-03	1.91E-03	1.77E-03	1.90E-03	1.84E-03	1.93E-03	1.95E-03	1.92E-03
STD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coefficient of Variation	2.18	0.25	1.07	0.46	2.21	1.11	1.07	0.48	1.61
% Change		-3.75	-2.21	-9.54	-3.07	-5.79	-1.53	-0.17	-2.04
CBR Puncture:	292	238	292	279	345	296	308	279	256
Puncture Resistance (lbs)	235	247	298	289	276	278	311	265	275
ASTM D6241	280	270	265	240	273	255	289	246	288
	285								
	286								
	284								
Average	277	252	285	269	298	276	303	263	273
STD	19	13	14	21	33	17	10	14	13
Coefficient of Variation	7	5	5	8	11	6	3	5	5
% Change		-9	3	-3	8	-0	9	-5	-1

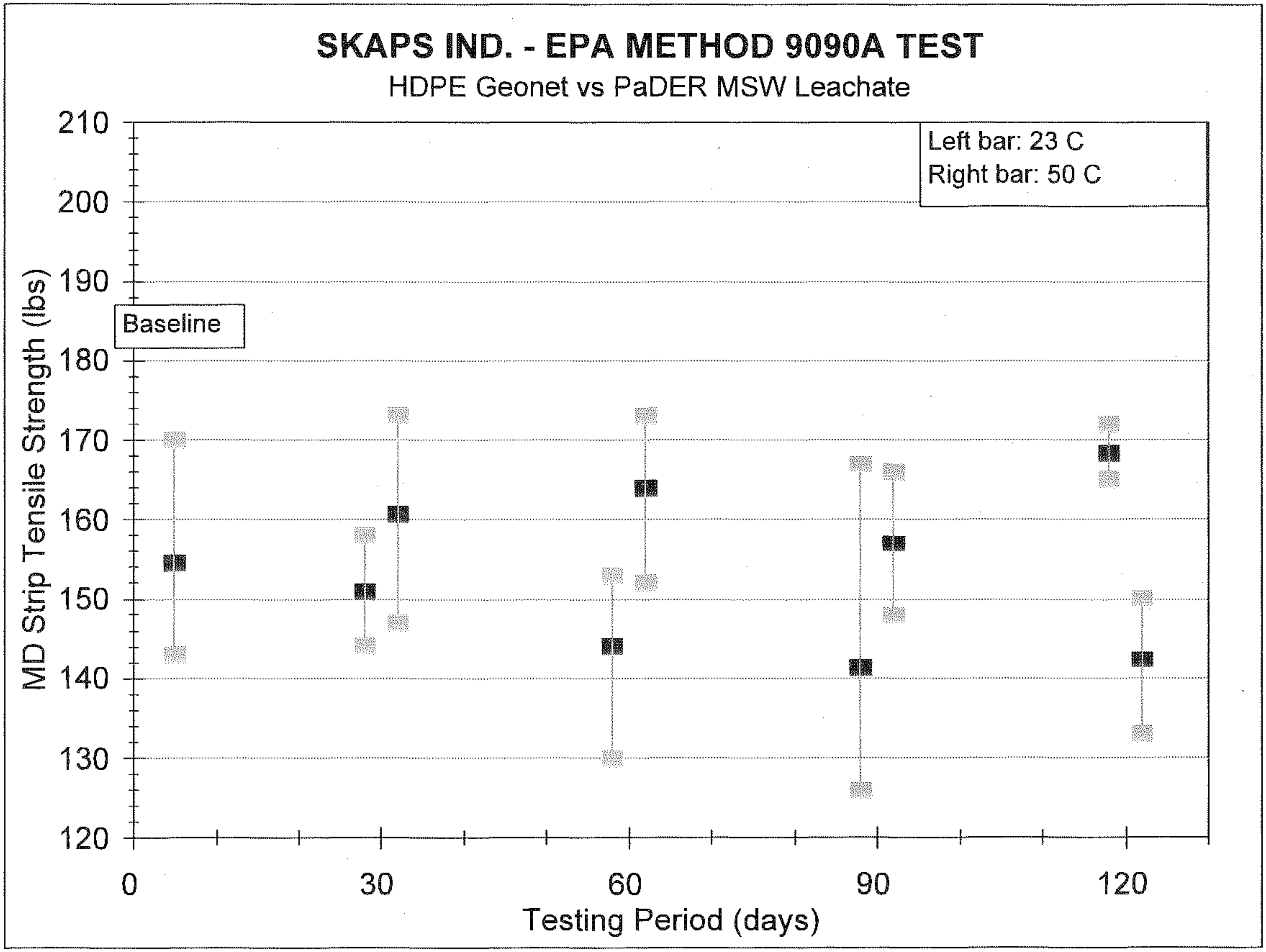
TABLE OF CHEMICAL COMPATIBILITY TEST RESULTS
Client: Skaps Industries

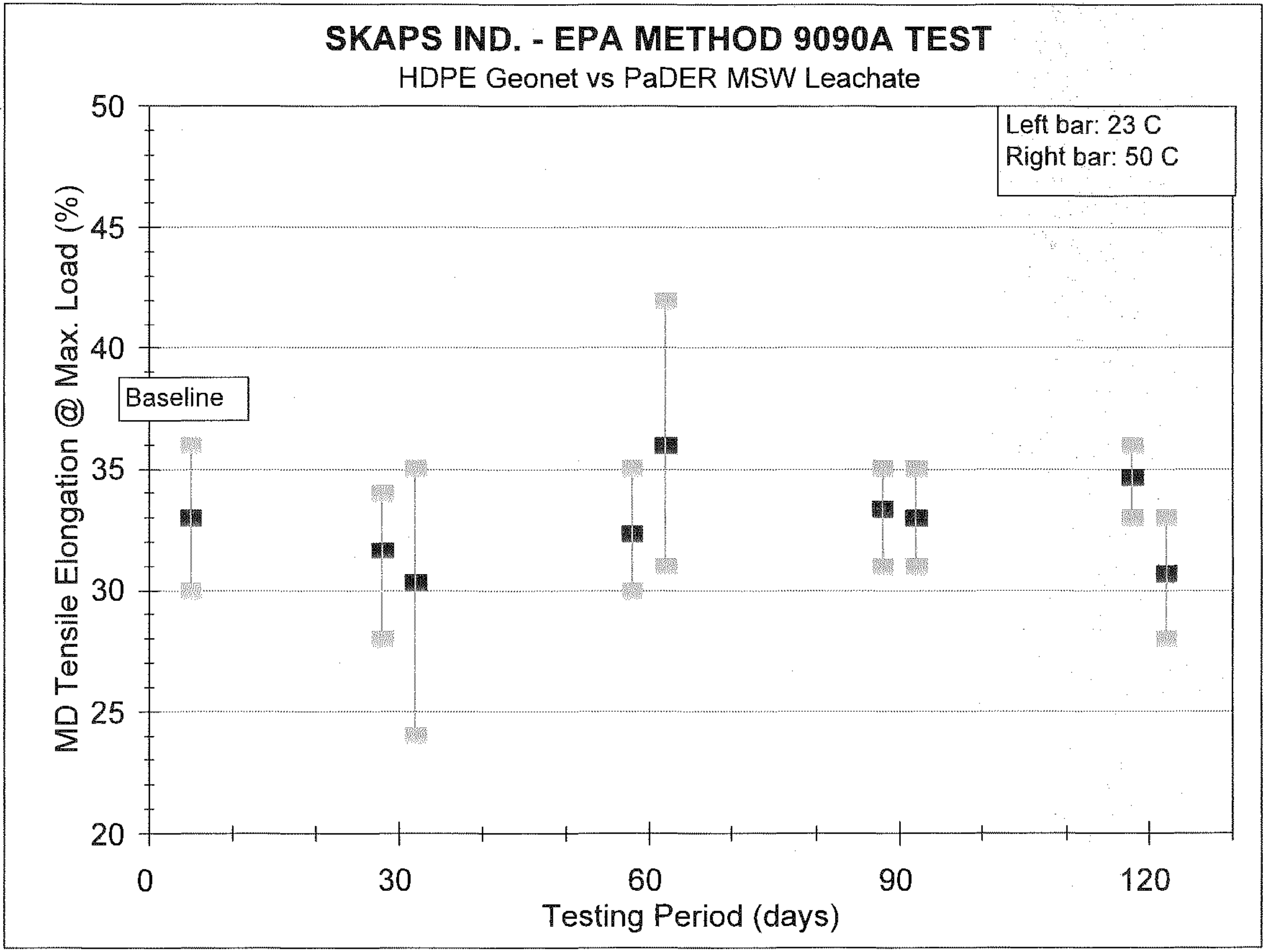
Report Date: January 2003
TRI Log Number: E2173-46-05

Test Parameters	Baseline	30 Day 23C	30 Day 50C	60 Day 23C	60 Day 50C	90 Day 23C	90 Day 50C	120 Day 23C	120 Day 50C
		Exposure Time and Temperature							

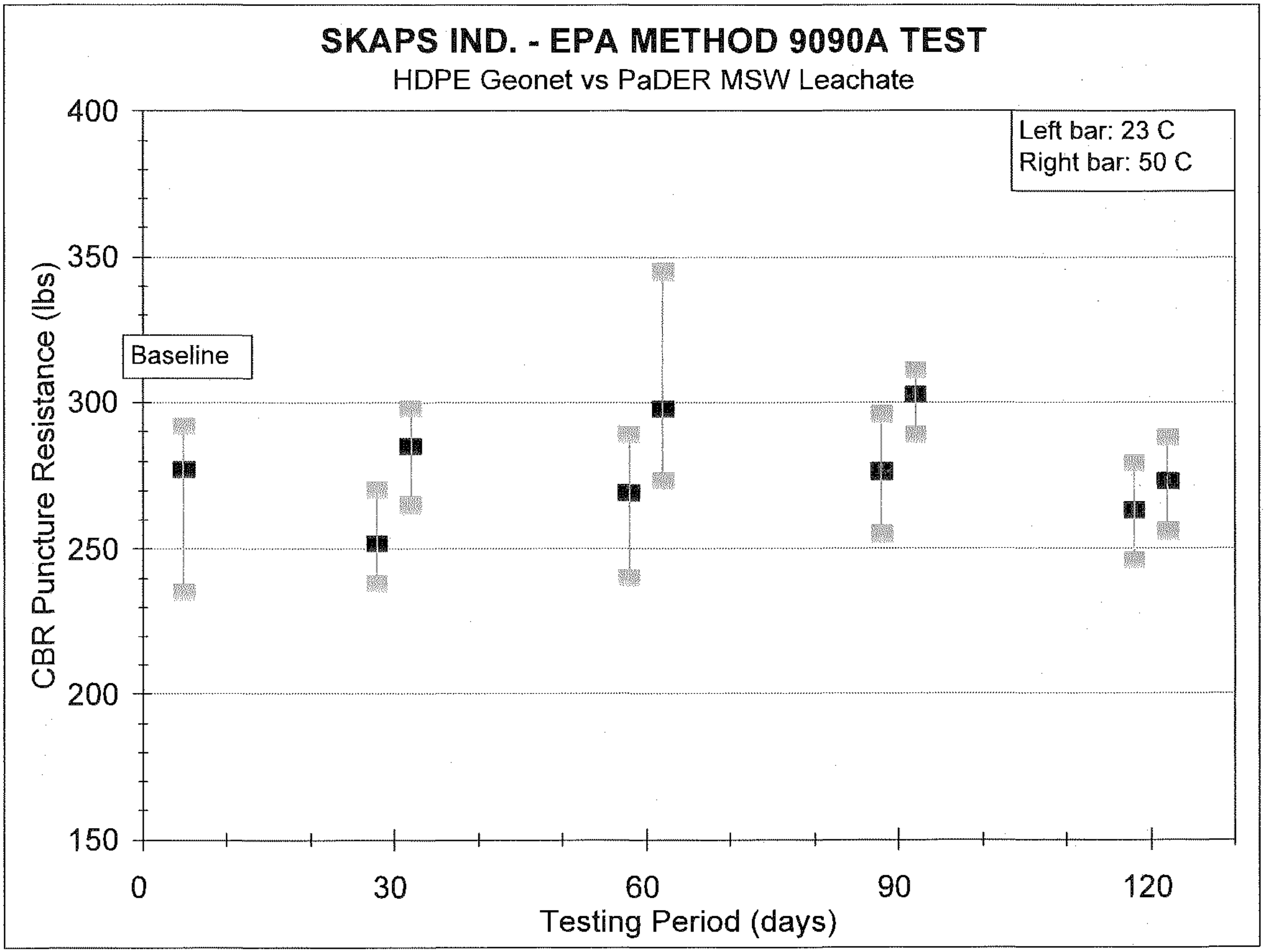
GEONET: HDPE GEONET EXPOSED TO PaDER MSW SYNTHETIC LEACHATE

Test Parameters	Baseline	30 Day 23C	30 Day 50C	60 Day 23C	60 Day 50C	90 Day 23C	90 Day 50C	120 Day 23C	120 Day 50C
Volatiles and Extractables:	-1.51	-1.51	-1.01	-2.00	-0.51	0.00	-1.00	-0.50	-1.01
Machine Diameter Change (%)	-3.02	-2.51	-1.51	-1.01	-1.50	-1.01	-2.01	-2.53	-0.51
SW 870 - Appendix III-D	-2.51								
	-1.01								
Average	-2.01	-2.01	-1.26	-1.51	-1.01	-0.51	-1.51	-1.52	-0.76
STD	0.79	0.50	0.25	0.50	0.50	0.51	0.50	1.02	0.25
Volatiles and Extractables:	-3.02	-3.48	-1.51	-1.04	-1.01	-1.49	-0.51	-1.03	-1.54
Transverse Diameter Change (%)	-3.98	-3.48	-1.00	-3.05	-1.00	-1.52	-1.02	-1.54	-1.53
SW 870 - Appendix III-D	-1.99								
	-0.50								
Average	-2.37	-3.48	-1.26	-2.05	-1.01	-1.51	-0.77	-1.29	-1.54
STD	1.29	0.00	0.26	1.01	0.01	0.02	0.26	0.25	0.00
Volatiles and Extractables:	0.07	0.11	0.09	0.11	0.16	0.12	0.11	0.12	0.11
% Volatiles	0.07	0.11	0.12	0.10	0.16	0.08	0.10	0.13	0.08
SW 870 - Appendix III-D	0.07								
	0.07								
Average	0.07	0.11	0.11	0.11	0.16	0.10	0.11	0.13	0.10
STD	0.00	0.00	0.02	0.00	0.00	0.02	0.00	0.01	0.01
Volatiles and Extractables:	0.16	0.25	0.21	0.16	0.13	0.22	0.08	0.18	0.10
% Extractables	0.14	0.18	0.25	0.32	0.30	0.27	0.19	0.35	0.30
SW 870 - Appendix III-D	0.16								
	0.25								
Average	0.18	0.22	0.23	0.24	0.22	0.25	0.14	0.27	0.20
STD	0.04	0.04	0.02	0.08	0.09	0.03	0.05	0.08	0.10

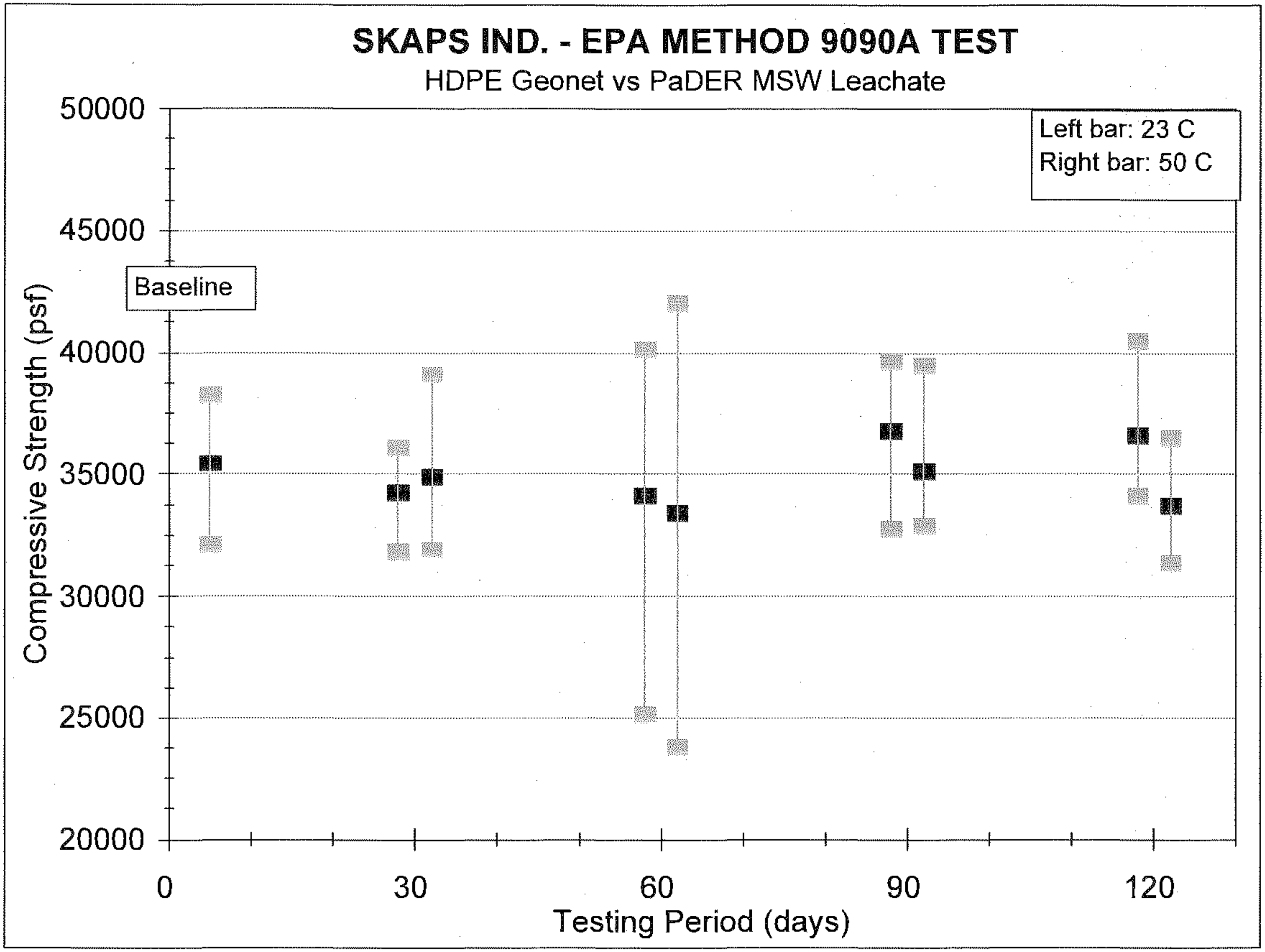

SKAPS IND. - EPA METHOD 9090A TEST
HDPE Geonet vs PaDER MSW Leachate
Left bar: 23 C
Right bar: 50 C
Baseline
MD Strip Tensile Strength (lbs)
210
200
190
180
170
160
150
140
130
120
0
30
60
90
120
Testing Period (days)



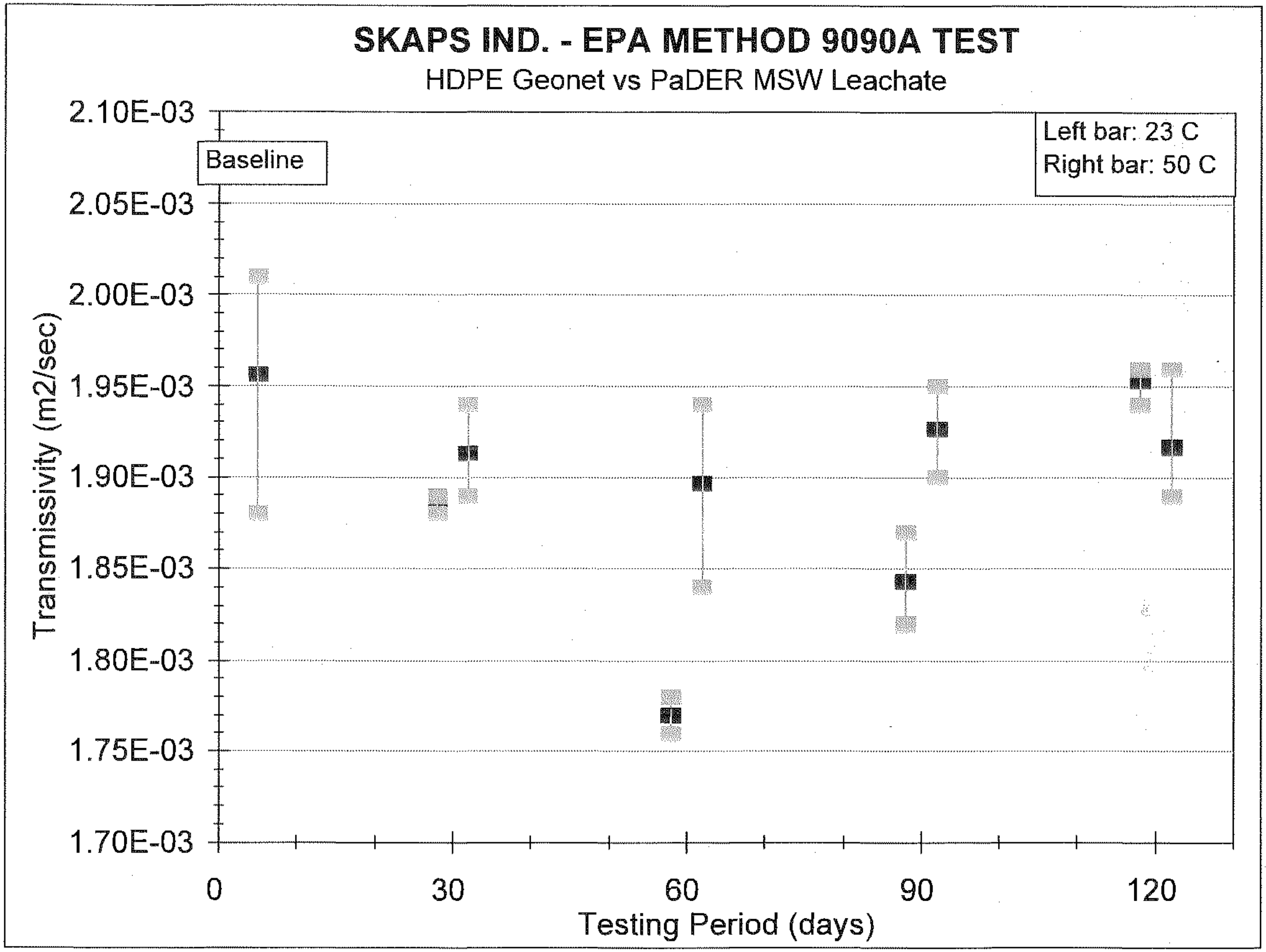
TRI Geosynthetics Division Client: Skaps Industries, File: 465-skaps-gn .WB1



TRI Geosynthetics Division Client: Skaps Industries, File: 465-skaps-gn .WB1



TRI Geosynthetics Division Client: Skaps Industries, File: 465-skaps-gn .WB1



TRI Geosynthetics Division Client: Skaps Industries, File: 465-skaps-gn .WB1

TRI/ENVIRONMENTAL, INC.
A Texas Research International Company

February 11, 2004

Mr. Anarag
Skaps Industries
571 Industrial Parkway
Commerce, GA 30529

Dear Mr. Anarag:

TRI/Environmental, Inc. (TRI) is pleased to present this Final Report for a geotextile chemical resistance study performed in general accordance with EPA Method 9090A as applied by ASTM D 6389-99, *Standard Practice for Tests to Evaluate the Chemical Resistance of Geotextiles to Liquids.*

TRI is very pleased to be of service to Skaps Industries. Please call me if you have any questions or require any additional information (800 880 8378).

Respectfully submitted,

Sam R. Allen

Sam R. Allen
Vice President and Division Manager
Geosynthetic Services Division
www.GeosyntheticTesting.com

A Final Report:

Laboratory Testing of Geotextile for Waste Containment EPA Method 9090A

February 2004

Submitted to:

Skaps Industries
571 Industrial Parkway
Commerce, GA 30529

Attn: **Mr. Anarag**

Submitted by:

TRI/Environmental, Inc.
9063 Bee Caves Rd.
Austin, Texas 78733

FOREWORD

The testing reported herein is based upon accepted industry practice as well as the test method listed. TRI/Environmental Inc. (TRI) neither accepts responsibility for nor makes claim as to the final use and purpose of the materials tested.

Tests were performed under laboratory conditions and not under actual usage conditions. TRI can give no conclusions as to the serviceability, life expectancy or general durability of the products tested when used in a lining and/or leachate collection system.

1.0 INTRODUCTION

This report describes the work performed by TRI/Environmental, Inc. (TRI) to determine the chemical compatibility of one geotextile product with one synthetic waste leachate. The objective was to determine the resistance of the geotextile to changes caused by exposure to leachate. Changes in physical, mechanical and hydraulic properties were measured after exposure to the leachate at 23°C and 50°C for 30, 60, 90 and 120 days. Exposures were performed in accordance with the exposure regimen specified in United States Environmental Protection Agency (EPA) Method 9090A.

All samples were logged in and all testing performed under TRI log number E2183-79-10. Methods, results and discussion are provided in the sections which follow. Test results are provided in the Tables of Results which accompany this report.

2.0 METHODS

2.1 Materials

The material selected for evaluation in this chemical compatibility study was Skaps.GTE 160 polypropylene staple fiber nonwoven needlepunched geotextile.

2.2 Leachate

The waste leachate used was supplied by TRI and was a synthetic MSW leachate approximating the PaDER leachate recipe.

2.3 Exposure Conditions

Geotextile specimens were exposed to the waste leachate following the specifications of EPA Method 9090A as they relate to exposure to waste fluids. The tanks used for these exposures were maintained at 23 ± 2°C and 50 ± 2°C throughout the 120-day exposure period. Tanks were constructed from chemically resistant glass fitted with stirrers. The 50°C tanks were heated with a circulating hot water heat exchanger system. They were also sealed with a lid, and a reflux condenser was installed to minimize loss of volatile leachate components.

2.4 Testing Procedures

Table 1 lists tests performed on the geotextile. The number of test replicates was doubled for baseline determinations on unexposed material.

Table 1. Tests performed on TNS - Nevown, Inc. nonwoven geotextile		
Test or Physical Property	**Method**	**Number of replicate specimens**
Dimensions and weight	EPA 9090A	2 readings
Grab Tensile Strength	ASTM D 4632	3 MD & TD readings
Grab Tensile Elongation	ASTM D 4632	3 MD & TD readings
Trapezoidal Tear Strength	ASTM D 4533	3 MD & TD readings
Puncture Resistance	ASTM D 4833	3 readings
Mullen Burst	ASTM D 3786	3 readings
Permittivity	ASTM D 4491	3 readings

3.0 RESULTS AND DISCUSSION

Test results are presented in the Test Results section which is included with this report. Test results are presented in tabular form as well as graphical form.

In considering these results, it must be determined through engineering judgment whether observed differences in the value of test results measured before and after immersion are due to product variability, unidentified factors relating to the test procedure, or leachate interaction with the product. Any significant chemical interaction with leachate would be expected to result in degradation trends which are consistent across the various properties being evaluated, and not isolated to one set of test results only. However, with each type of material there may be specific properties which are highly sensitive to leachate-induced effects. These factors must be considered in evaluating the various test results for a given product.

Also of critical importance is the issue of product variability. With nonwoven geotextiles, a range of physical and mechanical index test values covering 20% or more of the average is not uncommon. This can be traced to variability inherent in the product, and the randomness associated with the onset of failure under the specified testing conditions. However, in chemical compatibility testing the statistical sampling of a broad range of manufactured product is not possible. Therefore, the small size of the sample population tested at each time point must be taken into consideration. The criteria to be applied in evaluating data measured before and after leachate immersion should be that property changes, if observed, are consistent and so great that product variability and experimental factors can be ruled out.

In this report, standard deviations (STD) are reported for measurements involving three or more replicate specimens. In statistics, the standard deviation is defined as root of the mean squared deviations of individual test results about the mean value. The standard deviation is a quantitative measure of variability within a group of measurements.

One related measure of variability observed within a sample set, relative to the magnitude of the mean value itself, is the *coefficient of variation or variance* (COV). The coefficient of variance is defined as the standard deviation divided by the mean associated with a group of specimens, and may be expressed as a percentage. The COV provides an indication of what proportion of the mean value may be attributable to random experimental factors or product variability. It is useful to consider apparent changes in property values against the criterion of COV since observed changes which fall below the COV may not be significant. This approach was used in preparing the tables in the next section.

The term *range* refers to the difference between the extreme highest and lowest points within a group of measured values. Considering range as a percentage of the mean values provides another measure of variability within a dataset.

In the tables, the high and low extremes for percentage change in mean values are listed for comparison against COV and range as a percentage of mean from the baseline sample group. The high and low percentage changes are the extremes from data measured at 30, 60, 90 and 120 days.

SKAPS GTE 160 nonwoven polypropylene geotextile

Table 2 illustrates the range of variability in baseline data compared with some of the observed changes in average test values measured after immersion for the geotextile.

Table 2. Baseline coefficients of variation and range of percentage change results for geotextile

Test	Baseline COV (%)*	Baseline Range as % of Mean*	High Observed % Change	Low Observed % Change
Grab Tensile Strength (MD)	8	22	12	-1
Grab Tensile Elongation @ Maximum Load (MD)	8	24	2	-4
Trapezoidal Tear Strength (MD)	8	22	7	-8
Puncture Strength	17	50	3	-9
Mullen Burst Strength	8	26	5	-9

4.0 CONCLUSION

While some changes in certain measured physical and mechanical properties were noted for the geotextile, the observed variances were random and are believed to be the effects of product variability and experimental factors.

TRI/Environmental, Inc. is pleased to have been selected to participate in this project. We trust that the information provided in this report meets your requirements for technical documentation of this chemical compatibility study. Please do not hesitate to call if you have any questions or require any additional information.

Respectfully submitted,

Sam R. Allen

Sam R. Allen
Vice President and Division Manager
Geosynthetic Services Division

TRI/Environmental, Inc.

APPENDIX:

EPA METHOD 9090A TEST RESULTS

SKAPS GTE 160 Nonwoven Geotextile TEST RESULTS

Dimensions

TRI LOG NUMBER: E2183-79-10

TABLE OF CHEMICAL COMPATIBILITY TEST RESULTS
Client: Skaps Industries

Report Date: February 2004
TRI Log Number: E2189-79-10

Exposure Time and Temperature

Test Parameters	Temp.	30 Day Baseline	30 Day Exposed	30 Day % Change	60 Day Baseline	60 Day Exposed	60 Day % Change	90 Day Baseline	90 Day Exposed	90 Day % Change	120 Day Baseline	120 Day Exposed	120 Day % Change

GEOTEXTILE: POLYPROPYLENE NONWOVEN EXPOSED TO PaDER SYNTHETIC MSW LEACHATE
GEOTEXTILE ROLL ID: GTE-160

Test Parameters	Temp.	30 Day Baseline	30 Day Exposed	30 Day % Change	60 Day Baseline	60 Day Exposed	60 Day % Change	90 Day Baseline	90 Day Exposed	90 Day % Change	120 Day Baseline	120 Day Exposed	120 Day % Change
Thickness (mils)	23C	115	112	-2.6	112	112	0.0	118	118	0.0	108	107	-0.9
	50C	107	104	-2.8	118	117	-0.8	117	113	-3.4	114	117	2.6
Length (inches)	23C	8.06	8.04	-0.2	8.07	8.03	-0.5	8.10	8.00	-1.2	8.05	8.00	-0.6
	50C	8.08	7.97	-1.4	8.06	7.96	-1.2	8.08	7.95	-1.6	8.01	7.94	-0.9
Width (inches)	23C	4.05	4.01	-1.0	4.02	4.00	-0.5	4.00	3.96	-1.0	3.98	3.95	-0.8
	50C	4.00	3.92	-2.0	4.01	3.99	-0.5	4.06	4.02	-1.0	4.06	4.04	-0.5
Mass (g)	23C	4.88	4.87	-0.2	4.88	4.95	1.4	5.01	5.01	0.0	6.55	6.51	-0.6
	50C	4.38	4.38	0.0	5.15	5.08	-1.4	5.08	5.05	-0.6	5.60	5.53	-1.2

EPA METHOD 9090A TEST RESULTS

SKAPS GTE 160 Nonwoven Geotextile TEST RESULTS

TRI LOG NUMBER: E2183-79-10

NOTE ON TEST RESULTS

This section includes generated test data provided in both tabular and graphical form. Each graph is represented by a series of "I" beam plots. Each "I" beam represents a single test population and illustrates the high and low value as the end points, and the mean as a central box on the beam.

At each testing period, two "I" beams are shown. The left beam represents the 23°C exposed specimens while the right beam represents the 50°C specimens. The initial "I" beam represents the baseline or unexposed test specimens.

TABLE OF CHEMICAL COMPATIBILITY TEST RESULTS
Client: Skaps Industries

Report Date: February 2004
TRI Log Number: E2183-79-10

Exposure Time and Temperature

Test Parameters	Baseline	30 Day 23C	30 Day 50C	60 Day 23C	60 Day 50C	90 Day 23C	90 Day 50C	120 Day 23C	120 Day 50C
GEOTEXTILE: POLYPROPYLENE NONWOVEN EXPOSED TO PADER SYNTHETIC MSW LEACHATE									
GEOTEXTILE ROLL ID: GTE-160									
Grab Tensile Properties:	164	206	183	182	215	208	204	214	230
Maximum Strength (lbs)	167	185	208	184	223	196	199	246	205
ASTM D4632	202	211	222	232	240	215	192	161	218
Machine Direction	204								
	187								
	155								
Average	180	201	204	199	226	206	198	207	218
STD	19	11	16	23	10	8	5	35	10
Coefficient of Variation	11	6	8	12	5	4	2	17	5
% Change		12	14	11	26	15	10	15	21
Grab Tensile Properties:	96	109	93	119	94	91	91	95	108
Elongation @ Max. Strength (%)	89	105	100	106	95	98	99	107	98
ASTM D4632	95	107	101	113	91	101	87	103	103
Machine Direction	104								
	109								
	155								
Average	108	107	98	113	93	97	92	102	103
STD	22	2	4	5	2	4	5	5	4
Coefficient of Variation	20	2	4	5	2	4	5	5	4
% Change		-1	-9	4	-14	-10	-15	-6	-5

TABLE OF CHEMICAL COMPATIBILITY TEST RESULTS
Client: Skaps Industries

Report Date: February 2004
TRI Log Number: E2183-79-10

Test Parameters	Baseline	30 Day 23C	30 Day 50C	60 Day 23C	60 Day 50C	90 Day 23C	90 Day 50C	120 Day 23C	120 Day 50C
		Exposure Time and Temperature							

GEOTEXTILE: POLYPROPYLENE NONWOVEN EXPOSED TO PADER SYNTHETIC MSW LEACHATE
GEOTEXTILE ROLL ID: GTE-160

Test Parameters	Baseline	30 Day 23C	30 Day 50C	60 Day 23C	60 Day 50C	90 Day 23C	90 Day 50C	120 Day 23C	120 Day 50C
Grab Tensile Properties:	321	345	289	308	338	323	290	285	274
Maximum Strength (lbs)	325	343	310	338	277	317	309	303	309
ASTM D4632	282	252	282	287	252	329	292	310	298
Transverse Direction	288								
	220								
	258								
Average	282	313	294	311	289	323	297	299	294
STD	36	43	12	21	36	5	9	11	15
Coefficient of Variation	13	14	4	7	12	2	3	4	5
% Change		11	4	10	2	14	5	6	4
Grab Tensile Properties:	98	97	93	97	98	93	99	91	93
Elongation @ Max. Strength (%)	115	112	104	109	99	100	99	103	104
ASTM D4632	94	94	103	97	85	93	92	94	95
Transverse Direction	83								
	95								
	99								
Average	97	101	100	101	94	95	97	96	97
STD	9	8	5	6	6	3	3	5	5
Coefficient of Variation	10	8	5	6	7	3	3	5	5
% Change		4	3	4	-3	-2	-1	-1	0

TABLE OF CHEMICAL COMPATIBILITY TEST RESULTS
Client: Skaps Industries

Report Date: February 2004
TRI Log Number: E2183-79-10

		Exposure Time and Temperature							
		30 Day		60 Day		90 Day		120 Day	
Test Parameters	Baseline	23C	50C	23C	50C	23C	50C	23C	50C

GEOTEXTILE: POLYPROPYLENE NONWOVEN EXPOSED TO PADER SYNTHETIC MSW LEACHATE
GEOTEXTILE ROLL ID: GTE-160

Test Parameters	Baseline	30 Day 23C	30 Day 50C	60 Day 23C	60 Day 50C	90 Day 23C	90 Day 50C	120 Day 23C	120 Day 50C
Mullen Burst Strength:	455	380	415	390	450	450	435	415	380
Burst Strength (psi)	420	400	380	400	430	415	410	405	385
ASTM D3786	425	345	415	400	410	410	380	365	350
	400								
	350								
	405								
Average	409	375	403	397	430	425	408	395	372
STD	32	23	16	5	16	18	22	22	15
Coefficient of Variation	8	6	4	1	4	4	6	5	4
% Change		-8	-1	-3	5	4	-0	-3	-9
Permittivity:	1.63	1.61	1.79	1.53	1.66	1.97	1.83	2.06	1.72
(sec -1)	1.81	1.64	1.64	1.97	1.97	2.18	1.97	1.67	1.61
ASTM D4491	1.63	1.53	1.88	1.97	1.83	1.88	1.91	1.91	2.00
	1.79								
	1.76								
	1.68								
Average	1.72	1.59	1.77	1.82	1.82	2.01	1.90	1.88	1.78
STD	0.07	0.05	0.10	0.21	0.13	0.13	0.06	0.16	0.16
Coefficient of Variation	4.28	2.91	5.59	11.38	6.96	6.25	3.01	8.54	9.24
% Change		-7.18	3.11	6.21	6.02	17.09	10.87	9.51	3.50
Trapezoidal Tear	87	97	78	85	106	61	85	102	101
Tear Strength - (lbs)	86	87	94	82	91	78	101	70	104

APPENDIX G
SETTLEMENT ANALYSES

APPENDIX G.1	FOUNDATION SETTLEMENT
APPENDIX G.2	CLAY LINER RATE OF CONSOLIDATION
APPENDIX G.3	CLAY LINER CONSOLIDATION SETTLEMENT
APPENDIX G.4	POST-CLOSURE WASTE SETTLEMENT

APPENDIX G.1
FOUNDATION SETTLEMENT

Objectives:

1. To estimate the magnitude and distribution of settlement of the Landfill B-18 foundation due to the overlying waste.

2. To evaluate whether the final gradient of the Landfill B-18 foundation after settlement is the required minimum of 2% to maintain adequate drainage.

Given:

The Landfill B-18 expansion geometry and as-built landfill configuration used to generate the evaluated sections were obtained from AutoCAD drawings (see Drawings). All other data used for these calculations are based on the original Environmental Solutions, Inc. (ESI, 1990) calculations, including site geology and foundation stratigraphy (see Attachment 1). The original calculation was performed utilizing the computer program SETTLG developed by Geosoft Inc.; however, this program is no longer available. Golder programmed the settlement equations into Microsoft Excel to perform the foundation settlement calculations.

Assumptions (Assumptions are consistent with those used by ESI):

1. Claystone and siltstone are considered the same. Previous investigations indicate that the compression characteristics of the claystone and siltstone are practically the same.

2. Foundation materials are highly overconsolidated, therefore the stress-strain relationship under loading is considered to be within the elastic range of materials.

3. Rebound and settlement of foundation will occur during excavation and waste placement. Therefore the gross weight, rather than the net weight of the waste fill will be used.

4. Sandstone under the landfill foundation is considered to be incompressible.

5. The foundation materials are considered to be homogeneous and isotropic. The stress-strain behavior of the materials under load is characterized by the Young's Modulus and the Poisson's Ratio.

Method:

1. Determination of Young's Modulus (E)

   The elastic modulus may be expressed in terms of the shear strength of the soil:

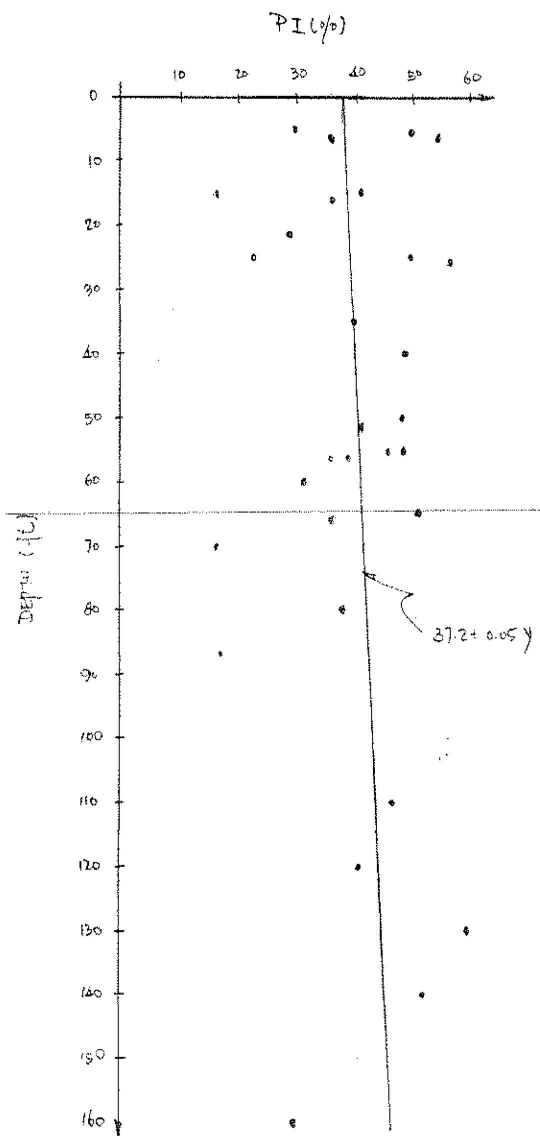
$$E = kS_u$$

   Where k is a function of the Plasticity Index (PI). Values for the on-site claystone materials at various depths are shown in Figure 1. By using the linear progression method, the scattered data may be represented by a straight line. The best fit straight line takes the form of:

$$PI\ (\%) = 37.2 + 0.05y\ (ft)$$

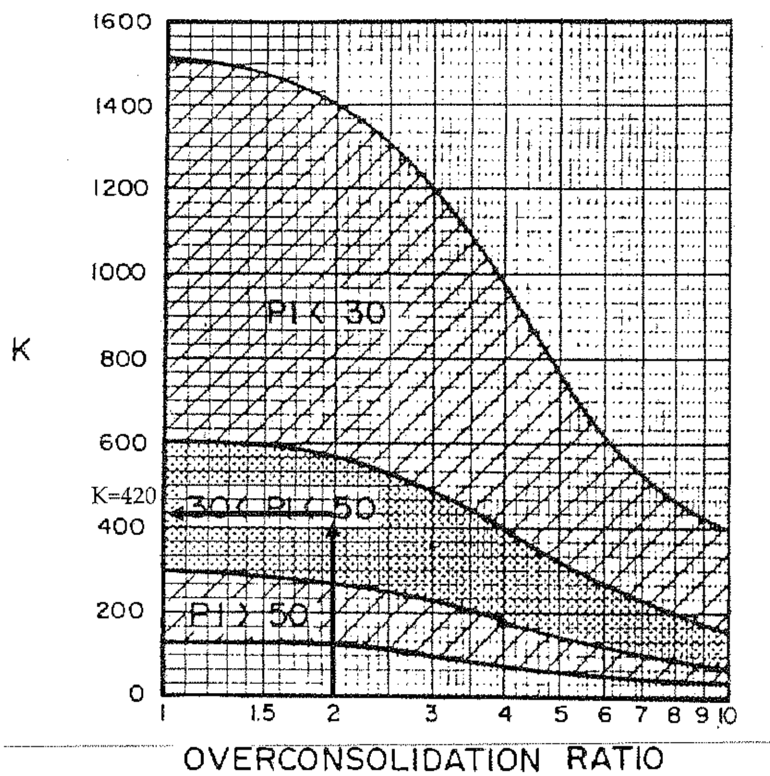
where y is equal to the depth below ground surface. The results of the above statistical analysis indicate that the variation of PI with depth is not significant.

Figure 1: PI vs. Depth for claystone material.



Therefore, it was assumed that the PI is constant with depth. Taking the average depth for all data, the PI value for the foundation material was estimated to be approximately 41. By assuming the overconsolidation ratio (OCR) of the claystone is 2, the value of K was estimated to be 420 as shown in the Figure 2.

Figure 2: Chart for estimating Undrained Modulus of Clay.



$E_u = KS_u$

E_u = UNDRAINED MODULUS OF CLAY

K = FACTOR FROM CHART ABOVE

S_u = UNDRAINED SHEAR STRENGTH OF CLAY

The shear strength of the foundation material is summarized in the following table:

Geologic Unit	Shear Strength (psi)[1]
18-5	127.0
18-7	110.6
18-8	91.1
18-12	72.2
Average	100.2

[1]Obtained from UU triaxial test results

Taking the average shear strength (S_u), the elastic modulus (E_u) is estimated to be:
Eu = K x Su = 420 x (100 lb/in^2 x 144 in^2/ft^2 / 1000 lb/kip) = 6,048 kip/ft^2, round to 6,000 ksf.

2. <u>Determination of Poisson's Ratio (ν)</u>
The value of Poisson's Ratio was found to be insensitive to the compressibility coefficient used to calculate the settlement. Poisson's Ratio was back-calculated using the average compressibility coefficient determined by using a value of the Poisson's Ratio from 0 to 0.5. The resulting Poisson's Ratio was estimated to be 0.38.

3. <u>Determination of Compressibility Index (C_u)</u>
The Compressibility coefficient is related to E and ν by:

$$C_u = \frac{1-\nu^2}{E}$$

4. <u>Determination of changes in stress with depth (Δσ)</u>
Since it was assumed that the deformation of the foundation is elastic under the waste loading, the Boussinesq Equation was used to determine Δσ. To calculate Δσ under the center of a rectangular loaded area:

$$\Delta\sigma = \sigma_0 m I$$

Where:

σ_0 = initial stress at a specific depth
m = number of influences, for the center of a foundation m = 4
$\sigma_0 = \gamma z$
γ = soil unit weight
z = depth to the middle of layer to be evaluated

$$I = \frac{1}{4\pi}\left[\frac{2MN\sqrt{V}}{V+V_1}\,\frac{V+1}{V} + \tan^{-1}\left(\frac{2MN\sqrt{V}}{V-V_1}\right)\right]$$

$$M = \frac{B}{z}; \; N = \frac{L}{z}$$

$V = M^2 + N + 1; \;\; V_1 = (MN)^2$
B = Base of foundation
L = Length of foundation

To calculate $\Delta\sigma$ under a point that is not at the center of the rectangular loaded area, the following is used:

$$\Delta\sigma = \sigma_0 I_1 + \sigma_0 I_2 + \sigma_0 I_3 + \sigma_0 I_4$$

5. Calculation of Settlement (ΔH)
The foundation settlement can then be calculated by:

$$\Delta H = \varepsilon H$$

Where:

ε = vertical strain determined by $\varepsilon = \Delta\sigma C_u$
H = thickness of the layer where settlement is calculated

The total settlement is determined by $\sum \Delta H$ under the point being evaluated.

Calculations and Results:

1. Settlement Calculation
Foundation settlement calculations were performed for Sections 1-1', 2-2', and 3-3' for each of the points shown on Drawing 1, Cross sections are shown on Drawings 3, 4 and 5, respectively. All settlement results are summarized in the Table 1 through Table 3 in the Tables Section of this calculation brief. Settlement along the landfill foundation ranges from 0.74 inches (Section 2-2' Point 2A) to 13.55 inches (Section 2-2 Point $2K_1$)).

2. Final Gradient Computation
The formula utilized for the final gradient calculation is defined as follows:

$$G_f = \frac{(EL_2 - \Delta H_2) - (EL_1 - \Delta H_1)}{(\Delta X_2 - \Delta X_1)}$$

Where:

EL_2 = elevation at point 2
EL_1 = elevation at point 1
ΔH_2 = settlement at point 2
ΔH_1 = settlement at point 1
(ΔX_2-ΔX_1) = Distance between two points

Final gradient calculations were performed in Sections 2-2' and 3-3'(as shown on Drawing 4 and 5) since the two sections are the ones along the drainage direction. All final gradient results are summarized in Table 4 and Table 5 in the Tables Section of this report.

In all cases the gradient remains in excess of 2% when measured in the direction of flow. Some locations in the sections are not perpendicular to the contours and therefore the slope is not reported; however, the computed settlement at these locations are observed to be of similar magnitude and the original grade would be maintained.

3. Strain Difference Computation

The formula utilized for the final gradient calculation is defined as follows:

$$\Delta\varepsilon = \frac{G_f - G_i}{d}$$

In where:

G_f = final gradient
G_i = initial gradient
d = distance between two points

Final strain calculations were performed in Sections 2-2' and 3-3'since these two sections are the ones along the drainage direction. All strain difference results are summarized in Table 6 through Table 7 in the Tables Section of this report.

The result all points have less than the design maximum strain of 0.1%.

Conclusions:

Based on the foundation settlement calculations for the selected sections, we can assume that the bottom gradient of the landfill along the critical sections will be maintained at a minimum of 2% meeting the minimum requirement for drainage.

Based on the foundation settlement calculations for the selected sections, we can assume that there will be no abrupt changes along the surface of the foundation due to settlement. The maximum allowable strain due to settlement is less than 0.1% which is less than the yield strain of the synthetic liner. Therefore the liner stays intact.

Reference:

Environmental Solutions, Inc. (ESI), "Engineering and Design Report, Landfill Unit B-18, Phases I and II and Final Closure, Kettleman Hills Facility," August 1990, Appendix G.1.

Bowles, J.E., "Foundation Analysis and Design," Fifth Edition, 1996, pp. 291-296.

Table 1
Settlement Calculation Summary
Section 1-1'

Point No.	A Geoligic Unit	B % Clay in A	C Calculated Settlement (assumed a 100% Clay Content) (in)	BxC Estimated Settlement (in)	Total Settlement (in)
1 A	18-7	30%	11.90	3.57	3.57
1 B	18-7	30%	13.85	4.16	4.16
1 C	18-8	100%	3.14	3.14	7.74
	18-7	30%	15.35	4.60	
1 D	18-8	100%	5.71	5.71	8.52
	18-7	30%	9.38	2.82	
1 E	18-9	0%	0.00	0.00	8.99
	18-8	100%	6.24	6.24	
	18-7	30%	9.17	2.75	
1 F	18-9	0%	0.00	0.00	11.18
	18-8	100%	8.26	8.26	
	18-7	30%	9.75	2.93	
1 G	18-9	0%	0.00	0.00	12.63
	18-8	100%	9.50	9.50	
	18-7	30%	10.43	3.13	
1 H	18-10	50%	4.72	2.36	9.63
	18-9	0%	0.00	0.00	
	18-8	100%	6.24	6.24	
	18-7	30%	3.41	1.02	
1 I	18-10	50%	6.55	3.28	5.47
	18-9	0%	0.00	0.00	
	18-8	100%	2.10	2.10	
	18-7	30%	0.33	0.10	
1 J	18-12	100%	0.69	0.69	1.80
	18-11	10%	1.48	0.15	
	18-10	50%	1.27	0.63	
	18-9	0%	0.00	0.00	
	18-8	100%	0.32	0.32	
1 K	18-13	10%	1.46	0.15	1.20
	18-12	100%	0.01	0.01	
	18-11	10%	0.99	0.10	
	18-10	50%	1.25	0.63	
	18-9	0%	0.00	0.00	
	18-8	100%	0.32	0.32	

Table 2
Settlement Calculation Summary
Section 2-2'

Point No.	A Geoligic Unit	B % Clay in A	C Calculated Settlement (assumed a 100% Clay Content) (in)	BxC Estimated Settlement (in)	Total Settlement (in)
2 A	18-4	100%	0.28	0.28	0.74
	18-3	20%	2.32	0.46	
2 B	18-5	20%	0.61	0.12	2.43
	18-4	100%	0.62	0.62	
	18-3	20%	8.43	1.69	
2 C	18-5	20%	2.56	0.51	2.90
	18-4	100%	0.81	0.81	
	18-3	20%	7.91	1.58	
2 D	18-6	20%	1.33	0.27	3.62
	18-5	20%	2.78	0.56	
	18-4	100%	0.96	0.96	
	18-3	20%	9.18	1.84	
2 E	18-7	30%	3.15	0.95	4.62
	18-6	20%	1.63	0.33	
	18-5	20%	3.14	0.63	
	18-4	100%	1.21	1.21	
	18-3	20%	7.57	1.51	
2 F	18-7	30%	7.57	2.27	5.92
	18-6	20%	1.90	0.38	
	18-5	20%	3.38	0.68	
	18-4	100%	1.49	1.49	
	18-3	20%	5.54	1.11	
2 G	18-8	100%	8.96	8.96	11.94
	18-7	30%	8.55	2.57	
	18-6	20%	2.07	0.41	
	18-5	20%	3.10	0.62	
	18-4	100%	1.22	1.22	
2 H	18-8	100%	1.22	1.22	5.14
	18-7	30%	9.21	2.76	
	18-6	20%	2.32	0.46	
	18-5	20%	3.47	0.69	
2 I	18-10	50%	0.63	0.31	6.45
	18-9	0%	0.00	0.00	
	18-8	100%	5.17	5.17	
	18-7	30%	2.74	0.82	
	18-6	20%	0.71	0.14	
2 J	18-10	50%	4.46	2.23	13.32
	18-9	0%	0.00	0.00	
	18-8	100%	9.10	9.10	
	18-7	30%	6.63	1.99	

Table 2
Settlement Calculation Summary
Section 2-2'

Point No.	A Geoligic Unit	B % Clay in A	C Calculated Settlement (assumed a 100% Clay Content) (in)	BxC Estimated Settlement (in)	Total Settlement (in)
2 K	18-10	50%	6.71	3.36	11.58
	18-9	0%	0.00	0.00	
	18-8	100%	7.54	7.54	
	18-7	30%	2.28	0.68	
2 K_1	18-10	50%	8.39	4.20	13.55
	18-9	0%	0.00	0.00	
	18-8	100%	7.81	7.81	
	18-7	30%	5.13	1.54	
2 L	18-10	50%	9.20	4.60	9.89
	18-9	0%	0.00	0.00	
	18-8	100%	5.09	5.09	
	18-7	30%	0.65	0.19	
2 M	18-11	10%	2.45	0.25	5.83
	18-10	50%	6.24	3.12	
	18-9	0%	0.00	0.00	
	18-8	100%	2.47	2.47	
2 N	18-12	100%	1.36	1.36	5.29
	18-11	10%	1.92	0.19	
	18-10	50%	3.23	1.62	
	18-9	0%	0.00	0.00	
	18-8	100%	2.12	2.12	
2 O	18-13	10%	2.91	0.29	1.25
	18-12	100%	0.42	0.42	
	18-11	10%	0.55	0.06	
	18-10	50%	0.97	0.48	
	18-9	0%	0.00	0.00	

Table 3
Settlement Calculation
Section 3-3'

Point No.	A Geoligic Unit	B % Clay in A	C Calculated Settlement (assumed a 100% Clay Content) (in)	BxC Estimated Settlement (in)	Total Settlement (in)
3 A	18-13	10%	14.10	1.41	1.41
3 B	18-13	10%	22.54	2.25	2.25
3 C	18-12	100%	4.07	4.07	5.79
	18-13	10%	17.24	1.72	
3 D	18-11	10%	10.13	1.01	4.89
	18-12	100%	3.73	3.73	
	18-13	10%	1.53	0.15	
3 D_1	18-10	50%	8.40	4.20	8.37
	18-11	10%	6.98	0.70	
	18-12	100%	3.18	3.18	
	18-13	10%	2.97	0.30	
3 D_2	18-10	50%	10.00	5.00	8.46
	18-11	10%	7.72	0.77	
	18-12	100%	2.55	2.55	
	18-13	10%	1.39	0.14	
3 D_3	18-10	50%	11.36	5.68	9.09
	18-11	10%	7.95	0.79	
	18-12	100%	2.61	2.61	
	18-13	10%	0.78	0.08	
3 E	18-10	50%	13.23	6.61	9.65
	18-11	10%	7.39	0.74	
	18-12	100%	2.29	2.29	
3 F	18-10	50%	11.58	5.79	5.79

Table 4
Grade Calculation
Section 2-2'

Point No.	Initial Elevation (ft)	Settlement (ft)	Final Elevation (ft)	Distance (ft)	Initial Grade (%)	Final Grade (%)	Allowable Grade 2.0%
2 A	739.09	0.06	739.03				
				108.83	29.41%	29.54%	OK
2 B	707.08	0.20	706.88				
				112.14	2.18%	2.15%	OK
2 C	709.53	0.24	709.29				
				Not connected with same slope			
2 D	710.65	0.30	710.35				
				139.54	2.34%	2.28%	OK
2 E	713.91	0.39	713.52				
				Not perpendicular to the slope			
2 F	716.55	0.49	716.06				
				297.93	2.42%	2.25%	OK
2 G	723.75	0.99	722.76				
				41.39	2.42%	3.78%	OK
2 H	724.75	0.43	724.32				
				95.62	44.72%	44.61%	OK
2 I	767.51	0.54	766.97				
				Not connected with same slope			
2 J	742.76	1.11	741.65				
				85.61	8.29%	8.12%	OK
2 K	735.66	0.96	734.70				
				58.91	2.29%	2.01%	OK
2 K_1	737.01	1.13	735.88				
				35.67	44.46%	45.32%	OK
2 L	752.87	0.82	752.05				
				60.9	44.55%	45.10%	OK
2 M	780.00	0.49	779.51				
				33.99	49.60%	49.73%	OK
2 N	796.86	0.44	796.42				
				Not connected with same slope			
2 O	837.27	0.10	837.17				

Table 5
Grade Calculation
Section 3-3'

Point No.	Initial Elevation (ft)	Settlement (ft)	Final Elevation (ft)	Distance (ft)	Initial Grade (%)	Final Grade (%)	Allowable Grade 2.0%
3 A	745.79	0.12	745.67	144.24	2.49%	2.54%	OK
3 B	742.2	0.19	742.01	130.45	2.42%	2.65%	OK
3 C	739.04	0.48	738.56	320.67	2.33%	2.31%	OK
3 D	731.57	0.41	731.16	266.92	2.32%	2.43%	OK
3 D_1	725.37	0.70	724.67	Not connected with same slope			
3 D_2	734.00	0.70	733.30	Not connected with same slope			
3 D_3	725.27	0.76	724.51	63.73	2.10%	2.10%	OK
3 E	726.61	0.76	725.85	396.01	2.46%	2.45%	OK
3 F	736.35	0.80	735.55	Not connected with same slope			
8	837.27	0.48	836.79				

Table 6
Strain Calculation
Section 2-2'

Point No.	Initial Elevation (ft)	Distance (ft)	Initial Grade (%)	Final Grade (%)	$\Delta\varepsilon$	Allowable Strain 0.1%
2 A	739.09					
		108.83	29.41%	29.54%	0.0012%	OK
2 B	707.08					
		112.14	2.18%	2.15%	0.0003%	OK
2 C	709.53					
		70.61	1.59%	1.50%	0.0012%	OK
2 D	710.65					
		139.54	2.34%	2.28%	0.0004%	OK
2 E	713.91					
		147.10	1.79%	1.72%	0.0005%	OK
2 F	716.55					
		297.93	2.42%	2.25%	0.0006%	OK
2 G	723.75					
		41.39	2.42%	3.78%	0.0331%	OK
2 H	724.75					
		95.62	44.72%	44.61%	0.0012%	OK
2 I	767.51					
		Not connected with same slope				
2 J	742.76					
		85.61	8.29%	8.12%	0.0020%	OK
2 K	735.66					
		58.91	2.29%	2.01%	0.0047%	OK
2 K_1	737.01					
		35.67	44.46%	45.32%	0.0240%	OK
2 L	752.87					
		60.90	44.55%	45.10%	0.0091%	OK
2 M	780.00					
		33.99	49.60%	49.73%	0.0039%	OK
2 N	796.86					
		Not connected with same slope				
2 O	837.27					
		162.7	44.70%	50.85%	0.0378%	OK
8	910.00					

Table 7
Strain Calculation
Section 3-3'

Point No.	Initial Elevation (ft)	Distance (ft)	Initial Grade (%)	Final Grade (%)	$\Delta\varepsilon$	Allowable Strain 0.1%
3 A	745.79					
		144.24	2.49%	2.54%	0.0003%	OK
3 B	742.2					
		130.45	2.42%	2.65%	0.0018%	OK
3 C	739.04					
		320.67	2.33%	2.31%	0.0001%	OK
3 D	731.57					
		266.92	2.20%	2.43%	0.0009%	OK
3 D_1	725.37					
		Not connected with same slope				
3 D_2	734.00					
		Not connected with same slope				
3 D_3	725.27					
		63.73	1.96%	2.10%	0.0022%	OK
3 E	726.61					
		396.01	2.46%	2.45%	0.0000%	OK
3 F	736.35					
		Not connected with same slope				
8	837.27					

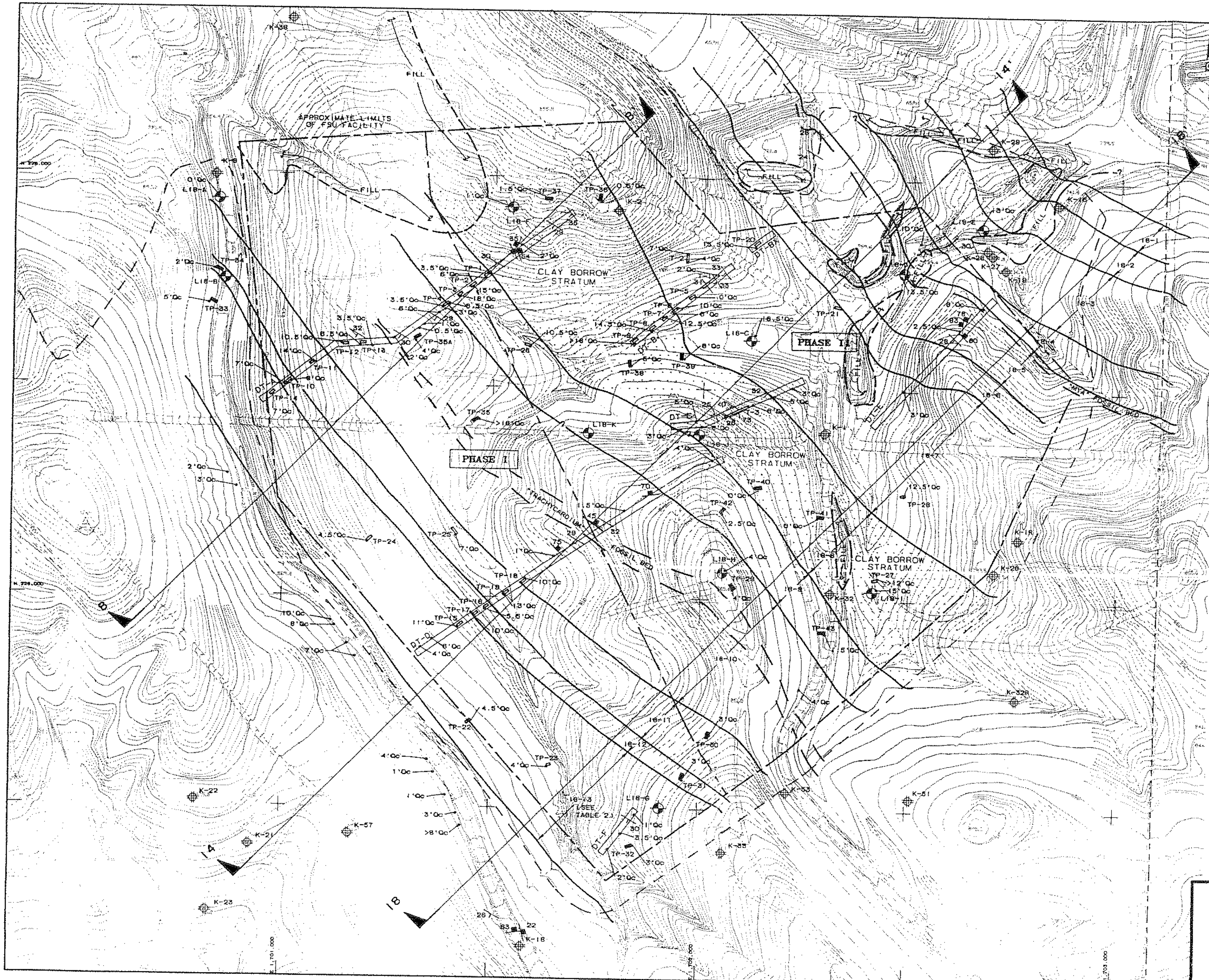


TABLE 1

BORING	NORTHING	EASTING
L18-A	226,840	1,700,840
L18-B	226,760	1,700,880
L18-C	226,820	1,702,130
L18-D	226,780	1,702,460
L18-E	226,880	1,702,670
L18-F	226,880	1,701,840
L18-G	227,800	1,701,810
L18-H	226,080	1,702,080
L18-I	226,020	1,702,410
L18-J	226,360	1,701,986
L18-K	226,380	1,701,722
K-1	226,986	1,702,395
K-5	226,922	1,701,788
K-6	226,867	1,700,842
K-10	226,646	1,702,652
K-12	227,166	1,701,340
K-16	226,762	1,702,724
K-21	227,407	1,700,827
K-22	227,515	1,700,787
K-23	227,246	1,700,626
K-26	226,070	1,702,707
K-27	226,626	1,702,688
K-28	226,336	1,702,661
K-29	226,061	1,702,668
K-32	226,018	1,702,513
K-33	227,366	1,702,080
K-35	226,366	1,701,010
K-48	226,812	1,701,781

TABLE 2

STRATIGRAPHIC UNIT	DESCRIPTION
18-1	SS, SILTY SS, OCCASIONAL SLT
18-2	CS, OCCASIONAL SS
18-3	SS, SLT, MINOR CS
18-4	CS
18-5	SS, SLT, MINOR CS; INCLUDES "MYA" FOSSIL BED
18-6	SS, OCCASIONAL THIN SLT, CS
18-7	SS, SLT, SILTY SS, SANDY SLT, CS
18-8	CS
18-9	SS, SILTY SS, SLT, SANDY SLT
18-10	SS, CS, SLT, SILTY SS; INCLUDES "TRACHYCARDIUM" FOSSIL BED
18-11	SS, MINOR CS
18-12	CS
18-13	SS, SILTY SS, MINOR CS

SS: SANDSTONE
CS: CLAYSTONE
SLT: SILTSTONE

NOTE: MORE THAN ONE LITHOLOGIC UNIT DENOTES INTERBEDDING

LEGEND

K-1 EXISTING MONITORING WELLS
L18-A BOREHOLES DRILLED FOR B-18 INVESTIGATION
DT-B DOZER TRENCH
TP-2 TEST PIT
TP-4 PROPOSED TEST PIT
T-3 EXPLORATORY TRENCH
APPROXIMATE STRATIGRAPHIC CONTACT
FACILITY BOUNDARY
LANDFILL BOUNDARY
PROPERTY BOUNDARY
2'Oc THICKNESS OF COLLUVIUM (WHERE MEASURED IN ROAD CUTS, BORINGS, TRENCHES OR TEST PITS.)
30 STRIKE AND DIP OF BEDDING
75 STRIKE AND DIP OF JOINT
VERTICAL JOINT
CLAY BORROW STRATUM

0 100 200 FEET
SCALE

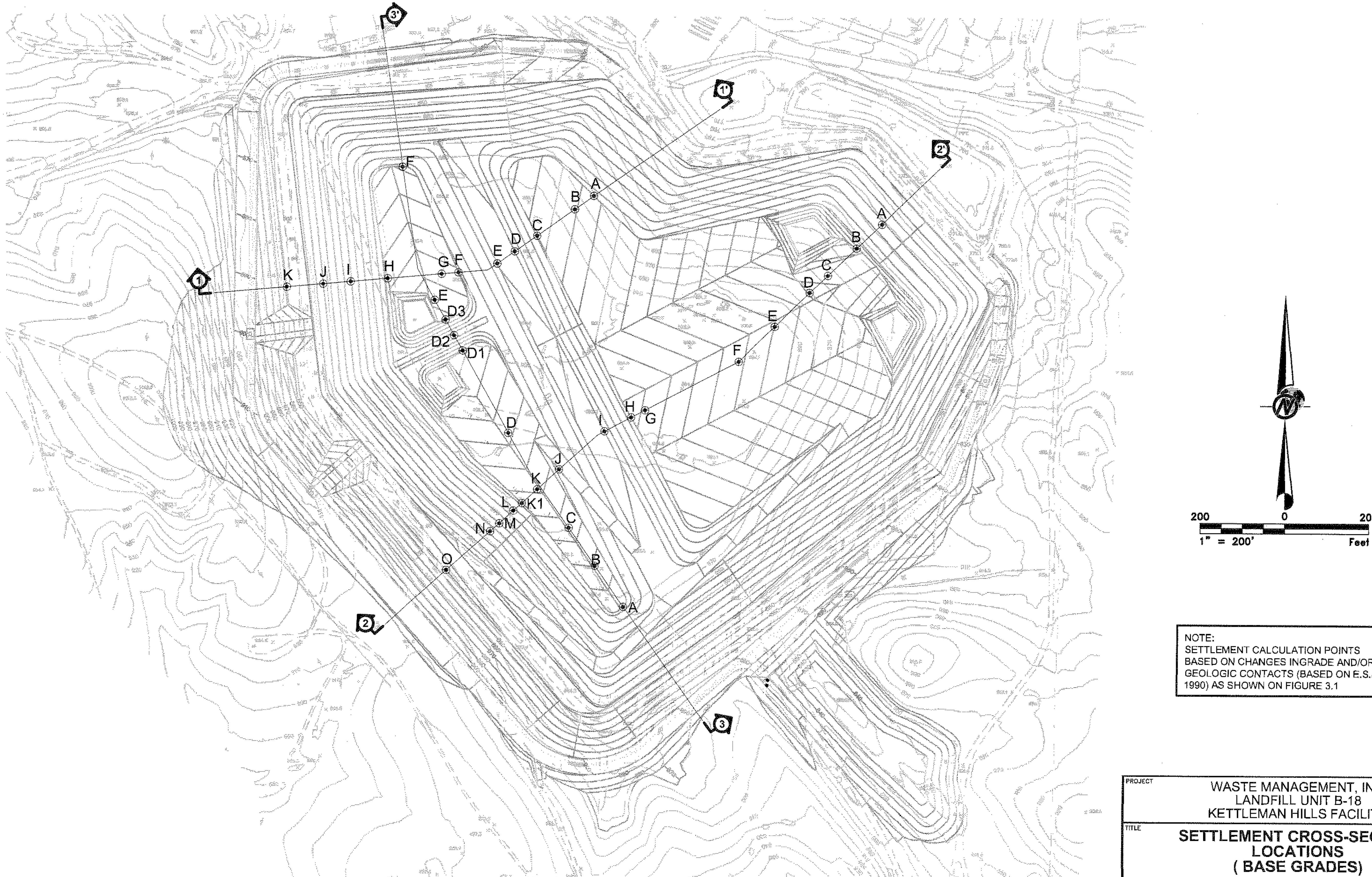
ATTACHMENT 1

FIGURE 3.1

SITE GEOLOGIC AND EXPLORATION MAP

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.



NOTE:
SETTLEMENT CALCULATION POINTS BASED ON CHANGES INGRADE AND/OR GEOLOGIC CONTACTS (BASED ON E.S.I., 1990) AS SHOWN ON FIGURE 3.1

PROJECT	
	WASTE MANAGEMENT, INC. LANDFILL UNIT B-18 KETTLEMAN HILLS FACILITY
TITLE	**SETTLEMENT CROSS-SECTION LOCATIONS (BASE GRADES)**

Golder Associates	PROJECT No.			FILE No. SETTL SECTIONS	
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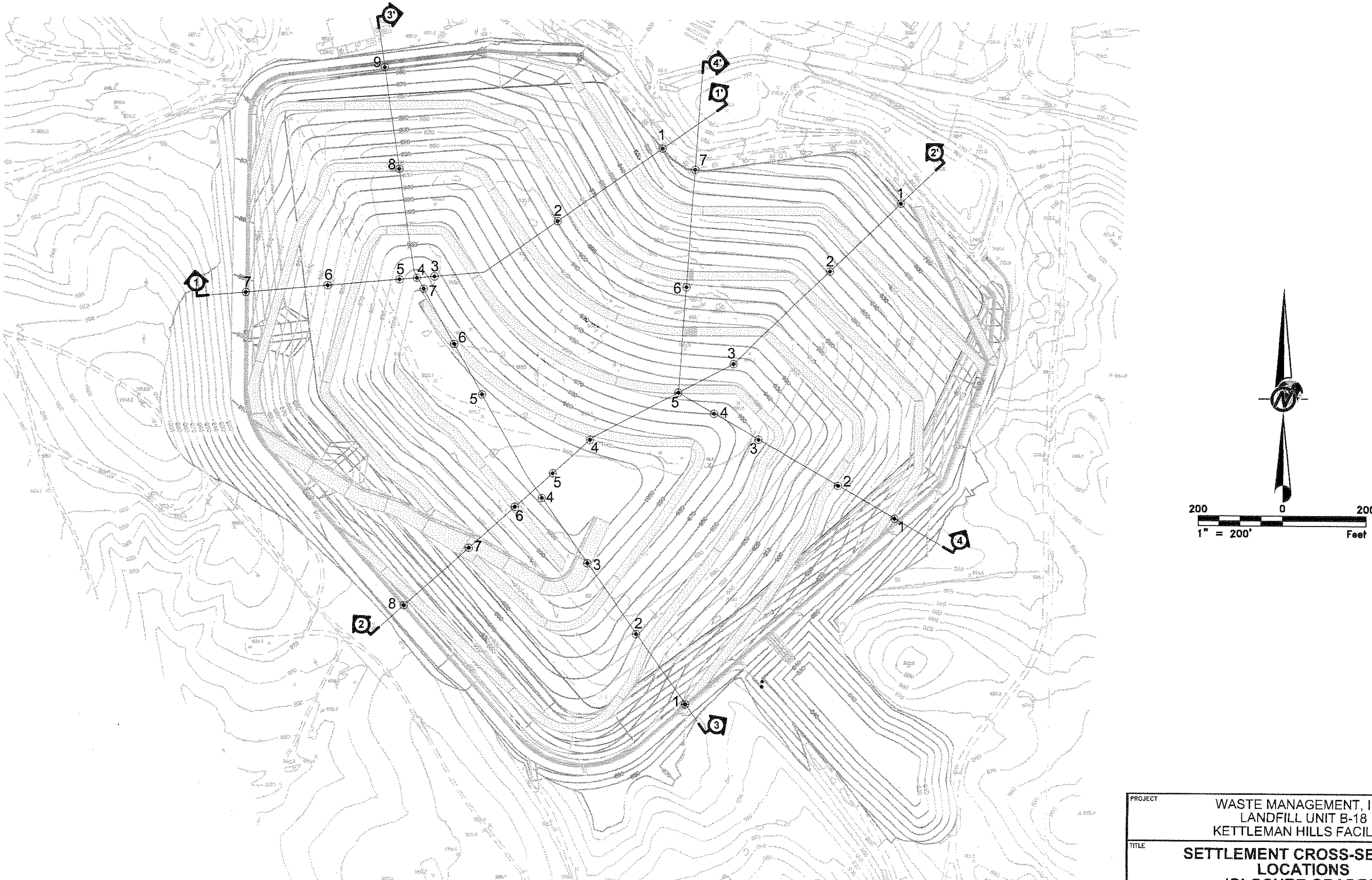
	CADD	FFG	10/08	**DWG 1**	
	CHECK	EH	05/08		
	REVIEW	SS	11/08		



PROJECT

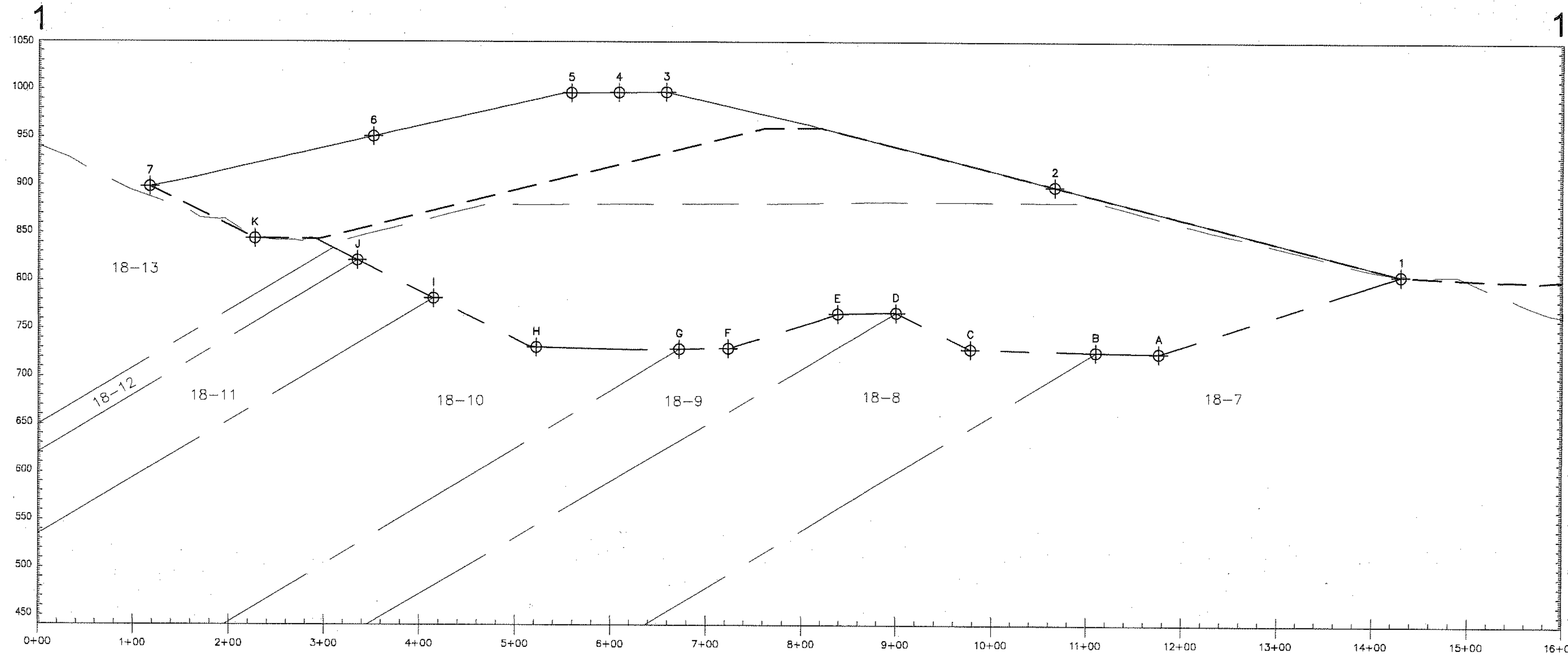
WASTE MANAGEMENT, INC.
LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

TITLE

SETTLEMENT CROSS-SECTION LOCATIONS (CLOSURE GRADES)

Golder Associates

PROJECT No.			FILE No. SETTL SECTIONS
DESIGN	KK	04/14/08	SCALE AS SHOWN REV. A
CADD	LAQ	04/18/08	DWG 2
CHECK			
REVIEW			



LEGEND

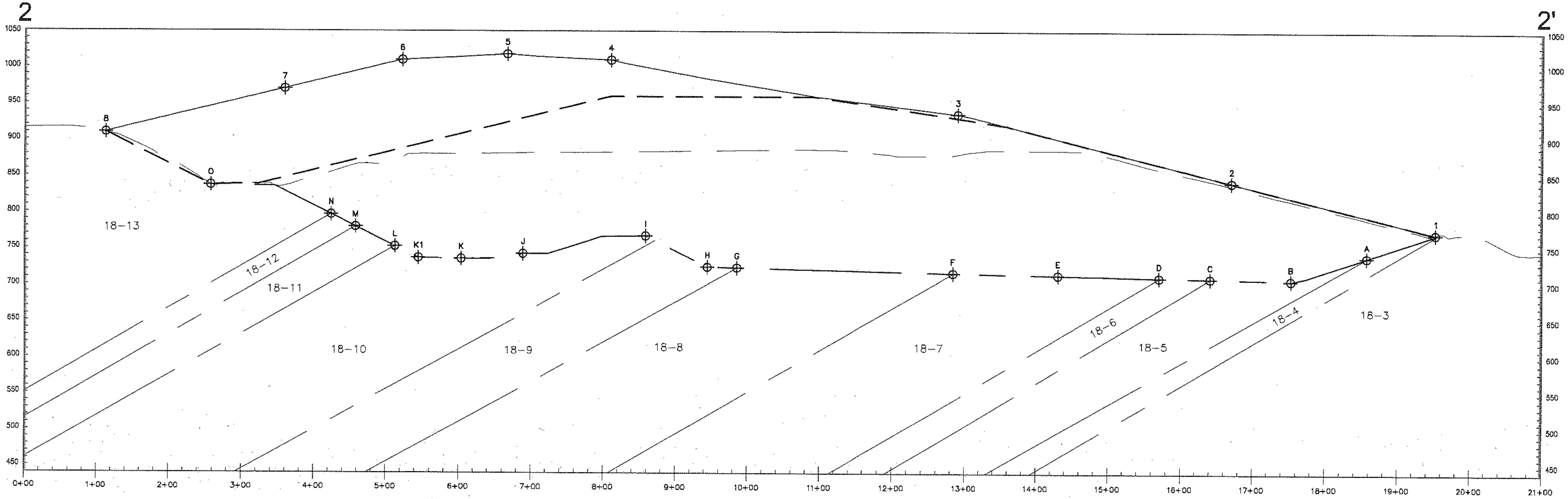
(solid line)	2008 DESIGN (FINAL CLOSURE)
(long dashed line)	1990 DESIGN (ESI)
(light dashed line)	EXISTING GROUND (MARCH 2008)
(dashed line)	ASBUILT SUBGRADE
(light line)	EXISTING SUBSURFACE GEOLOGY
B ⊕	SUBGRADE ANALYSIS POINT
2 ⊕	COVER ANALYSIS STATION

PROJECT
WASTE MANAGEMENT, INC.
LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

TITLE
SETTLEMENT CROSS-SECTION 1-1'

Golder Associates

PROJECT No.			FILE No. SETTL SECTIONS
DESIGN	KK	04/08	SCALE AS SHOWN REV. A
CADD	FFG	04/08	
CHECK	EH	05/08	DWG 3
REVIEW	SS	11/08	



LEGEND

- 2008 DESIGN (FINAL CLOSURE)
- 1990 DESIGN (ESI)
- EXISTING GROUND (MARCH 2008)
- ASBUILT SUBGRADE
- EXISTING SUBSURFACE GEOLOGY
- B — SUBGRADE ANALYSIS POINT
- 2 — COVER ANALYSIS STATION

PROJECT
WASTE MANAGEMENT
LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

TITLE
SETTLEMENT CROSS-SECTION 2-2'

Golder Associates

PROJECT No.			FILE No. SETTL SECTIONS
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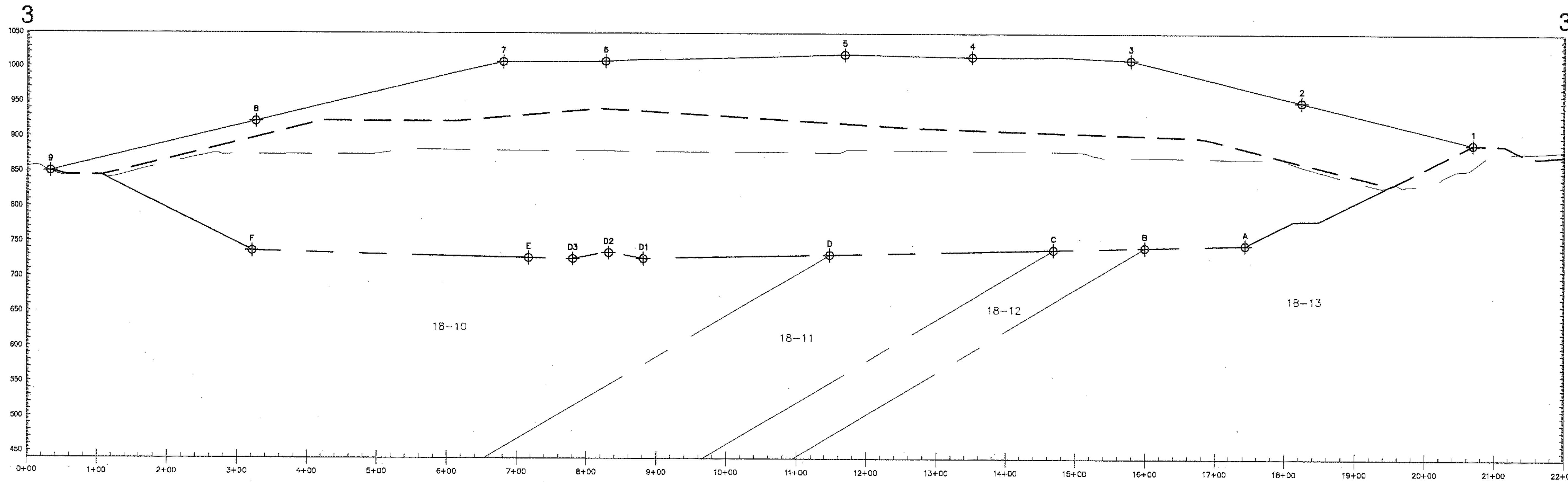
CHECK	EH	05/08	
REVIEW	SS	11/08	



LEGEND

Symbol	Description
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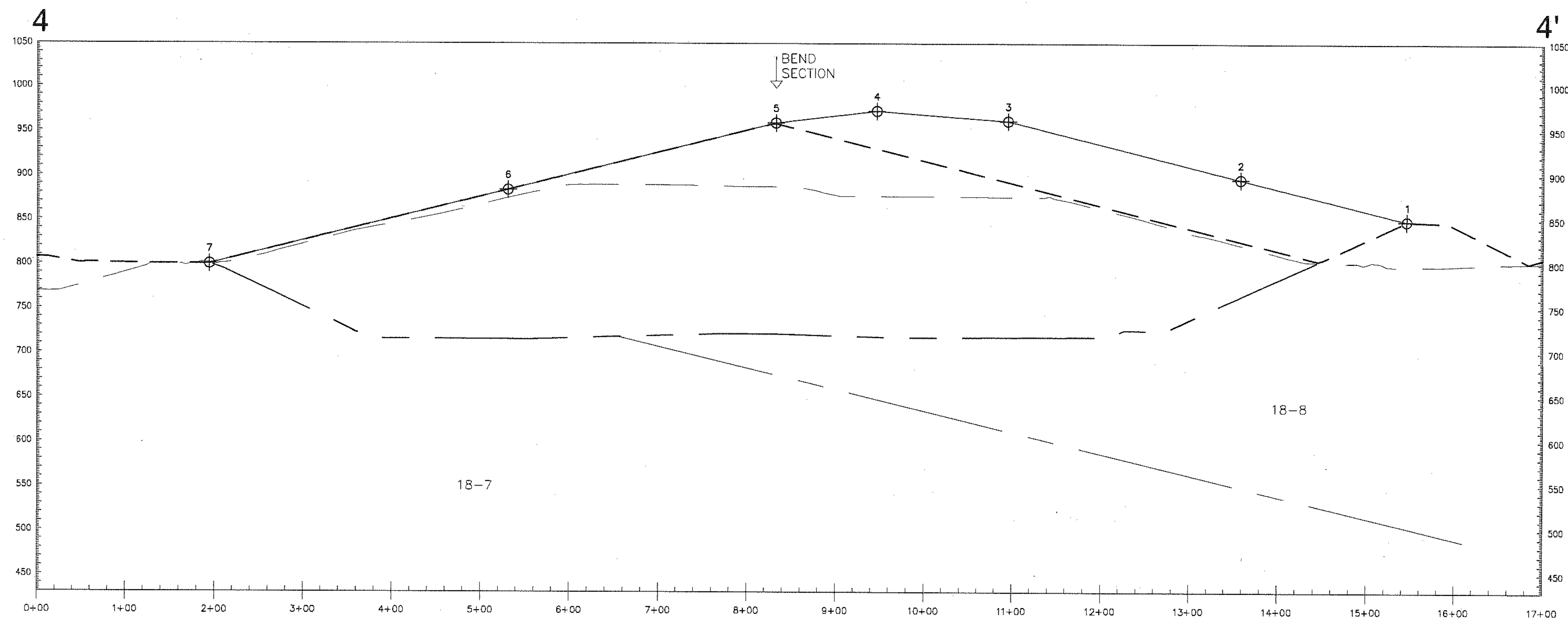
(long dash)	1990 DESIGN (ESI)
(light dash)	EXISTING GROUND (MARCH 2008)
(dash)	ASBUILT SUBGRADE
(dash)	EXISTING SUBSURFACE GEOLOGY
B ⊕	SUBGRADE ANALYSIS POINT
2 ⊕	COVER ANALYSIS STATION

PROJECT
WASTE MANAGEMENT
LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

TITLE
SETTLEMENT CROSS-SECTION 3-3'

Golder Associates

PROJECT No.			FILE No. SETTL SECTIONS
DESIGN	KK	04/08	SCALE AS SHOWN REV. A
CADD	FFC	04/08	DWG 5
CHECK	EH	05/08	
REVIEW	SS	11/08	



LEGEND

2008 DESIGN (FINAL CLOSURE)
1990 DESIGN (ESI)
EXISTING GROUND (MARCH 2008)
ASBUILT SUBGRADE
EXISTING SUBSURFACE GEOLOGY
B — SUBGRADE ANALYSIS POINT
2 — COVER ANALYSIS STATION

PROJECT	WASTE MANAGEMENT LANDFILL UNIT B-18 KETTLEMAN HILLS FACILITY
TITLE	SETTLEMENT CROSS-SECTION 4-4'

Golder Associates

PROJECT No.			FILE No. SETTL SECTIONS
DESIGN	KK	04/08	SCALE AS SHOWN REV. A
CADD	FFG	04/08	DWG 6
CHECK	EH	05/08	
REVIEW	SS	11/08	

APPENDIX G.2
CLAY LINER RATE OF CONSOLIDATION

ENVIRONMENTAL SOLUTIONS, INC.

By GSC Date 8/1/90 Subject CONSOLIDATION OF BOTTOM CLAY LINER FOR KETTLEMAN HILL B-18 LANDFILL Sheet No. 1 of 6

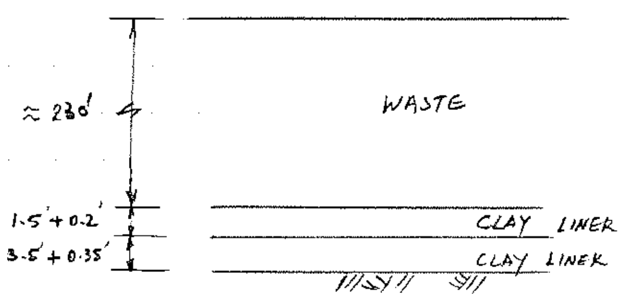
Chkd. By [illegible] Date 8/15/90 Proj. No. 89-977

OBJECTIVE : TO EVALUATE THE CONSOLIDATION CHARACTERISTIC OF BOTTOM CLAY LINER FOR STRENGHT EVAVATION

REF : (1) LAMBE & WHITEMAN (1969) "SOIL MECHANICS" PUBLISHED BY JOHN WILEY & SONS, INC. P408-410

(2) DEP. OF NAVY, NAVAL FACILITIES ENGINEERING COMMAND (1971) "DESIGN MANUAL, DM-7" MARCH

PHYSICAL PROPERTIES :



} DETAILS SEE FIG. 1

THICKNESS OF UPPER CLAY LINER : 1.5' + 0.2' (TOLERANCE)

LOWER CLAY LINER : 3.5' + 0.35' (TOLERANCE)

DRAINAGE PATH : ONE WAY DOWNWARD

CONSOLIDATION COEFFICIENT C_v : BASED ON CONSOLIDATION TESTS RESULTS ON TWO COMPACTED CLAY FROM KETTLEMAN HILL BORROW AREA (SEE FIGS 2 & 3)

BASED ON PRESENT INCOMING WASTE RATE OF 500,000 CY/YR

FILL OPERATION PERIOD = 16 yrs to 19 yrs TO FULL HEIGHT FOR TOTAL VOLUME OF 9.7×10^6 C.Y.

ENVIRONMENTAL SOLUTIONS, INC.

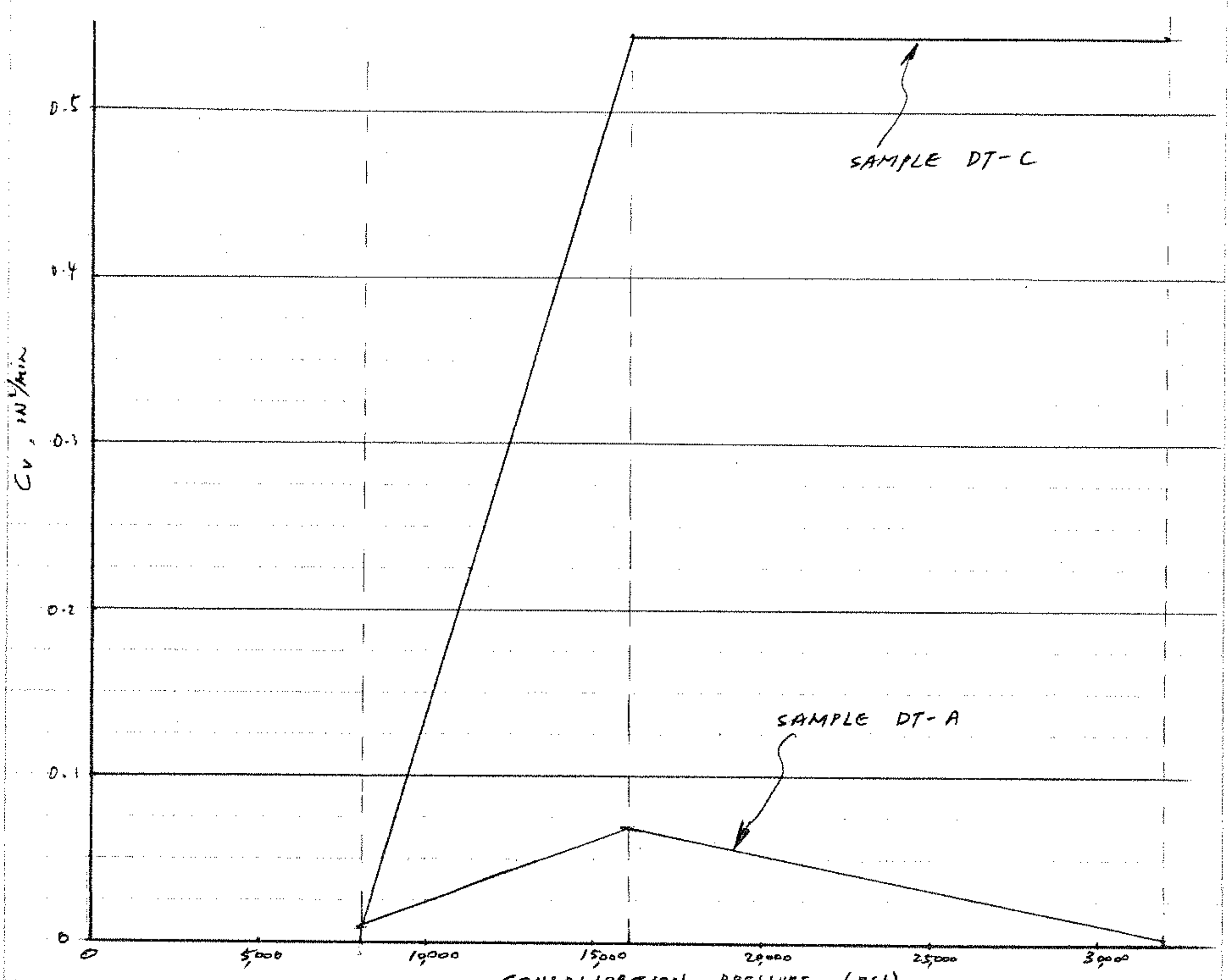
By GSC Date 8/1/90 Subject CONSOLIDATION OF BOTTOM CLAY LINER FOR KETTLEMAN HILL B-18 LANDFILL Sheet No. 2 of ____

Chkd. By [initials] Date 8/15/90 Proj. No. 89-977

FROM CONSOLIDATION TEST RESULTS
(SEE ATTACHED FIGS. 2 & 3)

H = LENGTH OF DRAIN PATH FOR SAMPLE = $\frac{1.0}{2}$ in

SAMPLE No.	CONSOLIDATION PRESSURE (psf)	D_0 (IN)	D_{100} (IN)	$D_{50} = \frac{D_0 + D_{100}}{2}$ (IN)	t_{50} (MIN)	$C_v = \frac{0.197\,(H)^2}{t_{50}}$ IN²/min
DT-C, B-1	8000	0.0036	0.0072	0.0054	5	0.00985
8'	16000	0.00	0.0240	0.0126	0.09	0.547
	32000	0.00	0.0442	0.0221	0.09	0.547
DT-A, B-2	8000	0.0020	0.0076	0.0048	4	0.0123
5'	16000	0.0	0.0286	0.0143	0.7	0.0704
	32000	0.0	0.046	0.023	23	0.00214



ENVIRONMENTAL SOLUTIONS, INC.

By GSC Date 8/2/90 Subject CONSOLIDATION Sheet No. 3 of ____
Chkd. By [illegible] Date 8/15/90 KETTLEMAN HILL B-18 LANDFILL Proj. No. 89-977

BASED ON THE TEST RESULTS, A CONSERVATIVE VALUE OF $C_V = 0.0021$ IN²/MIN IS USED FOR THE FOLLOWING CALCULATIONS.

UPPER CLAY LINER

$$T_o = \frac{C_v t_o}{H^2} \quad \text{------ (REF 2)}$$

WHERE T_o = TIME FACTOR AT END OF CONSTRUCTION
t_o = END OF LANDFILL OPERATION (USE 16 yrs)
H = THICKNESS OF CLAY LAYER = 1.7'

$$T_o = \frac{0.0021 \times 16 \times (365 \times 24 \times 60)}{(1.7 \times 12)^2} = 42.3$$

DEGREE OF CONSOLIDATION $U > 96\%$ —— SEE REF(2), FIG. 6.b
DURING AND AT END OF LANDFILL OPERATION (SEE ATTACHMENT)

LOWER CLAY LINER

$$T_o = \frac{0.0021 \times 16 \times (365 \times 24 \times 60)}{(3.9 \times 12)^2} = 8.1$$

DEGREE OF CONSOLIDATION $U = 96\%$ —— SEE REF (2) FIG. 6-6 (SEE ATTACHMENT 1)
DURING AND AT END OF LANDFILL OPERATION

$T \approx 10$ when $U = 100\%$

$$t = \frac{TH^2}{C_v} = \frac{10 \times (3.9 \times 12)^2}{0.0021} \times \frac{1}{365 \times 24 \times 60} = 19.8 \text{ yrs}$$

∴ THE LOWER LAYER OF CLAY LINER IS EXPECTED TO REACHED 100% CONSOLIDATION IN 3 YEARS AFTER THE FINAL FILL OPERATION.

ENVIRONMENTAL SOLUTIONS, INC.

By GSC Date 8/2/90 Subject CONSOLIDATION Sheet No. 4 of

Chkd. By [initials] Date 8/15/90 KETTLEMAN HILL B-18 LANDFILL Proj. No. 89-977

CHECK CONSOLIDATION OF CLAY LINER BENEATH RISER

THE THICKEST CLAY LINER BENEATH THE RISER WILL BE 5.0' + 0.35' (TOLERANCE) FOR THE LOWER CLAY LAYER.

$$T_o = \frac{0.0021 \times 16 \times (365 \times 24 \times 60)}{(5.35 \times 12)^2}$$

$$= 4.28$$

SEE REF. (2) FIG. 6-6 (SEE ATTACHMENT 1)

THE LOWEST DEGREE OF CONSOLIDATION WOULD BE NEAR THE END OF LANDFILL OPERATION AND WOULD HAVE AT LEAST ABOUT 92% DEGREE OF CONSOLIDATION AND REACH 100% DEGREE CONSOLIDATION IN WITHIN A FEW YEARS

TIME TO REACH 100% CONSOLIDATION $T = 6$ — Ref. (2)

$$t = \frac{TH^2}{C_v} = \frac{6 \times (5.35 \times 12)^2}{0.0021} \times \frac{1}{365 \times 24 \times 60}$$

$$= 22.3 \text{ yrs}$$

THAT IS $(22.3 - 16)$ yrs $= 6.3$ yrs AFTER CONSTRUCTION

ENVIRONMENTAL SOLUTIONS, INC.

By GSC Date 8/2/90 Subject CONSOLIDATION Sheet No. 5 of

Chkd. By [illegible] Date 8/15/90 KETTLEMAN HILL Proj. No. 89-977

B-18 LANDFILL

EVALUATE PHASE I LANDFILL OPERATION V.S. CONSOLIDATION

PHASE I OPERATION PERIOD ABOUT TWO YEARS

$$T_o = \frac{0.0021 \times 2 \times (365 \times 24 \times 60)}{(5.35 \times 12)^2}$$

$$= 0.53$$

REF (2) FIG. 6-6

AT THE END OF LANDFILL OPERATION, THE DEGREE OF CONSOLIDATION WOULD BE APPROXIMATELY 55% FOR THE OVERALL THICKNESS OF CLAY

FOR $U = 55\%$ REF (1) FIG. 27.3

$T \approx 0.25$

FOR $T \approx 0.25$ REF (1) FIG 27.2

$Z = 1$

U (AT HDPE/CLAY INTERFACE) ≈ 30% CONSOLIDATION AT INTERFACE

CONCLUSION :

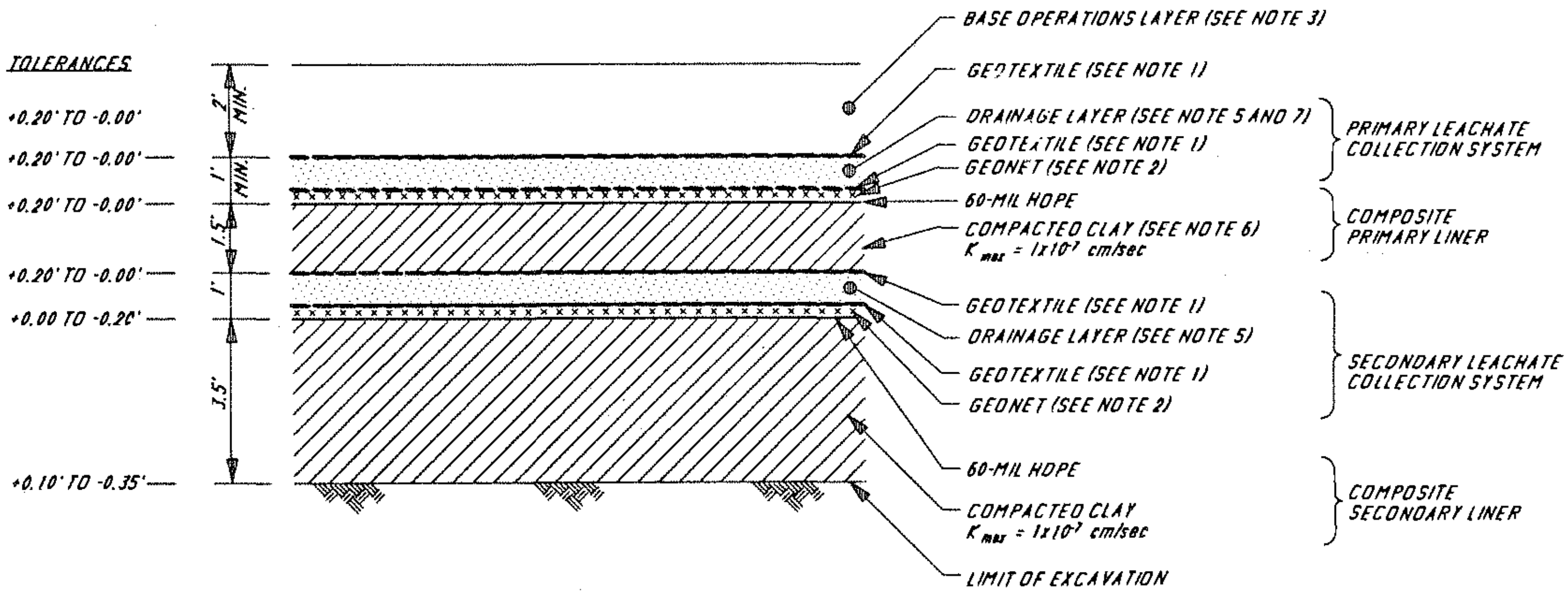
(1.) CONSOLIDATION HAS REACHED ABOUT 96% FOR THE TWO CLAY LINERS AT THE BOTTOM OF THE LANDFILL WHEN THE FINAL LANDFILL OPERATION IS COMPLETED. THE DEGREE OF CONSOLIDATION IS FOUND TO BE AT LEAST 96% THROUGH OUT THE OPERATION PERIOD. BECAUSE THIS DEGREE OF CONSOLIDATION IS CLOSE TO THE 100% MARK, THE CLAYS ARE PRACTICALLY FULLY CONCOLIDATED AND THE CLAY STRENGTH COULD BE ESTIMATED FROM THE CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION RESUTS.

ENVIRONMENTAL SOLUTIONS, INC.

By GSL Date 8/2/90 Subject CONSOLIDATION Sheet No. 6 of ____

Chkd. By [illegible] Date 8/15/90 Proj. No. 89-917

(2) BASED ON CONSOLIDATION EVALUATION FOR PHASE I FILL OPERATION, THE LOWEST DEGREE OF CONSOLIDATION AT THE INTERFACE OF THE CLAY LINER AND THE HDPE IS ABOUT 30% AT THE END OF PHASE I OPERATION. THEREFORE, THE STRENGTH OF THE CLAY LINER SHOULD BE ESTIMATED FROM THE UNCONSOLIDATED - UNDRAINED TRIAXIAL COMPRESSION TEST RESULTS FOR PHASE I STABILITY ANALYSIS. IT SHOULD ALSO BE REALIZED THAT THE STRENGTH FROM UU TEST OF AN UNSATURATED SAMPLE MAY BE HIGHER THAN THAT OF A SATURATED SAMPLE BECAUSE OF CAPILLARY ACTION. BASED ON THE UU TEST RESULTS, THE STRENGTH OF RECOMPACTED CLAY WAS REPORTED TO BE $\phi = 8^\circ$ & $C = 3600$ psf. IN CONSIDERATION OF THE SATURATED CONDITION, THE ϕ WAS NOT INCLUDED IN THE STRENGTH PARAMETER IN ANALYZING THE STABILITY OF THE PHASE I LANDFILL.



BASE LINER

FIG. 1

8-15-90

Npi
8-15-90

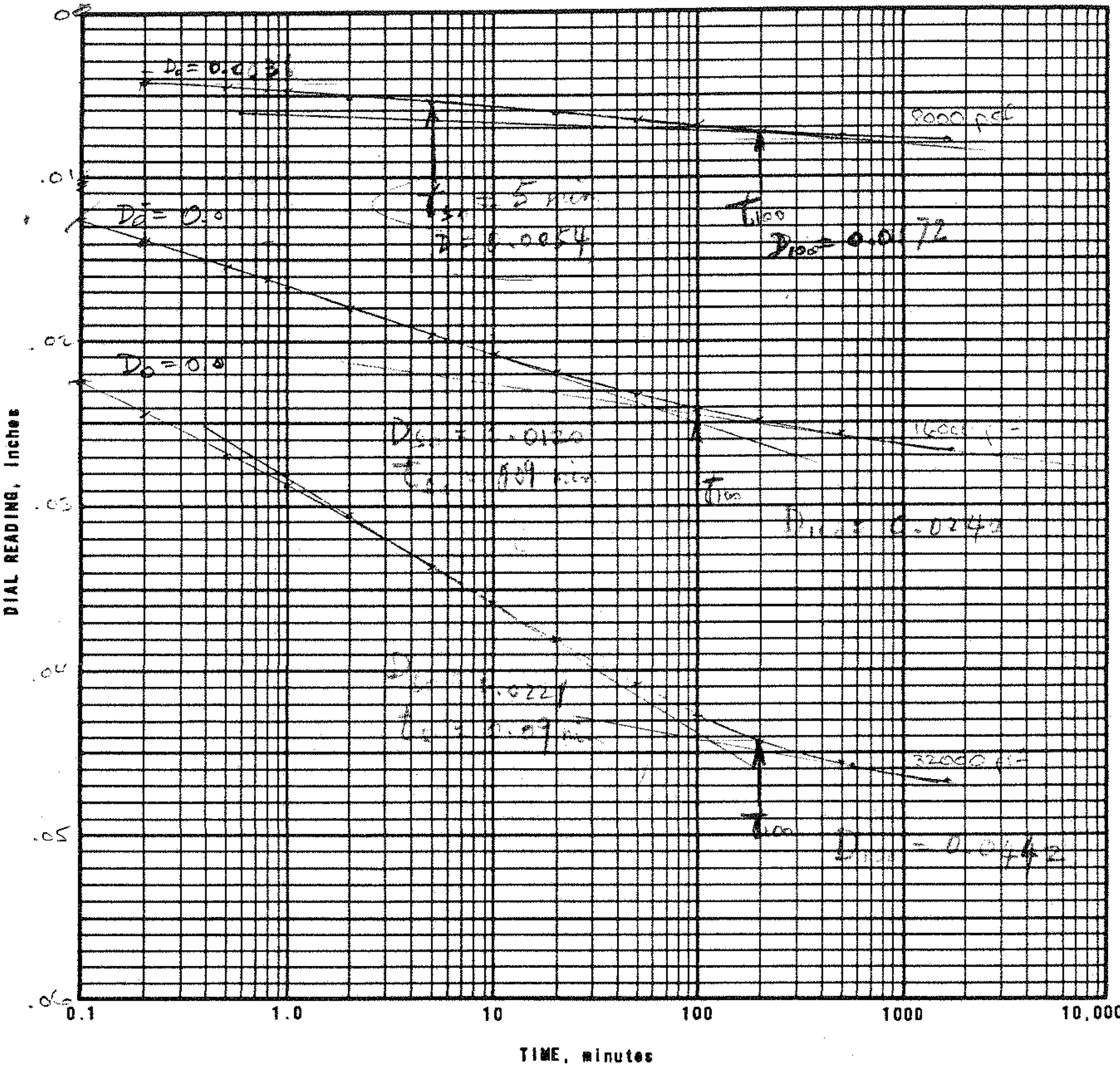
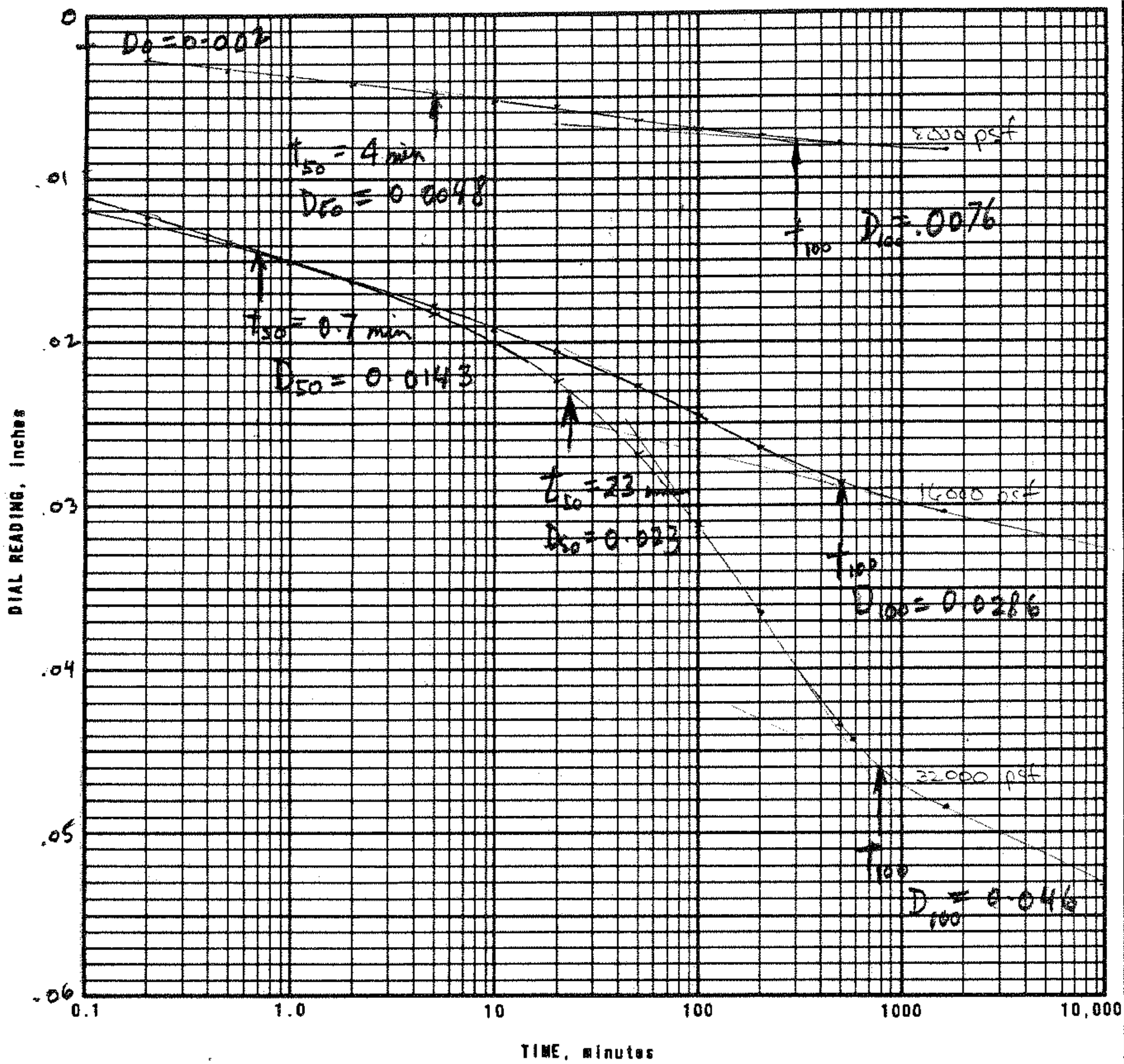


FIG. 2

DT-C, B-1, 8'

WAHLER ASSOCIATES	Kettleman	CONSOLIDATION TEST TIME – COMPRESSION CURVES		
PALO ALTO • [redacted] • CALIF.		PROJECT NO.	DATE	FIGURE NO.
		ESK 101A	7/90	

vpi
8-15-90



DT - A, B-2, 5

FIG. 3

WAHLER ASSOCIATES	Kettleman	CONSOLIDATION TEST TIME - COMPRESSION CURVES		
		PROJECT NO.	DATE	FIGURE NO.
PALO ALTO • [redacted] • CALIF.		ESK 101 A	7 90	

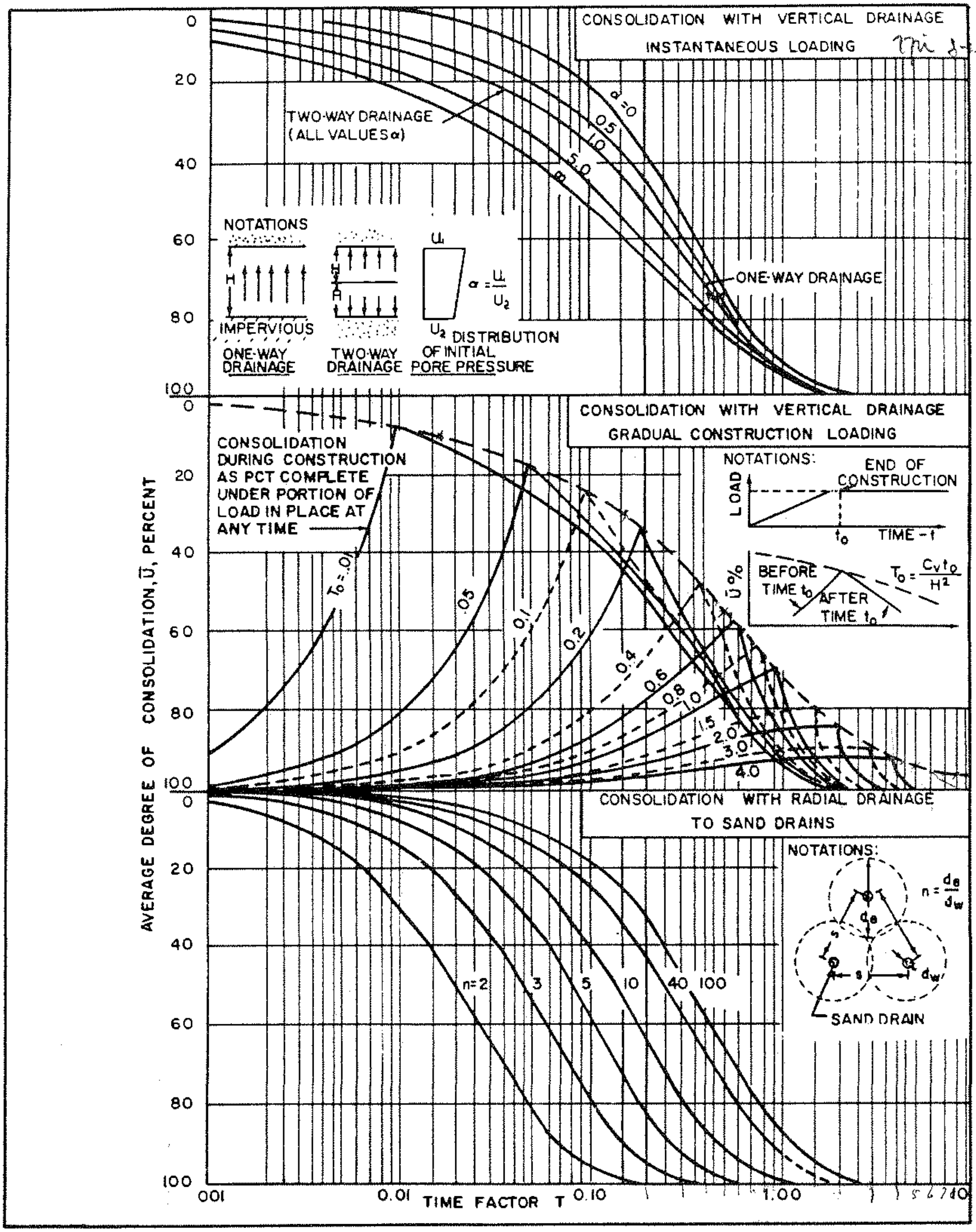


FIGURE 6-6
Time Factors for Consolidation Analysis

ATTACHMENT 1

Ref: "Soil Mechanics" By Lambe 8-15-90

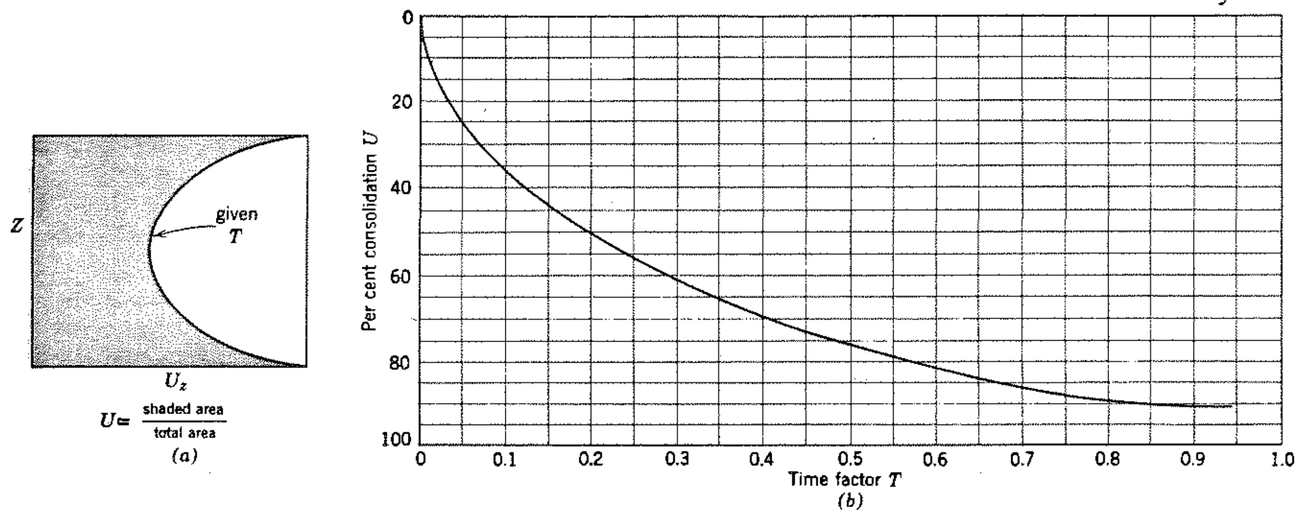


Fig. 27.3 Average consolidation ratio: linear initial excess pore pressure. (*a*) Graphical interpretation of average consolidation ratio. (*b*) U versus T.

value for c_v. This is generally done by observing the rate of compression of an undisturbed sample during an oedometer (or consolidation) test (see Sections 9.1 and 20.2).

Figure 27.4 shows a typical set of dial readings, showing change in thickness with time, obtained during one increment of load. The form of such actual time versus compression curves is similar to, but not exactly the same as, the theoretical curves predicted from consolidation theory. The following *fitting methods* are commonly used to determine c_v from such test results (Lambe, 1951).

Square root method. Extend a tangent to the straight-line portion of the observed curve back to intersect zero time and obtain the corrected zero point d_s. Through d_s draw a straight line having an inverse slope 1.15 times the tangent. Theoretically, this straight line should cut the observed compression-time curve at 90% compression. Thus the time to 90% compression is 12.3 minutes. From Fig. 27.3, the dimensionless time T for 90% compression is 0.848. Substituting these results, with H equal to the thickness of the sample per drainage surface (1.31 cm in this case) into Eq. 27.8*b*, c_v is determined to be 26.2×10^{-4} cm²/sec.

Log method. As shown in Fig. 27.4*b*, tangents are drawn to the two straight-line portions of the observed curve. The intersection of these curves defines the d_{100} point. The corrected zero point d_s is located by laying off above a point in the neighborhood of 0.1 minute a distance equal to the vertical distance between this point and one at a time which is four times greater. The 50% compression point is halfway between d_s and d_{100}, or at a time of 3.3 minutes. From the theoretical curve, $T = 0.197$ for 50% compression. Using Eq. 27.8b, c_v is then computed at 22.7×10^{-4} cm²/sec.

Discussion of results. Obviously, these fitting methods contain arbitrary steps that compensate for differences between actual and theoretical behavior. A correction for the initial point is usually required because of apparatus errors or the presence of a small amount of air in the specimen. An arbitrary determination of d_{90} or d_{100} is required because compression continues to occur even after excess pore pressures are dissipated. This *secondary compression* occurs because the mineral skeleton has time-dependent stress-strain properties (Chapter 20); the importance of secondary compression will be discussed in Section 27.7. The fitting methods have been developed to provide the best possible estimates for c_v. It is hardly surprising that the two methods yield somewhat different results. The square root method usually gives a larger value of c_v than does the log method, and this method is usually preferred.

In addition to the problems involved in evaluating c_v from a given increment, c_v varies from increment to increment and is different for loading and unloading. Figure 27.5 shows typical results. Moreover, c_v usually varies considerably among samples of the same soil.

Thus it is quite difficult to select a value of c_v for use in a particular engineering problem and hence it is difficult to predict accurately the rate of settlement or heave. Often the actual observed rate of settlement or heave of a structure is two to four times faster than the rate predicted on the basis of c_v as measured using undisturbed samples (e.g., see Bromwell and Lambe, 1968). Such differences arise partially because of the difficulties in measuring c_v, partially because of shortcomings in the linear theory of consolidation, and partially because of the two- and three-dimensional effects discussed in Section 27.6. Predictions of rate of consolidation are useful only to indicate in advance of construction the approximate time required for consolidation. If the actual rate of consolidation is critical to the design, as in certain stability problems where the excess

ATTACHMENT 2

Ref : "Soil Mechanics" By Lambe

equation applicable to numerous physical problems. In particular, the equations for transient heat flow are basically identical to these equations for consolidation, with temperature replacing excess pore pressure. Solutions have been obtained for many problems in heat flow involving a variety of initial and boundary conditions, and these solutions often may be used to considerable advantage in the study of consolidation.

27.2 SOLUTION FOR UNIFORM INITIAL EXCESS PORE PRESSURE

The simplest case of consolidation is the one-dimensional problem in which: (*a*) the total stress is constant with time, so that $\partial\sigma_v/\partial t = 0$; (*b*) the initial excess pore pressure is uniform with depth; and (*c*) there is drainage at both the top and bottom of the consolidating stratum. These conditions are met by the loading in Fig. 26.2 provided that the loading is applied in a time that is very small compared to the consolidation time so that literally no consolidation occurs before the loading is complete. The total vertical stress at any point will then be constant during the consolidation process.

For this problem, it is convenient to convert Eq. 27.4 by introducing nondimensional variables:

$$Z = \frac{z}{H} \qquad (27.8a)$$

$$T = \frac{c_v t}{H^2} \qquad (27.8b)$$

where z and Z are measured from the top of the consolidating stratum and H is *one-half* of the thickness of the consolidating stratum. (The reason for this choice of H will be apparent later.) The nondimensional time T is called the *time factor*. With these variables, Eq. 27.4 becomes

$$\frac{\partial^2 u_e}{\partial Z^2} = \frac{\partial u_e}{\partial T} \qquad (27.9)$$

We now need a solution to Eq. 27.9 satisfying the following conditions:

Initial condition at $t = 0$:

$$u_e = u_0 \text{ for } 0 \le Z \le 2$$

Boundary condition at all t:

$$u_e = 0 \text{ for } Z = 0 \text{ and } Z = 2$$

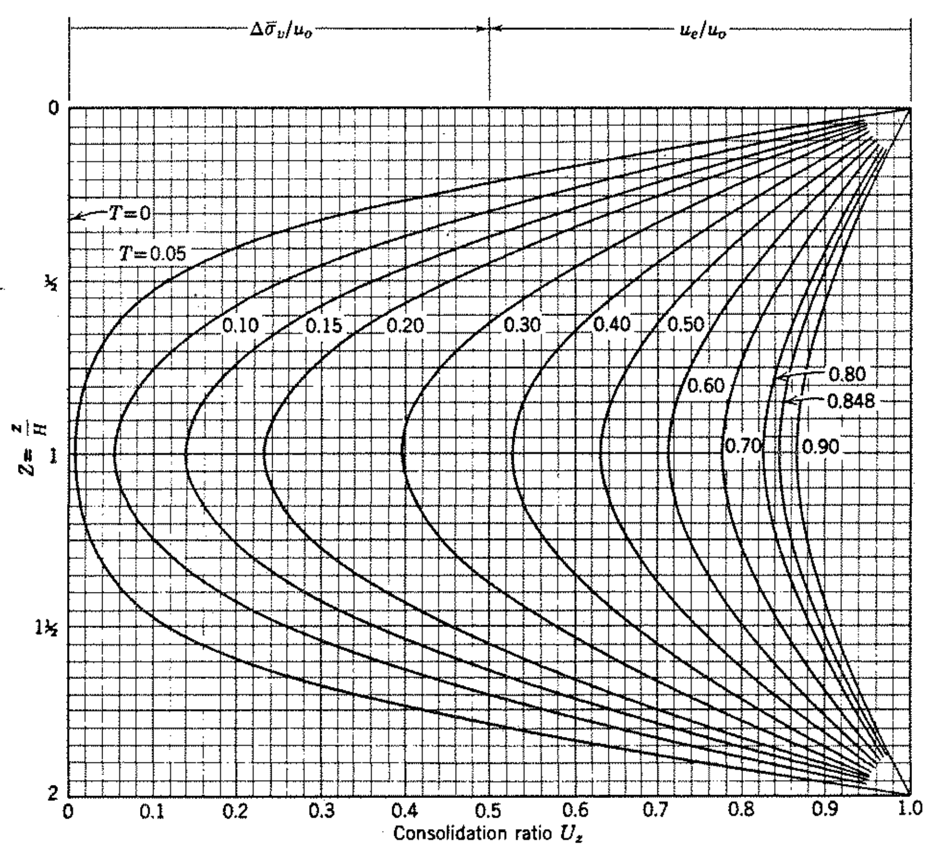


Fig. 27.2 Consolidation ratio as function of depth and time factor: uniform initial excess pore pressure.

ATTACHMENT 3

APPENDIX G.3
CLAY LINER CONSOLIDATION SETTLEMENT

	Kettleman Hills Facility – Landfill Unit B-18 Expansion Settlement of Clay Liner	
Golder Associates	Project No.: 083-91887	Made By: EH
	Date: 10/28/08	Checked By: RH
	Sheet: 1 of 2	Reviewed By: [signature]

Objective:

Estimate the additional settlement due to the increased waste loads from the Phase III expansion.

Reference:

Environmental Solutions Inc. (ESI) Engineering Report Settlement Calculations (Attached).

Discussion:

ESI previously calculated the settlement of the clay liner due to placement of 230 feet of waste. The expansion project will increase the waste height to approximately 300 feet. This additional load will result in further compression of the clay.

Calculation:

1) Primary consolidation settlement
   - The maximum load due to waste: Max. σ_v = 300' x 115pcf = 34.5 ksf
   - The consolidation settlement at 34.5 ksf is approximately 9.5% of the total thickness (see Figures 1 and 2).

Clay Liner	Primary	Secondary
Initial clay liner thickness	1.5'	3.5'
Consolidation settlement (9.5%)	0.14'	0.33'
Post Consolidation Thickness	1.36'	3.17'

2) Secondary consolidation settlement (or creep settlement)
   Secondary consolidation settlement will occur after the closure of the landfill. The secondary settlement can be computed using the following equation:

   $\Delta_s = C_\alpha (H_t) \text{Log}(t_s/t_p)$
   Δ_s =secondary settlement (ft)
   C_α= coefficient of secondary compression, 0.005 per ESI
   H_t = initial thickness
   t_s = duration of secondary compression assuming to be 30 years post closure period.
   t_s = time to complete primary consolidation conservatively assumed to be 20 years (1994-2014) to fill landfill.

   Primary Clay Liner: Δ_s = 0.005 (1.36) Log(30/20) = 0.0012 ft
   Secondary Clay Liner: Δ_s = 0.005 (3.17) Log(30/20) = 0.0028 ft

3) Final Clay Liner Thickness
   Primary clay liner: 1.5'-0.14'-0.0012' = 1.36' > 1.0' OK
   Secondary liner: 3.5'-0.33'-0.0028' > 3.0' OK
4) Settlement for clay liner beneath vertical riser

Settlement of the clay liner beneath the vertical riser is estimated to increase by an additional 5% due to riser imposed loads.

Thus, settlement of the clay below the riser will be 9.5% + 5.0% = 14.5% of the original thickness. Secondary compression is considered to be negligible based on previous calculation.

Settlement in the secondary clay liner = 14.5% x 5' = 0.725'
The final secondary clay liner thickness is estimated to be 5'-0.725' ≅ 4.3' > 3' OK

Settlement in the primary clay liner = 14.5% x 3' = 0.44'
The final primary clay liner thickness is estimated to be 3'-0.44' ≅ 2.5' > 1' OK

ENVIRONMENTAL SOLUTIONS, INC.

By GSC Date 8/8/90 Subject SETTLEMENT OF CLAY LINER Sheet No. 1 of ____

Chkd. By [illegible] Date 8/13/90 Proj. No. 89-977

OBJECTIVE : TO ESTIMATE SETTLEMENT OF CLAY LINER FOR KETTLEMAN HILL B-18 LANDFILL BASE IN DETERMINING COMPLIANCE WITH MINIMIUM THICKNESS (3') REQUIREMENT FOR BOTTOM CLAY LI[NER]

REFERENCE : (1) LAMBE & WHITEMAN (1969) "SOIL MECHANICS" PUBLISHED BY JOHN WILEY & SONS, INC.

(2) DEPT. OF NAVY, NAVAL FACILITIES ENGINEERING COMMAND (1971) "DESIGN MANUAL, DM-7" MARCH.

DISCUSSION : TOTAL SETTLEMENT OF BASE CLAY LINER WILL INCLUDE PRIMARY AND SECONDARY SETTLEMENT. THE PRIMARY SETTLEMENT IS ASSOCIATED WITH THE CONSOLIDATION SETTLEMENT AND THE SECONDARY SETTLEMENT IS ASSOCIATED WITH THE CREEP MOVEMENT AFTER THE COMPLETION OF PRIMARY SETTLEMENT OR CONSOLIDATION.

$$\Delta_T = \Delta_p + \Delta_s$$

WHERE Δ_T = TOTAL SETTLEMENT

Δ_p = PRIMARY SETTLEMENT DUE TO CONSOLIDATION

Δ_s = SECONDARY SETTLEMENT DUE TO CREEP AFTER Δ_p

MAX. FILL (OVERBURDEN PRESSURE) AT COMPLETION OF LANDFILL OPERATION IS ESTIMATED TO BE APPROXIMATELY 210-FEET OF WASTE ABOVE THE LINER SYSTEM.

$$\text{Max. } \sigma_v = 230' \times 115 \text{ pcf} = 26450 \text{ psf or } 26.4 \text{ KSF}$$

ENVIRONMENTAL SOLUTIONS, INC.

By GSC Date 8/3/90 Subject SETTLEMENT OF CLAY LINER Sheet No. 2 of ___
Chkd. By [illegible] Date 8/15/90 Proj. No. 89-977

BASED ON CONSOLIDATION TEST RESULTS ON COMPACTED CLAY SAMPLES FROM CLAY BORROW MATERIAL AT THE SITE. FOR MAX. σ_v = 24.2 KSF. THE CONSOLIDATION SETTLEMENT IS ESTIMATED TO BE APPROXIMATELY 7% OF THE TOTAL THICKNESS OF CLAY CONCERNED. (SEE ATTACHED FIGS. 1 & 2)

	PRIMARY	SECONDARY
INITIAL CLAY LINER THICKNESS	1.5'	3.5'
CONSOLIDATION SETTLEMENT Δ_p	1.5' x 0.07 = 0.105' = 1.26"	3.5' x 0.07 = 0.245' = 2.94"

HOWEVER, BASED ON THE CALCULATION ON CONSOLIDATION CHARACTERISTIC OF CLAY LINER FOR B-18 LANDFILL, IT WAS FOUND THAT AT LEAST 96% OF THE CONSOLIDATION WILL BE COMPLETED AT THE END OF THE FINAL LANDFILL OPERATION. THEREFORE, SETTLEMENT AFTER THE FINAL LANDFILL CLOSURE WILL BE MAINLY FROM THE SECONDARY SETTLEMENT OR CREEP SETTLEMENT. THE SECONDARY SETTLEMENT CAN BE COMPUTED USING THE FOLLOWING EQUATION:

$$\Delta_s = C_\alpha (H_t) \log \frac{t_{sec}}{t_p} \qquad \text{(REF 2)}$$

WHERE

Δ_s = SETTLEMENT FROM SECONDARY COMPRES[SION]
C_α = COEFFICIENT OF SECONDARY COMPRESSION
H_t = INITIAL THICKNESS OF COMPRESSIBLE STRATUM
t_{sec} = USEFUL LIFE OF STRUCTURE.
t_p = TIME TO COMPLETION OF PRIMARY CONSOLIDATION

ENVIRONMENTAL SOLUTIONS, INC.

By GSC Date 8/3/90 Subject SETTLEMENT OF CLAY LINER Sheet No. 3 of ____
Chkd. By [illegible] Date 8/3/90 Proj. No. ____

REF. 2 FIGURE 3.5 (SEE ATTACHMENT 1)
FOR COMPLETELY REMOLDED SAMPLES USING $w\% \approx 28\%$ (Fig. 1 & 2)
$C_\alpha = 0.003$ TO 0.005

BASED ON LAB RESULTS FROM LOG. TIME CURVE OF THE CONSOLIDATION TEST (SEE FIGS. 3 & 4)
$C_\alpha = 0.0015$ TO 0.006 FOR APPROPRIATE PRESSURES

USE $C_\alpha = 0.005$ FOR ESTIMATE

BASED ON CALCULATION OF CONSOLIDATION BEHAVIOR OF CLAY LINER, THE CONSOLIDATION SETTLEMENT OF CLAY LINER GENERALLY COMPLETE AT ABOUT 2 TO 3 YEARS AFTER THE FINAL LANDFILL CLOSURE. THEREFORE SECONDARY SETTLEMENT COMMENCE AFTER THAT. THE SETTLEMENT DURING THE POST-CLOSURE PERIOD =

SECONDARY SETTLEMENT FOR CLAY LINER AT LANDFILL BOTTOM

PRIMARY CLAY LINER (REDUNDANT) $= 0.005\,(1.5 - 0.105)\log\frac{30}{18}$ $= 0.0015'$	SECONDARY CLAY LINER $= 0.005\,(3.5 - 0.245)\log\frac{30}{18}$ $= 0.0036'$
FINAL THICKNESS FOR: PRIMARY CLAY LINER (REDUNDANT) $= 1.5 - 0.105 - 0.0015$ $= 1.39'$	SECONDARY CLAY LINER $= 3.5 - 0.245 - 0.0036$ $= 3.25'$

* CHECK SETTLEMENT FOR CLAY LINER BENEATH VERTICAL RISER
REF. RISER BEARING CAPACITY COMPUTATION, PAGE 3 OF 4
PRIMARY SETTLEMENT DUE TO RISER IMPOSED LOAD = 5% OF THICKNESS

	PRIMARY CLAY LINER	SECONDARY CLAY LINER
TOTAL PRIMARY SETTLEMENT	$(0.07 + 0.005) \times 3 = 0.225'$	$(0.07 + 0.005) \times 5 = 0.375'$
SECONDARY SETTLEMENT	$0.005\,(3 - 0.225)\log\frac{30}{18} = 0.0031'$	$0.005\,(5 - 0.375)\log\frac{30}{18} = 0.0051'$
TOTAL	$= 0.2281'$	$= 0.3801'$
FINAL THICKN	$(3 - 0.2281') = 2.77'$	$(5 - 0.3801) = 4.42'$

ENVIRONMENTAL SOLUTIONS, INC.

By GSC Date 8/8/90 Subject SETTLEMENT OF CLAY LINER Sheet No. 4 of ____
Chkd. By [illegible] Date 8/16/90 Proj. No. 89-977

CONCULSION :

1. BASED ON THE ABOVE CALCULATIONS, AT THE LANDFILL BASE, THE TOTAL SETTLEMENT OF THE SECONDARY CLAY LINER AT THE BOTTOM OF THE LANDFILL :

$$\Delta_T = \Delta_P + \Delta_S$$

$$= 0.245 + 0.0036$$

$$= 0.25'$$

THEREFORE, THE 3.5-FOOT CLAY LAYER BENEATH THE LEACHATE COLLECTION SYSTEM WILL MAINTAIN A MINIMIUM THICKNESS REQUIREMENT OF 3-FOOT DURING THE POST-CLOSURE PERIOD.

2. TOTAL SETTLEMENT AT THE VERTICAL RISER BASE FOR THE SECONDARY CLAY LINER IS COMPUTED IN THE FOLLOWING :

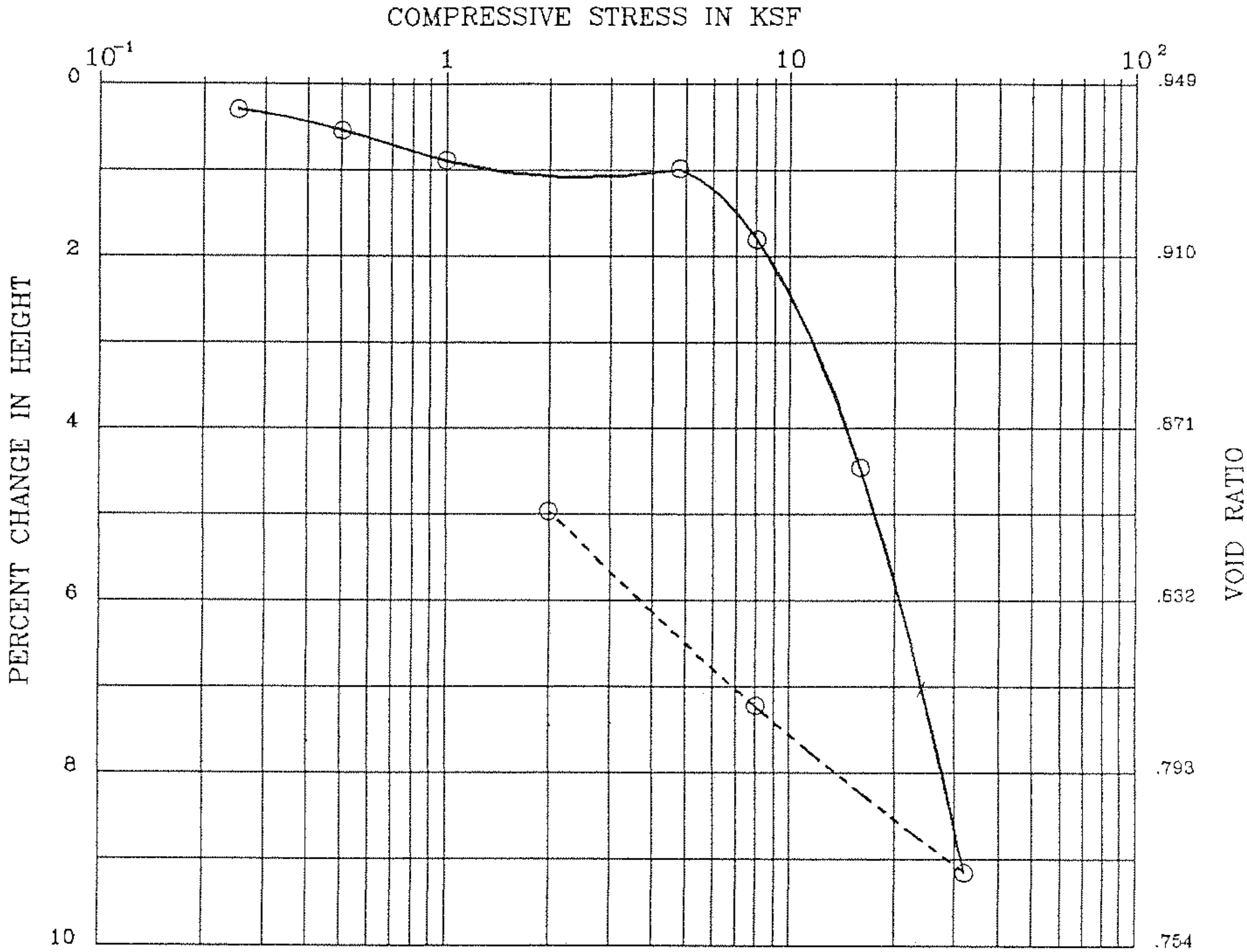
$$\Delta_T = \Delta_P + \Delta_S$$

$$= 0.375' + 0.0051'$$

$$= 0.38'$$

THEREFOR, THE 5-FOOT SECONDARY LCRS CLAY LINER WILL MAINTAIN ITS THICKNESS OF NO LESS THAN 3-Foot FOR THE PRIMIUM.

Vpi 8-16-90



BORING : DT-C, B-1
DEPTH (ft) : 8
SPEC. GRAVITY : 2.79

DESCRIPTION : silty CLAYSTONE, yellow brn (CH)
LIQUID LIMIT : 76
PLASTIC LIMIT : 45

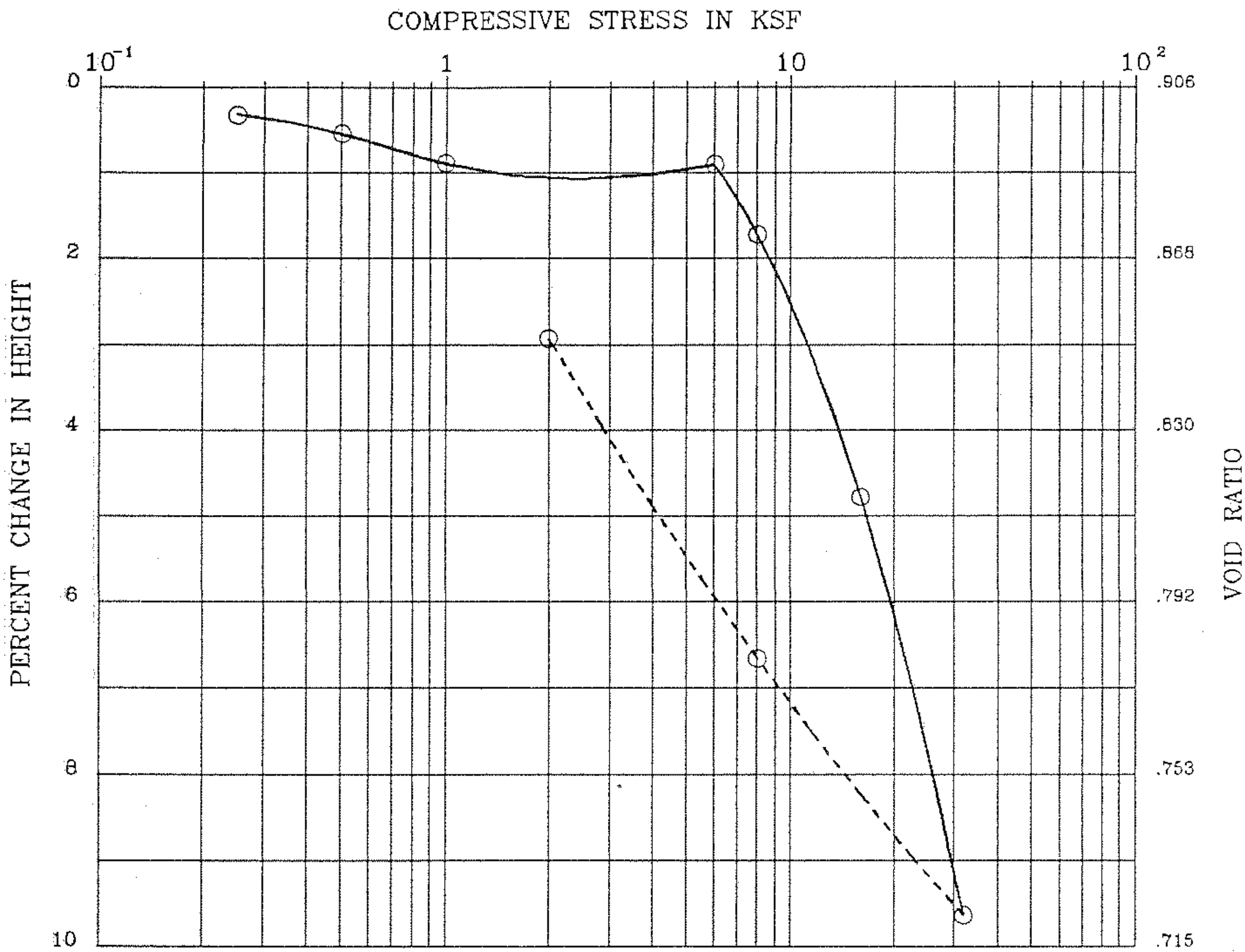
	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	PERCENT SATURATION	VOID RATIO
INITIAL	28.1	89.4	83	.949
FINAL	30.5	94.1	100	.852

FIG. 1

Remark : July 1990

Project ESK-101A	Kettleman
Wahler Associates	CONSOLIDATION TEST Figure No.

Vpi 8-16-90



BORING : DT–A, B–2

DEPTH (ft) : 5

SPEC. GRAVITY : 2.84

DESCRIPTION : silty CLAYSTONE, yellow brn (CH)

LIQUID LIMIT : 82

PLASTIC LIMIT : 54

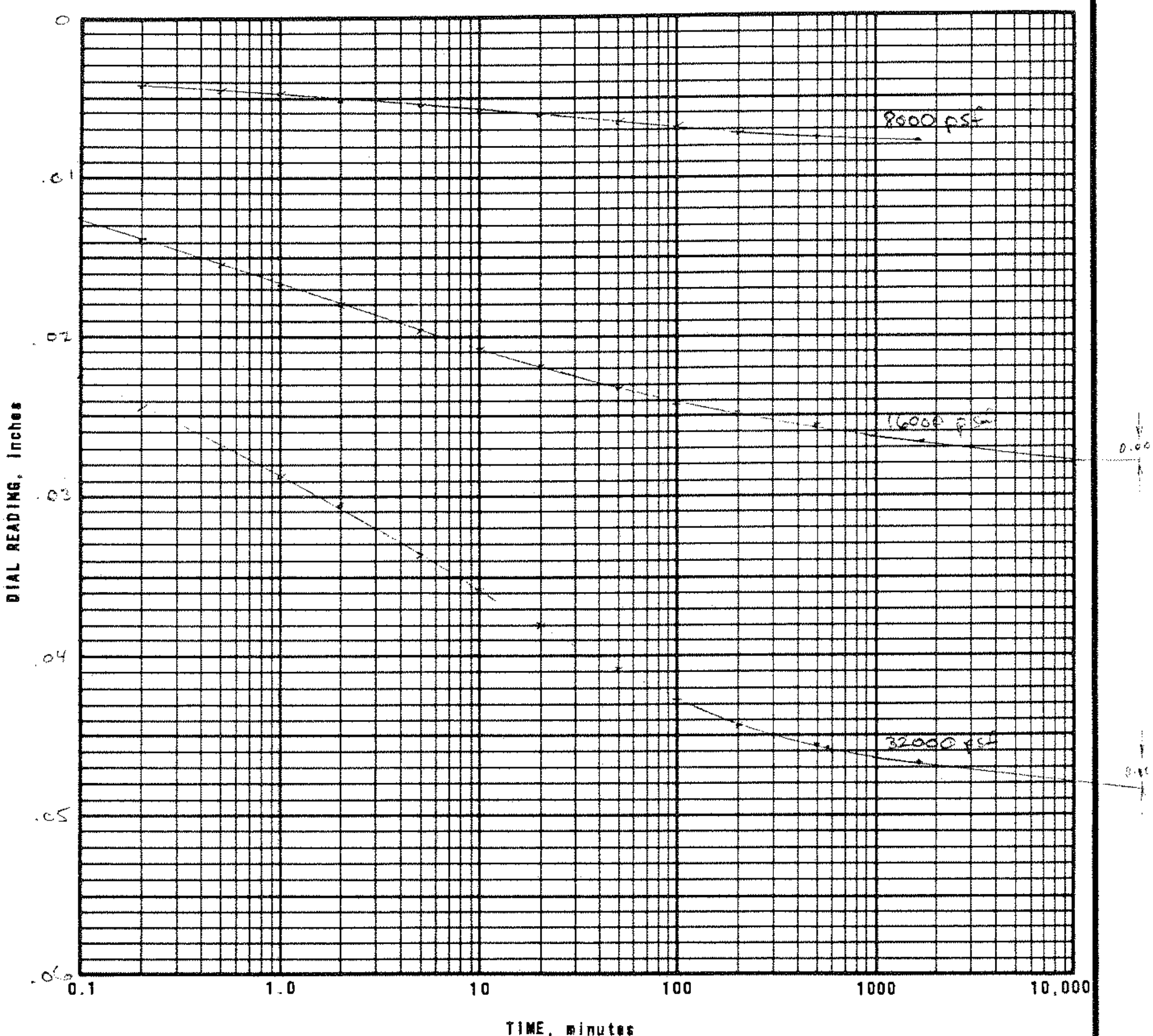
	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	PERCENT SATURATION	VOID RATIO
INITIAL	27.3	93.1	86	.906
FINAL	29.9	95.9	100	.851

FIG. 2

Remark : July 1990

Project ESK–101A	Kettleman
Wahler Associates	CONSOLIDATION TEST Figure No.

8-16-90

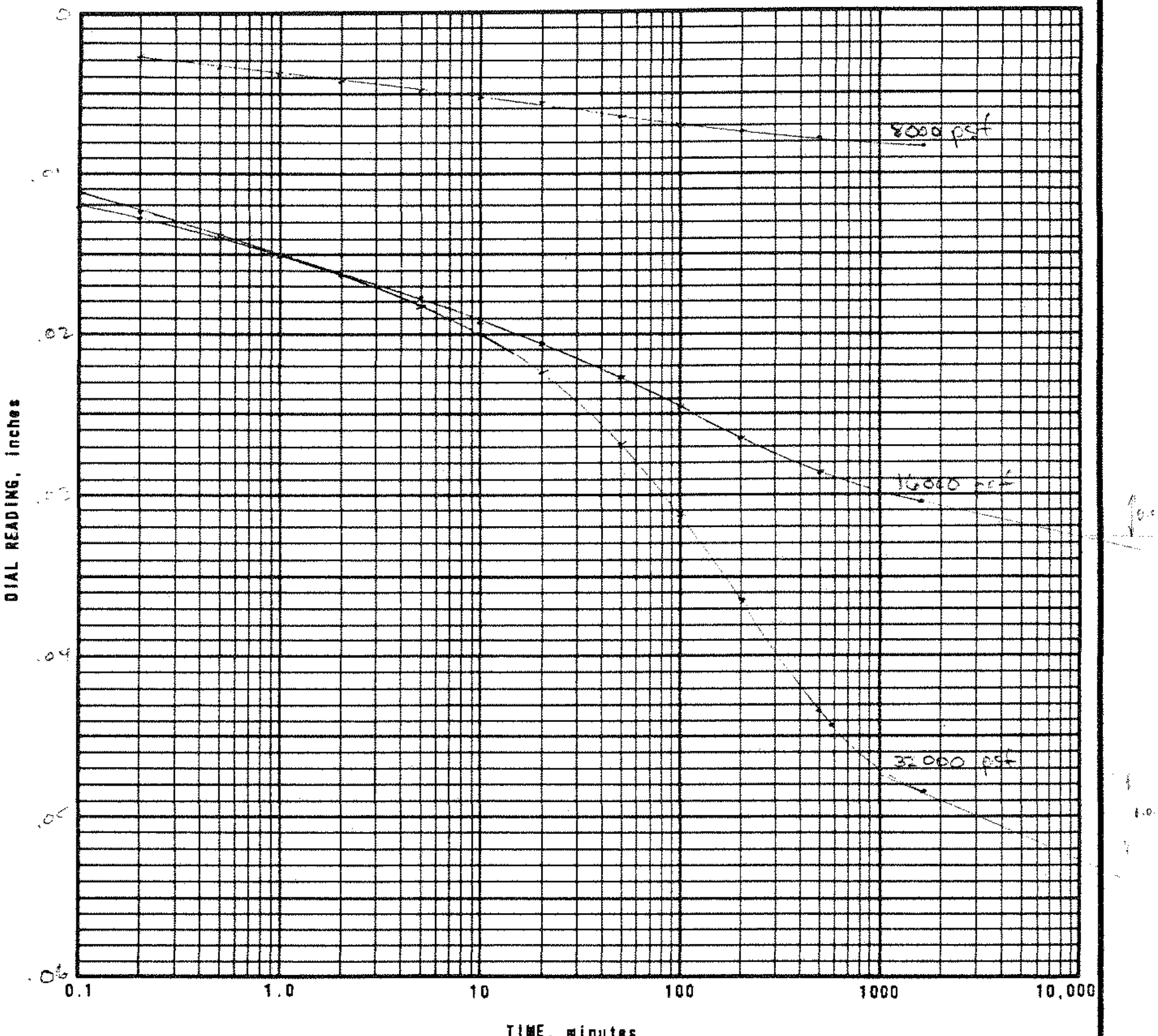


DT-C, B-1, 8'

FIG. 3

WAHLER ASSOCIATES	Kettleman	CONSOLIDATION TEST TIME – COMPRESSION CURVES		
		PROJECT NO.	DATE	FIGURE NO.
PALO ALTO • [redacted] • CALIF.		ESK 101A	7/90	

vpi - 8-16-90



DT. A, B-2, 5'

FIG. 4

WAHLER ASSOCIATES	Kettleman	CONSOLIDATION TEST TIME – COMPRESSION CURVES		
	PALO ALTO • [redacted] • CALIF.	PROJECT NO.	DATE	FIGURE NO.
		ESK 101A	7/90	

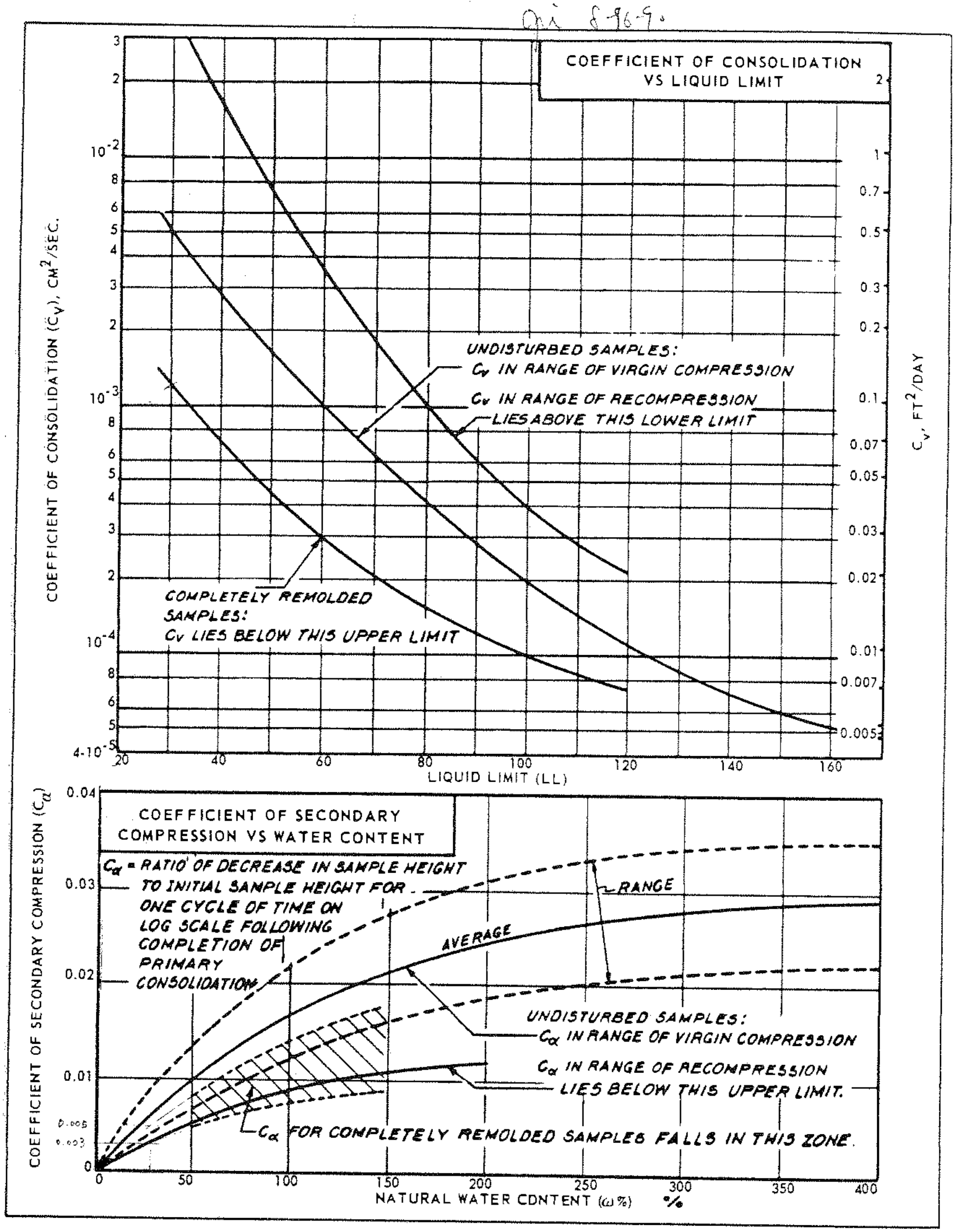


FIGURE 3-5

Approximate Correlations for Consolidation Characteristics of Silts and Clays

Ref : NAVFAC, DM-7

APPENDIX G.4
POST-CLOSURE WASTE SETTLEMENT

Golder Associates	Kettleman Hills Facility – Landfill Unit B-18 POST-CLOSURE WASTE SETTLEMENT	
	Project No.: 083-91887	Made By: LAQ
	Date: 05-28-2008	Checked By: EH
	Sheet: 1 of 1	Reviewed By:

Objective:

1. To estimate the effects of secondary settlement of the waste fill on the landfill cover post-closure grade for drainage.
2. Utilize Environmental Solutions Inc. (ESI) original calculation methods and assumptions and apply them to the new expansion configuration.

Given:

For the new landfill expansion geometry and as-built landfill configuration used to generate the evaluated sections where obtained from AutoCAD drawings (see Drawings 1 through 6 in Appendix G-1). All other data used for these calculations are based on the original Environmental Solutions Inc. (ESI) calculation, including site geology and foundation stratigraphy (see Attachment 1).

Assumptions and Methods:

All assumptions and methods utilized on this calculation are based on the ESI original calculation dated August 14, 1990. ESI calculations are included in Attachment 1.

Calculations and Results:

Calculation methods are described on ESI original calculation dated August 14, 1990. Calculations are shown in Attachment 1. Results for the new calculations are attached in Table 1 to 4. The calculations indicate the post-closure settlement will be approximately 9.3% of the waste thickness.

Conclusions:

As stated by ESI in their original calculation; "Based on the final cover post-closure settlement calculations for the selected sections, the results indicate that the changes of the grade after settlement will have no adverse effect on the surface drainage. After settlement, the gradients are still more than 3% which is the minimum requirement for drainage." Based on a review of ESI's calculations, Golder agrees with their original conclusions. In some cases shown in Table 3 the apparent gradient is less than 3%. The locations resulting in a value less than the required 3% are due to the location of the selected section not being nearly perpendicular to the new cover drainage slope. By observation and comparison with Section 2-2', these locations maintain a minimum 3% true slope.

As stated by ESI in their original calculation, "Due to the geometry of the final cover it is expected that the length of the slopes in the soil cover and liner systems will be reduced due to settlement. A minimal reduction strain is expected and should be readily absorbed by the soil cover and the liner systems without causing any damage".

Reference:

Environmental Solutions Inc. "Engineering and Design report Landfill Unit B-18 Phase 1, 2 and Final Closure, Kettleman Hills Facility". August 1990. Appendix G.4

Table 1
Post-Closure Waste Settlement
Section 1-1'

Assumptions:

Containers in waste:	0.15 %
Containers Voids:	0.10 %
H_{waste}:	280 ft
γ_{waste}:	115 pcf
E_{waste}:	40,000 psf
C_{α}:	0.02
W_{waste}:	14,500,000 cy^3
Incoming Waste:	550,000 cy^3/yr
Stages:	5
Post-Closure period:	30 yr

$S_T = S_C + S_V + S_D + S_S$

S_C	0.0%
S_V	1.5%
S_D	6.0%
S_S	1.7%
S_T	9.3%
T	27 yr
t	5.40 yr

S_{D1} 40%

Stage	t_1(yr)	t_2(yr)	log t_1/t_2	C_{α}	δH	
1	5.4	51.6	0.98	0.02	0.0039	H
2	5.4	46.2	0.93	0.02	0.0037	H
3	5.4	40.8	0.88	0.02	0.0035	H
4	5.4	35.4	0.82	0.02	0.0033	H
5	5.4	30.0	0.74	0.02	0.0030	H
				$\Delta\sigma$	0.0174	H

Final Grade Calculation

Station	Finish Elevation (ft)	Waste Thickness (ft)	ΔH 0.093H (ft)	Final Elevation (ft)	Distance (ft)	Initial Grade (%)	Final Grade (%)
1	806.18	0	0.00	806.18			
					375.43	24.6%	20.4%
2	898.62	171.15	15.88	882.74			
					419.64	23.5%	21.4%
3	997.29	268.59	24.92	972.37			
					49.85	19.2%	19.3%
4	1006.88	268.29	24.89	981.99			
					49.85	20.9%	20.6%
5	996.47	266.67	24.74	971.73			
					212.15	21.5%	15.9%
6	950.83	137.61	12.77	938.06			
					240.09	21.9%	16.6%
7	898.32	0	0.00	898.32			

Note: See Drawing 1 and 2 in Appendix G-1 for Section location and Drawing 3 for Cross Section profile.

Table 2
Post-Closure Waste Settlement
Section 2-2'

Assumptions:

Containers in waste:	0.15 %
Containers Voids:	0.10 %
H_{waste}:	280 ft
γ_{waste}:	115 pcf
E_{waste}:	40,000 psf
C_{α}:	0.02
W_{waste}:	14,500,000 cy^3
Incoming Waste:	550,000 cy^3/yr
Stages:	5
Post-Closure period:	30 yr

$S_T = S_C + S_V + S_D + S_S$

S_C	0.0%
S_V	1.5%
S_D	6.0%
S_S	1.7%
S_T	9.3%
T	27 yr
t	5.40 yr

S_{D1} 40.3%

Stage	t_1(yr)	t_2(yr)	log t_1/t_2	C_{α}	δH	
1	5.4	51.6	0.98	0.02	0.0039	H
2	5.4	46.2	0.93	0.02	0.0037	H
3	5.4	40.8	0.88	0.02	0.0035	H
4	5.4	35.4	0.82	0.02	0.0033	H
5	5.4	30.0	0.74	0.02	0.0030	H
				$\Delta\sigma$	0.0174	H

Final Grade Calculation

Station	Finish Elevation (ft)	Waste Thickness (ft)	ΔH 0.093H (ft)	Final Elevation (ft)	Distance (ft)	Initial Grade (%)	Final Grade (%)
1	771.69	0	0.00	771.69	290	24.2%	18.8%
2	842.00	171.5	15.91	826.09	392.34	23.9%	21.6%
3	935.86	268.59	24.92	910.94	484.83	15.3%	15.8%
4	1010.00	243.40	22.58	987.42	143.86	5.6%	3.1%
5	1018.00	281.55	26.12	991.88	114.56	7.0%	5.4%
6	1010.00	261.98	24.31	985.69	168.02	23.7%	17.0%
7	970.20	141.19	13.10	957.10	254.12	23.7%	18.5%
8	910.00	0	0.00	910.00			

Note: See Drawing 1 and 2 in Appendix G-1 for Section location and Drawing 4 for Cross Section profile.

Table 3
Post-Closure Waste Settlement
Section 3-3'

Assumptions:

Containers in waste:	0.15 %
Containers Voids:	0.10 %
H_{waste}:	280 ft
γ_{waste}:	115 pcf
E_{waste}:	40,000 psf
C_{α}:	0.02
W_{waste}:	14,500,000 cy^3
Incoming Waste:	550,000 cy^3/yr
Stages:	5
Post-Closure period:	30 yr

$S_T = S_C + S_V + S_D + S_S$

S_C	0.0%
S_V	1.5%
S_D	6.0%
S_S	1.7%
S_T	9.3%
T	27 yr
t	5.40 yr

S_{D1} 40.3%

Stage	t_1(yr)	t_2(yr)	log t_1/t_2	C_{α}	δH	
1	5.4	51.6	0.98	0.02	0.0039	H
2	5.4	46.2	0.93	0.02	0.0037	H
3	5.4	40.8	0.88	0.02	0.0035	H
4	5.4	35.4	0.82	0.02	0.0033	H
5	5.4	30.0	0.74	0.02	0.0030	H
				$\Delta\sigma$	0.0174	H

Final Grade Calculation

Station	Finish Elevation (ft)	Waste Thickness (ft)	ΔH 0.093H (ft)	Final Elevation (ft)	Distance (ft)	Initial Grade (%)	Final Grade[1] (%)
1	890.51	0	0.00	890.51	252.19	23.7%	17.4%
2	950.18	169.36	15.71	934.47	252.17	19.8%	16.1%
3	1000.00	268.31	24.89	975.11	227.75	6.3%	5.9%
4	1014.46	278.29	25.82	988.64	181.73	crossing ridge of top deck	
5	1012.84	285.82	26.52	986.32	341.58	crossing ridge of top deck	
6	1007.53	273.53	25.38	982.15	146.71	crossing ridge of top deck	
7	1006.62	279.34	25.92	980.70	364.03	22.8%	20.4%
8	923.48	185.27	17.19	906.29	301.74	24.4%	18.7%
9	850	0	0.00	850.00			

Notes: See Drawing 1 and 2 in Appendix G-1 for Section location and Drawing 5 for Cross Section profile.

Points 4, 5 and 6 currently cross the ridge line of the top deck and therefore do not reflect true slope. Secion 2-2' provides points across the top deck that are along true slope.

Table 4
Post-Closure Waste Settlement
Section 4-4'

Assumptions:

Containers in waste:	0.15 %
Containers Voids:	0.10 %
H_{waste}:	280 ft
γ_{waste}:	115 pcf
E_{waste}:	40,000 psf
C_α:	0.02
W_{waste}:	14,500,000 cy^3
Incoming Waste:	550,000 cy^3/yr
Stages:	5
Post-Closure period:	30 yr

$S_T = S_C + S_V + S_D + S_S$

S_C	0.0%
S_V	1.5%
S_D	6.0%
S_S	1.7%
S_T	9.3%
T	27 yr
t	5.40 yr

S_{D1} 40.3%

Stage	t_1(yr)	t_2(yr)	log t_1/t_2	C_α	δH	
1	5.4	51.6	0.98	0.02	0.0039	H
2	5.4	46.2	0.93	0.02	0.0037	H
3	5.4	40.8	0.88	0.02	0.0035	H
4	5.4	35.4	0.82	0.02	0.0033	H
5	5.4	30.0	0.74	0.02	0.0030	H
				Δσ	0.0174	H

Final Grade Calculation

Station	Finish Elevation (ft)	Waste Thickness (ft)	ΔH 0.093H (ft)	Final Elevation (ft)	Distance (ft)	Initial Grade (%)	Final Grade (%)
1	848.28	0.00	0.00	848.28			
					193.06	24.2%	17.9%
2	895.07	131.82	12.23	882.84			
					271.02	24.2%	20.4%
3	960.64	243.47	22.59	938.05			
					148.6	7.6%	6.9%
4	971.89	254.54	23.62	948.27			
					114.97	11.7%	10.3%
5	958.46	237.72	22.06	936.40			
					310.89	24.3%	22.2%
6	882.96	168.21	15.61	867.35			
					346.76	24.0%	19.5%
7	799.63	0.00	0.00	799.63			

See Drawing 1 and 2 in Appendix G-1 for Section location and Drawing 6 for Cross Section profile.

Attachment 1

ESI Settlement Calculations

ENVIRONMENTAL SOLUTIONS, INC.

By N.A. Date 8-10-90 Subject LANDFILL B-18 FINAL Sheet No._____ of_____

Chkd. By GSC Date 8/14/90 COVER POST-CLOSURE SETTLEMENT Proj. No. 89-977

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ENVIRONMENTAL SOLUTIONS, INC.

By VA/NA/GSC Date 7-12-90 Subject LANDFILL B-18 FINAL COVER Sheet No. 1 of 14
Chkd. By GSC Date 8/14/90 POST-CLOSURE GRADE EVALUATION Proj. No. 89-977

PURPOSE: TO EVALUATE THE EFFECT OF SECONDARY SETTLEMENT OF THE WASTE FILL ON THE LANDFILL COVER POST-CLOSURE GRADE FOR DRAINAGE.

REFERENCE:

1. SOIL MECHANICS, LAMBE & WHITMAN (Figure 1)

2. NAVFAC DM 7-1, (Figure 2)

3. WASTE SETTLEMENT REPORT FOR FINAL LANDFILL COVER DESIGN, GOLDER ASSOCIATES INC., JULY 1989

4. W.L. Murphy and P.A. Gilbert (1985) "Settlement and cover subsidence of Hazardous Waste landfills"

ENVIRONMENTAL SOLUTIONS, INC.

By GSC Date 8/10/90 Subject WASTE SETTLEMENT
Chkd. By ____ Date ________ KETTLEMAN HILL, B-18 LANDFILL Proj. No. 89-977

Objective : To evaluate the waste settlement behavior and parameters for waste settlement analysis. The results of the waste settlement analysis will be used to determine the influence of final grade of the final cover after closure of the landfill.

REF : (1) W.L. Murphy and P.A. Gilbert (1985) "Settlement and Cover Subsidence of Hazardous Waste Landfills"

DISCUSSION : TOTAL SETTLEMENT OF LANDFILL

$$S_T = S_c + S_v + S_D + S_s$$

WHERE S_c = CONSOLIDATION SETTLEMENT OF BULK WASTE

S_V = SETTLEMENT DUE TO COLLAPSE OF VOIDS INSIDE WASTE CONTAINERS

S_D = SETTLEMENT DUE TO CONTAINER WASTES AFTER CONTAINERS CORRODED AND COLLAPSE

S_s = SECONDARY SETTLEMENT OF WASTE DUE TO CREEP.

IT IS EXPECTED THAT THE CONSOLIDATION SETTLEMENT WILL BE ESSENTIALLY COMPLETE BEFORE THE FINAL CLOSURE. THEREFORE THE CONSOLIDATION SETTLEMENT IS NOT NECESSARY TO BE INCLUDED IN THIS EVALUATION WHICH WILL BE USED TO DETERMINE THE FINAL COVER INFLUENCE. THE FOLLOWING EVALUATION WILL ONLY INCLUDE THE DETERMINATION OF S_V & S_D. S_s HAS DETERMINED PREVIOUSLY (SEE ATTACHMENT) USING THE CORRELATION OF C_α V.S. WATER CONTENT OF

ENVIRONMENTAL SOLUTIONS, INC.

By G. Chou Date 8/10/90 Subject Waste Settlement Sheet No. 3 of 14
Chkd. By ___ Date ___ Kettleman Hill, B-18 Landfill Proj. No. 89-977

NORMALLY CONSOLIDATED CLAY.

ASSUMPTION : (1) BASED ON CHEM. WASTE OFFICALS, THE AMOUNT OF CONTAINERIZED WASTE CONTAINED IN THE B-18 LANDFILL IS EXPECTED TO BE APPROXIMATELY 15%

(2) THE % OF VOIDS IN THE CONTAINER IS EXPECTED TO HAVE AT MOST 10% OF THE CONTAINER VOLUME.

(3) ASSUME THE DRUM CONTAINER WILL BE EVENLY DISTRIBUTED IN THE LANDFILL DURING THE LIFE OF THE LANDFILL OPERTION.

(4) ASSUME ALL CONTAINER WILL BE INTACTED DURING THE PERIOD OF LANDFILL OPERATION. THEREFORE ALL SETTLEMENT CAUSED BY DRUM WASTE WILL OCCUR AFTER CLOSURE AND WILL DIRECTLY AFFECT THE FINAL COVER.

CALCULATION :

* S_v (Collapse of containers voids)
$= 0.10 \times 0.15$
$= 0.015$ or 1.5% OF THE TOTAL WASTE HEIGHT

* S_D (settlement of waste inside drums)
BECAUSE THE WASTE DRUM ARE EVENLY DISTRIBUTED, THE AVERAGE STRESS TO THE WASTE INSIDE THE DRUMS AFTER THE DRUMS CORRODED IS
$115\ pcf \times 210 \left(\frac{1}{2}\right)$ WHERE 210' IS THE TOTAL EXPECTED HEIGHT OF WASTE

ENVIRONMENTAL SOLUTIONS, INC.

By G. CHOU Date 8/10/90 Subject Waste settlement Sheet No. 4 of 14
Chkd. By ____ Date ________ Kettleman Hill, B-18 Landfill Proj. No. 87-977

$\therefore S_D = 115 \times \frac{210}{2} \times \frac{1}{E}$

WHERE $E = 40{,}000 psf$ (REF. 1)

$S_D = \frac{115 \times 105}{40{,}000} = 0.30$ or 30% OF THE DRUM WASTE

SINCE THE DRUM WASTE IS ONLY 15% OF THE WASTE

$S_D = 0.30 \times 0.15 = 0.045$ or 4.5% OF THE TOTAL WASTE HEIGHT

* $S_S = 0.02$ or 2% OF THE TOTAL WASTE HEIGHT (See page 5 & 6)

TOTAL SETTLEMENT AFTER CLOSURE

$S_T = 0.015 + 0.045 + 0.02$

$= 0.075$ or 7.5% OF THE TOTAL HEIGHT

CONCLUSION :

USE 7.5% OF THE TOTAL HEIGHT TO CALCULATE SETTLEMENT AFTER CLOSURE.

ENVIRONMENTAL SOLUTIONS, INC.

SETTLEMENT CHARACTERISTICS OF THE WASTE FILL IS SIMILAR TO THE BEHAVIOR OF NORMALLY CONSOLIDATED CLAY.

THE SECONDARY SETTLEMENT MAY BE ESTIMATED BY THE FOLLOWING EQUATION

$$\Delta_s = C_\alpha H \log \frac{t_2}{t_1}$$

WHERE

C_α = RATE OF SECONDARY COMPRESSION

H = THICKNESS OF THE SOIL LAYER

t_2 = FINAL TIME

t_1 = INITIAL TIME (time when primary consolidation completes)

TYPICAL VALUES OF C_α FOR NORMALLY CONSOLIDATED CLAY VARY FROM 0.005 TO 0.02 Ref. 1 (see fig. 1) BY ASSUMING THE NATURAL MOISTURE CONTENT OF THE WASTE FILL RANGES FROM 30 TO 40 %, THE VALUE OF C_α IS ESTIMATED TO BE ABOUT 0.003 TO 0.004. Ref. 2 (see fig. 2) TO BE CONSERVATIVE, A CONSTANT VALUE OF 0.02 WILL BE USED.

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ESTIMATE OF SECONDARY CONSOLIDATION OF WASTE FILL

TOTAL VOLUME OF B-18 ≈ 9.5×10^6 cy

ASSUME INCOMING WASTE IS ABOUT 500,000 cy/YEAR.

∴ OPERATIONAL LIFE OF B-18

$$T = \frac{9.5 \times 10^6}{500000} = 19 \text{ YEARS}$$

DIVIDE THE FULL OPERATIONAL LIFE OF THE LANDFILL INTO 5 STAGES, THE OPERATIONAL LIFE FOR EACH STAGE

$$t = \frac{19}{5} = 3.8 \text{ YEARS}$$ Assuming primary consolidation completed at the end of each stage

FOR A TYPICAL 30-YEAR POST-CLOSURE PERIOD, THE THE SECONDARY SETTLEMENT OF EACH STAGE

STAGE	FINAL TIME	$\log t_2/t_1$	C_α	$\delta = \frac{H}{t} C_\alpha \log t_2/t_1$
1	45.2	$\log 45.2/3.8$	0.02	0.0043
2	41.4	$\log 41.4/3.8$	0.02	0.0041
3	37.6	$\log 37.6/3.8$	0.02	0.0040
4	33.8	$\log 33.8/3.8$	0.02	0.0038
5	30	$\log 30/3.8$	0.02	0.0036

Δ_S 0.0198 H ≈ 2%

Figure. 1 7/14

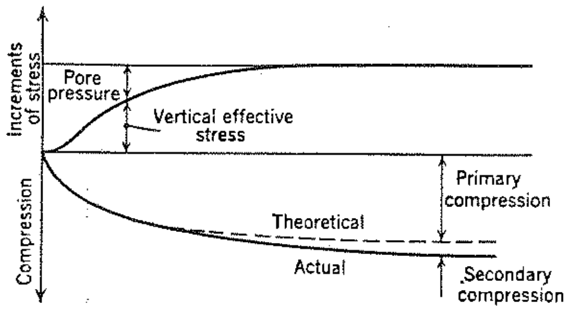

Fig. 27.14 Primary and secondary compression.

skeleton. The relative importance of primary and secondary compression depend on the time required to dissipate pore pressures and hence on the thickness of the soil.

The relative importance of secondary and primary compression varies with the type of soil and also with the ratio of stress increment to initial stress.

The magnitude of secondary compression is often expressed by the slope C_α of the final portion of the time compression curve on semi-log paper (Fig. 27.17). Table 27.2 gives typical values for this slope C_α. The

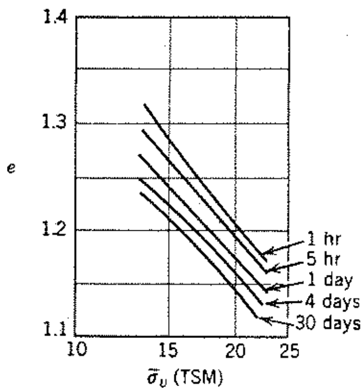

Fig. 27.15 e versus log $\bar{\sigma}_v$ as function of duration of secondary compression (After Bjerrum, 1967).

time rate of secondary compression is largest for highly plastic soils and especially for organic soils.

The ratio of secondary to primary compression is largest when the ratio of stress increment to initial stress is small. This is illustrated in Fig. 27.18, which shows that the usual form of time-compression curve occurs only when the stress increment is large. Fortunately, most problems involving important settlements involve relatively large increments of stress.

Taylor (1942) was the first person to propose a rational theory of secondary compression. This theory modeled the soil skeleton as a viscoelastic material. Recent work in this area is directed at the developing models of behavior and numerical techniques for solving secondary compression problems with complicated rheologic models.

The phenomenon of secondary compression greatly complicates prediction of the time history and final magnitude of settlement. Bjerrum (1967) has discussed this subject. Secondary compression also makes it difficult to determine c_v accurately from laboratory tests.

27.8 SUMMARY OF MAIN POINTS

1. The differential equation of continuity, which is the basis for the study of consolidation, equates the *net* flow to the change in volume of the soil.

Table 27.2 Typical Values for Rate of Secondary Compression C_α

	C_α
Normally consolidated clays	0.005 to 0.02
Very plastic soils; organic soils	0.03 or higher
Precompressed clays with OCR > 2	less than 0.001

From Ladd, 1967.

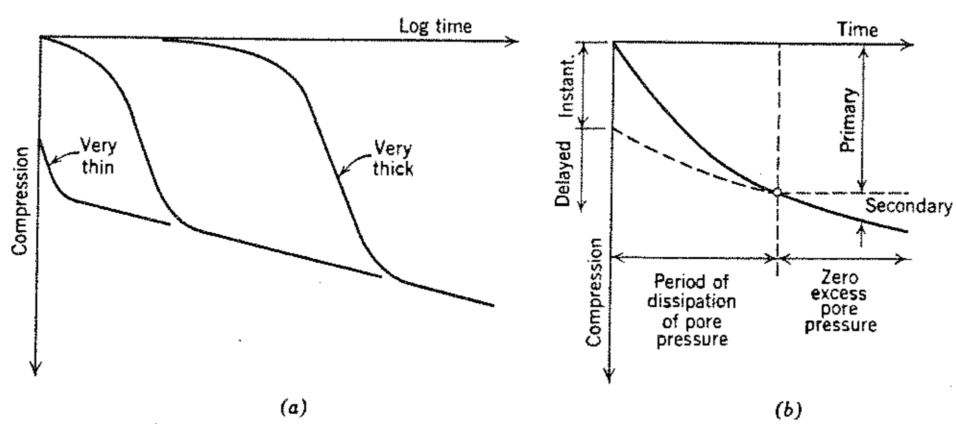

Fig. 27.16 Relation of instantaneous and delayed compression to primary and secondary compression. (*a*) For different thicknesses. (*b*) For a given thickness.

Ref! Soil Mechanics Lambe & Whitman

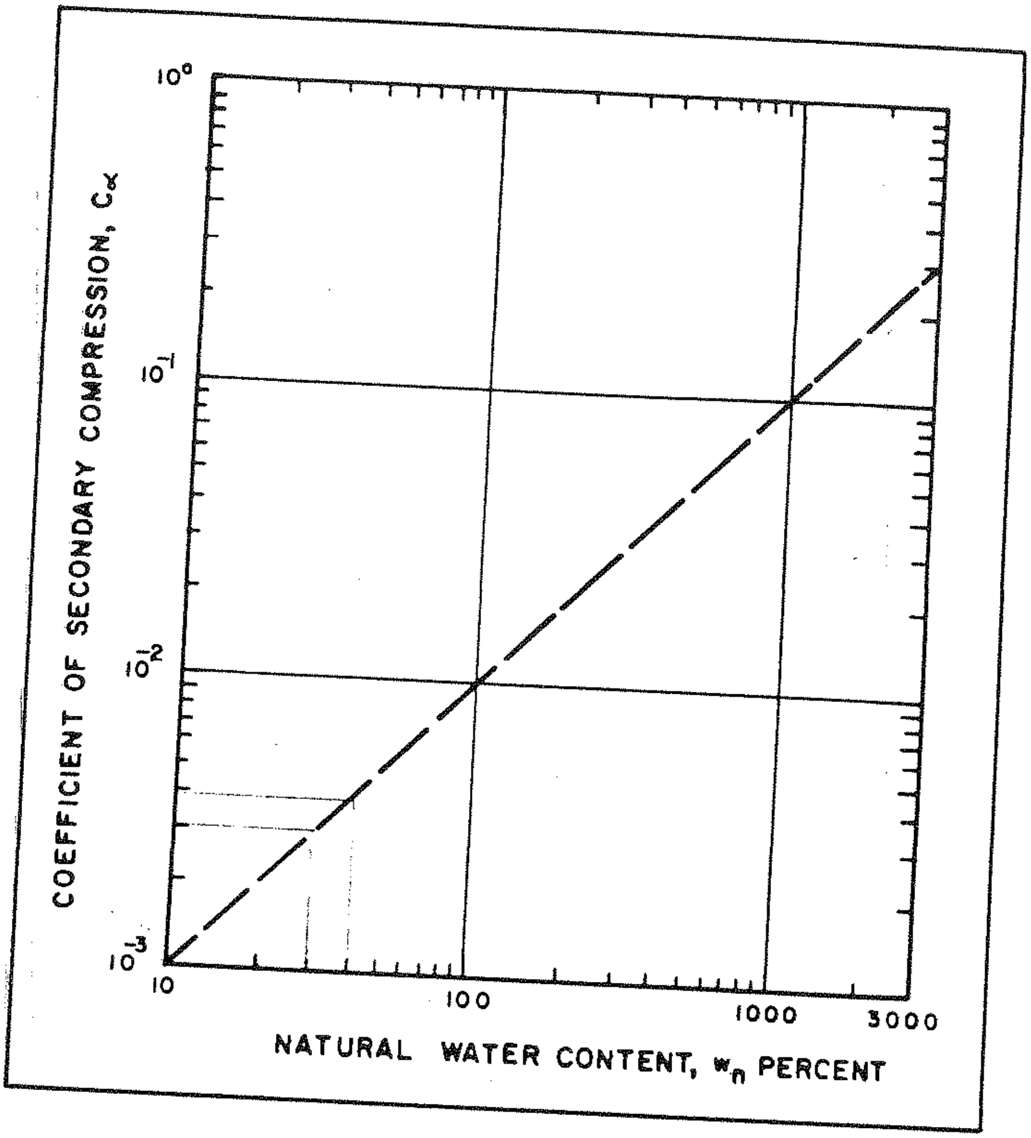

FIGURE 16
Coefficient of Secondary Compression as Related to Natural Water Content

Ref: NAVFAC DM 7-1

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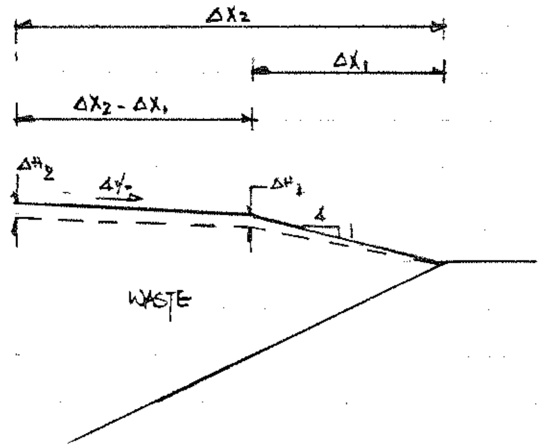
THE FINAL GRADE ON THE LANDFILL COVER BETWEEN ANY TWO POINTS MAY BE CALCULATED AS FOLLOW:

$$G_f = \frac{(EL_2 - \Delta H_2) - (EL_1 - \Delta H_1)}{(\Delta X_2 - \Delta X_1)}$$



WHERE

EL_2 = ELEVATION AT POINT 2

EL_1 : ELEVATION AT POINT 1

ΔH_2 = SETTLEMENT AT POINT 2

ΔH_1 = SETTLEMENT AT POINT 1

$(\Delta X_2 - \Delta X_1)$ = DISTANCE BETWEEN 2 POINTS

Total settlement after closure = 0.075 of the Total Ht.

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SECTION 1

STATION	FINISH ELEVATION (FT)	WASTE THICKNESS (FT)	ΔH 0.075 H (FT)	FINAL ELEVATION (FT)	DISTANCE (FT)	FINAL GRADE %
1	810	0	0	810		
					165	19.9
2	850	95	7.13	842.87		
					440	23.4
3	960	190	14.25	945.75		
					35	3.1
4	962.2	205	15.38	946.82		
					35	9.1
5	960	218	16.35	943.65		
					440	21.8
6	850	28	2.1	847.9		
					40	19.8
7	840	0	0	840		

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SECTION 2

STATION	FINISH ELEVATION (FT)	WASTE THICKNESS (FT)	ΔH 0.075 H (FT)	FINAL ELEVATION (FT)	DISTANCE (FT)	FINAL GRADE %
1	770	0	0	770		
2	850	150	11.25	838.75	335	20.5
3	935	230	17.25	917.75	350	22.6
4	960	252	18.9	941.1	170	13.7
5	968.25	240	18	950.25	140	6.5
6	960	190	14.25	945.75	135	3.4
7	850	38	2.85	847.15	440	22.4
8	835	0	0	835.0	55	22.1

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SECTION 3

STATION	ELEVATION (FT)	WASTE THICKNESS (FT)	ΔH 0.075 H (FT)	FINAL ELEVATION (FT)	DISTANCE (FT)	FINAL GRADE %
1	830	0	0	830		
2	850	55	4.13	845.87	85	18.7
3	890	145	10.88	879.12	165	20.15
4	910	175	13.13	896.87	470	3.8
5	940	210	15.75	924.25	450	6.1
6	920	192	14.4	905.6	220	8.5
7	920	190	14.25	905.75	205	0*
8	850	10	0.75	849.25	285	19.8
9	845	0	0	845	15	28.3

* Refer to Attachment A section on plan view, section not nearly perpendicular to the drain slope.

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SECTION 4

STATION	ELEVATION (FT)	WASTE THICKNESS (FT)	ΔH 0.075 H (FT)	FINAL ELEVATION (FT)	DISTANCE (FT)	FINAL GRADE %
1	808	0	0	808		
2	850	110	8.25	841.75	175	19.3
3	960	255	19.13	940.87	440	22.5
4	850	150	11.3	838.7	440	23.2
5	800	0	0	800	275	14.1

Based on the final cover post-closure settlement calculations for the four sections. The results indicate change of grade after settlement will have no adverse effect on surface drainage.

After settlement the gradients are still more than 3% which is the mini. requirement for drainage.

A summary for final cover Post-closure grade evaluation is shown on pages 10-13 for sections 1-4

Due to the geometry of the final cover, the length of the slope will be reduced due to the settlement and thus the liner. The reduce in strain is expected to be small and will be readily absorbted by the soil cover and the liner without causing damage to the system.

APPENDIX H

STABILITY ANALYSES

APPENDIX H.1	**GENERAL METHODOLOGY FOR ROCK CUTSLOPE, COMPACTED FILL SLOPE, AND INTERMEDIATE PHASE I CLOSURE STABILITY ANALYSES**
APPENDIX H.2	**ROCK CUTSLOPE STABILITY**
APPENDIX H.3	**COMPACTED FILL SLOPE STABILITY**
APPENDIX H.4	**INTERMEDIATE PHASE I CLOSURE AND INTERMEDIATE PHASE IIIA WASTE SLOPE STABILITY**
APPENDIX H.5	**FINAL CLOSURE STABILITY**

APPENDIX H.1

GENERAL METHODOLOGY FOR ROCK CUTSLOPE, COMPACTED FILL SLOPE, AND INTERMEDIATE PHASE I CLOSURE STABILITY ANALYSES

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GENERAL

B-18 LANDFILL

SLOPE STABILITY ANALYSIS

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SLOPE STABILITY ANALYSIS

OBJECTIVE EVALUATE THE STATIC AND SEISMIC STABILITY OF THE SLOPES FOR THE FOLLOWING CASES:

- ROCK CUTS
- COMPACTED FILL EMBANKMENTS
- TEMPORARY PHASE I INTERMEDIATE WASTE FILL
- CLOSURE CONDITIONS

REFERENCES

1- PERMANENT DISPLACEMENTS OF EARTH EMBANKMENTS BY NEWMARK SLIDING BLOCK ANALYSIS. FRANKLIN AND CHANG, U.S. ARMY ENGINEERS WATERWAYS EXPERIMENT STATION, NOVEMBER 1977

2. FIFTH RANKINE LECTURE, EFFECTS OF EARTHQUAKES ON DAMS AND EMBANKMENTS, N.M NEWMARK, 1965

3 A PRACTITIONER'S VIEW OF SITE EFFECTS ON STRONG GROUND MOTION. NEVILLE DONOVAN. PROCEEDINGS OF CONFERENCE XXII. U.S. DEPARTMENT OF THE INTERIOR GEOLOGICAL SURVEY, SANTA FE NEW MEXICO, JULY 1983.

4 SEISMIC STABILITY EVALUATION FOR THE TOE BUTTRESS CONSTRUCTION, OPERATING INDUSTRIES, INC. SITE, MONTEREY PARK, CALIFORNIA. DOCUMENT No 120-R12-RT-EPNN-1, PREPARED FOR U.S. EPA by Woodward-Clyde Consultants

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Chkd. By GSC Date 8/15/90 SLOPE STABILITY ANALYSIS Proj. No. 89-977

5 ENGINEERING REPORT, CHEMICAL WASTE MANAGEMENT, INC KETTLEMAN HILLS FACILITY, LANDFILL B-19, PHASES II AND III, DONOHUE & ASSOCIATES, OCTOBER 1983.

6 SLOPE STABILITY FAILURE INVESTIGATION, LANDFILL UNIT B-19, PHASE I-A, KETTLEMAN HILLS, CALIFORNIA, SEED R.B ET AL U.C.B, JULY 1988

7 OPERATIONS PLAN FOR LANDFILL UNIT B-19, CWI, KETTLEMAN HILLS FACILITY, REVISION 0, JUNE 26, 1989.

8 FEASIBILITY STUDY FOR FINAL LANDFILL COVER SYSTEMS, KETTLEMAN HILLS FACILITY - DRAFT- GOLDER ASSOCIATES INC., AUGUST 1989

9 DIRECT SHEAR TESTING PROGRAM FOR LANDFILL COVER DESIGN KETTLEMAN HILLS FACILITY, GOLDER ASSOCIATES, JUNE 29, 1990

10 UPDATED EVALUATION OF SITE DESIGN GROUND MOTIONS FOR THE CWM KETTLEMAN HILLS FACILITY, GOLDER ASSOCIATES, SEPTEMBER 1988.

11 FILLING PLAN LANDFILL B-19, PHASES II AND III, KETTLEMAN HILLS FACILITY, GOLDER ASSOCIATES, MAY 1989

12 SUPPORTING CALCULATIONS FOR THE LANDFILL B-15 CLOSURE PLAN, KETTLEMAN HILLS FACILITY, GOLDER ASSOCIATES, DECEMBER 1989

13 CLOSURE PLAN FOR LANDFILL B-16, KETTLEMAN HILLS FACILITY, KETTLEMAN CITY, CALIFORNIA, GOLDER ASSOCIATES, APRIL 23, 1990

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14 COMBINED CLOSURE PLAN FOR LANDFILLS B-1/4/5/6/7, B-8/9/9 EXPANSION/9 EXTENSION/10/11, SURFACE IMPOUNDMENTS P-5/12/12A/13/17 AND AREA S-3. REVISION 2 - DRAFT - KETTLEMAN HILLS FACILITY, GOLDER ASSOCIATES JUNE 1990

15 DIRECT SHEAR. INTERFACE STRENGTH TESTING SELECTED GEOTEXTILE INTERFACES, GEOSERVICES INC. CONSULTING ENGINEERS, APRIL 5 1990.

16 GEOSYNTEC PROJECT G88-383, FINAL REPORT ON THE DIRECT SHEAR TESTING FOR THE WASTE MANAGEMENT, INC. NEW MILFORD, CONNECTICUT, LANDFILL, GEOSERVICES INC. CONSULTING ENGINEERS, OCTOBER 11, 1988

17 FRICTIONFLEX™ APPLICATION DATA, SLT NORTH AMERICA, INC

18 DIRECT SHEAR TESTING OF FRICTION LINER MATERIALS, GUNDLE LINING SYSTEMS, INC, (SEVERAL SEPARATE REPORTS)

19 TECHNICAL GUIDANCE DOCUMENT: FINAL COVERS ON HAZARDOUS WASTE LANDFILLS AND SURFACE IMPOUNDMENTS, EPA/530-SW-89-047 JULY 1989.

20 STABL5 USER MANUAL - SCHOOL OF CIVIL ENGINEERING, INDIANA DEPARTMENT OF HIGHWAYS, RONALD A. SIEGEL, JUNE 4, 1975

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Chkd. By GKC Date 8/13/90 SLOPE STABILITY ANALYSIS Proj. No. 89-977

21 DYNAMIC STABILITY OF CUT SLOPES IN BEDROCK, LANDFILL B-19, GOLDER ASSOCIATES, JUNE 1989

22 Lambe, Whitman, Soil Mechanics, John Wiley & Sons. Inc, 1969

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EARTHQUAKE GROUND MOTION PARAMETERS

THE SEISMIC DESIGN OF THE B-18 LANDFILL SHOULD BE BASED ON THE MAXIMUM CREDIBLE EARTHQUAKE (MCE) ACCORDING TO 22 CAC 67108(b). THE MCE IS THE LARGEST EARTHQUAKE CONSIDERED POSSIBLE TO OCCUR ON A FAULT UNDER PRESENT GEOLOGIC CONDITIONS WITHOUT REGARD TO RECURRENCE INTERVAL.

THE IDENTIFICATION AND CHARACTERIZATION OF POTENTIAL SOURCES OF EARTHQUAKES IS PRESENTED IN REFERENCE 10.

FROM REFERENCE 10, THE DOMINANT SEISMIC SOURCE IS:

- Coalinga-Type EARTHQUAKE
- NORTH DOME SEGMENT OF THE RAMP-THRUST

- $M_S = 7.0$

- FOCAL DEPTH 10 KM

- HIGHEST POTENTIAL MEAN PEAK ACCELERATION IS 0.43 g. THE 0.43 g VALUE IS THE RESULT OF ADDING A FACTOR OF 20% TO THE BASE ACCELERATION OF 0.36 g BECAUSE THE SOURCE STRUCTURE IS A THRUST FAULT. (REFERENCE 10)

COMPUTER PROGRAM "STABL5" DEVELOPED BY PURDUE UNIVERSITY (REFERENCE 20). THE PROGRAM CALCULATES THE FACTOR OF SAFETY AGAINST SLOPE FAILURE BY A TWO-DIMENSIONAL LIMITING EQUILIBRIUM METHOD.

THE CALCULATION OF THE FACTOR OF SAFETY AGAINST SLOPE INSTABILITY IS PERFORMED USING:

- Modified Bishop METHOD OF SLICES (CIRCULAR FAILURE SURFACES)
- Modified JANBU METHOD OF SLICES (BLOCK, WEDGE FAILURE MODE)

SEISMICALLY-INDUCED PERMANENT DISPLACEMENTS

THE AMPLITUDE OF SEISMICALLY-INDUCED PERMANENT DISPLACEMENT IS CALCULATED USING THE METHOD SUGGESTED BY Newmark (REFERENCE 2) AND EXPANDED BY FRANKLIN & CHAN (REFERENCE 1). THIS METHOD OF ANALYSIS INVOLVES CALCULATING THE EARTHQUAKE-INDUCED INERTIA FORCE (THE DRIVING FORCE) ON A POTENTIAL SLIDING MASS AND COMPARING THIS DRIVING FORCE WITH THE RESISTING FORCE DUE TO THE SHEAR STRENGTH OF THE MATERIALS. THE SEISMICALLY-INDUCED PERMANENT DISPLACEMENT OF THE POTENTIAL SLIDE MASS OCCURS WHENEVER THE DRIVING FORCE EXCEED THE RESISTING FORCE. THEREFORE, IF THE AVERAGE INDUCED ACCELERATION ON A POTENTIAL SLIDE MASS IS LARGER THAN ITS YIELD ACCELERATION (THE ACCELERATION AT WHICH THE POTENTIAL MASS WILL JUST BEGIN TO MOVE), THE MOVEMENT WILL START AND STOP WHEN THE DIRECTION OF THE GROUND

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ACCELERATION IS REVERSED AND THE AVERAGE ACCELERATION BECOMES LESS THAN THE YIELD ACCELERATION. BY DOUBLE INTEGRATION OF THE PART OF THE AVERAGE ACCELERATION TIME HISTORY THAT EXCEEDS THE YIELD ACCELERATION, PERMANENT DISPLACEMENTS CAN BE CALCULATED. THIS PROCEDURE IS SHOWN IN FIGURE 1.

THE YIELD ACCELERATION FOR A GIVEN SLOPE CONFIGURATION IS DETERMINED BY ESTIMATING THE HORIZONTAL EARTHQUAKE LOADING COEFFICIENT "K" WHICH RESULTS IN A PSEUDOSTATIC FACTOR OF SAFETY EQUAL TO 1.

K IS GIVEN IN TERMS OF g, THEREFORE REPRESENTS THE HORIZONTAL ACCELERATION APPLIED TO THE SLIDING MASS.

PERMANENT DISPLACEMENTS ARE CALCULATED AS A FUNCTION OF THE YIELD ACCELERATION USING FRANKLIN & CHAN UPPER BOUND ENVELOPE CURVES SHOWN IN FIGURE 2. (REFERENCE 1)
FRANKLIN AND CHAN EXPANDED NEWMARK'S DATA BASE. ALL EARTHQUAKE RECORDS WERE SCALED TO 0.5 g PEAK ACCELERATION AND 30-IN./SEC PEAK VELOCITY AND THE RESULTING SCALED PERMANENT DISPLACEMENTS ARE PLOTTED AGAINST THE RATIO N/A ON A LOGARITHMIC PLOT. IN THIS PLOT UPPER BOUND CURVES ARE PRESENTED FOR VARIOUS RANGES IN THE VALUE OF N/A WHERE N IS THE YIELD ACCELERATION AND A IS THE MAXIMUM EARTHQUAKE ACCELERATION ACTING UPON THE POTENTIAL MOVING MASS. THE PROPOSED UPPER BOUND CURVES ARE DESCRIBED IN THE LEGEND OF FIGURE 2 (UPPER RIGHT HAND CURVES)

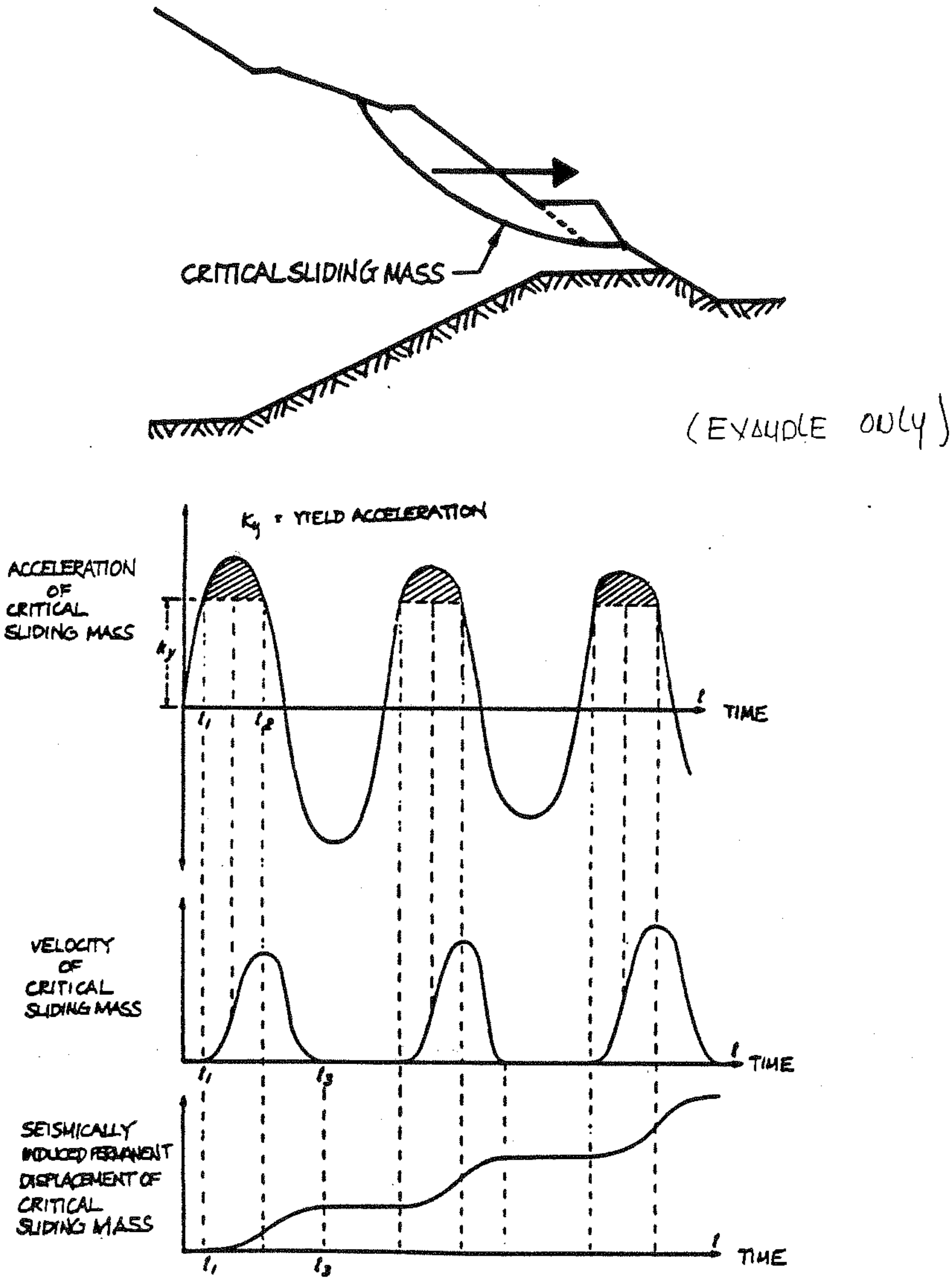
CRITICAL SLIDING MASS
(EXAMPLE ONLY)
k_y = YIELD ACCELERATION
ACCELERATION OF CRITICAL SLIDING MASS
k_y
t_1
t_2
t
TIME
VELOCITY OF CRITICAL SLIDING MASS
t_1
t_3
t
TIME
SEISMICALLY INDUCED PERMANENT DISPLACEMENT OF CRITICAL SLIDING MASS
t_1
t_3
t
TIME

FIGURE 1

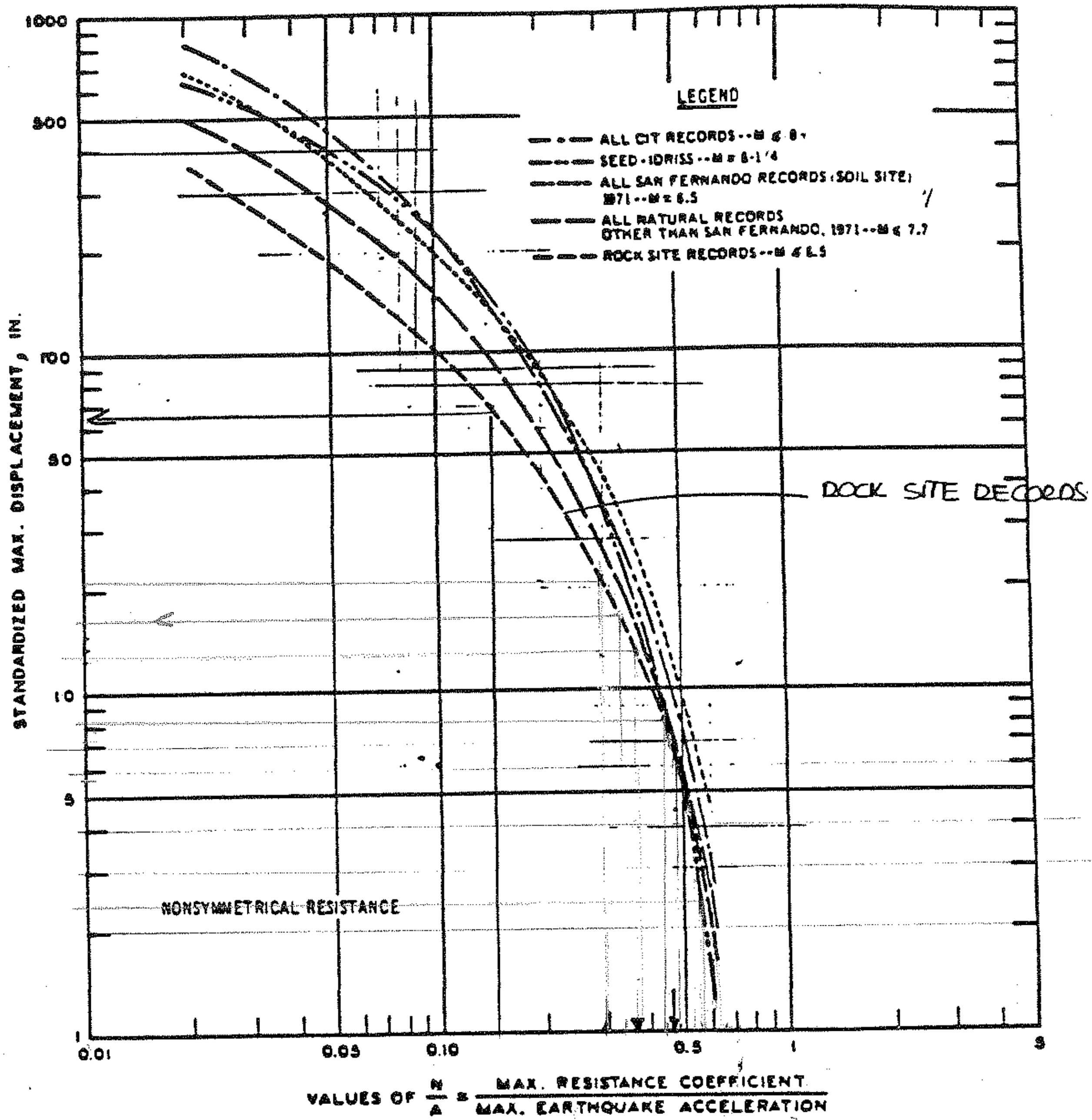

Figure 16. Upper bound envelope curves of permanent displacements for all natural and synthetic records analyzed

(REFERENCE 1)

18.5
13

FIGURE 2

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SOIL PROFILE AVAILABLE SUBSURFACE INFORMATION AND SITE GEOLOGY INDICATE THAT THE B-18 SITE IS CONSIDERED AS A "ROCK" SITE. CONSEQUENTLY THE UPPER BOUND CURVE IN FIGURE 2 DESIGNATED AS ROCK SITE RECORDS IS USED IS THIS ANALYSIS.

ANALYSIS PROCEDURE

THE PROCEDURE TO OBTAIN UNSCALED PERMANENT DISPLACEMENTS FOR A GIVEN SLOPE CONFIGURATION IS AS FOLLOWS:

OBTAIN K_y (YIELD ACCELERATION) BY USING STABL5 COMPUTER PROGRAM. K VARIES TO OBTAIN A S.F = 1

↓

ASSUME THREE DIFFERENT VALUES OF A (A_1, A_2 & A_3). A IS THE MAXIMUM GROUND ACCELERATION

↓

OBTAIN $\frac{K_y}{A_1}$, $\frac{K_y}{A_2}$, $\frac{K_y}{A_3}$

↓

$K_y = N \Rightarrow$ WITH $\frac{N}{A_1}$, $\frac{N}{A_2}$ AND $\frac{N}{A_3}$ ENTER FIGURE 2.

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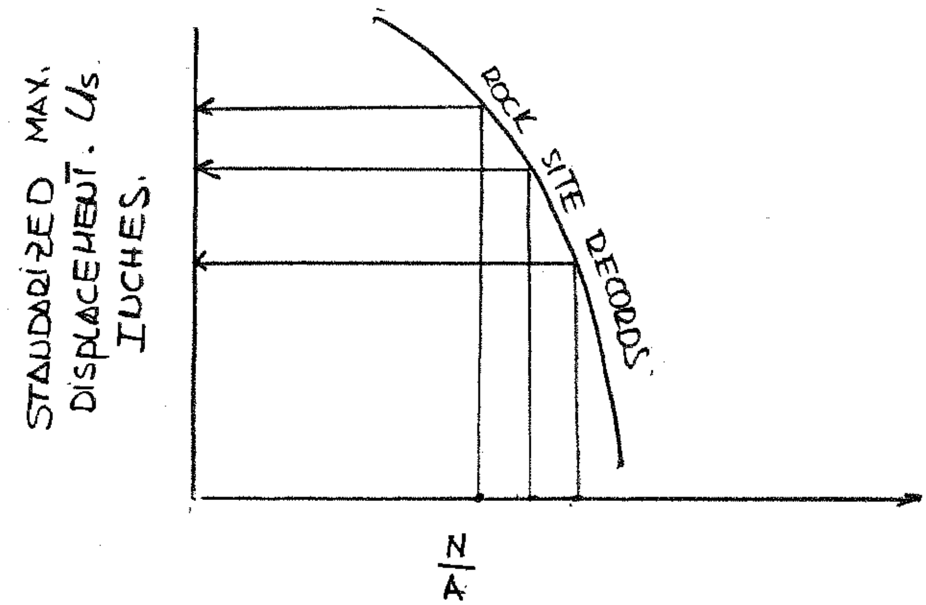
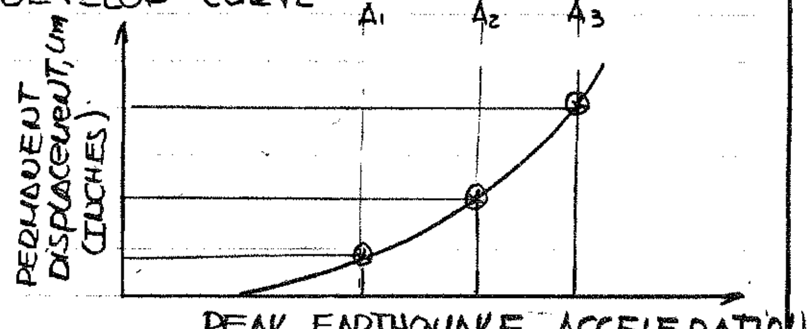


FIGURE 2

OBTAIN PERMANENT DISPLACEMENT VALUES BASED ON:

- $\frac{V}{A} = 30$ (SITE SPECIFIC PARAMETER)
- $U_m = U_s \frac{V^2}{1,800A}$ (FROM REFERENCE 1)

DEVELOP CURVE



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VELOCITY / ACCELERATION (V/A) RATIO

FROM REFERENCE 3. Donovan proposes relationships for site dependent $\frac{V}{A}$ ratios. Range of $\frac{V}{A}$ values for rock and soil sites are shown in Figure 3

A conservative estimate of $\frac{V}{A}$ ratio for the KHF is obtained by

$$\left(\frac{V}{A}\right)_{KHF} = \frac{\left(\frac{V}{A}\right)_{\substack{\text{AVERAGE}\\ \text{ROCK SITES}}} + \left(\frac{V}{A}\right)_{\substack{\text{AVERAGE}\\ \text{SOIL SITES}}}}{2}$$

$$\left(\frac{V}{A}\right)_{KHF} = \frac{37 + 23}{2} = 30$$

⇒ Estimate permanent displacements for a range of peak ground accelerations (.3g to .5g) for the site specific $\frac{V}{A}$ ratio of 30.

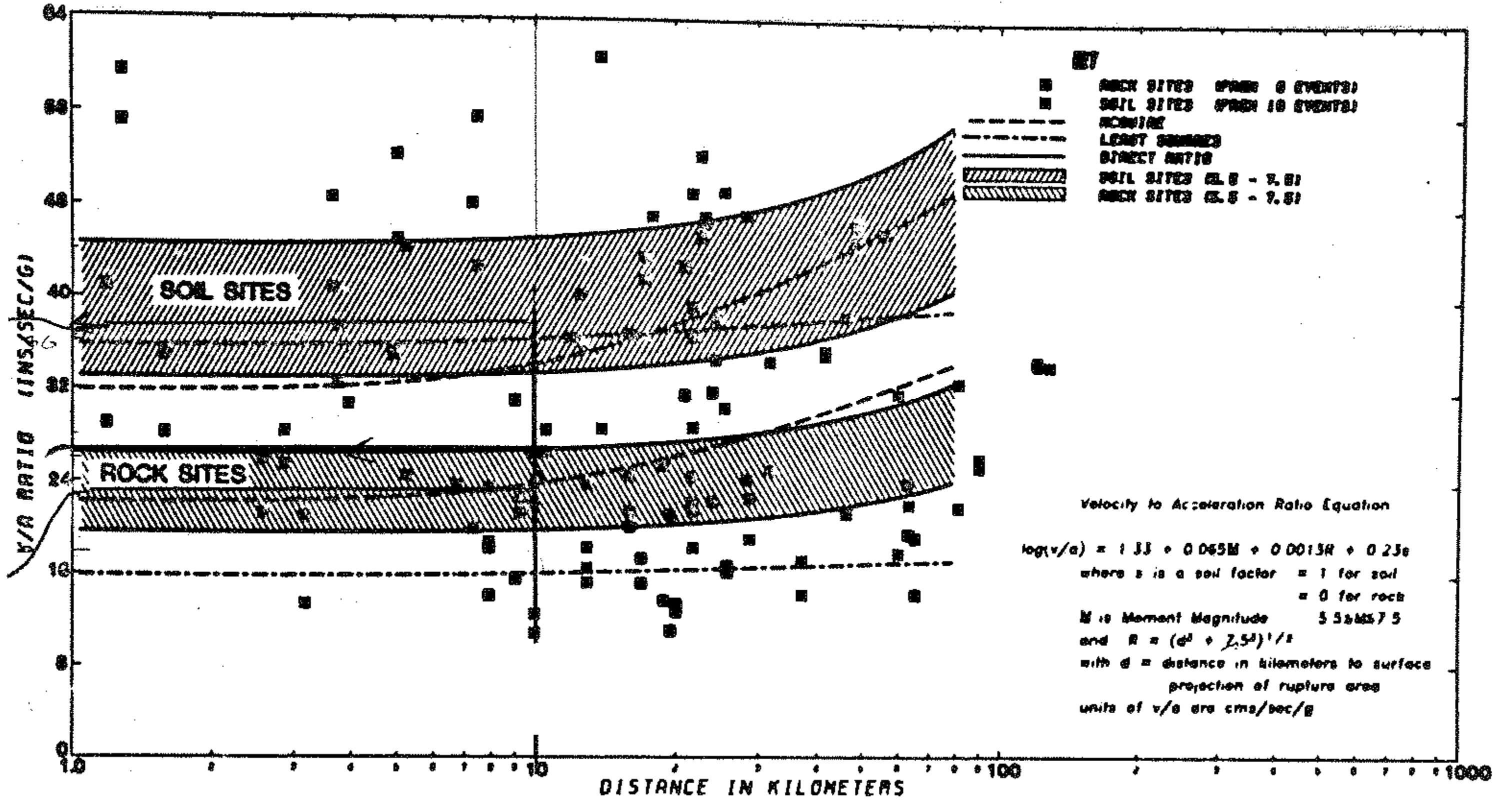

Figure 3. Measured velocity/acceleration (V/A) ratios and derived V/A equations. Shaded areas show range of values obtained using equation for rock and soil sites.

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UNSCALED PERMANENT DISPLACEMENTS

FROM REFERENCE 1 (PAGE 20)

$$U_m = U_s \times \frac{V^2}{1{,}800\ A}$$

U_m = UNSCALED PERMANENT DISPLACEMENT
A = MAXIMUM GROUND ACCELERATION
V = MAXIMUM GROUND VELOCITY
U_s = STANDARDIZED MAXIMUM DISPLACEMENT (FROM FIG 2)

FOR $\frac{V}{A} = 30$

V = 30 × A

A	V (INCH/sec)	$U_m = U_s \times \frac{V^2}{1{,}800 A}$
.3	9.0	U_m = .15 U_s
.4	12.0	U_m = .20 U_s
.5	15.0	U_m = .25 U_s
.6	18.0	U_m = .30 U_s
.7	21.0	U_m = .35 U_s

ENVIRONMENTAL SOLUTIONS, INC.

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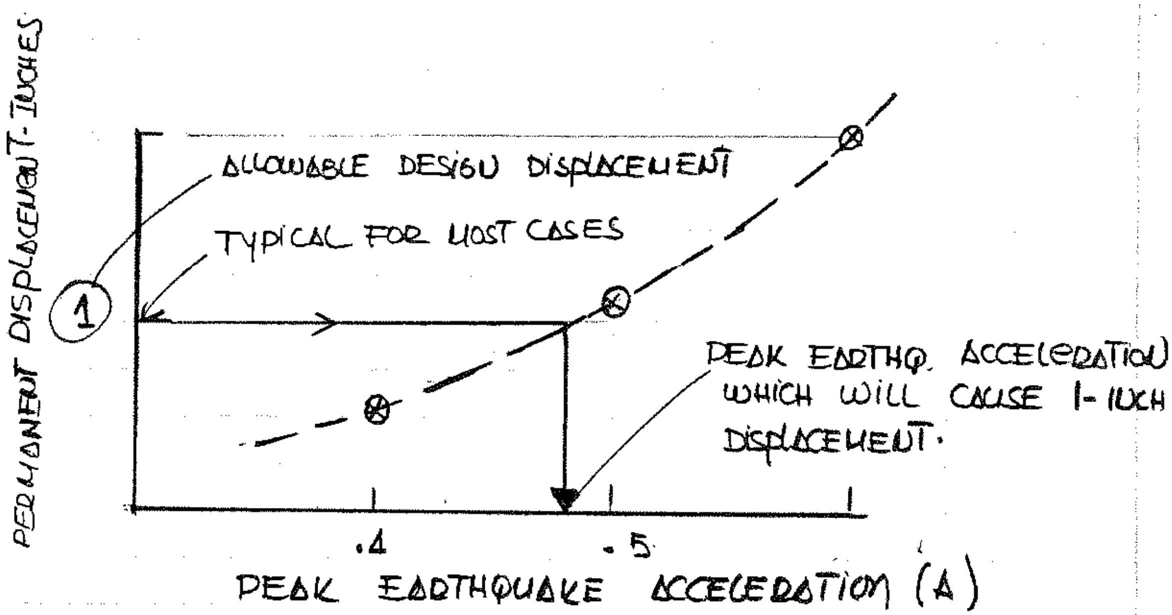
ALLOWABLE DESIGN DISPLACEMENT FOR THE MCE

FOR EACH CONDITION THE PEAK EARTHQUAKE ACCELERATION WHICH WILL CAUSE THE ALLOWABLE DESIGN DISPLACEMENT IS ESTIMATED AS FOLLOWS



BECAUSE OF THE WAY SEISMIC WAVES PROPAGATE, ATTENUATION FACTORS ARE CONSIDERED TO TAKE INTO ACCOUNT THE EFFECT OF THE WASTE PILE ON THE SEISMIC DEFORMATIONS.

FOR DEEP FAILURE MODE, THE ACCELERATION IN THE SLIDING MASS IS ASSUMED TO BE .8 TIMES THE PEAK BASE ACCELERATION (A_0)

$$A = .8 A_0$$

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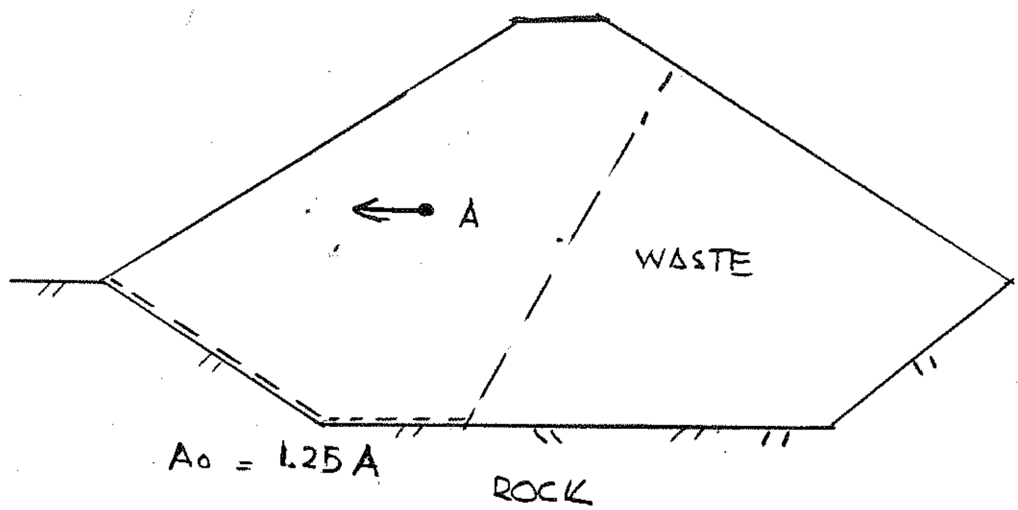
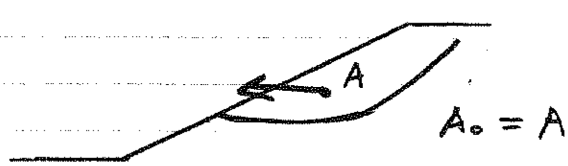
OR $A_o = 1.25\,A$



THIS RELATIONSHIP IS CONSERVATIVE BASED ON THE RESULTS OF DYNAMIC RESPONSE ANALYSIS FOR THE OPERATING INDUSTRIES LANDFILL (REFERENCE 4) FOR 0.50 g AND 0.25 g AS SHOWN IN FIGURES 5 AND 6 RESPECTIVELY.

- NOTE THAT FOUNDATION CONDITIONS FOR BOTH LANDFILLS ARE SIMILAR. DENSER WASTE MATERIALS WILL BE PLACED AT THE B-18 LANDFILL, THEREFORE A HIGHER ATTENUATION FACTOR IS CONSIDERED (.8 AS OPPOSSED TO .7 FOR .25 g)

- THE ACCELERATION IN THE SLIDING MASS (A) IS ASSUMED TO BE THE SAME AS THE PEAK BASE ACCELERATION FOR SHALLOW FAILURE MODE SUCH AS THE COVER LINER SLIDING. (SEE FIGURE 6)



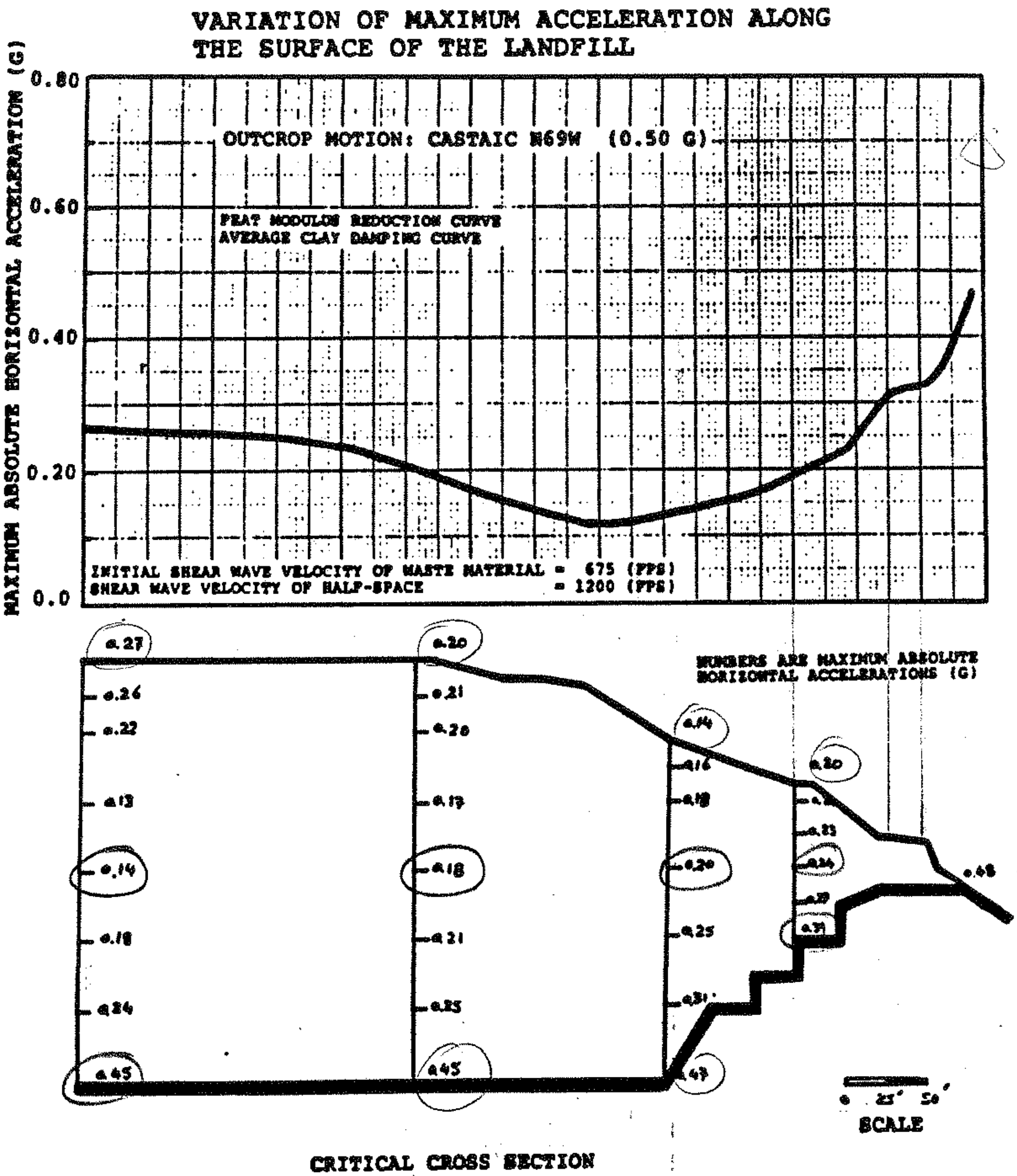
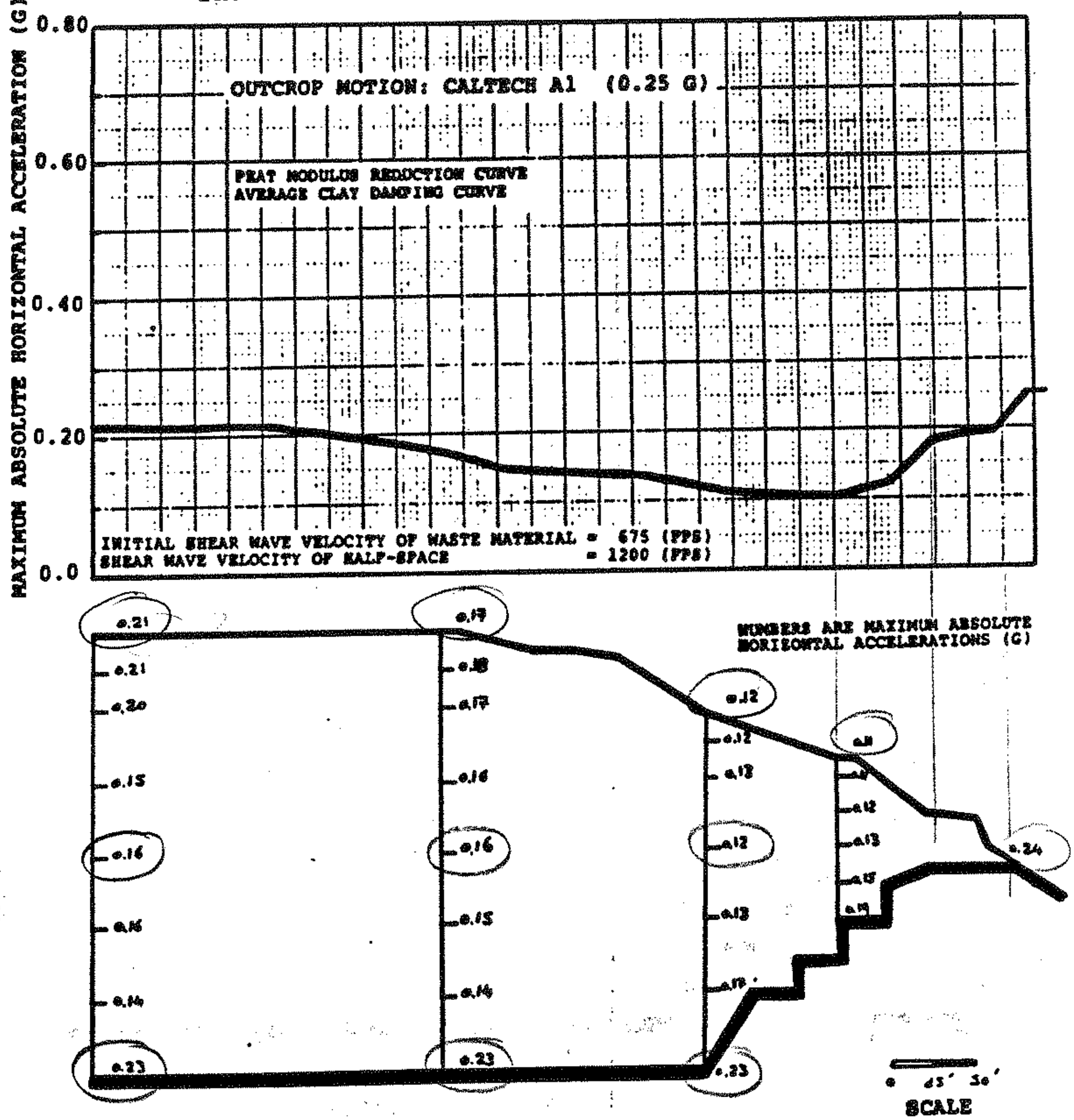


FIGURE 5

Project: OPERATING INDUSTRIES LANDFILL Project No. 120R12	RESULTS OF DYNAMIC RESPONSE ANALYSIS — CASE 1	Fig. E-5

WOODWARD-CLYDE CONSULTANTS

VARIATION OF MAXIMUM ACCELERATION ALONG THE SURFACE OF THE LANDFILL



CRITICAL CROSS SECTION

FIGURE 6

Project: OPERATING INDUSTRIES LANDFILL Project No. 120R12	RESULTS OF DYNAMIC RESPONSE ANALYSIS – CASE 3	Fig. E-7

WOODWARD-CLYDE CONSULTANTS

ENVIRONMENTAL SOLUTIONS, INC.

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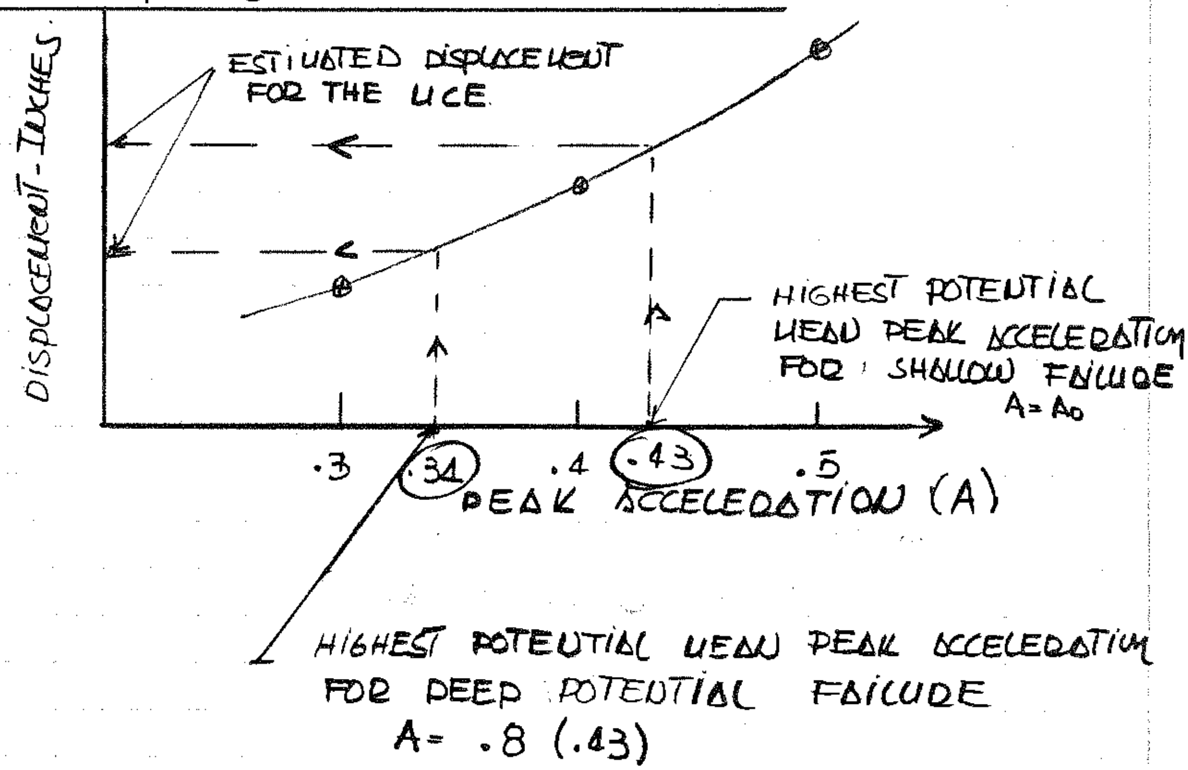
ESTIMATED DISPLACEMENT FOR THE MCE



RISK ASSESSMENT FOR DYNAMIC CONDITIONS

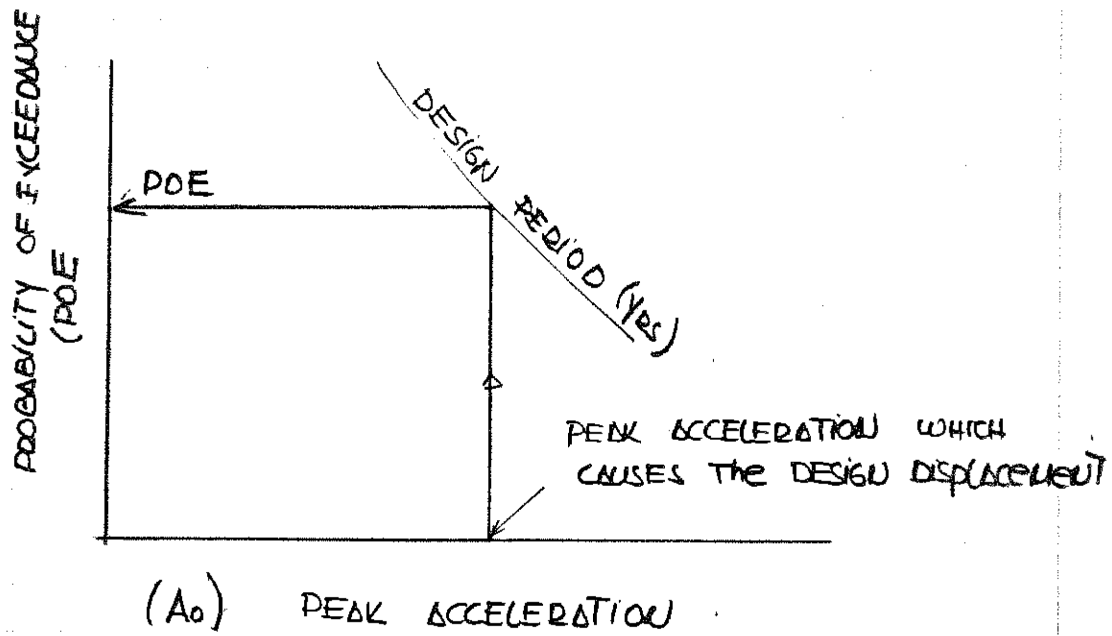
A PROBABILISTIC ASSESSMENT OF DESIGN GROUND MOTIONS FOR THE KETTLEMAN HILLS FACILITY IS PRESENTED IN REFERENCE 10 (GOLDER ASSOCIATES)

FIGURE 4 (FROM REFERENCE 10) PRESENTS THE RELATIONSHIP BETWEEN THE PROBABILITY OF EXCEEDANCE AND PEAK ACCELERATION (g) FOR TIME PERIODS OF 1, 20, AND 50 YEARS.

BASED ON THIS FIGURE THE PROBABILITY OF EXCEEDANCE

(POE) FOR THE ALLOWABLE DESIGN DISPLACEMENT IS ESTIMATED.

AS SHOWN IN FIGURE 4:



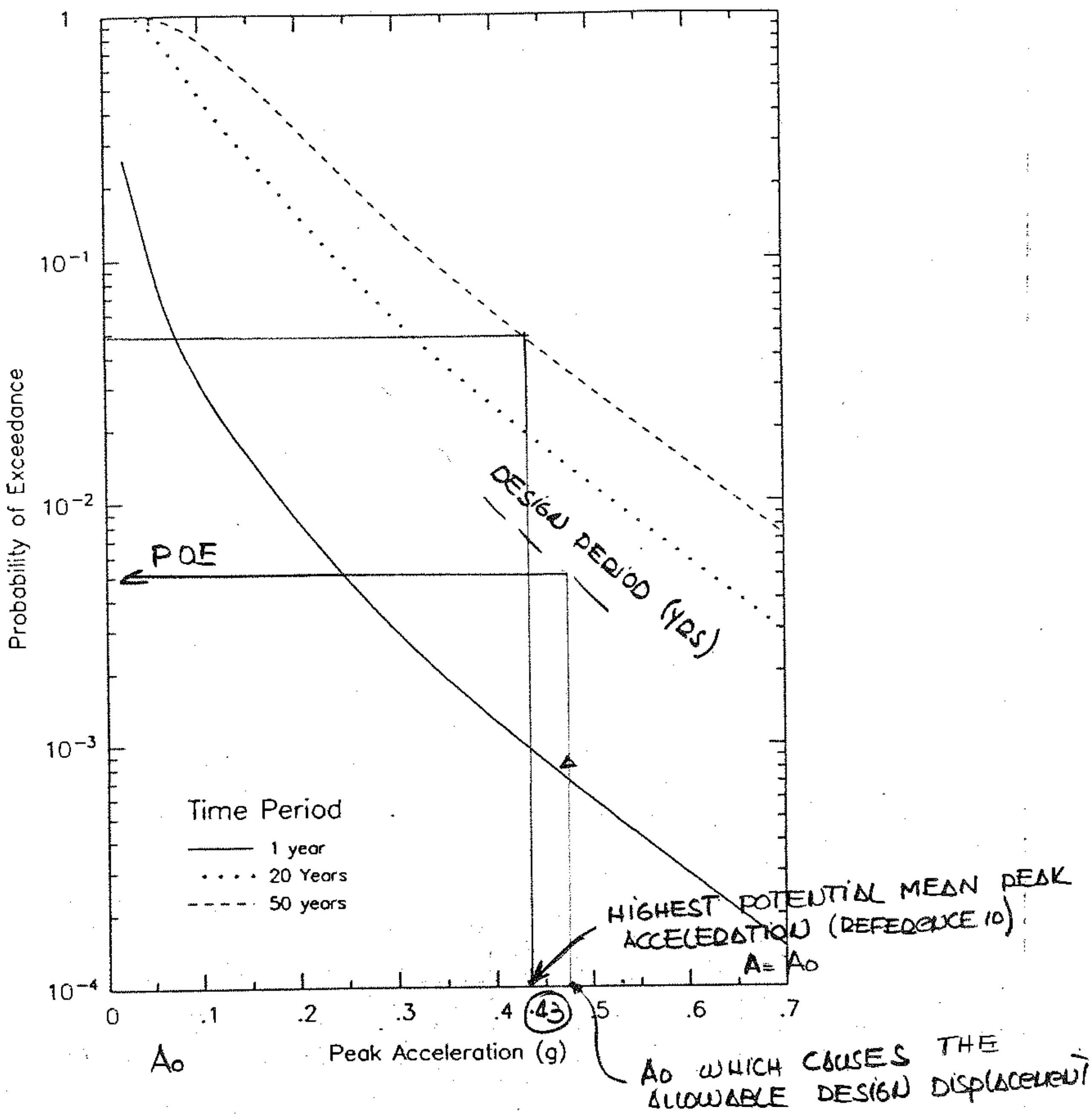


Figure 3. Probability of exceedance as a function of time period

FIGURE 4

ENVIRONMENTAL SOLUTIONS, INC.

By J. B Date 8/9/90 Subject B-18 LANDFILL Sheet No. 22 of 28
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CASES TO BE ANALYZED

I - ROCK CUTS

a- 2:1 SLOPES WITH POTENTIAL SLIDING ACCROSS BEDDING PLANES

b - 3:1 SLOPES WITH POTENTIAL SLIDING ALONG BEDDING PLANES.

II COMPACTED FILL EMBANKMENTS

a- RUNOFF RETENTION BASIN

b. Small EMBANKMENT TO COMPLETE PHASE I/II BERM

ENVIRONMENTAL SOLUTIONS, INC.

By J. B. Date 8/9/90 Subject B-18, LANDFILL Sheet No. 22A of 28
Chkd. By GSC Date 8/13/90 SLOPE STABILITY ANALYSIS Proj. No. 89-977

III TEMPORARY PHASE I INTERMEDIATE WASTE FILL

a – WEDGE MOVEMENT ALONG THE LINER SURFACE
- ENTIRELY ALONG INTERFACE
- THROUGH WASTE AT BASE / BERM INTERSECTION

b – CIRCULAR FAILURE WITHIN THE WASTE
- WITH WASTE STRENGTH : $\phi = 31°$, $c = 0$
- WITH WASTE STRENGTH $\phi = 27°$, $c = 300$ psf

IV FINAL CLOSURE CONDITIONS

a – 3.6 : 1 SLOPE BETWEEN BENCHES (INFINITE SLOPE MODEL)

1 - AT CLAY / OPERATION LAYER INTERFACE

2 - AT ROUGHENED HDPE / CLAY INTERFACE

3 - AT GEOCOMPOSITE / ROUGHENED HDPE INTERFACE (NO COHESION ALLOWANCE)

4 - AT GEOCOMPOSITE / ROUGHENED HDPE INTERFACE ($c = 50$ psf)

b – WEDGE MOVEMENT ALONG THE LINER SURFACE.

1 - ENTIRELY ALONG INTERFACE

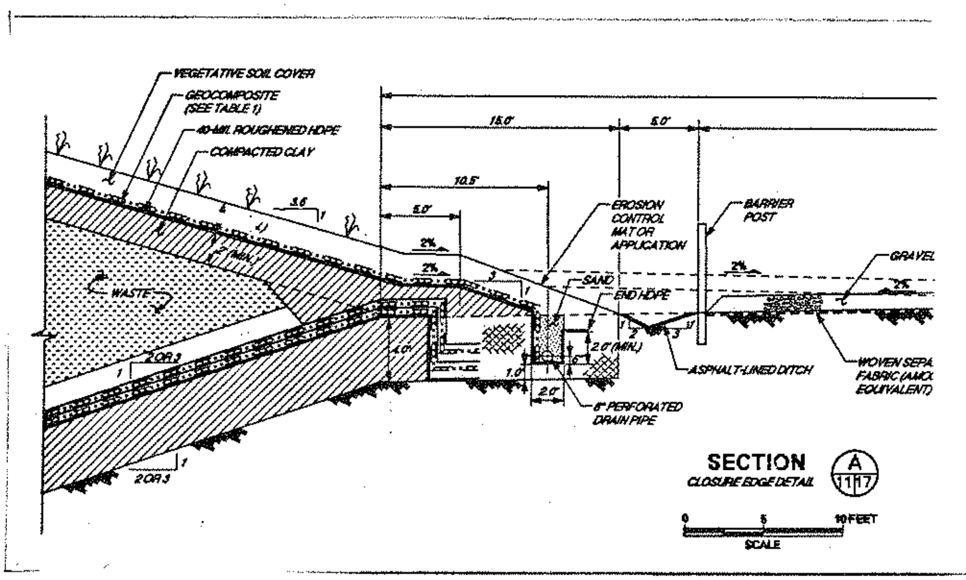
2 - THROUGH WASTE AT BASE / SLOPE INTERSECTION.

c - CIRCULAR FAILURE WITHIN THE WASTE

ENVIRONMENTAL SOLUTIONS, INC.

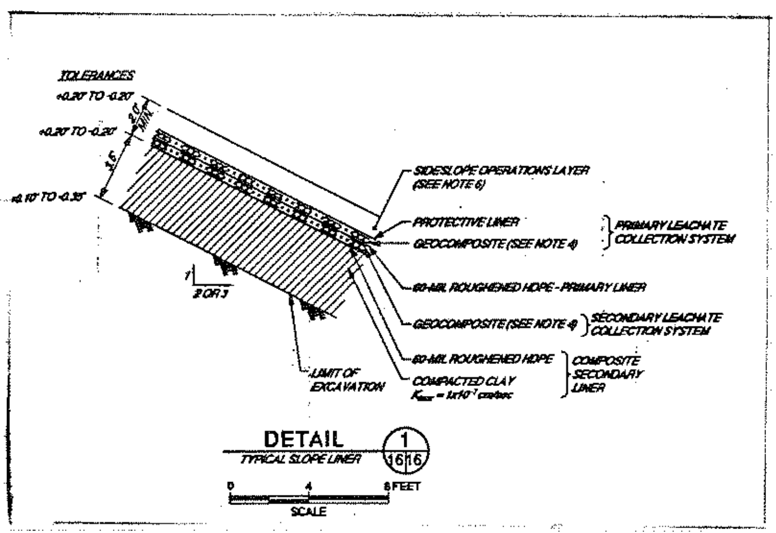
By J. B Date 8/9/90 Subject B-18 LANDFILL Sheet No. 23 of 28
Chkd. By GSC Date 8/13/90 SLOPE STABILITY ANALYSIS Proj. No. 89-977

TYPICAL LINER SYSTEM DETAILS.



SECTION (A 11/17)
CLOSURE EDGE DETAIL

SCALE 0 5 10 FEET



DETAIL (1 16/16)
TYPICAL SLOPE LINER

SCALE 0 4 8 FEET

ENVIRONMENTAL SOLUTIONS, INC.

By JB Date 8/9/90 Subject B-18 LANDFILL Sheet No. 24 of 28
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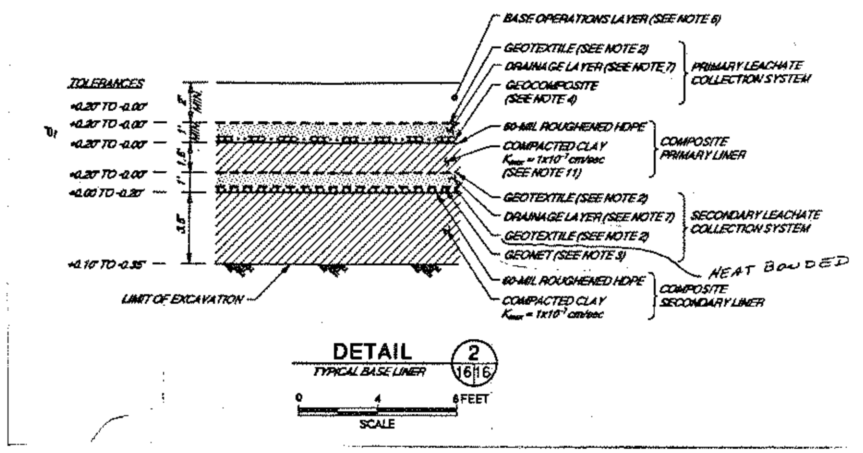


BOTTOM LINER SYSTEM

ENVIRONMENTAL SOLUTIONS, INC.

By J.B Date 8/9/90 Subject B-18 LANDFILL Sheet No. 25 of 28
Chkd. By GSC Date 8/18/90 SLOPE STABILITY ANALYSIS Proj. No. 89-977

MATERIAL AND INTERFACE STRENGTH PARAMETERS USED FOR STABILITY CALCULATIONS -

MATERIAL OR INTERFACE	DESIGN STRENGTH PARAMETERS			SOURCE / REMARKS
	TOTAL UNIT WEIGHT (PCF)	C (PSF)	φ (DEGREES)	
WASTE/OPERATIONS LAYER (SHALLOW FAILURE PLANES)	115	30	27	USED AS A CONSERVATIVE PARAMETER
WASTE/OPERATIONS LAYER (DEEP FAILURE PLANES)	115	0	31	Golder Associates, December 1989. Conservative
CROSS BEDDING				
CLAYSTONE	130	800	40	· Donohue & Associates, Inc, October 1988. Confirmed by Direct Shear Tests
SILTSTONE	130	800	40	
SANDSTONE	130	800	40	
ALONG BEDDING				
CLAYSTONE	130	0	36	· Donohue & Associates, Inc, October 1988. Confirmed by UU Triaxial Tests
SILTSTONE	130	0	36	
SANDSTONE	130	0	36	
STRUCTURAL FILL	125	2,000	30	CONSERVATIVE VALUE BASED ON UU TRIAXIAL TEST ON SANDSTONE COMPACTED TO 95% RELATIVE COMPACTION

ENVIRONMENTAL SOLUTIONS, INC.

By J.B Date 8/9/90 Subject B-18 LANDFILL Sheet No. 26 of 28

Chkd. By GSC Date 8/13/90 SLOPE STABILITY ANALYSIS Proj. No. 89-977

MATERIAL OR INTERFACE	DESIGN STRENGTH PARAMETERS			SOURCE / REMARKS
	TOTAL UNIT WEIGHT (PCF)	C (PSF)	φ (DEGREES)	
LINER SYSTEM: BASE AND SIDE SLOPES				
- COMPACTED CLAY (LONG TERM)	125	1,150 (1)	20°	CU Triaxial Tests on claystone compacted to 90% relative compaction
- COMPACTED CLAY / ROUGHENED HDPE LINER - (LONG TERM)	125	1,150 (1)	20°	
- COMPACTED CLAY (SHORT TERM OR LOW CONFINING STRESS	125	3,600	0	UU Triaxial Test on claystone compacted to 90% relative compaction
- COMPACTED CLAY / ROUGHENED HDPE LINER (SHORT TERM OR LOW CONFINING STRESS)	125	3,600	0	UU Triaxial Test on claystone compacted to 90% relative compaction
ROUGHENED HDPE / GEONET	—	0 (circled: CONTROLS)	15° (circled: CONTROLS)	- Gundle, March 11 1987 - GeoSynTec, Inc, October 11, 1988
GEONET / GEOTEXTILE (HEAT BONDED)	—	0	>30°	Fluid Systems, Inc
GEOTEXTILE / DRAINAGE LAYER	—	0	>25°	
GEOTEXTILE / COMPACTED CLAY	—	0	21°	Golder Associates, June 29, 1990
ROUGHENED HDPE / GEOCOMPOSITE	—	0 50	24° 24°	Golder Associates, June 29, 1990 " " "
GEOCOMPOSITE / DRAINAGE LAYER	—	0	>21°	ANTICIPATED TO BE HIGHER THAN GEOTEXTILE / COMPACTED CLAY
GEOTEXTILE / BASE OPERATIONS LAYER	— —	300 0	27° (SHALLOW FAILURE) 31 (DEEP FAILURE)	THE SHEAR STRENGTH OF

ENVIRONMENTAL SOLUTIONS, INC.

By J. B Date 8/9/90 Subject B-18 LANDFILL Sheet No. 27 of 28

Chkd. By GCC Date 8/13/90 SLOPE STABILITY ANALYSIS Proj. No. 89-977

MATERIAL OR INTERFACE	DESIGN STRENGTH PARAMETERS			SOURCE / REMARKS
	TOTAL UNIT WEIGHT (PCF)	C (PSF)	φ (DEGREES)	
				THE BASE OPERATIONS LAYER CONTROLS. PROPERTIES OF THE BASE OPERATIONS LAYER ARE CONSIDERED TO BE THE SAME AS THOSE OF THE WASTE.
LINER SYSTEM - FINAL COVER (CLOSURE)				
COMPACTED CLAY - (SHORT TERM OR LOW CONFINING STRESS)	125	3,600	0	U U TRIAXIAL TEST ON CLAYSTONE COMPACTED TO 90% RELATIVE COMPACTION
COMPACTED CLAY / ROUGHENED HDPE LINER - LOW CONFINING STRESS.	-	0	32	Golder Associates, June 29, 1990
ROUGHENED HDPE / GEOCOMPOSITE	-	0	24	Golder Associates, JUNE 29, 1990
GEOCOMPOSITE / VEGETATIVE SOIL COVER	-	100	22	Golder Associates, JUNE 29, 199
VEGETATIVE SOIL COVER		40	26°	ASSUMED FOR MEDIUM DENSE CLAYEY SAND

(1) BASED ON DT-A, B-2 TEST RESULTS. DT-C, B-1 IS LESS PLASTIC AND STRONGER

ENVIRONMENTAL SOLUTIONS, INC.

By J.B Date 8/9/90 Subject B-18 LANDFILL Sheet No. 28 of 28
Chkd. By GSC Date 8/13/90 SLOPE STABILITY ANALYSIS Proj. No. 89-977

PERFORMANCE CRITERIA (GENERAL)

STATIC FACTOR OF SAFETY : 1.5 (MINIMUM)

ALLOWABLE SEISMIC DEFORMATION : 1-INCH FOR FAILURE SURFACE THROUGH THE LINER SYSTEM. LARGER DEFORMATIONS ARE ACCEPTABLE FOR FAILURE MODES THROUGH THE WASTE PILE OR VEGETATIVE COVER

COMPUTER OUTPUT. REFER TO COMPUTER OUTPUT FOR EACH CASE. (CONTAINED IN A SEPARATE VOLUME). FILE NAME, FAILURE MODE, CALCULATED FACTORS OF SAFETY AND YIELD ACCELERATION ARE LISTED FOR EACH SPECIFIC CASE.

APPENDIX H.2
ROCK CUTSLOPE STABILITY

ENVIRONMENTAL SOLUTIONS, INC.

By J.B Date 8/9/90 Subject B-18 LANDFILL Sheet No. 0. of 13

Chkd. By ____ Date ______ SLOPE STABILITY ANALYSIS Proj. No. 89-977

CASE I

STABILITY OF CUT SLOPES

CASE IA

2:1 SLOPE
(CROSS BEDDING STRENGTH)

(DESIGN PERIOD: 5 YRS)

ENVIRONMENTAL SOLUTIONS, INC.

By J. B Date 8/9/90 Subject B-18 LANDFILL Sheet No. 2 of 13
Chkd. By GSC Date 8/13/90 SLOPE STABILITY ANALYSIS Proj. No. 89-977

CASE I-A

PERFORMANCE CRITERIA

- MINIMUM STATIC FACTOR OF SAFETY: 1.5
- ALLOWABLE MAXIMUM DISPLACEMENT FOR THE DESIGN EARTHQUAKE PEAK ACCELERATION: 1 INCH

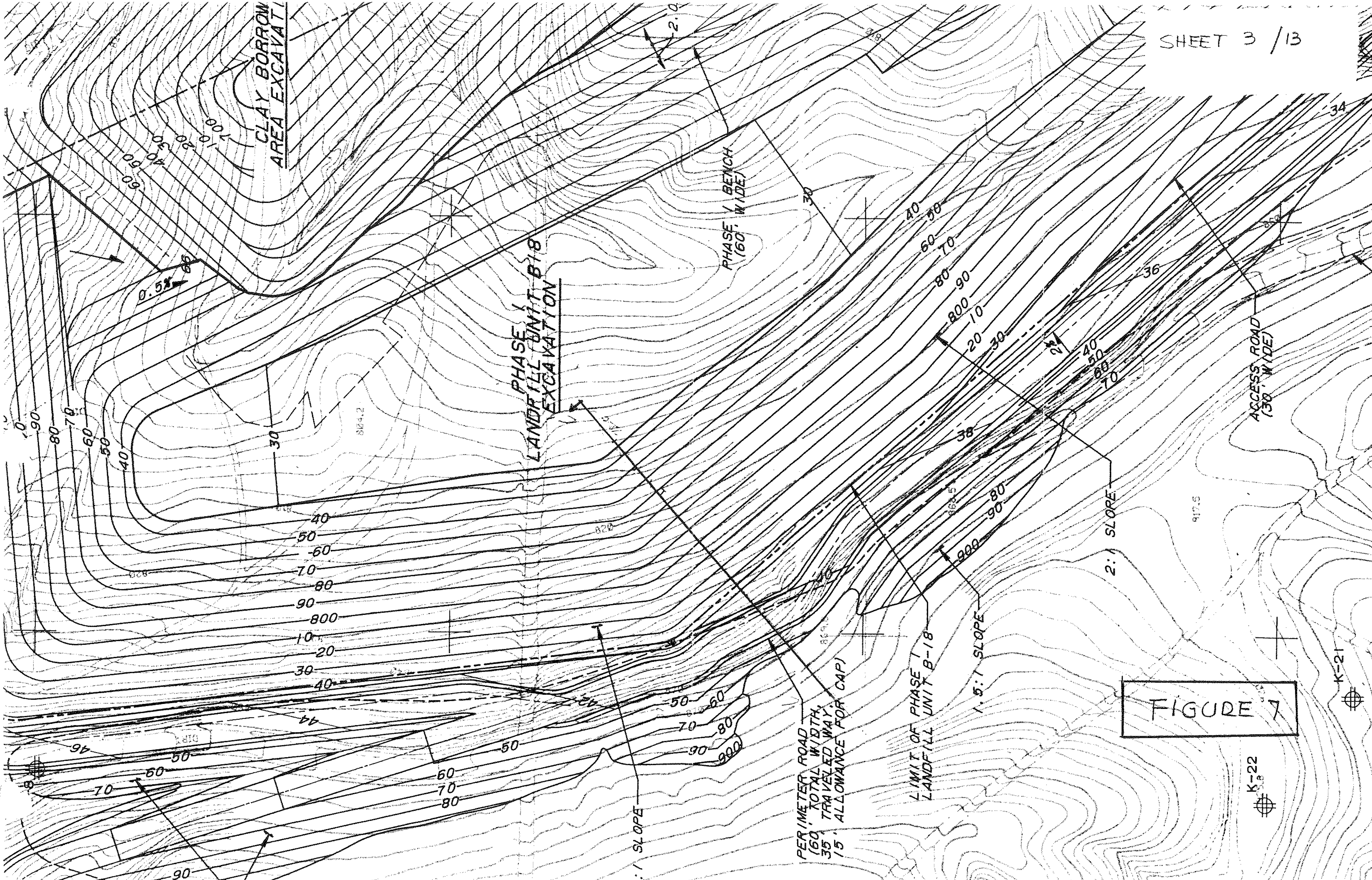
PLAN VIEW OF PHASE I EXCAVATION IS SHOWN IN FIGURE 7

SLOPE STABILITY MODEL IS SHOWN IN FIGURE 8

FILE NAME	E = EARTHQUAKE S = STATIC	FAILURE MODE	K (1)	FACTOR OF SAFETY	REMARKS
RUN 4 CUT	E	CIRCL2	.5	1.06 (2)	
RUN 5 CUT	E	CIRCL2	.54	1.0 (2)	
RUN 6 CUT	S	CIRCL2	0	2.42 (3)	

(1) HORIZONTAL EARTHQUAKE LOADING COEFFICIENT
(2) PSEUDOSTATIC
(3) STATIC

$N = K_y = .54$; FOR $A = .7$, $\frac{N}{A} = \frac{.54}{.7} = .77$



SHEET 3 /13
CLAY BORROW AREA EXCAVAT
PHASE I LANDFILL UNIT B-18 EXCAVATION
PHASE I BENCH (60' WIDE)
ACCESS ROAD (30' WIDE)
2:1 SLOPE
1.5:1 SLOPE
2:1 SLOPE
PERIMETER ROAD (60' TOTAL WIDTH, 35' TRAVELED WAY, 15' ALLOWANCE FOR CAP)
LIMIT OF PHASE I LANDFILL UNIT B-18
0.5%
K-21
K-22

FIGURE 7

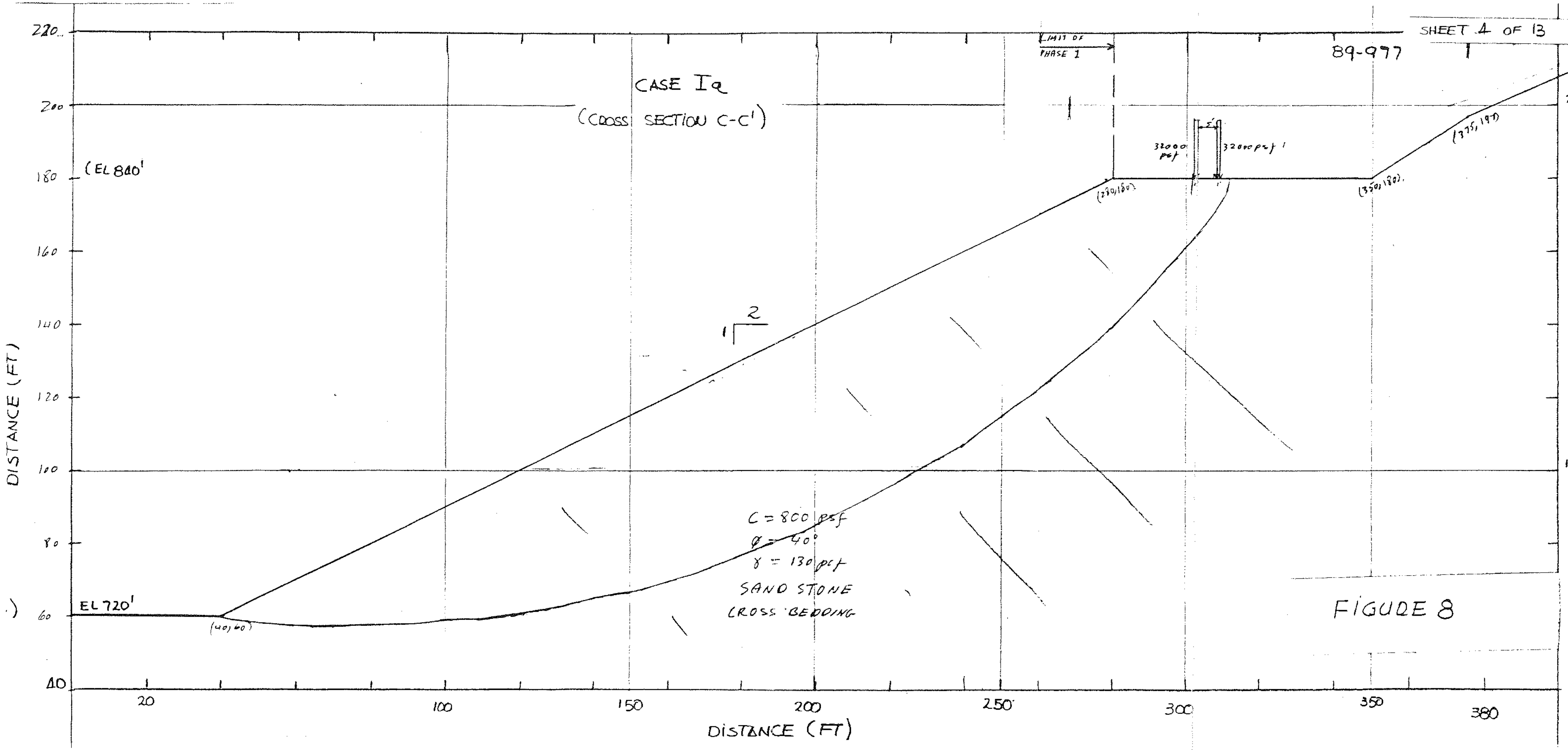

89-997
CASE Ia
(CROSS SECTION C-C')
LIMIT OF PHASE 1
EL 840'
EL 720'
32000 psf
32000 psf
(280,180)
(350,180)
(375,197)
(40,60)
1
2
C = 800 psf
φ = 40°
γ = 130 pcf
SAND STONE
CROSS BEDDING
DISTANCE (FT)
DISTANCE (FT)
220
200
180
160
140
120
100
80
60
40
20
100
150
200
250
300
350
380

FIGURE 8

⇒ FROM FIGURE 2, N/A = .77 THE STANDARDIZED MAXIMUM DISPLACEMENT IS LESS THAN 1 INCH. NO PERMANENT SEISMIC DISPLACEMENT

$A = A_0$,

⇒ FROM FIGURE 9 POE IS $< 4.0 \times 10^{-4}$ FOR 5 YEARS ;

CONCLUSION

- S.F > 1.5 OK.
- NEGLIGIBLE SEISMIC DISPLACEMENT
- Ky = .54
- POE $< 4.0 \times 10^{-4}$ FOR 5 YEARS WHICH IS THE DESIGN RECURRENCE PERIOD

TEMPORARY ROCK CUT , 2:1 SLOPE , CROSS BEDDING STRENGTH

CASE IA

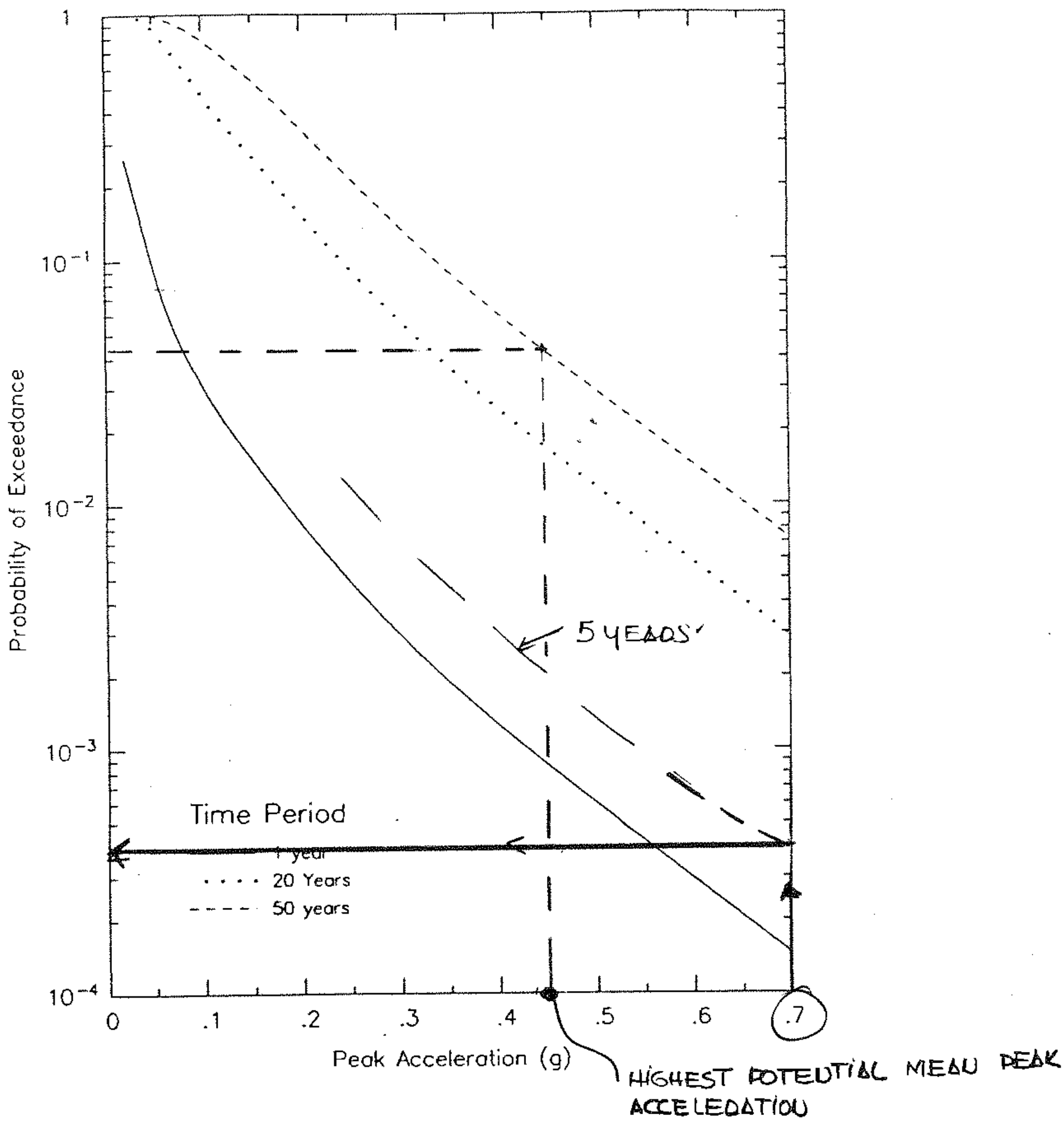


Figure 3. Probability of exceedance as a function of time period

FIGURE 9

ENVIRONMENTAL SOLUTIONS, INC.

By J. B Date 8/9/90 Subject B-18 LANDFILL Sheet No. 7 of 13

Chkd. By GSC Date 8/13/90 SLOPE STABILITY ANALYSIS Proj. No. 89-977

CASE I B

ROCK CUT

3:1 SLOPE

(ALONG BEDDING STRENGTH)

(DESIGN PERIOD 5 YEARS).

ENVIRONMENTAL SOLUTIONS, INC.

By J. B Date 8/9/90 Subject B-18 LANDFILL Sheet No. 8 of 13

Chkd. By GSC Date 8/13/90 SLOPE STABILITY ANALYSIS Proj. No. 89-977

CASE I B

PERFORMANCE CRITERIA SAME AS CASE IA

- PLAN VIEW OF PHASE II EXCAVATION IS SHOWN IN FIGURE 10

- SLOPE STABILITY MODEL IS SHOWN IN FIGURE 11

FILE NAME	E = EARTHQUAKE S = STATIC	FAILURE MODE	K (1)	SAFETY FACTOR	REMARKS
RUN 7 CUT	E	CIRCLE	.5	.73 (2)	
RUN 8 CUT	E	CIRCLE	.32	1.0 (2)	
RUN 9 CUT	S	CIRCLE	0	2.19	

(1) HORIZONTAL EARTHQUAKE LOADING COEFFICIENT
(2) PSEUDOSTATIC FACTOR OF SAFETY. USED TO ESTIMATE YIELD ACCELERATION, IN THIS CASE Ky = .32 (FILE NAME RUN8CUT)

ESTIMATE SEISMIC DEFORMATIONS FOR A = .5, .6 AND .7

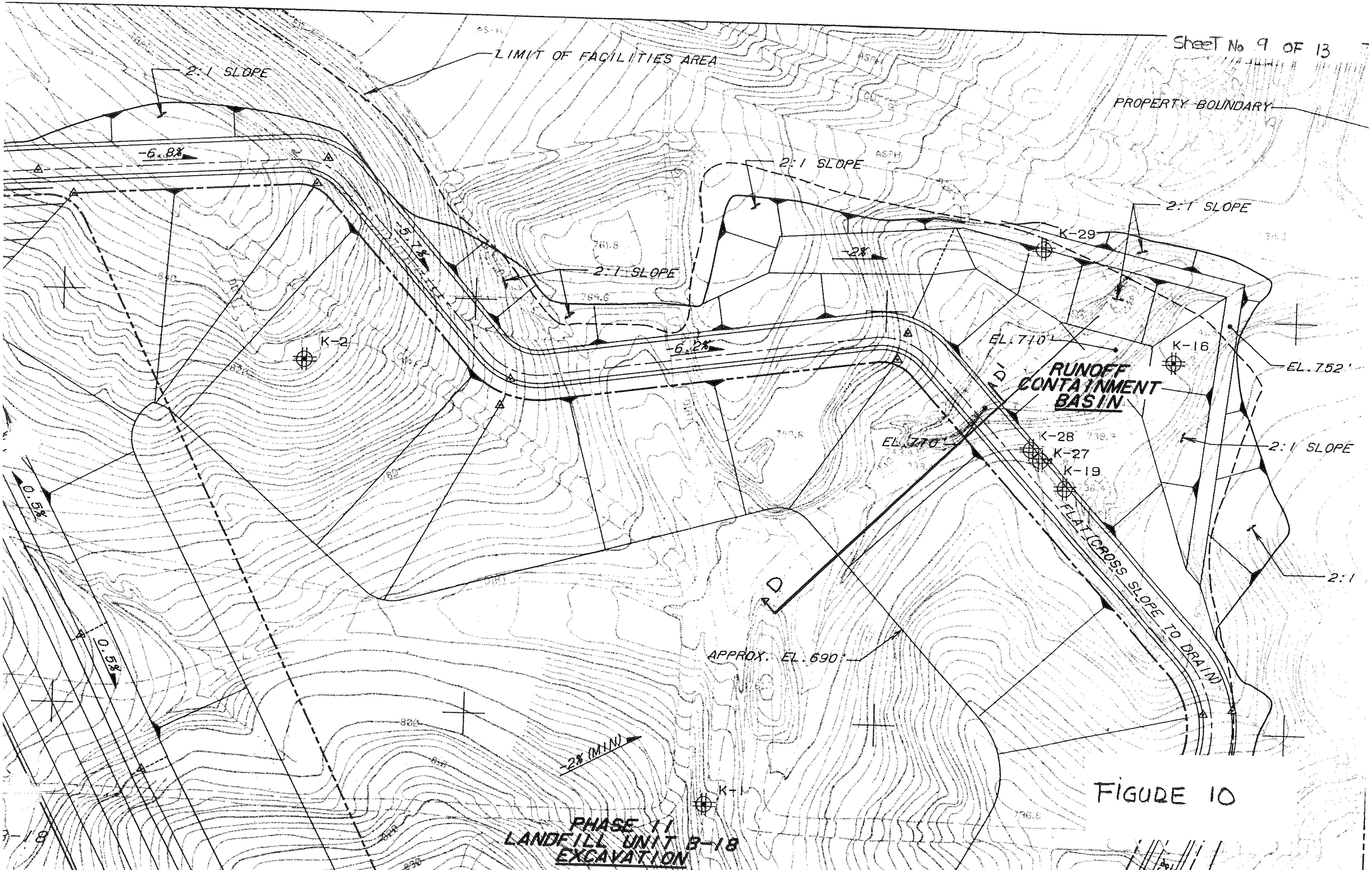

LIMIT OF FACILITIES AREA
2:1 SLOPE
PROPERTY BOUNDARY
-6.8%
5.7%
2:1 SLOPE
2:1 SLOPE
2:1 SLOPE
-2%
K-29
K-2
-6.2%
EL.710'
K-16
EL.752'
RUNOFF CONTAINMENT BASIN
D'
K-28
K-27
K-19
EL.710'
2:1 SLOPE
0.5%
FLAT (CROSS SLOPE TO DRAIN)
2:1
D
0.5%
APPROX. EL.690'
-2% (MIN)
K-1
PHASE II LANDFILL UNIT B-18 EXCAVATION

FIGURE 10

CHEM WASTE MANAG. INC.
SLOPE STABILITY ANALYSIS

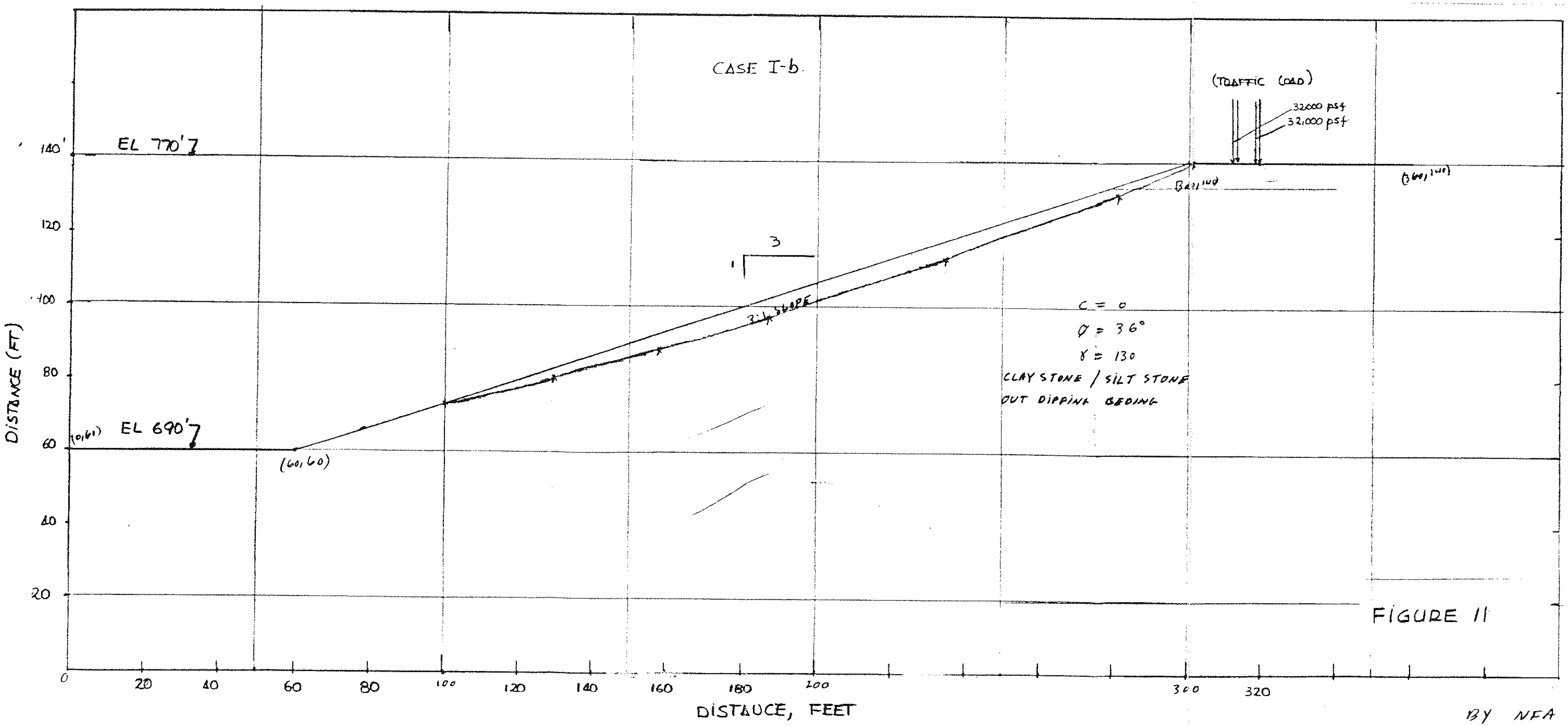


FIGURE 11

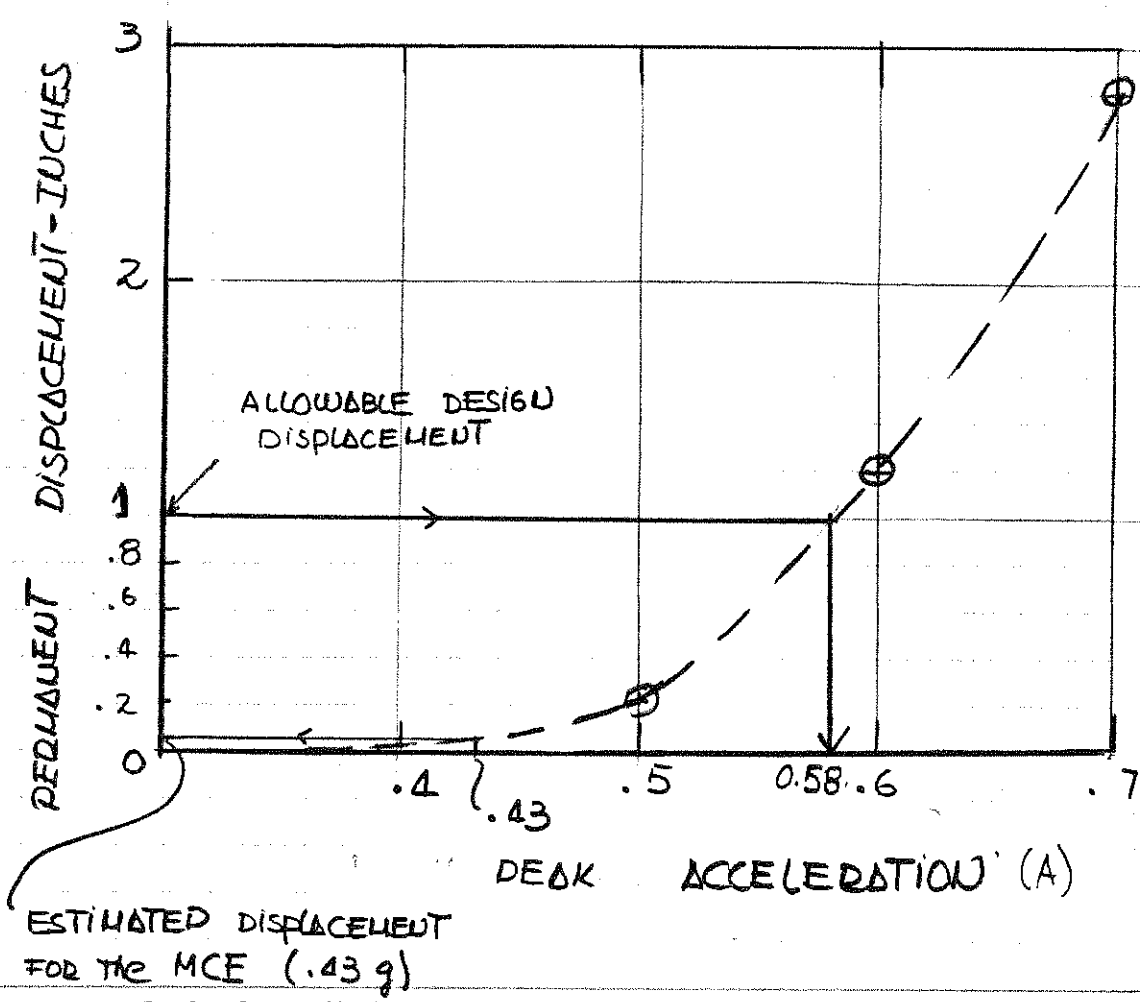
BY NFA

CASE I-b

$K_y = N$	A	K_y/A	Us * (INCHES)	$\frac{V}{A}$	$U_m = \frac{U_s V^2}{1,800 A}$	Um ** (INCHES)
.32	.5	.64	1	30	Um = .25 Us	.25
.32	.6	.53	4	30	Um = .30 Us	1.20
.32	.7	.46	8	30	Um = .35 Us	2.80

* FROM FIGURE 2

** PERMANENT DISPLACEMENT



ENVIRONMENTAL SOLUTIONS, INC.

By J. B Date 8/9/90 Subject B-18 LANDFILL Sheet No. 12 of 13
Chkd. By GSC Date 8/13/90 SLOPE STABILITY ANALYSIS Proj. No. 89-977

$A_0 = A$

FROM FIG 12 P O E = 8.0×10^{-4} FOR 5 YEARS
FOR 1-INCH DEFORMATION : .58g > .43g OK.

CONCLUSION:

STATIC SAFETY FACTOR = 2.2 > 1.5 OK.

- SEISMIC DISPLACEMENT : MINIMAL
- POE FOR 1-INCH DISPLACEMENT = 8.0×10^{-4} (5 YEARS)
- K_y = .32 (YIELD)

CASE I-b.

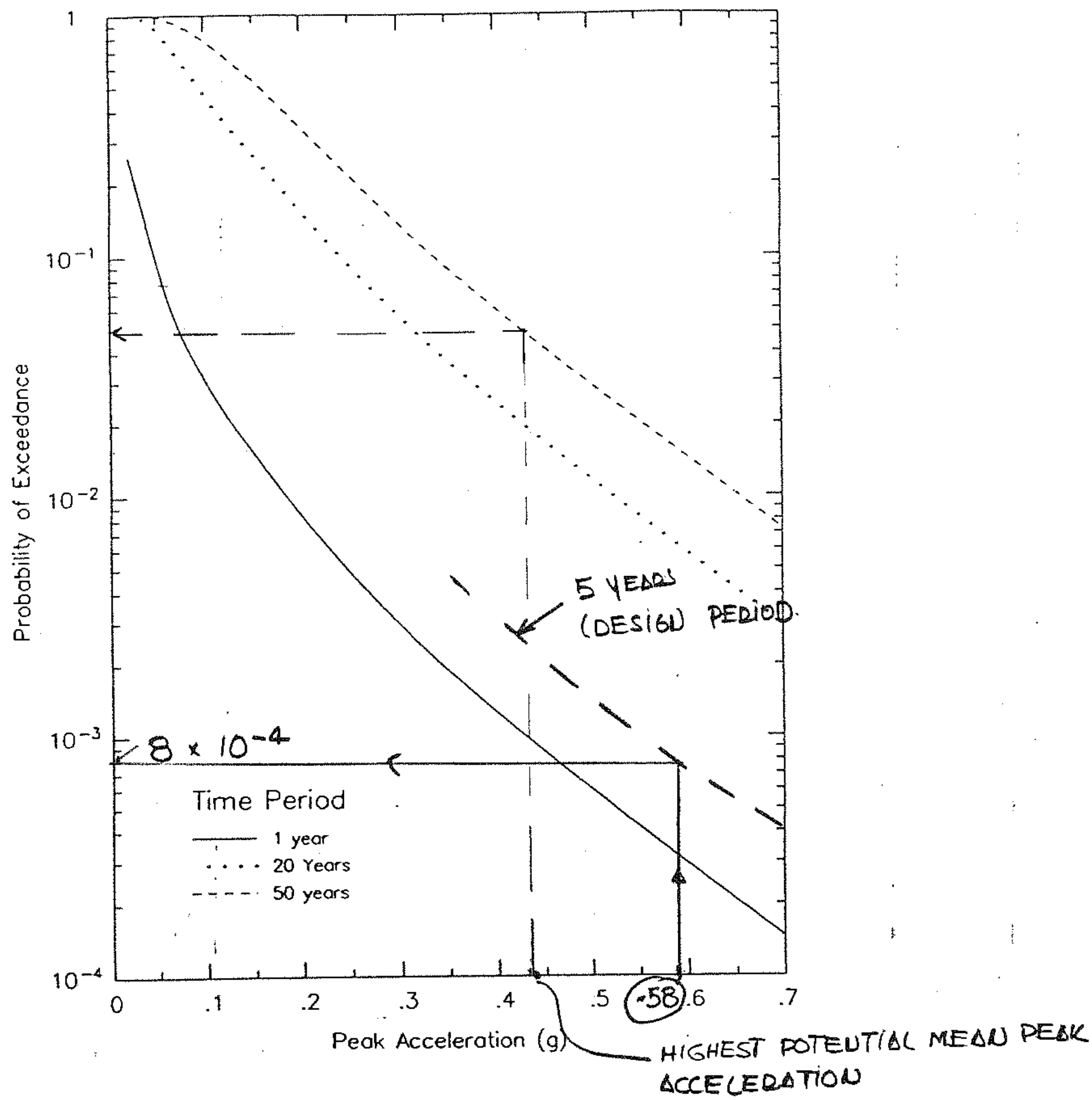


Figure 3. Probability of exceedance as a function of time period

FIGURE 12

APPENDIX H.3
COMPACTED FILL SLOPE STABILITY

ENVIRONMENTAL SOLUTIONS, INC.

By J. B Date 8/10/90 Subject B-18 LANDFILL Sheet No. 0 of 12
Chkd. By gsc Date 8/11/90 SLOPE STABILITY ANALYSIS Proj. No. 89-977

CASE II

STABILITY OF COMPACTED FILL EMBANKMENT

ENVIRONMENTAL SOLUTIONS, INC.

By J.B Date 8/10/90 Subject B-18 LANDFILL Sheet No. 1 of 12
Chkd. By GSC Date 8/11/90 SLOPE STABILITY ANALYSIS Proj. No. 89-977

CASE II-A

RUNOFF RETENTION BASIN

(DESIGN PERIOD: 20 YEARS)

ENVIRONMENTAL SOLUTIONS, INC.

By J.B Date 8/10/90 Subject B-18 LANDFILL Sheet No. 2 of 12
Chkd. By GSC Date 8/11/90 SLOPE STABILITY Proj. No. 89-977

CASE II-A

PERFORMANCE CRITERIA

- MINIMUM STATIC FACTOR OF SAFETY : 1.5
- ALLOWABLE MAXIMUM DISPLACEMENT FOR THE DESIGN EARTHQUAKE PEAK ACCELERATION : 3-INCH

PLAN VIEW OF THE RETENTION BASIN IS SHOWN IN FIGURE 13

SLOPE STABILITY MODEL (SECTION A) IS PRESENTED IN FIGURE 14

AS SHOWN IN FIGURE 14, THE CRITICAL SLOPE IS ON THE SOUTH WASTE SIDE FOR DEEP FAILURE MODE

- COMPUTED FACTOR OF SAFETY ARE PRESENTED IN SHEET 5.

- THE YIELD ACCELERATION FOR THE SOUTH WEST SLOPE IS ABOUT .5 (FILE NAME RN1BM2S.SW)

SEISMIC DEFORMATIONS * FROM FIGURE 2.

$K_y = N$	A	K_y/A	U_s * (INCHES)	$\frac{V}{A}$	U_m (INCHES)
.5	.7	.71	.70	30	NEGLIGIBLE
.5	.6	.83	< 1.0	30	"
.5	.5	1.0	< 1.0	30	"

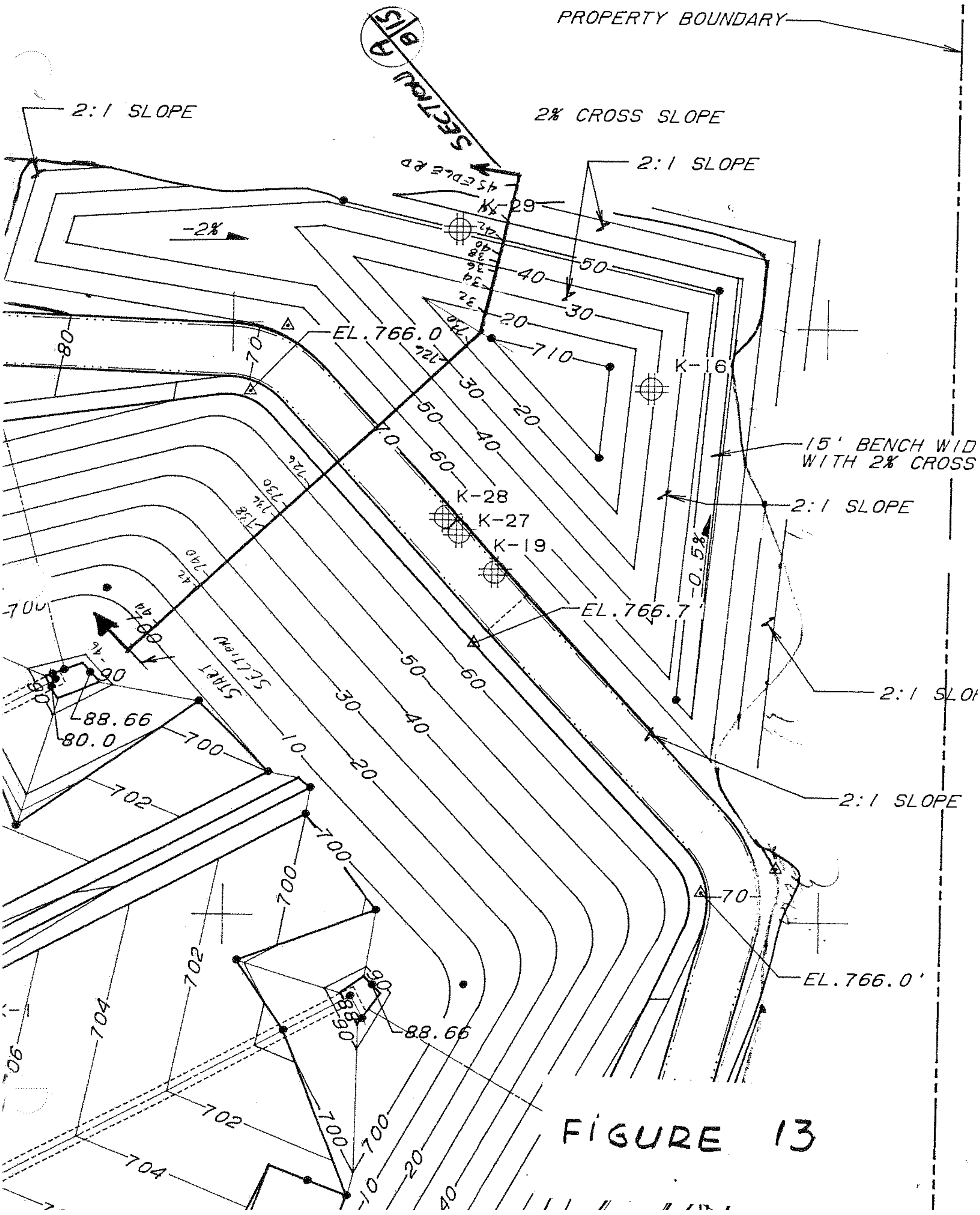

PROPERTY BOUNDARY
2:1 SLOPE
SECTION A/15 B/15
2% CROSS SLOPE
2:1 SLOPE
45 EDGE RD
K-29
-2%
50
40
30
20
710
K-16
EL.766.0
80
70
30
20
50
40
70
60
15' BENCH WID
WITH 2% CROSS
K-28
K-27
2:1 SLOPE
K-19
-0.5%
EL.766.7
-700
90
88.66
80.0
700
START SECTION
50
60
30
40
10
20
2:1 SLOPE
702
2:1 SLOPE
700
700
70
702
EL.766.0'
704
88.66
702
700
700
704
20
10
40

FIGURE 13

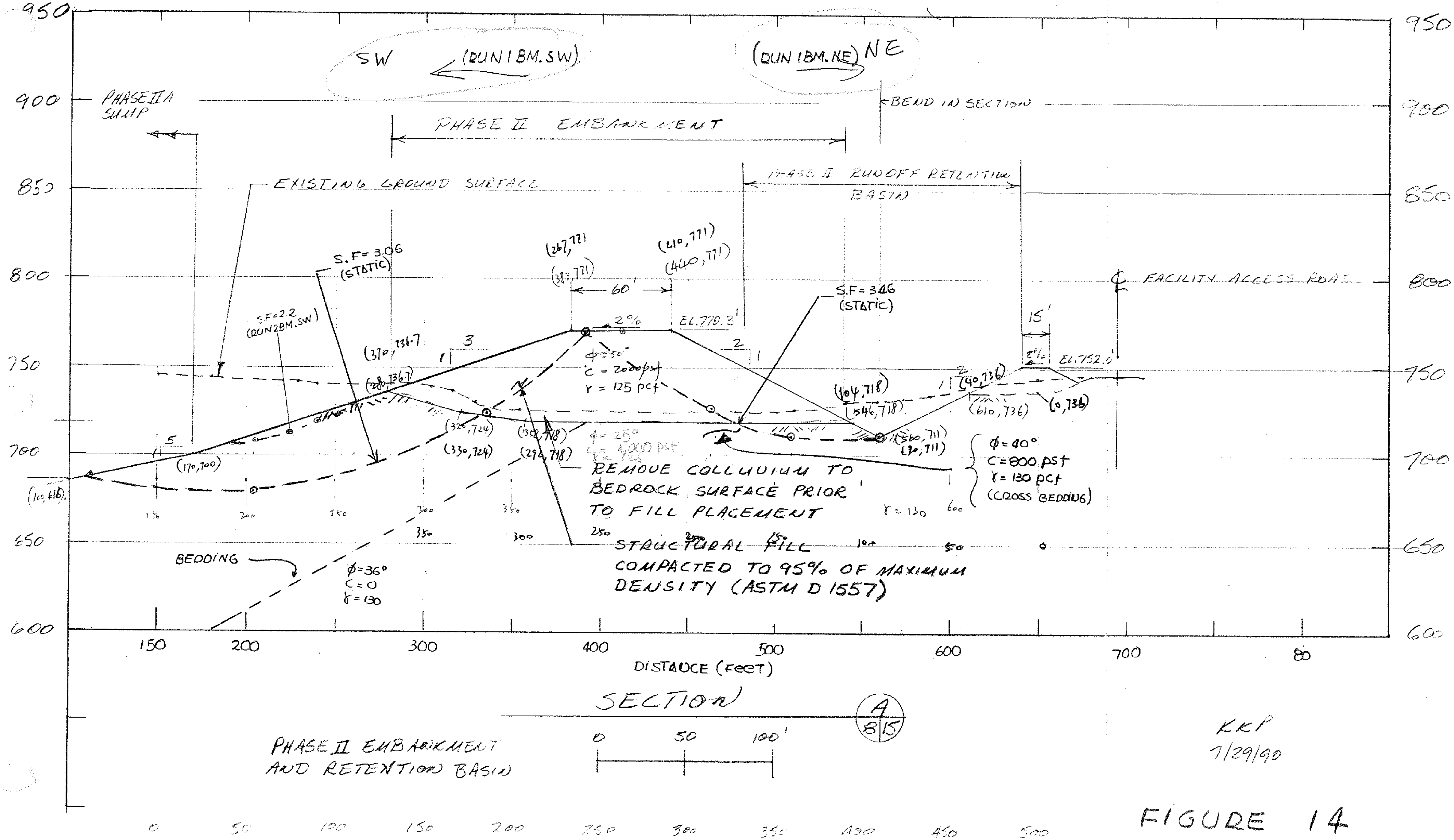

SW (RUN1BM.SW)
(RUN1BM.NE) NE
PHASE IIA SUMP
BEND IN SECTION
PHASE II EMBANKMENT
PHASE II RUNOFF RETENTION BASIN
EXISTING GROUND SURFACE
S.F = 3.06 (STATIC)
S.F = 3.46 (STATIC)
S.F = 2.2 (RUN2BM.SW)
EL. 770.3'
EL. 752.0'
FACILITY ACCESS ROAD
φ = 30° C = 2000 psf γ = 125 pcf
φ = 25° C = 4,000 psf γ = 125
φ = 40° C = 800 psf γ = 130 pcf (CROSS BEDDING)
φ = 36° C = 0 γ = 130
BEDDING
REMOVE COLLUVIUM TO BEDROCK SURFACE PRIOR TO FILL PLACEMENT
STRUCTURAL FILL COMPACTED TO 95% OF MAXIMUM DENSITY (ASTM D 1557)
DISTANCE (FEET)
SECTION 4/8 15
0 50 100'
PHASE II EMBANKMENT AND RETENTION BASIN
KKP 7/29/90

FIGURE 14

ENVIRONMENTAL SOLUTIONS, INC.

By J.B Date 8/10/90 Subject B-18 LANDFILL Sheet No. 5 of 12
Chkd. By GSC Date 8/11/90 SLOPE STABILITY ANALYSIS Proj. No. 89-977

RUNOFF RETENTION BASIN

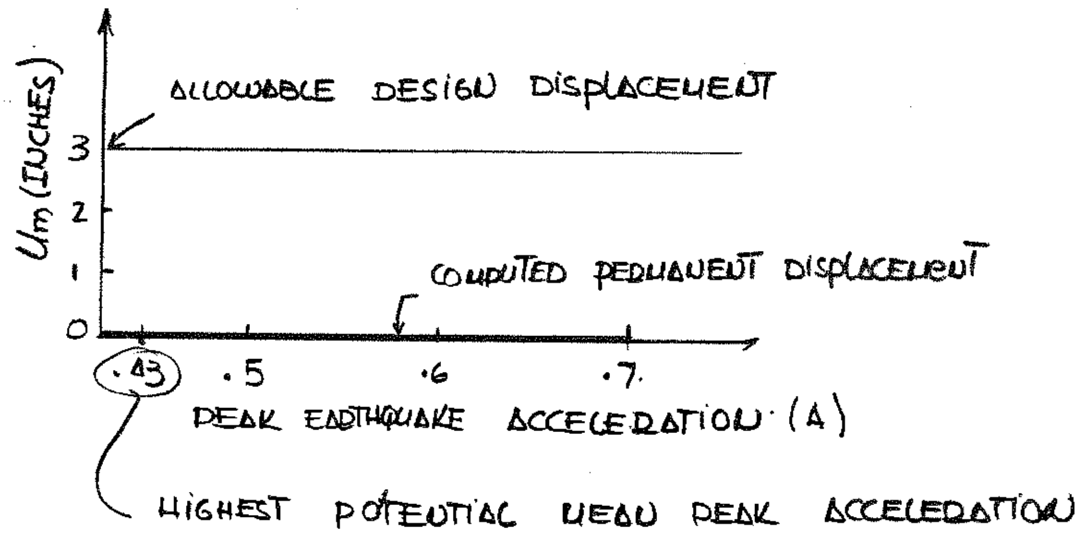
RUN No	FILE NAME	S = STATIC E = EARTHQUAKE	FAILURE MODE	K(1)	SAFETY FACTOR	REMARKS: (1) HORIZONTAL EARTHQUAKE LOADING COEFFICIENT (2) STATIC (3) PSEUDOSTATIC, USED TO ESTIMATE SEISMIC DISPLACEMENTS (4) A PSEUDOSTATIC F.S <1.0 DOES NOT IMPLY FAILURE CONDITIONS
1	RN1BM1S.SW	E	CIRCL2	0.4	1.21 (3)	DEEP FAILURE - SOUTH WEST SLOPE THROUGH STRUCTURAL FILL AND NATURAL MATERIAL
2	RN1BM2S.SW	E	CIRCL2	0.5	1.03 (3)	(same)
3	RUN1BM.SW	S	CIRCL2	0	3.06 (2)	(same)
4	RN2BM1S.SW	E	CIRCL2	0.4	0.87 (3)(4)	SHALLOW FAILURE - SOUTH WEST SLOPE
5	RN2BM2S.SW	E	CIRCL2	0.2	1.29 (3)	SHALLOW FAILURE - SOUTH WEST SLOPE
6	RN2BM3S.SW	E	CIRCL2	0.3	1.05 (3)	SHALLOW FAILURE - SOUTH WEST SLOPE
7	RUN2BM.SW	S	CIRCL2	0	2.20 (2)	SHALLOW FAILURE WITHIN NATURAL MATERIAL (LOCAL)
8	RUN3BM.SW	S	CIRCL2	0	5.15 (2)	FAILURE WITHIN STRUCTURAL FILL
9	RUN1BM.NE	S	CIRCL2	0	3.46 (2)	SLOPE ON NE SLOPE
10	RUN1BM1S.NE	E	CIRCL2	0.5	1.48 (3)	SLOPE ON NE SLOPE

ENVIRONMENTAL SOLUTIONS, INC.

By J. B Date 8/10/90 Subject B-18 LANDFILL Sheet No. 6 of 12

Chkd. By JSC Date 8/14/90 SLOPE STABILITY Proj. No. 89-977

FROM SHEET 2, U_m (PERMANENT DISPLACEMENTS) ARE NEGLIGIBLE



FROM FIGURE 15, POE $< 30 \times 10^{-3}$ (20 YRS)

CONCLUSIONS

STATIC FACTOR OF SAFETY $>$ 1.5

- PERMANENT SEISMIC DISPLACEMENTS: NONE
- $K_y = .5g$
- POE $< 30 \times 10^{-3}$ FOR 20 YEARS

CASE II-A
CASE II-B

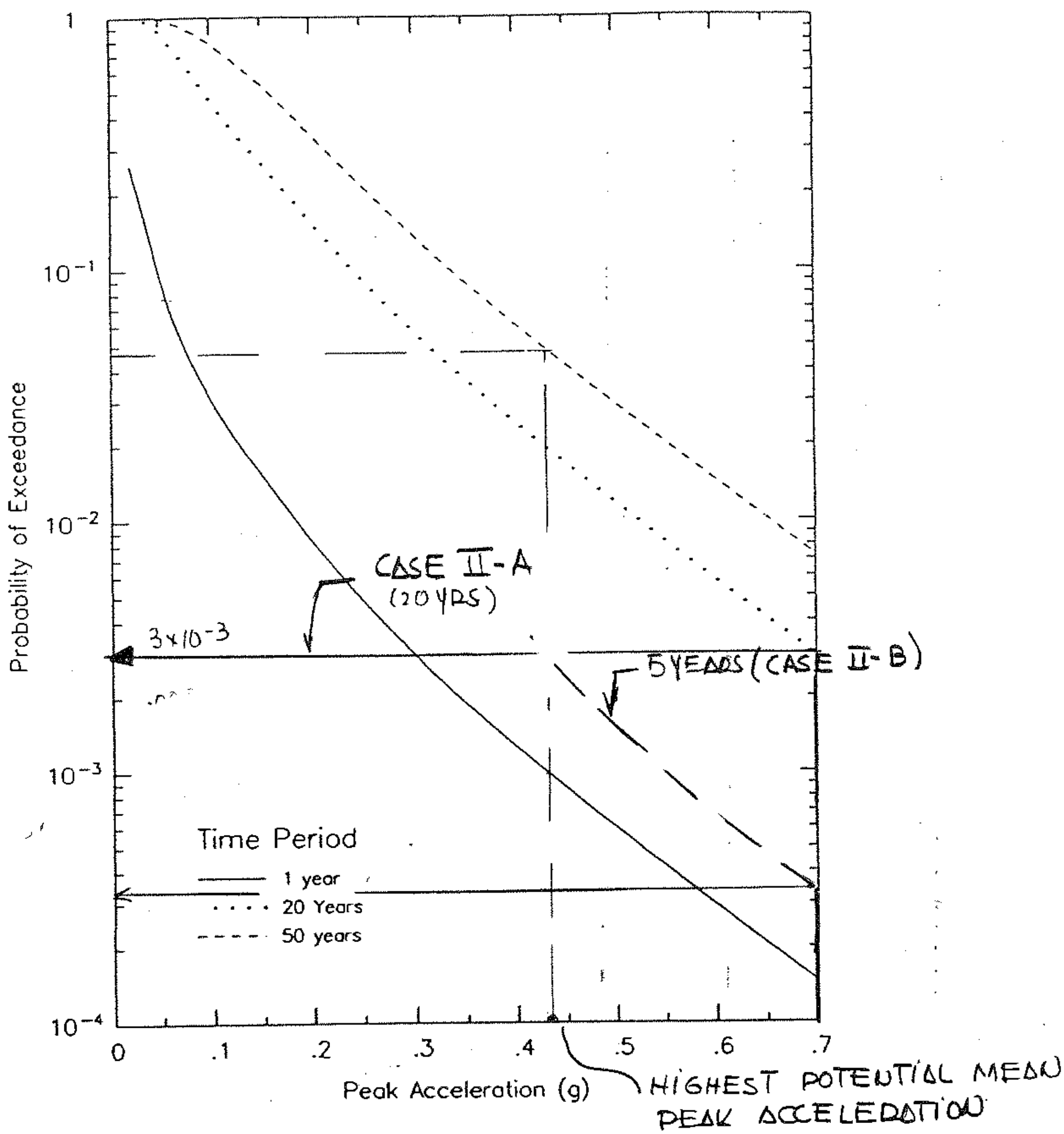


Figure 3. Probability of exceedance as a function of time period

FIGURE 15

CASE II-B.

(SMALL EMBANKMENT TO COMPLETE PHASE I/II BERM)

(DESIGN PERIOD 5 YEARS)

ENVIRONMENTAL SOLUTIONS, INC.

By J.B Date 8/10/90 Subject B-18 LANDFILL Sheet No. 9 of 12

Chkd. By GSC Date 8/11/90 SLOPE STABILITY ANALYSIS Proj. No. 84-977

CASE II-B

PERFORMANCE CRITERIA

1- MINIMUM STATIC FACTOR OF SAFETY = 1.5

2- ALLOWABLE MAXIMUM DISPLACEMENT FOR THE DESIGN EARTHQUAKE PEAK ACCELERATION = 1-1NCH

PLAN VIEW OF THE CLAY BORROW AREA IS SHOWN IN FIGURE 16

SLOPE STABILITY MODEL IS SHOWN IN FIGURE 17.

- FINAL BENCH ELEVATION IS 720' AS OPPOSSED TO 710' AS SHOWN IN THE MODEL. THIS MINOR DISCREPANCY SHOULD NOT AFFECT THE ANALYSIS RESULTS

- BENCHES BETWEEN THE FILL AND NATIVE MATERIAL WERE NOT INCLUDED IN THE MODEL FOR SIMPLICITY. THIS SHOULD NOT AFFECT THE ANALYSIS RESULTS.

CALCULATED FACTORS OF SAFETY ARE SHOWN IN SHEET 12

THE YIELD ACCELERATION IS GREATER THAN 0.6 ⇒ THE PEAK ACCELERATION TO INDUCE A PERMANENT DISPLACEMENT IS GREATER THAN 0.7 BASED ON PREVIOUS RESULTS ⇒ SEISMIC DISPLACEMENTS ARE NEGLIGIBLE

POE $<< 3.0 \times 10^{-4}$ (5 yrs) AS SHOWN IN FIGURE 15 FOR THE RUNOFF RETENTION BASIN EMBANKMENT. ACTUAL LIFE OF CLAY BORROW AREA EMBANKMENT IS ABOUT 5 YEARS

CONCLUSIONS
- STATIC FACTOR OF SAFETY > 1.5
- SEISMIC DISPLACEMENTS : NEGLIGIBLE
- $K_y > .6$
- POE $<< 3.0 \times 10^{-3}$ FOR 5 YEARS

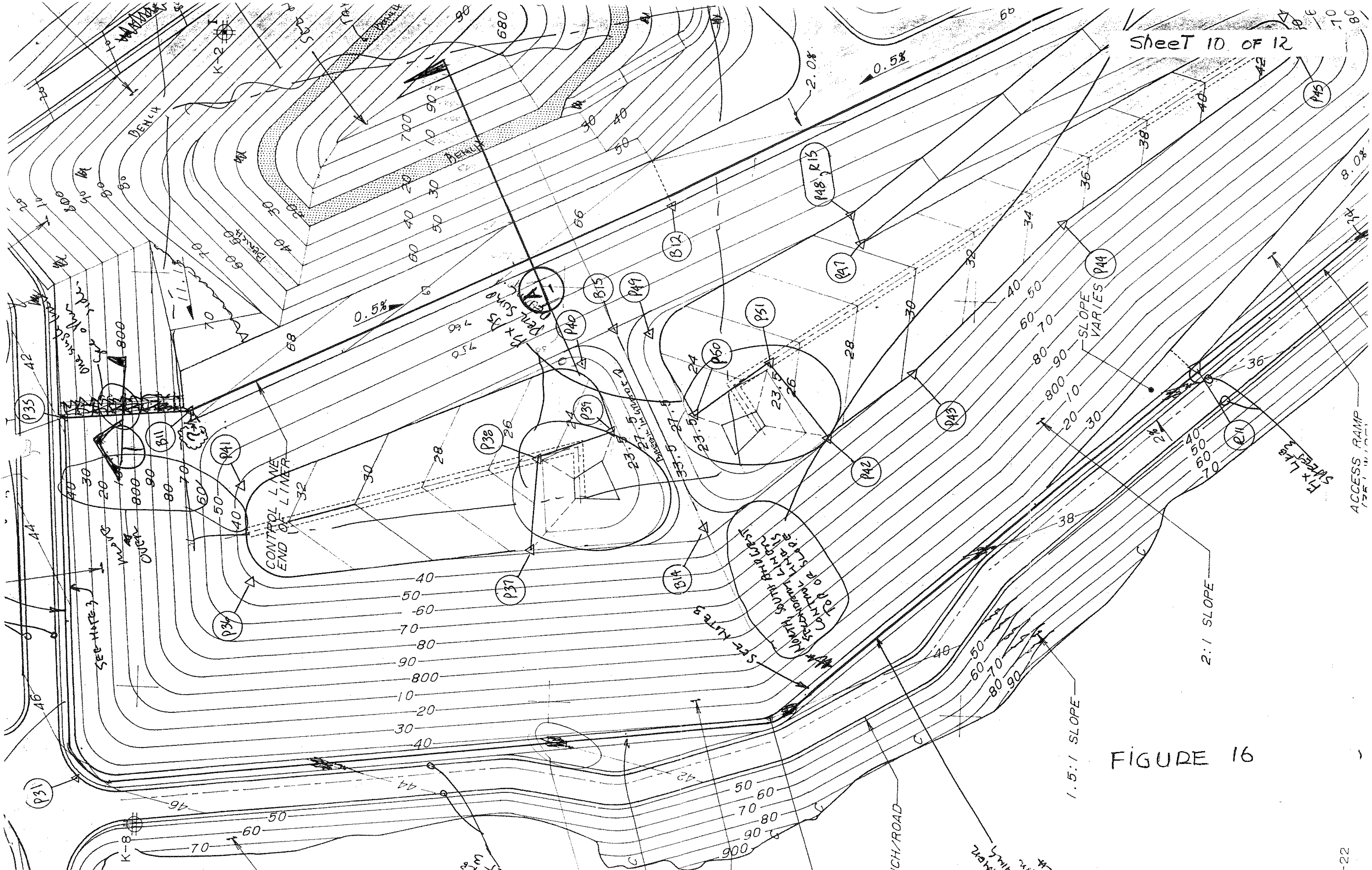

CONTROL LINE
END OF LINER
SLOPE
VARIES
2:1 SLOPE
1.5:1 SLOPE
ACCESS RAMP
0.5%
0.5%
2.0%
8.0%
2%
P31
P35
P36
P37
P38
P39
P40
P41
P42
P43
P44
P45
P47
P48, R15
P49
P50
P51
B11
B12
B14
B15
R11
K-2
K-8

FIGURE 16

JOB No 89-977
by J.B 7/28/90
SHEET 11 OF 12

CASE II-B'
(CLAY BORROW AREA)

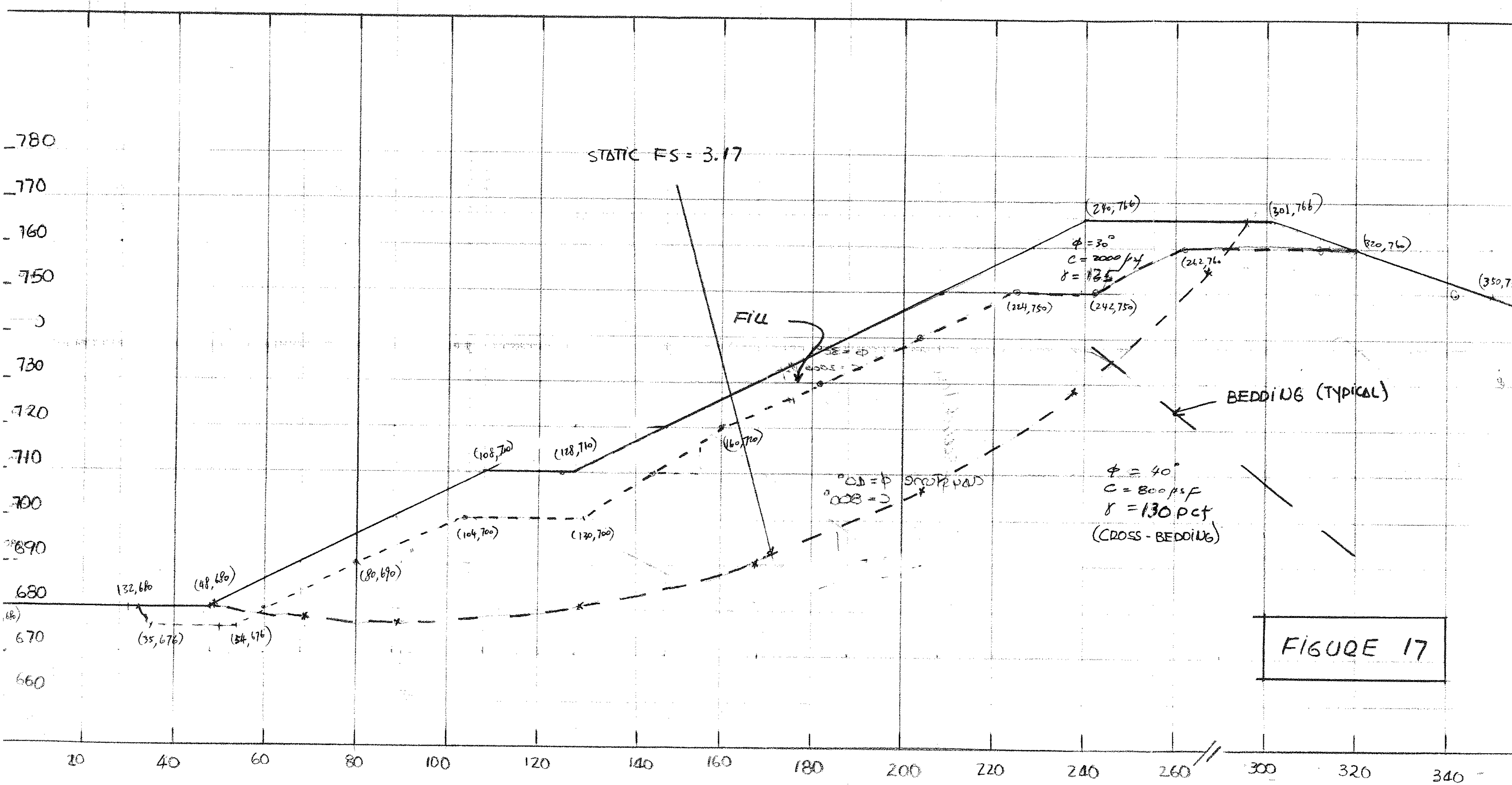


FIGURE 17

ENVIRONMENTAL SOLUTIONS, INC.

By J. B Date 8/10/90 Subject B-18 LANDFILL Sheet No. 12 of 12

Chkd. By QSC Date 8/11/90 SLOPE STABILITY ANALYSIS Proj. No. 89-997

SMALL EMBANKMENT TO COMPLETE PHASE I/II BERM)

	FILE NAME	S = STATIC E = EARTHQ.	FAILURE MODE	(3) K	FACTOR OF SAFETY	REMARKS
1	RUN 1 BERM	S	CIRCL2	0	3.17 (2)	THREE RUN WITH DIFFERENT INITIATION POINTS
2	RUN 2 BERM	E	CIRCL2	0.3	1.69 (P)	✓
3	RUN 3 BERM	E	CIRCL2	0.5	1.25 (1)	✓
4	RUN 4 BERM	E	CIRCL2	0.6	1.09 (1)	

(1) PSEUDOSTATIC , (2) STATIC

(3) K = HORIZONTAL EARTHQUAKE LOADING COEFFICIENT

$K_y > .6$ (FILE NAME RUN 4 BERM)

⇒ MINIMAL DEFORMATIONS

ALLOWABLE DESIGN DISPLACEMENT FOR THE MCE: 1 INCH

ESTIMATED DISPLACEMENT FOR THE MCE = 0

APPENDIX H.4

INTERMEDIATE PHASE I CLOSURE AND INTERMEDIATE PHASE IIIA WASTE SLOPE STABILITY

ENVIRONMENTAL SOLUTIONS, INC.

By J.B Date 8/10/90 Subject B-18 LANDFILL Sheet No. 0 of 24

Chkd. By GSC Date 8/13/96 SLOPE STABILITY ANALYSIS Proj. No. 89-977

CASE III

STABILITY OF TEMPORARY PHASE I INTERMEDIATE WASTE FILL

ENVIRONMENTAL SOLUTIONS, INC.

By J. B Date 8/10/90 Subject B-18 LANDFILL Sheet No. 1 of 24
Chkd. By GSC Date 9/13/90 SLOPE STABILITY ANALYSIS Proj. No. 89-997

CASE III - A

WEDGE MOVEMENT ALONG THE LINER SURFACE

(DESIGN PERIOD 10 YRS)

ENVIRONMENTAL SOLUTIONS, INC.

By J.B Date 8/10/90 Subject B-18 LANDFILL Sheet No. 2 of 24
Chkd. By GSC Date 9/13/90 SLOPE STABILITY Proj. No. 89-977

CASE III - A1

PERFORMANCE CRITERIA

- MINIMUM STATIC FACTOR OF SAFETY : 1.5
- MAXIMUM ALLOWABLE DISPLACEMENT FOR THE DESIGN EARTHQUAKE PEAK ACCELERATION : 1- INCH

PLAN VIEW OF THE TOP OF THE LINER AND TEMPORARY COVER ARE SHOWN IN FIGURES 18 AND 19 RESPECTIVELY.

- SLOPE STABILITY MODEL IS SHOWN IN FIGURE 20

COMPUTED FACTORS OF SAFETY ARE:

FILE NAME	S= STATIC E= EARTHQUAKE	FAILURE MODE	K (1)	SAFETY FACTOR	REMARKS
KH7BL.1S	S	BLOCK 2	0	2.54 (2)	FOR ALL CASES: GEOCOMPOSITE on 3:1 slope, $\phi = 24°$, $c=0$
KH7BL.1E	E	BLOCK 2	0.3	1.11 (3)	CLAY LINER $c = 3{,}600$ psf $\phi = 0$
KH7BL.2E	E	BLOCK 2	0.4	0.87 (3)	$\phi = 15°$ GEONET/
KH7BL.3E	E	Block 2	0.35	0.98 (3)	ROUGHENED HDPE AT BOTTOM

(1) HORIZONTAL EARTHQUAKE LOADING COEFFICIENT

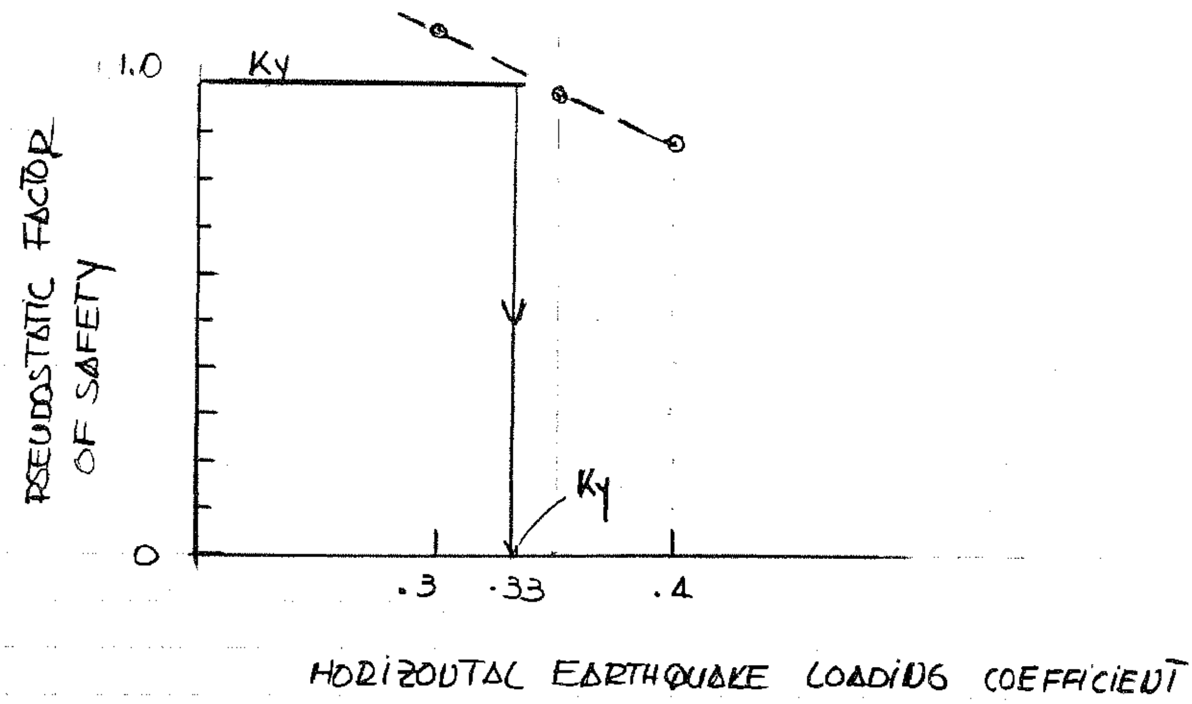
ENVIRONMENTAL SOLUTIONS, INC.

By J. B   Date 8/10/90   Subject B-18 LANDFILL   Sheet No. 3 of 24

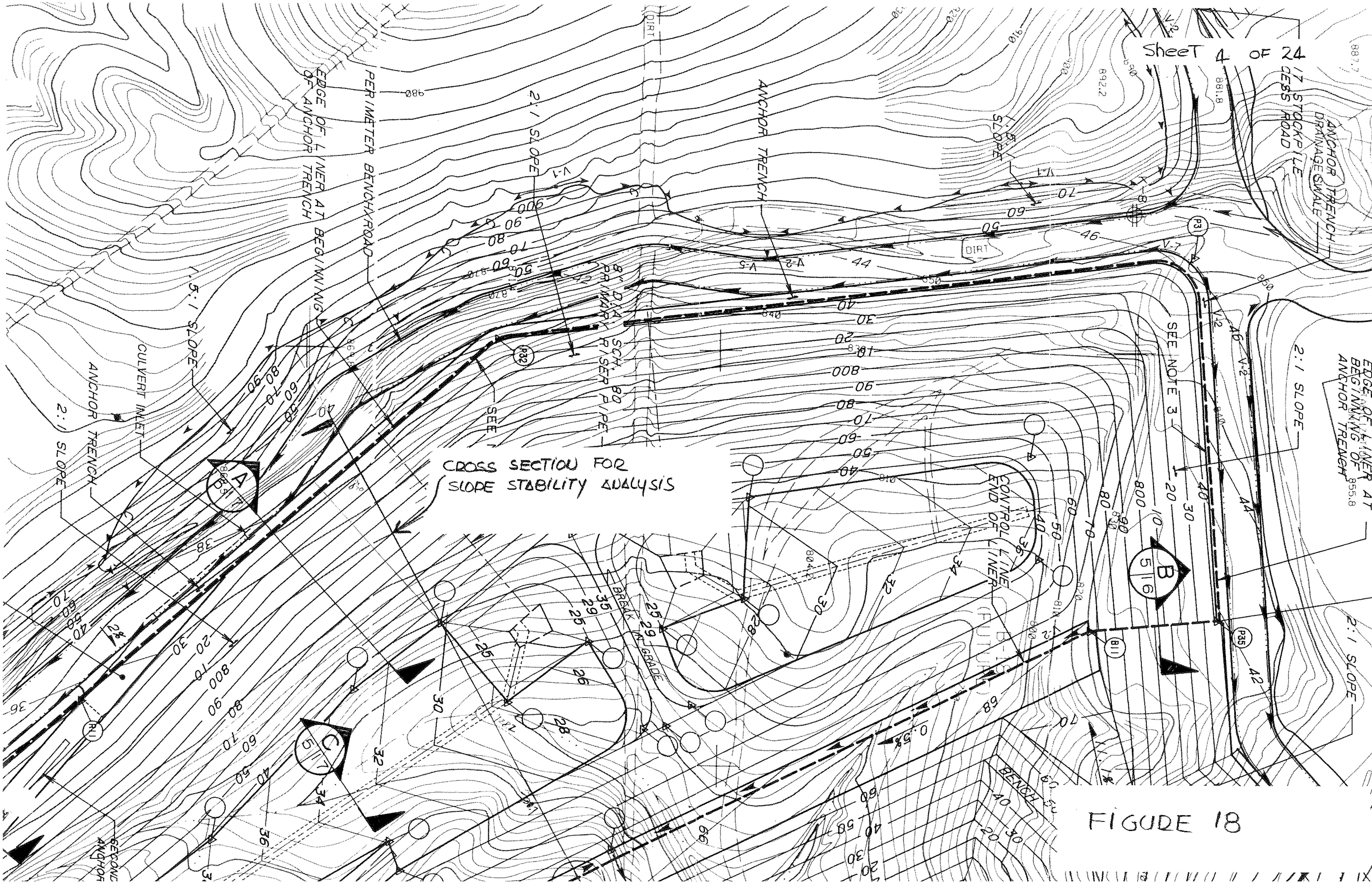
Chkd. By ___   Date ___   SLOPE STABILITY   Proj. No. 89-979

(2) STATIC

(3) PSEUDOSTATIC. A VALUE LESS THAN 1 DOES NOT necessarily imply FAILURE. THEY ARE USED TO ESTIMATE THE YIELD ACCELERATION WHICH RELATED TO THE PERMANENT DISPLACEMENT by THE N/A RATIO SHOWN IN FIGURE 2.



Ky = .33 (CONSERVATIVE)


CROSS SECTION FOR
SLOPE STABILITY ANALYSIS
PERIMETER BENCH/ROAD
EDGE OF LINER AT BEGINNING OF ANCHOR TRENCH
ANCHOR TRENCH
2:1 SLOPE
CULVERT INLET
SEE NOTE 3
CONTROL LINE
END OF LINER
ANCHOR TRENCH DRAINAGE SWALE
DIRT
BREAK IN GRADE
BENCH
V-1
V-2
V-5
V-7
P31
P32
P35
B11
R1
A
B
C

FIGUDE 18

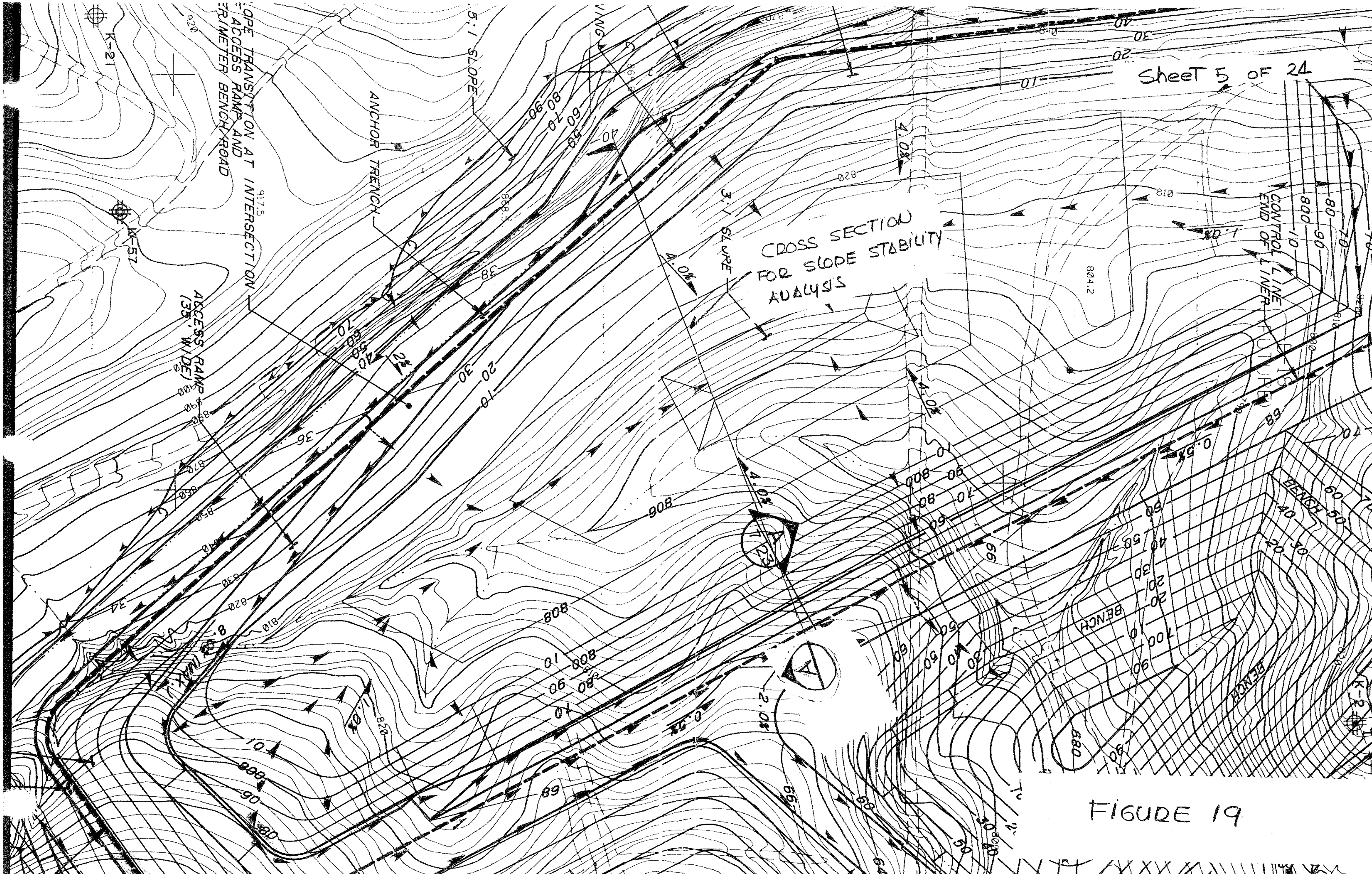

Sheet 5 of 24
CROSS SECTION FOR SLOPE STABILITY ANALYSIS
ANCHOR TRENCH
ACCESS RAMP (35' WIDE)
3:1 SLOPE
CONTROL LINE
END OF LINER
BENCH
4.0%
2.0%
0.5%

FIGURE 19

CASES III-a AND b

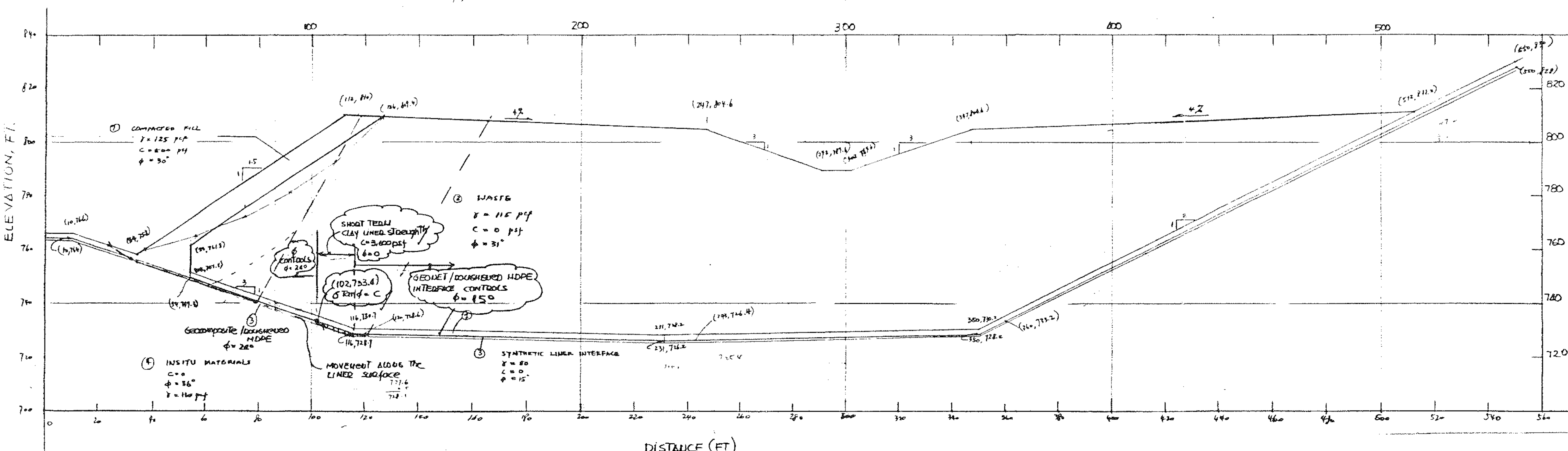


FIGURE 20

ENVIRONMENTAL SOLUTIONS, INC.

By J.B Date 8/10/90 Subject B-18 LANDFILL Sheet No. 7 of 24
Chkd. By GSC Date 8/13/90 SLOPE STABILITY Proj. No. 89-977

CRITICAL INTERFACE ON 3:1 SLOPE IS ROUGHENED HDPE/GEOCOMPOSITE, $\phi = 24°$ (SEE SHEET 21)

CRITICAL INTERFACE AT THE BOTTOM PART OF THE LANDFILL: GEONET / ROUGHENED HDPE, $\phi = 15°$. (SEE SHEET 21)

$$K_y \approx .33$$

CASE III - A(1)

K_y	A	$\frac{K_y}{A}$	U_s * (INCHES)	$U_m = \frac{U_s V^2}{11800 A}$	$\frac{V}{A}$	U_m ** (INCHES)
.33	.5	.66	1	$U_m = .25 U_s$	30	.25
.33	.6	.55	2.6	$U_m = .30 U_s$	30	.80
.33	.7	.47	7	$U_m = .35 U_s$	30	2.45

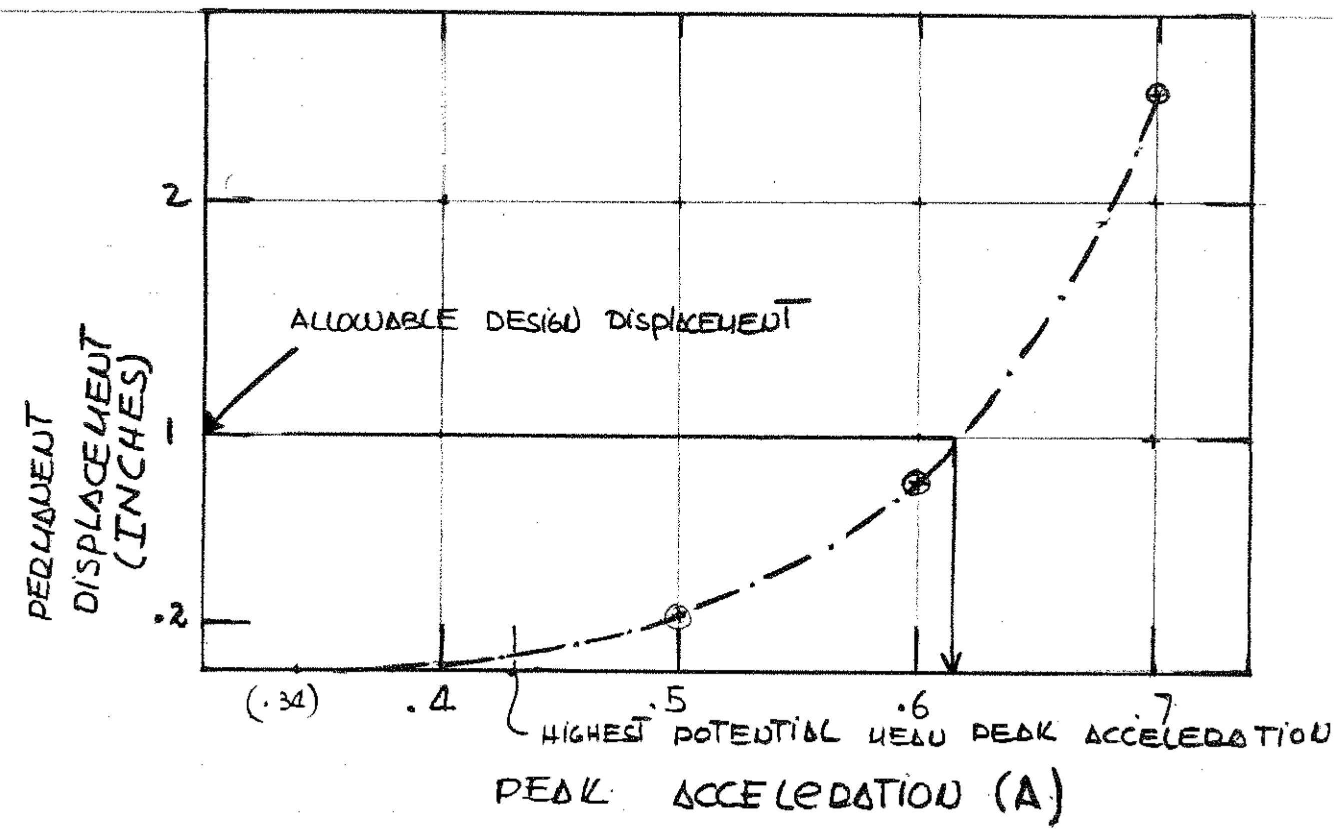
* FROM FIGURE 2

** PERMANENT DISPLACEMENTS

ENVIRONMENTAL SOLUTIONS, INC.

By J. B Date 8/10/90 Subject B-18 LANDFILL Sheet No. 8 of 24

Chkd. By GSC Date 8/13/90 SLOPE STABILITY Proj. No. 89-977



$A \approx .62$, $A_o = \frac{A}{.8}$ (DEEP FAILURE MODE)

$A_o = \frac{.61}{.8} = .76$

OPERATION PERIOD: ABOUT 10 YEARS

FROM FIGURE 21 POE $< 6 \times 10^{-4}$ FOR 10 YEARS

CONCLUSION

- STATIC FACTOR OF SAFETY $2.54 > 1.5$ OK
- SEISMIC DISPLACEMENT 1-INCH FOR $A_o > .7$
- POE 6×10^{-4} FOR 10 YEARS

CASE III - A1

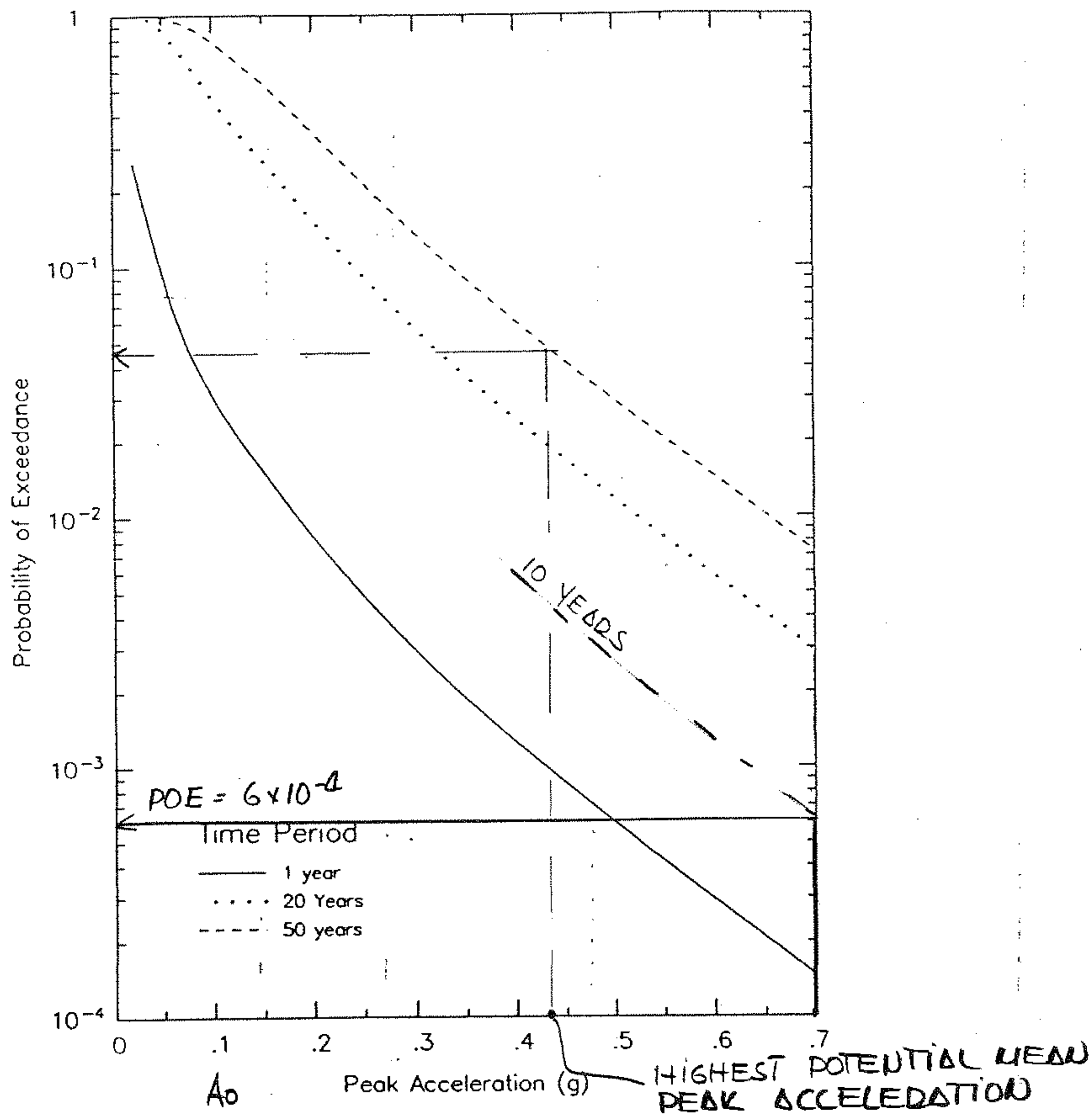


Figure 3. Probability of exceedance as a function of time period

FIGURE 20-A

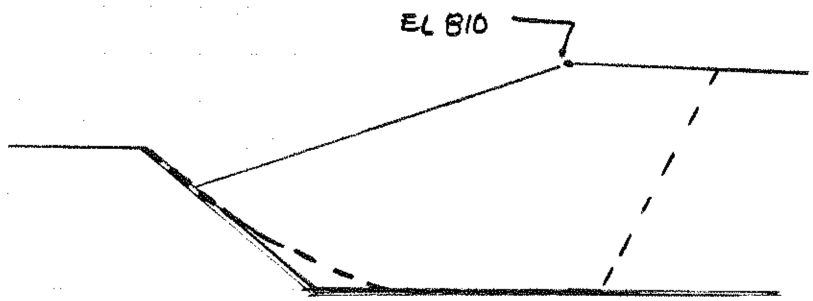
ENVIRONMENTAL SOLUTIONS, INC.

By J.B. Date 8/13/90 Subject B-18 LANDFILL Sheet No. 10 of 24

Chkd. By GSC Date 8/15/90 SLOPE STABILITY Proj. No. 89977

CASE III - A.2

FAILURE THROUGH THE LINER SYSTEM AT THE BASE AND THROUGH THE WASTE AT BASE/SLOPE INTERSECTION



PERFORMANCE CRITERIA

SAME AS CASE III - A.1

SLOPE STABILITY MODEL IS SHOWN IN FIGURE 20-A

COMPUTED FACTORS OF SAFETY ARE

FILE NAME	S = STATIC E = EARTHQUAKE	FAILURE MODE	K (1)	SAFETY FACTOR	REMARKS
NH 7BL.1S	S	BLOCK 2	0	3.10(2)	(1) HORIZONTAL EARTHQUAKE LOADING COEFFICIENT
NH 7BL.1E	E	BLOCK 2	0.30	1.37(3)	
NH 7BL.2E	E	BLOCK 2	0.40	1.15(3)	(2) STATIC
NH 7BL.3E	E	BLOCK 2	0.49	1.0 (3)	(3) PSEUDOSTATIC

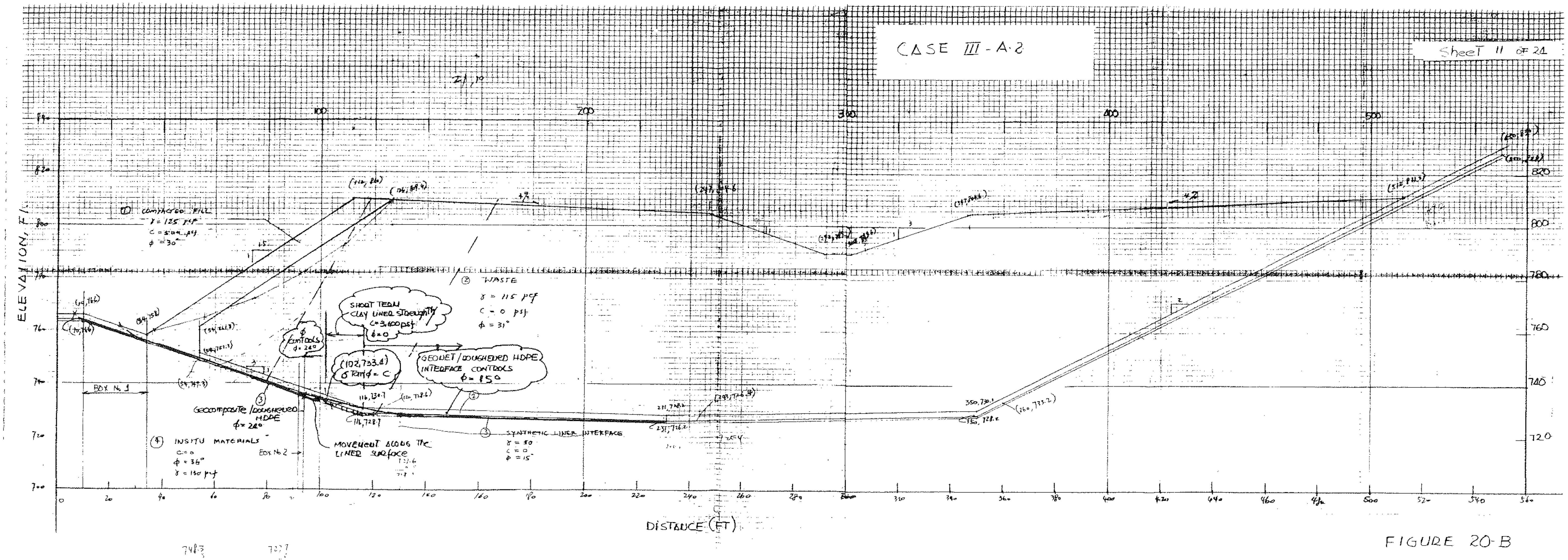

CASE III - A·2
Sheet 11 of 24
ELEVATION, FT
DISTANCE (FT)
① COMPACTED FILL
γ = 125 pcf
C = 500 psf
φ = 30°
② WASTE
γ = 115 pcf
C = 0 psf
φ = 31°
SHORT TERM CLAY LINER STRENGTH
C = 3,600 psf
φ = 0
φ CONTROLS
φ = 24°
(102, 733.4)
σ Tan φ = C
GEONET / ROUGHENED HDPE INTERFACE CONTROLS
φ = 15°
GEOCOMPOSITE / ROUGHENED HDPE
φ = 24°
④ INSITU MATERIALS
C = 0
φ = 36°
γ = 130 pcf
③ SYNTHETIC LINER INTERFACE
γ = 50
C = 0
φ = 15°
MOVEMENT ALONG THE LINER SURFACE
BOX No. 1
BOX No. 2

FIGURE 20-B

ENVIRONMENTAL SOLUTIONS, INC.

By J.B Date 8/14/90 Subject B-18 LANDFILL Sheet No. 12 of 24
Chkd. By GSC Date 8/15/90 SLOPE STABILITY Proj. No. 84-977

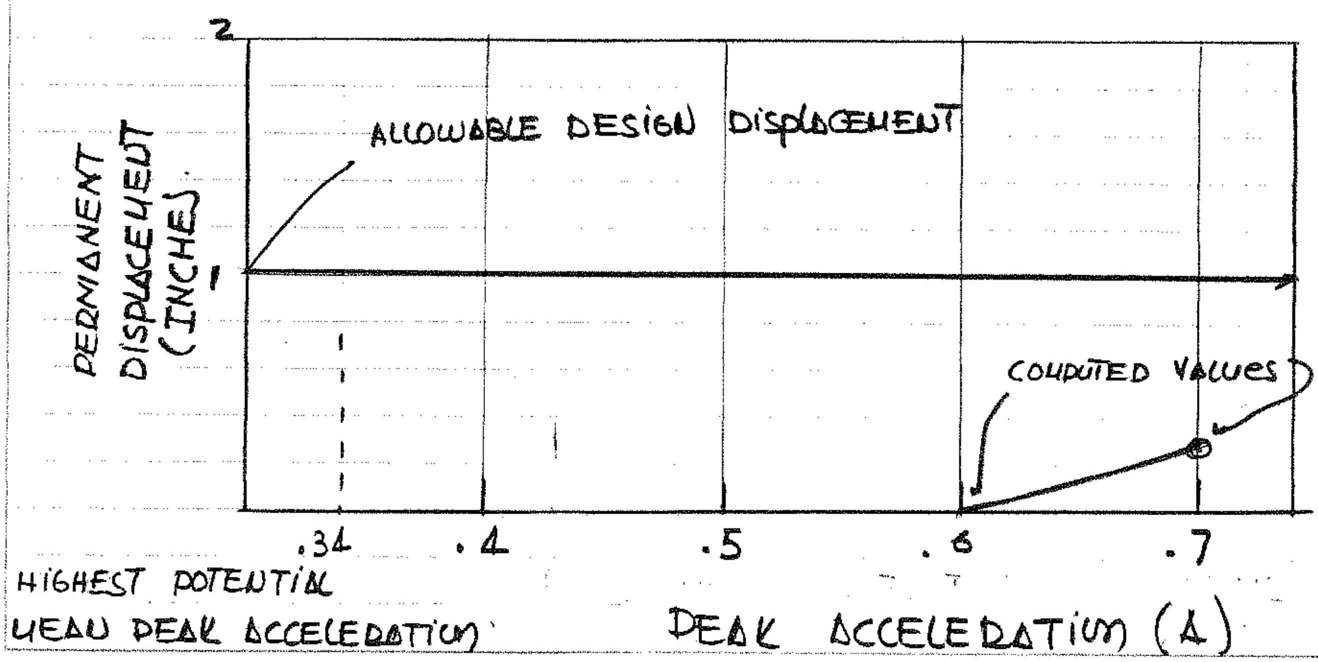
K_y = .49 (FROM SHEET 59-A, FILE NAME: NH7BL.3E

CASE III - A.2

SEISMIC DISPLACEMENT

K_y	A	$\frac{K_y}{A}$	U_s * (INCHES)	$U_m = U_s \times \frac{V^2}{1,800\,A}$	$\frac{V}{A}$	U_m (INCHES)
.49	.5	.98	0	U_m = .25 U_s	30	0
.49	.6	.82	0	U_m = .30 U_s	30	0
.49	.7	.70	.8	U_m = .35 U_s	30	.28

* FROM FIGURE 2



ENVIRONMENTAL SOLUTIONS, INC.

By J. B Date 8/14/90 Subject B-18 LANDFILL Sheet No. 13 of 24

Chkd. By GSC Date 8/15/90 SLOPE STABILITY Proj. No. 89-977

FOR 1 INCH DISPLACEMENT A > .7

A_o >> .7

OPERATION PERIOD : ABOUT 10 YEARS

FROM FIGURE 20-C : POE ∠ 6.0×10^{-4}

CONCLUSION

STATIC SAFETY FACTOR > 1.5

SEISMIC DISPLACEMENT: 0

POE ∠ 6.0×10^{-4}

CASE III- A·2

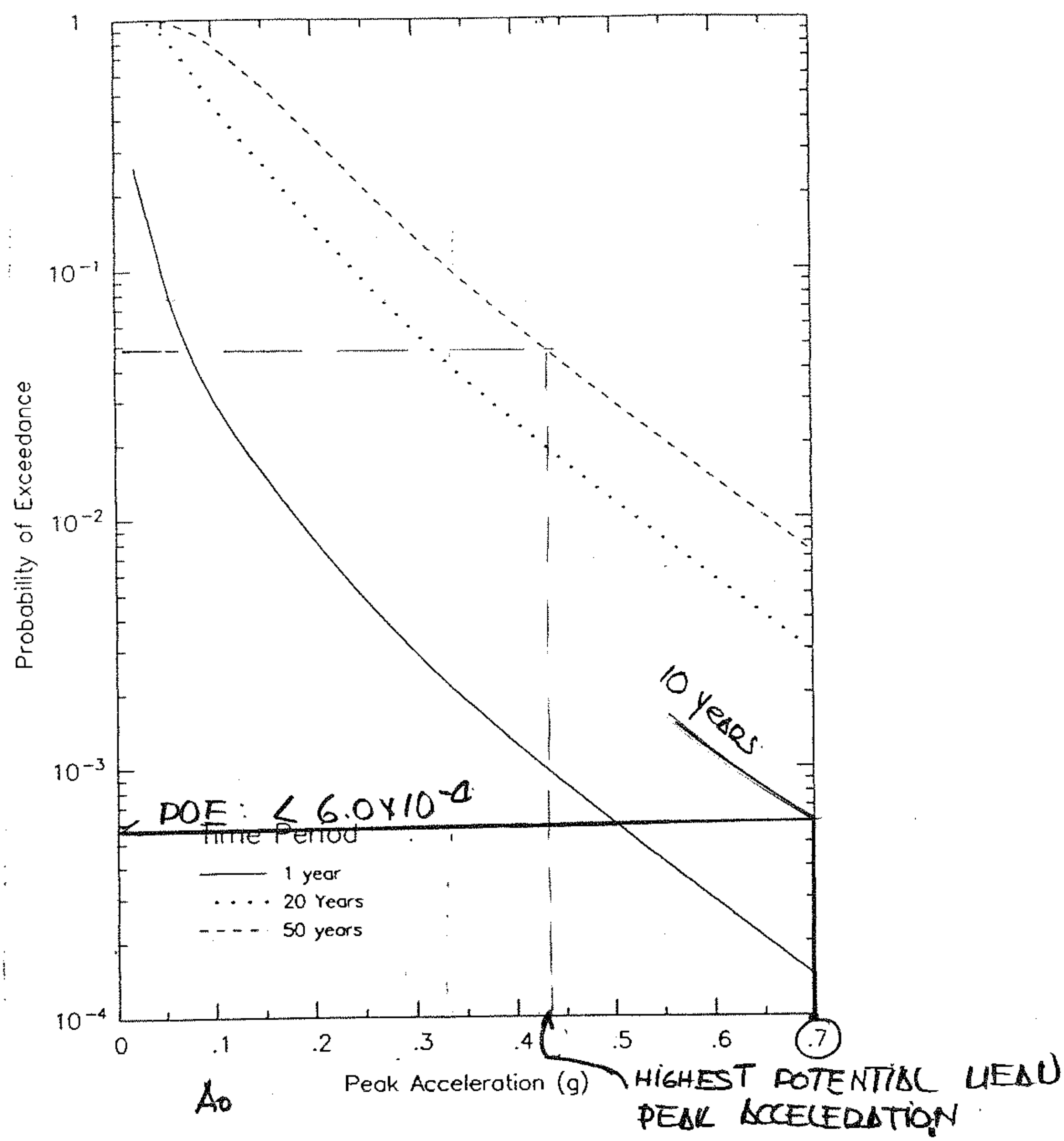


Figure 3. Probability of exceedance as a function of time period

FIGURE 20-C

CASE III - B

(CIRCULAR FAILURE THROUGH THE WASTE).

III B - 1. NO COHESION ALLOWED FOR WASTE

III B - 2. COHESION ALLOWED FOR WASTE

(DESIGN PERIOD 10 YEARS)

CASE III - B (1)

PERFORMANCE CRITERIA

- MINIMUM STATIC FACTOR OF SAFETY : 1.5.
- MAXIMUM ALLOWABLE DISPLACEMENT FOR THE DESIGN EARTHQUAKE PEAK ACCELERATION > 6 INCHES
- SLOPE STABILITY MODEL IS SHOWN IN FIGURE 21

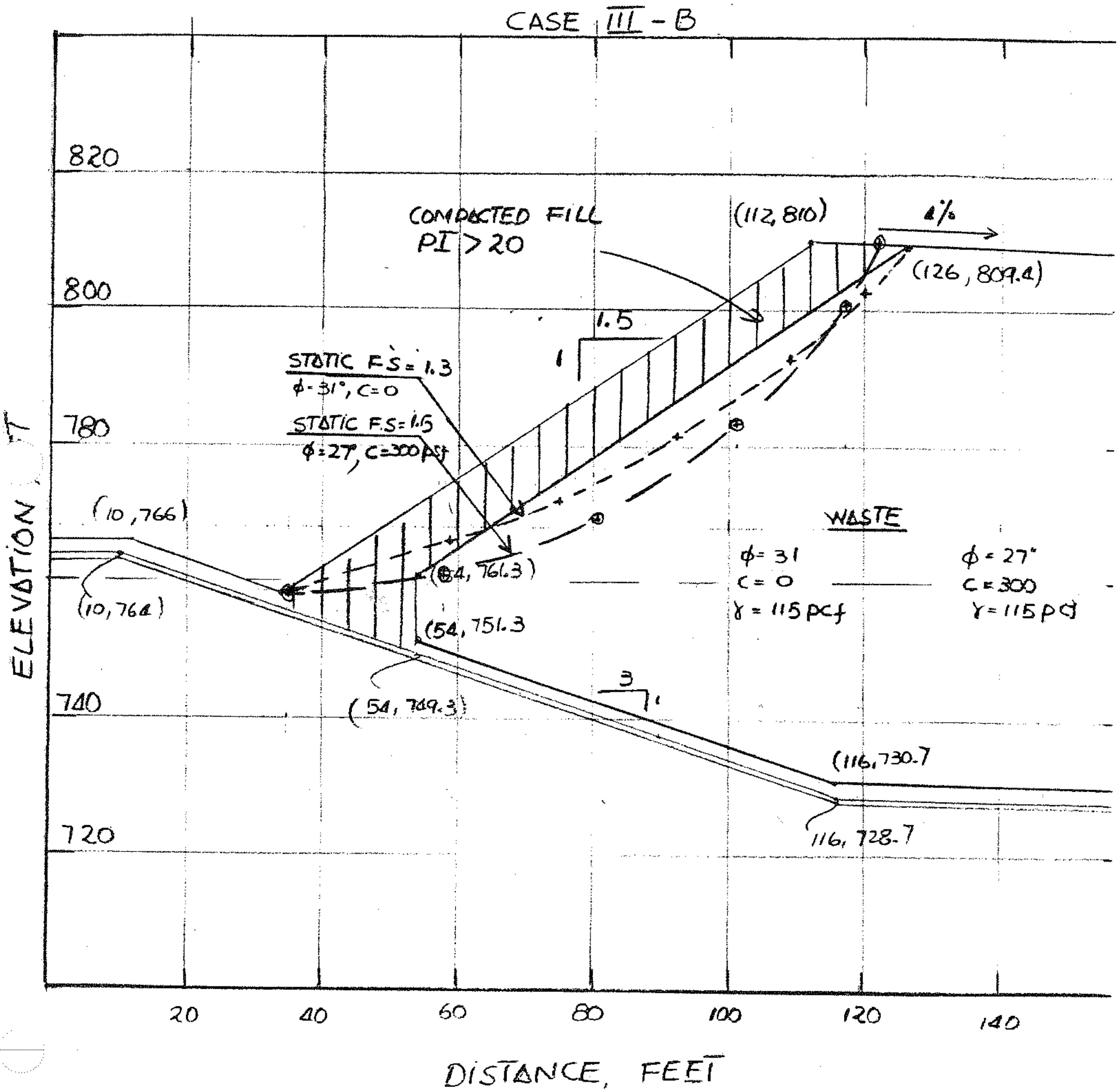
FACTORS OF SAFETY WERE COMPUTED USING TWO DIFFERENT STRENGTH PARAMETERS FOR THE WASTE

SHORT TERM $c = 300$ psf
$\phi = 27°$
$\gamma = 115$ pcf

LONG TERM $c = 0$
$\phi = 31°$
$\gamma = 115$ pcf

K — HORIZONTAL EARTHQUAKE LOADING COEFFICIENT

MAX WASTE ELEV.	FILE NAME	FAILURE MODE	E=EARTHQUAKE S=STATIC	K	SAFETY FACTOR	REMARKS (1) STATIC (2) PSEUDOSTATIC. USED TO ESTIMATE Ky.
810	KHICR.LS	CIRCL2	S	0	1.33 (1)	WASTE $c=0$, $\phi=31°$
810	KHICR.1E	CIRCL2	E	.3	.80 (2)	〃 〃
810	KHICR.2E	CIRCL2	E	.20	.93 (2)	〃 〃
810	KHICR.3E	CIRCL2	E	.14	1.03 (2)	〃 〃
810	KHICR.2S	CIRCL2	S	0	1.5 (1)	WASTE $c=300$ psf, $\phi=27°$



CASE III - B
820
800
780
740
720
COMPACTED FILL
PI > 20
(112, 810)
4%
(126, 809.4)
1.5
1
STATIC F.S = 1.3
ϕ = 31°, C = 0
STATIC F.S = 1.5
ϕ = 27°, C = 300 psf
(10, 766)
(10, 764)
(64, 761.3)
(54, 751.3)
(54, 749.3)
3
1
WASTE
ϕ = 31
C = 0
γ = 115 pcf
ϕ = 27°
C = 300
γ = 115 pcf
(116, 730.7)
116, 728.7
20
40
60
80
100
120
140
ELEVATION, FT
DISTANCE, FEET

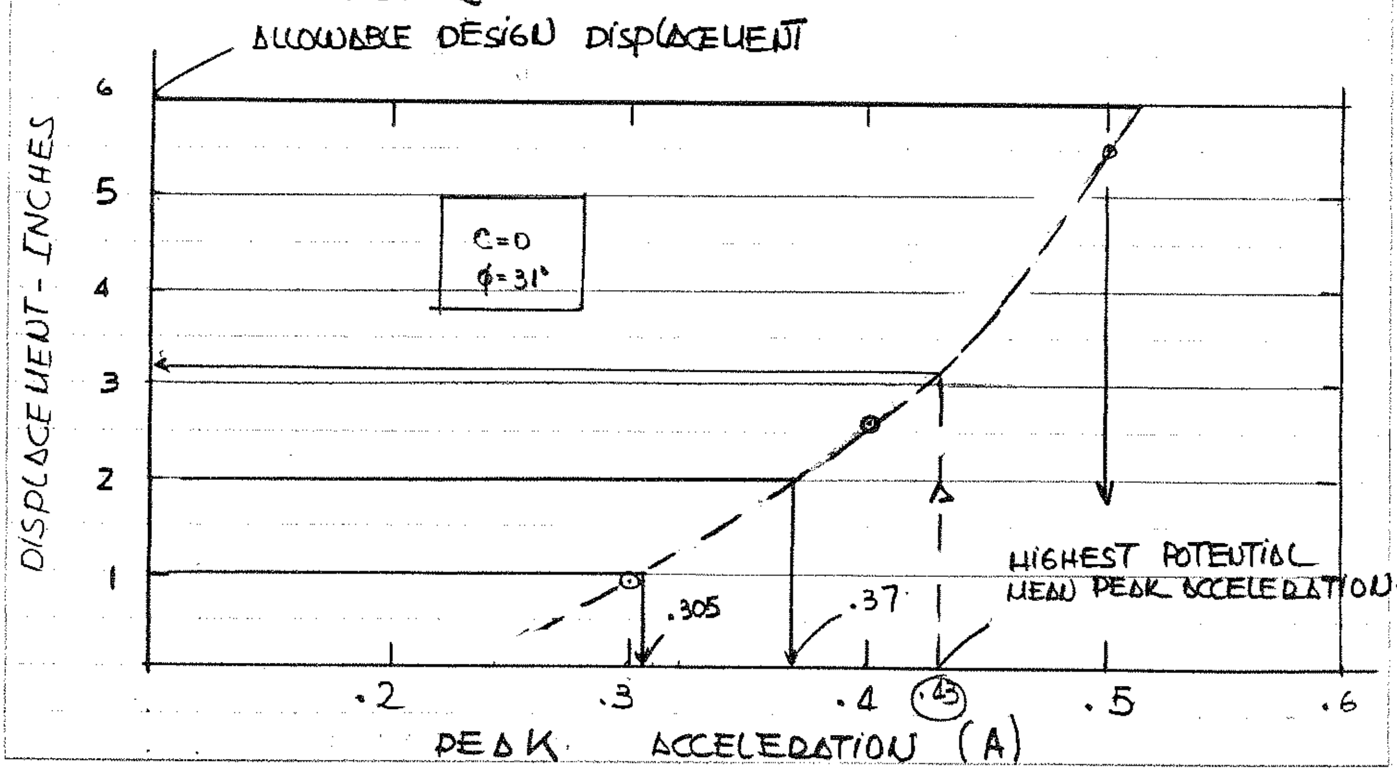
FIGURE 21

K_y = .145 (FILE NAME: KHICR.3E)

CASE III - B(1)

K_y	A	$\frac{K_y}{A}$	U_s * (INCHES)	$\frac{V}{A}$	$U_m = \frac{U_s V^2}{1{,}800\,A}$	U_m (INCHES)
.145	.3	.48	6	30	U_m = .15 U_s	.90
.145	.4	.36	13	30	U_m = .20 U_s	2.60
.145	.5	.29	22	30	U_m = .25 U_s	5.50

* FROM FIGURE 2



ENVIRONMENTAL SOLUTIONS, INC.

By J.B Date 8/10/90 Subject B-18 LANDFILL Sheet No. 19 of 24

Chkd. By GSC Date 8/13/90 SLOPE STABILITY Proj. No. 89-977

FOR SHALLOW FAILURE $A = A_0$

DESIGN PERIOD = 10 YEARS

A = .5 FOR AN ALLOWABLE DESIGN PERMANENT DISPLACEMENT OF 6 INCHES

FROM FIGURE 22 POE = 3.0×10^{-3}

CONCLUSION

1 - STATIC FACTOR OF SAFETY = $1.3 < 1.5$. SHALLOW FAILURE. CONSERVATIVE SINCE COHESION IS NOT ALLOWED FOR the WASTE. IN REALITY, SOME COHESION (~300 psf) SHOULD BE CONSIDERED FOR WASTE MATERIALS

- K_y = .145

- POE = 3.0×10^{-3} FOR 6-INCH DISPLACEMENT

- AN ALLOWABLE MAXIMUM DEFORMATION OF 6 INCHES IN THE WASTE PILE IS ACCEPTABLE BASED ON the SLOPE CONFIGURATION AT the TOE AND the FACT THAT HIGHER FACTORS OF SAFETY WERE CALCULATED FOR THE CASE III-A.

- STATIC FACTOR OF SAFETY FOR C = 300 psf and $\phi = 27°$ (waste) = 1.5 OK.

CASE III-b

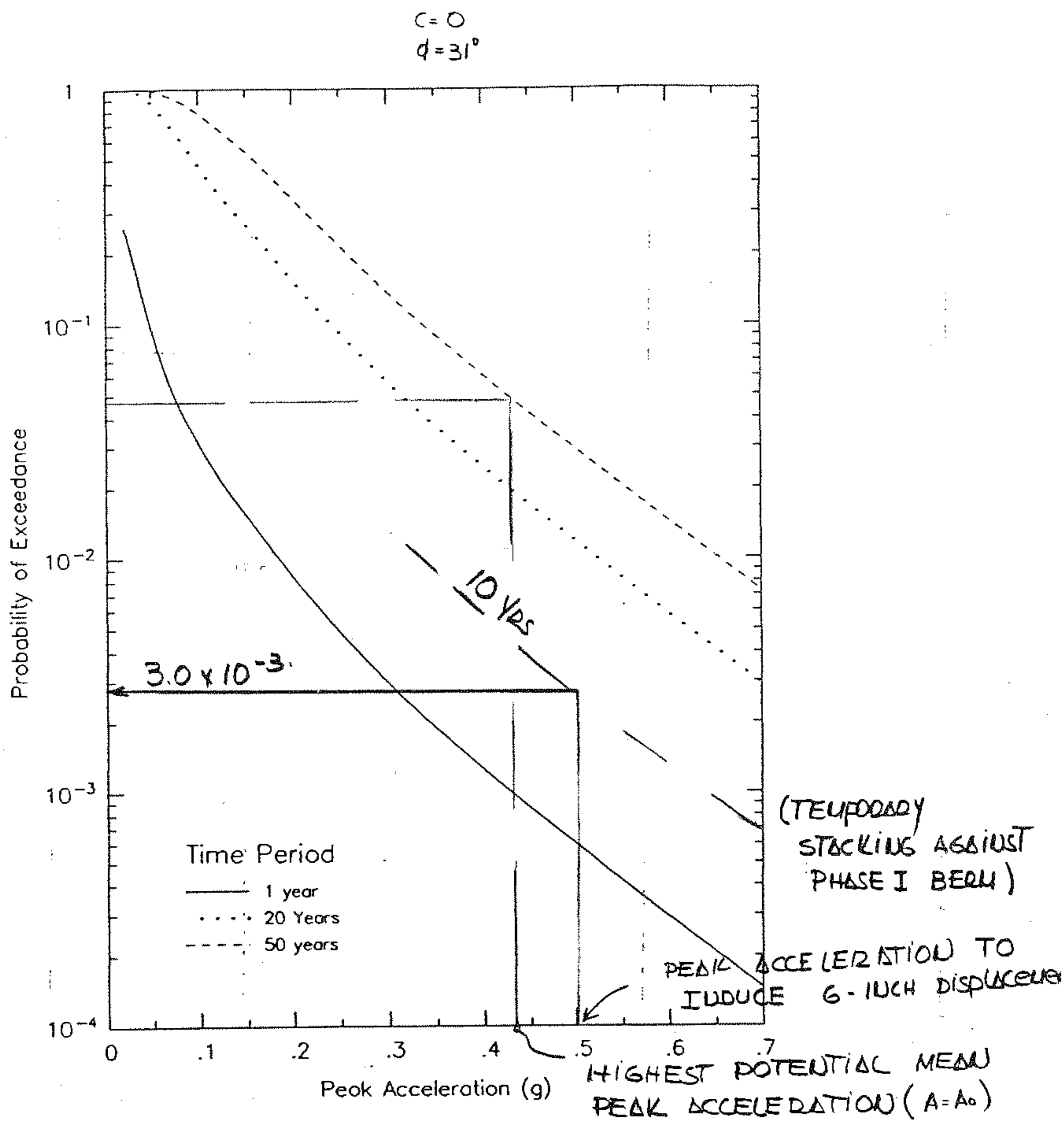


Figure 3. Probability of exceedance as a function of time period

FIGURE 22

ENVIRONMENTAL SOLUTIONS, INC.

By J.B Date 8/13/90 Subject B-18 LANDFILL Sheet No. 21 of 24
Chkd. By GSC Date 8/15/90 SLOPE STABILITY Proj. No. 89-977

CASE III - B(2) - COHESION ALLOWED FOR WASTE

$c = 300\ psf$
$\phi = 27°$
$\gamma = 115\ pcf$

PERFORMANCE CRITERIA

SAME AS III - B(1)

SLOPE STABILITY MODEL IS SHOWN IN FIGURE 21

FACTORS OF SAFETY ARE AS FOLLOWS

MAX. WASTE ELEV.	FILE NAME	FAILURE MODE	E=EARTHQ. S=STATIC	(1) K	SAFETY FACTOR	REMARKS
810	KHICR.2S	CIRCL2	S	0	1.5 (2)	WASTE
810	NH1CR.2S	CIRCL2	E	.3	.92 (3)	c = 300 psf
810	NHICR.3S	CIRCL2	E	.24	1.0 (3)	ϕ = 27°

(1) HORIZONTAL EARTHQUAKE LOADING COEFFICIENT

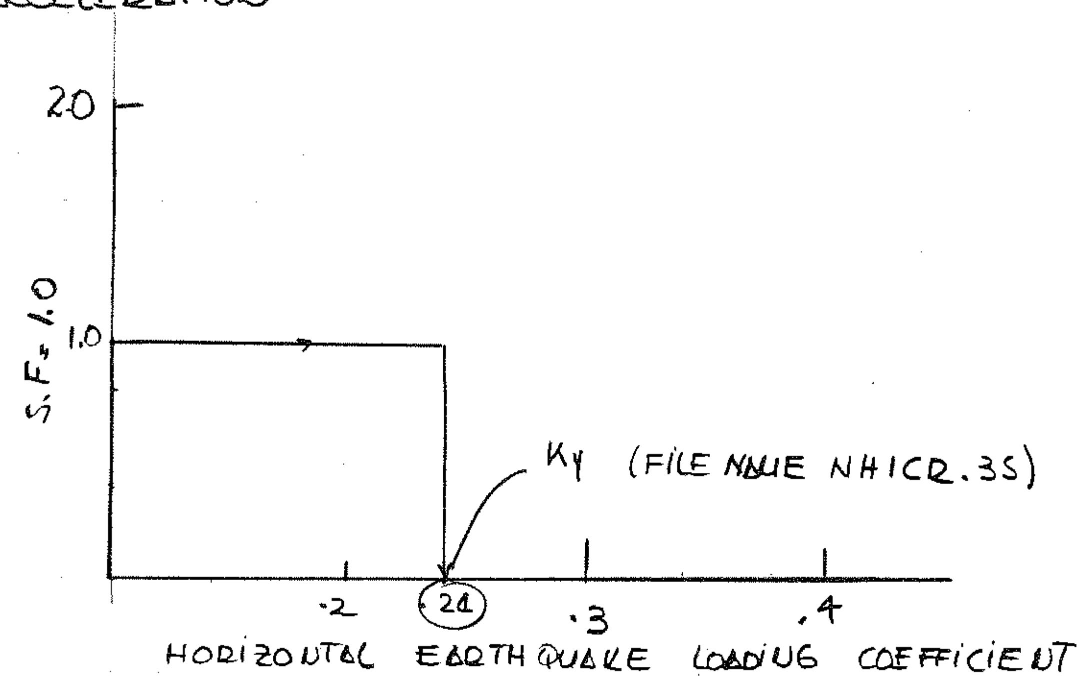
(2) STATIC

(3) PSEUDOSTATIC. A VALUE LESS THAN 1 DOES NOT NECESSARILY IMPLY FAILURE.

ENVIRONMENTAL SOLUTIONS, INC.

By J. B Date 8/13/90 Subject B-18 LANDFILL Sheet No. 22 of 24
Chkd. By GSC Date 8/15/90 SLOPE STABILITY Proj. No. 89-977

YIELD ACCELERATION



Ky = .24

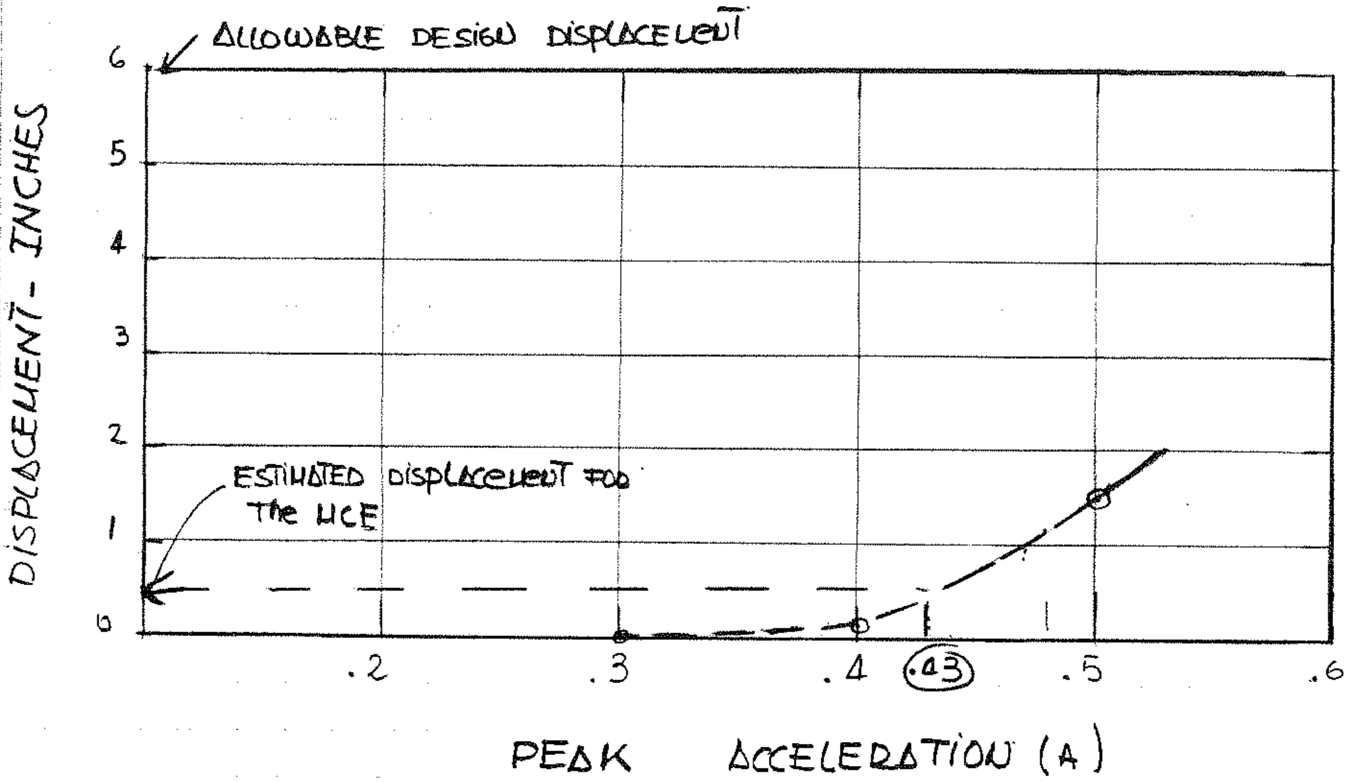
CASE III - B(2)

Ky	A	$\frac{Ky}{A}$	Us* (INCHES)	$\frac{V}{A}$	$Um = \frac{Us\ V^2}{1{,}800\ A}$	Um (INCHES)
.24	.3	.80	0	30	Um = .15 Us	0
.24	.4	.60	1	30	Um = .20 Us	.2
.24	.5	.48	6	30	Um = .25 Us	1.50

* FROM FIGURE 2

ENVIRONMENTAL SOLUTIONS, INC.

By J. B Date 8/13/90 Subject B-18 LANDFILL Sheet No. 23 of 24
Chkd. By GSC Date 8/15/90 SLOPE STABILITY Proj. No. 89-977



FOR SHALLOW FAILURE A = Ao

FROM FIGURE 22A.

A ≈ .6 FOR 6-INCH DISPLACEMENT CONSERVATIVE
A = Ao

POE = 10^{-3} (DESIGN PERIOD 10 YRS)

CONCLUSION

- STATIC FACTOR OF SAFETY 1.5
- ESTIMATED DISPLACEMENT FOR THE MCE = 0.5" < 6" OK
- POE = 10^{-3} (10 YRS)

CASE III - B(2)

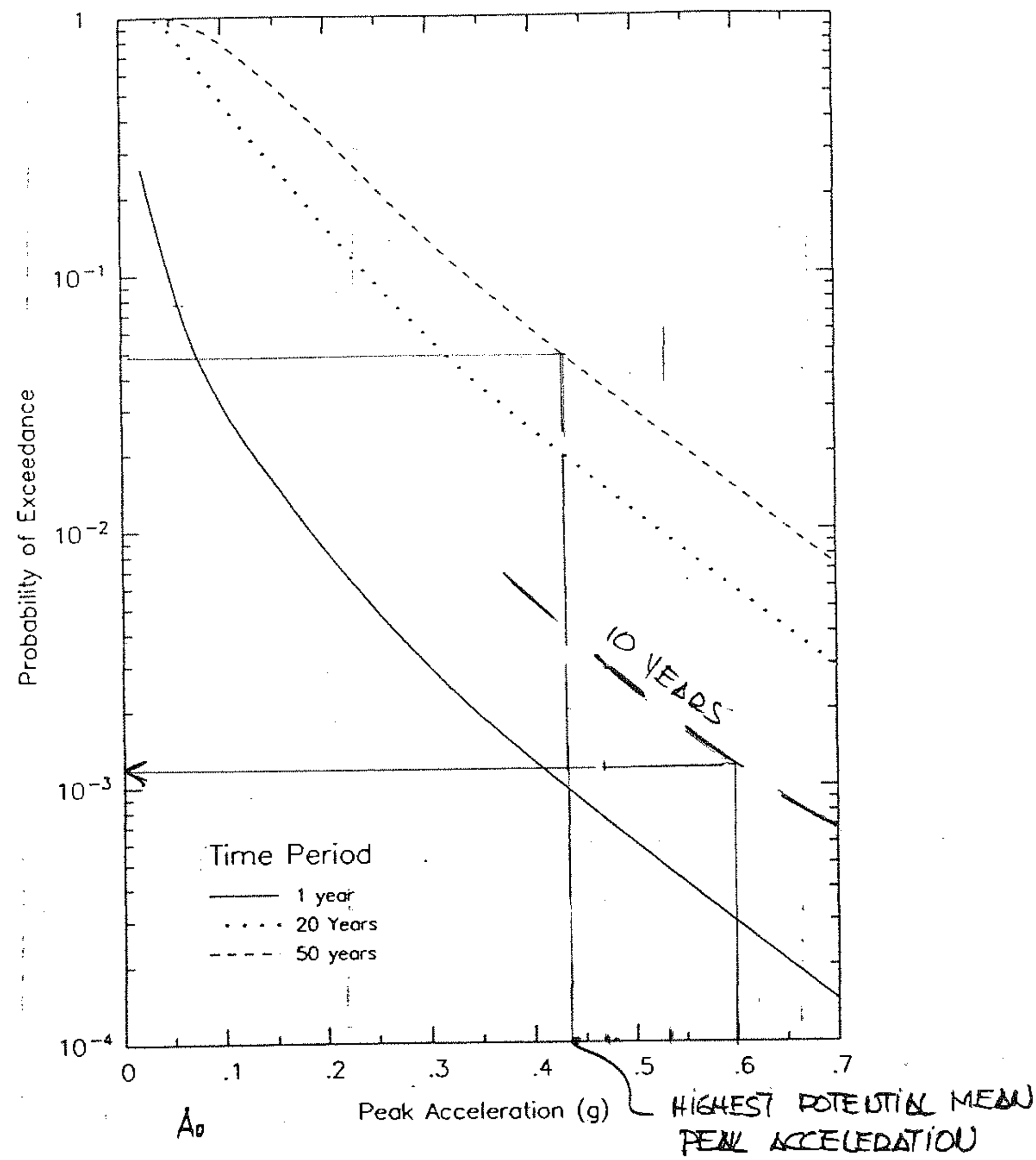


Figure 3. Probability of exceedance as a function of time period

FIGURE 22-A

HAI HUSHMAND ASSOCIATES, INCORPORATED
Geotechnical, Earthquake and Environmental Engineers

May 2, 2011

Golder Associates Inc.
230 Commerce, Suite 200
Irvine, California, USA 92602
Mr. Ryan Hillman, P.E.

SUBJECT: **SLOPE STABILITY ANALYSIS**
KETTLEMAN HILLS FACILITY
LANDFILL UNIT B-18, PHASE IIIA EXPANSION
KETTLEMAN CITY, KINGS COUNTY, CALIFORNIA
HAI PROJECT NO. GLD-11-001

This letter report summarizes the results of Hushmand Associates, Inc. (HAI) slope stability analyses for the proposed Phase IIIA temporary waste slopes of the Class I/II (hazardous and designated wastes) Landfill Unit B-18 at Chemical Waste Management (CWM) Kettleman Hills Facility (KHF). The KHF is located in Kettleman City, Kings County, California approximately one mile north of State Route 41 and 2.5 miles west of Interstate Freeway 5.

CWM is planning to construct the proposed Landfill B-18 Phase III expansion in 2 phases – Phase IIIA and Phase IIIB. The proposed final cover grades analyzed previously (HAI 2008 and 2009) are not changing; however, CWM has requested a static stability analysis be conducted for the temporary waste slope that would be formed at the Phase IIIA-IIIB interface.

This report presents the results of static slope stability evaluations for the most critical slope cross section of the temporary Phase IIIA expansion area of the landfill, identified and provided by Golder Associates Inc. (Golder). More details on the project background, project description, and regulatory requirements are provided in Golder's report (2011).

Material Properties

Key material properties of various components of the landfill needed to perform static slope stability analyses are: (1) unit weight, and (2) shear strength parameters.

Detailed site-specific information on waste, existing liner systems, and foundation bedrock material properties are provided in the design and conformance testing reports prepared during early 1990's (Golder, 1990, 1991; ESI, 1990, 1992, 1993), and more recent reports prepared for Kettleman Hills Facility (Rust, 1998; URS, 2005; HAI, 2008, 2009). HAI (2008) recommended that assumed properties used for design be further verified by performing site-specific tests on the actual materials that would be used during construction. Golder performed site-specific laboratory testing on the proposed liner system materials for the landfill expansion area to verify the interface properties. The proposed Phase III liner system configuration is shown in Appendix

A. Interface shear strength testing was performed on the sandwich-like multilayer structure of the Phase III liner system. The test results indicated that the weakest interface was the double sided (DS) geocomposite and 60-mil textured HDPE geomembrane for all applied normal loads. The peak interface shear strength properties were measured as approximately ϕ = 26° and C = 0. Additional testing also confirmed these results. Appendix A provides results of the interface shear tests performed on the Phase III proposed liner system materials. To be conservative reduced shear strength properties of ϕ = 22° and C = 0 were chosen for this static slope stability analyses. The material properties of the waste and liner interfaces used in the static stability analyses of Phase IIIA temporary slopes are shown in Table 1.

Table 1. Selected Material Properties for Static Stability Analysis

Material/Interface	**Unit Weight**	**ϕ (degree)**	**C (psf)**
HW [1]	115 pcf	31	0
Bedrock [1]	150 pcf	40	800
Expansion Area Liner Interface [2]	----	22	0

(1) Environmental Solutions, Inc. (1990, 1992, 1993); Rust Environmental & Infrastructure, Inc. (1998); URS (2005).
(2) Golder Associates, Inc. (2011).

Stability Analysis

Conventional two-dimensional (2-D) limit-equilibrium stability analyses were performed for the existing bottom/side slope liner and waste fill slopes using landfill cross section B-B' (see Figure 1). The computer program GSTABL7 v. 2.005 developed by Gregory Geotechnical Software was used to calculate the factors of safety against potential failure. The program uses 2-D limit equilibrium theory to provide general solutions for slope stability problems with provisions of using the Modified Bishop, Modified Janbu, or Spencer Methods. Both circular and non-circular potential sliding surfaces can be prespecified or randomly generated. The Spencer, and Modified Janbu methods were used for this study. The minimum factor of safety was obtained by varying the initiation and exit points of the trial failure planes.

The Modified Janbu Method of analysis, which normally provides conservative results, was initially used to evaluate a large number of potential failure mechanisms for each cross section analyzed. At least hundred (100) potential failure surfaces are randomly generated by the program and the most critical surface resulting in the lowest factor of safety is identified. The most critical failure plane determined by the Modified Janbu Method is then reanalyzed using the Spencer Method. This method satisfies both force and moment equilibrium and thus provides more realistic (usually higher) estimates of the factors of safety. The Janbu method is generally more conservative compared with the more rigorous Spencer Method and typically results in lower factors of safety than the Spencer Method.

The GSTABL7 output plots, presented in Appendix B, illustrate the 2-D cross section, various potential failure surface conditions considered, and the most critical failure surfaces analyzed in the stability analysis of the proposed landfill temporary fill slopes. The failure surface with the lowest factor of safety is identified with two arrows at its initiation and termination points. The factor of safety for the most critical potential failure plane (a deep failure plane along the Phase IIIA liner) computed using Spencer method was equal to 1.52.

Conclusion

This report addresses static stability of the landfill slopes for the proposed temporary Phase IIIA fill configuration of the Landfill B-18. The presented analyses demonstrated that computed static factors of safety is higher than 1.5 for the analyzed section. The analyses indicated that the proposed Phase IIIA temporary landfill configuration would result in a stable configuration under static loading conditions in compliance with applicable regulations.

Closure

We trust this report meets your present requirements. If you have any questions regarding this report, please contact this office at your convenience. We appreciate this opportunity to provide our professional services to Golder.

Sincerely yours,

Very truly yours,

HUSHMAND ASSOCIATES, INC.

Naz Mokarram, Ph.D.
Senior Staff Engineer

Ben Hushmand, Ph.D., P.E. 44777
President, Principal Engineer

References

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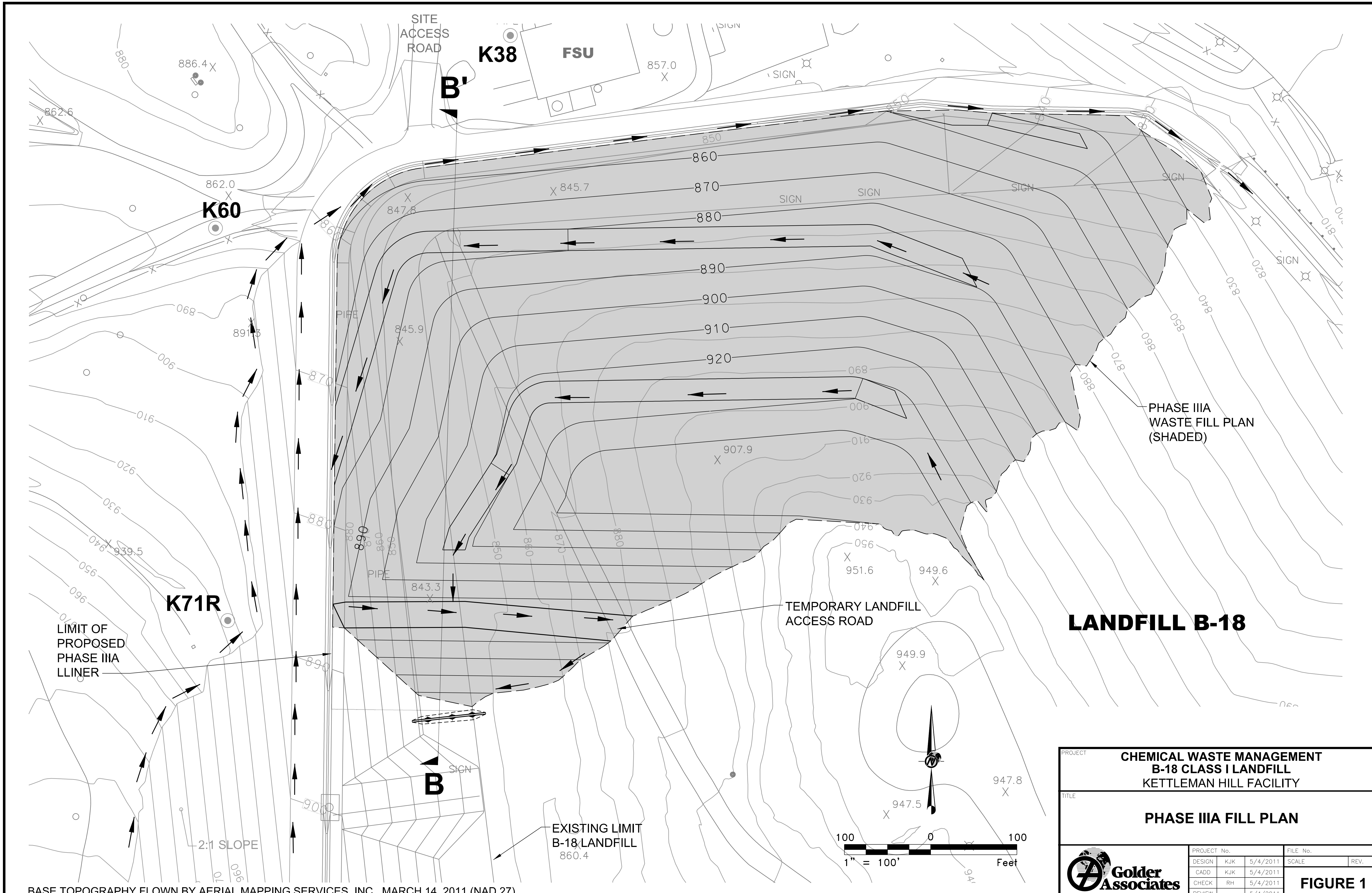
Rust Environment & Infrastructure, Inc., 1997 (Rev 1: 1998) "Preliminary Stability Evaluation, Municipal Solid Waste Landfill Unit B-19, Kettleman Hills Facility, Kettleman City, Kings County, California," Technical Report prepared for Chemical West Management, Inc., July.

URS (2005) "Preliminary Stability Analyses, Kettleman Hills Facility Expansion, Kettleman City, California," prepared for Chemical West Management, Inc.

FIGURES


SITE ACCESS ROAD
K38
FSU
B'
K60
K71R
LIMIT OF PROPOSED PHASE IIIA LLINER
PHASE IIIA WASTE FILL PLAN (SHADED)
TEMPORARY LANDFILL ACCESS ROAD
LANDFILL B-18
EXISTING LIMIT B-18 LANDFILL
B
2:1 SLOPE
SIGN
PIPE
850
860
870
880
890
900
910
920
886.4
862.6
857.0
862.0
845.7
847.8
845.9
891.5
939.5
907.9
951.6
949.6
843.3
949.9
947.8
947.5
860.4
100 0 100
1" = 100' Feet
BASE TOPOGRAPHY FLOWN BY AERIAL MAPPING SERVICES, INC., MARCH 14, 2011 (NAD 27).
PROJECT
CHEMICAL WASTE MANAGEMENT
B-18 CLASS I LANDFILL
KETTLEMAN HILL FACILITY
TITLE
PHASE IIIA FILL PLAN
Golder Associates
PROJECT No.
FILE No.
DESIGN KJK 5/4/2011
CADD KJK 5/4/2011
CHECK RH 5/4/2011
REVIEW -- 5/4/2011
SCALE
REV.
FIGURE 1

APPENDIX A

INTERFACE SHEAR TEST RESULTS

TABLE 1

CLIENT: GOLDER & ASSOCIATES

PROJECT: KETTLEMAN HILLS

INTERFACE SHEAR TEST RESULT (ASTM D5321/6243)

PGL Job No. G090907

Reviewed By ________

Date: 2-Oct-09

TEST CONFIGURATION 1

NORMAL LOAD

TOP BOX		
SKAPS, 8oz DS Geocomposite, TN 220-2-8	NA	62070
(Floating) GSE, 60 mil DS Textured HDPE	(as shown)	44500
(Floating) SKAPS, 8oz DS Geocomposite, TN 220-2-8	(NA)	62070
(Floating) GSE, 60 mil DS Textured HDPE	(as shown)	44501
Clay Soil	(NA)	62009
BOTTOM BOX		

TEST CONDITIONS:

SAMPLE PREPARATION:

1. Specimens were cut along machine direction to 14" x 17" for the upper box, and 14" x 19" for the lower box, with an effective test area of 12" x 12".
2. The Maximum Dry Density (**MDD**) of the soil is **111.8** **pcf** at **16.4%** Optimum Moisture Content (**OMC**).
3. Soil specimen was remolded to **102.86** **pcf** ; i.e.. **92.0%** of MDD at **20.5%** moisture content. (forming 2 inch layer in the TOP and BOTTOM boxes).
4. The three intermediate geosynthetic specimens were floating during shear run.

CONSOLIDATION:

1. Each set of specimen was consolidated under **Dry** condition for **24 hrs** @ normal load before shearing.
2. Normal loads were applied using **Hydraulics** for the highest load, **Bladder** for the intermediate and lowest loads.

SHEAR TEST:

1. Shear test was conducted @ **0.040** in/ min.
2. Sheared @ minimı **3.0** inch horizontal displacement.
3. Test specimens were sheared i **Dry** condition.
4. Test were performed in general accordance with ASTM D6243 / ASTM D5321 using Brainard-Kilman LG-112 Direct Shear machine with effective test area of 12 in X 12 in.

TEST RESULTS:

Normal Stresses Applied		Asperity Heights (C#44500)				Asperity Heights (C# 44501)				Moisture Content (Soil)		PEAK STRENGTH		POST- PEAK STRENGTH AT 3.0 INCHES	
		UP		DOWN		UP		DOWN				Shear Stress	Secant Angle	Shear Stress	Secant Angle
		Before	After	Before	After	Before	After	Before	After	Before	After				
(psi)	(psf)	(mils)	(mils)	(mils)	(mils)	(mils)	(mils)	(mils)	(mils)	(%)	(%)	(psf)	(degrees)	(psf)	(degrees)
34.7	5,000	23.7	23.1	24.4	23.2	23.5	19.4	24.4	23.7	20.5	18.6	2,709	28	1,148	13
69.4	10,000	23.7	22.9	23.7	22.3	22.9	17.7	24.3	22.1	20.5	19.8	4,737	25	2,032	11
104.2	15,000	24.6	22.8	25.3	24.6	24.8	16.3	24.0	23.0	20.5	20.1	7,953	28	3,283	12
Note: N/A - Not Applicable						COHESION (psf) :						0		19	
						COEFFICIENT OF FRICTION :						0.52		0.21	
						FRICTION ANGLE (degrees) :						27.7		12.1	

NOTE: The friction angles and cohesion results given here are based on mathematically determined best fit line.

OBSERVATIONS:

1. No tilting of the system or any abnormalities observed during and after the test.
2. Superficial abrasion on the geosynthetics interfacing sides (typical to all loads).
3. Sliding occurred between the DS Geocomposite (C# 62070) and 60 mil HDPE (C# 44501) on all loads. See attached photos (907-1-15,000 psf / 907-1-10,000 psf / 907-1-5,000 psf).

Figure #1
Normal Stress/ Interface Stress

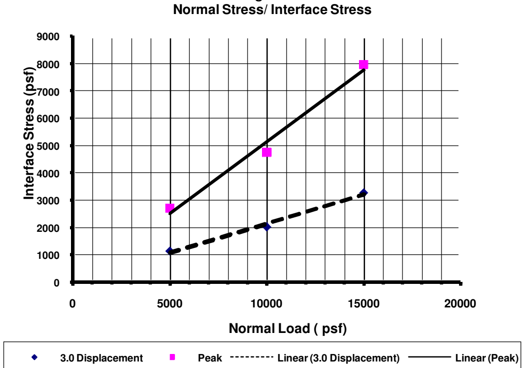


Figure #2
Shear Stress/ Displacement Curve

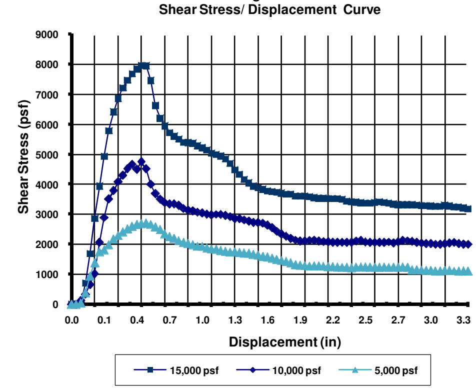
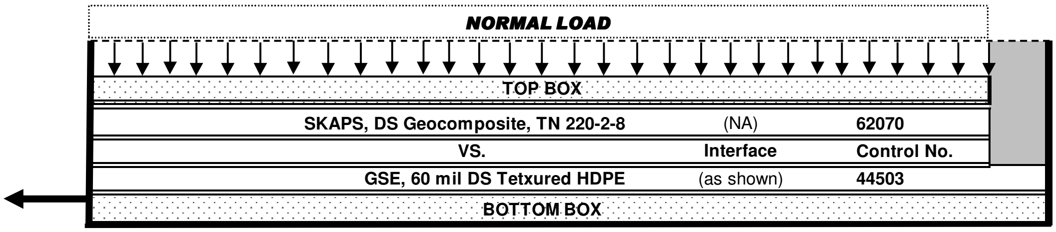


TABLE 1-A
CLIENT: GOLDER & ASSOCIATES
PROJECT: KETTLEMAN HILLS

INTERFACE SHEAR TEST RESULT (ASTM D5321/6243)
PGL Job No. G091078

Reviewed By: [signature]
Date: 19-Oct-09

TEST CONFIGURATION **1-A**



TEST CONDITIONS:

SAMPLE PREPARATION:

1. Specimens were cut along machine direction to 14" x 17" for the upper box, and 14" x 19" for the lower box, with an effective test area of 12" x 12".
2. Geosynthetic specimens were secured via flat bar clamping mechanisms complete with bolts and nuts (7-pairs).

CONSOLIDATION:

1. The specimen was consolidated under **Dry** condition for **2 hrs** @ normal load before shearing.
2. Normal load was applied using **Bladder**

SHEAR TEST:

1. Shear test was conducted @ **0.04** in/ min.
2. Sheared @ minimum **3.0** inch horizontal displacement.
3. The test specimens were sheared at **Dry** condition .
4. Test were performed in general accordance with ASTM D6243 / ASTM D5321 using Brainard-Kilman LG-112 Direct Shear machine with effective test area of 12 in X 12 in.

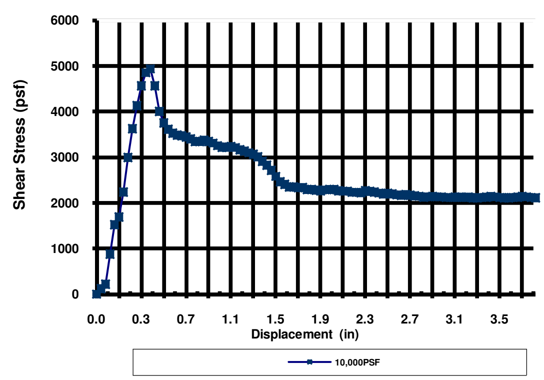
TEST RESULTS:

Normal Stresses Applied		Asperity Heights		PEAK STRENGTH		POST- PEAK STRENGTH AT 3.0 INCHES	
		mils		Shear Stress	Secant Angle	Shear Stress	Secant Angle
(psi)	(psf)	Before	After	(psf)	(degrees)	(psf)	(degrees)
69.44	10,000	25.5	18.4	4940	26	2135	12

OBSERVATIONS:

1. No tilting of the system or any abnormalities observed during and after the test.
2. Superficial abrasion on the geosynthetics interfacing sides (typical to all loads).
3. Sliding occurred between the two interfacing surfaces.

Figure #2
Shear Stress/ Displacement Curve



Precision Geosynthetic Laboratories

TABLE 1-B

CLIENT: GOLDER & ASSOCIATES

PROJECT: KETTLEMAN HILLS

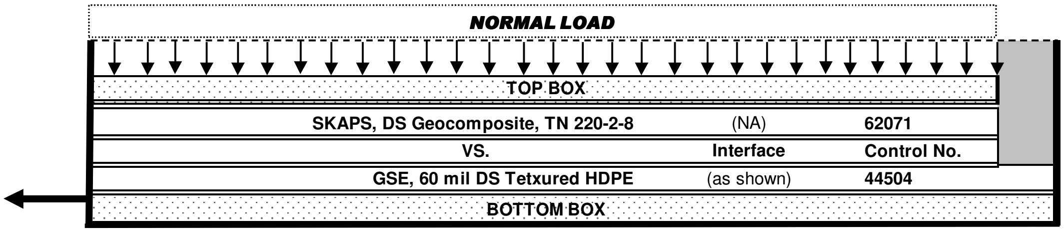
INTERFACE SHEAR TEST RESULT (ASTM D5321/6243)

PGL Job No. G091078

Reviewed By:

Date: 19-Oct-09

TEST CONFIGURATION 1-B



TEST CONDITIONS:

SAMPLE PREPARATION:

1. Specimens were cut along machine direction to 14" x 17" for the upper box, and 14" x 19" for the lower box, with an effective test area of 12" x 12".
2. Geosynthetic specimens were secured via flat bar clamping mechanisms complete with bolts and nuts (7-pairs).

CONSOLIDATION:

1. The specimen was consolidated under **Dry** condition for **2 hrs** @ normal load before shearing.
2. Normal load was applied using **Bladder**

SHEAR TEST:

1. Shear test was conducted @ **0.04** in/ min.
2. Sheared @ minimum **3.0** inch horizontal displacement.
3. The test specimens were sheared at **Dry** condition .
4. Test were performed in general accordance with ASTM D6243 / ASTM D5321 using Brainard-Kilman LG-112 Direct Shear machine with effective test area of 12 in X 12 in.

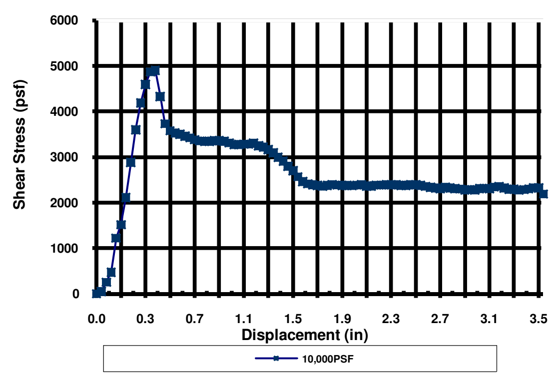
TEST RESULTS:

Normal Stresses Applied		Asperity Heights		PEAK STRENGTH		POST- PEAK STRENGTH AT 3.0 INCHES	
		mils		Shear Stress	Secant Angle	Shear Stress	Secant Angle
(psi)	(psf)	Before	After	(psf)	(degrees)	(psf)	(degrees)
69.44	10,000	24.8	19.3	4903	26	2282	13

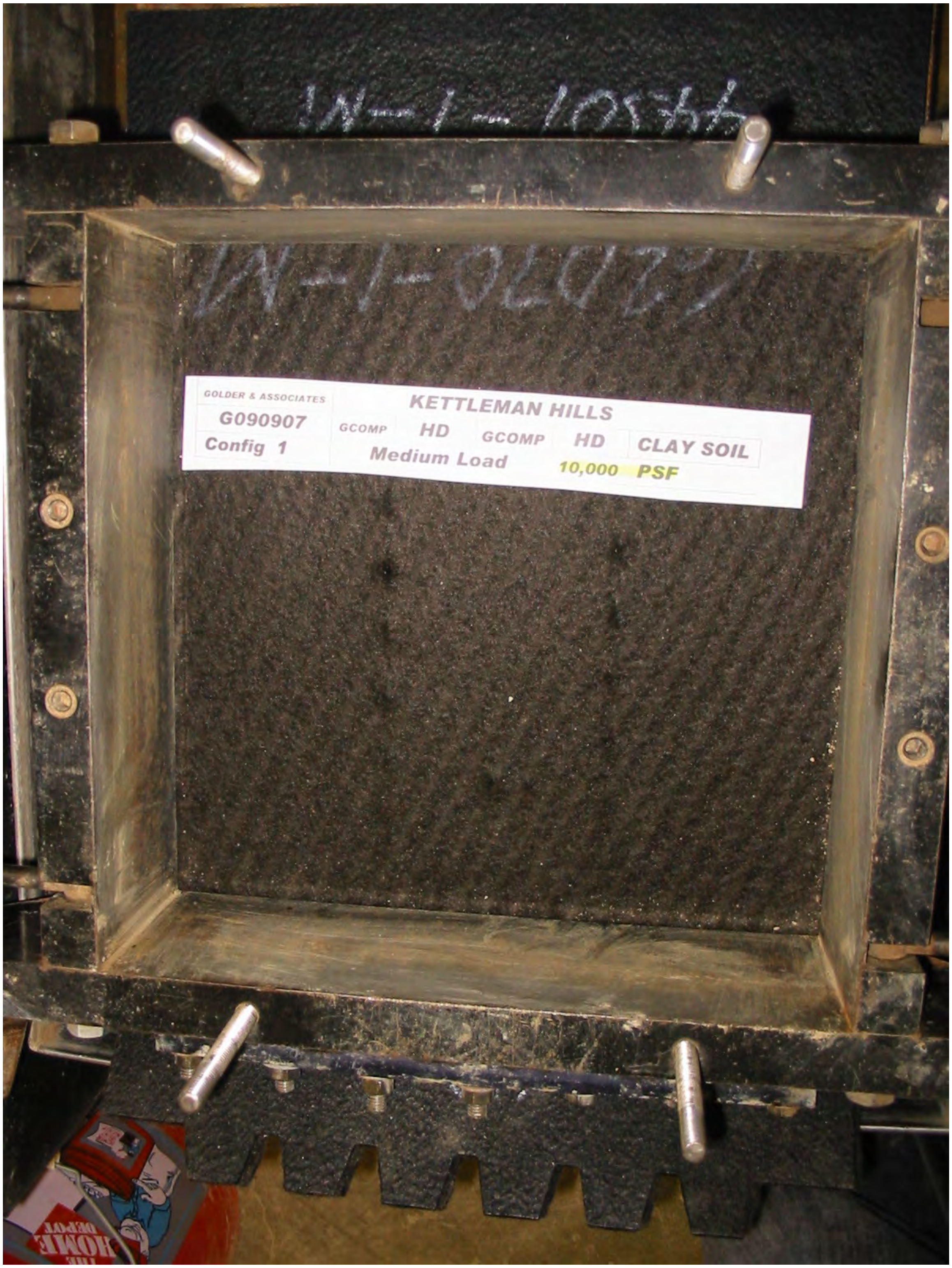
OBSERVATIONS:

1. No tilting of the system or any abnormalities observed during and after the test.
2. Superficial abrasion on the geosynthetics interfacing sides (typical to all loads).
3. Sliding occurred between the two interfacing surfaces.

Figure #2
Shear Stress/ Displacement Curve



@ 15,000 psf


GOLDER & ASSOCIATES
G090907
Config 1
KETTLEMAN HILLS
GCOMP
HD
GCOMP
HD
CLAY SOIL
Medium Load
10,000
PSF

@ 10,000 psf


4450I-H
GOLDER & ASSOCIATES
KETTLEMAN HILLS
G090907
GCOMP
HD
GCOMP
HD
CLAY SOIL
Config 1
Low Load
5,000 PSF

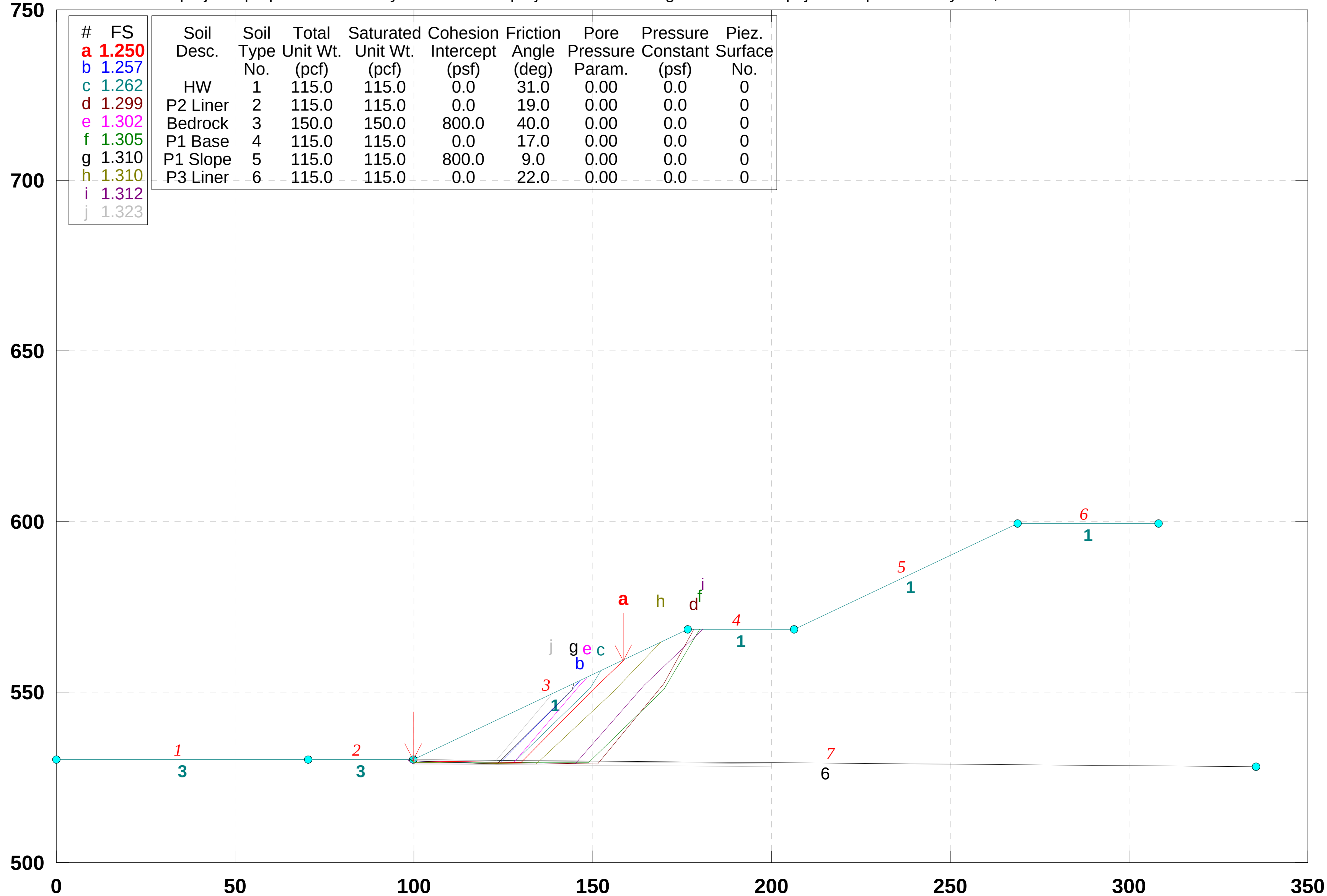
@ 5,000 psf

APPENDIX B

SLOPE STABILITY ANALYSIS PLOTS

Kettleman Hills Landfill B-18 Phase IIIA Interim Slope

z:\projects-proposals-laboratory\hai2011\2011 projects\waste management\khf\b-b'\p3jan1-22.pl2 Run By: NM, HAI 4/29/2011 03:18PM



#	FS
a	1.250
b	1.257
c	1.262
d	1.299
e	1.302
f	1.305
g	1.310
h	1.310
i	1.312
j	1.323

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
HW	1	115.0	115.0	0.0	31.0	0.00	0.0	0
P2 Liner	2	115.0	115.0	0.0	19.0	0.00	0.0	0
Bedrock	3	150.0	150.0	800.0	40.0	0.00	0.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0.00	0.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0.00	0.0	0
P3 Liner	6	115.0	115.0	0.0	22.0	0.00	0.0	0

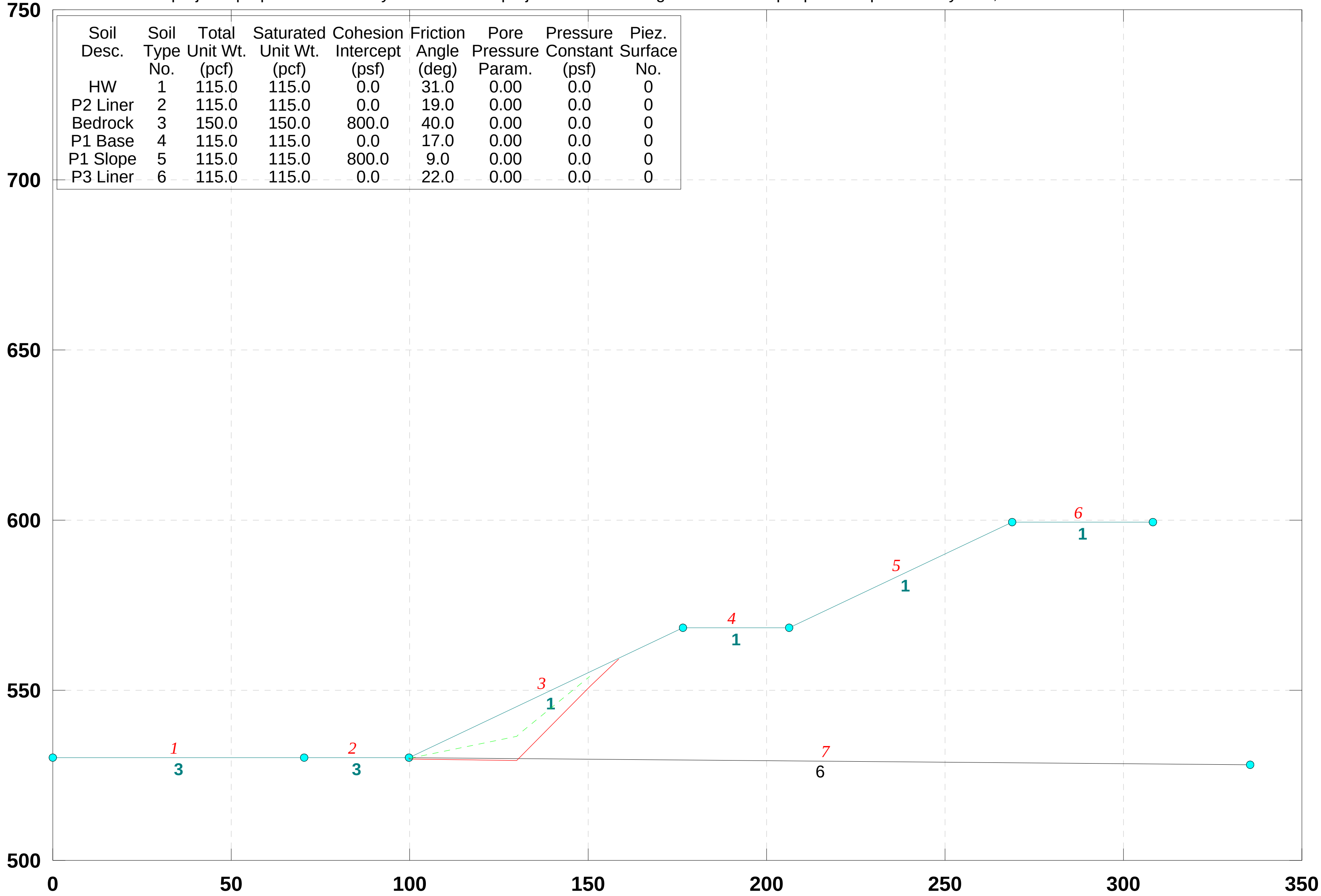
GSTABL7 v.2 FSmin=1.250

Safety Factors Are Calculated By The Simplified Janbu Method

GSTABL7

Kettleman Hills Landfill B-18 Phase IIIA Interim Slope

z:\projects-proposals-laboratory\hai2011\2011 projects\waste management\khf\b-b'\p3spen1-22.plt Run By: NM, HAI 4/29/2011 03:28PM



Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
HW	1	115.0	115.0	0.0	31.0	0.00	0.0	0
P2 Liner	2	115.0	115.0	0.0	19.0	0.00	0.0	0
Bedrock	3	150.0	150.0	800.0	40.0	0.00	0.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0.00	0.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0.00	0.0	0
P3 Liner	6	115.0	115.0	0.0	22.0	0.00	0.0	0

GSTABL7 v.2 FSmin=1.521

Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

APPENDIX H.5
FINAL CLOSURE STABILITY

HAI **HUSHMAND ASSOCIATES, INCORPORATED**
Geotechnical, Earthquake and Environmental Engineers

SLOPE STABILITY ANALYSIS REPORT

KETTLEMAN HILLS FACILITY
HAZARDOUS WASTE LANDFILL
UNIT B-18 EXPANSION
KETTLEMAN CITY, KINGS COUNTY, CALIFORNIA

Prepared for:

Chemical Waste Management, Inc.
Kettleman Hills Facility, 35251 Old Skyline Road
Kettleman City, California 93239

Prepared by:

Hushmand Associates, Inc.
250 Goddard
Irvine, California 92618

September 2008

HAI HUSHMAND ASSOCIATES, INCORPORATED
Geotechnical, Earthquake and Environmental Engineers

September 15, 2008

Golder Associates Inc.
230 Commerce, Suite 200
Irvine, California, USA 92602

Attn: Mr. Scott Sumner, P.E.
Principal

SUBJECT: SLOPE STABILITY ANALYSIS REPORT
KETTLEMAN HILLS FACILITY
HAZARDOUS WASTE LANDFILL UNIT B-18 EXPANSION
KETTLEMAN CITY, KINGS COUNTY, CALIFORNIA
HAI PROJECT No. 08-0228

Dear Mr. Sumner:

Hushmand Associates, Inc. (HAI) is pleased to submit to Golder Associates, Inc. (Golder) four (4) copies of the slope stability evaluation report for the Class I/II hazardous waste landfill unit B-18 (Landfill B-18) expansion at Waste Management, Inc. (WMI) Kettleman Hills Facility.

We trust this report meets your present requirements. If you have any questions regarding this report, please contact this office at your convenience. We appreciate this opportunity to provide our professional services to Golder.

Sincerely yours,

HUSHMAND ASSOCIATES, INC.

Ben Hushmand, PhD, PE 44777
President, Principal Engineer

REGISTERED PROFESSIONAL ENGINEER
BEHNAM HUSHMAND
No. C 044777
Exp. 3-31-10
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STATE OF CALIFORNIA

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SLOPE STABILITY ANALYSIS REPORT

KETTLEMAN HILLS FACILITY
HAZARDOUS WASTE LANDFILL UNIT B-18 EXPANSION
KETTLEMAN CITY, KINGS COUNTY, CALIFORNIA

1.0 INTRODUCTION

1.1 GENERAL

This report summarizes the results of Hushmand Associates, Inc. (HAI) slope stability analyses for the proposed expansion of the existing Class I/II (hazardous and designated wastes) Landfill Unit B-18 at Chemical Waste Management (CWM) Kettleman Hills Facility (KHF). The KHF is located in Kettleman City, Kings County, California approximately one mile north of State Route 41 and 2.5 miles west of Interstate Freeway 5.

In 2005, URS Corporation (URS) prepared a stability analysis report as part of an Environmental Impact Report (EIR) for the proposed Landfill Unit B-18 expansion (URS, 2005). To improve the proposed landfill expansion design, Golder Associates, Inc. (Golder) recently proposed some modifications to the URS final fill plan (Golder, 2008a, 2008b). These modifications required additional slope stability evaluations to demonstrate conformance of the proposed revised fill plan with regulatory requirements. A preliminary slope stability analysis report was then prepared by HAI (2008) in support of the EIR preparation for the proposed landfill expansion (CH2M Hill, 2008).

This report provides detailed stability evaluations for design of the revised landfill expansion fill plan, and is an appendix to a comprehensive design report prepared by Golder for the proposed landfill expansion (Golder, 2008b). The scope of this report is to evaluate static and seismic slope stability for the proposed Landfill Unit B-18 expansion fill plan configuration geometry as provided by Golder. Stability of landfill liner and waste slopes were analyzed to meet the design criteria discussed in Section 1.3. More details on the project background, project description, and regulatory requirements are provided in the landfill expansion EIR and design report (CH2M Hill, 2008; Golder, 2008b).

The following sections discuss the site design criteria, design earthquake motions, material properties used in static and pseudo-static slope stability and seismic deformation analyses, static slope stability and seismic deformation analysis methods, and results of the analyses.

1.2 BACKGROUND AND PROJECT DESCRIPTION

1.2.1 Background

The presently permitted design of the Class I/II Landfill Unit B-18 was developed in 1990 based on the results of detailed seismicity and static and dynamic slope stability analyses (Environmental Solutions, Inc. [ESI], 1990 and 1992). The landfill was constructed in two phases in early 1990's, designated as Phases I and II (see Figure A-1 of Appendix A) with corresponding leachate collection and removal systems (LCRSs). The existing liner systems in the Phase I and II areas meet applicable California Code of Regulations (CCR) Title 22 requirements. The configuration of the final fill plan for the 1990 design and existing liner systems for the landfill Phases I and II are provided in Appendix A (Figures A-2 to A-4).

1.2.2 Project Description and Scope

The CWM has proposed to expand the existing Class I/II Landfill Unit B-18 to provide an additional 5.0 million cubic yards of air space for a total capacity of approximately 15.7 million cubic yards. The proposed expansion design modifications to the 1990 ESI landfill liner grades and final grading plans includes expansion of the landfill footprint (mainly to the west and northwest of the site) requiring placement of approximately 12 acres of new composite liner, and increasing the landfill height and slope steepness (Figures 1 and 2, respectively). The expansion will also require rerouting of surface water and development of a new lined retention basin southeast of the landfill. Expansion of the site requires performing new analyses to demonstrate its conformance with applicable federal and state regulations for design of Class I/II landfills. These analyses include:

- Updating site seismicity and design ground motions using the recent attenuation relationships,
- Static and seismic stability of landfill slopes and liner system for final fill configuration,
- Landfill final cover stability, and
- Waste settlement and its effects on landfill final cover performance.

This report addresses the first three analysis items listed above (seismicity and ground motions, static and seismic stability of landfill slopes and liner system, and landfill final cover stability) and includes effects of increased landfill height and slope steepness on stability evaluations. The stability report presented here will be included as part of the Design Report being prepared by Golder for the proposed landfill expansion evaluation. The design issues associated with the landfill settlement and its effects on landfill cover performance are addressed in the Design Report.

The proposed final fill plan and landfill cover grades modified from the 1990 ESI final fill plan design are shown in Figure 2. A preliminary fill plan for the proposed Landfill B-18 expansion was initially developed, which was then refined based on the results of slope stability analysis iterations to arrive at the final fill plan design shown in Figure 2. Locations and configurations of the cross sections, which were evaluated for stability, are shown in Figures 1 through 4.

1.3 REGULATORY REQUIREMENTS FOR STATIC AND SEISMIC STABILITY

The existing Class I/II Landfill B-18 was designed in accordance with applicable regulations in CCR Titles 22 and 23 and the specific conditions in the site hazardous waste facility permit. CCR Titles 22 and 23 require consideration of the Maximum Credible Earthquake (MCE) for Class I landfills.

MCE is defined by California Geological Survey (CGS) as “the maximum earthquake that appears capable of occurring under the presently known tectonic framework.” Thus, for stability evaluations of the expanded Landfill Unit B-18, the MCE is used as the design earthquake and is evaluated for faults determined to produce potentially damaging ground motions at the site. Near- and far-field seismic events are evaluated to assure that both higher intensity and lower intensity earthquakes are considered. Near-field events at this site generate shorter duration, higher intensity, and higher frequency ground shaking compared to far-field earthquakes that result in longer duration but lower intensity and lower frequency ground shaking.

For seismic stability, the present state-of-the-practice is to estimate landfill slope displacements for design earthquakes, using a Newmark (Newmark, 1965) equivalent method, and demonstrate that they are below an allowable value that maintains the integrity of the landfill. Current engineering practice for slope stability evaluation along the landfill liner is to allow a maximum seismically-induced permanent slope displacement of six to twelve inches to correspond to acceptable performance for well-designed liner systems (Seed and Bonaparte, 1992). Class I landfills at KHF are designed to meet the lower bound displacement (more conservative) by limiting the maximum allowable slope displacement along the landfill liner to only six inches, which is also used in the design of the Class I/II Landfill Unit B-18 in this report. The criteria commonly used for landfill cover design, which allows a maximum seismically-induced permanent displacement of up to twenty four inches (2 feet) of the final covers, is based on the understanding that these would be relatively easily accessible and thus quickly repairable in the event of damage by a major seismic occurrence.

2.0 SITE DESIGN GROUND MOTIONS

2.1 PREVIOUS SITE DESIGN GROUND MOTIONS

A detailed discussion of the site geology, faulting, and seismicity was presented in the design report prepared for Landfill Unit B-18 (ESI, 1990) and more recent reports prepared for Landfill Unit B-19 at Kettleman Hills Facility (Rust Environment & Infrastructure [Rust], 1998; URS, 2005; HAI, 2006). Deterministic and probabilistic seismic hazard evaluations of the site were performed by Rust (1998), and also independently by William Lettis & Associates (WLA), reported as Appendix A of the 1998 Rust report. The ground motions and seismic design parameters presented in the 1998 Rust report were used in the 2005 URS and 2006 HAI reports, which were also used in the preliminary seismic deformation analyses performed for the Landfill B-18 expansion EIR preparation (HAI, 2008a). The following summarizes results of the 1998 seismic ground shaking evaluations and the selected ground motions used in two-dimensional seismic response analyses at the KHF site:

- The closest seismic sources to the site are segments of the blind Ramp Thrust Fault that is present beneath the site at approximate distances of 8 to 27 km, while the most active sources in the site area are associated with the San Andreas Fault zone at a distance of about 35 km from the site.
- No evidence of fault rupture hazard is known to exist at the project site (i.e., within 200 feet of Landfill Unit B-18).
- The Ramp Thrust Kettleman Hills North Dome segment (Magnitude [M_w] 6.6) of the blind Ramp Thrust faults and the San Andreas Slack Canyon-Cajon Pass segment (M_w 7.8) will produce the highest near-field and far-field ground motions at the site, respectively. The MCE’s associated with these faults were selected as the site design events.
- The deterministic values of peak horizontal ground accelerations (PHGA) for the near-field and far-field design events were estimated as 0.57g and 0.21g, respectively. The calculated PHGA of 0.57g approximately corresponds to an average probabilistic return period of 1,000 years (RUST, 1998).
- Duration of ground shaking is a major factor influencing the level of seismic-induced slope displacements. Empirical relations are available that provide an estimate of earthquake shaking duration as a function of earthquake magnitude, distance, and site condition (Abrahamson and Silva, 1996). Using the Abrahamson and Silva empirical relationship the ground shaking duration for Landfill Unit B-18, which is characterized as rock site, is estimated to be about 10 seconds and 32 seconds for the near-field design event ($M = 6.6$, $r = 10$ km) and far-field design event ($M = 7.8$, $r = 35$ km), respectively. Duration of the ground shaking was used in the simplified Newmark-type seismic deformation analyses for the proposed site expansion EIR (HAI, 2008a).

- One "distant" (far-field) and three "local" (near-field) earthquake records were selected and scaled to correspond to the design peak horizontal accelerations in rock as design input motions. These records have a peak acceleration, frequency content, and duration representative of the expected earthquake motions at the site. The selected records were:
  1) Caltech A-1 synthetic acceleration time history simulating a M 8+ earthquake on the San Andreas Fault, scaled to peak amplitude 0.21g,
  2) Seed-Hayward synthetic acceleration time history simulating a M ~ 7 earthquake matched to the site design response spectrum to approximate the near-field MCE,
  3) Castaic Old Ridge Route, sedimentary rock outcrop, Ch 1 (90 deg Component) acceleration record from the 1994 ($M_W \approx 6.7$) Northridge, California earthquake scaled to a peak amplitude of 0.57g, and
  4) Pacoima-Kagel Canyon, sedimentary rock outcrop, Ch 3 (360 deg Component) acceleration record from the 1994 ($M_W \approx 6.7$) Northridge, California earthquake scaled to a peak amplitude of 0.57g.

Details of the above site design earthquake parameters derivation, including figures illustrating time histories of the selected acceleration records and a comparison of their response spectra with the site design response spectrum are provided in the 1998 Rust report. The 1998 ground motion time history and response spectrum plots are also provided in Appendix A of this report. These acceleration time histories were adjusted by scaling the peak ground acceleration (PGA).

2.2 SITE DESIGN GROUND MOTIONS UPDATE

2.2.1 Site Design Response Spectra

Deterministic seismic hazard analyses (DSHA) were performed for the Ramp Thrust Kettleman Hills North Dome segment of the blind Ramp Thrust faults (Great Valley Fault, Segment 14) and an earthquake scenario similar to the San Andreas 1857 earthquake using the latest attenuation relationships and the site faulting and seismicity data. As discussed above, these faults produce the highest near-field and far-field ground motions at the site, respectively. The MCE's associated with these faults were selected as the site design events. The MCE magnitude and closest source to site distance for these faults were updated based on the latest information on the site faulting and seismicity. For the near-field source two different fault geometry models were used in the analyses. The first one was based on the fault database developed for the 2008 update of the national seismic hazard maps (Petersen et al., 2008) representing the site with averaged seismicity parameters from adjacent faults around the site, while the second one was based on an older but site-specific local seismicity investigation (Stein and Ekstrom, 1992; Ekstrom et al., 1992). The magnitude and distance values used in the deterministic seismic hazard analyses were:

- Ramp Thrust Kettleman Hills North Dome:
  - (Case 1) $M_w \cong 7$, Rx ≅ 6.5 km, Rrup ≅ 10 km, Rupture Width ≅ 38.4 km, Top of Rupture ≅ 8.1 km, and Dip Angle ≅ 22 degrees (Petersen et al., 2008)

  - (Case 2) $M_w \cong 7$, Rx ≅ 8 km, Rrup ≅ 8 km, Rupture Width ≅ 17 km, Top of Rupture ≅ 6 km and Dip Angle ≅ 45 degrees (Stein and Ekstrom, 1992; Ekstrom et al., 1992)

- San Andreas 1857 Earthquake: $M_w \cong 8$ and Distance ≅ 35 km (Petersen et al., 2008)

For the near-field source, using the above fault geometries, initially two different deterministic design response spectra were developed, and then the site final design response spectrum was generated by averaging these two response spectra. Based on the subsurface geology and results of exploratory borings drilled at the site (ESI, 1990; Rust, 1998), ground motion evaluations for the project site were performed using four recently developed attenuation relationships for an average shear wave velocity of approximately 760 m/s (~ 2500 ft/sec) estimated for the upper 30 meters (~ 100 feet) of the site.

Attenuation relationships describe the relation of ground motion levels with earthquake magnitude and distance (closest distance between site and earthquake rupture plane). These empirical relationships are used to describe the variation of response spectral accelerations at specific structural periods of vibration and damping ratios with earthquake magnitude and distance, and to incorporate the local geologic conditions and the near-source effects. The selected attenuation relationships are based on the Next Generation Attenuation (NGA) relationships as listed below:

- Abrahamson and Silva, 2008
- Campbell and Bozorgnia, 2008
- Boore and Atkinson, 2007
- Chiou and Young, 2006

Figure 5 presents the estimated site design response spectra for the near-field and far-field seismic sources (Ramp Thrust Kettleman Hills North Dome and San Andreas faults, respectively). Based on this figure, the deterministic values of PHGA for the near-field and far-field design events were estimated as 0.62g and 0.16g, respectively.

2.2.2 Design Ground Motions

One "distant" (far-field) and three "local" (near-field) earthquake records were selected and matched to the respective site design response spectrum to be used as input motions in site response analysis for the landfill. These records have a peak acceleration, frequency content, and duration approximately representative of the expected earthquake motions at the site. The selected records were from the Strong Motion Database of **P**acific **E**arthquake **E**ngineering **R**esearch (PEER) Center (http://peer.berkeley.edu/smcat/search.html) as listed below:

- The CHY042, USGS Class B site (Vs^* = 360-750 m/s), north component acceleration record from the 1999 ($M_W \approx 7.6$) Chi-Chi, Taiwan earthquake
- The Castaic Old Ridge Route, sedimentary rock outcrop (USGS Class B site, Vs^* = 360-750 m/s), Ch 1 (90 deg Component) acceleration record from the 1994 ($M_W \approx 6.7$) Northridge, California earthquake

- The Gilroy Array #1, sedimentary rock outcrop (USGS Class A site, Vs^* > 750 m/s), 90 deg component acceleration record from the 1989 ($M_W \approx 6.9$) Loma Prieta, California earthquake
- The Pacoima-Kagel Canyon, sedimentary rock outcrop (USGS Class B site, Vs^* = 360-750 m/s), Ch 3 (360 deg Component) acceleration record from the 1994 ($M_W \approx 6.7$) Northridge, California earthquake

Where Vs^* is the average shear wave velocity to a depth of 30 m (~ 100 ft).

The above candidate earthquake records were selected based on the following seismological properties:

- Spectral content (initial recordings with energy in the matching frequency band),
- Magnitude of the design earthquake ± 0.5,
- Source to site distance (source to recording station distances of 8 to 35 km), and
- Rupture directivity.

Once the reference time histories were selected, they were adjusted to provide the response spectrum compatible time histories according to the following approach and criteria:

1. Adjustment of the response spectrum of the reference time histories was performed using a time-domain procedure described by Abrahamson (1991, 1998).
2. The response spectrum of the spectrum compatible time histories should follow reasonably the recommended design response spectra.

The program EZ-FRISK version 7.26 spectral matching routine (Risk Engineering, 2008) was used to develop spectrum-compatible horizontal motions using the above-mentioned startup motions. The spectral matching was performed within the frequency range of PGA to 10.0 seconds. In order to remove the drift induced in displacement time histories as a result of spectral matching, the baseline correction module of EZ-FRISK was applied to the spectrally-matched ground motions. The final design ground motions are baseline-corrected.

Figures 6 through 17 illustrate plots of the original natural records and the final (the response spectrum compatible) time histories and response spectra for the selected earthquake records. Acceleration, velocity, and displacement time histories and 5-percent damped acceleration response spectra are provided in these plots.

These four spectrum compatible records were selected as the updated input ground motions for the landfill dynamic response analysis based on the site design spectra and seismological properties. These motions provide an estimate of the landfill median dynamic response. The selected records were used as input motion in two-dimensional seismic response analysis of the proposed Landfill Unit B-18 expansion. Digitized time history data for the spectrum compatible earthquake records are provided in electronic format for use in the analysis.

2.3 LIQUEFACTION

The potential for liquefaction occurrence in the area of the proposed landfill expansion is considered to be very low or non-existent. The KHF site is underlain by Tertiary sedimentary rocks of the Etchegoin-Jacalitos (Te), San Joaquin (Ts), and Tulare (Tt) Formations. The Landfill Unit B-18 is located within the San Joaquin Formation sedimentary bedrock. The San Joaquin Formation consists primarily of fine-grained sedimentary rocks, principally shale, claystone, and sandstone, which are not susceptible to liquefaction. Groundwater at the site is also deeper than 50 feet. Therefore, based on the site subsurface geology, the potential for liquefaction at the site is very low.

2.4 SEISMIC SETTLEMENT

Similarly, the potential for seismically-induced settlements of the landfill foundation materials was estimated to be negligible based on the subsurface geology and cemented nature of the bedrock. The site foundation materials are classified primarily as the Tertiary sedimentary rocks, which are not susceptible to seismically-induced settlement.

3.0 SLOPE STABILITY AND LANDFILL DISPLACEMENT ANALYSIS

3.1 GENERAL

The slopes of the proposed Class I/II Landfill B-18 expansion were evaluated for stability under both static and dynamic loading conditions. As part of this evaluation, the effects of dynamic landfill deformations were considered relative to performance of the base liner system during the estimated design ground motions due to the MCE as required by the California Code of Regulations for seismic design of Class I and Class II landfills (see Section 1.3 of the report). The approach used in evaluating the stability and deformation of the slopes involved conventional analytical methods of slope stability evaluation and a refined Newmark-type (Newmark, 1965) seismic deformation analysis including dynamic site response analysis using two-dimensional (2-D) equivalent-linear wave propagation and finite element models.

The information required for the slope stability and landfill deformation analyses consisted of the site geology and seismicity, geometry of the fill plan and landfill bottom excavation and side slopes, and material parameters for waste, the liner systems, and the foundation bedrock. This information was based on the site-specific data gathered for the analysis including laboratory test data (ESI, 1990, 1992; Rust, 1998; URS, 2005; HAI, 2006), design of preliminary proposed fill plans for expanded landfill configuration (URS, 2005; CH2M Hill, 2008; HAI, 2008; Golder, 2008a), in-house compiled database of material properties, and a literature survey of published data on slope stability and seismic deformation analysis of landfills.

The site geology and seismicity is described in detail in the ESI (1990) and Rust (1998) reports. The landfill bottom excavation and side slopes, and proposed new fill plan and cover grades are shown in Figures 1 and 2. A fill plan for the proposed new design of Landfill Unit B-18 expansion was developed by Golder. This fill plan shown in Figure 2, is evaluated for stability using the results of static and seismic slope stability analyses presented in this report.

3.2 LANDFILL GEOMETRY AND ANALYSIS SECTIONS

Figures 1 and 2 present plan views of the Landfill Unit B-18 base and the proposed final fill plan contours, respectively. Six cross sections of the landfill were analyzed for slope stability including waste slopes and landfill liner system. These cross sections (A-A’, B-B’, C-C’, D-D’, E-E’, and F-F’) are shown in Figures 3 and 4, and their locations are shown on Figures 1 and 2.

Stability of the bottom/side slope and waste fill slopes were analyzed using representative cross sections selected through critical areas of the landfill. Locations of the stability analysis sections were selected based on variations in the landfill geometry such as height and steepness of waste slopes, orientation, height, and steepness of landfill bottom and side slopes around the landfill perimeter.

3.3 LANDFILL LINER DESIGN

Configurations of the existing landfill bottom/side slope liners that comply with state and federal regulations are provided in the ESI 1990 and 2005 URS reports. Figures from the 1990 and 2005 reports are presented in Appendix A of this report illustrating the liner designs for the bottom/side slopes. Figure 18 presents configuration of the proposed liner system for the expansion areas of the landfill. In the slope stability analyses, for each liner configuration, the weakest interface in the composite liner system is expected to provide the preferred failure path for potential failure planes.

3.4 MATERIAL PROPERTIES

Key material properties of various components of the landfill needed to perform static and seismic slope stability analyses are: (1) unit weight, (2) shear strength parameters (static and dynamic), (3) dynamic small-strain shear modulus (or shear wave velocity) and damping ratio properties, and (4) variation of the shear modulus and damping ratio with shear strain during shaking.

Detailed site-specific information on waste, existing liner systems, and foundation bedrock material properties are provided in the Golder and ESI design and conformance testing reports prepared during early 1990's (Golder, 1990, 1991; ESI, 1990, 1992, 1993), and more recent reports prepared for Kettleman Hills Facility (Rust, 1998; URS, 2005; HAI, 2006). The preliminary stability evaluations performed in support of the EIR preparation for the proposed Landfill Unit B-18 expansion (URS, 2005; HAI, 2008) used the same material properties as in the earlier investigations listed above except for the liner interface shear strength properties in the Phase II area of the landfill. In 2003, URS obtained samples of the landfill Phase II liner system that were archived at the KHF site. Interface shear strength testing was performed on the sandwich-like multilayer structure of the liner system and the results were used to refine the interface properties reported in the previous investigations (URS, 2005). In this report, the material properties from the previous investigations (Phase I liner system) and the URS (2005) report for the Phase II liner system were used for the static and seismic slope stability analyses. The Class I waste and foundation bedrock shear strength and unit weight properties, liner interface shear strength values, and dynamic waste, clay liner, and bedrock properties used in the analyses presented in this report are provided in Table 1. The assumed properties used for design should be further verified by performing site-specific tests on the actual materials that will be used during construction. More detailed discussion of the material properties used is provided below.

<u>Hazardous Waste Material Properties</u>

The unit weight, shear strength, and dynamic properties of the existing hazardous (Class I) waste materials in the landfill were based on the prior KHF landfill investigations by Golder (1990, 1991), ESI (1990, 1993), and HAI (2006). The landfill Class I waste material was characterized as having static and dynamic properties similar to those for relatively dense cohesionless sand material with a Poisson's ratio of 0.35. The total unit weight of the waste was assumed as 115 pcf in stability and dynamic response analyses, and its shear strength parameters (friction angle and cohesion) were assumed to be 31 degrees and 0 psf, respectively.

The low-strain shear modulus of the Class I waste was assumed to be a function of the mean effective confining pressure as shown below (Seed and Idriss, 1970):

$$G_{max} = 1000\ K_2\ (\sigma'_m)^{1/2}$$

Where G_{max} and σ'_m represent the soil maximum (low-strain) shear modulus and mean effective stress, respectively, and are in psf. The dimensionless parameter K_2 is determined from the void ratio or relative density. The K_2 was assumed as 60, which is a typical value for relatively dense sands (Seed and Idriss, 1970).

<u>Liner Interface Shear Strength and Dynamic Properties</u>

In the slope stability analyses for Landfill Unit B-18, potential failure surfaces pass through the waste and the weakest interface in the liner above the landfill foundation bedrock due to relatively low interface shear strength properties of the liner and high strength of the bedrock. Based on the site-specific data from the earlier studies at Kettleman Hills Facility (Golder, 1990, 1991; ESI, 1990, 1992) and our in-house database and literature survey for existing liner system configurations, an interface friction angle of 17 and 9 degrees for the Phase I base liner and slope liner were used, respectively. An interface friction angle of 19 degrees was measured in the recent interface shear tests performed on the "sandwich-like" specimens of the Phase II liner system (URS, 2005). The same type of liner as in the Phase II liner system was assumed to be used for the proposed landfill expansion area. Adhesion coefficient for the liner interfaces is assumed to be zero except for the Phase I slope liner where an adhesion value of 800 psf was used (ESI, 1992). The assumed interface strength properties for the proposed new liner in the expanded landfill areas should be further evaluated by conformance testing on the materials used during construction.

The total unit weight of the clay used in the liner system was assumed as 115 pcf in stability and dynamic response analyses. The clay material used in the liner system was characterized as having a Poisson's ratio of 0.35 and a nonlinear shear modulus given by the relation shown below for the low-strain conditions (Hardin and Drenevich, 1972):

$$G_{max} = 14760\ [(2.973-e)^2/(1+e)]\ (OCR)^a\ (\sigma'_m)^{1/2}$$

Where G_{max} and σ'_m represent the soil maximum shear modulus and mean effective stress, respectively, and are in psf, "e" is void ratio and OCR is overconsolidation ratio, and the value of power "a" depends on the plasticity index of soil.

<u>Bedrock Properties</u>

Shear strength parameters for the foundation bedrock materials were estimated based on the previous KHF landfill investigations. A cohesion value of 800 psf and friction angle of 40 degrees were used in the stability analyses. The shear wave velocity and unit weight of the foundation rock were estimated to be about 2,500 fps and 150 pcf, respectively.

Modulus and Damping Ratio Variation

The nonlinear modulus reduction and damping ratio increase curves used in the dynamic response analyses for the landfill waste, clay liner, and foundation bedrock materials are the same as those used in the previous KHF investigations and are presented in Figure 19. The figure illustrates how the shear modulus and damping ratio change with the level of induced cyclic shear strains for different landfill materials.

3.5 ANALYSIS APPROACH

Landfill liners in seismically active areas such as California undergo dynamic loads during earthquakes in addition to static loads generated by the dead weight of the waste. Liners, particularly along landfill side slopes, are subjected to tensile stresses due to settlement and creep-induced downward movement of the waste mass. During earthquakes, the landfill mass moves dynamically under the effects of ground accelerations and generates additional stresses in the landfill liner.

CCR Title 22 requires that slopes of a landfill and the foundation beneath the slopes maintain a minimum factor of safety of 1.5 under seismic loading conditions. The factor of safety is usually calculated using pseudo-static limit equilibrium analytical methods. Since achieving a pseudo-static factor of safety of 1.5 for relatively high accelerations generated during MCE events is difficult and costly, the regulations allow for an alternate, more rigorous and detailed design approach involving quantified evaluation of the seismic deformations and displacements of the landfill mass in lieu of the pseudo-static analysis. At present the evaluation of seismic deformations is the most common approach for seismic design of waste fills in California.

The present state-of-practice in seismic design of landfills is based on Newmark (Newmark, 1965) or a simplified Newmark-type method (e.g. Franklin and Chang, 1977; Makdisi-Seed, 1978; Bray et al., 1998) to estimate the order of magnitude of seismically-induced permanent displacements of landfill slopes. Additionally, the current practice relies on engineering judgment by establishing an allowable deformation (about 6 inches) to compare with displacements computed from Newmark method along the liner system.

Our analyses were conducted in the following evaluation/computational sequence:

- Static slope stability and selection of critical failure surfaces;
- Evaluation of yield acceleration coefficients for the critical failure surfaces determined from static slope stability analyses;
- Dynamic site response analysis and calculation of potential slide mass average acceleration; and
- Estimation of seismically-induced permanent deformations for the design “local” and “distant” MCE events.

The above approach originally developed by Seed and Martin (1966) and later used by Makdisi and Seed (1978) for seismic analysis of earth dams, generally results in conservative (larger) permanent displacements, compared to more rigorous fully coupled nonlinear dynamic deformation analysis (Lin and Whitman, 1983).
The four stages of the approach used in this study are further described in the following sections.

3.6 STATIC AND PSEUDO-STATIC STABILITY ANALYSES

Analysis Method

Conventional two-dimensional (2-D) limit-equilibrium stability analyses were performed for the existing and proposed bottom/side slope liner and waste fill slopes using landfill cross sections A-A', B-B', C-C', D-D', E-E', and F-F'.

The computer program GSTABL7 v. 2.003 developed by Gregory Geotechnical Software was used to calculate the factors of safety against potential failure. This program was originally developed based on the computer program PC STABL 5M (Achilleos, 1988). The program uses 2-D limit equilibrium theory to provide general solutions for slope stability problems with provisions of using the Modified Bishop, Modified Janbu, or Spencer Methods. Both circular and non-circular potential sliding surfaces can be prespecified or randomly generated. The Spencer, Modified Janbu and Modified Bishop methods were used for this study. The minimum factor of safety was obtained by varying the initiation and exit points of the trial failure planes.

The Modified Janbu Method of analysis, which normally provides conservative results, was initially used to evaluate a large number of potential failure mechanisms for each cross section analyzed. In each analysis case, at least one thousand (1000) potential failure surfaces were randomly generated by the program and the most critical surface resulting in the lowest factor of safety was identified. The most critical failure plane determined by the Modified Janbu Method was then reanalyzed using the Spencer Method. This method satisfies both force and moment equilibrium and thus provides more realistic (usually higher) estimates of the factors of safety and yield acceleration coefficients. The Janbu method is generally more conservative compared with the more rigorous Spencer Method and typically results in lower factors of safety than the Spencer Method (Duncan, 1992). The modified Bishop method was used to analyze circular failure surfaces.

The GSTABL7 output plots, presented in Appendix B, illustrate the 2-D cross sections, various potential failure surface conditions considered, and the most critical failure surfaces analyzed in the stability analysis of the final fill slopes of the proposed landfill expansion.

The appendix presents computer plots for all the cases analyzed illustrating geometry of landfill cross-sections and the ten most critical potential failure planes searched by the program, as well as computed factors of safety. The failure surface with the lowest factor of safety is identified with two arrows at its initiation and termination points.

The material properties of the waste and liner interfaces used in the static and pseudo-static stability analyses are shown in Table 1 and the results of the analyses are summarized in Table 2 and on Figures 3 and 4.

3.6.1 Liner and Waste Mass Static Stability

Slope stability analyses were performed for the final fill plan geometry. Six cross sections at different locations across the landfill were selected for analysis. Figures 1 and 2 show plan views of the Landfill B-18 excavation and the final fill/landfill cover geometry, respectively, and the locations of the cross sections selected for the analysis. In each part of the landfill where its cross section configuration changes, one or more sections were selected for two-dimensional stability evaluations. The configuration of the proposed landfill expansion final fill slopes are illustrated by the selected cross sections shown in Figures 3 and 4.

The most important potential failure mechanism considered was for a wedge (block failure) sliding through the waste mass and along the existing and expanded landfill base liner system. Potential failure surfaces were assumed to pass along the weakest interface in the lining system and then through the landfill mass to the surface. Stability of the slopes against circular failure through the waste mass was also investigated.

The slope stability analyses for Landfill Unit B-18 showed that sliding along the liner systems and/or waste mass was consistently more critical than a sliding surface through the foundation material. Therefore, in the stability analyses, the foundation bedrock was modeled as being impenetrable.

3.6.2 Pseudo-Static Stability Analyses

Pseudo-static analyses, necessary to compute yield acceleration coefficient (K_y), were performed for the critical potential failure surfaces through waste and base liner system, identified from results of the static slope stability analyses discussed in Section 3.6.1 for the selected cross sections (Table 2 and Figures 3 and 4). The yield acceleration is defined as the acceleration which results in a pseudo-static factor of safety of 1.0. The computed yield acceleration, K_y, represents limiting value of the horizontal seismic coefficient beyond which movement of a potential slide mass will occur.

For each cross section, pseudo-static analysis using the Spencer Method was performed to compute an estimate of yield acceleration coefficient (K_y) for the most critical potential failure plane identified from the static slope stability analysis for that section. Density and shear strength properties summarized in Table 1 were also used for the pseudo-static stability analyses.

<u>Stability Results</u>

Table 2 presents a summary of the computed static factors of safety and yield acceleration coefficients for the critical cases analyzed in this study.

Appendix B presents plots of all the cases analyzed illustrating geometry of landfill cross-sections, the most critical potential failure surfaces, and values of computed static factors of safety and yield accelerations for these surfaces searched by the program. Sample printouts of input and output files providing details of the analysis results are also presented in Appendix B.

For all final (long-term) static conditions, the minimum acceptable factor of safety is 1.5. This criterion was satisfied by the potential failure surfaces analyzed for the proposed fill plan, base liner designs, and the estimated material properties.

The results of the pseudo-static stability analyses show that the lowest yield acceleration coefficient was approximately equal to 0.23 for failure along the liner and waste mass in cross sections A-A' (east), D-D' (east), E-E' (east), and F-F' (east).

The combination of yield acceleration coefficient and slide mass geometry that could potentially result in the largest estimates of the seismically-induced displacements were used in the site response and Newmark displacement analyses described in the following sections. Based on the computed yield accelerations presented in Table 2 and landfill cross sections geometry (Figure 4), the potential failure planes #1 and #3 associated with cross sections D-D' and F-F', respectively were judged to produce the largest seismic displacements and thus, were selected for dynamic site response and seismic deformation analyses.

3.7 SEISMIC DEFORMATION ANALYSES

The acceptability of a slope for earthquake conditions is generally determined by the magnitude of the seismically-induced permanent displacement resulting from the design earthquake.

A small allowable displacement is intended to preclude the possibility of large displacements that might disrupt the flexible membrane liner (FML)/clay composite layers or other components of the leachate collection and removal (LCR) system. A conservative value of the allowable displacement along the landfill liner on the order of 6 inches was considered acceptable for Landfill B-18. This is equal to the lower bound of the allowable displacement range commonly used in the industry (6 to 12 inches) as suggested by Seed and Bonaparte (1992).

Preliminary estimates of the landfill slopes seismic deformations were obtained previously (HAI, 2008) using the simplified analysis method by Bray et al. (1998) and are presented in the following section. A more detailed evaluation of the seismic deformations using two-dimensional site response analyses and Newmark (1965) slope displacement calculation method was performed for this study and is presented in Section 3.7.2 below.

3.7.1 Simplified Analysis of Landfill Slopes Seismic Deformations

Preliminary estimates of the landfill slopes seismic deformations were obtained using the simplified analysis method by Bray et al. (1998).

This method requires estimating the yield acceleration (k_y) for the potential slide mass, the ground motion parameters (MHA_r, T_m, and D_{5-95}), fundamental period of equivalent 1-D slide mass at small strains (T_s), and maximum horizontal equivalent acceleration (MHEA) for the potential slide mass. The ground motion parameters are defined as:

MHA_r = Maximum Horizontal Acceleration expected at the site at rock level (g),

T_m = Mean period of input rock motion (sec), and

D_{5-95} = Significant duration of shaking, i.e., 5-95% normalized Arias intensity (sec).

The MHA_r and D_{5-95} values for the site design ground motions are provided in Section 2.0 and T_m can be estimated from the following relationships:

$$\ln(T_m) = \ln(C_1 + C_2 \cdot (M\text{-}6) + C_3 \cdot r) \qquad M \leq 7.25$$

$$\ln(T_m) = \ln(C_1 + 1.25 \cdot C_2 + C_3 \cdot r) \qquad 7.25 \leq M \leq 8.0$$

where M and r are the earthquake magnitude and distance and parameters C_1, C_2, and C_3 and the standard error (ε_r) for a rock site condition are as listed below:

$C_1 = 0.411$, $C_2 = 0.0837$, $C_3 = 0.00208$, and $\varepsilon_r = 0.437$

The fundamental period of slide mass (T_s) is calculated using the equation $T_s = 4H/V_s$, where H is the maximum vertical distance between the ground surface and slip surface used to determine k_y and V_s is representative small-strain shear wave velocity of materials above sliding mass. The landfill shear wave velocity profile provided in the 2005 URS report was used to calculate the values of parameter T_s for this study.

Charts provided by Bray et al. (1998) were then used to estimate the normalized MHEA and sliding mass displacement for deep-seated slide surfaces. The normalized MHEA is defined as a function of the normalized fundamental period of slide mass (T_s/T_m). The normalized displacement of the potential slide mass is correlated to the ratio of k_y/k_{max}, where k_{max} = MHEA/g.

Table 3 provides results of the simplified seismic deformation analyses. The table provides yield accelerations, maximum horizontal equivalent accelerations (MHEA), k_y/k_{max} ratios, and estimated slope displacements for the cross sections analyzed.

As seen from Table 3, for potential deep failure planes along the landfill bottom liner the estimated permanent displacements are consistently less than 1 inch except for the western part of cross section B-B' where a slope displacement of about 1 inch was estimated. These preliminary estimated values of the seismic displacements are considerably smaller than the maximum allowable displacement of 6 inches commonly used in the industry (Seed and Bonaparte, 1992). These displacements are also in agreement with the seismic displacements estimated by URS (2005).

3.7.2 Site Response and Newmark Slope Deformation Analyses

Two-Dimensional Dynamic Site Response Analyses

After yield acceleration coefficients were determined, dynamic response of the landfill and average acceleration time histories of the potential sliding masses were evaluated for three representative "local" (near-field) and one "distant" (far-field) input ground motions. The analyses provide a measure of earthquake energy attenuation/amplification characteristics of the landfill.

To account for the uncertainties introduced by variation of the landfill geometry, two-dimensional finite element computer program QUAD4M (Hudson et al., 1994) was used to evaluate dynamic response of the landfill and average acceleration time histories of the potential sliding waste masses identified from the stability analyses. The two-dimensional analyses provide a more realistic estimate of the seismically-induced displacements of waste slopes compared to one-dimensional site response analysis computer codes such as SHAKE91 (Schnabel et al., 1972; Idriss and Sun, 1991). However, it should be noted that because the landfill geometry is three-dimensional, the use of two-dimensional site response analyses generally provides a conservative estimate of the landfill dynamic response.

QUAD4M was recently developed by modifying and improving QUAD4 program which was initially developed in 1973 (Idriss et al., 1973). The main changes in QUAD4M are: 1) addition of energy absorbing boundaries that can be used to model the material underlying the finite element model as a linear elastic half space, 2) computing average acceleration time history (seismic coefficients) of a defined potential failure mass, and 3) a new method for formulation of damping. QUAD4M approximately incorporates the nonlinear material properties of soil and waste in the analyses by using the equivalent linear method (Seed and Idriss, 1970). In this method, the strain-dependent shear modulus and damping ratio of the material are selected to be compatible with the computed level of strain in each element. The dynamic response is computed repeatedly until the dynamic properties determined from the two sequential cycles differ by less than a specified value. This analysis is done in the time domain, and for any set of properties it is a linear analysis.

QUAD4M analyses were performed for Cross Sections D-D' and F-F' and their most critical failure planes (failure planes 1 and 3 in Figure 4, respectively). These cross sections represent the most critical cases based on their geometry, factor of safeties and the minimum K_y values computed from the pseudo-static stability analyses. The finite element meshes used to model these cross sections are shown in Figures 20a and 20b. The "seismic coefficient" option in QUAD4M was used to calculate the average acceleration time history of potential deep failure mass sliding along the landfill bottom. This is done using the computed time histories of the shear forces for the elements along the bottom and dividing the resultant shear force by the mass of the waste bounded by the potential failure plane along the liner (Seed and Martin, 1966).

The input design ground motions were applied as outcrop motions at the top of the bedrock underlying the landfill, i.e., the "elastic halfspace" below the finite element mesh. The analyses were performed for two sets of ground motions:

1 - The near-field and far-field MCE ground motions used previously (see Section 2.1) for seismic deformation analyses of the KHF landfill units B-19 and B-18 (RUST, 1998; URS, 2005, and HAI, 2006), and

2 - The updated site design near-field and far-field MCE ground motions developed in this study (see Section 2.2.2).

This provides a comparison of the new landfill design seismic deformations for the old and updated ground motions, and also a comparison of the landfill response for scaled versus spectrally matched ground motions.

The finite element meshes for the cross sections analyzed (Figures 20a and 20b) show the critical potential failure surfaces that were specified for calculation of the average acceleration time histories (seismic coefficients) in the QUAD4M analyses. These seismic coefficient time histories were later used in a Newmark-type analysis method (Newmark, 1965) as described in the following section to estimate the order of magnitude of the permanent seismically-induced displacements along the liner.

<u>Seismically-Induced Permanent Displacements</u>

The consequences of earthquake shaking on the landfill slopes were evaluated using Makdisi and Seed's procedure (1978) which is a type of Newmark pseudo-dynamic double-integration displacement analysis. This approach is most appropriate for slopes consisting of materials that are not likely to suffer any significant loss of their shear strength due to seismic shaking. The waste and liner materials in the Landfill B-18 are such materials.

During an earthquake, over numerous cycles of loading, a slide mass can move incrementally along a potential failure plane through displacement accumulation. Based on this concept, the Newmark method computes, from a series of pseudo-static analyses, the yield acceleration, K_y beyond which movement of a slide mass will occur. The permanent displacement resulting from an earthquake is then computed by double integration of the slide mass average acceleration time history whenever the acceleration exceeds K_y.

The average acceleration time histories computed in the QUAD4M response analyses for the most critical potential failure mass identified in the pseudo-static analyses were used as input for Newmark deformation analyses to evaluate the permanent seismically-induced displacements along the liner system. The displacement calculated by this method is a function of the yield accelerations which were computed in the pseudo-static stability analyses. Figures 21 and 22 illustrate variation of potential slide mass displacement (δ) versus the yield acceleration K_y for Cross Section D-D' and for the two sets of design ground motions used in the analyses (the RUST 1998 design ground motions and the updated ground motions developed for this study). Figures 23 and 24 illustrate variation of potential slide mass displacement (δ) versus the yield acceleration K_y for Cross Section F-F' and for the two sets of design ground motions discussed above. Tables 4 and 5 and Figures 21 through 24 summarize the results of calculated seismically-induced permanent displacement (δ) using the average acceleration time history of the waste mass computed from the QUAD4M analyses as input in the Newmark double-integration method for cross sections D-D' and F-F'.

As seen from Figures 21 through 24, for the potential deep failure plane # 1 located in the northeastern part of cross section D-D', and the potential deep failure plane # 3 located in the northeastern part of cross section F-F' (Figure 4) the largest permanent displacements are induced for the 1994 Northridge earthquake Pacoima-Kagel Canyon and Castaic Old Ridge Route accelerograms scaled to a PHGA of 0.57g. However, calculated displacements for K_y values larger than 0.12 are less than 1 inch. Additionally, the Newmark deformation analyses show that the calculated seismically-induced permanent displacements of the critical potential slide mass are nearly zero for K_y values larger than 0.12 for the "distant" Caltech A-1 synthetic record and CHY042N Chi-Chi earthquake record scaled to 0.21g and 0.16g, respectively. These estimated values of the seismic displacements are considerably smaller than the maximum allowable displacement of 6 inches commonly used in the industry (Seed and Bonaparte, 1992).

3.8 STATIC AND SEISMIC STABILITY OF FINAL COVER

A preliminary estimate of the final cover seismic deformations was obtained by using the simplified analysis method by Franklin and Chang (1977). A more detailed evaluation of the landfill cover seismic deformations using two-dimensional site response analysis and Newmark (1965) displacement calculation method was also performed. The above analyses are presented below.

Simplified Analysis of Landfill Cover

Static and seismic stability of the landfill final cover were evaluated using the infinite slope stability analysis model. Effect of the slope benches were also considered in the analyses. The landfill final cover slope will have an overall inclination of 4.0H:1V with localized inclinations of approximately 3.5H:1V to allow for benching. The cover soils will not become fully saturated given the low annual rate of precipitation in the area, drainage through geotextile in the cover, and the steepness of the final cover slopes.

The proposed final cover for Landfill B-18, shown in Figure 25, includes a 40-mil textured HDPE geomembrane overlain by a geotextile and an approximately 2.5-foot-thick vegetative soil cover over the geosynthetics. The geotextile is a 12-oz/sy non-woven layer that cushions the HDEP geomembrane and provides some drainage. The slope stability analyses were performed for the weakest interface strength in the final cover. The weakest interface is assumed to be along the geomemberane/geotextile interface (see Appendix C).

Peak strength values were used for analysis of seismic loading and the partially saturated final cover condition. Access is available for the final cover to make any necessary repairs after a seismic event; therefore, residual strengths to evaluate short-term impacts are not appropriate.

Appendix C provides the cover soil and interface properties used in the stability analyses, and the detailed static and seismic stability calculations for the cover system described above. The appendix shows that the cover system is stable for both static and seismic loading conditions; however, the estimated permanent displacement is about 12 inches. Hence, a more rigorous two-dimensional dynamic site response and Newmark displacement analysis was performed to more accurately calculate the final cover displacement.

Two-Dimensional Dynamic Cover Response Analyses

After yield acceleration coefficient for the cover was determined (see Appendix C), dynamic response of the landfill and average acceleration time histories of the potential sliding cover section were evaluated for three representative "local" (near-field) and one "distant" (far-field) input ground motions. To account for the uncertainties introduced by variation of the landfill geometry, two-dimensional finite element computer program QUAD4M was used to evaluate dynamic response of the landfill and average acceleration time histories of the potential sliding cover section identified from the stability analyses. The two-dimensional analyses provide a more realistic estimate of the seismically-induced displacements of the cover compared to the simplified methods.

QUAD4M analysis was performed for the cover section of Cross Section D-D'. The finite element mesh used to model the cross section is shown in Figure 20c. The input design ground motions were applied as outcrop motions at the top of the bedrock underlying the landfill, i.e., the "elastic halfspace" below the finite element mesh. The analyses were performed for the same ground motions used for the liner stability analysis discussed in Section 3.7.2.

The finite element mesh for the cross section analyzed (Figure 20c) shows the critical potential failure surface through the landfill cover that was specified for calculation of the average acceleration time histories in the QUAD4M analyses. The computed average acceleration time history of the specified cover section was then used in a Newmark-type analysis method (Newmark, 1965) as described in the following section to estimate the order of magnitude of the seismically-induced permanent displacements of the cover.

Seismically-Induced Permanent Displacements

The permanent displacement resulting from the earthquakes are then computed by double integration of the slide mass average acceleration time history whenever the acceleration exceeds K_y.

The average acceleration time history computed from the QUAD4M dynamic response analyses for the most critical potential failure mass identified in the pseudo-static analyses was used as input for Newmark deformation analyses to evaluate the permanent seismically-induced displacements of the failure mass. The displacement calculated by this method is a function of the yield acceleration computed in the Appendix C ($K_y \sim 0.2g$). Table 6 summarizes the results of calculated landfill cover seismically-induced permanent displacement (δ) using the average acceleration time history of the potential failure section computed from the QUAD4M analyses as input in the Newmark double-integration method for cross section D-D'.

The Newmark deformation analyses show that the calculated seismically-induced permanent displacements of the landfill cover are considerably less than the maximum allowable displacement of 12 inches commonly used in the industry (Seed and Bonaparte, 1992).

4.0 CONCLUSIONS

This report addresses static and seismic stability of the landfill slopes for a proposed expansion of the Landfill B-18. The stability report presented here will be included as part of the design report, being prepared by Golder Associates, Inc. for the proposed Landfill B-18 expansion.

The following changes from the original design were implemented and evaluated in this report:

- Final fill plan geometry was modified to enhance landfill capacity while maintaining staticand seismic stability of the landfill slopes.

- The landfill footprint was expanded in the west-northwestern area, using the existing cut slopes in the hills west and northwest of the site to buttress the landfill slopes and enhance stability.

A deterministic seismic hazard analysis was performed to update the site seismic design response spectrum and ground motions. Static and seismic stability evaluations of the proposed final fill slopes and landfill base liner and cover systems were conducted for the new Landfill B-18 fill design. The presented analyses demonstrated that computed static factors of safety were higher than 1.5 for all analyzed sections.

The seismic stability analyses were conducted for the MCE design ground motions. The postulated near-field and far-field MCEs for Landfill B-18 were characterized by a peak horizontal acceleration in lithified earth material of approximately 0.62g and 0.16g, respectively.

The analyses indicated that the proposed new landfill expansion design (Golder, 2008) would result in a stable configuration under both static and seismic loading conditions in compliance with applicable regulations. The acceptability of the landfill slopes for earthquake loading conditions was determined by the relatively small magnitude of the seismically-induced permanent displacements resulting from the local and distant MCE design earthquake events. The results of the conservative Newmark-type permanent displacement analyses presented in this study indicated that computed maximum displacements along the liner system during the design earthquake events are less than 1 inch. Maximum seismically-induced permanent displacement within the waste prism in the cover/gas collection system is about 6 inches which is less than the maximum allowable value of 12 inches.

The analyses were performed for the landfill final fill configurations. Slope stability analyses are required for design of the proposed landfill expansion interim fill conditions. Site-specific laboratory testing of the proposed materials to be used in the liner systems should be performed for design of the landfill expansion. Additionally, conformance testing of the liner materials should be performed during construction to verify properties used in the design of the landfill expansion.

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Table 1. Selected Material Properties for Static and Seismic Stability Analyses

Material/Interface	Unit Weight	Shear Strength Properties		Shear Wave Velocity (V_s - ft/sec) or Shear Modulus (G, psf) Relation	Modulus Reduction & Damping Curves
		Friction Angle (degree)	Cohesion (psf)		
HW [1]	115 pcf	31	0	$G = 1000\,K_2\,(\sigma'_m)^{1/2}$ K_2 = 60 for relatively dense sands (Seed and Idriss, 1970)	See Figure 19 Relatively dense sand (Seed et al., 1984)
Clay Liner [1, 2]	115 pcf	20	1,150	$G = \frac{14{,}760(2.97-e)^2}{1+e}(OCR)^K \sigma_m^{0.5}$ (Hardin and Drenvich, 1972)	See Figure 19 (Seed and Idriss, 1970)
Bedrock [1]	150 pcf	40	800	V_s = 2500 fps	See Figure 19 (Schnabel et al. 1972)
Phase I Bottom Liner Interface [1]	----	17	0	----	----
Phase I Side Slope Liner Interface [1]	----	9	800	----	----
Phase II Bottom Liner Interface [1]	----	19	0	----	----
Phase II Side Slope Liner Interface [1]	----	19	0	----	----
Expansion Area Liner Interface [3]	----	19	0	----	----

(1) Environmental Solutions, Inc. (1990, 1992, 1993); Rust Environmental & Infrastructure, Inc. (1998); URS (2005).
(2) Modeled as a layer in site dynamic response analysis to include effects of softer clay layer on ground motion.
(3) Golder Associates, Inc. (2008b).

Table 2a. Summary of Slope Stability Analysis Results (Landfill East and North Sides)

Cross Section	Failure Plane Number	Description	Static Factor of Safety	Yield Acceleration, k_y (g)
A-A'	1	Deep Block Failure through Bottom Liner	2.589	0.254
	2	Deep Block Failure through Bottom Liner	2.689	0.225
	3	Deep Block Failure through Bottom Liner	2.722	0.237
B-B'	1	Deep Block Failure through Bottom Liner	6.8	0.453
	2	Deep Block Failure through Bottom Liner	8.59	0.385
	3	Deep Block Failure through Bottom Liner	6.54	0.356
C-C'	1	Deep Block Failure through Bottom Liner	3.06	0.395
	2	Deep Block Failure through Bottom Liner	4.35	0.47
D-D'	1	Deep Block Failure through Bottom Liner	2.34	0.232
	2	Deep Block Failure through Bottom Liner	2.82	0.273
E-E'	1	Deep Block Failure through Bottom Liner	2.743	0.265
	2	Deep Block Failure through Bottom Liner	2.747	0.23
	3	Deep Block Failure through Bottom Liner	2.73	0.237
F-F'	1	Deep Block Failure through Bottom Liner	2.805	0.252
	2	Deep Block Failure through Bottom Liner	2.467	0.225
	3	Deep Block Failure through Bottom Liner	2.46	0.225

Table 2b. Summary of Slope Stability Analysis Results (Landfill West and South Sides)

Cross Section	Failure Plane Number	Description	Static Factor of Safety	Yield Acceleration, k_y (g)
A-A'	I	Deep Block Failure through Bottom Liner	4.194	0.42
	II	Deep Block Failure through Bottom Liner	7.249	0.315
B-B'	I	Deep Block Failure through Bottom Liner	3.5	0.395
	II	Deep Block Failure through Bottom Liner	8.93	0.487
C-C'	I	Deep Block Failure through Bottom Liner	4.92	0.345
	II	Deep Block Failure through Bottom Liner	5.64	0.34
D-D'	I	Deep Block Failure through Bottom Liner	3.88	0.375
	II	Circular Failure	2.5	0.32
	III	Circular Failure	2.18	0.26
E-E'	I	Deep Block Failure through Bottom Liner	5.431	0.425
	II	Deep Block Failure through Bottom Liner	8.879	0.344
F-F'	I	Circular Failure	2.578	0.325
	II	Deep Block Failure through Bottom Liner	5.894	0.435
	III	Deep Block Failure through Bottom Liner	7.205	0.375

Table 3 - Results of Simplified Seismic Deformation Analyses for Landfill Liner

Analyzed Cross Section	Yield Acceleration K_y (g)	Maximum Horizontal Acceleration K_{max} (g)	K_y/K_{max}	Estimated Slope Deformation[1] (in)
A-A' - East	0.225	0.218	1.03	<1
A-A' - West	0.315	0.275	1.15	<1
B-B' - East	0.356	0.193	1.84	<1
B-B' - West	0.395	0.504	0.78	~ 1.0
C-C' - North	0.395	0.197	2.01	<1
C-C' - South	0.340	0.249	1.37	<1
D-D' - East	0.232	0.223	1.04	<1
D-D' - West	0.375	0.281	1.33	<1
E-E' - East	0.230	0.203	1.13	<1
E-E' - West	0.344	0.374	0.92	<1
F-F' - East	0.225	0.203	1.11	<1
F-F' - West	0.375	0.374	1.00	<1

Notes:

(1) Estimated seismic deformations in above table are for the local design earthquake on the blind Ramp Thrust at a distance of 10 km. Seismic deformations computed for the distant seismic event on the San Andreas Fault zone at 35 km from the site were negligible.

Table 4. Seismically-Induced Permanent Displacements from Newmark Deformation Analyses (Cross Section D-D', Failure Surface 1 along Landfill Liner)

	Ground Motion	Yield Acceleration Ky (g)	Maximum Acceleration Kmax (g)	Permanent Displacement (in)
Old Records[1]	Pacoima	0.232	0.187	<1
	Castaic	0.232	0.192	<1
	Seed Hayward	0.232	0.133	<1
	Caltech Synthetic Record A1	0.232	0.109	<1
New Records[2]	Pacoima	0.232	0.189	<1
	Castaic	0.232	0.145	<1
	Gilroy	0.232	0.183	<1
	Chi Chi	0.232	0.074	<1

Notes:
(1) Records scaled to design PGA used in the previous analyses of KHF Landfills (Rust, 1998; URS, 2005; HAI, 2006).
(2) Spectrally matched records developed based on an updated seismic hazard analysis in 2008 used for this project.

Table 5. Seismically-Induced Permanent Displacements from Newmark Deformation Analyses (Cross Section F-F', Failure Surface 3 along Landfill Liner)

	Ground Motion	**Yield Acceleration Ky (g)**	**Maximum Acceleration Kmax (g)**	**Permanent Displacement (in)**
Old Records[1]	Pacoima	0.225	0.184	<1
	Castaic	0.225	0.189	<1
	Seed Hayward	0.225	0.128	<1
	Caltech Synthetic Record A1	0.225	0.104	<1
New Records[2]	Pacoima	0.225	0.179	<1
	Castaic	0.225	0.137	<1
	Gilroy	0.225	0.175	<1
	Chi Chi	0.225	0.068	<1

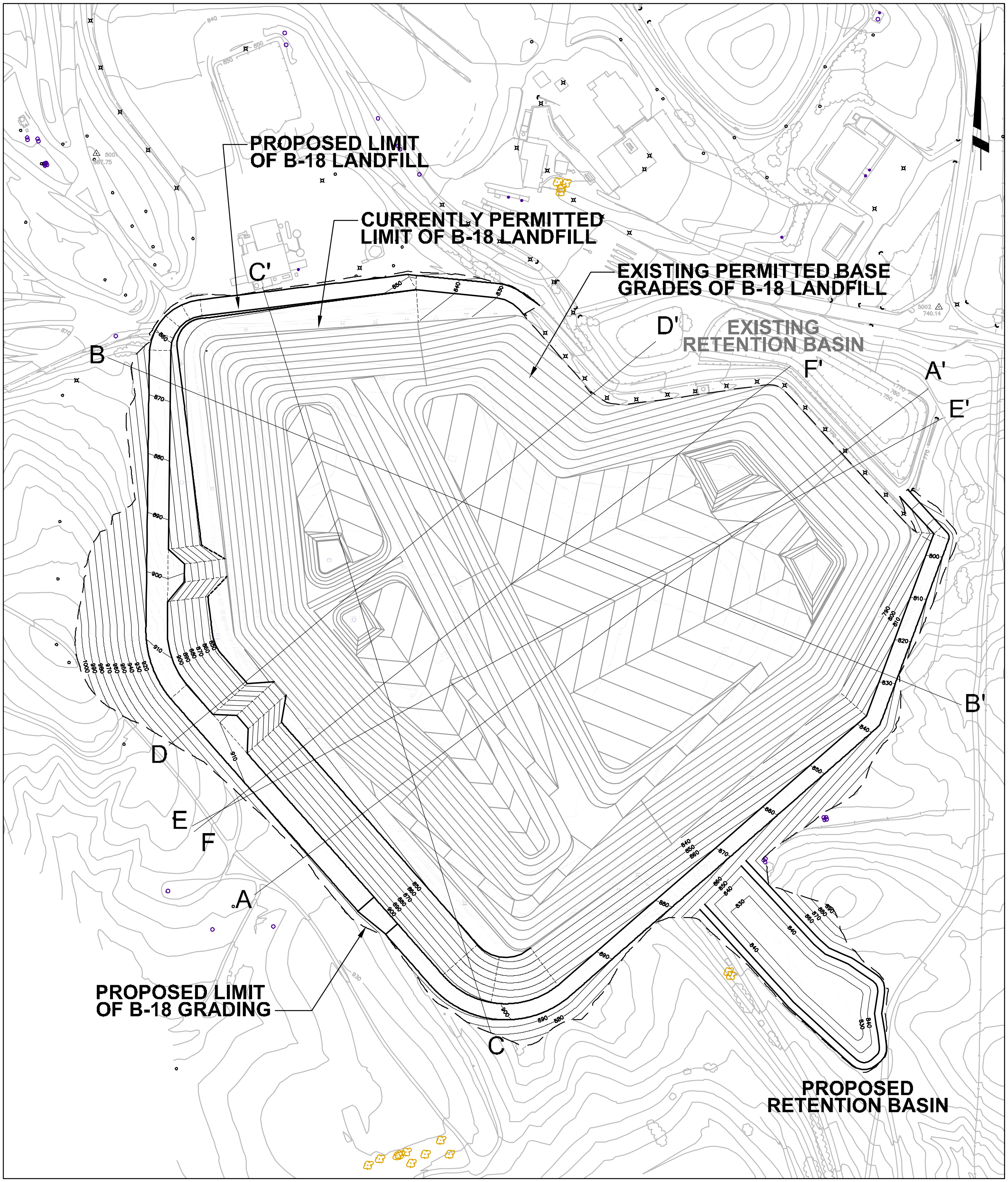
Notes:
(1) Records scaled to design PGA used in the previous analyses of KHF Landfills (Rust, 1998; URS, 2005; HAI, 2006).
(2) Spectrally matched records developed based on an updated seismic hazard analysis in 2008 used for this project.

Table 6. Seismically-Induced Permanent Displacements from Newmark Deformation Analyses (Cross Section D-D', Cover Analysis)

Record Sets	Ground Motion	Yield Acceleration Ky (g)	Maximum Acceleration Kmax (g)	Permanent Displacement (in)
Old Records[1]	Pacoima	0.2	0.58	6.29
	Castaic	0.2	0.42	3.73
	Seed Hayward	0.2	0.29	<1
	Caltech Synthetic Record A1	0.2	0.23	<1
New Records[2]	Pacoima	0.2	0.51	2.71
	Castaic	0.2	0.31	~1
	Gilroy	0.2	0.40	1.36
	Chi Chi	0.2	0.15	<1

Notes:
(1) Records scaled to design PGA used in the previous analyses of KHF Landfills (Rust, 1998; URS, 2005; HAI, 2006).
(2) Spectrally matched records developed based on an updated seismic hazard analysis in 2008 used for this project.

FIGURES



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SCALE

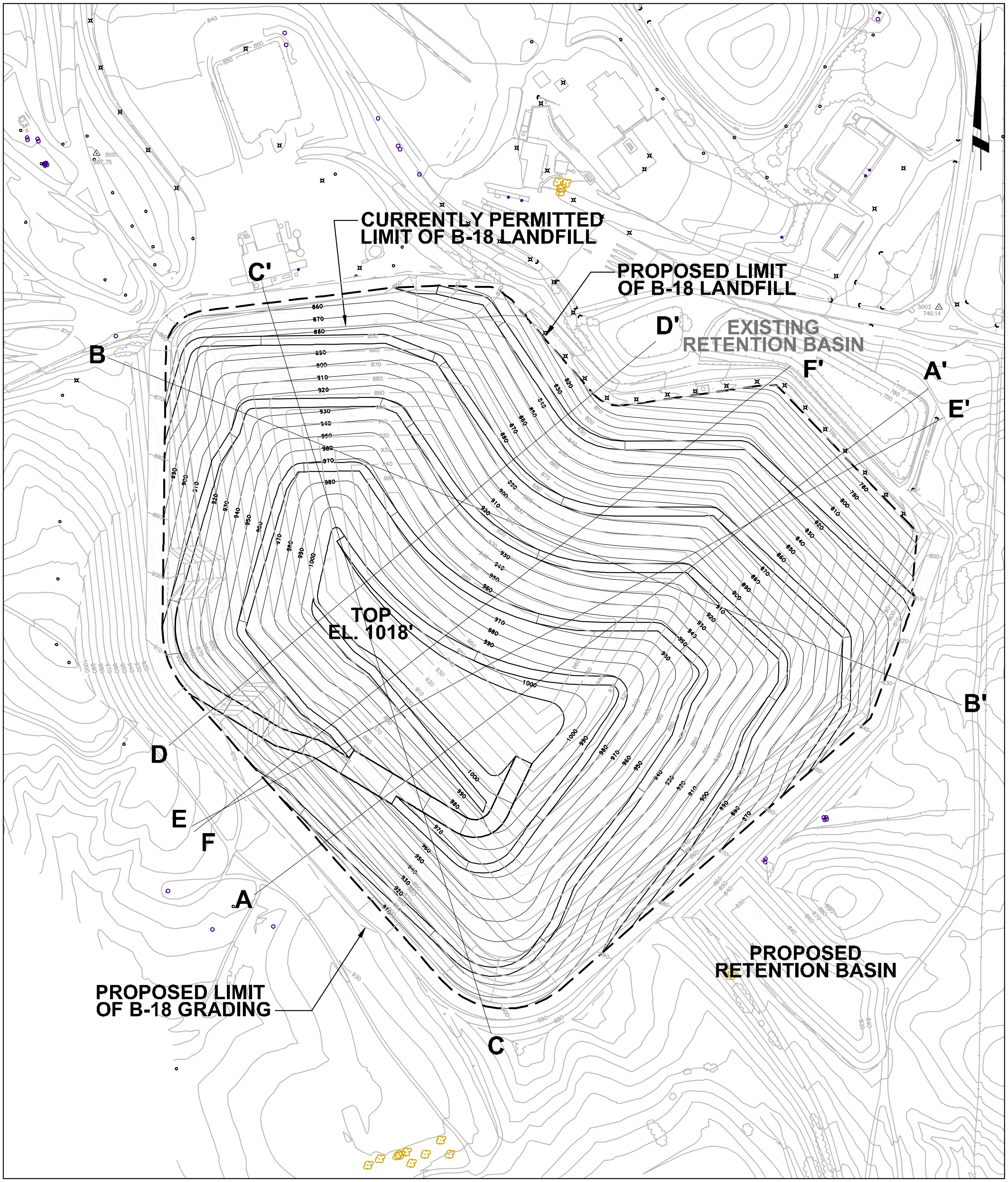
HAI

Project No.: 08-0228	Date: JULY, 2008
Drawn by: K.J.Kavli	Checked by: SGS

FIGURE 1

PROPOSED B-18 LANDFILL LINER GRADES

KETTLEMAN HILLS LANDFILL FACILITY



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SCALE

HAI

Project No.: 08-0228

Date: JULY, 2008

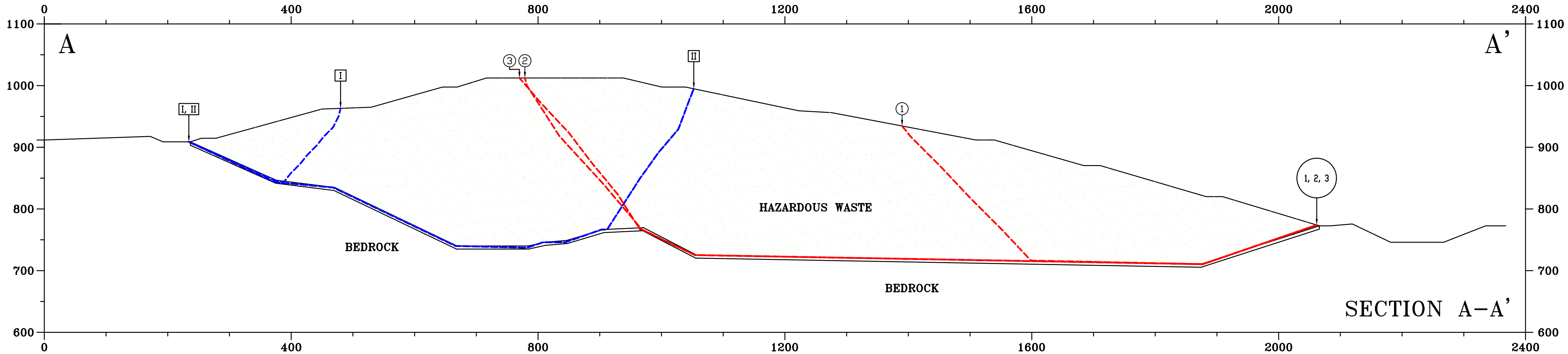
Drawn by: K.J.Kavli

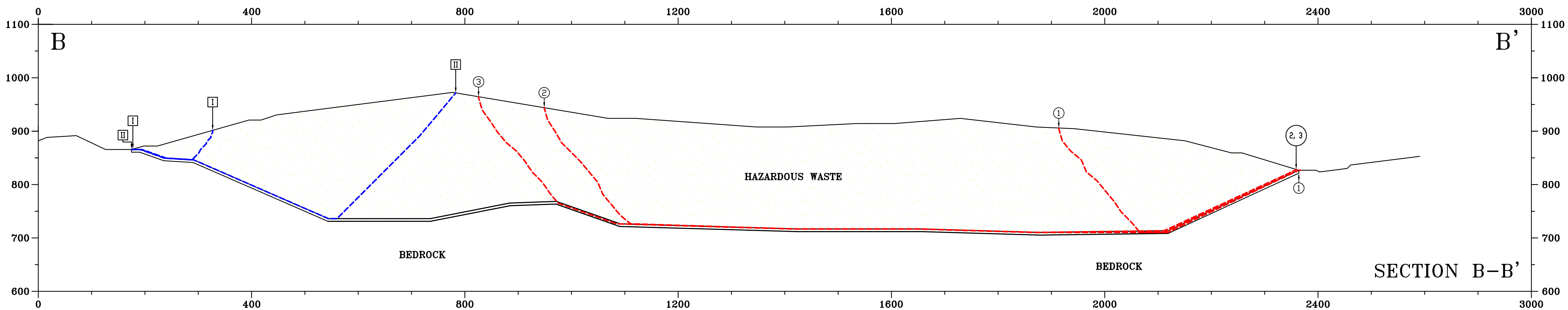
Checked by: SGS

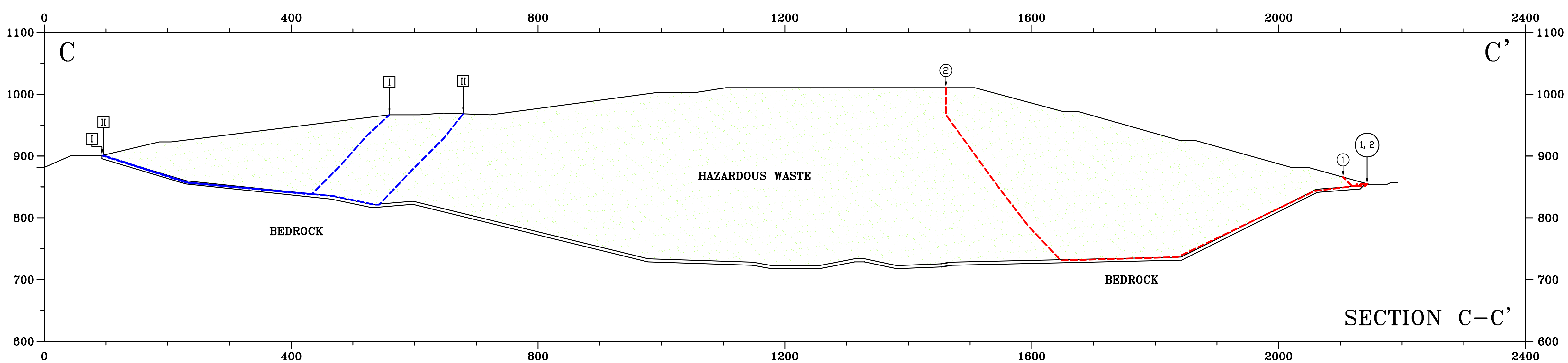
FIGURE 2

PROPOSED B-18 LANDFILL FINAL GRADING

KETTLEMAN HILLS LANDFILL FACILITY







SUMMARY OF
SLOPE STABILITY ANALYSIS RESULTS

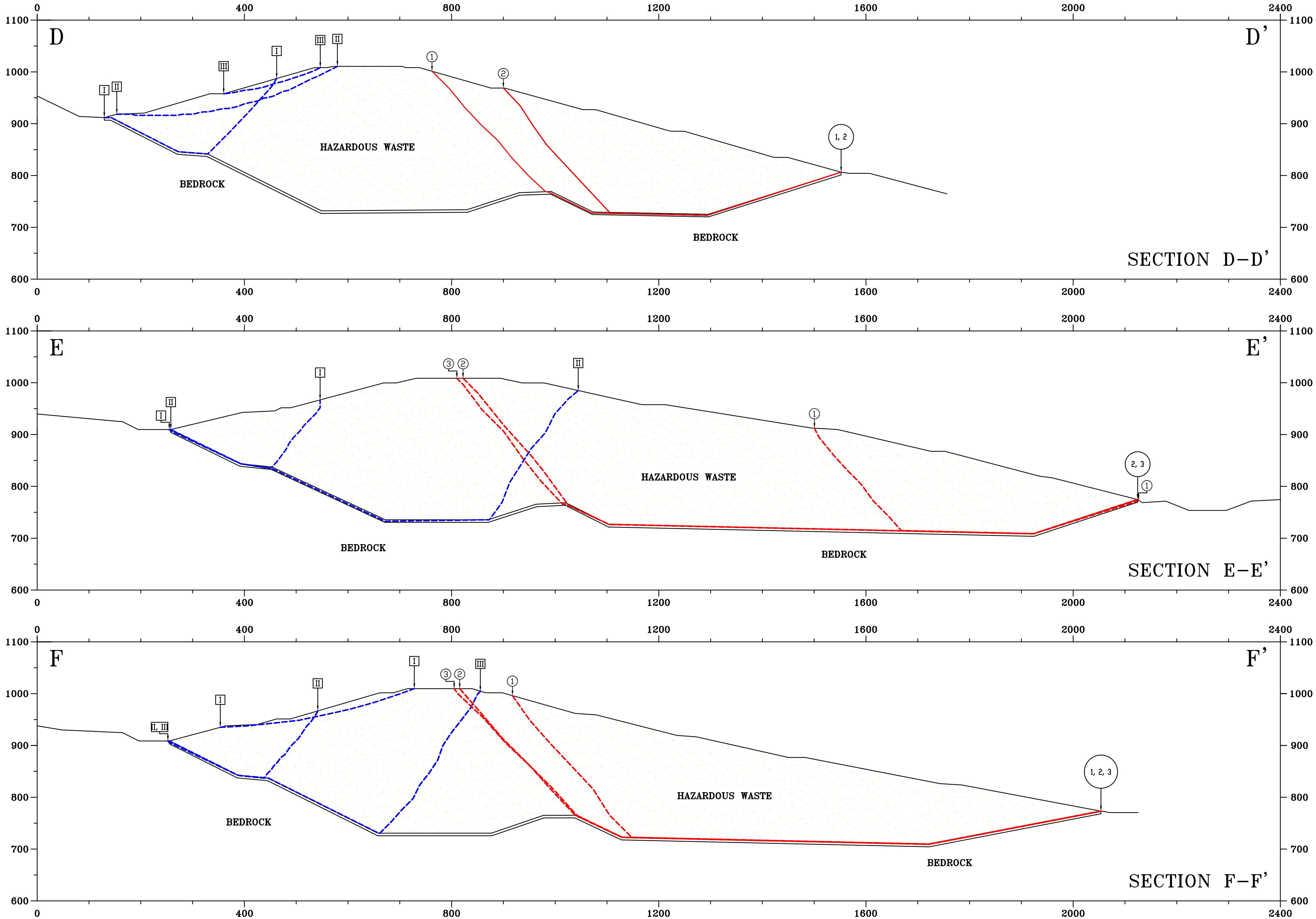
SECTION	CASE NO.	FS	Ky
A–A'	1	2.59	0.254
	2	2.69	0.225
	3	2.72	0.237
	I	>4.00	0.420
	II	>4.00	0.315
B–B'	1	>4.00	0.453
	2	>4.00	0.385
	3	>4.00	0.356
	I	3.50	0.395
	II	>4.00	0.487
C–C'	1	3.06	0.395
	2	>4.00	0.470
	I	>4.00	0.345
	II	>4.00	0.340

LEGEND:

- NORTH OR EAST FAILURE PLANE (red dashed line)
- WEST OR SOUTH FAILURE PLANE (blue dashed line)
- ② NORTH OR EAST PLANE NUMBER
- [I] WEST OR SOUTH PLANE NUMBER

SCALE 1 inch = 200 ft
0' 50' 100' 200'

Project No. 08–0228	Kettleman Hills Facility – Unit B-18 Kettleman City, Kings County, California	ANALYSIS CROSS SECTIONS A–A', B–B', C–C' AND POTENTIAL FAILURE PLANES	Figure 3
HAI	HUSHMAND ASSOCIATES INC. Geotechnical, Earthquake and Environmental Engineers		



SUMMARY OF
SLOPE STABILITY ANALYSIS RESULTS

SECTION	CASE NO.	FS	Ky
D-D'	1	2.34	0.232
	2	2.82	0.273
	I	3.88	0.375
	II	2.50 *	0.320*
	III	2.18 *	0.260*
E-E'	1	2.74	0.265
	2	2.75	0.230
	3	2.73	0.237
	I	>4.00	0.425
	II	>4.00	0.344
F-F'	1	2.81	0.252
	2	2.47	0.225
	3	2.46	0.225
	I	2.58 *	0.325*
	II	>4.00	0.435
	III	>4.00	0.375

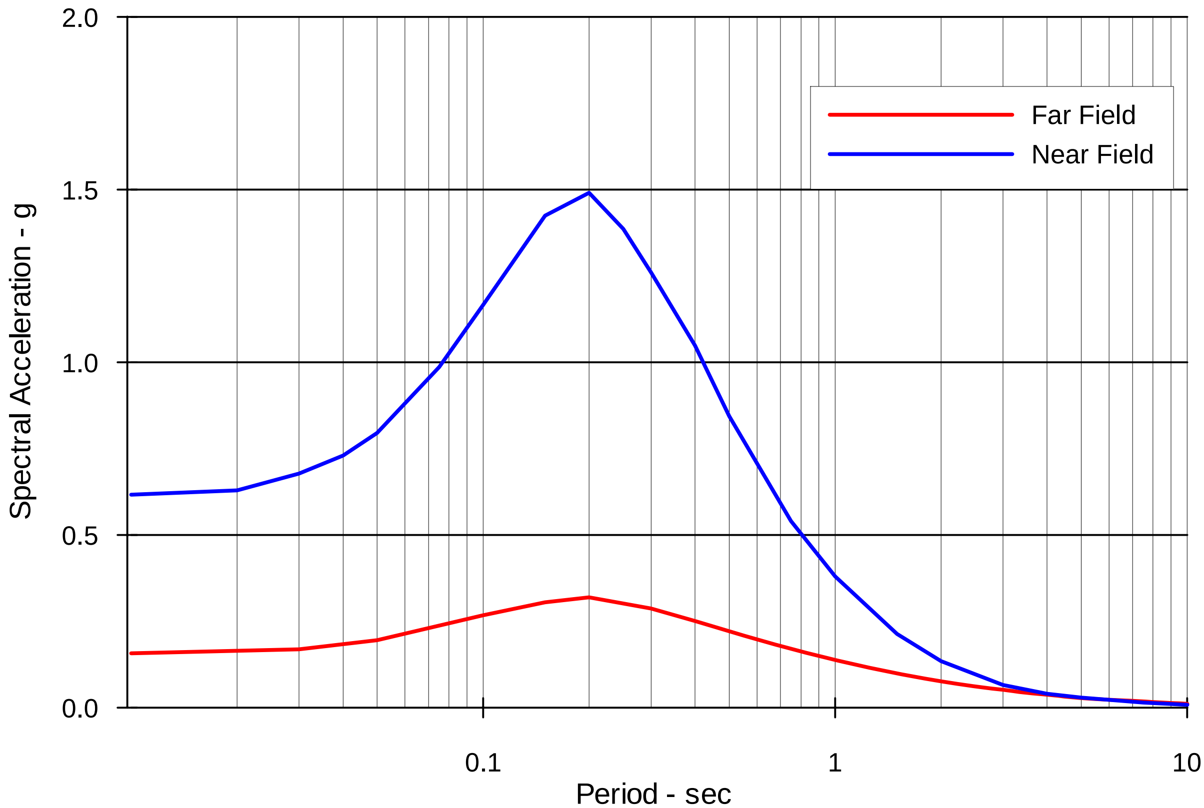
*Using Modified Bishop Method.

LEGEND:

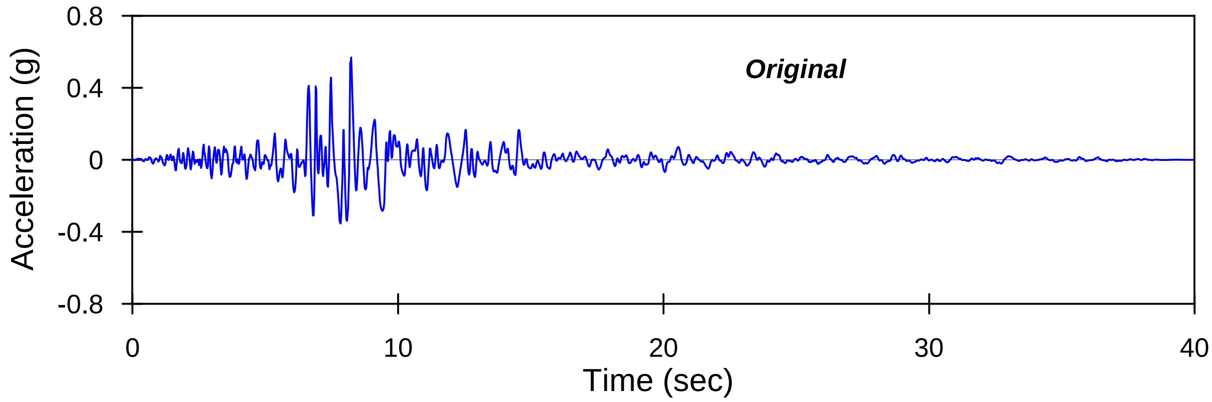
- NORTH OR EAST FAILURE PLANE
- WEST OR SOUTH FAILURE PLANE
- ② NORTH OR EAST PLANE NUMBER
- Ⅰ WEST OR SOUTH PLANE NUMBER

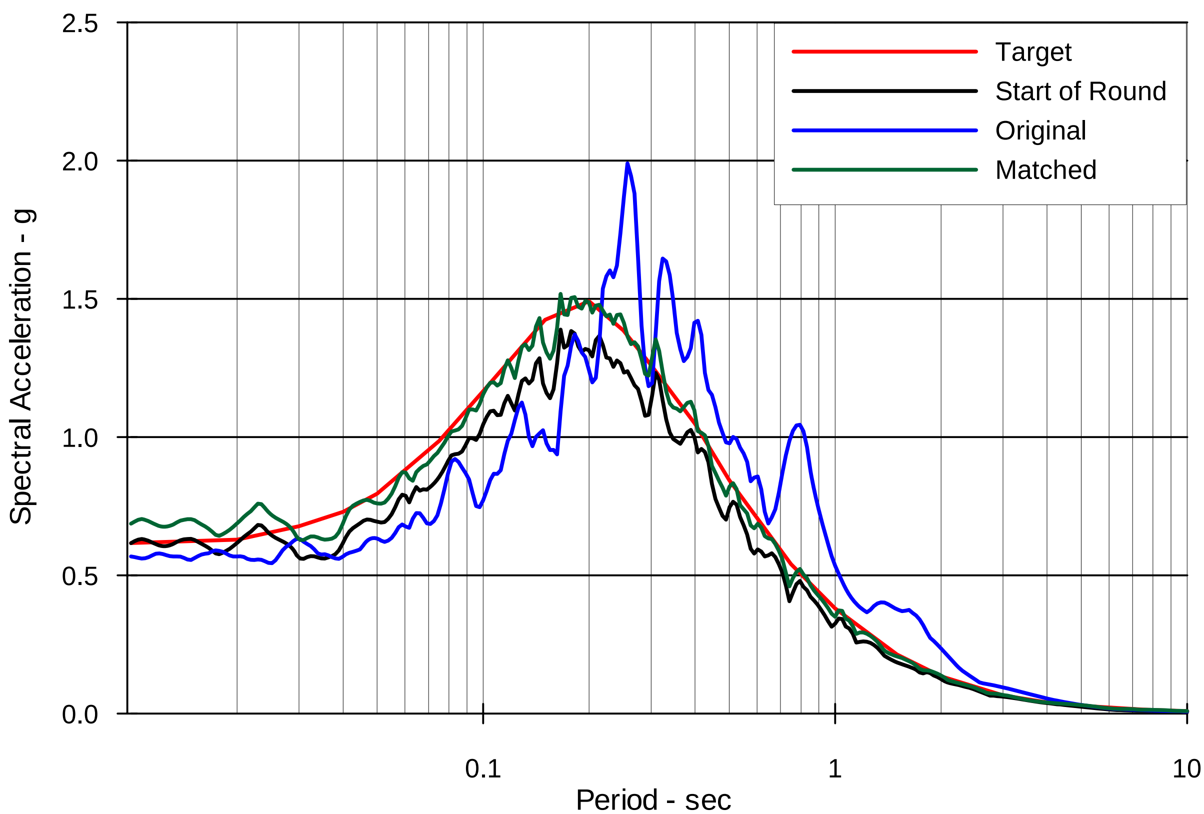
SCALE 1 inch = 200 ft
0' 50' 100' 200'

Project No. 08-0228	Kettleman Hills Facility - Unit B-18 Kettleman City, Kings County, California	ANALYSIS CROSS SECTIONS D-D', E-E', F-F' AND POTENTIAL FAILURE PLANES	Figure 4
HAI	HUSHMAND ASSOCIATES INC. Geotechnical, Earthquake and Environmental Engineers		

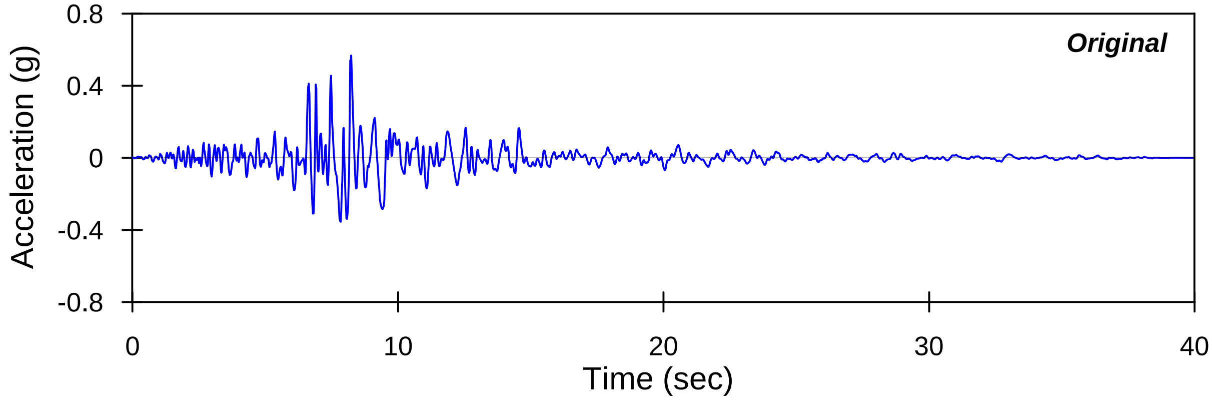


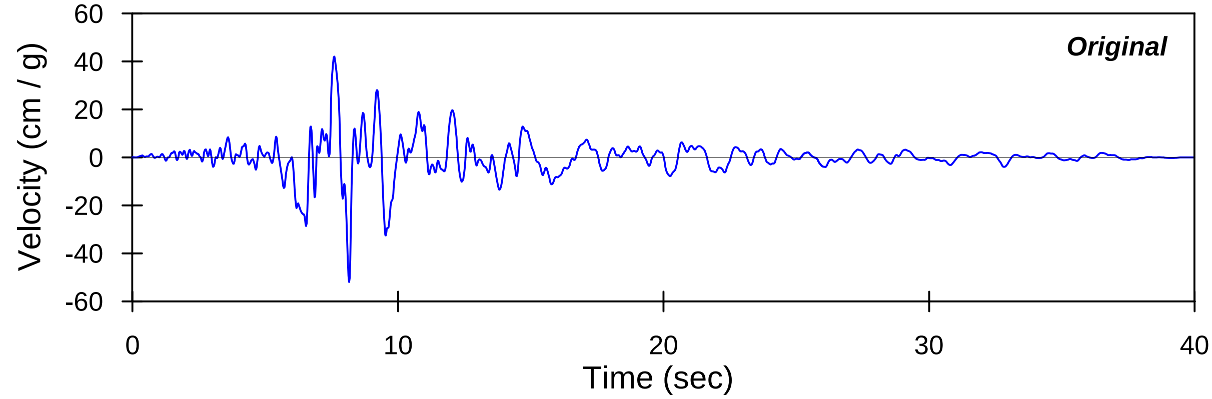
Project No. 08-0228	Landfill B-18 Expansion Project Kettleman City, Kings County, CA	**5-PERCENT DAMPED SITE DESIGN RESPONSE SPECTRA FOR NEAR-FIELD AND FAR-FIELD EARTHQUAKES**	Figure 5
HAI	***HUSHMAND ASSOCIATES INC.*** ***Geotechnical and Earthquake Engineers***		

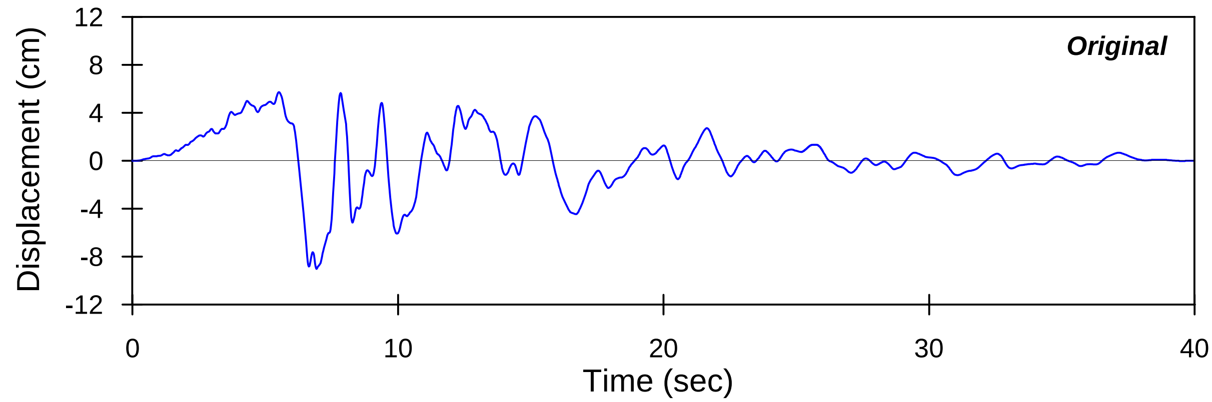




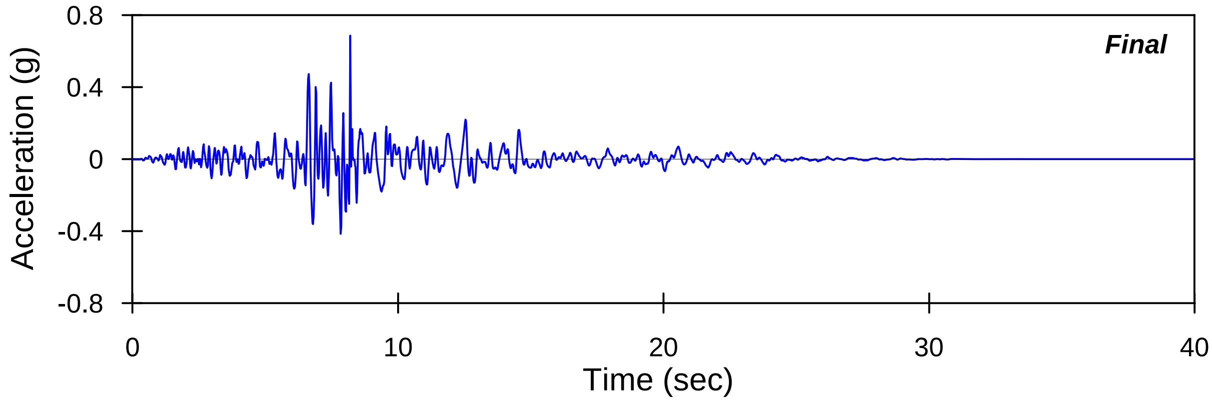
Project No. 08-0228	Landfill B-18 Expansion Project Kettleman City, Kings County, CA	ORIGINAL HORIZONTAL ACCELERATION RECORD & RESPONSE SPECTRUM MATCHED TO DESIGN RESPONSE SPECTRUM 1994 NORTHRIDGE EQ. CASTAIC 090	Figure 6
HAI	***HUSHMAND ASSOCIATES INC.*** ***Geotechnical and Earthquake Engineers***		

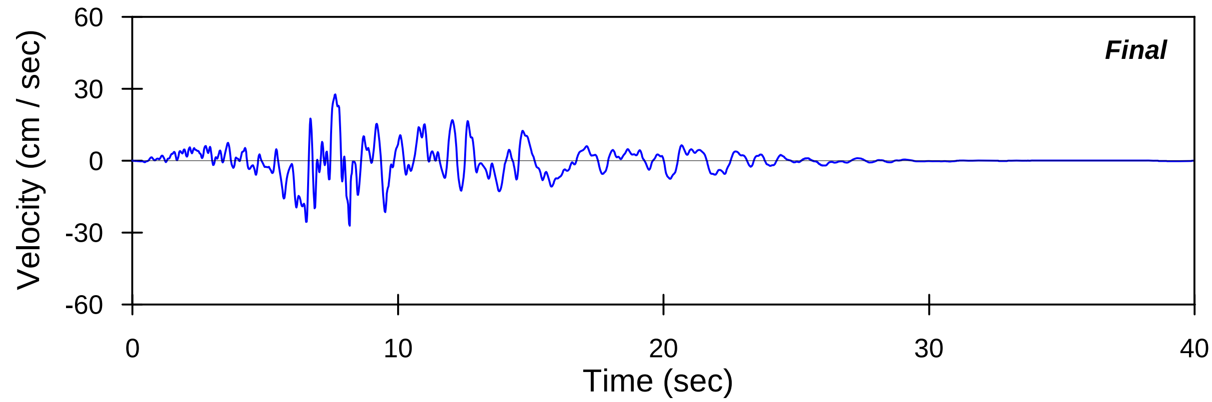


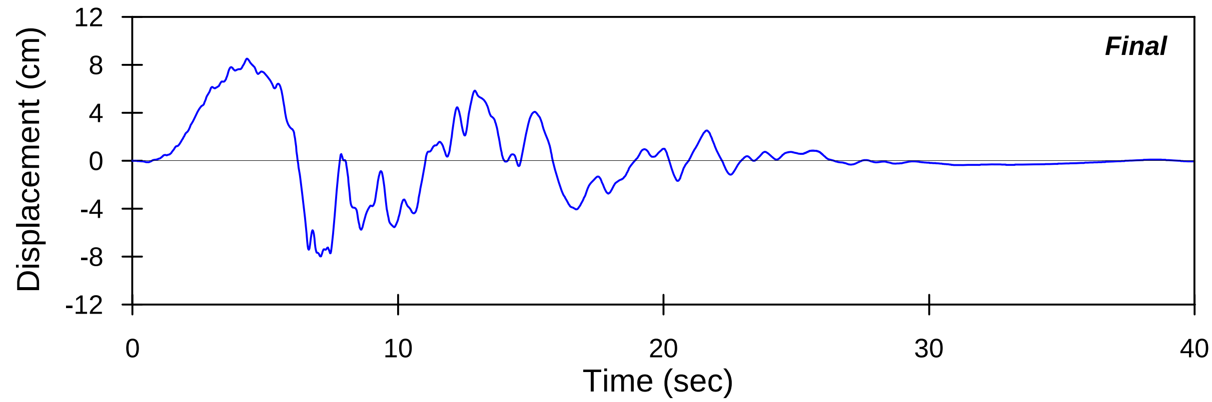




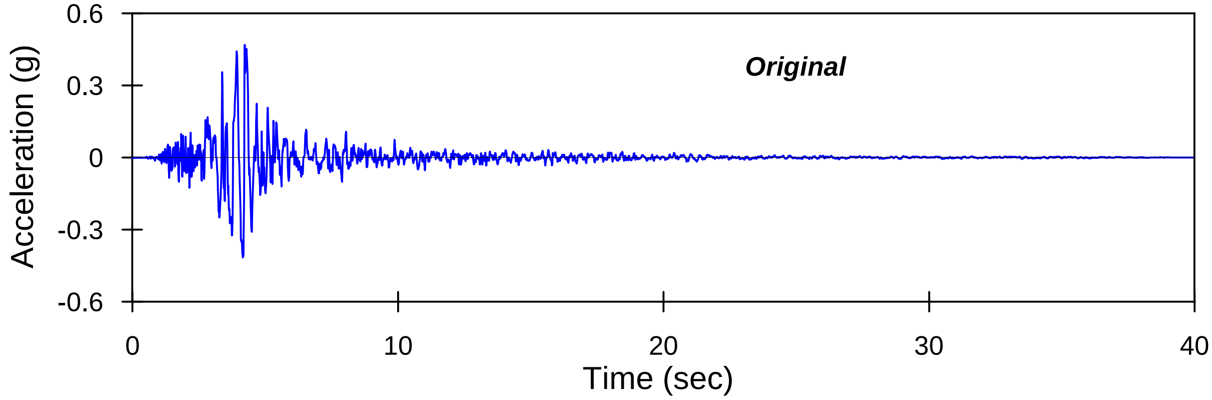
Project No. 08-0228	Landfill B-18 Expansion Project Kettleman City, Kings County, CA	ORIGINAL CORRECTED TIME HISTORIES 1994 NORTHRIDGE EARTHQUAKE STATION: CASTAIC OLD RIDGE_090	Figure 7
HAI	***HUSHMAND ASSOCIATES INC.*** ***Geotechnical and Earthquake Engineers***		

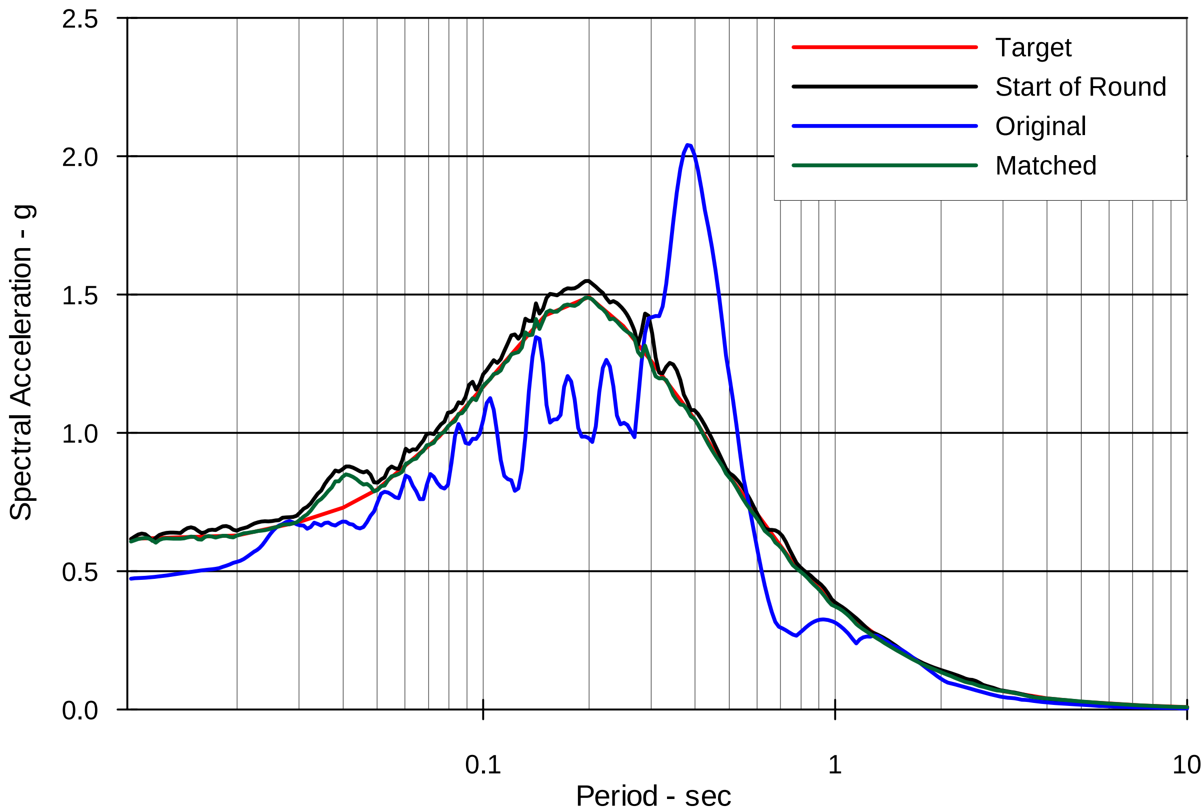




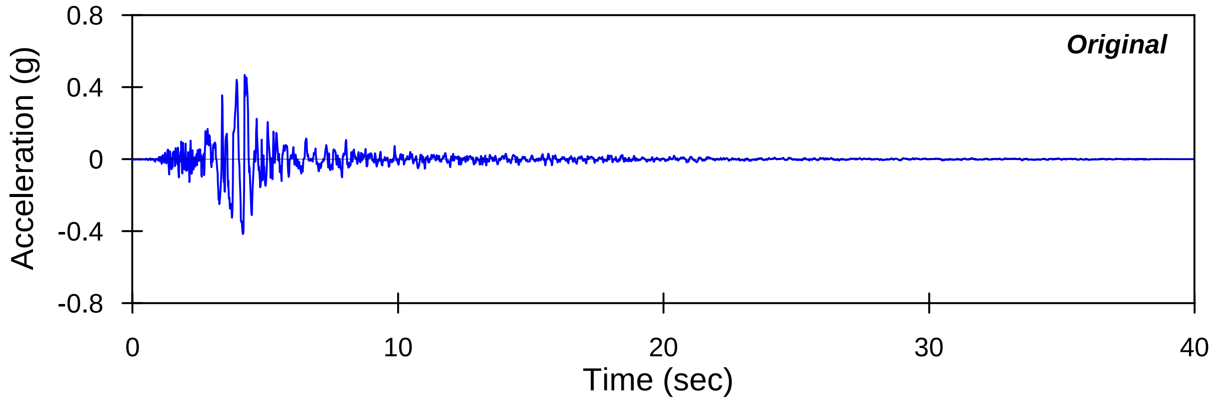


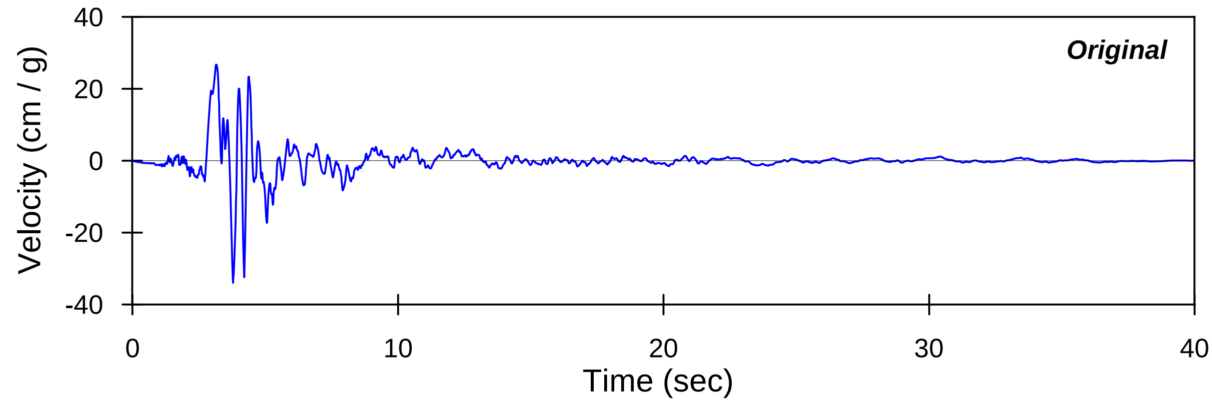
Project No. 08-0228	Landfill B-18 Expansion Project Kettleman City, Kings County, CA	**SPECTRUM COMPATIBLE TIME HISTORIES** **1994 NORTHRIDGE EARTHQUAKE** **STATION: CASTAIC OLD RIDGE_090**	Figure 8
HAI	***HUSHMAND ASSOCIATES INC.*** ***Geotechnical and Earthquake Engineers***		

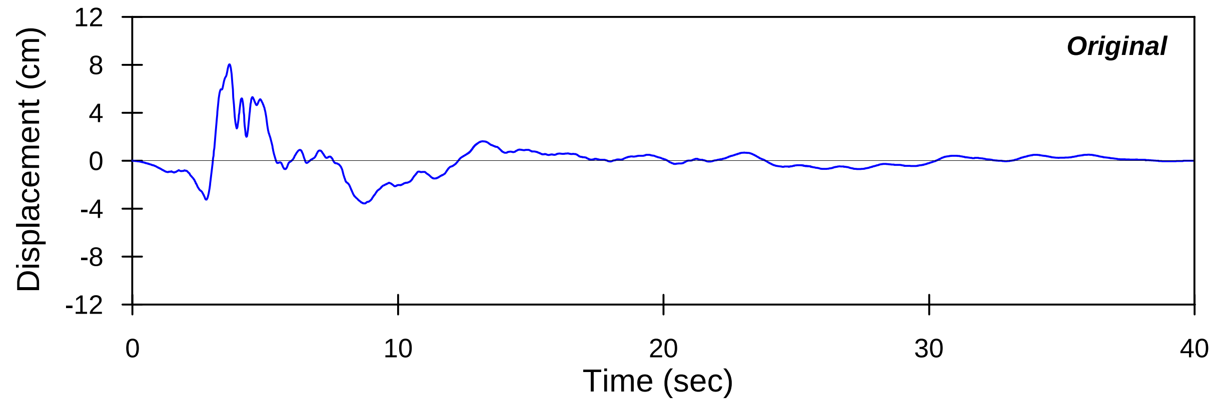




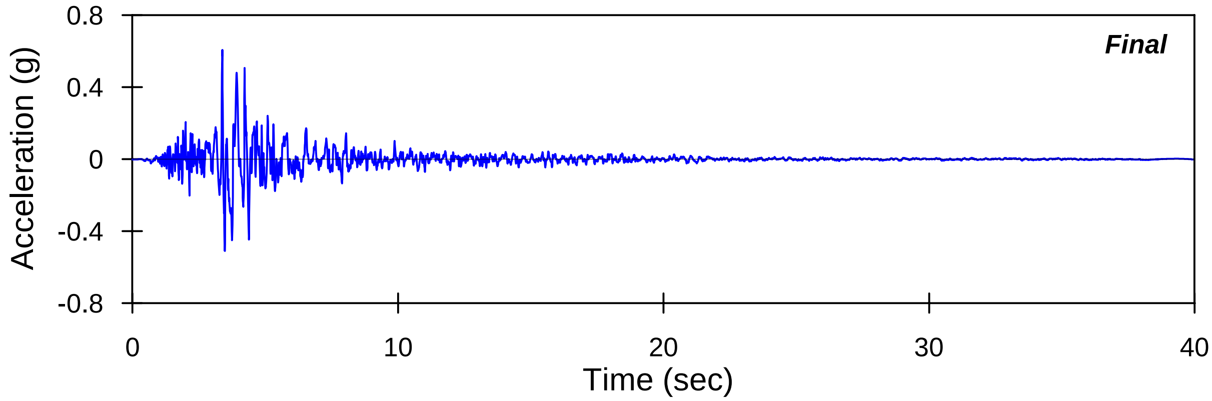
Project No. 08-0228	Landfill B-18 Expansion Project Kettleman City, Kings County, CA	ORIGINAL HORIZONTAL ACCELERATION RECORD & RESPONSE SPECTRUM MATCHED TO DESIGN RESPONSE SPECTRUM 1989 LOMA PRIETA EQ. GILROY ARRAY 090 RECORD	Figure 9
HAI	***HUSHMAND ASSOCIATES INC.*** ***Geotechnical and Earthquake Engineers***		

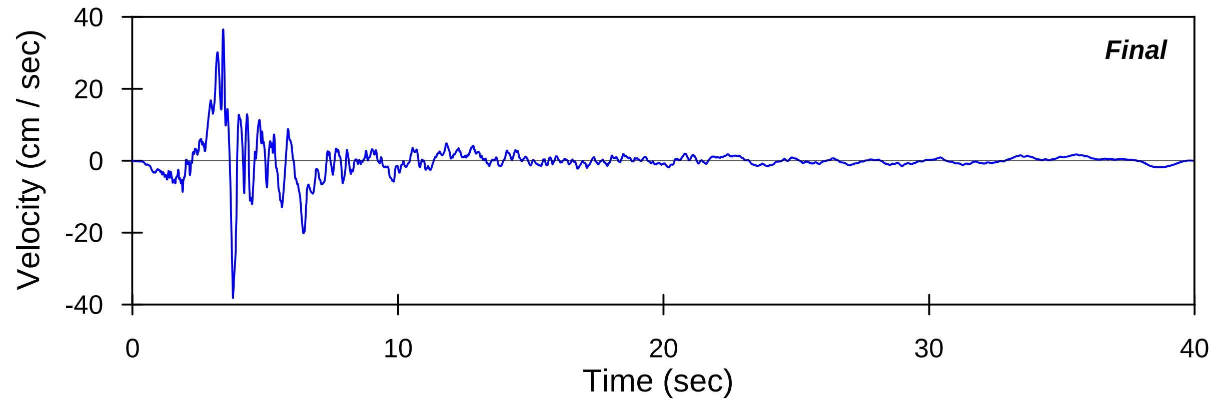


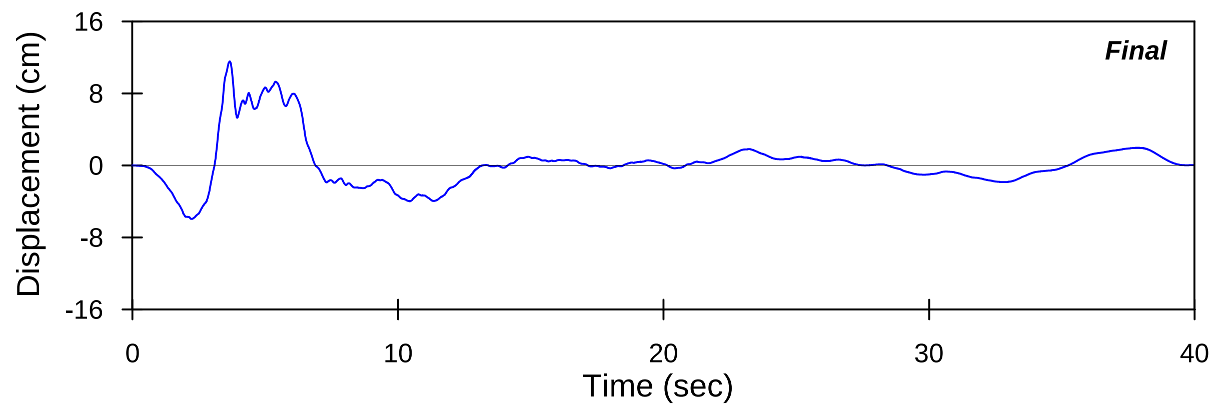




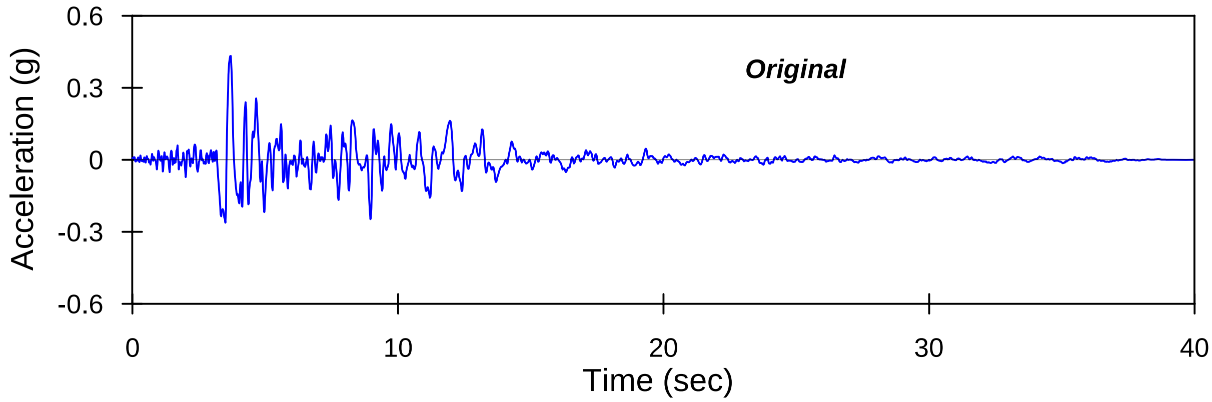
Project No. 08-0228	Landfill B-18 Expansion Project Kettleman City, Kings County, CA	ORIGINAL CORRECTED TIME HISTORIES 1989 LOMA PRIETA EARTHQUAKE STATION: GILROY ARRAY 090	Figure 10
HAI	**HUSHMAND ASSOCIATES INC.** *Geotechnical and Earthquake Engineers*		

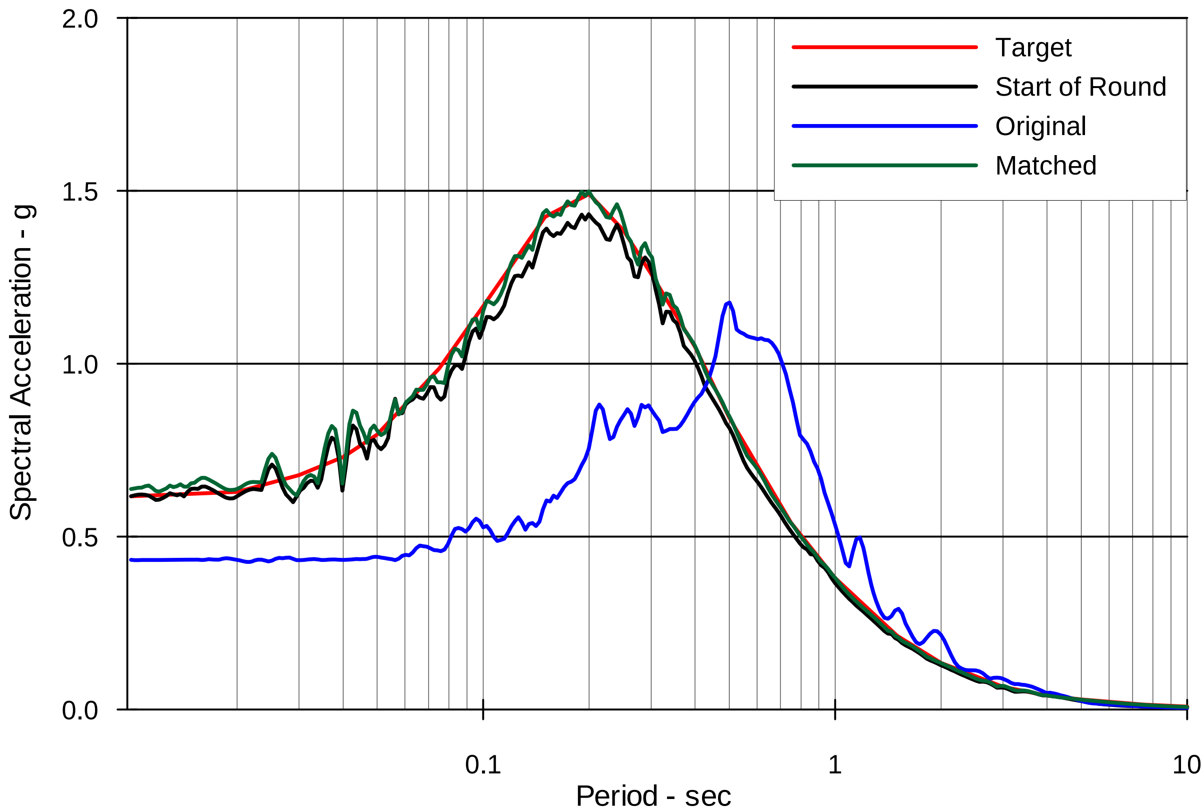




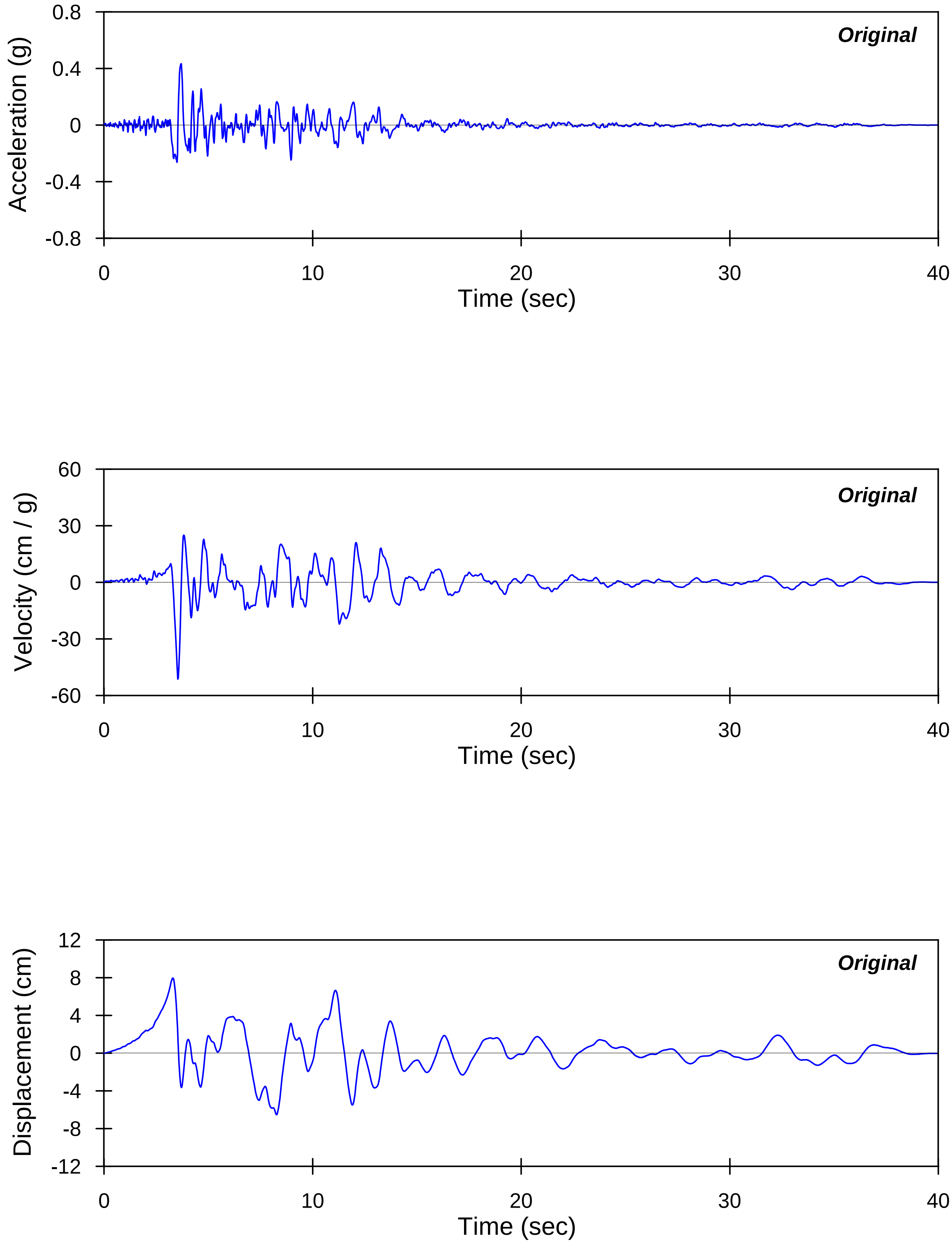


Project No. 08-0228	Landfill B-18 Expansion Project Kettleman City, Kings County, CA	**SPECTRUM COMPATIBLE TIME HISTORIES 1989 LOMA PRIETA EARTHQUAKE STATION: GILROY ARRAY 090**	Figure 11
HAI	***HUSHMAND ASSOCIATES INC.*** ***Geotechnical and Earthquake Engineers***		

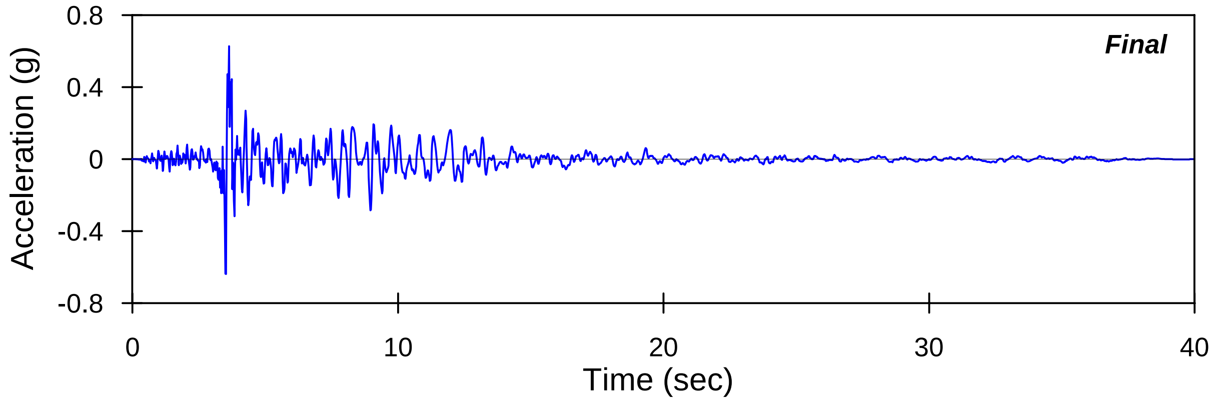


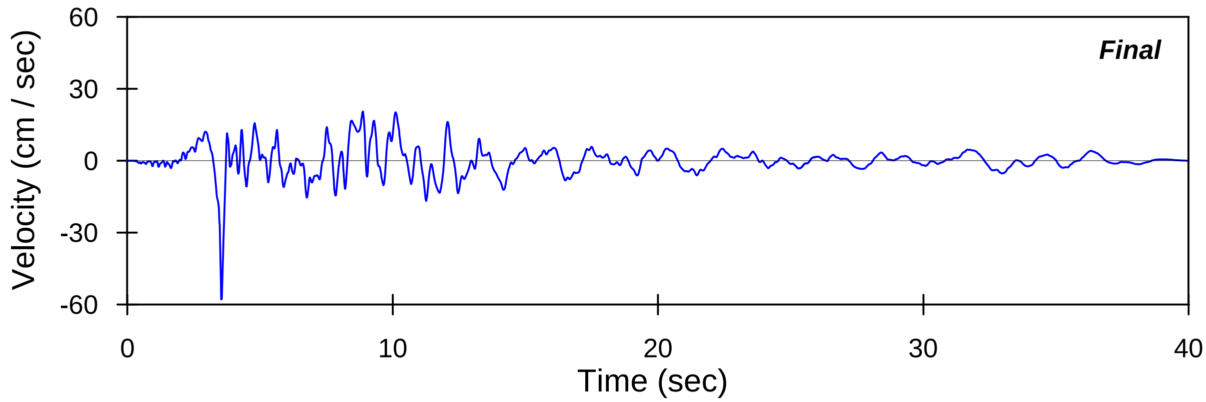


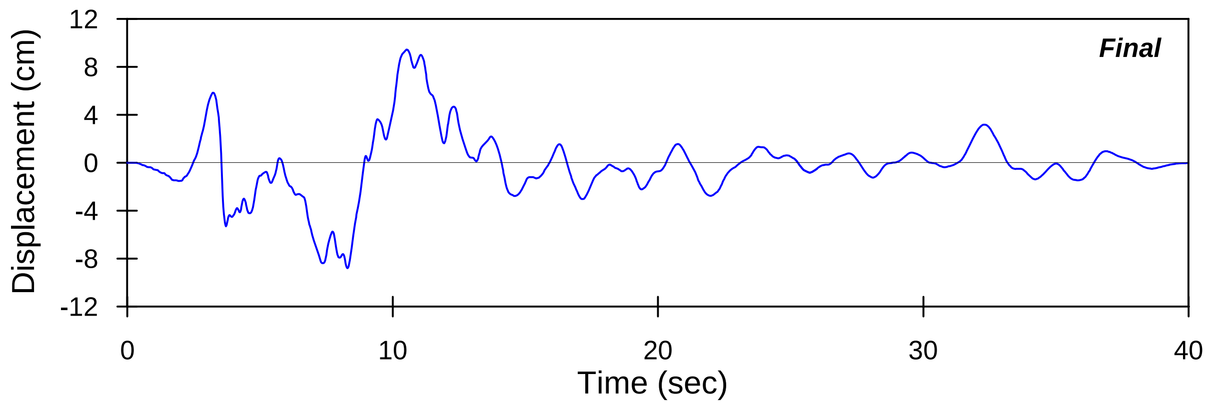
Project No. 08-0228	Landfill B-18 Expansion Project Kettleman City, Kings County, CA	ORIGINAL HORIZONTAL ACCELERATION RECORD & RESPONSE SPECTRUM MACHED TO DESIGN RESPONSE SPECTRUM 1994 NORTHRIDGE EQ. PACOIMA KAGEL CANYON 360 RECORD	Figure 12
HAI	***HUSHMAND ASSOCIATES INC.*** ***Geotechnical and Earthquake Engineers***		



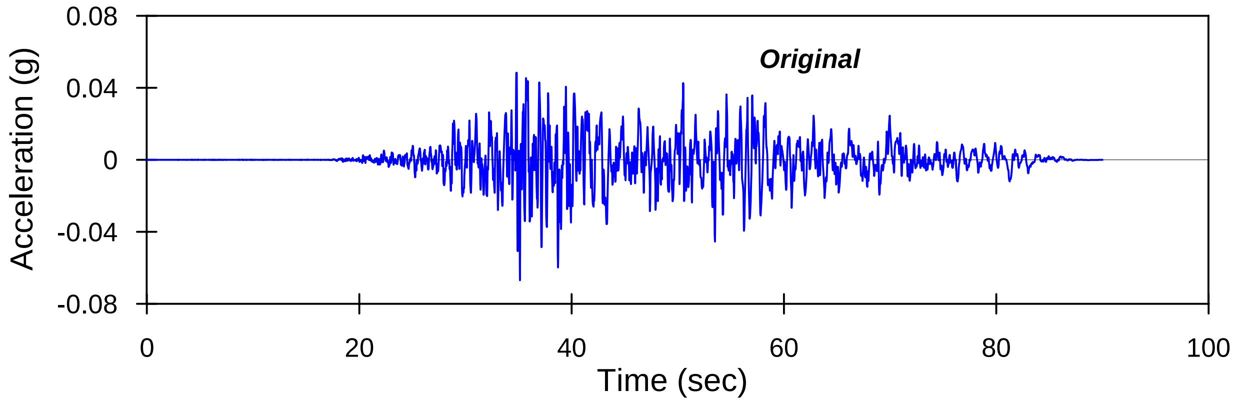
Project No. 08-0228	Landfill B-18 Expansion Project Kettleman City, Kings County, CA	**ORIGINAL CORRECTED TIME HISTORIES** **1994 NORTHRIDGE EARTHQUAKE** **STATION: PACOIMA KAGEL CANYON 360**	Figure 13
HAI	***HUSHMAND ASSOCIATES INC.*** ***Geotechnical and Earthquake Engineers***		

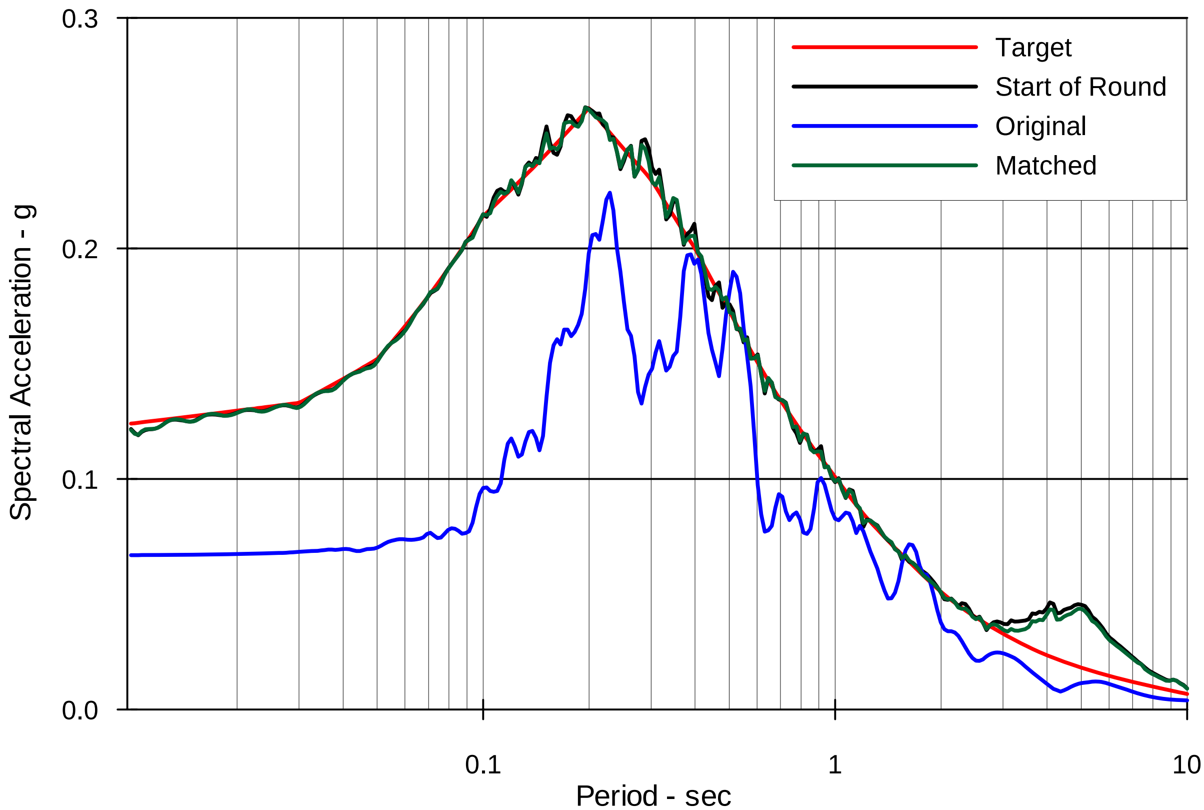




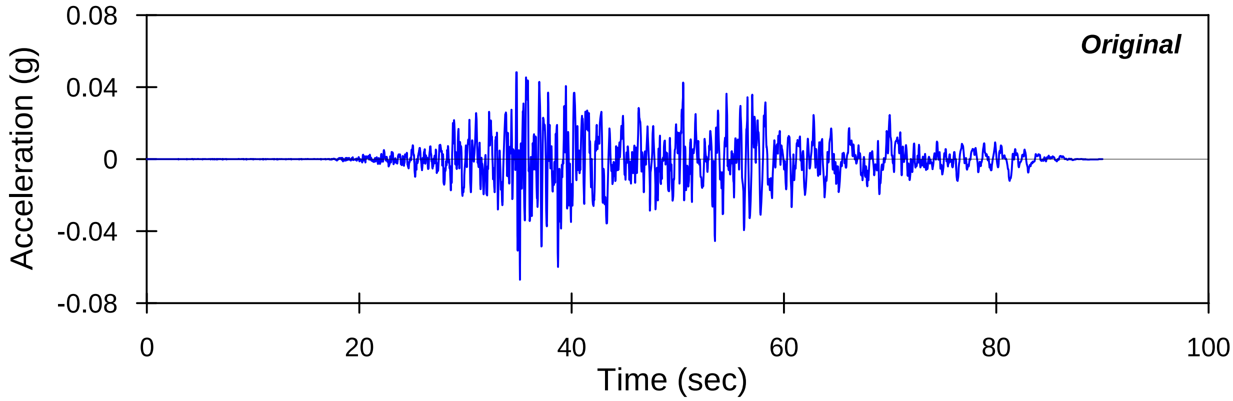


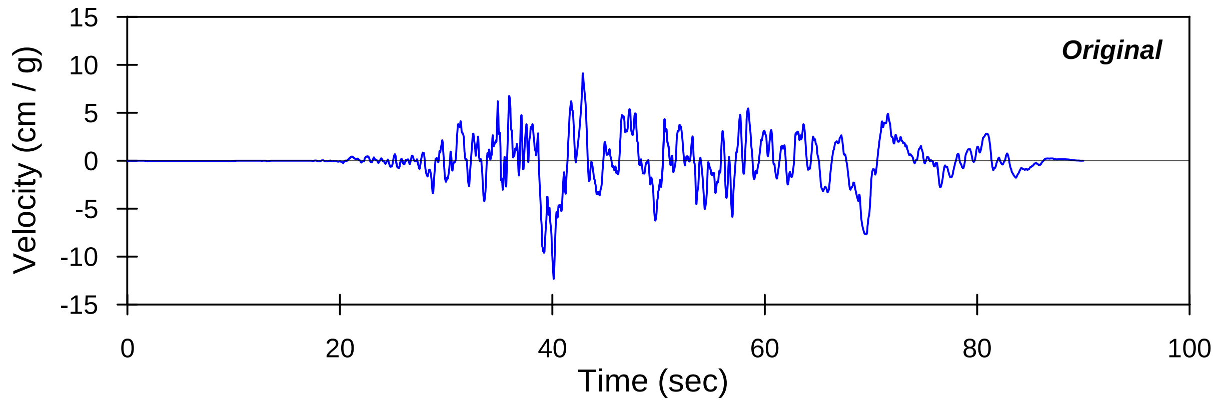
Project No. 08-0228	Landfill B-18 Expansion Project Kettleman City, Kings County, CA	**SPECTRUM COMPATIBLE TIME HISTORIES** **1994 NORTHRIDGE EARTHQUAKE** **STATION: PACOIMA KAGEL CANYON 360**	Figure 14
HAI	***HUSHMAND ASSOCIATES INC.*** ***Geotechnical and Earthquake Engineers***		

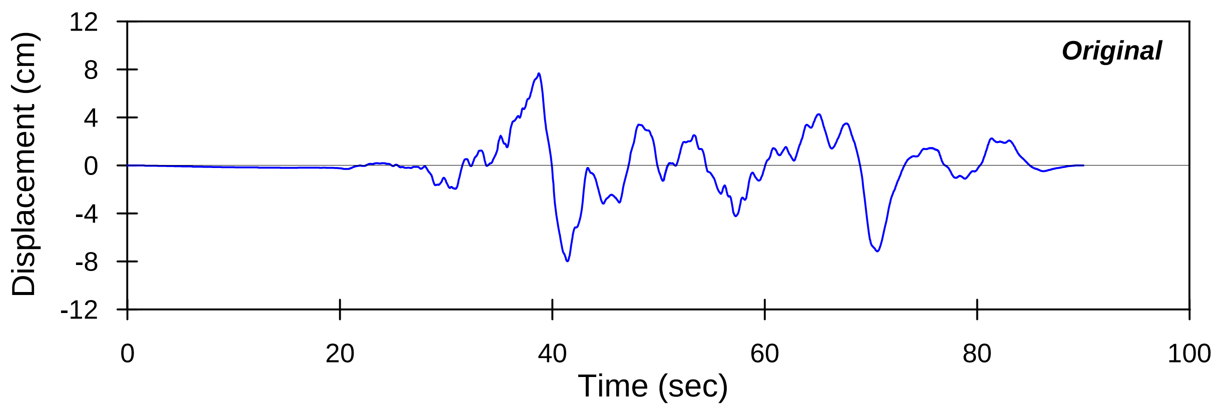




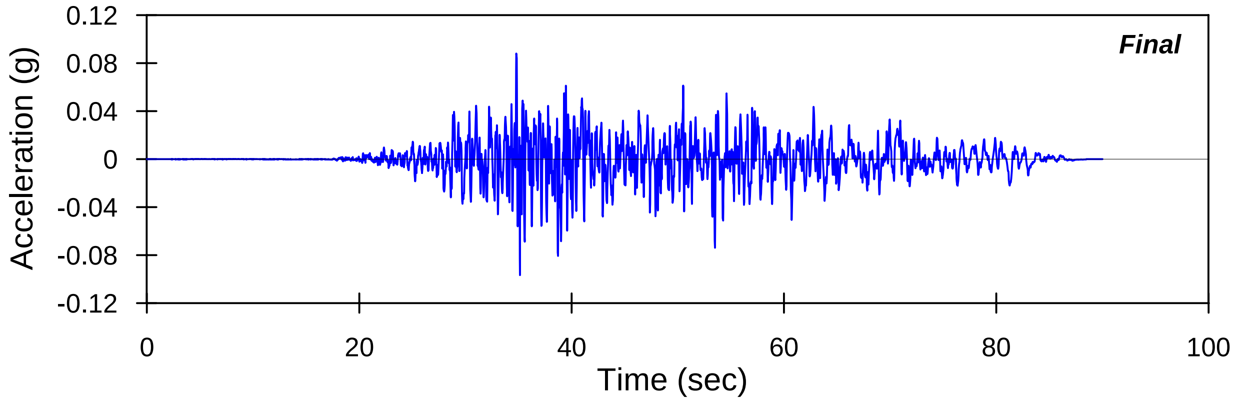
Project No. 08-0228	Landfill B-18 Expansion Project Kettleman City, Kings County, CA	ORIGINAL HORIZONTAL ACCELERATION RECORD & RESPONSE SPECTRUM MATCHED TO DESIGN RESPONSE SPECTRUM 1999 CHI CHI EQ. CHY042 N RECORD	Figure 15
HAI	***HUSHMAND ASSOCIATES INC.*** *Geotechnical and Earthquake Engineers*		

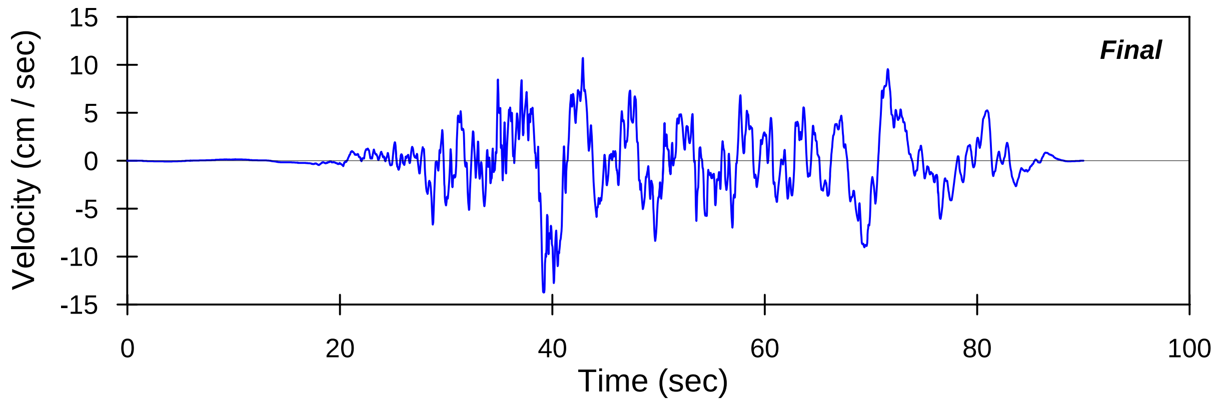


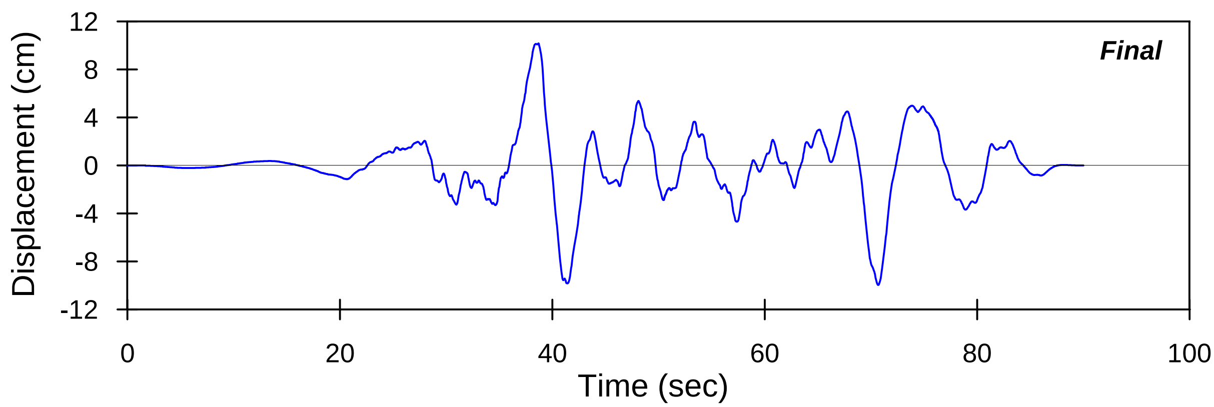




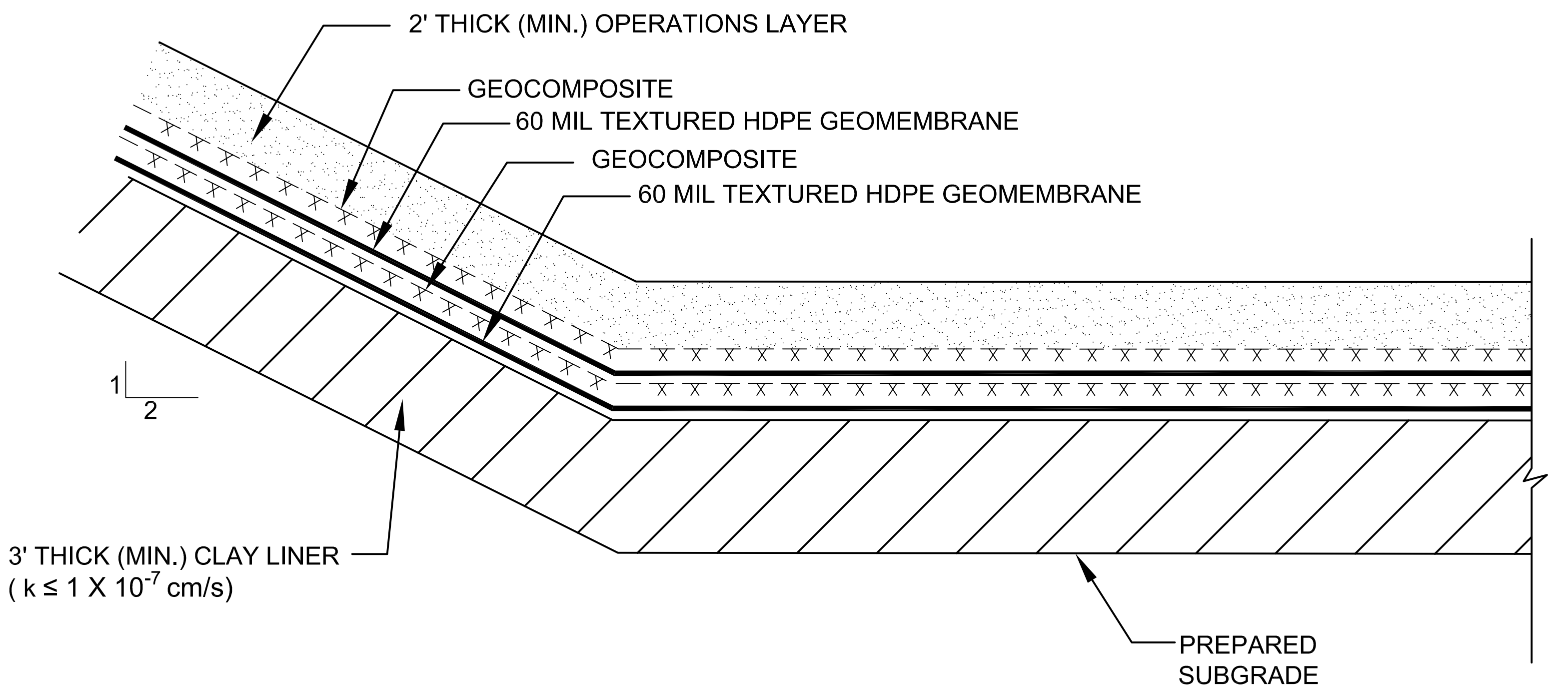
Project No. 08-0228	Landfill B-18 Expansion Project Kettleman City, Kings County, CA	**ORIGINAL CORRECTED TIME HISTORIES 1999 CHI CHI EARTHQUAKE STATION:CHY042 N**	Figure 16
HAI	***HUSHMAND ASSOCIATES INC.*** *Geotechnical and Earthquake Engineers*		



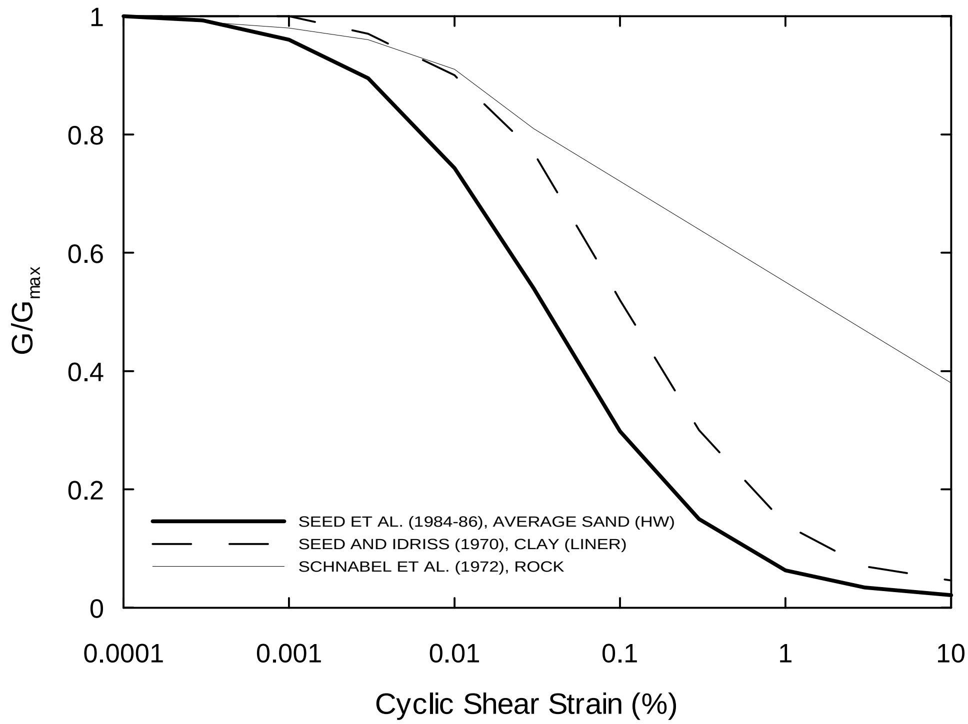


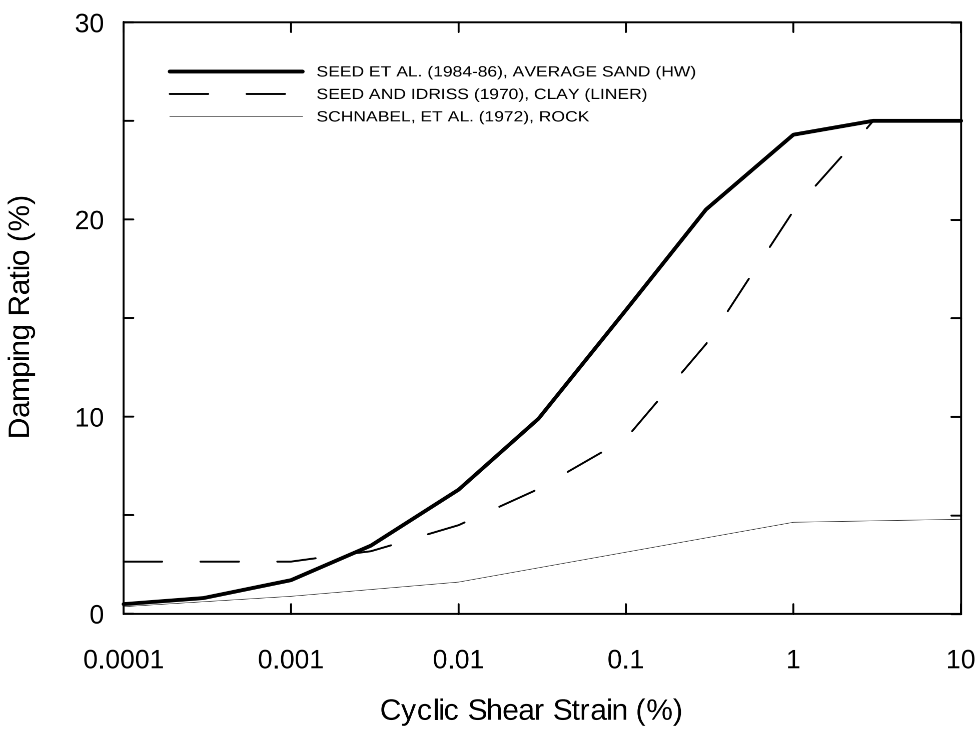


Project No. 08-0228	Landfill B-18 Expansion Project Kettleman City, Kings County, CA	SPECTRUM COMPATIBLE TIME HISTORIES 1999 CHI CHI EARTHQUAKE STATION:CHY042 N	Figure 17
HAI	**HUSHMAND ASSOCIATES INC.** *Geotechnical and Earthquake Engineers*		



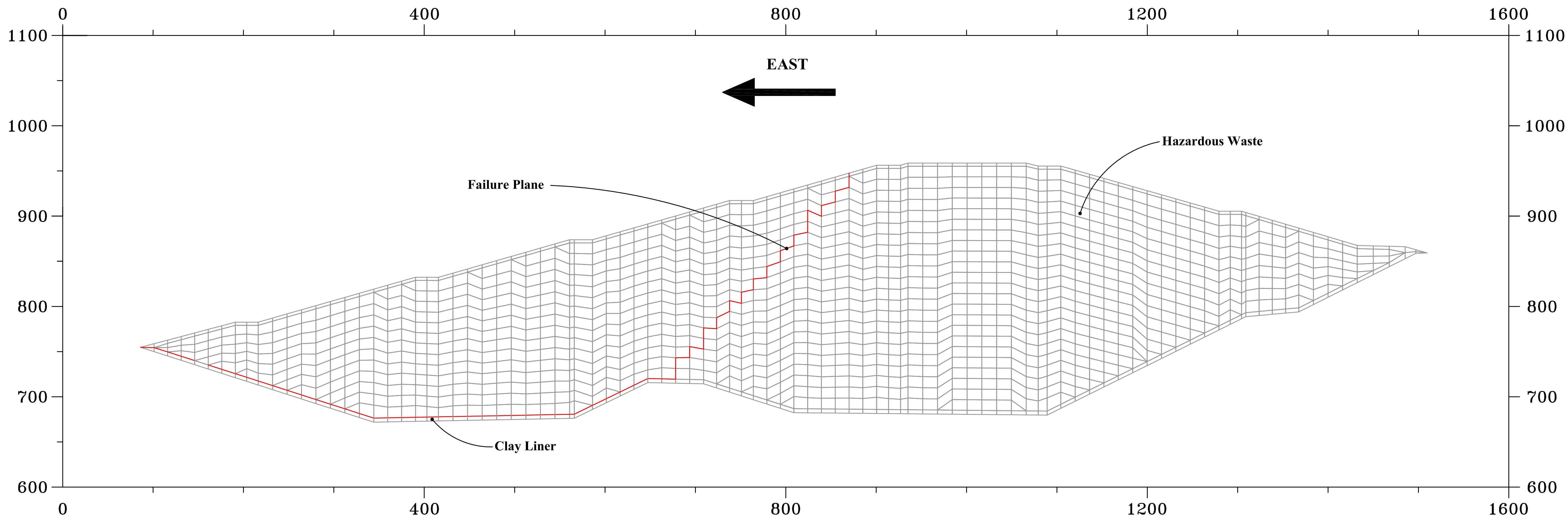
Project No. 08-0228	**Landfill B-18 Expansion Project** Kettleman, Kings County, California	**PROPOSED LANDFILL LINER SYSTEM**	Figure 18
HAI	***HUSHMAND ASSOCIATES, INC.*** *Geotechnical and Earthquake Engineers*		





HW: Hazardous Waste

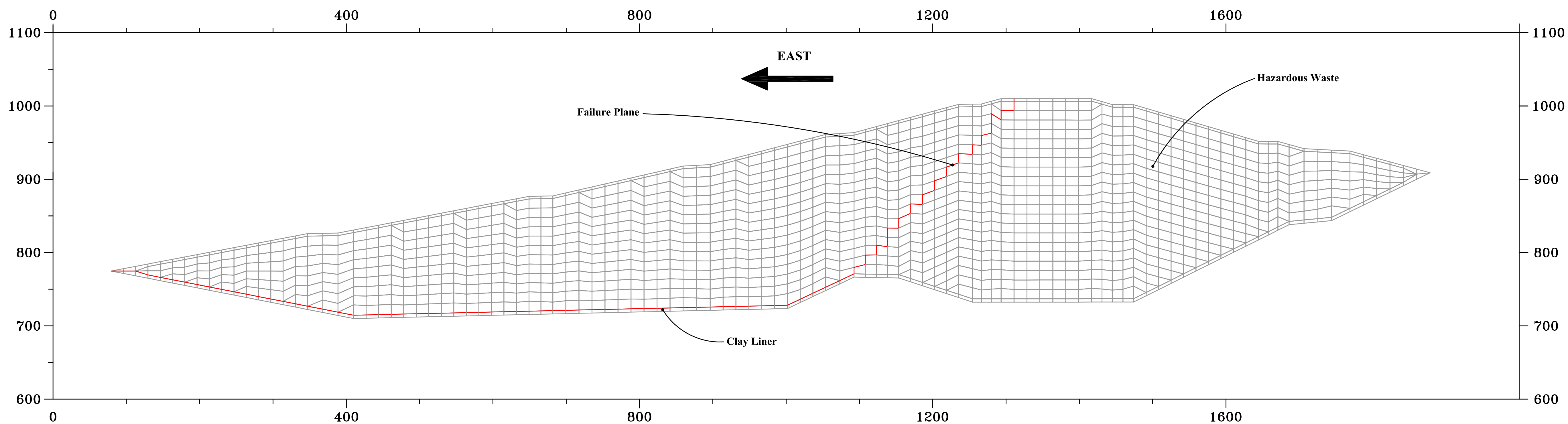
Project No. 08-0228	Landfill B-18 Expansion Project Kettleman City, Kings County, California	**SHEAR MODULUS REDUCTION AND DAMPING CURVES FOR SAND (Hazardous Waste) AND CLAY (Liner) USED IN THIS STUDY**	Figure 19
HAI	***HUSHMAND ASSOCIATES INC.*** ***Geotechnical and Earthquake Engineers***		



SCALE 1 inch = 120 ft

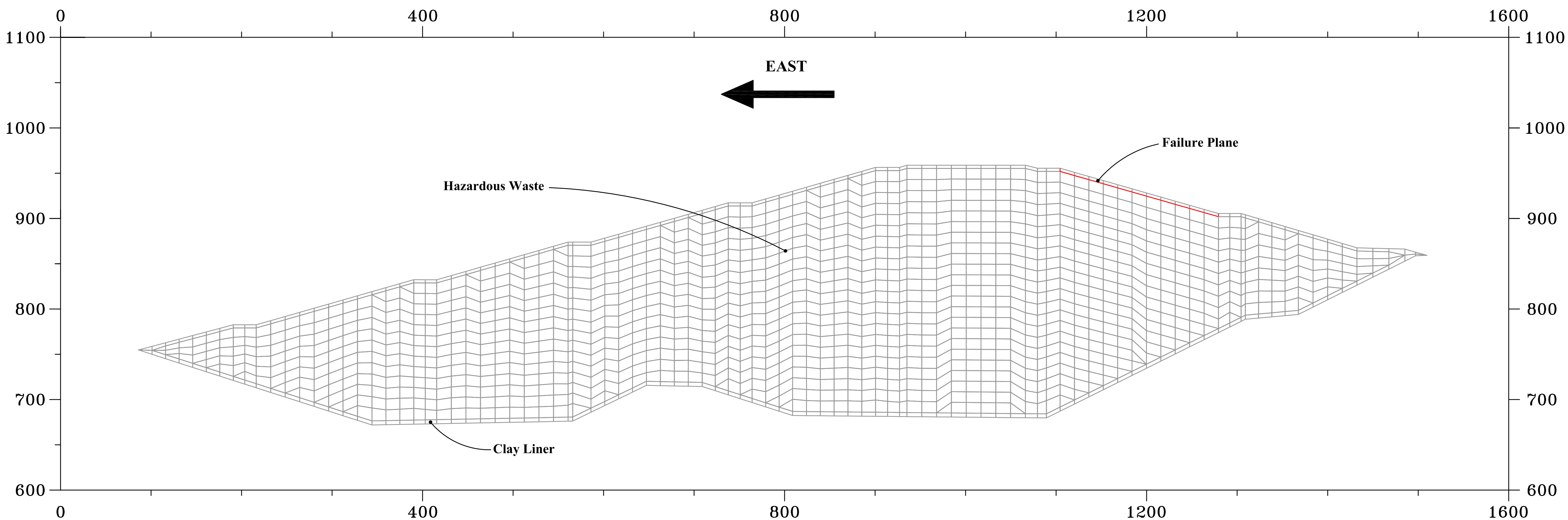
0' 30' 60' 120'

Project No. 08-0228	Landfill B-18 Expansion Project Kettleman City, Kings County, California	SECTION D - D' FINITE ELEMENT (QUAD4M) MESH	Figure 20a
HAI	HUSHMAND ASSOCIATES INC. Geotechnical, Earthquake and Environmental Engineers		



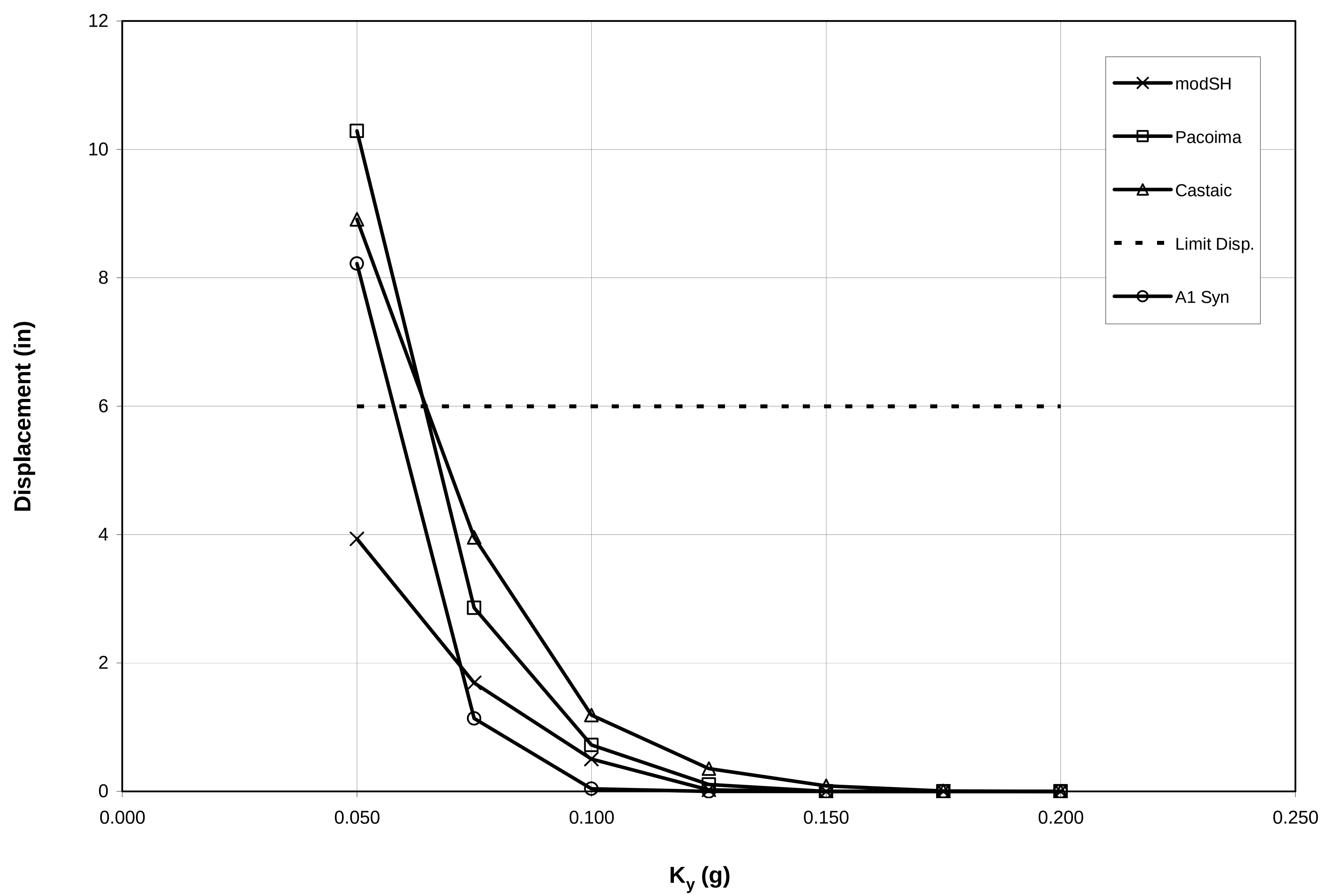
SCALE 1 inch = 150 ft
0' 37.5' 75' 150'

Project No. 08-0228	Landfill B-18 Expansion Project Kettleman City, Kings County, California	SECTION F – F' FINITE ELEMENT (QUAD4M) MESH	Figure 20b
HAI	HUSHMAND ASSOCIATES INC. Geotechnical, Earthquake and Environmental Engineers		

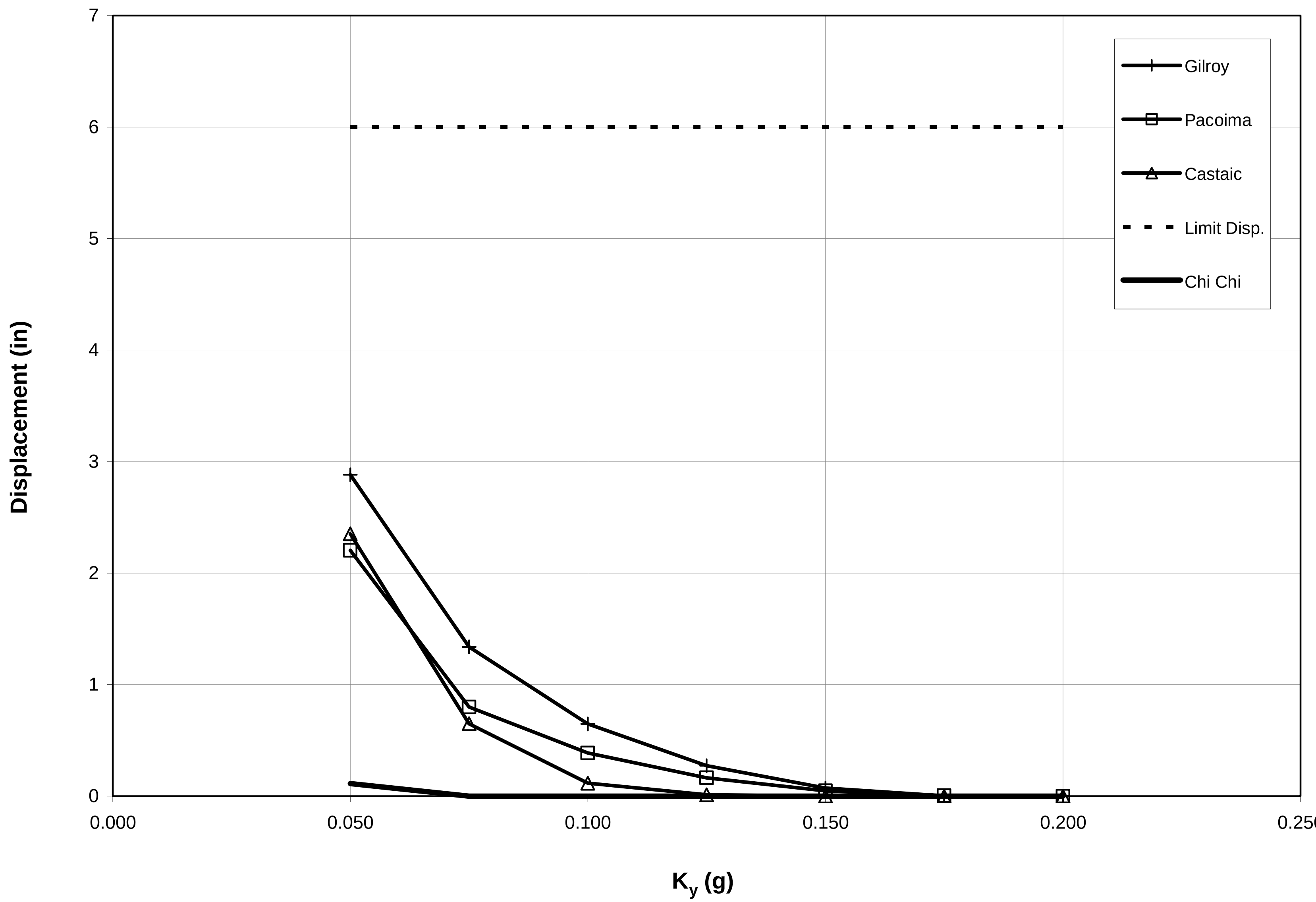


SCALE 1 inch = 120 ft
0' 30' 60' 120'

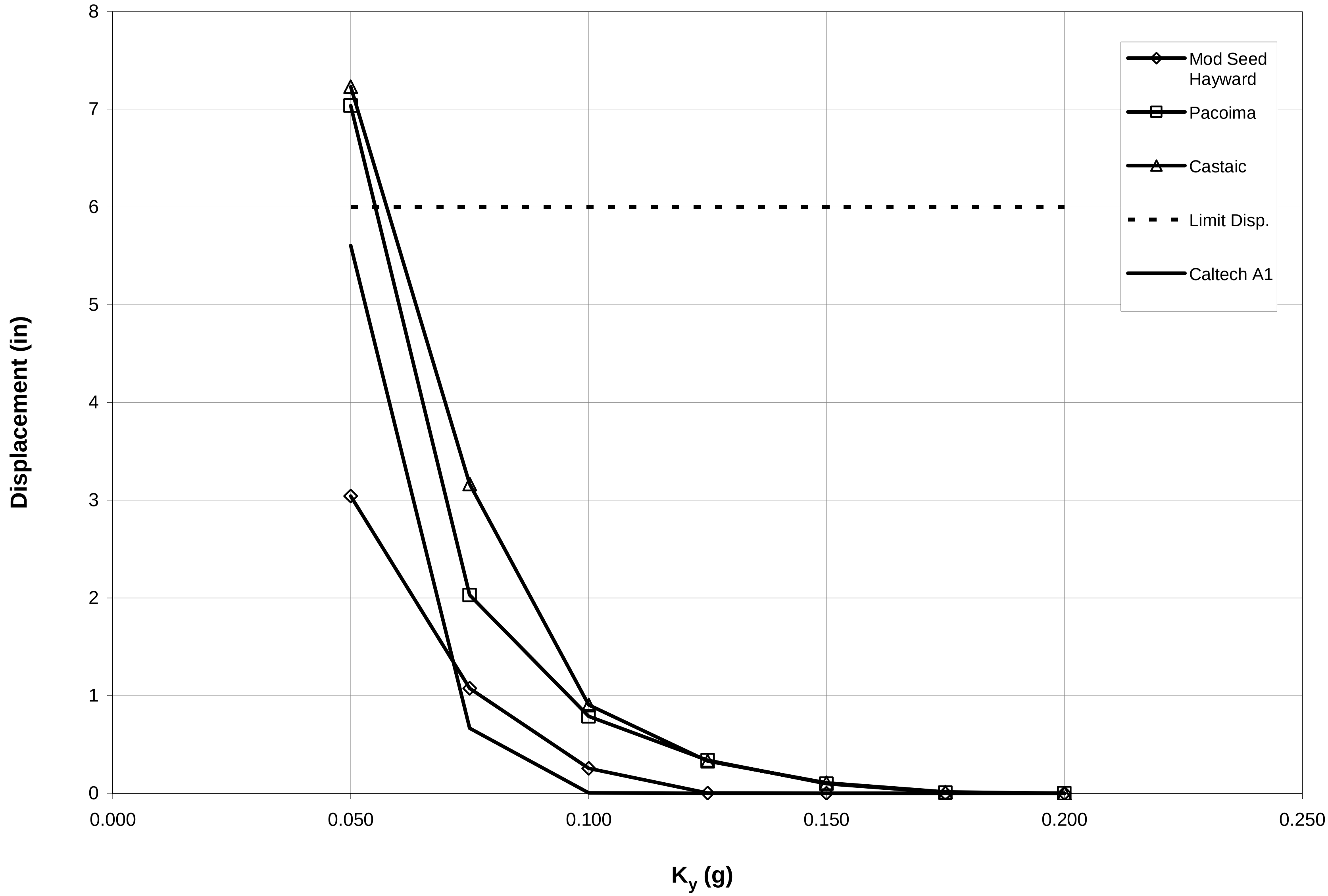
Project No. 08-0228	Landfill B-18 Expansion Project Kettleman City, Kings County, California	SECTION D – D' FINITE ELEMENT (QUAD4M) MESH	Figure 20c
HAI	HUSHMAND ASSOCIATES INC. Geotechnical, Earthquake and Environmental Engineers		



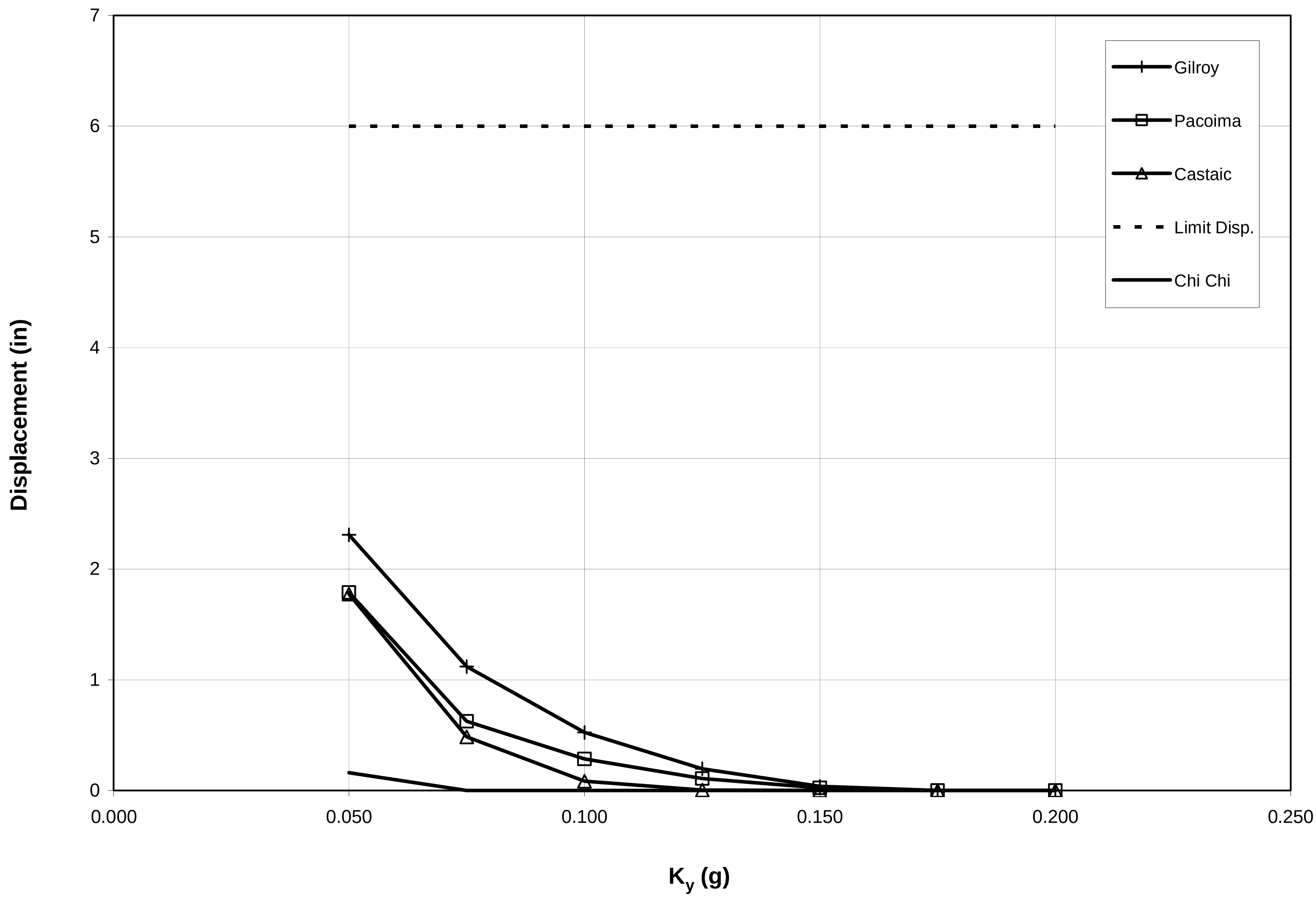
Project No. 08-0228	**Landfill B-18 Expansion Project** Kettleman City, Kings County, California	**EARTHQUAKE INDUCED DISPLACEMENTS SECTION D-D' – FAILURE PLANE 1 2-D QUAD4M DYNAMIC RESPONSE ANALYSIS (PREVIOUS GROUND MOTIONS)**	Figure 21
HAI ***HUSHMAND ASSOCIATES INC.*** *Geotechnical and Earthquake Engineers*			



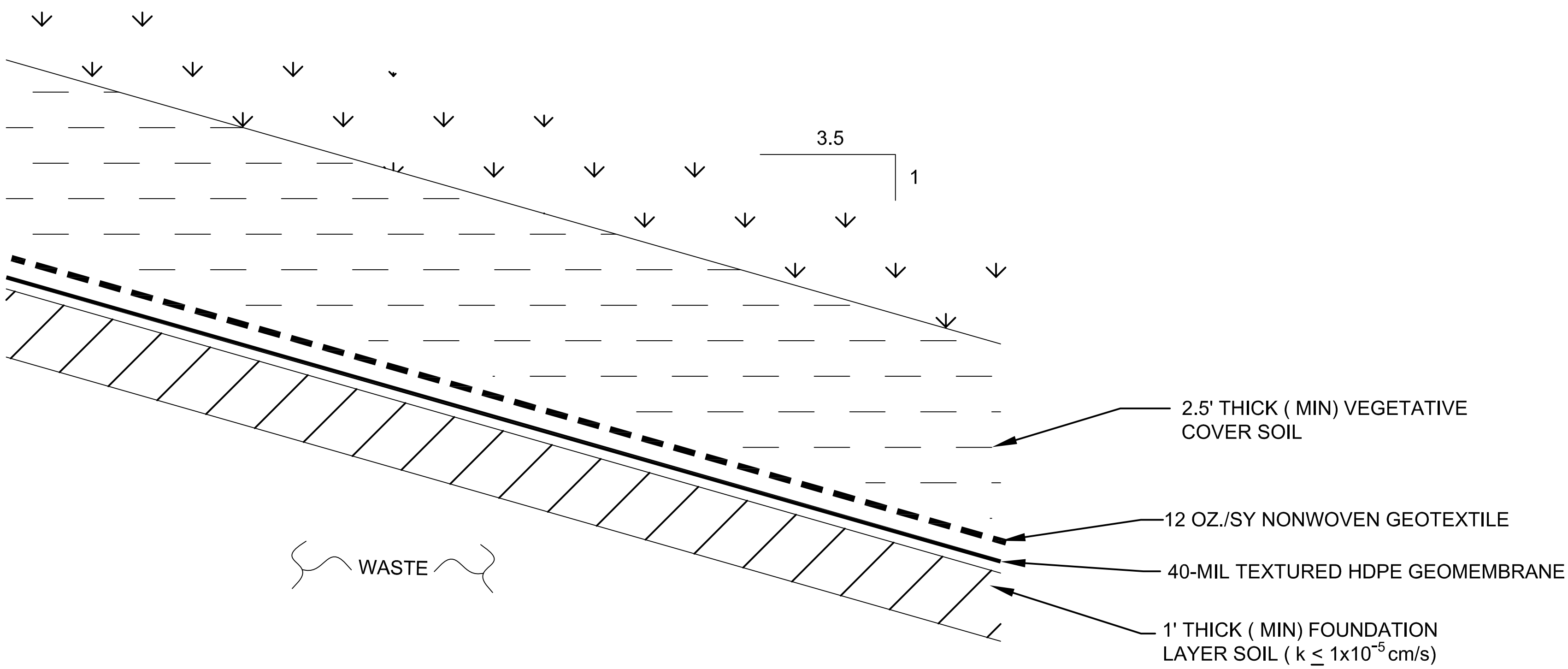
Project No. 08-0228	**Landfill B-18 Expansion Project** Kettleman City, Kings County, California	**EARTHQUAKE INDUCED DISPLACEMENTS SECTION D-D' – FAILURE PLANE 1 2-D QUAD4M DYNAMIC RESPONSE ANALYSIS (RECENT GROUND MOTIONS)**	Figure 22
HAI	***HUSHMAND ASSOCIATES INC.*** *Geotechnical and Earthquake Engineers*		



Project No. 08-0228	**Landfill B-18 Expansion Project** Kettleman City, Kings County, California	**EARTHQUAKE INDUCED DISPLACEMENTS SECTION F-F' – FAILURE PLANE 3 2-D QUAD4M DYNAMIC RESPONSE ANALYSIS (PREVIOUS GROUND MOTIONS)**	Figure 23
HAI	*HUSHMAND ASSOCIATES INC.* Geotechnical and Earthquake Engineers		

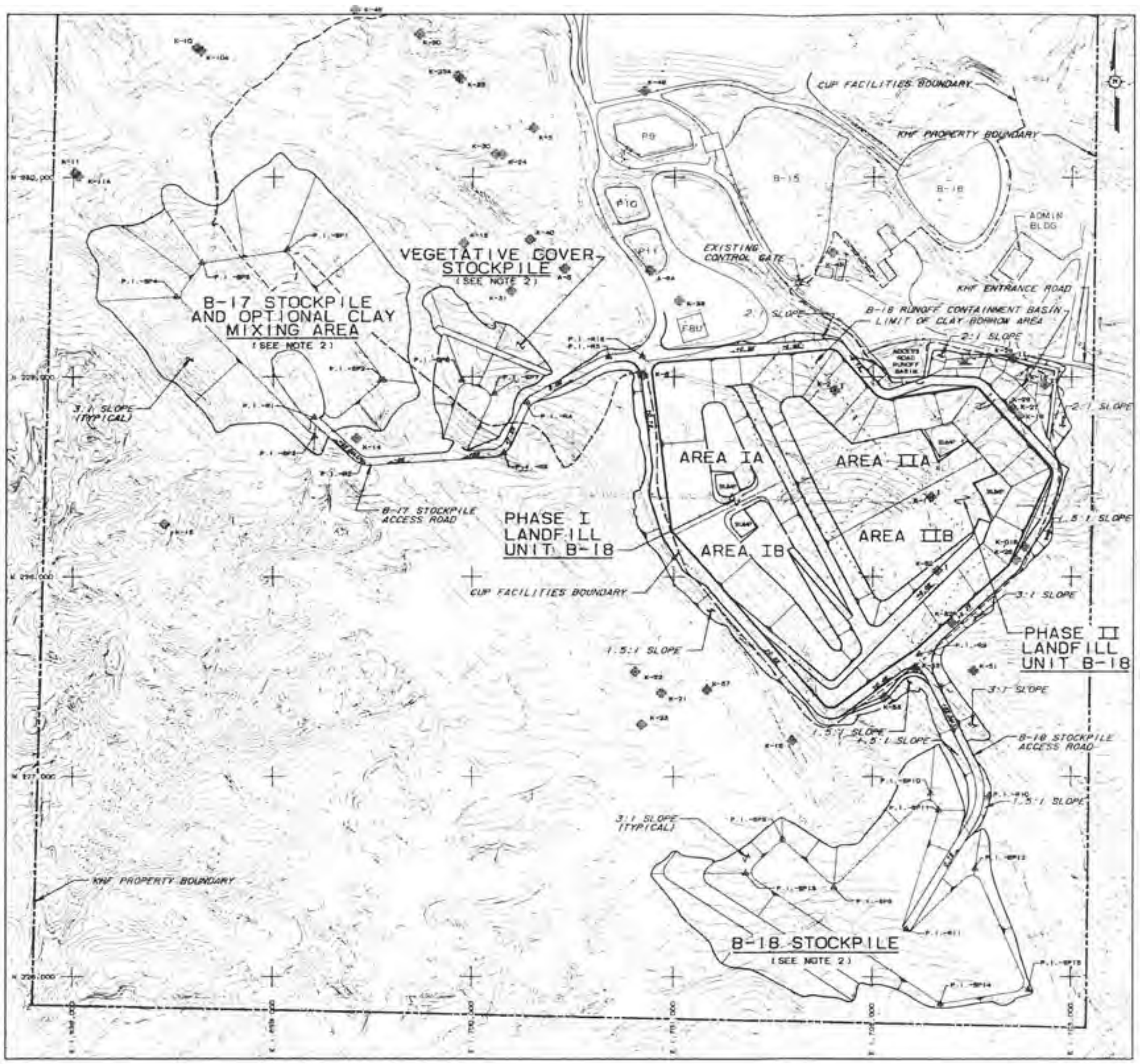


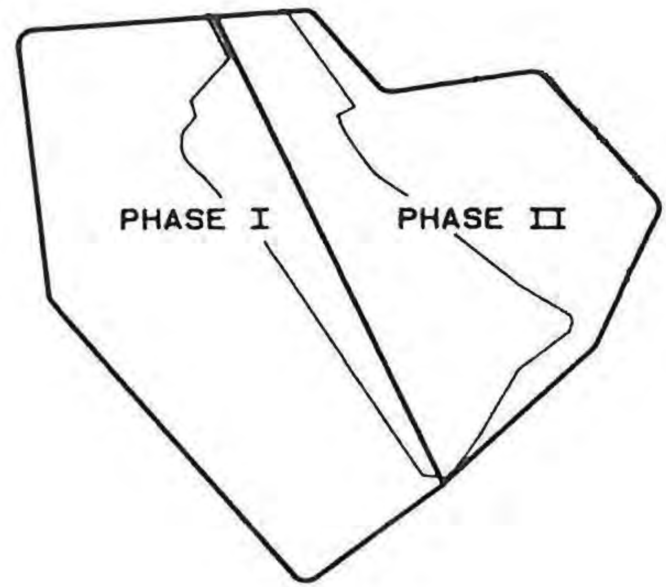
Project No. 08-0228	**Landfill B-18 Expansion Project** Kettleman City, Kings County, California	**EARTHQUAKE INDUCED DISPLACEMENTS SECTION F-F' – FAILURE PLANE 3 2-D QUAD4M DYNAMIC RESPONSE ANALYSIS (RECENT GROUND MOTIONS)**	Figure 24
HAI	***HUSHMAND ASSOCIATES INC.*** *Geotechnical and Earthquake Engineers*		



Project No. 08-0228	**Landfill B-18 Expansion Project** Kettleman, Kings County, California	**PROPOSED LANDFILL FINAL COVER**	Figure 25
HAI	***HUSHMAND ASSOCIATES, INC.*** *Geotechnical and Earthquake Engineers*		

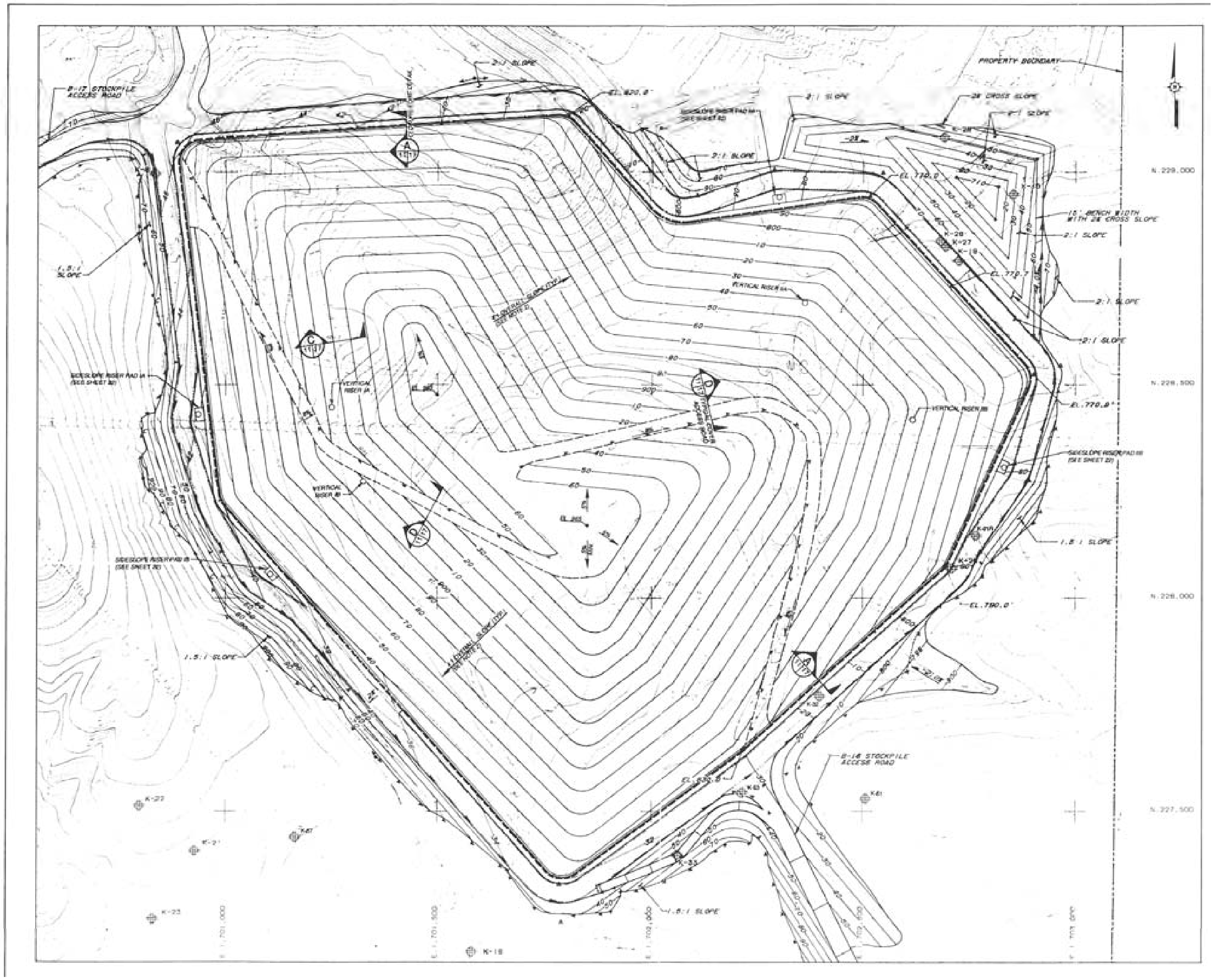
APPENDIX A





SOURCE: ENVIRONMENTAL SOLUTIONS, INC., 1990

Project No. 08-0228	**Landfill B-18 Expansion Project** Kettleman City, Kings County, California	**PROJECT PLAN** **(Landfill Unit B-18 Construction Plans)**	Figure A-1
HAI	***HUSHMAND ASSOCIATES INC.*** *Geotechnical and Earthquake Engineers*		



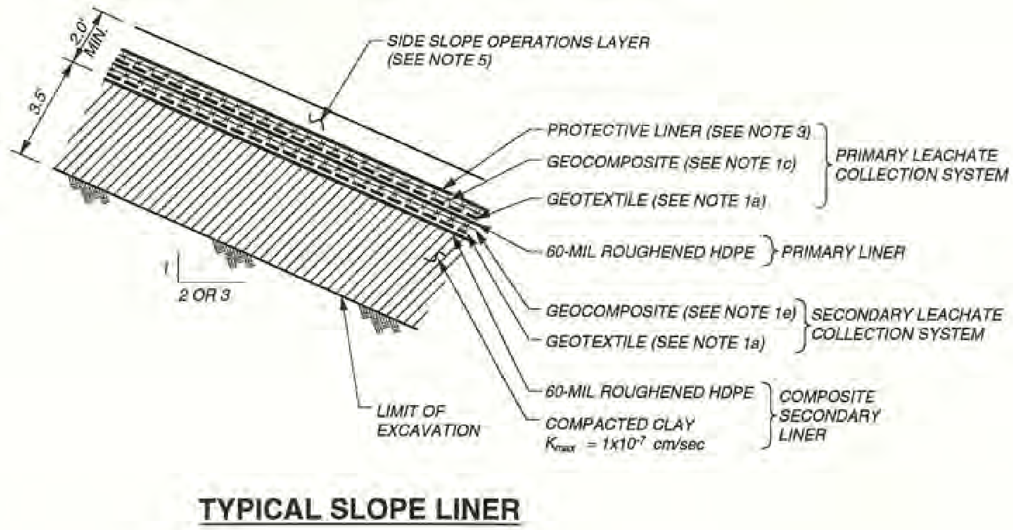
NOTES

1. SEE SHEET 1 FOR LEGEND AND GENERAL NOTES.

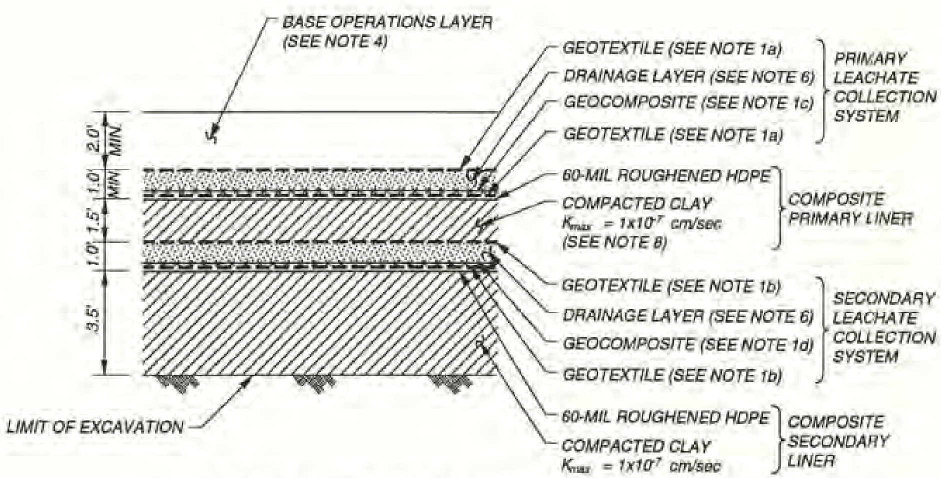
2. BENCHES WILL BE PROVIDED AT APPROXIMATELY 50-FOOT INTERVALS AS SHOWN ON SECTION B, SHEET 17. INTERMEDIATE BETWEEN BENCHES WILL HAVE A SLOPE OF APPROXIMATELY 3.6:1. THE BENCHES WILL SLOPE AT 3% TO CONTROL DRAINAGE.

SOURCE: ENVIRONMENTAL SOLUTIONS, INC., 1990

Project No. 08-0228	**Landfill B-18 Expansion Project** Kettleman City, Kings County, California	**PHASE I AND II FINAL CLOSURE PLAN (Landfill Unit B-18 Construction Plans)**	Figure A-2
HAI	***HUSHMAND ASSOCIATES INC.*** *Geotechnical and Earthquake Engineers*		



TYPICAL SLOPE LINER



TYPICAL BASE LINER

NOTES

1a. GEOTEXTILE SHALL BE TREVIRA 1125 OR EQUAL.
1b. GEOTEXTILE SHALL BE TREVIRA 1155 OR EQUAL.
1c. GEOCOMPOSITE SHALL BE TREVIRA 1125 HEAT BONDED TO POLYNET 3000.
1d. GEOCOMPOSITE SHALL BE TREVIRA 1125 OR 1155 HEAT BONDED TO POLYNET 3000.
1e. GEOCOMPOSITE SHALL BE TREVIRA 1125 OR 1155 HEAT BONDED TO POLYNET 3000 AT THE OPTION OF THE OWNER.
(1c–1e: SEE NOTE 1f AND 2)
1f. GEOTEXTILE SHALL ALWAYS BE FACING UP.

2. GEONET SHALL BE POLYNET 3000 OR EQUAL.

3. PROTECTIVE LINER SHALL BE REMOVED BY OPERATIONS STAFF PRIOR TO PLACEMENT OF OPERATIONS LAYER.

4. BASE OPERATIONS LAYER SHALL CONSIST OF SOILS EXCAVATED FROM ONSITE SOURCES. SOIL PARTICLE SIZE SHALL HAVE MAXIMUM DIAMETER OF 6 INCHES.

5. SIDE SLOPE OPERATIONS LAYER SHALL CONSIST OF SOILS EXCAVATED FROM ONSITE SOURCES. SOIL PARTICLE SIZE SHALL HAVE MAXIMUM DIAMETER OF 1 INCH.

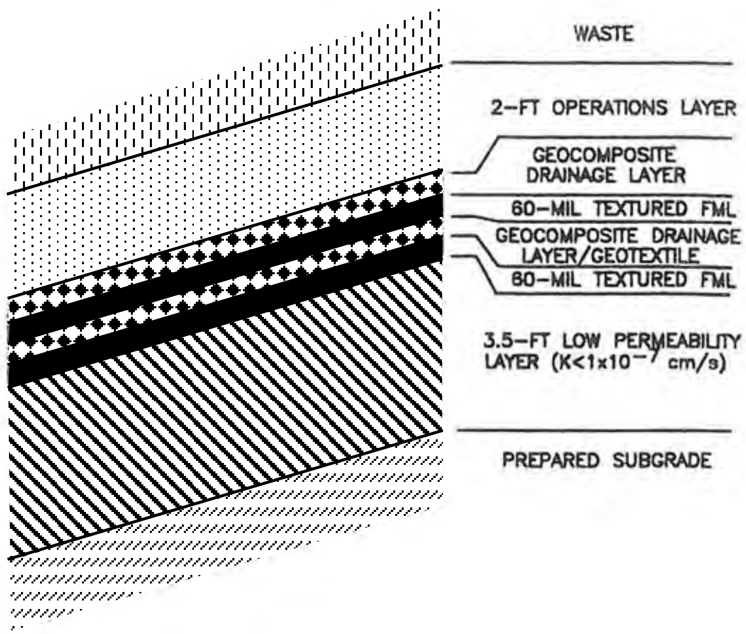
6. DRAINAGE LAYER MATERIAL SHALL CONSIST OF A SUB-ANGULAR TO ROUNDED WASHED GRAVEL MEETING THE GRADATION REQUIREMENTS SPECIFIED IN SECTION 02924 OF THE SPECIFICATIONS.

7. LINER SYSTEM SCALES ARE EXAGGERATED FOR CLARITY.

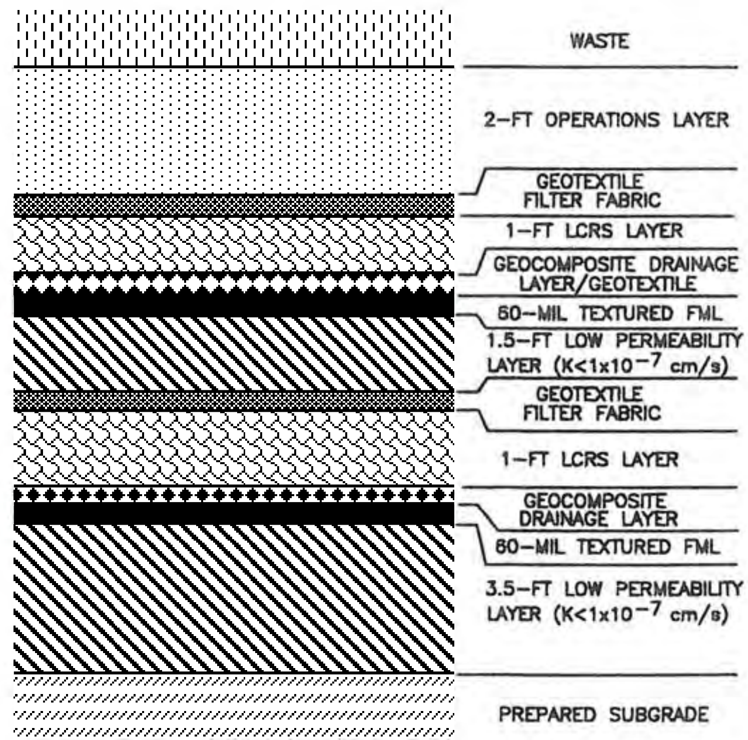
8. THE BOTTOM 12" OF PRIMARY CLAY LINER SHALL BE CONSTRUCTED IN ONE LIFT TO PROTECT UNDERLYING GEOSYNTHETIC LINER SYSTEM. THE UPPER 12" WILL HAVE A PERMEABILITY OF K_{max}= 10^{-7} cm/sec.

SOURCE: ENVIRONMENTAL SOLUTIONS, INC., 1990

Project No. 08-0228	**Landfill B-18 Expansion Project** Kettleman City, Kings County, California	**DETAILS OF THE LANDFILL BASE GEOCOMPOSITE LINER SYSTEM** **EXISTING PHASE 1 LINER**	Figure A-3
HAI	HUSHMAND ASSOCIATES INC. Geotechnical and Earthquake Engineers		



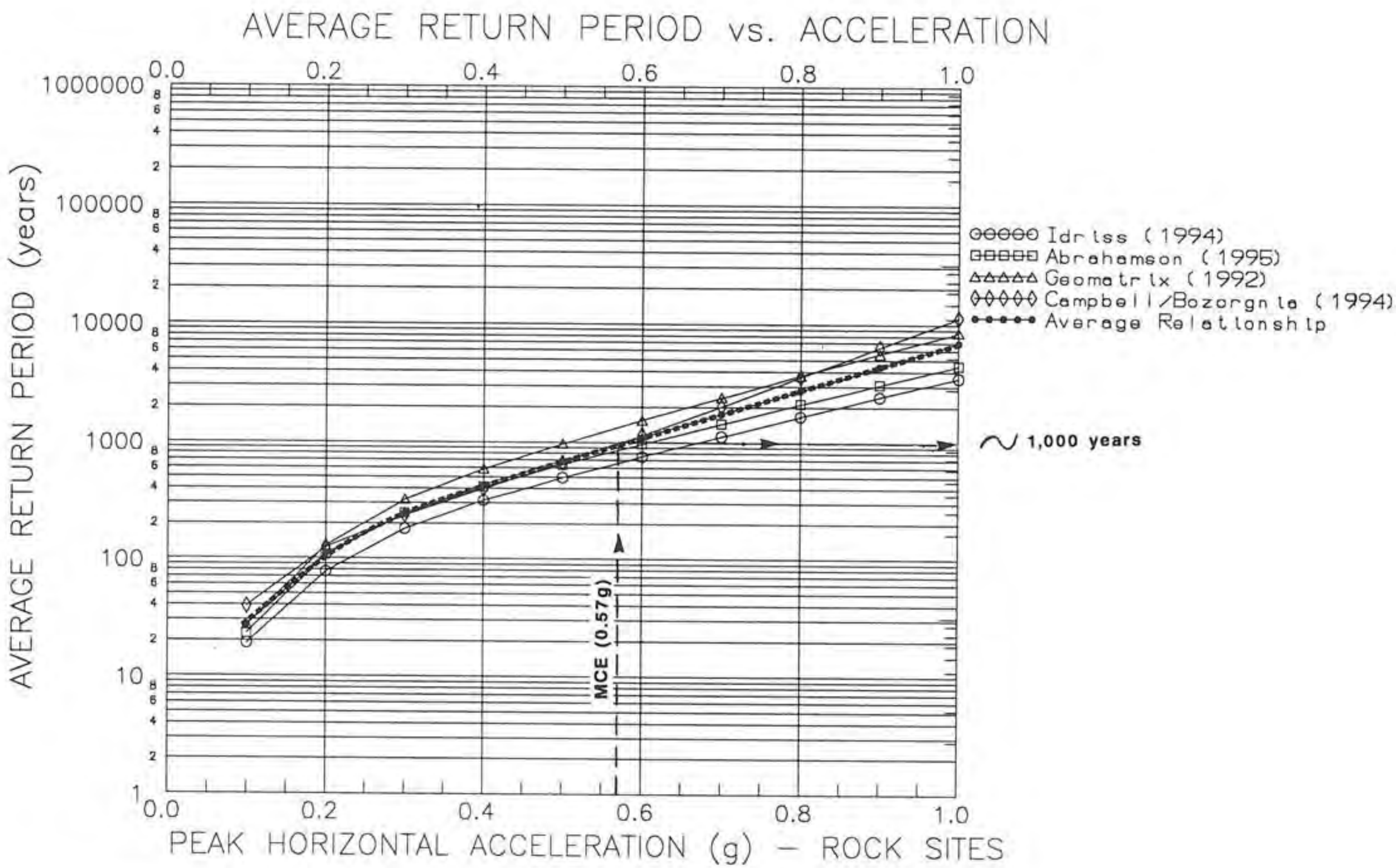
SLOPE LINER
SCALE: NTS



BOTTOM LINER
SCALE: NTS

SOURCE: URS, 2005

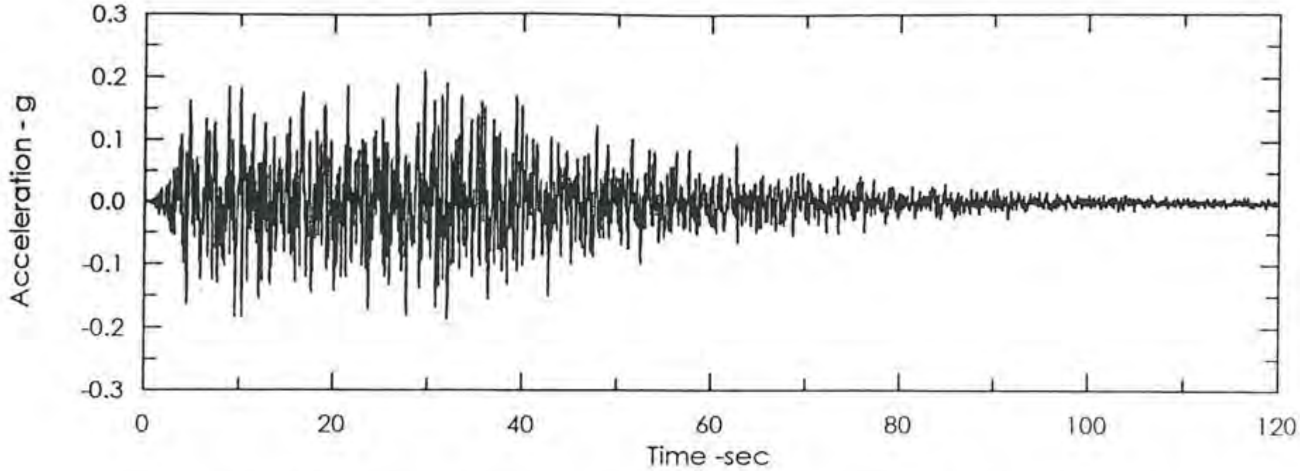
Project No. 08-0228	**Landfill B-18 Expansion Project** Kettleman City, Kings County, California	**PROPOSED LINER SYSTEM**	Figure A-4
HAI	*HUSHMAND ASSOCIATES INC.* *Geotechnical and Earthquake Engineers*		



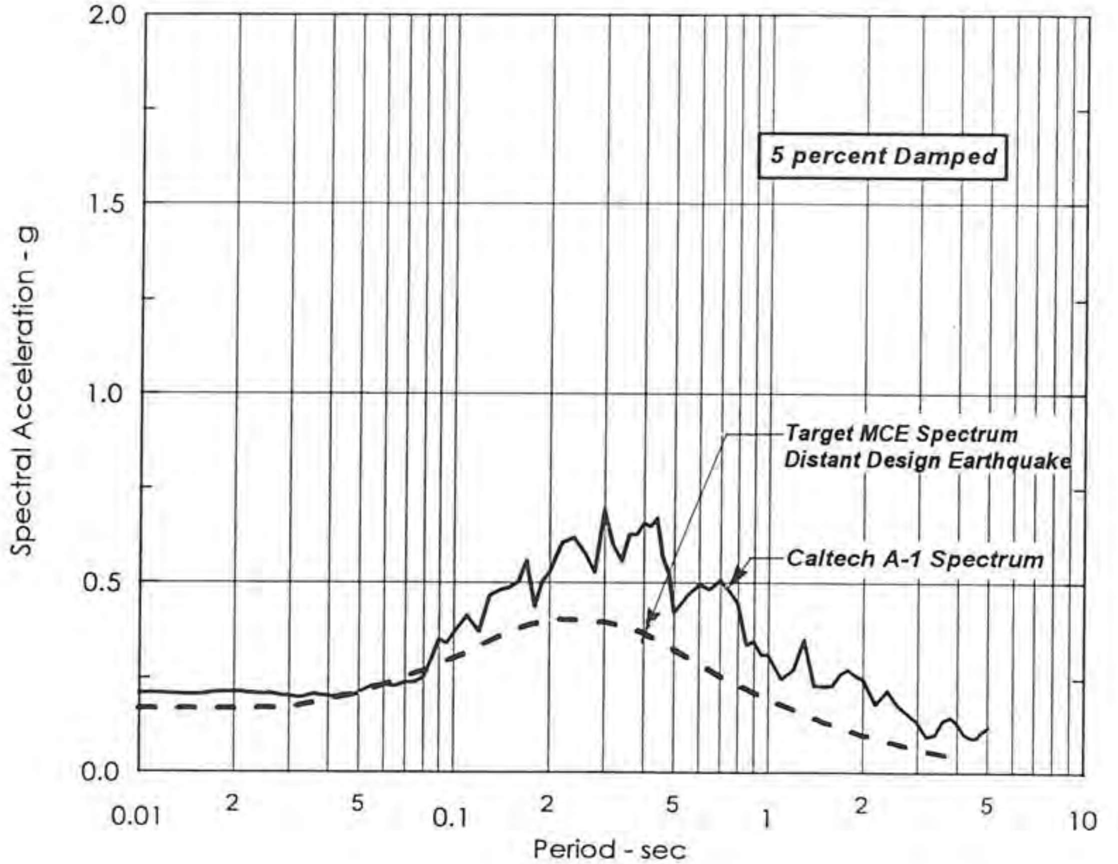
Seismic Hazard Evaluation, Landfill Unit B-19, Kettleman Hills Facility
Attenuation relations for blind thrust faults and rock sites.

SOURCE: RUST, 1998

Project No. 08-0228	**Landfill B-18 Expansion Project** Kettleman City, Kings County, California	**PEAK HORIZONTAL ACCELERATION IN ROCK VERSUS AVERAGE RETURN PERIOD**	Figure A-5
HAI	***HUSHMAND ASSOCIATES INC.*** *Geotechnical and Earthquake Engineers*		



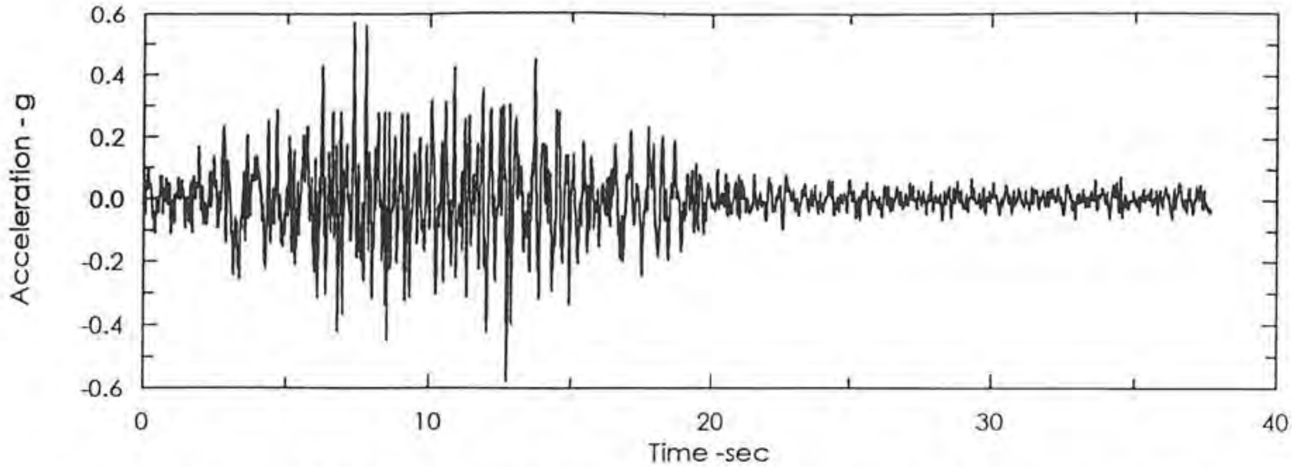
(a) Caltech A-1 Synthetic Record Scaled to 0.21g Peak Acceleration



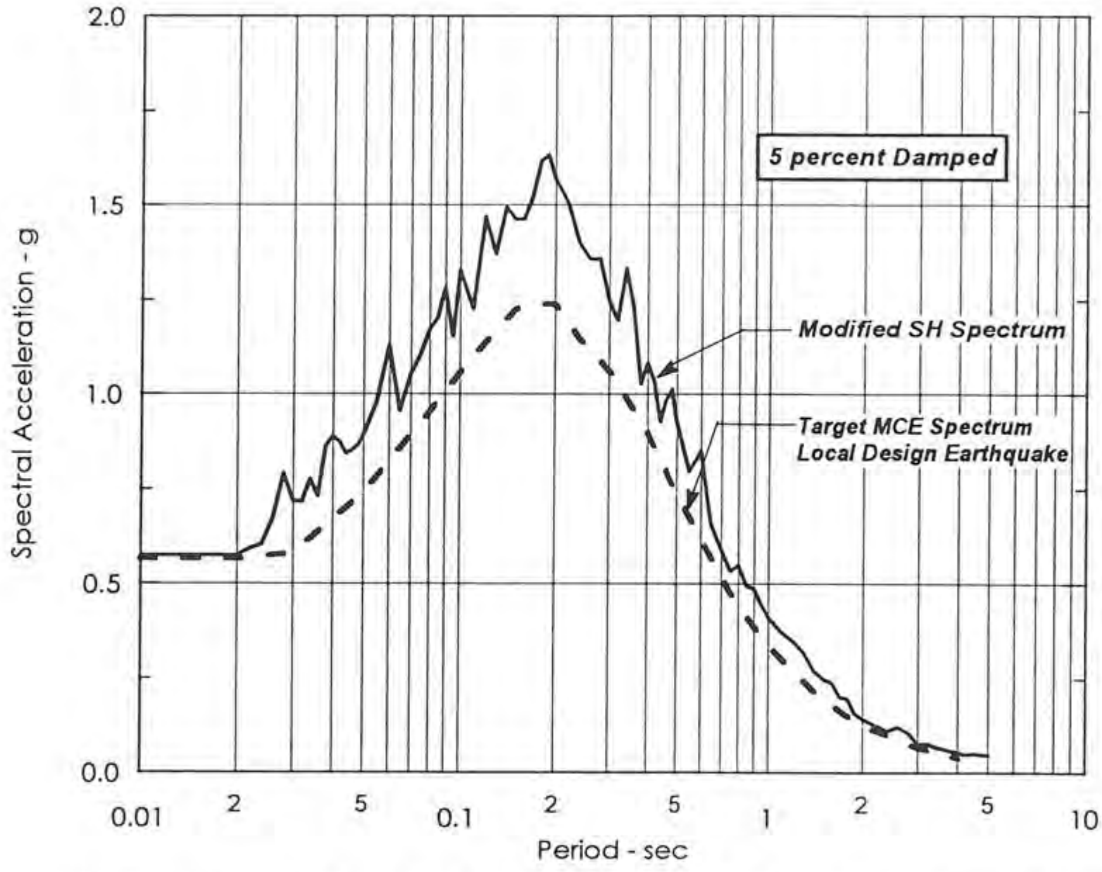
(b) Comparison of Pseudo-Acceleration Response Spectrum of Caltech A-1 Synthetic Earthquake Record and Target Design Spectrum (Peak Acceleration Scaled to 0.21g)

SOURCE: RUST, 1998

Project No. 08-0228	**Landfill B-18 Expansion Project** Kettleman City, Kings County, California	**CALTECH A-1 SYNTHETIC ACCELERATION RECORD AND DYNAMIC RESPONSE SPECTRUM** **DISTANT DESIGN EARTHQUAKE**	Figure A-6
HAI	***HUSHMAND ASSOCIATES INC.*** *Geotechnical and Earthquake Engineers*		



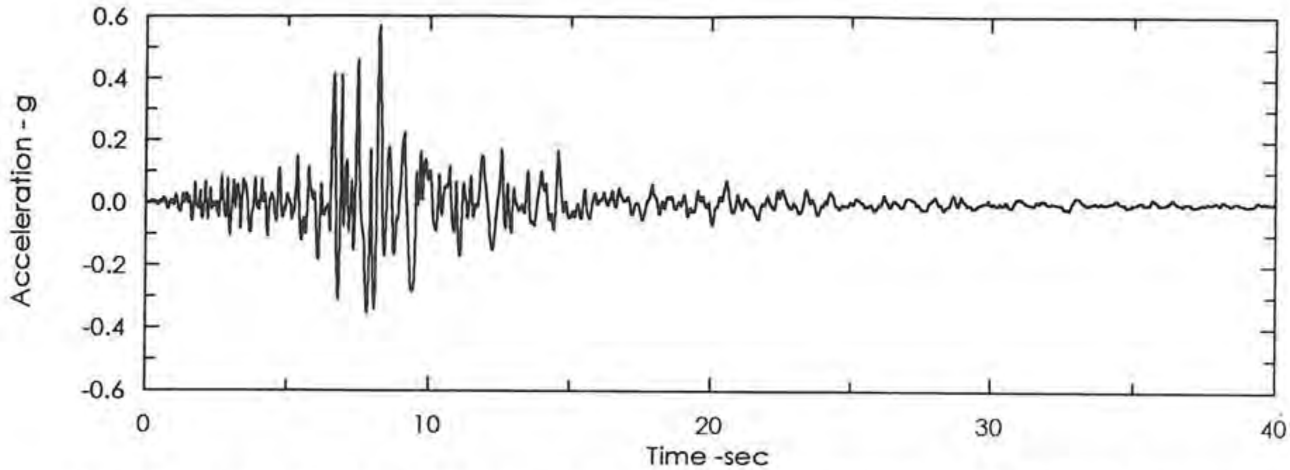
(a) Modified Seed-Hayward Synthetic Record Scaled to 0.57g Peak Acceleration



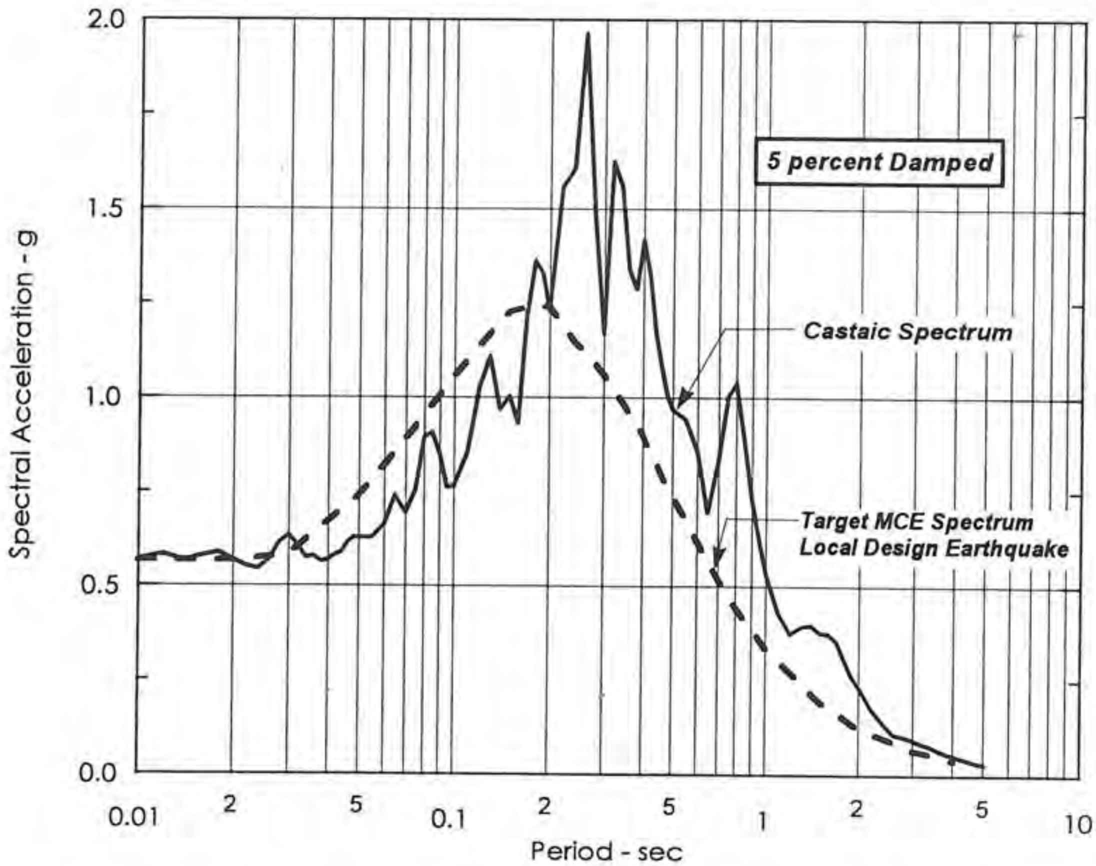
(b) Comparison of Pseudo-Acceleration Response Spectrum of the Modified Seed-Hayward Synthetic Earthquake Accelerogram and Target Design Spectrum (Peak Acceleration of Synthetic Record Scaled to 0.57g)

SOURCE: RUST, 1998

Project No. 08-0228	**Landfill B-18 Expansion Project** Kettleman City, Kings County, California	MODIFIED SEED-HAYWARD SYNTHETIC ACCELERATION RECORD AND DYNAMIC RESPONSE SPECTRUM SCALED TO TARGET MCE RESPONSE SPECTRUM	Figure
HAI	***HUSHMAND ASSOCIATES INC.*** *Geotechnical and Earthquake Engineers*	**LOCAL DESIGN EARTHQUAKE**	A-7



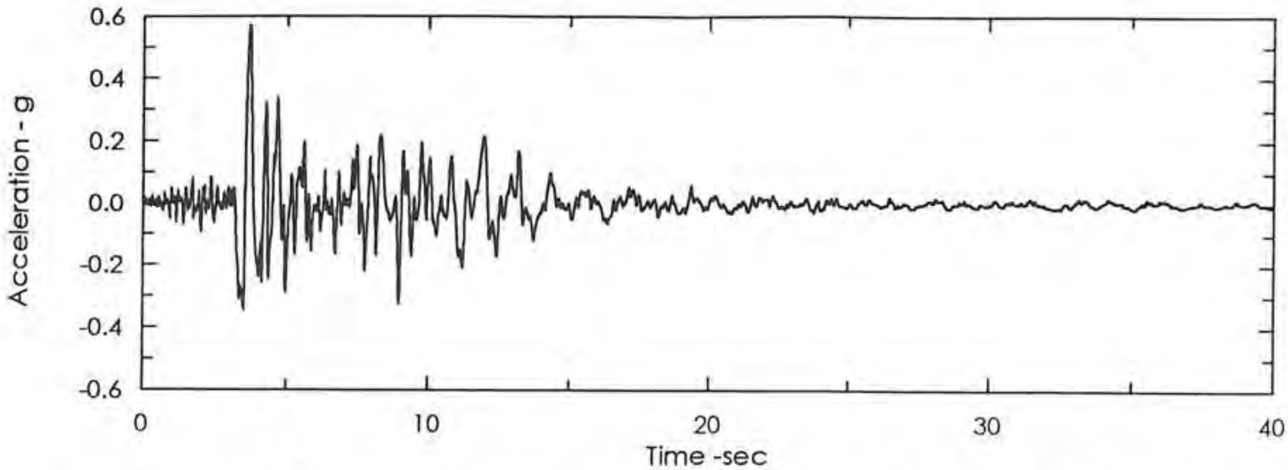
(a) Northridge Castaic Old Ridge Route CH 1 Record Scaled to 0.57g Peak Acceleration



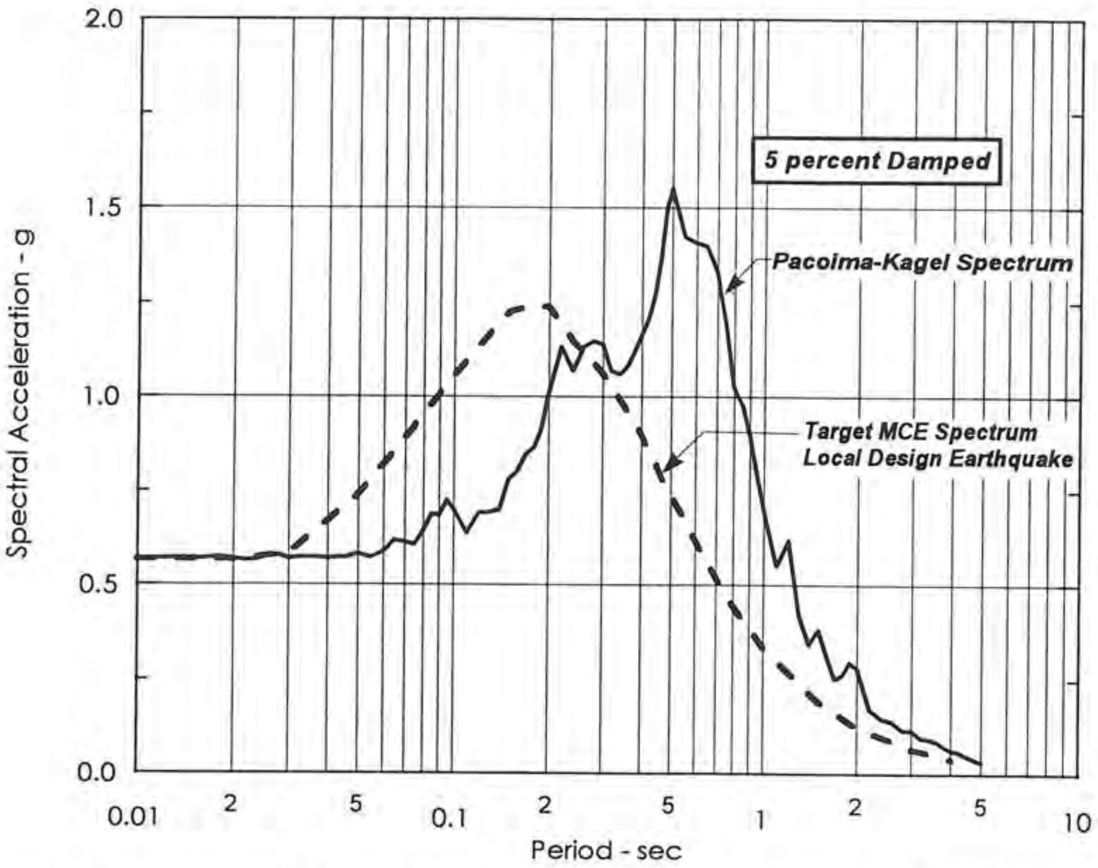
(b) Comparison of Pseudo-Acceleration Response Spectrum of M6.7 January 17, 1994 Northridge Earthquake Castaic - Old Ridge Route, CHN 1:90 DEG Record and Target Design Spectrum (Peak Acceleration Scaled to 0.57g)

SOURCE: RUST, 1998

Project No. 08-0228	**Landfill B-18 Expansion Project** Kettleman City, Kings County, California	**CASTAIC ACCELERATION RECORD AND DYNAMIC RESPONSE SPECTRUM**	Figure
HAI	***HUSHMAND ASSOCIATES INC.*** *Geotechnical and Earthquake Engineers*	**LOCAL DESIGN EARTHQUAKE**	A-8



(a) Northridge Pacoima - Kagel Canyon CH 3 Record Scaled to 0.57g Peak Acceleration



(b) Comparison of Pseudo-Acceleration Response Spectrum of M6.7 January 17, 1994 Northridge Earthquake Pacoima - Kagel Canyon, CHN 3:360 DEG Record and Target Design Spectrum (Peak Acceleration Scaled to 0.57g)

SOURCE: RUST, 1998

Project No. 08-0228	**Landfill B-18 Expansion Project** Kettleman City, Kings County, California	**PACOIMA-KAGEL CANYON ACCELERATION RECORD AND DYNAMIC RESPONSE SPECTRUM** **LOCAL DESIGN EARTHQUAKE**	Figure A-9
HAI	***HUSHMAND ASSOCIATES INC.*** *Geotechnical and Earthquake Engineers*		

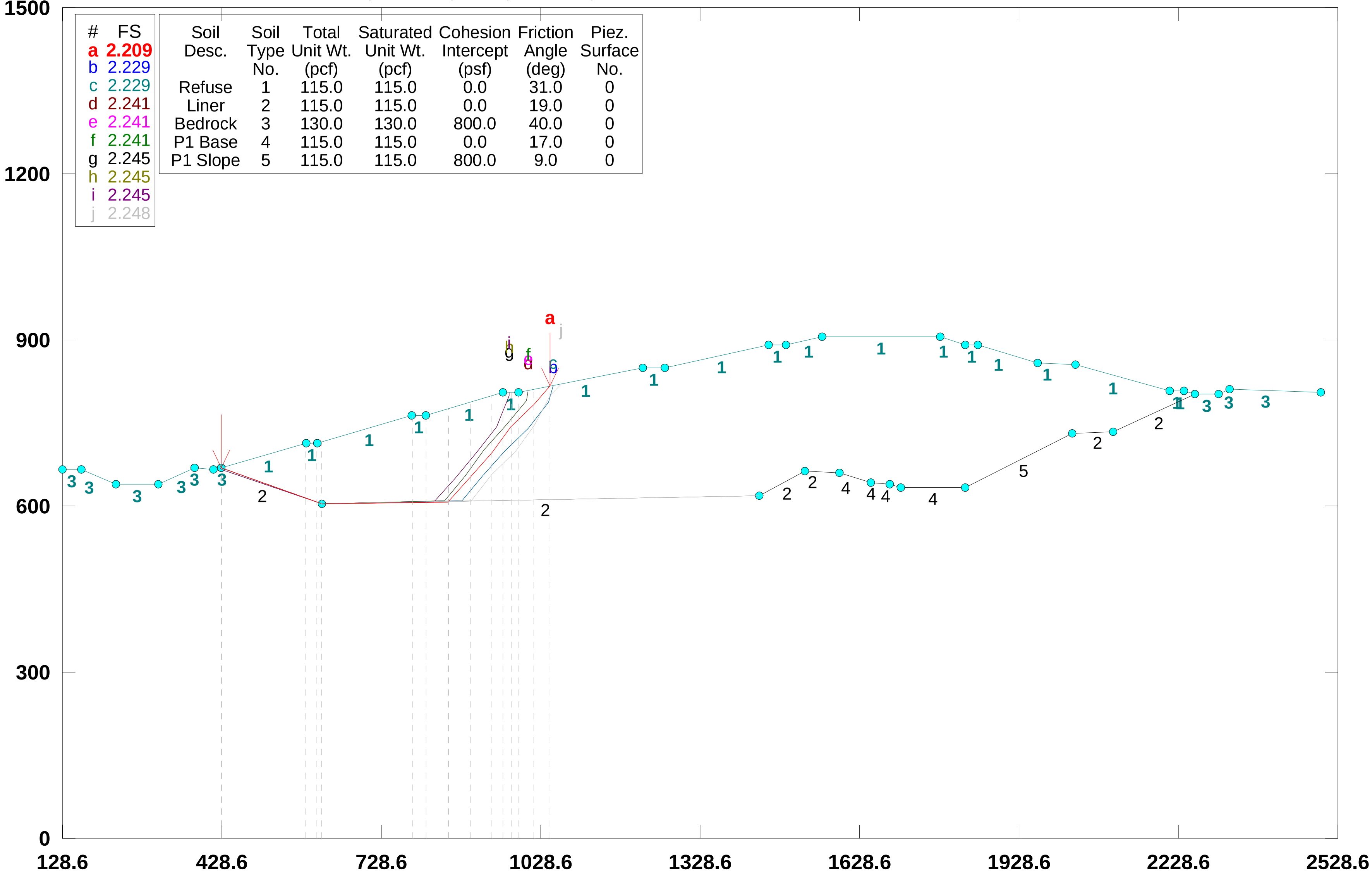
APPENDIX B

KHF, SECTION A-A', EAST, STATIC, FAILURE PLANE 1

c:\slope\seca-esj1 new.pl2   Run By: Jason Lee, Hushmand Associates, Inc   7/24/2008   05:46PM

#	FS
a	2.209
b	2.229
c	2.229
d	2.241
e	2.241
f	2.241
g	2.245
h	2.245
i	2.245
j	2.248

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0

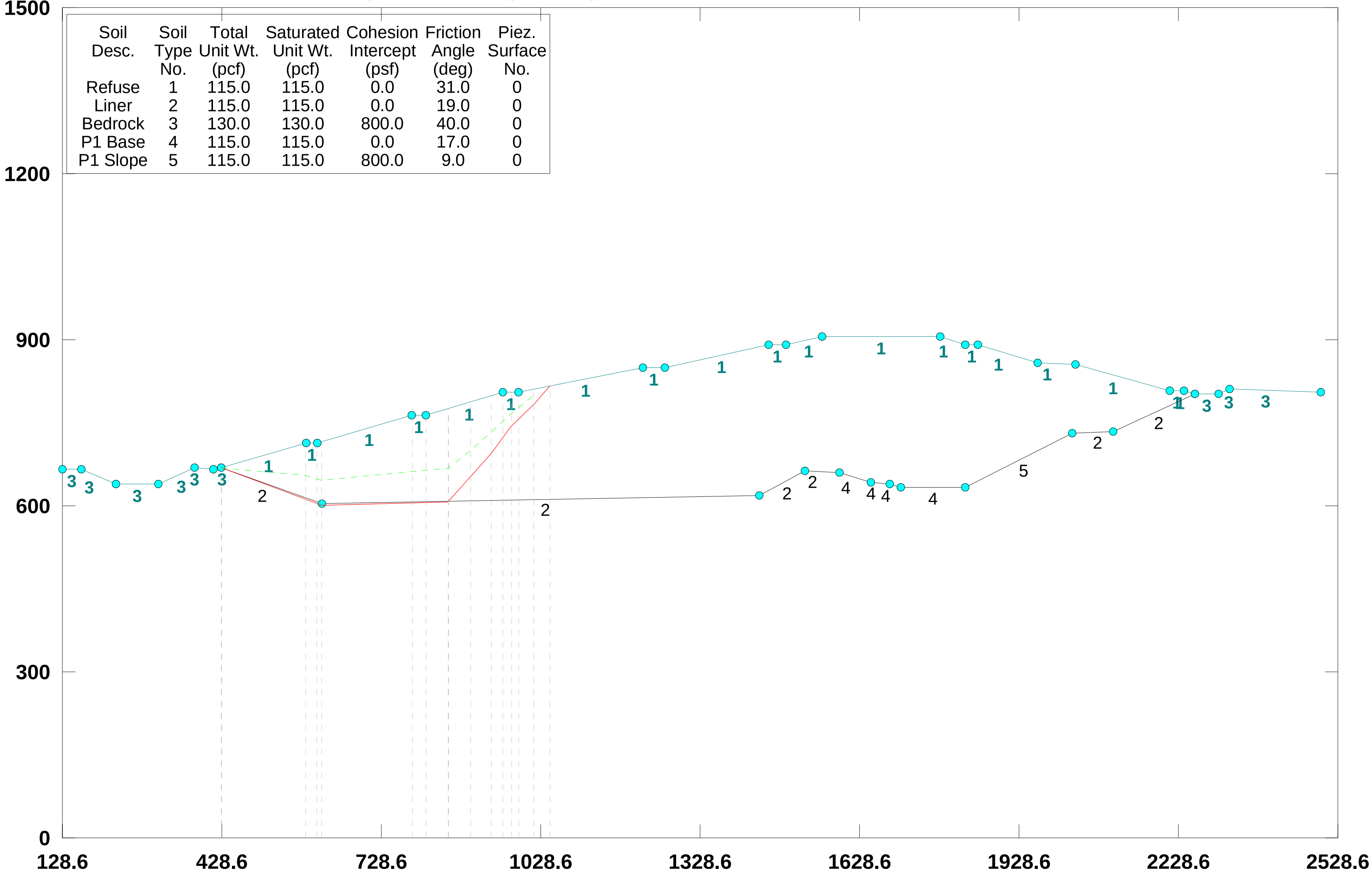


GSTABL7 v.2 FSmin=2.209
Safety Factors Are Calculated By The Simplified Janbu Method

GSTABL7

KHF, SECTION A-A', EAST, STATIC, FAILURE PLANE 1

c:\slope\seca-ess1 new.plt   Run By: Jason Lee, Hushmand Associates, Inc   7/24/2008   05:50PM



Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0

GSTABL7 v.2 FSmin=2.589

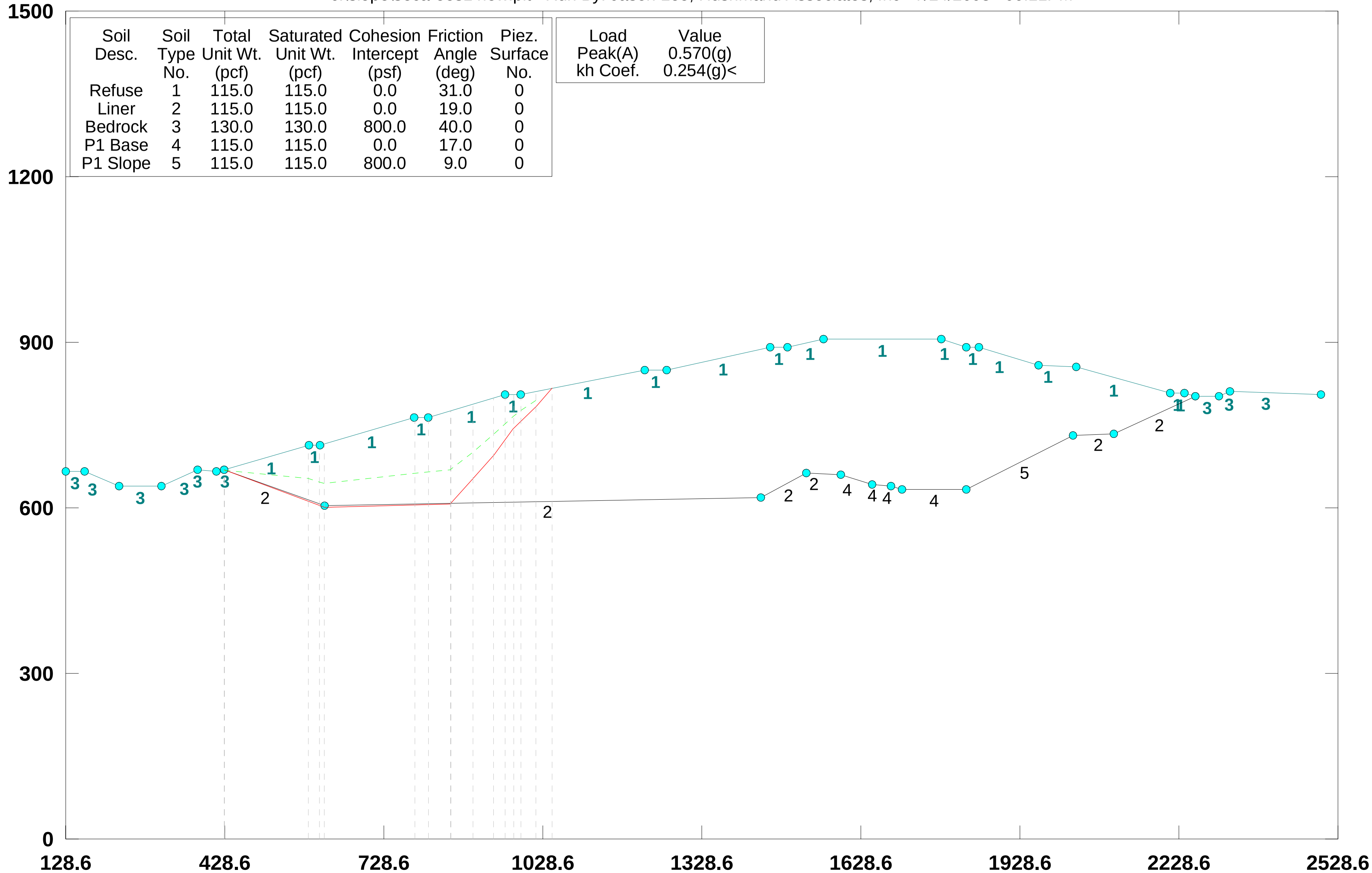
Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

KHF, SECTION A-A', EAST, STATIC, FAILURE PLANE 1

c:\slope\seca-ees1 new.plt   Run By: Jason Lee, Hushmand Associates, Inc   7/24/2008   06:11PM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0

Load	Value
Peak(A)	0.570(g)
kh Coef.	0.254(g)<



GSTABL7 v.2 FSmin=1.021
Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

KHF, SECTION A-A', EAST, STATIC, FAILURE PLANE 2

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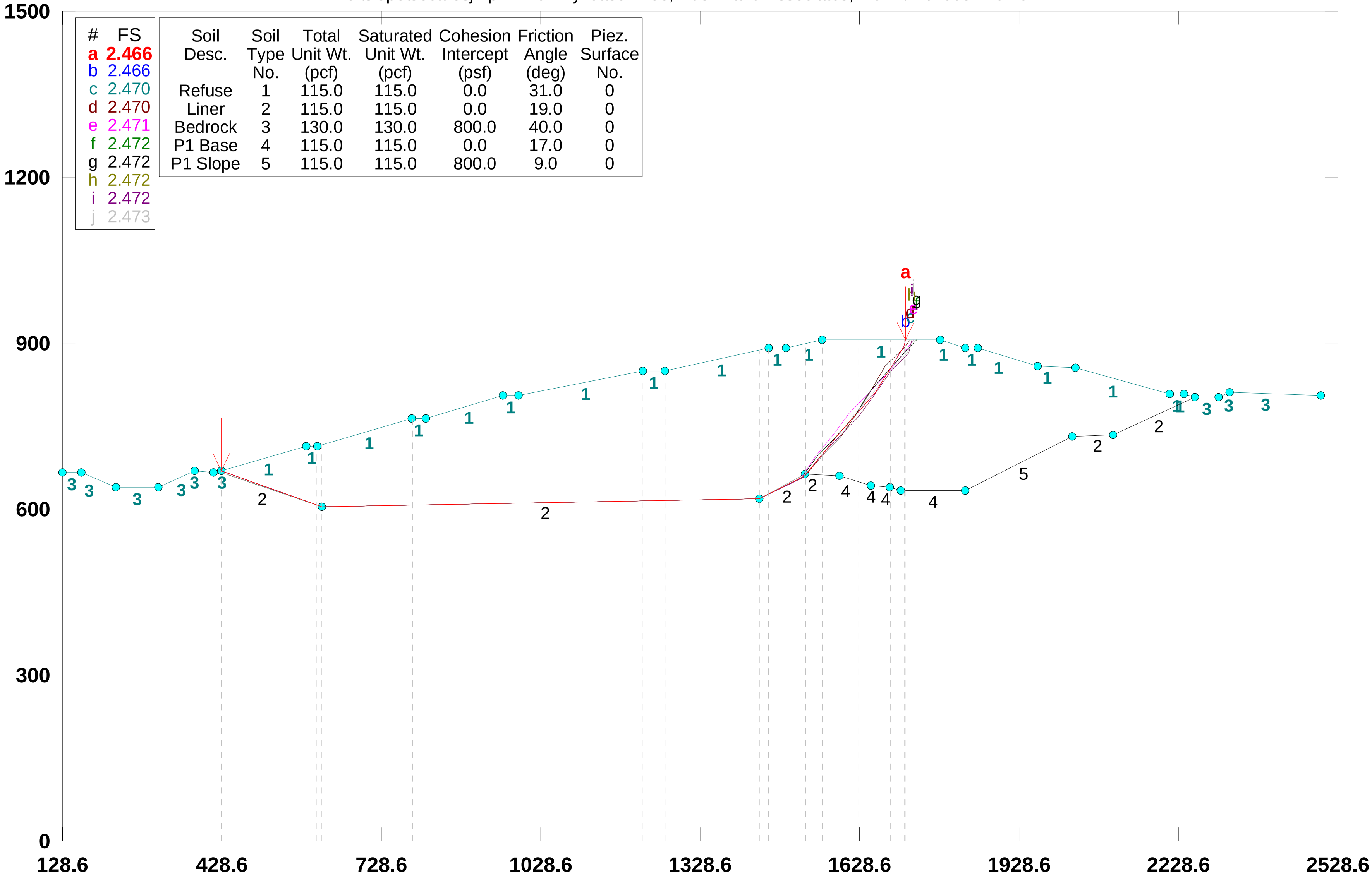

#	FS
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b	2.466
c	2.470
d	2.470
e	2.471
f	2.472
g	2.472
h	2.472
i	2.472
j	2.473

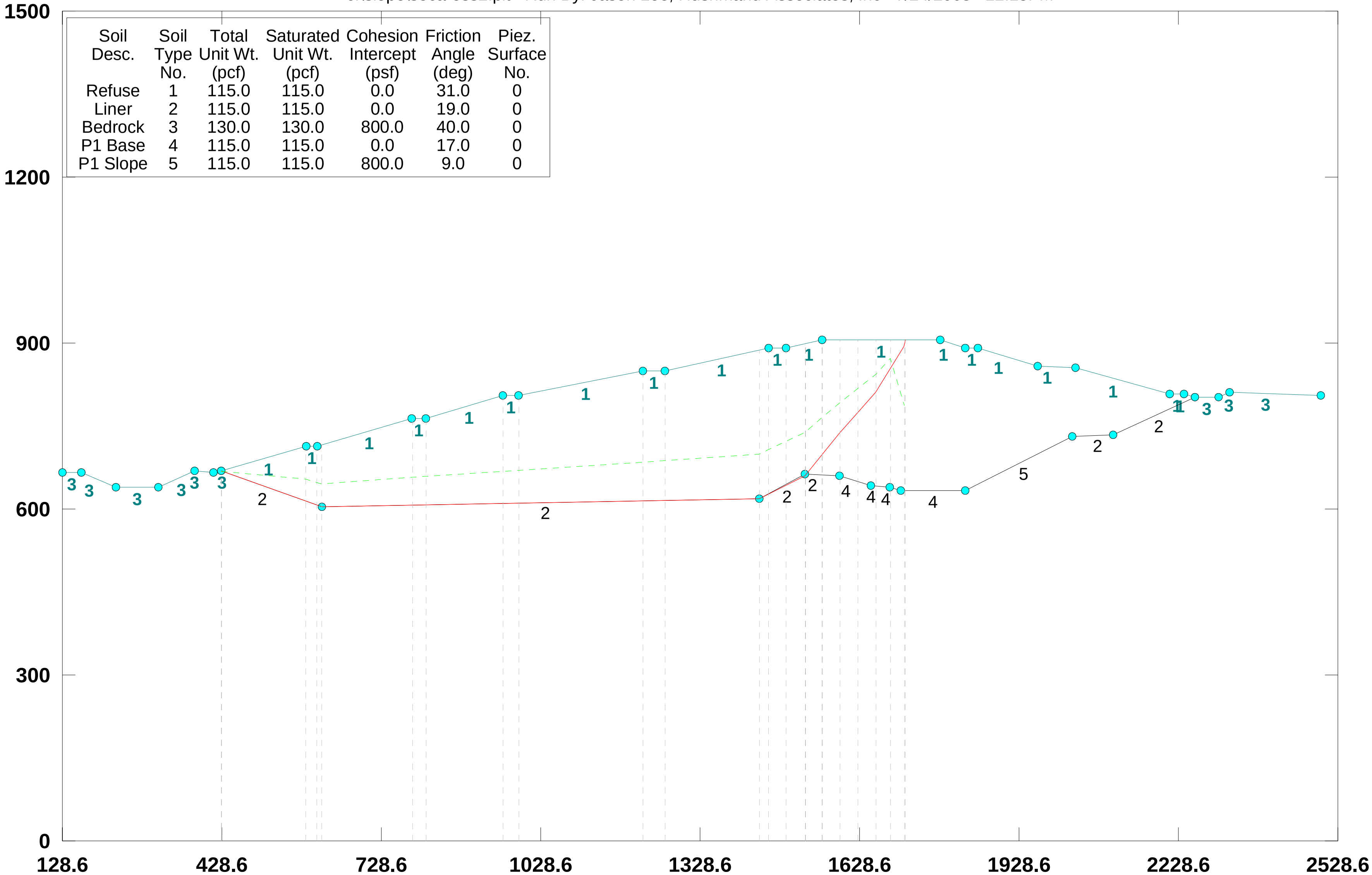
Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0

GSTABL7 v.2 FSmin=2.466

Safety Factors Are Calculated By The Simplified Janbu Method

KHF, SECTION A-A', EAST, STATIC, FAILURE PLANE 2

c:\slope\seca-ess2.plt Run By: Jason Lee, Hushmand Associates, Inc 7/24/2008 12:13PM



Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0

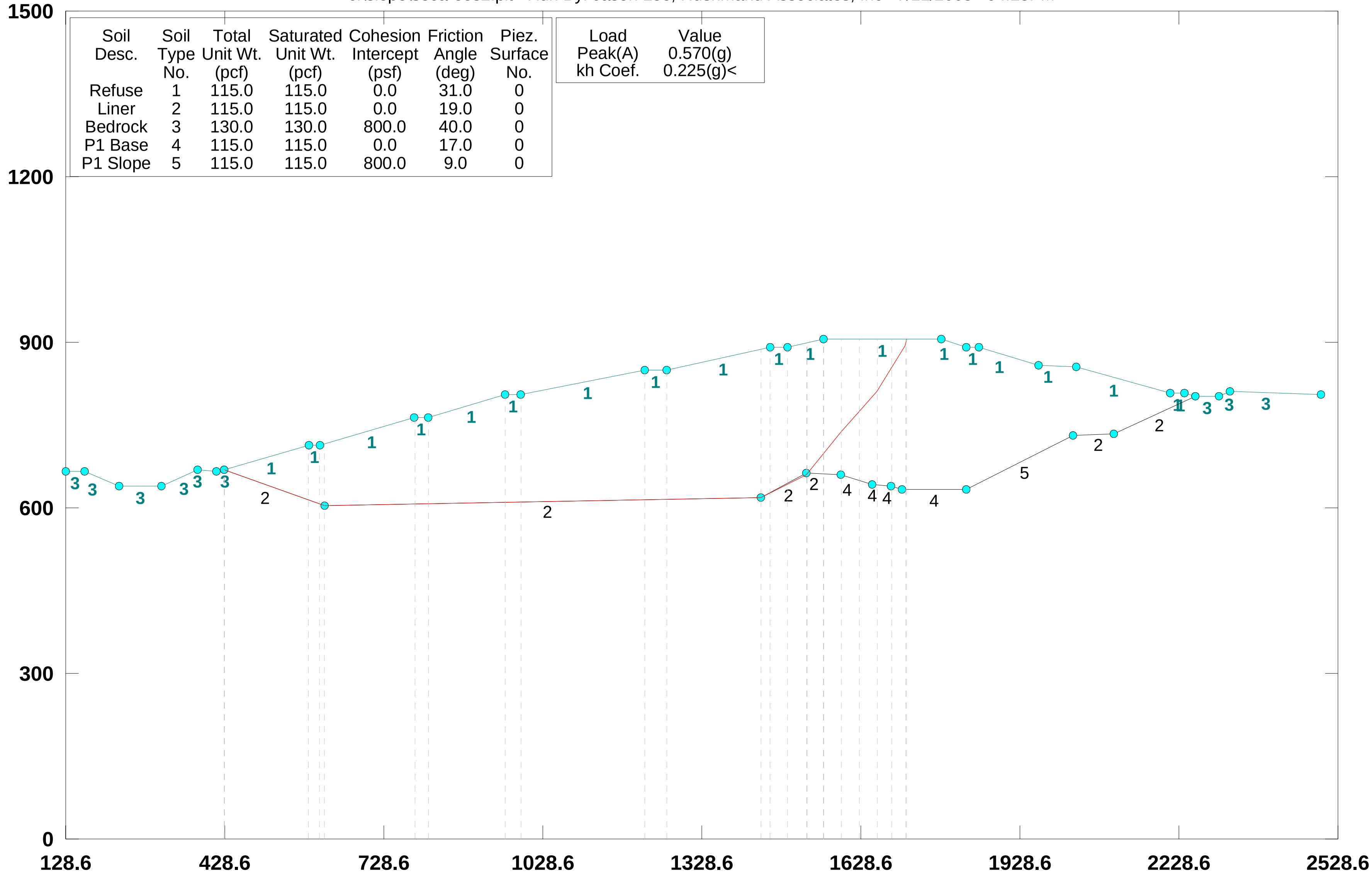
GSTABL7 v.2 FSmin=2.689

Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

GSTABL7

KHF, SECTION A-A', EAST, PSEUD-STATIC, FAILURE PLANE 2

c:\slope\seca-ees2.plt   Run By: Jason Lee, Hushmand Associates, Inc   7/11/2008   04:28PM



Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0

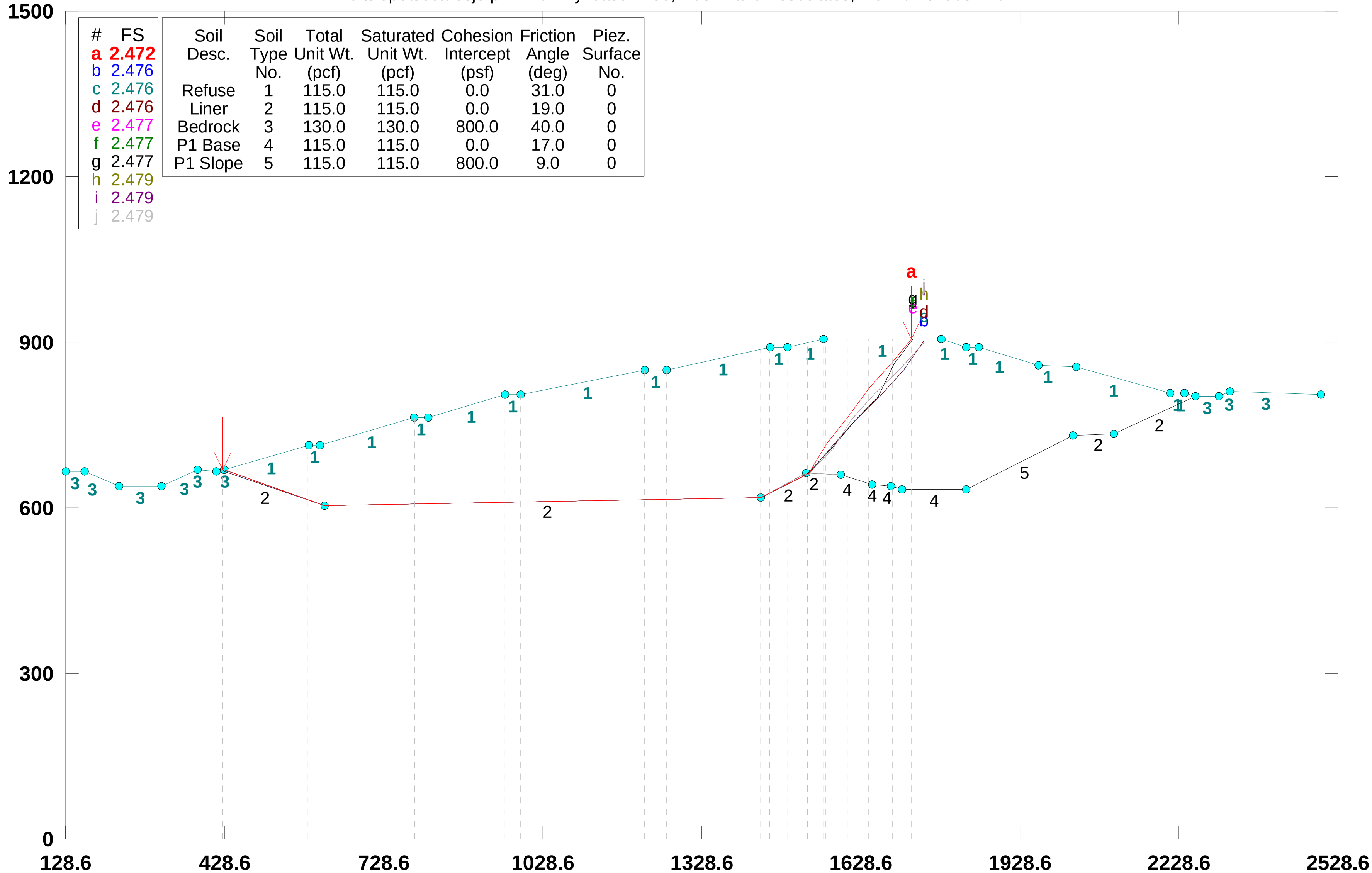
Load	Value
Peak(A)	0.570(g)
kh Coef.	0.225(g)<

GSTABL7 v.2 FSmin=1.008

Factor Of Safety Is Calculated By The Simplified Janbu Method

KHF, SECTION A-A', EAST, STATIC, FAILURE PLANE 3

c:\slope\seca-esj3.pl2   Run By: Jason Lee, Hushmand Associates, Inc   7/11/2008   10:42AM



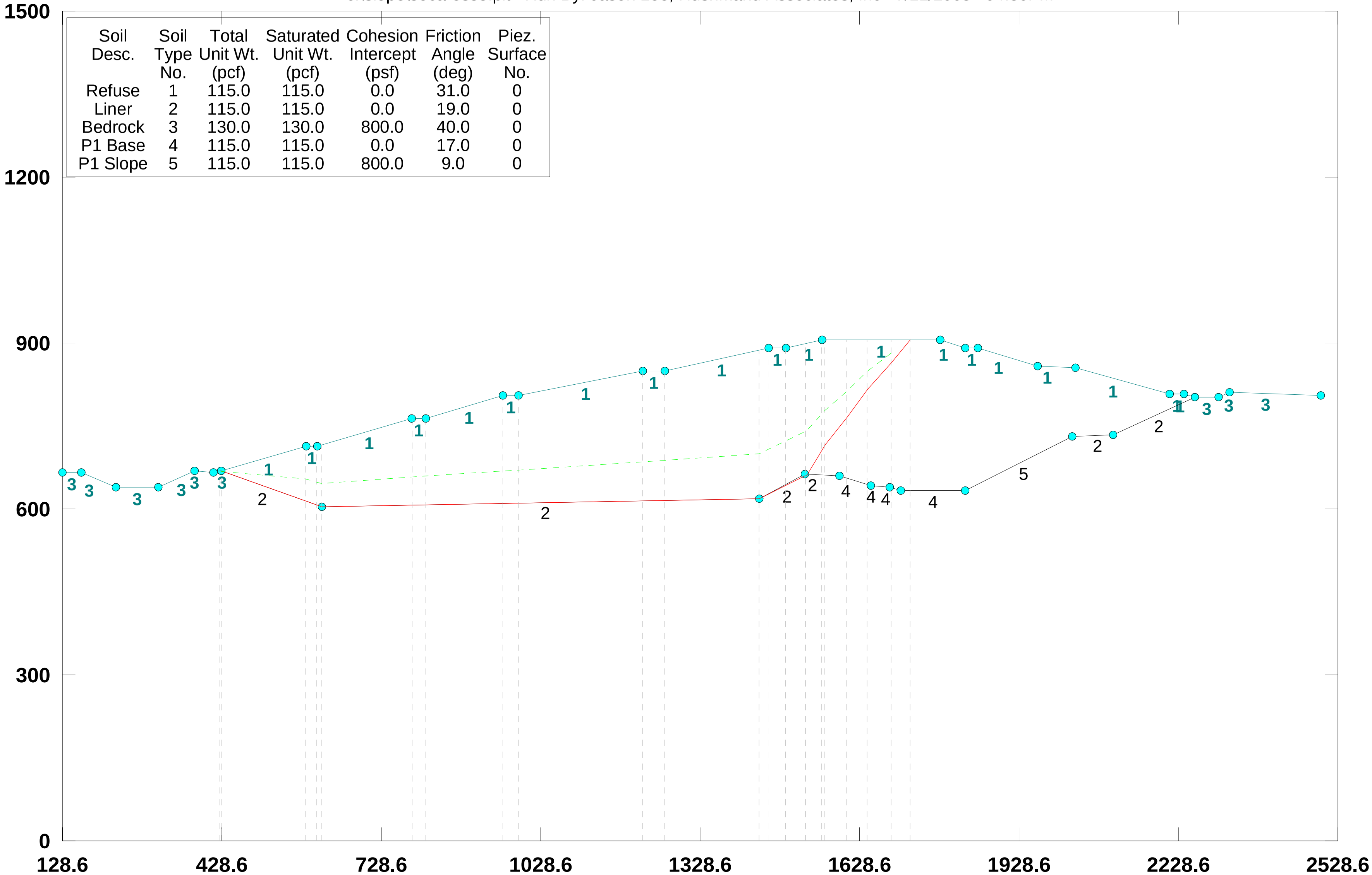
GSTABL7 v.2 FSmin=2.472

Safety Factors Are Calculated By The Simplified Janbu Method

KHF, SECTION A-A', EAST, STATIC, FAILURE PLANE 3

c:\slope\seca-ess3.plt   Run By: Jason Lee, Hushmand Associates, Inc   7/11/2008   04:36PM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0



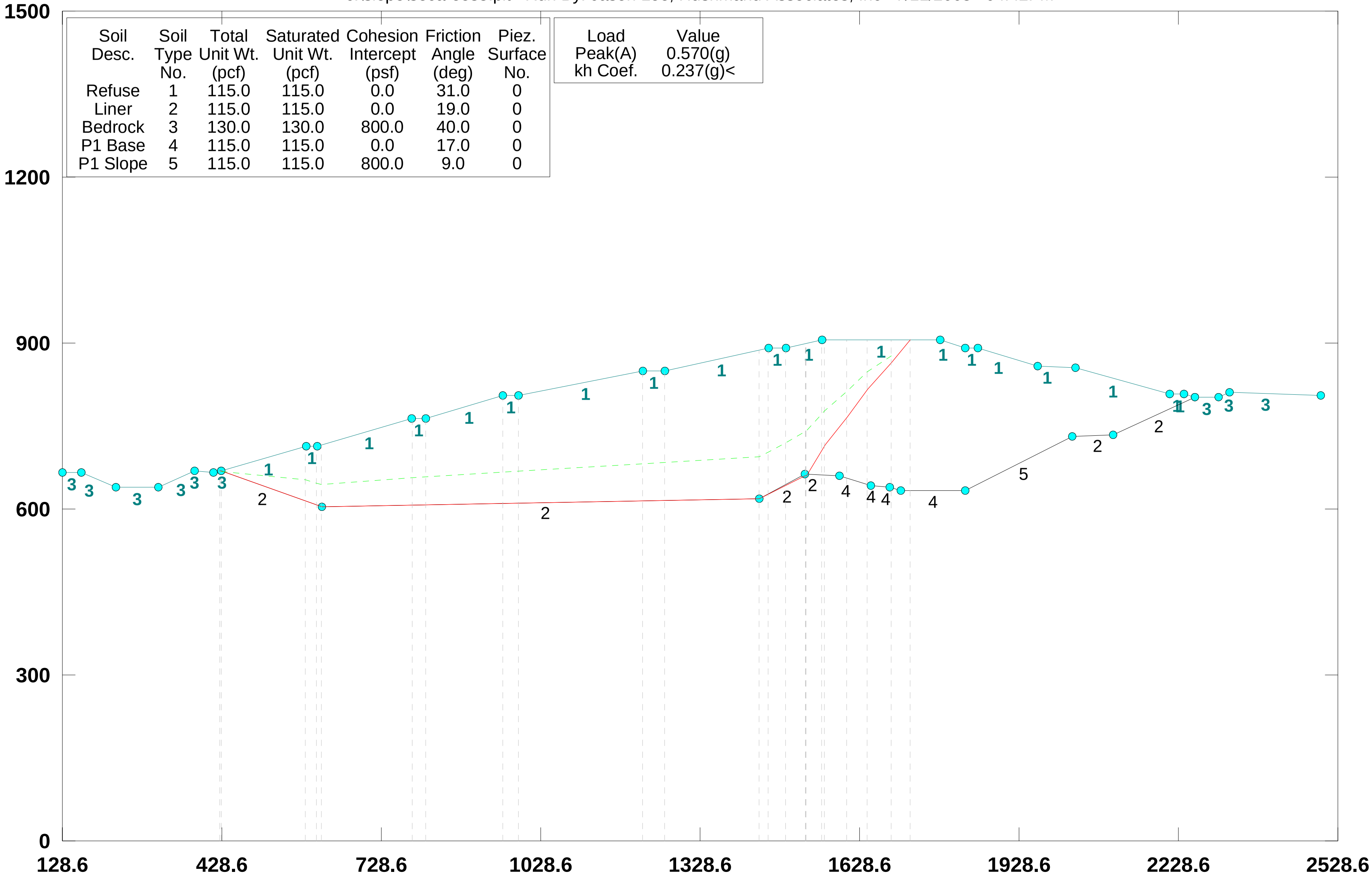
GSTABL7 v.2 FSmin=2.722
Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

KHF, SECTION A-A', EAST, PSEUD-STATIC, FAILURE PLANE 3

c:\slope\seca-ees3.plt   Run By: Jason Lee, Hushmand Associates, Inc   7/11/2008   04:42PM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0

Load	Value
Peak(A)	0.570(g)
kh Coef.	0.237(g)<

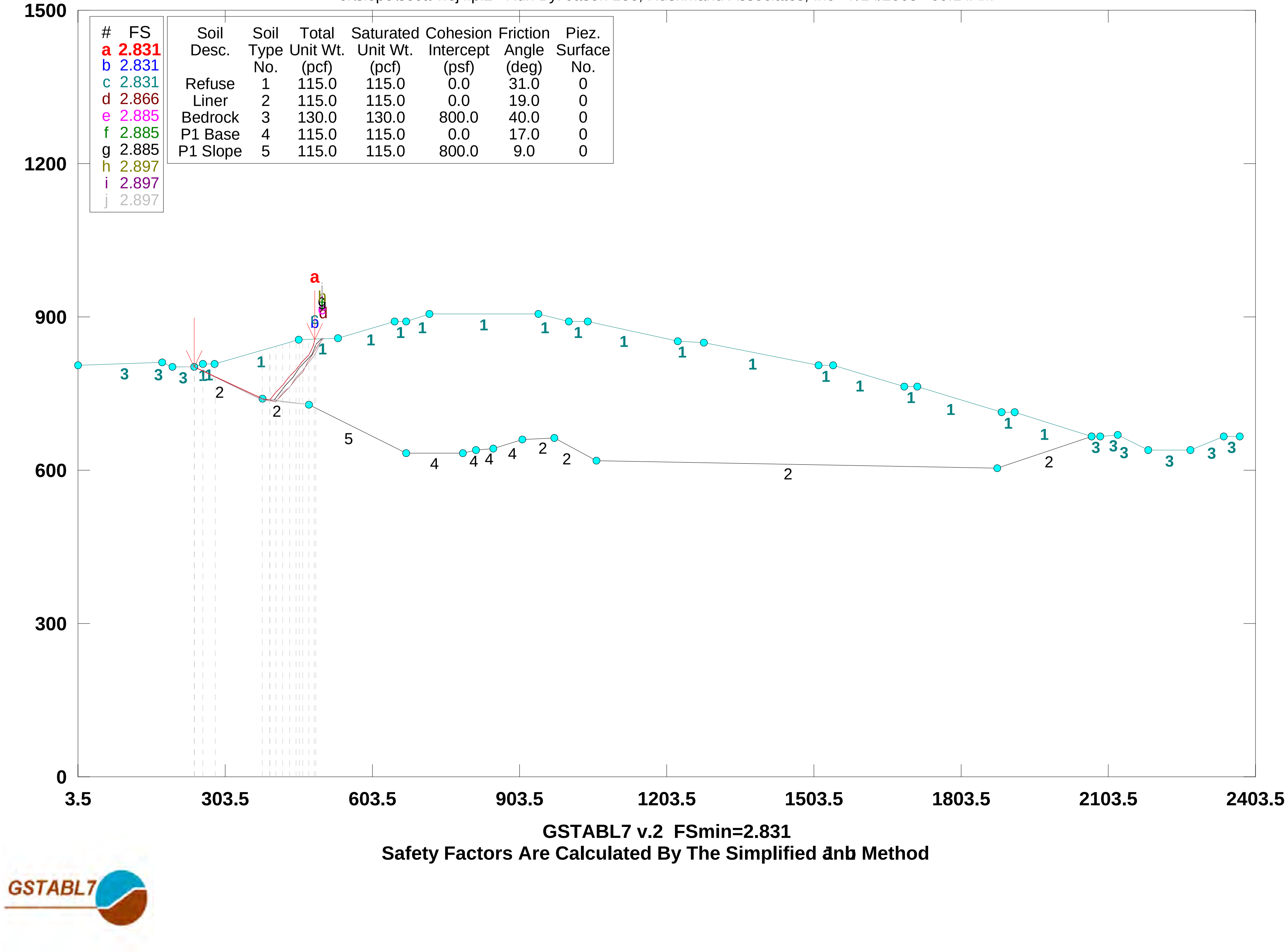


GSTABL7 v.2 FSmin=1.005

Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

KHF, SECTION A-A', WEST, STATIC, FAILURE PLANE I

c:\slope\seca-wsj i.pl2 Run By: Jason Lee, Hushmand Associates, Inc 7/14/2008 09:14AM



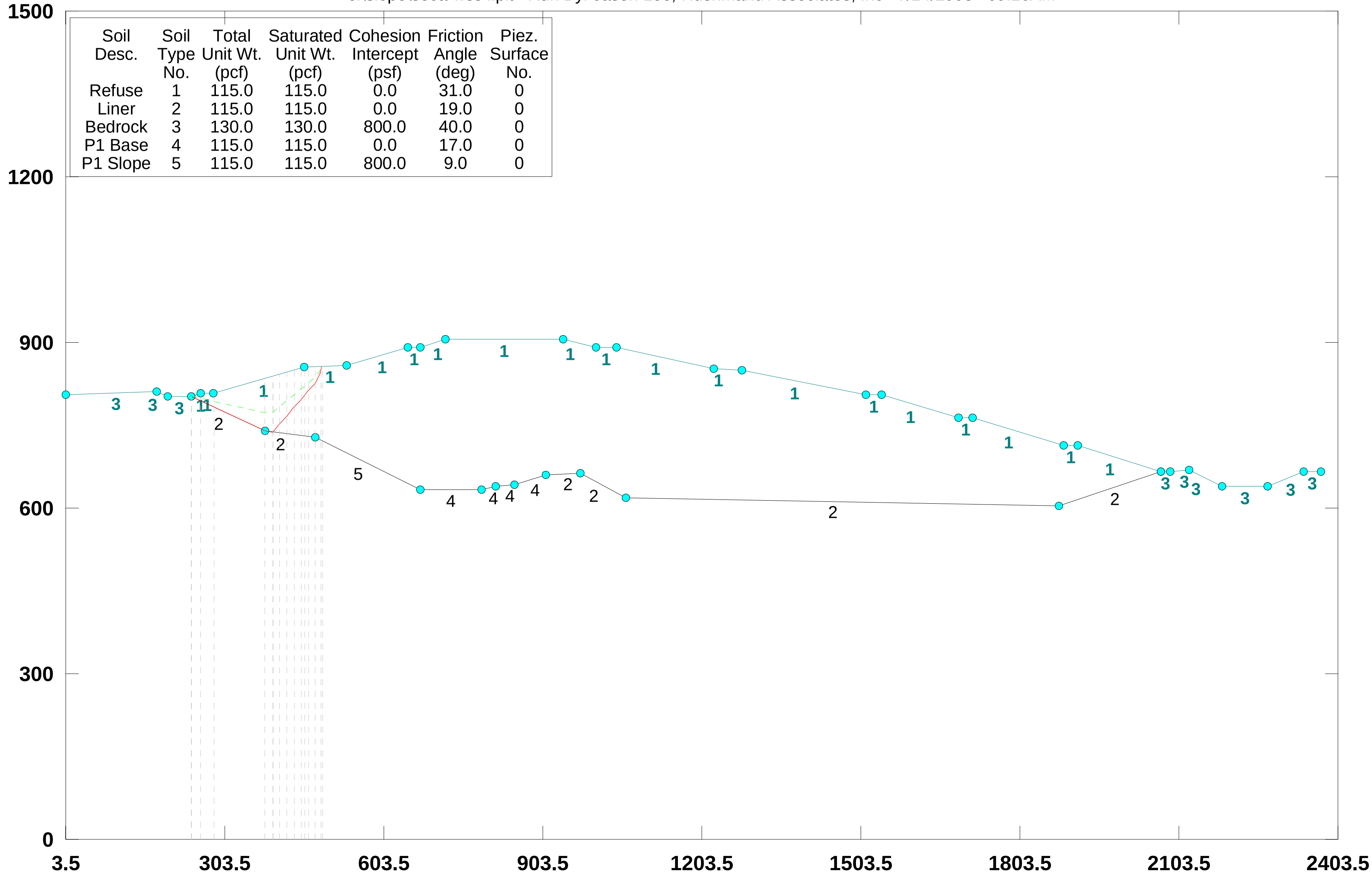
GSTABL7 v.2 FSmin=2.831

Safety Factors Are Calculated By The Simplified Janbu Method

KHF, SECTION A-A', WEST, STATIC, FAILURE PLANE I

c:\slope\seca-wss i.plt   Run By: Jason Lee, Hushmand Associates, Inc   7/14/2008   09:16AM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0

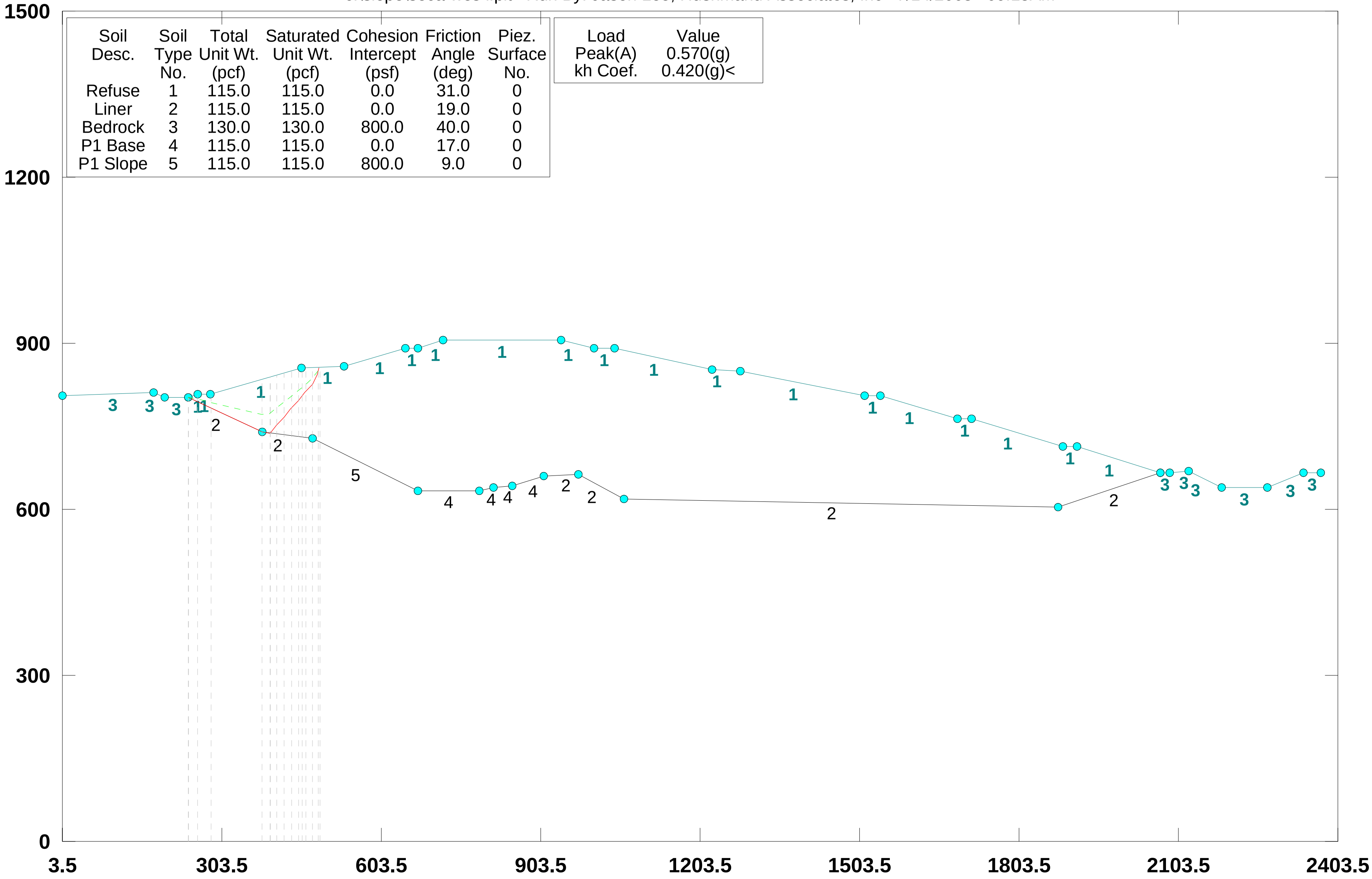


GSTABL7 v.2 FSmin=4.194

Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

KHF, SECTION A-A', WEST, PSEUD-STATIC, FAILURE PLANE I

c:\slope\seca-wes i.plt   Run By: Jason Lee, Hushmand Associates, Inc   7/14/2008   09:18AM



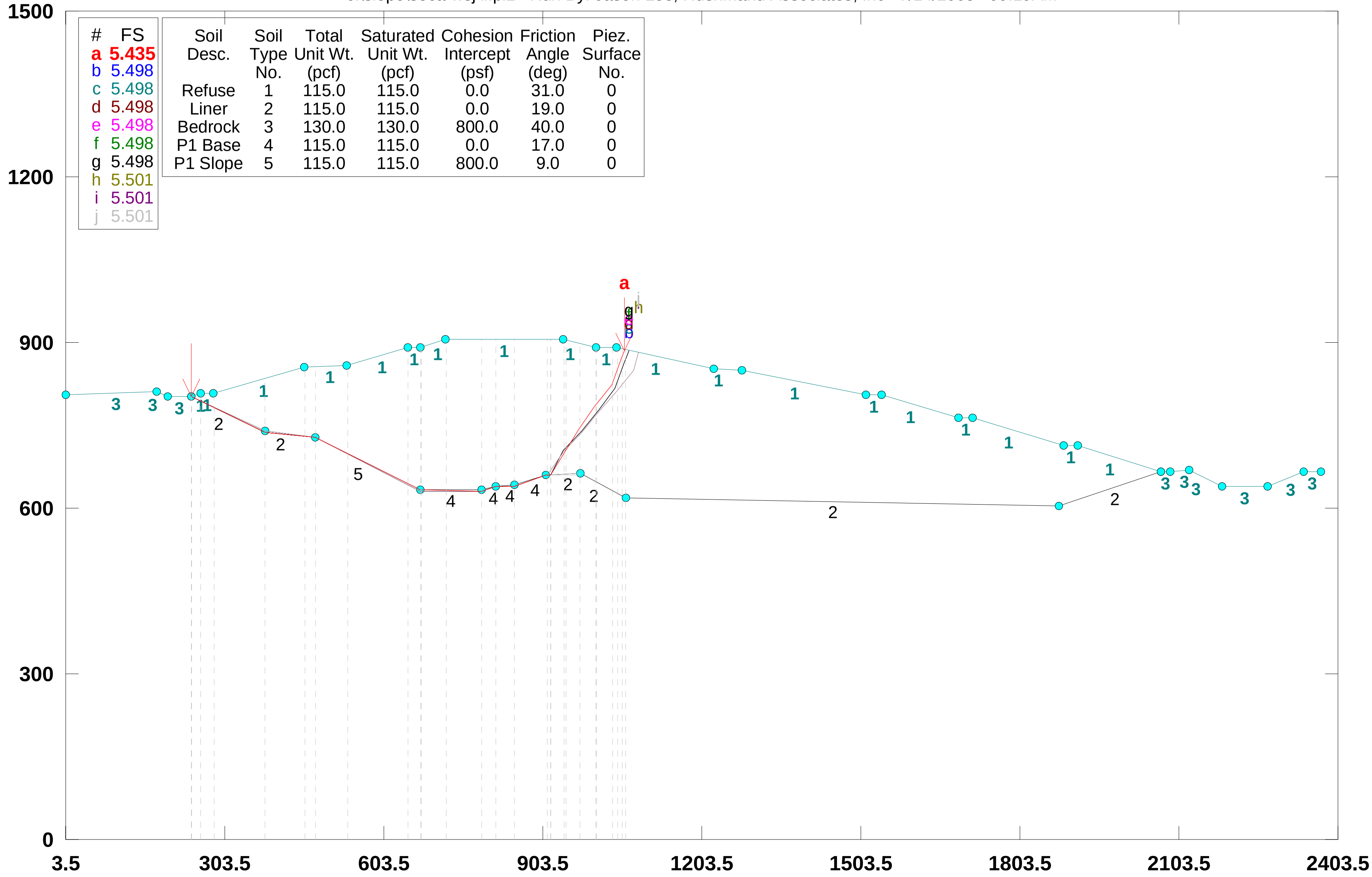
GSTABL7 v.2 FSmin=1.002

Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

GSTABL7

KHF, SECTION A-A', WEST, STATIC, FAILURE PLANE II

c:\slope\seca-wsj ii.pl2 Run By: Jason Lee, Hushmand Associates, Inc 7/14/2008 09:19AM



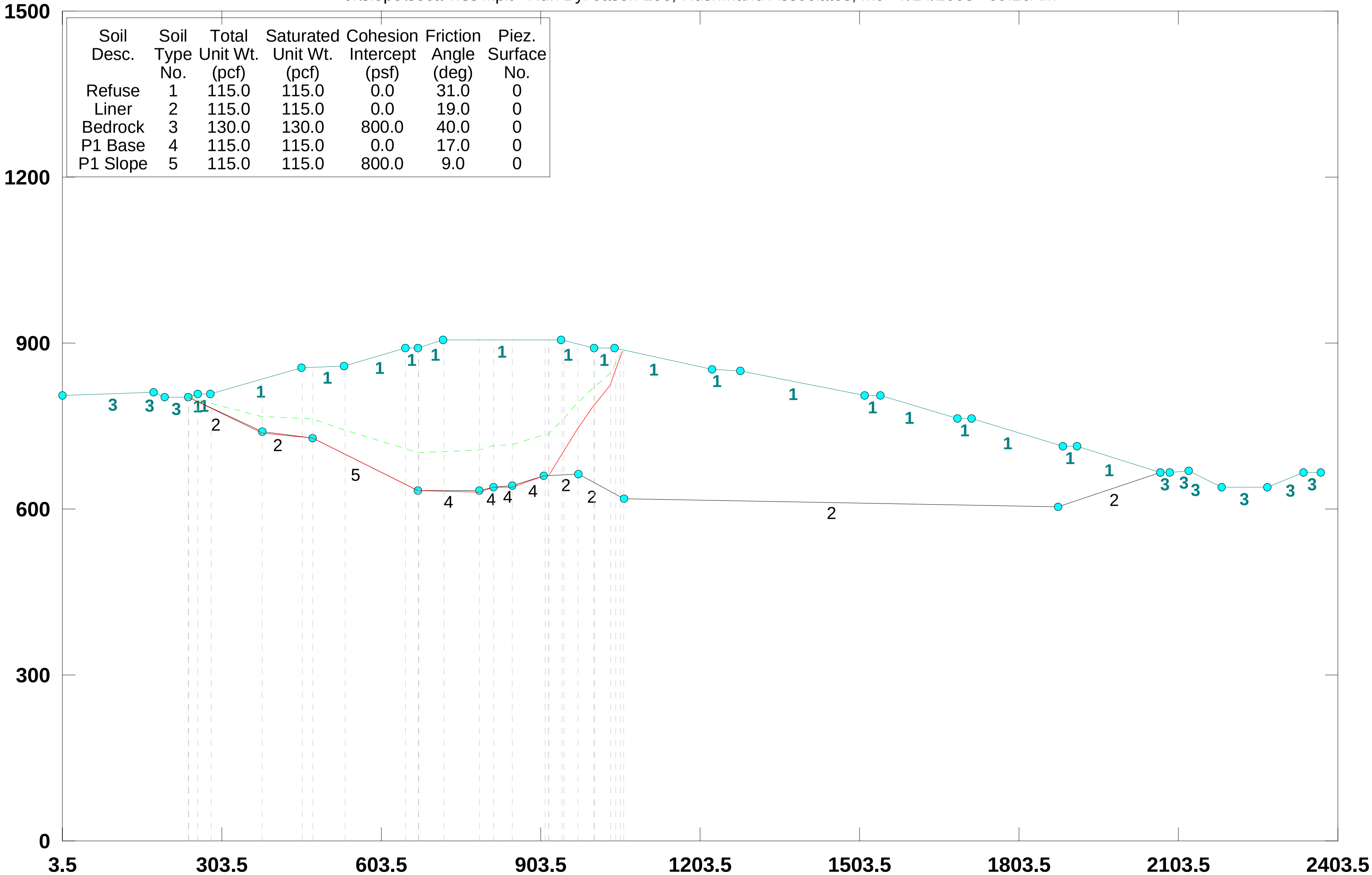
GSTABL7 v.2 FSmin=5.435

Safety Factors Are Calculated By The Simplified Janbu Method

KHF, SECTION A-A', WEST, STATIC, FAILURE PLANE II

c:\slope\seca-wss ii.plt Run By: Jason Lee, Hushmand Associates, Inc 7/14/2008 09:20AM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0



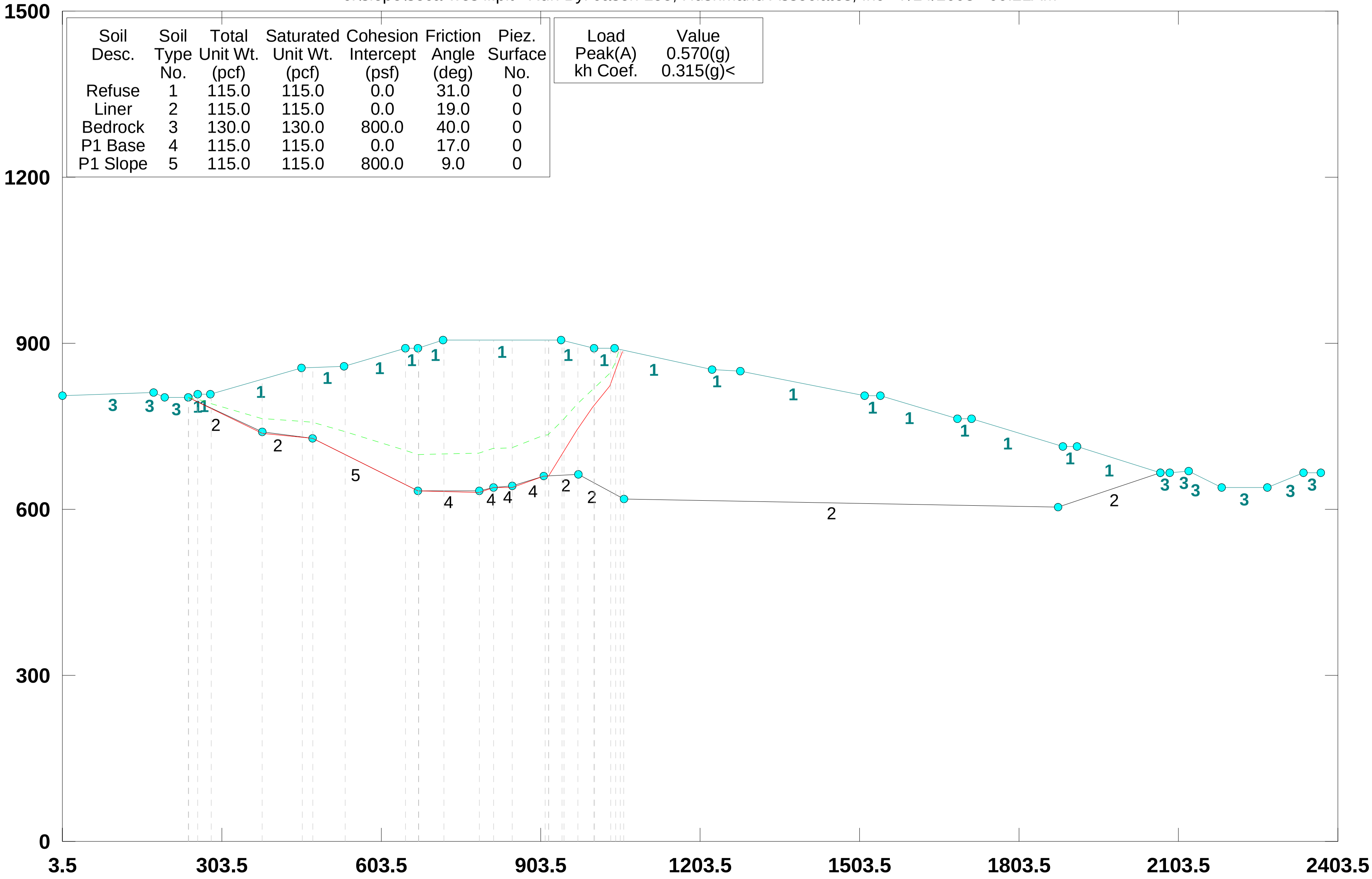
GSTABL7 v.2 FSmin=7.249

Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

GSTABL7

KHF, SECTION A-A', WEST, PSEUD-STATIC, FAILURE PLANE II

c:\slope\seca-wes ii.plt   Run By: Jason Lee, Hushmand Associates, Inc   7/14/2008   09:21AM



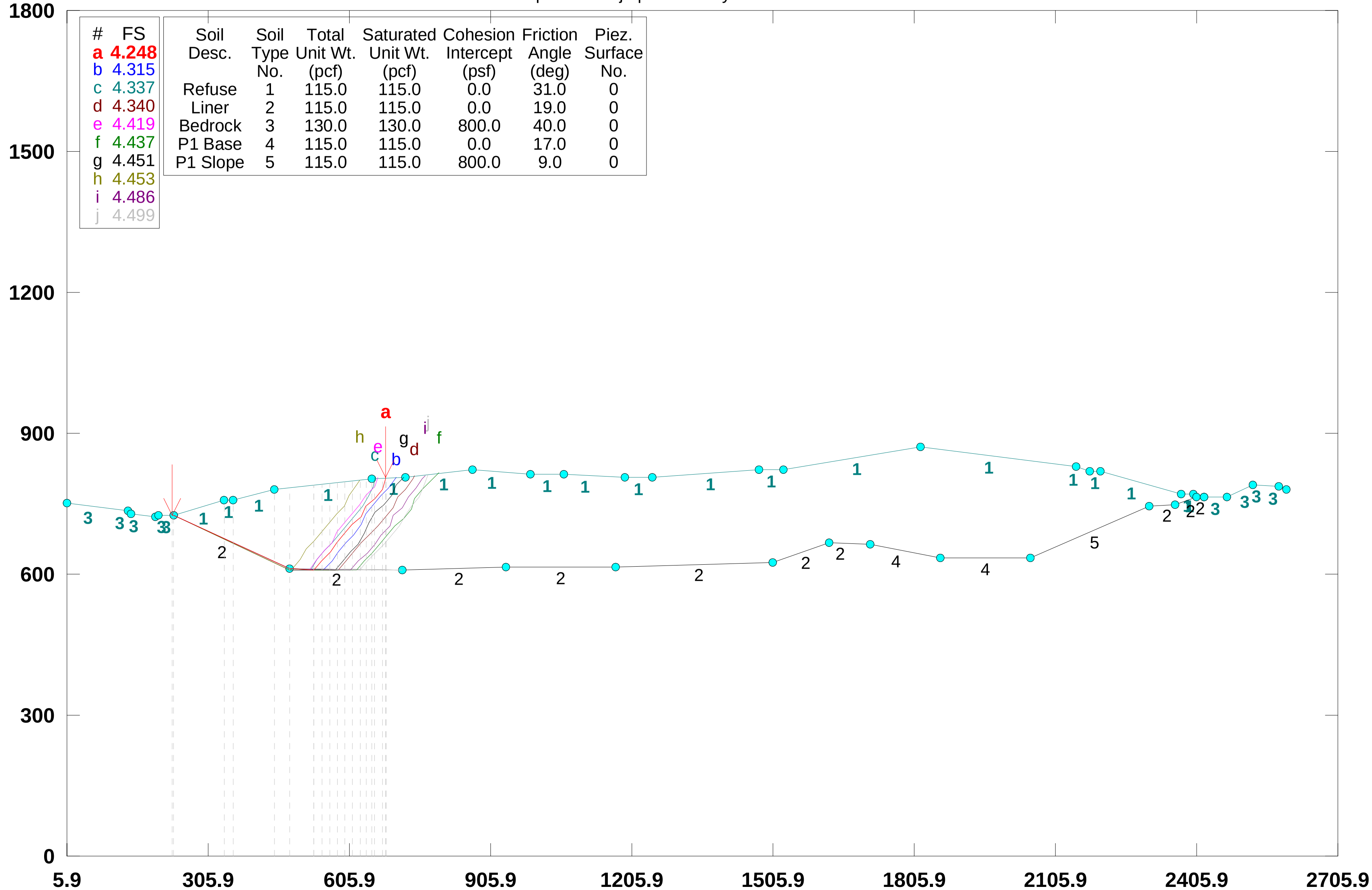
GSTABL7 v.2 FSmin=1.004

Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

GSTABL7

KHF, SEC. B-B', EAST, STATIC, FAILURE PLANE 1

c:\khf\slope\secb-esj1.pl2 Run By: BH 7/10/2008 02:23PM



GSTABL7 v.2 FSmin=4.248

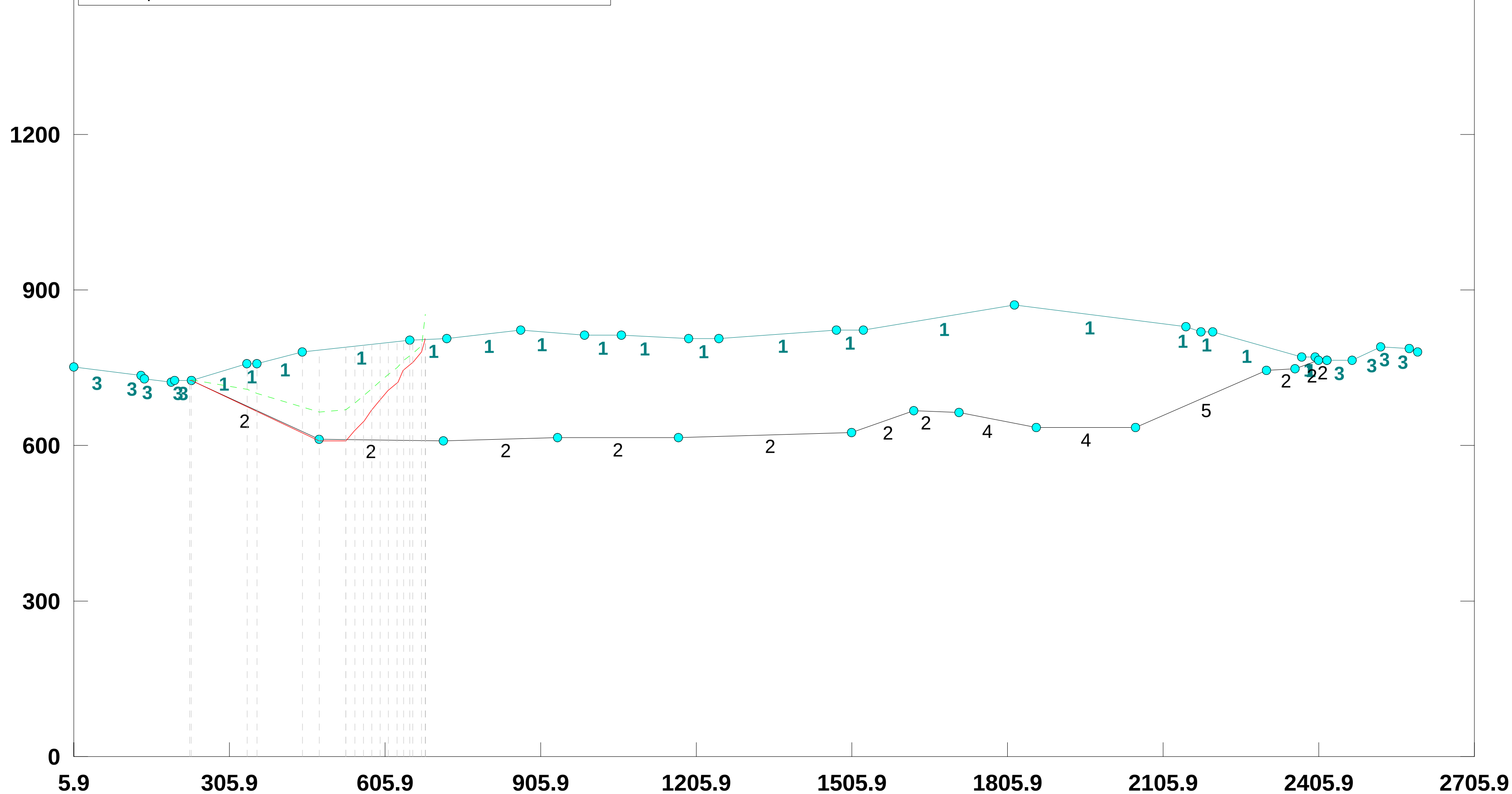
Safety Factors Are Calculated By The Simplified Janbu Method

GSTABL7

KHF, SEC. B-B', EAST, STATIC, FAILURE PLANE 1

c:\khf\slope\secb-ess1.plt   Run By: BH   7/10/2008   02:25PM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0



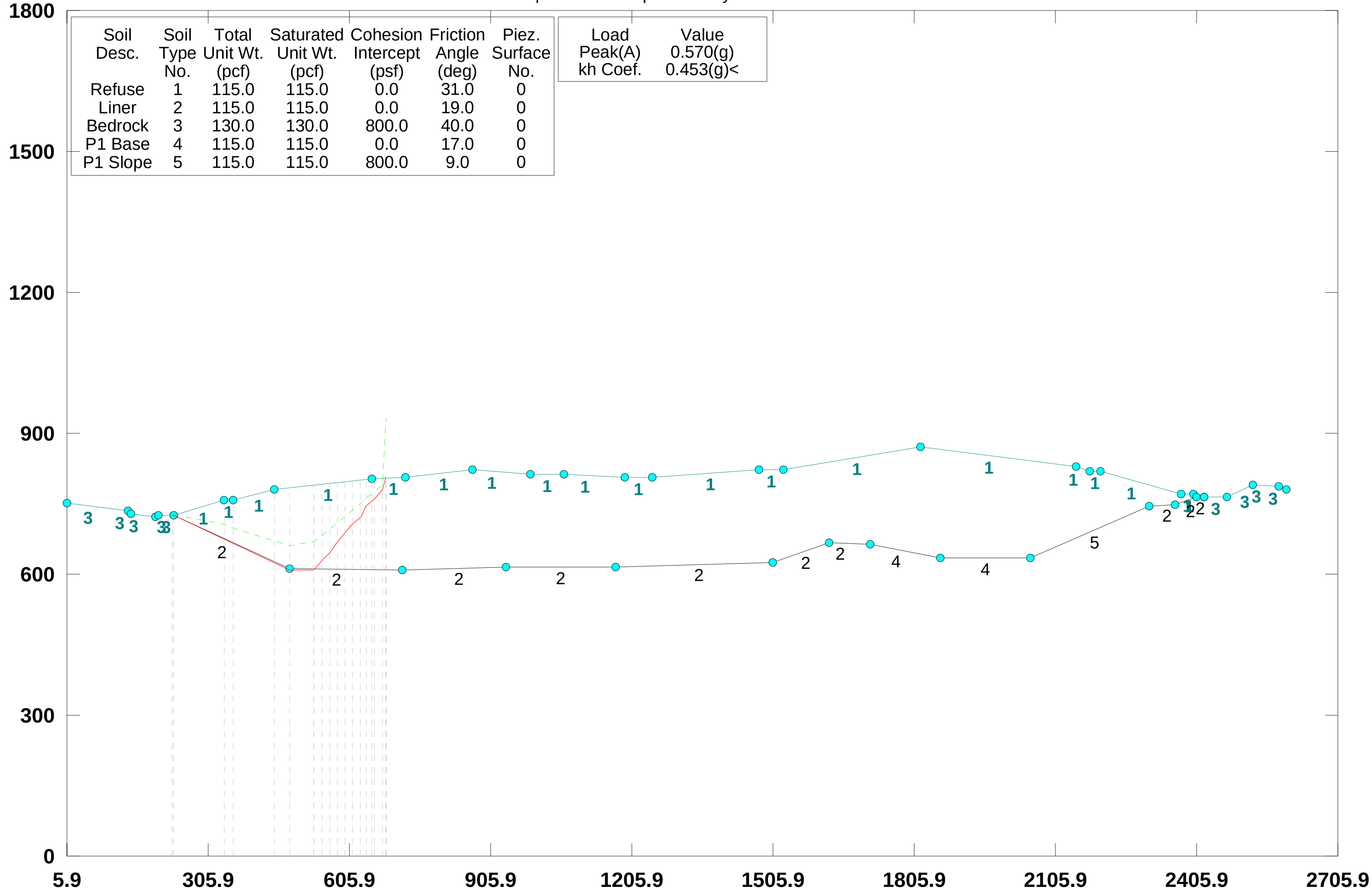
GSTABL7 v.2 FSmin=6.798
Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

KHF, SEC. B-B', EAST, PSEUD-STATIC, FAILURE PLANE 1

c:\khf\slope\secb-ees1.plt Run By: BH 7/10/2008 02:21PM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0

Load	Value
Peak(A)	0.570(g)
kh Coef.	0.453(g)<



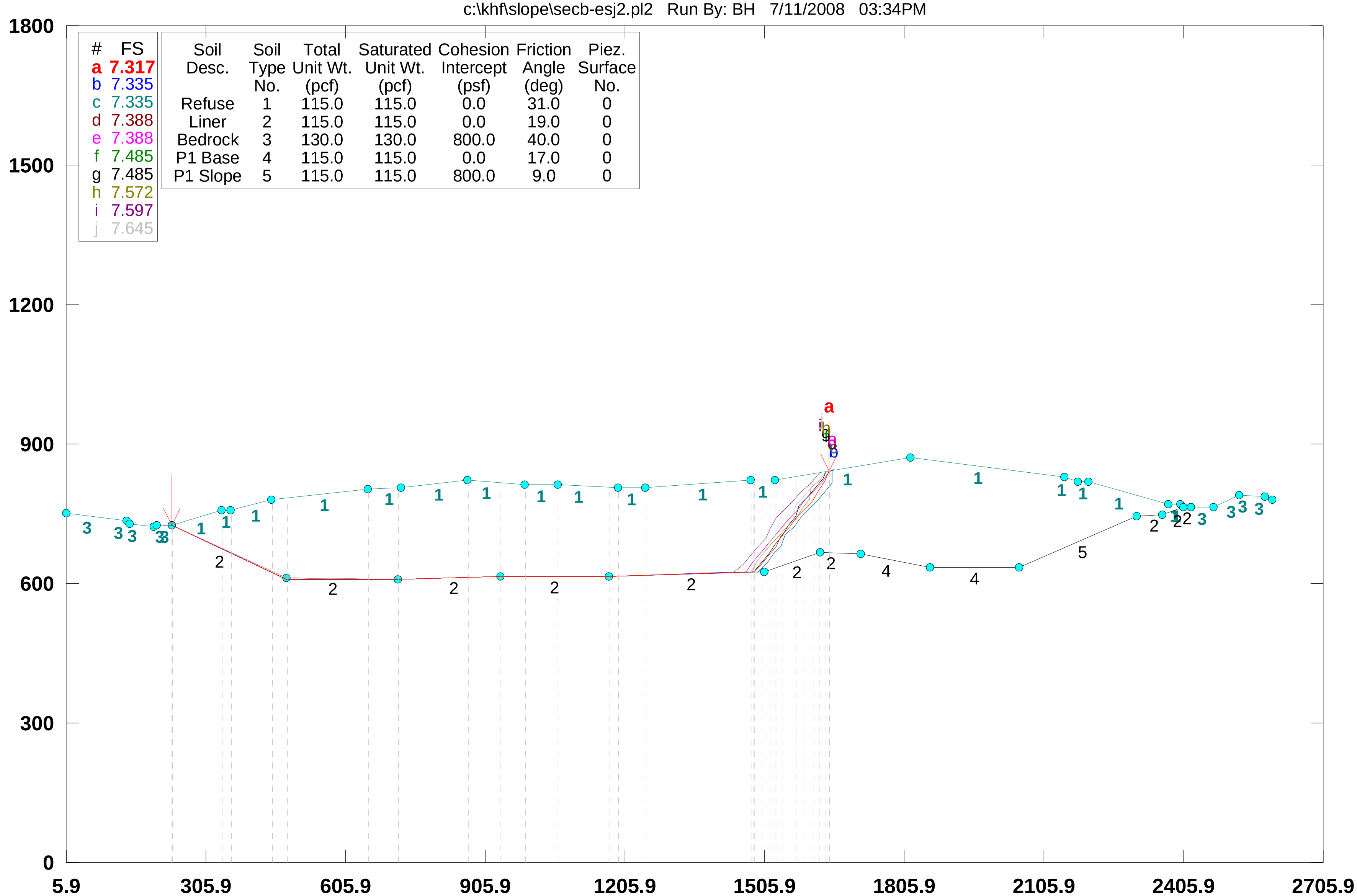
GSTABL7 v.2 FSmin=1.001

Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

GSTABL7

KHF, SEC. B-B', EAST, STATIC, FAILURE PLANE 2

c:\khf\slope\secb-esj2.pl2   Run By: BH   7/11/2008   03:34PM



GSTABL7 v.2 FSmin=7.317

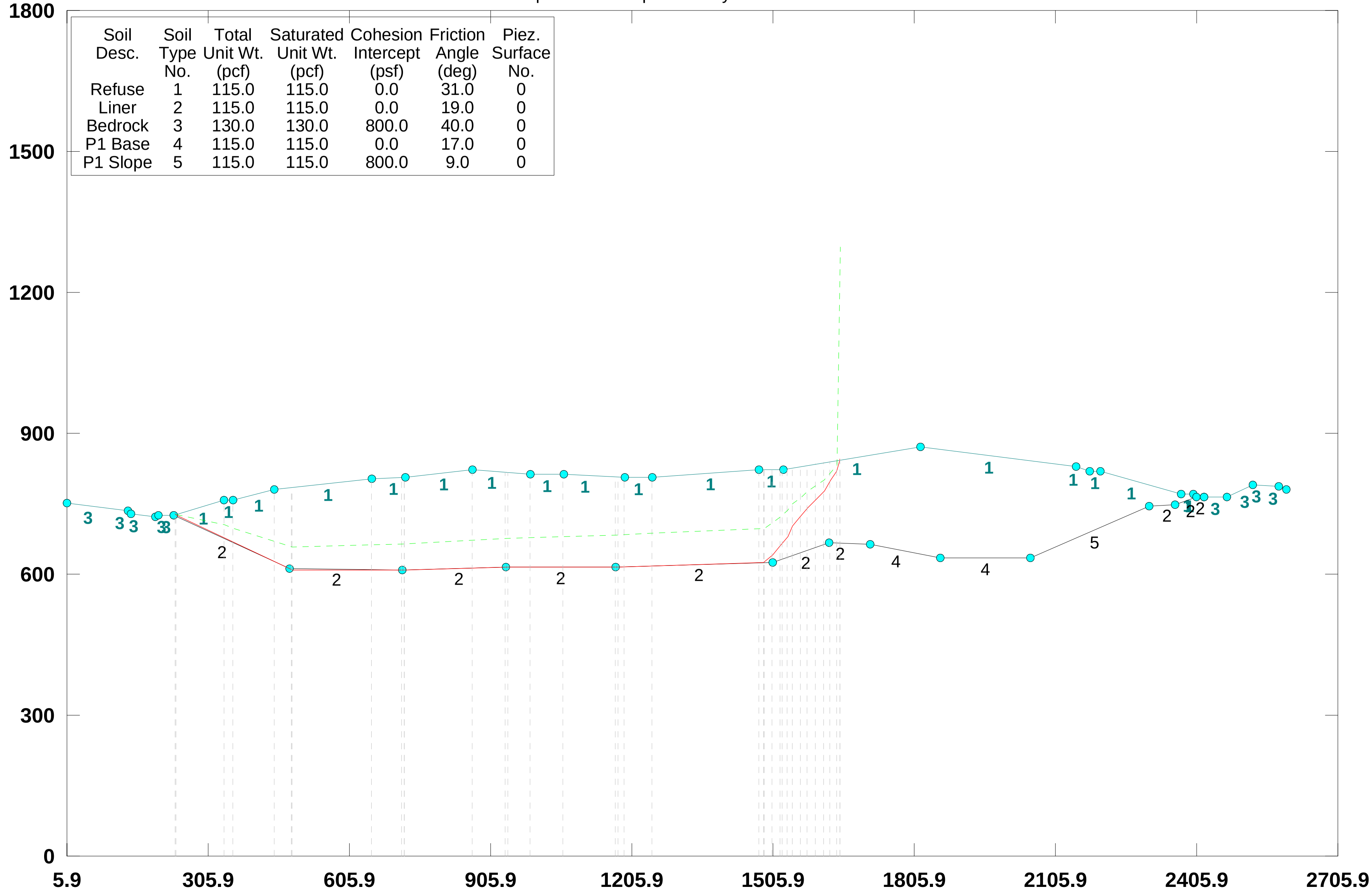
Safety Factors Are Calculated By The Simplified Janbu Method

GSTABL7

KHF, SEC. B-B', EAST, STATIC, FAILURE PLANE 2

c:\khf\slope\secb-ess2.plt Run By: BH 7/11/2008 03:35PM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0



GSTABL7 v.2 FSmin=8.590

Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

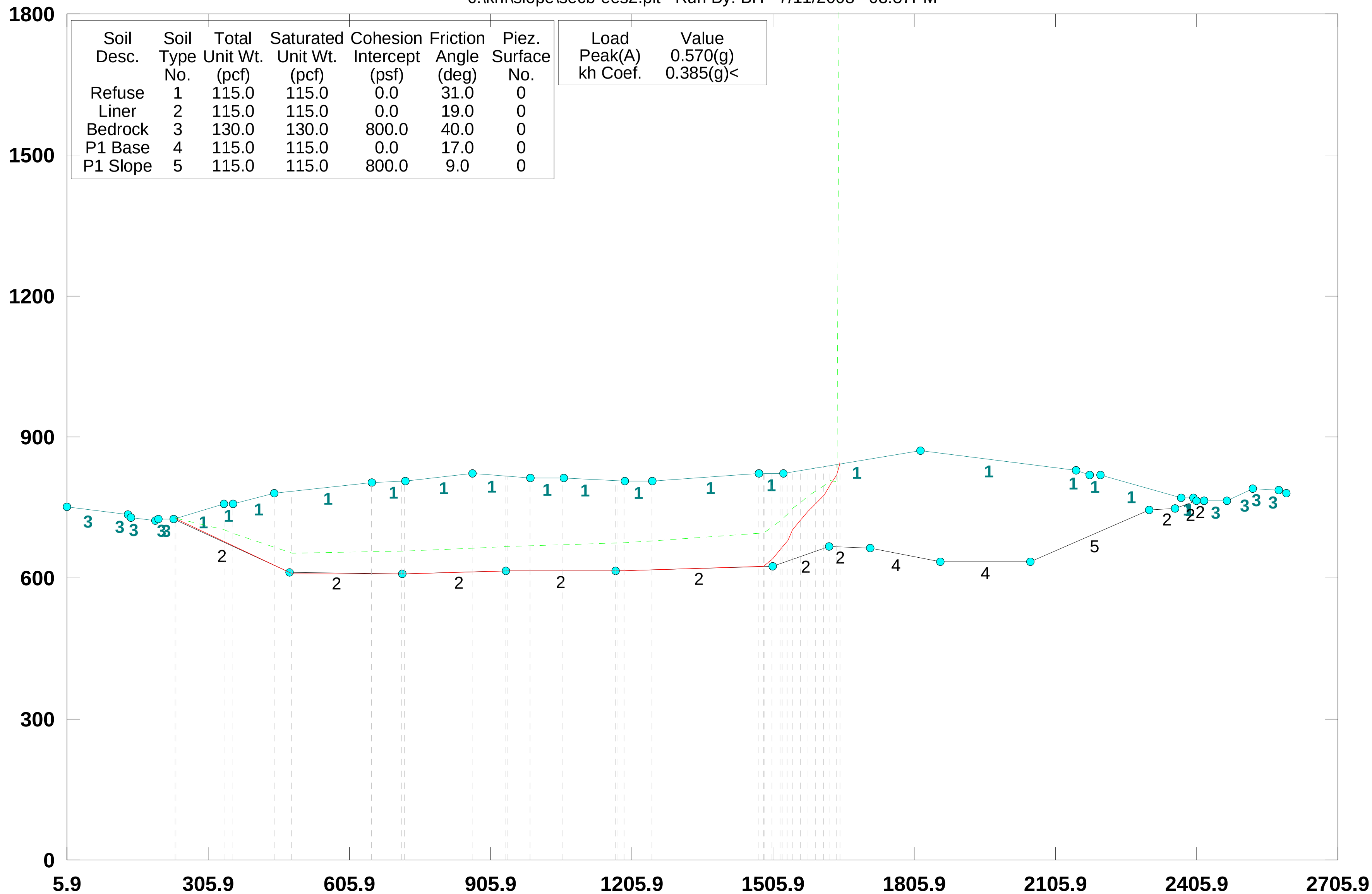
GSTABL7

KHF, SEC. B-B', EAST, PSEUD-STATIC, FAILURE PLANE 2

c:\khf\slope\secb-ees2.plt Run By: BH 7/11/2008 03:37PM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0

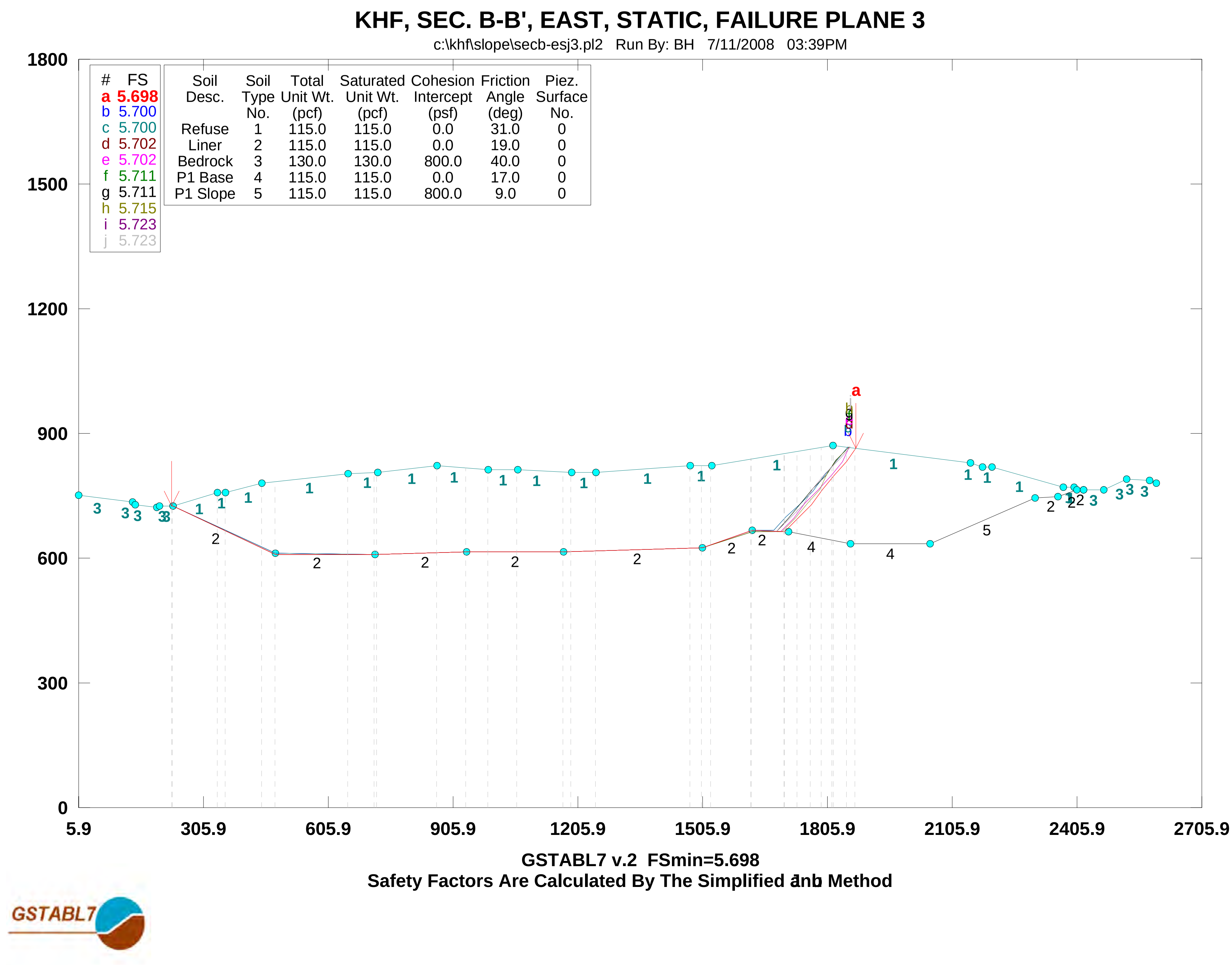
Load	Value
Peak(A)	0.570(g)
kh Coef.	0.385(g)<



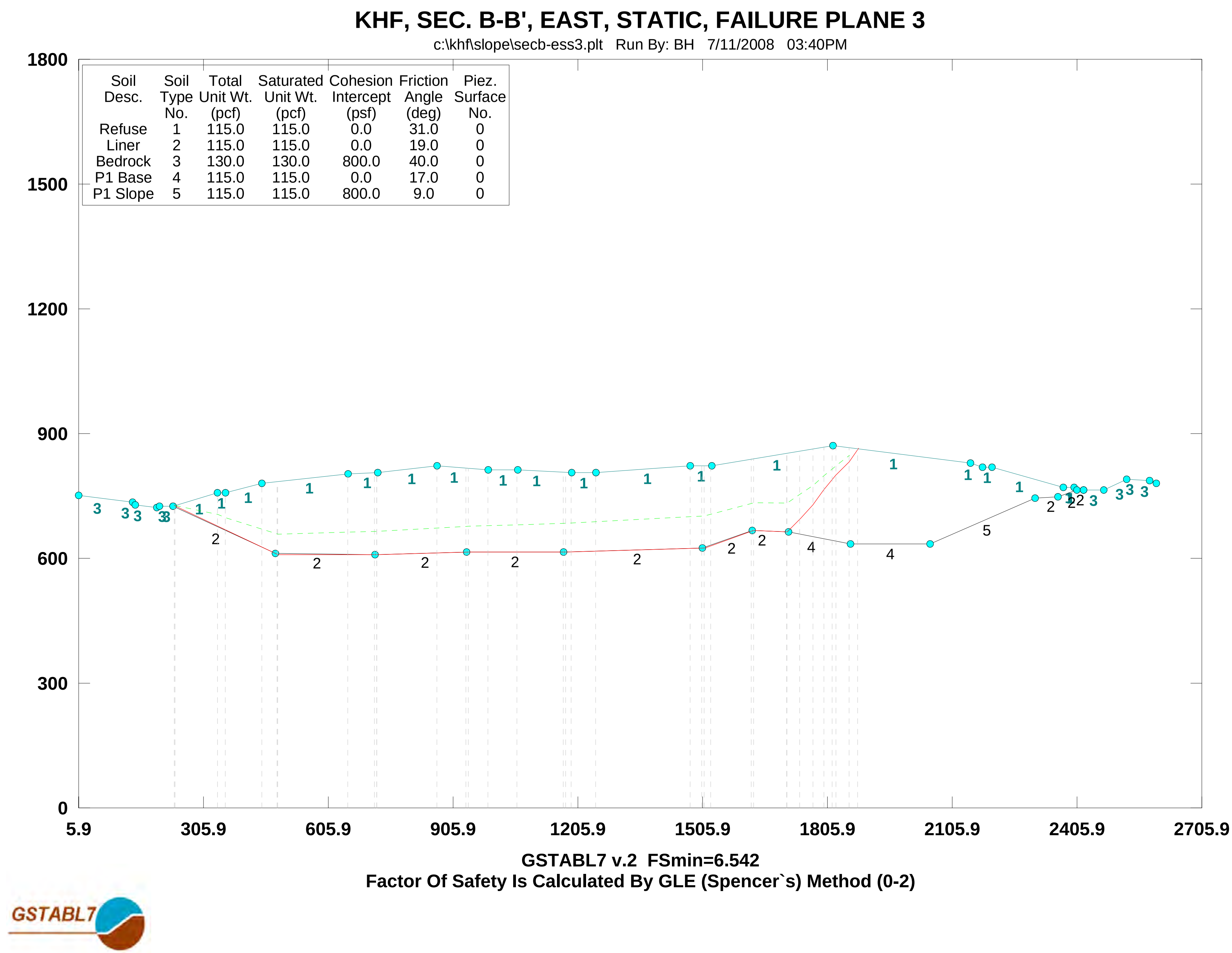
GSTABL7 v.2 FSmin=1.009

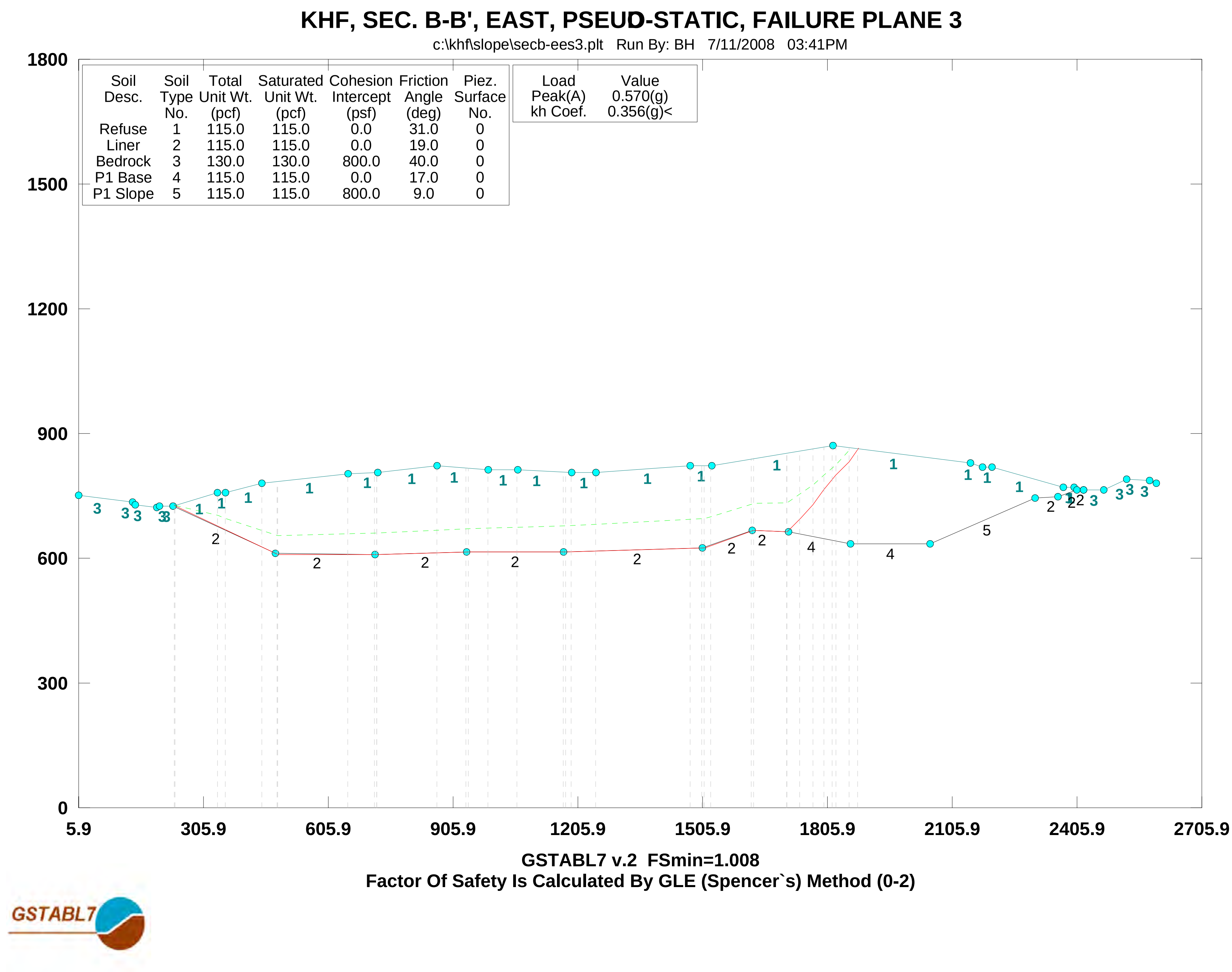
Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

GSTABL7



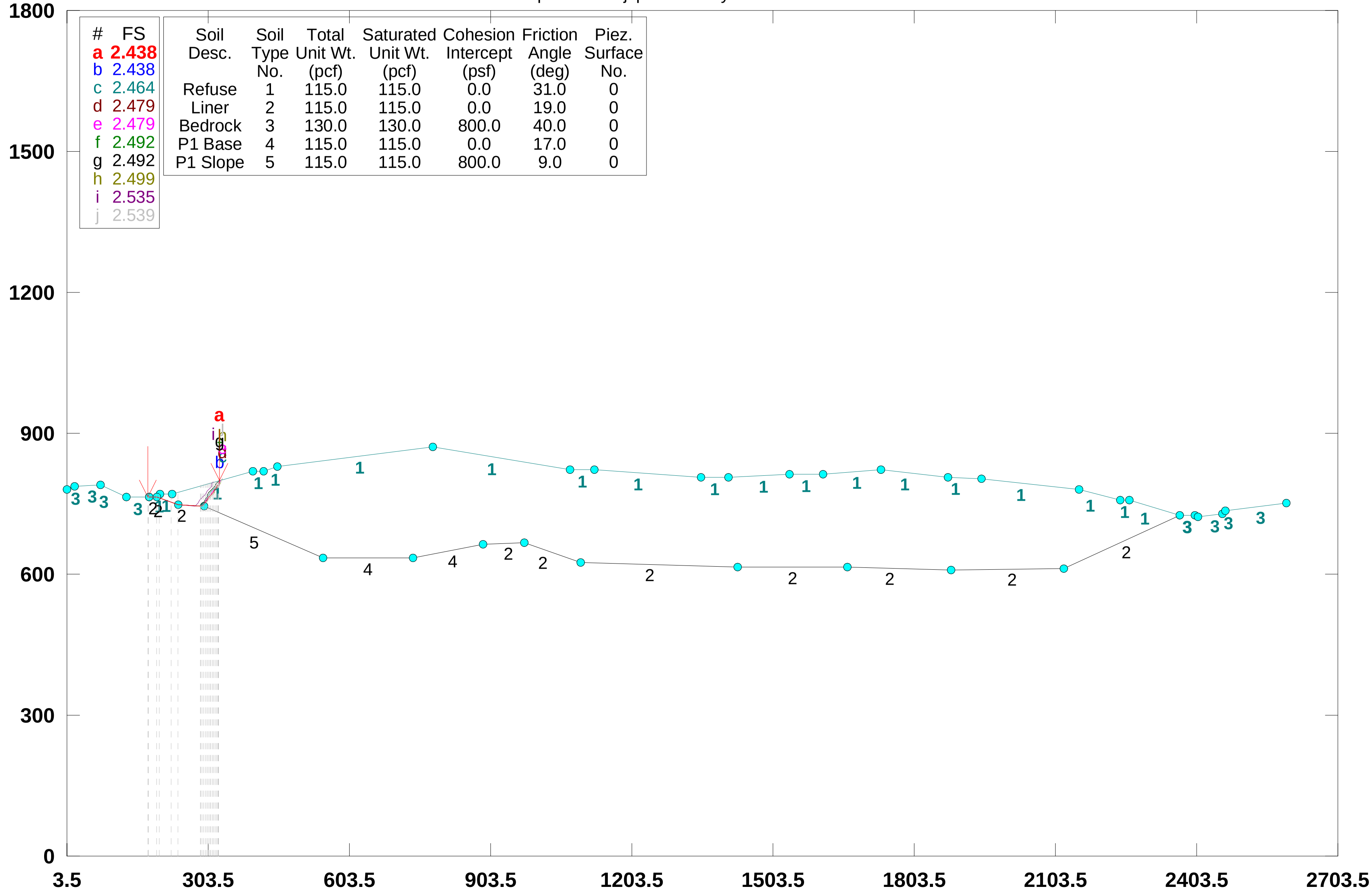
KHF, SEC. B-B', EAST, STATIC, FAILURE PLANE 3
c:\khf\slope\secb-esj3.pl2 Run By: BH 7/11/2008 03:39PM
FS
a 5.698
b 5.700
c 5.700
d 5.702
e 5.702
f 5.711
g 5.711
h 5.715
i 5.723
j 5.723
Soil Desc. | Soil Type No. | Total Unit Wt. (pcf) | Saturated Unit Wt. (pcf) | Cohesion Intercept (psf) | Friction Angle (deg) | Piez. Surface No.
Refuse 1 115.0 115.0 0.0 31.0 0
Liner 2 115.0 115.0 0.0 19.0 0
Bedrock 3 130.0 130.0 800.0 40.0 0
P1 Base 4 115.0 115.0 0.0 17.0 0
P1 Slope 5 115.0 115.0 800.0 9.0 0
1800
1500
1200
900
600
300
0
5.9
305.9
605.9
905.9
1205.9
1505.9
1805.9
2105.9
2405.9
2705.9
GSTABL7 v.2 FSmin=5.698
Safety Factors Are Calculated By The Simplified Janbu Method
GSTABL7


KHF, SEC. B-B', EAST, STATIC, FAILURE PLANE 3
c:\khf\slope\secb-ess3.plt Run By: BH 7/11/2008 03:40PM
Soil Desc. | Soil Type No. | Total Unit Wt. (pcf) | Saturated Unit Wt. (pcf) | Cohesion Intercept (psf) | Friction Angle (deg) | Piez. Surface No.
Refuse 1 115.0 115.0 0.0 31.0 0
Liner 2 115.0 115.0 0.0 19.0 0
Bedrock 3 130.0 130.0 800.0 40.0 0
P1 Base 4 115.0 115.0 0.0 17.0 0
P1 Slope 5 115.0 115.0 800.0 9.0 0
1800
1500
1200
900
600
300
0
5.9
305.9
605.9
905.9
1205.9
1505.9
1805.9
2105.9
2405.9
2705.9
GSTABL7 v.2 FSmin=6.542
Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)
GSTABL7


KHF, SEC. B-B', EAST, PSEUD-STATIC, FAILURE PLANE 3
c:\khf\slope\secb-ees3.plt Run By: BH 7/11/2008 03:41PM
Soil Desc. | Soil Type No. | Total Unit Wt. (pcf) | Saturated Unit Wt. (pcf) | Cohesion Intercept (psf) | Friction Angle (deg) | Piez. Surface No.
Refuse 1 115.0 115.0 0.0 31.0 0
Liner 2 115.0 115.0 0.0 19.0 0
Bedrock 3 130.0 130.0 800.0 40.0 0
P1 Base 4 115.0 115.0 0.0 17.0 0
P1 Slope 5 115.0 115.0 800.0 9.0 0
Load Value
Peak(A) 0.570(g)
kh Coef. 0.356(g)<
1800
1500
1200
900
600
300
0
5.9
305.9
605.9
905.9
1205.9
1505.9
1805.9
2105.9
2405.9
2705.9
GSTABL7 v.2 FSmin=1.008
Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)
GSTABL7

KHF, SEC. B-B', WEST, STATIC, FAILURE PLANE I

c:\khf\slope\secb-wsji.pl2   Run By: BH   7/10/2008   04:29PM



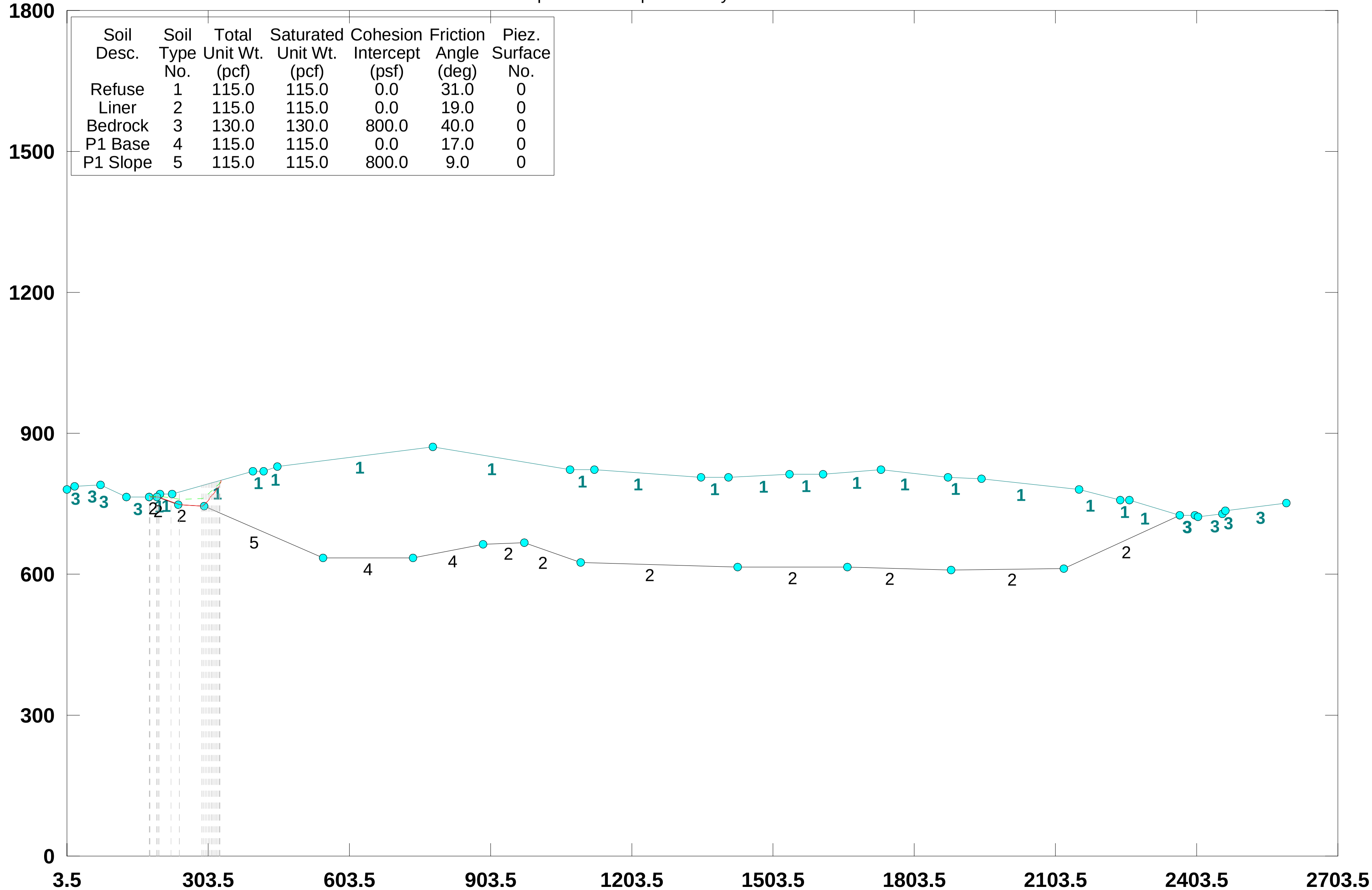
GSTABL7 v.2 FSmin=2.438

Safety Factors Are Calculated By The Simplified Janbu Method

KHF, SEC. B-B', WEST, STATIC, FAILURE PLANE I

c:\khf\slope\secb-wssi.plt Run By: BH 7/10/2008 04:30PM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0

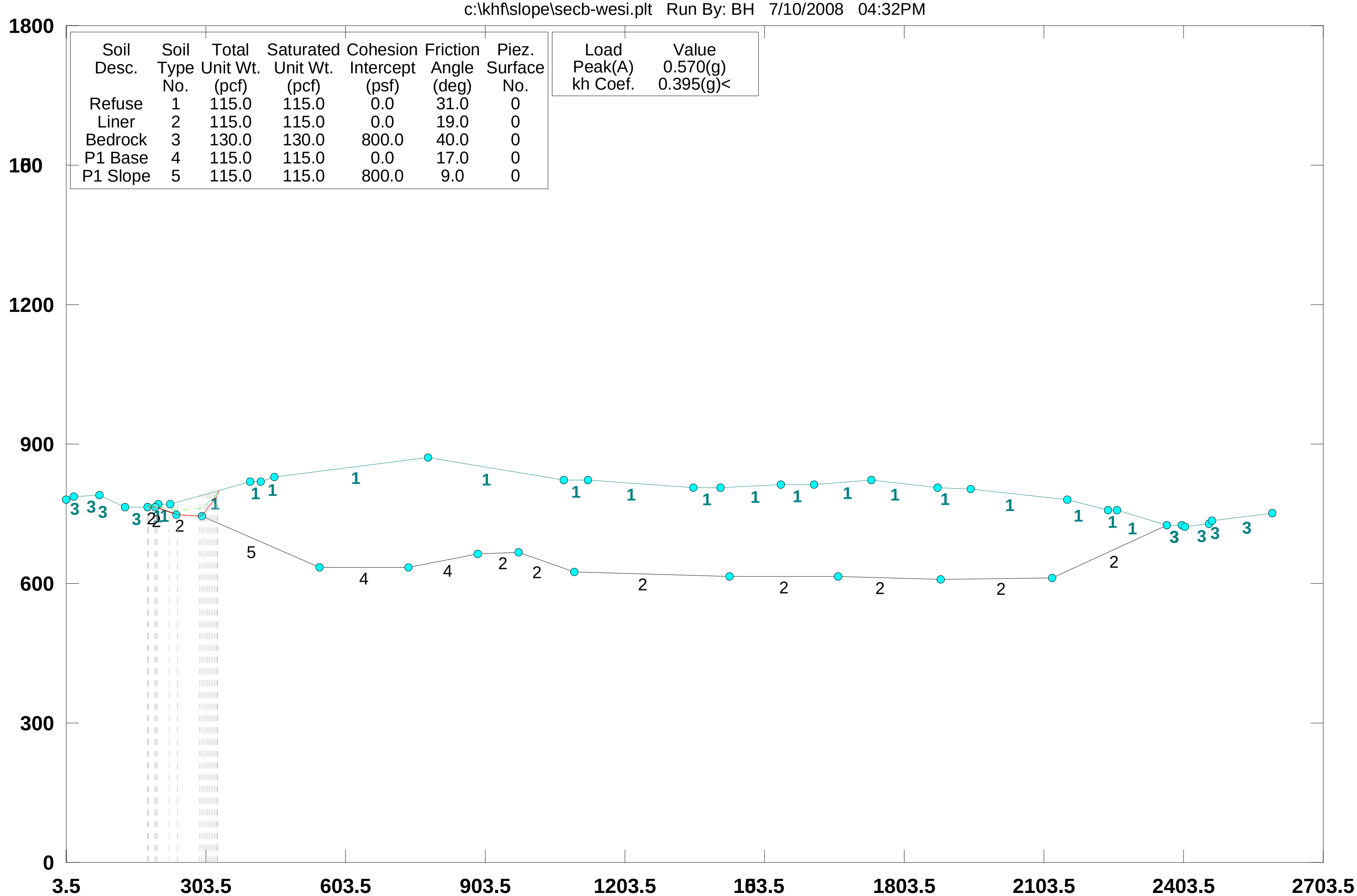


GSTABL7 v.2 FSmin=3.500
Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

GSTABL7

KHF, SEC. B-B', WEST, PSEUDO-STATIC, FAILURE PLANE I

c:\khf\slope\secb-wesi.plt Run By: BH 7/10/2008 04:32PM



Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0

Load	Value
Peak(A)	0.570(g)
kh Coef.	0.395(g)<

GSTABL7 v.2 FSmin=1.001

Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

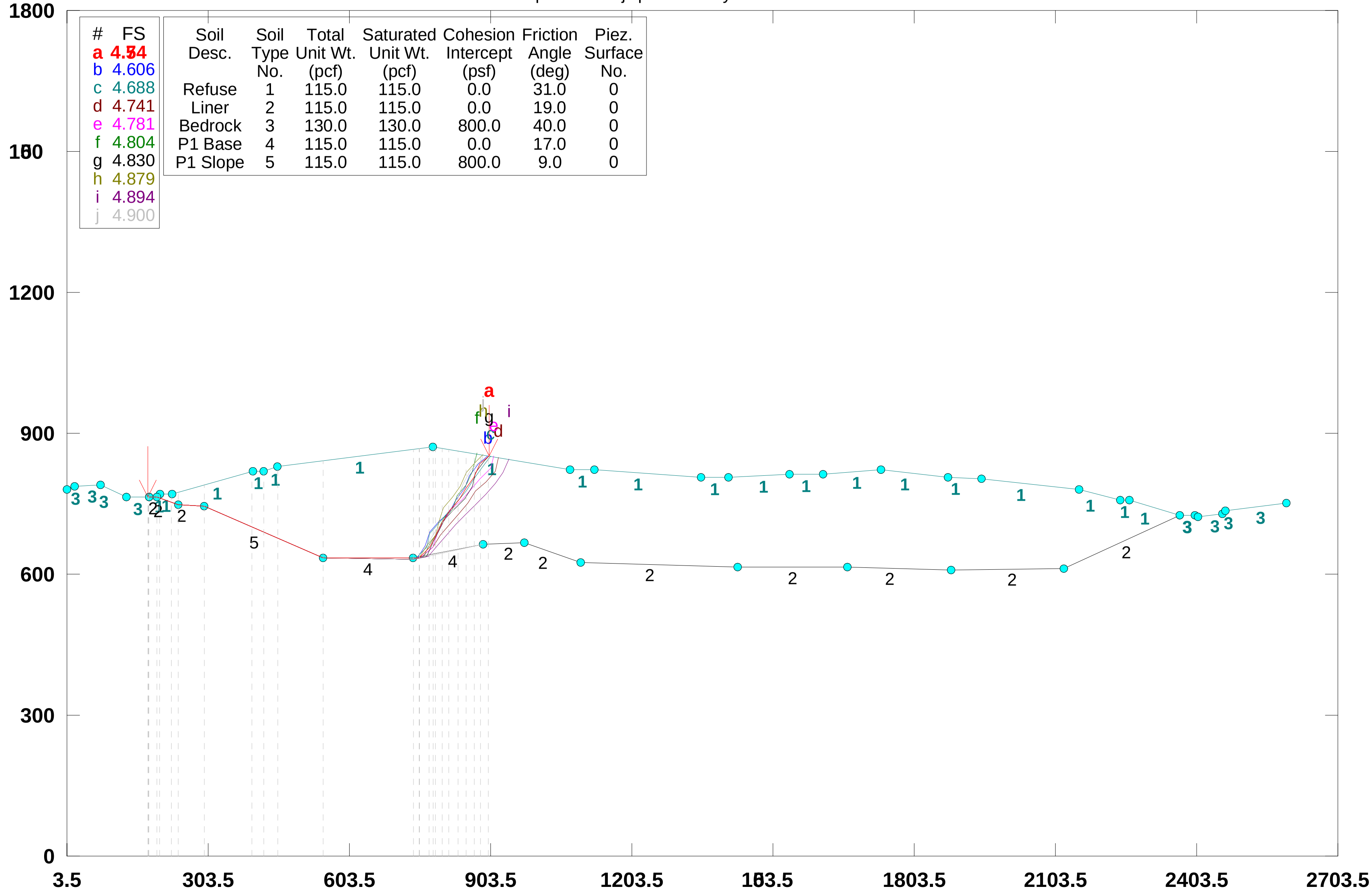
GSTABL7

KHF, SEC. B-B', WEST, STATIC, FAILURE PLANE II

c:\khf\slope\secb-wsjii.pl2 Run By: BH 7/10/2008 05:28PM

#	FS
a	4.534
b	4.606
c	4.688
d	4.741
e	4.781
f	4.804
g	4.830
h	4.879
i	4.894
j	4.900

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0



GSTABL7 v.2 FSmin=4.534

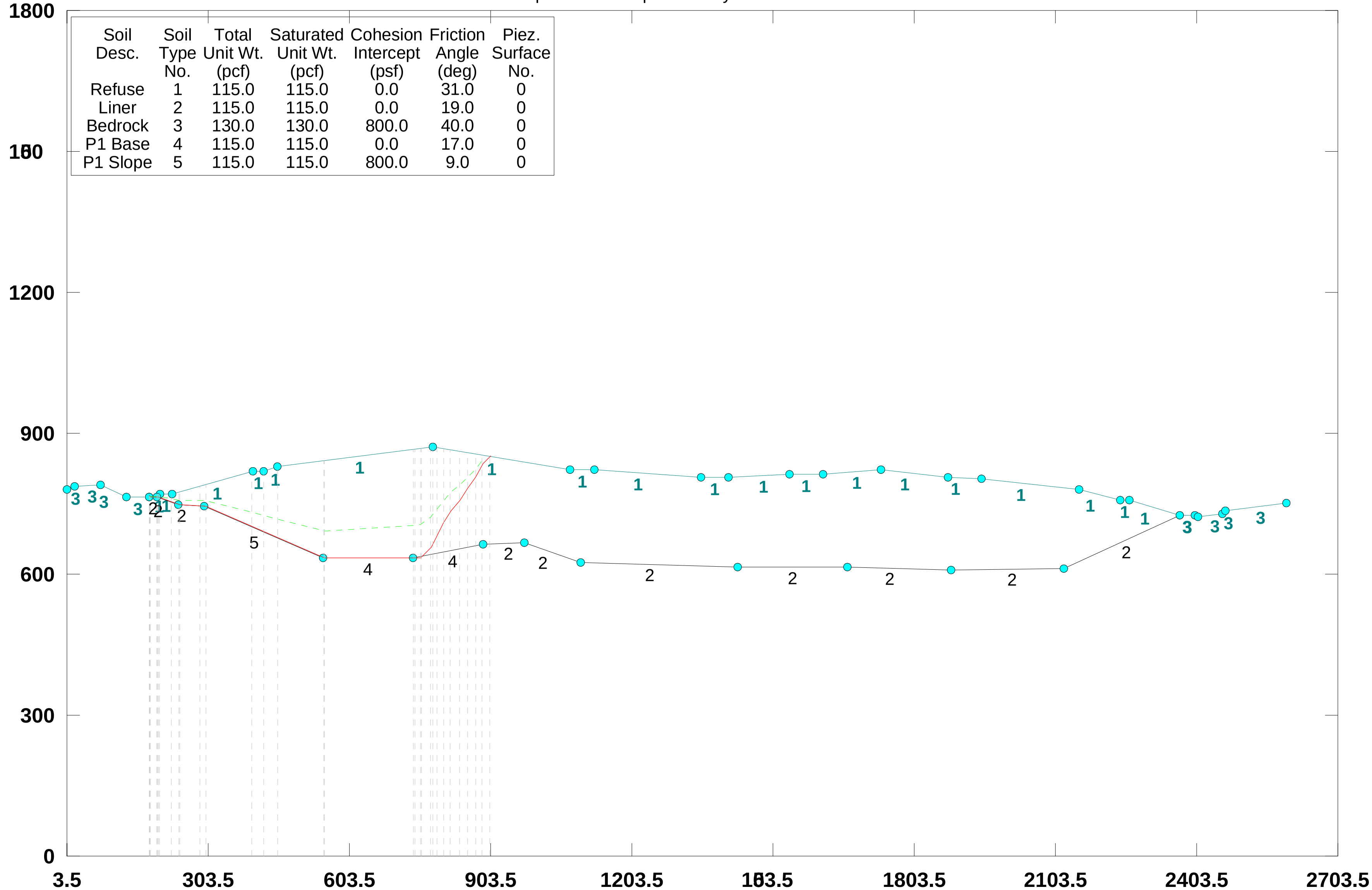
Safety Factors Are Calculated By The Simplified Janbu Method

GSTABL7

KHF, SEC. B-B', EAST, STATIC, FAILURE PLANE II

c:\khf\slope\secb-wssii.plt Run By: BH 7/10/2008 05:29PM

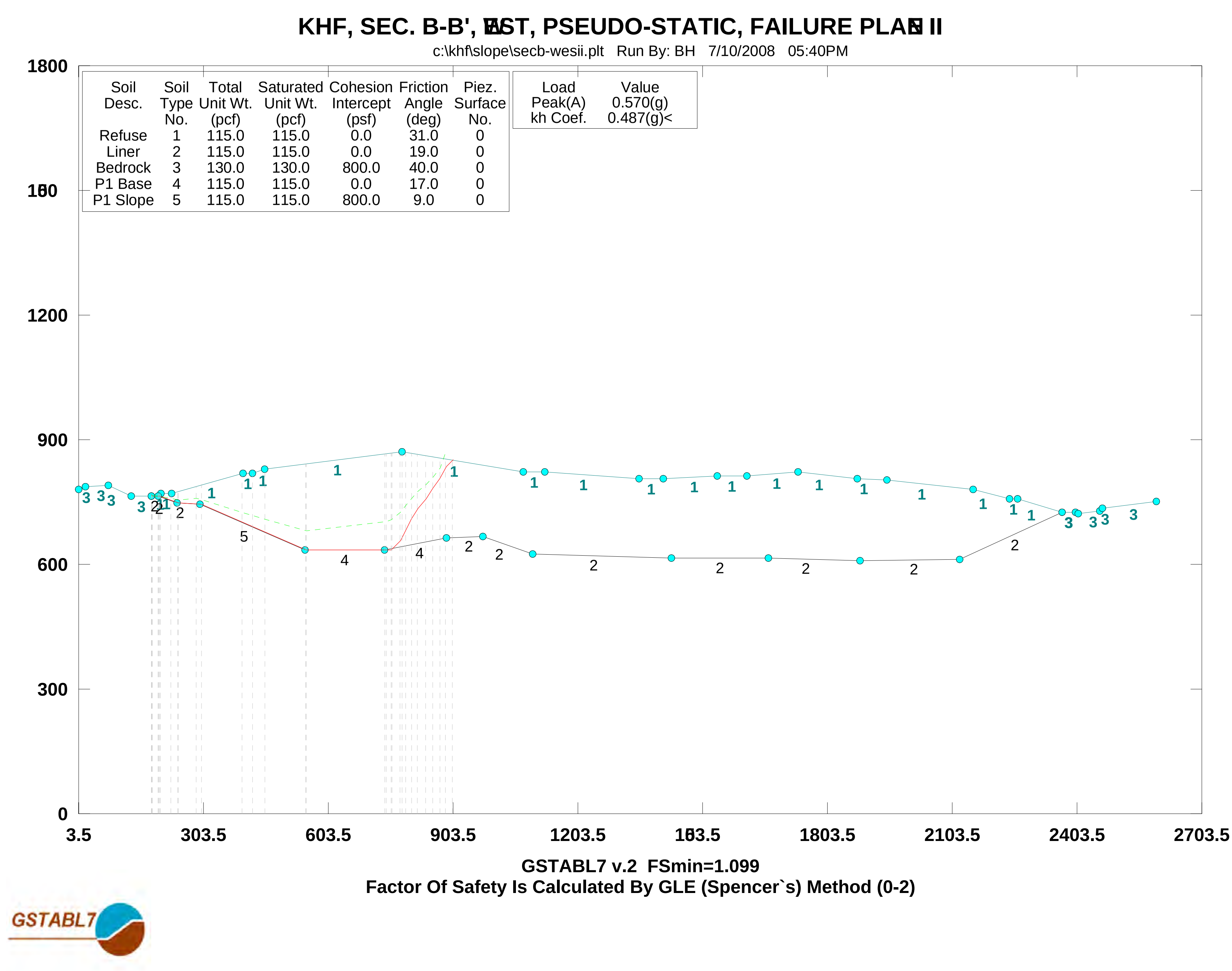
Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0

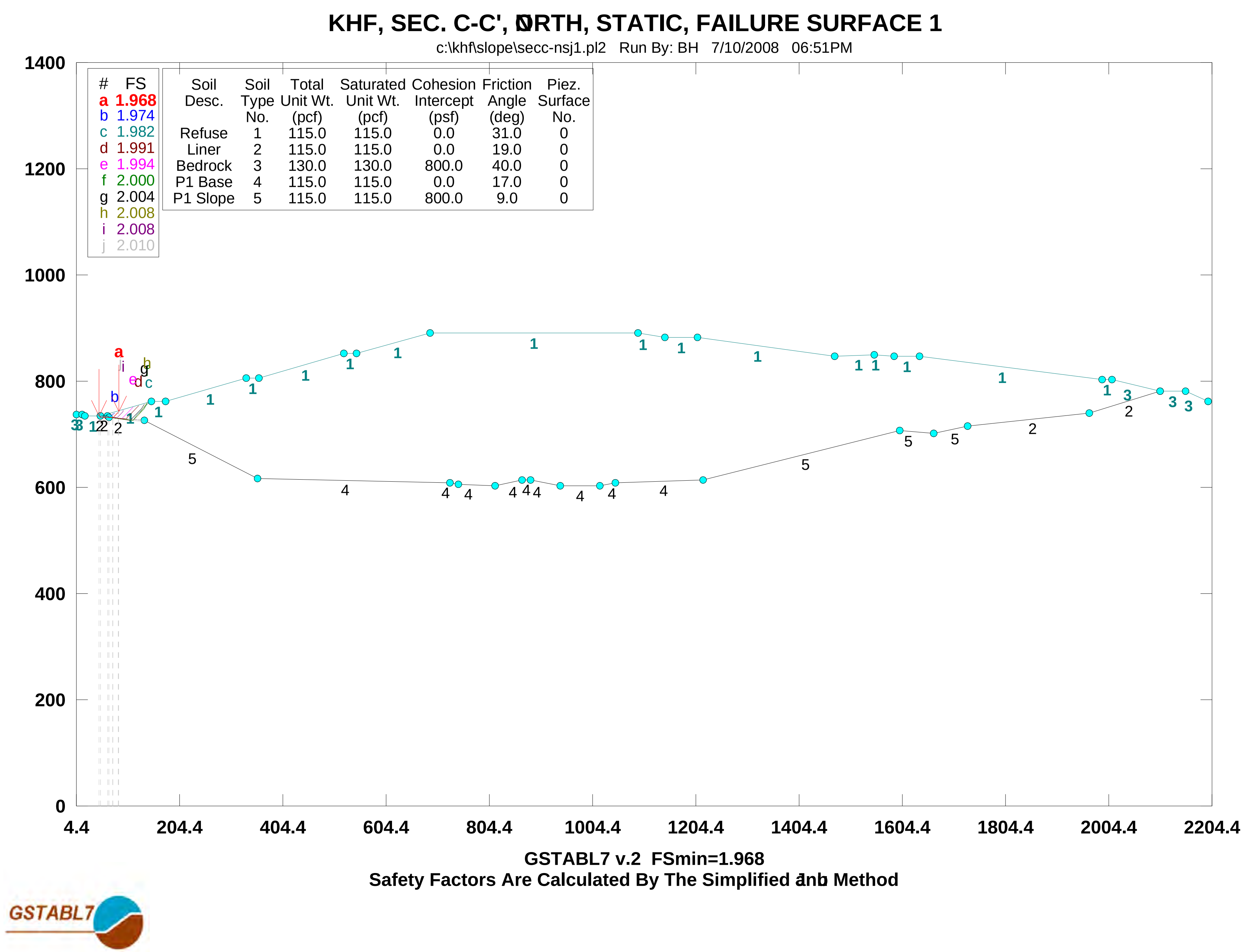


GSTABL7 v.2 FSmin=8.928

Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

GSTABL7

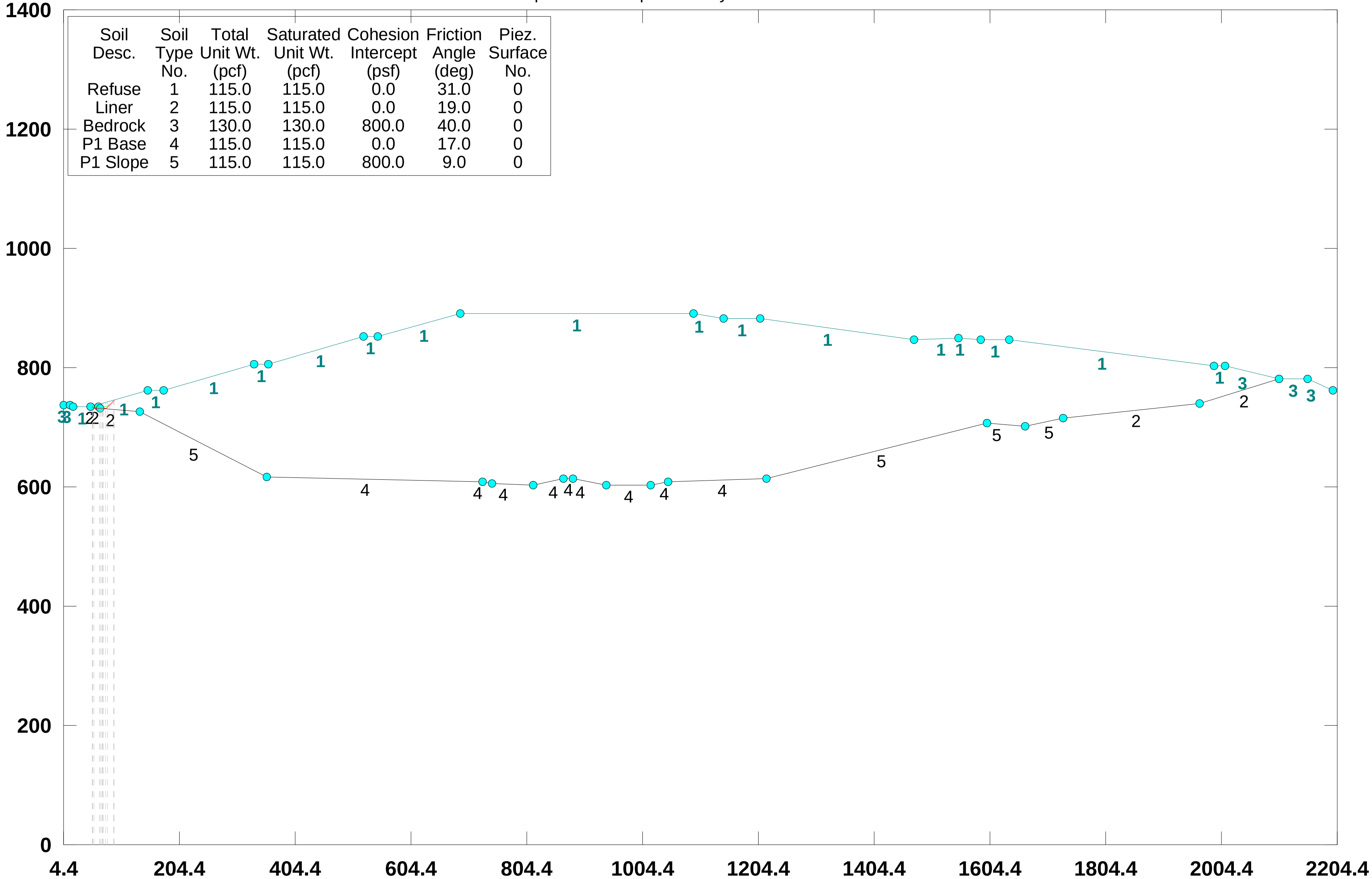

KHF, SEC. B-B', WEST, PSEUDO-STATIC, FAILURE PLANE II
c:\khf\slope\secb-wesii.plt Run By: BH 7/10/2008 05:40PM
Soil Desc. | Soil Type No. | Total Unit Wt. (pcf) | Saturated Unit Wt. (pcf) | Cohesion Intercept (psf) | Friction Angle (deg) | Piez. Surface No.
Refuse 1 115.0 115.0 0.0 31.0 0
Liner 2 115.0 115.0 0.0 19.0 0
Bedrock 3 130.0 130.0 800.0 40.0 0
P1 Base 4 115.0 115.0 0.0 17.0 0
P1 Slope 5 115.0 115.0 800.0 9.0 0
Load Value
Peak(A) 0.570(g)
kh Coef. 0.487(g)<
1800
1500
1200
900
600
300
0
3.5
303.5
603.5
903.5
1203.5
1503.5
1803.5
2103.5
2403.5
2703.5
GSTABL7 v.2 FSmin=1.099
Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)
GSTABL7



KHF, SEC. C-C', ORTH, STATIC, FAILURE SURFACE 1
c:\khf\slope\secc-nsj1.pl2 Run By: BH 7/10/2008 06:51PM
FS
a 1.968
b 1.974
c 1.982
d 1.991
e 1.994
f 2.000
g 2.004
h 2.008
i 2.008
j 2.010
Soil Desc. | Soil Type No. | Total Unit Wt. (pcf) | Saturated Unit Wt. (pcf) | Cohesion Intercept (psf) | Friction Angle (deg) | Piez. Surface No.
Refuse | 1 | 115.0 | 115.0 | 0.0 | 31.0 | 0
Liner | 2 | 115.0 | 115.0 | 0.0 | 19.0 | 0
Bedrock | 3 | 130.0 | 130.0 | 800.0 | 40.0 | 0
P1 Base | 4 | 115.0 | 115.0 | 0.0 | 17.0 | 0
P1 Slope | 5 | 115.0 | 115.0 | 800.0 | 9.0 | 0
0
200
400
600
800
1000
1200
1400
4.4
204.4
404.4
604.4
804.4
1004.4
1204.4
1404.4
1604.4
1804.4
2004.4
2204.4
GSTABL7 v.2 FSmin=1.968
Safety Factors Are Calculated By The Simplified Janbu Method
GSTABL7

KHF, SEC. C-C', NORTH, STATIC, FAILURE SURFACE 1

c:\khf\slope\secc-nss1.plt Run By: BH 7/10/2008 06:52PM



GSTABL7 v.2 FSmin=3.08

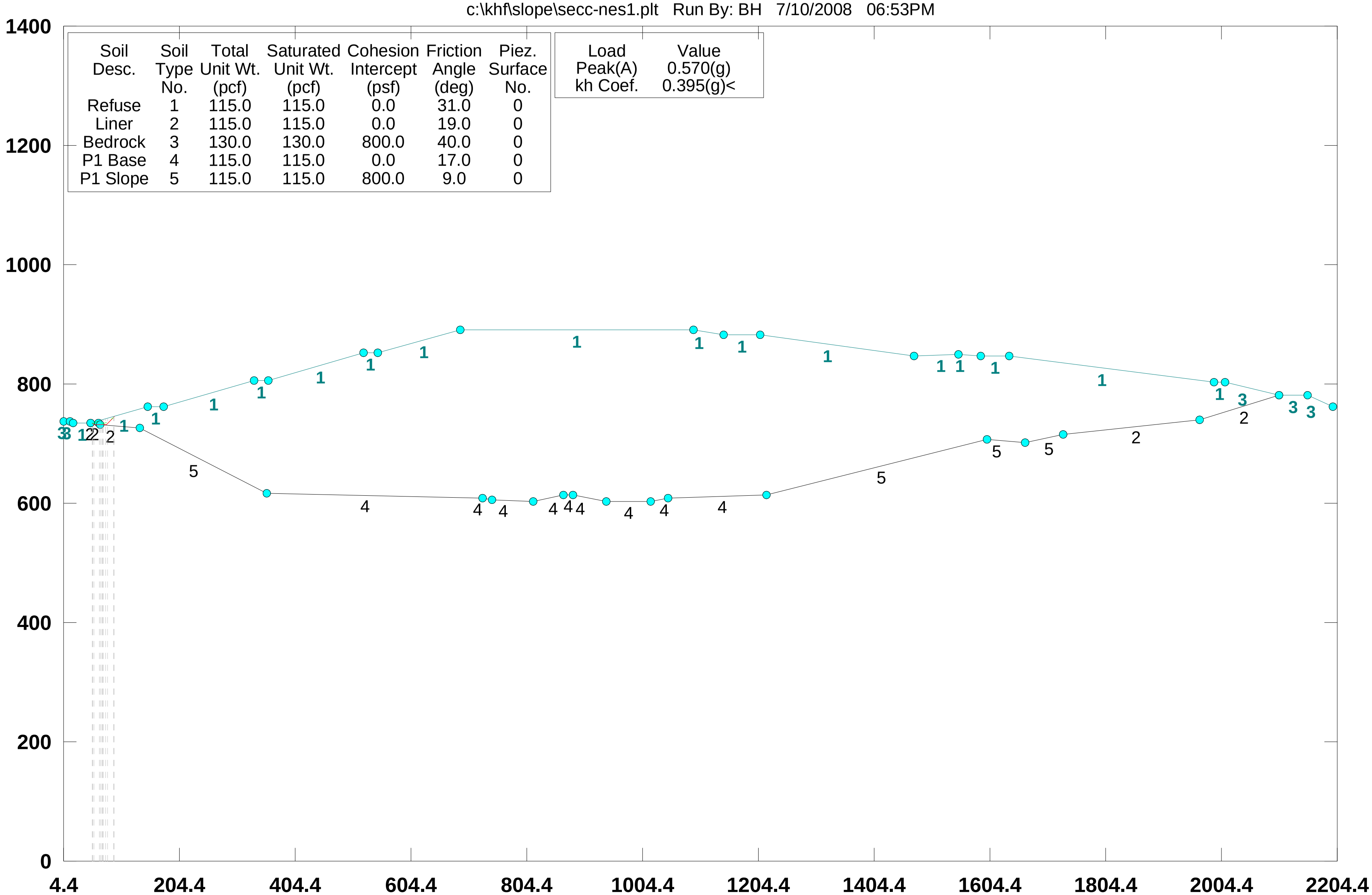
Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

KHF, SEC. C-C', NORTH, PSEUDO-STATIC, FAILURE SURFACE 1

c:\khf\slope\secc-nes1.plt Run By: BH 7/10/2008 06:53PM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0

Load	Value
Peak(A)	0.570(g)
kh Coef.	0.395(g)<

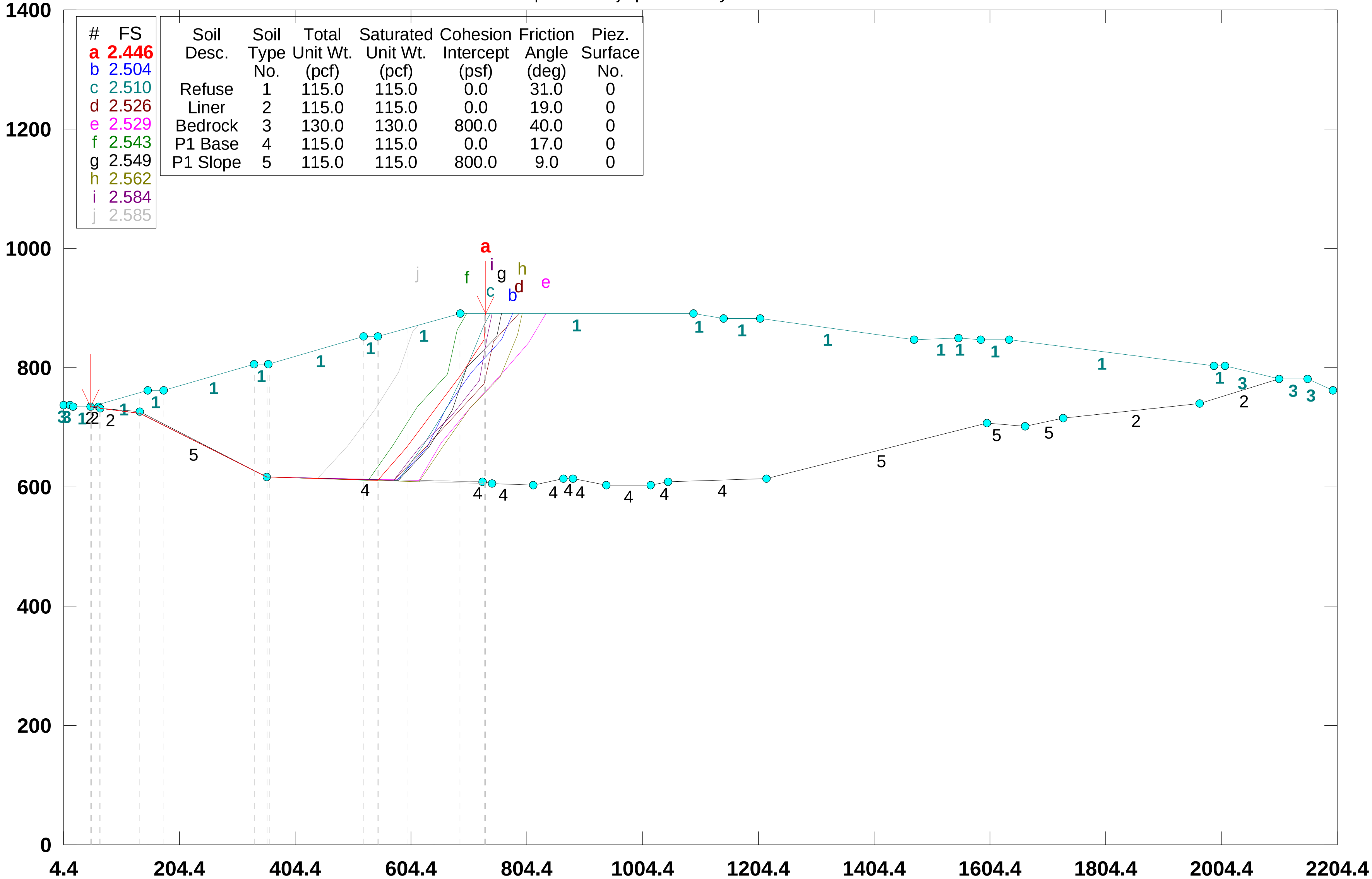


GSTABL7 v.2 FSmin=1.002

Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

KHF, SEC. C-C', NORTH, STATIC, FAILURE SURFACE 2

c:\khf\slope\secc-nsj2.pl2 Run By: BH 7/11/2008 02:51PM



#	FS
a	**2.446**
b	2.504
c	2.510
d	2.526
e	2.529
f	2.543
g	2.549
h	2.562
i	2.584
j	2.585

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0

GSTABL7 v.2 FSmin=2.446

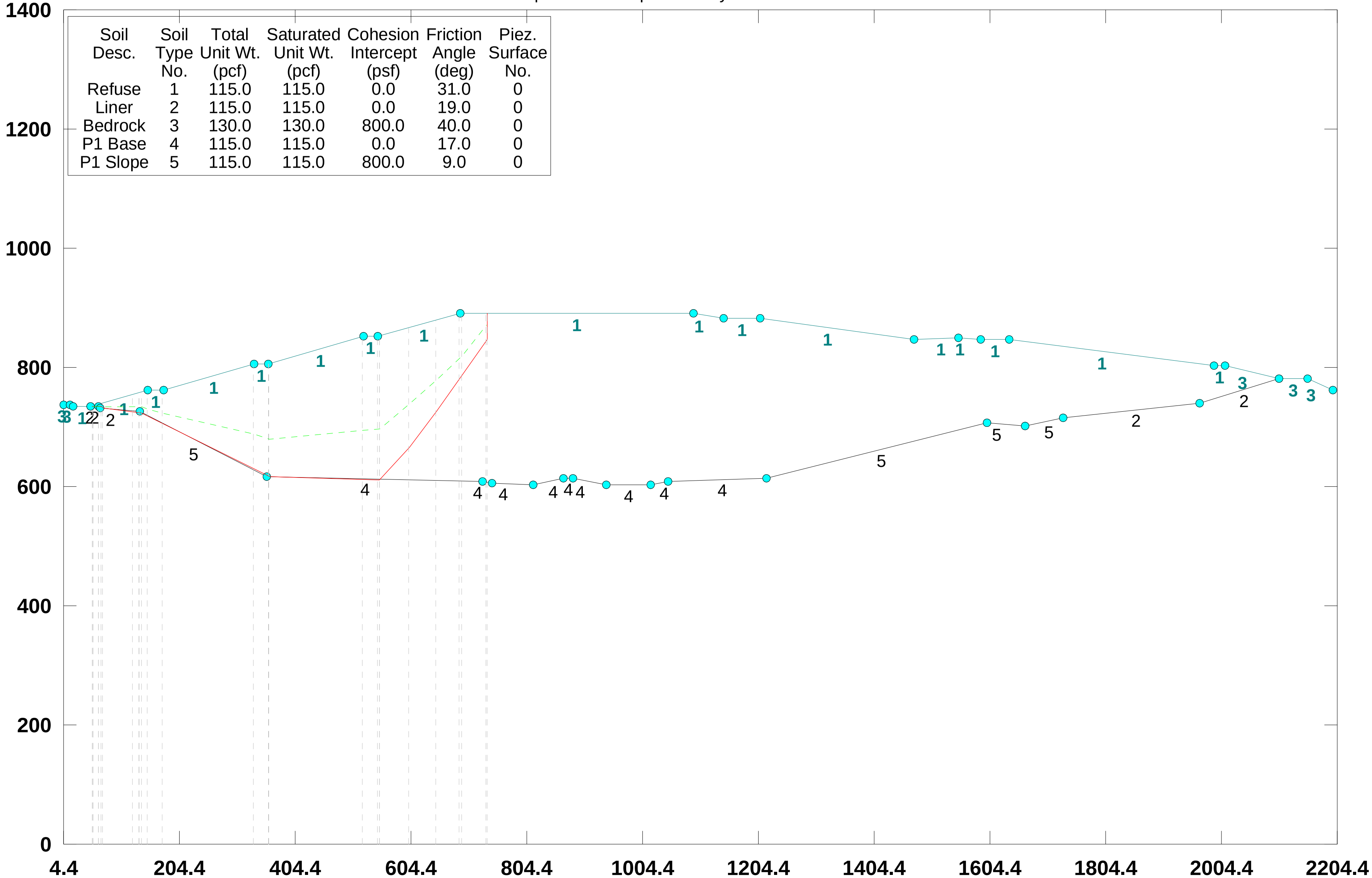
Safety Factors Are Calculated By The Simplified Janbu Method

GSTABL7

KHF, SEC. C-C', NORTH, STATIC, FAILURE SURFACE 2

c:\khf\slope\secc-nss2.plt   Run By: BH   7/11/2008   02:53PM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0



GSTABL7 v.2 FSmin=4.346

Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

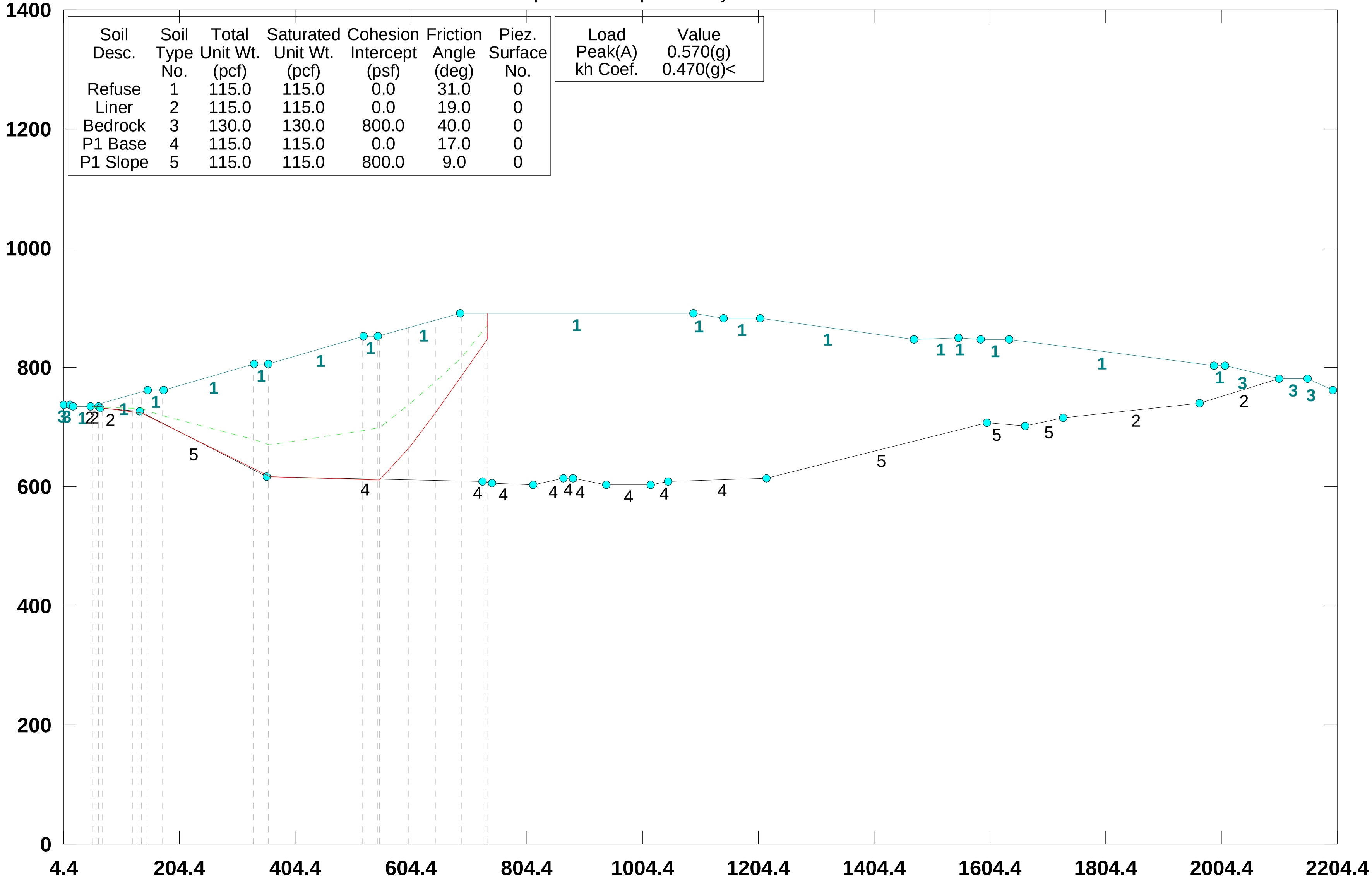
GSTABL7

KHF, SEC. C-C', NORTH, PSEUDO-STATIC, FAILURE SURFACE 2

c:\khf\slope\secc-nes2.plt   Run By: BH   7/11/2008   02:54PM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0

Load	Value
Peak(A)	0.570(g)
kh Coef.	0.470(g)<



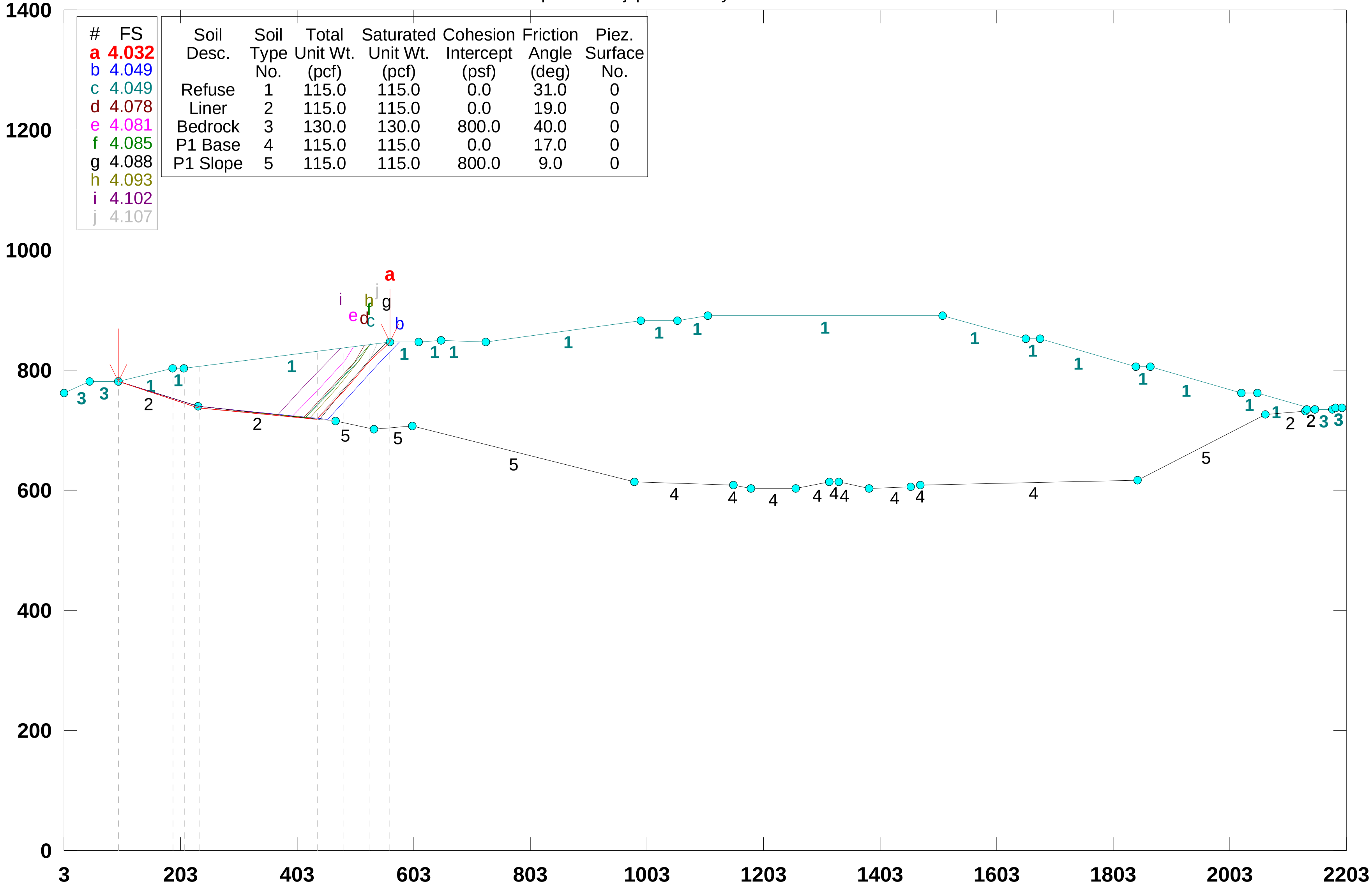
GSTABL7 v.2 FSmin=1.018

Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

GSTABL7

KHF, SEC. C-C', SOUTH, STATIC, FAILURE SURFACE I

c:\khf\slope\secc-ssji.pl2 Run By: BH 7/11/2008 02:25PM



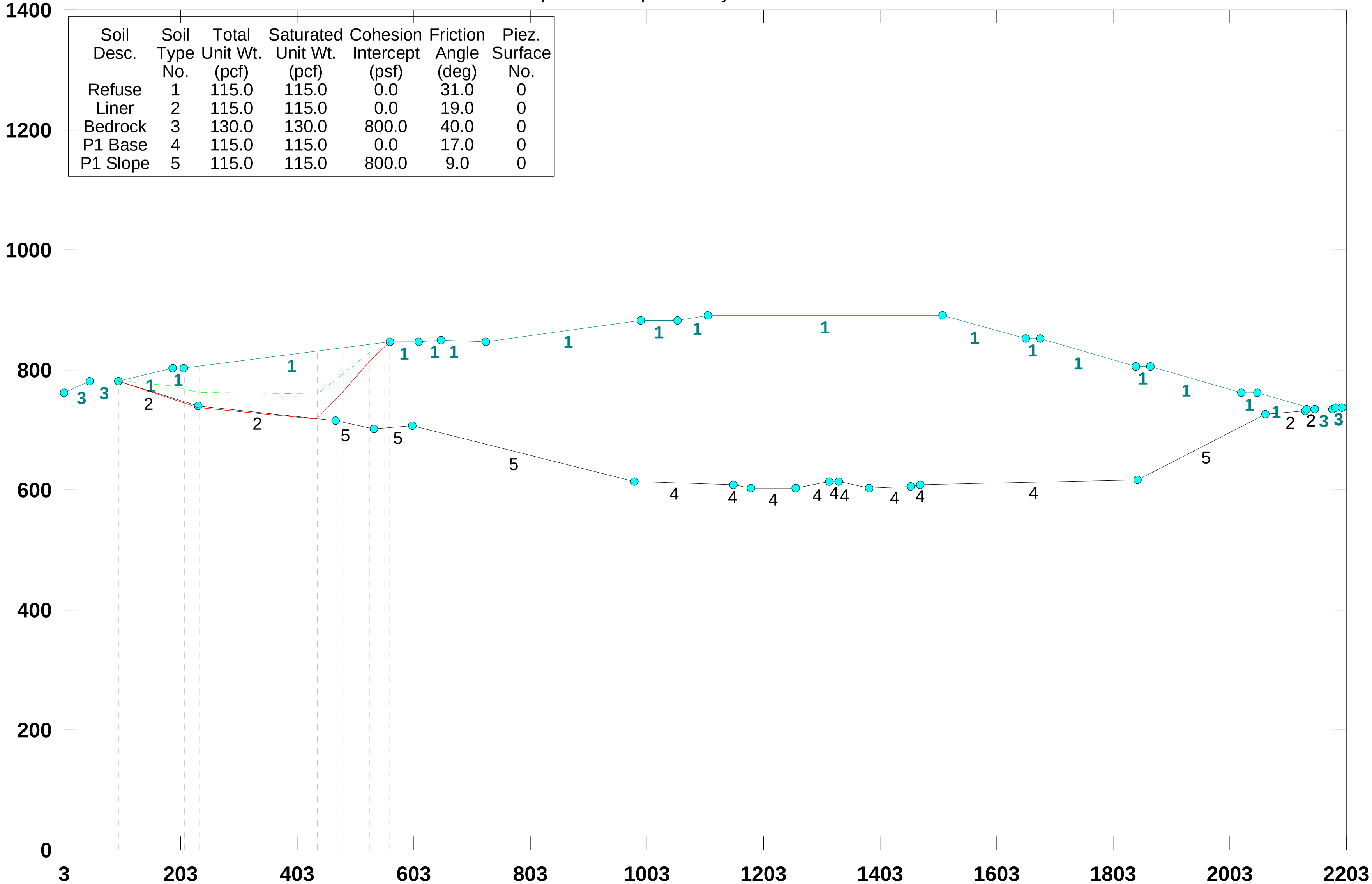
GSTABL7 v.2 FSmin=4.032

Safety Factors Are Calculated By The Simplified Janbu Method

KHF, SEC. C-C', SOUTH, STATIC, FAILURE SURFACE I

c:\khf\slope\secc-sssi.plt   Run By: BH   7/11/2008   02:26PM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0

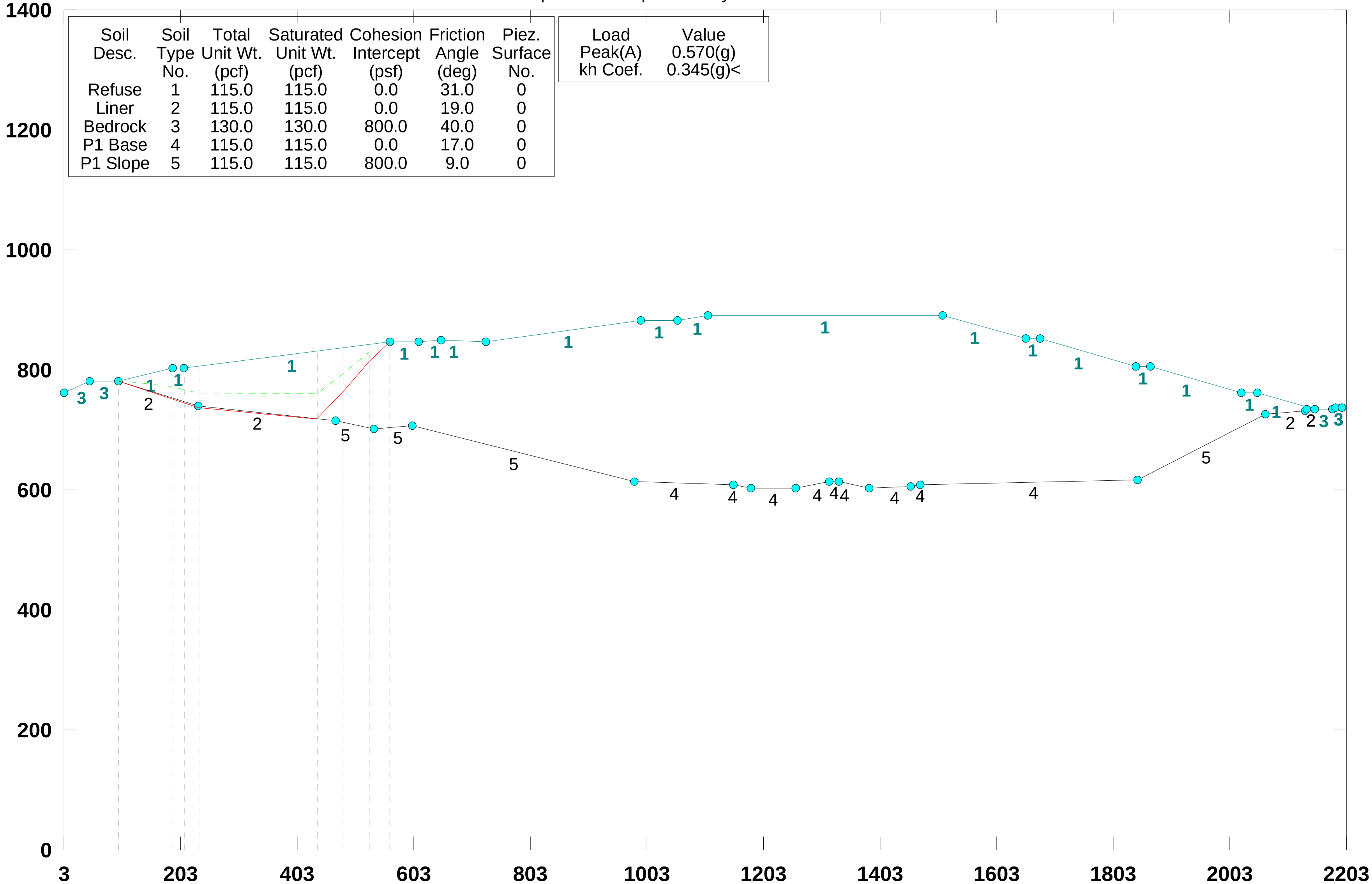


GSTABL7 v.2 FSmin=4.920
Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

GSTABL7

KHF, SEC. C-C', SOUTH, PSEUDO-STATIC, FAILURE SURFACE I

c:\khf\slope\secc-sesi.plt Run By: BH 7/11/2008 02:27PM



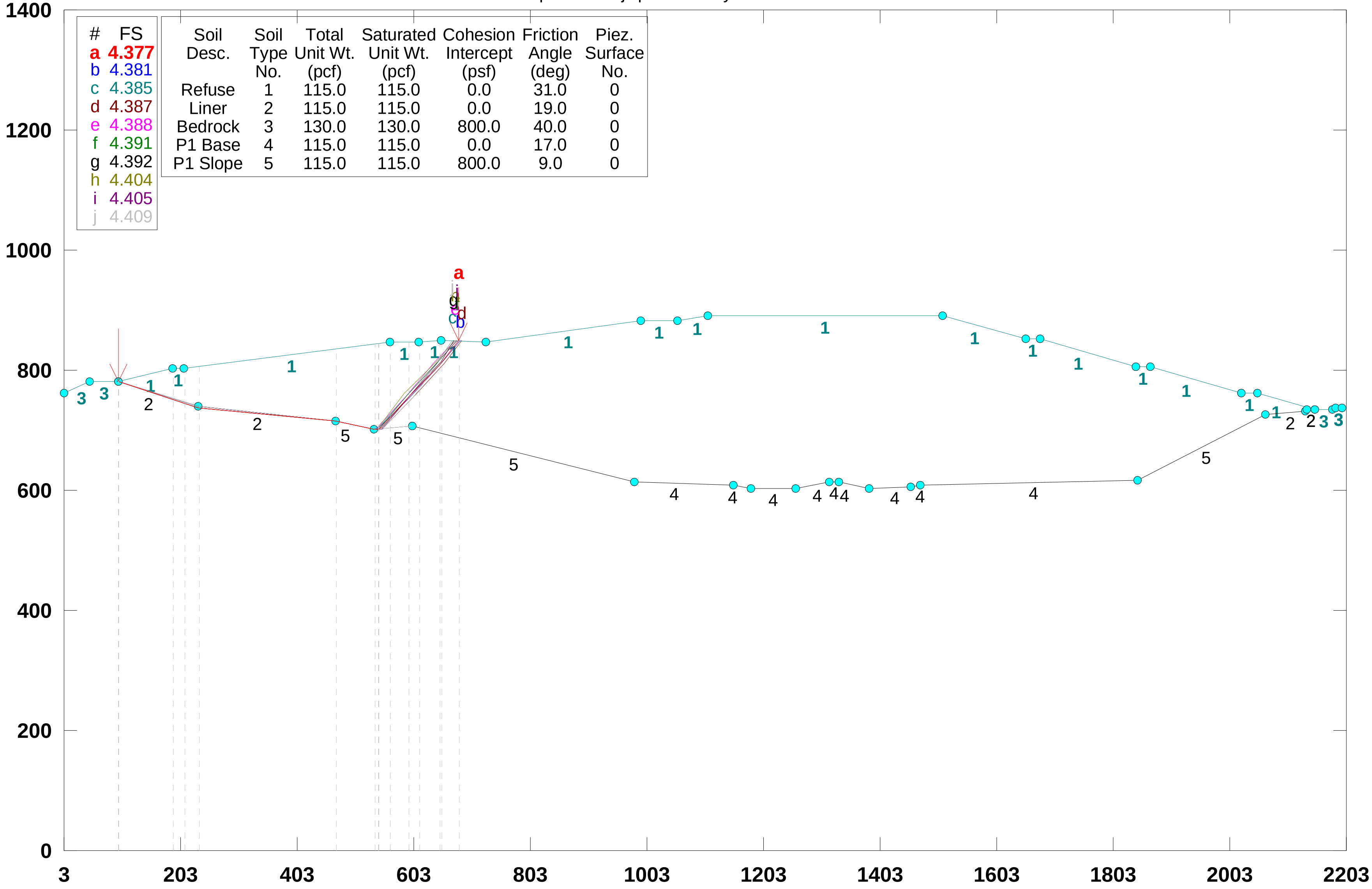
GSTABL7 v.2 FSmin=1.002

Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

GSTABL7

KHF, SEC. C-C', SOUTH, STATIC, FAILURE SURFACE II

c:\khf\slope\secc-ssjii.pl2 Run By: BH 7/11/2008 02:29PM



Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0

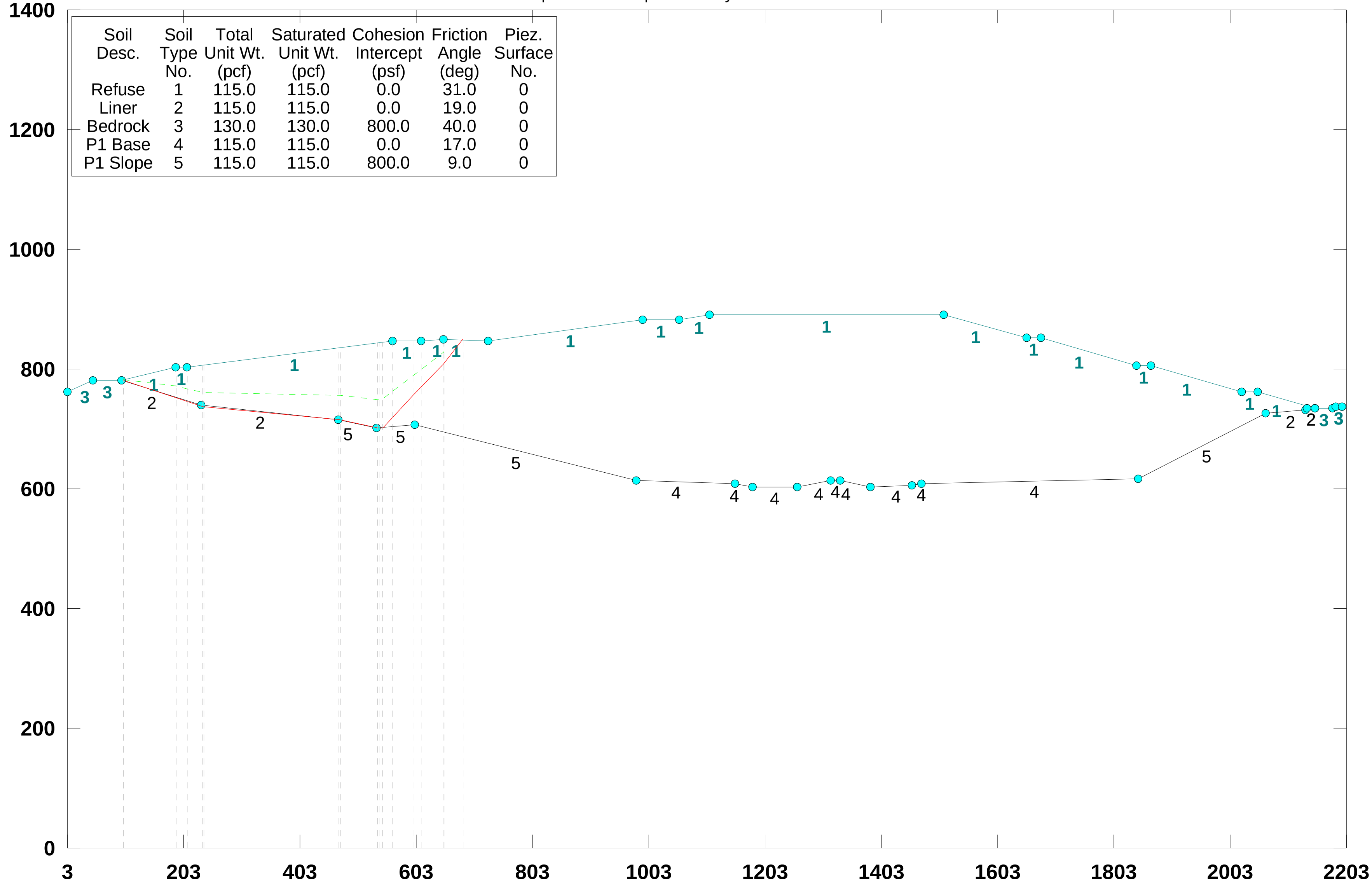
GSTABL7 v.2 FSmin=4.377

Safety Factors Are Calculated By The Simplified Janbu Method

KHF, SEC. C-C', SOUTH, STATIC, FAILURE SURFACE II

c:\khf\slope\secc-sssii.plt Run By: BH 7/11/2008 02:30PM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0



GSTABL7 v.2 FSmin=5.639

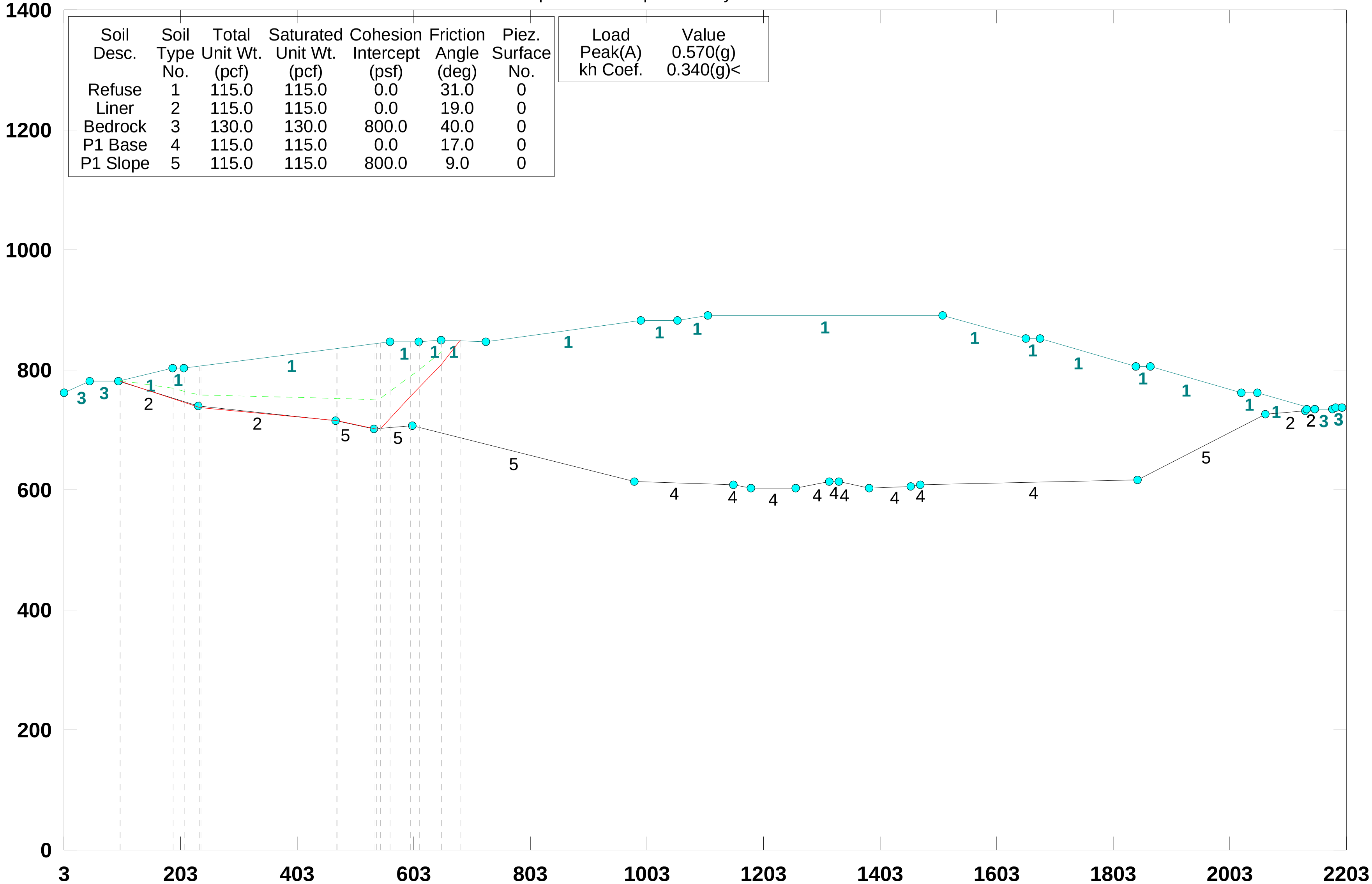
Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

KHF, SEC. C-C', SOUTH, PSEUDO-STATIC, FAILURE SURFACE II

c:\khf\slope\secc-sesii.plt Run By: BH 7/11/2008 02:32PM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0

Load	Value
Peak(A)	0.570(g)
kh Coef.	0.340(g)<



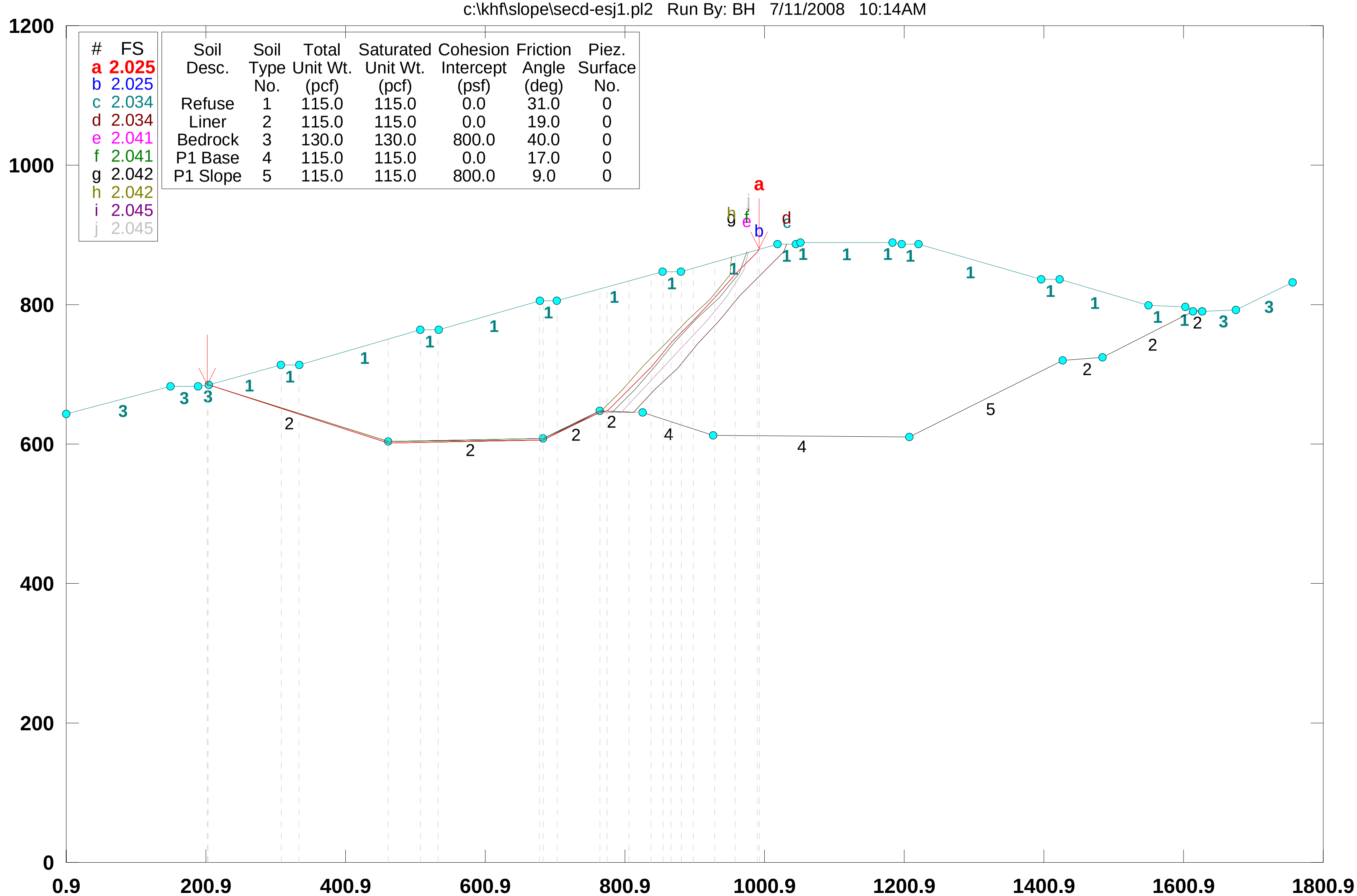
GSTABL7 v.2 FSmin=1.05

Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

GSTABL7

KHF, SEC. D-D', EAST, STATIC, FAILURE SURFACE 1

c:\khf\slope\secd-esj1.pl2   Run By: BH   7/11/2008   10:14AM



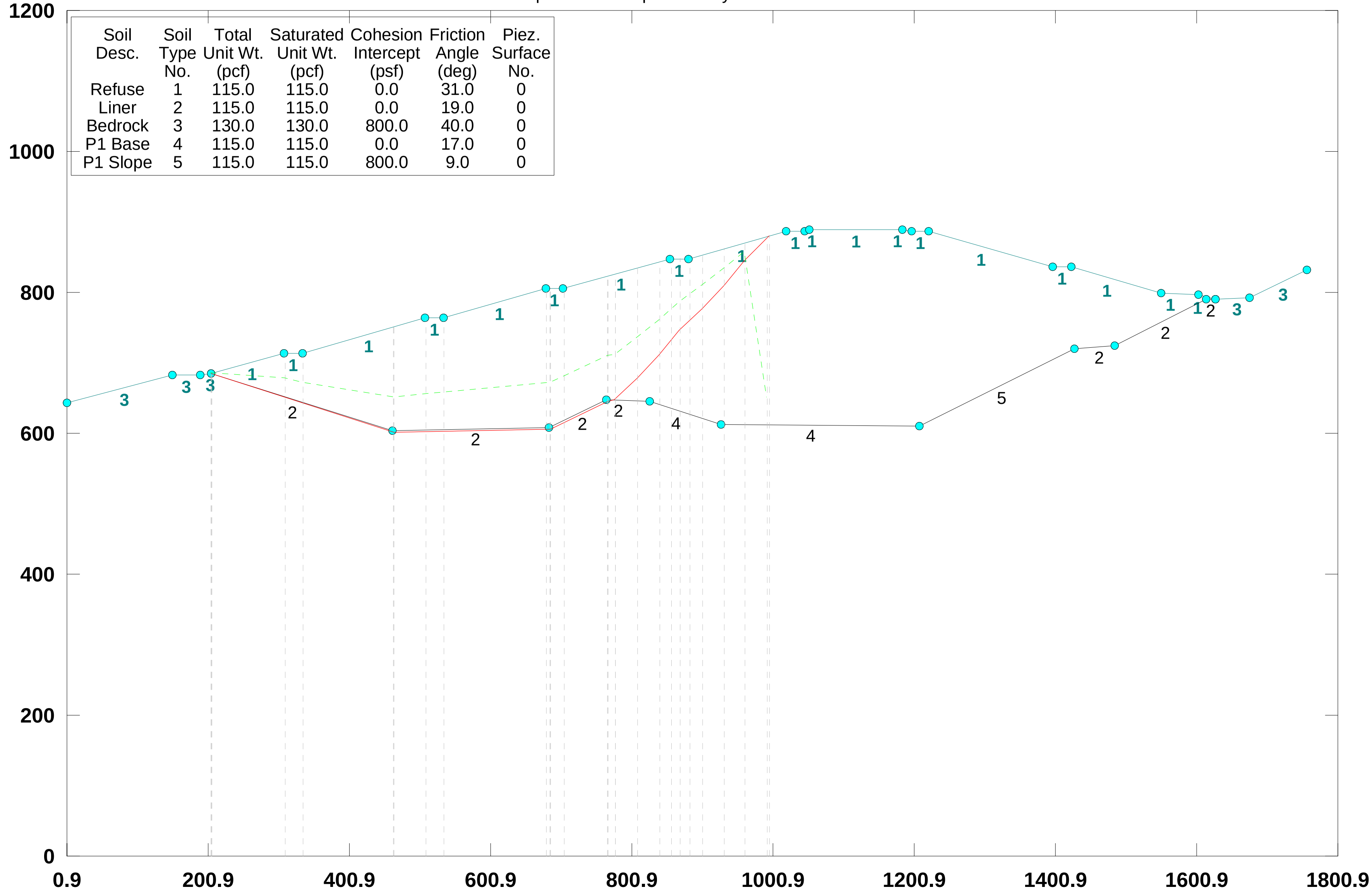
GSTABL7 v.2 FSmin=2.025
Safety Factors Are Calculated By The Simplified Janbu Method

GSTABL7

KHF, SEC. D-D', EAST, STATIC, FAILURE SURFACE 1

c:\khf\slope\secd-ess1.plt   Run By: BH   7/11/2008   10:15AM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0



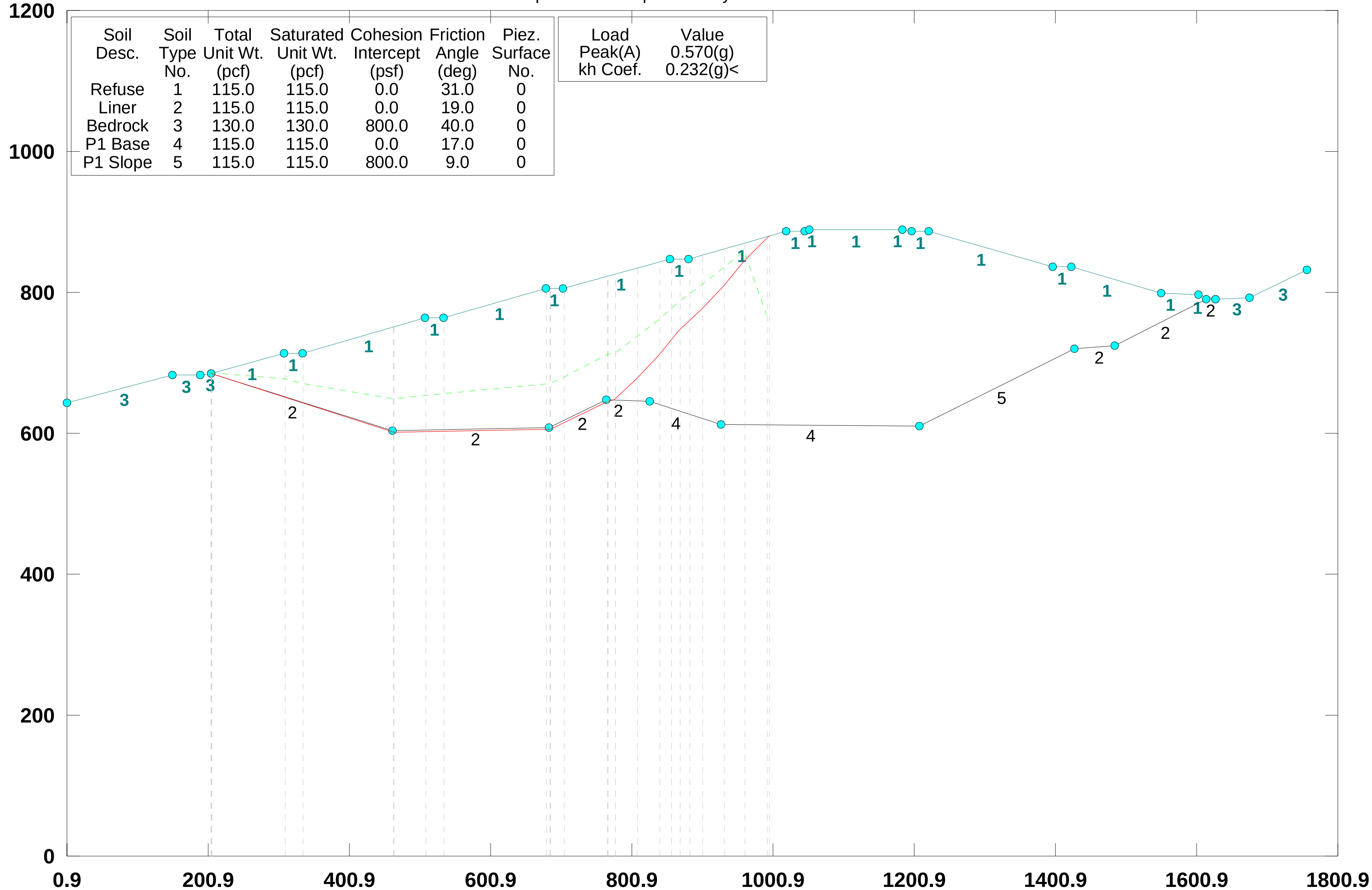
GSTABL7 v.2 FSmin=2.337
Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

KHF, SEC. D-D', EAST, PSEUDO-STATIC, FAILURE SURFACE 1

c:\khf\slope\secd-ees1.plt   Run By: BH   7/11/2008   10:16AM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0

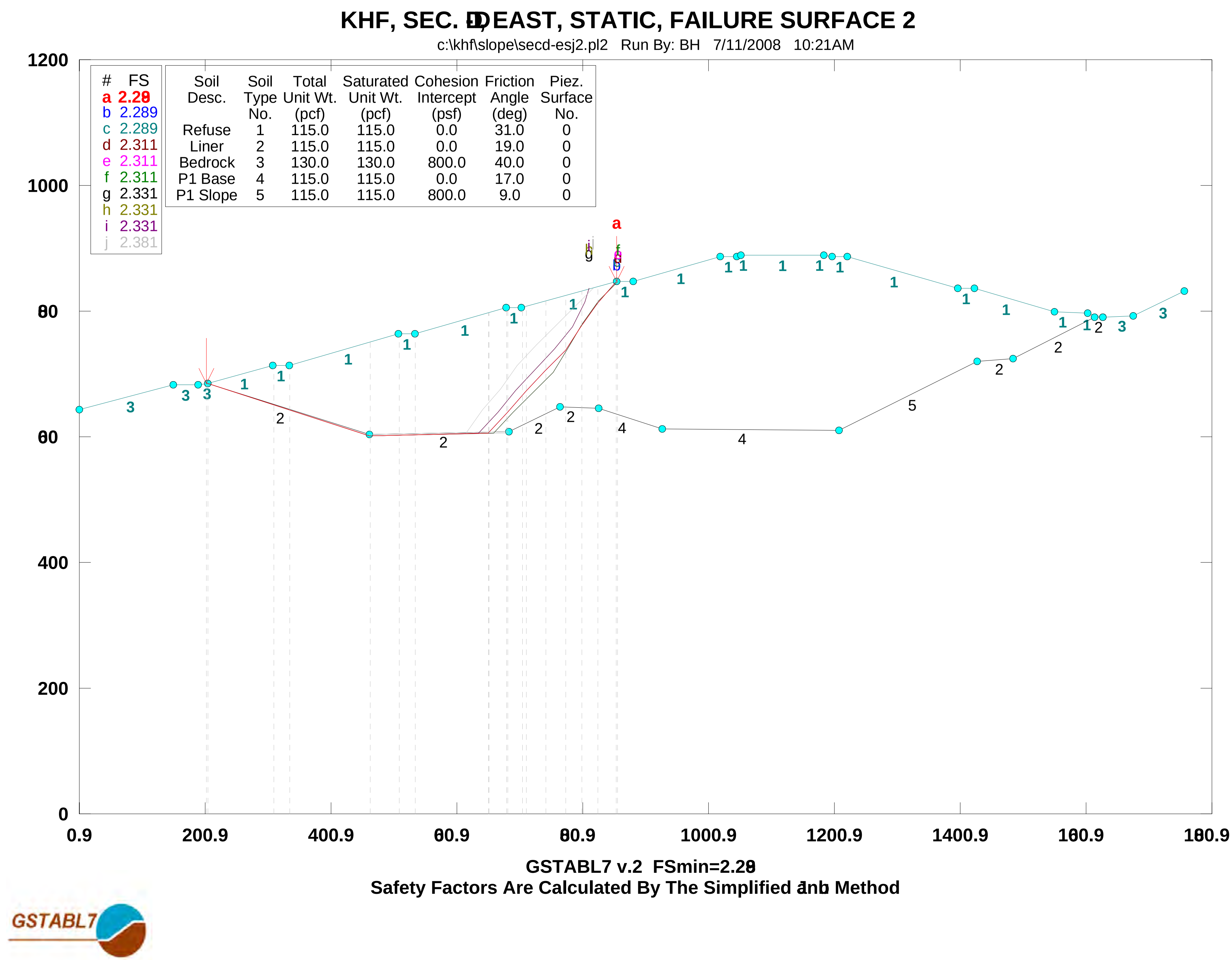
Load	Value
Peak(A)	0.570(g)
kh Coef.	0.232(g)<



GSTABL7 v.2 FSmin=1.004

Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

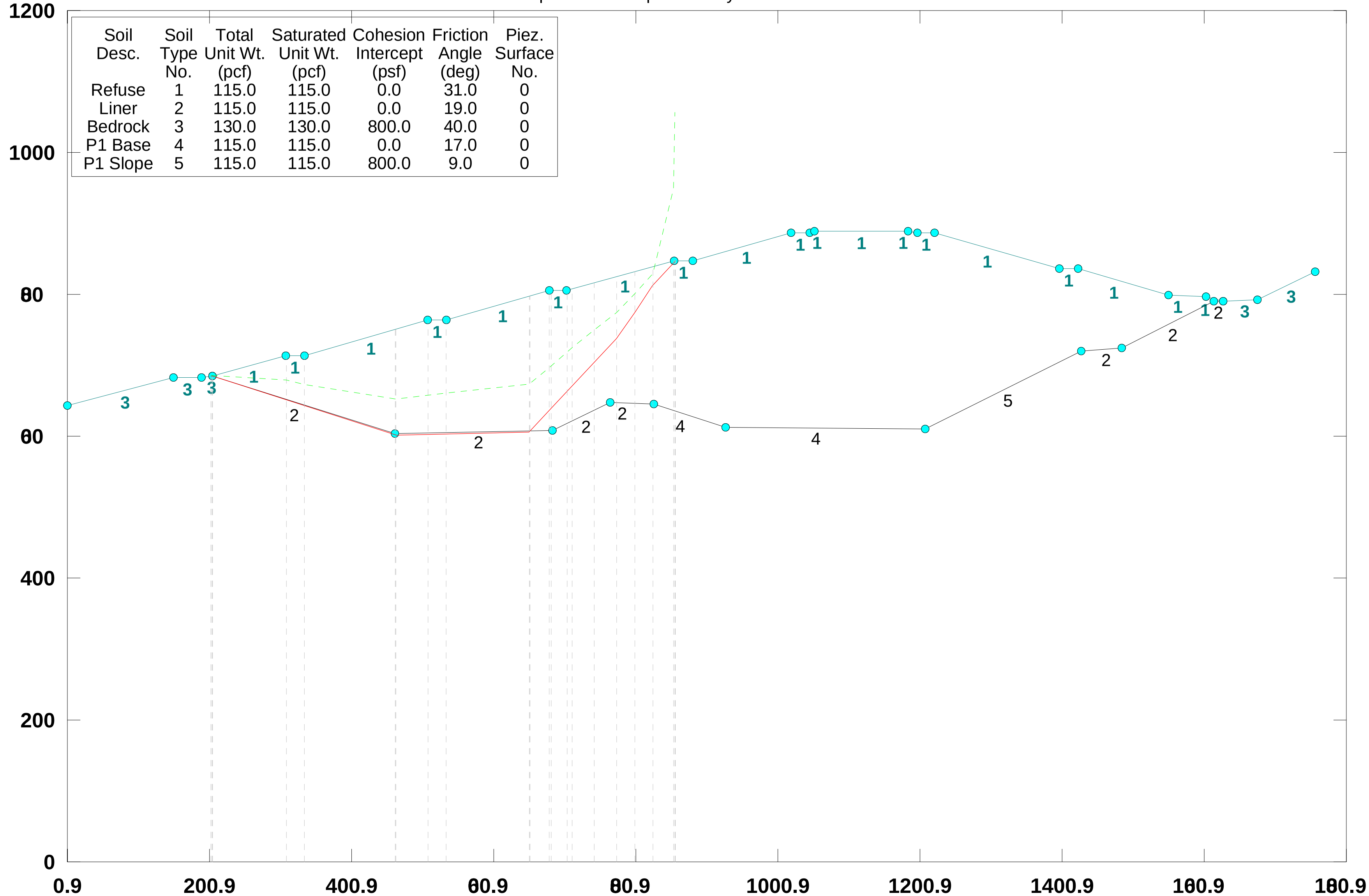
GSTABL7



KHF, SEC. D, EAST, STATIC, FAILURE SURFACE 2
c:\khf\slope\secd-esj2.pl2 Run By: BH 7/11/2008 10:21AM
FS
a 2.28
b 2.289
c 2.289
d 2.311
e 2.311
f 2.311
g 2.331
h 2.331
i 2.331
j 2.381
Soil Desc. | Soil Type No. | Total Unit Wt. (pcf) | Saturated Unit Wt. (pcf) | Cohesion Intercept (psf) | Friction Angle (deg) | Piez. Surface No.
Refuse 1 115.0 115.0 0.0 31.0 0
Liner 2 115.0 115.0 0.0 19.0 0
Bedrock 3 130.0 130.0 800.0 40.0 0
P1 Base 4 115.0 115.0 0.0 17.0 0
P1 Slope 5 115.0 115.0 800.0 9.0 0
1200
1000
80
60
400
200
0
0.9
200.9
400.9
60.9
80.9
1000.9
1200.9
1400.9
160.9
180.9
GSTABL7 v.2 FSmin=2.28
Safety Factors Are Calculated By The Simplified Janbu Method
GSTABL7

KHF, SEC. D, EAST, STATIC, FAILURE SURFACE 2

c:\khf\slope\secd-ess2.plt Run By: BH 7/11/2008 10:24AM

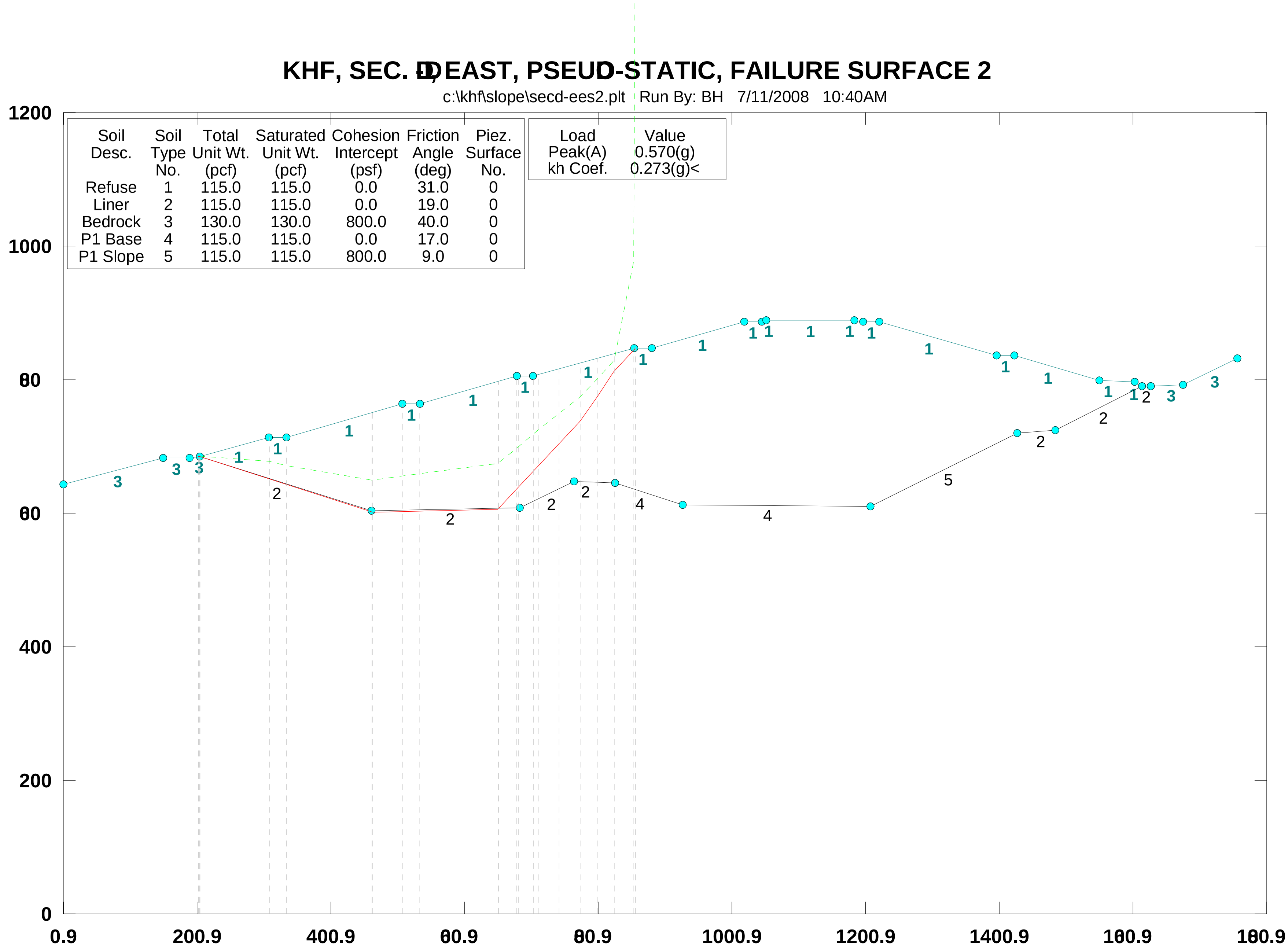


GSTABL7 v.2 FSmin=2.87

Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

KHF, SEC. D, EAST, PSEUD-STATIC, FAILURE SURFACE 2

c:\khf\slope\secd-ees2.plt Run By: BH 7/11/2008 10:40AM

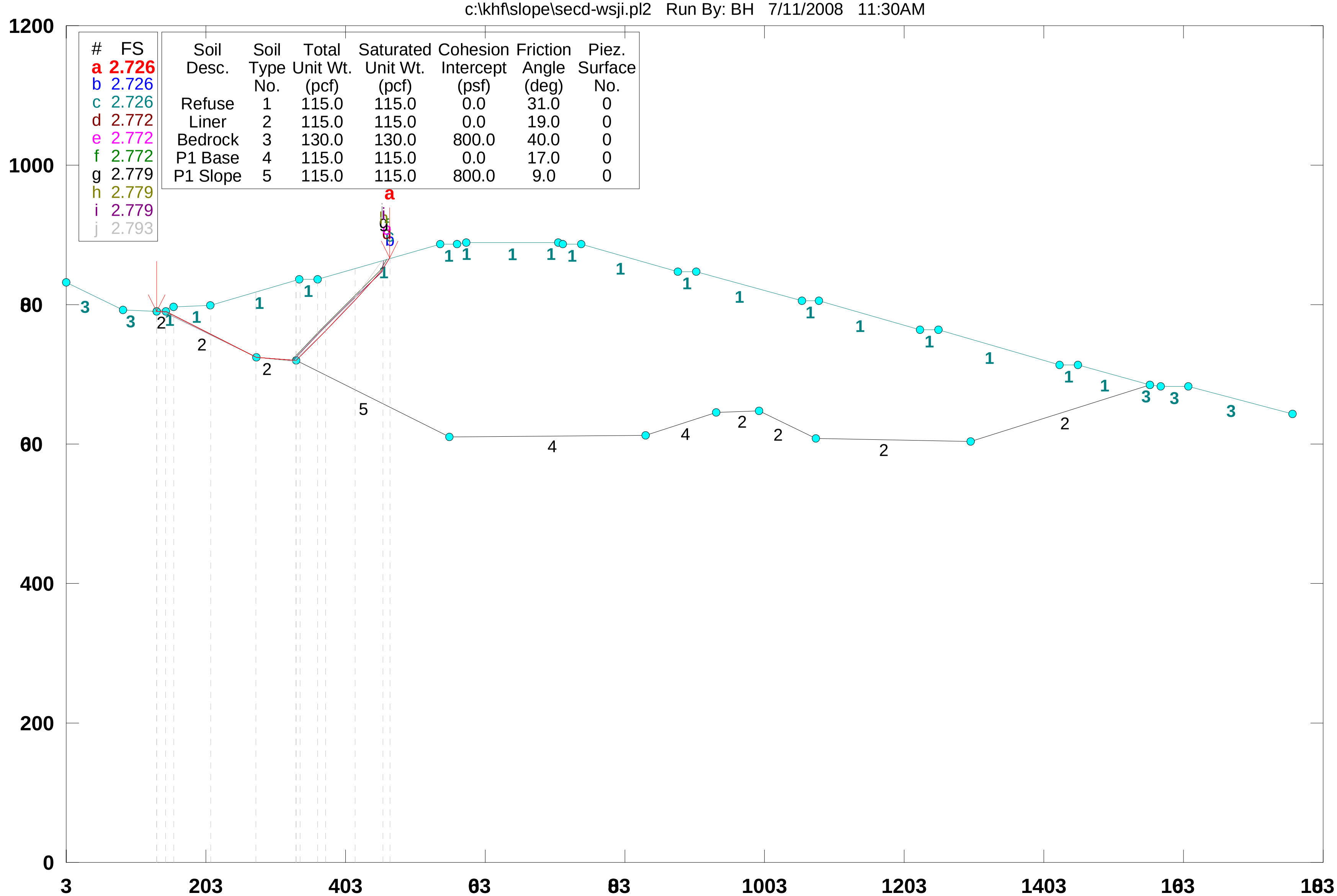


GSTABL7 v.2 FSmin=1.025

Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

KHF, SEC. D, WEST, STATIC, FAILURE PLANE I

c:\khf\slope\secd-wsji.pl2 Run By: BH 7/11/2008 11:30AM



GSTABL7 v.2 FSmin=2.726

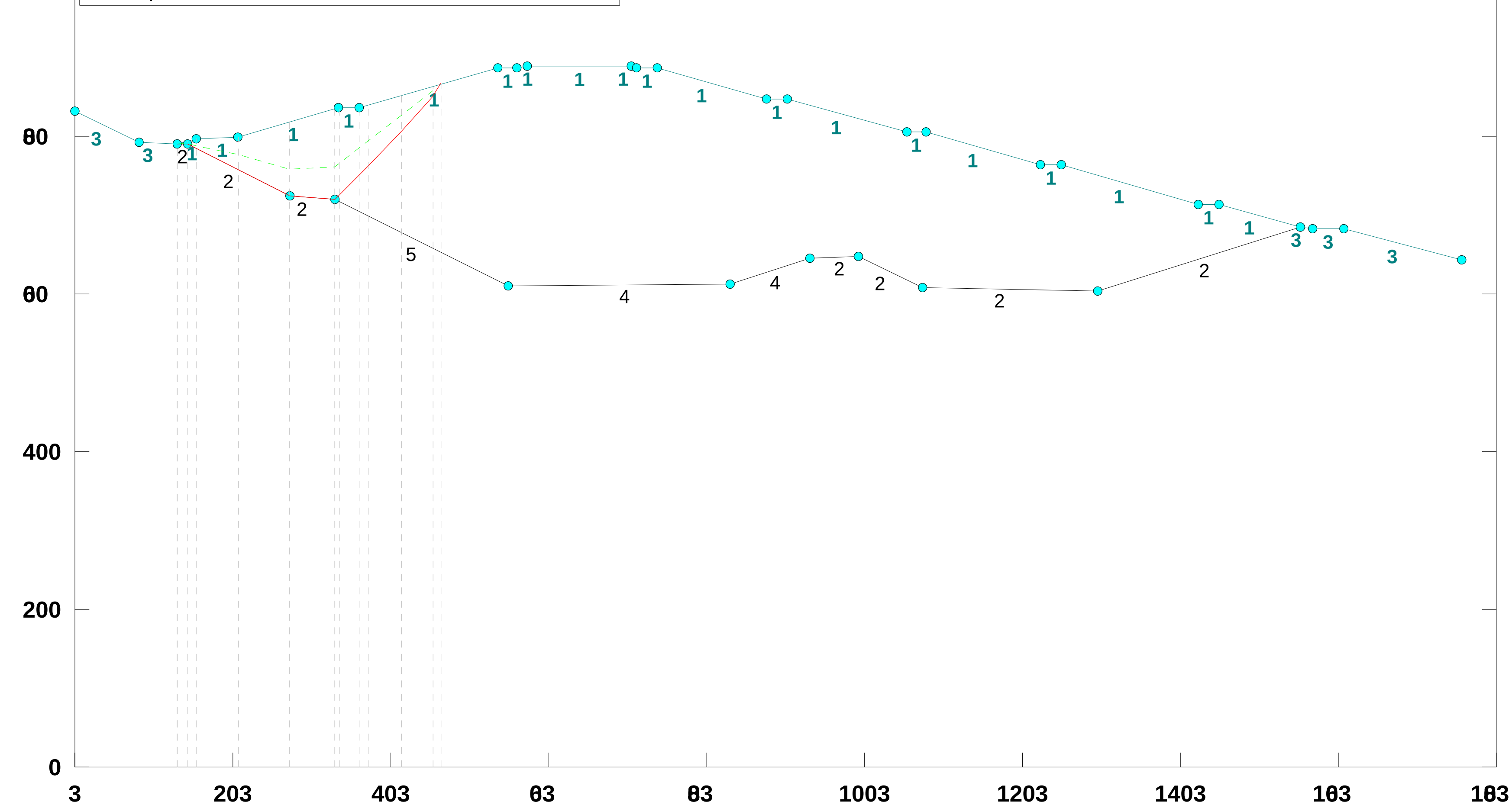
Safety Factors Are Calculated By The Simplified Janbu Method

GSTABL7

KHF, SEC. D, WEST, STATIC, FAILURE SURFACE I

c:\khf\slope\secd-wssi.plt Run By: BH 7/11/2008 11:35AM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0



GSTABL7 v.2 FSmin=3.8

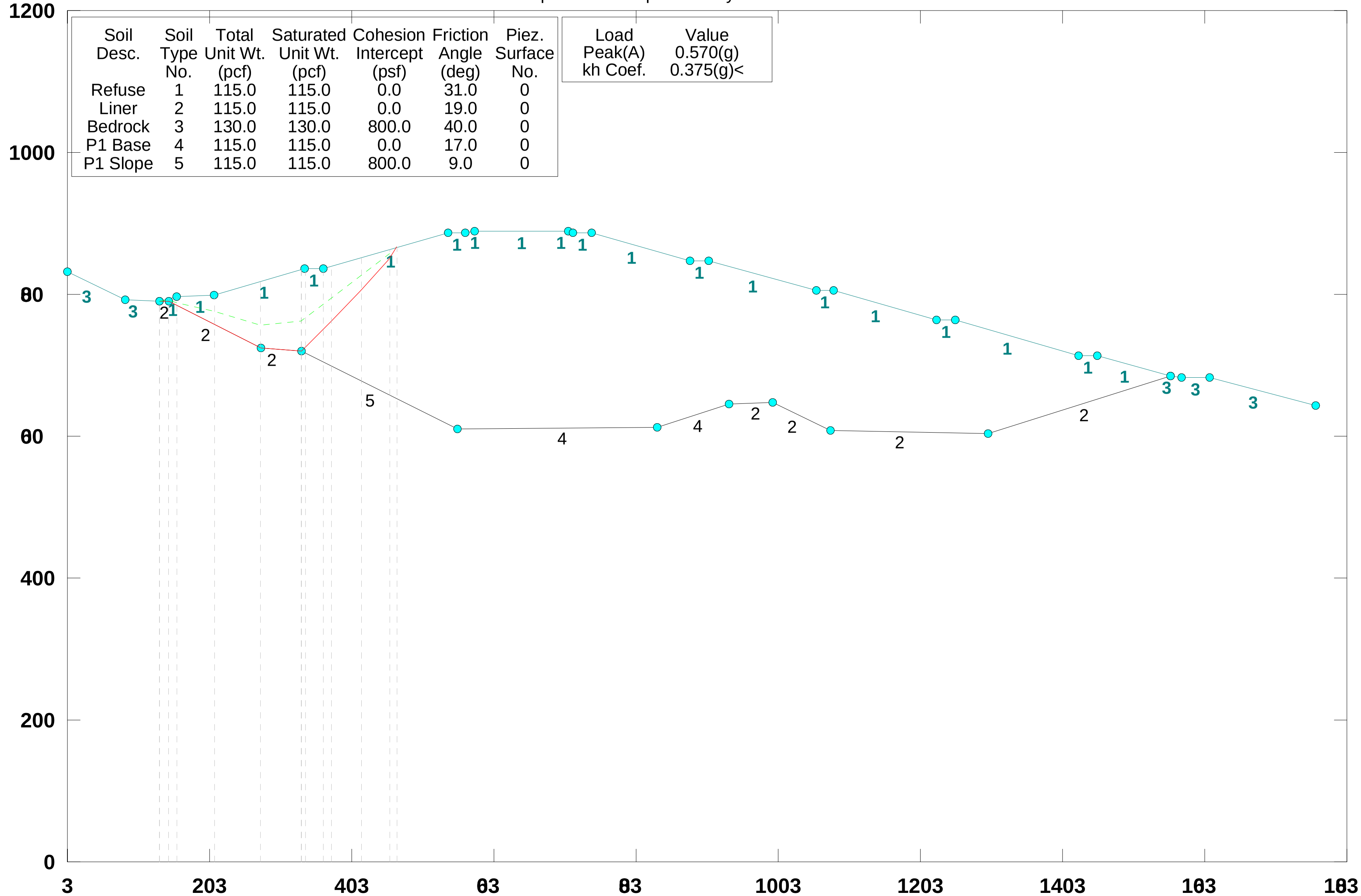
Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

KHF, SEC. D, WEST, PSEUD-STATIC, FAILURE SURFACE I

c:\khf\slope\secd-wesi.plt Run By: BH 7/11/2008 11:36AM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0

Load	Value
Peak(A)	0.570(g)
kh Coef.	0.375(g)<



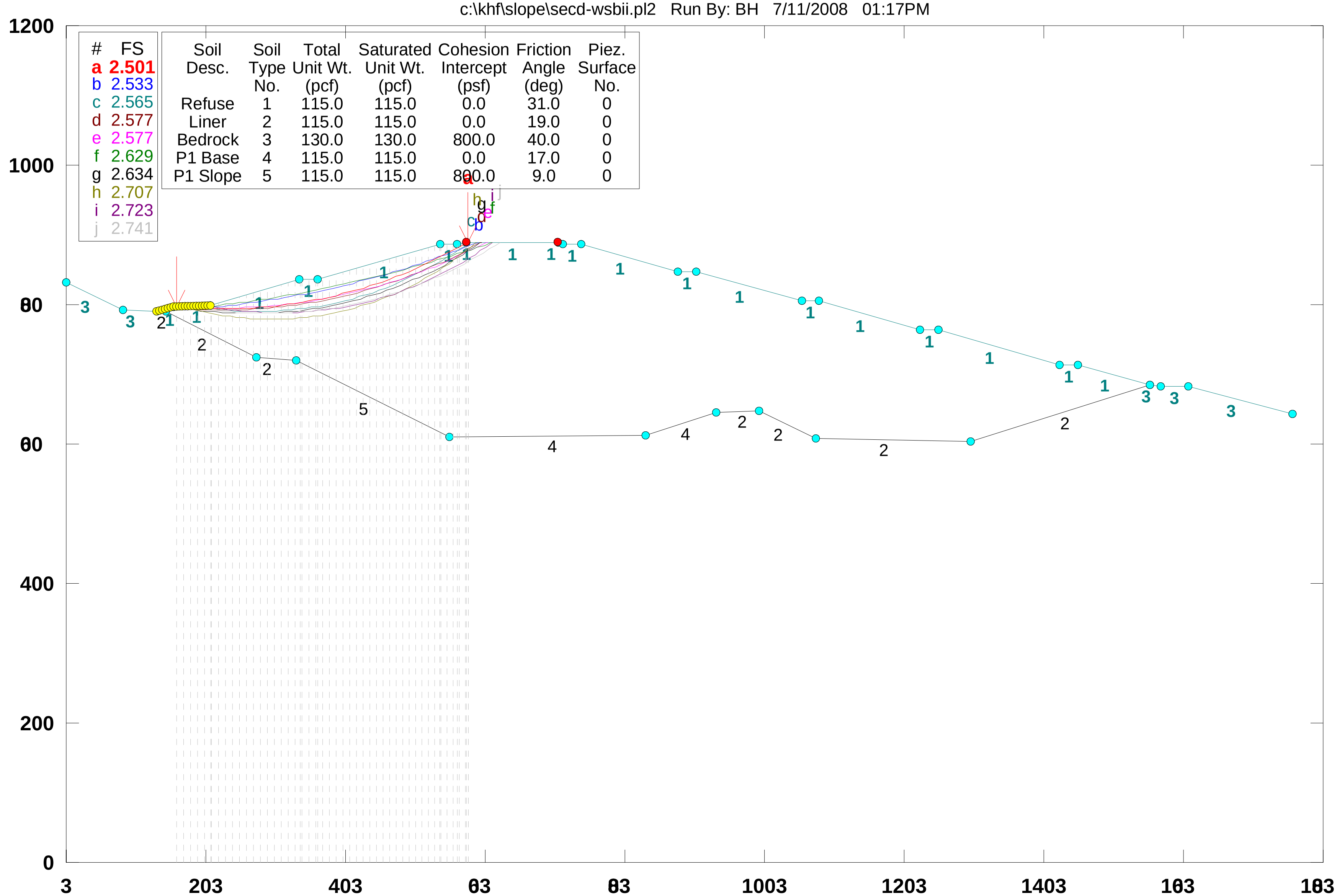
GSTABL7 v.2 FSmin=1.009

Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

GSTABL7

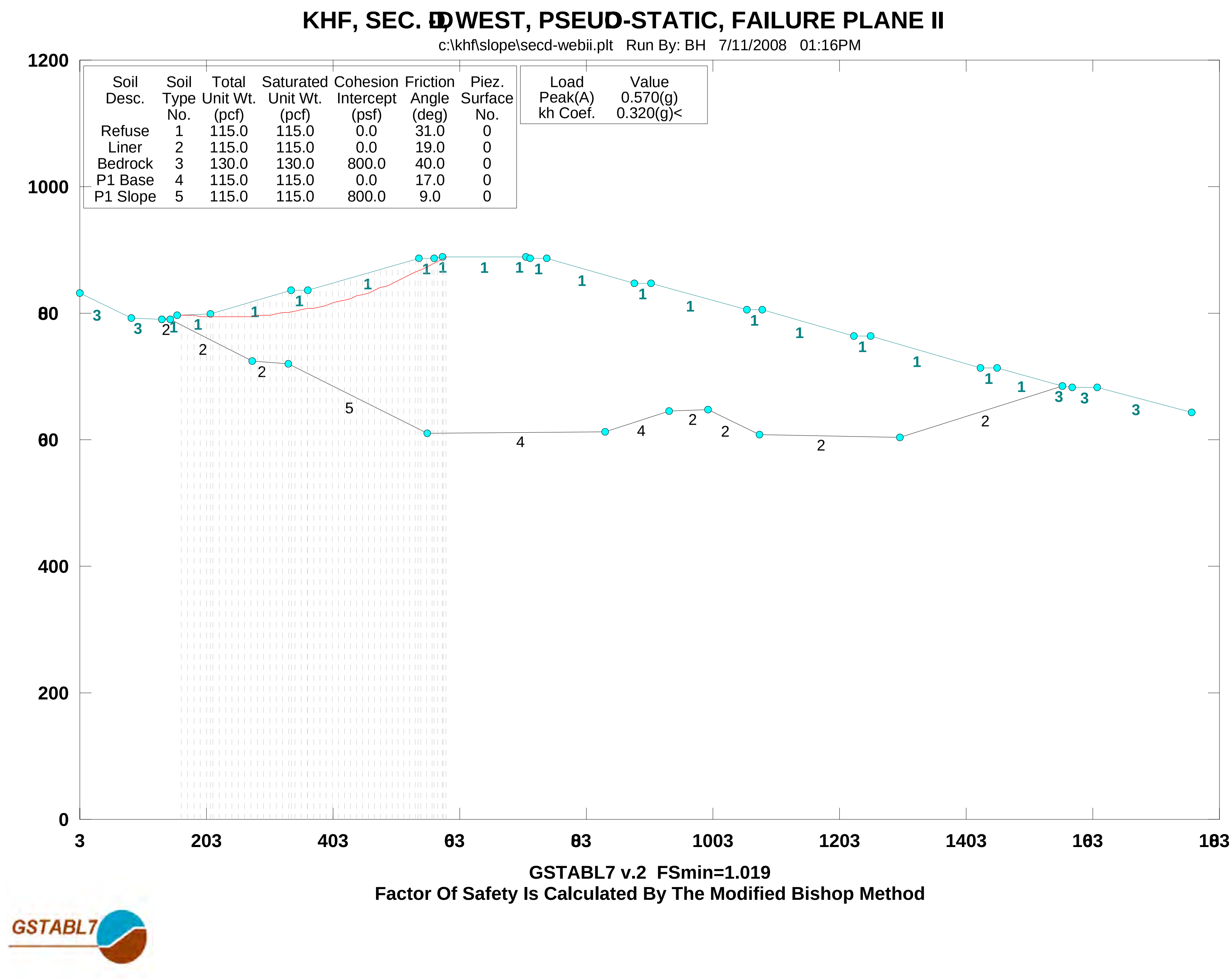
KHF, SEC. D, WEST, STATIC, FAILURE PLANE II

c:\khf\slope\secd-wsbii.pl2   Run By: BH   7/11/2008   01:17PM



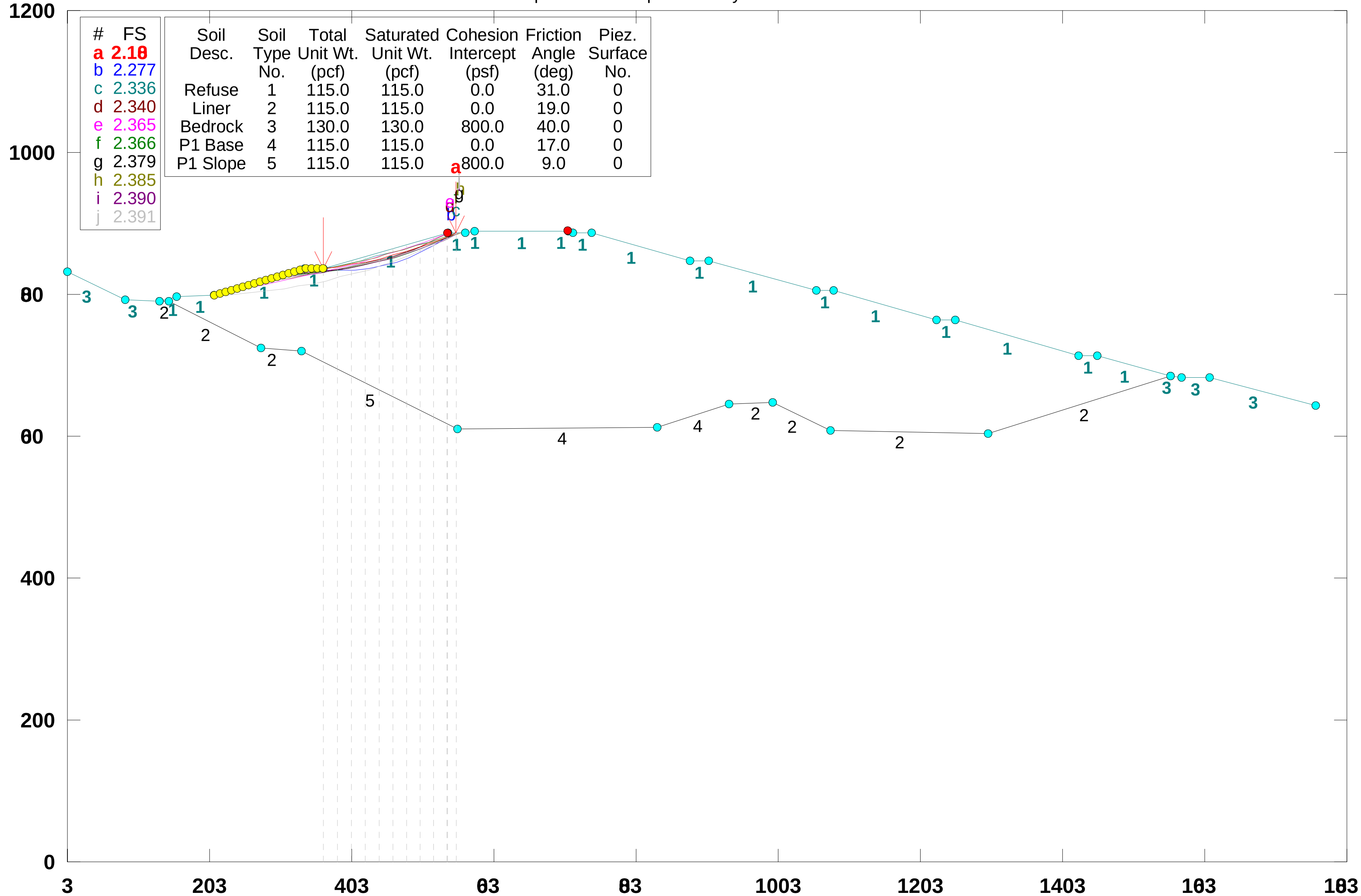
GSTABL7 v.2 FSmin=2.501

Safety Factors Are Calculated By The Modified Bishop Method


KHF, SEC. D, WEST, PSEUD-STATIC, FAILURE PLANE II
c:\khf\slope\secd-webii.plt Run By: BH 7/11/2008 01:16PM
Soil Desc. | Soil Type No. | Total Unit Wt. (pcf) | Saturated Unit Wt. (pcf) | Cohesion Intercept (psf) | Friction Angle (deg) | Piez. Surface No.
Refuse 1 115.0 115.0 0.0 31.0 0
Liner 2 115.0 115.0 0.0 19.0 0
Bedrock 3 130.0 130.0 800.0 40.0 0
P1 Base 4 115.0 115.0 0.0 17.0 0
P1 Slope 5 115.0 115.0 800.0 9.0 0
Load Value
Peak(A) 0.570(g)
kh Coef. 0.320(g)<
GSTABL7 v.2 FSmin=1.019
Factor Of Safety Is Calculated By The Modified Bishop Method
GSTABL7

KHF, SEC. D, WEST, STATIC, FAILURE PLANE III

c:\khf\slope\secd-wsbiii.pl2 Run By: BH 7/11/2008 01:31PM



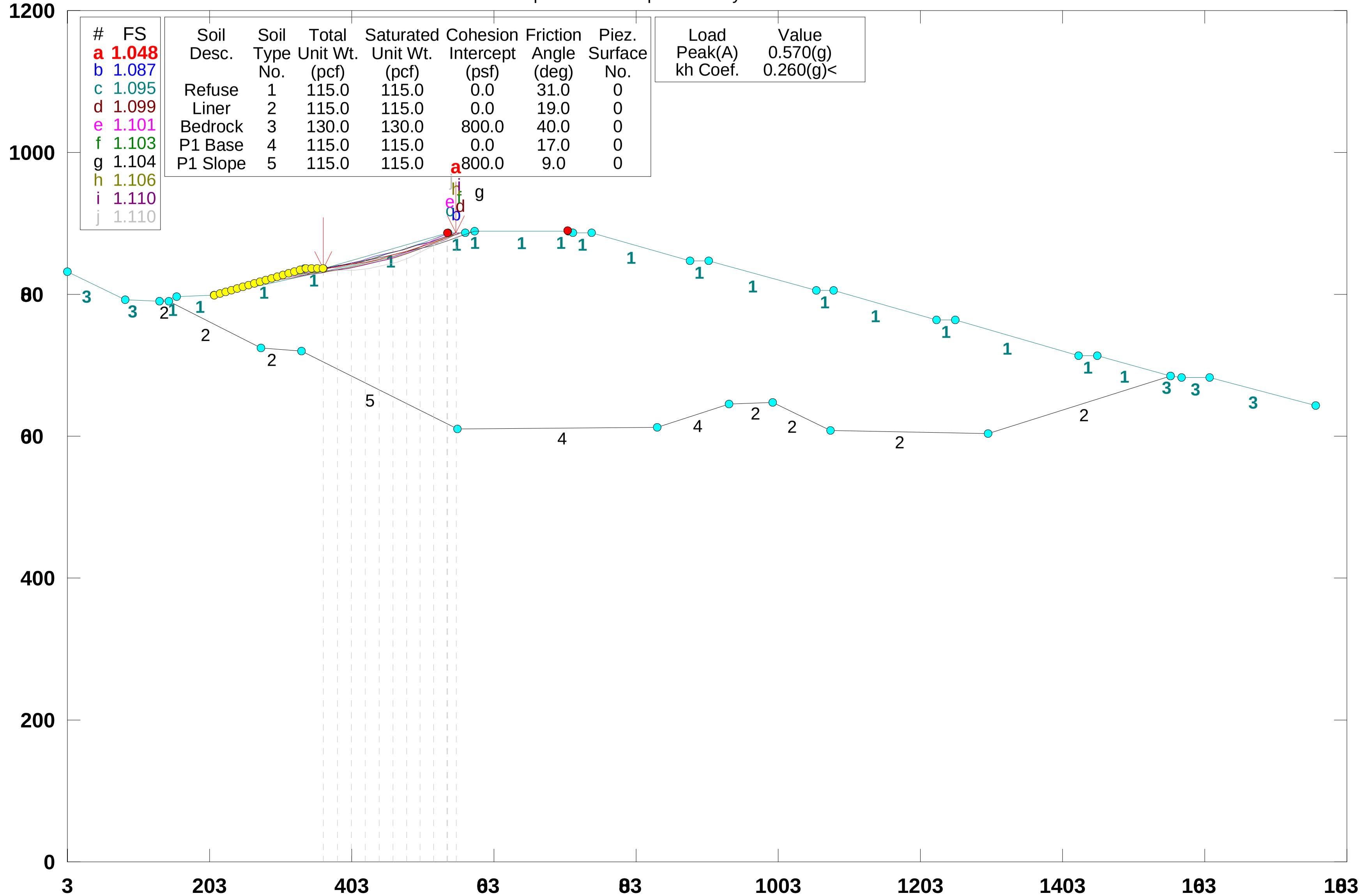
GSTABL7 v.2 FSmin=2.18

Safety Factors Are Calculated By The Modified Bishop Method

GSTABL7

KHF, SEC. D, WEST, PSEUD-STATIC, FAILURE PLANE III

c:\khf\slope\secd-webiii.pl2 Run By: BH 7/11/2008 01:33PM

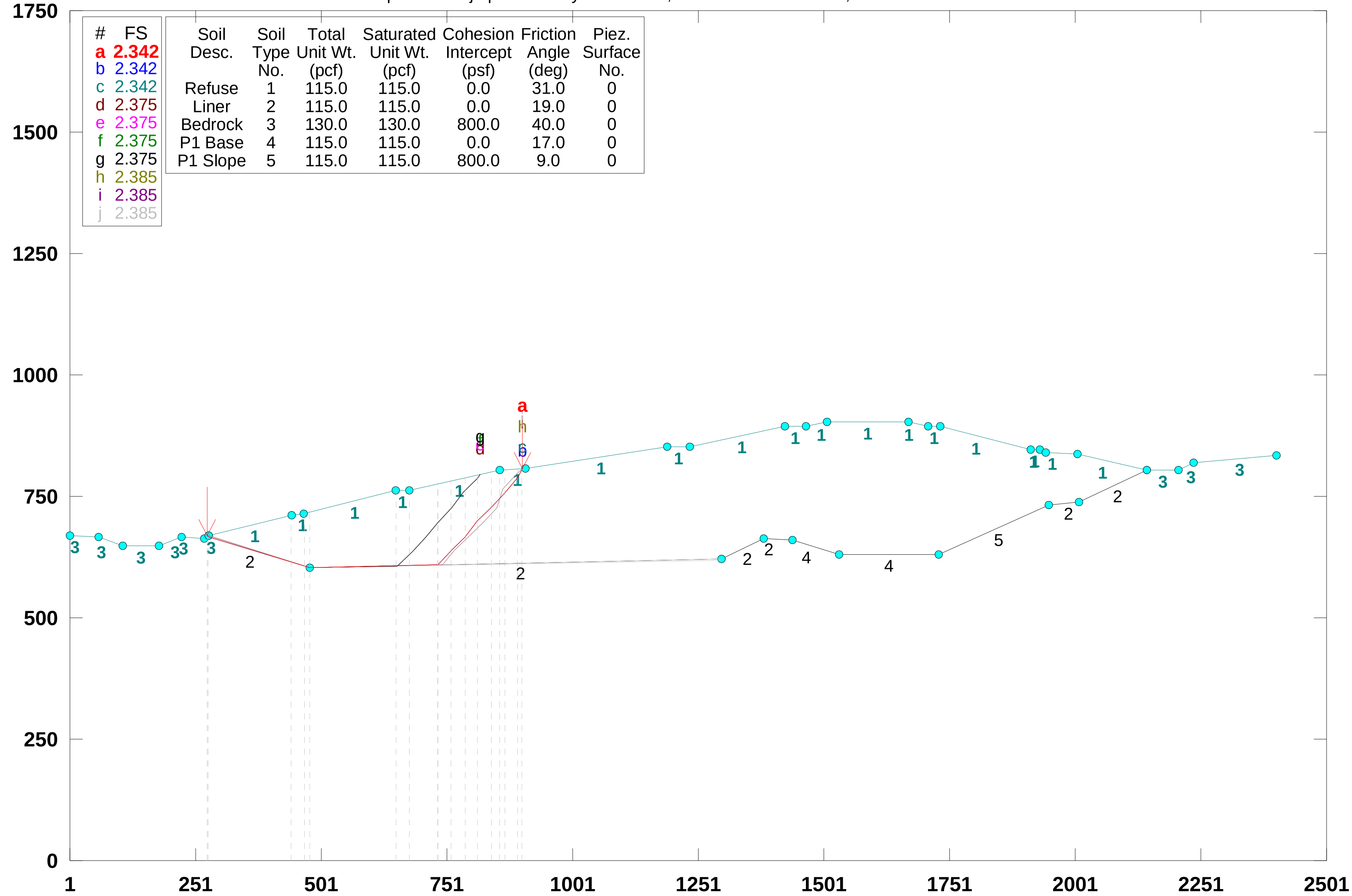


GSTABL7 v.2 FSmin=1.048

Safety Factors Are Calculated By The Modified Bishop Method

KHF, SECTION E-E', EAST, STATIC, FAILURE PLANE 1

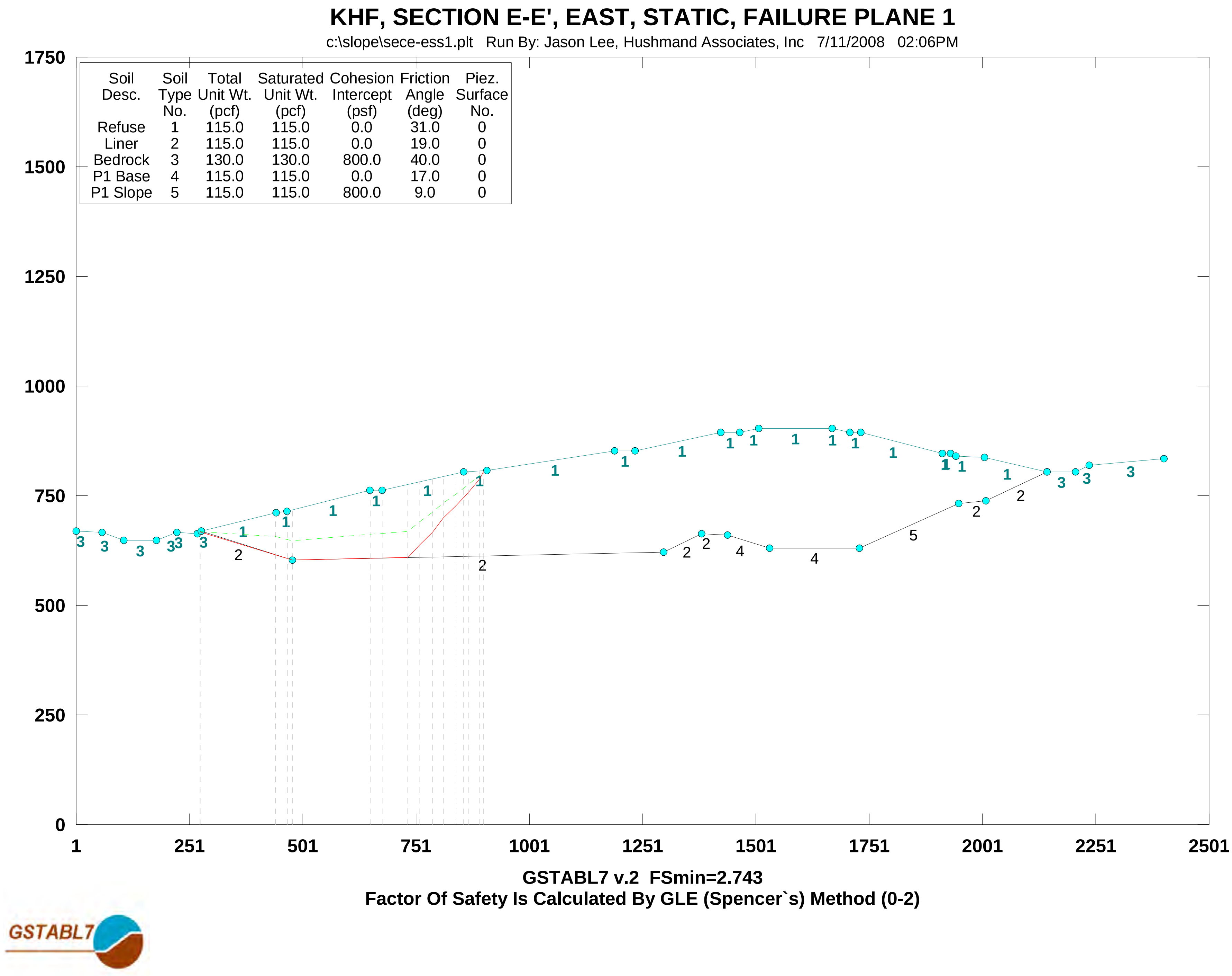
c:\slope\sece-esj1.pl2   Run By: Jason Lee, Hushmand Associates, Inc   7/11/2008   01:56PM



Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0

GSTABL7 v.2 FSmin=2.342

Safety Factors Are Calculated By The Simplified Janbu Method

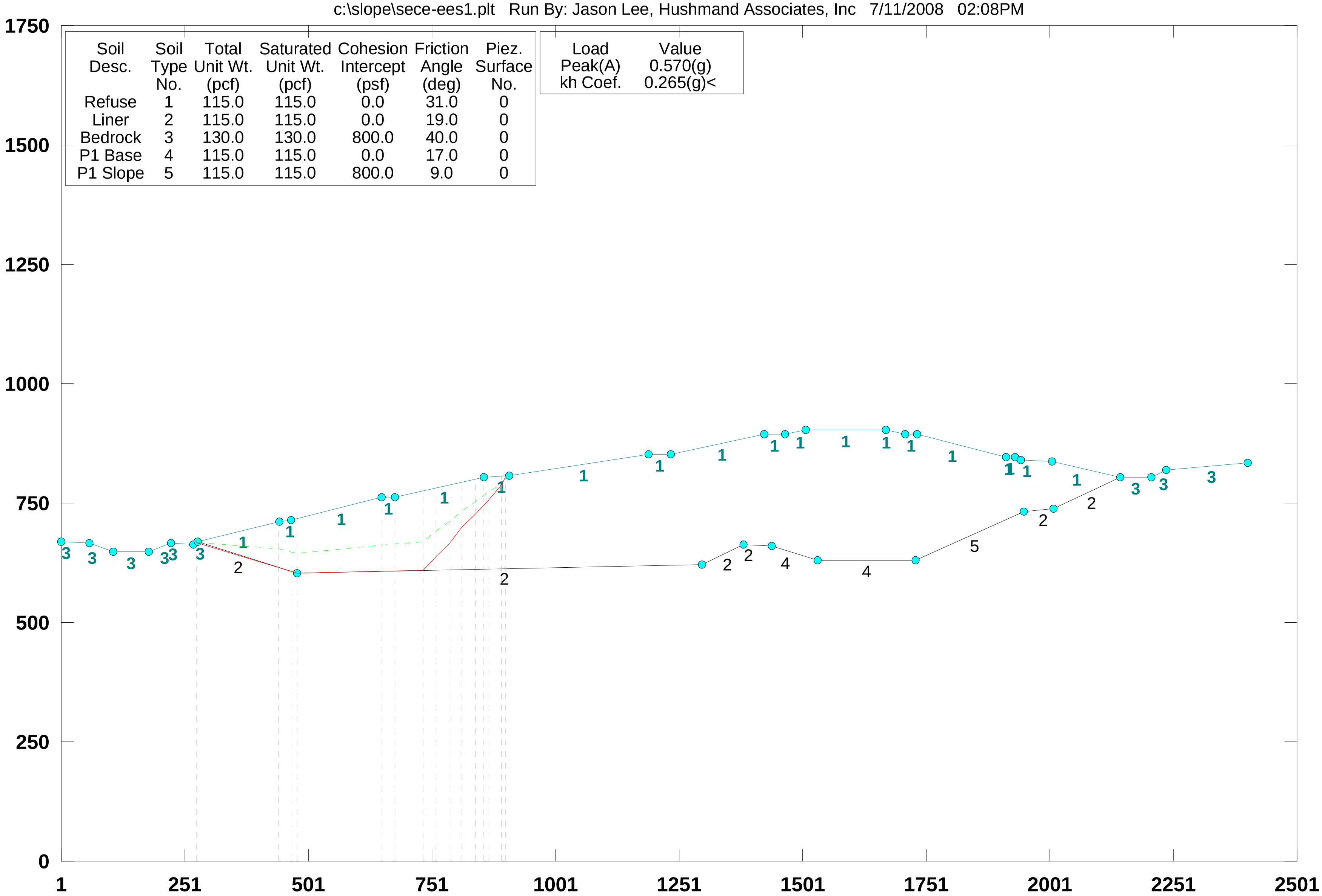

KHF, SECTION E-E', EAST, STATIC, FAILURE PLANE 1
c:\slope\sece-ess1.plt Run By: Jason Lee, Hushmand Associates, Inc 7/11/2008 02:06PM
Soil Desc. | Soil Type No. | Total Unit Wt. (pcf) | Saturated Unit Wt. (pcf) | Cohesion Intercept (psf) | Friction Angle (deg) | Piez. Surface No.
Refuse 1 115.0 115.0 0.0 31.0 0
Liner 2 115.0 115.0 0.0 19.0 0
Bedrock 3 130.0 130.0 800.0 40.0 0
P1 Base 4 115.0 115.0 0.0 17.0 0
P1 Slope 5 115.0 115.0 800.0 9.0 0
0
250
500
750
1000
1250
1500
1750
1
251
501
751
1001
1251
1501
1751
2001
2251
2501
GSTABL7 v.2 FSmin=2.743
Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)
GSTABL7

KHF, SECTION E-E', EAST, PSEUD-STATIC, FAILURE PLANE 1

c:\slope\sece-ees1.plt Run By: Jason Lee, Hushmand Associates, Inc 7/11/2008 02:08PM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0

Load	Value
Peak(A)	0.570(g)
kh Coef.	0.265(g)<



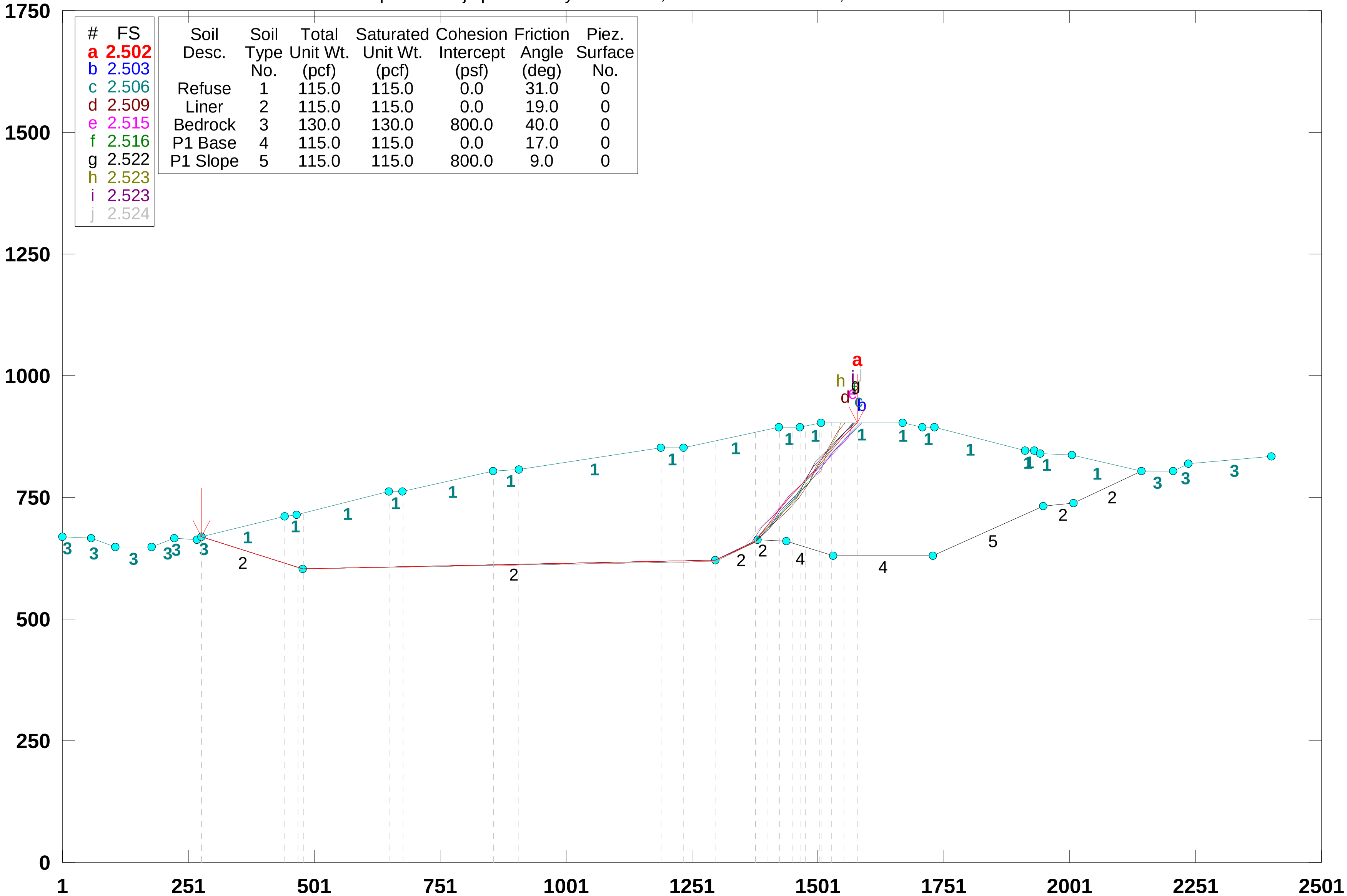
GSTABL7 v.2 FSmin=1.004

Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

GSTABL7

KHF, SECTION E-E', EAST, STATIC, FAILURE PLANE 2

c:\slope\sece-esj2.pl2 Run By: Jason Lee, Hushmand Associates, Inc 7/11/2008 01:46PM



GSTABL7 v.2 FSmin=2.502

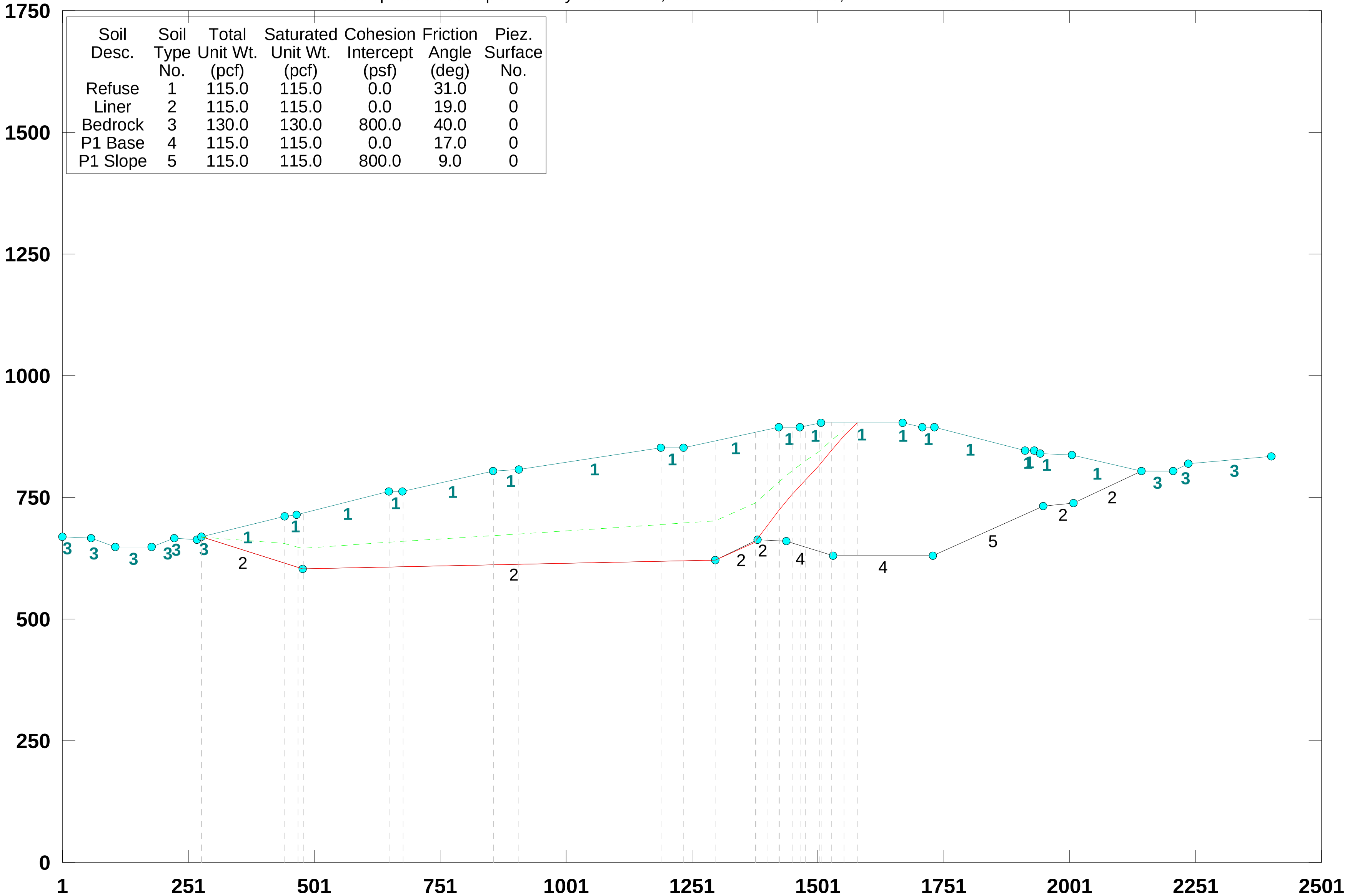
Safety Factors Are Calculated By The Simplified Janbu Method

GSTABL7

KHF, SECTION E-E', EAST, STATIC, FAILURE PLANE 2

c:\slope\sece-ess2.plt   Run By: Jason Lee, Hushmand Associates, Inc   7/11/2008   02:10PM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0

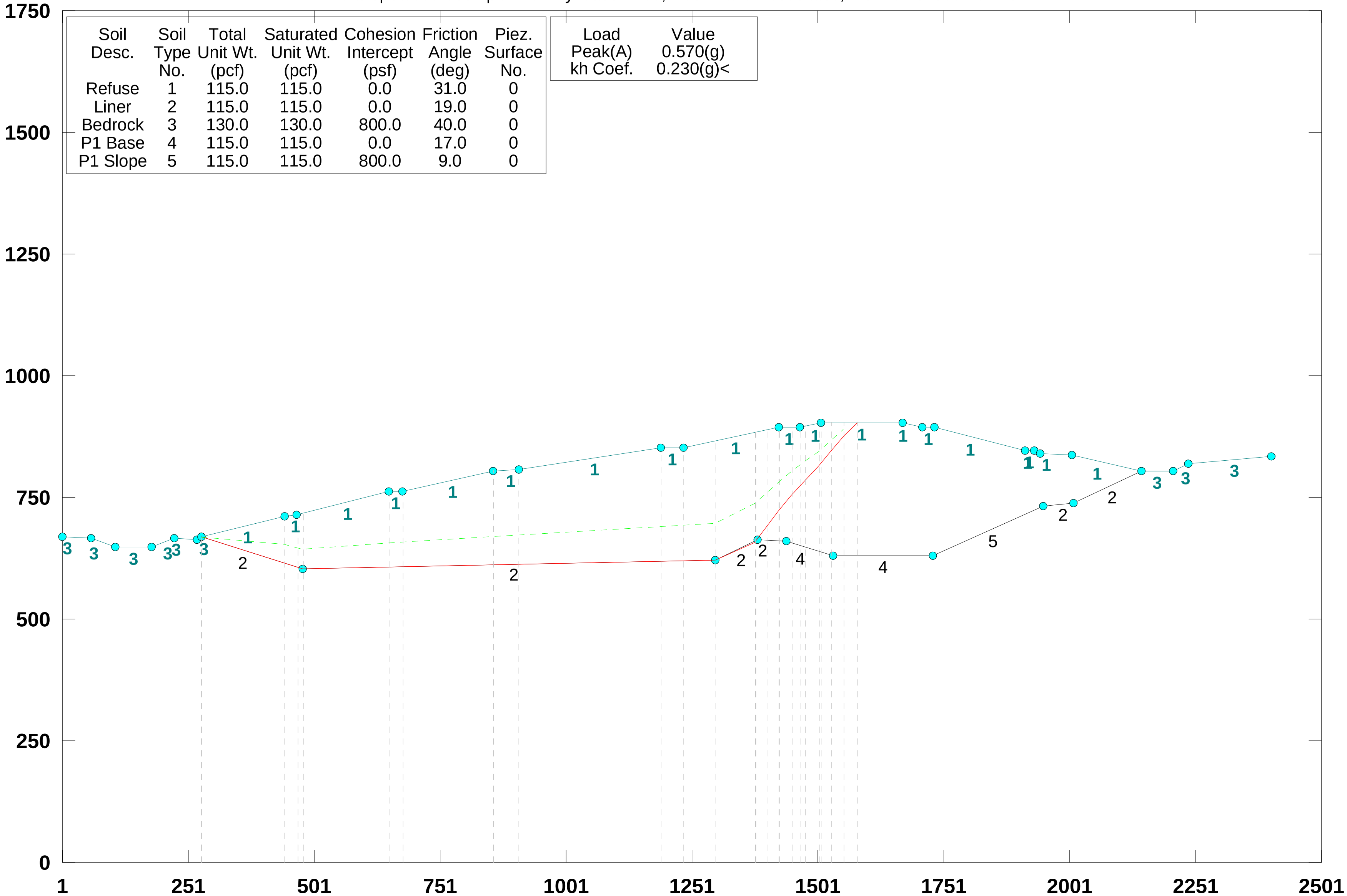


GSTABL7 v.2 FSmin=2.747

Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

KHF, SECTION E-E', EAST, PSEUD-STATIC, FAILURE PLANE 2

c:\slope\sece-ees2.plt   Run By: Jason Lee, Hushmand Associates, Inc   7/24/2008   01:23PM



Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0

Load	Value
Peak(A)	0.570(g)
kh Coef.	0.230(g)<

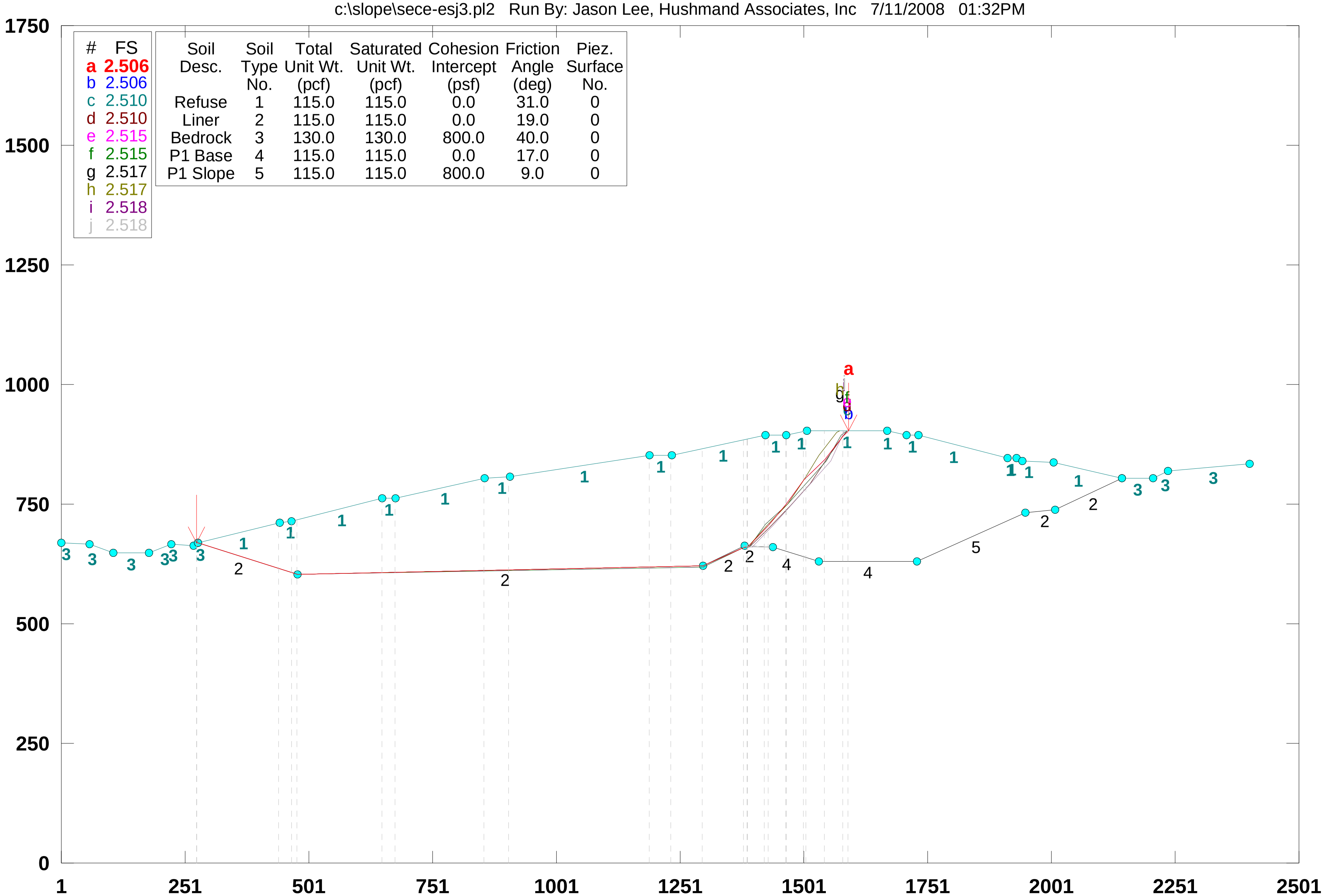
GSTABL7 v.2 FSmin=1.030

Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

GSTABL7

KHF, SECTION E-E', EAST, STATIC, FAILURE PLANE 3

c:\slope\sece-esj3.pl2   Run By: Jason Lee, Hushmand Associates, Inc   7/11/2008   01:32PM



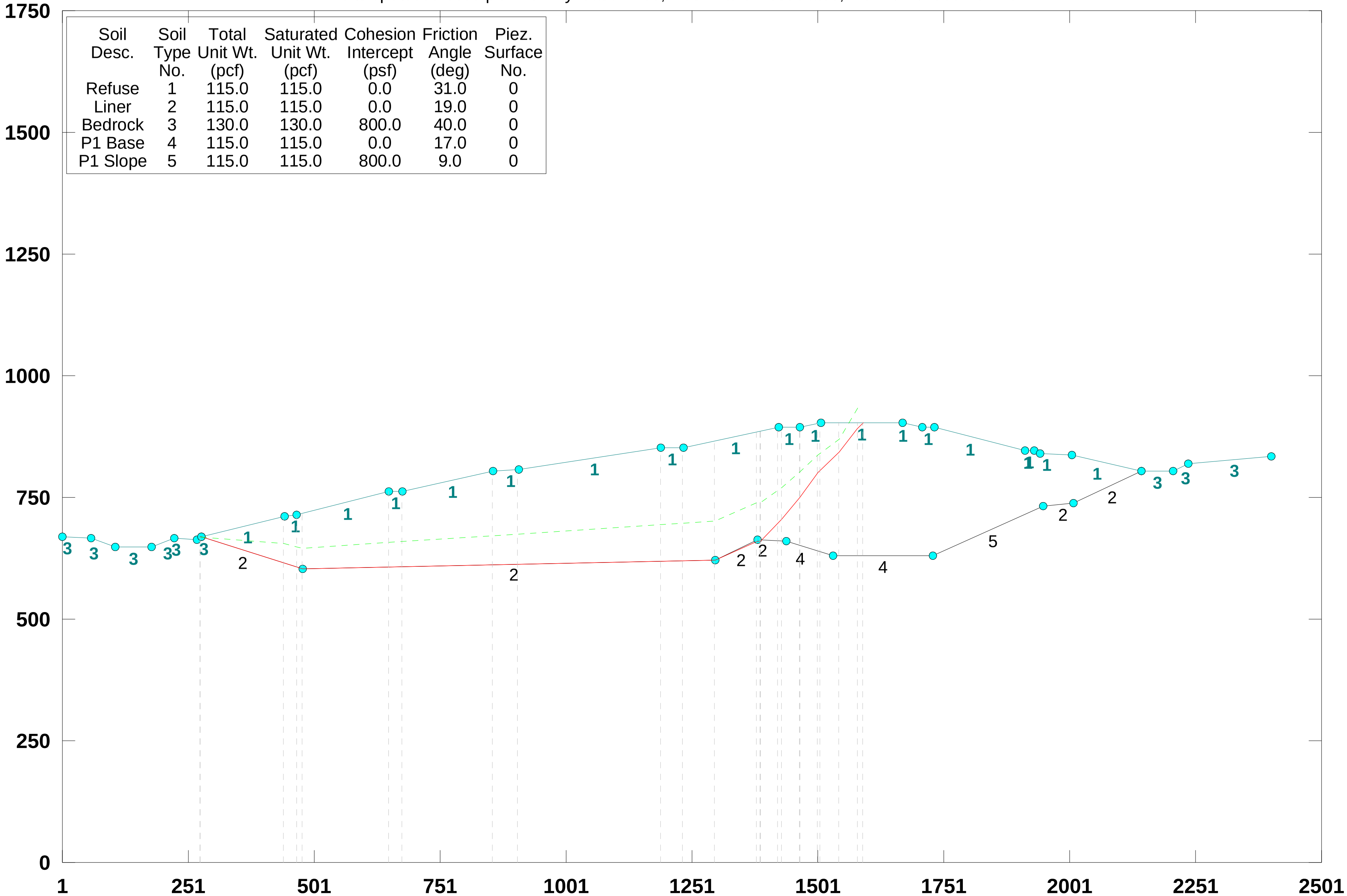
GSTABL7 v.2 FSmin=2.506

Safety Factors Are Calculated By The Simplified Janbu Method

KHF, SECTION E-E', EAST, STATIC, FAILURE PLANE 3

c:\slope\sece-ess3.plt Run By: Jason Lee, Hushmand Associates, Inc 7/11/2008 02:40PM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0



GSTABL7 v.2 FSmin=2.730

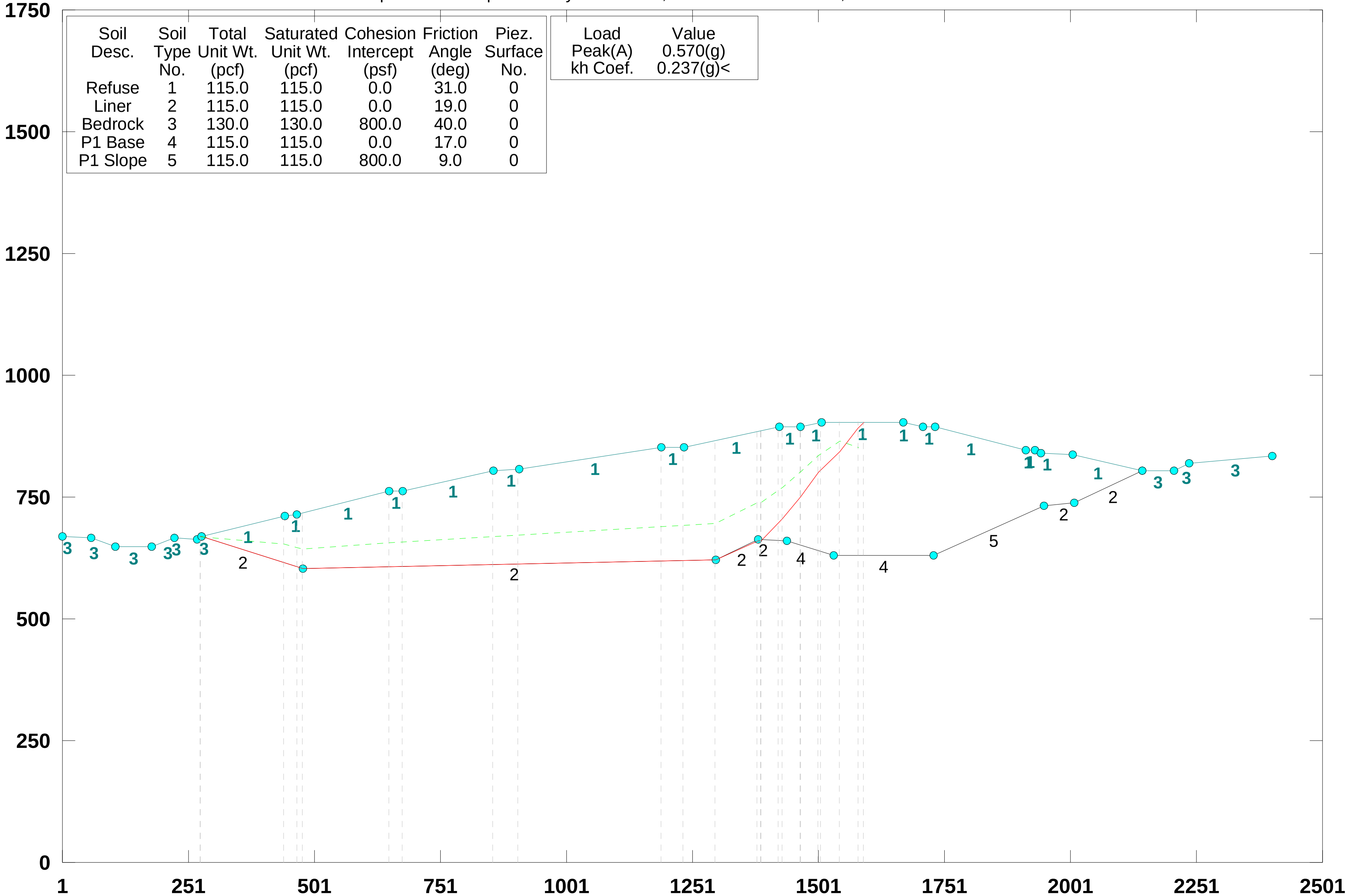
Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

KHF, SECTION E-E', EAST, PSEUD-STATIC, FAILURE PLANE 3

c:\slope\sece-ees3.plt Run By: Jason Lee, Hushmand Associates, Inc 7/11/2008 02:43PM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0

Load	Value
Peak(A)	0.570(g)
kh Coef.	0.237(g)<

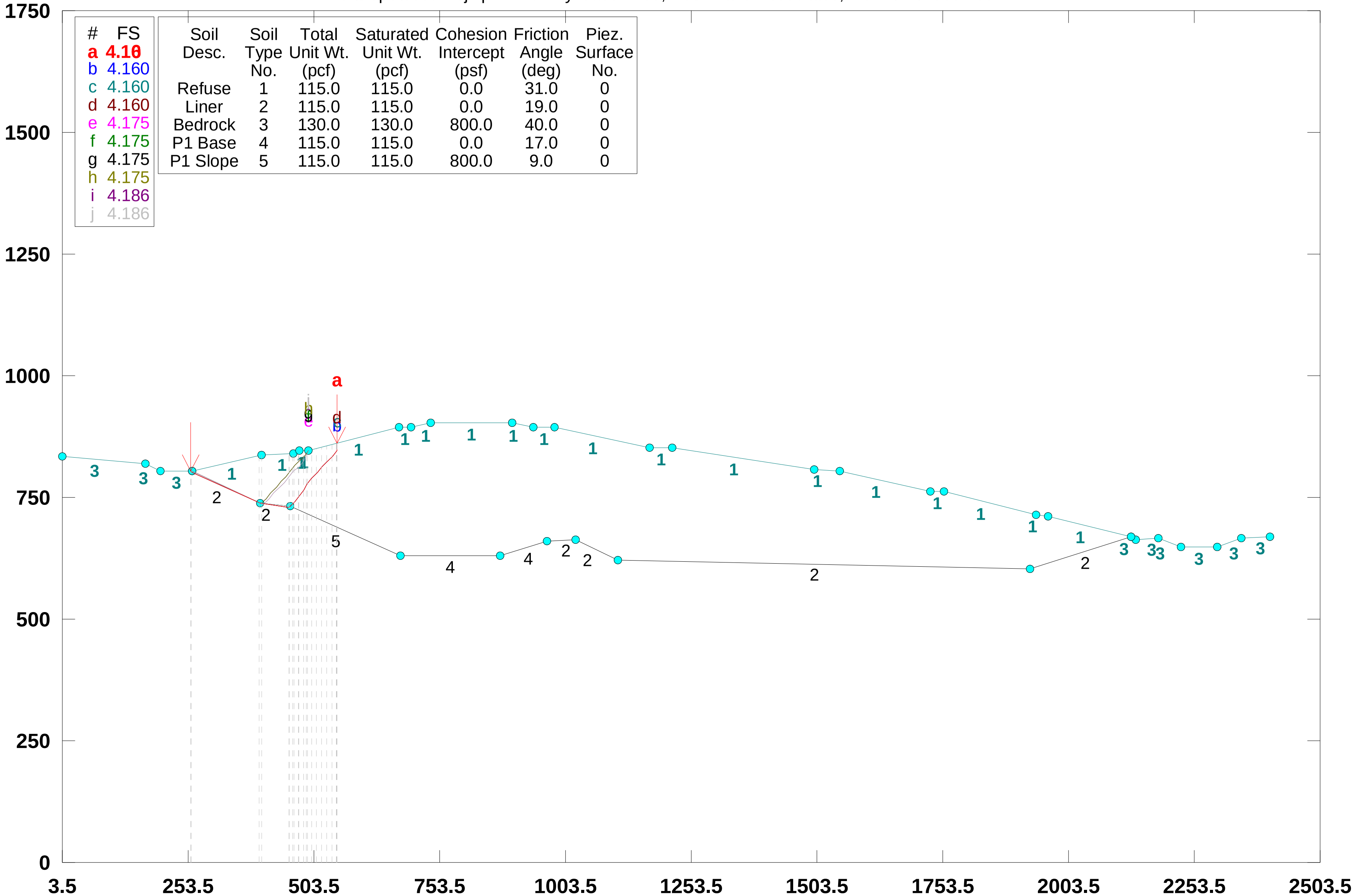


GSTABL7 v.2 FSmin=1.006

Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

KHF, SECTION E-E' WEST, STATIC, FAILURE PLANE I

c:\slope\sece-wsj i.pl2   Run By: Jason Lee, Hushmand Associates, Inc   7/14/2008   09:27AM



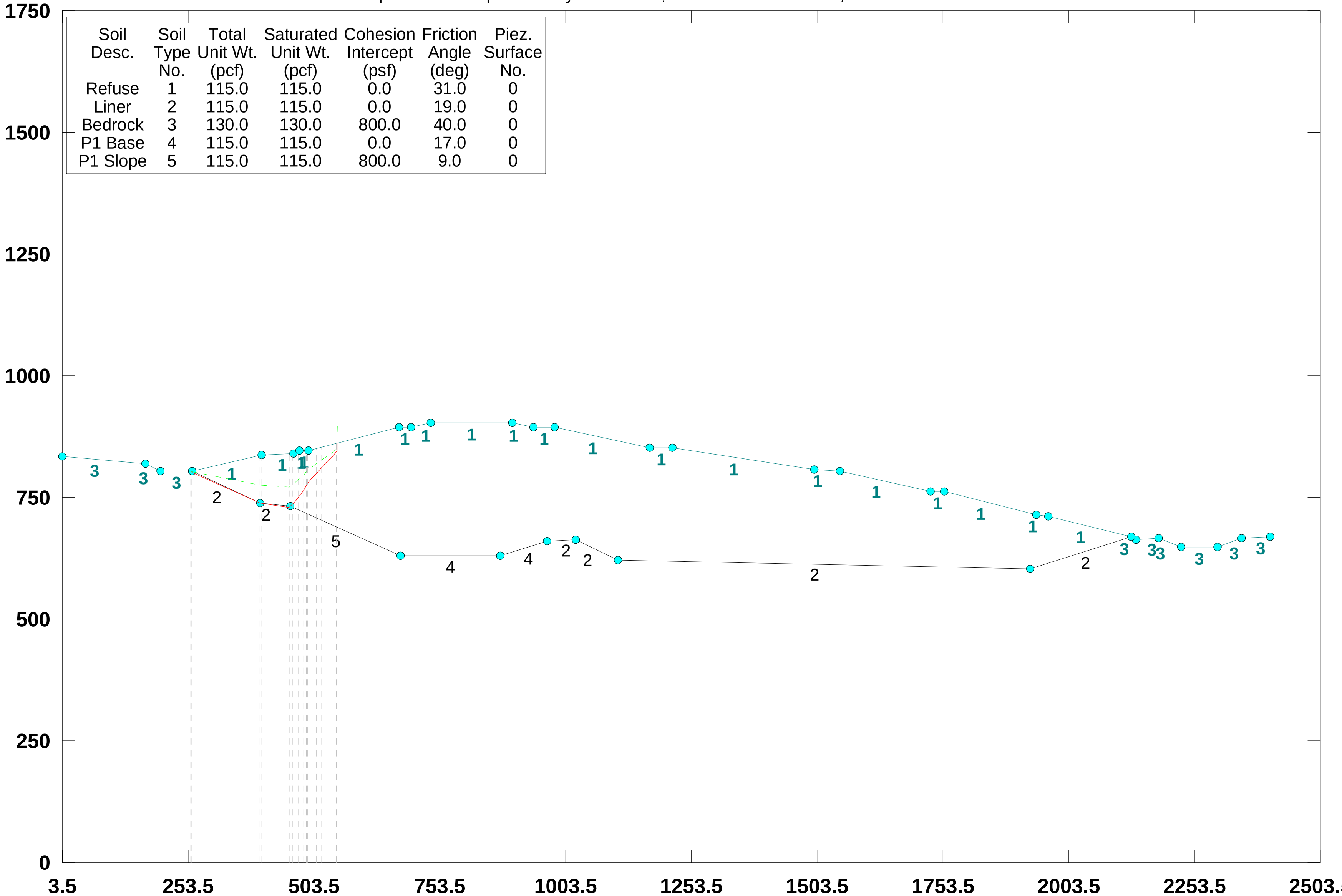
GSTABL7 v.2 FSmin=4.16

Safety Factors Are Calculated By The Simplified Janbu Method

KHF, SECTION E-E', WEST, STATIC, FAILURE PLANE I

c:\slope\sece-wss i.plt   Run By: Jason Lee, Hushmand Associates, Inc   7/14/2008   09:29AM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0



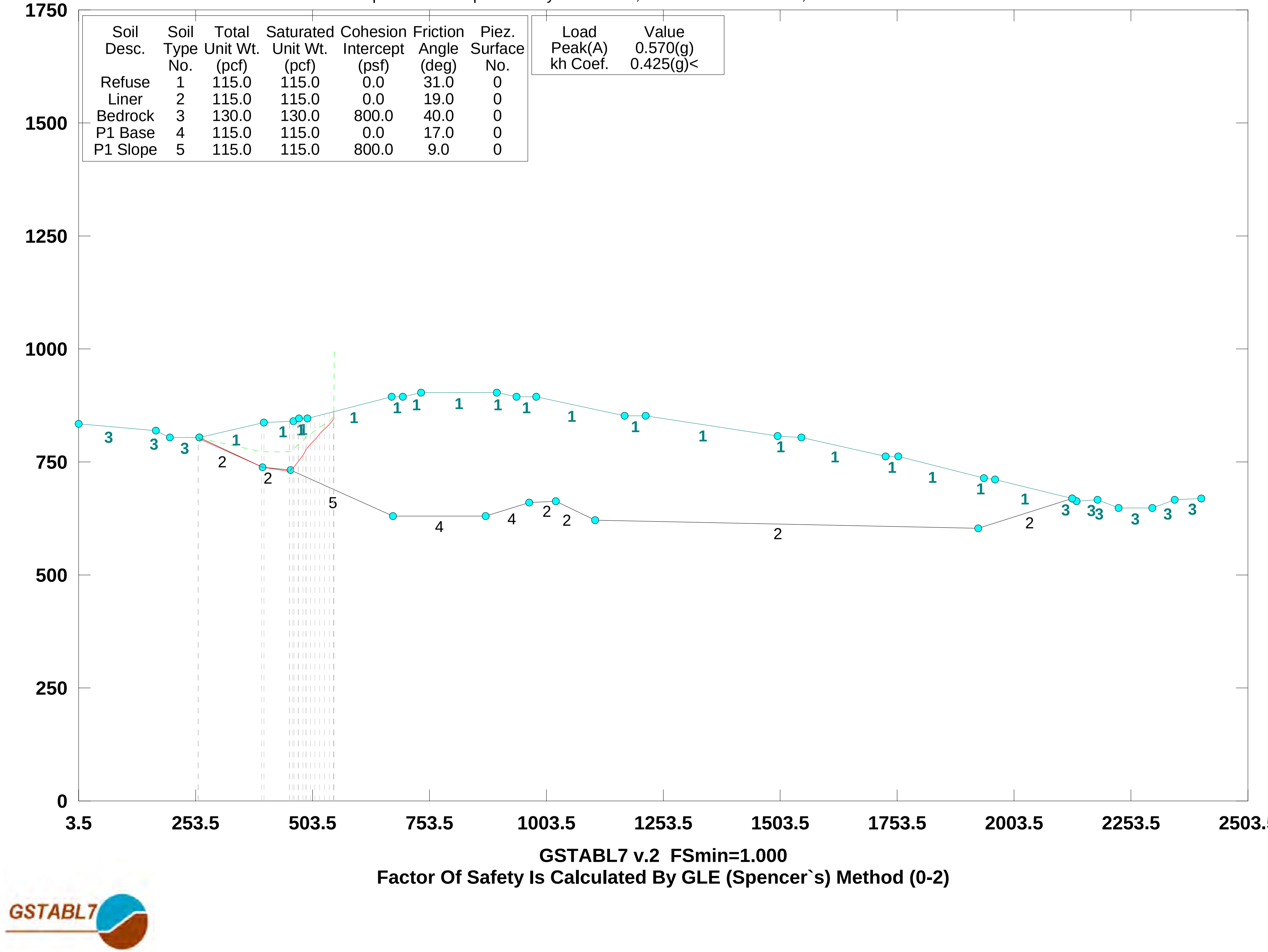
GSTABL7 v.2 FSmin=5.431

Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

GSTABL7

KHF, SECTION E-E', WEST, PSEUD-STATIC, FAILURE PLANE I

c:\slope\sece-wes i.plt   Run By: Jason Lee, Hushmand Associates, Inc   7/14/2008   09:31AM

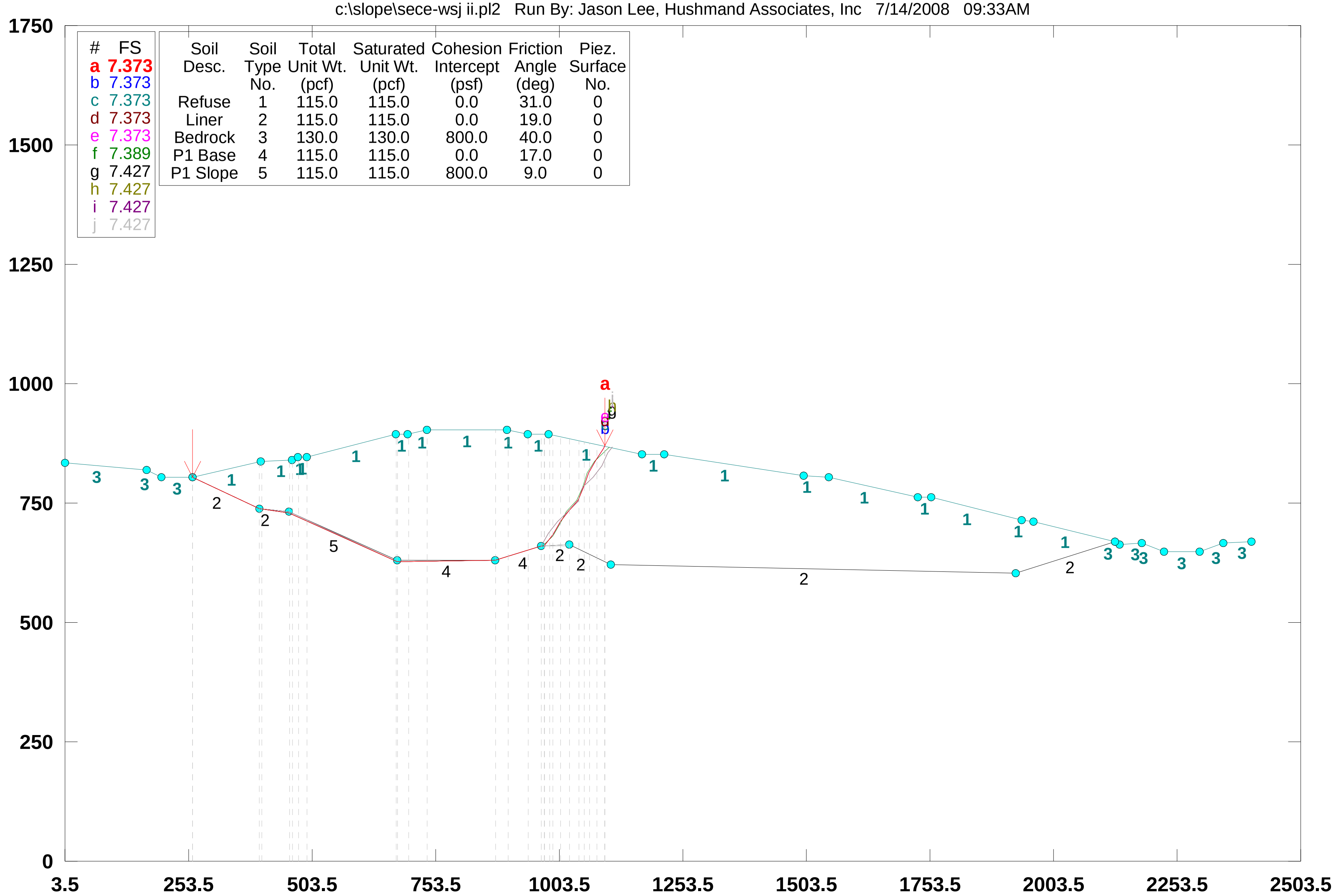


GSTABL7 v.2 FSmin=1.000

Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

KHF, SECTION E-E', WEST, STATIC, FAILURE PLANE II

c:\slope\sece-wsj ii.pl2   Run By: Jason Lee, Hushmand Associates, Inc   7/14/2008   09:33AM



GSTABL7 v.2 FSmin=7.373

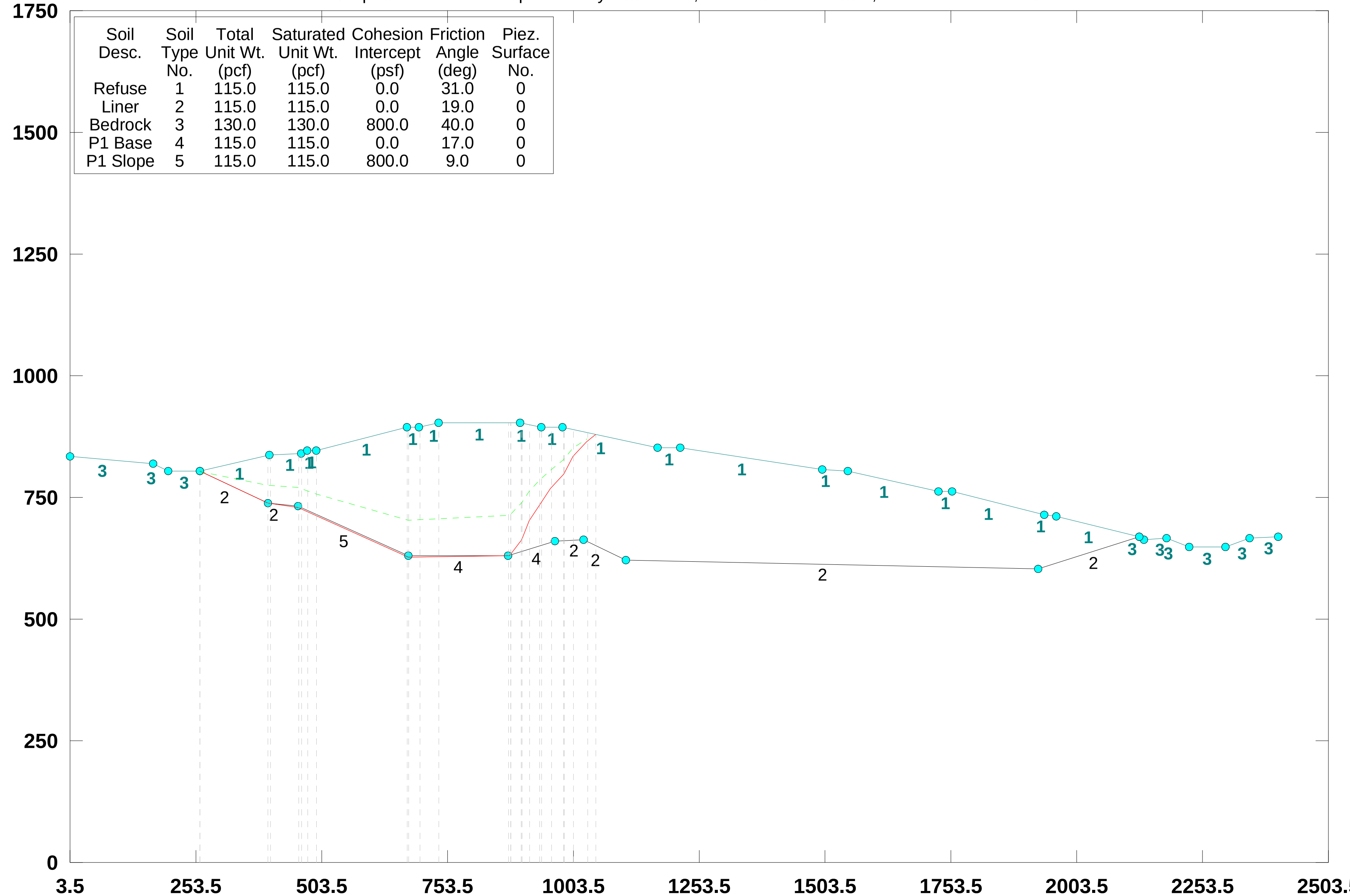
Safety Factors Are Calculated By The Simplified ânb Method

GSTABL7

KHF, SECTION E-E', WEST, STATIC, FAILURE PLANE II

c:\slope\sece-wss ii new2.plt   Run By: Jason Lee, Hushmand Associates, Inc   7/24/2008   03:53PM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0



GSTABL7 v.2 FSmin=879
Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

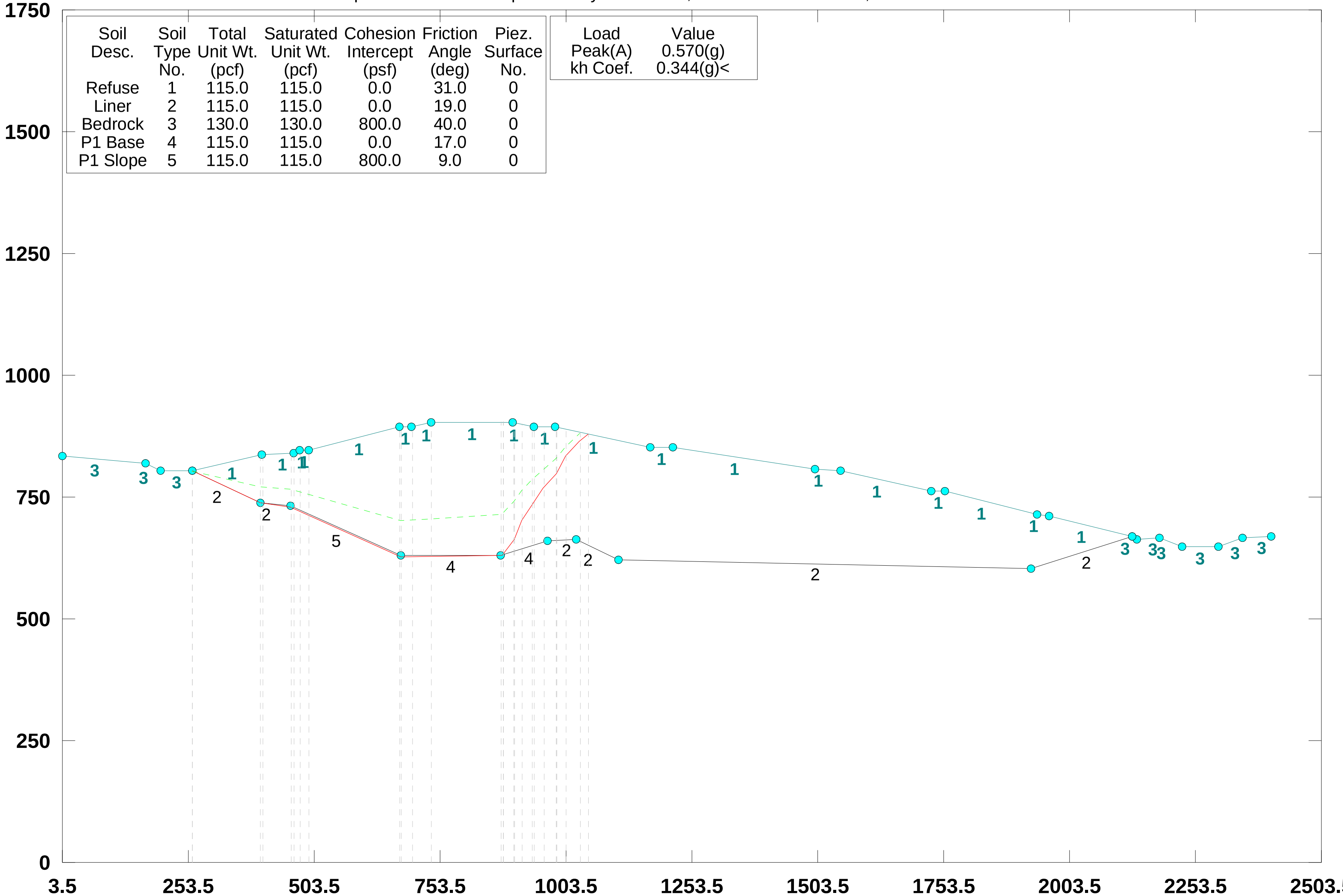
GSTABL7

KHF, SECTION E-E', WEST, STATIC, FAILURE PLANE II

c:\slope\sece-wes ii new2.plt   Run By: Jason Lee, Hushmand Associates, Inc   7/24/2008   04:03PM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0

Load	Value
Peak(A)	0.570(g)
kh Coef.	0.344(g)<



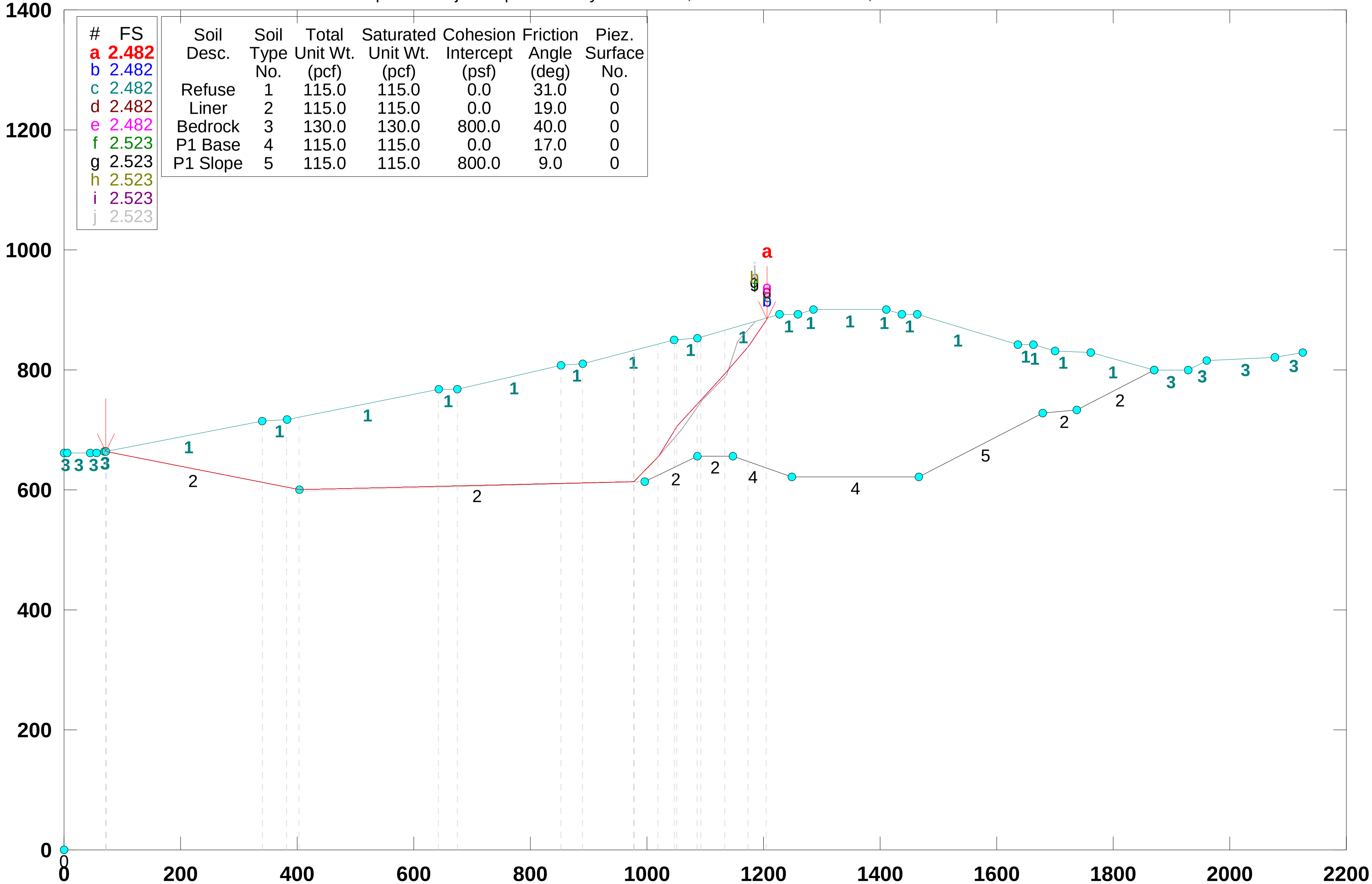
GSTABL7 v.2 FSmin=1.004

Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

GSTABL7

KHF, SECTION F-F', EAST, STATIC, FAILURE PLANE 1

c:\slope\secf-esj1new.pl2 Run By: Jason Lee, Hushmand Associates, Inc 7/24/2008 02:20PM



#	FS
a	2.482
b	2.482
c	2.482
d	2.482
e	2.482
f	2.523
g	2.523
h	2.523
i	2.523
j	2.523

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0

GSTABL7 v.2 FSmin=2.482

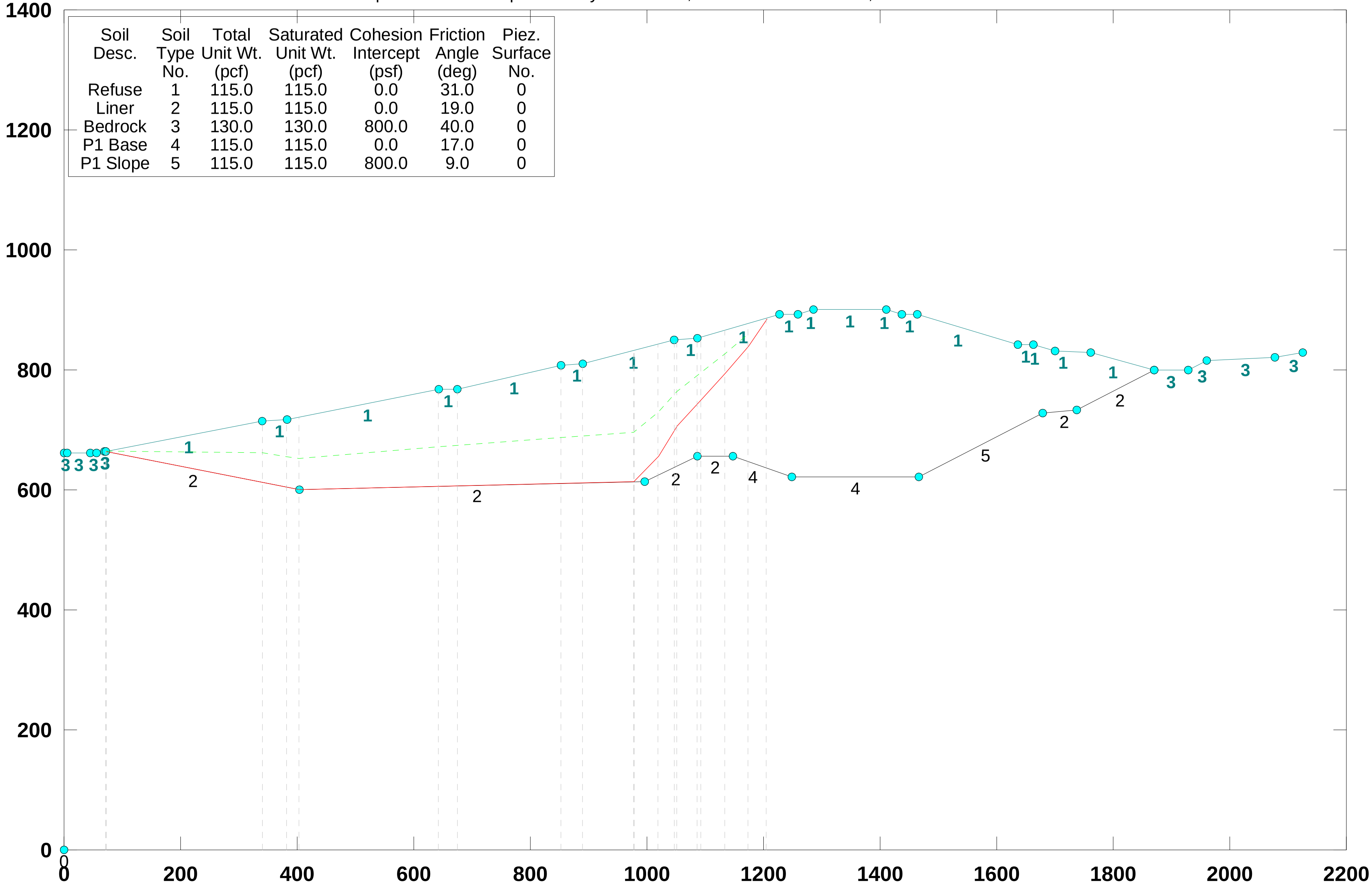
Safety Factors Are Calculated By The Simplified Janbu Method

GSTABL7

KHF, SECTION F-F', EAST, STATIC, FAILURE PLANE 1

c:\slope\secf-ess1new.plt   Run By: Jason Lee, Hushmand Associates, Inc   7/24/2008   02:21PM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0



GSTABL7 v.2 FSmin=2.805
Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

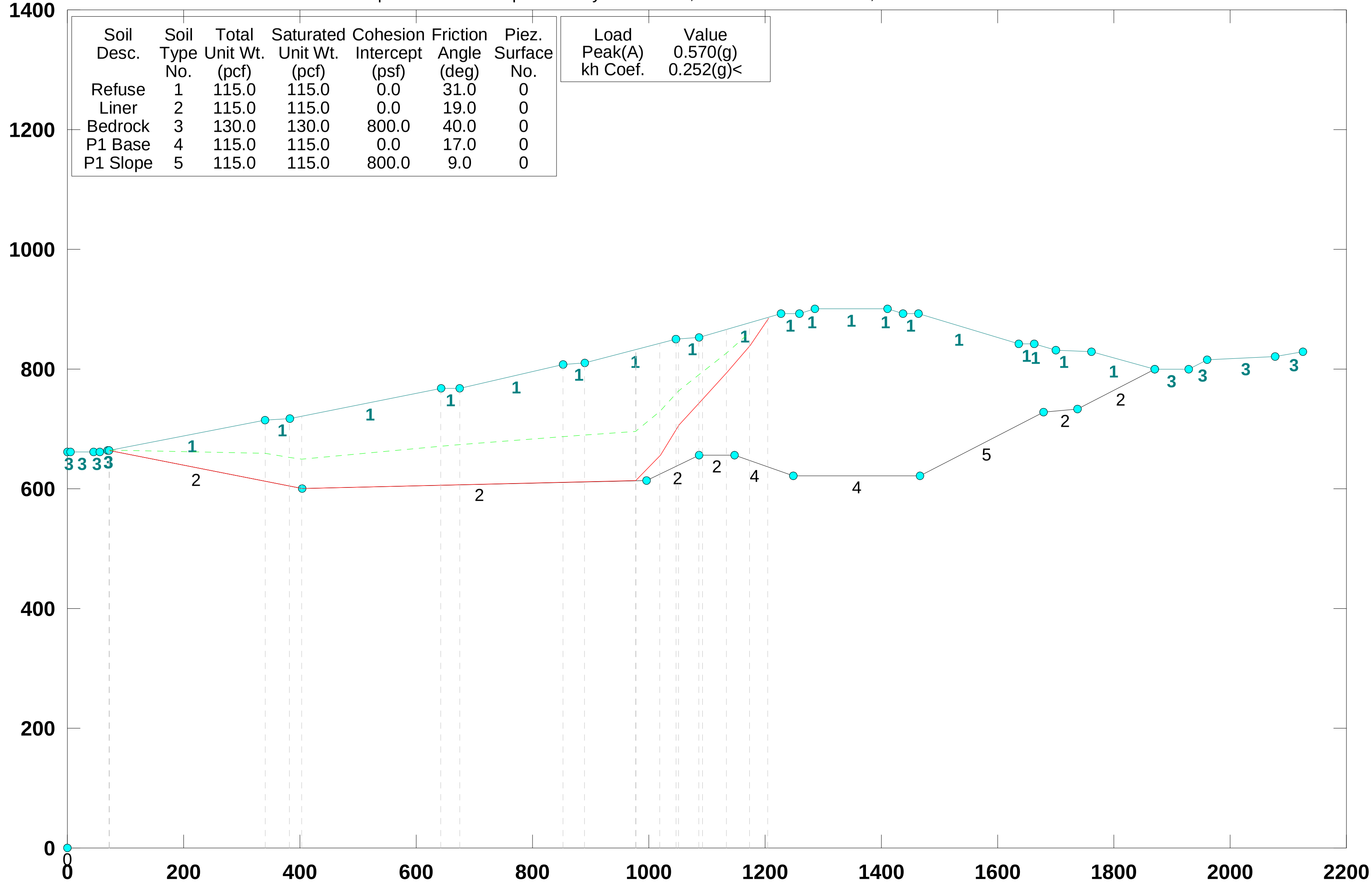
GSTABL7

KHF, SECTION F-F', EAST, STATIC, FAILURE PLANE 1

c:\slope\secf-ees1new.plt   Run By: Jason Lee, Hushmand Associates, Inc   7/24/2008   02:23PM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0

Load	Value
Peak(A)	0.570(g)
kh Coef.	0.252(g)<



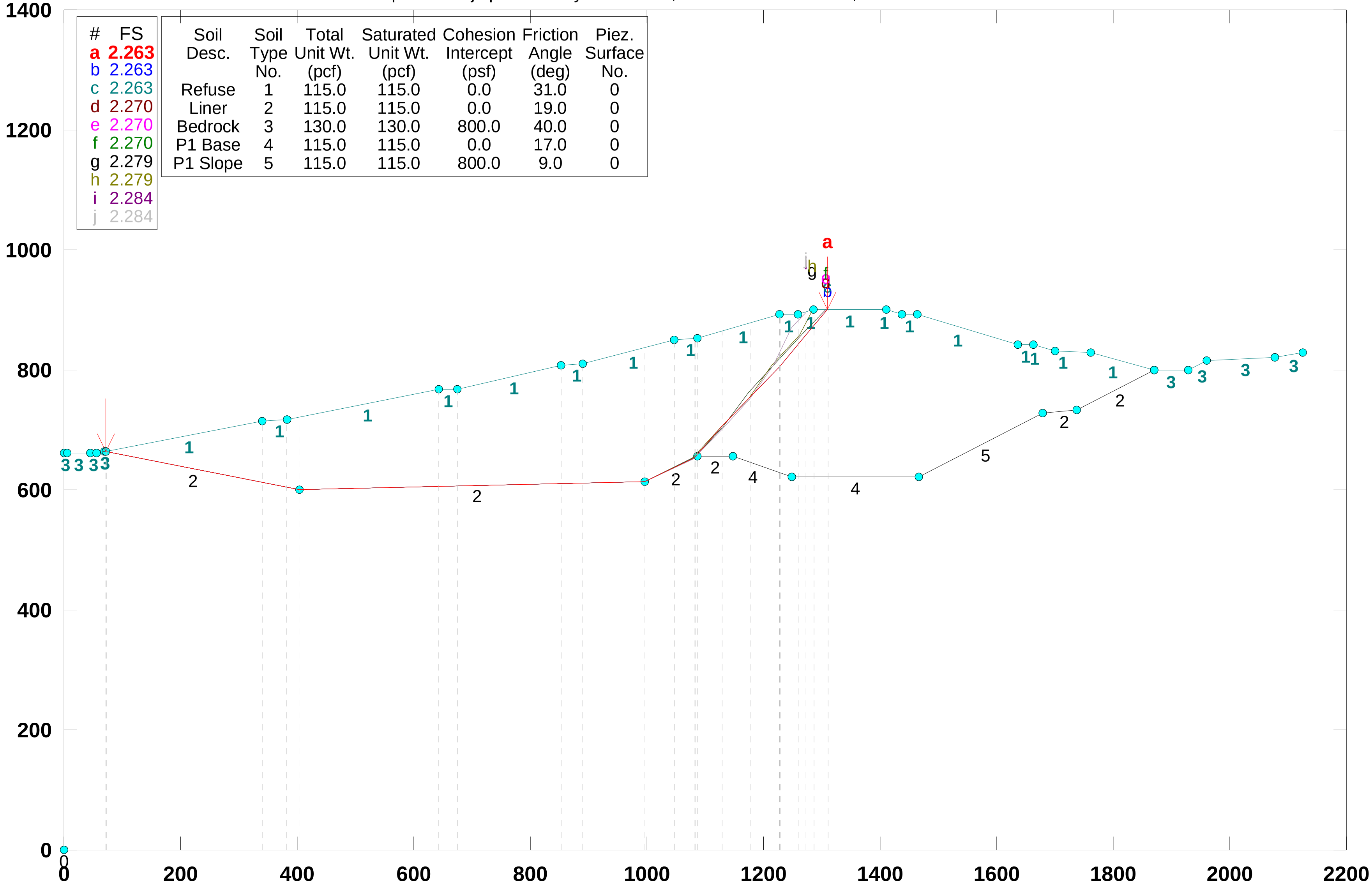
GSTABL7 v.2 FSmin=1.005
Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

KHF, SECTION F-F', EAST, STATIC, FAILURE PLANE 2

c:\slope\secf-esj2.pl2   Run By: Jason Lee, Hushmand Associates, Inc   7/10/2008   02:26PM

#	FS
a	2.263
b	2.263
c	2.263
d	2.270
e	2.270
f	2.270
g	2.279
h	2.279
i	2.284
j	2.284

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0



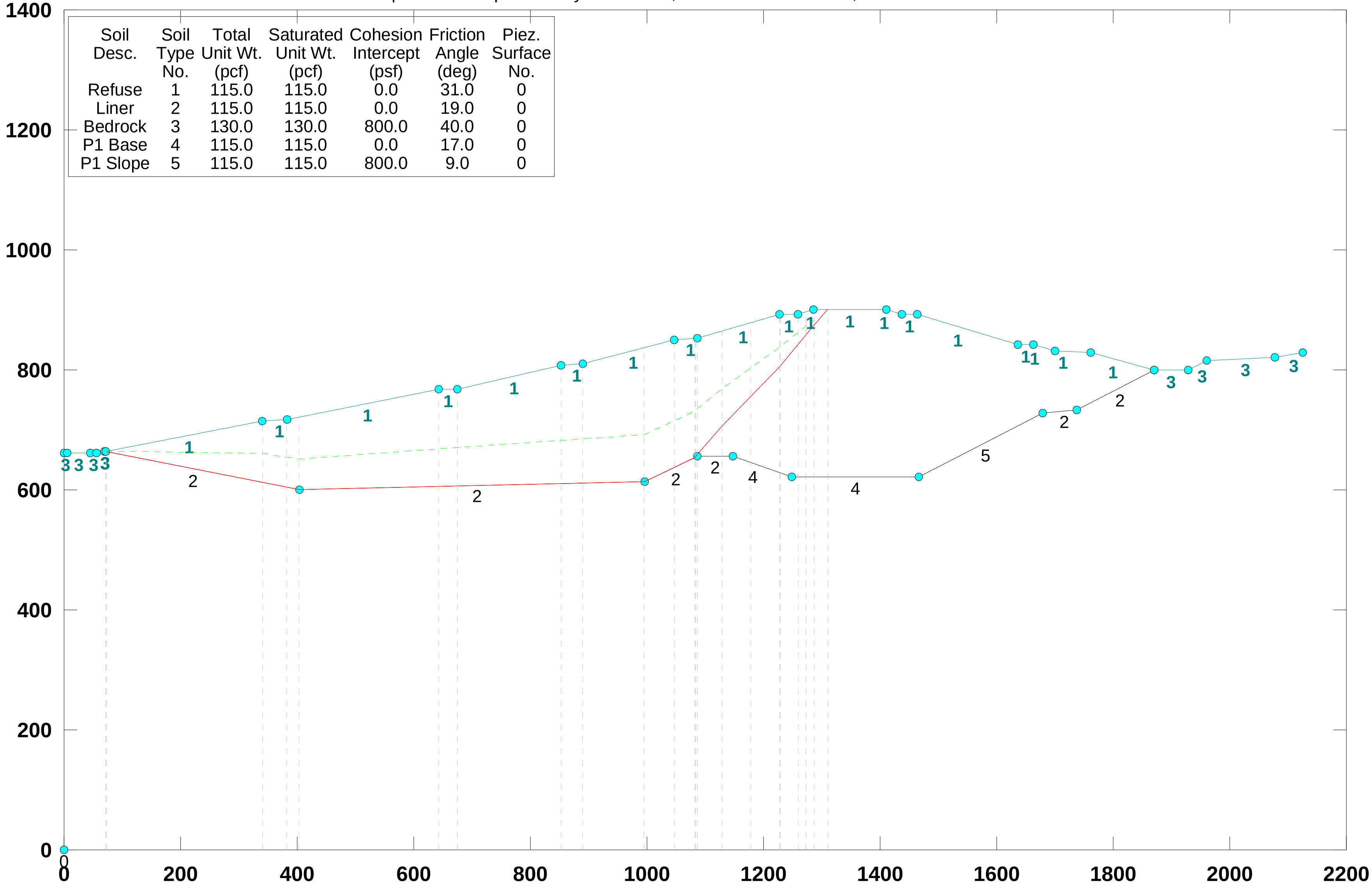
GSTABL7 v.2 FSmin=2.263

Safety Factors Are Calculated By The Simplified Janbu Method

KHF, SECTION F-F', EAST, STATIC, FAILURE PLANE 2

c:\slope\secf-ess2.plt   Run By: Jason Lee, Hushmand Associates, Inc   7/10/2008   02:29PM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0



GSTABL7 v.2 FSmin=2.467
Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

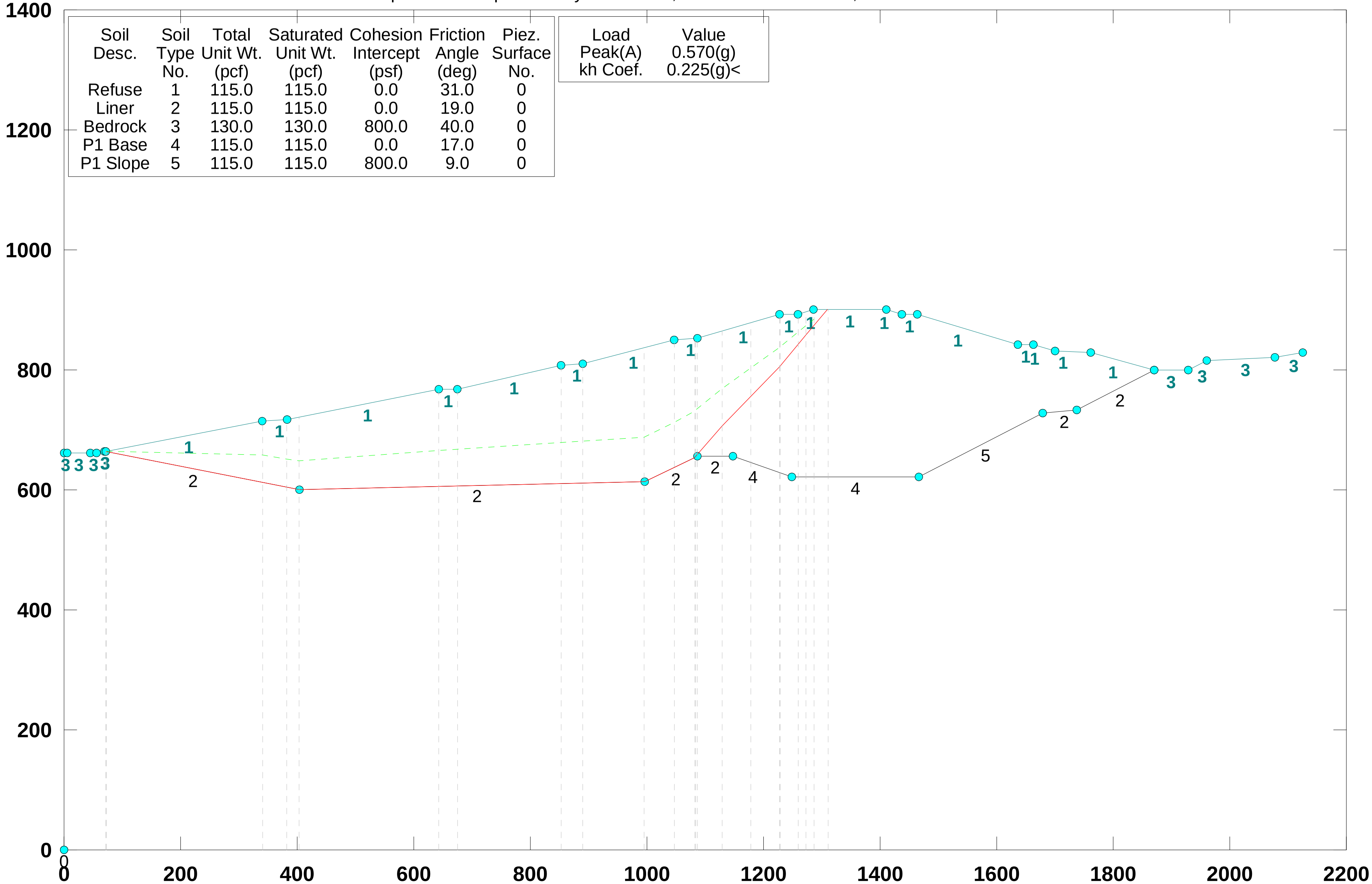
GSTABL7

KHF, SECTION F-F', EAST, PSEUDO-STATIC, FAILURE PLANE 2

c:\slope\secf-ees2.plt   Run By: Jason Lee, Hushmand Associates, Inc   7/10/2008   02:42PM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0

Load	Value
Peak(A)	0.570(g)
kh Coef.	0.225(g)<



GSTABL7 v.2 FSmin=1.004
Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

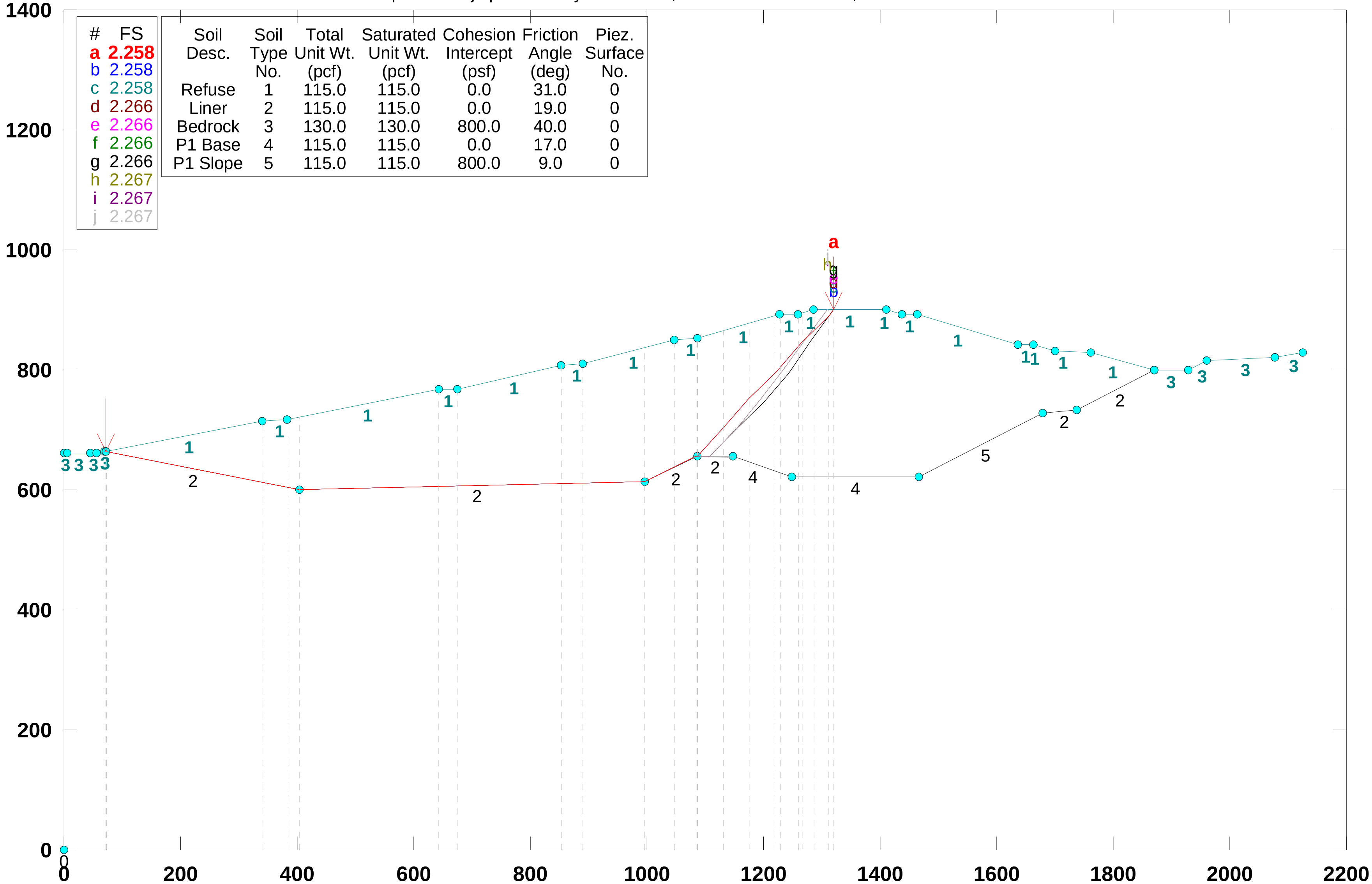
GSTABL7

KHF, SECTION F-F', EAST, STATIC, FAILURE PLANE 3

c:\slope\secf-esj3.pl2   Run By: Jason Lee, Hushmand Associates, Inc   7/10/2008   02:07PM

#	FS
a	2.258
b	2.258
c	2.258
d	2.266
e	2.266
f	2.266
g	2.266
h	2.267
i	2.267
j	2.267

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0



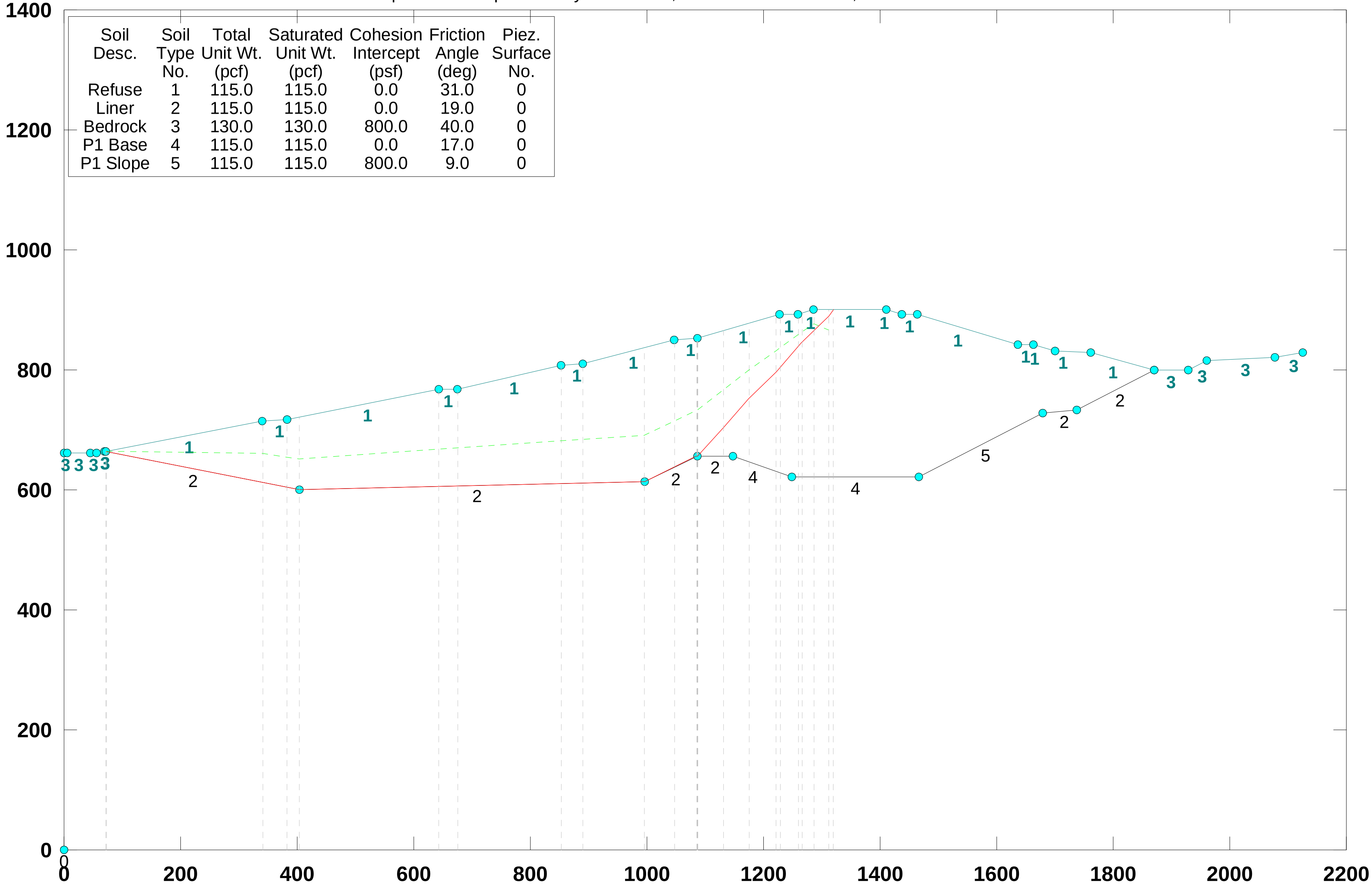
GSTABL7 v.2 FSmin=2.258

Safety Factors Are Calculated By The Simplified Janbu Method

KHF, SECTION F-F', EAST, STATIC, FAILURE PLANE 3

c:\slope\secf-ess3.plt   Run By: Jason Lee, Hushmand Associates, Inc   7/10/2008   02:10PM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0



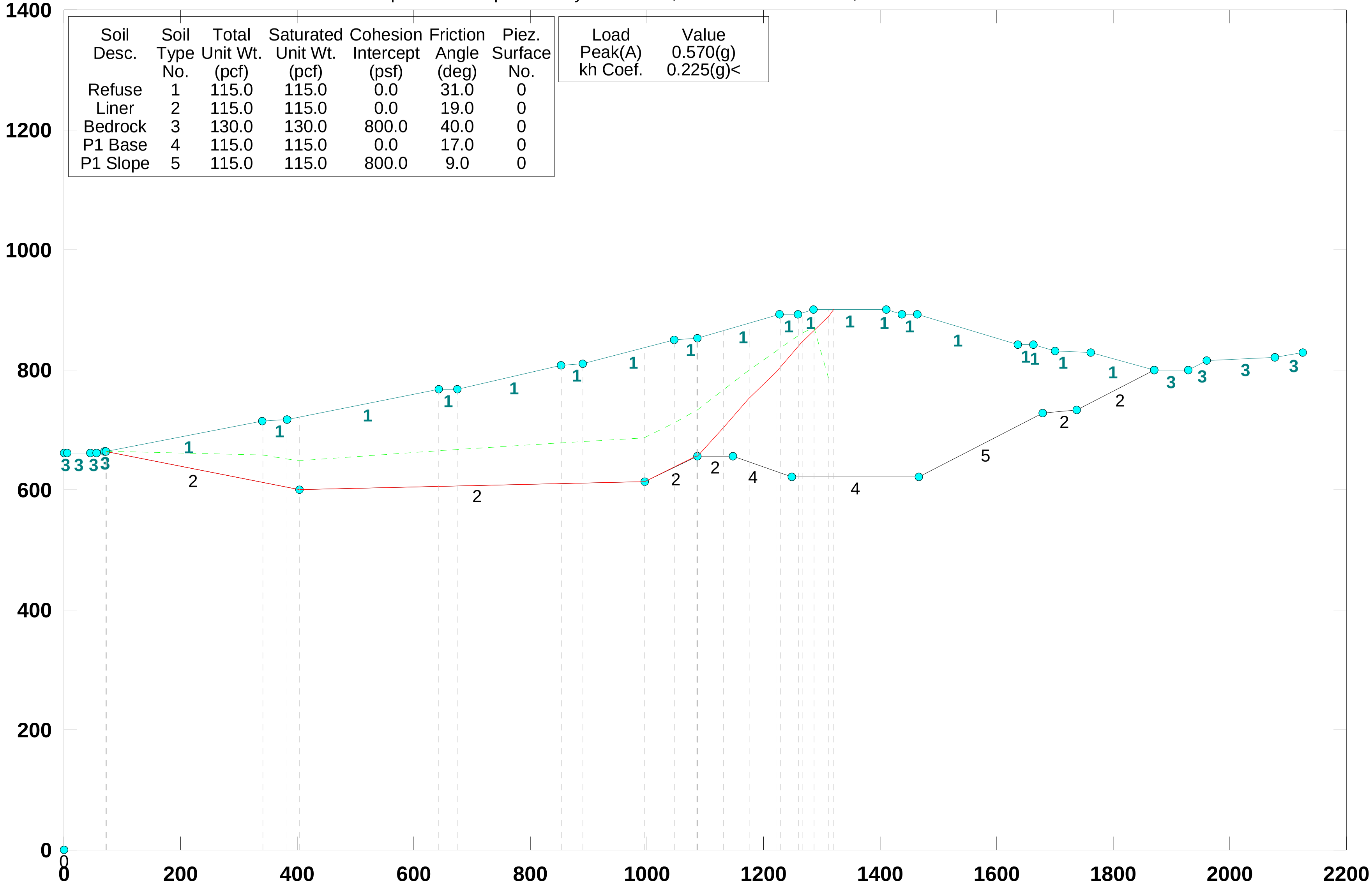
GSTABL7 v.2 FSmin=2.460
Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

KHF, SECTION F-F', EAST, PSEUDO-STATIC, FAILURE PLANE 3

c:\slope\secf-ees3.plt   Run By: Jason Lee, Hushmand Associates, Inc   7/10/2008   02:12PM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0

Load	Value
Peak(A)	0.570(g)
kh Coef.	0.225(g)<



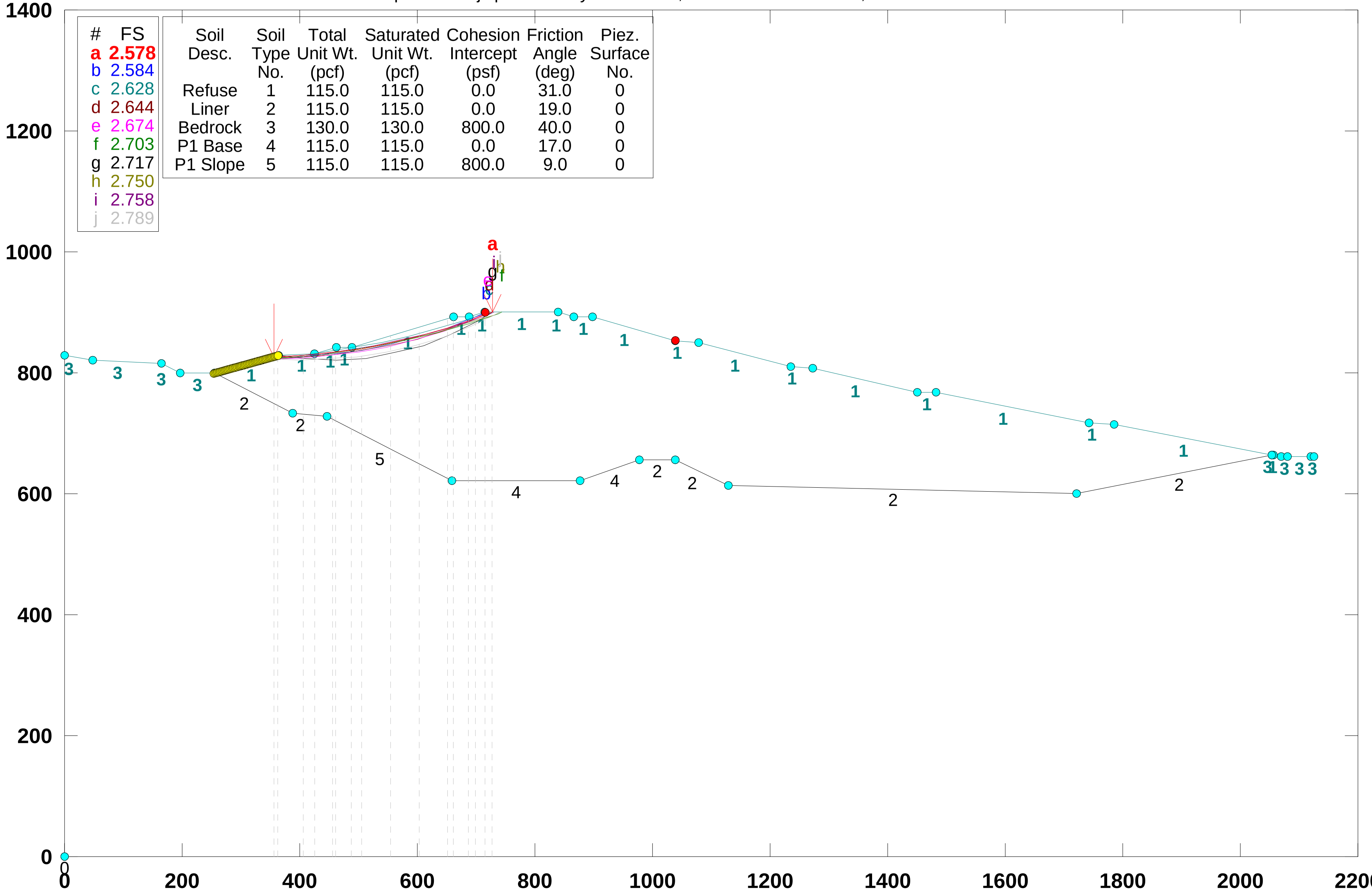
GSTABL7 v.2 FSmin=1.002

Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

GSTABL7

KHF, SECTION F-F', WEST, STATIC, FAILURE PLANE I

c:\slope\secf-wsj i.pl2   Run By: Jason Lee, Hushmand Associates, Inc   7/10/2008   04:39PM



#	FS
a	2.578
b	2.584
c	2.628
d	2.644
e	2.674
f	2.703
g	2.717
h	2.750
i	2.758
j	2.789

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0

GSTABL7 v.2 FSmin=2.578

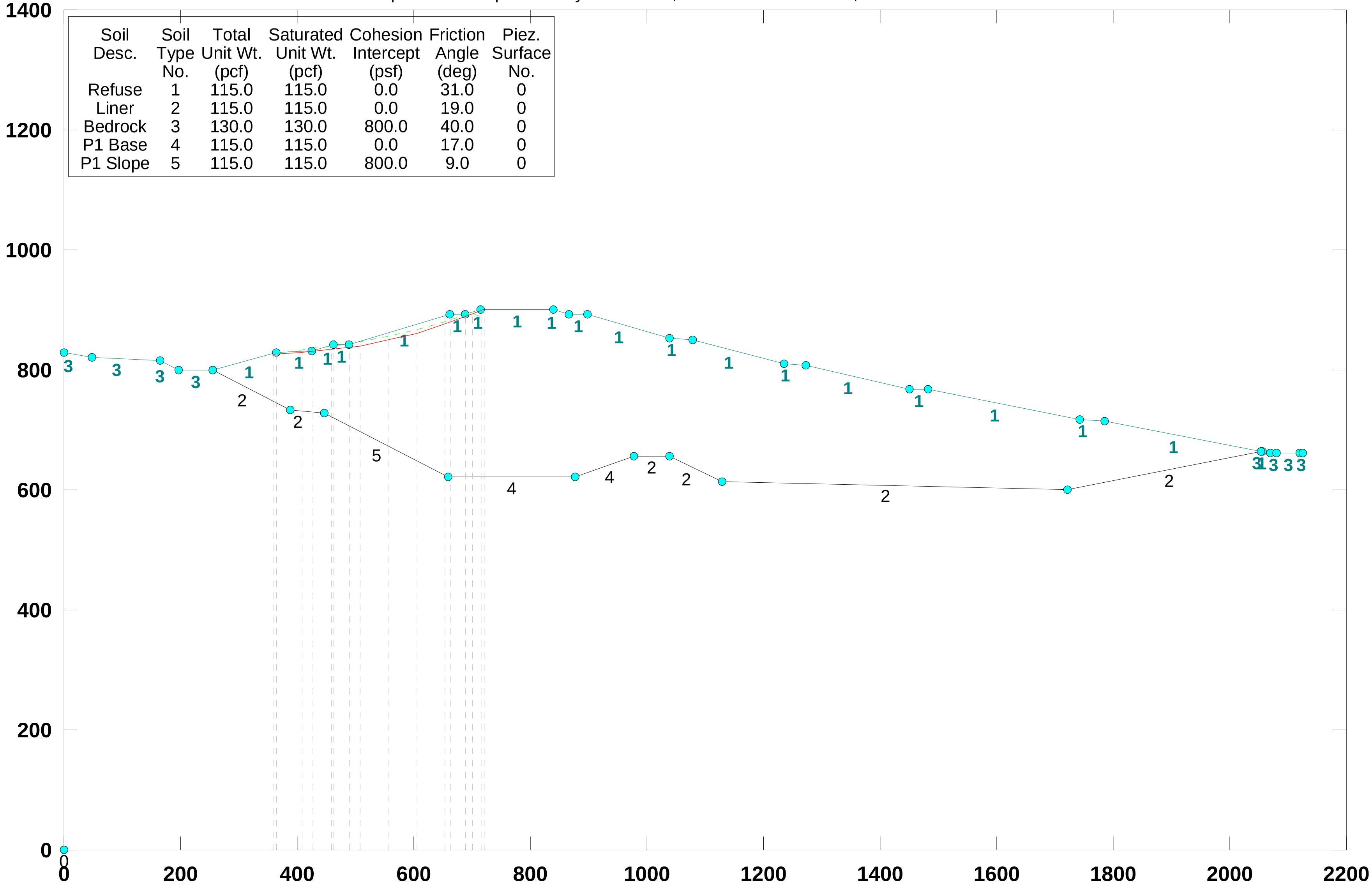
Safety Factors Are Calculated By The Modified Bishop Method

GSTABL7

KHF, SECTION F-F', WEST, STATIC, FAILURE PLANE I

c:\slope\secf-wss i.plt   Run By: Jason Lee, Hushmand Associates, Inc   7/10/2008   04:30PM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0



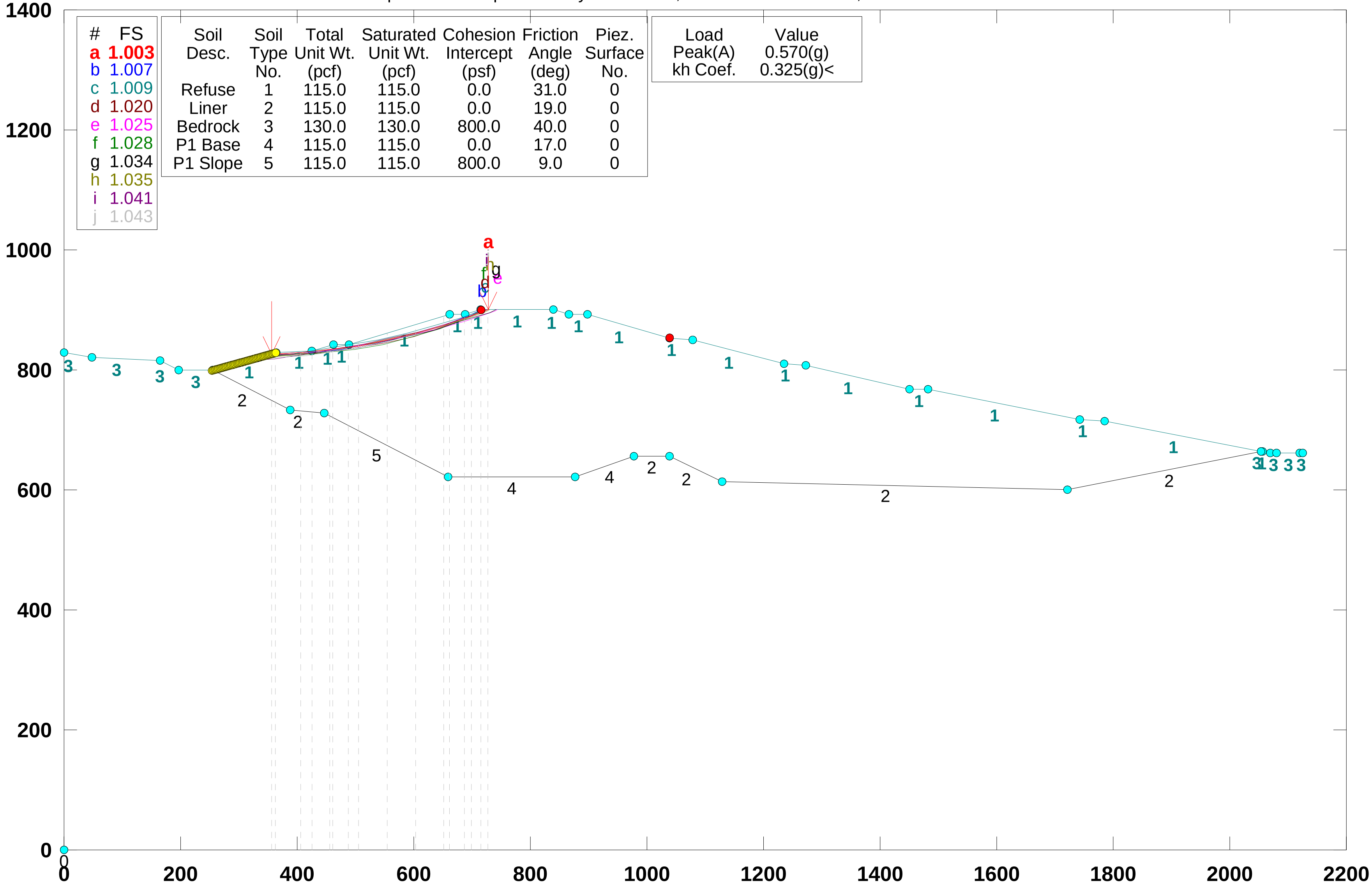
GSTABL7 v.2 FSmin=2.547

Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

GSTABL7

KHF, SECTION F-F', WEST, STATIC, FAILURE PLANE I

c:\slope\secf-web i.pl2 Run By: Jason Lee, Hushmand Associates, Inc 7/25/2008 11:40AM



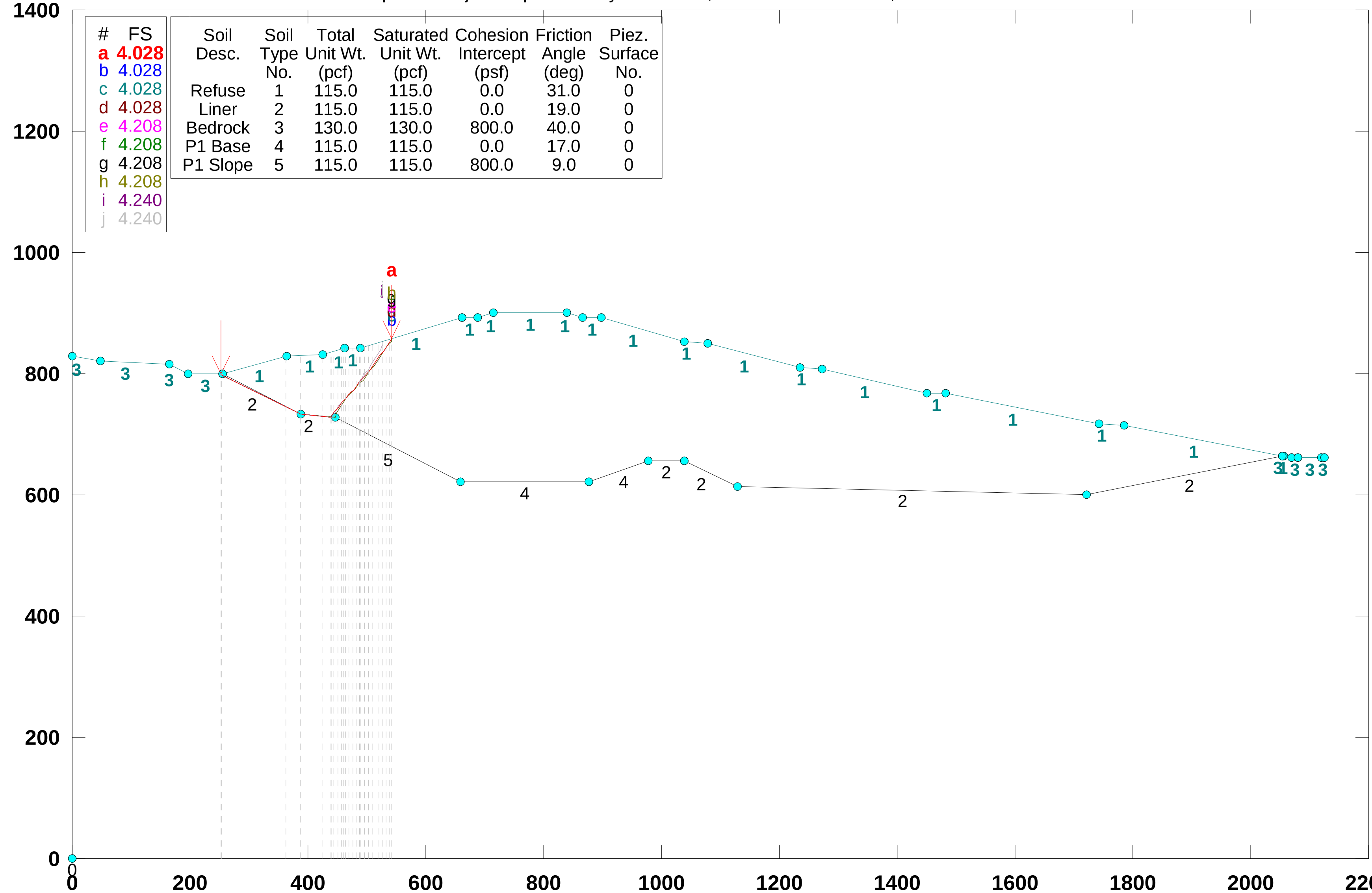
GSTABL7 v.2 FSmin=1.003

Safety Factors Are Calculated By The Modified Bishop Method

GSTABL7

KHF, SECTION F-F', WEST, STATIC, FAILURE PLANE II

c:\slope\secf-wsj ii new.pl2   Run By: Jason Lee, Hushmand Associates, Inc   7/14/2008   09:51AM



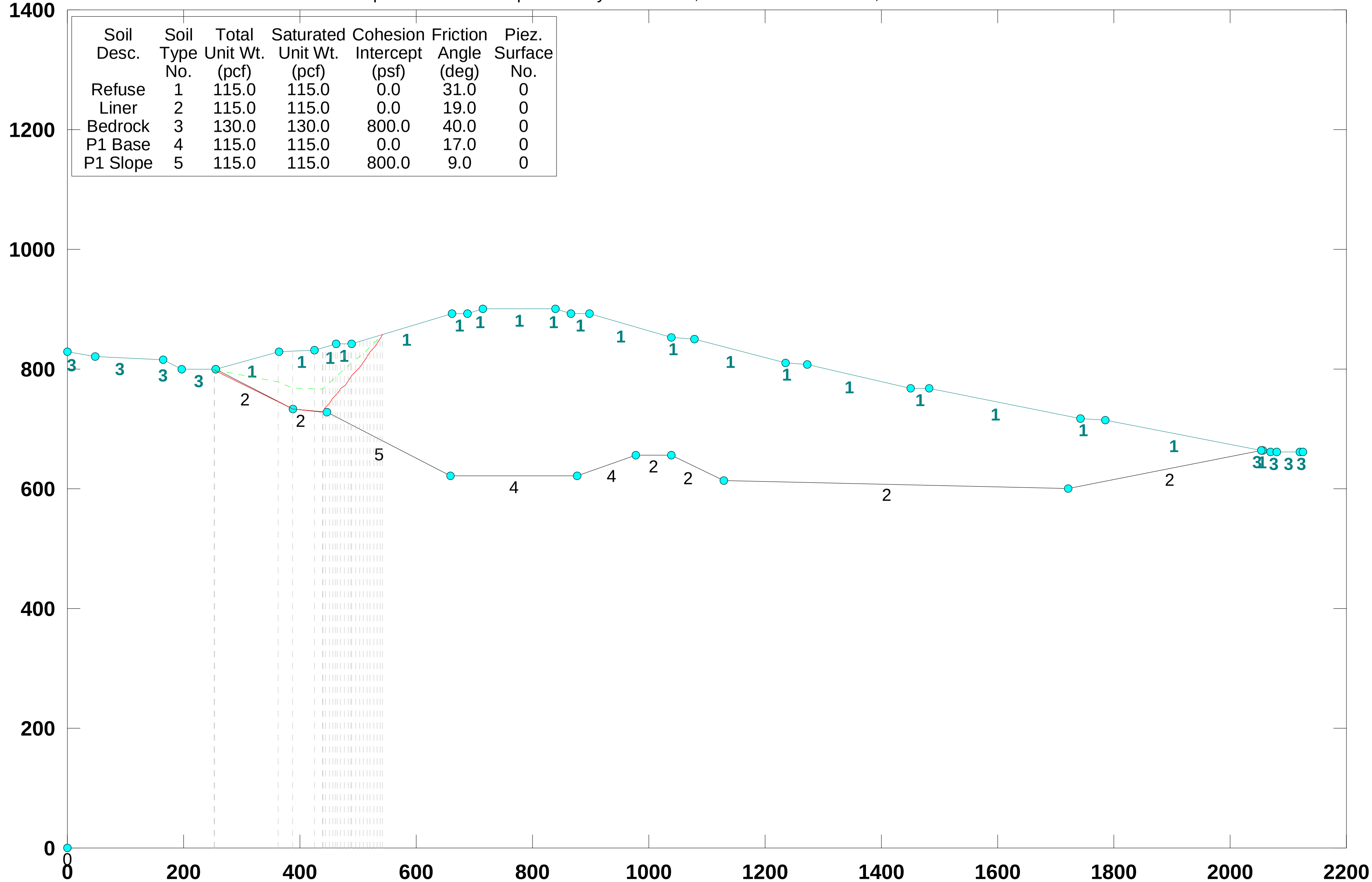
GSTABL7 v.2 FSmin=4.028

Safety Factors Are Calculated By The Simplified Janbu Method

GSTABL7

KHF, SECTION F-F', WEST, STATIC, FAILURE PLANE II

c:\slope\secf-wss ii new.plt   Run By: Jason Lee, Hushmand Associates, Inc   7/14/2008   09:53AM



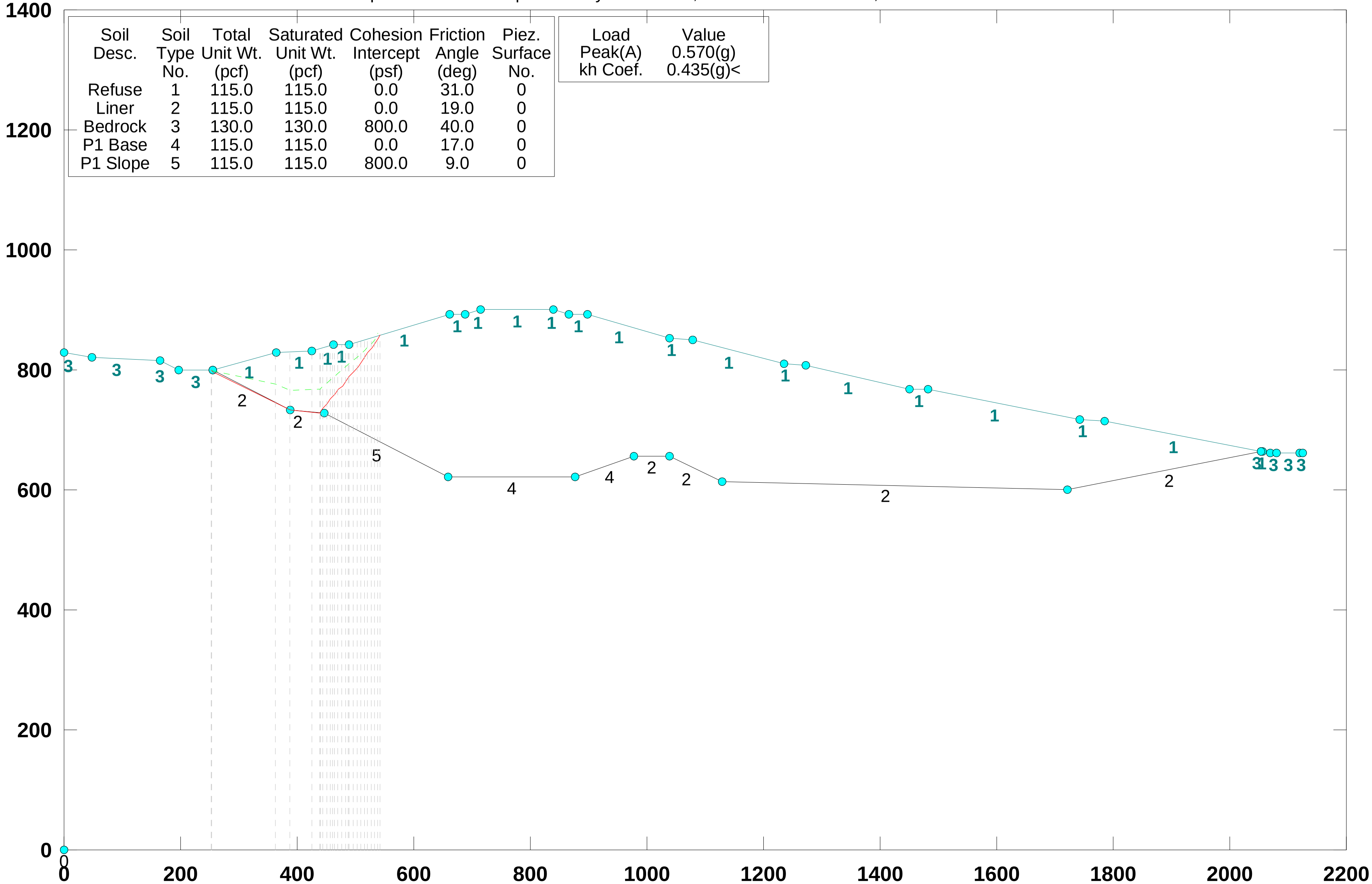
GSTABL7 v.2 FSmin=5.894

Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

GSTABL7

KHF, SECTION F-F', WEST, PSEUDO-STATIC, FAILURE PLANE II

c:\slope\secf-wes ii new.plt   Run By: Jason Lee, Hushmand Associates, Inc   7/14/2008   09:55AM



GSTABL7 v.2 FSmin=1.006

Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

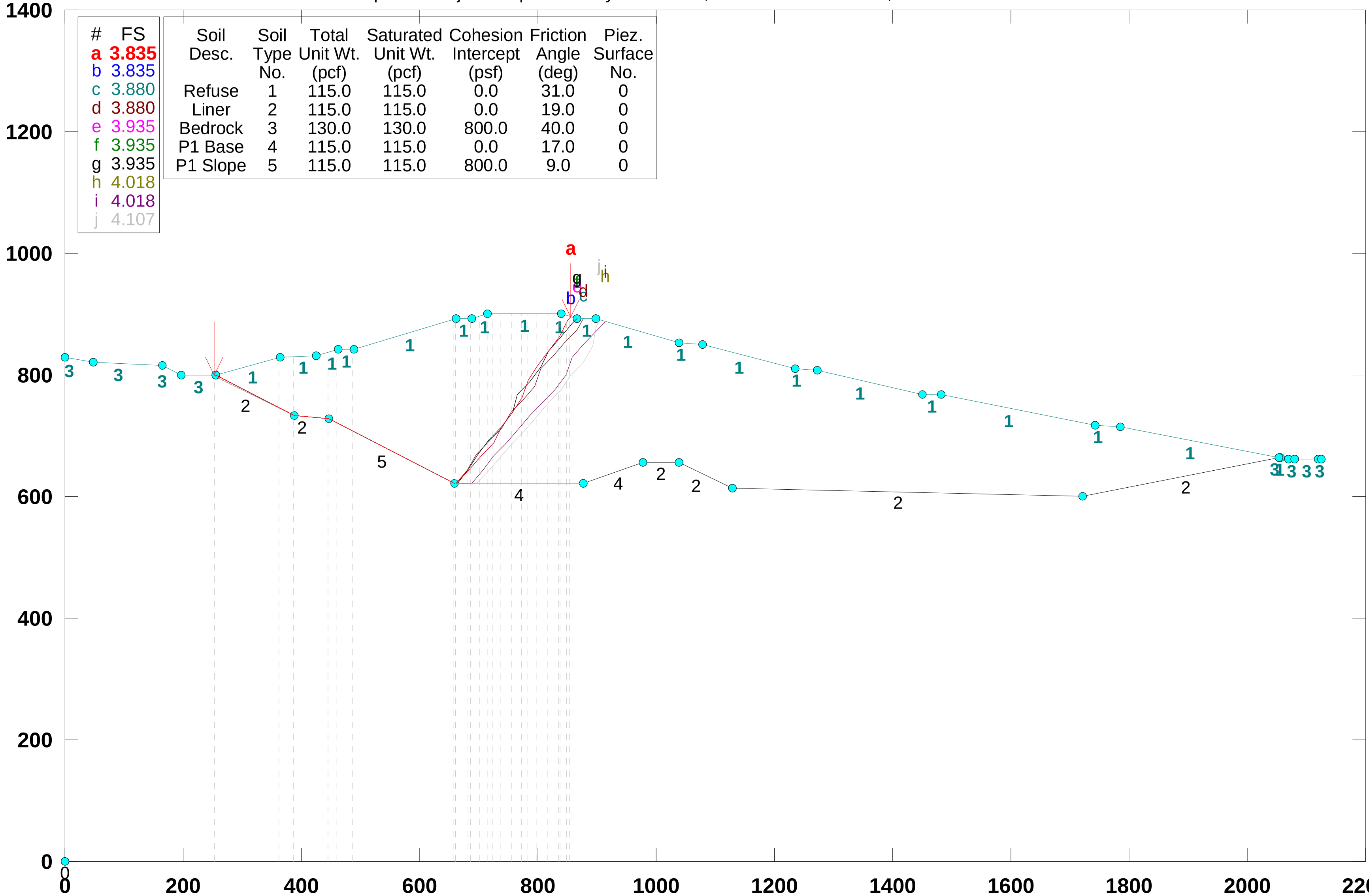
GSTABL7

KHF, SECTION F-F', WEST, STATIC, FAILURE PLANE III

c:\slope\secf-wsj iii new.pl2   Run By: Jason Lee, Hushmand Associates, Inc   7/14/2008   09:57AM

#	FS
a	3.835
b	3.835
c	3.880
d	3.880
e	3.935
f	3.935
g	3.935
h	4.018
i	4.018
j	4.107

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0



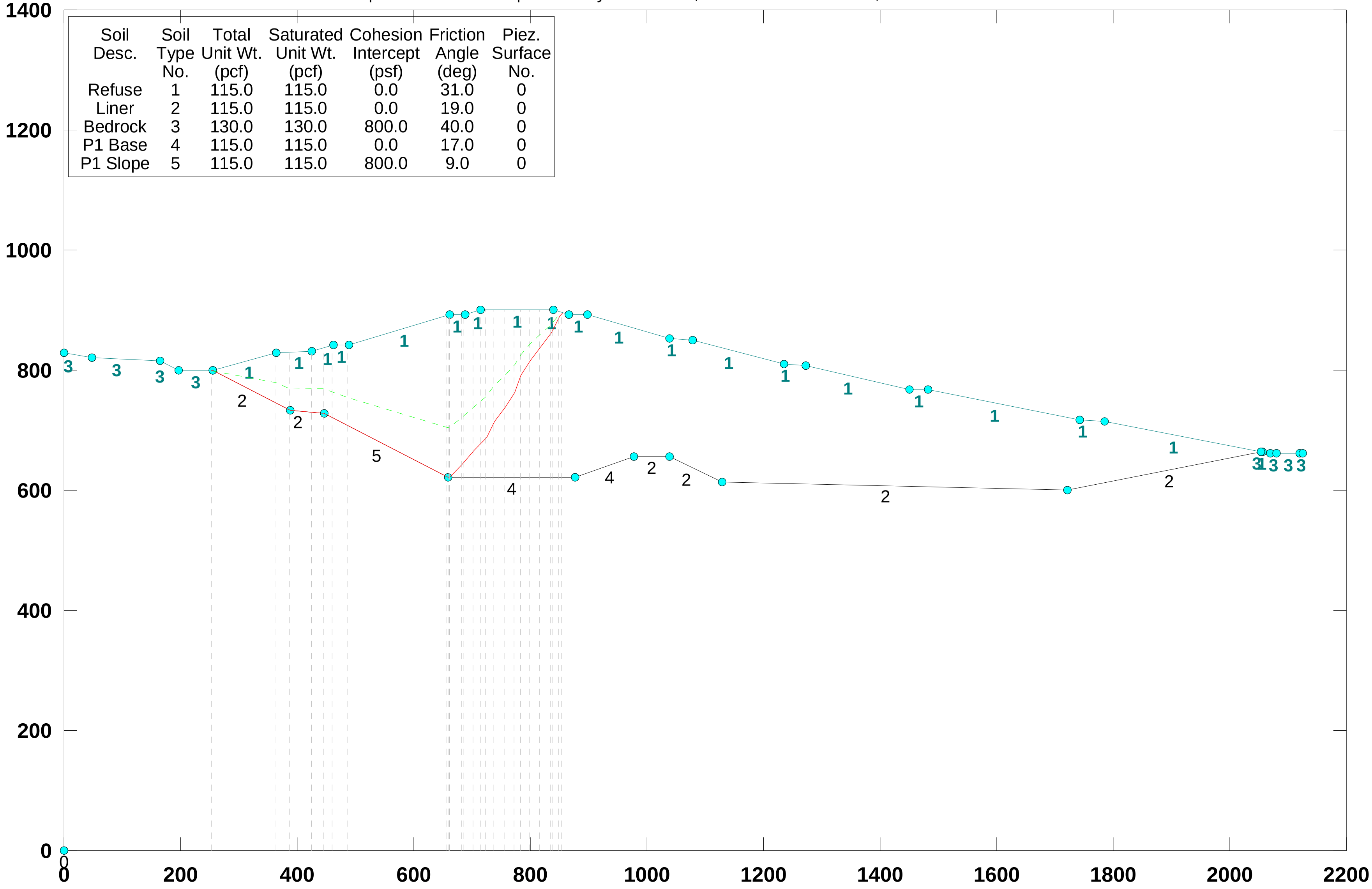
GSTABL7 v.2 FSmin=3.835
Safety Factors Are Calculated By The Simplified Janbu Method

GSTABL7

KHF, SECTION F-F', WEST, STATIC, FAILURE PLANE III

c:\slope\secf-wss iii new.plt   Run By: Jason Lee, Hushmand Associates, Inc   7/14/2008   09:59AM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0

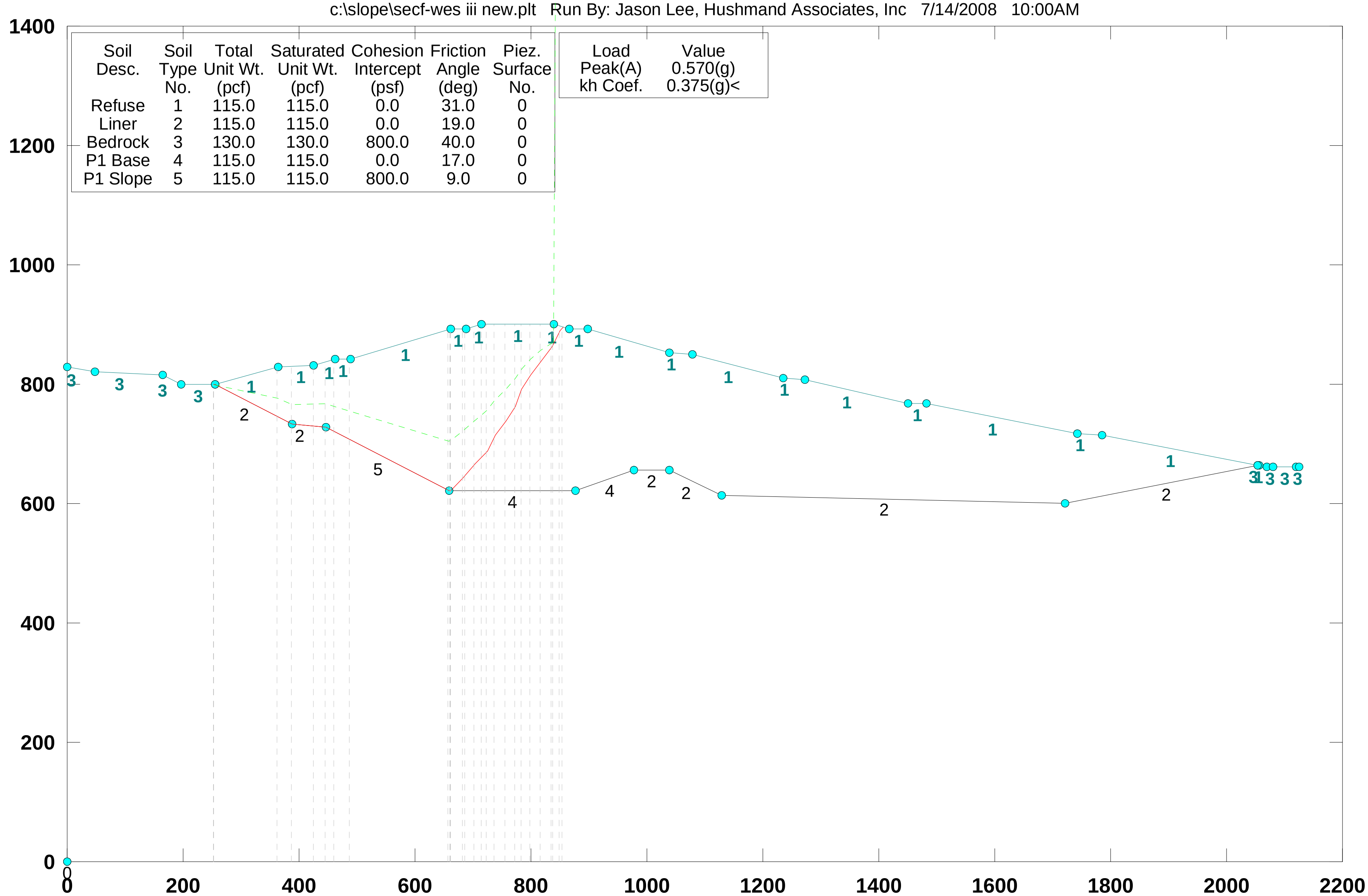


GSTABL7 v.2 FSmin=7.205

Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

KHF, SECTION F-F', WEST, PSEUDO-STATIC, FAILURE PLANE III

c:\slope\secf-wes iii new.plt   Run By: Jason Lee, Hushmand Associates, Inc   7/14/2008   10:00AM



GSTABL7 v.2 FSmin=1.006

Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

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Kettelman Hills Landfill B-18 Site Response, F East, Pacoima 360
UNITS (E for English, S for SI):                          *** (A1)
***
E
      DRF       PRM    ROCKVP    ROCKVS   ROCKRHO             *** (5F10.0)
***
        1      0.65   3000.00   2500.00    150.00
 NELM NDPT NSLP                                           *** (3I5)
***
 1504 1586    1
KGMAX KGEQ N1EQ N2EQ N3EQ NUMB   KV KSAV                  *** (8I5)
***
 2000 2000    1    1 2000    4    1
      DTEQ    EQMUL1    EQMUL2    UGMAX1    UGMAX2 HDRX HDRY NPLX NPLY   PRINPUT ***
(5F10.0,4I5,F10.0) ***
      0.02       1.0       0.0       0.0       0.0    5    0    0    0      0.20
EARTHQUAKE INPUT FILE NAME(S) & FORMAT(S) (* for FREE FORMAT)  *** (A)
***
pac360A.DAT
*
 SOUT AOUT KOUT                                           *** (3I5)
***
    0    0    1
SEISMIC COEFF OUTPUT FORMAT (M or C), FILE PREFIX, AND SUFFIX: *** (A)
***
C
fEpac2
Q4K
 NSEG ESEG                                                *** (2I5)
***
   91  771
NOSEG                                                     *** (15I5)
***
    2    3    6   11   16   22   28   35   42   50   58   67   76   85   94
  104  114  125  136  148  160  172  184  197  210  223  236  249  263  277
  291  305  320  335  350  365  380  395  411  427  443  459  476  493  510
  528  546  564  582  600  619  638  657  676  695  714  733  751  769  768
  786  785  803  802  821  820  819  838  837  856  855  875  874  894  893
  914  913  935  934  957  956  955  978  977 1000  999 1023 1022 1046 1045
 1044
ELSEG                                                     *** (15I5)
***
    3    5    6    7    9   10   11   13   14   15   16   18   19   20   21
   23   24   25   26   27   29   30   31   32   33   35   36   37   38   39
   40   42   43   44   45   46   47   49   50   51   52   53   54   55   57
   58   59   60   61   62   63   65   66   67   68   69   70   71   73   74
   75   76   77   78   79   81   82   83   84   85   86   87   88   90   91
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  930  950  951  952  973  974
    N  NP1  NP2  NP3  NP4 TYPE      DENS        PO       GMX         G        XL
LSTR  *** (6I5,5F10.0,I5) ***
    1    1    3    2    2    3    115.00      0.35    257.69    206.16      0.05
    2    1    1    4    3    3    115.00      0.35    579.81    463.85      0.05
    3    2    3    6    5    3    115.00      0.35    579.81    463.85      0.05
    4    3    4    7    6    3    115.00      0.35   1376.02   1100.82      0.05
    5    5    6    9    8    3    115.00      0.35    595.55    476.44      0.05
    6    6   10    9    9    2    115.00      0.35   1283.92   1027.14      0.05
    7    6   11   10   10    2    115.00      0.35   1582.02   1265.62      0.05
    8    6    7   12   11    3    115.00      0.35   1866.26   1493.01      0.05
    9    8    9   14   13    3    115.00      0.35    418.01    334.41      0.05
   10    9   10   15   14    2    115.00      0.35   1344.20   1075.36      0.05
   11   10   11   16   15    2    115.00      0.35   1918.08   1534.47      0.05
   12   11   12   17   16    3    115.00      0.35   2408.69   1926.95      0.05
   13   13   14   19   18    3    115.00      0.35    418.01    334.41      0.05
   14   14   15   20   19    2    115.00      0.35   1391.43   1113.14      0.05
   15   15   16   21   20    2    115.00      0.35   2059.77   1647.81      0.05
   16   16   22   21   21    2    115.00      0.35   2495.46   1996.37      0.05
   17   16   17   23   22    3    115.00      0.35   2728.91   2183.13      0.05
   18   18   19   25   24    3    115.00      0.35    418.01    334.41      0.05
   19   19   20   26   25    2    115.00      0.35   1417.53   1134.03      0.05
   20   20   21   27   26    2    115.00      0.35   2138.08   1710.47      0.05
   21   21   22   28   27    2    115.00      0.35   2665.82   2132.66      0.05
   22   22   23   29   28    3    115.00      0.35   3049.14   2439.31      0.05
   23   24   25   31   30    3    115.00      0.35    418.01    334.41      0.05
   24   25   26   32   31    2    115.00      0.35   1441.15   1152.92      0.05
   25   26   27   33   32    2    115.00      0.35   2208.92   1767.14      0.05
   26   27   28   34   33    2    115.00      0.35   2739.18   2191.34      0.05
   27   28   35   34   34    2    115.00      0.35   3105.84   2484.67      0.05
   28   28   29   36   35    3    115.00      0.35   3369.36   2695.49      0.05
   29   30   31   38   37    3    115.00      0.35    418.01    334.41      0.05
   30   31   32   39   38    2    115.00      0.35   1454.20   1163.36      0.05
```

31	32	33	40	39	2	115.00	0.35	2248.08	1798.47	0.05
32	33	34	41	40	2	115.00	0.35	2779.73	2223.78	0.05
33	34	35	42	41	2	115.00	0.35	3272.98	2618.39	0.05
34	35	36	43	42	3	115.00	0.35	3617.09	2893.67	0.05
35	37	38	45	44	3	115.00	0.35	418.01	334.41	0.05
36	38	39	46	45	2	115.00	0.35	1468.37	1174.70	0.05
37	39	40	47	46	2	115.00	0.35	2290.59	1832.47	0.05
38	40	41	48	47	2	115.00	0.35	2823.74	2259.00	0.05
39	41	42	49	48	2	115.00	0.35	3331.82	2665.46	0.05
40	42	50	49	49	2	115.00	0.35	3630.65	2904.52	0.05
41	42	43	51	50	3	115.00	0.35	3862.80	3090.24	0.05
42	44	45	53	52	3	115.00	0.35	418.01	334.41	0.05
43	45	46	54	53	2	115.00	0.35	1476.20	1180.96	0.05
44	46	47	55	54	2	115.00	0.35	2314.08	1851.27	0.05
45	47	48	56	55	2	115.00	0.35	2848.07	2278.46	0.05
46	48	49	57	56	2	115.00	0.35	3357.96	2686.37	0.05
47	49	50	58	57	2	115.00	0.35	3757.42	3005.94	0.05
48	50	51	59	58	3	115.00	0.35	4108.52	3286.81	0.05
49	52	53	61	60	3	115.00	0.35	418.01	334.41	0.05
50	53	54	62	61	2	115.00	0.35	1485.65	1188.52	0.05
51	54	55	63	62	2	115.00	0.35	2342.42	1873.93	0.05
52	55	56	64	63	2	115.00	0.35	2877.42	2301.93	0.05
53	56	57	65	64	2	115.00	0.35	3389.48	2711.59	0.05
54	57	58	66	65	2	115.00	0.35	3797.95	3038.36	0.05
55	58	67	66	66	2	115.00	0.35	4101.96	3281.57	0.05
56	58	59	68	67	3	115.00	0.35	4320.17	3456.14	0.05
57	60	61	70	69	3	115.00	0.35	418.01	334.41	0.05
58	61	62	71	70	2	115.00	0.35	1490.87	1192.69	0.05
59	62	63	72	71	2	115.00	0.35	2354.82	1883.86	0.05
60	63	64	73	72	2	115.00	0.35	2893.64	2314.91	0.05
61	64	65	74	73	2	115.00	0.35	3406.91	2725.52	0.05
62	65	66	75	74	2	115.00	0.35	3820.36	3056.28	0.05
63	66	67	76	75	2	115.00	0.35	4208.00	3366.40	0.05
64	67	68	77	76	3	115.00	0.35	4527.32	3621.85	0.05
65	69	70	79	78	3	115.00	0.35	418.01	334.41	0.05
66	70	71	80	79	2	115.00	0.35	1533.11	1226.49	0.05
67	71	72	81	80	2	115.00	0.35	2433.56	1946.85	0.05
68	72	73	82	81	2	115.00	0.35	3024.88	2419.90	0.05
69	73	74	83	82	2	115.00	0.35	3547.89	2838.31	0.05
70	74	75	84	83	2	115.00	0.35	4001.62	3201.30	0.05
71	75	76	85	84	2	115.00	0.35	4394.77	3515.82	0.05
72	76	77	86	85	3	115.00	0.35	4734.46	3787.57	0.05
73	78	79	88	87	3	115.00	0.35	418.01	334.41	0.05
74	79	80	89	88	2	115.00	0.35	1575.36	1260.29	0.05
75	80	81	90	89	2	115.00	0.35	2512.31	2009.84	0.05
76	81	82	91	90	2	115.00	0.35	3156.11	2524.89	0.05
77	82	83	92	91	2	115.00	0.35	3688.87	2951.10	0.05
78	83	84	93	92	2	115.00	0.35	4165.07	3332.06	0.05
79	84	85	94	93	2	115.00	0.35	4581.54	3665.23	0.05
80	85	86	95	94	3	115.00	0.35	4922.06	3937.64	0.05
81	87	88	97	96	3	115.00	0.35	418.01	334.41	0.05
82	88	89	98	97	2	115.00	0.35	1576.07	1260.86	0.05
83	89	90	99	98	2	115.00	0.35	2513.63	2010.91	0.05
84	90	91	100	99	2	115.00	0.35	3158.33	2526.66	0.05
85	91	92	101	100	2	115.00	0.35	3691.25	2953.00	0.05
86	92	93	102	101	2	115.00	0.35	4167.65	3334.12	0.05
87	93	94	103	102	2	115.00	0.35	4584.69	3667.75	0.05
88	94	104	103	103	2	115.00	0.35	4870.74	3896.59	0.05
89	94	95	105	104	3	115.00	0.35	5104.56	4083.64	0.05
90	96	97	107	106	3	115.00	0.35	418.01	334.41	0.05
91	97	98	108	107	2	115.00	0.35	1571.88	1257.51	0.05
92	98	99	109	108	2	115.00	0.35	2505.83	2004.66	0.05
93	99	100	110	109	2	115.00	0.35	3145.32	2516.26	0.05

94	100	101	111	110	2	115.00	0.35	3677.28	2941.82	0.05
95	101	102	112	111	2	115.00	0.35	4152.50	3322.00	0.05
96	102	103	113	112	2	115.00	0.35	4566.18	3652.95	0.05
97	103	104	114	113	2	115.00	0.35	4951.10	3960.88	0.05
98	104	105	115	114	3	115.00	0.35	5287.06	4229.64	0.05
99	106	107	117	116	3	115.00	0.35	418.01	334.41	0.05
100	107	108	118	117	2	115.00	0.35	1567.48	1253.98	0.05
101	108	109	119	118	2	115.00	0.35	2497.62	1998.10	0.05
102	109	110	120	119	2	115.00	0.35	3131.65	2505.32	0.05
103	110	111	121	120	2	115.00	0.35	3662.59	2930.07	0.05
104	111	112	122	121	2	115.00	0.35	4136.58	3309.26	0.05
105	112	113	123	122	2	115.00	0.35	4546.72	3637.38	0.05
106	113	114	124	123	2	115.00	0.35	4930.83	3944.67	0.05
107	114	125	124	124	2	115.00	0.35	5194.55	4155.64	0.05
108	114	115	126	125	3	115.00	0.35	5431.53	4345.23	0.05
109	116	117	128	127	3	115.00	0.35	418.01	334.41	0.05
110	117	118	129	128	2	115.00	0.35	1560.84	1248.68	0.05
111	118	119	130	129	2	115.00	0.35	2485.25	1988.20	0.05
112	119	120	131	130	2	115.00	0.35	3111.03	2488.82	0.05
113	120	121	132	131	2	115.00	0.35	3640.44	2912.35	0.05
114	121	122	133	132	2	115.00	0.35	4112.57	3290.06	0.05
115	122	123	134	133	2	115.00	0.35	4517.38	3613.90	0.05
116	123	124	135	134	2	115.00	0.35	4895.62	3916.50	0.05
117	124	125	136	135	2	115.00	0.35	5243.52	4194.82	0.05
118	125	126	137	136	3	115.00	0.35	5545.12	4436.09	0.05
119	127	128	139	138	3	115.00	0.35	418.01	334.41	0.05
120	128	129	140	139	2	115.00	0.35	1557.38	1245.90	0.05
121	129	130	141	140	2	115.00	0.35	2478.79	1983.03	0.05
122	130	131	142	141	2	115.00	0.35	3100.26	2480.21	0.05
123	131	132	143	142	2	115.00	0.35	3628.87	2903.10	0.05
124	132	133	144	143	2	115.00	0.35	4100.04	3280.03	0.05
125	133	134	145	144	2	115.00	0.35	4502.05	3601.64	0.05
126	134	135	146	145	2	115.00	0.35	4879.67	3903.73	0.05
127	135	136	147	146	2	115.00	0.35	5225.12	4180.09	0.05
128	136	148	147	147	2	115.00	0.35	5473.42	4378.74	0.05
129	136	137	149	148	3	115.00	0.35	5706.88	4565.50	0.05
130	139	151	150	138	3	115.00	0.35	418.01	334.41	0.05
131	140	152	151	139	2	115.00	0.35	1550.09	1240.07	0.05
132	141	153	152	140	2	115.00	0.35	2465.20	1972.16	0.05
133	142	154	153	141	2	115.00	0.35	3077.60	2462.08	0.05
134	143	155	154	142	2	115.00	0.35	3604.53	2883.63	0.05
135	144	156	155	143	2	115.00	0.35	4073.65	3258.92	0.05
136	145	157	156	144	2	115.00	0.35	4469.81	3575.85	0.05
137	146	158	157	145	2	115.00	0.35	4846.09	3876.87	0.05
138	147	159	158	146	2	115.00	0.35	5195.11	4156.09	0.05
139	148	160	159	147	2	115.00	0.35	5527.43	4421.94	0.05
140	149	161	160	148	3	115.00	0.35	5848.66	4678.93	0.05
141	151	163	162	150	3	115.00	0.35	418.01	334.41	0.05
142	152	164	163	151	2	115.00	0.35	1566.53	1253.23	0.05
143	153	165	164	152	2	115.00	0.35	2495.85	1996.68	0.05
144	154	166	165	153	2	115.00	0.35	3128.70	2502.96	0.05
145	155	167	166	154	2	115.00	0.35	3659.42	2927.54	0.05
146	156	168	167	155	2	115.00	0.35	4133.15	3306.52	0.05
147	157	169	168	156	2	115.00	0.35	4542.52	3634.02	0.05
148	158	170	169	157	2	115.00	0.35	4921.80	3937.44	0.05
149	159	171	170	158	2	115.00	0.35	5279.70	4223.76	0.05
150	160	172	171	159	2	115.00	0.35	5605.76	4484.61	0.05
151	161	173	172	160	3	115.00	0.35	5916.56	4733.25	0.05
152	163	175	174	162	3	115.00	0.35	418.01	334.41	0.05
153	164	176	175	163	2	115.00	0.35	1579.10	1263.28	0.05
154	165	177	176	164	2	115.00	0.35	2519.28	2015.43	0.05
155	166	178	177	165	2	115.00	0.35	3167.74	2534.19	0.05
156	167	179	178	166	2	115.00	0.35	3701.36	2961.09	0.05

157	168	180	179	167	2	115.00	0.35	4178.61	3342.89	0.05
158	169	181	180	168	2	115.00	0.35	4598.09	3678.47	0.05
159	170	182	181	169	2	115.00	0.35	4979.66	3983.73	0.05
160	171	183	182	170	2	115.00	0.35	5340.05	4272.04	0.05
161	172	184	183	171	2	115.00	0.35	5674.17	4539.33	0.05
162	173	185	184	172	3	115.00	0.35	5984.27	4787.41	0.05
163	175	187	186	174	3	115.00	0.35	418.01	334.41	0.05
164	175	188	187	187	2	115.00	0.35	1381.68	1105.34	0.05
165	176	189	188	175	2	115.00	0.35	2051.26	1641.01	0.05
166	177	190	189	176	2	115.00	0.35	2794.67	2235.73	0.05
167	178	191	190	177	2	115.00	0.35	3401.30	2721.04	0.05
168	179	192	191	178	2	115.00	0.35	3885.09	3108.07	0.05
169	180	193	192	179	2	115.00	0.35	4321.87	3457.49	0.05
170	181	194	193	180	2	115.00	0.35	4726.06	3780.85	0.05
171	182	195	194	181	2	115.00	0.35	5085.38	4068.30	0.05
172	183	196	195	182	2	115.00	0.35	5426.37	4341.10	0.05
173	184	197	196	183	2	115.00	0.35	5751.22	4600.98	0.05
174	185	198	197	184	3	115.00	0.35	6051.98	4841.58	0.05
175	187	200	199	186	3	115.00	0.35	418.01	334.41	0.05
176	188	201	200	187	2	115.00	0.35	1549.54	1239.63	0.05
177	189	202	201	188	2	115.00	0.35	2464.18	1971.35	0.05
178	190	203	202	189	2	115.00	0.35	3075.91	2460.73	0.05
179	191	204	203	190	2	115.00	0.35	3602.71	2882.17	0.05
180	192	205	204	191	2	115.00	0.35	4071.68	3257.35	0.05
181	193	206	205	192	2	115.00	0.35	4467.40	3573.92	0.05
182	194	207	206	193	2	115.00	0.35	4843.58	3874.87	0.05
183	195	208	207	194	2	115.00	0.35	5192.22	4153.77	0.05
184	196	209	208	195	2	115.00	0.35	5513.29	4410.63	0.05
185	197	210	209	196	2	115.00	0.35	5822.57	4658.06	0.05
186	198	211	210	197	3	115.00	0.35	6119.69	4895.75	0.05
187	200	213	212	199	3	115.00	0.35	418.01	334.41	0.05
188	201	214	213	200	2	115.00	0.35	1560.85	1248.68	0.05
189	202	215	214	201	2	115.00	0.35	2485.27	1988.21	0.05
190	203	216	215	202	2	115.00	0.35	3111.05	2488.84	0.05
191	204	217	216	203	2	115.00	0.35	3640.46	2912.37	0.05
192	205	218	217	204	2	115.00	0.35	4112.60	3290.08	0.05
193	206	219	218	205	2	115.00	0.35	4517.41	3613.93	0.05
194	207	220	219	206	2	115.00	0.35	4895.65	3916.52	0.05
195	208	221	220	207	2	115.00	0.35	5252.30	4201.84	0.05
196	209	222	221	208	2	115.00	0.35	5574.85	4459.88	0.05
197	210	223	222	209	2	115.00	0.35	5885.84	4708.68	0.05
198	211	224	223	210	3	115.00	0.35	6187.41	4949.92	0.05
199	213	226	225	212	3	115.00	0.35	418.01	334.41	0.05
200	214	227	226	213	2	115.00	0.35	1572.16	1257.73	0.05
201	215	228	227	214	2	115.00	0.35	2506.35	2005.08	0.05
202	216	229	228	215	2	115.00	0.35	3146.19	2516.95	0.05
203	217	230	229	216	2	115.00	0.35	3678.21	2942.57	0.05
204	218	231	230	217	2	115.00	0.35	4153.52	3322.81	0.05
205	219	232	231	218	2	115.00	0.35	4567.42	3653.94	0.05
206	220	233	232	219	2	115.00	0.35	4947.73	3958.18	0.05
207	221	234	233	220	2	115.00	0.35	5306.74	4245.39	0.05
208	222	235	234	221	2	115.00	0.35	5636.41	4509.13	0.05
209	223	236	235	222	2	115.00	0.35	5949.12	4759.29	0.05
210	224	237	236	223	3	115.00	0.35	6255.12	5004.09	0.05
211	226	239	238	225	3	115.00	0.35	418.01	334.41	0.05
212	227	240	239	226	2	115.00	0.35	1583.48	1266.78	0.05
213	228	241	240	227	2	115.00	0.35	2527.44	2021.95	0.05
214	229	242	241	228	2	115.00	0.35	3181.33	2545.07	0.05
215	230	243	242	229	2	115.00	0.35	3715.97	2972.77	0.05
216	231	244	243	230	2	115.00	0.35	4194.44	3355.55	0.05
217	232	245	244	231	2	115.00	0.35	4617.43	3693.95	0.05
218	233	246	245	232	2	115.00	0.35	4999.80	3999.84	0.05
219	234	247	246	233	2	115.00	0.35	5361.06	4288.85	0.05

220	235	248	247	234	2	115.00	0.35	5697.98	4558.38	0.05
221	236	249	248	235	2	115.00	0.35	6012.39	4809.91	0.05
222	237	250	249	236	3	115.00	0.35	6322.61	5058.09	0.05
223	239	252	251	238	3	115.00	0.35	418.01	334.41	0.05
224	239	253	252	252	2	115.00	0.35	1386.46	1109.17	0.05
225	240	254	253	239	2	115.00	0.35	2063.90	1651.12	0.05
226	241	255	254	240	2	115.00	0.35	2809.31	2247.45	0.05
227	242	256	255	241	2	115.00	0.35	3417.75	2734.20	0.05
228	243	257	256	242	2	115.00	0.35	3906.74	3125.39	0.05
229	244	258	257	243	2	115.00	0.35	4344.51	3475.61	0.05
230	245	259	258	244	2	115.00	0.35	4749.88	3799.90	0.05
231	246	260	259	245	2	115.00	0.35	5113.07	4090.46	0.05
232	247	261	260	246	2	115.00	0.35	5454.90	4363.92	0.05
233	248	262	261	247	2	115.00	0.35	5780.98	4624.78	0.05
234	249	263	262	248	2	115.00	0.35	6082.93	4866.34	0.05
235	250	264	263	249	3	115.00	0.35	6385.64	5108.51	0.05
236	252	266	265	251	3	115.00	0.35	418.01	334.41	0.05
237	253	267	266	252	2	115.00	0.35	1556.20	1244.96	0.05
238	254	268	267	253	2	115.00	0.35	2476.61	1981.28	0.05
239	255	269	268	254	2	115.00	0.35	3096.61	2477.29	0.05
240	256	270	269	255	2	115.00	0.35	3624.95	2899.96	0.05
241	257	271	270	256	2	115.00	0.35	4095.79	3276.63	0.05
242	258	272	271	257	2	115.00	0.35	4496.87	3597.49	0.05
243	259	273	272	258	2	115.00	0.35	4874.26	3899.41	0.05
244	260	274	273	259	2	115.00	0.35	5227.62	4182.09	0.05
245	261	275	274	260	2	115.00	0.35	5549.56	4439.65	0.05
246	262	276	275	261	2	115.00	0.35	5859.85	4687.88	0.05
247	263	277	276	262	2	115.00	0.35	6153.62	4922.90	0.05
248	264	278	277	263	3	115.00	0.35	6448.66	5158.93	0.05
249	266	280	279	265	3	115.00	0.35	418.01	334.41	0.05
250	267	281	280	266	2	115.00	0.35	1566.49	1253.19	0.05
251	268	282	281	267	2	115.00	0.35	2495.77	1996.62	0.05
252	269	283	282	268	2	115.00	0.35	3128.56	2502.85	0.05
253	270	284	283	269	2	115.00	0.35	3659.27	2927.42	0.05
254	271	285	284	270	2	115.00	0.35	4132.99	3306.39	0.05
255	272	286	285	271	2	115.00	0.35	4542.33	3633.86	0.05
256	273	287	286	272	2	115.00	0.35	4921.60	3937.28	0.05
257	274	288	287	273	2	115.00	0.35	5279.49	4223.59	0.05
258	275	289	288	274	2	115.00	0.35	5605.53	4484.42	0.05
259	276	290	289	275	2	115.00	0.35	5917.37	4733.90	0.05
260	277	291	290	276	2	115.00	0.35	6217.12	4973.70	0.05
261	278	292	291	277	3	115.00	0.35	6511.69	5209.35	0.05
262	280	294	293	279	3	115.00	0.35	418.01	334.41	0.05
263	281	295	294	280	2	115.00	0.35	1576.77	1261.42	0.05
264	282	296	295	281	2	115.00	0.35	2514.94	2011.95	0.05
265	283	297	296	282	2	115.00	0.35	3160.51	2528.41	0.05
266	284	298	297	283	2	115.00	0.35	3693.59	2954.87	0.05
267	285	299	298	284	2	115.00	0.35	4170.19	3336.15	0.05
268	286	300	299	285	2	115.00	0.35	4587.79	3670.24	0.05
269	287	301	300	286	2	115.00	0.35	4968.94	3975.15	0.05
270	288	302	301	287	2	115.00	0.35	5328.87	4263.09	0.05
271	289	303	302	288	2	115.00	0.35	5661.49	4529.19	0.05
272	290	304	303	289	2	115.00	0.35	5974.89	4779.91	0.05
273	291	305	304	290	2	115.00	0.35	6276.30	5021.04	0.05
274	292	306	305	291	3	115.00	0.35	6574.71	5259.77	0.05
275	294	308	307	293	3	115.00	0.35	418.01	334.41	0.05
276	294	309	308	308	2	115.00	0.35	1384.17	1107.33	0.05
277	295	310	309	294	2	115.00	0.35	2055.12	1644.10	0.05
278	296	311	310	295	2	115.00	0.35	2797.23	2237.79	0.05
279	297	312	311	296	2	115.00	0.35	3403.40	2722.72	0.05
280	298	313	312	297	2	115.00	0.35	3887.31	3109.85	0.05
281	299	314	313	298	2	115.00	0.35	4323.85	3459.08	0.05
282	300	315	314	299	2	115.00	0.35	4727.89	3782.31	0.05

283	301	316	315	300	2	115.00	0.35	5087.31	4069.85	0.05
284	302	317	316	301	2	115.00	0.35	5428.20	4342.56	0.05
285	303	318	317	302	2	115.00	0.35	5753.14	4602.51	0.05
286	304	319	318	303	2	115.00	0.35	6052.10	4841.68	0.05
287	305	320	319	304	2	115.00	0.35	6341.58	5073.26	0.05
288	306	321	320	305	3	115.00	0.35	6637.74	5310.19	0.05
289	308	323	322	307	3	115.00	0.35	418.01	334.41	0.05
290	309	324	323	308	2	115.00	0.35	1550.73	1240.58	0.05
291	310	325	324	309	2	115.00	0.35	2466.39	1973.12	0.05
292	311	326	325	310	2	115.00	0.35	3079.59	2463.68	0.05
293	312	327	326	311	2	115.00	0.35	3606.67	2885.34	0.05
294	313	328	327	312	2	115.00	0.35	4075.97	3260.78	0.05
295	314	329	328	313	2	115.00	0.35	4472.64	3578.12	0.05
296	315	330	329	314	2	115.00	0.35	4849.04	3879.23	0.05
297	316	331	330	315	2	115.00	0.35	5198.52	4158.81	0.05
298	317	332	331	316	2	115.00	0.35	5519.75	4415.80	0.05
299	318	333	332	317	2	115.00	0.35	5829.21	4663.37	0.05
300	319	334	333	318	2	115.00	0.35	6119.75	4895.80	0.05
301	320	335	334	319	2	115.00	0.35	6402.14	5121.71	0.05
302	321	336	335	320	3	115.00	0.35	6700.76	5360.61	0.05
303	322	323	338	337	3	115.00	0.35	418.01	334.41	0.05
304	323	324	339	338	2	115.00	0.35	1555.34	1244.27	0.05
305	324	325	340	339	2	115.00	0.35	2474.99	1979.99	0.05
306	325	326	341	340	2	115.00	0.35	3093.91	2475.13	0.05
307	326	327	342	341	2	115.00	0.35	3622.06	2897.64	0.05
308	327	328	343	342	2	115.00	0.35	4092.65	3274.12	0.05
309	328	329	344	343	2	115.00	0.35	4493.02	3594.42	0.05
310	329	330	345	344	2	115.00	0.35	4870.26	3896.21	0.05
311	330	331	346	345	2	115.00	0.35	5223.00	4178.40	0.05
312	331	332	347	346	2	115.00	0.35	5544.83	4435.87	0.05
313	332	333	348	347	2	115.00	0.35	5854.99	4683.99	0.05
314	333	334	349	348	2	115.00	0.35	6148.25	4918.60	0.05
315	334	335	350	349	2	115.00	0.35	6431.19	5144.95	0.05
316	335	336	351	350	3	115.00	0.35	6731.58	5385.27	0.05
317	337	338	353	352	3	115.00	0.35	418.01	334.41	0.05
318	338	339	354	353	2	115.00	0.35	1558.76	1247.01	0.05
319	339	340	355	354	2	115.00	0.35	2481.37	1985.10	0.05
320	340	341	356	355	2	115.00	0.35	3104.56	2483.65	0.05
321	341	342	357	356	2	115.00	0.35	3633.49	2906.79	0.05
322	342	343	358	357	2	115.00	0.35	4105.04	3284.03	0.05
323	343	344	359	358	2	115.00	0.35	4508.17	3606.54	0.05
324	344	345	360	359	2	115.00	0.35	4886.03	3908.83	0.05
325	345	346	361	360	2	115.00	0.35	5241.20	4192.96	0.05
326	346	347	362	361	2	115.00	0.35	5563.48	4450.78	0.05
327	347	348	363	362	2	115.00	0.35	5874.16	4699.32	0.05
328	348	349	364	363	2	115.00	0.35	6169.43	4935.55	0.05
329	349	350	365	364	2	115.00	0.35	6440.83	5152.66	0.05
330	350	351	366	365	3	115.00	0.35	6730.20	5384.16	0.05
331	353	368	367	352	3	115.00	0.35	418.01	334.41	0.05
332	354	369	368	353	2	115.00	0.35	1564.64	1251.71	0.05
333	355	370	369	354	2	115.00	0.35	2492.33	1993.86	0.05
334	356	371	370	355	2	115.00	0.35	3122.81	2498.25	0.05
335	357	372	371	356	2	115.00	0.35	3653.10	2922.48	0.05
336	358	373	372	357	2	115.00	0.35	4126.30	3301.04	0.05
337	359	374	373	358	2	115.00	0.35	4534.15	3627.32	0.05
338	360	375	374	359	2	115.00	0.35	4913.09	3930.47	0.05
339	361	376	375	360	2	115.00	0.35	5270.61	4216.48	0.05
340	362	377	376	361	2	115.00	0.35	5595.46	4476.37	0.05
341	363	378	377	362	2	115.00	0.35	5907.03	4725.62	0.05
342	364	379	378	363	2	115.00	0.35	6205.76	4964.61	0.05
343	365	380	379	364	2	115.00	0.35	6477.87	5182.29	0.05
344	366	381	380	365	3	115.00	0.35	6768.67	5414.94	0.05
345	368	383	382	367	3	115.00	0.35	418.01	334.41	0.05

346	369	384	383	368	2	115.00	0.35	1574.57	1259.66	0.05
347	370	385	384	369	2	115.00	0.35	2510.84	2008.67	0.05
348	371	386	385	370	2	115.00	0.35	3153.67	2522.94	0.05
349	372	387	386	371	2	115.00	0.35	3686.25	2949.00	0.05
350	373	388	387	372	2	115.00	0.35	4162.23	3329.78	0.05
351	374	389	388	373	2	115.00	0.35	4578.07	3662.45	0.05
352	375	390	389	374	2	115.00	0.35	4958.81	3967.05	0.05
353	376	391	390	375	2	115.00	0.35	5318.30	4254.64	0.05
354	377	392	391	376	2	115.00	0.35	5649.52	4519.62	0.05
355	378	393	392	377	2	115.00	0.35	5962.59	4770.07	0.05
356	379	394	393	378	2	115.00	0.35	6263.64	5010.91	0.05
357	380	395	394	379	2	115.00	0.35	6547.14	5237.71	0.05
358	381	396	395	380	3	115.00	0.35	6843.78	5475.02	0.05
359	383	398	397	382	3	115.00	0.35	418.01	334.41	0.05
360	383	399	398	398	2	115.00	0.35	1386.65	1109.32	0.05
361	384	400	399	383	2	115.00	0.35	2060.02	1648.02	0.05
362	385	401	400	384	2	115.00	0.35	2801.74	2241.40	0.05
363	386	402	401	385	2	115.00	0.35	3407.98	2726.39	0.05
364	387	403	402	386	2	115.00	0.35	3893.02	3114.42	0.05
365	388	404	403	387	2	115.00	0.35	4329.61	3463.69	0.05
366	389	405	404	388	2	115.00	0.35	4733.81	3787.04	0.05
367	390	406	405	389	2	115.00	0.35	5094.06	4075.25	0.05
368	391	407	406	390	2	115.00	0.35	5435.05	4348.04	0.05
369	392	408	407	391	2	115.00	0.35	5760.28	4608.23	0.05
370	393	409	408	392	2	115.00	0.35	6059.79	4847.83	0.05
371	394	410	409	393	2	115.00	0.35	6349.39	5079.51	0.05
372	395	411	410	394	2	115.00	0.35	6628.16	5302.53	0.05
373	396	412	411	395	3	115.00	0.35	6918.89	5535.11	0.05
374	398	414	413	397	3	115.00	0.35	418.01	334.41	0.05
375	399	415	414	398	2	115.00	0.35	1556.86	1245.49	0.05
376	400	416	415	399	2	115.00	0.35	2477.83	1982.26	0.05
377	401	417	416	400	2	115.00	0.35	3098.65	2478.92	0.05
378	402	418	417	401	2	115.00	0.35	3627.14	2901.71	0.05
379	403	419	418	402	2	115.00	0.35	4098.16	3278.53	0.05
380	404	420	419	403	2	115.00	0.35	4499.76	3599.81	0.05
381	405	421	420	404	2	115.00	0.35	4877.28	3901.82	0.05
382	406	422	421	405	2	115.00	0.35	5231.10	4184.88	0.05
383	407	423	422	406	2	115.00	0.35	5553.13	4442.50	0.05
384	408	424	423	407	2	115.00	0.35	5863.52	4690.81	0.05
385	409	425	424	408	2	115.00	0.35	6157.67	4926.14	0.05
386	410	426	425	409	2	115.00	0.35	6435.51	5148.41	0.05
387	411	427	426	410	2	115.00	0.35	6705.42	5364.33	0.05
388	412	428	427	411	3	115.00	0.35	6994.00	5595.20	0.05
389	414	430	429	413	3	115.00	0.35	418.01	334.41	0.05
390	415	431	430	414	2	115.00	0.35	1567.90	1254.32	0.05
391	416	432	431	415	2	115.00	0.35	2498.41	1998.73	0.05
392	417	433	432	416	2	115.00	0.35	3132.95	2506.36	0.05
393	418	434	433	417	2	115.00	0.35	3663.99	2931.19	0.05
394	419	435	434	418	2	115.00	0.35	4138.10	3310.48	0.05
395	420	436	435	419	2	115.00	0.35	4548.58	3638.86	0.05
396	421	437	436	420	2	115.00	0.35	4928.10	3942.48	0.05
397	422	438	437	421	2	115.00	0.35	5286.27	4229.02	0.05
398	423	439	438	422	2	115.00	0.35	5613.22	4490.57	0.05
399	424	440	439	423	2	115.00	0.35	5925.27	4740.22	0.05
400	425	441	440	424	2	115.00	0.35	6225.25	4980.20	0.05
401	426	442	441	425	2	115.00	0.35	6505.10	5204.08	0.05
402	427	443	442	426	2	115.00	0.35	6776.45	5421.16	0.05
403	428	444	443	427	3	115.00	0.35	7069.11	5655.29	0.05
404	430	446	445	429	3	115.00	0.35	418.01	334.41	0.05
405	431	447	446	430	2	115.00	0.35	1578.94	1263.15	0.05
406	432	448	447	431	2	115.00	0.35	2518.99	2015.19	0.05
407	433	449	448	432	2	115.00	0.35	3167.25	2533.80	0.05
408	434	450	449	433	2	115.00	0.35	3700.84	2960.67	0.05

409	435	451	450	434	2	115.00	0.35	4178.04	3342.43	0.05
410	436	452	451	435	2	115.00	0.35	4597.39	3677.91	0.05
411	437	453	452	436	2	115.00	0.35	4978.93	3983.14	0.05
412	438	454	453	437	2	115.00	0.35	5339.29	4271.43	0.05
413	439	455	454	438	2	115.00	0.35	5673.30	4538.64	0.05
414	440	456	455	439	2	115.00	0.35	5987.03	4789.62	0.05
415	441	457	456	440	2	115.00	0.35	6288.78	5031.03	0.05
416	442	458	457	441	2	115.00	0.35	6574.68	5259.74	0.05
417	443	459	458	442	2	115.00	0.35	6847.49	5477.99	0.05
418	444	460	459	443	3	115.00	0.35	7144.22	5715.37	0.05
419	446	462	461	445	3	115.00	0.35	418.01	334.41	0.05
420	446	463	462	462	2	115.00	0.35	1390.46	1112.37	0.05
421	447	464	463	446	2	115.00	0.35	2070.56	1656.45	0.05
422	448	465	464	447	2	115.00	0.35	2814.27	2251.42	0.05
423	449	466	465	448	2	115.00	0.35	3422.18	2737.75	0.05
424	450	467	466	449	2	115.00	0.35	3911.81	3129.45	0.05
425	451	468	467	450	2	115.00	0.35	4349.32	3479.46	0.05
426	452	469	468	451	2	115.00	0.35	4754.58	3803.66	0.05
427	453	470	469	452	2	115.00	0.35	5118.24	4094.59	0.05
428	454	471	470	453	2	115.00	0.35	5460.00	4368.00	0.05
429	455	472	471	454	2	115.00	0.35	5786.06	4628.85	0.05
430	456	473	472	455	2	115.00	0.35	6088.40	4870.72	0.05
431	457	474	473	456	2	115.00	0.35	6378.65	5102.92	0.05
432	458	475	474	457	2	115.00	0.35	6659.17	5327.33	0.05
433	459	476	475	458	2	115.00	0.35	6923.47	5538.78	0.05
434	460	477	476	459	3	115.00	0.35	7216.43	5773.15	0.05
435	462	479	478	461	3	115.00	0.35	418.01	334.41	0.05
436	463	480	479	462	2	115.00	0.35	1562.18	1249.75	0.05
437	464	481	480	463	2	115.00	0.35	2487.75	1990.20	0.05
438	465	482	481	464	2	115.00	0.35	3115.19	2492.15	0.05
439	466	483	482	465	2	115.00	0.35	3644.91	2915.93	0.05
440	467	484	483	466	2	115.00	0.35	4117.42	3293.93	0.05
441	468	485	484	467	2	115.00	0.35	4523.30	3618.64	0.05
442	469	486	485	468	2	115.00	0.35	4901.78	3921.43	0.05
443	470	487	486	469	2	115.00	0.35	5258.82	4207.05	0.05
444	471	488	487	470	2	115.00	0.35	5582.10	4465.68	0.05
445	472	489	488	471	2	115.00	0.35	5893.29	4714.63	0.05
446	473	490	489	472	2	115.00	0.35	6190.58	4952.47	0.05
447	474	491	490	473	2	115.00	0.35	6469.06	5175.25	0.05
448	475	492	491	474	2	115.00	0.35	6739.67	5391.73	0.05
449	476	493	492	475	2	115.00	0.35	6999.56	5599.65	0.05
450	477	494	493	476	3	115.00	0.35	7287.47	5829.98	0.05
451	479	496	495	478	3	115.00	0.35	418.01	334.41	0.05
452	480	497	496	479	2	115.00	0.35	1572.44	1257.95	0.05
453	481	498	497	480	2	115.00	0.35	2506.86	2005.49	0.05
454	482	499	498	481	2	115.00	0.35	3147.04	2517.63	0.05
455	483	500	499	482	2	115.00	0.35	3679.12	2943.30	0.05
456	484	501	500	483	2	115.00	0.35	4154.50	3323.60	0.05
457	485	502	501	484	2	115.00	0.35	4568.62	3654.90	0.05
458	486	503	502	485	2	115.00	0.35	4948.98	3959.18	0.05
459	487	504	503	486	2	115.00	0.35	5308.05	4246.44	0.05
460	488	505	504	487	2	115.00	0.35	5637.90	4510.32	0.05
461	489	506	505	488	2	115.00	0.35	5950.64	4760.51	0.05
462	490	507	506	489	2	115.00	0.35	6251.35	5001.08	0.05
463	491	508	507	490	2	115.00	0.35	6533.68	5226.94	0.05
464	492	509	508	491	2	115.00	0.35	6805.63	5444.50	0.05
465	493	510	509	492	2	115.00	0.35	7069.59	5655.67	0.05
466	494	511	510	493	3	115.00	0.35	7358.51	5886.81	0.05
467	496	513	512	495	3	115.00	0.35	418.01	334.41	0.05
468	496	514	513	513	2	115.00	0.35	1385.59	1108.47	0.05
469	497	515	514	496	2	115.00	0.35	2056.15	1644.92	0.05
470	498	516	515	497	2	115.00	0.35	2796.50	2237.20	0.05
471	499	517	516	498	2	115.00	0.35	3401.77	2721.42	0.05

472	500	518	517	499	2	115.00	0.35	3884.63	3107.70	0.05
473	501	519	518	500	2	115.00	0.35	4320.70	3456.56	0.05
474	502	520	519	501	2	115.00	0.35	4724.33	3779.47	0.05
475	503	521	520	502	2	115.00	0.35	5082.97	4066.37	0.05
476	504	522	521	503	2	115.00	0.35	5423.56	4338.85	0.05
477	505	523	522	504	2	115.00	0.35	5747.79	4598.23	0.05
478	506	524	523	505	2	115.00	0.35	6046.53	4837.22	0.05
479	507	525	524	506	2	115.00	0.35	6335.79	5068.63	0.05
480	508	526	525	507	2	115.00	0.35	6613.31	5290.65	0.05
481	509	527	526	508	2	115.00	0.35	6875.91	5500.72	0.05
482	510	528	527	509	2	115.00	0.35	7136.69	5709.35	0.05
483	511	529	528	510	3	115.00	0.35	7429.55	5943.64	0.05
484	513	531	530	512	3	115.00	0.35	418.01	334.41	0.05
485	514	532	531	513	2	115.00	0.35	1551.85	1241.48	0.05
486	515	533	532	514	2	115.00	0.35	2468.49	1974.79	0.05
487	516	534	533	515	2	115.00	0.35	3083.09	2466.47	0.05
488	517	535	534	516	2	115.00	0.35	3610.43	2888.34	0.05
489	518	536	535	517	2	115.00	0.35	4080.04	3264.03	0.05
490	519	537	536	518	2	115.00	0.35	4477.62	3582.09	0.05
491	520	538	537	519	2	115.00	0.35	4854.22	3883.38	0.05
492	521	539	538	520	2	115.00	0.35	5204.49	4163.59	0.05
493	522	540	539	521	2	115.00	0.35	5525.87	4420.70	0.05
494	523	541	540	522	2	115.00	0.35	5835.50	4668.40	0.05
495	524	542	541	523	2	115.00	0.35	6126.71	4901.37	0.05
496	525	543	542	524	2	115.00	0.35	6403.94	5123.16	0.05
497	526	544	543	525	2	115.00	0.35	6673.19	5338.55	0.05
498	527	545	544	526	2	115.00	0.35	6927.76	5542.21	0.05
499	528	546	545	527	2	115.00	0.35	7179.99	5743.99	0.05
500	529	547	546	528	3	115.00	0.35	7470.65	5976.52	0.05
501	531	549	548	530	3	115.00	0.35	418.01	334.41	0.05
502	532	550	549	531	2	115.00	0.35	1556.27	1245.02	0.05
503	533	551	550	532	2	115.00	0.35	2476.73	1981.38	0.05
504	534	552	551	533	2	115.00	0.35	3096.81	2477.45	0.05
505	535	553	552	534	2	115.00	0.35	3625.17	2900.14	0.05
506	536	554	553	535	2	115.00	0.35	4096.02	3276.82	0.05
507	537	555	554	536	2	115.00	0.35	4497.15	3597.72	0.05
508	538	556	555	537	2	115.00	0.35	4874.56	3899.65	0.05
509	539	557	556	538	2	115.00	0.35	5227.96	4182.37	0.05
510	540	558	557	539	2	115.00	0.35	5549.91	4439.93	0.05
511	541	559	558	540	2	115.00	0.35	5860.21	4688.17	0.05
512	542	560	559	541	2	115.00	0.35	6154.02	4923.22	0.05
513	543	561	560	542	2	115.00	0.35	6431.79	5145.43	0.05
514	544	562	561	543	2	115.00	0.35	6701.61	5361.29	0.05
515	545	563	562	544	2	115.00	0.35	6958.46	5566.77	0.05
516	546	564	563	545	2	115.00	0.35	7200.53	5760.43	0.05
517	547	565	564	546	3	115.00	0.35	7481.81	5985.45	0.05
518	549	567	566	548	3	115.00	0.35	418.01	334.41	0.05
519	550	568	567	549	2	115.00	0.35	1562.48	1249.99	0.05
520	551	569	568	550	2	115.00	0.35	2488.31	1990.65	0.05
521	552	570	569	551	2	115.00	0.35	3116.12	2492.90	0.05
522	553	571	570	552	2	115.00	0.35	3645.91	2916.73	0.05
523	554	572	571	553	2	115.00	0.35	4118.50	3294.80	0.05
524	555	573	572	554	2	115.00	0.35	4524.63	3619.70	0.05
525	556	574	573	555	2	115.00	0.35	4903.17	3922.53	0.05
526	557	575	574	556	2	115.00	0.35	5260.26	4208.21	0.05
527	558	576	575	557	2	115.00	0.35	5583.73	4466.99	0.05
528	559	577	576	558	2	115.00	0.35	5894.97	4715.98	0.05
529	560	578	577	559	2	115.00	0.35	6192.44	4953.95	0.05
530	561	579	578	560	2	115.00	0.35	6470.95	5176.76	0.05
531	562	580	579	561	2	115.00	0.35	6741.60	5393.28	0.05
532	563	581	580	562	2	115.00	0.35	7001.65	5601.32	0.05
533	564	582	581	563	2	115.00	0.35	7244.40	5795.52	0.05
534	565	583	582	564	3	115.00	0.35	7527.95	6022.36	0.05

535	567	585	584	566	3	115.00	0.35	418.01	334.41	0.05
536	568	586	585	567	2	115.00	0.35	1571.84	1257.47	0.05
537	569	587	586	568	2	115.00	0.35	2505.75	2004.60	0.05
538	570	588	587	569	2	115.00	0.35	3145.18	2516.15	0.05
539	571	589	588	570	2	115.00	0.35	3677.13	2941.71	0.05
540	572	590	589	571	2	115.00	0.35	4152.35	3321.88	0.05
541	573	591	590	572	2	115.00	0.35	4565.99	3652.79	0.05
542	574	592	591	573	2	115.00	0.35	4946.23	3956.99	0.05
543	575	593	592	574	2	115.00	0.35	5305.18	4244.15	0.05
544	576	594	593	575	2	115.00	0.35	5634.65	4507.72	0.05
545	577	595	594	576	2	115.00	0.35	5947.30	4757.84	0.05
546	578	596	595	577	2	115.00	0.35	6247.91	4998.33	0.05
547	579	597	596	578	2	115.00	0.35	6529.92	5223.93	0.05
548	580	598	597	579	2	115.00	0.35	6801.79	5441.43	0.05
549	581	599	598	580	2	115.00	0.35	7065.67	5652.53	0.05
550	582	600	599	581	2	115.00	0.35	7316.18	5852.95	0.05
551	583	601	600	582	3	115.00	0.35	7604.63	6083.70	0.05
552	585	603	602	584	3	115.00	0.35	418.01	334.41	0.05
553	585	604	603	603	2	115.00	0.35	1389.12	1111.29	0.05
554	586	605	604	585	2	115.00	0.35	2063.96	1651.16	0.05
555	587	606	605	586	2	115.00	0.35	2804.47	2243.57	0.05
556	588	607	606	587	2	115.00	0.35	3410.29	2728.23	0.05
557	589	608	607	588	2	115.00	0.35	3895.54	3116.43	0.05
558	590	609	608	589	2	115.00	0.35	4331.92	3465.54	0.05
559	591	610	609	590	2	115.00	0.35	4736.00	3788.80	0.05
560	592	611	610	591	2	115.00	0.35	5096.42	4077.13	0.05
561	593	612	611	592	2	115.00	0.35	5437.33	4349.86	0.05
562	594	613	612	593	2	115.00	0.35	5762.51	4610.01	0.05
563	595	614	613	594	2	115.00	0.35	6062.15	4849.72	0.05
564	596	615	614	595	2	115.00	0.35	6351.71	5081.37	0.05
565	597	616	615	596	2	115.00	0.35	6630.60	5304.48	0.05
566	598	617	616	597	2	115.00	0.35	6893.44	5514.76	0.05
567	599	618	617	598	2	115.00	0.35	7149.59	5719.68	0.05
568	600	619	618	599	2	115.00	0.35	7397.35	5917.88	0.05
569	601	620	619	600	3	115.00	0.35	7679.26	6143.41	0.05
570	603	622	621	602	3	115.00	0.35	418.01	334.41	0.05
571	604	623	622	603	2	115.00	0.35	1560.16	1248.13	0.05
572	605	624	623	604	2	115.00	0.35	2483.99	1987.19	0.05
573	606	625	624	605	2	115.00	0.35	3108.92	2487.13	0.05
574	607	626	625	606	2	115.00	0.35	3638.17	2910.54	0.05
575	608	627	626	607	2	115.00	0.35	4110.12	3288.09	0.05
576	609	628	627	608	2	115.00	0.35	4514.37	3611.50	0.05
577	610	629	628	609	2	115.00	0.35	4892.49	3913.99	0.05
578	611	630	629	610	2	115.00	0.35	5248.65	4198.92	0.05
579	612	631	630	611	2	115.00	0.35	5571.12	4456.89	0.05
580	613	632	631	612	2	115.00	0.35	5882.00	4705.60	0.05
581	614	633	632	613	2	115.00	0.35	6178.11	4942.48	0.05
582	615	634	633	614	2	115.00	0.35	6456.34	5165.07	0.05
583	616	635	634	615	2	115.00	0.35	6726.68	5381.34	0.05
584	617	636	635	616	2	115.00	0.35	6985.53	5588.43	0.05
585	618	637	636	617	2	115.00	0.35	7233.77	5787.02	0.05
586	619	638	637	618	2	115.00	0.35	7474.69	5979.75	0.05
587	620	639	638	619	3	115.00	0.35	7753.89	6203.11	0.05
588	622	641	640	621	3	115.00	0.35	418.01	334.41	0.05
589	623	642	641	622	2	115.00	0.35	1570.41	1256.33	0.05
590	624	643	642	623	2	115.00	0.35	2503.08	2002.46	0.05
591	625	644	643	624	2	115.00	0.35	3140.74	2512.59	0.05
592	626	645	644	625	2	115.00	0.35	3672.36	2937.89	0.05
593	627	646	645	626	2	115.00	0.35	4147.17	3317.74	0.05
594	628	647	646	627	2	115.00	0.35	4559.66	3647.73	0.05
595	629	648	647	628	2	115.00	0.35	4939.65	3951.72	0.05
596	630	649	648	629	2	115.00	0.35	5298.31	4238.65	0.05
597	631	650	649	630	2	115.00	0.35	5626.86	4501.49	0.05

598	632	651	650	631	2	115.00	0.35	5939.30	4751.44	0.05
599	633	652	651	632	2	115.00	0.35	6239.68	4991.74	0.05
600	634	653	652	633	2	115.00	0.35	6520.90	5216.72	0.05
601	635	654	653	634	2	115.00	0.35	6792.59	5434.07	0.05
602	636	655	654	635	2	115.00	0.35	7056.26	5645.01	0.05
603	637	656	655	636	2	115.00	0.35	7306.08	5844.86	0.05
604	638	657	656	637	2	115.00	0.35	7545.80	6036.64	0.05
605	639	658	657	638	3	115.00	0.35	7828.53	6262.82	0.05
606	641	660	659	640	3	115.00	0.35	418.01	334.41	0.05
607	642	661	660	641	2	115.00	0.35	1577.45	1261.96	0.05
608	643	662	661	642	2	115.00	0.35	2516.21	2012.97	0.05
609	644	663	662	643	2	115.00	0.35	3162.63	2530.10	0.05
610	645	664	663	644	2	115.00	0.35	3695.87	2956.70	0.05
611	646	665	664	645	2	115.00	0.35	4172.66	3338.13	0.05
612	647	666	665	646	2	115.00	0.35	4590.81	3672.65	0.05
613	648	667	666	647	2	115.00	0.35	4972.08	3977.67	0.05
614	649	668	667	648	2	115.00	0.35	5332.15	4265.72	0.05
615	650	669	668	649	2	115.00	0.35	5665.21	4532.17	0.05
616	651	670	669	650	2	115.00	0.35	5978.71	4782.97	0.05
617	652	671	670	651	2	115.00	0.35	6280.23	5024.18	0.05
618	653	672	671	652	2	115.00	0.35	6565.31	5252.24	0.05
619	654	673	672	653	2	115.00	0.35	6837.92	5470.34	0.05
620	655	674	673	654	2	115.00	0.35	7102.57	5682.06	0.05
621	656	675	674	655	2	115.00	0.35	7355.82	5884.66	0.05
622	657	676	675	656	2	115.00	0.35	7606.18	6084.94	0.05
623	658	677	676	657	3	115.00	0.35	7903.16	6322.53	0.05
624	659	660	679	678	3	115.00	0.35	418.01	334.41	0.05
625	660	661	680	679	2	115.00	0.35	1578.11	1262.48	0.05
626	661	662	681	680	2	115.00	0.35	2517.43	2013.94	0.05
627	662	663	682	681	2	115.00	0.35	3164.65	2531.72	0.05
628	663	664	683	682	2	115.00	0.35	3698.05	2958.44	0.05
629	664	665	684	683	2	115.00	0.35	4175.01	3340.01	0.05
630	665	666	685	684	2	115.00	0.35	4593.70	3674.96	0.05
631	666	667	686	685	2	115.00	0.35	4975.08	3980.07	0.05
632	667	668	687	686	2	115.00	0.35	5335.28	4268.22	0.05
633	668	669	688	687	2	115.00	0.35	5668.76	4535.00	0.05
634	669	670	689	688	2	115.00	0.35	5982.36	4785.88	0.05
635	670	671	690	689	2	115.00	0.35	6283.97	5027.18	0.05
636	671	672	691	690	2	115.00	0.35	6569.41	5255.53	0.05
637	672	673	692	691	2	115.00	0.35	6842.11	5473.69	0.05
638	673	674	693	692	2	115.00	0.35	7106.85	5685.48	0.05
639	674	675	694	693	2	115.00	0.35	7360.42	5888.34	0.05
640	675	676	695	694	2	115.00	0.35	7610.70	6088.56	0.05
641	676	677	696	695	3	115.00	0.35	7907.91	6326.32	0.05
642	678	679	698	697	3	115.00	0.35	418.01	334.41	0.05
643	679	680	699	698	2	115.00	0.35	1572.36	1257.89	0.05
644	680	681	700	699	2	115.00	0.35	2506.72	2005.38	0.05
645	681	682	701	700	2	115.00	0.35	3146.81	2517.45	0.05
646	682	683	702	701	2	115.00	0.35	3678.88	2943.10	0.05
647	683	684	703	702	2	115.00	0.35	4154.24	3323.39	0.05
648	684	685	704	703	2	115.00	0.35	4568.30	3654.64	0.05
649	685	686	705	704	2	115.00	0.35	4948.65	3958.92	0.05
650	686	687	706	705	2	115.00	0.35	5307.70	4246.16	0.05
651	687	688	707	706	2	115.00	0.35	5637.50	4510.00	0.05
652	688	689	708	707	2	115.00	0.35	5950.23	4760.19	0.05
653	689	690	709	708	2	115.00	0.35	6250.93	5000.74	0.05
654	690	691	710	709	2	115.00	0.35	6533.22	5226.57	0.05
655	691	692	711	710	2	115.00	0.35	6805.16	5444.13	0.05
656	692	693	712	711	2	115.00	0.35	7069.11	5655.29	0.05
657	693	694	713	712	2	115.00	0.35	7319.88	5855.90	0.05
658	694	695	714	713	2	115.00	0.35	7559.38	6047.50	0.05
659	695	696	715	714	3	115.00	0.35	7842.77	6274.21	0.05
660	697	698	717	716	3	115.00	0.35	418.01	334.41	0.05

661	698	699	718	717	2	115.00	0.35	1561.67	1249.34	0.05
662	699	700	719	718	2	115.00	0.35	2486.80	1989.44	0.05
663	700	701	720	719	2	115.00	0.35	3113.60	2490.88	0.05
664	701	702	721	720	2	115.00	0.35	3643.20	2914.56	0.05
665	702	703	722	721	2	115.00	0.35	4115.57	3292.45	0.05
666	703	704	723	722	2	115.00	0.35	4521.04	3616.83	0.05
667	704	705	724	723	2	115.00	0.35	4899.43	3919.54	0.05
668	705	706	725	724	2	115.00	0.35	5256.36	4205.09	0.05
669	706	707	726	725	2	115.00	0.35	5579.32	4463.45	0.05
670	707	708	727	726	2	115.00	0.35	5890.43	4712.34	0.05
671	708	709	728	727	2	115.00	0.35	6187.42	4949.94	0.05
672	709	710	729	728	2	115.00	0.35	6465.84	5172.67	0.05
673	710	711	730	729	2	115.00	0.35	6736.37	5389.10	0.05
674	711	712	731	730	2	115.00	0.35	6996.00	5596.80	0.05
675	712	713	732	731	2	115.00	0.35	7244.41	5795.53	0.05
676	713	714	733	732	2	115.00	0.35	7491.43	5993.14	0.05
677	714	715	734	733	3	115.00	0.35	7777.63	6222.10	0.05
678	716	717	736	735	3	115.00	0.35	418.01	334.41	0.05
679	717	718	737	736	2	115.00	0.35	1563.55	1250.84	0.05
680	718	719	738	737	2	115.00	0.35	2490.30	1992.24	0.05
681	719	720	739	738	2	115.00	0.35	3119.44	2495.55	0.05
682	720	721	740	739	2	115.00	0.35	3649.48	2919.58	0.05
683	721	722	741	740	2	115.00	0.35	4122.37	3297.90	0.05
684	722	723	742	741	2	115.00	0.35	4529.35	3623.48	0.05
685	723	724	743	742	2	115.00	0.35	4908.09	3926.47	0.05
686	724	725	744	743	2	115.00	0.35	5265.39	4212.31	0.05
687	725	726	745	744	2	115.00	0.35	5589.55	4471.64	0.05
688	726	727	746	745	2	115.00	0.35	5900.95	4720.76	0.05
689	727	728	747	746	2	115.00	0.35	6199.05	4959.24	0.05
690	728	729	748	747	2	115.00	0.35	6477.69	5182.15	0.05
691	729	730	749	748	2	115.00	0.35	6748.48	5398.78	0.05
692	730	731	750	749	2	115.00	0.35	7009.07	5607.26	0.05
693	731	732	751	750	2	115.00	0.35	7257.68	5806.15	0.05
694	732	733	751	751	2	115.00	0.35	7449.42	5959.54	0.05
695	733	734	752	751	3	115.00	0.35	7674.21	6139.37	0.05
696	735	736	754	753	3	115.00	0.35	418.01	334.41	0.05
697	736	737	755	754	2	115.00	0.35	1566.66	1253.33	0.05
698	737	738	756	755	2	115.00	0.35	2496.09	1996.87	0.05
699	738	739	757	756	2	115.00	0.35	3129.09	2503.27	0.05
700	739	740	758	757	2	115.00	0.35	3659.85	2927.88	0.05
701	740	741	759	758	2	115.00	0.35	4133.61	3306.89	0.05
702	741	742	760	759	2	115.00	0.35	4543.09	3634.47	0.05
703	742	743	761	760	2	115.00	0.35	4922.39	3937.91	0.05
704	743	744	762	761	2	115.00	0.35	5280.31	4224.25	0.05
705	744	745	763	762	2	115.00	0.35	5606.46	4485.17	0.05
706	745	746	764	763	2	115.00	0.35	5918.33	4734.66	0.05
707	746	747	765	764	2	115.00	0.35	6218.11	4974.49	0.05
708	747	748	766	765	2	115.00	0.35	6497.27	5197.82	0.05
709	748	749	767	766	2	115.00	0.35	6768.47	5414.77	0.05
710	749	750	768	767	2	115.00	0.35	7030.66	5624.53	0.05
711	750	751	769	768	2	115.00	0.35	7259.98	5807.99	0.05
712	751	752	770	769	3	115.00	0.35	7530.69	6024.55	0.05
713	754	772	771	753	3	115.00	0.35	418.01	334.41	0.05
714	755	773	772	754	2	115.00	0.35	1562.05	1249.64	0.05
715	756	774	773	755	2	115.00	0.35	2487.49	1990.00	0.05
716	757	775	774	756	2	115.00	0.35	3114.76	2491.81	0.05
717	758	776	775	757	2	115.00	0.35	3644.45	2915.56	0.05
718	759	777	776	758	2	115.00	0.35	4116.92	3293.54	0.05
719	760	778	777	759	2	115.00	0.35	4522.69	3618.15	0.05
720	761	779	778	760	2	115.00	0.35	4901.15	3920.92	0.05
721	762	780	779	761	2	115.00	0.35	5258.16	4206.53	0.05
722	763	781	780	762	2	115.00	0.35	5581.36	4465.09	0.05
723	764	782	781	763	2	115.00	0.35	5892.53	4714.02	0.05

724	765	783	782	764	2	115.00	0.35	6189.74	4951.79	0.05
725	766	784	783	765	2	115.00	0.35	6468.20	5174.56	0.05
726	767	785	784	766	2	115.00	0.35	6738.79	5391.03	0.05
727	768	786	785	767	2	115.00	0.35	6998.61	5598.89	0.05
728	769	787	786	768	2	115.00	0.35	7227.42	5781.94	0.05
729	770	788	787	769	3	115.00	0.35	7496.45	5997.16	0.05
730	772	790	789	771	3	115.00	0.35	418.01	334.41	0.05
731	773	791	790	772	2	115.00	0.35	1568.19	1254.55	0.05
732	774	792	791	773	2	115.00	0.35	2498.94	1999.15	0.05
733	775	793	792	774	2	115.00	0.35	3133.84	2507.07	0.05
734	776	794	793	775	2	115.00	0.35	3664.95	2931.96	0.05
735	777	795	794	776	2	115.00	0.35	4139.14	3311.31	0.05
736	778	796	795	777	2	115.00	0.35	4549.85	3639.88	0.05
737	779	797	796	778	2	115.00	0.35	4929.43	3943.54	0.05
738	780	798	797	779	2	115.00	0.35	5287.65	4230.12	0.05
739	781	799	798	780	2	115.00	0.35	5614.78	4491.82	0.05
740	782	800	799	781	2	115.00	0.35	5926.88	4741.51	0.05
741	783	801	800	782	2	115.00	0.35	6226.90	4981.52	0.05
742	784	802	801	783	2	115.00	0.35	6506.91	5205.53	0.05
743	785	803	802	784	2	115.00	0.35	6778.30	5422.64	0.05
744	786	804	803	785	2	115.00	0.35	7041.29	5633.03	0.05
745	787	805	804	786	2	115.00	0.35	7290.41	5832.33	0.05
746	788	806	805	787	3	115.00	0.35	7579.69	6063.75	0.05
747	790	808	807	789	3	115.00	0.35	418.01	334.41	0.05
748	790	809	808	808	2	115.00	0.35	1387.39	1109.91	0.05
749	791	810	809	790	2	115.00	0.35	2058.39	1646.72	0.05
750	792	811	810	791	2	115.00	0.35	2797.32	2237.86	0.05
751	793	812	811	792	2	115.00	0.35	3401.97	2721.58	0.05
752	794	813	812	793	2	115.00	0.35	3884.39	3107.51	0.05
753	795	814	813	794	2	115.00	0.35	4320.13	3456.10	0.05
754	796	815	814	795	2	115.00	0.35	4723.51	3778.81	0.05
755	797	816	815	796	2	115.00	0.35	5081.82	4065.45	0.05
756	798	817	816	797	2	115.00	0.35	5422.23	4337.78	0.05
757	799	818	817	798	2	115.00	0.35	5746.16	4596.93	0.05
758	800	819	818	799	2	115.00	0.35	6044.76	4835.81	0.05
759	801	820	819	800	2	115.00	0.35	6333.89	5067.12	0.05
760	802	821	820	801	2	115.00	0.35	6611.16	5288.93	0.05
761	803	822	821	802	2	115.00	0.35	6873.66	5498.92	0.05
762	804	823	822	803	2	115.00	0.35	7129.43	5703.54	0.05
763	805	824	823	804	2	115.00	0.35	7375.74	5900.59	0.05
764	806	825	824	805	3	115.00	0.35	7658.37	6126.69	0.05
765	808	827	826	807	3	115.00	0.35	418.01	334.41	0.05
766	809	828	827	808	2	115.00	0.35	1560.03	1248.03	0.05
767	810	829	828	809	2	115.00	0.35	2483.74	1987.00	0.05
768	811	830	829	810	2	115.00	0.35	3108.51	2486.81	0.05
769	812	831	830	811	2	115.00	0.35	3637.74	2910.19	0.05
770	813	832	831	812	2	115.00	0.35	4109.64	3287.72	0.05
771	814	833	832	813	2	115.00	0.35	4513.80	3611.04	0.05
772	815	834	833	814	2	115.00	0.35	4891.89	3913.51	0.05
773	816	835	834	815	2	115.00	0.35	5247.96	4198.37	0.05
774	817	836	835	816	2	115.00	0.35	5570.41	4456.32	0.05
775	818	837	836	817	2	115.00	0.35	5881.27	4705.02	0.05
776	819	838	837	818	2	115.00	0.35	6177.30	4941.84	0.05
777	820	839	838	819	2	115.00	0.35	6455.52	5164.42	0.05
778	821	840	839	820	2	115.00	0.35	6725.84	5380.67	0.05
779	822	841	840	821	2	115.00	0.35	6984.63	5587.70	0.05
780	823	842	841	822	2	115.00	0.35	7232.85	5786.28	0.05
781	824	843	842	823	2	115.00	0.35	7465.97	5972.77	0.05
782	825	844	843	824	3	115.00	0.35	7737.05	6189.64	0.05
783	826	827	846	845	3	115.00	0.35	418.01	334.41	0.05
784	827	828	847	846	2	115.00	0.35	1561.79	1249.43	0.05
785	828	829	848	847	2	115.00	0.35	2487.02	1989.62	0.05
786	829	830	849	848	2	115.00	0.35	3113.97	2491.18	0.05

787	830	831	850	849	2	115.00	0.35	3643.60	2914.88	0.05
788	831	832	851	850	2	115.00	0.35	4116.00	3292.80	0.05
789	832	833	852	851	2	115.00	0.35	4521.57	3617.26	0.05
790	833	834	853	852	2	115.00	0.35	4899.99	3919.99	0.05
791	834	835	854	853	2	115.00	0.35	5256.94	4205.55	0.05
792	835	836	855	854	2	115.00	0.35	5579.97	4463.98	0.05
793	836	837	856	855	2	115.00	0.35	5891.11	4712.89	0.05
794	837	838	857	856	2	115.00	0.35	6188.17	4950.53	0.05
795	838	839	858	857	2	115.00	0.35	6466.60	5173.28	0.05
796	839	840	859	858	2	115.00	0.35	6737.15	5389.72	0.05
797	840	841	860	859	2	115.00	0.35	6996.85	5597.48	0.05
798	841	842	861	860	2	115.00	0.35	7245.26	5796.21	0.05
799	842	843	862	861	2	115.00	0.35	7478.17	5982.54	0.05
800	843	863	862	862	2	115.00	0.35	7649.11	6119.29	0.05
801	843	844	864	863	3	115.00	0.35	7863.41	6290.73	0.05
802	845	846	866	865	3	115.00	0.35	418.01	334.41	0.05
803	846	847	867	866	2	115.00	0.35	1567.21	1253.77	0.05
804	847	848	868	867	2	115.00	0.35	2497.12	1997.70	0.05
805	848	849	869	868	2	115.00	0.35	3130.81	2504.64	0.05
806	849	850	870	869	2	115.00	0.35	3661.69	2929.35	0.05
807	850	851	871	870	2	115.00	0.35	4135.60	3308.48	0.05
808	851	852	872	871	2	115.00	0.35	4545.53	3636.42	0.05
809	852	853	873	872	2	115.00	0.35	4924.93	3939.94	0.05
810	853	854	874	873	2	115.00	0.35	5282.96	4226.37	0.05
811	854	855	875	874	2	115.00	0.35	5609.46	4487.57	0.05
812	855	856	876	875	2	115.00	0.35	5921.41	4737.13	0.05
813	856	857	877	876	2	115.00	0.35	6221.28	4977.02	0.05
814	857	858	878	877	2	115.00	0.35	6500.75	5200.60	0.05
815	858	859	879	878	2	115.00	0.35	6772.01	5417.61	0.05
816	859	860	880	879	2	115.00	0.35	7034.49	5627.60	0.05
817	860	861	881	880	2	115.00	0.35	7283.51	5826.81	0.05
818	861	862	882	881	2	115.00	0.35	7523.61	6018.88	0.05
819	862	863	883	882	2	115.00	0.35	7752.02	6201.61	0.05
820	863	864	884	883	3	115.00	0.35	8037.45	6429.96	0.05
821	865	866	886	885	3	115.00	0.35	418.01	334.41	0.05
822	866	867	887	886	2	115.00	0.35	1574.59	1259.67	0.05
823	867	868	888	887	2	115.00	0.35	2510.88	2008.70	0.05
824	868	869	889	888	2	115.00	0.35	3153.73	2522.98	0.05
825	869	870	890	889	2	115.00	0.35	3686.31	2949.05	0.05
826	870	871	891	890	2	115.00	0.35	4162.30	3329.84	0.05
827	871	872	892	891	2	115.00	0.35	4578.15	3662.52	0.05
828	872	873	893	892	2	115.00	0.35	4958.90	3967.12	0.05
829	873	874	894	893	2	115.00	0.35	5318.39	4254.72	0.05
830	874	875	895	894	2	115.00	0.35	5649.62	4519.70	0.05
831	875	876	896	895	2	115.00	0.35	5962.69	4770.15	0.05
832	876	877	897	896	2	115.00	0.35	6263.74	5011.00	0.05
833	877	878	898	897	2	115.00	0.35	6547.25	5237.80	0.05
834	878	879	899	898	2	115.00	0.35	6819.49	5455.59	0.05
835	879	880	900	899	2	115.00	0.35	7083.75	5667.00	0.05
836	880	881	901	900	2	115.00	0.35	7335.60	5868.48	0.05
837	881	882	902	901	2	115.00	0.35	7574.84	6059.87	0.05
838	882	883	903	902	2	115.00	0.35	7806.55	6245.24	0.05
839	883	904	903	903	2	115.00	0.35	7989.27	6391.42	0.05
840	883	884	905	904	3	115.00	0.35	8211.48	6569.19	0.05
841	885	886	907	906	3	115.00	0.35	418.01	334.41	0.05
842	886	887	908	907	2	115.00	0.35	1567.27	1253.82	0.05
843	887	888	909	908	2	115.00	0.35	2497.24	1997.79	0.05
844	888	889	910	909	2	115.00	0.35	3131.00	2504.80	0.05
845	889	890	911	910	2	115.00	0.35	3661.90	2929.52	0.05
846	890	891	912	911	2	115.00	0.35	4135.83	3308.67	0.05
847	891	892	913	912	2	115.00	0.35	4545.81	3636.64	0.05
848	892	893	914	913	2	115.00	0.35	4925.22	3940.18	0.05
849	893	894	915	914	2	115.00	0.35	5283.26	4226.61	0.05

850	894	895	916	915	2	115.00	0.35	5609.81	4487.85	0.05
851	895	896	917	916	2	115.00	0.35	5921.77	4737.41	0.05
852	896	897	918	917	2	115.00	0.35	6221.65	4977.32	0.05
853	897	898	919	918	2	115.00	0.35	6501.15	5200.92	0.05
854	898	899	920	919	2	115.00	0.35	6772.42	5417.94	0.05
855	899	900	921	920	2	115.00	0.35	7034.94	5627.95	0.05
856	900	901	922	921	2	115.00	0.35	7283.96	5827.17	0.05
857	901	902	923	922	2	115.00	0.35	7524.05	6019.24	0.05
858	902	903	924	923	2	115.00	0.35	7752.49	6201.99	0.05
859	903	904	925	924	2	115.00	0.35	7980.92	6384.74	0.05
860	904	926	925	925	2	115.00	0.35	8161.49	6529.19	0.05
861	904	905	927	926	3	115.00	0.35	8385.52	6708.42	0.05
862	906	907	929	928	3	115.00	0.35	418.01	334.41	0.05
863	907	908	930	929	2	115.00	0.35	1559.66	1247.73	0.05
864	908	909	931	930	2	115.00	0.35	2483.05	1986.44	0.05
865	909	910	932	931	2	115.00	0.35	3107.35	2485.88	0.05
866	910	911	933	932	2	115.00	0.35	3636.49	2909.19	0.05
867	911	912	934	933	2	115.00	0.35	4108.29	3286.63	0.05
868	912	913	935	934	2	115.00	0.35	4512.14	3609.71	0.05
869	913	914	936	935	2	115.00	0.35	4890.17	3912.13	0.05
870	914	915	937	936	2	115.00	0.35	5245.97	4196.77	0.05
871	915	916	938	937	2	115.00	0.35	5568.37	4454.69	0.05
872	916	917	939	938	2	115.00	0.35	5879.18	4703.34	0.05
873	917	918	940	939	2	115.00	0.35	6174.98	4939.99	0.05
874	918	919	941	940	2	115.00	0.35	6453.16	5162.53	0.05
875	919	920	942	941	2	115.00	0.35	6723.43	5378.74	0.05
876	920	921	943	942	2	115.00	0.35	6982.02	5585.62	0.05
877	921	922	944	943	2	115.00	0.35	7230.20	5784.16	0.05
878	922	923	945	944	2	115.00	0.35	7471.18	5976.95	0.05
879	923	924	946	945	2	115.00	0.35	7696.21	6156.97	0.05
880	924	925	947	946	2	115.00	0.35	7921.24	6336.99	0.05
881	925	926	948	947	2	115.00	0.35	8146.27	6517.01	0.05
882	926	949	948	948	2	115.00	0.35	8325.63	6660.50	0.05
883	926	927	950	949	3	115.00	0.35	8548.57	6838.86	0.05
884	928	929	952	951	3	115.00	0.35	418.01	334.41	0.05
885	929	930	953	952	2	115.00	0.35	1560.87	1248.70	0.05
886	930	931	954	953	2	115.00	0.35	2485.30	1988.24	0.05
887	931	932	955	954	2	115.00	0.35	3111.11	2488.89	0.05
888	932	933	956	955	2	115.00	0.35	3640.53	2912.42	0.05
889	933	934	957	956	2	115.00	0.35	4112.67	3290.14	0.05
890	934	935	958	957	2	115.00	0.35	4517.50	3614.00	0.05
891	935	936	959	958	2	115.00	0.35	4895.75	3916.60	0.05
892	936	937	960	959	2	115.00	0.35	5252.40	4201.92	0.05
893	937	938	961	960	2	115.00	0.35	5574.96	4459.97	0.05
894	938	939	962	961	2	115.00	0.35	5885.96	4708.76	0.05
895	939	940	963	962	2	115.00	0.35	6182.47	4945.98	0.05
896	940	941	964	963	2	115.00	0.35	6460.79	5168.64	0.05
897	941	942	965	964	2	115.00	0.35	6731.23	5384.98	0.05
898	942	943	966	965	2	115.00	0.35	6990.44	5592.36	0.05
899	943	944	967	966	2	115.00	0.35	7238.76	5791.01	0.05
900	944	945	968	967	2	115.00	0.35	7479.59	5983.68	0.05
901	945	946	969	968	2	115.00	0.35	7705.17	6164.13	0.05
902	946	947	970	969	2	115.00	0.35	7930.74	6344.59	0.05
903	947	948	971	970	2	115.00	0.35	8156.31	6525.05	0.05
904	948	949	972	971	2	115.00	0.35	8387.34	6709.88	0.05
905	949	950	973	972	3	115.00	0.35	8679.97	6943.97	0.05
906	952	975	974	951	3	115.00	0.35	418.01	334.41	0.05
907	953	976	975	952	2	115.00	0.35	1569.64	1255.71	0.05
908	954	977	976	953	2	115.00	0.35	2501.65	2001.32	0.05
909	955	978	977	954	2	115.00	0.35	3138.35	2510.68	0.05
910	956	979	978	955	2	115.00	0.35	3669.79	2935.83	0.05
911	957	980	979	956	2	115.00	0.35	4144.39	3315.51	0.05
912	958	981	980	957	2	115.00	0.35	4556.26	3645.01	0.05

913	959	982	981	958	2	115.00	0.35	4936.10	3948.88	0.05
914	960	983	982	959	2	115.00	0.35	5294.62	4235.69	0.05
915	961	984	983	960	2	115.00	0.35	5622.68	4498.14	0.05
916	962	985	984	961	2	115.00	0.35	5935.00	4748.00	0.05
917	963	986	985	962	2	115.00	0.35	6235.25	4988.20	0.05
918	964	987	986	963	2	115.00	0.35	6516.05	5212.84	0.05
919	965	988	987	964	2	115.00	0.35	6787.64	5430.11	0.05
920	966	989	988	965	2	115.00	0.35	7051.21	5640.97	0.05
921	967	990	989	966	2	115.00	0.35	7300.65	5840.52	0.05
922	968	991	990	967	2	115.00	0.35	7540.46	6032.37	0.05
923	969	992	991	968	2	115.00	0.35	7769.96	6215.97	0.05
924	970	993	992	969	2	115.00	0.35	7999.46	6399.57	0.05
925	971	994	993	970	2	115.00	0.35	8228.96	6583.17	0.05
926	972	995	994	971	2	115.00	0.35	8447.64	6758.11	0.05
927	973	996	995	972	3	115.00	0.35	8733.98	6987.19	0.05
928	975	998	997	974	3	115.00	0.35	418.01	334.41	0.05
929	976	999	998	975	2	115.00	0.35	1575.51	1260.40	0.05
930	977	1000	999	976	2	115.00	0.35	2512.58	2010.07	0.05
931	978	1001	1000	977	2	115.00	0.35	3156.57	2525.26	0.05
932	979	1002	1001	978	2	115.00	0.35	3689.37	2951.49	0.05
933	980	1003	1002	979	2	115.00	0.35	4165.61	3332.49	0.05
934	981	1004	1003	980	2	115.00	0.35	4582.20	3665.76	0.05
935	982	1005	1004	981	2	115.00	0.35	4963.11	3970.49	0.05
936	983	1006	1005	982	2	115.00	0.35	5322.79	4258.23	0.05
937	984	1007	1006	983	2	115.00	0.35	5654.60	4523.68	0.05
938	985	1008	1007	984	2	115.00	0.35	5967.81	4774.25	0.05
939	986	1009	1008	985	2	115.00	0.35	6269.01	5015.21	0.05
940	987	1010	1009	986	2	115.00	0.35	6553.02	5242.42	0.05
941	988	1011	1010	987	2	115.00	0.35	6825.38	5460.31	0.05
942	989	1012	1011	988	2	115.00	0.35	7089.76	5671.81	0.05
943	990	1013	1012	989	2	115.00	0.35	7342.06	5873.65	0.05
944	991	1014	1013	990	2	115.00	0.35	7581.19	6064.95	0.05
945	992	1015	1014	991	2	115.00	0.35	7813.32	6250.66	0.05
946	993	1016	1015	992	2	115.00	0.35	8045.45	6436.36	0.05
947	994	1017	1016	993	2	115.00	0.35	8277.57	6622.06	0.05
948	995	1018	1017	994	2	115.00	0.35	8485.53	6788.42	0.05
949	996	1019	1018	995	3	115.00	0.35	8765.14	7012.11	0.05
950	998	1021	1020	997	3	115.00	0.35	418.01	334.41	0.05
951	998	1022	1021	1021	2	115.00	0.35	1390.93	1112.75	0.05
952	999	1023	1022	998	2	115.00	0.35	2068.39	1654.71	0.05
953	1000	1024	1023	999	2	115.00	0.35	2809.33	2247.47	0.05
954	1001	1025	1024	1000	2	115.00	0.35	3415.65	2732.52	0.05
955	1002	1026	1025	1001	2	115.00	0.35	3902.52	3122.02	0.05
956	1003	1027	1026	1002	2	115.00	0.35	4339.17	3471.34	0.05
957	1004	1028	1027	1003	2	115.00	0.35	4743.59	3794.88	0.05
958	1005	1029	1028	1004	2	115.00	0.35	5105.21	4084.17	0.05
959	1006	1030	1029	1005	2	115.00	0.35	5446.37	4357.10	0.05
960	1007	1031	1030	1006	2	115.00	0.35	5771.83	4617.46	0.05
961	1008	1032	1031	1007	2	115.00	0.35	6072.47	4857.98	0.05
962	1009	1033	1032	1008	2	115.00	0.35	6362.24	5089.79	0.05
963	1010	1034	1033	1009	2	115.00	0.35	6642.07	5313.66	0.05
964	1011	1035	1034	1010	2	115.00	0.35	6905.09	5524.07	0.05
965	1012	1036	1035	1011	2	115.00	0.35	7161.44	5729.15	0.05
966	1013	1037	1036	1012	2	115.00	0.35	7410.02	5928.02	0.05
967	1014	1038	1037	1013	2	115.00	0.35	7640.30	6112.24	0.05
968	1015	1039	1038	1014	2	115.00	0.35	7869.01	6295.21	0.05
969	1016	1040	1039	1015	2	115.00	0.35	8097.72	6478.17	0.05
970	1017	1041	1040	1016	2	115.00	0.35	8324.52	6659.62	0.05
971	1018	1042	1041	1017	2	115.00	0.35	8536.22	6828.98	0.05
972	1019	1043	1042	1018	3	115.00	0.35	8824.88	7059.91	0.05
973	1021	1045	1044	1020	3	115.00	0.35	418.01	334.41	0.05
974	1022	1046	1045	1021	2	115.00	0.35	1558.91	1247.13	0.05
975	1023	1047	1046	1022	2	115.00	0.35	2481.64	1985.32	0.05

976	1024	1048	1047	1023	2	115.00	0.35	3105.01	2484.01	0.05
977	1025	1049	1048	1024	2	115.00	0.35	3633.98	2907.18	0.05
978	1026	1050	1049	1025	2	115.00	0.35	4105.57	3284.45	0.05
979	1027	1051	1050	1026	2	115.00	0.35	4508.82	3607.05	0.05
980	1028	1052	1051	1027	2	115.00	0.35	4886.71	3909.36	0.05
981	1029	1053	1052	1028	2	115.00	0.35	5241.97	4193.58	0.05
982	1030	1054	1053	1029	2	115.00	0.35	5564.27	4451.42	0.05
983	1031	1055	1054	1030	2	115.00	0.35	5874.97	4699.98	0.05
984	1032	1056	1055	1031	2	115.00	0.35	6170.33	4936.27	0.05
985	1033	1057	1056	1032	2	115.00	0.35	6448.42	5158.74	0.05
986	1034	1058	1057	1033	2	115.00	0.35	6718.59	5374.87	0.05
987	1035	1059	1058	1034	2	115.00	0.35	6976.80	5581.44	0.05
988	1036	1060	1059	1035	2	115.00	0.35	7224.90	5779.92	0.05
989	1037	1061	1060	1036	2	115.00	0.35	7465.96	5972.77	0.05
990	1038	1062	1061	1037	2	115.00	0.35	7690.65	6152.52	0.05
991	1039	1063	1062	1038	2	115.00	0.35	7915.34	6332.28	0.05
992	1040	1064	1063	1039	2	115.00	0.35	8140.04	6512.03	0.05
993	1041	1065	1064	1040	2	115.00	0.35	8359.15	6687.32	0.05
994	1042	1066	1065	1041	2	115.00	0.35	8567.22	6853.78	0.05
995	1043	1067	1066	1042	3	115.00	0.35	8854.55	7083.64	0.05
996	1045	1069	1068	1044	3	115.00	0.35	418.01	334.41	0.05
997	1046	1070	1069	1045	2	115.00	0.35	1560.02	1248.02	0.05
998	1047	1071	1070	1046	2	115.00	0.35	2483.72	1986.97	0.05
999	1048	1072	1071	1047	2	115.00	0.35	3108.47	2486.78	0.05
1000	1049	1073	1072	1048	2	115.00	0.35	3637.69	2910.15	0.05
1001	1050	1074	1073	1049	2	115.00	0.35	4109.59	3287.68	0.05
1002	1051	1075	1074	1050	2	115.00	0.35	4513.74	3610.99	0.05
1003	1052	1076	1075	1051	2	115.00	0.35	4891.83	3913.46	0.05
1004	1053	1077	1076	1052	2	115.00	0.35	5247.89	4198.31	0.05
1005	1054	1078	1077	1053	2	115.00	0.35	5570.33	4456.27	0.05
1006	1055	1079	1078	1054	2	115.00	0.35	5881.20	4704.96	0.05
1007	1056	1080	1079	1055	2	115.00	0.35	6177.21	4941.77	0.05
1008	1057	1081	1080	1056	2	115.00	0.35	6455.43	5164.35	0.05
1009	1058	1082	1081	1057	2	115.00	0.35	6725.75	5380.60	0.05
1010	1059	1083	1082	1058	2	115.00	0.35	6984.53	5587.63	0.05
1011	1060	1084	1083	1059	2	115.00	0.35	7232.75	5786.20	0.05
1012	1061	1085	1084	1060	2	115.00	0.35	7473.69	5978.95	0.05
1013	1062	1086	1085	1061	2	115.00	0.35	7698.88	6159.10	0.05
1014	1063	1087	1086	1062	2	115.00	0.35	7924.07	6339.25	0.05
1015	1064	1088	1087	1063	2	115.00	0.35	8149.26	6519.41	0.05
1016	1065	1089	1088	1064	2	115.00	0.35	8367.94	6694.35	0.05
1017	1066	1090	1089	1065	2	115.00	0.35	8571.53	6857.22	0.05
1018	1067	1091	1090	1066	3	115.00	0.35	8854.15	7083.32	0.05
1019	1069	1093	1092	1068	3	115.00	0.35	418.01	334.41	0.05
1020	1070	1094	1093	1069	2	115.00	0.35	1559.97	1247.98	0.05
1021	1071	1095	1094	1070	2	115.00	0.35	2483.63	1986.91	0.05
1022	1072	1096	1095	1071	2	115.00	0.35	3108.32	2486.66	0.05
1023	1073	1097	1096	1072	2	115.00	0.35	3637.54	2910.03	0.05
1024	1074	1098	1097	1073	2	115.00	0.35	4109.43	3287.54	0.05
1025	1075	1099	1098	1074	2	115.00	0.35	4513.53	3610.83	0.05
1026	1076	1100	1099	1075	2	115.00	0.35	4891.62	3913.29	0.05
1027	1077	1101	1100	1076	2	115.00	0.35	5247.64	4198.11	0.05
1028	1078	1102	1101	1077	2	115.00	0.35	5570.08	4456.06	0.05
1029	1079	1103	1102	1078	2	115.00	0.35	5880.94	4704.75	0.05
1030	1080	1104	1103	1079	2	115.00	0.35	6176.93	4941.54	0.05
1031	1081	1105	1104	1080	2	115.00	0.35	6455.14	5164.11	0.05
1032	1082	1106	1105	1081	2	115.00	0.35	6725.45	5380.36	0.05
1033	1083	1107	1106	1082	2	115.00	0.35	6984.21	5587.37	0.05
1034	1084	1108	1107	1083	2	115.00	0.35	7232.43	5785.94	0.05
1035	1085	1109	1108	1084	2	115.00	0.35	7473.37	5978.69	0.05
1036	1086	1110	1109	1085	2	115.00	0.35	7698.54	6158.83	0.05
1037	1087	1111	1110	1086	2	115.00	0.35	7923.70	6338.96	0.05
1038	1088	1112	1111	1087	2	115.00	0.35	8148.87	6519.10	0.05

1039	1089	1113	1112	1088	2	115.00	0.35	8367.58	6694.06	0.05
1040	1090	1114	1113	1089	2	115.00	0.35	8571.14	6856.92	0.05
1041	1091	1115	1114	1090	3	115.00	0.35	8853.75	7083.00	0.05
1042	1093	1117	1116	1092	3	115.00	0.35	418.01	334.41	0.05
1043	1094	1118	1117	1093	2	115.00	0.35	1559.93	1247.94	0.05
1044	1095	1119	1118	1094	2	115.00	0.35	2483.55	1986.84	0.05
1045	1096	1120	1119	1095	2	115.00	0.35	3108.18	2486.54	0.05
1046	1097	1121	1120	1096	2	115.00	0.35	3637.38	2909.90	0.05
1047	1098	1122	1121	1097	2	115.00	0.35	4109.26	3287.41	0.05
1048	1099	1123	1122	1098	2	115.00	0.35	4513.33	3610.66	0.05
1049	1100	1124	1123	1099	2	115.00	0.35	4891.40	3913.12	0.05
1050	1101	1125	1124	1100	2	115.00	0.35	5247.39	4197.91	0.05
1051	1102	1126	1125	1101	2	115.00	0.35	5569.83	4455.86	0.05
1052	1103	1127	1126	1102	2	115.00	0.35	5880.68	4704.54	0.05
1053	1104	1128	1127	1103	2	115.00	0.35	6176.64	4941.31	0.05
1054	1105	1129	1128	1104	2	115.00	0.35	6454.85	5163.88	0.05
1055	1106	1130	1129	1105	2	115.00	0.35	6725.16	5380.12	0.05
1056	1107	1131	1130	1106	2	115.00	0.35	6983.89	5587.11	0.05
1057	1108	1132	1131	1107	2	115.00	0.35	7232.10	5785.68	0.05
1058	1109	1133	1132	1108	2	115.00	0.35	7473.04	5978.44	0.05
1059	1110	1134	1133	1109	2	115.00	0.35	7698.19	6158.55	0.05
1060	1111	1135	1134	1110	2	115.00	0.35	7923.34	6338.67	0.05
1061	1112	1136	1135	1111	2	115.00	0.35	8148.49	6518.79	0.05
1062	1113	1137	1136	1112	2	115.00	0.35	8367.21	6693.77	0.05
1063	1114	1138	1137	1113	2	115.00	0.35	8570.76	6856.61	0.05
1064	1115	1139	1138	1114	3	115.00	0.35	8853.35	7082.68	0.05
1065	1117	1141	1140	1116	3	115.00	0.35	418.01	334.41	0.05
1066	1118	1142	1141	1117	2	115.00	0.35	1559.88	1247.91	0.05
1067	1119	1143	1142	1118	2	115.00	0.35	2483.46	1986.77	0.05
1068	1120	1144	1143	1119	2	115.00	0.35	3108.04	2486.43	0.05
1069	1121	1145	1144	1120	2	115.00	0.35	3637.23	2909.78	0.05
1070	1122	1146	1145	1121	2	115.00	0.35	4109.09	3287.27	0.05
1071	1123	1147	1146	1122	2	115.00	0.35	4513.12	3610.50	0.05
1072	1124	1148	1147	1123	2	115.00	0.35	4891.19	3912.95	0.05
1073	1125	1149	1148	1124	2	115.00	0.35	5247.15	4197.72	0.05
1074	1126	1150	1149	1125	2	115.00	0.35	5569.57	4455.66	0.05
1075	1127	1151	1150	1126	2	115.00	0.35	5880.42	4704.33	0.05
1076	1128	1152	1151	1127	2	115.00	0.35	6176.35	4941.08	0.05
1077	1129	1153	1152	1128	2	115.00	0.35	6454.56	5163.64	0.05
1078	1130	1154	1153	1129	2	115.00	0.35	6724.86	5379.89	0.05
1079	1131	1155	1154	1130	2	115.00	0.35	6983.57	5586.85	0.05
1080	1132	1156	1155	1131	2	115.00	0.35	7231.77	5785.42	0.05
1081	1133	1157	1156	1132	2	115.00	0.35	7472.72	5978.18	0.05
1082	1134	1158	1157	1133	2	115.00	0.35	7697.85	6158.28	0.05
1083	1135	1159	1158	1134	2	115.00	0.35	7922.98	6338.38	0.05
1084	1136	1160	1159	1135	2	115.00	0.35	8148.10	6518.48	0.05
1085	1137	1161	1160	1136	2	115.00	0.35	8366.84	6693.47	0.05
1086	1138	1162	1161	1137	2	115.00	0.35	8570.37	6856.30	0.05
1087	1139	1163	1162	1138	3	115.00	0.35	8852.95	7082.36	0.05
1088	1141	1165	1164	1140	3	115.00	0.35	418.01	334.41	0.05
1089	1142	1166	1165	1141	2	115.00	0.35	1559.84	1247.87	0.05
1090	1143	1167	1166	1142	2	115.00	0.35	2483.37	1986.70	0.05
1091	1144	1168	1167	1143	2	115.00	0.35	3107.89	2486.31	0.05
1092	1145	1169	1168	1144	2	115.00	0.35	3637.07	2909.66	0.05
1093	1146	1170	1169	1145	2	115.00	0.35	4108.92	3287.14	0.05
1094	1147	1171	1170	1146	2	115.00	0.35	4512.92	3610.33	0.05
1095	1148	1172	1171	1147	2	115.00	0.35	4890.97	3912.78	0.05
1096	1149	1173	1172	1148	2	115.00	0.35	5246.90	4197.52	0.05
1097	1150	1174	1173	1149	2	115.00	0.35	5569.32	4455.46	0.05
1098	1151	1175	1174	1150	2	115.00	0.35	5880.16	4704.13	0.05
1099	1152	1176	1175	1151	2	115.00	0.35	6176.07	4940.85	0.05
1100	1153	1177	1176	1152	2	115.00	0.35	6454.26	5163.41	0.05
1101	1154	1178	1177	1153	2	115.00	0.35	6724.56	5379.65	0.05

1102	1155	1179	1178	1154	2	115.00	0.35	6983.24	5586.59	0.05
1103	1156	1180	1179	1155	2	115.00	0.35	7231.44	5785.15	0.05
1104	1157	1181	1180	1156	2	115.00	0.35	7472.40	5977.92	0.05
1105	1158	1182	1181	1157	2	115.00	0.35	7697.51	6158.01	0.05
1106	1159	1183	1182	1158	2	115.00	0.35	7922.61	6338.09	0.05
1107	1160	1184	1183	1159	2	115.00	0.35	8147.72	6518.18	0.05
1108	1161	1185	1184	1160	2	115.00	0.35	8366.48	6693.18	0.05
1109	1162	1186	1185	1161	2	115.00	0.35	8569.99	6855.99	0.05
1110	1163	1187	1186	1162	3	115.00	0.35	8852.55	7082.04	0.05
1111	1165	1189	1188	1164	3	115.00	0.35	418.01	334.41	0.05
1112	1166	1190	1189	1165	2	115.00	0.35	1558.54	1246.83	0.05
1113	1167	1191	1190	1166	2	115.00	0.35	2480.96	1984.77	0.05
1114	1168	1192	1191	1167	2	115.00	0.35	3103.88	2483.10	0.05
1115	1169	1193	1192	1168	2	115.00	0.35	3632.76	2906.21	0.05
1116	1170	1194	1193	1169	2	115.00	0.35	4104.25	3283.40	0.05
1117	1171	1195	1194	1170	2	115.00	0.35	4507.20	3605.76	0.05
1118	1172	1196	1195	1171	2	115.00	0.35	4885.02	3908.02	0.05
1119	1173	1197	1196	1172	2	115.00	0.35	5240.03	4192.03	0.05
1120	1174	1198	1197	1173	2	115.00	0.35	5562.29	4449.83	0.05
1121	1175	1199	1198	1174	2	115.00	0.35	5872.93	4698.34	0.05
1122	1176	1200	1199	1175	2	115.00	0.35	6168.08	4934.46	0.05
1123	1177	1201	1200	1176	2	115.00	0.35	6446.12	5156.89	0.05
1124	1178	1202	1201	1177	2	115.00	0.35	6716.24	5372.99	0.05
1125	1179	1203	1202	1178	2	115.00	0.35	6974.26	5579.41	0.05
1126	1180	1204	1203	1179	2	115.00	0.35	7222.32	5777.86	0.05
1127	1181	1205	1204	1180	2	115.00	0.35	7463.43	5970.74	0.05
1128	1182	1206	1205	1181	2	115.00	0.35	7687.95	6150.36	0.05
1129	1183	1207	1206	1182	2	115.00	0.35	7912.48	6329.99	0.05
1130	1184	1208	1207	1183	2	115.00	0.35	8137.01	6509.61	0.05
1131	1185	1209	1208	1184	2	115.00	0.35	8356.27	6685.02	0.05
1132	1186	1210	1209	1185	2	115.00	0.35	8564.56	6851.65	0.05
1133	1187	1211	1210	1186	3	115.00	0.35	8852.14	7081.72	0.05
1134	1189	1213	1212	1188	3	115.00	0.35	418.01	334.41	0.05
1135	1190	1213	1189	1189	2	115.00	0.35	1390.60	1112.48	0.05
1136	1191	1214	1213	1190	2	115.00	0.35	2067.14	1653.72	0.05
1137	1192	1215	1214	1191	2	115.00	0.35	2807.64	2246.11	0.05
1138	1193	1216	1215	1192	2	115.00	0.35	3413.64	2730.91	0.05
1139	1194	1217	1216	1193	2	115.00	0.35	3899.81	3119.85	0.05
1140	1195	1218	1217	1194	2	115.00	0.35	4336.29	3469.03	0.05
1141	1196	1219	1218	1195	2	115.00	0.35	4740.53	3792.42	0.05
1142	1197	1220	1219	1196	2	115.00	0.35	5101.62	4081.30	0.05
1143	1198	1221	1220	1197	2	115.00	0.35	5442.65	4354.12	0.05
1144	1199	1222	1221	1198	2	115.00	0.35	5767.97	4614.38	0.05
1145	1200	1223	1222	1199	2	115.00	0.35	6068.17	4854.54	0.05
1146	1201	1224	1223	1200	2	115.00	0.35	6357.84	5086.27	0.05
1147	1202	1225	1224	1201	2	115.00	0.35	6637.26	5309.81	0.05
1148	1203	1226	1225	1202	2	115.00	0.35	6900.19	5520.15	0.05
1149	1204	1227	1226	1203	2	115.00	0.35	7156.44	5725.15	0.05
1150	1205	1228	1227	1204	2	115.00	0.35	7404.67	5923.73	0.05
1151	1206	1229	1228	1205	2	115.00	0.35	7635.04	6108.03	0.05
1152	1207	1230	1229	1206	2	115.00	0.35	7863.42	6290.73	0.05
1153	1208	1231	1230	1207	2	115.00	0.35	8091.79	6473.43	0.05
1154	1209	1232	1231	1208	2	115.00	0.35	8318.87	6655.09	0.05
1155	1210	1233	1232	1209	2	115.00	0.35	8530.63	6824.51	0.05
1156	1211	1234	1233	1210	3	115.00	0.35	8819.42	7055.54	0.05
1157	1213	1236	1235	1212	3	115.00	0.35	418.01	334.41	0.05
1158	1214	1237	1236	1213	2	115.00	0.35	1574.33	1259.46	0.05
1159	1215	1238	1237	1214	2	115.00	0.35	2510.38	2008.31	0.05
1160	1216	1239	1238	1215	2	115.00	0.35	3152.91	2522.33	0.05
1161	1217	1240	1239	1216	2	115.00	0.35	3685.43	2948.34	0.05
1162	1218	1241	1240	1217	2	115.00	0.35	4161.34	3329.07	0.05
1163	1219	1242	1241	1218	2	115.00	0.35	4576.98	3661.58	0.05
1164	1220	1243	1242	1219	2	115.00	0.35	4957.68	3966.14	0.05

1165	1221	1244	1243	1220	2	115.00	0.35	5317.12	4253.70	0.05
1166	1222	1245	1244	1221	2	115.00	0.35	5648.18	4518.55	0.05
1167	1223	1246	1245	1222	2	115.00	0.35	5961.21	4768.97	0.05
1168	1224	1247	1246	1223	2	115.00	0.35	6262.22	5009.78	0.05
1169	1225	1248	1247	1224	2	115.00	0.35	6545.59	5236.47	0.05
1170	1226	1249	1248	1225	2	115.00	0.35	6817.79	5454.23	0.05
1171	1227	1250	1249	1226	2	115.00	0.35	7082.01	5665.61	0.05
1172	1228	1251	1250	1227	2	115.00	0.35	7333.73	5866.99	0.05
1173	1229	1252	1251	1228	2	115.00	0.35	7573.00	6058.40	0.05
1174	1230	1253	1252	1229	2	115.00	0.35	7804.60	6243.68	0.05
1175	1231	1254	1253	1230	2	115.00	0.35	8036.20	6428.96	0.05
1176	1232	1255	1254	1231	2	115.00	0.35	8267.79	6614.23	0.05
1177	1233	1256	1255	1232	2	115.00	0.35	8475.70	6780.56	0.05
1178	1234	1257	1256	1233	3	115.00	0.35	8754.38	7003.50	0.05
1179	1236	1259	1258	1235	3	115.00	0.35	418.01	334.41	0.05
1180	1237	1260	1259	1236	2	115.00	0.35	1570.28	1256.22	0.05
1181	1238	1261	1260	1237	2	115.00	0.35	2502.84	2002.27	0.05
1182	1239	1262	1261	1238	2	115.00	0.35	3140.33	2512.27	0.05
1183	1240	1263	1262	1239	2	115.00	0.35	3671.92	2937.54	0.05
1184	1241	1264	1263	1240	2	115.00	0.35	4146.70	3317.36	0.05
1185	1242	1265	1264	1241	2	115.00	0.35	4559.09	3647.27	0.05
1186	1243	1266	1265	1242	2	115.00	0.35	4939.05	3951.24	0.05
1187	1244	1267	1266	1243	2	115.00	0.35	5297.69	4238.15	0.05
1188	1245	1268	1267	1244	2	115.00	0.35	5626.15	4500.92	0.05
1189	1246	1269	1268	1245	2	115.00	0.35	5938.57	4750.86	0.05
1190	1247	1270	1269	1246	2	115.00	0.35	6238.93	4991.14	0.05
1191	1248	1271	1270	1247	2	115.00	0.35	6520.08	5216.06	0.05
1192	1249	1272	1271	1248	2	115.00	0.35	6791.75	5433.40	0.05
1193	1250	1273	1272	1249	2	115.00	0.35	7055.41	5644.33	0.05
1194	1251	1274	1273	1250	2	115.00	0.35	7305.16	5844.13	0.05
1195	1252	1275	1274	1251	2	115.00	0.35	7544.90	6035.92	0.05
1196	1253	1276	1275	1252	2	115.00	0.35	7774.68	6219.75	0.05
1197	1254	1277	1276	1253	2	115.00	0.35	8004.47	6403.58	0.05
1198	1255	1278	1277	1254	2	115.00	0.35	8234.25	6587.40	0.05
1199	1256	1279	1278	1255	2	115.00	0.35	8443.74	6754.99	0.05
1200	1257	1280	1279	1256	3	115.00	0.35	8721.05	6976.84	0.05
1201	1259	1282	1281	1258	3	115.00	0.35	418.01	334.41	0.05
1202	1260	1283	1282	1259	2	115.00	0.35	1564.44	1251.55	0.05
1203	1261	1284	1283	1260	2	115.00	0.35	2491.95	1993.56	0.05
1204	1262	1285	1284	1261	2	115.00	0.35	3122.19	2497.75	0.05
1205	1263	1286	1285	1262	2	115.00	0.35	3652.43	2921.94	0.05
1206	1264	1287	1286	1263	2	115.00	0.35	4125.57	3300.45	0.05
1207	1265	1288	1287	1264	2	115.00	0.35	4533.26	3626.61	0.05
1208	1266	1289	1288	1265	2	115.00	0.35	4912.15	3929.72	0.05
1209	1267	1290	1289	1266	2	115.00	0.35	5269.63	4215.71	0.05
1210	1268	1291	1290	1267	2	115.00	0.35	5594.36	4475.49	0.05
1211	1269	1292	1291	1268	2	115.00	0.35	5905.89	4724.72	0.05
1212	1270	1293	1292	1269	2	115.00	0.35	6204.51	4963.61	0.05
1213	1271	1294	1293	1270	2	115.00	0.35	6483.26	5186.61	0.05
1214	1272	1295	1294	1271	2	115.00	0.35	6754.16	5403.33	0.05
1215	1273	1296	1295	1272	2	115.00	0.35	7015.21	5612.17	0.05
1216	1274	1297	1296	1273	2	115.00	0.35	7263.92	5811.14	0.05
1217	1275	1298	1297	1274	2	115.00	0.35	7504.34	6003.47	0.05
1218	1276	1299	1298	1275	2	115.00	0.35	7731.51	6185.21	0.05
1219	1277	1300	1299	1276	2	115.00	0.35	7958.68	6366.94	0.05
1220	1278	1301	1300	1277	2	115.00	0.35	8185.85	6548.68	0.05
1221	1279	1302	1301	1278	2	115.00	0.35	8420.47	6736.38	0.05
1222	1280	1303	1302	1279	3	115.00	0.35	8719.44	6975.55	0.05
1223	1281	1282	1305	1304	3	115.00	0.35	418.01	334.41	0.05
1224	1282	1283	1306	1305	2	115.00	0.35	1563.92	1251.14	0.05
1225	1283	1284	1307	1306	2	115.00	0.35	2490.98	1992.79	0.05
1226	1284	1285	1308	1307	2	115.00	0.35	3120.58	2496.46	0.05
1227	1285	1286	1309	1308	2	115.00	0.35	3650.70	2920.56	0.05

1228	1286	1287	1310	1309	2	115.00	0.35	4123.69	3298.96	0.05
1229	1287	1288	1311	1310	2	115.00	0.35	4530.97	3624.78	0.05
1230	1288	1289	1312	1311	2	115.00	0.35	4909.77	3927.82	0.05
1231	1289	1290	1313	1312	2	115.00	0.35	5267.15	4213.72	0.05
1232	1290	1291	1314	1313	2	115.00	0.35	5591.54	4473.24	0.05
1233	1291	1292	1315	1314	2	115.00	0.35	5903.00	4722.40	0.05
1234	1292	1293	1316	1315	2	115.00	0.35	6201.31	4961.05	0.05
1235	1293	1294	1317	1316	2	115.00	0.35	6480.00	5184.00	0.05
1236	1294	1295	1318	1317	2	115.00	0.35	6750.83	5400.67	0.05
1237	1295	1296	1319	1318	2	115.00	0.35	7011.62	5609.30	0.05
1238	1296	1297	1320	1319	2	115.00	0.35	7260.27	5808.22	0.05
1239	1297	1298	1321	1320	2	115.00	0.35	7500.75	6000.60	0.05
1240	1298	1299	1322	1321	2	115.00	0.35	7727.69	6182.15	0.05
1241	1299	1300	1323	1322	2	115.00	0.35	7954.62	6363.70	0.05
1242	1300	1301	1324	1323	2	115.00	0.35	8181.56	6545.25	0.05
1243	1301	1302	1324	1324	2	115.00	0.35	8377.44	6701.95	0.05
1244	1302	1303	1325	1324	3	115.00	0.35	8610.08	6888.06	0.05
1245	1304	1305	1327	1326	3	115.00	0.35	418.01	334.41	0.05
1246	1305	1306	1328	1327	2	115.00	0.35	1567.40	1253.92	0.05
1247	1306	1307	1329	1328	2	115.00	0.35	2497.46	1997.97	0.05
1248	1307	1308	1330	1329	2	115.00	0.35	3131.38	2505.10	0.05
1249	1308	1309	1331	1330	2	115.00	0.35	3662.30	2929.84	0.05
1250	1309	1310	1332	1331	2	115.00	0.35	4136.27	3309.02	0.05
1251	1310	1311	1333	1332	2	115.00	0.35	4546.34	3637.07	0.05
1252	1311	1312	1334	1333	2	115.00	0.35	4925.78	3940.62	0.05
1253	1312	1313	1335	1334	2	115.00	0.35	5283.84	4227.07	0.05
1254	1313	1314	1336	1335	2	115.00	0.35	5610.46	4488.37	0.05
1255	1314	1315	1337	1336	2	115.00	0.35	5922.45	4737.96	0.05
1256	1315	1316	1338	1337	2	115.00	0.35	6222.34	4977.87	0.05
1257	1316	1317	1339	1338	2	115.00	0.35	6501.91	5201.53	0.05
1258	1317	1318	1340	1339	2	115.00	0.35	6773.20	5418.56	0.05
1259	1318	1319	1341	1340	2	115.00	0.35	7035.78	5628.62	0.05
1260	1319	1320	1342	1341	2	115.00	0.35	7284.81	5827.85	0.05
1261	1320	1321	1343	1342	2	115.00	0.35	7524.89	6019.91	0.05
1262	1321	1322	1344	1343	2	115.00	0.35	7753.38	6202.70	0.05
1263	1322	1323	1345	1344	2	115.00	0.35	7981.87	6385.50	0.05
1264	1323	1324	1345	1345	2	115.00	0.35	8173.61	6538.88	0.05
1265	1324	1325	1346	1345	3	115.00	0.35	8387.43	6709.95	0.05
1266	1326	1327	1348	1347	3	115.00	0.35	418.01	334.41	0.05
1267	1327	1328	1349	1348	2	115.00	0.35	1566.41	1253.13	0.05
1268	1328	1329	1350	1349	2	115.00	0.35	2495.62	1996.50	0.05
1269	1329	1330	1351	1350	2	115.00	0.35	3128.31	2502.65	0.05
1270	1330	1331	1352	1351	2	115.00	0.35	3659.01	2927.21	0.05
1271	1331	1332	1353	1352	2	115.00	0.35	4132.70	3306.16	0.05
1272	1332	1333	1354	1353	2	115.00	0.35	4541.98	3633.58	0.05
1273	1333	1334	1355	1354	2	115.00	0.35	4921.23	3936.98	0.05
1274	1334	1335	1356	1355	2	115.00	0.35	5279.10	4223.28	0.05
1275	1335	1336	1357	1356	2	115.00	0.35	5605.09	4484.07	0.05
1276	1336	1337	1358	1357	2	115.00	0.35	5916.92	4733.54	0.05
1277	1337	1338	1359	1358	2	115.00	0.35	6216.66	4973.33	0.05
1278	1338	1339	1360	1359	2	115.00	0.35	6495.69	5196.55	0.05
1279	1339	1340	1361	1360	2	115.00	0.35	6766.85	5413.48	0.05
1280	1340	1341	1362	1361	2	115.00	0.35	7028.92	5623.13	0.05
1281	1341	1342	1363	1362	2	115.00	0.35	7277.84	5822.27	0.05
1282	1342	1343	1364	1363	2	115.00	0.35	7518.03	6014.43	0.05
1283	1343	1344	1365	1364	2	115.00	0.35	7746.08	6196.87	0.05
1284	1344	1345	1365	1365	2	115.00	0.35	7937.53	6350.02	0.05
1285	1345	1346	1366	1365	3	115.00	0.35	8147.27	6517.82	0.05
1286	1347	1348	1368	1367	3	115.00	0.35	418.01	334.41	0.05
1287	1348	1349	1369	1368	2	115.00	0.35	1565.30	1252.24	0.05
1288	1349	1350	1370	1369	2	115.00	0.35	2493.56	1994.85	0.05
1289	1350	1351	1371	1370	2	115.00	0.35	3124.87	2499.90	0.05
1290	1351	1352	1372	1371	2	115.00	0.35	3655.31	2924.25	0.05

1291	1352	1353	1373	1372	2	115.00	0.35	4128.69	3302.95	0.05
1292	1353	1354	1374	1373	2	115.00	0.35	4537.08	3629.66	0.05
1293	1354	1355	1375	1374	2	115.00	0.35	4916.13	3932.91	0.05
1294	1355	1356	1376	1375	2	115.00	0.35	5273.79	4219.03	0.05
1295	1356	1357	1377	1376	2	115.00	0.35	5599.07	4479.25	0.05
1296	1357	1358	1378	1377	2	115.00	0.35	5910.73	4728.58	0.05
1297	1358	1359	1379	1378	2	115.00	0.35	6209.86	4967.88	0.05
1298	1359	1360	1380	1379	2	115.00	0.35	6488.71	5190.97	0.05
1299	1360	1361	1381	1380	2	115.00	0.35	6759.72	5407.78	0.05
1300	1361	1362	1382	1381	2	115.00	0.35	7021.22	5616.98	0.05
1301	1362	1363	1383	1382	2	115.00	0.35	7270.02	5816.02	0.05
1302	1363	1364	1384	1383	2	115.00	0.35	7510.34	6008.28	0.05
1303	1364	1365	1384	1384	2	115.00	0.35	7701.46	6161.17	0.05
1304	1365	1366	1385	1384	3	115.00	0.35	7907.12	6325.69	0.05
1305	1367	1368	1387	1386	3	115.00	0.35	418.01	334.41	0.05
1306	1368	1369	1388	1387	2	115.00	0.35	1564.05	1251.24	0.05
1307	1369	1370	1389	1388	2	115.00	0.35	2491.23	1992.98	0.05
1308	1370	1371	1390	1389	2	115.00	0.35	3120.99	2496.79	0.05
1309	1371	1372	1391	1390	2	115.00	0.35	3651.14	2920.91	0.05
1310	1372	1373	1392	1391	2	115.00	0.35	4124.17	3299.34	0.05
1311	1373	1374	1393	1392	2	115.00	0.35	4531.55	3625.24	0.05
1312	1374	1375	1394	1393	2	115.00	0.35	4910.38	3928.30	0.05
1313	1375	1376	1395	1394	2	115.00	0.35	5267.78	4214.22	0.05
1314	1376	1377	1396	1395	2	115.00	0.35	5592.26	4473.81	0.05
1315	1377	1378	1397	1396	2	115.00	0.35	5903.73	4722.99	0.05
1316	1378	1379	1398	1397	2	115.00	0.35	6202.12	4961.70	0.05
1317	1379	1380	1399	1398	2	115.00	0.35	6480.83	5184.66	0.05
1318	1380	1381	1400	1399	2	115.00	0.35	6751.68	5401.34	0.05
1319	1381	1382	1401	1400	2	115.00	0.35	7012.53	5610.03	0.05
1320	1382	1383	1402	1401	2	115.00	0.35	7261.20	5808.96	0.05
1321	1383	1384	1402	1402	2	115.00	0.35	7465.42	5972.33	0.05
1322	1384	1385	1403	1402	3	115.00	0.35	7666.96	6133.57	0.05
1323	1386	1387	1405	1404	3	115.00	0.35	418.01	334.41	0.05
1324	1387	1388	1406	1405	2	115.00	0.35	1562.63	1250.10	0.05
1325	1388	1389	1407	1406	2	115.00	0.35	2488.58	1990.86	0.05
1326	1389	1390	1408	1407	2	115.00	0.35	3116.56	2493.25	0.05
1327	1390	1391	1409	1408	2	115.00	0.35	3646.39	2917.11	0.05
1328	1391	1392	1410	1409	2	115.00	0.35	4119.02	3295.22	0.05
1329	1392	1393	1411	1410	2	115.00	0.35	4525.26	3620.21	0.05
1330	1393	1394	1412	1411	2	115.00	0.35	4903.82	3923.06	0.05
1331	1394	1395	1413	1412	2	115.00	0.35	5260.94	4208.75	0.05
1332	1395	1396	1414	1413	2	115.00	0.35	5584.51	4467.61	0.05
1333	1396	1397	1415	1414	2	115.00	0.35	5895.77	4716.62	0.05
1334	1397	1398	1416	1415	2	115.00	0.35	6193.32	4954.66	0.05
1335	1398	1399	1417	1416	2	115.00	0.35	6471.85	5177.48	0.05
1336	1399	1400	1418	1417	2	115.00	0.35	6742.52	5394.01	0.05
1337	1400	1401	1419	1418	2	115.00	0.35	7002.64	5602.11	0.05
1338	1401	1402	1419	1419	2	115.00	0.35	7211.99	5769.59	0.05
1339	1402	1403	1420	1419	3	115.00	0.35	7415.79	5932.64	0.05
1340	1404	1405	1422	1421	3	115.00	0.35	418.01	334.41	0.05
1341	1405	1406	1423	1422	2	115.00	0.35	1560.99	1248.79	0.05
1342	1406	1407	1424	1423	2	115.00	0.35	2485.53	1988.42	0.05
1343	1407	1408	1425	1424	2	115.00	0.35	3111.48	2489.19	0.05
1344	1408	1409	1426	1425	2	115.00	0.35	3640.93	2912.74	0.05
1345	1409	1410	1427	1426	2	115.00	0.35	4113.10	3290.48	0.05
1346	1410	1411	1428	1427	2	115.00	0.35	4518.03	3614.42	0.05
1347	1411	1412	1429	1428	2	115.00	0.35	4896.30	3917.04	0.05
1348	1412	1413	1430	1429	2	115.00	0.35	5253.04	4202.43	0.05
1349	1413	1414	1431	1430	2	115.00	0.35	5575.61	4460.49	0.05
1350	1414	1415	1432	1431	2	115.00	0.35	5886.62	4709.30	0.05
1351	1415	1416	1433	1432	2	115.00	0.35	6183.21	4946.57	0.05
1352	1416	1417	1434	1433	2	115.00	0.35	6461.55	5169.24	0.05
1353	1417	1418	1435	1434	2	115.00	0.35	6732.00	5385.60	0.05

1354	1418	1419	1435	1435	2	115.00	0.35	6950.17	5560.13	0.05
1355	1419	1420	1436	1435	3	115.00	0.35	7154.13	5723.30	0.05
1356	1421	1422	1438	1437	3	115.00	0.35	418.01	334.41	0.05
1357	1422	1423	1439	1438	2	115.00	0.35	1559.09	1247.27	0.05
1358	1423	1424	1440	1439	2	115.00	0.35	2481.99	1985.59	0.05
1359	1424	1425	1441	1440	2	115.00	0.35	3105.59	2484.47	0.05
1360	1425	1426	1442	1441	2	115.00	0.35	3634.59	2907.68	0.05
1361	1426	1427	1443	1442	2	115.00	0.35	4106.24	3284.99	0.05
1362	1427	1428	1444	1443	2	115.00	0.35	4509.63	3607.71	0.05
1363	1428	1429	1445	1444	2	115.00	0.35	4887.56	3910.05	0.05
1364	1429	1430	1446	1445	2	115.00	0.35	5242.96	4194.37	0.05
1365	1430	1431	1447	1446	2	115.00	0.35	5565.28	4452.23	0.05
1366	1431	1432	1448	1447	2	115.00	0.35	5876.01	4700.81	0.05
1367	1432	1433	1449	1448	2	115.00	0.35	6171.48	4937.18	0.05
1368	1433	1434	1450	1449	2	115.00	0.35	6449.59	5159.67	0.05
1369	1434	1435	1450	1450	2	115.00	0.35	6679.01	5343.21	0.05
1370	1435	1436	1451	1450	3	115.00	0.35	6878.15	5502.52	0.05
1371	1437	1438	1453	1452	3	115.00	0.35	418.01	334.41	0.05
1372	1438	1439	1454	1453	2	115.00	0.35	1556.86	1245.49	0.05
1373	1439	1440	1455	1454	2	115.00	0.35	2477.83	1982.27	0.05
1374	1440	1441	1456	1455	2	115.00	0.35	3098.66	2478.93	0.05
1375	1441	1442	1457	1456	2	115.00	0.35	3627.15	2901.72	0.05
1376	1442	1443	1458	1457	2	115.00	0.35	4098.17	3278.54	0.05
1377	1443	1444	1459	1458	2	115.00	0.35	4499.78	3599.82	0.05
1378	1444	1445	1460	1459	2	115.00	0.35	4877.29	3901.83	0.05
1379	1445	1446	1461	1460	2	115.00	0.35	5231.11	4184.89	0.05
1380	1446	1447	1462	1461	2	115.00	0.35	5553.14	4442.52	0.05
1381	1447	1448	1463	1462	2	115.00	0.35	5863.53	4690.83	0.05
1382	1448	1449	1464	1463	2	115.00	0.35	6157.69	4926.15	0.05
1383	1449	1450	1464	1464	2	115.00	0.35	6392.55	5114.04	0.05
1384	1450	1451	1465	1464	3	115.00	0.35	6592.21	5273.77	0.05
1385	1452	1453	1467	1466	3	115.00	0.35	418.01	334.41	0.05
1386	1453	1454	1468	1467	2	115.00	0.35	1558.63	1246.91	0.05
1387	1454	1455	1469	1468	2	115.00	0.35	2481.13	1984.90	0.05
1388	1455	1456	1470	1469	2	115.00	0.35	3104.16	2483.32	0.05
1389	1456	1457	1471	1470	2	115.00	0.35	3633.06	2906.45	0.05
1390	1457	1458	1472	1471	2	115.00	0.35	4104.57	3283.66	0.05
1391	1458	1459	1473	1472	2	115.00	0.35	4507.60	3606.08	0.05
1392	1459	1460	1474	1473	2	115.00	0.35	4885.44	3908.35	0.05
1393	1460	1461	1475	1474	2	115.00	0.35	5240.51	4192.41	0.05
1394	1461	1462	1476	1475	2	115.00	0.35	5562.77	4450.22	0.05
1395	1462	1463	1477	1476	2	115.00	0.35	5860.40	4688.32	0.05
1396	1463	1464	1477	1477	2	115.00	0.35	6095.63	4876.50	0.05
1397	1464	1465	1478	1477	3	115.00	0.35	6296.79	5037.43	0.05
1398	1466	1467	1480	1479	3	115.00	0.35	418.01	334.41	0.05
1399	1467	1468	1481	1480	2	115.00	0.35	1570.17	1256.13	0.05
1400	1468	1469	1482	1481	2	115.00	0.35	2502.63	2002.11	0.05
1401	1469	1470	1483	1482	2	115.00	0.35	3139.99	2511.99	0.05
1402	1470	1471	1484	1483	2	115.00	0.35	3671.55	2937.24	0.05
1403	1471	1472	1485	1484	2	115.00	0.35	4146.30	3317.04	0.05
1404	1472	1473	1486	1485	2	115.00	0.35	4558.60	3646.88	0.05
1405	1473	1474	1487	1486	2	115.00	0.35	4938.54	3950.83	0.05
1406	1474	1475	1488	1487	2	115.00	0.35	5297.16	4237.72	0.05
1407	1475	1476	1489	1488	2	115.00	0.35	5625.55	4500.44	0.05
1408	1476	1477	1489	1489	2	115.00	0.35	5853.45	4682.76	0.05
1409	1477	1478	1490	1489	3	115.00	0.35	6060.60	4848.48	0.05
1410	1479	1480	1492	1491	3	115.00	0.35	418.01	334.41	0.05
1411	1480	1481	1493	1492	2	115.00	0.35	1560.44	1248.35	0.05
1412	1481	1482	1494	1493	2	115.00	0.35	2484.49	1987.60	0.05
1413	1482	1483	1495	1494	2	115.00	0.35	3109.76	2487.81	0.05
1414	1483	1484	1496	1495	2	115.00	0.35	3639.08	2911.26	0.05
1415	1484	1485	1497	1496	2	115.00	0.35	4111.10	3288.88	0.05
1416	1485	1486	1498	1497	2	115.00	0.35	4515.58	3612.46	0.05

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1417 1486 1487 1499 1498    2    115.00     0.35    4893.74    3915.00      0.05
1418 1487 1488 1500 1499    2    115.00     0.35    5250.10    4200.08      0.05
1419 1488 1489 1501 1500    2    115.00     0.35    5583.39    4466.71      0.05
1420 1489 1490 1502 1501    3    115.00     0.35    5903.90    4723.12      0.05
1421 1491 1492 1504 1503    3    115.00     0.35     418.01     334.41      0.05
1422 1492 1493 1505 1504    2    115.00     0.35    1551.12    1240.90      0.05
1423 1493 1494 1506 1505    2    115.00     0.35    2467.13    1973.71      0.05
1424 1494 1495 1507 1506    2    115.00     0.35    3080.83    2464.66      0.05
1425 1495 1496 1508 1507    2    115.00     0.35    3608.00    2886.40      0.05
1426 1496 1497 1509 1508    2    115.00     0.35    4077.41    3261.93      0.05
1427 1497 1498 1510 1509    2    115.00     0.35    4474.40    3579.52      0.05
1428 1498 1499 1511 1510    2    115.00     0.35    4850.87    3880.69      0.05
1429 1499 1500 1512 1511    2    115.00     0.35    5190.83    4152.67      0.05
1430 1500 1501 1512 1512    2    115.00     0.35    5454.55    4363.64      0.05
1431 1501 1502 1513 1512    3    115.00     0.35    5672.31    4537.85      0.05
1432 1504 1515 1514 1503    3    115.00     0.35     418.01     334.41      0.05
1433 1505 1515 1504 1504    2    115.00     0.35    1392.48    1113.99      0.05
1434 1506 1516 1515 1505    2    115.00     0.35    2078.11    1662.49      0.05
1435 1507 1517 1516 1506    2    115.00     0.35    2824.57    2259.66      0.05
1436 1508 1518 1517 1507    2    115.00     0.35    3434.40    2747.52      0.05
1437 1509 1519 1518 1508    2    115.00     0.35    3928.33    3142.66      0.05
1438 1510 1520 1519 1509    2    115.00     0.35    4366.88    3493.50      0.05
1439 1511 1521 1520 1510    2    115.00     0.35    4773.24    3818.60      0.05
1440 1512 1522 1521 1511    2    115.00     0.35    5119.15    4095.32      0.05
1441 1513 1523 1522 1512    3    115.00     0.35    5424.26    4339.41      0.05
1442 1514 1515 1525 1524    3    115.00     0.35     418.01     334.41      0.05
1443 1515 1516 1526 1525    2    115.00     0.35    1578.17    1262.54      0.05
1444 1516 1517 1527 1526    2    115.00     0.35    2517.55    2014.04      0.05
1445 1517 1518 1528 1527    2    115.00     0.35    3164.85    2531.88      0.05
1446 1518 1519 1529 1528    2    115.00     0.35    3698.26    2958.61      0.05
1447 1519 1520 1530 1529    2    115.00     0.35    4175.25    3340.20      0.05
1448 1520 1521 1531 1530    2    115.00     0.35    4593.98    3675.18      0.05
1449 1521 1522 1532 1531    2    115.00     0.35    4964.21    3971.37      0.05
1450 1522 1523 1533 1532    3    115.00     0.35    5286.56    4229.25      0.05
1451 1524 1525 1535 1534    3    115.00     0.35     418.01     334.41      0.05
1452 1525 1526 1536 1535    2    115.00     0.35    1548.24    1238.59      0.05
1453 1526 1527 1537 1536    2    115.00     0.35    2461.77    1969.41      0.05
1454 1527 1528 1538 1537    2    115.00     0.35    3071.88    2457.51      0.05
1455 1528 1529 1539 1538    2    115.00     0.35    3598.39    2878.71      0.05
1456 1529 1530 1540 1539    2    115.00     0.35    4066.55    3253.24      0.05
1457 1530 1531 1541 1540    2    115.00     0.35    4461.67    3569.33      0.05
1458 1531 1532 1542 1541    2    115.00     0.35    4862.07    3889.65      0.05
1459 1532 1533 1543 1542    3    115.00     0.35    5208.15    4166.52      0.05
1460 1534 1535 1545 1544    3    115.00     0.35     418.01     334.41      0.05
1461 1535 1536 1546 1545    2    115.00     0.35    1537.48    1229.98      0.05
1462 1536 1537 1547 1546    2    115.00     0.35    2441.70    1953.36      0.05
1463 1537 1538 1548 1547    2    115.00     0.35    3038.44    2430.75      0.05
1464 1538 1539 1549 1548    2    115.00     0.35    3562.47    2849.97      0.05
1465 1539 1540 1550 1549    2    115.00     0.35    4020.36    3216.29      0.05
1466 1540 1541 1551 1550    2    115.00     0.35    4415.22    3532.18      0.05
1467 1541 1542 1551 1551    2    115.00     0.35    4753.96    3803.17      0.05
1468 1542 1543 1552 1551    3    115.00     0.35    4980.59    3984.47      0.05
1469 1544 1545 1554 1553    3    115.00     0.35     418.01     334.41      0.05
1470 1545 1546 1555 1554    2    115.00     0.35    1499.81    1199.85      0.05
1471 1546 1547 1556 1555    2    115.00     0.35    2371.49    1897.19      0.05
1472 1547 1548 1557 1556    2    115.00     0.35    2921.42    2337.14      0.05
1473 1548 1549 1558 1557    2    115.00     0.35    3436.75    2749.40      0.05
1474 1549 1550 1559 1558    2    115.00     0.35    3858.73    3086.98      0.05
1475 1550 1551 1560 1559    2    115.00     0.35    4248.68    3398.95      0.05
1476 1551 1552 1561 1560    3    115.00     0.35    4573.49    3658.79      0.05
1477 1553 1554 1563 1562    3    115.00     0.35     418.01     334.41      0.05
1478 1554 1555 1564 1563    2    115.00     0.35    1441.04    1152.83      0.05
1479 1555 1556 1565 1564    2    115.00     0.35    2208.59    1766.87      0.05
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1480 1556 1557 1566 1565    2    115.00     0.35    2738.84    2191.07      0.05
1481 1557 1558 1567 1566    2    115.00     0.35    3215.73    2572.59      0.05
1482 1558 1559 1568 1567    2    115.00     0.35    3606.55    2885.24      0.05
1483 1559 1560 1568 1568    2    115.00     0.35    3938.62    3150.90      0.05
1484 1560 1561 1569 1568    3    115.00     0.35    4130.99    3304.80      0.05
1485 1562 1563 1571 1570    3    115.00     0.35     418.01     334.41      0.05
1486 1563 1564 1572 1571    2    115.00     0.35    1405.47    1124.38      0.05
1487 1564 1565 1573 1572    2    115.00     0.35    2101.90    1681.52      0.05
1488 1565 1566 1574 1573    2    115.00     0.35    2628.36    2102.68      0.05
1489 1566 1567 1575 1574    2    115.00     0.35    3061.06    2448.85      0.05
1490 1567 1568 1575 1575    2    115.00     0.35    3432.52    2746.02      0.05
1491 1568 1569 1576 1575    3    115.00     0.35    3607.27    2885.81      0.05
1492 1570 1571 1578 1577    3    115.00     0.35     418.01     334.41      0.05
1493 1571 1572 1579 1578    2    115.00     0.35    1348.57    1078.86      0.05
1494 1572 1573 1580 1579    2    115.00     0.35    1931.20    1544.96      0.05
1495 1573 1574 1581 1580    2    115.00     0.35    2451.59    1961.27      0.05
1496 1574 1575 1581 1581    2    115.00     0.35    2812.17    2249.74      0.05
1497 1575 1576 1582 1581    3    115.00     0.35    2994.25    2395.40      0.05
1498 1577 1578 1584 1583    3    115.00     0.35     620.95     496.76      0.05
1499 1578 1579 1584 1584    2    115.00     0.35    1316.48    1053.18      0.05
1500 1579 1580 1584 1584    2    115.00     0.35    1657.48    1325.98      0.05
1501 1580 1581 1584 1584    2    115.00     0.35    1998.48    1598.78      0.05
1502 1581 1582 1585 1584    3    115.00     0.35    2217.10    1773.68      0.05
1503 1583 1584 1586 1586    3    115.00     0.35     549.26     439.41      0.05
1504 1584 1585 1586 1586    3    115.00     0.35    1345.47    1076.37      0.05
   N      XORD      YORD   BC  OUT       X2IH        X1IH          XIH
X2IV         X1IV          XIV   *** (I5,2F10.0,2I5,6E13.0) ***
   1     72.29    664.77    4
   2     89.05    667.96    0
   3     89.05    664.73    0
   4     89.05    661.49    4
   5    105.80    671.15    0
   6    105.80    664.68    0
   7    105.80    658.21    4
   8    122.56    674.35    0
   9    122.56    670.85    0
  10    122.56    665.14    0
  11    122.56    659.43    0
  12    122.56    654.93    4
  13    139.32    677.54    0
  14    139.32    674.04    0
  15    139.32    665.09    0
  16    139.32    656.15    0
  17    139.32    651.65    4
  18    156.07    680.73    0
  19    156.07    677.23    0
  20    156.07    669.11    0
  21    156.07    660.99    0
  22    156.07    652.86    0
  23    156.07    648.36    4
  24    172.83    683.92    0
  25    172.83    680.42    0
  26    172.83    670.14    0
  27    172.83    659.86    0
  28    172.83    649.58    0
  29    172.83    645.08    4
  30    189.59    687.11    0
  31    189.59    683.61    0
  32    189.59    674.29    0
  33    189.59    664.96    0
  34    189.59    655.63    0
  35    189.59    646.30    0
  36    189.59    641.80    4
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37	206.35	690.31	0
38	206.35	686.81	0
39	206.35	675.86	0
40	206.35	664.91	0
41	206.35	653.97	0
42	206.35	643.02	0
43	206.35	638.52	4
44	223.10	693.50	0
45	223.10	690.00	0
46	223.10	679.95	0
47	223.10	669.89	0
48	223.10	659.84	0
49	223.10	649.79	0
50	223.10	639.74	0
51	223.10	635.24	4
52	239.86	696.69	0
53	239.86	693.19	0
54	239.86	681.84	0
55	239.86	670.50	0
56	239.86	659.15	0
57	239.86	647.80	0
58	239.86	636.46	0
59	239.86	631.96	4
60	256.62	699.88	0
61	256.62	696.38	0
62	256.62	685.85	0
63	256.62	675.31	0
64	256.62	664.78	0
65	256.62	654.25	0
66	256.62	643.71	0
67	256.62	633.18	0
68	256.62	628.68	4
69	273.37	703.07	0
70	273.37	699.57	0
71	273.37	687.96	0
72	273.37	676.35	0
73	273.37	664.73	0
74	273.37	653.12	0
75	273.37	641.51	0
76	273.37	629.90	0
77	273.37	625.40	4
78	290.13	706.26	0
79	290.13	702.76	0
80	290.13	690.07	0
81	290.13	677.38	0
82	290.13	664.69	0
83	290.13	652.00	0
84	290.13	639.31	0
85	290.13	626.61	0
86	290.13	622.11	4
87	306.89	709.46	0
88	306.89	705.96	0
89	306.89	692.19	0
90	306.89	678.42	0
91	306.89	664.64	0
92	306.89	650.87	0
93	306.89	637.10	0
94	306.89	623.33	0
95	306.89	618.83	4
96	323.64	712.65	0
97	323.64	709.15	0
98	323.64	696.42	0
99	323.64	683.69	0

100	323.64	670.96	0
101	323.64	658.24	0
102	323.64	645.51	0
103	323.64	632.78	0
104	323.64	620.05	0
105	323.64	615.55	4
106	340.40	715.84	0
107	340.40	712.34	0
108	340.40	698.78	0
109	340.40	685.23	0
110	340.40	671.67	0
111	340.40	658.11	0
112	340.40	644.56	0
113	340.40	631.00	0
114	340.40	616.77	0
115	340.40	612.27	4
116	361.12	716.24	0
117	361.12	712.74	0
118	361.12	700.24	0
119	361.12	687.73	0
120	361.12	675.23	0
121	361.12	662.73	0
122	361.12	650.22	0
123	361.12	637.72	0
124	361.12	625.22	0
125	361.12	612.72	0
126	361.12	608.22	4
127	381.83	716.64	0
128	381.83	713.14	0
129	381.83	699.92	0
130	381.83	686.70	0
131	381.83	673.49	0
132	381.83	660.27	0
133	381.83	647.05	0
134	381.83	633.83	0
135	381.83	620.62	0
136	381.83	608.66	0
137	381.83	604.16	4
138	403.07	720.72	0
139	403.07	717.22	0
140	403.07	704.89	0
141	403.07	692.57	0
142	403.07	680.24	0
143	403.07	667.91	0
144	403.07	655.59	0
145	403.07	643.26	0
146	403.07	630.93	0
147	403.07	618.61	0
148	403.07	604.50	0
149	403.07	600.00	4
150	420.16	724.00	0
151	420.16	720.50	0
152	420.16	707.65	0
153	420.16	694.81	0
154	420.16	681.96	0
155	420.16	669.12	0
156	420.16	656.27	0
157	420.16	643.43	0
158	420.16	630.58	0
159	420.16	617.74	0
160	420.16	604.89	0
161	420.16	600.39	4
162	437.25	727.28	0

163	437.25	723.78	0
164	437.25	710.61	0
165	437.25	697.45	0
166	437.25	684.28	0
167	437.25	671.11	0
168	437.25	657.95	0
169	437.25	644.78	0
170	437.25	631.62	0
171	437.25	618.45	0
172	437.25	605.28	0
173	437.25	600.78	4
174	454.34	730.56	0
175	454.34	727.06	0
176	454.34	713.57	0
177	454.34	700.09	0
178	454.34	686.60	0
179	454.34	673.11	0
180	454.34	659.62	0
181	454.34	646.14	0
182	454.34	632.65	0
183	454.34	619.16	0
184	454.34	605.68	0
185	454.34	601.18	4
186	471.44	733.84	0
187	471.44	730.34	0
188	471.44	717.91	0
189	471.44	705.49	0
190	471.44	693.06	0
191	471.44	680.63	0
192	471.44	668.20	0
193	471.44	655.78	0
194	471.44	643.35	0
195	471.44	630.92	0
196	471.44	618.50	0
197	471.44	606.07	0
198	471.44	601.57	4
199	488.53	737.12	0
200	488.53	733.62	0
201	488.53	720.91	0
202	488.53	708.19	0
203	488.53	695.47	0
204	488.53	682.76	0
205	488.53	670.04	0
206	488.53	657.33	0
207	488.53	644.61	0
208	488.53	631.89	0
209	488.53	619.18	0
210	488.53	606.46	0
211	488.53	601.96	4
212	505.62	740.40	0
213	505.62	736.90	0
214	505.62	723.90	0
215	505.62	710.89	0
216	505.62	697.89	0
217	505.62	684.88	0
218	505.62	671.88	0
219	505.62	658.87	0
220	505.62	645.87	0
221	505.62	632.86	0
222	505.62	619.86	0
223	505.62	606.85	0
224	505.62	602.35	4
225	522.71	743.68	0

226	522.71	740.18	0
227	522.71	726.89	0
228	522.71	713.60	0
229	522.71	700.30	0
230	522.71	687.01	0
231	522.71	673.71	0
232	522.71	660.42	0
233	522.71	647.13	0
234	522.71	633.83	0
235	522.71	620.54	0
236	522.71	607.24	0
237	522.71	602.74	4
238	539.80	746.96	0
239	539.80	743.46	0
240	539.80	729.88	0
241	539.80	716.30	0
242	539.80	702.72	0
243	539.80	689.13	0
244	539.80	675.55	0
245	539.80	661.97	0
246	539.80	648.39	0
247	539.80	634.80	0
248	539.80	621.22	0
249	539.80	607.64	0
250	539.80	603.14	4
251	556.89	750.25	0
252	556.89	746.75	0
253	556.89	734.13	0
254	556.89	721.52	0
255	556.89	708.91	0
256	556.89	696.30	0
257	556.89	683.69	0
258	556.89	671.08	0
259	556.89	658.47	0
260	556.89	645.86	0
261	556.89	633.25	0
262	556.89	620.64	0
263	556.89	608.03	0
264	556.89	603.53	4
265	573.98	753.53	0
266	573.98	750.03	0
267	573.98	737.15	0
268	573.98	724.28	0
269	573.98	711.41	0
270	573.98	698.53	0
271	573.98	685.66	0
272	573.98	672.79	0
273	573.98	659.91	0
274	573.98	647.04	0
275	573.98	634.17	0
276	573.98	621.29	0
277	573.98	608.42	0
278	573.98	603.92	4
279	591.08	756.81	0
280	591.08	753.31	0
281	591.08	740.17	0
282	591.08	727.04	0
283	591.08	713.90	0
284	591.08	700.76	0
285	591.08	687.63	0
286	591.08	674.49	0
287	591.08	661.36	0
288	591.08	648.22	0

289	591.08	635.09	0
290	591.08	621.95	0
291	591.08	608.81	0
292	591.08	604.31	4
293	608.17	760.09	0
294	608.17	756.59	0
295	608.17	743.19	0
296	608.17	729.79	0
297	608.17	716.39	0
298	608.17	702.99	0
299	608.17	689.60	0
300	608.17	676.20	0
301	608.17	662.80	0
302	608.17	649.40	0
303	608.17	636.00	0
304	608.17	622.60	0
305	608.17	609.21	0
306	608.17	604.71	4
307	625.26	763.37	0
308	625.26	759.87	0
309	625.26	747.35	0
310	625.26	734.82	0
311	625.26	722.30	0
312	625.26	709.78	0
313	625.26	697.26	0
314	625.26	684.73	0
315	625.26	672.21	0
316	625.26	659.69	0
317	625.26	647.17	0
318	625.26	634.64	0
319	625.26	622.12	0
320	625.26	609.60	0
321	625.26	605.10	4
322	642.35	766.65	0
323	642.35	763.15	0
324	642.35	750.47	0
325	642.35	737.79	0
326	642.35	725.11	0
327	642.35	712.42	0
328	642.35	699.74	0
329	642.35	687.06	0
330	642.35	674.38	0
331	642.35	661.70	0
332	642.35	649.02	0
333	642.35	636.34	0
334	642.35	623.66	0
335	642.35	609.99	0
336	642.35	605.49	4
337	658.64	766.96	0
338	658.64	763.46	0
339	658.64	750.70	0
340	658.64	737.94	0
341	658.64	725.19	0
342	658.64	712.43	0
343	658.64	699.67	0
344	658.64	686.91	0
345	658.64	674.15	0
346	658.64	661.40	0
347	658.64	648.64	0
348	658.64	635.88	0
349	658.64	623.12	0
350	658.64	610.36	0
351	658.64	605.86	4

352	674.92	767.27	0
353	674.92	763.77	0
354	674.92	750.91	0
355	674.92	738.06	0
356	674.92	725.20	0
357	674.92	712.34	0
358	674.92	699.49	0
359	674.92	686.63	0
360	674.92	673.78	0
361	674.92	660.92	0
362	674.92	648.06	0
363	674.92	635.21	0
364	674.92	622.35	0
365	674.92	610.74	0
366	674.92	606.24	4
367	692.68	771.34	0
368	692.68	767.84	0
369	692.68	754.78	0
370	692.68	741.73	0
371	692.68	728.67	0
372	692.68	715.61	0
373	692.68	702.55	0
374	692.68	689.49	0
375	692.68	676.44	0
376	692.68	663.38	0
377	692.68	650.32	0
378	692.68	637.26	0
379	692.68	624.20	0
380	692.68	611.14	0
381	692.68	606.64	4
382	710.45	775.42	0
383	710.45	771.92	0
384	710.45	758.55	0
385	710.45	745.19	0
386	710.45	731.83	0
387	710.45	718.46	0
388	710.45	705.10	0
389	710.45	691.73	0
390	710.45	678.37	0
391	710.45	665.01	0
392	710.45	651.64	0
393	710.45	638.28	0
394	710.45	624.92	0
395	710.45	611.55	0
396	710.45	607.05	4
397	728.21	779.49	0
398	728.21	775.99	0
399	728.21	763.37	0
400	728.21	750.75	0
401	728.21	738.14	0
402	728.21	725.52	0
403	728.21	712.90	0
404	728.21	700.28	0
405	728.21	687.67	0
406	728.21	675.05	0
407	728.21	662.43	0
408	728.21	649.81	0
409	728.21	637.19	0
410	728.21	624.58	0
411	728.21	611.96	0
412	728.21	607.46	4
413	745.97	783.56	0
414	745.97	780.06	0

415	745.97	767.16	0
416	745.97	754.26	0
417	745.97	741.36	0
418	745.97	728.46	0
419	745.97	715.56	0
420	745.97	702.66	0
421	745.97	689.76	0
422	745.97	676.87	0
423	745.97	663.97	0
424	745.97	651.07	0
425	745.97	638.17	0
426	745.97	625.27	0
427	745.97	612.37	0
428	745.97	607.87	4
429	763.74	787.64	0
430	763.74	784.14	0
431	763.74	770.95	0
432	763.74	757.77	0
433	763.74	744.59	0
434	763.74	731.41	0
435	763.74	718.23	0
436	763.74	705.05	0
437	763.74	691.86	0
438	763.74	678.68	0
439	763.74	665.50	0
440	763.74	652.32	0
441	763.74	639.14	0
442	763.74	625.96	0
443	763.74	612.77	0
444	763.74	608.27	4
445	781.50	791.71	0
446	781.50	788.21	0
447	781.50	774.74	0
448	781.50	761.28	0
449	781.50	747.82	0
450	781.50	734.35	0
451	781.50	720.89	0
452	781.50	707.43	0
453	781.50	693.96	0
454	781.50	680.50	0
455	781.50	667.04	0
456	781.50	653.57	0
457	781.50	640.11	0
458	781.50	626.65	0
459	781.50	613.18	0
460	781.50	608.68	4
461	799.26	795.78	0
462	799.26	792.28	0
463	799.26	779.52	0
464	799.26	766.75	0
465	799.26	753.99	0
466	799.26	741.23	0
467	799.26	728.46	0
468	799.26	715.70	0
469	799.26	702.94	0
470	799.26	690.17	0
471	799.26	677.41	0
472	799.26	664.64	0
473	799.26	651.88	0
474	799.26	639.12	0
475	799.26	626.35	0
476	799.26	613.59	0
477	799.26	609.09	4

478	817.02	799.85	0
479	817.02	796.35	0
480	817.02	783.33	0
481	817.02	770.30	0
482	817.02	757.28	0
483	817.02	744.25	0
484	817.02	731.23	0
485	817.02	718.20	0
486	817.02	705.18	0
487	817.02	692.15	0
488	817.02	679.12	0
489	817.02	666.10	0
490	817.02	653.07	0
491	817.02	640.05	0
492	817.02	627.02	0
493	817.02	614.00	0
494	817.02	609.50	4
495	834.79	803.93	0
496	834.79	800.43	0
497	834.79	787.14	0
498	834.79	773.85	0
499	834.79	760.57	0
500	834.79	747.28	0
501	834.79	733.99	0
502	834.79	720.70	0
503	834.79	707.42	0
504	834.79	694.13	0
505	834.79	680.84	0
506	834.79	667.55	0
507	834.79	654.27	0
508	834.79	640.98	0
509	834.79	627.69	0
510	834.79	614.40	0
511	834.79	609.90	4
512	852.55	808.00	0
513	852.55	804.50	0
514	852.55	791.92	0
515	852.55	779.35	0
516	852.55	766.77	0
517	852.55	754.19	0
518	852.55	741.61	0
519	852.55	729.04	0
520	852.55	716.46	0
521	852.55	703.88	0
522	852.55	691.31	0
523	852.55	678.73	0
524	852.55	666.15	0
525	852.55	653.57	0
526	852.55	641.00	0
527	852.55	628.42	0
528	852.55	614.81	0
529	852.55	610.31	4
530	871.04	809.00	0
531	871.04	805.50	0
532	871.04	792.82	0
533	871.04	780.13	0
534	871.04	767.45	0
535	871.04	754.76	0
536	871.04	742.08	0
537	871.04	729.39	0
538	871.04	716.71	0
539	871.04	704.03	0
540	871.04	691.34	0

541	871.04	678.66	0
542	871.04	665.97	0
543	871.04	653.29	0
544	871.04	640.61	0
545	871.04	627.92	0
546	871.04	615.24	0
547	871.04	610.74	4
548	889.53	810.00	0
549	889.53	806.50	0
550	889.53	793.70	0
551	889.53	780.89	0
552	889.53	768.09	0
553	889.53	755.29	0
554	889.53	742.49	0
555	889.53	729.68	0
556	889.53	716.88	0
557	889.53	704.08	0
558	889.53	691.27	0
559	889.53	678.47	0
560	889.53	665.67	0
561	889.53	652.87	0
562	889.53	640.06	0
563	889.53	627.26	0
564	889.53	615.66	0
565	889.53	611.16	4
566	907.10	814.59	0
567	907.10	811.09	0
568	907.10	798.09	0
569	907.10	785.09	0
570	907.10	772.08	0
571	907.10	759.08	0
572	907.10	746.08	0
573	907.10	733.08	0
574	907.10	720.08	0
575	907.10	707.08	0
576	907.10	694.07	0
577	907.10	681.07	0
578	907.10	668.07	0
579	907.10	655.07	0
580	907.10	642.07	0
581	907.10	629.07	0
582	907.10	616.06	0
583	907.10	611.56	4
584	924.68	819.18	0
585	924.68	815.68	0
586	924.68	802.40	0
587	924.68	789.12	0
588	924.68	775.84	0
589	924.68	762.55	0
590	924.68	749.27	0
591	924.68	735.99	0
592	924.68	722.71	0
593	924.68	709.43	0
594	924.68	696.15	0
595	924.68	682.87	0
596	924.68	669.59	0
597	924.68	656.31	0
598	924.68	643.03	0
599	924.68	629.75	0
600	924.68	616.47	0
601	924.68	611.97	4
602	942.25	823.77	0
603	942.25	820.27	0

604	942.25	807.55	0
605	942.25	794.84	0
606	942.25	782.13	0
607	942.25	769.42	0
608	942.25	756.70	0
609	942.25	743.99	0
610	942.25	731.28	0
611	942.25	718.57	0
612	942.25	705.86	0
613	942.25	693.14	0
614	942.25	680.43	0
615	942.25	667.72	0
616	942.25	655.01	0
617	942.25	642.29	0
618	942.25	629.58	0
619	942.25	616.87	0
620	942.25	612.37	4
621	959.82	828.35	0
622	959.82	824.85	0
623	959.82	811.88	0
624	959.82	798.91	0
625	959.82	785.93	0
626	959.82	772.96	0
627	959.82	759.99	0
628	959.82	747.01	0
629	959.82	734.04	0
630	959.82	721.06	0
631	959.82	708.09	0
632	959.82	695.12	0
633	959.82	682.14	0
634	959.82	669.17	0
635	959.82	656.20	0
636	959.82	643.22	0
637	959.82	630.25	0
638	959.82	617.27	0
639	959.82	612.77	4
640	977.40	832.94	0
641	977.40	829.44	0
642	977.40	816.21	0
643	977.40	802.97	0
644	977.40	789.74	0
645	977.40	776.50	0
646	977.40	763.27	0
647	977.40	750.03	0
648	977.40	736.80	0
649	977.40	723.56	0
650	977.40	710.32	0
651	977.40	697.09	0
652	977.40	683.85	0
653	977.40	670.62	0
654	977.40	657.38	0
655	977.40	644.15	0
656	977.40	630.91	0
657	977.40	617.68	0
658	977.40	613.18	4
659	994.97	837.53	0
660	994.97	834.03	0
661	994.97	820.70	0
662	994.97	807.36	0
663	994.97	794.03	0
664	994.97	780.70	0
665	994.97	767.36	0
666	994.97	754.03	0

667	994.97	740.70	0
668	994.97	727.36	0
669	994.97	714.03	0
670	994.97	700.70	0
671	994.97	687.36	0
672	994.97	674.03	0
673	994.97	660.69	0
674	994.97	647.36	0
675	994.97	634.03	0
676	994.97	618.08	0
677	994.97	613.58	4
678	1012.30	842.06	0
679	1012.30	838.56	0
680	1012.30	825.29	0
681	1012.30	812.02	0
682	1012.30	798.75	0
683	1012.30	785.48	0
684	1012.30	772.21	0
685	1012.30	758.95	0
686	1012.30	745.68	0
687	1012.30	732.41	0
688	1012.30	719.14	0
689	1012.30	705.87	0
690	1012.30	692.60	0
691	1012.30	679.33	0
692	1012.30	666.07	0
693	1012.30	652.80	0
694	1012.30	639.53	0
695	1012.30	626.26	0
696	1012.30	621.76	4
697	1029.64	846.58	0
698	1029.64	843.08	0
699	1029.64	830.04	0
700	1029.64	817.00	0
701	1029.64	803.96	0
702	1029.64	790.92	0
703	1029.64	777.88	0
704	1029.64	764.84	0
705	1029.64	751.80	0
706	1029.64	738.76	0
707	1029.64	725.72	0
708	1029.64	712.68	0
709	1029.64	699.64	0
710	1029.64	686.60	0
711	1029.64	673.56	0
712	1029.64	660.52	0
713	1029.64	647.48	0
714	1029.64	634.44	0
715	1029.64	629.94	4
716	1046.97	851.11	0
717	1046.97	847.61	0
718	1046.97	834.89	0
719	1046.97	822.16	0
720	1046.97	809.44	0
721	1046.97	796.72	0
722	1046.97	784.00	0
723	1046.97	771.27	0
724	1046.97	758.55	0
725	1046.97	745.83	0
726	1046.97	733.11	0
727	1046.97	720.38	0
728	1046.97	707.66	0
729	1046.97	694.94	0

730	1046.97	682.22	0
731	1046.97	669.49	0
732	1046.97	656.77	0
733	1046.97	642.62	0
734	1046.97	638.12	4
735	1066.38	852.32	0
736	1066.38	848.82	0
737	1066.38	835.68	0
738	1066.38	822.55	0
739	1066.38	809.41	0
740	1066.38	796.27	0
741	1066.38	783.14	0
742	1066.38	770.00	0
743	1066.38	756.86	0
744	1066.38	743.73	0
745	1066.38	730.59	0
746	1066.38	717.46	0
747	1066.38	704.32	0
748	1066.38	691.18	0
749	1066.38	678.05	0
750	1066.38	664.91	0
751	1066.38	651.77	0
752	1066.38	647.27	4
753	1085.78	853.53	0
754	1085.78	850.03	0
755	1085.78	837.15	0
756	1085.78	824.27	0
757	1085.78	811.39	0
758	1085.78	798.50	0
759	1085.78	785.62	0
760	1085.78	772.74	0
761	1085.78	759.86	0
762	1085.78	746.98	0
763	1085.78	734.10	0
764	1085.78	721.22	0
765	1085.78	708.34	0
766	1085.78	695.45	0
767	1085.78	682.57	0
768	1085.78	669.69	0
769	1085.78	660.93	0
770	1085.78	656.43	4
771	1101.03	857.66	0
772	1101.03	854.16	0
773	1101.03	841.26	0
774	1101.03	828.36	0
775	1101.03	815.45	0
776	1101.03	802.55	0
777	1101.03	789.65	0
778	1101.03	776.75	0
779	1101.03	763.85	0
780	1101.03	750.95	0
781	1101.03	738.05	0
782	1101.03	725.15	0
783	1101.03	712.25	0
784	1101.03	699.35	0
785	1101.03	686.45	0
786	1101.03	673.55	0
787	1101.03	660.65	0
788	1101.03	656.15	4
789	1116.27	861.78	0
790	1116.27	858.28	0
791	1116.27	845.09	0
792	1116.27	831.89	0

793	1116.27	818.70	0
794	1116.27	805.50	0
795	1116.27	792.31	0
796	1116.27	779.11	0
797	1116.27	765.92	0
798	1116.27	752.72	0
799	1116.27	739.53	0
800	1116.27	726.33	0
801	1116.27	713.14	0
802	1116.27	699.94	0
803	1116.27	686.75	0
804	1116.27	673.55	0
805	1116.27	660.36	0
806	1116.27	655.86	4
807	1131.52	865.91	0
808	1131.52	862.41	0
809	1131.52	849.77	0
810	1131.52	837.12	0
811	1131.52	824.47	0
812	1131.52	811.83	0
813	1131.52	799.18	0
814	1131.52	786.54	0
815	1131.52	773.89	0
816	1131.52	761.24	0
817	1131.52	748.60	0
818	1131.52	735.95	0
819	1131.52	723.31	0
820	1131.52	710.66	0
821	1131.52	698.01	0
822	1131.52	685.37	0
823	1131.52	672.72	0
824	1131.52	660.08	0
825	1131.52	655.58	4
826	1146.76	870.04	0
827	1146.76	866.54	0
828	1146.76	853.51	0
829	1146.76	840.47	0
830	1146.76	827.44	0
831	1146.76	814.41	0
832	1146.76	801.37	0
833	1146.76	788.34	0
834	1146.76	775.31	0
835	1146.76	762.27	0
836	1146.76	749.24	0
837	1146.76	736.21	0
838	1146.76	723.17	0
839	1146.76	710.14	0
840	1146.76	697.11	0
841	1146.76	684.07	0
842	1146.76	671.04	0
843	1146.76	659.79	0
844	1146.76	655.29	4
845	1163.08	874.46	0
846	1163.08	870.96	0
847	1163.08	858.22	0
848	1163.08	845.49	0
849	1163.08	832.75	0
850	1163.08	820.01	0
851	1163.08	807.28	0
852	1163.08	794.54	0
853	1163.08	781.81	0
854	1163.08	769.07	0
855	1163.08	756.33	0

856	1163.08	743.60	0
857	1163.08	730.86	0
858	1163.08	718.13	0
859	1163.08	705.39	0
860	1163.08	692.66	0
861	1163.08	679.92	0
862	1163.08	667.18	0
863	1163.08	654.45	0
864	1163.08	649.95	4
865	1179.40	878.88	0
866	1179.40	875.38	0
867	1179.40	862.07	0
868	1179.40	848.76	0
869	1179.40	835.45	0
870	1179.40	822.14	0
871	1179.40	808.83	0
872	1179.40	795.52	0
873	1179.40	782.21	0
874	1179.40	768.90	0
875	1179.40	755.59	0
876	1179.40	742.28	0
877	1179.40	728.97	0
878	1179.40	715.66	0
879	1179.40	702.35	0
880	1179.40	689.04	0
881	1179.40	675.73	0
882	1179.40	662.42	0
883	1179.40	649.11	0
884	1179.40	644.61	4
885	1195.71	883.29	0
886	1195.71	879.79	0
887	1195.71	866.68	0
888	1195.71	853.57	0
889	1195.71	840.46	0
890	1195.71	827.34	0
891	1195.71	814.23	0
892	1195.71	801.12	0
893	1195.71	788.00	0
894	1195.71	774.89	0
895	1195.71	761.78	0
896	1195.71	748.67	0
897	1195.71	735.55	0
898	1195.71	722.44	0
899	1195.71	709.33	0
900	1195.71	696.21	0
901	1195.71	683.10	0
902	1195.71	669.99	0
903	1195.71	656.88	0
904	1195.71	643.76	0
905	1195.71	639.26	4
906	1212.03	887.71	0
907	1212.03	884.21	0
908	1212.03	871.28	0
909	1212.03	858.34	0
910	1212.03	845.40	0
911	1212.03	832.47	0
912	1212.03	819.53	0
913	1212.03	806.59	0
914	1212.03	793.66	0
915	1212.03	780.72	0
916	1212.03	767.78	0
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924	1212.03	664.29	0
925	1212.03	651.36	0
926	1212.03	638.42	0
927	1212.03	633.92	4
928	1228.35	892.13	0
929	1228.35	888.63	0
930	1228.35	875.91	0
931	1228.35	863.18	0
932	1228.35	850.46	0
933	1228.35	837.73	0
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935	1228.35	812.29	0
936	1228.35	799.56	0
937	1228.35	786.84	0
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940	1228.35	748.67	0
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942	1228.35	723.22	0
943	1228.35	710.50	0
944	1228.35	697.77	0
945	1228.35	685.05	0
946	1228.35	672.32	0
947	1228.35	659.60	0
948	1228.35	646.88	0
949	1228.35	633.08	0
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952	1247.50	888.90	0
953	1247.50	875.90	0
954	1247.50	862.91	0
955	1247.50	849.91	0
956	1247.50	836.91	0
957	1247.50	823.91	0
958	1247.50	810.91	0
959	1247.50	797.91	0
960	1247.50	784.92	0
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962	1247.50	758.92	0
963	1247.50	745.92	0
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967	1247.50	693.93	0
968	1247.50	680.93	0
969	1247.50	667.93	0
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971	1247.50	641.94	0
972	1247.50	626.81	0
973	1247.50	622.31	4
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986	1259.36	744.18	0
987	1259.36	731.01	0
988	1259.36	717.84	0
989	1259.36	704.67	0
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993	1259.36	651.98	0
994	1259.36	638.81	0
995	1259.36	626.82	0
996	1259.36	622.32	4
997	1272.89	896.29	0
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1002	1272.89	839.59	0
1003	1272.89	826.30	0
1004	1272.89	813.00	0
1005	1272.89	799.70	0
1006	1272.89	786.40	0
1007	1272.89	773.10	0
1008	1272.89	759.81	0
1009	1272.89	746.51	0
1010	1272.89	733.21	0
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1080	1321.66	755.25	0
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1168	1392.17	857.92	0
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1170	1392.17	832.25	0

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1335	1501.18	774.05	0
1336	1501.18	761.03	0
1337	1501.18	748.02	0
1338	1501.18	735.00	0
1339	1501.18	721.98	0
1340	1501.18	708.97	0
1341	1501.18	695.95	0
1342	1501.18	682.94	0
1343	1501.18	669.92	0
1344	1501.18	656.91	0
1345	1501.18	643.89	0
1346	1501.18	639.39	4
1347	1518.19	876.67	0
1348	1518.19	873.17	0
1349	1518.19	860.18	0
1350	1518.19	847.19	0
1351	1518.19	834.20	0
1352	1518.19	821.21	0
1353	1518.19	808.23	0
1354	1518.19	795.24	0
1355	1518.19	782.25	0
1356	1518.19	769.26	0
1357	1518.19	756.27	0
1358	1518.19	743.28	0
1359	1518.19	730.29	0

1360	1518.19	717.30	0
1361	1518.19	704.31	0
1362	1518.19	691.32	0
1363	1518.19	678.33	0
1364	1518.19	665.34	0
1365	1518.19	652.36	0
1366	1518.19	647.86	4
1367	1535.20	871.67	0
1368	1535.20	868.17	0
1369	1535.20	855.21	0
1370	1535.20	842.25	0
1371	1535.20	829.29	0
1372	1535.20	816.33	0
1373	1535.20	803.37	0
1374	1535.20	790.41	0
1375	1535.20	777.45	0
1376	1535.20	764.49	0
1377	1535.20	751.54	0
1378	1535.20	738.58	0
1379	1535.20	725.62	0
1380	1535.20	712.66	0
1381	1535.20	699.70	0
1382	1535.20	686.74	0
1383	1535.20	673.78	0
1384	1535.20	660.82	0
1385	1535.20	656.32	4
1386	1552.22	866.67	0
1387	1552.22	863.17	0
1388	1552.22	850.24	0
1389	1552.22	837.31	0
1390	1552.22	824.39	0
1391	1552.22	811.46	0
1392	1552.22	798.54	0
1393	1552.22	785.61	0
1394	1552.22	772.69	0
1395	1552.22	759.76	0
1396	1552.22	746.84	0
1397	1552.22	733.91	0
1398	1552.22	720.99	0
1399	1552.22	708.06	0
1400	1552.22	695.14	0
1401	1552.22	682.21	0
1402	1552.22	669.29	0
1403	1552.22	664.79	4
1404	1569.23	861.66	0
1405	1569.23	858.16	0
1406	1569.23	845.28	0
1407	1569.23	832.39	0
1408	1569.23	819.50	0
1409	1569.23	806.62	0
1410	1569.23	793.73	0
1411	1569.23	780.84	0
1412	1569.23	767.96	0
1413	1569.23	755.07	0
1414	1569.23	742.18	0
1415	1569.23	729.30	0
1416	1569.23	716.41	0
1417	1569.23	703.52	0
1418	1569.23	690.64	0
1419	1569.23	677.75	0
1420	1569.23	673.25	4
1421	1586.24	856.66	0
1422	1586.24	853.16	0

1423	1586.24	840.32	0
1424	1586.24	827.48	0
1425	1586.24	814.63	0
1426	1586.24	801.79	0
1427	1586.24	788.95	0
1428	1586.24	776.11	0
1429	1586.24	763.27	0
1430	1586.24	750.43	0
1431	1586.24	737.58	0
1432	1586.24	724.74	0
1433	1586.24	711.90	0
1434	1586.24	699.06	0
1435	1586.24	686.22	0
1436	1586.24	681.72	4
1437	1603.25	851.66	0
1438	1603.25	848.16	0
1439	1603.25	835.37	0
1440	1603.25	822.58	0
1441	1603.25	809.79	0
1442	1603.25	797.00	0
1443	1603.25	784.21	0
1444	1603.25	771.42	0
1445	1603.25	758.63	0
1446	1603.25	745.84	0
1447	1603.25	733.05	0
1448	1603.25	720.26	0
1449	1603.25	707.47	0
1450	1603.25	694.68	0
1451	1603.25	690.18	4
1452	1620.27	846.65	0
1453	1620.27	843.15	0
1454	1620.27	830.43	0
1455	1620.27	817.70	0
1456	1620.27	804.97	0
1457	1620.27	792.24	0
1458	1620.27	779.51	0
1459	1620.27	766.79	0
1460	1620.27	754.06	0
1461	1620.27	741.33	0
1462	1620.27	728.60	0
1463	1620.27	715.87	0
1464	1620.27	703.15	0
1465	1620.27	698.65	4
1466	1637.28	841.65	0
1467	1637.28	838.15	0
1468	1637.28	825.27	0
1469	1637.28	812.39	0
1470	1637.28	799.51	0
1471	1637.28	786.63	0
1472	1637.28	773.75	0
1473	1637.28	760.87	0
1474	1637.28	747.99	0
1475	1637.28	735.11	0
1476	1637.28	722.23	0
1477	1637.28	711.61	0
1478	1637.28	707.11	4
1479	1650.65	841.62	0
1480	1650.65	838.12	0
1481	1650.65	824.80	0
1482	1650.65	811.48	0
1483	1650.65	798.16	0
1484	1650.65	784.85	0
1485	1650.65	771.53	0

1486	1650.65	758.21	0
1487	1650.65	744.90	0
1488	1650.65	731.58	0
1489	1650.65	718.26	0
1490	1650.65	713.76	4
1491	1664.01	841.58	0
1492	1664.01	838.08	0
1493	1664.01	825.70	0
1494	1664.01	813.31	0
1495	1664.01	800.93	0
1496	1664.01	788.55	0
1497	1664.01	776.17	0
1498	1664.01	763.78	0
1499	1664.01	751.40	0
1500	1664.01	739.02	0
1501	1664.01	724.91	0
1502	1664.01	720.41	4
1503	1679.26	837.32	0
1504	1679.26	833.82	0
1505	1679.26	820.98	0
1506	1679.26	808.14	0
1507	1679.26	795.29	0
1508	1679.26	782.45	0
1509	1679.26	769.61	0
1510	1679.26	756.77	0
1511	1679.26	743.93	0
1512	1679.26	732.50	0
1513	1679.26	728.00	4
1514	1699.54	831.65	0
1515	1699.54	828.15	0
1516	1699.54	814.53	0
1517	1699.54	800.92	0
1518	1699.54	787.30	0
1519	1699.54	773.68	0
1520	1699.54	760.07	0
1521	1699.54	746.45	0
1522	1699.54	734.45	0
1523	1699.54	729.95	4
1524	1718.44	830.68	0
1525	1718.44	827.18	0
1526	1718.44	814.19	0
1527	1718.44	801.20	0
1528	1718.44	788.21	0
1529	1718.44	775.23	0
1530	1718.44	762.24	0
1531	1718.44	749.25	0
1532	1718.44	736.26	0
1533	1718.44	731.76	4
1534	1737.33	829.71	0
1535	1737.33	826.21	0
1536	1737.33	814.13	0
1537	1737.33	802.04	0
1538	1737.33	789.95	0
1539	1737.33	777.86	0
1540	1737.33	765.77	0
1541	1737.33	753.69	0
1542	1737.33	738.07	0
1543	1737.33	733.57	4
1544	1762.17	828.44	0
1545	1762.17	824.94	0
1546	1762.17	812.50	0
1547	1762.17	800.06	0
1548	1762.17	787.62	0

1549	1762.17	775.18	0
1550	1762.17	762.74	0
1551	1762.17	750.16	0
1552	1762.17	745.66	4
1553	1780.40	823.52	0
1554	1780.40	820.02	0
1555	1780.40	809.85	0
1556	1780.40	799.69	0
1557	1780.40	789.52	0
1558	1780.40	779.36	0
1559	1780.40	769.19	0
1560	1780.40	759.03	0
1561	1780.40	754.53	4
1562	1798.63	818.59	0
1563	1798.63	815.09	0
1564	1798.63	805.65	0
1565	1798.63	796.21	0
1566	1798.63	786.78	0
1567	1798.63	777.34	0
1568	1798.63	767.90	0
1569	1798.63	763.40	4
1570	1816.86	813.67	0
1571	1816.86	810.17	0
1572	1816.86	801.82	0
1573	1816.86	793.47	0
1574	1816.86	785.12	0
1575	1816.86	776.77	0
1576	1816.86	772.27	4
1577	1835.09	808.74	0
1578	1835.09	805.24	0
1579	1835.09	798.71	0
1580	1835.09	792.18	0
1581	1835.09	785.65	0
1582	1835.09	781.15	4
1583	1853.32	803.82	0
1584	1853.32	796.92	0
1585	1853.32	790.02	4
1586	1871.55	798.89	4

Kettelman Hills Landfill B-18 Site Response, F East, Pacoima 360
Seismic Coefficient Surface Histories

Time-sec	Block 1
.020	-.000004
.040	-.000016
.060	-.000032
.080	-.000048
.100	-.000063
.120	-.000076
.140	-.000086
.160	-.000092
.180	-.000091
.200	-.000080
.220	-.000055
.240	-.000013
.260	.000051
.280	.000149
.300	.000278
.320	.000370
.340	.000371
.360	.000416
.380	.000683
.400	.001138
.420	.001665
.440	.002241
.460	.002553
.480	.002252
.500	.001975
.520	.002433
.540	.003064
.560	.002986
.580	.002300
.600	.001630
.620	.001173
.640	.001070
.660	.001377
.680	.001737
.700	.002254
.720	.002910
.740	.002971
.760	.002088
.780	.000655
.800	-.000272
.820	-.000423
.840	-.000626
.860	-.000947
.880	-.001039
.900	-.000873
.920	-.000282
.940	.001195
.960	.003352
.980	.004516
1.000	.003482
1.020	.001082
1.040	-.001028
1.060	-.001929
1.080	-.001845
1.100	-.001590
1.120	-.001899
1.140	-.002520
1.160	-.001866
1.180	.000812
1.200	.003594

1.220	.004171
1.240	.002720
1.260	.001171
1.280	.000360
1.300	-.000186
1.320	-.000795
1.340	-.001651
1.360	-.002511
1.380	-.002955
1.400	-.002384
1.420	.000002
1.440	.003131
1.460	.004667
1.480	.003835
1.500	.001576
1.520	-.000514
1.540	-.001025
1.560	-.000086
1.580	.000825
1.600	.001411
1.620	.002394
1.640	.003789
1.660	.005241
1.680	.005717
1.700	.004479
1.720	.001708
1.740	-.001707
1.760	-.003507
1.780	-.003309
1.800	-.003223
1.820	-.003830
1.840	-.004393
1.860	-.004221
1.880	-.003126
1.900	-.001785
1.920	-.000759
1.940	-.000697
1.960	-.001728
1.980	-.003070
2.000	-.004231
2.020	-.004531
2.040	-.003906
2.060	-.004178
2.080	-.006837
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2.120	-.012922
2.140	-.013447
2.160	-.012517
2.180	-.010145
2.200	-.006827
2.220	-.004264
2.240	-.004163
2.260	-.006305
2.280	-.009108
2.300	-.010945
2.320	-.011208
2.340	-.010912
2.360	-.010893
2.380	-.011102
2.400	-.011780
2.420	-.012773
2.440	-.013201
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2.480	-.012169
2.500	-.011140
2.520	-.009895
2.540	-.008014
2.560	-.005204
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2.660	-.012723
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2.720	-.016114
2.740	-.014995
2.760	-.013528
2.780	-.011868
2.800	-.010323
2.820	-.009103
2.840	-.007832
2.860	-.007049
2.880	-.007969
2.900	-.010303
2.920	-.012988
2.940	-.014876
2.960	-.015171
2.980	-.014450
3.000	-.013409
3.020	-.011825
3.040	-.009324
3.060	-.005724
3.080	-.001495
3.100	.002048
3.120	.004775
3.140	.007874
3.160	.011572
3.180	.014837
3.200	.017084
3.220	.018872
3.240	.021509
3.260	.026404
3.280	.032427
3.300	.037228
3.320	.041911
3.340	.048044
3.360	.055265
3.380	.062495
3.400	.068164
3.420	.070810
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3.460	.075056
3.480	.079391
3.500	.087563
3.520	.107145
3.540	.137652
3.560	.167314
3.580	.178836
3.600	.165358
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3.640	.109092
3.660	.077475
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3.720	-.005217

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4.000	-.077546
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4.080	-.093964
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4.120	-.094784
4.140	-.087496
4.160	-.075308
4.180	-.060831
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4.220	-.040007
4.240	-.036457
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4.320	-.050688
4.340	-.047340
4.360	-.035823
4.380	-.017657
4.400	.003452
4.420	.022560
4.440	.036851
4.460	.047284
4.480	.056103
4.500	.063752
4.520	.067831
4.540	.065412
4.560	.056986
4.580	.046430
4.600	.037466
4.620	.031171
4.640	.026645
4.660	.022221
4.680	.016280
4.700	.008681
4.720	.000629
4.740	-.007419
4.760	-.016245
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4.940	-.011628
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5.060	.011618
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5.100	.002754
5.120	.001034
5.140	.001307
5.160	.002192
5.180	.002581
5.200	.002671
5.220	.003303
5.240	.005328
5.260	.009646
5.280	.016740
5.300	.025898
5.320	.034543
5.340	.039209
5.360	.038329
5.380	.033191
5.400	.026244
5.420	.018856
5.440	.011090
5.460	.003248
5.480	-.003677
5.500	-.008709
5.520	-.011661
5.540	-.012940
5.560	-.013264
5.580	-.014286
5.600	-.018047
5.620	-.025012
5.640	-.033340
5.660	-.039507
5.680	-.040075
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5.740	-.012458
5.760	-.002658
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5.800	.006547
5.820	.008698
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5.940	.034424
5.960	.032211
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6.000	.026840
6.020	.025069
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6.060	.022436
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6.140	.014978
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6.760	.030592
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6.800	.040730
6.820	.039352
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6.920	.014375
6.940	.015477
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6.980	.018077
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9.120	.049738
9.140	.038102
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26.820	.000405
26.840	.000445
26.860	.000561
26.880	.000661
26.900	.000722
26.920	.000666
26.940	.000459
26.960	.000234
26.980	.000131
27.000	.000155
27.020	.000232
27.040	.000305
27.060	.000385
27.080	.000495
27.100	.000626
27.120	.000793
27.140	.001047
27.160	.001420
27.180	.001897
27.200	.002520
27.220	.003277
27.240	.004020
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27.280	.005271
27.300	.005831
27.320	.006392
27.340	.006980
27.360	.007577
27.380	.008090
27.400	.008384
27.420	.008435
27.440	.008355
27.460	.008273
27.480	.008235
27.500	.008211
27.520	.008141
27.540	.008005
27.560	.007814
27.580	.007599
27.600	.007408
27.620	.007254
27.640	.007161
27.660	.007074

27.680	.006872
27.700	.006597
27.720	.006329
27.740	.006060
27.760	.005759
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28.120	-.010273
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28.160	-.012370
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28.220	-.014008
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28.260	-.014281
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28.300	-.014427
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28.340	-.014490
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28.380	-.014512
28.400	-.014270
28.420	-.013767
28.440	-.013036
28.460	-.012088
28.480	-.010908
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28.520	-.007886
28.540	-.006181
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28.580	-.002757
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28.620	.000388
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28.700	.005690
28.720	.006379
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28.820	.008478
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28.920	.009415

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29.640	.003795
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29.680	.004605
29.700	.004732
29.720	.004899
29.740	.005146
29.760	.005394
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29.840	.005804
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29.920	.006634
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30.140	.004606
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30.380	-.004178
30.400	-.003983
30.420	-.003714
30.440	-.003404
30.460	-.003057
30.480	-.002661
30.500	-.002230
30.520	-.001813
30.540	-.001456
30.560	-.001217
30.580	-.001194
30.600	-.001375
30.620	-.001645
30.640	-.001892
30.660	-.002109
30.680	-.002372
30.700	-.002627
30.720	-.002756
30.740	-.002764
30.760	-.002729
30.780	-.002726
30.800	-.002852
30.820	-.003125
30.840	-.003448
30.860	-.003734
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32.360	.014211
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32.400	.015149
32.420	.015376
32.440	.015478
32.460	.015509
32.480	.015546
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32.540	.016037
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32.700	.011455

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33.860	.004847
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33.940	.007580
33.960	.007928

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34.080	.007393
34.100	.006929
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34.140	.005430
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35.120	.012214
35.140	.012979
35.160	.013574
35.180	.013934
35.200	.014141
35.220	.014251

35.240	.014196
35.260	.014002
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35.400	.009600
35.420	.009043
35.440	.008529
35.460	.007927
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35.520	.004345
35.540	.002743
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35.720	-.007997
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36.280	-.008692
36.300	-.008328
36.320	-.007889
36.340	-.007356
36.360	-.006657
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36.420	-.004184
36.440	-.003505
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36.700	.006239
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36.800	.009917
36.820	.010538
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36.880	.011651
36.900	.011844
36.920	.011943
36.940	.011896
36.960	.011697
36.980	.011406
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37.040	.010359
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37.080	.009213
37.100	.008504
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37.140	.007232
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37.220	.004900
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37.580	-.003880
37.600	-.003874
37.620	-.003805
37.640	-.003682
37.660	-.003531
37.680	-.003388
37.700	-.003239
37.720	-.003073
37.740	-.002913

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37.780	-.002489
37.800	-.002161
37.820	-.001775
37.840	-.001380
37.860	-.000991
37.880	-.000618
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37.940	.000594
37.960	.001029
37.980	.001442
38.000	.001809
38.020	.002114
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38.140	.002970
38.160	.003018
38.180	.002983
38.200	.002865
38.220	.002681
38.240	.002434
38.260	.002133
38.280	.001795
38.300	.001451
38.320	.001120
38.340	.000810
38.360	.000524
38.380	.000243
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38.420	-.000337
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38.540	-.002054
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38.580	-.002622
38.600	-.002921
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38.640	-.003503
38.660	-.003778
38.680	-.004029
38.700	-.004229
38.720	-.004357
38.740	-.004414
38.760	-.004414
38.780	-.004365
38.800	-.004280
38.820	-.004165
38.840	-.004023
38.860	-.003860
38.880	-.003678
38.900	-.003480
38.920	-.003269
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39.140	-.000683
39.160	-.000467
39.180	-.000256
39.200	-.000048
39.220	.000156
39.240	.000352
39.260	.000538
39.280	.000714
39.300	.000879
39.320	.001034
39.340	.001176
39.360	.001306
39.380	.001421
39.400	.001521
39.420	.001605
39.440	.001673
39.460	.001726
39.480	.001764
39.500	.001787
39.520	.001797
39.540	.001793
39.560	.001777
39.580	.001749
39.600	.001710
39.620	.001662
39.640	.001604
39.660	.001539
39.680	.001467
39.700	.001391
39.720	.001311
39.740	.001229
39.760	.001145
39.780	.001062
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39.840	.000813
39.860	.000732
39.880	.000652
39.900	.000573
39.920	.000495
39.940	.000419
39.960	.000345
39.980	.000274
40.000	.000204

APPENDIX C

Subject: Cover Slope Stability **Project Name:** Kettleman B-18
By: N.M. **Date:** 7/21/08 **Project No:** 08-0228
Checked By: B.H. **Date:** 7/21/08 **Sheet:** 1 **of** 8

CLASS I WASTE FINAL COVER STABILITY

Objective:
Evaluate static and seismic stability (long term condition) and temporary stability during construction of the final landfill cover for Class I waste area at Kettleman Hills Facility (KHF) Landfill Unit B-18.

Performance Criteria:

- Static Loading: Minimum Factor of Safety of 1.5.
- Dynamic Loading: Allowable seismic displacements up to 12 inches.
- Temporary Loading Case during Construction: Minimum Factor of Safety 1.25.

Geometry:
The typical cover system for Class I waste is shown in Figure 1.

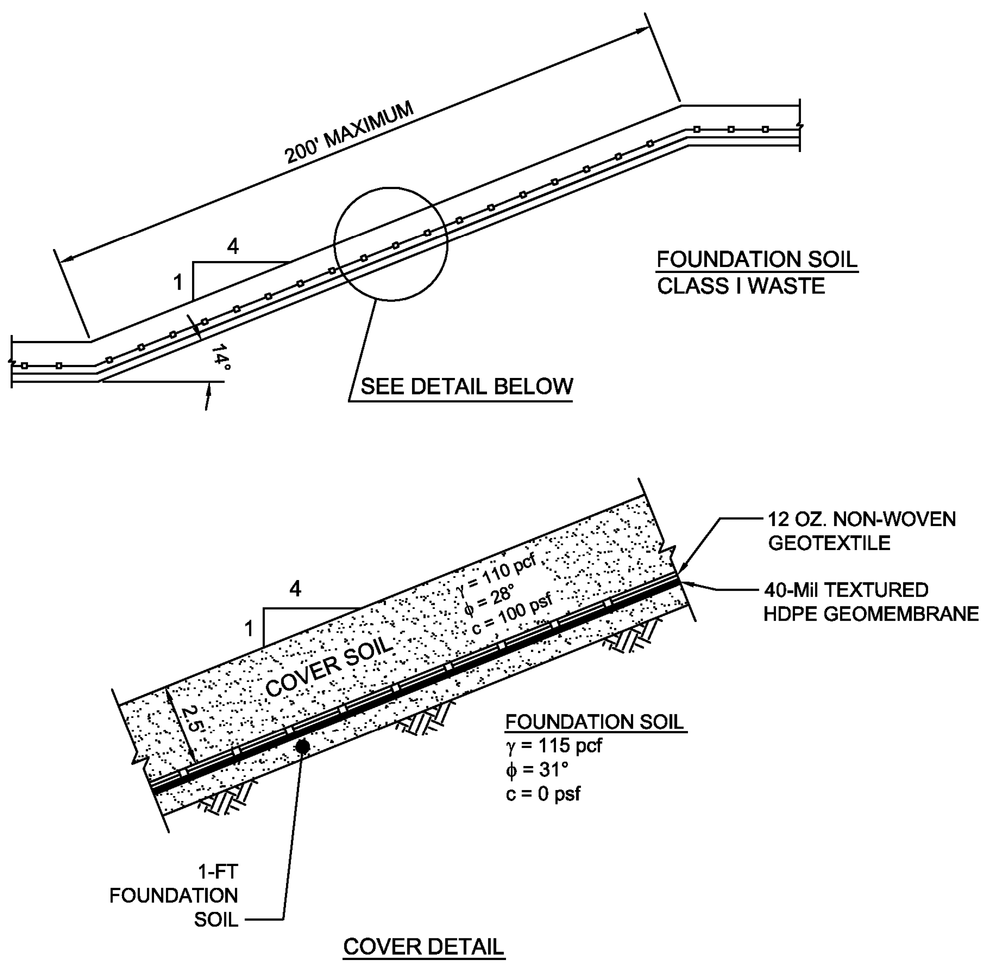

Figure 1. Typical Cover System for Class I Waste

The shear strength parameters of the cover interfaces are shown in Table 1. The site-specific values of these parameters should be verified prior to the construction of the cover.

Table 1. Shear Strength Properties for Interfaces in Figure 1

INTERFACE	STRENGTH PARAMETERS γ (pcf)	c (psf)	ϕ (degrees)
Cover Soil / Geotextile	110	100	21
Geotextile / 40-Mil HDPE	110	0	25*
40-Mil HDPE / Intermediate Soil	110	0	28
Foundation Soil / Class I Waste	110	0	31

* Results of site-specific laboratory interface direct shear tests performed on textured geomembrane and geotextile materials to be used for Class I waste cover construction under low confining pressures (pressure due to the weight of cover soil) indicate a residual friction angle of approximately 28 degrees for this interface (see attached). A conservative value of 25 degrees, however, was used in our analyses.

Design Theory:
The long-term stability of the cover (stability analysis for static case) is based on the infinite slope model shown in Figure 2.

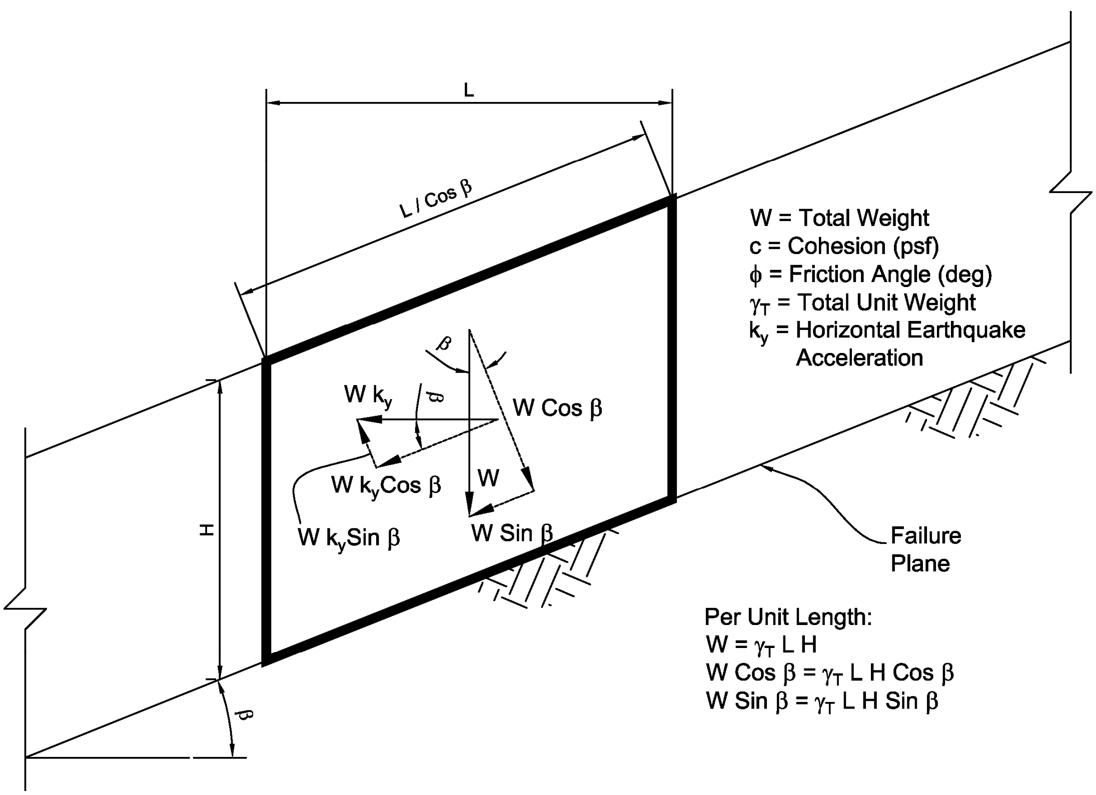

Figure 2. Equilibrium of Loads for a Unit Length of Cover

The safety factor against sliding can be evaluated using the following equation (Huang, 1983):

$$F.S. = \frac{c}{\gamma_T H \cos^2\beta \tan\beta} + \frac{\tan\phi}{\tan\beta}$$

If $c = 0$, then: $F.S. = \frac{\tan\phi}{\tan\beta}$

For seismic case ($k_y > 0$):

$$F.S. = \frac{c(L/\cos\beta) + \gamma_T LH\cos\beta\tan\phi - k_y\gamma_T LH\sin\beta\tan\phi}{\gamma_T LH\sin\beta + k_y\gamma_T LH\cos\beta}$$

Note: This analysis is conservative since the effect of finite slope length and passive resistance wedge at the toe of the slope is not included.

Long-Term Static Stability:
Based on the interface and material properties shown in Table 1, for Class I waste cover the weakest interface of the cover is the Geotextile / HDPE geomembrane interface. The following presents the infinite slope stability analysis performed for the Class I waste cover.

Static Stability for Geotextile / HDPE geomembrane interface:

c = 0 psf, ϕ = 25º, β = 16º, H = 2.5 / (cos 16) = 2.60 ft, γ = 110 pcf

$$F.S. = \frac{0}{110 \cdot 2.60 \cdot \cos^2 16 \cdot \tan 16} + \frac{\tan 25}{\tan 16} = 1.63 > 1.5 \text{ o.k.}$$

Construction Stage/Temporary Loading (Short-Term) Static Stability:
The stability of cover needs to be evaluated for the temporary condition during cover placement. It is assumed that the cover is placed from bottom to top (backfilling up slope). When the equipment weight is considered, the stability is evaluated for a finite length of the slope, usually the distance between two benches. The equilibrium of forces for a finite length of the slope is shown on Figure 3 (Qian, Koerner, Gray, 2002). Figure 3 illustrates the forces applied on the cover for this case. The following symbols are used in this figure:

W_A = total weight of the active wedge including additional weight of soil wedge from the upper bench (W_{A1} and W_{A2}) plus equipment weights on the slope and upper bench (W_{e1} and W_{e2});
W_{A1} = weight of soil cover on the slope (included in W_A);
W_{A2} = weight of soil wedge from the upper bench (included in W_A);
W_{e1} = weight of equipment on slope (included in W_A);

W_{e2} = weight of equipment on upper bench (included in W_A);
W_P = total weight of the passive wedge;
N_A = effective force normal to the failure plane of the active wedge;
N_P = effective force normal to the failure plane of the passive wedge;
γ = unit weight of the cover soil;

h = thickness of the cover;
L = length of the slope measured along the slip plane;
β = soil slope angle;
ϕ = friction angle of cover soil;
δ = interface friction angle;
C_a = adhesion force between cover soil of the active wedge and geo-membrane or foundation;
c_a = adhesion between cover soil of the active wedge and geo-membrane or foundation;
C = cohesion force along the failure plane of the passive wedge;
c = cohesion of the cover soil;
E_A = inter-wedge force acting on the active wedge from the passive wedge;
E_P = inter-wedge force acting on the passive wedge from the active wedge;
FS = factor of safety against cover soil sliding.

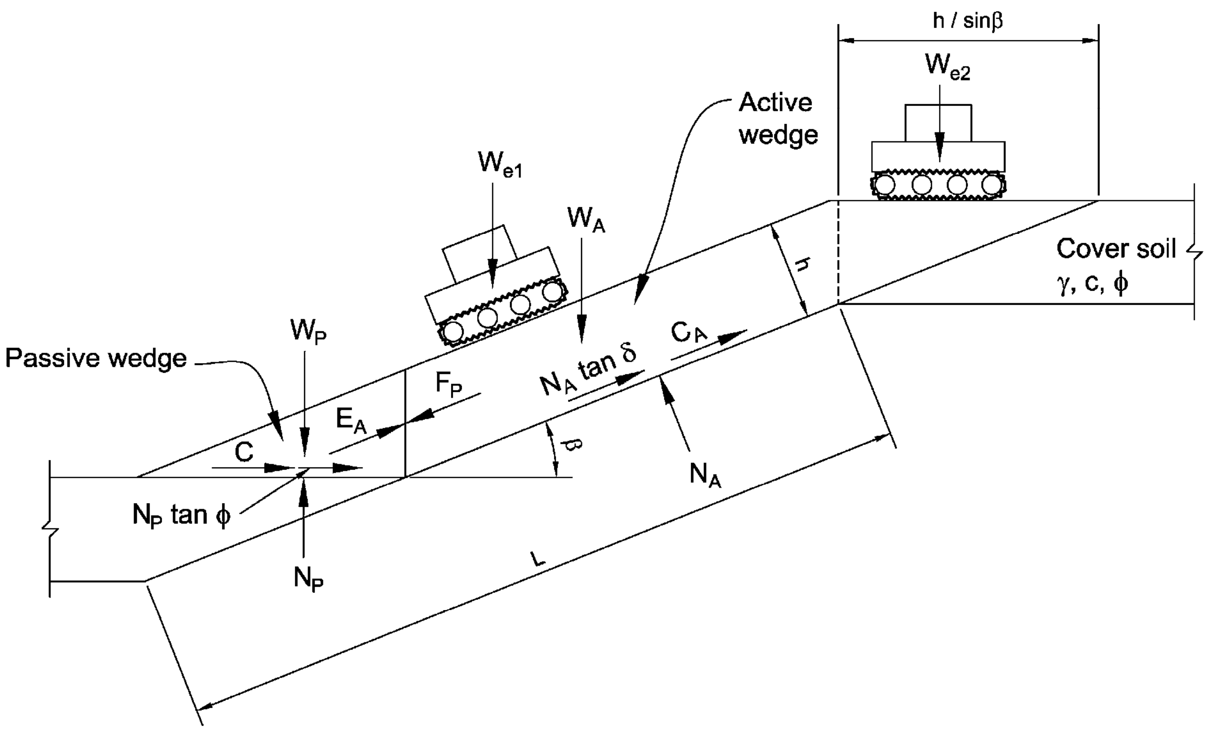

Figure 3. Equilibrium of Forces for a Finite Length Slope of a Uniformly Thick Cover Soil

For this condition the stability of the cover can be evaluated using the following equation:

$$FS = \frac{-b \pm \sqrt{b^2 - 4 \times a \times cc}}{2 \times a}$$

Where:

$a = (W_A - N_A \times \cos\beta) \times \cos\beta$

$b = -[(W_A - N_A \times \cos\beta) \times \sin\beta \times \tan\phi + (N_A \times \tan\delta + C_a) \times \sin\beta \times \cos\beta$
$+ (C + W_P \times \tan\phi) \times \sin\beta]$

$cc = (N_A \times \tan\delta + C_a) \times \sin^2\beta \times \tan\phi$

$W_A = W_{A1} + W_{A2} + W_{e1} + W_{e2}$

$W_{A1} = (\gamma \times h^2) \times [L/h - 1/\sin\beta - \tan(\beta/2)]$

$W_{A2} = (\gamma \times h^2) / (\sin 2\beta)$

$W_P = (\gamma \times h^2) / (\sin 2\beta)$

$N_A = W_A \times \cos\beta$

$C_a = c_a \times (L - h/\sin\beta)$

$C = (c \times h) / (\sin\beta)$

For the up slope backfilling, the dynamic force resulting from acceleration and braking of the construction equipment is not considered. The weight of the equipment is added to the weight of the cover soil.

The pressure at the potential slip interface can be calculated from the following equation:

Equivalent equipment force per unit width at slip plane interface: $W_e = q \times w \times I$

Where:

$q = W_b / (2 \times w \times b)$;
W_b = operating weight of equipment;
w = length of equipment track;
b = width of equipment track;
I = influence factor at slip plane interface.

The contact pressure for a CAT D6N LGP tractor is 4.8 psi, with an operating weight of 40,000 lbs. The track dimensions are length (w) = 122 in and width (b) = 34 in. The track gauge (distance between centers of tracks) is 85 inches.

The influence factor for cover thickness (h) of 2.5 ft can be calculated as:

$b / h = 34 / (2.5 \times 12) = 1.13$ ➔ I = 0.92

Using this influence factor, the equivalent pressure is evaluated below:

$q = 40{,}000 / (2\times122\times34) = 4.8$ psi = 695 psf

$h = 2.5$ ft ➔ $W_{e1} = 695 \times (122/12) \times 0.92 = 6{,}500$ lbs

We have also included additional surcharge of the construction equipment on the upper bench of the cover veneer. This load is estimated as a 500 psf uniform pressure acting on a length equal to h/sin β.

$\beta = 16°$ ➔ $W_{e2} = 500\times2.5/\sin(16°) = 4{,}550$ lbs

Using these equipment weights, the safety factor for temporary stability of geotextile / HDPE interface is calculated below:

$\gamma = 110$ pcf;
$h = 2.5$ ft;
$L = 182$ ft (Section D-D');
$\beta = 16°$;
$\phi = 28°$;
$\delta = 25°$;
$c_a = 0$ psf;
$c = 100$ psf;
$W_e = 6{,}500 + 4{,}550 = 11{,}050$ lbs.

The following values are calculated using above parameters:

$W_A = 59{,}801$ lbs
$W_P = 1{,}301$ lbs
$N_A = 57{,}500$ lbs
$C_a = 0$ lbs
$C = 910.0$ lbs

$a = 4339.4$ lb/ft
$b = -8181.7$ lb/ft
$cc = 1075.9$ lb/ft

These values result in a factor of safety of 1.74 for finite length cover slope. This value is higher than the factor of safety of 1.63 for infinite slope analysis without the construction equipment weight.

Seismic Stability:
Seismic stability is evaluated for a finite length of the slope, usually the distance between two benches. This provides a more realistic analytical model of the cover stability since it includes the effect of passive

resistance wedge at the toe of the slope. For this case equipment forces shown in Figure 3 will be set equal to zero and seismic acceleration will be applied on the cover mass. For this condition the stability of the cover can be evaluated using the following equation:

$$FS = \frac{-b \pm \sqrt{b^2 - 4 \times a \times cc}}{2 \times a}$$

Where:

$a = (C_S \times W_A + N_A \times \sin\beta) \times \cos\beta + C_S \times W_P \times \cos\beta$

$b = -[(C_S \times W_A + N_A \times \sin\beta) \times \sin\beta \times \tan\phi + (N_A \times \tan\delta + C_a) \times \cos^2\beta$
$+ (C + W_P \times \tan\phi) \times \cos\beta]$

$cc = (N_A \times \tan\delta + C_a) \times \sin\beta \times \cos\beta \times \tan\phi$

C_S = Seismic Coefficient

W_A = total weight of the active wedge = $\gamma \times h^2 \times [L/h - 1/\sin\beta - \tan(\beta/2)] + (\gamma \times h^2) / (\sin 2\beta)$

$W_P = (\gamma \times h^2) / (\sin 2\beta)$

$N_A = W_A \times \cos\beta$

$C_a = c_a \times (L - h/\sin\beta)$

$C = (c \times h) / (\sin\beta)$

Using the above equations, the Yield Acceleration (k_y), corresponding to factor of safety of 1.0 was calculated for Geotextile / HDPE geomembrane interface (weakest interface in Class I waste cover):

L = 182 ft, h = 2.5 ft, γ = 110 pcf, c_a = 0 psf, c = 100 psf, $\beta = 16^o$, $\phi = 28^o$, $\delta = 25^o$,
H = 2.5 / (cos 16) = 2.60 ft, $F.S.$ = 1.0 ==> $k_y = 0.20$

The Newmark Displacement Correlations developed by Franklin and Chang (1977) were used to estimate the permanent seismic deformation of the cover system.

$$U_m = U_S \times \frac{V^2}{1800A}$$

Where:
- U_m = Unscaled Permanent Displacement (in.)
- U_s = Standardized Maximum Displacement (in.)
- A = Maximum Ground Acceleration (as fraction of g)
- V = Maximum Ground Velocity (in/s)

A conservative V/A ratio of 60 was used in the analyses, resulting in a maximum ground velocity of 34.8 in/s. U_s was obtained from standard displacement chart based on k_y/A ratio.

Based on these assumptions, the seismic displacement value in Table 2 was obtained for Class I waste landfill cover system. Based on our calculation it appears that the permanent seismic displacement is in the allowable range for the weakest interface of the cover, therefore the cover system meets the static and seismic stability criteria.

Table 2. Permanent Seismic Displacement Evaluation for Class I Waste Cover

Interface	k_y* (g)	A (g)	V (in/s)	k_y/A	U_s (in)	U_m (in)
Geotextile / HDPE*	0.20	0.58	34.8	0.35	~10.5	~12

References:

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December 15, 2009

Golder Associates Inc.
230 Commerce, Suite 200
Irvine, California, USA 92602

Mr. Scott Sumner, P.E., Principal

SUBJECT: ADDENDUM REPORT – PHASE III SLOPE STABILITY ANALYSIS KETTLEMAN HILLS FACILITY, HAZARDOUS WASTE LANDFILL UNIT B-18 EXPANSION, KETTLEMAN CITY, KINGS COUNTY, CALIFORNIA - HAI PROJECT No. 08-0228

Dear Mr. Sumner:

Hushmand Associates, Inc. (HAI) is pleased to submit to Golder Associates, Inc. (Golder) this addendum letter report of the slope stability evaluations for the Class I/II hazardous waste landfill unit B-18 (Landfill B-18) expansion at Waste Management, Inc. (WMI) Kettleman Hills Facility.

This addendum updates portions of the HAI "Slope Stability Analysis Report, Kettleman Hills Facility, Hazardous Waste Landfill Unit B-18 Expansion, Kettleman City, Kings County, California," Report to Kettleman Hills Facility, September 2008. The addendum report has been prepared to incorporate revised interface shear strength testing results for the proposed liner system. The addendum report updates only those portions of the original report that are effected by the change in interface shear strength, references are included to sections of the original report as appropriate. This report should therefore be used in conjunction with the original HAI (2008) report.

Introduction

The existing Class I/II (hazardous and designated wastes) Landfill Unit B-18 at Chemical Waste Management (CWM) Kettleman Hills Facility (KHF) in Kettleman City, Kings County, California is proposed to be expanded. The existing landfill was constructed in phases (Phase I and II) in 1990's. For the proposed expansion (Phase III), URS Corporation and Hushmand Associates, Inc. performed slope stability and seismic deformation analyses in support of the EIR preparation and design of the landfill expansion, respectively (URS, 2005; HAI, 2008). The results of these analyses were provided in a comprehensive design report by Golder Associates (Golder, 2008).

A number of investigations including site-specific testing on the landfill material properties were performed for design and construction of the earlier phases of the landfill (Golder, 1990, 1991; ESI, 1990, 1992, 1993). In 2003, URS obtained samples of the landfill Phase II liner system that were archived at the KHF site. Interface shear strength testing was performed on the sandwich-like multilayer structure of the liner system and the results (friction angle, ϕ =19° and cohesion/adhesion, C = 0) were used to refine the interface properties reported in the previous investigations (URS, 2005).

Landfill Geometry and Analysis Sections

HAI (2008) developed six cross sections for the proposed landfill expansion (see Figures 1 and 2 of the HAI 2008 Report). These same six cross sections are evaluated in the addendum report using the updated interface shear strength properties.

This addendum report summarizes the results of the slope stability and seismic deformation analyses for the proposed landfill expansion area, extending from the landfill's southeast corner to northwest corner, along its southern and western boundaries.

The expansion area is located on the western and southern sides of cross sections A-A' through F-F' that were used in the previous stability analyses (HAI, 2008). Additionally, east side of Cross Section B-B' also passes through the expansion area and was also analyzed in the addendum. The interface shear strength of Phase I was not modified and therefore analysis of the northern and eastern boundaries for all cross sections except B-B' remains valid.

Liner Interface Shear Strength Properties

HAI (2008), Section 3.4, used the material properties from the previous investigations for Phase I liner system and the URS (2005) report for Phase II liner system for static and seismic slope stability and deformation analyses. For the proposed expansion area liner system, the same interface properties (ϕ =19°, C = 0) measured for the Phase II liner system were used (URS, 2005).

HAI (2008) recommended that assumed properties used for design be further verified by performing site-specific tests on the actual materials that would be used during construction. Golder recently performed site-specific laboratory testing on the proposed standard liner system materials for the landfill expansion area to determine the interface properties for the expansion liner system design.

Interface shear strength testing was performed by Precision Geosynthetic Laboratories of Anaheim, California on the sandwich-like multilayer structure of the liner system. The test results indicated that the weakest interface was the double sided (DS) geocomposite and 60-mil

HDPE for all applied normal loads. The ultimate interface shear strength properties at 3 inch displacement were measured as approximately ϕ = 12° and C = 0. Attachment A provides results of the interface shear tests performed on the Phase III proposed liner system materials. The results were used to refine the slope stability and seismic deformation analyses performed previously (HAI, 2008) for the landfill expansion design.

In the revised slope stability analyses presented here, residual interface shear strength properties measured by URS (2005) and Golder (2009) were used for the Phase II and Phase III slopes, respectively. The Phase I slopes have a slightly different liner system and a residual interface friction angle of 9 degrees was used for the analysis. The material properties for static and seismic stability analyses are summarized in Table 1 (updated version of HAI 2008 Table 1).

Table 1. Selected Material Properties for Static and Seismic Stability Analysis
(Replaces Table 1 of HAI 2008)

Material/Interface	Unit Weight	Shear Strength Properties		Shear Wave Velocity (V_s - ft/sec) or Shear Modulus (G, psf) Relation	Modulus Reduction & Damping Curves
		ϕ (degree)	C (psf)		
HW [1]	115 pcf	31	0	$G = 1000\,K_2\,(\sigma'_m)^{1/2}$ K_2 = 60 for relatively dense sands (Seed and Idriss, 1970)	See Figure 19 Relatively dense sand (Seed et al., 1984)
Clay Liner [1, 2]	115 pcf	20	1,150	$G = \frac{14{,}760(2.97-e)^2}{1+e}(OCR)^K \sigma_m^{0.5}$ (Hardin and Drenvich, 1972)	See Figure 19 (Seed and Idriss, 1970)
Bedrock [1]	150 pcf	40	800	V_s = 2500 fps	See Figure 19 (Schnabel et al. 1972)
Phase I Bottom Liner Interface [1]	----	17	0	----	----
Phase I Side Slope Liner Interface [1]	----	9	800	----	----
Phase II Bottom Liner Interface [1]	----	19	0	----	----
Phase II Side Slope Liner Interface [3]	----	19	0	----	----
Revised Expansion Area Liner Interface [4]	----	12	0	----	----

(1) Environmental Solutions, Inc. (1990, 1992, 1993); Rust Environment & Infrastructure, Inc. (1998); URS (2005).
(2) Modeled as a layer in site dynamic response analysis to include effects of softer clay layer on ground motion.
(3) The residual interface shear strength properties measured by URS (2005) were used for the Phase II slopes.
(4) Golder Associates, Inc. (2009).

Static and Pseudo-Static Slope Stability Analyses

The analysis approach discussed in Section 3.5 of the original stability report (HAI 2008) remains unchanged in the addendum report.

As discussed in Section 3.6 of the HAI 2008 report, slope stability analyses were performed for the six cross sections analyzed in the 2008 report. Since the landfill is planned to be expanded mainly along its western and southern boundaries, and the new liner system properties only apply to these areas, potential failure planes on the west and south sides of Cross Sections A-A', B-B', C-C', D-D', E-E', and F-F' were analyzed. Additionally potential failure planes on the east side of Cross Section B-B' were analyzed. The most important potential failure mechanism considered was for a wedge (block failure) sliding through the waste mass and along the existing and expanded landfill base liner system. Potential failure surfaces were assumed to pass along the weakest interface in the lining system and then through the landfill mass to the surface.

Pseudo-static analyses, necessary to compute yield acceleration coefficient (K_y), were also performed for the critical potential failure surfaces through waste and base liner system, identified from results of the static slope stability analyses for the selected cross sections. The yield acceleration is defined as the acceleration which results in a pseudo-static factor of safety of 1.0. The computed yield acceleration, K_y, represents limiting value of the horizontal seismic coefficient beyond which movement of a potential slide mass will occur.

For each cross section, pseudo-static analysis using the Spencer or Janbu Method was performed to compute an estimate of yield acceleration coefficient (K_y) for the most critical potential failure plane identified from the static slope stability analysis for that section. The GSTABL7 output plots are presented in Attachment B for the various potential failure surface conditions considered, and the most critical failure surfaces analyzed in the stability analysis of the final fill slopes of the proposed landfill expansion.

Table 2b (replaces Table 2b of HAI 2008) below presents the results of the updated slope stability analyses (computed static factors of safety and yield acceleration coefficients) for the most critical potential failure surfaces using the new interface properties of $\phi = 12°$ and $C = 0$.

Table 2b. Summary of Slope Stability Analysis Results (Landfill West and South Sides)
(Replaces Table 2b of HAI 2008)

Cross Section	Failure Plane Number	Description	Static Factor of Safety	Yield Acceleration, K_y (g)
A-A' (west)	I	Deep Block Failure through Bottom Liner	2.55*	0.27*
	II	Deep Block Failure through Bottom Liner	5.41*	0.30*
B-B' (west)	I	Deep Block Failure through Bottom Liner	2.41	0.20
	II	Deep Block Failure through Bottom Liner	6.44	0.31
C-C' (south)	I	Deep Block Failure through Bottom Liner	3.74	0.23
	II	Deep Block Failure through Bottom Liner	3.62*	0.23*
D-D' (west)	I	Deep Block Failure through Bottom Liner	3.73	0.27
	II**	Circular Failure	2.50	0.32
	III**	Circular Failure	2.18	0.26
E-E' (west)	I	Deep Block Failure through Bottom Liner	3.42*	0.28*
	II	Deep Block Failure through Bottom Liner	3.90*	0.32*
F-F' (west)	I**	Circular Failure	2.58	0.33
	II	Deep Block Failure through Bottom Liner	4.40	0.29
	III	Deep Block Failure through Bottom Liner	3.31*	0.28*

Notes: * Static Factor of Safety and K_y computed using Janbu's method.
** Circular failure analysis from HAI 2008 included for completeness.
Static factor of safety and K_y for section B-B' (east) changed only slightly and thus are not reported. Static factors of safety and K_y values for Section B-B' are larger than 3.0 and 0.3, respectively.

For all final (long-term) static conditions, the minimum acceptable factor of safety is 1.5. This criterion was satisfied by the potential failure surfaces analyzed for the proposed fill plan, base liner designs, and the site-specific and estimated landfill material properties.

The results of the pseudo-static stability analyses show that the lowest yield acceleration coefficient was approximately equal to 0.20 for failure along the liner and waste mass in cross sections B-B' (west).

The combination of yield acceleration coefficient and slide mass geometry that could potentially result in the largest estimates of the seismically-induced displacements were used in the site response and Newmark displacement analyses as described in detail in the 2008 report (Golder, 2008). Based on the computed yield accelerations presented in Table 2b and landfill cross sections geometry, the potential failure plane #I for cross section B-B' and failure plane #I associated with cross section D-D' were judged to produce the largest seismic displacements and thus, were selected for dynamic site response and seismic deformation analyses. The estimated displacements were calculated based on updated 2008 site specific ground motions for the Kettleman Hills Landfill (HAI 2008).

Seismically-Induced Permanent Displacements

A detailed evaluation of the seismic deformations using two-dimensional finite element site response analyses and Newmark (1965) slope displacement calculation method was performed for this study. The analyses were performed for the most critical combinations of K_y values and failure plane geometries (Sections B-B', Failure Plane I, West and Section D-D', Failure Plane I, West) and the two sets of design earthquake motions used in the 2008 analyses (1994 Northridge Earthquake and 1979 Loma Prieta Earthquake records).

The average acceleration time histories computed in the QUAD4M response analyses for the most critical potential failure mass identified in the pseudo-static analyses were used as input for Newmark deformation analyses to evaluate the permanent seismically-induced displacements along the liner system. The displacement calculated by this method is a function of the yield accelerations which were computed in the pseudo-static stability analyses. Figures 1 through 4 (replace Figures 21 to 24 in HAI 2008) illustrate variation of potential slide mass displacement (δ) versus the yield acceleration K_y for cross sections B-B' and D-D' and for the two sets of design ground motions used in the analyses (Golder, 2008). Based on the K_y values in Table 2b and Figures 1 through 4, for the potential failure plane # I, located in the northwestern part of cross section B-B' the largest permanent displacement (~ 1.5 inch) is induced for the 1994 Northridge earthquake Castaic Old Ridge Route accelerograms scaled to a PHGA of 0.57g. For all other sections and potential failure planes for K_y values larger than 0.2 seismic induced liner displacements are less than 1 inch. These estimated values of the seismic displacements are considerably smaller than the maximum allowable displacement of 6 inches commonly used in the industry (Seed and Bonaparte, 1992). Therefore, the landfill will be stable both statically and seismically for the updated site-specific liner interface properties.

Conclusion

This addendum report summarizes the site specific liner interface shear strength testing performed by Golder and the updated slope stability and seismic deformation analyses for the proposed landfill expansion area slopes using the new strength properties. The site specific testing was performed to verify the strength properties originally used in the landfill expansion design in the HAI 2008 report. The measured liner interface friction angle ($\phi = 12°$) was found to be lower than the original value used in the design ($\phi = 19°$). Using this new interface friction angle, static and dynamic stability analyses were conducted for various cross sections of the proposed landfill expansion area.

The analyses indicated that the proposed new landfill expansion design (Golder, 2008) would result in a stable configuration under both static and seismic loading conditions in compliance with applicable regulations. The acceptability of the landfill slopes for earthquake loading conditions was determined by the relatively small magnitude of the seismically-induced permanent displacements resulting from the local and distant design earthquake events. The results of the analysis show that the computed static factors of safety are greater than 1.5 for all analyzed sections. The results of the conservative Newmark-type permanent displacement analyses presented in this study indicated that computed maximum displacements along the liner system during the design earthquake events are less than 1.5 inches.

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URS (2005) "Preliminary Stability Analyses, Kettleman Hills Facility Expansion, Kettleman City, California," prepared for Chemical West Management, Inc.

Closure

We trust this addendum report meets your present requirements. If you have any questions regarding this report, please contact this office at your convenience. We appreciate this opportunity to provide our professional services to Golder.

Sincerely yours,

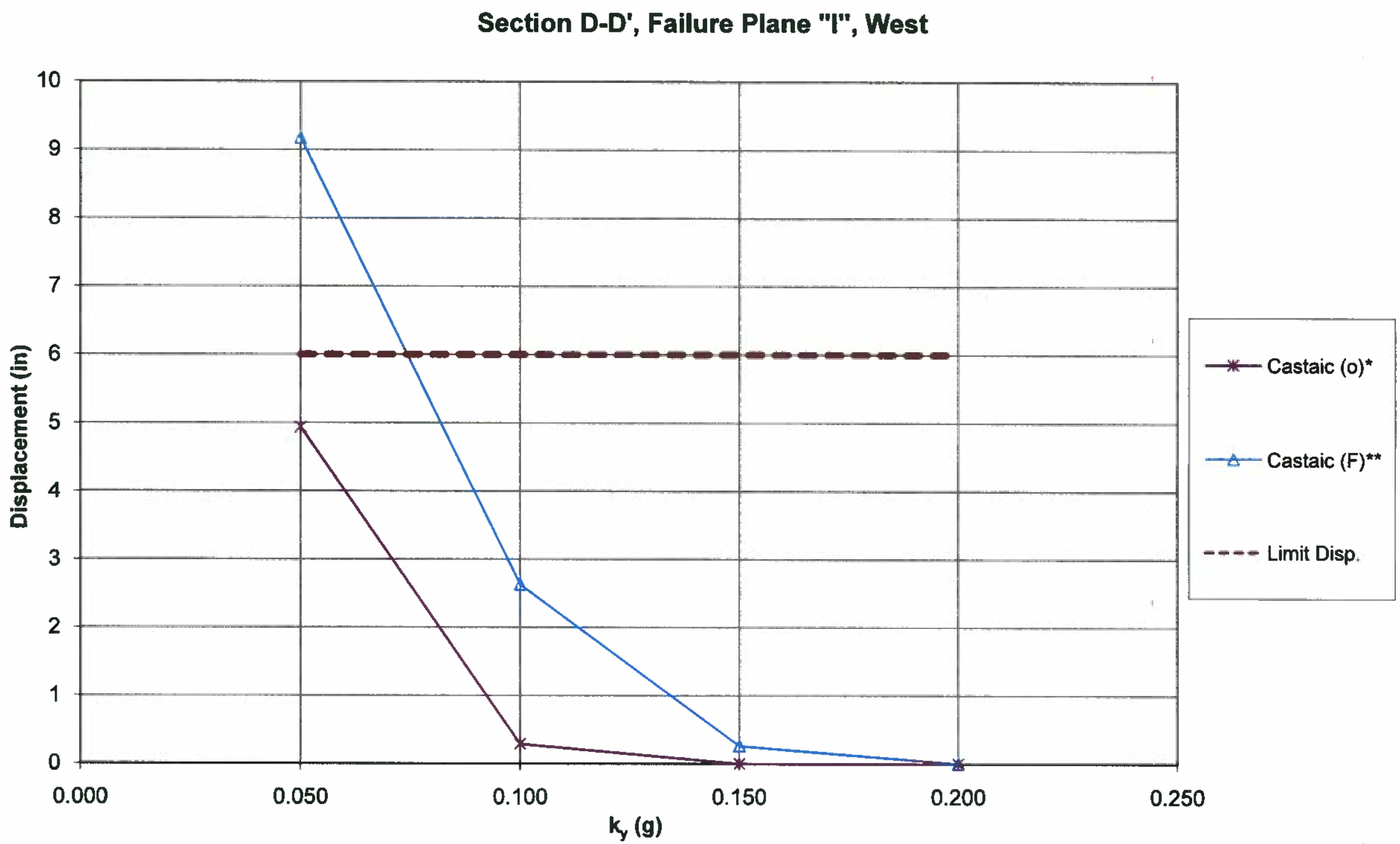
Very truly yours,

HUSHMAND ASSOCIATES, INC.

REGISTERED PROFESSIONAL ENGINEER
BEHNAM HUSHMAND
No. C 044777
Exp. 03-31-10
CIVIL
STATE OF CALIFORNIA

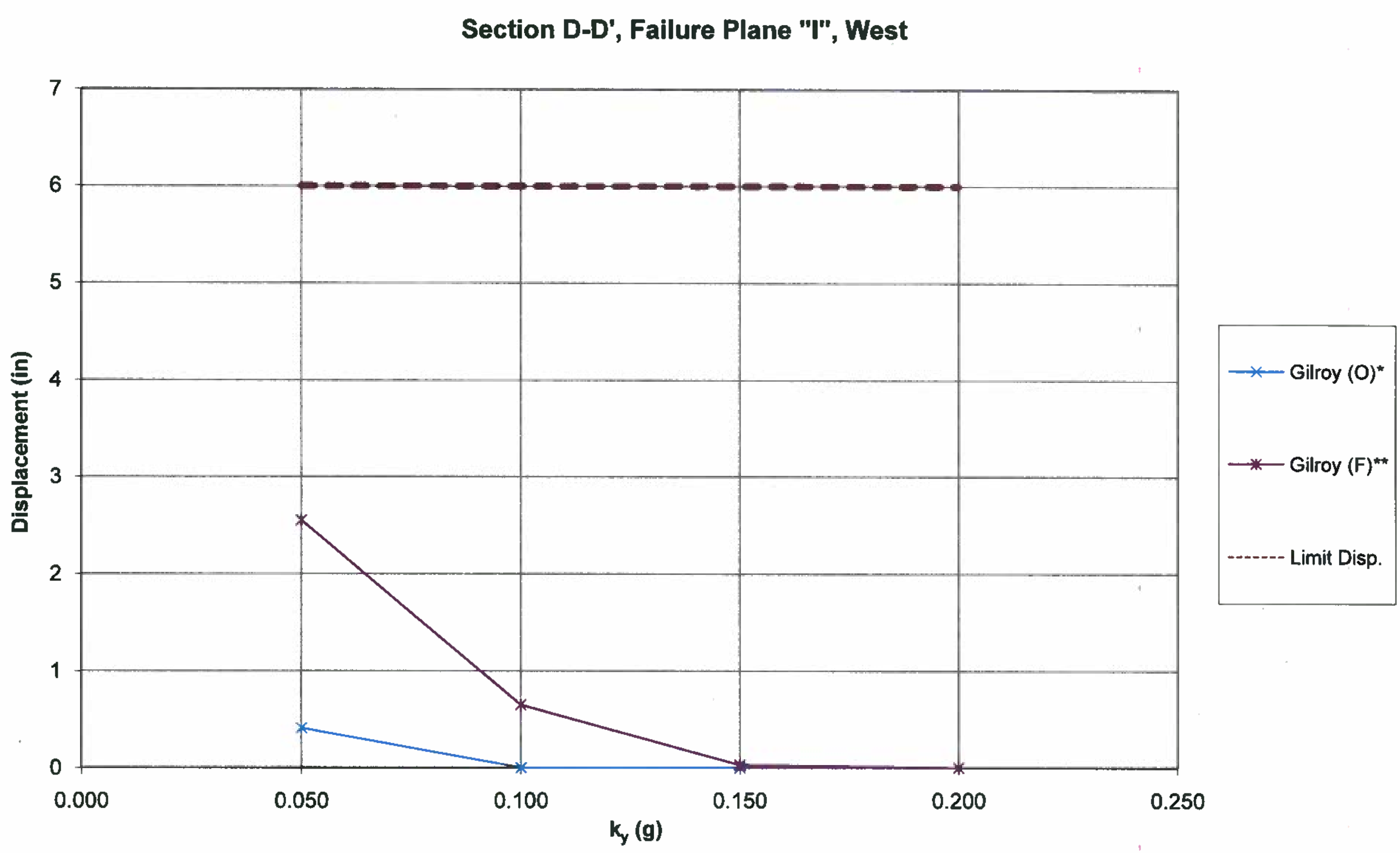
Ben Hushmand, Ph.D., P.E. 44777
President, Principal Engineer

FIGURES



Legend
*(O) Original record
**(F) Flipped record (multiplied by -1)

Project No. 08-0228	Landfill B-18 Expansion Project Kettleman City, Kings County, California	EARTHQUAKE INDUCED DISPLACEMENTS SECTION D-D' – FAILURE PLANE I 2-D QUAD4M DYNAMIC RESPONSE ANALYSIS (PREVIOUS GROUND MOTIONS)	Figure 1
HAI HUSHMAND ASSOCIATES INC. Geotechnical and Earthquake Engineers			



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*(O) Original record
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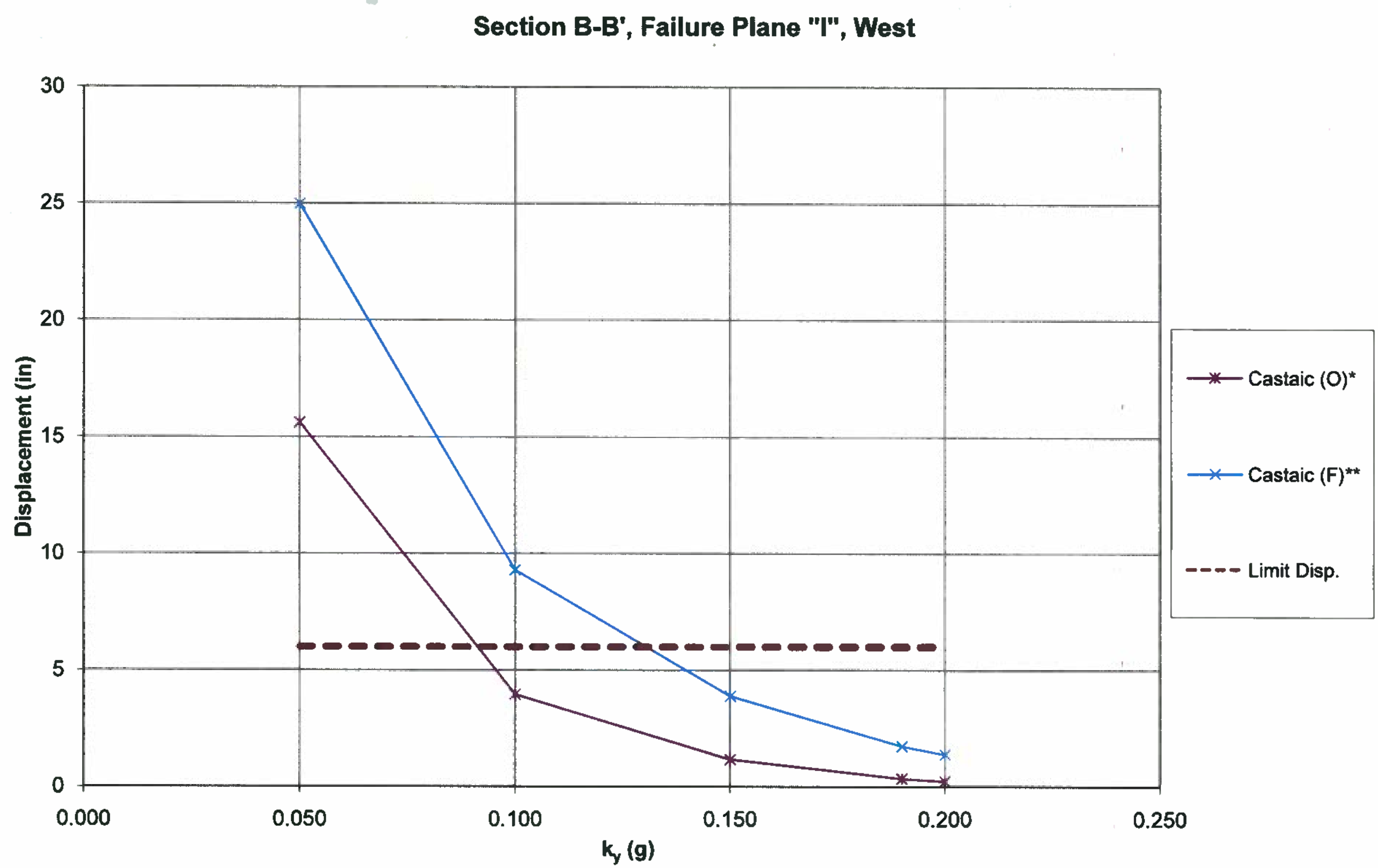
Project No. 08-0228	Landfill B-18 Expansion Project Kettleman City, Kings County, California	EARTHQUAKE INDUCED DISPLACEMENTS SECTION D-D' – FAILURE PLANE I 2-D QUAD4M DYNAMIC RESPONSE ANALYSIS (PREVIOUS GROUND MOTIONS)	Figure 2
HAI	HUSHMAND ASSOCIATES INC. Geotechnical and Earthquake Engineers		



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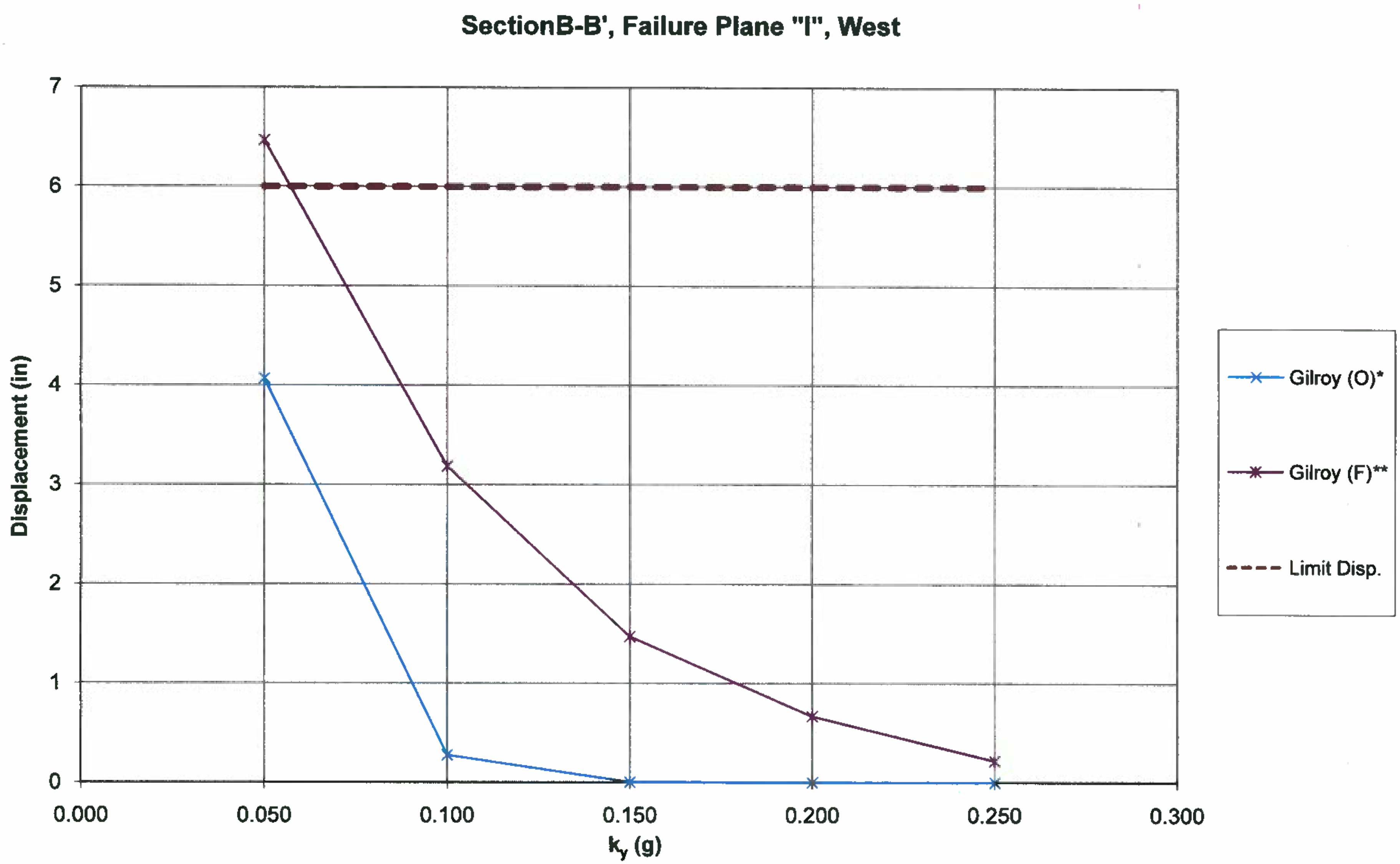
*(O) Original record
**(F) Flipped record (multiplied by -1)

Project No. 08-0228	Landfill B-18 Expansion Project Kettleman City, Kings County, California	EARTHQUAKE INDUCED DISPLACEMENTS SECTION B-B' – FAILURE PLANE I 2-D QUAD4M DYNAMIC RESPONSE ANALYSIS (PREVIOUS GROUND MOTIONS)	Figure 3
HAI	HUSHMAND ASSOCIATES INC. Geotechnical and Earthquake Engineers		



Legend
*(O) Original record
**(F) Flipped record (multiplied by -1)

Project No. 08-0228	Landfill B-18 Expansion Project Kettleman City, Kings County, California	EARTHQUAKE INDUCED DISPLACEMENTS SECTION B-B'– FAILURE PLANE I 2-D QUAD4M DYNAMIC RESPONSE ANALYSIS (UPDATED GROUND MOTIONS)	Figure 4
HAI	HUSHMAND ASSOCIATES INC. Geotechnical and Earthquake Engineers		

APPENDIX A

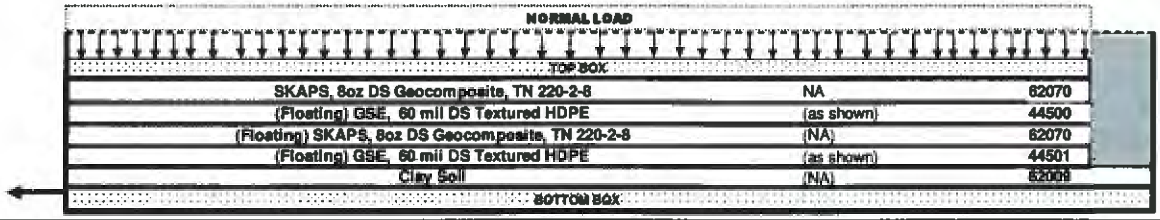
INTERFACE SHEAR TEST RESULTS

TABLE 1
CLIENT: GOLDER & ASSOCIATES
PROJECT: KETTLEMAN HILLS

INTERFACE SHEAR TEST RESULT (ASTM D5321/6243)
PGL Job No. G090907

Reviewed By [signature]
Date: 2-Oct-09

TEST CONFIGURATION 1



TEST CONDITIONS:

SAMPLE PREPARATION:

1. Specimens were cut along machine direction to 14" x 17" for the upper box, and 14" x 19" for the lower box, with an effective test area of 12" x 12".
2. The Maximum Dry Density (MDD) of the soil is 111.8 pcf at 16.4% Optimum Moisture Content (OMC).
3. Soil specimen was remolded to 102.86 pcf ; i.e.. 92.0% of MDD at 20.5% moisture content. (forming 2 inch layer in the TOP and BOTTOM boxes).
4. The three intermediate geosynthetic specimens were floating during shear run.

CONSOLIDATION:

1. Each set of specimen was consolidated under Dry condition for 24 hrs @ normal load before shearing.
2. Normal loads were applied using Hydraulics for the highest load, Bladder for the intermediate and lowest loads.

SHEAR TEST:

1. Shear test was conducted @ 0.040 in/ min
2. Sheared @ minimi 3.0 inch horizontal displacement.
3. Test specimens were sheared i Dry condition.
4. Test were performed in general accordance with ASTM D6243 / ASTM D5321 using Brainard-Kilman LG-112 Direct Shear machine with effective test area of 12 in X 12 in.

TEST RESULTS:

Normal Stresses Applied		Asperity Heights (C#44500)				Asperity Heights (C# 44501)				Moisture Content (Soil)		PEAK STRENGTH		POST- PEAK STRENGTH AT 3.0 INCHES	
		UP		DOWN		UP		DOWN				Shear Stress	Secant Angle	Shear Stress	Secant Angle
		Before	After	Before	After	Before	After	Before	After	Before	After				
(psi)	(psf)	(mils)	(mils)	(mils)	(mils)	(mils)	(mils)	(mils)	(mils)	(%)	(%)	(psf)	(degrees)	(psf)	(degrees)
34.7	5,000	23.7	23.1	24.4	23.2	23.5	19.4	24.4	23.7	20.5	18.6	2,709	28	1,148	13
69.4	10,000	23.7	22.9	23.7	22.3	22.9	17.7	24.3	22.1	20.5	19.8	4,737	25	2,032	11
104.2	15,000	24.6	22.8	25.3	24.6	24.6	16.3	24.0	23.0	20.5	20.1	7,953	28	3,283	12
Note: N/A Not Applicable						COHESION (psf) :						0		19	
						COEFFICIENT OF FRICTION :						0.52		0.21	
						FRICTION ANGLE (degrees) :						27.7		12.1	

NOTE The friction angles and cohesion results given here are based on mathematically determined best fit line.

OBSERVATIONS:

1. No tilting of the system or any abnormalities observed during and after the test.
2. Superficial abrasion on the geosynthetics interfacing sides (typical to all loads).
3. Sliding occurred between the DS Geocomposite (C# 62070) and 60 mil HDPE (C# 44501) on all loads. See attached photos (907-1-15,000 psf / 907-1-10,000 psf / 907-1-5,000 psf)

Figure #1
Normal Stress/ Interface Stress

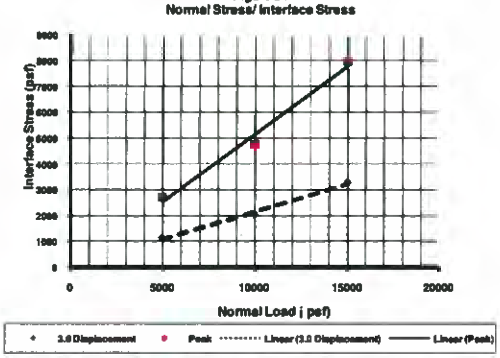


Figure #2
Shear Stress/ Displacement Curve

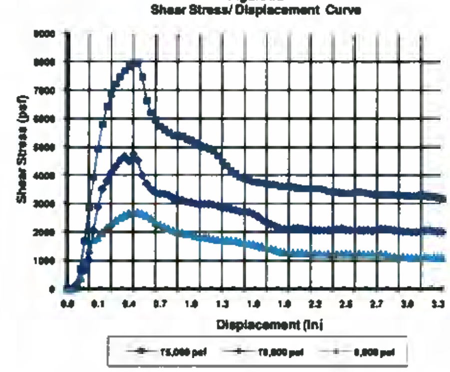
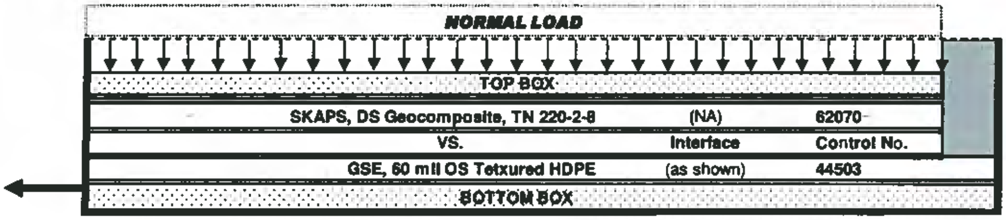


TABLE 1-A
CLIENT: GOLDER & ASSOCIATES
PROJECT: KETTLEMAN HILLS

INTERFACE SHEAR TEST RESULT (ASTM D5321/6243)
PGL Job No. G091078

Reviewed By: ______
Date: 19-Oct-09

TEST CONFIGURATION 1-A



TEST CONDITIONS:

SAMPLE PREPARATION:

1. Specimens were cut along machine direction to 14" x 17" for the upper box, and 14" x 19" for the lower box, with an effective test area of 12" x 12".
2. Geosynthetic specimens were secured via flat bar clamping mechanisms complete with bolts and nuts (7-pairs).

CONSOLIDATION:

1. The specimen was consolidated under **Dry** condition for **2 hrs** @ normal load before shearing.
2. Normal load was applied using **Bladder**

SHEAR TEST:

1. Shear test was conducted @ **0.04** in/ min.
2. Sheared @ minimum **3.0** inch horizontal displacement.
3. The test specimens were sheared at **Dry** condition .
4. Test were performed in general accordance with ASTM D6243 / ASTM D5321 using Brainard-Kilman LG-112 Direct Shear machine with effective test area of 12 in X 12 in.

TEST RESULTS:

Normal Stresses Applied		Asperity Heights (mils)		PEAK STRENGTH		POST- PEAK STRENGTH AT 3.0 INCHES	
				Shear Stress	Secant Angle	Shear Stress	Secant Angle
(psi)	(psf)	Before	After	(psf)	(degrees)	(psf)	(degrees)
69.44	10,000	25.5	18.4	4940	26	2135	12

OBSERVATIONS:

1. No tilting of the system or any abnormalities observed during and after the test.
2. Superficial abrasion on the geosynthetics interfacing sides (typical to all loads).
3. Sliding occurred between the two interfacing surfaces.

Figure #2
Shear Stress/ Displacement Curve

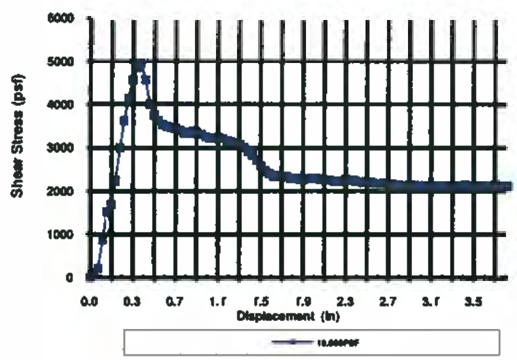


TABLE 1-B

CLIENT: GOLDER & ASSOCIATES

PROJECT: KETTLEMAN HILLS

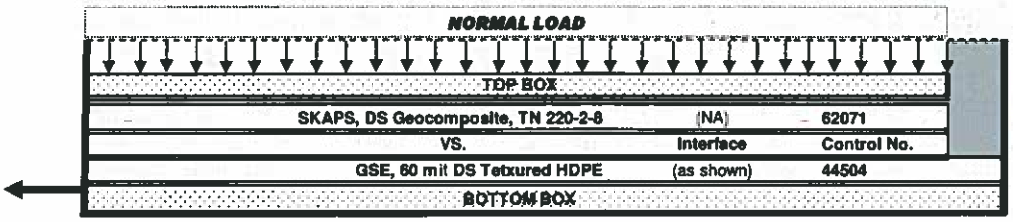
INTERFACE SHEAR TEST RESULT (ASTM D5321/6243)

PGL Job No. G091078

Reviewed By: [signature]

Date: 19-Oct-09

TEST CONFIGURATION **1-B**



TEST CONDITIONS:

SAMPLE PREPARATION:

1. Specimens were cut along machine direction to 14" x 17" for the upper box, and 14" x 19" for the lower box, with an effective test area of 12" x 12".
2. Geosynthetic specimens were secured via flat bar clamping mechanisms complete with bolts and nuts (7-pairs).

CONSOLIDATION:

1. The specimen was consolidated under **Dry** condition for **2 hrs** @ normal load before shearing.
2. Normal load was applied using **Bladder**

SHEAR TEST:

1. Shear test was conducted @ **0.04** in/ min.
2. Sheared @ minimum **3.0** inch horizontal displacement.
3. The test specimens were sheared at **Dry** condition .
4. Test were performed in general accordance with ASTM D6243 / ASTM D5321 using Brainard-Kilman LG-112 Direct Shear machine with effective test area of 12 in X 12 in.

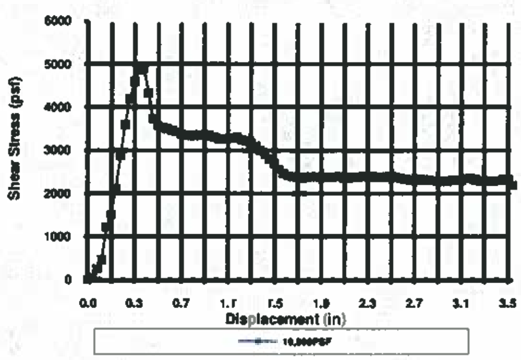
TEST RESULTS:

Normal Stresses Applied		Asperity Heights		PEAK STRENGTH		POST- PEAK STRENGTH AT 3.0 INCHES	
		mils		Shear Stress	Secant Angle	Shear Stress	Secant Angle
(psi)	(psf)	Before	After	(psf)	(degrees)	(psf)	(degrees)
69.44	10,000	24.8	19.3	4903	26	2282	13

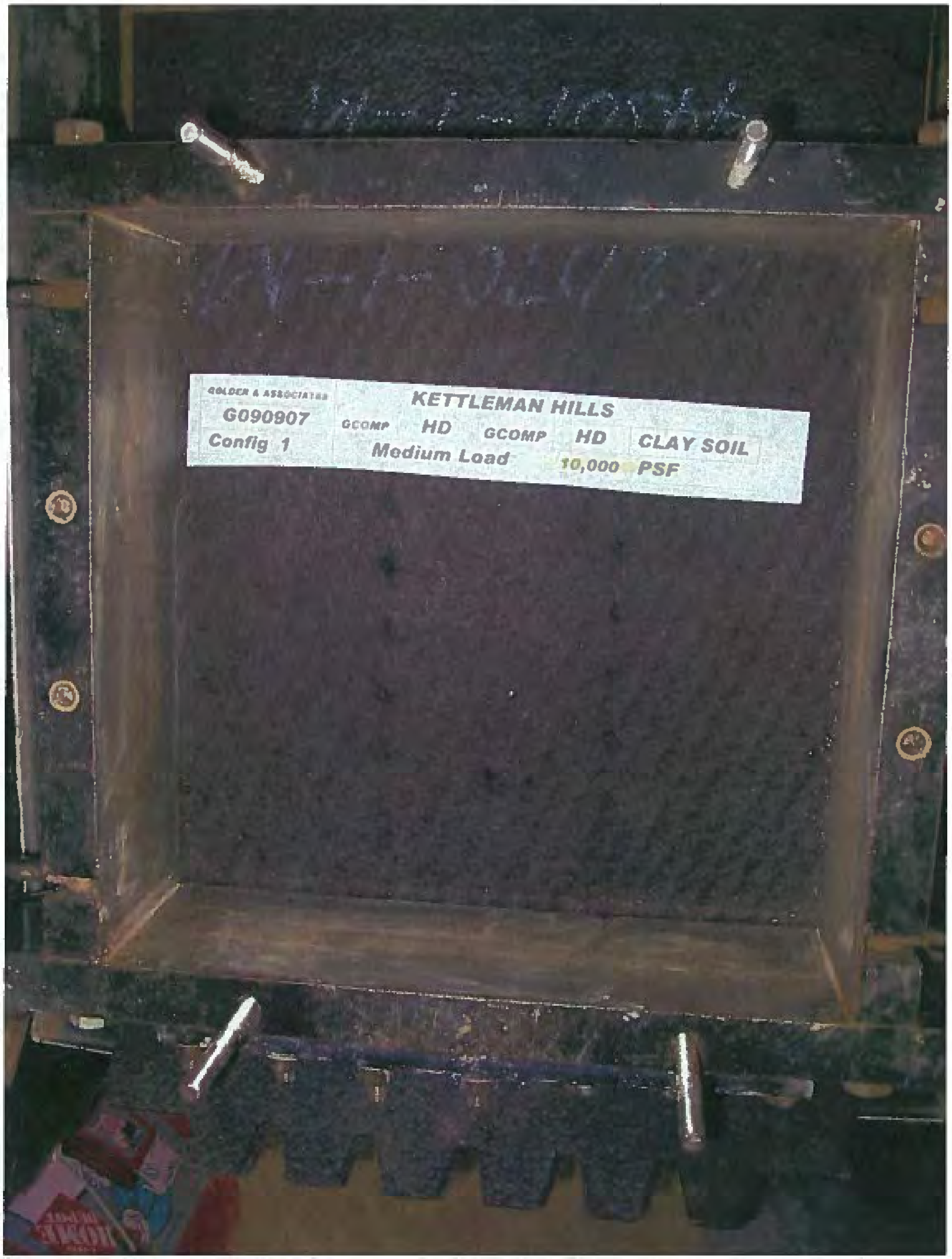
OBSERVATIONS:

1. No tilting of the system or any abnormalities observed during and after the test.
2. Superficial abrasion on the geosynthetics interfacing sides (typical to all loads).
3. Sliding occurred between the two interfacing surfaces.

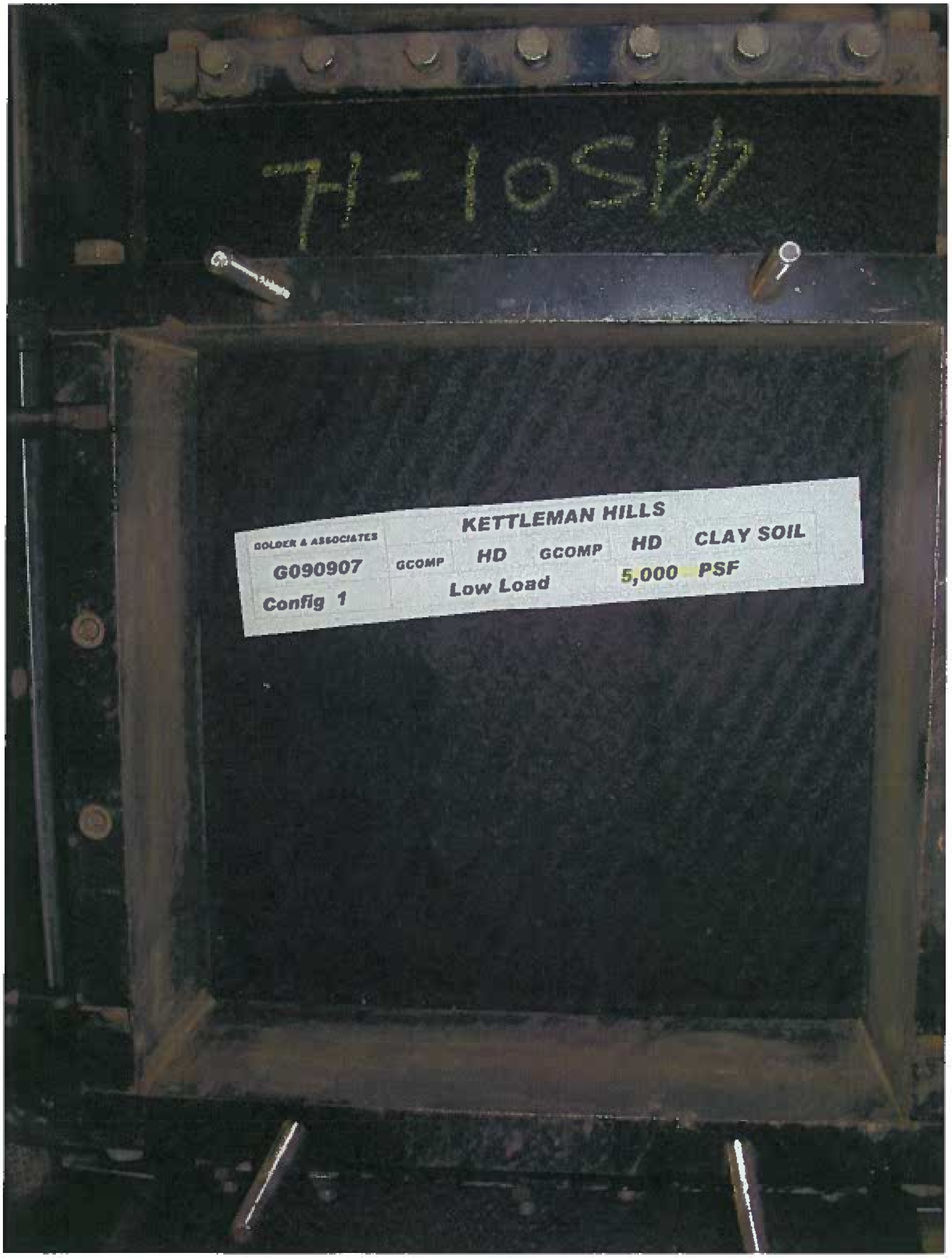
Figure #2
Shear Stress/ Displacement Curve



@ 15,000 psf


GOLDER & ASSOCIATES
G090907
Config 1
KETTLEMAN HILLS
GCOMP
HD
GCOMP
HD
CLAY SOIL
Medium Load
10,000
PSF

@ 10,000 psf

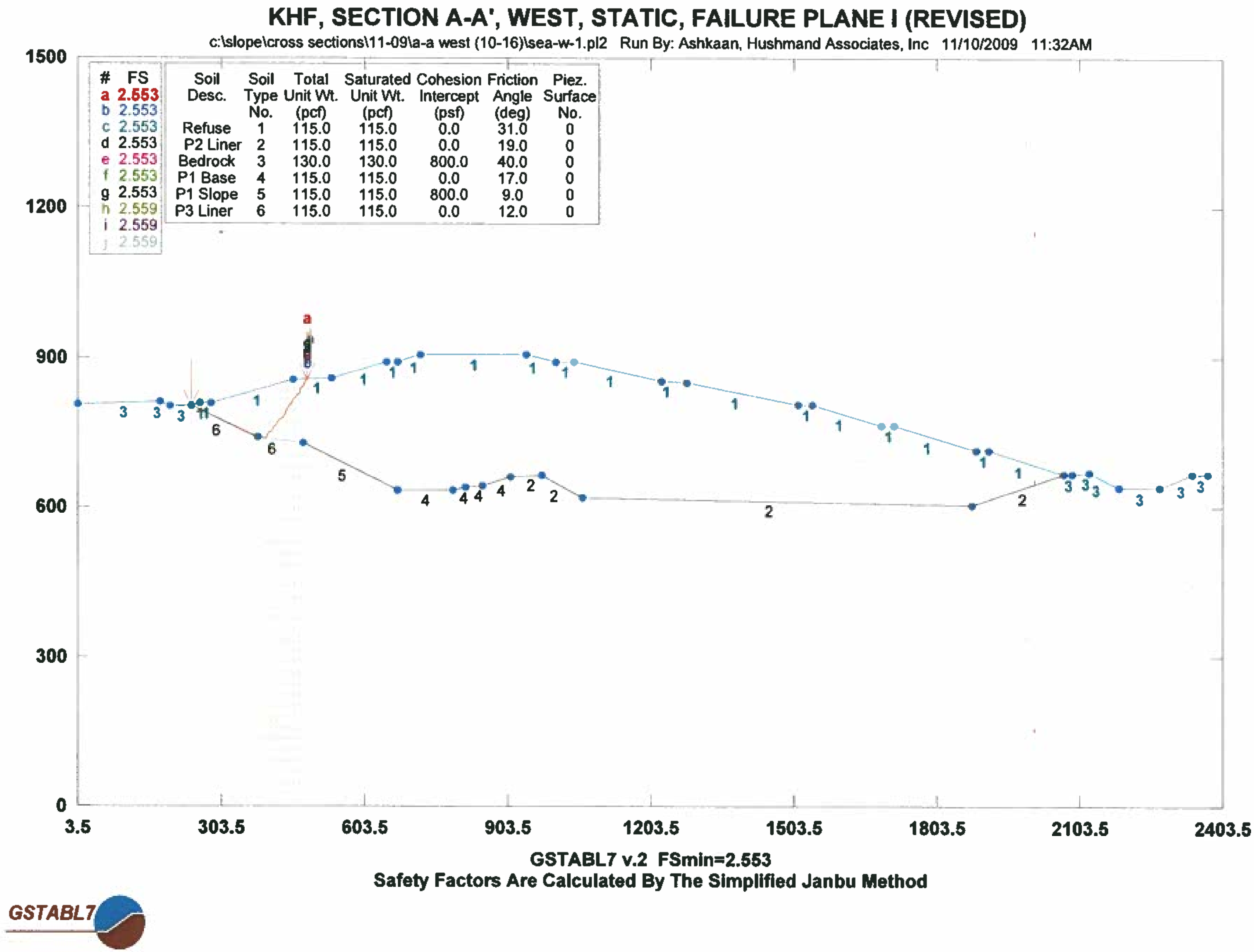


HSOI-H
GOLDER & ASSOCIATES
G090907
Config 1
KETTLEMAN HILLS
GCOMP
HD
GCOMP
HD
CLAY SOIL
Low Load
5,000
PSF

@ 5,000 psf

APPENDIX B

SLOPE STABILITY ANALYSIS PLOTS

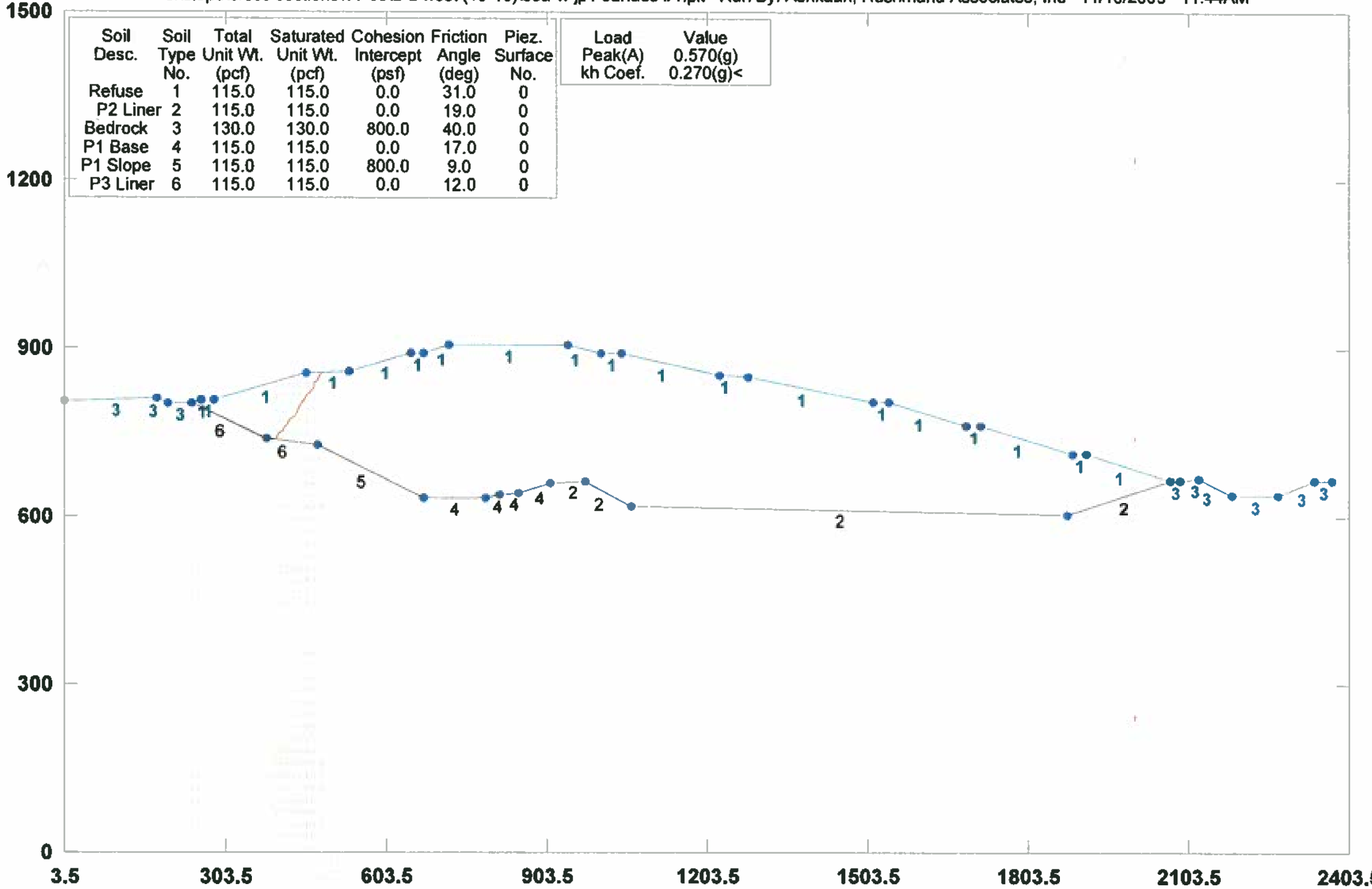

KHF, SECTION A-A', WEST, STATIC, FAILURE PLANE I (REVISED)
c:\slope\cross sections\11-09\a-a west (10-16)\sea-w-1.pl2 Run By: Ashkaan, Hushmand Associates, Inc 11/10/2009 11:32AM
FS
a 2.553
b 2.553
c 2.553
d 2.553
e 2.553
f 2.553
g 2.553
h 2.559
i 2.559
j 2.559
Soil Desc. | Soil Type No. | Total Unit Wt. (pcf) | Saturated Unit Wt. (pcf) | Cohesion Intercept (psf) | Friction Angle (deg) | Piez. Surface No.
Refuse 1 115.0 115.0 0.0 31.0 0
P2 Liner 2 115.0 115.0 0.0 19.0 0
Bedrock 3 130.0 130.0 800.0 40.0 0
P1 Base 4 115.0 115.0 0.0 17.0 0
P1 Slope 5 115.0 115.0 800.0 9.0 0
P3 Liner 6 115.0 115.0 0.0 12.0 0
1500
1200
900
600
300
0
3.5
303.5
603.5
903.5
1203.5
1503.5
1803.5
2103.5
2403.5
GSTABL7 v.2 FSmin=2.553
Safety Factors Are Calculated By The Simplified Janbu Method
GSTABL7

KHF, SECTION A-A', WEST, PSEUDO-STATIC, FAILURE PLANE I (REVISED)

c:\slope\cross sections\11-09\a-a west (10-16)\sea-w-jp1 surface #1.plt Run By: Ashkaan, Hushmand Associates, Inc 11/10/2009 11:44AM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
P2 Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0
P3 Liner	6	115.0	115.0	0.0	12.0	0

Load	Value
Peak(A)	0.570(g)
kh Coef.	0.270(g)<



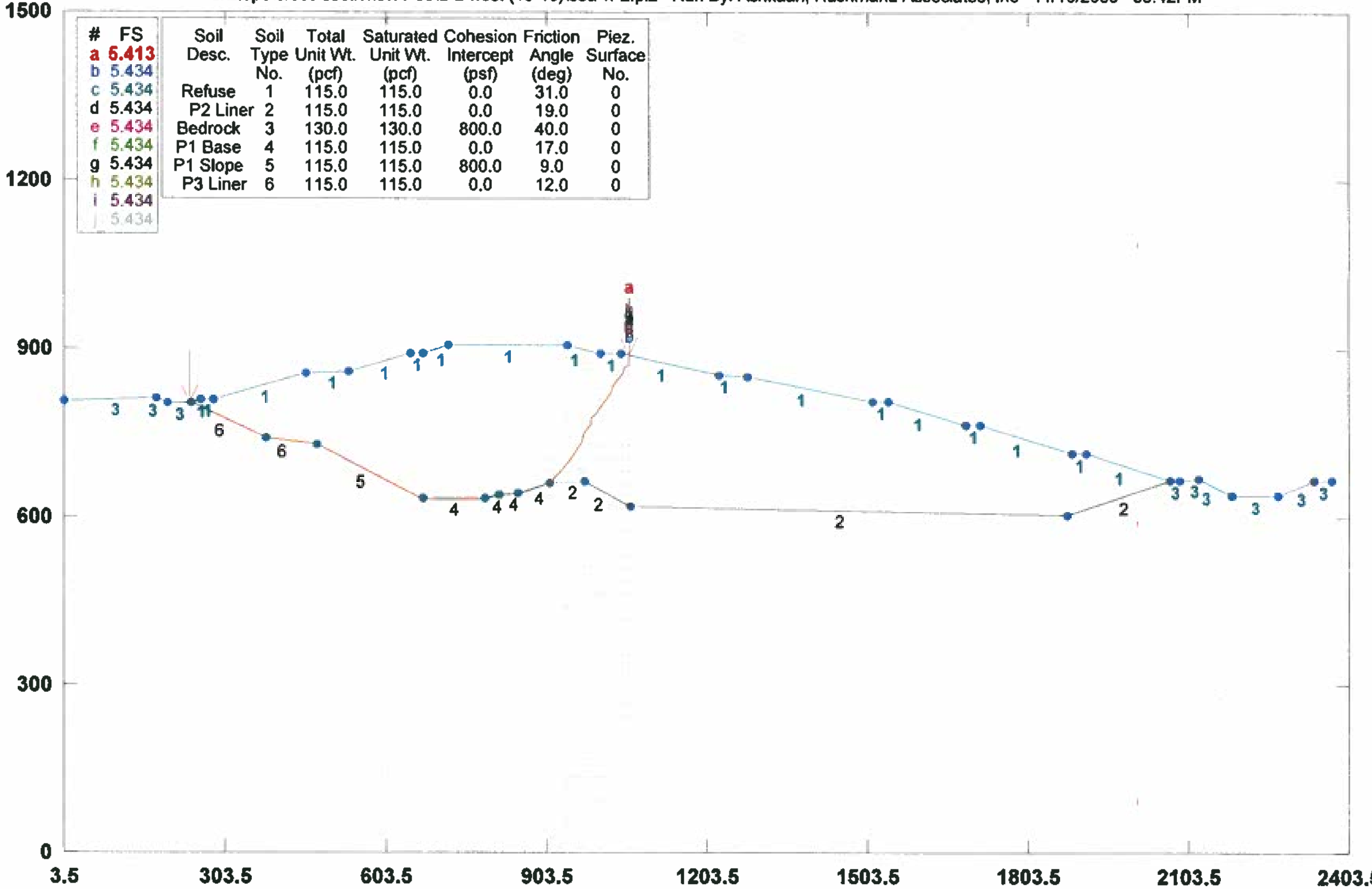
GSTABL7 v.2 FSmin=1.002

Factor Of Safety Is Calculated By The Simplified Janbu Method

GSTABL7

KHF, SECTION A-A', WEST, STATIC, FAILURE PLANE II (REVISED)

c:\slope\cross sections\11-09\a-a west (10-16)\sea-w-2.pl2 Run By: Ashkaan, Hushmand Associates, Inc 11/10/2009 06:42PM



GSTABL7 v.2 FSmin=5.413
Safety Factors Are Calculated By The Simplified Janbu Method

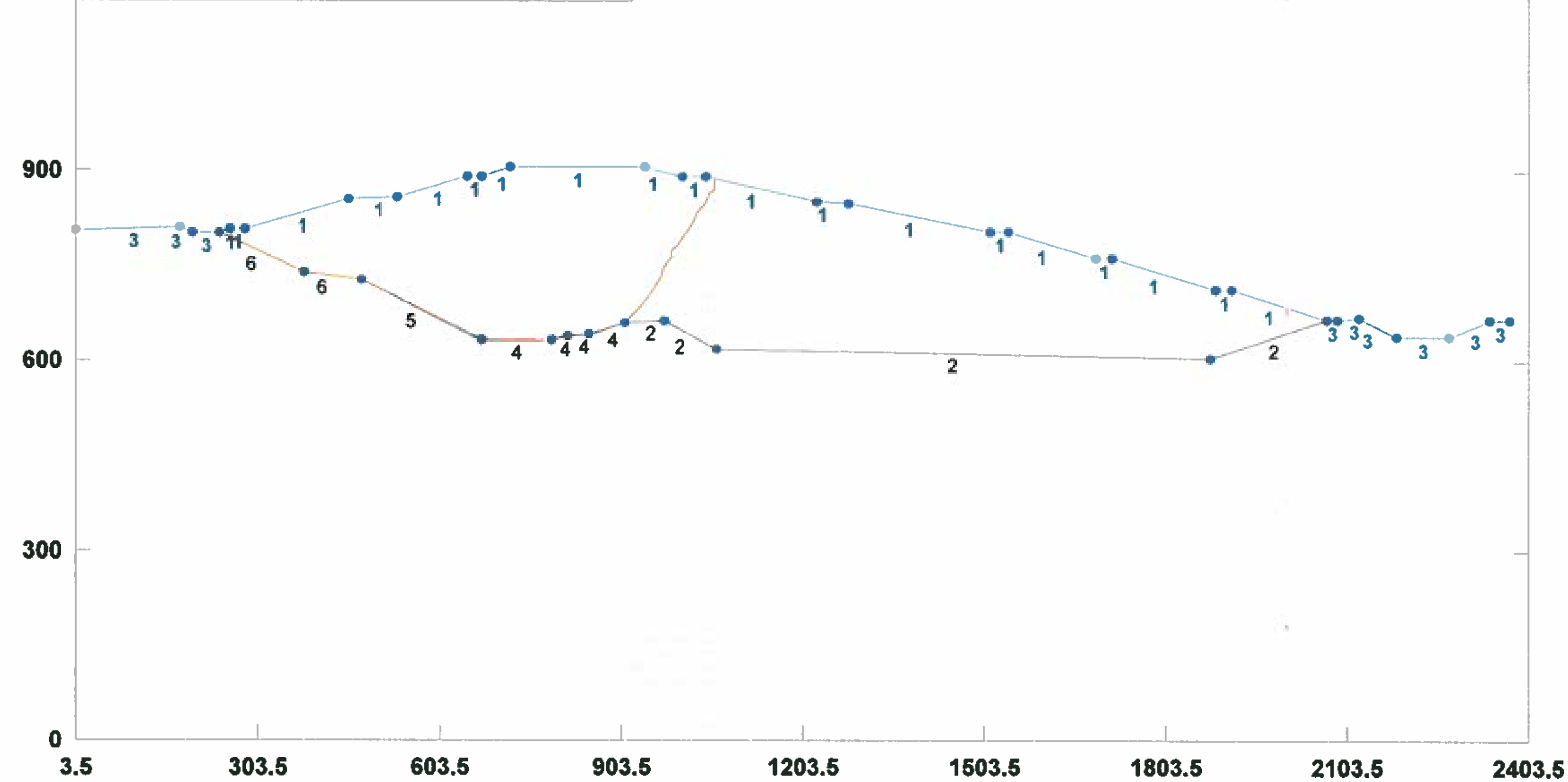
GSTABL7

KHF, SECTION A-A', WEST, PSEUDO-STATIC, FAILURE PLANE II (REVISED)

c:\slope\cross sections\11-09\a-a west (10-16)\sea-wps-2 surface #1.plt   Run By: Ashkaan, Hushmand Associates, Inc   11/10/2009   06:34PM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
P2 Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0
P3 Liner	6	115.0	115.0	0.0	12.0	0

Load	Value
Peak(A)	0.570(g)
kh Coef.	0.290(g)<

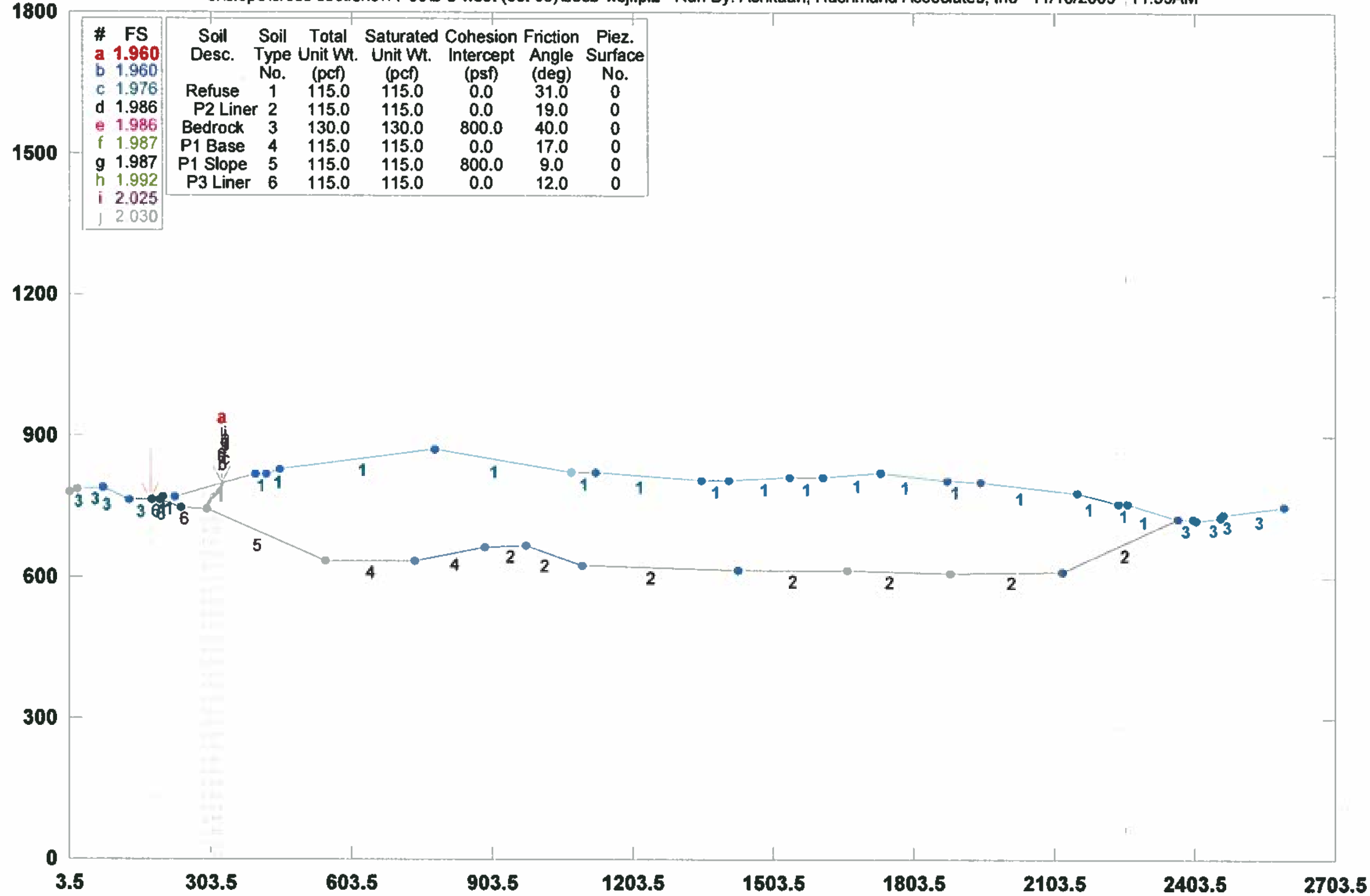


GSTABL7 v.2 FSmin=1.021
Factor Of Safety Is Calculated By The Simplified Janbu Method

GSTABL7

KHF, SEC. B-B', WEST, STATIC, FAILURE PLANE II (REVISED)

c:\slope\cross sections\11-09\b-b west (oct 09)\secb-wsji.pl2 Run By: Ashkaan, Hushmand Associates, Inc 11/10/2009 11:59AM



GSTABL7 v.2 FSmin=1.960

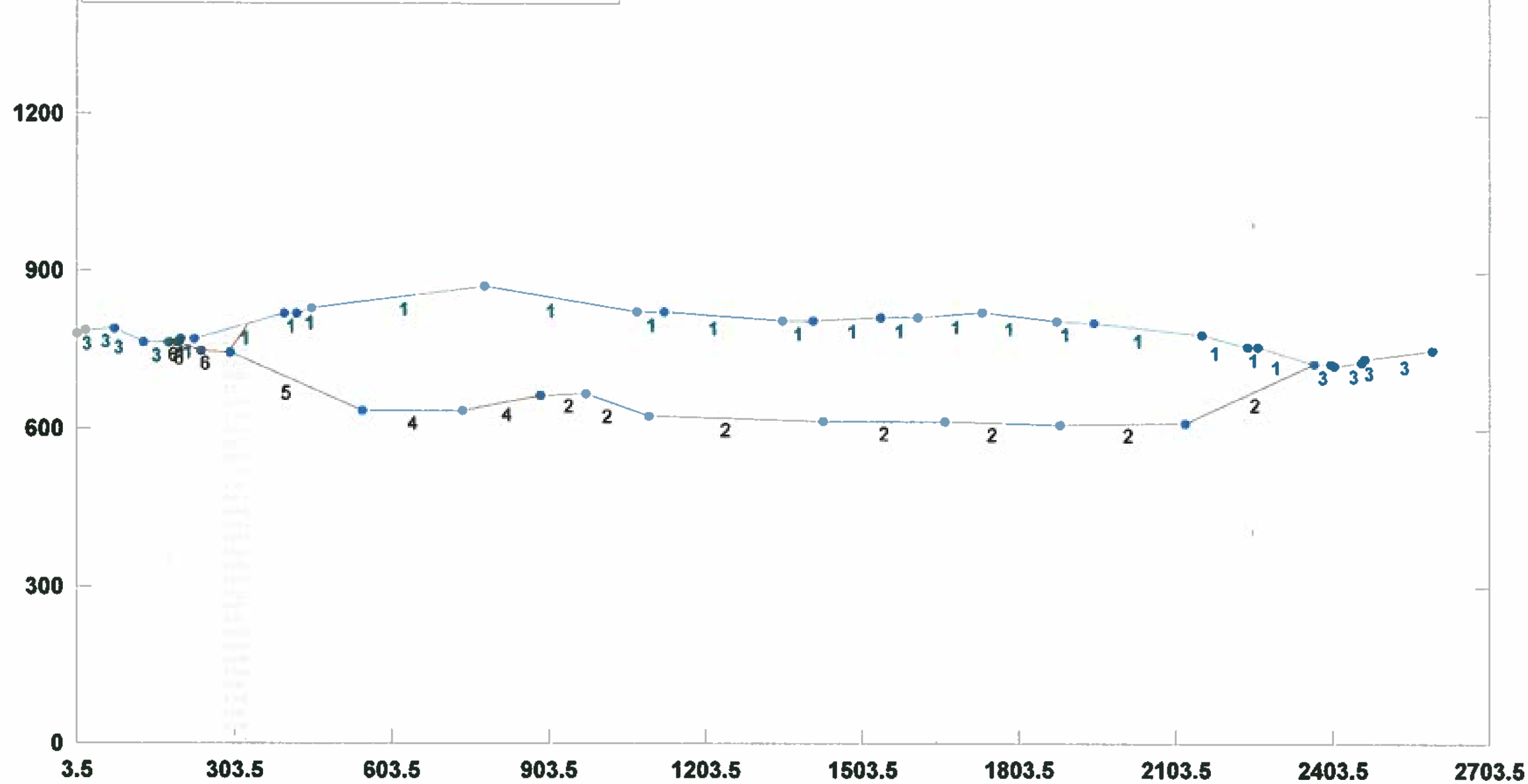
Safety Factors Are Calculated By The Simplified Janbu Method

GSTABL7

KHF, SEC. B-B', WEST, STATIC, FAILURE PLANE I (REVISED)

c:\slope\cross sections\11-09\b-b west (oct 09)\secb-ws1 surface #1.plt   Run By: Ashkaan, Hushmand Associates, Inc   11/10/2009   12:02PM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
P2 Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0
P3 Liner	6	115.0	115.0	0.0	12.0	0



GSTABL7 v.2 FSmin=2.412
Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

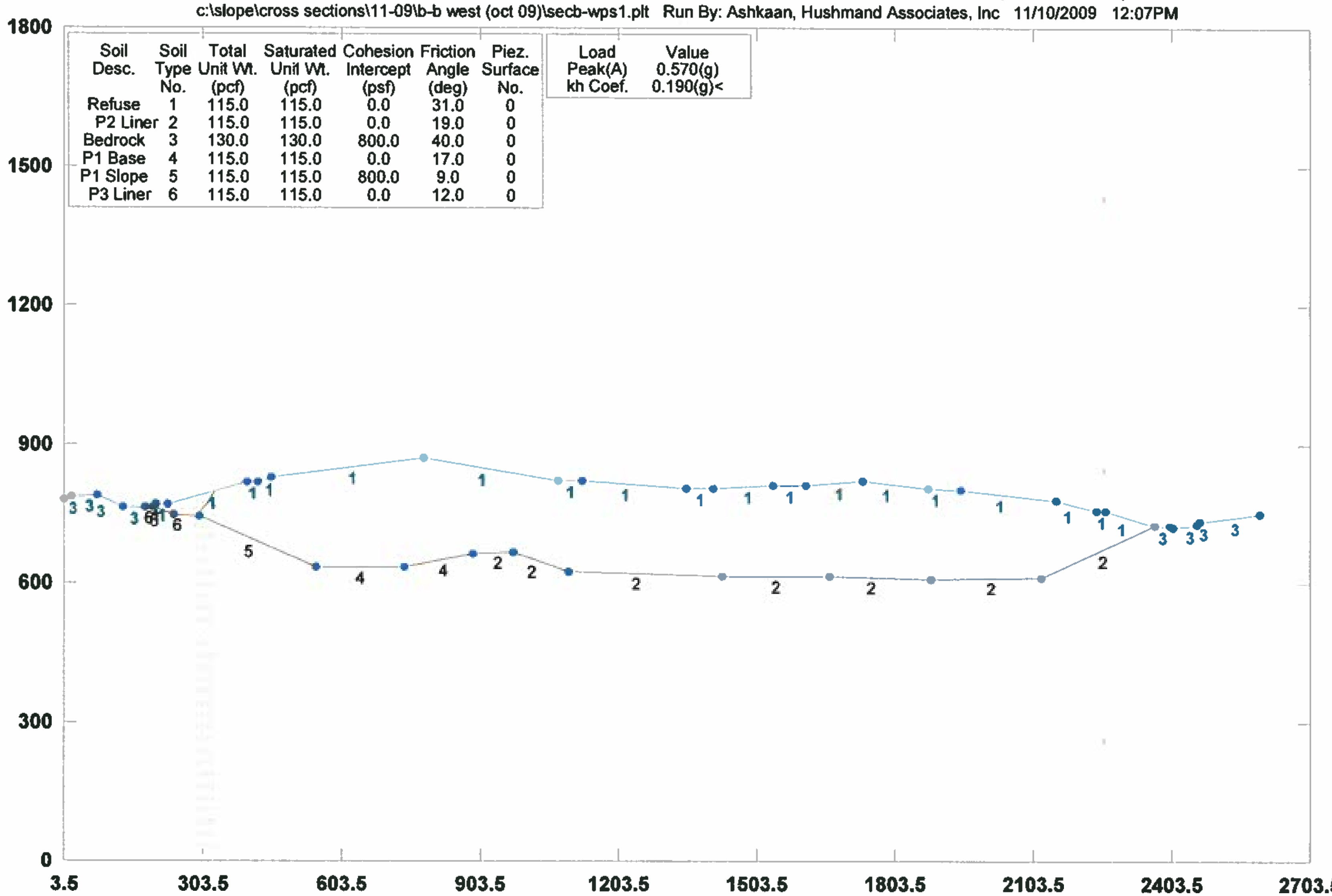
GSTABL7

KHF, SEC. B-B',WEST, PSEUDO-STATIC, FAILURE PLANE I (REVISED)

c:\slope\cross sections\11-09\b-b west (oct 09)\secb-wps1.plt Run By: Ashkaan, Hushmand Associates, Inc 11/10/2009 12:07PM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
P2 Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0
P3 Liner	6	115.0	115.0	0.0	12.0	0

Load	Value
Peak(A)	0.570(g)
kh Coef.	0.190(g)<



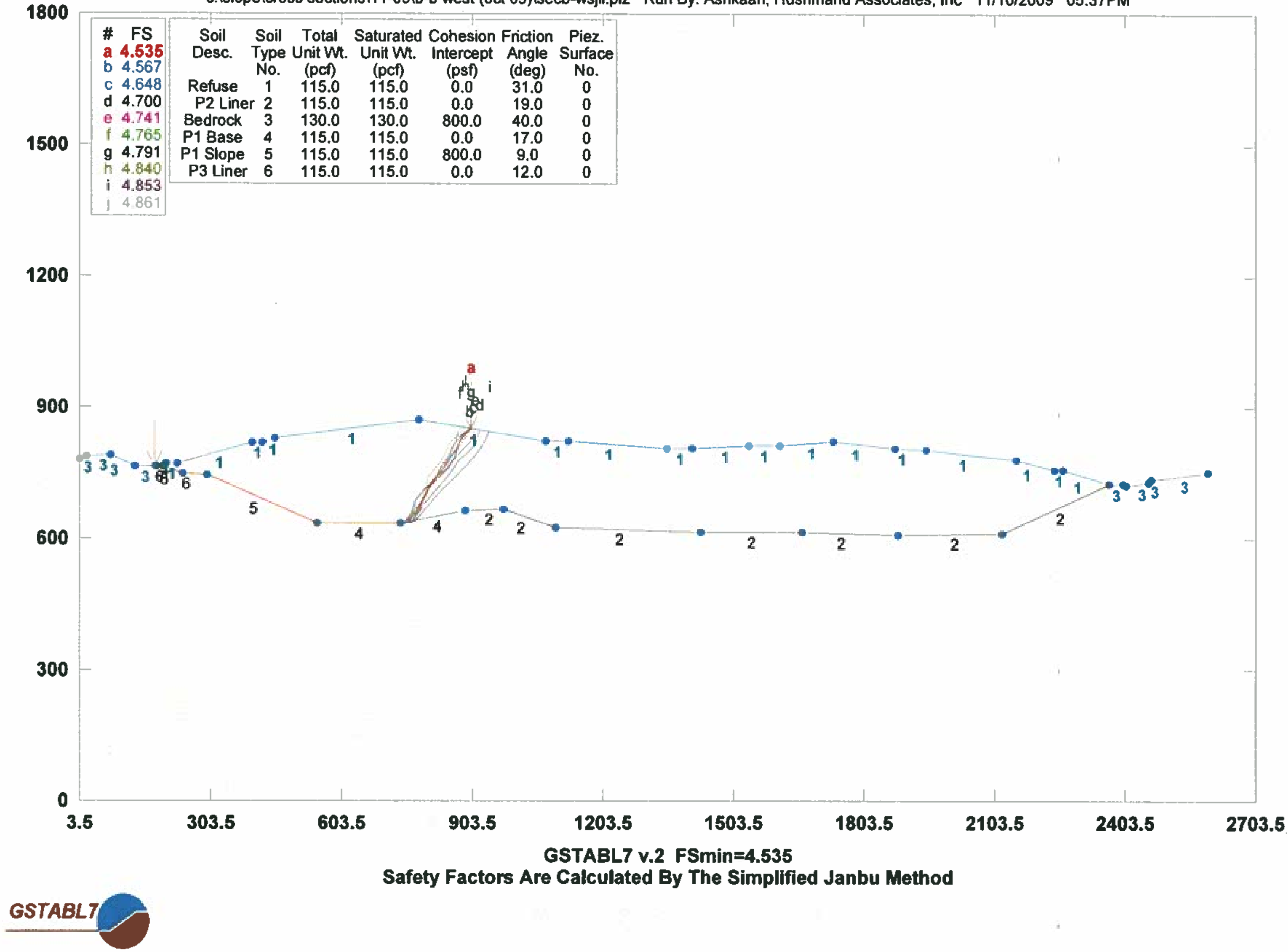
GSTABL7 v.2 FSmin=1.025

Factor Of Safety Is Calculated By GLE (Spencer's) Method (0-2)

GSTABL7

KHF, SEC. B-B', WEST, STATIC, FAILURE PLANE II (REVISED)

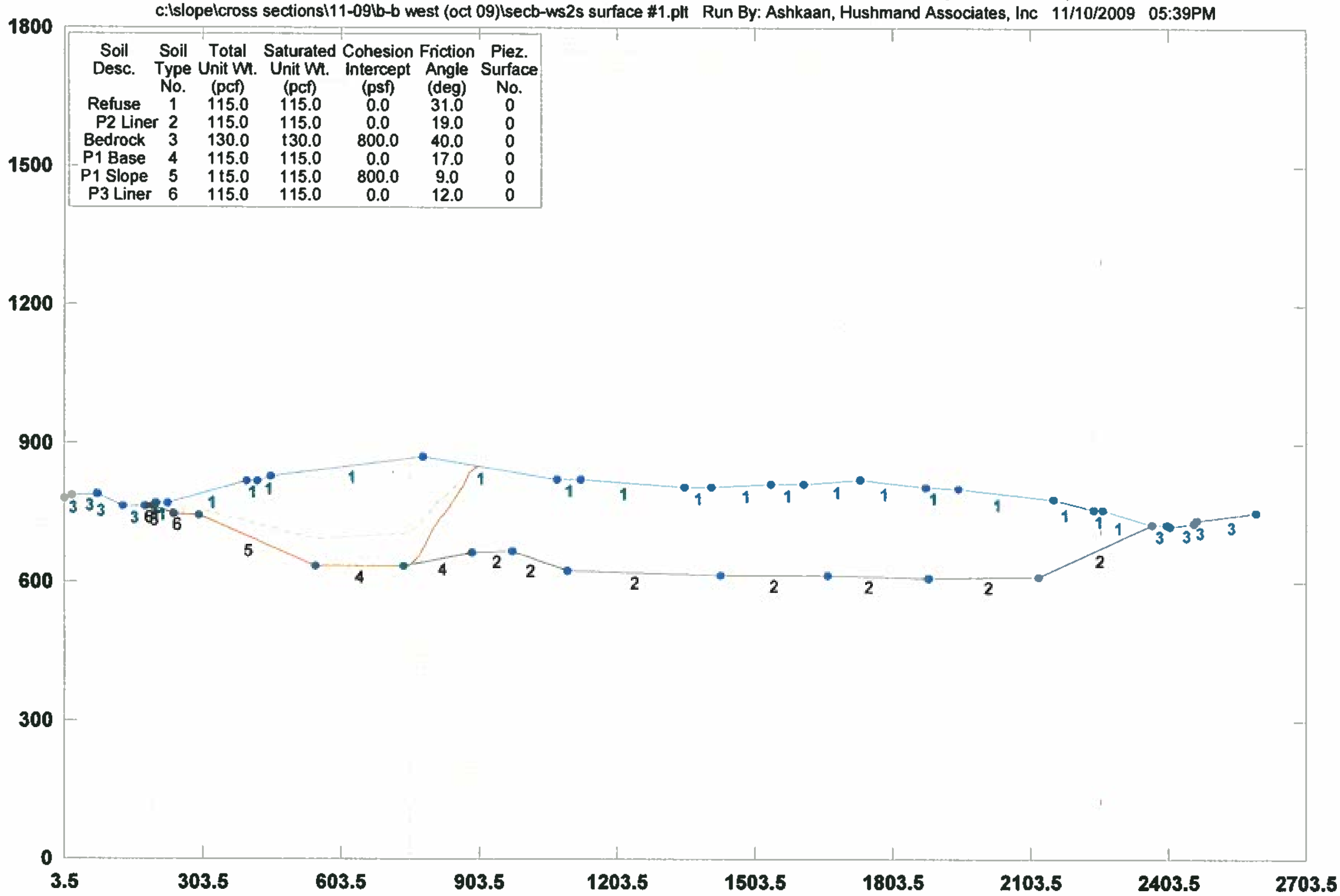
c:\slope\cross sections\11-09\b-b west (oct 09)\secb-wsjii.pl2   Run By: Ashkaan, Hushmand Associates, Inc   11/10/2009   05:37PM



KHF, SEC. B-B', WEST, STATIC, FAILURE PLANE II (REVISED)

c:\slope\cross sections\11-09\b-b west (oct 09)\secb-ws2s surface #1.plt Run By: Ashkaan, Hushmand Associates, Inc 11/10/2009 05:39PM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
P2 Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0
P3 Liner	6	115.0	115.0	0.0	12.0	0



GSTABL7 v.2 FSmin=6.443
Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

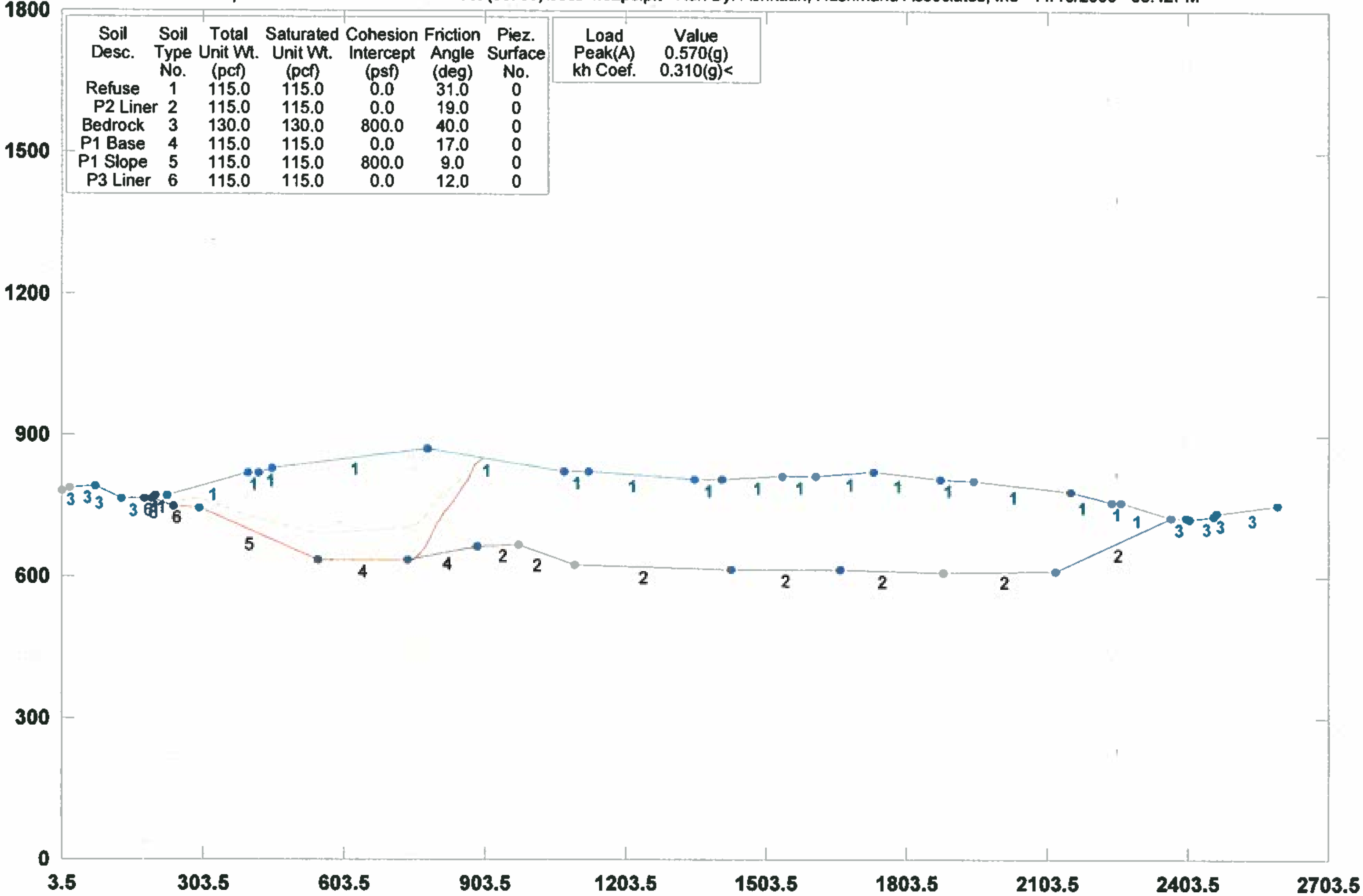
GSTABL7

KHF, SEC. B-B',WEST, PSEUDO-STATIC, FAILURE PLANE II (REVISED)

c:\slope\cross sections\11-09\b-b west (oct 09)\secb-ws2ps.plt Run By: Ashkaan, Hushmand Associates, Inc 11/10/2009 05:42PM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
P2 Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0
P3 Liner	6	115.0	115.0	0.0	12.0	0

Load	Value
Peak(A)	0.570(g)
kh Coef.	0.310(g)<



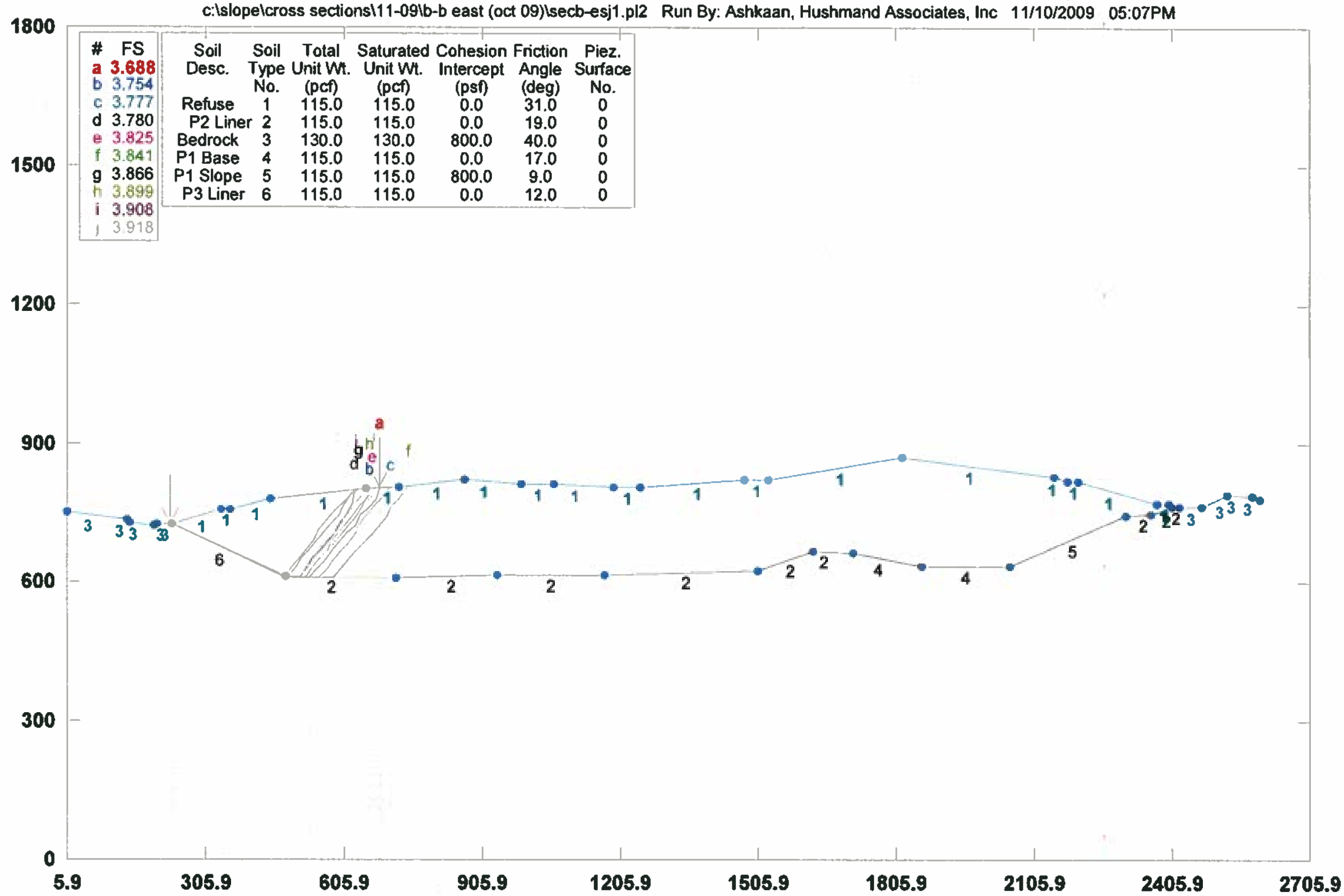
GSTABL7 v.2 FSmin=1.015

Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

GSTABL7

KHF, SEC. B-B', EAST, STATIC, FAILURE PLANE 1 (REVISED)

c:\slope\cross sections\11-09\b-b east (oct 09)\secb-esj1.pl2 Run By: Ashkaan, Hushmand Associates, Inc 11/10/2009 05:07PM



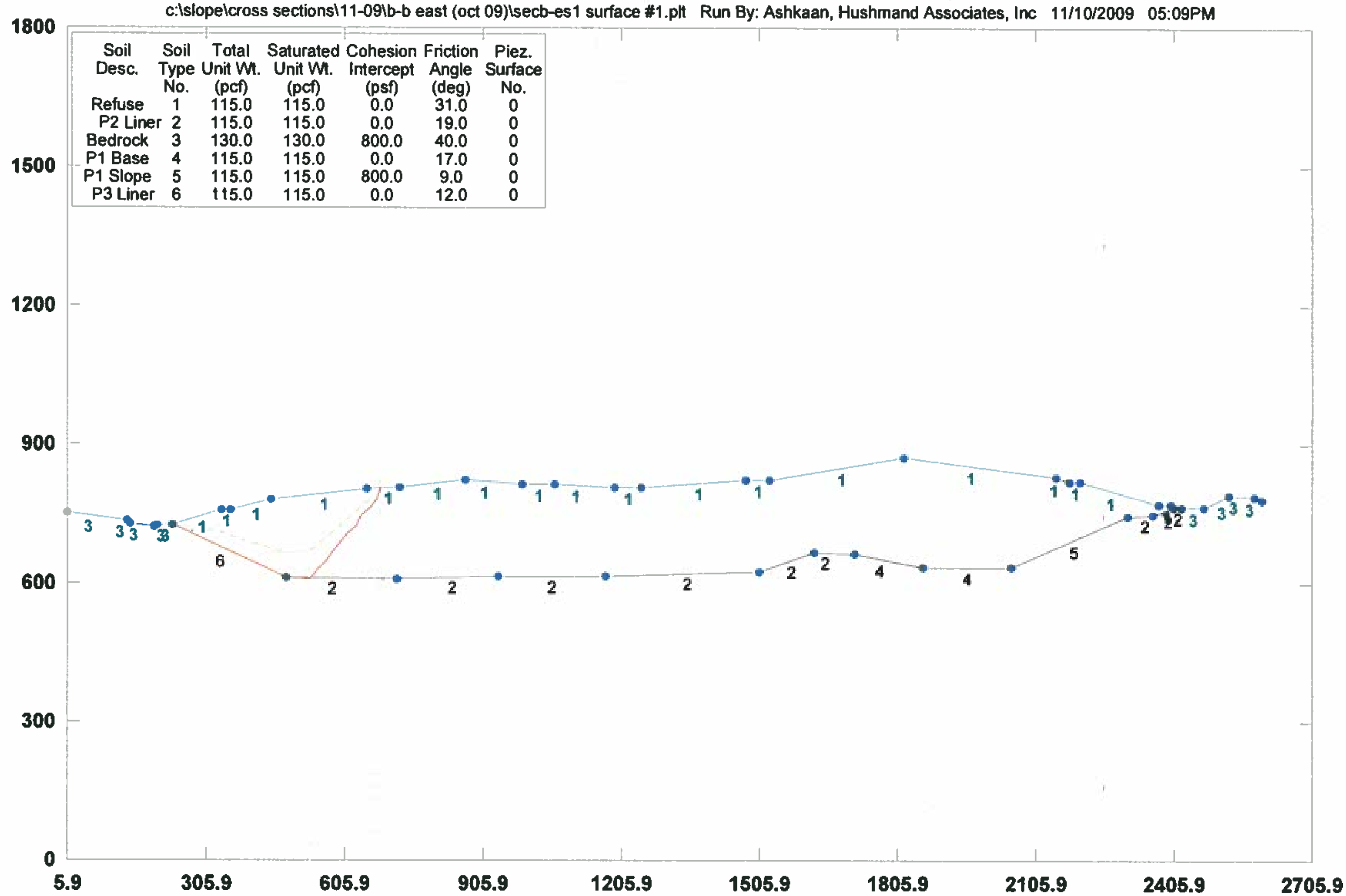
GSTABL7 v.2 FSmin=3.688

Safety Factors Are Calculated By The Simplified Janbu Method

GSTABL7

KHF, SEC. B-B', EAST, STATIC, FAILURE PLANE 1 (REVISED)

c:\slope\cross sections\11-09\b-b east (oct 09)\secb-es1 surface #1.plt Run By: Ashkaan, Hushmand Associates, Inc 11/10/2009 05:09PM



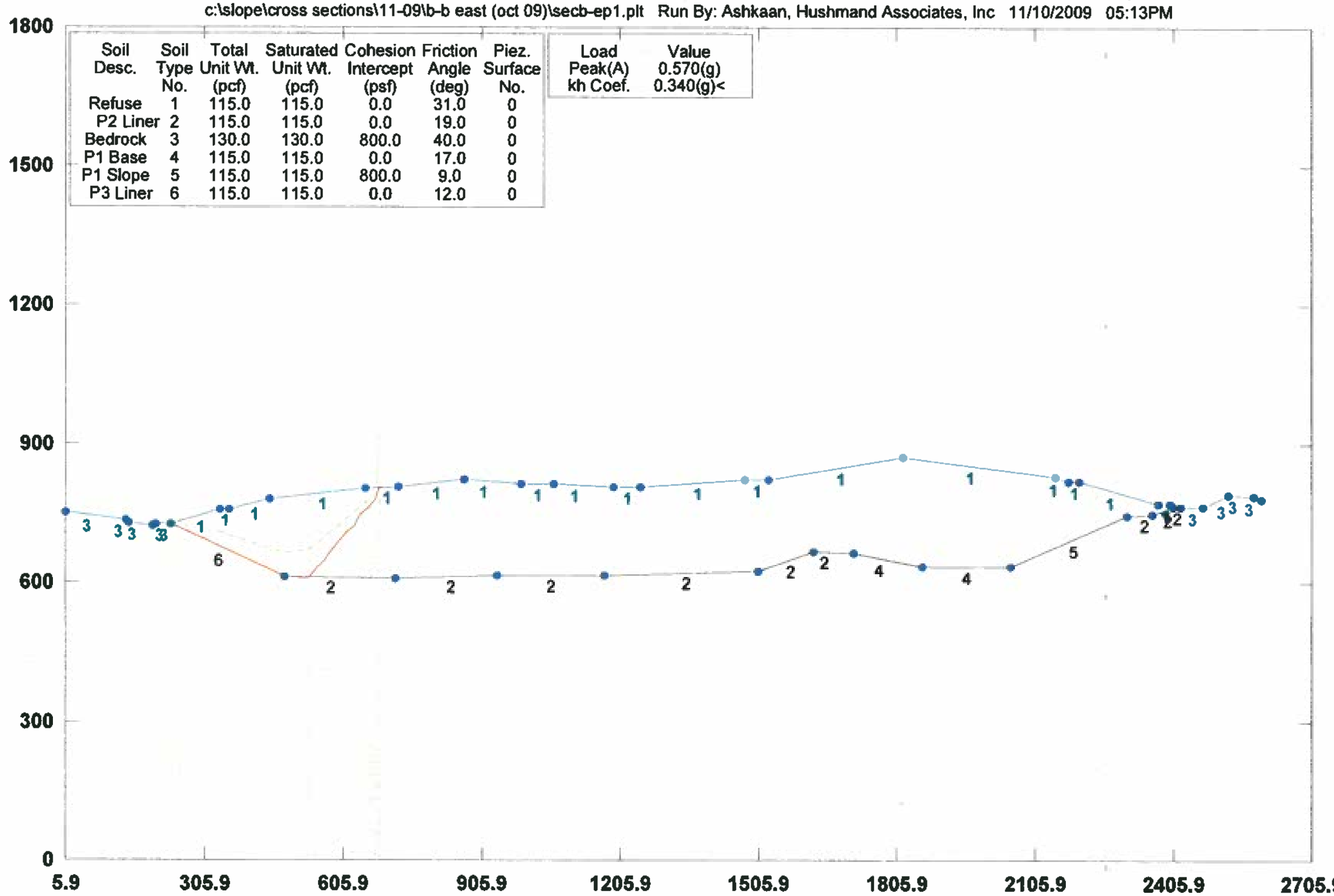
Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
P2 Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0
P3 Liner	6	115.0	115.0	0.0	12.0	0

GSTABL7 v.2 FSmin=5.817

Factor Of Safety Is Calculated By GLE (Spencer's) Method (0-2)

KHF, SEC. B-B', EAST, PSEUDO-STATIC, FAILURE PLANE 1 (REVISED)

c:\slope\cross sections\11-09\b-b east (oct 09)\secb-ep1.plt Run By: Ashkaan, Hushmand Associates, Inc 11/10/2009 05:13PM



Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
P2 Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0
P3 Liner	6	115.0	115.0	0.0	12.0	0

Load	Value
Peak(A)	0.570(g)
kh Coef.	0.340(g)<

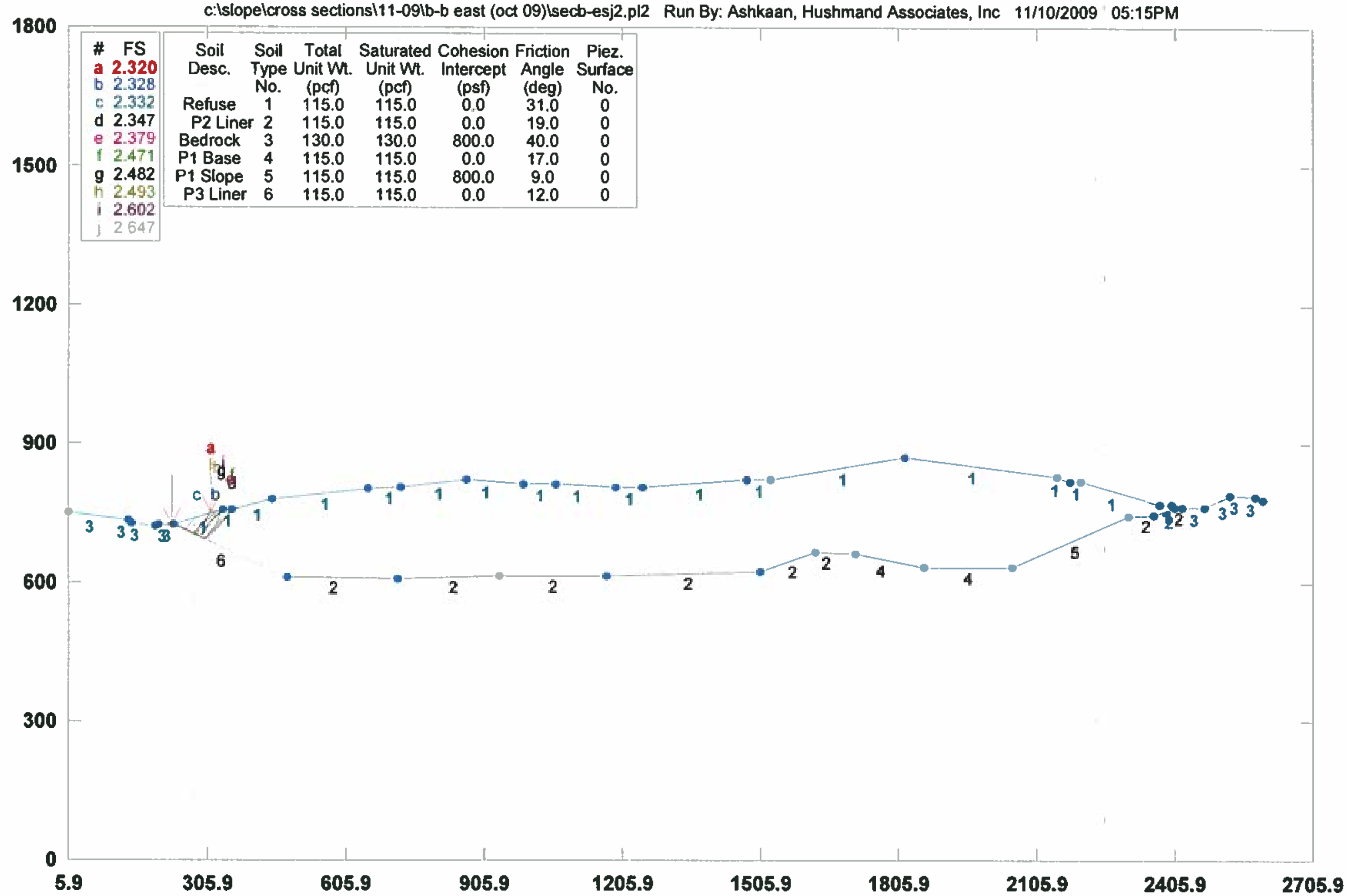
GSTABL7 v.2 FSmin=1.022

Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

GSTABL7

KHF, SEC. B-B', EAST, STATIC, FAILURE PLANE 2 (REVISED)

c:\slope\cross sections\11-09\b-b east (oct 09)\secb-esj2.pl2   Run By: Ashkaan, Hushmand Associates, Inc   11/10/2009   05:15PM



#	FS
a	2.320
b	2.328
c	2.332
d	2.347
e	2.379
f	2.471
g	2.482
h	2.493
i	2.602
j	2.647

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
P2 Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0
P3 Liner	6	115.0	115.0	0.0	12.0	0

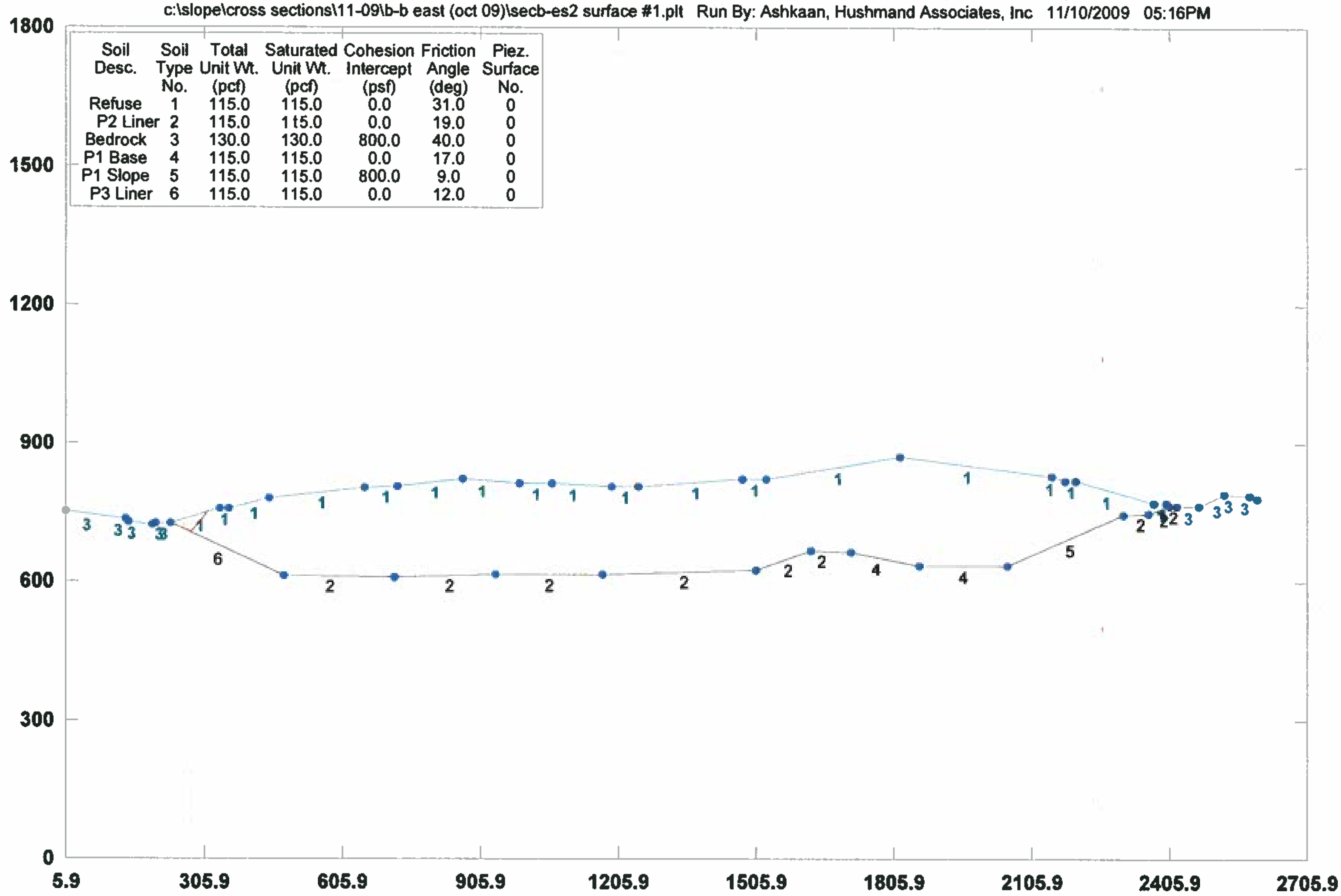
GSTABL7 v.2 FSmin=2.320
Safety Factors Are Calculated By The Simplified Janbu Method

GSTABL7

KHF, SEC. B-B', EAST, STATIC, FAILURE PLANE 2 (REVISED)

c:\slope\cross sections\11-09\b-b east (oct 09)\secb-es2 surface #1.plt Run By: Ashkaan, Hushmand Associates, Inc 11/10/2009 05:16PM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
P2 Liner	2	115.0	1 t5.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0
P3 Liner	6	115.0	115.0	0.0	12.0	0



GSTABL7 v.2 FSmin=3.327
Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

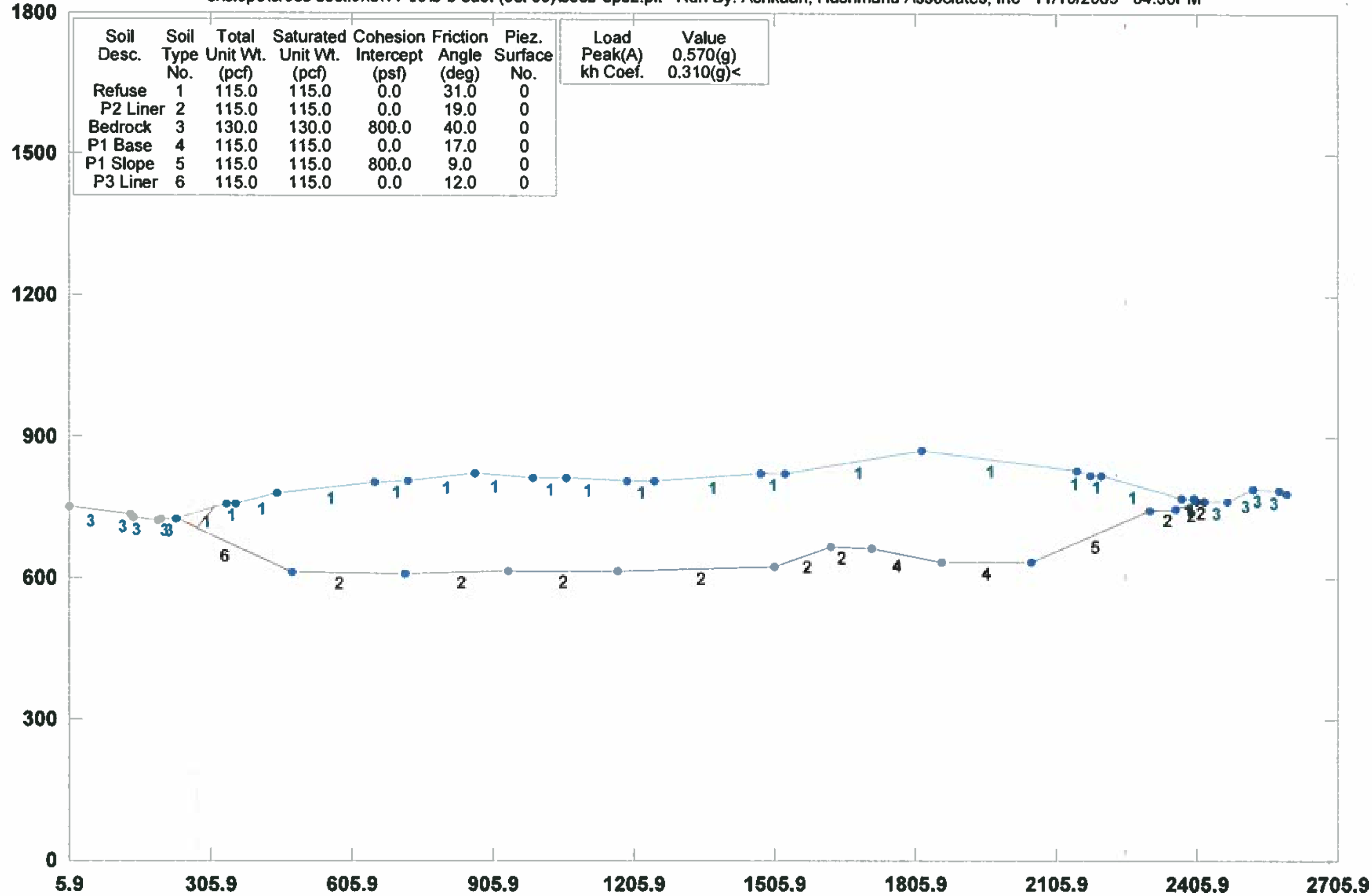
GSTABL7

KHF, SEC. B-B', EAST, PSEUDO-STATIC, FAILURE PLANE 2 (REVISED)

c:\slope\cross sections\11-09\b-b east (oct 09)\secb-eps2.plt Run By: Ashkaan, Hushmand Associates, Inc 11/10/2009 04:30PM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
P2 Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0
P3 Liner	6	115.0	115.0	0.0	12.0	0

Load	Value
Peak(A)	0.570(g)
kh Coef.	0.310(g)<

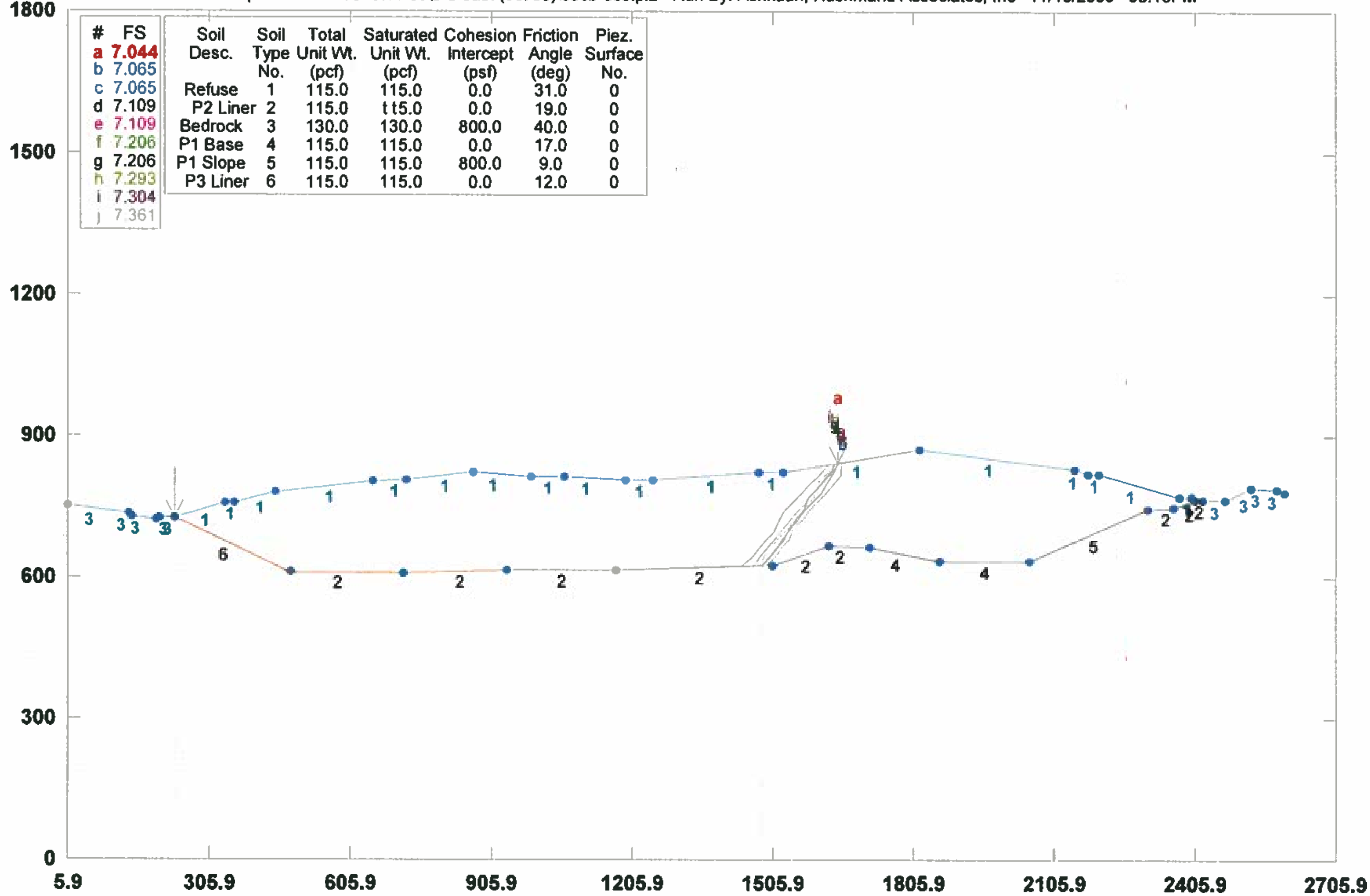


GSTABL7 v.2 FSmin=1.011
Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

GSTABL7

KHF, SEC. B-B', EAST, STATIC, FAILURE PLANE 3 (REVISED)

c:\slope\cross sections\11-09\b-b east (oct 09)\secb-es3.pl2 Run By: Ashkaan, Hushmand Associates, Inc 11/10/2009 05:18PM



GSTABL7 v.2 FSmin=7.044

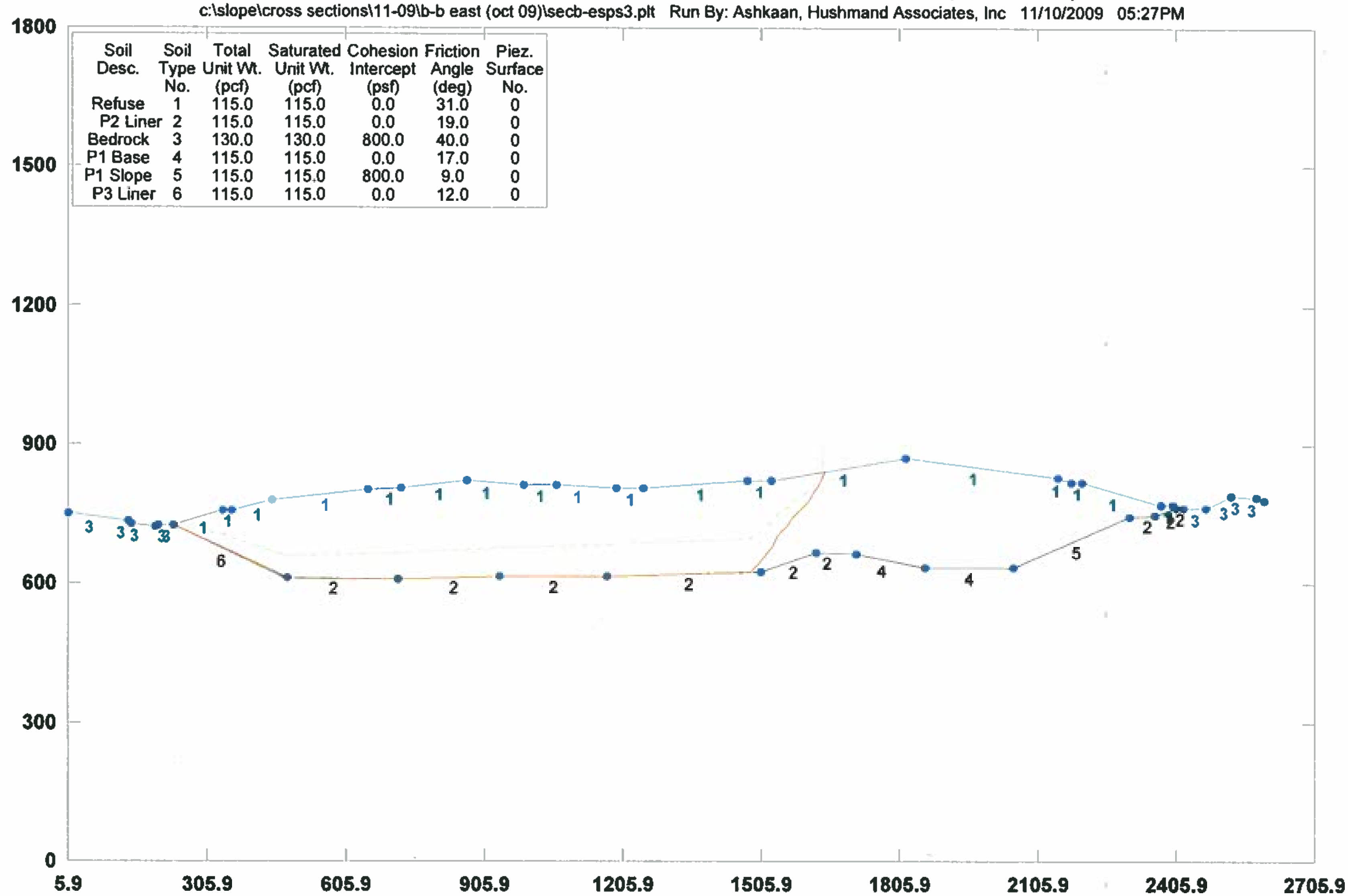
Safety Factors Are Calculated By The Simplified Janbu Method

GSTABL7

KHF, SEC. B-B', EAST, STATIC, FAILURE PLANE 3 (REVISED)

c:\slope\cross sections\11-09\b-b east (oct 09)\secb-esps3.plt Run By: Ashkaan, Hushmand Associates, Inc 11/10/2009 05:27PM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
P2 Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0
P3 Liner	6	115.0	115.0	0.0	12.0	0



GSTABL7 v.2 FSmin=7.665

Factor Of Safety Is Calculated By GLE (Spencer's) Method (0-2)

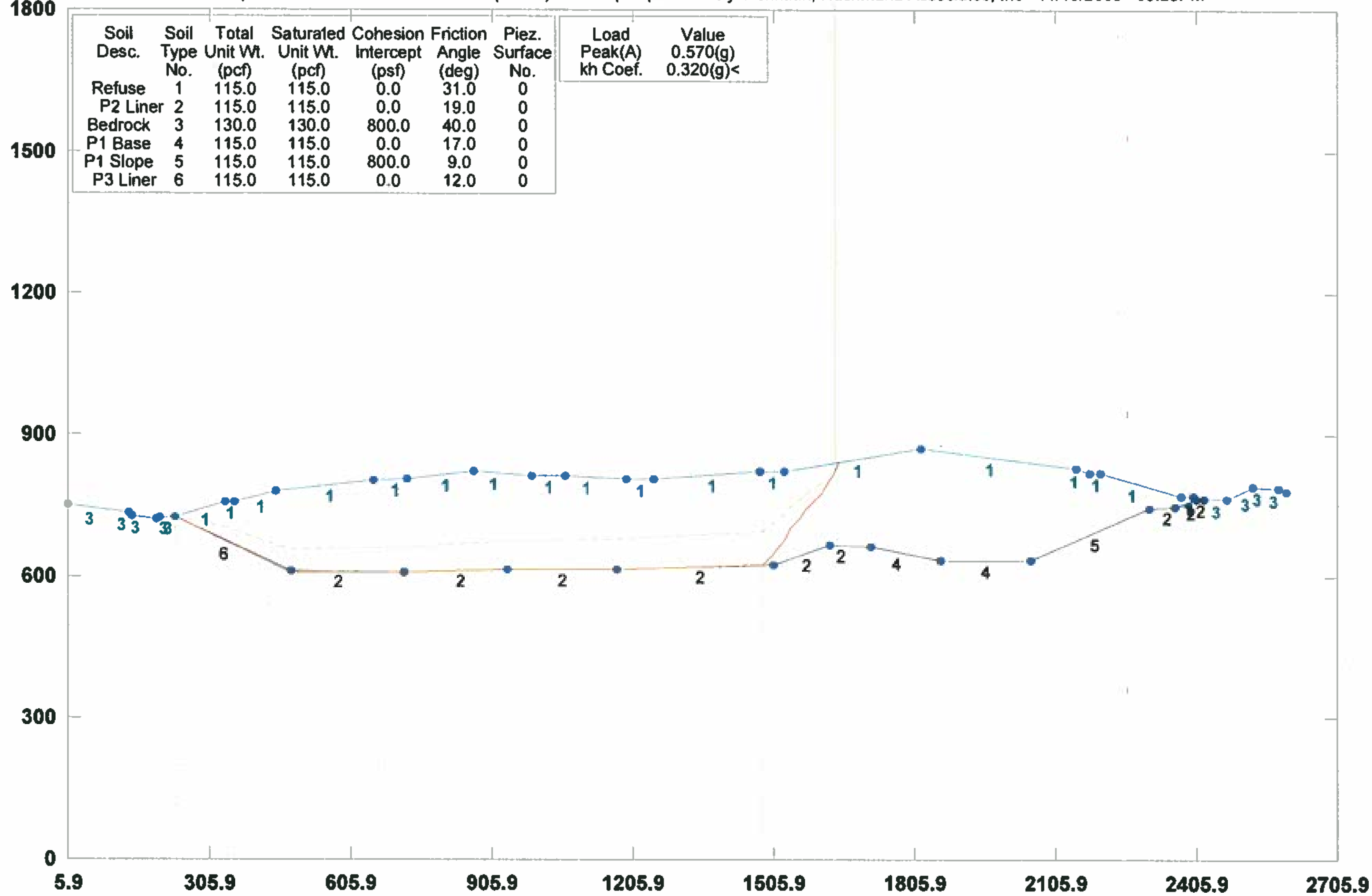
GSTABL7

KHF, SEC. B-B', EAST, PSEUDO-STATIC, FAILURE PLANE 3 (REVISED)

c:\slope\cross sections\11-09\b-b east (oct 09)\secb-esps3.plt Run By: Ashkaan, Hushmand Associates, Inc 11/10/2009 05:28PM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
P2 Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0
P3 Liner	6	115.0	115.0	0.0	12.0	0

Load	Value
Peak(A)	0.570(g)
kh Coef.	0.320(g)<

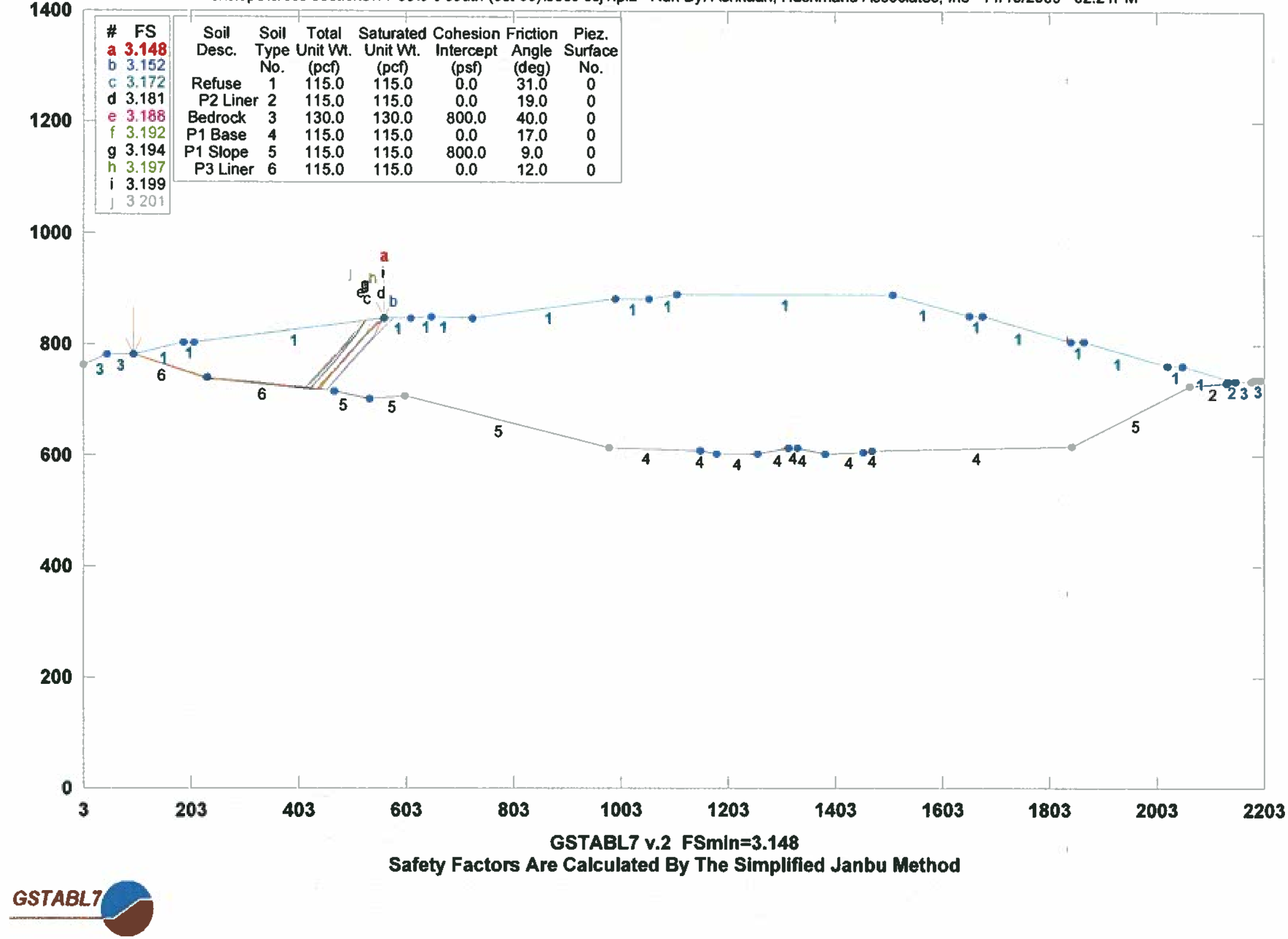


GSTABL7 v.2 FSmin=1.001
Factor Of Safety Is Calculated By GLE (Spencer's) Method (0-2)

GSTABL7

KHF, SEC. C-C', SOUTH, STATIC, FAILURE SURFACE I (REVISED)

c:\slope\cross sections\11-09\c-c south (oct 09)\secc-ssj1.pl2 Run By: Ashkaan, Hushmand Associates, Inc 11/10/2009 02:21PM

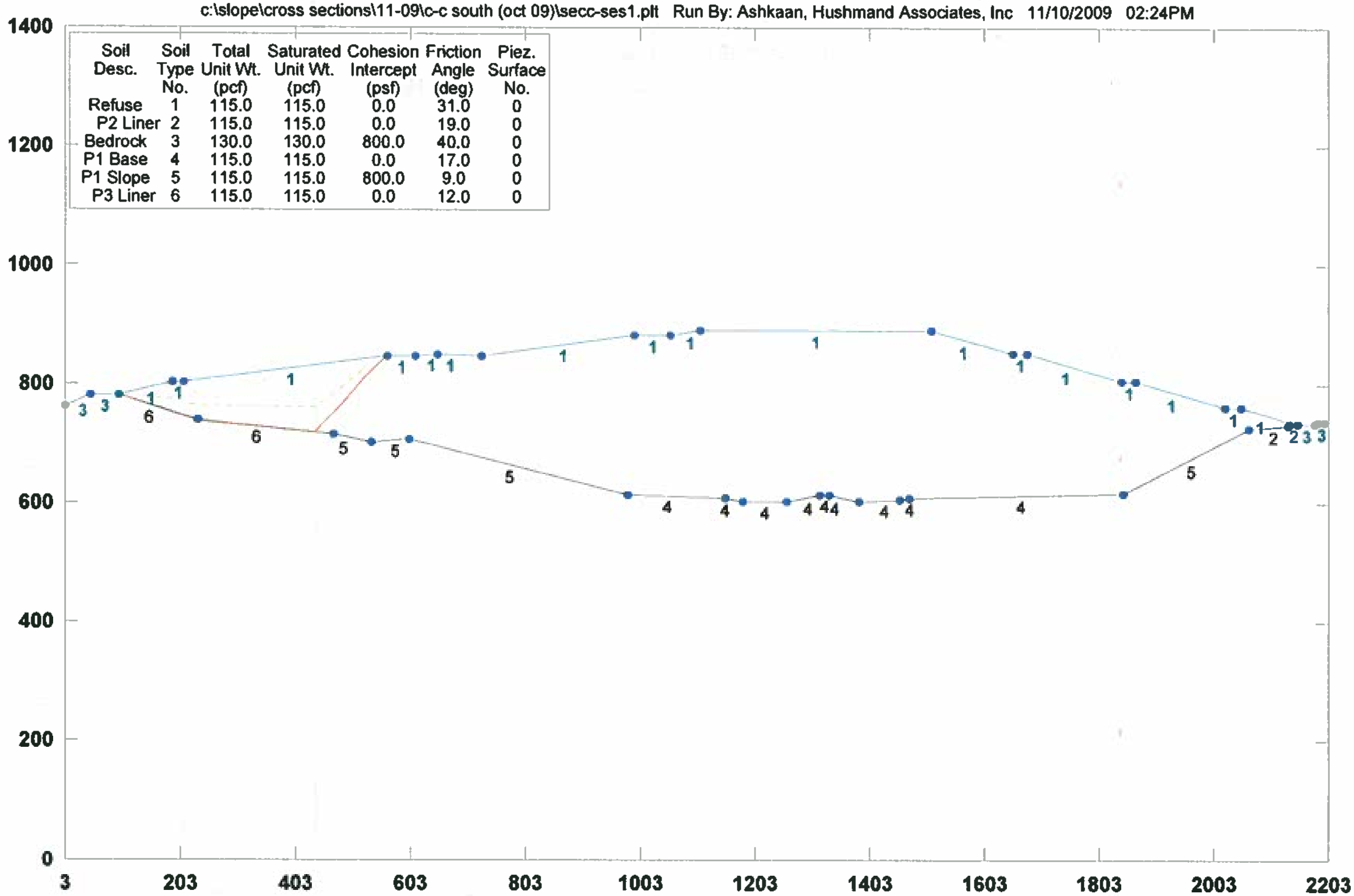


GSTABL7 v.2 FSmin=3.148

Safety Factors Are Calculated By The Simplified Janbu Method

KHF, SEC. C-C',SOUTH, STATIC, FAILURE SURFACE I (REVISED)

c:\slope\cross sections\11-09\c-c south (oct 09)\secc-ses1.plt Run By: Ashkaan, Hushmand Associates, Inc 11/10/2009 02:24PM



GSTABL7 v.2 FSmin=3.743

Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

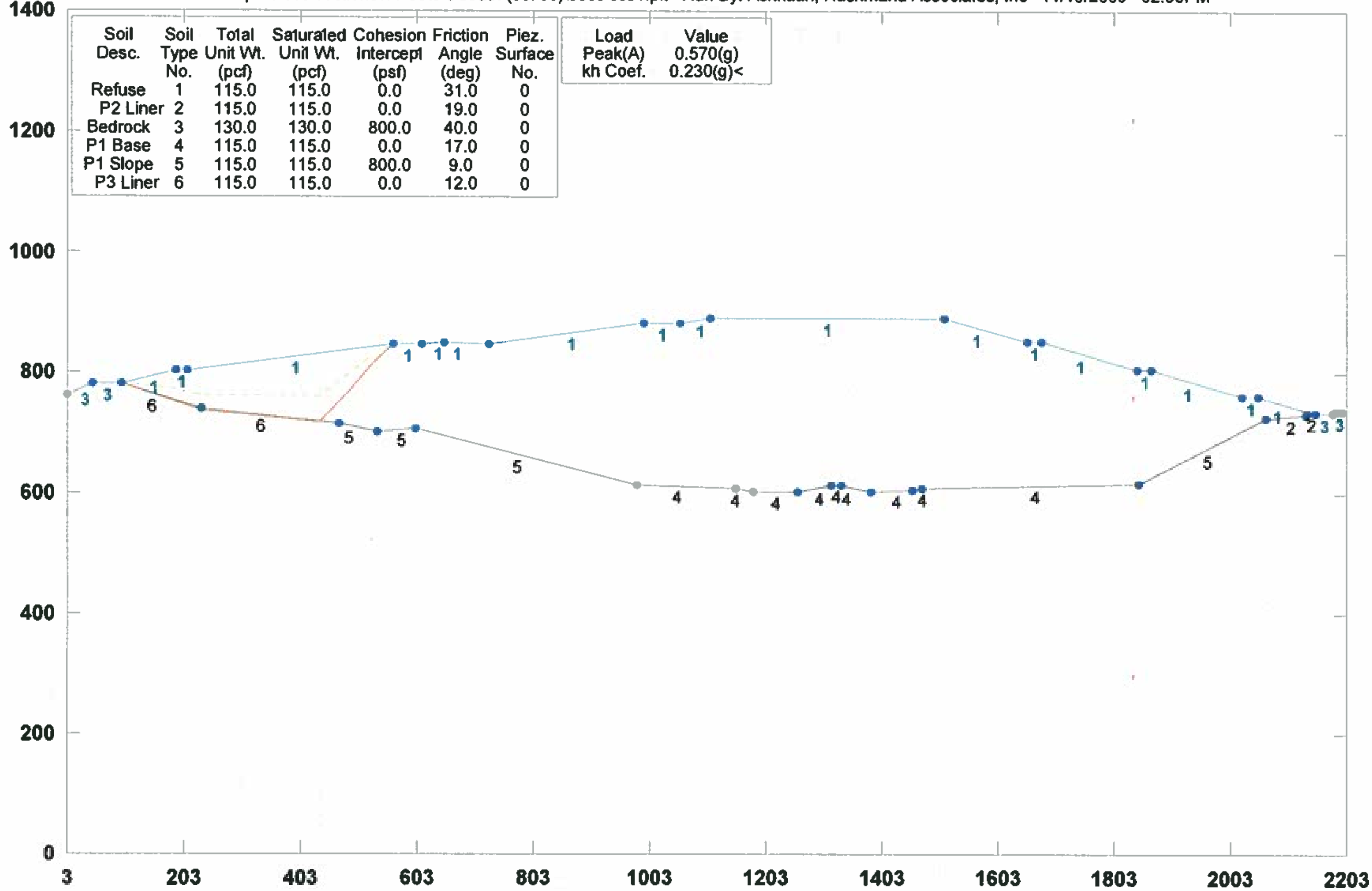
GSTABL7

KHF, SEC. C-C',SOUTH, PSEUDO-STATIC, FAILURE SURFACE I (REVISED)

c:\slope\cross sections\11-09\c-c south (oct 09)\secc-sss1.plt Run By: Ashkaan, Hushmand Associates, Inc 11/10/2009 02:39PM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
P2 Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0
P3 Liner	6	115.0	115.0	0.0	12.0	0

Load	Value
Peak(A)	0.570(g)
kh Coef.	0.230(g)<

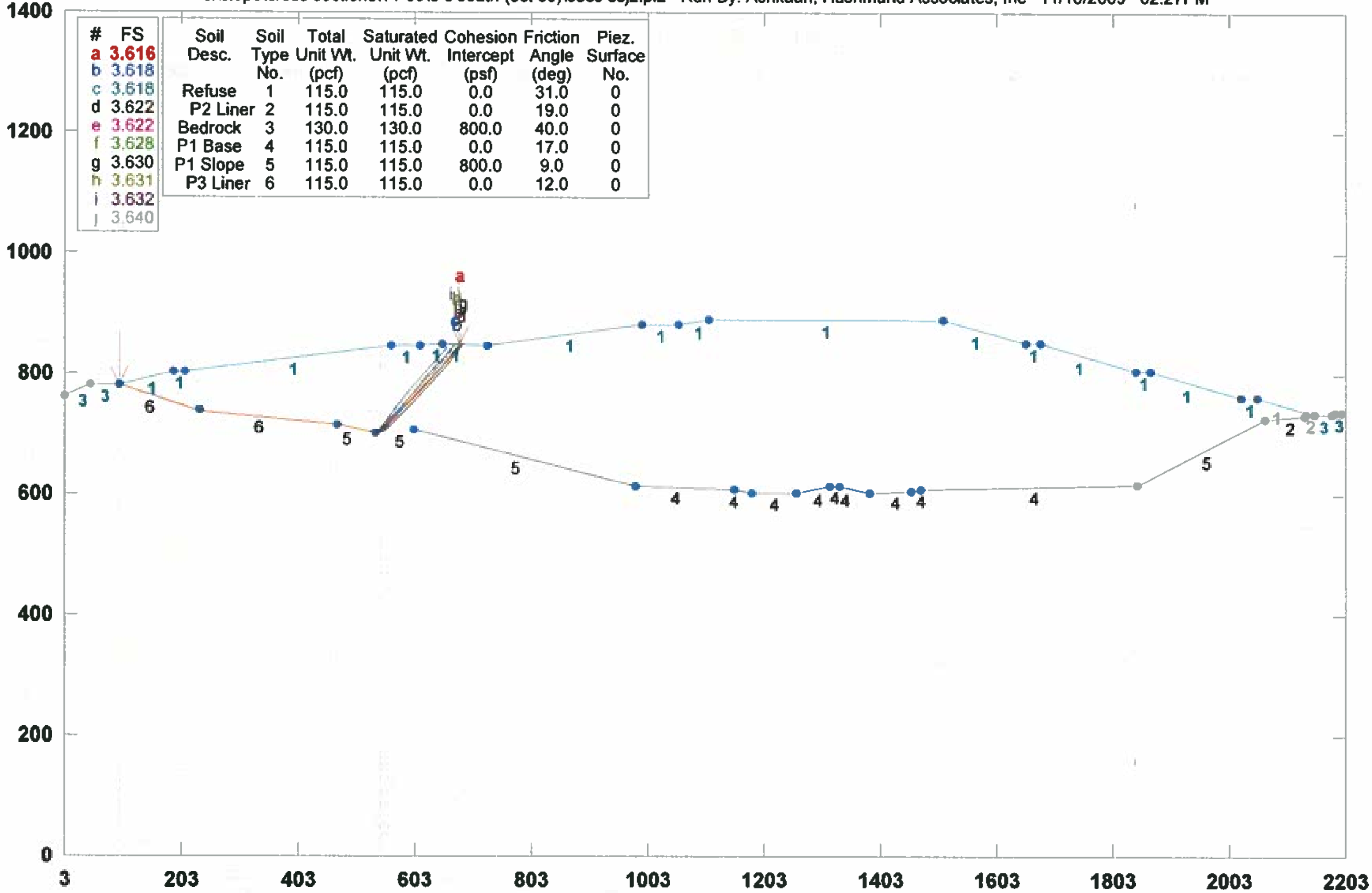


GSTABL7 v.2 FSmin=0.993
Factor Of Safety Is Calculated By GLE (Spencer's) Method (0-2)

GSTABL7

KHF, SEC. C-C',SOUTH, STATIC, FAILURE SURFACE II (REVISED)

c:\slope\cross sections\11-09\c-c south (oct 09)\secc-ssj2.pl2 Run By: Ashkaan, Hushmand Associates, Inc 11/10/2009 02:27PM



GSTABL7 v.2 FSmin=3.616

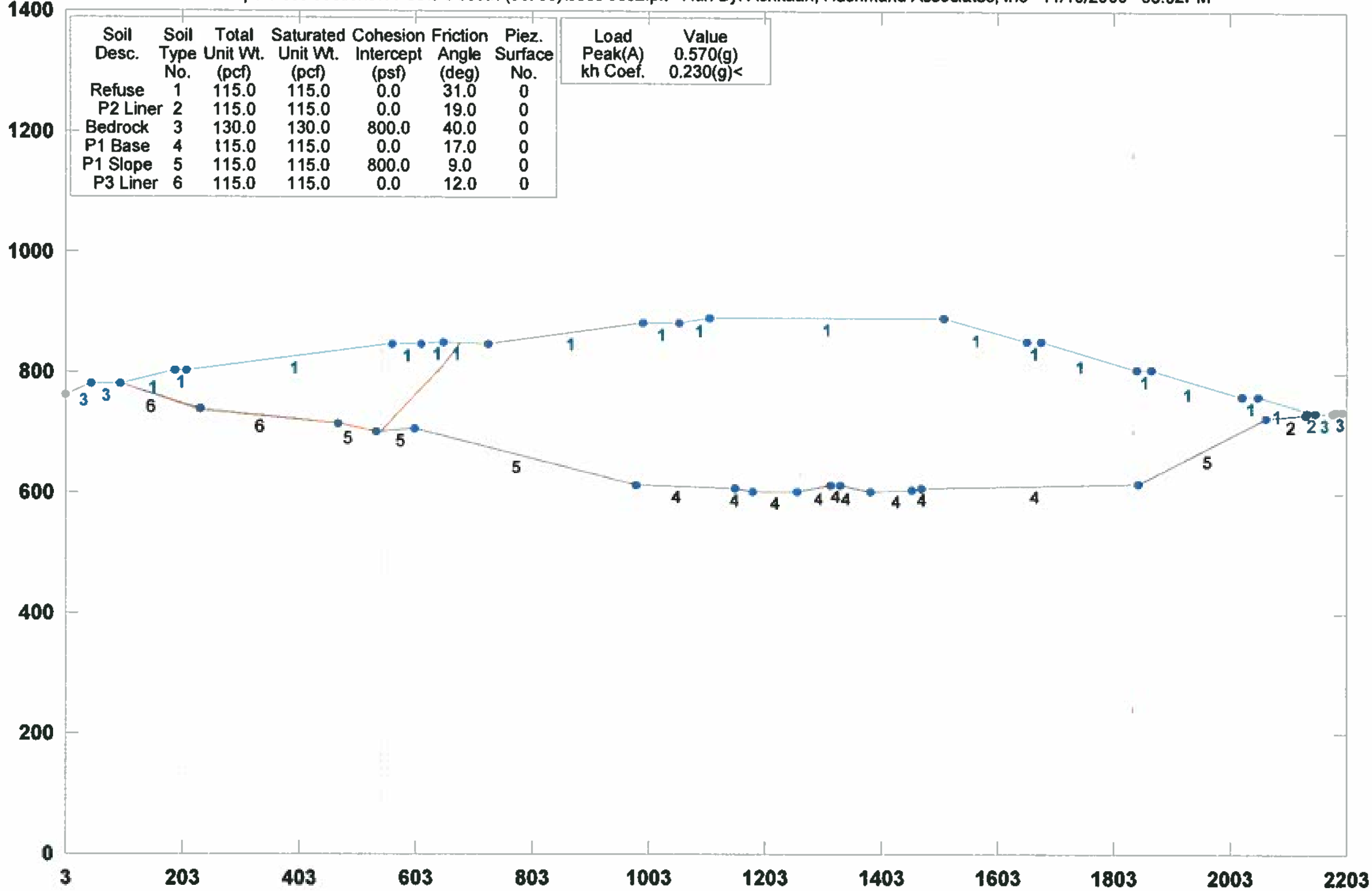
Safety Factors Are Calculated By The Simplified Janbu Method

KHF, SEC. C-C',SOUTH,PSEUDO-STATIC, FAILURE SURFACE II (REVISED)

c:\slope\cross sections\11-09\c-c south (oct 09)\secc-ses2.plt Run By: Ashkaan, Hushmand Associates, Inc 11/10/2009 03:02PM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
P2 Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	t15.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0
P3 Liner	6	115.0	115.0	0.0	12.0	0

Load	Value
Peak(A)	0.570(g)
kh Coef.	0.230(g)<



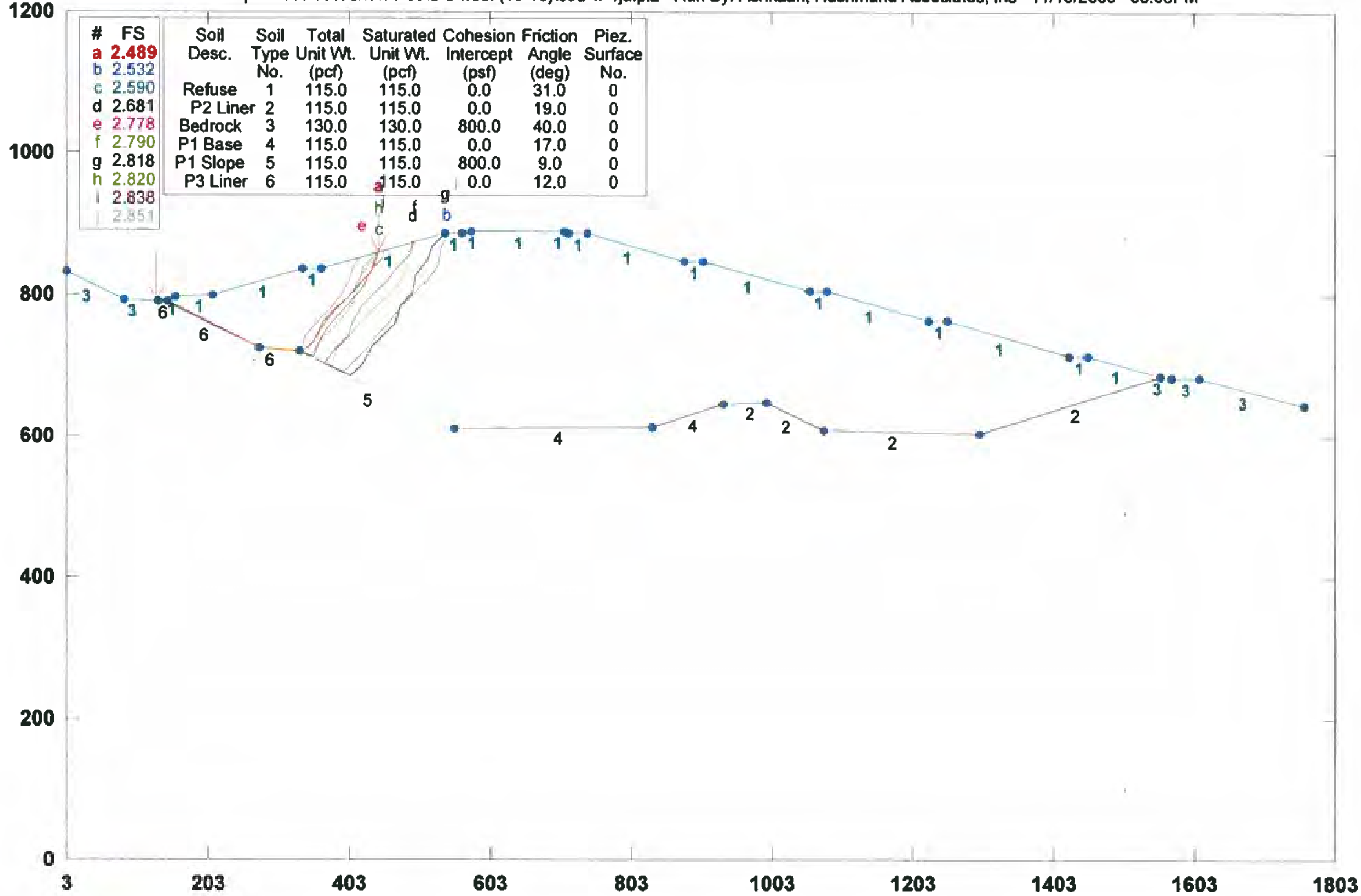
GSTABL7 v.2 FSmin=1.008

Factor Of Safety Is Calculated By The Simplified Janbu Method

GSTABL7

KHF, SEC. D-D',WEST, STATIC, FAILURE PLANE I (REVISED)

c:\slope\cross sections\11-09\d-d west (10-16)\sed-w-1ja.pl2 Run By: Ashkaan, Hushmand Associates, Inc 11/10/2009 03:06PM



GSTABL7 v.2 FSmin=2.489

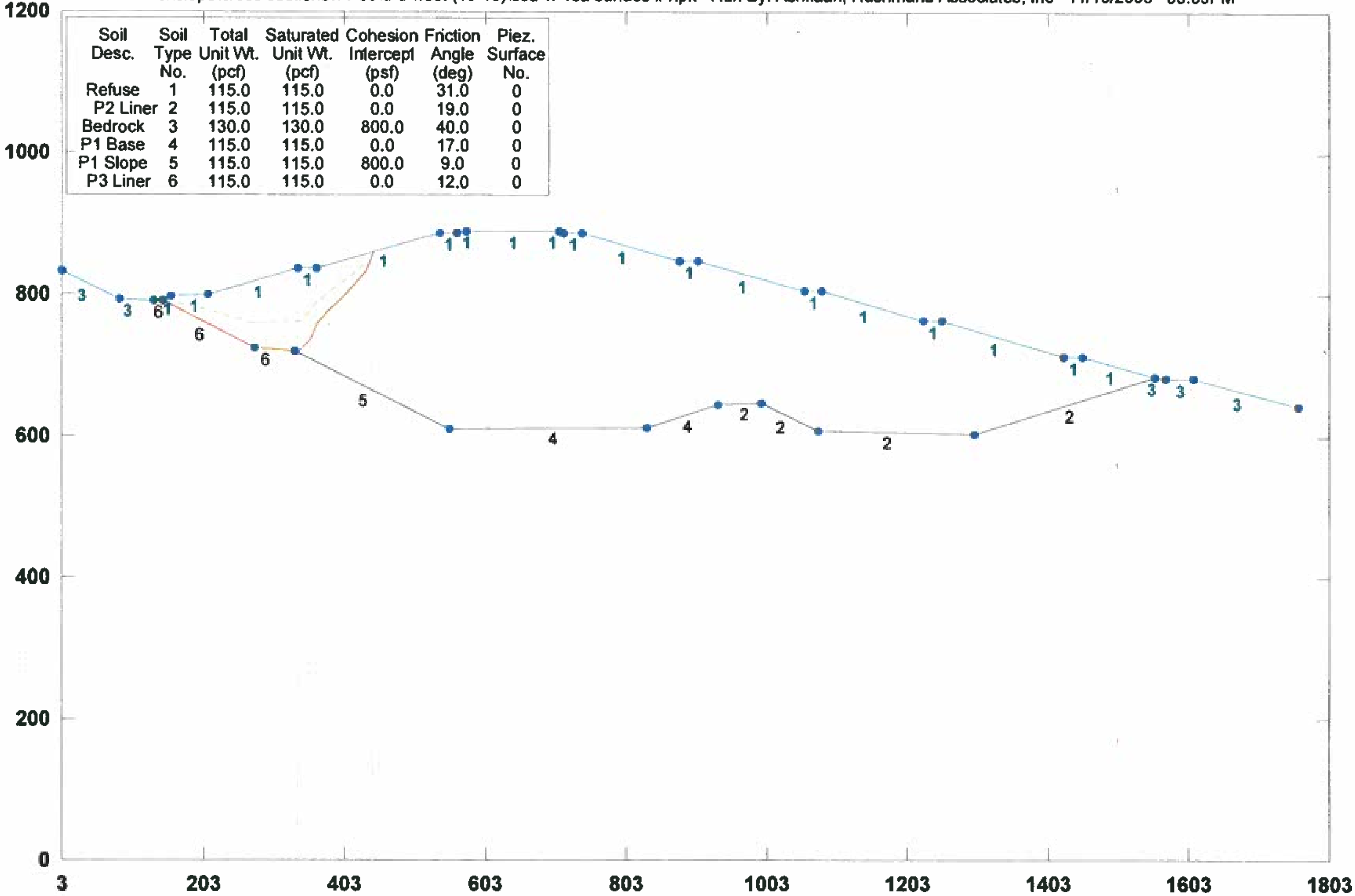
Safety Factors Are Calculated By The Simplified Janbu Method

GSTABL7

KHF, SEC. D-D',WEST, STATIC, FAILURE PLANE I (REVISED)

c:\slope\cross sections\11-09\d-d west (10-16)\sed-w-1sa surface #1.plt   Run By: Ashkaan, Hushmand Associates, Inc   11/10/2009   03:09PM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
P2 Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0
P3 Liner	6	115.0	115.0	0.0	12.0	0



GSTABL7 v.2 FSmin=3.733

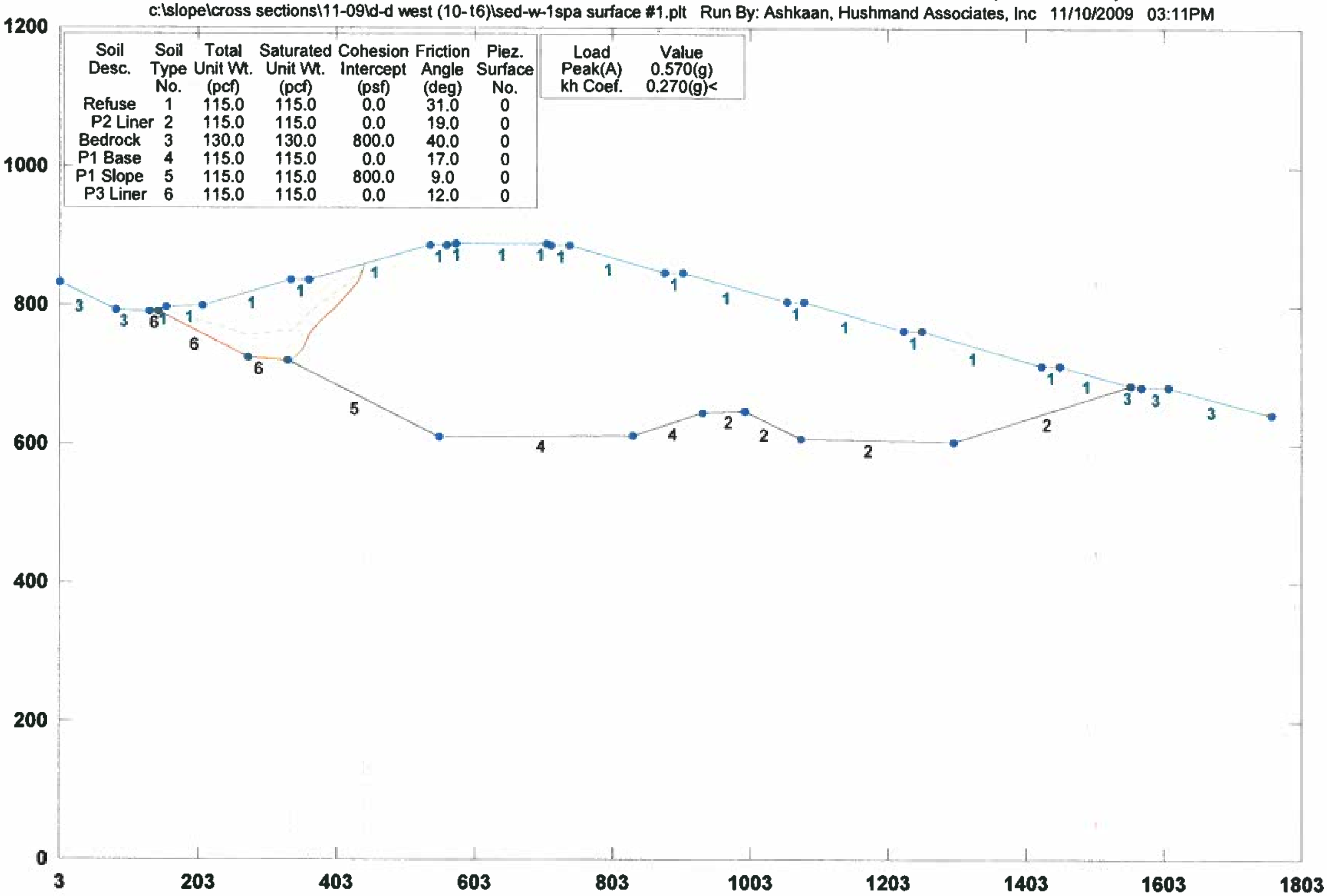
Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

KHF, SEC. D-D',WEST, PSEUDO-STATIC, FAILURE PLANE I (REVISED)

c:\slope\cross sections\11-09\d-d west (10-16)\sed-w-1spa surface #1.plt Run By: Ashkaan, Hushmand Associates, Inc 11/10/2009 03:11PM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
P2 Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0
P3 Liner	6	115.0	115.0	0.0	12.0	0

Load	Value
Peak(A)	0.570(g)
kh Coef.	0.270(g)<



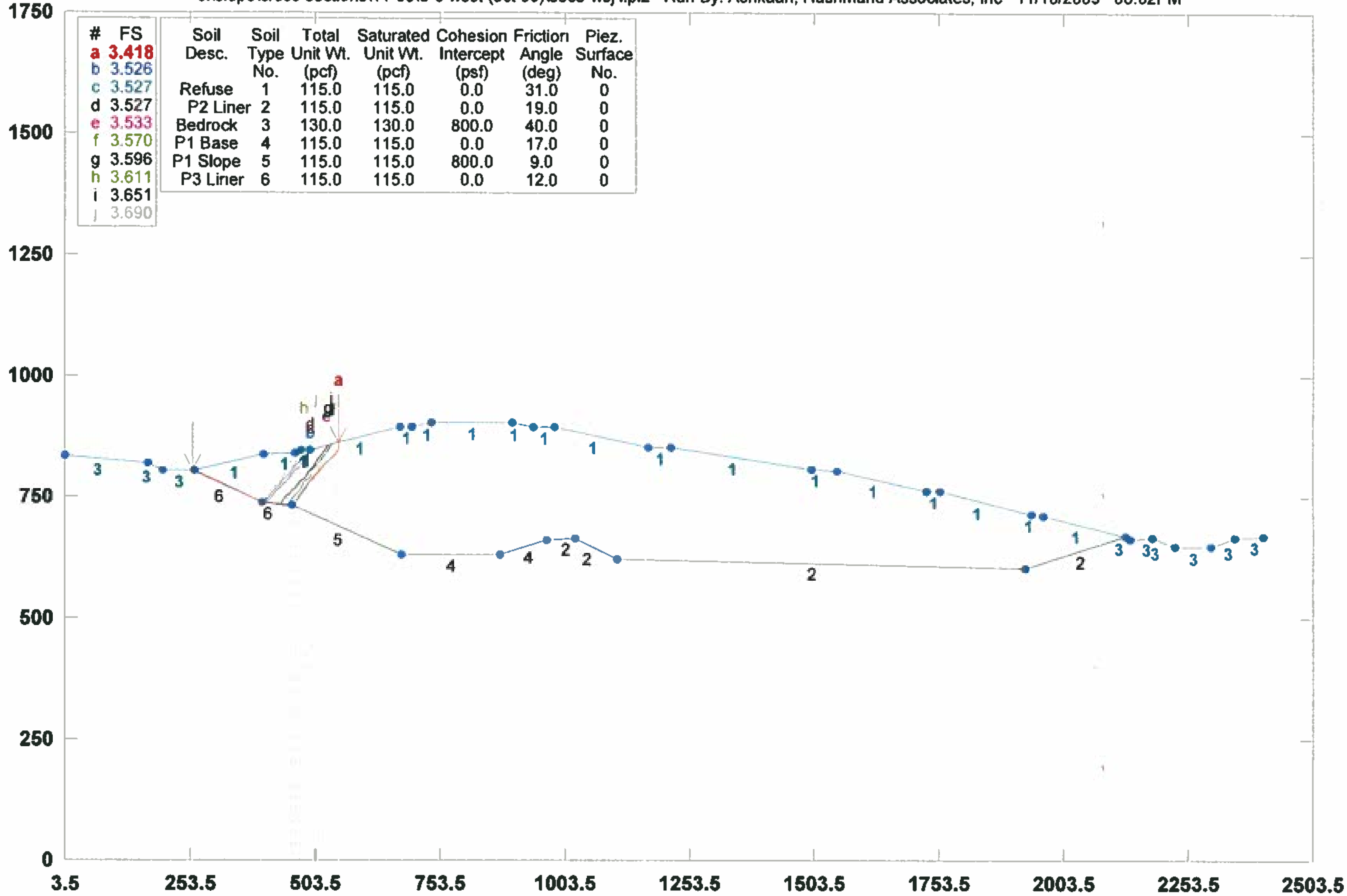
GSTABL7 v.2 FSmin=1.021

Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

GSTABL7

KHF, SECTION E-E' WEST, STATIC, FAILURE PLANE I (REVISED)

c:\slope\cross sections\11-09\e-e west (oct 09)\sece-wsj i.pl2 Run By: Ashkaan, Hushmand Associates, Inc 11/10/2009 06:02PM



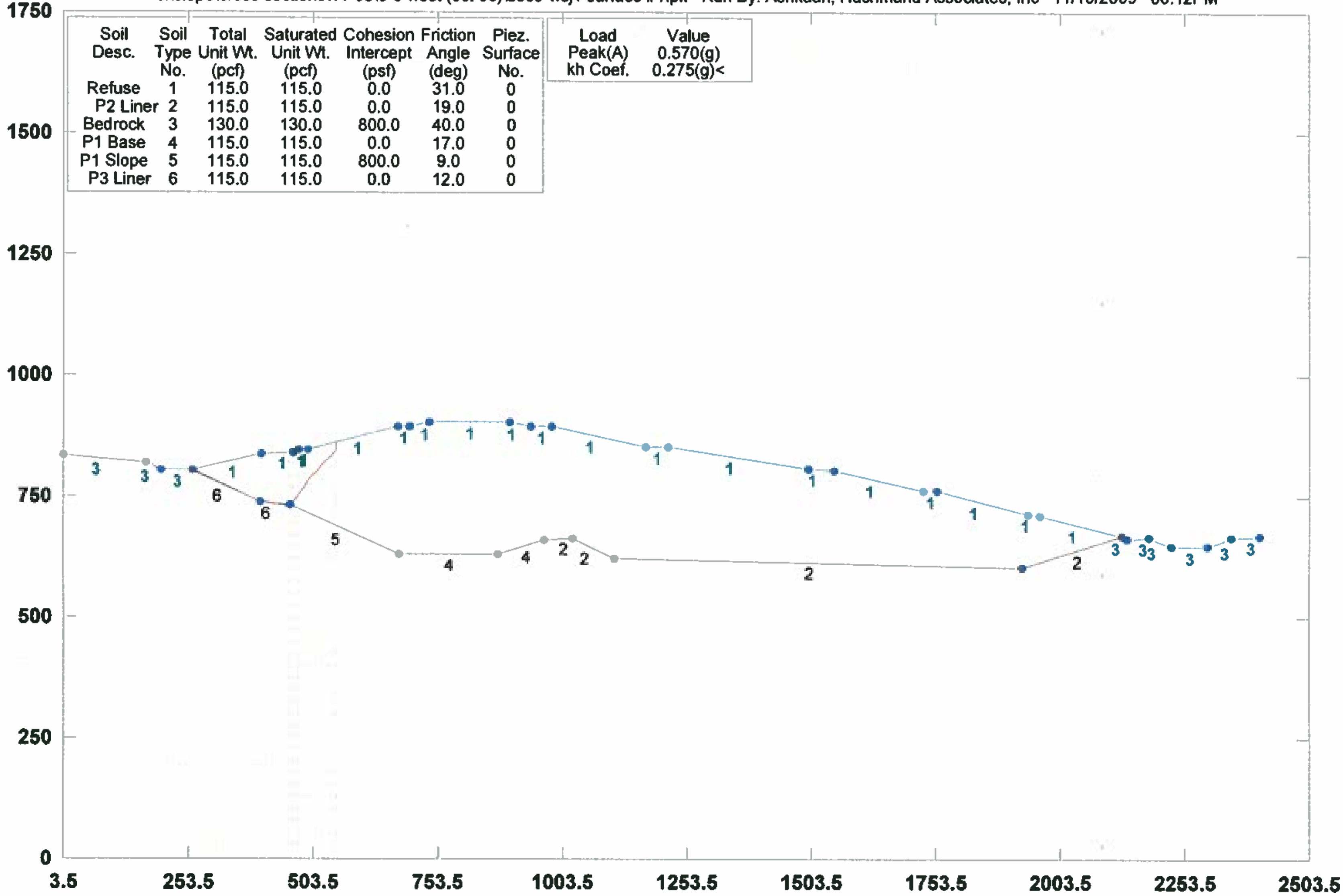
GSTABL7 v.2 FSmin=3.418

Safety Factors Are Calculated By The Simplified Janbu Method

GSTABL7

KHF, SECTION E-E' WEST, PSEUDO-STATIC, FAILURE PLANE I (REVISED)

c:\slope\cross sections\11-09\e-e west (oct 09)\sece-wsj1 surface #1.plt Run By: Ashkaan, Hushmand Associates, Inc 11/10/2009 06:12PM



Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
P2 Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0
P3 Liner	6	115.0	115.0	0.0	12.0	0

Load	Value
Peak(A)	0.570(g)
kh Coef.	0.275(g)<

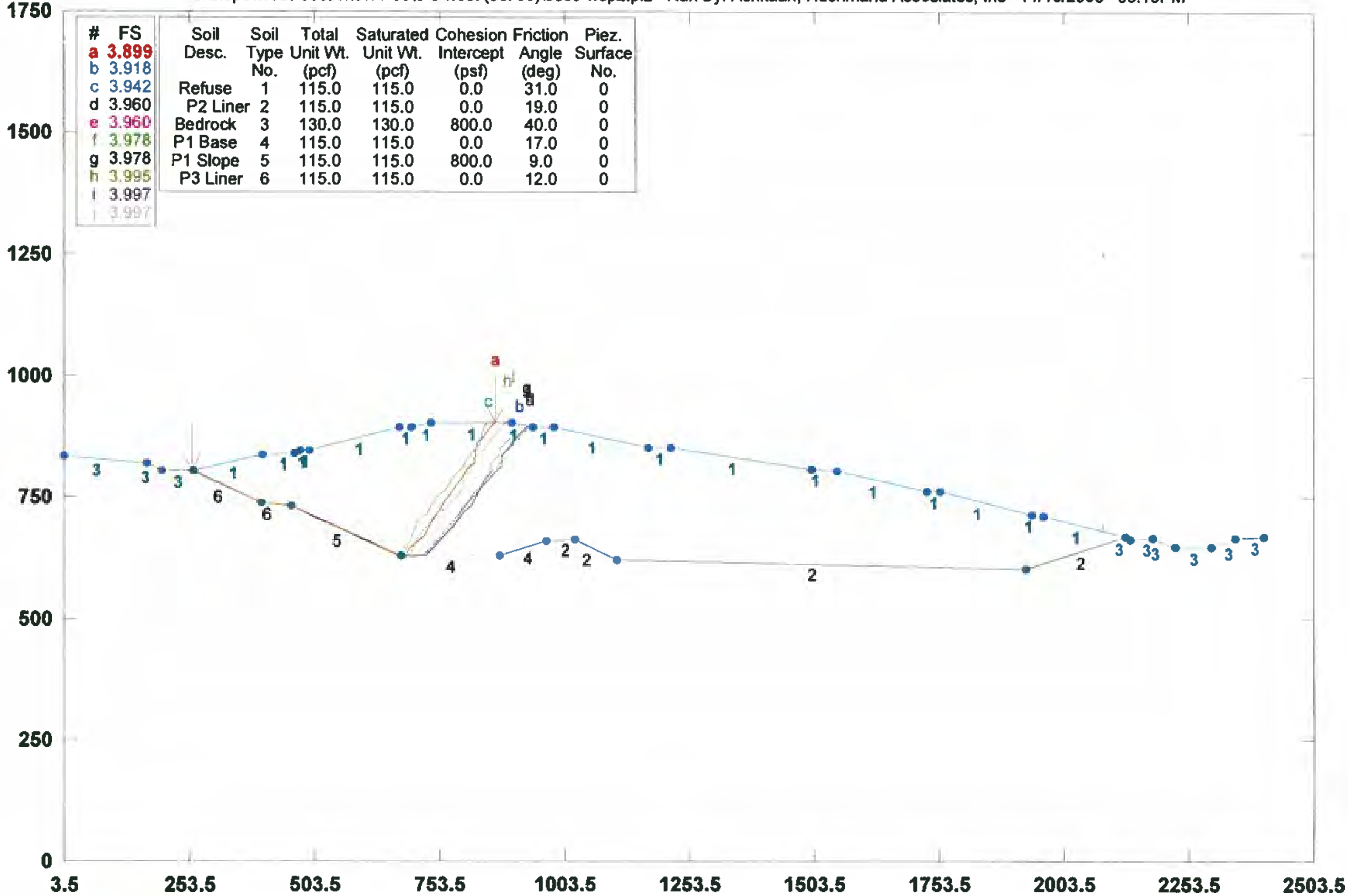
GSTABL7 v.2 FSmin=1.033

Factor Of Safety Is Calculated By The Simplified Janbu Method

GSTABL7

KHF, SECTION E-E', WEST, STATIC, FAILURE PLANE II (REVISED)

c:\slope\cross sections\11-09\e-e west (oct 09)\sece-wsp2.pl2 Run By: Ashkaan, Hushmand Associates, Inc 11/10/2009 06:15PM



GSTABL7 v.2 FSmin=3.899

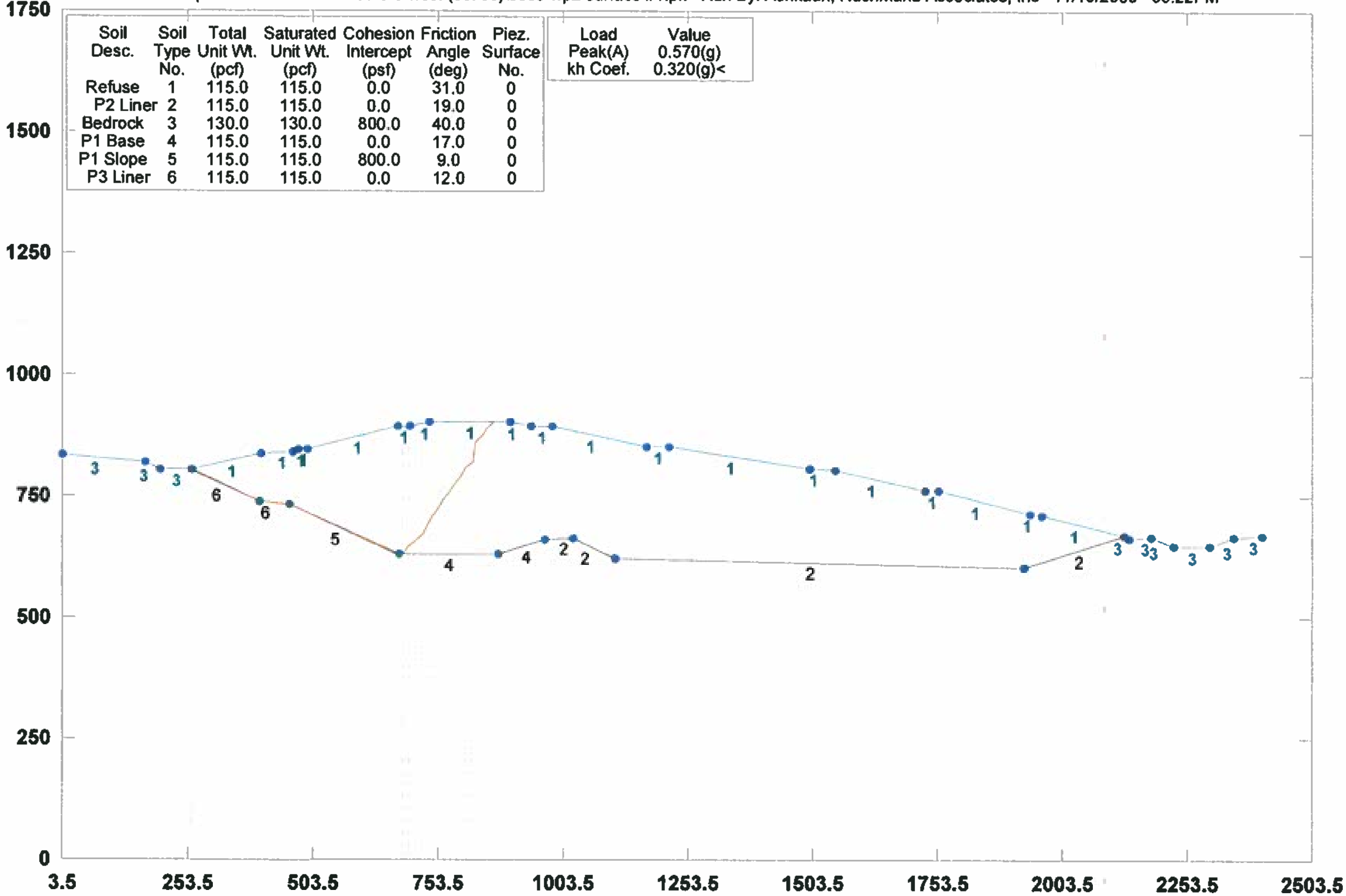
Safety Factors Are Calculated By The Simplified Janbu Method

KHF, SECTION E-E', WEST, PSEUDO-STATIC, FAILURE PLANE II (REVISED)

c:\slope\cross sections\11-09\e-e west (oct 09)\sece-wp2 surface #1.plt Run By: Ashkaan, Hushmand Associates, Inc 11/10/2009 06:22PM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
P2 Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0
P3 Liner	6	115.0	115.0	0.0	12.0	0

Load	Value
Peak(A)	0.570(g)
kh Coef.	0.320(g)<

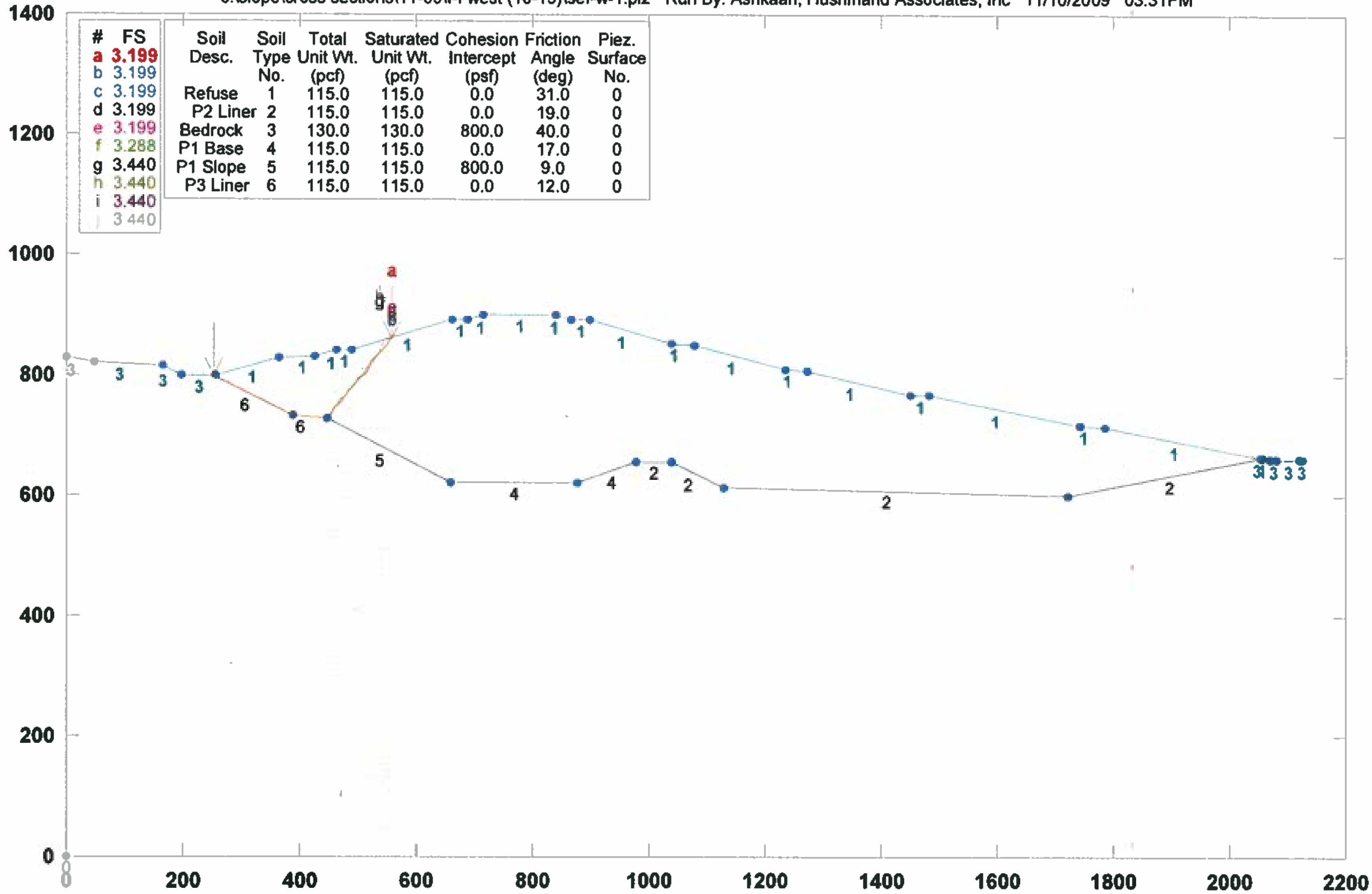


GSTABL7 v.2 FSmin=1.021
Factor Of Safety Is Calculated By The Simplified Janbu Method

GSTABL7

KHF, SECTION F-F', WEST, STATIC, FAILURE PLANE II (REVISED)

c:\slope\cross sections\11-09\f-f west (10-19)\sef-w-1.pl2 Run By: Ashkaan, Hushmand Associates, Inc 11/10/2009 03:31PM



GSTABL7 v.2 FSmin=3.199

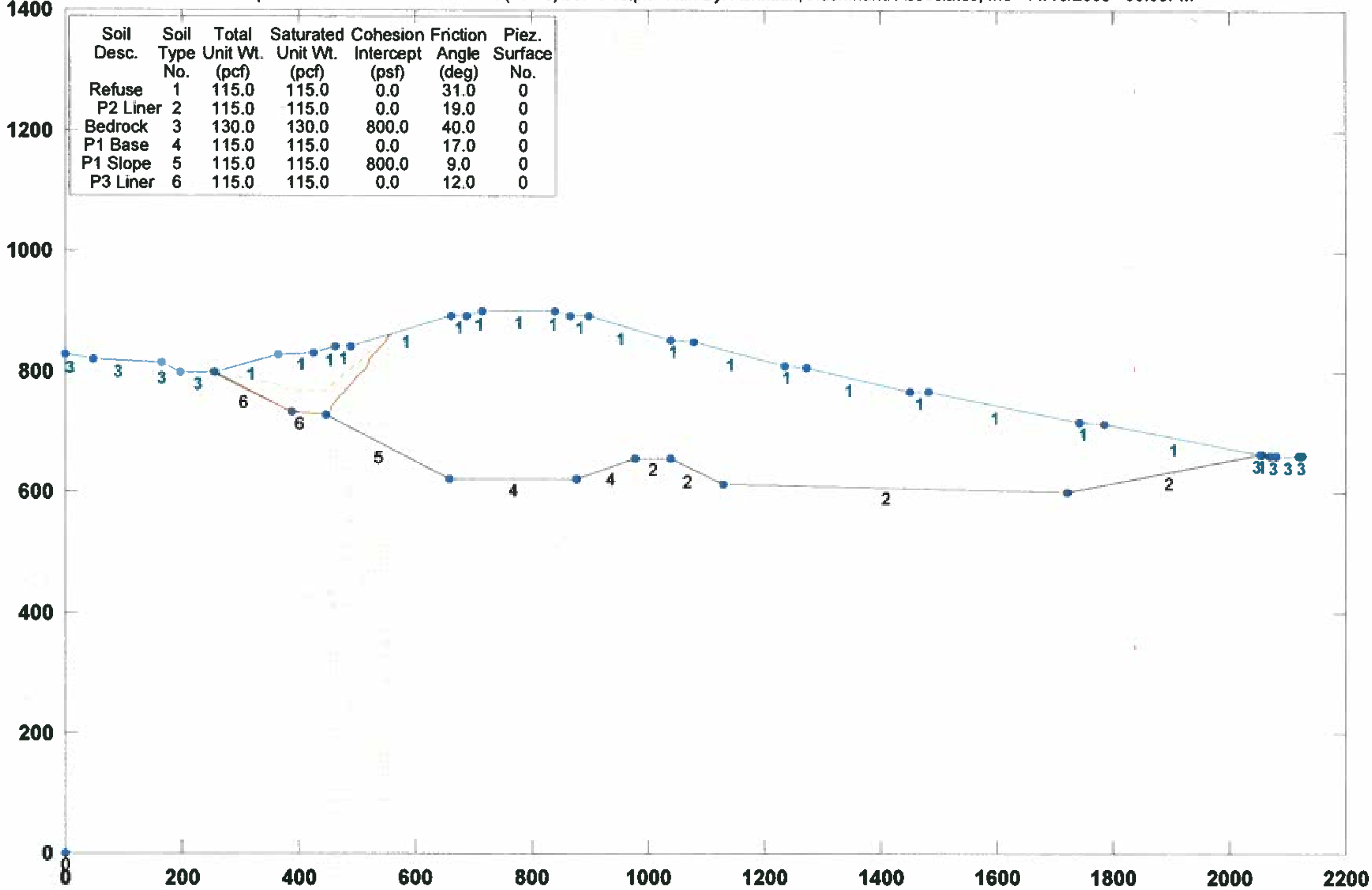
Safety Factors Are Calculated By The Simplified Janbu Method

GSTABL7

KHF, SECTION F-F', WEST, STATIC, FAILURE PLANE II (REVISED)

c:\slope\cross sections\11-09\f-f west (10-19)\sef-w-1s.plt Run By: Ashkaan, Hushmand Associates, Inc 11/10/2009 03:35PM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
P2 Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0
P3 Liner	6	115.0	115.0	0.0	12.0	0



GSTABL7 v.2 FSmin=4.398

Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

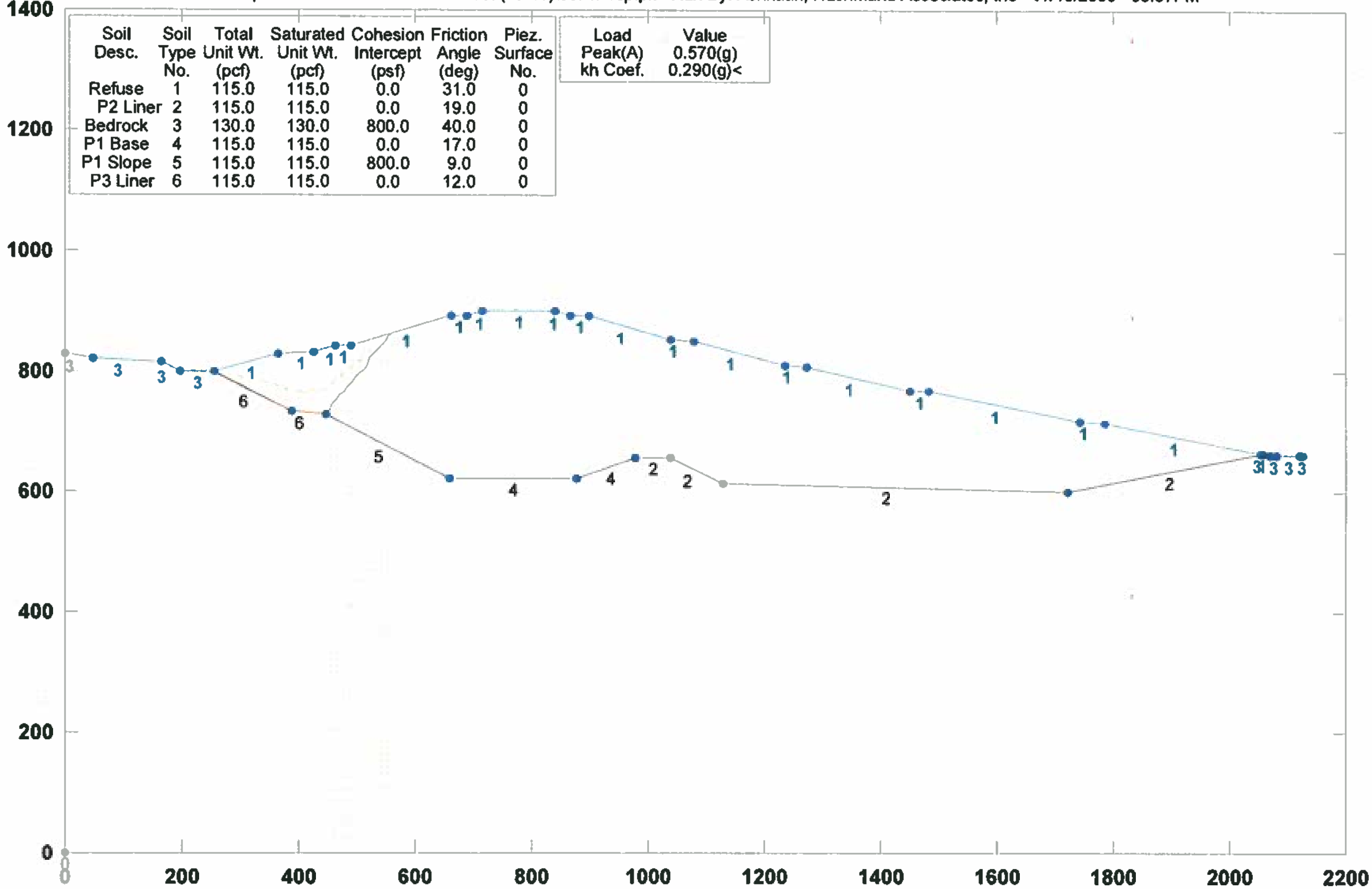
GSTABL7

KHF, SECTION F-F', WEST,PSEUDO-STATIC, FAILURE PLANE II (REVISED)

c:\slope\cross sections\11-09\f-f west (10-19)\sef-w-1sp.plt Run By: Ashkaan, Hushmand Associates, Inc 11/10/2009 03:37PM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
P2 Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0
P3 Liner	6	115.0	115.0	0.0	12.0	0

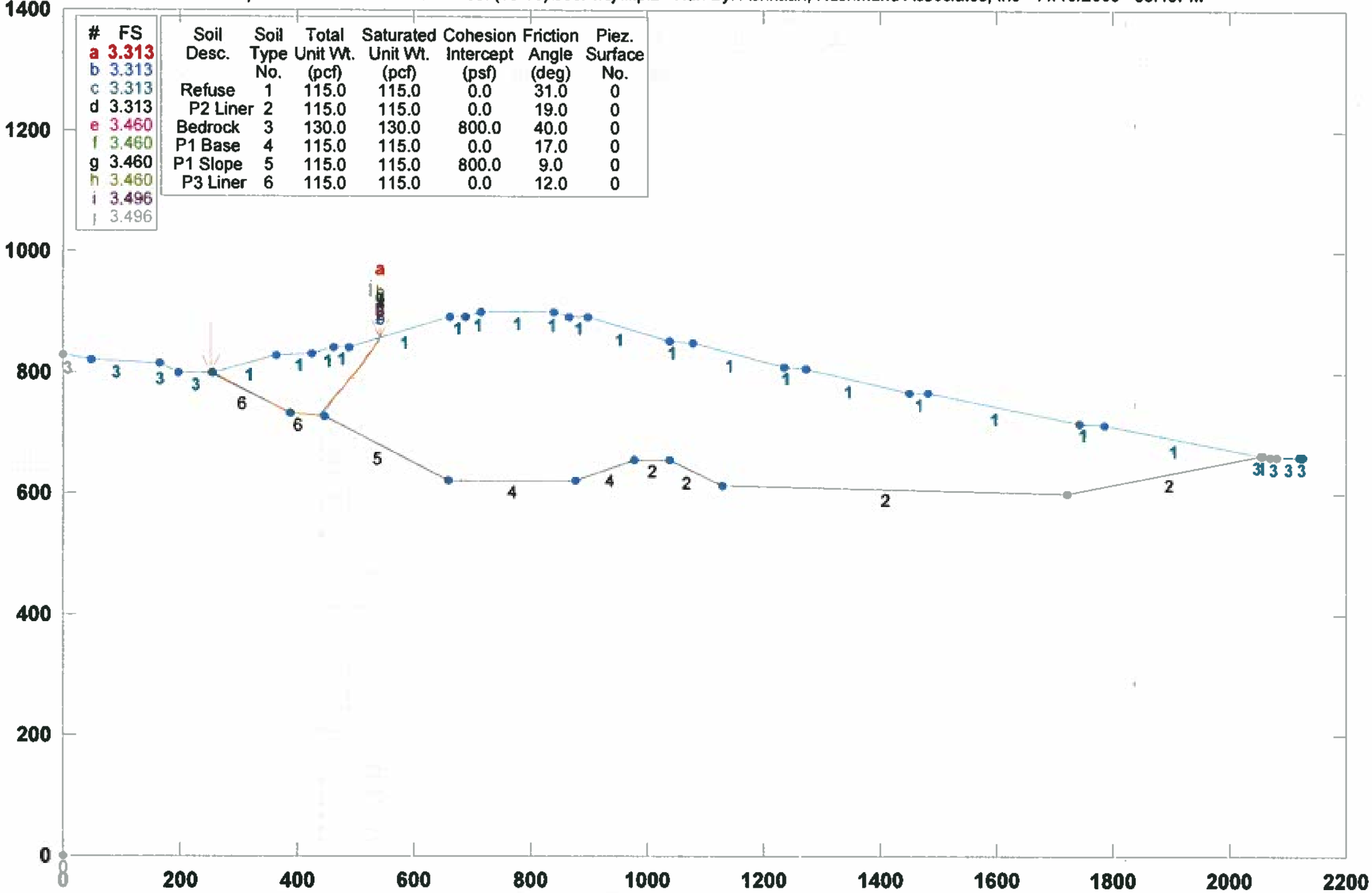
Load	Value
Peak(A)	0.570(g)
kh Coef.	0.290(g)<



GSTABL7 v.2 FSmin=1.010
Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

KHF, SECTION F-F', WEST, STATIC, FAILURE PLANE III (REVISED)

c:\slope\cross sections\11-09\f-f west (10-19)\secf-wsj iii.pl2 Run By: Ashkaan, Hushmand Associates, Inc 11/10/2009 03:40PM



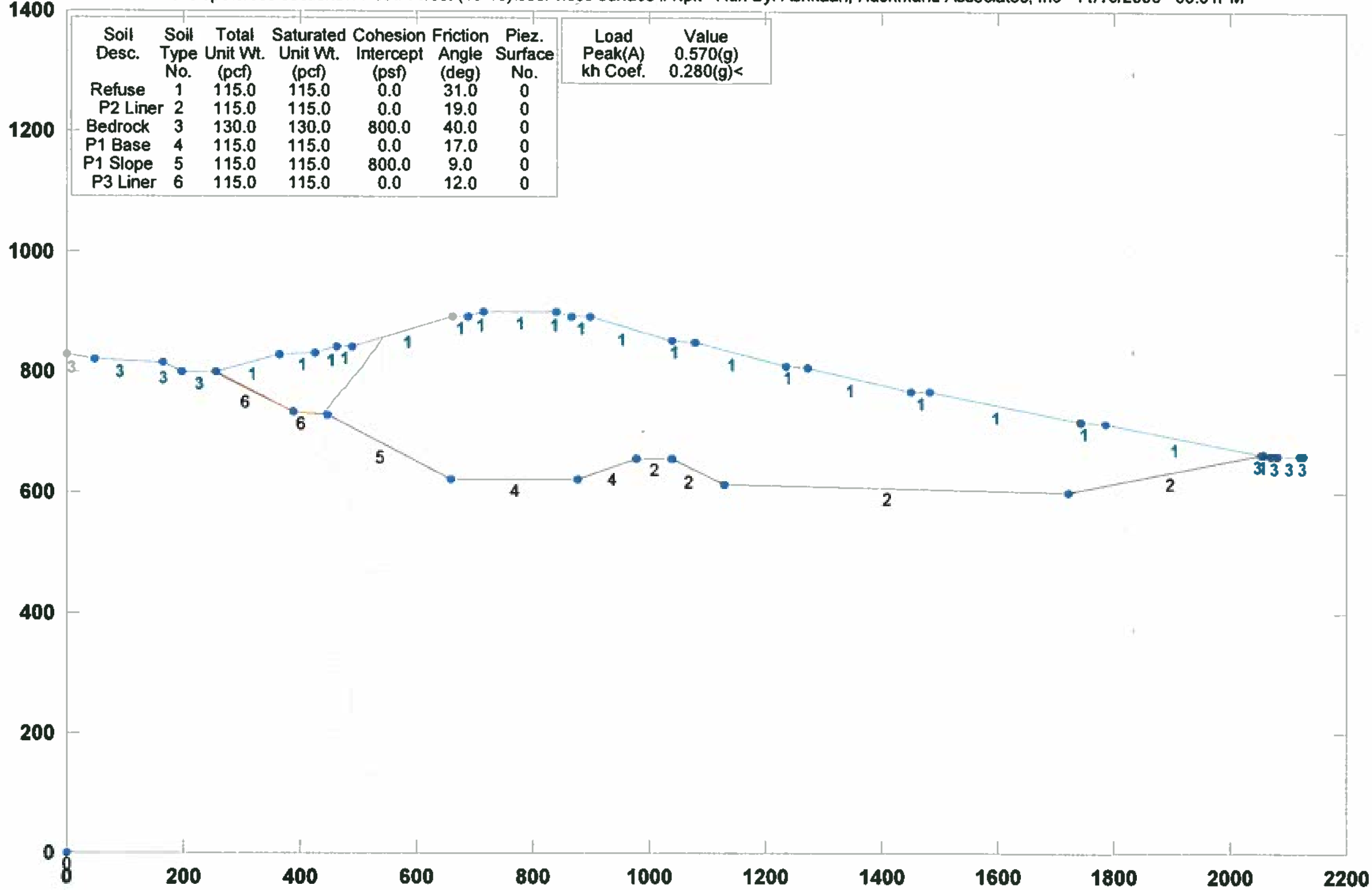
GSTABL7 v.2 FSmin=3.313

Safety Factors Are Calculated By The Simplified Janbu Method

GSTABL7

KHF, SECTION F-F', WEST,PSEUDO-STATIC, FAILURE PLANE III (REVISED)

c:\slope\cross sections\11-09\f-f west (10-19)\secf-wss3 surface #1.plt   Run By: Ashkaan, Hushmand Associates, Inc   11/10/2009   03:51PM



Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Refuse	1	115.0	115.0	0.0	31.0	0
P2 Liner	2	115.0	115.0	0.0	19.0	0
Bedrock	3	130.0	130.0	800.0	40.0	0
P1 Base	4	115.0	115.0	0.0	17.0	0
P1 Slope	5	115.0	115.0	800.0	9.0	0
P3 Liner	6	115.0	115.0	0.0	12.0	0

Load	Value
Peak(A)	0.570(g)
kh Coef.	0.280(g)<

GSTABL7 v.2 FSmin=1.018

Factor Of Safety Is Calculated By The Simplified Janbu Method

GSTABL7

APPENDIX I
SOIL EROSION ANALYSES

Objective:

To estimate and evaluate the soil loss due to surface water erosion from the proposed final closure cover slopes of Landfill B-18.

Given:

The proposed final closure cover slopes of Landfill B-18 will generally consist of benches every 50 vertical feet (maximum) with 3.5H:1V (horizontal:vertical) slopes between benches. Therefore, the worst case cover slope with regard to soil erosion is:

Slope Inclination = 3.5H:1V

Slope = $\frac{1}{3.5}$ = 28.6%

Slope Vertical Height = 50 feet

Slope Horizontal Length = 50×3.5 = 175 feet

Slope Length = $\sqrt{50^2 + 175^2}$ = 182 feet

This worst case cover slope was analyzed as described below.

Based on guidance from the United States Environmental Protection Agency (USEPA, 1989), the soil erosion loss should be less than 2 tons/acre/year (t/ac/yr), as shown in Attachment #1.

Method:

In order to estimate the amount of soil loss on the Landfill B-18 cover due to water erosion, the Revised Universal Soil Loss Equation (RUSLE) was used. The RUSLE was developed by the United States Department of Agriculture, Natural Resources Conservation Service (NRCS) to estimate sheet-rill (both rill and inter-rill) erosion and it considers soil and vegetation type as well as physical and climatic features of the landfill area. The RUSLE is expressed mathematically as:

$$a = r \times k \times l \times s \times c \times p$$

where:

a = daily soil loss due to erosion (units of tons/acre/day);
r = rainfall and runoff erosivity factor;
k = soil erodibility factor;
l = slope length factor;
s = slope steepness factor;
c = cover-management factor; and
p = supporting practices factor.

The daily values of soil erosion loss ("a" values) are summed over an entire year to calculate the estimated annual soil erosion loss (in t/ac/yr). These soil erosion calculations are best made using a computer program.

The RUSLE – Version 2 (RUSLE2) computer program, developed by the NRCS, was used to calculate the potential soil erosion loss from the Landfill B-18 worst-case cover slope described above. The RUSLE2 program was downloaded from the following URL:

http://fargo.nserl.purdue.edu/rusle2_dataweb/RUSLE2_Index.htm

Assumptions:

Climate: The default climate "CA_Kings_R6" was selected from the Kings County climate zones in RUSLE2 as most accurately representing the climate at the Kettleman Hills Facility. The CA_Kings_R6 climate has an annual precipitation of 6.9 inches. For the period of July 1948 through December 2001, the mean annual precipitation for the site was 6.82 inches according to data obtained from the Western Regional Climate Center data base for the Kettleman Climatological Station (see Attachment #2).

Soils: The NRCS has identified three types of soils at the Kettleman Hills Facility. These soils are: Kettleman Loam (5-15% slopes), Kettleman Loam (15-30% slopes), and Kettleman-Cantua Complex (30-50% slopes). The properties of these three soil types, as listed in the RUSLE2 program files, are as follows:

Soil Property	Kettleman Loam (5-15% Slopes)	Kettleman Loam (15-30% Slopes)	Kettleman-Cantua (30-50% Slopes)
Sand Content	40%	40%	40%
Silt Content	38%	38%	38%
Clay Content	23%	23%	23%
Erodibility Factor (k)	0.37	0.37	0.37
RUSLE2 Soil No.	#127	#128	#129

Based on the similarity of the above-listed soils at the Kettleman Hills Facility, Kettleman Loam (15-30% Slopes, RUSLE2 Soil No. 128) was selected to model the Landfill B-18 cover soil. Sensitivity analyses indicated that the three soil types listed above result in the same calculated soil loss if all other variables are held constant.

Calculations:

The soil erosion calculations were performed using the RUSLE2 computer program downloaded from the above-listed URL. The calculations were performed for two scenarios:

1) Bare Slope – the final cover slope was modeled as a construction site with bare ground.
2) Vegetated Slope – the final cover slope was modeled as having permanent ground cover consisting of warm season grass that is not harvested. The amount of grass canopy was reduced 50% from the default (base) value, which increased the amount of calculated erosion.

Results:
The results of the RUSLE2 calculations are shown in Attachment #3, which contains the RUSLE2 Worksheet Erosion Calculation Record sheets for each of the two scenarios analyzed. A summary of the results is given in the table below:

Scenario	Final Cover Slope Inclination	Computed Soil Erosion Loss (t/ac/yr)
Bare Ground	3.5H:1V	9.2
Vegetated Ground	3.5H:1V	0.97

Conclusions:
Once vegetation is established on the Landfill B-18 final cover slopes, the amount of soil erosion loss is estimated to be approximately half of the recommended maximum of 2 t/ac/yr (USEPA, 1989). As discussed in the RUSLE2 program documentation, the results obtained from RUSLE2 are to be used as guides in evaluating soil erosion potential and mitigation measures for soil erosion. As shown in the current case for Landfill B-18, maintaining vegetative cover on the final landfill sideslopes is essential for limiting soil erosion loss to an acceptable amount.

Commentary:
Golder has been providing engineering services at the Kettleman Hills Facility for over 20 years, including over 10 years of annual post-closure inspections. During this period, several landfill units have been closed. Unit B-13, Unit B-15, and the Combined Closure Area (totaling over 100 acres) were closed in the early- to mid- 1990's. Based on observations of the final cover slopes of these areas, soil erosion does not appear to be a problem at the Kettleman Hills Facility when vegetation is present.

Reference:

United States Environmental Protection Agency, "Technical Guidance Document: Final Covers on Hazardous Waste Landfills and Surface Impoundments," EPA/530-SW-89-047, July 1989.

ATTACHMENT #1
SOIL EROSION ANALYSES

Attachment #1 p. 1/6

United States Environmental Protection Agency

Office of Solid Waste and Emergency Response Washington DC 20460

EPA/530-SW-89-047
July 1989

EPA

Technical Guidance Document:

Final Covers on Hazardous Waste Landfills and Surface Impoundments

Attachment #1 p. 4/6

EPA/530-SW-89-047
July 1989

TECHNICAL GUIDANCE DOCUMENT

FINAL COVERS ON HAZARDOUS WASTE LANDFILLS AND SURFACE IMPOUNDMENTS

Office of Solid Waste and Emergency Response
U.S. Environmental Protection Agency
Washington, DC 20460

In cooperation with

RISK REDUCTION ENGINEERING LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OHIO 45268

Table 2. Synopsis of Minimum Technology Guidance for Covers

Layer	Thickness	Slope	Requirements
Top Layer			
Vegetation	--	--	Persistent, drought-resistant, adapted to local conditions.
OR			
Surface Armor	5-10 in. (13-25 cm)		Cobbles, gravel.
ON			
Soil	≥ 24 in. (≥ 60 cm)	3-5%	Erosion rate <2 ton/acre/yr (5.5 MT/ha/yr). *
Drainage Layer			
Soil	≥ 12 in. (≥ 30 cm)	≥ 3%	SP (USCS) soil $K > 1 \times 10^{-2}$ cm/s; gravel toe drain.
OR			
Geosynthetic	variable	≥ 3%	Performance equivalent to soil, hydraulic transmissivity $\geq 3 \times 10^{-5}$ m^2/sec.
Low-Permeability Layer			
FML	≥ 20 mils (≥ 0.5 mm)	≥ 3%	In EPA Report No. EPA 600/2-88-052.
ON			
Low-Permeability Soil	≥ 24 in. (≥ 60 cm)	≥ 3%	In-place $K < 1 \times 10^{-7}$ cm/s and test fill.
Optional Layers (site-specific design)			
Gas Vent Layer	≥ 12 in. (≥ 30 cm)	≥ 2%	Similar to drainage layer.
Biotic Barrier	animal or root-dependent	--	Large materials, e.g., cobbles.

2. TOP LAYER

The Agency recommends a two-component top layer for a landfill cover system (Figure 1). The upper component should be vegetation or other surface treatment, designed to impede erosion but allowing surface runoff from major storm events. The Agency believes that, in most cases, vegetation underlain by soil, at least part of which is topsoil, will best accomplish these objectives. However, in some areas the prevailing climate may inhibit the establishment and maintenance of vegetation, or a planned alternative use of the site may preclude vegetation. In those cases, an armored surface without vegetation (Figure 2), and underlain by fill soil, might be used if it will minimize erosion and abrasion of the cover and allow, to the maximum practicable extent, surface drainage off the cover.

2.1 DESIGN

The Agency recommends that the vegetation component of the top layer meet the following specifications:

- o Locally adapted perennial plants.
- o Resistant to drought and temperature extremes.
- o Roots that will not disrupt the low-permeability layer.
- o Capable of thriving in low-nutrient soil with minimum nutrient addition.
- o Sufficient plant density to minimize cover soil erosion to no more than 2 tons/acre/year (5.5 MT/ha/yr), calculated using the USDA Universal Soil Loss Equation. } *
- o Capable of surviving and functioning with little or no maintenance.

In landfill situations where the environment or other considerations make it inappropriate for maintaining sufficiently dense vegetation, armoring material may be substituted as the upper component of the top layer or in rare cases the whole layer. It is recommended that the material possess the following characteristics:

- capable of remaining in place and minimizing erosion of itself and the underlying soil component during extreme weather events of rainfall and/or wind;

- capable of accommodating settlement of the underlying material without compromising the purpose of the component;

- surface slope approximately the same as the underlying soil (at least 3 percent slope); and

- capable of controlling the rate of soil erosion from the cover to no more than 2 tons/acre/year (5.5 MT/ha/yr), calculated by using the USDA Universal Soil Loss Equation. *

Agency-recommended specifications for the lower soil component of the top layer include the following:

- for vegetation support, a minimum thickness of 60 cm (24 in.) including at least 15 cm (6 in.) of topsoil (soil of lower quality may be used beneath an armored surface); greater total thickness where required, e.g., where maximum frost penetration exceeds this depth, or where greater plant-available water storage is necessary or desirable;

- medium texture to facilitate seed germination and plant root development;

- final top slope, after allowance for settling and subsidence, of at least 3 percent, but no greater than 5 percent, to facilitate runoff while minimizing erosion; and

- minimum compaction to facilitate root development and sufficient infiltration to maintain growth through drier periods.

The owner or operator of the landfill should prepare a separate section specific to monitoring construction of the top layer to be included in the construction quality assurance (CQA) plan.

2.2 DISCUSSION

2.2.1 <u>Upper Component of Top Layer</u>

As noted in the design recommendations above, the upper component of the top layer may be vegetation (Agency-preferred where possible) or other erosion-impeding materials. These are discussed separately below.

Attachment #1 p. 6/6

and, in general, increase the long-term maintenance of the cover system. Owners and operators using final slopes based on site-specific conditions should determine that the slopes will not result in the formation of erosion rills and gullies and will limit total erosion to less than 2.0 tons/acre/year (5.5 MT/ha/yr). The U.S. Department of Agriculture's Universal Soil Loss Equation (USLE) is recommended as the tool for use in evaluating erosion potential (EPA, 1982a). The Agency believes that a maximum erosion rate of 2.0 tons/acre/year (5.5 MT/ha/yr) is realistically achievable for a wide range of soils, climates, and vegetation. The Agency also believes that reliance on this criterion will minimize gully development and cover maintenance. *

ATTACHMENT #2
SOIL EROSION ANALYSES

Attachment #2 p. 1/1

KETTLEMAN STN, CALIFORNIA (044536)

Period of Record Monthly Climate Summary

Period of Record : 7/ 1/1948 to 12/31/2001

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	55.2	61.9	67.3	75.1	84.3	93.1	99.2	97.1	91.3	80.7	66.6	55.9	77.3
Average Min. Temperature (F)	38.5	43.3	45.8	50.0	56.2	63.3	69.2	67.9	63.7	56.2	46.8	39.5	53.4
Average Total Precipitation (in.)	1.42	1.37	1.13	0.61	0.29	0.05	0.01	0.03	0.19	0.28	0.64	0.80	6.82
Average Total SnowFall (in.)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Average Snow Depth (in.)	0	0	0	0	0	0	0	0	0	0	0	0	0

Percent of possible observations for period of record.
Max. Temp.: 60.6% Min. Temp.: 60.1% Precipitation: 97.2% Snowfall: 97.4% Snow Depth: 97.4%
Check Station Metadata or Metadata graphics for more detail about data completeness.

Western Regional Climate Center, wrcc@dri.edu

ATTACHMENT #3
SOIL EROSION ANALYSES

Attachment #5
p. 1/2

NRCS Natural Resources Conservation Service

RUSLE2 Worksheet Erosion Calculation Record

Info: Kettleman Hills Facility - Landfill Unit B-18
3.5H:1V, 50-foot-tall final cover slopes (bare)

Inputs:

Owner name	***Location***
Waste Management, Inc.	**California\Kings County\CA_Kings_ R6**

Location	*Soil*	*Slope length (horiz)*	*Avg. slope steepness, %*
California\Kings County\CA_Kings_ R6	128 KETTLEMAN LOAM, 15 TO 30 PERCENT SLOPES\KETTLEMAN loam 85%	182	28.6

Outputs:

Management	*Contouring*	*Strips / barriers*	*Diversion/terrace, sediment basin*	*Soil loss erod. portion, t/ac/yr*	*Soil detachment, t/ac/yr*	*Cons. plan. soil loss, t/ac/yr*	*Sed. delivery, t/ac/yr*
Bare ground	a. rows up-and-down hill	(none)	(none)	9.2	9.2	9.2	9.2

NRCS Natural Resources Conservation Service

Attachment #3
p. 2/2

RUSLE2 Worksheet Erosion Calculation Record

Info: Kettleman Hills Facility - Landfill Unit B-18
3.5H:1V, 50-foot-tall final cover slopes (vegetated)

Inputs:

Owner name	*Location*
Waste Management, Inc.	**California\Kings County\CA_Kings_ R6**

Location	*Soil*	*Slope length (horiz)*	*Avg. slope steepness, %*
California\Kings County\CA_Kings_ R6	128 KETTLEMAN LOAM, 15 TO 30 PERCENT SLOPES\KETTLEMAN loam 85%	182	28.6

Outputs:

Management	*Contouring*	*Strips / barriers*	*Diversion/terrace, sediment basin*	*Soil loss erod. portion, t/ac/yr*	*Soil detachment, t/ac/yr*	*Cons. plan. soil loss, t/ac/yr*	*Sed. delivery, t/ac/yr*
Warm season grass; not harvested	a. rows up-and-down hill	(none)	(none)	0.97	0.97	0.97	0.97

APPENDIX J

SURFACE WATER DRAINAGE ANALYSES

APPENDIX J.1

PHASES I AND II HYDROLOGY AND DESIGN CRITERIA

ENVIRONMENTAL SOLUTIONS, INC.

By JJm Date 8-15-90 Subject LANDFILL B+8 Sheet No. 1 of 59

Chkd. By ____ Date ____ DRAINAGE DESIGN Proj. No. 89.97?

TABLE OF CONTENT

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29

ENVIRONMENTAL SOLUTIONS, INC.

By TPL Date 7-24-90 Subject LANDFILL B-18 DRAINAGE SYSTEM Sheet No. 2 of 59
Chkd. By N.A. Date 8-14-90 Proj. No. 89-977

PURPOSE: DESIGN LANDFILL B-18 DRAINAGE SYSTEM

DESIGN CRITERIA:

1. MAJOR DRAINAGE FEATURES ARE SIZED FOR PROBABLE MAXIMUM PRECIPITATION.
2. LESS CRITICAL DRAINAGE FEATURES ARE SIZED FOR 25-YEAR STORM.

METHODOLOGY: MAXIMUM DISCHARGE FOR DIVERSION DITCHES AND CULVERTS ARE DETERMINED BY THE RATIONAL METHOD, WHICH TAKES THE FORM OF

$$Q = C i A$$

WHERE

Q = MAXIMUM DISCHARGE (cfs)
i = RAINFALL INTENSITY (in/HR)
A = DRAINAGE AREA
C = RUNOFF COEFFICIENT

DIVERSION PIPES/DITCHES WILL BE SIZED USING THE MANNING'S FORMULA WHICH TAKES THE FORM OF

$$Q = \frac{1.486}{n} A R^{2/3} S^{1/2}$$

WHERE

R = HYDRAULIC RADIUS
S = DITCH BED SLOPE
Q = MAXIMUM DISCHARGE CAPACITY
n = ROUGHNESS COEFFICIENT
A = EFFECTIVE DRAINAGE AREA.

DETERMINATION OF TIME OF CONCENTRATION

TIME OF CONCENTRATION MAY BE DETERMINED BY

1. $T_c = \left(\frac{11.9\ L^3}{H}\right)^{0.385}$ (REFERENCE)

WHERE

T_c = TIME OF CONCENTRATION

L = LENGTH OF FLOW PATH (MILES)

H = ELEVATION DIFFERENCE (FEET)

OR

2. $T_c = L / \left(\frac{1.486}{n} R^{2/3} S^{1/2}\right)$

WHERE

L = LENGTH OF FLOW PATH

n = ROUGHNESS COEFFICIENT

R = HYDRAULIC RADIUS

S = DITCH BED SLOPE

DETERMINATION OF RUNOFF COEFFICIENT

IF THE DRAINAGE BASIN UNDER CONSIDERATION CONSISTS OF MATERIALS WITH DIFFERENT SURFACE CHARACTERISTICS, A COMPOSITE RUNOFF COEFFICIENT WILL BE USED. THE COMPOSITE RUNOFF COEFFICIENT C_c MAY BE DETERMINED BY:

$$C_c = \frac{\Sigma C_i A_i}{\Sigma A_i}$$

WHERE C_i & A_i IS THE RUNOFF COEFFICIENT AND THE SURFACE AREA FOR EACH INDIVIDUAL MATERIAL, RESPECTIVELY. TYPICAL RUNOFF COEFFICIENT VALUES FOR DIFFERENT MATERIALS ARE SHOWN IN EXHIBIT 1.

WITH THE ON-SITE MATERIAL IS SIMILAR TO THE TYPE C SOIL IN SOLANO COUNTY, A RUNOFF COEFFICIENT C OF 0.4 IS USED

ENVIRONMENTAL SOLUTIONS, INC.

By Vpi Date 8-12-90 Subject LANDFILL B-18 Sheet No. 4 of 59

Chkd. By N.A. Date 8-14-90 DRAINAGE DESIGN Proj. No. 89-977

CULVERT DESIGN IS BASED ON INLET CONTROL MONOGRAPH (EXHIBIT 2.).

SHORT-TERM RAINFALL INTENSITY / DURATION RELATIONSHIPS ARE BASED ON PMP RECORD FOR COALINGA STATION (EXHIBIT 3) THE RAINFALL INTENSITY DURATION CURVE IS SHOWN ON EXHIBIT 4. EXHIBIT 5 ALSO SHOWS THE THE 25-YEAR STORM RAINFALL INTENSITY / DURATION RELATIONSHIPS FOR COALINGA STATION FOR CULVERT DESIGN. EXHIBIT 6 SHOWS THE RELATIVE LOCATION BETWEEN THE SITE AND THE COALINGA STATION. EXHIBIT 7 SHOWS THE PRECIPITATION DEPTH - DURATION - FREQUENCY DATA USED TO DEVELOPE THE RAINFALL INTENSITY CURVE.

ENVIRONMENTAL SOLUTIONS, INC.

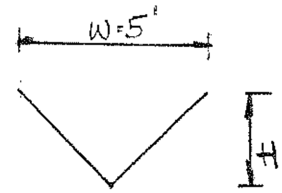
By JPL Date 7-31-90 Subject LANDFILL BHB DRAINAGE DESIGN Sheet No. 5 of 59

Chkd. By N.A. Date 8-14-90 Proj. No. 89-971

TRIANGULAR DITCH CAPACITY

(W=5 ft)

A_F = FLOW AREA (ASSUME FLOW FULL)



P_W = WETTED PERIMETER = $2 \times \sqrt{2.5^2 + H^2}$

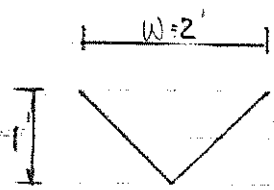
R = HYDRAULIC RADIUS = A_T / P_W

$$Q = \frac{1.486}{n} A R^{2/3} S^{1/2}$$

n = 0.013 FOR SMOOTH ASPHALT (EXHIBIT 9)

TYPE	H (FT)	A_T (FT²)	P_W (FT)	R (FT)	Q (CFS)	V (FPS)
2	1	2.5	5.38	0.46	171.3 $S^{1/2}$	68.52 $S^{1/2}$
3	1.25	3.13	5.59	0.56	243.0 $S^{1/2}$	77.66 $S^{1/2}$
4	1.5	3.75	5.83	0.64	319.4 $S^{1/2}$	84.89 $S^{1/2}$
5	2	5	6.40	0.78	484.5 $S^{1/2}$	96.9 $S^{1/2}$
6	2.5	6.25	7.07	0.88	658.0 $S^{1/2}$	105.3 $S^{1/2}$
7	3	7.5	7.81	0.96	834.2 $S^{1/2}$	111.2 $S^{1/2}$

BROW DITCH (see page 17)



W = 2 ft TYPE 1

A_F = 1 FT²

$P_W = 2 \times 1 \times \sqrt{2} = 2.83$ FT

R = 0.35 FT

$Q = 57.1\ S^{1/2}$ (CFS)

ENVIRONMENTAL SOLUTIONS, INC.

By: JPL Date: 8-2-90 Subject: LANDFILL B-18 DRAINAGE DESIGN Sheet No. 6 of 59
Chkd. By: N.A. Date: 8-14-90 Proj. No. 89917

DROP INLET CAPACITY

USING THE ORIFICE EQUATION, DROP INLET CAPACITY MAY BE ESTIMATED AS

$$Q = CA\sqrt{2gh}$$

WHERE

C = INLET COEFFICIENT = 0.61
g = 32.2 ft/sec²
h = HEAD (ft)
A = PIPE AREA (ft²)

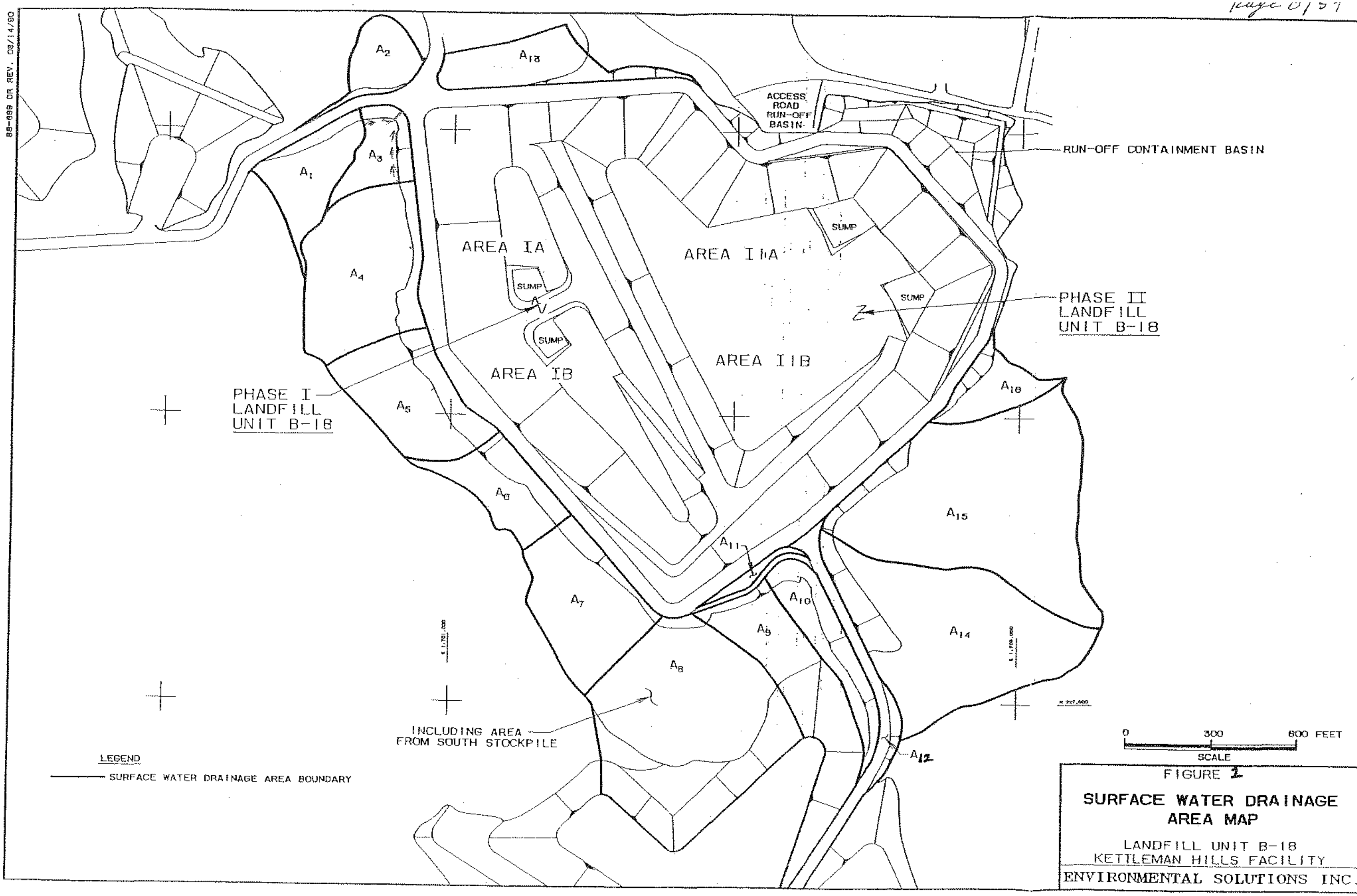
PIPE DIAMETER	Q (cfs)
12"	$3.78\sqrt{h}$
18"	$8.50\sqrt{h}$
24"	$15.1\sqrt{h}$
30"	$24.0\sqrt{h}$

ENVIRONMENTAL SOLUTIONS, INC.

By JPL Date 8-12-90 Subject LANDFILL B-18 DRAINAGE DESIGN

Chkd. By N.A Date 8-14-90 Proj. No. 81-977

FIGURES 1 AND 2 SHOW THE RUN-OFF AREAS FOR LANDFILL B-18 PHASE I AND PHASE II DEVELOPMENT. PAGES 10 THROUGH 12 TABULATED THE AREA, AND MAXIMUM DISCHARGE FOR THE RUN-OFF AREAS.



page 0/57
89-699 DR REV. 08/14/90
ACCESS ROAD RUN-OFF BASIN
RUN-OFF CONTAINMENT BASIN
AREA IA
AREA IB
AREA IIA
AREA IIB
SUMP
PHASE I LANDFILL UNIT B-18
PHASE II LANDFILL UNIT B-18
A_1
A_2
A_3
A_4
A_5
A_6
A_7
A_8
A_9
A_{10}
A_{11}
A_{12}
A_{13}
A_{14}
A_{15}
A_{16}
INCLUDING AREA FROM SOUTH STOCKPILE
LEGEND
SURFACE WATER DRAINAGE AREA BOUNDARY
0
300
600 FEET
SCALE
FIGURE 1
SURFACE WATER DRAINAGE AREA MAP
LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY
ENVIRONMENTAL SOLUTIONS INC.

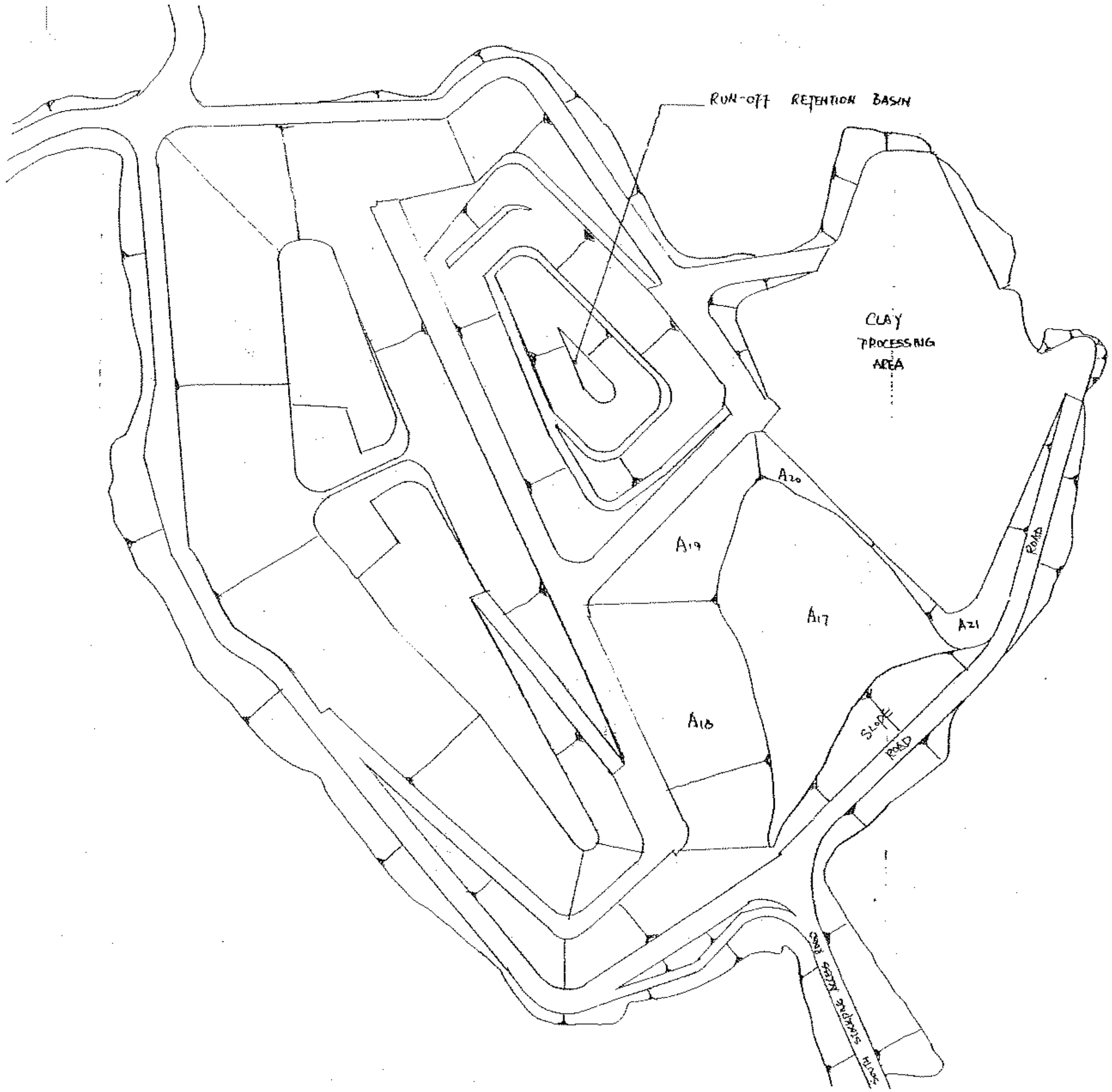


FIGURE 2
SURFACE WATER DRAINAGE AREA MAP
LANDFILL UNIT 3-1B

ENVIRONMENTAL SOLUTIONS, INC.

Run-off **DRAINAGE DESIGN CALCULATION** for Phase 1 and Phase II

BY JJPL DATE 8-6-90 SUBJECT LANDFILL E-18 DRAINAGE SHEET NO 10 OF 59

CHKD N.A. DATE 8-14-90 DESIGN PROJECT NO 89.977

DRAINAGE AREA	AREA (Ac)	LONGEST FLOW PATH (MI)	ELEVATION DIFFERENCE (Ft)	TIME OF CONCENTRATION (Min) (see page 3)	RAINFALL (2) INTENSITY (in/Hr) (See Exhibit 4)	RUNOFF COEFFICIENT	MAXIMUM DISCHARGE (cfs)
A1	1.86	0.1	94	2	7.92 (1)	0.4	5.9
CUTSLOPE	0.19	0.05	38		7.92	0.4	0.6
TOTAL	2.05						
A3	0.96	0.08	74	2	7.92 (1)	0.4	3.0
CUT SLOPE	0.29						
TOTAL	1.25						
A4	4.35	0.1	153	2	7.92 (1)	0.4	13.8
CUT SLOPE	0.55						
TOTAL	4.90						
A5	2.65	0.07	135	1	7.92 (1)	0.4	8.4
CUTSLOPE	0.73						
TOTAL	3.38						
A6	1.41	0.08	90	2	7.92 (1)	0.4	4.5
CUTSLOPE	0.62						
TOTAL	2.03						
A7	3.41	0.07	96	1	7.92 (1)	0.4	10.8
CUTSLOPE	0.36						
TOTAL	3.77						
A8	8.77	0.15	115	3	7.92 (1)	0.4	27.8
CUTSLOPE	0.14						
TOTAL	8.91						

Notes :

1. Assumed minimum time of concentration. (5 minutes)
2. See Figure 1.

DRAINAGE DESIGN CALCULATION

BY JJPL DATE 8-6-90 SUBJECT LANDFILL B-18 DRAINAGE DESIGN SHEET NO 11 OF 59

CHKD N.A. DATE 8-14-90 PROJECT NO 89-977

DRAINAGE AREA	AREA (Ac)	LONGEST FLOW PATH (Mi)	ELEVATION DIFFERENCE (Ft)	TIME OF CONCENTRATION (Min)	RAINFALL (2) INTENSITY (in/Hr)	RUNOFF COEFFICIENT	MAXIMUM DISCHARGE (cfs)
A9	1.91	0.1	100	2	7.92 (1)	0.4	6.1
CUTSLOPE	0.15						
TOTAL	2.06						
A10	2.60	0.14	40	4	7.92 (1)	0.4	8.2
CUTSLOPE	0.22						
TOTAL	2.82						
A11	0.29						
A12	4.02	0.27	120	6	7.00	0.4	11.3
(STOCKPILE	ACCESS ROAD	AND SIDE SLOPES)					
TOTAL	35.48						
A2	1.08	0.05	38	1	7.92 (1)	0.4	3.4
ee page 18) CUTSLOPE	0.58	0.09	38	-	7.92	0.4	
ROAD	0.91						
TOTAL	2.37						
A13	1.96				7.92 (1)	0.9	13.9
CUTSLOPE	0.66				7.92 (1)	0.9	
TOTAL	2.62						
A14	7.7	0.20	180	5	7.92	0.4	24.3
A15	10.8	0.22	98	5	7.92	0.4	34.2
A16	1.81	0.09	70	2	7.92 (1)	0.4	5.73

Notes :
1. Assumed minimum time of concentration. (5 minutes)
2. See Figure 1.

DRAINAGE DESIGN CALCULATION

BY Vpi DATE 8-8-90 SUBJECT LANDFILL B-18 SHEET NO 12 OF 59
CHKD N.A. DATE 8-14-90 DRAINAGE DESIGN PROJECT NO 89-977

DRAINAGE AREA	AREA (Ac)	LONGEST FLOW PATH (MI)	ELEVATION DIFFERENCE (Ft)	TIME OF CONCENTRATION (Min)	RAINFALL (2) INTENSITY (in/Hr)	RUNOFF COEFFICIENT	MAXIMUM DISCHARGE (cfs)
A17	4.08	0.14	66	5	7.92 (1)	0.4	12.9
A18	3.14				7.92 (1)	0.4	10
A19	1.29				7.92 (1)	0.4	4.1
A20	0.42				7.92 (1)	0.4	1.3
A21	0.54				7.92 (1)	0.4	1.71

Notes :
1. Assumed minimum time of concentration. (5 minutes)
2. See Figure 2

APPENDIX J.2
PHASES I AND II RUN-ON CONTROL

ENVIRONMENTAL SOLUTIONS, INC.

By JPL Date 8-6-90 Subject LANDFILL B-18 Sheet No. 13 of 59

Chkd. By N.A. Date 8-14-90 DRAINAGE DESIGN Proj. No. 02-977

RUN-ON CONTROL PERIMETER DITCH (PHASE 1) FIGURE 3

DRAINAGE AREAS A1 & A3 DESIGN POINT A

TOTAL AREA: 3.30 ACRES (see page 10)

FLOW LENGTH: 890 ft

USE TYPE 2 V-DITCH AND 0.6 % SLOPE D = 1.0'

$V = 68.52 S^{1/2} = 68.52 \times \sqrt{0.006} = 5.3$ fps

TIME OF CONCENTRATION $t_c = 2 + \frac{890}{5.3} = 4.8$ min SAY 5

RAINFALL INTENSITY = 7.92 in/HR (see Exhibit 4)

$Q = 0.4 \times 3.3 \times 7.92 = 10.4$ cfs

Q DESIGN $= 171.3\ S^{1/2} = 171.3 \times \sqrt{0.006} = 13.3 > 10.4$ cfs O.K.
(see page 5)

DRAINAGE AREAS A1, A3 & A6 DESIGN POINT: B

TOTAL AREA: 13.61 ACRES

FLOW LENGTH: 2270 ft

USE TYPE 5 V-DITCH AND 0.6 % SLOPE D = 2.0 ft

$V = 96.9\ S^{1/2} = 96.9 \times \sqrt{0.006} = 7.5$ fps

$t_c = 4.8 + \frac{1380}{7.5} = 7.8$ min

ENVIRONMENTAL SOLUTIONS, INC.

By JPL Date 8-6-90 Subject LANDFILL B-18 Sheet No. 14 of 59

Chkd. By N.A. Date 8-14-90 DRAINAGE DESIGN Proj. No. 89-077

RAINFALL INTENSITY = 6.2 in/HR

$Q = 0.4 \times 13.61 \times 6.2 = 33.8$ cfs.

$Q_{DESIGN} = 484.5\, S^{1/2} = 484.5 \times \sqrt{0.006} = 37.5$ cfs > 33.8 cfs O.K.

DRAINAGE AREAS A1, A3 & A7 DESIGN POINT C

TOTAL AREA = 17.62 ACRES

FLOW LENGTH = 2750 ft

USE TYPE 6 V-DITCH AND 0.6 % SLOPE D=2.5

$V = 105.3\, S^{1/2} = 105.3 \times \sqrt{0.006} = 8.15$

$t_c = 7.8 + \frac{480}{8.15} = 8.8$ min

RAINFALL INTENSITY = 5.8 in/HR

$Q = 0.4 \times 17.62 \times 5.8 = 40.9$ cfs

$Q_{DESIGN} = 658.0 \times \sqrt{0.006} = 50.9$ cfs > 40.9 O.K.

ENVIRONMENTAL SOLUTIONS, INC.

By DPL Date 8-6-90 Subject LANDFILL B-18 Sheet No. 15 of 59

Chkd. By M.A. Date 8-14-90 DRAINAGE DESIGN Proj. No. 89-977

DRAINAGE AREAS A1, A3 & A8   DESIGN POINT D

TOTAL AREA: 26.53 Ac.

FLOW LENGTH: 2930 ft.

USE TYPE 7 V-DITCH AND 0.6 % SLOPE   D=3

$V = 111.2\, S^{1/2} = 111.2 \times \sqrt{0.0075} = 9.6$ fps

$t_c = 8.8 + \frac{180}{9.6} = 9.1$ min

RAINFALL INTENSITY = 5.8 IN/HR

$Q = 0.4 \times 26.53 \times 5.8 = 61.5$ cfs

$Q_{DESIGN} = 834.2 \times \sqrt{0.006} = 64.6$ cfs   OK.

DRAINAGE AREAS A1, A3 & A11   DESIGN POINT E

TOTAL AREA = 31.64 AC

FLOW LENGTH: 2945 ft

$t_c = 9.7$ min

RAINFALL INTENSITY = 5.8 IN/HR

$Q = 31.64 \times 0.4 \times 5.8 = 73.4$ cfs

TYPE 7 V-DITCH AND 0.8 % SLOPE

$Q = 834.2 \times \sqrt{0.008} = 74.6$ cfs > 73.4 cfs   O.K.

ENVIRONMENTAL SOLUTIONS, INC.

By DPL Date 8-7-90 Subject LANDFILL B-18 Sheet No. 16 of 59

Chkd. By N.A. Date 8-14-90 DRAINAGE DESIGN Proj. No. 89977

DRAINAGE AREAS A1, A3~A9, A11, A12, A14, A15, A16 DESIGN POINT F

AREAS A_1, $A_3 \sim A_{11}$

$T_c = 9.1$ min , $i = 5.8$ in/HR , $Q = 66.8$ c/s

AREAS A_{12} & A_{14}

A_{12} = $T_c = 6$ $i = 7$ $Q = 11.3$ (see p. 11)

A_{14} = $T_c = 5$ $i = 7.92$ $Q = 24.3$ (see p. 11)

$$Q_{12+14} = 24.3 + \frac{7.92}{7} \times \frac{5}{6} \times 11.3 = 34.9 \text{ c/s}$$

Q FOR A_1, $A_3 \sim A_{11}$, A_{12}, A_{14}

$$Q = 73.4 + \frac{5.8}{7.92} \times 34.9 = 98.9 \text{ c/s}$$

Q FOR A_1, $A_3 \sim A_{11}$, A_{12}, A_{14}, AND A_{15}

$$Q = 98.9 + \frac{5.8}{7.92} \times 34.2 = 123.9 \text{ c/s}$$

Q FOR A_1, $A_3 \sim A_{11}$, A_{12}, A_{14}, A_{15} AND A_{16}

$$Q = 123.9 + \frac{5.8}{7.92} \times 5.73 = 128.1 \text{ c/s}$$

USE TYPE 5 V-DITCH WITH 8.3 % SLOPE

$$Q = 484.5 \times \sqrt{0.083} = 139.6 \text{ c/s} > 128.1 \text{ c/s}$$

DRAINAGE DESIGN CALCULATION

for Brow ditches & drop Inlet
Phase 1

BY JJM DATE 8-6-90 SUBJECT LANDFILL B-1B SHEET NO 17 OF 59
CHKD N.A. DATE 8-14-90 DRAINAGE DESIGN PROJECT NO 39.977

	(see p. 10 (11))	(see page 5)		(see figure 3)			
		BROW DITCH		DROP INLET			TYPE.
DRAINAGE AREA	MAXIMUM FLOW (cfs)	DESIGN(1) SLOPE (%)	DESIGN (2) FLOW (cfs)	PIPE DIAMETER (in)	HEAD (ft)	DESIGN FLOW (cfs)	
A1	5.9	10.0	18.1		NOT REQUIRED		
A2	3.4	10.9	18.9		NOT REQUIRED		
A3	3.0	11.5	19.4	12	1	3.8	D1
A4	13.8	7.7	15.8	24	1	15.1	D2
A5	8.4	8.9	17.0	18	1	8.5	D3
A6	4.5	2.4	8.8	12	1.5	4.6	~~D4~~
A7	10.8	3.6	10.8	NOT REQUIRED			
A8	27.8	11.2	19.1	30	1.5	29.4	D5
A9	6.1	14.3	21.6	NOT REQUIRED			
A10	8.7	5.6	13.5	18	1	8.5	D6
A13	6.2	6.6	14.7	NOT REQUIRED			

NOTES

1. ONLY CONSIDER DITCHES WITH THE Existing SHALLOWEST SLOPE IN THE DRAINAGE AREA.
2. UNLESS SPECIFIED, DITCHES ARE DESIGNED FOR MAXIMUM FLOW IN THE DRAINAGE AREA

ENVIRONMENTAL SOLUTIONS, INC.

By DRL Date 8-7-90 Subject LANDFILL 6-B DRAINAGE DESIGN

Chkd. By N.A. Date 8-14-90 Proj. No. 89-977

DRAINAGE AREA A2 DESIGN POINT G. SWALE DESIGN

AREA : A2 = 1.08 (see p. 1)

SLOPE = 0.58

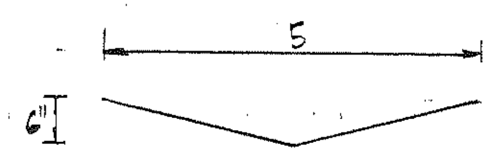
ROAD = 0.71

TOTAL = 2.37

RUN-OFF COEFFICIENT : $\dfrac{1.08 \times 0.4 + 0.58 \times 0.4 + 0.71 \times 0.9}{2.37} = 0.55$

RAINFALL INTENSITY = 7.92 IN/HR (5 MIN. minimum TIME OF CONCENTRATION)

$Q = 0.55 \times 2.37 \times 7.92 = 10.3$ cfs



TRY SWALE AS SHOWN :

$A_f = 0.5 \times 5 \times 0.5 = 1.25$ ft²

$P_w = 2 \times \sqrt{0.5^2 + 2.5^2} = 5.1$ ft

$R = \dfrac{1.25}{5.1} = 0.25$ ft

slope = 0.09 (Existing shallowest slope in the drainage area)

$Q = \dfrac{1.486}{0.013} \times 1.25 \times 0.25^{2/3} \times \sqrt{0.09}$

n = 0.013 EXHIBT TROWEL FINISH CONCRETE OR EQUIVALENT –

$= 16.7$ cfs > 10.3 cfs O.K.

ENVIRONMENTAL SOLUTIONS, INC.

By JPL Date 8-7-90 Subject LANDFILL B-18 Sheet No. 19 of 57
Chkd. By N.A. Date 8-14-90 DRAINAGE DESIGN Proj. No. 89-917

DRAINAGE AREAS A2 & A13 DESIGN POINT H (see p. 11)

TOTAL AREA = 4.28

TIME OF CONCENTRATION = < 5 min

RAINFALL INTENSITY = 7.92 IN/HR (USE MIN 5 MIN)

$$C = \frac{0.4 \times 1.08 + 0.58 \times 0.4 + 0.9 \times (0.66 + 1.96)}{4.28} = 0.71$$

$Q = 0.71 \times 7.92 \times 4.28 = 24.0$ cfs

USE TYPE 3 V-DITCH AND 1% SLOPE D=1.25 (see p. 5)

$Q_{DESIGN} = 243 \times \sqrt{0.01} = 24.3$ cfs > 24.0 O.K.

DRAINAGE AREAS A2, A13, AND SLOPE DESIGN POINT I

TOTAL AREA = 4.33 + 0.66 = 4.99

TIME OF CONCENTRATION = < 5 min Use 5 minutes

RAINFALL INTENSITY = 7.92 IN/HR. see Exhibit 4

$$C = \frac{0.4(1.08 + 0.58 + 0.66) + 0.9(0.66 + 1.96)}{4.99} = 0.66$$

$Q = 0.66 \times 4.99 \times 7.92 = 26.08$

USE TYPE 2 V-DITCH AND 8% SLOPE

$Q_{DESIGN} = 171.3 \times \sqrt{0.08} = 48.5$ cfs > 26.0 cfs O.K.

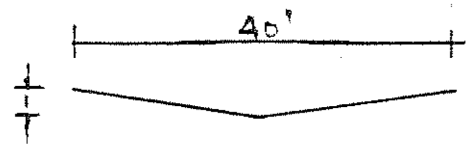
ENVIRONMENTAL SOLUTIONS, INC.

By JJN Date 8-7-90 Subject LANDFILL B-1B Sheet No. 20 of 59

Chkd. By N.A. Date 8-14-90 DRAINAGE DESIGN Proj. No. 89-977

Design pt. J SWALE DESIGN

USE SWALE SIZE AS SHOWN IN CLAY PROCESSING AREA



$A_T = 0.5 \times 40 \times 1 = 20\ ft^2$

$P_w = 2 \times \sqrt{1 + 20^2} = 40\ ft$

$R = \frac{20}{40} = 0.5\ ft$

slope = 0.015

n = 0.022

FOR EARTH CLEAN, AFTER WEATHERING

$Q = \frac{1.486}{0.022} \times 0.5^{2/3} \times 20 \times \sqrt{0.015}$

$= 104$ cfs > 26.4 cfs OK.

CUTSLOPE AND ACCESS ROAD EAST OF B-1B STOCKPILE ACCESS ROAD

TOTAL AREA: 1.47 Ac. DESIGN POINT K

ASSUMED RAINFALL = 7.92 IN/HR 5 min TIME OF CONCENTRATION

$C = \frac{0.99 \times 0.4 + 0.48 \times 0.9}{1.47} = 0.56$

$Q = 0.56 \times 1.47 \times 7.92 = 6.55$

USE TYPE 2 V-DITCH & 6% SLOPE (see p. 5)

$Q = 171.3 \times \sqrt{0.06}$

$= 42.0$ cfs > 6.55 cfs O.K.

ENVIRONMENTAL SOLUTIONS, INC.

DRAINAGE AREA A18 — DESIGN POINT L

Q = 10 cfs (see p. 12)

USE TYPE 2 V-DITCH & 0.5 % SLOPE (see p. 5)

$Q_{DESIGN} = 171.3 \times \sqrt{0.005} = 12.1$ cfs > 10 cfs O.K.

DRAINAGE AREAS A18 & A19 — DESIGN POINT M

Q = 10 + 4.1 = 14.1 $T_{18} = T_{19} = 5$ min (see p. 12)

USE TYPE 2 V-DITCH & 1 % SLOPE (see p. 5)

$Q_{DESIGN} = 171.3 \times \sqrt{0.01} = 17.1$ cfs > 14.1 cfs OK

DRAINAGE AREAS A17 ~ A20 — DESIGN POINT N

Q = 12.9 + 10 + 4.1 + 1.3 = 28.3 cfs $T_{17} = T_{18} = T_{19} = T_{20} = 5$ min (see p. 12)

USE TYPE 4 V-DITCH AND 0.8 % SLOPE (see p. 5)

$Q_{DESIGN} = 319.4 \times \sqrt{0.008} = 28.6$ cfs > 28.3 cfs OK.

DRAINAGE AREA A17 ~ A21 — DESIGN POINT O

Q = 12.9 + 10 + 4.1 + 1.3 + 1.71 = 30.01 cfs (see p. 12)

USE TYPE 4 V-DITCH AND 1 % SLOPE see p. 5

$Q_{DESIGN} = 319.4 \times \sqrt{0.01} = 31.9$ cfs > 30.01 cfs OK

ENVIRONMENTAL SOLUTIONS, INC.

By DPL Date 8-8-90 Subject LANDFILL B-18 Sheet No. 22 of 59
Chkd. By N.A. Date 8-14-90 DRAINAGE DESIGN Proj. No. 80-977

RUN-ON CONTROL PERIMETER DITCH PHASE II FIGURE 4

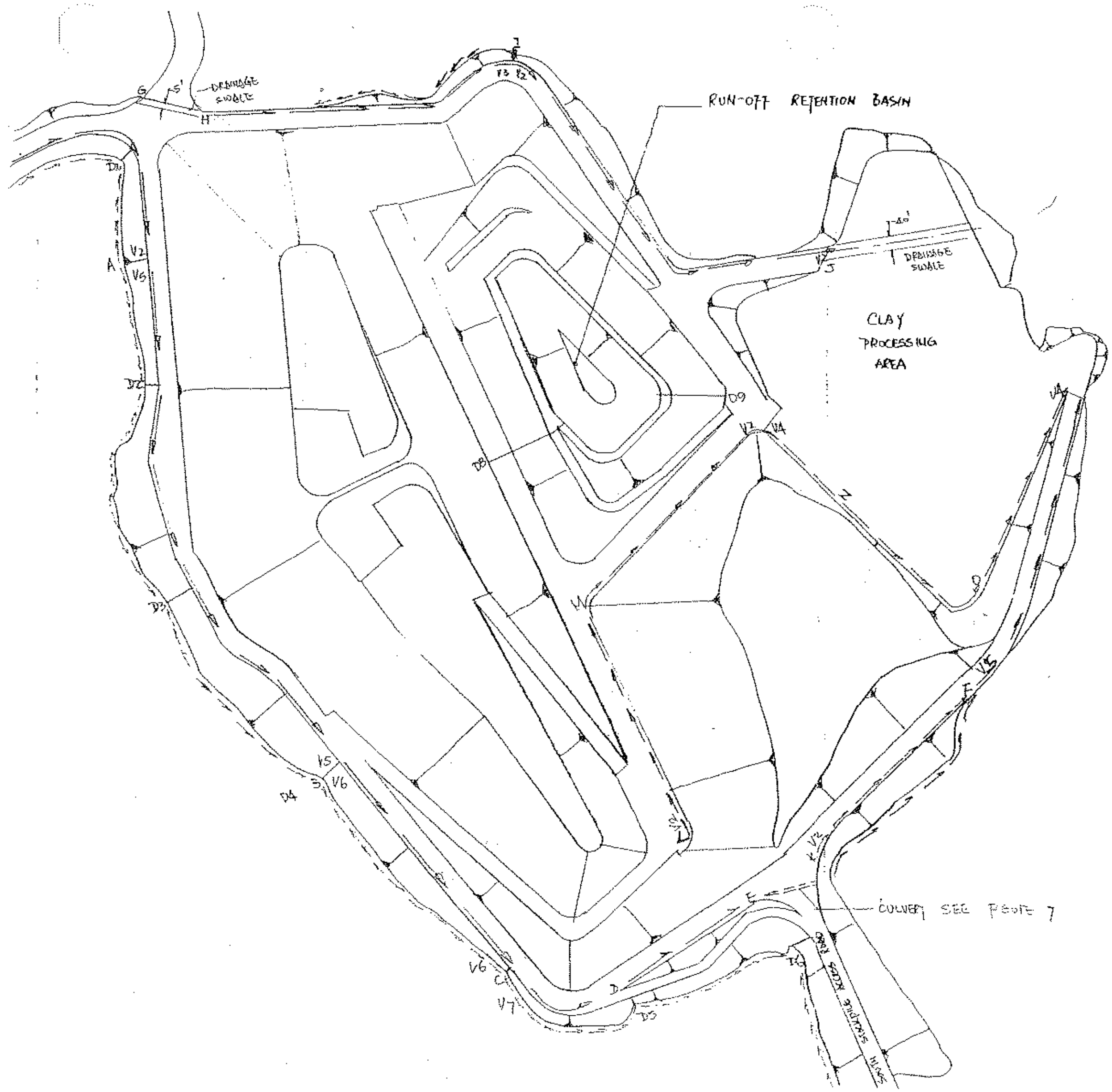
DRAINAGE AREAS A1, A3 & A16 DESIGN POINT A

TOTAL Q = 121.5 cfs (see p. 16)

USE TYPE 6 V-DITCH AND 3.6 % SLOPE (see p. 5)

$Q = 658 \times \sqrt{0.036} = 124.8$ cfs > 121.5 cfs OK.

p. 23/51



DROP INLET SCHEDULE (see p. 6)

TYPE	HEAD (FT)	PIPE DIAMETER (IN)	PIPE LENGTH FT
D1	1	12	30
D2	1	24	30
D3	1	18	60
D4	1.5	12	45
D5	1.5	30	20
D6	1	18	40

FIGURE 3
RUN-ON DRAINAGE PLAN
PHASE 1

ENVIRONMENTAL SOLUTIONS, INC.

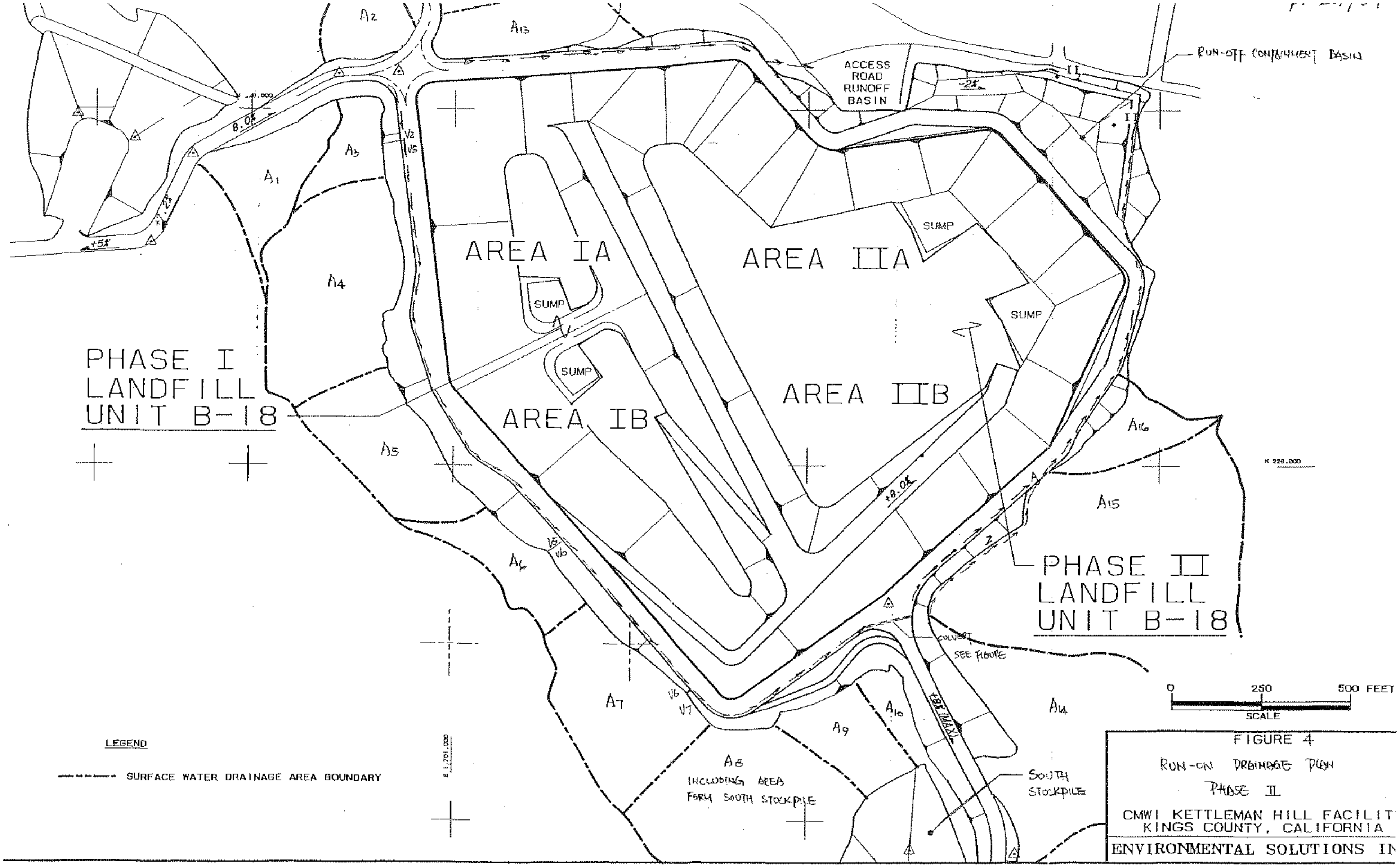


FIGURE 4
RUN-ON DRAINAGE PLAN
PHASE II
CMWI KETTLEMAN HILL FACILIT
KINGS COUNTY, CALIFORNIA
ENVIRONMENTAL SOLUTIONS IN

APPENDIX J.3

PHASES I AND II RUN-OFF CONTROL AND RUN-OFF CONTROL FOR PHASE IIIA

ENVIRONMENTAL SOLUTIONS, INC.

By: mpi Date: 8-8-90 Subject: LANDFILL B-18 Sheet No. 25 of 59
Chkd. By: N.A. Date: 8-14-90 DRAINAGE DESIGN Proj. No. 89-977

RUN-OFF CONTROL PERIMETER DITCHES PHASE I FIGURE 5

WESTERN & SOUTHERN BENCH ROAD DESIGN POINT A

LENGTH = 2600 ft WIDTH = 40 ft

AREA = 2.38 ACRES RUNOFF COEFFICIENT = 0.9

USE TYPE 3 V-DITCH & 0.6 % SLOPE D = 1.25 (see p. 5)

$V = 77.6 \times \sqrt{0.006}$
$= 6$ fps

$T_c = \frac{2600}{6} = 432.4$ sec $= 7.2$ min

$i = 6.7$ IN/HR see Exhibit 4

$\therefore Q = 0.9 \times 6.7 \times 2.38 = 14.4$ cfs

$Q_{DESIGN} = 243 \times \sqrt{0.006} = 18.8$ cfs > 14.4 cfs O.K.

DROP INLET AT END OF DITCH

USE 18" ϕ CMP & 3 ft HEAD

$Q = 15.1$ cfs > 14.4 cfs O.K.

USE SAME TYPE OF DITCH TO DIVERT RUN-OFF TO DROP INLET AT TOP OF CLAY PIT. $Q = 243 \times \sqrt{0.005} = 17.2 > 14.4$

ENVIRONMENTAL SOLUTIONS, INC.

By JJM Date 8-8-90 Subject LANDFILL B-1B Sheet No. 26 of 59
Chkd. By N.A. Date 8-14-90 DRAINAGE DESIGN Proj. No. 89-977

NORTHERN BENCH ROAD TO CLAY PIT DESIGN POINT B (see fig 5)

LENGTH : 1200 ft WIDTH = 40'

AREA = 1.1 ACRE RUNOFF COEFFICIENT = 0.9

t_c = 5 min i = 7.92 IN/HR

$Q = 0.9 \times 7.92 \times 1.1 = 7.8$ cfs

USE TYPE 2 V-DITCH AND 1% SLOPE D=1'

$Q_{DESIGN} = 171.3 \times \sqrt{0.01} = 17.1$ cfs > 7.8 cfs

DROP INLET

USE 18" φ CMP & 12" HEAD

$Q = 8.5\sqrt{1} = 8.5$ cfs > 7.8 cfs OK.

PHASE I/II DIVIDING BERM

SOUTHERN SECTION

LENGTH = 850 FT WIDTH = 40'

AREA = .78 Acre RUNOFF Coefficient = 0.9

Tc = 5 min i = 7.92 in/hr

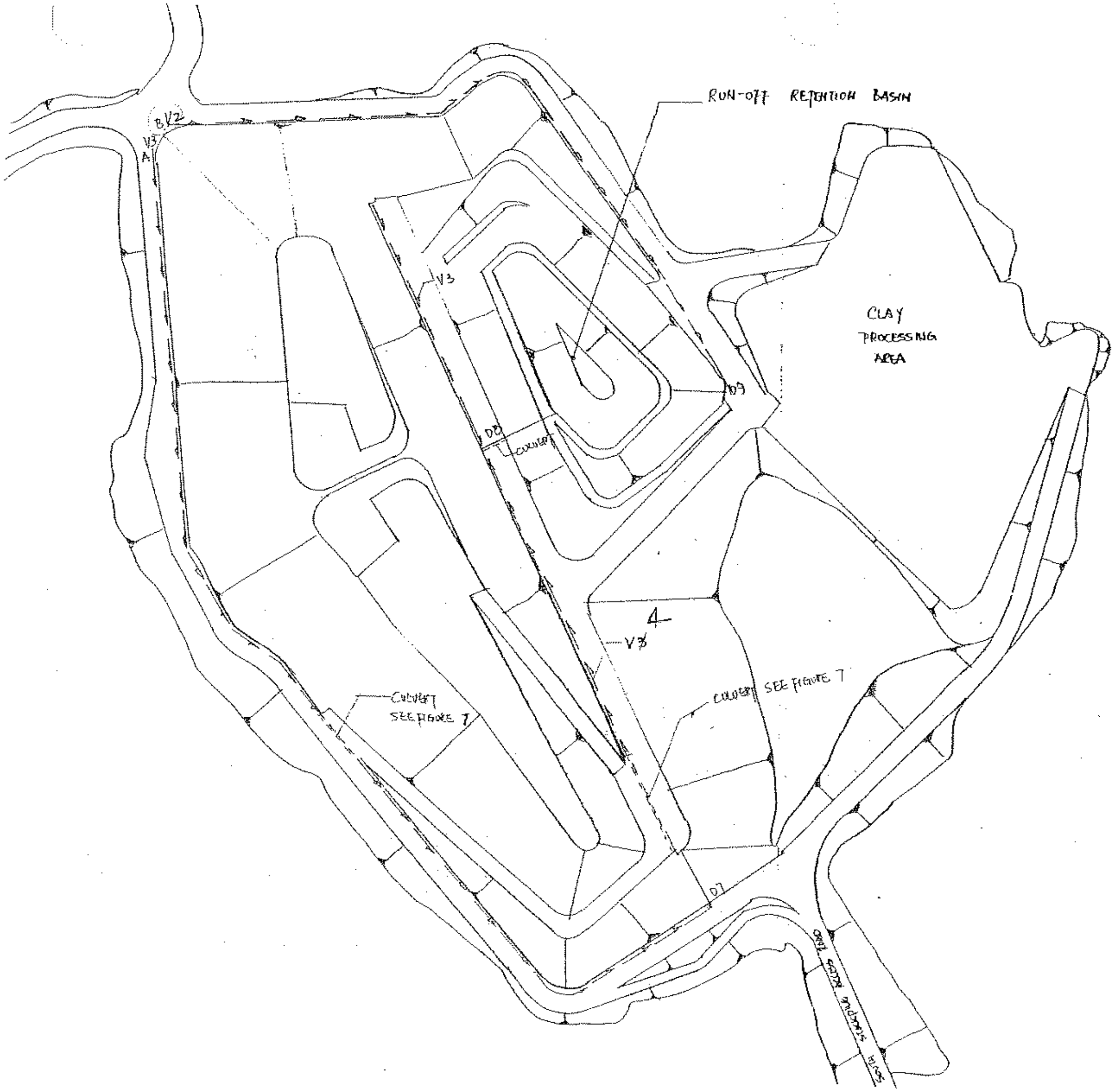
$Q = 0.9 \times 7.92 \times .78 = 5.56$ CFS

Q_T = 14.4 CFS + 5.56 CFS = 19.96 CFS

(SOUTHERN) SECTION
Use Type 4 : $Q = 319.4\, S^{1/2} = 319.4\,(.01)^{1/2} = 31.94$ CFS

31.94 > 19.96 OK

TYPE 4 NEEDED BECAUSE OF CULVERT



DROP INLET SCHEDULE (see page 25)

TYPE	HEAD (ft)	PIPE DIAMETER (in)	PIPE LENGTH (ft)
D7	3	18	140
D8	2.5	24	140
D9	1	18	110

FIGURE 5
PHASE I RUN-OFF CONTROL PLAN

ENVIRONMENTAL SOLUTIONS, INC.

ENVIRONMENTAL SOLUTIONS, INC.

By DRL Date 8-8-90 Subject LANDFILL B-18 Sheet No. 28 of 59
Chkd. By K.A. Date 8-14-90 DRAINAGE DESIGN Proj. No. 89-977

RUN - OFF CONTROL PERIMETER DITCH PHASE II FIGURE 6

SOUTHERN BENCH ROAD DESIGN POINT A

LENGTH: 1600 ft WIDTH = 40'

AREA = 1.47 ACRES RUN-OFF COEFFICIENT = 0.9

USE TYPE 2 V-DITCH D = 1.25

ALONG 6.1 % SLOPE PORTION

$V = 68.5 \times \sqrt{0.061} = 17$ fps

$t_c = \frac{830}{17} = 0.8$ min

ALONG 3.6 % SLOPE PORTION

$V = 68.5 \times \sqrt{0.036} = 13$ fps

$t_c = \frac{520}{13} = 0.7$ min

$T_c = 7.2 + 0.8 + 0.7 = 8.7$

$i = 6.1$ IN/HR

$Q = 0.9 \times 6.1 \times (2.38 + 1.47) = 21.1$ cfs

$Q_{DESIGN} = 171.3 \times \sqrt{0.036} = 32.5$ cfs > 21.1 cfs O.K.

ENVIRONMENTAL SOLUTIONS, INC.

By JJPL Date 8-8-90 Subject LANDFILL B-18 Sheet No. 29 of 59
Chkd. By N.A Date 8-14-90 DRAINAGE DESIGN Proj. No. 89.977

NORTHERN BENCH ROAD DESIGN POINT B (see figure 6)

LENGTH = 1720 ft WIDTH = 40' AREA: 1.58 ACRES

Tc = < 5 min

i = 7.92 IN/HR

Q = 0.9 X 1.58 X 7.92 = 11.3 cfs

USE TYPE 2 V-DITCH AND 1% SLOPE min

$Q_{DESIGN} = 171.3 \times \sqrt{0.01} = 17.1$ cfs > 11.3 cfs O.K.

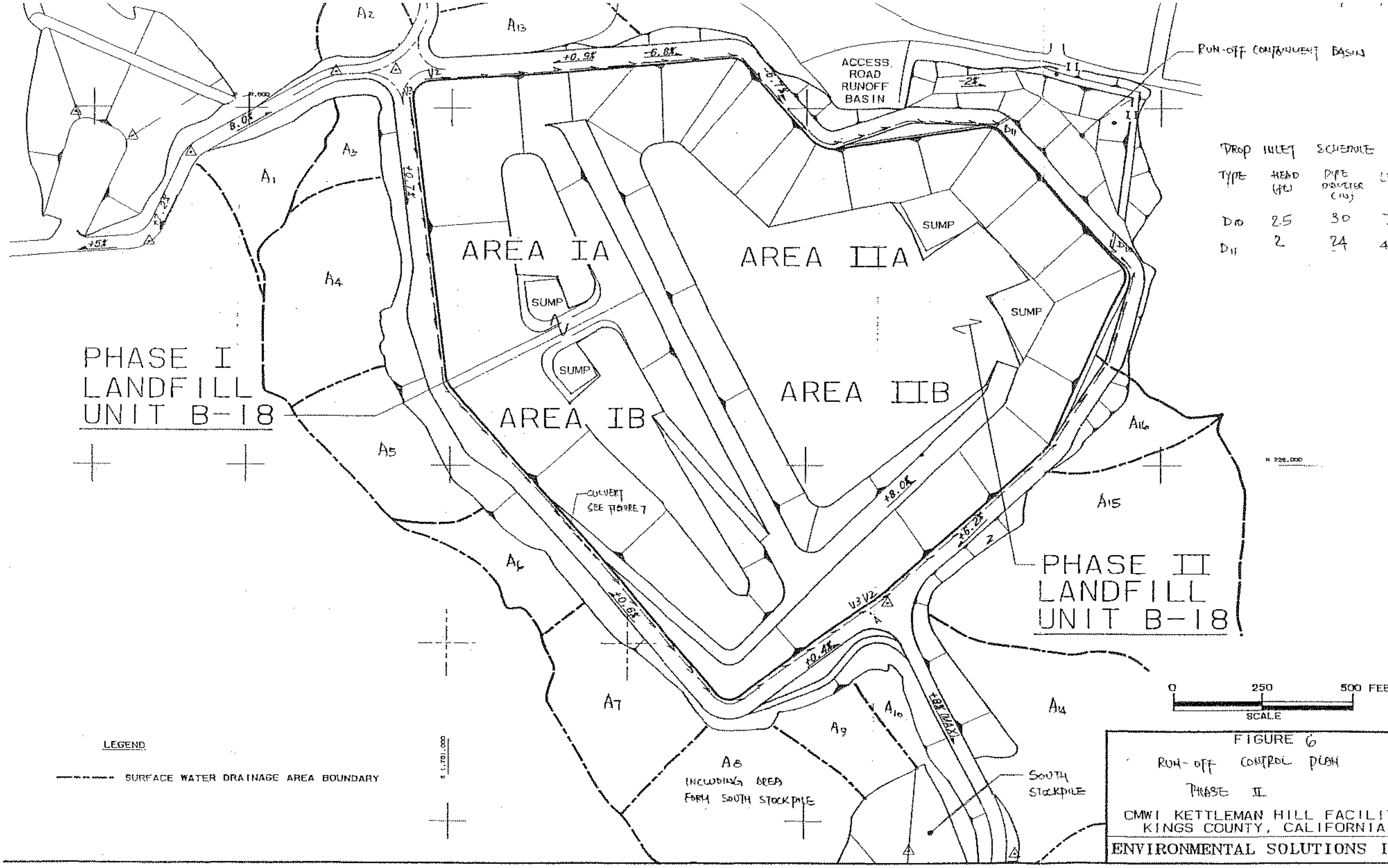


FIGURE 6
RUN-OFF CONTROL PLAN
PHASE II
CMWI KETTLEMAN HILL FACILIT
KINGS COUNTY, CALIFORNIA
ENVIRONMENTAL SOLUTIONS IN

ENVIRONMENTAL SOLUTIONS, INC.

CULVERT DESIGN FIGURE 7 & FIGURE 8

ALL CULVERTS WILL BE DESIGNED FOR INLET CONTROL.

CULVERT C1

LOCATION : PHASE 1 PRISM ACCESS ROAD & WEST PERIMETER BENCH ROAD

LENGTH = 150 ft

DIAMETER = 12" φ CONCRETE ENCASED

DRAINAGE AREA : NORTHERN HALF OF WEST PERIMETER ROAD

LENGTH: 1170 ft WIDTH = 40'

AREA = (1170 X 40)/43560 = 1.07 ACRES

SLOPE = 0.6 %

APPROACH VELOCITY : $V = 77.64 \times \sqrt{0.006} = 6$ fps. (TYPE 2 V-DITCH)

TIME OF CONCENTRATION TO CULVERT INLET = 1170/6 = 3.25 min

USE 5 min

i = 2.1 in/HR (25-YEAR)

$Q = CiA = 0.9 \times 2.1 \times 1.07 = 2$ cfs.

FROM INLET CONTROL NOMOGRAPH

HW/D = 0.9 ∴ HW = 0.9 X 12 = 10.8" < 12" OK

ENVIRONMENTAL SOLUTIONS, INC.

By JPL Date 8-9-90 Subject LANDFILL B-18 Sheet No. 32 of 59

Chkd. By JL Date 8-14-90 DRAINAGE DESIGN Proj. No. 89-977

CULVERT 2

LOCATION: SOUTH STOCKPILE ROAD AND SOUTH PERIMETER ROAD

LENGTH = 120 ft

DIAMETER = 24" ϕ CMP

DRAINAGE AREAS: A1, A3 ~ A9, AND A11

AREA = 28.82 ACRES

SLOPE = 0.5 %

APPROACH VELOCITY: $V = 111.2 \sqrt{0.006} = 8.6$ fps

TIME OF CONCENTRATION TO CULVERT $t_c = 9.1$ min

$i = 1.7$ IN/HR (25-YEAR STORM)

$Q = 0.4 \times 1.7 \times 28.82 = 19.6$ cfs

FROM INLET CONTROL NOMOGRAPH:

$HW/D = 1.39$ $\therefore HW = 1.39 \times 24 = 33.36"$

USE 24" ϕ CMP INLET & 3 ft HEAD

$Q = 15.1\sqrt{3} = 26.2$ cfs > 19.6 cfs O.K.

ENVIRONMENTAL SOLUTIONS, INC.

By JPL Date 8-9-90 Subject LANDFILL B+B Sheet No. 33 of 59
Chkd. By AL Date 8-14-90 DRAINAGE DESIGN Proj. No. 89.977

CULVERT 3

LOCATION = ENTRANCE OF THE PHASE I/II BERM ROAD AND PHASE I PRISM ACCESS ROAD

LENGTH : 220 ft

DIAMETER : 18" CMP

DRAINAGE AREA = WESTERN BENCH ROAD

AREA : 2.38 ACRES

SLOPE = 0.5 %

TIME OF CONCENTRATION TO INLET = 7.2 min

i = 1.8 in/HR (25-YEAR STORM)

Q = 0.9 X 1.8 X 2.38 = 3.9 cfs

FROM INLET CONTROL MONOGRAPH

$Hw/D = 0.74 \therefore Hw = 0.74 \times 18 = 13.32'' < 18''$ OK

CULVERT 4

LOCATION : PHASE I/II BERM CREST AT TOP OF CLAY PIT

LENGTH : 60 ft

DIAMETER = 30" ϕ CMP

DRAINAGE AREA = WESTERN BENCH ROAD AND TOP OF PHASE I/II BERM

AREA : 3.75 ACRES

SLOPE = 0.5 %

TIME OF CONCENTRATION TO INLET = 9.5 min

i = 5.8 IN/HR PMP STORM

$$C = \frac{1.37 \times 0.4 + 2.38 \times 0.9}{3.75} = 0.72$$

$Q = 0.72 \times 5.8 \times 3.75 = 15.6$ cfs

FROM INLET CONTROL MONOGRAPH

$Hw/D = 0.79 \quad \therefore \quad Hw = 0.79 \times 30 = 23.7$

USE 30 ϕ CMP DROP INLET & 2 ft HEAD

$Q = 24\sqrt{2} = 33.8$ cfs > 15.6 cfs O.K

ENVIRONMENTAL SOLUTIONS, INC.

By JPL Date 8-10-90 Subject LANDFILL B+B
Chkd. By Ah Date 8-14-90 DRAINAGE DESIGN Proj. No. 89-977

CULVERT 5

LOCATION : EASTERN END OF SOUTH PERIMETER BENCH ROAD

LENGTH : 70 ft

DIAMETER : 30" ϕ CMP

DRAINAGE AREA: WESTERN & SOUTHERN BENCH ROAD

AREA: 3.85 ACRES

SLOPE = 0.5 %

TIME OF CONCENTRATION = 8.7 min

$i = 6.2$ IN/HR

$Q = 0.9 \times 6.2 \times 3.85 = 21.$ cfs

FROM INLET CONTROL MONOGRAPH

$Hw/D = 0.95$ $\therefore Hw = 28.5$

USE 30" ϕ CMP DROP INLET & 2.5' HEAD

$Q = 24 \times \sqrt{2.5}$ 33.9 cfs > 21. cfs O.K.

CULVERT 6

LOCATION = EASTERN END OF NORTH BENCH ROAD

LENGTH = 40'

DIAMETER = 24" CMP

DRAINAGE AREA = NORTHERN BENCH ROAD

AREA = 1.58 ACRES

TIME OF CONCENTRATION TO INLET = <5 min

$i = 7.92$ IN/HR

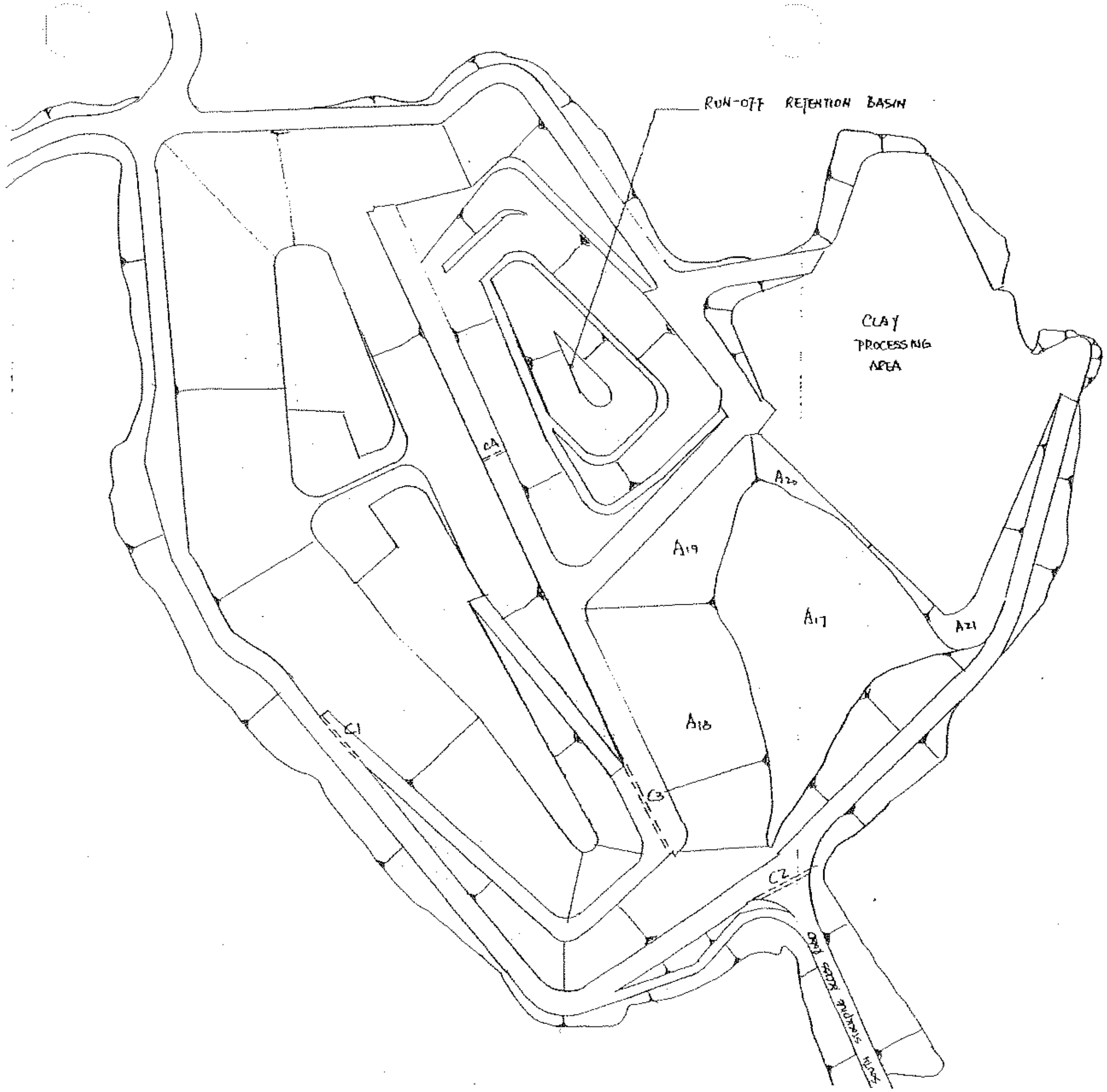
$Q = 0.9 \times 7.92 \times 1.58 = 11.2$ cfs

FROM INLET CONTROL NOMOGRAPH

$H_W/D = 0.9$ $\therefore H_W = 0.9 \times 24 = 21.6$

USE 24" CMP DROP INLET & 24" HEAD

$Q = 15.1 \times \sqrt{2} = 21.3$ cfs > 11.2 cfs OK.



CULVERT SCHEDUEL

TYPE	CULVERT DIAMETER (IN)	LENGTH (FT)
C1	12	150
C2	24	120
C3	18	220
C4	30	60
C5[1]	24	70
C6[1]	24	40

NOTE

(1) SAME AS DROP INLET D10 AND D11
SEE FIGURE 6 FOR LOCATIONS.

FIGURE 7

CULVERT LOCATIONS PLAN

LANDFILL B-1B

ENVIRONMENTAL SOLUTIONS, INC.

TABLE 6

RUNOFF COEFFICIENT FOR 10-YEAR* RETURN PERIOD

I. LAND USE

Nonagricultural	Coefficient C
Business	
Downtown	0.70 to 0.95
Neighborhood	0.50 to 0.70
Residential	
Single-family	0.30 to 0.50
Multi-units, detached	0.40 to 0.60
Multi-units, attached	0.60 to 0.75
Residential (suburban lots > 1/2 acre)	0.25 to 0.40
Apartment dwelling	0.50 to 0.70
Industrial	
Light	0.50 to 0.80
Heavy	0.60 to 0.90
Parks, cemeteries	0.10 to 0.25
Playgrounds	0.20 to 0.35
Railroad yard	0.20 to 0.35
Unimproved	0.10 to 0.30

Agricultural/Open Space

Hydrologic Soil Group (See Table 2 and Fig. 2)	Cultivated	Pasture	Oak Timber and Brush
A	0.20	0.15	0.10
B	0.40	0.35	0.30
C	0.45	0.40	0.35
D	0.50	0.45	0.40

II. SURFACE TYPE

Character of Surface	Coefficient C
Pavement	
Asphaltic and Concrete	0.70 to 0.95
Brick	0.70 to 0.85
Roofs	0.75 to 0.95
Lawns, sandy soil	
Flat, 2 percent or less	0.05 to 0.10
Average, 2 to 7 percent	0.10 to 0.15
Steep, 7 percent or more	0.15 to 0.20
Lawns, heavy soil	
Flat, 2 percent	0.13 to 0.17
Average, 2 to 7 percent	0.18 to 0.22
Steep, 7 percent	0.25 to 0.35

*For other return periods, determine runoff coefficient from Figure 10.

EXHIBIT 2

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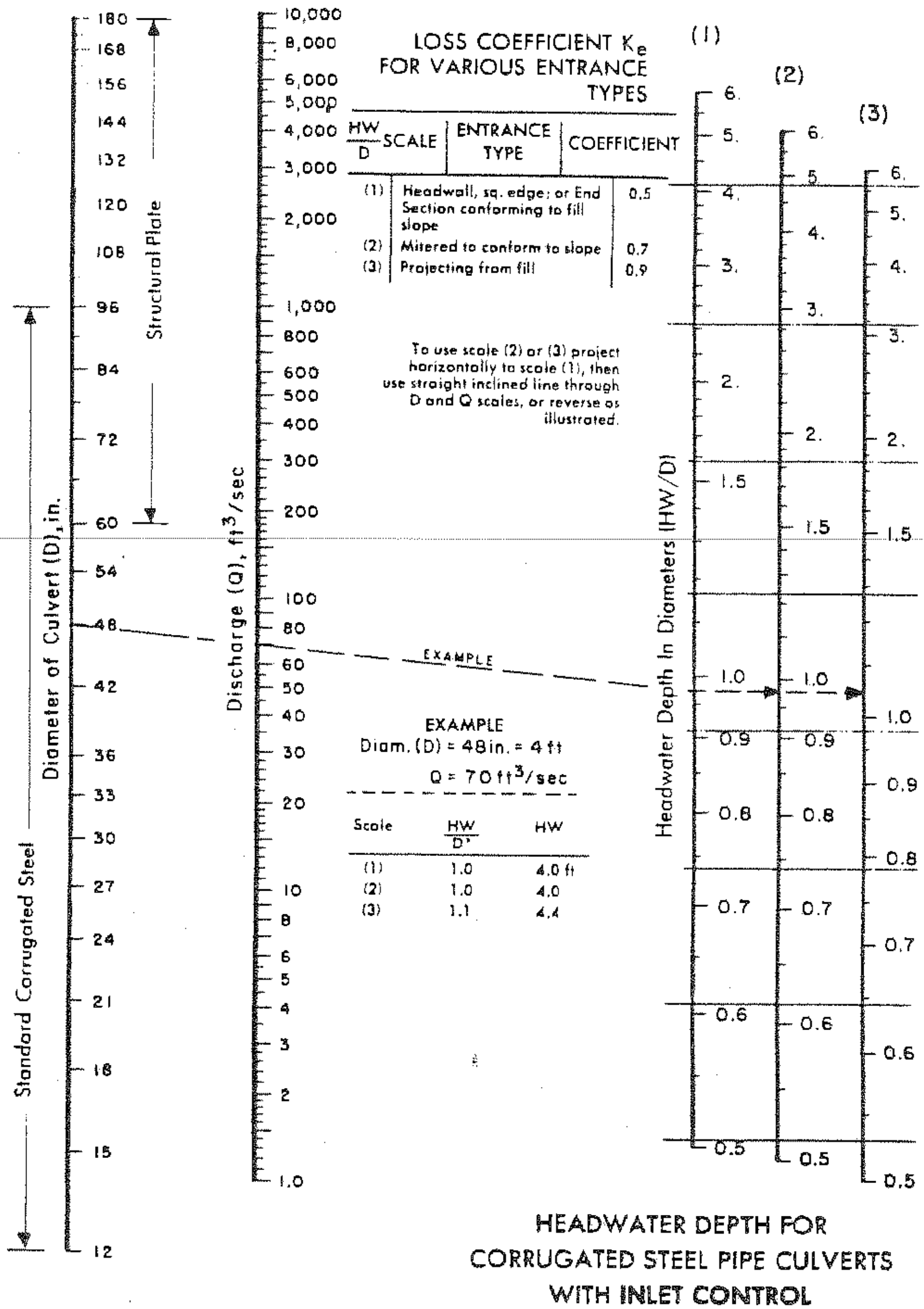

FHWA HEC 5

Figure 4-28 *Inlet control* nomograph for corrugated steel *pipe* culverts. The manufacturers recommended keeping *HW/D* to a maximum of 1.5 and preferably to no more than 1.0.

EXHIBIT 3

MAXIMUM ANNUAL PRECIPITATION (UNITS=INCHES)
(TO CONVERT TO MILLIMETERS MULTIPLY BY 25.4)

STATION NO. BSN ORDER SUB	STATION NAME	ELEV	SEC	TWP	RNG	LOT	PMM	LATITUDE	LONGITUDE	COUNTY
C00 1867 0	COALINGA 1SE	663	04	21S	15E	J	M	36.128	120.344	FRESNO

M=MINUTES,H=HOURS,D=DAYS,C YR=CALENDAR YEAR,W YR=WATER YEAR,F YR=FISCAL YEAR
***** = NO DATA AVAILABLE

YEAR	5M	10M	15M	30M	1H	2H	3H	6H	12H	24H	C-YR
1940	0.09	0.14	0.21	0.28	0.43	0.64	0.84	1.24	1.75	1.77	10.76
1941	0.14	0.19	0.22	0.30	0.43	0.56	0.65	0.88	1.06	1.41	14.21
1942	0.10	0.14	0.19	0.22	0.25	0.48	0.65	0.93	0.95	0.98	5.10
1943	0.12	0.17	0.18	0.22	0.30	0.37	0.50	0.80	0.84	1.10	8.08
1944	0.07	0.10	0.13	0.16	0.21	0.37	0.49	0.69	0.76	1.39	5.49
1945	0.10	0.12	0.17	0.20	0.25	0.29	0.40	0.53	0.65	0.77	6.90
1946	0.06	0.10	0.12	0.18	0.32	0.48	0.61	0.80	0.87	0.90	5.73
1947	*****	*****	*****	*****	0.17	0.22	0.22	0.23	0.23	0.32	1.98
1948	0.05	0.08	0.12	0.17	0.23	0.46	0.50	0.54	0.64	0.86	5.48
1949	0.07	0.11	0.12	0.14	0.25	0.41	0.50	0.73	0.76	1.19	5.23
1950	0.13	0.15	0.17	0.17	0.27	0.37	0.47	0.65	0.81	0.85	5.86
1951	0.09	0.13	0.16	0.22	0.22	0.35	0.45	0.49	0.60	0.75	5.59
1952	0.20	0.28	0.47	0.49	0.50	0.57	0.57	0.83	0.90	0.90	10.92
1953	*****	*****	*****	*****	0.40	0.70	0.90	1.14	1.57	1.57	2.60
1954	0.03	0.05	0.08	0.15	0.24	0.44	0.60	1.15	1.24	1.30	5.60
1955	0.16	0.26	0.27	0.52	0.92	1.06	1.07	1.07	1.08	1.49	11.85
1956	0.20	0.26	0.39	0.54	0.59	0.60	0.61	0.65	0.65	0.65	4.30
1957	0.16	0.23	0.29	0.52	0.62	0.70	0.77	0.77	0.82	0.99	9.73
1958	0.10	0.16	0.18	0.21	0.32	0.56	0.59	0.69	0.87	0.94	11.04
1959	0.02	0.04	0.07	0.13	0.24	0.33	0.42	0.58	0.80	1.02	3.86
1960	0.05	0.07	0.09	0.16	0.27	0.51	0.63	0.78	1.41	1.76	5.15
1961	0.15	0.24	0.28	0.37	0.51	0.60	0.60	1.00	1.33	1.50	5.12
1962	0.06	0.08	0.11	0.20	0.38	0.74	0.75	1.10	1.15	1.37	7.98
1963	0.17	0.19	0.22	0.32	0.48	0.73	0.85	0.98	1.05	1.05	8.51
1964	0.05	0.07	0.10	0.19	0.34	0.41	0.42	0.79	0.98	1.00	4.31
1965	0.21	0.23	0.25	0.36	0.45	0.58	0.84	1.15	1.17	1.63	9.96
1966	0.09	0.14	0.16	0.23	0.32	0.47	0.50	0.92	1.40	2.27	5.79
1967	0.09	0.14	0.17	0.26	0.35	0.36	0.37	0.53	0.69	0.74	6.12
1968	0.02	0.06	0.09	0.15	0.25	0.38	0.38	0.45	0.65	0.96	5.30
1969	0.16	0.18	0.27	0.36	0.50	0.70	0.90	1.53	2.27	2.66	13.25
1970	0.03	0.06	0.09	0.14	0.25	0.41	0.54	0.72	0.79	0.86	6.47
1971	0.04	0.07	0.10	0.14	0.20	0.28	0.44	0.75	0.81	0.85	4.27
1972	0.04	0.07	0.08	0.13	0.23	0.27	0.32	0.45	0.62	0.62	3.28
1973	*****	*****	*****	0.29	0.34	0.50	0.64	0.80	0.85	1.00	8.53
1974	*****	*****	*****	*****	0.16	0.31	0.41	0.62	0.85	1.55	6.86

PRECIPITATION DEPTH-DURATION-FREQUENCY TABLE

STATION NO. BSN ORDER SUB	STATION NAME	ELEV	SEC	TWP	RNG	LOT	PMM	LATITUDE	LONGITUDE	COUNTY
C00 1867 0	COALINGA 1SE	663	04	21S	15E	J	M	36.128	120.344	FRESNO

MAXIMUM PRECIPITATION (IN) FOR INDICATED DURATION D=DAYS H=HOURS M=MINUTES

RETURN PERIOD IN YEARS	5M	10M	15M	30M	1H	2H	3H	6H	12H	24H	C-YR
2	0.09	0.13	0.17	0.23	0.32	0.45	0.54	0.74	0.89	1.08	6.46
5	0.13	0.18	0.23	0.32	0.44	0.62	0.74	1.01	1.23	1.49	8.88
10	0.15	0.21	0.27	0.38	0.52	0.73	0.88	1.20	1.45	1.76	10.41
20	0.17	0.24	0.31	0.44	0.60	0.84	1.01	1.38	1.66	2.02	11.82
25	0.18	0.25	0.32	0.45	0.62	0.87	1.05	1.43	1.73	2.10	12.26
40	0.19	0.27	0.35	0.49	0.67	0.94	1.13	1.55	1.87	2.27	13.15
50	0.20	0.28	0.36	0.51	0.69	0.97	1.17	1.60	1.93	2.34	13.57
100	0.22	0.31	0.40	0.56	0.77	1.07	1.29	1.76	2.13	2.58	14.83
200	0.24	0.33	0.44	0.61	0.84	1.17	1.41	1.92	2.32	2.87	16.05
1000	0.28	0.40	0.52	0.73	0.99	1.39	1.68	2.29	2.76	3.35	18.79
10000	0.35	0.49	0.63	0.89	1.21	1.70	2.05	2.79	3.37	4.09	22.53
PMP	0.66	0.92	1.20	1.68	2.30	3.22	3.89	5.30	6.41	7.77	46.28

	5M	10M	15M	30M	1H	2H	3H	6H	12H	24H	C-YR
MEAN	0.099	0.139	0.181	0.254	0.347	0.485	0.586	0.799	0.965	1.171	6.892
CLOCK HR. COR.	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
CALCULATED SKEW	0.480	0.900	1.349	1.194	1.497	1.158	0.561	0.477	1.402	1.172	0.776
REGIONAL SKEW	1.300	1.300	1.300	1.300	1.300	1.300	1.300	1.300	1.300	1.300	1.000
SKEW USED	1.300	1.300	1.300	1.300	1.300	1.300	1.300	1.300	1.300	1.300	1.000

SLOPE OF LOG INTENSITY / LOG TIME = -.504 ; INTERCEPT (TIME=1 HOUR) =0.346 ; COEFFICIENT OF DETERMINATION = 0.999
1HR INTERCEPT / MEAN YR =0.05025 ; AVERAGE CALC CV / USED CV = 1.22

	5M	10M	15M	30M	1H	2H	3H	6H	12H	24H	C-YR
KURTOSIS	2.373	2.435	4.877	3.644	7.192	5.620	3.239	3.731	6.249	5.112	5.178
N	31	31	31	32	38	35	35	35	35	35	35
RECORD YEAR	1965	1952	1952	1956	1955	1955	1955	1969	1969	1969	1941
RECORD MAXIMUM	0.210	0.280	0.470	0.540	0.920	1.060	1.070	1.530	2.270	2.660	14.210
NORMILIZED MAX	1.984	2.029	2.966	2.330	3.673	3.407	2.556	2.749	3.418	3.139	2.448
CALC. COEF. VAR	0.568	0.500	0.540	0.484	0.450	0.348	0.323	0.333	0.396	0.405	0.434
REGN. COEF. VAR	0.376	0.376	0.376	0.376	0.376	0.376	0.376	0.376	0.376	0.376	0.381
USED COEF. VAR	0.376	0.376	0.376	0.376	0.376	0.376	0.376	0.376	0.376	0.376	0.381

	5M	10M	15M	30M	1H	2H	3H	6H	12H	24H	C-YR
MEAN/A	0.0143	0.0202	0.0262	0.0368	0.0503	0.0704	0.0851	0.1159	0.1400	0.1699	1.0000
RP10/A	0.0215	0.0303	0.0394	0.0554	0.0757	0.1058	0.1279	0.1743	0.2105	0.2554	1.5107
RP25/A	0.0257	0.0362	0.0470	0.0660	0.0902	0.1262	0.1525	0.2078	0.2510	0.3045	1.7783
RP50/A	0.0287	0.0404	0.0525	0.0737	0.1008	0.1410	0.1704	0.2321	0.2804	0.3401	1.9685
RP100/A	0.0316	0.0445	0.0579	0.0813	0.1111	0.1554	0.1878	0.2559	0.3090	0.3749	2.1516
RP1000/A	0.0410	0.0578	0.0751	0.1054	0.1441	0.2016	0.2436	0.3319	0.4009	0.4863	2.7264
RP10000/A	0.0501	0.0705	0.0917	0.1287	0.1760	0.2461	0.2975	0.4053	0.4895	0.5939	3.2696
PMP/A	0.0951	0.1340	0.1740	0.2445	0.3342	0.4674	0.5649	0.7697	0.9296	1.1278	6.7150

PEARSON TYPE III DISTRIBUTION USED
PROBABLE MAXIMUM PRECIPITATION ESTIMATE BASED ON 15 STANDARD DEVIATIONS
WHERE N IS SMALL (<25) RESULTS ARE NOT DEPENDABLE

ENVIRONMENTAL SOLUTIONS, INC.

By VDI Date 6-1-90 Subject LANDFILL B-18 DRAINAGE DESIGN Sheet No. 54 of 59

Chkd. By NA Date Proj. No. 89-997

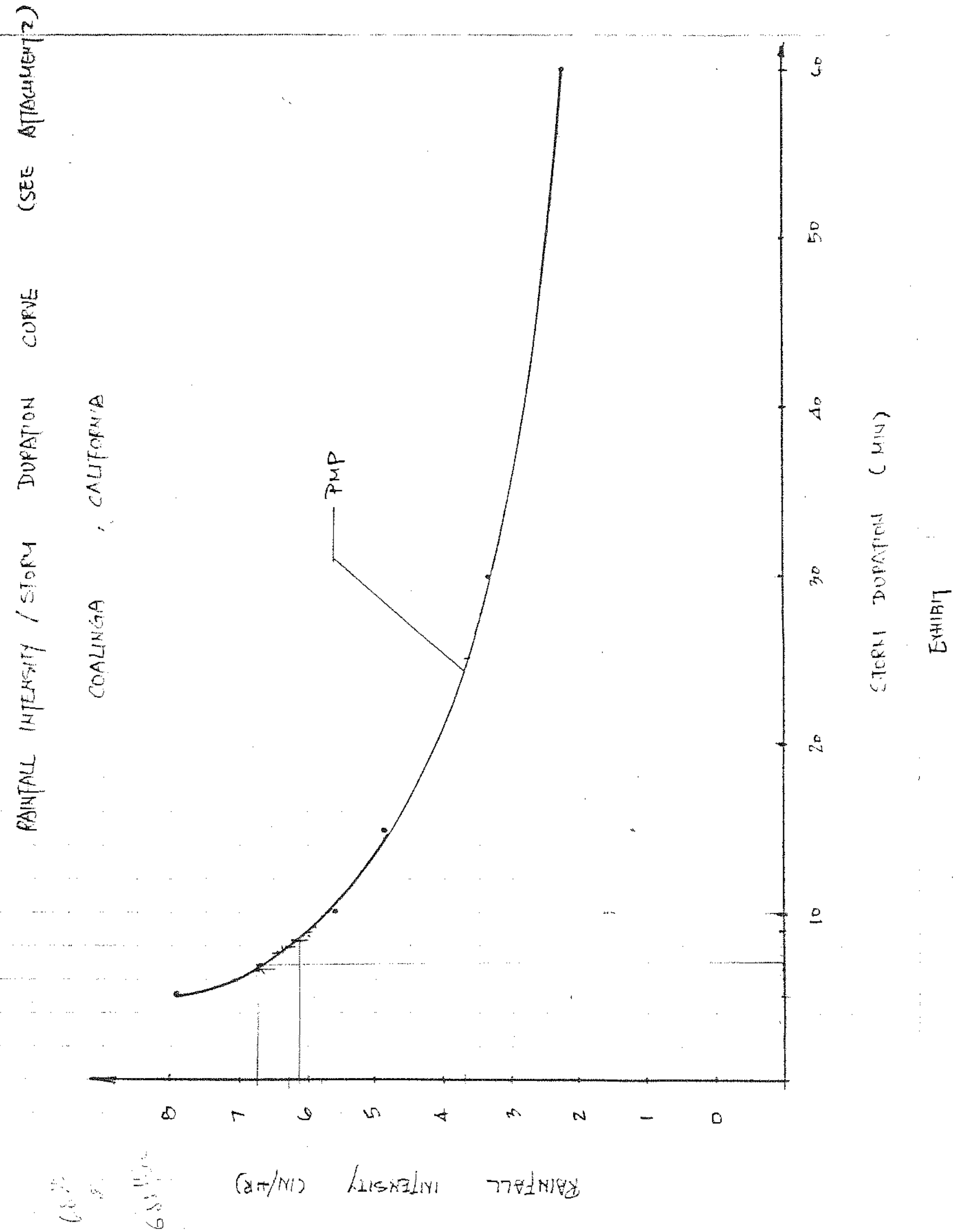

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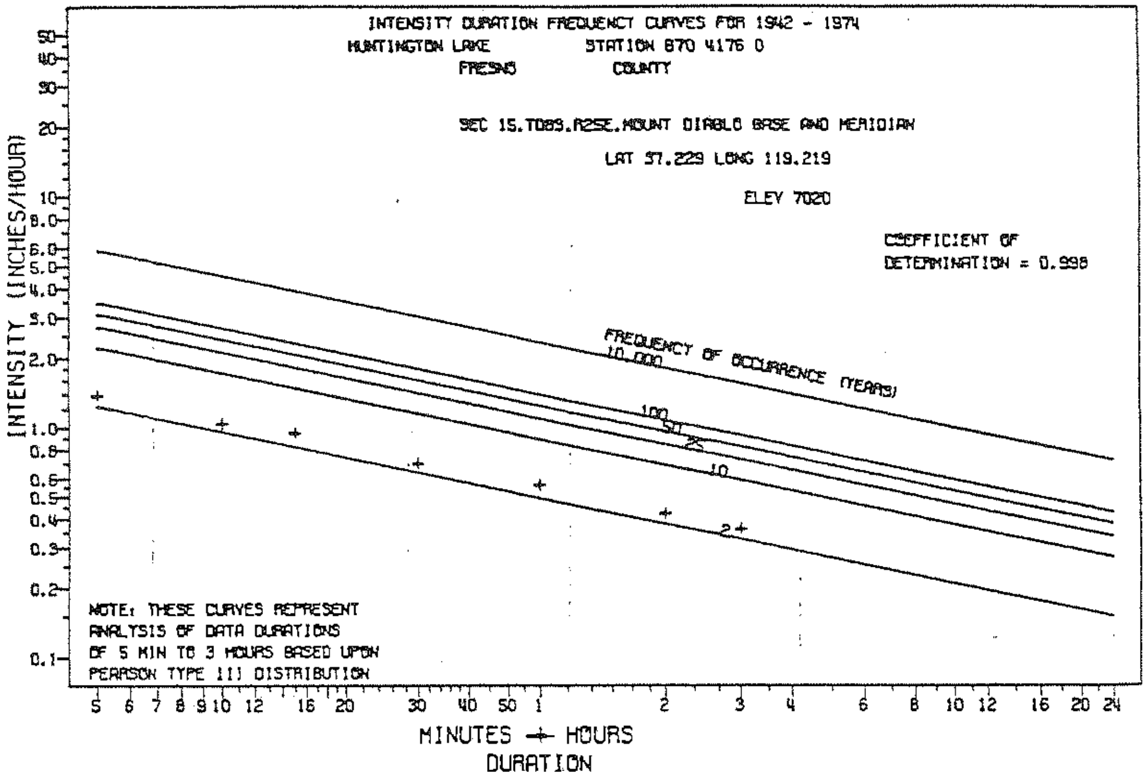
EXHIBIT 5



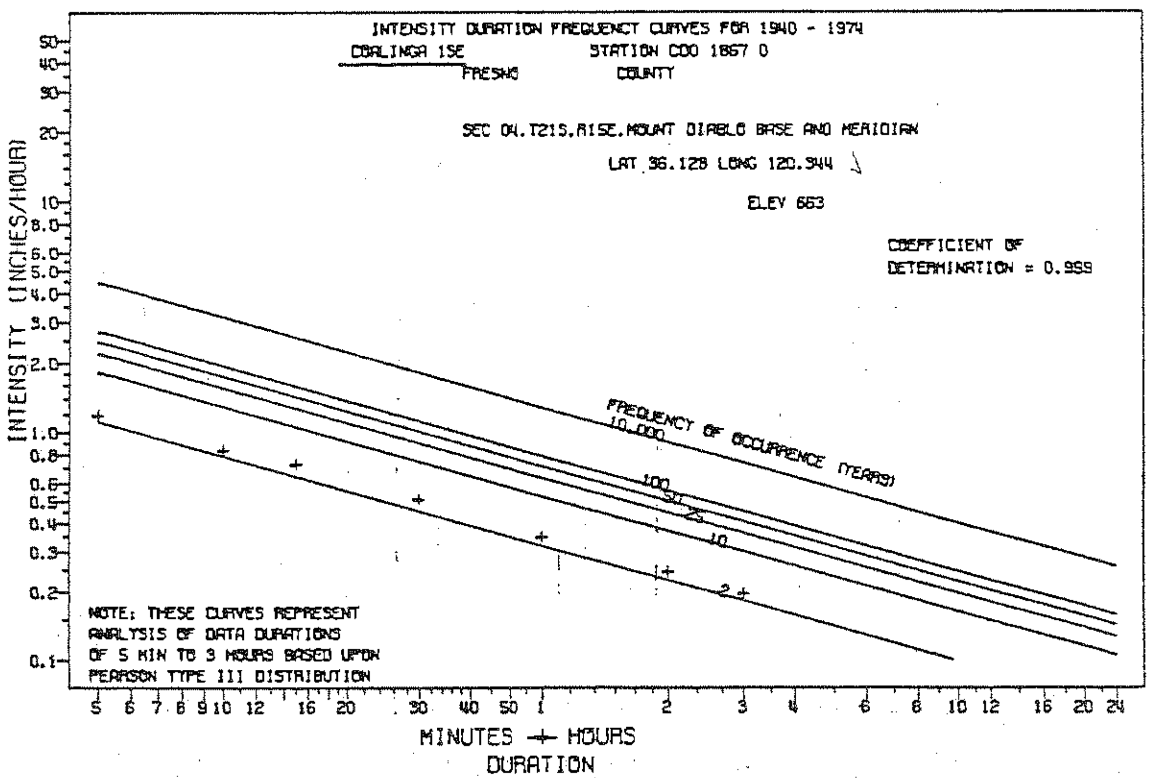
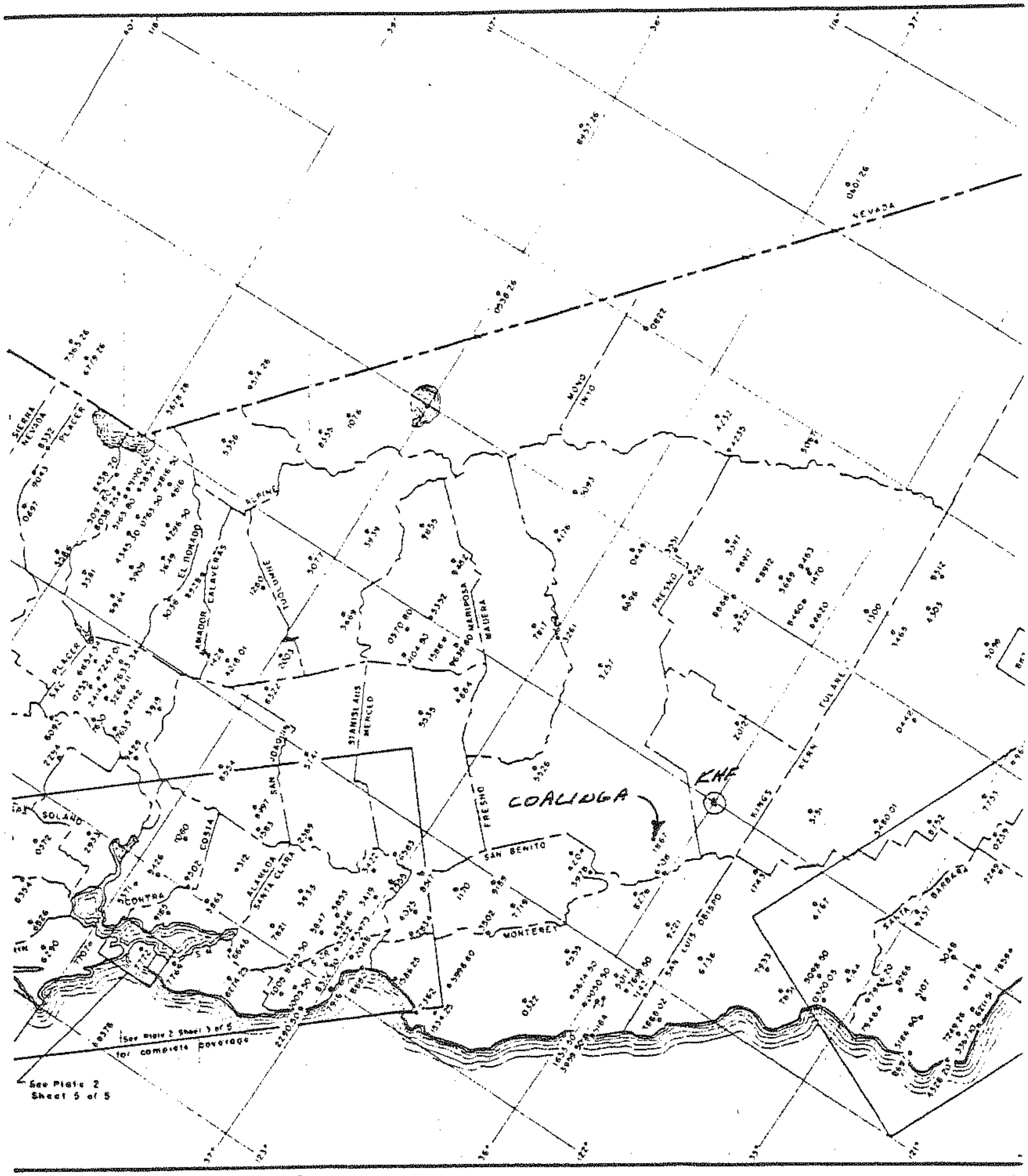


EXHIBIT 6



KHF
⊙ LOCATION OF SITE

EXHIBIT 7

P. 57/59

Table 2

MINIMUM RUNOFF COEFFICIENTS FOR BUILT-UP AREAS

RESIDENTIAL AREAS:	C = 0.55 to 0.70
HOTEL-APARTMENT AREAS:	C = 0.70 to 0.90
BUSINESS AREAS:	C = 0.80 to 0.90
INDUSTRIAL AREAS:	C = 0.80 to 0.90

The type of soil, the type of open space and ground cover and the slope of the ground shall be considered in arriving at reasonable and acceptable runoff coefficients.

Table 3

APPROXIMATE AVERAGE VELOCITIES OF RUNOFF FOR CALCULATING TIME OF CONCENTRATION

TYPE OF FLOW	VELOCITY IN FPS FOR SLOPES (in percent) INDICATED			
OVERLAND FLOW:	0–3%	4–7%	8–11%	12–15%
Woodlands	1.0	2.0	3.0	3.5
Pastures	1.5	3.0	4.0	4.5
Cultivated	2.0	4.0	5.0	6.0
Pavements	5.0	12.0	15.0	18.0
OPEN CHANNEL FLOW:				
Improved Channels	Determine Velocity by Manning's Formula			
Natural Channel* (not well defined)	1.0	3.0	5.0	8.0

**These values vary with the channel size and other conditions so that the ones given are the averages of a wide range. Wherever possible, more accurate determinations should be made for particular conditions by Manning's formula.*

18 K13 ###

PRECIPITATION DEPTH-DURATION-FREQUENCY TABLE

STATION NO. DSN ORDER SUB	STATION NAME	ELEV	SEC	TWP	RNG LOT	BWM	LATITUDE	LONGITUDE	COUNTY CODE
COO 4536 00	KETTLEMAN STATION	508	25	21S	17E L	M	36.075	120.085	16

MAXIMUM PRECIPITATION FOR INDICATED DURATION D-DAYS H-HOURS

RETURN PERIOD IN YEARS	1D	2D	3D	4D	5D	6D	8D	10D	15D	20D	30D	60D	365D
2	.98	1.21	1.31	1.38	1.44	1.50	1.60	1.76	2.00	2.14	2.58	3.49	6.08
5	1.35	1.71	1.89	2.00	2.09	2.18	2.33	2.53	2.93	3.10	3.65	4.98	8.35
10	1.59	2.05	2.28	2.42	2.53	2.64	2.83	3.04	3.56	3.74	4.34	5.96	9.79
20	1.83	2.38	2.65	2.82	2.95	3.08	3.30	3.52	4.17	4.35	4.98	6.88	11.12
25	1.90	2.48	2.77	2.94	3.08	3.21	3.45	3.67	4.36	4.54	5.17	7.16	11.53
40	2.05	2.70	3.01	3.20	3.36	3.50	3.76	3.99	4.75	4.93	5.27	7.75	12.37
50	2.12	2.80	3.13	3.33	3.48	3.64	3.90	4.14	4.94	5.12	5.77	8.03	12.76
100	2.34	3.10	3.48	3.70	3.88	4.05	4.34	4.59	5.50	5.68	6.35	8.87	13.95
200	2.55	3.41	3.82	4.07	4.27	4.45	4.78	5.03	6.06	6.23	6.91	9.69	15.10
1000	3.03	4.09	4.60	4.91	5.15	5.37	5.78	6.03	7.33	7.49	8.18	11.54	17.67
10000	3.71	5.05	5.70	6.09	6.38	6.66	7.17	7.42	9.10	9.23	9.92	14.11	21.19
PMP	7.06	9.47	10.72	11.49	12.05	12.58	13.55	14.32	17.25	17.88	20.09	27.91	43.52
MEAN	1.060	1.329	1.454	1.530	1.598	1.666	1.779	1.934	2.226	2.358	2.792	3.807	6.481
CLOCK HR. COR.	1.140	1.070	1.040	1.020	1.010	1.010	1.000	1.000	1.000	1.000	1.000	1.000	1.000
CALCULATED SKEW	.663	.605	.815	1.008	1.037	1.133	1.237	1.084	1.499	1.444	1.302	1.936	1.578
REGIONAL SKEW	1.300	1.400	1.400	1.400	1.400	1.400	1.400	1.300	1.400	1.300	1.100	1.200	1.000
SKEW USED	1.300	1.400	1.400	1.400	1.400	1.400	1.400	1.300	1.400	1.300	1.100	1.200	1.000
KURTOSIS	3.212	3.150	2.880	3.426	3.574	3.701	4.394	4.095	6.012	5.746	4.328	7.584	5.922
N	24	24	24	24	24	24	24	24	24	24	24	24	43
RECORD YEAR	1956	1956	1962	1974	1974	1974	1969	1969	1969	1969	1969	1969	1969
RECORD MAXIMUM	1.680	2.170	2.600	3.120	3.360	3.360	3.860	4.190	5.650	5.660	6.390	10.370	14.710
NORMALIZED MAX	1.557	1.768	1.869	2.284	2.369	2.351	2.630	2.631	3.092	3.033	2.712	3.328	2.748
CALC. COEF. VAR	.376	.358	.422	.453	.465	.433	.444	.443	.498	.462	.475	.518	.462
REGN. COEF. VAR	.376	.408	.425	.434	.436	.437	.441	.427	.450	.439	.413	.422	.381
USED COEF. VAR	.376	.408	.425	.434	.436	.437	.441	.427	.450	.439	.413	.422	.381
MEAN/A	.1635	.2051	.2243	.2361	.2466	.2570	.2744	.2984	.3434	.3638	.4307	.5874	1.0000
RP10/A	.2458	.3170	.3517	.3731	.3903	.4071	.4362	.4690	.5500	.5777	.6693	.9197	1.5107
RP25/A	.2931	.3832	.4271	.4542	.4754	.4959	.5320	.5669	.6722	.7005	.7982	1.1049	1.7783
RP50/A	.3274	.4316	.4822	.5134	.5375	.5608	.6019	.6381	.7615	.7897	.8905	1.2384	1.9685
RP100/A	.3609	.4789	.5362	.5714	.5983	.6244	.6704	.7074	.8490	.8766	.9798	1.3681	2.1516
RP1000/A	.4482	.6315	.7100	.7583	.7944	.8292	.8911	.9297	1.1308	1.1552	1.2621	1.7809	2.7264
RP10000/A	.5717	.7798	.8789	.9398	.9849	1.0282	1.1055	1.1443	1.4046	1.4242	1.5309	2.1769	3.2696
PMP/A	1.0857	1.4605	1.6543	1.7733	1.8594	1.9416	2.0899	2.2093	2.6615	2.7594	3.0991	4.3056	6.7150

PEARSON TYPE III DISTRIBUTION USED
PROBABLE MAXIMUM PRECIPITATION ESTIMATE BASED ON 15 STANDARD DEVIATIONS
WHERE N IS SMALL RESULTS ARE NOT DEPENDABLE

EXHIBIT 8

B

TABLE 5-6. VALUES OF THE ROUGHNESS COEFFICIENT n
(Boldface figures are values generally recommended in design)

Type of channel and description	Minimum	Normal	Maximum
A. CLOSED CONDUITS FLOWING PARTLY FULL			
A-1. Metal			
a. Brass, smooth	0.009	**0.010**	0.013
b. Steel			
1. Lockbar and welded	0.010	0.012	0.014
2. Riveted and spiral	0.013	0.016	0.017
c. Cast iron			
1. Coated	0.010	0.013	0.014
2. Uncoated	0.011	0.014	0.016
d. Wrought iron			
1. Black	0.012	0.014	0.015
2. Galvanized	0.013	0.016	0.017
e. Corrugated metal			
1. Subdrain	0.017	0.019	0.021
2. Storm drain	0.021	**0.024**	0.030
A-2. Nonmetal			
a. Lucite	0.008	0.009	0.010
b. Glass	0.009	**0.010**	0.013
c. Cement			
1. Neat, surface	0.010	0.011	0.013
2. Mortar	0.011	0.013	0.015
d. Concrete			
1. Culvert, straight and free of debris	0.010	0.011	0.013
2. Culvert with bends, connections, and some debris	0.011	**0.013**	0.014
3. Finished	0.011	0.012	0.014
4. Sewer with manholes, inlet, etc., straight	0.013	0.015	0.017
5. Unfinished, steel form	0.012	0.013	0.014
6. Unfinished, smooth wood form	0.012	**0.014**	0.016
7. Unfinished, rough wood form	0.015	0.017	0.020
e. Wood			
1. Stave	0.010	0.012	0.014
2. Laminated, treated	0.015	0.017	0.020
f. Clay			
1. Common drainage tile	0.011	**0.013**	0.017
2. Vitrified sewer	0.011	0.014	0.017
3. Vitrified sewer with manholes, inlet, etc.	0.013	0.015	0.017
4. Vitrified subdrain with open joint	0.014	**0.016**	0.018
g. Brickwork			
1. Glazed	0.011	0.013	0.015
2. Lined with cement mortar	0.012	0.015	0.017
h. Sanitary sewers coated with sewage slimes, with bends and connections	0.012	0.013	0.016
i. Paved invert, sewer, smooth bottom	0.016	0.019	0.020
j. Rubble masonry, cemented	0.018	0.025	0.030

TABLE 5-6. VALUES OF THE ROUGHNESS COEFFICIENT n (*continued*)

Type of channel and description	Minimum	Normal	Maximum
B. LINED OR BUILT-UP CHANNELS			
B-1. Metal			
a. Smooth steel surface			
1. Unpainted	0.011	**0.012**	0.014
2. Painted	0.012	0.013	0.017
b. Corrugated	0.021	0.025	0.030
B-2. Nonmetal			
a. Cement			
1. Neat, surface	0.010	0.011	0.013
2. Mortar	0.011	0.013	0.015
b. Wood			
1. Planed, untreated	0.010	0.012	0.014
2. Planed, creosoted	0.011	0.012	0.015
3. Unplaned	0.011	0.013	0.015
4. Plank with battens	0.012	0.015	0.018
5. Lined with roofing paper	0.010	0.014	0.017
c. Concrete			
1. Trowel finish	0.011	**0.013**	0.015
2. Float finish	0.013	0.015	0.016
3. Finished, with gravel on bottom	0.015	0.017	0.020
4. Unfinished	0.014	0.017	0.020
5. Gunite, good section	0.016	0.019	0.023
6. Gunite, wavy section	0.018	0.022	0.025
7. On good excavated rock	0.017	0.020	
8. On irregular excavated rock	0.022	0.027	
d. Concrete bottom float finished with sides of			
1. Dressed stone in mortar	0.015	0.017	0.020
2. Random stone in mortar	0.017	0.020	0.024
3. Cement rubble masonry, plastered	0.016	0.020	0.024
4. Cement rubble masonry	0.020	0.025	0.030
5. Dry rubble or riprap	0.020	0.030	0.035
e. Gravel bottom with sides of			
1. Formed concrete	0.017	0.020	0.025
2. Random stone in mortar	0.020	0.023	0.026
3. Dry rubble or riprap	0.023	0.033	0.036
f. Brick			
1. Glazed	0.011	**0.013**	0.015
2. In cement mortar	0.012	**0.015**	0.018
g. Masonry			
1. Cemented rubble	0.017	0.025	0.030
2. Dry rubble	0.023	0.032	0.035
h. Dressed ashlar	0.013	0.015	0.017
i. Asphalt			
1. Smooth	0.013	0.013	
2. Rough	0.016	0.016	
j. Vegetal lining	0.030	.....	0.500

Exh 1T9

P.54/59

RE: TEMPORARY PHASE IIIA STORMWATER BERM AND CAPACITY OF NE B-18 CONTAINMENT BASIN DURING PHASE III CONSTRUCTION

1.0 OBJECTIVES

- Design the height of the proposed Phase IIIA temporary stormwater containment berm. This berm is required to be designed to function without failure to capture and retain the volume from the 24-hour, Probable Maximum Precipitation (PMP) storm event on the north side of the berm (i.e., this berm will contain stormwater run-off from the lower portion of the interim Phase IIIA waste slope and the surrounding areas).
- Evaluate the capacity versus demand of the existing NE B-18 Containment Basin during construction of Phase III. During the Phase III construction (i.e., before the South Containment Basin comes online), an outlet control system will be required during the 24-hour, PMP storm to prevent overtopping of the existing NE B-18 Containment Basin.

2.0 METHODOLOGY

The SCS Runoff Curve Number method was used to calculate the Phase IIIA interim drainage berm retention volume demand for the 24-hour, PMP storm event. This was compared to the proposed storage capacity of the Phase IIIA temporary basin to evaluate if the proposed berm is tall enough.

HEC-HMS modeling software (USACE) was used to evaluate the required outlet control peak flow rate to prevent overtopping of the existing NE B-18 Containment Basin during the Phase III construction.

3.0 ASSUMPTIONS

- The 24-hour PMP rainfall event equals 10.3 inches
- SCS Type 1 rainfall synthetic distribution was used
- SCS Curve Number (CN) of 81 was used for all basins

4.0 INTERIM PHASE IIIA DRAINAGE BERM CALCULATIONS

4.1 Storage Capacity

The interim Phase IIIA drainage berm will be constructed 10 feet high and have a maximum storage capacity of 52,100 cubic feet on its north side. This storage capacity assumes a freeboard of 1 foot (i.e., the 52,100 cubic feet of storage capacity is for a 9-foot depth of water contained by the berm on its north side).

It should be noted that stormwater run-on contained by the interim Phase IIIA drainage berm on its south side will be clean stormwater and will have a maximum depth of approximately 2 feet during the 24-hour PMP. This maximum depth corresponds to the elevation difference between the toe of the south side of the berm and the local high point on the Phase IIIB lined "floor bench" that lies to the south. It follows that the south side of the interim Phase IIIA drainage berm has an unlimited stormwater run-on storage capacity since the top of this berm is much higher than the local high point to the south.

4.2 PMP Volume Calculation

The SCS Curve Number method was used to evaluate the runoff volume from the 24-hour, PMP storm event for the north side of the Phase IIIA interim drainage berm. This interim drainage berm will capture 0.85 acres of storm water (see Figure 1). A Curve Number, CN, of 81 was used.

$$Q = (P - 0.2S)^2 / (P + 0.8S)$$

Where: Q = runoff, in

P = rainfall (10.3 in)

S = potential maximum retention after runoff, in

Where: S = 1000/CN - 10

The estimated runoff was calculated to be 7.94 inches over the 0.85-acre drainage basin. The minimum required volume for the Phase IIIA interim drainage basin to contain the 24-hour PMP is therefore 24,500 cubic feet.

5.0 EXISTING NE B-18 CONTAINMENT BASIN CALCULATIONS

The existing NE B-18 Containment Basin is approximately 25 feet deep with a capacity of approximately 30 acre-feet. A HEC-HMS analysis was performed using the existing conditions of the basin. If the 24-hour, PMP storm event was to occur during the Phase III construction (i.e., before the South Containment Basin is online), it is predicted that runoff to the NE B-18 Containment Basin will exceed capacity by approximately 14 acre-feet. Therefore, an outlet control device will be used to prevent overtopping of this basin during the 24-hour, PMP storm event. Excess water will be conveyed through the outlet and into a gravity pipe that will convey the overflow to the site's existing East Retention Basin located approximately 2,000 feet to the north.

5.1 Outlet Control System

HEC-HMS modeling software was used to calculate the peak flow rate required for an outlet control device set approximately 3 feet below the top of the existing NE B-18 Containment Basin embankment. Using a 21-inch orifice outlet device, it was calculated that a peak flow of 17 cfs was sufficient to prevent the basin from overtopping during the 24-hour PMP.

A preliminary minimum pipe size was calculated to convey the required 17 cfs from the NE B-18 Containment Basin. Pipe calculations were performed using the Federal Highway Administration software program Hydraulic Toolbox 2.1. A pipeline with a minimum slope of 1% and a Manning's coefficient of 0.010 was used to calculate the minimum size required to convey the required flow rate of 17 cfs. A minimum 21-inch inside diameter pipe is needed to convey the flow rate of 17 cfs.

6.0 CONCLUSIONS

The stormwater run-off volume from the 24-hour, PMP storm event captured on the north side of the proposed interim Phase IIIA drainage berm was calculated to be 24,500 cubic feet. The proposed interim Phase IIIA berm will be constructed to a height of 10 feet and will have a capacity of 52,100 cubic feet (assuming 1 foot of freeboard). Therefore, the proposed interim Phase IIIA drainage berm will have sufficient capacity to contain the flows from the 24-hour, PMP event with a freeboard greater than 1 foot.

The existing NE B-18 Containment Basin has a capacity of approximately 30 acre-feet. If the 24-hour, PMP storm event occurs during the construction of Phase III (i.e., before the South Containment Basin comes online), it is predicted that runoff to the existing NE B-18 Containment Basin will exceed its capacity by approximately 14 acre-feet. A 21-inch orifice outlet set approximately 3 feet below the top of the existing NE B-18 Containment Basin berm will prevent overtopping of this basin during the 24-hour, PMP event. The peak flows from the orifice outlet will be 17 cfs. The excess water from the outlet system will be conveyed by gravity pipe to the site's existing East Retention Basin located approximately 2,000 feet to the north.

7.0 REFERENCES

Hydraulic Toolbox [computer software] 2011 Federal Highway Administration (FHWA), Version 2.1

Ernest F. Brater and Horace H. King 1976. Handbook of Hydraulics, 6th edition. McGraw-Hill Inc.

U.S Department of Commerce, National Oceanic and Atmospheric Administration, U.S. Army Corps of Engineers. 1999. *Hydrometeorological Report No. 59* Probable Maximum Precipitation for California.

HEC-HMS Hydrologic Modeling System [computer software] US Army Corps of Engineers Version 3.1.0

8.0 ATTACHMENTS

Figure 1: Watershed Area for Phase IIIA Temporary Stormwater Berm

Attachment 1: HEC-HMS Kettleman B-18 Basin Schematic

Attachment 2: HEC-HMS NE B-18 Containment Basin Outlet Control Discharge Results

Attachment 3: NE B-18 Containment Basin Conveyance Pipe Calculation Results

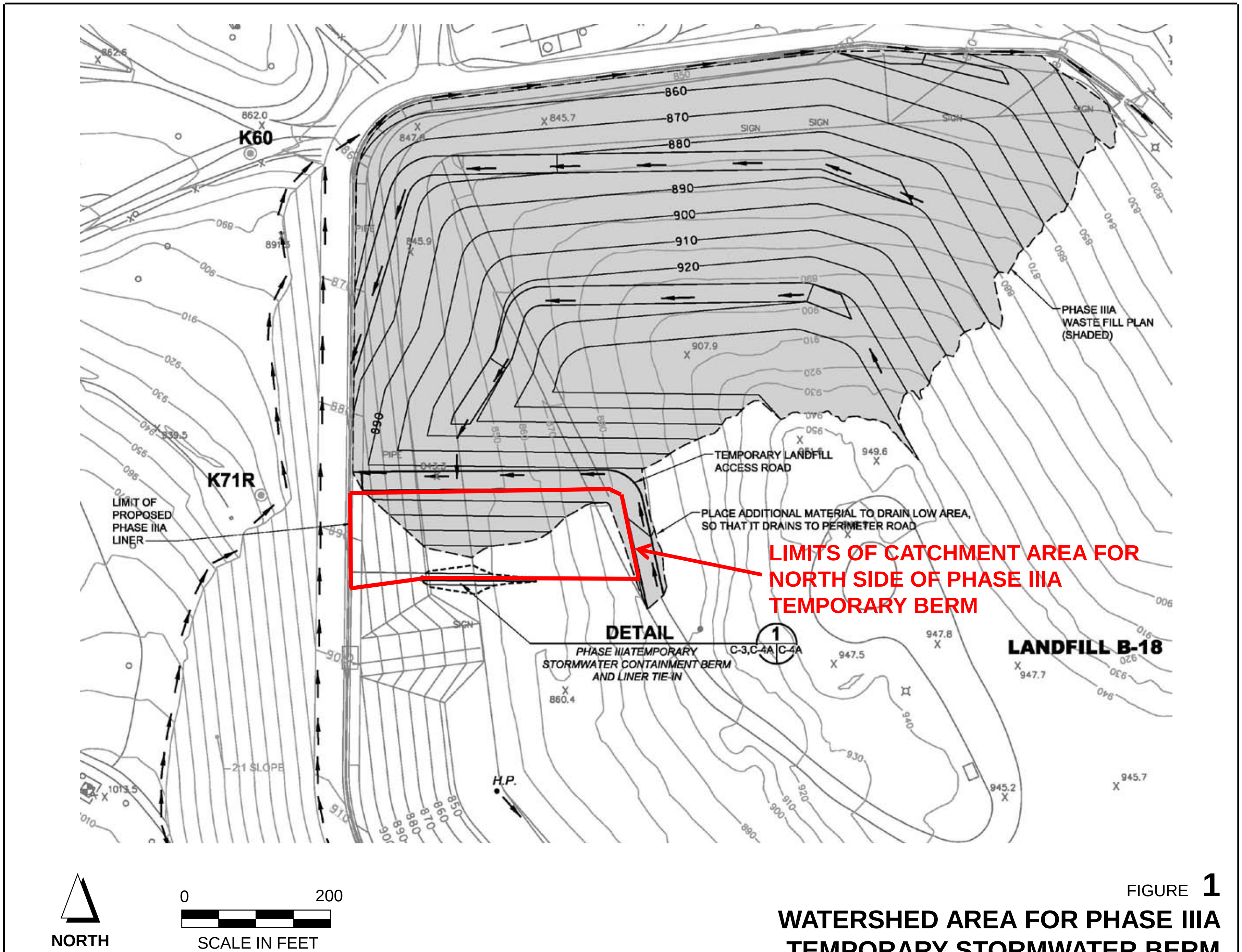


FIGURE **1**

WATERSHED AREA FOR PHASE IIIA TEMPORARY STORMWATER BERM

KETTLEMAN HILLS FACILITY, LANDFILL UNIT B-18

PROJECT NO.: 083-91887 DRAWN BY: RH CHECKED BY: RH DATE: AUGUST 2011

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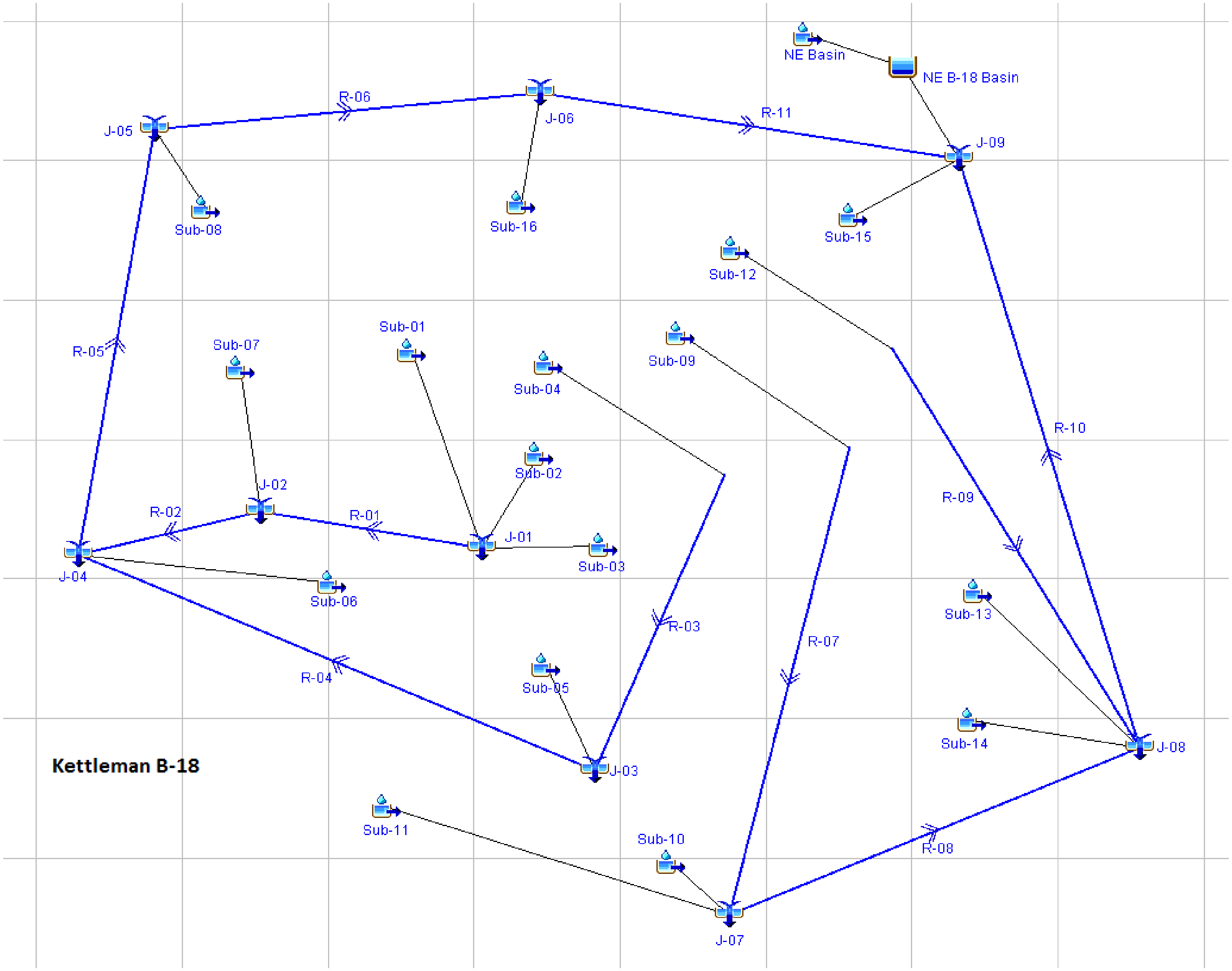
Attachment 1

HEC-HMS Kettleman B-18 Basin Schematic

Attachment 2
HEC-HMS
B-18 Cover
Basin Layout

HEC-HMS Basin Model Schematic



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8/10/2011

Attachment 2

HEC-HMS NE B-18 Containment Basin Outlet Control Discharge Results

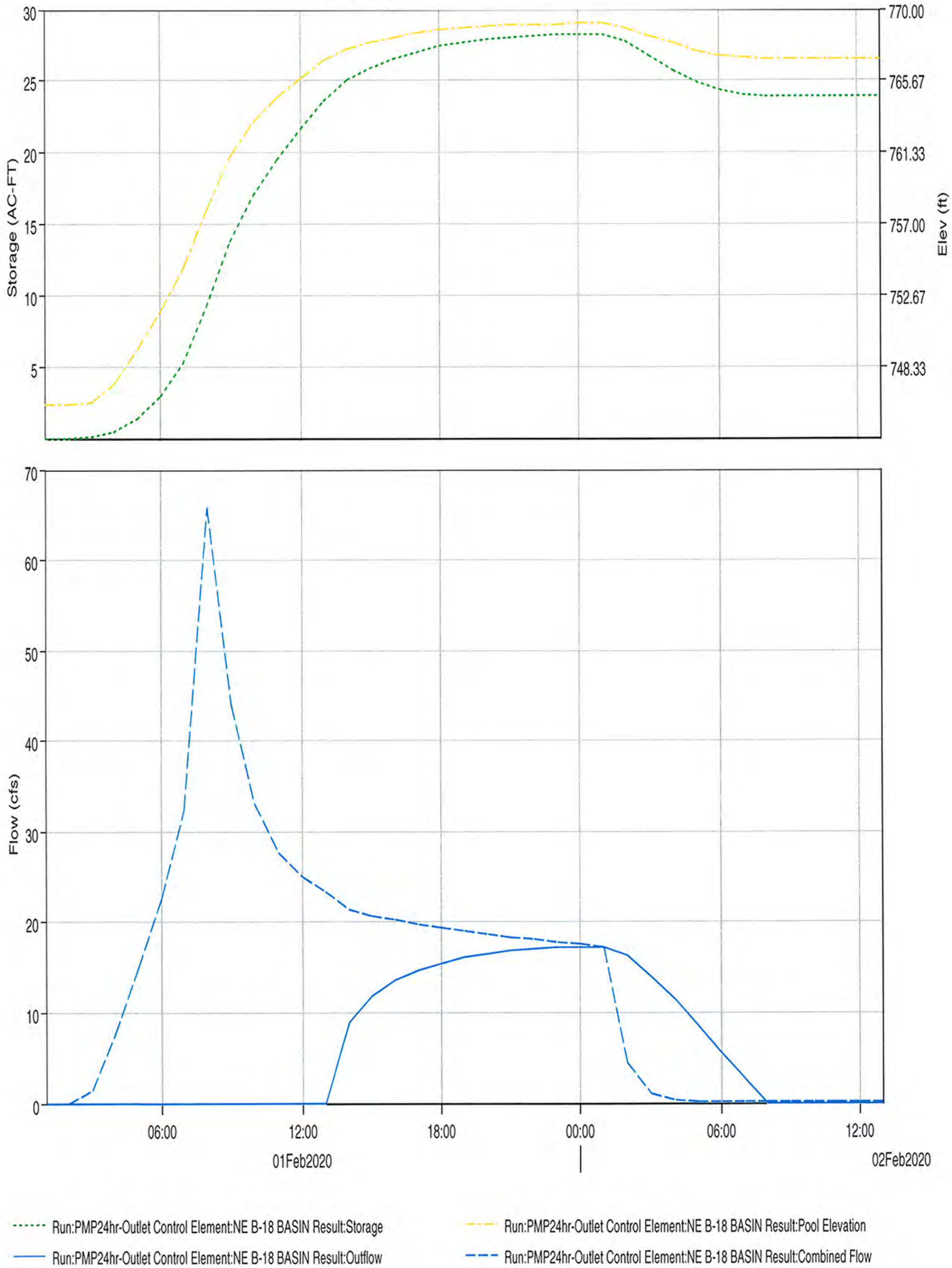
	Project:	Kettleman_B18_Rev2	
Simulation Run:	PMP24hr-Outlet Control	Reservoir:	NE B-18 Basin
Start of Run:	01Feb2020, 01:00	Basin Model:	B-18 Cover-Outlet Control
End of Run:	02Feb2020, 13:00	Meteorologic Model:	LocalPMP24hr
Compute Time:	10Aug2011, 10:15:53	Control Specifications:	1Hr36Hr

Volume Units: AC-FT

Computed Results

Peak Inflow :	65.7 (CFS)	Date/Time of Peak Inflow :	01Feb2020, 08:00
Peak Outflow :	17.2 (CFS)	Date/Time of Peak Outflow :	02Feb2020, 01:00
Total Inflow :	43.8 (AC-FT)	Peak Storage :	28.3 (AC-FT)
Total Outflow :	19.9 (AC-FT)	Peak Elevation :	769.1 (FT)

Reservoir "NE B-18 Basin" Results for Run "PMP24hr-Outlet Control"



Project: Kettleman_B18_Rev2
Simulation Run: PMP24hr-Outlet Control Reservoir: NE B-18 Basin

Start of Run: 01Feb2020, 01:00 Basin Model: B-18 Cover-Outlet C
End of Run: 02Feb2020, 13:00 Meteorologic Model: LocalPMP24hr
Compute Time: 10Aug2011, 10:15:53 Control Specifications: 1Hr36Hr

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
01Feb2020	01:00	0.0	0.0	746.0	0.0
01Feb2020	02:00	0.0	0.0	746.0	0.0
01Feb2020	03:00	1.3	0.1	746.2	0.0
01Feb2020	04:00	7.4	0.4	747.2	0.0
01Feb2020	05:00	14.9	1.3	749.3	0.0
01Feb2020	06:00	22.7	2.9	751.7	0.0
01Feb2020	07:00	32.4	5.2	754.2	0.0
01Feb2020	08:00	65.7	9.2	757.8	0.0
01Feb2020	09:00	44.1	13.7	761.1	0.0
01Feb2020	10:00	33.0	16.9	763.1	0.0
01Feb2020	11:00	27.6	19.4	764.6	0.0
01Feb2020	12:00	25.0	21.6	765.8	0.0
01Feb2020	13:00	23.3	23.6	766.8	0.0
01Feb2020	14:00	21.4	25.0	767.6	8.9
01Feb2020	15:00	20.7	25.9	768.0	11.9
01Feb2020	16:00	20.2	26.5	768.3	13.5
01Feb2020	17:00	19.8	27.0	768.5	14.6
01Feb2020	18:00	19.4	27.4	768.7	15.4
01Feb2020	19:00	19.0	27.7	768.9	16.0
01Feb2020	20:00	18.6	27.9	769.0	16.5
01Feb2020	21:00	18.3	28.0	769.0	16.8
01Feb2020	22:00	18.0	28.1	769.1	17.0
01Feb2020	23:00	17.7	28.2	769.1	17.1
02Feb2020	00:00	17.5	28.2	769.1	17.2
02Feb2020	01:00	17.1	28.3	769.1	17.2

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
02Feb2020	02:00	4.3	27.8	768.9	16.2
02Feb2020	03:00	1.0	26.7	768.4	14.0
02Feb2020	04:00	0.2	25.7	767.9	11.4
02Feb2020	05:00	0.1	24.9	767.5	8.5
02Feb2020	06:00	0.0	24.3	767.2	5.6
02Feb2020	07:00	0.0	24.0	767.0	2.6
02Feb2020	08:00	0.0	23.9	767.0	0.0
02Feb2020	09:00	0.0	23.9	767.0	0.0
02Feb2020	10:00	0.0	23.9	767.0	0.0
02Feb2020	11:00	0.0	23.9	767.0	0.0
02Feb2020	12:00	0.0	23.9	767.0	0.0
02Feb2020	13:00	0.0	23.9	767.0	0.0

Attachment 3

NE B-18 Containment Basin Conveyance Pipe Calculation Results

Pipe Flow Results

Project Data

Project Title: Kettleman B-18 Phase IIIA

Designer: Golder

Project Date: Wednesday, August 10, 2011

Project Units: U.S. Customary Units

Channel Analysis: 18" Pipe - 10 cfs

Input Parameters

Channel Type: Circular

Pipe Diameter: 1.5000 (ft)

Longitudinal Slope: 0.0100 (ft/ft)

Manning's n: 0.0100

Flow: 10.0000 (cfs)

Result Parameters

Depth: 0.9533 (ft)

Area of Flow: 1.1848 (ft^2)

Wetted Perimeter: 2.7680 (ft)

Hydraulic Radius: 0.4280 (ft)

Average Velocity: 8.4402 (ft/s)

Top Width: 1.4438 (ft)

Froude Number: 1.6419

Critical Depth: 1.2188 (ft)

Critical Velocity: 8.8096 (ft/s)

Critical Slope: 0.0054 (ft/ft)

Critical Top Width: 1.1709 (ft)

Calculated Max Shear Stress: 0.5949 (lb/ft^2)

Calculated Avg Shear Stress: 0.2671 (lb/ft^2)

Channel Analysis: 21" Pipe - 18 cfs

Input Parameters

Channel Type: Circular

Pipe Diameter: 1.7500 (ft)

Longitudinal Slope: 0.0100 (ft/ft)

Manning's n: 0.0100

Flow: 18.0000 (cfs)

Result Parameters

Depth: 1.2668 (ft)

Area of Flow: 1.8647 (ft^2)

Wetted Perimeter: 3.5614 (ft)

Hydraulic Radius: 0.5236 (ft)

Average Velocity: 9.6531 (ft/s)

Top Width: 1.5647 (ft)

Froude Number: 1.5583

Critical Depth: 1.5441 (ft)

Critical Velocity: 9.6806 (ft/s)

Critical Slope: 0.0069 (ft/ft)

Critical Top Width: 1.1278 (ft)

Calculated Max Shear Stress: 0.7905 (lb/ft^2)

Calculated Avg Shear Stress: 0.3267 (lb/ft^2)

APPENDIX J.4
FINAL CLOSURE DRAINAGE

OBJECTIVE:

The cover system and drainage control systems for the existing Landfill B-18 are required to be designed to function without failure when subjected to capacity, hydrostatic and hydrodynamic loads resulting from a 24-hour, Probable Maximum Precipitation storm [CCR 22, 66264.25]. Design surface water conveyance channels and bench channels, design the proposed retention pond (Reservoir 1) and analyze the existing retention pond (Reservoir 2) for the Kettleman Hills B-18 Landfill cover configuration. All runoff from the B-18 Landfill configuration is to be routed to the proposed retention pond (Reservoir 1) located on the southeast section of the landfill or to the existing retention pond (Reservoir 2) located on the northeast section of the landfill.

METHOD:

The local PMP (Probable Maximum Precipitation) storm event results in a higher precipitation intensity and thus higher peak channel flow, the 6-hour PMP, was used to evaluate all channels. The 24-hour rainfall event for the PMP was used for evaluating retention volume. The 6-hour and 24-hour PMPs were derived from the Hydrometeorological Report No. 59 (Reference Attachment C). The surface water parameters as described below were used to model the Kettleman Hills B-18 Landfill. Figure 1 presents the watershed delineation map for sub-basin boundaries. Figures 2 & 3 present typical drainage channel geometries. Basin areas and curve numbers (CNs) were entered into HEC-HMS modeling software (USACE) and routed to calculate the peak flows for each basin. Kinematic wave transform methodology was used to develop hydrographs for each sub-basin except for offsite sub-basins Offsite 3, Offsite 4, and Offsite 5 which were modeled using the SCS unit hydrograph method. The peak flows were then used to size the landfill perimeter and bench channels, assuming normal depth. All model output can be found attached in this appendix.

ASSUMPTIONS:

- The 6-hour rainfall event for the local PMP equals 6.5 inches (used for designing channels). Ref. Attachment C.
- The 24-hour rainfall event for the PMP equals 10.3 inches (used for checking retention volume). Ref. Attachment C.
- SCS Type I rainfall synthetic distribution.
- Landfill final cover SCS Curve Numbers (CN):

Location	Soil Type	Hydrologic Soil Group	Assumed Cover	SCS CN
Landfill Final Cover	Mercey Loam	C	Herbaceous: fair cover	81
Natural Terrain (south)	Mercey Loam	C	Herbaceous: fair cover	81
Natural Terrain (west)	Mercey Loam	C	Herbaceous: good cover	74

- Manning's n for routing and channel design:

Channel Lining	Manning's n for Stability	Manning's n for Capacity
Grass	0.030	0.035
Turf Reinf. Mat	0.030	0.035
Rip-rap	0.035	0.040
Asphalt	0.016	0.016

- Grass lining was used with velocities up to 7 fps, turf reinforcement mat was used with velocities up to 10 fps or at directional changes in grass lined channels, and hard lined (asphalt or shotcrete) or riprap for velocities higher than 10 fps. Given the short term nature of the peak velocity during the conservatively assumed Local PMP, these velocities are considered acceptable.

CALCULATIONS:

The HEC-HMS modeling software (USACE) was used to calculate flows at design points and the retention volume. All channel calculations were performed using a spreadsheet to calculate normal depth for both stability and capacity and FlowMaster to evaluate road/ditch sections.

CONCLUSIONS/RESULTS:

The proposed retention pond (Reservoir 1) and the existing retention pond (Reservoir 2) have the capacity to contain the PMP (Probable Maximum Precipitation) flows. Subbasin delineation can be found in **Figure 1**. Attached are spreadsheet and other calculations. A summary of subbasins can be found in **Table 1**, times of concentration can be found in **Table 2**, flow results from HEC-HMS in **Table 3**. Also attached are pond sizing calculations, HEC-HMS input & routing diagrams, and Flowmaster calculations for channels.

Based on the calculations, the maximum velocity for the bench channel on the landfill is 6.1feet per second. This is below the design criteria of 7 feet per second for grass-lined channels. The closure access road will contain stormwater flows within the asphalt lined channel. The peak velocity within the asphalt-lined channel during a PMP, 6-hour event will be 23.4 feet per second which is below the maximum allowable velocity of 25 feet per second. The perimeter road channel will exceed the flow capacity of the roadside asphalt-lined channel. The peak PMP, 6-hour stormwater flows will be contained within the roadway. Velocities within the channel will be less than the maximum allowable 25 feet per second. During the 24-hour PMP, it is predicted that run-off to the existing retention basin (Reservoir 2) located on the north side of the proposed landfill will exceed capacity by approximately 2 AC-FT. In the event of a PMP storm event, the excess stormwater will have to be pumped to the proposed retention basin (Reservoir 1).

REFERENCES:

HEC-HMS Hydrologic Modeling System [computer software] US Army Corps of Engineers Version 3.1.0

Bentley FlowMaster [computer software] 2005 Bentley Systems Inc. Service Pack 3

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U.S. Bureau of Reclamation (USBR). 1977. *Design of small dams 2nd ed.* Washington D.C. : United States Government Printing Office.

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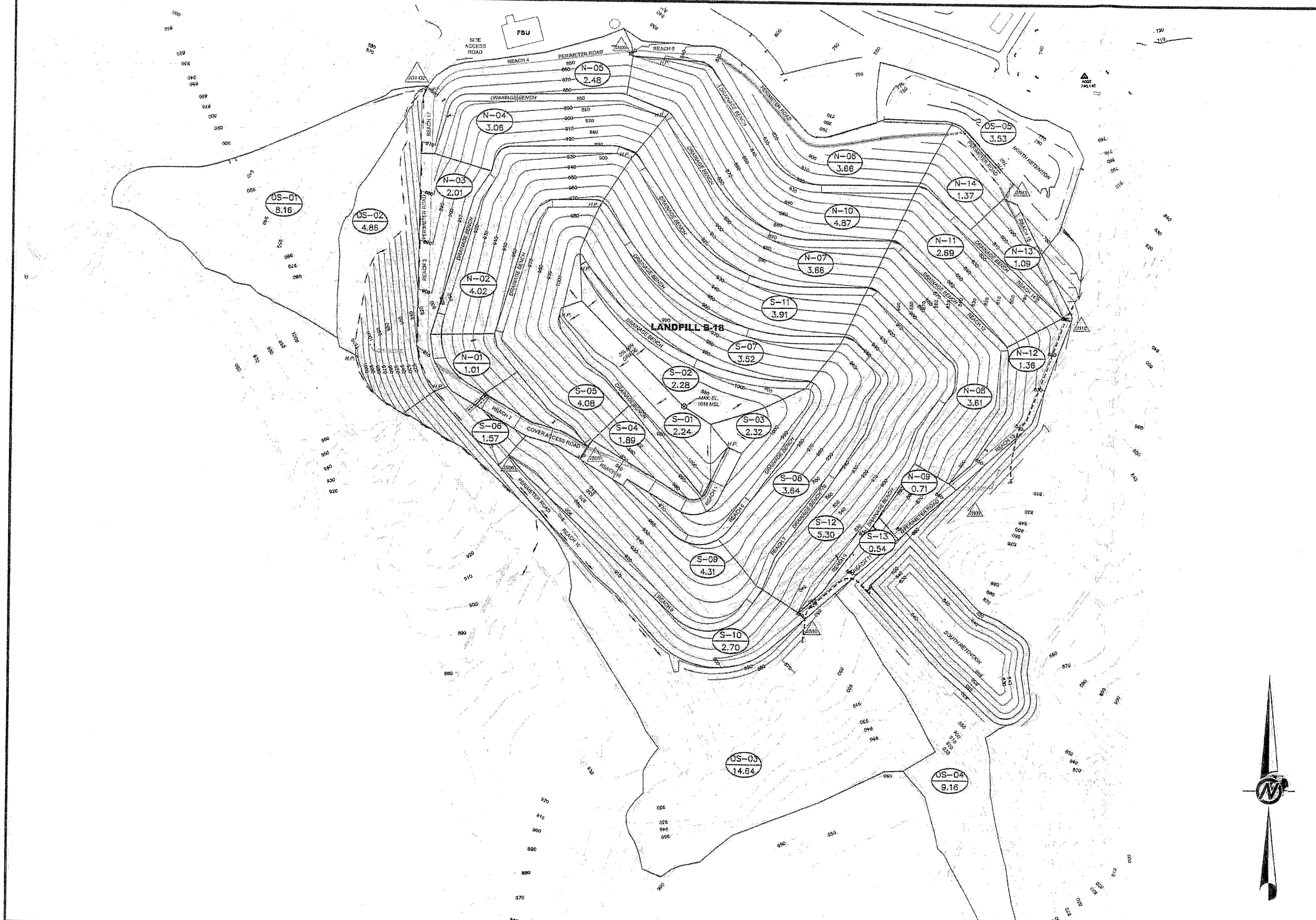
U.S Department of Commerce, National Oceanic and Atmospheric Administration, U.S. Army Corps of Engineers. 1999. *Hydrometeorological Report No. 59* Probable Maximum Precipitation for California.



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DENVER, COLORADO

PROJECT

KETTLEMAN HILLS
B-18 LANDFILL HYDROLOGY
KETTLEMAN HILLS, CA.

TITLE

B-18 LANDFILL COVER BASIN MAP

PROJECT No. 083-91887		
FILE No. 08391887A001		
REV. A	SCALE	1"=300'
DESIGN	PM	10/31/08
CADD	PM	10/31/01
CHECK	RH	11/4/08
REVIEW	[signature]	

FIGURE 1

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SUBJECT TYPICAL DRAINAGE CHANNELS		
Job No. Ref. KHF818	Made by SGS Checked RH Reviewed	Date 9-11-08 Sheet 1 of 1

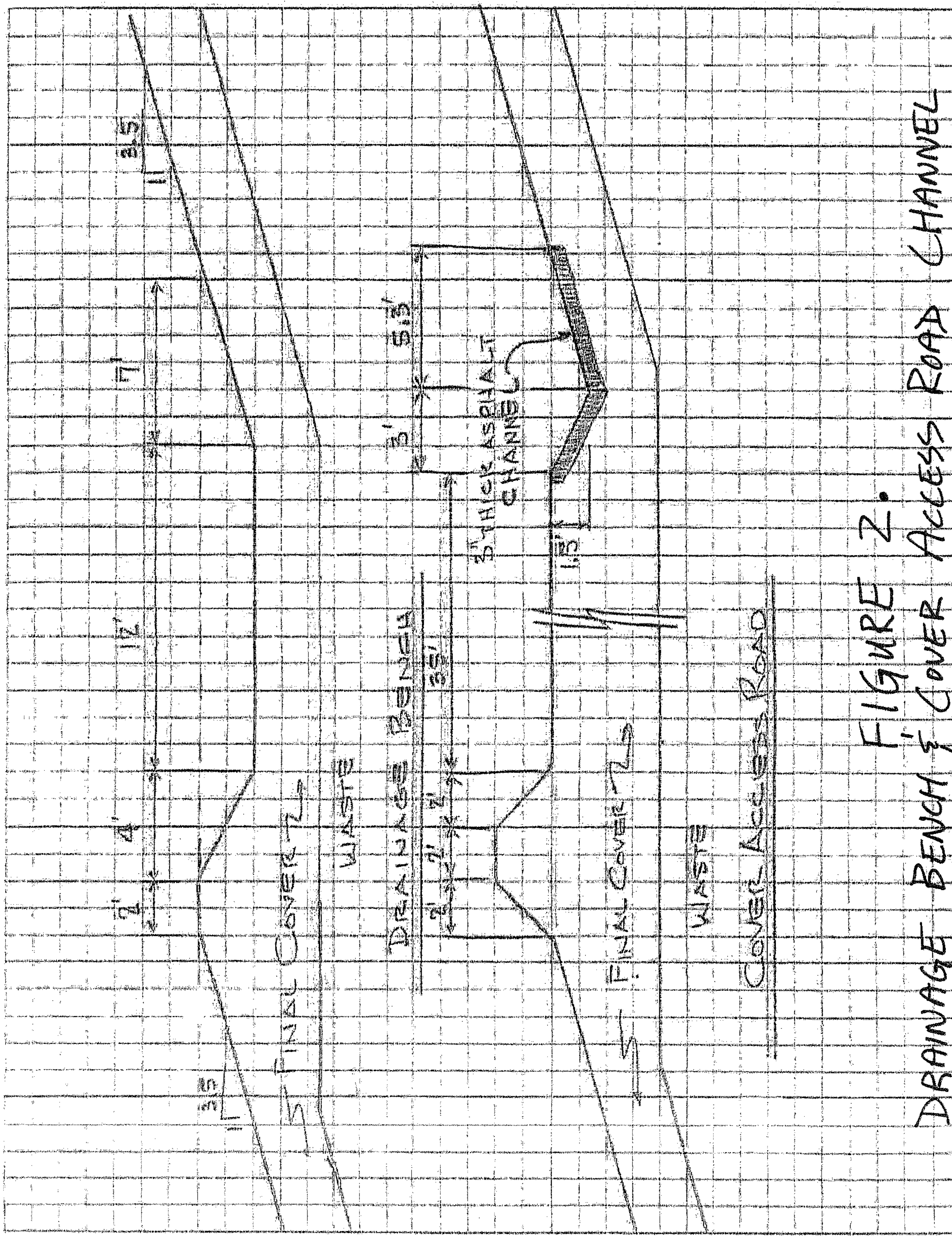

FIGURE 2.
DRAINAGE BENCH & COVER ACCESS ROAD CHANNEL CONFIGURATIONS (TYPICAL)

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SUBJECT TYPICAL DRAINAGE CHANNELS		
Job No.	Made by SGS	Date 9-11-08
Ref. KHF 818	Checked KH	Sheet 1 of 1
	Reviewed	

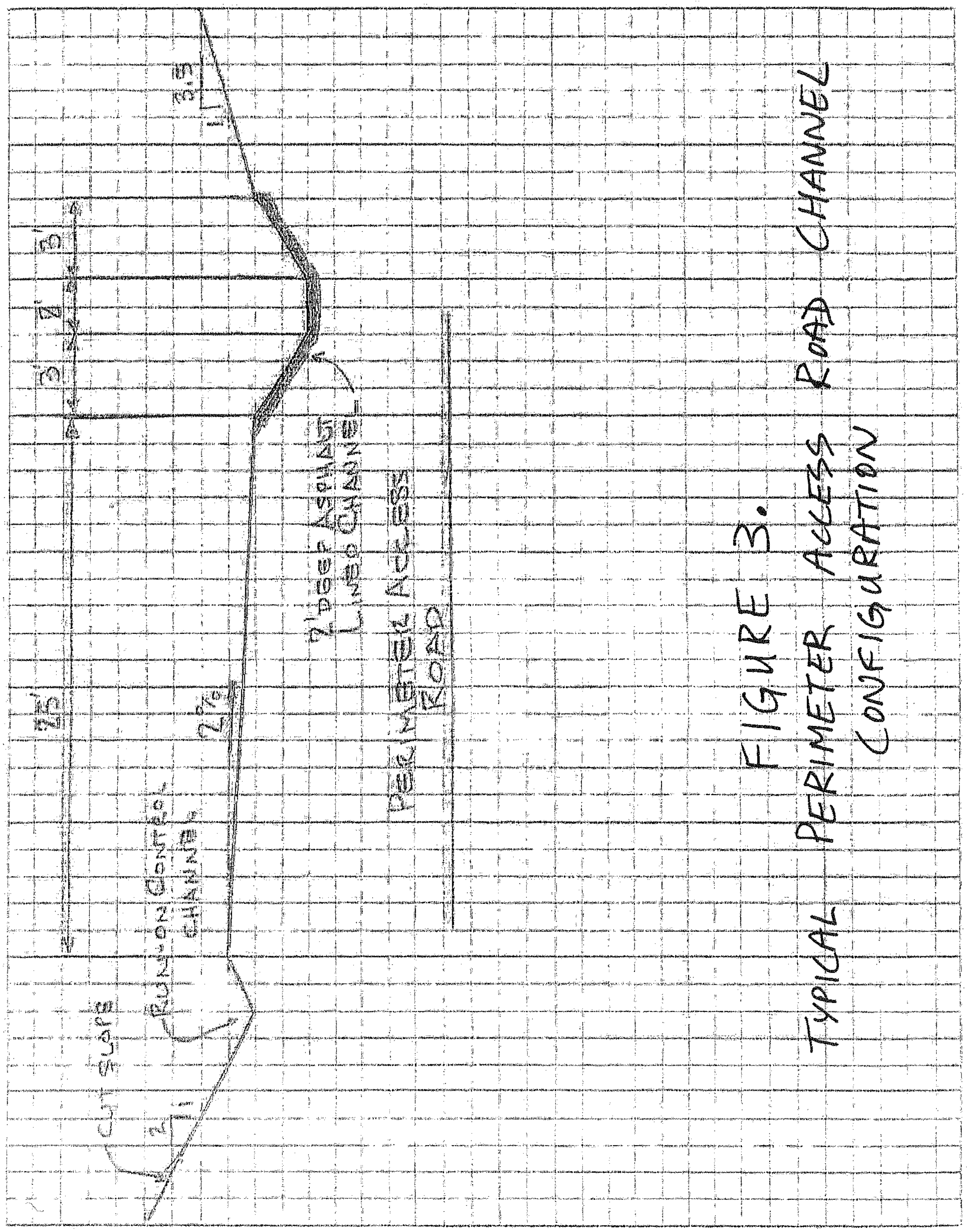


FIGURE 3. TYPICAL PERIMETER ACCESS ROAD CHANNEL CONFIGURATION

TABLE 1
SUBBASIN SUMMARY TABLE

Kettleman B-18 Hydrology
Project Number: 083-91887

Date:	10/31/08
By:	PM
Chkd:	RH
Apprvd:	[signature]

Design Storm PMP - Recurrance Interval

Storm Duration (hours)	2-Year Depth (inches)	PMP - Depth (inches)	Storm Distribution
24	0.94	10.30	I

Subbasin ID	Subbasin Area (ft^2)	Subbasin Area (acres)	Subbasin Area (sq mile)	CN = 81 Covered Landfill HSG C (acres)	Open Rangeland HSG C (acres)	CN = 84 Pond Area (acres)	Composite SCS Curve No.	S = 1000/CN - 10	Unit Runoff Q (in)	Runoff Volume (ac-ft)	Runoff Volume (ft^3)
North 01	43,996	1.01	0.0016	1.01			CN = 81	2.35	7.94	0.67	29,100
North 02	175,111	4.02	0.0063	4.02			CN = 81	2.35	7.94	2.66	115,822
North 03	87,556	2.01	0.0031	2.01			CN = 81	2.35	7.94	1.33	57,911
North 04	133,294	3.06	0.0048	3.06			CN = 81	2.35	7.94	2.02	88,163
North 05	108,029	2.48	0.0039	2.48			CN = 81	2.35	7.94	1.64	71,453
North 06	159,430	3.66	0.0057	3.66			CN = 81	2.35	7.94	2.42	105,450
North 07	159,430	3.66	0.0057	3.66			CN = 81	2.35	7.94	2.42	105,450
North 08	157,252	3.61	0.0056	3.61			CN = 81	2.35	7.94	2.39	104,010
North 09	30,928	0.71	0.0011	0.71			CN = 81	2.35	7.94	0.47	20,456
North 10	212,137	4.87	0.0076	4.87			CN = 81	2.35	7.94	3.22	140,312
North 11	117,176	2.69	0.0042	2.69			CN = 81	2.35	7.94	1.78	77,503
North 12	59,242	1.36	0.0021	1.36			CN = 81	2.35	7.94	0.90	39,184
North 13	47,480	1.09	0.0017	1.09			CN = 81	2.35	7.94	0.72	31,405
North 14	59,677	1.37	0.0021	1.37			CN = 81	2.35	7.94	0.91	39,472
South 01	97,574	2.24	0.0035	2.24			CN = 81	2.35	7.94	1.48	64,538
South 02	99,317	2.28	0.0036	2.28			CN = 81	2.35	7.94	1.51	65,690
South 03	101,059	2.32	0.0036	2.32			CN = 81	2.35	7.94	1.53	66,843
South 04	82,328	1.89	0.0030	1.89			CN = 81	2.35	7.94	1.25	54,454
South 05	177,725	4.08	0.0064	4.08			CN = 81	2.35	7.94	2.70	117,551
South 06	68,389	1.57	0.0025	1.57			CN = 81	2.35	7.94	1.04	45,234
South 07	153,331	3.52	0.0055	3.52			CN = 81	2.35	7.94	2.33	101,417
South 08	158,558	3.64	0.0057	3.64			CN = 81	2.35	7.94	2.41	104,874
South 09	187,744	4.31	0.0067	4.31			CN = 81	2.35	7.94	2.85	124,178
South 10	117,612	2.70	0.0042	2.70			CN = 81	2.35	7.94	1.79	77,791
South 11	170,320	3.91	0.0061	3.91			CN = 81	2.35	7.94	2.59	112,653
South 12	230,868	5.30	0.0083	5.30			CN = 81	2.35	7.94	3.51	152,701
South 13	23,522	0.54	0.0008	0.54			CN = 81	2.35	7.94	0.36	15,558
OffSite 01	355,450	8.16	0.0128		8.16		CN = 74	3.51	7.03	4.78	208,097
OffSite 02	211,702	4.86	0.0076		4.86		CN = 81	2.35	7.94	3.21	140,024
OffSite 03	637,718	14.64	0.0229		14.64		CN = 81	2.35	7.94	9.68	421,800
OffSite 04	399,010	9.16	0.0143			9.16	CN = 84	1.90	8.32	6.35	276,684
OffSite 05	153,767	3.53	0.0055			3.53	CN = 84	1.90	8.32	2.45	106,626
Total:	4,976,730	114.25	0.18							75.35	3,282,402

TOTAL RUNOFF TO RESERVOIR 1 DURING PMP STORM: 31.8 AC-FT

TOTAL RUNOFF TO RESERVOIR 2 DURING PMP STORM: 34.1 AC-FT
STORAGE CAPACITY OF RESERVOIR 2: 32.5 AC-FT
EXCESS RUNOFF TO BE PUMPED OR DIVERTED OFF-SITE: 2.2 AC-FT

TABLE 2
BASIN TIME OF CONCENTRATION CALCULATIONS

Date:	10/31/08
By:	PM
Chkd:	RH
Apprvd:	[illegible]

Project Name : Kettleman Hydrology
Project Number: 083-91887

					Flow Segment 1						Flow Segment 2					
Subbasin ID	Subbasin Area (sq mile)	Composite Curve Number	Total Lag (0.6*Tc) (min)	Total Travel Time (min)	Type of Flow	Length (ft)	Slope (ft/ft)	Roughness Condition[1]	Typical Hydraulic Radius (Channel Only) (ft)	Travel Time (min)	Type of Flow	Length (ft)	Slope (ft/ft)	Roughness Condition[1]	Typical Hydraulic Radius (Channel Only) (ft)	Travel Time (min)
North 01	0.0016	81	0.0	0.0												
North 02	0.0063	81	0.0	0.0												
North 03	0.0031	81	0.0	0.0												
North 04	0.0048	81	0.0	0.0												
North 05	0.0039	81	0.0	0.0												
North 06	0.0057	81	0.0	0.0												
North 07	0.0057	81	0.0	0.0												
North 08	0.0056	81	0.0	0.0												
North 09	0.0011	81	0.0	0.0												
North 10	0.0076	81	0.0	0.0												
North 11	0.0042	81	0.0	0.0												
North 12	0.0021	81	0.0	0.0												
North 13	0.0017	81	0.0	0.0												
North 14	0.0021	81	0.0	0.0												
South 01	0.0035	81	0.0	0.0												
South 02	0.0036	81	0.0	0.0												
South 03	0.0036	81	0.0	0.0												
South 04	0.0030	81	0.0	0.0												
South 05	0.0064	81	0.0	0.0												
South 06	0.0025	81	0.0	0.0												
South 07	0.0055	81	0.0	0.0												
South 08	0.0057	81	0.0	0.0												
South 09	0.0067	81	0.0	0.0												
South 10	0.0042	81	0.0	0.0												
South 11	0.0061	81	0.0	0.0												
South 12	0.0083	81	0.0	0.0												
South 13	0.0008	81	0.0	0.0												
OffSite 01	0.0128	72	0.0	0.0												
OffSite 02	0.0076	81	0.0	0.0												
OffSite 03	0.0229	81	5.1	8.5	Sheet	100.0	0.420	H Range		4.8	Shallow	1200.0	0.110	U Unpaved		3.7
OffSite 04	0.0143	84	2.8	4.7	Sheet	65.0	0.500	H Range		3.2	Shallow	600.0	0.160	U Unpaved		1.5
OffSite 05	0.0055	84	2.8	4.7	Sheet	50.0	0.020	B Fallow		4.3	Shallow	80.0	0.020	U Unpaved		0.4

Notes:
(1) Refer to Attachment A for Roughness Condition descriptions and Tc Coefficients.

TABLE 3
FLOW RESULTS FROM HEC-HMS

Kettleman B-18 Hydrology
Project Number: 083-91887

Date:	10/31/08
By:	PM
Chkd:	RH
Apprvd:	[signature]

HEC-HMS Basin Model:	Kettleman B-18
HEC-HMS Met. Model:	Local PMP 6hr
HEC-HMS Control Specs:	15min 24hr

Hydrologic Element	Drainage Area (sq mile)	Peak Discharge (cfs)	Time of Peak	Total Volume (ac-ft)
North 01	0.002	9.1	2:45	0.4
North 02	0.006	35.9	2:45	1.5
North 03	0.003	17.6	2:45	0.7
North 04	0.005	27.4	2:45	1.1
North 05	0.004	22.2	2:45	0.9
North 06	0.006	32.4	2:45	1.3
North 07	0.006	32.5	2:45	1.3
North 08	0.006	31.8	2:45	1.3
North 09	0.001	6.3	2:45	0.3
North 10	0.008	43.3	2:45	1.8
North 11	0.004	23.9	2:45	1.0
North 12	0.002	12.0	2:45	0.5
North 13	0.002	9.7	2:45	0.4
North 14	0.002	11.9	2:45	0.5
South 01	0.004	19.9	2:45	0.8
South 02	0.004	20.5	2:45	0.8
South 03	0.004	20.6	2:45	0.8
South 04	0.003	17.1	2:45	0.7
South 05	0.006	36.4	2:45	1.5
South 06	0.003	14.3	2:45	0.6
South 07	0.006	31.4	2:45	1.3
South 08	0.006	32.5	2:45	1.3
South 09	0.007	38.2	2:45	1.6
South 10	0.004	23.9	2:45	1.0
South 11	0.006	34.8	2:45	1.4
South 12	0.008	47.3	2:45	1.9
South 13	0.001	4.6	2:45	0.2
Offsite 01	0.013	58.1	2:45	2.5
Offsite 02	0.008	43.3	2:45	1.8
Offsite 03	0.023	104.2	2:45	5.3
Offsite 04	0.014	69.6	2:45	3.6
Offsite 05	0.006	26.8	2:45	1.4
J N01-N02	0.008	45.0	2:45	1.8
J N03-N04	0.016	87.4	2:45	3.7
J N05	0.040	198.7	2:45	8.9
J N06-N14	0.048	228.0	2:45	10.8
J N08	0.011	59.3	2:45	2.6
J N09	0.012	65.6	2:45	2.9
J N11	0.012	63.3	2:45	2.8
J N12	0.026	136.9	2:45	6.2
J N13	0.028	142.8	2:45	6.6
J O1-O2	0.036	187.2	2:45	8.0
J S03	0.007	37.3	2:45	1.7
J S04	0.007	36.1	2:45	1.5
J S05	0.020	109.2	2:45	4.7
J S06	0.041	206.8	2:45	9.6
J S08	0.011	58.9	2:45	2.6
J S09	0.018	88.6	2:45	4.2
J S10	0.059	277.1	2:45	14.1
J S12	0.014	75.0	2:45	3.4
J S13	0.060	273.7	2:45	14.4
Reach-1	0.004	19.0	2:45	4.4
Reach-2	0.020	103.9	2:45	4.4
Reach-3	0.008	42.3	2:45	4.4
Reach-4	0.036	176.4	2:45	4.1
Reach-5	0.040	183.6	2:45	4.2
Reach-6	0.004	16.7	2:45	4.4
Reach-7	0.006	26.3	2:45	4.4
Reach-8	0.011	50.4	2:45	4.5
Reach-9	0.006	27.6	2:45	4.4
Reach-10	0.041	178.3	2:45	4.5
Reach-11	0.059	269.1	2:45	4.5
Reach-12	0.006	27.4	2:45	4.4
Reach-13	0.012	61.7	2:45	4.5
Reach-14	0.008	39.3	2:45	4.4
Reach-15	0.026	133.2	2:45	4.5
Reach-16	0.007	36.7	2:45	4.4
Reach-17	0.016	85.7	2:45	4.4

TABLE 3
FLOW RESULTS FROM HEC-HMS

Kettleman B-18 Hydrology
Project Number: 083-91887

Date:	10/31/08
By:	PM
Chkd:	KH
Apprvd:	

HEC-HMS Basin Model:	Kettleman B-18
HEC-HMS Met. Model:	Local PMP 6hr
HEC-HMS Control Specs:	15min 24hr

Hydrologic Element	Drainage Area (sq mile)	Peak Discharge (cfs)	Time of Peak	Total Volume (ac-ft)
North 01	0.002	9.1	2:45	0.4
North 02	0.006	35.9	2:45	1.5
North 03	0.003	17.6	2:45	0.7
North 04	0.005	27.4	2:45	1.1
North 05	0.004	22.2	2:45	0.9
North 06	0.006	32.4	2:45	1.3
North 07	0.006	32.5	2:45	1.3
North 08	0.006	31.9	2:45	1.3
North 09	0.001	6.3	2:45	0.3
North 10	0.008	43.3	2:45	1.8
North 11	0.004	23.9	2:45	1.0
North 12	0.002	12.0	2:45	0.5
North 13	0.002	9.7	2:45	0.4
North 14	0.002	11.9	2:45	0.5
South 01	0.004	19.9	2:45	0.8
South 02	0.004	20.5	2:45	0.8
South 03	0.004	20.6	2:45	0.8
South 04	0.003	17.1	2:45	0.7
South 05	0.006	36.4	2:45	1.5
South 06	0.003	14.3	2:45	0.6
South 07	0.006	31.4	2:45	1.3
South 08	0.006	32.5	2:45	1.3
South 09	0.007	38.2	2:45	1.6
South 10	0.004	23.9	2:45	1.0
South 11	0.006	34.8	2:45	1.4
South 12	0.008	47.3	2:45	1.9
South 13	0.001	4.6	2:45	0.2
Offsite 01	0.013	58.1	2:45	2.5
Offsite 02	0.008	43.3	2:45	1.8
Offsite 03	0.023	104.2	2:45	5.3
Offsite 04	0.014	69.6	2:45	3.6
Offsite 05	0.006	26.8	2:45	1.4
J N01-N02	0.008	45.0	2:45	1.8
J N03-N04	0.016	87.4	2:45	3.7
J N05	0.040	198.7	2:45	8.9
J N06-N14	0.048	228.0	2:45	10.8
J N08	0.011	59.3	2:45	2.6
J N09	0.012	65.6	2:45	2.9
J N11	0.012	63.3	2:45	2.8
J N12	0.026	136.9	2:45	6.2
J N13	0.028	142.8	2:45	6.6
J O1-O2	0.036	187.2	2:45	8.0
J S03	0.007	37.3	2:45	1.7
J S04	0.007	36.1	2:45	1.5
J S05	0.020	109.2	2:45	4.7
J S06	0.041	206.8	2:45	9.6
J S08	0.011	58.9	2:45	2.6
J S09	0.018	88.6	2:45	4.2
J S10	0.059	277.1	2:45	14.1
J S12	0.014	75.0	2:45	3.4
J S13	0.060	273.7	2:45	14.4
Reach-1	0.004	19.0	2:45	4.4
Reach-2	0.020	103.9	2:45	4.4
Reach-3	0.008	42.3	2:45	4.4
Reach-4	0.036	176.4	2:45	4.1
Reach-5	0.040	183.6	2:45	4.2
Reach-6	0.004	16.7	2:45	4.4
Reach-7	0.006	26.3	2:45	4.4
Reach-8	0.011	50.4	2:45	4.5
Reach-9	0.005	27.6	2:45	4.4
Reach-10	0.041	178.3	2:45	4.5
Reach-11	0.059	269.1	2:45	4.5
Reach-12	0.006	27.4	2:45	4.4
Reach-13	0.012	61.7	2:45	4.5
Reach-14	0.008	39.3	2:45	4.4
Reach-15	0.026	133.2	2:45	4.5
Reach-16	0.007	36.7	2:45	4.4
Reach-17	0.016	85.7	2:45	4.4

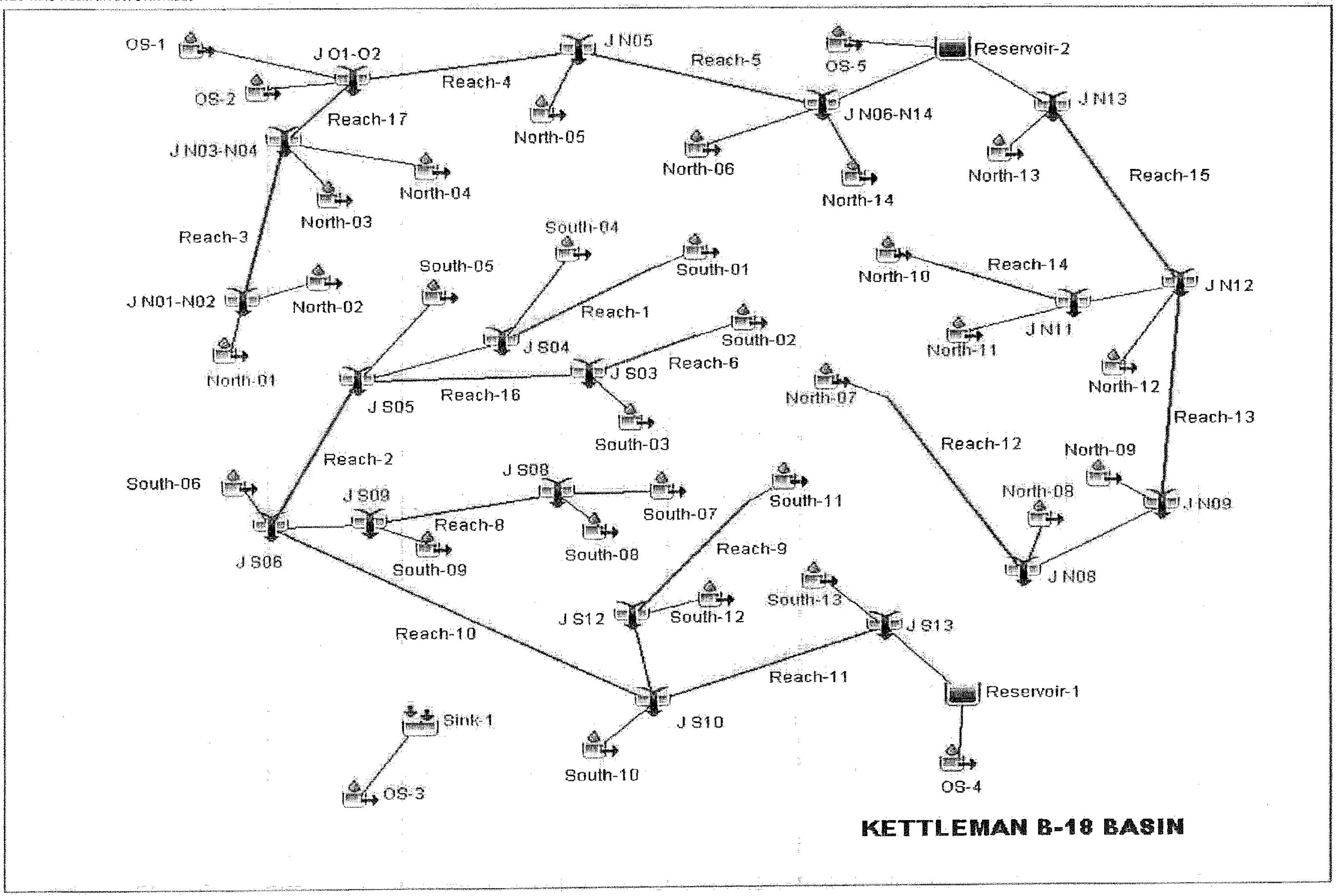
Table 4
Channel Hydraulic Calculations

Kettleman B-18 Hydrology

Date:	10/31/08
By:	PM
Chkd:	RH
Apprvd:	

Reach Designation	QPMP from HEC-HMS (cfs)	HEC HMS Element ID for Q	Channel Design Geometry: Approximate Channel Length (ft)	Channel Slope (ft/ft)	Left Side Slope (H:1V)	Right Side Slope (H:1V)	Bottom Width (ft)	Minimum Channel Depth (ft)	Channel Roughness Parameters: Design Channel Lining	Mannings 'n' for Capacity (Depth Calculation)	Mannings 'n' for Stability (Velocity Calculation)	Hydraulic Calculations: Maximum Velocity (ft/sec)	Maximum Normal Flow Depth (ft)	Froude Number	Normal Depth Shear Stress (lb/ft^2)
Bench S01	19.9	South 01	770	0.020	2.0	3.5	12	2.0	G Grass-lined	0.035	0.030	3.7	0.45	1.04	0.56
Bench S02	20.5	South 02	910	0.020	2.0	3.5	12	2.0	G Grass-lined	0.035	0.030	3.7	0.46	1.05	0.57
Bench S03	16.7	Reach-6	1000	0.020	2.0	3.5	12	2.0	G Grass-lined	0.035	0.030	3.4	0.41	0.89	0.51
Cover S04	19.0	Reach-1	415	0.080	1.0	3.5	35	2.0	B Asphalt	0.016	0.016	12.9	0.73	3.75	3.64
Cover S03	36.7	Reach-16	175	0.080	1.0	3.5	35	2.0	G Grass-lined	0.035	0.030	7.1	0.04	1.80	0.21
Bench S05	36.4	South 05	1150	0.020	2.0	3.5	12	2.0	G Grass-lined	0.035	0.030	4.5	0.65	1.10	0.81
Cover S05	103.9	Reach-2	175	0.080	2.0	3.5	35	2.0	B Asphalt	0.016	0.016	8.5	1.64	2.81	8.19
Bench S07	31.4	South 07	990	0.020	2.0	3.5	12	2.0	G Grass-lined	0.035	0.030	4.3	0.59	1.08	0.74
Bench S08	26.3	Reach-7	980	0.020	2.0	3.5	12	2.0	G Grass-lined	0.035	0.030	4.4	0.53	0.93	0.66
Bench S09	50.4	Reach-8	1050	0.020	2.0	3.5	12	2.0	G Grass-lined	0.035	0.030	5.1	0.78	0.98	0.97
Perimeter S06	178.3	Reach-10	1290	0.014	2.0	3.5	25	3.0	G Grass-lined	0.035	0.030	5.3	2.84	0.93	2.48
Bench S11	34.8	South 11	975	0.020	2.0	3.5	12	2.0	G Grass-lined	0.035	0.030	4.5	0.63	1.09	0.79
Bench S12	27.6	Reach-9	1280	0.020	2.0	3.5	12	2.0	G Grass-lined	0.035	0.030	4.1	0.55	0.93	0.69
Bench S13	4.6	South 13	450	0.020	2.0	3.5	12	2.0	G Grass-lined	0.035	0.030	2.1	0.19	0.91	0.24
Perimeter S10	269.1	Reach-11	450	0.047	2.0	3.5	25	3.0	G Grass-lined	0.035	0.030	9.0	2.73	1.67	8.01
Bench N01	9.1	North 01	280	0.020	2.0	3.5	12	2.0	G Grass-lined	0.035	0.030	2.7	0.29	0.97	0.36
Bench N02	35.9	North 02	1050	0.020	2.0	3.5	12	2.0	G Grass-lined	0.035	0.030	4.5	0.64	1.10	0.80
Perimeter N02	42.3	Reach-3	610	0.060	2.0	3.5	25	3.0	B Asphalt	0.016	0.016	15.3	0.85	3.44	3.18
Bench N03	17.6	North 03	590	0.020	2.0	3.5	12	2.0	G Grass-lined	0.035	0.030	3.5	0.42	1.03	0.52
Bench N04	27.4	North 04	880	0.020	2.0	3.5	12	2.0	G Grass-lined	0.035	0.030	4.1	0.55	1.07	0.69
Perimeter N04	85.7	Reach-17	220	0.056	2.0	3.5	25	3.0	B Asphalt	0.016	0.016	18.0	1.24	3.46	4.33
Offsite-2 Ditch	43.3	Offsite 02	1010	0.075	3.0	3.0	0	2.0	B Asphalt	0.016	0.016	15.2	0.97	3.84	4.54
Perimeter O2	176.4	Reach-4	660	0.026	2.0	3.5	25	3.0	G Grass-lined	0.035	0.030	6.4	2.67	1.23	4.33
Bench N05	22.2	North 05	875	0.020	2.0	3.5	12	2.0	G Grass-lined	0.035	0.030	3.8	0.48	1.05	0.60
Perimeter N05	183.6	Reach-5	1175	0.060	2.0	3.5	25	3.0	G Grass-lined	0.035	0.030	8.7	2.51	1.80	9.40
Bench N06	32.4	North 06	1175	0.020	2.0	3.5	12	2.0	G Grass-lined	0.035	0.030	4.4	0.60	1.09	0.75
Bench N07	32.5	North 07	955	0.020	2.0	3.5	12	2.0	G Grass-lined	0.035	0.030	4.4	0.60	1.09	0.75
Bench N08	27.4	Reach-12	990	0.020	2.0	3.5	12	2.0	G Grass-lined	0.035	0.030	4.1	0.55	0.93	0.69
Perimeter N09	61.7	Reach-13	695	0.067	2.0	3.5	25	3.0	B Asphalt	0.016	0.016	17.6	1.00	3.70	4.18
Bench N10	43.3	North 10	1160	0.020	2.0	3.5	12	2.0	G Grass-lined	0.035	0.030	4.9	0.71	1.12	0.89
Bench N11	39.3	Reach-14	640	0.020	2.0	3.5	12	2.0	G Grass-lined	0.035	0.030	4.7	0.62	1.11	0.77
Perimeter N12	133.2	Reach-15	435	0.080	2.0	3.5	25	3.0	B Asphalt	0.016	0.016	23.0	1.41	4.20	7.04

HEC-HMS Basin Model Schematic



Attachment B
HEC-HMS Screen Captures and Inputs

Sub Basin Area	
Subbasin	Area (mi^2)
North 01	0.001600
North 02	0.006300
North 03	0.003100
North 04	0.004800
North 05	0.003900
North 06	0.005700
North 07	0.005700
North 08	0.005600
North 09	0.001100
North 10	0.007600
North 11	0.004200
North 12	0.002100
North 13	0.001700
North 14	0.002100
South 01	0.003500
South 02	0.003600
South 03	0.003600
South 04	0.003000
South 05	0.006400
South 06	0.002500
South 07	0.005500
South 08	0.005700
South 09	0.006700
South 10	0.004200
South 11	0.006100
South 12	0.008300
South 13	0.000800
Offsite 1	0.012800
Offsite 2	0.007600
Offsite 3	0.022900
Offsite 4	0.014300
Offsite 5	0.005500

Loss SCS Curve Number			
Subbasin	Initial Abstraction (in)	Curve Number	Impervious (%)
North 01		81	0
North 02		81	0
North 03		81	0
North 04		81	0
North 05		81	0
North 06		81	0
North 07		81	0
North 08		81	0
North 09		81	0
North 10		81	0
North 11		81	0
North 12		81	0
North 13		81	0
North 14		81	0
South 01		81	0
South 02		81	0
South 03		81	0
South 04		81	0
South 05		81	0
South 06		81	0
South 07		81	0
South 08		81	0
South 09		81	0
South 10		81	0
South 11		81	0
South 12		81	0
South 13		81	0
Offsite 1		74	0
Offsite 2		81	0
Offsite 3		81	0
Offsite 4		84	0
Offsite 5		84	0

Transform SCS Unit Hydrograph	
Subbasin	Lag Time (min)
Offsite 3	5.1
Offsite 4	2.8
Offsite 5	2.8

Kinematic Wave Transform (Main Channel)

Subbsain	Route Upstream	Route Mothod	Length (ft)	Slope (ft/ft)	subreaches	Shape	Manning's n	Width (ft)	Side Slope (xH:1V)
North 01	No	Kinematic Wave	280	0.065	5	Trapezoid	0.035	12	3.25
North 02	No	Kinematic Wave	1050	0.020	5	Trapezoid	0.035	12	3.25
North 03	No	Kinematic Wave	590	0.056	5	Trapezoid	0.035	12	3.25
North 04	No	Kinematic Wave	880	0.020	5	Trapezoid	0.035	12	3.25
North 05	No	Kinematic Wave	875	0.026	5	Trapezoid	0.035	12	3.25
North 06	No	Kinematic Wave	1175	0.060	5	Trapezoid	0.035	12	3.25
North 07	No	Kinematic Wave	955	0.020	5	Trapezoid	0.035	12	3.25
North 08	No	Kinematic Wave	990	0.020	5	Trapezoid	0.035	12	3.25
North 09	No	Kinematic Wave	250	0.057	5	Trapezoid	0.035	12	3.25
North 10	No	Kinematic Wave	1160	0.022	5	Trapezoid	0.035	12	3.25
North 11	No	Kinematic Wave	640	0.020	5	Trapezoid	0.035	12	3.25
North 12	No	Kinematic Wave	695	0.067	5	Trapezoid	0.035	12	3.25
North 13	No	Kinematic Wave	435	0.080	5	Trapezoid	0.035	12	3.25
North 14	No	Kinematic Wave	290	0.042	5	Trapezoid	0.035	12	3.25
South 01	No	Kinematic Wave	770	0.020	5	Trapezoid	0.035	12	3.25
South 02	No	Kinematic Wave	910	0.020	5	Trapezoid	0.035	12	3.25
South 03	No	Kinematic Wave	1000	0.020	5	Trapezoid	0.035	12	3.25
South 04	No	Kinematic Wave	615	0.080	5	Trapezoid	0.035	12	3.25
South 05	No	Kinematic Wave	1150	0.020	5	Trapezoid	0.035	12	3.25
South 06	No	Kinematic Wave	650	0.007	5	Trapezoid	0.035	12	3.25
South 07	No	Kinematic Wave	990	0.020	5	Trapezoid	0.035	12	3.25
South 08	No	Kinematic Wave	980	0.020	5	Trapezoid	0.035	12	3.25
South 09	No	Kinematic Wave	1050	0.020	5	Trapezoid	0.035	12	3.25
South 10	No	Kinematic Wave	1290	0.014	5	Trapezoid	0.035	12	3.25
South 11	No	Kinematic Wave	975	0.020	5	Trapezoid	0.035	12	3.25
South 12	No	Kinematic Wave	1280	0.020	5	Trapezoid	0.035	12	3.25
South 13	No	Kinematic Wave	450	0.047	5	Trapezoid	0.035	12	3.25
Offsite 1	No	Kinematic Wave	1180	0.075	5	Trapezoid	0.035	12	3.25
Offsite 2	No	Kinematic Wave	1010	0.060	5	Trapezoid	0.035	12	3.25

Routing
Kinematic Wave Channel

Reach	Length (ft)	Slope (ft/ft)	Manning's n	subreaches	Shape	Diameter (ft)	Width (ft)	Side Slope (xH:1V)
Reach-1	415	0.080	0.035	2	Trapezoid		12	3.25
Reach-2	665	0.062	0.035	2	Trapezoid		12	3.25
Reach-3	610	0.060	0.035	2	Trapezoid		12	3.25
Reach-4	660	0.026	0.035	2	Trapezoid		12	3.25
Reach-5	1175	0.060	0.035	2	Trapezoid		12	3.25
Reach-6	1000	0.020	0.035	2	Trapezoid		12	3.25
Reach-7	980	0.020	0.035	2	Trapezoid		12	3.25
Reach-8	1050	0.020	0.035	2	Trapezoid		12	3.25
Reach-9	1280	0.020	0.035	2	Trapezoid		12	3.25
Reach-10	1290	0.014	0.035	2	Trapezoid		12	3.25
Reach-11	450	0.047	0.035	2	Trapezoid		12	3.25
Reach-12	990	0.020	0.035	2	Trapezoid		12	3.25
Reach-13	695	0.067	0.035	2	Trapezoid		12	3.25
Reach-14	640	0.020	0.035	2	Trapezoid		12	3.25
Reach-15	435	0.080	0.035	2	Trapezoid		12	3.25
Reach-16	175	0.080	0.035	2	Trapezoid		12	3.25
Reach-17	220	0.056	0.035	2	Trapezoid		12	3.25

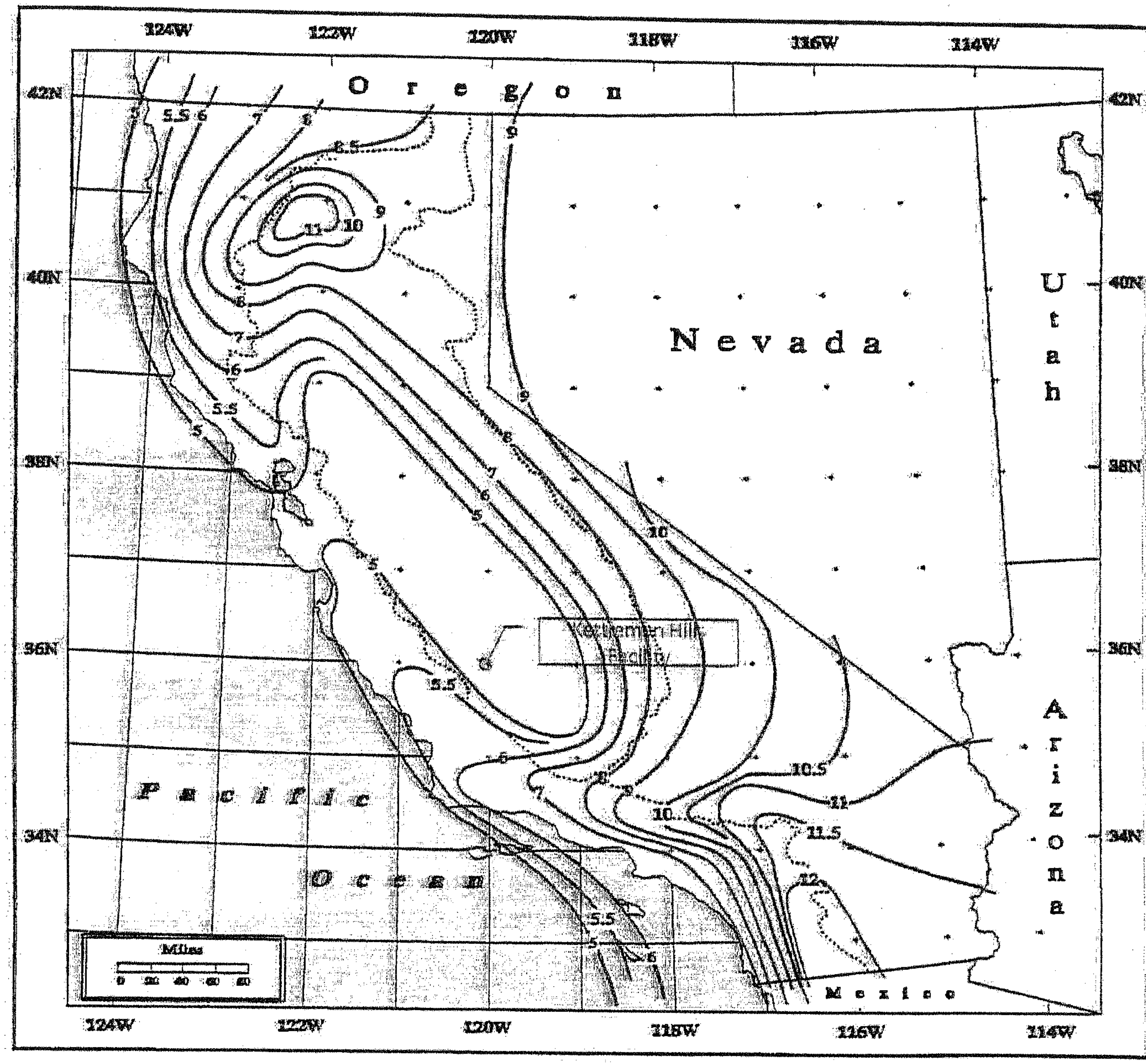
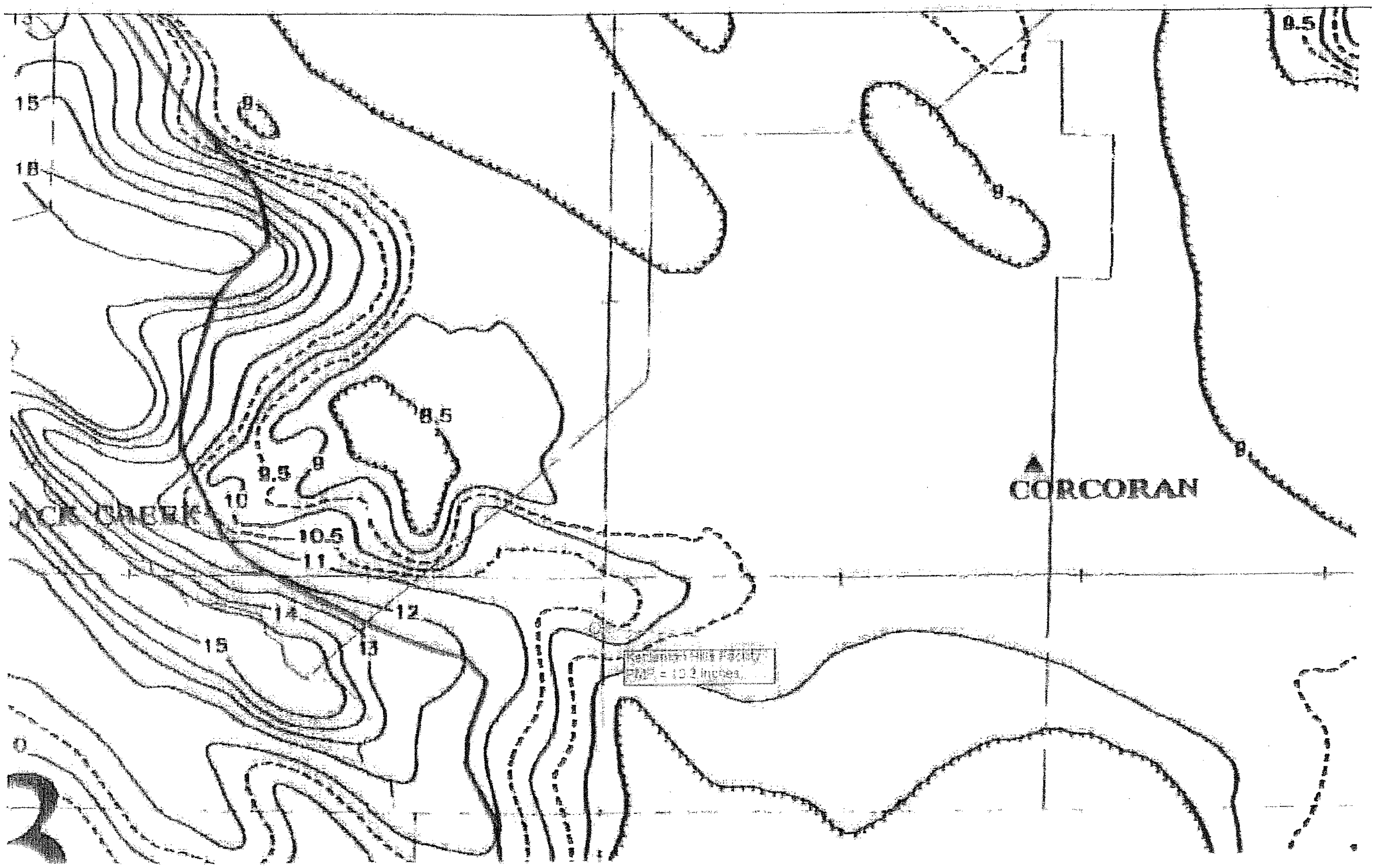


Figure 13.21. *California local-storm PMP precipitation estimates for 1 mi², 1 hour (inches). Dashed lines are drainage divides. Same as Figure 9.23.*

Figure 13.21 from HMR No. 59 is used to derive the 6 hour PMP.

Attachment C ~ General Storm



Golder Associates

Project: Kettleman_Final_10-08
Simulation Run: PMP24hr Reservoir: Reservoir-1

Start of Run:	01Feb2020, 01:00	Basin Model:	Final Cover
End of Run:	02Feb2020, 13:00	Meteorologic Model:	LocalPMP24hr
Compute Time:	03Nov2008, 09:31:12	Control Specifications:	1Hr36Hr

Volume Units: AC-FT

Computed Results

Peak Inflow :	47.1 (CFS)	Date/Time of Peak Inflow :	01Feb2020, 08:00
Peak Outflow :	0.0 (CFS)	Date/Time of Peak Outflow :	01Feb2020, 01:00
Total Inflow :	31.8 (AC-FT)	Peak Storage (CAPACITY)	48 ~~31.8~~ (AC-FT)
Total Outflow :	0.0 (AC-FT)	Peak Elevation :	857 ~~840.3~~ (FT)

Project: Kettleman_Final_10-08
Simulation Run: PMP24hr Reservoir: Reservoir-2

Start of Run:	01Feb2020, 01:00	Basin Model:	Final Cover
End of Run:	02Feb2020, 13:00	Meteorologic Model:	LocalPMP24hr
Compute Time:	03Nov2008, 09:31:12	Control Specifications:	1Hr36Hr

Volume Units: AC-FT

Computed Results

Peak Inflow :	52.0 (CFS)	Date/Time of Peak Inflow :	01Feb2020, 08:00
Peak Outflow :	19.0 (CFS)	Date/Time of Peak Outflow :	02Feb2020, 01:00
Total Inflow :	34.1 (AC-FT)	Peak Storage :	32.5 (AC-FT)
Total Outflow :	2.2 (AC-FT)	Peak Elevation :	771.0 (FT)

Worksheet for Cover Road Reach 1

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.08000	ft/ft
Discharge	19.0	ft^3/s

Section Definitions

Station (ft)	Elevation (ft)
0+00.0	820.00
0+02.0	818.00
0+37.0	818.00
0+40.0	816.50
0+45.3	818.00
0+52.3	820.00

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00.0, 820.00)	(0+02.0, 818.00)	0.030
(0+02.0, 818.00)	(0+37.0, 818.00)	0.030
(0+37.0, 818.00)	(0+45.3, 818.00)	0.016
(0+45.3, 818.00)	(0+52.3, 820.00)	0.030

Results

Normal Depth	0.73	ft
Elevation Range	816.50 to 820.00 ft	
Flow Area	1.48	ft^2
Wetted Perimeter	4.32	ft
Top Width	4.04	ft
Normal Depth	0.73	ft
Critical Depth	1.54	ft
Critical Slope	0.00671	ft/ft
Velocity	12.85	ft/s

Worksheet for Cover Road Reach 1

Results

Velocity Head		2.57	ft
Specific Energy		3.30	ft
Froude Number		3.75	
Flow Type	Supercritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.73	ft
Critical Depth	1.54	ft
Channel Slope	0.08000	ft/ft
Critical Slope	0.00671	ft/ft

Cross Section for Cover Road Reach 1

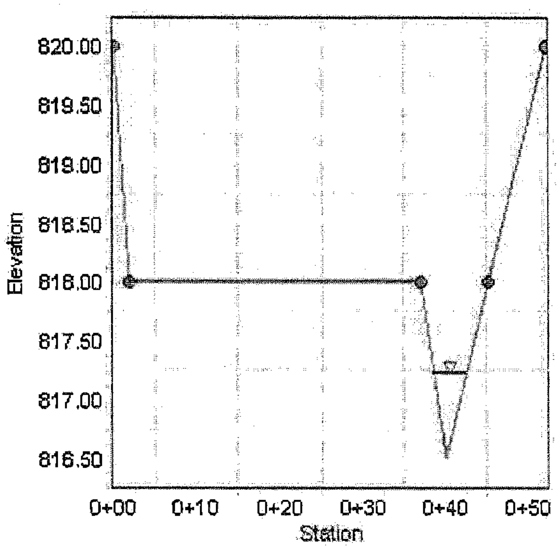
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.08000	ft/ft
Normal Depth	0.73	ft
Discharge	19.0	ft^3/s

Cross Section Image



Worksheet for Cover Road Reach 2

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.08000	ft/ft
Discharge	103.9	ft^3/s
Section Definitions		

Station (ft)	Elevation (ft)
0+00.0	820.00
0+02.0	818.00
0+37.0	818.00
0+40.0	816.50
0+45.3	818.00
0+52.3	820.00

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00.0, 820.00)	(0+02.0, 818.00)	0.030
(0+02.0, 818.00)	(0+37.0, 818.00)	0.022
(0+37.0, 818.00)	(0+45.3, 818.00)	0.016
(0+45.3, 818.00)	(0+52.3, 820.00)	0.030

Results

Normal Depth	1.64	ft
Elevation Range	816.50 to 820.00 ft	
Flow Area	12.30	ft^2
Wetted Perimeter	44.57	ft
Top Width	43.93	ft
Normal Depth	1.64	ft
Critical Depth	1.92	ft
Critical Slope	0.00812	ft/ft
Velocity	8.45	ft/s

Worksheet for Cover Road Reach 2

Results

Velocity Head		1.11	ft
Specific Energy		2.75	ft
Froude Number		2.81	
Flow Type	Supercritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.64	ft
Critical Depth	1.92	ft
Channel Slope	0.08000	ft/ft
Critical Slope	0.00812	ft/ft

Cross Section for Cover Road Reach 2

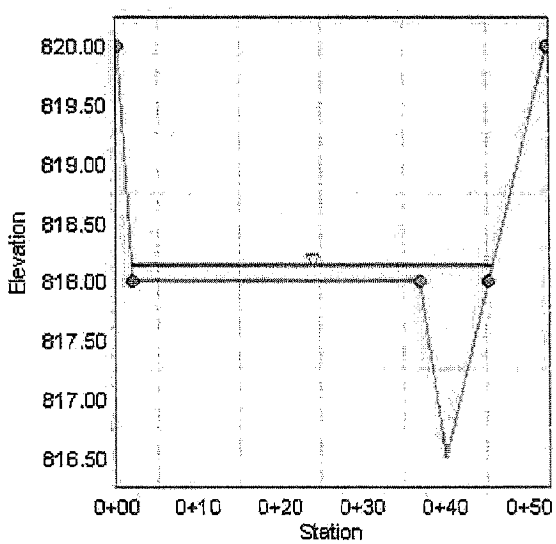
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.08000	ft/ft
Normal Depth	1.64	ft
Discharge	103.9	ft^3/s

Cross Section Image



Worksheet for Perimeter Road Reach 3

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.06000	ft/ft
Discharge	42.3	ft^3/s
Section Definitions		

Station (ft)	Elevation (ft)
0+00.0	820.00
0+08.0	816.00
0+10.0	817.00
0+35.0	816.50
0+38.0	814.50
0+40.0	814.50
0+43.0	816.50
0+50.0	818.50

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00.0, 820.00)	(0+10.0, 817.00)	0.035
(0+10.0, 817.00)	(0+35.0, 816.50)	0.035
(0+35.0, 816.50)	(0+43.0, 816.50)	0.016
(0+43.0, 816.50)	(0+50.0, 818.50)	0.035

Results

Normal Depth	0.85	ft
Elevation Range	814.50 to 820.00 ft	
Flow Area	2.77	ft^2
Wetted Perimeter	5.06	ft
Top Width	4.54	ft
Normal Depth	0.85	ft
Critical Depth	1.66	ft

Worksheet for Perimeter Road Reach 3

Results

Critical Slope		0.00447	ft/ft
Velocity		15.25	ft/s
Velocity Head		3.61	ft
Specific Energy		4.46	ft
Froude Number		3.44	
Flow Type	Supercritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.85	ft
Critical Depth	1.66	ft
Channel Slope	0.06000	ft/ft
Critical Slope	0.00447	ft/ft

Cross Section for Perimeter Road Reach 3

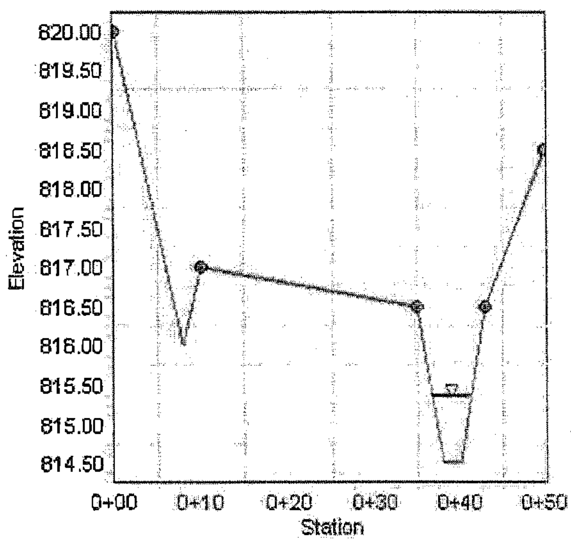
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.06000	ft/ft
Normal Depth	0.85	ft
Discharge	42.3	ft^3/s

Cross Section Image



Worksheet for Perimeter Road Reach 4

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.02600	ft/ft
Discharge	176.4	ft³/s

Section Definitions

Station (ft)	Elevation (ft)
0+00.0	820.00
0+08.0	816.00
0+10.0	817.00
0+35.0	816.50
0+38.0	814.50
0+40.0	814.50
0+43.0	816.50
0+50.0	818.50

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00.0, 820.00)	(0+10.0, 817.00)	0.035
(0+10.0, 817.00)	(0+35.0, 816.50)	0.035
(0+35.0, 816.50)	(0+43.0, 816.50)	0.016
(0+43.0, 816.50)	(0+50.0, 818.50)	0.035

Results

Normal Depth	2.67	ft
Elevation Range	814.50 to 820.00 ft	
Flow Area	29.43	ft²
Wetted Perimeter	41.52	ft
Top Width	39.70	ft
Normal Depth	2.67	ft
Critical Depth	2.78	ft

Worksheet for Perimeter Road Reach 4

Results

Critical Slope		0.01656	ft/ft
Velocity		5.99	ft/s ✓
Velocity Head		0.56	ft
Specific Energy		3.23	ft
Froude Number		1.23	
Flow Type	Supercritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	2.67	ft
Critical Depth	2.78	ft
Channel Slope	0.02600	ft/ft
Critical Slope	0.01656	ft/ft

Cross Section for Perimeter Road Reach 4

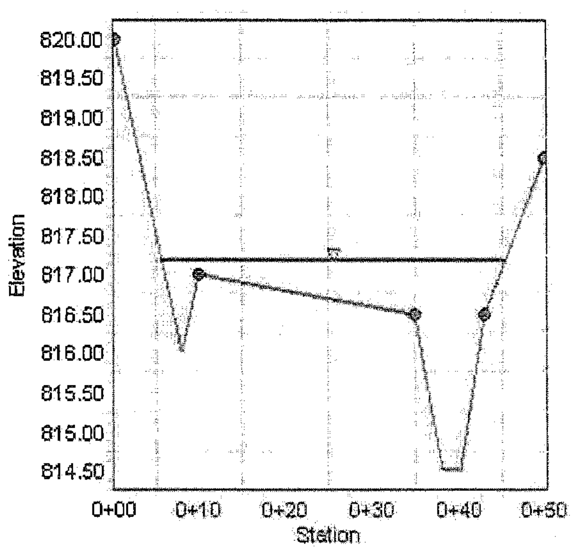
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.02600	ft/ft
Normal Depth	2.67	ft
Discharge	176.4	ft³/s

Cross Section Image



Worksheet for Perimeter Road Reach 5

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.06000	ft/ft
Discharge	183.6	ft^3/s

Section Definitions

Station (ft)	Elevation (ft)
0+00.0	820.00
0+08.0	816.00
0+10.0	817.00
0+35.0	816.50
0+38.0	814.50
0+40.0	814.50
0+43.0	816.50
0+50.0	818.50

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00.0, 820.00)	(0+10.0, 817.00)	0.035
(0+10.0, 817.00)	(0+35.0, 816.50)	0.035
(0+35.0, 816.50)	(0+43.0, 816.50)	0.016
(0+43.0, 816.50)	(0+50.0, 818.50)	0.035

Results

Normal Depth	2.51	ft
Elevation Range	814.50 to 820.00 ft	
Flow Area	23.21	ft^2
Wetted Perimeter	40.59	ft
Top Width	38.82	ft
Normal Depth	2.51	ft
Critical Depth	2.81	ft

Worksheet for Perimeter Road Reach 5

Results

Critical Slope		0.01635	ft/ft
Velocity		7.91	ft/s ✓
Velocity Head		0.97	ft
Specific Energy		3.49	ft
Froude Number		1.80	
Flow Type	Supercritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	2.51	ft
Critical Depth	2.81	ft
Channel Slope	0.06000	ft/ft
Critical Slope	0.01635	ft/ft

Cross Section for Perimeter Road Reach 5

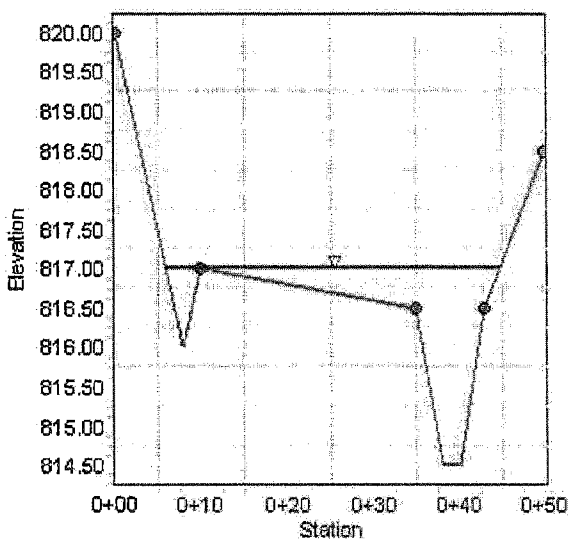
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.06000	ft/ft
Normal Depth	2.51	ft
Discharge	183.6	ft³/s

Cross Section Image



Worksheet for Bench Reach 6

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.02000	ft/ft
Left Side Slope	2.00	ft/ft (H:V)
Right Side Slope	3.50	ft/ft (H:V)
Bottom Width	12.00	ft
Discharge	16.7	ft³/s ✓

Results

Normal Depth	0.41	ft
Flow Area	5.37	ft²
Wetted Perimeter	14.41	ft
Top Width	14.25	ft
Critical Depth	0.38	ft
Critical Slope	0.02562	ft/ft
Velocity	3.11	ft/s ✓
Velocity Head	0.15	ft
Specific Energy	0.56	ft
Froude Number	0.89	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.41	ft
Critical Depth	0.38	ft
Channel Slope	0.02000	ft/ft
Critical Slope	0.02562	ft/ft

Cross Section for Bench Reach 6

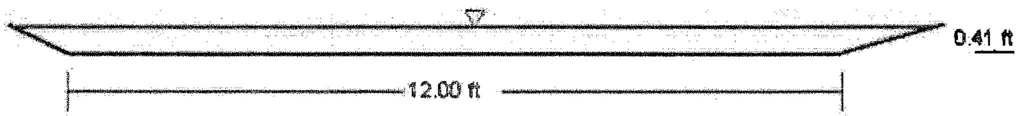
Project Description

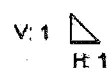
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.02000	ft/ft
Normal Depth	0.41	ft
Left Side Slope	2.00	ft/ft (H:V)
Right Side Slope	3.50	ft/ft (H:V)
Bottom Width	12.00	ft
Discharge	16.7	ft³/s

Cross Section Image





Worksheet for Bench Reach 7

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.02000	ft/ft
Left Side Slope	2.00	ft/ft (H:V)
Right Side Slope	3.50	ft/ft (H:V)
Bottom Width	12.00	ft
Discharge	26.3	ft³/s ✓

Results

Normal Depth	0.53	ft
Flow Area	7.20	ft²
Wetted Perimeter	15.14	ft
Top Width	14.94	ft
Critical Depth	0.51	ft
Critical Slope	0.02351	ft/ft
Velocity	3.66	ft/s ✓
Velocity Head	0.21	ft
Specific Energy	0.74	ft
Froude Number	0.93	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.53	ft
Critical Depth	0.51	ft
Channel Slope	0.02000	ft/ft
Critical Slope	0.02351	ft/ft

Cross Section for Bench Reach 7

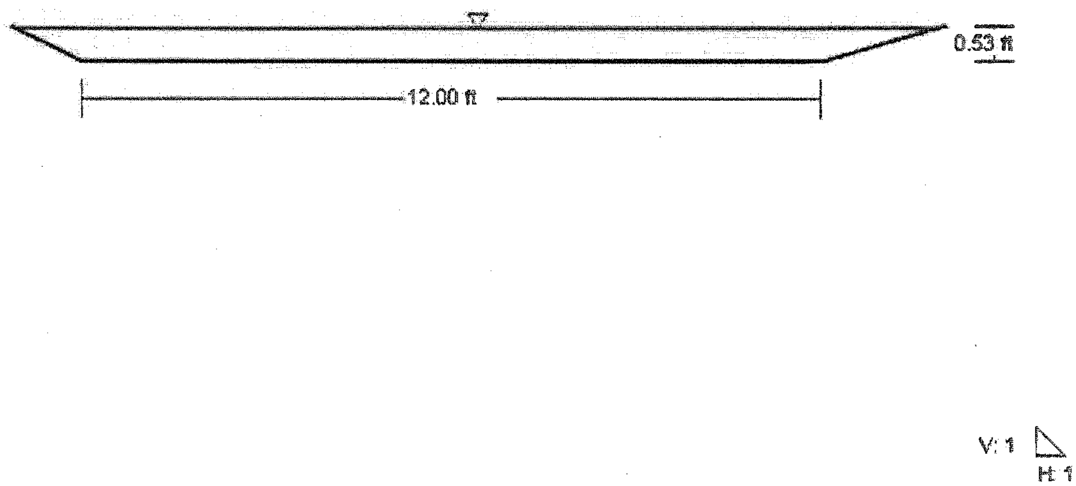
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.02000	ft/ft
Normal Depth	0.53	ft
Left Side Slope	2.00	ft/ft (H:V)
Right Side Slope	3.50	ft/ft (H:V)
Bottom Width	12.00	ft
Discharge	26.3	ft³/s

Cross Section Image



Worksheet for Bench Reach 8

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.02000	ft/ft
Left Side Slope	2.00	ft/ft (H:V)
Right Side Slope	3.50	ft/ft (H:V)
Bottom Width	12.00	ft
Discharge	50.4	ft^3/s

Results

Normal Depth	0.78	ft
Flow Area	11.03	ft^2
Wetted Perimeter	16.58	ft
Top Width	16.29	ft
Critical Depth	0.77	ft
Critical Slope	0.02089	ft/ft
Velocity	4.57	ft/s
Velocity Head	0.32	ft
Specific Energy	1.10	ft
Froude Number	0.98	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.78	ft
Critical Depth	0.77	ft
Channel Slope	0.02000	ft/ft
Critical Slope	0.02089	ft/ft

Cross Section for Bench Reach 8

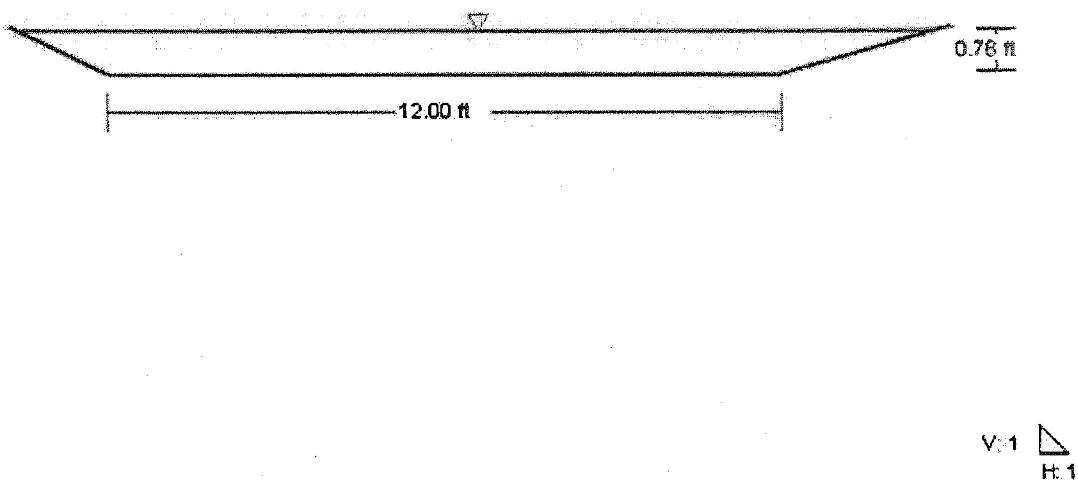
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.02000	ft/ft
Normal Depth	0.78	ft
Left Side Slope	2.00	ft/ft (H:V)
Right Side Slope	3.50	ft/ft (H:V)
Bottom Width	12.00	ft
Discharge	50.4	ft^3/s

Cross Section Image



Worksheet for Bench Reach 9

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.02000	ft/ft
Left Side Slope	2.00	ft/ft (H:V)
Right Side Slope	3.50	ft/ft (H:V)
Bottom Width	12.00	ft
Discharge	27.6	ft³/s ✓

Results

Normal Depth	0.55	ft
Flow Area	7.42	ft²
Wetted Perimeter	15.23	ft
Top Width	15.02	ft
Critical Depth	0.53	ft
Critical Slope	0.02329	ft/ft
Velocity	3.72	ft/s ✓
Velocity Head	0.21	ft
Specific Energy	0.76	ft
Froude Number	0.93	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.55	ft
Critical Depth	0.53	ft
Channel Slope	0.02000	ft/ft
Critical Slope	0.02329	ft/ft

Cross Section for Bench Reach 9

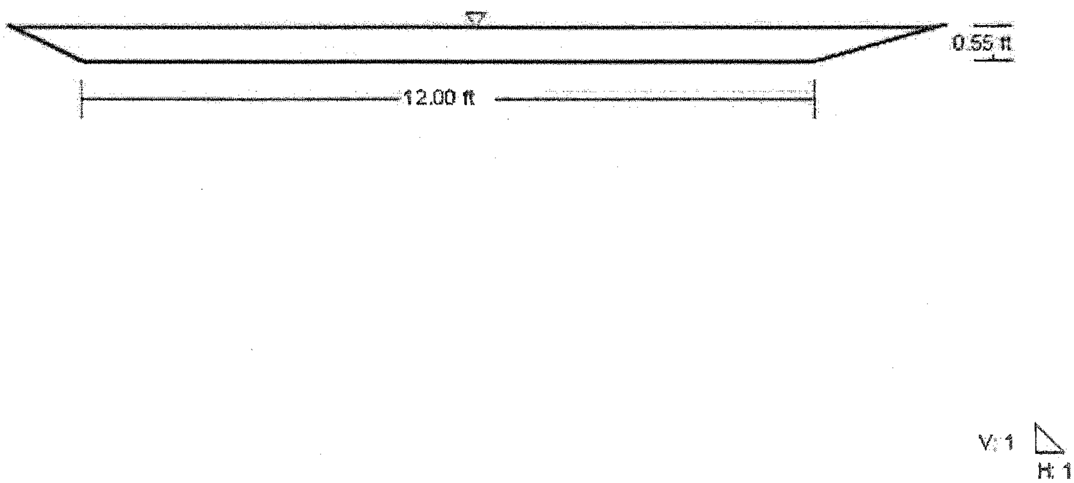
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.02000	ft/ft
Normal Depth	0.55	ft
Left Side Slope	2.00	ft/ft (H:V)
Right Side Slope	3.50	ft/ft (H:V)
Bottom Width	12.00	ft
Discharge	27.6	ft^3/s

Cross Section Image



Worksheet for Perimeter Road Reach 10

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.01400	ft/ft
Discharge	178.3	ft^3/s

✓

Section Definitions

Station (ft)	Elevation (ft)
0+00.0	820.00
0+08.0	816.00
0+10.0	817.00
0+35.0	816.50
0+38.0	814.50
0+40.0	814.50
0+43.0	816.50
0+50.0	818.50

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00.0, 820.00)	(0+10.0, 817.00)	0.035
(0+10.0, 817.00)	(0+35.0, 816.50)	0.035
(0+35.0, 816.50)	(0+43.0, 816.50)	0.016
(0+43.0, 816.50)	(0+50.0, 818.50)	0.035

Results

Normal Depth	2.84	ft
Elevation Range	814.50 to 820.00 ft	
Flow Area	36.05	ft^2
Wetted Perimeter	42.49	ft
Top Width	40.60	ft
Normal Depth	2.84	ft
Critical Depth	2.79	ft

Worksheet for Perimeter Road Reach 10

Results

Critical Slope		0.01660	ft/ft
Velocity		4.95	ft/s
Velocity Head		0.38	ft
Specific Energy		3.22	ft
Froude Number		0.93	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	2.84	ft
Critical Depth	2.79	ft
Channel Slope	0.01400	ft/ft
Critical Slope	0.01660	ft/ft

Cross Section for Perimeter Road Reach 10

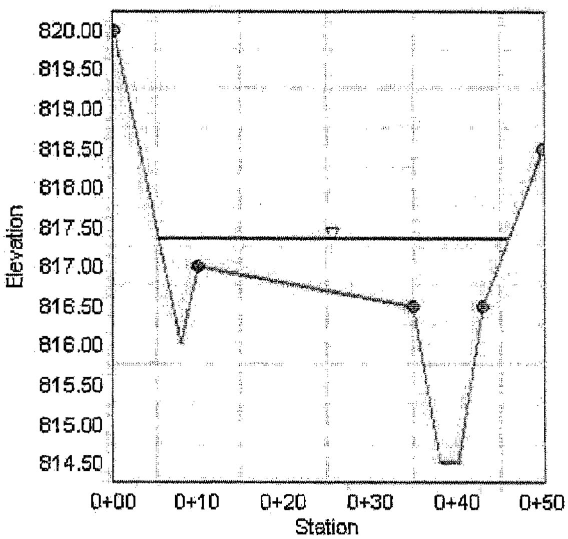
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.01400	ft/ft
Normal Depth	2.84	ft
Discharge	178.3	ft³/s

Cross Section Image



Worksheet for Perimeter Road Reach 11

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.04700	ft/ft
Discharge	269.1	ft^3/s

Section Definitions

Station (ft)	Elevation (ft)
0+00.0	820.00
0+08.0	816.00
0+10.0	817.00
0+35.0	816.50
0+38.0	814.50
0+40.0	814.50
0+43.0	816.50
0+50.0	818.50

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00.0, 820.00)	(0+10.0, 817.00)	0.035
(0+10.0, 817.00)	(0+35.0, 816.50)	0.035
(0+35.0, 816.50)	(0+43.0, 816.50)	0.016
(0+43.0, 816.50)	(0+50.0, 818.50)	0.035

Results

Normal Depth	2.73	ft
Elevation Range	814.50 to 820.00 ft	
Flow Area	31.87	ft^2
Wetted Perimeter	41.88	ft
Top Width	40.03	ft
Normal Depth	2.73	ft
Critical Depth	3.07	ft

Worksheet for Perimeter Road Reach 11

Results

Critical Slope		0.01525	ft/ft
Velocity		8.44	ft/s
Velocity Head		1.11	ft
Specific Energy		3.84	ft
Froude Number		1.67	
Flow Type	Supercritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	2.73	ft
Critical Depth	3.07	ft
Channel Slope	0.04700	ft/ft
Critical Slope	0.01525	ft/ft

Cross Section for Perimeter Road Reach 11

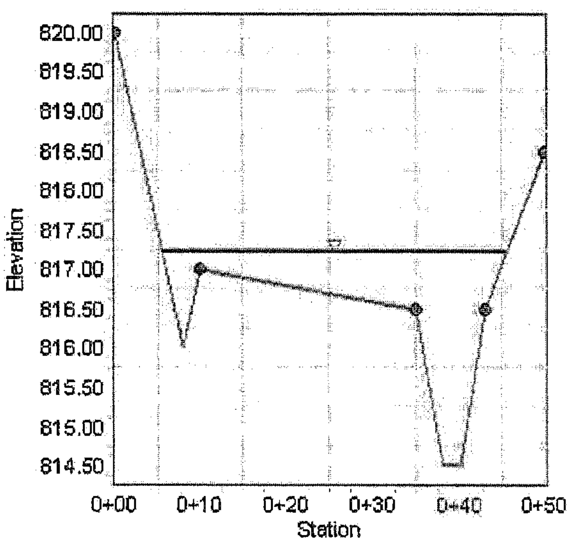
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.04700	ft/ft
Normal Depth	2.73	ft
Discharge	269.1	ft³/s

Cross Section Image



Worksheet for Bench Reach 12

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.02000	ft/ft
Left Side Slope	2.00	ft/ft (H:V)
Right Side Slope	3.50	ft/ft (H:V)
Bottom Width	12.00	ft
Discharge	27.4	ft³/s ✓

Results

Normal Depth	0.55	ft
Flow Area	7.39	ft²
Wetted Perimeter	15.21	ft
Top Width	15.01	ft
Critical Depth	0.52	ft
Critical Slope	0.02332	ft/ft
Velocity	3.71	ft/s ✓
Velocity Head	0.21	ft
Specific Energy	0.76	ft
Froude Number	0.93	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.55	ft
Critical Depth	0.52	ft
Channel Slope	0.02000	ft/ft
Critical Slope	0.02332	ft/ft

Cross Section for Bench Reach 12

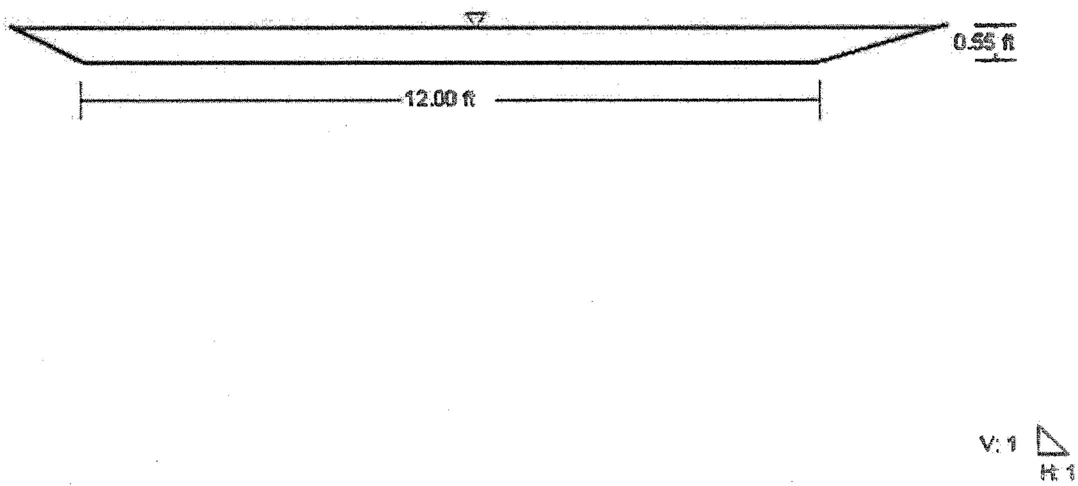
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.02000	ft/ft
Normal Depth	0.55	ft
Left Side Slope	2.00	ft/ft (H:V)
Right Side Slope	3.50	ft/ft (H:V)
Bottom Width	12.00	ft
Discharge	27.4	ft³/s

Cross Section Image



Worksheet for Perimeter Road Reach 13

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.06700	ft/ft
Discharge	61.7	ft³/s

Section Definitions

Station (ft)	Elevation (ft)
0+00.0	820.00
0+08.0	816.00
0+10.0	817.00
0+35.0	816.50
0+38.0	814.50
0+40.0	814.50
0+43.0	816.50
0+50.0	818.50

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00.0, 820.00)	(0+10.0, 817.00)	0.035
(0+10.0, 817.00)	(0+35.0, 816.50)	0.035
(0+35.0, 816.50)	(0+43.0, 816.50)	0.016
(0+43.0, 816.50)	(0+50.0, 818.50)	0.035

Results

Normal Depth	1.00	ft
Elevation Range	814.50 to 820.00 ft	
Flow Area	3.51	ft²
Wetted Perimeter	5.61	ft
Top Width	5.01	ft
Normal Depth	1.00	ft
Critical Depth	2.20	ft

Worksheet for Perimeter Road Reach 13

Results

Critical Slope		0.00477	ft/ft
Velocity		17.58	ft/s
Velocity Head		4.80	ft
Specific Energy		5.80	ft
Froude Number		3.70	
Flow Type	Supercritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.00	ft
Critical Depth	2.20	ft
Channel Slope	0.06700	ft/ft
Critical Slope	0.00477	ft/ft

Cross Section for Perimeter Road Reach 13

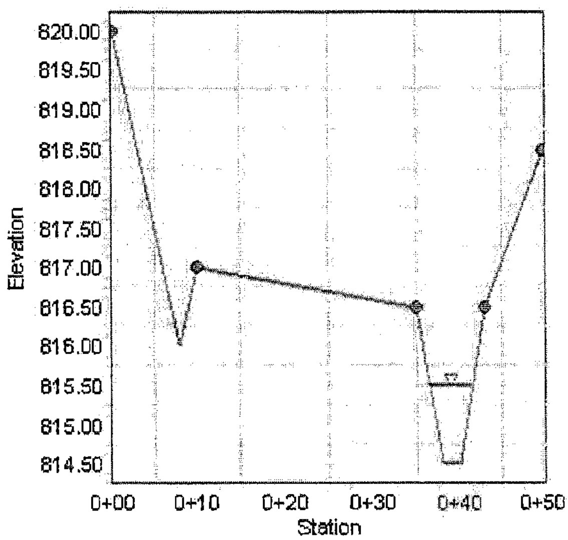
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.06700	ft/ft
Normal Depth	1.00	ft
Discharge	61.7	ft^3/s

Cross Section Image



Worksheet for Bench Reach 14

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.02000	ft/ft
Left Side Slope	2.00	ft/ft (H:V)
Right Side Slope	3.50	ft/ft (H:V)
Bottom Width	12.00	ft
Discharge	39.3	ft³/s ✓

Results

Normal Depth	0.68	ft
Flow Area	9.35	ft²
Wetted Perimeter	15.97	ft
Top Width	15.71	ft
Critical Depth	0.66	ft
Critical Slope	0.02184	ft/ft
Velocity	4.20	ft/s ✓
Velocity Head	0.27	ft
Specific Energy	0.95	ft
Froude Number	0.96	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.68	ft
Critical Depth	0.66	ft
Channel Slope	0.02000	ft/ft
Critical Slope	0.02184	ft/ft

Cross Section for Bench Reach 14

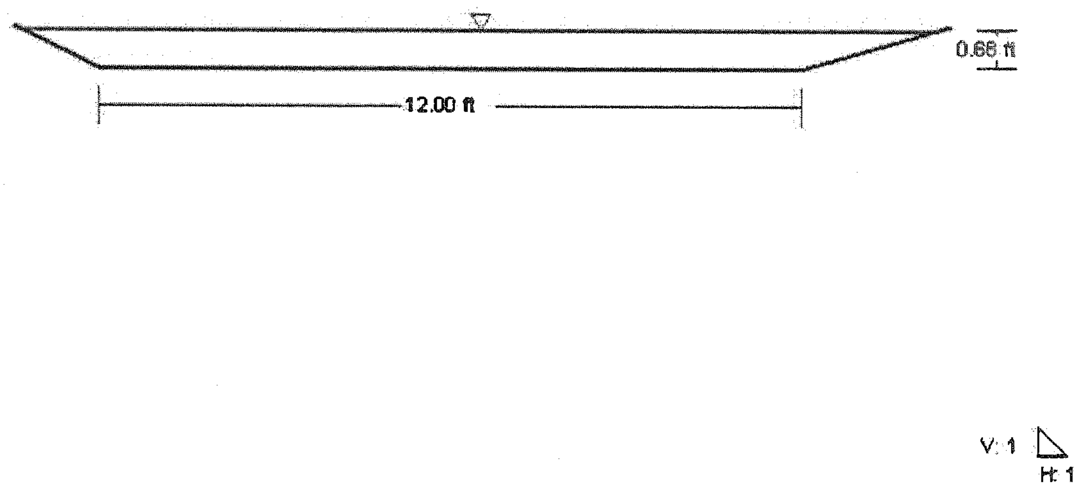
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.02000	ft/ft
Normal Depth	0.68	ft
Left Side Slope	2.00	ft/ft (H:V)
Right Side Slope	3.50	ft/ft (H:V)
Bottom Width	12.00	ft
Discharge	39.3	ft^3/s

Cross Section Image



Worksheet for Perimeter Road Reach 15

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.08000	ft/ft
Discharge	133.2	ft^3/s ✓
Section Definitions		

Station (ft)	Elevation (ft)
0+00.0	820.00
0+08.0	816.00
0+10.0	817.00
0+35.0	816.50
0+38.0	814.50
0+40.0	814.50
0+43.0	816.50
0+50.0	818.50

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00.0, 820.00)	(0+10.0, 817.00)	0.035
(0+10.0, 817.00)	(0+35.0, 816.50)	0.035
(0+35.0, 816.50)	(0+43.0, 816.50)	0.016
(0+43.0, 816.50)	(0+50.0, 818.50)	0.035

Results

Normal Depth	1.41	ft
Elevation Range	814.50 to 820.00 ft	
Flow Area	5.80	ft^2
Wetted Perimeter	7.08	ft
Top Width	6.23	ft
Normal Depth	1.41	ft
Critical Depth	2.63	ft

Worksheet for Perimeter Road Reach 15

Results

Critical Slope		0.00444	ft/ft
Velocity		22.98	ft/s
Velocity Head		8.21	ft
Specific Energy		9.62	ft
Froude Number		4.20	
Flow Type	Supercritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.41	ft
Critical Depth	2.63	ft
Channel Slope	0.08000	ft/ft
Critical Slope	0.00444	ft/ft

Cross Section for Perimeter Road Reach 15

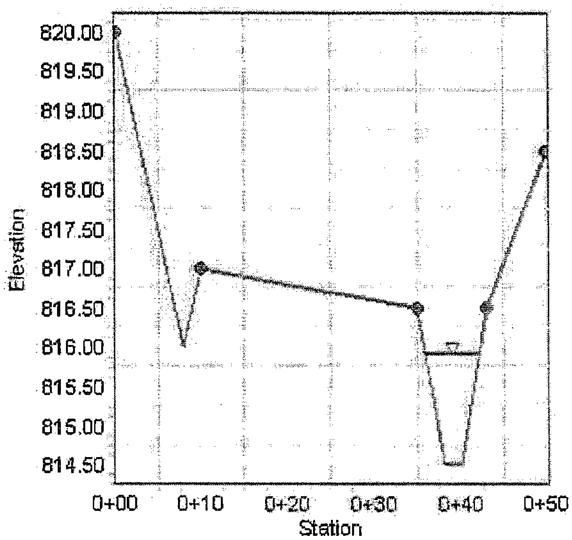
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.08000	ft/ft
Normal Depth	1.41	ft
Discharge	133.2	ft³/s

Cross Section Image



Worksheet for Bench Reach 16

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.08000	ft/ft
Left Side Slope	2.00	ft/ft (H:V)
Right Side Slope	3.50	ft/ft (H:V)
Bottom Width	12.00	ft
Discharge	36.7	ft^3/s

Results

Normal Depth	0.43	ft
Flow Area	5.70	ft^2
Wetted Perimeter	14.54	ft
Top Width	14.38	ft
Critical Depth	0.63	ft
Critical Slope	0.02211	ft/ft
Velocity	6.43	ft/s
Velocity Head	0.64	ft
Specific Energy	1.08	ft
Froude Number	1.80	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.43	ft
Critical Depth	0.63	ft
Channel Slope	0.08000	ft/ft
Critical Slope	0.02211	ft/ft

Cross Section for Bench Reach 16

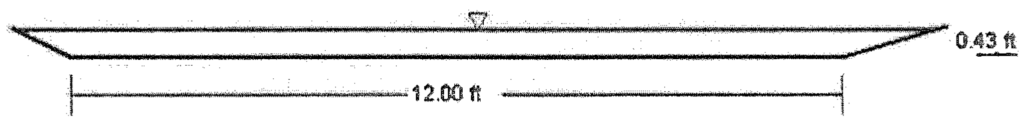
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.08000	ft/ft
Normal Depth	0.43	ft
Left Side Slope	2.00	ft/ft (H:V)
Right Side Slope	3.50	ft/ft (H:V)
Bottom Width	12.00	ft
Discharge	36.7	ft³/s

Cross Section Image



V: 1
H: 1

Worksheet for Perimeter Road Reach 17

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.05600	ft/ft
Discharge	85.7	ft³/s

Section Definitions

Station (ft)	Elevation (ft)
0+00.0	820.00
0+08.0	816.00
0+10.0	817.00
0+35.0	816.50
0+38.0	814.50
0+40.0	814.50
0+43.0	816.50
0+50.0	818.50

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00.0, 820.00)	(0+10.0, 817.00)	0.035
(0+10.0, 817.00)	(0+35.0, 816.50)	0.035
(0+35.0, 816.50)	(0+43.0, 816.50)	0.016
(0+43.0, 816.50)	(0+50.0, 818.50)	0.035

Results

Normal Depth	1.24	ft
Elevation Range	814.50 to 820.00 ft	
Flow Area	4.77	ft²
Wetted Perimeter	6.46	ft
Top Width	5.71	ft
Normal Depth	1.24	ft
Critical Depth	2.42	ft

Worksheet for Perimeter Road Reach 17

Results

Critical Slope		0.00478	ft/ft
Velocity		17.96	ft/s
Velocity Head		5.01	ft
Specific Energy		6.25	ft
Froude Number		3.46	
Flow Type	Supercritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.24	ft
Critical Depth	2.42	ft
Channel Slope	0.05600	ft/ft
Critical Slope	0.00478	ft/ft

Cross Section for Perimeter Road Reach 17

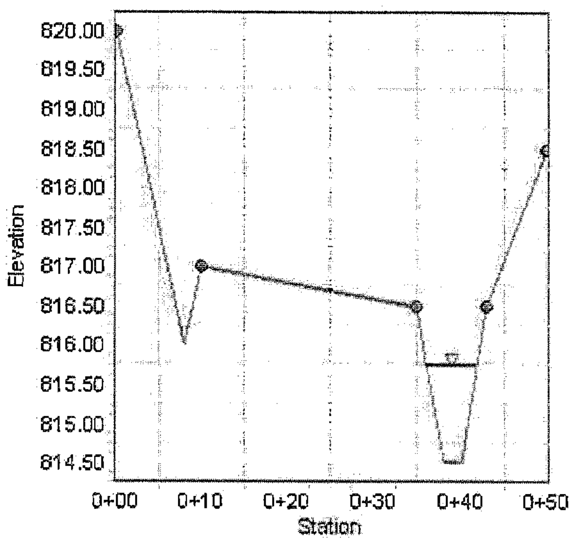
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

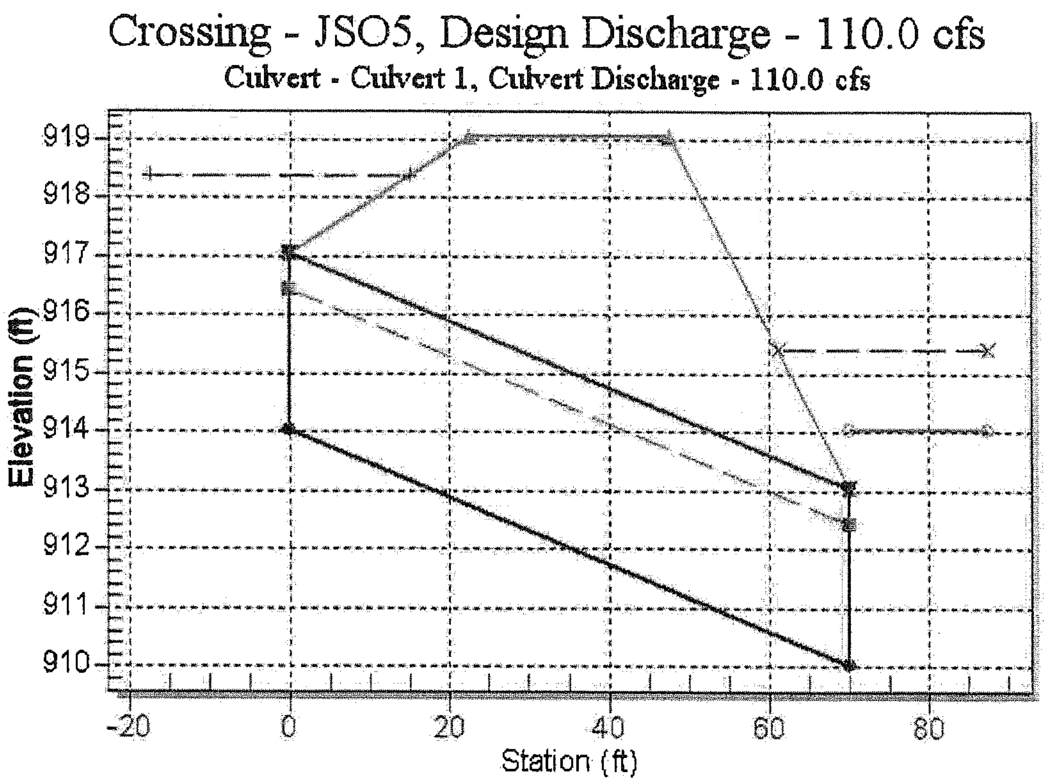
Channel Slope	0.05600	ft/ft
Normal Depth	1.24	ft
Discharge	85.7	ft³/s

Cross Section Image



HY-8 Culvert Analysis Report

Water Surface Profile Plot for Culvert: Culvert 1



Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 914.00 ft

Outlet Station: 70.00 ft

Outlet Elevation: 910.00 ft

Number of Barrels: 2

Culvert Data Summary - Culvert 1

Barrel Shape: Circular

Barrel Diameter: 3.00 ft

Barrel Material: Smooth HDPE

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge with Headwall

Inlet Depression: None

Table 1 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
110.00	110.00	918.32	4.320	3.173	4-FFf	1.159	2.405	1.159	1.365	21.793	19.665
110.00	110.00	918.32	4.320	3.173	4-FFf	1.159	2.405	1.159	1.365	21.793	19.665
110.00	110.00	918.32	4.320	3.173	4-FFf	1.159	2.405	1.159	1.365	21.793	19.665
110.00	110.00	918.32	4.320	3.173	4-FFf	1.159	2.405	1.159	1.365	21.793	19.665
110.00	110.00	918.32	4.320	3.173	4-FFf	1.159	2.405	1.159	1.365	21.793	19.665
110.00	110.00	918.32	4.320	3.173	4-FFf	1.159	2.405	1.159	1.365	21.793	19.665
110.00	110.00	918.32	4.320	3.173	4-FFf	1.159	2.405	1.159	1.365	21.793	19.665
110.00	110.00	918.32	4.320	3.173	4-FFf	1.159	2.405	1.159	1.365	21.793	19.665
110.00	110.00	918.32	4.320	3.173	4-FFf	1.159	2.405	1.159	1.365	21.793	19.665
110.00	110.00	918.32	4.320	3.173	4-FFf	1.159	2.405	1.159	1.365	21.793	19.665
110.00	110.00	918.32	4.320	3.173	4-FFf	1.159	2.405	1.159	1.365	21.793	19.665

****

Inlet Elevation (invert): 914.00 ft, Outlet Elevation (invert): 910.00 ft

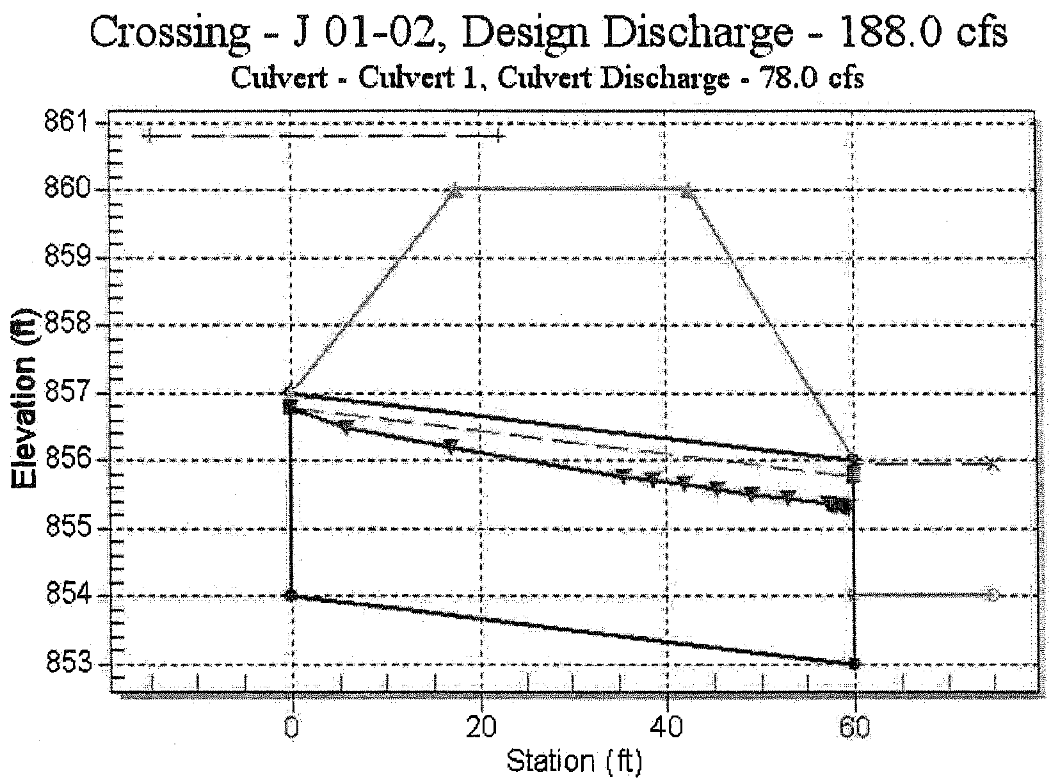
Culvert Length: 70.11 ft, Culvert Slope: 0.0571

****

Table 2 - Summary of Culvert Flows at Crossing: JSO5

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
918.32	110.00	110.00	0.00	1
918.32	110.00	110.00	0.00	1
918.32	110.00	110.00	0.00	1
918.32	110.00	110.00	0.00	1
918.32	110.00	110.00	0.00	1
918.32	110.00	110.00	0.00	1
918.32	110.00	110.00	0.00	1
918.32	110.00	110.00	0.00	1
918.32	110.00	110.00	0.00	1
918.32	110.00	110.00	0.00	1
918.32	110.00	110.00	0.00	1
919.00	124.86	124.86	0.00	Overtopping

Water Surface Profile Plot for Culvert: Culvert 1



Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 854.00 ft

Outlet Station: 60.00 ft

Outlet Elevation: 853.00 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 1

Barrel Shape: Circular

Barrel Diameter: 3.00 ft

Barrel Material: Smooth HDPE

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge with Headwall

Inlet Depression: None

Table 3 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
188.00	78.04	860.81	6.807	6.807	5-S2n	2.096	2.775	2.310	1.959	13.387	12.185
188.00	78.04	860.81	6.807	6.807	5-S2n	2.096	2.775	2.310	1.959	13.387	12.185
188.00	78.04	860.81	6.807	6.807	5-S2n	2.096	2.775	2.310	1.959	13.387	12.185
188.00	78.04	860.81	6.807	6.807	5-S2n	2.096	2.775	2.310	1.959	13.387	12.185
188.00	78.04	860.81	6.807	6.807	5-S2n	2.096	2.775	2.310	1.959	13.387	12.185
188.00	78.04	860.81	6.807	6.807	5-S2n	2.096	2.775	2.310	1.959	13.387	12.185
188.00	78.04	860.81	6.807	6.807	5-S2n	2.096	2.775	2.310	1.959	13.387	12.185
188.00	78.04	860.81	6.807	6.807	5-S2n	2.096	2.775	2.310	1.959	13.387	12.185
188.00	78.04	860.81	6.807	6.807	5-S2n	2.096	2.775	2.310	1.959	13.387	12.185
188.00	78.04	860.81	6.807	6.807	5-S2n	2.096	2.775	2.310	1.959	13.387	12.185
188.00	78.04	860.81	6.807	6.807	5-S2n	2.096	2.775	2.310	1.959	13.387	12.185

****

Inlet Elevation (invert): 854.00 ft, Outlet Elevation (invert): 853.00 ft

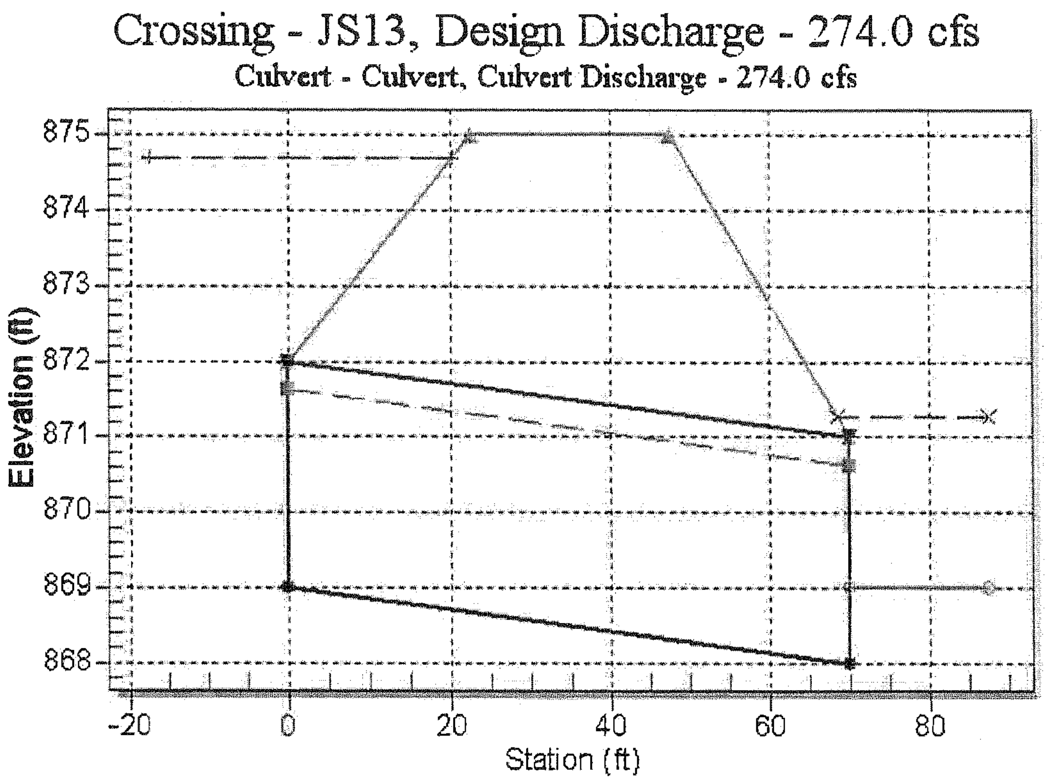
Culvert Length: 60.01 ft, Culvert Slope: 0.0167

****

Table 4 - Summary of Culvert Flows at Crossing: J 01-02

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
860.81	188.00	78.04	109.94	8
860.81	188.00	78.04	109.94	2
860.81	188.00	78.04	109.94	2
860.81	188.00	78.04	109.94	2
860.81	188.00	78.04	109.94	2
860.81	188.00	78.04	109.94	2
860.81	188.00	78.04	109.94	2
860.81	188.00	78.04	109.94	2
860.81	188.00	78.04	109.94	2
860.81	188.00	78.04	109.94	2
860.81	188.00	78.04	109.94	2
860.00	71.29	71.29	0.00	Overtopping

Water Surface Profile Plot for Culvert: Culvert



Site Data - Culvert

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 869.00 ft

Outlet Station: 70.00 ft

Outlet Elevation: 868.00 ft

Number of Barrels: 4

Culvert Data Summary - Culvert

Barrel Shape: Circular

Barrel Diameter: 3.00 ft

Barrel Material: Smooth HDPE

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge with Headwall

Inlet Depression: None

Table 5 - Culvert Summary Table: Culvert

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
274.00	274.00	874.69	5.692	5.084	4-FFf	2.017	2.622	2.017	2.271	13.568	22.317
274.00	274.00	874.69	5.692	5.084	4-FFf	2.017	2.622	2.017	2.271	13.568	22.317
274.00	274.00	874.69	5.692	5.084	4-FFf	2.017	2.622	2.017	2.271	13.568	22.317
274.00	274.00	874.69	5.692	5.084	4-FFf	2.017	2.622	2.017	2.271	13.568	22.317
274.00	274.00	874.69	5.692	5.084	4-FFf	2.017	2.622	2.017	2.271	13.568	22.317
274.00	274.00	874.69	5.692	5.084	4-FFf	2.017	2.622	2.017	2.271	13.568	22.317
274.00	274.00	874.69	5.692	5.084	4-FFf	2.017	2.622	2.017	2.271	13.568	22.317
274.00	274.00	874.69	5.692	5.084	4-FFf	2.017	2.622	2.017	2.271	13.568	22.317
274.00	274.00	874.69	5.692	5.084	4-FFf	2.017	2.622	2.017	2.271	13.568	22.317
274.00	274.00	874.69	5.692	5.084	4-FFf	2.017	2.622	2.017	2.271	13.568	22.317
274.00	274.00	874.69	5.692	5.084	4-FFf	2.017	2.622	2.017	2.271	13.568	22.317

****

Inlet Elevation (invert): 869.00 ft, Outlet Elevation (invert): 868.00 ft

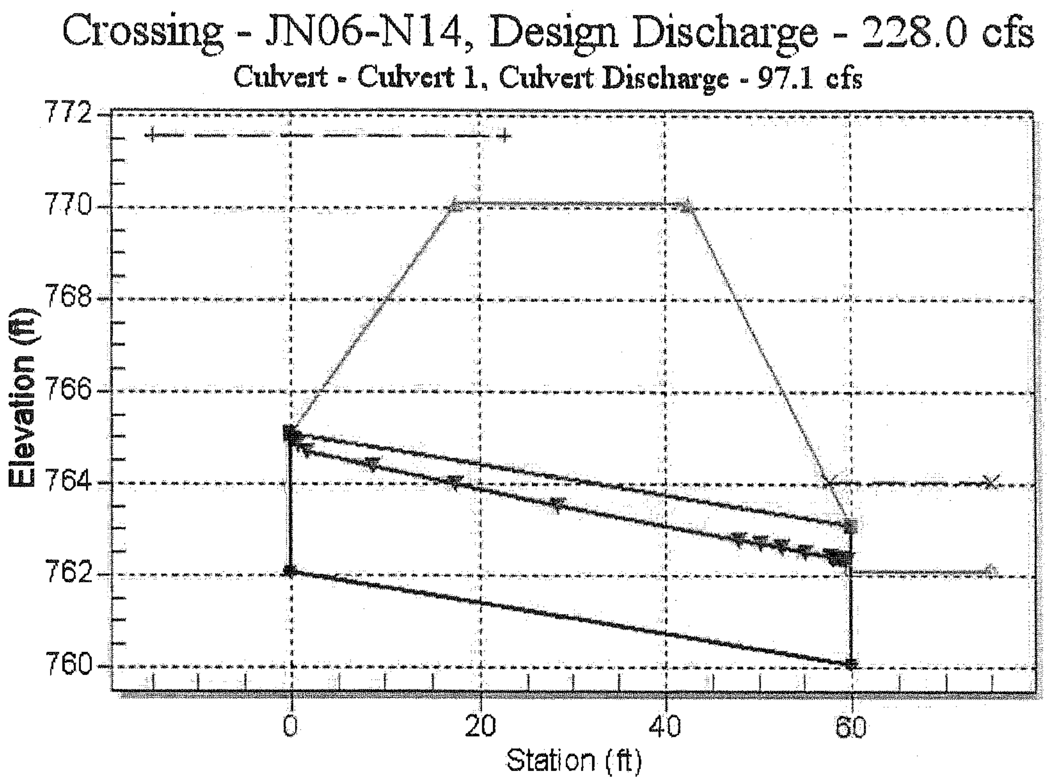
Culvert Length: 70.01 ft, Culvert Slope: 0.0143

****

Table 6 - Summary of Culvert Flows at Crossing: JS13

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert Discharge (cfs)	Roadway Discharge (cfs)	Iterations
874.69	274.00	274.00	0.00	1
874.69	274.00	274.00	0.00	1
874.69	274.00	274.00	0.00	1
874.69	274.00	274.00	0.00	1
874.69	274.00	274.00	0.00	1
874.69	274.00	274.00	0.00	1
874.69	274.00	274.00	0.00	1
874.69	274.00	274.00	0.00	1
874.69	274.00	274.00	0.00	1
874.69	274.00	274.00	0.00	1
874.69	274.00	274.00	0.00	1
875.00	285.05	285.05	0.00	Overtopping

Water Surface Profile Plot for Culvert: Culvert 1



Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 762.00 ft

Outlet Station: 60.00 ft

Outlet Elevation: 760.00 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 1

Barrel Shape: Circular

Barrel Diameter: 3.00 ft

Barrel Material: Smooth HDPE

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge with Headwall

Inlet Depression: None

Table 7 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
228.00	97.07	771.48	9.480	7.420	5-S2n	1.913	3.000	2.253	1.952	17.085	23.710
228.00	97.07	771.48	9.480	7.420	5-S2n	1.913	3.000	2.253	1.952	17.085	23.710
228.00	97.07	771.48	9.480	7.420	5-S2n	1.913	3.000	2.253	1.952	17.085	23.710
228.00	97.07	771.48	9.480	7.420	5-S2n	1.913	3.000	2.253	1.952	17.085	23.710
228.00	97.07	771.48	9.480	7.420	5-S2n	1.913	3.000	2.253	1.952	17.085	23.710
228.00	97.07	771.48	9.480	7.420	5-S2n	1.913	3.000	2.253	1.952	17.085	23.710
228.00	97.07	771.48	9.480	7.420	5-S2n	1.913	3.000	2.253	1.952	17.085	23.710
228.00	97.07	771.48	9.480	7.420	5-S2n	1.913	3.000	2.253	1.952	17.085	23.710
228.00	97.07	771.48	9.480	7.420	5-S2n	1.913	3.000	2.253	1.952	17.085	23.710
228.00	97.07	771.48	9.480	7.420	5-S2n	1.913	3.000	2.253	1.952	17.085	23.710
228.00	97.07	771.48	9.480	7.420	5-S2n	1.913	3.000	2.253	1.952	17.085	23.710

****

Inlet Elevation (invert): 762.00 ft, Outlet Elevation (invert): 760.00 ft

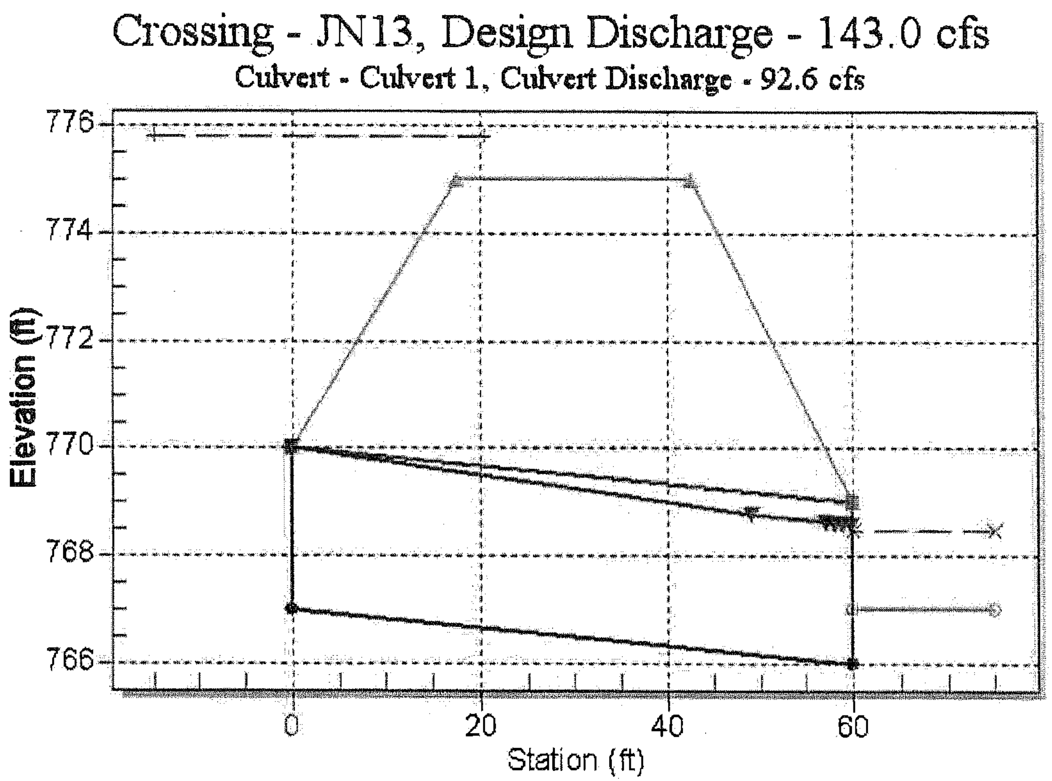
Culvert Length: 60.03 ft, Culvert Slope: 0.0333

****

Table 8 - Summary of Culvert Flows at Crossing: JN06-N14

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
771.48	228.00	97.07	130.89	11
771.48	228.00	97.07	130.89	2
771.48	228.00	97.07	130.89	2
771.48	228.00	97.07	130.89	2
771.48	228.00	97.07	130.89	2
771.48	228.00	97.07	130.89	2
771.48	228.00	97.07	130.89	2
771.48	228.00	97.07	130.89	2
771.48	228.00	97.07	130.89	2
771.48	228.00	97.07	130.89	2
771.48	228.00	97.07	130.89	2
770.00	87.19	87.19	0.00	Overtopping

Water Surface Profile Plot for Culvert: Culvert 1



Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 767.00 ft

Outlet Station: 60.00 ft

Outlet Elevation: 766.00 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 1

Barrel Shape: Circular

Barrel Diameter: 3.00 ft

Barrel Material: Smooth HDPE

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge with Headwall

Inlet Depression: None

Table 9 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
143.00	92.62	775.81	8.807	6.979	5-S2n	2.446	3.000	2.587	1.458	14.337	23.424
143.00	92.62	775.81	8.807	6.979	5-S2n	2.446	3.000	2.587	1.458	14.337	23.424
143.00	92.62	775.81	8.807	6.979	5-S2n	2.446	3.000	2.587	1.458	14.337	23.424
143.00	92.62	775.81	8.807	6.979	5-S2n	2.446	3.000	2.587	1.458	14.337	23.424
143.00	92.62	775.81	8.807	6.979	5-S2n	2.446	3.000	2.587	1.458	14.337	23.424
143.00	92.62	775.81	8.807	6.979	5-S2n	2.446	3.000	2.587	1.458	14.337	23.424
143.00	92.62	775.81	8.807	6.979	5-S2n	2.446	3.000	2.587	1.458	14.337	23.424
143.00	92.62	775.81	8.807	6.979	5-S2n	2.446	3.000	2.587	1.458	14.337	23.424
143.00	92.62	775.81	8.807	6.979	5-S2n	2.446	3.000	2.587	1.458	14.337	23.424
143.00	92.62	775.81	8.807	6.979	5-S2n	2.446	3.000	2.587	1.458	14.337	23.424
143.00	92.62	775.81	8.807	6.979	5-S2n	2.446	3.000	2.587	1.458	14.337	23.424

****

Inlet Elevation (invert): 767.00 ft, Outlet Elevation (invert): 766.00 ft

Culvert Length: 60.01 ft, Culvert Slope: 0.0167

****

Table 10 - Summary of Culvert Flows at Crossing: JN13

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
775.81	143.00	92.62	50.35	12
775.81	143.00	92.62	50.35	2
775.81	143.00	92.62	50.35	2
775.81	143.00	92.62	50.35	2
775.81	143.00	92.62	50.35	2
775.81	143.00	92.62	50.35	2
775.81	143.00	92.62	50.35	2
775.81	143.00	92.62	50.35	2
775.81	143.00	92.62	50.35	2
775.81	143.00	92.62	50.35	2
775.81	143.00	92.62	50.35	2
775.00	87.02	87.02	0.00	Overtopping

APPENDIX K
LCRS ANALYSES

APPENDIX K.1	LCRS CAPACITY
APPENDIX K.2	GEOTEXTILE FILTER CAPACITY

APPENDIX K.1
LCRS CAPACITY

OBJECTIVE:

Evaluate if the existing Landfill B-18 Leachate Collection and Removal System (LCRS) will be sufficient to support the proposed Phase III expansion. Also confirm that the maximum head on the base liner will not exceed 12 inches at any point.

Compare capacity calculations with measured leachate volumes.

METHOD:

The original LCRS calculations performed by ESI (1990) assumed that 100% of the rainwater falling on B-18 would infiltrate into the LCRS. This assumption is very conservative and no longer valid as the current B-18 waste mass has significant absorptive capacity and given the climatic conditions much of the rainfall will either runoff and be collected or evaporate.

Perform calculations similar to the Phase I and II LCRS calculations to confirm the transmissivity of the LCRS geocomposite is adequate to convey the potential leachate (equal to rainfall volume) to the sump. Compute the capacity of the LCRS gravel around the sump to convey leachate and compare to potential maximum leachate volumes and historical recorded leachate generation rates.

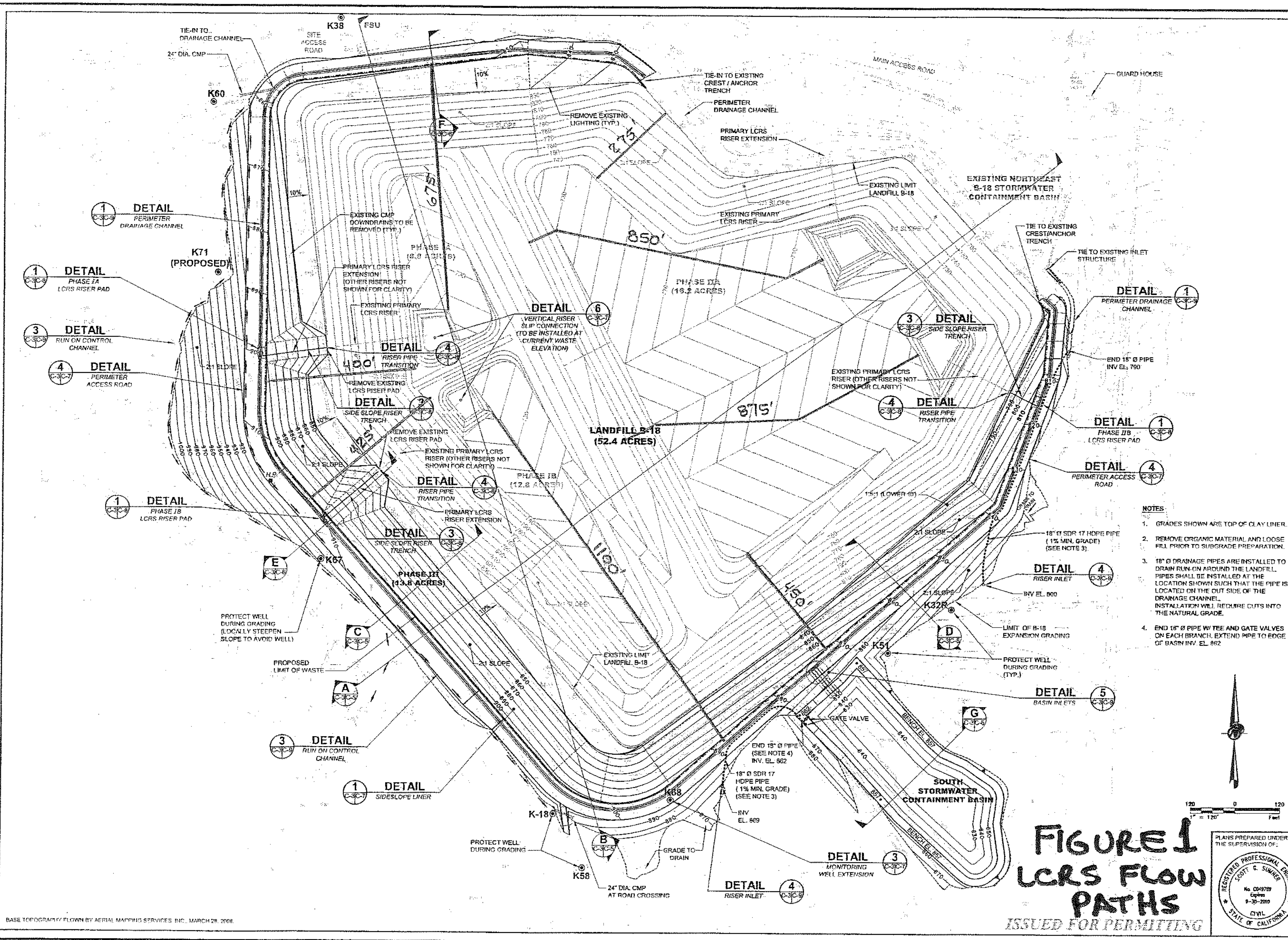
CALCULATIONS:

Following the calculation approach used by ESI (see Pages 3 to 5 in Attachment 1), confirm the increased slope length (i.e. greater capture area) is able to convey the annualized average leachate volume (assuming all rainfall becomes leachate). The flow length for the base considers the contributory flow from the upstream slope. Flow paths are shown on Figure 1 in Attachment 2. Based on the calculations the geocomposite is capable of conveying the annual rainfall to the sump.

Sump capacity was determined by Darcy's Law where the capacity (Q) is equal to the permeability (k) multiplied by the cross sectional area of the LCRS gravel (A) multiplied by the gradient of the floor (i). The capacity of the B-18 sump perimeter is approximately 9,000 gallons per day for each sump. Historic records (see Figure 2) indicate that the average flow is approximately 200 gallons per day maximum (Sump IB) with a maximum measured generation rate of approximately 6,000 gallons per day. The maximum flow rate resulted from exposing an area of geocomposite during a storm event allowing runoff to enter the LCRS system. The geocomposite is typically covered by protective geomembrane, operations layer and waste which limit the flow. Based on the observation the LCRS system is capable of conveying much larger volumes than typically encountered.

CONCLUSIONS/RESULTS:

The LCRS system is capable of conveying the expected leachate volumes. The geocomposite is shown to be capable of conveying the leachate to the sump without exceeding 12 inches of head on the liner. The original calculations are shown in Attachment 1, and the updated calculations are shown in Attachment 2.



NOTES:

1. GRADES SHOWN ARE TOP OF CLAY LINER.
2. REMOVE ORGANIC MATERIAL AND LOOSE FILL PRIOR TO SUBGRADE PREPARATION.
3. 18" Ø DRAINAGE PIPES ARE INSTALLED TO DRAIN RUN-ON AROUND THE LANDFILL. PIPES SHALL BE INSTALLED AT THE LOCATION SHOWN SUCH THAT THE PIPE IS LOCATED ON THE OUT SIDE OF THE DRAINAGE CHANNEL. INSTALLATION WILL REQUIRE CUTS INTO THE NATURAL GRADE.
4. END 18" Ø PIPE W/ TEE AND GATE VALVES ON EACH BRANCH. EXTEND PIPE TO EDGE OF BASIN INV. EL. 862

PLANS PREPARED UNDER THE SUPERVISION OF:

REGISTERED PROFESSIONAL ENGINEER SCOTT G. SUMNER No. C049729 Expires 9-30-2010 CIVIL STATE OF CALIFORNIA

REV	DATE	DESCRIPTION	DESIGN	DRAWN	REVIEW
A	9/16/2008	ISSUED FOR PERMITTING MEETING	KJK	KJK	SGS
B	11/04/2008	ISSUED FOR PERMITTING	KJK	KJK	SGS

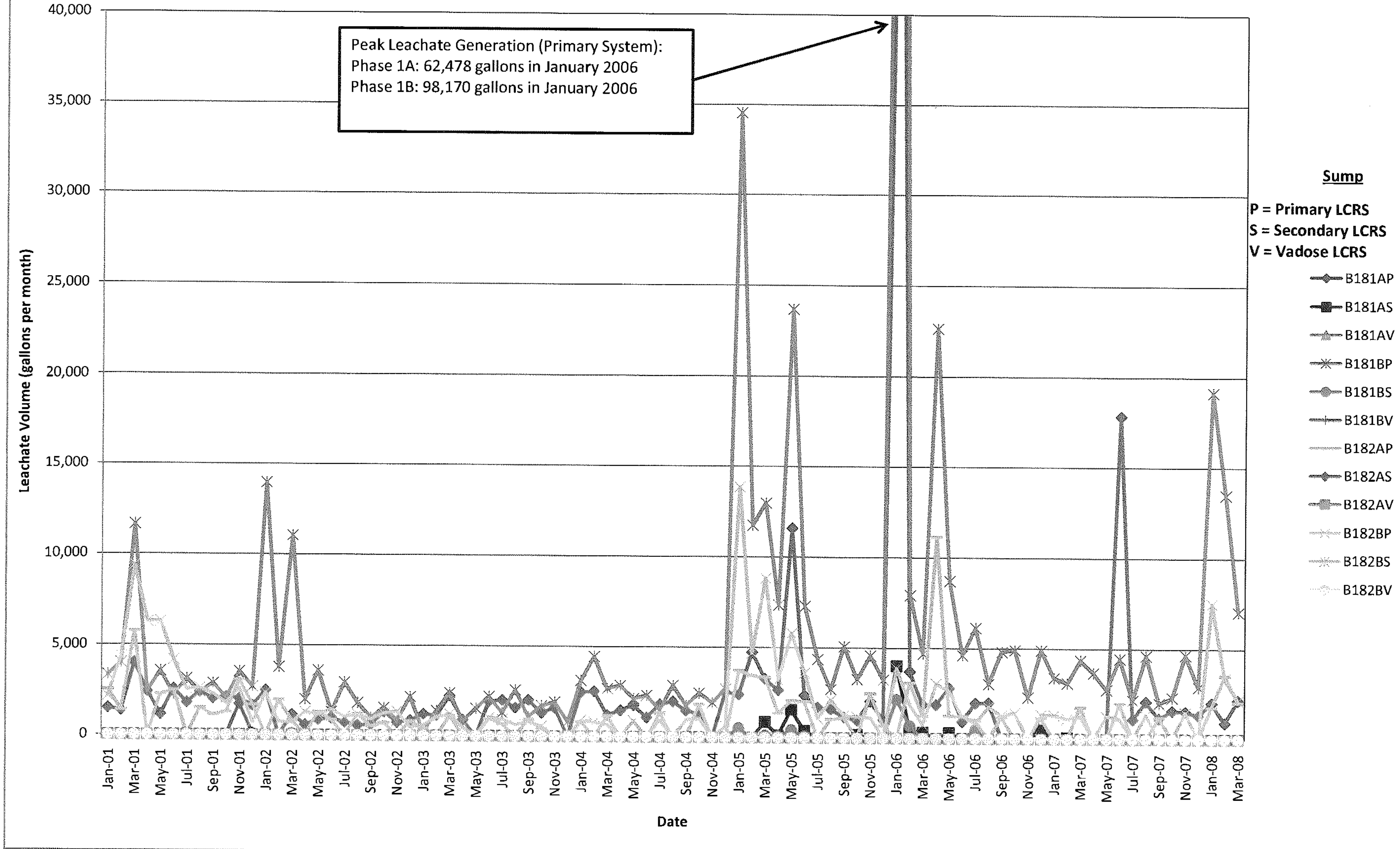
Golder Associates
230 Commerce, Suite 200
Irvine, California 92602
(714) 508-4400

CHEMICAL WASTE MANAGEMENT
KETTLEMAN HILLS FACILITY
35251 OLD SKYLINE ROAD
KETTLEMAN CITY, CALIFORNIA 93239
(559) 386-9711

B-18 CLASS I LANDFILL
PHASE III EXPANSION AND FINAL
CLOSURE
BASE LINER PLAN

SHEET NUMBER

Figure 2 - Historical Leachate Removal Rates from Landfill B-18



Attachment 1

Original LCRS Calculations

TABLE OF CONTENT

ENVIRONMENTAL SOLUTIONS, INC.

By MPW Date 8-10-90 Subject LANDFILL B-19 LCRS Sheet No. 2 of 33

Chkd. By GSC Date 8/13/90 EVALUATION Proj. No. 89-977

PURPOSE : TO EVALUATE THE CAPACITY OF THE LCR SYSTEM AND THE GEOTEXTILE DESIGN IN THE PRIMARY LCRS.

CRITERIA : THE LCR SYSTEM CAPACITY SHOULD BE SUFFICIENT TO HANDLE THE FLOW OF

1. LEACHATE GENERATED BY ANNUAL PRECIPITATION.

2. SURFACE WATER OF A 100-YR STORM IN 24-HOUR PERIOD.

REFERENCE =

1 GEOSYNTHETIC DESIGN GUIDANCE FOR HAZARDOUS WASTE LANDFILL CELL AND SURFACE IMPOUNDMENTS. EPA/600/2-87/097 BY SOIL & MATERIAL ENGINEERS INC. (DEC. 1987)

2 ENGINEERING REPORT, LANDFILL B-19, PHASE II & III BY DONOHUE & ASSOCIATES, INC. OCT 1989

3. SOIL MECHANICS LAMBE & WHITMAN

4. DESIGN WITH GEOSYNTHETICS KOERNER, 1986

ENVIRONMENTAL SOLUTIONS, INC.

By JPL Date 7-30-90 Subject LANDFILL B-18, LCRS EVALUATION Sheet No. 3 of 23
Chkd. By GSC Date 8/13/90 Proj. No. 89-977

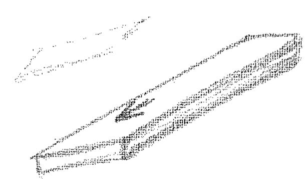
LCR SYSTEM CAPACITY FOR ANNUAL LEACHATE GENERATION

BASED ON KETTLEMAN STATION RECORD (EXHIBIT 1), THE AVERAGE ANNUAL PRECIPITATION RATE IS 6.48 IN. TO BE CONSERVATIVE, ASSUME 100 % OF THE RAINFALL WILL PERCOLATE THROUGH THE LANDFILL. THE LEACHATE GENERATION RATE IS THEREFORE

$$q = \frac{6.48}{365 \times 24 \times 60 \times 60 \times 12} = 1.71 \times 10^{-8} \ ft/sec ✓$$

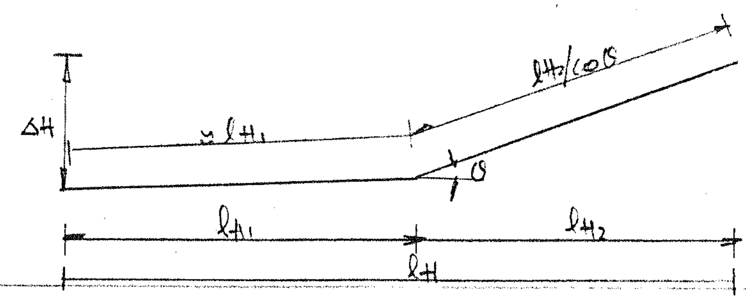
ASSUME EACH LEACHATE SUMP WILL BE OPERATED INDEPENDENTLY, THE REQUIRED TRANSMISSIVITY OF A STRIP ALONG THE LONGEST FLOW PATH IN EACH CELL MAY BE ESTIMATED USING THE FOLLOWING FORMULA:

$$\theta_{REQ} = \frac{q\,l}{i}$$



WHERE

l = LENGTH OF LONGEST FLOW PATH
i = HYDRAULIC GRADIENT
θ_{req} = TRANSMISSIVITY



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BASED ON THE ANNUAL LEACHATE GENERATION RATE, THE REQUIRED TRANSMISSIVITY FOR EACH CELL ARE CALCULATED AS FOLLOWS:

SUMP	l_H	ΔH	l	i	Q_{REQ} TRANSMISSIVITY (m²/sec)
IA SLOPE	220	113	247	0.51	7.7×10^{-7}
IA BOTTOM	420	10	420	0.024	2.8×10^{-5}
IB SLOPE	230	92	248	0.4	1.0×10^{-6}
IB BOTTOM	600	20	800	0.025	5×10^{-5}
IIA SLOPE	90	44	100	0.49	3.2×10^{-7}
IIA BOTTOM	600	16	600	0.027	3.5×10^{-5}
IIB SLOPE	90	46	101	0.51	3.1×10^{-7}
IIB BOTTOM	710	16	710	0.023	4.9×10^{-5}

TEST RESULTS FOR A GEOCOMPOSITE (GEOTEXTILE/GEONET/GEOTEXTILE) PLACED BETWEEN TWO LAYERS OF SOILS ARE AS FOLLOW

i	Q_{TEST}	
0.25	5×10^{-5} m²/sec	SEE EXHIBIT 2 AT PRESSURE OF 7500 psf
0.5	4×10^{-5} m²/sec	

BY COMPARING THE TEST RESULTS USING HIGHER GRADIENT FOR THE SLOPES AND LOWER GRADIENT FOR THE BOTTOMS OF THE LANDFILL WITH THE REQUIRED TRANSMISSIVITY,

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THE TEST RESULTS ARE MUCH HIGHER FOR THE SLOPE PORTION BUT ONLY SLIGHTLY HIGER FOR THE BOTTOM PORTION HOWEVER, THE ASSUMPTION OF 100 % OF THE PRECIPITATION WILL PERCOLATE THROUGH THE WASTE IS VERY CONSERVATIVE. FURTHERMORE, THE TRANSMISSIVITY FOR THE B-18 GEOCOMPOSITE SYSTEM IS EXPECTED TO BE HIGHER THAN THE REPORTED VALUES BECAUSE THE GEOCOMPOSITE SYSTEM FOR THE B-18 LANDFILL WILL BE PLACED BELOW A GRANUL... LAYER AND ATOP A HDPE LAYER; WHICH WILL BE LESS RESTRICTIVE FOR FLUID FLOW THAN THE SOIL LAYERS USED IN THE TEST. THEREFORE, THE CAPACITY OF THE LCRS IS CONSIDERED ADEQUATE.

(RESULTS ARE COMPARED TO TREVIRA 1125

=>

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PER DARCY'S LAW, THE REQUIRED TRANSMISSIVITY ALONG THE PERIMETER OF THE LEACHATE SUMP MAY BE EXPRESSED BY

$$Q = k i A$$
$$= k i w t$$

$$\theta_{REQ} = \frac{Q}{w i}$$

WHERE w IS THE PERIMETER OF THE LEACHATE SUMP.

BASED ON THE AVERAGE ANNUAL PRECIPITATION OF 6.48 IN THE RUN-OFF VOLUME FOR EACH SUMP IS

SUMP	C ft/ac	RUN-OFF AREA (ACRES)	VOLUME (1) (cfs)
IA	1.71×10^{-8}	9.0	6.7×10^{-3}
IB	↓	12.5	9.2×10^{-3}
IIA	↓	16.9	1.3×10^{-2}
IIB	↓	15.1	1.1×10^{-2}

(1) VOLUME = C i A WHERE $i = \frac{6.48}{365 \times 24} = 7.4 \times 10^{-4}$ IN/HR

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BASED ON THE ANNUAL LEACHATE GENERATION RATE, THE REQUIRED TRANSMISSIVITY FOR EACH SUMP IS CALCULATED AS FOLLOW:

PHASE	W (ft)	i	Q (cfs)	θ_{REQ} (m²/sec)	OVERBURDEN (psf)	θ_{TEST} (1) (m²/sec)
IA	550	0.02	6.7×10^{-3}	5.7×10^{-5}	21275	6.5×10^{-5}
IB	540	0.02	9.2×10^{-3}	8.2×10^{-6}	21275	6.5×10^{-5}
IIA	600	0.02	1.3×10^{-2}	1×10^{-4}	13225	1.4×10^{-4}
IIB	650	0.02	1.1×10^{-2}	7.9×10^{-5}	13225	1.4×10^{-4}

(1) EXHIBIT 2

$\theta_{TEST} > \theta_{REQ}$ IN ALL CASES

BASED ON THE ABOVE CALCULATION, THE GEOCOMPOSITE CAPACITY ALONE IN PHASE IB SUMP WILL NOT BE SUFFICIENT TO ? HANDLE THE FLOW. THEREFORE, HYDRAULIC HEAD IS EXPECTED TO BUILD UP IN THE GRANULAR DRAINAGE LAYER. BASED ON MINIMUM TECHNOLOGY GUIDANCE, THE HYDRAULIC HEAD BUILD-UP ATOP THE LCRS CANNOT EXCEED 12" AT ALL TIME.

GRANULAR DRAINAGE LAYER

THE MAXIMUM HYDRAULIC HEAD IN THE DRAINAGE LAYER CAN BE ESTIMATED USING THE FORMULA:

$$h_{max} = \frac{L}{2n}\left[\sqrt{\frac{e}{K_s} + \tan\alpha^2} - \tan\alpha\right]$$ (REF. 1) EQ (3.6)

WHERE

L = EFFECTIVE FLOW LENGTH OF THE LCR

n = POROSITY OF DRAINAGE LAYER = 0.4 (REF 2)

e = INFILTRATION RATE

α = HYDRAULIC GRADIENT

K_s = DRAINAGE LAYER PERMEABILITY = 0.5 cm/sec (REF 2)
= 0.19 in/sec

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BASED ON AVERAGE ANNUAL PRECIPITATION OF 6.48 IN, THE INFILTRATION RATE e IS

$$e = \frac{6.48}{365 \times 24 \times 3600} = 2.1 \times 10^{-7} \text{ in/sec}$$

$L = 110$ $\quad d = 0.02$

$$\therefore \quad h = \frac{110 \times 12}{2 \times 0.4} \left[\sqrt{\frac{2.1 \times 10^{-7}}{0.19} + 0.02^2} - 0.02 \right]$$

$$= 0.04'' \ll 12'' \quad \text{OK.}$$

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Chkd. By ESC Date 8/13/90 Proj. No. 89-977

LCR SYSTEM CAPACITY FOR SURFACE WATER FLOW

BASED ON KETTLEMAN STATION RECORD, THE 24-HOUR RAINFALL OF A 100-YEAR STORM IS 2.34 IN (EXHIBIT 1).

THE SURFACE WATER RUN-OFF IN EACH CELL IS CALCULATED AS FOLLOW:

SUMP	RUNOFF AREA (ACRES)	VOLUME (1) (cfs)
IA	9.0	0.88
IB	12.5	1.22
IIA	16.9	1.65
IIB	15.1	1.47

(1) VOLUME = CiA $i = \frac{2.34}{24} = 0.09$ IN/HR

BASED ON THE 24-HR 100-YR STORM RUN-OFF VOLUME, THE REQUIRED TRANSMISSIVITY FOR EACH SUMP IS CALCULATED AS FOLLOW:

PHASE	W (ft)	i	Q (cfs)	θ_{REQ} (m²/sec)	OVERBURDEN (psf)	θ_{TEST} (1) (m²/sec)
IA	540	0.02	0.88	7.6×10^{-3}	21275	6.5×10^{-5}
IB	520	0.02	1.22	1.1×10^{-2}	21275	6.5×10^{-5}
IIA	600	0.02	1.65	1.3×10^{-2}	13225	1.4×10^{-4}
IIB	650	0.02	1.47	1.1×10^{-2}	13225	1.4×10^{-4}

(1) EXHIBIT 2

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BASED ON THE ABOVE CALCULATION, THE GEOCOMPOSITE ALONE IS NOT CAPABLE TO HANDLE THE SURFACE WATER FROM A 100-YEAR STORM. THEREFORE, HYDRAULIC HEAD IS EXPECTED TO BUILD UP IN THE LEACHATE SUMP

THE INFILTRATION RATE FOR A 24-HR 100-YR STORM IS

$$e = \frac{2.34}{24 \times 3600} = 2.71 \times 10^{-5} \text{ IN/SEC}$$

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BASED ON A 100-YR STORM IN A 24 HOUR PERIOD, THE HYDRAULIC HEAD BUILT-UP IN EACH SOU IS CALCULATED AS FOLLOW:

PHASE	L (ft)	i	$h_{(MAX)}$ (IN)
IA	100	0.02	4.9
IB	110	0.02	5.4
IIA	100	0.02	4.9
IIB	130	0.02	6.4

(1) L: FT

THE HYDRAULIC HEAD BUILT UP IN THE GRANULAR LAYER WILL BE LESS THAN 12", THEREFORE, THE HYDRAULIC HEAD BUILT-UP WILL BE LESS THAN THE MTG (MINIMUM TECNOLOGY GUIDANCE) CRITERIA OF NO MORE THAN 1 FOOT OF LEACHATE ACTING ON THE LINER AT ALL TIME.

Attachment 2

Updated LCRS Calculations

LCRS Calculations

by:	RJS
Checked:	RH
Reviewed:	SS

Avg. Annual Rainfall = 6.48 in

Average Leachate gen. Rate = 1.71E-08 ft/sec/ft^2

Area	ΔL	i	Required Transmissivity (m^2/sec)	Geocomposite transmisivity (m2/sec)	Drainage layer Transmissivity (m2/sec)	Total Transmisivity (m2/sec)	Required Capacity met?
IA Slope	400	0.411	1.55E-06	4.00E-05		4.00E-05	yes
IA Bottom	675	0.024	4.51E-05	5.00E-05	3.05E-05	8.05E-05	yes
IB Slope	425	0.363	1.86E-06	4.00E-05		4.00E-05	yes
IB Bottom	1100	0.026	6.78E-05	5.00E-05	3.05E-05	8.05E-05	yes
IIA Slope	275	0.354	1.24E-06	4.00E-05		4.00E-05	yes
IIA Bottom	850	0.026	5.18E-05	5.00E-05	3.05E-05	8.05E-05	yes
IIB Slope	450	0.406	1.76E-06	4.00E-05		4.00E-05	yes
IIB Bottom	875	0.028	5.06E-05	5.00E-05	3.05E-05	8.05E-05	yes

Adequacy of system along perimeter of leachate sump

Sump	Leachate generation	Run-off Area (acres)	w (ft)	i	Potential Leachate Volume (cfs)	Drainage Layer Hydraulic Conductivity (in^2/sec)	Sump Capacity (cfs) Q = kiA	Sump Capacity (gallons/day)	Adequate Sump Capacity
IA	1.71E-08	12.9	550	0.02	9.6E-03	0.19	1.5E-02	9,380	yes
IB	1.71E-08	19.7	540	0.02	1.5E-02	0.19	1.4E-02	9,209	no
IIA	1.71E-08	17.8	600	0.02	1.3E-02	0.19	1.6E-02	10,233	yes
IIB	1.71E-08	17.5	650	0.02	1.3E-02	0.19	1.7E-02	11,085	yes

Leachate generation assumes all rainfall will be collected as leachate.

Note: the leachate flow capacity for each sump is in excess of 9,000 gallons per day. Based on historic measurements the maximum leachate generation rate has been approximatley 6,000 gallons per day. This peak generation was measured during a one month period and can be attributed to an exposure of the geocomposite. Leachate generation has typically been less than 200 gallons per day, on average (January 2001 to December 2007). Given the dry nature of the facility and that the existing waste is below field capacity, the leachate generation rate is expected to remain in the 200 to 300 gallons per day per sump (maximum). The construction of Phase III is not expected to result in significantly larger volumes of leachate.

APPENDIX K.2
GEOTEXTILE FILTER CAPACITY

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FILTER - RETENTION CAPACITY

THE FILTER-RETENTION CAPACITY COMPUTATION IS NOT NECESSARY FOR THE GEOTEXTILE PLACED IN THE SECONDARY LCRS BECAUSE INSUFFICIENT WATER FLOW IS EXPECTED IN THE LCRS TO CAUSE SOIL PARTICLES MOVEMENT. FOR THE PRIMARY LCRS, A LAYER OF GEOTEXTILE IS PLACED BETWEEN THE OPERATION LAYER AND THE DRAINAGE LAYER; SINCE THE OPERATION LAYER MATERIAL WILL BE NON-COHESIVE, IT IS ASSUMED THAT THE GRAIN SIZE CHARACTERISTICS ARE SIMILAR TO THE ON-SITE SANDSTONE MATERIALS.

THE CALCULATION IS NOT REQUIRED FOR THE SLOPE PORTION OF THE LANDFILL BECAUSE THE POTENTIAL FOR HYDRAULIC HEAD BUILT-UP ON SLOPE IS UNLIKELY.

CRITERION 1 - RETENTION CAPACITY

FOR SOIL LESS THAN 50% PASSING #200 SIEVE

AOS OF FABRIC > NO 30 SIEVE

(SEE EXHIBIT 3 - SANDSTONE GRAIN SIZE CHARACTERISTIC)

		SIEVE #		
AOS OF FABRIC	(TREVIRA 1155) :	120 - 170	> #30	OK
	(TREVIRA 1120) :	70 - 100	> 30	OK

REF = EXHIBIT 4

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CRITERION 2 - FLOWING THROUGH & CLOGGING

<i> $\frac{O_{95}}{d_{85}} < 2$ FLOWING THROUGH CRITERION (REF 1 EQ 3.11)

<ii> $\frac{O_{95}}{d_{15}} > 2$ CLOGGING CRITERION (REF 1 EQ. 3.12)

FOR THE SANDSTONE MATERIALS, (EXHIBIT 3), THE AVERAGE d_{85} & d_{15} IS 0.46 mm AND 0.075 OR LESS, RESPECTIVELY; AND O_{95} FOR TREVIRA 1155 RANGES FROM 0.125 ~ 0.088. (EXHIBIT ~~4~~) 5 MP
THEREFORE

$$\frac{O_{95}}{d_{85}} = \frac{0.125}{0.46} = 0.27 < 2 \quad \text{OK}$$

$$\frac{O_{95}}{d_{15}} = \frac{0.088}{<0.075} = 1.17 \text{ OR GREATER}$$ (SHOULD BE > 2)

FOR TREVIRA 1125 O_{95} RANGES FROM 0.21 TO 0.149 (EXHIBIT ~~4~~) 5 MP

THEREFORE

$$\frac{O_{95}}{d_{85}} = \frac{0.21}{0.46} = 0.46 < 2 \quad \text{OK}$$

$$\frac{O_{95}}{d_{15}} = \frac{0.149}{0.06} = 2.5 > 2 \quad \text{OK}$$

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CRITERION 3. - EXCESSIVE LOSS OF FINES

ASSUME THE SANDSTONE MATERIAL WILL BECOME DENSE ($D_r > 80\%$)

AFTER WATER PERCOLATING THROUGH THE LAYER (JETTING EFFECT).

COEFFICIENT OF UNIFORMITY OF THE MATERIAL

$$CU = \frac{d_{60}}{d_{10}} > 3 \qquad d_{60} = 0.25 \sim 0.28\,mm \quad d_{10} = < 0.06 \qquad C_V = \frac{0.28}{0.06} = 4.7$$

THEREFORE :

TREVIRA 1155 TREVIRA 1125

$$\frac{18 d_{50}}{CU} = \frac{18 \times 0.2}{4.7} = 0.77 > O_{95}\ (0.125 \sim 0.088)\ (0.21 - 0.149) \quad OK$$

USING A MORE RESTRICTIVE CRITERION BY ASSUMING THE

SANDSTONE IS LOOSE , THUS

$$\frac{9 d_{50}}{CU} = \frac{9 \times 0.21}{4.7} = 0.38 > O_{95} \qquad OK$$

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PERMEABILITY

THE PERMEABILITY OF THE GEOTEXTILE SHOULD BE GREATER THAN THE PERMEABILITY OF THE OPERATION LAYER. BASED ON GRAIN SIZE CHARACTERISTICS OF THE OPERATION LAYER MATERIAL, THE PERMEABILITY OF THE MATERIAL MAY BE ESTIMATED AS:

$k_{SOIL} = C\,D_{10}^2$ $C = 100$ (REF 3 EQ 19.9)

$= 100 \times 0.006^2$ $D_{10} < 0.006$ cm EXHIBIT 3

$= 0.0036$ cm/sec

$\therefore k_{soil} < 0.0036$ cm/sec $< k_{fabric}$ (TREVIRA 1125 = 0.59 cm/sec) ✓

PUNCTURE RESISTANCE

BASED ON REFERENCE 4, THE TENSILE FORCE IN THE GEOTEXTILE T MAY BE ESTIMATED AS

$$T = \pi\,(d_i\, d_a)\, p'\, s'$$

WHERE

d_i : INITIAL AVERAGE VOID DIAMETER OF THE GEOTEXTILE. = 0.21 mm = 0.008 in (TREVIRA 1120) (EXHIBIT (EXHIBIT 3)

d_a : AVERAGE DIAMETER OF THE MATERIAL, USE d_{50} = 0.2 mm = 0.008 in

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ρ' = OVERBURDEN PRESSURE = 210 X 115 = 168 psi

S' = SHAPE FACTOR USE 1 FOR SHARP OBJECT (CONSERVATIVE)

$\therefore$ $T = \pi \times 0.008 \times 0.008 \times 168 \times 1 = 0.03$ lb

PUNCTURE STRENGTH FOR TREVIRA 1120 = 100 lb $\gg$ 0.03 lb O.K.

CONSIDER THE PUNCTURE POTENTIAL FROM THE GRANULAR DRAINAGE LAYER.

$S' = 0.6$ CRUSHED STONE (REF 2)

$d_a = 0.25$ CRUSHED STONE (REF 2)

$\therefore$ $T = \pi \times 0.008 \times 0.25 \times 168 \times 0.6 = 0.6$ lb $\ll$ 100 lb.

RETENTION CAPACITY AND POTENTIAL FOR CLOGGING AND EXCESSIVE LOSS OF FINES ARE NO CONCERN FOR THE GEOTEXTILE UNDER THE GRANULAR DRAINAGE LAYER BECAUSE OF LACK OF FINES IN THE GRADATION OF THE GRANULAR MATERIALS (SEE SPECIFICATION 2.03, LESS THAN 5% OF THE MATERIAL WILL PASS #100 SIEVE)

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CONCLUSION

THE CAPACITY OF THE LCRS AND THE GEOTEXTILE DESIGN IN THE PRIMARY LCRS HAVE BEEN EVALUATED. BASED ON THE CALCULATION PERFORMED, THE LCRS CAPACITY IS CONSIDERED ADEQUATE TO HANDLE LEACHATE FLOW THAT MAY GENERATED DURING LANDFILL OPERATION. THE CALCULATION ALSO INDICATED THAT THE GEOTEXTILE (TREVIRA 1125) USED IN THE PRIMARY LCRS HAS MET THE CRITERIA FOR RETENTION, CLOGGING, AND PREVENTION OF EXCESSIVE LOSS OF FINES.

PRECIPITATION DEPTH-DURATION-FREQUENCY TABLE

STATION NO. BSN ORDER SUB	STATION NAME	ELEV	SEC	TWP	RNG	LOT	BWM	LATITUDE	LONGITUDE	COUNTY CODE
COO 4536 00	KETTLEMAN STATION	508	25	21S	17E	L	M	36.075	120.085	16

MAXIMUM PRECIPITATION FOR INDICATED DURATION D-DAYS H-HOURS

RETURN PERIOD IN YEARS	1D	2D	3D	4D	5D	6D	8D	10D	15D	20D	30D	60D	365D
2	.98	1.21	1.31	1.38	1.44	1.50	1.60	1.76	2.00	2.14	2.58	3.49	6.08
5	1.35	1.71	1.89	2.00	2.09	2.18	2.33	2.53	2.93	3.10	3.65	4.98	8.35
10	1.59	2.05	2.28	2.42	2.53	2.64	2.83	3.04	3.56	3.74	4.34	5.96	9.79
20	1.83	2.38	2.65	2.82	2.95	3.08	3.30	3.52	4.17	4.35	4.98	6.88	11.12
25	1.90	2.48	2.77	2.94	3.08	3.21	3.45	3.67	4.36	4.54	5.17	7.16	11.53
40	2.05	2.70	3.01	3.20	3.36	3.50	3.76	3.99	4.75	4.93	5.27	7.75	12.37
50	2.12	2.80	3.13	3.33	3.48	3.64	3.90	4.14	4.94	5.12	5.77	8.03	12.76
100	2.34	3.10	3.48	3.70	3.88	4.05	4.34	4.59	5.50	5.68	6.35	8.87	13.95
200	2.55	3.41	3.82	4.07	4.27	4.45	4.78	5.03	6.06	6.23	6.91	9.69	15.10
1000	3.03	4.09	4.60	4.91	5.15	5.37	5.78	6.03	7.33	7.49	8.18	11.54	17.67
10000	3.71	5.05	5.70	6.09	6.38	6.66	7.17	7.42	9.10	9.23	9.92	14.11	21.19
PMP	7.04	9.47	10.72	11.49	12.05	12.58	13.55	14.32	17.25	17.88	20.09	27.91	43.52
MEAN	1.060	1.329	1.454	1.530	1.598	1.666	1.779	1.934	2.226	2.358	2.792	3.807	6.481
CLOCK HR. COR.	1.140	1.070	1.040	1.020	1.010	1.010	1.000	1.000	1.000	1.000	1.000	1.000	1.000
CALCULATED SKEW	.663	.605	.815	1.008	1.037	1.133	1.237	1.084	1.499	1.444	1.302	1.936	1.578
REGIONAL SKEW	1.300	1.400	1.400	1.400	1.400	1.400	1.400	1.300	1.400	1.300	1.100	1.200	1.000
SKEW USED	1.300	1.400	1.400	1.400	1.400	1.400	1.400	1.300	1.400	1.300	1.100	1.200	1.000
KURTOSIS	3.212	3.150	2.880	3.426	3.574	3.701	4.394	4.095	6.012	5.746	4.328	7.584	5.922
N	24	24	24	24	24	24	24	24	24	24	24	24	23
RECORD YEAR	1956	1956	1962	1974	1974	1974	1969	1969	1969	1969	1969	1969	1969
RECORD MAXIMUM	1.680	2.170	2.600	3.120	3.360	3.360	3.860	4.190	5.650	5.660	6.390	10.370	14.710
NORMALIZED MAX	1.557	1.768	1.869	2.284	2.369	2.351	2.638	2.631	3.092	3.033	2.712	3.328	2.748
CALC. COEF. VAR	.376	.358	.422	.455	.465	.433	.444	.443	.498	.462	.475	.518	.462
REGN. COEF. VAR	.376	.408	.425	.434	.436	.437	.441	.427	.450	.439	.413	.422	.381
USED COEF. VAR	.376	.408	.425	.434	.436	.437	.441	.427	.450	.439	.413	.422	.381
MEAN/A	.1635	.2051	.2243	.2361	.2466	.2570	.2744	.2984	.3434	.3638	.4307	.5874	1.0000
RP10/A	.2458	.3170	.3517	.3731	.3903	.4071	.4362	.4690	.5500	.5777	.6693	.9197	1.5107
RP25/A	.2931	.3832	.4271	.4542	.4754	.4959	.5320	.5669	.6722	.7005	.7982	1.1049	1.7783
RP50/A	.3274	.4316	.4822	.5134	.5375	.5608	.6019	.6381	.7615	.7897	.8905	1.2384	1.9685
RP100/A	.3609	.4789	.5362	.5714	.5983	.6244	.6704	.7074	.8490	.8766	.9798	1.3681	2.1516
RP1000/A	.4682	.6315	.7100	.7583	.7944	.8292	.8911	.9297	1.1308	1.1552	1.2621	1.7809	2.7264
RP10000/A	.5717	.7798	.8789	.9398	.9849	1.0282	1.1055	1.1443	1.4046	1.4242	1.5309	2.1769	3.2696
PMP/A	1.0857	1.4605	1.6543	1.7733	1.8594	1.9416	2.0899	2.2093	2.6615	2.7594	3.0991	4.3056	6.7150

PEARSON TYPE III DISTRIBUTION USED
PROBABLE MAXIMUM PRECIPITATION ESTIMATE BASED ON 15 STANDARD DEVIATIONS
WHERE N IS SMALL RESULTS ARE NOT DEPENDABLE

B

EXHIBIT 2

20/23

TABLE 3. HYDRAULIC TRANSMISSIVITY (M^2/Sec X 10^{-3})
SOIL/TREVIRA 1120/PN3000 GEONET/TREVIRA 1120/SOIL

BY FLUID SYSTEM, INC, CINCINNATI, OHIO.

GRADIENT = 0.25

Specimen	5,000 psf	10,000 psf	15,000 psf	20,000 psf	25,000 psf
1.	0.41	0.16	0.07	0.04	0.02
2.	0.42	0.17	0.08	0.05	0.04
3.	0.48	0.23	0.14	0.11	0.09
Avg:	0.44	0.19 0.14	0.10	0.07 0.065	0.05
SD:	0.04	0.04	0.04	0.04	0.04

GRADIENT = 0.50

Specimen	5,000 psf	10,000 psf	15,000 psf	20,000 psf	25,000 psf
1.	0.36	0.14	0.08	0.03	0.02
2.	0.37	0.14	0.08	0.04	0.03
3.	0.40	0.18	0.11	0.07	0.06
Avg:	0.38	0.15	0.09	0.05	0.04
SD:	0.02	0.02	0.02	0.02	0.02

GRADIENT = 0.75

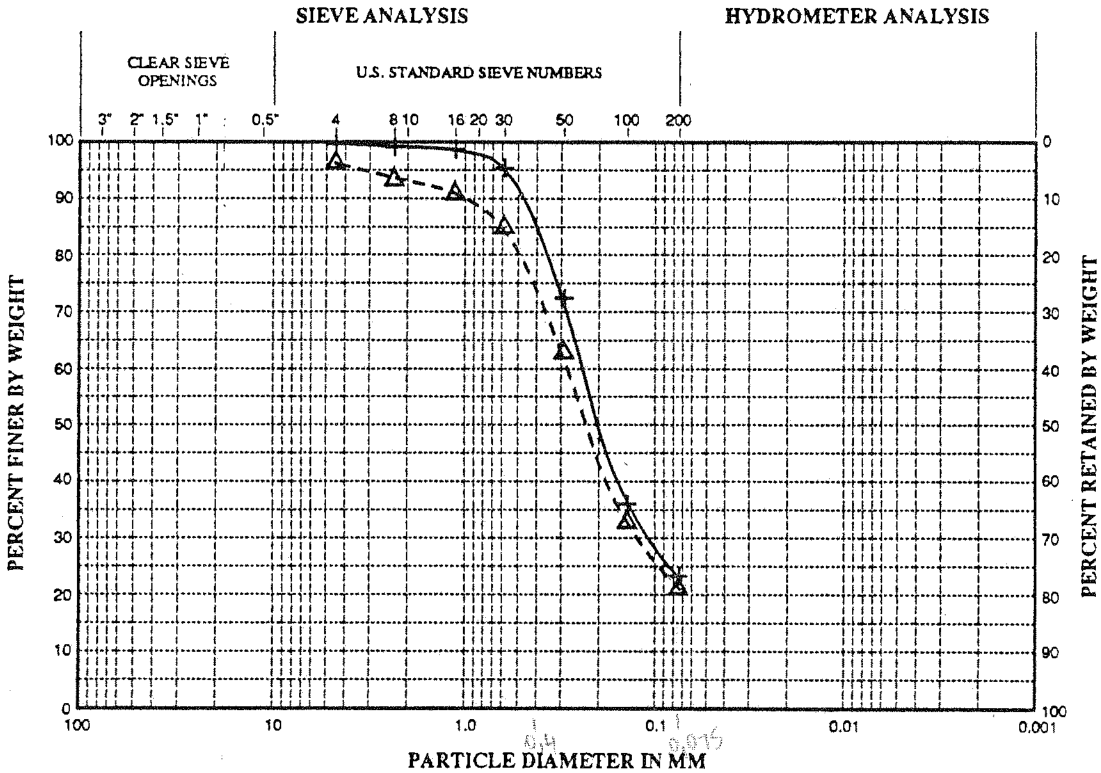
Specimen	5,000 psf	10,000 psf	15,000 psf	20,000 psf	25,000 psf
1.	0.32	0.14	0.06	0.04	0.03
2.	0.32	0.14	0.06	0.05	0.03
3.	0.35	0.16	0.08	0.06	0.05
Avg:	0.33	0.15	0.07	0.05	0.04
SD:	0.02	0.01	0.01	0.01	0.01

GRADIENT = 1.0

Specimen	5,000 psf	10,000 psf	15,000 psf	20,000 psf	25,000 psf
1.	0.26	0.12	0.05	0.03	0.03
2.	0.26	0.12	0.06	0.04	0.03
3.	0.29	0.14	0.07	0.05	0.04
Avg:	0.27	0.13	0.06	0.04	0.03
SD:	0.02	0.01	0.01	0.01	0.01

89-977/Fig D.2.7/GrSiD/U18-9 REV. 8/7/90

SYMBOL	TEST PIT TYPE	DEPTH (ft.)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	STRATIGRAPHIC UNIT	MATERIAL TYPE	USCS
+———+	TP-1, B-1	7.0	--	--	18-9	Sandstone	SM
Δ - - - - Δ	TP-42, B-1	6.0	--	--	18-9	Sandstone	SM



COBBLES	GRAVEL		SAND			SILT AND CLAY FRACTION
	coarse	fine	coarse	medium	fine	

FIGURE D.2.7

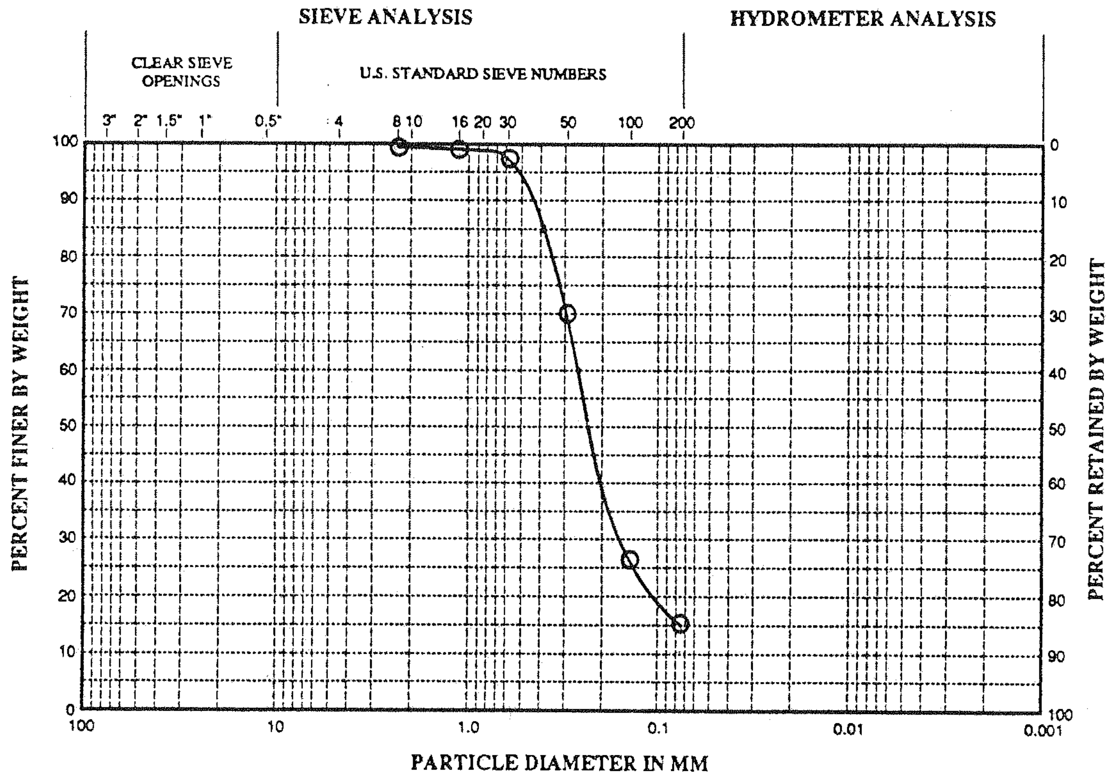
GRAIN SIZE DISTRIBUTION STRATIGRAPHIC UNIT 18-9

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.

89-977/Fig D.2.8/GrSIDI/U18-11 REV. 8/7/90

SYMBOL	BORING	DEPTH (ft.)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	STRATIGRAPHIC UNIT	MATERIAL TYPE	USCS
O———O	L18-B	37.0-39.5	--	--	18-11	Sandstone	SM



COBBLES	GRAVEL		SAND			SILT AND CLAY FRACTION
	coarse	fine	coarse	medium	fine	

FIGURE D.2.8

GRAIN SIZE DISTRIBUTION
STRATIGRAPHIC UNIT 18-11

LANDFILL UNIT B-18
KETTLEMAN HILLS FACILITY

ENVIRONMENTAL SOLUTIONS, INC.

TRANSMISSIVITY DATA IS BASED ON TREVIRA 1120

EXHIBIT 5

23/23

Trevira® Spunbond nonwoven engineering products are highly needled fabrics with excellent tensile properties, high filtration potential and outstanding permeability.

Trevira® Spunbond Type 11 products are 100% continuous filament polyester nonwoven needlepunched engineering fabrics. They deliver a combination of advantages unmatched by any other spunbonded geotextiles. They're resistant to freeze-thaw, soil chemicals and ultraviolet light exposure.

Trevira® Spunbond nonwoven engineering fabrics offer excellent performance where the requirement is tensile reinforcement, planar flow, filtration, or separation. They are ideal for roadways, railbeds, drainage systems, pondliners, retaining walls. And much more.

TYPICAL PHYSICAL PROPERTIES OF TREVIRA® TYPE 11 PRODUCTS

Fabric Property	Unit	Test Method	1112	1114	1120	1125	1135	1145	1155
Fabric Weight	oz/yd²	ASTM D-3776	3.5	4.2	6.0	7.5	10.5	13.5	16.5
Thickness, t	mils	ASTM D-1777	60	70	95	115	150	175	215
Grab Strength (MD/CD)[1]	lbs	ASTM D-4632	120/95	150/115	230/180	305/235	420/350	500/425	650/750
Grab Elongation (MD/CD)[1]	%	ASTM D-4632	65/75	65/70	65/75	65/75	65/75	70/75	70/75
Trapezoid Tear Strength (MD/CD)[1]	lbs	ASTM D-4533	50/40	55/50	80/75	105/90	145/130	185/170	215/190
Puncture Resistance	lbs	ASTM D-4833	55	65	100	115	160	180	230
Mullen Burst Strength	psi	ASTM D-3786	195	230	345	400	590	750	900
Water Flow Rate	gpm/ft²	ASTM D-4491	200	200	180	150	120	90	75
Permittivity, Ψ	sec⁻¹	ASTM D-4491	2.71	2.71	2.44	2.04	1.63	1.22	1.02
Permeability, k	cm/sec	k = Ψt	.41	.48	.59	.59	.62	.54	.56
AOS	Sieve Size mm	ASTM D-4751	70–100 .210–.149	70–100 .210–.149	70–100 .210–.149	70–100 .210–.149	70–120 .210–.125	100–120 .149–.125	120–170 .125–.088
Standard Roll Widths[2]	ft		← 12.5 and 15.0 →						
Standard Roll Length[2]	ft		400	400	300	300	300	300	300

[1]MD = Machine Direction, CD = Cross Machine Direction. [2]Other width and length rolls are available upon request.

.56 cm/sec ≈ .215 inch/sec; .31; .31×10; .59 cm/sec ≈ .115 inches; .17 cm²/sec

MINIMUM AVERAGE ROLL VALUES (WEAKEST PRINCIPAL DIRECTION) OF TREVIRA® TYPE 11 PRODUCTS

Fabric Property	Unit	Test Method	1112	1114	1120	1125	1135	1145	1155
Fabric Weight	oz/yd²	ASTM D-3776	3.3	4.0	5.7	7.1	10.0	13.0	16.0
Thickness, t	mils	ASTM D-1777	50	55	80	95	130	155	200
Grab Strength	lbs	ASTM D-4632	80	100	160	210	300	375	500
Grab Elongation	%	ASTM D-4632	50	50	50	50	50	50	50
Trapezoid Tear Strength	lbs	ASTM D-4533	30	40	60	75	100	130	160
Puncture Resistance	lbs	ASTM D-4833	40	45	80	95	130	155	195
Mullen Burst Strength	psi	ASTM D-3786	170	190	305	360	530	700	825
Water Flow Rate	gpm/ft²	ASTM D-4491	150	150	130	100	80	60	40
Permittivity, Ψ	sec⁻¹	ASTM D-4491	2.03	2.03	1.76	1.36	1.08	0.81	0.54
Permeability, k	cm/sec	k = Ψt	.26	.28	.36	.33	.36	.32	.28
AOS[3]	Sieve Size mm	ASTM D-4751							

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APPENDIX L
RISER PIPE ANALYSES

Objectives:

1. Evaluate the ability of the existing vertical LCRS riser pipes and underlying clay liner to withstand loading from an additional 90 vertical feet of waste placed above the original top of waste grade to the proposed Phase III top of waste grade.
2. Evaluate the ability of the existing sideslope riser pipes to withstand loading from an additional 90 vertical feet of waste placed above the original top of waste grade to the proposed Phase III top of waste grade.

Given:

The currently-permitted maximum waste height in the vicinity of the vertical and sideslope riser pipes is approximately 210 feet. The proposed Phase III expansion will increase this maximum waste height to approximately 300 feet (i.e., an approximately 90-foot increase). The as-built locations and configurations of the existing piping as well as the pipe materials and properties are shown on the Phases I and II construction drawings in Appendix A.1. The construction drawings in Appendix A.2 show the proposed final waste configuration.

Assumptions and Methodology:

The assumptions and methodology used to evaluate the existing vertical and sideslope riser pipes follows that of ESI (1990) for the original design of B-18. Golder has updated ESI's previous calculations to reflect the increased waste height (the methods utilized in the calculations are taken directly from the 1990 ESI calculations).

Summary of Results:

The calculations for the riser pipes are presented in Attachment A. The vertical riser pipe calculations are shown on pages 1 thru 11 while the sideslope riser pipe calculations are shown on pages 12 thru 17. The calculations indicate the following:

1. Vertical riser pipes: the existing vertical riser pipes and underlying clay liner are anticipated to have sufficient strength to resist the additional pressures from 90 extra feet of waste.

2. Sideslope riser pipes: the existing 8-inch-diameter steel riser pipes are anticipated to deflect a maximum of approximately 0.9% of their diameter under the full height of waste (300 feet), which is an acceptable deflection. As in the original design (ESI, 1990), the 8-inch-diameter HDPE riser pipes are anticipated to deflect more than 20% of their diameter (i.e., 21% to 34%). This amount of deflection exceeds the manufacturer's recommended maximum, but since the HDPE pipe is a backup to the steel pipe, it is considered acceptable for the sideslope riser application.

3. The proposed design provides for a transition from carbon steel pipe to a HDPE pipe. During the B-18 Phases I and II construction in the early 1990s, steel pipes were used due to the anticipated high loads and relatively new use of HPDE pipe. Since this time, however,

HDPE pipes are commonly used for LCRS riser pipes, including Landfill B-17 and Landfill B-19 Phase 1A at the Kettleman Hills Facility. Based on Golder's experience, there is little movement of the LCRS riser pipes once these pipes have been confined by soil cover/operations layer. This would be particularly true for the vadose and secondary riser pipes which are placed within excavated trenches and are below the weakest liner interface. For the primary riser pipe, movement of the waste could result in deflection of the LCRS riser. However, the movement of the waste (due to settlement) would primarily be down slope. Down slope movement would not result in significant shear on the LCRS riser; in fact the slip connection between the HDPE and steel pipes would allow for stress release if compression forces develop due to waste settlement. Additionally, it should be noted that the magnitude of settlement for the Class I waste in B-18 is relatively small compared with that of Class III municipal solid wastes. In summary, Golder believes that the riser pipes will not be subjected to shear forces that could damage the pipes and, therefore, the pipes will perform as designed. In the unlikely event of a failure at the steel/HDPE transition, the design includes redundant primary and secondary riser pipe systems which do not include the transition from steel to HDPE.

Reference:

Environmental Solutions Inc. (ESI), "Engineering and Design Report, Landfill Unit B-18, Phases I and II and Final Closure, Kettleman Hills Facility," August 1990.

Attachment A

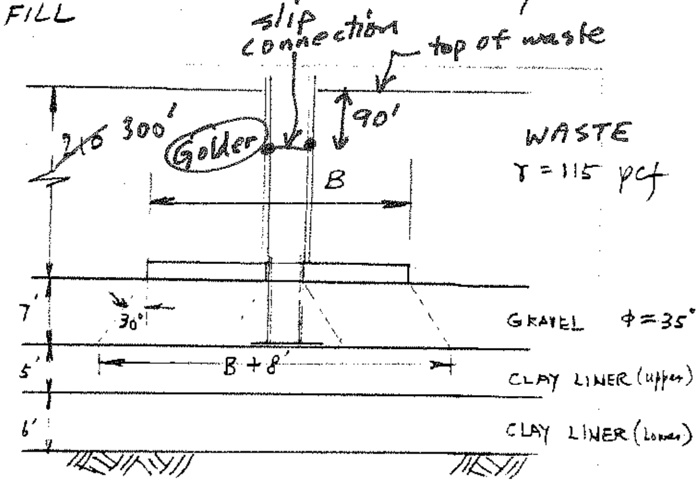
Riser Pipe Calculations

ENVIRONMENTAL SOLUTIONS, INC.

By GSC Date 7/27/90 Subject BEARING CAPACITY Sheet No. ~~3~~ 1 of ~~29~~ 26

Chkd. By [illegible] Date 8/15/90 VERTICAL RISER FOR Proj. No. 89-77

Modified By: (Golder) 5/18/08 KETTLEMAN LANDFILL



Objective : To calculate the available bearing capacity of the clay liner and design the riser base dimension

RESULTS FROM UU TEST OF MODIFIED PROCTOR FOR CLAYSTONE

INDICATE $\phi = 8°$ $c = 3600$ psf ---- CLAY LINER

USE $C = 3600$ psf for design

— Check squeezing effect to clay liner

Ref : "Foundation design & Construction" by Hamlington P. 211

See ~~attachment 1~~ page 23 (Golder)

$$\frac{B + 8}{\text{Thickness of clay layer}}$$

Assuming max. $B = 10'$

$$\frac{10+8}{5} = \frac{18}{5} = 3.6 < 6$$ Therefore, no squeezing effect is considered.

— Check allowable bearing pressure for clay liner

$q_u = cN_c + \gamma' d$ where C = undrained shear strength

$N_c = 6\,(1 + 0.2\,D/B)$ or limit to 9.0

D = Depth of footing below ground

B = width of foot

γ' = effective unit weight of soil

d = Thickness of footing

$= 9c + \gamma' d$

$= 9 \times 3600$ psf $+ 115 \times 2$ psf

$= 32400 + 230 = 32630$ psf or 32.6 KSF

ENVIRONMENTAL SOLUTIONS, INC.

By GSC Date 7/27/90 Subject BEARING CAPACITY Sheet No. ~~4~~ of 29

Chkd. By [illegible] Date 8/15/90 VERTICAL RISER BASE Proj. No. 89-977

Modified By: (Golder) 5/18/08

Use factor of safety of 2.0

Allowable bearing pressure at top of upper liner

$$= \frac{32.6}{2} = 16.3 \text{ ksf}$$

Assume use 8 × 8 riser base, and 30° tranfer of load from the base at top of gravel to top of clay liner

Area at top of clay liner $= (8+8)^2 - \left(\frac{2+8}{2}\right)^2 \pi$

$= 256 - 78.5$

$= 177.5$

Top load at base include weight of base

= ~~184.4~~ Kips (Ref. to ~~Leachate Sump Riser Calculations p. 3 & 4 of 14~~) pages 5-7

302.5 (Golder)

Pressure exerted on top of upper clay liner

$= \frac{\sout{184.4}\ 302.5}{177.5} = \sout{1.0}\ 1.7$ ksf < 16.3 ksf (Golder)

O.K.

For worst case if clay strength be c = 2000 psf

$q_u = 9 \times 2000 + (115 - 62.4) z$

$= 18000 + 105$

$= 18105$ psf or 18.1 ksf

$q_{allowable} = \frac{18.1}{2} = 9.1$ ksf

Applied pressure = ~~1.0~~ 1.7 ksf < 9.1 ksf O.K. (Golder)

Attachment A

ENVIRONMENTAL SOLUTIONS, INC.

By GSC Date 7/27/90 Subject BEARING CAPACITY Sheet No. ~~8~~ 3 of ~~29~~ 26

Chkd. By JPL Date 8/15/90 Proj. No. 89-977

Modified By: (Golder) 5/18/08

For 6 x 6 riser base

Area at top clay liner $= (6+8)^2 - \left(\frac{2+8}{2}\right)^2 \pi$

$= 196 - 78.5$

$= 117.5 \ ft^2$ (Golder)

Pressure exerted on clay liner $= \frac{\sout{184.4}\ 302.5}{117.5} = \sout{1.57}\ 2.57$ ksf < 9.1 ksf

O.K.

– Check consolidation settlement

The weight of fill above the clay liner ~~= 237 x 115 = 27255 psf = 27.3 ksf~~

= 300 × 115 + 7 × 130

= 35410 PSF (35.4 KSF)

(Golder)

Additional pressure due to riser = 1.56 ksf

Based on consolidation test results (see attached test results) pages 24-25

An additional settlement of 0.5 percent may be expected

∴ 0.5% × 8' = 0.04 inch (at base of riser)

Attachment A

ENVIRONMENTAL SOLUTIONS, INC.

- Check settlement in the gravel layer below the base of vertical riser

Elastic settlement :

Vertical stress at bottom of riser base

σ_v = ~~237~~ 300 × 0.115 + 184.4 / [6×6 − $(\frac{2}{2})^2\pi$] ksf

(Golder) = ~~27.3~~ 34.5 + 5.6

= ~~32.9~~ 40.1 ksf

Typical value of E_s for sand and gravel (see ~~attachment~~ p. 26)

Assume E_s = 14 ksi

= 2016 ksf

$\epsilon = \frac{\sigma_v}{E} = \frac{\text{~~32.9~~ } 40.1}{2016}$ = 0.~~016~~ 0.02

∴ Elastic settlement = ~~0.016~~ 0.02 × 7' (Golder)

1.67" (0.139')

= 1.37 inches

CONCLUSIONS :

1). WITH A 6'×6' VERTICAL RISER BASE, THE PRESSURE EXERTED ON CLAY LINER BENEATH THE BASE IS ABOUT (Golder) ~~1.6~~ 3.0 KSF. THIS COMPARES WITH A ULTIMATE BEARING CAPACITY OF AT LEAST 18.1 KSF FOR THE CLAY LINER. IT PROVIDES A FACTOR OF SAFETY OF AT LEAST ~~11~~ 7 AGAINST BEARING FAILURE FOR THE RISER BASE. (Golder)

2.) IT IS ANTICIPATED THAT THERE WILL BE A DIFFERENTAL MOVEMENT BETWEEN THE RISER BASE AND THE BOTTOM STEEL PIPE INSERT. THE MOVEMENT IS EXPECTED TO BE ABOUT ~~1.3~~ 1.67 INCHES DUE TO THE ELASTIC DEFORMATION OF THE GARVEL LAYER BENEATH THE BASE. (Golder)

TO BE CONSERVATIVE, IT IS ASSUMED THAT DOWNDRAG FORCE DUE TO WASTE SETTLEMENT WILL BE TRANSFERRED TO THE STEEL PIPES THROUGH CONTACT BETWEEN THE TWO PIPES. USING A AREA OF 10% OF THE STEEL PIPE, THE DOWNDRAG FORCE IS:

$$F_D = \int_{H_1}^{H_2} (p K_0 \gamma \tan\delta) z \, dz$$

$$= \frac{K_0 \gamma (H_1 + H_2)}{2} \cdot (H_2 - H_1) \cdot \pi \cdot \frac{24}{12} \cdot \tan\delta \cdot 10\%$$

$$= \frac{(1-\sin 27^\circ) \cdot 115 \cdot (90+300)}{2} \cdot (300-90) \cdot \pi \cdot 2 \cdot \tan\delta \cdot 10\%$$

$$= 255.8 \text{ kips}$$

WEIGHT OF STEEL PILE SCH 40

$$W_P = 171 \cdot 210 = 35.9 \text{ kips}$$

WEIGHT OF HDPE PIPE

$$W_H = 15.5 \cdot 210 = 3.3 \text{ kips}$$

TOTAL FORCE

$$F = 255.8 + 35.9 + 3.3 = 295 \text{ kips}$$

A 6x6x1.5 CONCRETE PAD USED

CHECK ON ORIGINAL DESIGN OF THE RISER FOUNDATION

BEARING PLATE FOR THE STEEL PIPE

CIRCUMFERENCE OF VERTICAL RISER

$C = (24 - 0.687) \times \pi = 73.24$ in

CONTACT AREA = $73.24 \cdot 0.687 = 50.3\ in^2$

WEIGHT OF PIPE + DOWNDRAG = $35.9 + 255.8 = 291.7$ kips

BEARING PRESSURE AT STEEL PLATE = $\frac{291.7}{73.24} = 3.98$ kips/in

BEARING PRESSURE @ CONCRETE = $\frac{295}{\frac{\pi}{4}(36^2 - 19^2)} = 0.401$ ksi

3000 psi CONCRETE USED

ALLOWABLE BEARING PRESSURE = $0.5 \cdot 3000 = 1500$ psi > 401 psi OK

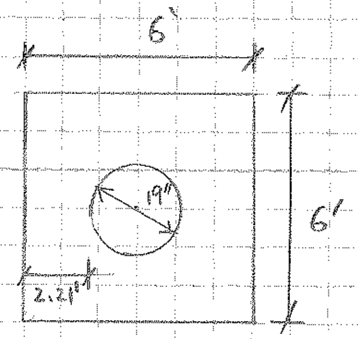
ALLOWABLE SHEAR STRESS IN BEARING PLATE = $0.4 F_y$

USE A36 STEEL $F_y = 36$ ksi

$\therefore F_v = 0.4 \cdot 36 = 14.4$ ksi > $\frac{291.7}{50.3} = 5.8$ ksi OK

Golder Associates	SUBJECT *Attachment A – B-18 Riser Pipes*		
	Job No. Ref. 083-91887	Made by EH Checked RH Reviewed	Date 04/11/08 Sheet 7 of 26

A 6×6×1.5 CONCRETE PAD USED



$W = 6 \cdot 6 \cdot 1.5 \cdot 144 - \frac{\pi}{4}\left(\frac{19}{12}\right)^2 \cdot 1.5 \cdot 144$

$= 7.35$ kips

TOTAL DEAD : $295 + 7.35 = 302.35$ kips

$f'_c = 3000$ psi, $f_y = 60{,}000$ psi, $d = 1.5 - 0.25 - \left(\frac{0.5}{2}\right)/12 = 1.23' = 14.76''$

$q_u = \dfrac{1.4 \cdot 302.35}{34.03} = 12.44$ ksf

CRITICAL SHEAR :

ONE-WAY SHEAR

$V_u = q_u \cdot b \cdot (2.21 - d)$

$= 12.44 \cdot 6 \cdot (2.21 - 1.23)$

$= 73.15$ kips

$V_c = \phi \cdot 2 \sqrt{f'_c} \; bd$

$= 0.85 \cdot 2 \cdot \sqrt{3000} \cdot (6 \cdot 12) \cdot (1.23 \times 12)$

$= 98.9$ kips $> V_u$ <u>OK</u>

TWO-WAY SHEAR

$V_u = q_u \cdot \left(6^2 - \left(\frac{19+d}{12}\right)^2\right)$

$= 12.44 \cdot \left(6^2 - \left(\frac{19 + 14.76}{12}\right)^2\right)$

$= 349.4$ kips

Golder Associates	SUBJECT Attachment A – B-18 Riser Pipes		
	Job No. Ref. 083-91887	Made by EH Checked RH Reviewed	Date 04/11/08 Sheet 8 of 26

$V_c = \phi \cdot 4 \sqrt{f'_c}\, b_o d$

$b_o = 4 \cdot (19 + d) = 4 \cdot (19 + 14.76) = 135.04$

$V_c = 0.85 \cdot 4 \cdot \sqrt{3000} \cdot 135.04 \cdot 14.76$

$= 371 \text{ kips} > 349.4 \text{ kips}$

BENDING

CRITICAL BENDING MOMENT:

$M_u = q_u \cdot \frac{(2.21 - d)^2}{2}$

$= 12.44 \cdot \frac{(2.21 - 1.23)^2}{2}$

$= 5.97 \text{ ft-kips}$

PERCENTAGE OF STEEL REQUIRED

$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2 m R_u}{f_y}}\right)$

WHERE $m = \frac{f_y}{0.85 f'_c} = \frac{60000}{0.85 \cdot 3000} = 23.5$

$R_u = \frac{M_u}{\phi b d^2} = \frac{5.97 \cdot 12 \cdot 1000}{0.9 \cdot 12 \cdot 14.76} = 30.45$

$\therefore \rho = \frac{1}{23.5}\left(1 - \sqrt{1 - \frac{2 \cdot 23.5 \cdot 30.45}{60000}}\right)$

$= 0.00051 = 0.051\,\%$

Golder Associates	SUBJECT Attachment A – B-18 Riser Pipes		
	Job No. Ref. 683-91887	Made by EH Checked RH Reviewed	Date 04/11/08 Sheet 9 of 26

#5 RE-BAR @ 6" c/c BW USED

$A_s = 0.62 \text{ in}^2$

$$\rho = \frac{0.62}{bd} = \frac{0.62}{12 \cdot 14.76} = 0.35\% > 0.051\% \quad \text{OK}$$

LOWER VERTICAL RISER

PRESSURE AT TOP OF PIPE

OVERBURDEN = 300 · 115 = 34500 psf

BEARING PRESSURE = 4950 psf

PRESSURE AT BOTTOM OF PIPE

OVERBURDEN = 34500 + 7 · 130 = 35410 psf

BEARING PRESSURE = 1017 psf

LATERAL PRESSURE UNDER AT-REST CONDITION

$K_o = (1 - \sin\phi) = (1 - \sin 40°) = 0.35$

$\therefore$

$P_T = 0.35 \cdot (34500 + 4950) = 13808$ psf

$P_B = 0.35 \cdot (35410 + 1017) = 12749$ psf

RING COMPRESSION AT TOP OF PIPE

$$P = \frac{13808}{2} \cdot D$$

$$= 6904D$$

Golder Associates	SUBJECT Attachment A – E-18 Riser Pipes		
	Job No. Ref. 083-91997	Made by EH Checked RH Reviewed	Date 04/11/08 Sheet 11 of 26

18" STAINLESS STEEL PIPE ($E = 28 \times 10^6$ psi) USED

NOMINAL DIAMETER	OD	ID	t	r	I
18	18	16.5	0.75	8.625	0.035

$\therefore P = 6904 \cdot \left(\frac{18}{12}\right) = 10356 \text{ lb/ft} = 863 \text{ lb/in}$

STRESS IN PIPE WALL $= 863/0.75 = 1150.7$ psi

A FS of 3 IS REQUIRED TO AVOID COLLAPSING OF THE PIPE

THE MAX. CRITICAL PRESSURE IS:

$$P_{CR} = \frac{3EI}{R^3} = \frac{24EI}{R^3}$$

$$FS = \frac{P_{CR}}{P} = \frac{24 \cdot 28 \times 10^6 \cdot 0.035}{(8.625 \cdot 2)^3 \cdot 1150.7} = 3.98 > 3. \quad \underline{OK}$$

PIPE DEFLECTION MAY BE DETERMINED BY THE IOWA'S EQUATION:

$$\Delta_x = \frac{Kwr^3}{EI + 0.061E'r^3} \cdot D_e = \text{pipe deflection}$$

WHERE:

D_e = DEFLECTION FACTOR (= 1.5)

K = BENDING COEFFICIENT (= 0.1)

W = DESIGN LOAD

r = MEAN RADIUS OF PIPE $\left(= \frac{OD - t}{2}\right)$

E = MODULUS OF PIPE (= 20,000 psi)

I = MOMENT INERTIA OF PIPE $\left(= \frac{t^3}{12}\right)$

E' = MODULUS OF SOIL REACTION (= 1000 psi)

(COARSE GRAVEL MODERATELY COMPACTED)

Golder Associates	SUBJECT Attachment A – B-18 Riser Pipes		
	Job No. Ref. 083-91887	Made by EH Checked RH Reviewed	Date 04/11/08 Sheet 13 of 26

DEFLECTION OF THE SLOPE RISER

(1) 8" ϕ DUCTILE IRON PIPE (SCH80)

NOMINAL DIAMETER	OD	ID	t	r	I
8"	8.625	7.625	0.5	4.063	0.010

$E = 24 \times 10^6$ FOR DUCTILE IRON PIPE

TRENCH CONDITION

WASTE FILL OVERBURDEN

$$q_f = 115 \times 300 = 34500 \text{ psf}$$

PRESSURE AT TOP OF PIPES DUE TO WASTE FILL

$$\sigma_{v_1} = q_f \, C_{\mu s}$$

$$= q_f \cdot e^{-2K\mu' (H/B_d)}$$

$$= 34500 \cdot e^{-2 \cdot 0.165 \cdot \left(\frac{18-3-8.625}{18}\right)}$$

$$= 30694 \text{ psf}$$

PRESSURE AT TOP OF PIPE DUE TO TRENCH BACKFILL

$$\sigma_{v_2} = B_d \cdot \gamma \cdot C_d$$

$$= 1.5 \cdot 130 \cdot \frac{1 - e^{-2 \cdot 0.165 \cdot (6.375/18)}}{2 \cdot 0.165}$$

$$= 65 \text{ psf}$$

TOTAL PRESSURE AT TOP OF PIPE

$$\sigma_{vo} = 30694 + 65 = 30759 \text{ psf}$$

INCREASE OF STRESS DUE TO VERTICAL RISER:

$$\Delta\sigma = \frac{1837}{13^2 - \left(\frac{7+19}{12}\right)^2 \frac{\pi}{4}} = 1111 \text{ psf}$$

$$\sigma_v = 30759 + 1111 = 31870 \text{ psf}$$

FORCE PER UNIT LENGTH OF PIPE

$w = \sigma_v \cdot B_c$

$= 31870 \cdot 8.625/12$

$= 22906$ lb/ft

$= 1909$ lb/in

$$\therefore \Delta y = \frac{K w r^3}{EI + 0.061 E' r^3} \cdot D_e$$

$$= \frac{0.1 \times 1909 \times 4.063^3}{24 \cdot 10^6 \times \frac{0.5^3}{12} + 0.061 \times 1000 \times 4.063^3} \cdot 1.5$$

$= 0.079$

$$\therefore \frac{\Delta y}{D} = \frac{0.079}{8.625} = 0.9\,\% \ll 5\,\% \quad \underline{OK}$$

POSITIVE PROJECTION

TOTAL VERTICAL STRESS AT TOP OF PIPE

$\sigma_v = \sigma_{v1} + \Delta\sigma = 34500 + 1017 = 35517$

FORCE PER UNIT LENGTH OF PIPE

$w = \sigma_v B_c$

$= 35517 \cdot \frac{8.625}{12}$

$= 25527$ lb/ft

$= 2127$ lb/in

$$\therefore \Delta y = \frac{0.1 \times 2127 \cdot 4.063^3}{24\times10^6 \times \frac{0.5^3}{12} + 0.061 \cdot 1000 \cdot 4.063^3} = 0.08''$$

$$\frac{\Delta y}{D} = \frac{0.08}{8.625} = 0.7\,\% \ll 5\,\% \quad OK \quad \#$$

(2)
CHECK DEFLECTION OF THE 8"φ HDPE PIPE (SDR = 8.3), THE HDPE PIPE HAS THE FOLLOWING PROPERTIES:

NOMINAL DIAMETER	OD	ID	t	r	I	E
8"	8.625	6.549	1.039	3.793	0.093	20,000 psi

IN TRENCH CONDITION, THE NOMINAL PRESSURE AT TOP OF PIPE IS 30759 psf (= 213.6 psi)

$\therefore$ FORCE PER UNIT LENGTH OF PIPE

$$W = 30759 \cdot \frac{8.625}{12} = 22108 \ lb/ft$$

$$= 1842.3 \ lb/in$$

$$\therefore \Delta y = \frac{0.1 \times 1842.3 \times 3.793^3}{20000 \times 0.093 + 0.061 \times 1000 \times 3.793^3} \cdot 1.5 = 2.91''$$

$$\frac{\Delta y}{D} = \frac{2.91}{8.625} = 34\,\%$$

THE FOLLOWING IS BASED ON THE PROCEDURES SUGGESTED BY THE HDPE PIPE MANUFACTURER (pages 18-22)

Golder Associates	SUBJECT Attachment A – B-1B Riser Pipes		
	Job No. Ref. 083-91887	Made by EH Checked RH Reviewed	Date 04/11/08 Sheet 17 of 26

TOTAL EXTERNAL PRESSURE AT TOP OF PIPE:

$P_t = 213.6$ psi (see page 16)

EXAMINE SHORT-TERM WALL CRUSHING:

$$S_A = \frac{(SDR-1)P_t}{2} = \frac{(8.3-1)\times 213.6}{2} = 780 \text{ psi} < 1500 \text{ psi}$$

CALCULATE THE CRITICAL COLLAPSE PRESSURE:

$$P_c = \frac{2.32 \cdot 20000}{8.3^3} = 81$$

EXAMINE WALL-BUCKLING OF THE PIPE SOIL SYSTEM

ASSUME $P_{CB} = P_t$

THE REQUIRED SOIL MODULUS E' TO RESIST BUCKLING IS:

$$E' = \frac{213.6^2}{0.64 \cdot 81} = 880 \text{ psi}$$

SINCE THE PIPE IS SURROUNDED BY GRAVEL, TO BE CONSERVATIVE, A SOIL MODULUS OF 1000 psi IS USED:

$$\text{PIPE DEFLECTION} = \% \text{ SOIL STRAIN} = \frac{213.6}{1000} \cdot 100 = 21\% > 2\%$$

THE DEFLECTION EXCEEDS THE MANUFATURER'S RECOMMENED ALLOWABLE DEFLECTION. SINCE THE HDPE PIPE SYSTEM IS A REDUNDANT SYSTEM. ~~IT CAN BE REPLACED BY THE STEEL PIPE ALONGSIDE THE HDPE PIPE.~~

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DRISCOPIPE® 8600

ULTRA-HIGH MOLECULAR WEIGHT HIGH DENSITY POLYETHYLENE

Dimensions and Pressure Ratings

ORDERING INFORMATION

PRICE Prices subject to change without notice.

FREIGHT
1. All prices F.O.B. shipping point.
2. Less than truckload shipments will be shipped freight collect, or freight prepaid and charged, from point of origin.

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5. Preferred method of shipment
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7. Desired delivery date

NOTE: Standard Length is 40 feet for all sizes.

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LOW PRESSURE

NOMINAL SIZE	DIMENSIONS-INCHES NOMINAL OD	APPROX. ID	MINIMUM WALL	SDR	NOMINAL WEIGHT LBS/100'	JOINT LENGTH FT.	DESIGN PRESSURE PSI-73.4°F
3"	3.500	3.300	0.100	35	46	40	47
4"	4.500	4.200	0.150	30	88	40	55
*4"	4.500	4.026	0.237	19.0	135	40	89
5"	5.250	4.926	0.162	32.5	111	40	51
*5"	5.563	5.047	0.258	21.5	183	40	78
6"	6.625	6.217	0.204	32.5	176	40	51
7"	7.125	6.687	0.219	32.5	203	40	51
*7"	7.125	6.333	0.396	18	357	40	94
8"	8.625	8.095	0.265	32.5	297	40	51
10"	10.750	10.088	0.331	32.5	463	40	51
*10"	10.750	10.022	0.364	29.5	507	40	56
*12"	12.750	11.940	0.405	31.5	671	40	52
*14"	14.000	13.138	0.431	32.5	784	40	51
16"	16.000	15.016	0.492	32.5	1023	40	51
*16"	16.000	15.000	0.500	32.0	1039	40	52
18"	18.000	16.892	0.554	32.5	1296	40	51
*20"	20.000	18.806	0.597	33.5	1554	40	49
20"	20.000	18.770	0.615	32.5	1599	40	51
22"	21.500	20.176	0.662	32.5	1850	40	51
24"	24.000	22.524	0.738	32.5	2303	40	51
28"	27.953(1)	26.233	0.860	32.5	3125	40	51
32"	31.496(2)	29.558	0.969	32.5	3967	40	51
36"	36.000	33.784	1.108	32.5	5185	40	51
42"	42.000	39.416	1.292	32.5	7054	40	51
48"	47.244(3)	44.336	1.454	32.5	8930	40	51

(1) 710 MM (2) 800 MM (3) 1200 MM

65 psi

NOMINAL SIZE	DIMENSIONS NOMINAL OD	APPROX. ID	MINIMUM WALL	SDR	NOMINAL WEIGHT LBS/100'	JOINT LENGTH FT.
*6"	6.625	6.065	0.280	23.5 (71 psi)	238	40
*8"	8.625	7.981	0.322	27 (62 psi)	359	40
10"	10.750	9.900	0.425	25.3	588	40
20"	20.000	18.418	0.791	25.3	2037	40
24"	24.000	22.102	0.949	25.3	2933	40
28"	27.953(1)	25.743	1.105	25.3	3978	40
36"	36.000	32.572	1.714	21	7877	40
48"	47.244(3)	43.610	1.817	26	11068	40

(1) 710 mm (3) 1200 mm

110 psi

NOMINAL SIZE	DIMENSIONS-INCHES NOMINAL OD	APPROX. ID	MINIMUM WALL	SDR	NOMINAL WEIGHT LBS/100'	COIL OR JOINT LENGTH FT.
*1½"	1.900	1.610	0.145	13.1	34	500
*2"	2.375	2.069	0.153	15.5	46	300
*3"	3.500	3.068	0.216	16 (107 psi)	95	40
3"	3.500	3.048	0.226	15.5	99	40
4"	4.500	3.920	0.290	15.5	164	40
6"	6.625	5.771	0.427	15.5	355	40
8"	8.625	7.513	0.556	15.5	601	40
10"	10.750	9.362	0.694	15.5	935	40
12"	12.750	11.104	0.823	15.5	1315	40
14"	14.000	12.194	0.903	15.5	1584	40
16"	16.000	13.936	1.032	15.5	2069	40
18"	18.000	15.678	1.161	15.5	2619	40
22"	21.500	18.726	1.387	15.5	3737	40
24"	24.000	20.904	1.548	15.5	4656	40

130 psi

NOMINAL SIZE	DIMENSIONS-INCHES NOMINAL OD	APPROX. ID	MINIMUM WALL	SDR	NOMINAL WEIGHT LBS/100'	JOINT LENGTH FT.	DESIGN PRESSURE PSI-73.4°F
3"	3.500	2.982	0.259	13.5	112	40	130
4"	4.500	3.834	0.333	13.5	186	40	130
6"	6.625	5.643	0.491	13.5	403	40	130
8"	8.625	7.347	0.639	13.5	683	40	130

160 psi

NOMINAL SIZE	DIMENSIONS-INCHES NOMINAL OD	APPROX. ID	MINIMUM WALL	SDR	NOMINAL WEIGHT LBS/100'	COIL OR JOINT LENGTH FT.
¾"	1.050	0.860	0.095	11	12	500
1"	1.315	1.075	0.120	11	19	500
1¼"	1.660	1.348	0.151	11	31	500
1½"	1.900	1.554	0.173	11	40	500
2"	2.375	1.943	0.216	11	62	350
3"	3.500	2.864	0.318	11	135	40
4"	4.500	3.682	0.409	11	224	40
5"	5.563	4.551	0.506	11	342	40
6"	6.625	5.421	0.602	11	485	40
8"	8.625	7.057	0.784	11	823	40
10"	10.750	8.796	0.977	11	1278	40
12"	12.750	10.432	1.159	11	1798	40
14"	14.000	11.454	1.273	11	2168	40
16"	16.000	13.090	1.455	11	2833	40
18"	18.000	14.728	1.636	11	3583	40
22"	21.500	17.590	1.955	11	5114	40
24"	24.000	19.636	2.182	11	6372	40

190 psi

NOMINAL SIZE	DIMENSIONS-INCHES NOMINAL OD	APPROX. ID	MINIMUM WALL	SDR	NOMINAL WEIGHT LBS/100'	COIL OR JOINT LENGTH FT.
¾"	1.050	0.824	0.113	9.33	14	300
1"	1.315	1.033	0.141	9.33	22	300
1¼"	1.660	1.304	0.178	9.33	35	500
2"	2.375	1.865	0.255	9.33	72	350
3"	3.500	2.750	0.375	9.33	157	40
4"	4.500	3.536	0.482	9.33	259	40
6"	6.625	5.205	0.710	9.33	562	40

220 psi

NOMINAL SIZE	DIMENSIONS-INCHES NOMINAL OD	APPROX. ID	MINIMUM WALL	SDR	NOMINAL WEIGHT LBS/100'	JOINT LENGTH FT.
8"	8.625	6.547	1.039	8.3	1054	40
14"	14.000	10.164	1.918	7.3 (254 psi)	3096	40

STANDARD PACKAGING FOR DRISCOPIPE® 8600 INDUSTRIAL PIPE

PIPE DESCRIPTION		BUNDLE		TRUCK LOAD BUNDLED		40 FT. FLOAT TRUCKLOAD — LOOSE	
NOMINAL SIZE	O.D.	JOINTS	LINEAR FEET	BUNDLES	LINEAR FEET	JOINTS	LINEAR FEET
2"	2.375	88	3,520	14	49,280		
3"	3.500	46	1,840	14	25,760		
4"	4.500	27	1,080	14	15,120		
5"	5.563	15	600	14	8,400		
6"	6.625	11	440	14	6,160		
7"	7.125	11	440	12	5,280		
8"	8.625	8	320	12	3,840		
10"	10.750					80	3,200
12"	12.750					59	2,360
14"	14.000					48	1,920
16"	16.000					35	1,400
18"	18.000					28	1,120
20"	20.000					20	800
22"	21.500					18	720
24"	24.000					16	640
28"	27.953					10	400
32"	31.496					9	360
36"	36.000					6	240
42"	42.000					4	160
48"	47.244					4	160

NOTE: OBTAIN TRUCK LOAD WEIGHT BY MULTIPLYING LINEAR FEET TIMES PIPE WEIGHT PER FOOT.

NOTE: Approximate ID = Nominal OD − 2 × Minimum Wall
SDR (Standard Dimension Ratio) = OD ÷ Minimum Wall
*These sizes are also Schedule 40 dimensions.
Pressure rating computed on the basis of the following:

$$P = \frac{2S}{SDR-1} @ 73.4°F$$

Where:
Dp = Nominal OD of Pipe, Inches
t = Minimum Wall Thickness
S = Hydrostatic Design Stress, 800 psi
P = Pressure Rating, psi @173.4°F

NOTE:
Approximate ID = Dp − 2t

$$SDR\ (Standard\ Dimension\ Ratio) = \frac{Dp}{t}$$

Burial Design Guidelines: By combining the Burial Design Considerations with the Total External Soil Pressure, calculated by components, the designer can select the proper pipe SDR and specify the soil density to engineer into the pipeline the desired performance of the "pipe-soil" system. The following guidelines are presented for evaluation when designing a specific Driscopipe system. Because various parameters are available, in different situations, the guidelines may be approached in a mixed order or the equations may require mathematical re-arrangement. These guidelines, along with the following notes and sample problem, should be helpful:

1. Calculate by components the total external soil pressure P_t at the top of the pipe.

2. Examine Short Term Wall Crushing by calculating the compressive stress in the wall of the pipe at the springline:

   $$S_A = \frac{(SDR-1)\ P_t}{2}$$

   (a) If $S_A < 1500$ psi proceed to #3
   (b) If $S_A > 1500$ psi consider a heavier pipe wall

3. Calculate the critical-collapse pressure, P_c, from this formula using the time dependent modulus of elasticity, E, rated at the stress level calculated above in #2. (see Chart 25).

   $$P_c = \frac{2.32\ E}{(SDR)^3}$$

4. Examine Wall-Buckling of the pipe-soil system. By assuming the critical-buckling pressure, P_{cb}, equals the pressure at the top of the pipe, P_t, (see #1), and by using the critical pressure, P_c, calculated in #3, the basic soil modulus, E', required to resist buckling can be calculated by:

   $$E' = \frac{(P_{cb})^2}{.64\ (P_c)}$$

5. To safeguard against wall buckling, multiply E' by a reasonable safety factor (S.F.) equal to or greater than 2.0.

   $$E'_{MIN} = (E')(S.F.)$$

6. Calculate pipe deflection based upon the principle that its deflection will be the same as the backfill surrounding the pipe under the influence of the soil pressure at the top of the pipe:

   $$\%\ \text{Soil Strain} = \xi_S = \frac{P_t}{E'_{MIN}} \times 100$$

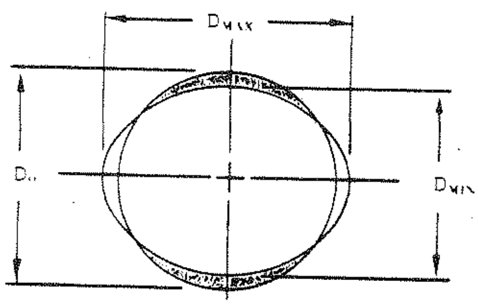
7. Examine allowable Ring Deflection for the specific SDR under consideration to insure the pipe deflection (#6) is less than the allowable deflection for that SDR. (See Chart 27).

- If the actual deflection exceeds the permissable value, increase E', the soil strength modulus, and re-calculate #6. The other alternative is to consider another SDR at #1.

Design by Ring Deflection: Ring deflection is defined as the ratio of the vertical change in diameter to the original diameter. It is often expressed as a percentage. Ring deflection for buried Driscopipe is conservatively the same as (no more than) the vertical compression of the soil envelope around the pipe. Design by ring deflection matches the ability of Driscopipe to accommodate, without structural distress, the vertical compression of the soil enveloping the buried pipeline. *Design by ring deflection comprises a calculation of vertical soil strain to insure it will be less than the allowable ring deflection of the pipe.* See Chart 27. The tabulation shows that with lower values of SDR, the allowable deflection is less. For installations which require this thicker wall to resist the external soil pressure, actual ring deflection can easily be limited to the tabular values by proper compaction of the backfill around the pipe. The recommended allowable deflection for the various SDR's are:

CHART 27

SDR	ALLOWABLE RING DEFLECTION
32.5	8.1%
26.0	6.5%
21.0	5.2%
19.0	4.7%
17.0	4.2%
15.5	3.9%
13.5	3.4%
11.0	2.7%



$$\% \text{ RING DEFLECTION} = \left(1 - \frac{D_{MIN}}{D_O}\right) \times 100\%$$

The allowable ring deflection of polyethylene pipe is a function of the allowable tangential strain in the outer surface of the pipe wall. A conservative limit of 1 - 1½% tangential strain in the outer surface of the pipe wall due to vertical deflection of the pipe "ring" by soil compression can be understood by comparing two pipes of the same diameter but different wall thickness.

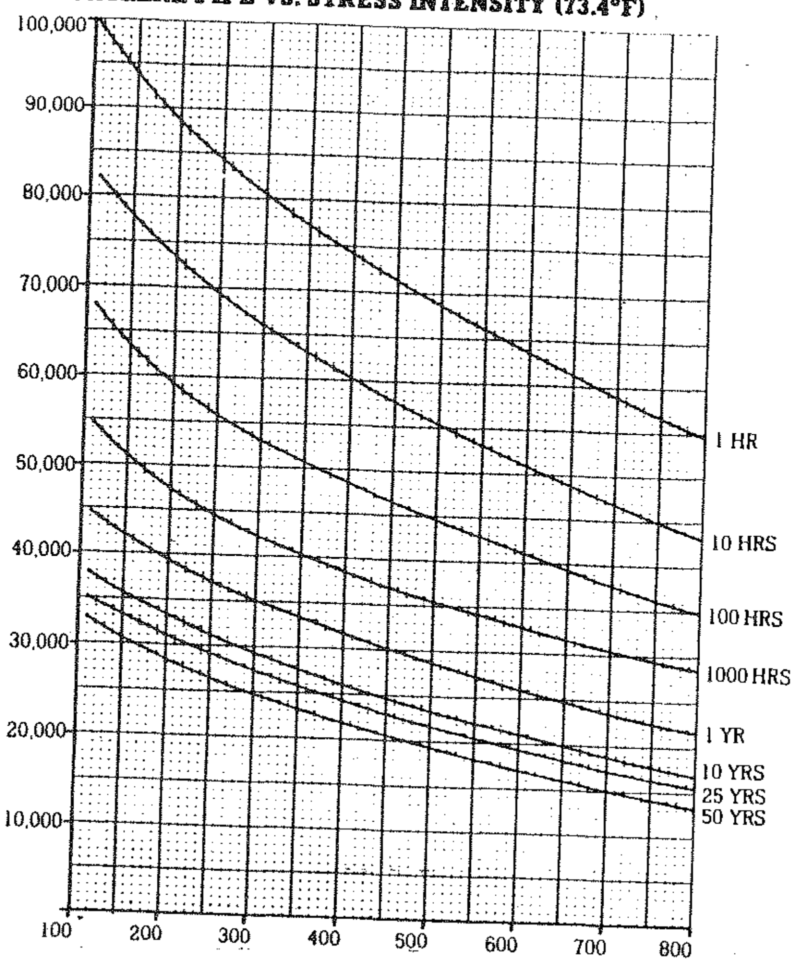
Assume each of the pipes is equally deflected under loads required to achieve that result. The tangential surface strain developed in the thickwall pipe is much greater than the surface strain in the thinwall pipe. The tangential strain varies directly as the wall thickness (i.e.: distance from the neutral axis) and is proportional to the amount of ring deflection. For a given ring deflection, the thicker the wall, the higher the strain.

Alternately, assume that each of the pipes are subjected to loads such that the tangential surface strain in the pipe's wall surface is equal for both pipes. For equal surface strain, the degree of vertical deflection of the pipe ring is different for the two pipes. Under these circumstances, the degree of deflection would be less for the thickwall pipe and greater for the thinwall pipe.

53.

CHART 25

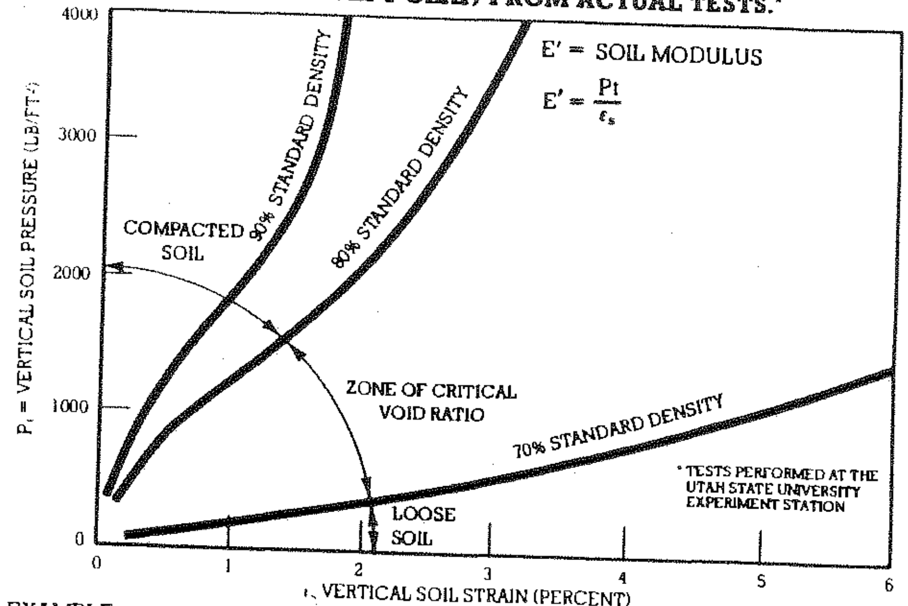
TIME DEPENDENT MODULUS OF ELASTICITY FOR POLYETHYLENE PIPE VS. STRESS INTENSITY (73.4°F)



NOTE: The short term modulus of elasticity of Driscopipe per ASTM D 638 is approximately 100,000 psi. Due to the cold flow (creep) characteristic of the pipe material, this modulus is dependent upon the stress intensity and the time duration of the applied stress.

CHART 26

PLOT OF VERTICAL STRESS-STRAIN DATA FOR TYPICAL TRENCH BACKFILL (EXCEPT CLAY) FROM ACTUAL TESTS.*



EXAMPLE

FIND: E' @ 2000 PSF AND 80% DENSITY

FORMULA: $E' = Pt/\epsilon_s$

CALCULATIONS: E' = 2000 PSF / .018 = 111111 PSF = 771 psi

NOTE: The curves shown on this chart are sample curves for a granular soil. If other types of soil are used for backfill, such as clay or clay loam, curves should be developed from laboratory test data for the material used. Soil pressures greater than 4000 psf may be examined by extrapolating the slope of the curve or by generating curves by testing at those higher soil pressures. Probable error of curves is about half the distance between adjacent lines.

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underside of a pad foundation and the top of the soft clay exceeds half the width of the foundation, the resistance of the stiff layer in

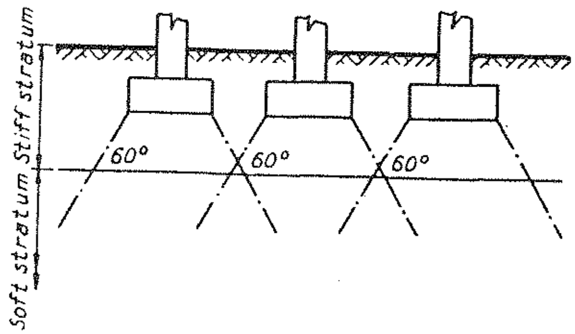


FIG. 4.3. CLOSE-SPACED FOUNDATIONS

forming a natural raft should be allowed for by the following procedure—

Pressure on surface of buried soft stratum $= q$

$$= \frac{W - P_s}{A} \quad . \quad . \quad (4.3)$$

where W = total load at base of foundation

P_s = perimeter shearing resistance

= peripheral area of stiff clay × shear strength of stiff clay

A = base area of foundation.

The value of q should not exceed the safe bearing capacity of the soft clay. Also, as in all cases of foundations on clay soils, the settlement of the foundation due to consolidation within both the stiff and the soft strata should be considered. The peripheral area of stiff clay is obtained by multiplying the peripheral length of the foundation by the depth of stiff clay *below* foundation level. It is inadvisable to allow for any transfer of load from the foundation sides to the stiff clay because shrinkage of the soil or of the foundation concrete, or a combination of both, will open up a gap between the soil and the concrete. If the zone of soil affected by seasonal moisture content changes extends below foundation level, cracking of the soil in the dry season will destroy the perimeter shearing resistance. Therefore, the latter should be calculated only over the thickness of the clay layer *below* the zone of seasonal moisture changes.

FOUNDATIONS CONSTRUCTED ON A THIN CLAY STRATUM

When foundations are constructed on a thin surface stratum of clay overlying a relatively rigid stratum, there may be a tendency for the thin layer to be squeezed from beneath the foundation, particularly if the soft layer is of varying thickness. Fig. 4.4 shows a foundation of width B on a thin clay layer overlying a stratum of different characteristics and appreciably higher bearing capacity, for example a sand layer. The net ultimate bearing capacity of the thin clay layer is given by the formulae—

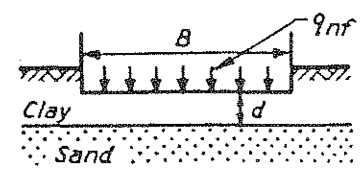


FIG. 4.4. FOUNDATION ON THIN CLAY LAYER

For a strip foundation of width B:

$$q_{nf} = \left(\frac{B}{2d} + \pi + 1\right)c \quad \text{for } \frac{B}{d} \geqslant 2 \quad . \quad . \quad (4.4)$$

For a circular foundation of diameter B:

$$q_{nf} = \left(\frac{B}{3d} + \pi + 1\right)c \quad \text{for } \frac{B}{d} \geqslant 6 \quad . \quad . \quad (4.5)$$

For smaller values of B/d than those given above, q_{nf} can be obtained from equations 2.11 and 2.12, i.e. the formulae for a thick clay layer.

It should also be noted that, with a thin clay layer, plastic deformation resulting from overstressing begins at a lower foundation pressure than with a thick clay layer. For both strip and circular foundations, the maximum shear stress induced in the clay stratum is approximately $\frac{1}{2}q_n$.

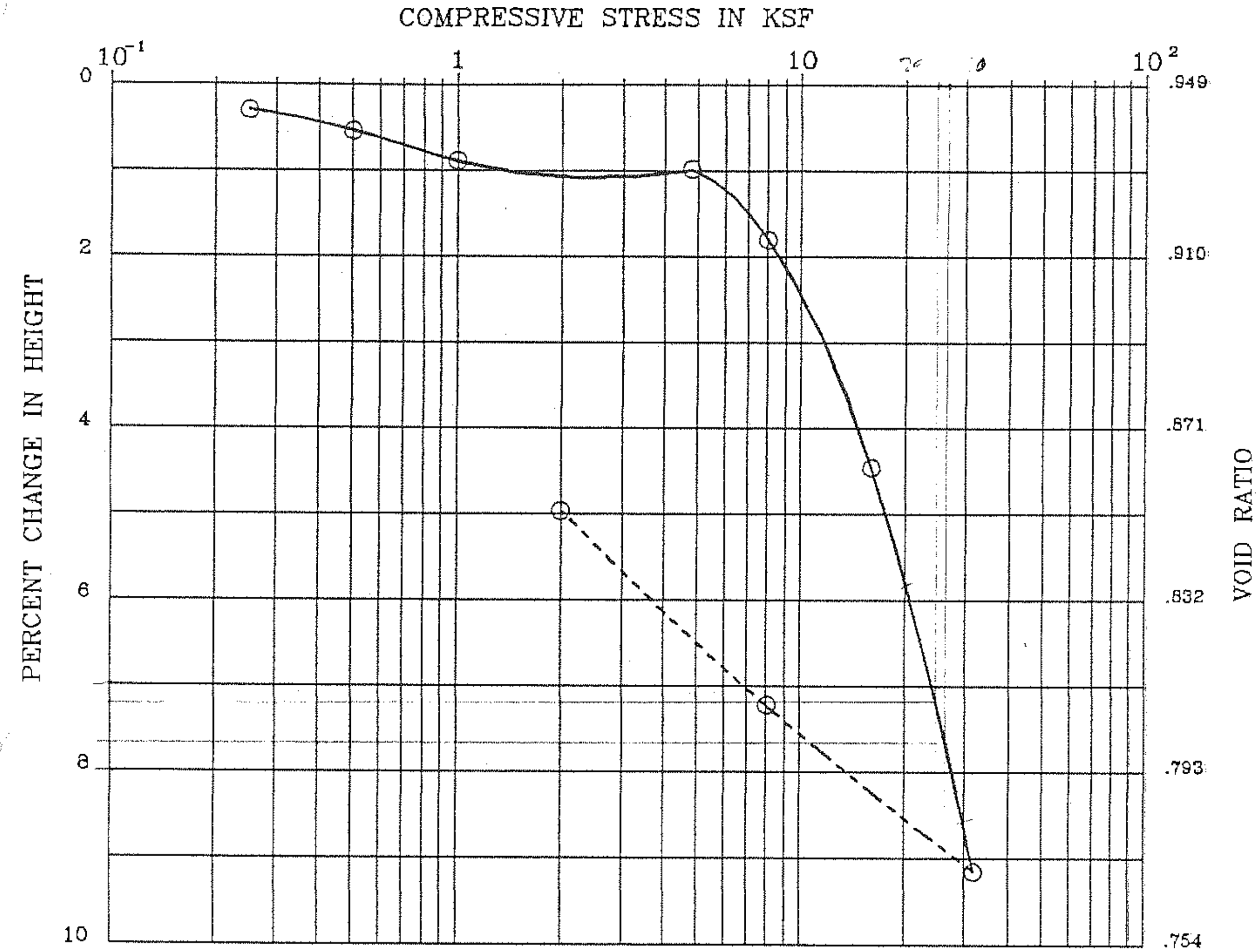
Spread Foundations Carrying Eccentric Loading

Examples of foundations subject to eccentric loading are column foundations to tall buildings where wind pressures cause appreciable bending moments at the base of the columns, foundations of stanchions carrying brackets supporting travelling crane girders, and the foundations of retaining walls.

The pressure distribution below eccentrically loaded foundations is assumed to be linear as shown in Fig. 4.5 (*a*), and the maximum pressure must not exceed the maximum pressure permissible for a centrally loaded foundation. For the pad foundation shown in Fig. 4.5 (*a*), where the resultant falls within the middle third of the base,

$$\text{Maximum pressure} = q_{max} = \frac{W}{BL} + \frac{My}{I} \quad . \quad . \quad . \quad (4.6)$$

23/26



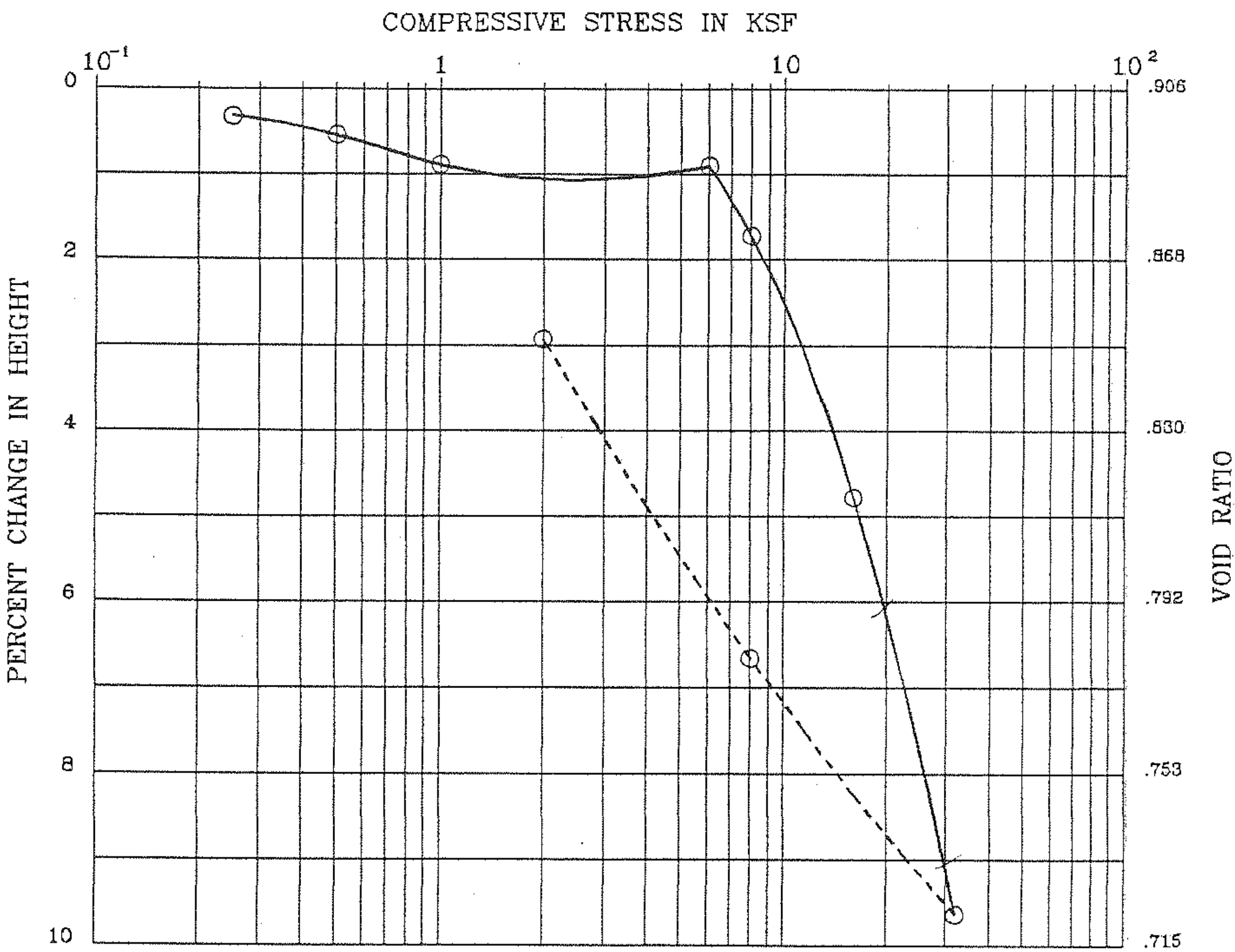
BORING : DT-C, B-1
DEPTH (ft) : 8
SPEC. GRAVITY : 2.79

DESCRIPTION : silty CLAYSTONE, yellow brn (CH)
LIQUID LIMIT : 76
PLASTIC LIMIT : 45

	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	PERCENT SATURATION	VOID RATIO
INITIAL	28.1	89.4	83	.949
FINAL	30.5	94.1	100	.852

Remark : July 1990

Project ESK-101A	Kettleman
Wahler Associates	CONSOLIDATION TEST Figure No.



BORING : DT-A, B-2
DEPTH (ft) : 5
SPEC. GRAVITY : 2.84

DESCRIPTION : silty CLAYSTONE, yellow brn (CH)
LIQUID LIMIT : 82
PLASTIC LIMIT : 54

	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	PERCENT SATURATION	VOID RATIO
INITIAL	27.3	93.1	86	.906
FINAL	29.9	95.9	100	.851

Remark : July 1990

Project ESK-101A	Kettleman
Wahler Associates	CONSOLIDATION TEST Figure No.

...ndation Analysis & Design by J.E. Bowles

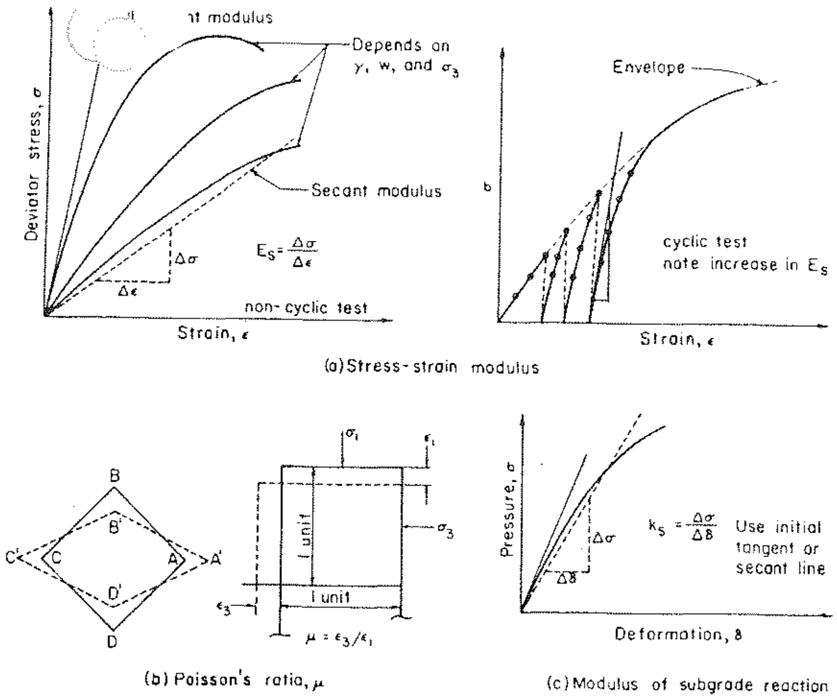


Figure 2-8. Elastic properties of soil.

The stress-strain modulus is computed from mechanics of materials (refer to Fig. 2-8*a*; typical values in Table 2-3) as

$$E_s = \frac{\text{stress}}{\text{strain}} = \frac{\sigma}{\varepsilon} \qquad (d)$$

Poisson's ratio is defined as the ratio of lateral strain ε_3 to longitudinal strain ε_1 when the applied stress is uniaxial (refer to Fig. 2-8*b*; typical values in Table 2-4).

$$\mu = \frac{\varepsilon_3}{\varepsilon_1} \qquad (e)$$

The modulus of subgrade reaction is defined as the ratio of stress to deformation (refer to Fig. 2-8*c*)

$$k_s = \frac{\sigma}{\delta} \qquad (2\text{-}17)$$

The shearing modulus G, defined as the ratio of shear stress to shear strain, is related to E_s and μ as follows:

$$G = \frac{\text{shear stress}}{\text{shear strain}} = \frac{s}{\varepsilon_s} = \frac{E_s}{2(1+\mu)} \qquad (f)$$

Table 2-3. Typical range of values for the static stress-strain modulus E_s for selected soils. Field values depend on stress history, water content, density, etc.

Soil	E_s ksi	E_s kg/cm²
Clay		
Very soft	0.05–0.4	3–30
Soft	0.2–0.6	20–40
Medium	0.6–1.2	45–90
Hard	1–3	70–200
Sandy	4–6	300–425
Glacial fill	1.5–22	100–1,600
Loess	2–8	150–600
Sand		
Silty	1–3	50–200
Loose	1.5–3.5	100–250
Dense	7–12	500–1,000
Sand and gravel		
Dense	14–28	800–2,000
Loose	7–20	500–1,400
Shales	20–2,000	1,400–14,000
Silt	0.3–3	20–200

2880 — 288000 ksf

Table 2-4. Typical range of values for Poisson's ratio μ

Type of soil	μ
Clay, saturated	0.4–0.5
Clay, unsaturated	0.1–0.3
Sandy clay	0.2–0.3
Silt	0.3–0.35
Sand (dense)	0.2–0.4
Coarse (void ratio = 0.4–0.7)	0.15
Fine-grained (void ratio = 0.4–0.7)	0.25
Rock	0.1–0.4 (depends somewhat on type of rock)
Loess	0.1–0.3
Ice	0.36
Concrete	0.15

APPENDIX M
COVER INFILTRATION ANALYSES

Golder Associates	Kettleman Hills Facility – Landfill Unit B-18 COVER INFILTRATION	
	Project No.: 083-91887	Made By: RH
	Date: 5-15-2008	Checked By: SS
	Sheet: 1 of 2	Reviewed By: SS

Objective:
To estimate the amount of infiltration into and through the proposed (and permitted) final cover system for Landfill B-18.

Given:
The proposed B-18 final cover system consists of the following components (from top to bottom):

- 2.5-foot-thick (minimum) vegetative cover soil;
- 12-oz/sy nonwoven geotextile (transmissivity ≥ 0.03 gallons/minute/foot);
- 40-mil textured high-density polyethylene (HDPE) geomembrane; and
- 1-foot-thick (minimum) foundation layer soil (permeability ≤ 1 x 10^{-5} cm/sec).

The proposed B-18 final cover slopes have an inclination of 3.5H:1V (horizontal:vertical), or 28.6%, between benches and an average overall inclination of approximately 4H:1V, or 25%, including the benches.

Method:
In May 1995, Golder performed water balance analyses for the cover system of the Combined Closure Area at the Kettleman Hills Facility (KHF). These analyses are also applicable to the proposed B-18 closure cover since: 1) the cover system of the Combined Closure Area is identical to that proposed for B-18, 2) the Combined Closure Area and B-18 are both located at the KHF, and 3) the water balance analyses are conducted on a per-acre basis. The results of Golder's May 1995 water balance analyses were previously presented and approved for closure of the Combined Closure Area. For this evaluation, Golder has followed the same approach useing the Hydrologic Evaluation of Landfill Performance (HELP) Version 3.07 computer program (Schroeder et al., 1997) to perform the water balance modeling of the final cover system. The HELP program performs water balance calculations by taking into account factors such as infiltration, evapotranspiration, runoff, soil moisture storage, and lateral subsurface drainage.

Assumptions:
The primary assumptions used by Golder in performing the water balance modeling of the Combined Closure Area (1995) and Landfill B-18's final cover system were:

1. The HELP program's default climate data for Fresno, CA were used to model the climate conditions at the KHF. This is considered a conservative assumption since the mean annual rainfall in Fresno is approximately 50% greater than at the KHF (RUST E&I, 1995). For comparison Golder also evaluated the cover using the default climate data for Bakersfield, CA which has an mean annual rainfall of 5.72 inches, slightly less than KHF.
2. The permeability of the vegetative cover soil ranges from 1.9 x 10^{-4} cm/sec (Soil Texture 9).
3. The HDPE geomembrane has 0.50 holes per acre resulting from manufacturing flaws (where the hole diameter = 1 mm), has 1.0 hole per acre resulting from installation defects (where the hole area = 1 cm^2), and has an "excellent" placement quality.

Golder Associates	Kettleman Hills Facility – Landfill Unit B-18 COVER INFILTRATION	
	Project No.: 083-91887	Made By: RH
	Date: 5-15-2008	Checked By: SS
	Sheet: 2 of 2	Reviewed By: SS

Calculations and Results:

The output files from the HELP program runs are contained in Attachment #1. The results of the water balance calculations performed using the HELP program are summarized in the table below:

Cover Slope (%)	Vegetative Cover Soil Permeability (cm/sec)	Geotextile Permeability (cm/sec)	Avg. /Max. Head on Geomembrane (inches)	Average Infiltration Rate Through Cover (inches/year)
Fresno Climate Data				
25	1.9×10^{-4}	0.25	0.012/3.84	0.00003
Bakersfield Climate Data				
25	1.9×10^{-4}	0.25	0.00/0.03	0.00000

Conclusions:

Based on the above-tabulated results of the water balance analyses conducted using the HELP Model 3.07, the proposed cover system for B-18 is anticipated to have a maximum head of between 3 and 4 inches on the geomembrane during peak precipitation years (i.e. comparable to Fresno). This amount of head is considered acceptable and is not anticipated to compromise the stability of the final cover system. Furthermore, the average infiltration rate through the geomembrane is anticipated to be approximately 0.00003 inches/year. This infiltration rate is very low and therefore considered acceptable and consistent with prior approvals. As expected, the Bakersfield climate data results in lower head on the geomembrane and less infiltration; however, both provide acceptable results.

References:

RUST Environment & Infrastructure (RUST E&I), “Kettleman Hills Facility, Combined Closure Plan,” June 1995.

Schroeder, P.R., Aziz, N.M., Lloyd, C.M., and Zappi, P.A., 1994, “The Hydrologic Evaluation of Landfill Performance (HELP) Model: User’s Guide for Version 3,” EPA/600/R-94/168a, September 1994, U.S. Environmental Protection Agency Office of Research and Development, Washington, DC.

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**          HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**             HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)               **
**              DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                USAE WATERWAYS EXPERIMENT STATION                     **
**          FOR USEPA RISK REDUCTION ENGINEERING LABORATORY             **
**                                                                      **
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 TEMPERATURE DATA FILE:       C:\HELP3\T7B18.D7
 SOLAR RADIATION DATA FILE:   C:\HELP3\SR13B18.D13
 EVAPOTRANSPIRATION DATA:     C:\HELP3\E11B18.D11
 SOIL AND DESIGN DATA FILE:   C:\HELP3\SDD10B18.D10
 OUTPUT DATA FILE:            C:\HELP3\B18 CC.OUT

 TIME: 23:22     DATE: 11/17/2008


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      TITLE:  Landfill B-18 Closure Infiltration Evaluation
              (Fresno Climate Data)

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      NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
               COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   9
            THICKNESS                  =     30.00   INCHES
            POROSITY                   =      0.5010 VOL/VOL
            FIELD CAPACITY             =      0.2840 VOL/VOL
            WILTING POINT              =      0.1350 VOL/VOL
            INITIAL SOIL WATER CONTENT =      0.1684 VOL/VOL
            EFFECTIVE SAT. HYD. COND.  =      0.19E-03 CM/SEC
          NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  2.36
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

LAYER 2

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.15	INCHES
POROSITY	=	0.3510	VOL/VOL
FIELD CAPACITY	=	0.1740	VOL/VOL
WILTING POINT	=	0.1070	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1474	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.25000	CM/SEC
SLOPE	=	25.00	PERCENT
DRAINAGE LENGTH	=	300.0	FEET

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.04	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	1.00E-12	CM/SEC
FML PINHOLE DENSITY	=	0.50	HOLES/ACRE
FML INSTALLATION DEFECTS	=	1.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	2 - EXCELLENT	

LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	24.00	INCHES
POROSITY	=	0.4190	VOL/VOL
FIELD CAPACITY	=	0.3070	VOL/VOL
WILTING POINT	=	0.1800	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4190	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	1.00E-05	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 9 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 25.% AND A SLOPE LENGTH OF 300. FEET.

SCS RUNOFF CURVE NUMBER	=	88.10	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	30.1	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	5.064	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	15.065	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	4.061	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	15.129	INCHES
TOTAL INITIAL WATER	=	15.129	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM FRESNO CALIFORNIA

STATION LATITUDE	=	36.46	DEGREES
MAXIMUM LEAF AREA INDEX	=	1.50	
START OF GROWING SEASON (JULIAN DATE)	=	65	
END OF GROWING SEASON (JULIAN DATE)	=	320	
EVAPORATIVE ZONE DEPTH	=	30.1	INCHES
AVERAGE ANNUAL WIND SPEED	=	6.40	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	70.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	49.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	46.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	72.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR FRESNO CALIFORNIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
2.05	1.85	1.61	1.15	0.31	0.08
0.01	0.02	0.16	0.43	1.24	1.61

Mean Annual Precipitation (Inches)= 10.52

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR FRESNO CALIFORNIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
45.50	50.50	54.30	60.10	67.70	75.00
81.00	78.90	74.10	64.80	53.20	45.30

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR FRESNO CALIFORNIA
AND STATION LATITUDE = 36.46 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.23	1.93	1.68	1.12	0.34	0.08
	0.02	0.02	0.21	0.45	1.12	1.57
STD. DEVIATIONS	1.31	1.28	1.03	0.90	0.38	0.13
	0.04	0.06	0.32	0.54	0.96	0.86
RUNOFF						
TOTALS	0.062	0.056	0.035	0.015	0.000	0.000
	0.000	0.000	0.001	0.007	0.019	0.013
STD. DEVIATIONS	0.128	0.110	0.093	0.040	0.001	0.000
	0.000	0.000	0.004	0.021	0.069	0.033
EVAPOTRANSPIRATION						
TOTALS	1.143	1.626	2.091	1.581	1.582	0.145
	0.015	0.016	0.144	0.280	0.542	0.787
STD. DEVIATIONS	0.165	0.268	0.658	0.775	0.888	0.214
	0.036	0.059	0.257	0.377	0.369	0.252

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	0.0749	0.2288	0.1979	0.0664	0.0208	0.0006
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0039
STD. DEVIATIONS	0.3161	0.5221	0.4164	0.1268	0.0293	0.0046
	0.0000	0.0000	0.0001	0.0001	0.0000	0.0271
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3						
AVERAGES	0.0272	0.0787	0.0332	0.0020	0.0006	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
STD. DEVIATIONS	0.1435	0.3015	0.1517	0.0038	0.0008	0.0001
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0009

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 100

	INCHES		CU. FEET	PERCENT
PRECIPITATION	10.76	(2.688)	39053.7	100.00
RUNOFF	0.208	(0.2277)	755.31	1.934
EVAPOTRANSPIRATION	9.951	(1.9427)	36121.62	92.492
LATERAL DRAINAGE FROM LAYER 2	0.59327	(1.06331)	2153.569	5.51438
PERCOLATION THROUGH LAYER 4	0.00003 (.001 mm)	(0.00008)	0.095	0.00024
AVERAGE HEAD ON TOP OF LAYER 3	0.012	(0.036)		
CHANGE IN WATER STORAGE	0.006	(1.5550)	23.11	0.059

Handwritten notes: "INFILTRATION THROUGH COVER." (beside percolation row); "AVERAGE HEAD" (beside average head row).

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 100

	(INCHES)	(CU. FT.)
PRECIPITATION	2.24	8131.200
RUNOFF	0.562	2039.3490
DRAINAGE COLLECTED FROM LAYER 2	0.14244	517.04419
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000024	0.08696
AVERAGE HEAD ON TOP OF LAYER 3	3.838 MAX DAILY	
MAXIMUM HEAD ON TOP OF LAYER 3	7.430 MAXIMUM	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	2.06	7478.9429
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3638	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1349	

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 100

LAYER	(INCHES)	(VOL/VOL)
1	5.6873	0.1896
2	0.0222	0.1477
3	0.0000	0.0000
4	10.0560	0.4190
SNOW WATER	0.000	

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**           HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE              **
**            HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**               DEVELOPED BY ENVIRONMENTAL LABORATORY                  **
**                 USAE WATERWAYS EXPERIMENT STATION                    **
**           FOR USEPA RISK REDUCTION ENGINEERING LABORATORY            **
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 TEMPERATURE DATA FILE:       C:\HELP3\T7B18B.D7
 SOLAR RADIATION DATA FILE:   C:\HELP3\SR13B18B.D13
 EVAPOTRANSPIRATION DATA:     C:\HELP3\E11B18B.D11
 SOIL AND DESIGN DATA FILE:   C:\HELP3\SD10B18B.D10
 OUTPUT DATA FILE:            C:\HELP3\B18 BKS.OUT

 TIME:   10:21      DATE:  11/18/2008

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      TITLE:  Landfill B-18 Closure Infiltration Evaluation
              (Bakersfield Climate Data)

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      NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
               COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                 LAYER  1
                                 --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER   9
            THICKNESS                 =    30.00   INCHES
            POROSITY                  =      0.5010 VOL/VOL
            FIELD CAPACITY            =      0.2840 VOL/VOL
            WILTING POINT             =      0.1350 VOL/VOL
            INITIAL SOIL WATER CONTENT =     0.1456 VOL/VOL
            EFFECTIVE SAT. HYD. COND.  =  0.190000006000E-03 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  2.36
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

LAYER 2

TYPE 2 - LATERAL DRAINAGE LAYER

MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.15 INCHES
POROSITY	=	0.3510 VOL/VOL
FIELD CAPACITY	=	0.1740 VOL/VOL
WILTING POINT	=	0.1070 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1478 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.250000000000 CM/SEC
SLOPE	=	25.00 PERCENT
DRAINAGE LENGTH	=	300.0 FEET

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER

MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.04 INCHES
POROSITY	=	0.0000 VOL/VOL
FIELD CAPACITY	=	0.0000 VOL/VOL
WILTING POINT	=	0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999999982000E-13 CM/SEC
FML PINHOLE DENSITY	=	0.50 HOLES/ACRE
FML INSTALLATION DEFECTS	=	1.00 HOLES/ACRE
FML PLACEMENT QUALITY	=	2 - EXCELLENT

LAYER 4

TYPE 3 - BARRIER SOIL LINER

MATERIAL TEXTURE NUMBER 0

THICKNESS	=	24.00 INCHES
POROSITY	=	0.4190 VOL/VOL
FIELD CAPACITY	=	0.3070 VOL/VOL
WILTING POINT	=	0.1800 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4190 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999999975000E-05 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

SCS RUNOFF CURVE NUMBER	=	88.10	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	30.1	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	4.381	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	15.065	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	4.061	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	14.446	INCHES
TOTAL INITIAL WATER	=	14.446	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
BAKERSFIELD CALIFORNIA

STATION LATITUDE	=	35.42	DEGREES
MAXIMUM LEAF AREA INDEX	=	1.50	
START OF GROWING SEASON (JULIAN DATE)	=	44	
END OF GROWING SEASON (JULIAN DATE)	=	331	
EVAPORATIVE ZONE DEPTH	=	30.1	INCHES
AVERAGE ANNUAL WIND SPEED	=	6.40	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	67.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	42.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	38.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	63.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR BAKERSFIELD CALIFORNIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
0.98	1.07	0.87	0.70	0.24	0.07
0.01	0.05	0.13	0.30	0.65	0.65

Mean Annual Precipitation (Inches)= 5.72

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR BAKERSFIELD CALIFORNIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
48.20	53.20	57.10	62.70	70.80	78.30
84.50	82.40	77.30	68.00	56.20	48.20

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR BAKERSFIELD CALIFORNIA
AND STATION LATITUDE = 35.42 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.10	1.13	0.93	0.72	0.24	0.08
	0.01	0.05	0.14	0.27	0.70	0.65
STD. DEVIATIONS	0.65	0.82	0.61	0.56	0.28	0.23
	0.04	0.20	0.22	0.45	0.64	0.43
RUNOFF						
TOTALS	0.002	0.005	0.005	0.001	0.000	0.001
	0.000	0.002	0.000	0.001	0.004	0.000
STD. DEVIATIONS	0.009	0.017	0.018	0.007	0.002	0.007
	0.000	0.019	0.000	0.009	0.021	0.001
EVAPOTRANSPIRATION						
TOTALS	0.654	0.961	1.377	1.236	0.472	0.082
	0.022	0.045	0.116	0.160	0.382	0.451
STD. DEVIATIONS	0.249	0.303	0.556	0.805	0.476	0.208
	0.088	0.185	0.190	0.244	0.303	0.243

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	0.0000	0.0007	0.0072	0.0048	0.0009	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0072	0.0509	0.0323	0.0056	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3						
AVERAGES	0.0000	0.0000	0.0002	0.0001	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0002	0.0015	0.0010	0.0002	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

****
****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 100

	INCHES		CU. FEET	PERCENT
PRECIPITATION	6.00	(1.635)	21768.7	100.00
RUNOFF	0.021	(0.0412)	77.75	0.357
EVAPOTRANSPIRATION	5.958	(1.5587)	21628.86	99.357
LATERAL DRAINAGE FROM LAYER 2	0.01381	(0.09400)	50.141	0.23034
PERCOLATION THROUGH LAYER 4	0.00000	(0.00000)	0.001	0.00000
AVERAGE HEAD ON TOP OF LAYER 3	0.000	(0.000)		
CHANGE IN WATER STORAGE	0.003	(0.6911)	12.00	0.055

0.00 INFILTRATION THROUGH COVER

AVERAGE HEAD

****
****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 100

	(INCHES)	(CU. FT.)
PRECIPITATION	1.62	5880.600
RUNOFF	0.195	707.0040
DRAINAGE COLLECTED FROM LAYER 2	0.03062	111.16240
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000000	0.00062
AVERAGE HEAD ON TOP OF LAYER 3	0.028 MAX DAILY	
MAXIMUM HEAD ON TOP OF LAYER 3	0.052 MAXIMUM	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	0.21	763.4433
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.2910	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1349	

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

****
****

FINAL WATER STORAGE AT END OF YEAR 100

LAYER	(INCHES)	(VOL/VOL)
1	4.6981	0.1566
2	0.0221	0.1474
3	0.0000	0.0000
4	10.0560	0.4190
SNOW WATER	0.000	

****
****

APPENDIX N
FROST AND BIOTIC PROTECTION EVALUATION

APPENDIX N.1
FROST PENETRATION EVALUATION

	Kettleman Hills Facility – Landfill Unit B-18 FROST PENETRATION	
Golder Associates	Project No.: 083-91887	Made By: RH
	Date: 5-19-2008	Checked By: SS
	Sheet: 1 of 1	Reviewed By: SS

Objective:
To evaluate the potential frost penetration effects on the proposed (and permitted) cover system for Landfill B-18.

Given:
The proposed B-18 final cover system consists of the following components (from top to bottom):

- 2.5-foot-thick (minimum) vegetative cover soil;
- 12-oz/sy nonwoven geotextile (transmissivity ≥ 0.03 gallons/minute/foot);
- 40-mil textured high-density polyethylene (HDPE) geomembrane; and
- 1-foot-thick (minimum) foundation layer soil (permeability ≤ 1 x 10^{-5} cm/sec).

Findings:
Based on a regional published map (USEPA, 1989) of frost penetration depths for the United States shown in Attachment #1, the average depth of frost penetration at the Kettleman Hills Facility (KHF) is anticipated to be approximately 2 inches. Another regional published map (NAVFAC, 1986) of frost penetration depths for the United States shows the extreme frost penetration depth at the KHF to be between 0 and 5 inches (see Attachment #2).

Conclusions:
Since the proposed B-18 final cover does not contain a clay liner component, degradation of the final cover due to frost penetration is not a concern. Furthermore, available data on frost penetration depths (USEPA, 1989; NAVFAC, 1986) indicate that no more than approximately 0.5 feet of frost penetration is anticipated at the KHF. Hence, any frost penetration will be confined to the uppermost portion of the vegetative cover soil layer. This degree of frost penetration is not anticipated to affect the performance of the B-18 final cover system.

References:
United States Environmental Protection Agency (USEPA), "Technical Guidance Document: Final Covers on Hazardous Waste Landfills and Surface Impoundments," EPA/530-SW-89-047, July 1989.

Naval Facilities Engineering Command (NAVFAC), "Design Manual 7.01 – Soil Mechanics," September 1, 1986.

ATTACHMENT #1
FROST PENETRATION EVALUATION

Attachment #1 p. 1/4

United States Environmental Protection Agency

Office of Solid Waste and Emergency Response Washington DC 20460

EPA/530-SW-89-047
July 1989

EPA

Technical Guidance Document:

Final Covers on Hazardous Waste Landfills and Surface Impoundments

Attachment #1 p. 2/4

EPA/530-SW-89-047
July 1989

TECHNICAL GUIDANCE DOCUMENT

FINAL COVERS ON HAZARDOUS WASTE LANDFILLS AND SURFACE IMPOUNDMENTS

Office of Solid Waste and Emergency Response
U.S. Environmental Protection Agency
Washington, DC 20460

In cooperation with

RISK REDUCTION ENGINEERING LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OHIO 45268

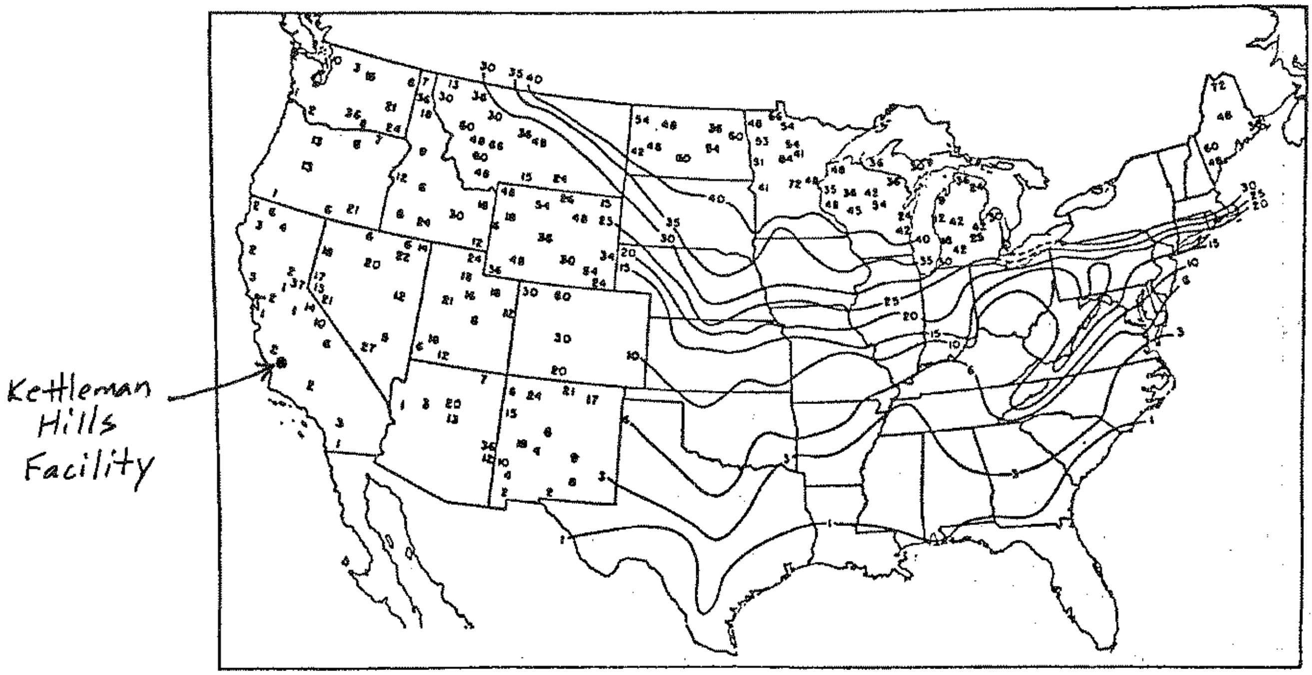

Figure 6. Regional average depth of frost penetration in inches (Stewart, et al., 1975).

Stewart, B. A., et al. 1975. Control of Water Pollution from Cropland: Volume 1 - A Manual for Guideline Development. USDA Report No. ARS-H-5-1. U. S. Dept. of Agriculture, Hyattsville, MD.

Thornburg, A. A. 1979. Plant Materials for Use on Surface Mined Lands. TP-157 and EPA-600/7-79-134. Soil Conservation Service, U.S. Department of Agriculture, Washington, D.C.

Wright, M. J. (Ed.). 1976. Plant Adaptation to Mineral Stress in Problem Soils. Cornell University Agricultural Experiment Station. Ithaca, NY.

☆U.S. GOVERNMENT PRINTING OFFICE: 1989-648-163/00303

ATTACHMENT #2
FROST PENETRATION EVALUATION

Attachment #2 p. 1/2

Naval Facilities Engineering Command
200 Stovall Street
Alexandria, Virginia 22322-2300
APPROVED FOR PUBLIC RELEASE

))

Soil Mechanics

DESIGN MANUAL 7.01

REVALIDATED BY CHANGE 1 SEPTEMBER 1986

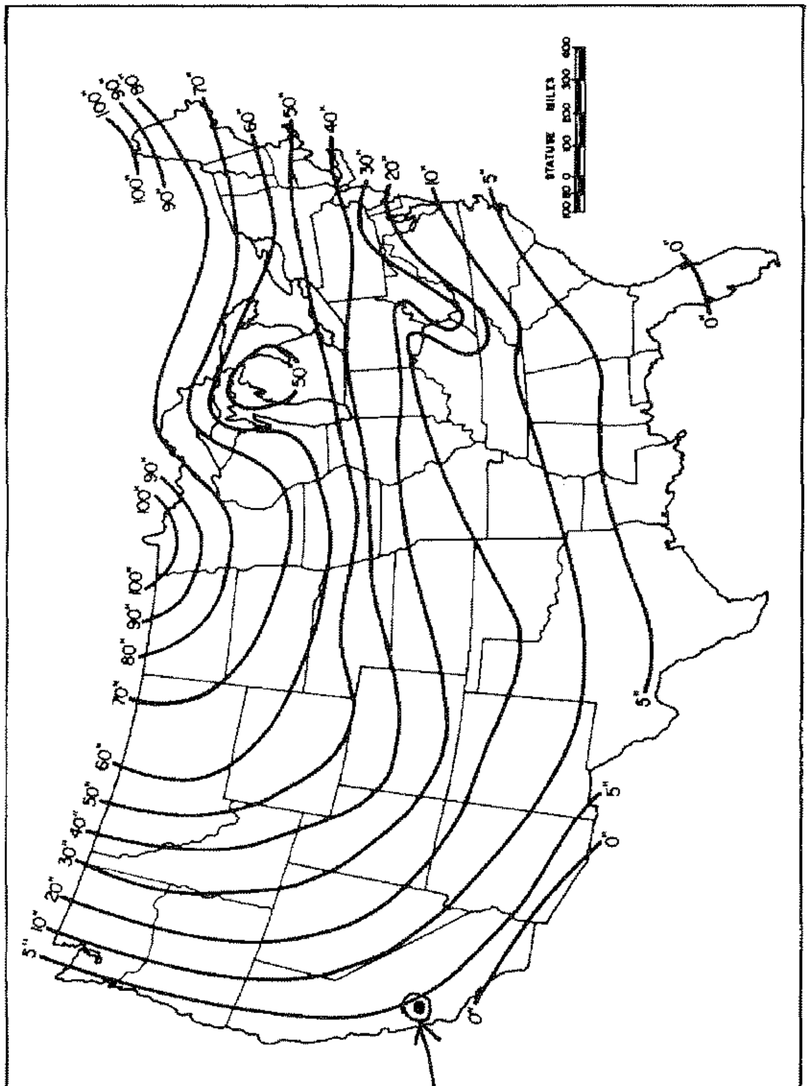

FIGURE 7
Extreme Frost Penetration (in inches) Based Upon State Average

Kettleman Hills Facility

APPENDIX N.2
BIOTIC PROTECTION EVALUATION

Golder Associates	Kettleman Hills Facility – Landfill Unit B-18 BIOTIC PROTECTION	
	Project No.: 083-91887	Made By: RH
	Date: 5-19-2008	Checked By: SS
	Sheet: 1 of 1	Reviewed By: SS

Objective:
To evaluate the effects of burrowing rodents on the proposed (and permitted) cover system for Landfill B-18.

Given:
The proposed B-18 final cover system consists of the following components (from top to bottom):

- 2.5-foot-thick (minimum) vegetative cover soil;
- 12-oz/sy nonwoven geotextile (transmissivity ≥ 0.03 gallons/minute/foot);
- 40-mil textured high-density polyethylene (HDPE) geomembrane; and
- 1-foot-thick (minimum) foundation layer soil (permeability ≤ 1×10^{-5} cm/sec).

Conclusions:
Based on the recommendations provided by Biosystems Analysis, Inc. in their August 4, 1989 letter to the Kettleman Hills Facility (KHF), the 40-mil HDPE geomembrane component of the B-18 final cover is expected to constrain any rodent burrowing to the overlying vegetative cover soil layer. A copy of the Biosystems Analysis, Inc. August 4, 1989 letter is presented in Attachment #1. Past experience at the KHF indicates that HDPE geomembrane is an effective barrier to rodent burrowing. Hence, the 40-mil HDPE geomembrane component of the B-18 final cover is anticipated to fully discourage and/or prevent animals from burrowing through the final cover system.

ATTACHMENT #1
BIOTIC PROTECTION EVALUATION

Attachment #1
p. 1/1

1 OF 1

BIOSYSTEMS ANALYSIS, INC.

RECEIVED
AUG 09 1989
C. W. M

August 4, 1989

Christopher W. Hansen
Chemical Waste Management, Inc.
Kettleman Hills Facility
P.O. Box 471
Kettleman City, CA 93239

RE: Mitigation for Rodent Burrowing in Closure Caps

Dear Chris:

We talked this morning about rodents burrowing into cover systems of closed waste management units at the Kettleman Hills Facility. I understand that some of your cover system cross sections contain compacted clay overlain by 1.5 feet or more of vegetative soil. You are concerned about rodents burrowing through the clay and impacting the integrity of the cover system.

As we discussed, the placement of a layer of HDPE geonet between the clay and the vegetative soil should completely discourage or prevent the animals from burrowing into the compacted clay. These animals will encounter the geonet, and will then constrain any burrowing to the overlying vegetative layer.

Please call if you have any questions.

Sincerely,
BIOSYSTEMS ANALYSIS, INC.

Sue G. Orloff
Wildlife Biologist

3152 Paradise Drive, Bldg. 39, Tiburon, CA 94920 • Phone (415) 435-[illegible] • FAX (415) 435-[illegible]

APPENDIX O
TECHNICAL SPECIFICATIONS

APPENDIX O.1 PHASE III SPECIFICATIONS

APPENDIX O.2 FINAL CLOSURE SPECIFICATIONS

APPENDIX O.1
PHASE III SPECIFICATIONS

Golder Associates Inc.

230 Commerce, Suite 200
Irvine, California 92602
Telephone (714) 508-4400
Fax (714) 508-4401
www.golder.com

TECHNICAL SPECIFICATIONS
LANDFILL UNIT B-18 PHASE III
KETTLEMAN HILLS FACILITY
KETTLEMAN CITY, CALIFORNIA

Prepared for:

Chemical Waste Management, Inc.
Kettleman Hills Facility
35251 Old Skyline Road
Kettleman City, California 93239

Prepared by:

Golder Associates Inc.
230 Commerce, Suite 200
Irvine, California 92602

November 2008
Revision 1: February 2010
Revision 2: August 2011

Project No.: 083-91887

SECTION 01010

SUMMARY OF WORK

PART 1 GENERAL

1.01 SUMMARY

A. The section describes the general requirements for the construction of Phase III of Landfill Unit B-18 at the Kettleman Hills Facility located outside of Kettleman City, California. The Work will consist of excavation, engineered fill placement, subgrade preparation, installation of a double-composite geosynthetic sideslope liner system, placement of operations layer soil, extending sideslope riser pipes, and installing surface water drainage structures.

1.02 CONTRACTOR'S RESPONSIBILITIES:

A. Start, lay out, construct, and complete the Project in accordance with the Contract Documents;

B. Provide a competent superintendent, capable of reading and understanding the Contract Documents, who shall receive instructions from the OWNER or his authorized representative. The superintendent shall have full authority to execute the Work in accordance with the Contract Documents;

C. The CONTRACTOR shall be responsible for transporting, permitting, and/or conveying all required construction water.

D. Pay costs of legally required sales, consumer, and use taxes, and governmental fees.

E. Forward submittals and communications to the CONSTRUCTION MANAGER. Where applicable, the CONSTRUCTION MANAGER will coordinate submittals and communications with the representatives who will give approvals and directions through the CONSTRUCTION MANAGER.

F. Maintain order, safe practices and proper conduct at all times among CONTRACTOR's employees. The OWNER, and its authorized representative, may require that disciplinary action be taken against an employee of the CONTRACTOR for disorderly, improper, and unsafe conduct. Should an employee of the CONTRACTOR be dismissed from his duties for misconduct, incompetence, or unsafe practice, or combination thereof, that employee should not be rehired for the duration of the Work.

G. Coordinate prosecution of the Work with the utilities, private utilities, or OWNER performing work on or adjacent to the work site; either eliminate, or minimize as far as possible, delays in the Work and conflicts with those utilities or contractors. Coordinate utility activities, and activities of OWNER, with the CONSTRUCTION MANAGER. Schedule private utility and public utility work relying on survey points, lines, and grades established by the CONTRACTOR to occur immediately after those points, lines and grades have been established. Confirm coordinate measures for each individual case with the CONSTRUCTION MANAGER by memorandum.

J. Coordinate activities of the several trades, suppliers, and subcontractors, if any, performing the Work.

K. Obtain all necessary building and construction permits. Permit fees will be paid by the OWNER.

1.03 RESERVED

1.04 CONFORMANCE

A. Work shall conform to the following Drawings that form a part of these Contract Documents.

SHEET NO.	TITLE
T-1	TITLE SHEET
C-1	SITE PLAN
C-2	EXISTING CONDITIONS (AS OF MARCH 28, 2008)
C-3	BASE LINER PLAN
C-4	FINAL CLOSURE PLAN
C-5	CROSS-SECTIONS A TO D
C-6	CROSS-SECTIONS E TO I
C-7	PHASE III BASE LINER CONSTRUCTION DETAILS
C-8	PHASE III LCRS DETAILS
C-9	DRAINAGE DETAILS
C-10	CLOSURE DETAILS

1.05 DEFINITIONS

OWNER	The term OWNER means Kettleman Hills Facility with whom the CONTRACTOR has entered into the Agreement and for whom the Work is to be provided.
CONSTRUCTION MANAGER	The term CONSTRUCTION MANAGER means the representative of the OWNER for the purpose of administration and inspection of the Work. The CONSTRUCTION MANAGER may be a member or group of the staff or may be an external firm. The OWNER will inform the CONTRACTOR in writing at the start of the Work who the CONSTRUCTION MANAGER will be. During the period of Work the CONSTRUCTION MANAGER will act as an authorized representative of the OWNER.
DESIGN ENGINEER	The term DESIGN ENGINEER means Golder Associates Inc., the firm responsible for the design and preparation of the construction drawings and specifications. The

	DESIGN ENGINEER is responsible for approving all design changes, modifications, or clarifications encountered during construction.
CQA CONSULTANT	The term CQA CONSULTANT means the representative of the OWNER for the purpose of conducting CQA testing, monitoring, documenting, and reporting.
CONTRACTOR	The term CONTRACTOR means the firm that is responsible prosecuting the Work. The CONTRACTOR's responsibilities include the Work of any and all subcontractors and suppliers.
Geosynthetics CONTRACTOR	The term Geosynthetics CONTRACTOR means the firm that is responsible for the supply and installation of all geosynthetics including the Work of all of the subcontractors and suppliers. The Geosynthetics Installer may work directly for the OWNER or as a subcontractor to the CONTRACTOR. The Geosynthetics CONTRACTOR is also referred to as the CONTRACTOR.
Work	The term Work means the entire completed construction or various separately identifiable parts, thereof, required to be furnished under the Contract Documents. Work includes any and all labor, services, materials, equipment, tools, supplies, and facilities required by the Contract Documents and necessary for the completion of the project. Work is the result of performing services, furnishing labor and furnishing and incorporating materials and equipment into the construction, all as required by the Contract Documents.
Working day	A calendar day, exclusive of Saturdays, Sundays, and OWNER's recognized legal holidays, on which weather and other conditions not under the control of the CONTRACTOR will permit construction operations to proceed for the major part of the day with the normal working force engaged in performing the controlling item or items of work which would be in progress at that time. The working day is subject to the conditions and work restrictions outlined in these Specifications.
Regular Working Hours	Between 6:30 a.m. and 6:00 p.m. on allowable work days.

Calendar Days	Each day of the year including all OWNER approved holidays.

1.06 CONTRACT TIMES

A. The CONTRACTOR shall commence Work in accordance with Section 18 of the General Conditions and Section 7 of the Standard Contract.

1.07 CONTRACTOR USE OF WORK SITE

A. Confine work site operations to areas permitted by law, ordinances, permits, and the Contract Documents. The CONTRACTOR shall ensure that all persons under his control (including Subcontractors, their workers and agents) are kept within the boundaries of the Site and shall be responsible for any acts of trespass or damage to property by persons who are under his control. Consider the safety of the Work, and that of people and property on and adjacent to work site, when determining amount, location, movement, and use of materials and equipment on work site.

B. The CONTRACTOR shall be responsible for protecting private and public property including pavements, drainage culverts, electricity, highway, telephone and similar property and making good of, or paying for, all damage caused thereto. Control of erosion throughout the project is of prime importance and is the responsibility of the CONTRACTOR. The CONTRACTOR shall comply with the requirements of the Storm Water Pollution Prevention Plan (SWPPP) provided by the OWNER for the Kettleman Hills Facility and prepare and submit a SWPPP specific to the Work in accordance with requirements of local or state agencies (see Section 01300). The CONTRACTOR shall provide and maintain all necessary measures to control erosion during progress of the Work to the satisfaction of the CONSTRUCTION MANAGER and all applicable Laws and Regulations and remove such measures and debris upon completion of the project. All provisions for erosion and sedimentation control apply equally to all areas of the Work.

C. CONTRACTOR shall promptly notify OWNER and CONSTRUCTION MANAGER in writing of any subsurface or latent physical conditions at the Site which differ materially from those indicated or referred to in the Contract Documents. CONSTRUCTION MANAGER will promptly review those conditions and advise OWNER in writing if further investigations or tests are necessary. Promptly thereafter, OWNER shall obtain the necessary additional investigations and tests and furnish copies to the CONSTRUCTION MANAGER and CONTRACTOR. If CONSTRUCTION MANAGER finds that the results of such investigations or tests indicate that there are subsurface and latent physical conditions which differ materially from those intended in the Contract Documents, and which could not reasonably have been anticipated by CONTRACTOR, a Change Order shall be issued incorporating the necessary revisions.

1.08 PRESERVATION OF SCIENTIFIC INFORMATION

A. Federal and State legislation provides for the protection, preservation, and collection of data having scientific, prehistoric, historical, or archaeological value (including relics and specimens) which might otherwise be lost due to alteration of the terrain as a result of any construction work.

B. If evidence of such information is discovered during the course of the Work, the CONTRACTOR shall notify the CONSTRUCTION MANAGER immediately, giving the location and nature of the findings. Written confirmation shall be forwarded within two (2) working days. The CONTRACTOR shall exercise care so as not to damage artifacts uncovered during excavation operations, and shall provide such cooperation and assistance as may be necessary to preserve the findings for removal or other disposition by the OWNER's representative or Government agency.

C. Where appropriate, by reason of a discovery, the OWNER may order delays in the time of performance, or changes in the Work, or both. If such delays, or changes, or both, are ordered, the time of performance and contract price shall be adjusted in accordance with the applicable clauses of the Contract.

1.09 EXISTING UTILITIES

A. The CONTRACTOR shall be responsible for locating, protecting, flagging, and identifying all existing utilities. The CONTRACTOR shall request that Underground Service Alert (USA) locate and identify the existing utilities. The request shall be made 48 hours in advance.

B. Costs resulting from damage to utilities shall be borne by the CONTRACTOR. Costs of damage shall include repair and incidental costs resulting from the unscheduled loss of utility service to affected parties.

C. The CONTRACTOR shall immediately stop work and notify the CONSTRUCTION MANAGER of all utilities encountered or damaged. The CONTRACTOR shall also provide the CONSTRUCTION MANAGER with the exact location of any utilities encountered during construction.

D. If specified by the CONSTRUCTION MANAGER, utility pot holes shall be carefully dug by the CONTRACTOR to identify the presence of underground utilities.

E. Damage to utilities by the CONTRACTOR during pothole operations shall be born by the CONTRACTOR.

PART 2 PRODUCTS

(Not Used)

PART 3 EXECUTION

(Not Used)

END OF SECTION

SECTION 01032

INTENT OF DRAWINGS AND SPECIFICATIONS

PART 1 GENERAL

1.01 CONTRACT DRAWINGS ASND SPECIFICATIONS

A. The intent of the Drawings and Specifications is to prescribe a complete work which the CONTRACTOR shall perform in a manner acceptable to the OWNER and in full compliance with the terms of the Contract.

B. The Drawings show general arrangements for the work which shall be used by the CONTRACTOR in the preparation of shop and field drawings. Particular care shall be given to all layouts to make sure all equipment is accessible for operation.

C. The CONTRACTOR shall provide the OWNER with a complete and operable system, even though the Drawings and Specifications may not specifically call out all items of work required of the CONTRACTOR to complete his tasks, incidental appurtenances, materials, and the like and maintenance.

D. The CONTRACTOR is to perform the Work in accordance with the cross-sections, thickness, gradients and dimensions shown on the Drawings. Any deviations must be approved by the DESIGN ENGINEER prior to doing the work.

E. The dimensions on the Drawings are presumed to be correct, but the CONTRACTOR shall be required to check carefully all dimensions prior to beginning the Work. If errors or omissions are discovered by the CONTRACTOR, the CONTRACTOR shall immediately notify the CONSTRUCTION MANAGER in writing and await the CONSTRUCTION MANAGER's notification before proceeding.

1.02 PRECENDENCE OF CONTRACT DOCUMENTS

A. If there is a conflict between Contract Documents, the document highest in precedence shall control. The precedence, unless otherwise stipulated by the OWNER, shall be:

1. Permits.
2. Special Provisions.
3. General Terms and Conditions.
4. Construction Drawings.
5. Technical Specifications.
6. Construction Quality Assurance (CQA) Plan.

1.03 CHANGES TO DRAWINGS, SPECIFICATIONS AND CQA PLAN

A. It is inherent in the nature of construction that some changes in the Drawings, Specifications, and/or CQA Plan may be necessary during the course of construction to adjust them to field conditions, and it is the essence of the Contract to recognize a normal and expected margin of change. The CONSTRUCTION MANAGER shall have the right to make such changes, from time to time, in the Drawings, in the character of the Work as may be necessary or desirable to insure the completion of the Work in the most satisfactory manner without invalidating the Contract.

B. Design and specification changes will only be made with written agreement of the Design Engineer, Owner and Contractor. Design and specification changes which affect the containment or environmental controls shall also require approval of the Regional Water Quality Control Board (RWQCB).

PART 2 PRODUCTS

(Not Used)

PART 3 EXECUTION

(Not Used)

END OF SECTION

SECTION 01300

SUBMITTALS

PART 1 GENERAL

1.01 SUBMITTAL PROCEDURES

A. Transmit each submittal with cover letter to the OWNER.

B. Each submittal shall have a unique submittal number.

C. Submittals shall be numbered sequentially. Re-submittals shall have original number with an alphabetic suffix (A, B, C, etc.) to indicate the sequence of the re-submittal.

D. Identify Project, CONTRACTOR, Subcontractor or supplier; pertinent Drawing sheet and detail number(s), and specification Section number, as appropriate.

E. Identify variations from Contract Documents and Product or system limitations that may be detrimental to successful performance of the completed Work.

F. Provide space for DESIGN ENGINEER and/or CQA CONSULTANT review stamps.

G. Revise and resubmit submittals as required, identify all changes made since previous submittal.

H. Distribute copies of reviewed submittals to concerned parties. Instruct parties to promptly report any inability to comply with provisions.

I. When catalog pages are submitted, applicable items shall be clearly identified.

J. An electronic copy (preferred) or three (3) hard copies of each submittal shall be provided to the OWNER. The OWNER will not accept submittals from anyone other than the CONTRACTOR.

K. The CONTRACTOR shall review all submittal packages prior to transmittal to OWNER for completeness and accuracy.

1.02 CHECK OF RETURNED SUBMITTALS AND WAIVER OF CLAIMS

A. The CONTRACTOR shall check and review the submittals returned for correction and ascertain whether the required corrections result in extra cost above that included in the Contract, and shall give written notice to the CONSTRUCTION MANAGER within five (5) working days if, in the CONTRACTOR's estimation, extra costs result from the corrections. The CONTRACTOR's failure to give such written notice before the starting of the Work covered by returned submittal constitutes a waiver by the CONTRACTOR of claims for extra costs resulting from required corrections. Payment based on such written notice is not approved until authorized by the OWNER.

1.03 PRODUCT DATA SUBMISSION

A. For each product item included in the Work, include the manufacturer's name and address, the trade or brand name, all conditions of manufacturer's guarantee and warranty, information to fully describe each item, and supplementary information as may be required for approval. Mark catalog cuts, brochures, and data to indicate the items proposed and the intended use. Clearly mark product parameters which were specifically called out on the original specifications.

1.04 EQUIPMENT DATA SUBMISSION

A. Submit complete technical, performance, and catalog information for every item of civil, mechanical, and electrical equipment and machinery proposed for installation in the Work. Include information on performance and operating curves, ratings, capacities, characteristics, power efficiencies, manufacturers' standard guarantees and warranties with the terms and conditions fully described, and all other information to fully illustrate and describe the items as may be specified or required for approval.

1.05 SUBMITTAL REVIEW AND ACCEPTANCE

A. The submittal review period shall be ten (10) consecutive work days in length and shall commence on the first working day immediately following the date of arrival of the submittal or re-submittal in the OWNER's office. The time required for mail delivery of the submittal or re-submittal back to the CONTRACTOR shall not be considered a part of the submittal review period.

B. The acceptance of drawings and data submitted by the CONTRACTOR will cover only general conformity to the Drawings and Specifications, external connections, and dimensions which affect the layout. The DESIGN ENGINEER's and/or CQA CONSULTANT's review of submittals shall not relieve the CONTRACTOR from responsibility for errors, omissions, or deviations, nor responsibility for compliance with the contract documents.

1.06 RE-SUBMITTALS

A. When the drawings and data are returned marked "AMEND AND RESUBMIT" or "REJECTED, SEE REMARKS," the corrections shall be made as noted thereon and as instructed by the DESIGN ENGINEER's and/or CQA CONSULTANT's and shall be resubmitted.

B. When corrected copies are resubmitted, the CONTRACTOR shall highlight or otherwise direct specific attention to all revisions and shall list separately those revisions made other than those called for on previous submissions.

C. The need for more than one resubmission shall not entitle the CONTRACTOR to extension of the Contract Time.

1.07 COSTS FOR SUBMITTALS

A. All costs for the preparation, correction, and delivery of the submittals are considered incidental to the contract and shall be included in CONTRACTOR's costs.

PART 2 PRODUCTS

(Not Used)

PART 3 EXECUTION

3.01 MATERIALS REQUIRING SUBMITTALS

A. The following materials shall require submittals.

1. Material certifications and product data for all geosynthetics;
2. Material quality control data for all geosynthetics;
3. Material certifications and product data for piping;
4. Material quality control data for piping; and
5. Items not fully detailed and specified in the Contract Drawings or these Specifications.

3.02 ITEMS NOT REQUIRING SUBMITTALS

A. A submittal is not required for products and equipment completely specified or salvaged on-site. A submittal is required if the product has not been completely specified or when the specified product is not available within the construction schedule. Substitutions requested by the CONTRACTOR require a submittal.

3.03 CONSTRUCTION SCHEDULE

A. At the pre-construction meeting, the CONTRACTOR shall submit to the CONSTRUCTION MANAGER for review a schedule of the proposed construction operations. The construction schedule shall indicate the sequence of the Work indicating the time of completion of each component of the Work.

B. Submit initial progress schedule in duplicate within ten (10) days after Effective Date of Agreement for CONSTRUCTION MANAGER to review.

C. Revise and resubmit as required.

D. Submit revised schedules with each Application for Payment, identifying changes since previous version.

E. Submit a horizontal bar chart with separate line for each major section of Work or operation, identifying first work day of each week. Include on the bar chart construction/placement rates for all the major items of Work. CONTRACTOR shall develop proposed Construction Schedule on basis of a five or six day working week. Sufficient labor, equipment, and materials shall be provided by CONTRACTOR to complete the Work on a five or six day per week basis. Night work and work on Sundays will only be approved by the OWNER if the Work falls behind the approved Construction Schedule.

F. Show complete sequence of construction by activity, identifying Work of separate stages and other logically grouped activities. Indicate the start date, finish date, and duration. At a minimum, the following activities must be shown on the project schedule:

1. Mobilization;
2. Excavation;
3. Subgrade preparation;
4. Placement of the clay liner;
5. Installation of the geomembranes;
6. Installation of the geocomposites;
7. Placement of the operations layer soil;
8. Construction of surface water controls;
9. Construction of new riser pipes and pads; and
10. Demobilization and site clean-up.

G. Indicate estimated percentage of completion for each item of Work at each submission with Application for Payment.

H. Indicate submittal dates required for shop drawings, product data, samples and product delivery dates.

I. The Construction Schedule as approved by the OWNER will be an integral part of the Contract, and will establish interim Contract completion dates for various activities. Should an activity not be completed within ten (10) days after the stated Schedule date, the CONSTRUCTION MANAGER shall have the option to recommend to the CONTRACTOR to expedite completion of the activity by whatever means deemed appropriate and necessary, without additional compensation to the CONTRACTOR.

J. Should any activity be twenty (20) or more working days behind Schedule, the OWNER shall have the right to perform the activity or to have the activity performed by whatever method the OWNER deems appropriate. Costs incurred by the OWNER in connection with expediting construction activities under this Paragraph shall be reimbursed to the OWNER by the CONTRACTOR.

K. It is expressly understood and agreed that failure by the OWNER to exercise the option to either order the CONTRACTOR to expedite an activity or to expedite the activity by other means shall not be considered precedent-setting for any other activities. The Work shall be executed in strict accordance with the Construction Schedule unless a variance has been received by the CONSTRUCTION MANAGER and approved by the OWNER.

3.04 PROGRESS REPORTS

A. The CONTRACTOR shall submit progress reports as requested indicating work performed and completed that week, quantity of material used, and equipment used to perform the Work.

B. A progress report shall also be furnished to the ENGINEER with each application for progress payment. If the Work falls behind schedule, the CONTRACTOR shall submit additional progress reports at such intervals as the CONSTRUCTION MANAGER may request.

C. Each progress report shall include sufficient narrative to describe current and anticipated delaying factors, their effect on the construction schedule, and proposed corrective actions.

Work reported complete, but which is not readily apparent as complete to the CONSTRUCTION MANAGER, must be substantiated with satisfactory evidence.

D. Each progress report shall also include a graphic schedule marked to indicate actual progress. Revised schedules shall be included when warranted.

3.05 MANUFACTURER'S CERTIFICATES

A. When specified in individual Specification Sections, submit manufacturers' certificate to the CQA CONSULTANT for review, in quantities specified for Product Data.

B. Indicate whether material or product conforms to or exceeds specified requirements. Submit supporting reference date, affidavits, and certifications as appropriate.

C. Certificates may be recent or previous test results on material or Product, but must be acceptable to the CONSTRUCTION MANAGER.

3.06 RECORD SURVEY AND DRAWINGS

A. The CONTRACTOR shall keep a set of construction drawings on the job and mark in red pencil the as-built conditions.

B. A complete and accurate set of record drawings shall be signed and dated by the CONTRACTOR and shall be labeled with the following, "These record drawings completely and truly represent the contract work as installed."

C. Record drawings shall be delivered to the CONSTRUCTION MANAGER prior to final acceptance of the work by the CONSTRUCTION MANAGER.

D. Record drawings shall show all changes in "clouds" to clearly identify any deviations from the plans.

E. Any utilities uncovered during construction shall be identified on the record drawings.

F. The record survey shall be performed by the CONTRACTOR in accordance with Section 01400, Part 1.04 and shall meet the requirements of these Specifications and the CQA Plan and include, but not be limited to:

1. edges, bottom, and limits of anchor trenches;
2. limits of excavation and fill;
3. final subgrades (including geologic mapping developed by CQA Consultant);
4. top of compacted clay liner;
5. HDPE geomembrane panel layouts and intersections;
6. destructive seam test locations on HDPE geomembranes;
7. location and crown elevations of piping;
8. top of operations layer soil;
9. grade breaks;
10. appurtenant structures (e.g., riser pads); and
11. layout and flow line elevations of surface water control structures.

G. Survey of the excavated subgrades (including geologic mapping), Clay Liner, and Operations Layer surfaces shall be on a grid with a maximum spacing of 50 feet or an equivalent method approved by the CQA CONSULTANT, with additional elevations at slope change locations. The elevations for the subgrade, top of Clay Liner, and top of Operations Layer shall be at the same grid locations and shall be used to document thickness conformance. The record survey shall include locations and elevations of all other work as directed by the CONSTRUCTION MANAGER.

H. Record drawings shall be prepared to scale, with the scale clearly marked. Record drawings of details may not be to scale, but all dimensions shall be clearly identified. Record drawings shall be submitted to the CQA CONSULTANT for review and approval. Record drawings shall be provided on Bond and electronically in AutoCAD 2005 format or more recent. The DESIGN ENGINEER will provide the base AutoCAD file map. Different elements of the work shall be presented on different layers in the base AutoCAD file provided by the DESIGN ENGINEER.

3.07 HEALTH AND SAFETY PLAN

A. The CONTRACTOR shall submit a Health and Safety Plan in accordance with Section 01810 of these Specifications.

3.08 STORM WATER POLLUTION PREVENTION PLAN (SWPPP)

A. The CONTRACTOR shall prepare and submit a SWPPP specific to the work to the OWNER for approval. The SWPPP shall be consistent with the provisions of the "California Construction Best Management Practice Handbook," the site National Pollutant Discharge Elimination System (NPDES) site permit, and the Kettleman Hills Facility SWPPP. The SWPPP shall include specific measures to protect the Work and comply with the regulations, including specific erosion and sediment controls. The CONTRACTOR is responsible to control storm water run-on, run-off, erosion, and sediment to such an extent as needed to maintain compliance with the SWPPP and protect the Work, protect adjacent landfill operations, and adjacent structures.

END OF SECTION

SECTION 01400

CONSTRUCTION QUALITY CONTROL

PART 1 GENERAL

1.01 CONSTRUCTION QUALITY CONTROL

A. The CONTRACTOR shall be responsible for construction quality control of the Work and all appurtenances as described in these Specifications.

B. The CONTRACTOR shall monitor quality control over suppliers, manufacturers, products, services, site conditions, and workmanship, to produce Work of specified quality.

C. The CONTRACTOR shall comply fully with manufacturers' instructions, including each step in sequence.

D. Should manufacturers' instructions conflict with Contract Documents, the CONTRACTOR shall request clarification from CONSTRUCTION MANAGER before proceeding.

E. The CONTRACTOR shall comply with specified standards as a minimum quality for the Work except when more stringent tolerances, codes, or specified requirements indicate higher standards or more precise workmanship.

F. The CONTRACTOR shall perform work using persons qualified to produce workmanship of specified quality.

G. The CONTRACTOR shall secure products in place with positive anchorage devices designed and sized to withstand stresses, vibration, physical distortion or disfigurement.

H. The CONSTRUCTION MANAGER shall determine and decide all questions which may arise as to the quality and acceptability of materials and Work performed; the manner of performance and the rate of progress of said Work; the interpretations of the Contract Documents relating to the Work; the acceptable fulfillment of the Contract Documents on the part of the CONTRACTOR; and the amount and quantity of the several kinds of Work performed and materials which are to be paid for under the Contract.

I. All materials and equipment shall be new and of the specified quality and equal to the samples found to be acceptable by the CQA CONSULTANT, if samples have been submitted.

J. The Work shall be done and completed in a thorough, workmanlike manner, notwithstanding omissions in the Contract Documents; and it shall be the duty of the CONTRACTOR to call the CONSTRUCTION MANAGER's attention to apparent errors or omissions and request instructions in writing before proceeding with the Work.

K. The CONSTRUCTION MANAGER may, by appropriate written instructions, correct errors and omissions. Instructions and corrections shall be as binding upon the CONTRACTOR as though contained in the original Contract Documents.

1.02 CONSTRUCTION QUALITY ASSURANCE

A. Materials, equipment, methods of construction and workmanship shall be subject to the inspection of the CQA CONSULTANT as outlined in the CQA Plan. Defective materials, equipment, or work shall be replaced, corrected or otherwise made good by the CONTRACTOR at the CONTRACTOR's own expense.

B. On all questions concerning the acceptability of materials or equipment, execution of the Work, and the determination of costs, the decision of the CONSTRUCTION MANAGER shall be final and binding upon all parties.

C. The CONTRACTOR shall at all times maintain proper facilities and provide safe access to all parts of the Work, to the shops wherein the Work is in preparation, and to all warehouses and storage yards wherein materials and equipment are stored, for purposes of inspection by the CQA CONSULTANT.

D. The CONTRACTOR shall provide incidental labor and facilities to provide access to Work to be tested, to obtain and handle samples at the Site or at source of products to be tested, and to facilitate tests and inspections.

E. Notify CQA CONSULTANT 24 hours prior to expected time for operations requiring inspection services.

F. Retesting required because of non-conformance to specified requirements shall be performed by the CQA CONSULTANT on instructions by the CONSTRUCTION MANAGER. Payment for retesting will be charged to the CONTRACTOR by deducting inspection or testing charges from the Contract Price.

G. Employment of CQA CONSULTANT by OWNER shall in no way relieve the CONTRACTOR of obligations to perform Work in accordance with requirements of Contract Documents.

1.03 MANUFACTURERS' FIELD SERVICES AND REPORTS

A. When specified in individual Specification Sections, required material or Product suppliers or manufacturers shall provide qualified staff personnel to observe site conditions, conditions of surfaces and installation, and quality of workmanship as applicable, and to initiate instructions when necessary.

B. Individuals shall report observations and site decisions or instructions given to applicators or installers that are supplemental or contrary to manufacturers' written instructions.

1.04 SURVEYING

A. At least two control monuments shall be established by the CONTRACTOR at locations convenient for daily tie-in. The vertical and horizontal controls for these control points shall be established within normal land surveying standards. The CONTRACTOR shall use these control points in laying out and providing ongoing geometric control of the work. The control monuments shall be shown on all record drawings.

B. Surveying shall be performed under the direct supervision of a licensed land surveyor or registered civil engineer authorized to practice land surveying under Chapter 15, Article 3, Section 8731 of the Professional Engineering Act of California, as amended January 1, 1992 who may also be the senior surveyor on site. The survey crew shall consist of the senior surveyor and as many surveying assistants as required to satisfactorily undertake the work. Personnel shall be experienced in all aspects of surveying, including detailed, accurate documentation.

C. The survey instruments used for this work shall be sufficiently precise and accurate to meet the needs of the project. Survey instruments shall be capable of reading to a precision of 0.01 feet and with a setting accuracy of 10 seconds. Calibration certificates for survey instruments shall be submitted on request to the CQA CONSULTANT prior to the initiation of surveying activities.

D. It shall be the CONTRACTOR's sole responsibility to control the Work so that all of the geometric requirements of the project are met. The CONTRACTOR shall immediately notify the CONSTRUCTION MANAGER and the CQA CONSULTANT of any discrepancy found in the Work. It will be the CONSTRUCTION MANAGER's sole prerogative to approve or reject work which does not meet the requirements contained in these Specifications and the Drawings, but which, in the CONSTRUCTION MANAGER's sole opinion, may nevertheless meet the intention of the Contract Documents.

E. The CONTRACTOR shall be responsible for the accuracy of all work and shall maintain all reference points, stakes, etc., throughout the life of the project. Damaged or destroyed points, bench marks or stakes, or any reference points made inaccessible by the progress of the construction shall be replaced or transferred by the CONTRACTOR. Any of the above points shall be referenced by ties to acceptable objects and recorded. Any alternations or revisions in the ties shall be so noted and the information furnished to the CONSTRUCTION MANAGER immediately. All computations necessary to establish the exact position of the work from control points shall be made and preserved by the CONTRACTOR. All computations, survey notes and other records necessary to accomplish the work shall be neatly made and shall be made available onsite for review by the CQA CONSULTANT.

F. During the progress of the construction work, the CONTRACTOR shall be required to furnish all of the surveying and state-out incidental to the proper location by line and grade for each phase of the work. For any operation requiring extreme accuracy, the CONTRACTOR shall restake with pins or other acceptable hubs located directly adjacent to the work at a spacing approved by the CONSTRUCTION MANAGER.

PART 2 PRODUCTS

(Not Used)

PART 3 EXECUTION

(Not Used)

END OF SECTION

SECTION 01402

CONTROL OF WORK

PART 1 GENERAL

1.01 AUTHORITY OF THE CONSTRUCTION MANAGER

A. The CONSTRUCTION MANAGER will decide all questions which may arise as to the quality and acceptability of materials furnished and work performed; all questions which may arise as to the interpretation of the Drawings and Specifications; and all questions as to the satisfactory and acceptable fulfillment of the Contract on the part of the CONTRACTOR.

B. The OWNER shall have the authority to stop the Work if odor or dust becomes a nuisance.

1.02 AUTHORITY OF THE CQA CONSULTANT

A. The CQA CONSULTANT employed by the OWNER shall be authorized to monitor all work done and materials and equipment furnished. Such monitoring may extend to all or part of the Work, and to the preparation, fabrication, or manufacture of the materials and equipment to be used. The CQA CONSULTANT will not alter or waive the provisions of the Contract Documents.

B. The CQA CONSULTANT will keep the CONSTRUCTION MANAGER informed as to the progress of the Work and the manner in which it is being done; also, the CQA CONSULTANT will call the CONTRACTOR's attention to non-conformance with the Contract Documents that the CQA CONSULTANT may have observed. The CQA CONSULTANT will not approve or accept any portion of the Work, issue instructions contrary to the Contract Documents, or act as foreman for the CONTRACTOR. The CQA CONSULTANT may reject defective materials, equipment, or work subject to final decision of the CONSTRUCTION MANAGER.

C. The CONSTRUCTION MANAGER may delegate additional authority to the CQA CONSULTANT. In such cases, the CONSTRUCTION MANAGER will notify the CONTRACTOR of such action.

1.03 COORDINATION AND INTERPRETATION OF DRAWINGS AND SPECIFICATIONS

A. The Specifications, General Conditions, Special Conditions, CQA Plan, Contract Change Orders, and all supplementary documents are essential parts of the Contract, and a requirement occurring in one is as binding as though occurring in all. They are intended to be coordinated and to describe and provide for a complete work.

B. Should it appear that the Work or other matters relative thereto are not sufficiently detailed or explained in the Contract Documents, the CONTRACTOR shall apply to the CONSTRUCTION MANAGER for such further explanations as may be necessary and shall conform to them as part of the Contract.

C. In the event of a doubt or question arising regarding the true meaning of the Contract Document, reference shall be made to the CONSTRUCTION MANAGER, whose decision thereon shall be final.

D. In the event of a discrepancy between a drawing and the figures written thereon, and/or the Drawings and the Specifications, the CONTRACTOR shall notify the CONSTRUCTION MANAGER in writing and wait for approval before proceeding. Scaled dimensions shall not be used in the performance of the Work.

PART 2 PRODUCTS

(Not Used)

PART 3 EXECUTION

3.01 PERFORMANCE REQUIREMENTS

A. The CONTRACTOR shall furnish the CONSTRUCTION MANAGER with every reasonable facility for ascertaining whether or not the Work as performed is in accordance with the requirements and intent of the Specifications and Contract.

B. Should a work be covered before acceptance or consent of the CONSTRUCTION MANAGER, it must, if required by the CONSTRUCTION MANAGER, be uncovered for examination at the CONTRACTOR's expense.

END OF SECTION

SECTION 01565

TEMPORARY FACILITIES

PART 1 GENERAL

1.01 SUMMARY

A. The CONTRACTOR shall provide all temporary facilities and utilities required for prosecuting the Work, protection of employees and the public, protection of the Work from damage by fire, weather or vandalism, and such other facilities as may be specified or required by an applicable law, ordinance, rule, or regulation.

B. The CONTRACTOR must provide their own office space for their needs if necessary. The location of the office shall be approved by the OWNER.

1.02 ELECTRICAL SERVICE

A. Electrical power is not available at the site. The CONTRACTOR shall arrange for temporary electric connection or supply a generator capable of providing the power required to operate tools or equipment or to provide area lighting as needed. Temporary power whether supplied by a utility company or by a generator shall conform to the requirements of the 1993 National Electrical Code, the 1993 National Electrical Safety Code, and all applicable national standards, local regulations and ordinances.

B. The allowable hours of generator operation is the same as the regular working hours for the project. All generators shall be fitted with a residential quality muffler.

1.03 FIRST AID

A. First aid kits meeting the minimum requirements of the Occupational Safety and Health Administration shall be provided in a readily accessible location or locations indicated in the CONTRACTOR's Health and Safety Plan as outlined in Section 01810 of these Specifications.

1.04 CONSTRUCTION FACILITIES

A. Construction hoists, elevators, scaffolds, stages, shoring and. similar temporary facilities shall be of ample size and capacity to adequately support and move the loads to which they will be subjected. Railings, enclosures, safety devices, and controls required by law or for adequate protection of life and property shall be provided.

1.05 STAGING AND SHORING

A. Temporary supports shall be designed with an adequate safety factor to assure stability and adequate load bearing capacity.

B. Trenches greater in depth than four (4) feet shall be shored or sloped according to OSHA requirements.

1.06 TEMPORARY ENCLOSURES

A. When any activity hazardous to property or the health of employees and the public is in progress, the area of activity shall be enclosed adequately to contain the dust, overspray, or other hazard. In the event there are not permanent enclosures in the area, or such enclosures are incomplete or inadequate, the CONTRACTOR shall provide suitable temporary enclosures.

1.07 WARNING DEVICES AND BARRICADES

A. The CONTRACTORs shall adequately identify and guard all hazardous areas, holes, pits, and conditions by visual warning devices and physical barriers. Such devices shall, as a minimum, conform to the requirements of OSHA and Cal-OSHA.

1.08 HAZARDS IN PUBLIC ACCESS AREAS

A. Trenches and other essentially continuous excavations in public access areas, running parallel to the general flow of traffic, shall be marked at reasonable intervals by traffic cones, barricades, or other suitable visual markers during daylight hours. During hours of darkness, these markers shall be provided with either torches, flashers or other adequate lights.

1.09 FIRE EXTINGUISHERS

A. A sufficient number of fire extinguishers of the type and capacity required to protect the site and ancillary facilities shall be provided in readily accessible locations.

1.10 ODOR CONTROL

A. The CONTRACTOR shall comply with the provisions for control of odor and emissions as required by the MDAQMD or the OWNER.

1.11 SANITATION FACILITIES

A. CONTRACTOR shall provide and maintain ample field latrines and ablution accommodations in accordance with OSHA requirements for all workers employed on the project under the contract. Field latrines and ablution accommodations shall be provided and maintained in a sanitary condition at all times during the work on this project.

1.12 MATERIAL STORAGE

A. A materials storage area shall be designated to the CONTRACTOR by the CONSTRUCTION MANAGER. The CONTRACTOR is responsible for security of all of his materials and equipment.

PART 2 PRODUCTS

(Not Used)

PART 3 EXECUTION

(Not Used)

END OF SECTION

SECTION 01810

SAFETY PROCEDURES

PART 1 GENERAL

1.01 SUMMARY

A. This section establishes minimum safety requirements and guidelines for the performance of the Work.

B. The CONTRACTOR is advised that decomposing waste produces landfill gas which is potentially flammable or explosive.

C. The CONTRACTOR shall submit a Health and Safety Plan and a copy of their Injury and Illness Prevention Program to the OWNER for review prior to beginning work.

D. The CONTRACTOR shall hold mandatory daily tailgate safety meetings on the site, as well as formal weekly safety meetings.

1.02 GENERAL REQUIREMENTS

A. The CONTRACTOR shall have sole responsibility and liability for the safety, efficiency, and adequacy of the CONTRACTOR's personnel, equipment and methods, and for any damage or injury resulting from their failure, or improper maintenance, use, or operation.

B. The CONTRACTOR shall be solely and completely responsible for the conditions at the Work area arising from the CONTRACTOR's execution of the Work. This requirement shall apply continuously and not be limited to normal working hours.

C. The CONTRACTOR shall provide all personnel working on the project with orientation and training on the potential hazards anticipated and the appropriate use of safety equipment.

D. Neither the OWNER nor the CONSTRUCTION MANAGER shall have liability resulting from injury or death to CONTRACTOR's employees or subcontractors and their employees.

E. A health and safety officer, employed by the CONTRACTOR, shall be present at all times during construction of underground facilities. The health and safety officer may be the site superintendent or other responsible regular employee of the CONTRACTOR provided he has had special health and safety training, and shall have responsibility for the enforcement of the Health and Safety Plan, particularly as it applies to drilling activities. The health and safety officer shall be identified by name in the Health and Safety Plan.

F. Many gases are heavier than air and settle in low areas such as trenches and excavations, therefore additional precautions shall be observed in these areas. Specifically, the need for constant O_2 monitoring, forced ventilation, combustible gas monitoring, VOC monitoring, respiratory protective equipment, etc. shall be determined by the CONTRACTOR. The CONSTRUCTION MANAGER may impose additional requirements when deemed necessary for worker safety.

1.03 HEALTH AND SAFETY PLAN

A. The CONTRACTOR shall develop and maintain for the duration of work activities at the site, a written, site specific Health and Safety Plan for landfill operations that will effectively incorporate and implement all applicable requirements. The plan will meet the requirements of CCR Title 8 Section 5192.

B. In addition to requirements set forth in other sections, the CONTRACTOR's Health and Safety Plan shall contain provisions for aspects of protection against bodily injury from heavy construction equipment, tools and equipment required to construct the system.

C. The Health and Safety Plan shall include the location and route to the nearest hospital or emergency facility. All CONTRACTOR employees and subcontractors working on the project shall be thoroughly familiar with the emergency route.

D. In the event the Health and Safety Plan is determined by the CONSTRUCTION MANAGER, OWNER or the State or Federal Regulatory Agencies to be inadequate to protect the employees and the public, the plan shall be modified prior to the beginning of the Work to meet the minimum requirements of the OWNER or the State or Federal Regulatory Agencies at no additional cost to the OWNER.

E. Acceptance of the CONTRACTOR's Health and Safety Plan by the OWNER does not release the CONTRACTOR of liability in the event of an accident or injury, nor does it place any liability on the CONSTRUCTION MANAGER or OWNER.

F. Provisions shall be made to protect against ingestion, absorption or inhalation of hazardous compounds and for the handling of refuse in a safe, sanitary, and proper manner.

G. The CONTRACTOR's Health and Safety Plan shall contain trenching and excavation safety guidelines particular to landfill work.

1.04 REGULATORY REQUIREMENTS

A. The CONTRACTOR shall comply with provisions of safety regulatory bodies including, but not necessarily limited to:

1. OSHA/Cal-OSHA regulations for construction
2. 29 Code of Federal Regulations (CFR) 1926/1910 and CFR 1910.120
3. Title 8 California Code of Regulations, in particular Section 5192.
4. All other applicable federal, state, county and local laws, ordinances, codes, the requirements

B. If any of these requirements are in conflict, the more stringent requirement shall apply. The CONTRACTOR's failure to be thoroughly familiarized with the aforementioned safety and health provisions shall not relieve the CONTRACTOR of responsibility for full compliance with the obligations and requirements set forth herein.

C. The CONTRACTOR shall conform to the rules and regulations of the State Construction Safety regulations pertaining to excavations and trenches. A copy of the regulations is available at the OWNER.

1.05 SPECIAL SAFETY CONSIDERATION RELATED TO LANDFILL WORK

A. Portions of the Work involve excavation and removal of and construction near hazardous waste.

B. The landfill may contain leachate water contaminated with substances found in the landfill which may be corrosive, toxic, carcinogenic, mutanogenic or otherwise hazardous.

PART 2 PRODUCTS

(Not Used)

PART 3 EXECUTION

3.01 GENERAL REQUIREMENTS

A. The CONTRACTOR shall assume full responsibility to assure that during construction his employees, subcontractors and their employees follow the Health and Safety Plan.

B. The CONTRACTOR shall hold mandatory weekly safety meetings on the site. The CONTRACTOR shall notify the CONSTRUCTION MANAGER of the time and place of all meetings and allow the CONSTRUCTION MANAGER to participate. Meetings should reiterate safety measures to be taken and discuss any violations committed and preventive measures to avoid future violations.

C. The CONTRACTOR shall require all personnel on the site to wear the appropriate personnel protective equipment such as steel toe boots, hard hats, orange safety vests, safety belts and lanyards, and others.

D. The CONTRACTOR shall provide appropriate fall protection (i.e., harness and shock absorbing lanyard) that must be worn and secured to a stationary object when working within a distance of ten 10 feet of an excavation greater than eight (8) inches in diameter or deeper than four (4) feet.

E. No smoking or consumption of alcohol or any drug which could impair sight, balance or judgment is permitted on the job.

3.02 TRENCHING SAFETY

A. The CONTRACTOR shall complete each excavated trench prior to the end of the working day. A trench shall be considered complete if it has been backfilled to the landfill surface.

B. Any time excavations and trenching exceed four (4) feet in depth, shoring, bracing or sloping of the side walls is required prior to entry. If sloping is the method used, side walls of the trench shall be sloped at a 2H:1V slope (Cal-OSHA requirement).

C. Welding is to be avoided within the barricaded area. If HDPE pipe welding is performed in the trench, continuous methane monitoring shall be performed.

D. Solvent cleaning, gluing or bonding of pipe shall be done, to the extent practicable, outside the trench.

E. All trenches shall be backfilled as soon as practical after excavation, and under no circumstances shall a trench remain open after the crew has left the vicinity of the trench. A maximum of 300 feet of trench may be exposed at any one time. All exposed refuse must be covered at the end of each day using cover soil or a tarp.

F. Electric motors shall not be used in trenches. Pneumatic operated tools shall be used in the trench.

3.03 VIOLATIONS

A. Should any health and safety violations be called to the CONTRACTOR's attention by anyone, the CONTRACTOR shall immediately correct the violations.

B. If the CONTRACTOR violates any health and safety rule or regulation, the OWNER may issue an order to stop all work until the violations are remedied. The CONTRACTOR shall not be entitled to any extension of the time or any claim for damage or to any compensation for either the directive or the work suspension order. A decision by the OWNER not to order discontinuance of any or all of the CONTRACTOR's operations shall not relieve the CONTRACTOR of responsibility for safety.

END OF SECTION

SECTION 02105

EROSION CONTROL

PART 1 GENERAL

1.01 DESCRIPTION

A. This section describes the general requirements for erosion control measures associated with lining materials for drainage channels.

PART 2 PRODUCTS

2.01 EROSION CONTROL BLANKET

Permanent Turf Reinforcement Mat shall be Propex Landlok 407, or equivalent. To be used in drainage channels at the locations shown on the Plans.

PART 3 EXECUTION

3.01 GENERAL

A. Grade and compact area of installation and remove all rocks, clods, vegetation or other obstructions so that the installed mat will have direct contact with soil surface. Prepare seedbed by loosening 2-3 inches of topsoil. Incorporate amendments such as fertilizer into soil.

B. For temporary erosion control mat, apply seed to soil surface before installing blanket/mat. For permanent erosion control mat, apply seeding after installation and prior to filling mat with soil.

C. The CONTRACTOR shall install the permanent and temporary control mats in accordance with the manufacturer's recommendations. In general the installation should include:

1. Anchor trenches or check slots (6-inches deep) at 30 foot intervals along the trench.

2. Longitudinal anchor trenches (4-inches deep) to secure outside edges.

3. Anchor erosion control mat with U-shaped wire staples. Staples shall be a minimum of 6-inches in length and have sufficient ground penetration to resist pullout. Longer anchors may be required. Anchors for the permanent erosion control mat shall be installed with a minimum of 2 anchors per square yard. Temporary erosion control mats shall be installed with a minimum of 1.5 anchors per square yard.

4. After installation of permanent erosion control mat, apply seed and apply ½ to ¾ inches of fine soil into the mat to completely fill the voids. Use backside of rake, or similar, to smooth soil fill in order to just expose the top netting.

END OF SECTION

SECTION 02110

SITE CLEARING, GRUBBING AND STRIPPING

PART 1 GENERAL

1.01 DESCRIPTION

A. This section describes the general requirements for site clearing, grubbing and stripping associated with the construction of Phase III of Landfill B-18 at the Kettleman Hills Facility.

B. Clearing, grubbing and stripping shall be performed to remove organic, soft, loose, and deleterious materials and expose a firm, unyielding subgrade.

1.02 RELATED SECTIONS

A. Section 02200 - Earthwork

B. Section 02751 - HDPE Geomembranes

PART 2 PRODUCTS

A. Organic, soft, loose and deleterious materials includes, but is not limited to, vegetative growth, non-engineered fills, alluvial deposits, soft, loose, or saturated subgrade soils, refuse, and construction debris.

PART 3 EXECUTION

3.01 PROTECTION

A. Locate, identify, and protect utilities that remain from damage.

B. Protect existing groundwater monitoring wells and piezometers from damage or displacement.

3.02 CLEARING

A. Clear areas required for access to site and execution of work.

B. Earthwork CONTRACTOR shall remove all organic and deleterious material, and trash from the subgrade surface. Vegetative growth greater than 1 inch in dimension shall be removed to a depth of 6 inches below the subgrade surface.

C. The Earthwork CONTRACTOR shall consider that clearing, grubbing, and stripping will necessitate the use of manual labor to remove all organic and deleterious material from the subgrade surface.

D. The Earthwork CONTRACTOR shall remove soft, loose, or saturated materials as approved by the CQA CONSULTANT. The materials shall be removed until a firm, unyielding subgrade, approved by the CQA CONSULTANT, is exposed.

E. All removed materials shall be disposed of onsite in an area designated by the PROJECT MANAGER. No accumulation of flammable material shall remain on or adjacent to the construction area.

F. The Earthwork CONTRACTOR shall expose existing liner terminations as required on the Drawings. The Work may require hand excavation to avoid damage to the existing liner. Any damage to the existing liner shall be repaired by the Earthwork CONTRACTOR at no additional cost to the OWNER.

END OF SECTION

SECTION 02200

EARTHWORK

PART 1 GENERAL

1.01 SUMMARY

A. The Earthwork CONTRACTOR shall furnish all labor, materials, equipment and incidentals necessary to perform all excavation, backfilling, compaction and grading required to complete the work shown on the Drawings and specified herein. The Work shall include, but not necessarily be limited to, survey and staking, borrow excavation and hauling, excavation for trenches, fill placement and compaction, grading, and all related work.

B. The Earthwork CONTRACTOR shall comply with the safety procedures given in Section 01810 of these Specifications.

1.02 RELATED SECTIONS

A. Section 01300 - Submittals

B. Section 01400 - Construction Quality Control

C. Section 02110 - Site Clearing, Grubbing and Stripping.

D. Section 02220 - Compacted Clay Liner

E. Section 02751 - HDPE Geomembranes

1.03 REFERENCE STANDARDS

A. American Society for Testing and Materials (ASTM), latest editions:

1. ASTM D422 - Test Method for Particle Size Analysis of Soils.
2. ASTM D1556 - Test Method for Density of Soil In-Place by the Sand Cone Method.
3. ASTM D1557 - Test Methods for Moisture-Density Relations of Soils and Soil Aggregate Mixtures Using 10-lb. Rammer and 18-inch Drop.
4. ASTM D2216 - Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.
5. ASTM D2419 - Test Method for Sand Equivalent Value of Soil/Fine Aggregate.
6. ASTM D2497 - Standard Test Method for Classification of Soils for Engineering Purposes.
7. ASTM D2937 - Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method.
8. ASTM D6938 – In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

B. Standard Specifications for Public Works Construction (SSPWC).

1.04 QUALITY ASSURANCE/CONTROL

A. The Earthwork CONTRACTOR shall adhere to the requirements of Section 01400 of these Specifications.

B. Compaction testing of engineered fill and backfill shall be performed by the CQA CONSULTANT. Testing shall be performed at locations to be determined by the CQA CONSULTANT, in order to determine if the soils meet the compaction requirements. Costs for testing to verify compaction and soil moisture content will be assumed by the OWNER. The cost of retesting, should corrections to construction be required, shall be the responsibility of the Earthwork CONTRACTOR.

C. The OWNER shall have complete authority to order immediate stoppage of work due to use of improper construction procedures, or for any reason that in his sole opinion, may result in a defective work.

1.05 DEFINITIONS

A. Excavation: Consists of the removal of material encountered to subgrade elevations and the reuse or disposal of materials removed.

B. Subgrade: The surface upon which structures/systems/fills are constructed.

C. Borrow: Soil material obtained from other than the excavation.

D. Unauthorized excavation consists of removing materials beyond indicated subgrade elevations or dimensions without direction by the PROJECT MANAGER. Unauthorized excavation, as well as remedial work directed by the PROJECT MANAGER, shall solely be at the Earthwork CONTRACTOR's expense.

E. Utilities include on-site above ground and underground pipes, conduits, ducts, and cables, as well as underground services.

1.06 SAFETY

A. CONTRACTOR is solely responsible for performing work in a safe manner and complying with all applicable local, state and federal codes, ordinances, laws, and regulations.

B. CONTRACTOR shall comply with the requirements of the Health and Safety Plan.

PART 2 PRODUCTS

2.01 MATERIALS

A. Structural Fill

1. Structural Fill shall be removed from the on-site borrow area(s) designated by the OWNER. Material shall be predominantly free from roots, wood, organic matter,

refuse or other deleterious matter, and shall not contain particles over 6 inches in greatest dimension.

2. The OWNER has designated on-site borrow source(s) for the CONTRACTOR. The CONTRACTOR shall be responsible for excavating, loading, hauling, placing and compacting the material from the designated borrow source(s).

B. Clay Liner (see Section 02220)

C. Operations Layer (see Section 02228)

D. Trench Backfill

1. Trench Backfill shall be removed from the on-site borrow area(s) designated by the OWNER. Material shall be predominantly free from roots, wood, organic matter, refuse or other deleterious matter, and shall not contain particles over 1 inch in greatest dimension.

2. The OWNER has designated on-site borrow source(s) for the CONTRACTOR. The CONTRACTOR shall be responsible for excavating, loading, hauling, placing and compacting the material from the designated borrow source(s).

E. Water

1. Water shall be potable water or reclaimed water approved for use by OWNER.

2. The OWNER will provide water for dust control and soil preparation to the Earthwork CONTRACTOR at no cost to the Earthwork CONTRACTOR.

3. The CONTRACTOR shall only obtain water from sources designated by the OWNER.

PART 3 EXECUTION

3.01 GENERAL

A. The Earthwork CONTRACTOR shall be solely responsible for the satisfactory completion of all earthwork in accordance with the Drawings and Specifications.

B. Equipment used in the excavation, transport, placement and compaction of all materials used in construction will be standard of practice grading machinery of known specifications suitable for performing the required work in a timely and efficient manner.

C. All material considered by the CQA CONSULTANT to be unsuitable for use in the construction of the earthwork shall be removed. All materials incorporated as part of engineered fill must be inspected and placement must be observed by the CQA CONSULTANT. Unsuitable material shall be disposed of in the designated area.

D. Where work is interrupted by heavy rains, earthwork operations shall not be resumed until observations and field tests by the CQA CONSULTANT indicate the moisture content and density of the in-place fills and/or materials intended for placement are within the specified requirements.

E. If any unanticipated earth conditions of an adverse or potentially adverse nature are encountered during grading, the Earthwork CONTRACTOR shall immediately notify the CQA CONSULTANT. The CQA CONSULTANT and DESIGN ENGINEER shall investigate, analyze, and make recommendations to mitigate these conditions.

F. Throughout construction, all excavated and/or fill areas shall be graded to provide positive drainage and prevent ponding of water. Surface water shall be controlled to avoid damage to adjoining properties or to finished work on the site.

G. No heavy equipment shall be permitted to operate within 3 feet of existing wellheads or piping. Compaction of material within these limits shall be completed with hand equipment.

H. The Earthwork CONTRACTOR shall apply water to any exposed earthen areas during construction to minimize airborne dust. This shall include active and inactive excavation areas, haul roads, and any non-vegetated stockpiles. The Earthwork CONTRACTOR shall be responsible for complying with all state and local regulations regarding dust and/or air quality.

I. Earthwork CONTRACTOR **shall not** use "paddle-wheel" (i.e., Caterpillar 613 or equivalent) equipment to excavate soils.

J. Earthwork CONTRACTOR shall provide manned traffic control (e.g., flagman) at locations identified by Owner and/or Contractor as being a potential safety hazard.

3.02 CONTROL OF WATER

A. The Earthwork CONTRACTOR shall excavate and backfill in a manner and sequence that will provide proper drainage at all times. The Earthwork CONTRACTOR shall remove all water, including runoff and run-on collected from rainwater encountered during excavation, to a location approved by the PROJECT MANAGER, by pumps, drains, and other approved methods.

B. The Earthwork CONTRACTOR shall take all necessary precautions to preclude the accidental discharge of fuel, oil, etc. and to prevent such accidents that may endanger the environment. The Earthwork CONTRACTOR will be responsible for the cost of remediating the results of any such discharges or accidents.

3.03 BORROW

A. CONTRACTOR shall submit the proposed limits of the borrow area to the OWNER for approval prior to the commencement of the Work. The maximum limits of the borrow area are shown on the Drawings.

B. The gradients of the borrow slopes and the depth of the borrow excavation should not exceed those specified on the Drawings. If the slopes are constructed steeper or the depth of the borrow excavation is greater than that specified on the Drawings, the CONTRACTOR shall reconstruct the slopes/refill the bottom to the gradients/depth specified by backfilling and compacting material in accordance with the requirements for engineered fill in this Section. The cost to reconstruct the slopes/refill the bottom will be borne solely by the CONTRACTOR.

C. The CONTRACTOR shall maintain a secure work site at all times.

3.04 STRUCTURAL FILL

A. Prior to placing structural fill, CONTRACTOR shall clear and grub the area in accordance with Section 02110 of these Specifications. CONTRACTOR shall also remove uncertified existing fills, disturbed soils and deleterious materials from the area to the satisfaction of the CQA CONSULTANT.

B. The ground surface (i.e. areas with less than 10% slope) to receive fill shall be over excavated a minimum of 2 feet. The base of the excavation shall be scarified to a depth of 8 inches. The scarified ground surface shall then be brought to within 3 percent of optimum moisture content, mixed as required, and compacted to a minimum of 90 percent of the maximum dry density as determined by ASTM D1557. Excavated soil may be used for filling the excavation if placed in accordance with the structural fill requirements. If the scarified zone is greater than 12 inches in depth, the excess shall be removed, placed in loose lifts not to exceed 8 inches in loose thickness. Prior to fill placement, the ground surface to receive fill shall be stabilized and inspected by the CQA CONSULTANT.

C. Fill placed against existing slopes (i.e., areas with greater than 10% slope) shall be keyed into the slope. Keys shall extend a minimum of 6 feet horizontally into the existing slope. The keys shall form a series of steps in the existing fill.

D. Fill shall be placed in loose lifts not to exceed 8-inches thick, brought to a uniform moisture content within 3 percent of optimum, and compacted to 90 percent of the maximum dry density as determined by ASTM D1557.

E. Where tests indicate the moisture content or density of any layer of fill or portion thereof is below the Project requirements, the particular layer or portion thereof shall be reworked until the required moisture or density has been attained. No additional fill shall be placed over an area until the prior fill lift has been tested and meets the present requirements to the satisfaction of the CQA CONSULTANT.

F. In the event of rain or other reason, if the moisture content of previously placed fill material or processed soils intended for placement is more than 3 percent above optimum as determined by ASTM D1557, the fill material shall be aerated by blading, disking, or other satisfactory method until the moisture content complies with the requirements of this Section. Any previously compacted materials which are disturbed (aerated, bladed, etc.) to reduce or increase the moisture content must be recompacted to the Specifications and to the satisfaction of the CQA CONSULTANT once specified moisture contents are attained.

3.05 SURFACE PREPARATION

A. All surfaces to be overlain by geosynthetics shall be smooth, uniformly sloped (minimum 5%), firm, and free of rocks, protrusions, or depressions greater than 0.5-

inch in maximum dimension. The Earthwork CONTRACTOR shall consider that manual removal/repair of unacceptable areas may be required and shall be considered inherent to the work described herein.

3.06 TRENCH EXCAVATION AND BACKFILL

A. All trenches shall be excavated to lines and grades and dimensions indicated on the Drawings. All trench excavation, backfill, and compaction shall be in accordance with pertinent provisions of this Section.

B. All pipe work placed inside the trenches shall have a minimum of 8-inch clearance from any protrusions from the trench side walls or bottom.

C. The Earthwork CONTRACTOR shall backfill excavated trenches as promptly as progress of the work permits and immediately after the pipe has been laid, jointed, and tested.

D. The trench bottom shall be compacted to provide a uniform bed for the pipe. Backfill material shall be placed around the pipe and shall be compacted by hand-tamping, or methods acceptable to the CQA CONSULTANT.

E. The Earthwork CONTRACTOR shall compact the select engineered fill for trench backfill to at least 90 percent of the maximum dry density and within 3 percent of the optimum moisture content as determined in accordance with ASTM D1557.

F. Trench backfill shall be placed as shown on the Drawings. The backfill shall not be placed at ambient temperatures below 41°F nor above 100°F unless otherwise specified. The material shall be placed in a manner that does not cause movement or excessive wrinkling of, or induce excessive wrinkling of the geosynthetics. The CONTACTOR shall not operate equipment directly on any geosynthetics.

3.07 TOLERANCES

A. All material limits shall be constructed within a tolerance of ±1.0 ft for horizontal State Plane coordinates, 0 to +0.1 ft vertical for reference to mean sea level (MSL), and 0 to +0.1 ft where dimensions are shown or specified as a minimum. The plane of the surface shall not vary more than 0.10 feet when measured with a 10-foot straight edge.

3.08 EXCAVATION BELOW GRADE

A. All excavation shall be performed within the limits of the work to the lines, grades, and elevations indicated and specified herein. The Earthwork CONTRACTOR shall not excavate or remove materials beyond indicated subgrade elevations or dimensions without the approval of the PROJECT MANAGER. The Earthwork CONTRACTOR shall backfill and compact any unauthorized excavation to the satisfaction of the PROJECT MANAGER at no additional cost to the OWNER.

B. When acceptable to the PROJECT MANAGER, lean concrete may be used to bring the bottom elevation of excavations under footings or trenches to correct elevations.

END OF SECTION

SECTION 02220

COMPACTED CLAY LINER

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, tools, supervision, transportation, and installation equipment necessary for the construction of the Compacted Clay Liner (CCL), as specified herein, as shown on the Construction Drawings, and in accordance with the Construction Quality Assurance (CQA) Plan.

B. Contractor shall construct the CCL to the elevations, lines, grades, and dimensions as shown on the Plans and described in the Specifications, unless otherwise directed by the Engineer.

C. Process, moisture condition, and transport clay from stockpiled low permeability clay source.

D. Construct the CCL in conjunction with the installation and construction of the other components of the liner system.

E. Contractor shall use clay from the approved Pecten claystone borrow source shown on the Construction Drawings. Alternate clay sources which meet the requirements of this Section may be used if approved by the Owner and Engineer, the Regional Water Quality Control Board (RWQCB), and the Department of Toxic Substances Control (DTSC).

F. The clay borrow source may contain some gypsum debris. The Contractor shall remove large and easily recognizable pieces of gypsum and debris. Gypsum and debris must be removed prior to clay placement. Removal is considered part of the cost of clay placement.

1.02 RELATED SECTIONS

A. Section 01300 – Submittals.

B. Section 01402 – Control of the Work.

C. Section 02200 – Earthwork.

D. Section 02751 – HDPE Geomembranes.

1.03 REFERENCES

A. ASTM D422 - Standard Test Method for Particle Size Analysis of Soils.

B. ASTM D854 - Standard Test Methods for Specific Gravity of Soils.

C. ASTM D1140 - Standard Test Methods for Amount of Material in Soils Finer than the No. 200 Sieve.

D. ASTM D1556 - Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.

E. ASTM D1557 - Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort.

F. ASTM D1587 - Standard Practice for Thin-Walled Tube Geotechnical Sampling of Soils.

G. ASTM D2216 - Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures.

H. ASTM D2487 - Standard Test Method for Classification of Soils for Engineering Purposes (Unified Soil Classification System).

I. ASTM D4318 - Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

J. ASTM D5084 - Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.

K. ASTM D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

1.04 REGULATORY REQUIREMENTS

Permits: Contractor shall obtain and comply with the appropriate local, state, and federal permits and licenses required for all Work performed on the site.

1.05 QUALITY ASSURANCE

A. Construction Quality Assurance (CQA) monitoring shall be the responsibility of the Owner or Owner's Representative in accordance with the approved CQA Plan.

B. Quality control testing associated with filling and compaction operations shall be performed by the Owner or Owner's Representative in compliance with the CQA Plan and this Specification. The Contractor shall assist the Owner or Owner's Representative in obtaining clay samples at the frequencies provided in the CQA Plan.

C. Contractor shall give advance notice of at least 24 hours to the Owner or Owner's Representative when ready for compaction or subgrade testing and inspection.

D. Contractor shall give advance notice of at least 24 hours to the Owner or Owner's Representative prior to commencement of proof rolling.

1.06 TOLERANCES

A. The final surface of the finished clay liner shall be within +0.0 feet to +0.2 feet of the design thickness. The Contractor shall not be reimbursed for material that exceeds +0.2 feet.

PART 2 PRODUCTS

2.01 CLAY

A. The clay liner material shall be obtained from the Pecten Claystone borrow source as shown on the Construction Drawings. Based on field permeability testing completed by Geosyntec in 2008, the Pecten Claystone, when processed, has a field permeability of less than 1 x 10^{-7} cm/sec.

B. Clay liner material shall:

1. Be clean soil free of debris, rocks, any particles greater than 1 inch in maximum dimension, and other deleterious material.

2. Be classified as CH, CL, ML, SM, or SC in accordance with ASTM D2487.

3. Have a minimum of 30 percent passing the #200 sieve.

C. The in-situ Pecten Claystone may not meet the requirements of this Specification for moisture content. Processing of this material shall be required prior to its placement. At a minimum, the Contractor shall process and moisture condition the clay in accordance with the "Test Fill and Infiltrometer Test Results" report for the Phases I and II clay liner (Environmental Solutions, Inc.; 1992). The Contractor may elect to use alternative processing and moisture conditioning methods. Alternative methods may require a test pad and field permeability test (i.e., Sealed Double-Ring Infiltrometer) to demonstrate that this Specification is met as well as to evaluate the appropriate compaction specification and associated correction factor.

D. If another clay source (other than the Pecten Claystone) is required to complete the work, that alternative clay source shall be approved by the Owner, Engineer, RWQCB, and DTSC. In order to obtain said approval, clay material obtained from the alternative source shall be laboratory and field tested to demonstrate that the clay meets the requirements in items 2.01 A and B of this Section. It should be noted that the field permeability test requires a minimum of 8 weeks to complete.

2.02 EQUIPMENT

A. Provide equipment to transport clay from borrow source to project site.

B. Provide heavy compaction equipment sufficient to obtain the densities specified. Equipment shall be similar to that used for the Phases I and II clay liner test pad construction (reference Environmental Solutions, Inc. 1992 report).

C. Locations inaccessible to heavy equipment shall be compacted by means of manually controlled pneumatic or vibrating tampers or by Owner-approved equivalent methods to achieve specified densities.

D. Operate compaction equipment in strict accordance with the manufacturer's instructions and recommendations. If inadequate densities are obtained, provide larger and/or different types of additional equipment at no cost to the Owner.

E. Provide water application equipment free of leaks and equipped with a distributor bar or other accepted device to ensure uniform application.

F. Provide processing equipment suitable for providing a material that has uniform moisture content.

PART 3 EXECUTION

3.01 GENERAL

The Contractor shall:

A. Excavate, process for size and moisture content, and stockpile clay from the approved borrow source.

B. Transport processed and moisture conditioned clay from stockpile to the project area.

C. Verify that the survey control system is installed and properly protected from construction operations prior to all earthwork, including clay placement.

D. Placement of successive clay layers shall not begin until the Owner or CQA Consultant has accepted the previous layer. Any damage to the previous layer or deterioration subsequent to acceptance shall be repaired by the Contractor to the satisfaction of the Owner or CQA Consultant at the expense of the Contractor.

E. Fill and compact all holes and other depressions prior to placement of clay.

F. Fill areas to contours and elevations shown on the Drawings.

G. Maintain surface of clay at the minimum grades for drainage shown on the Drawings.

H. Place and compact clay in continuous layers not exceeding 6 inches in compacted thickness. The CONTRACTOR shall implement a systematic method to ensure lift thickness is in compliance with this Specification. Preferred systems include laser levels and global positioning system (GPS). If lath stakes are utilized in the control of grades / thickness then the CONTRACTOR shall ensure recovery of all stakes by implementing a control numbering system. Grade control systems shall be approved by the CQA CONSULTANT.

I. Material incorporated into clay, determined by the OWNER or CQA CONSULTANT to be in violation of Specification requirements, shall be removed by the CONTRACTOR at the CONTRACTOR’s expense.

J. Protect stockpiles so that stockpiled material remains in a condition suitable for use on the project.

K. Transport borrow materials over land or roads designated by the OWNER or CQA CONSULTANT. Perform perimeter/access road maintenance including dust control by sprinkling with water as needed or by other suitable means accepted by the Owner or CQA CONSULTANT. Additionally, road maintenance shall include periodic grading, as necessary, to remove ruts and to maintain construction access roads in a safe and sound condition.

L. Obey all applicable laws where borrow materials are transported along public roads, including but not limited to, laws relating to vehicle speed, vehicle weight, and covering of loads.

3.02 COMPACTED CLAY LINER

A. Work associated with construction of the CCL includes: processing and moisture conditioning clay from borrow sources, any supplementary processing and moisture conditioning of clay at the area of placement to achieve the required moisture content and texture, spreading and compaction of clay layers, and protection of the completed work. The work also includes supplying of all labor and equipment necessary to achieve the construction in accordance with the Drawings and Specifications or as directed by the OWNER or CQA CONSULTANT.

B. The CONTRACTOR shall be responsible for verification that material that does not meet the Specifications is removed from the clay prior to placement.

C. The clay material shall be compacted to a dry density and moisture content that lies within the compaction window bounded by the following 4 points on a moisture content-dry density plot (where optimum moisture and maximum dry density are obtained using the ASTM D1557 test method):

   a. 2 percent above the optimum moisture content for a relative compaction of 90 percent.

   b. 5 percent above the optimum moisture content for a relative compaction of 90 percent.

   c. 3 percent above the optimum moisture content for a relative compaction of 97 percent.

   d. 1 percent above the optimum moisture content for a relative compaction of 98 percent.

   Up to 20 percent of the moisture content-dry density compaction tests per equipment spread per day are allowed to lie slightly outside of the compaction window defined above if the following conditions are met:

   a. The moisture content is within ±0.5 percent of the specified compaction window.

   b. The relative compaction is within -0.5 percent of the specified compaction window.

c. The average for all acceptable tests per equipment spread per day falls within the compaction window described above.

Moisture content and dry density shall be used as an indicator, but the primary requirement for the clay liner is a maximum permeability of 1×10^{-7} cm/sec.

D. Changes to the above compaction specification shall require approval of the Owner, Engineer, CQA Consultant, RWQCB, and DTSC. Modifications will likely require demonstration through a test pad and field permeability test that the modified procedures are acceptable.

E. Clay shall be compacted with a Caterpillar 825 Sheepsfoot Compactor or Rex 3-35 Pad Foot Compactor (or heavier equipment) with a minimum of four complete passes.

F. CONTRACTOR shall take adequate measurements to prevent moisture loss from and desiccation of the CCL.

G. CONTRACTOR shall scarify the top of each lift and confirm the moisture content is acceptable prior to placement of the overlying lift.

H. Clay shall not be placed and compacted if the ambient air temperature drops below 32°F.

I. CONTRACTOR shall seal the last and uppermost layer of CCL, after achieving the compaction and permeability requirements, with two passes of a single drum smooth roller. The final lift shall be suitable for placement of the geomembrane liner (Section 02751).

J. Where test results indicate that the lift thickness, maximum particle size, in-place density/moisture content, and/or permeability of any portion of the clay does not meet the specified requirements, that particular portion shall be re-tested by the OWNER or CQA CONSULTANT and/or re-worked or replaced by the CONTRACTOR at his expense until the required condition has been attained and the resulting product meets or exceeds the Specification requirements. No additional fill shall be placed over an area until the existing fill has been tested horizontally and vertically and determined by the OWNER or CQA CONSULTANT to meet the requirements of this Specification.

K. Upon placement, if test results indicate densities or moisture contents outside the specified compaction window, then two additional field density/moisture content tests shall be conducted in the immediate area. If either of these tests fail to meet the compaction requirements, the area shall be considered inadequate and shall be reworked by the CONTRACTOR. Any reworked areas shall be re-tested by the OWNER or CQA CONSULTANT to assure the reworked area meets the density and moisture content requirements.

L. If the laboratory permeability value exceeds 1.0×10^{-7} cm/sec, then two (2) additional tests of the same type shall be taken by the OWNER or CQA CONSULTANT in the immediate vicinity. If either of the additional tests fails to meet the minimum requirements, the area represented by the test shall be considered inadequate and shall be removed or reprocessed and recompacted by the CONTRACTOR at his expense.

M. If at any time the OWNER or CQA CONSULTANT observes an uncompacted lift thickness in excess of eight inches or observes materials being placed without the required mixing, processing, or stockpiling, the CONTRACTOR shall immediately discontinue placing additional fills in that area. For an over-thick lift, the CONTRACTOR shall immediately blade the surface to reduce the lift to an acceptable thickness at his expense.

N. Prior to placement of the geomembrane liner, all clay surfaces shall be observed for any particles greater than 1 inch in size, and oversize materials shall be removed. The final surface shall be rolled smooth to remove protrusions of ½ inch or greater, to the satisfaction of the CQA Consultant and the Geosynthetics CONTRACTOR.

END OF SECTION

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SECTION 02228

OPERATIONS LAYER

PART 1: GENERAL

1.01 DESCRIPTION

A. This section describes the requirements for placement of operations layer material associated with the performance of the Work.

1.02 SUBMITTALS

A. An earthwork operations plan and schedule shall be submitted to the Owner.

1.03 QUALITY ASSURANCE

A. The Contractor shall make allowances for sampling and testing by the CQA Engineer in both his production operations and schedule.

1.04 TOLERANCES

A. The final surface of the finished operations layer shall be within +0.0 feet to +0.2 feet of the design thickness. The Contractor shall not be reimbursed for material that exceeds +0.2 feet.

PART 2: PRODUCTS

2.01 OPERATIONS LAYER MATERIAL

A. Materials shall consist of on-site soil materials meeting the requirements for Structural Fill in Section 02200 of these Specifications with the additional particle size requirements in Articles 2.01.B and 2.01.C below.

B. The maximum particle size for the operations layer material shall be as follows:

- Material to be placed on or within 0.5-feet of the geosynthetic liner: 1-inch in largest dimension;
- Material to be placed at a distance greater than 0.5 feet of geosynthetic liner: 2-inches in largest dimension.

C. Material shall form a firm and stable base when placed.

PART 3: EXECUTION

3.01 PLACEMENT OF OPERATIONS LAYER

A. Operations layer shall be placed over the geocomposite across the base area to the extent and thicknesses shown on the drawings. On the sideslopes, operations layer shall be placed up the slopes a maximum of 10 vertical feet ahead of the rising waste mass. The final elevation of the operations layer shall be approximately 2 feet above the permitted waste level.

B. Prior to placement of operations layer material, final inspection of the geocomposite by the CQA Engineer will be made to verify integrity.

C. Hauling and placing equipment shall operate on a minimum of 3 feet of material over any geosynthetic layer. Equipment with maximum ground pressure of 6 psi may operate on a minimum of 1 foot of material.

D. The Contractor shall take steps to minimize wrinkle generation in the geosynthetic materials during placement of the operations layer. These measures may include placing material in the early morning hours when the geosynthetic materials are cool and monitoring and walking out wrinkles in the geosynthetic materials that appear at the face of the placement operation. Wrinkles which may fold and or crease shall be removed and repaired in accordance with the specifications.

E. There is no compaction requirement for operations layer placement.

END OF SECTION

SECTION 02725

HDPE PIPE

PART 1 GENERAL

1.01 DESCRIPTION

A. This section describes the requirements for the manufacture, supply, installation, and quality control (QC) of high density polyethylene (HDPE) pipes, fittings and connections.

1.02 SUBMITTALS

A. Prior to the delivery of any HDPE pipe to the site, Earthwork CONTRACTOR shall submit to ENGINEER for review and approval complete, detailed shop drawings of all HDPE pipe and fittings, a list of materials to be furnished, the name of the pipe manufacturer, and the manufacturer's recommendations for handling, storage, and installation.

B. Earthwork CONTRACTOR shall also submit the pipe manufacturer's certification of compliance with the Specifications, including certification that stress regression testing has been performed in accordance with ASTM D2837, for all HDPE pipe materials delivered to the site.

C. In addition to the certification cited above, Earthwork CONTRACTOR shall submit in writing the following documentation of the pipe manufacturer on the raw materials used to manufacture the pipe and fittings:

1. certificate of compliance stating the specific resin, its source, and the information required by ASTM D3350; if in-plant blending of the resin is performed, the pipe manufacturer shall provide a certificate of compliance stating that the blended resin meets the requirements of ASTM D3350; and
2. certificate of compliance stating that no recycled resin was used in manufacturing the pipe except for a small percentage (i.e., less than 10 percent) of resin generated in the pipe manufacturer's own plan from production using the same resin as the recycled material.

1.03 REFERENCES

A. The American Society for Testing and Materials (ASTM), latest editions:

1. ASTM D1603 – Standard Test Method for Carbon Black in Olefin Plastics
2. ASTM D1693 – Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics
3. ASTM D2657 – Standard Practice for Heat-Joining for Polyolefin Pie and Fittings
4. ASTM D2837 – Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials

5. ASTM D3350 – Standard Specification for Polyethylene Plastics Pipe and Fittings Materials

6. ASTM F714 – Standard Specification for Polyethylene (PE) Plastics Pipe (SDR-PR) Based on Outside Diameter

1.04 RELATED SECTIONS

A. Section 02200 - Earthwork

PART 2 PRODUCTS

2.01 MATERIALS

A. HDPE pipe shall be of the diameter and SDR rating (per ASTM F714) as indicated on the plans.

B. The HDPE pipe and fittings shall be manufactured from new, high molecular weight, high density polyethylene (HDPE) resin conforming to ASTM D3350 (Type III, Class C Category 5, Grade P 64), pipe cell classification PE 345464C according to ASTM D3350, and having a Plastic Pipe Institute (PPI) Rating of PE 3408. The resin shall be pre-compounded. In plant blending of non-compounded resins shall be permitted if the manufacturer provides a certificate of compliance that the blended resin conforms to the requirements of the Specifications. Pipe and fittings shall be manufactured from the same resin and by the same manufacturer.

C. The polyethylene compound shall contain a minimum of 2 percent carbon black (per ASTM D1603) to withstand outdoor exposure without loss of properties.

D. The polyethylene compound shall have a minimum resistance of 5,000 hours when tested for environmental stress crack in accordance with requirements of ASTM D1693.

2.02 HDPE PIPE AND PIPE FITTINGS

A. Earthwork CONTRACTOR shall provide HDPE pipe having the nominal diameters specified herein and shown on the Drawings.

B. HDPE pipe and fittings shall have a minimum hydrostatic design basis (HDB) of 1,600 pounds per square inch (psi) when determined in accordance with ASTM D2837 unless otherwise indicated herein or on the Drawings.

C. HDPE pipe shall be supplied in standard laying lengths not exceeding 50 feet.

D. HDPE pipes and fittings shall be homogeneous throughout and free of visible cracks, holes, (i.e., other than intentional manufactured perforations), foreign inclusions, or other deleterious effects, and shall be uniform in color, density, melt index, and other physical properties.

E. Fittings at each end of pipes shall consist of HDPE end caps unless indicated otherwise herein or on the Drawings.

2.03 LABELING

A. The following shall be continuously indent-printed on the HDPE pipe, or spaced at intervals not exceeding 5 feet:

1. name and/or trademark of the pipe manufacturer;
2. nominal pipe size;
3. pipe stiffness;
4. the letters PE followed by the polyethylene grade per ASTM D3350, and by the Hydrostatic Design Basis in 100's of psi (e.g., PE 3408);
5. test method references (e.g., ASTM D2412); and
6. a production code from which the date and place of manufacture can be determined.

PART 3 EXECUTION

3.01 GENERAL

A. Transportation of HDPE pipe and fittings shall be the responsibility of Earthwork CONTRACTOR. Earthwork CONTRACTOR shall be liable for all damage incurred prior to and during transportation to the site.

B. Handling, storage, and care of the HDPE pipe and fittings prior to and following installation at the site is the responsibility of Earthwork CONTRACTOR. Earthwork CONTRACTOR shall be liable for all damage to the material incurred prior to final acceptance of the project by OWNER.

C. Earthwork CONTRACTOR shall be responsible for storage of HDPE pipe and fittings at the site. Pipe and fittings shall be stored on clean level ground, preferable turf or sand, free of sharp objects which could damage the pipe. Stacking shall be limited to a height that will not cause excessive deformation of the bottom layers of pipe under anticipated temperature conditions. Where necessary, due to ground conditions, the pipe shall be stored on wooden sleepers, spaced suitable and of such width as not to allow deformation of the pipe at the point of contact with the sleeper or between supports. The pipe shall be stored out of direct sunlight (i.e., to minimize pipe bowing). Earthwork CONTRACTOR shall also comply with the pipe manufacturer's recommendations for handling, storage, and installation of HDPE pipe and fittings.

D. Earthwork CONTRACTOR shall exercise care when transporting, handling and placing HDPE pipe and fittings such that they will not be cut, kinked, twisted, or otherwise damaged. Ropes, fabric, or rubber-protected slings and straps shall be used when handling pipe. Slings, straps, etc., shall not be positioned at butt-fused joints. Chains, cables or hooks shall not be inserted into the pipe ends as a means of handling pipe. Pipe or fittings shall not be dropped onto rocky or unprepared ground. Under no circumstances shall pipe or fittings be dropped into trenches, or dragged over sharp objects.

E. Earthwork CONTRACTOR shall carefully examine all pipe and fittings for cracks, damage, or defects before installation. Defective or damaged materials shall be immediately removed from the site and replaced at no additional cost to OWNER.

F. The maximum allowable depth of cuts, gouges or scratches on the exterior surface of pipe or fittings is 10 percent of the wall thickness. The interior of the pipe and fittings shall be free of cuts, gouges and scratches. CQA CONSULTANT will inspect all pipes. Sections of pipe with excessive cuts, gouges or scratches will be rejected and Earthwork CONTRACTOR shall be required to remove and replace the rejected pipe, at no additional cost to OWNER.

G. Whenever pipe laying is not actively in progress, the open end of pipe that has been placed shall be closed using a watertight cap.

H. The interior of all pipe and fittings shall be inspected and any foreign material shall be completely removed from the pipe interior before it is moved into final position.

I. Field-cutting of pipes, when required, shall be made with a machine specifically designed for cutting pipe. Cuts shall be carefully made, without damage to pipe or lining, so as to leave a smooth end at right angles to the axis of pipe. Cutter ends shall be tapered and sharp edges filed off smooth. Flame cutting will not be allowed.

J. No pipe shall be laid until CQA CONSULTANT has observed the condition of the pipe.

K. No pipe shall be brought into position until the preceding length has been bedded and secured in its final position.

L. Blocking under piping shall not be permitted unless specifically accepted by PROJECT MANAGER for special conditions or as indicated on the Drawings.

M. Pipe will be inspected in the field before and after placement in the trench. If upon inspection, pipe is found not to be in compliance with the Specifications, it shall be subject to rejection. Any corrective work shall be approved by CQA CONSULTANT. The costs for the corrective work shall be at Earthwork CONTRACTOR's sole expense. Pipe shall be laid to the line and grade shown on the Drawings, with uniform bearing under the full length of the barrel of the pipe. Any pipe which is not in true alignment or shows any undue settlement after laying shall be taken up and relaid at Earthwork CONTRACTOR's sole expense. The joining of the pipe shall be in accordance with the manufacturer's written instructions and the Specifications, as approved by PROJECT MANAGER.

N. All placed pipes shall be surveyed along the top of the pipe to complete the record drawings prior to backfilling. All start points, angle joints, junctions, connections, and end points of the pipe shall be surveyed. All survey work shall conform to the quality and practice required by CQA CONSULTANT, specified herein, and in the CQA Plan.

O. Both during the construction period and immediately prior to acceptance of the construction work by OWNER, Earthwork CONTRACTOR shall keep the pipe free-draining and free of rocks, soil, and debris.

P. Earthwork CONTRACTOR shall provide all necessary adapters and/or pipe connection pieces required when connecting different types and sizes of pipe or when connecting pipe made by different manufacturers. Earthwork CONTRACTOR shall weld flanges to existing Stainless Steel pipes in Phase II for connection of new HDPE pipe.

Q. HDPE pipe shall be jointed with butt fusion joints or eletro-fusion couplers. All joints shall be made in strict compliance with the pipe manufacturer's recommendations and ASTM D2657. Use of adhesives or solvents in the joints will not be allowed.

R. Testing of the HDPE pipe after backfilling and compaction shall be required. Testing shall be performed by Earthwork CONTRACTOR and shall include pulling a test mandrel through the pipe, as specified in Section 306-1.2.12 of the SSPWC. This test will be used to ensure that the pipe has not been excessively deformed, crushed, or blocked during backfilling. Alternative test procedures will require approval by PROJECT MANAGER. Any corrections required due to test failure as evaluated by CQA CONSULTANT, shall be at Earthwork CONTRACTOR's sole expense.

END OF SECTION

SECTION 02751

HDPE GEOMEMBRANES

PART 1 GENERAL

1.01 SUMMARY

A. This Section describes the requirements for the manufacture, supply, installation, and quality assurance/quality control (QA/QC) of high density polyethylene (HDPE) geomembranes associated with the construction of Phase III of Landfill Unit B-18 at the Kettleman Hills Facility.

B. The following two types of HDPE geomembranes shall be used for the Project:

1. 60-mil double-sided textured HDPE geomembrane shall be used for the primary and secondary geomembranes in the Phase III composite sideslope base liner system.

2. 40-mil smooth HDPE geomembrane for the protective cover shall be used for:

   i. White protective liner for the Phase III composite sideslope liner system.

   ii. The liner for the South Stormwater Containment Basin.

1.02 RELATED SECTIONS

A. Section 1300 - Submittals.

B. Section 02200 - Earthworks.

C. Section 02752 - Geotextiles.

D. Section 02774 - Geocomposite.

1.03 REFERENCES

A. "Construction Quality Assurance (CQA) Plan for Landfill Unit B-18, Phase III Construction, Kettleman Hills Facility, Kettleman City, California," prepared by Golder Associates Inc., Revision 1, dated February 2010.

B. Latest version of the following American Society for Testing and Materials (ASTM) standards:

1. ASTM D792 - Specific Gravity (Relative Density) and Density of Plastics by Displacement.

2. ASTM D1004 - Test Method for Initial Tear Resistance of Plastic Film and Sheeting.

3. ASTM D1238 - Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer.
4. ASTM D1505 - Test Method for Density of Plastics by the Density-Gradient Technique.
5. ASTM D1603 - Test Method for Carbon Black in Olefin Plastics.
6. ASTM D3895 - Test Method for Oxidative Induction Time of Polyolefins by Thermal Analysis.
7. ASTM D4218 - Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique.
8. ASTM D4833 - Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products.
9. ASTM D5199 - Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes.
10. ASTM D5321 - Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method.
11. ASTM D5397 - Procedure to Perform a Single Point Notched Constant Tensile Load – (SP-NCTL) Test: Appendix.
12. ASTM D5596 - Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics.
13. ASTM D5721 - Practice for Air-Oven Aging of Polyolefin Geomembranes.
14. ASTM D5885 - Test Method of Oxidative Induction Time of Polyolefin Geosynthetics by High Pressure Differential Scanning Calorimetry.
15. ASTM D5994 - Test Method for Measuring the Core Thickness of Textured Geomembranes.
16. ASTM D6693 - Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes.
17. ASTM D7238 - Test Method for Effect of Exposure of Unreinforced Polyolefin Geomembrane Using Fluorescent UV Condensation Apparatus.
18. ASTM D7466 - Test Method for Measuring the Asperity Height of Textured Geomembranes.

C. Latest version of the following Geosynthetic Research Institute (GRI) standards:

1. GM10 - The Stress Crack Resistance of HDPE Geomembrane Sheet.
2. GM13 - Test Methods, Test Properties and Testing Frequency for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes.

1.04 PRE-QUALIFICATION

A. The Geosynthetic CONTRACTOR shall pre-qualify for geomembrane installation by providing the following documentation:

1. The Geosynthetic CONTRACTOR shall have a minimum of 10,000,000 square feet (sf) of polyethylene geomembrane cumulative installation experience.
2. The Geosynthetic CONTRACTOR shall provide at least three references from prior geomembrane installation projects in excess of 500,000 sf including the following information:
    a. Client's name, address, phone number, and contact/representative's name.
    b. Project site name, location, and description.
    c. Geomembrane type and quantity installed.

1.05 SUBMITTALS

A. Submittals shall be provided in general accordance with Section 01300.

B. <u>HDPE Resin</u>: Furnish the following in writing to the CQA CONSULTANT a minimum of 7 calendar days prior to geomembrane shipment to the site:

1. Statement of production dates and origin of resin used to manufacture the geomembrane for the Project.
2. Certification stating all resin is from the same Manufacturer and that no reclaimed polymer was added to the resin during the manufacturing of the geomembrane and that recycled polymer does not exceed 2 percent by weight.
3. Copies of the quality control certificates issued by the Manufacturer and resin supplier indicating that the resin used to manufacture the geomembrane meets the requirements of these Specifications. These certifications shall contain manufacturing quality control test results, including specific gravity (ASTM D792 or D1505) and melt index (ASTM D1238, Condition E).

C. <u>Manufacturing Quality Control</u>: A copy of the Manufacturer's quality control program shall be submitted to the CQA CONSULTANT a minimum of 7 calendar days prior to geomembrane shipment to the site. Quality control testing shall be performed by the Manufacturer in accordance with GRI-GM13 and as approved by the CQA CONSULTANT. Prior to delivery, the following shall be submitted to the CQA CONSULTANT for review:

1. Certificates for each shift's production of geomembrane.
2. Copies of quality control certificates issued by the Manufacturer. The quality control certificates shall include:
    a. Roll numbers, lot numbers, and identification;
    b. Sampling procedures; and
    c. Results of quality control tests, including descriptions of the test methods used.
3. The results of the manufacturing quality control tests shall meet or exceed the property values listed in Table 02751-1.

4. Geomembrane delivery, storage, handling, and installation instructions.
5. Extrudate Beads and/or Rod:
    a. Statement of production dates.
    b. Certification stating all extrudate is from one Manufacturer, is the same resin type, and was obtained from the same resin supplier as the resin used to manufacture the geomembrane rolls.
    c. Copies of quality control certificates issued by the Manufacturer including test results for specific gravity (ASTM D792 or D1505) and melt index (ASTM D1238, Condition E).

D. Geomembrane Installer: Prior to mobilization of the Geosynthetic CONTRACTOR to the site, the following information shall be submitted:

1. Shop drawings indicating panel layout and field seams at least 14 calendar days prior to installation of geomembrane.
2. Installation schedule.
3. Copy of Geosynthetic CONTRACTOR's letter of approval or license by the geomembrane Manufacturer.
4. Installation capabilities, including:
    a. Information on equipment proposed for the Project;
    b. Average daily production anticipated for the Project; and
    c. Quality control procedures.
5. Copy of the geomembrane Manufacturer's quality control/quality assurance program.
6. Resume of the Field Superintendent to be assigned to the Project, including dates and duration of employment.
7. Resumes of all personnel who will perform seaming operations on the Project, including dates and duration of employment.
8. The geomembrane installation crew shall have the following experience:
    a. The Field Superintendent shall have supervised the installation of a minimum of 2,000,000 sf of polyethylene geomembrane.
    b. The Master Seamer shall have seamed a minimum of 1,000,000 sf of polyethylene geomembrane using the same type of seaming apparatus to be used for the Project.
    c. All other seaming personnel shall have seamed at least 100,000 sf of polyethylene geomembrane using the same type of seaming apparatus to be used for the Project. Personnel who have seamed less than 100,000 sf of polyethylene geomembrane shall be allowed to seam only under the direct supervision of the Master Seamer or Field Superintendent.

E. During the installation, the Geosynthetic CONTRACTOR shall be responsible for the timely submission to the CQA CONSULTANT of subgrade acceptance certificates, signed by the Geosynthetic CONTRACTOR, for each area to be covered by geomembrane.

F. The Geosynthetic CONTRACTOR shall furnish the OWNER upon completion of the Project:

1. A warranty provided by the Manufacturer against defects in material. Warranty conditions concerning limits of liability shall be evaluated and must be acceptable to the OWNER.

2. A 1-year warranty provided by the Geosynthetic CONTRACTOR against defects in workmanship. Warranty conditions concerning limits of liability shall be evaluated and must be acceptable to the OWNER.

3. As-built panel drawings in compliance with Section 01052.

G. Certificate of calibration less than 12 months old shall be submitted prior to installation for all field tensiometers to be used for the Project.

1.06 QUALITY ASSURANCE

A. Perform work in accordance with Section 01400, Section 01410, the Geosynthetic CONTRACTOR'S Quality Control Program, and the Project's CQA Plan.

PART 2 PRODUCTS

2.01 MATERIALS

A. The geomembrane shall be comprised of high density polyethylene (HDPE) material as indicated on the Drawings, manufactured of new, first-quality products designed and manufactured specifically for the purpose of liquid containment in hydraulic structures.

B. The geomembrane shall be produced free of holes, blisters, undispersed raw materials, or any sign of contamination by foreign matter. Any such defect shall be repaired in accordance with the repair procedures in Item 3.06 of this Section.

C. The geomembrane shall be manufactured with a minimum 15.0-foot seamless width. There shall be no factory seams.

D. The geomembrane shall be either HDPE 60-mils thick and textured on both sides or HDPE 40-mils thick and smooth on both sides, as indicated on the Drawings. White liner shall be provided for the protective cover.

E. The geomembrane shall be supplied in rolls. Folds shall not be permitted.

F. Requirements for the HDPE geomembrane properties are presented in Table 02751-1..

G. Resin:

1. Shall be HDPE, new, first-quality, compounded and manufactured specifically for producing HDPE geomembrane.
2. Do not intermix resin types.
3. Shall meet the following additional requirements:

Property	Test Method	Minimum Test Frequency	Required
Specific Gravity[(1)]	ASTM D792, Method B or ASTM D1505	1 per resin batch	≥ 0.932
Melt Index	ASTM D1238, Condition E	1 per resin batch	≤ 1.0 g per 10 minutes
Note: (1) Resin without carbon black			

H. Extrudate Rod or Bead:

1. Shall be made from same resin as the geomembrane.
2. Additives shall be thoroughly dispersed.
3. Shall be free of contamination by moisture or foreign matter.
4. Shall meet the following requirements:

Property	Test Method	Minimum Test Frequency	Required
Specific Gravity	ASTM D792, Method B or ASTM D1505	1 per resin batch	≥ 0.940
Carbon Black Content	ASTM D1603	1 per resin batch	2.0 - 3.0%
Melt Index	ASTM D1238, Condition E	1 per resin batch	≤ 1.0 g per 10 minutes

2.02 DELIVERY, STORAGE, AND HANDLING

A. Handling, storage, and care of the geomembrane following transportation to the site shall be the responsibility of the Geosynthetic CONTRACTOR. The Geosynthetic CONTRACTOR shall be liable for all damage to the materials incurred prior to final acceptance of the liner system by the CQA CONSULTANT and OWNER.

B. Conform to the Manufacturer's requirements to prevent damage to the geomembrane.

C. Delivery:

1. Deliver materials to the site only after the CQA CONSULTANT and the OWNER approve all of the required submittals.
2. All rolls of geomembrane delivered to the site shall be identified at the factory with the following:
    a. Manufacturer's name.

b. Product identification and thickness.

c. Lot number.

d. Roll number.

e. Roll dimensions and weight.

3. Separate damaged rolls from undamaged rolls and store at locations designated by the OWNER until proper disposition of material is determined by the OWNER and CQA CONSULTANT.

4. The OWNER shall be the final authority regarding damage.

5. Separate rolls without proper documentation and store until CQA CONSULTANT and OWNER approval is received.

D. On-Site Storage:

1. Store in space allocated by the OWNER.

2. Protect from puncture, dirt, grease, water, moisture, mud, mechanical abrasions, excessive heat, and any other damage.

3. Store on a level prepared surface (not on wooden pallets).

4. Stack per Manufacturer's recommendations but no more than three rolls high.

E. On-Site Handling:

1. Use appropriate handling equipment to load, move, or deploy geomembrane rolls. Appropriate handling equipment includes cloth chokers and spreader bar for loading and spreader and roll bars for deployment. Dragging panels on the ground surface shall not be permitted.

2. Do not fold geomembrane material; folded material shall be rejected.

3. The Geosynthetic CONTRACTOR is responsible for storage and transporting material from the storage area to the work area.

F. Damaged Geomembrane:

1. Geomembrane damage shall be documented by the CQA CONSULTANT.

2. Damaged geomembrane shall be repaired, if possible, in accordance with this Section or shall be replaced at no additional cost to the OWNER.

2.03 EQUIPMENT

A. Welding equipment and accessories shall meet the following requirements:

1. Equipped with gauges showing temperatures both in apparatus and at nozzle (extrusion welders) or at wedge (fusion welders).

2. Maintain adequate number of welding machines to avoid delaying the Work.

3. Use power source(s) capable of providing constant voltage under combined-line load.

4. Provide secondary containment to catch spilled fuel under electric generators, if located on geomembrane.

B. Provide calibrated tensiometer(s) capable of quantitatively measuring geomembrane seam strength:

1. Equipped with gauge accurate to ± 2 lbs per inch of geomembrane width and capable of pulling at 2 inches per minute and 20 inches per minute.
2. Provide one-inch wide die for cutting test specimens.
3. Provide a certificate of calibration for each tensiometer showing that each tensiometer has been calibrated within the past 12 months.

PART 3 EXECUTION

3.01 EXAMINATION

A. The Geosynthetic CONTRACTOR shall document in writing that the surface upon which the geomembrane will be installed is acceptable. In so doing, the Geosynthetic CONTRACTOR shall assume full liability for the accepted surface.

B. The beginning of geomembrane installation means acceptance of existing conditions. The Geosynthetic CONTRACTOR shall be responsible for maintenance of the geomembrane-covered subgrade once installation of geomembrane begins.

3.02 PREPARATION

A. Maintain the surface suitability and integrity until the lining installation is completed and accepted.

B. Repair rough areas and any damage to the subgrade caused by installation of the lining and fill any ruts in subgrade caused by equipment prior to geomembrane deployment.

C. To avoid sharp bends in the geomembrane, bevel the leading edges of the anchor trenches.

D. Subgrade shall be smooth, uniform, firm, and free of rocks or other debris. For deployment over soil subgrade, the subgrade shall not contain any protrusions that are greater than 0.25 inches in height from the finished subgrade surface.

3.03 DEPLOYMENT

A. Geomembrane shall not be deployed:

1. During precipitation.
2. In the presence of excessive moisture.
3. In areas of ponded water.
4. In the presence of excessive winds (i.e., greater than 20 mph).
5. In excessive heat (i.e., greater than 110° F) or cold (i.e., less than 40°F), unless the Geosynthetic CONTRACTOR is able to demonstrate (i.e., through trial

seams) to the satisfaction of the CQA CONSULTANT that acceptable welds can be made in these temperatures. See Items 3.04.O and 3.04.P of this Section for cold weather and hot weather seaming procedures, respectively.

B. Each panel shall be marked with an "identification code" (number and/or letter) consistent with the layout plan. The identification code shall be simple and logical. The number of panels deployed in one day shall be limited by the number of panels which can be seamed on that same day. All deployed panels shall be seamed to adjacent panels by the end of each day.

C. The following is the acceptable method of deployment:

1. Use equipment which will not damage geomembrane by handling, trafficking, leakage of hydrocarbons, or any other means.
2. Do not allow personnel working on geomembrane to wear damaging shoes or engage in activities that could damage geomembrane.
3. Smoking on the geomembrane is prohibited.
4. Round sharp corners of clamps and other metal tools used in the work area.
5. Do not allow clamps and other metal tools to be tossed or thrown.
6. Unroll panels using a method that protects geomembrane from scratches and crimps and protects the soil surface and any underlying geosynthetics from damage.
7. Use a method to minimize geomembrane wrinkles, especially differential wrinkles between adjacent panels.
8. Place adequate hold-downs to prevent uplift by wind.
9. Use hold-downs that will not damage geomembrane (such as sandbags).
10. Use continuous hold-downs along leading edges to minimize risk of wind flow under panels.
11. Panels shall be deployed perpendicular to slope elevation contours and the number of seams shall be minimized.
12. Protect geomembrane in heavy traffic areas by geotextile, extra geomembrane, or other suitable materials.
13. Vehicular traffic shall not be allowed on the geomembrane.
14. Panels deployed on grades steeper than 12% shall extend a minimum of 3 feet beyond the crest or toe of that grade.
15. Shingle or overlap panels in a downward direction to facilitate drainage.
16. Rub sheets used during installation shall be removed prior to placement of subsequent panels.

D. Visually inspect sheet surface during unrolling of geomembrane and mark faulty or suspect areas for repair or testing. Replace faulty (requires more than one patch per 200 square feet) geomembrane stock at no additional cost to the OWNER.

3.04 FIELD SEAMING

A. Orient seams perpendicular to slope elevation contours, i.e., orient down (not across) slope and use seam numbering system compatible with panel number system.

B. Minimize the number of field seams, especially in corners, odd-shaped geometric locations, sumps, and outside corners.

C. Overlap panels by a minimum of 3 inches for extrusion welding and 4 inches for fusion welding. Use procedures to temporarily bond adjacent panels together that do not damage the geomembrane and that are not detrimental to the material to be seamed.

D. Do not use solvents or adhesives unless product is approved in writing by the OWNER.

E. For the base liners, no horizontal seams shall be allowed on grades steeper than 12% or within 3 feet of the crest or toe of slopes. A horizontal seam is defined as more than half of the panel width.

F. Clean geomembrane surface of grease, moisture, dust, dirt, debris, or other foreign material prior to welding.

G. Prior to any extrusion welding, the geomembrane seam or repair shall be prepared as follows:

1. Clean surface of oxidation by disc grinder or equivalent not more than ½ hour before seaming; use number 80 grit sandpaper for the disc grinder. Bevel edges of geomembrane before bonding and provide continuous tacking in repair areas.
2. Repair area where excessive grinding substantially reduces sheet thickness by more than 4 mils beyond extent of weld.
3. Clean grinding dust around weld area after grinding.
4. The following procedure shall be followed for wrinkles and fishmouths:
    a. Cut along the ridge of the wrinkle or fishmouth.
    b. Overlap a minimum of 3 inches and weld.
    c. Any portion where the overlap is less than 3 inches shall be patched with an oval or round patch of geomembrane that extends a minimum of 6 inches beyond the cut in all directions.
5. If required, a firm, dry substrate (piece of geomembrane or other material) may be placed directly under the seam overlap to achieve proper support.
6. Keep water from intercepting the weld during and immediately after welding the seam.
7. For existing welds, or welds that are over 3 minutes old, grind the existing weld two inches back from point of termination and restart welding on ground weld.

H. At least one spare operable seaming apparatus shall be maintained for every three seaming teams. Place protective fabric or piece of geomembrane beneath hot welding apparatus when resting on geomembrane lining and use an electric generator capable of providing constant voltage under combined line load. The electric generator shall generally be located outside of the lined area. Provide protective lining and secondary containment large enough to catch spilled fuel under electric generators when located on the geomembrane. The welding apparatus shall be equipped with gauges giving temperatures in apparatus and at nozzle/wedge.

I. For extrusion welding, purge welding apparatus of heat-degraded extrudate before welding if extruder is stopped for longer than two minutes. All purged extrudate shall be disposed of off the geomembrane. Each extruder shoe shall be inspected daily for wear to assure that its offset is the same as the geomembrane thickness. Repair or replace worn shoes, damaged or misaligned armature brushes, nozzle contamination, or other worn or damaged parts. Avoid stop-start welding. Remove extrudate rod from welder when not using welder for long periods (over two hours). No welding may commence on the liner until the field trial seam sample made by that equipment and seamer passes destructive testing.

J. Test and set "hot air system" using scrap material at least each day prior to commencing seaming and adjust hot air velocity to preclude wind effects. Adjust contact pressure rollers to prevent surface ripples in sheet. No equipment shall be used for welding the geomembrane until a field trial seam sample made by that equipment and seamer has passed destructive testing.

K. In performing hot wedge welding, the welding machines shall be dual-tracked automated vehicular mounted devices equipped with gauges giving applicable temperatures and pressures. The edge of cross seams shall be ground to a smooth incline (top and bottom) prior to welding. A smooth insulating plate or fabric shall be placed beneath the hot welding apparatus after usage. Protect against moisture buildup between sheets. If welding across cross seams, conduct field trial seams at least every two hours.

L. Field trial seams shall be performed, per seaming apparatus and per seamer, on pieces of geomembrane to verify adequate seaming conditions at the following frequency:

1. At the beginning of each seaming period.
2. At least once every five hours.
3. At the discretion of the CQA CONSULTANT.

M. Make the trial seams at the work area and in contact with the soil subgrade or the geosynthetic component that the geomembrane will be deployed over (i.e., the same condition as the geomembrane to be seamed). The trial seam sample shall be at least 42-inches long and 12-inches wide with the seam centered lengthwise. A one-foot length of each trial seam sample shall be submitted to the CQA CONSULTANT for archive. Cut 1-inch wide specimens and test at least three for peel adhesion and two for bonded seam strength (shear). Specimens that will be subjected to peel and shear tests shall be selected alternately from the trial weld sample. Each double wedge welded seam specimen shall be tested for peel on both sides of the weld. A specimen passes when:

1. The break is film-tear bond (FTB), as defined in publication EPA/600/2-88/052 ("Lining of Waste Containment and Other Impoundment Facilities"), Appendix N.
2. The break is ductile.
3. The strength of breaks for the trial seam testing shall conform to the values listed in Table 02751-1, included at the end of this Section.

N. A trial seam sample passes when all specimens have passing results in peel and shear tests. If a specimen fails (one of the specimens fails in either peel or shear mode), the trial seam procedure shall be repeated in its entirety. If the repeated trial seam fails, the seaming apparatus or operator may not weld until the deficiencies or conditions are corrected and two consecutive passing field trial seams are achieved.

O. The following procedures shall by followed during cold weather conditions.

1. Geomembrane surface temperatures shall be determined by the CQA CONSULTANT at intervals of at lease once per 100 feet of seam length to determine if preheating is required. For extrusion welding, preheating is required if the surface temperature of the geomembrane is below 32°F.
2. For fusion welding, preheating may be waived by the OWNER based upon a recommendation by the CQA CONSULTANT, if the Geosynthetic CONTRACTOR demonstrates to the CQA CONSULTANT'S satisfaction that welds of equivalent quality may be obtained without preheating at the expected temperature of installation.
3. If preheating is required, the CQA CONSULTANT shall observe all areas of geomembrane that have been preheated by a hot air device prior to seaming to ensure that they have not been overheated.
4. Care shall be taken to confirm that the surface temperatures are not lowered below the minimum surface temperatures specified for welding due to winds or other adverse conditions. It may be necessary to provide wind protection for the seam area.
5. All preheating devices shall receive approval by the CQA CONSULTANT prior to use.
6. Additional destructive tests shall be taken at an interval between 250 and 500 feet of seam length, at the discretion of the CQA CONSULTANT.
7. Sheet grinding may be performed before preheating, if applicable.
8. Trial seaming shall be conducted under the same ambient temperature and preheating conditions as the production seams. Under cold weather conditions, new trial seams shall be conducted if the ambient temperature drops by more than 10°F from the initial trial seam test conditions. Such new trial seams shall be conducted upon completion of seams in progress during the temperature drop.

P. The following procedures shall be followed during hot weather conditions.

1. At ambient temperatures above 110°F, no seaming of the geomembrane shall be permitted unless the Geosynthetic CONTRACTOR can demonstrate to the satisfaction of the CQA CONSULTANT that the geomembrane seam quality is not compromised. Trial seaming shall be conducted under the same ambient

temperature conditions as the production seams. At the option of the CQA CONSULTANT, additional destructive testing may be required for any suspect areas.

3.05 FIELD QUALITY CONTROL

A. The Geosynthetic CONTRACTOR shall designate a full-time Quality Control (QC) Technician who shall be responsible for supervising and/or conducting the field quality control program. The QC Technician shall not be replaced without written authorization by the OWNER.

B. Non-Destructive Seam Testing

1. The Geosynthetic CONTRACTOR shall non-destructively test field welds for continuity over their full length. The non-destructive testing shall be performed concurrently with seaming work progress, not at the completion of all seaming. Any defects located in the seam shall be repaired in accordance with Item 3.06 of this Section. The following non-destructive testing procedures shall be used to test the field seams for continuity.

    a. Vacuum box testing for extrusion welds.

    b. Air pressure testing for dual-wedge fusion seams.

2. Vacuum Box Testing

    a. The vacuum box testing equipment shall consist of the following:

        i. Rigid housing; transparent viewing window; a soft rubber gasket attached to the bottom of the housing; porthole or valve assembly; and a vacuum gauge.
        ii. A vacuum pump capable of applying 5 psi gage pressure of vacuum to the box.
        iii. A bucket of soapy solution and applicator.

    b. The procedure for vacuum testing shall be as follows:

        i. Clean window, gasket surfaces, and check box assembly for leaks.
        ii. Energize vacuum pump and reduce tank pressure to approximately 5 psi.
        iii. Wet a strip of geomembrane seam approximately 12 inches by 30 inches (length of box) with soapy solution.
        iv. Place box over wetted area and compress.
        v. Close bleed valve and open vacuum valve.
        vi. Ensure that a leak-tight seal is created.
        vii. Examine length of weld through viewing window for presence of soap bubbles for a period of not less than 10 seconds.
        viii. If no bubbles appear after 10 seconds, close vacuum valve and open bleed valve, move box over next adjoining area with minimum three inches overlap from the previous tested area and repeat process.
        ix. Areas where soap bubbles appear shall be marked by the CQA CONSULTANT with a defect code. The Geosynthetic

CONTRACTOR shall then repair these areas in accordance with Item 3.06 of this Section and then retest the repaired area.

3. Air Pressure Testing (Dual-Wedge Fusion Seams Only)

   a. The air pressure testing equipment shall consist of the following:

      i. An air pump, equipped with pressure gauge having an accuracy of 1 psi, capable of generating and sustaining a pressure of 30 psi, and mounted on a cushion to protect the geomembrane.
      ii. Rubber hose with fittings and connections.
      iii. Sharp hollow needle or other pressure feed device approved by the OWNER.

   b. To perform the test:

      i. Seal both ends of the seam to be tested.
      ii. Insert a needle or other approved pressure feed device into air tunnel created by dual-wedge seaming and insert a protective cushion between air pump and underlying geomembrane.
      iii. Energize air pump to 28 to 30 psi, close valve, and sustain pressure for a minimum of 5 minutes.
      iv. If loss of air pressure in the tunnel exceeds 2 psi over 5 minutes or if this pressure does not stabilize, locate the faulty seam area and repair in accordance with Item 3.06 of this Section.
      v. Release pressure at opposite end of seam from gauge (i.e., by cutting the seam) to verify that the seam is not blocked.
      vi. Remove approved pressure feed device and seal penetration holes by extrusion welding.

C. Destructive Seam Testing

1. For destructive seam testing, the CQA CONSULTANT shall be provided with a minimum of one sample per 500 feet of seam length by each welding apparatus. The location shall be selected by the CQA CONSULTANT; the Geosynthetic CONTRACTOR shall not be informed of the destructive sample location in advance. The Geosynthetic CONTRACTOR shall visually observe, mark, and repair suspect welds before release of a section to the CQA CONSULTANT for destructive sample marking. Cut destructive samples as seaming and non-destructive testing progresses, prior to completion of geomembrane installation. The CQA CONSULTANT shall mark destructive samples with consecutive numbering, location, apparatus I.D., technician I.D., Engineer I.D., and apparatus settings and date. Record, in written form, weld and test date, time, location, seam number, ambient temperatures, machine settings, technician I.D., apparatus I.D., and pass or fail description. The Geosynthetic CONTRACTOR shall immediately repair holes in geomembrane resulting from obtaining destructive samples and shall vacuum test the resulting patches. The size of destructive samples shall be 12 inches wide by 44 inches long with the seam centered lengthwise.

2. Two 1-inch wide specimens shall be taken, one at each end of the sample, and tested by the Geosynthetic CONTRACTOR for peel and shear in the field prior

to CQA destructive testing. If any of these specimens fail, the Geosynthetic CONTRACTOR shall track the failure immediately. The remaining sample shall be cut into three 14-inch long by 12-inch wide pieces and distributed as follows:

a. To the CQA CONSULTANT for destructive testing.

b. To the CQA CONSULTANT for archive.

c. To the Geosynthetic CONTRACTOR for its use.

3. Ten 1-inch wide specimens shall be taken from one piece. Five specimens shall be tested for peel and five for shear in accordance with the CQA Plan. Specimens that will be subjected to peel and shear tests shall be selected alternately from the sample. Each fusion wedge welded seam specimen shall be tested for peel on both sides of the weld. A destructive sample shall be considered passing when all 10 specimens meet the following criteria:

a. The break is FTB.

b. The break is ductile.

c. The strength of breaks for the trial seam testing shall conform to the values listed in Table 02751-1, included at the end of this Section.

4. In the event of sample failure, the procedures for failed seam tracking are:

a. Retrace welding path a minimum of 10 feet in both directions from the failed test location and remove (at these locations) a one inch wide specimen for testing. Repeat tracking procedures until the Geosynthetic CONTRACTOR is confident of seam quality.

b. Obtain destructive samples from each side of the welding path and give samples to the CQA CONSULTANT for destructive testing.

c. Repeat process if additional tests fail.

d. Reconstruct seam between passing test locations to the satisfaction of the CQA CONSULTANT.

e. Reconstruction may be one of the following:

i. Cut out old seam, reposition panel and re-seam.
ii. Add cap strip.

f. Cut additional destructive samples from reconstruction at discretion of CQA CONSULTANT.

g. If additional destructive sample results are not acceptable, repeat process until reconstructed seam is judged satisfactory by the CQA CONSULTANT.

D. For final seaming inspection, check the seams and surface of geomembrane for defects, holes, blisters, undispersed raw materials, or signs of contamination by foreign matter. Brush, blow, or wash geomembrane surface if dirt inhibits inspection.

The CQA CONSULTANT shall decide if cleaning of geomembrane surface and welds is needed to facilitate inspection. Distinctively mark repair areas and indicate required type of repair.

E. At the discretion of the OWNER, the 40-mil smooth HDPE geomembrane seams may not require non-destructive or destructive testing.

3.06 REPAIR PROCEDURES

A. The geomembrane shall be inspected before and after seaming for evidence of defects, holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter. The surface of the geomembrane shall be clean at the time of inspection. The geomembrane surface shall be swept or washed by the Geosynthetic CONTRACTOR if surface contamination inhibits inspection. The Geosynthetic CONTRACTOR shall ensure that an inspection of the geomembrane precedes any seaming of that section.

B. Remove damaged geomembrane and replace with acceptable geomembrane materials if damage cannot be satisfactorily repaired.

C. Repair, removal, and replacement shall be at the Geosynthetic CONTRACTOR'S expense.

D. Repair any portion of the geomembrane exhibiting a flaw, or failing a destructive or non-destructive test. The Geosynthetic CONTRACTOR shall be responsible for repair of damaged or defective areas. Agreement upon the appropriate repair method shall be decided between the CQA CONSULTANT and the Geosynthetic CONTRACTOR. Procedures available include:

1. Patching: Used to repair holes (over ¼-inch diameter), tears (over ¼-inch long), undispersed raw materials, and contamination by foreign matter.
2. Grinding and welding: Used to repair pinholes, blemishes, and over-grinding.
3. Capping: Used to repair large lengths of failed seams.
4. Removing the seam and replacing with a strip of new material.

E. In addition, the following procedures shall be observed:

1. Geomembrane surfaces to be repaired shall be abraded (extrusion welds only) no more than ½ hour prior to the repair.
2. All geomembrane surfaces shall be clean and dry at the time of repair.
3. The repair procedures, materials, and techniques shall be approved in advance of the specific repair by the CQA CONSULTANT.
4. Extend patches or caps at least 6 inches beyond the edge of the defect, i.e., be a minimum of 12 inches in diameter, and round all corners of material to be patched.
5. Bevel the edge of the patch and do not cut patch with repair sheet in contact with geomembrane. Temporary bond the patch to the geomembrane with an approved method, extrusion weld the patch, and then vacuum test the repair.

F. Repair Verification:

1. The CQA CONSULTANT shall number and log each repair.
2. Non-destructively test each repair using methods specified in this Section.
3. Provide daily documentation of non-destructive and destructive testing to the CQA CONSULTANT. The documentation shall identify seams that initially failed testing and include any evidence that these seams were repaired and retested successfully.

3.07 ACCEPTANCE

A. The Geosynthetic CONTRACTOR shall retain ownership and responsibility for the geomembrane until acceptance by the OWNER.

B. Acceptance Criteria: The following shall be completed:

1. Verification of adequacy of field seams, repairs, and testing by the CQA CONSULTANT.
2. All submittals.
3. "As-built" drawings approved and final drawings submitted.
4. Construction area cleaned.
5. Final field inspection.
6. Warranty signed over to the OWNER.

C. Field Inspections: Inspect the completed work with the OWNER; defects, wrinkles, suspicious looking welds shall be noted and marked; document, correct, and arrange further field inspections until no further corrective action is necessary.

TABLE 02751-1
REQUIRED PHYSICAL PROPERTIES OF 40- and 60-MIL HDPE GEOMEMBRANE

PROPERTY	METHOD	VALUE	
		60 mil Textured HDPE	40 mil Smooth HDPE
Thickness, mil	ASTM D 5994	- 57 mils minimum average - 54 mils lowest individual value for 8 out of 10 specimens - 51 mils lowest individual value for any of the 10 specimens	- 36 minimum average
Sheet Density (min. avg.)	ASTM D 792 or ASTM D 1505	0.940 g/cc	0.940
Asperity Height, mil(1)	ASTM D7466	- 10 mils minimum average - 8 of 10 readings ≥ 7 mils - lowest individual reading ≥ 5 mils	Not Applicable (N/A)
Tensile Properties (min. avg.)(2) • Tension at Yield (lb/in) • Strain at Yield (%) • Tension at Break (lb/in) • Strain at Break (%)	ASTM D6693 Type IV	126 lb/in 12% 90 lb/in 100%	84 lb/in 12% 60 lb/in 100%
Tear Resistance, lbs. (min. avg.)	ASTM D1004, Die C	42 lbs	28 lbs
Oxidative Induction Time (OIT) (min. avg.) • Standard OIT, or • High Pressure OIT	ASTM D3895 ASTM D5885	100 minutes 400 minutes	100 minutes 400 minutes
Oven Aging at 85°C (min. avg.) • Standard OIT (min. avg.), % retained after 90 days, or • High Pressure OIT (min. avg.), % retained after 90 days	ASTM D5721 ASTM D3895 ASTM D5885	55% retained after 90 days 80% retained after 90 days	55% retained after 90 days 80% retained after 90 days
UV Resistance (min. avg.) • High Pressure OIT (min. avg.), retained after 1,600 hr	GRI-GM11 ASTM D5885	50% retained after 1,600 hours	50% retained after 1,600 hours
Stress Crack Resistance (min.)(3)	ASTM D5397 (Appendix)	300 hours with no failures	300 hours with no failures
Puncture Resistance, lbs. (min. avg.)	ASTM D4833	90 lbs	60 lbs
Carbon Black Content (range)	ASTM D1603	2.0 – 3.0%	N/A
Carbon Black Dispersion	ASTM D5596	- min 9 out of 10 specimens in Cat. 1 or 2 - all in Cat. 1, 2, or 3	N/A
Seam Strength (min. avg.) • Peel (lb/in) • Shear (lb/in)	ASTM D6392	90 lb/in 120 lb/in	60 lb/in 80 lb/in

Notes:
(1) Alternate the measurement side for double-sided textured sheets.
(2) Elongation at yield and elongation at break shall be calculated using a gage length of 1.3 inches and 2.0 inches, respectively.
(3) Test is not applicable for textured geomembranes. Test should be performed on the smooth edges of textured rolls or on smooth rolls made from same formulation as textured rolls.

END OF SECTION

SECTION 02752

GEOTEXTILES

PART 1 GENERAL

1.01 DESCRIPTION

A. This section describes the general requirements for the manufacture, supply, installation, and quality control (QC) of geotextiles.

1.02 RELATED SECTIONS

A. Section 02200 – Earthwork

B. Section 02751 – HDPE Geomembranes

1.03 REFERENCES

A. Latest version of the following American Society for Testing and Materials (ASTM) standards:

1. ASTM D4355. Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus.

2. ASTM D4632. Standard Test Method for Breaking Load and Elongation of Geotextiles (Grab Method).

3. ASTM D4833. Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.

4. ASTM D4873. Standard Guide for Identification, Storage, and Handling of Geotextiles.

5. ASTM D5199. Standard Test Method for Measuring Geotextiles.

6. ASTM D5261. Standard Test Method for Measuring Mass Per Unit Area of Geotextiles.

1.04 SUBMITTALS

A. Quality Control Submittals:

1. A copy of the manufacturer's quality control (QC) plan.

2. Manufacturing QC certificates for each production run. The certificates shall identify the origin and the manufacturer of the resin. The certificates shall be signed by responsible parties employed by the manufacturer (such as the production manager). Tests shall be performed at the frequency indicated in the manufacturer's QC Plan.

3. The QC certificates shall include roll numbers and identification, sampling procedures, and results of quality control tests verifying that each of the properties

listed in Table 02752-1 is met. Samples shall be tested at a minimum frequency of once every 100,000 sf. The manufacturer quality control tests to be performed include the tests specified in Article 2.01 of this section.

4. Manufacturer's certification that the geotextile products meet or exceed specified requirements and are 100% free of needles.

B. The Geosynthetic CONTRACTOR shall submit the following.

1. Installation plan; and

2. Proposed seam stitching methods.

C. Submittals shall be in accordance with Section 01300.

1.05 QUALITY ASSURANCE

A. Perform work in accordance with the CQA Plan.

1.06 QUALIFICATIONS

A. Geotextile shall be supplied by a geotextile manufacturer meeting the following qualification requirements:

1. The geotextile manufacturer shall be responsible for the production and delivery of geotextile rolls and shall be a well-established firm with more than two years experience in the manufacture of geotextiles. The geotextile manufacturer shall submit a statement to the CQA CONSULTANT listing:

a. Certified minimum average roll property values of the proposed geotextiles and the test methods used to determine those properties.

b. Projected delivery date of the material for this project.

B. The Geosynthetic CONTRACTOR shall meet the requirements of the CQA Plan.

PART 2 PRODUCTS

2.01 MATERIALS

A. Non-woven geotextiles shall have the following minimum average roll value (MARV) properties:

TABLE 02752-1

REQUIRED PHYSICAL PROPERTIES OF GEOTEXTILE

Fabric Property	ASTM Test Method	Manufacturer QC Test Frequency (1)	Required Test Values
Mass Per Unit Area (min. ave.)	D5261	1 per 100,000 sf	12 oz/sy
Grab Strength (min. ave.)	D4632	1 per 100,000 sf	300 lbs
Puncture Strength (min. ave.)	D4833	1 per 100,000 sf	150 lbs
UV Resistance (min.)	D4355	1 per resin formulation	70 percent (2)

Notes: (1) Manufacturer may elect to provide certification of values for geotextiles.
(2) After 500 hours of exposure.

B. Geotextile shall be non-woven, needle-punched polyester or polypropylene fabric free from needles or other foreign material.

2.02 DELIVERY, STORAGE, AND HANDLING

A. Handling, storage, and care of the geotextiles following transportation to the site shall be the responsibility of the CONTRACTOR. The CONTRACTOR shall be liable for all damage to the materials incurred prior to final acceptance of the liner system by the CQA CONSULTANT.

B. The CONTRACTOR shall be responsible for storage of the geotextile at the site after the material is delivered. The geotextile shall be stored off the ground and out of direct sunlight, and shall be protected from mud, dirt, dust, and any additional storage procedures required by the Geotextile manufacturer.

C. All rolls of geotextile shall be identified at the factory with the following:

1. Manufacturer's name
2. Product identification
3. Lot Number
4. Roll number
5. Roll dimensions

D. Geotextiles shall be handled in a manner as to ensure they are not damaged in any way.

E. Precautions shall be taken to prevent damage to underlying materials during placement of the geotextile.

F. After unwrapping the geotextile from its cover, the geotextile shall not be left exposed for a period in excess of 30 days.

PART 3 EXECUTION

3.01 INSTALLATION

A. Geotextile seams shall be continuously sewn or heat bonded. Geotextile seams shall be overlapped a minimum of 6 inches prior to sewing. No horizontal seams shall be allowed on slopes steeper than 5 horizontal to 1 vertical.

B. Polymeric thread, with chemical resistance properties equal to or exceeding those of the geotextile, shall be used for all sewing. The seams shall be sewn using Stitch Type 401. The seam type shall be Federal Standard Type SSa-1.

C. The CONTRACTOR shall examine the entire geotextile surface after installation to ensure that no potentially harmful foreign objects are present. Such foreign objects shall be removed and damaged geotextile shall be repaired or replaced at no cost to OWNER.

D. Use care not to damage underlying materials during installation.

E. Prevent the geotextile from accumulating excessive dust.

F. The CONTRACTOR shall be responsible for field handling, storing, deploying, seaming or connecting, temporary restraining (against wind), anchoring, and other aspects of geotextile installation. Specifically, the CONTRACTOR shall follow the guidelines in ASTM D4873 regarding the placement, handling and storage or geotextiles.

G. The CONTRACTOR shall accept and retain full responsibility for all materials and installation and shall be held responsible for any defects in the completed system.

H. No equipment shall operate directly on the geotextile.

I. Use sandbags or other acceptable anchorage to prevent wind uplift.

3.02 REPAIRS

A. Any holes or tears in the geotextile shall be repaired using a geotextile patch consisting of the same geotextile.

1. On slopes inclined steeper than 10 horizontal to 1 vertical, patches shall be sewn into place with a minimum 6-inch overlap.

2. On slopes inclined at 10 horizontal to 1 vertical or less, patches may be heat-bonded with a 6-inch overlap in all directions.

END OF SECTION

SECTION 02774

GEOCOMPOSITE

PART 1 GENERAL

1.01 DESCRIPTION

A. This section describes the general requirements for the manufacture, supply, installation, and quality control (QC) of geocomposite.

1.02 RELATED SECTIONS

A. Section 02200 - Earthworks

B. Section 02751 - HDPE Geomembranes

C. Section 02752 – Geotextiles

1.03 REFERENCES

A. Latest version of the following American Society for Testing and Materials (ASTM) standards:

1. ASTM D413. Standard Test Method for Rubber Property-Adhesion to Flexible Substrate

2. ASTM D792. Test Method for Specific Gravity and Density of Plastics by Displacement

3. ASTM F904. Standard Test Method for Comparison of Bond Strength or Ply Adhesion of Similar Laminates Made from Flexible Materials

4. ASTM D1238. Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer

5. ASTM D1505. Standard Test Method for Density of Plastics by Density - Gradient Technique

6. ASTM D1603. Test Method for Carbon Black in Olefin Plastics

7. ASTM D3786. Standard Text Method for Hydraulic Bursting Strength of Knitted Goods and Non-woven Fabrics: Diaphragm Bursting Strength Test Method

8. ASTM D4491. Standard Test Methods for Water Permeability of Geotextiles by Permittivity

9. ASTM D4533. Standard Test Method for Trapezoid Testing Strength of Geotextiles

10. ASTM D4632. Standard Test Method for Breaking Load and Elongation of Geotextiles (Grab Method)

11. ASTM D4716. Standard Test Method for Constant Head Hydraulic Transmissivity (in-plane flow) of Geotextiles and Geotextile Related Products

12. ASTM D4751. Standard Test Method for Determining Apparent Opening Size of a Geotextile

13. ASTM D4833. Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products

14. ASTM D5199. Standard Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes

15. ASTM D5261. Standard Test Method for Weight (Mass) Per Unit Area of Geotextiles

1.04 SUBMITTALS

A. Geosynthetic CONTRACTOR shall submit to the CQA CONSULTANT the following documentation on the raw materials used to manufacture the geocomposite:

1. Quality control certificates issued by the raw material supplier including the production dates of the raw material used to manufacture geocomposite for the project.

2. Results of tests conducted by the manufacturer to verify the quality of the resin used to manufacture the geocomposite rolls assigned to the project and the origin of the resin and quality control certificates issued by the resin supplier.

3. Certification that no reclaimed polymer was used in the manufacturing of the geocomposite to be used for the project and that recycled material reworked from the manufacturing process does not exceed 10 percent by weight.

B. A copy of the manufacturer's Quality Control (QC) Program.

C. Quality control certificates for test results at the sampling frequency indicated by the manufacturer's QC Plan shall be submitted.

1. Manufacturing quality control certificates for each shift's production shall be signed by responsible parties employed by the manufacturer (such as the production manager).

2. The quality control certificates shall include:

a. Roll numbers and identification;

b. Sampling procedures; and

c. Results of the quality control tests verifying each of the properties listed in Table 02774-1.

D. Submittals shall be provided in general accordance with Section 01300.

1.05 QUALITY ASSURANCE

A. Perform work in accordance with manufacturer's instructions and the CQA Plan.

1.06 QUALIFICATIONS

A. Manufacturer shall be a well-established firm with more than two years of experience in the manufacture of geocomposites.

B. Geosynthetic CONTRACTOR shall meet the requirements of the CQA Plan.

PART 2 PRODUCTS

2.01 MATERIALS

A. The geocomposite to be used on the project shall comprise HDPE bi-planar geonet drainage material with a non-woven, needle-punched geotextile bonded to the top and bottom. The geotextile will be thermally bonded to the geonet component of the geocomposite. Chemical bonding is not allowed.

B. Geocomposite shall meet the minimum properties listed in Table 02774-1.

2.02 DELIVERY, STORAGE, AND HANDLING

A. The Geosynthetic CONTRACTOR shall be responsible for handling, storage, and care of the geocomposites following transportation to the site. The Geosynthetic CONTRACTOR shall be liable for all damage to the materials incurred prior to final acceptance of the liner system by the CQA CONSULTANT.

B. The geocomposite shall be stored off the ground and out of direct sunlight, and shall be protected from mud, dirt, dust, and any additional storage procedures required by the manufacturer.

C. All rolls of geocomposite shall be identified at the factory with the following:

1. Manufacturer's name
2. Product identification
3. Lot Number
4. Roll number
5. Roll dimensions

D. The geocomposites shall be handled in such a manner as to ensure they are not damaged in any way.

E. Precautions shall be taken to prevent damage to underlying layers during placement of the geocomposite.

F. After unwrapping the geocomposite from its cover, the geocomposite shall not be left exposed for a period in excess of 30 days.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that other work is complete over the areas where the geocomposite is to be deployed.

3.02 PREPARATION

A. Protect elements surrounding the work of this section from damage.

3.03 INSTALLATION

A. The geocomposite shall be installed in accordance with the manufacturer's recommended procedures and the CQA Plan.

B. The CQA CONSULTANT shall verify that all geocomposite rolls and underlying layers are free from deleterious material or debris prior to the geocomposite deployment. Dirt entrapped in the geocomposite following deployment shall be cleaned or affected geocomposite removed and replaced prior to placement of successive layers.

C. The Geosynthetic CONTRACTOR is responsible for anchoring exposed geocomposite to protect against wind damage until subsequent layers are placed.

D. The geocomposite shall not be welded to the geomembrane unless specified otherwise.

E. The geocomposite shall only be cut utilizing methods and tools (i.e., a hooked utility blade) which will not damage the geocomposite.

F. The geonet component of the geocomposite shall be overlapped a minimum of 4 inches between adjacent panels and shall be fastened by nylon ties. Ties shall be yellow or white for easy inspection. No metallic materials are allowed. Ties shall be placed every 5 feet along the lengths of adjacent panels, every 6 in. across butt-seams, and every 6 in. in any anchor trench.

G. In general, butt-seams will only be allowed on grades less than 15%. Butt-seams shall be overlapped a minimum of two feet and be secured with two rows of ties a minimum of 6 in. apart. Ties shall be spaced at six inch intervals and staggered between rows.

H. The top geotextile component shall be overlapped a minimum of 6 in. and shall be continuously sewn. Leister seaming shall be allowed following a field demonstration of performance and approval by the Design Engineer.

I. Polymeric thread, with chemical resistance properties equal to or exceeding those of the geotextile, shall be used for all sewing. The seams shall be sewn using Stitch Type 401. The seam type shall be Federal Standard Type SSa-1.

J. The Geosynthetic CONTRACTOR shall be responsible for field handling, storing, deploying, seaming or joining, temporary restraining (against wind), anchoring, and other aspects of geocomposite installation.

K. The Geosynthetic CONTRACTOR shall accept and retain full responsibility for all materials and installation and shall be held responsible for any defects in the completed systems.

3.04 REPAIRS

A. Any defects observed in the geocomposite shall be brought to the attention of the CQA CONSULTANT.

B. Holes or tears in the geocomposite shall be repaired with geocomposite patches extending 2 feet beyond the edges of the hole or tear. The patch shall be secured in place by using approved ties spaced at 6 inches. The ties shall extend though the geonet component of the patch and through the geotextile and geonet components of the geocomposite requiring repair. The upper geotextile component of the patch shall be heat bonded to the geotextile component of the geocomposite requiring repair.

C. If only the upper geotextile is damaged, then it may be repaired by heat-bonding a geotextile patch of equal weight.

3.05 FIELD QUALITY CONTROL

A. Field inspection and testing shall be performed in accordance with the CQA Plan.

3.06 PROTECTION

A. Do not permit traffic over any of the Products related to this Section.

B. The CONTRACTOR shall place all soil materials in such a manner as to ensure that:

1. The geocomposite and underlying materials are not damaged;
2. Minimal slippage occurs between the geocomposite and the underlying geosynthetic layers; and
3. Excess tensile stresses are not developed in the geocomposite.

TABLE 02774-1
GEOCOMPOSITE PROPERTY VALUES

PROPERTY	UNITS	SPECIFIED VALUES	TEST METHOD
Geonet Component:			
Thickness	mils	200	ASTM D-751 or ASTM D-5199
Density	g/cc	0.940	ASTM D-792 or ASTM D-1505
Carbon Black Content (range)	%	2-3	ASTM D-1603
Geotextile Component:			
Mass	oz/yd^2	8	ASTM D-5261
Grab Tensile	Lb	220	ASTM D-4632
Puncture	Lb	120	ASTM D-4833
AOS	Mm	0.180	ASTM D-4751
Permeability	Sec^{-1}	1.5	ASTM D-4491
UV Resistance)	% retained after 500 hr.	70	ASTM D-4355
Finished Geocomposite:			
Transmissivity	m^2/sec	1 x 10^{-3} (see notes 1 and 2 below)	ASTM D-4716
Peel Strength	lb/in.	0.75	GRI GC7

Notes:

1. Required value shall be taken from manufacturer's standard material specification sheet for the selected geonet/geocomposite material. Geonet/geocomposite selection shall be based on the material's ability to meet or exceed the transmissivity identified in the site's design.

2. Transmissivity shall be measured in a 12-inch by 12-inch box with the geocomposite between steel plates under a normal stress of 15,000 psf and a hydraulic gradient of 0.1. A seating time of 15 minutes shall be used.

3. The geotextile component shall conform to the requirements contained in Section 02752 of these Specifications, except that the values listed in Table 02774-1 above take precedence over those in Section 02752.

END OF SECTION

APPENDIX O.2
FINAL CLOSURE SPECIFICATIONS

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TECHNICAL SPECIFICATIONS
LANDFILL UNIT B-18 FINAL CLOSURE
KETTLEMAN HILLS FACILITY
KETTLEMAN CITY, CALIFORNIA

Prepared for:

Waste Management, Inc.
Kettleman Hills Facility
35251 Old Skyline Road
Kettleman City, California 93239

Prepared by:

Golder Associates Inc.
230 Commerce, Suite 200
Irvine, California 92602

November 2008
Revision 0

Project No.: 083-91887

TABLE OF CONTENTS

SECTION 01010

SUMMARY OF WORK

PART 1 GENERAL

1.01 SUMMARY

A. The section describes the general requirements for the final closure construction of Landfill Unit B-18 at the Kettleman Hills Facility located outside of Kettleman City, California. The Work will consist of excavation, engineered fill placement, subgrade preparation, installation of a composite geosynthetic liner system, and placement of a vegetative cover soil layer.

1.02 CONTRACTOR'S RESPONSIBILITIES:

A. Start, lay out, construct, and complete the Project in accordance with the Contract Documents;

B. Provide a competent superintendent, capable of reading and understanding the Contract Documents, who shall receive instructions from the OWNER or his authorized representative. The superintendent shall have full authority to execute the Work in accordance with the Contract Documents;

C. The CONTRACTOR shall be responsible for transporting, permitting, and/or conveying all required construction water.

D. Pay costs of legally required sales, consumer, and use taxes, and governmental fees.

E. Forward submittals and communications to the CONSTRUCTION MANAGER. Where applicable, the CONSTRUCTION MANAGER will coordinate submittals and communications with the representatives who will give approvals and directions through the CONSTRUCTION MANAGER.

F. Maintain order, safe practices and proper conduct at all times among CONTRACTOR's employees. The OWNER, and its authorized representative, may require that disciplinary action be taken against an employee of the CONTRACTOR for disorderly, improper, and unsafe conduct. Should an employee of the CONTRACTOR be dismissed from his duties for misconduct, incompetence, or unsafe practice, or combination thereof, that employee should not be rehired for the duration of the Work.

G. Coordinate prosecution of the Work with the utilities, private utilities, or OWNER performing work on or adjacent to the work site; either eliminate, or minimize as far as possible, delays in the Work and conflicts with those utilities or contractors. Coordinate utility activities, and activities of OWNER, with the CONSTRUCTION MANAGER. Schedule private utility and public utility work relying on survey points, lines, and grades established by the CONTRACTOR to occur immediately after those points, lines and grades have been established. Confirm coordinate measures for each individual case with the CONSTRUCTION MANAGER by memorandum.

J. Coordinate activities of the several trades, suppliers, and subcontractors, if any, performing the Work.

K. Obtain all necessary building and construction permits. Permit fees will be paid by the OWNER.

1.03 RESERVED

1.04 CONFORMANCE

A. Work shall conform to the following Drawings that form a part of these Contract Documents.

SHEET NO.	TITLE
T-1	TITLE SHEET
C-1	SITE PLAN
C-2	EXISTING CONDITIONS (AS OF MARCH 28, 2008)
C-3	BASE LINER PLAN
C-4	FINAL CLOSURE PLAN
C-5	CROSS-SECTIONS A TO D
C-6	CROSS-SECTIONS E TO I
C-7	PHASE III BASE LINER CONSTRUCTION DETAILS
C-8	PHASE III LCRS DETAILS
C-9	DRAINAGE DETAILS
C-10	CLOSURE DETAILS

1.05 DEFINITIONS

OWNER	The term OWNER means Kettleman Hills Facility with whom the CONTRACTOR has entered into the Agreement and for whom the Work is to be provided.
CONSTRUCTION MANAGER	The term CONSTRUCTION MANAGER means the representative of the OWNER for the purpose of administration and inspection of the Work. The CONSTRUCTION MANAGER may be a member or group of the staff or may be an external firm. The OWNER will inform the CONTRACTOR in writing at the start of the Work who the CONSTRUCTION MANAGER will be. During the period of Work the CONSTRUCTION MANAGER will act as an authorized representative of the OWNER.
DESIGN ENGINEER	The term DESIGN ENGINEER means Golder Associates Inc., the firm responsible for the design and preparation of the construction drawings and specifications. The DESIGN ENGINEER is responsible for approving all design changes, modifications, or clarifications encountered during construction.

CQA CONSULTANT	The term CQA CONSULTANT means the representative of the OWNER for the purpose of conducting CQA testing, monitoring, documenting, and reporting.
CONTRACTOR	The term CONTRACTOR means the firm that is responsible prosecuting the Work. The CONTRACTOR's responsibilities include the Work of any and all subcontractors and suppliers.
Geosynthetics CONTRACTOR	The term Geosynthetics CONTRACTOR means the firm that is responsible for the supply and installation of all geosynthetics including the Work of all of the subcontractors and suppliers. The Geosynthetics Installer may work directly for the OWNER or as a subcontractor to the CONTRACTOR. The Geosynthetics CONTRACTOR is also referred to as the CONTRACTOR.
Work	The term Work means the entire completed construction or various separately identifiable parts, thereof, required to be furnished under the Contract Documents. Work includes any and all labor, services, materials, equipment, tools, supplies, and facilities required by the Contract Documents and necessary for the completion of the project. Work is the result of performing services, furnishing labor and furnishing and incorporating materials and equipment into the construction, all as required by the Contract Documents.
Working day	A calendar day, exclusive of Saturdays, Sundays, and OWNER's recognized legal holidays, on which weather and other conditions not under the control of the CONTRACTOR will permit construction operations to proceed for the major part of the day with the normal working force engaged in performing the controlling item or items of work which would be in progress at that time. The working day is subject to the conditions and work restrictions outlined in these Specifications.
Regular Working Hours	Between 6:30 a.m. and 6:00 p.m. on allowable work days.
Calendar Days	Each day of the year including all OWNER approved holidays.

1.06 CONTRACT TIMES

A. The CONTRACTOR shall commence Work in accordance with Section 18 of the General Conditions and Section 7 of the Standard Contract.

1.07 CONTRACTOR USE OF WORK SITE

A. Confine work site operations to areas permitted by law, ordinances, permits, and the Contract Documents. The CONTRACTOR shall ensure that all persons under his control (including Subcontractors, their workers and agents) are kept within the boundaries of the Site and shall be responsible for any acts of trespass or damage to property by persons who are under his control. Consider the safety of the Work, and that of people and property on and adjacent to work site, when determining amount, location, movement, and use of materials and equipment on work site.

B. The CONTRACTOR shall be responsible for protecting private and public property including pavements, drainage culverts, electricity, highway, telephone and similar property and making good of, or paying for, all damage caused thereto. Control of erosion throughout the project is of prime importance and is the responsibility of the CONTRACTOR. The CONTRACTOR shall comply with the requirements of the Storm Water Pollution Prevention Plan (SWPPP) provided by the OWNER for the Kettleman Hills Facility and prepare and submit a SWPPP specific to the Work in accordance with requirements of local or state agencies (see Section 01300). The CONTRACTOR shall provide and maintain all necessary measures to control erosion during progress of the Work to the satisfaction of the CONSTRUCTION MANAGER and all applicable Laws and Regulations and remove such measures and debris upon completion of the project. All provisions for erosion and sedimentation control apply equally to all areas of the Work.

C. CONTRACTOR shall promptly notify OWNER and CONSTRUCTION MANAGER in writing of any subsurface or latent physical conditions at the Site which differ materially from those indicated or referred to in the Contract Documents. CONSTRUCTION MANAGER will promptly review those conditions and advise OWNER in writing if further investigations or tests are necessary. Promptly thereafter, OWNER shall obtain the necessary additional investigations and tests and furnish copies to the CONSTRUCTION MANAGER and CONTRACTOR. If CONSTRUCTION MANAGER finds that the results of such investigations or tests indicate that there are subsurface and latent physical conditious which differ materially from those intended in the Contract Documents, and which could not reasonably have been anticipated by CONTRACTOR, a Change Order shall be issued incorporating the necessary revisions.

1.08 PRESERVATION OF SCIENTIFIC INFORMATION

A. Federal and State legislation provides for the protection, preservation, and collection of data having scientific, prehistoric, historical, or archaeological value (including relics and specimens) which might otherwise be lost due to alteration of the terrain as a result of any construction work.

B. If evidence of such information is discovered during the course of the Work, the CONTRACTOR shall notify the CONSTRUCTION MANAGER immediately, giving the location and nature of the findings. Written confirmation shall be forwarded within two (2) working days. The CONTRACTOR shall exercise care so as not to damage artifacts uncovered during excavation operations, and shall provide such cooperation and assistance as may be necessary to preserve the findings for removal or other disposition by the OWNER's representative or Government agency.

C. Where appropriate, by reason of a discovery, the OWNER may order delays in the time of performance, or changes in the Work, or both. If such delays, or changes, or both, are ordered, the time of performance and contract price shall be adjusted in accordance with the applicable clauses of the Contract.

1.09 EXISTING UTILITIES

A. The CONTRACTOR shall be responsible for locating, protecting, flagging, and identifying all existing utilities. The CONTRACTOR shall request that Underground Service Alert (USA) locate and identify the existing utilities. The request shall be made 48 hours in advance.

B. Costs resulting from damage to utilities shall be borne by the CONTRACTOR. Costs of damage shall include repair and incidental costs resulting from the unscheduled loss of utility service to affected parties.

C. The CONTRACTOR shall immediately stop work and notify the CONSTRUCTION MANAGER of all utilities encountered or damaged. The CONTRACTOR shall also provide the CONSTRUCTION MANAGER with the exact location of any utilities encountered during construction.

D. If specified by the CONSTRUCTION MANAGER, utility pot holes shall be carefully dug by the CONTRACTOR to identify the presence of underground utilities.

E. Damage to utilities by the CONTRACTOR during pothole operations shall be born by the CONTRACTOR.

PART 2 PRODUCTS

(Not Used)

PART 3 EXECUTION

(Not Used)

END OF SECTION

SECTION 01032

INTENT OF DRAWINGS AND SPECIFICATIONS

PART 1 GENERAL

1.01 CONTRACT DRAWINGS ASND SPECIFICATIONS

A. The intent of the Drawings and Specifications is to prescribe a complete work which the CONTRACTOR shall perform in a manner acceptable to the OWNER and in full compliance with the terms of the Contract.

B. The Drawings show general arrangements for the work which shall be used by the CONTRACTOR in the preparation of shop and field drawings. Particular care shall be given to all layouts to make sure all equipment is accessible for operation.

C. The CONTRACTOR shall provide the OWNER with a complete and operable system, even though the Drawings and Specifications may not specifically call out all items of work required of the CONTRACTOR to complete his tasks, incidental appurtenances, materials, and the like and maintenance.

D. The CONTRACTOR is to perform the Work in accordance with the cross-sections, thickness, gradients and dimensions shown on the Drawings. Any deviations must be approved by the DESIGN ENGINEER prior to doing the work.

E. The dimensions on the Drawings are presumed to be correct, but the CONTRACTOR shall be required to check carefully all dimensions prior to beginning the Work. If errors or omissions are discovered by the CONTRACTOR, the CONTRACTOR shall immediately notify the CONSTRUCTION MANAGER in writing and await the CONSTRUCTION MANAGER's notification before proceeding.

1.02 PRECENDENCE OF CONTRACT DOCUMENTS

A. If there is a conflict between Contract Documents, the document highest in precedence shall control. The precedence shall be:

1. Permits.
2. Special Provisions.
3. General Terms and Conditions.
4. Construction Drawings.
5. Technical Specifications.

1.03 CHANGES TO DRAWINGS

A. It is inherent in the nature of construction that some changes in the Drawings and Specifications may be necessary during the course of construction to adjust them to field conditions, and it is the essence of the Contract to recognize a normal and expected margin of change. The CONSTRUCTION MANAGER shall have the right to make such changes, from time to time, in the Drawings, in the character of the Work as may be necessary or desirable to insure the completion of the Work in the most satisfactory manner without invalidating the Contract.

PART 2 PRODUCTS

(Not Used)

PART 3 EXECUTION

(Not Used)

END OF SECTION

SECTION 01300

SUBMITTALS

PART 1 GENERAL

1.01 SUBMITTAL PROCEDURES

A. Transmit each submittal with cover letter to the OWNER.

B. Each submittal shall have a unique submittal number.

C. Submittals shall be numbered sequentially. Re-submittals shall have original number with an alphabetic suffix (A, B, C, etc.) to indicate the sequence of the re-submittal.

D. Identify Project, CONTRACTOR, Subcontractor or supplier; pertinent Drawing sheet and detail number(s), and specification Section number, as appropriate.

E. Identify variations from Contract Documents and Product or system limitations that may be detrimental to successful performance of the completed Work.

F. Provide space for DESIGN ENGINEER and/or CQA CONSULTANT review stamps.

G. Revise and resubmit submittals as required, identify all changes made since previous submittal.

H. Distribute copies of reviewed submittals to concerned parties. Instruct parties to promptly report any inability to comply with provisions.

I. When catalog pages are submitted, applicable items shall be clearly identified.

J. An electronic copy (preferred) or three (3) hard copies of each submittal shall be provided to the OWNER. The OWNER will not accept submittals from anyone other than the CONTRACTOR.

K. The CONTRACTOR shall review all submittal packages prior to transmittal to OWNER for completeness and accuracy.

1.02 CHECK OF RETURNED SUBMITTALS AND WAIVER OF CLAIMS

A. The CONTRACTOR shall check and review the submittals returned for correction and ascertain whether the required corrections result in extra cost above that included in the Contract, and shall give written notice to the CONSTRUCTION MANAGER within five (5) working days if, in the CONTRACTOR's estimation, extra costs result from the corrections. The CONTRACTOR's failure to give such written notice before the starting of the Work covered by returned submittal constitutes a waiver by the CONTRACTOR of claims for extra costs resulting from required corrections. Payment based on such written notice is not approved until authorized by the OWNER.

1.03 PRODUCT DATA SUBMISSION

A. For each product item included in the Work, include the manufacturer's name and address, the trade or brand name, all conditions of manufacturer's guarantee and warranty, information to fully describe each item, and supplementary information as may be required for approval. Mark catalog cuts, brochures, and data to indicate the items proposed and the intended use. Clearly mark product parameters which were specifically called out on the original specifications.

1.04 EQUIPMENT DATA SUBMISSION

A. Submit complete technical, performance, and catalog information for every item of civil, mechanical, and electrical equipment and machinery proposed for installation in the Work. Include information on performance and operating curves, ratings, capacities, characteristics, power efficiencies, manufacturers' standard guarantees and warranties with the terms and conditions fully described, and all other information to fully illustrate and describe the items as may be specified or required for approval.

1.05 SUBMITTAL REVIEW AND ACCEPTANCE

A. The submittal review period shall be ten (10) consecutive work days in length and shall commence on the first working day immediately following the date of arrival of the submittal or re-submittal in the OWNER's office. The time required for mail delivery of the submittal or re-submittal back to the CONTRACTOR shall not be considered a part of the submittal review period.

B. The acceptance of drawings and data submitted by the CONTRACTOR will cover only general conformity to the Drawings and Specifications, external connections, and dimensions which affect the layout. The DESIGN ENGINEER's and/or CQA CONSULTANT's review of submittals shall not relieve the CONTRACTOR from responsibility for errors, omissions, or deviations, nor responsibility for compliance with the contract documents.

1.06 RE-SUBMITTALS

A. When the drawings and data are returned marked "AMEND AND RESUBMIT" or "REJECTED, SEE REMARKS," the corrections shall be made as noted thereon and as instructed by the DESIGN ENGINEER's and/or CQA CONSULTANT's and shall be resubmitted.

B. When corrected copies are resubmitted, the CONTRACTOR shall highlight or otherwise direct specific attention to all revisions and shall list separately those revisions made other than those called for on previous submissions.

C. The need for more than one resubmission shall not entitle the CONTRACTOR to extension of the Contract Time.

1.07 COSTS FOR SUBMITTALS

A. All costs for the preparation, correction, and delivery of the submittals are considered incidental to the contract and shall be included in CONTRACTOR's costs.

PART 2 PRODUCTS

(Not Used)

PART 3 EXECUTION

3.01 MATERIALS REQUIRING SUBMITTALS

A. The following materials shall require submittals.

1. Material certifications and product data for all geosynthetics;
2. Material quality control data for all geosynthetics;
3. Material certifications and product data for piping;
4. Material quality control data for piping; and
5. Items not fully detailed and specified in the Contract Drawings or these Specifications.

3.02 ITEMS NOT REQUIRING SUBMITTALS

A. A submittal is not required for products and equipment completely specified or salvaged on-site. A submittal is required if the product has not been completely specified or when the specified product is not available within the construction schedule. Substitutions requested by the CONTRACTOR require a submittal.

3.03 CONSTRUCTION SCHEDULE

A. At the pre-construction meeting, the CONTRACTOR shall submit to the CONSTRUCTION MANAGER for review a schedule of the proposed construction operations. The construction schedule shall indicate the sequence of the Work indicating the time of completion of each component of the Work.

B. Submit initial progress schedule in duplicate within ten (10) days after Effective Date of Agreement for CONSTRUCTION MANAGER to review.

C. Revise and resubmit as required.

D. Submit revised schedules with each Application for Payment, identifying chauges since previous version.

E. Submit a horizontal bar chart with separate line for each major section of Work or operation, identifying first work day of each week. Include on the bar chart construction/placement rates for all the major items of Work. CONTRACTOR shall develop proposed Construction Schedule on basis of a five or six day working week. Sufficient labor, equipment, and materials shall be provided by CONTRACTOR to complete the Work on a five or six day per week basis. Night work and work on Sundays will only be approved by the OWNER if the Work falls behind the approved Construction Schedule.

F. Show complete sequence of construction by activity, identifying Work of separate stages and other logically grouped activities. Indicate the start date, finish date, and duration. At a minimum, the following activities must be shown on the project schedule:

1. Mobilization;
2. Excavation;
3. Subgrade preparation;
4. Placement of the geomembrane;
5. Installation of the geotextile;
6. Placement of the vegetative cover soil;
7. Hydroseeding of the final cover; and
8. Demobilization and site clean-up.

G. Indicate estimated percentage of completion for each item of Work at each submission with Application for Payment.

H. Indicate submittal dates required for shop drawings, product data, samples and product delivery dates.

I. The Construction Schedule as approved by the OWNER will be an integral part of the Contract, and will establish interim Contract completion dates for various activities. Should an activity not be completed within ten (10) days after the stated Schedule date, the CONSTRUCTION MANAGER shall have the option to recommend to the CONTRACTOR to expedite completion of the activity by whatever means deemed appropriate and necessary, without additional compensation to the CONTRACTOR.

J. Should any activity be twenty (20) or more working days behind Schedule, the OWNER shall have the right to perform the activity or to have the activity performed by whatever method the OWNER deems appropriate. Costs incurred by the OWNER in connection with expediting construction activities under this Paragraph shall be reimbursed to the OWNER by the CONTRACTOR.

K. It is expressly understood and agreed that failure by the OWNER to exercise the option to either order the CONTRACTOR to expedite an activity or to expedite the activity by other means shall not be considered precedent-setting for any other activities. The Work shall be executed in strict accordance with the Construction Schedule unless a variance has been received by the CONSTRUCTION MANAGER and approved by the OWNER.

3.04 PROGRESS REPORTS

A. The CONTRACTOR shall submit progress reports as requested indicating work performed and completed that week, quantity of material used, and equipment used to perform the Work.

B. A progress report shall also be furnished to the ENGINEER with each application for progress payment. If the Work falls behind schedule, the CONTRACTOR shall submit additional progress reports at such intervals as the CONSTRUCTION MANAGER may request.

C. Each progress report shall include sufficient narrative to describe current and anticipated delaying factors, their effect on the construction schedule, and proposed corrective actions. Work reported complete, but which is not readily apparent as complete to the CONSTRUCTION MANAGER, must be substantiated with satisfactory evidence.

D. Each progress report shall also include a graphic schedule marked to indicate actual progress. Revised schedules shall be included when warranted.

3.05 MANUFACTURER'S CERTIFICATES

A. When specified in individual Specification Sections, submit manufacturers' certificate to the CQA CONSULTANT for review, in quantities specified for Product Data.

B. Indicate whether material or product conforms to or exceeds specified requirements. Submit supporting reference date, affidavits, and certifications as appropriate.

C. Certificates may be recent or previous test results on material or Product, but must be acceptable to the CONSTRUCTION MANAGER.

3.06 RECORD SURVEY AND DRAWINGS

A. The CONTRACTOR shall keep a set of construction drawings on the job and mark in red pencil the as-built conditions.

B. A complete and accurate set of record drawings shall be signed and dated by the CONTRACTOR and shall be labeled with the following, "These record drawings completely and truly represent the contract work as installed."

C. Record drawings shall be delivered to the CONSTRUCTION MANAGER prior to final acceptance of the work by the CONSTRUCTION MANAGER.

D. Record drawings shall show all changes in "clouds" to clearly identify any deviations from the plans.

E. Any utilities uncovered during construction shall be identified on the record drawings.

F. The record survey shall be performed by the CONTRACTOR in accordance with Section 01400, Part 1.04 and shall meet the requirements of these Specifications and the CQA Plan and include, but not be limited to:

1. edges, bottom, and limits of anchor trenches;
2. limits of excavation and fill;
3. subgrades;
4. HDPE panel layout, intersections;
5. destructive test locations on HDPE geomembrane;
6. location and crown elevations of piping;
7. top of the vegetative cover soil layer;
8. grade breaks; and
9. layout and flow line elevations of surface water control structures.

G. Survey of the excavated subgrades and Operations Layer surfaces shall be on a grid with a maximum spacing of 50 feet or an equivalent method approved by the CQA CONSULTANT, with additional elevations at slope change locations. The elevations for the subgrade and top of the Operations Layer shall be at the same grid locations and shall be used to document thickness conformance. The record survey shall include locations and elevations of all other work as directed by the CONSTRUCTION MANAGER.

H. Record drawings shall be prepared to scale, with the scale clearly marked. Record drawings of details may not be to scale, but all dimensions shall be clearly identified. Record drawings shall be submitted to the CQA CONSULTANT for review and approval. Record drawings shall be provided on Bond and electronically in AutoCAD 2005 format or more recent. The DESIGN ENGINEER will provide the base AutoCAD file map. Different elements of the work shall be presented on different layers in the base AutoCAD file provided by the DESIGN ENGINEER.

3.07 HEALTH AND SAFETY PLAN

A. The CONTRACTOR shall submit a Health and Safety Plan in accordance with Section 01810 of these Specifications.

3.08 STORM WATER POLLUTION PREVENTION PLAN (SWPPP)

A. The CONTRACTOR shall prepare and submit a SWPPP specific to the work to the OWNER for approval. The SWPPP shall be consistent with the provisions of the "California Construction Best Management Practice Handbook," the site National Pollutant Discharge Elimination System (NPDES) site permit, and the Kettleman Hills Facility SWPPP. The SWPPP shall include specific measures to protect the Work and comply with the regulations, including specific erosion and sediment controls. The CONTRACTOR is responsible to control storm water run-on, run-off, erosion, and sediment to such an extent as needed to maintain compliance with the SWPPP and protect the Work, protect adjacent landfill operations, and adjacent structures.

END OF SECTION

SECTION 01400

CONSTRUCTION QUALITY CONTROL

PART 1 GENERAL

1.01 CONSTRUCTION QUALITY CONTROL

A. The CONTRACTOR shall be responsible for construction quality control of the Work and all appurtenances as described in these Specifications.

B. The CONTRACTOR shall monitor quality control over suppliers, manufacturers, products, services, site conditions, and workmanship, to produce Work of specified quality.

C. The CONTRACTOR shall comply fully with manufacturers' instructions, including each step in sequence.

D. Should manufacturers' instructions conflict with Contract Documents, the CONTRACTOR shall request clarification from CONSTRUCTION MANAGER before proceeding.

E. The CONTRACTOR shall comply with specified standards as a minimum quality for the Work except when more stringent tolerances, codes, or specified requirements indicate higher standards or more precise workmanship.

F. The CONTRACTOR shall perform work using persons qualified to produce workmanship of specified quality.

G. The CONTRACTOR shall secure products in place with positive anchorage devices designed and sized to withstand stresses, vibration, physical distortion or disfigurement.

H. The CONSTRUCTION MANAGER shall determine and decide all questions which may arise as to the quality and acceptability of materials and Work performed; the manner of performance and the rate of progress of said Work; the interpretations of the Contract Documents relating to the Work; the acceptable fulfillment of the Contract Documents on the part of the CONTRACTOR; and the amount and quantity of the several kinds of Work performed and materials which are to be paid for under the Contract.

I. All materials and equipment shall be new and of the specified quality and equal to the samples found to be acceptable by the CQA CONSULTANT, if samples have been submitted.

J. The Work shall be done and completed in a thorough, workmanlike manner, notwithstanding omissions in the Contract Documents; and it shall be the duty of the CONTRACTOR to call the CONSTRUCTION MANAGER's attention to apparent errors or omissions and request instructions in writing before proceeding with the Work.

K. The CONSTRUCTION MANAGER may, by appropriate written instructions, correct errors and omissions. Instructions and corrections shall be as binding upon the CONTRACTOR as though contained in the original Contract Documents.

1.02 CONSTRUCTION QUALITY ASSURANCE

A. Materials, equipment, methods of construction and workmanship shall be subject to the inspection of the CQA CONSULTANT as outlined in the CQA Plan. Defective materials, equipment, or work shall be replaced, corrected or otherwise made good by the CONTRACTOR at the CONTRACTOR's own expense.

B. On all questions concerning the acceptability of materials or equipment, execution of the Work, and the determination of costs, the decision of the CONSTRUCTION MANAGER shall be final and binding upon all parties.

C. The CONTRACTOR shall at all times maintain proper facilities and provide safe access to all parts of the Work, to the shops wherein the Work is in preparation, and to all warehouses and storage yards wherein materials and equipment are stored, for purposes of inspection by the CQA CONSULTANT.

D. The CONTRACTOR shall provide incidental labor and facilities to provide access to Work to be tested, to obtain and handle samples at the Site or at source of products to be tested, and to facilitate tests and inspections.

E. Notify CQA CONSULTANT 24 hours prior to expected time for operations requiring inspection services.

F. Retesting required because of non-conformance to specified requirements shall be performed by the CQA CONSULTANT on instructions by the CONSTRUCTION MANAGER. Payment for retesting will be charged to the CONTRACTOR by deducting inspection or testing charges from the Contract Price.

G. Employment of CQA CONSULTANT by OWNER shall in no way relieve the CONTRACTOR of obligations to perform Work in accordance with requirements of Contract Documents.

1.03 MANUFACTURERS' FIELD SERVICES AND REPORTS

A. When specified in individual Specification Sections, required material or Product suppliers or manufacturers shall provide qualified staff personnel to observe site conditions, conditions of surfaces and installation, and quality of workmanship as applicable, and to initiate instructions when necessary.

B. Individuals shall report observations and site decisions or instructions given to applicators or installers that are supplemental or contrary to manufacturers' written instructions.

1.04 SURVEYING

A. At least two control monuments shall be established by the CONTRACTOR at locations convenient for daily tie-in. The vertical and horizontal controls for these control points shall be established within normal land surveying standards. The CONTRACTOR shall use these control points in laying out and providing ongoing geometric control of the work. The control monuments shall be shown on all record drawings.

B. Surveying shall be performed under the direct supervision of a licensed land surveyor or registered civil engineer authorized to practice land surveying under Chapter 15, Article 3, Section 8731 of the Professional Engineering Act of California, as amended January 1, 1992 who may also be the senior surveyor on site. The survey crew shall consist of the senior surveyor and as many surveying assistants as required to satisfactorily undertake the work. Personnel shall be experienced in all aspects of surveying, including detailed, accurate documentation.

C. The survey instruments used for this work shall be sufficiently precise and accurate to meet the needs of the project. Survey instruments shall be capable of reading to a precision of 0.01 feet and with a setting accuracy of 10 seconds. Calibration certificates for survey instruments shall be submitted on request to the CQA CONSULTANT prior to the initiation of surveying activities.

D. It shall be the CONTRACTOR's sole responsibility to control the Work so that all of the geometric requirements of the project are met. The CONTRACTOR shall immediately notify the CONSTRUCTION MANAGER and the CQA CONSULTANT of any discrepancy found in the Work. It will be the CONSTRUCTION MANAGER's sole prerogative to approve or reject work which does not meet the requirements contained in these Specifications and the Drawings, but which, in the CONSTRUCTION MANAGER's sole opinion, may nevertheless meet the intention of the Contract Documents.

E. The CONTRACTOR shall be responsible for the accuracy of all work and shall maintain all reference points, stakes, etc., throughout the life of the project. Damaged or destroyed points, bench marks or stakes, or any reference points made inaccessible by the progress of the construction shall be replaced or transferred by the CONTRACTOR. Any of the above points shall be referenced by ties to acceptable objects and recorded. Any alternations or revisions in the ties shall be so noted and the information furnished to the CONSTRUCTION MANAGER immediately. All computations necessary to establish the exact position of the work from control points shall be made and preserved by the CONTRACTOR. All computations, survey notes and other records necessary to accomplish the work shall be neatly made and shall be made available onsite for review by the CQA CONSULTANT.

F. During the progress of the construction work, the CONTRACTOR shall be required to furnish all of the surveying and state-out incidental to the proper location by line and grade for each phase of the work. For any operation requiring extreme accuracy, the CONTRACTOR shall restake with pins or other acceptable hubs located directly adjacent to the work at a spacing approved by the CONSTRUCTION MANAGER.

PART 2 PRODUCTS

(Not Used)

PART 3 EXECUTION

(Not Used)

END OF SECTION

SECTION 01402

CONTROL OF WORK

PART 1 GENERAL

1.01 AUTHORITY OF THE CONSTRUCTION MANAGER

A. The CONSTRUCTION MANAGER will decide all questions which may arise as to the quality and acceptability of materials furnished and work performed; all questions which may arise as to the interpretation of the Drawings and Specifications; and all questions as to the satisfactory and acceptable fulfillment of the Contract on the part of the CONTRACTOR.

B. The OWNER shall have the authority to stop the Work if odor or dust becomes a nuisance.

1.02 AUTHORITY OF THE CQA CONSULTANT

A. The CQA CONSULTANT employed by the OWNER shall be authorized to monitor all work done and materials and equipment furnished. Such monitoring may extend to all or part of the Work, and to the preparation, fabrication, or manufacture of the materials and equipment to be used. The CQA CONSULTANT will not alter or waive the provisions of the Contract Documents.

B. The CQA CONSULTANT will keep the CONSTRUCTION MANAGER informed as to the progress of the Work and the manner in which it is being done; also, the CQA CONSULTANT will call the CONTRACTOR's attention to non-conformance with the Contract Documents that the CQA CONSULTANT may have observed. The CQA CONSULTANT will not approve or accept any portion of the Work, issue instructions contrary to the Contract Documents, or act as foreman for the CONTRACTOR. The CQA CONSULTANT may reject defective materials, equipment, or work subject to final decision of the CONSTRUCTION MANAGER.

C. The CONSTRUCTION MANAGER may delegate additional authority to the CQA CONSULTANT. In such cases, the CONSTRUCTION MANAGER will notify the CONTRACTOR of such action.

1.03 COORDINATION AND INTERPRETATION OF DRAWINGS AND SPECIFICATIONS

A. The Specifications, General Conditions, Special Conditions, CQA Plan, Contract Change Orders, and all supplementary documents are essential parts of the Contract, and a requirement occurring in one is as binding as though occurring in all. They are intended to be coordinated and to describe and provide for a complete work.

B. Should it appear that the Work or other matters relative thereto are not sufficiently detailed or explained in the Contract Documents, the CONTRACTOR shall apply to the CONSTRUCTION MANAGER for such further explanations as may be necessary and shall conform to them as part of the Contract.

C. In the event of a doubt or question arising regarding the true meaning of the Contract Document, reference shall be made to the CONSTRUCTION MANAGER, whose decision thereon shall be final.

D. In the event of a discrepancy between a drawing and the figures written thereon, and/or the Drawings and the Specifications, the CONTRACTOR shall notify the CONSTRUCTION MANAGER in writing and wait for approval before proceeding. Scaled dimensions shall not be used in the performance of the Work.

PART 2 PRODUCTS

(Not Used)

PART 3 EXECUTION

3.01 PERFORMANCE REQUIREMENTS

A. The CONTRACTOR shall furnish the CONSTRUCTION MANAGER with every reasonable facility for ascertaining whether or not the Work as performed is in accordance with the requirements and intent of the Specifications and Contract.

B. Should a work be covered before acceptance or consent of the CONSTRUCTION MANAGER, it must, if required by the CONSTRUCTION MANAGER, be uncovered for examination at the CONTRACTOR's expense.

END OF SECTION

SECTION 01565

TEMPORARY FACILITIES

PART 1 GENERAL

1.01 SUMMARY

A. The CONTRACTOR shall provide all temporary facilities and utilities required for prosecuting the Work, protection of employees and the public, protection of the Work from damage by fire, weather or vandalism, and such other facilities as may be specified or required by an applicable law, ordinance, rule, or regulation.

B. The CONTRACTOR must provide their own office space for their needs if necessary. The location of the office shall be approved by the OWNER.

1.02 ELECTRICAL SERVICE

A. Electrical power is not available at the site. The CONTRACTOR shall arrange for temporary electric connection or supply a generator capable of providing the power required to operate tools or equipment or to provide area lighting as needed. Temporary power whether supplied by a utility company or by a generator shall conform to the requirements of the 1993 National Electrical Code, the 1993 National Electrical Safety Code, and all applicable national standards, local regulations and ordinances.

B. The allowable hours of generator operation is the same as the regular working hours for the project. All generators shall be fitted with a residential quality muffler.

1.03 FIRST AID

A. First aid kits meeting the minimum requirements of the Occupational Safety and Health Administration shall be provided in a readily accessible location or locations indicated in the CONTRACTOR's Health and Safety Plan as outlined in Section 01810 of these Specifications.

1.04 CONSTRUCTION FACILITIES

A. Construction hoists, elevators, scaffolds, stages, shoring and. similar temporary facilities shall be of ample size and capacity to adequately support and move the loads to which they will be subjected. Railings, enclosures, safety devices, and controls required by law or for adequate protection of life and property shall be provided.

1.05 STAGING AND SHORING

A. Temporary supports shall be designed with an adequate safety factor to assure stability and adequate load bearing capacity.

B. Trenches greater in depth than four (4) feet shall be shored or sloped according to OSHA requirements.

1.06 TEMPORARY ENCLOSURES

A. When any activity hazardous to property or the health of employees and the public is in progress, the area of activity shall be enclosed adequately to contain the dust, overspray, or other hazard. In the event there are not permanent enclosures in the area, or such enclosures are incomplete or inadequate, the CONTRACTOR shall provide suitable temporary enclosures.

1.07 WARNING DEVICES AND BARRICADES

A. The CONTRACTORs shall adequately identify and guard all hazardous areas, holes, pits, and conditions by visual warning devices and physical barriers. Such devices shall, as a minimum, conform to the requirements of OSHA and Cal-OSHA.

1.08 HAZARDS IN PUBLIC ACCESS AREAS

A. Trenches and other essentially continuous excavations in public access areas, running parallel to the general flow of traffic, shall be marked at reasonable intervals by traffic cones, barricades, or other suitable visual markers during daylight hours. During hours of darkness, these markers shall be provided with either torches, flashers or other adequate lights.

1.09 FIRE EXTINGUISHERS

A. A sufficient number of fire extinguishers of the type and capacity required to protect the site and ancillary facilities shall be provided in readily accessible locations.

1.10 ODOR CONTROL

A. The CONTRACTOR shall comply with the provisions for control of odor and emissions as required by the MDAQMD or the OWNER.

1.11 SANITATION FACILITIES

A. CONTRACTOR shall provide and maintain ample field latrines and ablution accommodations in accordance with OSHA requirements for all workers employed on the project under the contract. Field latrines and ablution accommodations shall be provided and maintained in a sanitary condition at all times during the work on this project.

1.12 MATERIAL STORAGE

A. A materials storage area shall be designated to the CONTRACTOR by the CONSTRUCTION MANAGER. The CONTRACTOR is responsible for security of all of his materials and equipment.

PART 2 PRODUCTS

(Not Used)

PART 3 EXECUTION

(Not Used)

END OF SECTION

SECTION 01810

SAFETY PROCEDURES

PART 1 GENERAL

1.01 SUMMARY

A. This section establishes minimum safety requirements and guidelines for the performance of the Work.

B. The CONTRACTOR is advised that decomposing refuse produces landfill gas which is approximately 50 percent methane (natural gas) by volume, and is potentially flammable or explosive.

C. The CONTRACTOR shall submit a Health and Safety Plan and a copy of their Injury and Illness Prevention Program to the OWNER for review prior to beginning work.

D. The CONTRACTOR shall hold mandatory daily tailgate safety meetings on the site, as well as formal weekly safety meetings.

1.02 GENERAL REQUIREMENTS

A. The CONTRACTOR shall have sole responsibility and liability for the safety, efficiency, and adequacy of the CONTRACTOR's personnel, equipment and methods, and for any damage or injury resulting from their failure, or improper maintenance, use, or operation.

B. The CONTRACTOR shall be solely and completely responsible for the conditions at the Work area arising from the CONTRACTOR's execution of the Work. This requirement shall apply continuously and not be limited to normal working hours.

C. The CONTRACTOR shall provide all personnel working on the project with orientation and training on the potential hazards anticipated and the appropriate use of safety equipment.

D. Neither the OWNER nor the CONSTRUCTION MANAGER shall have liability resulting from injury or death to CONTRACTOR's employees or subcontractors and their employees.

E. A health and safety officer, employed by the CONTRACTOR, shall be present at all times during construction of underground facilities. The health and safety officer may be the site superintendent or other responsible regular employee of the CONTRACTOR provided he has had special health and safety training, and shall have responsibility for the enforcement of the Health and Safety Plan, particularly as it applies to drilling activities. The health and safety officer shall be identified by name in the Health and Safety Plan.

F. Many gases are heavier than air and settle in low areas such as trenches and excavations, therefore additional precautions shall be observed in these areas. Specifically, the need for constant O_2 monitoring, forced ventilation, combustible gas monitoring, VOC monitoring, respiratory protective equipment, etc. shall be determined by the CONTRACTOR. The CONSTRUCTION MANAGER may impose additional requirements when deemed necessary for worker safety.

1.03 HEALTH AND SAFETY PLAN

A. The CONTRACTOR shall develop and maintain for the duration of work activities at the site, a written, site specific Health and Safety Plan for landfill operations that will effectively incorporate and implement all applicable requirements. The plan will meet the requirements of CCR Title 8 Section 5192.

B. In addition to requirements set forth in other sections, the CONTRACTOR's Health and Safety Plan shall contain provisions for aspects of protection against bodily injury from heavy construction equipment, tools and equipment required to construct the system.

C. The Health and Safety Plan shall include the location and route to the nearest hospital or emergency facility. All CONTRACTOR employees and subcontractors working on the project shall be thoroughly familiar with the emergency route.

D. In the event the Health and Safety Plan is determined by the CONSTRUCTION MANAGER, OWNER or the State or Federal Regulatory Agencies to be inadequate to protect the employees and the public, the plan shall be modified prior to the beginning of the Work to meet the minimum requirements of the OWNER or the State or Federal Regulatory Agencies at no additional cost to the OWNER.

E. Acceptance of the CONTRACTOR's Health and Safety Plan by the OWNER does not release the CONTRACTOR of liability in the event of an accident or injury, nor does it place any liability on the CONSTRUCTION MANAGER or OWNER.

F. Provisions shall be made to protect against ingestion, absorption or inhalation of hazardous compounds and for the handling of refuse in a safe, sanitary, and proper manner.

G. The CONTRACTOR's Health and Safety Plan shall contain trenching and excavation safety guidelines particular to landfill work.

1.04 REGULATORY REQUIREMENTS

A. The CONTRACTOR shall comply with provisions of safety regulatory bodies including, but not necessarily limited to:

1. OSHA/Cal-OSHA regulations for construction
2. 29 Code of Federal Regulations (CFR) 1926/1910 and CFR 1910.120
3. Title 8 California Code of Regulations, in particular Section 5192.
4. All other applicable federal, state, county and local laws, ordinances, codes, the requirements

B. If any of these requirements are in conflict, the more stringent requirement shall apply. The CONTRACTOR's failure to be thoroughly familiarized with the aforementioned safety and health provisions shall not relieve the CONTRACTOR of responsibility for full compliance with the obligations and requirements set forth herein.

C. The CONTRACTOR shall conform to the rules and regulations of the State Construction Safety regulations pertaining to excavations and trenches. A copy of the regulations is available at the OWNER.

1.05 SPECIAL SAFETY CONSIDERATION RELATED TO LANDFILL WORK

A. Portions of the Work involve excavation and removal of and construction near hazardous waste.

B. The landfill may contain leachate water contaminated with substances found in the landfill which may be corrosive, toxic, carcinogenic, mutanogenic or otherwise hazardous.

PART 2 PRODUCTS

(Not Used)

PART 3 EXECUTION

3.01 GENERAL REQUIREMENTS

A. The CONTRACTOR shall assume full responsibility to assure that during construction his employees, subcontractors and their employees follow the Health and Safety Plan.

B. The CONTRACTOR shall hold mandatory weekly safety meetings on the site. The CONTRACTOR shall notify the CONSTRUCTION MANAGER of the time and place of all meetings and allow the CONSTRUCTION MANAGER to participate. Meetings should reiterate safety measures to be taken and discuss any violations committed and preventive measures to avoid future violations.

C. The CONTRACTOR shall require all personnel on the site to wear the appropriate personnel protective equipment such as steel toe boots, hard hats, orange safety vests, safety belts and lanyards, and others.

D. The CONTRACTOR shall provide appropriate fall protection (i.e., harness and shock absorbing lanyard) that must be worn and secured to a stationary object when working within a distance of ten 10 feet of an excavation greater than eight (8) inches in diameter or deeper than four (4) feet.

E. No smoking or consumption of alcohol or any drug which could impair sight, balance or judgment is permitted on the job.

3.02 TRENCHING SAFETY

A. The CONTRACTOR shall complete each excavated trench prior to the end of the working day. A trench shall be considered complete if it has been backfilled to the landfill surface.

B. Any time excavations and trenching exceed four (4) feet in depth, shoring, bracing or sloping of the side walls is required prior to entry. If sloping is the method used, side walls of the trench shall be sloped at a 2:1 slope (Cal-OSHA requirement).

C. Welding is to be avoided within the barricaded area. If HDPE pipe welding is performed in the trench, continuous methane monitoring shall be performed.

D. Solvent cleaning, gluing or bonding of pipe shall be done, to the extent practicable, outside the trench.

E. All trenches shall be backfilled as soon as practical after excavation, and under no circumstances shall a trench remain open after the crew has left the vicinity of the trench. A maximum of 300 feet of trench may be exposed at any one time. All exposed refuse must be covered at the end of each day using cover soil or a tarp.

F. Electric motors shall not be used in trenches. Pneumatic operated tools shall be used in the trench.

3.03 VIOLATIONS

A. Should any health and safety violations be called to the CONTRACTOR's attention by anyone, the CONTRACTOR shall immediately correct the violations.

B. If the CONTRACTOR violates any health and safety rule or regulation, the OWNER may issue an order to stop all work until the violations are remedied. The CONTRACTOR shall not be entitled to any extension of the time or any claim for damage or to any compensation for either the directive or the work suspension order. A decision by the OWNER not to order discontinuance of any or all of the CONTRACTOR's operations shall not relieve the CONTRACTOR of responsibility for safety.

END OF SECTION

SECTION 02105

EROSION CONTROL

PART 1 GENERAL

1.01 DESCRIPTION

A. This section describes the general requirements for erosion control measures associated with lining materials for drainage channels.

PART 2 PRODUCTS

2.01 EROSION CONTROL BLANKET

Permanent Turf Reinforcement Mat shall be Propex Landlok 407, or equivalent. To be used in Type IB, II and IV channels.

Temporary Erosion Control Mat shall be SI Geosolutions ECB CS2, or equivalent. To be used in Type IA channels.

PART 3 EXECUTION

3.01 GENERAL

A. Grade and compact area of installation and remove all rocks, clods, vegetation or other obstructions so that the installed mat will have direct contact with soil surface. Prepare seedbed by loosening 2-3 inches of topsoil. Incorporate amendments such as fertilizer into soil.

B. For temporary erosion control mat, apply seed to soil surface before installing blanket/mat. For permanent erosion control mat, apply seeding after installation and prior to filling mat with soil.

C. The CONTRACTOR shall install the permanent and temporary control mats in accordance with the manufacturer's recommendations. In general the installation should include:

1. Anchor trenches or check slots (6-inches deep) at 30 foot intervals along the trench.

2. Longitudinal anchor trenches (4-inches deep) to secure outside edges.

3. Anchor erosion control mat with U-shaped wire staples. Staples shall be a minimum of 6-inches in length and have sufficient ground penetration to resist pullout. Longer anchors may be required. Anchors for the permanent erosion control mat shall be installed with a minimum of 2 anchors per

square yard. Temporary erosion control mats shall be installed with a minimum of 1.5 anchors per square yard.

4. After installation of permanent erosion control mat, apply seed and apply ½ to ¾ inches of fine soil into the mat to completely fill the voids. Use backside of rake, or similar, to smooth soil fill in order to just expose the top netting.

END OF SECTION

SECTION 02110

SITE CLEARING, GRUBBING AND STRIPPING

PART 1 GENERAL

1.01 DESCRIPTION

A. This section describes the general requirements for site clearing, grubbing and stripping associated with final closure construction of Landfill B-18 at the Kettleman Hills Facility.

B. Clearing, grubbing and stripping shall be performed to remove organic, soft, loose, and deleterious materials and expose a firm, unyielding subgrade.

1.02 RELATED SECTIONS

A. Section 02200 - Earthwork

B. Section 02751 - HDPE Geomembrane

PART 2 PRODUCTS

A. Organic, soft, loose and deleterious materials includes, but is not limited to, vegetative growth, non-engineered fills, alluvial deposits, soft, loose, or saturated subgrade soils, refuse, and construction debris.

PART 3 EXECUTION

3.01 PROTECTION

A. Locate, identify, and protect utilities that remain from damage.

B. Protect groundwater monitoring wells and piezometers, and landfill gas extraction wells and monitoring probes from damage or displacement.

3.02 CLEARING

A. Clear areas required for access to site and execution of work.

B. Earthwork CONTRACTOR shall remove all organic and deleterious material, and trash from the subgrade surface. Vegetative growth greater than 1 inch in dimension shall be removed to a depth of 6 inches below the subgrade surface.

C. The Earthwork CONTRACTOR shall consider that clearing, grubbing, and stripping will necessitate the use of manual labor to remove all organic and deleterious material from the subgrade surface.

D. The Earthwork CONTRACTOR shall remove soft, loose, or saturated materials as approved by the CQA CONSULTANT. The materials shall be removed until a firm, unyielding subgrade, approved by the CQA CONSULTANT, is exposed.

E. All removed materials shall be disposed of onsite in an area designated by the PROJECT MANAGER. No accumulation of flammable material shall remain on or adjacent to the construction area.

F. The Earthwork CONTRACTOR shall expose existing liner terminations as required on the Drawings. The Work may require hand excavation to avoid damage to the existing liner. Any damage to the existing liner shall be repaired by the Earthwork CONTRACTOR at no additional cost to the OWNER.

END OF SECTION

SECTION 02200

EARTHWORK

PART 1 GENERAL

1.01 SUMMARY

A. This section describes the general requirements for earthworks associated with the final closure construction of Landfill B-18 at the Kettleman Hills Facility.

B. The Earthwork CONTRACTOR shall furnish all labor, materials, equipment and incidentals necessary to perform all excavation, backfilling, compaction and grading required to complete the work shown on the Drawings and specified herein. The Work shall include, but not necessarily be limited to, survey and staking, borrow excavation and hauling, excavation for trenches, fill placement and compaction, grading, and all related work.

C. The Earthwork CONTRACTOR shall comply with the safety procedures given in Section 01810 of these Specifications.

1.02 RELATED SECTIONS

A. Section 01300 - Submittals

B. Section 01400 - Construction Quality Control

C. Section 02110 - Site Clearing, Grubbing and Stripping.

D. Section 02720 – Drainage Facilities

E. Section 02751 - HDPE Geomembranes

1.03 REFERENCE STANDARDS

A. American Society for Testing and Materials (ASTM), latest editions:

1. ASTM D422 - Test Method for Particle Size Analysis of Soils.
2. ASTM D1556 - Test Method for Density of Soil In-Place by the Sand Cone Method.
3. ASTM D1557 - Test Methods for Moisture-Density Relations of Soils and Soil Aggregate Mixtures Using 10-lb. Rammer and 18-inch Drop.
4. ASTM D2216 - Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
5. ASTM D2419 - Test Method for Sand Equivalent Value of Soil/Fine Aggregate.
6. ASTM D2497 - Standard Test Method for Classification of Soils for Engineering Purposes.
7. ASTM D2922 - Test Methods for Density of Soil and Soil Aggregate in Place by Nuclear Methods (Shallow Depth).

8. ASTM D2937 - Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method
9. ASTM D3017 - Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).

B. Standard Specifications for Public Works Construction (SSPWC).

1.04 QUALITY ASSURANCE/CONTROL

A. The Earthwork CONTRACTOR shall adhere to the requirements of Section 01400 of these Specifications.

B. Compaction testing of engineered fill and backfill shall be performed by the CQA CONSULTANT. Testing shall be performed at locations to be determined by the CQA CONSULTANT, in order to determine if the soils meet the compaction requirements. Costs for testing to verify compaction and soil moisture content will be assumed by the OWNER. The cost of retesting, should corrections to construction be required, shall be the responsibility of the Earthwork CONTRACTOR.

C. The OWNER shall have complete authority to order immediate stoppage of work due to use of improper construction procedures, or for any reason that in his sole opinion, may result in a defective work.

1.05 DEFINITIONS

A. Excavation: Consists of the removal of material encountered to subgrade elevations and the reuse or disposal of materials removed.

B. Subgrade: The surface upon which structures/systems/fills are constructed.

C. Borrow: Soil material obtained from other than the excavation.

D. Unauthorized excavation consists of removing materials beyond indicated subgrade elevations or dimensions without direction by the PROJECT MANAGER. Unauthorized excavation, as well as remedial work directed by the PROJECT MANAGER, shall solely be at the Earthwork CONTRACTOR's expense.

E. Utilities include on-site above ground and underground pipes, conduits, ducts, and cables, as well as underground services.

1.06 SAFETY

A. CONTRACTOR is solely responsible for performing work in a safe manner and complying with all applicable local, state and federal codes, ordinances, laws, and regulations.

B. CONTRACTOR shall comply with the requirements of the Health and Safety Plan.

PART 2 PRODUCTS

2.01 MATERIALS

A. Structural Fill

1. Structural Fill shall be removed from the on-site borrow area(s) designated by the OWNER. Material shall be predominantly free from roots, wood, organic matter, refuse or other deleterious matter, and shall not contain particles over 6 inches in greatest dimension.

2. The OWNER has designated on-site borrow source(s) for the CONTRACTOR. The CONTRACTOR shall be responsible for excavating, loading, hauling, placing and compacting the material from the designated borrow source(s).

B. Foundation Layer

1. Foundation Layer is structural fill placed within 1-foot of HDPE geomembrane.

2. In addition to the structural fill requirements, Foundation layer shall not contain particles over 1 inch in greatest dimension and have a hydraulic conductivity of less than or equal to 1×10^{-5} cm/sec as determined by ASTM D5084.

C. Vegetative Cover

1. Vegetative Cover shall be removed from the on-site borrow area(s) designated by the OWNER. Material shall contain no particles over 3 inches in greatest dimension.

2. The OWNER has designated on-site borrow source(s) for the CONTRACTOR. The CONTRACTOR shall be responsible for excavating, loading, hauling, placing and compacting the material from the designated borrow source(s).

D. Trench Backfill

1. Trench Backfill shall be removed from the on-site borrow area(s) designated by the OWNER. Material shall be predominantly free from roots, wood, organic matter, refuse or other deleterious matter, and shall not contain particles over 1 inch in greatest dimension.

2. The OWNER has designated on-site borrow source(s) for the CONTRACTOR. The CONTRACTOR shall be responsible for excavating, loading, hauling, placing and compacting the material from the designated borrow source(s).

E. Water

1. Water shall be potable water or reclaimed water approved for use by OWNER.

2. The OWNER will provide water for dust control and soil preparation to the Earthwork CONTRACTOR at no cost to the Earthwork CONTRACTOR.

3. The CONTRACTOR shall only obtain water from sources designated by the OWNER.

PART 3 EXECUTION

3.01 GENERAL

A. The Earthwork CONTRACTOR shall be solely responsible for the satisfactory completion of all earthwork in accordance with the Drawings and Specifications.

B. Equipment used in the excavation, transport, placement and compaction of all materials used in construction will be standard of practice grading machinery of known specifications suitable for performing the required work in a timely and efficient manner.

C. All material considered by the CQA CONSULTANT to be unsuitable for use in the construction of the earthwork shall be removed. All materials incorporated as part of engineered fill must be inspected and placement must be observed by the CQA CONSULTANT. Unsuitable material shall be disposed of in the designated area.

D. Where work is interrupted by heavy rains, earthwork operations shall not be resumed until observations and field tests by the CQA CONSULTANT indicate the moisture content and density of the in-place fills and/or materials intended for placement are within the specified requirements.

E. If any unanticipated earth conditions of an adverse or potentially adverse nature are encountered during grading, the Earthwork CONTRACTOR shall immediately notify the CQA CONSULTANT. The CQA CONSULTANT and DESIGN ENGINEER shall investigate, analyze, and make recommendations to mitigate these conditions.

F. Throughout construction, all excavated and/or fill areas shall be graded to provide positive drainage and prevent ponding of water. Surface water shall be controlled to avoid damage to adjoining properties or to finished work on the site.

G. No heavy equipment shall be permitted to operate within 3 feet of existing wellheads or piping. Compaction of material within these limits shall be completed with hand equipment.

H. The Earthwork CONTRACTOR shall apply water to any exposed earthen areas during construction to minimize airborne dust. This shall include active and inactive excavation areas, haul roads, and any nonvegetated stockpiles. The Earthwork CONTRACTOR shall be responsible for complying with all state and local regulations regarding dust and/or air quality.

I. Earthwork CONTRACTOR **shall not** use "paddle-wheel" (i.e., Caterpillar 613 or equivalent) equipment to excavate soils.

J. Earthwork CONTRACTOR shall provide manned traffic control (e.g., flagman) at locations identified by Owner and/or Contractor as being a potential safety hazard.

3.02 CONTROL OF WATER

A. The Earthwork CONTRACTOR shall excavate and backfill in a manner and sequence that will provide proper drainage at all times. The Earthwork CONTRACTOR shall remove all water, including runoff and run-on collected from rainwater encountered during excavation, to a location approved by the PROJECT MANAGER, by pumps, drains, and other approved methods.

B. The Earthwork CONTRACTOR shall take all necessary precautions to preclude the accidental discharge of fuel, oil, etc. and to prevent such accidents that may endanger the environment. The Earthwork CONTRACTOR will be responsible for the cost of remediating the results of any such discharges or accidents.

3.03 BORROW

A. CONTRACTOR shall submit the proposed limits of the borrow area to the OWNER for approval prior to the commencement of the Work. The maximum limits of the borrow area are shown on the Drawings.

B. The gradients of the borrow slopes and the depth of the borrow excavation should not exceed those specified on the Drawings. If the slopes are constructed steeper or the depth of the borrow excavation is greater than that specified on the Drawings, the CONTRACTOR shall reconstruct the slopes/refill the bottom to the gradients/depth specified by backfilling and compacting material in accordance with the requirements for engineered fill in this Section. The cost to reconstruct the slopes/refill the bottom will be borne solely by the CONTRACTOR.

C. The CONTRACTOR shall maintain a secure work site at all times.

3.04 STRUCTURAL FILL

A. Prior to placing structural fill, CONTRACTOR shall clear and grub the area in accordance with Section 02110 of these Specifications. CONTRACTOR shall also remove uncertified existing fills, disturbed soils and deleterious materials from the area to the satisfaction of the CQA CONSULTANT.

B. The ground surface (i.e. areas with less than 10% slope) to receive fill shall be over excavated a minimum of 2 feet. The base of the excavation shall be scarified to a depth of 8 inches. The scarified ground surface shall then be brought to within 3 percent of optimum moisture content, mixed as required, and compacted to a minimum of 90 percent of the maximum dry density as determined by ASTM D1557. Excavated soil may be used for filling the excavation if placed in accordance with the structural fill requirements. If the scarified zone is greater than 12 inches in depth, the excess shall be removed, placed in loose lifts not to exceed 8 inches in loose thickness. Prior to fill placement, the ground surface to receive fill shall be stabilized and inspected by the CQA CONSULTANT.

C. Fill placed against existing slopes (i.e. areas with greater than 10% slope) shall be keyed into the slope. Keys shall extend a minimum of 6 feet horizontally into the existing slope. The keys shall form a series of steps in the existing fill.

D. Fill shall be placed in loose lifts not to exceed 8-inches thick, brought to a uniform moisture content within 4 percent of optimum (3 percent for Foundation Layer), and compacted to 90 percent of the maximum dry density as determined by ASTM D1557.

E. Where tests indicate the moisture content or density of any layer of fill or portion thereof is below the Project requirements, the particular layer or portion thereof shall be reworked until the required moisture or density has been attained. No additional fill shall be placed over an area until the prior fill lift has been tested and meets the present requirements to the satisfaction of the CQA CONSULTANT.

F. In the event of rain or other reason, if the moisture content of previously placed fill material or processed soils intended for placement is more than 4 percent above optimum as determined by ASTM D1557, the fill material shall be aerated by blading, disking, or other satisfactory method until the moisture content complies with the requirements of this Section. Any previously compacted materials which are disturbed (aerated, bladed, etc.) to reduce or increase the moisture content must be recompacted to the Specifications and to the satisfaction of the CQA CONSULTANT once specified moisture contents are attained.

3.05 VEGETATIVE COVER

A. Vegetative cover layer shall be placed as shown on the Drawings. Soils shall not be placed over geosynthetic materials at ambient temperatures below 41 degrees F nor above 100 degrees F unless otherwise specified. The soils shall be placed in a manner which does not cause excessive movement or wrinkling of the geosynthetics.

B. Vegetative cover layer shall be placed and compacted by tracking with the low ground-pressure pressure dozer used for placement or other relatively light-compaction equipment wherever the soil thickness is less than 3 feet. The equipment used to spread and compact the backfill shall not exert a ground pressure in excess of 6 psi on no less than 1 foot of material. Manually operated compaction equipment may be required in constricted locations and directly adjacent to sensitive structures.

C. Hauling and spreading equipment for the vegetative cover layer shall operate on a minimum of 3 feet of soil above a geosynthetic layer. Low-ground pressure (i.e., less than 6 psi) spreading equipment may operate on a minimum of one foot of soil above a geosynthetic layer.

D. Fill shall be placed in loose lifts not to exceed 8-inches thick, brought to a uniform moisture content within 3 percent of optimum, and compacted between 85 to 90 percent of the maximum dry density as determined by ASTM D1557.

E. Where tests indicate the moisture content or density of any layer of fill or portion thereof is below the Project requirements, the particular layer or portion thereof shall be reworked until the required moisture or density has been attained. No additional fill shall be placed over an area until the prior fill lift has been tested and meets the present requirements to the satisfaction of the CQA CONSULTANT.

F. In the event of rain or other reason, if the moisture content of previously placed fill material or processed soils intended for placement is more than 3 percent above optimum as determined by ASTM D1557, the fill material shall be aerated by blading, disking, or other satisfactory method until the moisture content is within four percent of optimum moisture content as determined by ASTM D1557. Any previously compacted materials which are disturbed (aerated, bladed, etc.) to reduce or increase the moisture content must be recompacted to the Specifications and to the satisfaction of the CQA CONSULTANT once specified moisture contents are attained.

3.06 SURFACE PREPARATION

A. All surfaces to be overlain by geosynthetics shall be smooth, uniformly sloped (minimum 5%), firm, and free of rocks, protrusions, or depressions greater than 0.5-inch in maximum dimension. The Earthwork CONTRACTOR shall consider that manual removal/repair of unacceptable areas may be required and shall be considered inherent to the work described herein.

3.07 TRENCH EXCAVATION AND BACKFILL

A. All trenches shall be excavated to lines and grades and dimensions indicated on the Drawings. All trench excavation, backfill, and compaction shall be in accordance with pertinent provisions of this Section.

B. All pipe work placed inside the trenches shall have a minimum of 8-inch clearance from any protrusions from the trench side walls or bottom.

C. The Earthwork CONTRACTOR shall backfill excavated trenches as promptly as progress of the work permits and immediately after the pipe has been laid, jointed, and tested.

D. The trench bottom shall be compacted to provide a uniform bed for the pipe. Backfill material shall be placed around the pipe and shall be compacted by hand-tamping, or methods acceptable to the CQA CONSULTANT.

E. The Earthwork CONTRACTOR shall compact the select engineered fill for trench backfill to at least 90 percent of the maximum dry density and within 4 percent of the optimum moisture content as determined in accordance with ASTM D1557.

F. Trench backfill shall be placed as shown on the Drawings. The backfill shall not be placed at ambient temperatures below 41°F nor above 100°F unless otherwise specified. The material shall be placed in a manner that does not cause movement or excessive wrinkling of, or induce excessive wrinkling of the geosynthetics. The CONTACTOR shall not operate equipment directly on any geosynthetics.

3.08 TOLERANCES

A. All material limits shall be constructed within a tolerance of ±1.0 ft for horizontal state plan coordinates, 0 to +0.1 ft vertical for reference to mean sea level (MSL), and 0 to +0.1 ft where dimensions are shown or specified as a minimum. The plane of the surface shall not vary more than 0.10 feet when measured with a 10-foot straight edge.

3.09 EXCAVATION BELOW GRADE

A. All excavation shall be performed within the limits of the work to the lines, grades, and elevations indicated and specified herein. The Earthwork CONTRACTOR shall not excavate or remove materials beyond indicated subgrade elevations or dimensions without the approval of the PROJECT MANAGER. The Earthwork CONTRACTOR shall backfill and compact any unauthorized excavation to the satisfaction of the PROJECT MANAGER at no additional cost to the OWNER.

B. When acceptable to the PROJECT MANAGER, lean concrete may be used to bring the bottom elevation of excavations under footings or trenches to correct elevations.

END OF SECTION

SECTION 02751

HDPE GEOMEMBRANES

PART 1 GENERAL

1.01 SUMMARY

A. This section describes the requirements for the manufacture, supply, installation, and quality control (QC) of high density polyethylene (HDPE) geomembrane associated with the final closure construction at the Kettleman Hills Facility, Landfill B-18.

1.02 RELATED SECTIONS

A. Section 02200 - Earthwork

1.03 REFERENCES

A. Latest Version of American Society for Testing and Materials (ASTM) standards:

1. ASTM D638 - Test Method for Tensile Properties of Plastics
2. ASTM D792 - Specific Gravity (Relative Density) and Density of Plastics
3. ASTM D1004 - Test Method for Initial Tear Resistance of Plastic File and Sheeting
4. ASTM D1238 - Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer
5. ASTM D1505 - Test Method for Density of Plastics by Density-Gradient Technique
6. ASTM D1603 - Test Method for Carbon Black in Olefin Plastics
7. ASTM D3895 - Test Method for Oxidative Induction Time of Polyolefins by Thermal Analysis
8. ASTM D4218 - Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique
9. ASTM D4833 - Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products
10. ASTM D5199 - Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes
11. ASTM D5321 - Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method

12. ASTM D 5397 - Procedure to Perform a Single Point Notched Content Tensile Load – Appendix (SP-NCTL) Test

13. ASTM D5596 - Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics

14. ASTM D5721 - Practice for Air-Oven Aging of Polyolefin Geomembranes

15. ASTM D5885 - Test Method of Oxidative Induction Time of Polyolefin Geosynthetics by High Pressure Differential Scanning Colorimetry

16. ASTM D5994 - Test Method for Measuring Core Thickness of Textured Geomembranes

B. Geosynthetics Research Institute (GRI):

1. GRI-GM 10 - Specification for the Stress Crack Resistance of Geomembrane Sheet

2. GRI-GM11 - Accelerated Weathering of Geomembranes Using a Fluorescent UVA – Condensation Exposure Device

3. GRI-GM12 - Measurement of the Asparity Height of Textured Geomembranes Using a Depth Gage.

4. GRI-GM13 - Test Properties, Testing Frequency and Recommended Warranty for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes

1.04 PRE-QUALIFICATION

A. The Geosynthetic CONTRACTOR shall pre-qualify for geomembrane installation by providing the following documentation:

1. The Geosynthetic CONTRACTOR shall have a minimum of 10,000,000 square feet (sf) of polyethylene geomembrane cumulative installation experience.

2. The Geosynthetic CONTRACTOR shall provide at least three references from prior installation projects in excess of 500,000 sf including the following information:

   a. Client's name, address, phone number and contact or representatives name.

   b. Project site and description.

   c. Geomembrane type and quantity installed.

1.05 SUBMITTALS

A. Submittals shall be provided in general accordance with Section 01300.

B. <u>HDPE Resin</u>: Furnish the following in writing to the CQA CONSULTANT a minimum of seven calendar days prior to geomembrane shipment to the site:

1. Statement of production dates and origin of resin used to manufacture the geomembrane for the project.

2. Certification stating all resin is from the same manufacturer and that no reclaimed polymer was added to the resin during the manufacturing of the geomembrane and that recycled polymer does not exceed 2 percent by weight.

3. Copies of the quality control certificates issued by the manufacturer and resin supplier indicating that the resin used to manufacture the geomembrane meets these specifications. These shall contain manufacturing quality control test results including specific gravity (ASTM D792 or D1505) and melt index (ASTM D1238, Condition E).

C. Manufacturing Quality Control: A copy of the manufacturer's quality control program shall be submitted to the CQA CONSULTANT a minimum of seven calendar days prior to geomembrane shipment to the site. Quality control testing shall be performed by the manufacturer in accordance with GRI-GM13 and as approved by the CQA CONSULTANT. Prior to delivery the following shall be submitted to the CQA CONSULTANT for review:

1. Certificates for each shift's production of geomembrane.

2. Copies of quality control certificates issued by the manufacturer. The quality control certificates shall include:

   a. Roll numbers and identification;

   b. Sampling procedures; and

   c. Results of quality control tests, including descriptions of the test methods used.

3. The results of the manufacturing quality control tests shall meet or exceed the property values listed in Table 02751-1.

4. Geomembrane delivery, storage, handling and installation instructions.

5. Extrudate Beads and/or Rod:

   a. Statement of production dates.

   b. Certification stating all extrudate is from one manufacturer, is the same resin type, and was obtained from the same resin supplier as the resin used to manufacture the geomembrane rolls.

   c. Copies of quality control certificates issued by the manufacturer including test results for specific gravity ASTM D792 and melt index ASTM 1288 Condition E.

D. Geomembrane Installer: Prior to mobilization of the Geosynthetic CONTRACTOR to the site, the following information shall be submitted:

1. Shop drawings indicating panel layout and field seams 14 calendar days prior to installation of geomembrane.

2. Installation schedule.

3. Copy of Geosynthetic CONTRACTOR's letter of approval or license by the geomembrane manufacturer.

4. Installation capabilities, including:

   a. Information on equipment proposed for this project;

   b. Average daily production anticipated for this project; and

   c. Quality control procedures.

5. Provide copies of the quality control/quality assurance program for the manufacturer of the geomembrane liner.

6. Resume of the superintendent to be assigned to this project, including dates and duration of employment.

7. Resumes of all personnel who will perform seaming operations on this project, including dates and duration of employment.

8. The installation crew shall have the following experience.

   a. The superintendent shall have supervised the installation of a minimum of 2,000,000 ft^2 of polyethylene geomembrane and 500,000 ft^2 of geotextile.

   b. The master seamer shall have experience seaming a minimum of 1,000,000 ft^2 of polyethylene geomembrane using the same type of seaming apparatus to be used at this site.

   c. All other seaming personnel shall have seamed at least 100,000 ft^2 of polyethylene geomembrane using the same type of seaming apparatus to be used at this site. Personnel who have seamed less than 100,000 ft^2 of polyethylene geomembrane shall be allowed to seam only under the direct supervision of the master seamer or Superintendent.

E. During the installation, the Geosynthetic CONTRACTOR shall be responsible for the timely submission to the CQA CONSULTANT of subgrade acceptance certificates, signed by the Installer, for each area to be covered by geomembrane.

F. The Geosynthetic CONTRACTOR shall furnish the OWNER upon completion of the project:

   1. A warranty provided by the manufacturer in accordance with GRI-GM13 against defects in material. Warranty conditions concerning limits of liability will be evaluated and must be acceptable to the OWNER.

2. A 1-year warranty provided by the Geosynthetic CONTRACTOR against defects in workmanship. Warranty conditions concerning limits of liability will be evaluated and must be acceptable to the OWNER.

3. As-built panel drawings in compliance with Section 01400.

E. Certificate of calibration less than 12 months old shall be submitted prior to installation for all field tensiometers.

1.06 QUALITY ASSURANCE

A. Perform work in accordance with Section 01400, the Geosynthetic CONTRACTOR's Quality Control Program, and CQA Plan.

PART 2 PRODUCTS

2.01 MATERIALS

A. The geomembrane shall be comprised of high density polyethylene (HDPE) material as indicated on the drawings, manufactured of new, first-quality products designed and manufactured specifically for the purpose of liquid containment in hydraulic structures.

B. The geomembrane shall be produced free of holes, blisters, undispersed raw materials, or any sign of contamination by foreign matter. Any such defect shall be repaired in accordance with the repair procedures in Article 3.06.

C. The geomembrane shall be manufactured with a minimum of 15.0 feet seamless width. There shall be no factory seams.

D. The geomembrane shall be HDPE 40-mil thick and textured on both sides as indicated on the Drawings.

E. The geomembrane shall be supplied in rolls. Folds will not be permitted.

F. Specifications for the HDPE geomembrane properties are presented in Table 02751-1.

G. Resin:

1. Shall be HDPE, new, first quality, compounded and manufactured specifically for producing HDPE geomembrane.

2. Do not intermix resin types.

3. Shall meet the following additional requirements:

Test	Test Designation	Minimum Frequency	Requirements
Specific Gravity(1)	ASTM D 792 Method A	(2)	≥ 0.932
Melt Index	ASTM D 1238 Condition E	(2)	≤ 1.0 g per 10 minutes

Notes: (1) Resin without carbon black (2) 1 test per resin batch

H. Extrudate Rod or Bead:

1. Shall be made from same resin as the geomembrane.

2. Additives shall be thoroughly dispersed.

3. Shall be free of contamination by moisture or foreign matter.

4. Shall meet the following requirements:

Test	Test Designation	Minimnm Frequency	Requirements
Specific Gravity	ASTM D 792 Method A	(1)	≥ 0.940
Carbon Black Content	ASTM D 1603	(1)	2-3%
Melt Index	ASTM D 1238 Condition E	(1)	≤ 1.0 g per 10 minutes
Notes: (1) 1 test per resin batch.			

2.02 DELIVERY, STORAGE AND HANDLING

A. Handling, storage, and care of the geomembrane following transportation to the site shall be the responsibility of the Geosynthetic CONTRACTOR. The Geosynthetic CONTRACTOR shall be liable for all damage to the materials incurred prior to final acceptance of the liner system by the CQA ENGINEER.

B. Conform to the manufacturer's requirements to prevent damage to geomembrane.

C. Delivery:

1. Deliver materials to the site only after the CQA CONSULTANT and the OWNER approve required submittals.

2. All rolls of geomembrane delivered to the site shall be identified at the factory with the following:

   a. Manufacturer's name

   b. Product identification and thickness

   c. Lot number

   d. Roll number

   e. Roll dimensions

3. Separate damaged rolls from undamaged rolls and store at locations designated by the OWNER until proper disposition of material is determined by the OWNER the CQA CONSULTANT.

4. The OWNER will be the final authority regarding damage.

5. Separate rolls without proper documentation and store until CQA CONSULTANT approval is received.

D. On-Site Storage:

1. Store in space allocated by the OWNER.

2. Protect from puncture, dirt, grease, water, moisture, mud, mechanical abrasions, excessive heat or other damage.

3. Store on level prepared surface (not on wooden pallets).

4. Stack per manufacturer's recommendation but no more than three rolls high.

E. On-Site Handling:

1. Use appropriate handling equipment to load, move or deploy geomembrane rolls. Appropriate handling equipment includes cloth chokers and spreader bar for loading, spreader and roll bars for deployment. Dragging panels on ground surface will not be permitted.

2. Do not fold geomembrane material; folded material shall be rejected.

3. The Geosynthetic CONTRACTOR is responsible for storage, and transporting material from storage area to liner facility.

F. Damaged Geomembrane:

1. Geomembrane damage will be documented by the CQA CONSULTANT.

2. Damaged geomembrane shall be repaired, if possible, in accordance with these specifications or shall be replaced at no additional cost to the OWNER.

2.03 EQUIPMENT

A. Welding equipment and accessories shall meet the following requirements:

1. Equipped with gauges showing temperatures both in apparatus and at nozzle (extrusion welder) or at wedge (fusion welder).

2. Maintain adequate number of welding apparatus to avoid delaying work.

3. Use power source capable of providing constant voltage under combined-line load.

4. Provide secondary containment to catch spilled fuel under electric generator, if located on geomembrane.

B. Provide calibrated tensiometer capable of quantitatively measuring geomembrane strength:

1. Equipped with gauge accurate to ± 2 lbs per inch of geomembrane width and capable of pulling at 2 inches per minute and 20 inches per minute.

2. Provide one inch die for cutting sample specimens.

3. Provide certificate of tensiometer calibration within the past 12 months.

PART 3 EXECUTION

3.01 EXAMINATION

A. The Geosynthetic CONTRACTOR shall document in writing that the surface on which the geomembrane will be installed is acceptable. In so doing the Geosynthetic CONTRACTOR shall assume full liability for the accepted surface.

B. The beginning of installation means acceptance of existing conditions. The Geosynthetic CONTRACTOR shall be responsible for maintenance of the geomembrane covered subgrade once installation of geomembrane begins.

3.02 PREPARATION

A. Maintain the surface suitability and integrity until the lining installation is completed and accepted.

B. Repair rough areas and any damage to the subgrade caused by installation of the lining and fill any ruts in subgrade caused by equipment prior to geomembrane deployment.

C. To avoid sharp bends in the geomembrane, bevel the leading edges of the anchor trench.

D. Subgrade shall be smooth, uniform, firm and free from rocks or other debris. For deployment over soil subgrade, no rocks or protrusions greater than 0.5 inch in diameter shall be exposed at the subgrade surface.

3.03 DEPLOYMENT

A. Geomembrane shall not be deployed:

1. During precipitation;

2. In the presence of excessive moisture;

3. In areas of ponded water;

4. In the presence of excessive winds (i.e., greater than 20 mph); and

5. In excessive heat (i.e., greater than 110° F) or cold (i.e., less than 40° F).

B. Each panel shall be marked with an "identification code" (number or letter) consistent with the layout plan. The identification code shall be simple and logical. The number of panels deployed in one day shall be limited by the number of panels which can be seamed on the same day. All deployed panels shall be seamed to adjacent panels by the end of each day.

C. The following is the acceptable method of deployment:

1. Use equipment which will not damage geomembrane by handling, trafficking, leakage of hydrocarbons or other means.
2. Do not allow personnel working on geomembrane to wear damaging shoes, or engage in activities that could damage geomembrane.
3. Smoking on the liner is prohibited.
4. Round sharp corners of clamps and other metal tools used in the work area.
5. Do not allow clamps and other metal tools to be tossed or thrown.
6. Unroll panels with a method that protects geomembrane from scratches and crimps and protects soil surface and underlying geotextile from damage.
7. Use a method to minimize wrinkles, especially differential wrinkles between adjacent panels.
8. Place adequate hold-downs to prevent uplift by wind.
9. Use hold-downs that will not damage geomembrane such as sandbags.
10. Use continuous hold-downs along leading edges to minimize risk of wind flow under panels.
11. Panels shall be deployed perpendicular to slope elevation contours and the generation of seams shall be minimized.
12. Protect geomembrane in heavy traffic areas by geotextile, extra geomembrane or other suitable materials.
13. Do not allow vehicular traffic on geomembrane surface.
14. Panels deployed on grades steeper than 12% shall extend a minimum of 3 feet beyond the crest or toe of that grade.
15. Shingles or overlap panels in a downward direction to facilitate drainage.
16. Rub sheets used during installation shall be removed prior to placement of subsequent panels.

D. Visually inspect sheet surface during unrolling of geomembrane and mark faulty or suspect areas for repair or test. Replace faulty (requires more than one patch per 200 square feet) geomembrane stock at no additional cost to the OWNER.

3.04 FIELD SEAMING

A. Orient seams perpendicular to slope elevation contours, i.e., orient down (not across) slope and use seam numbering system compatible with panel number system.

B. Minimize the number of field seams in corners, odd-shaped geometric locations, sumps, and outside corners.

C. Overlap panels by a minimum of 3 inches for extrusion welding and 4 inches for fusion welding. Use procedures to temporarily bond adjacent panels together that do not damage the geomembrane and that are not detrimental to seam weld material for extension welding.

D. Do not use solvent or adhesive unless product is approved in writing by the OWNER.

E. No horizontal seams shall be allowed on grades steeper than 12% or within 3 feet of the crest or toe of slopes. A horizontal seam is defined as more than half of the panel width.

F. Clean surface of grease, moisture, dust, dirt, debris or other foreign material.

G. Prior to any extrusion welding, the geomembrane seam or repair shall be prepared as follows:

1. Clean surface of oxidation by disc grinder or equivalent not more than one hour before seaming; use number 80 grit sandpaper for the disc grinder. Bevel edges of geomembrane before bonding and provide continuous tacking in repair areas.

2. Repair area where excessive grinding substantially reduces sheet thickness by more than 4 mils beyond extent of weld.

3. Clean grinding dust around weld area after grinding.

4. The following procedure shall be followed for wrinkles and fishmouths.

    a. Cut along the ridge of the wrinkle or fishmouth.

    b. Overlap a minimum of 3 inches and seam.

    c. Any portion where the overlap is less than 3 inches shall be patched with an oval or round patch of geomembrane that extends a minimum of 6 inches beyond the cut in all directions.

5. If required, a firm, dry substrate (piece of geomembrane or other material) may be placed directly under the seam overlap to achieve proper support.

6. Keep water from intercepting the weld during and immediately after welding the seam.

7. For existing welds, or welds that are over 3 minutes old, grind the existing weld two inches back from point of termination and restart welding on ground weld.

H. At least one spare operable seaming apparatus shall be maintained for every three seaming teams. Place protective fabric or piece of geomembrane beneath hot welding apparatus when resting on geomembrane lining and use an electric generator capable of providing constant voltage under combined line load. The electric generator shall generally be located outside of liner. Provide protective lining and secondary containment large enough to catch spilled fuel under electric generators when located on the liner. The welding apparatus shall be equipped with gauges giving temperatures in apparatus and at nozzle.

I. For extrusion welding, purge welding apparatus of heat-degraded extrudate before welding if extruder is stopped for longer than five minutes. All purged extrudate shall be disposed of off the geomembrane. Each extruder shoe shall be inspected daily for wear to assure that its offset is the same as the geomembrane thickness. Repair or replace worn shoes, damaged or misaligned armature brushes, nozzle contamination, or other worn or damaged parts. Avoid stop-start welding. Remove extrudate rod from welder when not using welder for long period (over two hours). No welding may commence on the liner until the field trial seam sample, made by that equipment and seamer, passes destructive testing.

J. Test and set "hot air system" using scrap material at least each day prior to commencing seaming and adjust hot air velocity to preclude wind effects. Adjust contact pressure rollers to prevent surface ripples in sheet. No equipment shall be used for welding the geomembrane until a field trial seam sample made by that equipment has passed destructive testing.

K. In performing hot wedge welding, the welding apparatus shall be automated vehicular mounted devices equipped with gauges giving applicable temperatures and pressures. The edge of cross seams shall be ground to a smooth incline (top and bottom) prior to welding. A smooth insulating plate or fabric shall be placed beneath the hot welding apparatus after usage. Protect against moisture buildup between sheets. If welding across cross seams, conduct field test seams at least every two hours, otherwise once prior to start of work and once at mid-day. No equipment is allowed to commence welding on geomembrane until the field trial seam sample made by that equipment has passed destructive testing.

L. Field trial seams shall be conducted, per seaming apparatus and per seamer, on pieces of geomembrane liner to verify adequate seaming conditions at the following frequency:

1. At beginning of each seaming period.

2. At least once every five hours.

3. At the discretion of the CQA CONSULTANT.

M. Make the trial seams at area of seaming and in contact with subgrade or GCL (same condition as the liner to be seamed). The seam sample shall be at least 42-inches long and 12-inches wide with the seam centered lengthwise. A one foot length of each trial seam sample shall be submitted to the CQA CONSULTANT for archive. Cut three 1-inch wide specimens and test two for peel adhesion, and one for bonded seam strength (shear). Each double wedge fusion seam specimen shall be tested for peel on both sides of the weld. A specimen passes when:

1. The break is film tearing bond (FTB) conforming to National Sanitation Foundation (NSF) Standard 54, Definition 2.15.

2. The break is ductile.

3. The strength of breaks for the trial seam testing shall conform to the values listed in Table 02751-1, included at the end of this section.

N. A trial seam sample passes when all specimens have passing results in peel and shear tests. If a specimen fails (one of the specimens fails in either peel or shear mode), the trial seam procedure shall be repeated in its entirety. If the repeated trial seam fails, the seaming apparatus or operator may not weld until the deficiencies or conditions are corrected and two consecutive passing field trial seams are achieved.

O. The following procedures shall by followed during cold weather conditions.

1. Geomembrane surface temperatures shall be determined by the CQA CONSULTANT at intervals of at lease once per 100 feet of seam length to determine if preheating is required. For extrusion welding, preheating is required if the surface temperature of the geomembrane is below 32° F.

2. For fusion welding, preheating may be waived by the OWNER based upon a recommendation by the CQA CONSULTANT, if the Geosynthetic CONTRACTOR demonstrates to the CQA CONSULTANT's satisfaction that welds of equivalent quality may be obtained without preheating at the expected temperature of installation.

3. If preheating is required, the CQA CONSULTANT will observe all areas of geomembrane that have been preheated by a hot air device prior to seaming, to ensure that they have not been overheated.

4. Care shall be taken to confirm that the surface temperatures are not lowered below the minimum surface temperatures specified for welding due to winds or other adverse conditions. It may be necessary to provide wind protection for the seam area.

5. All preheating devices shall receive approval by the CQA CONSULTANT prior to use.

6. Additional destructive tests will be taken at an interval between 250 and 500 feet of seam length, at the discretion of the CQA CONSULTANT.

7. Sheet grinding may be performed before preheating, if applicable.

8. Trial seaming shall be conducted under the same ambient temperature and preheating conditions as the production seams. Under cold weather conditions, new trial seams shall be conducted if the ambient temperature drops by more than 10° F from the initial trial seam test conditions. Such new trial seams shall be conducted upon completion of seams in progress during the temperature drop.

P. The following procedures shall by followed during warm weather conditions.

1. At ambient temperatures above 104° F, no seaming of the geomembrane shall be permitted unless the Geosynthetic CONTRACTOR can demonstrate to the satisfaction of the CQA CONSULTANT that the geomembrane seam quality is not compromised. Trial seaming shall be conducted under the same ambient temperature conditions as the production seams. At the option of the CQA CONSULTANT, additional destructive testing may be required for any suspected areas.

3.05 FIELD QUALITY CONTROL

A. The Geosynthetic CONTRACTOR shall designate a full-time quality control (QC) technician who shall be responsible for supervising and/or conducting the field quality control program. The QC technician may not be replaced without written authorization by the OWNER.

B. Non-Destructive Seam Testing

1. The Geosynthetic CONTRACTOR shall non-destructively test field welds for continuity over their full length using vacuum test units. The non-destructive testing shall be performed concurrently with seaming work progress, not at the completion of all seaming. Any defects located in the seam shall he repaired in accordance with Article 3.06. The following non-destructive testing procedures shall be used to test the field seams for continuity.

a. Vacuum box testing for extrusion welds.

b. Air pressure testing for double fusion seams.

2. Vacuum Box Testing

a. The vacuum box testing equipment shall comprise the following.

i. Rigid housing; transparent viewing window; a soft rubber gasket attached to bottom of housing; porthole or valve assembly; and a vacuum gauge.
ii. A vacuum pump capahle of applying 5 psi gage pressure of vacuum to the box.
iii. A bucket of soapy solution and applicator.

b. The procedure for vacuum testing is as follows:

i. Clean window, gasket surfaces, and check for leaks.

sample marking. Cut destructive samples as seaming and nondestructive testing progresses, prior to completion of liner installation. The CQA CONSULTANT will mark destructive samples with consecutive numbering, location, apparatus I.D., technician I.D., Engineer I.D., and apparatus settings and date. Record, in written form, weld and test date, time, location, seam number, ambient temperatures, machine settings, technician I.D., apparatus I.D., and pass or fail description. The Geosynthetic CONTRACTOR shall immediately repair holes in geomembrane resulting from obtaining destructive samples and vacuum test patches. The size of destructive samples shall be 12 inches wide by 44 inches long with seam centered lengthwise.

2. Two 1-inch wide specimens shall be taken from each side of the sample and tested by the Geosynthetic CONTRACTOR for peel and shear in the field prior to CQA destructive testing. If any of these specimens fail, the Geosynthetic CONTRACTOR shall track the failure immediately. The remaining sample shall be cut into three 14-inch long by 12 inches wide pieces and distributed as follows:

   a. To the CQA CONSULTANT for destructive testing.

   b. To the CQA CONSULTANT for archive.

   c. To the Geosynthetic CONTRACTOR for its use.

3. Ten 1-inch wide specimens shall be taken from one piece. Five specimens shall be tested for peel and five for shear in accordance with the CQA Plan, with test results meeting the requirements of Table 02751-1, included at the end of this section. In the event of failure, the procedures for failed seam tracking are:

   a. Retrace welding path a minimum of 10 feet in both directions from the failed test location and remove (at these locations) a one inch wide specimen for testing. Repeat tracking procedures until the Geosynthetic CONTRACTOR is confident of seam quality.

   b. Obtain destructive samples from each side of the welding path and give samples to the CQA CONSULTANT for destructive testing.

   c. Repeat process if additional tests fail.

   d. Reconstruct seam between passing test locations to satisfaction of the CQA CONSULTANT.

   e. Reconstruction may be one of the following:

      i. Cut out old seam, reposition panel and re-seam.
      ii. Add cap strip.

   f. Cut additional destructive samples from reconstruction at discretion of CQA CONSULTANT.

g. If additional destructive sample results are not acceptable, repeat process until reconstructed seam is judged satisfactory by the CQA CONSULTANT.

D. For final seaming inspection, check the seams and surface of geomembrane for defects, holes, blisters, undispersed raw materials, or signs of contamination by foreign matter. Brush, blow, or wash geomembrane surface if dirt inhibits inspection. The CQA CONSULTANT shall decide if cleaning of geomembrane surface and welds is needed to facilitate inspection. Distinctively mark repair areas and indicate required type of repair.

3.06 REPAIR PROCEDURES

A. The geomembrane will be inspected before and after seaming for evidence of defects, holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter. The surface of the geomembrane shall be clean at the time of inspection. The geomembrane surface shall be swept or washed by the Geosynthetic CONTRACTOR if surface contamination inhibits inspection. The Geosynthetic CONTRACTOR shall ensure that an inspection of the geomembrane precedes any seaming of that section.

B. Remove damaged geomembrane and replace with acceptable geomembrane materials if damage cannot be satisfactorily repaired.

C. Repair, removal and replacement shall be at the Geosynthetic CONTRACTOR's expense.

D. Repair any portion of the geomembrane exhibiting a flaw, or failing a destructive or non-destructive test. The Geosynthetic CONTRACTOR shall be responsible for repair of damaged or defective areas. Agreement upon the appropriate repair method shall be decided between the CQA CONSULTANT and the Geosynthetic CONTRACTOR. Procedures available include:

1. Patching: Used to repair holes (over 1/4-inch diameter), tears (over 1/4 inch long), undispersed raw materials, and contamination by foreign matter.

2. Grinding and welding: Used to repair pinholes, blemishes and over-grinding.

3. Capping: Used to repair large lengths of failed seams.

4. Removing the seam and replacing with a strip of new material.

E. In addition, the following procedures shall be observed.

1. Geomembrane surfaces to be repaired shall be abraded (extrusion welds only) no more than 1/2 hour prior to the repair.

2. All geomembrane surfaces shall be clean and dry at the time of repair.

3. The repair procedures, materials, and techniques shall be approved in advance of the specific repair by the CQA CONSULTANT.

4. Extend patches or caps at least 6 inches beyond the edge of the defect, i.e., be a minimum of 12 inches in diameter, and round all corners of material to be patched.

5. Bevel the edge of the patch and do not cut patch with repair sheet in contact with geomembrane. Temporary bond the patch to the geomembrane with an approved method, extrusion weld the patch and then vacuum test the repair.

F. Repair Verification:

1. Number and log each patch repair (performed by the CQA CONSULTANT).

2. Non-destructively test each repair using methods specified in this Section.

3. Provide daily documentation of non-destructive and destructive testing to the CQA CONSULTANT. The documentation shall identify seams that initially failed the test and include the evidence that these seams were repaired and retested successfully.

3.07 ACCEPTANCE

A. The Geosynthetic CONTRACTOR shall retain OWNERSHIP and responsibility for the geomembrane until acceptance by the OWNER.

B. Acceptance Criteria: The following shall be completed:

1. Verification of adequacy of field seams, repairs and testing by the CQA CONSULTANT.

2. All submittals.

3. "As-built" drawings, approved and final drawings submitted.

4. Construction area cleaned.

5. Final field inspection

6. Warranty signed over to the OWNER.

C. Field Inspections: Inspect the completed work with the OWNER; defects, wrinkles, suspicious looking welds shall be noted and marked; document, correct and arrange further field inspections until no corrective action is necessary.

TABLE 02751-1
REQUIRED PHYSICAL PROPERTIES OF 40-MIL TEXTURED HDPE GEOMEMBRANE

PROPERTY	METHOD	VALUE
Thickness, mil.	ASTM D 5994	- 38 minimum average - 36 lowest indiv. value for 8 out of 10 specimens - 34 lowest indiv. value for any of the 10 specimens
Sheet Density (min.)	ASTM D 792 or ASTM D 1505	0.940
Asperity Height (min. ave.)	GM12	10 mil
Min. Ave. Tensile Properties (1) • Tension at Yield (lb/in) • Strain at Yield (%) • Tension at Break (lb/in) • Strain at Break (%)	ASTM D 6693	 84 12 60 100
Tear Resistance, lbs. (min. ave.)	ASTM D1004, Die C	28
Oxidative Induction Time (OIT) (min. ave.) • Standard OIT, or • High Pressure OIT	 ASTM D3895 ASTM D5885	 100 minutes 400 minutes
Oven Aging at 85°C • Standard OIT (min. ave.), % retained after 90 days, or • High Pressure OIT (min. ave.), % retained after 90 days	ASTM D5721 ASTM D3895 ASTM D5885	55% 80%
UV Resistance • High Pressure OIT (min. ave.)	GRI-GM11 ASTM D5885	 50%
Stress Crack Resistance (min. hours with no failures)	ASTM D5397 (Appendix)	300
Puncture Resistance, lbs. (min. ave.)	ASTM D4833	60
Carbon Black Content (allowable range in percent)	ASTM D1603	2.0 – 3.0
Carbon Black Dispersion	ASTM D5596	- minimum 9 out of 10 specimens in category 1 or 2 - all 10 specimens in Category 1, 2, or 3
Seam Strength • Peel (lb/in) (fusiou/ ext.) • Shear (lb/in)	 ASTM D4437	 65 / 52 81

Notes: (1) Elongation at yield and elongation at break shall be calculated using a gage length of 1.3 inches and 2.0 inches, respectively.

END OF SECTION

SECTION 02752

GEOTEXTILES

PART 1 GENERAL

1.01 DESCRIPTION

A. This section describes the general requirements for the manufacture, supply, installation, and quality control (QC) of geotextiles.

1.02 RELATED SECTIONS

A. Section 02220 – Earthwork

B. Section 02751 – HDPE Geomembranes

1.03 REFERENCES

A. Latest version of the American Society for Testing and Materials (ASTM) standards:

1. ASTM D4355. Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus.

2. ASTM D4632. Standard Test Method for Breaking Load and Elongation of Geotextiles (Grab Method)

3. ASTM D4833. Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products

4. ASTM D4873. Standard Guide for Identification, Storage, and Handling of Geotextiles.

5. ASTM D5199. Standard Test Method for Measuring Geotextiles

6. ASTM D5261. Standard Test Method for Measuring Mass Per Unit Area of Geotextiles.

1.04 SUBMITTALS

A. Quality Control Submittals:

1. A copy of the manufacturer's quality control (QC) plan.

2. Manufacturing QC certificates for each production run. The certificates shall identify the origin and the manufacturer of the resin. The certificates shall be signed by responsible parties employed by the manufacturer (such as the production manager). Tests shall be performed at the frequency indicated in the manufacturer's QC Plan.

3. The QC certificates shall include roll numbers and identification, sampling procedures, and results of quality control tests verifying that each of the properties listed in Table 02752-1 is met. Samples shall be tested at a minimum frequency of

once every 100,000 sf. The manufacturer quality control tests to be performed include the tests specified in Article 2.01 of this section.

4. Manufacturer's certification that the geotextile products meet or exceed specified requirements and are 100% free of needles.

B. The Geosynthetic CONTRACTOR shall submit the following.

1. Installation plan; and

2. Proposed seam stitching methods.

C. Submittals shall be in accordance with Section 01300.

1.05 QUALITY ASSURANCE

A. Perform work in accordance with the CQA Plan.

1.06 QUALIFICATIONS

A. Geotextile shall be supplied by a geotextile manufacturer meeting the following qualification requirements:

1. The geotextile manufacturer shall be responsible for the production and delivery of geotextile rolls and shall be a well-established firm with more than two years experience in the manufacture of geotextiles. The geotextile manufacturer shall submit a statement to the CQA CONSULTANT listing:

a. Certified minimum average roll property values of the proposed geotextiles and the test methods used to determine those properties.

b. Projected delivery date of the material for this project.

B. The Geosynthetic CONTRACTOR shall meet the requirements of the CQA Plan.

PART 2 PRODUCTS

2.01 MATERIALS

A. Non-woven geotextiles shall have the following minimum average roll value (MARV) properties:

TABLE 02752-1

REQUIRED PHYSICAL PROPERTIES OF GEOTEXTILE

Fabric Property	ASTM Test Method	Manufacturer QC Test Frequency (1)	Required Test Values
Mass Per Unit Area (min. ave.)	D-5261	1 per 100,000 sf	12 oz/sy
Grab Strength (min. ave.)	D-4632	1 per 100,000 sf	300 lbs
Puncture Strength (min. ave.)	D-4833	1 per 100,000 sf	180 lbs
UV Resistance	D-4355	1 per resin formulation	70 percent (2)

Notes: (1) Manufacturer may elect to provide certification of values for geotextiles.
(2) After 500 hours of exposure.

B. Geotextile shall be non-woven, needle-punched polyester or polypropylene fabric free from needles or other foreign material.

2.02 DELIVERY, STORAGE, AND HANDLING

A. Handling, storage, and care of the geotextiles following transportation to the site shall be the responsibility of the CONTRACTOR. The CONTRACTOR shall be liable for all damage to the materials incurred prior to final acceptance of the liner system by the CQA CONSULTANT.

B. The CONTRACTOR shall be responsible for storage of the geotextile at the site after the material is delivered. The geotextile shall be stored off the ground and out of direct sunlight, and shall be protected from mud, dirt, dust, and any additional storage procedures required by the Geotextile manufacturer.

C. All rolls of geotextile shall be identified at the factory with the following:

1. Manufacturer's name
2. Product identification
3. Lot Number
4. Roll number
5. Roll dimensions

D. Geotextiles shall be handled in a manner as to ensure they are not damaged in any way.

E. Precautions shall be taken to prevent damage to underlying materials during placement of the geotextile.

F. After unwrapping the geotextile from its cover, the geotextile shall not be left exposed for a period in excess of 30 days.

PART 3 EXECUTION

3.01 INSTALLATION

A. Geotextile seams shall be continuously sewn or heat bonded. Geotextile seams shall be overlapped a minimum of 6 inches prior to sewing. No horizontal seams shall be allowed on slopes steeper than 5 horizontal to 1 vertical.

B. Polymeric thread, with chemical resistance properties equal to or exceeding those of the geotextile, shall be used for all sewing. The seams shall be sewn using Stitch Type 401. The seam type shall be Federal Standard Type SSa-1.

C. The CONTRACTOR shall examine the entire geotextile surface after installation to ensure that no potentially harmful foreign objects are present. Such foreign objects shall be removed and damaged geotextile shall be repaired or replaced at no cost to OWNER.

D. Use care not to damage underlying materials during installation.

E. Prevent the geotextile from accumulating excessive dust.

F. The CONTRACTOR shall be responsible for field handling, storing, deploying, seaming or connecting, temporary restraining (against wind), anchoring, and other aspects of geotextile installation. Specifically, the CONTRACTOR shall follow the guidelines in ASTM D 4873 regarding the placement, handling and storage or geotextiles.

G. The CONTRACTOR shall accept and retain full responsibility for all materials and installation and shall be held responsible for any defects in the completed system.

H. No equipment shall operate directly on the geotextile.

I. Use sandbags or other acceptable anchorage to prevent wind uplift.

3.02 REPAIRS

A. Any holes or tears in the geotextile shall be repaired using a geotextile patch consisting of the same geotextile.

1. On slopes inclined steeper than 10 horizontal to 1 vertical, patches shall be sewn into place with a minimum 6-inch overlap.

2. On slopes inclined at 10 horizontal to 1 vertical or less, patches may be heat-bonded with a 6-inch overlap in all directions.

END OF SECTION

SECTION 02932

REVEGETATION

PART 1 GENERAL

1.01 SUMMARY

A. This section describes the general requirements for vegetating areas associated with the final closure construction at the Kettleman Hills Facility Landfill B-18.

B. The CONTRACTOR shall furnish all labor, materials, tools, equipment, supervision, transportation, manufacturing and installation services necessary to vegetate areas of the final cover as required.

1.02 RELATED SECTIONS

A. Section 01300 - Submittals

B. Section 02200 - Earthwork

1.03 REFERENCES

A. State of California Department of Transportation (CALTRANS) Standard Specifications, latest editions.

1.04 SUBMITTALS

A. Submit the seed mix a minimum of 2 weeks prior to starting of vegetation work for review by the CQA Consultant.

B. Submittals shall be in accordance with Section 01300.

1.05 QUALITY ASSURANCE

CQA Consultant to verify adequate seed application.

PART 2 PRODUCTS

2.01 SEED/ FERTILIZER

A. The seed shall be a mixture of Zorro Fescue (Festuca megalura) at a rate of 4.0 lbs/acre and Panoche Red Brome (Bromus rubens) as a rate of 12.0 lbs/acre. Seed shall have been tested for purity and germination not more than 12 months prior to the application of the seed. The test results from seed testing shall be delivered to the Owner prior to applying the seed. Seed labels furnished by the seed vendors supplying the seed shall indicate the purity, germination and pure live seed as determined by testing.

B. Fertilizer shall be either 15-15-15 or 16-20-0 applied at a rate of 500 lbs/acre.

PART 3 EXECUTION

3.01 PREPARATION

A. The area to be seeded should be weed free and have a firm seed bed which has previously been roughened by scarifying, disking, harrowing, or otherwise worked to a depth of two to four inches. The seed bed may be prepared when earth moving work is completed.

B. The vegetated soil layer should be seeded with the seed mix listed in Section 2.01.

C. The vegetated soil layer should be fertilized with the fertilizer listed in Section 2.01. The fertilizer should be distributed uniformly over the seed bed and incorporated into the soil. Incorporation of the fertilizer may be done as part of the seedbed preparation or as part of the seeding operation unless the seed is broadcast. If fertilizing is a part of the seed bed preparation, it should not be performed more than 15 days prior to seeding.

D. If the Contractor elects to Drill/Cultipacker, a straw mulch shall be applied at a rate of 4,000 lbs/acre to stabilize the soil and retain moisture during seed germination. At least 50 percent of the applied straw should be more than six inches in length. The mulch should be applied immediately after seeding. To prevent removal of straw by wind, the mulch shall be anchored using either mulching rollers or disks. If disks are used for anchoring they should be dull and run straight.

E. If the Contractor elects to hydro-seed, a minimum of 525 pounds of fiber per acre shall be mixed and applied with the seed, and fertilizer may be mixed with the seed and fiber and applied in the hydro-seeding operation. The fiber shall be furnished and applied at the Contractor's expense. Mixing of materials for application with hydro-seeding equipment shall be performed in a tank with a built-in continuous agitation system of sufficient operating capacity to produce a homogeneous mixture and a discharge system which will apply the mixture at a continuous and uniform rate. The tank shall have a minimum capacity of 1,000 gallons. A dispersing agent may be added to the mixture provided the Contractor furnishes evidence that the additive is not harmful. Any material considered harmful, as determined by the Engineer, shall not be used. Any mixture containing stabilizing emulsion shall not be applied during rainy weather or when soil temperatures are below 40° F. Pedestrians or equipment shall not be permitted to enter areas where mixtures containing stabilizing emulsion have been applied.

END OF SECTION

APPENDIX P
CQA PLAN

APPENDIX P.1	PHASE III CQA PLAN
APPENDIX P.2	FINAL CLOSURE CQA PLAN

APPENDIX P.1
PHASE III CQA PLAN

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CONSTRUCTION QUALITY ASSURANCE (CQA) PLAN FOR LANDFILL UNIT B-18 PHASE III EXPANSION KETTLEMAN HILLS FACILITY KETTLEMAN CITY, CALIFORNIA

Prepared for:

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Kettleman Hills Facility
35251 Old Skyline Road
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November 2008
Revision 1: February 2010
Revision 2: May 2011

Project No.: 083-91887

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ENGINEER'S CERTIFICATION

In accordance with the requirements of California Code of Regulations (CCR) Title 22 Section 66264.19, this Construction Quality Assurance (CQA) Plan has been developed under the direction of a Civil Engineer registered in the State of California.

I hereby certify that this CQA Plan was developed under my direct supervision.

REGISTERED PROFESSIONAL ENGINEER
RYAN HILLMAN
C 71988
Exp. 3-31-12
CIVIL
STATE OF CALIFORNIA

5-2-2011

Ryan Hillman, P.E. Date
RCE No. 071988 Expires: 03-31-2012

1. INTRODUCTION

1.1 Purpose

The purpose of this document is to describe the Construction Quality Assurance (CQA) procedures required during the Phase III expansion of Landfill Unit B-18 (B-18) at the Kettleman Hills Facility in Kettleman City, California. This CQA Plan establishes procedures to document that the construction is performed in accordance with the approved engineering standards and specifications, meets the appropriate regulatory requirements (i.e., California Code of Regulations Title 22 §66264.19 and Title 27 §20323 and §20324), and that the necessary documentation is developed for submittal to the regulators. This CQA Plan shall be implemented under the direction of a CQA Officer who is a registered Civil Engineer in the State of California.

This CQA Plan is a guidance document that contains general and specific work element requirements for monitoring construction. General requirements include the organization and responsibilities of CQA personnel, documentation control, and reporting procedures. Specific work elements include the following:

- Clearing, Grubbing, and Stripping;
- Stockpiling and Soil Management;
- Excavation;
- Subgrade Preparation;
- Earthfill;
- Compacted Clay Liner;
- Geomembranes;
- Geotextiles;
- Drainage Geocomposites;
- Operations Layer;
- Piping; and
- Culverts/Drainage Channels.

The CQA Consultant will prepare a Final CQA Report upon completion of construction. The Final CQA Report will include information generated through the CQA program and will document the extent to which construction was performed in accordance with the intent of the Contract Documents and design. The CQA Consultant will be required to submit the Final CQA Report within one week of substantial completion of construction.

1.2 CQA Consultant

The CQA Consultant has the primary responsibility of implementing and managing the CQA program described herein and will document to the appropriate regulatory agencies that construction of the facility was performed in accordance with the design and the Contract Documents. Specific responsibilities for the CQA Consultant's site personnel are presented in Section 2.2.

1.3 Project Organization

The project will be completed by Contractors performing earthworks construction, geosynthetic materials installation, and construction of associated ancillary facilities. The CQA Consultant will be independent of the Contractors and will report directly to the Owner's Project Manager.

1.4 Reference Documents

The latest editions of the following reference documents provide background information and support this CQA Plan:

> *American Society for Testing and Materials (ASTM), Annual Book of ASTM Standards, Section 4, Construction, Volume 04.02, Concrete and Aggregates.*
>
> *American Society for Testing and Materials (ASTM), Annual Book of ASTM Standards, Section 4, Construction, Volume 04.08, Soil and Rock(I), and Volume 04.09, Soil and Rock (II); Geosynthetics.*
>
> *American Society for Testing and Materials (ASTM), Annual Book of ASTM Standards, Section 8, Plastics, Volumes 08.01, Plastics (I), Volume 08.02, Plastics (II), and Volume 08.03, Plastics (III).*
>
> *California Code of Regulations (CCR), Titles 22 (Social Security) and 27 (Environmental Protection).*
>
> *Standard Specifications for Public Works Construction, Joint Cooperative Committee of the Southern California Chapter, American Public Works Association And Southern California Districts, Associated General Contractors of California, Building News.*

1.5 Definitions

Whenever the terms listed below are used, the intent and meaning shall be interpreted as indicated.

ACI: American Concrete Institute.

AISC: American Institute of Steel Construction.

ASTM: American Society for Testing and Materials.

Construction Manager: The individual or firm responsible for administering the construction contract and providing overall construction management for the project. The construction manager is the primary contact on the project site representing the Owner.

Construction Quality Assurance (CQA): A planned and systematic pattern of procedures and documentation designed to provide confidence that items of work or services meet the requirements of the Contract Documents. Construction quality assurance includes verifying that the Contractor is performing the quality control requirements of the Specifications.

CQA Consultant: See Section 1.2

CQA Manager: Authorized representative of the CQA Consultant responsible for managing the CQA program.

CQA Monitors: Authorized representatives of the CQA Consultant responsible for observing and documenting activities related to CQA during construction.

CQA Officer: Authorized representative of the CQA Consultant and a California-Registered Civil Engineer responsible for certifying that construction was performed in accordance with the intent of the Contract Documents and design.

Construction Quality Control: Those actions which provide a means to measure and regulate the characteristics of an item or service to comply with the requirements of the Contract Documents. Quality control will be performed by the Contractor/Geosynthetics Contractor, except where designated in the Specifications.

Contract Drawings: The official plans, profiles, typical cross-sections, elevations, and details, as well as their amendments and supplemental drawings, that show the locations, character, dimensions, and details of the work to be performed. Contract Drawings are also referred to as the "Plans."

Contract Documents: The official set of documents issued by the Owner, which includes bidding requirements, contract forms, contract conditions, Specifications, Contract Drawings, addenda, and contract modifications.

Contractor: The person or persons, firm, partnership, corporation, or any combination of these or any combination of private, municipal, or public entities who, as an independent Contractor, has entered into a contract with the Owner and who is referred to throughout the Contract Documents by singular number and masculine gender.

Contract Specifications: The requirements for products, materials, and workmanship upon which the contract is based. Contract Specifications are also referred to as the "Specifications."

Design Engineer: The individuals or firms responsible for the project's design and preparation of the Plans and Specifications. The Design Engineer is also referred to as the "Designer" or "Engineer." The Design Engineer for the Phase III expansion of Landfill Unit B-18 is Golder Associates Inc. of Irvine, California.

Earthwork: A construction activity involving the use of soil materials as defined in the Specifications and Section 3 of this document.

Flexible Membrane Liner (FML): A synthetic lining material, also referred to as geomembrane, membrane, liner, or sheet.

Geosynthetics Contractor: Also referred to as the "Installer." The person or firm responsible for installation of geosynthetic components. This definition applies to any party installing geomembrane, geotextile, geocomposite, geosynthetic clay liner, or any other geosynthetic material, even if it is not their primary function.

GRI: Geosynthetics Research Institute.

Non-Conformance: A deficiency in characteristic, documentation, or procedure that renders the quality of an item or activity unacceptable or indeterminate. Examples of non-conformance include, but are not limited to, physical defects, test failures, and inadequate documentation.

Owner: Waste Management, Inc. – Kettleman Hills Facility.

Owner's Project Manager: Authorized representative of the Owner responsible for planning, organizing, and control of the design and construction activities. Responsibilities include scheduling, cost control, engineering, procurement, and contracting functions. Referred to as the "Project Manager" in this document.

Panel: A unit area of the FML that is seamed in the field or in the fabricator's plant.

Procedure: A document that specifies or describes how an activity is to be performed.

Project Documents: Contractor submittals, Construction Drawings, Record Drawings, Specifications, shop drawings, construction quality control and quality assurance plans, health and safety plans, and project schedules.

Record Drawings: Drawings recording the constructed dimensions, details, and coordinates of the project. Also referred to as "as-builts."

SSPWC: Standard Specifications for Public Works Construction.

Testing: Verification that an item meets specified requirements by subjecting that item to a set of physical, chemical, environmental, or operating conditions.

Testing Laboratory: A laboratory capable of conducting the tests required by this CQA Plan and the Specifications.

2. GENERAL REQUIREMENTS

2.1 Meetings

In order to facilitate construction and to clearly define construction goals and activities, close coordination between the Owner, Design Engineer, CQA Consultant, and Contractor is essential. To meet this objective, pre-construction and progress meetings will be held.

2.1.1 Pre-Construction Meeting

Following the bid award, a pre-construction meeting will be held at the site. Attendees at this meeting will include the Owner, Contractor, Design Engineer, CQA Consultant, agencies, and others designated by the Owner. The primary purposes of the pre-construction meeting will be to:

- Review the Plans, Specifications, this CQA Plan, work area security, health and safety procedures, and related issues.
- Provide all parties with relevant project documents.
- Review responsibilities and qualifications of each party.
- Define lines of communication and authority.
- Establish reporting and documenting procedures.
- Review procedures for handling submittals.
- Review testing equipment and procedures.
- Review procedures for field directives and change orders.
- Establish testing protocols and procedures for correcting and documenting construction or non-conformance.
- Establish the weekly meeting schedule.
- Discuss work areas, stockpile areas, lay down areas, access roads, haul roads, and related items.
- Review the project schedule and critical path items.
- Review the Contractor's work plan.

The pre-construction meeting will be documented by the CQA Manager. Copies of the minutes and other pertinent material will be prepared and provided to the relevant parties.

2.1.2 Progress Meetings

Informal progress meetings will be held each morning before the start of work. At a minimum, these meetings will be attended by the CQA Monitor and Contractor. The purpose of these meetings will be to:

- Discuss problems and resolutions.
- Review test data.
- Discuss the Contractor's personnel and equipment assignments for the day.
- Review the previous day's activities and accomplishments.
- Resolve any outstanding problems or disputes.

2.1.3 Weekly Meetings

Throughout the duration of construction, scheduled weekly meetings will be held. The Project Manager, Construction Manager, CQA Manager, and Contractor will be present. These meetings will be held to discuss progress, problems, construction schedule, changes, test data, health and safety, environmental issues, and any other issues necessary. The Project Manager will prepare the agenda for each meeting and prepare meeting minutes for distribution to the relevant parties.

2.1.4 Other Meetings

As required, other meetings may be held to plan work items and/or to discuss problems or non-conformance. These meetings will be attended by parties as directed by the Owner. If the problem requires a design modification and subsequent change order, the Engineer and Project Manager should be present. These meetings will be documented as directed by the Project Manager.

2.2 Responsibilities of Construction Quality Assurance Staff

2.2.1 Communications with the Contractor

Only the individuals assigned to this project, as defined in this document, can communicate with the Contractor. Communications of an official nature must be clear, direct, and professional. When written communications are required, they must be documented on the appropriate forms. Formal letters to the Contractor should normally be signed by the CQA Manager and reviewed by the Owner.

2.2.2 Communications with the Owner

Only those individuals assigned to this project, as defined in this document, can communicate with representatives of the Owner. All communications must be through proper channels as defined during the project's pre-construction meeting. Communications of an official nature must be written, clear, direct, and professional.

2.2.3 Responsibilities of the CQA Manager

The CQA Manager administers the CQA program. CQA procedures and reports must be reviewed by the CQA Manager for compliance with this CQA Plan. The CQA Manager acts as an auditor to monitor and document the proper and complete implementation of the CQA program. The CQA Manager has authority to identify deficiencies and implement corrective action to the CQA program. The CQA Manager collects, distributes, and addresses the disposition of Contractor submittals approved by the Design Engineer. The CQA Manager coordinates testing with independent testing laboratories and maintains the Record Drawings. The CQA Manager reports directly to the Construction Manager. The CQA Manager will aid in preparing the Final CQA Report for the project under the direction of the CQA Officer.

2.2.4 Responsibilities of the CQA Officer

The CQA Officer is responsible for documenting and certifying to the Department of Toxic Substances Control (DTSC) and the Regional Water Quality Control Board (RWQCB) that the construction was performed in accordance with the intent of the design and the Contract Documents. The CQA Officer may also be the CQA Manager.

2.2.5 Responsibilities of the Design Engineer

The Design Engineer is responsible for site engineering services related to the project's design. Those services include reviewing Contractor submittals, resolving technical issues related to construction, providing interpretation of the Plans and Specifications, and approving substantial design modifications and technical revisions.

2.2.6 Responsibilities of the CQA Monitors

The CQA Monitors implement the CQA program under the direction of the CQA Manager. The CQA Monitors perform the construction monitoring and construction materials testing. The CQA Monitors maintain the documentation and test data summaries related to construction monitoring and construction materials testing. The CQA Monitors report directly to the CQA Manager.

2.3 Control of Documents, Records, and Forms

2.3.1 Project Control of Contract Documents

The Contract Documents, including the Specifications, Plans, and change orders, are controlled by the Construction Manager. The Construction Manager maintains one or more copies of the most current set of Contract Documents for use by the CQA Consultant. Upon issuance of new copies or revisions, it is the responsibility of the Construction Manager to notify the Contractor of the revisions, provide revised Contract Documents, and order the recall of superseded copies of the Contract Documents. The Construction Manager also provides the latest revised set of Contract Documents to the CQA Consultant.

2.3.2 Project Control of As-Built Information

As-built information generated by the Contractor and CQA Consultant is controlled by the CQA Manager. During the progress of the work, the CQA Manager obtains as-built information provided from the CQA Monitors, Contractor, surveyors, or others and compiles the as-built data into one set of drawings. The as-built drawing set must be maintained on site and be clearly marked as "Record Drawings."

2.3.3 Project Control of Forms

Daily report forms, test report forms, and other project forms are controlled by the CQA Manager, who maintains a master of each form for copies. Upon issuance of a new form, the CQA Manager must recall and remove all superseded copies along with the master, notify the CQA Monitors, and provide new copies for their use.

2.3.4 Processing Daily Reports

The CQA Monitors write a daily record of work progress. These daily reports are reviewed by the CQA Manager for legibility, clarity, traceability, and completeness. The review must be evidenced by a signature of the reviewer. Daily reports are submitted to the Construction Manager on a daily basis and are maintained at the site. A weekly summary construction report will be prepared by the CQA Manager and submitted on a weekly basis to the Construction Manager.

2.3.5 Processing Test Reports

A test report must be completed by the CQA Monitors whenever testing is performed. The test reports must be reviewed by the CQA Manager. The review includes a check for mathematical accuracy, conformance to test requirements, conformance to the Specifications, and for clarity, legibility, traceability, and completeness. The review must be evidenced by a signature of the reviewer. Test reports (or summaries) from independent testing laboratories will also be transmitted to the CQA Manager for review.

2.3.6 Processing Project Records

Project records are completed as needed. Use of the project records is limited to the scope for which they are intended. The record must be completed by filling in all of the blanks provided on the form, followed by the signature of the individual completing the form. All project records must be maintained at the site.

2.4 Documentation and Control of Non-Conformance

2.4.1 Observation of Non-Conformance

Whenever a non-conformance is discovered or observed in the construction process, product, job-related materials, documentation, or elsewhere, the CQA Manager and CQA Monitors should first notify the Contractor's foreman/superintendent supervising the work in question. The CQA Manager should then notify the Construction Manager.

2.4.2 Determining Extent of Non-Conformance

Whenever a non-conformance is discovered or observed in the construction process, product, job-related materials, documentation, or elsewhere, the CQA Consultant will determine the extent of the non-conformance. The extent of the deficiency may be determined by additional sampling, testing, observations, review of records, or any other means deemed appropriate.

2.4.3 Documenting Non-Conformance

All non-conformance must be documented in writing on the daily records, logs, and elsewhere, as appropriate. This documentation must occur immediately upon determining the extent of the non-conformance. For a non-conformance that is considered serious or complex in nature, or which requires an engineering evaluation, a Non-Conformance Report will be prepared and issued to the Construction Manager and Contractor.

2.4.4 Corrective Measures

For a straightforward or routine non-conformance, corrective measures will be determined by direction from the Specifications. If no direction exists in the Specifications, the Construction Manager, CQA Manager, and Contractor will discuss construction methods to correct the deficiency. For Non-Conformance Reports that require an engineering evaluation, the Design Engineer must determine corrective measures. A copy of the Non-Conformance Report, with the Design Engineer's corrective measure determination, will be forwarded to the Construction Manager, CQA Manager, and Contractor for implementation of the corrective action.

2.4.5 Verification of Corrective Measures

Upon notification by the Contractor that a corrective measure is complete, the CQA Manager will verify its completion. The verification must be accomplished by observations or re-testing and documented photographically. Written documentation of the corrective measures must be made by the CQA Manager on daily reports, logs, forms, and, if applicable, the Non-Conformance Report. Verification of corrective measures will be reviewed by the Construction Manager. Corrective action measures that require an engineering evaluation will be reviewed and verified by the Design Engineer.

2.5 Construction Monitoring

2.5.1 Monitoring Priorities

Before commencement of construction, the CQA Manager will establish a list of monitoring priorities. This list will include the various construction activities and the monitoring priority of those activities. The monitoring priorities may change during construction, based upon the Contractor's performance and/or the Owner's request. Changes in the monitoring priorities must be approved by the CQA Manager.

2.5.2 Discrepancies

CQA testing must be conducted in accordance with this CQA Plan. However, discrepancies that occur between this document and other construction documents must be resolved. The document that requires the most frequent tests or more stringent requirements will govern, unless otherwise specified by the Design Engineer and/or CQA Manager.

2.6 Materials Quality Verification

2.6.1 General

Material sources will be identified and samples tested to determine if the material meets the requirements of the Specifications. Definitions and requirements of materials are provided in the Specifications. Test samples will be obtained in accordance with applicable ASTM and GRI standards. Archive samples and test results of the test samples will be maintained and stored at the project site. The CQA Monitors will establish and maintain a materials quality verification list. This list will include material sources, sample locations, testing requirements, test results, and verification action items.

2.6.2 Material Submittals

Material submittals may be used by the CQA Consultant to establish the acceptability of materials. When material sample submittals are required, they will be made available to the CQA Consultant by the Contractor. Acceptance and proper review of material submittals are the responsibility of the CQA Manager.

2.6.3 Certificates of Compliance and Conformance

Certificates of compliance and conformance may be used by the CQA Manager to establish the acceptability of materials. These certificates generally state that the material is in compliance or conformance with a particular code, standard, or specification. These certificates may be used for acceptance of a product before or in lieu of testing, if allowed by the Specifications.

2.7 Equipment Control

2.7.1 Equipment List

Before the start of construction, the CQA Manager will complete a list of all measuring, sampling, and testing equipment being used at the site. As new equipment becomes available during the course of the project, it must be added to the list. When more than one type of equipment is available, a unique number will be affixed to each piece to maintain identity. The equipment list will be maintained in the project files and contains the following information:

- Type of equipment;
- Serial number or identifying number;
- Date item received at site;
- Use of the equipment; and
- Date removed from service.

2.7.2 Calibration of Equipment and Materials

Before placing a piece of testing equipment into service, its accuracy must be established and calibrated by the CQA Manager or CQA Monitor. Types of equipment requiring calibration include: nuclear gauges, sand cone devices, sand to be used in sand cones, and scales. The calibration procedures and frequencies must be per the equipment manufacturer's instructions or ASTM standards. Whenever the equipment is suspect or is producing questionable results, it must be removed from service immediately and re-calibrated.

3. CONSTRUCTION QUALITY ASSURANCE FOR EARTHWORK

3.1 General

This section describes CQA procedures for earthwork operations. The scope of earthwork and related CQA includes the following elements:

- Clearing, Grubbing, and Stripping;
- Stockpiling and Soil Management;
- Excavation;
- Structural Fill;
- Subgrade Preparation;
- Compacted Clay Liner;
- Operations Layer; and
- Trench Excavation and Backfill.

3.2 Earthwork Construction Testing

3.2.1 Test Standards

The latest editions of the following test standards apply as called out in this document or the Specifications:

Standard	Test Description
ASTM D422	Standard Test Method for Particle Size Analysis of Soils
ASTM D1556	Standard Test Method for Density and Unit Weight of Soil in Place by the Sand Cone Method
ASTM D1557	Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort
ASTM D1587	Standard Practice for Thin-Walled Tube Geotechnical Sampling of Soils
ASTM D2216	Standard Test Method of Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
ASTM D2487	Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D2488	Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)
ASTM D2937	Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method

ASTM D4318	Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D5084	Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter
ASTM D6938	Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

3.2.2 Test Frequencies

Tables 3-1 and 3-2 establish the test frequencies for earthwork CQA. The test frequencies listed establish a minimum number of required tests. Extra testing must be conducted whenever work or materials are suspect, marginal, or of poor quality. Extra testing may also be performed to provide additional data for engineering evaluation. Any re-tests performed as a result of a failing test do not contribute to the total number of tests performed in satisfying the minimum test frequency.

The Final CQA Report shall include tables similar to Tables 3-1 and 3-2 that document compliance with the testing frequencies and that document test results that comply with the Specifications.

TABLE 3-1
STRUCTURAL FILL CONFORMANCE
TESTING FREQUENCIES

ASTM Test Method	ASTM Designation	Frequency	Frequency (Bench Fill/Trench)
Prior to Placement:			
Moisture-Density Relationship[1]	D1557	1 Per 10,000 CY or Each Material Type (minimum of 2)	1 Per Material Type
Sieve Analysis	D422	1 Per 10,000 CY or Each Material Type	1 Per Material Type
Atterberg Limits	D4318	1 Per 10,000 CY or Each Material Type	1 Per Material Type
During / After Placement:			
Nuclear Water Content and Density[2]	D6938	1 Per 1,000 CY Per 1.5 Vertical Feet	1 Per Lift Per 200 Linear Feet
Sand Cone Test or Drive Cylinder Test[3]	D1556 D2937	1 Per 20 Nuclear Density Tests	1 Per 10 Nuclear Density Tests

Notes to Table 3-1:

1. Perform a Check Point (one point selected at near optimum and compared to the ASTM D1557 curve) at least once for every 10,000 cubic yards of material placed.
2. Tests shall be performed on an even grid to provide adequate testing coverage. For large fills in small areas, the testing frequency shall be increased as necessary to ensure testing for each lift of soil placed.
3. Drive cylinder tests may be performed on clay or silt samples only.

TABLE 3-2
CLAY LINER CONFORMANCE TESTING FREQUENCIES

ASTM Test Method	ASTM Designation	Frequency	Frequency (Bench Fill/Trench)
Prior to Placement:			
Moisture-Density Relationship[1]	D1557	1 Per 5,000 CY or Each Material Type (minimum of 2)	1 Per Material Type
Sieve Analysis	D422	1 Per 5,000 CY or Each Material Type	1 Per Material Type
Atterberg Limits	D4318	1 Per 5,000 CY or Each Material Type	1 Per Material Type
Hydraulic Conductivity	D5084	1 Per 5,000 CY or Each Material Type	1 Per Material Type
During / After Placement:			
Nuclear Water Content and Density[2]	D6938	1 Per 500 CY or Per Lift, whichever is greater	1 Per Lift Per 200 Linear Feet
Sand Cone Test or Drive Cylinder Test	D1556 D2937	1 Per 20 Nuclear Density Tests	1 Per 10 Nuclear Density Tests
Hydraulic Conductivity	D5084	1 Per 1,000 CY or Per Lift, whichever is greater	1 Per 200 Linear Feet

Notes to Table 3-2:

1. Perform a Check Point (one point selected at near optimum and compared to the ASTM D1557 curve) at least once for every 10,000 cubic yards of material placed.
2. Tests shall be performed on an even grid to provide adequate testing coverage. For large fills in small areas, the testing frequency shall be increased as necessary to ensure testing for each lift of soil placed.

3.2.3 Soil Sample Numbering

The CQA Monitor will maintain soil sample numbers in a master log to be maintained at the site. Sample numbers will begin at 001 and proceed upward. No sample number can be repeated and re-tests of a failing sample will be given the original number with a letter suffix (i.e., re-tests for a failing sample 021 would be: 021A, 021B, etc.). Information contained in the master log of test samples will include:

- Sample number;
- Test(s) to be performed;
- Dated sampled;
- CQA Monitor obtaining sample;
- Location sampled;
- Location of testing (on-site vs. off-site);

- Date sample sent off-site;
- Date test results received;
- Site testing CQA Monitor;
- Date testing completed at site; and
- Test results and remarks.

3.2.4 Soil Sample Tagging

The CQA Monitor is responsible for maintaining sample identification for all soil samples while on site, from the time of sampling through the completion of testing. The CQA Monitor must place a sample tag on the soil sample container immediately upon sampling. This tag must remain with the soil sample throughout processing. The tag will contain the following information:

- Sample number;
- Material type;
- Project name and project number;
- Sampling CQA Monitor;
- Date sampled; and
- Test(s) to be performed.

3.2.5 Soil Sample Processing

The CQA Monitor is responsible for the timely processing of soil test samples. The CQA Manager will determine which samples are tested on-site and which are tested off-site. This determination will be made based on available manpower, available equipment, complexity of testing, and the desired turnaround time for results. For expediency, samples to be tested off-site should be shipped the same day they are collected.

3.3 Field Density Tests

3.3.1 Test Numbering

The CQA Monitor is responsible for maintaining test numbers and results for field density tests performed using the nuclear gauge (ASTM D6938), sand cone (ASTM D1556), and drive cylinder (ASTM D2937). All other testing is identified through the sample number (Section 3.2.3). The CQA Monitor will maintain field books that identify soil segments, test data, the CQA Monitor performing the test, and the sequential test number. Each soil segment will have a unique series of numbers. No test number can be repeated for a given soil segment, and re-tests of failing tests must be given a letter suffix along with the original test number (i.e., re-tests for a failing test 1201 would be: 1201A, 1201B, etc.). Test data and results must be filled out on the field density test form.

3.3.2 Test Locations

The intent of the CQA program is to provide confidence that the earthwork materials and work conform to the requirements of the Specifications. To meet this intent, the CQA Monitor will perform density tests of earthfills during construction. Density tests must be located at various elevations and uniformly dispersed throughout the entire plan dimensions of the fill. Density test locations must be chosen without bias; however, additional testing can be performed in any areas that are suspect, marginal, or appear to be of poor quality. During the progress of the work, density test locations will be plotted on a drawing by the CQA Monitor to document that no significant areas are left untested. This drawing will be included in the Final CQA Report.

3.4 Monitoring and Testing Requirements

Earthwork components of the construction are summarized in Section 3.1. Each component has specific construction requirements that must be monitored. The following sections list monitoring requirements for each type of earthwork.

3.4.1 Clearing, Grubbing, and Stripping

- Document that erosion and sediment control silt fences, straw bale barriers, and other measures are securely in place prior to initiating clearing, grubbing, and stripping operations in any area.
- Document that existing plant life designated to remain is protected against damage during construction.
- Document that clearing and stripping in areas required for site access and execution of the work is complete.
- Document that vegetation, roots, and highly organic soil within the work area are removed to the appropriate extent.

3.4.2 Stockpiling and Soil Management

- Review the Contractor's approved work plan submittal. Verify stockpile locations, stockpile dimensions, clay mixing areas, haul routes, material segregation procedures, and erosion, sediment, and drainage control measures. Determine and note corrective action items, if applicable.
- Document that stockpile locations have been cleared, grubbed, and stripped in accordance with Section 3.4.1 of this CQA Plan and the Specifications.
- Document that stockpile subgrades are surveyed prior to stockpiling.

The CQA Monitor will maintain a separate soil test data summary sheet for the specific purpose of soil classification of stockpiled materials.

- During excavation, hauling, and stockpiling operations, continually identify and verify material classifications in general accordance with ASTM D2487 (Unified Soil Classification System) and ASTM D2488 as necessary to characterize material stockpile designations.

- Observe that stockpiles are constructed with slopes no greater than 2H:1V (horizontal:vertical) and that the top surface maintains a minimum 5 percent grade. The Contractor shall include 15-foot-wide drainage benches every 50 vertical feet on all stockpiles.

3.4.3 Excavation

- Document that construction staking is performed before work and that survey bench marks with elevations are secured outside the work area.
- If applicable, document that the Contractor has notified Underground Service Alert to identify and locate underground utilities.
- Document that excavated materials are segregated into proper stockpiles.
- Coordinate with the Contractor to perform excavation verification surveys upon completion of excavating operations. Verify corrective action measures as determined by verification surveys. Verification surveys will also be used to determine limits of excavation for measurement and payment applications. Submit a copy of verification surveys to the Construction Manager.
- Document that unsuitable materials are removed from areas that will receive earthfill. Unsuitable materials include uncertified existing fills, disturbed soils, weak/highly compressible soils, and deleterious materials.
- Prepare a geologic map and geotechnical report of the subgrade for inclusion in the final certification report. Mapping shall be performed by a competent person under the supervision of a California Certified Engineering Geologist.

3.4.4 Structural Fill

- Monitor that subgrade for placement of soil is consistent with the Specifications.
- Monitor that construction staking is performed before the beginning of the work and that survey bench marks with elevations are secured outside the work area.
- Perform visual and manual soil classifications (ASTM D2488) to verify that the material source is suitable for structural fill. Verify that the material is free of organic and oversized materials and perform classifications continually during excavation of borrow materials.
- Perform moisture-density relationship testing (ASTM D1557) to determine the maximum dry density and optimum moisture content for structural fill materials. Perform tests at the testing frequencies specified in Table 3-1.
- Monitor that structural fill materials are placed in loose lifts not exceeding 8-inches thick and are then properly compacted.
- Perform nuclear density-moisture tests (ASTM D6938) to document that each lift is compacted to the appropriate relative compaction, as stipulated in the Specifications. Perform tests at the testing frequencies specified in Table 3-1.
- Monitor that soil materials are kept within the specified moisture content range listed in the Specifications. Monitor that soil materials that are wet and over the optimum moisture content (as determined by ASTM D1557) are properly aerated and processed to

bring the moisture content of the material into the acceptable range. Monitor that soils that are dry and below the optimum moisture content (as determined by ASTM D1557) are properly moisture conditioned and processed to bring the moisture content into the acceptable range.

- Monitor that desiccated structural fills are properly repaired or removed before placing subsequent lifts.

- Monitor that final structural fill surfaces are free of ruts, gouges, and other features that might contribute to erosion and sediment run-off.

- During fill operations, field-verify lines, grades, and dimensions using hand-held levels, range poles, and measuring tapes.

- Coordinate with the Contractor to perform verification surveys at the completion of structural fill placement. Verify corrective action measures as determined by verification surveys. Verification surveys will also be used to determine the limits of structural fill for measurement and payment applications. Submit copies of verification surveys to the Construction Manager.

3.4.5 Compacted Clay Liner

- Monitor that material borrow sources are suitable for compacted clay liner.

- Monitor that processing and moisture conditioning of the compacted clay liner are in conformance with the Specifications.

- Monitor that grade control construction staking is performed before the work.

- Monitor that the proper number of passes are made with an approved compactor.

- Monitor lift thickness and other construction procedures as covered in the Specifications and verify that test results are in accordance with the Specifications.

- Perform tests at the frequencies specified in Table 3-2.

3.4.6 Geosynthetics Subgrade Preparation

- Monitor that the subgrade is free of organic and oversized materials and meets the requirements of the Specifications.

- Monitor that grade control construction staking is performed prior to the work.

- Perform moisture-density relationship testing (ASTM D1557) to determine the maximum dry density and optimum moisture content of subgrade materials.

- Monitor that angular or sharp rocks, rocks that protrude more than 0.5 inches, and other debris that could damage the overlying geomembrane are removed from the surface of the subgrade. Verify that the subgrade is free of irregularities and is steel drum rolled smooth prior to geomembrane placement.

- Monitor that the final surface provides continuous and intimate contact with the overlying geomembrane.
- Coordinate with the Contractor to perform subgrade verification surveys upon completion of the subgrade preparation. Verify corrective action measures as determined by the verification surveys. Verification surveys will also be used to determine the limits of the subgrade preparation for measurement and payment applications. Submit copies of verification surveys to the Construction Manager.

3.4.7 Operations Layer

- Monitor that the material source is suitable for the operations layer and is free of organic or other deleterious materials and free of oversized particles, as defined by the Specifications.
- Monitor that grade control construction staking is performed before the work.
- Verify that the operations layer and is placed in a manner that does not damage the underlying geosynthetic layers.
- Coordinate with the Contractor to perform operations layer verification surveys upon completion of placement operations. Verify corrective action measures as determined by the verification surveys. Verification surveys will also be used to determine the limits of the operations layer for measurement and payment applications. Submit a copy of verification surveys to the Construction Manager.

3.4.8 Trenching and Backfilling

- Monitor that construction staking is performed before the work and that survey bench marks with elevations are secured outside the work area.
- Monitor that trenches are excavated in accordance with the dimensional cross-sections and design elevations shown on the Plans.
- Monitor profile surveys conducted by the Contractor during trenching operations.
- Perform moisture-density relationship testing (ASTM D1557) to determine the maximum dry density and optimum moisture content of soil materials that will be used as backfill.
- Perform nuclear density-moisture tests (ASTM D6938) to verify that backfill materials are moisture conditioned and compacted in accordance with the Specifications.

4. CONSTRUCTION QUALITY ASSURANCE FOR GEOSYNTHETICS

4.1 General

The objectives of the geosynthetics CQA program are to assure that: (i) proper construction techniques and procedures are used, and (ii) the project is completed in accordance with the Plans and Specifications. The intents of the CQA program are to: (i) identify and define problems that may occur during construction, and (ii) document that these problems are corrected before construction is complete.

This section describes CQA procedures for the installation of geosynthetic components. The following geosynthetics will be utilized for this project:

- 60-mil HDPE geomembrane (textured on both sides);
- Non-woven geotextile; and
- Double-sided geocomposite.

CQA for the geosynthetics installations will be performed to monitor that geosynthetics are installed in accordance with the design. Construction must be conducted in accordance with the Plans and Specifications. To monitor compliance, the CQA Manager will: (i) review the Contractor's quality control submittals; (ii) perform material conformance testing; (iii) monitor construction testing; and (iv) monitor installations. Conformance testing refers to activities that take place before geosynthetics installation. Construction testing includes activities that occur during geosynthetics installation.

The CQA testing will be conducted in accordance with this CQA Plan and the project's Plans and Specifications. If a discrepancy exists in the testing requirements, the document that requires the most stringent testing will govern.

4.2 Geomembrane

4.2.1 Delivery, Storage, and Handling

Upon delivery of geomembrane, the CQA Monitor will:

- Observe geomembrane rolls for damage during shipping and handling, identify and mark any damaged materials, and document that damaged materials are set aside.
- Observe that the geomembrane is stored in accordance with the Specifications and is protected from puncture, dirt, grease, water, moisture, mud, mechanical abrasions, excessive heat, direct sunlight, and other damage.
- Document that all manufacturing documentation required by the Specifications has been received.
- Complete the geosynthetics inventory form for all geomembrane materials received.

Damaged geomembrane may be rejected. If rejected, document that material is removed from the site or stored at a location separate from accepted geomembrane. Geomembrane that does not have proper documentation from the manufacturer must be stored at a separate location until all documentation has been received, reviewed, and accepted.

4.2.2 Conformance Testing

Geomembrane Material Tests. Geomembrane samples will be obtained for conformance testing in accordance with Table 4-1. The material will be sampled at the site by the CQA Monitor or at the manufacturing plant under the direction of the CQA Consultant. The samples will be forwarded to an independent testing laboratory for the following conformance tests:

TABLE 4-1
HIGH DENSITY POLYETHYLENE (HDPE) GEOMEMBRANE
CONFORMANCE TESTING FREQUENCIES

Property	Test Method	Conformance Test Frequency[6]
Thickness (min. avg.)	ASTM D5994	1 per 250,000 sf
Asperity Height (min. avg.)[1]	GRI GM 12	1 per 250,000 sf
Melt Flow Index	ASTM 1238	1 per 250,000 sf
Sheet Density (min avg.)	ASTM D792 or ASTM D1505	1 per 250,000 sf
Tensile Properties[2] (min. avg.) • Yield strength • Break strength • Yield elongation • Break elongation	ASTM D6693 Type IV	1 per 250,000 sf
Puncture Resistance (min. avg.)	ASTM D4833	1 per 250,000 sf
Carbon Black Content (range)	ASTM D1603[3]	1 per 250,000 sf
Carbon Black Dispersion[4]	ASTM D2663 ASTM D5596	1 per 250,000 sf
Interface Shear Strength[5] • geocomposite / geomembrane • clay liner / geomembrane	ASTM D6243	1 per project

Notes to Table 4-1:
(1) Applies only to textured geomembranes. Alternate the measurement side for double-sided textured sheets.
(2) Machine direction (MD) and cross machine direction (XMD) average values shall be on the basis of 5 test specimens in 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.

(3) Other methods such as D4218 (muffle furnace) or microwave methods are acceptable if an appropriate correlation to D1603 (tube furnace) can be established.
(4) Carbon black dispersion (only near spherical agglomerates) for 10 different views.
(5) Interface shear strength tests shall be tested at normal loads of 1,000; 4,000; 8,000; and 15,000 pounds per square foot. Results of the testing shall be forwarded to the Engineer for review and approval. Test reports shall include peak and large-displacement (2.5 inches) shear stress values.
(6) Minimum testing frequency shall be one sample per lot.

The CQA Manager will review all conformance test results and report any non-conformance to the Construction Manager and Contractor.

The Final CQA Report shall include a table similar to Table 4-1 documenting compliance with the testing frequencies and results documenting compliance with the Specifications.

Sampling Procedure. Samples will be taken across the entire roll width. Samples may be cut for shipping purposes, but a minimum of five square feet must be sent to the testing laboratory. Samplers must mark the machine direction and the manufacturer's roll identification number on the sample (each piece). Samplers will also assign a conformance test number to the sample and mark the sample with that number.

4.2.3 Geomembrane Installation

Surface Preparation. The soil surface must be prepared in accordance with the Specifications. Before geomembrane installation, the subgrade will be inspected by the CQA Monitor and Geosynthetics Contractor. The CQA Monitor must check the following:

- All lines and grades for the soil surface have been verified by the Contractor.
- The soil surface has been rolled/compacted and is free of surface irregularities, loose soil, and protrusions.
- The soil surface is firm and does not contain stones or other objects that could damage the geomembrane.
- The anchor trench dimensions have been checked and the trenches are free of sharp objects and stones.
- There are no excessively soft areas.
- The soil surface is not saturated and no standing water is present.
- The soil surface is not desiccated.
- All construction stakes, if utilized, have been removed and accounted for and there is no debris, rocks, or any other objects in or on the soil surface.
- The Geosynthetics Contractor has certified in writing that the surface on which the geomembrane will be installed is acceptable.

Panel Placement. Before installing any of the geomembrane, the Geosynthetics Contractor must submit drawings in accordance with the Specifications. These drawings will show the proposed layout of the panels, including panel identification numbers, field seams, and any other details that do not conform to the Plans.

The CQA Monitor will maintain an up to date panel layout drawing that shows the following: (i) roll numbers; (ii) panel numbers; (iii) seam numbers; (iv) test locations; (v) repair locations; and, (vi) non-destructive testing information.

During panel placement operations, the CQA Monitor will:

- Record panel numbers and dimensions on the panel/seam log.

- Observe the panel surface as it is deployed and record all panel defects and defect corrective actions (panel rejected, patch installed, extrudate placed over the defect, etc.) on the repair sheet. Verify that corrective actions are made in accordance with the Specifications.

- Monitor that equipment used during deployment operations does not damage the geomembrane. Verify that equipment used on the geomembrane does not leak hydrocarbons onto the geomembrane or that corrective measures are taken to prevent leakage.

- Observe that the surface beneath the geomembrane has not deteriorated since previous acceptance. Verify that no stones, construction debris, or other items are beneath the geomembrane that could damage the geomembrane.

- Monitor that the geomembrane is not dragged across an unprotected surface. If the geomembrane is dragged across an unprotected surface, the geomembrane must be inspected for scratches and repaired or rejected, if necessary.

- Record weather conditions including temperature, wind speed and direction, and humidity. Verify that the geomembrane is not deployed in the presence of excess moisture (fog, dew, mist, etc.). In addition, verify that the geomembrane is not placed when the air temperature is less than 40° F or when standing water or frost is on the ground.

- Monitor that crews working on the geomembrane do not smoke, do not wear shoes that could damage the liner, and do not engage in activities that could damage the geomembrane.

- Monitor that methods used to deploy the geomembrane minimize wrinkles and that panels are anchored to prevent movement by the wind. Verify that the Geosynthetics Contractor corrects any damage resulting to or from windblown geomembrane.

- Monitor that no more panels are deployed than can be seamed on the same day.

- The CQA Monitor must inform both the Geosynthetics Contractor and the CQA Manager if any of the above conditions are not met.

Field Seaming. Before the start of geomembrane welding and during welding operations, each welder and welding apparatus will be tested in accordance with the Specifications to verify that the equipment is functioning properly. One trial weld will be taken before the start of work and one at mid-shift. The trial weld sample will be at least 42-inches-long and 12-inches-wide, with the seam centered lengthwise. The CQA Monitor will observe all welding operations and verify that the Geosynthetics Contractor quantitatively tests each trial weld for peel adhesion and bonded seam strength (ASTM D6392). (Peel adhesion tests will be referred to as "peel" and bonded seam strength tests will be referred to as "shear" in this document.) The main purposes of the trial weld tests are to evaluate seam strength and to confirm that each welding machine is working properly. Shear tests measure the continuity of tensile strength through the seam and into the parent material. Peel tests measure the strength of the bond created by the welding process.

The results of the peel and shear tests on trial welds will be recorded on the trial weld form. Trial welds must be completed under conditions similar to those under which the panels will be welded.

Trial welds must meet specified requirements for peel and shear and the failure must be ductile or a film tearing bond (FTB) for a wedge weld. An FTB failure occurs when the test specimen breaks at the edge of the outside of the seam but not within that seam. If at any time the CQA Monitor believes that a welding machine is not functioning properly, a trial weld by that machine must be performed and tested. If there are wide changes in temperature (> 30° F), humidity, or wind speed, another trial weld must be performed and tested. The trial weld must be allowed to cool to ambient temperature before it is tested.

During geomembrane welding operations, the CQA Monitor will:

- Monitor that the Geosynthetics Contractor has an appropriate number of welding machines and spare parts necessary to perform the work.
- Monitor that equipment used for welding will not damage the geomembrane.
- Monitor that extrusion welders are purged before beginning a weld so that all heat-degraded extrudate is removed from the nozzle of the extrusion welder.
- Monitor that seam grinding is completed less than 1 hour before seam welding and that the upper sheet is beveled (extrusion welding only).
- Monitor that the ambient temperature measured 6-inches above the geomembrane surface is between 40° F and 110° F.
- Monitor that the ends of extrusion welds that are more than 5 minutes old are ground to expose new material before restarting a weld.
- Monitor that contact surfaces of the panels are clean and free of dust, grease, dirt, debris, and moisture before welding.
- Monitor that welds are free of dust, rocks, and other debris.
- Monitor that cross seams are ground to a smooth incline before welding (fusion welding only).
- Monitor that all seams are overlapped a minimum of 3 inches or in accordance with the manufacturer's recommendations, whichever is more stringent.
- Monitor that solvents or adhesives are not present in the seam area.
- Monitor that procedures used to temporarily hold the panels together do not damage the panels and do not preclude CQA testing.
- Monitor that strips of geomembrane, wide enough and long enough to protect the hot wedge welder from running on the subgrade, are placed below the geomembrane. These strips may be as long as the seam itself or shorter and moved with the seaming equipment. If necessary, a firm material such as a flat board or similar hard surface may be placed directly under the weld overlap to achieve firm support.
- Monitor that panels are being welded in accordance with the Plans and Specifications.

- Monitor that there is no free moisture in the weld area.
- Measure surface temperature of the panels every 2 hours.

4.2.4 Construction Testing

Nondestructive Seam Testing. The purpose of nondestructive geomembrane seam testing is to detect discontinuities or holes in the seams. Nondestructive geomembrane seam tests include vacuum box and air pressure testing. Nondestructive testing must be performed over the entire length of each seam.

It is the Geosynthetics Contractor's responsibility to perform all nondestructive testing as part of their quality control (QC) program. The CQA Monitor's responsibility is to observe and document that the Geosynthetics Contractor's QC testing is in compliance with the Specifications and to document seam defects and repairs.

Nondestructive seam testing procedures are described below:

- For welds tested by the vacuum box method, the weld is placed under suction utilizing a vacuum box constructed with rigid sides, a transparent top for viewing the seams, a neoprene rubber gasket attached to the bottom of the rigid sides, a vacuum gauge on the inside, and a valve assembly attached to a vacuum hose connection. The box is placed over a seam section which has been thoroughly saturated with a soapy water solution (1 oz. soap to 1 gallon water). The rubber gasket on the bottom of the box must fit snugly against the soaped seam section of the panel to ensure a leak-tight seal.
- A vacuum pump is energized and the vacuum box pressure reduced to approximately 5 psi gauge. Any pinholes, porosity, or non-bonded areas are detected by the appearance of soap bubbles in the vicinity of the defect. Dwell time must not be less than 10 seconds.
- Air pressure testing is used to test double wedge seams that have an enclosed air channel between them. Both ends of the air channel must be sealed. A pressure feed device, usually a hollow needle equipped with a pressure gauge, is inserted into one end of the channel. Air is then pumped into the channel to a minimum pressure of 25 to 30 psi. The air channel must sustain this pressure for 5 minutes without losing more than 2 psi. Following the 5-minute hold time, the opposite end of the tested seam must be punctured to release the air. The pressure gauge must return to zero; if it does not return to zero a blockage is likely present in the seam channel. Locate the blockage and test the seam on both sides of the blockage. The penetration holes must be sealed after testing.

During nondestructive seam testing, the CQA Monitor will:

- Review the Specifications regarding test procedures.
- Monitor that equipment operators are fully trained and qualified to perform their work.
- Monitor that test equipment meets the Specifications.
- Monitor that the entire length of each seam is tested in accordance with the Specifications.

- Observe testing and record results on the panel/seam log and the panel layout drawing.
- Identify any failed areas by marking the area with a waterproof marker compatible with the geomembrane, inform the Geosynthetics Contractor of any required repairs, and record the repair on the panel/seam log.
- Monitor that all repairs are completed and tested in accordance with the Specifications.
- Record all completed and tested repairs on a repair sheet and the panel layout drawing.

Destructive Seam Sampling Procedures and Field Testing. Destructive seam samples will be taken at intervals of at least one per 500 linear feet of geomembrane seam. However, additional samples will be taken if the CQA Monitor suspects that a seam does not meet the Specification's requirements. Reasons for taking additional samples may include, but are not limited to:

1. Wrinkling in the seam area.
2. Excess crystallinity.
3. Suspect seaming equipment or techniques.
4. Weld contamination.
5. Insufficient overlap.
6. Adverse weather conditions.
7. Failing tests.

The CQA Monitor will select the locations from where seam samples will be cut for destructive laboratory testing as follows:

- A minimum of one test per 500 feet of seam length. This is an average frequency for the entire installation; individual samples may be taken at greater or lesser intervals. The testing frequency will be increased if welding operations are conducted in temperatures below 40° F. This increase will be agreed to by the Construction Manager, CQA Manager, and Geosynthetics Contractor.
- A maximum frequency must be agreed to by the Construction Manager, CQA Manager, and Geosynthetics Contractor at the pre-construction meeting. However, if the number of failed samples exceeds 5 percent of the tested samples, this frequency may be increased at the discretion of the CQA Manager. Samples taken as the result of failed tests do not count toward the total number of required tests.

The CQA Monitor will not inform the Geosynthetics Contractor in advance of selecting the destructive sample locations.

The Geosynthetics Contractor will remove the destructive samples at locations identified by the CQA Monitor and field test the specimens for peel and shear before the samples are shipped off-site for laboratory testing. During sampling procedures the CQA Monitor will:

- Observe sample cutting.
- Mark each specimen and sample with an identifying number which contains the seam number, destructive sample test number, welder, and date and time welded.
- Record sample locations on the panel layout drawing and panel-seam logs.

- Record the sample locations, weather conditions, and reasons samples were taken (e.g., random sample, visual appearance, result of a previous failure, etc.) in the destructive seam test form.

At each location, obtain two seam specimens that are 44-inches apart. The specimens should be 1-inch wide and 12-inches long with the weld centered across the length of the specimen. The Geosynthetics Contractor must test these samples to failure in the field using a tensiometer capable of quantitatively measuring shear and peel strengths. For double wedge welding, the Geosynthetics Contractor must test both welds. The CQA Monitor will observe the tests. Geomembrane seam specimens pass when the break is a ductile FTB and the seam strength meets the specified values.

If one or both of the 1-inch specimens fails in either peel or shear, the Geosynthetics Contractor can, at his discretion: (1) reconstruct the entire seam between passed test locations; or (2) take another test sample 10 feet from the point of the failed test and repeat this procedure. If the second test passes, the Geosynthetics Contractor can either reconstruct or cap strip the seam between the two passed test locations. If subsequent tests fail, the sampling and testing procedure is repeated until the length of the poor quality seam is established. Repeated failures indicate that either the seaming equipment or operator is not performing properly and that appropriate corrective action must be taken immediately.

Once the field test specimens have passed, a sample must be recovered for laboratory testing from between the passing field specimen locations. The sample must be 42-inches long and 12-inches wide, with the weld centered along the length of the sample. The sample must be divided into three sections: one 12-inch by 12-inch section for the Geosynthetics Contractor, one 12-inch by 18-inch section for laboratory testing, and one 12-inch by 12-inch section for the Owner to archive. Record the results of field testing on the destructive seam test form and the panel/seam log.

Third Party Laboratory Testing. The CQA destructive seam samples can be shipped to the testing laboratory to verify seam quality. The laboratory will test five specimens from each sample in both shear and peel modes of failure. Minimum required test values are presented in the Specifications. The testing laboratory must provide verbal test results within 24 hours to the CQA Manager and written certified test results within 5 days.

The CQA Manager must immediately notify the Construction Manager and Geosynthetics Contractor in the event of failed seam test results.

If a laboratory test fails in either peel or shear, the Geosynthetics Contractor must either reconstruct the entire seam or recover additional samples at least 10 feet on either side of the failed sample for retesting. This process is repeated until passed tests bracket the failed seam section. All seams must be bounded by locations from which passing laboratory tests have been taken. Laboratory testing governs seam acceptance. In no case can field testing of repaired seams be used for final acceptance.

4.2.5 Repairs

Portions of geomembrane panels and seams that contain: (1) a flaw; (2) a destructive test; or (3) nondestructive test cuts or holes must be repaired in accordance with the Specifications. The CQA Monitor must locate and record all repairs on the repair sheet and panel layout drawing. Acceptable repair techniques include the following:

- Patching: used to repair large holes, tears, large panel defects, undispersed raw materials, welds, contamination by foreign matter, and destructive sample locations.

- Extrusion: used to repair small defects in the panels and seams. In general, this procedure should be used for defects less than 2-inches in the largest dimension.

- Capping: used to repair failed welds or to cover seams where welds cannot be nondestructively tested.

- Removal: used to replace areas with large defects where preceding methods are not appropriate. Also used to remove excess material (wrinkles, fishmouths, intersections, etc.) from the installed geomembrane. Areas of removal shall be patched or capped.

Repair procedures include the following:

- Abrade geomembrane surfaces to be repaired (extrusion welds only) no more than 1 hour before the repair.

- Clean and dry all surfaces at the time of repair.

- Monitor acceptance of the repair procedures, materials, and techniques by the CQA Monitor in advance of the specific repair.

- Extend patches or caps at least 6 inches beyond the edge of the defect and round all corners of material to be patched and the patches to a radius of at least 3 inches. Bevel the top edges of patches before extrusion welding.

4.2.6 Folded Material

Geomembrane with excessive folding (i.e., creased), as determined by the CQA Consultant, must be removed.

4.2.7 Geomembrane Anchor Trench

The geomembrane anchor trench should be left open until seaming is completed. Expansion and contraction of the geomembrane should be accounted for in the liner placement. The anchor trench should be filled in the morning when temperatures are coolest to reduce bridging of the geomembrane.

4.2.8 Geomembrane Acceptance

The Contractor retains all ownership and responsibility for the geomembrane until acceptance by the Owner. In the event the Contractor is responsible for placing cover over the geomembrane, the Contractor retains all ownership and responsibility for the geomembrane until all required documentation is complete and the cover material is placed. After panels are placed, seamed, tested successfully, and repairs made, the completed installation will be walked by the CQA Monitor and Contractor. Any damage or defects found during this inspection will be repaired by the Geosynthetics Contractor. The installation will not be accepted until it meets the requirements of both parties. In addition, the geomembrane will be recommended for acceptance by the CQA Manager only when the following have been completed:

- The installation is finished.

- All seams have been inspected and verified to be acceptable and all required laboratory and field tests have been completed and reviewed.

- All required Contractor-supplied documentation has been received and reviewed.

- All as-built drawings have been reviewed and verified by the CQA Manager to show the true panel dimensions, the locations of all seams, trenches, pipes, appurtenances, and destructive test locations.

4.2.9 Qualifications

Proper layout, seaming, and testing of the geomembrane requires skill and experience. As such, the integrity of the geomembrane is dependent upon the installers. In order to assure a minimum level of experience and expertise, the following experience standards have been established in the Specifications:

Manufacturer/Fabricator/Installer. The Specifications list the required qualifications for the geomembrane manufacturer / fabricator / installer companies. The CQA Manager must verify qualifications of the manufacturer, fabricator, and installer through review of Engineer-approved project submittals.

Installation Superintendent. The installation field superintendent must have been responsible for the completed installation of a minimum of 5,000,000 square feet of polyethylene geomembrane in the past 5 years utilizing the type of seaming techniques and apparatus proposed for use on this project. A resume with references and phone numbers of satisfactory installations is required. Any superintendent proposed for this project must be present whenever geomembrane is installed.

Master Seamer and Other Welders. The master seamer must have demonstrated expertise on previous geomembrane installations. The master seamer must have successfully welded a minimum of 1,000,000 square feet of polyethylene geomembrane within the past 3 years. A resume for this work, with references and phone numbers, is required. Other welders are required to have welded a minimum of 100,000 square feet of geomembrane within the past 3 years. Resumes for all welders, with references and phone numbers, are required. Personnel that have welded less than 100,000 square feet of geomembrane within the past 3 years will only be allowed to weld under the direct supervision of either the master seamer or the installation superintendent.

CQA Manager Qualifications. The CQA Manager must have provided CQA services on a minimum of 1,000,000 square feet of polyethylene installations or be level II certified in geosynthetics installations by National Institute for Certification in Engineering Technologies (NICET). The CQA Manager must provide verification of this experience by references in a current resume.

4.3 Geotextiles

4.3.1 Delivery, Storage, and Handling

During delivery of geotextiles the CQA Monitor will:

- Monitor that equipment used to unload the rolls does not damage the geotextile.
- Monitor that rolls are wrapped in impermeable and opaque protective covers.
- Monitor that care is used to unload the rolls.
- Monitor that all documentation required by the Specifications has been received.
- Monitor that each roll is marked or tagged with the following information: manufacturer's name; project identification; lot number; roll number; and roll dimensions. Log this information on the geosynthetic inventory form.
- Monitor that materials are stored in a location that will protect the rolls from ultraviolet light exposure, precipitation, mud, dirt, dust, puncture, cutting, or any other damaging or deleterious conditions.

Any damaged rolls may be rejected. Monitor that rejected material is removed from the site and stored at a location separate from accepted rolls. Geotextile rolls which do not have proper manufacturer's documentation must also be stored at a separate location until all documentation has been received and approved.

4.3.2 Conformance Testing

Geotextile Material Tests. The CQA Manager will arrange to obtain geotextile conformance test samples as indicated in Table 4-2. These samples will be sent to the testing laboratory for the following conformance tests:

TABLE 4-2
NON-WOVEN GEOTEXTILE CONFORMANCE TESTING FREQUENCIES

Property	Test Method	Conformance Test Frequency(1)
Mass/Unit Area (min. avg.)	ASTM D5261	1 per 250,000 sf
Apparent Opening Size2 (max.)	ASTM D4751	1 per project
Grab Strength (min. avg.)	ASTM D4632	1 per 250,000 sf
Permittivity2 (min.)	ASTM D4491	1 per project
Puncture Strength (min. avg.)	ASTM D4833	1 per 250,000 sf

Notes to Table 4-2:
(1) Minimum testing frequency shall be one sample per lot.
(2) AOS and permittivity shall only be tested for geotextiles used in filter applications.

The CQA Manager will review all conformance test results and report any non-conformance to the Construction Manager and Contractor.

The Final CQA Report shall include a table similar to Table 4-2 documenting compliance with the testing frequencies and results documenting compliance with the Specifications.

Sampling Procedure. Samples will be obtained across the entire roll width and will be 3-feet long. Samplers must mark the manufacturer's roll identification number and the machine direction on the sample. Samplers will also assign a conformance test number to the sample and mark the sample with that number.

4.3.3 Geotextile Installation

Surface Preparation. Before geotextile installation, the CQA Monitor will:

- Monitor that all lines and grades have been verified by the Contractor.
- Monitor that the subgrade has been prepared in accordance with the Specifications and that the geomembrane installation and all associated documentation has been completed.
- Monitor that soil or geomembrane surfaces do not contain stones that could damage the geotextile.
- Monitor that there are no excessively soft areas in soil surfaces that could damage the geotextile.

Geotextile Placement and Seaming. During geotextile placement and seaming operations, the CQA Monitor will:

- Observe the geotextile as it is deployed and record all defects and defect corrective actions (panel rejected, patch installed, etc.). Verify that corrective actions are performed in accordance with the Specifications.
- Monitor that equipment used does not damage the geotextile by handling, equipment transit, leakage of hydrocarbons, or other means.
- Monitor that crews working on the geotextile do not smoke, do not wear shoes that could damage the geotextile, and do not engage in activities that could damage the geotextile.
- Monitor that the geotextile is securely anchored in an anchor trench and is temporarily anchored to prevent movement by the wind.
- Monitor that adjacent panels are overlapped and seamed in accordance with the Specifications.
- Monitor that the geotextile is not exposed to direct sunlight for more than 5 days.
- Examine the geotextile after installation to ensure that no potentially harmful foreign objects are present.
- The CQA Monitor must inform both the CQA Manager and Contractor if the above conditions are not met.

4.3.4 Repairs

Repair procedures include:

- Patching: used to repair large holes, tears, and small defective areas.
- Removal: used to replace large defective areas where the preceding method is not appropriate.

4.4 Geocomposite

4.4.1 Delivery, Storage, and Handling

During delivery of geocomposite the CQA Monitor will:

- Monitor that equipment used to unload the rolls does not damage the geocomposite.
- Monitor that care is used to unload the rolls.
- Monitor that all documentation required by the Specifications has been received.
- Monitor that each roll is marked or tagged with the following information: manufacturer's name; project identification; lot number; roll number; and roll dimensions. Record this information on the geosynthetic inventory log.
- Monitor that the geosynthetic inventory log is completed.
- Monitor that materials are stored in a location that will protect the rolls from ultraviolet light exposure, precipitation, mud, dirt, dust, puncture, cutting, or any other damaging or deleterious conditions.

Any damaged rolls may be rejected. Verify that rejected material is removed from the site or stored at a location separate from accepted rolls. Geocomposite rolls that do not have proper manufacturer's documentation must also be stored at a separate location until all documentation has been received and approved.

4.4.2 Conformance Testing

Geocomposite Material Tests. The CQA Manager will arrange to obtain geocomposite conformance test samples as indicated in Table 4-3. These samples will be sent to the testing laboratory for the following conformance tests:

TABLE 4-3
GEOCOMPOSITE CONFORMANCE TESTING FREQUENCIES

Property	Test Method	Conformance Test Frequency
Density (min. avg.)	ASTM D792 or ASTM D1505	1 per 250,000 sf
Thickness (min. avg.)	ASTM D751 or ASTM D5199	1 per 250,000 sf
Carbon Black Content (range)	ASTM D1603	1 per 250,000 sf
Mass/Unit Area (min. avg.)	ASTM D5261	1 per 250,000 sf
Peel Strength (min. avg.)	GRI GC7	1 per 250,000 sf
Transmissivity(1) (min. avg.)	ASTM D4716	1 per project

Note to Table 4-3:
(1) Transmissivity shall be measured in a 12-inch by 12-inch box between steel plates under a normal stress of 15,000 psf and a hydraulic gradient of 0.1. A seating time of 15 minutes shall be used.

The CQA Manager will review all conformance test results and report any non-conformance to the Construction Manager.

The Final CQA Report shall include a table similar to Table 4-3 documenting compliance with the testing frequencies and results documenting compliance with the Specifications.

Sampling Procedure. Samples will be obtained across the entire roll width and will be 3-feet long. Samplers must mark the manufacturer's roll identification number and the machine direction on the sample. Samplers will also assign a conformance test number to the sample and mark the sample with that number.

4.4.3 Geocomposite Installation

Surface Preparation. Before geocomposite installation, the CQA Monitor will:

- Monitor that all lines and grades have been verified by the Contractor.
- Monitor that the geomembrane has been prepared in accordance with the Specifications and all associated documentation has been completed.
- Monitor that soil or geomembrane surfaces do not contain stones that could damage the geocomposite.
- Monitor that there are no excessively soft areas in soil surfaces that could damage the geocomposite.
- Observe that all construction stakes have been removed.
- Monitor that all aspects of surface preparation have been performed according to the Specifications.

Geocomposite Placement. During geocomposite placement, the CQA Monitor will:

- Observe the geocomposite as it is deployed and record all defects and defect corrective actions (panel rejected, patch installed, etc.). Verify that corrective actions are performed in accordance with the Specifications.

- Monitor that equipment used does not damage the geocomposite by handling, equipment transit, leakage of hydrocarbons, or other means.

- Monitor that crews working on the geocomposite do not smoke, do not wear shoes that could damage the geocomposite, and do not engage in activities that could damage the geocomposite.

- Monitor that the geocomposite is securely anchored to prevent movement by the wind.

- Monitor that adjacent panels are overlapped and seamed in accordance with the Specifications.

- Examine the geocomposite after installation to ensure that no potentially harmful foreign objects are present.

The CQA Monitor must inform both the CQA Manager and Contractor if the above conditions are not met.

4.4.4 Repairs

Repair procedures for geocomposite include:

- Patching: used to repair large holes, tears, and small defective areas.

- Removal: used to replace large defective areas where the preceding method is not appropriate.

5. CONSTRUCTION QUALITY ASSURANCE FOR HDPE PIPE

5.1 General

This section describes CQA procedures for HDPE pipe installations. Solid HDPE pipe will be utilized to construct the LCRS riser extensions.

CQA for the HDPE pipe installations will be performed to verify that HDPE pipe systems are installed in accordance with the design. Construction must be conducted in accordance with the Plans and Specifications. To monitor compliance, the CQA Consultant will: (1) review the Contractor's quality control submittals; (2) monitor construction testing; and (3) monitor installations.

All construction testing will be conducted in accordance with the Specifications.

5.2 Construction Monitoring

The following sections list monitoring requirements during HDPE pipe operations.

5.2.1 Delivery, Handling, and Storage

- Monitor that chains, end hooks, cable slings, or any other devices that may scar the pipe are not used to handle pipe. Wide nylon web slings are recommended to handle the pipe.
- Monitor that the pipe is not damaged during handling operations and that damaged pipe is separated from accepted pipe.
- Monitor that pipe out-of-roundness will not occur due to excessive stacking heights when the pipe is stored at the site.
- Monitor that the pipe is not damaged by sharp rocks or excessive abrasion when the pipe is pulled into place during fusion welding and installation operations.

5.2.2 Fusion Welding

- Before pipe fusion welding operations and installations, verify that solid pipe, perforated pipe, fittings, and flanged couplings comply with the product requirements of the Specifications.
- Monitor that certified fusion welding operators will be performing the welding.
- Monitor that caution is taken to prevent water from coming in contact with the pipe and heater plates during welding operations. A shelter may be required for the fusion welding machine to allow operations to continue in adverse weather conditions.
- Monitor that heater plate surface temperatures are maintained between 375°F and 400°F for both coated plates and uncoated plates. Monitor that the operator checks the heater plate surface temperatures with a pyrometer.
- Monitor that inside and outside of pipe ends are cleaned to remove dirt, water, grease, and other foreign material.

- Monitor that pipe ends are squarely faced with the facing tool of the fusion welding machine.

- Monitor that pipe ends line up in the fusion welding machine and that the pipe ends meet squarely and completely over the entire surface to be welded. Monitor at this point that the pipe is securely clamped into place so that the pipe does not move during the fusion welding process.

- Monitor that the heater plate is clean and maintains the appropriate temperature. Monitor that the heater plate is inserted between the aligned pipe ends and that the pipe ends are firmly brought into contact with the heater plate. NO PRESSURE should be applied to achieve the melt pattern.

- Monitor that the pipe ends are allowed to heat and soften. As the pipe heats and softens a melt bead begins to roll back from the contact point of the heater plate and the pipe ends.

- Monitor that the heater plate is removed quickly and cleanly when the appropriate melt bead is achieved and that no melted pipe material sticks to the heater plate. If melted material sticks to the heater plate, Monitor that this joint is discontinued, the heater plate is cleaned, the pipe ends are re-faced, and that the joint is re-started.

- Monitor that the melted pipe ends are rapidly joined together and that enough pressure is applied to the joint to form a melt bead 1/8-inch to 3/16-inch in diameter around the entire circumference of the pipe. Pressure is critical to cause the heated material of each pipe end to flow together.

- Monitor that the joint is allowed to cool and solidify properly before the pipe is released from the fusion welding machine. Cooling and solidification is completed when a person's finger can remain comfortably on the bead.

- Examine the joint when the pipe is released from the fusion welding machine to verify that the weld is completely around the entire circumference of the pipe.

5.2.3 Slip Joints

- Monitor that all joints extend to the minimum overlap and comply with the requirements of the Plans and Specifications.

- Monitor that there is a snug fit with zero air gaps surrounding the connection.

6. CONSTRUCTION QUALITY ASSURANCE FOR EROSION CONTROL

6.1 Introduction

This section describes CQA procedures for temporary and permanent erosion control installations.

CQA for the temporary and permanent erosion control measures will be performed to verify that the Contractor complies with the requirements of the project's Stormwater Pollution Prevention Plan (SWPPP) and that the permanent erosion control measures are installed in accordance with the design. Construction must be conducted in accordance with the Plans and Specifications. To monitor compliance, the CQA Consultant will: (1) review the Contractor's quality control submittals, and (2) monitor installations.

6.2 Construction Monitoring

6.2.1 Temporary Erosion Control

- Monitor that the Contractor implements temporary erosion control measures in compliance with the project's SWPPP.

6.2.2 Permanent Erosion Control Measures

Straw Wattles

- Review the Contractor's submittals for the straw wattles and verify that the material complies with the manufacturer's recommendations and the Specifications.
- Monitor that the Contractor installs the straw wattles at the locations indicated on the Plans.
- Monitor that the Contractor installs the straw wattles in accordance with the manufacturer's recommendations.

7. CONSTRUCTION QUALITY ASSURANCE FOR DRAINAGE FACILITIES

7.1 Introduction

This section describes CQA procedures for the surface water drainage facilities. The drainage facilities consist of various types of drainage channels, drop inlets, culverts, and diversion berms.

CQA for the drainage facilities installation will be performed to verify that these facilities are constructed in accordance with the Plans and Specifications. To monitor compliance, the CQA program will: (1) review the Contractor's quality control submittals; (2) monitor construction testing; and (3) monitor installations.

Construction testing will be conducted in accordance with the Specifications.

7.2 Construction Monitoring

7.2.1 Drainage Channels

- Monitor that grade control construction staking for the drainage channels is performed before the work.
- Monitor that the drainage channels are constructed in accordance with the Drawings and Specifications.
- Monitor that the subgrades of the drainage channels are dry, firm, and unyielding and do not have loose or extraneous material.
- Document that drainage ditches are graded and sloped in accordance with the Plans and Specifications. Review verification surveys and notify the Contractor of areas needing repair. Submit copies of verification surveys to the Construction Manager.

7.2.2 Drop Inlets and Culverts

- Review the Contractor's submittals for the piping and drop inlets for compliance with the Specifications.
- Monitor that the Contractor has excavated pipe trenches to the proper depth.
- Monitor that the Contractor has graded the slope of the pipe trenches to uniform gradient.
- Monitor that the pipe subgrades are firm and unyielding and do not have loose or extraneous material.
- Monitor and test backfilling of pipe trenches.
- Verify that inlets to drainage structures are smooth and prevent ponding.

7.2.3 Diversion Berms

- Monitor that the material used to construct the diversion berms complies with the Specifications for structural fill.

8. DOCUMENTATION

This CQA Plan requires thorough monitoring and documentation of the construction activities. The CQA Manager will document that the CQA requirements have been addressed and satisfied. Documentation will consist of daily record keeping, testing and installation reports, non-conformance reports (if necessary), progress reports, photographic records, design and Specification revisions, and a Final CQA Report.

8.1 Daily Record Keeping

At a minimum, daily records will consist of a daily record of construction progress, daily construction report, observation and test data sheets, and, as needed, non-conformance/corrective measure reports. All forms will have peer review.

8.1.1 Daily Record of Construction Progress

The daily field report will summarize ongoing construction and discussions with the Contractor and will be prepared by the CQA Manager and CQA Monitor. At a minimum, the report will include the following:

1. Date, project name, project number, and location.
2. A unique number for cross-referencing and document control.
3. Weather data.
4. A description of ongoing construction for the day in the area of the CQA Monitor's responsibility.
5. An inventory of equipment utilized by the Contractor.
6. Significant items of discussion and names of parties involved in these discussions.
7. A brief description of tests and observations, identified as passing or failing, or, in the event of failure, a retest.
8. Areas of non-conformance/corrective actions, if any (non-conformance/corrective action form to be attached).
9. Summary of materials received and quality control documentation.
10. Follow-up information on previously reported problems or deficiencies.
11. Record of site visitors involved with the project.
12. Signature of CQA Manager and/or CQA Monitor.
13. Signature of the peer reviewer.

8.1.2 Observation and Test Data Sheets

Observation and test data sheets should include the following information as is appropriate for the form being used.

1. Date, project name, project number, and location.
2. A unique number for cross-referencing and document control.
3. Weather data, as applicable.
4. A reduced scale site plan showing sample and test locations.
5. Test equipment calibrations, if applicable.
6. A summary of test results identified as passing, failing, or, in the event of a failed test, retest.
7. Completed calculations.
8. Signature of the CQA Manager and/or CQA Monitor.
9. Signature of the peer reviewer.

8.1.3 Non-Conformance Reports

In the event of a non-conformance event, a non-conformance verification report form will be included with the daily report. Procedures for implementing and resolving any non-conformities to the Contract Documents are outlined in Section 2.4 of this CQA Plan.

8.2 Weekly Progress Reports

The CQA Manager will prepare weekly progress reports summarizing construction and CQA activities. These reports will contain, at a minimum, the following information:

- The date, project name, project number, and location.
- A summary of work activities completed in the last week and those expected to be performed in the next week.
- A summary of deficiencies and/or defects and resolutions.
- Ongoing summary of changes and/or change orders to the work.
- The signature of the CQA Manager.
- On the fourth week of each month the report will include a summary of on-site and third party laboratory test results.

8.3 Photographs

Construction activities will be photographed. Photographs will show any significant problems encountered and corrective actions and will document the construction progress. The photographs will be identified by location, date, and photographer. The photographer should document the subject or the photograph, either on the back of the picture or in a photograph log.

8.4 Design and Specification Changes

Design and Specification changes may be required during construction. Design and Specification changes will only be made with the written agreement of the Design Engineer, Owner, and Contractor. Design and specification changes which affect the containment system or environmental controls shall also require approval of the Regional Water Quality Control Board (RWQCB). These changes will be made by change order to the contract. When change orders are issued, they will be prepared by the Construction Manager. The Construction Manager will distribute change orders for signature and execution to the required parties.

8.5 Final Construction Quality Assurance Report

The CQA Manager and CQA Officer shall submit two Final CQA Reports for Phase III: one report for the Phase IIIA construction and one report for the Phase IIIB construction. These reports shall be submitted at the completion of construction of each Phase and shall document that the work for each Phase has been performed in compliance with the Plans and Specifications.

At a minimum, each Final CQA Report will contain:

- Daily Field Reports per Section 8.1.1.
- Inspection data sheets that contain observations and a record of field and laboratory tests per Section 8.1.2.
- A summary of the construction activities.
- A tabular summary of the laboratory and field test results demonstrating construction is in compliance with the Specifications.
- Sampling and testing location drawings.
- A description of significant construction problems and the resolution of these problems.
- A list of changes from the Plans and Specifications and the justifications for these changes.
- As-built (record) drawings.
- A statement of compliance with the Contract Documents and design intent that is signed and stamped by the CQA Officer.

The as-built drawings will accurately show the constructed location of the work items, including the location of piping, anchor trenches, etc. All surveying and base maps required for the development of the as-built drawings will be prepared by the Contractor. The CQA Manager will review and verify that the as-builts are correct.

APPENDIX P.2
FINAL CLOSURE CQA PLAN

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CONSTRUCTION QUALITY ASSURANCE (CQA) PLAN FOR LANDFILL UNIT B-18 FINAL CLOSURE KETTLEMAN HILLS FACILITY KETTLEMAN CITY, CALIFORNIA

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Revision 0

Project No.: 083-91887

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ENGINEER'S CERTIFICATION

In accordance with the requirements of California Code of Regulations (CCR) Title 22 Section 66264.19, this Construction Quality Assurance (CQA) Plan has been developed under the direction of a Civil Engineer registered in the State of California.

I hereby certify that this CQA Plan was developed under my direct supervision.

REGISTERED PROFESSIONAL ENGINEER
SCOTT G. SUMNER
No. C049769
EXP. 9-30-10
CIVIL
STATE OF CALIFORNIA

11-17-08

Scott G. Sumner, P.E. Date
RCE No. 049769 Expires: 09-30-2010

1. INTRODUCTION

1.1 Purpose

The purpose of this document is to describe the Construction Quality Assurance (CQA) procedures required during the final closure construction of Landfill Unit B-18 (B-18) at the Kettleman Hills Facility in Kettleman City, California. This CQA Plan establishes procedures to document that the construction is performed in accordance with the approved engineering standards and specifications, meets the appropriate regulatory requirements (i.e., California Code of Regulations Title 22 §66264.19 and Title 27 §20323 and §20324), and that the necessary documentation is developed for submittal to the regulators. This CQA Plan shall be implemented under the direction of a CQA Officer who is a registered Civil Engineer in the State of California.

This CQA Plan is a guidance document that contains general and specific work element requirements for monitoring construction. General requirements include the organization and responsibilities of CQA personnel, documentation control, and reporting procedures. Specific work elements include the following:

- Clearing, Grubbing, and Stripping;
- Stockpiling and Soil Management;
- Excavation;
- Subgrade Preparation;
- Earthfill;
- Geomembranes;
- Geotextiles; and
- Culverts/Drainage Channels.

The CQA Consultant will prepare a Final CQA Report upon completion of construction. The Final CQA Report will include information generated through the CQA program and will document the extent to which construction was performed in accordance with the intent of the Contract Documents and design. The CQA Consultant will be required to submit the Final CQA Report within one week of substantial completion of construction.

1.2 CQA Consultant

The CQA Consultant has the primary responsibility of implementing and managing the CQA program described herein and will document to the appropriate regulatory agencies that construction of the facility was performed in accordance with the design and the Contract Documents. Specific responsibilities for the CQA Consultant's site personnel are presented in Section 2.2.

1.3 Project Organization

The project will be completed by Contractors performing earthworks construction, geosynthetic materials installation, and construction of associated ancillary facilities. The CQA Consultant will be independent of the Contractors and will report directly to the Owner's Project Manager.

1.4 Reference Documents

The latest editions of the following reference documents provide background information and support this CQA Plan:

American Society for Testing and Materials (ASTM), Annual Book of ASTM Standards, Section 4, Construction, Volume 04.02, Concrete and Aggregates.

American Society for Testing and Materials (ASTM), Annual Book of ASTM Standards, Section 4, Construction, Volume 04.08, Soil and Rock(I), and Volume 04.09, Soil and Rock (II); Geosynthetics.

American Society for Testing and Materials (ASTM), Annual Book of ASTM Standards, Section 8, Plastics, Volumes 08.01, Plastics (I), Volume 08.02, Plastics (II), and Volume 08.03, Plastics (III).

California Code of Regulations (CCR), Titles 22 (Social Security) and 27 (Environmental Protection).

Standard Specifications for Public Works Construction, Joint Cooperative Committee of the Southern California Chapter, American Public Works Association And Southern California Districts, Associated General Contractors of California, Building News.

1.5 Definitions

Whenever the terms listed below are used, the intent and meaning shall be interpreted as indicated.

ACI: American Concrete Institute.

AISC: American Institute of Steel Construction.

ASTM: American Society for Testing and Materials.

Construction Manager: The individual or firm responsible for administering the construction contract and providing overall construction management for the project. The construction manager is the primary contact on the project site representing the Owner.

Construction Quality Assurance (CQA): A planned and systematic pattern of procedures and documentation designed to provide confidence that items of work or services meet the requirements of the Contract Documents. Construction quality assurance includes verifying that the Contractor is performing the quality control requirements of the Specifications.

CQA Consultant: See Section 1.2

CQA Manager: Authorized representative of the CQA Consultant responsible for managing the CQA program.

CQA Monitors: Authorized representatives of the CQA Consultant responsible for observing and documenting activities related to CQA during construction.

CQA Officer: Authorized representative of the CQA Consultant and a California-Registered Civil Engineer responsible for certifying that construction was performed in accordance with the intent of the Contract Documents and design.

Construction Quality Control: Those actions which provide a means to measure and regulate the characteristics of an item or service to comply with the requirements of the Contract Documents. Quality control will be performed by the Contractor/Geosynthetics Contractor, except where designated in the Specifications.

Contract Drawings: The official plans, profiles, typical cross-sections, elevations, and details, as well as their amendments and supplemental drawings, that show the locations, character, dimensions, and details of the work to be performed. Contract Drawings are also referred to as the "Plans."

Contract Documents: The official set of documents issued by the Owner, which includes bidding requirements, contract forms, contract conditions, Specifications, Contract Drawings, addenda, and contract modifications.

Contractor: The person or persons, firm, partnership, corporation, or any combination of these or any combination of private, municipal, or public entities who, as an independent Contractor, has entered into a contract with the Owner and who is referred to throughout the Contract Documents by singular number and masculine gender.

Contract Specifications: The requirements for products, materials, and workmanship upon which the contract is based. Contract Specifications are also referred to as the "Specifications."

Design Engineer: The individuals or firms responsible for the project's design and preparation of the Plans and Specifications. The Design Engineer is also referred to as the "Designer" or "Engineer." The Design Engineer for the Final Closure of Landfill Unit B-18 is Golder Associates Inc. of Irvine, California.

Earthwork: A construction activity involving the use of soil materials as defined in the Specifications and Section 3 of this document.

Flexible Membrane Liner (FML): A synthetic lining material, also referred to as geomembrane, membrane, liner, or sheet.

Geosynthetics Contractor: Also referred to as the "Installer." The person or firm responsible for installation of geosynthetic components. This definition applies to any party installing geomembrane, geotextile, geocomposite, geosynthetic clay liner, or any other geosynthetic material, even if it is not their primary function.

GRI: Geosynthetics Research Institute.

Non-Conformance: A deficiency in characteristic, documentation, or procedure that renders the quality of an item or activity unacceptable or indeterminate. Examples of non-conformance include, but are not limited to, physical defects, test failures, and inadequate documentation.

Owner: Waste Management, Inc. – Kettleman Hills Facility.

Owner's Project Manager: Authorized representative of the Owner responsible for planning, organizing, and control of the design and construction activities. Responsibilities include scheduling, cost control, engineering, procurement, and contracting functions. Referred to as the "Project Manager" in this document.

Panel: A unit area of the FML that is seamed in the field or in the fabricator's plant.

Procedure: A document that specifies or describes how an activity is to be performed.

Project Documents: Contractor submittals, Construction Drawings, Record Drawings, Specifications, shop drawings, construction quality control and quality assurance plans, health and safety plans, and project schedules.

Record Drawings: Drawings recording the constructed dimensions, details, and coordinates of the project. Also referred to as "as-builts."

SSPWC: Standard Specifications for Public Works Construction.

Testing: Verification that an item meets specified requirements by subjecting that item to a set of physical, chemical, environmental, or operating conditions.

Testing Laboratory: A laboratory capable of conducting the tests required by this CQA Plan and the Specifications.

2. GENERAL REQUIREMENTS

2.1 Meetings

In order to facilitate construction and to clearly define construction goals and activities, close coordination between the Owner, Design Engineer, CQA Consultant, and Contractor is essential. To meet this objective, pre-construction and progress meetings will be held.

2.1.1 Pre-Construction Meeting

Following the bid award, a pre-construction meeting will be held at the site. Attendees at this meeting will include the Owner, Contractor, Design Engineer, CQA Consultant, agencies, and others designated by the Owner. The primary purposes of the pre-construction meeting will be to:

- Review the Plans, Specifications, this CQA Plan, work area security, health and safety procedures, and related issues.
- Provide all parties with relevant project documents.
- Review responsibilities and qualifications of each party.
- Define lines of communication and authority.
- Establish reporting and documenting procedures.
- Review procedures for handling submittals.
- Review testing equipment and procedures.
- Review procedures for field directives and change orders.
- Establish testing protocols and procedures for correcting and documenting construction or non-conformance.
- Establish the weekly meeting schedule.
- Discuss work areas, stockpile areas, lay down areas, access roads, haul roads, and related items.
- Review the project schedule and critical path items.
- Review the Contractor's work plan.

The pre-construction meeting will be documented by the CQA Manager. Copies of the minutes and other pertinent material will be prepared and provided to the relevant parties.

2.1.2 Progress Meetings

Informal progress meetings will be held each morning before the start of work. At a minimum, these meetings will be attended by the CQA Monitor and Contractor. The purpose of these meetings will be to:

- Discuss problems and resolutions.
- Review test data.
- Discuss the Contractor's personnel and equipment assignments for the day.
- Review the previous day's activities and accomplishments.
- Resolve any outstanding problems or disputes.

2.1.3 Weekly Meetings

Throughout the duration of construction, scheduled weekly meetings will be held. The Project Manager, Construction Manager, CQA Manager, and Contractor will be present. These meetings will be held to discuss progress, problems, construction schedule, changes, test data, health and safety, environmental issues, and any other issues necessary. The Project Manager will prepare the agenda for each meeting and prepare meeting minutes for distribution to the relevant parties.

2.1.4 Other Meetings

As required, other meetings may be held to plan work items and/or to discuss problems or non-conformance. These meetings will be attended by parties as directed by the Owner. If the problem requires a design modification and subsequent change order, the Engineer and Project Manager should be present. These meetings will be documented as directed by the Project Manager.

2.2 Responsibilities of Construction Quality Assurance Staff

2.2.1 Communications with the Contractor

Only the individuals assigned to this project, as defined in this document, can communicate with the Contractor. Communications of an official nature must be clear, direct, and professional. When written communications are required, they must be documented on the appropriate forms. Formal letters to the Contractor should normally be signed by the CQA Manager and reviewed by the Owner.

2.2.2 Communications with the Owner

Only those individuals assigned to this project, as defined in this document, can communicate with representatives of the Owner. All communications must be through proper channels as defined during the project's pre-construction meeting. Communications of an official nature must be written, clear, direct, and professional.

2.2.3 Responsibilities of the CQA Manager

The CQA Manager administers the CQA program. CQA procedures and reports must be reviewed by the CQA Manager for compliance with this CQA Plan. The CQA Manager acts as an auditor to monitor and document the proper and complete implementation of the CQA program. The CQA Manager has authority to identify deficiencies and implement corrective action to the CQA program. The CQA Manager collects, distributes, and addresses the disposition of Contractor submittals approved by the Design Engineer. The CQA Manager coordinates testing with independent testing laboratories and maintains the Record Drawings. The CQA Manager reports directly to the Construction Manager. The CQA Manager will aid in preparing the Final CQA Report for the project under the direction of the CQA Officer.

2.2.4 Responsibilities of the CQA Officer

The CQA Officer is responsible for documenting and certifying to the Department of Toxic Substances Control (DTSC) and the Regional Water Quality Control Board (RWQCB) that the construction was performed in accordance with the intent of the design and the Contract Documents. The CQA Officer may also be the CQA Manager.

2.2.5 Responsibilities of the Design Engineer

The Design Engineer is responsible for site engineering services related to the project's design. Those services include reviewing Contractor submittals, resolving technical issues related to construction, providing interpretation of the Plans and Specifications, and approving substantial design modifications and technical revisions.

2.2.6 Responsibilities of the CQA Monitors

The CQA Monitors implement the CQA program under the direction of the CQA Manager. The CQA Monitors perform the construction monitoring and construction materials testing. The CQA Monitors maintain the documentation and test data summaries related to construction monitoring and construction materials testing. The CQA Monitors report directly to the CQA Manager.

2.3 Control of Documents, Records, and Forms

2.3.1 Project Control of Contract Documents

The Contract Documents, including the Specifications, Plans, and change orders, are controlled by the Construction Manager. The Construction Manager maintains one or more copies of the most current set of Contract Documents for use by the CQA Consultant. Upon issuance of new copies or revisions, it is the responsibility of the Construction Manager to notify the Contractor of the revisions, provide revised Contract Documents, and order the recall of superseded copies of the Contract Documents. The Construction Manager also provides the latest revised set of Contract Documents to the CQA Consultant.

2.3.2 Project Control of As-Built Information

As-built information generated by the Contractor and CQA Consultant is controlled by the CQA Manager. During the progress of the work, the CQA Manager obtains as-built information provided from the CQA Monitors, Contractor, surveyors, or others and compiles the as-built data into one set of drawings. The as-built drawing set must be maintained on site and be clearly marked as "Record Drawings."

2.3.3 Project Control of Forms

Daily report forms, test report forms, and other project forms are controlled by the CQA Manager, who maintains a master of each form for copies. Upon issuance of a new form, the CQA Manager must recall and remove all superseded copies along with the master, notify the CQA Monitors, and provide new copies for their use.

2.3.4 Processing Daily Reports

The CQA Monitors write a daily record of work progress. These daily reports are reviewed by the CQA Manager for legibility, clarity, traceability, and completeness. The review must be evidenced by a signature of the reviewer. Daily reports are submitted to the Construction Manager on a daily basis and are maintained at the site. A weekly summary construction report will be prepared by the CQA Manager and submitted on a weekly basis to the Construction Manager.

2.3.5 Processing Test Reports

A test report must be completed by the CQA Monitors whenever testing is performed. The test reports must be reviewed by the CQA Manager. The review includes a check for mathematical accuracy, conformance to test requirements, conformance to the Specifications, and for clarity, legibility, traceability, and completeness. The review must be evidenced by a signature of the reviewer. Test reports (or summaries) from independent testing laboratories will also be transmitted to the CQA Manager for review.

2.3.6 Processing Project Records

Project records are completed as needed. Use of the project records is limited to the scope for which they are intended. The record must be completed by filling in all of the blanks provided on the form, followed by the signature of the individual completing the form. All project records must be maintained at the site.

2.4 Documentation and Control of Non-Conformance

2.4.1 Observation of Non-Conformance

Whenever a non-conformance is discovered or observed in the construction process, product, job-related materials, documentation, or elsewhere, the CQA Manager and CQA Monitors should first notify the Contractor's foreman/superintendent supervising the work in question. The CQA Manager should then notify the Construction Manager.

2.4.2 Determining Extent of Non-Conformance

Whenever a non-conformance is discovered or observed in the construction process, product, job-related materials, documentation, or elsewhere, the CQA Consultant will determine the extent of the non-conformance. The extent of the deficiency may be determined by additional sampling, testing, observations, review of records, or any other means deemed appropriate.

2.4.3 Documenting Non-Conformance

All non-conformance must be documented in writing on the daily records, logs, and elsewhere, as appropriate. This documentation must occur immediately upon determining the extent of the non-conformance. For a non-conformance that is considered serious or complex in nature, or which requires an engineering evaluation, a Non-Conformance Report will be prepared and issued to the Construction Manager and Contractor.

2.4.4 Corrective Measures

For a straightforward or routine non-conformance, corrective measures will be determined by direction from the Specifications. If no direction exists in the Specifications, the Construction Manager, CQA Manager, and Contractor will discuss construction methods to correct the deficiency. For Non-Conformance Reports that require an engineering evaluation, the Design Engineer must determine corrective measures. A copy of the Non-Conformance Report, with the Design Engineer's corrective measure determination, will be forwarded to the Construction Manager, CQA Manager, and Contractor for implementation of the corrective action.

2.4.5 Verification of Corrective Measures

Upon notification by the Contractor that a corrective measure is complete, the CQA Manager will verify its completion. The verification must be accomplished by observations or re-testing and documented photographically. Written documentation of the corrective measures must be made by the CQA Manager on daily reports, logs, forms, and, if applicable, the Non-Conformance Report. Verification of corrective measures will be reviewed by the Construction Manager. Corrective action measures that require an engineering evaluation will be reviewed and verified by the Design Engineer.

2.5 Construction Monitoring

2.5.1 Monitoring Priorities

Before commencement of construction, the CQA Manager will establish a list of monitoring priorities. This list will include the various construction activities and the monitoring priority of those activities. The monitoring priorities may change during construction, based upon the Contractor's performance and/or the Owner's request. Changes in the monitoring priorities must be approved by the CQA Manager.

2.5.2 Discrepancies

CQA testing must be conducted in accordance with this CQA Plan. However, discrepancies that occur between this document and other construction documents must be resolved. The document that requires the most frequent tests or more stringent requirements will govern, unless otherwise specified by the Design Engineer and/or CQA Manager.

2.6 Materials Quality Verification

2.6.1 General

Material sources will be identified and samples tested to determine if the material meets the requirements of the Specifications. Definitions and requirements of materials are provided in the Specifications. Test samples will be obtained in accordance with applicable ASTM and GRI standards. Archive samples and test results of the test samples will be maintained and stored at the project site. The CQA Monitors will establish and maintain a materials quality verification list. This list will include material sources, sample locations, testing requirements, test results, and verification action items.

2.6.2 Material Submittals

Material submittals may be used by the CQA Consultant to establish the acceptability of materials. When material sample submittals are required, they will be made available to the CQA Consultant by the Contractor. Acceptance and proper review of material submittals are the responsibility of the CQA Manager.

2.6.3 Certificates of Compliance and Conformance

Certificates of compliance and conformance may be used by the CQA Manager to establish the acceptability of materials. These certificates generally state that the material is in compliance or conformance with a particular code, standard, or specification. These certificates may be used for acceptance of a product before or in lieu of testing, if allowed by the Specifications.

2.7 Equipment Control

2.7.1 Equipment List

Before the start of construction, the CQA Manager will complete a list of all measuring, sampling, and testing equipment being used at the site. As new equipment becomes available during the course of the project, it must be added to the list. When more than one type of equipment is available, a unique number will be affixed to each piece to maintain identity. The equipment list will be maintained in the project files and contains the following information:

- Type of equipment;
- Serial number or identifying number;
- Date item received at site;
- Use of the equipment; and
- Date removed from service.

2.7.2 Calibration of Equipment and Materials

Before placing a piece of testing equipment into service, its accuracy must be established and calibrated by the CQA Manager or CQA Monitor. Types of equipment requiring calibration include: nuclear gauges, sand cone devices, sand to be used in sand cones, and scales. The calibration procedures and frequencies must be per the equipment manufacturer's instructions or ASTM standards. Whenever the equipment is suspect or is producing questionable results, it must be removed from service immediately and re-calibrated.

3. CONSTRUCTION QUALITY ASSURANCE FOR EARTHWORK

3.1 General

This section describes CQA procedures for earthwork operations. The scope of earthwork and related CQA includes the following elements:

- Clearing, Grubbing, and Stripping;
- Stockpiling and Soil Management;
- Excavation;
- Structural Fill/Foundation Layer;
- Subgrade Preparation;
- Vegetative Cover Soil; and
- Trench Excavation and Backfill.

3.2 Earthwork Construction Testing

3.2.1 Test Standards

The latest editions of the following test standards apply as called out in this document or the Specifications:

Standard	Test Description
ASTM D422	Standard Test Method for Particle Size Analysis of Soils
ASTM D1556	Standard Test Method for Density and Unit Weight of Soil in Place by the Sand Cone Method
ASTM D1557	Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort
ASTM D1587	Standard Practice for Thin-Walled Tube Geotechnical Sampling of Soils
ASTM D2216	Standard Test Method of Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
ASTM D2487	Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D2488	Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)
ASTM D2937	Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method
ASTM D4318	Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

ASTM D5084	Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter
ASTM D6938	Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

3.2.2 Test Frequencies

Tables 3-1 and 3-2 establish the test frequencies for earthwork CQA. The test frequencies listed establish a minimum number of required tests. Extra testing must be conducted whenever work or materials are suspect, marginal, or of poor quality. Extra testing may also be performed to provide additional data for engineering evaluation. Any re-tests performed as a result of a failing test do not contribute to the total number of tests performed in satisfying the minimum test frequency.

The Final CQA Report shall include tables similar to Tables 3-1 and 3-2 that document compliance with the testing frequencies and that document test results that comply with the Specifications.

TABLE 3-1
STRUCTURAL FILL AND FOUNDATION LAYER CONFORMANCE TESTING FREQUENCIES

ASTM Test Method	ASTM Designation	Frequency (Structural Fill and Foundation Layer)	Frequency (Bench Fill/Trench)
Prior to Placement:			
Moisture-Density Relationship[1]	D1557	1 Per 10,000 CY or Each Material Type (minimum of 2)	1 Per Material Type
Sieve Analysis	D422	1 Per 30,000 CY or Each Material Type	-
Atterberg Limits	D4318	1 Per 30,000 CY or Each Material Type	-
During / After Placement:			
Nuclear Water Content and Density[2]	D6938	1 Per 1,000 CY Per 1.5 Vertical Feet	1 Per Lift Per 200 Linear Feet
Sand Cone Test or Drive Cylinder Test[3]	D1556 D2937	1 Per 20 Nuclear Density Tests	1 Per 10 Nuclear Density Tests
Test Pit to Confirm Cover Thickness (for existing Interim Cover Only)	-	1 per 100,000 SF	-
Hydraulic Conductivity (Foundation Layer Only)[4]	D5084	1 per 100,000 SF	-

Notes to Table 3-1:

1. Perform a Check Point (one point selected at near optimum and compared to the ASTM D1557 curve) at least once for every 10,000 cubic yards of material placed.
2. Tests shall be performed on an even grid to provide adequate testing coverage. For large fills in small areas, the testing frequency shall be increased as necessary to ensure testing for each lift of soil placed.
3. Drive cylinder tests may be performed on clay or silt samples only.
4. Hydraulic conductivity tests shall be conducted on relatively undisturbed samples obtained using a thin-walled sampler (i.e., Shelby tube) with a minimum diameter of 3 inches.

TABLE 3-2
VEGETATIVE COVER SOIL CONFORMANCE TESTING FREQUENCIES

ASTM Test Method	ASTM Designation	Frequency	Frequency (Bench Fill/Trench)
Prior to Placement:			
Moisture-Density Relationship[1]	D1557	1 Per 10,000 CY or Each Material Type (minimum of 2)	1 Per Material Type
During / After Placement:			
Nuclear Water Content and Density[2]	D6938	1 Per 1,000 CY Per 1.5 Vertical Feet	1 Per Lift Per 200 Linear Feet
Sand Cone Test or Drive Cylinder Test[3]	D1556 D2937	1 Per 20 Nuclear Density Tests	1 Per 10 Nuclear Density Tests

Notes to Table 3-2:

1. Perform a Check Point (one point selected at near optimum and compared to the ASTM D1557 curve) at least once for every 10,000 cubic yards of material placed.
2. Tests shall be performed on an even grid to provide adequate testing coverage. For large fills in small areas, the testing frequency shall be increased as necessary to ensure testing for each lift of soil placed.
3. Drive cylinder tests may be performed on clay or silt samples only.

3.2.3 Soil Sample Numbering

The CQA Monitor will maintain soil sample numbers in a master log to be maintained at the site. Sample numbers will begin at 001 and proceed upward. No sample number can be repeated and re-tests of a failing sample will be given the original number with a letter suffix (i.e., re-tests for a failing sample 021 would be: 021A, 021B, etc.). Information contained in the master log of test samples will include:

- Sample number;
- Test(s) to be performed;
- Dated sampled;
- CQA Monitor obtaining sample;
- Location sampled;
- Location of testing (on-site vs. off-site);
- Date sample sent off-site;
- Date test results received;
- Site testing CQA Monitor;
- Date testing completed at site; and

- Test results and remarks.

3.2.4 Soil Sample Tagging

The CQA Monitor is responsible for maintaining sample identification for all soil samples while on site, from the time of sampling through the completion of testing. The CQA Monitor must place a sample tag on the soil sample container immediately upon sampling. This tag must remain with the soil sample throughout processing. The tag will contain the following information:

- Sample number;
- Material type;
- Project name and project number;
- Sampling CQA Monitor;
- Date sampled; and
- Test(s) to be performed.

3.2.5 Soil Sample Processing

The CQA Monitor is responsible for the timely processing of soil test samples. The CQA Manager will determine which samples are tested on-site and which are tested off-site. This determination will be made based on available manpower, available equipment, complexity of testing, and the desired turnaround time for results. For expediency, samples to be tested off-site should be shipped the same day they are collected.

3.3 Field Density Tests

3.3.1 Test Numbering

The CQA Monitor is responsible for maintaining test numbers and results for field density tests performed using the nuclear gauge (ASTM D6938), sand cone (ASTM D1556), and drive cylinder (ASTM D2937). All other testing is identified through the sample number (Section 3.2.3). The CQA Monitor will maintain field books that identify soil segments, test data, the CQA Monitor performing the test, and the sequential test number. Each soil segment will have a unique series of numbers. No test number can be repeated for a given soil segment, and re-tests of failing tests must be given a letter suffix along with the original test number (i.e., re-tests for a failing test 1201 would be: 1201A, 1201B, etc.). Test data and results must be filled out on the field density test form.

3.3.2 Test Locations

The intent of the CQA program is to provide confidence that the earthwork materials and work conform to the requirements of the Specifications. To meet this intent, the CQA Monitor will perform density tests of earthfills during construction. Density tests must be located at various elevations and uniformly dispersed throughout the entire plan dimensions of the fill. Density test locations must be chosen without bias; however, additional testing can be performed in any areas that are suspect, marginal, or appear to be of poor quality. During the progress of the work, density test locations will be plotted on a drawing by the CQA Monitor to document that no significant areas are left untested. This drawing will be included in the Final CQA Report.

3.4 Monitoring and Testing Requirements

Earthwork components of the construction are summarized in Section 3.1. Each component has specific construction requirements that must be monitored. The following sections list monitoring requirements for each type of earthwork.

3.4.1 Clearing, Grubbing, and Stripping

- Document that erosion and sediment control silt fences, straw bale barriers, and other measures are securely in place prior to initiating clearing, grubbing, and stripping operations in any area.
- Document that existing plant life designated to remain is protected against damage during construction.
- Document that clearing and stripping in areas required for site access and execution of the work is complete.
- Document that vegetation, roots, and highly organic soil within the work area are removed to the appropriate extent.

3.4.2 Stockpiling and Soil Management

- Review the Contractor's approved work plan submittal. Verify stockpile locations, stockpile dimensions, haul routes, material segregation procedures, and erosion, sediment, and drainage control measures. Determine and note corrective action items, if applicable.
- Document that stockpile locations have been cleared, grubbed, and stripped in accordance with Section 3.4.1 of this CQA Plan and the Specifications.
- Document that stockpile subgrades are surveyed prior to stockpiling.

The CQA Monitor will maintain a separate soil test data summary sheet for the specific purpose of soil classification of stockpiled materials.

- During excavation, hauling, and stockpiling operations, continually identify and verify material classifications in general accordance with ASTM D2487 (Unified Soil Classification System) and ASTM D2488 as necessary to characterize material stockpile designations.
- Observe that stockpiles are constructed with slopes no greater than 2H:1V (horizontal:vertical) and that the top surface maintains a minimum 5 percent grade. The Contractor shall include 15-foot-wide drainage benches every 50 vertical feet on all stockpiles.

3.4.3 Excavation

- Document that construction staking is performed before work and that survey bench marks with elevations are secured outside the work area.
- If applicable, document that the Contractor has notified Underground Service Alert to identify and locate underground utilities.
- Document that excavated materials are segregated into proper stockpiles.
- Coordinate with the Contractor to perform excavation verification surveys upon completion of excavating operations. Verify corrective action measures as determined by verification surveys. Verification surveys will also be used to determine limits of excavation for measurement and payment applications. Submit a copy of verification surveys to the Construction Manager.
- Document that unsuitable materials are removed from areas that will receive earthfill. Unsuitable materials include uncertified existing fills, disturbed soils, weak/highly compressible soils, and deleterious materials.

3.4.4 Structural Fill/Foundation Layer

- Monitor that subgrade for placement of soil is consistent with the Specifications.
- Monitor that construction staking is performed before the beginning of the work and that survey bench marks with elevations are secured outside the work area.
- Perform visual and manual soil classifications (ASTM D2488) to verify that the material source is suitable for structural fill. Verify that the material is free of organic and oversized materials and perform classifications continually during excavation of borrow materials.
- Perform moisture-density relationship testing (ASTM D1557) to determine the maximum dry density and optimum moisture content for structural fill/foundation layer materials. Perform tests at the testing frequencies specified in Table 3-1.
- Monitor that structural fill materials are placed in loose lifts not exceeding 8-inches thick and are then properly compacted.
- Perform nuclear density-moisture tests (ASTM D6938) to document that each lift is compacted to the appropriate relative compaction, as stipulated in the Specifications. Perform tests at the testing frequencies specified in Table 3-1.
- Monitor that soil materials are kept within the specified moisture content range listed in the Specifications. Monitor that soil materials that are wet and over the optimum moisture content (as determined by ASTM D1557) are properly aerated and processed to bring the moisture content of the material into the acceptable range. Monitor that soils that are dry and below the optimum moisture content (as determined by ASTM D1557) are properly moisture conditioned and processed to bring the moisture content into the acceptable range.

- Monitor that desiccated structural fills are properly repaired or removed before placing subsequent lifts.

- Monitor that final structural fill/foundation layer surfaces are free of ruts, gouges, and other features that might contribute to erosion and sediment run-off.

- During fill operations, field-verify lines, grades, and dimensions using hand-held levels, range poles, and measuring tapes.

- Coordinate with the Contractor to perform verification surveys at the completion of structural fill/foundation layer operations. Verify corrective action measures as determined by verification surveys. Verification surveys will also be used to determine the limits of structural fill/foundation layer for measurement and payment applications. Submit copies of verification surveys to the Construction Manager.

3.4.5 Geosynthetics Subgrade Preparation

- Monitor that the subgrade is free of organic and oversized materials and meets the requirements of the Specifications.

- Monitor that grade control construction staking is performed prior to the work.

- Perform moisture-density relationship testing (ASTM D1557) to determine the maximum dry density and optimum moisture content of subgrade materials.

- Monitor that angular or sharp rocks, rocks that protrude more than 0.5 inches, and other debris that could damage the overlying geomembrane are removed from the surface of the subgrade. Verify that the subgrade is free of irregularities and is steel drum rolled smooth prior to geomembrane placement.

- Monitor that the final surface provides continuous and intimate contact with the overlying geomembrane.

- Coordinate with the Contractor to perform subgrade verification surveys upon completion of the subgrade preparation. Verify corrective action measures as determined by the verification surveys. Verification surveys will also be used to determine the limits of the subgrade preparation for measurement and payment applications. Submit copies of verification surveys to the Construction Manager.

3.4.6 Vegetative Cover Soil

- Monitor that the material source is suitable for the vegetative cover soil layer and is free of organic or other deleterious materials and free of over-sized particles as described in the Specifications.

- Monitor that grade control construction staking is performed before the work.

- Verify that the vegetative cover soil is placed in a manner that does not damage the underlying geosynthetic layers.

- Coordinate with the Contractor to perform vegetative cover soil verification surveys upon completion of placement operations. Verify corrective action measures as determined by the verification surveys. Verification surveys will also be used to determine the limits of the vegetative cover soil for measurement and payment applications. Submit copies of verification surveys to the Construction Manager.

3.4.7 Trenching and Backfilling

- Monitor that construction staking is performed before the work and that survey bench marks with elevations are secured outside the work area.

- Monitor that trenches are excavated in accordance with the dimensional cross-sections and design elevations shown on the Plans.

- Monitor profile surveys conducted by the Contractor during trenching operations.

- Perform moisture-density relationship testing (ASTM D1557) to determine the maximum dry density and optimum moisture content of soil materials that will be used as backfill.

- Perform nuclear density-moisture tests (ASTM D6938) to verify that backfill materials are moisture conditioned and compacted in accordance with the Specifications.

4. CONSTRUCTION QUALITY ASSURANCE FOR GEOSYNTHETICS

4.1 General

The objectives of the geosynthetics CQA program are to assure that: (i) proper construction techniques and procedures are used, and (ii) the project is completed in accordance with the Plans and Specifications. The intents of the CQA program are to: (i) identify and define problems that may occur during construction, and (ii) document that these problems are corrected before construction is complete.

This section describes CQA procedures for the installation of geosynthetic components. The following geosynthetics will be utilized for this project:

- Non-woven geotextile; and
- 40-mil HDPE geomembrane (textured on both sides).

CQA for the geosynthetics installations will be performed to monitor that geosynthetics are installed in accordance with the design. Construction must be conducted in accordance with the Plans and Specifications. To monitor compliance, the CQA Manager will: (i) review the Contractor's quality control submittals; (ii) perform material conformance testing; (iii) monitor construction testing; and (iv) monitor installations. Conformance testing refers to activities that take place before geosynthetics installation. Construction testing includes activities that occur during geosynthetics installation.

The CQA testing will be conducted in accordance with this CQA Plan and the project's Plans and Specifications. If a discrepancy exists in the testing requirements, the document that requires the most stringent testing will govern.

4.2 Geomembrane

4.2.1 Delivery, Storage, and Handling

Upon delivery of geomembrane, the CQA Monitor will:

- Observe geomembrane rolls for damage during shipping and handling, identify and mark any damaged materials, and document that damaged materials are set aside.
- Observe that the geomembrane is stored in accordance with the Specifications and is protected from puncture, dirt, grease, water, moisture, mud, mechanical abrasions, excessive heat, direct sunlight, and other damage.
- Document that all manufacturing documentation required by the Specifications has been received.
- Complete the geosynthetics inventory form for all geomembrane materials received.

Damaged geomembrane may be rejected. If rejected, document that material is removed from the site or stored at a location separate from accepted geomembrane. Geomembrane that does not have proper documentation from the manufacturer must be stored at a separate location until all documentation has been received, reviewed, and accepted.

4.2.2 Conformance Testing

Geomembrane Material Tests. Geomembrane samples will be obtained for conformance testing in accordance with Table 4-1. The material will be sampled at the site by the CQA Monitor or at the manufacturing plant under the direction of the CQA Consultant. The samples will be forwarded to an independent testing laboratory for the following conformance tests:

TABLE 4-1
HIGH DENSITY POLYETHYLENE (HDPE) GEOMEMBRANE CONFORMANCE TESTING FREQUENCIES

Property	Test Method	Conformance Test Frequency(6)
Thickness (min. avg.)	ASTM D5994	1 per 250,000 sf
Asperity Height (min. avg.)(1)	GRI GM 12	1 per 250,000 sf
Melt Flow Index	ASTM 1238	1 per 250,000 sf
Sheet Density (min avg.)	ASTM D792 or ASTM D1505	1 per 250,000 sf
Tensile Properties(2) (min. avg.) • Yield strength • Break strength • Yield elongation • Break elongation	ASTM D6693 Type IV	1 per 250,000 sf
Puncture Resistance (min. avg.)	ASTM D4833	1 per 250,000 sf
Carbon Black Content (range)	ASTM D1603(3)	1 per 250,000 sf
Carbon Black Dispersion(4)	ASTM D2663 ASTM D5596	1 per 250,000 sf
Interface Shear Strength(5) • cover soil / geotextile • geotextile / geomembrane • geomembrane / foundation layer	ASTM D6243	1 per project

Notes to Table 4-1:
(1) Alternate the measurement side for double sided textured sheets.
(2) Machine direction (MD) and cross machine direction (XMD) average values shall be on the basis of 5 test specimens in 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.

(3) Other methods such as D4218 (muffle furnace) or microwave methods are acceptable if an appropriate correlation to D1603 (tube furnace) can be established.
(4) Carbon black dispersion (only near spherical agglomerates) for 10 different views.
(5) Interface shear strength tests shall be tested at normal loads of 200; 500; 1,000; and 2,000 pounds per square foot. Results of the testing shall be forwarded to the Engineer for review and approval. Test reports shall include peak and large-displacement (2.5 inches) shear stress values.
(6) Minimum testing frequency shall be one sample per lot.

The CQA Manager will review all conformance test results and report any non-conformance to the Construction Manager and Contractor.

The Final CQA Report shall include a table similar to Table 4-1 documenting compliance with the testing frequencies and results documenting compliance with the Specifications.

Sampling Procedure. Samples will be taken across the entire roll width. Samples may be cut for shipping purposes, but a minimum of five square feet must be sent to the testing laboratory. Samplers must mark the machine direction and the manufacturer's roll identification number on the sample (each piece). Samplers will also assign a conformance test number to the sample and mark the sample with that number.

4.2.3 Geomembrane Installation

Surface Preparation. The soil surface must be prepared in accordance with the Specifications. Before geomembrane installation, the subgrade will be inspected by the CQA Monitor and Geosynthetics Contractor. The CQA Monitor must check the following:

- All lines and grades for the soil surface have been verified by the Contractor.
- The soil surface has been rolled/compacted and is free of surface irregularities, loose soil, and protrusions.
- The soil surface is firm and does not contain stones or other objects that could damage the geomembrane.
- The anchor trench dimensions have been checked and the trenches are free of sharp objects and stones.
- There are no excessively soft areas.
- The soil surface is not saturated and no standing water is present.
- The soil surface is not desiccated.
- All construction stakes, if utilized, have been removed and accounted for and there is no debris, rocks, or any other objects in or on the soil surface.
- The Geosynthetics Contractor has certified in writing that the surface on which the geomembrane will be installed is acceptable.

Panel Placement. Before installing any of the geomembrane, the Geosynthetics Contractor must submit drawings in accordance with the Specifications. These drawings will show the proposed layout of the panels, including panel identification numbers, field seams, and any other details that do not conform to the Plans.

The CQA Monitor will maintain an up to date panel layout drawing that shows the following: (i) roll numbers; (ii) panel numbers; (iii) seam numbers; (iv) test locations; (v) repair locations; and, (vi) non-destructive testing information.

During panel placement operations, the CQA Monitor will:

- Record panel numbers and dimensions on the panel/seam log.
- Observe the panel surface as it is deployed and record all panel defects and defect corrective actions (panel rejected, patch installed, extrudate placed over the defect, etc.)

on the repair sheet. Verify that corrective actions are made in accordance with the Specifications.

- Monitor that equipment used during deployment operations does not damage the geomembrane. Verify that equipment used on the geomembrane does not leak hydrocarbons onto the geomembrane or that corrective measures are taken to prevent leakage.

- Observe that the surface beneath the geomembrane has not deteriorated since previous acceptance. Verify that no stones, construction debris, or other items are beneath the geomembrane that could damage the geomembrane.

- Monitor that the geomembrane is not dragged across an unprotected surface. If the geomembrane is dragged across an unprotected surface, the geomembrane must be inspected for scratches and repaired or rejected, if necessary.

- Record weather conditions including temperature, wind speed and direction, and humidity. Verify that the geomembrane is not deployed in the presence of excess moisture (fog, dew, mist, etc.). In addition, verify that the geomembrane is not placed when the air temperature is less than 40° F or when standing water or frost is on the ground.

- Monitor that crews working on the geomembrane do not smoke, do not wear shoes that could damage the liner, and do not engage in activities that could damage the geomembrane.

- Monitor that methods used to deploy the geomembrane minimize wrinkles and that panels are anchored to prevent movement by the wind. Verify that the Geosynthetics Contractor corrects any damage resulting to or from windblown geomembrane.

- Monitor that no more panels are deployed than can be seamed on the same day.

- The CQA Monitor must inform both the Geosynthetics Contractor and the CQA Manager if any of the above conditions are not met.

Field Seaming. Before the start of geomembrane welding and during welding operations, each welder and welding apparatus will be tested in accordance with the Specifications to verify that the equipment is functioning properly. One trial weld will be taken before the start of work and one at mid-shift. The trial weld sample will be at least 42-inches-long and 12-inches-wide, with the seam centered lengthwise. The CQA Monitor will observe all welding operations and verify that the Geosynthetics Contractor quantitatively tests each trial weld for peel adhesion and bonded seam strength (ASTM D6392). (Peel adhesion tests will be referred to as "peel" and bonded seam strength tests will be referred to as "shear" in this document.) The main purposes of the trial weld tests are to evaluate seam strength and to confirm that each welding machine is working properly. Shear tests measure the continuity of tensile strength through the seam and into the parent material. Peel tests measure the strength of the bond created by the welding process.

The results of the peel and shear tests on trial welds will be recorded on the trial weld form. Trial welds must be completed under conditions similar to those under which the panels will be welded. Trial welds must meet specified requirements for peel and shear and the failure must be ductile or a film tearing bond (FTB) for a wedge weld. An FTB failure occurs when the test specimen breaks at the edge of the outside of the seam but not within that seam. If at any time the CQA Monitor believes that a welding machine is not functioning properly, a trial weld by that machine must be performed and tested. If there are wide changes in temperature (> 30° F), humidity, or wind speed, another trial weld must be performed and tested. The trial weld must be allowed to cool to ambient temperature before it is tested.

During geomembrane welding operations, the CQA Monitor will:

- Monitor that the Geosynthetics Contractor has an appropriate number of welding machines and spare parts necessary to perform the work.
- Monitor that equipment used for welding will not damage the geomembrane.
- Monitor that extrusion welders are purged before beginning a weld so that all heat-degraded extrudate is removed from the nozzle of the extrusion welder.
- Monitor that seam grinding is completed less than 1 hour before seam welding and that the upper sheet is beveled (extrusion welding only).
- Monitor that the ambient temperature measured 6-inches above the geomembrane surface is between 40° F and 110° F.
- Monitor that the ends of extrusion welds that are more than 5 minutes old are ground to expose new material before restarting a weld.
- Monitor that contact surfaces of the panels are clean and free of dust, grease, dirt, debris, and moisture before welding.
- Monitor that welds are free of dust, rocks, and other debris.
- Monitor that cross seams are ground to a smooth incline before welding (fusion welding only).
- Monitor that all seams are overlapped a minimum of 3 inches or in accordance with the manufacturer's recommendations, whichever is more stringent.
- Monitor that solvents or adhesives are not present in the seam area.
- Monitor that procedures used to temporarily hold the panels together do not damage the panels and do not preclude CQA testing.
- Monitor that strips of geomembrane, wide enough and long enough to protect the hot wedge welder from running on the subgrade, are placed below the geomembrane. These strips may be as long as the seam itself or shorter and moved with the seaming equipment. If necessary, a firm material such as a flat board or similar hard surface may be placed directly under the weld overlap to achieve firm support.
- Monitor that panels are being welded in accordance with the Plans and Specifications.
- Monitor that there is no free moisture in the weld area.

- Measure surface temperature of the panels every 2 hours.

4.2.4 Construction Testing

Nondestructive Seam Testing. The purpose of nondestructive geomembrane seam testing is to detect discontinuities or holes in the seams. Nondestructive geomembrane seam tests include vacuum box and air pressure testing. Nondestructive testing must be performed over the entire length of each seam.

It is the Geosynthetics Contractor's responsibility to perform all nondestructive testing as part of their quality control (QC) program. The CQA Monitor's responsibility is to observe and document that the Geosynthetics Contractor's QC testing is in compliance with the Specifications and to document seam defects and repairs.

Nondestructive seam testing procedures are described below:

- For welds tested by the vacuum box method, the weld is placed under suction utilizing a vacuum box constructed with rigid sides, a transparent top for viewing the seams, a neoprene rubber gasket attached to the bottom of the rigid sides, a vacuum gauge on the inside, and a valve assembly attached to a vacuum hose connection. The box is placed over a seam section which has been thoroughly saturated with a soapy water solution (1 oz. soap to 1 gallon water). The rubber gasket on the bottom of the box must fit snugly against the soaped seam section of the panel to ensure a leak-tight seal.

- A vacuum pump is energized and the vacuum box pressure reduced to approximately 5 psi gauge. Any pinholes, porosity, or non-bonded areas are detected by the appearance of soap bubbles in the vicinity of the defect. Dwell time must not be less than 10 seconds.

- Air pressure testing is used to test double wedge seams that have an enclosed air channel between them. Both ends of the air channel must be sealed. A pressure feed device, usually a hollow needle equipped with a pressure gauge, is inserted into one end of the channel. Air is then pumped into the channel to a minimum pressure of 25 to 30 psi. The air channel must sustain this pressure for 5 minutes without losing more than 2 psi. Following the 5-minute hold time, the opposite end of the tested seam must be punctured to release the air. The pressure gauge must return to zero; if it does not return to zero a blockage is likely present in the seam channel. Locate the blockage and test the seam on both sides of the blockage. The penetration holes must be sealed after testing.

During nondestructive seam testing, the CQA Monitor will:

- Review the Specifications regarding test procedures.

- Monitor that equipment operators are fully trained and qualified to perform their work.

- Monitor that test equipment meets the Specifications.

- Monitor that the entire length of each seam is tested in accordance with the Specifications.

- Observe testing and record results on the panel/seam log and the panel layout drawing.

- Identify any failed areas by marking the area with a waterproof marker compatible with the geomembrane, inform the Geosynthetics Contractor of any required repairs, and record the repair on the panel/seam log.

- Monitor that all repairs are completed and tested in accordance with the Specifications.

- Record all completed and tested repairs on a repair sheet and the panel layout drawing.

Destructive Seam Sampling Procedures and Field Testing. Destructive seam samples will be taken at intervals of at least one per 500 linear feet of geomembrane seam. However, additional samples will be taken if the CQA Monitor suspects that a seam does not meet the Specification's requirements. Reasons for taking additional samples may include, but are not limited to:

1. Wrinkling in the seam area.
2. Excess crystallinity.
3. Suspect seaming equipment or techniques.
4. Weld contamination.
5. Insufficient overlap.
6. Adverse weather conditions.
7. Failing tests.

The CQA Monitor will select the locations from where seam samples will be cut for destructive laboratory testing as follows:

- A minimum of one test per 500 feet of seam length. This is an average frequency for the entire installation; individual samples may be taken at greater or lesser intervals. The testing frequency will be increased if welding operations are conducted in temperatures below 40° F. This increase will be agreed to by the Construction Manager, CQA Manager, and Geosynthetics Contractor.

- A maximum frequency must be agreed to by the Construction Manager, CQA Manager, and Geosynthetics Contractor at the pre-construction meeting. However, if the number of failed samples exceeds 5 percent of the tested samples, this frequency may be increased at the discretion of the CQA Manager. Samples taken as the result of failed tests do not count toward the total number of required tests.

The CQA Monitor will not inform the Geosynthetics Contractor in advance of selecting the destructive sample locations.

The Geosynthetics Contractor will remove the destructive samples at locations identified by the CQA Monitor and field test the specimens for peel and shear before the samples are shipped off-site for laboratory testing. During sampling procedures the CQA Monitor will:

- Observe sample cutting.

- Mark each specimen and sample with an identifying number which contains the seam number, destructive sample test number, welder, and date and time welded.

- Record sample locations on the panel layout drawing and panel-seam logs.

- Record the sample locations, weather conditions, and reasons samples were taken (e.g., random sample, visual appearance, result of a previous failure, etc.) in the destructive seam test form.

At each location, obtain two seam specimens that are 44-inches apart. The specimens should be 1-inch wide and 12-inches long with the weld centered across the length of the specimen. The Geosynthetics Contractor must test these samples to failure in the field using a tensiometer capable of quantitatively measuring shear and peel strengths. For double wedge welding, the Geosynthetics Contractor must test both welds. The CQA Monitor will observe the tests. Geomembrane seam specimens pass when the break is a ductile FTB and the seam strength meets the specified values.

If one or both of the 1-inch specimens fails in either peel or shear, the Geosynthetics Contractor can, at his discretion: (1) reconstruct the entire seam between passed test locations; or (2) take another test sample 10 feet from the point of the failed test and repeat this procedure. If the second test passes, the Geosynthetics Contractor can either reconstruct or cap strip the seam between the two passed test locations. If subsequent tests fail, the sampling and testing procedure is repeated until the length of the poor quality seam is established. Repeated failures indicate that either the seaming equipment or operator is not performing properly and that appropriate corrective action must be taken immediately.

Once the field test specimens have passed, a sample must be recovered for laboratory testing from between the passing field specimen locations. The sample must be 42-inches long and 12-inches wide, with the weld centered along the length of the sample. The sample must be divided into three sections: one 12-inch by 12-inch section for the Geosynthetics Contractor, one 12-inch by 18-inch section for laboratory testing, and one 12-inch by 12-inch section for the Owner to archive. Record the results of field testing on the destructive seam test form and the panel/seam log.

Third Party Laboratory Testing. The CQA destructive seam samples can be shipped to the testing laboratory to verify seam quality. The laboratory will test five specimens from each sample in both shear and peel modes of failure. Minimum required test values are presented in the Specifications. The testing laboratory must provide verbal test results within 24 hours to the CQA Manager and written certified test results within 5 days.

The CQA Manager must immediately notify the Construction Manager and Geosynthetics Contractor in the event of failed seam test results.

If a laboratory test fails in either peel or shear, the Geosynthetics Contractor must either reconstruct the entire seam or recover additional samples at least 10 feet on either side of the failed sample for retesting. This process is repeated until passed tests bracket the failed seam section. All seams must be bounded by locations from which passing laboratory tests have been taken. Laboratory testing governs seam acceptance. In no case can field testing of repaired seams be used for final acceptance.

4.2.5 Repairs

Portions of geomembrane panels and seams that contain: (1) a flaw; (2) a destructive test; or (3) nondestructive test cuts or holes must be repaired in accordance with the Specifications. The CQA Monitor must locate and record all repairs on the repair sheet and panel layout drawing. Acceptable repair techniques include the following:

- Patching: used to repair large holes, tears, large panel defects, undispersed raw materials, welds, contamination by foreign matter, and destructive sample locations.

- Extrusion: used to repair small defects in the panels and seams. In general, this procedure should be used for defects less than 2-inches in the largest dimension.

- Capping: used to repair failed welds or to cover seams where welds cannot be nondestructively tested.

- Removal: used to replace areas with large defects where preceding methods are not appropriate. Also used to remove excess material (wrinkles, fishmouths, intersections, etc.) from the installed geomembrane. Areas of removal shall be patched or capped.

Repair procedures include the following:

- Abrade geomembrane surfaces to be repaired (extrusion welds only) no more than 1 hour before the repair.

- Clean and dry all surfaces at the time of repair.

- Monitor acceptance of the repair procedures, materials, and techniques by the CQA Monitor in advance of the specific repair.

- Extend patches or caps at least 6 inches beyond the edge of the defect and round all corners of material to be patched and the patches to a radius of at least 3 inches. Bevel the top edges of patches before extrusion welding.

4.2.6 Folded Material

Geomembrane with excessive folding (i.e., creased), as determined by the CQA Consultant, must be removed.

4.2.7 Geomembrane Anchor Trench

The geomembrane anchor trench should be left open until seaming is completed. Expansion and contraction of the geomembrane should be accounted for in the liner placement. The anchor trench should be filled in the morning when temperatures are coolest to reduce bridging of the geomembrane.

4.2.8 Geomembrane Acceptance

The Contractor retains all ownership and responsibility for the geomembrane until acceptance by the Owner. In the event the Contractor is responsible for placing cover over the geomembrane, the Contractor retains all ownership and responsibility for the geomembrane until all required documentation is complete and the cover material is placed. After panels are placed, seamed, tested successfully, and repairs made, the completed installation will be walked by the CQA Monitor and Contractor. Any damage or defects fonnd during this inspection will be repaired by the Geosynthetics Contractor. The installation will not be accepted until it meets the requirements of both parties. In addition, the geomembrane will be recommended for acceptance by the CQA Manager only when the following have been completed:

- The installation is finished.

- All seams have been inspected and verified to be acceptable and all required laboratory and field tests have been completed and reviewed.

- All required Contractor-supplied documentation has been received and reviewed.

- All as-built drawings have been reviewed and verified by the CQA Manager to show the true panel dimensions, the locations of all seams, trenches, pipes, appurtenances, and destructive test locations.

4.2.9 Qualifications

Proper layout, seaming, and testing of the geomembrane requires skill and experience. As such, the integrity of the geomembrane is dependent upon the installers. In order to assure a minimum level of experience and expertise, the following experience standards have been established in the Specifications:

Manufacturer/Fabricator/Installer. The Specifications list the required qualifications for the geomembrane manufacturer / fabricator / installer companies. The CQA Manager must verify qualifications of the manufacturer, fabricator, and installer through review of Engineer-approved project submittals.

Installation Superintendent. The installation field superintendent must have been responsible for the completed installation of a minimum of 5,000,000 square feet of polyethylene geomembrane in the past 5 years utilizing the type of seaming techniques and apparatus proposed for use on this project. A resume with references and phone numbers of satisfactory installations is required. Any superintendent proposed for this project must be present whenever geomembrane is installed.

Master Seamer and Other Welders. The master seamer must have demonstrated expertise on previous geomembrane installations. The master seamer must have successfully welded a minimum of 1,000,000 square feet of polyethylene geomembrane within the past 3 years. A resume for this work, witb references and phone numbers, is required. Other welders are required to have welded a minimum of 100,000 square feet of geomembrane within the past 3 years. Resumes for all welders, with references and phone numbers, are required. Personnel that have welded less than 100,000 square feet of geomembrane within the past 3 years will only be allowed to weld under the direct supervision of either the master seamer or the installation superintendent.

CQA Manager Qualifications. The CQA Manager must have provided CQA services on a minimum of 1,000,000 square feet of polyethylene installations or be level II certified in geosynthetics installations by National Institute for Certification in Engineering Technologies (NICET). The CQA Manager must provide verification of this experience by references in a current resume.

4.3 Geotextiles

4.3.1 Delivery, Storage, and Handling

During delivery of geotextiles the CQA Monitor will:

- Monitor that equipment used to unload the rolls does not damage the geotextile.
- Monitor that rolls are wrapped in impermeable and opaque protective covers.
- Monitor that care is used to unload the rolls.
- Monitor that all documentation required by the Specifications has been received.
- Monitor that each roll is marked or tagged with the following information: manufacturer's name; project identification; lot number; roll number; and roll dimensions. Log this information on the geosynthetic inventory form.
- Monitor that materials are stored in a location that will protect the rolls from ultraviolet light exposure, precipitation, mud, dirt, dust, puncture, cutting, or any other damaging or deleterious conditions.

Any damaged rolls may be rejected. Monitor that rejected material is removed from the site and stored at a location separate from accepted rolls. Geotextile rolls which do not have proper manufacturer's documentation must also be stored at a separate location until all documentation has been received and approved.

4.3.2 Conformance Testing

Geotextile Material Tests. The CQA Manager will arrange to obtain geotextile conformance test samples as indicated in Table 4-2. These samples will be sent to the testing laboratory for the following conformance tests:

TABLE 4-2
NON-WOVEN GEOTEXTILE CONFORMANCE TESTING FREQUENCIES

Property	Test Method	Conformance Test Frequency(1)
Mass/Unit Area (min. avg.)	ASTM D5261	1 per 250,000 sf
Apparent Opening Size (max.)	ASTM D4751	1 per project
Grab Strength (min. avg.)	ASTM D4632	1 per 250,000 sf
Permittivity (min.)	ASTM D4491	1 per project
Puncture Strength (min. avg.)	ASTM D4833	1 per 250,000 sf

Note to Table 4-2:
(1) Minimum testing frequency shall be one sample per lot.

The CQA Manager will review all conformance test results and report any non-conformance to the Construction Manager and Contractor.

The Final CQA Report shall include a table similar to Table 4-2 documenting compliance with the testing frequencies and results documenting compliance with the Specifications.

Sampling Procedure. Samples will be obtained across the entire roll width and will be 3-feet long. Samplers must mark the manufacturer's roll identification number and the machine direction on the sample. Samplers will also assign a conformance test number to the sample and mark the sample with that number.

4.3.3 Geotextile Installation

Surface Preparation. Before geotextile installation, the CQA Monitor will:

- Monitor that all lines and grades have been verified by the Contractor.
- Monitor that the subgrade has been prepared in accordance with the Specifications and that the geomembrane installation and all associated documentation has been completed.
- Monitor that soil or geomembrane surfaces do not contain stones that could damage the geotextile.
- Monitor that there are no excessively soft areas in soil surfaces that could damage the geotextile.

Geotextile Placement and Seaming. During geotextile placement and seaming operations, the CQA Monitor will:

- Observe the geotextile as it is deployed and record all defects and defect corrective actions (panel rejected, patch installed, etc.). Verify that corrective actions are performed in accordance with the Specifications.
- Monitor that equipment used does not damage the geotextile by handling, equipment transit, leakage of hydrocarbons, or other means.
- Monitor that crews working on the geotextile do not smoke, do not wear shoes that could damage the geotextile, and do not engage in activities that could damage the geotextile.
- Monitor that the geotextile is securely anchored in an anchor trench and is temporarily anchored to prevent movement by the wind.
- Monitor that adjacent panels are overlapped and seamed in accordance with the Specifications.
- Monitor that the geotextile is not exposed to direct sunlight for more than 5 days.
- Examine the geotextile after installation to ensure that no potentially harmful foreign objects are present.
- The CQA Monitor must inform both the CQA Manager and Contractor if the above conditions are not met.

4.3.4 Repairs

Repair procedures include:

- Patching: used to repair large holes, tears, and small defective areas.
- Removal: used to replace large defective areas where the preceding method is not appropriate.

5. CONSTRUCTION QUALITY ASSURANCE FOR EROSION CONTROL

5.1 Introduction

This section describes CQA procedures for temporary and permanent erosion control installations.

CQA for the temporary and permanent erosion control measures will be performed to verify that the Contractor complies with the requirements of the project's Stormwater Pollution Prevention Plan (SWPPP) and that the permanent erosion control measures are installed in accordance with the design. Construction must be conducted in accordance with the Plans and Specifications. To monitor compliance, the CQA Consultant will: (1) review the Contractor's quality control submittals, and (2) monitor installations.

5.2 Construction Monitoring

5.2.1 Temporary Erosion Control

- Monitor that the Contractor implements temporary erosion control measures in compliance with the project's SWPPP.

5.2.2 Permanent Erosion Control Measures

Erosion Mats

- Review the Contractor's submittals for the erosion mats and verify that the material complies with the manufacturer's recommendations and the Specifications.
- Monitor that the Contractor installs the erosion mats at the locations indicated on the Plans.
- Monitor that the Contractor installs the erosion mats prior to revegetation of the final cover.
- Monitor that the Contractor installs the erosion mats in accordance with the manufacturer's recommendations.

Straw Wattles

- Review the Contractor's submittals for the straw wattles and verify that the material complies with the manufacturer's recommendations and the Specifications.
- Monitor that the Contractor installs the straw wattles at the locations indicated on the Plans.
- Monitor that the Contractor installs the straw wattles prior to revegetation of the final cover.
- Monitor that the Contractor installs the straw wattles in accordance with the manufacturer's recommendations.

Revegetation

- Review the Contractor's submittals for the hydroseed mix design and straw mulch for compliance with the Specifications.

- Monitor that the Contractor evenly and uniformly distributes the hydroseed mixture over the final cover and that there are no bare spots.

- Monitor that the Contractor evenly and uniformly distributes the straw mulch in accordance with the Specifications.

- Monitor that the Contractor irrigates the revegetated areas during construction.

6. CONSTRUCTION QUALITY ASSURANCE FOR DRAINAGE FACILITIES

6.1 Introduction

This section describes CQA procedures for the surface water drainage facilities. The drainage facilities consist of various types of drainage channels, drop inlets, culverts, and diversion berms.

CQA for the drainage facilities installation will be performed to verify that these facilities are constructed in accordance with the Plans and Specifications. To monitor compliance, the CQA program will: (1) review the Contractor's quality control submittals; (2) monitor construction testing; and (3) monitor installations.

Construction testing will be conducted in accordance with the Specifications.

6.2 Construction Monitoring

6.2.1 Drainage Channels

- Monitor that grade control construction staking for the drainage channels is performed before the work.
- Monitor that the drainage channels are constructed in accordance with the Drawings and Specifications.
- Monitor that the subgrades of the drainage channels are dry, firm, and unyielding and do not have loose or extraneous material.
- Document that drainage ditches are graded and sloped in accordance with the Plans and Specifications. Review verification surveys and notify the Contractor of areas needing repair. Submit copies of verification surveys to the Construction Manager.

6.2.2 Drop Inlets and Culverts

- Review the Contractor's submittals for the piping and drop inlets for compliance with the Specifications.
- Monitor that the Contractor has excavated pipe trenches to the proper depth.
- Monitor that the Contractor has graded the slope of the pipe trenches to uniform gradient.
- Monitor that the pipe subgrades are firm and unyielding and do not have loose or extraneous material.
- Monitor and test backfilling of pipe trenches.
- Verify that inlets to drainage structures are smooth and prevent ponding.

6.2.3 Diversion Berms

- Monitor that the material used to construct the diversion berms complies with the Specifications for structural fill.

7. DOCUMENTATION

This CQA Plan requires thorough monitoring and documentation of the construction activities. The CQA Manager will document that the CQA requirements have been addressed and satisfied. Documentation will consist of daily record keeping, testing and installation reports, non-conformance reports (if necessary), progress reports, photographic records, design and Specification revisions, and a Final CQA Report.

7.1 Daily Record Keeping

At a minimum, daily records will consist of a daily record of construction progress, daily construction report, observation and test data sheets, and, as needed, non-conformance/corrective measure reports. All forms will have peer review.

7.1.1 Daily Record of Construction Progress

The daily field report will summarize ongoing construction and discussions with the Contractor and will be prepared by the CQA Manager and CQA Monitor. At a minimum, the report will include the following:

1. Date, project name, project number, and location.
2. A unique number for cross-referencing and document control.
3. Weather data.
4. A description of ongoing construction for the day in the area of the CQA Monitor's responsibility.
5. An inventory of equipment utilized by the Contractor.
6. Significant items of discussion and names of parties involved in these discussions.
7. A brief description of tests and observations, identified as passing or failing, or, in the event of failure, a retest.
8. Areas of non-conformance/corrective actions, if any (non-conformance/corrective action form to be attached).
9. Summary of materials received and quality control documentation.
10. Follow-up information on previously reported problems or deficiencies.
11. Record of site visitors involved with the project.
12. Signature of CQA Manager and/or CQA Monitor.
13. Signature of the peer reviewer.

7.1.2 Observation and Test Data Sheets

Observation and test data sheets should include the following information as is appropriate for the form being used.

1. Date, project name, project number, and location.

2. A unique number for cross-referencing and document control.

3. Weather data, as applicable.

4. A reduced scale site plan showing sample and test locations.

5. Test equipment calibrations, if applicable.

6. A summary of test results identified as passing, failing, or, in the event of a failed test, retest.

7. Completed calculations.

8. Signature of the CQA Manager and/or CQA Monitor.

9. Signature of the peer reviewer.

7.1.3 Non-Conformance Reports

In the event of a non-conformance event, a non-conformance verification report form will be included with the daily report. Procedures for implementing and resolving any non-conformities to the Contract Documents are outlined in Section 2.4 of this CQA Plan.

7.2 Weekly Progress Reports

The CQA Manager will prepare weekly progress reports summarizing construction and CQA activities. These reports will contain, at a minimum, the following information:

- The date, project name, project number, and location.
- A summary of work activities completed in the last week and those expected to be performed in the next week.
- A summary of deficiencies and/or defects and resolutions.
- Ongoing summary of changes and/or change orders to the work.
- The signature of the CQA Manager.
- On the fourth week of each month the report will include a summary of on-site and third party laboratory test results.

7.3 Photographs

Construction activities will be photographed. Photographs will show any significant problems encountered and corrective actions and will document the construction progress. The photographs will be identified by location, date, and photographer. The photographer should document the subject or the photograph, either on the back of the picture or in a photograph log.

7.4 Design and Specification Changes

Design and Specification changes may be required during construction. Design and Specification changes will only be made with the written agreement of the Design Engineer, Owner, and Contractor. These changes will be made by change order to the contract. When change orders are issued, they will be prepared by the Construction Manager. The Construction Manager will distribute change orders for signature and execution to the required parties.

7.5 Final Construction Quality Assurance Report

At the completion of the project, the CQA Manager and CQA Officer will submit a Final CQA Report. This report will document that the work has been performed in compliance with the Plans and Specifications.

At a minimum, the Final CQA Report will contain:

- Daily Field Reports per Section 7.1.1.
- Inspection data sheets that contain observations and a record of field and laboratory tests per Section 7.1.2.
- A summary of the construction activities.
- A tabular summary of the laboratory and field test results demonstrating construction is in compliance with the Specifications.
- Sampling and testing location drawings.
- A description of significant construction problems and the resolution of these problems.
- A list of changes from the Plans and Specifications and the justifications for these changes.
- As-built (record) drawings.
- A statement of compliance with the Contract Documents and design intent that is signed and stamped by the CQA Officer.

The as-built drawings will accurately show the constructed location of the work items, including the location of piping, anchor trenches, etc. All surveying and base maps required for the development of the as-built drawings will be prepared by the Contractor. The CQA Manager will review and verify that the as-builts are correct.