REVISION II
TO
VOLUME IV OF IV REPLACEMENT
AMENDMENT TO FINAL CLOSURE PLAN
LOPEZ CANYON SANITARY LANDFILL
LAKEVIEW TERRACE, CALIFORNIA

By
Bureau of Sanitation

Department of Public Works
City of Los Angeles
419 South Spring Street, Suite 800
Los Angeles, California

October 1998

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October 22, 1998

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LOPEZ CANYON LANDFILL- SUBMITTAL OF REVISION 2 TO VOLUME IV OF IV REPLACEMENT OF AMENDMENT TO THE FINAL CLOSURE PLAN

The Bureau of Sanitation (BOS) hereby transmits two copies of the subject document for your review and approval. This document contains revisions to the final cover design for the slopes of Disposal Areas "A" and "AB+" and the decks of Disposal Areas "A", "B" and "AB+" from the original and approved closure plan dated February 1994 and revised June 1996 and March 1997. The revised design for these areas of the landfill is based on an engineered alternative final cover that employs a monolithic soil layer as an evapo-transpirative infiltration barrier. The monolithic cover was shown to perform better than the Title 27 prescriptive cover in controlling infiltration. The monolithic soil cover is also more economical to procure, place, maintain and repair than the prescriptive cover. Refer to the technical report as presented in Appendix J. Also, the proposed monolithic cover report was submitted to both the RWQCB and the LEA on April 8 and July 1, 1998. Both agencies found the report to have met the state requirements and subsequently issued conditional approvals on July 23 and August 5, 1998. Copies of the approval letters are presented in Appendix G.

As part of this revision, BOS prepared a revised closure cost estimate demonstrating that the construction of the monolithic cover will result in an overall decrease of $2,066,661 excluding contingencies. The total cost reduction including 20% contingency is $2,480,000. A revised initial cost estimate worksheet is presented in Appendix F.

The attached revisions replace in full all prior pages within Volume IV of IV Replacement Amendment to the Final Closure Plan, dated June 1996 and later revised in March 1997. These revisions are also summarized on the attached summary table.

Due to the potential for enhanced performance at lower cost, BOS requests an expedited review and approval of the revised closure plans. The BOS also requests reimbursement for the total cost reduction. Upon your approval of the revised plans, please instruct the Union Bank of California to disburse the amount of $2,480,000 to the City of Los Angeles.

If you should have any questions, please call Kelly Gharios at (213) 893-8209.

Very truly yours,

Stephen A. Fortune

STEPHEN A. FORTUNE, Division Manager
Solid Resources Engineering & Construction Division

Attachment

C: Drew Sones, BOS
Joe Maturino, LEA
Rod Nelson, RWQCB
Kelly Gharios, BOS
Paul Blount, BOS
Ken Redd, BOS
Reina Pereira, BOS
Ed Kavazanjian, Geosyntec Consultants

SUMMARY TABLE OF REVISIONS TO VOLUME IV OF IV REPLACEMENT AMENDMENT TO FINAL CLOSURE PLAN
Revised October 1998

The following revisions and additions to the final closure plan address the conditional approval by the CIWMB, RWQCB and LEA of an alternative final cover on the slopes of Disposal Areas A and AB+, and the decks of Disposal Areas A, B and AB+. Please ensure that these revisions are incorporated into your closure plan, and all previous sections discarded.

Sections, Details, Drawings to be Amended	Description of Change	Comment
Cover Sheet	Replace	Reflects revision dates
Summary of Revisions	Replace in Entirety	Accounts for all revisions made to this document
Table of Contents of Volume IV of IV	Replace pages ii - x	Updated to reflect revisions/additions
Section 1: "Introduction"	Replace in Entirety	Updated to reflect revisions
Section 2: "Revised Final Cover Design"	Replace in Entirety	Revised to reflect use of a monolithic cover on the slopes of Disposal Areas A and AB+, and on the decks of Disposal Areas A, B and AB+.
Section 8: "Revised Landscaping and Irrigation"	Replace in Entirety	Revised to reflect the advantages of a monolithic cover with respect to allowing for deeper rooted vegetation, and better evapotranspiration performance.
Section 9: "Revised Closure Cost Estimate"	Replace in Entirety	Revised Sections 9.2.1 and 9.3 to include corrected final cover costs.
Tables	Add Table 2-3 Replace Table 9-1	Monolithic Soil Cover Testing Summary Revised Summary of Closure Cost Estimate
Figures	Add Fig. 2-0 Replace Fig. 2-2 Delete Fig. 2-2(a) Delete Fig. 2-2(b) Add Fig 2-2(a) Add Fig 2-2(b) Delete Fig. 2-2(c) Delete Fig. 2-2(d) Replace Fig. 2-3 Replace Fig. 2-3(a) Replace Fig. 2-3(b) Replace Fig. 2-4 Replace Fig. 10-1	Landfill Final Cover Configuration Final Cover on B Deck GCL on A, B and AB+ Decks GCL on A, B, AB+ and C Decks Final Cover on A and AB+ Decks Vertical well on A, B, AB+ Decks Vert. Well on A, B, AB+ Decks – prescriptive Vert. Well on A, B, AB+ Decks – GCL Final Cover on Slopes/Benches of B Canyon Final Cover on Slopes/Benches of A Canyon Final Cover on Slopes/Benches of AB+ Cny. Final Cover System under Haul Road Revised Closure Schedule
Appendix F: "Updated Closure and Post-Closure Cost Estimates"	Replace in Entirety	Reflects cost revisions pertaining to use of a monolithic cover
Appendix G: "Approval Letters from CIWMB, RWQCB and LEA"	Add additional approval letters to back of Appendix G	RWQCB and LEA's approval of monolithic cover
Appendix I: "Revised CQA Plan"	Replace in Entirety	Includes CQA for monolithic cover

SUMMARY TABLE OF REVISIONS TO
VOLUME IV OF IV REPLACEMENT AMENDMENT TO
FINAL CLOSURE PLAN
Revised October 1998

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Sections, Details, Drawings To be Amended	Description of Change	Comment
Appendix J: "Proposed Engineere Alternative Final Cover on the Slopes of Disposal Areas A and AB+ and the Decks of Disposal Areas A, B and AB+	Add new Appendix J	Technical report on the feasibility of an alternative final cover
Appendix K: "Evaluation of the Phase III West Ridge as a Borrow Source for Monolithic Soil Cover	Add new Appendix K	An additional source of dirt for final closure

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FINAL CLOSURE PLAN
LOPEZ CANYON SANITARY LANDFILL
LAKEVIEW TERRACE, CALIFORNIA

VOLUME IV OF IV REPLACEMENT
AMENDMENT TO FINAL CLOSURE PLAN

Prepared for:

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Project Number CE4100-06

June 1996
Revised March 1997
Revised October 1998

SUMMARY OF REVISIONS
FINAL CLOSURE AND POST-CLOSURE MAINTENANCE PLANS
LOPEZ CANYON SANITARY LANDFILL

This Summary of Revisions outlines the amendments to the Final Closure Plan (FCP) and the Final Post-Closure Maintenance Plan (FPCMP) for Lopez Canyon Landfill. The FCP is comprised of the Partial Closure Plan (PCP) (Volumes I through III) dated April 1993 and the Amendment to the PCP (Volume IV of IV), dated February 1994. The Amendment (Volume IV of IV) dated June 1996, transformed the PCP into the FCP. The FPCMP is comprised of the Partial Post-Closure Maintenance Plan (PPCMP) (Volume I) dated January 1993 and the Amendment to the PPCMP (Volume II of II) dated February 1994. The Amendment (Volume II of II) transformed the PPCMP into the FPCMP.

The June 1996 document (Volume IV of IV Replacement) replaced in whole the February 1994 Volume IV of IV and amended the FCP and the FPCMP. Revision I to Volume IV of IV Replacement Amendment to Final Closure Plan was prepared in March 1997 to address comments from the CIWMB and LEA, prior to final approval of the closure plan being granted. Applicable sections were revised and replaced the respective sections of the original June 1996 document. Revision II to Volume IV of IV Replacement Amendment is being submitted October 1998 as an additional revision of applicable sections to be incorporated into the June 1996 report, to reflect a conditionally approved alternative final cover.

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DRAWINGS

1. INTRODUCTION

1.1 Terms of Reference

This volume presents an amendment to the Final Closure Plan (FCP) for the Lopez Canyon Sanitary Landfill. Outlined below is a chronological order of amendments made to this report:

- Volume IV of IV Replacement Amendment to Final Closure Plan was revised in June 1996, to replace in whole the February 1994 Volume IV of IV and amend the Final Closure Plan and Final Post Closure Maintenance Plan. The objective of this first amendment was to incorporate into the Final Closure Plan (FCP) information on the closure of the deck area of Disposal Areas A and B, and the deck and slopes of Disposal Areas AB+ and C sufficient to constitute a FCP for the entire landfill. This volume included revisions to the FCP necessitated by changes in the design of the landfill since submission of the FCP. These changes required revisions to the final cover, final grading plan, post-closure settlement estimates, surface-water drainage controls, soil loss analysis, landfill gas control system, landscaping and irrigation, cost estimate for closure, closure implementation schedule, and final cover construction quality assurance (CQA) plan for the landfill.

- Revision I to Volume IV of IV Replacement Amendment to Final Closure Plan was submitted to the CIWMB, RWQCB and LEA in March 1997 to address comments from the CIWMB and LEA, prior to final approval of the closure plan being granted. Applicable sections of the amended FCP were revised to reflect these comments, and incorporated into the original June 1996 document. Revised sections included the final cover design, landfill gas control system, closure cost estimate, final cover performance evaluation report and CQA plan.

- Revision II to Volume IV of IV Replacement Amendment to Final Closure Plan is being submitted October 1998 as an additional revision of applicable sections to be incorporated into the amended FCP June 1996 report, to reflect a conditionally approved alternative final cover. Revised sections include the final cover design, landscaping and irrigation, closure cost estimate, closure plan implementation schedule and CQA plan, with new appendices added to address monolithic cover water balance analyses and final cover performance evaluation.

The June 1996 report was prepared by GeoSyntec Consultants (GeoSyntec) for the Bureau of Sanitation, Department of Public Works of the City of Los Angeles (BOS). The report was written by Mr. Michael S. Snow, P.E., and Dr. Neven Matasovic and was reviewed by Dr. Edward Kavazanjian, Jr., P.E., G.E., of GeoSyntec.

The two subsequent reports, submitted March 1997 and October 1998 respectively, were prepared and written by Ms. Reina Pereira, P.E., and were reviewed by Mr. Kelly Gharios, P.E., of BOS. GeoSyntec Consultants assisted BOS in the preparation of the technical documents which are part of these revisions.

1.2 Background and Purpose of Amendment

The purpose of this amendment to the FCP is to provide the Local Enforcement Agency (LEA), Los Angeles Regional Water Quality Control Board (RWQCB), and California Integrated Waste Management Board (CIWMB) with the necessary information to consider the FCP and this amendment as the FCP for the entire landfill in accordance with Title 27 of the California Code of Regulations. Closure requirements for municipal solid waste landfills are contained in Title 27, RWQCB Order No. 93-062, and in '258. of Title 40 of the Code of Federal Regulations, commonly referred to as Subtitle D of the Resource Conservation and Recovery Act (Subtitle D).

The Partial Closure Plan-Volumes I through III (PCP) was submitted in January 1993, revised in April 1993, and approved by the RWQCB on 21 July 1993, by the LEA on 4 November 1993, and by the CIWMB on 16 December 1993. The amendment to the PCP (Volume IV of IV) was first submitted in February 1994. The PCP and the amendment to the PCP constitute the FCP. The amendment of the PCP was revised in June 1996 (Volume IV of IV Replacement) and was resubmitted as the amended FCP to replace in whole the February 1994 submittal. A revision to the amended FCP was made in March 1997 to address comments from the CIWMB and LEA prior to final approval being granted. This replaced applicable sections of the June 1996 report.

By letters dated July 31, 1997, and August 5, 1997, the LEA and CIWMB found the revised closure plan technically adequate, with final approval contingent on the approval of the environmental documents. Subsequently, Revision II to the amended FCP is being submitted October 1998 as an additional revision to applicable sections of the June 1996 report to reflect a conditionally approved alternative final cover.

The PCP (Volumes I through III) was prepared in order to accommodate closure of the slopes of Disposal Areas A and B in advance of the remaining areas. The amendment to the PCP was prepared to address additional information on the closure of the deck areas of Disposal Areas A and B, and the deck and slope areas of Disposal Areas AB+ and C. The amendment to the FCP addresses the additional information on the closure of the deck area of Disposal Areas A and B, and the deck and slope areas at Disposal Areas AB+ and C resulting from the change in final elevation of the deck of Disposal Area C. The FCP proposed that the closure of the landfill be accomplished in two phases. Phase I closure includes the slopes of Disposal Areas A and B. Phase I closure began in the Spring of 1994. Phase I closure was to be completed by Summer 1996. As a result of the suspension of closure activities in order to allow city resources to work on future CUP areas, the Phase I closure was not completed by 1996. Phase II closure includes the top decks of Disposal Areas A and B and all of Disposal Areas AB+ and C. Phase II closure is currently scheduled to commence in the Winter of 1999.

1.3 Report Organization

The remainder of this report is organized into sections which describe the necessary revisions to the FCP as follows:

- Section 2 presents a description of the revised final cover design;
- Section 3 presents the revised final grading plan for the decks of Disposal Areas A, B, AB+, and C, and the slopes of Disposal Areas AB+ and C;

- Section 4 presents revised post-closure settlement estimates for Disposal Areas A, B, AB+, and C resulting from the modifications to the final grading plan;

- Section 5 presents the revisions to the surface-water drainage design for the decks of Disposal Areas A, B, AB+, and C, and slopes of Areas AB+ and C resulting from the modifications to the final grading plan;

- Section 6 presents revised soil loss estimates for Disposal Areas A, B, AB+, and C resulting from the modifications to the final grading plan, surface-water drainage system, and final cover cross-section;

- Section 7 presents the revisions to the landfill gas control system resulting from the modifications to the final grading plan;

- Section 8 presents the revised landscaping and irrigation design resulting from the changes to the final grading plan;

- Section 9 presents revised cost estimates for implementing closure resulting from the modifications described in Sections 1 through 8;

- Section 10 presents an updated closure implementation schedule;

- Section 11 presents revisions to construction quality assurance (CQA) procedures resulting from modifications to the final cover cross-sections;

- Appendix A presents the Updated Site Facilities Map which amends the Site Facilities Map of Volume III of IV of the FCP;

- Appendix B presents the Updated Site Radius Maps which amend the Site Radius Maps of Volume III of IV of the FCP;

- Appendix C presents the Updated Ground-Water Monitoring Network which amends Drawing No. 1 of Volume II of II of the FPCMP;

- Appendix D presents the Updated Figures 1-1 and 3-1 which amend Figures 1-1 and 3-1 of Volume II of II of the FPCMP;

- Appendix E presents the Revised Post-Closure Maintenance Cost Estimate which amends Section 4 of Volume II of II of the FPCMP;

- Appendix F presents the updated Closure and Post-Closure Cost Estimates. Revised Initial Cost Estimate Worksheet which amends the Appendix K of Volume II of IV of the FCP and Table 4-1 of Volume II of II of the FPCMP;

- Appendix G presents various approval letters from the CIWMB approving the revised final cover design;

- Appendix H presents a Final Cover Performance Evaluation report, including water balance (infiltration) and slope stability analyses for the final cover of Disposal Area C;

- Appendix I presents a revised CQA Plan for implementing the procedures presented in Section 11;

- Appendix J presents a report on the Proposed Engineered Alternative Final Cover on the Slopes of Disposal Areas A and AB+, and the Decks of Disposal Areas A, B and AB+;

- Appendix K presents a report on the Evaluation of the Phase III West Ridge as a Borrow Source for Monolithic Soil Cover; and

2. REVISED FINAL COVER DESIGN

2.1 General

The final cover for Disposal Area C has been revised from the design presented in the PCP to conform to the requirements of Subtitle D, Title 27, and RWQCB Order No. 93-062 for final covers over bottom liners which include a geomembrane. This revised final cover design was submitted to the CIWMB in February 1994 and was approved on 10 October 1995. A copy of the approval is presented in Appendix G. The final cover presented in the PCP employed an infiltration barrier layer composed of compacted soil only. The revised design for Disposal Area C incorporates a geomembrane in the infiltration barrier layer in the deck and bench areas. The geomembrane was included in the deck and bench areas in accordance with the prescribed minimum construction standards of Subtitle D and Title 27. On the slopes of the waste face, an engineered alternative final cover is employed. The alternative slope final cover was designed in accordance with state and federal regulatory standards for a performance-based design of an engineered alternative final cover.

A performance evaluation of the Disposal Area C alternative slope final cover was conducted to demonstrate compliance with applicable state and federal regulations. The performance evaluation included an infiltration analysis and a slope stability assessment for the alternative slope final cover design. The performance evaluation also included a demonstration that the construction of the prescriptive final cover provided in state and federal regulations on the side slopes was burdensome and impractical and would not promote attainment of the performance goals for final covers, as required by the state regulations. A detailed presentation of the performance evaluation is contained in the Final Cover Performance Evaluation report presented as Appendix H of this addendum. A summary of the performance evaluation is presented herein.

Additionally, the final cover design for the slopes of Disposal Areas A and AB+, and the decks of Disposal Areas A, B and AB+ have been revised from the prescriptive standards outlined in Subtitle D and Title 27 to reflect an alternative engineered monolithic cover. This request was submitted to the RWQCB and LEA on April 8, 1998, and conditionally approved by the RWQCB in a letter dated July 23, 1998, and by the LEA on August 5, 1998. Copies of the approvals are shown in Appendix G.

The final cover presented in the amended FCP utilized a one foot infiltration barrier layer under a two foot vegetative layer on the slopes of Disposal Areas A and AB+, and a GCL liner under a two foot vegetative layer on the decks of Disposal Areas A, B and AB+. The revised design for these areas employs a monolithic final cover which was shown to perform better than the Title 27 prescriptive cover in controlling infiltration in a report entitled "Proposed Engineered Alternative Final Cover on the Slope of Disposal Areas A and AB+ and the Decks of Disposal Areas A, B and AB+ - Lopez Canyon Restoration Project," as presented in Appendix J.

2.2 Regulatory Framework

State of California regulations concerning design and construction of final covers for closure of municipal solid waste landfills are found in Title 27, and RWQCB Order No. 93-062. Federal regulations for final covers are provided in Subtitle D. State and federal regulations both provide a minimum prescriptive construction standard for the final cover of Municipal Solid Waste Landfills (MSWLFs) that includes a protective vegetative erosion control layer and a low-permeability soil infiltration barrier layer. State regulations are somewhat more restrictive than federal regulations with respect to these layers, requiring a thicker erosion control layer and an order of magnitude lower hydraulic conductivity for the barrier layer. The state and federal regulations both require that the final cover have a "permeability" less than or equal to that of any bottom liner or underlying material. This requirement is generally interpreted as an implied prescriptive requirement that a geomembrane be included in the final cover barrier layer above areas which incorporate a geomembrane in the bottom liner. This "permeability" requirement is also interpreted as a performance standard requiring less infiltration of surface water through the final cover than liquid flux through the base of the landfill.

Based upon the state and federal regulations and considering that Disposal Area C does have a geomembrane bottom liner, the prescriptive final cover for Disposal Area C is inferred to consist of (from top to bottom):

- a vegetative layer at least 12-in. (300-mm) thick and of greater thickness than the rooting depth of any vegetation planted on the final cover;
- a geomembrane infiltration barrier;
- a compacted soil barrier layer not less than 12-in. (300-mm) thick with a maximum hydraulic conductivity of 1×10^{-6} cm/sec;
- a foundation layer at least 24-in. (600-mm) thick; and
- a design which provides for the minimum maintenance possible.

Both federal and state regulations provide for design of an alternative to the prescriptive final cover. Federal regulations allow the director of an approved state to approve an alternative design shown to be equivalent or superior to the performance of the prescriptive design with respect to infiltration and wind and water erosion. California is an approved state.

Section 21140. of Title 27 provides for the approval of alternative final covers when the owner demonstrates that:

- "the final cover shall function with minimum maintenance and provide waste containment to protect public health and safety by controlling at a minimum, vectors, fire, odor, litter and landfill gas migration. The final cover shall also be compatible with postclosure land use."

- the engineered alternative is consistent with the performance requirements as established in 40 CFR 258.60(b), which states that the alternative final cover design shall meet or exceed the prescriptive permeability of $1x10^{-5}$ cm/sec, or less than the permeability of any bottom liner, with a minimum of 18-inches of earthen material. Additionally, provide an erosion layer that provides protection from wind and water erosion, equivalent to the prescriptive minimum of 6-inches of earthen material capable of sustaining native plant growth.

The state and federal requirement that the final cover have a "permeability" less than or equal to the bottom liner or underlying material is generally interpreted as an implied final cover infiltration performance standard that the flux through the cover should be less than the flux through the base liner. United States Environmental

Protection Agency (USEPA) has confirmed this interpretation of the implied prescriptive requirement and performance standard of the Subtitle D closure requirement in the "Final rule; corrections" for Subtitle D published in the Federal Register of 26 June 1992 (Vol. 57, No. 124, pp. 28626-28628). USEPA's comments on the prescriptive and performance standards for final cover design are discussed in detail in the Final Cover Performance Evaluation report presented in Appendix H.

The Final Cover Performance Evaluation report presented in Appendix H of this addendum contains the demonstration required by state regulations that construction of the prescriptive final cover on the slopes of the waste face of Disposal Area C is both burdensome and impractical and will not promote attainment of the performance goals for final covers. On the basis of this demonstration, an engineered alternative final cover for the Disposal Area C waste slopes was developed.

The Proposed Engineered Alternative Final Cover report presented in Appendix J shows that the monolithic soil cover model provides better infiltration control than the prescriptive standard described in Title 27, thus providing better ground water protection. Moreover, the prescriptive standard illustrates constructability that is more burdensome, quality assurance testing procedures that are more stringent, it is more susceptible to cracking, involves more labor intensive maintenance, and is significantly higher in cost of purchase and placement of material. Based on the above findings, it was determined that the engineered alternative cover developed for the slope of Disposal Areas A and AB+, and the deck of Disposal Areas A, B and AB+ would be more practical and would better promote attainment of performance goals.

2.3 Revised Final Cover Configuration

Final cover configuration for the entire landfill is shown in Figure 2-0.

2.3.1 Disposal Area C Deck/Bench Areas

The final cover on deck and bench areas of Disposal Area C satisfies the prescriptive standard in the California regulations. The deck and bench area final cover, shown in Figures 2-1 through 2-1(f), consists of the following components (from top to bottom):

- vegetative layer at least 24-in. (600-mm) thick;
- 12 oz/yd^2 (410 g/m^2) non-woven geotextile cushion;
- 40-mil (1-mm) thick very-flexible polyethylene (VFPE) geomembrane (smooth on the deck areas and textured on the bench areas). Technical specifications are shown in Table 2-1. Note that VFPE geomembranes include very low density polyethylene (VLDPE) and linear low density polyethylene (LLDPE), as noted in Appendices H and I;
- 12-in. (300-mm) thick barrier layer of compacted low-permeability soil, with a hydraulic conductivity no greater than 1 x 10^{-6} cm/s. A geosynthetic clay liner (GCL) with a hydraulic conductivity no greater than 5 x 10^{-9} cm/s may be used as a barrier layer for the deck area instead of the low-permeability soil. Technical specifications for GCL are shown in Table 2-2; and

- 24-in. (600-mm) thick foundation layer.

2.3.2 Disposal Area A, B, and AB+ Deck Areas

The final cover on the deck of Disposal Areas A, B, and AB+ has been modified from that presented in the PCP to delete the geotextile between the vegetative layer and the low-permeability soil barrier layer. It has also been modified from the original Amendment to the Final Closure Plan to delete the option of using a geosynthetic clay liner (GCL) as a low permeability barrier layer. The revised final cover comprises a three foot single layer monolithic cover of silty sand or clayey sand with a saturated hydraulic conductivity no greater than 3 x 10^{-5} cm/s overlying a minimum of two foot existing foundation layer. The modified final cover is presented in Figures 2-2 through 2-2(b).

2.3.3 Disposal Area C Slope Areas

An engineered alternative final cover was developed for the slope areas of the Disposal Area C waste face. The engineered alternative was developed on the basis of the demonstration included in Appendix H of this amendment, the Final Cover Performance Evaluation report, that inclusion of a geomembrane in the slope areas of the Disposal Area C final cover would be burdensome and impractical and would not promote attainment of the performance goals of a final cover. Use of a geomembrane in the final cover on the waste slopes was deemed burdensome and impractical due to constructability, stability, and cost considerations. Furthermore, the maintenance requirements for a slope final cover incorporating a geomembrane were deemed contrary to the performance goal of minimizing final cover maintenance.

The engineered alternative final cover design for the slope areas of the Disposal Area C waste face is shown in Figure 2-3. The final cover for the slope area consists of the following components (from top to bottom):

- vegetative layer at least 24-in. (600-mm) thick;
- 12-in. (300-mm) thick barrier layer of compacted low-permeability soil with a hydraulic conductivity no greater than 1 x 10^{-6} cm/s; and
- 24-in. (600-mm) thick foundation layer.

2.3.4 Disposal Area B Slope Areas

The same final cover used on the Disposal Area C slopes will be used on the slopes of Disposal Area B. This final cover for the B slopes is different than that which was originally submitted in the PCP. The monolithic clay cover was replaced with the final cover as described in the above section. This modification was submitted to the CIWMB on 31 May 1994 and approved on 10 October 1995. A copy of the approval letter is presented in Appendix G. This final cover is shown in Figure 2-3 and described in the preceding section. As the slopes of Disposal Area B are not underlain by a geomembrane liner, the final cover for the benches in these areas do not require a geomembrane. The final cover conforms to the prescriptive design standard.

2.3.5 Disposal Areas A and AB+ Slope Areas

The final cover for the slopes of Disposal Area A has been modified from the monolithic clay cover originally submitted in the PCP, and the 2 ft (0.6m) foundation layer, 1 ft (0.3m) clay layer and two ft (0.6m) vegetative layer final cover as submitted in the June 1996 Amendment to the Final Closure Plan. The modified final cover consists of an engineered monolithic soil cover composed of a minimum 2 ft (0.6m) thick foundation layer overlain by a 3 ft (0.9m) layer of silty sand or clayey sand with a saturated hydraulic conductivity no greater than 3 x 10^{-5} cm/s. The existing interim soil cover on the slopes of Disposal Area A consists of at least 6.5 ft (2m) of silty sand or clayey sand characterized by a hydraulic conductivity of 4.6 x 10^{-5} cm/s. Additionally, the Proposed Engineered Alternative Final Cover report (refer to Appendix J), shows that the existing interim soil cover demonstrates less percolation than the Title 27 prescriptive cover. Therefore, the existing slope areas of Disposal Area A meet final closure specifications. Refer to Figure 2-3(a).

The final cover for the slopes of Disposal Area AB+ has also been modified from the 2 ft (0.6 m) foundation layer, 1 ft (0.3m) clay layer and two ft (0.6 m) foundation layer as submitted in the Amendment to the Final Closure Plan. The modified final cover also consists of an engineered monolithic soil cover as described for the slope areas of Disposal Area A above. However, a 3 ft (0.9m) thick layer of soil with a hydraulic conductivity of no greater than 3 x 10^{-5} cm/s is required to be placed in this area to meet minimal final cover thicknesses, as illustrated in Appendix J, and shown in Figure 2-3(b).

The change in the final elevation of Disposal Area C has produced a split-deck final grading plan, with the deck of Disposal Area C at elevation 1,600 ft msl and the deck of Disposal Area AB+ at elevation 1770 ft msl. This split deck has created a need for construction of a final cover on the waste slopes of Disposal Area AB+ between the decks of Disposal Areas AB+ and C. Additionally, a portion of the haul road and perimeter channel in Disposal Area AB+ will be reconstructed to include a final cover, since refuse underlies this area. This final cover detail is shown in Figure 2-4.

2.3.6 Sources of Dirt for the Monolithic and Prescriptive Final Cover

The amount of dirt required to close the decks of Disposal Areas A, B and AB+, and the slopes of Disposal Areas AB+ with a monolithic cover, and the slopes and deck of Disposal Area C with the prescriptive vegetative layer is approximately 494,000 CY (377,910 m^3). Approximately 250,000 CY (188,955 m^3) of this dirt will be recovered from a native ridge regrade within the landfill. Appendix K presents a report entitled Evaluation of the Phase III West Ridge as a Borrow Source for Monolithic Soil Cover, that demonstrates the ridge to be a feasible borrow source of material for monolithic soil cover.

The remaining quantity is being obtained from construction contractors either free or through purchase orders.

2.4 Infiltration Analyses

Use of an engineered alternative final cover on the waste slopes of Disposal Area C requires a demonstration that the alternative design provides equivalent protection to ground water and resistance to infiltration compared to the prescriptive design. The potential for infiltration of surface water through the alternative final cover on the slopes of the waste face was evaluated using two USEPA-developed water balance models: (i) HELP Model Version 2 [USEPA; 1984 a,b]; and (ii) the SW-168 Model developed by Fenn et al. [1975]. The infiltration calculations are included in Appendix H of this addendum, the Final Cover Performance Evaluation report.

Neither the HELP nor the SW-168 Model predicted infiltration through the cover. One factor influencing the lack of infiltration is the high percentage of run-off from the 2H:1V Disposal Area C slopes. In addition, the annual precipitation is significantly less than the annual pan evaporation rate. As a result, the soil moisture storage capacity was not exceeded in either short term or long term conditions, resulting in no infiltration through the final cover barrier layer. Because there was no infiltration through the barrier layer, the engineered alternative final cover design for the Disposal Area C slopes meets the infiltration performance standard of less infiltration through the final cover than through the bottom liner.

Likewise, use of an engineered alternative final cover on the decks of Disposal Areas A, B and AB+, and the slopes of Disposal Areas A and AB+ demonstrate that the alternative design provides equivalent or better protection to ground water and resistance to infiltration compared to the prescriptive design. The infiltration performance evaluation was conducted using the LEACHM Model under existing site conditions. This infiltration water balance analysis is included in Appendix J of this report.

2.5 Final Cover Slope Stability

Both one-dimensional (infinite slope) and two-dimensional slope stability analyses of the Disposal Area C final cover were performed. Slope stability calculations are included in Appendix H of this report, the Final Cover Performance Evaluation report. The one-dimensional slope stability analyses were performed using the methodology suggested by Matasović [1991]. Two-dimensional slope stability analyses were performed using the computer program PC STABL 5M [Achilleos, 1988].

One-dimensional stability analyses yielded a minimum (static) factor of safety of 2.0 for a failure surface passing through the waste immediately below the existing foundation layer. The corresponding pseudo-static factor of safety for a seismic coefficient of 0.2 was 1.41. GeoSyntec considers this pseudo-static factor of safety acceptable based upon the conclusions of Seed [1979]. Based upon observations of the performance of slopes and embankments in earthquakes around the world, Seed [1979] concluded that slopes designed with a pseudo-static factor of safety of 1.15 for a seismic coefficient of 0.15 experienced "acceptable" deformations (less than 1 ft (0.3 m)) in earthquakes of all magnitudes and intensities. However, to substantiate this conclusion, maximum permanent seismic displacements were estimated using charts developed by Hynes and Franklin [1984] using Newmark analyses. Predicted displacements for the critical final cover failure surface were on the order of 2 in. (50 mm) for the design peak ground acceleration of 0.69 g. Two-dimensional slope stability analyses yielded a minimum (static) factor of safety of 2.86 and a pseudo-static factor of safety of 2.0.

The infiltration analyses indicated the potential for development of down slope seepage parallel to the face of the slope within the vegetative cover layer was negligible, even for the 100-year, 24-hour storm. However, stability analyses were conducted for the limiting case of seepage parallel to the slope. Stability analyses for the condition of seepage parallel to the slope yielded a minimum (static) factor of safety of 2.5 for this condition.

The final cover on the slopes of the Disposal Area AB+ waste face will have the same cross section as the final cover on the Disposal Area C waste face. However, the inclination of the slopes on the Disposal Area AB+ waste face is 2.5H:1V, flatter than the 2H:1V inclination of the slopes on the Disposal Area C waste face. As the final cover on the Disposal Area C waste face was demonstrated to be stable, separate stability calculations for the flatter Disposal Area AB+ final cover were not considered necessary.

The stability calculations are included in Appendix H of this addendum, the Final Cover Performance Evaluation report.

8. REVISED LANDSCAPING AND IRRIGATION

8.1 Introduction

The proposed landscape design for the closed Lopez Canyon Landfill is an interim open space landscape revegetated with California native plant materials suited for Southern California. The primary purpose of the vegetative cover will be the protection of surface soils against erosive elements such as water and wind. Secondary or indirect purposes of the cover include aesthetic enhancement and restoration and replacement of native grass and sage scrub species. The deck and slope areas of the landfill will receive vegetative types which respond to site factors such as solar orientation, degree of erosion potential, and water conservation. Figures 8-1 through 8-5 show slope and deck planting areas; with typical planting legends and details in Figures 8-6 and 8-7.

All deck and south/southwest oriented areas of the landfill will be planted with native grassland species of Southern California with additional non-native, noncompetitive grasses. Pioneer plant species will be included to rejuvenate the soil environment. All north/northeast oriented slopes will be revegetated with native shrubs and grasses typical of the local slope areas adjacent to little water, little maintenance, and will be shallow rooted to avoid penetration of the low-permeability final cover layer.

It is intended that whenever possible, the deck areas will be seeded during the rainy months in order to reduce the amount of supplemental irrigation. It is also anticipated that construction schedule demands may not allow waiting for a rainy season. There may also be little or no rain in any given year. Therefore, at the discretion of the Engineer, temporary overhead spray irrigation systems may be used to assist germination and establishment of seed on the deck areas. These systems may be rented and left in place until the vegetation is well established, a period between six and eighteen months.

As an alternative to permanent irrigation systems, temporary irrigation systems may be used for all or part of the landfill. However, permanent overhead spray irrigation systems will be designed for all slope areas. In some areas, sufficient natural vegetation may already have become established by the time irrigation construction is ready to begin. The Engineer may exercise the option to postpone installation of permanent irrigation on some slope areas, or to use temporary irrigation systems, for areas which have well established vegetation, or which are not over the waste prism and would not affect the final cover system.

A water balance study was performed to determine if irrigation of the final cover would create excess infiltration of water into the trash prism. Based on the results of the study, irrigation of the final cover to establish vegetation will not result in unacceptable percolation through the cover, even under the wettest conditions. A water balance study for the Lopez Canyon Landfill was prepared by Law Environmental dated March 27, 1992, and is included as Appendix J of Volume II of IV of the FCP. In addition, periodic monitoring of watering by a landscape architect representative will be conducted until final cover vegetation is established.

Based on the conditionally approved alternative final cover for the decks of Disposal Areas A, B and AB+, and the slopes of Disposal Areas A and AB+, an important factor governing the performance of the monolithic soil cover is evapotranspiration. Evapotranspiration of infiltration water from the cover soil requires the establishment of vegetation on the cover, and should display rooting depths of at least 12 to 18 in. (200 to 450 mm). Only plant species that can survive on the natural precipitation should be considered for vegetating these areas of the landfill.

These requirements are consistent with the seed mix currently established for the other areas of the landfill. The time of planting should be in the fall to coincide with the natural seasonal rains, as in the other areas of the landfill, with temporary irrigation used in the event that additional water is needed to establish vegetation. Additionally, this alternative cover system allows for a wider variety of native vegetation to establish itself, which has deeper roots than would be acceptable with the prescriptive cover, thus requiring less maintenance and removal. A water balance analysis performed on the alternative final cover determined that there is less infiltration into the landfill than the prescriptive cover, however, if any irrigation is applied, the daily volume will be monitored and recorded.

8.2 Post-Closure End Use

The proposed interim end use for the site is open space and will be planted with foothill grass plant species and inland sage scrub plant species. The vegetation established on the slopes at the completion of closure should be compatible with most ultimate end uses. The cover has been designed to accommodate irrigation so as not to limit any future end use selected for the site.

8.3 Landscape Materials

8.3.1 General Description

All plant species for the site have been selected because of their adaptability to a limiting set of site criteria. The more important criteria includes low water consumption, tolerance of high salt content in the soils, adaptability to clay soils, ease of maintenance, low fire fuel load, shallow root systems and wind tolerance. The layout of containerized plants which is shown on the plans is intended as a general design. The actual number and layout of plants will be determined in the field by the Site Engineer based on actual conditions at the time of planting.

8.3.2 Deck and Slope Area Plant Materials

All deck and south/southwest oriented areas will be vegetated with a select grass seed mix comprised of native annual and perennial bunch grass species. Individual species selected as the vegetative cover are identified in Table 8-1. The grasses will provide a green vegetative color during the wet season and a light green/light brown color during the dry season. Several grass species are warm season perennials providing green foliage during the summer months on limited water. Their warm season perennial characteristic should limit fire fuel load buildup. Establishment of the grass should occur in the first two to three growing seasons.

All north/northeast oriented slopes will be revegetated with perennial shrubs common to the local slopes of the area. The shrubs will provide visual integration of these disposal areas to the adjacent open space areas. The ultimate height of the vegetative cover will be approximately four feet with most species reaching two feet in height. Establishment of the shrubs should occur in the fourth or fifth growing season. Individual species selected as the vegetative cover are identified in Table 8-1.

The lower slope area of Disposal Area A can be seeded and/or planted with deeper rooting shrubs. The shrubs will not threaten cover integrity since the final cover design in this area provides for a vegetative layer 10 to 40 feet thick. During cover construction, soil depths should be noted to ensure proper placement of deeper rooted plants.

Shrub and tree species common to the chaparral belt plant community can be installed on the Disposal Area A slopes where deeper vegetative soil layers will be placed. These shrubs and trees are not available in seed source and should be installed from field containers following the first stage of plant establishment. These shrub species are identified in Table 8-1.

8.3.3 Soil Amendment

Prior to seeding, a soil activator/conditioner will be applied to the decks and slopes. The soil activator will provide an available nutrient base for quick establishment and will provide a long-term fertile soil environment for full plant development. The soil activator is formulated to provide an appropriate soil environment for the native plant species proposed as a vegetative cover.

8.4 Landscape Installation

8.4.1 Weed Eradication

Upon completion of closure construction, and prior to seeding operations, an aggressive weed eradication program should be implemented to eliminate invasive weeds such as mustard and thistles. These undesirable plants are natural to disturbed sites of the region and their control will be necessary to ensure proper establishment of the desired plant species, to reduce fire potential, and to eliminate possible penetration of the final cover by undesirable deep rooting species. The weed eradication program for each area may be modified by the Engineer, depending upon the condition of the area and project schedule.

The initial removal of weeds may be accomplished by mechanical means and/or by herbicides, as determined during a site inspection by a State licensed Agricultural Advisor and the Engineer. During testing of the irrigation system and following the first-stage of weed removal, dormant weed seeds will germinate. Two to three weeks following the appearance of these weeds, a second eradication effort is required to kill the second generation weeds. This is usually accomplished by herbicide application. Following eradication of the second generation of weeds, the slopes are ready for planting.

After seeding and germination, each area should receive continued weed monitoring during the plant establishment period, with supplemental weed eradication activities as necessary.

8.4.2 Slope Preparation

The slopes will be constructed to limit water infiltration and allow for proper establishment of the vegetative cover. The minimum cover thickness required for vegetation will be 24 inches and may be highly compacted. Slope scarification and texturing will eliminate high run-off velocities of water and will create pockets for seed dispersal and germination. The selected method for texturing will produce surface pockets to a minimum depth of two inches normal to the slope at not greater than eight inches apart. Prior to slope texturing, the surface will be dampened to a minimum depth of two inches.

8.4.3 Hydroseeding Procedures

Seeding procedures for the deck area will be performed by mechanical drill seeding. This technique provides better contact between the seeds and the soil which will increase the germination percentages. Prior to drill seeding, and the addition of soil activators, all compacted soils should be watered to reduce soil compaction in the upper three inches of soil. This step increases the drill seeding equipment's efficiency at dropping seeds into the soil and will incorporate the soil activator with existing cover soils. Drill seeding can occur following the installation of the temporary irrigation system and weed eradication.

Installation of the slope vegetative cover will be performed by two-stage hydroseeding in the fall months after weed eradication. The two-stage hydroseed installation creates a better growth environment resulting in increased landscape coverage. The first stage of the process is an application of the seed mix and soil activator in the form of a light slurry on the textured slope. The second stage is an application of a tackifier and mulch over the seed. This process provides soil contact between the seed and soil and provides a heavy mulch cover over the seed which will reduce exposure to the sun. The tackifier prevents loss of the mulch from rain or irrigation and wind.

8.5 Irrigation System

The final cover irrigation system will consist of a pressured water supply line, the existing one million gallon (1 MG) water tank, a booster pump at the reservoir, mainline distribution networks on the irrigated areas, permanent or temporary sprinkler systems on the slopes, and irrigation controllers sufficient to operate each area of the landfill.

The existing landfill water supply system is designed to lift water from the Los Angeles Department of Water & Power main pipeline on Lopez Canyon Road to the 1 MG water tank. This system consists of two 400 gallon per minute (gpm) pumps and an above ground ten inch diameter cast iron pipeline to the 1 MG water tank at the top of the landfill. Irrigation scheduling will account for the rate of filling and depletion of the tank reservoir. This limitation will restrict the size of area which can be irrigated at full germination rates during any period. Water Management will be the responsibility of the Site Engineer.

A 485 gpm duplex booster pump station is located at the reservoir in order to pressurize the upper deck and upper slope distribution systems which do not receive sufficient head pressure from the tank. These pumps could be operated up to 24 hours per day to meet demand during critical seed germination periods, depending on the limitations of the water supply system.

Air and vacuum release valves will be located at all high points in the system. Blow-off valves will be placed at low points, with a lateral connection to the storm drain for all discharges. Pressure regulating valves will be located at main supply lines that feed slopes to reduce the water pressure to acceptable levels. Pressure relief valves will also be installed in the supply line to eliminate pressure surges. Isolation valves will be installed at a spacing of approximately 1,000 feet to provide for flexibility during operation and maintenance of the system

8.5.1 Deck Area Irrigation

The deck area irrigation system for the Lopez Canyon landfill is proposed to be a temporary manually operated system.

The major components of the system will be rented and consist of a mainline, lateral pipes, risers, manual valves, and sprinkler heads. The point of connection to the water supply for the deck systems will be a flange fitting, located at the edge of the deck area. The booster pumps may be used to provide adequate pressure for the deck systems. Sprinkler laterals will be placed directly on the ground and spring check valves will be utilized at all risers to minimize gravity drainage from the laterals. This will eliminate the wasting of water and reduce the potential for erosion. The supply system will be designed to provide a minimum of 40 psi pressure to the sprinkler heads.

8.5.2 Slope Area Irrigation System

The proposed method of irrigation for slope areas is permanent, automatically operated systems. Layout and installation details are shown in Figures 8-8 through 8-17. Typical layout will include a supply line and a lateral line placed along the outside of each bench at the top of the slopes. These pipes would be buried in the vegetative layer for protection from physical and ultraviolet (U.V.) damage. Other lateral lines may run under benches or down slopes as necessary for adequate coverage on large slope areas. Laterals on slope faces should be avoided if possible. Most mainline and lateral lines will be PVC with U.V. inhibitors. The main system distribution lines will be steel. Sleeves will be installed at bench crossing to protect the PVC pipe.

Sprinkler heads will have a gear driven rotary design with part circle coverage at the top of the slopes, and full circle heads at mid-slope where necessary. The supply system will be designed to provide a minimum of 40 psi pressure to the sprinklers. The sprinkler nozzle sizes will vary depending on the water pressure and desired coverage at each head. Check valves will be used to minimize drainage and reduce the potential for erosion and rutting.

An alternative, less expensive method for irrigating slopes will be to use temporary rental type systems. The Engineer will make the final determination of which type of system will be used, depending upon conditions and schedule requirements when the slopes are ready for irrigation and seeding. Temporary systems for slopes will include a mainline, lateral pipes, risers, manual valves, and sprinkler heads which will be placed on the surface of the cover at the outer edge of the bench above the slope. The source of irrigation water for temporary systems on slopes would be points of connection at the permanent mainlines at the end of each bench.

8.6 Description of Figures

Figures 8-1, 8-2, and 8-3 illustrate Decks A, B, C, and AB+; Slopes areas AB+ and C; and the Haul Road landscape areas. Figures 8-4 and 8-5 illustrate A and B Slopes landscaping.

Figures 8-8, 8-9, and 8-10 illustrate Decks A, B, C, and AB+; Slopes areas AB+ and C; and the Haul Road irrigation areas. Figures 8-11, 8-12, and 8-13 illustrate A and B Slopes irrigation areas.

9. REVISED CLOSURE COST ESTIMATE

9.1 General

This section presents the July 1998 revised cost estimate for closure of the Lopez Canyon Sanitary Landfill. This estimate supersedes the February 1995 estimate, the estimate presented in Section 11 of the PCP and the estimate presented in Section 8 of the amendment to the PCP (FCP) submitted in February 1994. The modifications to the closure cost estimate are related to the modifications in the final cover design and final grading, landfill gas control system, irrigation system, and surface-water drainage system. In addition, the City of Los Angeles maintains a fully funded trust fund for the entire value of the closure cost estimate.

9.2 Cost Categories

9.2.1 Final Cover

The Lopez Canyon Sanitary Landfill Disposal Areas A, B, AB+, and C are comprised of about 84 acres (34 hectares) of deck surface area and about 77 acres (31 hectares) of slope surface area. A minimum 24-in. (600-mm) thick layer of interim cover will exist over the entire landfill area once filling is complete. This cover is placed during the normal landfill operations at the site. The planned final cover for the decks of Disposal Areas A, B, and AB+ and the slopes of Disposal Areas A and AB+, consists of a 36-in (900-mm) monolithic cover. The final cover for the slopes of Disposal area B and C consists of a compacted low-permeability soil barrier layer approximately 12-in. (300-mm) thick, and a 24-in. (600-mm) thick protective soil vegetation layer.

The final cover design for the deck and bench areas of Disposal Area C consists of an 12-in. (150-mm) thick compacted low-permeability soil barrier layer, a 40-mil (1-mm) thick VFPE geomembrane, a 12 oz/yd^2 (410 g/m^2) nonwoven geotextile cushion, and a 24-in. (600-mm) thick protective soil vegetative layer. The final cover for the slope areas of Disposal Area C differs from the deck and bench areas of Disposal Area C in that no geotextile cushion or geomembrane is used. The deck/bench surface area of Disposal Area C is about 24.1 acres (9.8 hectares) while the slope surface area is about 10.9 acres (4.4 hectares). The deck surface area of Disposal Area AB+ is about 31.6 acres (12.8 hectares). The Disposal Area AB+ deck includes about 4.8 acres (2.0 hectares) and about 2,000 linear feet of the existing paved haul road and concrete trapezoidal perimeter channel to the north of the proposed access road. The slope surface area of Disposal Area AB+ is about 17.5 acres (7.1 hectares).

The revised cost estimate for final cover construction reflects the supply and installation of the geotextile cushion and VFPE geomembrane on the deck and bench areas of Disposal Area C, the revised quantity of earthen material used in the final cover for Disposal Areas AB+ and C, the changes in surface areas resulting from the final grading design modifications, and the need to reconstruct the existing haul road and perimeter channel. Additionally, it reflects the revised cost estimate for the modification to an alternative final cover for the decks of Disposal Areas A, B and AB+, and the slopes of Disposal Areas A and AB+.

Installation of the geotextile cushion and VFPE geomembrane is estimated to cost about $785,740 based on a unit cost of $0.75 per square foot ($8.07 per square meter) which includes construction quality assurance. The revised final grading design for Disposal Areas AB+ and C resulted in a decrease in earthwork quantities (i.e., low-permeability clay and vegetative cover). This resulted in a decrease of $1,722,585 in earthwork costs. The cost of demolishing and reconstructing those portions of the existing haul road and perimeter channel that overly waste has been estimated at $305,640. This resulted in a decrease of $1,466,586 in total closure costs. As a result of the above changes, the total cost of final cover construction has decreased from $10,687,998 to $9,221,412 in 1995 dollars. Note that this includes an increase of $359 for construction management costs and a reduction of $50,000 for closure plan costs that were considered when figuring the total cost reduction of closure construction.

Additionally, with the modification to the monolithic final cover for the deck of Disposal Areas A, B and AB+, and the slopes of Disposal Areas A and AB+, this resulted in a decrease in material and construction cost (i.e. low permeability vs. monolithic cover). The original cost for closure of the above mentioned decks and slopes using the low-permeability clay layer was $10,275,503. The revised cost for closure using a combination of prescriptive and monolithic cover is $8,208,842, resulting in an overall decrease of $2,066,661 for the final cover.

9.2.2 Revegetation and Irrigation

Revegetation and irrigation costs cover the cost of soil preparation and planting of the vegetative cover, and temporary and permanent irrigation systems on the deck and slope areas, respectively. The revised revegetation and irrigation plan and figures are presented in Section 8 of this document. The revised cost estimate for revegetation reflects the decrease of about 5 acres (4 hectares) in the total surface area of the landfill to be revegetated. At a unit cost of about $3,225 per acre ($8,000 per hectare) for soil preparation, planting, fertilizing, and mulching, the revised surface area results in a revegetation cost savings of $16,125. The elimination of the temporary irrigation system on the deck areas resulted in an additional cost savings of $232,000. The permanent slope irrigation system has a unit cost of about $19,000 per acre ($47,000 per hectare). The revised final grading plan resulted in a decrease of slope surface area of about 16.5 acres (hectares). The revised surface area results in a decrease in irrigation costs of about $313,500. The total cost for revegetation and irrigation decreased from $2,382,350 to $1,821,823 in 1995 dollars.

9.2.3 Landfill Gas Control System

The cost estimate for the landfill gas control system is essentially unchanged from that presented in the FCP since the proposed vertical and horizontal landfill gas wells in Disposal Area C will already be in place when closure is implemented.

9.2.4 Surface-Water Drainage System

Costs for the surface-water drainage system include construction of the on-site drainage facilities. The revised cost for the surface-water drainage system reflects the decrease of about 5 acres (2 hectares) in the total landfill surface area and the corresponding changes to the surface-water drainage system presented in the FCP and which are described in Section 5 of this amendment. These changes result in: (i) a reduction of about 780 ft (240 m) in the total length of downchutes; (ii) a reduction of 6 inlet structures and bench crossings; (iii) the addition of about 1,000 ft (305 m) of diversion channel; and (iv) the addition of two splash walls.

In addition, several surface-water drainage elements included in the closure cost estimate presented in the FCP have either been: (i) built since the FCP was issued; or (ii) eliminated as a result of design modifications. These elements include: (i) three detention basins ($980,000); (ii) one debris basin ($180,000); (iii) 6,100 ft (1,860 m) of concrete trapezoidal channel ($176,530); (iv) 2,070 ft (630 m) of reinforced concrete pipe; (v) 6,000 square feet (560 square meters) of grouted riprap ($48,000); and (vi) 143,250 square feet (13,310 square meters) of 4-in. (100-mm) thick asphaltic concrete paving for access roads ($14,800). As a result of all the above changes, the total cost for the surface-water drainage system has decreased from $2,394,989 to $829,870 in 1995 dollars.

9.2.5 Security Installation

This category includes installation of the signs and perimeter fence and the cost is unchanged from that presented in the FCP.

9.2.6 Contingency

A 20 percent contingency factor has been added to the closure construction cost estimate presented in Section 9.3. This percentage is unchanged from the FCP.

9.3 Cost Estimate

Table 9-1 presents a summary of costs for the closure features previously described by category. The revised total cost for closure implementation has decreased from $21,849,558 to $15,058,997 in 1995 dollars. Any cost overruns that result from this cost estimate will be paid by the City. Appendix K of the FCP Volume II of IV has been revised to include the updated closure cost estimate. Appendix K is provided as Appendix F of this document.

10. UPDATED CLOSURE PLAN IMPLEMENTATION SCHEDULE

10.1 General

The updated closure implementation schedule presented in Figure 10-1 reflects the most current closure schedule as of October 1998.

10.2 Closure Process

Closure activities initially started on the slope of Disposal Area A in the Spring of 1994. However, some staff were released to the Bureau of Street Maintenance later that year due to budgetary reasons. The remaining staff were unable to continue with this slope closure. The closure of Lopez will commence again after July 1, 1996, when the last shipment of refuse is received.

The length of time for closure construction depends on the amount of staff available. Staff currently performing actual trash disposal activities will be reassigned to closure construction. Attrition rates will then be a factor, as that will determine remaining available staff for construction.

The closure construction process will be implemented in two phases: (i) Phase I will include the slopes of Disposal Areas A and B; and (ii) Phase II will include the remainder of the landfill. The schedules will delineate the estimated time frame to complete tasks relative to the closure activities associated with the slopes of Disposal

Areas A and B (Phase I) and the decks of Disposal Areas A, B and Disposal Areas AB+ and C (Phase II).

10.2.1 Phase I Closure

As shown on Figure 10-1, closure construction activities for Phase I will recommence July 1, 1996 and will continue until May 1999.

Phase I closure shall start with abandonment of vertical gas wells followed by the rough grading of the slopes, which includes some clearing and grubbing. During preparation of the slopes for final cover placement, the final cover materials will be stockpiled on the decks of Disposal Areas A and B. Borrow material will continue to be transported and stockpiled on site during construction of the final cover, as necessary.

Placement of the final cover materials will begin after rough grading of the slopes has been initiated. As placement of the final cover progresses, landfill gas control system modifications and surface-water drainage controls will be constructed.

The integration of the landfill gas control system with placement of the final cover will include lateral extensions of the horizontal landfill gas wells through the final cover and connection to the main landfill gas collection header. Existing vertical landfill gas wells will also be extended up through the final cover or abandoned and redrilled as necessary at the time of closure.

Landfill gas control system modifications will begin approximately one month before placement of final cover begins, and will be conducted one lift at a time to reduce as much as possible any down-time of the system. Landscaping and irrigation will begin after final cover placement has been initiated. The estimated time for completion of the Phase I closure construction has been revised from 29 months to 35 months.

All waste materials generated from closure construction, including, but not limited to, drill cuttings, waste from clearing and grubbing, corrugated metal pipe, concrete, masonry, excavated trash, spoils, asphalt, non-salvageable gas system pipe, and all other construction debris will be disposed of on-site in Disposal Area C. In addition, all non-recyclable refuse generated at the landfill during closure construction by, but not limited to, BOS personnel, consultants, and contractors, will also be disposed of on-site in Disposal Area C.

10.2.2 Phase II Closure

As shown on Figure 10-1, closure construction activities for Phase II has been revised to commence in May 1999 and will continue until April 2001. It is anticipated that the final cover borrow source for Phases I and II may be different. As a result, an additional test pad may be required for the new borrow source. Equipment mobilized for Phase I will also be used for Phase II.

Rough grading of the site can begin after the final lift of refuse has been placed. Final cover placement will begin with the slopes (upper and lower) of Disposal Area C. During preparation of the site for final cover placement, the final cover materials will be stockpiled on the deck in such a manner so as not to interfere with final cover placement, or it will be stockpiled in a nearby location. Borrow material will continue to be transported and stockpiled on site during construction of the final cover, as necessary.

Placement of the final cover materials will begin after rough grading of the site. Abandonment of landfill gas wells for the slopes, if necessary, will take place in conjunction with final cover placement. As placement of the final cover progresses, landfill gas control system modifications and surface-water drainage controls can be constructed. The construction of the surface-water drainage controls and landfill gas control system modifications will be completed just after completion of the final cover construction.

The integration of the landfill gas control system with placement of the final cover will include lateral extensions of the horizontal landfill gas wells through the final cover to the main landfill gas collection header. Existing vertical landfill gas wells at the time of closure will also be extended up through the final cover or abandoned and redrilled, if necessary. Landscaping and irrigation will begin prior to completion of the placement of final cover.

Waste materials generated during Phase II closure activities including, but not limited to, drill cuttings, waste from clearing and grubbing, corrugated metal pipe, concrete, masonry, excavated trash, spoils, asphalt, non-salvageable gas system pipe, and all other construction debris will be disposed of on-site in Disposal Area C. In addition, all non-recyclable refuse generated at the landfill during closure construction by, but not limited to, BOS personnel, consultants, and contractors, will also be disposed of on-site in Disposal Area C. Waste (construction debris and non-recyclable on-site refuse) generated after completion of closure construction will be disposed of off-site.

Upon completion of the tasks described for closure, existing site structures will be utilized for post-closure maintenance activities and potential post-closure end uses. The estimated time for completion of all Phase II closure construction has been revised from 28 months to 48 months.

11. REVISED CONSTRUCTION QUALITY ASSURANCE PLAN

The construction quality assurance (CQA) plan presented in the PCP has been revised to reflect the changes in the final cover design presented in Section 2 of this amendment. The revised CQA Plan is presented in Appendix I and contains descriptions of:

- site and project control meetings;
- documentation requirements;
- VFPE geomembrane CQA;
- geotextile cushion CQA;
- soils CQA, including construction of the low-permeability soil barrier layer;
- geosynthetic clay liner CQA; and
- monolithic soil cover CQA.

TABLE 2-3
SOILS FIELD AND LABORATORY TESTING SUMMARY
MONOLITHIC SOIL FINAL COVER
LOPEZ CANYON SANITARY LANDFILL

TEST METHOD	MINIMUM TEST FREQUENCY	ACCEPTANCE CRITERIA
In-Place Moisture/Density Nuclear Method (ASTM D 2911)	1 per 1,000 yd^3	Dry density no less than 90% of the maximum dry density. Moisture content within ±2 percent of optimum moisture content
Standard Proctor Compaction Test (ASTM D 698)	1 per 10,000 yd^3 (7,650 m^3)	N/A
In-Place Density and Moisture Content (Sand-Cone) (ASTM D 1556)	1 per 10,000 yd^3 (7,650 m^3)	Dry density no less than 90% of the maximum dry density. Moisture content within ±2 percent of optimum moisture content
Particle Size Analysis (ASTM D 422)	1 per 5,000 yd^3 (3,825 m^3)	No particle greater than 4 inches at least 25 percent passing No. 200 sieve
Atterberg Limits (ASTM D 4318)	1 per 5,000 yd^3 (3,825 m^3)	Plasticity Index less than 15
Laboratory Permeability (ASTM D 5084)	1 per 10,000 yd^3 (7,650 m^3)	Hydraulic Conductivity no greater than $1x10^{-5}$ cm/sec

Note: Since Atterberg Limit and grain-size distribution testing will be performed on representative materials during processing of stockpile materials, additional tests will be conducted only on materials obtained for laboratory permeability analysis.

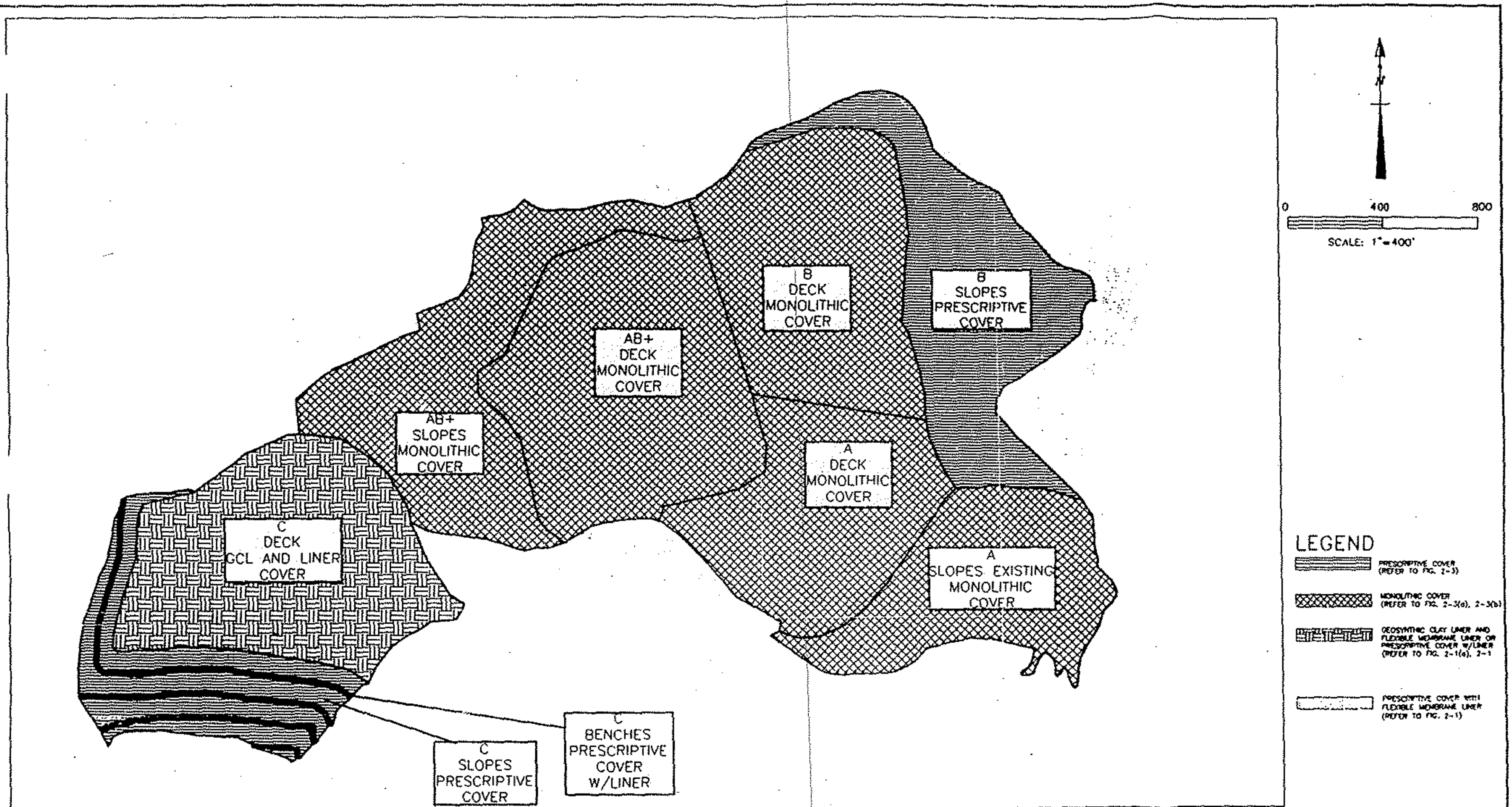
TABLE 9-1

REVISED SUMMARY OF CLOSURE COST ESTIMATE
PARTIAL CLOSURE PLAN AMENDMENT
LOPEZ CANYON SANITARY LANDFILL

CLOSURE FEATURE		ESTIMATED COST (1995 Dollars)
Final Cover Construction*		$ 4,076,882
Revegetation/Irrigation*		$1,821,823
Surface-Water Drainage System Installation*		$829,870
Site Security Installation		$33,000
Other[1] (includes clay - C Deck, geotextile - C Deck & Benches, clay - all slopes, rebuilding portions of the haul road and drainage channel, landfill gas system modifications, ground-water monitoring modifications, vadose zone monitoring modifications, and construction management)		$5,787,589
I.	Subtotal	12,549,164
II.	Contingency Costs (20 percent)	$2,509,833
III.	Total Closure Costs	$15,058,997

[1] Total final cover cost is the sum of "Final Cover Construction" costs and a portion of "Other" costs.

Note: * Cost estimate features changed from the PCP. Revised 10/98

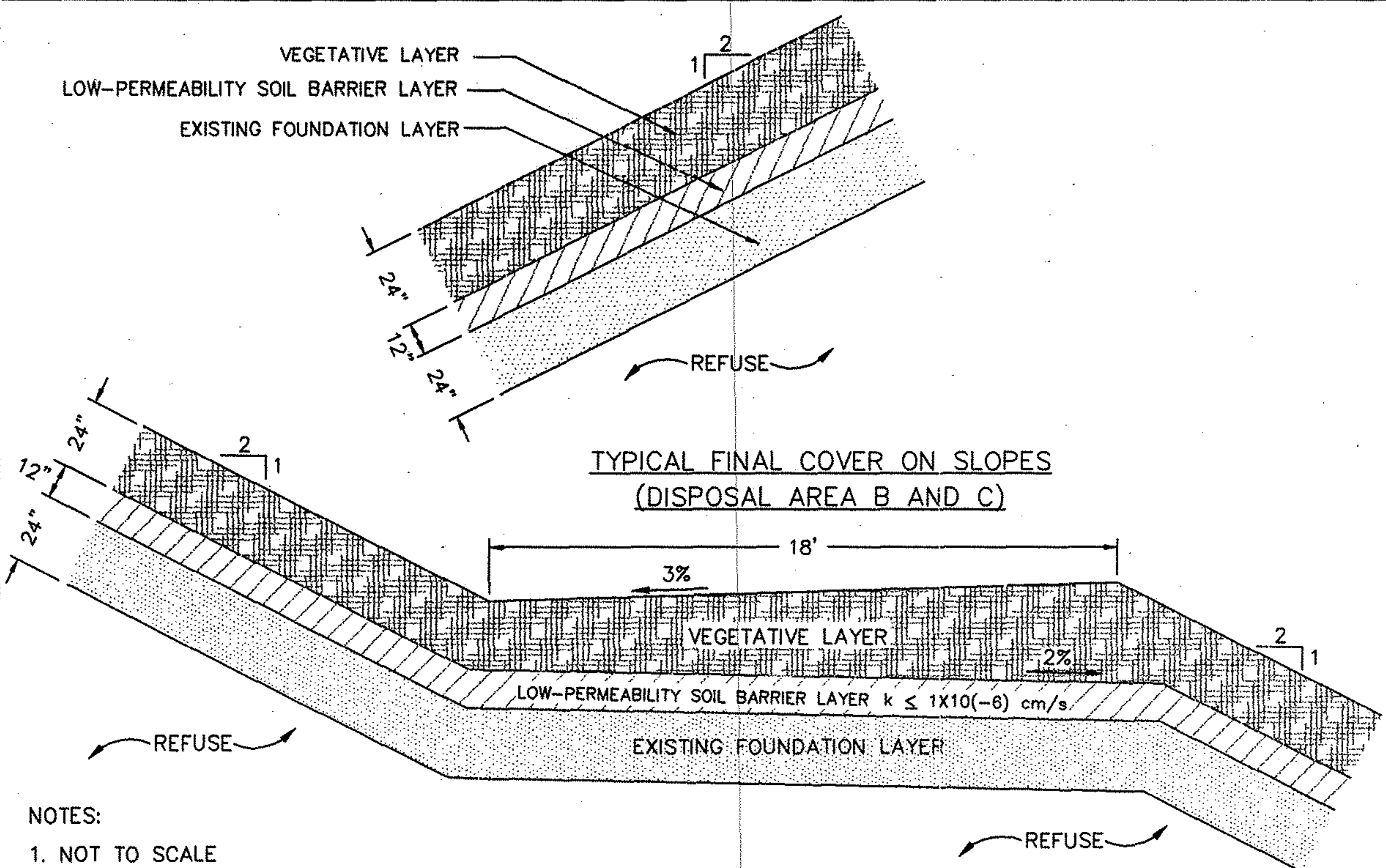


LOPEZ CANYON
RESTORATION PROJECT
COVER PLACEMENT

FIGURE 2-0

OCT 14, 1998

SCALE: 1"=400'



NOTES:

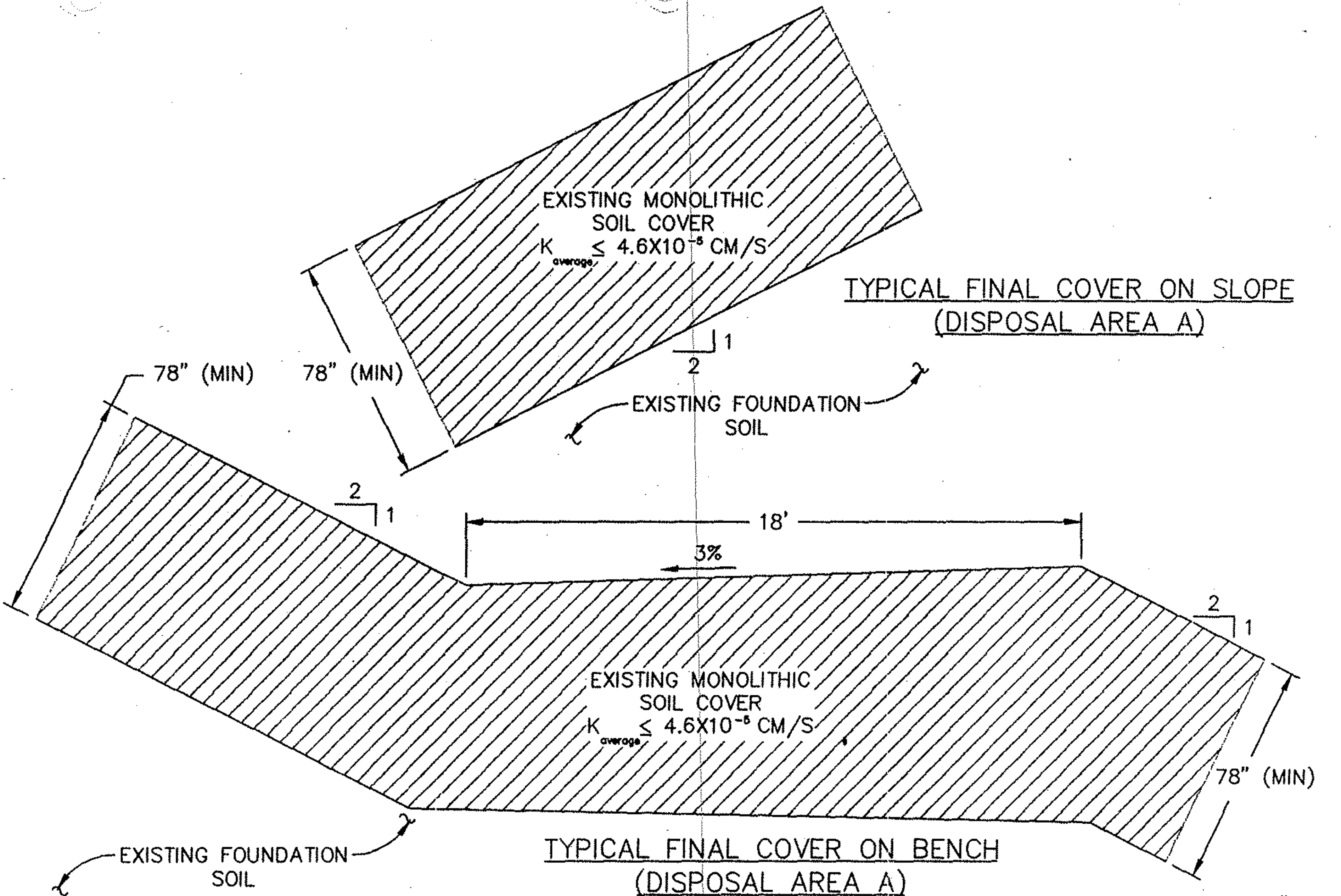
1. NOT TO SCALE

TYPICAL FINAL COVER ON BENCH
(DISPOSAL AREA B)

GEOSYNTEC CONSULTANTS

FINAL COVER ON SLOPE/BENCH AREAS DISPOSAL AREA B AND C LOPEZ CANYON SANITARY LANDFILL	FIGURE NO.	2-3
	PROJECT NO.	CE4100-06
	DATE:	SEP-17-98

DWG: 41F401-1.DWG



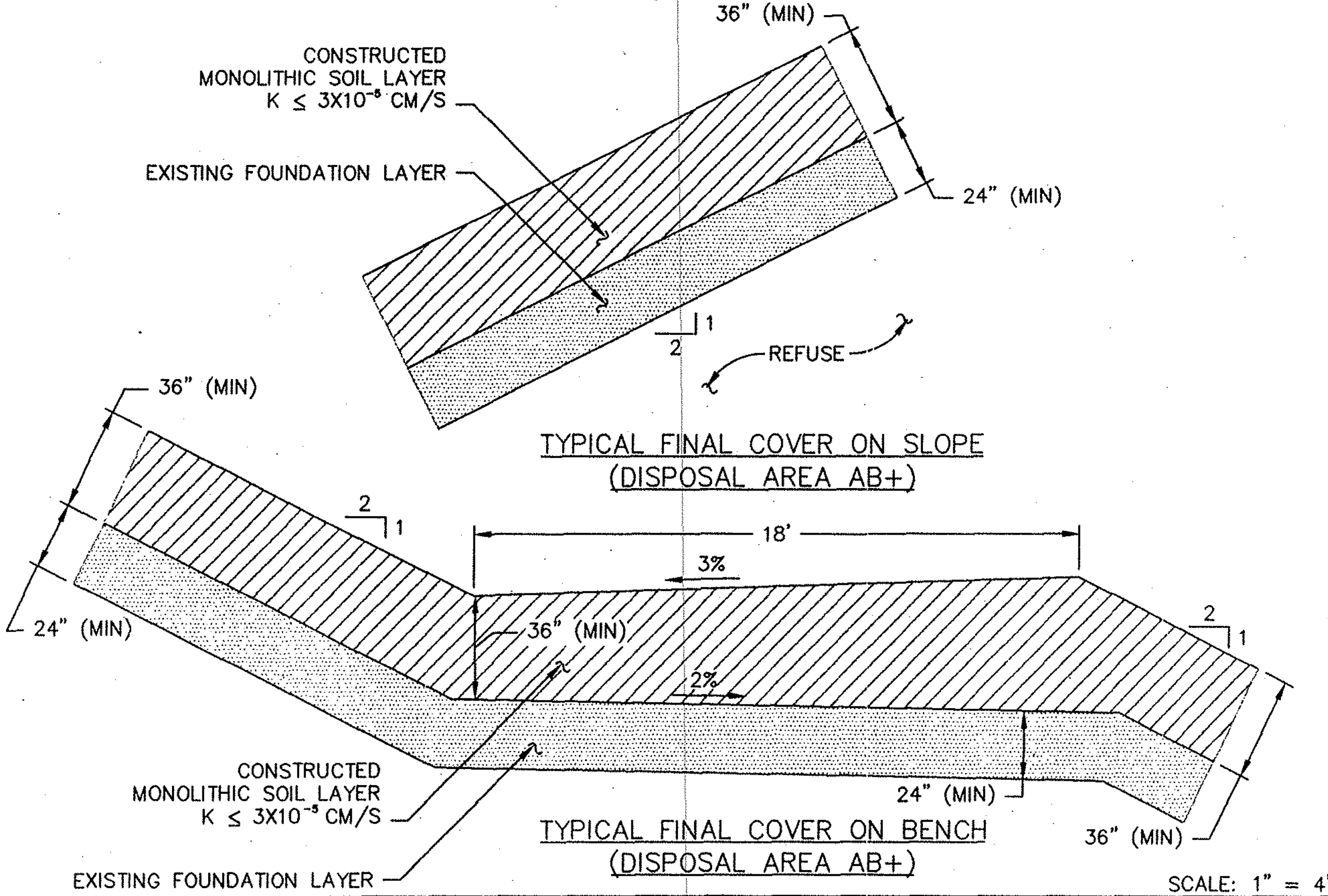
SCALE: 1" = 4'

GEOSYNTEC CONSULTANTS

MONOLITHIC SOIL FINAL COVER
SLOPE/BENCH OF DISPOSAL AREAS
LOPEZ CANYON SANITARY LANDFILL

FIGURE NO.	2-3(a)
PROJECT NO.	CE4100-04
DATE:	30 JUNE 1998

4100F035.DWG

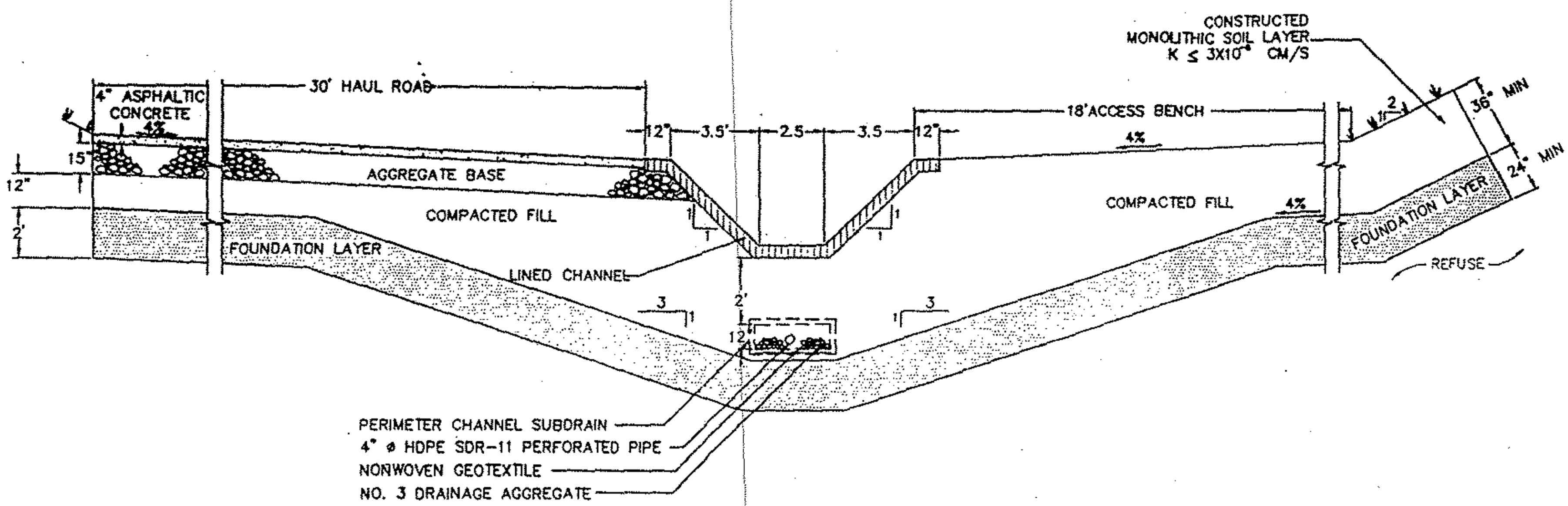


SCALE: 1" = 4'

GEOSYNTEC CONSULTANTS

MONOLITHIC SOIL FINAL COVER SLOPE/BENCH OF DISPOSAL AREA AB+ LOPEZ CANYON SANITARY LANDFILL	FIGURE NO. 2-3(b) PROJECT NO. CE4100-04 DATE: 30 JUNE 1998

4100F033.DWG



BASE DRAWING SUPPLIED BY GEOSYNTEC CONSULTANTS

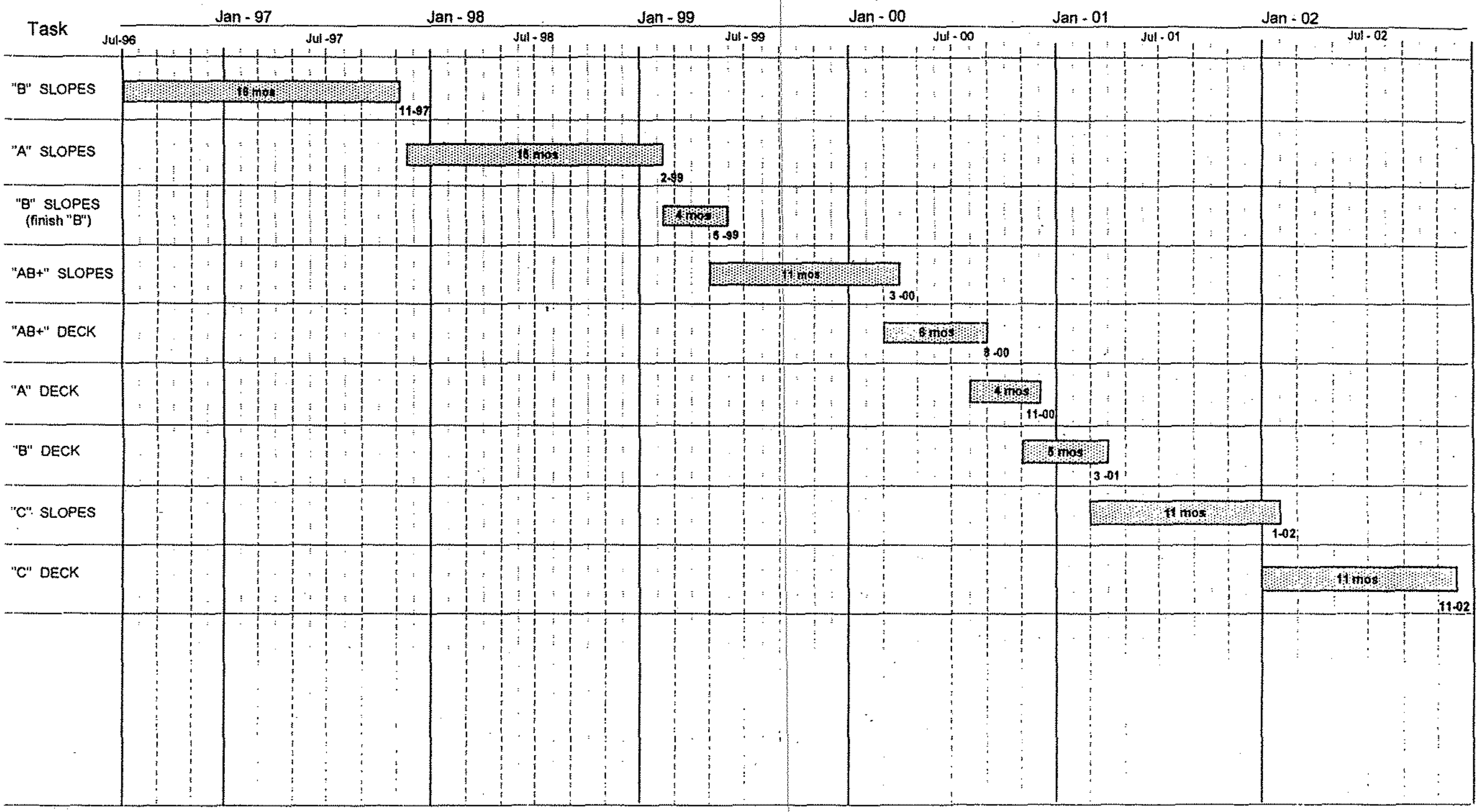
GEOSYNTEC CONSULTANTS

FINAL COVER TERMINATION SYSTEM AT HAUL ROAD IN DISPOSAL AREA AB+ LOPEZ CANYON SANITARY LANDFILL

FIGURE NO.	2-4
PROJECT NO.	
DATE:	SEPT-17-98

DWG: 41F603-1

LOPEZ CLOSURE SCHEDULE



NOTE: DATES BASED FROM DECOMMISIONING
TO RECOMMISSIONING GAS SYSTEM
IN EACH AREA

C drw - LPclos2
09-23-1998

FIGURE 10-1

APPENDIX F

UPDATED CLOSURE AND POST-CLOSURE ESTIMATES – REVISED INITIAL COST ESTIMATE WORKSHEET

INITIAL COST ESTIMATE WORKSHEET
(rev. 10/89)

SITE DESCRIPTION

The following questions will provide general information regarding the site description, the type of waste accepted at the site and basic geological information. This information will aid in assessing factors that may affect the initial cost estimates.

Prepared By: GeoSyntec Consultants Revised By: City of Los Angeles Bureau of Sanitation

General Site Information:

Name of Solid Waste Landfill Lopez Canyon Sanitary Landfill

Solid Waste Facilities Permit Number 19-AA-0820

Facility Operator CITY OF LOS ANGELES BUREAU OF SANITATION

Site Owner CITY OF LOS ANGELES BUREAU OF SANITATION

Site Location (California coordinates, township & range or longitude/latitude, preferred)

Section 6

Assessors Parcel Number ____________

Site Address 11950 Lopez Canyon Road, Lakeview Terrace, CA 91342

1. What is the existing State Water Resources Control Board classification of the solid waste landfill? (mark the appropriate response)

NEW If Waste Discharge Requirements (WDR) revised since 11-84		OLD	
____	Class I	____	Class I
		X	Class II-1

Note: The solid waste landfill is excluded from these requirements, if the facility is a hazardous waste facility or co-disposal facility of both hazardous and nonhazardous waste as a RCRA Subtitle C facility subject to specific closure plan requirements.

____	Class II	____	Class II-2
X	Class III	____	Class III

2. What is the anticipated closing date for the existing permitted landfill? Proposed expansions which have not been approved by the Board and LEA are not to be included in these calculations. Include calculations supporting the estimate date. (Attach additional sheets as necessary.)

month February , year 1996

Note: All facilities with an anticipated closure date of September 28, 1992, or earlier, will be required to submit their closure and postclosure maintenance plan no later than July 1, 1990.

Type of Fill

3. Type of fill (check appropriate type)

______	Trench	X	Canyon
X	Area	______	Other (describe)
______	Pit		

Volume of Waste

4. What is the estimated in-place volume of landfilled wastes at the site in cubic yards? 13,320,000

5. What is the design capacity of the site in cubic yards? 26,562,000

6.Minimum thickness of waste (ft)? 25'

7. Average thickness of waste (ft)? 120'

8.Maximum thickness of waste (ft)? 245'

9.Average height above surrounding terrain (ft)? N/A

10. Typical inclination of side slopes, in slope ratio (horizontal:vertical)? (e.g., 5:1, 2:1) 2:1

Note: ______________________________

11. Quantity of waste typically received (tons/day)? 4,000

12. Total permitted site acreage? 399

13. Waste disposal area acreage? 161

Waste Description:

14. Estimate of solid waste received (total of entries for residential, commercial, industrial, demolition and other should add up to 100%).

% Residential 85 | % Commercial____

% Industrial_____ | % Demolition____

% Other (special waste streams, such as ash, auto shredder waste, infectious waste, sludge, asbestos)

Describe material under "other" and give its percentage.

Material	Percentage
Street Sweeping	15

Resid. + Indus. + Comm. + Demo. + Other = 100%

Site Geology and Groundwater Data

15. Briefly describe the underlying geology of the site. (Mark as many boxes that apply).

X	Shallow alluvium <50'	________	Deep alluvium >50'
X	Sedimentary	________	Igneous
________	Metamorphic		

a. What is the name of the nearest major fault? San Fernando Zone

b. Distance from site (miles)? Onsite

c. On-site fault(s), if known? Yes

16. What are the groundwater characteristics?

a. What is the depth to groundwater (ft)? A seasonal water table was obtained from MW 88-5 drilled to a depth of 42 ft or 1429.7 ft MSL

This will be the range of water levels, from well data, in a groundwater well network. Note: Consider seasonal variations from rainy to dry periods, wet and dry years, well locations and variations in the subsurface geology.

Highest recorded level (depth in ft) | ELEV. 42 ft, 1429.7 ft MSL

Well Number MW 88-5 | Date Recorded 3/9/88

Lowest recorded level (depth in ft) | ELEV. N/A

Well Number__N/A____ Date Recorded__N/A___

Typical____N/A_____

b. What direction does the groundwater flow?

The apparent ground water flow direction is north to south.

c. What is the groundwater gradient?

Data is insufficient to determine ground water gradient.

CLOSURE COSTS

Final Cover

17. Area of Landfill for Final Cover

a. Area of top deck to be capped (ft^2) A_d= 3,673,850

b. Area of side slopes to be capped (ft^2) A_s= 2,985,603
(map area)

Side Slopes Horizontal:Vertical	Conversion Factor (C)
5 : 1	1.02
4 : 1	1.03
3 : 1	1.05
2½: 1	1.08
2 : 1	1.12
1¾: 1	1.15

18. Final Cover Soil - Foundation Layer (Already in place)

a. Thickness

1) Top deck (minimum 3 feet of soil)

$T_d = (\geq 3')$ 0

2) Side slope (minimum 3 feet normal to slope)
$T_s = (\geq 3')$ 0

b. Volume = $[(T_d \times A_d) + (T_s \times A_s \times \text{Conv. factor})]/27$ (yd^3) ____

c. % Native soil ____

d. Native material acquisition cost (excavation, hauling,etc.) ($\$/yd^3$) ____

e. Native soil cost ($) ____
(Line 18b x Line 18c x Line 18d)

f. % Imported soil ______

g. Imported material acquisition cost (purchase, delivery, etc.) ($/yd^3) ______

h. Imported soil cost ($) (Line 18b x Line 18f x Line 18g) ______

i. Placement, grading and compaction (to achieve relative compaction of .90) unit cost ($/yd^3) ______

j. Placement, grading and compaction cost ($) (Line 18b x Line 18i) ______

k. Subtotal final cover soil ($) (Line 18e + Line 18h + Line 18j) $0

Clay Layer

a.	Area to be capped (ft^2) of A, B and AB+Decks	0
	Thickness (ft) (minimum 1 foot)	1.00
c.	Volume (yd^3) (Line 19a x Line 19b)/27	0
d.	% On-site Clay	0
e.	On-site material acquisition cost (excavation, hauling, etc.) ($/yd^3)	$0
f.	On-site clay cost ($) (Line 19c x Line 19d x Line 19e)	$0
g.	% Imported Clay	100
h.	Imported material acquisition cost (purchase, delivery, etc.) ($/yd^3)	$6.50
i.	Imported clay cost ($) (Line 19c x Line 19g x Line 19h)	$0
j.	Placement/spreading, grading, compaction (to achieve permeability no greater than 1 x 10-6 cm/sec) unit costs ($/yd^3)	$8.35
k.	Placement, grading and compaction cost ($) (Line 19c x Line 19j)	$0
l.	Subtotal clay costs ($) (Line 19f + Line 19i + Line 19k)	$0

20. Synthetic Membrane

Note: This item must be estimated in addition to the clay barrier layer unless/until an alternative final cover design has been approved in the closure plan.

a.	Type of membrane (e.g., HDPE, CPE, PVC)	VLDPE
	Thickness (minimum 30 mils)	40
b.	Quantity (ft^2)	1,051,158
c.	Purchase, delivery and installation unit cost ($\$/ft^2$)	$0.45
d.	Synthetic layer testing (percent of total synthetic membrane unit cost) (%/100)	0.15
e.	Synthetic layer costs ($) (Line 20b x Line 20c x (1 +20d)	$543,974

21. What other types of materials/layers are included in the design (e.g., asphalt-tar, gravel for gas venting)?

16 oz.geotextile cushion layer, 1 ft. thick drainage layer, 8 oz. geotextile filter layer, 1 ft. thick erosion layer

a. Geotextile filter (8 oz. nonwoven)

1)	Quantity (ft^2)	2,691,572
2)	Purchase, delivery and installation unit cost ($\$/ft^2$)	$0.17
a.	Synthetic layer testing (% of total synthetic membrane unit cost) (%/100)	0.15
3)	Geotextile layer costs ($)	526,202

b. Drainage layer (1-ft thick sand layer, min. $k=10^{-2}$ cm/sec) ______

1)	Quantity (yd^3)	
2)	Purchase, delivery and installation unit cost ($\$/yd^3$)	______
3)	Drainage layer costs	$0

c. Erosion layer (2-ft thick native soil layer) (A,B, AB+ and C)

1)	Volume of soil on deck areas (A,B, AB+ and C) (yd^3)	272,137
2)	Purchase, delivery and installation on decks unit cost ($\$/yd^3$)	$4.00

3) Volume of soil on slope areas (A, B, AB+ and C) (yd^3) 247,695

4) Purchase, delivery and installation on slopes unit cost ($\$/yd^3$) $4.50

5) Total cost of erosion layer
(Line 21c.1x Line 21c..2 + Line 21c.3 x Line 21c.4) $2,203,176

d. Total other types of layers ($)
(Line 21a.3 + Line 21b.3 – Line 21c.5) $2,729,378

NOTE: Thickness of individual layers may be modified depending on the integrated cover design.

22. Construction Quality Assurance

The following cost estimates apply to the quality assurance activities necessary to ensure that the final cover is installed properly, as specified in the design parameters, and fulfill the conditions mandated by regulations.

a. Monitoring costs incurred while evaluating the final cover system components:

1) Laboratory test fees (e.g.. soil permeability, soil density and moisture content) ($) $136,990

2) Field test expenditures (e.g., test pad field permeability tests, relative compaction tests) ($) $125,000

b. Inspections (e.g., initial inspection of native and imported soil or clay, visual check of completed cover) ($) $244,000

c. Reporting costs (e.g., daily reporting procedures, corrective measure report, as-built reports) ($) $63,040

d. Engineering design costs ($) $234,500

e. Quality assurance costs ($)
(Line 22a1 + Line 22a2 + Line 22b + Line 22c + Line 22d) $803,530

23. Final Cover Subtotal ($)
(Line 18k + Line 19l + Line 20e + Line 21d+ Line 22e) $4,076,882

Revegetation

24. Soil Preparation

a. Area to be vegetated, including closed areas that need replanting (acres) (Line 17a + Line 17b)/43560 161.1

b. Preparation unit cost ($/acre) $325

c. Soil preparation subtotal ($)
(Line 24a x Line 24b) $52,358

25. Planting

a. Type of vegetation — Annual and perennial native grasses and flowers

b. Planting unit cost (e.g., seeding, sprigging, plugs) (include cost of seeds, sprigs, plugs) ($/acre) — $2,000

c. Planting cost ($) (Line 24a x Line 25b) — $322,200

26. Fertilizing

a. Type of fertilizer — Root stimulant

b. Fertilizer unit cost ($/acre) — $300

c. Fertilizing cost ($) (Line 24a x Line 26b) — $48,330

27. Mulching

a. Mulch unit cost ($/acre) — $600.00

b. Mulching cost ($) (Line 24a x Line 27a) — $96,660

28. Irrigation installation cost ($) (temporary) — $1,302,275

29. Revegetation Subtotal ($) (Line 24c + Line 25c + Line 26c + Line 27b + Line 28) — $1,821,823

Landfill Gas Monitoring and Control

30. Does the landfill have a gas monitoring network?

YES X NO

If NO,

a. What will be the spacing between monitoring wells (≤ 1000 ft)? ________

b. What criteria was used to select this spacing?

____

____

c. Total number of gas monitoring wells? ________
Note: Depth of probes should equal at least 1 x depth of refuse within 1000'.

d. Number of probes per wellbore? ________

Suggested minimum;

1. Surface (5-10 ft)
2. Intermediate (half the depth of boring)
3. Deep (to depth of boring)

e.	Cost of Design ($)	0.00
f.	Cost of drilling, materials ($)	0.00
g.	Cost of installation ($)	0.00
h.	Subtotal for monitoring network ($) (Line 30e + Line 30f + Line 30g)	0.00

If YES,

i.	How many gas monitoring wells are in place?	52
j.	What is the lateral spacing between gas monitoring wells?	<1,000 ft
k.	What is the number of probes per wellbore?	one to four
l.	Additional monitoring wells required at closure?	None
m.	Number of probes per boring?	N/A
n.	Cost to expand existing monitoring network (design, drilling, and installation)?	$0.00

31. Is there a gas control system operating at the landfill?

YES X NO

If YES,

a.	What type(s) (e.g., recovery, perimeter extraction, air injection, etc.) is/are in place?	Extraction
b.	What type of system will be installed during closure?	None
c.	Cost of design ($)	0.00
d.	Cost of materials ($)	0.00
e.	Cost of installation ($)	0.00
f.	Subtotal for control system ($) (Line 31c + Line 31d + Line 31e)	0.00

32. Landfill Gas Subtotal ($)
(Line 30h + Line 30n + Line 31f) 0.00

Groundwater Monitoring Installations

33. Does the landfill have a ground-water monitoring network?

YES X NO

If YES,

a. Number of upgradient (minimum 1) wells 4

b. Number of downgradient (minimum 3) wells (number of background wells) 0

If less than minimum or NO,

c. Number of wells to be installed (minimum 1 upgradient and minimum 3 downgradient). 0

d. Drilling total footage (ft) 0

e. Cost of design ($) 0

f. Developing, installing, materials ($)

34. Groundwater monitoring subtotal ($)
(Line 33e + Line 33f) $0

Drainage

35. Is there a surface water runon and runoff control system existing at the site:

YES X NO

If NO,

a. What will be the estimated cost of installation and construction of the drainage conveyance system to accommodate anticipated runoff (e.g., diversion ditches, downdrains, energy dissipators) and protection from runon (e.g., dikes. levees, protective berms)? ($) $747,283

b. Cost of grading and drainage design ($) $82,587

c. Drainage subtotal ($)
(Line 35a + Line 35b) $829,870

Security

36. Is there a security system established at the landfill (e.g., fencing, access gates, locks on the gates, informational signs)?

YES X NO

a. What is presently in place at the site? (mark appropriate boxes)

X	Fencing	X	Locks
X	Gates		Other (describe)
X	Signs		

b. What will be the estimated cost of installing a security fence, access gates with locks, and/or informational signs (e.g., either around site perimeter or around enclosures) to protect equipment and the public and is compatible with postclosure use? $33,000

c. What will be the estimated cost of dismantling and removing security equipment not necessary after closure and incompatible with postclosure use? $00

d. Security system costs ($) (Line 36b + line 36c) $33,000

SUPPLEMENTAL DATA

37. Itemize cost on additional worksheets for closure procedures, specific to this solid waste disposal site, and attach at the end of this worksheet. Make sure each page is appropriately labeled with site name and SWIS number.

Other Closure Costs (Lines: 55l + 80s+ 81d + 84i + 85n + 86c + 87c+89f) **$4,131,960**

Administrative Costs - Construction Management (Line 88) $1,655,629

POSTCLOSURE MONITORING AND MAINTENANCE COSTS

Revegetation

38. Fertilizing (first 2 years)

a. Area to be fertilized (acres) 161

b. Type of fertilizer 7-1-7 starter and 8-5-1 slow release

c. Fertilizer unit cost ($/acre/yr) $1,000

d.	Fertilizing cost (first 2 years) (Line 38a x Line 38c)	$322,000
e.	Fertilizing costs for the four year period	$644,000

39. Irrigation (first 4 years)

a.	Type of irrigation system	Overhead spray
b.	Quantity (gallon/day)	165,422
c.	Unit cost ($/gallon)	$0.0011
d.	How many irrigation days per week?	7
e.	Annual irrigation costs ($/yr) {(Line 39b x Line 39c) x Line 39d} x 52 wk/yr	$66,235
f.	Annual maintenance costs ($/yr)	$73,992
g.	Irrigation costs ($/yr) (Line 39e + line 39f)	$140,227
h.	Irrigation costs for a four-year period	$560,908

40. Revegetation Subtotal (first 4 years) (Line 38e + Line 39h) $1,204,908

Leachate Management

41. Does the solid waste disposal site have a liner?

YES X (Disposal Area C) NO X (Disposal Areas A,B, and AB+)

42. Does the landfill have a leachate collection/removal system? (e.g., leachate barrier and recovery system, dendritic system)

YES X NO If YES,

What type of system? A leachate seepage cut-off barrier wall at the downstream end of disposal area AB+ with a gravel collector placed upstream of the barrier wall. The leachate collection and removal system for Disposal Area C consists of a drainage blanket on the liner with an integrated drainage system on the bottom canyon.

b. Annual cost of operation and maintenance of system ($/yr). $29,000

43. List types of leachate (including leachate-affected water and landfill gas condensate) treatment used and that will continue to be used during closure and postclosure maintenance (e.g., discharge to sewer, on-site or off-site management).

a. Type of treatment (on-site).

Landfill Gas Condensate pH Adjustment
(Note: Leachate production is not anticipated and has not been detected to-date.)

b.	Volume/unit frequency (e.g., gals/day, gals/month)	210 gal/day
c.	Unit cost of treatment ($/gal.)	$0.38/gal
d.	Annual costs of on-site treatment. ($/yr)	$29,127
44.	Type of treatment (off-site)	N/A
a.	Volume/unit frequency (e.g., gals/day, gals/month)	N/A
b.	Unit cost of treatment - including hauling ($)	N/A
c.	Annual costs of off-site treatment. ($/yr)	$0
d.	Other (explain)	
45.	Leachate sampling and testing	
a.	Number of samples/round	1
b.	Sampling costs/round ($)	$40
c.	Frequency of sampling per year	52
d.	Annual sampling costs ($/yr) (Line 45b x Line 45c)	$2,080
e.	Testing costs/sample ($)	$58
f.	Annual testing costs ($/yr) (Line 45a x Line 45c x Line 45e)	$3,016
g.	Annual sampling/testing cost subtotal ($) (Line 45d + Line 45f)	$5,096
46.	Leachate management costs ($/yr) (Line 42b + Line 43d + Line 44c + Line 45g)	$63,223

Monitoring

47. Gas Monitoring Systems

a. Monitoring devices of principal gases (e.g., Gastech, OVA, etc.) — OVA Meters; Gas Chromatography; Flame Ionization Detector

b. Frequency of monitoring (e.g., daily, weekly, monthly)

Note: See supplemental cost worksheets for additional gas monitoring costs.

c.	On-site annual monitoring costs for principal gases? ($/yr)	$0.00
d.	Annual sampling costs for trace gases ($/yr)	$0.00
e.	Annual testing costs for trace gases ($/yr)	$0.00
f.	Assumed replacement frequency, of probes, in years.	52
g.	Installation unit cost for probes ($)	$2,500
h.	Annual replacement costs ($) (Line 30i x Line 47g)/Line 47f	$2,500
i.	Annual maintenance costs ($/yr)	$3,000
j.	Gas monitoring subtotal ($/yr) (Line 47c + Line 47d + Line 47e + Line 47h + Line 47i)	$5,500

48. Is the vadose (unsaturated) zone monitored at this landfill?

YES ______ NO __X__

If YES,

a. What type of monitoring procedures and equipment are utilized? (e.g., vacuum/pressure lysimeter)

b. How many monitoring devices are utilized? ______

c. Annual sampling costs ($/yr) ______

d. Annual testing costs ($/yr) ______

e. Assumed replacement frequency, of devices, in years ______

f. Installation unit cost of devices ($) ______

g. Annual replacement cost ($/yr) (Line 48b x Line 48f)/Line 48e ______

h.	Annual maintenance costs ($/yr)	______
i.	Vadose zone monitoring subtotal ($/yr) (Line 48c + Line 48d + Line 48g + Line 48h)	$0.00

49. Ground-Water Monitoring

a.	Number of wells	12
b.	Frequency of monitoring, per year	4
c.	Analytical methods (e.g., EPA 601 and 602 or 624, and 625) EPA 624 and 625, and 8080, Metals (unfiltered), pH, electrical conductivity, BOD, COD, TDS, Total Hardness	
d.	Number of samples/round	1
e.	Testing costs/sample ($)	$1,700
f.	Annual groundwater sampling & testing costs ($/yr) [(Line 49d x Line 49e) x Line 49a] x Line 49b	$81,600
g.	Annual monitoring costs ($/yr)	$5,267
h.	Assumed replacement frequency, of wells, in years	20 years
i.	Installation unit cost of wells ($)	$8,333
j.	Annual replacement cost ($/yr) (Line 49a x Line 49i)/Line 49h	$5,000
k.	Annual maintenance costs ($/yr)	$2,400
l.	Ground-water monitoring subtotal ($/yr) (Line 49f + Line 49g + Line 49j + Line 49k)	$94,267

50. Monitoring Cost Subtotal ($/yr)
(Line 48i + Line 49l) $94,267

See supplemental worksheets for additional monitoring costs.

Drainage

51. How often do you anticipate the need to perform maintenance activities (e.g., clear material from runoff surface water conveyances, erosion repair, minor grading, repair of articulated drains; also problems with runon maintenance and repairs of levees, dikes, protective berms)?

Once during the summer months and after each heavy rainfall.

a.	Annual maintenance costs ($/yr)	$37,000

Security

52. What are the estimated annual maintenance costs to repair/replace fencing, gates, locks, signs, and/or other security equipment at the landfill site? ($/yr) $7,000

Inspection

53. What will be the routine maintenance inspection frequency of the landfill during postclosure (minimum semi-annually)?

    Varies (see Post-Closure Plan)

    a. Inspection unit cost ($) $0.00

    b. Annual inspection costs during the postclosure care period? ($/yr) $300,000

    Components that should be inspected include, but are not limited to:

    - Final cover - erosion damage
    - Final grading - ponding caused by settlement
    - Drainage control systems - continuity of articulated drains, sediment choked conduits
    - Gas collection/control systems
    - Leachate collection and treatment systems effectiveness, and continuity
    - Security - fences, gates and signs
    - Vector and fire control
    - Monitoring equipment
    - Litter control

SUPPLEMENTAL DATA

54. Itemize annual costs on additional worksheets for monitoring and postclosure maintenance procedures, specific to this solid waste disposal site, and attach at the end of this worksheet. Make sure each page is appropriate labeled with site name and SWIS number.

    Other-Annual Postclosure Maintenance Costs
    (Lines 66c, 67c, 68c, 69f, 70e, 71b, 72g, 73d, 74b
    75d, 76b, 78d, and 79b) $390,150
    Administrative Costs

SUMMARY OF COST ESTIMATES

Facility Name Lopez Canyon

Closure

Final Cover (Line 23)	$4,076,882
Revegetation (Line 29)	$1,821,823
Landfill Gas Monitoring and Control (Line 32)	$0
Groundwater Monitoring Installations (Line 34)	$0
Drainage Installation (Line 35c)	$829,870
Security Installation (Line 36d)	$33,000
Other (Line 37)	$5,787,589
I. Subtotal Closure	**$12,549,164**
II. Subtotal I x 20% Contingency Costs	**$2,509,833**
Total Closure Cost	**$15,058,997**

Monitoring and Postclosure Maintenance

Leachate Management (Line 46)	$63,223
Water Monitoring (Line 48i + 49l)	$94,267
Drainage (Line 51a)	$37,000
Security (Line 52)	$7,000
Inspection (Line 53b)	$300,000
Landfill Gas Management (Line 47j, 56e, 57d, 58b,59c, 60e, 61e, 62e, 63e, 64d, 65c)	$277,500
Other (Line 54)	$390,150
Final Cover Maintenance (82f, 83b)	$18,658
III. Subtotal	$1,187,798
IV. Subtotal III x 30 years	$35,633,940
V. Revegetation (Line 40)	$1,204,908

TOTAL COSTS (Item I, Item II, Item IV, Item V) (Total Closure and Postclosure Maintenance Cost)	Total Postclosure Maintenance Cost	$51,897,847

N/A: NOT APPLICABLE TOWARDS CLOSURE
SUPPLEMENTAL WORKSHEETS

55. Clay Layer (C Deck)

a.	Area to be capped (ft^2) of C Deck	982,278
b.	Thickness (ft) (minimum 1 foot)	1.00
c.	Volume (yd^3) (Line 55a x Line 55b)/27	36,381
d.	% On-site Clay	0
e.	On-site material acquisition cost (excavation, hauling, etc.) ($\$/yr^3$)	0
f.	On-site clay cost ($) (Line 55c x Line 55d x Line 55e)	$0
g.	% Imported clay	100
h.	Imported material acquisition cost (purchase, delivery, etc.) ($\$/yd^3$)	6.50
i.	Imported clay cost ($) (Line 55c x Line 55g x Line 55h)	$236,477
j.	Placement/spreading, grading, compaction (to achieve permeability no greater than 1×10^{-6} cm/sec) unit costs ($\$/yd^3$)	8.37
k.	Placement, grading and compaction cost ($) (Line 55c x Line 55j)	$304,509
l.	Subtotal clay costs ($) (Line 55f + Line 55i+ + Line 55k)	$540,986

GAS RECOVERY SYSTEM MONITORING

56. a. Monitoring devices of principal gases (e.g., Gastech, OVA, etc.)

Kuetz velocity meter, thermometer, magnehelic, differential pressure gauge, Gas-tech NP-204

b.	Frequency of monitoring (e.g., daily, weekly, monthly)	Quarterly
c.	On-site monitoring costs? ($/yr)	$16,000

d.	Annual analysis costs ($/yr)	$3,000
e.	Gas Recovery System monitoring subtotal ($/yr) Line 56c + Line 56d)	$19,000

57. Gas Migration Control System - Gas Collection Indicator Probe (GCIP) Monitoring

a.	Monitoring devices of principal gases (e.g., Gastech, OVA, etc.) OVA, Gas Tech NP-204, Magnehelic, Differential Pressure Gauge, Barometer	
b.	Frequency of monitoring (e.g., daily, weekly, monthly)	Quarterly
c.	On-site monitoring costs? ($/yr)	$7,000
d.	Gas Migration System - (GCIP) Monitoring Subtotal ($/yr)	$7,000

58. Visual Inspection of Landfill Surface

a.	Frequency of monitoring (e.g., daily, weekly, monthly)	Weekly
b.	On-site monitoring costs? ($/yr)	$20,000

59. Instantaneous Surface Emissions Monitoring

a.	Monitoring devices of principal gases (e.g., Gastech, OVA, etc.)	Organic Vapor Analyzer
b.	Frequency of monitoring (e.g., daily, weekly, monthly)	
c.	On-site monitoring costs? ($/yr)	$28,000

60. Integrated Surface Emissions Monitoring

a.	Monitoring devices of principal gases (e.g., Gastech, OVA, etc.)	Organic Vapor Analyzer, Integrated Surface Sampler
b.	Frequency of monitoring (e.g., daily, weekly, monthly)	
c.	On-site monitoring costs? ($/yr)	$74,500
d.	Annual analysis costs ($/yr)	$10,000
e.	Integrated Surface Emissions monitoring subtotal ($/yr)	$84,500

61. Sampling Gas in Branch Line, Probes, and Headers

a.	Monitoring devices of principal gases (e.g., Gastech, OVA, etc.)	Kurtz Velocity Meter, Magnehelic Differential Pressure Gauge, Gas Tech NP-204
b.	Frequency of monitoring (e.g., daily, weekly, monthly)	Quarterly
c.	On-site monitoring costs? ($/yr)	$1,000
d.	Annual analysis costs ($/yr)	$5,500
e.	Sampling gas in branch lines, probes and headers subtotal ($/yr)	$6,500

62. Ambient Air Sampling at Perimeter of the Site

a.	Monitoring devices of principal gases (e.g., Gastech, OVA, etc.)	Integrated Ambient Air Sampling Unit, Line Monitoring Station, Organic Vapor Analyzer
b.	Frequency of monitoring (e.g., daily, weekly, monthly)	Quarterly
c.	On-site monitoring costs? ($/yr)	$10,000
d.	Annual analysis costs ($/yr)	$35,000
e.	Integrated Surface Emissions monitoring subtotal ($/yr)	$45,000

63. Gas Recovery System - Flare Station Sampling

a.	Monitoring devices of principal gases (e.g., Gastech, OVA, etc.)	Tedlar Bag, Organic Vapor Analyzer
b.	Frequency of testing (e.g., daily, weekly, monthly)	Quarterly
c.	On-site monitoring costs? ($/yr)	$500
d.	Annual analysis costs? ($/yr)	$2,500
e.	Flare Station Sampling subtotal ($/yr)	$3,000

64. Flare Source Testing

a.	Frequency of testing (e.g., daily, weekly, monthly)	Annually
b.	On-site monitoring costs ($/yr)	0.00
c.	Annual analysis costs ($/yr)	$52,000

d. Flare Source Testing subtotal ($/yr) $52,000

65. Gas Recovery System Monitoring - Sumps and Condensate Drain Lines

a. Monitoring devices of principal gases (e.g., Gastech, OVA, etc.)

OVA meters, Gas Chromatography, Gas Sampling Equipment

b. Frequency of monitoring (e.g., daily, weekly, monthly) Weekly

c. On-site monitoring costs? ($/yr) $7,000

66. Reseeding and Mulching

a. Labor $13,150

b. Materials $13,000

c. Reseeding and Mulching Total ($/yr.) $26,150

67. Monitoring Supervisor

a. Duties

Supervise and coordinate post-closure monitoring activities and provide QA/QC.

b. On-site costs ($/yr) $90,000

c. Supervisor subtotal ($/yr) $90,000

68. Health and Safety Officer

a. Duties

Supervise, coordinate, and administrate health and safety activities relative to post-closure monitoring and maintenance.

b. On-site costs ($/yr) $38,000

c. Health and Safety subtotal ($/yr) $38,000

69. Monitoring Equipment Maintenance and Repair

a. Monitoring Devices

Organic Vapor Analyzer, Kurz Velocity Meters, Thermometers, Magnehelic, Differential Pressure Gauges, Gas Tech NP-204, Wind Monitoring Stations, Integrated Ambient Air Sampling units, Vacuum Pumps, Integrated Surface Sampler, Barometer

b. Frequency of maintenance Monthly

c. Frequency of Repair — As Required

d. On-site maintenance and repair costs ($/yr) — $40,000

e. Replacement parts costs ($/yr) — $15,000

f. Equipment Maintenance and Repair subtotal ($/yr) — $55,000

70. Monitoring Equipment Replacement Amortization

a. Monitoring Devices

Organic Vapor Analyzer, Kurz Velocity Meters, Thermometers, Magnehelic, Differential Pressure Gauges, Gas Tech NP-204, Wind Monitoring Stations, Integrated Ambient Air Sampling units sample train, Integrated Surface Sampler, Organic Vapor Monitor

b. Average equipment life or replacement cycle. — Every 5 years

c. Equipment Cost List

OVA - 8 @	$8,500/ea.		$68,000
Kurz - 5 @	$1,200/ea.		$6,000
Magnehelic - 5 @	$300/ea.		$1,500
NP-204 - 2 @	$1,500/ea.		$3,000
Wind Station - 3 @	$2,700/ea.		$8,100
Ambient Air Sampling Unit - 5 @	$2,200/ea.		$11,000
Sample Train - 4 @	$2,500/ea.		$10,000
Surface Sampler - 5 @	$750/ea.		$3,750
OVM - 2 @	$1,800/ea.		$3,600
		TOTAL	$114,950

d. Amortization Costs ($/yr) — $23,000

e. Amortization Subtotal ($/yr) — $23,000

71. Monitoring Materials

a. Material Items

Tedlar bags, Tygon Tubing, Calibration Gases, Safety Equipment, Misc. Tools, cleaning and maintenance supplies

b. On-site Material Costs ($/yr) — $25,000

72. Monitoring Vehicles

a. Type of Vehicles

4-Wheel drive vehicles

b. Number of Vehicles — 6

	c. Unit cost of vehicles	$18,000
	d. Average vehicle life or replacement cycle	5 years
	e. Estimated trade-in value	$2,000
	f. Amortization costs ($/yr)	$16,000
	g. Monitoring Vehicle Cost ($/yr)	$19,000
73.	Weather Station Management	
	a. Number of Stations	3
	b. Frequency of monitoring	Weekly
	c. On-site monitoring costs ($/yr)	$72,000
	d. Weather Station Management Subtotal ($/yr)	$72,000
74.	Subdrain Collection System Maintenance	
	a. Frequency of monitoring (e.g., daily, weekly, monthly)	As Required
	b. On-site monitoring costs? ($/yr)	$5,000
75.	Subdrain Collection System Sampling	
	a. Frequency of monitoring, per year	Quarterly
	b. On-site monitoring costs? ($/yr)	$3,000
	c. Annual analysis costs ($/yr)	$2,000
	d. Subdrain Collection System Monitoring subtotal ($/yr)	$5,000
76.	Outfall System Inspection	
	a. Frequency of monitoring, per year	Quarterly
	b. On-site monitoring costs? ($/yr)	$10,000
77.	Final Closure/Post-Closure Plan Preparation	$0.00
78.	Surface Water Monitoring	
	a. Frequency of monitoring, per year	Two times annually during discharges
	b. On-site monitoring costs	$3,000

l. **Imported clay cost ($)**
((Line 80f.2+Line 80f.5) x Line 80j x Line 80k) — **$393,868**

m. Placement/spreading, grading, compaction
(to achieve permeability no greater than 1×10^{-6} cm/sec)
unit costs ($/yd^3) — $15.91

n. **Placement, grading and compaction cost ($)**
((Line 80f.2+Line 80f.5) x Line 80m) — **$962,110**

o. **Subtotal clay cost ($)**
(Line 80i + Line 80l + Line 80n) — **$1,355,178**

p. **Percent on-site soil for monolithic soil cover** — **0**

q. **Purchase, delivery and installation on slopes unit cost ($/yd^3)** — **$4.68**

r. **Cost of monolithic soil cover layer on slopes A & AB+**
(Line 80f.3+Line 80f.4) x Line 80q — **$285,188**

s. **Cost of slope liners**
(Line 80o + Line 80r) — **$1,640,366**

81. Geotextile Cushion (12 oz./yd^3 nonwoven)

a. Quantity (ft^2) — 1,051,158

b. Purchase, delivery and installation unit cost ($/ft^2) — $0.20

c. Cushion fabric testing (percent of total cushion fabric
unit cost (%/100) — 0.15

d. Geotextile layer cost ($)
(Line 81a x Line 81b x [1 + 81c]) — $241,766

FINAL COVER MAINTENANCE

82. Repair and Replacement of VLDPE Geomembrane and of Geotextile Cushion

a. Assumed repair/replacement frequency — Annually

b. Assumed area of repair replacement (ft^2) — 5,000

c. Purchase, delivery and installation unit cost ($/ft^2) — $1.10

d. Cost of repair/replacement ($) — $5,500

e. Annual cost of providing construction quality assurance (CQA)
during the repairs (25% of the construction cost) ($) — $1,375

f. Total annual cost of repairs ($) — $6,875

83.	Final Cover Earthen Repair		
	a.	Assumed area to be repaired (ft^2)	17,500
	b.	Total annual cost of earthen cover repair (including CQA during the repair) ($)	$11,783
84.	Rebuilding of Haul Road and Channel		
	a.	Total length of the Haul Road to rebuild (ft)	2,000
	b.	Haul Road rebuild unit cost ($/ft)	$90
	c.	Total Haul Road rebuild cost ($) (Line 84a x Line 84b)	$180,000
	d.	Total length of channel to rebuild	1,660
	e.	Channel rebuild unit cost ($/ft)	$45
	f.	Total channel rebuild cost ($) (Line 84d x Line 84e)	$74,700
	g.	Total rebuild cost ($) (Line 84c + Line 84f)	$254,700
	h.	Design cost ($) (20%/100 Line 84g)	$50,940
	i.	Total Haul Road and Channel Cost (Line 84g + Line 84h)	$305,640
85.	Gas System Modifications		
	a.	Decommission Existing Shallow Vertical Wells	
		1. Wells at 12.5' (#23)	288 ft.
		2. Wells at 37.5' (#81)	3,038 ft.
		3. Wells at 62.5 (#106)	6,625 ft.
	b.	Subtotal Decommissioning Wells @ $5/ft.	$50,000
	c.	Abandonment Materials and Labor	
		1. Sand - 1,000 bags @ $8/bag	$8,000
		2. Bentonite Chips - 350 bags @ $9/bag	$3,150
		3. Labor (2 per Crew) - 130 hours @ $20/hr.	$2,600
		4. Backhoe - 130 hours @ $90/hr.	$11,700
		5. Foreman - 130 hours @ $35/hr.	$4,550
		6. Water Truck - 130 hours @ $60/hr.	$7,800
	d.	Subtotal Abandonment Materials and Labor	$37,800
	e.	New Shallow Well Construction - 10,333 LF @ $36/ft.	$372,000

f.	Well disconnection materials and labor (Disposal Area C) - 186 @ $20 ea.		$3,720
g.	Well Connection Materials		
1.	2" Slide Gate Valve	450 @ $12 ea.	$5,400
2.	6" PVC Tee	450 @ $25 ea.	$11,250
3.	6" Cap PVC	450 @ $10 ea.	$4,500
4.	6"x2" PVC Red	450 @ $20 ea.	$9,000
5.	2" PVC El	450 @ $5 ea.	$2,250
6.	1" Make Adapter-PVC	450 @ $3 ea.	$1,350
7.	1" PVC Cap	450 @ $2 ea.	$900
8.	2" Flex Cplg.	450 @ $75 ea.	$33,750
9.	2" PVC pipe	450 @ $5 ea.	$2,250
h.	Connection Assembly-Labor	450 @ $17.50 ea.	$7,875
i.	Connection Installation	450 @ $26,40 ea.	$11,880
j.	Subtotal Well Connection Materials		$90,405
k.	Relocate and Replace Header System - 36,780 LF @ $8/ft.		$294,240
l.	Relocate condensate sumps - 8 @ $4,000/ea.		$32,000
m.	Gas Well Protection - 233 @ $425/ea.		$99,025
n.	Total Gas System Modifications (Line 85b + Line 85d + Line 85e + Line 85f + Line 85j + Line 85k + Line 85l + Line 85m)		$979,190

86. Groundwater Monitoring Well Abandonment and Replacement at Closure

a.	Abandonment of Wells MW 88-5 and MW 88-4	$5,240
b.	Replacement of Wells MW 88-5 and MW 88-4	$10,300
c.	Groundwater Well Replacement Total	$15,540

87. Lysimeter Abandonment and Replacement at Closure

a.	Abandonment of Lysimeters 88-1 and 88-2	$1,320
b.	Replacement of Lysimeters	$8,400
c.	Lysimeter Replacement Total	$9,720

88. Construction Management - QA/QC (Note: does not include final cover QA/QC) $1,655,629

89. Deck Liners

a.	Total Area to be Capped (decks of Disposal Area A, B, AB+) (ft^2)	2,691,572
b.	Thickness (ft) on decks of Disposal Area A, B, AB+	1.00
c.	Volume of decks of Disposal Area A, B, AB+(yd^3)	99,688
d.	Percent on-site soil for monolithic soil cover	0
e.	Purchase, delivery and installation on decks unit cost ($\$/yd^3$)	$4.00
f.	Cost of monolithic soil cover layer on decks off Disposal Area A, B, AB+ (Line 89c x Line 80q)	$398,752

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APPENDIX G

APPROVAL LETTERS FROM CIWMB, RWQCB AND LEA

CITY OF LOS ANGELES
CALIFORNIA

RICHARD J. RIORDAN
MAYOR

DEPARTMENT OF
PUBLIC WORKS
BUREAU OF SANITATION
JUDITH A. WILSON
DIRECTOR
DREW SONES
JOHN T. CROSSE
JAMES F. LANGLEY
ASSISTANT DIRECTORS
SOLID RESOURCES
ENGINEERING & CONSTRUCTION DIVISION
419 SO. SPRING STREET, SUITE 800
LOS ANGELES, CA 90013
(213) 893-8391
FAX: (213) 893-8223

APR 08 1998

Mr. Dennis Dickerson, Executive Officer
California Regional Water Control Board (RWQCB)
101 Centre Plaza Drive
Monterey Park, California 91754-2156

Attention: Rodney H. Nelson
Head of Landfills Unit

PROPOSED ENGINEERED ALTERNATIVE FINAL COVER ON THE SLOPE OF DISPOSAL AREAS "A" AND "AB+" AND THE DECKS OF DISPOSAL AREAS "A", "B" AND "AB+"- LOPEZ CANYON RESTORATION PROJECT

In accordance with Title 27 of California Code of Regulations, the City of Los Angeles, Bureau of Sanitation is submitting an engineered alternative to the prescriptive final cover described in the Final Closure Plan of Lopez Canyon Restoration Project. Attached to this letter is the technical report prepared by Geosyntec Consultants for the Bureau of Sanitation. In this report, we are proposing to utilize a monolithic soil final cover on the slopes of Disposal Areas "A" and "AB+" and the decks of Disposal Areas "A", "B" and "AB+". The analysis presented in the report demonstrates that a properly engineered monolithic soil cover performs better than Title 27 prescriptive cover in controlling infiltration at the site. The monolithic soil cover is also more economical to procure, place, maintain and repair than the prescriptive cover.

Due to the potential for enhanced performance at lower cost, the Bureau of Sanitation request an expedited review and approval of our proposal. To help you expedite the review process, Bureau and Geosyntec staffs will be presenting and discussing the report with you and your staff on Wednesday, April 8, 1998 at 9.00 o'clock in your office.

If you should have any questions, please contact Kelly Gharios of the Bureau at (213) 893-8209 or Ed Kavazanjian of Geosyntec at (714) 969-0800.

For STEPHEN A. FORTUNE, Division Manager,
Solid Resources Engineering & Construction Division

Attachment
c: Peter Janicki, CIWMB
Joe Maturino, LEA

C: lopez.closure
File: 2.1.9

California [redacted] Control Board
Los Angeles Region

Internet Address: http://www.swrcb.ca.gov/~rwqcb4
101 Centre Plaza Drive, Monterey Park, California 91754-2156
Phone (323) 266-7500 FAX (323) 266-7600

ter M. Rooney
Secretary for
Environmental
Protection

Pete Wils
Governor

July 23, 1998

Stephen A. Fortune, Division Manager
Solid Resources Engineering & Construction Division
City of Los Angeles
419 South Spring Street, Suite 800
Los Angeles, CA 90013

CONDITIONAL APPROVAL OF ALTERNATIVE FINAL COVER ON THE SLOPES OF DISPOSAL AREAS A AND AB+ AND THE DECKS OF DISPOSAL AREAS A, B, AND AB+ - LOPEZ CANYON RESTORATION PROJECT (CASE FILE 69-068)

Dear Mr. Fortune:

On April 8, 1998, we received from you a report, entitled "Alternative Final Cover Water Analysis, Decks of Disposal Areas A, B, and AB+, Slopes of Disposal Area A and AB+, Lopez Canyon Landfill, Lakeview Terrace, California". In a letter to you dated May 20, 1998, we provided our comments on the subject report. In response to our comments, you have submitted two letters to the Regional Board, dated June 23, 1998, and July 1, 1998, respectively.

We have reviewed the subject letters and found that they adequately addressed our comments. The use of the proposed monolithic final cover is therefore conditionally approved per the requirements of Section 20080 of Title 27, California Code of Regulations (CCR). The approval is conditional because Section 20080(b) of Title 27, CCR, requires that the engineered alternative "(A) is consistent with the performance goal addressed by the particular construction or prescriptive standard and (B) affords equivalent protection against water quality impairment." Although the computer modeling in your report and letters demonstrated that the proposed monolithic final cover can exceed the infiltration control performance of the Title 27 prescriptive cover, this conclusion must be supported by actual monitoring data, which is only available after the landfill is closed. The formal approval of the alternative final cover is therefore subjected to the results of post-construction infiltration monitoring data of the site.

If you have any questions, please contact Mr. Wen Yang at (213) 266-7659.

Sincerely,

Rodney Nelson

RODNEY NELSON, Chief
Groundwater Regulatory Unit

cc Peter Janicki, Remediation, Closure and Technical Assistance Branch, CIWMB

ENVIRONMENTAL AFFAIRS DEPARTMENT

IAN Y. KAWASAKI
ERAL MANAGER

20 H FIGUEROA STREET
SU. 200, MAIL STOP 177
LOS ANGELES, CA 90012
(213) 580-1040

CITY OF LOS ANGELES

CALIFORNIA

G-6 AM 9:34

RICHARD J. RIORDAN
MAYOR

ENVIRONMENTAL AF
COMMISSION

MARK S. ARMBRUSTE
PRESIDENT

ANNE SHEN SMITH
VICE-PRESIDENT

EDWARD J. BEGLEY, JR.
TOD A. BURNETT
ELIZABETH D. ROGERS

Warren
FYI
KV

August 5, 1998

Mr. Stephen Fortune, Division Manager
Solid Resources Engineering and Construction Division
City of Los Angeles Department of Public Works, Bureau of Sanitation
419 South Spring Street, Suite 800
Los Angeles, CA 90013

Re: Proposed Alternative Final Cover for Lopez Canyon

Dear Mr. Fortune:

The City of Los Angeles Local Enforcement Agency has received your request for conditional approval of the proposed monolithic cover design. We have reviewed the following documents submitted to us in the technical briefing meeting held on June 25, 1998 at Lopez Canyon.

1. Memorandum from E. Kavazanjian, Tarik Hadj-Hamou (GeoSyntec Consultants) to Kelly Gharios (BOS), Additional LEACHM Analyses, Engineered Alternative Final Cover Disposal Areas A, B, and AB+ Decks and Disposal Area A and AB+ Slopes, Lopez Canyon Sanitary Landfill, Lake View Terrace, CA., June 22, 1998

2. Construction Quality Assurance Plan, Final Cover Construction, Disposal Areas A, B, and AB+, Lopez Canyon Sanitary Landfill Lakeview Terrace, California, Revised June 25, 1998.

3. Initial Cost Estimate (rev. 10.89)

The LEA grants conditional approval for the use of an alternative final cover (for Deck of Disposal Areas A, B, and AB+, Slope of AB+) consisting of a three foot layer of borrow soil (k value of 1×10^{-5} cm/s) over an existing interim cover (k value of 4.5×10^{-4} cm/s, minimum two feet thick). Conditional approval is also granted for the use of the alternative final cover (existing interim cover) for the slopes of Disposal Area A. The approval is conditioned upon the following requirements:

Reviewed by: Wayne Tsuda

Wayne Tsuda

Cc: Kelly Gharios (BOS)
Rod Nelson (RWQCB)
Peter Janicki (CIWMB)
Darryl Petker (CIWMB)
Ed Kavazanjian (GeoSyntec Consultants)

REVISED
CONSTRUCTION QUALITY ASSURANCE PLAN
FINAL COVER CONSTRUCTION
LOPEZ CANYON SANITARY LANDFILL
LAKE VIEW TERRACE, CALIFORNIA

Prepared for:

Bureau of Sanitation
Department of Public Works
City of Los Angeles
600 South Spring Street, Suite 600
Los Angeles, California 90014

Prepared by:

GeoSyntec Consultants
2100 Main Street, Suite 150
Huntington Beach, California 92648
(714) 969-0800

GeoSyntec Consultants Project No. CE4100

Revised February 1994
Revised December 1996
Revised June 1998

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APPENDIX

1. SITE AND PROJECT CONTROL

1.1 Project Coordination Meetings

To guarantee a high degree of quality during installation, clear, open channels of communication are essential. To this end, meetings of key project personnel are necessary.

1.1.1 Resolution Meeting

Following the completion of the design, plans, and specifications for the project, a Resolution Meeting will be held. This meeting will include the Geosynthetic CQA Managing Engineer, the Geosynthetic Site CQA Manager, the Soils CQA Managing Engineer, the Soils Site CQA Manager, the Engineer, and the Project Manager.

The purpose of this meeting is to begin planning for coordination of construction tasks, anticipate any installation problems which might cause difficulties and delays in construction, and, above all, present the CQA Plan to all of the parties involved. It is very important that the criteria regarding testing, repair, etc., be known and accepted by all parties prior to the installation of geosynthetic materials and construction of the soil components of the final cover system.

1.1.2 Preconstruction Meeting

A Preconstruction Meeting will be held at the site prior to installation of the geosynthetic materials and construction of soil components. As a minimum, the Preconstruction Meeting will be attended by the Geosynthetic Installer's Superintendent, the Geosynthetic CQA Managing Engineer, the Soils CQA Managing Engineer, the Geosynthetic Site CQA Manager, the Soils CQA Manager, the Earthwork Contractor, and the Project Manager.

1.1.3 Progress Meetings

A weekly progress meeting will be held between the Soils Site CQA Manager, the Geosynthetic Site CQA Manager, the Geosynthetic Installer's Superintendent, the Earthworks Contractor, the Project Manager, and any other concerned parties. The progress meetings will be used to discuss current progress, planned activities for the upcoming week, and any new business or revisions to the work. The Site CQA Managers will document any problems, decisions, or questions arising at this meeting in their daily reports. Any matter requiring action which is raised in this meeting will be reported to the appropriate parties. Minutes of the weekly progress meetings shall be documented by the Project Manager or his representative and distributed to all appropriate parties.

1.1.4 Problem or Work Deficiency Meeting

A special meeting will be held when and if a problem or deficiency is present or likely to occur. The meeting will be attended by the affected contractors, the Project Manager, the Site CQA Manager(s), and other parties as appropriate. If the problem requires a design modification, the Engineer should either be present at, consulted prior to, or notified immediately upon conclusion of this meeting. The purpose of the work deficiency meeting is to define and resolve the problem or work deficiency.

1.2 <u>Project Control Visits</u>

Periodically, the construction site will be visited by each CQA Managing Engineer and/or each CQA Project Manager (if different from the CQA Managing Engineer). If possible, each such visit should be coordinated with a similar visit by the Engineer. State of California regulatory officials may be informed of the dates of the visits.

2. DOCUMENTATION

2.1 General

An effective CQA plan depends largely on recognition of all construction activities that should be monitored, and on assigning responsibilities for the monitoring of each activity. This is most effectively accomplished and verified by the documentation of quality assurance activities. Each CQA Representative will document that all quality assurance requirements have been addressed and satisfied.

Each Site CQA Manager will provide the Project Manager with signed descriptive remarks, data sheets, and logs to verify that all monitoring activities have been carried out. Each Site CQA Manager will also maintain at the job site a complete file of plans and specifications, a CQA plan, checklists, test procedures, daily logs, and other pertinent documents.

2.2 Daily Recordkeeping

Standard reporting procedures will include preparation of daily CQA documentation which, at a minimum, will consist of: (i) field notes, including memoranda of meetings and/or discussions with the Earthwork Contractor, Installer, or Project Manager; (ii) CQA monitoring logs, and testing data sheets; and (iii) construction problem and solution summary sheets. This information will be regularly submitted to and reviewed by the Project Manager.

2.2.1 Monitoring Logs and Testing Data Sheets

Monitoring logs and testing data sheets will be prepared daily. At a minimum, these logs and data sheets will include the following information:

- an identifying sheet number for cross referencing and document control;

- date, project name, location, and other identification;
- data on weather conditions;
- a Site Plan showing work areas and test locations;
- descriptions and locations of ongoing construction;
- equipment and personnel in each work area, including subcontractors;
- descriptions and specific locations of areas, or units, of work being tested and/or observed and documented;
- locations where tests and samples were taken;
- ~~a summary of test results;~~
- calibrations or recalibrations of test equipment, and actions taken as a result of recalibration;
- delivery schedule of off-site materials received, including quality control documentation;
- decisions made regarding acceptance of units of work, and/or corrective actions to be taken in instances of substandard testing results; and
- signature of the respective Site CQA Manager(s) and/or the Field Monitor(s).

In any case, all logs must be completely filled out with no items left blank.

2.2.2 Construction Problems

The Project Manager will be made aware of any significant recurring nonconformance with the construction plans, project specifications or CQA Plan. The cause of the nonconformance will be determined and appropriate changes in procedures or specifications will be recommended. These changes will be submitted to the Engineer for approval. When this type of evaluation is made, the results will be documented, and any revision to procedures or specifications will be approved by the City and Engineer.

A summary of all supporting data sheets, along with final testing results and the respective Site CQA Manager's approval of the work, will be required upon completion of construction.

2.3 Photographic Reporting

Photographs will serve as a pictorial record of work progress, problems, and mitigation activities. The primary project file will contain color prints; negatives will also be stored in a separate file. These records will be presented to the Project Manager upon completion of the project.

2.4 Design and/or Specifications Changes

Design and/or specifications changes may be required during construction. In such cases, the respective Site CQA Manager will notify the Project Manager.

Design and/or specifications changes will be made only with the written agreement of the Project Manager and the Engineer, and will take the form of an amendment to the specifications.

2.5 Final Report

At the completion of the work, the Soils and Geosynthetic CQA Representatives will submit to the Project Manager a signed and sealed final report. These reports will acknowledge: (i) that the work has been performed in compliance with the plans and specifications; (ii) physical sampling and testing has been conducted at the appropriate frequencies; and (iii) that the summary document provides the necessary supporting information.

At a minimum, this report will include:

- summaries of all construction activities;
- monitoring logs and testing data sheets including sample location plans;
- construction problems and solutions summary sheets;
- changes from design and material specifications;
- record drawings; and
- a summary statement indicating compliance with project plans and specifications which is signed and sealed by a Registered Civil Engineer or Certified Engineering Geologist in the State of California.

The record drawings will include scale drawings depicting the location of the construction and details pertaining to the extent of construction (e.g., depths, plan dimensions, elevations, soil component thicknesses, etc.). These documents will be prepared by the appropriate CQA Representative and included as part of the CQA plan documentation.

3. VERY FLEXIBLE POLYETHYLENE (VFPE) GEOMEMBRANE QUALITY ASSURANCE

3.1 Design

A copy of the VFPE geomembrane construction drawings and specifications prepared by the Engineer will be given to the Geosynthetics CQA Representative. The Geosynthetics CQA Representative will review these items for familiarity. This review should not be considered as the peer review of the design. Peer review should have been conducted at an earlier stage.

3.2 Manufacturing

The VFPE Geomembrane Manufacturer (Manufacturer) will provide the Project Manager with a list of guaranteed "minimum average roll value" properties for the type of geomembrane to be delivered. The Manufacturer will also provide the Project Manager with a written certification signed by a responsible representative of the Manufacturer that the materials actually delivered have "minimum average roll value" properties which meet or exceed all certified property values for that type of geomembrane.

The Manufacturer will also provide the Project Manager with the following information:

- the origin (Resin Supplier's name and resin production plant), identification (brand name, lot number), and production date of the resin; and

- a copy of the quality control certificates issued by the Resin Supplier.

The Geosynthetics CQA Representative will examine all of the Manufacturer and resin suppliers certificates to ensure that the property values listed on the certifications meet or exceed those specified. Any deviations will be reported to the Project Manager.

3.3 Shipment and Storage

During shipment and storage, the VFPE geomembrane will be protected from puncture, cutting, or any other damaging or deleterious conditions. The Geosynthetics CQA Representative will observe rolls upon delivery to the site and any deviations from the above requirements will be reported to the Project Manager. Any damaged rolls will be rejected and replaced at no cost to the City.

3.4 Conformance Testing

3.4.1 Testing Procedures

In order to ensure that the VFPE to be installed for this project meets the design requirements, a minimum Design Yield Point is specified. For the purpose of these specifications, the Design Yield Point is defined as the point on the stress-strain curve at which the tangent modulus first becomes 290 psi. The stress-strain curve will be determined based on testing method ASTM D 638.

The following test procedures will also be conducted:

- thickness (ASTM D 751 with conical tip);
- specific gravity (ASTM D 792 Method A or ASTM D 1505);
- carbon black content (ASTM D 1603); and
- carbon black dispersion (ASTM D 5596).

Where optional procedures are noted in the test method, the requirements of the specifications shall prevail.

3.4.2 Sampling Procedures

Upon delivery of the geomembrane rolls, the Geosynthetics CQA Representative will ensure that samples are obtained from individual rolls at the frequency specified in this CQA plan. The samples will be forwarded to the Geosynthetics CQA Laboratory for testing to ensure conformance to both the design specifications and the list of physical properties certified by the Manufacturer.

Samples will be taken across the entire width of the roll and will not include the first lineal 3 ft (1 m). Unless otherwise specified, samples will be 3 ft (1 m) long by the roll width. The Geosynthetics CQA Representative will indicate the machine direction on the samples by marking an arrow on each sample.

Unless otherwise specified, conformance samples of the VFPE geomembrane rolls will be taken at a frequency of one sample per lot or one per 100,000 ft^2 (10,000 m^2) of material delivered to the site, whichever requires the greater number of samples.

3.4.3 Test Results

The Geosynthetics CQA Representative will examine all results from laboratory conformance testing and compare results to the project specifications. The criteria used to determine acceptability are presented in the Specifications. The Geosynthetics CQA Representative will report any nonconformance to the Project Manager.

3.5 Handling and Placement

Transportation of the geomembrane is the responsibility of the Manufacturer, Installer, or other party as agreed upon. All handling on site is the responsibility of the Installer.

During the installation, the Geosynthetics CQA Representative will verify that:

- handling equipment used on the site is adequate to handle the geomembrane without causing damage to the geomembrane; and

- the Installer's personnel handle the geomembrane with care.

Upon delivery at the site, the Installer and the Geosynthetics CQA Representative will, to the best of his or her ability, conduct a surface observation of all rolls or factory panels for defects and damage. This examination will be conducted without unrolling each individual roll unless an above average frequency of defects or damage is observed or suspected. The Geosynthetics CQA Representative will report to the Project Manager:

- any rolls or portions thereof, which should be rejected and removed from the site because they have severe manufacturing defects or damage; and

- any rolls which exhibit an average occurrence of manufacturing defects or damage which are considered by the Geosynthetics CQA Representative as repairable flaws.

3.6 Storage

The Installer will be responsible for the storage of the geomembrane on site. The Project Manager will designate storage space in a location (or several locations) such that on-site transportation and handling are optimized if possible. Storage space should be protected from theft, vandalism, passage of vehicles, stormwater runon, etc. The storage space, if unpaved, should be graded and rolled smooth in order to protect the geomembrane materials from puncture.

The Geosynthetics CQA Representative will verify that storage of the geomembrane ensures adequate protection against dirt and sources of damage.

3.7 Geomembrane Installation

3.7.1 Surface Preparation

The Earthwork Contractor will be responsible for preparing the soil subbase which supports the geomembrane materials according to the Engineer's specifications.

The Geosynthetics CQA Representative will verify that:

- a qualified geotechnical engineer, normally the Soils CQA Representative, has verified that the supporting soil meets maximum dry density and moisture specifications (if applicable);
- the surface to be lined has been rolled and compacted so as to be free of irregularities, ruts, protrusions, loose soil, and abrupt changes in grade;
- the surface of the supporting soil does not contain angular to subangular stones, debris, or other objects which may damage the geomembrane; and
- there is no area of the supporting soils excessively softened by high moisture content.

The Installer will certify in writing that the surface on which the geomembrane will be installed is acceptable. The certificate of subgrade acceptance for the area under consideration will be given by the Installer to the Project Manager prior to commencement of geomembrane installation. The Geosynthetics CQA Representative will be furnished a copy of this certificate by the Project Manager.

After the supporting soil has been accepted by the Installer, it will be the Installer's responsibility to indicate to the Project Manager any change in the supporting soil condition that may require repair work. If the Geosynthetics CQA Representative and/or Soils CQA Representative concurs with the Installer assessment of the subgrade damage, then the Project Manager will ensure that the supporting soil is repaired.

3.7.2 Geomembrane Placement

3.7.2.1 Field Panel Identification

A field panel is the unit area of geomembrane which is to be seamed in the field (i.e., a field panel is a roll or a portion of roll cut in the field).

It will be the responsibility of the Geosynthetics CQA Representative to ensure that each field panel is given an "identification code" (number or letter-number) which may or may not be consistent with the Installer's proposed layout plan. This identification code will be agreed upon by the Project Manager, Installer, and Geosynthetics CQA Representative. This field panel identification code should be as simple and logical as possible. (Note: roll numbers established in the manufacturing plant are usually cumbersome and are not related to location in the field.) It will be the responsibility of the Installer to ensure that each field panel placed is marked with the original roll number. The roll number will be marked at a location agreed upon by the Project Manager, Installer, and Geosynthetics CQA Representative. The Geosynthetics CQA Representative will record the identification code, dimensions, weather conditions, time, location, and date of installation for each field panel.

The Geosynthetics CQA Representative will establish a table or chart showing correspondence between roll numbers, factory panels, and field panel identification codes. The field panel identification code will be used for all requisite quality assurance documentation.

3.7.2.2 Field Panel Placement

The Geosynthetics CQA Representative will verify that field panels are installed in the manner indicated in the geomembrane seam layout plan, as approved or modified.

Field panels will be placed one at a time, and each field panel will be seamed immediately after its placement (in order to minimize the number of unseamed field panels exposed to wind).

Geomembrane placement will not proceed at an ambient temperature below 40°F (5°C) or above 100°F (38°C) unless otherwise authorized by the Project Manager. Geomembrane placement will not be conducted during precipitation events, in an area of ponded water, or in the presence of excessive winds as determined by the Geosynthetics CQA Representative or Project Manager. The Geosynthetics CQA Representative will verify that the above conditions are fulfilled. The Geosynthetics Site CQA Manager will inform the Project Manager if the above conditions are not fulfilled.

The Geosynthetics CQA Representative will visually observe each panel, after placement and prior to seaming, for damage. The Geosynthetics Site CQA Manager will advise the Project Manager which panels, or portions of panels, should be rejected, repaired, or accepted. Damaged panels or portions of damaged panels which have been rejected will be marked and their removal from the work area recorded by the Geosynthetics CQA Representative. Repairs will be made according to procedures described in Section 3.7.4.

3.7.3 Field Seaming

3.7.3.1 Seam Layout

The Installer will provide the Project Manager and the Geosynthetics CQA Representative with a seam layout drawing, i.e., a drawing of the facility to be lined showing all expected seams. The Geosynthetics CQA Representative will review the seam layout drawing and verify that it is consistent with the accepted state-of-practice and this CQA Plan. Seams not specifically shown on the seam layout drawing may not be constructed without the Project Manager's prior approval. A seam numbering system compatible with the panel numbering system will be agreed upon at the Resolution and/or Pre-Construction Meeting.

3.7.3.2 Seaming Equipment and Products

Approved field seaming processes are fillet extrusion seaming and double-track fusion seaming. Proposed alternate processes will be documented and submitted to the Project Manager for approval. Only seaming apparatus which have been specifically approved by make and model will be used. The Installer will ensure that all seaming equipment used on this project are in good working order including accurate temperature gauging devices.

The Project Manager will submit all seaming documentation provided by the Installer to the Geosynthetics CQA Representative for his concurrence.

Extrusion Process

The extrusion seaming apparatus will be equipped with gauges giving the relevant temperatures of the apparatus such as the temperatures of the extrudate, nozzle, and preheat. The Installer will verify equipment operating temperature with a pyrometer to ensure that accurate temperatures are being achieved throughout the course of the geomembrane installation.

The Geosynthetics CQA Representative will record machine operating temperatures, extrudate temperatures, and ambient temperatures at appropriate intervals. Ambient temperatures will be measured approximately 6 in. (150 mm) above the geomembrane surface.

Fusion Process

The fusion-seaming apparatus must be automated vehicular-mounted devices. The fusion-seaming apparatus will be equipped with gauges indicating operating temperatures. Pinch roller pressure settings will be adjusted by the Installer as required.

The Geosynthetics CQA Representative will record ambient temperatures, seaming apparatus temperatures, and speeds. Ambient temperatures will be measured approximately 6 in. (150 mm) above the geomembrane surface.

3.7.3.3 Seam Preparation

The Geosynthetics CQA Representative will monitor the preparation of the geomembrane for seaming operations to assure that:

- prior to seaming, the seam area is clean and free of moisture, dust, dirt, debris of any kind, and foreign material;

- if seam overlap grinding is required, the process is completed according to the Geomembrane Manufacturer's instructions within one hour of the seaming operation, and in a way that does not damage the geomembrane;

- the abrading does not extend more than 0.5 in. (12 mm) on either side of the extruded weld; and

- seams are aligned to minimize the number of wrinkles and "fishmouths."

The Geosynthetics Site CQA Manager will inform the Project Manager if the conditions identified above are not met.

3.7.3.4 Trial Seams

Trial seams will be made using extraneous pieces of VFPE geomembrane to verify that seaming conditions are adequate. Such trial seams will be made at the beginning of each seaming period, and at least once every five hours, for both fusion and extrusion seaming apparatus used during the seaming period. A trial seam will also be made in the event that the ambient temperature varies more than 18°F (10°C) since the last passing trial seam test. The ambient temperature will be measured approximately 6 in. (150 mm) above the liner. Also, each seaming technician will make at least one trial seam for each seaming period. Trial seams will be made under the same conditions as actual seams. If any seaming apparatus is turned off for any reason, a new passing trial seam must be completed for that specific seaming apparatus.

If a trial seam specimen fails according to the criteria identified in the project specifications, the entire trial seam testing operation should be repeated. If a specimen fails in the subsequent testing, the seaming apparatus and seamer will not be accepted and will not be used for seaming until the deficiencies are corrected and two consecutive successful full trial seams are achieved.

Additional testing of trial seams may be conducted if agreed upon between the parties involved. Any such agreements will be documented by the Geosynthetics CQA Representative. After completion of the testing described above, the remainder of the trial seam sample may be cut into three pieces and distributed, one to be retained in the City's archives, one to be given to the Installer, and one to be provided to the Geosynthetics CQA Laboratory for the additional testing, as required. If a trial seam sample fails a test conducted by the Geosynthetics CQA Laboratory, then a destructive sample will be taken from each of the seams completed by the seaming technician and apparatus subsequent to the successful field trial seam test. The conditions of this paragraph will be considered as met for a given seam if a corresponding destructive sample has already been taken and meet or exceed the requirements of the project specifications and this CQA plan.

3.7.3.5 Nondestructive Testing

Concept

The Installer will nondestructively test all field seams over their full length using a vacuum test, spark test, air pressure test (for double-track fusion seams only), or other approved method. Vacuum testing and air pressure testing are described in the *Vacuum Testing* and the *Air Pressure Testing* of this section, respectively. The purpose of nondestructive tests is to check the continuity of seams. It does not provide any information on seam strength. Nondestructive testing will be carried out as the seaming work progresses, not at the completion of all field seaming. Nondestructive testing will not be permitted without adequate illumination unless the Installer demonstrates capabilities to do so to the satisfaction of the Project Manager.

The Geosynthetics CQA Representative will:

- observe all nondestructive testing;

- record location, date, test unit number, name of tester, and outcome of all testing; and

- inform the Installer and Project Manager of any required repairs.

The Installer will complete any required repairs in accordance with Section 3.7.4.

In some cases, seams may be inaccessible for nondestructive testing due to the design of the closure system. Provisions may be made to prefabricate portions of the geomembrane to allow nondestructive testing of seams that would otherwise be inaccessible. Once tested, the prefabricated portions may be installed. In those cases where no provisions can be made to nondestructively test a seam, the seam must be capped following the method described in Section 3.7.4.3. The seaming and capping operation will be observed by the Geosynthetics CQA Representative for uniformity and completeness.

The seam number, date of observation, name of tester, and outcome of the test or observation will be recorded by the Geosynthetics CQA Representative.

Vacuum Testing

The equipment for seam vacuum testing will consist of the following:

- a vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, port hole or valve assembly, and a vacuum gauge;

- a vacuum tank and pump assembly equipped with a pressure controller and pipe connections;
- a pressure/vacuum hose with fittings and connections;
- an approved applicator; and
- a soapy solution.

The following procedures will be followed:

- if vacuum testing a fusion seam, the flap must be removed prior to testing;
- energize the vacuum pump to maintain a tank pressure of approximately 5 psi (34 kPa) gauge;
- with a soapy solution, wet a strip of geomembrane which is 6 in. (150 mm) larger in area than the vacuum box;
- place the box over the wetted area;
- close the bleed valve and open the vacuum valve;
- ensure that a leak tight seal is created;
- for a period of not less than 10 seconds, examine the geomembrane seam through the viewing window for the presence of leaks indicated by soap bubbles;
- if no leak indications appear after 10 seconds, close the vacuum valve and open the bleed valve. Before moving the box over the next adjoining area, place a mark (with an approved marker) on the geomembrane at the leading edge of the viewing window, then move the box over the next adjoining area so that the last mark on the

geomembrane is at the rear of the viewing window, and repeat the process; and

- all areas where leaks appear will be marked by the vacuum testing technician and repaired by the Installer in accordance with Section 3.7.4.3.

Air Pressure Testing (For Double-Track Fusion Seams Only)

The following procedures are applicable to those processes which produce a double seam with an enclosed air channel space.

The equipment will be comprised of the following:

- an air pump equipped with a pressure gauge capable of generating and sustaining a pressure between 25 to 30 psi (175 and 210 kPa) and mounted on a cushion to protect the geomembrane;

- a hose with fittings and connections; and

- a sharp hollow needle, or other approved air pressure feed device and pressure gauge.

The following procedures will be followed:

- insert a protective cushion between the air pump and the geomembrane;

- seal both ends of the seam to be tested;

- insert the needle or other approved pressure feed device into the channel created by the fusion seam;

- insert the needle with the pressure gauge into the channel at the opposite end of the seam where the pressure feed device is located;

- energize the air pump to a pressure between 25 and 30 psi (175 and 210 kPa), close the valve, and sustain the pressure for a minimum period of 5 minutes;

- if any loss of pressure exceeds 2 psi (15 kPa) on the gauge at the opposite end of the seam to the pressure feed device or if the pressure does not stabilize, locate the faulty area and repair it in accordance with Section 5.8.4.3;

- verify the relief of the air pressure of the end of the seam opposite the pressure gauge; and

- remove the needles or other approved pressure feed devices and repair all holes created during the test procedures.

3.7.3.6 Destructive Testing

Concept

Destructive seam tests will be performed at selected locations. The purpose of these tests is to evaluate seam strength. Seam strength testing will be conducted as the seaming work progresses, not at the completion of production seaming.

Location and Frequency

The Geosynthetics Site CQA Manager will select locations where seam samples will be cut out for laboratory testing. Those locations will be established as follows:

- A minimum average frequency of one test per 500 lineal ft (150 lineal m) of seam length. This minimum frequency is to be determined as an average taken over the total length of the geomembrane seams constructed for the final cover system.

- A maximum frequency will be agreed upon by the Installer, Project Manager and Geosynthetics Site CQA Manager at the Resolution and/or Pre-Construction Meeting.

- Test locations will be determined during seaming at the Geosynthetics Site CQA Manager's discretion. Selection of such locations may be prompted by suspicion of excess crystallinity, contamination, offset seams, or any other potential cause of inadequate seaming.

The Installer will not be informed in advance of the locations where the seam samples will be taken.

Sampling Procedure

Samples will be marked by the Geosynthetic CQA Representative and removed by the Installer for field and laboratory testing as the seaming progresses. This procedure will allow review of laboratory test results before the geomembrane is covered by another material. The Geosynthetics CQA Representative will:

- observe sample removal;

- assign a number to each sampling location, and mark the sample removed from that location accordingly;

- record the sample location on the layout drawing; and

- record the reason for taking the sample at this location (e.g., statistical routine, suspicious feature of the geomembrane).

All holes in the geomembrane resulting from the destructive sampling procedures will be immediately repaired by the Installer in accordance with repair procedures described in Section 3.7.4.3. The continuity of the new seams constructed as part of the repaired area will be tested according to the *Vacuum Testing* of Section 3.7.3.5.

Prior to the removal of a sample, two specimens for field testing should be taken. Each of these specimens will be 1 in. (25 mm) wide by 8 in. (200 mm) long, with the seam centered parallel to the width. The distance between these two specimens will be 44 in. (1.1 m). If both specimens pass the field peel tests described in the *Field Testing* of Section 3.7.3.6, a sample for laboratory testing will be taken. If either specimen fails the testing, the seam should be repaired in accordance with the procedures identified in Section 3.7.4.3.

Size and Distribution of Samples

The sample for laboratory testing will be located between the two specimens removed for field testing as described in the *Sampling Procedure* of Section 3.7.3.6. The destructive sample will be 12 in. (0.3 m) wide by 42 in. (1.1 m) long with the seam centered lengthwise. The sample will be cut into three parts and distributed as follows:

- one portion, measuring 12 in. x 12 in. (0.3 m x 0.3 m), to the Installer for laboratory testing (if required);
- one portion, measuring 12 in. x 12 in. (0.3 m x 0.3 m), to the City for archive storage; and
- one portion, measuring 12 in. x 18 in. (0.3 m x 0.45 m), for Geosynthetic CQA Laboratory testing.

Final determination of the destructive sample dimensions and distribution will be made at the Pre-Construction Meeting.

Field Testing

The two 1 in. (25 mm) wide specimens mentioned in the *Sampling Procedure* of Section 3.7.3.6 will be tested in the field for peel. The testing will be conducted using a gauged tensiometer which has been calibrated within the last six months. If any field test sample fails to pass the criteria identified in the specifications, then the procedures outlined in the *Procedures for Destructive Test Failures* of Section 3.7.3.6 will be followed.

The Geosynthetics CQA Representative will witness all field destructive testing and record the date, seam number, panel numbers, location, the assigned destructive sample number, and the results of the field tests.

Geosynthetics Construction Quality Assurance Laboratory Testing

Destructive test samples will be packaged and shipped, if necessary, by the Geosynthetics CQA Representative in a manner that will not damage the test sample. The Project Manager will verify that packaging and shipping conditions are acceptable. The Project Manager will be responsible for storing the archive samples. This procedure will be fully outlined at the Resolution and Pre-Construction Meetings. Destructive samples will be tested by the Geosynthetics CQA Laboratory. The Geosynthetics CQA Laboratory will be selected by the Geosynthetics CQA Representative with the concurrence of the City.

Testing will include "Seam Strength" (ASTM D 4437 as modified in NSF 54 Appendix A), and "Peel Strength" (ASTM D 4437 as modified in NSF 54, Appendix A). Modifications to the testing procedures and the minimum acceptable values to be obtained in these tests are indicated in the Specifications. At least five specimens will be tested for each test method. Specimens will be selected alternately by test from the samples (i.e., peel, shear, peel, shear...).

The Geosynthetics CQA Laboratory will provide test results to the Geosynthetic Site CQA Manager no more than 24 hours after receipt of the samples. The Geosynthetics Site CQA Manager will review laboratory test results as soon as they become available and make appropriate recommendations to the Project Manager.

Acceptable seams must be bounded by two locations which meet the following criteria: (i) where destructive samples have passed all laboratory tests; (ii) the entire production seam length and seaming apparatus in question is capped; and (iii) constructed by the seamer. Whenever a reconstructed seam length exceeds 150 ft

(50 m), a sample will be taken from the zone in which the seam has been reconstructed. This sample must pass destructive testing or the procedure outlined in this section must be repeated.

The Geosynthetics CQA Representative will document all actions taken in conjunction with destructive test failures.

3.7.4 Defects and Repairs

3.7.4.1 Identification

Seams and non-seam areas of the geomembrane will be examined by the Geosynthetics CQA Representative for identification of defects, holes, blisters, undispersed raw materials and any sign of contamination by foreign matter. The surface of the geomembrane will be clean at the time of examination. The geomembrane surface will be swept or washed by the Installer if debris of any kind inhibits examination.

3.7.4.2 Evaluation

Each suspect location both in seam and non-seam areas will be nondestructively tested using the methods described in the *Vacuum Testing* of Section 3.7.3.5. Each location which fails the nondestructive testing will be marked by the Installer or the Geosynthetics CQA Representative and repaired by the Installer. Work will not proceed with any materials which will cover geomembrane locations that have been repaired until laboratory destructive test results have been approved by the Geosynthetic CQA Representative.

3.7.4.3 Repair Procedures

Any portion of the geomembrane exhibiting a flaw or failing a destructive or nondestructive test will be repaired. Several procedures exist for the repair of these

3.7.5 Geosynthetic Final Cover System Acceptance

The Installer will retain all responsibility for the installed geosynthetics until accepted by the City.

The installed geosynthetics will be accepted by the City when:

- the installation is finished;
- verification of the adequacy of all seams and repairs, including passing nondestructive and destructive tests, are complete;
- Installer's representative furnishes the Project Manager with certification that the VFPE geomembrane was installed in accordance with the Manufacturer's recommendations as well as the plans and specifications;
- all documentation of installation is completed; and
- the Geosynthetics CQA Representative's Final Report and Record Drawings, sealed by a Professional Engineer registered by the State of Illinois, have been received by the City.

4. GEOTEXTILE CONSTRUCTION QUALITY ASSURANCE

4.1 Design

A copy of the geotextile construction drawings and project specifications prepared by the Engineer will be given to the Geosynthetic CQA Representative. The Geosynthetic CQA Representative will review these items for familiarity. This review should not be considered as the peer review of the design. Peer review should have been conducted at an earlier stage.

4.2 Manufacturing

The Geotextile Manufacturer (Manufacturer) will provide the Project Manager with a list of certified "minimum average roll value" properties for the type of geotextile to be delivered. The Manufacturer will also provide the Project Manager with a written certification signed by a responsible representative of the Manufacturer that the materials actually delivered have "minimum average roll values" properties which meet or exceed all certified property values for that type of geotextile.

The Geosynthetic CQA Representative will examine all the Manufacturers' certifications to ensure that the property values listed on the certifications meet or exceed those specified for the particular type of geotextile. Any deviations will be reported to the Project Manager.

4.3 Labeling

The Manufacturer will identify all rolls of geotextile with the following:

- Geotextile Manufacturer's name;
- product identification;
- lot number;
- roll number;
- roll weight; and

- roll dimensions.

The Geosynthetic CQA Representative will examine rolls upon delivery and any deviation from the above requirements will be reported to the Project Manager.

4.4 Shipment and Storage

During shipment and storage, the geotextile will be protected from ultraviolet light exposure, precipitation or other inundation, mud, dirt, dust, puncture, cutting or any other damaging or deleterious conditions. To that effect, geotextile rolls will be shipped and stored in relatively opaque and watertight wrappings. The Geosynthetic CQA Representative will observe rolls upon delivery to the site and any deviation from the above requirements will be reported to the Project Manager. Any damaged rolls will be rejected and replaced at no cost to the Owner.

4.5 Conformance Testing

4.5.1 Tests

Upon delivery of the geotextile rolls, the Geosynthetic CQA Representative will ensure that samples are removed and forwarded to the Geosynthetic CQA Laboratory for testing to ensure conformance to both the design specifications and the list of guaranteed properties.

As a minimum, the following tests will be performed on geotextiles in accordance with the referenced ASTM Standards:

- mass per unit area (ASTM D 3776);
- grab strength (ASTM D 4632);
- tear strength (ASTM D 4533);
- burst strength (ASTM D 3786); and
- puncture strength (ASTM D 3787).

4.5.2 Sampling Procedures

Upon delivery of the geotextile rolls, the Geosynthetics CQA Representative will ensure that samples are obtained from individual rolls at the frequency specified in this CQA plan. The samples will be forwarded to the Geosynthetics CQA Laboratory for testing to ensure conformance to both the design specifications and the list of physical properties certified by the Manufacturer.

Samples will be taken across the entire width of the roll and will not include the first linear 3 ft (1 m). Unless otherwise specified, samples will be 3 ft (1 m) long by the roll width. The Geosynthetic CQA Representative will mark the machine direction on the samples with an arrow. Samples will be taken at a rate of one per manufactured lot or one per 100,000 ft^2 (9,300 m^2), whichever requires the greater number of samples.

4.5.3 Test Results

The Geosynthetic CQA Representative will examine all results from laboratory conformance testing and compare results to the project specifications. The criteria used to determine acceptability are presented in the Specifications. The Geosynthetic CQA Representative will report any nonconformance to the Project Manager.

4.5.4 Conformance Test Failure

The following procedure will apply whenever a sample fails a conformance test that is conducted by the Geosynthetic CQA Laboratory:

- The Manufacturer will replace every roll of geotextile that is in nonconformance with the specifications with a roll that meets specifications.

- The Installer will remove conformance samples for testing by the Geosynthetic CQA Laboratory from the closest numerical rolls on both sides of the failed roll. These two samples must conform to the specifications. If either of these samples fail, the numerically closest rolls on the side of the failed sample that is not tested, will be tested by the Geotextile CQA Laboratory. These samples must conform to the specifications. If any of these samples fail, every roll of geotextile on site from this lot and every subsequently delivered roll that is from the same lot must be tested by the Geosynthetic CQA Laboratory for conformance to the specifications. This additional conformance testing will be at the expense of the Manufacturer.

The Geosynthetics CQA Representative will document actions taken in conjunction with conformance test failures.

4.6 Handling and Placement

The Installer will handle all geotextiles in such a manner as to ensure they are not damaged in any way. The Installer will comply with the following:

- In the presence of wind, the geotextile will be weighted with sandbags or the equivalent. Sandbags will be used during installation only and will remain until replaced with the appropriate protective cover soils.

- The geotextile will be kept continually under tension to minimize the presence of wrinkles in the geotextile.

- The geotextile will be cut using an approved geotextile cutter only. If in place, special care must be taken to protect other materials from damage which could be caused by the cutting of the geotextile.

- The Installer will take any necessary precautions to prevent damage to the underlying VFPE geomembrane during placement of the geotextile.

- During placement of geotextile, care will be taken not to entrap stones, excessive dust, or moisture that could damage the geotextile, cause clogging, or hamper subsequent seaming.

- A visual examination of the geotextile will be carried out over the entire surface, after installation to ensure that no potentially harmful foreign objects are present.

The Geosynthetics CQA Representative will note any noncompliance and report it to the Project Manager.

4.7 Geotextile Seams and Overlaps

All geotextile seams will be sewn using thread approved by the Manufacturer and which is resistant to ultraviolet radiation. Spot sewing is not permitted. Thermal bonding is not permitted without written approval of the Engineer. Geotextiles shall be overlapped a minimum of 6 in. (150 mm) prior to seaming. No horizontal seams will be allowed on side slopes steeper than 20 percent (i.e. seams will be along, not across, slopes steeper than 5H:1V), except as part of a patch or for seams connecting the ends of two panels of geotextile deployed parallel to the slope (referred to as cross seams). Cross seams shall not be continuous across two or more panel widths.

4.8 Geotextile Repair

Any holes or tears in the geotextile will be repaired using a patch made from the same geotextile. Geotextile patches will extend a minimum of 1 ft (0.3 m) beyond the damaged area. Geotextile patches will be sewn into place no closer than 1 in. (25 mm) from any panel edge. Should any tear exceed 50 percent of the width of the roll, that roll will be removed from the slope and replaced. Care will be taken to remove any soil or other material which may have penetrated the torn geotextile.

The Geosynthetic CQA Representative will observe any repair, note any noncompliance with the above requirements and report them to the Project Manager.

4.9 Placement of Soil Materials

The Earthwork Contractor will place all soil materials located on top of a geotextile in such a manner as to ensure:

- no damage to the geotextile;
- minimal slippage of the geotextile on underlying layers; and
- no excess tensile stresses in the geotextile.

Any noncompliance will be noted by the Geosynthetic CQA Representative and reported to the Project Manager.

5. SOILS CONSTRUCTION QUALITY ASSURANCE

Soils CQA will be performed on all soil components used during construction of the final cover. The criteria to be used for the determination of acceptability of the construction work will be as identified in Table 5-1.

5.1 Monitoring

The Soils CQA Consultant will monitor and document the construction of all soils components. Monitoring the construction work includes the following:

- monitoring the quality of the material stockpiles, obtaining borrow soil samples for conformance testing;
- testing to determine the moisture content and unit weight of each lift during placement and compaction of soil used in construction of the foundation, low-permeability soil barrier, and vegetative layers;
- recording test results and locations;
- noting any deficiencies;
- monitoring the thickness of lifts as loosely placed and as compacted;
- monitoring that the total thickness of the foundation, low-permeability soil barrier, and vegetative layers is as indicated on the construction plans;

TABLE 5-1
SOILS FIELD AND LABORATORY TESTING SUMMARY
TITLE 27 FINAL COVER CONSTRUCTION
LOPEZ CANYON SANITARY LANDFILL

TEST METHOD	MINIMUM TESTING FREQUENCY	ACCEPTANCE CRITERIA
FOUNDATION AND VEGETATIVE LAYERS		
Grain Size Distribution (ASTM D 422)	1 test per 10,000 yd^3 (7,650 m^3)	Maximum particle size of 6 in.
Modified Proctor (ASTM D 1557)	1 test per 10,000 yd^3 (7,650 m^3)	N/A
In-Place Moisture/ Density Nuclear Method (ASTM D 2911)	1 test per 1,000 yd^3 (765 m^3)	Dry density no less than 90% of the max. dry density for the foundation layer, no less than 85% of the max dry density for the vegetative layer moisture content no less than the optimum moisture content, as measured by ASTM D 1557.
In-Place Moisture/Density Sand Cone Method (ASTM D 1556)	1 test per 10,000 yd^3 (7,650 m^3)	Dry density no less than 90% of the max. dry density for the foundation layer, no less than 85% of the max dry density for the vegetative layer moisture content no less than the optimum moisture content, as measured by ASTM D 1557.
LOW-PERMEABILITY SOIL BARRIER LAYER		
Grain Size Distribution (ASTM D 422)	1 test per 5,000 yd^3 (3,820 m^3)	Minimum fines content of 50%. Maximum particle size of 3 in. (75 mm).
Atterberg Limits (ASTM D 4318)	1 test per 5,000 yd^3 (3,820 m^3)	Criteria to be determined by Engineer prior to construction following test pad evaluation.
In-Place Moisture/ Density Nuclear Method (ASTM D 2911)	1 test per 250 ^{yd3} (190 m^3) Minimum of 4 tests per day	Criteria to be determined by Engineer prior to construction following test pad evaluation.
In-Place Moisture/Density Sand Cone Method (ASTM D 1556)	1 test per 2,500 yd^3 (1,900 m^3)	Criteria to be determined by Engineer prior to construction following test pad evaluation.
Modified Proctor (ASTM D 1557)	1 test per 5,000 yd^3 (3,820 m^3)	N/A
BAT Hydraulic Conductivity	1 test per 2,000 yd^3 (1,530 m^3)	Maximum saturated hydraulic conductivity of 1 x 10^{-6} cm/s based upon correlation between BAT test and in situ hydraulic conductivity from test pad.

- monitoring the action of the compaction and heavy hauling equipment on the construction surface (i.e., penetration, pumping, cracking, etc.); and

- monitoring the repair of nonconforming areas and testing perforations.

Monitoring the earthwork for the foundation layer specifically includes the following:

- monitor clearing, grubbing, and stripping of the existing interim cover surface;

- monitor the scarification of the interim cover surface to a depth of 6 to 8 in. (150 to 200 mm) and recompaction;

- reviewing documentation of quality control test results;

- visually monitoring the physical condition of the material during placement; and

- visually monitoring the foundation layer stability under the action of the compaction equipment.

Monitoring the earthwork for the compacted low-permeability soil barrier layer specifically includes the following:

- reviewing documentation of the quality control test results;

- monitoring the soil for deleterious material;

- monitoring moisture conditioning and preprocessing, if any, of the borrow soil material;

- monitoring the thickness of lifts during placement of the material;

- monitoring that the surface of each lift is scarified to a depth of 2 to 4 in. (50 to 100 mm) prior to placement of the following lift;

- recording the construction equipment used for material placement;

- performing BAT hydraulic conductivity tests and recording the test results and location;

- monitoring the protection of the final surface of the low-permeability soil barrier layer from excessive moisture loss prior to placement of the vegetative cover layer; and

- monitoring preparation and smoothness of the surface prior to the installation of the VLDPE geomembrane in 'C' Canyon.

Monitoring the earthwork for the vegetative layer specifically includes the following:

- reviewing documentation of the quality control test results;

- monitoring soil for deleterious material;
- monitoring the thickness of lifts during placement of the materials;

- monitoring wrinkles that may appear in the underlying geotextile cushion on VLDPE geomembrane during placement of the vegetative layer in 'C' Canyon; and

- recording field density and field moisture content measurement at location of each test on test logs.

5.2 Laboratory and Field Tests

The laboratory and field test methods, laboratory and field testing frequencies, and criteria used to determine acceptability are presented in Table 5-1. A special testing frequency will be used at the discretion of the Landfill Engineer or the Soils CQA Consultant when visual observations of construction performance indicate a potential or recurring deficiency.

5.3 Survey

The top of the low-permeability soil barrier shall be surveyed before the installation of the immediately overlying vegetative cover layer. The thickness of the low-permeability soil barrier shall be determined by comparing the survey of the finished foundation layer and the top of the low-permeability soil barrier layer.

5.4 Deficiencies

5.4.1 General

If a defect is discovered in the earthwork product, the Soils Site Monitor will immediately inform the Soils CQA Managing Engineer or his designated representative. The Soils Site Monitor, in consultation with the Soils CQA Managing Engineer, will determine the extent and nature of the defect. If the defect is indicated by an unsatisfactory test result, extent of the deficient area will be determined by additional tests, observations, a review of records, or other means that the Soils CQA Managing Engineer deems appropriate.

If the defect is related to adverse site conditions, such as overly wet soils or surface desiccation, the Soils Site Monitor, in consultation with the Soils CQA Managing Engineer, will define the limits and nature of the defect.

5.4.2 Notification

After determining the extent and nature of a defect, the Soils CQA Site Manager will notify the Landfill Engineer and Landfill Manager and schedule appropriate retests when the work deficiency is to be corrected.

5.4.3 Corrective Action

At locations where the field testing of the soil indicates that the compacted unit weight, moisture content, or field or laboratory hydraulic conductivities do not meet the requirements presented in Table 5-1, the failing area will be reworked as indicated below:

- If the results of any in-situ moisture or dry density, or field hydraulic conductivity value fails to meet the specified criteria presented in Table 5-1, two additional tests of the same type will be performed in the vicinity of the failed test. If either of the two additional tests results in a failure, then this area of the low-permeability soil barrier will be considered in nonconformance and will be removed, reworked, and recompacted to meet the requirements specified in Table 5-1.

- Perform in-place density and moisture content testing in the vicinity of a nonconforming area to evaluate deficiency in-place density and moisture content.

- Obtain samples of low-permeability soil liner material from nonconforming areas for potential laboratory testing to evaluate differences in soil properties that could contribute to the nonconforming test results.

Criteria to be used for determination of acceptability will be as identified herein. Other tests conducted on hydraulic conductivity samples will consist of Atterberg limits and grain size distribution.

5.4.4 Repairs and Retesting

The City's work force will correct the deficiency to the satisfaction of the Soils CQA Consultant. If a project specification criterion cannot be met, or unusual weather conditions hinder work, then the Soils CQA Consultant will develop and present to the Landfill Engineer suggested solutions for approval.

All retests recommended by the Soils CQA Consultant must verify that the defect has been corrected before any additional work is performed by the City's work force in the area of the deficiency. The Soils CQA Consultant will also verify that all installation requirements are met.

Penetrations into the compacted low-permeability soil barrier resulting from sampling or other activities shall be properly backfilled with hand-tamped select low-permeability material and/or bentonite powder. CQA personnel will repair nuclear density, sand cone, and BAT hole perforations. The City's work force shall repair perforations and/or excavations resulting from CQA sampling and testing. All repairs will be inspected by the Site Soils Monitor for compliance.

6. GEOSYNTHETIC CLAY LINER (GCL) QUALITY ASSURANCE

During the installation of the GCL, the CQA CONSULTANT will monitor and document that material handling and storage, deployment, seaming, anchoring and protection, and repairs are in conformance with the Contract Drawings and the Technical Specifications. The Site CQA Manager will review the Geosynthetics CONTRACTOR's submittals and provide recommendations to the OWNER. Monitoring activities will be documented, as will all deviations from the Contract Drawings and the Technical Specifications, and their resolutions. Any nonconformance identified by the CQA CONSULTANT will be reported to the OWNER and the Geosynthetics Contractor. The GCL CQA activities are described in greater detail in the following sections.

6.1 Geosynthetic Clay Liner (GCL) Conformance Testing

CQA personnel will sample the GCL at the manufacturer's plant and/or after delivery to the construction site. The samples will be forwarded to the Geosynthetics CQA Laboratory for testing to assess conformance with the Technical Specifications. The test methods and minimum testing frequencies are indicated in Table 6-1.

Samples will be taken across the entire width of the roll and will not include the first 3 ft (0.9 m) if the sample is cut onsite. Unless otherwise specified, samples will be 3 ft (0.9 m) long by the roll width. The CQA CONSULTANT will mark the machine direction with an arrow and the manufacturer's roll number on each sample.

6.2 GCL Delivery and Storage

Upon delivery to the site, the CQA CONSULTANT will check the GCL rolls for defects (e.g., tears, holes) and for damage. The CQA CONSULTANT will report to OWNER and the Geosynthetics CONTRACTOR:

- any rolls, or portions thereof, which should be rejected and removed from the site because they have severe flaws; and

- any rolls which include minor repairable flaws.

The GCL rolls delivered to the site will be checked by the CQA CONSULTANT to ensure that the roll numbers correspond to those on the approved manufacturer's quality control certificate of compliance.

6.3 GCL Installation

The CQA CONSULTANT will monitor and document that the GCL is installed in accordance with the Contract Drawings and the Technical Specifications. The Geosynthetics CONTRACTOR shall provide the CQA CONSULTANT a certificate of subgrade acceptance prior to the installation of the GCL as outlined in the Technical Specifications. The GCL installation activities to be monitored and documented by the CQA CONSULTANT include:

- monitoring that the GCL rolls are stored and handled in a manner which does not result in any damage to the GCL;

- monitoring that the GCL is not exposed to UV radiation for extended periods of time without prior approval;

- monitoring that placement and compaction of soil does not cause damage, create large wrinkles, or induce excessive tensile stresses to the GCL;

- monitoring that the GCL are seamed in accordance with the Technical Specifications and the manufacturer's recommendations;

- monitoring and documenting that the GCL is installed on an approved subgrade, free of debris, protrusions, or uneven surfaces;

- monitoring that no needles are in the GCL or bentonite powder using a metal detector;

- monitoring that the GCL is not installed on a saturated subgrade or standing water and is not exposed such that it is hydrated prior to completion of the side-slope liner system; and

- monitoring that any damage to the GCL is repaired as outlined in the Technical Specifications.

7. MONOLITHIC SOIL COVER CONSTRUCTION QUALITY ASSURANCE

7.1 General

Soils CQA will be performed on all soil components used during construction of the monolithic soil final cover. The criteria to be used for the determination of acceptability of the construction work will be as identified in Table 7-1.

7.2 Monitoring

The Soils CQA Consultant will monitor and document the construction of all soils components. Monitoring the construction work includes the following:

- monitoring the quality of the material stockpiles, obtaining borrow soil samples for conformance testing;
- testing to determine the moisture content and unit weight of each lift during placement and compaction of soil used in construction of the foundation, and monolithic soil layers;
- recording test results and locations;
- noting any deficiencies;
- monitoring the thickness of lifts as loosely placed and as compacted;
- monitoring that the total thickness of the foundation and monolithic soil layers is as indicated on the construction plans;
- monitoring the action of the compaction and heavy hauling equipment on the construction surface (i.e., penetration, pumping, cracking, etc.); and
- monitoring the repair of nonconforming areas and testing perforations.

TABLE 7-1
SOILS FIELD AND LABORATORY TESTING SUMMARY
MONOLITHIC SOIL FINAL COVER
LOPEZ CANYON SANITARY LANDFILL

TEST METHOD	MINIMUM TEST FREQUENCY	ACCEPTANCE CRITERIA
In-Place Moisture/Density Nuclear Method (ASTM D 2911)	1 per 1,000 yd^3	Dry density no less than 90% of the maximum dry density. Moisture content within ±2 percent of optimum moisture content
Standard Proctor Compaction Test (ASTM D 698)	1 per 10,000 yd^3 (7,650 m^3)	N/A
In-Place Density and Moisture Content (Sand-Cone) (ASTM D 1556)	1 per 10,000 yd^3 (7,650 m^3)	Dry density no less than 90% of the maximum dry density. Moisture content within ±2 percent of optimum moisture content
Particle Size Analysis (ASTM D 422)	1 per 5,000 yd^3 (3,825 m^3)	No particle greater than 4 inches at least 25 percent passing No. 200 sieve
Atterberg Limits (ASTM D 4318)	1 per 5,000 yd^3 (3,825 m^3)	Plasticity Index less than 15
Laboratory Permeability (ASTM D 5084)	1 per 10,000 yd^3 (7,650 m^3)	Hydraulic Conductivity no greater than 1×10^{-5} cm/sec

Note: Since Atterberg Limit and grain-size distribution testing will be performed on representative materials during processing of stockpile materials, additional tests will be conducted only on materials obtained for laboratory permeability analysis.

Monitoring the earthwork for the foundation layer specifically includes the following:

- monitor clearing, grubbing, and stripping of the existing interim cover surface;
- monitor the scarification of the interim cover surface to a depth of 6 to 8 in. (150 to 200 mm) and recompaction;
- reviewing documentation of quality control test results;
- visually monitoring the physical condition of the material during placement; and
- visually monitoring the foundation layer stability under the action of the compaction equipment.

Monitoring the earthwork for the monolithic soil layer specifically includes the following:

- reviewing documentation of the quality control test results;
- monitoring soil for deleterious material;
- monitoring the thickness of lifts during placement of the materials; and
- recording field density and field moisture content measurement at location of each test on test logs.

7.3 Laboratory and Field Tests

The laboratory and field test methods, laboratory and field testing frequencies, and criteria used to determine acceptability are presented in Table 6-1. A special testing frequency will be used at the discretion of the Landfill Engineer or the Soils CQA Consultant when visual observations of construction performance indicate a potential or recurring deficiency.

TABLE 6-1
GEOSYNTHETIC CLAY LINER CONFORMANCE TESTING

PROPERTY	TEST METHOD	MINIMUM TESTING FREQUENCY
Dry Mass per Unit Area	ASTM D 3776	40,000 ft^2 (3,715 m^2) or one per lot(2)
Puncture Strength, Unhydrated GCL	ASTM D 4833	40,000 ft^2 (3,715 m^2) or one per lot(2)
Bentonite Free Swell	USP NF XVII	40,000 ft^2 (3,715 m^2) or one per lot(2)
Hydraulic Conductivity(1)	ASTM D 5084	100,000 ft^2 (9,290 m^2) or one per lot(2)

Notes: (1) Performed at a confining stress of 5 psi.
(2) A lot is defined as a series of consecutively numbered rolls from the same manufacturing line.

7.4 Survey

The top of the monolithic soil layer shall be surveyed immediately following the installation end of construction. The thickness of the monolithic soil layer shall be determined by comparing the survey of the finished foundation layer and the top of the monolithic soil layer.

7.5 Deficiencies

7.5.1 General

If a defect is discovered in the earthwork product, the Soils Site Monitor will immediately inform the Soils CQA Managing Engineer or his designated representative. The Soils Site Monitor, in consultation with the Soils CQA Managing Engineer, will determine the extent and nature of the defect. If the defect is indicated by an unsatisfactory test result, extent of the deficient area will be determined by additional tests, observations, a review of records, or other means that the Soils CQA Managing Engineer deems appropriate.

If the defect is related to adverse site conditions, such as overly wet soils or surface desiccation, the Soils Site Monitor, in consultation with the Soils CQA Managing Engineer, will define the limits and nature of the defect.

7.5.2 Notification

After determining the extent and nature of a defect, the Soils CQA Site Manager will notify the Landfill Engineer and Landfill Manager and schedule appropriate retests when the work deficiency is to be corrected.

7.5.3 Corrective Action

At locations where the field testing of the soil indicates that the compacted unit weight, moisture content, or laboratory hydraulic conductivities do not meet the requirements presented in Table 6-1, the failing area will be reworked as indicated below:

- If the results of any in-situ moisture or dry density, or field hydraulic conductivity value fails to meet the specified criteria presented in Table 6-1, two additional tests of the same type will be performed in the vicinity of the failed test. If either of the two additional tests results in a failure, then this area will be considered in nonconformance and will be removed, reworked, and recompacted to meet the requirements specified in Table 6-1.
- Perform in-place density and moisture content testing in the vicinity of a nonconforming area to evaluate deficiency in-place density and moisture content.
- Obtain samples of soil material from nonconforming areas for potential laboratory testing to evaluate differences in soil properties that could contribute to the nonconforming test results.

Criteria to be used for determination of acceptability will be as identified herein. Other tests conducted on hydraulic conductivity samples will consist of Atterberg limits and grain size distribution.

7.5.4 Repairs and Retesting

The City's work force will correct the deficiency to the satisfaction of the Soils CQA Consultant. If a project specification criterion cannot be met, or unusual weather conditions hinder work, then the Soils CQA Consultant will develop and present to the Landfill Engineer suggested solutions for approval.

All retests recommended by the Soils CQA Consultant must verify that the defect has been corrected before any additional work is performed by the City's work force in the area of the deficiency. The Soils CQA Consultant will also verify that all installation requirements are met.

Penetrations into the compacted low-permeability soil barrier resulting from sampling or other activities shall be properly backfilled with hand-tamped select low-permeability material and/or bentonite powder. CQA personnel will repair nuclear density and sand cone hole perforations. The City's work force shall repair perforations and/or excavations resulting from CQA sampling and testing. All repairs will be inspected by the Site Soils Monitor for compliance.

APPENDIX J

PROPOSED ENGINEERED ALTERNATIVE FINAL COVER ON THE SLOPES OF DISPOSAL AREAS A AND AB+ AND THE DECKS OF DISPOSAL AREAS A, B AND AB+

ALTERNATIVE FINAL COVER WATER BALANCE ANALYSIS DECK OF DISPOSAL AREAS A, B, AND AB+ SLOPES OF DISPOSAL AREA A AND AB+ LOPEZ CANYON SANITARY LANDFILL LAKEVIEW TERRACE, CALIFORNIA

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APPENDICES

1. INTRODUCTION

1.1 Terms of Reference

This report presents a technical evaluation of the infiltration control performance of a monolithic soil cover for the decks of Disposal Areas A, B, and AB+ and the slopes of Disposal Areas A and AB+ at the Lopez Canyon Sanitary Landfill. The Lopez Canyon Sanitary landfill is an inactive California Class III municipal solid waste landfill located in the Lake View Terrace section of the City of Los Angeles, California. This report was prepared by the Huntington Beach, California office of GeoSyntec Consultants (GeoSyntec) for the City of Los Angeles Bureau of Sanitation (BOS).

This report was prepared at the request of Mr. Kelly Gharios, P.E., of BOS. The scope of services included in this report is described in the memoranda entitled Cost Estimate and Schedule for Engineering Services. Engineered Alternative Final Cover, Disposal Areas A, B, and AB+ Decks and Disposal Area AB+ Slopes, Lopez Canyon Restoration Project, dated 11 December 1997, and Cost Estimate for Engineering Services. Evaluation of Existing Soil Cover as a Monolithic Soil Final Cover on the Slopes of Disposal Area A. Lopez Canyon Restoration Project, dated 11 March 1998 from Edward Kavazanjian. Jr. and Tarik Hadj-Hamou of GeoSyntec to Mr. Gharios. The work presented in this report was performed under the GeoSyntec contract with BOS for engineering services in support of the Lopez Canyon Restoration project.

This report was prepared by Mr. Michael Reardon, Ms. Colleen Caldwell, and Dr. Tarik Hadj-Hamou, P.E., all of GeoSyntec. This report was reviewed by Dr. Edward Kavazanjian. Jr., P.E., G.E., also of GeoSyntec in accordance with the peer review policy of the firm.

1.2 Project Overview

The Lopez Canyon Sanitary Landfill is an inactive California Class III municipal solid waste landfill which is owned and was operated by the City of Los

Angeles (the City) Bureau of Sanitation (BOS). The Lopez Canyon Sanitary Landfill received waste from the mid-1970's until 1 July 1996. The Lopez Canyon Sanitary Landfill is located in the Lake View Terrace section of the City. The site location is shown in Figure 1-1.

The Lopez Canyon Sanitary Landfill covers approximately 399 acres (162 ha) of which 162 acres (65.6 ha) are designated for landfilling. The Lopez Canyon Sanitary landfill is divided into four disposal areas known as Disposal Areas A, B, AB+, and C. In order to accommodate closure of the slopes of Disposal Areas A and B in advance of final closure of the remaining disposal areas, the Final Closure Plan (FCP) [BAS, 1993] proposed that the closure of Lopez Canyon Sanitary Landfill be accomplished in two phases. Phase I closure includes the slopes of Disposal Areas A and B. Construction is currently underway on Phase I closure. Phase II closure includes the decks of Disposal Areas A, B, AB+, and C and the slopes of Disposal Areas AB+ and C. Phase II closure construction has yet to begin.

The currently proposed final cover for the decks of Disposal Areas A, B, AB+, and C and the slopes of Disposal Areas AB+ and C is described in *Final Closure Plan, Lopez Canyon Sanitary Landfill, Lakeview Terrace, Volume IV of IV, Replacement Amendment to Final Closure Plan [GeoSyntec, 1996]* and *Revision to Volume IV of IV, Replacement Amended to Final Closure Plan* [Bureau of Sanitation, 1997]. The currently proposed final cover on the decks of Disposal Areas A, B, and AB+ and the slopes of Disposal Areas A and AB+ consist of the following components (from top to bottom):

- a vegetative layer at least 24-in. (600-mm) thick;
- a barrier layer composed of either compacted low-permeability soil with a hydraulic conductivity no greater than 1×10^{-6} cm/sec 12-in. (300-mm) thick or a geosynthetic clay liner (GCL); and
- a foundation layer at least 24-in. (600-mm) thick.

This currently proposed final cover meets or exceeds the prescriptive requirements of Section 21090(a) of Title 27 of the California Code of Regulation (27 CCR) for final covers. If compacted low-permeability soil is used as the barrier layer, the proposed cover conforms to the prescriptive requirements of 27 CCR. The use of a GCL as the barrier layer constitutes an engineered alternative to the prescriptive final cover.

State regulations provide explicit criteria that must be satisfied for approval of engineered alternatives to the prescriptive final cover in Section 20080(b) of 27 CCR. The objective of this report is to demonstrate that a monolithic soil cover is an engineered alternative that satisfies state regulations for the final cover at municipal waste landfill facilities with respect to infiltration resistance. The engineering evaluation conducted by GeoSyntec to demonstrate that a monolithic soil cover is an acceptable engineered alternative to the prescriptive final cover with respect to infiltration resistance include:

- reviewing federal and state requirements for final cover design;

- selecting an analytical model to compare the infiltration performance of the Title 27 prescriptive cover to that of the monolithic soil cover proposed as an engineered alternative;

- evaluating the geotechnical characteristics of the existing interim soil cover on the decks of Disposal Areas A, B, and AB+ and the slopes of Disposal Areas A and AB+; and

- evaluating and comparing the performance of both the existing interim soil cover and a layer of compacted soil placed for the specific purpose of serving as an engineered monolithic soil cover to the Title 27 prescriptive soil cover for the site-specific conditions at the Lopez Canyon Sanitary Landfill.

- developing a performance evaluation program for the proposed monolithic soil cover, including details of the instrumentation, the monitoring frequency, and the performance evaluation methodology.

The analyses presented in this report demonstrate that the infiltration control performance of a monolithic soil cover on the decks of Disposal Areas A, B, and AB+ and the slopes of Disposal Areas A and AB+ can exceed the infiltration control performance of the Title 27 prescriptive cover if the monolithic soil cover has the appropriate hydraulic properties. As a monolithic soil cover can be shown to be equally effective as the prescriptive cover with respect to other final cover functions (e.g., waste isolation, erosion control), it may therefore be concluded that a monolithic soil cover with the appropriate hydraulic properties is an acceptable engineered alternative for the final cover on the decks of Disposal Areas A, B, and AB+ and the slopes of Disposal Areas A and AB+ at the Lopez Canyon Sanitary Landfill.

Analyses presented in this report indicate that the existing interim cover soil on the slopes of Disposal Area A are likely to have the appropriate hydraulic properties to serve as a monolithic soil final cover. A performance monitoring plan is provided to demonstrate that the existing interim soil cover provides satisfactory infiltration control. The analyses presented in this report also indicate that the existing interim soil cover on the decks of Disposal Areas A, B, and AB+ and on the slopes of Disposal Area AB+ do not have the appropriate hydraulic properties to serve as a monolithic soil final cover. Recommendations are provided for procurement of soil with the appropriate properties for use as a monolithic soil final cover in these areas. A monitoring program for implementation after placement of the procured soil is also provided herein to demonstrate that the infiltration performance of the monolithic soil cover exceeds that of the Title 27 prescriptive cover in these areas.

1.3 Report Organization

The remainder of this report is organized as follows:

- Section 2, *Background Information*, provides general background information regarding the Lopez Canyon Sanitary Landfill.

- Section 3, *Alternative Final Cover Requirements*, presents the relevant state and federal regulatory requirements and the proposed alternative final cover configuration.

- Section 4, *Water Balance Analysis*, describe the water mass balance equation and discusses the component of the equation. The section also describes the LEACHM computer program used to model infiltration through the alternative and prescriptive final covers and the input data required for the analyses. This section also presents the weather data selected for use in evaluating cover performance at the Lopez Canyon Sanitary Landfill.

- Section 5, *Geotechnical Evaluation of Existing Conditions*, describes the geotechnical field and laboratory investigation programs performed to assess the geotechnical characteristics of the existing interim soil cover on the decks of Disposal Areas A, B, and AB+ and the slopes of Disposal Areas A and AB+.

- Section 6, *Monolithic Soil Final Cover Evaluation*, presents the infiltration control performance evaluation for the existing interim cover soil and of a layer of additional soil placed as a monolithic soil cover on the decks of Disposal Areas A, B, and AB+ and on the slopes of Disposal Areas A and AB+. This section also presents a comparison of the infiltration control performance of the Title 27 prescriptive cover to the existing interim cover and to an engineered monolithic soil cover at the Lopez Canyon Sanitary Landfill.

- Section 7, *Performance Evaluation Program*, presents recommendations for instrumentation and performance monitoring of the monolithic soil cover and the performance evaluation methodology.

- Section 8, *Summary and Recommendations*, summarizes the work described in the report and presents GeoSyntec's recommendations with respect to the use of a monolithic soil cover as an engineered alternative final cover for the decks of Disposal Areas A, B, and AB+ and the slopes of Disposal Areas A and AB+ at the Lopez Canyon Sanitary Landfill.

Tables, figures, and appendices are included at the end of this report.

2. BACKGROUND INFORMATION

2.1 General

The Lopez Canyon Sanitary Landfill is owned by the City of Los Angeles and is located at 11950 Lopez Canyon Road in Lakeview Terrace, California. The Lopez Canyon Sanitary Landfill received waste from mid-1970's until it closed on 1 July 1996. Closure construction work at Lopez Canyon Sanitary Landfill started on the slopes of Disposal Areas A and B on 7 July 1996. As of 31 December 1997, 17 acres of the slopes of Disposal Area B have been closed in accordance with the prescriptive requirements.

2.2 Climate

The Lopez Canyon Sanitary Landfill is located within, but on the margin of, the Los Angeles basin. The Los Angeles basin area climate can best be described as relatively mild, with cool, wet winters and warm, dry summers, both moderated by sea breezes. This climatic pattern is caused by a semi-permanent high pressure system from the eastern Pacific Ocean. During the summer months, this high pressure system is generally located in a northern position and prevents storms from moving across the region.

The climate in the area of the Lopez Canyon Sanitary Landfill is characterized as semi-arid. The 100-year mean rainfall in the vicinity of the site is approximately 16 in. (406 mm). This precipitation falls predominately during the winter months (November through March). Typical daily high temperatures for the area range from approximately 60° F (15.5° C) in the winter to 95° F (35° C) in the summer. Typical daily low temperatures for the area range from approximately 40° F (4.5° C) in the winter to 60° F (15.5° C) in the summer.

2.3 Existing Conditions

The Lopez Canyon Sanitary Landfill is divided into four disposal areas, denoted as Disposal Areas A, B, AB+, and C. The limits of these four disposal areas are shown in Figure 2-1. Closure construction has already commenced on the slopes of Disposal Areas A and B. The final cover in these areas is the prescriptive final cover contained in California Title 27 regulations and is composed of a 2-ft (0.6-m) vegetative soil layer underlain by 1 ft (0.3 m) of low-permeability soil with a hydraulic conductivity less than or equal to 1×10^{-6} cm/s underlain by a foundation soil layer at least 2 ft (0.6 m) thick. The final closure plan currently calls for the decks of Disposal Areas A, B, and AB+ and the slopes of Disposal Areas A and AB+ to be covered with either the same final cover as the slopes of Disposal Areas A and B (i.e., the Title 27 prescriptive final cover) or an alternative final cover that uses a GCL composed of 0.25 in. (6.25 mm) of bentonite soil with a saturated hydraulic conductivity less than or equal to 5×10^{-9} cm/s in lieu of the 1-ft (0.3-m) layer of compacted low-permeability soil. The infiltration resistance of the GCL has been shown to be superior to that of the prescriptive clay barrier layer in satisfaction of the regulatory requirements for an alternative final cover.

The decks of Disposal Areas A, B, and AB+ and the slopes of Disposal Areas A and AB+ are currently covered with an interim soil cover. Test pits excavated on the existing interim cover on the slopes of Disposal Areas A and AB+ and on the decks of Disposal Areas A, B, and AB+ indicate that the thickness of the existing interim cover in these areas ranges from a minimum of 2 ft (0.6 m) to over 18 ft (5.5 m).

2.4 Proposed Alternative Cover

Monolithic soil covers are being used with increasing frequency in southern California as an alternative to the Title 27 prescriptive cover for California Class III municipal solid waste landfills. The increasing popularity of the monolithic soil cover can be attributed to both lower cost and superior performance. The monolithic soil cover alternative is cheaper than the prescriptive final cover because the monolithic soil cover is generally cheaper to procure, is cheaper and easier to construct, and is cheaper to maintain and repair. The performance of the monolithic soil cover, if properly configured, is superior to that of the Title 27 prescriptive soil cover because, in the semi-arid to arid southern California climate, it can have superior infiltration resistance and it is less susceptible to degradation (e.g., cracking during and after construction from desiccation and/or differential settlement). Due to the potential for enhanced performance at a lower cost, the BOS requested that GeoSyntec perform the analyses described herein to determine the range of soil properties and cover thicknesses within which the infiltration resistance of the monolithic soil cover exceeds that of the Title 27 prescriptive cover at the Lopez Canyon Landfill.

3. ALTERNATIVE FINAL COVER REQUIREMENTS

3.1 Regulatory Considerations

3.1.1 Federal Regulations

The federal regulations for closure of municipal solid waste landfills are found in Section 258.60 of 40 CFR Subpart F - Closure and Post Closure (Subtitle D). The federal regulations provide that the final cover of a municipal solid waste landfill shall:

- be designed to minimize percolation and erosion;
- include a barrier layer with a minimum thickness of 18 in., a maximum permeability (saturated hydraulic conductivity) of 1×10^{-5} cm/s, and a permeability less than or equal to the bottom liner system and natural subsoils present; and
- include an erosion layer, a minimum of 6-in. thick, capable of sustaining native plant growth.

The federal regulations allow the director of an approved state, such as California, to approve an alternative design to the prescriptive final cover design provided that the performance of the barrier layer and erosion layer are shown to be equivalent or superior to the performance of the prescribed layers with respect to percolation and wind and water erosion.

3.1.2 State Regulations

The state of California regulations for design and construction of final covers for closure of municipal solid waste landfills are found in Title 27 of the California Code of Regulations (27 CCR). These are the same regulations formerly contained in 14 CCR and 23 CCR.

Section 21090(a) of 27 CCR, provides the following requirements for the final cover, called herein the "Title 27 prescriptive cover":

- a foundation layer of at least 2 ft, unless the Regional Board finds that differential settlement of the waste and ultimate land use allow for a lessor thickness without impacting the integrity of the cover;

- a "low hydraulic-conductivity" layer not less than one-foot thick with a minimum permeability of 1×10^{-6} cm/s and a permeability equal to or less than any bottom liner or underlying natural materials;

- a vegetative layer containing no waste or leachate, placed on top of the barrier layer, not less than one foot and of greater thickness than the rooting depth of any vegetation planted on the cover; and

- design and construction which provides for the minimum maintenance possible.

State regulations also allow engineered alternatives to the Title 27 prescriptive cover. Criteria are provided for both Regional Water Quality Control Board (RWQCB) and California Integrated Waste Management Board (CIWMB) approval of an engineered alternative final cover. Sections 20080(b) and (c) of Title 27 provide the criteria for approval of an engineered alternative by the RWQCB. These criteria are:

- The prescriptive standard is not feasible because it is unreasonable and unnecessarily burdensome and will cost substantially more than alternatives which meet criteria, or the prescriptive standard is not feasible because it is impractical and will not promote attainment of applicable performance standards; and

- There is a specific engineered alternative that is consistent with the performance goal of the prescriptive standard and affords equivalent protection against water quality impairment.

Section 21140 of 27 CCR provides criteria for CIWMB approval. This section allows for alternative covers provided the design will function with minimum maintenance and provide waste containment to protect public health and safety by controlling at a minimum, vectors, fire, odor, liter and landfill gas migration. The alternative final cover shall also be compatible with post-closure land use.

It should be noted that the RWQCB and CIWMB have already approved an alternative final cover for the decks of Disposal Areas A, B, and AB+ in which a GCL is used in lieu of the low hydraulic conductivity layer of the Title 27 prescriptive cover on the basis of superior infiltration resistance.

3.2 Proposed Alternative Final Cover Configuration

The monolithic soil final cover is an engineered alternative final cover which has been previously approved by the RWQCB for other sites in the region on a conditional basis. The monolithic soil cover design concept utilizes a single layer of soil several feet thick to serve the combined functions of the vegetative layer and the barrier layer in the Title 27 prescriptive cover. The monolithic soil cover is typically vegetated with native plants that live on the natural seasonal precipitation. The monolithic soil cover controls infiltration by the following mechanism: rain water percolates into the monolithic soil cover and is stored by capillary tension in the soil until removed by evaporation and transpiration. The monolithic soil cover must have sufficient storage capacity to retain the infiltrating water until the storage capacity of the soil is restored by evaporation. The conditional approvals granted to date by the RWQCB have required performance monitoring of monolithic soil covers after construction to demonstrate their effectiveness.

3.3 Technical Approach for Demonstrating Compliance

Monolithic soil covers have been approved as alternative final covers on the following basis. There is essentially no difference between the erosion resistance of a monolithic soil cover and the Title 27 prescriptive cover. Furthermore, in arid and semi-arid environments, the ability of the Title 27 prescriptive cover to control infiltration may be impaired due to desiccation and cracking due to differential settlement. This cracking may result in a diminished ability of the Title 27 prescriptive cover to attain the applicable performance standard. The monolithic soil cover will also be less expensive to construct and should require less maintenance than the Title 27 prescriptive cover. Therefore, if the infiltration control performance of a monolithic soil cover in the semi-arid climate of the Lopez Canyon Sanitary Landfill can be shown equivalent or superior to the infiltration control performance of the Title 27 prescriptive cover under the as-designed conditions, the monolithic soil cover may be said to afford superior protection against water quality impairment and the monolithic soil cover should be acceptable as an engineered alternative final cover per the governing regulations.

The technical approach used to demonstrate that a monolithic soil cover performs as well or better than a Title 27 prescriptive cover with respect to infiltration control consists of water balance analyses of the two final cover concepts under similar, representative climate conditions. The water balance analyses are used to show that the percolation through a monolithic soil cover is less than the percolation through a Title 27 prescriptive cover for the climatic conditions found at the landfill site. The technical approach includes the following steps:

- Selection of a Water Balance Model.
- Evaluation of Material Properties.
- Evaluation of Climate Data.
- Evaluation of the Vegetation Properties.
- Monolithic Soil Cover Design.
- Water Balance Evaluation and Comparison.
- Instrumentation and Monitoring of Monolithic Soil Cover.
- Calibration of Water Balance Model.
- Final Water Balance Evaluation and Comparison.

The nine steps of the above technical approach are employed in the remainder of this report.

4. WATER BALANCE ANALYSIS

4.1 Introduction

The water balance analysis presented in this report uses an unsaturated flow computer code. The computer code employs a mass balance finite difference based approach to predict unsaturated flow. A description of the components of the mass balance equation used in the computer code is presented in Section 4.2. Details of the computer code and specific input used in the computer simulations are provided in Section 4.3.

4.2 Water Balance Equation

The computer code used in the analyses presented in this report employs a mass balance finite difference based calculation to track infiltration (percolation) through the cover. The mass balance equation presented below represents the conceptual approach taken by the computer model in predicting the hydrologic performance of the final cover system.

Water Balance Equation:

$$Perc = P - Of - \Delta S - (E+T)$$

Where: Perc = Percolation that has passed through the cover,
P = Precipitation falling on the cover,
Of = Overland flow, or precipitation runoff,
ΔS = Change in soil storage of infiltration,
E = Evaporation, and
T = Transpiration of vegetation.

The following sections define the various components of the mass balance equation, and how they may affect an earthen cover system performance.

4.2.1 Percolation

Percolation is the result of the mass balance calculation. Percolation is defined as the quantity of water, typically expressed as volume per unit time, that exits the base or bottom layer of the cover system. Water that enters, or infiltrates the cover but does not exit the cover is termed infiltration. Percolation may consist of water that either infiltrates the cover by rainfall, snowmelt or that is released from the cover soil storage component. Water is released from soil storage when the soil is placed at a water contents higher than the soils natural equilibrium water content with the atmosphere.

4.2.2 Precipitation

Precipitation, for purposes of this report, is defined as rainfall that lands on the cover surface. (In areas of colder climates the water equivalent of snowfall must also be included.) Of significance to an earthen cover's hydraulic performance is both the total magnitude and distribution of precipitation.

4.2.3 Overland Flow

Overland flow is defined as precipitation that falls on the cover but does not infiltrate. There is a maximum rate at which a soil profile can absorb water. When the rate of precipitation exceeds this maximum rate, overland flow is generated.

4.2.4 Soil Storage

Soil storage is defined as the volume of water that is held in the pore spaces of the soil. A change in soil storage corresponds to a change in soil water content. The maximum storage capacity of a soil is the storage capacity at saturation. The soil may approach saturation, and thus the storage capacity of soil may become depleted, with repeated rainfall events. A period of dry weather may restore the storage capacity of the soil. The water contained in a soil layer can move downward as percolation driven by the unsaturated hydraulic conductivity and potential gradient present in the soil. Water contained in a soil layer can be removed by evaporation and transpiration. Upward movement is also driven by suction gradients created in the soil when a lower moisture content exists at an upper depth, usually created by evaporative or transpirative losses. All of these water movements can affect soil storage capacity (i.e., change the water content of the soil).

4.2.5 Evaporation

For the purposes of this report, evaporation is defined as water held in soil storage that is converted from the liquid to the gas phase. The energy required for the phase change comes primarily from solar radiation and the relative humidity of the atmospheric air above the soil cover. Comparatively, evaporative losses from the upper soil layers are greater in dry, warm, sunny days, than on cloudy, rainy, or cool days. Evaporation is a factor in restoring soil cover storage. Water lost from the soil layers by evaporation combined with the water losses from plants (transpiration) is termed evapotranspiration. The following section discusses transpiration.

4.2.6 Transpiration

Water lost due to the action of plants on the soil cover is termed transpiration. Water flows through the plant, from the soil to the air, along a gradient of decreasing water potential. The water movement through the plant is driven a potential gradient created by solar powered evaporation at the leaf surface, which maintains a low water potential in leaves. This potential gradient enables roots to extract water from the soil in proportion to their rooting depth during the daylight hours. Cohesion and adhesion of water molecules to holds the microscopic water column inside the plant stems together.

The gradients that are created by evaporation at the leaf surface are only strong enough to extract water at a certain maximum soil suction. The soil suction at which plant roots can no longer extract water is termed the wilting point. The roots of a plant must also exert a suction themselves to prevent water loss from the root to the soil if the soil dries and the soil suction becomes less than the wilting point. A minimum root water potential less than the wilting point is created by osmotic suctions in the root cells to prevent these losses. Roots also become less efficient in the uptake of water at greater depths due to a decrease in the driving gradient. A root resistance factor, with a value greater than one, approximates this occurrence. Transpiration and evaporation both work to remove soil water from storage, creating upward suction gradients and acting to dry out the soil profile. This drying action restores the soil storage capacity for future rain events. These processes are enhanced by prolonged periods of dry, warm, and sunny weather.

4.3 LEACHM Model

LEACHM (Leachate Estimation and Chemistry Model) [Hutson and Wagenet, 1992], a one-dimensional finite-difference computer program, was selected as the water balance model for comparison of the performance of the monolithic soil cover to that of a Title 27 prescriptive cover. LEACHM was selected because it has already been accepted by several southern California RWQCB's as the basis for conditional regulatory approval of monolithic soil covers (pending performance monitoring of the as-constructed cover). LEACHM simulates water and solute transport through unsaturated soils to a maximum depth of 6.6 ft (2 m). LEACHM uses Richards' equation [Richards, 1931] to simulate flow of water in unsaturated soils. The model has algorithms to predict evaporation from the soil surface and transpiration of plants from the root zone. Precipitation in excess of the infiltration capacity of the profile is shed as overland flow.

LEACHM models the unsaturated hydraulic conductivity of soil at a given water content using Campbell's prediction function [Campbell, 1974]. LEACHM uses a soil-water retention fitting program to compute fitting parameters for Campbell's soil-water retention function from engineering and index properties of the soil. Site specific measured soil parameters and weather data can be used for model input. The specific input file variables are discussed in more detail in the following section.

4.4 Input Parameters

4.4.1 General

The input file parameters and variables for LEACHM include soil properties, weather data, vegetation data, finite-difference nodal arrangement, initial conditions and boundary conditions. The following sections discuss the selection process for the input parameters.

4.4.2 Soil Properties

Soil properties input for LEACHM consist of saturated hydraulic conductivity and fitting parameters for the Campbell's soil-water retention function.

The fitting parameters for the Campbell's soil water retention function can be derived in two ways using LEACHM. The first way is to directly input measured moisture content and soil suction values into the model's curve fitting program. The measured values are typically evaluated in the laboratory using pressure plate apparatus [ASTM D 2325]. The second way is to use one of the several regression equations integrated in the curve fitting program to calculate the retention fitting parameters. The input to the regression equations consist of grain size distribution parameters, bulk density, and one match point of hydraulic conductivity and soil suction. This match point is usually specified as the saturated hydraulic conductivity at zero suction.

Both of the methods described above were used to obtain retention fitting parameters for soils used in evaluations presented in this report. Soil water retention properties were directly evaluated from laboratory testing data for the existing interim cover soils. Figure 4-1 shows the result of the moisture retention test (ASTM D 2325) conducted on a sample collected in Test Pit A-6. The figure shows the variation of volumetric moisture content, θ, as a function of suction, h. The figure also shows the

Campbell's soil water retention function fit through the data obtained in the laboratory test. The Campbell's soil water retention function relates the suction, h, to the volumetric moisture content, θ and is defined by the following two equations:

$$h = a\left(\frac{\theta}{\theta_s}\right)^{-b} \text{ for } \theta > \theta_c$$

$$h = a\frac{\left[\dfrac{\theta_s - \theta}{\theta_s}\right]^{1/2}\left[\dfrac{\theta_c}{\sigma_c}\right]^{-b}}{\left[\dfrac{\theta_s - \theta_c}{\theta_s}\right]} \text{ for } \theta_c > \theta > \theta_s$$

with

$$\theta_c = \frac{2b\,\theta_s}{(1+2b)}$$

where a and b are the parameters of Campbell's soil water retention function, θ_s is the volumetric moisture content at saturation, and θ_c is the volumetric moisture content separating the domain of validity of each equation used to define the moisture retention curve. The Campbell's soil water retention curve fit through the data obtained from the laboratory test in sample for Test Pit A-6 is characterized by a = 0.26, b = 9.703, θ_c = 0.3624, and θ_s = 0.3811.

The curve fitting method was used to develop soil properties for potential import soils. Further description of the soil sampling and laboratory testing of the existing interim cover soils can be found in Section 5 of this report. Input values used in the LEACHM analysis for the properties of the generic import and existing cover soils are presented in Section 6 of this report.

4.4.3 Weather Data

Weather data for LEACHM include daily precipitation, daily minimum and maximum air temperatures, and pan evaporation rates. However, in the absence of pan evaporation data, the pan evaporation rate can be calculated by LEACHM using the Linacre equation [Hutson and Wagenet, 1992] and data about location of the site (latitude, elevation) and weather (temperature, precipitation). LEACHM can perform infiltration simulations for durations of up to 10 years. Simulations performed for the Lopez Canyon Sanitary Landfill used 10 years of actual weather data selected as indicated below.

Weather data used for the Lopez Canyon Sanitary Landfill simulations was obtained through the use of a weather database published by EarthInfo, Inc. EarthInfo, Inc. obtains data from the National Climatic Data Center (NCDC) for weather stations nationwide [EarthInfo, 1996].

A search of the EarthInfo, Inc. data base revealed that seven weather stations lay within an approximate radius of 17 miles (10.6 km) of the Lopez Canyon Sanitary Landfill. Table 4-1 lists these stations and summarizes their characteristics. Of particular importance is the station elevation, number of record years, percent coverage (or data completeness), the average rainfall for the period of record, and distance from Lopez Canyon Sanitary Landfill.

Precipitation is one of the major factors affecting cover performance. Annual precipitation totals and statistics for the entire period of record consisting of the average and standard deviation were studied for each weather station in comparison to available Lopez Canyon Sanitary Landfill statistics. Generally, as stations increase in elevation temperatures become cooler and precipitation increases. Likewise, as elevations decrease temperature extremes drop and precipitation decreases. The disposal areas of Lopez Canyon Sanitary Landfill under consideration for monolithic soil cover are at an approximate elevation of 1500 ft (450 m) mean sea level. The station that best approximates this elevation and is the closest to Lopez Canyon Sanitary Landfill is the Sunland station.

The Sunland station has an annual average precipitation of 16.18 in. (410 mm) per year for the period of record (18 years). The 100-year mean rainfall for the Lopez Canyon Sanitary Landfill is approximately 16 in. (406 mm) per year. The time period of 1951 through 1962 for the Sunland station has an average annual precipitation of approximately 18.1 in. (460 mm) per year and includes several wet years of 35.43, 19.97, and 19.8 in. (900, 507, 503 mm) of precipitation. Thus, the 10-year period 1951 to 1962 from the Sunland weather station was deemed a conservative representation of a 10-year weather pattern of the Lopez Canyon Sanitary Landfill. The daily precipitation and daily minimum and maximum temperature values from the Sunland station for the time period of 1951 through 1962 were used for weather data input to LEACHM. Figure 4-2 displays a plot of the cumulative annual precipitation values from the Sunland station from 1951 through 1962. Also shown in Figure 4-2 is the 100-year average rainfall at Lopez Canyon Sanitary Landfill.

4.4.4 Vegetation Data

Plant data for LEACHM include:

- root depth and root distribution;
- plant growth options of constant vegetation and "growing" vegetation;
- wilting point;
- minimum root potential;
- maximum ratio of actual to potential transpiration;
- root resistance; and
- germination, emergence, maturity, and harvest dates.

Grasses planted and established on alternative final covers can have an average root depth of up to 18 in. (200 to 450 mm). However, to be conservative, a root depth of 12 in. (30 cm) was used in the model. A vegetation growth option of constant vegetation was selected. Vegetation percent coverage was input at 75 percent for the LEACHM simulations. A wilting point of 1,500 kPa and a minimum root potential 3,000 kPa were input to the program. The maximum ratio of actual to potential transpiration and root resistance were set at 1.1 and 1.05, respectively. These are typical values recommended by Dr. Hutson for southern California [personal communication, 1996] in the absence of species-specific information. The values for the germination, emergence, and maturity dates of vegetation are overridden when the constant vegetation option is selected.

4.4.5 Finite-Difference Nodal Arrangement

The LEACHM model has the capacity to simulate the vertical water regime in a saturated or partially saturated soil profile up to 6.6 ft (2 m) thick. The soil profile to be simulated is divided into a number of horizontal layers of equal thickness. Soil properties are specified for each layer. Soil properties may vary from layer to layer to simulate layered profiles. Nodes are situated at the center of each layer for finite difference calculations. Two additional nodes are required for boundary conditions, one above the surface and one below the lowest depth.

For the covers simulated at Lopez Canyon Sanitary Landfill the profiles were divided into 20 to 25 layers depending on the thickness of the cover. Nodal spacing was kept constant at 2.4 in. (60 mm) for all simulations. Each layer was assigned specific properties according to the soil it models. The maximum time step for iteration was set at 0.05 day. LEACHM reduces this time step, depending on the rate of precipitation, to gain added accuracy in the water balance calculation.

4.4.6 Initial and Boundary Conditions

Initial conditions for LEACHM are specified by assigning the initial head or water content to each node in the finite-difference nodal grid. Initial water content conditions are either volumetric water contents corresponding to optimum conditions, as defined by Proctor compaction tests, for assumed borrow source soils, representative in-situ moisture contents for in-place cover soils, or published literature values for soils used in the Title 27 prescriptive cover design. The values used for model input are given in Section 6, Monolithic Soil Cover Evaluation.

The boundary condition at the bottom of the soil column can be selected as a fixed water table, free drainage (or unit gradient), zero flux, or lysimeter boundary. The simulations were conducted by using the lower boundary as a unit gradient boundary. This boundary condition allows water to flow through the bottom of the cover in an unsaturated condition at less than field capacity.

5. GEOTECHNICAL EVALUATION OF EXISTING INTERIM COVER

5.1 Introduction

A geotechnical investigation of the characteristics of the existing interim cover was conducted on the slopes of Disposal Areas A and AB+ and the decks of Disposal Areas A, B, and AB+. The purpose of the geotechnical investigation was to evaluate the thickness of the existing interim cover and to assess the material properties of the soils in the existing interim cover for use in LEACHM analyses.

The geotechnical investigation consisted of a field investigation and a laboratory testing program. The field investigation included the excavation of test pits, logging of the test pits, in-situ measurement of unit weight and moisture content of the existing interim cover, and collection of bulk samples for laboratory testing.

The test pits were excavated by the on-site City operations crew using a John Deere 892 ELC excavator with a 4 ft (1.2 m) wide bucket. Test pit excavations were performed in Level D PPE (including half-mask respirators) in accordance with GeoSyntec's Site Health and Safety Plan. Air monitoring during excavations was performed by on-site gas inspectors in accordance with the Lopez Canyon Sanitary Landfill Health and Safety Plan for excavations in waste. Following completion of each test pit excavation, the test pit was backfilled with the excavated material. The backfilled material was compacted by track-walking with the excavator. The test pits were logged by Colleen Caldwell, GeoSyntec staff engineer. Detailed test pit logs are provided in Appendix A.

The in-situ unit weight and moisture content of the interim existing cover were measured using a Troxler 3440 nuclear density moisture gauge [ASTM D 2922]. In-situ unit weight testing was limited to shallow surfaces (depth of 8 in. (200 mm)) due to disturbance caused by excavation at depths greater than 1 ft (0.3 m). In-situ testing for unit weight was further limited by presence of gravel and cobbles in the top 6 to 8-in. (150 to 200 mm) of the existing interim cover on the deck of Disposal Areas A and AB+ and by the stockpile present on the decks of Disposal Areas A and B.

Bulk samples were collected from each excavated test pit. The bulk samples were visually classified at the Huntington Beach laboratory of GeoSyntec. Representative samples of the different types of soil encountered during the excavation were shipped to GeoSyntec's Geomechanics and Environmental Laboratory (GEL) in Atlanta, Georgia for testing.

The remainder of this section presents the results of the field investigations on the slopes of Disposal Areas A and AB+ and the decks of Disposal Areas A, B, and AB+.

5.2 <u>Deck of Disposal Area AB+</u>

A total of 15 test pits, designated AB-1 through AB-13, AB-24, and AB-25, were excavated during the field investigation of Disposal Area AB+ deck. The locations of the test pits are reported in Figure 5-1.

The thickness of the existing interim cover on the deck of Disposal Area AB+ varies from 2 ft (0.6 m) to 11 ft (3.3 m). Table 5-1 summarizes the elevation of existing interim cover and thickness of interim existing cover at each test pit. The detailed logs for the test pits are provided in Appendix A.

The soils found in the test pits were visually classified as being predominantly silty sands with gravel and cobbles in test pits AB-1 through AB-8, AB-10 through AB-13, and AB-25. In test pit AB-3, a layer of darker brown sandy-clayey silt was found at depth 0 to 4 ft (0 to 1.2 m). Based on discussion with the City operations crew, it was decided that this represents a mix of various stockpiles placed after the landfill had reached final grade. Bulk samples from AB-3, AB-4, AB-7, AB-10, and AB-25 were selected as representative of the range of soils found in the existing interim cover on the decks of Disposal Area AB+ and were shipped to GEL for laboratory testing.

The in-situ unit weight of the existing interim cover was evaluated using the nuclear gauge method [ASTM D 2922]. The in-situ dry unit weight was measured at test pits AB-1, AB-2, AB-10, AB-11, and AB-25 and was found to range from 76 to

98 percent of maximum dry unit weight obtained from ASTM D 1557 (76 to 98 percent relative compaction), with an average value of 88.6 percent relative compaction. The presence of gravel and cobbles within the top 10 in. (250 mm) of the existing interim cover impaired the installation of the nuclear gauge at other test pit locations for measurement of in-situ dry density. In addition, it was not possible to reliably measure the dry density at depth greater than about 1 ft (0.3 m) because of the disturbance to the soil caused by the excavator bucket. Consequently, it was decided on site to assume that the in-situ unit weight of the existing cover soil was on the order of 85 percent of maximum dry unit weight as obtained from ASTM D1557. Based upon GeoSyntec's experience in evaluating interim soil covers at southern California landfills, this is a reasonable value.

5.3 Slopes of Disposal Area AB+

A total of ten test pits designated AB-14 through AB-23, were excavated on the slopes of Disposal Area AB+. The thickness of the existing interim cover on the slopes of Disposal Area AB+ averaged 3 to 10 ft (0.9 to 3 m) on the lower slopes and 2 to 3 ft (0.6 to 0.9 m) on the upper slopes. The locations of the test pits are shown on Figure 5-1. The thickness of existing soil cover at each test pit is reported in Table 5-2. Detailed logs of the test pits are provided in Appendix A.

The existing interim cover soils on the slopes of Disposal Area AB+ were visually classified as silty sands with gravel and cobbles (Test pits AB-14, AB-16, AB-19, and AB-23) and sandy-clayey silts (AB-17, AB-18, AB-20, AB-21, and AB-22). According to City Operations personnel, the soil placed on the slopes of Disposal Area AB+ are a combination of both daily cover soils and/or cover fills employed for hot spot repairs.

5.4 Deck of Disposal Area A

A total of five test pits designated A-1 through A-5, were excavated on the deck of Disposal Area A. The locations of the test pits are reported in Figure 5-1 and detailed logs are provided in Appendix A. At the time of the investigation, approximately 90 percent of the deck of Disposal Area A was covered by stockpiles of vegetative cover soil and clay which hampered an extensive investigation of the existing interim cover. The thickness of existing interim cover on the deck of Disposal Area A is estimated to vary between 5 to 6 ft (1.5 to 1.8 m). Table 5-3 lists the thickness of existing interim cover at each test pit location.

The existing interim cover soils were visually classified as silty sand with gravel and cobbles, a soil very similar to that encountered on the deck of Disposal Area AB+. Bulk samples were collected during the investigation for further evaluation.

5.5 Slopes of Disposal Area A

A total of six test pits designated A-6 through A-11, were excavated on the slopes of Disposal Area A. The thickness of the existing interim cover on the slopes of Disposal Area A ranged from 7 to 18 ft (2.1 to 5.5 m). The minimum thickness of the interim final cover encountered in the test pits excavated on the Disposal Area A slopes was found to be 7 ft (2.1 m). The locations of the test pits are shown on Figure 5-1. The thickness of existing soil cover at each test pit is reported in Table 5-4. Detailed logs of the test pits are provided in Appendix A.

The existing interim cover soils on the slopes of Disposal Area A were visually classified primarily as sandy silt with few gravel and cobbles. According to City Operations personnel, the slopes of Disposal Area A were constructed out of daily cover soils utilizing scrapers and dozers to build-up approximately 18 ft wide "push-up" berms on the outside edges of the slopes.

The in-situ unit weight of the existing interim cover on the slopes of Disposal Area A was evaluated using the nuclear gauge method [ASTM D 2922]. The in-situ dry unit weight was measured at test pits A-7 through A-11 and was found to range from 84 to 94 percent of maximum dry density obtained from ASTM D 1557 (85 to 95 percent relative compaction), with an average value of 90 percent relative compaction. In-situ unit weight measurements were also taken at additional locations on the slopes of Disposal Area A. Unit weight measurements were taken in test areas approximately 4 ft by 5 ft (1.2 by 1.5 m) cleared adjacent to test pit locations. Test areas were cleared and grubbed of existing vegetation and roots to a depth of 1 to 2 ft (0.3 to 0.6 m) utilizing a 4 ft (1.2 m) wide grader blade attached to a backhoe.

5.6 Deck of Disposal Area B

A total of eight test pits designated B-1 through B-8, were excavated on the deck of Disposal Area B. Table 5-4 lists the thickness of the existing interim cover at each test pit. Detail logs are provided in Appendix A. At the time of the investigation, approximately 60 percent of the deck of Disposal Area B was covered by a stockpile of vegetative cover soil.

The soils encountered in the test pits excavated on the deck of Disposal Area B were visually classified as varying from silty sands to sandy, clayey silts, as shown on the test pit logs attached in Appendix A. However, the soil condition on the deck of Disposal Area B are very variable because of the mixture of vegetative cover soils and concrete and asphalt 'winter fills' mixed with daily cover soils present at this location. Bulk samples were collected from each test pit for further evaluation.

5.7 Laboratory Testing Program

5.7.1 Introduction

Laboratory testing program consisted of index and engineering property tests on selected representative bulk samples collected during the geotechnical field investigation. A complete soil sample log, including those samples selected for laboratory testing, is provided in Appendix A. Sampling locations are indicated on Figure 5-1. Laboratory testing was conducted by GeoSyntec's Geotechnical and Environmental Laboratory (GEL).

The laboratory testing program included:

- soil classification per ASTM D 2487, including associated index testing (sieve analysis ASTM D 422, hydrometer, moisture content ASTM D 422, Atterberg limits ASTM D 4318);
- modified Proctor compaction tests (ASTM D 1557); and
- saturated hydraulic conductivity tests (ASTM D 5084; and
- moisture retention tests (ASTM D 2325).

A summary of the laboratory test results performed on representative bulk samples is presented in Table 5-5. Complete laboratory testing result are presented in Appendix B.

5.7.2 Laboratory Testing Results

A summary of the results of laboratory testing performed on representative bulk samples obtained during the interim final cover field investigation are presented in Table 5-5. As shown in this table, the existing interim cover soils on the decks of Disposal Areas A, B, and AB+ and the slopes of Disposal Areas A and AB+ classify primarily as clayey sand or silty sand (SC or SM) according to the Unified Soil Classification System (ASTM D 2487).

The saturated hydraulic conductivity was measured on two representative samples of soil collected on the deck of Disposal Area AB+. The saturated hydraulic conductivity tests (ASTM D 5084) were performed on remolded samples. Based on field observation and result of in-situ measurements, a dry density of about 85 to 90 percent of maximum dry density measured in accordance with ASTM D 1557 was deemed representative of in-situ conditions of the existing interim cover on the decks of Disposal Area AB+. Consequently, two hydraulic conductivity tests were performed. The first test was performed on a sample from test pit AB-10 compacted to a dry density of 85 percent of maximum dry density at a moisture content equal to 2 percent greater than the optimum water content obtained from ASTM D 1557. The second test was performed on a sample from test pit AB-25 compacted to a dry density of 90 percent of the maximum dry density at a moisture content equal to 2 percent greater than the optimum moisture content obtained from ASTM D 1557.

The saturated hydraulic conductivity were measured to be 4.5×10^{-4} cm/s on the remolded sample from test pit AB-10 and 7.6×10^{-5} cm/s on the sample from test pit AB-25. A saturated hydraulic conductivity of 4.5×10^{-4} cm/s was then used to characterize the existing interim cover on the decks of Disposal Areas A, B, and AB+ and the slopes of Disposal Area AB+ for further engineering evaluations. The heterogeneity of the soils composing the existing interim cover and the presence of gravel within the silty sand and clayey sand favored the use of the higher value of saturated hydraulic conductivity measured in the laboratory for these subsequent analyses.

To further characterize the existing interim cover on the decks of Disposal Area AB+, a moisture retention test (ASTM D 2325) was performed on a sample from test pit AB-10. The results of this test are provided in Appendix B. The results from the moisture retention test were used to characterize the foundation layer in the water balance evaluation of the monolithic soil cover and Title 27 prescriptive cover.

The saturated hydraulic conductivity was measured on the four samples of soil collected on slopes of Disposal Area A. The saturated hydraulic conductivity tests (ASTM D 5084) were performed on remolded samples. Based on field observation and result of in-situ measurements, a dry density of about 90 percent of maximum dry density measured in accordance with ASTM D 1557 was deemed representative of in-situ conditions of the existing interim cover on the slopes of Disposal Area A. Consequently, the hydraulic conductivity tests were performed. Samples from test pits A6, A8, A9, and A10 compacted to dry densities of 90 percent of maximum dry density at a moisture content equal to 2 percent greater than the optimum water content obtained from ASTM D 1557.

The saturated hydraulic conductivity on the four samples from the slopes of Disposal Area A were measured to range from 3.6×10^{-6} cm/s to 8.6×10^{-5} cm/s. An average saturated hydraulic conductivity of 4.6×10^{-5} cm/s was then used to characterize the existing interim cover on the slopes of Disposal Area A for further engineering evaluations.

To further characterize the existing interim cover on the slopes of Disposal Area A, a moisture retention test (ASTM D 2325) was performed on a sample from test pit A6. The results of this test are provided in Appendix B. The results from the moisture retention test were used to characterize the existing soil cover in the water balance evaluation of the monolithic soil cover and Title 27 prescriptive cover.

6. MONOLITHIC SOIL FINAL COVER EVALUATION

6.1 Vegetation

An important factor governing the performance of the monolithic soil cover is evapotranspiration. Evapotranspiration of infiltration water from the cover soil requires the establishment of vegetation on the cover. The vegetation type selected should have the ability to establish itself and survive on the natural seasonal precipitation of the site and should display rooting depths of at least 12 to 18 in. (200 to 450 mm).

A seeding program should include vegetation that will establish quickly, provide a percent coverage as great as possible, and will be self sustaining. The main variables to be controlled for a successful seeding program in the Southern California interior area consist of the time of planting, the method of planting, and the type of species that are planted. Only plant species that can survive on the natural precipitation should be considered for vegetating the slopes of the Lopez Canyon Sanitary Landfill. These requirements are consistent with the seed mix currently established for the final cover at Lopez Canyon.

The time of planting should be in the fall prior to the natural seasonal rains. This timing allows the plants to achieve rapid seeding and sufficient biomass to sustain them through the summer months. Seeding at other times of the year may be performed with some degree of success if irrigation is used during the establishment period. However, some species of grasses may be more susceptible to summer funguses when not fully mature. Generally only 10 to 11 in. (250 to 275 mm) of rainfall is required to sustain the perennial grasses found in the area of the Lopez Canyon Sanitary Landfill, eliminating the need for irrigation if planted during the fall. Therefore, it is recommended to plant during the fall [Paul Albright, 1997].

Hydroseeding is a proven method for planting seeds over large open areas that involves spraying the seeds onto the desired areas with water as the transport medium. Hydroseeding will be utilized for the Lopez Canyon Sanitary Landfill seeding program. The hydroseeding process can be used to deliver nutrients, pesticides, or fungicides along with the seeds. A nutrient analysis of the final cover soil could be performed to asses whether or not there exist any gross nutrient deficiencies. Specific additives should be per the recommendation of the seed supplier.

Following hydroseeding the placement of a protective cover or mulch may be used. A protective cover or mulch helps prevent erosion of soil by reducing the effects of rainfall impact and runoff, and wind while providing a suitable environment for the development of the vegetative cover. Types of covers or mulch consist of plastic sheeting, hay, straw, chipped wood, and synthetic or natural nettings and blankets.

The specific species to be planted consist of mostly grasses that can survive on the natural precipitation of the area. Table 6-1 lists the seed mix recommended for Lopez Canyon Sanitary Landfill. This mix is designed for fast vigorous establishment of a final cover of native vegetation that reseeds itself. The recommended application density is on the order of 72 lb per acre (0.79 kN/ha).

6.2 <u>Existing Interim Soil Cover Performance Evaluation</u>

6.2.1 Decks of Disposal Areas A, B, and AB+ and Slopes of Disposal Area AB+

The characteristics of the existing interim cover on the decks of Disposal Areas A, B, and AB+ and the slopes of Disposal Area AB+ were established through the field investigation and laboratory testing program described in Section 5.2, 5.3, 5.5, 5.6, and 5.7. The thickness of the existing interim cover was found to vary from 2 ft (0.6 m) to 11 ft (3.3 m) over decks of Disposal Areas A, B, and AB+ and the slopes of Disposal Area AB+. The soils found in the existing interim cover in these areas range from silty sand to clayey sand with gravel.

The in-situ dry density of the existing interim cover soils on the decks of Disposal Areas A, B, and AB+ and on the slopes of Disposal Area AB+ was measured to range from 76 to 98 percent of maximum dry density obtained from ASTM D 1557. The saturated hydraulic conductivity measured in that range of dry density was on the order of 4.5×10^{-4} cm/sec. Water balance analyses indicate that, in its current condition, the existing interim cover on the decks of Disposal Area A, B, and AB+ and on the slopes of Disposal Area AB+ does not perform as well as the Title 27 prescriptive cover. However, the existing interim cover can still be integrated into a monolithic soil cover on the decks of Disposal Areas A, B, and AB+ and the slopes of Disposal Areas AB+ as the foundation layer.

6.2.2 Slopes of Disposal Area A

The characteristics of the existing interim cover on the slopes of Disposal Area A were established through the field investigation and laboratory testing program described in Section 5.5 and 5.7. The thickness of the existing interim cover was found to vary from 7 ft (2.1 m) to 18 ft (5.5 m) over the slopes of Disposal Area A. The soils found in the existing interim cover on the slopes of Disposal Area A include silty sand, clayey sand, and sandy silt.

The in-situ dry density of the existing interim cover soils on the slopes of Disposal Area A was measured to range from 86 to 94 percent of maximum dry density ~~obtained from ASTM D 1557. The saturated hydraulic conductivity measured at that~~ range of dry density was on the order of 4.6×10^{-5} cm/sec.

Water balance simulations using LEACHM were performed for a period of 10 years using the weather data from the Sunland weather station for the time period 1951 to 1962. Cumulative percolations predicted by LEACHM for the Title 27 prescriptive cover and for the existing interim soil cover on the slopes of Disposal Area A using the input parameters listed in Table 6-2 are shown in Figure 6-1. The water balance components predicted by LEACHM for the Title 27 prescriptive cover and the existing interim soil cover are summarized in Table 6-3. Figure 6-1 shows that the percolation through the existing interim soil cover on the slopes of Disposal Area A is less than that through the Title 27 prescriptive cover.

Based on the results of the water balance analyses, the performance of the existing interim soil cover exceeds the performance of the Title 27 prescriptive cover. The existing interim soil cover on the slopes of Disposal Area A can therefore be considered to be an engineered alternative cover to the Title 27 prescriptive cover.

6.3 Engineered Monolithic Cover Evaluation

6.3.1 Engineered Monolithic Cover Configurations

Water balance analysis were performed to evaluate the performance of an engineered monolithic soil cover for the decks of Disposal Areas A, B, and AB+ and the slopes of Disposal Area AB+ consisting of a combination of existing cover soil and imported borrow soil. Two alternative configurations were simulated in the water balance analyses. Both configurations employed the existing interim cover soil as the foundation layer. However, two different types of imported borrow soil were used in the configurations, as described below.

Alternative 1 consists of 2 ft (0.6 m) of existing interim cover soil overlain by 3 ft (1 m) of an assumed low plasticity silt (SC). The low plasticity silt is characterized by a grain size distribution such that about 75 percent of the material passes the number 200 sieve (opening of 0.075 mm) and with a clay content of about 8 percent. The plasticity index for this soil should not exceed 15.

Alternative 2 consists of 2 ft (0.6 m) of existing interim cover soil overlain by 3 ft (1 m) of an assumed silty or clayey sand (SM or SC). The silty sand or clayey sand are characterized by grain size distribution such that about 40 to 50 percent of the material passes through the number 200 sieve (opening of about 0.075 mm). The Atterberg limits for the fines in the material should be characterized by a plastic limit less than 15. The cross section of these alternative cover designs is illustrated in Figure 6-2. Since both alternatives have the same configuration they are illustrated by the same cross section.

Laboratory testing provided input parameters for the foundation layer composed of existing interim soil cover on the decks of Disposal Areas A, B, and AB+ and the slopes of Disposal Area AB+. Curve fitting was performed to establish the input parameters for the imported borrow soils. Hydraulic conductivity parameters for the existing interim cover soil were obtained from the laboratory tests on the samples remolded to representative densities. The initial moisture contents of these remolded samples corresponded to optimum moisture contents evaluated by modified Proctor tests based upon the assumption that the foundation layer will be re-worked at optimum moisture content prior to placement of the imported borrow soil. A value for hydraulic conductivity of 4.5×10^{-4} cm/s was input for the existing interim soil cover on the decks of Disposal Areas A, B, and AB+ and the slopes of Disposal Area AB+. A hydraulic conductivity of 1×10^{-5} cm/s was assumed for the imported borrow soils (SC, ML, and SM). Soil property values input to LEACHM are summarized in Table 6-2.

6.3.2 Title 27 Prescriptive Cover Configuration

The Title 27 prescriptive cover was modeled as a 4 ft thick cover section. This cover section consisted of a 1 ft (0.3 m) thick vegetative layer underlain by a 1 ft (0.3 m) thick compacted clay layer, underlain by a 2 ft (0.6 m) thick foundation layer. The cross section of the Title 27 prescriptive cover is illustrated in Figure 6-2.

Soil properties input for the Title 27 prescriptive soil cover are summarized in Table 6-2. The vegetative layer was assumed to have a saturated hydraulic conductivity equal to 1×10^{-4} cm/s. The compacted clay layer was modeled with a saturated hydraulic conductivity equal to 1×10^{-6} cm/s. The foundation layer was assumed to have a saturated hydraulic conductivity equal 1×10^{-4} cm/s, a value considered typical of native sandy silt and silty sand soil often use for structural fill. Campbell's fitting parameters were obtained from soil water retention data measured for silty soils by Khire et al. [1994, 1996] and Benson et al. [1994] for the vegetative, clay, and foundation layers. Initial water contents were assumed from data for typical silt and clay soils used in constructing Title 27 prescriptive cover in southern California.

Vegetation of the same rooting depths, percent coverage, and growth option was input for the simulation of the Title 27 prescriptive cover as for the simulation of the monolithic soil cover.

6.3.3 Results of the Water Balance Analysis

Water balance simulations using LEACHM were performed for a period of ten years using the weather data from the Sunland weather station for the time period

1951 to 1962. Cumulative percolations predicted by LEACHM for the Title 27 prescriptive cover and for the two monolithic soil cover alternatives are shown in Figure 6-3. The water balance components predicted by LEACHM for the Title 27 prescriptive cover and for the two monolithic soil cover alternatives are summarized in Table 6-4. Figure 6-3 shows that for the first year the percolation through the Title 27 prescriptive cover and through the monolithic soil covers are comparable. This comparable percolation is due to the migration of construction moisture from the foundation layer into the waste. Figure 6-3 clearly shows that after the first year, percolation predicted by LEACHM, for both monolithic soil cover alternatives is significantly less than the percolation predicted for the Title 27 prescriptive cover.

The water balance simulations performed using the model LEACHM indicate that predicted percolation from the monolithic soil cover alternatives presented in the previous sections is less than from Title 27 prescriptive cover. Therefore, based on modeling results, performance of the proposed monolithic soil cover exceeds the performance of the Title 27 prescriptive cover.

6.3.4 Sensitivity Analysis

6.3.4.1 General

To evaluate the impact of variability in soil properties on percolation through the final cover, three series of sensitivity analyses were performed on the monolithic soil covers designed in Section 6.3. The sensitivity analyses were carried out using the computer program LEACHM. The sensitivity analyses were performed to evaluate the effects of hydraulic conductivity degradation and the absence of vegetation on the 10 year cumulative percolation through the monolithic soil cover compared percolation through the Title 27 prescriptive cover. The following sections describe and present the results of the sensitivity analyses.

6.3.4.2 Monolithic Soil Covers

The first series of sensitivity analyses were performed over the three different monolithic soil cover configurations (Alternative 1, Alternative 2, and A Slope) to evaluate the consequence of degradation of the saturated hydraulic conductivity of the top foot of the cover. For each of these configurations, the saturated hydraulic conductivity for the top 1 ft (0.3 m) was increased by an up to an order of magnitude (e.g. from 1×10^{-5} cm/sec to 1×10^{-4} cm/sec). Figure 6-4 compares the 10-year cumulative percolation through the three alternative monolithic soil covers as designed to the percolation through the percolation through the monolithic soil cover with a degraded saturated hydraulic conductivity in the top foot of the cover profile. A description of the legend for Figure 6-4 is presented below:

Alt1:

Monolithic soil cover Alternative 1 for the deck of Disposal Areas A, B, and AB+ with the design saturated hydraulic conductivity of $k = 1 \times 10^{-5}$ cm/s

Alt2:

Monolithic soil cover Alternative 2 for the deck of Disposal Areas A, B, and AB+ with the design saturated hydraulic conductivity of $k = 1 \times 10^{-5}$ cm/s

A Slope:

Monolithic soil cover on slopes of Disposal Area A with the design saturated hydraulic conductivity of $k = 4.6 \times 10^{-5}$ cm/s

Alt1 deg:

Monolithic soil cover Alternative 1 for the deck of Disposal Areas A, B, and AB+ with the saturated hydraulic conductivity of the top foot increased to $k = 1 \times 10^{-4}$ cm/s due to degradation of the soil

Alt2 deg:

Monolithic soil cover Alternative 2 for the deck of Disposal Areas A, B, and AB+ with the saturated hydraulic conductivity of the top foot set at $k = 1 \times 10^{-4}$ cm/s due to degradation of the soil

A Slope deg:

Monolithic soil cover on slopes of Disposal Area A with the saturated hydraulic conductivity of the top foot set at $k = 1 \times 10^{-4}$ cm/s due to degradation of the soil

A second series of sensitivity analyses were carried out to evaluate the effect of vegetation on the performance of the monolithic soil covers. Figure 6-5 compares the 10-year cumulative percolation through the three alternative monolithic soil covers as designed with vegetation and without vegetation. A description of the legend for Figure 6-5 is presented below:

Alt1:

vegetated monolithic soil cover Alternative 1 for the deck of Disposal Areas A, B, and AB+ with the design saturated hydraulic conductivity of $k = 1 \times 10^{-5}$ cm/s

Alt2:

Vegetated monolithic soil cover Alternative 2 for the deck of Disposal Areas A, B, and AB+ with the design saturated hydraulic conductivity of $k = 1 \times 10^{-5}$ cm/s

A Slope:

Vegetated monolithic soil cover on slopes of Disposal Area A with the design saturated hydraulic conductivity of $k = 4.6 \times 10^{-5}$ cm/s

Alt1 no veg:

Monolithic soil cover Alternative 1 for the deck of Disposal Areas A, B, and AB+ with the design saturated hydraulic conductivity of $k = 1 \times 10^{-5}$ cm/s and no vegetation

Alt2 no veg:

Monolithic soil cover Alternative 2 for the deck of Disposal Areas A, B, and AB+ with the design saturated hydraulic conductivity of $k = 1 \times 10^{-5}$ cm/s and no vegetation

A Slope no veg:

Monolithic soil cover on slopes of Disposal Area A with the design saturated hydraulic conductivity of $k = 4.6 \times 10^{-5}$ cm/s and no vegetation

6.3.4.3 Title 27 Prescriptive Cover

A third series of sensitivity analyses was performed to evaluate the effect of degradation of the hydraulic conductivity of the 21 ft (0.3 m) thick compacted clay layer and the effect of vegetation on the percolation through the Title 27 prescriptive cover. Water balance analyses were performed assuming that the saturated hydraulic conductivity of the compacted clay layer degraded from the prescriptive maximum value of 1×10^{-6} cm/sec to 2×10^{-6} cm/sec and 5×10^{-6} cm/sec. The water balance analyses were performed for each value of hydraulic conductivity for both the vegetated and the no vegetation case. Figure 6-6 shows the effects of degradation and of vegetation on the 10-year cumulative percolation through a Title 27. A description for the legend of Figure 6-6 is provided below:

prsc:

Title 27 prescriptive cover with the hydraulic conductivity of the compacted clay layer equal to $k = 1 \times 10^{-6}$ cm/s and well established vegetation on the cover prsc n/veg :

Title 27 prescriptive cover with the hydraulic conductivity of the compacted clay layer equal to $k = 1 \times 10^{-6}$ cm/s and no vegetation on the cover

prsc k2e6 :

Title 27 prescriptive cover with the hydraulic conductivity of the compacted clay layer increased to $k = 2 \times 10^{-6}$ cm/s due to degradation and established vegetation

prsc k2e6 n/veg:

Title 27 prescriptive cover with the hydraulic conductivity of the compacted clay layer of increased to $k = 2 \times 10^{-6}$ cm/s due to degradation and no vegetation on the cover

prsc k5e6:

Title 27 prescriptive cover with the hydraulic conductivity of the compacted clay layer increased to $k = 5 \times 10^{-6}$ cm/s due to degradation and established vegetation

prsc k5e6 n/veg:

Title 27 prescriptive cover with the hydraulic conductivity of the compacted clay layer of increased to $k = 5 \times 10^{-6}$ cm/s due to degradation assuming no vegetation on the cover.

6.3.4.4 Evaluation of the results

Several noteworthy observations can be made regarding the results of the sensitivity analyses.

As shown on Figure 6-6, the performance of the Title 27 prescriptive cover with respect to surface water infiltration is not particularly sensitive to the presence of vegetation. However, the percolation through the Title 27 prescriptive cover doubles if the saturated hydraulic conductivity of the compacted clay layer degrades by one-half an order of magnitude. If the compacted clay layer does desiccate or crack, assuming a one-half order of magnitude increase in saturated hydraulic conductivity may actually be conservative.

As shown on Figure 6-4 and 6-5, increase of the saturated hydraulic conductivity in the top foot of the monolithic soil covers by up to one order of does result in a significant increase of the 10-year cumulative percolation. However, this increase is approximately equal to the increase in percolation through the Title 27 prescriptive cover when the hydraulic conductivity of the compacted clay layer has been degraded by only one half an order of magnitude. Figure 6-5 illustrates that even without vegetation, the infiltration performances of Alternative 1 and Alternative 2 is superior to the performance of the Title 27 prescriptive cover as long as the saturated hydraulic conductivity is maintained at the target value. However, the A Slope configuration is more sensitive to a loss of compared to Alternatives 1 and 2. Even without degradation of the saturated hydraulic conductivity the percolation through the A-slope configuration is above that of the Tittle 27 prescriptive cover if vegetation is not established.

6.3.4.5 Summary

In summary, results of the sensitivity analyses illustrate different cover maintenance approaches that may be taken to maintain the performance of the monolithic final cover alternatives. For monolithic Alternatives 1 and 2 (deck areas) the sensitivity analyses indicates that it would be better to strip the vegetation and rework the top one foot of cover soil if degradation in the saturated hydraulic conductivity occurs than to keeping the vegetation intact and allowing the saturated hydraulic conductivity of the soil to degrade. Conversely, the sensitivity analysis indicates that for the A-slope monolithic alternative it is better to allow the vegetation to remain as opposed to reworking the upper layers of the cover soil to counteract degradation the saturated hydraulic conductivity.

7. PERFORMANCE EVALUATION PROGRAM

7.1 Methodology

The objective of the performance evaluation program is to demonstrate that the infiltration control performance of a monolithic soil cover on the decks of Disposal Areas A, B, and AB+ and the slopes of Disposal Areas A and AB+ can exceed the infiltration control performance of the Title 27 prescriptive cover if the monolithic soil cover has the appropriate hydraulic properties.

The methodology for evaluation of the performance of the monolithic final cover consists of the following:

- Monitoring the soil moisture content and environmental conditions in two test sections for a period of two years;
- Calibrating the analytical numerical model (LEACHM) for infiltration and moisture migration based upon the first year monitoring data;
- Validating the analytical numerical model using the second year monitoring data;
- Demonstrating that the infiltration performance control of the monolithic soil cover exceeds that of Title 27 prescriptive cover using the validated numerical model.

In this cover performance evaluation program, characteristic soil properties will be directly measured and the analytical model will be calibrated based upon the first year of field data. The calibrated model will then be used to predict moisture movement in the soil cover during the second year of monitoring. Comparison of predicted moisture movement during the second year to actual field observations will be used to validate the analytical model. The validated model will then be used to compare the performance of the monolithic soil cover to the performance of the Title 27 prescriptive cover. In the evaluation program, the final cover performance will be monitored at two locations: one on the deck of Disposal Area AB+ and one on the slopes of Disposal Area A. Figure 7-1 shows the proposed monitoring locations.

In order to test the validity of the analytical model for an extreme precipitation even, if at the end of the 2-year monitoring period a storm with a rainfall intensity which exceeds 75 percent of the intensity of the 100-year 24-hour rainfall has not occurred, a temporary irrigation will be set up adjacent to the monitoring stations to artificially induce the 100-year, 24-hour rainfall for monitoring purposes.

7.2 Data Requirements

The data required to perform the cover performance evaluation include:

- data on the soil used to construct the monolithic soil cover;
- data on weather conditions; and
- data on moisture content in the monolithic soil cover.

Data on the soil used to construct the monolithic soil cover include soil type, in-situ density, and hydraulic properties such as saturated hydraulic constructivity and moisture retention curves. This data will be obtained from laboratory testing on soils collected during construction of the monolithic soil cover. Data on weather conditions include records of precipitation and temperatures and irrigation if used. Data from the Sunland weather station and data from an on-site weather station will be collected. Data on moisture content in the monolithic soil cover will be obtained using the monitoring system described in Section 7.3 of this report.

7.3 Proposed Soil Moisture Monitoring System

7.3.1 Introduction

For the Lopez Canyon Landfill monolithic soil cover monitoring, it is proposed to use Time Domain Reflectometry (TDR) probes for soil moisture monitoring and a site weather station to gather accompanying weather data. TDR probes have been selected due to their automated data collection abilities, minimal disturbance installation methods, and prior successful use on similar projects in southern California. A TDR monitoring probe system consists of a segmented profiling probe for monitoring multiple depths, transmission cables, a battery power supply, and an integral data logger.

The configuration and type of soil moisture monitoring probe system for the Lopez Canyon Landfill monolithic soil cover is designed to provide flexibility so that it can be modified to accommodate whatever frequency, quality, and quantity of data is required for monitoring.

7.3.2 Soil Moisture Monitoring Probe

It is proposed to use a segmented profiling probe containing five individual probes for monitoring at depths of 6, 12, 20, 30, and 42 in. (152, 305, 508, 762, and 1067 mm, respectively) for the test section on the deck of Disposal Area AB+ where the total thickness of the proposed monolithic final cover, including the foundation layer, is 60 in. (1,500 mm).

It is proposed to use a segmented profiling probe containing seven individual probes for monitoring at depths of 6, 12, 20, 30, 42, 54, and 66 in. (152, 305, 508, 762, 1067, 1372, and 1677 mm, respectively) for the test section on Disposal Area A, where the total thickness of the proposal monolithic final cover is 78 in. (1,950 mm). A 6-in. (152-mm) spacing in the upper 1-ft (0.3 m) of the cover is required to better quantify cover performance.

Two probes will be installed in the test section on the deck of Disposal Area AB+ and two probes will be installed on the test section of the slopes of Disposal Area A.

The final location of the probes will be decided in the field and submitted for approval to the RWQCB. The probes will be connected to data loggers and a power supply will be installed in the field. Soil moisture readings from the probes will be automatically taken daily and stored in the data loggers. Data will be downloaded with a lap top computer. It is anticipated that data will be downloaded and analyzed once a month.

7.3.3 Data Logging System

Each probe will be connected to a data logger unit. The data logger interrogates the probe at user specified sampling intervals and then measures, interprets, and stores the sensor values in the non-volatile memory. Each data record will be time and date stamped. The data loggers will be powered by either solar or AC current and will be enclosed in a rugged enclosure which protects the electronics from the atmosphere and other damage. The data logger will be equipped with an RS-232 port which enables data to be downloaded with a personal computer (PC). A laptop PC will be used for data downloading. The data will be downloaded to the laptop PC using the probe manufacturers supplied software.

7.3.4 Weather Station

A self-contained weather station capable of recording wind speed, wind direction, relative humidity, rainfall, solar radiation, and air temperature will be installed and connected to the data logger. Weather data will be downloaded at the same time as the soil moisture data with the lap top PC. The weather station will be located at one of the test sections.

7.4 Vegetation

Following construction of the monolithic soil and installation of the performance monitoring system the monolithic soil cover will be hydroseeded using the seed mix designed for Lopez Canyon Landfill.

If the seeds are planted in the fall, no irrigation will be needed to establish the vegetation. If the seeds are planted at any other time, irrigation will be required during the initial stages of vegetation establishment. Once established, the vegetation will have the ability to survive on the natural seasonal precipitation of the area. Therefore, once the vegetation has been established, the need for irrigation should be minimal, if at all. If any irrigation is applied, the daily volume will be monitored and recorded.

7.5 Performance Modeling

Hydrologic performance modeling of the monolithic soil cover will be performed using the model LEACHM [Hutson and Wagenet, 1992] discussed in Section 4.3 of this report. The weather data and moisture migration data gathered during the first year of performance monitoring period will be used to simulate the performance of the monolithic soil cover over the second year of monitoring.

7.6 Reporting

Three reports will be prepared for submission to the RWQCB during the final cover performance evaluation:

- an installation report;
- a model calibration report; and
- a performance evaluation report.

The installation report will be submitted within 12 weeks of completion of installation of the test sections. This report will document moisture probe installation, soil test data, and initial probe readings. The report will include a record drawing presenting surveyed probe locations, manufacturers' product information on the probes, and data logging equipment, field logs from probe installation, and laboratory data sheets and summary tables.

The model calibration report will be submitted 15 months after probe installation. The model calibration report will include the weather and moisture content data for the first 12 months of operation at each test section. The report will also include a preliminary evaluation of the performance of the monolithic soil cover in comparison to the Title 27 prescriptive cover.

The performance evaluation report will be submitted 27 months after test section installation. The performance evaluation report will include weather and moisture content data collected in the second 12 months of monitoring, a forecast of moisture migration over the second 12 months using LEACHM calibrated using the data collected over the first 12 months, a comparison of forecast and observed moisture migration, a description of any alterations or enhancements to the model required to obtain agreement between observed and predicted moisture migration in the second year of operation, and final evaluation of the performance of the monolithic soil cover as an engineered alternative to the Title 27 prescriptive cover. If the monolithic soil cover does not perform as well as the Title 27 prescriptive cover, the report will include recommendations for measures required to achieve equivalent Title 27 prescriptive cover performance for the monolithic soil cover.

8. SUMMARY AND RECOMMENDATIONS

8.1 Summary

This report describes water balance conducted to demonstrate that a monolithic soil cover is an acceptable engineered alternative to Title 27 prescriptive cover for the decks of Disposal Areas A, B, and AB+ and the slopes of Disposal Areas A and AB+ at Lopez Canyon Sanitary landfill.

The work conducted included a field investigation, a laboratory testing program, and water balance analyses. The field investigation and laboratory testing program were conducted to characterize the existing interim soil cover. The water balance analyses were used to demonstrate that the performance of the monolithic soil cover met or exceeded the performance of the Title 27 prescriptive cover with respect to infiltration control.

The field investigation consisted of excavating and logging test pits, collecting bulk samples from the existing interim cover soil, and in-situ measurements of the density of the existing interim cover soil. A total of 44 test pits were excavated on the decks of Disposal Areas A, B, and AB+ and the slopes of Disposal Areas A and AB+ at Lopez Canyon Sanitary landfill. The test pits logs indicate that the existing interim cover soils consist mostly of silty sand and clayey sand mixed in some areas with gravel and cobbles . The thickness of the existing interim cover ranges from 2 ft (0.6 m) to 18 ft (5.5 m) with an in-situ dry density ranging from 76 to 98 percent of maximum dry density as obtained from ASTM D1557. Reliable measurement of in-situ dry density was impaired by the presence of gravel and cobbles and the disturbance caused by the excavation activity.

Laboratory testing was conducted on selected bulk samples to classify the soil according to the Unified Soil Classification System and to obtain compaction characteristics, hydraulic conductivity values, and moisture retention relationships for the interim cover soils. The soils forming the existing interim soil covers ranged in classification from silty sand (SM) to clayey sand (SC) and include some low plasticity silts (ML). The representative hydraulic conductivity of the in place soils of the existing interim soil cover was set at 4.5×10^{-4} cm/s on the decks of Disposal Areas A, B, and

AB+ and slopes of Disposal Area AB+ the larger of two values measured in the laboratory, due to the heterogeneity of the encountered soil. The representative hydraulic conductivity of the in-place soils of the existing interim soil cover was set at 4.6×10^{-5} cm/s for the slopes of Disposal Area A, the average of the four values measured in the laboratory.

The water balance analyses were conducted using the computer program LEACHM. Input data for LEACHM includes the soil profile to be modeled, soil properties, weather data, and vegetation data. The soil profiles analyzed included the Title 27 prescriptive cover, the existing interim soil cover, and two different engineered monolithic soil covers. The Title 27 prescriptive cover consisting of a 1 ft (0.3 m) thick vegetative soil layer, a 1 ft (0.3 m) thick compacted clay layer, and a 2 ft (0.6 m) thick foundation layer. The engineered monolithic soil covers consisted of a 3 ft (0.9 m) thick layer of either a silty sand or a silty clay and a 2 ft (0.6 m) thick foundation layer.

The soil properties for the existing interim soil cover were established from the laboratory testing program conducted on the samples collected at the test pits. Soil properties for the clay layer, vegetative layer, silty sand layer, and clayey sand layer were estimated from published data. Weather data from the Sunland station were used for the water balance analyses. The Sunland station is located 3.5 miles (5.6 km) from Lopez Canyon Sanitary Landfill at a comparable elevation. A 10-year period was selected for the water balance analysis. The 10-year period exhibits an average annual rainfall of 18.1 in. (460 mm), compared to the 16 in. (406 mm) 100-year average rainfall at Lopez Canyon Sanitary Landfill. The 10-year period also includes several wet years and was deemed to be representative of the weather conditions at Lopez Canyon Sanitary Landfill. The vegetation data used in the water balance analyses is representative of the vegetation mix approved for use on the final cover at Lopez Canyon Sanitary Landfill.

The results of the water balance analyses indicate that the percolation through the existing interim soil cover on the decks of Disposal Areas A, B, and AB+ and the slopes of Disposal Area AB+ exceeds that through the Title 27 prescriptive cover. The results of the water balance analyses indicate that the predicted percolation from the existing interim cover on the slopes of Disposal Area A is about 68 percent less than that from the Title 27 prescriptive cover over the 10 year period modeled. The results of the water balance analyses indicate that predicted percolation from the engineered monolithic soil cover on the decks of Disposal Areas A, B, and AB+ and the slopes of Disposal Area AB+ is about 75 percent less than that from the Title 27 prescriptive cover over the 10-year period modeled. The results of the water balance analyses indicate that the predicted percolation from the existing interim cover on the slopes of Disposal Area A is about 68 percent less than that from the Title 27 prescriptive cover over the 10 year period modeled.

8.2 Recommendations

The work presented in this report demonstrate that a "properly configured" monolithic soil cover performs better than the Title 27 prescriptive cover infiltration control at the Lopez Canyon Landfill. Properly configured covers include the engineered monolithic soil cover on the decks of Disposal Areas A, B, and AB+ and the slopes of Disposal Area AB+ and the existing interim soil cover on the slopes of Disposal Area A. The engineered monolithic soil cover consists of a 2 ft (0.6 m) thick layer of foundation soil composed of the existing interim cover soil overlain by a 3 ft (1 m) thick layer of silty sand or clayey sand with a saturated hydraulic conductivity no greater than 1×10^{-5} cm/s. To mitigate the potential for cracking due to desiccation or differential settlement, the plasticity index of the engineered monolithic soil cover should not exceed 15. The existing interim soil cover on the slopes of Disposal Area A consists of at least 6.5 ft (2 m) of silty sand or clayey sand characterized by a hydraulic conductivity of 4.6×10^{-5} cm/s.

Because the monolithic soil cover has the same erosion resistance as the prescriptive cover and can be constructed more economically than the prescriptive cover, and because the use of the prescriptive cover may not promote attainment of the water quality objectives of a final cover, the monolithic soil cover should be acceptable as an alternative final cover in accordance with state and federal regulations. However, because it is likely that performance monitoring will be required by the RWQCB to demonstrate acceptable performance of the proposed monolithic soil cover, a performance monitoring program has been developed. This performance monitoring program includes two monitoring stations on the slopes of Disposal Area A, where the monolithic soil cover already exists, and one monitoring station on the decks of

Disposal Areas A, B, and AB+, where a monolithic soil cover will be constructed. The recommended monitoring program employs time-domain-reflectometry probes and an automated weather station. The recommended performance monitoring program includes two years of monitoring, with model calibration after year one and model validation after year two. The monitoring program is expected to result in final regulatory approval of the monolithic soil final cover for the slopes of Disposal Areas A and AB+ and the decks of Disposal Areas A, B, and AB+.

REFERENCES

ASTM D 422 [1992], "Standard Test Method for Particle Size Analysis of Soils," Annual Book of ASTM Standards, Soil and Rock; Dimension Stone; Geosynthetics, Vol. 04.08.

ASTM D 1557 [1992], "Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort," Annual Book of ASTM Standards, Soil and Rock; Dimension Stone; Geosynthetics, Vol. 04.08.

ASTM D 2325 [1996], "Standard Test Method for Capillary Moisture Relationship for Coarse and Medium Textured Soils by Porous Plate Apparatus," Annual Book of ASTM Standards, Soil and Rock; Dimension Stone; Geosynthetics, Vol. 04.08.

ASTM D 2487 [1992], "Standard Test Method for Classification of Soils for Engineering Purposes," Annual Book of ASTM Standards, Soil and Rock; Dimension Stone; Geosynthetics, Vol. 04.08.

ASTM D 2922 [1993], "Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods," Annual Book of ASTM Standards, Soil and Rock; Dimension Stone; Geosynthetics, Vol. 04.08.

ASTM D 4318 [1993], "Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils" Annual Book of ASTM Standards, Soil and Rock; Dimension Stone; Geosynthetics, Vol. 04.08.

ASTM D 5084 [1990], "Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter, American Society for Testing Materials.

BAS [1993] "Partial Closure Plan Lopez Canyon Sanitary Landfill, Lake View Terrace California." Prepared for City of Los Angeles, Dept. of Public Works, Bureau of Sanitation , Solid Waste Management Division. Bryan Stirrat & Associates, January 1993.

Benson, C., Bosscher, P., Lane, D., and Pliska, R. [1994], "Monitoring System for Hydrologic Evaluation of Landfill Final Covers," *Geotechnical Testing Journal*, ASTM, Vol. 17, No. 2, pp. 138-149.

Benson, C. and Khire, M. [1995], "Earthen Covers for Semi-Arid and Arid Climates," *ASCE 1995 National Convention on Landfill Closures-Environmental Protection and Land Recovery*, Geotechnical Special Publication No. 53, pp. 201-217.

Bureau of Sanitation [1997], "Revision to Volume IV of IV Replacement Amendment to Final Closure Plan, Lopez Canyon Sanitary Landfill, Lakeview Terrace, California," Prepared by the City of Los Angeles, Department of Public Works, Department of Sanitation, March.

Campbell, G. [1974] "A Simple Model for Determined Unsaturated Conductivity from Moisture Retention Data," Soil Science. Vol. 117(6), pp. 311-314.

EarthInfo Inc., "EarthInfo Summary of the Day," 1996, Boulder, CO 80301.

GeoSyntec [1996] "Final Closure Plan Lopez Canyon Sanitary Landfill, Lake View Terrace, California. Vol. IV of IV, Replacement Amendment to Final Closure Plan." Prepared for City of Los Angeles, Dept. of Public Works, Bureau of Sanitation, Solid Waste Management Division. GeoSyntec Consultants, June 1996.

Hutson, J.L. and Wagenet, R.J. [1992], "Leaching Estimation and Chemistry Model, LEACHM," New York State College of Agriculture and Life Sciences, Cornell University.

Khire, M. [1995], "Field Hydrology and Water Balance Modeling of Earthen Final Covers for Waste Containment," Ph.D. Thesis, University of Wisconsin, Madison, Wisconsin.

Khire, M., Benson, C., and Bosscher, P. [1996], "Water Balance Modeling of Final Covers at Humid and Semi-Arid Sites," *Journal of Geotechnical Engineering*, ASCE, in press.

Khire, M., Benson, C., and Bosscher, P. [1997], "Water Balance of Two Earthen Landfill Caps in a Semi-Arid Climate," *Proceedings of International Containment Technology Conference and Exhibition*, St. Petersburg, Florida, February.

Khire, M., Benson, C., Bosscher, P., and Pliska, R. [1994], "Field-Scale Comparison of Capillary and Resistive Landfill Covers in an Arid Climate," *Fourteenth Annual Hydrology Days Conference*, Fort Collins, Colorado, pp. 195-209.

Personal Communication with Jim Earson, (909) 799-7407, U.S. Department of Agriculture, Natural Resource Conservation Service, Redlands Office, Redlands, California, November 1996, 1997 - regarding plants.

Personal Communication with J.L. Hutson, (607) 255-7631, Cornell University, New York, November 1996.

Personal and Facsimile Communication with Paul Albright, 1-800-423-8112, Albright Seed Company, Camarillo, California, April 9, 1997.

Personal and Facsimile Communication with Jody Miller, (805) 684-0436, S&S Seeds, Carpenteria, California, April 11, 1997.

Richards, L. [1931], "Capillary Condition of Liquid in Porous Mediums" Physics 1, pp. 318-333.

TABLES

TABLE 4-1

PROXIMAL WEATHER STATIONS
LOPEZ CANYON SANITARY LANDFILL

Station Name	Number of Years	Percent Coverage	Latitude	Longitude	Elevation (ft)	Distance (miles)	Average Rainfall (in.)
LOPEZ CANYON LANDFILL	100		N34:17:30	W118:21:30	1600-1800		aprox. 16(1)
CANOGA PARK PIERCE C	46	100	N34:11:00	W118:34:00	790	14.0	15.84
DRY CANYON RESERVOIR	43	78-94	N34:29:00	W118:32:00	1455	16.7	13.88
NEWHALL	6	100	N34:22:00	W118:34:00	1400	13.1	19.53
PASADENA	68	95-99	N34:09:00	W118:09:00	864	15.0	19.47
SAN FERNANDO	48	96-99	N34:17:00	W118:28:00	971	7.3	16.39
SUNLAND	18	99-100	N34:16:00	W118:18:00	1460	3.5	16.18
TUJUNGA	22	96-97	N34:16:00	W118:17:00	1819	4.3	20.85

Notes: (1) 100 year mean rainfall from RDSI dated September 1995

TABLE 5-1

TEST PIT SUMMARY
DECK OF DISPOSAL AREA AB+
LOPEZ CANYON SANITARY LANDFILL

TEST PIT NO.	EXISTING INTERIM FINAL COVER EL. (ft)	EXISTING COVER SOIL THICKNESS (ft)	REFUSE EL. (ft)
AB-1	1774.4	9.5	1764.9
AB-2	1768.4	5	1763.4
AB-3	1763.9	5	1758.9
AB-4	1759.7	4	1755.7
AB-5	1759.9	>8	<1752
AB-6	1766.2	>9	<1757
AB-7	1755.6	6	1749.6
AB-8	1755.9	6	1749.9
AB-9	1749.1	1.5	1747.6
AB-10	1761.5	4	1757.5
AB-11	1763.3	4	1759.3
AB-12	1759.4	>7	<1752
AB-13	1767.4	>11	<1756
AB-24	1773.5	9	1764.5
AB-25	1762.1	>9	<1751

TABLE 5-2

TEST PIT SUMMARY
SLOPES OF DISPOSAL AREA AB+
LOPEZ CANYON SANITARY LANDFILL

TEST PIT NO.	EXISTING INTERIM FINAL COVER EL. (ft)	EXISTING COVER SOIL THICKNESS (ft)	REFUSE EL. (ft)
AB-14	1742.0	6	1736.0
AB-15	1759.9	8.5	1751.4
AB-16	1698.5	2.5	1696.0
AB-17	1700.0	2	1698.0
AB-18	1685.2	2	1683.2
AB-19	1691.9	5	1686.9
AB-20	1622.0	2.5	1619.5
AB-21	1730.8	3.5	1727.3
AB-22	1744.1	3	1741.1
AB-23	1737.8	10	1727.8

TABLE 5-3

TEST PIT SUMMARY
DECK OF DISPOSAL AREA A
LOPEZ CANYON SANITARY LANDFILL

TEST PIT NO.	EXISTING INTERIM FINAL COVER EL. (ft)	EXISTING COVER SOIL THICKNESS (ft)	REFUSE EL. (ft)
A-1	1745.2	6.5	1738.7
A-2	1741.32	6	1735.32
A-3	1741	5	1736
A-4	1732.93	6	1726.93
A-5	1744.16	5	1739.16

TABLE 5-4

TEST PIT SUMMARY
SLOPES OF DISPOSAL AREA A
LOPEZ CANYON SANITARY LANDFILL

TEST PIT NO.	EXISTING INTERIM FINAL COVER EL. (ft)	EXISTING COVER SOIL THICKNESS (ft)	REFUSE EL. (ft)
A-6	1738.2	7-14	1731.2
A-7	1721.2	8-18	1713.2
A-8	1678.8	>9	1669.8
A-9	1659.2	>14	1645.2
A-10	1610.0	7	1603.0
A-11	1570.5	11	1559.5

TABLE 5-5

TEST PIT SUMMARY
DECK OF DISPOSAL AREA B
LOPEZ CANYON SANITARY LANDFILL

TEST PIT NO.	EXISTING INTERIM FINAL COVER EL. (ft)	EXISTING COVER SOIL THICKNESS (ft)	REFUSE EL. (ft)
B-1	1707.44	3	1704.44
B-2	1719.02	2	1717.02
B-3	1732.1	3	1729.1
B-4	1741.8	3.5	1738.3
B-5	1727.7	5	1722.7
B-6	1743.5	>8	1735.5
B-7	1727.57	6	1721.6
B-8	1741.7	5	1736.7

TABLE 5-6

SUMMARY OF LABORATORY TEST RESULTS
LOPEZ CANYON SANITARY LANDFILL

Site Sample ID	Lab Sample No	As-Received Moisture Content ASTM D 2216 (%)	Grain Size: Percent Passing #200 Sieve ASTM D 1140 (%)	Grain Size: ASTM D 422 Sieve Figure No.	Grain Size: ASTM D 422 Hydrom. Figure No.	Atterberg Limits ASTM D 4318 LL (%)	Atterberg Limits ASTM D 4318 PL (%)	Atterberg Limits ASTM D 4318 PI (-)	Soil Classification ASTM D 2487	Compaction Modified Proctor ASTM D 1557 Max. Dry Unit Weight (pcf)	Compaction Modified Proctor ASTM D 1557 Optimum Moisture Content (%)	Compaction Fig. No.	Hydraulic Conductivity ASTM D 5084 Test Specimen Initial Conditions Dry Unit Weight (pcf)	Hydraulic Conductivity ASTM D 5084 Test Specimen Initial Conditions Moisture Content (%)	Hydraulic Conductivity ASTM D 5084 Test Specimen Initial Conditions Consol. Pressure (psi)	Hydraulic Conductivity (cm/s)	Remarks
AB-3	98A86		46.6	1	1	35	18	17	SC - Clayey Sand								
AB-4	98A87		19.9	2	2	31	21	10	SC - Clayey Sand with Gravel								
AB-7	98A88		43.5	3	3	40	25	15	SC - Clayey Sand with Gravel								
	98A89		46.4	4	4	40	28	12	SM - Silty Sand with Gravel								
AB-10	98B32									122.5	11.3	5					Not corrected for over-sized particles
										125.7	10.1	6					
	98B32-1												104.2	13.2	1.5	4.5E-4	Moisture Retention see Fig. 13
AB-25-B	98B34									124.4	11.2	7					Not corrected for over-sized particles
										128.9	9.4	8					
	98B34-1												112.0	10.9	1.5	7.6E-5	
B-3	98B15		52.4	9		37	20	17	CL - Sandy Lean Clay								
B-6	98A90		61.9	10	10	39	30	9	ML - Sandy Silt								

TABLE 5-6 (continued)

SUMMARY OF LABORATORY TEST RESULTS
LOPEZ CANYON SANITARY LANDFILL

Site Sample ID	Lab Sample No.	As-Received Moisture Content ASTM D 2216 (%)	Grain Size: Percent Passing #200 Sieve ASTM D 1140 (%)	Grain Size: ASTM D 422 Sieve Figure No.	Grain Size: ASTM D 422 Hydrom. Figure No.	Atterberg Limits ASTM D 4318 LL (%)	PL (%)	PI (-)	Soil Classification ASTM D 2487	Compaction: Modified Proctor ASTM D 1557 Max. Dry Unit Weight (pcf)	Optimum Moisture Content (%)	Fig. No.	Hydraulic Conductivity ASTM D 5084: Test Specimen Initial Conditions Dry Unit Weight (pcf)	Moisture Content (%)	Consol. Pressure (psi)	Hydraulic Conductivity (cm/s)	Remarks
A-6	98B65		37.6	1	1	34	24	10	SM - Silty Sand	126.0	10.5	2	113.3	12.2	1.5	7.8E-5	Not corrected for over-sized particles
										128.2	9.7	3					Moisture Retention see Fig. 12
A-8	98B66		46.1	4	4	36	24	12	SC - Clayey Sand	122.0	11.5	5	110.0	13.1	1.5	8.8E-5	
A-9	98B67		50.6	6	6	44	28	16	ML - Sandy Silt	116.2	14.3	7	102.9	17.0	1.5	1.4E-5	Not corrected for over-sized particles
										118.7	13.2	8					
A-10	98B68		53.2	9	9	48	30	18	ML - Sandy Silt	119.5	12.0	10	107.4	14.8	1.5	3.6E-6	Not corrected for over-sized particles
										122.7	10.9	11					

TABLE 6-1

POTENTIAL MONOLITHIC SOIL COVER SEED MIX
LOPEZ CANYON SANITARY LANDFILL

PLANT SPECIES	PURITY/ GERMINATION	POUNDS/ ACRE
Artemesia Californica (Sagebrush)	15/60	2
Encelia Califonica (Bush Sunflower)	40/60	3
Eriogonum Fasciculatum (California Buckeye)	50/10	4
Lotus Scoparius (Deer Weed)	90/60	6
Mimulus Longiflorus (Monkey Flower)	2/55	2
Salvia Apiana (White Sage)	70/50	3
Salvia Mellifera (Black Sage)	85/50	4
Salvia Leucophylla (Purple Sage)	75/70	3
Trifolium Hirtum (Clover)	95/85	10
Vulpia Myuros	90/80	3
Stipa Cernua (Feather Grass)	80/50	8
Hordeum Californica	90/80	8
Bromux Carinatus (California Brome)	95/80	6
Eschscholzia Californica (California Poppy)	98/75	2
Lupinus Bicolor (Lupine)	98/80	4

Source: S&S Seeds

TABLE 6-2

SOIL PROPERTIES INPUT TO LEACHM
LOPEZ CANYON SANITARY LANDFILL

SOIL	SATURATED HYDRAULIC CONDUCTIVITY INPUT TO LEACHM (cm/s)	CAMPBELL'S SOIL WATER RETENTION FITTING PARAMETER: AIR ENTRY VALUE (a)	CAMPBELL'S SOIL WATER RETENTION FITTING PARAMETER: EXPONENT (b)	INITIAL WATER CONTENT (Volumetric)
Decks of Disposal Areas A, B, And AB+, Slopes of Disposal Area AB+ Existing Cover	4.5×10^{-4}	-1.34	8.783	0.22
Slopes of Disposal Area A Existing Cover	4.6×10^{-5}	-0.26	9.703	0.25
Alternative 1 Borrow - ML	1.0×10^{-5}	-2.66	3.640	0.22
Alternative 2 Borrow - SM OR SC	1.0×10^{-5}	-1.15	4.725	0.25
Prescriptive Vegetative	1×10^{-4}	-4.89	3.720	0.19
Prescriptive Clay layer	1×10^{-6}	-1.88	5.973	0.30

Notes:
For Silty and Clayey Sand Borrow Soil, initial water content equals optimum water content based on Proctor compaction tests.
For Chapter 15 Soils, initial water contents assumed from data for typical silty soils.
For Existing Cover, initail moisture content equals optimum based on Proctor compaction tests.
a and b are the designation of the air entry value and exponent in Campbell's equation used in LEACHM.

TABLE 6-3

SUMMARY OF WATER BALANCE PREDICTION USING LEACHM
SLOPES OF DISPOSAL AREA A
LOPEZ CANYON SANITARY LANDFILL

Simulation	Saturated Hydraulic Conductivity (cm/s)	Cover Thickness (feet)	Root Depth (in.)	Evapotran-spiration (mm/yr, %)[3]	Overland Flow (mm/yr, %)[3]	Change In Cover Storage (mm/yr)	Percolation (mm/yr, %)[3]
Prescriptive[1]	$10^{-4}/10^{-6}/10^{-4}$	2/1/1	12	351.7 (76.7%)	99.0 (21.6%)	-6.4 (-1.4%)	13.8 (3.0%)
A-Slope, Alternative, (Avg-K)[2]	4.6×10^{-5}	6.5	12	229.9 (50.1%)	229.6 (50.1%)	-7.0 (-1.53%)	4.4 (1.0%)

Note: Values are annual average based on a 10-year simulation
(1) Title 27 prescriptive cover
(2) Alternative monolithic cover.
(3) Totals do not necessarily add to 100% due to rounding.

TABLE 6-4

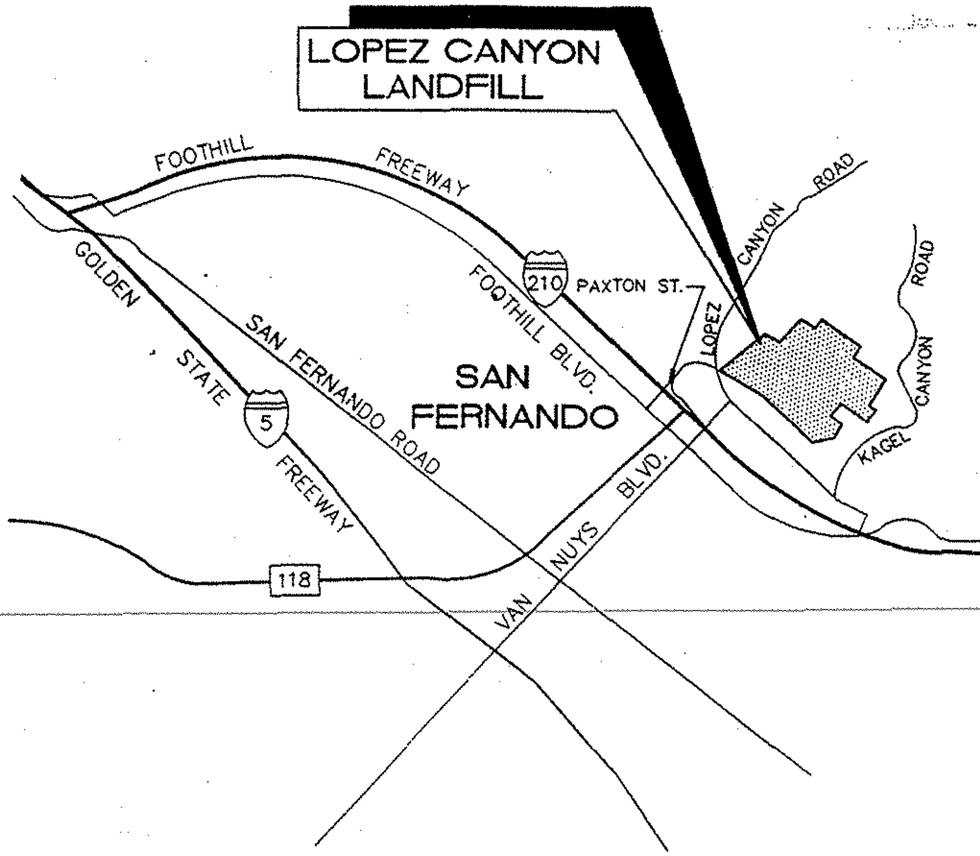
SUMMARY OF WATER BALANCE PREDICTION USING LEACHM
DECKS OF DISPOSAL AREAS A, B, AND AB+ AND SLOPES OF DISPOSAL AREA AB+
LOPEZ CANYON SANITARY LANDFILL

Simulation	Saturated Hydraulic Conductivity (cm/s)	Cover Thickness (feet)	Root Depth (in.)	Evapotranspiration (mm/yr, %)(3)	Overland Flow (mm/yr, %)(3)	Change In Cover Storage (mm/yr)	Percolation (mm/yr, %)(3)
Prescriptive(1)	$10^{-4}/10^{-6}/10^{-4}$	2/1/1	12	351.7 (76.7%)	99.0 (21.6%)	-6.4 (-1.4%)	13.8 (3.0%)
Alternative 1(2)	$4.5 \times 10^{-4}/10^{-5}$	2 / 3	12	255.2 (55.6%)	208.5 (45.5%)	-8.7 (-1.89%)	3.2 (0.7%)
Alternative 2(2)	$4.5 \times 10^{-4}/10^{-5}$	2 / 3	12	143.7 (31.3%)	319.9 (69.8%)	-8.7 (-1.89%)	3.4 (0.7%)

Note: Values are annual average based on a 10-year simulation.
(1) Title 27 prescriptive cover
(2) Alternative monolithic cover.
(3) Totals do not necessarily add to 100% due to rounding.

FIGURES

FIGURES

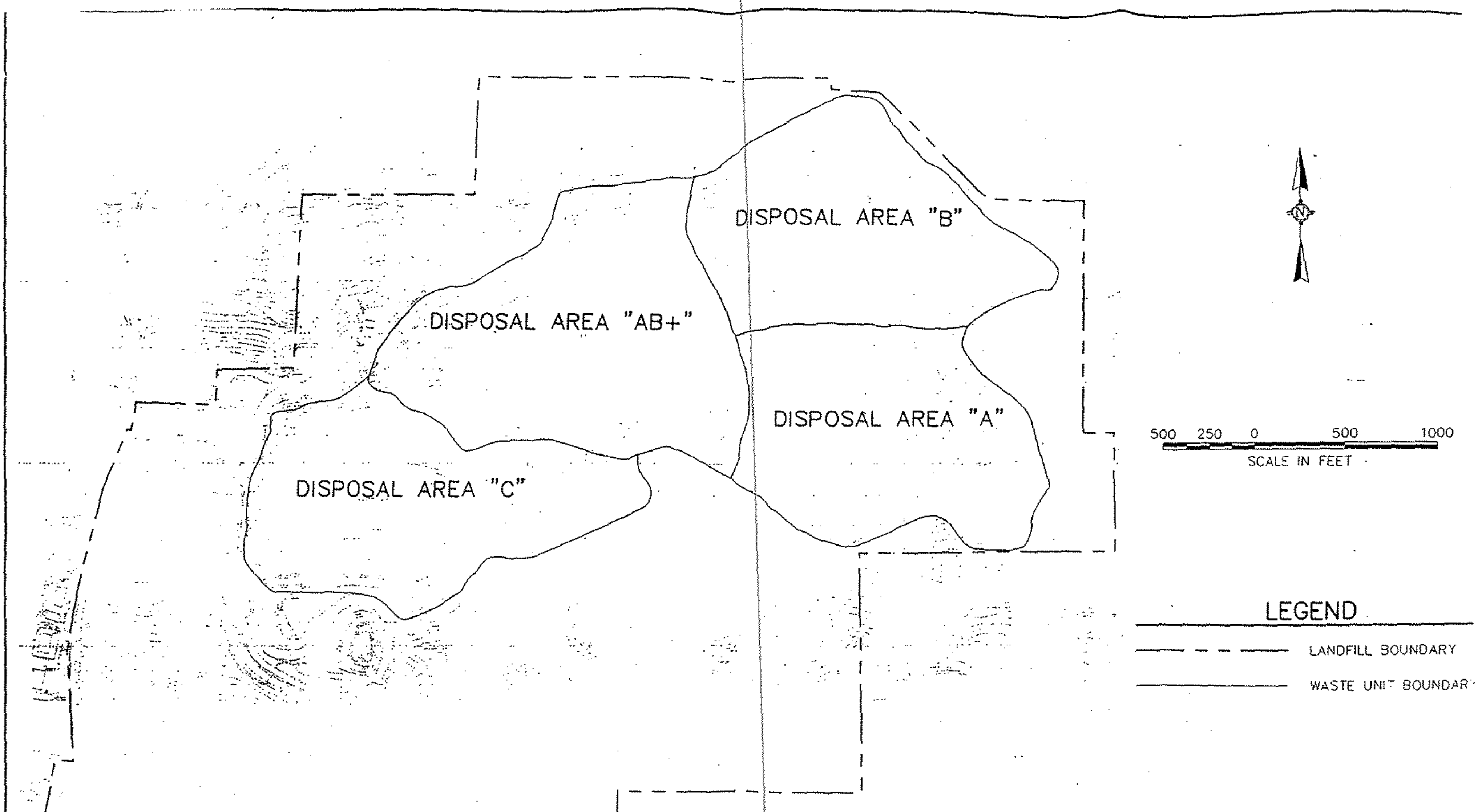


GeoSyntec Consultants

SITE LOCATION MAP
LOPEZ CANYON SANITARY LANDFILL
LAKEVIEW TERRACE, CALIFORNIA

FIGURE NO.	1-1
DOCUMENT NO.	LPZ98-13.RPT
PROJECT NO.	CE4100-04
DATE:	5 MARCH 1998

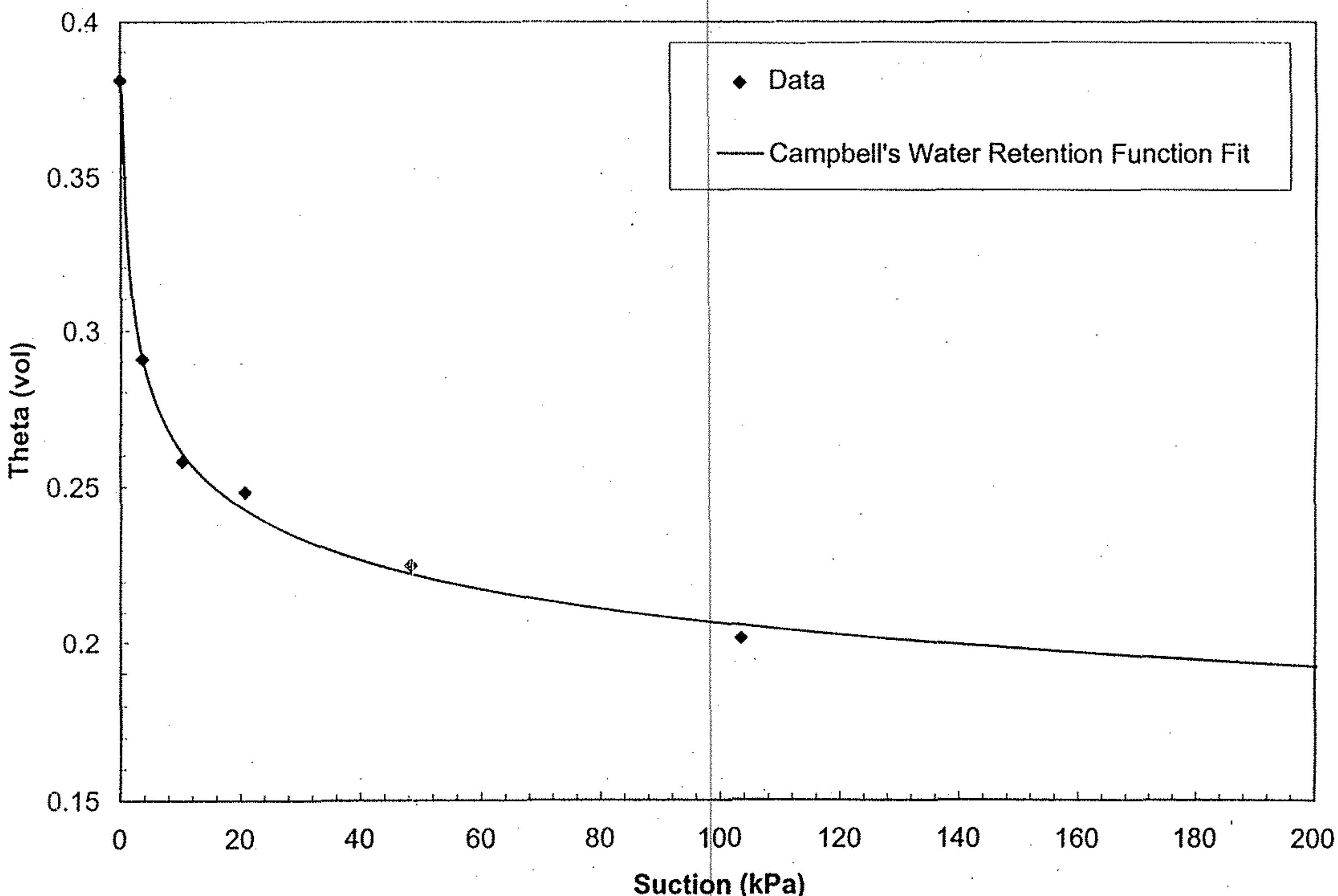
DWG: 4100F705.DWG 199803051603 RCG



GEOSYNTEC CONSULTANTS

SITE PLAN	FIGURE NO. 2-1
LOPEZ CANYON SANITARY LANDFILL	PROJECT NO. CE4100-04
LAKEVIEW TERRACE, CALIFORNIA	DOCUMENT NO. LPZ98-13.RPT
	DATE 5 MARCH 1998

DWG: 4100F702.DWG 199803051637 RCG



GEOSYNTEC CONSULTANTS

SUCTION DATA FOR
SAMPLE A-6
LOPEZ CANYON SANITARY LANDFILL
LAKEVIEW TERRACE, CALIFORNIA

FIGURE NO.	4-1
PROJECT NO.	CE4100-04
DATE:	5 MARCH 1998

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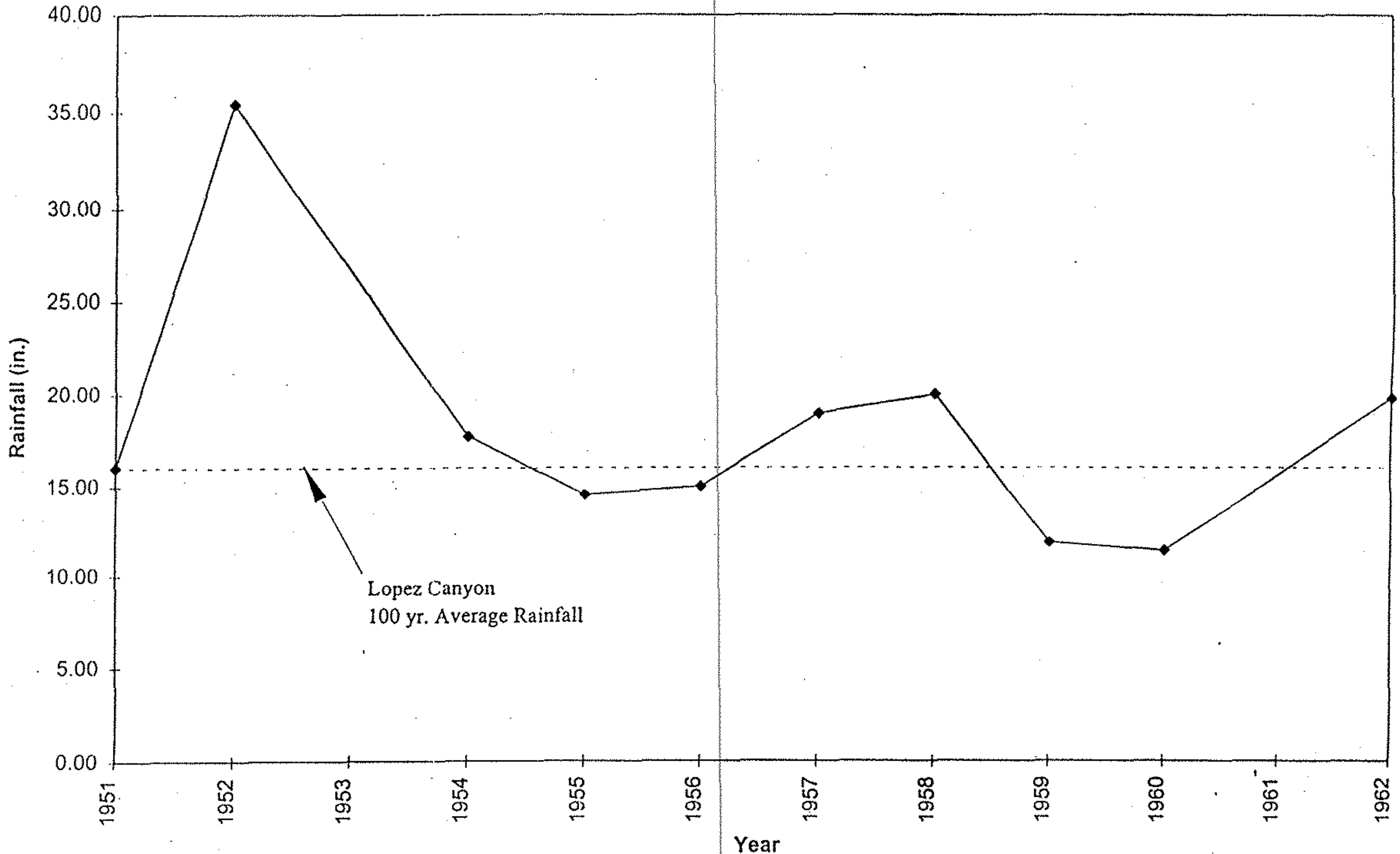
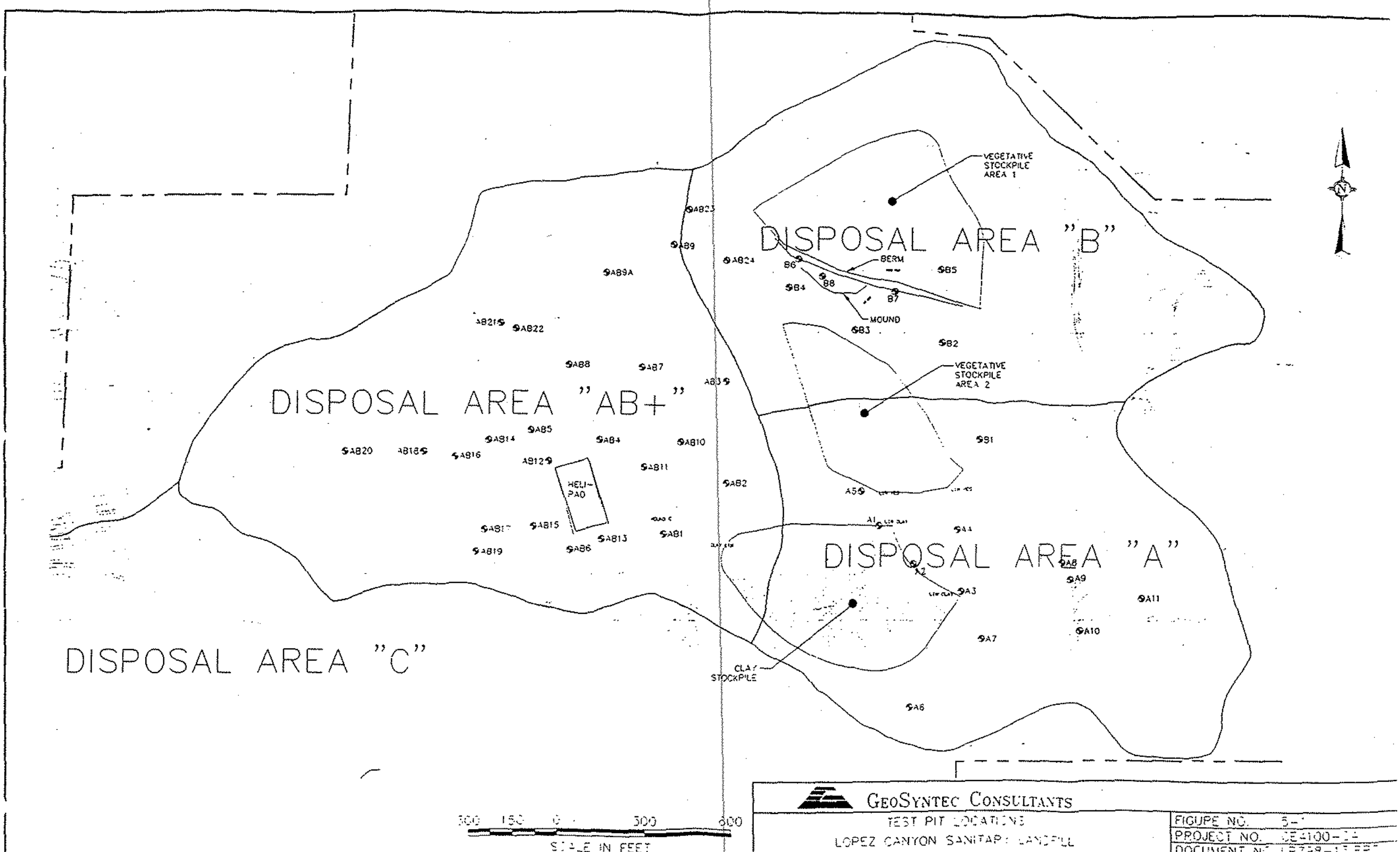


GEOSYNTEC CONSULTANTS

SUNLAND WEATHER STATION PRECIPITATION DATA FOR MODELING LOPEZ CANYON SANITARY LANDFILL LAKEVIEW TERRACE, CALIFORNIA	FIGURE NO.	4-2
	PROJECT NO.	CE4100-04
	DATE:	5 MARCH 1998

A Recycled and Recyclable Paper

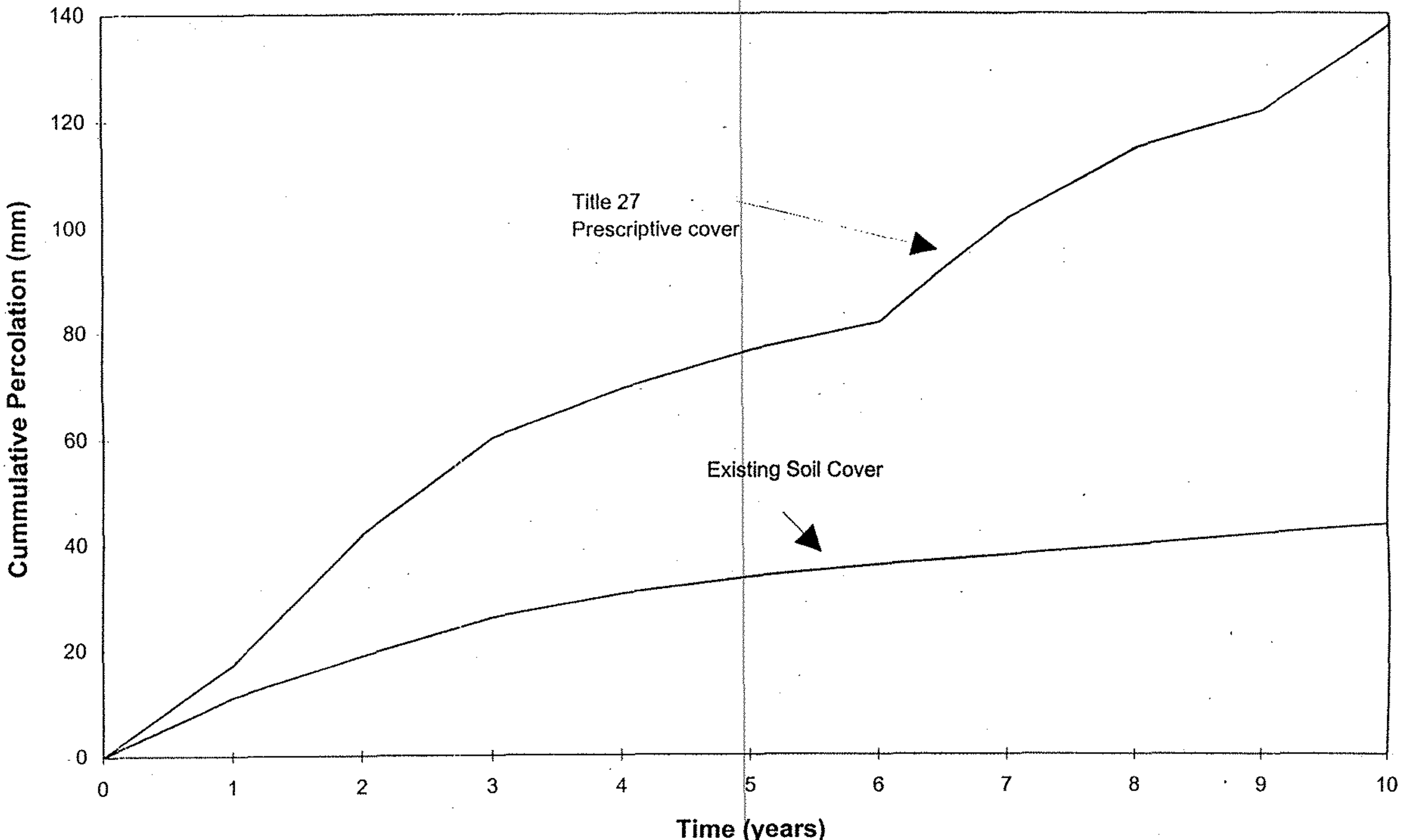


GeoSyntec Consultants

TEST PIT LOCATIONS
LOPEZ CANYON SANITARY LANDFILL
LAKEVIEW TERRACE, CALIFORNIA

FIGURE NO.	5-[illegible]
PROJECT NO.	[illegible]E4100-[illegible]
DOCUMENT NO.	[illegible]
DATE:	5 MARCH [illegible]

DWG: 4100F703.DWG 19980305I639 RCC



GeoSyntec Consultants

PREDICTED CUMULATIVE PERCOLATION SLOPES OF DISPOSAL AREA A LOPEZ CANYON SANITARY LANDFILL LAKEVIEW TERRACE, CALIFORNIA	FIGURE NO.	6-1
	PROJECT NO.	CE4100-04
	DATE:	5 MARCH 1998

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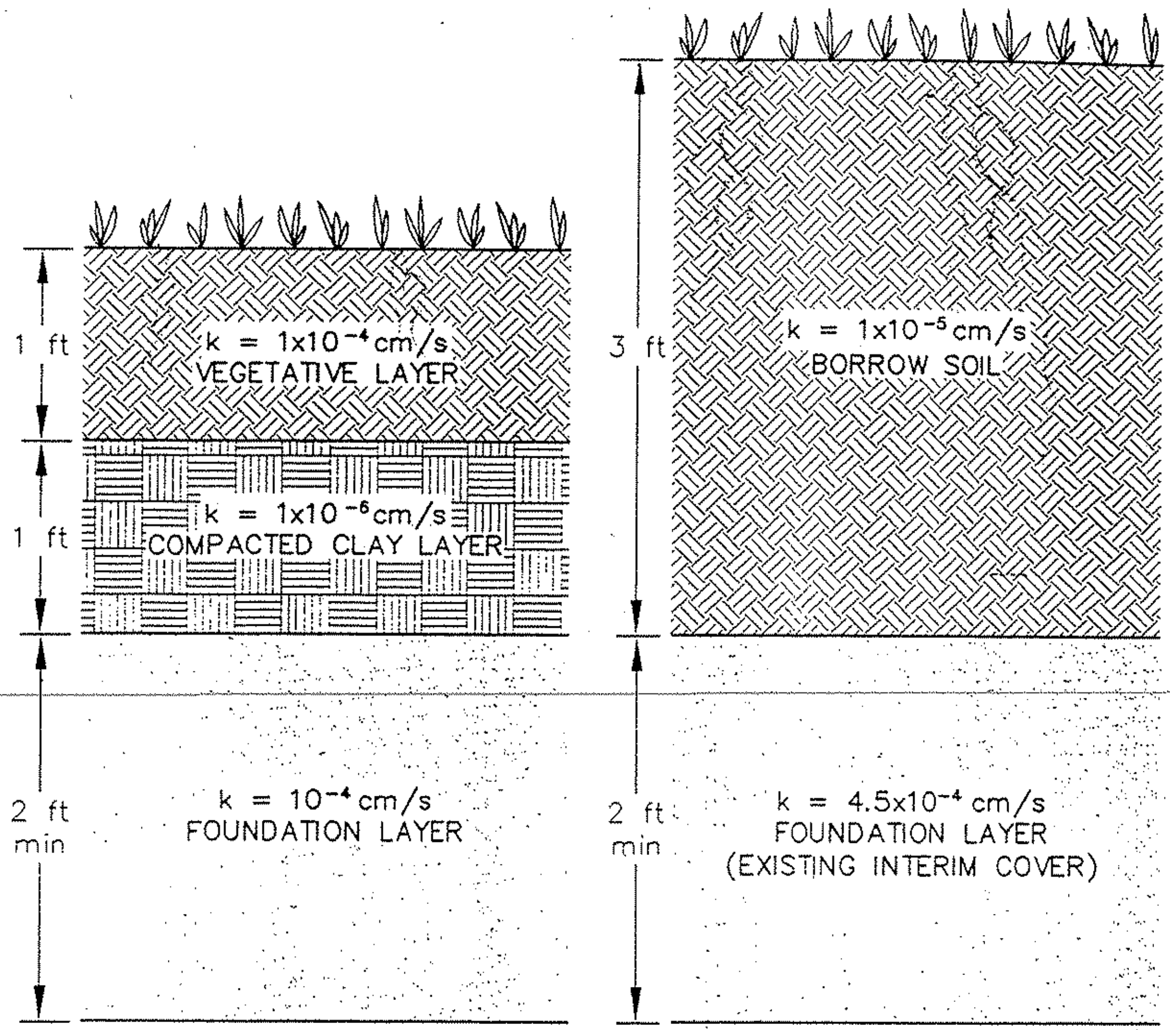
J:\CAWP\CE4100\LPZ98 13 FIG



TITLE 27 "PRESCRIPTIVE"
COVER CROSS-SECTION

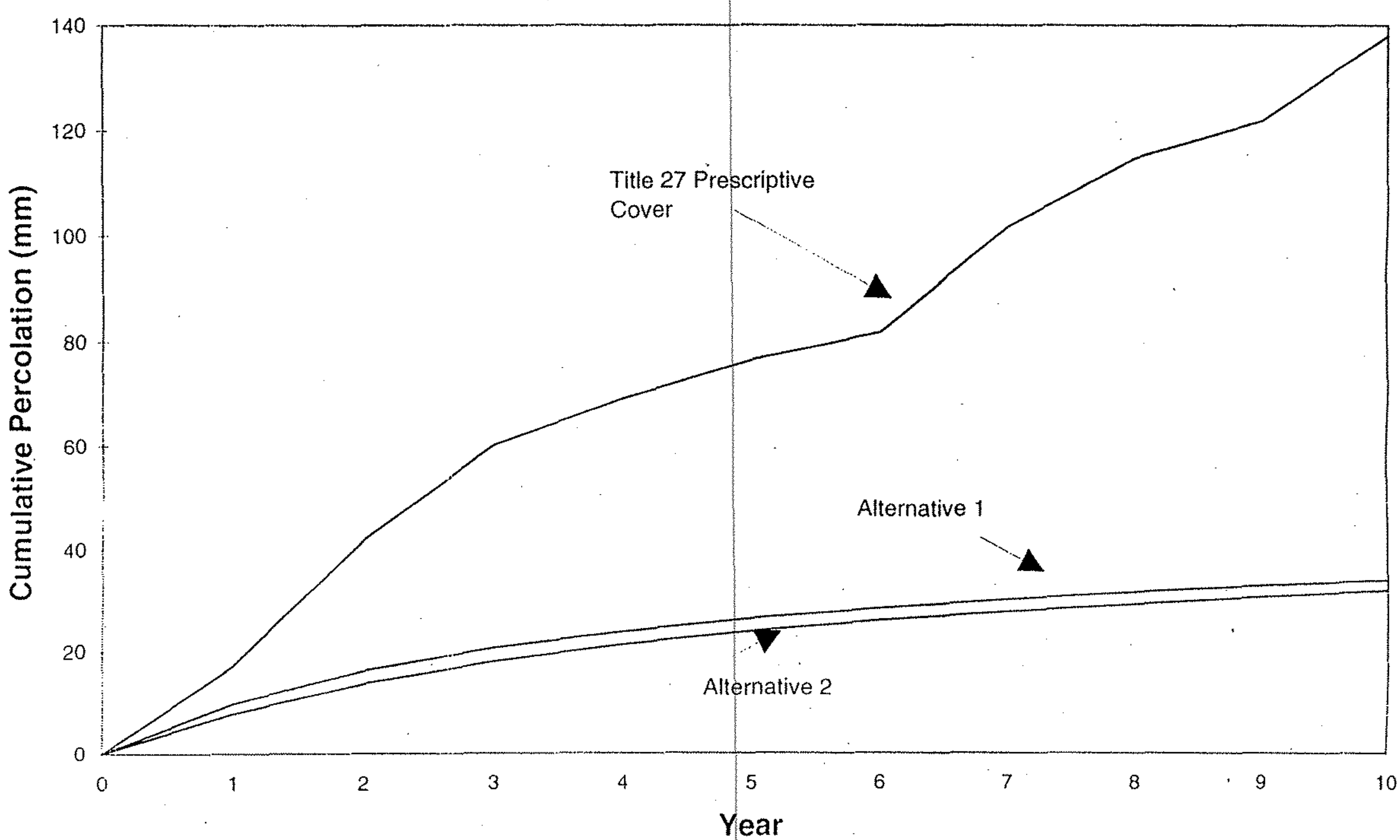
MONOLITHIC
COVER CROSS-SECTION
ALTERNATIVES 1 AND 2

GEOSYNTEC CONSULTANTS

FINAL COVER CROSS-SECTIONS MODELED
LOPEZ CANYON SANITARY LANDFILL
LAKEVIEW TERRACE, CALIFORNIA

FIGURE NO.	6-2
DOCUMENT NO.	LPZ98-13.RPT
PROJECT NO.	CE4100-04
DATE:	5 MARCH 1998

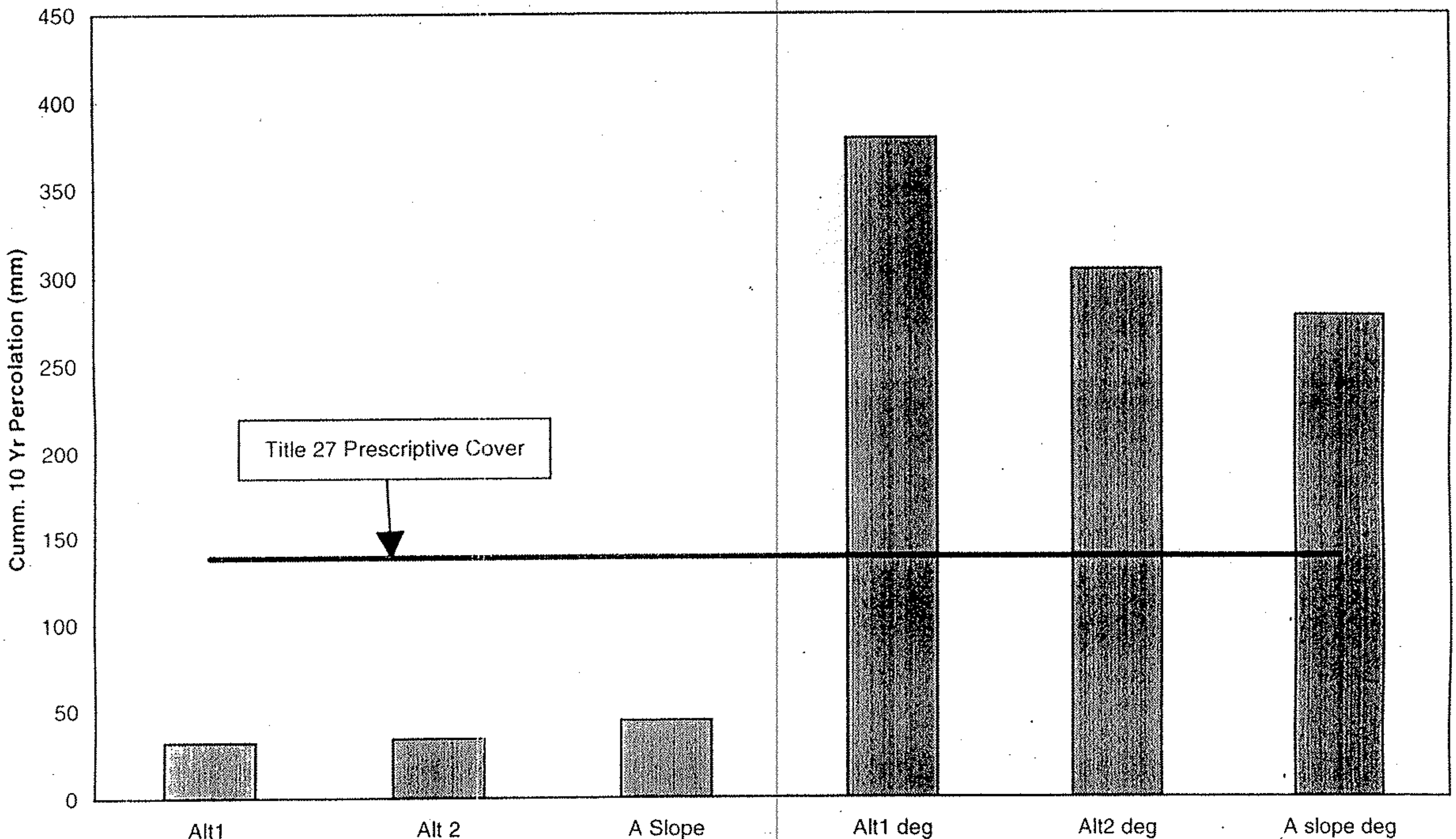
DWG: 4100F704.DWG 199804060851 AC



GEOSYNTEC CONSULTANTS

PREDICTED CUMULATIVE PERCOLATION FOR ALTERNATIVE AND PRESCRIPTIVE COVERS
LOPEZ CANYON SANITARY LANDFILL
LAKEVIEW TERRACE, CALIFORNIA

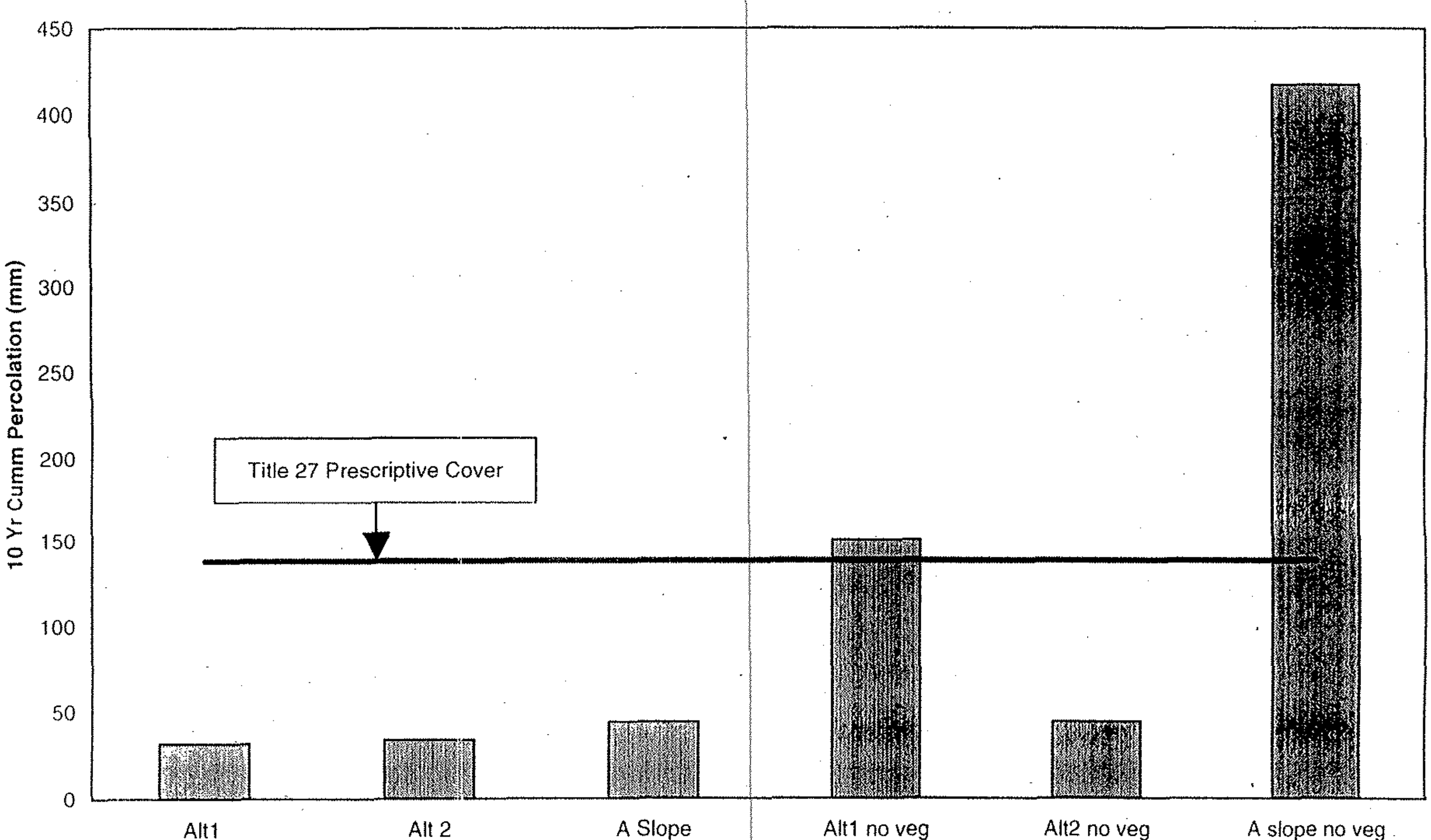
FIGURE NO.	6-3
PROJECT NO.	CE4100-04
DATE:	5 MARCH 1998



GEOSYNTEC CONSULTANTS

SENSITIVITY ANALYSIS
DEGRADED SATURATED HYDRAULIC CONDUCTIVITY
MONOLITHIC SOIL COVER
LOPEZ CANYON SANITARY LANDFILL
LAKE VIEW TERRACE, CALIFORNIA

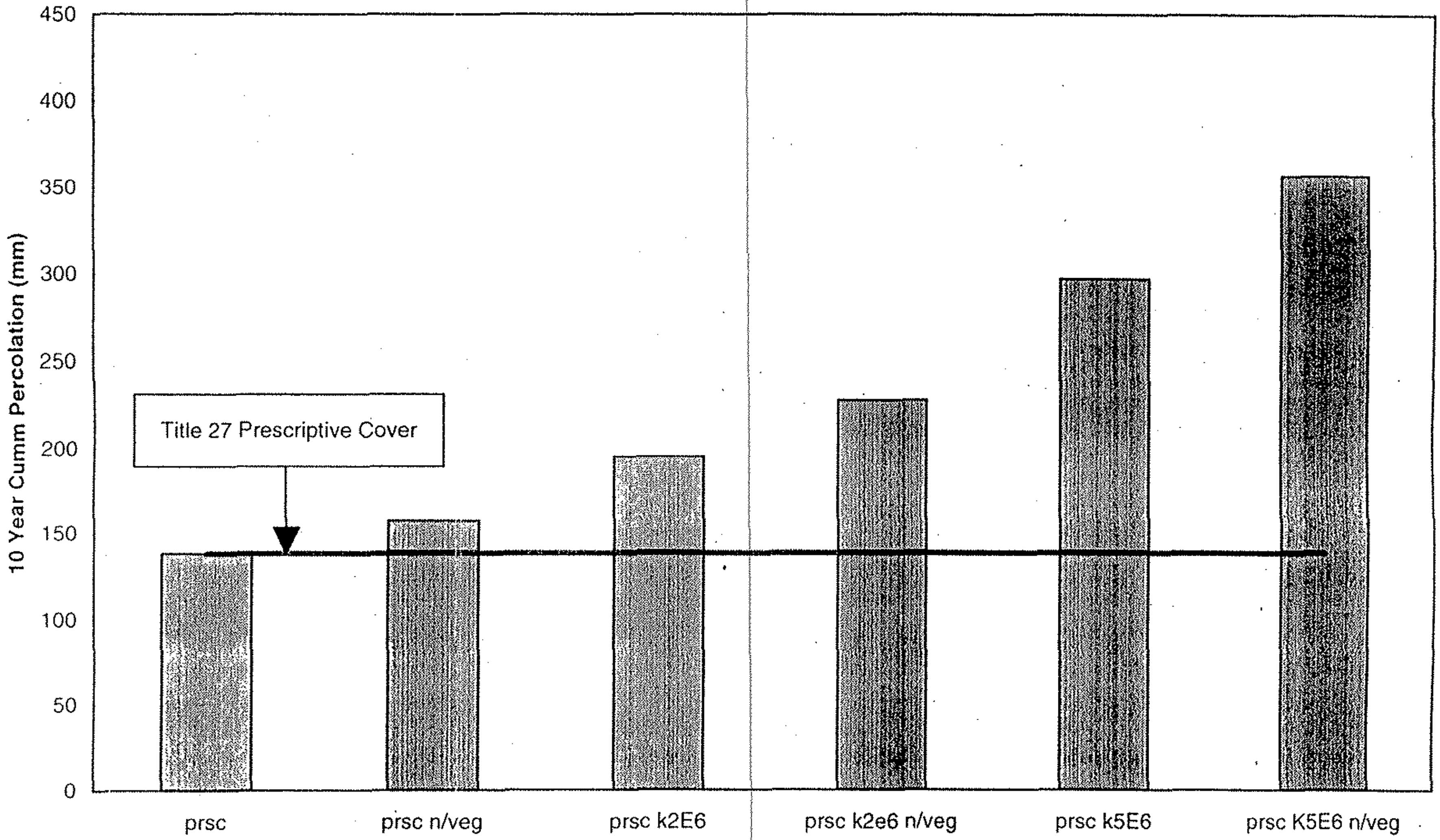
FIGURE NO.	6-4
PROJECT NO.	CE4100-04
DATE:	11 SEPTEMBER 1998



GEOSYNTEC CONSULTANTS

SENSITIVITY ANALYSIS
VEGETATION
MONOLITHIC SOIL COVER
LOPEZ CANYON SANITARY LANDFILL
LAKE VIEW TERRACE, CALIFORNIA

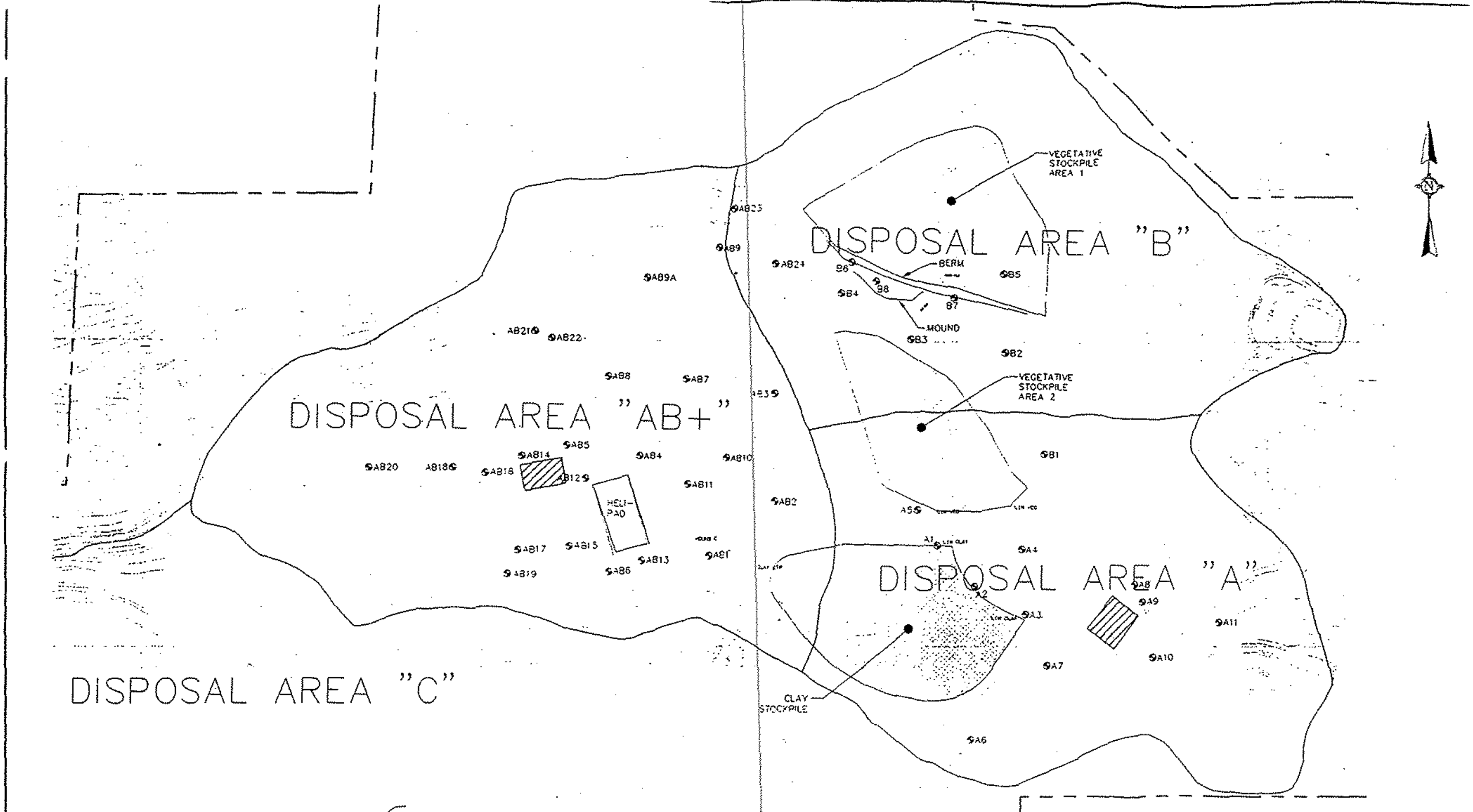
FIGURE NO.	6-5
PROJECT NO.	CE4100-04
DATE:	11 SEPTEMBER 1998



GEOSYNTEC CONSULTANTS

SENSITIVITY ANALYSES VEGETATION AND DEGRADED HYDRAULIC CONDUCTIVITY TITLE 27 PRESCRIPTIVE COVER LOPEZ CANYON SANITARY LANDFILL LAKE VIEW TERRACE, CALIFORNIA	FIGURE NO.	6-6
	PROJECT NO.	CE4100-04
	DATE:	11 SEPTEMBER 1998

A Recycled and Recyclable Paper



PROPOSED TEST LOCATIONS

300 150 0 300 600

SCALE IN FEET

GeoSyntec Consultants	
LOCATION OF MONITORING TEST SECTIONS	FIGURE NO. 7-1
LOPEZ CANYON SANITARY LANDFILL	PROJECT NO. CE4100-04
LAKEVIEW TERRACE, CALIFORNIA	DOCUMENT NO. LPZ98-1[illegible]
	DATE: 7 APRIL 1998

DWG: 4100F706.DWG 19980407151[illegible] AC

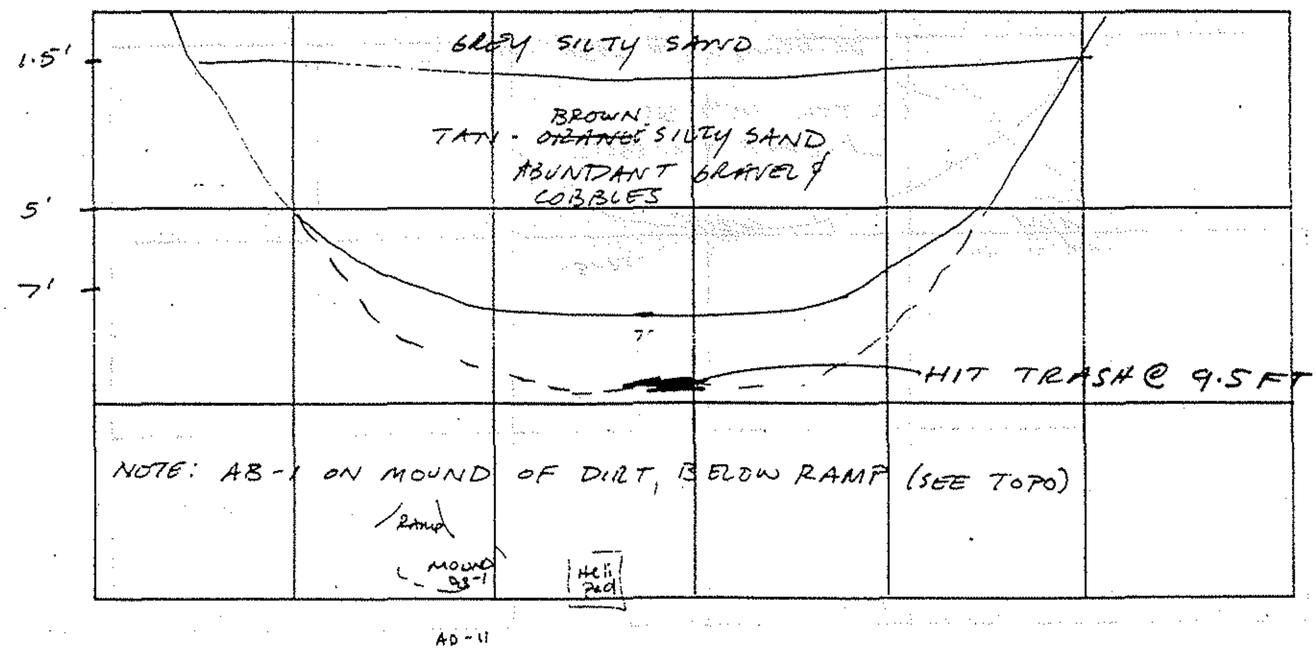
APPENDIX A:
FIELD LOGS FROM TEST PITS

GeoSyntec Consultants

REF. NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY * DENSITY (PCF)	γw
		1.5	GREY SILTY SAND (STAINED)		12.4	110.5	124.2
			LT. TAN - ~~ORANGE~~ BROWN SILTY SAND w/ GRAVEL & COBBLES TO 6"	AB-1			
		7'	NO TRASH ENCOUNTERED				
		9.5	1-16-98 RE-EXCAVATED TRENCH, HIT TRASH @ 9.5 FT				

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE *USED CURVE γDMAX = 118.5

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: AB+ DECK DATE: 1-12-98 & 1-16-98 (RE-DUG TRENCH @ SAME LOCATION)

ELEVATION: 1774 EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: CC

LOG OF TEST PIT NO. AB-1

FIGURE NO.

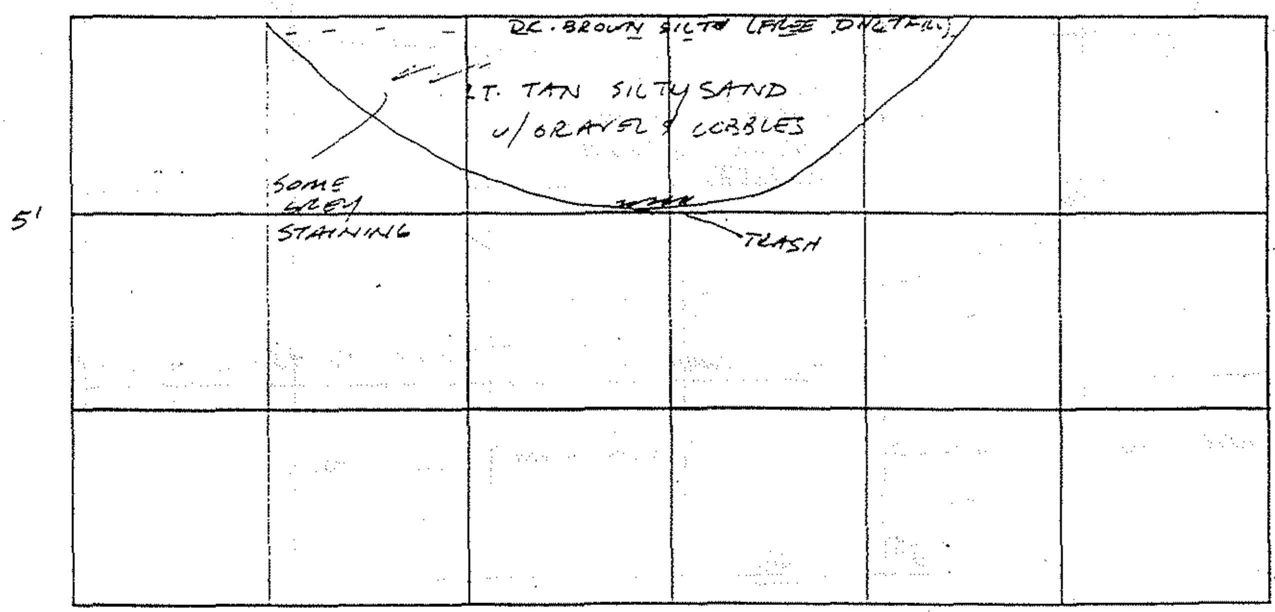
GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE* CONTENT (%)	DRY DENSITY (PCF)
			DARK BROWN SANDY SILT		15.4	112.8
		3-4"	LT. TAN SILTY SAND w/ GRAVEL & COBBLES			
		5'	HIT TRASH AT 5 FT. (PLASTIC BAGS)			

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

* TOP 6", RAINED .5" OVER WEEKEND.

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: AB + PERK DATE: 1-12-98

ELEVATION: 1768 EQUIPMENT: EXCAVATOR

WATER LEVEL: LOGGED BY: CC

LOG OF TEST PIT NO. AB-2

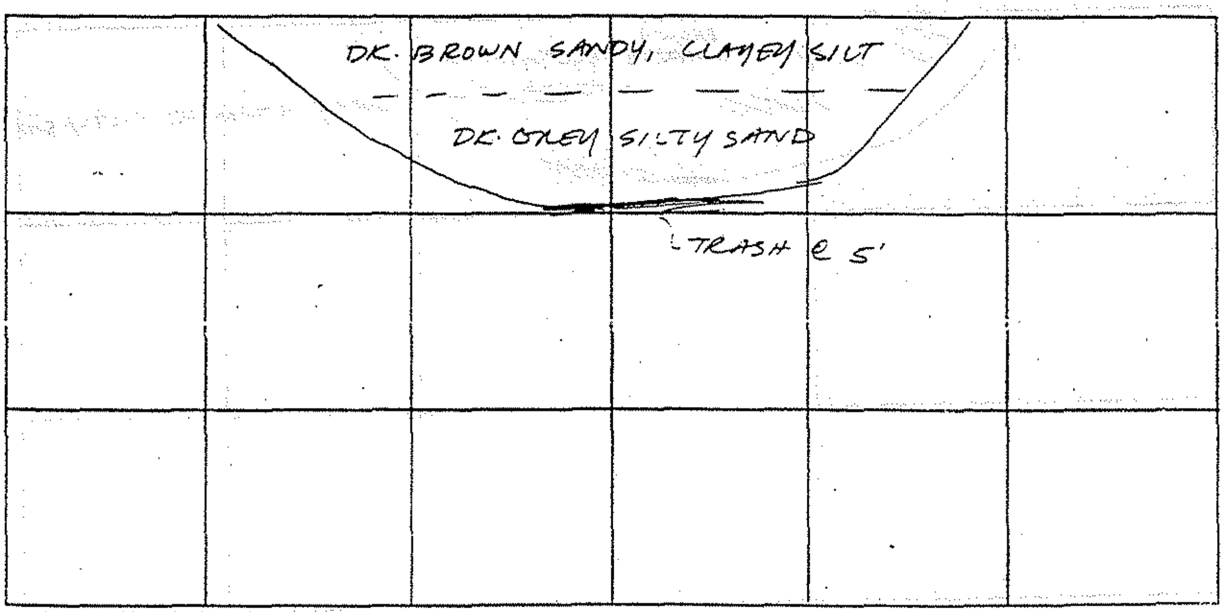
FIGURE NO. ____

GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
		2FT –	DK. BROWN SANDY SILT, SOME CLAYEY FINES (SAMPLED) – FREE DIRT FILL	AB-3	-	
		5' –	GREY (STAINED) SILTY SAND w/ GRAVEL & COBBLES TO 6"			
			HIT TRASH @ 5 FT.		-	

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: AB+ DECK DATE: 1 - 13 - 98

ELEVATION: 1764 EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: CC

LOG OF TEST PIT NO. AB-3

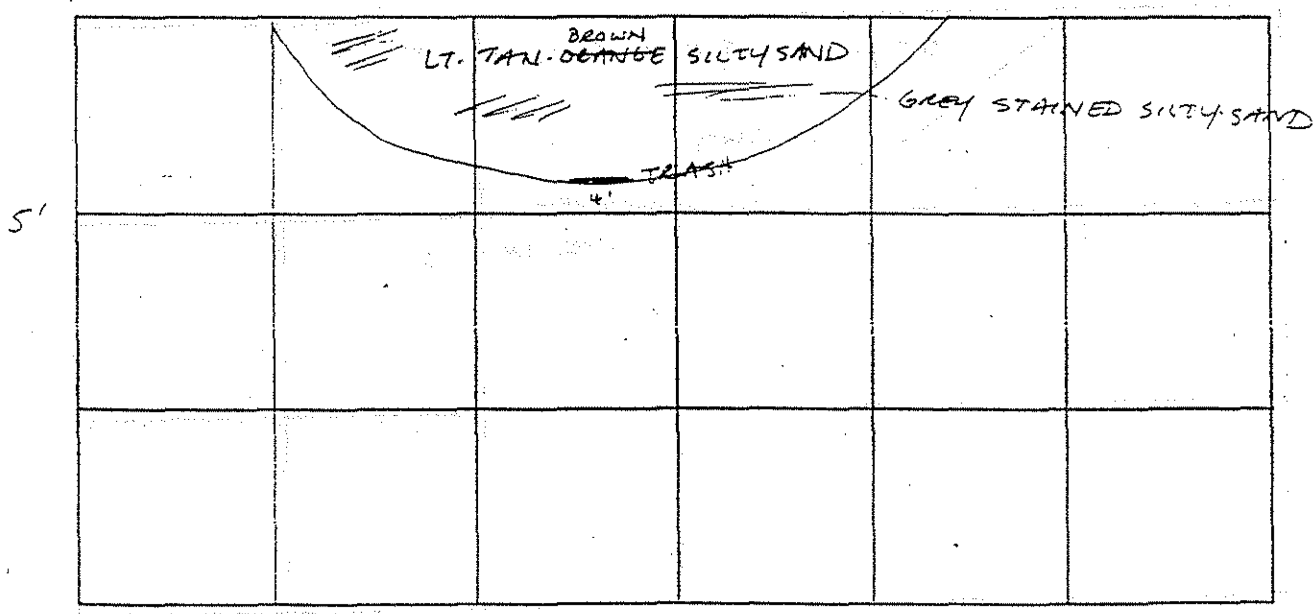
FIGURE NO.

GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			LT. TAN - ~~ORANGE~~ BROWN SILTY SAND, GREY STREAKS (STAINING) W/GRAVEL & COBBLES -AS AB-11			
		4'	HIT TRASH			

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: AB+ DECK DATE: 1-12-98

ELEVATION: 1760 EQUIPMENT: EXCAVATOR

WATER LEVEL. LOGGED BY: CC

LOG OF TEST PIT NO. AB-4

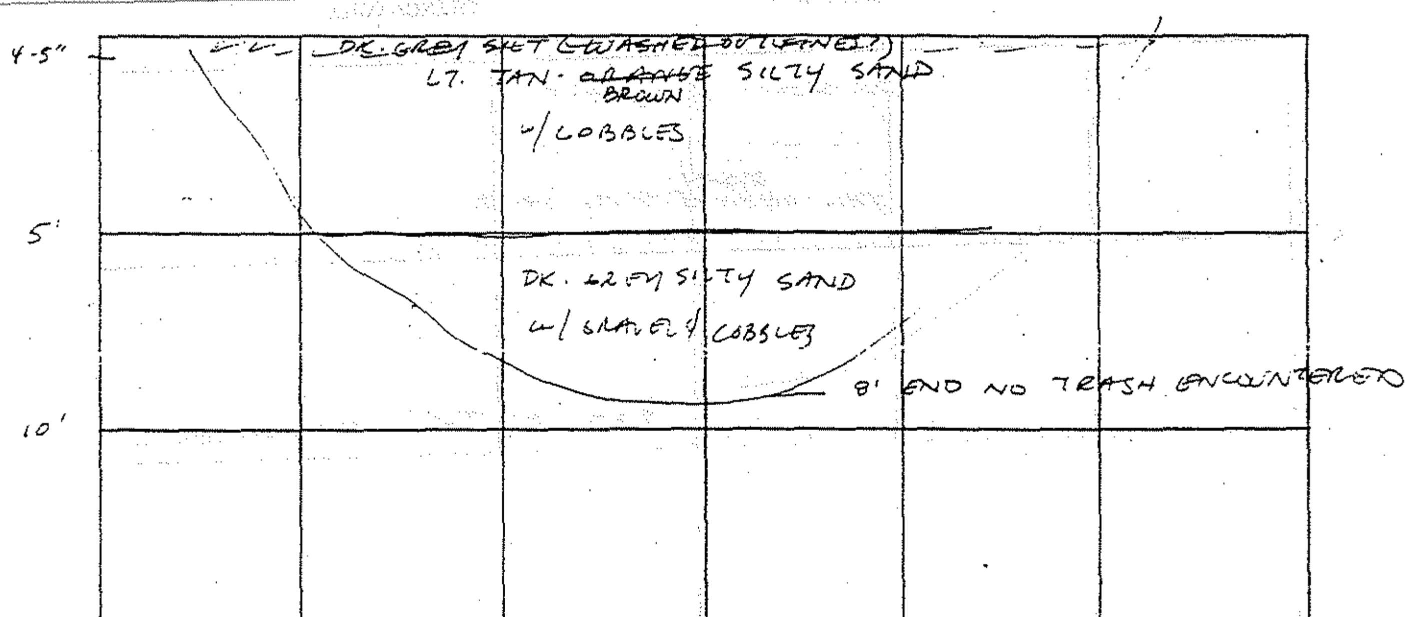
FIGURE NO.

GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			MOIST DK. GREY SILT			
		4-5"				
			LT. TAN-~~ORANGE~~ BROWN SILTY SAND W/COBBLES TO 6"		-	
		5'				
			DK GREY (STAINED?) SILTY SAND W/ GRAVEL & COBBLES TO 6"		-	
		8'	NO TRASH ENCOUNTERED, END TESTPIT.			

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: AB+ DECK DATE: 1-12-98

ELEVATION: 1760 EQUIPMENT: EXCAVATOR

WATER LEVEL: LOGGED BY: CC

LOG OF TEST PIT NO. AB-5

FIGURE NO. ____

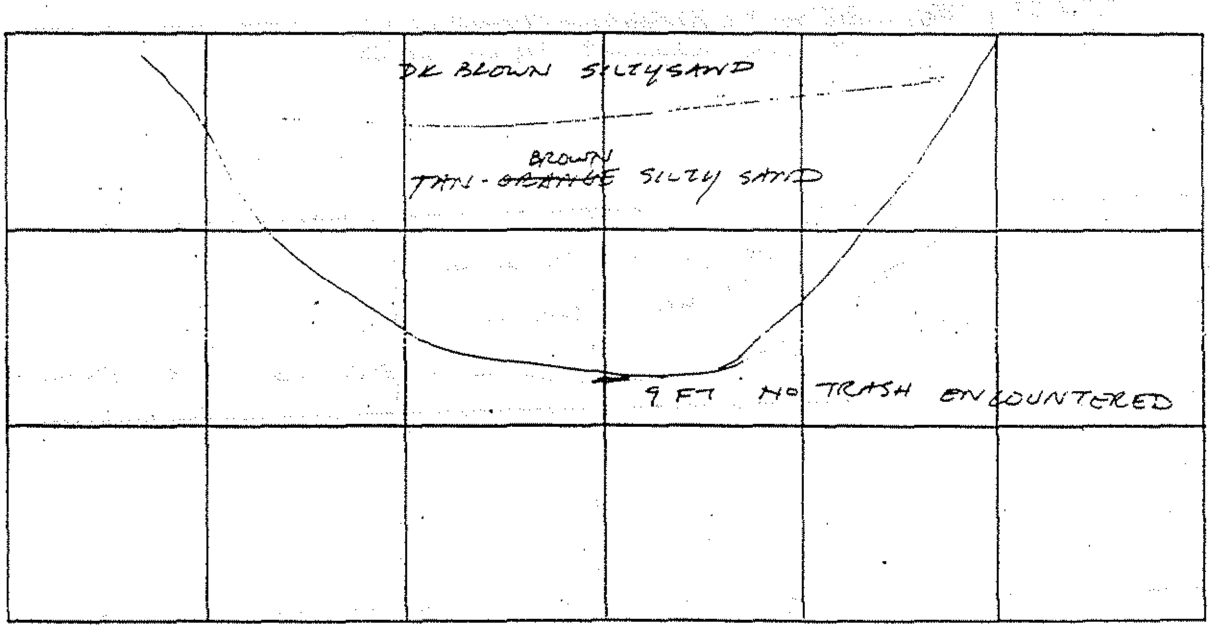
GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			BROWN SILTY SAND (FREE DIRT FILL ?)			
		2'				
			LT. TAN-~~ORANGE~~ BROWN SILTY SAND W/GRAVEL & COBBLES			
		9'	NO TRASH ENCOUNTERED.			

B - BULK SAMPLE   T - TUBE SAMPLE   D - DRIVE SAMPLE

SCALE 1" =   BEARING =   TRENCH WALL:

5'



LOCATION: AB+ DECK   DATE: 1-12-98

ELEVATION: 1766   EQUIPMENT: EXCAVATOR

WATER LEVEL: LOGGED BY: CC

LOG OF TEST PIT NO. AB-6

FIGURE NO.

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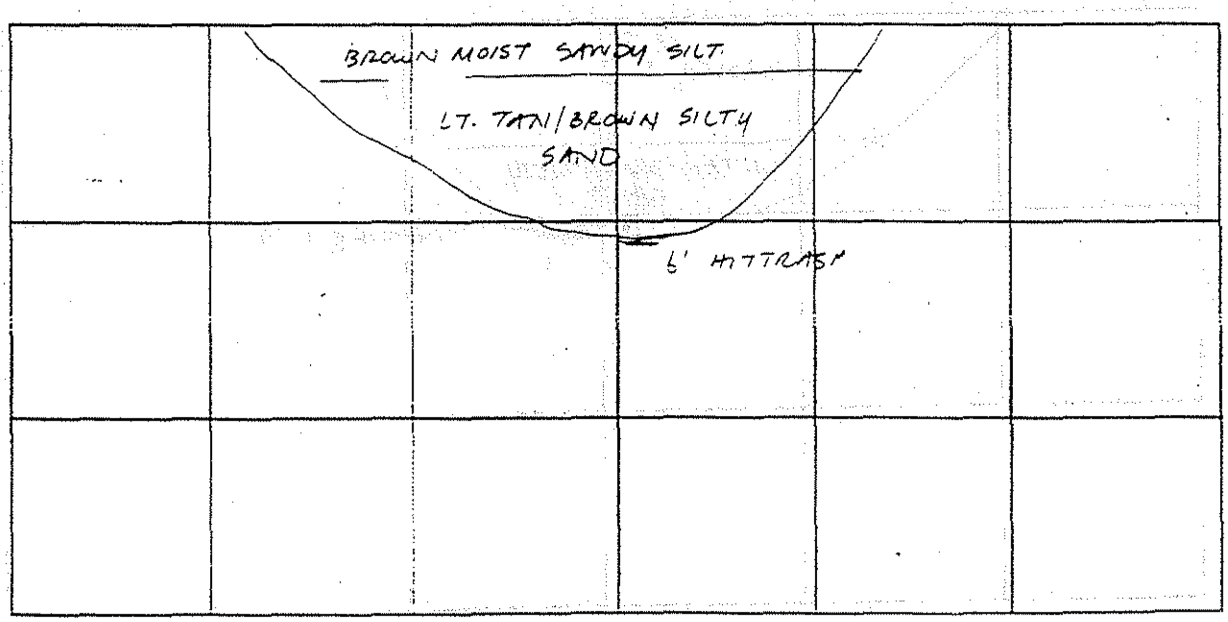
GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			BROWN SANDY SILT (WET) (SAMPLED)	AB-7		
		2'				
			LT. TAN/BROWN SILTY SAND w/GRAVEL & COBBLES			
		6'	HIT TRASH			

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:

5'



LOCATION: AB+ DECK DATE: 1-13-98

ELEVATION: 1755 EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: CL

LOG OF TEST PIT NO. AB-7

FIGURE NO.

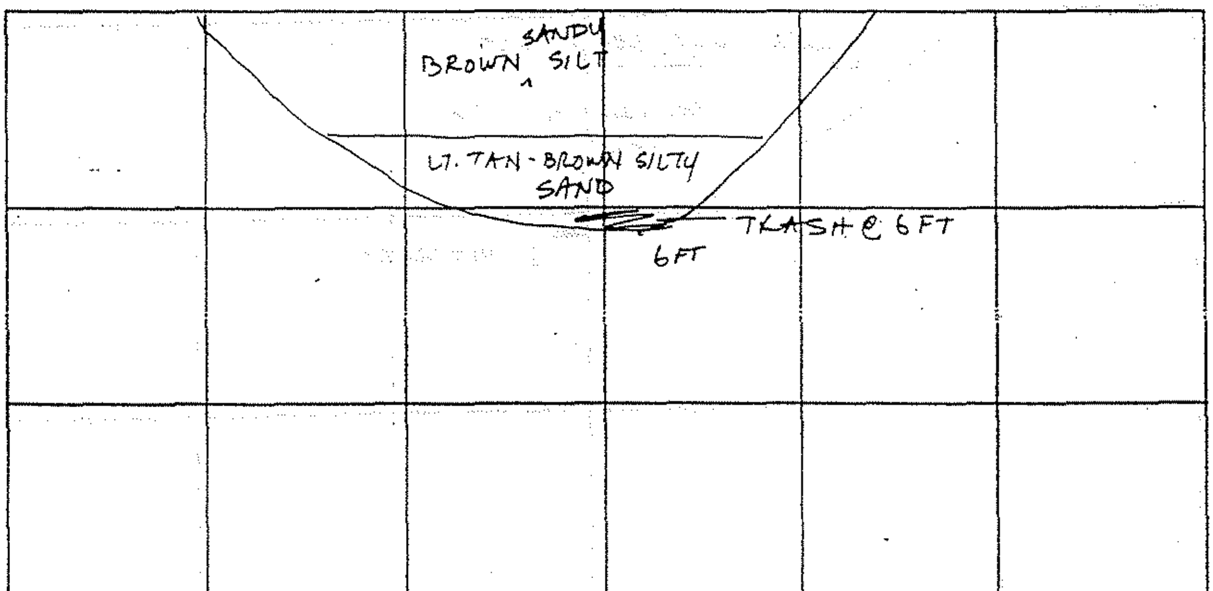
GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			BROWN SANDY SILT w/ GRAVEL & COBBLES TO 4"			
		3'	(FREE DIRT FILL ?)			
			LT. TAN/BROWN SILTY SAND w/ GRAVEL & COBBLES - GREY STAINING			
		6'	HIT TRASH			

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:

5'



LOCATION: AB+ DECK DATE: 1-13-98

ELEVATION: 1755 EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: CL

LOG OF TEST PIT NO. AB-8

FIGURE NO.

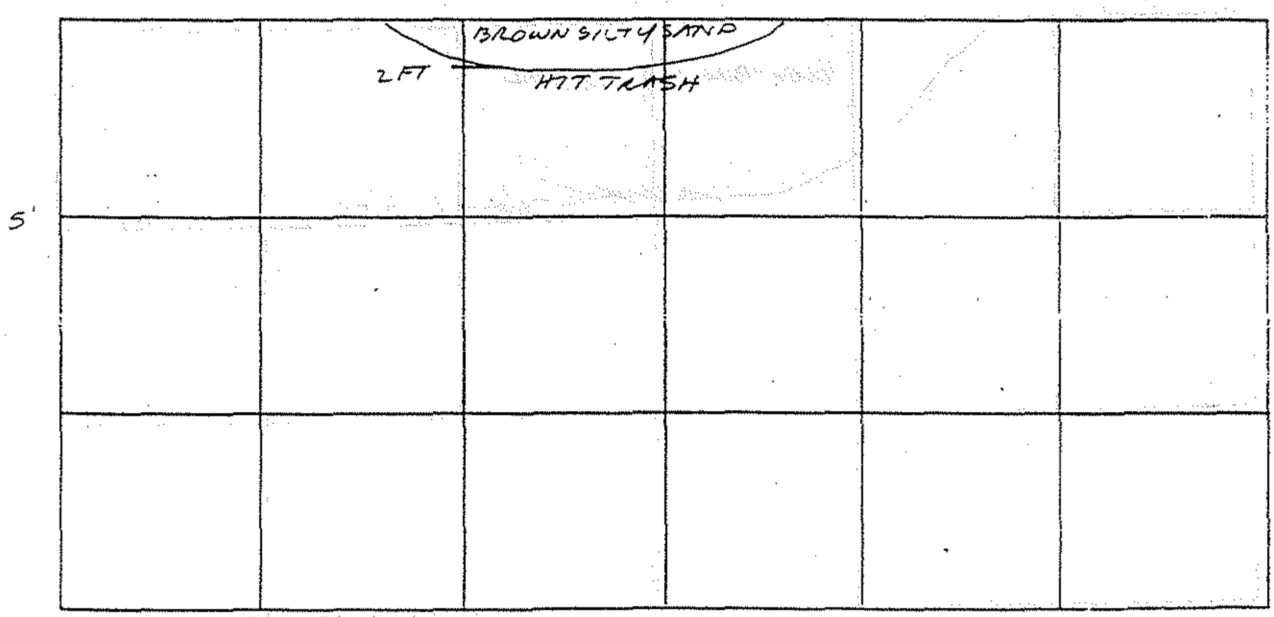
A Recycled and Recyclable Paper

GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			BROWN SILTY SAND			
		2' —	TRASH (IN FIRST BUCKET EXCAVATED) @1.5 - 2FT.		-	

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: AB+ DECKS DATE: 1-13-98

ELEVATION: 1749 EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: CC

* MOVED AB-9 LOCATION TO LOW-SPOT, AS ORIGINALLY ON 6-9 FT FREE DIRT FILL

LOG OF TEST PIT NO. AB-9A*

FIGURE NO. ____

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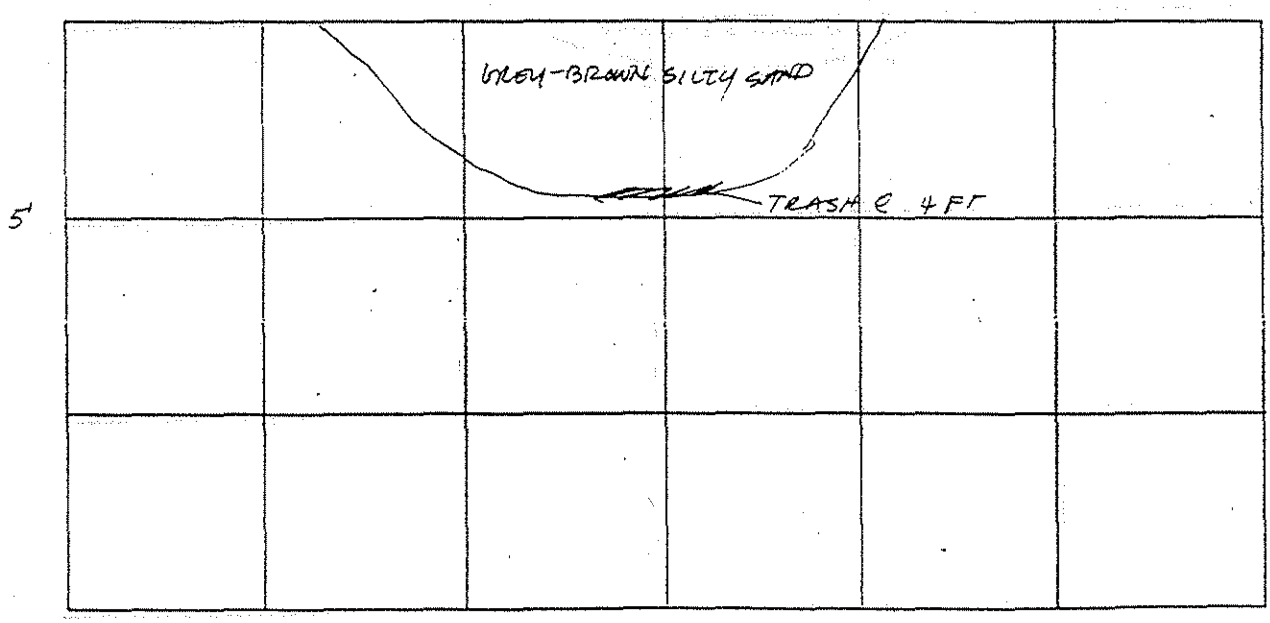
GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			GREY-BROWN SILTY SAND w/ GRAVEL & COBBLES TO 4"			
		4'	HIT TRASH @ 4 FT. STOPPED			

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: AB+ DECK DATE: 1-13-98

ELEVATION: 1761.5 EQUIPMENT: EXCAVATOR

WATER LEVEL: LOGGED BY:

LOG OF TEST PIT NO. AB-10

FIGURE NO. ____

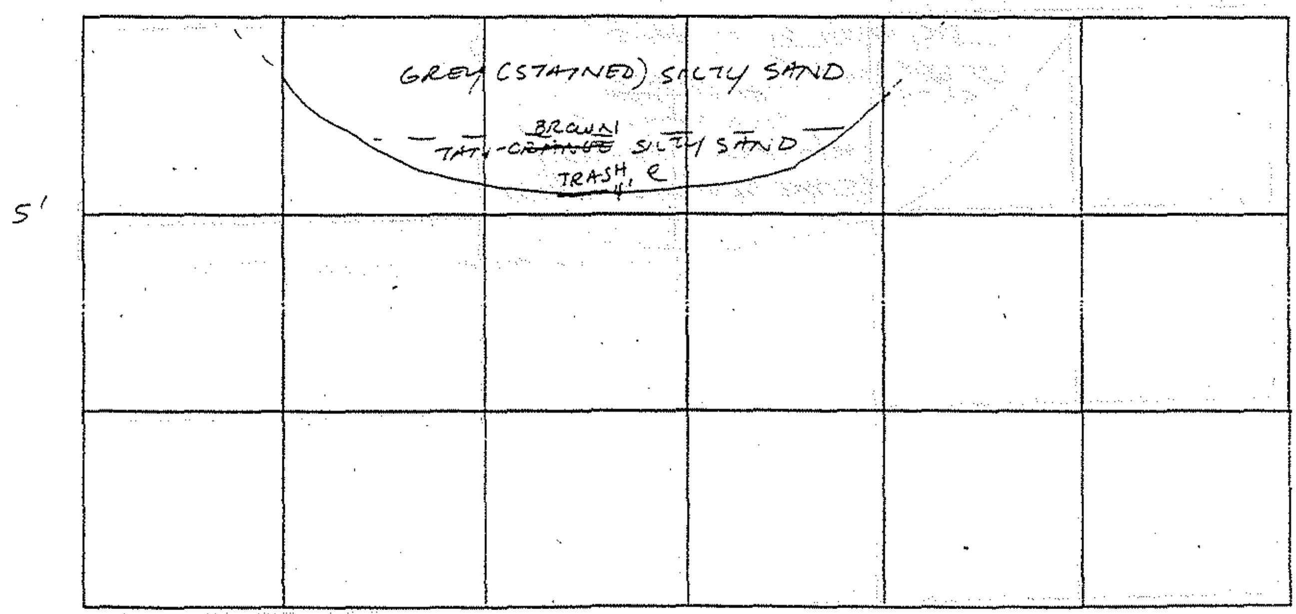
GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			GREY SILTY SAND w/ GRAVEL (STAINED) (SAMPLED)	AB-11	18.5	92.7
		3'	LT. TAN-~~ORANGE~~ BROWN SILTY SAND w/ GRAVEL			
		4'	HIT TRASH AT 4 FT.			

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

STAINED 1.5" OVER WEEKEND, TOP 3-4" VERY MOIST.

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: AB+ DECK DATE: 1-12-98

ELEVATION: 1763 EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: CC

LOG OF TEST PIT NO. AB-11

FIGURE NO.

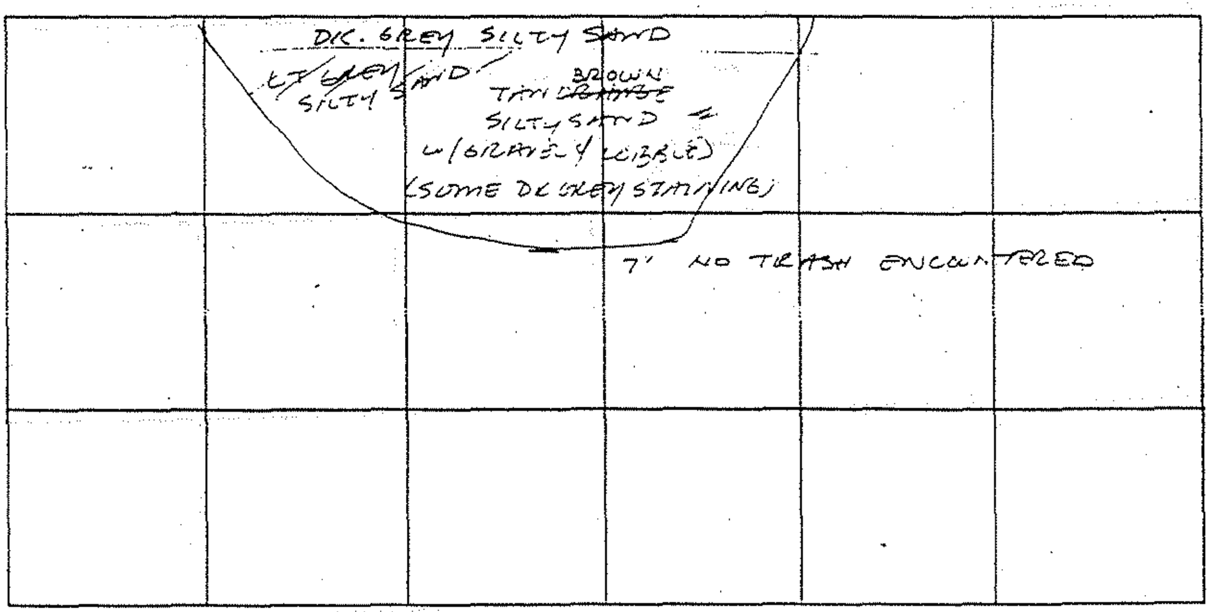
GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			DK. GREY SILTY SAND			
		2'				
		3'	LT GREY SILTY SAND			
			LT. TAN ~~ORANGE~~ BROWN SILTY SAND w/GRAVEL & COBBLES DK. GREY STREAKS			
		7'	NO TRASH ENCOUNTERED, END TESTPIT @ ~~8~~ 7 FT.			

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:

5'



* ADDED AB-12 BECAUSE DIDN'T FIND TRASH @ AB-5, ATTEMPTING TO GET EL. OF TRASH IN THIS CORNER (SEE LOCATION MAP)

LOCATION: AB+ DECK DATE: 1-12-98

ELEVATION: 1759 EQUIPMENT: EXCAVATOR

WATER LEVEL: LOGGED BY: CC

LOG OF TEST PIT NO. AB-12

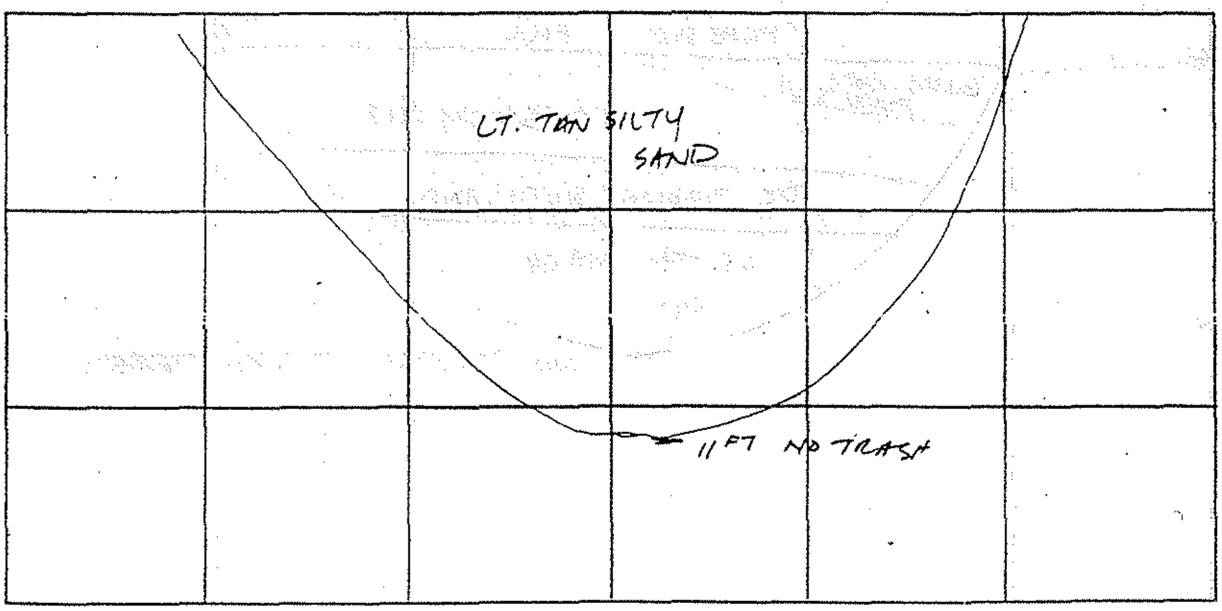
FIGURE NO.

GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			LT. TAN SILTY SAND w/ GRAVEL & COBBLES			
		11'	— NO TRASH ENCOUNTERED			

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: AB+ DECK DATE: 1-13-93

ELEVATION: 1767 EQUIPMENT: EXCAVATOR

WATER LEVEL: LOGGED BY:

LOG OF TEST PIT NO. AB-13

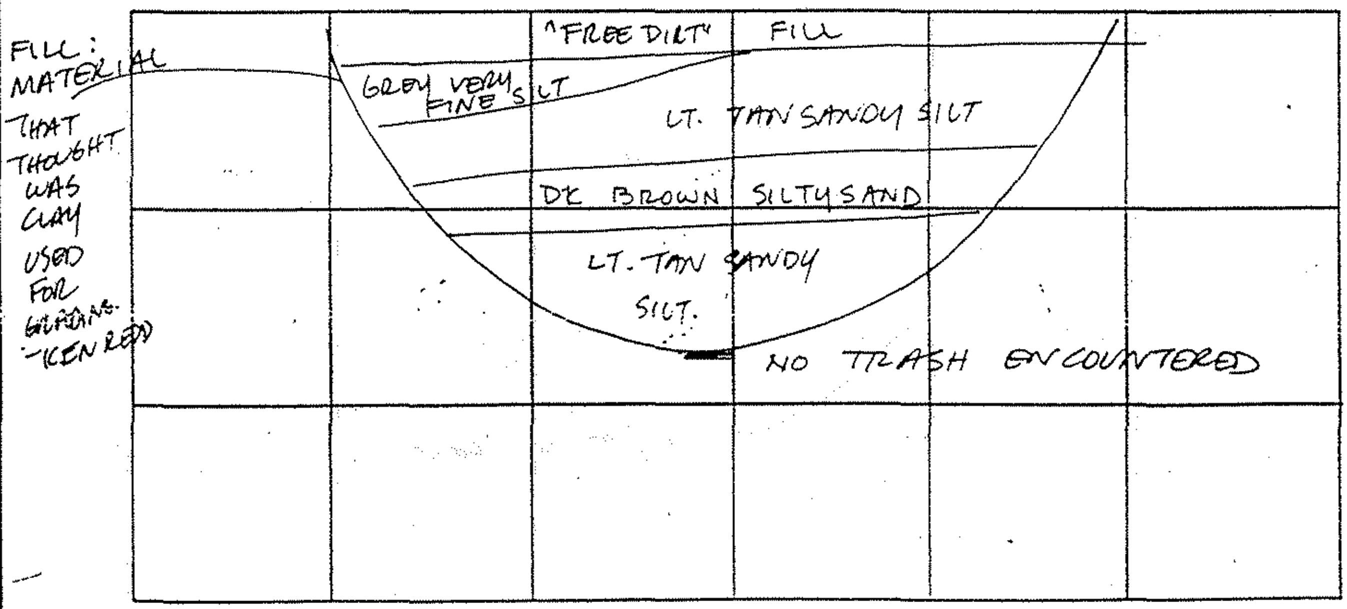
FIGURE NO. ____

GeoSynTec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			DK. BROWN SANDY SILT W/ CLAY (FREE DIRT FILL) (WET)		20.0	105.6
		6"	GREY VERY FINE SILT (SAMPLED)	AB25-A	-	
		1'	LT. TAN SANDY SILT		-	
		3'	DARK BROWN SILTY SAND (FILL)			
		5'	LT. TAN/BROWN SILTY SAND W/ COBBLES.	AB25-B		
		9'				

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: AB+ DECK DATE: 2-5-98

ELEVATION: 1762 EQUIPMENT: J.D. 892ELC

WATER LEVEL: N/A. LOGGED BY: CC

LOG OF TEST PIT NO. AB-25 ~~(RE-DUG)~~

FIGURE NO.

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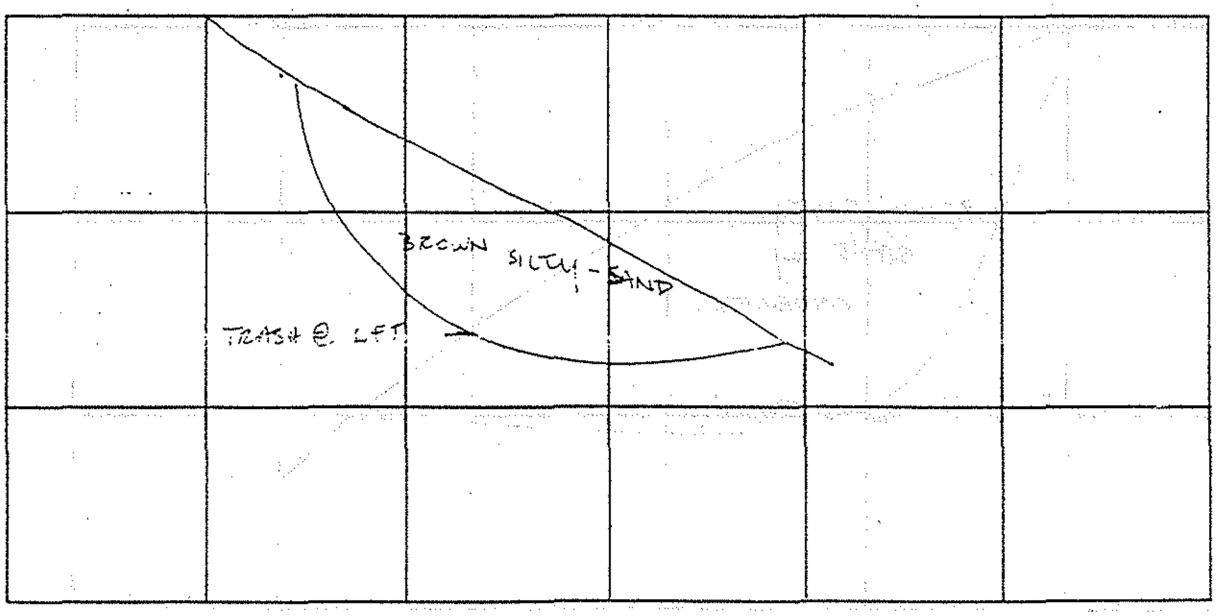
GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			BROWN SILTY SAND			
			(LOTS OF GRAVEL & COBBLES - TO BOULDERS (PT ϕ)			
			STAINED/STREAKED WITH GREY			
		6'	— HIT TRASH			

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: AB+ SLOPES DATE: 1-15-98

ELEVATION: 1742.4 EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: CC

LOG OF TEST PIT NO. AB-14

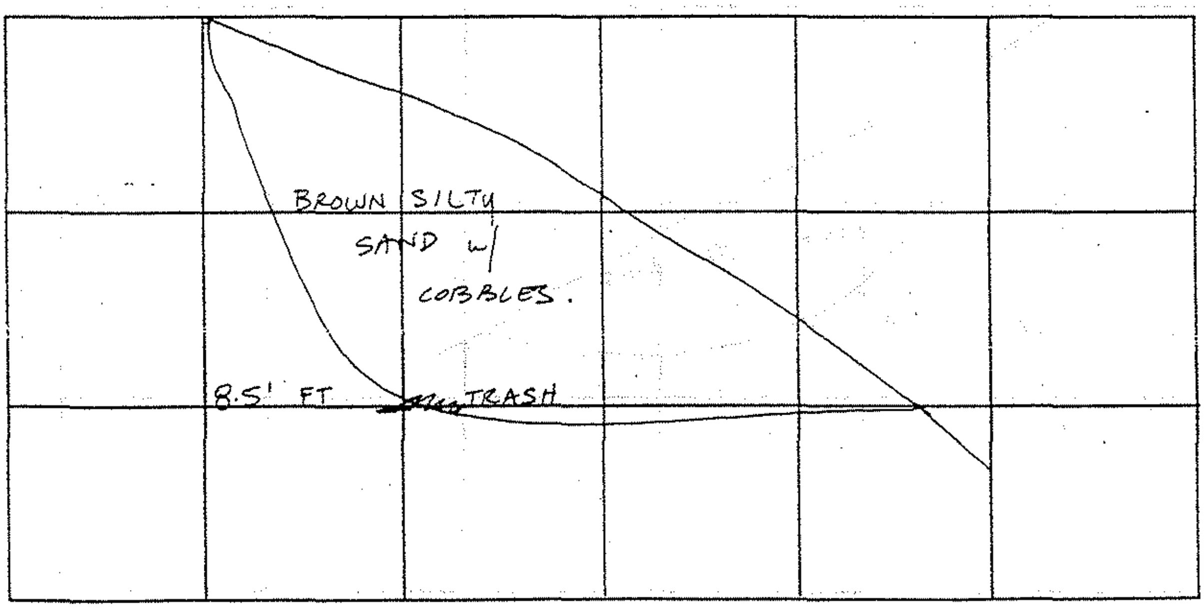
FIGURE NO. ____

GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			BROWN SILTY SAND w/ COBBLES			
		8.5	HIT TRASH			

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: AB SLOPES DATE: 1-15-98

ELEVATION: 1759.9 EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: CC

LOG OF TEST PIT NO. AB-15

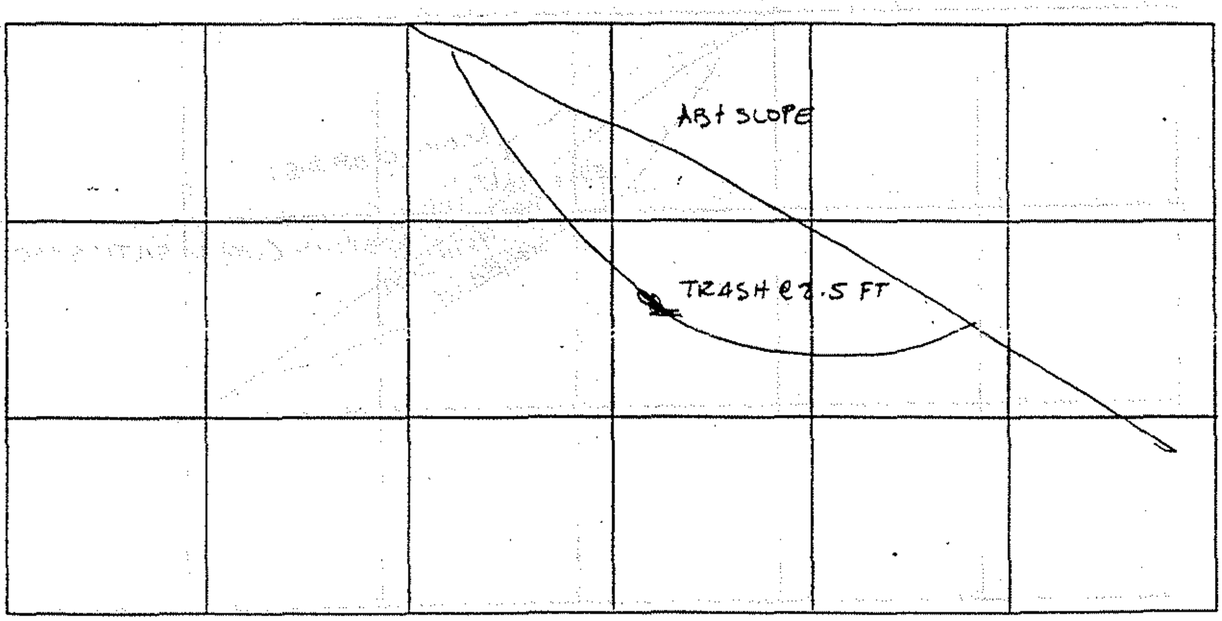
FIGURE NO. ____

GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			BROWN SILTY SAND, SOME GREY STAINING			
		2.5	TRASH @ 2.5 - 3 FT			

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: AB + SLOPES DATE: 1-15-98

ELEVATION: 1698.5 EQUIPMENT: EXCAVATOR

WATER LEVEL: N|A LOGGED BY: CC

LOG OF TEST PIT NO. AB-16

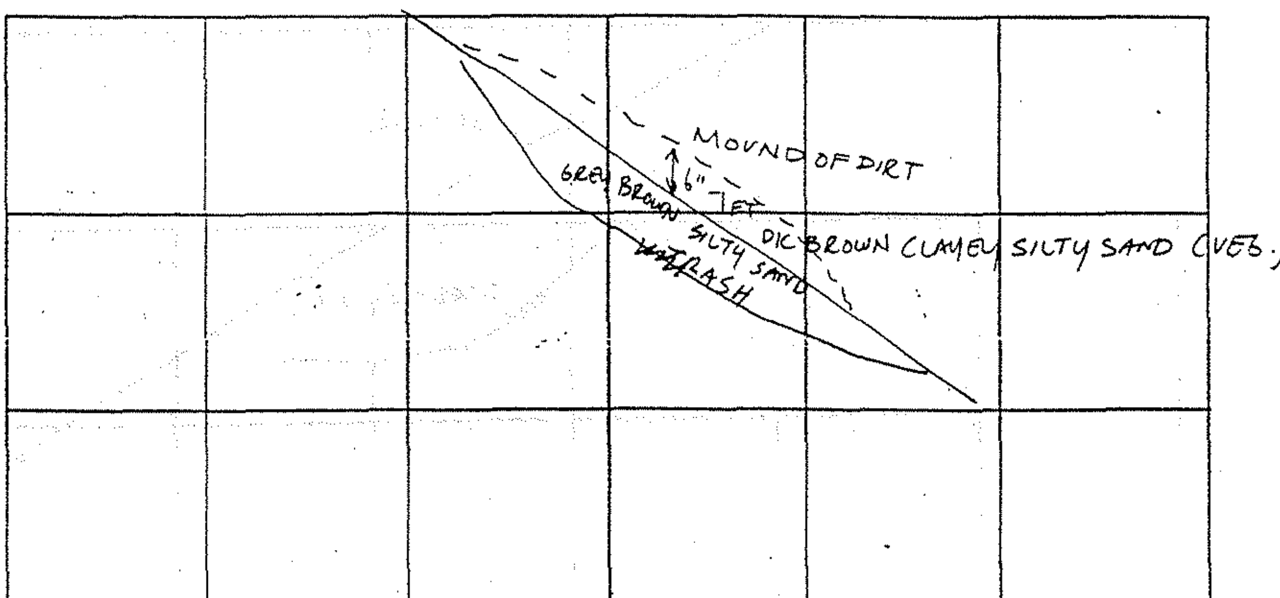
FIGURE NO.

GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			DK. BROWN CLAYEY, SILTY SAND (VEG) MOUNDED. (HOT SPOT)			
		6"	GREY (STAINED) - BROWN SILTY SAND			
		2'	TRASH @ 1 FT - 2 FT			

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: AB+SLOPES DATE: 1-15-98

ELEVATION: 1700 EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: CL

LOG OF TEST PIT NO. AB-17

FIGURE NO.

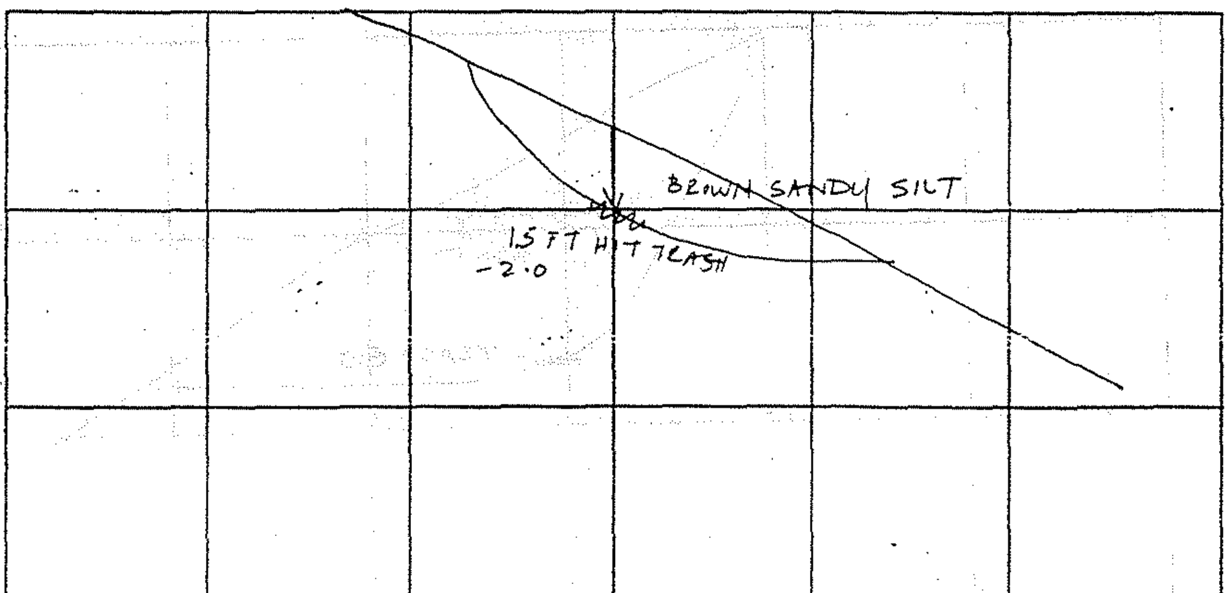
A Recycled and Recyclable Paper

GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			BROWN SANDY SILT (SAMPLED) ROOTS & VEGETATION	AB-18		
		1.5	HIT TRASH (~~???~~ IN 1st BUCKET)			
		2.0				

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: AB + SLOPES DATE: 1-16-98

ELEVATION: 1685 EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: CC

LOG OF TEST PIT NO. AB-18

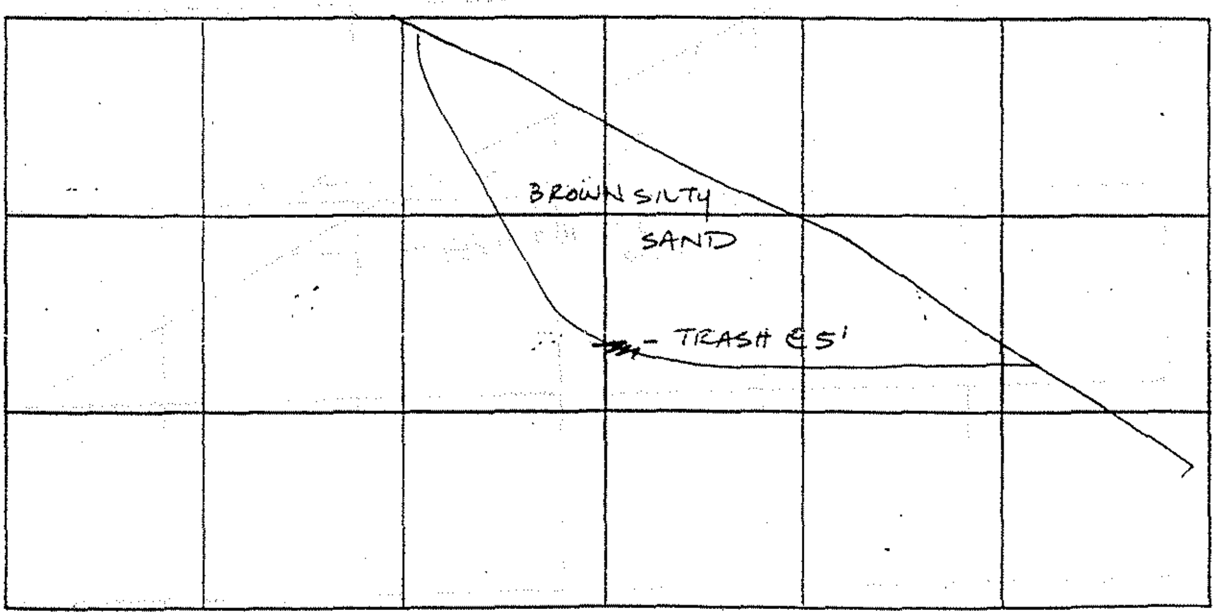
FIGURE NO.

GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			LT. BROWN SILTY SAND			
		5'	— HIT TRASH			

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: AB + SLOPES DATE: 1-16-98

ELEVATION: 1691.9 EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: CC

LOG OF TEST PIT NO. AB-19

FIGURE NO.

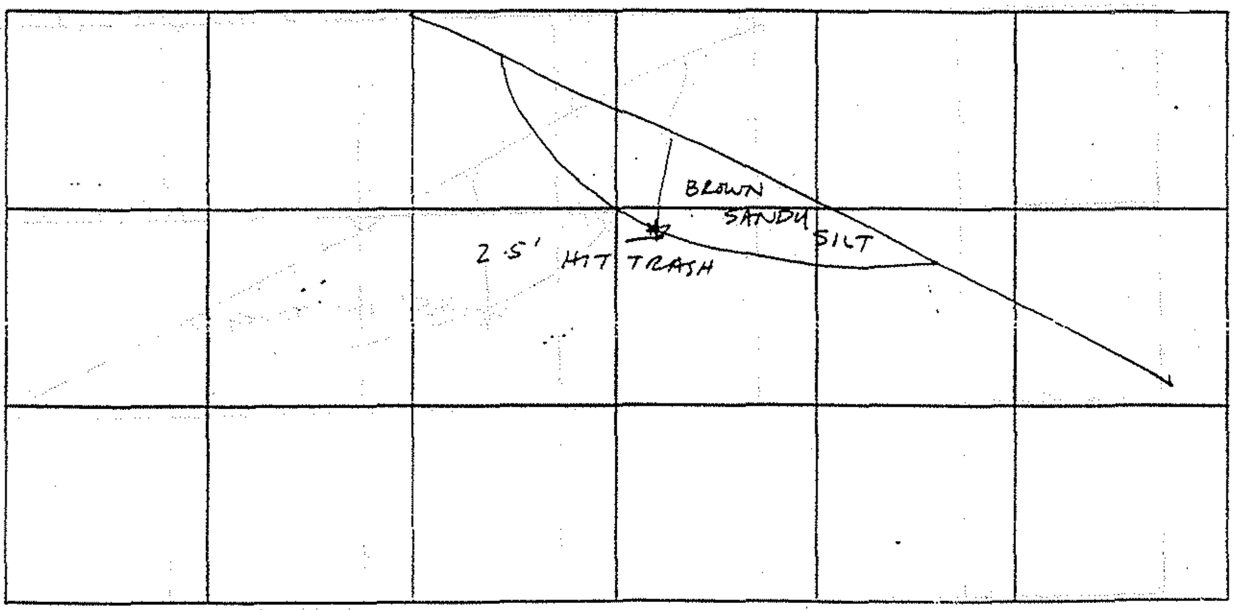
A Recycled and Recyclable Paper

GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			BROWN & GREY (STAINED) SANDY SILT			
		2.5	2.5 - 3 FT HIT TRASH			

B - BULK SAMPLE   T - TUBE SAMPLE   D - DRIVE SAMPLE

SCALE 1" =   BEARING =   TRENCH WALL:



LOCATION: AB+ SLOPES DATE: 1-16-98

ELEVATION: 1622   EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A   LOGGED BY: CC

LOG OF TEST PIT NO. AB-20

FIGURE NO. ___

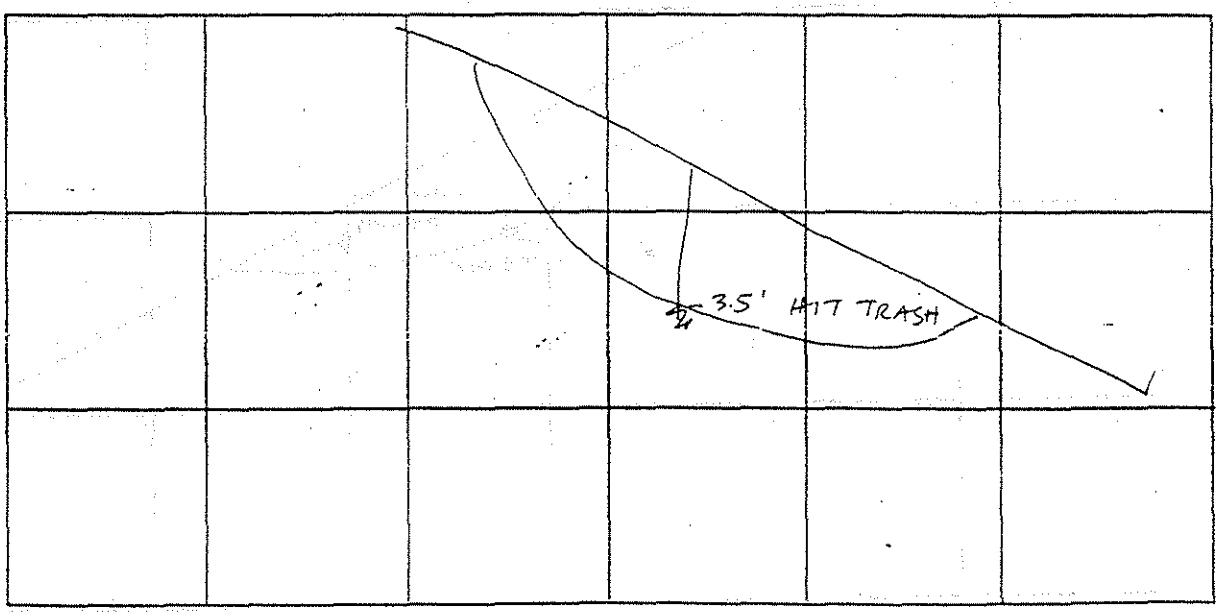
A Recycled and Recyclable Paper

GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			DK. BROWN SANDY SILT			
		3.5	HIT TRASH			

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: AB + SLOPES DATE: 1-16-98

ELEVATION: 1730.7 EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: CC

LOG OF TEST PIT NO. AB-21

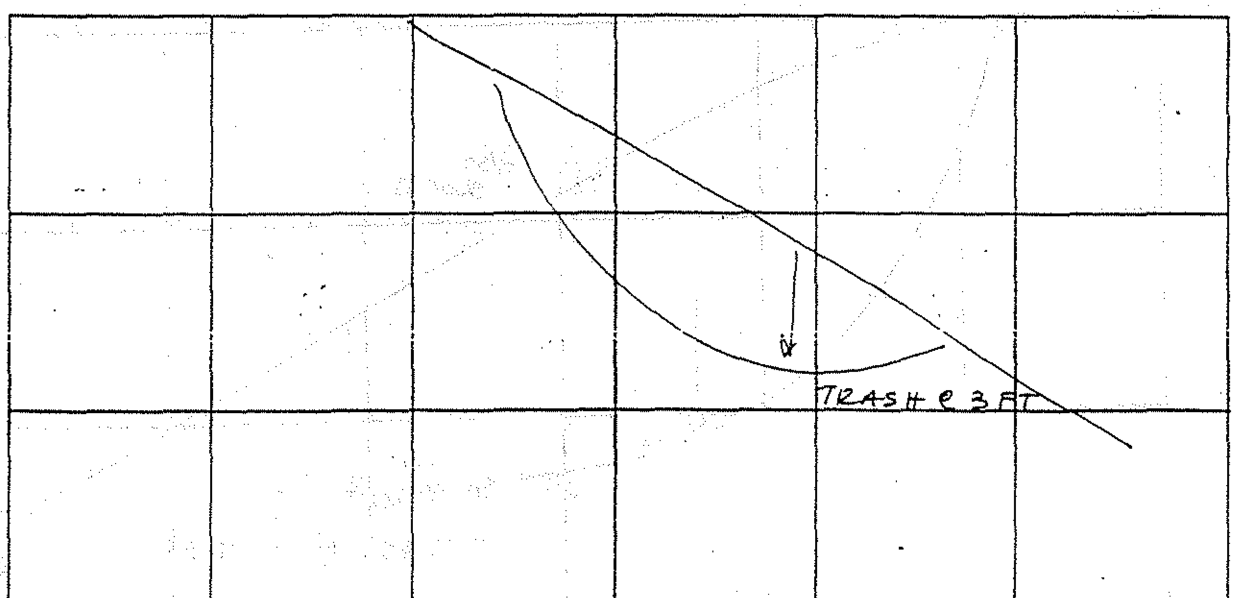
FIGURE NO.

GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
		4''	DK BROWN SANDY SILT (VEG OVER HOTSPOTS)			
			GREY-BROWN SILTY SAND			
		3'	HIT TRASH			

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: AB + SLOPES DATE: 1-16-98

ELEVATION: 1744.0 EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: CC

LOG OF TEST PIT NO. AB-22

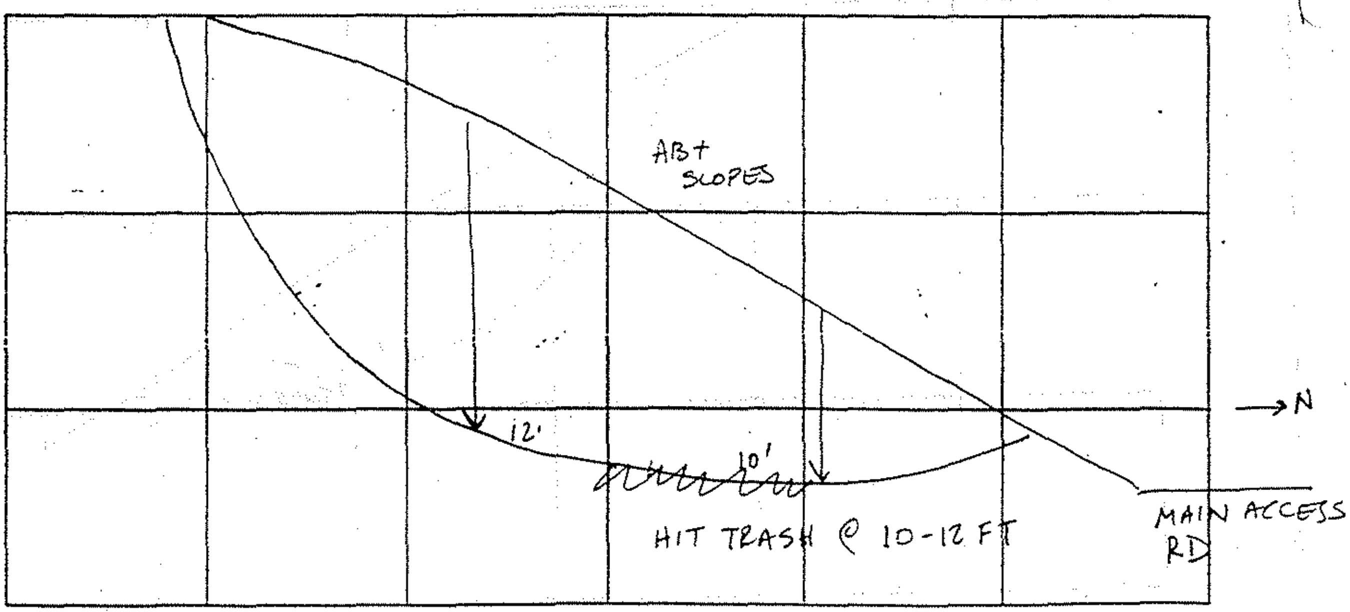
FIGURE NO.

GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			BROWN SILTY SAND (SAMPLED)	AB-23		
			NO GREY STAINING			
		10'	HIT TRASH			

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: AB+ SLOPES DATE: 1-16-98

ELEVATION: 1737.8 EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: CC

LOG OF TEST PIT NO. AB-23

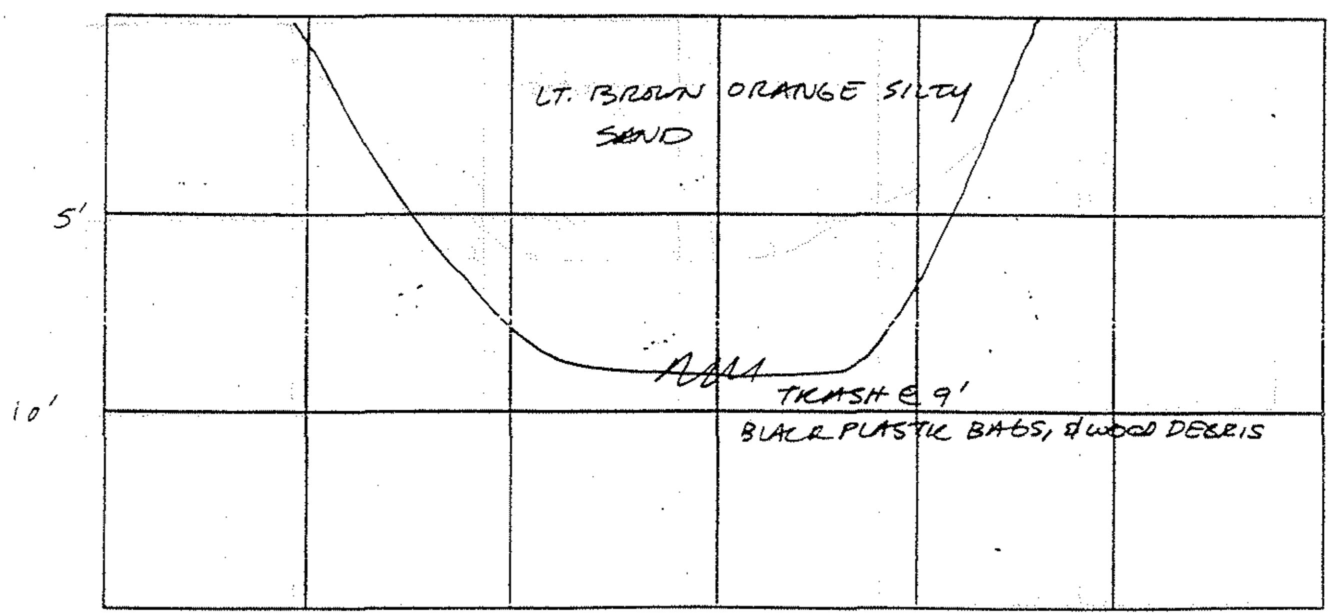
FIGURE NO.

GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			LT. BROWN / ORANGE SILTY SAND w/ GRAVEL & COBBLES SOME GREY STREAKS / STAINING			
		9'	— TRASH @ 9 FT			

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



@ "MOUND" el stake on GPS SURVEY

LOCATION: AB + DECK DATE: 1-16-98

ELEVATION: 1773 EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: CC

LOG OF TEST PIT NO. AB-24*

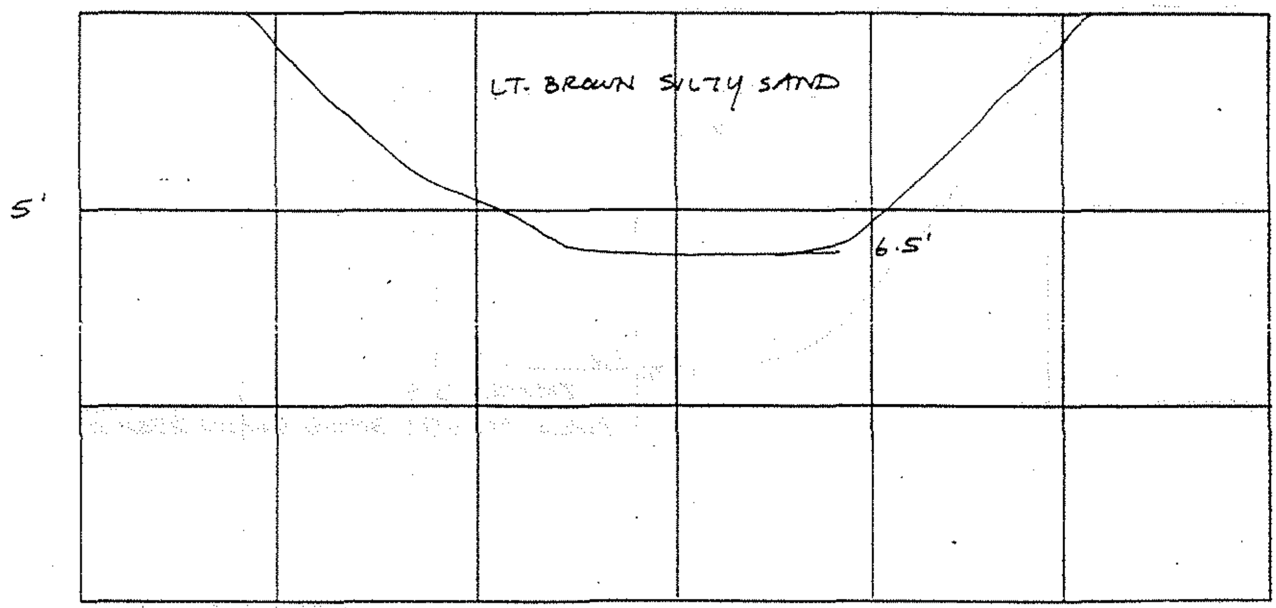
FIGURE NO.

A Recycled and Recyclable Paper

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			LT. BROWN SILTY SAND (TAN/ORANGE - SAME AS A-4) SOME GRAVEL & COBBLES			
		6.5'	NO TRASH ENCOUNTERED			

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: A-DEZR DATE: 1-14-98

ELEVATION: 1745.42 EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: CC

LOG OF TEST PIT NO. A-1

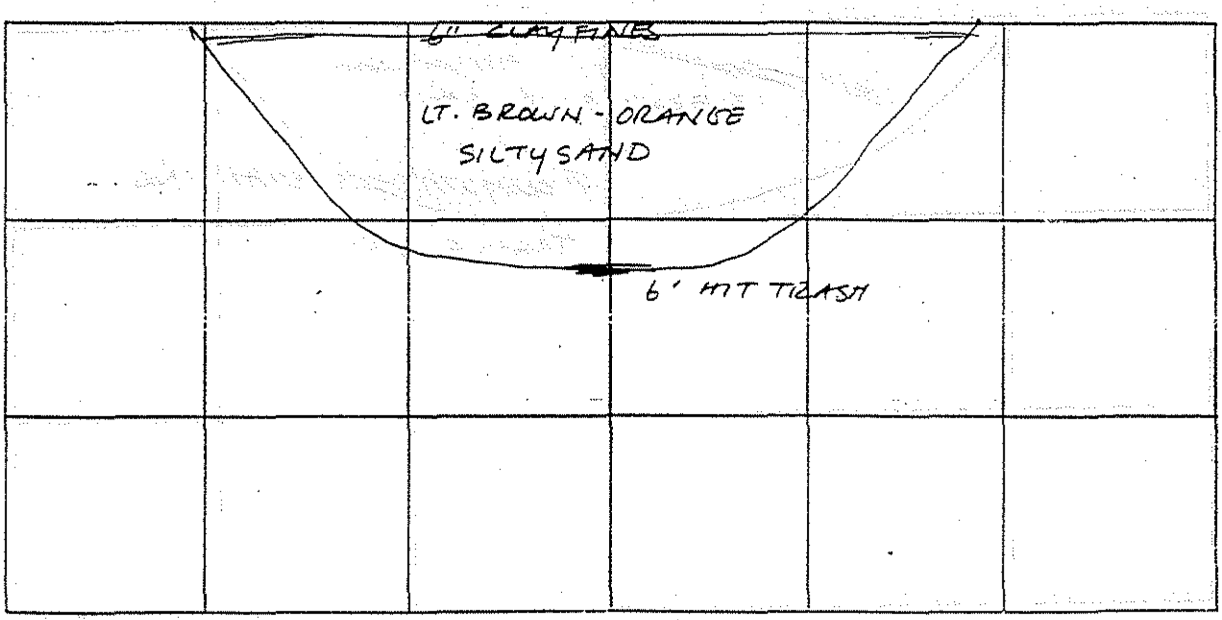
FIGURE NO.

GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
		6"	CLAY (WASHED OFF STOCKPILE)			
			LT. BROWN - ORANGE SILTY SAND (GREY STAINING) w/ GRAVEL & COBBLES TO 6"			
		6'	HIT TRASH @ 6FT			

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: A-DECK DATE: 1-14-98

7 @ TOE OF CLAY STOCKPILE

ELEVATION: 1741 EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: CC

LOG OF TEST PIT NO. A-2*

FIGURE NO.

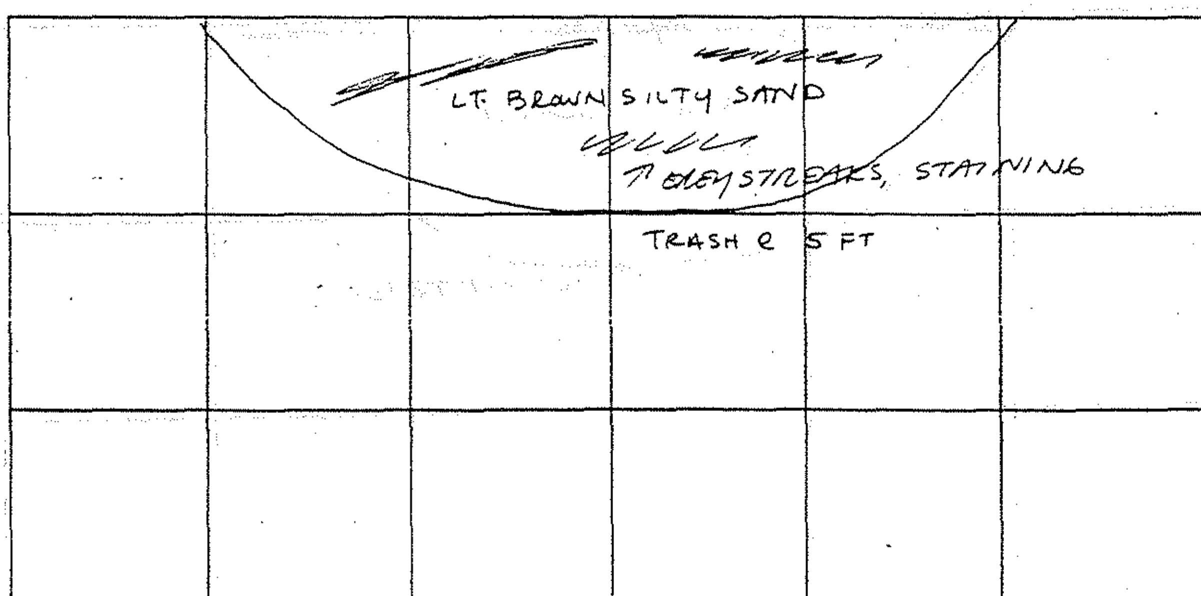
Recycled and Recyclable Paper

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			DK. BROWN SILT			
		6"	LT. BROWN SILTY SAND (GREY STREAKS - STAINING) (SAME AS A-4)			
		5'	HIT TRASH			

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:

5'



LOCATION: A-DECK DATE: 1-14-98

@ TOE OF CLAY STOCKPILE

ELEVATION: EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: CC

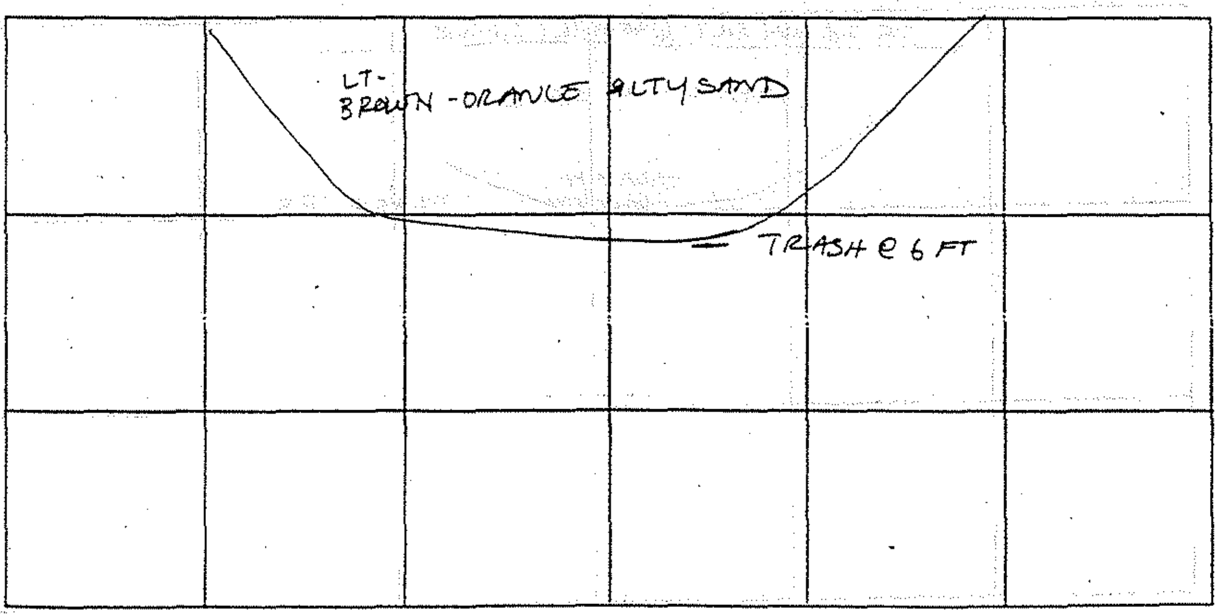
LOG OF TEST PIT NO. A-3

FIGURE NO.

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			LT. BROWN - ORANGE SILTY SAND (SAMPLED)	A-4	-	
		6'	TRASH @ 6 FT		-	

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: A - PECK DATE: 1 - 14 - 98

ELEVATION: 1733 EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: CC

LOG OF TEST PIT NO. A-4

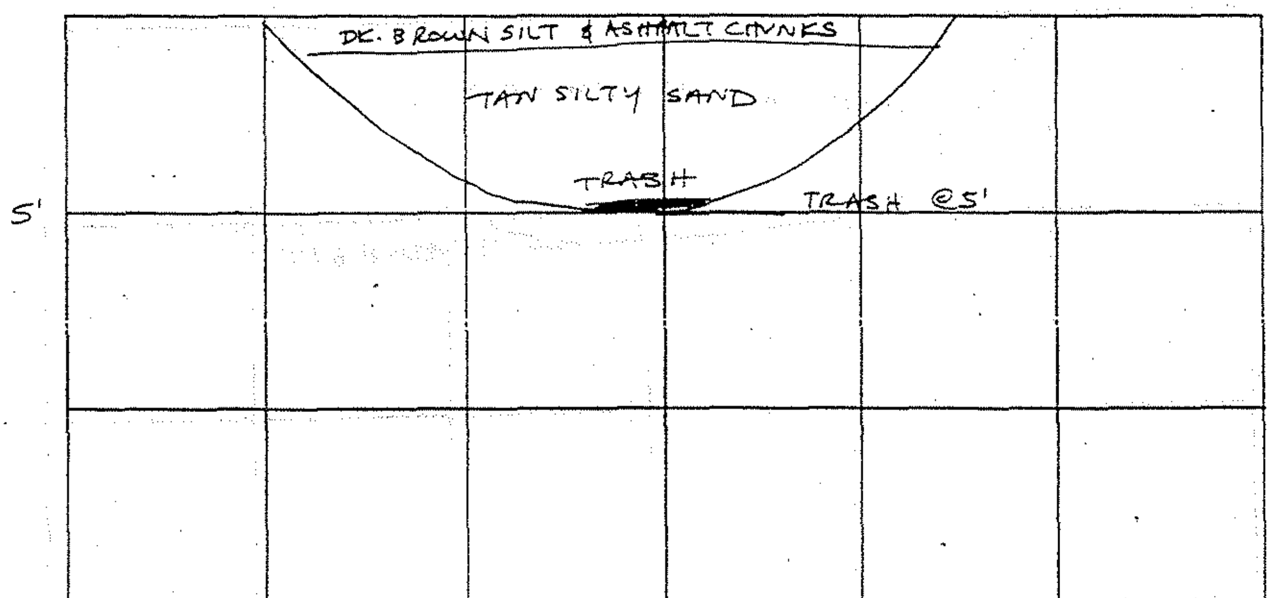
FIGURE NO.

GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
		6"	DK. BROWN SILT & ASPHALT CHUNKS			
			TAN SILTY SAND			
		5'	TRASH @ 5 FT (L.A. RIOT - BURNED DEBRIS.)			

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: A-DECK DATE: 1-14-98

ELEVATION: 1744 EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: CC

* RE-LABELLED A-7 AS A-5
GPS SURVEYED A-5 ON MID VEG. STOCKPILE, CURRENTLY DUMP

LOG OF TEST PIT NO. A-5*

FIGURE NO. ____

GeoSyntec Consultants

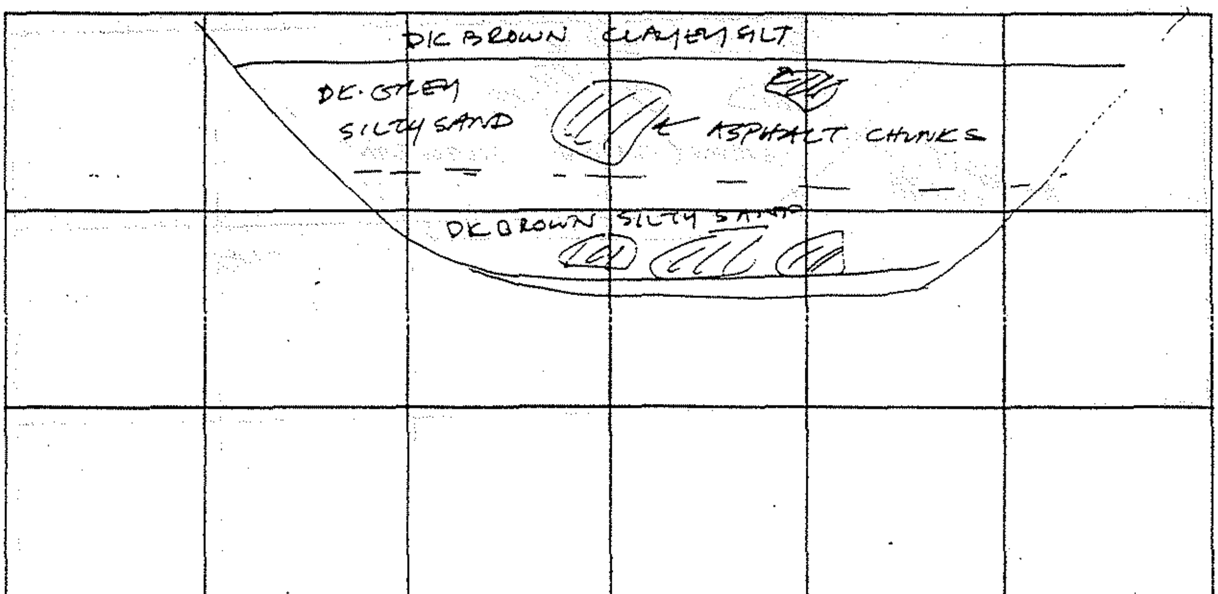
REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
		1	6"-1 FT DK BROWN CLAYEY SILT (AS B-3)			
			DK. GREY SILTY SAND (STAINED)			
		3'	@ 3' LARGE CHUNKS ASPHALT & CONCRETE			
		7'	DK. BROWN SILTY SAND MIXED WITH LARGE ASPHALT CHUNKS			
			* NO OTHER TRASH (IE. PLASTIC)			

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

* ACCORDING TO OPERATOR, THIS AREA OF B-DECK SOLID "WINTER" FILL ASPHALT & CONCRETE DEBRIS

SCALE 1" = BEARING = TRENCH WALL:

5'



LOCATION: B-DECK DATE: 1-14-98

ELEVATION: 1707. EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: CC

LOG OF TEST PIT NO. B-1

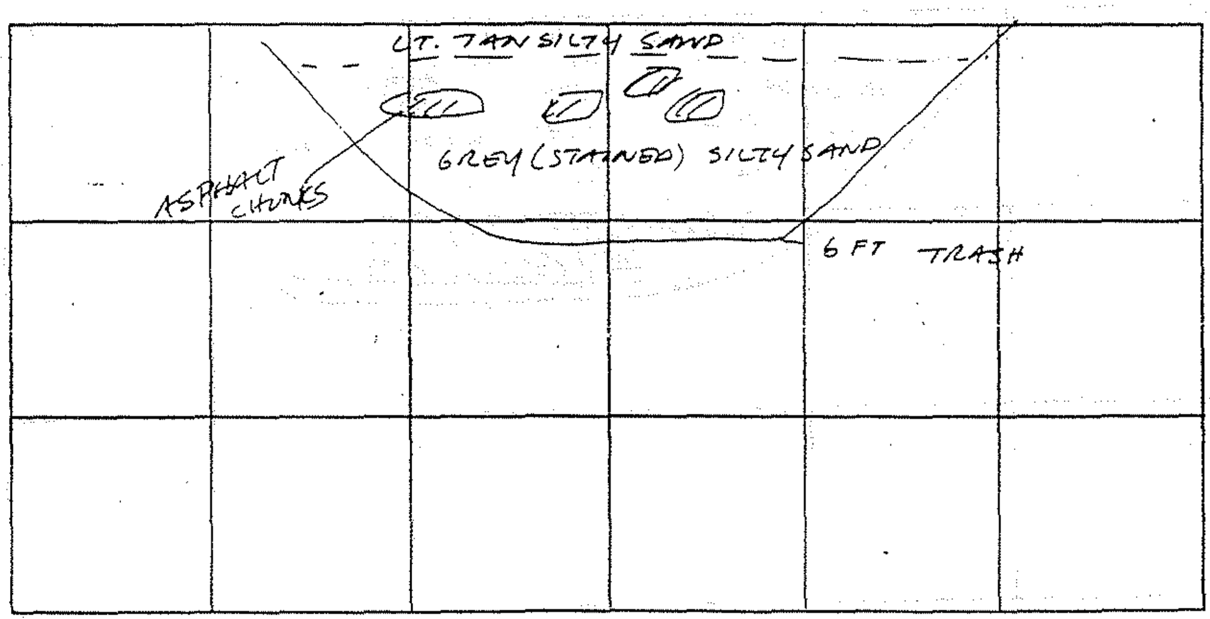
FIGURE NO.

GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			OUT OF DK. BROWN CLAYEY SILT (AS B-3)			
		1.5	0-1.5' LT. TAN SILTY SAND w/ GRAVEL & COBBLES TO 6"			
		2'	LARGE CHUNKS ASPHALT & GREY (STAINED) SILTY SAND			
		6FT	TRASH @ 6 FT			

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: B-DECC DATE: 1-14-98

ELEVATION: 1719 EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: CC

LOG OF TEST PIT NO. B-2

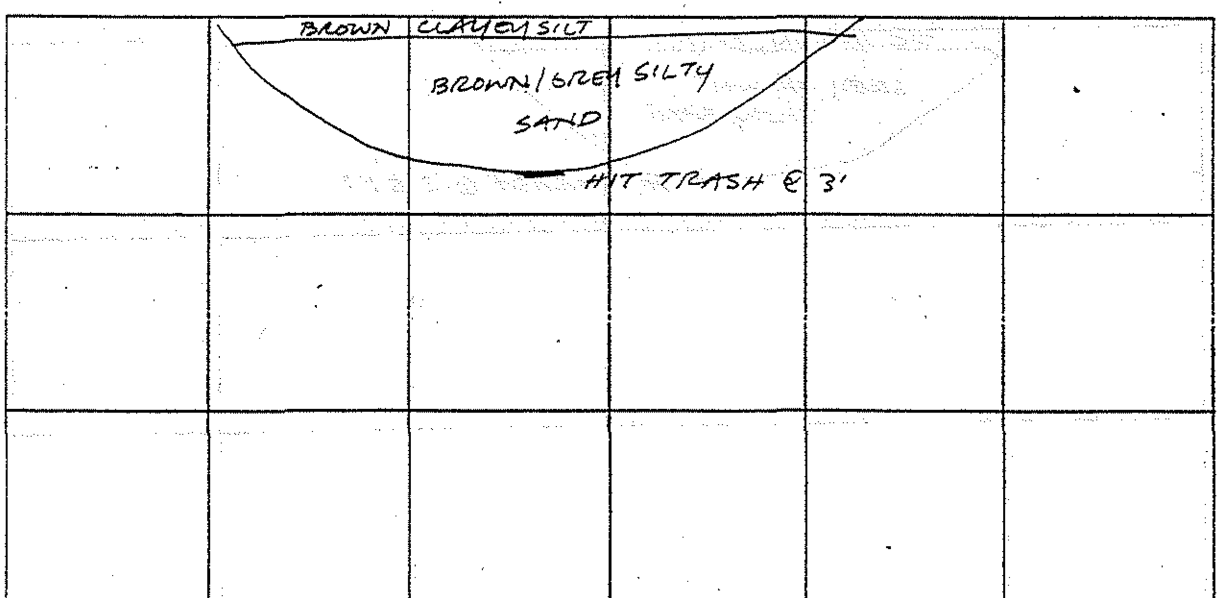
FIGURE NO.

GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
		1'	DK. BROWN CLAYEY SILT (SAMPLED)	B-3		
			BROWN SILTY SAND, STAINED GREY			
		3'	HIT TRASH			

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: B - DECK DATE: 1-14-98

ELEVATION: 1732 EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: CC

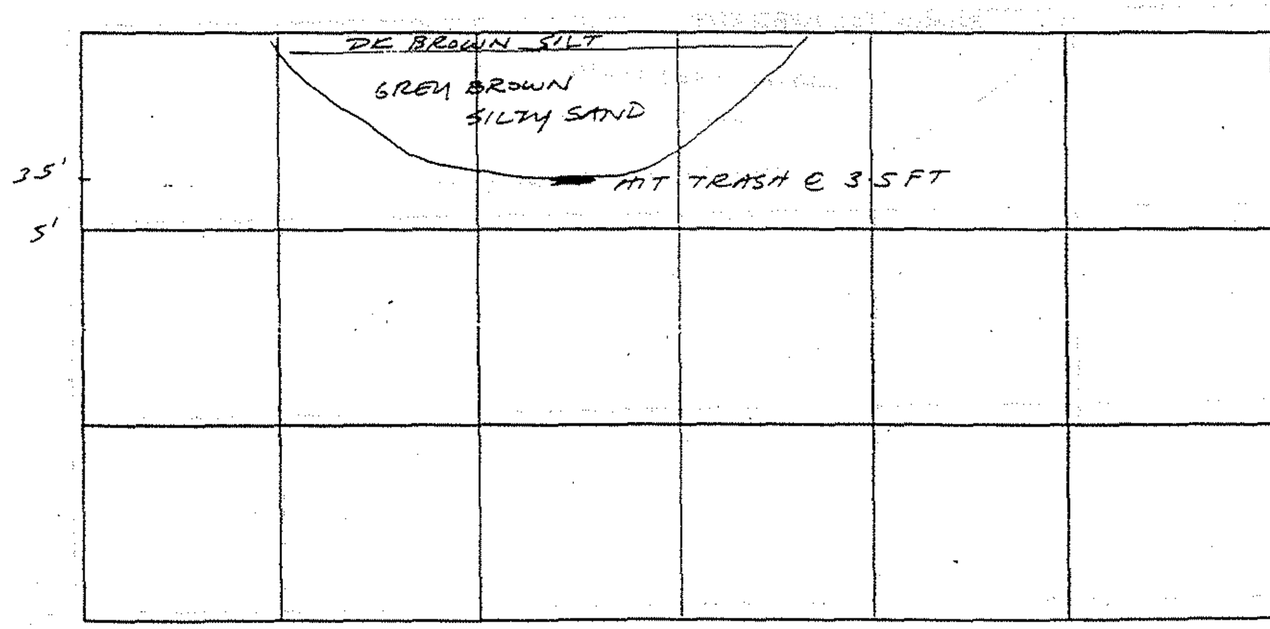
LOG OF TEST PIT NO. B-3

FIGURE NO.

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			DC. BROWN SILT			
		1'	GREY/BROWN ~~SANDY SILT~~ SILTY SAND (SAME AS B-6)			
		3.5'	HIT TRASH @ 3.5'			

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: B DECK DATE: 1-14-98

ELEVATION: EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: CC

* MOVED B-4 OFF RAMP UP TO VEG. (RESURVEYED BY ONSITE CREW)

LOG OF TEST PIT NO. B-4A *

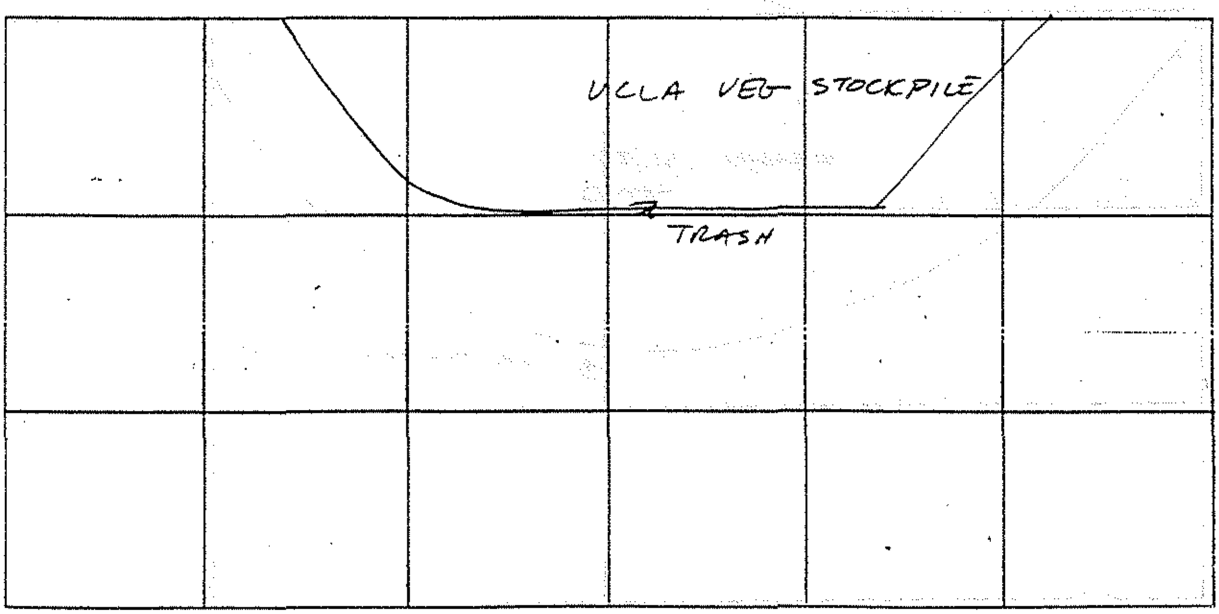
FIGURE NO.

GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			BROWN SILTY, CLAYEY SAND (VEG. COVER-UCLA)			
		5'	— HIT TRASH @ 5 FT			

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



* VEG STOCKPILE 10-15 THICK @ THICKEST PART, UNDERNEATH DIRECTLY TO GRADING PLAN.

LOCATION: B-DECK DATE: 1-14-98
ON VEG STOCKPILE - LOWEST POINT

ELEVATION: 1729 EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: CC

LOG OF TEST PIT NO. B-5

FIGURE NO.

A Recycled and Recyclable Paper

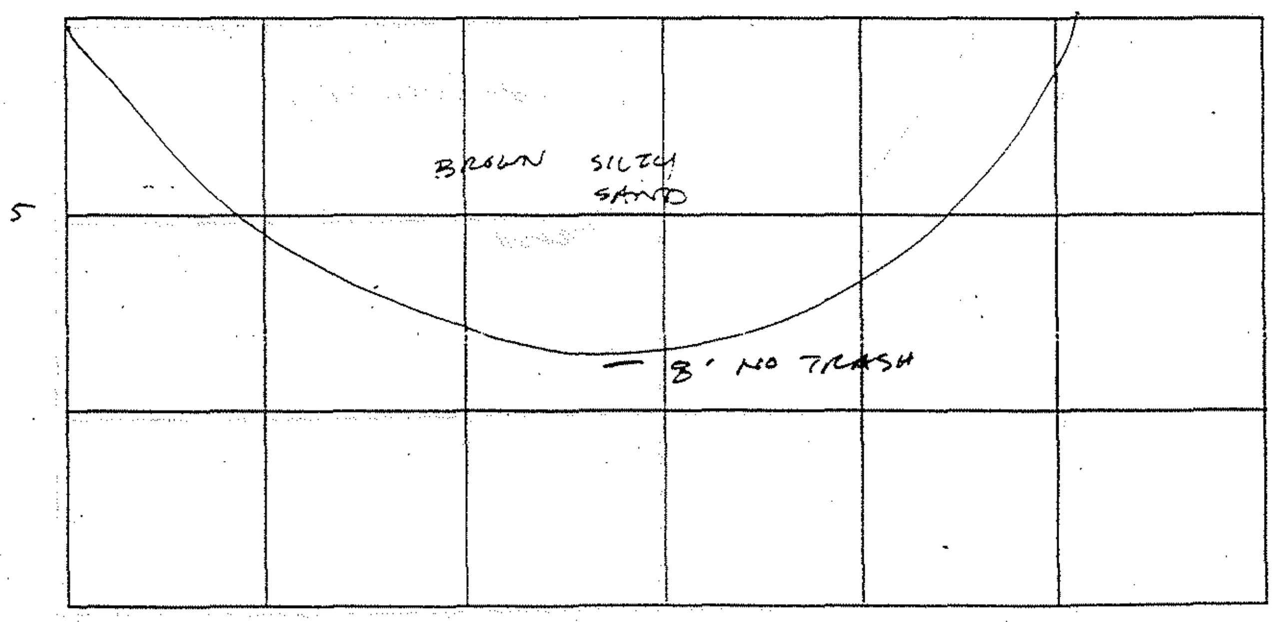
GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			BROWN SILTY SAND			
			PATCHES/ STREAKS OF GREY			
			STAINING			
			SOME GRAVEL			
		8'	NO TRASH STOPPED TRENCH.			
			(LOCATION B-6 ON RAMP UP TO VED STOCKPILE.)			

MOVED B-4, & ADDED B-7, & B-8 TO FIND TRASH BELOW BERM.

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: LOPEZ B- DECK DATE: 1-14-98

ELEVATION: 1743 5 EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: CC.

LOG OF TEST PIT NO. B-6

FIGURE NO.

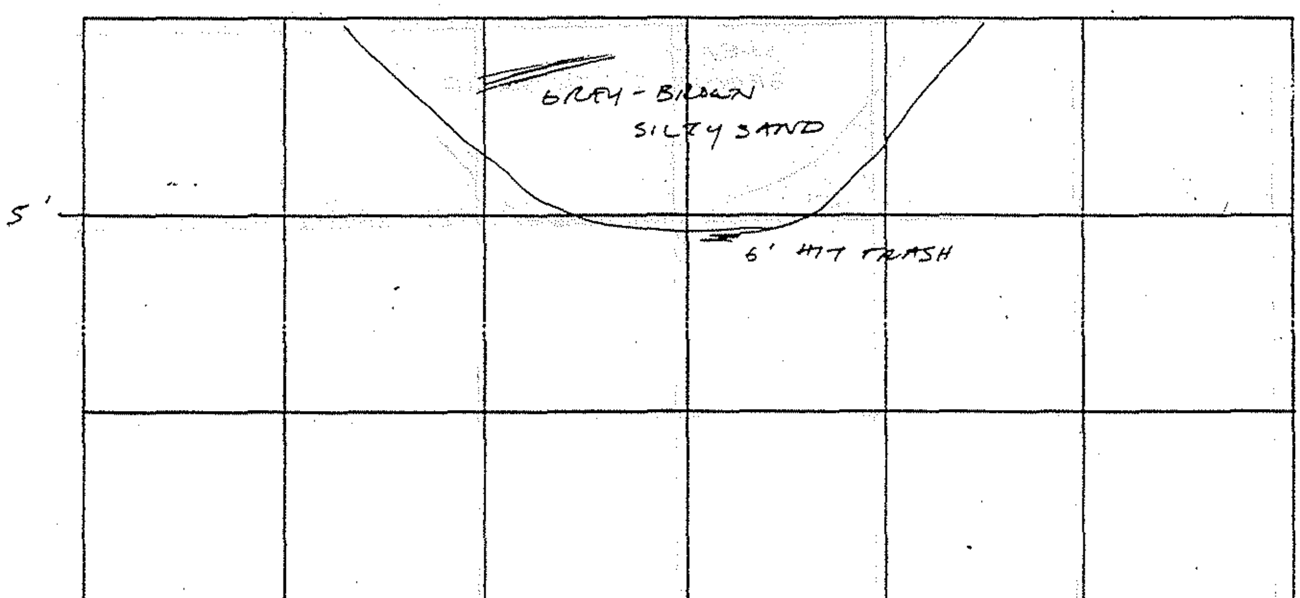
Recycled and Recyclable Paper

GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			GREY-BROWN SILTY SAND		-	
		6'	— HIT TRASH		-	

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: B-DECK DATE: 1-14-98

ELEVATION: 1727.5 EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: CC

LOG OF TEST PIT NO. B-7

FIGURE NO. ____

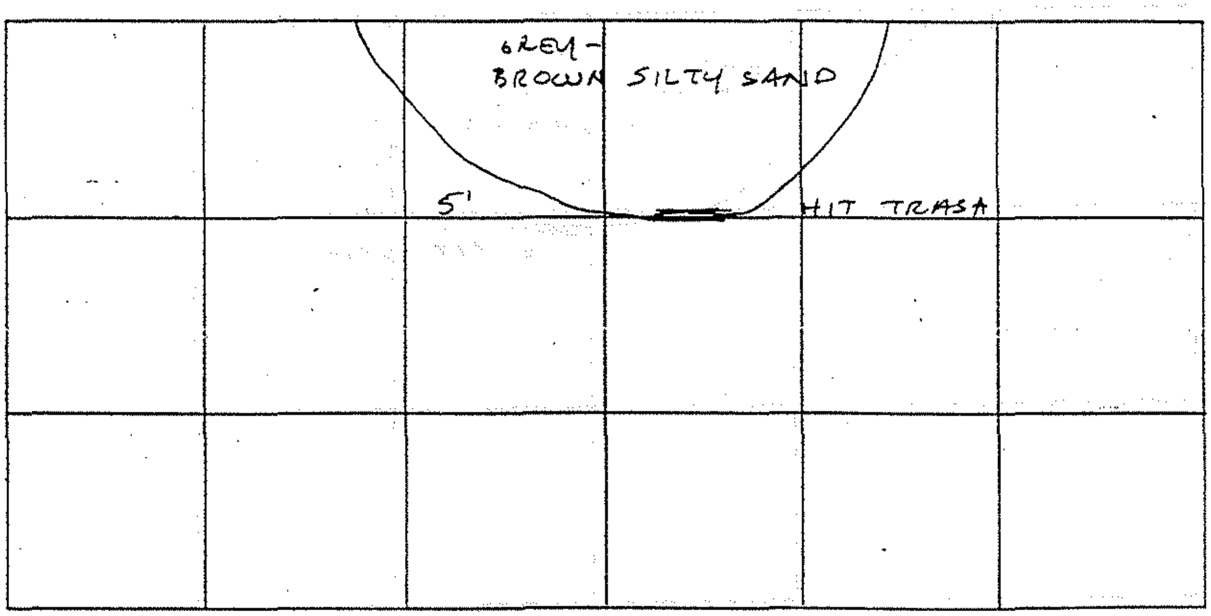
A Recycled and Recyclable Paper

GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			GREY (STAINED) - BROWN SILTY SAND SOME GRAVEL & COBBLES TO 6'			
		5'	— HIT TRASH @ 5'			

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: B-DECK DATE: 1-14-98

ELEVATION: EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: CC

* ADDED, ON MOUND OF TRASH, BELOW BERM ON-SITE CREW TO SURVEY + MOUND

LOG OF TEST PIT NO. B-8*

FIGURE NO. ____

Recycled and Recyclable Paper

APPENDIX B:
RESULTS FROM LABORATORY TESTING

ATTACHMENT A

Sample Identification, Handling, Storage and Disposal

Laboratory Test Standards

Application of Test Results

GEOSYNTEC CONSULTANTS
Geomechanics and Environmental Laboratory

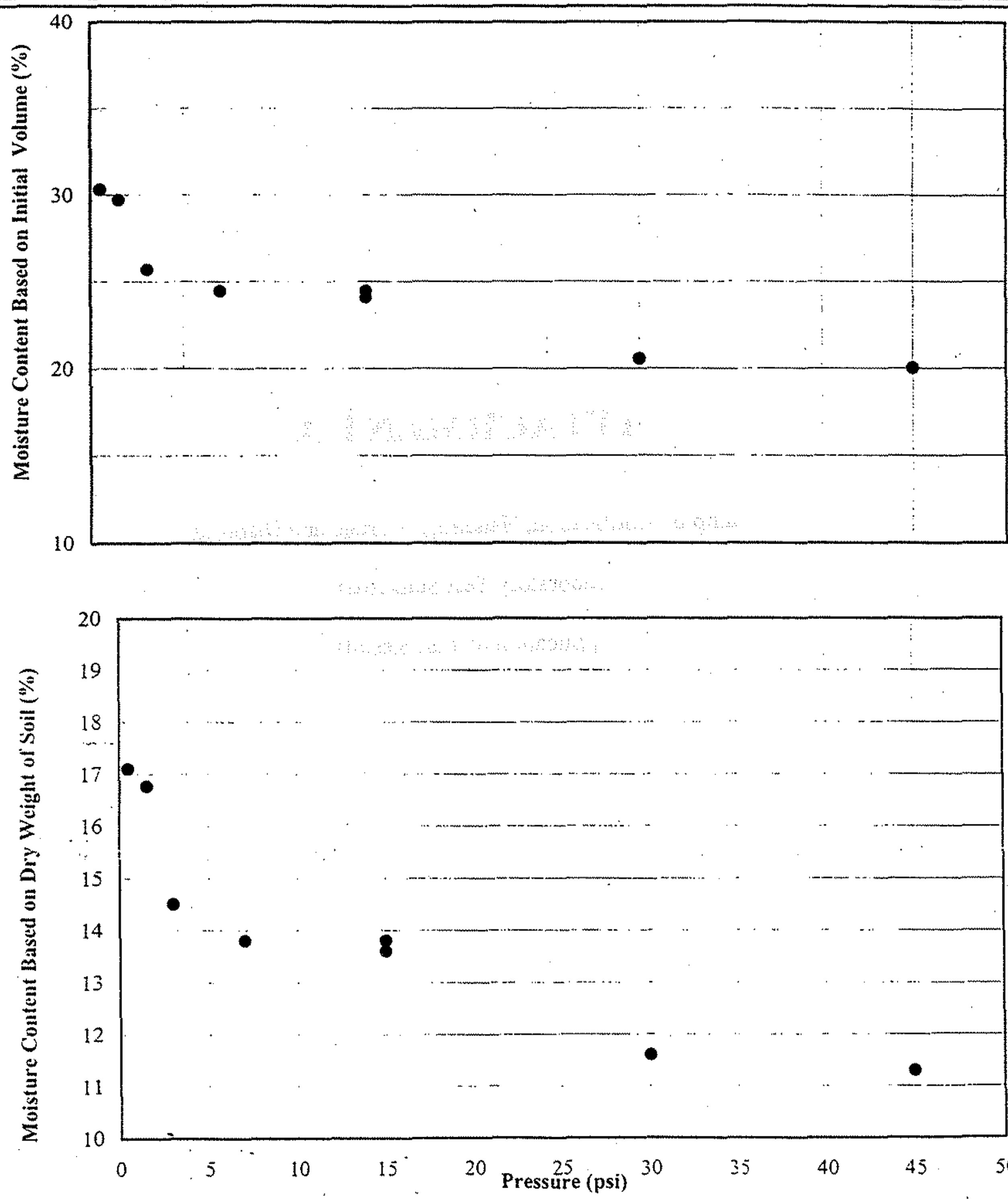
FIGURE 13

Project Name: Lopez Canyon Landfill
Project No.: CE4100

File Name: 98B32.xls

MOISTURE RETENTION TEST

ASTM D 2325



Note(s): Site Sample ID: AB - 10
Lab Sample No.: 98B32

GEO SYNTEC CONSULTANTS
Geomechanics and Environmental Laboratory
Atlanta, Georgia

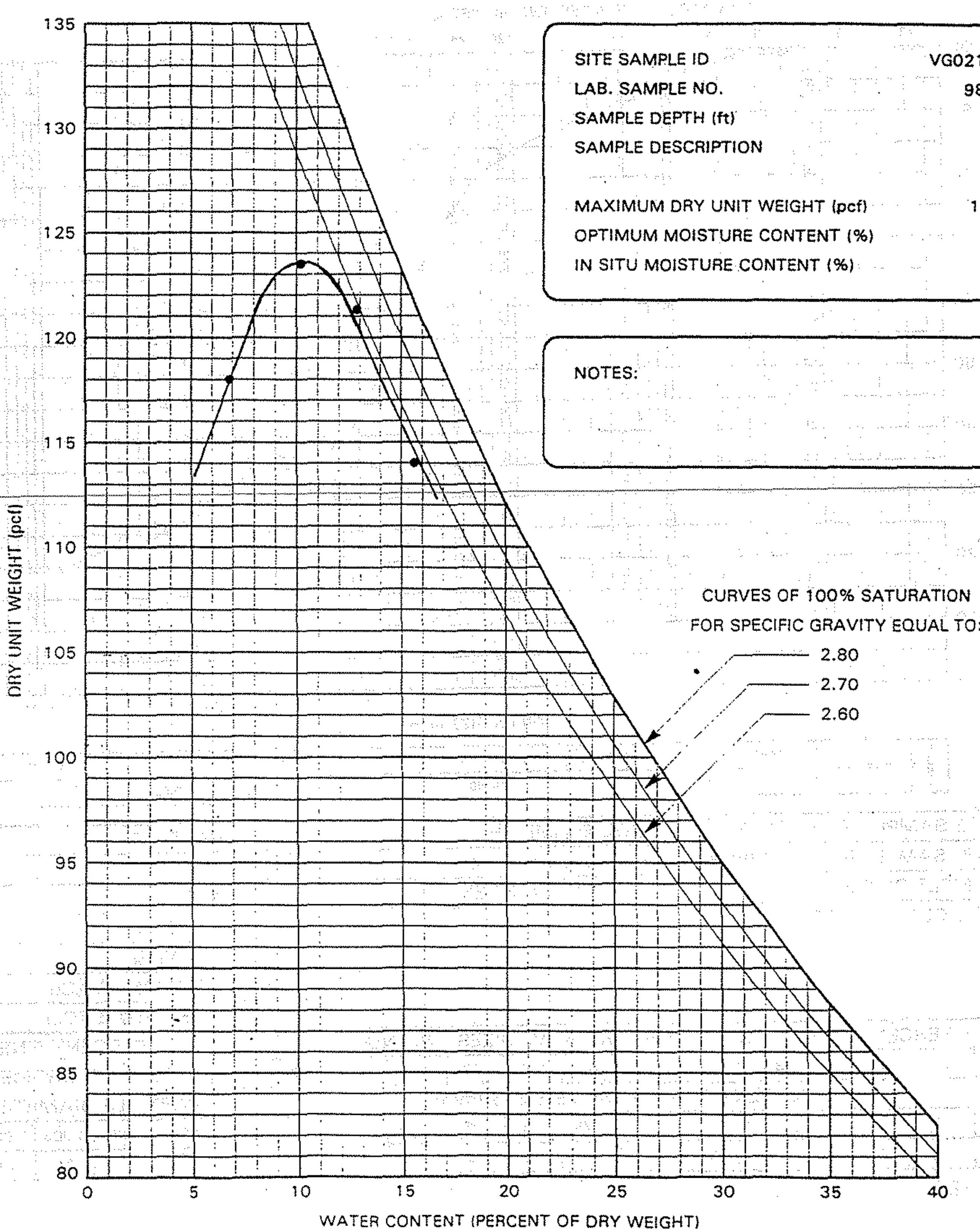
FIGURE 12

PROJECT: LOPEZ CANYON LANDFILL
PROJECT NO.: CE4100
DOCUMENT NO.:

GS FORM: 4MD1 02/26/98

MOISTURE-DENSITY RELATIONSHIP, COMPACTION TESTING

ASTM D-1557-B



SITE SAMPLE ID	VG021398
LAB. SAMPLE NO.	98B69
SAMPLE DEPTH (ft)	
SAMPLE DESCRIPTION	
MAXIMUM DRY UNIT WEIGHT (pcf)	123.6
OPTIMUM MOISTURE CONTENT (%)	10.3
IN SITU MOISTURE CONTENT (%)	

NOTES:

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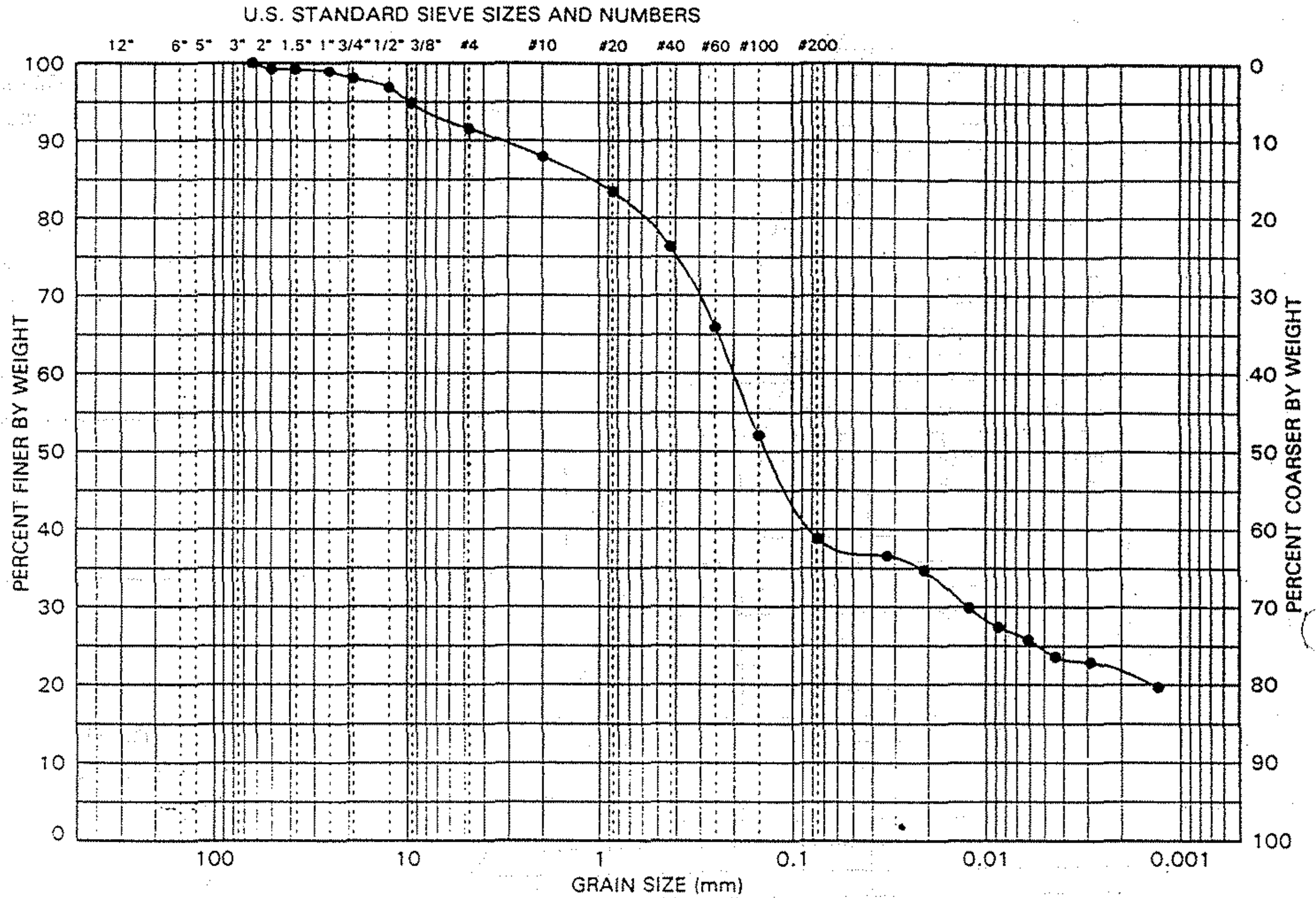
FIGURE 11

PROJECT: LOPEZ CANYON LANDFILL
PROJECT NO.: CE4100
DOCUMENT NO.:

GS FORM: 4PS2 02/27/98

PARTICLE SIZE DISTRIBUTION AND PHYSICAL PROPERTIES

ASTM C 136, D 422, D 2487 D 3042 AND D 4318



BOULDERS	COBBLES	COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
		GRAVEL		SAND			FINES	

SITE SAMPLE ID VG021398	LIQUID LIMIT (%)	SOIL FRACTIONS	GRAVEL (%)	8.5
LAB. SAMPLE NO. 98B69	PLASTIC LIMIT (%)		SAND (%)	52.7
SAMPLE DEPTH (ft)	PLASTICITY INDEX		FINES (%)	38.8
SOIL CLASSIFICATION: -			SILT (%)	17.4
			CLAY(%)	21.4
			COEFF. UNIFORMITY (Cu)	
			COEFF. CURVATURE (Cc)	

PERCENT PASSING U.S. STANDARD SIEVE SIZES AND NUMBERS														PERCENT FINER THAN HYDROMETER PARTICLE DIAMETER (mm)				
3"	2"	1.5"	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200					
PERCENT PASSING SIEVE SIZES (mm)																		
75	50	37.5	25	19	12.5	9.5	4.75	2.00	0.850	0.425	0.250	0.150	0.075	0.050	0.020	0.005	0.002	0.[illegible]
100	99	99	99	98	97	95	92	88	83	76	66	52	39	38	34	24	21	

NOTES:

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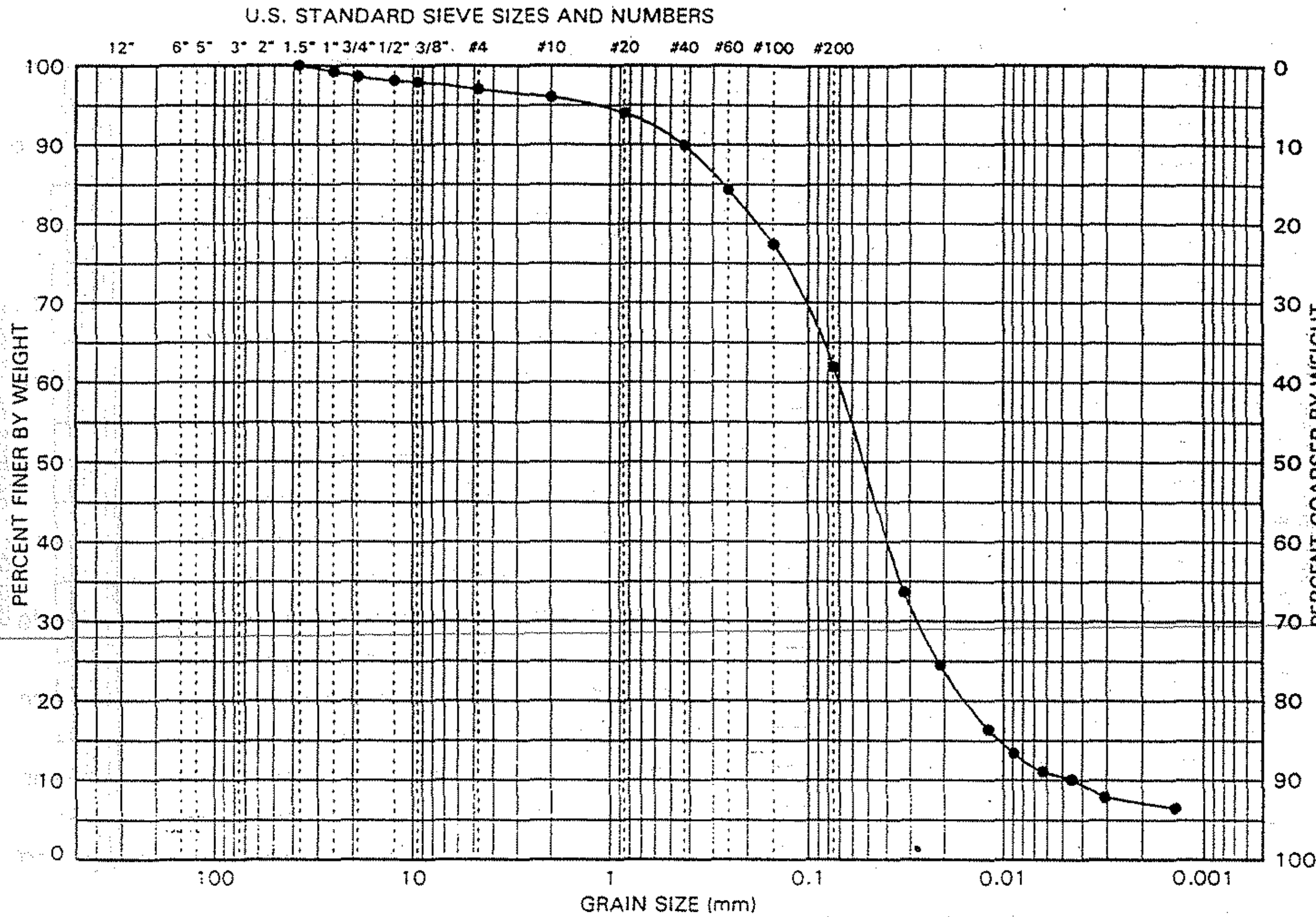
FIGURE 10
PROJECT: LOPEZ CANYON LANDFILL
PROJECT NO.: CE4100
DOCUMENT NO.:

GS FORM: 4PS2 02/03/98

PARTICLE SIZE DISTRIBUTION AND PHYSICAL PROPERTIES

ASTM C 136, D 422, D 2487 D 3042 AND D 4318



BOULDERS	COBBLES	COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
		GRAVEL		SAND			FINES	

SITE SAMPLE ID	B-6	LIQUID LIMIT (%)	39
LAB. SAMPLE NO.	98A90	PLASTIC LIMIT (%)	30
SAMPLE DEPTH (ft)		PLASTICITY INDEX	9

SOIL CLASSIFICATION:

ML - Sandy Silt

SOIL FRACTIONS	
GRAVEL (%)	3.0
SAND (%)	35.1
FINES (%)	61.9
SILT (%)	54.8
CLAY(%)	7.1
COEFF. UNIFORMITY (Cu)	
COEFF. CURVATURE (Cc)	

PERCENT PASSING U.S. STANDARD SIEVE SIZES AND NUMBERS														PERCENT FINER THAN HYDROMETER				
3"	2"	1.5"	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200					
PERCENT PASSING SIEVE SIZES (mm)														PARTICLE DIAMETER (mm)				
75	50	37.5	25	19	12.5	9.5	4.75	2.00	0.850	0.425	0.250	0.150	0.075	0.050	0.020	0.005	0.002	0.001
100	100	100	99	99	98	98	97	96	94	90	84	77	62	48	24	10	7	

NOTES:

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Atlanta, Georgia

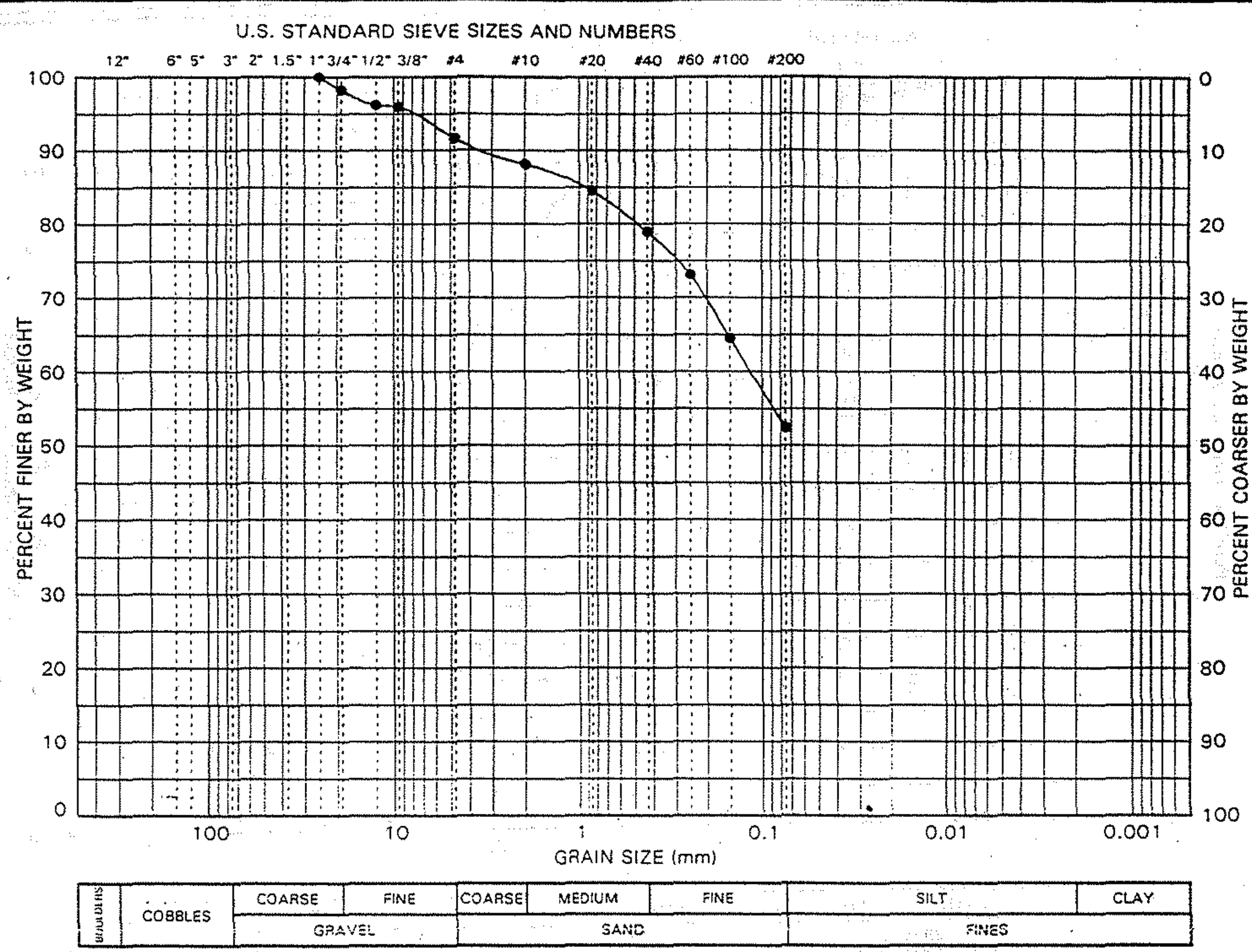
FIGURE 9

PROJECT: LOPEZ CANYON LANDFILL
PROJECT NO.: CE4100
DOCUMENT NO.:

GS FORM: 4PS2 02/17/98

PARTICLE SIZE DISTRIBUTION AND PHYSICAL PROPERTIES

ASTM C 136, D 422, D 2487 D 3042 AND D 4318



SITE SAMPLE ID	B-3	LIQUID LIMIT (%)	37	GRAVEL (%)	8.4
LAB. SAMPLE NO.	98B15	PLASTIC LIMIT (%)	20	SAND (%)	39.2
SAMPLE DEPTH (ft)		PLASTICITY INDEX	17	FINES (%)	52.4
SOIL CLASSIFICATION: CL - Sandy Lean Clay				SILT (%)	
				CLAY(%)	
				COEFF. UNIFORMITY (Cu)	
				COEFF. CURVATURE (Cc)	

SOIL FRACTIONS

PERCENT PASSING U.S. STANDARD SIEVE SIZES AND NUMBERS														PERCENT FINER THAN HYDROMETER PARTICLE DIAMETER (mm)				
3"	2"	1.5"	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200					
PERCENT PASSING SIEVE SIZES (mm)																		
75	50	37.5	25	19	12.5	9.5	4.75	2.00	0.850	0.425	0.250	0.150	0.075	0.050	0.020	0.005	0.002	0.001
100	100	100	100	98	96	96	92	88	85	79	73	65	52					

NOTES:

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Atlanta, Georgia

FIGURE 8

PROJECT: LOPEZ CANYON LANDFILL
PROJECT NO.: CE4100
DOCUMENT NO.:

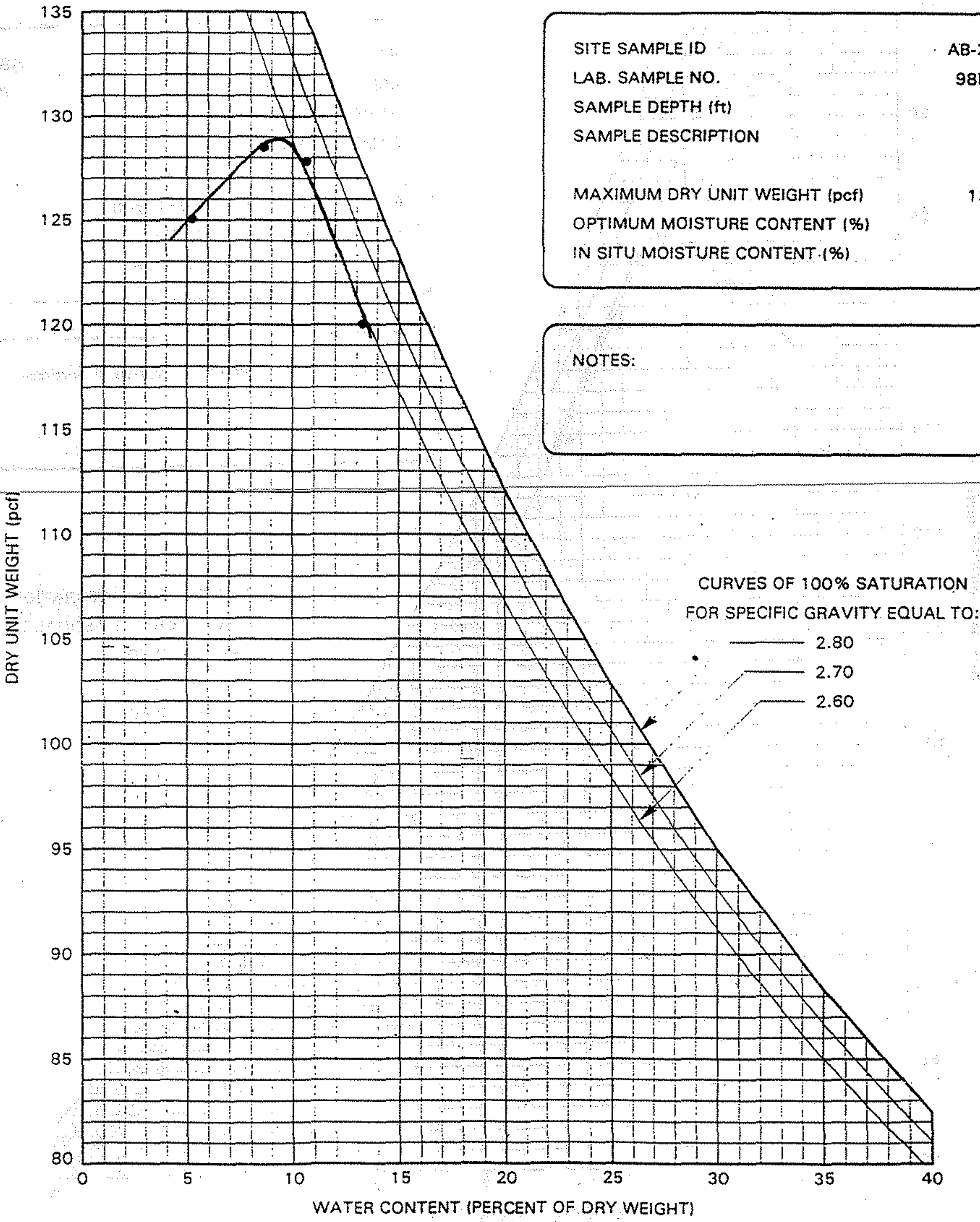
GS FORM:
4MD1 03/03/98

MOISTURE-DENSITY RELATIONSHIP, COMPACTION TESTING

ASTM D 4178 correction applied
ASTM D-1557-B

SITE SAMPLE ID	AB-25-B
LAB. SAMPLE NO.	98B34.
SAMPLE DEPTH (ft)	
SAMPLE DESCRIPTION	
MAXIMUM DRY UNIT WEIGHT (pcf)	128.9
OPTIMUM MOISTURE CONTENT (%)	9.4
IN SITU MOISTURE CONTENT (%)	

NOTES:



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Atlanta, Georgia

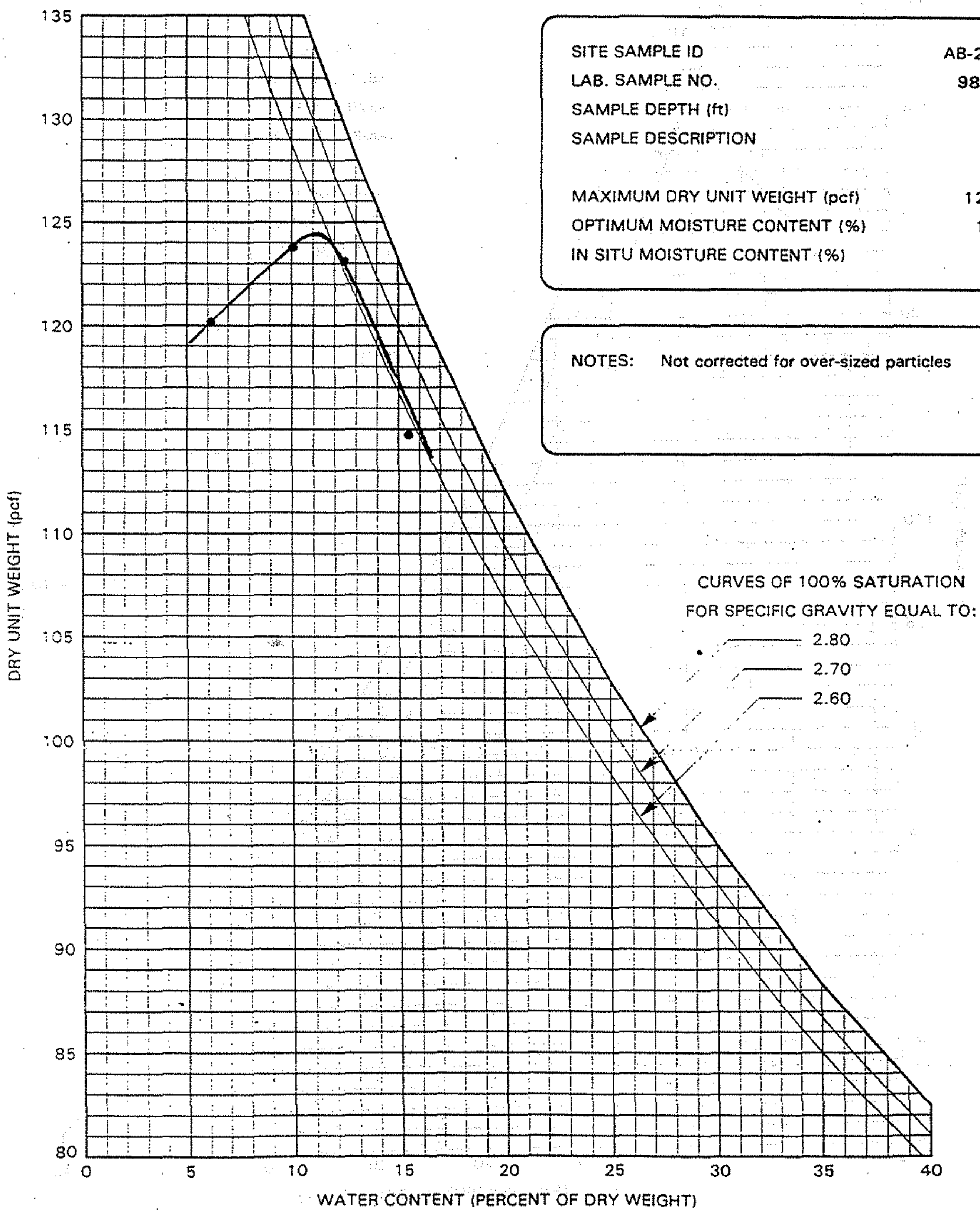
FIGURE 7

PROJECT: LOPEZ CANYON LANDFILL
PROJECT NO.: CE4100
DOCUMENT NO.:

GS FORM: 4MD1 03/03/98

MOISTURE-DENSITY RELATIONSHIP, COMPACTION TESTING

ASTM D-1557-B



SITE SAMPLE ID	AB-25-B
LAB. SAMPLE NO.	98B34
SAMPLE DEPTH (ft)	
SAMPLE DESCRIPTION	
MAXIMUM DRY UNIT WEIGHT (pcf)	124.4
OPTIMUM MOISTURE CONTENT (%)	11.2
IN SITU MOISTURE CONTENT (%)	

NOTES: Not corrected for over-sized particles

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Atlanta, Georgia

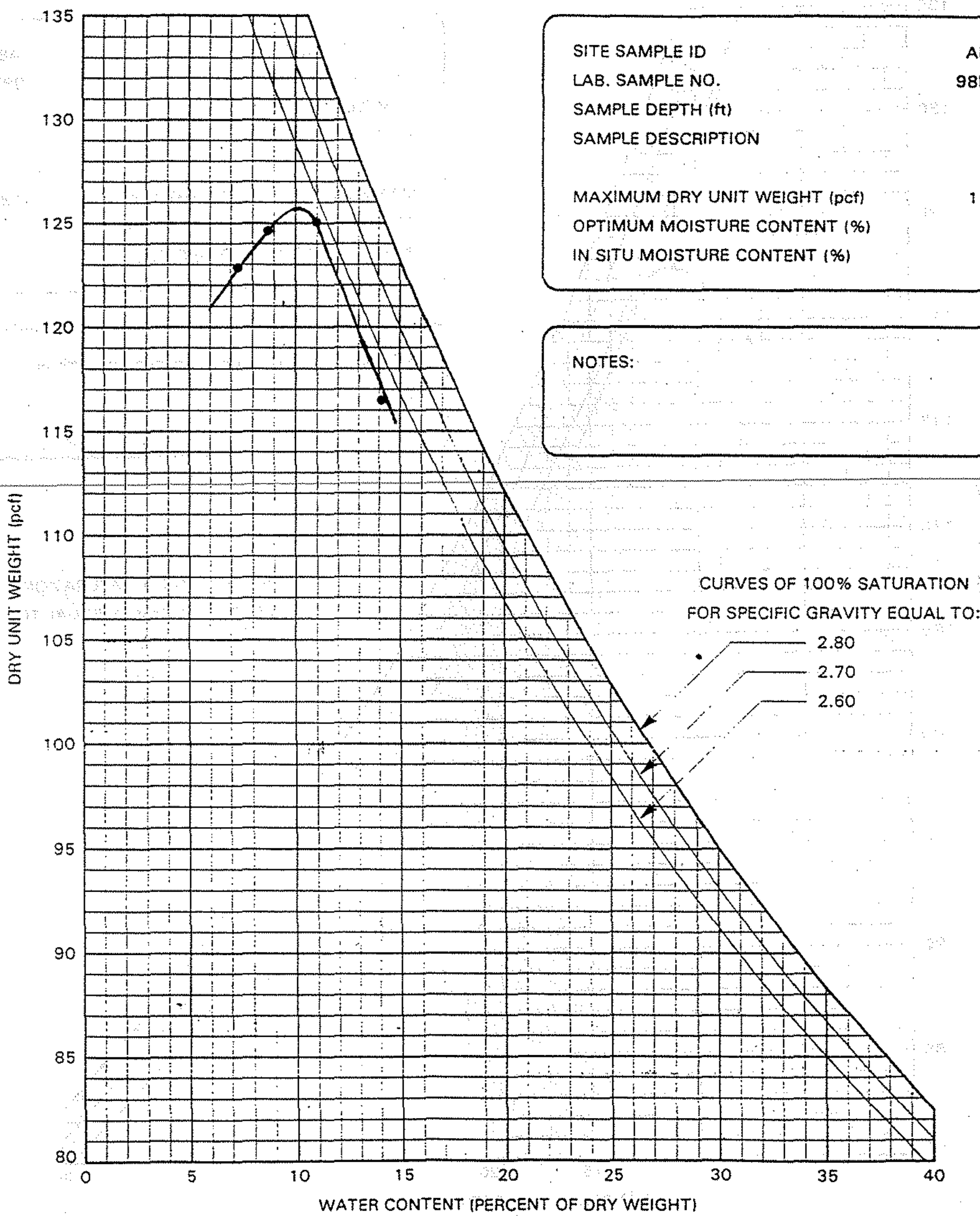
FIGURE 6

PROJECT: LOPEZ CANYON LANDFILL
PROJECT NO.: CE4100
DOCUMENT NO.:

GS FORM: 4MD1 03/03/98

MOISTURE-DENSITY RELATIONSHIP, COMPACTION TESTING

ASTM D 4178 correction applied
ASTM D-1557-B



SITE SAMPLE ID	AB-10
LAB. SAMPLE NO.	98B32.
SAMPLE DEPTH (ft)	
SAMPLE DESCRIPTION	
MAXIMUM DRY UNIT WEIGHT (pcf)	125.7
OPTIMUM MOISTURE CONTENT (%)	10.1
IN SITU MOISTURE CONTENT (%)	

NOTES:

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Atlanta, Georgia

FIGURE 5

PROJECT: LOPEZ CANYON LANDFILL
PROJECT NO.: CE4100
DOCUMENT NO.:

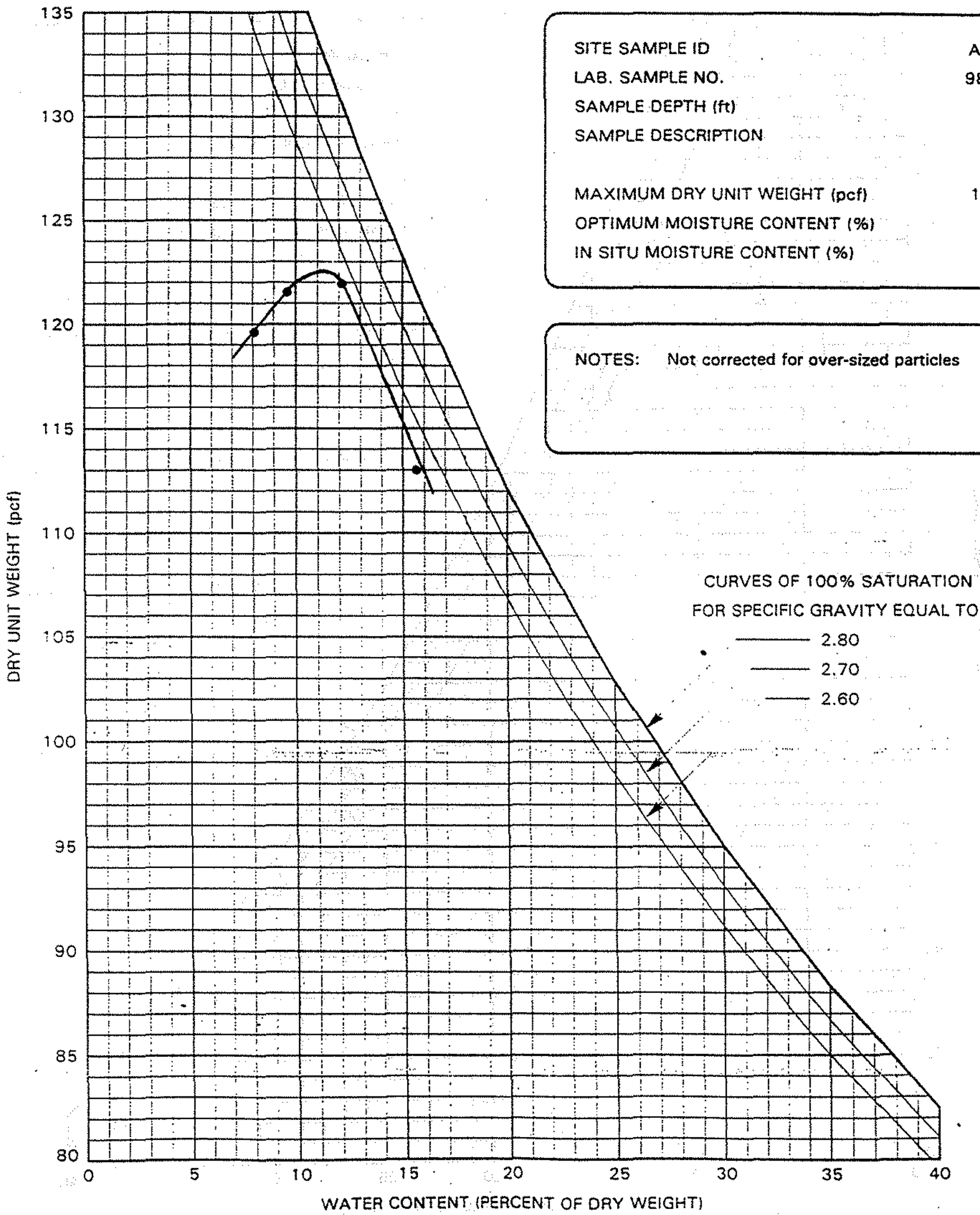
GS FORM:
4MD1 03/03/98

MOISTURE-DENSITY RELATIONSHIP, COMPACTION TESTING

ASTM D-1557-B

SITE SAMPLE ID	AB-10
LAB. SAMPLE NO.	98B32
SAMPLE DEPTH (ft)	
SAMPLE DESCRIPTION	
MAXIMUM DRY UNIT WEIGHT (pcf)	122.5
OPTIMUM MOISTURE CONTENT (%)	11.3
IN SITU MOISTURE CONTENT (%)	

NOTES: Not corrected for over-sized particles



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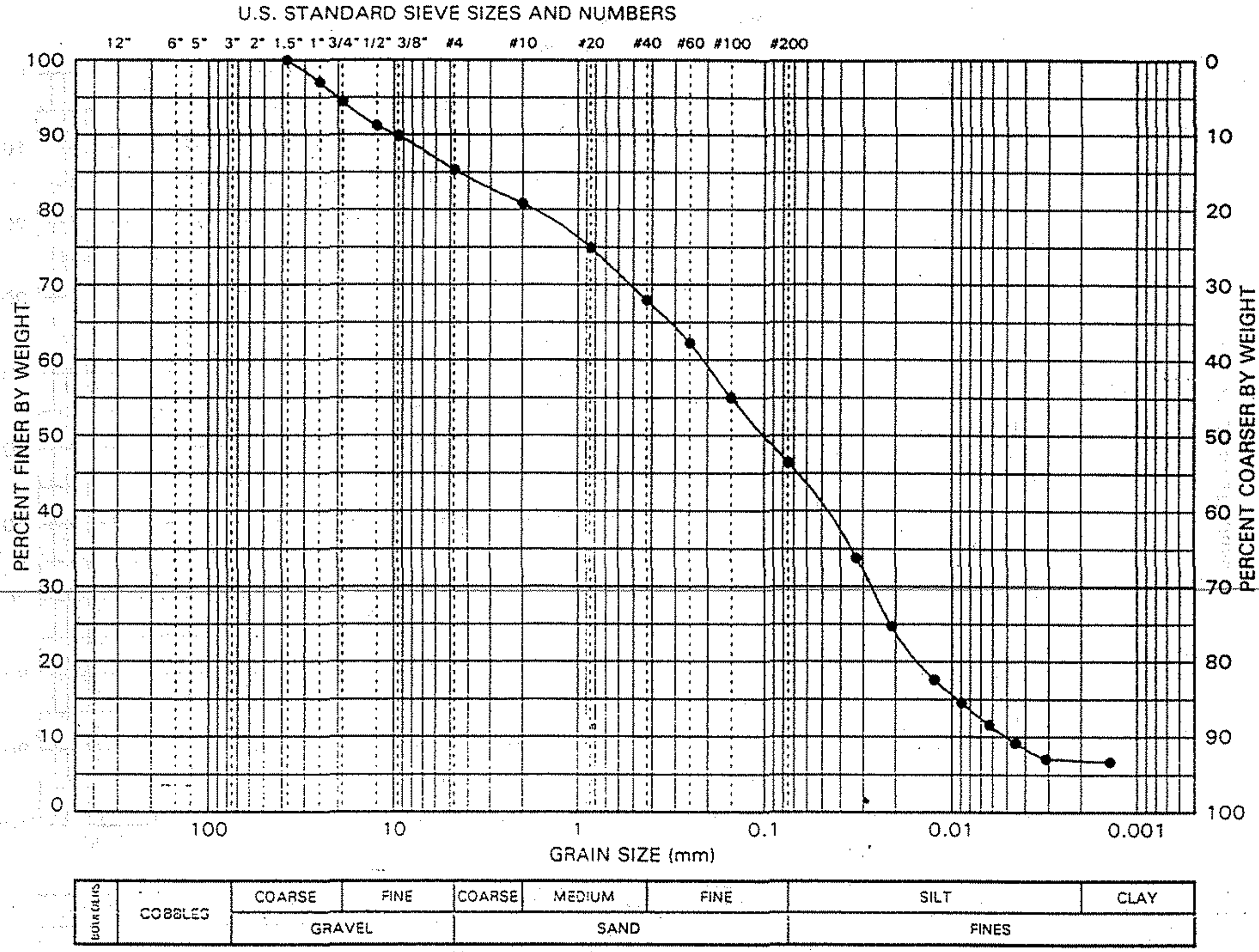
Atlanta, Georgia

FIGURE 4
PROJECT: LOPEZ CANYON LANDFILL
PROJECT NO.: CE4100
DOCUMENT NO.:

GS FORM: 4PS2 02/03/98

PARTICLE SIZE DISTRIBUTION AND PHYSICAL PROPERTIES

ASTM C 136, D 422, D 2487 D 3042 AND D 4318



SITE SAMPLE ID	AB-10	LIQUID LIMIT (%)	40	GRAVEL (%)	14.7
LAB. SAMPLE NO.	98A89	PLASTIC LIMIT (%)	28	SAND (%)	38.9
SAMPLE DEPTH (ft)		PLASTICITY INDEX	12	FINES (%)	46.4
SOIL CLASSIFICATION:				SILT (%)	39.5
SM - Silty Sand with Gravel				CLAY(%)	6.9
				COEFF. UNIFORMITY (Cu)	
				COEFF. CURVATURE (Cc)	

SOIL FRACTIONS

PERCENT PASSING U.S. STANDARD SIEVE SIZES AND NUMBERS														PERCENT FINER THAN HYDROMETER				
3"	2"	1.5"	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200					
PERCENT PASSING SIEVE SIZES (mm)														PARTICLE DIAMETER (mm)				
75	50	37.5	25	19	12.5	9.5	4.75	2.00	0.850	0.425	0.250	0.150	0.075	0.050	0.020	0.005	0.002	0.001
100	100	100	97	94	91	90	85	81	75	68	62	55	46	40	24	10	7	

NOTES:

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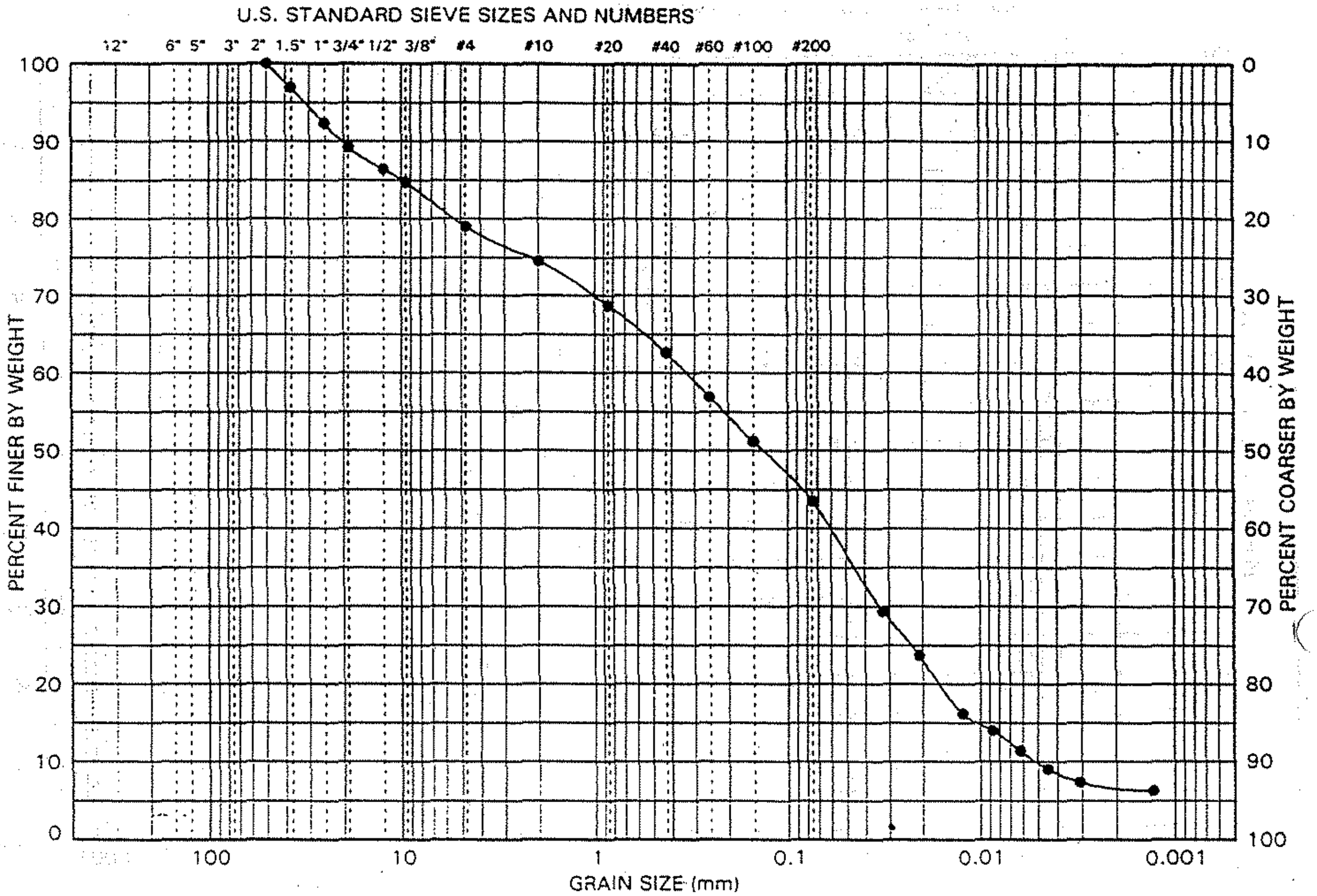
Atlanta, Georgia

FIGURE 3
PROJECT: LOPEZ CANYON LANDFILL
PROJECT NO.: CE4100
DOCUMENT NO.:

GS FORM: 4PS2 02/03/98

PARTICLE SIZE DISTRIBUTION AND PHYSICAL PROPERTIES

ASTM C 136, D 422, D 2487 D 3042 AND D 4318



	COBBLES	COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
		GRAVEL		SAND			FINES	

SITE SAMPLE ID	AB-7	LIQUID LIMIT (%)	40	GRAVEL (%)	21.0
LAB. SAMPLE NO.	98A88	PLASTIC LIMIT (%)	25	SAND (%)	35.5
SAMPLE DEPTH (ft)		PLASTICITY INDEX	15	FINES (%)	43.5
SOIL CLASSIFICATION:			SOIL FRACTIONS	SILT (%)	36.7
SC - Clayey Sand with Gravel				CLAY(%)	6.8
				COEFF. UNIFORMITY (Cu)	
				COEFF. CURVATURE (Cc)	

PERCENT PASSING U.S. STANDARD SIEVE SIZES AND NUMBERS														PERCENT FINER THAN HYDROMETER				
3"	2"	1.5"	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200					
PERCENT PASSING SIEVE SIZES (mm)														PARTICLE DIAMETER (mm)				
75	50	37.5	25	19	12.5	9.5	4.75	2.00	0.850	0.425	0.250	0.150	0.075	0.050	0.020	0.005	0.002	0.0
100	100	97	92	89	86	85	79	75	69	63	57	51	44	37	23	10	7	

NOTES:

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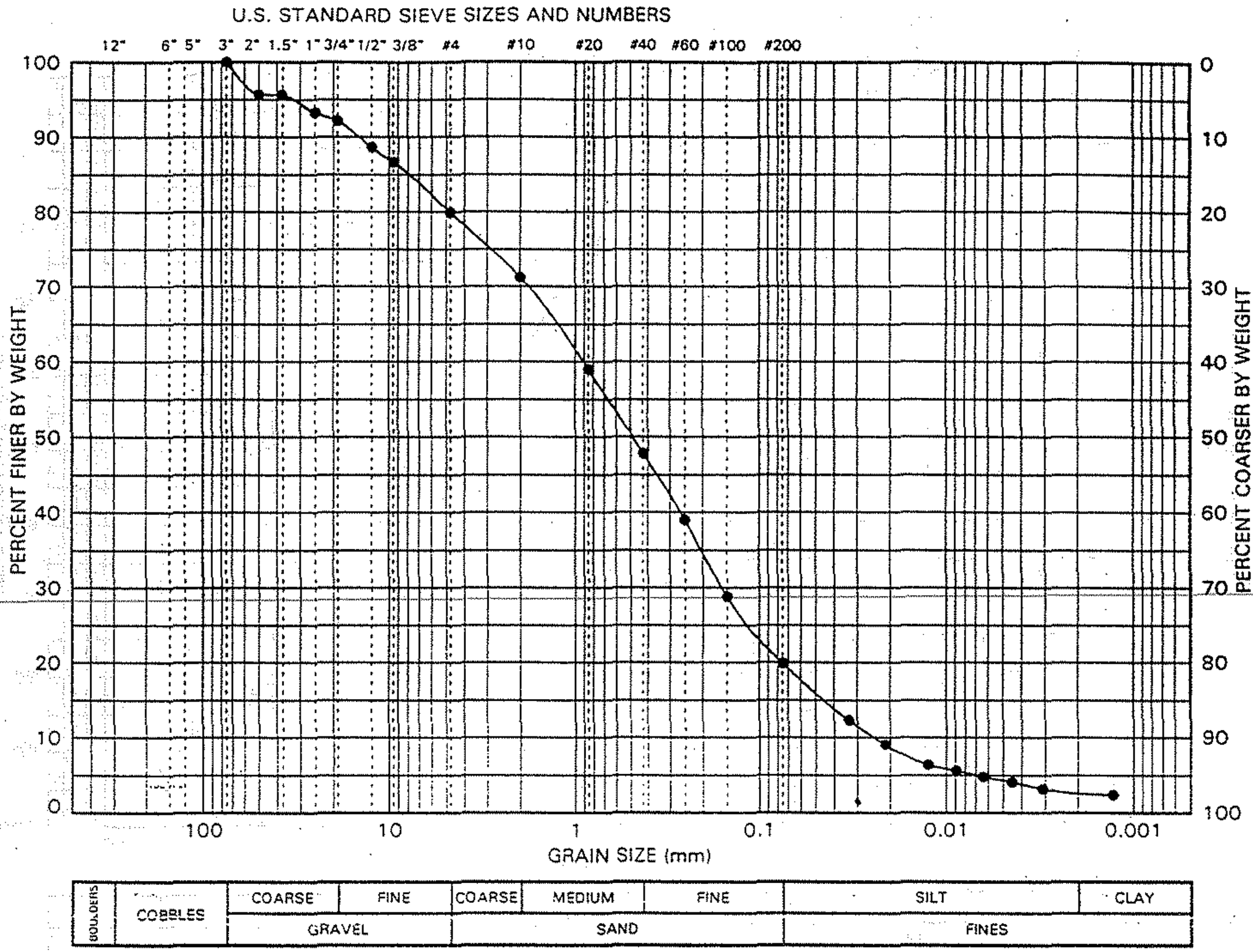
Atlanta, Georgia

FIGURE 2
PROJECT: LOPEZ CANYON LANDFILL
PROJECT NO.: CE4100
DOCUMENT NO.:

GS FORM: 4PS2 02/03/98

PARTICLE SIZE DISTRIBUTION AND PHYSICAL PROPERTIES

ASTM C 136, D 422, D 2487 D 3042 AND D 4318



SITE SAMPLE ID	AB-4	LIQUID LIMIT (%)	31	SOIL FRACTIONS GRAVEL (%)	20.1
LAB. SAMPLE NO.	98A87	PLASTIC LIMIT (%)	21	SAND (%)	60.0
SAMPLE DEPTH (ft)		PLASTICITY INDEX	10	FINES (%)	19.9
SOIL CLASSIFICATION:				SILT (%)	17.1
SC - Clayey Sand with Gravel				CLAY(%)	2.8
				COEFF. UNIFORMITY (Cu)	
				COEFF. CURVATURE (Cc)	

PERCENT PASSING U.S. STANDARD SIEVE SIZES AND NUMBERS														PERCENT FINER THAN HYDROMETER PARTICLE DIAMETER (mm)				
3"	2"	1.5"	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200					
PERCENT PASSING SIEVE SIZES (mm)																		
75	50	37.5	25	19	12.5	9.5	4.75	2.00	0.850	0.425	0.250	0.150	0.075	0.050	0.020	0.005	0.002	0.001
100	96	96	93	92	89	87	80	71	59	48	39	29	20	16	9	4	3	

NOTES:

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Atlanta, Georgia

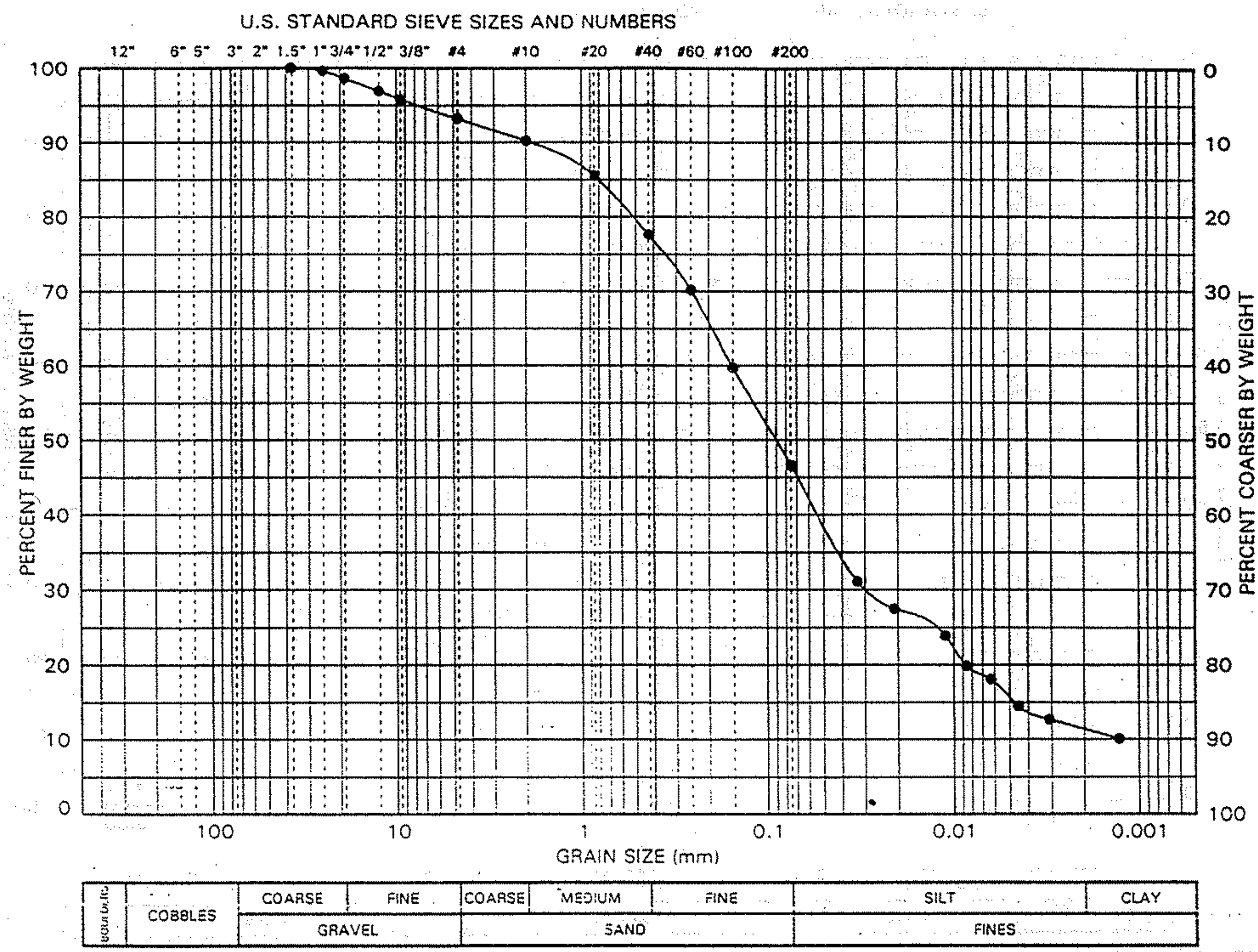
FIGURE 1

PROJECT: LOPEZ CANYON LANDFILL
PROJECT NO.: CE4100
DOCUMENT NO.:

GS FORM: 4PS2 02/03/98

PARTICLE SIZE DISTRIBUTION AND PHYSICAL PROPERTIES

ASTM C 136, D 422, D 2487 D 3042 AND D 4318



SITE SAMPLE ID	AB-3	LIQUID LIMIT (%)	35	GRAVEL (%)	6.8
LAB. SAMPLE NO.	98A86	PLASTIC LIMIT (%)	18	SAND (%)	46.6
SAMPLE DEPTH (ft)		PLASTICITY INDEX	17	FINES (%)	46.6
SOIL CLASSIFICATION:				SILT (%)	35.2
SC - Clayey Sand				CLAY(%)	11.4
				COEFF. UNIFORMITY (Cu)	
				COEFF. CURVATURE (Cc)	

SOIL FRACTIONS

PERCENT PASSING U.S. STANDARD SIEVE SIZES AND NUMBERS														PERCENT FINER THAN HYDROMETER PARTICLE DIAMETER (mm)				
3"	2"	1.5"	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200					
PERCENT PASSING SIEVE SIZES (mm)																		
75	50	37.5	25	19	12.5	9.5	4.75	2.00	0.850	0.425	0.250	0.150	0.075	0.050	0.020	0.005	0.002	0.0
100	100	100	100	99	97	96	93	90	86	78	70	60	47	39	27	16	11	

NOTES:

TABLE 1

LABORATORY TEST RESULTS

BUREAU OF SANITATION - CITY OF LOS ANGELES
LOPEZ CANYON LANDFILL

Site Sample ID	Lab Sample No	As-Received Moisture Content ASTM D 2216 (%)	Grain Size: Percent Passing #200 Sieve ASTM D 1140 (%)	Grain Size: ASTM D 422 Sieve Figure No	Grain Size: ASTM D 422 Hydrom. Figure No.	Atterberg Limits ASTM D 4318: LL (%)	Atterberg Limits ASTM D 4318: PL (%)	Atterberg Limits ASTM D 4318: PI (-)	Soil Classification ASTM D 2487	Compaction, Modified Proctor ASTM D 1557: Max. Dry Unit Weight (pcf)	Compaction, Modified Proctor ASTM D 1557: Optimum Moisture Content (%)	Compaction, Modified Proctor ASTM D 1557: Fig. No	Hydraulic Conductivity ASTM D 5084, Test Specimen Initial Conditions: Dry Unit Weight (pcf)	Hydraulic Conductivity ASTM D 5084, Test Specimen Initial Conditions: Moisture Content (%)	Hydraulic Conductivity ASTM D 5084, Test Specimen Initial Conditions: Consol. Pressure (psi)	Hydraulic Conductivity ASTM D 5084: Hydraulic Conductivity (cm/s)	Remarks
AB-3	98A86		46.6	1	1	35	18	17	SC - Clayey Sand								
AB-4	98A87		19.9	2	2	31	21	10	SC - Clayey Sand with Gravel								
AB -7	98A88		43.5	3	3	40	25	15	SC - Clayey Sand with Gravel								
	98A89		46.4	4	4	40	28	12	SM - Silty Sand with Gravel								
AB -10	98B32									122.5	11.3	5					Not corrected for over-sized particles
										125.7	10.1	6					
	98B32.1												104.2	13.2	1.5	4.5E-4	Moisture Retention see Fig. 13
AB -25-B	98B34									124.4	11.2	7					Not corrected for over-sized particles
										128.9	9.4	8					
	98B34.1												112.0	10.9	1.5	7.6E-5	
B-3	98B15		52.4	9		37	20	17	CL - Sandy Lean Clay								
B-6	98A90		61.9	10	10	39	30	9	ML - Sandy Silt								
VGO21398	98B69		38.8	11	11					123.6	10.3	12	111.3	12.6	1.5	7.5E-5	

Note:

1. Moisture Retention test ongoing; test results will be presented in a revised report.

SAMPLE IDENTIFICATION, HANDLING, STORAGE AND DISPOSAL

Test materials were sent to GeoSyntec Consultants (GeoSyntec) Geomechanics and Environmental Laboratory in Atlanta, Georgia by the client or its representative(s). Samples delivered to the laboratory were identified by client sample identification (ID) numbers which had been assigned by representative(s) of the client. Upon being received at the laboratory, each sample was assigned a laboratory sample number to facilitate tracking and documentation.

Based on the information provided to GeoSyntec by the client or its representative(s) and, when applicable, procedural guidelines recommended by an industrial hygiene consultant, the following Occupational Safety and Health Administration (OSHA) level of personal protection was adopted for handling and testing of the test materials:

[X] test materials were not contaminated, no special protection measures were taken;
[ ] level D
[ ] level C
[ ] level B

In accordance with the health and safety guidelines of GeoSyntec, contaminated materials are stored in a designated containment area in the laboratory. Non-contaminated materials are stored in a general storage area in the laboratory.

GeoSyntec Geomechanics and Environmental Laboratory will return contaminated materials to the client or designated representative(s), at the clients' cost, 30 days following the completion of the testing program, unless special arrangements for proper disposal have been made with the laboratory. Materials which are not contaminated will be discarded 90 days after they were received at the laboratory, unless long-term storage arrangements are specifically made with GeoSyntec Geomechanics and Environmental Laboratory .

LABORATORY TEST STANDARDS

At the request of the client, the laboratory testing program was performed utilizing the guidelines provided in the following test standards:

[X] **moisture content** - American Society for Testing and Materials (ASTM) D 2216 "*Standard Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures*";

[ ] **moisture content** - ASTM D 4643 "*Standard Test Method for Determination of Water (Moisture) Content of Soil by the Microwave Method*";

[X] **particle-size analysis** - ASTM D 422, "*Standard Method for Particle-Size Analysis of Soils*";

[X] **percent passing No. 200 sieve** - ASTM D 1140, "*Standard Test Method for Amount of Material in Soil Finer Than No. 200 (75 microns) sieve*";

[X] **Atterberg limits** - ASTM D 4318, "*Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils*";

[X] **soil classification** - ASTM D 2487, "*Standard Test Method for Classification of Soils for Engineering Purposes*";

[ ] **soil pH** - ASTM D 4972, "*Standard Test Method for pH of Soils*";

[ ] **soil pH** - United States Environmental Protection Agency (USEPA) SW-846 Method 9045, Revision 1, 1987, Standard Test Method for Measurement of "*Soil pH*";

[ ] **specific gravity** - ASTM D 854, "*Standard Test Method for Specific Gravity of Soils*";

[ ] **carbonate content** - ASTM D 3042, "*Standard Test Method for Insoluble Residue in Carbonate Aggregates*";

[ ] **carbonate content** - ASTM D 4373, "*Standard Test Method for Calcium Carbonate Content of Soils*";

[ ] **acid reactivity** - ASTM D 2488, "*Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)*";

[ ] **soundness** - ASTM C 88, "*Standard Test Method for Soundness of Aggregates by use of Sodium Sulfate or Magnesium Sulfate*";

[ ] **loss-on-ignition (LOI)** - ASTM D 2974, "*Test Methods for Moisture, Ash, and Organic Matter of Peat and Other*

Organic Soils";

[ ] **standard Proctor compaction** - ASTM D 698, *"Standard Test Method for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 5.5-lb (2.49-kg) Rammer and 12-in. (305-mm) Drop"*;

[X] **modified Proctor compaction** - ASTM D 1557, *"Standard Test Method for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 10-lb (4.54-kg) Rammer and 18-in. (457-mm) Drop"*;

[ ] **maximum relative density** - ASTM D 4253, *"Standard Test Method for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table"*;

[ ] **minimum relative density** - ASTM D 4254, *"Standard Test Method for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density"*;

[ ] **unit weight** - ASTM D 2937, *"Standard Test Method for Density of Soil In Place by the Drive-Cylinder Method"*;

[ ] **unit weight, void ratio, porosity, and degree of saturation** - U. S. Army Corps of Engineers (USCOE); EM-1110-2-1906, *"Unit Weight, Void Ratio, Porosity, and Degree of Saturation, Appendix II"*;

[ ] **mass per unit area** - ASTM D 3776, *"Standard Test Method for Mass Per Unit Area (weight) of Woven Fabric"*;

[ ] **thickness measurement** - ASTM D 1777, *"Standard Test Method for Measuring Thickness of Textile Materials"*;

[ ] **free swell** - United States Pharmacopoeia National Formulary (USP-NF) XVII, *"Swell Index of Clay"*;

[ ] **swell of clay in GCL's** - Geosynthetic Research Institute (GRI) GCL-1, *"Standard Test Method for Swell Measurement of the Clay Component of GCL's"*;

[ ] **fluid loss** - American Petroleum Institute (API) RP 13B, *"Section 4, Bentonite"*;

[ ] **marsh funnel** - API RP 13B, *"Section 4, Field Testing of Oil Mud Viscosity and Gel Strength"*;

[ ] **pinhole dispersion** - ASTM D 4647, *"Standard Test Method for Identification and Classification of Dispersive Clay Soils by the Pinhole Test"*;

[ ] **gradient ratio** - ASTM D 5101, *"Standard Test Method for Measuring the Soil-Geotextile System Clogging Potential by the Gradient Ratio"*;

[ ] **hydraulic conductivity ratio (HCR)** - ASTM D 5567, *"Standard Test Method for Hydraulic Conductivity Ratio (HCR) Testing of Soil/Geotextile Systems"*;

[ ] **hydraulic transmissivity** - ASTM D 4716, *"Standard Test Method for Constant Head Hydraulic Transmissivity (In-plane flow) of Geotextiles and Geotextile Related Products"*;

[ ] **one-dimensional consolidation** - ASTM D 2435, *"Standard Test Method for One-Dimensional Consolidation Properties of Soil"*;

[ ] **one-dimensional swell/collapse** - ASTM D 4546, *"Standard Test Method for One-Dimensional Swell or Settlement Potential of Cohesive Soils"*;

[ ] **unconfined compressive strength (UCS)** - ASTM D 2166, *" Standard Test Method for Unconfined Compressive Strength of Cohesive Soil"*;

[ ] **triaxial compressive strength (ICU)** - ASTM D 4767, *"Standard Test Method for Triaxial Compression Test on Cohesive Soils"*;

[ ] **triaxial compressive strength (UU)** - ASTM D 2850, *"Standard Test Method for Unconsolidated, Undrained Compressive Strength of Cohesive Soils in Triaxial Compression"*;

[ ] **rigid wall constant head hydraulic conductivity** - ASTM D 2434, *"Standard Test Method for Permeability of Granular Soils (Constant Head)"*;

[ ] **rigid wall constant head hydraulic conductivity** - USCOE; EM-1110-2-1906, *"Standard Test Method for Permeability Tests, Appendix VII"*;

[X] **flexible wall falling head hydraulic conductivity** - ASTM D 5084, *"Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter"*;

[ ] **flexible wall falling head hydraulic conductivity** - USCOE; EM-1110-2-1906, *"Standard Test Method for Permeability Tests, Appendix VII"*;

[ ] **index flux of GCL** - proposed ASTM method rough draft # 1, 6/18/94, *"Standard Test Method for Measurement of Index Flux Through Saturated Geosynthetic Clay Liner Specimens Using a Flexible Wall Permeameter"*;

[ ] **flexible wall falling head hydraulic conductivity** - GRI GCL-2, *"Standard Test Method for Permeability of Geosynthetic Clay Liners (GCLs)"*;

[ ] **permeability/compatibility** - USEPA Method 9100 SW-846, Revision 1, 1987, Standard Test Method for Measurement of *"Saturated Hydraulic Conductivity, Saturated Leachate Conductivity and Intrinsic Permeability"*;

[ ] **permeability** - API RP 27, *"Recommended Practice for Determining Permeability of Porous Media"*;

[X] **capillary-moisture** - ASTM D 2325, *"Standard Test Method for Capillary-Moisture Relationships for Coarse- and Medium-Textured Soils by Porous-Plate Apparatus"*;

[ ] **capillary-moisture** - ASTM D 3152, *"Standard Test Method for Capillary-Moisture Relationships for Fine-Textured Soils by Pressure-Membrane Apparatus"*;

[ ] **paint filter liquids** - USEPA Method 9095, SW-846, Revision 1, 1987, *"Paint Filter Liquids Test"*; and

[ ] **slump** - ASTM C 143-90a, *"Standard Test Method for Slump of Hydraulic Cement Concrete"*.

APPLICATION OF TEST RESULTS

The reported test results apply to the field materials inasmuch as the samples sent to the laboratory for testing are representative of these materials. This report applies only to the materials tested and does not necessarily indicate the quality or condition of apparently identical or similar materials. The testing was performed in accordance with the general engineering standards and conditions reported. The test results are related to the testing conditions used during the testing program. As a mutual protection to the client, the public, and GeoSyntec, this report is submitted and accepted for the exclusive use of the client and upon the condition that this report is not used, in whole or in part, in any advertising, promotional or publicity matter without prior written authorization from GeoSyntec.

TABLE 1

LABORATORY TEST RESULTS

BUREAU OF SANITATION - CITY OF LOS ANGELES
LOPEZ CANYON LANDFILL

Site Sample ID	Lab Sample No	As-Received Moisture Content ASTM D 2216 (%)	Grain Size: Percent Passing #200 Sieve ASTM D 1140 (%)	Grain Size: ASTM D 422 Sieve Figure No.	Grain Size: ASTM D 422 Hydrom. Figure No.	Atterberg Limits ASTM D 4318 LL (%)	Atterberg Limits ASTM D 4318 PL (%)	Atterberg Limits ASTM D 4318 PI (-)	Soil Classification ASTM D 2487	Compaction Modified Proctor ASTM D 1557 Max. Dry Unit Weight (pcf)	Compaction Modified Proctor ASTM D 1557 Optimum Moisture Content (%)	Compaction Fig. No.	Hydraulic Conductivity ASTM D 5084 Test Specimen Initial Conditions Dry Unit Weight (pcf)	Hydraulic Conductivity ASTM D 5084 Test Specimen Initial Conditions Moisture Content (%)	Hydraulic Conductivity ASTM D 5084 Test Specimen Initial Conditions Consol. Pressure (psi)	Hydraulic Conductivity (cm/s)	Remarks
A-6	98B65		37.6	1	1	34	24	10	SM - Silty Sand	126.0	10.5	2	113.3	12.2	1.5	7.8E-5	Not corrected for over-sized particles
										128.2	9.7	3					Moisture Retention see Fig. 12
A-8	98B66		46.1	4	4	36	24	12	SC - Clayey Sand	122.0	11.5	5	110.0	13.1	1.5	8.8E-5	
A-9	98B67		50.6	6	6	44	28	16	ML - Sandy Silt	116.2	14.3	7	102.9	17.0	1.5	1.4E-5	Not corrected for over-sized particles
										118.7	13.2	8					
A-10	98B68		53.2	9	9	48	30	18	ML - Sandy Silt	119.5	12.0	10	107.4	14.8	1.5	3.6E-6	Not corrected for over-sized particles
										122.7	10.9	11					

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Atlanta, Georgia

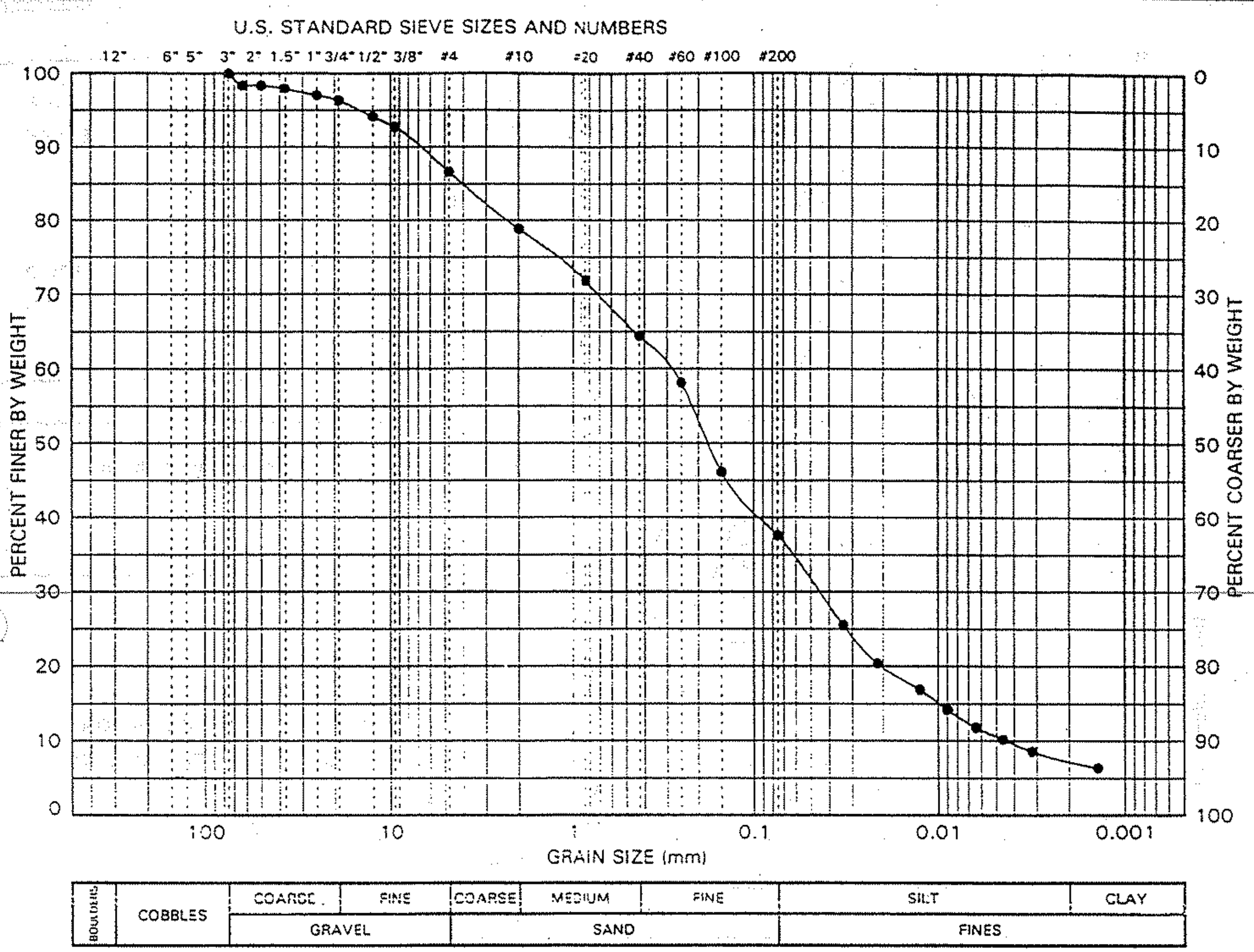
FIGURE 1

PROJECT:	LOPEZ CANYON LANDFILL
PROJECT NO.:	CE4100
DOCUMENT NO.:	

GS FORM:
4PS2 03/12/98

PARTICLE SIZE DISTRIBUTION AND PHYSICAL PROPERTIES

ASTM C 136, D 422, D 2487
D 3042 AND D 4318



SITE SAMPLE ID	A-6	LIQUID LIMIT (%)	34	GRAVEL (%)	13.4
LAB. SAMPLE NO.	98B65	PLASTIC LIMIT (%)	24	SAND (%)	49.0
SAMPLE DEPTH (ft)		PLASTICITY INDEX	10	FINES (%)	37.6
SOIL CLASSIFICATION:				SILT (%)	30.3
SM - Silty Sand				CLAY(%)	7.3
				COEFF. UNIFORMITY (Cu)	
				COEFF. CURVATURE (Cc)	

SOIL FRACTIONS

PERCENT PASSING U.S. STANDARD SIEVE SIZES AND NUMBERS														PERCENT FINER THAN HYDROMETER				
3"	2"	1.5"	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200					
PERCENT PASSING SIEVE SIZES (mm)														PARTICLE DIAMETER (mm)				
75	50	37.5	25	19	12.5	9.5	4.75	2.00	0.850	0.425	0.250	0.150	0.075	0.050	0.020	0.005	0.002	0.001
100	98	98	97	96	94	93	87	79	72	64	58	46	38	31	20	11	7	

NOTES:

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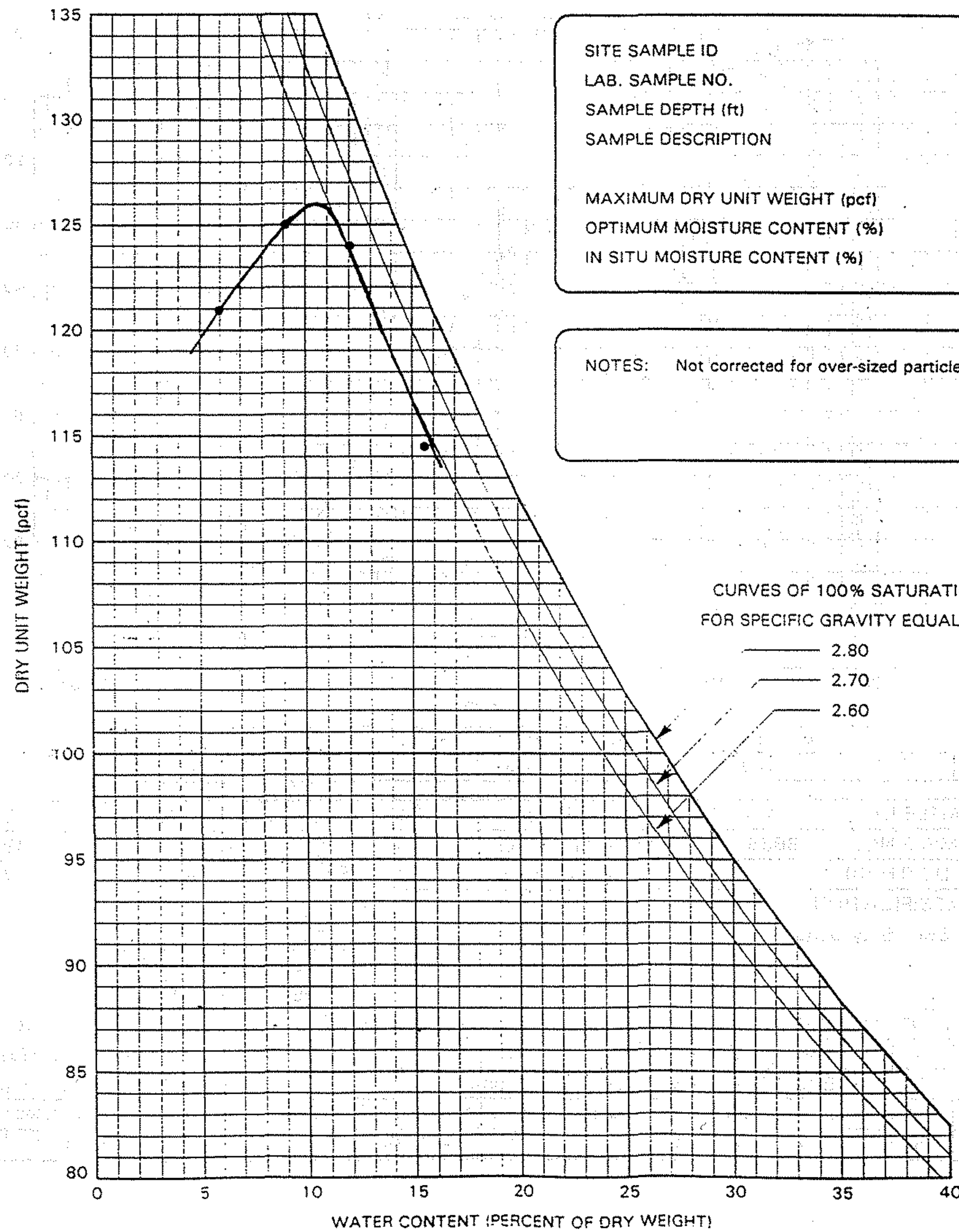
FIGURE 2

PROJECT: LOPEZ CANYON LANDFILL
PROJECT NO.: CE4100
DOCUMENT NO.:

GS FORM: 4MD1 03/04/98

MOISTURE-DENSITY RELATIONSHIP, COMPACTION TESTING

ASTM D-1557-B



SITE SAMPLE ID	A-6
LAB. SAMPLE NO.	98865
SAMPLE DEPTH (ft)	
SAMPLE DESCRIPTION	
MAXIMUM DRY UNIT WEIGHT (pcf)	126.0
OPTIMUM MOISTURE CONTENT (%)	10.5
IN SITU MOISTURE CONTENT (%)	

NOTES: Not corrected for over-sized particles

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Atlanta, Georgia

FIGURE 3

PROJECT: LOPEZ CANYON LANDFILL
PROJECT NO.: CE4100
DOCUMENT NO.:

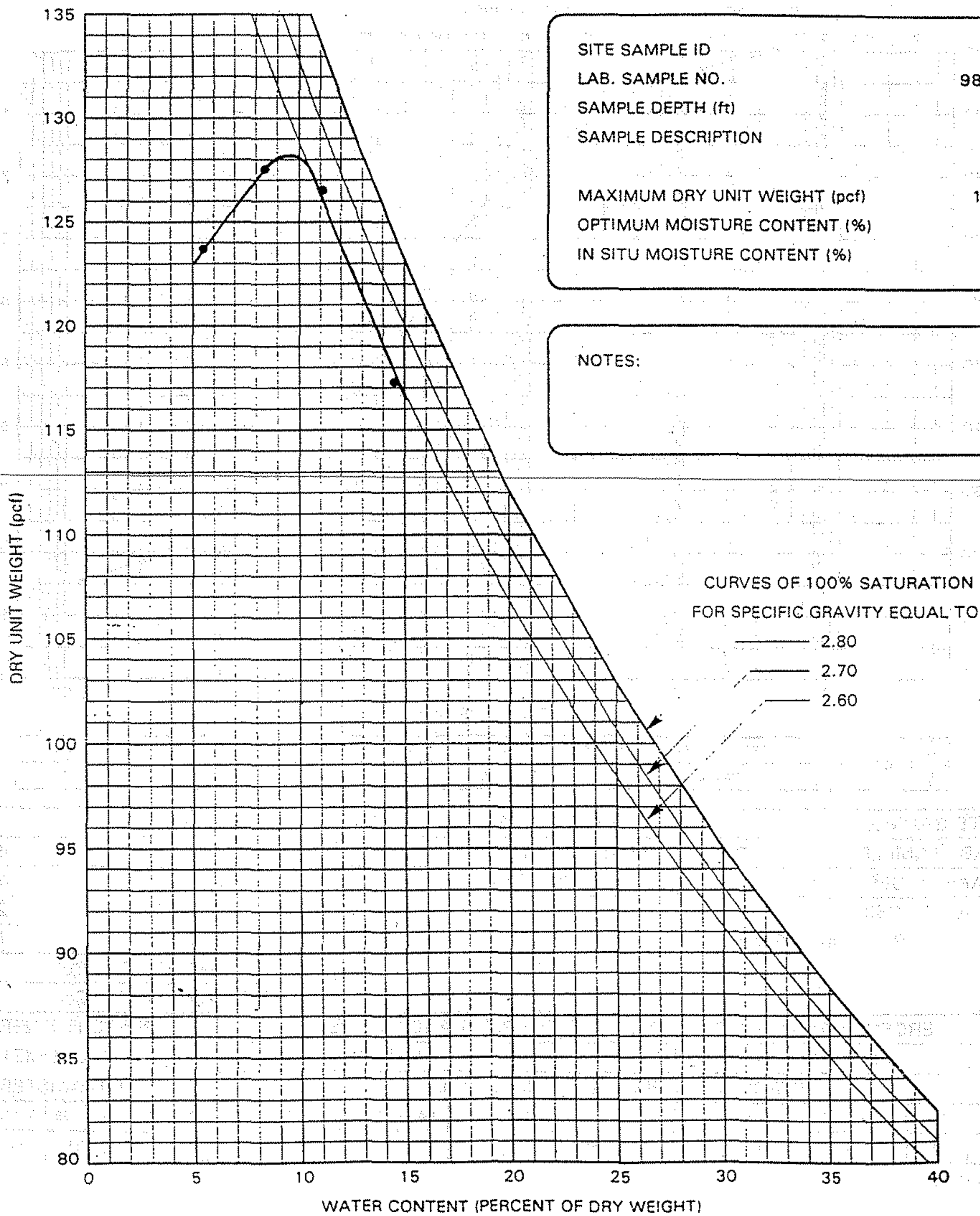
GS FORM: 4MD1 03/03/98

MOISTURE-DENSITY RELATIONSHIP, COMPACTION TESTING

ASTM D 4178 correction applied
ASTM D-1557-B

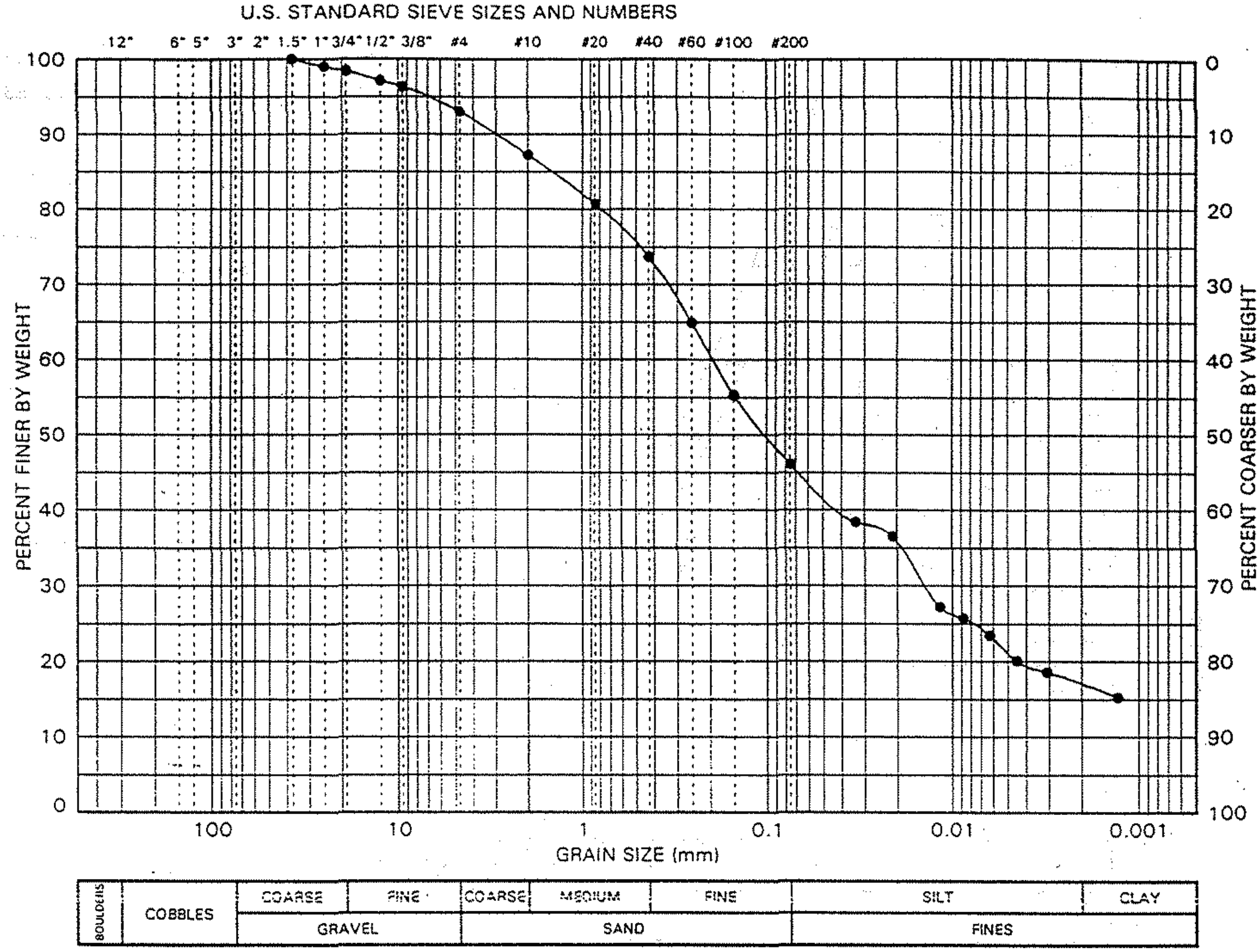
SITE SAMPLE ID	A-6
LAB. SAMPLE NO.	98B65.
SAMPLE DEPTH (ft)	
SAMPLE DESCRIPTION	
MAXIMUM DRY UNIT WEIGHT (pcf)	128.2
OPTIMUM MOISTURE CONTENT (%)	9.7
IN SITU MOISTURE CONTENT (%)	

NOTES:



GEO SYNTEC CONSULTANTS Geomechanics and Environmental Laboratory Atlanta, Georgia	**FIGURE 4** PROJECT: LOPEZ CANYON LANDFILL PROJECT NO.: CE4100 DOCUMENT NO.:

GS FORM: 4PS2 02/26/98	**PARTICLE SIZE DISTRIBUTION AND PHYSICAL PROPERTIES**	ASTM C 136, D 422, D 2487 D 3042 AND D 4318



SITE SAMPLE ID	A-8	LIQUID LIMIT (%)	36	GRAVEL (%)	7.0
LAB. SAMPLE NO.	98B66	PLASTIC LIMIT (%)	24	SAND (%)	46.9
SAMPLE DEPTH (ft)		PLASTICITY INDEX	12	FINES (%)	46.1
SOIL CLASSIFICATION:				SILT (%)	29.2
SC - Clayey Sand				CLAY(%)	16.9
				COEFF. UNIFORMITY (Cu)	
				COEFF. CURVATURE (Cc)	

SOIL FRACTIONS

PERCENT PASSING U.S. STANDARD SIEVE SIZES AND NUMBERS														PERCENT FINER THAN HYDROMETER PARTICLE DIAMETER (mm)				
3"	2"	1.5"	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200					
PERCENT PASSING SIEVE SIZES (mm)																		
75	50	37.5	25	19	12.5	9.5	4.75	2.00	0.850	0.425	0.250	0.150	0.075	0.050	0.020	0.005	0.002	0.0
100	100	100	99	98	97	96	93	87	81	74	65	55	46	42	36	21	17	

NOTES:

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FIGURE 5

PROJECT: LOPEZ CANYON LANDFILL
PROJECT NO.: CE4100
DOCUMENT NO.:

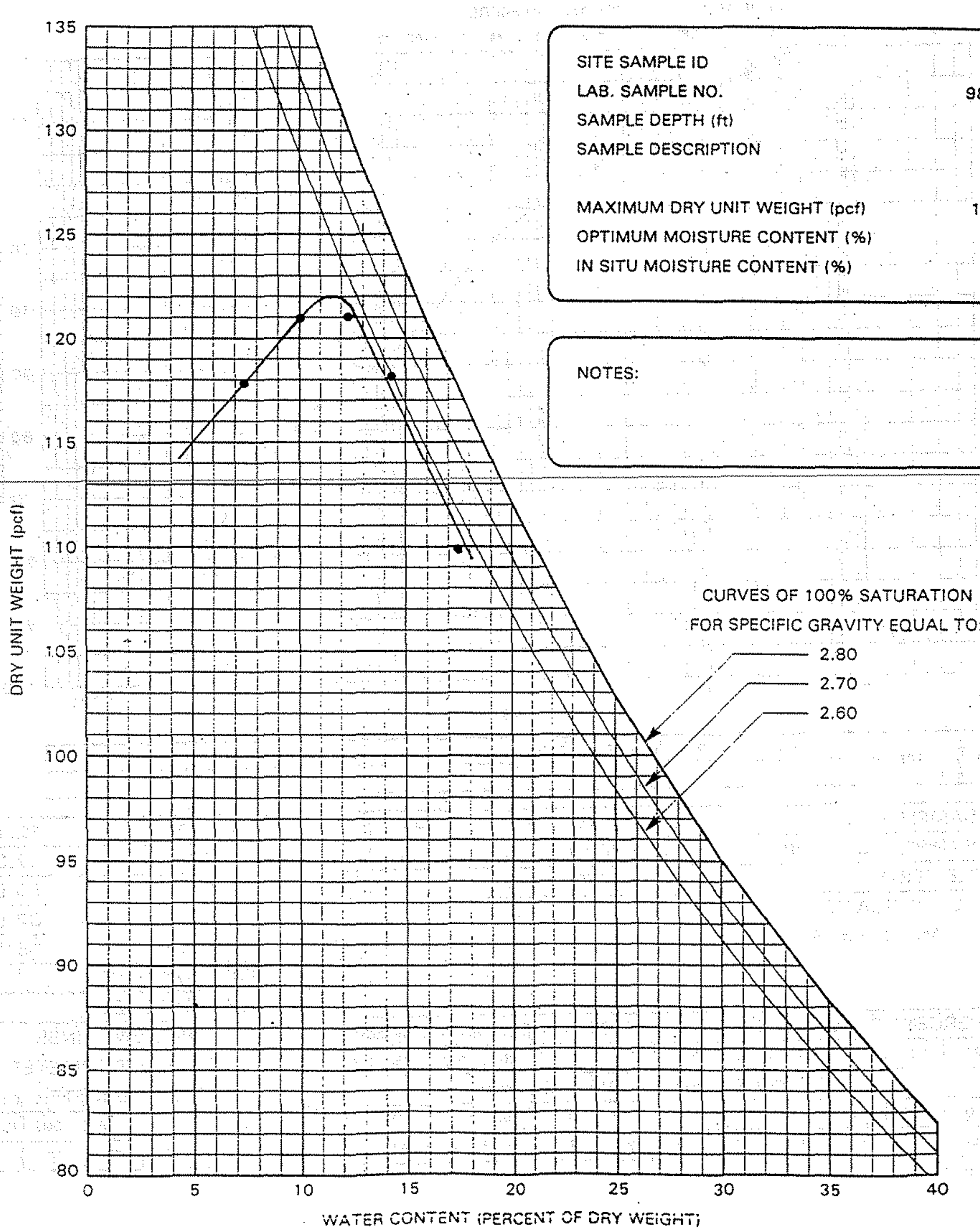
GS FORM: 4MD1 02/27/98

MOISTURE-DENSITY RELATIONSHIP, COMPACTION TESTING

ASTM D-1557-B

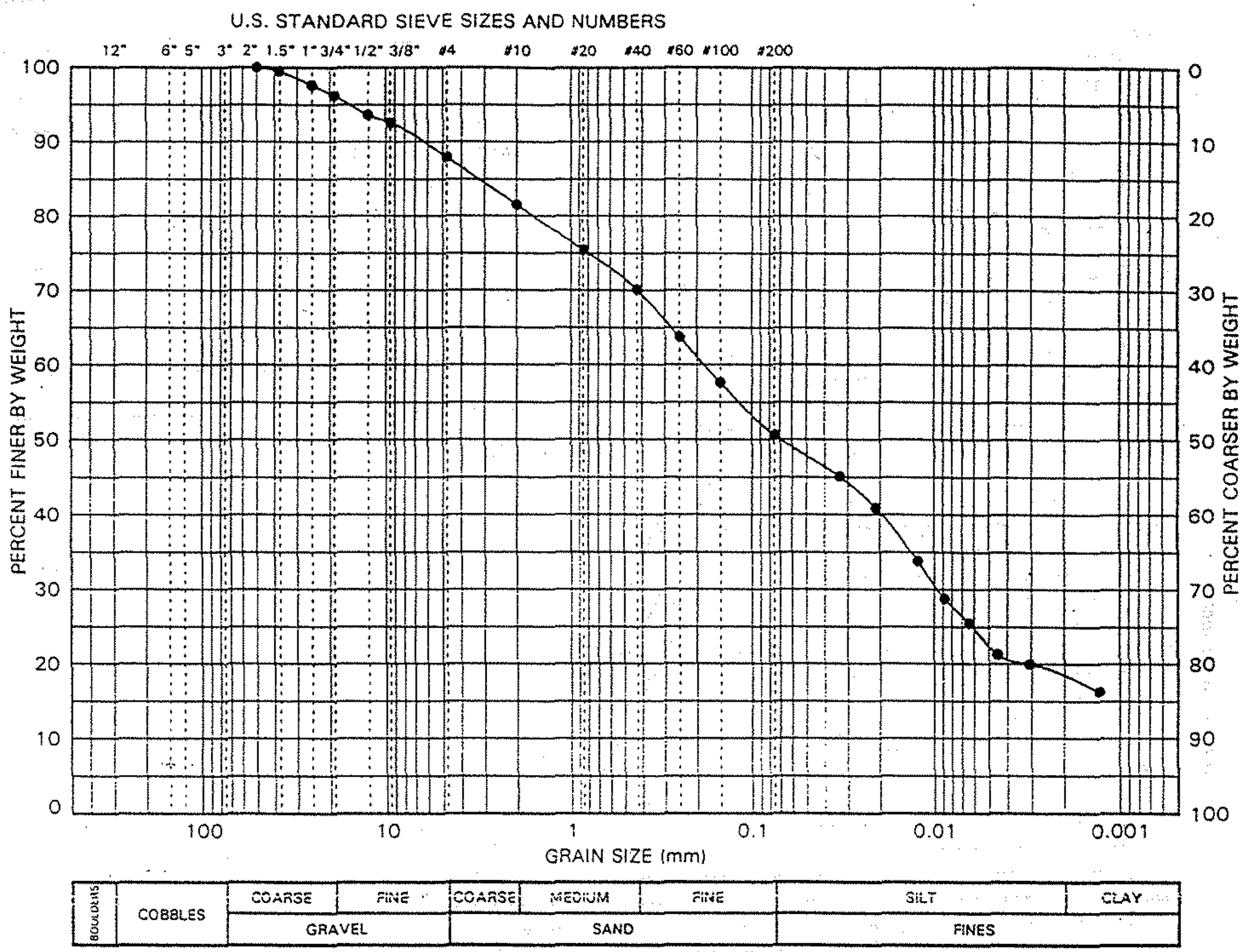
SITE SAMPLE ID	A-8
LAB. SAMPLE NO.	98B66
SAMPLE DEPTH (ft)	
SAMPLE DESCRIPTION	
MAXIMUM DRY UNIT WEIGHT (pcf)	122.0
OPTIMUM MOISTURE CONTENT (%)	11.5
IN SITU MOISTURE CONTENT (%)	

NOTES:



GEO SYNTEC CONSULTANTS Geomechanics and Environmental Laboratory Atlanta, Georgia	FIGURE 6 PROJECT: LOPEZ CANYON LANDFILL PROJECT NO.: CE4100 DOCUMENT NO.:

GS FORM: 4PS2 02/27/98	PARTICLE SIZE DISTRIBUTION AND PHYSICAL PROPERTIES	ASTM C 136, D 422, D 2487 D 3042 AND D 4318



SITE SAMPLE ID	A-9	LIQUID LIMIT (%)	44	SOIL FRACTIONS	GRAVEL (%)	12.1
LAB. SAMPLE NO.	98B67	PLASTIC LIMIT (%)	28		SAND (%)	37.3
SAMPLE DEPTH (ft)		PLASTICITY INDEX	16		FINES (%)	50.6
SOIL CLASSIFICATION: ML - Sandy Silt					SILT (%)	32.5
					CLAY(%)	18.1
					COEFF. UNIFORMITY (Cu)	
					COEFF. CURVATURE (Cc)	

PERCENT PASSING U.S. STANDARD SIEVE SIZES AND NUMBERS														PERCENT FINER THAN HYDROMETER PARTICLE DIAMETER (mm)				
3"	2"	1.5"	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200					
PERCENT PASSING SIEVE SIZES (mm)																		
75	50	37.5	25	19	12.5	9.5	4.75	2.00	0.850	0.425	0.250	0.150	0.075	0.050	0.020	0.005	0.002	0.0[illegible]
100	100	100	98	96	94	93	88	82	75	70	64	58	51	48	40	23	18	

NOTES:

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FIGURE 7

PROJECT: LOPEZ CANYON LANDFILL
PROJECT NO.: CE4100
DOCUMENT NO.:

GS FORM: 4MD1 03/03/98

MOISTURE-DENSITY RELATIONSHIP, COMPACTION TESTING

ASTM D-1557-B

SITE SAMPLE ID	A-9
LAB. SAMPLE NO.	98867
SAMPLE DEPTH (ft)	
SAMPLE DESCRIPTION	
MAXIMUM DRY UNIT WEIGHT (pcf)	116.2
OPTIMUM MOISTURE CONTENT (%)	14.3
IN SITU MOISTURE CONTENT (%)	

NOTES: Not corrected for over-sized particles

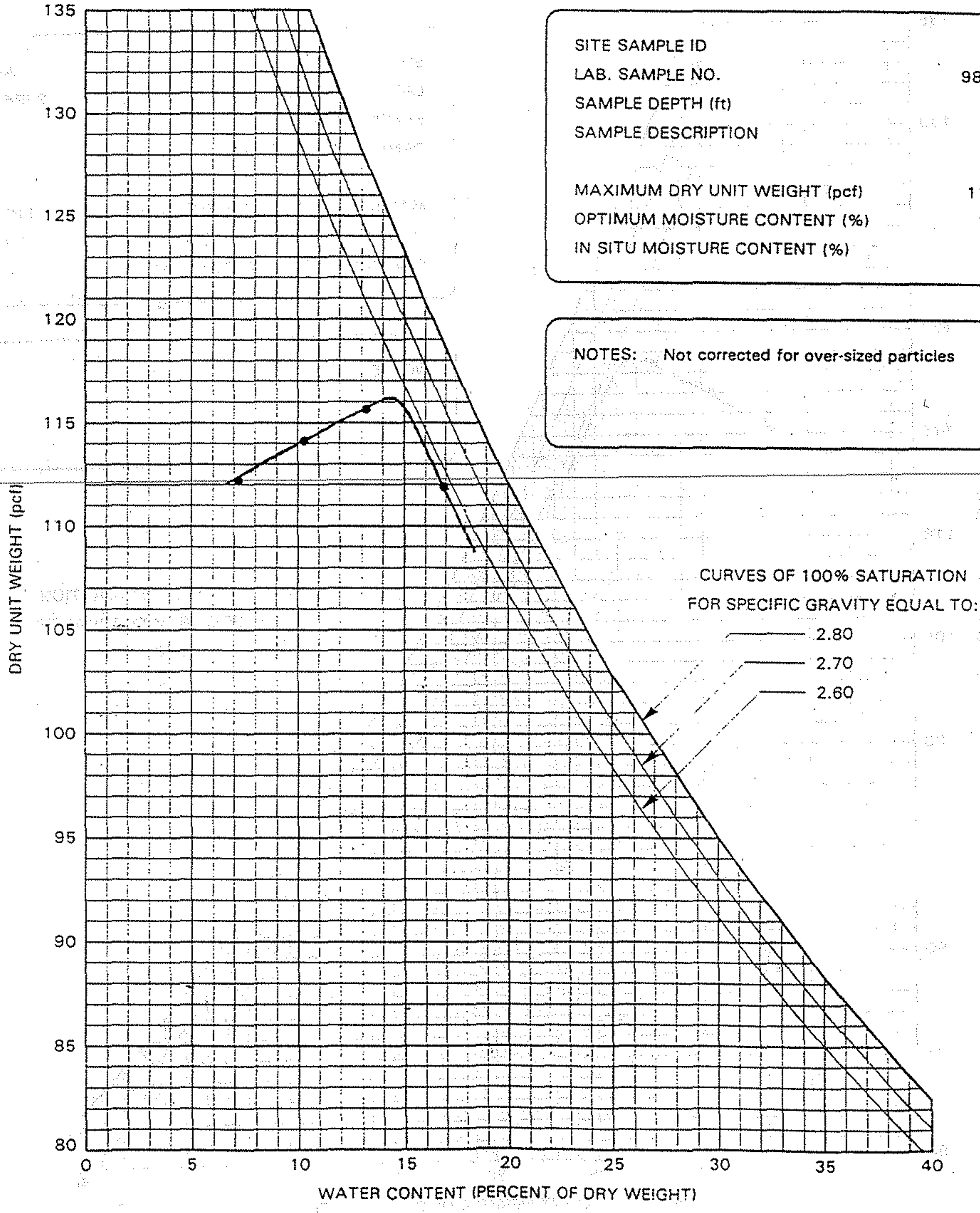

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FIGURE 8

PROJECT: LOPEZ CANYON LANDFILL
PROJECT NO.: CE4100
DOCUMENT NO.:

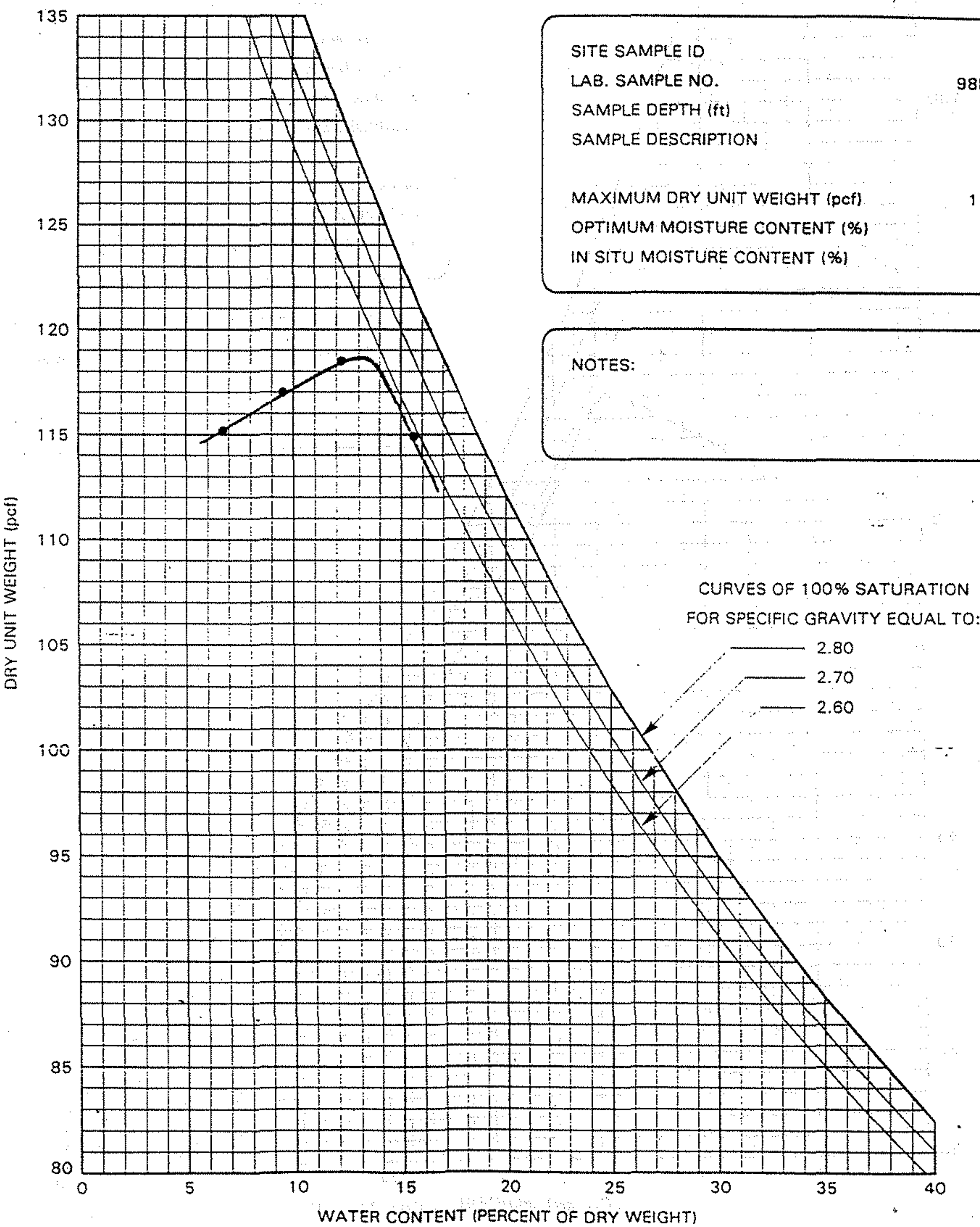
GS FORM:
4MD1 03/03/98

MOISTURE-DENSITY RELATIONSHIP, COMPACTION TESTING

ASTM D 4178 correction applied
ASTM D-1557-B

SITE SAMPLE ID	A-9
LAB. SAMPLE NO.	98B67.
SAMPLE DEPTH (ft)	
SAMPLE DESCRIPTION	
MAXIMUM DRY UNIT WEIGHT (pcf)	118.7
OPTIMUM MOISTURE CONTENT (%)	13.2
IN SITU MOISTURE CONTENT (%)	

NOTES:



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Atlanta, Georgia

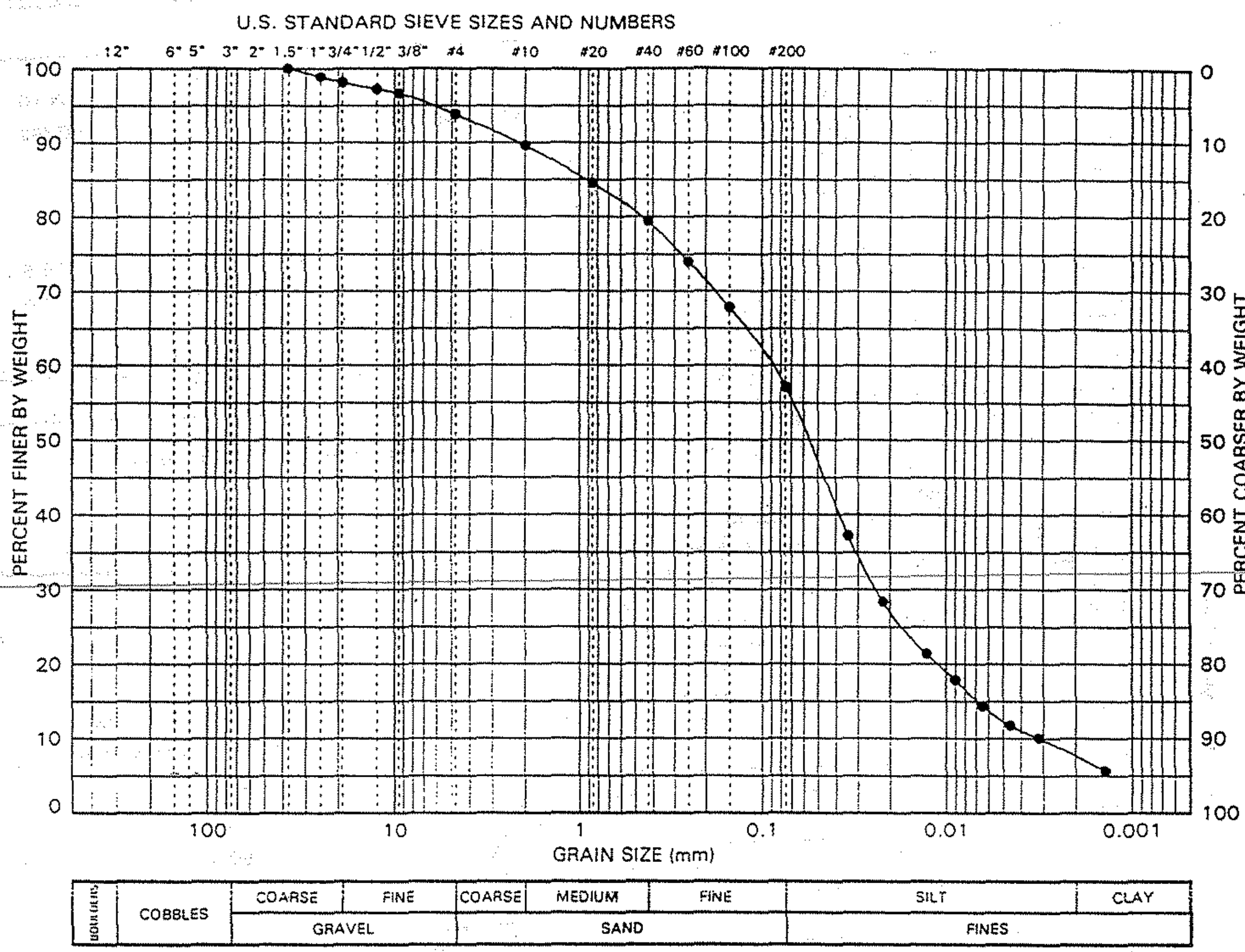
FIGURE 9

PROJECT: LOPEZ CANYON LANDFILL
PROJECT NO.: CE4100
DOCUMENT NO.:

GS FORM: 4PS2 03/04/98

PARTICLE SIZE DISTRIBUTION AND PHYSICAL PROPERTIES

ASTM C 136, D 422, D 2487
D 3042 AND D 4318



SITE SAMPLE ID	A-10	LIQUID LIMIT (%)	48
LAB. SAMPLE NO.	98B68	PLASTIC LIMIT (%)	30
SAMPLE DEPTH (ft)		PLASTICITY INDEX	18

SOIL CLASSIFICATION:

ML - Sandy Silt

SOIL FRACTIONS	
GRAVEL (%)	6.2
SAND (%)	36.7
FINES (%)	57.1
SILT (%)	49.5
CLAY(%)	7.6
COEFF. UNIFORMITY (Cu)	
COEFF. CURVATURE (Cc)	

PERCENT PASSING U.S. STANDARD SIEVE SIZES AND NUMBERS														PERCENT FINER THAN HYDROMETER				
3"	2"	1.5"	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200					
PERCENT PASSING SIEVE SIZES (mm)														PARTICLE DIAMETER (mm)				
75	50	37.5	25	19	12.5	9.5	4.75	2.00	0.850	0.425	0.250	0.150	0.075	0.050	0.020	0.005	0.002	0.001
100	100	100	99	98	97	97	94	90	85	79	74	68	57	47	27	12	8	

NOTES: The bulk sample contained some particles greater than 3 in. (75 mm) diameter.
The soil classification should include "with Cobbles".

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Atlanta, Georgia

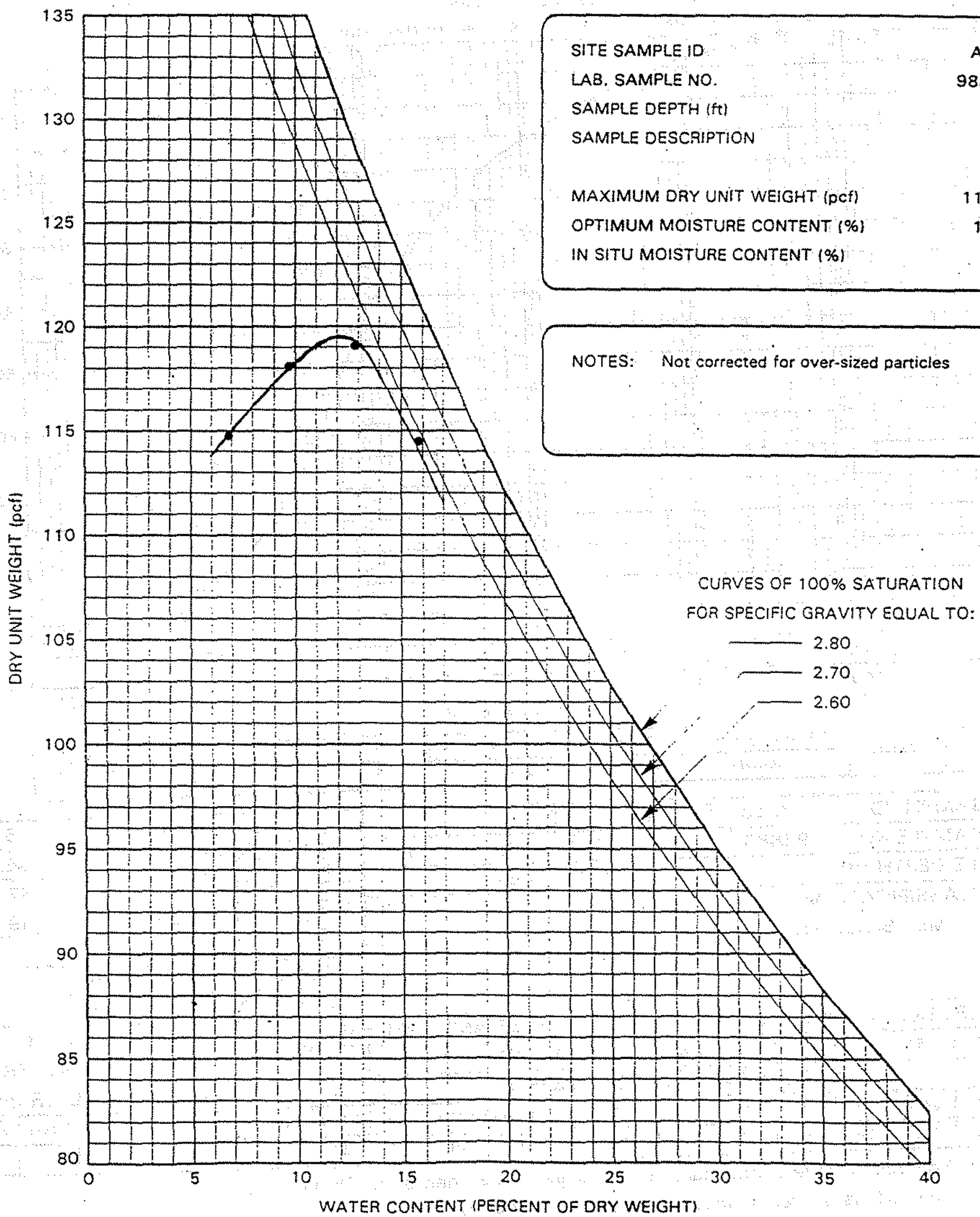
FIGURE 10

PROJECT: LOPEZ CANYON LANDFILL
PROJECT NO.: CE4100
DOCUMENT NO.:

GS FORM: 4MD1 03/03/98

MOISTURE-DENSITY RELATIONSHIP, COMPACTION TESTING

ASTM D-1557-B



SITE SAMPLE ID	A-10
LAB. SAMPLE NO.	98B68
SAMPLE DEPTH (ft)	
SAMPLE DESCRIPTION	
MAXIMUM DRY UNIT WEIGHT (pcf)	119.5
OPTIMUM MOISTURE CONTENT (%)	12.0
IN SITU MOISTURE CONTENT (%)	

NOTES: Not corrected for over-sized particles

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Atlanta, Georgia

FIGURE 11

PROJECT: LOPEZ CANYON LANDFILL
PROJECT NO.: CE4100
DOCUMENT NO.:

GS FORM: 4MD1 03/03/98

MOISTURE-DENSITY RELATIONSHIP, COMPACTION TESTING

ASTM D 4178 correction applied
ASTM D-1557-B

SITE SAMPLE ID	A-10
LAB. SAMPLE NO.	98B68.
SAMPLE DEPTH (ft)	
SAMPLE DESCRIPTION	
MAXIMUM DRY UNIT WEIGHT (pcf)	122.7
OPTIMUM MOISTURE CONTENT (%)	10.9
IN SITU MOISTURE CONTENT (%)	

NOTES:

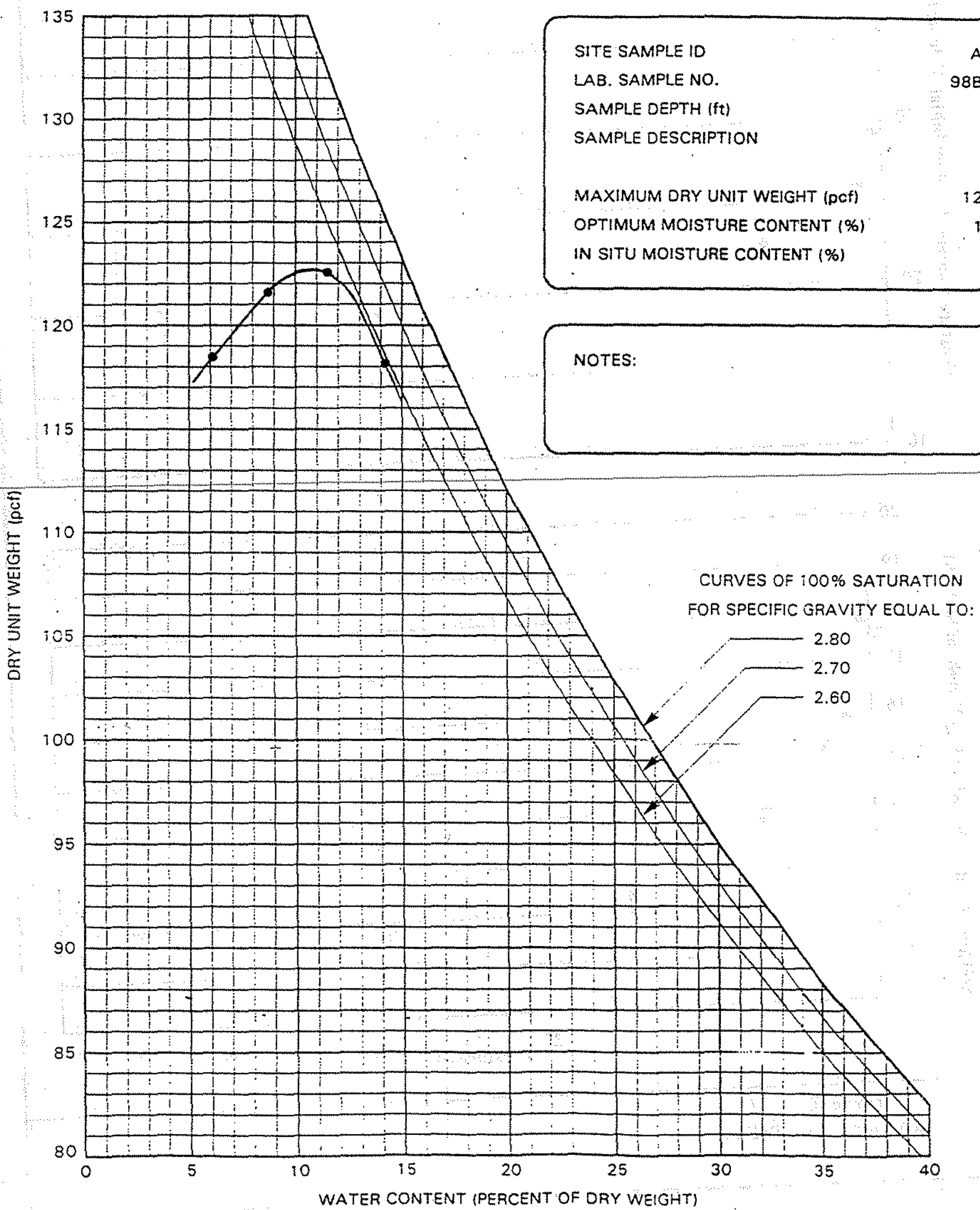

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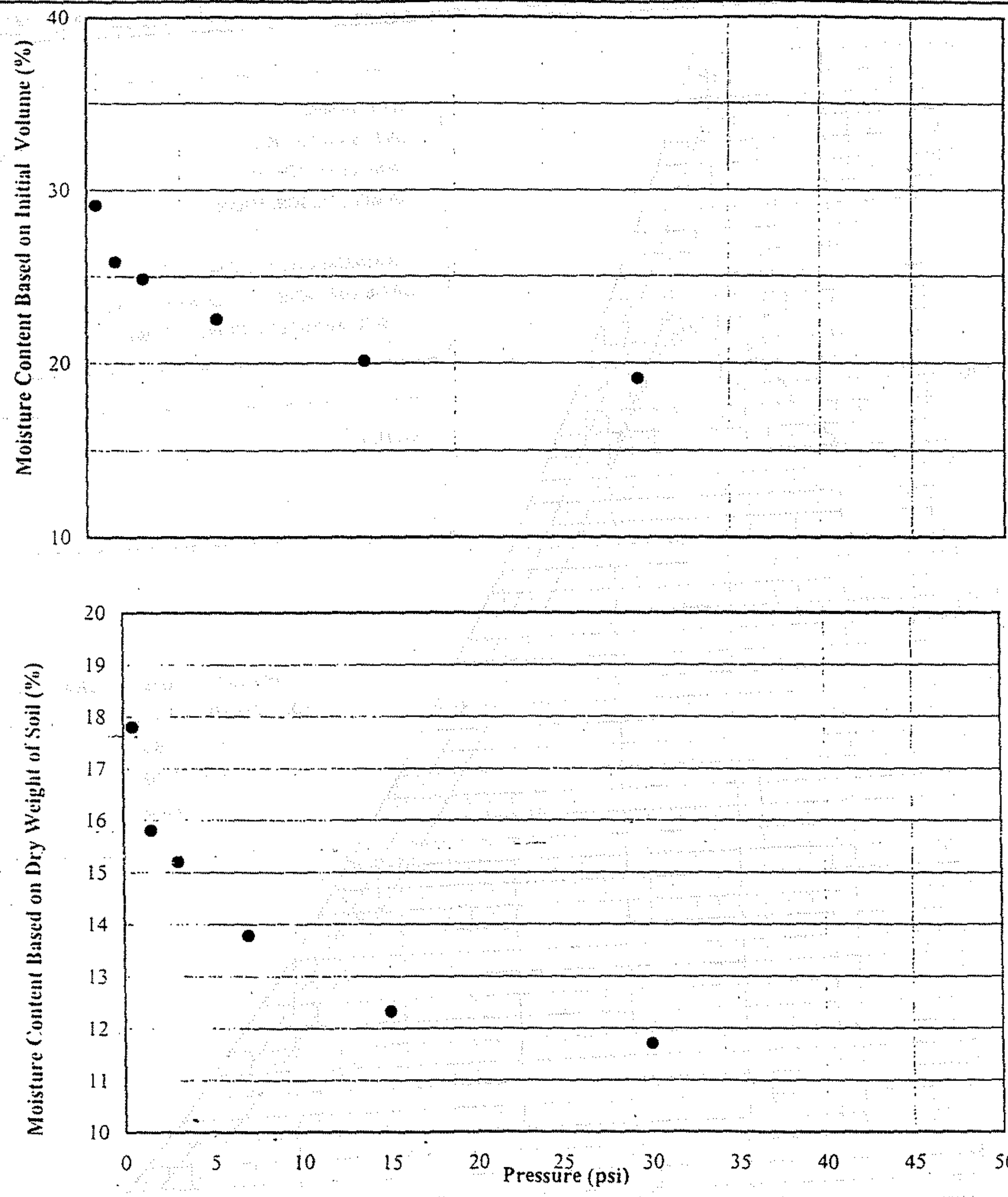
FIGURE 12

Project Name: Lopez Canyon Landfill
Project No.: CE4100

File Name: 98B65.xls

MOISTURE RETENTION TEST

ASTM D 2325



Note(s): Site Sample ID: A - 6
Lab Sample No.: 98B65

APPENDIX K

EVALUATION OF THE PHASE III WEST RIDGE AS A BORROW SOURCE FOR MONOLITHIC SOIL COVER

TECHNICAL MEMORANDUM

TO: Javier Palanco, P.E. and Ken Redd, P.E.
City of Los Angeles
Solid Resources Engineering and Construction Division

FROM: Jason Holcomb, R.G., C.E.G., GeoSyntec Consultants
Tarik Hadj-Hamou, Ph.D., P.E., GeoSyntec Consultants
Edward Kavazanjian Jr., PhD., P.E., G.E., GeoSyntec Consultants

DATE: 6 September 1998

SUBJECT: **Evaluation of the Phase III West Ridge as a Borrow Source for Monolithic Soil Cover Lopez Canyon Restoration Project**

INTRODUCTION

This technical memorandum presents the results of the GeoSyntec Consultants (GeoSyntec) evaluation of the Phase III West Ridge (the ridge) as a potential borrow source of material for use as monolithic soil cover at the Lopez Canyon Sanitary Landfill. The evaluation consisted of a geologic investigation and a stability analysis of the final grading of the ridge following excavation. The work presented in this technical memorandum was performed by the Huntington Beach office of GeoSyntec for the City of Los Angeles Bureau of Sanitation (BOS). This work was performed at the request of Mr. Javier Palanco, P.E. of BOS. The work was conducted by Mr. Jason Holcomb, R.G., C.E.G and Mr. Kenneth Daly of GeoSyntec under the direction of Dr. Tarik Hadj-Hamou, P.E. of GeoSyntec. The work presented in this technical memorandum was reviewed by Dr. Kavazanjian, Jr., P.E., G.E. of GeoSyntec in accordance with the peer review policy of the firm.

GEOLOGIC INVESTIGATION

The geologic investigation was carried out by Mr. Jason Holcomb, R.G., C.E.G on 23 February 1998 and 27 February 1998. The results of the geologic investigation were reported in a memorandum to Mr. Javier Palanco P.E. of BOS dated 6 March 1998 and are summarized in the following.

The ridge consists of interbedded siltstone, shale, fine sandstone, and conglomerate. A resistant conglomerate bed representing the base of the Pico-Towsley Formation is located within the eastern portion of the ridge. This gravel to cobble conglomerate separates interbedded siltstone and fine sandstone of the Pico-Towsley Formation to the northwest, with interbedded sandstone and shale of the Modello Formation to the southeast. An additional conglomerate unit occurs in the extreme western portion of the ridge near the existing asphalt access road. The overall percentage of coarse material (i.e. gravel to cobble size clasts) appears to consist of less than 20% of the proposed total volume of the proposed borrow material. The remaining material consists primarily of silts and fine to medium grained sands suitable for use as monolithic soil cover.

Structure as observed within the cut face consists of well bedded sediments dipping steeply to the northwest, as shown on Figure 1 and in the cross section shown on Figure 2

SLOPE STABILITY ANALYSES

The objective of the slope stability analyses presented herein is to evaluate the stability of the proposed final grading of the ridge following excavation of the borrow material for use as monolithic soil cover.

Proposed Grading

The current grading of the ridge is shown on Figure 3. A grading plan representing the slope configuration following excavation of the ridge was developed by

BOS and is shown on Figure 4. The proposed final grading plan consists of slopes graded at an inclination of 1.5H:1V (Horizontal to Vertical) with approximately 8 ft (2.4 m) wide benches at 40 ft (12m) intervals (measured vertically). The maximum slope height along the ridge is approximately 190 feet (57.9 m). The combination of slope height, bench width, and vertical bench interval proposed in the final grading plan for the ridge leads to an average slope inclination of 1.7:1.

Design Criterion

Following excavation and grading, the slopes of the ridge will probably not be altered by future landfill developments. Therefore, these slopes are considered permanent slopes. The factor of safety commonly accepted in engineering practice for the static stability of permanent slopes is 1.5. On this basis, a factor of safety of 1.5 was established as the static stability design criterion in this technical memorandum.

Several different approaches are used to evaluate seismic stability of permanent slopes in current practice. It is proposed herein to use the Seed (1979) pseudo-static stability criterion. Seed states that, in the absence of significant soil strength loss due to cyclic loading (e.g., liquefaction), slopes with a pseudo-static factor of safety greater than 1.15 for a seismic coefficient of 0.15 have sustained acceptable deformations when subjected to earthquakes of magnitudes as great as 8.25 with peak accelerations as high as 0.75 g. The Maximum Probable Earthquake for the Lopez Canyon Landfill site, defined in accordance with California Division of Mines and Geology Note 43, is a magnitude 6.6 earthquake on the San Fernando-Sierra Madre Fault, capable of generating a peak ground acceleration of 0.69g [GeoSyntec, 1995]. Therefore, the Seed criterion is considered applicable herein.

Method Of Analysis

The slope stability analysis was performed using the computer program PCSTABL5 [Achilleos, 1988]. The program PCSTABL5 employs limit equilibrium principles to provide general solutions to slope stability problems. Potential sliding surfaces, both circular and polygonal, can be pre-specified or randomly generated. The program includes provisions for using the simplified Bishop, modified Janbu or Spencer method of slices.

Bishop's simplified method was used herein for circular failure surfaces per the recommendation of the PCSTABL5 manual [Achilleos, 1988]. The simplified Janbu method of slices was used herein for polygonal sliding surfaces. The simplified Bishop and Janbu methods are approximate methods in that they do not satisfy both force and moment equilibrium simultaneously, but only satisfy one of these conditions. These simplified methods are generally conservative compared to "exact" methods such as Spencer's method in that the simplified methods typically yield lower factor of safety values than exact methods [Duncan, 1992].

Cross Section

GeoSyntec developed a representative cross-section for the stability analyses. The representative cross section was taken as the section with the a maximum vertical height of 190 feet (57.9 m) and characterized by an average slope inclination of 1.6:1 (horizontal to vertical). Note that a uniform slope without benches was used to simplify the cross section geometry. An average slope inclination of 1.6H:1V was used rather than the characteristic average of 1.7H:1V to provide basis a more conservative basis for overall stability analyses. The stability of the 40 ft (12 m) high, 1.5H:1V segments between benches was considered acceptable on the basis of the overall stability of the 190 ft (57 m), 1.6H:1V slope and the observed behavior of 1.5H:1V, 40 ft (12 m) high slopes of similar orientation within Disposal Area C.

Material Parameters

GeoSyntec reviewed available information regarding bedrock formations at the site to evaluate the material parameters for use in stability analyses. MAA Consultants (1993) conducted back analyses and direct shear tests on bedrock materials at the site for a landslide area investigation. Based on results of back analyses and direct shear tests, MAA Consultants (1993) recommended using a friction angle of 40 degrees and a cohesion of 500 psf (152 kPa) for bedrock materials in stability analyses.

Therefore, GeoSyntec assigned a friction angle of 40 degrees and a cohesion of 500 psf (152 kPa) to bedrock materials for the stability analyses presented herein.

BAS [1994] conducted direct shear tests on undisturbed samples of bedrock materials in support of stability analyses for final grading for the final closure plan. BAS [1994] reported shear strength parameters for undisturbed samples which were sheared across the natural bedding orientations. BAS reported shear strength parameters of a friction angle of 34 degrees and a cohesion of 200 psf (9.6 kPa) for these conditions. On this basis, GeoSyntec assigned a friction angle of 34 degrees and a cohesion of 200 psf (9.6 kPa) to bedding planes for the stability analyses presented herein.

GeoSyntec assumed a unit weight of 120 pcf (18.8 kN/m^3) for the bedrock materials for the stability analyses presented herein. This unit weight is consistent with typical unit weights of the weak sedimentary bedrock materials in the area.

Results

GeoSyntec evaluated two scenarios for static and pseudo-static stability of the representative cross section configuration. In the first scenario, the representative cross section was modeled as a homogeneous mass of bedrock. In the second scenario, weak planes representative of natural bedding orientations were modeled within the bedrock. The orientation of the weak planes was estimated from the strike and dip of the bedrock material as indicated in the geologic map and geologic cross section (Figures1 and 2).

Figure 5 and 6 show the critical failure surfaces for the first scenario (the homogeneous case). Results of the stability analyses for this scenario indicate a static factor of safety of 1.80 (Figure 5) and a pseudo static factor of safety of 1.35 (Figure 6) for a seismic coefficient of 0.15g. These results indicate compliance with the design criteria established.

CONCLUSION

Based on the geologic investigation, the ridge appears to be a feasible borrow source of material for monolithic soil cover. If oversize material is selectively graded and processed out from the borrow material during excavation, the resulting material, representing about 80 percent of the total volume of excavated material, appear to be meet the specifications for soil to be used in the monolithic soil cover. Laboratory testing in accordance with the Construction Quality Assurance plan for monolithic soil cover construction will need to be performed to verify this conclusion.

The stability analyses described in this technical memorandum indicate that the proposed final grading plan of the ridge meets the established static and pseudo static stability criteria.

LIMITATIONS

The conclusions and professional opinions presented in this technical memorandum for the Evaluation of the Phase III West Ridge as a Borrow Source for Monolithic Soil Cover at the Lopez Canyon Restoration Project were developed by GeoSyntec Consultants (GeoSyntec) for the City of Los Angeles, Bureau of Sanitation. This report was prepared in general accordance with accepted standards of geotechnical practice.

It should be recognized that information provided and work conducted by others provided basis for the data, conclusions, and recommendations contained in this technical memorandum. GeoSyntec is not responsible for circumstances resulting from errors, omissions, and inaccuracies in the information and work conducted by others. Conditions which deviate from those assumed in this technical memorandum should be brought to GeoSyntec's attention for assessment of their impact on the conclusions and recommendations contained herein.

Figure 7 and 8 show the critical failure surfaces for the second scenario (wherein weak bedding planes are assumed). Results of the stability analyses for this scenario indicate a static factor of safety of 1.51 (Figure 7) and a pseudo static factor of safety of 1. (Figure 8) for a seismic coefficient of 0.15g. These results indicate compliance with the design criteria established.

The results of the slope stability analyses are summarized in Table 1. The computer output of the stability analyses are presented in Attachment A to this technical memorandum.

REFERENCES

Achilleos. E., [1988], "PC STABL5M. User Manual" *Informational Report*, School of Civil Engineering, Purdue University, West Lafayette, Indiana, 132 p.

BAS [1994], "Final Closure Plan, Lopez Canyon Sanitary Landfill, Lake View Terrace, California," Report prepared for Bureau of Sanitation, Department of Public Works, City of Los Angeles, Prepared by Bryan A. Stirrat & Associates, 1 February.

Duncan, J.M. (1992), "State of the Art: Static Stability and Deformation Analysis," ASCE Geotechnical Special Publication No. 31, Stability and Performance of Slopes and Embankments - II, pp. 222-266.

GeoSyntec [1995], "Report of Disposal Site Information. Lopez Canyon Sanitary Landfill, Lake View Terrace, California." Report prepared for Bureau of Sanitation, Resources Disposal, and Engineering Division, Department of Public Works, City of Los Angeles, September.

MAA [1994], "Landslide Area Investigation for Lopez Canyon Sanitary Landfill," Report prepared for GeoSyntec Consultants, Inc., Prepared by MAA Consultants, MAA Project No. 0144-001, September.

Seed, H.B. [1979], "Consideration on the Earthquake-Resistant Design of Earth and Rockfill Dams," Geotechnique, Vol. 29, No. 3, pp. 215-263.

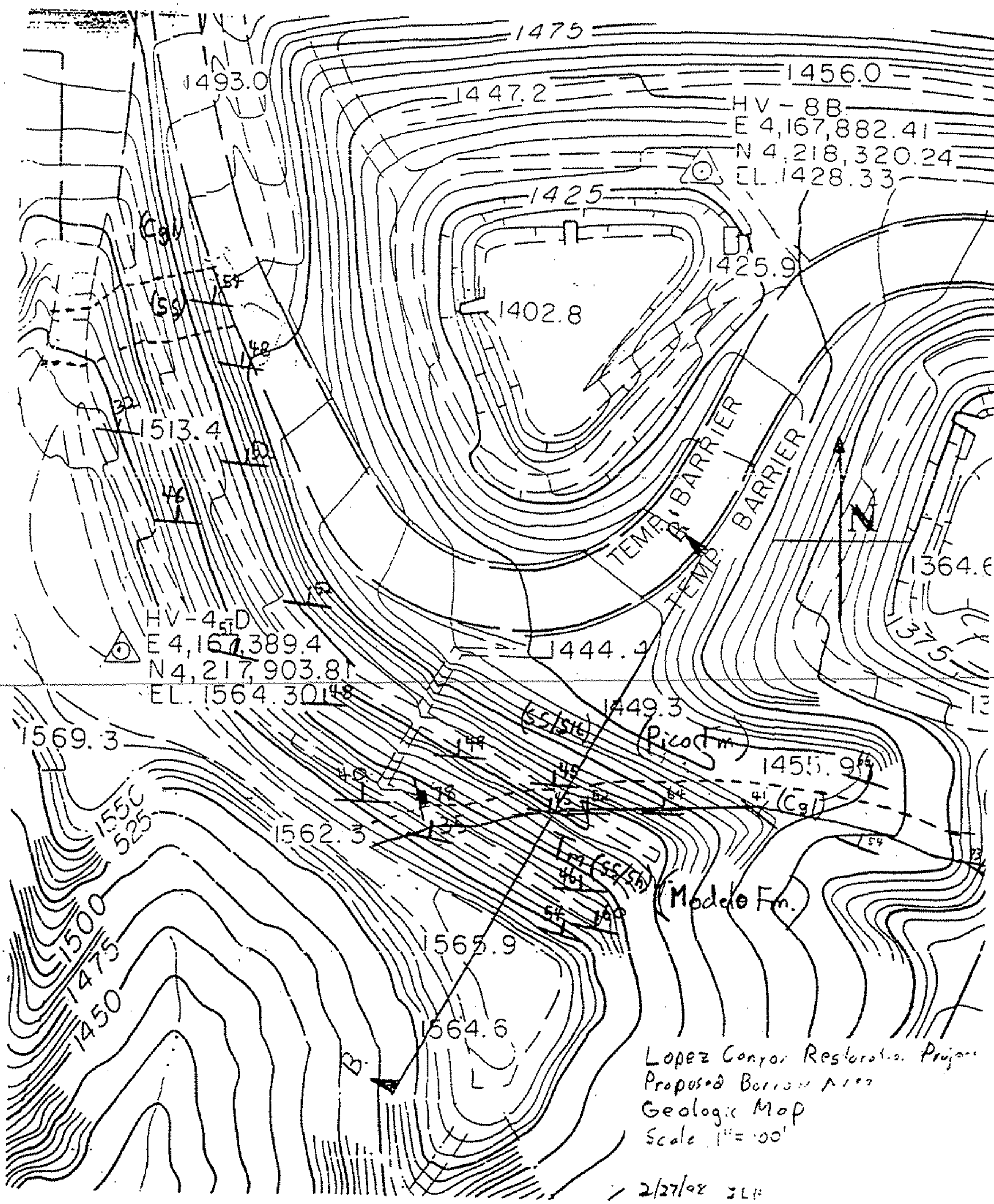
* * * * *

TABLE 1

SUMMARY OF SLOPE STABILITY
LOPEZ CANYON SANITARY LANDFILL
LAKE VIEW TERRACE, CALIFORNIA

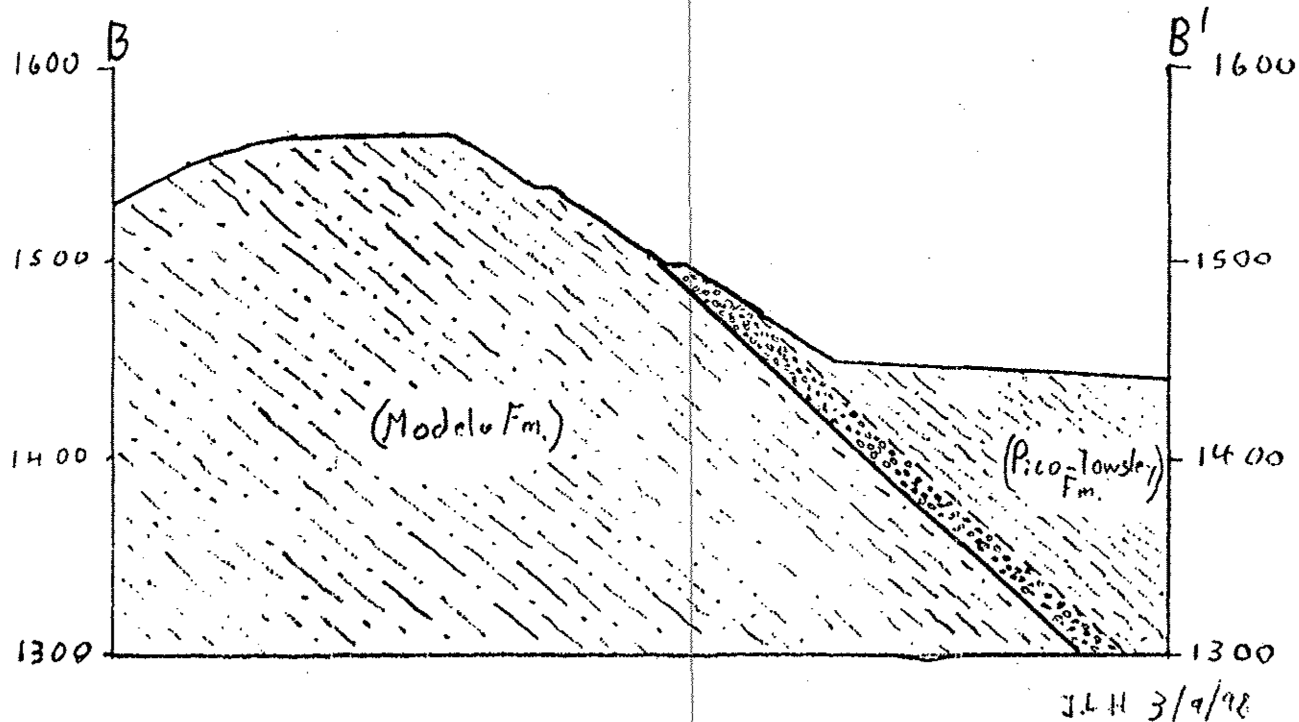
AVERAGE SLOPE INCLINATION (Horz:Vert)	FAILURE SURFACE [1]	ANALYSIS TYPE	FACTOR OF SAFETY	SIESMIC COEFFICENT (g)
1.6:1	Circular	Static	1.80	NA
1.6:1	Circular	Pseudo-Static	1.35	0.15
1.6:1	Polygonal[2]	Static	1.51	NA
1.6:1	Polygonal[2]	Pseudo-Static	1.15	0.15

Notes: (1) Failure surfaces are illustrated in the graphical output presented in Figures 4 through 7.
(2) Polygonal-potential failure surfaces propagated through weak seam oriented at an apparent dip of 40 degrees



GEOSYNTEC CONSULTANTS

GEOLOGIC MAP PHASE III WEST RIDGE LOPEZ CANYON SANITARY LANDFILL LAKE VIEW TERRACE, CALIFORNIA	FIGURE NO.	1
	PROJECT NO.	CE4100-04
	DATE:	11 September 1998



GEOSYNTEC CONSULTANTS

GEOLOGIC CROSS SECTION
PHASE III WEST RIDGE
LOPEZ CANYON SANITARY LANDFILL
LAKE VIEW TERRACE, CALIFORNIA

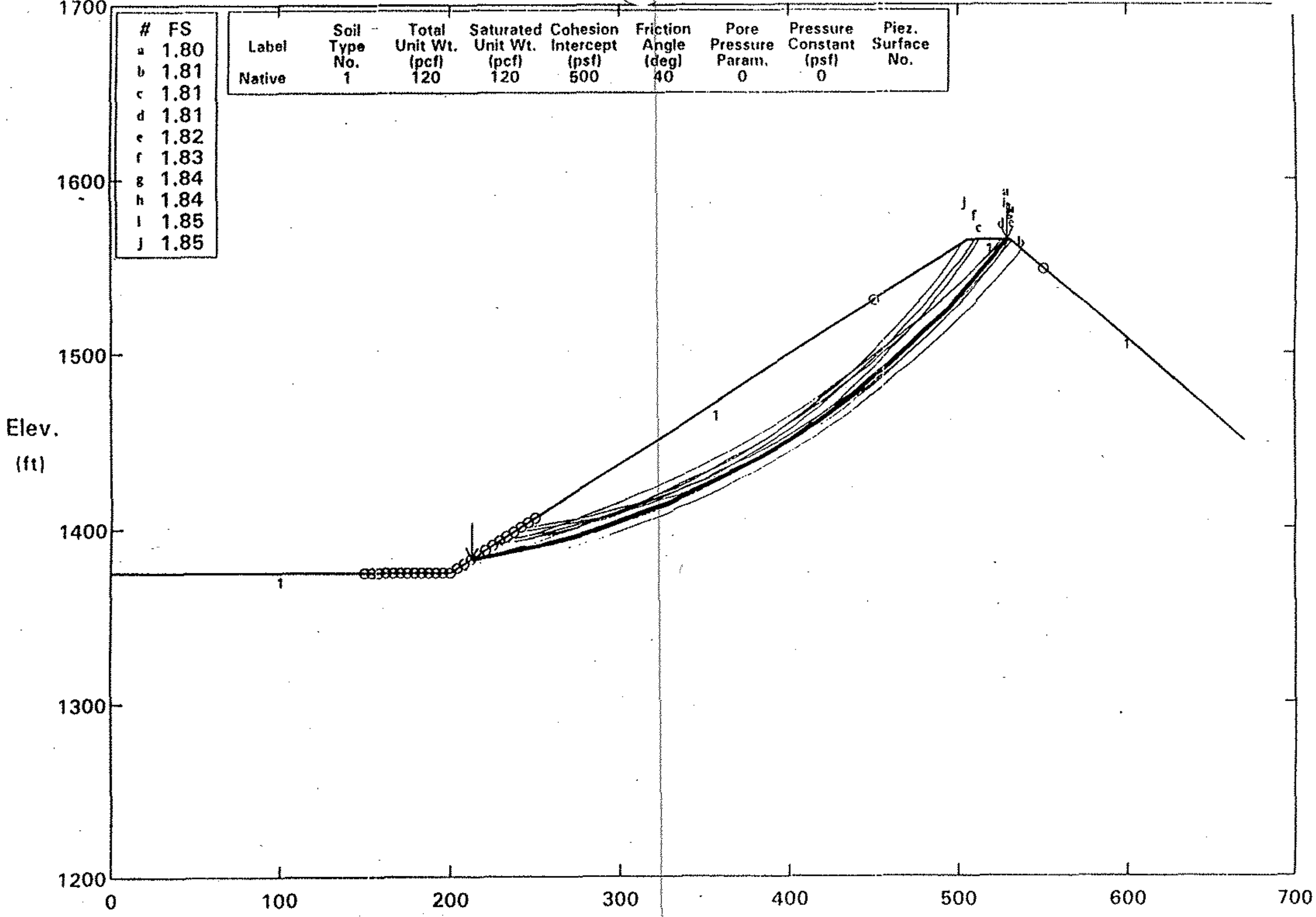
FIGURE NO.	2
PROJECT NO.	CE4100-04
DATE:	11 September 1998

GEOSYNTEC CONSULTANTS

INITIAL GRADING PHASE III WEST RIDGE LOPEZ CANYON SANITARY LANDFILL LAKE VIEW TERRACE, CALIFORNIA	FIGURE NO.	3
	PROJECT NO.	CE4100-04
	DATE:	11 September 1998

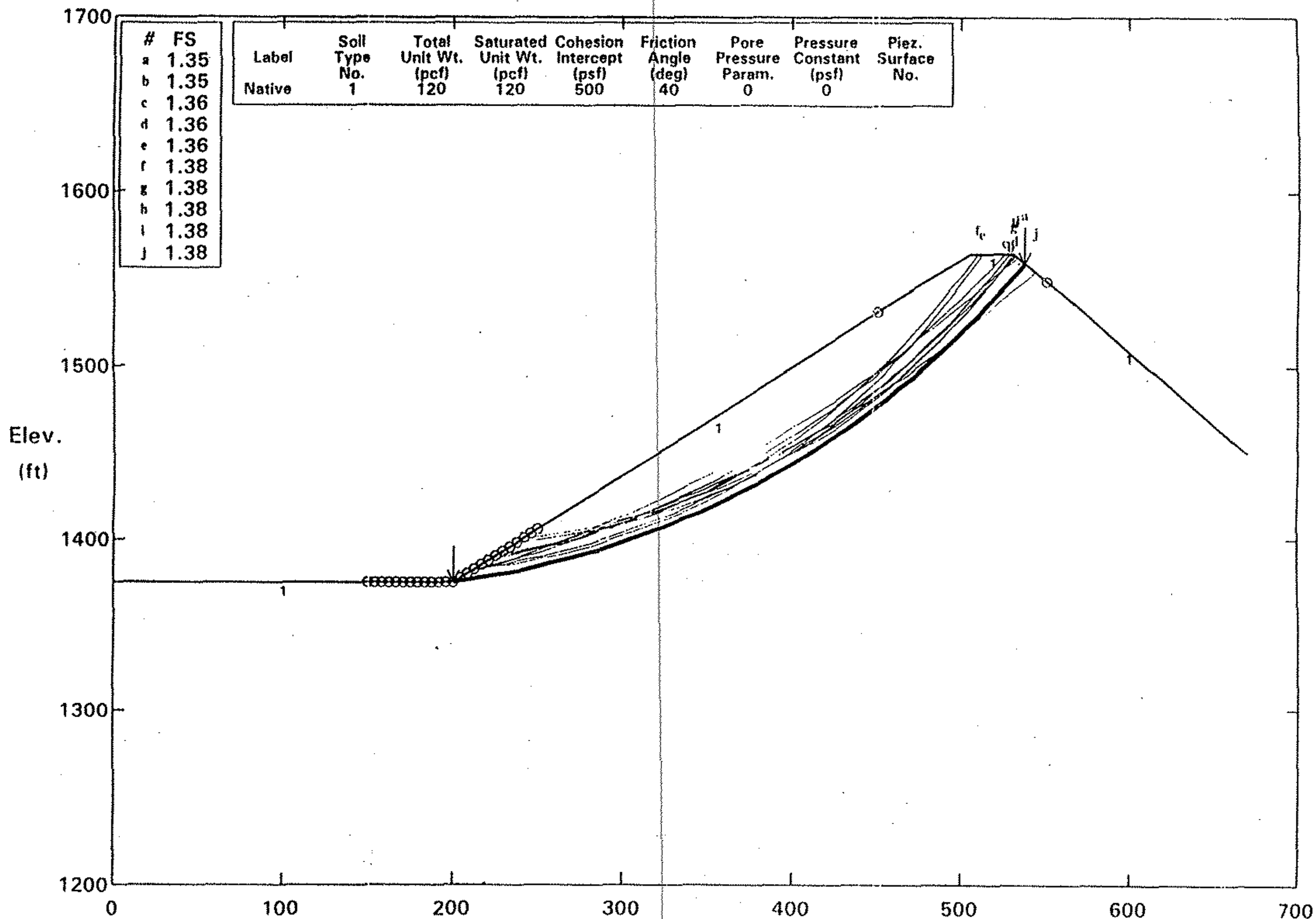
GEOSYNTEC CONSULTANTS

PROPOSED FINAL GRADING PHASE III WEST RIDGE LOPEZ CANYON SANITARY LANDFILL LAKE VIEW TERRACE, CALIFORNIA	FIGURE NO.	4
	PROJECT NO.	CE4100-04
	DATE:	11 September 1998



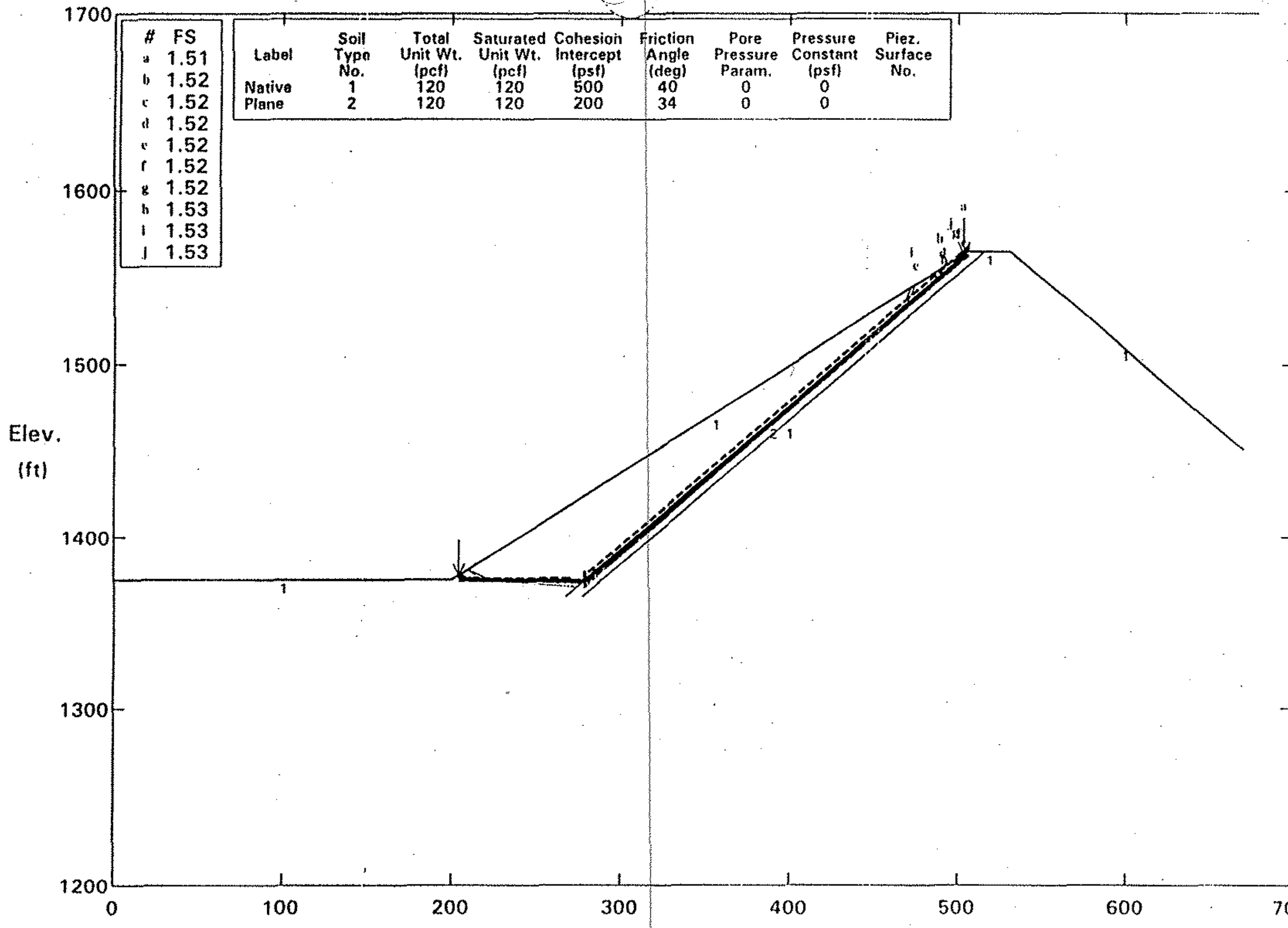
GEOSYNTEC CONSULTANTS

STATIC ANALYSIS ACROSS INTACT BEDROCK LOPEZ CANYON SANITARY LANDFILL LAKE VIEW TERRACE, CALIFORNIA	FIGURE NO.	5
	PROJECT NO.	CE4100-04
	DATE:	11 September 1998



GEOSYNTEC CONSULTANTS

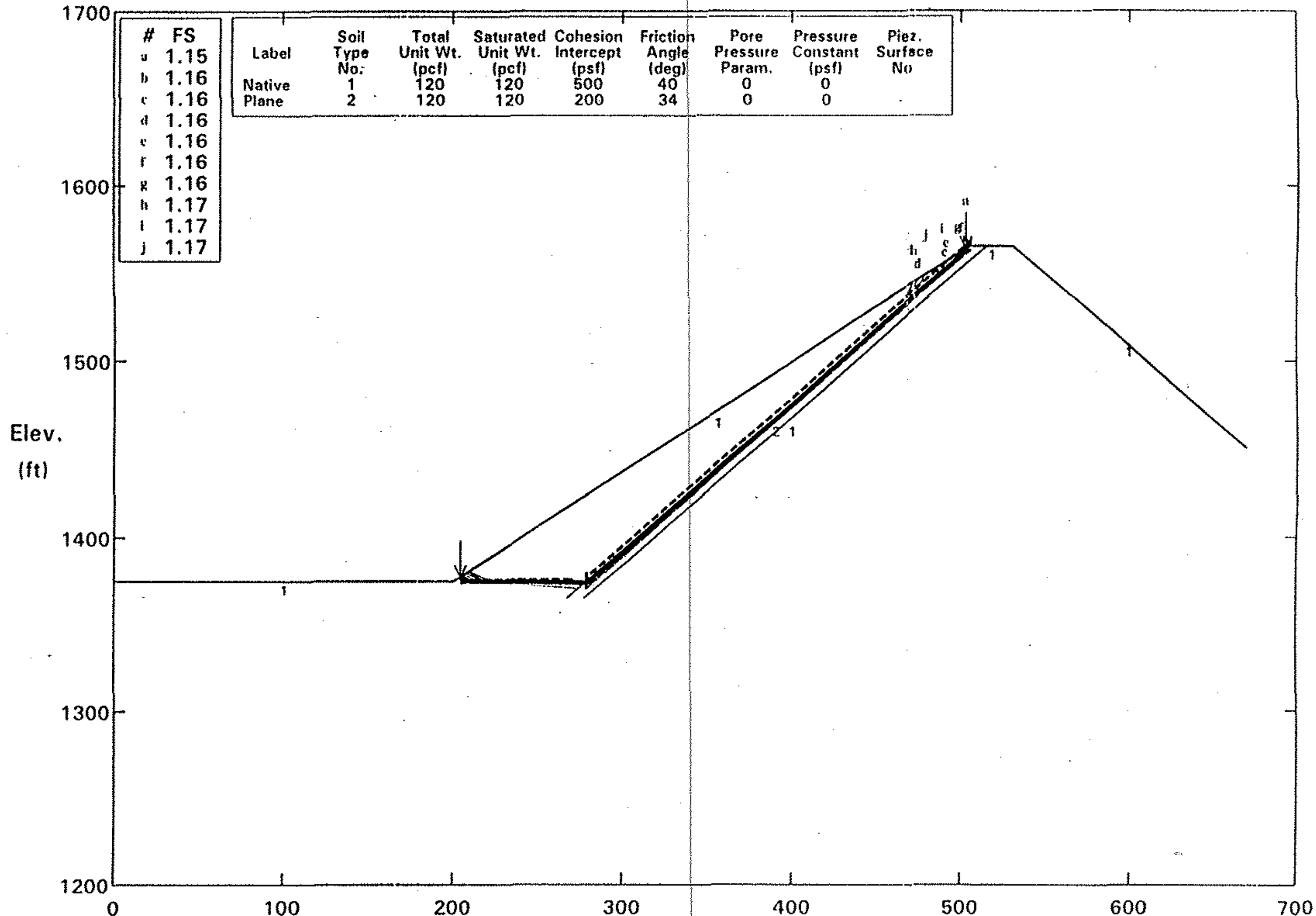
PSEUDO STATIC ANALYSIS ACROSS INTACT BEDROCK LOPEZ CANYON SANITARY LANDFILL LAKE VIEW TERRACE, CALIFORNIA	FIGURE NO.	6
	PROJECT NO.	CE4100-04
	DATE:	11 September 1998



GEOSYNTEC CONSULTANTS

STATIC ANALYSIS
ALONG BEDDING ORIENTATION
LOPEZ CANYON SANITARY LANDFILL
LAKE VIEW TERRACE, CALIFORNIA

FIGURE NO.	7
PROJECT NO.	CE4100-04
DATE:	11 September 1998



GEOSYNTEC CONSULTANTS

PSEUDO STATIC ANALYSIS ALONG BEDDING ORIENTATION LOPEZ CANYON SANITARY LANDFILL LAKE VIEW TERRACE, CALIFORNIA	FIGURE NO.	8
	PROJECT NO.	CE4100-04
	DATE:	11 September 1998

Evaluation of Phase III West Ridge
6 September 1998

ATTACHEMENT A

SLOPE STABILITY ANALYSES
COMPUTER OUTPUT

** PCSTABL5 **

by
Purdue University

1

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer's Method of Slices

Run Date:	09-11-98
Time of Run:	8:56am
Run By:	KRD
Input Data Filename:	C:BBCS.DAT
Output Filename:	C:BBCS.OUT
Plotted Output Filename:	C:BBCS.PLT

PROBLEM DESCRIPTION Lopez Canyon Landfill - Borrow Area C
B-B' 1.6:1 slope Circular

BOUNDARY COORDINATES

4 Top Boundaries
4 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	.00	175.00	200.00	175.00	1
2	200.00	175.00	505.00	365.00	1
3	505.00	365.00	530.00	365.00	1
4	530.00	365.00	670.00	250.00	1

1

ISOTROPIC SOIL PARAMETERS

1 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	120.0	120.0	500.0	40.0	.00	.0	0

1

A Critical Failure Surface Searching Method, Using A Random
Technique For Generating Circular Surfaces, Has Been Specified.

250 Trial Surfaces Have Been Generated.

10 Surfaces Initiate From Each Of 25 Points Equally Spaced
Along The Ground Surface Between X = 150.00 ft.
and X = 250.00 ft.

Each Surface Terminates Between X = 450.00 ft.
and X = 550.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y = .00 ft.

10.00 ft. Line Segments Define Each Trial Failure Surface.

1

Following Are Displayed The Ten Most Critical Of The Trial
Failure Surfaces Examined. They Are Ordered - Most Critical
First.

* * Safety Factors Are Calculated By The Modified Bishop Method * *

Failure Surface Specified By 39 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	204.17	177.60
2	214.14	178.31
3	224.09	179.28
4	234.02	180.51
5	243.91	181.99
6	253.76	183.72
7	263.56	185.70
8	273.31	187.94
9	282.99	190.42
10	292.61	193.16
11	302.16	196.13
12	311.63	199.35
13	321.01	202.82
14	330.30	206.52
15	339.49	210.46
16	348.58	214.63
17	357.55	219.04
18	366.41	223.67
19	375.15	228.53
20	383.77	233.61
21	392.25	238.91
22	400.59	244.43
23	408.78	250.16
24	416.83	256.09

	424.72	262.23
	432.46	268.58
27	440.02	275.11
28	447.42	281.84
29	454.64	288.76
30	461.69	295.86
31	468.54	303.14
32	475.21	310.59
33	481.69	318.21
34	487.97	325.99
35	494.05	333.93
36	499.92	342.03
37	505.58	350.27
38	511.03	358.65
39	514.93	365.00

Circle Center At X = 181.2 ; Y = 567.0 and Radius, 390.1

*** 1.813 ***

Failure Surface Specified By 37 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	229.17	193.17
2	239.00	195.00
3	248.79	197.01
4	258.55	199.21
5	268.26	201.59
6	277.93	204.15
7	287.54	206.89
8	297.11	209.82
9	306.62	212.92
10	316.06	216.19
11	325.45	219.65
12	334.77	223.28
13	344.01	227.08
14	353.19	231.06
15	362.29	235.20
16	371.31	239.52
17	380.25	244.00
18	389.10	248.66
19	397.86	253.47
20	406.54	258.45
21	415.11	263.59
22	423.59	268.90
23	431.97	274.35
24	440.25	279.97
25	448.41	285.74
26	456.47	291.66
27	464.42	297.73
28	472.25	303.95
29	479.96	310.31
30	487.56	316.82
31	495.02	323.47

32	502.37	330.26
33	509.58	337.18
34	516.67	344.24
35	523.62	351.43
36	530.43	358.75
37	533.48	362.14

Circle Center At X = 136.4 ; Y = 718.9 and Radius, 533.8

*** 1.829 ***

Failure Surface Specified By 36 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	208.33	180.19
2	218.15	182.12
3	227.92	184.25
4	237.64	186.60
5	247.31	189.15
6	256.92	191.91
7	266.47	194.88
8	275.95	198.05
9	285.36	201.43
10	294.70	205.01
11	303.96	208.79
12	313.13	212.77
13	322.22	216.95
14	331.21	221.32
15	340.11	225.88
16	348.91	230.63
17	357.60	235.58
18	366.19	240.71
19	374.66	246.02
20	383.01	251.51
21	391.25	257.19
22	399.36	263.04
23	407.34	269.06
24	415.19	275.25
25	422.91	281.61
26	430.48	288.14
27	437.92	294.83
28	445.21	301.68
29	452.35	308.68
30	459.33	315.83
31	466.16	323.14
32	472.83	330.58
33	479.34	338.18
34	485.69	345.91
35	491.86	353.77
36	496.16	359.50

Circle Center At X = 124.0 ; Y = 636.3 and Radius, 463.8

* 1.840 ***

Failure Surface Specified By 38 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	208.33	180.19
2	217.96	182.91
3	227.54	185.77
4	237.08	188.77
5	246.57	191.92
6	256.02	195.20
7	265.41	198.63
8	274.75	202.20
9	284.04	205.91
10	293.27	209.75
11	302.44	213.74
12	311.55	217.86
13	320.60	222.11
14	329.59	226.50
15	338.51	231.03
16	347.36	235.68
17	356.13	240.47
18	364.84	245.39
19	373.47	250.44
20	382.03	255.62
21	390.50	260.93
22	398.90	266.36
23	407.21	271.91
24	415.44	277.59
25	423.59	283.40
26	431.64	289.32
27	439.61	295.36
28	447.49	301.53
29	455.27	307.80
30	462.96	314.20
31	470.55	320.71
32	478.04	327.33
33	485.44	334.06
34	492.73	340.91
35	499.92	347.86
36	507.00	354.92
37	513.98	362.08
38	516.74	365.00

Circle Center At X = 31.5 ; Y = 825.1 and Radius, 668.7

*** 1.843 ***

1

Failure Surface Specified By 34 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	225.00	190.57
2	234.85	192.33
3	244.65	194.32
4	254.39	196.54
5	264.09	199.00
6	273.72	201.69
7	283.29	204.60
8	292.78	207.74
9	302.20	211.11
10	311.53	214.70
11	320.77	218.52
12	329.92	222.55
13	338.98	226.80
14	347.93	231.26
15	356.76	235.94
16	365.49	240.82
17	374.10	245.91
18	382.58	251.21
19	390.93	256.71
20	399.15	262.40
21	407.24	268.29
22	415.18	274.37
23	422.97	280.64
24	430.61	287.09
25	438.09	293.72
26	445.42	300.53
27	452.58	307.51
28	459.57	314.66
29	466.39	321.97
30	473.03	329.45
31	479.49	337.08
32	485.77	344.86
33	491.86	352.79
34	497.26	360.18

Circle Center At X = 156.3 ; Y = 604.2 and Radius, 419.3

*** 1.856 ***

Failure Surface Specified By 40 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	208.33	180.19
2	218.33	180.56
3	228.31	181.17
4	238.27	182.01
5	248.21	183.10
6	258.13	184.42
7	268.00	185.98
8	277.84	187.77

	287.63	189.80
	297.37	192.07
11	307.06	194.56
12	316.68	197.29
13	326.23	200.24
14	335.71	203.43
15	345.11	206.84
16	354.43	210.47
17	363.66	214.33
18	372.79	218.40
19	381.82	222.69
20	390.75	227.20
21	399.56	231.92
22	408.26	236.85
23	416.84	241.98
24	425.30	247.32
25	433.63	252.86
26	441.82	258.60
27	449.87	264.53
28	457.77	270.66
29	465.53	276.97
30	473.13	283.46
31	480.58	290.13
32	487.87	296.98
33	494.99	304.01
34	501.94	311.20
35	508.71	318.55
36	515.31	326.07
37	521.72	333.74
38	527.95	341.56
39	533.99	349.53
40	539.52	357.18

Circle Center At X = 197.9 ; Y = 598.1 and Radius, 418.0

*** 1.859 ***

1

Failure Surface Specified By 38 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	220.83	187.98
2	230.67	189.80
3	240.47	191.78
4	250.24	193.92
5	259.97	196.23
6	269.66	198.69
7	279.31	201.31
8	288.92	204.09
9	298.48	207.03
10	307.99	210.12
11	317.44	213.37
12	326.85	216.77
13	336.19	220.32

14	345.48	224.03
15	354.70	227.90
16	363.86	231.91
17	372.96	236.07
18	381.98	240.38
19	390.93	244.84
20	399.81	249.44
21	408.61	254.19
22	417.33	259.08
23	425.97	264.12
24	434.53	269.29
25	443.00	274.61
26	451.38	280.06
27	459.67	285.66
28	467.87	291.38
29	475.97	297.24
30	483.98	303.23
31	491.88	309.36
32	499.69	315.61
33	507.39	321.99
34	514.98	328.49
35	522.47	335.12
36	529.85	341.87
37	537.12	348.74
38	542.91	354.40

Circle Center At X = 114.8 ; Y = 788.2 and Radius, 609.5

*** 1.859 ***

Failure Surface Specified By 35 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	250.00	206.15
2	259.95	207.10
3	269.88	208.30
4	279.78	209.75
5	289.63	211.43
6	299.45	213.36
7	309.21	215.53
8	318.91	217.94
9	328.56	220.58
10	338.13	223.47
11	347.64	226.58
12	357.06	229.93
13	366.40	233.51
14	375.64	237.32
15	384.79	241.35
16	393.84	245.61
17	402.78	250.09
18	411.61	254.78
19	420.32	259.69
20	428.91	264.82
21	437.37	270.15

	445.69	275.69
	453.88	281.43
24	461.92	287.38
25	469.82	293.51
26	477.56	299.85
27	485.14	306.36
28	492.56	313.07
29	499.82	319.95
30	506.90	327.01
31	513.81	334.24
32	520.54	341.64
33	527.08	349.20
34	533.44	356.92
35	535.94	360.12

Circle Center At X = 216.1 ; Y = 611.7 and Radius, 407.0

*** 1.873 ***

1

Failure Surface Specified By 42 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	200.00	175.00
2	209.99	175.50
3	219.96	176.21
4	229.92	177.14
5	239.85	178.29
6	249.76	179.65
7	259.64	181.22
8	269.47	183.01
9	279.27	185.01
10	289.03	187.22
11	298.73	189.64
12	308.37	192.28
13	317.96	195.11
14	327.49	198.16
15	336.94	201.41
16	346.33	204.87
17	355.64	208.53
18	364.86	212.39
19	374.00	216.44
20	383.05	220.70
21	392.01	225.15
22	400.86	229.79
23	409.62	234.62
24	418.27	239.64
25	426.80	244.85
26	435.23	250.24
27	443.53	255.81
28	451.71	261.56
29	459.77	267.49
30	467.69	273.58
31	475.48	279.85

32	483.14	286.29
33	490.65	292.89
34	498.02	299.65
35	505.24	306.57
36	512.31	313.64
37	519.22	320.87
38	525.98	328.24
39	532.57	335.76
40	539.00	343.41
41	545.27	351.21
42	545.86	351.97

Circle Center At X = 182.0 ; Y = 636.7 and Radius, 462.1

*** 1.874 ***

Failure Surface Specified By 34 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	204.17	177.60
2	214.16	177.93
3	224.14	178.59
4	234.09	179.58
5	244.00	180.89
6	253.87	182.53
7	263.68	184.49
8	273.41	186.76
9	283.07	189.36
10	292.64	192.27
11	302.10	195.49
12	311.46	199.02
13	320.70	202.86
14	329.80	206.99
15	338.77	211.42
16	347.58	216.14
17	356.24	221.15
18	364.72	226.44
19	373.03	232.00
20	381.16	237.83
21	389.09	243.93
22	396.81	250.28
23	404.32	256.88
24	411.61	263.72
25	418.68	270.80
26	425.51	278.11
27	432.09	285.63
28	438.43	293.37
29	444.51	301.31
30	450.33	309.44
31	455.87	317.76
32	461.15	326.26
33	466.14	334.92
34	470.82	343.71

```
C    enter At X =  199.0 ; Y =  483.0  and Radius,  305.5

     ***    1.877   ***


1

            Y            A     X     I     S            F     T

            .00      83.75    167.50    251.25    335.00    418.75
X        .00 +---------+---------+*--------+---------+---------+
             -
             -
             -
             -
             -
        83.75 +
             -
             -
             -
             -
             -                   ..
A     167.50 +                  ...
             -                 ....
             -                ....*
             -               .....13
             -               .....132
             -              ......912.
X     251.25 +              ......91328
             -             ........1328.
             -             ........1124..
             -             ........9132..
             -             .........1124..
             -             .........91724..
I     335.00 +             ..........61324..
             -             ..........96122...
             -              ..........91123...
             -              ...........611234..
             -              ............6.123...
             -               ...........961123...
S     418.75 +                ............661233...
             -                 ...........96.1233...
             -                  ............6611.33...
             -                   ............661124330.
             -                    ............966114330.
             -                      ...........966711133.
      502.50 +                        ...........9662.113*
             -                          ..........99622.11
             -                             .........99622*
             -                               . .......976
             -
             -
F     586.25 +
             -
             -
             -

             -
             -
T     670.00 +                              *
```

[illegible]	334.72	211.62
16	343.92	215.56
17	353.03	219.66
18	362.08	223.93
19	371.04	228.37
20	379.91	232.98
21	388.70	237.74
22	397.40	242.67
23	406.01	247.76
24	414.52	253.01
25	422.94	258.42
26	431.25	263.98
27	439.46	269.69
28	447.56	275.55
29	455.55	281.57
30	463.42	287.73
31	471.19	294.03
32	478.83	300.48
33	486.35	307.07
34	493.75	313.79
35	501.03	320.66
36	508.17	327.65
37	515.19	334.78
38	522.07	342.03
39	528.82	349.42
40	535.42	356.92
41	537.24	359.06

Circle Center At X = 126.9 ; Y = 709.9 and Radius, 539.9

*** 1.348 ***

Failure Surface Specified By 39 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	212.50	182.79
2	222.38	184.36
3	232.22	186.14
4	242.02	188.11
5	251.78	190.28
6	261.50	192.65
7	271.17	195.21
8	280.78	197.96
9	290.33	200.91
10	299.83	204.05
11	309.26	207.38
12	318.62	210.89
13	327.91	214.60
14	337.12	218.49
15	346.25	222.57
16	355.30	226.83
17	364.26	231.27
18	373.13	235.89
19	381.90	240.68
20	390.58	245.66
21	399.15	250.80
22	407.62	256.12
23	415.98	261.61
24	424.23	267.26
25	432.36	273.08
26	440.37	279.06
27	448.27	285.21
28	456.03	291.51
29	463.67	297.96
30	471.18	304.57
31	478.55	311.32
32	485.78	318.23
33	492.88	325.27
34	499.83	332.46
35	506.64	339.79
36	513.29	347.25
37	519.80	354.85
38	526.15	362.57
39	528.07	365.00

Circle Center At X = 139.1 ; Y = 674.3 and Radius, 497.0

*** 1.351 ***

Failure Surface Specified By 38 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	212.50	182.79
2	222.23	185.10
3	231.92	187.58
4	241.56	190.21
5	251.17	193.01
6	260.72	195.96
7	270.23	199.07
8	279.68	202.33
9	289.07	205.75
10	298.41	209.32
11	307.69	213.05
12	316.91	216.93
13	326.06	220.96
14	335.15	225.14
15	344.16	229.47
16	353.10	233.94
17	361.97	238.57
18	370.76	243.34
19	379.47	248.25
20	388.10	253.30
21	396.64	258.50
22	405.10	263.84
23	413.47	269.31
24	421.74	274.93
25	429.93	280.67

	438.01	286.56
	446.00	292.57
28	453.89	298.71
29	461.68	304.99
30	469.36	311.39
31	476.94	317.92
32	484.41	324.57
33	491.77	331.34
34	499.01	338.23
35	506.14	345.24
36	513.16	352.37
37	520.05	359.61
38	525.02	365.00

Circle Center At X = 76.7 ; Y = 774.9 and Radius, 607.5

*** 1.360 ***

Failure Surface Specified By 37 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	225.00	190.57
2	234.84	192.35
3	244.64	194.32
4	254.41	196.48
5	264.13	198.83
6	273.80	201.36
7	283.43	204.08
8	293.00	206.98
9	302.51	210.06
10	311.96	213.33
11	321.35	216.78
12	330.67	220.41
13	339.91	224.22
14	349.08	228.20
15	358.18	232.36
16	367.19	236.70
17	376.12	241.21
18	384.95	245.88
19	393.70	250.73
20	402.35	255.75
21	410.91	260.93
22	419.36	266.27
23	427.71	271.78
24	435.95	277.44
25	444.08	283.26
26	452.09	289.24
27	459.99	295.37
28	467.77	301.65
29	475.43	308.08
30	482.97	314.66
31	490.37	321.38
32	497.65	328.24
33	504.79	335.24

34	511.79	342.38
35	518.66	349.65
36	525.39	357.05
37	531.36	363.88

Circle Center At X = 137.4 ; Y = 702.9 and Radius, 519.8

*** 1.361 ***

Failure Surface Specified By 38 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	212.50	182.79
2	222.43	184.01
3	232.32	185.48
4	242.17	187.18
5	251.98	189.12
6	261.74	191.29
7	271.45	193.71
8	281.09	196.35
9	290.67	199.23
10	300.17	202.33
11	309.60	205.67
12	318.94	209.23
13	328.20	213.02
14	337.36	217.03
15	346.42	221.26
16	355.38	225.70
17	364.23	230.36
18	372.96	235.24
19	381.57	240.32
20	390.06	245.61
21	398.41	251.10
22	406.63	256.80
23	414.72	262.69
24	422.65	268.77
25	430.44	275.04
26	438.07	281.50
27	445.55	288.14
28	452.86	294.96
29	460.01	301.96
30	466.99	309.12
31	473.79	316.46
32	480.41	323.95
33	486.85	331.60
34	493.10	339.41
35	499.16	347.36
36	505.03	355.46
37	510.70	363.69
38	511.55	365.00

Circle Center At X = 166.7 ; Y = 594.4 and Radius, 414.2

*** 1.364 ***

Failure Surface Specified By 36 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	225.00	190.57
2	234.89	192.07
3	244.74	193.81
4	254.54	195.78
5	264.29	197.99
6	273.99	200.44
7	283.62	203.11
8	293.19	206.02
9	302.69	209.15
10	312.11	212.52
11	321.44	216.10
12	330.68	219.92
13	339.84	223.95
14	348.89	228.20
15	357.83	232.67
16	366.67	237.35
17	375.39	242.25
18	383.99	247.35
19	392.46	252.66
20	400.81	258.17
21	409.02	263.88
22	417.09	269.78
23	425.01	275.88
24	432.79	282.17
25	440.41	288.64
26	447.88	295.29
27	455.18	302.13
28	462.32	309.13
29	469.29	316.30
30	476.08	323.64
31	482.69	331.15
32	489.12	338.80
33	495.36	346.61
34	501.42	354.57
35	507.28	362.68
36	508.88	365.00

Circle Center At X = 167.6 ; Y = 602.2 and Radius, 415.6

*** 1.378 ***

1

Failure Surface Specified By 36 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	237.50	198.36
2	247.44	199.42
3	257.36	200.72
4	267.24	202.26
5	277.08	204.04
6	286.87	206.06
7	296.62	208.32
8	306.30	210.82
9	315.92	213.55
10	325.47	216.51
11	334.94	219.71
12	344.34	223.14
13	353.65	226.79
14	362.86	230.67
15	371.98	234.78
16	381.00	239.10
17	389.91	243.65
18	398.70	248.41
19	407.38	253.38
20	415.93	258.56
21	424.35	263.95
22	432.64	269.55
23	440.79	275.34
24	448.80	281.33
25	456.65	287.52
26	464.36	293.89
27	471.91	300.45
28	479.29	307.20
29	486.51	314.12
30	493.56	321.21
31	500.43	328.47
32	507.13	335.90
33	513.64	343.49
34	519.96	351.24
35	526.09	359.14
36	530.26	364.79

Circle Center At X = 199.1 ; Y = 606.7 and Radius, 410.1

*** 1.380 ***

Failure Surface Specified By 36 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	241.67	200.96
2	251.60	202.13
3	261.50	203.54
4	271.36	205.18
5	281.18	207.07
6	290.96	209.18
7	300.68	211.53
8	310.34	214.12

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            441.84      278.71
            450.30      284.04
  27        458.68      289.49
  28        466.99      295.05
  29        475.23      300.73
  30        483.38      306.52
  31        491.45      312.42
  32        499.44      318.44
  33        507.35      324.56
  34        515.17      330.79
  35        522.90      337.13
  36        530.54      343.58
  37        538.10      350.13
  38        542.90      354.41

Circle Center At X =   60.3 ; Y =  893.4  and Radius,  723.5


      ***    1.382   ***



1

              Y            A     X     I     S           F     T


             .00     83.75    167.50    251.25    335.00    418.75

X       .00 +---------+---------+*--------+---------+---------+
            -
            -
            -
            -
            -
     83.75 +
            -
            -
            -
            -
            -
A   167.50 +                   ..
            -                  ...
            -                 ....
            -                ....*
            -               .....12
            -               .....124
            -              .......137
X   251.25 +              .......127.
            -             ........113.
            -             .........128.
            -             .........113..
            -             ..........128..
            -             ..........1129..
I   335.00 +             ...........1239..
            -             ............123....
            -             .............129...
            -              ............1123...
            -              .............1133....
            -               ..............123....
S   418.75 +                ..............11239...
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            -                  ...............123....
            -                  ................1239....
            -                    ...............1225....
            -                     ...............11235...
            -                       ...............12235..
    502.50 +                        ...............112256*
            -                           .............011235
            -                             ............011*
            -                                 .........0.
            -
            -
F   586.25 +
            -
            -
            -
            -
            -
T   670.00 +                             *
```

Failure Surface Specified By 6 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	202.78	176.73
2	205.77	175.33
3	278.78	170.72
4	501.29	360.92
5	502.21	362.66
6	502.61	363.51

*** 1.157 ***

1

Failure Surface Specified By 6 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	202.51	176.56
2	205.52	175.16
3	278.79	171.15
4	486.27	348.36
5	487.14	349.99
6	489.69	355.46

*** 1.157 ***

Failure Surface Specified By 6 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	207.68	179.78
2	217.61	175.15
3	278.79	174.44
4	466.51	330.22
5	468.86	334.63
6	474.02	345.70

*** 1.157 ***

1

Failure Surface Specified By 6 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	209.56	180.95
2	222.72	174.82
3	278.73	174.54
4	486.05	346.71
5	488.33	350.99
6	490.71	356.10

*** 1.157 ***

Failure Surface Specified By 6 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	206.01	178.74
2	214.31	174.87
3	278.70	170.02
4	497.42	356.95
5	499.04	359.99
6	499.89	361.82

*** 1.162 ***

1

Failure Surface Specified By 6 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	206.64	179.14
2	215.23	175.13
3	278.80	172.22
4	495.33	356.23
5	495.94	357.39
6	497.24	360.16

*** 1.162 ***

Failure Surface Specified By 6 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)

	222.72	174.82
3	278.73	174.54
4	486.05	346.71
5	488.33	350.99
6	490.71	356.10

*** 1.515 ***

1

Failure Surface Specified By 6 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	202.78	176.73
2	205.77	175.33
3	278.78	170.72
4	501.29	360.92
5	502.21	362.66
6	502.61	363.51

*** 1.517 ***

Failure Surface Specified By 6 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	202.51	176.56
2	205.52	175.16
3	278.79	171.15
4	486.27	348.36
5	487.14	349.99
6	489.69	355.46

*** 1.518 ***

1

Failure Surface Specified By 6 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	207.68	179.78
2	217.61	175.15
3	278.79	174.44
4	466.51	330.22
5	468.86	334.63

6	474.02	345.70

*** 1.518 ***

Failure Surface Specified By 6 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	206.01	178.74
2	214.31	174.87
3	278.70	170.02
4	497.42	356.95
5	499.04	359.99
6	499.89	361.82

*** 1.520 ***

1

Failure Surface Specified By 6 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	206.64	179.14
2	215.23	175.13
3	278.80	172.22
4	495.33	356.23
5	495.94	357.39
6	497.24	360.16

*** 1.521 ***

Failure Surface Specified By 6 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	208.90	180.54
2	219.83	175.44
3	278.76	173.18
4	484.84	347.60
5	485.27	348.42
6	488.09	354.47

*** 1.528 ***