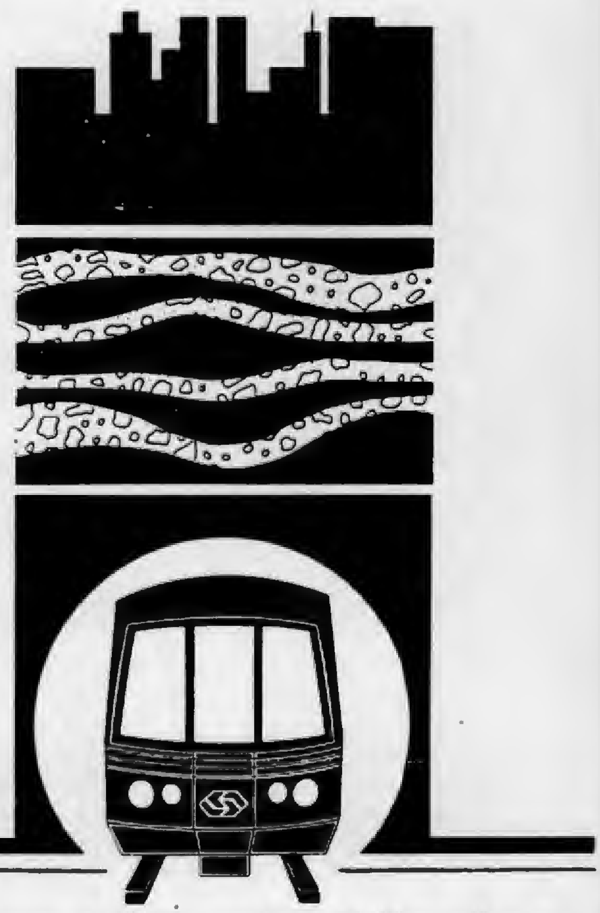
The Earth Technology Corporation

May 1990



Geotechnical Report

Metro Rail Project

Vermont/Santa Monica Station and Adjacent Tunnel Segments

Prepared for

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Prepared for

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Long Beach, CA 90802

Geotechnical Report

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1.0 Executive Summary

1.0 EXECUTIVE SUMMARY

This report provides the results of a geotechnical investigation for the planned Vermont/Santa Monica Station and its adjacent tunnel segments. The station and the tunnel segments are located beneath Vermont Avenue. One tunnel segment (Beverly-Santa Monica Tunnel) spans between the planned Vermont/Beverly Station and the Vermont/Santa Monica Station. The other tunnel segment (Santa Monica-Sunset Tunnel) spans between the planned Vermont/Santa Monica Station and the Vermont/Sunset Station. The primary objective of the geotechnical investigation was to evaluate subsurface soil and groundwater conditions to obtain geotechnical information for design of the station and tunnels. The geotechnical investigation consisted of drilling and sampling 21 borings, installing groundwater monitoring wells, electric wireline logging, field permeability tests, soil mechanics and chemical laboratory tests, and engineering evaluation.

The subsurface conditions along the station and tunnel alignments, as encountered in this investigation, generally consist of a shallow fill zone and Pleistocene-aged Old Alluvium overlying Puente Formation bedrock. The thin surface fill should have little or no effect on the design and construction of the station and the tunnels. The Old Alluvium in this alignment portion generally ranges from about 5 feet to about 40 feet in thickness except in the vicinity of Boring PII-44 where Old Alluvium is present to a depth of about 80 feet. The Old Alluvium consists predominantly of stiff to very stiff silty clay, clayey silt and clayey sand interspersed with layers of dense to very dense sand, silty sand and sandy silt. The presence of very deep Old Alluvium at Boring PII-44 appears to be a local anomaly in the subsurface. The lateral extent and depth variation of deep alluvium in the vicinity of Boring PII-44 are not known. Puente Formation bedrock in the site area consists predominantly of silty claystone or clayey siltstone with weak and thinly bedded sandstone. Very hard sandstone beds from fractions of an inch to one foot or more in thickness are locally present in the bedrock. Although not encountered during the field investigation, thick or massive layers of hard sandstone similar to those encountered in the Wilshire-Beverly Tunnel segment (Earth Technology, 1990b) may be present in the subsurface of this alignment portion. The unconfined compression strength of the very hard sandstone beds may range from 5,000 psi to 20,000 psi or more. The top 10 feet to 60 feet of Puente Formation bedrock in the site area show varying degrees of oxidation and weathering. Highly weathered Puente Formation materials, which behave like stiff to very stiff and hard silty clay/clayey silt with undistinguishable bedding planes were encountered in most of the borings. Highly weathered Puente Formation materials encountered at Borings PII-28, PII-35, and PII-38 consist of some dense to very dense clayey sand- and silty sand-type of materials. The Puente Formation in the remaining portion of the oxidized/weathered zone is oxidized and cemented to some extent and is referred to as "oxidized Puente Formation" in this report. Below the oxidized Puente Formation, the bedrock is fresh (i.e., unweathered and nonoxidized). From an engineering viewpoint, both oxidized and fresh Puente Formation materials have similar engineering properties and behaviors which are, in turn, similar to hard, dense soils with a significant cohesive strength component.

Within this alignment portion, perched groundwater exists at a shallow depth. In the southern portion of the alignment (south of Boring PII-38) perched groundwater exists in the Puente Formation bedrock. In the northern portion (north of PII-38) perched groundwater exists mainly in Old Alluvium. Interpretation of available groundwater level data indicate groundwater level depth ranges approximately from 10 feet to 40 feet.

The planned tunnel portions (Beverly-Santa Monica and Santa Monica-Sunset) are located predominantly within either oxidized or fresh Puente Formation materials, except in the vicinities of Borings PII-39, PII-43 and PII-44 where the tunnel is located either in highly weathered Puente Formation or Old Alluvium. The encountered subsurface conditions are conducive to mechanical shielded excavation. However, several conditions may significantly reduce the excavation rate if they are not properly considered in the design of excavation equipment and in construction procedures. These conditions include, but are not necessarily limited to, the potential presence of very hard sandstone beds, concretionary nodules, and cased or uncased oil wells. In addition, mixed face conditions in the vicinities of Borings PII-39 (weathered Puente/oxidized Puente interface) and PII-44 (weathered

Puente/oxidized Puente and Old Alluvium/oxidized Puente interfaces), and raveling to running conditions in the vicinity of Boring PII-44 may be encountered. Since geotechnical design reports for the tunnels are being prepared by MRTC under separate cover, the following conclusions and recommendations for design and construction of the Beverly-Santa Monica and Santa Monica-Sunset tunnels are provided for information purposes only:

1. Stability and Support: In general, the subsurface materials are sufficiently strong and the face should be stable in a shielded mechanical excavation with appropriate and immediate use of the initial lining support following the shields, except in the vicinity of Boring PII-44 where running conditions are likely in the granular alluvium below the water table and will require remedial measures. These measures include chemical grouting from the tunnel face, compaction grouting, or the use of compressed air.

2. Groundwater: Although the perched groundwater is observed to be above the planned tunnel crowns, seepage rates are expected to vary from too small to measure to about 0.1 gpm per foot of tunnel, except in the vicinity of Boring PII-44 where initial seepage rates of about 1 gpm to 2 gpm per foot of tunnel are expected.

3. Ground Movement: Tunnel excavation in the vicinities of Borings PII-39, PII-43, PII-44 and PII-45 will require proper procedures and care by the contractor to minimize potential settlement and ground loss.

The planned Vermont/Santa Monica Station is located within Puente Formation bedrock and Old Alluvium. The observed subsurface conditions can provide excellent foundation support for the planned station structures. The required station excavation can be accomplished relatively rapidly using mechanical excavation techniques and readily available equipment. The geotechnical evaluation for various engineering aspects of station design and construction are summarized below:

1. Dewatering: The presence of shallow perched groundwater in the relatively permeable Old Alluvium at the northern portion of the excavation indicates that dewatering will be needed. We anticipate that drawdown of the groundwater level below the Old Alluvium can be accomplished by deep wells, and the volume of inflow into the excavation during construction can be handled by a drain/sump system. It is also anticipated that dewatering-induced subsidence will be small and should not cause adverse impacts on buildings beyond 50 feet of the excavation opening.

2. Shoring: Due to the planned station's proximity to existing buildings and the limited construction space, shoring will be required for station excavation and construction. Based on subsurface conditions and cost considerations, the contractor will most likely use drilled soldier piles and lagging walls with tiebacks or internal bracing for lateral support. Accordingly, design input for these shoring types is presented in this report.

3. Underpinning: Underpinning requirements for most of the adjacent low-rise (less than 4 stories) buildings may be minimal if the building surcharges are properly incorporated into the shoring design. However, underpinning recommendations are presented.

4. Foundation Design: The main station structure can be adequately supported on Puente Formation bedrock using a mat foundation. Spread footings can be used as supports for other components of the structure. Recommended earth pressures on structural walls and slabs are also presented in this report.

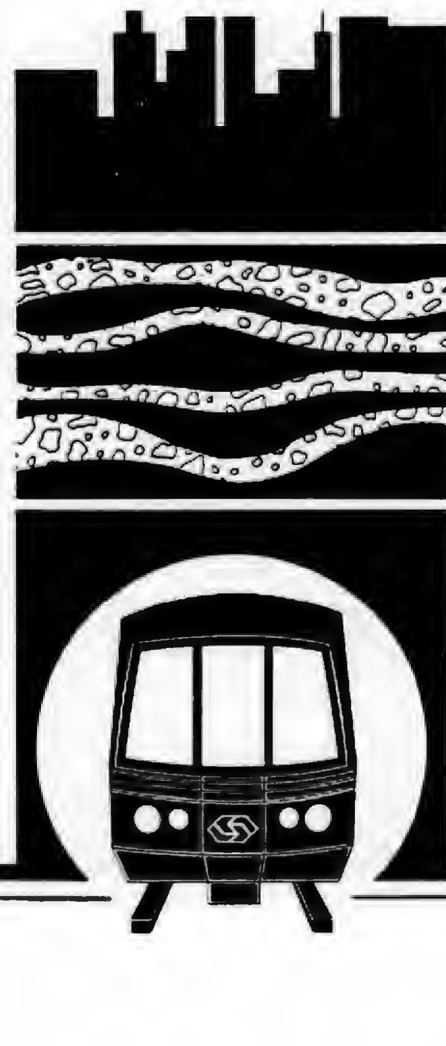
5. Settlement: Immediate elastic settlement of the mat foundation will be on the order of one inch. The majority of the long-term consolidation settlement due to the load imposed by the mat foundation will be negated by the unloading effect of the water level elevation subsequent to station construction. However, differential settlement of the mat foundation is expected.

In addition to the above-mentioned construction-related engineering aspects, the following aspects need careful consideration:

1. Material Handling: It is unlikely that excavated materials will require special cleanup or handling except at some localized areas. Extensive treatment of pumped groundwater prior to disposal is not anticipated. These issues may require further chemical testing and coordination with the California Regional Water Quality Control Board and the Department of Health Services.

2. Health and Safety: Due to the proximity of this station and its accompanying tunnels to the Los Angeles City Oil Field, the potential for harmful concentrations of methane and hydrogen sulfide in the study area cannot be eliminated. Methane and hydrogen sulfide should be continuously monitored during excavation and construction of the Vermont/Santa Monica Station and its adjacent tunnel segments. Proper ventilation should be maintained continuously to prevent accumulation of these gases.

2.0 Introduction



2.0 INTRODUCTION

2.1 GENERAL

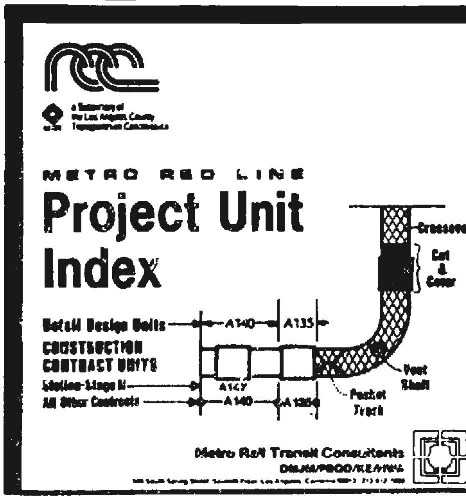
This report presents the results of a geotechnical investigation for the planned Vermont/Santa Monica Station and its adjacent tunnel segments. The tunnel portions are comprised of a 4,070-foot-long section located south of the planned station and a 2,036-foot-long section located north of the planned station. The planned tunnels and station are part of the Metro Rail MOS-2 alignment. The location of the station and tunnel segments, with respect to the MOS-2 alignment, is shown in Figure 2-1. This investigation was performed to evaluate subsurface and groundwater conditions along the tunnels and at the station. Investigation results will be used for a detailed design of the tunnels and station. For simplicity, when a distinction becomes necessary, the two tunnel portions are referred to as the "Beverly-Santa Monica Tunnel" and the "Santa Monica-Sunset Tunnel."

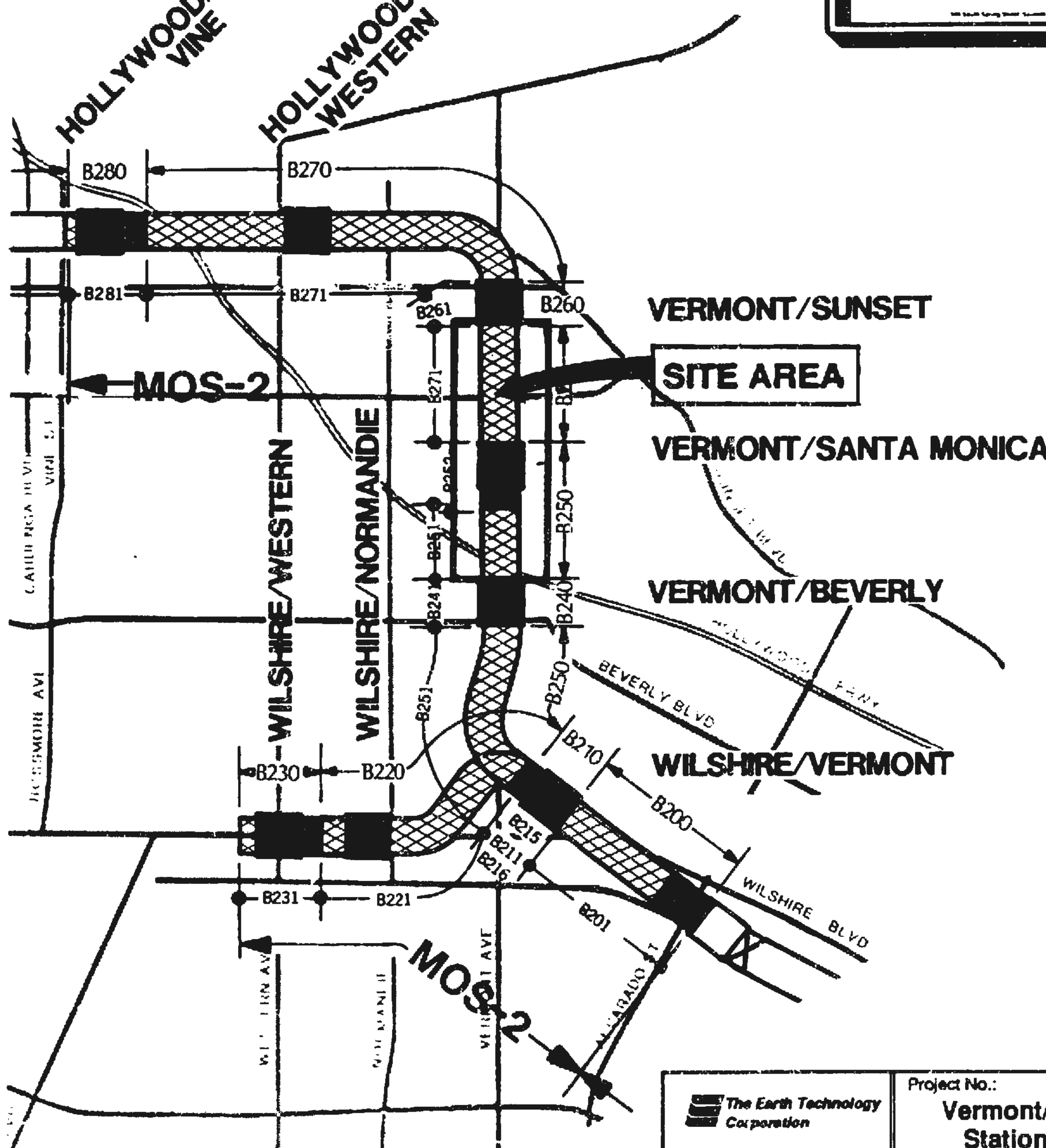
2.2 LOCATION/ALIGNMENT AND PLANNED CONSTRUCTION

Engineering efforts for planning and design of the Phase II alignment have been initiated and are ongoing. Figures 2-2, 2-3, and 2-4 show the current locations and alignments of the planned Beverly-Santa Monica Tunnel, Vermont/Santa Monica Station, and the Santa Monica-Sunset Tunnel, respectively. These locations and alignments were finalized in June 1989, and are described in Metro Rail Transit Consultant's (MRTC) "Design Drawings for Six Stations and Line Segments (MRTC, 1989)."

The planned tunnels and station are located in a well-developed commercial and residential area. The tunnels will consist of two, single-track, 18-foot-diameter finished openings in double-line configuration. Tunnel support will consist of a permanent cast-in-place concrete liner preceded by initial support during excavation.

Rail Construction Corporation





The Earth Technology Corporation

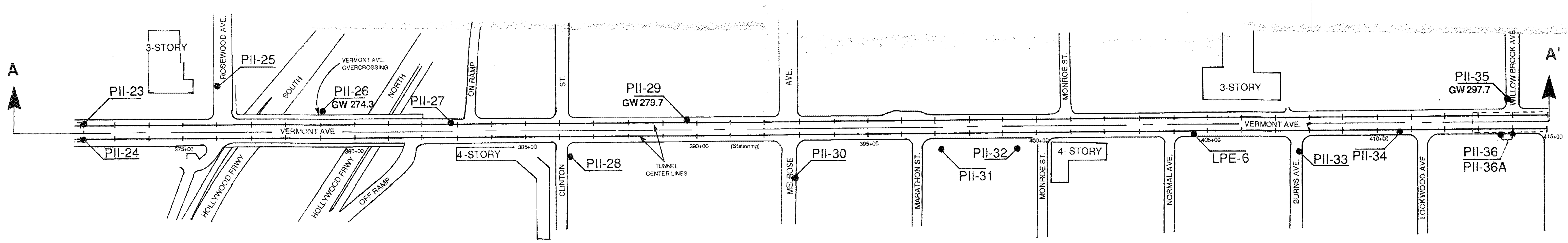
Project No.: 89-409

Vermont/Santa Monica Station and Tunnel

MOS-2 Alignment and Location of Vermont/Santa Monica Station and Adjacent Tunnels

05-90

Figure 2-1



PLAN

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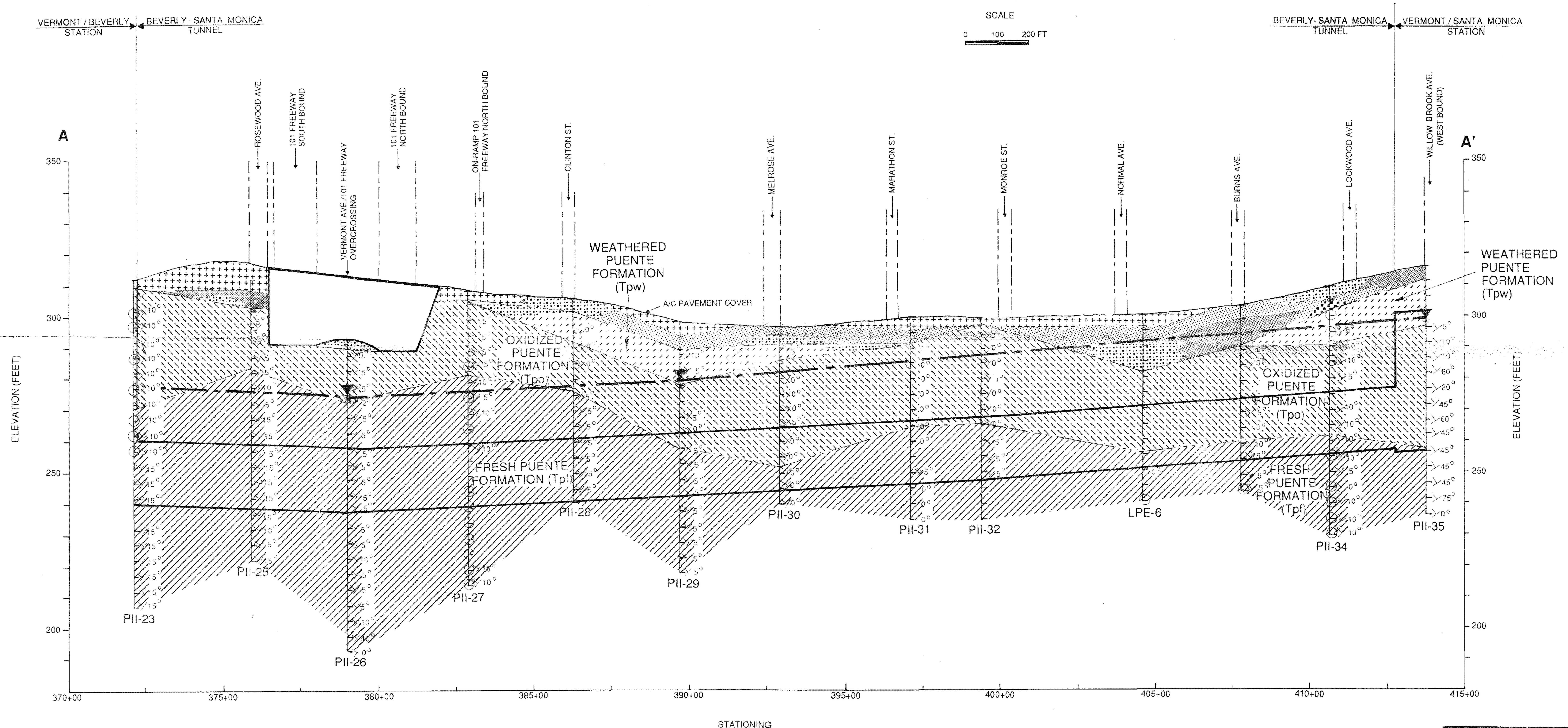
SCALE

0 100 200 FT



PROFILE A-A'

SCALE

HORIZONTAL 0 100 200 FT

VERTICAL 0 10 20 FT

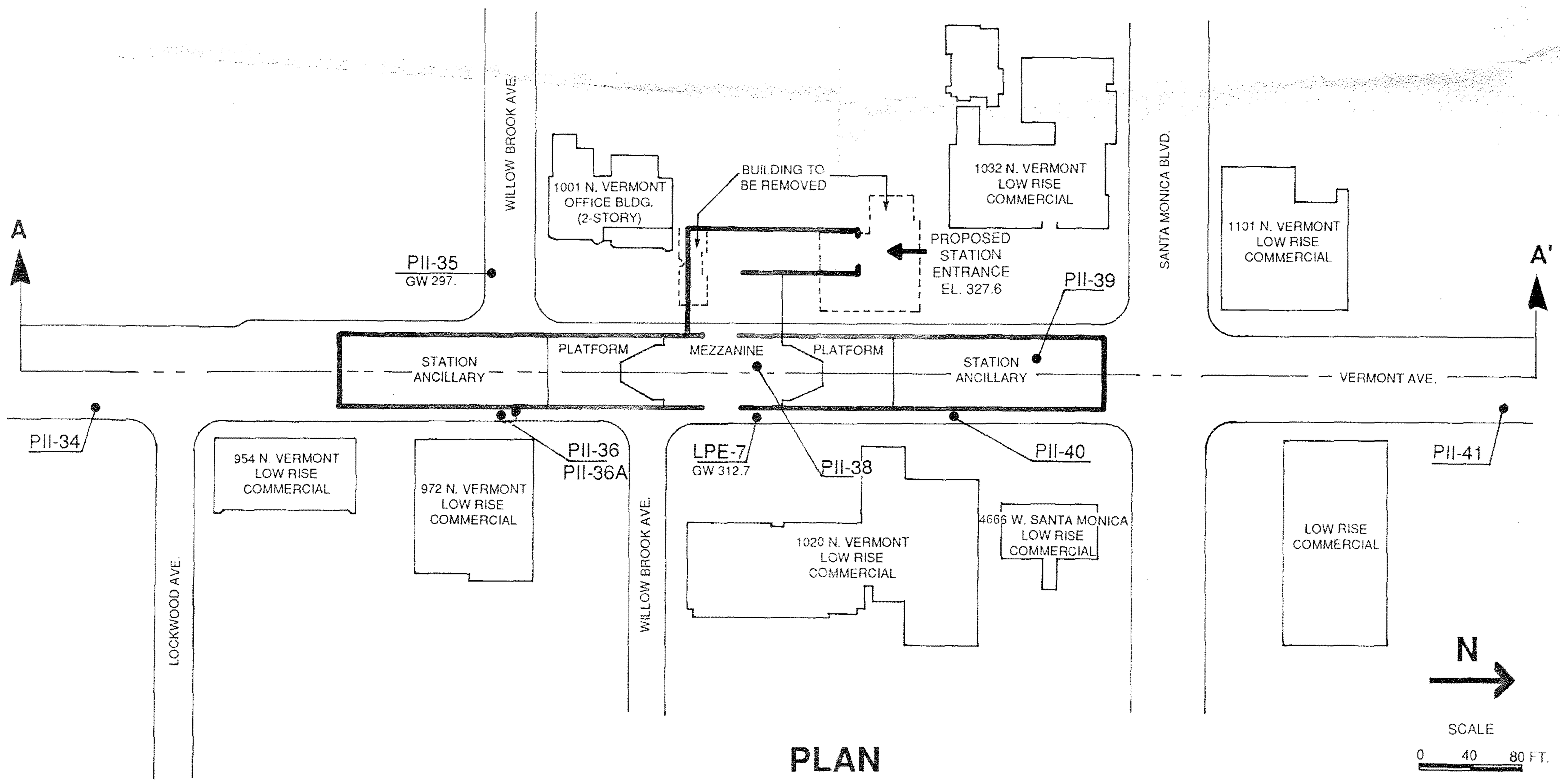
EXPLANATION

- FILL (AND A/C PAVEMENT COVER IF PRESENT)
- FINE-GRAINED ALLUVIUM (CLAY OR CLAYEY SILT-CL, CH, ML, MH), UNIT A4
- FINE-GRAINED ALLUVIUM (CLAYEY SAND WITH>35% FINES-SC) UNIT A4
- GRANULAR ALLUVIUM (SANDY SILT, SAND OR GRAVEL WITH>12% FINES-SP, GP SP-SM, GM) UNIT A3
- POORLY GRADED GRANULAR ALLUVIUM (SAND OR GRAVEL WITH<12% FINES-SP, GP, SP-SM, GP-GM) UNIT A3
- HIGHLY WEATHERED PUENTE FORMATION UNIT Tpw
- OXIDIZED PUENTE FORMATION UNIT Tpo
- FRESH PUENTE FORMATION UNIT Tpf
- GW 274.3 APPROXIMATE GROUNDWATER LEVEL ELEVATION (PLAN)
- APPROXIMATE GROUNDWATER LEVEL ELEVATIONS (PROFILE) RECORDED IN THIS INVESTIGATION
- APPROXIMATE GROUNDWATER LEVEL ELEVATION (PROFILE) RECORDED BY ENGINEERING SCIENCE (ESA, 1990)
- PII-30 LOCATIONS AND NUMBERS OF BORINGS IN THIS INVESTIGATION
- LPE-6 LOCATIONS AND NUMBERS OF MOS-2 BORING (EARTH TECHNOLOGY, 1988)
- SAMPLES WITH OVA HEADSPACE READING 10ppm OR MORE ABOVE OVA BACKGROUND READING
- DIP ANGEL
- PROPOSED STATION CONFIGURATION

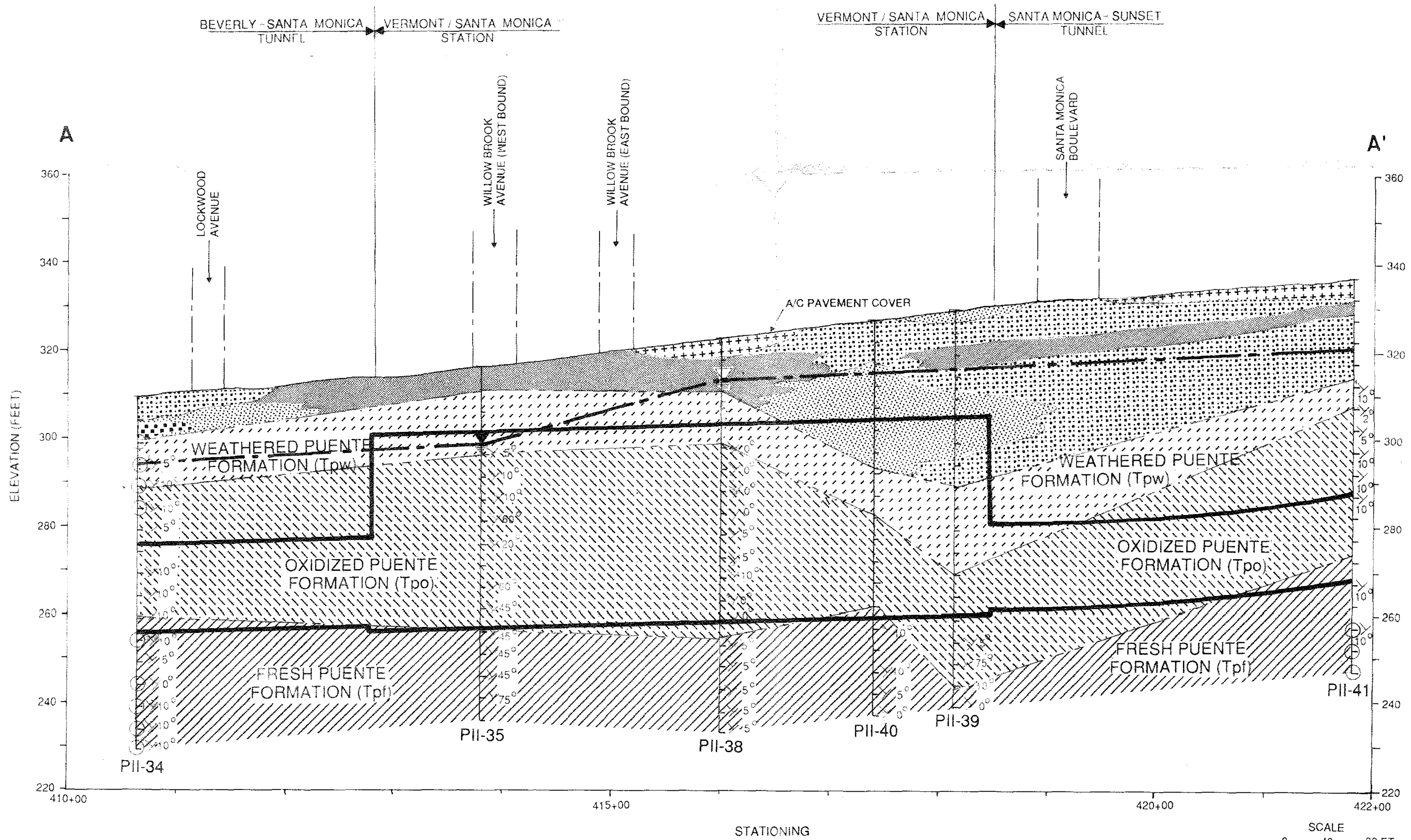
NOTES

1. THIS PROFILE IS BASED ON ENGINEERING INTERPRETATION BETWEEN BORINGS AND AVAILABLE PIEZOMETRIC DATA, AND WAS DEVELOPED AS A VISUAL AID IN DEVELOPING A GENERAL UNDERSTANDING OF SUBSURFACE CONDITIONS AND ENGINEERING CONSIDERATIONS. ACTUAL CONDITIONS ENCOUNTERED DURING SUBSEQUENT INVESTIGATION OR CONSTRUCTION MAY BE DIFFERENT.
2. SUBSURFACE DATA AT BORING LOCATIONS PRESENTED HEREIN ARE SIMPLIFIED INTERPRETATIONS OF BOREHOLE DATA INCLUDED IN APPENDIX A.
3. GROUNDWATER LEVEL DATA ARE BASED ON MONITORING OF PIEZOMETERS FOR A LIMITED PERIOD OF TIME. SEASONAL AND SPATIAL VARIATIONS MUST BE EXPECTED.
4. LOCATION AND CONFIGURATION OF TUNNEL ARE BASED ON "DESIGN DRAWINGS FOR SIX STATIONS & LINE SEGMENTS" PREPARED BY MRTC AND DATED JUNE 1989.
5. ELEVATIONS REFER TO LOS ANGELES CITY ENGINEER'S DATUM - 1975 ADJUSTMENT.
6. BOREHOLE DATA ARE PROJECTED HORIZONTALLY ON THE CROSS-SECTION LINE. GROUND ELEVATIONS AT BOREHOLE LOCATION AND AT CROSS-SECTION LINE LOCATION MAY BE DIFFERENT.
7. END POINTS OF LAYERS BETWEEN BORINGS ARE ILLUSTRATIVE ONLY. THEIR LOCATIONS AND GEOMETRY ARE NOT KNOWN.

	The Earth Technology Corporation 100 West Broadway, Suite 5000, Long Beach, CA. 90802	
REVISION DESCRIPTION	PLAN AND PROFILE BEVERLY – SANTA MONICA TUNNEL	
	DRAWN BY: C.C.H.	SCALE: AS SHOWN
	APPROVED BY: M.G. CHECKED BY: P.C.	DATE: MAY 1990
	DRAWING NUMBER	FIGURE 2-2
	SHEET 1 OF 1	



PLAN



PROFILE A-A'

EXPLANATION

- FILL (AND A/C PAVEMENT COVER IF PRESENT)
- FINE-GRAINED ALLUVIUM (CLAY OR CLAYEY SILT-CL, CH, ML, MH), UNIT A4
- FINE-GRAINED ALLUVIUM (CLAYEY SAND WITH>35% FINES-SC) UNIT A4
- GRANULAR ALLUVIUM (SANDY SILT, SILTY SAND OR SILTY GRAVEL >12% FINES) UNIT A3 (ML, SM, GM)
- POORLY GRADED GRANULAR ALLUVIUM (SAND OR GRAVEL WITH<12% FINES-SP, GP, SP-SM, GP-GM) UNIT A3
- HIGHLY WEATHERED PUENTE FORMATION UNIT Tpw
- OXIDIZED PUENTE FORMATION UNIT Tpo
- FRESH PUENTE FORMATION UNIT Tpf
- GW 297.7 APPROXIMATE GROUNDWATER LEVEL ELEVATION (PLAN)
- APPROXIMATE GROUNDWATER LEVEL ELEVATIONS (PROFILE) RECORDED IN THIS INVESTIGATION
- APPROXIMATE GROUNDWATER LEVEL ELEVATION (PROFILE) RECORDED BY ENGINEERING SCIENCE (ESA, 1990)
- PII-40 LOCATIONS AND NUMBERS OF BORINGS IN THIS INVESTIGATION
- LPE-7 LOCATIONS AND NUMBERS OF MOS-2 BORING (EARTH TECHNOLOGY, 1988)
- SAMPLES WITH OVA HEADSPACE READING 10ppm OR MORE ABOVE OVA BACKGROUND READING
- DIP ANGEL
- PROPOSED STATION CONFIGURATION

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REVISION DESCRIPTION	The Earth Technology Corporation 100 West Broadway, Suite 5000, Long Beach, CA. 90802
	PLAN AND PROFILE VERMONT / SANTA MONICA STATION

DRAWN BY: C.C.H.		SCALE: AS SHOWN
APPROVED BY: M.G.	CHECKED BY: P.C.	DATE: MAY 1990
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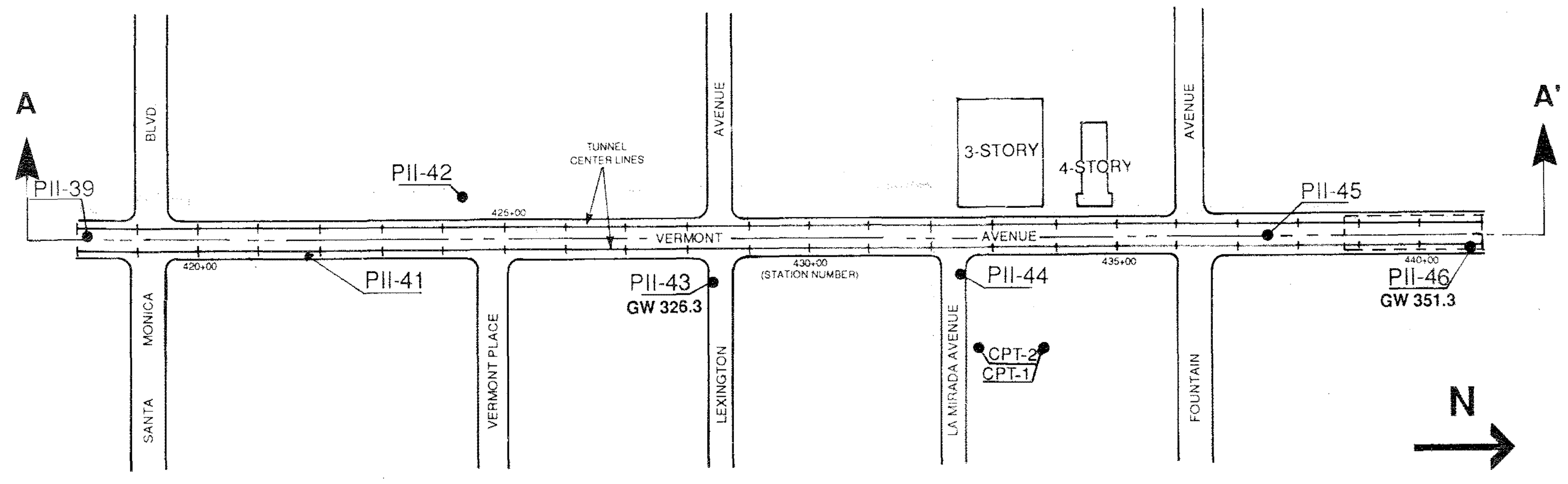
SHEET 1 OF 1		



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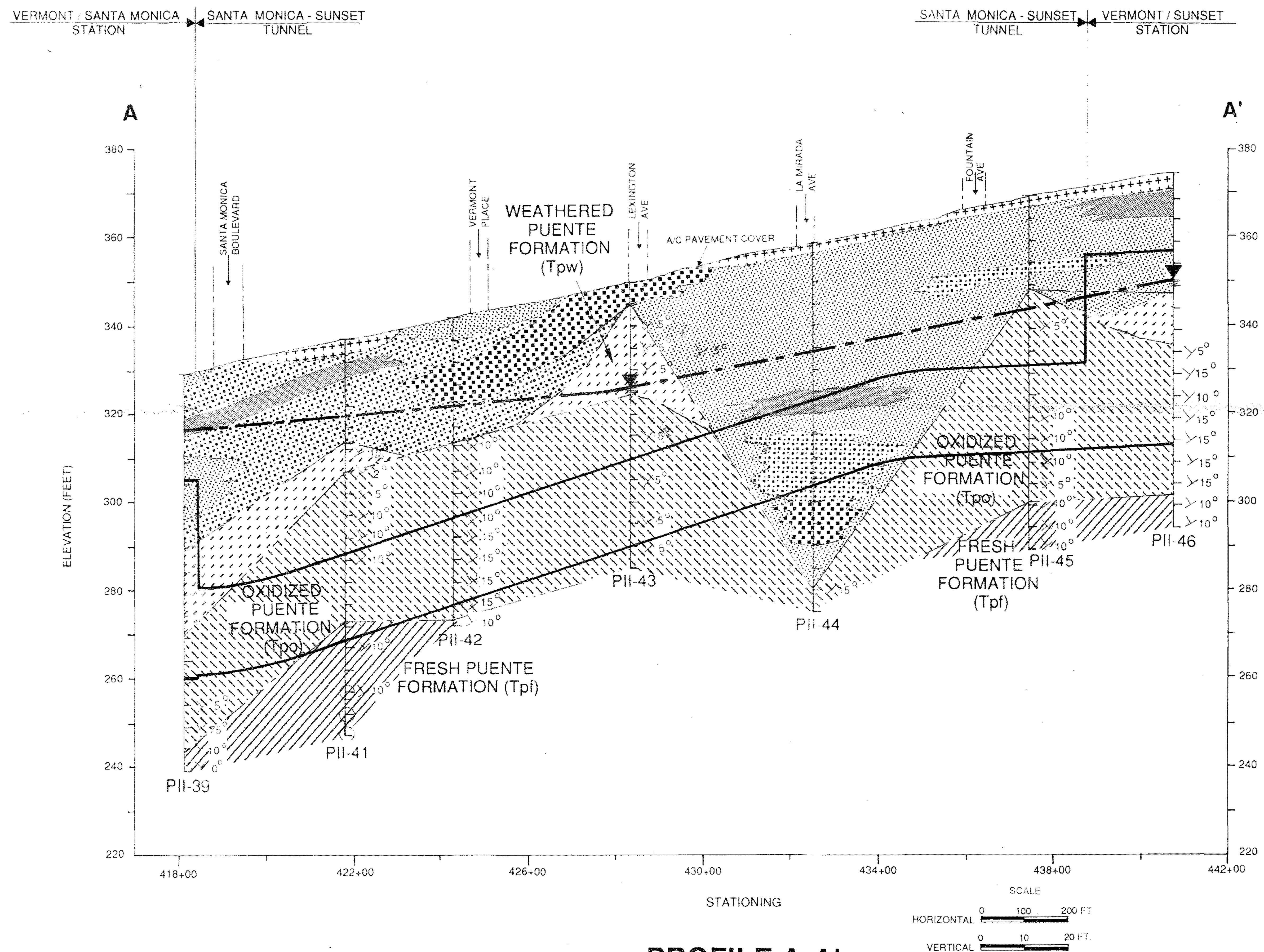

PROFILE A-A'

EXPLANATION

- FILL (AND A/C PAVEMENT COVER IF PRESENT)
- FINE-GRAINED ALLUVIUM (CLAY OR CLAYEY SILT-CL, CH, ML, MH), UNIT A4
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- HIGHLY WEATHERED PUENTE FORMATION UNIT Tpw
- OXIDIZED PUENTE FORMATION UNIT Tpo
- FRESH PUENTE FORMATION UNIT Tpf
- GW 326.3 APPROXIMATE GROUNDWATER LEVEL ELEVATION (PLAN)
- APPROXIMATE GROUNDWATER LEVEL ELEVATIONS (PROFILE) RECORDED IN THIS INVESTIGATION
- APPROXIMATE GROUNDWATER LEVEL ELEVATION (PROFILE) RECORDED BY ENGINEERING SCIENCE (ESA, 1990)
- PII-41 LOCATIONS AND NUMBERS OF BORINGS IN THIS INVESTIGATION
- SAMPLES WITH OVA HEADSPACE READING 10ppm OR MORE ABOVE OVA BACKGROUND READING
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- PROPOSED STATION CONFIGURATION

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REVISION DESCRIPTION	PLAN AND PROFILE SANTA MONICA – SUNSET TUNNEL		
	DRAWN BY: C.C.H.		SCALE: AS SHOWN
	APPROVED BY: M.G.	CHECKED BY: P.C	DATE: MAY 1990
	DRAWING NUMBER		FIGURE 2-4
	SHEET 1 OF 1		

2.2.1 Beverly-Santa Monica Tunnel

As shown in Figure 2-2, the Beverly-Santa Monica Tunnel segment runs from the northern end of the Vermont/Beverly Station (Station 372+00) to the southern end of the planned Vermont/Santa Monica Station (Station 403+00).

The Beverly-Santa Monica Tunnel is located in a well-developed commercial and residential area. The ground surface in the tunnel area is essentially paved, with little, if any, vegetative cover. The ground surface along the alignment gently slopes up from about Elevation 313 feet at the northern end of the Vermont/Beverly Station to about Elevation 318 feet near the Vermont/101 Freeway overpass. The freeway passes beneath Vermont Avenue at an approximate elevation of about 291±2 feet. The ground surface slopes down along the tunnel alignment from the southern end of the overpass and across the overpass to the Melrose/Vermont Avenue intersection. The ground surface elevations within this portion vary from about Elevation 318 feet near the southern end of the freeway overpass to about Elevation 297 feet near the Melrose Avenue/Vermont Avenue intersection. From the Melrose Avenue/Vermont Avenue intersection to the Normal Street/Vermont Avenue intersection, the ground surface along the alignment remains generally flat at about Elevation 298±2 feet. From the Normal Street/Vermont Avenue intersection, the ground surface slopes upward to about Elevation 314 feet at the southern end of the Vermont/Santa Monica Station. Most of the buildings located within 100 feet of the tunnel alignment are low-rise and less than 3 stories, except for the California Highway Patrol building located at the Rosewood Avenue/Vermont Avenue intersection (3-story), the chiropractic college building located at the Clinton Street/Vermont Avenue intersection (4-story), a building at the northeast corner of the Monroe Street/Vermont Avenue intersection (4-story), and the Los Angeles City College (LACC) buildings (3-story).

2.2.2 Vermont/Santa Monica Station

As shown in Figure 2-3, the planned Vermont/Santa Monica Station will be located beneath Vermont Avenue from about 150 feet north of Lockwood Avenue

(Station 413+00) to about 50 feet south of Santa Monica Boulevard (Station 418+00). The ground surface in the station area is essentially paved. Along the station alignment (due north) the ground surface slopes up at an approximate gradient of 3 percent. The ground surface elevation varies from about Elevation 314 feet at the southern end to about Elevation 330 feet at the northern end of the planned station. All buildings located within 100 feet of the planned station location are low-rise and less than 3 stories.

Cut-and-cover construction is planned for the station. The main structure, including ancillary facilities at both ends, is about 605 feet long with an inside width of about 50 feet. The overall excavation width will be about 60 feet, assuming a 5-foot space for wall construction at each side. The planned excavation subgrade is at about Elevation 256 feet. This means the excavation depth for the main structure will range from about 58 feet to 74 feet.

Proposed entrance to the mezzanine level is planned at the middle of the station. The ground surface elevation at the entrance location is about Elevation 328 feet. The planned mezzanine level is at about Elevation 283 feet and the planned platform is at an elevation of about 267 feet with a south-north gradient of about 0.7 percent.

2.2.3 Santa Monica-Sunset Tunnel

As shown in Figure 2-4, this tunnel segment runs from the northern end of planned Vermont/Santa Monica Station (Station 418+00) to the southern end of planned Vermont/Sunset Station (Station 439+00).

The ground surface along the tunnel alignment is essentially paved. Along the alignment (due north), the ground surface gently slopes up at an approximate gradient of 2 percent. The ground surface elevation varies from about Elevation 330 feet near the southern end of the tunnel to about Elevation 370 feet at the northern end of the tunnel. Most of the buildings located within 100 feet of the tunnel are low-rise and less than 3 stories, except for two buildings; the Pacific Bell building (3-story) and the adjacent building on the north side (4-story).

2.3 OBJECTIVE AND SCOPE

The primary objective of the geotechnical investigation was to evaluate subsurface soil and groundwater conditions to obtain geotechnical information for design and construction of the planned Vermont/Santa Monica Station and adjacent tunnel segments.

The scope of this investigation consisted of the following:

1. Reviewing available literature and reports.

2. Planning and coordinating field work, including:

   - o Developing field procedures and manual
   - o Planning the field investigation program
   - o Obtaining permits from government agencies
   - o Obtaining authorizations from private property owners
   - o Coordinating with government agencies and utility companies prior to, during, and after the field work
   - o Developing and implementing a project-specific Health and Safety Plan.

3. Performing a field exploration program, including:

   - o Drilling and sampling 21 test borings
   - o Conducting two Cone Penetrometer Test (CPT) soundings
   - o Obtaining Organic Vapor Analyzer (OVA) readings on soil samples and background environments
   - o Installing four piezometers at selected boring locations
   - o Monitoring groundwater levels and taking water samples for chemical testing
   - o Performing one field permeability test (slug test)
   - o Conducting wireline logging surveys in four selected boring locations.

4. Performing a laboratory testing program on selected representative soil and water samples to assess their index and engineering properties and general chemical characteristics of the encountered subsurface materials and groundwater.

5. Preparing this report documenting the findings, geotechnical evaluations, and recommendations.

2.4 ADDITIONAL INFORMATION

This geotechnical investigation is part of an overall geotechnical investigation for a major part of the MOS-2 alignment. The alignment starts at the Wilshire/Vermont Station, turns north along Vermont Avenue, and then curves west along Hollywood Boulevard. The subsurface conditions along the planned Vermont/Santa Monica Station and adjacent tunnel segments are similar to those found at the MOS-2 alignment portion along most of Vermont Avenue. Thus, applicable geotechnical information from the MOS-2 alignment portion along Vermont Avenue have been incorporated in this report.

In addition to this report, pertinent project information for the planned Vermont/Santa Monica Station and adjacent tunnels is also included in the following reports:

- "Geotechnical Report, Metro Rail Project, Wilshire/Vermont Station," Report to Metro Rail Transit Consultants (MRTC) by The Earth Technology Corporation (1990).
- "Geotechnical Report, Metro Rail Project, Wilshire-Beverly Tunnel," Report to Metro Rail Transit Consultants (MRTC) by The Earth Technology Corporation (1990).
- "Geotechnical Report, Metro Rail Project, Vermont/Beverly Station," Report to Metro Rail Transit Consultants (MRTC) by The Earth Technology Corporation (1990).
- "Geotechnical Report, Metro Rail Project, Vermont/Sunset Station and Adjacent Tunnel Segment," Report to Metro Rail Transit Consultants (MRTC) by The Earth Technology Corporation (1990).
- "Report of Subsurface Gas Investigation - Southern California Rapid Transit District, Metro Rail Project, Phase II Alignment," Report prepared by Engineering Science Associates (ESA, 1990).

- "Geotechnical Investigation Report, Limited Preliminary Engineering Program, MOS-2 Alignment, Metro Rail Project," prepared for Metro Rail Transit Consultants (MRTC) by The Earth Technology Corporation (1988).

- "Geotechnical Investigation Report for Metro Rail Project," prepared for SCRTD by CWDD/ESA/GRC (1981).

2.5 REMARKS

For the Metro Rail project, design procedures and criteria for permanent underground structures under earthquake loading conditions are defined in the Southern California Rapid Transit District (SCRTD) report entitled "Supplemental Criteria for Seismic Design of Underground Structures," dated June 1984. Evaluations of the seismological conditions which may impact the project and the probable maximum earthquake which may be anticipated in the Los Angeles area are described in the SCRTD report entitled "Seismological Investigation and Design Criteria," dated May 1983.

3.0 Field Exploration and Laboratory Testing

3.0 FIELD EXPLORATION AND LABORATORY TESTING

This section provides a description of the subsurface exploration and laboratory testing work performed in this program. This field investigation program was a part of a larger geotechnical program performed along the MOS-2 alignment. Results of the larger geotechnical investigation applicable to the planned station and tunnel segments, as well as available reports and project data files (Section 2.4), were also used in developing conclusions and recommendations presented in this report.

3.1 FIELD EXPLORATION

Field exploration consisted of drilling and sampling 21 borings (PII-25 through PII-36, PII-36A, and PII-38 through PII-45); conducting two Cone Penetrometer Test (CPT) soundings (CPT-1 and CPT-2); installing groundwater monitoring wells and performing geophysical wireline logging in four borings; monitoring groundwater levels; performing a field permeability test (slug test) and groundwater sampling. Plot plans showing boring locations and CPT locations are presented in Figures 2-2, 2-3, and 2-4. Detailed locations and logs of the borings and CPT soundings are presented in Appendix A.

3.1.1 Borings

Borings were drilled using rotary wash methods with a 4-7/8-inch-diameter bit which produces a nominal 5- to 6-inch-diameter borehole. A tri-cone bit was used in coarse-grained (granular) soils and a drag-bit was used in fine-grained soils. A bentonite drilling fluid was used. Borings were generally drilled to depths of about 20 feet or more below the planned tunnel invert in the tunnel sections and about 30 feet below the planned bottom slab elevation in the station. Penetration depths of the 21 borings are shown in Table 3-1. Soil samples were obtained at 5-foot-depth intervals by alternately using standard split-spoon samplers (Standard Penetration Test Method) and California-type drive samplers lined with 1-inch-high brass rings.

TABLE 3-1. TOTAL PENETRATION DEPTHS FOR SOIL BORINGS

Boring No.	Penetration Depth (Feet)
PII-25	91.5
PII-26	101.0
PII-27	96.5
PII-28	67.5
PII-29	81.0
PII-30	56.0
PII-31	66.0
PII-32	66.5
PII-33	61.5
PII-34	81.0
PII-35	81.5
PII-36	47.0
PII-36A	86.5
PII-38	91.5
PII-39	91.5
PII-40	91.0
PII-41	92.5
PII-42	72.5
PII-43	66.0
PII-44	86.5
PII-45	81.0

Standard penetration tests were performed in accordance with the American Society for Testing Materials (ASTM) specification (ASTM D1586). This method consists of driving the standard split-spoon sampler 18 inches into the soil with a 140-pound hammer falling 30 inches. Blow counts were recorded for each 6-inch driving increment. The total blow count for the last 12 of 18 inches of driving is called the standard penetration resistance.

The driving was terminated when one of the following occurred:

- A total of 100 blows was reached for a penetration of 12 inches or less
- No obvious sampler advance was observed during driving
- The sampler was advanced 18 inches.

Relatively undisturbed soil samples were obtained with the California-type drive samplers. Hammer weights and the corresponding heights of the drop used for driving the samplers are indicated in boring logs (Appendix A). Blow counts were recorded for each 6-inch driving increment. A Pitcher-barrel sampler was occasionally used when penetration or soil recovery with the drive samplers was difficult due to hard/dense subsurface conditions or when longer samples were required for laboratory testing.

The borings were continuously logged by an experienced geologist or soils engineer using the Unified Soil Classification System (USCS). The boring logs were prepared and/or reviewed by a certified engineering geologist (CEG).

3.1.2 Cone Penetrometer Test Soundings

Two Cone Penetrometer Test (CPT) soundings were conducted in the vicinity of Boring PII-44. CPT sounding logs with interpretation are presented in Appendix A. Penetration depths of the two CPT soundings are shown in Table 3-2, and the locations of the CPT soundings are shown in Figure 2-4. The CPT soundings were performed using Earth Technology's 60-degree-angle cone with a 15 cm^2 cross-sectional area. The cone is pushed into the soil while simultaneously recording the end bearing and side frictional resistance of the soil to that penetration. The tests were conducted in accordance with ASTM specifications (ASTM D3441-79) using an electric cone penetrometer. Details of equipment and guidelines for general interpretation of CPT data are given in Appendix D.

TABLE 3-2. TOTAL PENETRATION DEPTHS FOR CPT SOUNDINGS

Sounding No.	Penetration Depth (feet)
CPT-1	94.0
CPT-2	108.0

3.1.3 Piezometer Installation

Four piezometers were installed, at Borings PII-26, PII-29, PII-35, and PII-43, to monitor groundwater levels and obtain water quality samples. A 2-inch-diameter PVC casing with 0.02-inch slotted well screen was used for the piezometers. The piezometer well-screened depth intervals were estimated based on groundwater levels extrapolated from the closest existing available water-level records. In the rotary wash drilling method, observation of groundwater during drilling and soil sampling was not possible since the boreholes were filled with drilling fluid.

Piezometers were installed in the borings after the completion of soil sampling. Tap water was used to flush the boring to remove or thin the drilling fluid prior to installation. About two feet of backfill sand was placed at the bottom of the boring. The PVC casing assembly was inserted into the boring and backfill sand was placed to about two feet above the top of the screened interval, except in Piezometer PII-26. In Piezometer PII-26, backfill sand was placed to about five feet below the bottom of the screened interval of the casing assembly and then bentonite pellets (Hole Plug™) were poured by gravity to form a bentonite plug about three feet thick. Backfill sand was then placed to about two feet above the top of the screened interval.

After sand backfilling, bentonite pellets (Hole Plug™) were poured by gravity to form a plug about three feet thick in all of the piezometers. Cement grout was then poured into the annulus between the PVC casing and the borehole wall from the top of the bentonite plug to within 12 inches to 18 inches of the ground surface. At completion, a circular 8-inch-diameter metal traffic box (Pomeco™) was also installed at the piezometer location flush with the ground surface. Piezometer installation diagrams are presented in Appendix A.

3.1.4 Groundwater Level Monitoring and Groundwater Sampling

Groundwater levels were monitored in the piezometers using an electronic water-level indicator. Groundwater level readings were taken periodically and are summarized in Table 3-3. Each piezometer was developed by bailing about 10 casing volumes of water. Groundwater samples were obtained from the piezometers for chemical analyses. At every sampling event, at least three well volumes of water were bailed out from each well before samples for water quality testing were obtained.

3.1.5 Slug Test

One slug test was performed to evaluate the horizontal permeability of the Puente Formation bedrock. The slug test involved the injection of a slug of water into the piezometer well through the well screen and into the Puente Formation bedrock, and monitoring water level at various time intervals until the water level had approached its original static level. The permeability of the bedrock as determined by the slug test is about 7×10^{-6} cm/sec, which is about 50 times to 500 times more than the vertical permeability of the bedrock as determined by the laboratory tests (Table B-8 in Appendix B of this report; Geotechnical Report, Wilshire/Vermont Station, Earth Technology 1990a;

TABLE 3-3. SUMMARY OF GROUNDWATER READINGS

Date of Reading	Piezometer Location									
	PII-26 GSE=292.7		PII-29 GSE=298.0		PII-35 GSE=316.0		PII-43 GSE=349.5		LPE-7 GSE=323.0	
	GLD (Feet)	GLE (Feet)	GLD (Feet)	GLE (Feet)	GLD (Feet)	GLE (Feet)	GLD (Feet)	GLE (Feet)	GLD (Feet)	GLE (Feet)
11/14/88									9.9	313.1
12/08/88									10.1	312.9
05/02/89									10.0	313.0
05/15/89			17.0	281.0	17.9	298.1	22.9	326.6		
05/18/89			16.8	281.2	19.2	296.8	23.1	326.4		
06/11/89			17.4	280.6	18.9	297.1	22.0	327.5		
07/02/89			17.6	280.4	18.9	297.1	22.7	326.8	10.0	313.0
07/06/89	17.2	275.5								
07/16/89									10.0	313.0
07/25/89										
09/06/89	18.4	274.3	18.3	279.7	18.3	297.7	23.2	326.3	10.3	312.7
01/22/90			17.9	280.1	19.6	296.4	23.0	326.5	10.3	312.7
01/27/90	17.1	275.6								

Notes: GSE = Ground Surface Elevation (Feet)
GLD = Groundwater Level Depth (Feet)
GLE = Groundwater Level Elevation (Feet)

Geotechnical Report, Vermont/Beverly Station 1990c). The most logical and plausible explanation for such an anisotropic behavior is the presence of thin sandstone beds and bedding planes which serve as preferred hydrological pathways. These hydrological pathways may also serve as hydrologic connections between Old Alluvium and Puente Formation bedrock.

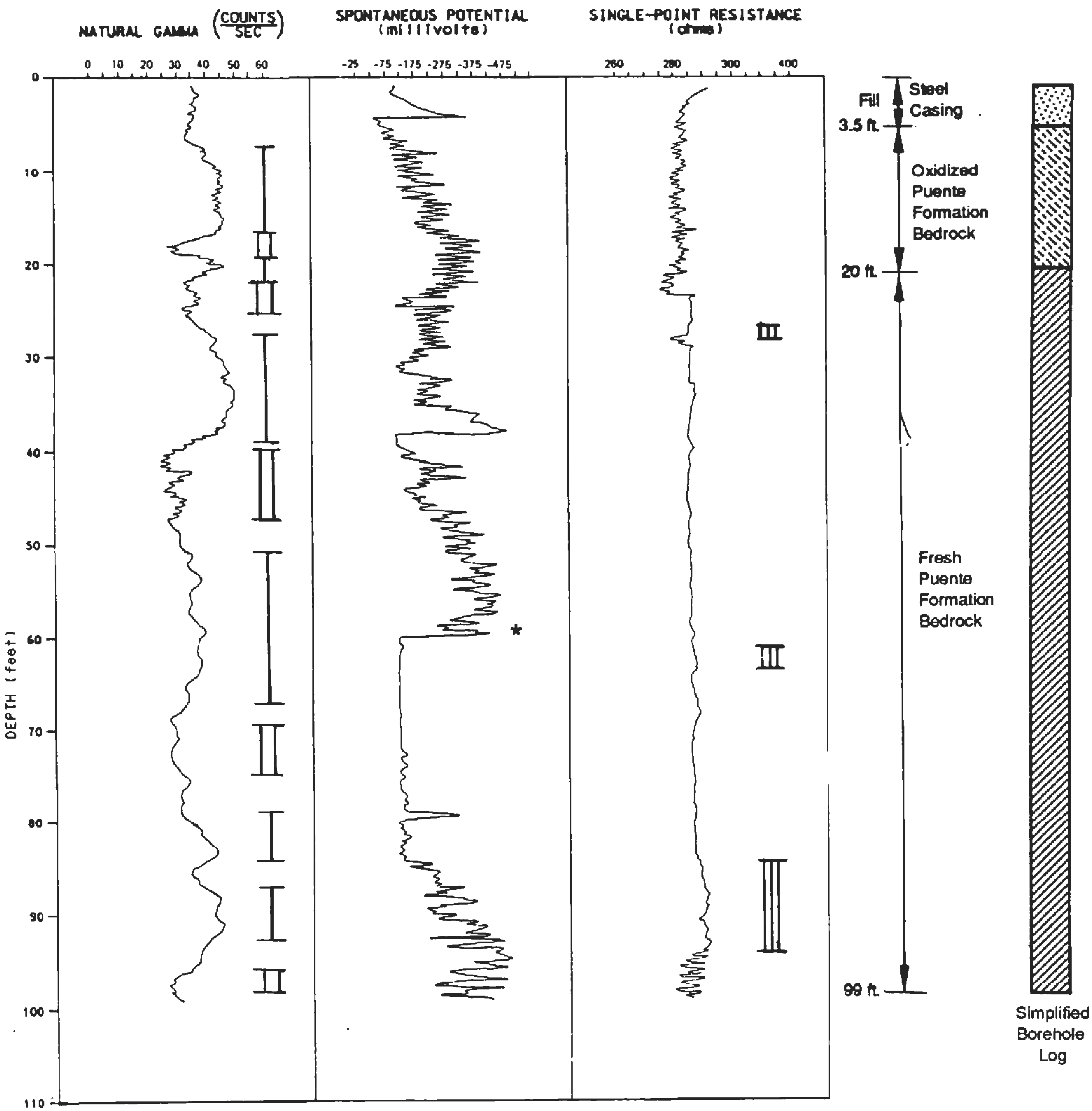
3.1.6 Wireline Logging

Wireline logging was performed at Borings PII-26, PII-29, PII-35, and PII-43 with a Mt. Sophris Model 1000-C portable logger. Three physical properties of subsurface formations were measured: natural gamma, spontaneous potential (SP), and single-point resistance. Each technique measured a different physical property, as described below:

- The natural gamma log measures naturally occurring radioactivity levels of uranium-related elements. Clayey materials absorb these elements and, therefore, produce high-value peaks on the log. This log can distinguish between clay and sand zones.
- The SP log measures electrical currents produced by chemical reactions between drilling mud, geological formations, and groundwater. This log shows chemical changes related to changing clay content and groundwater quantity/quality.
- The resistance log measures a material's inherent resistance to electrical current flow. A rock matrix has very high resistance, therefore, current flow is confined to pore space fluids. The quantity/quality of pore fluids, porosity, and permeability control the rock's resistance. This log can distinguish between clay and sand zones and changes in groundwater conditions.

Simultaneous interpretation of these three complementary data sets with the boring log increases the reliability of data. Results of wireline logging at each of the four borings and our interpretation of the results are provided below.

3.1.6.1 Boring PII-26. Figure 3-1 shows wireline data and interpreted results for Boring PII-26. Steel casing installed to a depth of about 3.5 feet prevented collecting reliable wireline data near the surface. The SP and



Explanation

I - Increased clay content

II - Decreased clay content

III - Cementation

- Old Alluvium and Fill

- Oxidized Puente Formation

- Fresh Puente Formation

*Water added to the boring at this depth during logging to prevent caving.

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Wireline Logging Data and Interpretation Boring PII-26

05-90

Figure 3-1

resistance logs show effects from the casing shallower than a depth of five feet. Puente Formation bedrock, which consists predominately of clayey siltstone/silty claystone was encountered below the tip of the steel casing. The large fluctuations shown in all three borings indicate significant variations in clay content in the bedrock. Wireline data terminated at a depth of 99 feet.

The SP and resistance scales are unusually large because of highly variable, large-amplitude, electrical currents at this site. This electrical interference can be seen as random scatter of these two logs in the upper 25 feet. Measurement parameters and electrical connections were adjusted in the field to minimize the interference. Water was added to the boring because of water loss to the formation when the sounder was at a depth of about 60 feet. The relatively fresh water added to the boring caused the sudden SP shift at that depth.

Wireline data indicates there is not a major formation change at this boring. Instead, the alternating high-/low-value gamma peaks indicate alternating zones of increased/decreased clay content, respectively. Increased chemical activity of minerals absorbed by the clay may produce the high-value SP peaks. High-value resistance peaks represent the localized presence of less porous material, such as cemented siltstone. Relevant stratigraphic features interpreted from the data are described below:

- Predominately clayey interbeds within the siltstone matrix are shown as high-value gamma peaks at depth intervals of 7 feet to 17 feet, 19 feet to 21.5 feet, 27 feet to 38.5 feet, 50.5 feet to 68 feet, 79 feet to 85 feet, and 87 feet to 93 feet. Most of these clayey zones also produce high-value SP peaks. The SP peak within the bottom clayey zone continues to the boring termination depth even though the gamma log decreases below 93 feet. This SP peak may be caused by interaction of drilling fluids with formation water

- Siltstone with decreased clay content is shown as low-value gamma peaks at depth intervals of 17 feet to 19 feet, 21.5 feet to 25 feet, 39.5 feet to 47 feet, 69 feet to 75 feet, and 96.5 feet to 99 feet. A siltstone zone from depths of 22.5 feet to 25 feet is unusually conductive as shown by a low-value resistance peak

- Possible cemented clayey siltstone lenses are shown as high-value peaks on the resistance log at depth intervals of 28 feet to 29.5

feet, 61.5 feet to 64.5 feet, and 84.5 feet to 94.5 feet. High-value resistance peaks probably indicate less porous material. High-value gamma peaks may indicate these zones are not sandstone. Hence, it is logical to assume that these peaks indicate cemented clayey siltstone in the bedrock.

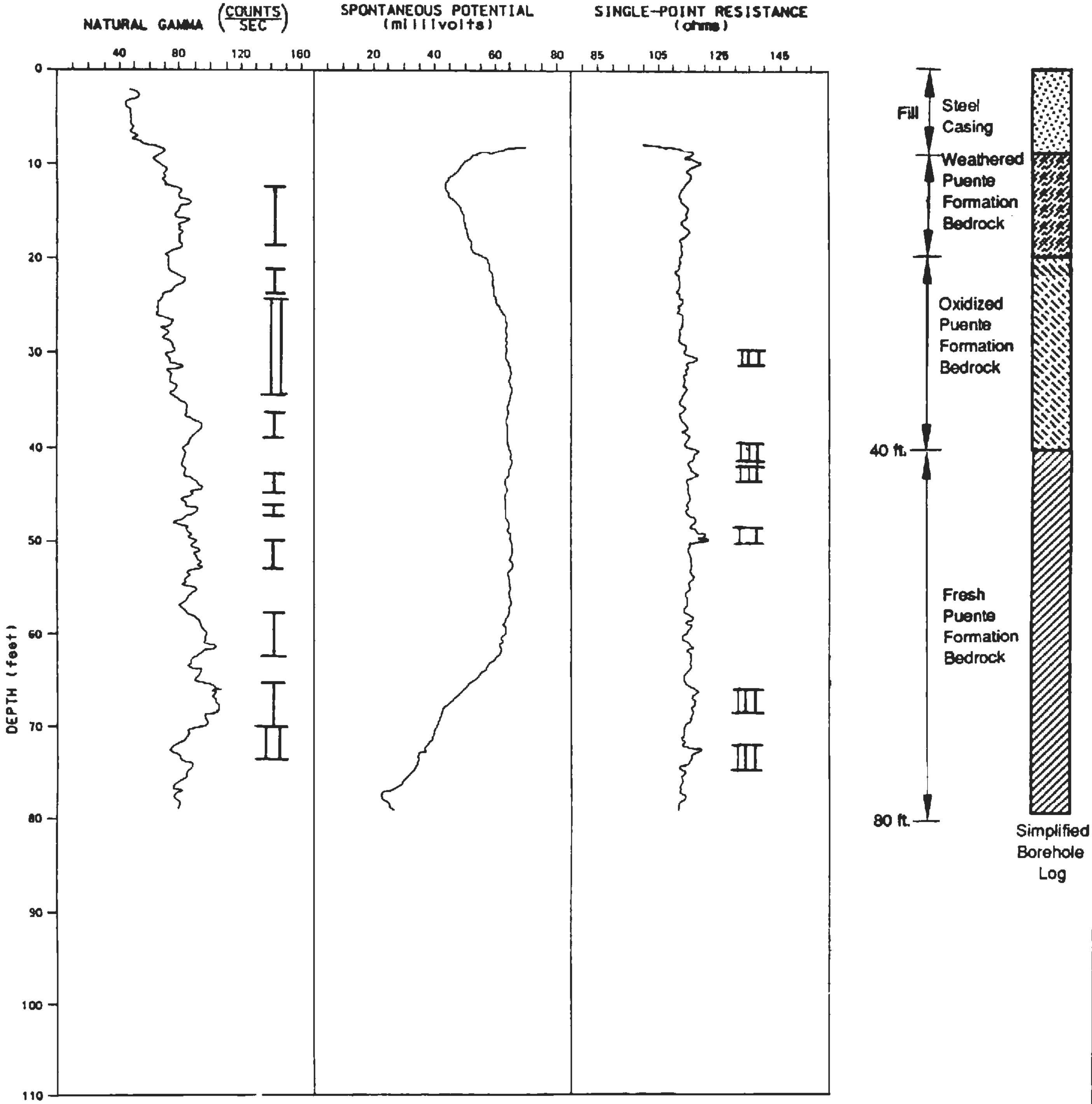
3.1.6.2 Boring PII-29. Figure 3-2 shows wireline data and interpreted results for Boring PII-29. Steel casing installed to a depth of about eight feet prevented collecting reliable wireline data near the surface. Puente Formation bedrock, which is predominately clayey siltstone/silty claystone is encountered at a depth of about nine feet. As indicated by gamma and resistance logs, bedrock material is relatively uniform to the boring termination depth. The logs show no major shifts, except thin localized fluctuations. An interface between fresh and oxidized Puente Formation bedrock was encountered at a depth of about 36 feet. This interface produced a slight shift toward higher values in the gamma log at a depth of 36 feet. Increased gamma values mean more clay content in fresh Puente Formation bedrock than the overlying oxidized unit. There were no resistance or SP changes at this interface. Wireline data terminated at a depth of 79.5 feet.

The gamma log generally increased slightly with depth and high-value peaks indicate zones of increased clay content. The resistance log remains relatively constant with thin, high-value peaks probably representing hard, cemented siltstone and sandstone lenses. Large variations in the SP log are probably related to the presence of organic materials. Stratigraphic features interpreted from the data are described below:

- Predominately clayey interbeds within the siltstone matrix are shown as high-value gamma peaks at depth intervals of 13 feet to 19 feet, 21.5 feet to 24 feet, 37 feet to 39 feet, 43.5 feet to 45 feet, 46.5 feet to 47.5 feet, 50 feet to 53 feet, 55 feet to 56.5 feet, and 58.5 feet to 62.5 feet

- Siltstone with decreased clay content is shown as a low-value gamma peak at the depth interval of 24 feet to 34 feet

- Possible cemented sandstone lenses are shown as high-value resistance peaks at depth intervals of 30 feet to 31.5 feet, 40 feet to 42 feet, 42.5 feet to 44 feet, 49 feet to 50.5 feet, and 72 feet to 74.5 feet. Corresponding low-value gamma peaks occur at all these intervals which strengthens the interpretation of these lenses being sandstone. A high-value resistance peak at the depth interval of nine feet to 11 feet is possibly due to the



Explanation

I - Increased clay content

II - Decreased clay content

III - Cementation

- Old Alluvium and Fill
- Weathered Puente Formation
- Oxidized Puente Formation
- Fresh Puente Formation

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Wireline Logging Data and Interpretation Boring PII-29

05-90

Figure 3-2

presence of gravel in the alluvium. The drilling log describes hard zones at depths of 8.5 feet, 50 feet, and 73 feet to 74 feet, and a cemented sandstone lens at a depth of 75.5 feet

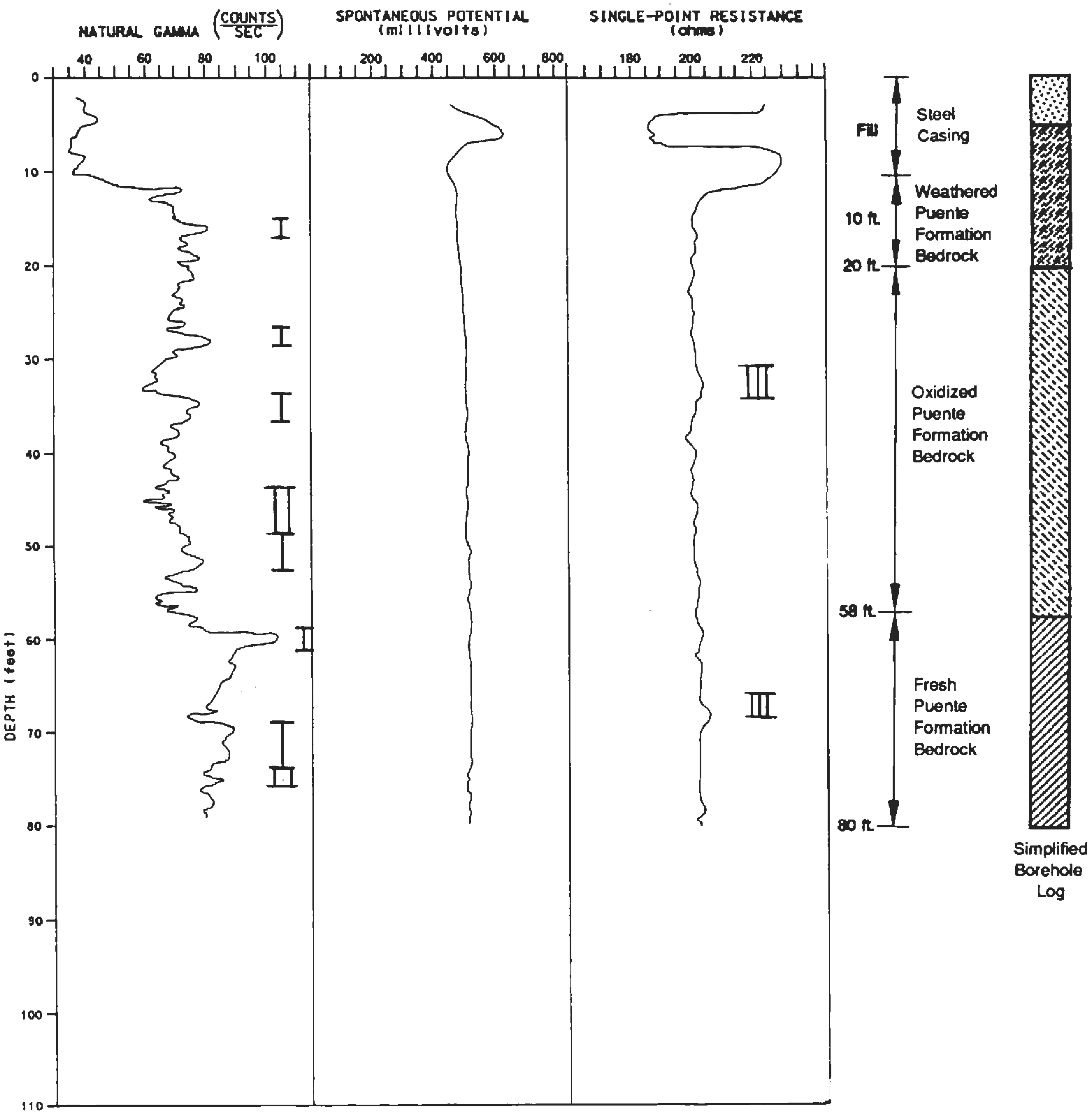
- There are high-value peaks in the gamma and resistance logs at a depth of 66 feet to 69.5 feet. This layer is probably less porous and may be localized cementation of the clayey siltstone. This zone is probably not a sandstone lens because of the high-value gamma peak. The drilling log describes drill chatter at a depth of 67.5 feet

- A steep decrease in the SP log between depths of eight feet and 11 feet is caused by casing effects. A relative low-value peak from depths of 11 feet to 19.5 feet could be caused by increased chemical activity of organic material described in the drilling log. This SP change is not thought to represent a material change because the gamma and resistance logs are relatively constant. A sharp decrease with depth below 62.5 feet may be due to chemical processes associated with the organic stains and gasoline odor described in the drilling log at depths of 60 feet and 80 feet, respectively.

3.1.6.3 Boring PII-35. Figure 3-3 shows wireline data and interpreted results for Boring PII-35. Steel casing installed to a depth of about 10 feet prevented collecting reliable wireline data near the surface. Gamma is low within the casing and SP and resistance show large-amplitude fluctuations due to casing effects. Low-value gamma peak from depths of 10 feet to 12 feet is probably caused by the sand layer described in the drilling log. Beneath the sand is Puente Formation bedrock which is predominately clayey siltstone/silty claystone with varying clay content at this boring, as seen by fluctuations in the gamma and resistnce logs. The top of the oxidized Puente Formation bedrock and the oxidized/fresh Puente Formation bedrock interface cause large positive shifts in the gamma log because each formation contains more clay content than the overlying material. Wireline data terminated at a depth of 81 feet.

The SP and resistance scales are small to accommodate the large-amplitude anomalies generated by the casing bottom. This small scale renders the SP featureless and the resistance peaks subdued.

Wireline data indicate there is not a major formation change at this boring. High-value gamma peaks probably indicate zones of increased clay content.



Explanation

I - Increased clay content

II - Decreased clay content

III - Cementation

- Old Alluvium and Fill

- Weathered Puente Formation

- Oxidized Puente Formation

- Fresh Puente Formation

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Wireline Logging Data and Interpretation Boring PII-35

05-90

Figure 3-3

High-value resistance peaks probably indicate cemented clayey siltstone. A slight increase in the SP log with depth below the water table probably indicates an increase in formation water salinity with depth. Stratigraphic features interpreted from the data are described below:

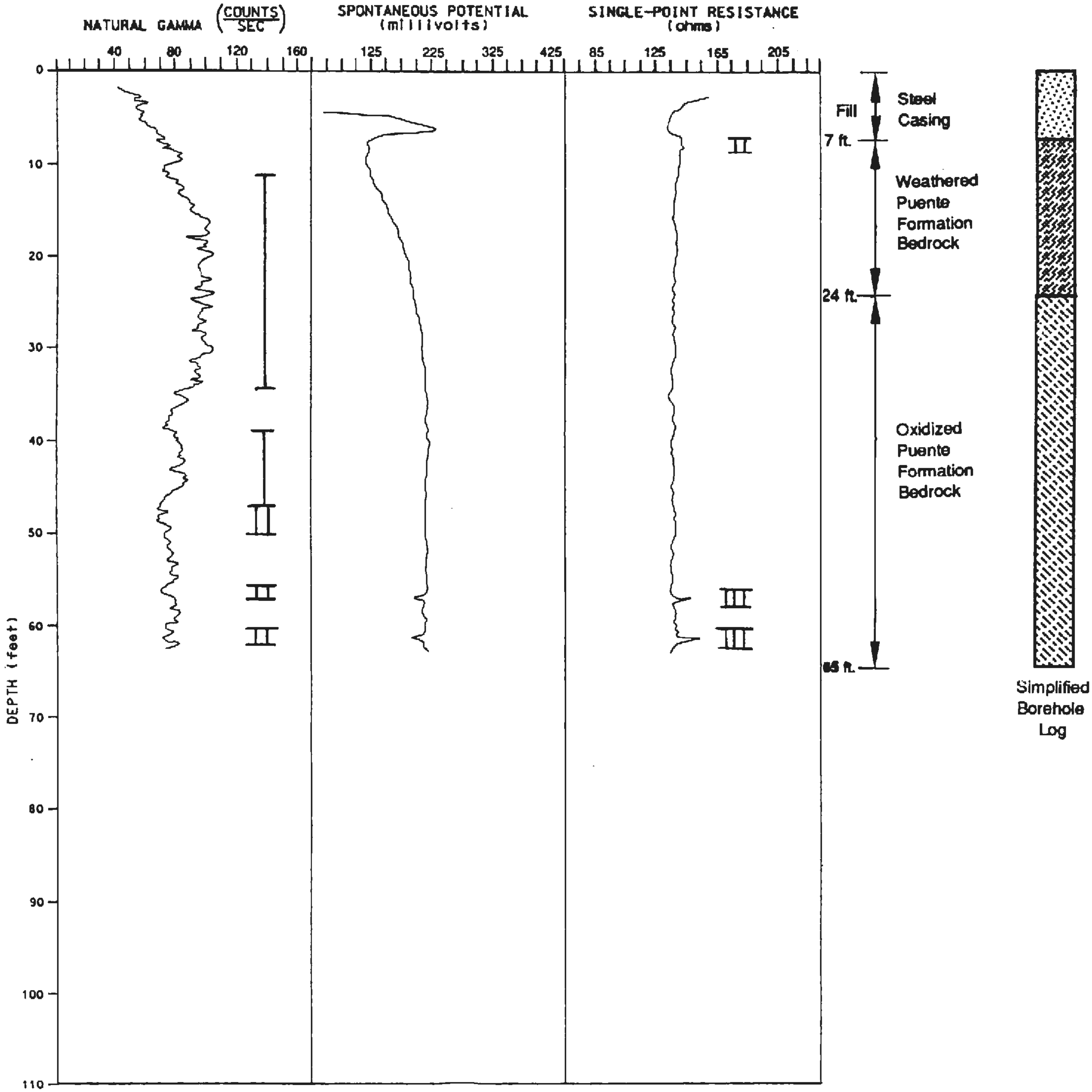
- Predominately clayey interbeds within the siltstone matrix are shown as high-value gamma peaks at depth intervals of 15.5 feet to 17 feet, 27 feet to 29 feet, 34 feet to 36.5 feet, 48.5 feet to 52.5 feet, 59 feet to 61 feet, and 69 feet to 74 feet.

- Siltstone with decreased clay content is shown as low-value gamma peaks at depth intervals of 43.5 feet to 47.5 feet, 55 feet to 57.5 feet, 74 feet to 75.5 feet, and 76 feet to 77 feet. The 43.5-foot to 47.5-foot interval is described in the drilling log as being cemented, but must be relatively poorly cemented because there is no resistance peak within this zone.

- Cemented siltstone lenses probably occur at depth intervals of 30 feet to 34 feet and 67 feet to 69 feet because there are low-value gamma and high-value resistance peaks within these zones. The drilling log describes cementation at 30 feet to 34 feet.

3.1.6.4 Boring PII-43. Figure 3-4 shows wireline data and interpreted results for Boring PII-43. Steel casing installed to a depth of about seven feet prevented collecting reliable wireline data near the surface. Gamma is low within the casing and SP and resistance logs show large-amplitude fluctuations at the casing bottom. Puente Formation bedrock, which is predominately clayey siltstone/silty claystone was encountered below the tip of the casing. Weathering is unusually deep at this boring. High-value gamma peaks at depths from seven feet to 34.5 feet indicate increased clay content that may be completely weathered Puente Formation bedrock. The corresponding low-value SP peak which steadily increases within this zone probably indicates increased chemical activity of minerals absorbed by the clay. A significant decrease in the gamma log below 34.5 feet indicates decreasing clay content below this depth. Wireline data terminated at 63 feet.

The SP and resistance scales are small to accommodate the large-amplitude anomalies generated by the casing bottom. This small scale renders the SP featureless and makes the resistance peaks subdued.



Explanation

I - Increased clay content

II - Decreased clay content

III - Cementation

- Old Alluvium and Fill

- Weathered Puente Formation

- Oxidized Puente Formation

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Wireline Logging Data and Interpretation Boring PII-43

05-90

Figure 3-4

Wireline data indicates there are no major shifts within the weathered or oxidized Puente Formation bedrock. The SP log is constant within the oxidized Puente Formation bedrock and the entire resistance log is constant. High-value resistance peaks near the bottom of the boring indicate decreased porosity usually associated with localized cemented sandstone lenses. Relevant stratigraphic features interpreted from the data are described below:

- A predominately clayey interbed within the siltstone matrix is shown as a high-value gamma peak at depth intervals of 12 feet to 34 feet and 39 feet to 46 feet.

- A siltstone matrix with decreased clay content is shown as low-value gamma peaks at depth intervals of 36 feet to 39 feet, 46 feet to 50 feet, 56 feet to 57.5 feet and 60 feet to 62 feet.

- Possible cemented sandstone lenses are shown as low-value gamma peaks and high-value resistance peaks at depth intervals of seven feet to 10 feet, 57 feet to 58 feet, and 61.5 feet to 63 feet. A low-value gamma peak indicates a predominate sand unit, and a high-value resistance peak usually means less porosity caused by cementation. The drilling log describes cementation at a depth of 12 feet. There are two low-value peaks in the SP log corresponding to high-value resistance peaks at depth intervals of 57 feet to 58 feet and 61.5 feet to 63 feet. These low-value SP peaks probably were caused by less interaction of drilling fluid with formation water due to decreased porosity.

3.1.6.5 Wireline Logging Interpretation Summary

In summary, wireline logging results closely reflect the subsurface conditions encountered in the borings and provide a continuous stratigraphic profile. Physical properties determined from laboratory analyses on samples can be interpolated between the discrete sampling points using the wireline results as a guide. Wireline data are especially useful in locating cemented sandstone and siltstone lenses and zones of increased clay content within the Puente Formation bedrock.

3.2 LABORATORY TESTING PROGRAM

A laboratory testing program was developed and performed on selected soil, bedrock, and water samples obtained in this investigation. The laboratory tests were intended to provide data for further refinement of subsurface conditions and associated engineering parameters, as well as to assess the extent of possible chemical contamination at the Vermont/Santa Monica Station site area. In general, the laboratory test program was developed to:

1. Aid in soil classification.
2. Obtain an initial assessment of engineering properties of the soils encountered in the investigation.
3. Provide a preliminary chemical characterization of selected soil and water samples.

3.2.1 Soil Mechanics Laboratory Testing

A series of soil mechanics laboratory tests was performed on selected representative samples. All tests were performed in accordance with applicable standard test methods specified by the ASTM, the U.S. Army Corps of Engineers, or the Environmental Protection Agency (EPA). The test program and procedures are summarized in Table 3-4.

The results of soil mechanics laboratory tests are presented in Appendix B. In addition, moisture content and dry density data are included in boring logs found in Appendix A. Results of the laboratory test data evaluation for the engineering properties of encountered subsurface materials are presented in Section 4.

3.2.2 Analytical (Chemical) Laboratory Testing

In addition to monitoring the background and headspace Organic Vapor Analyzer (OVA) readings of every soil sample, triple-meter monitoring was performed on samples with high OVA readings for indication of the potential presence of

TABLE 3-4. SUMMARY OF TESTS AND TEST PROCEDURES

Test Type	No. of Tests	Test Procedure
Visual Examination	Every sample	ASTM D 2488-84
Grain Size Distribution	33	ASTM D 422-63 and D 1140-54
Hydrometer Analysis	23	ASTM D 422-63
Unit Weight	116	ASTM D 2937-83
Moisture Content	116	ASTM D 2216-80
Specific Gravity	2	ASTM D 854-83
Atterberg Limit	37	ASTM D 4318-84
Direct Shear	52	ASTM D 3080-72
Permeability	3	ASTM D 2434-68 and EPA 9100
Consolidation	3	ASTM D 2435-80
Unconfined Compression	19	ASTM D 2166-85
Triaxial Compression	6	EM 110-2-1906[(a)] Appendix 10

Notes: (a) U.S. Army Corps of Engineers

hydrogen sulfide (H_2S) concentration, explosivity level, and carbon monoxide concentration during the field work. A limited analytical (chemical) laboratory testing program was also performed on selected soil and water samples. The chemical analysis program performed for the investigation is summarized in Table 3-5.

Results of the chemical analysis program are presented in Appendix C and summarized in Tables 3-6 through 3-13c. An evaluation of the results and the potential impacts on design and construction are presented in Section 4.

TABLE 3-5. SUMMARY OF ANALYTICAL LABORATORY ANALYSES

Test Type	Sample Type	No. of Tests	Test Procedure
Total Recoverable Petroleum Hydrocarbons (TRPH)	soil water	22 5(a)	EPA 418.1 EPA 418.1
Aromatic Organic Compounds (BTEX)	soil water	22 5(a)	EPA 8020 EPA 8020
Volatile Organic Compounds	soil	3	EPA 8240
Semivolatile Organic Compounds	soil	3	EPA 8270
CAM Metals	soil	3	California Metals
Sulfide	soil water	22 4	EPA 9030 EPA 9030
Sulfate	soil water	22 4	EPA 9038 EPA 9038
pH	water	4	EPA 9040

Notes: (a) Including one equipment field blank. The equipment field blank (EFB) is used to verify the cleaning procedure for sampling equipment. The equipment field blank was taken at the beginning of the sampling event.

TABLE 3-6. RESULTS OF CHEMICAL TESTS FOR SULFATE CONCENTRATIONS

Location/ Sample No.[a]	Sample Type	Sulfate Concentration (ppm)[b]	Detection Limit (ppm)	Potential Cement Type for Construction[c]
LPE-7 (Nov 88)	water	160	50	II
PII-26	water	10	10	Regular
PII-29	water	31	10	Regular
PII-35	water	100	10	Regular
PII-43	water	150	10	II
LPE-6/D-12 (Nov 88)	soil	1,100	50	II
LPE-7/D-7 (Nov 88)	soil	P[d]	50	Regular
PII-25/D-10	soil	710	10	Regular
PII-25/D-16	soil	920	10	Regular
PII-26/D-13	soil	210	10	Regular
PII-32/D-10	soil	480	10	Regular
PII-33/D-9	soil	960	10	Regular
PII-34/D-6	soil	68	10	Regular
PII-34/D-10	soil	100	10	Regular
PII-35/D-3	soil	80	10	Regular
PII-35/D-9	soil	60	10	Regular
PII-38/D-3	soil	280	10	Regular
PII-38/D-7	soil	190	10	Regular
PII-38/D-13	soil	43	10	Regular
PII-40/D-2	soil	290	10	Regular
PII-40/D-12	soil	43	10	Regular
PII-41/D-12	soil	53	10	Regular
PII-41/D-18	soil	340	10	Regular
PII-42/D-9	soil	220	10	Regular
PII-42/D-13	soil	58	10	Regular
PII-43/D-11	soil	130	10	Regular
PII-44/D-10	soil	45	10	Regular
PII-44/D-14	soil	120	10	Regular
PII-45/D-12	soil	120	10	Regular

Notes: (a) Dates of sampling and testing from 1988 investigation (LPE) are indicated in parenthesis.
(b) ppm = Parts per million.
(c) Cement types are based on recommendations specified in Uniform Building Code (UBC, 1988).
(d) P = Present in concentrations less than Detection Limits.

TABLE 3-7. RESULTS OF CHEMICAL TESTS FOR SULFIDE CONCENTRATIONS

Location/ Sample No.	Sample Type	Sulfide Concentration (ppm)[a]	Detection Limit (ppm)
LPE-7 (Nov 88)	water	P[b]	1
PII-26	water	ND[c]	1
PII-29	water	12	1
PII-35	water	2	1
PII-43	water	ND	1
LPE-6/D-12 (Nov 88)	soil	P	3
LPE-7/D-7 (Nov 88)	soil	P	3
PII-25/D-10	soil	7.2	1
PII-25/D-16	soil	12	1
PII-26/D-13	soil	5	1
PII-32/D-10	soil	3.7	1
PII-33/D-9	soil	15	1
PII-34/D-6	soil	ND	1
PII-34/D-10	soil	9.2	1
PII-35/D-3	soil	9.2	1
PII-35/D-9	soil	6.8	1
PII-38/D-3	soil	14	1
PII-38/D-7	soil	4.2	1
PII-38/D-13	soil	12	1
PII-40/D-2	soil	6.3	1
PII-40/D-12	soil	ND	1
PII-41/D-12	soil	2.8	1
PII-41/D-18	soil	ND	1
PII-42/D-9	soil	7.8	1
PII-42/D-13	soil	3.3	1
PII-43/D-11	soil	6.2	1
PII-44/D-10	soil	ND	1
PII-44/D-14	soil	13	1
PII-45/D-12	soil	8.7	1

Notes: (a) ppm = Parts per million.
(b) P = Present in concentrations less than Detection Limits.
(c) ND = Not detected.

TABLE 3-8. RESULTS OF CHEMICAL TESTS FOR pH IN WATER SAMPLES

Location	pH
PII-26	8.5
PII-29	7.0
PII-35	6.4
PII-43	6.4

TABLE 3-9. RESULTS OF CHEMICAL TESTS FOR AROMATIC ORGANIC COMPOUNDS (BTEX) CONCENTRATIONS

Location/ Sample No.	Sample Type	Concentration (ppb)[a] Benzene[b]	Toluene[b]	Ethylbenzene[b]	Xylenes[b]
LPE-7 (Nov 88)	water	3	3	3	ND[c]
E.F.B.[d]	water	ND	ND	ND	ND
PII-26	water	ND	ND	ND	ND
PII-29	water	ND	ND	ND	2.5
PII-35	water	ND	ND	21	4.5
PII-43	water	ND	ND	11	16
LPE-6/D-12 (Nov 88)	soil	ND	42	ND	5
LPE-7/D-7 (Nov 88)	soil	ND	ND	ND	ND
PII-25/D-10	soil	18	170	44	290
PII-25/D-16	soil	15	340	150	570
PII-26/D-13	soil	ND	33	5.6	48
PII-32/D-10	soil	36	320	120	490
PII-33/D-9	soil	P	29	8.2	62
PII-34/D-6	soil	37	400	270	740
PII-34/D-10	soil	ND	210	54	360
PII-35/D-3	soil	P	25	P[e]	36
PII-35/D-9	soil	P	17	P	27
PII-38/D-3	soil	P	28	5.9	44
PII-38/D-7	soil	P	16	P	29
PII-38/D-13	soil	13	180	53	350
PII-40/D-2	soil	ND	25	72	57
PII-40/D-12	soil	5.4	39	8.6	64
PII-41/D-13	soil	5.0	41	8.4	69
PII-41/D-18	soil	P	380	20.0	650
PII-42/D-9	soil	ND	33	8.2	67
PII-42/D-13	soil	P	31	7.1	54
PII-43/D-11	soil	5.8	40	8.4	65
PII-44/D-10	soil	P	25	5.7	39
PII-44/D-14	soil	P	19	4.0	31
PII-45/D-12	soil	ND	18	ND	34

Notes: (a) ppb = Parts per billion.
(b Cleanup action levels for BTEX concentrations are 300 ppb, 300 ppb, 1,000 ppb and 1,000 ppb for benzene, toluene, ethylbenzene and xylenes, respectively, as per leaching potential analysis specified in Table 2-1, Leaking Underground Fuel Tank (LUFT) Field Manual (California Water Resources Control Board, 1987).
(c) ND = Not detected. Detection limits for benzene, toluene, ethylbenzene and xylenes are 0.5, 1.0, 1.0 and 1.0 ppb for water samples, respectively. Detection limits for BTEX are 5 ppb for soil samples.
(d) E.F.B. = Equipment field blank. (Refer to Table 3-5 for explanation)
(e) P = Present in concentrations less than Detection Limits.

TABLE 3-10. RESULTS OF CHEMICAL TESTS FOR TOTAL RECOVERABLE PETROLEUM HYDROCARBONS (TRPH)[a] CONCENTRATIONS

Location/ Sample No.	Sample Type	Concentration (ppm)[b]	Detection Limit (ppm)
LPE-7 (Nov 88)	water	96	5
E.F.B.[c]	water	ND[d]	1
PII-26	water	ND	1
PII-29	water	34	1
PII-35	water	ND	1
PII-43	water	ND	1
LPE-6/D-12 (Nov 88)	soil	84	5
LPE-7/D-7 (Nov 88)	soil	120	5
PII-25/D-10	soil	220	5
PII-25/D-16	soil	150	5
PII-26/D-13	soil	30,000	5
PII-32/D-10	soil	6.0	5
PII-33/D-9	soil	8.0	5
PII-34/D-6	soil	P[e]	5
PII-34/D-10	soil	P	5
PII-35/D-3	soil	ND	5
PII-35/D-9	soil	ND	5
PII-38/D-3	soil	ND	5
PII-38/D-7	soil	ND	5
PII-38/D-13	soil	6.0	5
PII-40/D-2	soil	ND	5
PII-40/D-12	soil	ND	5
PII-41/D-12	soil	ND	5
PII-41/D-18	soil	18	5
PII-42/D-9	soil	ND	5
PII-42/D-13	soil	ND	5
PII-43/D-11	soil	ND	5
PII-44/D-10	soil	ND	5
PII-44/D-14	soil	ND	5
PII-45/D-12	soil	ND	5

Notes: (a) Cleanup action level for TRPH concentration ranges from 100 ppm to 1,000 ppm for soil samples as per leaching potential analysis as specified in Table 2-1, Leaking Underground Fuel Tank Field Manual (California Water Resources Control Board, 1987).
(b) ppm = Parts per million.
(c) E.F.B. = Equipment field blank. (Refer to Table 3-5 for explanation)
(d) ND = Not detected.
(e) P = Present in concentrations less than Detection Limits.

TABLE 3-11a. RESULTS OF CHEMICAL TESTS FOR SEMIVOLATILE ORGANICS CONCENTRATIONS BY GC/MS (EPA METHOD-8270) IN SOIL SAMPLE NO. D-10, BORING PII-25

Parameter	Concentration (ppm)(a)	Detection Limits (ppm)(a)	Parameter	Concentration (ppm)(a)	Detection Limits (ppm)(a)
Phenol	ND(b)	2.0	Acenaphthene	ND	2.0
Bis(2-chloroethyl)ether	ND	2.0	2,4-dinitrophenol	ND	10.0
2-chlorophenol	ND	2.0	4-nitrophenol	ND	10.0
1,3-dichlorobenzene	ND	2.0	Dibenzofuran	ND	2 0
1,4-dichlorobenzene	ND	2.0	2,4-dinitrotoluene	ND	2.0
Benzyl alcohol	ND	4.0	2,6-dinitrotoluene	ND	2.0
1,2-dichlorobenzene	ND	2.0	Diethylphthalate	ND	2.0
2-methylphenol	ND	2.0	4-chlorophenyl-phenylether	ND	2.0
Bis(2-chloroisopropyl)ether	ND	2.0	Fluorene	ND	2.0
4-methylphenol	ND	2.0	4-nitroaniline	ND	10.0
N-nitroso-di-n-propylamine	ND	2.0	4,6-dinitro-2-methylphenol	ND	10.0
Hexachloroethane	ND	2.0	N-nitrosodiphenylamine	ND	2.0
Nitrobenzene	ND	2.0	4-bromophenyl-phenylether	ND	2.0
Isophorone	ND	2.0	Hexachlorobenzene	ND	2.0
2-nitrophenol	ND	2.0	Pentachlorophenol	ND	10.0
2,4-dimethylphenol	ND	2.0	Phenanthrene	ND	2.0
Benzoic Acid	ND	10.0	Anthracene	ND	2.0
Bis-(2-chloroethoxy)methane	ND	2.0	Di-n-butylphthalate	ND	2.0
2,4-dichlorophenol	ND	2.0	Fluoranthene	ND	2.0
1,2,4-trichlorobenzene	ND	2.0	Pyrene	ND	2.0
Naphthalene	ND	2.0	Butylbenzylphthalate	ND	2.0
4-chloroaniline	ND	4.0	3,3'-dichlorobenzidine	ND	4.0
Hexachlorobutadiene	ND	2.0	Benzo(a)anthracene	ND	2.0
4-chloro-3-methylphenol	ND	4.0	Bis(2-ethylhexyl)phthalate	ND	2.0
2-methylnaphthalene	ND	2.0	Chrysene	ND	2.0
Hexachlorocyclopentadiene	ND	2.0	Di-n-octyl phthalate	ND	2.0
2,4,6-trichlorophenol	ND	2.0	Benzo(b)fluoranthene	ND	2.0
2,4,5-trichlorophenol	ND	2.0	Benzo(k)fluoranthene	ND	2.0
2-chloronaphthalene	ND	2.0	Benzo(a)pyrene	ND	2.0
2-nitroaniline	ND	10.0	Indeno(1,2,3-cd)pyrene	ND	2.0
Dimethyl phthalate	ND	2.0	Dibenz(a,h)anthracene	ND	2.0
Acenaphthylene	ND	2.0	Benzo(g,h,i)perylene	ND	2.0
3-nitroaniline	ND	10.0			

Notes: (a) ppm = Parts per million.
(b) ND = Not detected.

TABLE 3-11b. RESULTS OF CHEMICAL TESTS FOR SEMIVOLATILE ORGANICS CONCENTRATIONS BY GC/MS (EPA METHOD-8270) IN SOIL SAMPLE NO. D-9, BORING PII-35

Parameter	Concentration (ppm)[a]	Detection Limits (ppm)[a]	Parameter	Concentration (ppm)[a]	Detection Limits (ppm)[a]
Phenol	ND[b]	0.1	Acenaphthene	ND	0.1
Bis(2-chloroethyl)ether	ND	0.1	2,4-dinitrophenol	ND	0.5
2-chlorophenol	ND	0.1	4-nitrophenol	ND	0.5
1,3-dichlorobenzene	ND	0.1	Dibenzofuran	ND	0.1
1,4-dichlorobenzene	ND	0.1	2,4-dinitrotoluene	ND	0.1
Benzyl alcohol	ND	0.2	2,6-dinitrotoluene	ND	0.1
1,2-dichlorobenzene	ND	0.1	Diethylphthalate	ND	0.1
2-methylphenol	ND	0.1	4-chlorophenyl-phenylether	ND	0.1
Bis(2-chloroisopropyl)ether	ND	0.1	Fluorene	ND	0.1
4-methylphenol	ND	0.1	4-nitroaniline	ND	0.5
N-nitroso-di-n-propylamine	ND	0.1	4,6-dinitro-2-methylphenol	ND	0.5
Hexachloroethane	ND	0.1	N-nitrosodiphenylamine	ND	0.1
Nitrobenzene	ND	0.1	4-bromophenyl-phenylether	ND	0.1
Isophorone	ND	0.1	Hexachlorobenzene	ND	0.1
2-nitrophenol	ND	0.1	Pentachlorophenol	ND	0.5
2,4-dimethylphenol	ND	0.1	Phenanthrene	ND	0.1
Benzoic acid	ND	0.5	Anthracene	ND	0.1
Bis-(2-chloroethoxy)methane	ND	0.1	Di-n-butylphthalate	ND	0.1
2,4-dichlorophenol	ND	0.1	Fluoranthene	ND	0.1
1,2,4-trichlorobenzene	ND	0.1	Pyrene	ND	0.1
Naphthalene	ND	0.1	Butylbenzylphthalate	ND	0.1
4-chloroaniline	ND	0.2	3,3'-dichlorobenzidine	ND	0.2
Hexachlorobutadiene	ND	0.1	Benzo(a)anthracene	ND	0.1
4-chloro-3-methylphenol	ND	0.2	Bis(2-ethylhexyl)phthalate	ND	0.1
2-methylnaphthalene	ND	0.1	Chrysene	ND	0.1
Hexachlorocyclopentadiene	ND	0.1	Di-n-octyl phthalate	ND	0.1
2,4,6-trichlorophenol	ND	0.1	Benzo(b)fluoranthene	ND	0.1
2,4,5-trichlorophenol	ND	0.1	Benzo(k)fluoranthene	ND	0.1
2-chloronaphthalene	ND	0.1	Benzo(a)pyrene	ND	0.1
2-nitroaniline	ND	0.5	Indeno(1,2,3-cd)pyrene	ND	0.1
Dimethyl phthalate	ND	0.1	Dibenz(a,h)anthracene	ND	0.1
Acenaphthylene	ND	0.1	Benzo(g,h,i)perylene	ND	0.1
3-nitroaniline	ND	0.5			

<u>% Surrogate Recovery</u>

2-fluorophenol	46	2-fluorobiphenyl	76
Phenol-d_5	63	Terphenyl-d_{14}	112
Nitrobenzene-d_5	58		

Notes: (a) ppm = Parts per million.
(b) ND = Not detected.

TABLE 3-11c. RESULTS OF CHEMICAL TESTS FOR SEMIVOLATILE ORGANICS CONCENTRATIONS BY GC/MS (EPA METHOD-8270) IN SOIL SAMPLE NO. D-9, BORING PII-42

Parameter	Concentration (ppm)[a]	Detection Limits (ppm)[a]	Parameter	Concentration (ppm)[a]	Detection Limits (ppm)[a]
Phenol	ND[b]	0.1	Acenaphthene	ND	0.1
Bis(2-chloroethyl)ether	ND	0.1	2,4-dinitrophenol	ND	0.5
2-chlorophenol	ND	0.1	4-nitrophenol	ND	0.5
1,3-dichlorobenzene	ND	0.1	Dibenzofuran	ND	0.1
1,4-dichlorobenzene	ND	0.1	2,4-dinitrotoluene	ND	0.1
Benzyl alcohol	ND	0.2	2,6-dinitrotoluene	ND	0.1
1,2-dichlorobenzene	ND	0.1	Diethylphthalate	ND	0.1
2-methylphenol	ND	0.1	4-chlorophenyl-phenylether	ND	0.1
Bis(2-chloroisopropyl)ether	ND	0.1	Fluorene	ND	0.1
4-methylphenol	ND	0.1	4-nitroaniline	ND	0.5
N-nitroso-di-n-propylamine	ND	0.1	4,6-dinitro-2-methylphenol	ND	0.5
Hexachloroethane	ND	0.1	N-nitrosodiphenylamine	ND	0.1
Nitrobenzene	ND	0.1	4-bromophenyl-phenylether	ND	0.1
Isophorone	ND	0.1	Hexachlorobenzene	ND	0.1
2-nitrophenol	ND	0.1	Pentachlorophenol	ND	0.5
2,4-dimethylphenol	ND	0.1	Phenanthrene	ND	0.1
Benzoic acid	ND	0.5	Anthracene	ND	0.1
Bis-(2-chloroethoxy)methane	ND	0.1	Di-n-butylphthalate	ND	0.1
2,4-dichlorophenol	ND	0.1	Fluoranthene	ND	0.1
1,2,4-trichlorobenzene	ND	0.1	Pyrene	ND	0.1
Naphthalene	ND	0.1	Butylbenzylphthalate	ND	0.1
4-chloroaniline	ND	0.2	3,3'-dichlorobenzidine	ND	0.2
Hexachlorobutadiene	ND	0.1	Benzo(a)anthracene	ND	0.1
4-chloro-3-methylphenol	ND	0.2	Bis(2-ethylhexyl)phthalate	ND	0.1
2-methylnaphthalene	ND	0.1	Chrysene	ND	0.1
Hexachlorocyclopentadiene	ND	0.1	Di-n-octyl phthalate	ND	0.1
2,4,6-trichlorophenol	ND	0.1	Benzo(b)fluoranthene	ND	0.1
2,4,5-trichlorophenol	ND	0.1	Benzo(k)fluoranthene	ND	0.1
2-chloronaphthalene	ND	0.1	Benzo(a)pyrene	ND	0.1
2-nitroaniline	ND	0.5	Indeno(1,2,3-cd)pyrene	ND	0.1
Dimethyl phthalate	ND	0.1	Dibenz(a,h)anthracene	ND	0.1
Acenaphthylene	ND	0.1	Benzo(g,h,i)perylene	ND	0.1
3-nitroaniline	ND	0.5			

% Surrogate Recovery

2-fluorophenol	84	2-fluorobiphenyl	114
Phenol-d_5	93	Terphenyl-d_{14}	114
Nitrobenzene-d_5	98		

Notes: (a) ppm = Parts per million.
(b) ND = Not detected.

TABLE 3-12a. RESULTS OF CHEMICAL TESTS FOR VOLATILE ORGANICS CONCENTRATIONS BY GC/MS (EPA METHOD 8240) IN SOIL SAMPLE NO. D-10, BORING PII-25

Parameters (8240)	Concentration (ppb)[a]	Detection Limit (ppb)
Acetone	ND[b]	200
Benzene[c]	40	10
Bromodichloromethane	ND	10
Bromoform	ND	10
Bromomethane	ND	50
2-butanone (MEK)	ND	100
Carbon disulfide	ND	10
Carbon tetrachloride	ND	10
Chlorobenzene	ND	10
Chlorodibromomethane	ND	10
Chloroethane	ND	50
2-chloroethyl vinyl ether	ND	10
Chloroform	ND	10
Chloromethane	ND	50
1,1-dichloroethane	ND	10
1,2-dichloroethane	ND	10
1,1-dichloroethene	ND	10
1,2-dichloroethene (total)	ND	10
1,2-dichloropropane	ND	10
Cis-1,3-dichloropropene	ND	10
Trans-1,3-dichloropropene	ND	10
Ethylbenzene[c]	ND	10
2-hexanone	ND	100
Methylene chloride	ND	200
4-methyl-2-pentanone (MIBK)	ND	50
Styrene	ND	10
1,1,2,2-tetrachloroethane	ND	10
Tetrachloroethene	ND	10
Toluene[c]	85	10
1,1,1-trichloroethane	ND	10
1,1,2-trichloroethane	ND	10
Trichloroethene	ND	10
Trichlorofluoromethane	ND	50
Vinyl acetate	ND	100
Vinyl chloride	ND	50
Xylenes (total)[c]	100	10
% Surrogate Recovery		
1,2-dichloroethane d4	92	
Toluene-d8	93	
Bromofluorobenzene	64	

Notes: (a) ppb = Parts per billion.
(b) ND = Not detected.
(c) Refer to Table 3-9 for action levels for benzene, toluene, ethylbenzene and xylenes concentrations.

TABLE 3-12b. RESULTS OF CHEMICAL TESTS FOR VOLATILE ORGANICS CONCENTRATIONS BY GC/MS (EPA METHOD 8240) IN SOIL SAMPLE NO. D-9, BORING PII-35

Parameters (8240)	Concentration (ppb)[a]	Detection Limit (ppb)
Acetone	ND[b]	200
Benzene[c]	ND	10
Bromodichloromethane	ND	10
Bromoform	ND	10
Bromomethane	ND	50
2-butanone (MEK)	ND	100
Carbon disulfide	ND	10
Carbon tetrachloride	ND	10
Chlorobenzene	ND	10
Chlorodibromomethane	ND	10
Chloroethane	ND	50
2-chloroethyl vinyl ether	ND	10
Chloroform	ND	10
Chloromethane	ND	50
1,1-dichloroethane	ND	10
1,2-dichloroethane	ND	10
1,1-dichloroethene	ND	10
1,2-dichloroethene (total)	ND	10
1,2-dichloropropane	ND	10
Cis-1,3-dichloropropene	ND	10
Trans-1,3-dichloropropene	ND	10
Ethylbenzene[c]	ND	10
2-hexanone	ND	100
Methylene chloride	ND	200
4-methyl-2-pentanone (MIBK)	ND	50
Styrene	ND	10
1,1,2,2-tetrachloroethane	ND	10
Tetrachloroethene	ND	10
Toluene[c]	25	10
1,1,1-trichloroethane	ND	10
1,1,2-trichloroethane	ND	10
Trichloroethene	ND	10
Trichlorofluoromethane	ND	50
Vinyl acetate	ND	100
Vinyl chloride	ND	50
Xylenes (total)[c]	ND	10
<u>% Surrogate Recovery</u>		
1,2-dichloroethane d4	97	
Toluene-d8	105	
Bromofluorobenzene	89	

Notes: (a) ppb = Parts per billion.
(b) ND = Not detected.
(c) Refer to Table 3-9 for action levels for benzene, toluene, ethylbenzene and xylenes concentrations.

TABLE 3-12c. RESULTS OF CHEMICAL TESTS FOR VOLATILE ORGANICS CONCENTRATIONS BY GC/MS (EPA METHOD 8240) IN SOIL SAMPLE NO. D-9, BORING PII-42

Parameters (8240)	Concentration (ppb)[a]	Detection Limit (ppb)
Acetone	ND[b]	200
Benzene[c]	ND	10
Bromodichloromethane	ND	10
Bromoform	ND	10
Bromomethane	ND	50
2-butanone (MEK)	ND	100
Carbon disulfide	ND	10
Carbon tetrachloride	ND	10
Chlorobenzene	ND	10
Chlorodibromomethane	ND	10
Chloroethane	ND	50
2-chloroethyl vinyl ether	ND	10
Chloroform	ND	10
Chloromethane	ND	50
1,1-dichloroethane	ND	10
1,2-dichloroethane	ND	10
1,1-dichloroethene	ND	10
1,2-dichloroethene (total)	ND	10
1,2-dichloropropane	ND	10
Cis-1,3-dichloropropene	ND	10
Trans-1,3-dichloropropene	ND	10
Ethylbenzene[c]	ND	10
2-hexanone	ND	100
Methylene chloride	ND	200
4-methyl-2-pentanone (MIBK)	ND	50
Styrene	ND	10
1,1,2,2-tetrachloroethane	ND	10
Tetrachloroethene	ND	10
Toluene[c]	25	10
1,1,1-trichloroethane	ND	10
1,1,2-trichloroethane	ND	10
Trichloroethene	ND	10
Trichlorofluoromethane	ND	50
Vinyl acetate	ND	100
Vinyl chloride	ND	50
Xylenes (total)[c]	ND	10
<u>% Surrogate Recovery</u>		
1,2-dichloroethane d4	90	
Toluene-d8	102	
Bromofluorobenzene	86	

Notes: (a) ppb = Parts per billion.
(b) ND = Not detected.
(c) Refer to Table 3-9 for action levels for benzene, toluene, ethylbenzene and xylenes concentrations.

TABLE 3-13a. RESULTS OF CHEMICAL TESTS FOR CAM METALS CONCENTRATIONS IN SOIL SAMPLE NO. D-10, BORING PII-25

	Concentration (ppm)[a]		
Substances	PII-25/D-10	Detection Limit	Cleanup Action Level[b]
Antimony	P[c]	5.0	500
Arsenic	8.9	1.0	500
Barium	11	5.0	10,000
Beryllium	P	1.0	75
Cadmium	5.3	1.0	100
Chromium - Total	14	1.0	500
Cobalt	9.5	1.0	8,000
Copper	51	1.0	2,500
Lead	11	1.0	1,000
Mercury	ND	0.05	20
Molybdenum	2.9	1.0	3,500
Nickel	21	1.0	2,000
Selenium	2.3	1.0	100
Silver	P	1.0	500
Thallium	8.8	1.0	700
Vanadium	21	5.0	2,400
Zinc	70	1.0	5,000

Notes: (a) ppm = Parts per million.
(b) California Code of Regulations, Title 22, Section 66699.
(c) P = Present in concentrations less than Detection Limits.

TABLE 3-13b. RESULTS OF CHEMICAL TESTS FOR CAM METALS CONCENTRATIONS IN SOIL SAMPLE NO. D-9, BORING PII-35

Substances	Concentration (ppm)[a] PII-35/D-9	Detection Limit	Cleanup Action Level[b]
Antimony	P[c]	5.0	500
Arsenic	9.4	1.0	500
Barium	95	5.0	10,000
Beryllium	P	1.0	75
Cadmium	5.4	1.0	100
Chromium - Total	14	1.0	500
Cobalt	7.3	1.0	8,000
Copper	27	1.0	2,500
Lead	9.2	1.0	1,000
Mercury	ND	0.05	20
Molybdenum	1.2	1.0	3,500
Nickel	25	1.0	2,000
Selenium	ND	1.0	100
Silver	P	1.0	500
Thallium	8.1	1.0	700
Vanadium	21	5.0	2,400
Zinc	130	1.0	5,000

Notes: (a) ppm = Parts per million.
(b) California Code of Regulations, Title 22, Section 66699.
(c) P = Present in concentrations less than Detection Limits.

TABLE 3-13c. RESULTS OF CHEMICAL TESTS FOR CAM METALS CONCENTRATIONS IN SOIL SAMPLE NO. D-9, BORING PII-42

Substances	Concentration (ppm)[a] PII-42/D-9	Detection Limit	Cleanup Action Level[b]
Antimony	P[c]	5.0	500
Arsenic	9.6	1.0	500
Barium	100	5.0	10,000
Beryllium	P	1.0	75
Cadmium	4.6	1.0	100
Chromium - Total	17	1.0	500
Cobalt	4.1	1.0	8,000
Copper	27	1.0	2,500
Lead	14	1.0	1,000
Mercury	ND	0.05	20
Molybdenum	1.8	1.0	3,500
Nickel	17	1.0	2,000
Selenium	P	1.0	100
Silver	ND	1.0	500
Thallium	9.8	1.0	700
Vanadium	30	5.0	2,400
Zinc	87	1.0	5,000

Notes: (a) ppm = Parts per million.
(b) California Code of Regulations, Title 22, Section 66699.
(c) P = Present in concentrations less than Detection Limits.

4.0 Geologic and Subsurface Conditions

4.0 GEOLOGIC AND SUBSURFACE CONDITIONS

4.1 GEOLOGIC SETTING AND CONDITIONS

The MOS-2 alignment is located within the Los Angeles Basin, as defined by Yerkes et al. (1965), based on tectonic or structural blocks. As shown in Figure 4-1, the basin so defined can be further subdivided into four structural blocks including the Northwestern Block, the Northeastern Block, the Central Block, and the Southwestern Block. The planned Vermont/Santa Monica Station and adjacent tunnel segments are within the Central Block, which is bounded on the north by the Santa Monica-Raymond Hill Fault zones, on the northeast and east by the Whittier-Elsinore Fault zones, and on the west-southwest by the Newport-Inglewood Fault zones (Figure 4-1).

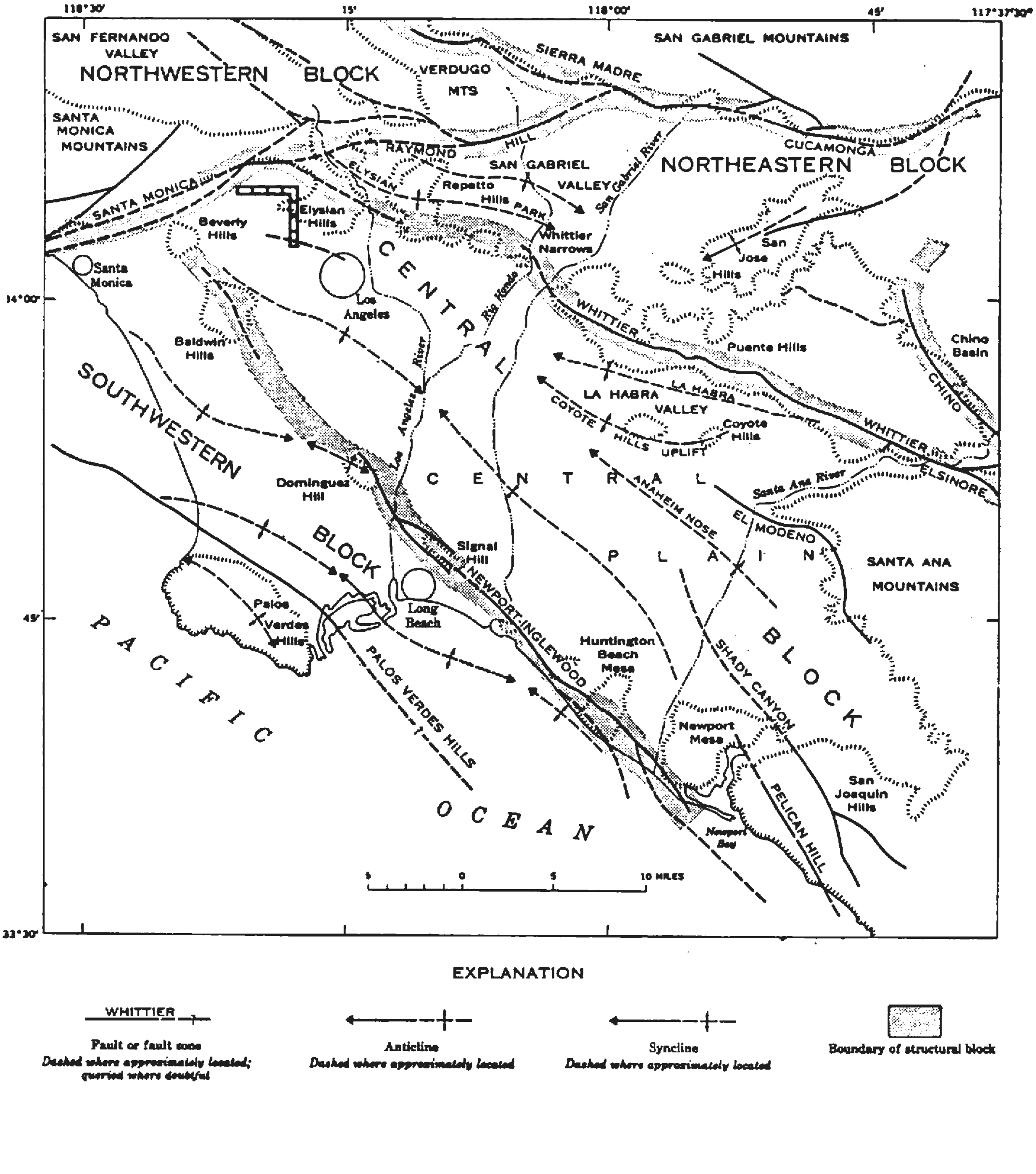
4.2 STRATIGRAPHY AND GEOLOGY

4.2.1 Regional Stratigraphy and Geology

The Central Block of the Los Angeles Basin is underlain by a deep structural depression filled with the following geologic units, in order of deposition:

- Puente Formation (Tp): The Upper Miocene bedrock underlying the area consists predominantly of stratified and weakly interbedded claystone, siltstone, and sandstone. The materials in the Puente Formation are generally low-strength (weak) rocks with a local presence of hard sandstone beds which may range from fractions of an inch to several feet or more. Up to the top 15 feet of the Puente Formation bedrock may be completely weathered (Tpw) and may exhibit soil-like characteristics with little or no cementation and without distinguishable bedding planes. This weathered zone is underlain by an approximate 10- to 50-foot-thick moderately to slightly weathered or oxidized (Tpo) portion of the bedrock that is cemented to some extent and has distinguishable bedding planes that range from easily separable to intact. The lowest portion of the bedrock is unoxidized and fresh (Tpf), generally has well-defined bedding planes, and is generally moderately cemented.

- Fernando Formation (Tf): This Pliocene sediment consists of massive and well-bedded claystone, siltstone, and sandstone,



Adopted from Yerkes et al. (1965)

The Earth Technology Corporation

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Vermont/Santa Monica Station and Tunnel

Major Structural Features in Los Angeles Basin

05-90

Figure 4-1

overlying the Puente Formation. The contact is mostly gradational and difficult to locate. This formation was not encountered in the geotechnical investigation performed for the Phase II alignment.

- Old Alluvium (A3 and A4): These Pleistocene sediments consist of granular alluvium (A3) deposited in relatively "swift" water environments, and fine-grained alluvium (A4) deposited in relatively "quiet" water environments. The granular Old Alluvium consists primarily of medium-dense to very dense clean sand, silty sand, gravelly sand, sandy gravel, and gravel. The fine-grained Old Alluvium consists primarily of medium-stiff to very hard clay, silty clay, sandy clay, silt, clayey silt, and clayey sand.

- Young Alluvium (A1 and A2): These Holocene sediments consist of granular alluvium (A1) deposited in relatively "swift" water environments and fine-grained alluvium (A2) deposited in relatively "quiet" water environments. The granular Young Alluvium consists predominantly of loose to dense clean sand, silty sand, gravelly sand, and sandy gravel, with a potential local presence of cobbles and boulders. The fine-grained Young Alluvium consists of firm to hard clay, silty clay, silt, clayey silt, and clayey sand, with a local presence of traces of gravel.

The margins of the basin and its four blocks are formed by zones of folding and uplifting along basin/block-bounding faults, including the Santa Monica-Raymond Hill, Whittier-Elsinore, and Newport-Inglewood Fault zones. In addition, there exist several major geologic features which are mostly inferred and not well delineated. Within the Central Block and adjacent to the MOS-2 alignment, major geologic features include the Santa Monica Fault zone and the Los Angeles Anticline. The Santa Monica Fault zone forms the northwestern boundary of the Los Angeles Basin's Central Block. The presence of the fault zone is not disputed; however, the actual surface location of this fault zone with respect to the MOS-2 alignment is not known.

The Los Angeles Anticline is a gentle upfold in the Puente Formation and trends about N 70° W, which influences the dip of bedrock strata in the area. This anticline acts as a trap for oil and gas within the Puente Formation. The Los Angeles City Oil Field is within this anticline. For the most part, this oil field has been abandoned except near the east end of the oil field (about 15,000 feet east of the MOS-2 alignment), where several producing wells exist. The oil field traverses Vermont Avenue between Second and Fourth streets along the MOS-2 alignment. Thus, the closest known boundaries of the oil field are about 3,000 feet from the southern end of the planned Beverly-Santa Monica Tunnel segment. Although the known production zones (150 feet or deeper below the ground surface) are deeper than the invert depths of the MOS-2 alignment (100 feet or less below the ground surface), the potential presence of trapped oil, tar, or gas in the Puente Formation bedrock within the construction depths of the alignment cannot be eliminated because of the proximity of the alignment to the Los Angeles City Oil Field.

4.2.2 Site Stratigraphy and Geology

The results of this investigation and available data in the project data file (Section 2.4) indicate the geologic units encountered in the site area consist of Old Alluvium (A3 and A4) and bedrock of the Puente Formation (Tp). A more detailed description of these subsurface materials is provided in Section 4.3

The southern end of the site area is located approximately 2,000 feet north of the crest of the Los Angeles Anticline. The closest known oil production field is the Los Angeles City Oil Field, with the closest known boundaries about 3,000 feet south of the site area. There is an inferred fault projecting toward the site area. This fault proceeds northwesterly from the Los Angeles downtown area, along the south slope of the Elysian Hills, and is mappable up to the Santa Monica Boulevard/Hoover Street intersection area, approximately 2,000 feet east of the alignment.

4.3 SUBSURFACE CONDITIONS

4.3.1 Subsurface Soils and Rocks

The alignment (planned station and tunnel segments) is located in a relatively well-developed area. Selection of borehole locations was restricted by the presence of existing buildings, underground utilities, and extent of cooperation given by private property owners. The borings performed for this investigation were located as close as possible to the alignment. The boring penetration depths were selected to be about 30 feet below the planned tunnel invert depths and about 40 feet below the planned bottom slab elevation (MRTC, 1988) in the station at the time of the field investigation. The field work for 20 of the 21 borings was completed by May 7, 1989. The last boring was completed on June 30, 1989. Since the completion of the first 20 borings, the tunnel invert and bottom slab elevations were revised to be about 10 feet to 20 feet deeper than before. As a result, and as can be seen from Figures 2-2, 2-3 and 2-4, and Table 3-1, the penetration depths of these borings were generally about 20 feet below the planned tunnel invert elevations and about 30 feet below the planned station bottom slab elevation.

Borings from a previous investigation (Earth Technology, 1988) and borings completed for the proposed Vermont/Beverly Station (Earth Technology, 1990c) and the Vermont/Sunset Station (Earth Technology, 1990d) were also used to evaluate the subsurface conditions. Locations and logs of these borings (PII-23 and PII-46, LPE-6 and LPE-7) are included in Appendix A. The following sections provide detailed descriptions of the planned Beverly-Santa Monica Tunnel, the Vermont/Santa Monica Station and the Santa Monica-Sunset Tunnel, separately.

4.3.1.1 Beverly-Santa Monica Tunnel. Based on the results of this investigation and other available data, a generalized cross-sectional profile of the subsurface materials along the Beverly-Santa Monica Tunnel alignment is shown in Figure 2-2. As can be seen from this figure, the stratigraphy along the tunnel beneath approximately 3- to 12-inch-thick asphalt/concrete pavement generally consists of shallow fill zones and Old Alluvium overlying the Puente Formation bedrock. The shallow fill zones are about 0 feet to eight feet thick and consist of coarse, granular base course materials or silty sand, or fine-grained clayey backfill materials.

The thickness of the Old Alluvium along this tunnel alignment ranges from a few inches (at Boring PII-27) to about 16.5 feet (at Boring LPE-6). Besides being nonuniform in nature, the materials in the Old Alluvium along the tunnel alignment are variable in type and consistency. However, for design and construction purposes, they can be generally categorized to consist predominantly of dense to very dense sand, silty sand, and sandy silt (granular Old Alluvium, Unit A3) with an occasional thin zone of gravel interspersed with layers of stiff to very stiff silty clay, clayey silt, and clayey sand (fine-grained Old Alluvium, Unit A4). It should be noted that the clayey sand encountered in the tunnel alignment as well as in the station area was categorized into Unit A4, since the fines content of this material in the general area was found to range from about 35 percent to 50 percent with significant plasticity, which should exhibit engineering behavior similar to fine-grained clayey soil. When clayey sand was found to have a fine content less than about 35 percent, it was included in Unit A3 (granular Old Alluvium).

The Puente Formation bedrock in this segment consists predominantly of claystone, clayey siltstone, and sandy siltstone with weak and mostly thinly bedded sandstone interbeds. The sandstone interbeds comprise up to about 30 percent of the bedrock. These sandstone interbeds are mostly weakly cemented with thicknesses generally on the order of fractions of an inch, except for the infrequent presence of hard sandstone beds of up to about one foot thick, as evidenced by the chattering of the drill rod observed in the drilling operation (noted in the boring logs presented in Appendix A). Based on available results of an unconfined compression test on a hard sandstone sample (Boring PII-14, Wilshire-Beverly Tunnel; Earth Technology, 1990b), and data from similar conditions elsewhere (e.g., Los Angeles City Flood Control District's (LACFCD) Sacatella Tunnel (LACFCD, 1973, CWDD/ESA/GRC, 1981) and Metropolitan Water District's Tonner Tunnel (MWD, 1976), the unconfined compression strength of the hard sandstone interbeds may range from 5,000 psi to 20,000 psi, or more.

Although not encountered during drilling operations in the site area, the possible presence of thick, high-strength sandstone and conglomerate beds, similar to those found in the Wilshire-Beverly Tunnel alignment, LACFCD's nearby Sacatella Tunnel, and in MWD's Tonner Tunnel, cannot be eliminated in the planned station and tunnel segments.

The dip angles of the bedrock ranged from 0 degrees to 15 degrees and were predominantly in the range of 0 degrees to 5 degrees. The strike of the bedding planes was not determined during the field operations. However, the regional trend of both anticlines described in section 4.2.2 would indicate an approximate N 70° W strike. The dip direction of bedding planes was not determined. The location of the tunnel with respect to the Los Angeles Anticline would indicate a northeasterly dip to be most likely.

In this tunnel segment, the thin sandstone interbeds and the dipping weakly intact bedding planes in the bedrock may dictate the following behavioral features:

1. Their presence indicates that engineering properties, in terms of strength and permeability, are anisotropic.

2. Their shear strengths are lower than the remaining bedrock (claystone and clayey siltstone).

3. They are more permeable and may act as preferred pathways for groundwater flow.

In this tunnel segment, the top 15 feet to 40 feet of the Puente Formation is oxidized and shows varying degrees of weathering. Highly weathered Puente Formation (Tpw) materials were encountered in the top 15 feet of this zone at Borings PII-28, PII-29, PII-30, and PII-34, and were found to consist of materials similar to silty clay, clayey silt, sandy silt, and silty sand. The weathered Puente Formation materials are soil-like with little or no cementation and with undistinguishable bedding planes. The Puente Formation bedrock in the other portion of the oxidized/weathered zone is oxidized (Tpo) and cemented to some extent and generally has distinguishable bedding planes which range from intact to easily separable. The bedrock below the oxidized Puente Formation is unweathered and nonoxidized (fresh Puente Formation-Unit Tpf). From an engineering viewpoint, both oxidized and fresh Puente Formation materials in the site area have similar engineering properties and behavior.

As shown in Figure 2-2, the currently planned tunnel along this tunnel segment is within either the fresh or the oxidized Puente Formation bedrock.

4.3.1.2 Vermont/Santa Monica Station. As shown on Figure 2-3, the subsurface materials encountered in the Vermont/Santa Monica Station area are similar to those described in Section 4.3.1.1. However, the following specific features of the stratigraphy in the station area are observed:

- The thickness of the Old Alluvium ranges from about five feet at PII-35 to about 44 feet at PII-39. Below the Old Alluvium, the thickness of highly weathered Puente Formation bedrock ranges from about 10 feet to 20 feet. Highly weathered Puente Formation bedrock materials encountered in the station area consist mostly of silty clay and clayey sand with zones of silty sand. These silty sand zones are mostly under the observed perched groundwater levels and are more permeable when compared with the other materials in the unit

- The dip angles of the bedding planes show considerable variation along the station area. The dip angles of the bedrock were observed to range from about 0 degrees to 15 degrees and to be predominantly in the range of 0 degrees to 10 degrees. However, some of the samples obtained from Borings PII-35, PII-36, PII-38 and PII-39 showed localized steeping and erratically varying dip angles at different depth intervals. In some of the samples from the above-mentioned borings, bedding planes were not very apparent (Boring PII-35/Sample P-10, Boring PII-39/Sample S-16) and, occasionally, dip angles within the same sample varied erratically (Boring PII-39/Sample D-15). Such localized dip variation may be due to either soft sediment deformation or thrusting (faulting) at low angles to bedding. Soft sediment deformation is associated with deformation triggered by earthquake, gravity or other loading (such as wave loading) before the sediment was lithified, and is common in tectonically active basins such as the Los Angeles Basin. No weak clay gouge is developed in such a soft sediment deformation process. However, thrusting at low angles to the bedding can also yield similar dip variations and, if faulting occurs after lithification, may develop clay gouge along the fault surface and beddings. Clay gouge generally has very low shear strength (an effective friction angle of about 7 degrees to 10 degrees or less) and can cause blocks of materials to slide and pop out along bedding planes if they are adversely oriented with respect to the station excavation. Although a detailed examination of the samples obtained from the above-mentioned borings indicates the absence of such gouge materials, it is prudent that periodic mapping be performed during station excavation to monitor the presence or absence of such materials and appropriate remedial measures be taken when gouge is detected. It should also be noted that dip directions were not determined during this field investigation. If bedding planes dip into the station excavation at steep angles, they will significantly increase lateral earth pressure on shored walls. If such steep dip angles are observed consistently during station excavation, appropriate measures should be taken to increase the lateral resistance of shored walls.

4.3.1.3 Santa Monica-Sunset Tunnel. Subsurface conditions in this tunnel segment, shown in Figure 2-4, are very similar to those in the Beverly-Santa Monica Tunnel, with a notable exception found at the vicinity of Boring PII-44. As indicated by boring log data, the Old Alluvium thickness extends up to about 80 feet at this location. The lateral extent of this alluvial zone is not known. Along the alignment, the two adjacent borings, PII-43 and PII-45, located about 420 feet south and 500 feet north, respectively, show a limited thickness of Old Alluvium ranging from about five feet to 20 feet. Along a direction roughly transversal to the alignment, two CPT soundings were performed at a distance of about 125 feet east and about 190 feet northeast of Boring PII-44 (see Figure 2-3). Both CPT soundings indicated the presence of shallow Puente Formation bedrock (CPT sounding logs included in Appendix A) and did not confirm the presence of deep alluvium. An examination of an old topographic map (USGS, 1928) of the area did not reveal the presence of a stream bed crossing the proposed alignment near Boring PII-44 location. This pocket of deep Alluvium appears to be a local anomaly in the subsurface. Although the lateral extent of this alluvial zone is not known, interpolated subsurface condition form other nearby borings indicate that two-face conditions should be expected during tunneling in the vicinity of Boring PII-44. Groundwater level data interpolated from closest piezometers indicate depth to groundwater at Boring PII-44 location is about 26 feet.

As shown in Figure 2-4, the currently planned tunnel crown along this tunnel segment is mostly within oxidized Puente Formation bedrock, except in the vicinity of Borings PII-39, PII-43, PII-44 and PII-45 where portions of the tunnels will be either within the highly weathered Puente Formation bedrock which consists primarily of saturated, silty clay/clayey silt with zones of silty sand, or within Old Alluvium which consists primarily of saturated sand, silty sand and clayey sand. Thus, the following conditions will be encountered in the vicinity of the above borings during tunnel excavation:

- Mixed-face condition between highly weathered Puente Formation (uncemented, soil-like) and oxidized Puente Formation
- Mixed-face condition between Old Alluvium (Unit A3 and/or Unit A4) and oxidized Puente Formation bedrock
- Running sand condition with comparatively higher seepage flow, especially in the vicinity of Boring PII-44.

4.3.2 Groundwater

Groundwater levels were monitored in Piezometers PII-26, PII-29, PII-35, and PII-43 (this investigation) and LPE-7 (Earth Technology, 1988) using an electronic water-level indicator. Groundwater level readings were taken periodically and are summarized in Table 3-3. The most recent groundwater level data are presented in the cross-sectional profiles (Figures 2-2, 2-3, and 2-4).

In both tunnel sections (Beverly-Santa Monica and Santa Monica-Sunset), groundwater level readings indicate that the planned tunnel crown will be below the groundwater table, which has a gentle gradient of about 0.02 or less. Along the excavation of the planned Vermont/Santa Monica Station, the groundwater gradient changes from about 0.02 (southern end of the station excavation) to about 0.07 (middle portion of the excavation) and 0.011 (northern end of the excavation). The sharp gradient between Borings PII-35 and LPE-7 has been consistently observed during the first 4 months of this investigation.

Available data indicates Old Alluvium at the Vermont/Santa Monica Station contains groundwater. As much as about 30 feet of Old Alluvium may be below the groundwater table at the northern end of the station site area. Puente Formation bedrock can also be submerged if hydrologic connections exist between the saturated alluvium and the bedrock. The thin sandstone beds and weakly intact bedding planes in Puente Formation bedrock may act as such hydrologic connections, as evidenced by the field permeability test (slug test) results. Slug test results indicated the permeability of bedrock in horizontal directions is about $5X10^{-6}$ cm/sec, approximately 50 times to 500 times more than the vertical permeability (10^{-7} cm/sec to 10^{-8} cm/sec) indicated by the results of laboratory permeability tests performed during this investigation and in different investigations for other MOS-2 segments along Vermont Avenue.

4.3.3 Chemical Contamination and Construction Considerations

The results of chemical tests on selected soil and water samples are presented in Section 3.2.2 and Appendix C. The site area is located in a well-developed area with the Los Angeles City Oil Field located only a few thousand feet away. Chemical contamination of subsurface materials and groundwater in the site area, if any, are most likely from the following sources:

1. Past and ongoing industrial and commercial (especially gas stations) facilities and activities in the site area and vicinity.

2. The presence of methane, hydrogen sulfide (H_2S) and residual petroleum (oil or tar) from natural sources.

The discussions presented in this section on chemical contamination levels in soil and groundwater samples and their potential effects on disposal and work space environments during construction are solely based on the results of a limited number of tests from this investigation. They are presented to illustrate the potential chemical contamination extent in the alignment.

In addition, cleanup action levels and exposure limits set or recommended by various regulatory agencies typically change as time passes. The action levels and exposure limits described in this section should be verified and modified, if necessary, to reflect up-to-date requirements at the time of station and tunnel construction.

4.3.3.1 Chemical Contamination in Subsurface Materials. Headspace OVA readings were taken for most of the recovered samples to evaluate the possible presence and approximate concentration of volatile chemical compounds. All borings in this investigation encountered zones with headspace OVA readings (ranging from 0 ppm to 1,000 ppm) higher than the corresponding background values. The locations of samples with headspace OVA readings of 10 ppm or more above the corresponding background values are indicated in the cross-sectional profiles (Figures 2-2, 2-3, and 2-4). The organic vapor type which generated high OVA readings on soil samples during this investigation was not known. Hence, an exposure limit of 10 ppm recommended for benzene (National Institute for Occupational Safety and Health, 1985) was conservatively selected, for differentiating samples with high OVA readings. As can be seen from these figures, zones of high OVA readings are mostly located in the Puente Formation bedrock.

During drilling, strong hydrocarbon odors were occasionally noticed in the work space and from the samples. Oil traces were also occasionally observed floating in drilling mud. However, the results of chemical tests performed on selected soil samples indicate that concentration levels of total recoverable petroleum hydrocarbons (TRPH) and four selected volatile (aromatic) organic compounds (BTEX which includes benzene, toluene, ethylbenzene, and xylenes) are low, and all, except for few samples, are less than cleanup action levels as defined in the Leaking Underground Fuel Tank (LUFT) Field Manual (State Water Resources Control Board, 1987). Tables 4-1 and 4-2 show the analytical results for soil samples with concentration levels above cleanup action levels as defined in the LUFT Field Manual. These samples were all collected in Puente Formation bedrock where most of the high headspace OVA readings have been recorded.

Results indicate the toluene concentration levels in samples included in Table 4-1 are slightly above the cleanup action level. Results also indicate samples collected in the same borings as the samples with higher toluene concentrations (PII-25/D-10, PII-34/D-10, and PII-41/D-13) and in adjacent borings (PII-23, PII-26, PII-33, PII-35, PII-40 and PII-42) do not exhibit concentration levels above cleanup action levels. Such results suggest localized contamination. The high TRPH concentration levels found in samples listed in Table 4-2 also appear to be localized. Analytical results from tests performed for the Vermont/Beverly Station (Earth Technology, 1990c) also support this conclusion of localized contamination. Thus, the source of contamination appears to be natural and could be due to the localized presence of residual petroleum in the Puente Formation and thus could be explained in part by the site's proximity to the Los Angeles City Oil Field.

TABLE 4-1. TOLUENE CONCENTRATION LEVELS OF SOIL SAMPLES ABOVE CLEANUP ACTION LEVELS

Sample Location	Toluene Concentration (ppb)[b]	LUFT[a] Cleanup Action Level (ppb)
PII-25/D-16	340	300
PII-32/D-10	320	300
PII-34/D-6	400	300
PII-41/D-18	380	300

Notes: (a) LUFT = Leaking Underground Fuel Tank Field Manual. (State Water Resources Control Board, 1987)
(b) ppb = Parts per billion.

TABLE 4-2. TRPH[a] CONCENTRATION LEVELS OF SOIL SAMPLES ABOVE CLEANUP ACTION LEVELS

Sample Location	TRPH Concentration (ppm)[c]	LUFT[b] Cleanup Action Level (ppm)
LPE-7/D-7	120	100 - 1,000
PI-25/D-10	220	100 - 1,000
PII-25/D-16	150	100 - 1,000
PII-26/D-13	30,000	100 - 1,000

Notes: (a) TRPH = Total recoverable petroleum hydrocarbons.
(b) LUFT = Leaking Underground Fuel Tank Field Manual. (State Water Resources Control Board, 1987)
(c) ppm = Parts per million.

It should be noted that the cleanup action levels in the LUFT Field Manual are specified only as guidelines. These action levels depend on various factors including location of groundwater table, the nature of groundwater usage, possibility of groundwater contamination due to the presence of contaminants in subsurface soils and other regulatory requirements. Most of these factors are decided on a case-by-case basis by the regulatory agencies. Hence, it is recommended that the requirements on cleanup action levels be determined in consultation with the California Regional Water Quality Control Board (CRWQCB) and the Department of Health Services (DHS) before consruction.

Results of chemical analyses on selected samples to detect concentration levels of heavy metals also indicate that the concentration levels of a suite of heavy metals in the subsurface materials are low and below cleanup action levels as specified in the California Code of Regulation, Title 22, Section 66699 (Department of Health Services, 1987).

Disposal of excavation spoils depend on the contamination level in spoils. Excavation spoils will require special handling if they are classified as hazardous waste. The criteria to identify hazardous wastes are toxicity, ignitability, reactivity and corrositivity as established in Article II, Title 22 of the California Code of Regulations. Based on the ignitability characteristic of TRPH in "sandy soils," the Department of Health Services (DHS) has set a Total Recoverable Petroleum Hydrocarbon (TRPH) concentration of 1,000 ppm in soil as a criterion to classify hazardous waste (Appendix E, LUFT Field Manual). However, it is recommended the DHS be consulted for hazardous waste classification criterion for TRPH levels in Puente Formation bedrock which primarily consists of clayey siltstone with thin sandstone interbeds. Only one soil sample (PII-26/D-13) tested in this investigation indicated a contamination level above the hazardous waste criterion limit of 1,000 ppm. However, the potential for contamination exceeding hazardous criterion limits between boring locations cannot be eliminated. It is recommended monitoring be performed during construction for contamination levels that may require special handling of excavation spoils (i.e., treatment or disposal at specific landfills that receive hazardous waste).

The sulfate concentration levels in three samples (PII-25/D-16, PII-33/D-9, and LPE-6/D-12) are relatively high and may require the use of Type II cement during construction.

4.3.3.2 **Chemical Contamination in Groundwater.** There are five piezometers installed in the station and tunnel area: Boring LPE-7 (Earth Technology, 1988) and Borings PII-26, PII-29, PII-35, and PII-43 (this investigation).

Results of analytical testing on selected water samples obtained from these piezometers are shown in Tables 3-6 through 3-10, and in Appendix C. Results indicate that the concentration levels of TRPH, BTEX, and sulfide in the water are generally low or not detected. The results also indicate that BTEX and TRPH concentrations in water samples are less than the cleanup action levels defined by the Leaking Underground Fuel Tank (LUFT) Field Manual. Results also revealed the presence of moderate levels of sulfate concentrations in water samples indicating Type II cement will be required for construction.

The disposal method for groundwater collected during construction may need further consideration and will depend on the concentration level of contaminants in groundwater. Although the LUFT Field Manual provides guidelines for cleanup action levels, the California Regional Water Quality Control Board (CRWQCB) is the regulatory agency for related issues. The CRWQCB requires chemical analyses of a suite of constituents in the groundwater for a National Pollutant Discharge Elimination System (NPDES) permit application to discharge wastewater. These include suspended solids, BOD_5 at 20°C, oil and grease, solids with the ability to settle, turbidity, sulfide, total petroleum hydrocarbons, volatile organic compounds (EPA Method 624), total dissolved solids, chlorides, sulfate and nitrate plus nitrate nitrogen. The CRWQCB action limits depend on discharge locations and physical characteristics of specific groundwater aquifers and basins, and are determined on a case-by-case basis. It is recommended that the issues and required data for permit application be discussed with the CRWQCB before taking further action.

4.3.3.3 Hydrogen Sulfide and Methane. The workspace and breathing-zone hydrogen sulfide (H_2S) readings during this field operation were observed to be minimal, ranging from 0 ppm to 4 ppm. This is less than the action level of 10 ppm specified by the American Conference of Governmental Industrial Hygienists (ACGIH, 1988) and the National Institute for Occupational Safety and Health (NIOSH, 1985). However, sulfur odors were occasionally noticed during drilling and sampling of borings in this investigation (refer to boring logs in appendix A). The results of available chemical tests show some concentrations of sulfide compounds in selected soil samples as well as moderate (100 ppm to 1,200 ppm) concentrations of sulfate compounds in soil and water samples. Sulfide and sulfate compounds may be potential sources for generating H_2S under certain chemical environments. Thus, the possibility of breathing-zone H_2S concentrations exceeding the action level during construction cannot be eliminated in the site area. Continuous monitoring of H_2S concentrations during construction will be necessary.

Some of the soil samples obtained during the field investigation exhibited high headspace OVA readings. Methane is one of the compounds which may generate high OVA readings in soil samples. In addition, the site area is in the general vicinity of the Los Angeles City Oil Field which may be the generating and propogating source of methane. Thus, the possibility of high methane concentrations in the site area and vicinity cannot be eliminated. Methane is combustible in air and can explode when the air mixture is between about 5 percent to 15 percent by volume. During station and tunnel construction, provisions to monitor the methane concentration, explosivity level, and oxygen concentration will be necessary. To ensure worker safety and to minimize shutdown, adequate ventilation should be provided during construction to maintain methane concentrations and explosivity levels in the work area within safety levels. The potential presence of high methane concentrations also requires that the tunnel be tightly sealed to prevent accumulation of methane and to avoid combustion and explosion hazards.

4.4 ENGINEERING PROPERTIES OF SUBSURFACE MATERIALS

4.4.1 General

Engineering properties of subsurface materials based on the results of laboratory tests in this investigation are summarized in terms of ranges of variation, mean and standard deviation values. These are presented in Table B-9 in Appendix B. Similarly, shear wave velocity, static and dynamic modulus, and subgrade modulus based on available literature correlations with SPT blowcounts observed in the field exploration (Ohta and Goto, 1978; Schmertmann, 1970; and Terzaghi, 1955), are summarized and presented in Table B-10 in Appendix B. The results of laboratory tests and available correlations with SPT blowcounts (e.g., Mitchell, 1977), together with available data from project data files (Section 2.4), other published data in the engineering literature, and engineering judgement were used to develop relevant static and dynamic engineering properties for engineering design and evaluations for the Vermont/Santa Monica Station and adjacent tunnel segments. These engineering properties are presented in Tables 4-3 and 4-4.

Detailed descriptions of the static and dynamic properties presented in Tables 4-3 and 4-4 are provided in Section 4.4.2 and 4.4.3, respectively. It should be noted that, although, the ranges of variation and recommended values of various engineering properties presented in Tables 4-3 and 4-4 are considered reasonable for engineering evaluation purposes, they are not intended for the purpose of selecting construction machinery or equipment. The actual ranges of variation of various engineering properties for the subsurface materials are expected to be greater than those presented in Tables 4-3 and 4-4 because of the following reasons:

1. The ranges of variation in Tables 4-3 and 4-4 were obtained from field and laboratory data from discrete boring locations. The potential of engineering property variations for the subsurface materials between borings to be different from those in Tables 4-3 and 4-4 cannot be eliminated.

TABLE 4-3. ENGINEERING PROPERTIES FOR STATIC ANALYSES

	GEOLOGIC UNIT													
	GRANULAR OLD ALLUVIUM (A3)		FINE-GRAINED OLD ALLUVIUM (A4)		WEATHERED PUENTE FORMATION BEDROCK (fine-grained, Tpw)		WEATHERED PUENTE FORMATION BEDROCK (granular, Tpw)		FRESH/OXIDIZED PUENTE FORMATION BEDROCK (Tpf/Tpo)		EXTREMELY HARD SANDSTONE		WEAK SANDSTONE AND BEDDING PLANES	
MATERIAL PROPERTY	RANGE	RECOMMENDED VALUE	RANGE	RECOMMENDED VALUE	RANGE	RECOMMENDED VALUE	RANGE	RECOMMENDED VALUE	RANGE	RECOMMENDED VALUE	RANGE	RECOMMENDED VALUE	RANGE	RECOMMENDED VALUE
DRY UNIT WEIGHT (pcf)	90-113	110	90-115	110	75-112	100	75-112	100	75-138	95				
MOIST UNIT WEIGHT (pcf)	110-142	130	110-142	130	98-130	125	98-130	125	83-143	125	-	-	-	-
SATURATED UNIT WEIGHT (pcf)	-	-	-	-	95-130	125	95-130	125	83-149	125	-	-	-	-
EFFECTIVE SHEAR STRENGTH														
e (degrees)	-	37	22-30	25	24-38	28	24-38	32	25-40	30	-	-	20-30	25
Ce (psf)	-	0	150-1,500	500	0-2,000	500	0-2,000	0	300-4,000	800			0-850	200
PERMEABILITY (cm/sec)														
VERTICAL	10^{-4}-$5x10^{-4}$	10^{-4}	$5x10^{-5}$-10^{-7}	10^{-5}	5 x 10^{-5}-10^{-7}	10^{-5}	$5x10^{-3}$-5x10-5	10^{-4}	10^{-8}-$2x10^{-7}$	10^{-7}	10^{-7}-10^{-8}	10^{-7}	10^{-7}	10^{-7}
HORIZONTAL	10^{-4}-$5x10^{-4}$	10^{-4}	$5x10^{-5}$-10^{-7}	10^{-5}	5 x 10^{-5}-10^{-7}	10^{-5}	$5x10^{-3}$-5x10-5	10^{-4}	10^{-6}-$2x10^{-5}$	10^{-6} - 10^{-5}	-	-	10^{-5}-$5x10^{-5}$	$5x10^{-5}$
POISSON'S RATIO,	-	0.4	-	0.35	-	0.35		0.4	-	0.35	-	-	-	-
YOUNG'S MODULUS, E (ksf)	200-1,700	1,200	80-900	400	80-1,700	800	80-1,700	800	950-5,600	2,000	-	-	-	-
UNDRAINED SHEAR STRENGTH, Su (psf)	-	-	-	1,500	900-3,500	1,500	-	-	850-20,000	5,000	-	-	-	-
UNCONFINED COMPRESSIVE STRENGTH (psi)	-	-	-	-	-	-	-	-	-	-	500-20,000	5,000-20,000	-	-

TABLE 4-4. ENGINEERING PROPERTIES FOR DYNAMIC ANALYSES

MATERIAL PROPERTY	GEOLOGIC UNIT: FINE-GRAINED OLD ALLUVIUM (A4)		GRANULAR OLD ALLUVIUM (A3)		WEATHERED FORMATION PUENTE BEDROCK (Tpw)		OXIDIZED/FRESH PUENTE FORMATION BEDROCK (Tpo and Tpf)	
	RANGE OF VARIATION	RECOMMENDED VALUES	RANGE OF VARIATION	RECOMMENDED VALUES	RANGE OF VARIATION	RECOMMENDED VALUES	RANGE OF VARIATION	RECOMMENDED VALUES
SHEAR WAVE VELOCITY (ft/s)	410-1,220	680	475-1,225	750	520-1,150	750	400-1,750	1,160
DYNAMIC SHEAR MODULUS (ksf)	640-5,570	1,840	840-5,600	2,000	1,010-4,930	2,000	620-11,320	5,200
POISSION'S RATIO	-	0.4	-	0.3	-	0.35	-	0.35
DAMPING[a] (%)		5-10		5-10		5-10		4

Note: (a) - For small strains.

2. Due to sample disturbance, the actual stiffness and strength characteristics of the subsurface soils will be higher than those exhibited by the laboratory testing on somewhat disturbed soil samples. Some sample disturbance is inevitable even under extreme care in the field exploration.

Strength and stiffness characteristics of the subsurface materials are an important considerations in selecting appropriate construction equipment and procedures. The above discussion indicates that, although the exact extent is not known, the actual ranges of variations in subsurface materials' strength and stiffness characteristics will be higher than those summarized in Tables 4-3 and 4-4. It is advisable that the contractor should select construction equipment and procedures based on stiffness and strength variation values that can appropriately cover potential variations in subsurface materials as well as sample disturbance effects. Other factors that may affect the selection of construction equipment and procedures are described in the following paragraph.

Puente Formation bedrock in the site area mainly consists of clayey siltstone/silty claystone with occasional beds of cemented sandstone. These sandstone beds are up to about one-foot thick, as indicated by drill rod chatter observed during drilling operation. Available data in the general vicinity (Earth Technology, 1990b; CWDD/ESA/GRC, 1981; MWD, 1976; and LACFCD, 1973) indicate unconfined compressive strength of this cemented sandstone may be as high as 20,000 psi or more. The potential presence of these high strength sandstone beds may have a significant affect on construction equipment selection.

In addition, rail and/or rail tie from an old abandoned railway were encountered at various locations along Vermont Avenue and Hollywood Boulevard during the field exploration for MOS-2 alignment. The potential presence of these abandoned railway remains should be considered in the planning of the station excavation.

4.4.2 Static Engineering Properties of Subsurface Materials

As described previously, relevant static engineering properties of the subsurface materials encountered in the site area, summarized in Table 4-3, were used in subsequent engineering evaluation (Section 5).

No engineering properties are presented for the localized presence of thin surficial fill, which has little or no effect on the planned design and construction of the station.

The following sections provide a description of the properties for the Old Alluvium and Puente Formation bedrock.

4.4.2.1 Granular Old Alluvium (A3). The granular Old Alluvium, when present, consists of predominantly medium-dense to very dense silty sand, clayey sand, and gravelly silty sand with fines content ranging predominantly from about 6 percent to 34 percent. Properties of this layer are expected to vary significantly, depending on the fines content.

Results of field permeability tests (slug tests, pump tests), performed in earlier investigations (Wilshire/Vermont Station, Earth Technology, 1990a) indicate that field permeability of this layer varies between 1 x 10^{-4} cm/sec and 7 x 10^{-4} cm/sec. Available correlations of grain size data with permeability indicate permeability of granular Old Alluvium ranges from 10^{-4} cm/sec to 10^{-3} cm/sec. Based on our experience, a permeability of 10^{-4} cm/sec is reasonable for this layer.

Based on laboratory direct shear test results, SPT correlations and engineering judgement, the use of a friction angle of 37 degrees and zero cohesion as effective strength parameters for this stratum above and below the perched groundwater is reasonably conservative and should be used for design purposes.

Elastic modulus (initial tangent modulus) and Poisson's ratio for this stratum were also estimated based on literature data, available correlations with SPT data, and engineering judgement. Elastic modulus of granular soils is usually

a function of density and gradation of soil, confining stress, and past stress history. The modulus values shown in Table 4-3 for this stratum represent the estimated values for use in the engineering evaluation.

4.4.2.2 Fine-Grained Old Alluvium (A4). The fine-grained Old Alluvium consists primarily of medium-dense to stiff clayey sand and stiff to very stiff silt, clayey silt, silty clay, and sandy clay. This layer is about five feet to 25 feet thick. The shear strength properties were determined based on direct shear test results on selected samples from this investigation, available data from the 1988 investigation (Earth Technology, 1988), and SPT data and index properties correlated with literature data. Based on the above data, a friction angle of 25 degrees and a cohesion of 500 psf seems to be reasonable strength parameters for this stratum. Elastic properties were primarily based on laboratory test data, available correlations of literature data with SPT data and index properties, and engineering judgement.

4.4.2.3 Puente Formation Bedrock. Engineering parameters for Puente Formation bedrock were developed based on the results of this investigation and engineering judgement.

Strength Parameters

As described in Section 4.3.1, the Puente Formation bedrock in the alignment consists of three different types of materials: highly weathered (Tpw), oxidized (Tpo) and fresh (Tpf). The highly weathered Puente Formation materials (soil-like) were encountered in most of the borings. On the basis of available data results, the overall engineering behavior and properties of oxidized and fresh materials are considered similar. Except for a local presence of highly cemented sandstone interbeds and layers, as described in Section 4.3.1, the oxidized and fresh Puente Formation bedrock behave similar to hard or dense soil with significant cohesion strengths. In general, Puente Formation bedrock material in the site area contains more clayey materials and is weaker and more compressible than the bedrock materials encountered in the MOS-2 alignment south of Beverly Boulevard. Examinations of Standard

Penetration Test (SPT) blow count variations and results of laboratory tests in Puente Formation bedrock along the MOS-2 alignment portion also support this conclusion.

Highly Weathered Puente Formation (Tpw)

The engineering behavior of this unit is, in general, similar to saturated stiff to very stiff fine-grained materials (clayey sand, clayey silt, sandy clay, silty clay and clay) with some cohesion. However, zones of granular materials consisting of dense sandy silt/silty sand-type materials were also encountered in the highly weathered Puente Formation. The engineering properties of this unit are divided into fine-grained and granular groups and are shown in Table 4-3.

Overall Engineering Behavior of Oxidized and Fresh Puente Materials

The oxidized/fresh Puente Formation bedrock in the site area consists primarily of clayey siltstone or silty claystone interbedded with predominantly thin and cemented sandstone beds. The overall engineering behavior of this bedrock is similar to very stiff to hard and highly overconsolidated fine-grained soils, except for a local presence of highly cemented (hard), thin sandstone beds as indicated by drill rig chatter during drilling operations. In addition, there are thin sandstone beds (fractions of an inch thick) sandwiched within clayey siltstone and silty claystone which appear to be weaker and more permeable than clayey siltstone and silty claystone. For purposes of evaluating engineering properties, oxidized and fresh Puente Formation bedrock with sandstone interbeds are considered a single unit (Tpo/Tpf).

Results of this investigation and previous investigations in the site area were evaluated to develop shear strength parameters. Both drained and undrained shear strength parameters were considered.

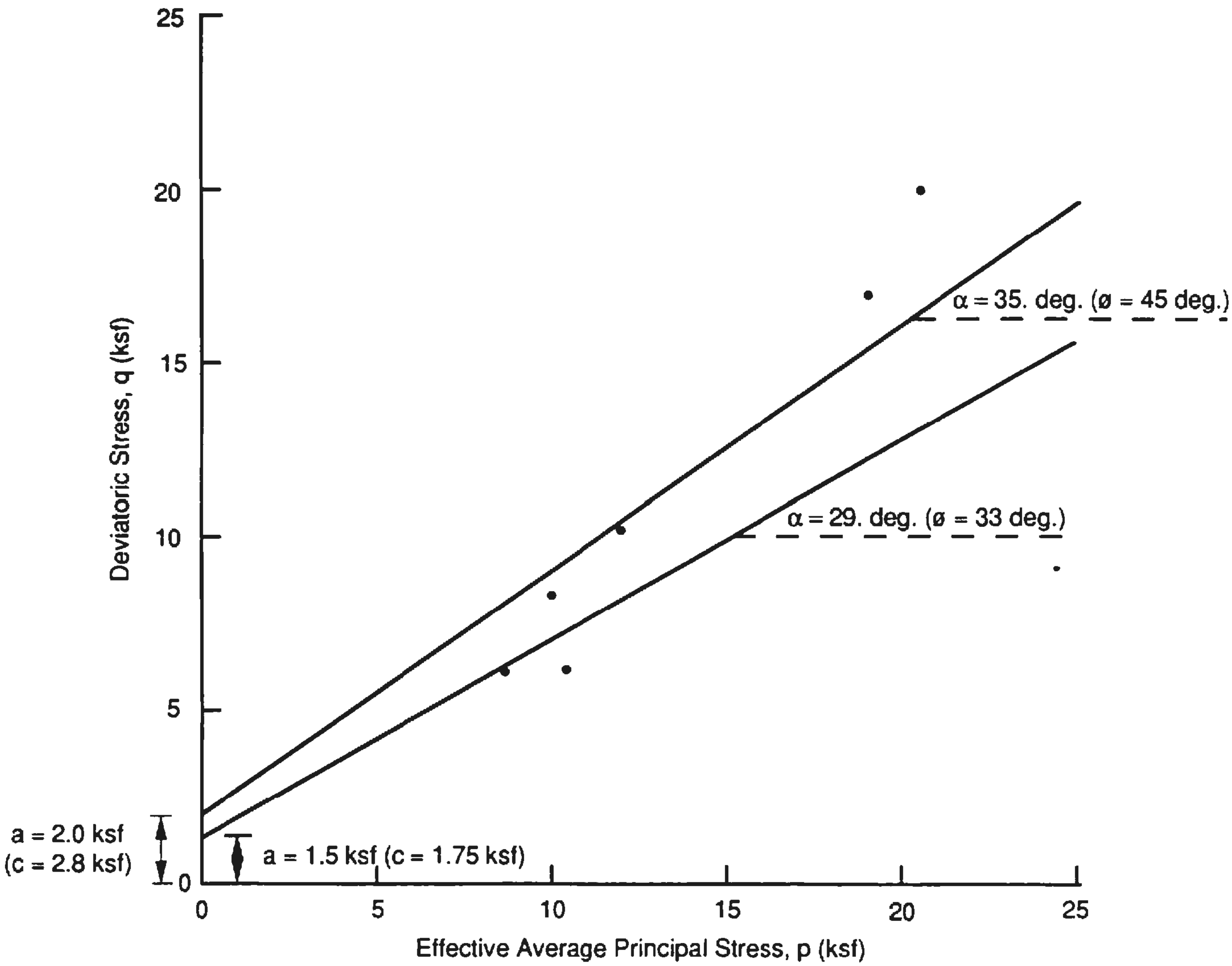
Based on the available data, the maximum past pressure on the Puente Formation bedrock may be approximately 100 ksf. This means that the bedrock within the excavation depth is overconsolidated, with an estimated overconsolidation

ratio (the ratio of maximum past pressure and the present effective overburden stress) of about 15 or more. Undrained shear strength of such an overconsolidated material is expected to be very high. Undrained strength can be estimated either based on the results of unconfined compression (UC) tests or undrained triaxial compression tests (CIU).

Results from UC and CIU tests on selected samples indicate the undrained shear strength of Puente Formation bedrock varies between about 3,100 psf and 20,000 psf. This wide variation in strength values may be attributed to the level of cementation in the bedrock material, and sample disturbance. Based on the above test results, visual observation, engineering judgment and comparison of test samples with other samples from bedrock, an undrained shear strength of 5,000 psf is recommended for use in the design. This value represents a reasonably conservative undrained shear strength of the bedrock for short-term support and stability analysis using the $\phi = 0$ method.

Under confining stresses significantly less than the maximum past pressure, long-term, effective shear strength parameters for highly overconsolidated clayey materials such as the Puente Formation bedrock consist of two components: effective friction angle and effective cohesion. In this investigation, the effective shear strength parameters of the bedrock were evaluated based on the results of the CIU tests, direct shear tests, and engineering judgement.

Results from CIU tests and direct shear tests on bedrock samples are summarized in Figures 4-2, 4-3, and 4-4 respectively. As can be seen, direct shear test results indicated more data scatter than CIU test results. Laboratory test data (Appendix B, Tables B-6 and B-7) indicate that, in general, CIU tests were performed on Pitcher samples and direct shear tests were performed on drive samples. Drive samples may have more sample disturbances and, hence, the wide data scatter indicated by direct shear test results may be attributed to varying degrees of sample disturbance. In addition, the variability of the in situ bedrock also influences test results. Based on these test results, an effective friction angle (ϕ_e) of 30 degrees and an effective cohesion coefficient (C_e) of 800 psf are recommended for design purposes. These recommended values correspond to the near-lower bound values to account for bedrock variability and, thus, are reasonable.



Explanation

$p = (\sigma_1' + \sigma_3')/2$
$q = (\sigma_1' - \sigma_3')/2$
ø = Arc sin (tan α) = Friction angle
c = a/cos ϕ = Cohesion

The Earth Technology Corporation

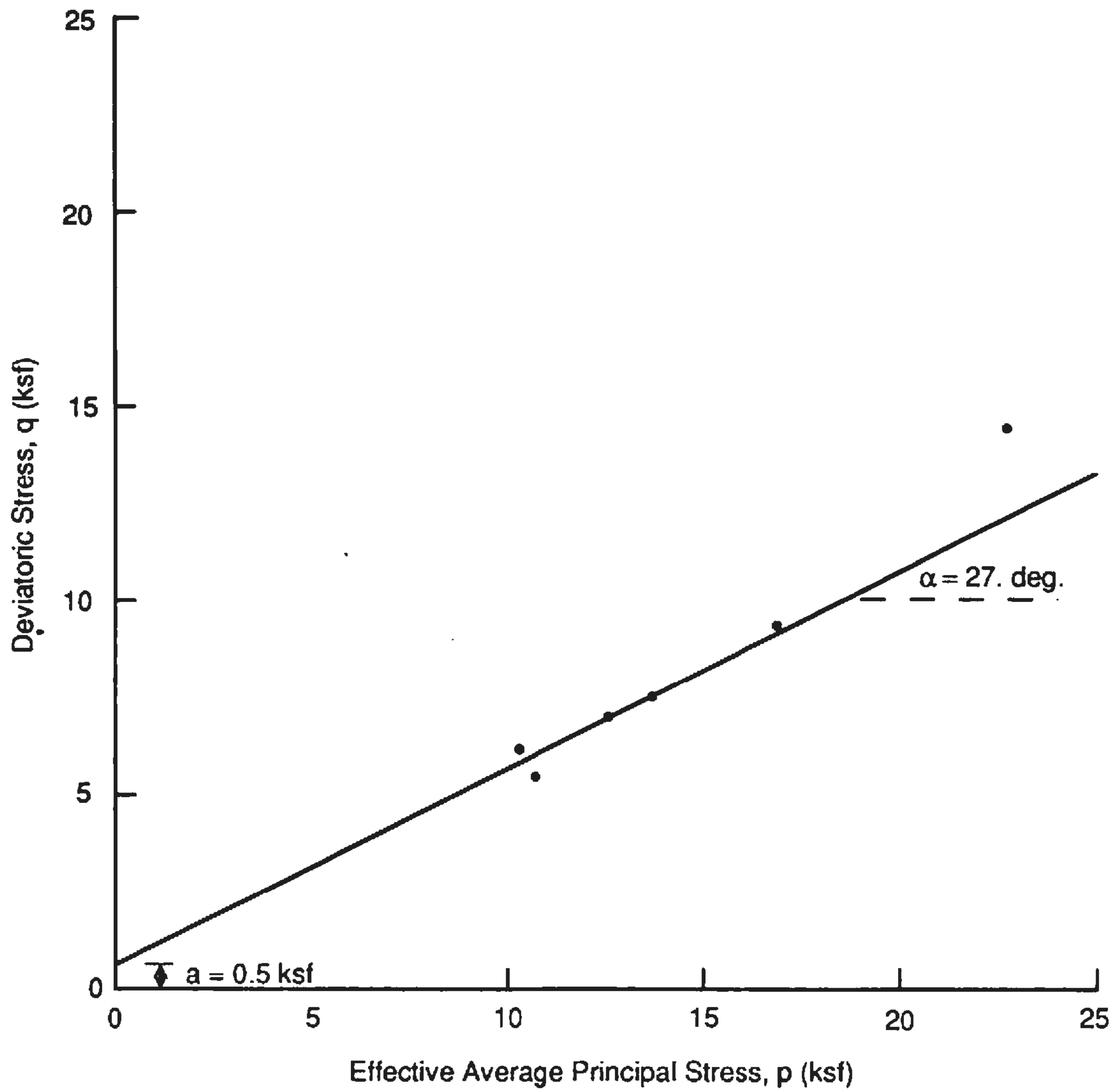
Project No.: 89-409

Vermont/Santa Monica Station and Tunnel

CIU Test Results (At Peak Shear Stress)

05-90

Figure 4-2



Explanation

$p = (\sigma_1' + \sigma_3')/2$
$q = (\sigma_1' - \sigma_3')/2$
ϕ = Friction angle = Arc sin (tan α) = 30deg.
c = Cohesion = a/cos ϕ = 575 psf

The Earth Technology Corporation

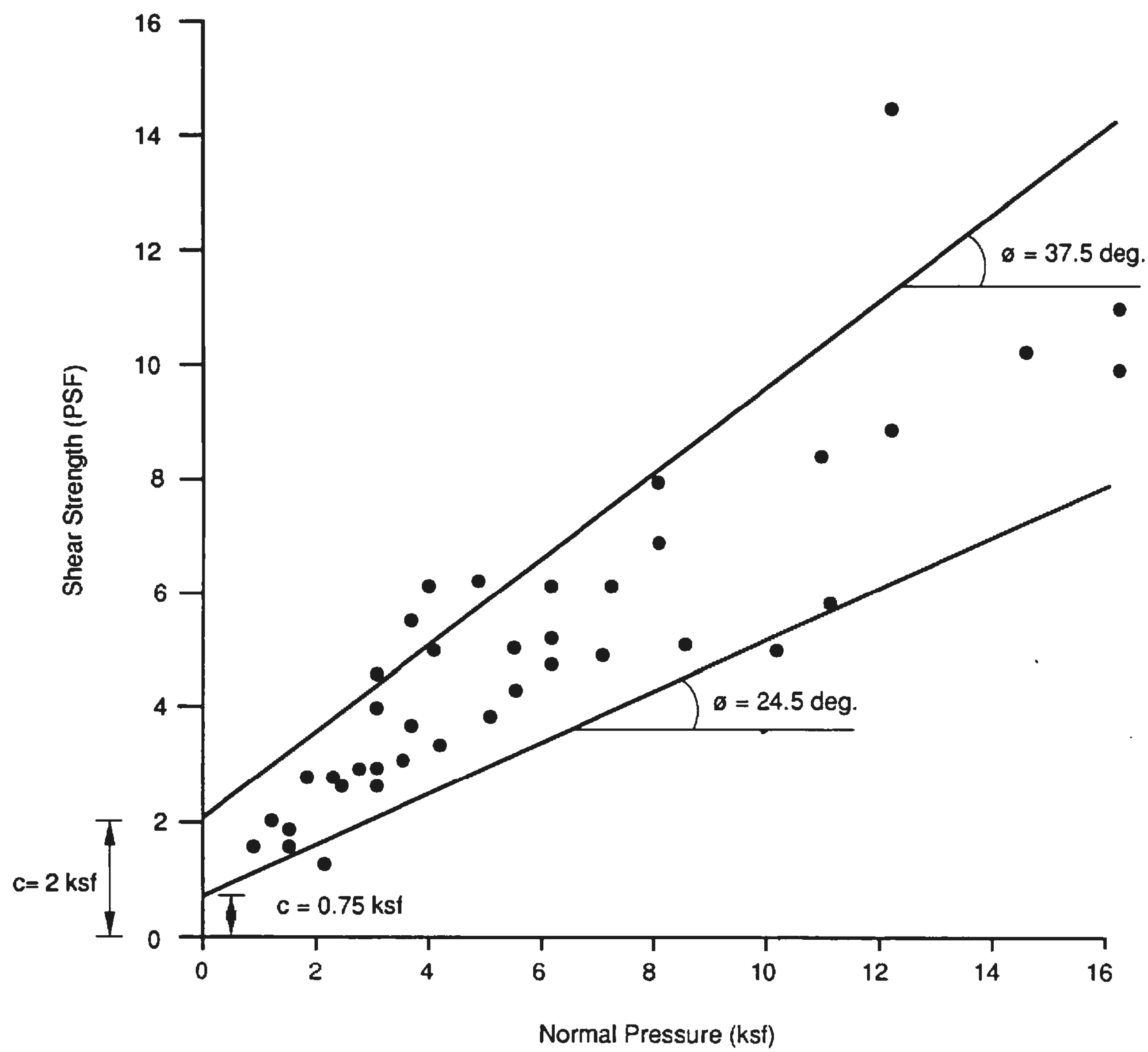
Project No.: 89-409

Vermont/Santa Monica Station and Tunnel

CIU Test Results (At Residual Shear Stress)

05-90

Figure 4-3



Explanation

c = Cohesion
ø = Friction Angle

The Earth Technology Corporation

Project No.: 89-409

Vermont/Santa Monica Station and Tunnel

Direct Shear Test Results

05-90

Figure-4-4

Hard Sandstone Interbeds

As mentioned previously, occasional hard, highly cemented sandstone interbeds up to one foot thick were encountered in the borings drilled in the site area. The presence of thicker interbeds of similar materials occuring elsewhere in the site area cannot be confirmed. However, it is certain that their presence would significantly affect the excavation rate and selection of excavation equipment. Although no specific tests were performed on samples of hard sandstone interbeds for this investigation, available test data from the Wilshire-Beverly Tunnel unit (Earth Technology, 1990b), the Metropolitan Water District's Tonner Tunnel (MWD, 1976), and the Los Angeles County Flood Control District's Scatella Tunnel (CWDD/ESA/GRC, 1981; LACFCD; 1973) indicate that the unconfined compression strength of the hard, calcite-cemented sandstone interbeds could be as high as 5,000 psi to 20,000 psi or more.

Weak Sandstone Beds and Bedding Planes

As described in Section 4.3.1, the Puente Formation in the tunnel alignment consists of up to 20 percent to 30 percent thin and weakly cemented dipping sandstone beds. These sandstone beds and bedding planes are generally weaker than the overall strengths of the bedrock as evidenced by the observed shearing patterns (failure along sandstone beds and bedding planes) in the unconfined compression (UC) tests performed for the Wilshire/Vermont Station (Earth Technology, 1990a). Based on data from the Wilshire/Vermont Station, we believe that a friction angle of 25 degrees and a cohesion of 200 psf will be reasonably representative strength parameters of these beds and bedding planes.

Permeability

Based on the results of laboratory tests performed for this and earlier investigations, vertical permeability for the bedrock ranges from 10^{-9} cm/sec to 10^{-7} cm/sec. However, due to the presence of more pervious sandstone beds and bedding planes, permeability along the dips or near-horizontal direction will be significantly higher. Slug tests performed at Piezometer PII-26 and

at other locations along the MOS-2 alignment indicated that field horizontal permeability is higher than the vertical permeability measured in the laboratory. Therefore, a horizontal permeability of about 10^{-6} cm/sec to 10^{-5} cm/sec is reasonable for the oxidized/fresh Puente Formation bedrock.

Elastic Properties

Laboratory test results and other available data in the project files, together with engineering judgement, were used to evaluate elastic properties of the bedrock. The recommended initial tangent modulus value for the bedrock, shown in Table 4-3, represents a somewhat conservative near-lower bound value to account for potential variations in the bedrock, as evidence by a large scatter shown in the laboratory test results.

4.4.3 Dynamic Engineering Properties of Subsurface Materials

No laboratory tests were performed to determine the dynamic engineering properties of subsurface materials of the Vermont/Santa Monica Station. Blow counts observed during soil sampling are the only available data which could be used to estimate dynamic engineering properties of subsurface material. There are two types of blow counts obtained during soil sampling: blow counts required to drive a standard split-spoon sampler, and blow counts for a California-type drive sampler. These sampling procedures were described in Section 3.1.1 of this report.

The number of blows required to drive a standard split-spoon sampler for the last 12 of 18 inches is called a standard penetration test blow count (SPT number). Blow counts required to drive a California-type drive sampler could be converted to approximate equivalent SPT numbers. Our recommended dynamic engineering properties are based on available correlation with SPT numbers and engineering judgment. These properties are summarized in Table 4-4.

5.0 Geotechnical Evaluation and Recommendations

5.0 GEOTECHNICAL EVALUATIONS AND RECOMMENDATIONS

Subsurface conditions and potential features that may affect the design and construction of the Vermont/Santa Monica Station and its adjacent tunnel segments are described in Section 4.0 of this report. The subsurface conditions along the tunnel segment are similar to those encountered in the Wilshire-Beverly Tunnel and Sunset-Western Tunnel segments (Earth Technology, 1990b and d), LACFCD's Sacatella Tunnel (LACFCD; 1973, CWDD/ESA/GRC, 1981), and the Metro Rail Phase I Contract A171 Tunnel (Escandon et al., 1989; Robison et al., 1989). The experience and performance of these tunnels should be used in the design and construction of the Beverly-Santa Monica and Santa Monica-Sunset tunnels. The subsurface conditions encountered at the Vermont/Santa Monica Station area are similar to those encountered in the other planned stations for the MOS-2 alignment along Vermont Avenue (Earth Technology, 1990a, 1990c, and 1990d). The data from geotechnical reports for these stations have been incorporated in developing recommendations for the planned Vermont/Santa Monica Station design and construction. In the following subsections, recommendations for design and construction of the station are presented. Recommendations for the tunnels are also presented in this report for information purposes only, since the geotechnical design report for the tunnel segments is being prepared by MRTC under separate cover.

5.1 VERMONT/SANTA MONICA STATION

5.1.1 General

Cut-and-cover construction of the Vermont/Santa Monica Station will involve about 58 feet to 74 feet of excavation from the ground surface (at about Elevations 314 feet to 330 feet) to the station bottom slab elevation at about Elevation 256 feet. In the southern half of the station (south of Boring PII-38) the excavation will penetrate through surficial pavement, fill (if present), about 10 feet of stiff, fine-grained Old Alluvium, about 15 feet of highly weathered Puente Formation (soil-like), and about 40 feet of the low-strength (weak) bedrock of the oxidized and fresh Puente Formation. In

the northern half, the excavation will penetrate a less regular stratigraphy which contains alternating layers of stiff, fine-grained Old Alluvium (clay, clayey silt, and clayey sand) and dense to very dense granular Old Alluvium for about 15 feet to 40 feet, underlain by about 15 feet to 20 feet of highly weathered Puente Formation and about 10 feet to 40 feet of oxidized/fresh Puente Formation bedrock. Since the shallow perched groundwater level is between about Elevations 298 feet and 315 feet, the excavation will penetrate about 40 feet to 60 feet below the perched groundwater level and will need dewatering or groundwater control measures. The effects of dewatering or groundwater control measures on adjacent existing buildings will require consideration and are discussed herein.

Station construction will be very close to adjacent existing buildings. The foundations of these buildings may be located above the bottom of the station excavation. Thus, a means of protecting these existing buildings from damage due to station excavation may be required. In addition to the closeness of these buildings to the planned station construction, the limited construction space and the prevailing subsurface conditions in the station area indicate that shoring will be required.

The above issues and other geotechnical considerations that require geotechnical engineering evaluation for design and construction purposes are summarized as follows:

- Groundwater control or construction dewatering and subsidence considerations
- Construction effects on adjacent existing buildings and remedial needs
- Excavation-related shoring provisions and bottom stability/heave issues
- Foundation design of station structures.

5.1.2 Groundwater Control and Construction Dewatering

5.1.2.1 Groundwater Control. Perched groundwater levels across the station site area were observed to range from about Elevations 298 feet to 315 feet. Since the bottom of the station excavation will be at about Elevation 256 feet, the excavation will extend about 40 feet to 60 feet below the perched groundwater level. Within the southern half of the station, excavation below the groundwater level will mostly penetrate highly weathered and oxidized/fresh Puente Formation bedrock which is relatively less permeable than the overlying Old Alluvium. However, in the northern half of the station, excavation below groundwater level will penetrate up to about 25 feet of Old Alluvium (Units A3 and A4) about five feet to 20 feet of weathered Puente Formation bedrock and about 10 feet to 40 feet or more of oxidized/fresh Puente Formation bedrock. Because Old Alluvium is relatively pervious, water flows at relatively high rates into the excavation, especially at the initial excavation stage, are likely if groundwater control provisions are not implemented.

Two options were considered for groundwater control during construction. These options are described below:

OPTION I - Dewater the Old Alluvium prior to excavation. The lowest depth along the Old Alluvium/Puente Formation contact is at about Elevation 290 feet. Dewatering to this elevation will include pumping water from Old Alluvium within the northern half of the station excavation by deep wells installed into the bedrock.

OPTION II - Dewater to the planned bottom slab elevation of the station.

Hydrological analyses were performed to estimate water amounts that need to be pumped during preconstruction dewatering and from sumps located inside the excavation during construction for each of the above options. Water amounts that flow into the excavation are time-dependent and depend on the area of the excavation, permeability and storage coefficients of surrounding formations, and the excavation rate. According to available information, the plan area of the excavation needed for the station is approximately 60 feet by 605 feet. Based on the results of the slug test performed in this investigation, and slug tests and pump tests performed for other MOS-2 alignment portions along

Vermont Avenue (Earth Technology, 1990a and 1990d), and considering the potential variability of subsurface conditions, it was assumed in the analyses that the permeability of Old Alluvium might range from 10^{-4} cm/sec to 5 x 10^{-4} cm/sec with a storage coefficient varying between 0.001 and .01, and the permeability of Puente Formation bedrock might range from 10^{-6} cm/sec to 10^{-5} cm/sec with a storage coefficient varying between 0.0001 to 0.005. The excavation rate may vary, depending on the equipment used for excavation. However, for estimation purposes, it was assumed construction progress would average approximately one foot of excavation per day. Based on these assumptions, evaluations of each of the options described previously are given below:

OPTION I - Dewater to the lowest point of the Old Alluvium/Puente Formation contact (deepest at an elevation of about 290 feet) prior to construction. Hydrological analyses were performed assuming the northern half of the excavation area consists of about 25 feet to 30 feet of Old Alluvium below the groundwater. Dewatering may be accomplished by using a series of deep wells of one foot or larger in diameter installed to an elevation of about 280 feet. Analyses indicate wells installed in Old Alluvium in the northern half of the station need to be spaced at about 40 feet to 60 feet apart. A pumping rate of about 0.5 gallon to 2 gallons per minute for the wells installed in Old Alluvium was estimated to accomplish a drawdown of about 25 feet in 20 days to 30 days. This amounts to a total of about 200,000 gallons to 1 million gallons of water during this period. Beyond this time period, wells should still be in operation to maintain groundwater at the dewatered level. However, the pumping rate will be lower. It should be noted that according to the cross-sectional profile generated using data from this investigation (Figure 2-3), groundwater exists in the Old Alluvium north of Boring PII-38. Due to limited data available, the thickness of the saturated Old Alluvium layer between borings cannot be accurately estimated. Hence, the field engineer at the time of well installation should verify the thickness of Old Alluvium and select well spacing and pumping rates accordingly.

When the excavation penetrates into Puente Formation bedrock below the dewatered elevation in the northern portion of the station and during excavation of the southern portion of the station, water that flows into the excavation will need to be pumped from sumps located inside the excavation. It is estimated that the rate of water flow into the excavation may range from about 1,000 gpd to 50,000 gpd. The total amount of water, including the water generated from deep wells, may range from about 500,000 gallons to 3 million gallons.

OPTION II - Dewater both Old Alluvium and Puente Formation bedrock prior to excavation. Analyses were performed to determine the feasibility of dewatering the entire excavation depth prior to excavating the opening. These analyses indicated that deep wells of one foot or larger in diameter, spaced at about 60-foot intervals around the excavation perimeter may be needed. The drawdown level in the excavation area may be designed to progress slightly ahead of the excavation rate of one foot per day. Pumping rates of wells installed in the northern half of the station should be maintained at a higher rate than wells in the southern half of the station. It was estimated a pumping rate of about 0.5 gpm to 2.5 gpm from each well installed in the northern portion of the station and 0.01 gpm to 0.2 gpm from each well installed in the southern portion of the station will be required to achieve the desired drawdown. This amounts to a total of about 500,000 gallons to 4 million gallons of water generated during the excavation period.

It should be noted that additional water will be generated from construction spoils during excavation. The amount of water depends on the selected dewatering control scheme, method of excavation, and spoils handling. It should also be noted that after completion of the excavation, additional water will be generated from seepage from walls and the excavation floor and continuous pumping from dewatering wells. The amount of water that will be generated depends on construction constraints and the rate of construction. However, it is estimated that 8,000 gallons to 50,000 gallons per day may be generated to maintain the excavation floor in a dry, workable condition.

Further hydrological analysis, design, and cost evaluation will be necessary to establish the most suitable groundwater control scheme. It is understood that the contractor will be responsible for design, installation, and operation of a suitable groundwater control system. As a general guideline, an appropriate groundwater control system should:

- Be installed and in operation for a sufficient time to draw down the groundwater to a desirable level or to adequately prevent significant inflows prior to excavation below the groundwater level
- Reduce the inflow to levels that can be handled by a drain/sump system and allow excavation and construction to proceed without delay
- Not incur ground loss due to piping of the subsurface materials

- o Not induce undue and unsafe amounts of settlement to the adjacent existing buildings and cause distress
- o Be operated continuously and be equipped with emergency power and backup pumps and accessories
- o Incorporate continuous monitoring for evidence of piping and amounts of settlements in the adjacent existing buildings
- o Have contingency plan if distress in the adjacent buildings is detected.

5.1.2.2 Induced Subsidence. Groundwater control pumping during construction will induce some groundwater subsidence. The amount of subsidence depends on the groundwater control scheme used, amounts of groundwater-level drawdown, permeability of the subsurface materials, subsurface conditions, and excavation configuration and construction. Groundwater-level drawdown can be caused by construction dewatering and gravity flow of groundwater into the excavation opening, and is also dependent on distances from the dewatering system and excavation openings. Thus, groundwater drawdown is time- and distance-dependent.

Settlements caused by groundwater-level drawdowns were calculated assuming that subsurface conditions within a couple of hundred feet of the station excavation were similar to those encountered in the borings in this investigation. It is estimated that surface settlements for 30 feet to 50 feet of drawdowns would be about two inches to 3 1/2 inches. Drawdown levels will decrease as the distance from the excavation increases. This drawdown level decrease would generally depend on the permeability of subsurface materials. Subsurface materials at the northern end of the station consist of relatively pervious Old Alluvium compared to less pervious Puente Formation bedrock at the southern end of the station. This indicates the effect of dewatering would diminish faster at the southern end than at the northern end as the distance from the excavation opening increases.

It is anticipated that differential settlements will be significantly less than the total settlement. Our estimate of the differential settlements assuming about 30 feet drawdown at the southern end and about 50 feet drawdown at the northern end of the station (due to difference in groundwater level elevation) would be as follows:

Distance From Excavation Opening (feet)	Differential Settlement Over A 50-Foot Span	
	Southern End	Northern End
Within 50 feet	0.8 inch	1.0 inch
50 feet to 100 feet	0.5 inch	0.3 inch
100 feet to 200 feet	0.3 inch	0.3 inch
200 feet to 400 feet	negligible	0.1 inch

The above differential settlement estimates are relatively small, except within 50 feet of the station, and should not cause undue impact on the adjacent buildings. Provisions should be made for any building within 50 feet of the excavation to resist dewatering-induced settlements. However, it is prudent that any existing building located within 100 feet of excavation be monitored for settlement during dewatering, excavation, and construction to reduce potential liability.

5.1.3 Station Excavation

Groundwater control will be needed since perched groundwater levels, observed to be at about Elevations 298 feet to 315 feet across the site area, are about 40 feet to 60 feet above the excavation bottom for all structural components of the station. Station excavations may either be shored or sloped back. Sloped excavations may not be feasible at the site due to the close proximity of the excavation limits to existing structures. As an alternative to shored excavations, sloped excavation can be used above the groundwater level if sufficient easements can be obtained. Sloped excavation can also be used for the portion under groundwater level if anticipated groundwater flow from the alluvium and Puente Formation into the excavation can be handled through proper groundwater control provisions without delaying construction.

5.1.3.1 Sloped Excavation. Compared to shored excavation, sloped excavations will increase the volume of excavated material. Sloped excavations can be used for the station's structural components that require shallower excavations, or be used to reduce the height of shoring if sufficient easements can be obtained and proper groundwater control provisions are implemented.

A series of slope stability analyses were performed assuming the perched groundwater at the site is drawn down and maintained at least five feet below the granular Old Alluvium at the site and no heavy loads are at or near the top of the slope. Our recommendations for sloped excavations are as follows:

1. 1H:1V (one horizontal to one vertical) for the fine-grained Old Alluvium (Unit A4).

2. 1 1/2H:1V for the granular Old Alluvium (Unit A3) and the highly weathered Puente Formation (Unit Tpw).

3. 1H:1V for the fresh/oxidized Puente Formation (Unit Tpf/Tpo) bedrock in the sides of the excavation, where sandstone beds and bedding planes are either parallel to or dip away from the excavation openings or in areas where bedding plane dip angles are smaller than 25 degrees.

4. At borings PII-35 and PII-36A, large dip angles (45 degrees and more) were observed in samples obtained within station excavation depths. Bedding planes in these samples were randomly oriented. During excavation periodic mapping should be performed to monitor the presence of bedding planes dipping steeply into the excavation. Provision should be made by changing the slope to 2H:1V at these locations if such conditions exist.

The above recommendations for allowable slopes should be used as general guidelines. Actual slopes will depend on the subsurface condition encountered during excavation and construction condition. If heavy loads (stored materials, cranes, etc.) are anticipated at the top of the slopes, the slopes must be modified accordingly by taking the impact of these loads into consideration.

It should be noted that construction and proper maintenance of safe, stable slopes are the responsibility of the contractor, based on factors that must be determined in the field from actual construction conditions and the subsurface conditions encountered during construction.

5.1.3.2 Shored Excavation. The excavation for the cut-and-cover station will extend to a maximum depth of about 74 feet below the ground surface. It is anticipated that about 40 feet to 60 feet of the excavation will be below the perched groundwater table. The proximity of the excavation to adjacent

buildings, limited construction space, and the subsurface conditions in the general area indicate that shoring will be required.

Various shoring systems exist in engineering practice. These include sheeting systems of sheet pile, structural slurry, soldier pile and lagging walls with bracing system of tiebacks or internal bracing. Based on local practices in the Los Angeles area with subsurface conditions similar to those encountered in the site area, soldier pile and lagging walls with tiebacks or internal bracing (struts and wales), are the most likely shoring systems. These systems are recommended over the other systems for the following reasons:

1. Structural slurry walls are generally significantly more expensive.
2. It is difficult to drive sheet piles into Puente Formation bedrock.
3. Since the bedrock appears to be submerged, continuous slurry or sheet pile walls may accumulate water and build up significant water pressures behind the shored walls. Design and construction of a deep shored wall to resist significant water pressure differential will be extremely costly compared to soldier pile walls with lagging and tiebacks or internal bracing.

The engineering evaluation and discussions provided in this section for the shoring support of the station excavation are related to the soldier pile and lagging walls with tiebacks or internal bracing. If a shoring system with combined tiebacks and internal bracings is selected, a complete soil-structure interaction study must be performed considering the difference in stiffness between the tiebacks and internal bracing. Results of such a study should be reviewed and approved by the owner agency or its authorized consultants.

It should be noted that appropriate shoring system, selection, design, installation and maintenance will be the responsibility of the contractor, and subject to review and acceptance by the owner agency or its authorized consultants.

Assumptions. Shoring systems for deep excavations consist of soldier pile and lagging, and tiebacks or internal bracing to resist lateral earth and water pressures exerted by the excavation and/or the lateral pressure resulting from the adjacent existing structures if they are not underpinned below the final excavation depth (Section 5.1.4).

Both soldier pile and lagging walls with tiebacks or internal bracing were considered in the engineering evaluation. The following assumptions were made in the engineering evaluation provided in subsequent sections:

1. The perched groundwater level at the site is drawn down at least five feet below the bottom of the Old Alluvium prior to excavation.

2. There will not be significant accumulation of water and water pressure buildup behind the walls during station excavation and construction.

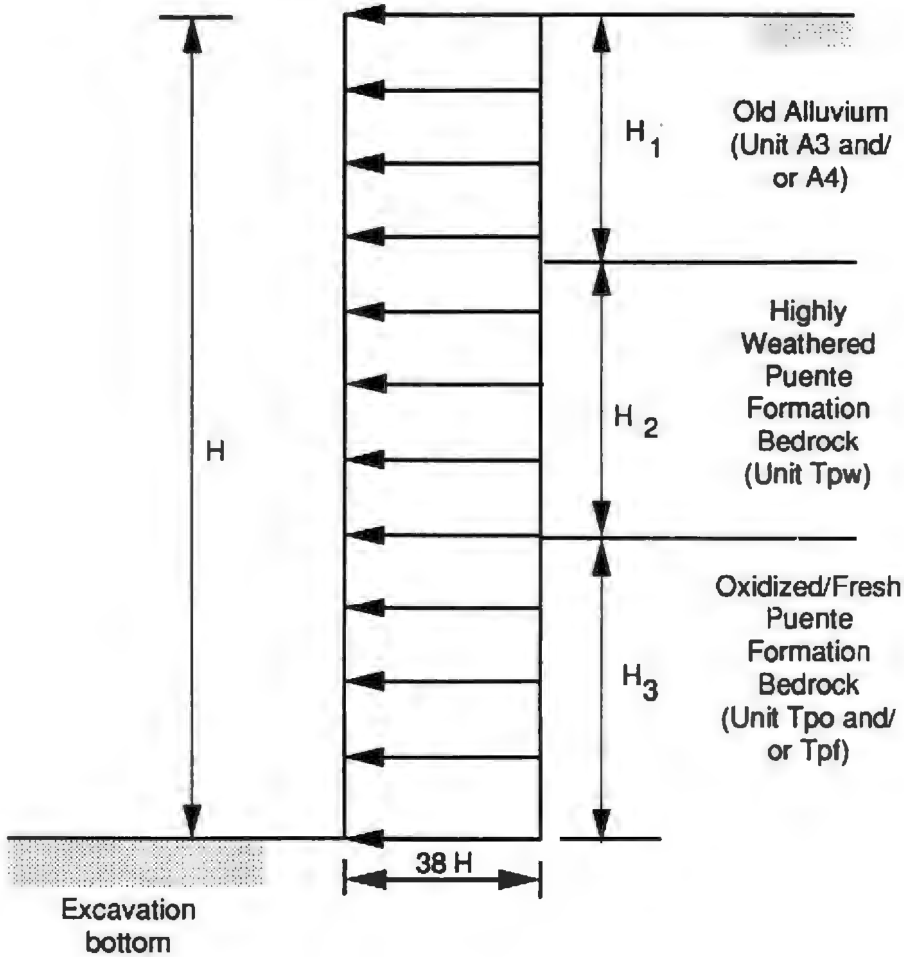
3. Permeability of Puente Formation is low and does not create additional seepage forces on the shoring system.

The first assumption has been described previously. Although the bedrock is considered to be submerged, the second assumption is appropriate for soldier pile and lagging sheeting systems since the openings between soldier pile and laggings should prevent water accumulation and pressure buildup behind the wall.

Based on the above assumptions, our engineering evaluation and recommendations, with respect to soldier pile and lagging walls with internal bracing or tiebacks, are described in the following sections.

Lateral Wall Pressure. Lateral pressure on the sheeting system depends on the type of shoring system, construction procedures, and subsurface and groundwater conditions. Based on the available results, anticipated shoring system, and construction procedures, as well as previously stated engineering assumptions, lateral earth pressures on the soldier pile and lagging walls for the following cases are shown in Figures 5-1 through 5-4:

- Braced sheeting above excavation
- Cantilevered sheeting above excavation
- Surcharges from sloped excavation, existing buildings, construction loads, and earthquake-induced loads
- Active and passive earth pressures on soldier piles below the excavation.



Notes: (1) This pressure diagram is applicable to all sides of excavation
(2) Earth pressure in psf
(3) H_1, H_2, H_3, and H in feet

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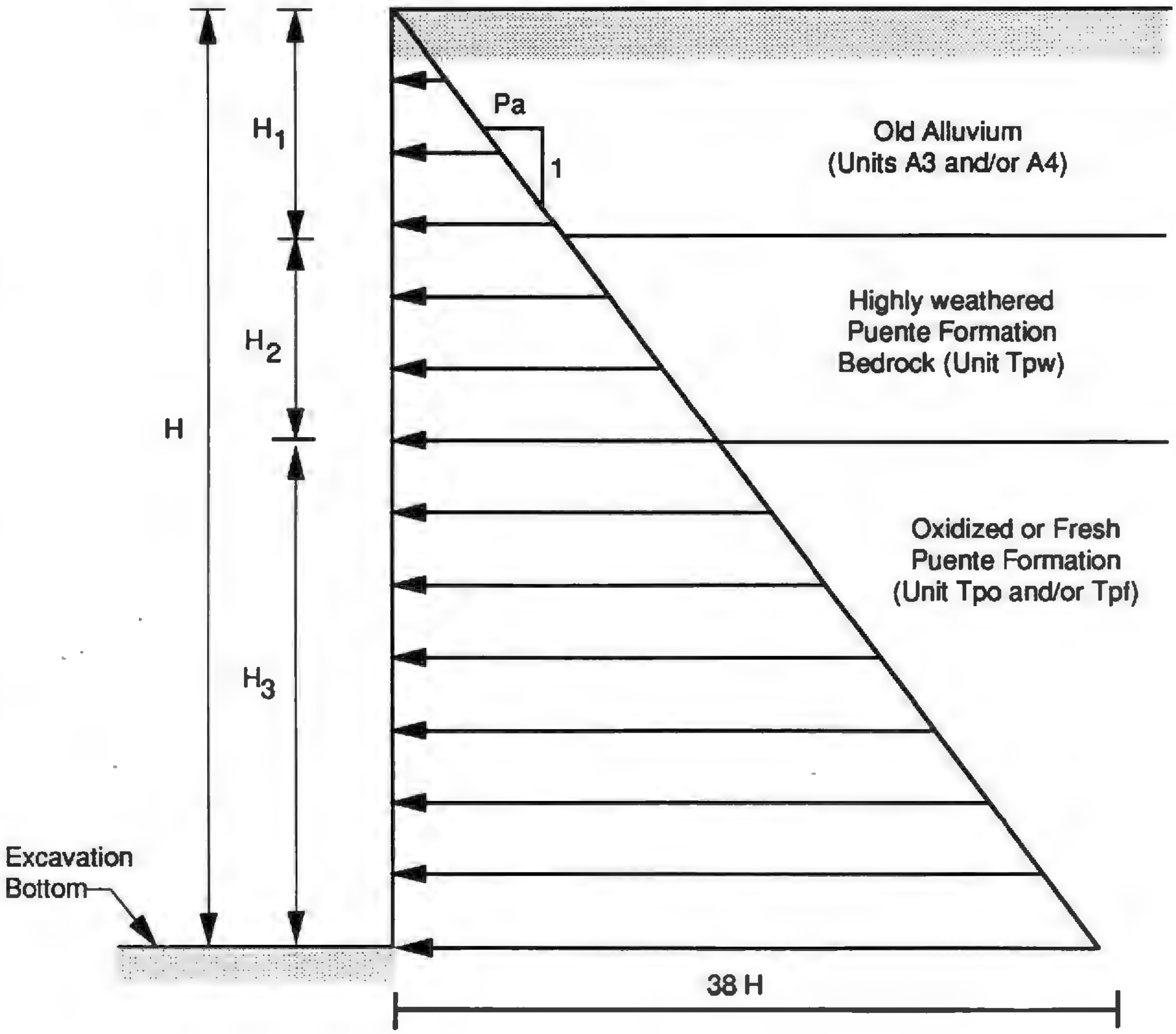
Lateral Earth Pressure On Braced Sheeting

05-90

Figure 5-1



Pa = 38 psf/ft

Notes: (1) All earth pressures in psf.
(2) H, H_1, H_2, and H_3 in feet.

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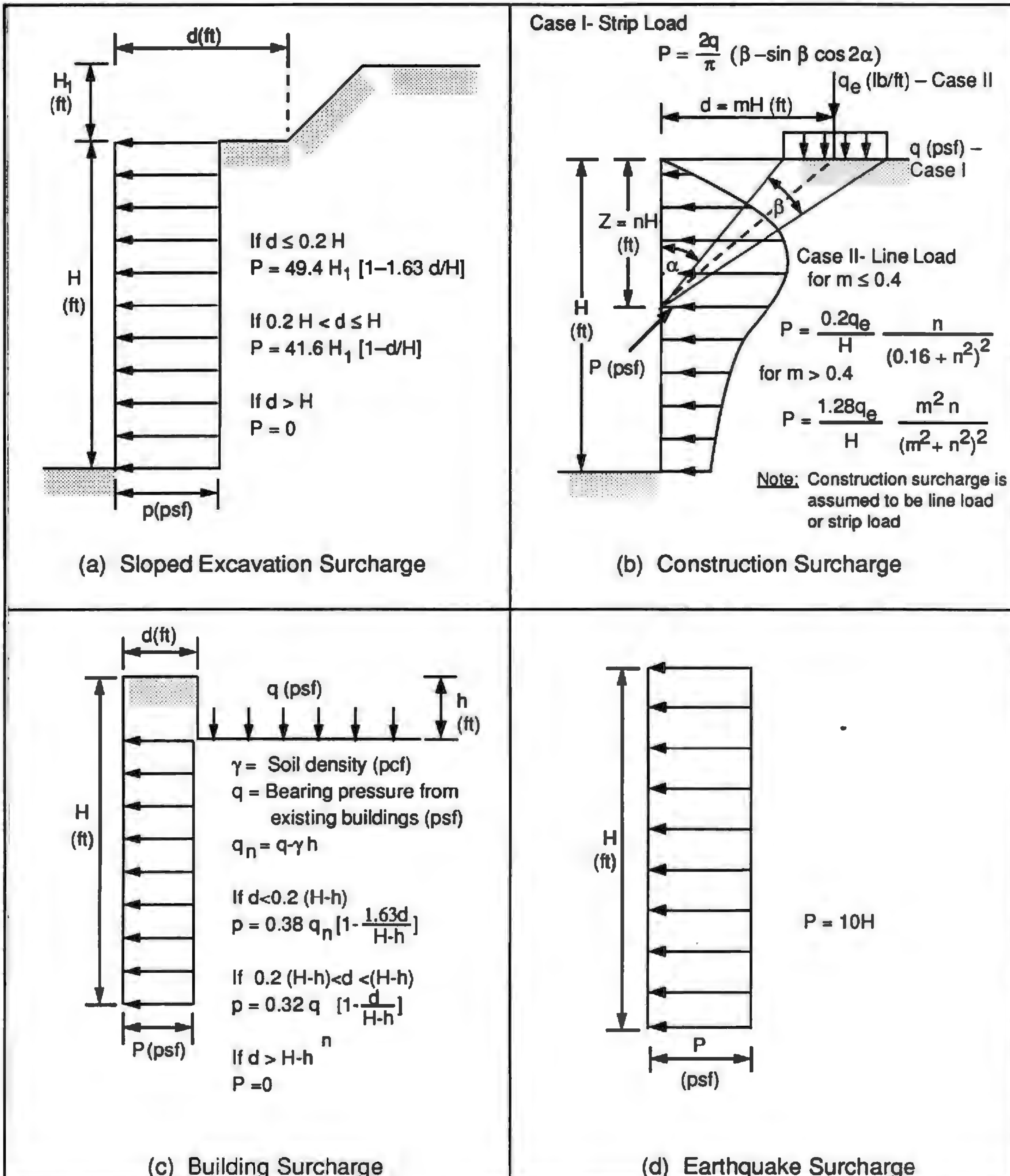
Lateral Earth Pressure on Cantilevered Sheeting

05-90

Figure 5-2



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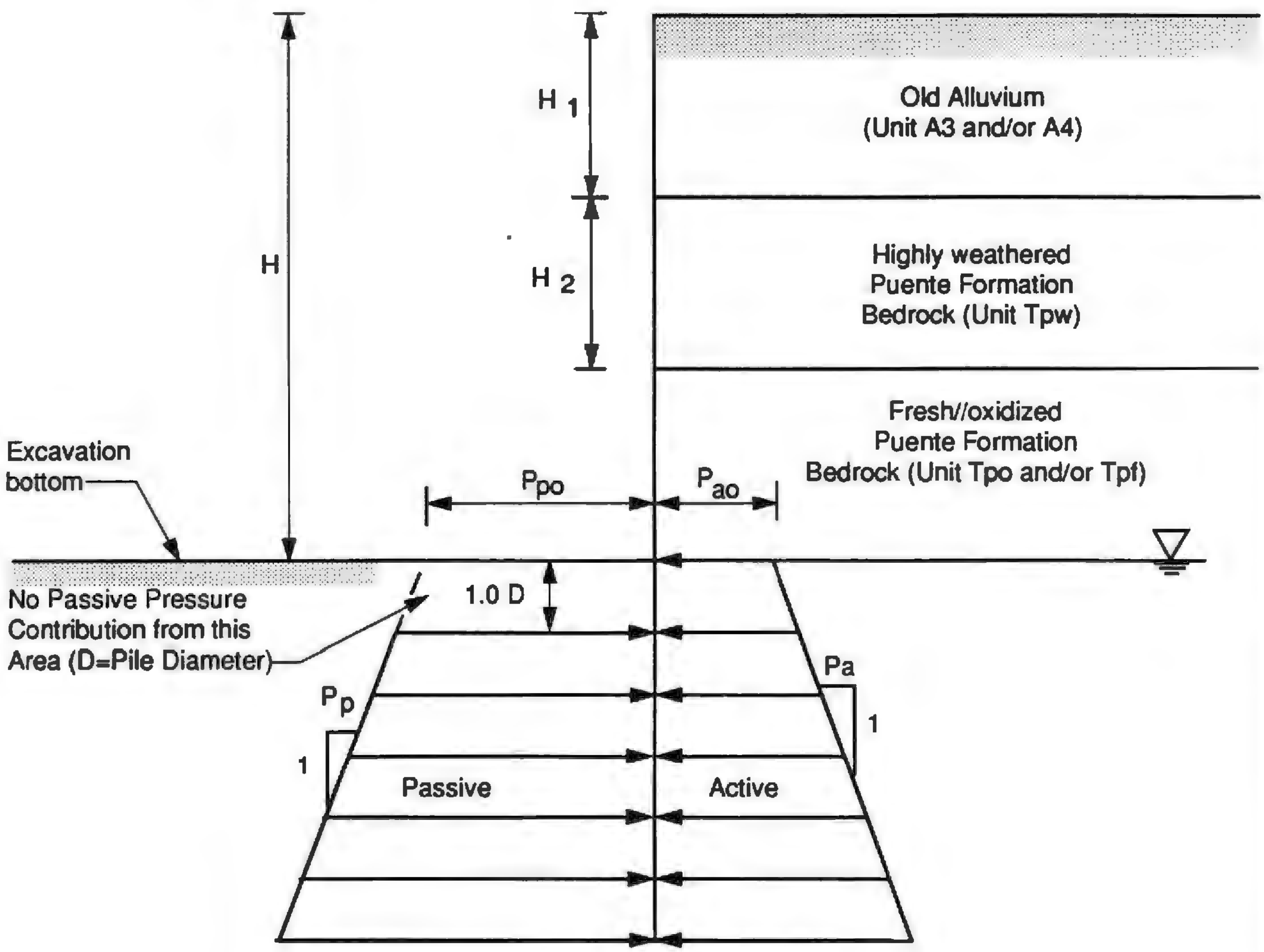
Additional Lateral Earth Pressure on Braced or Cantilevered Sheeting

05-90

Figure 5-3



Ppo = 850 psf
Pp = 94 psf/ft
Pa = 21 psf/ft
Pao = Active earth pressure at excavation bottom (See Fig. 5-1 or 5-2)

Notes: (1) Bedrock below excavation bottom is assumed to be submerged.
(2) Factor of safety of 2.0 is included for passive pressure.
(3) All earth pressures in psf.
(4) H, H_1, H_2, and D in feet.

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Lateral Earth Pressure On Soldier Piles Below Excavation

05-90

Figure 5-4

The lateral loading diagrams presented in Figures 5-1 to 5-4 are for use in the design of soldier pile and lagging details, tiebacks, or an internal bracing system. Various design considerations are described in the following sections.

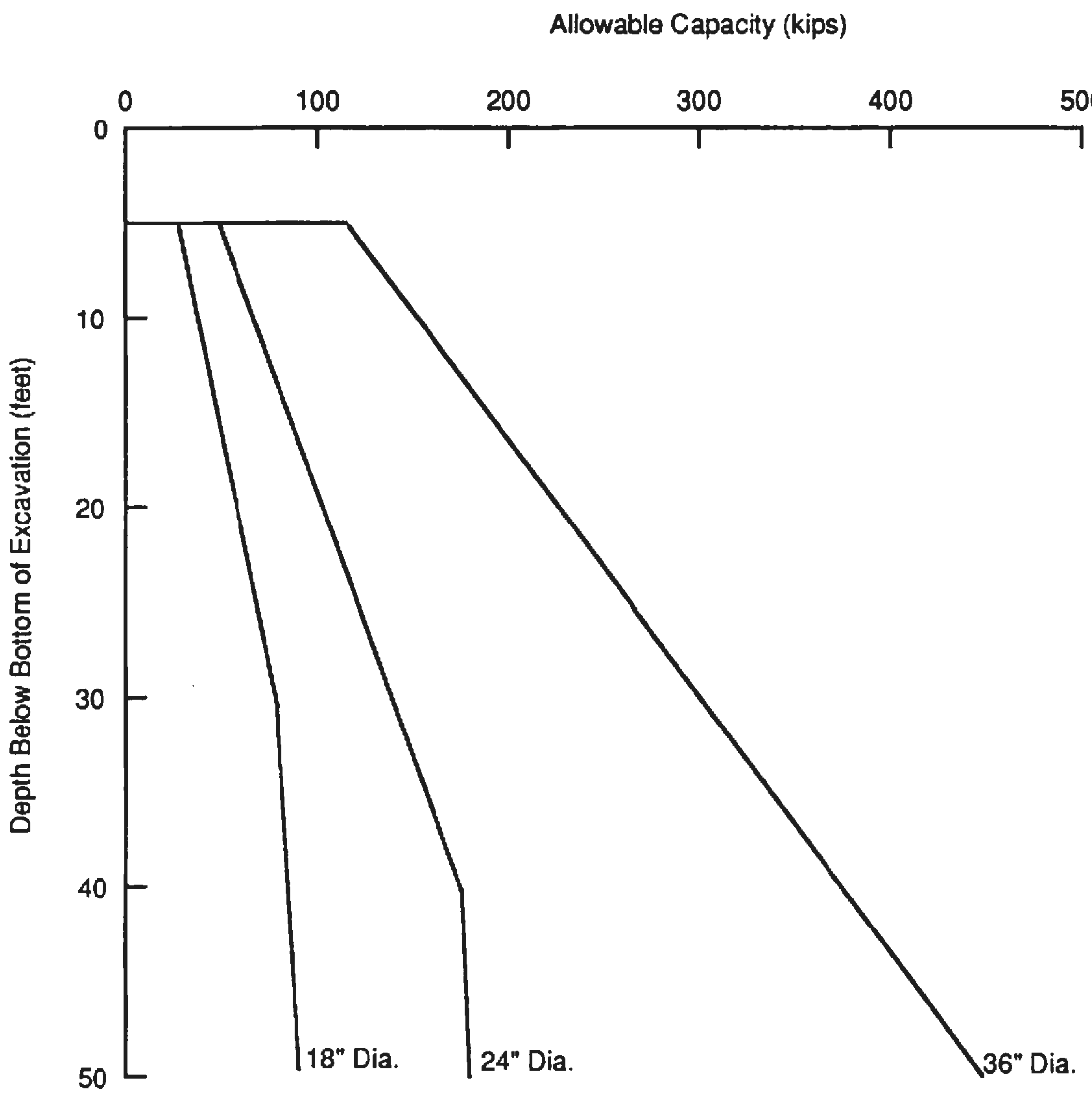
Design Considerations - Soldier Piles and Lagging. The soldier pile and lagging walls should be designed to safely resist lateral and vertical loads imposed by the excavation, existing structures, construction loading, environmental loading (such as earthquake loading), and the shoring system itself. Design considerations, which include pile sizing, embedment depth, spacing, installation, and lagging provisions, should be in compliance with appropriate building codes and city requirements.

Pile Sizing

Pile sizing includes a proper determination of pile size (diameter or cross section) and type (stiffness) so that stresses in the piles are within allowable limits. All anticipated lateral and vertical loads as well as calculated loads from tiebacks or internal bracing should be applied in calculating the pile stresses. The calculated stresses in the pile can be reduced by 20 percent to account for arching effects due to pile flexibility.

Embedment Depth

The soldier piles should be sufficiently embedded below the excavation depth to safely resist anticipated lateral and vertical loads. The passive resistance should be much more than the imposed lateral loads (active pressure in Figures 5-1 to 5-4 minus the resistance from tiebacks or internal bracing) with a reasonable safety factor. The effective width of excavation that each pile can support should be taken as 1-1/2 times the soldier pile diameter or half of the pile spacing, whichever is less. For vertical load considerations, the allowable vertical pile capacity, shown in Figure 5-5, should be more than the vertical load components from tiebacks and load from decking. Groundwater-control induced settlement adjacent to the soldier pile wall, if sufficiently large, may result in negative skin friction on the



Note: Factor of safety of 3 is included.

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Vertical Capacity for Straight Shaft Soldier Piles

05-90

Figure 5-5

piles, which would reduce the allowable vertical capacity. After evaluating the negative skin friction potential, it was concluded that the potential for such a condition to develop within the pile embedment depth below the excavation would be minimal; therefore, it was not considered in developing the vertical load capacity, shown in Figure 5-5. However, it should be noted that piles may undergo some settlement before mobilizing the anticipated capacities. It is estimated these settlements may range from about 0.5 percent to 2 percent of the pile diameter.

Pile Spacing

Optimal pile spacing depends on a number of factors, including subsurface conditions and engineering properties of subsurface materials, pile sizing, construction procedures, and cost. Considering the need for lagging to alleviate soil raveling and minimize ground loss, a pile spacing of eight feet or less would be reasonable.

Pile Installation

As in similar deep excavations in the Los Angeles area, the soldier piles in the site area should be installed in predrilled holes to the design embedment depths. The presence of dense to very dense granular Old Alluvium overlying Puente Formation bedrock in the site area precludes the use of impact driving. Potential caving conditions exist in granular Old Alluvium. Provisions such as the use of bentonite slurry in the predrilled holes should be implemented to alleviate caving conditions.

Lagging

Lagging between soldier piles will be needed to minimize soil raveling or ground loss, especially in the granular Old Alluvium zones and in the bedrock in the northeast side of the excavation, where weak sandstone beds and bedding planes dip into the excavation. It is the contractor's responsibility to control the temporary height of exposed soil prior to lagging placement to eliminate raveling and ground loss problems.

Tiebacks

Installing tiebacks in the site area will require permission from the owners of adjacent buildings and avoidance of below-grade obstructions such as basements or foundations in adjacent buildings. Many types of tieback anchors exist, including shaft anchors, belled anchors, anchor blocks, and high-pressure grout anchors. For this project, it is assumed that straight shaft anchors will be used in construction.

In general, the allowable capacity of the tieback anchor should be determined in the field based on anchor load tests. The following paragraphs describe our anchor capacity estimates and recommendations for load testing and maintaining.

Effective friction of a tieback anchor can develop only beyond a no-load zone. Our recommendation for the no-load zones considering depth of excavation and potential wedge failure planes are shown in Figure 5-6. The allowable anchor capacity can be determined as follows:

$$P = q(\pi DL)$$

where:

P = allowable anchor load in kips
L = length of anchor beyond the no-load zone in feet
D = anchor diameter in feet
q = soil friction in ksf, which can be determined as follows:

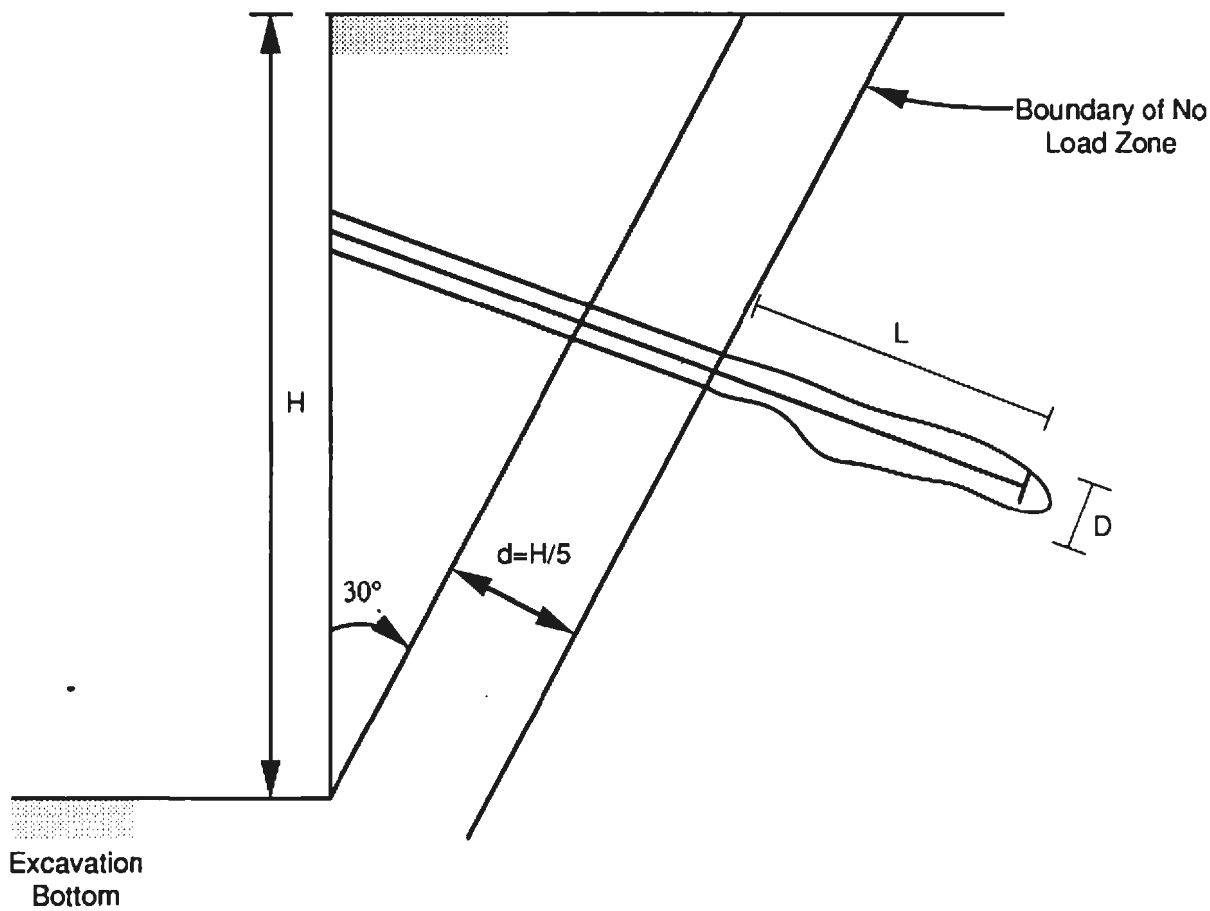
$q = 0.03z < 1.5$ ksf in granular Old Alluvium above perched water.
$q = 0.15 + 0.015z < 1.5$ ksf in granular Old Alluvium below groundwater.
$q = 0.08 + 0.02z < 0.5$ ksf in fine-grained Old Alluvium above groundwater.

$q = 0.2 + 0.01z < 0.5$ ksf in fine-grained Old Alluvium and in weathered Puente Formation bedrock below groundwater.

$q = 0.2 + 0.01z < 0.6$ ksf in fresh/oxidized Puente Formation bedrock below groundwater.

where z = depth to the middle of bonded anchor in feet.

In addition, the allowble capacity of the anchors completely embedded in granular Old Alluvium should not exceed 150 kips, and in fine-grained alluvium and weathered Puente Formation bedrock should not exceed 120 kips. The



L = Length of bonded anchor block beyond no load zone.
d, D, H, and L are in feet.

Reference: FHWA, Permanent Ground Anchors, 1984

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Anchor Locations For Tieback Walls

05-90

Figure 5-6

anchors may be installed at angles between 20 degrees to 50 degrees below the horizontal direction. Potential caving conditions in the granular Old Alluvium are possible, so the contractor should use appropriate methods and measures to prevent caving to minimize ground loss.

Each tieback anchor should be load tested to 150 percent of the design load in accordance with standard acceptance criteria (FHWA-DP-68-IR, November 1984; Winterkorn and Fang, 1975) or local site-specific experience of the contractor. The load in the tiebacks should be locked-off at 100 percent of the design load. The load in a selected number of tiebacks should be periodically monitored and reloaded to 100 percent of the design load if the load decreases to less than 75 percent of the design load.

Internal Bracing

If braced sheeting systems are employed, the strut loads should be determined using the full load diagrams shown in Figures 5-1 and 5-3. The vertical spacing between struts should be appropriately designed to minimize ground movements. All struts should be preloaded to eliminate slack and minimize ground movement. A preload of 25 percent of the design load is recommended. However, it should be noted that strut preloads may induce undue loading on any basement of the adjacent buildings. This possibility should be analyzed on a case-by-case basis.

Procedures to compensate for the effects of temperature changes on the strut loads should be developed and implemented so that proper strut load levels can be monitored and maintained during construction.

Ground Movement and Bottom Stability

Shored excavation will incur ground movements in terms of wall movement and ground heave. The magnitude of wall movement depends on many factors, including the design and construction of shoring systems, construction schedule, specifications, and subsurface conditions. In general, for a well-designed and constructed sheeting system, the maximum horizontal wall deflection will be about 0.1 percent to 0.2 percent of the excavation depth.

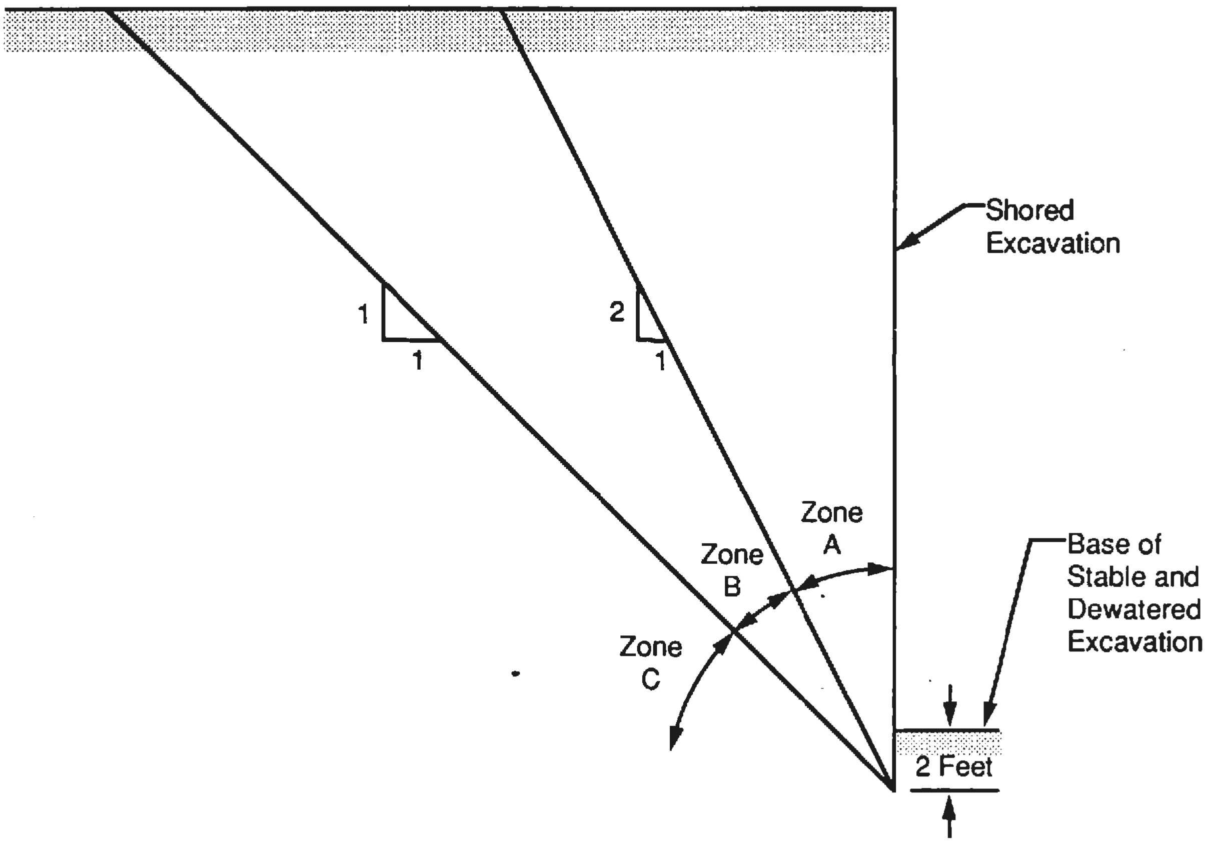
For the Vermont/Santa Monica Station, the maximum horizontal wall movement may be about 0.5 inch to one inch. For the shored system with tiebacks, this maximum horizontal deflection will occur near the surface, and the horizontal deflection will decrease with depth. For an internally braced system with struts and wales, the maximum horizontal deflection will probably occur near the bottom of the excavation and decrease to about 0.2 inch to 0.5 inch near the surface.

It is estimated that a maximum vertical settlement of about 0.5 inch to one inch will probably occur behind the wall to about 25 feet to 50 feet from the wall and will decrease as the distance from the maximum settlement location increases.

The maximum excavation depth of the Vermont/Santa Monica Station is about 75 feet. This would mean a maximum stress relief of about 4,300 psf to 5,700 psf at the excavation bottom, resulting in bottom heave due to elastic and consolidation rebounds. We estimate that the heave at the center of the excavation bottom will be about two inches to five inches. A majority of the heave will occur during the excavation. After the excavation is completed, the consolidation heave should be minimal and should pose no concerns. We also concluded that rupture of the excavation bottom due to excessive heave or piping is not likely.

5.1.4 Underpinning

There are several methods for underpinning existing adjacent buildings. These may include, but are not limited to, jacked piles, drilled piers, and shafts/piers constructed in pre-dug lagged pits to the bearing stratum. To minimize settlement, the bearing stratum in the site area would be the Puente jacked piles and drilled piers are presented in Figures 5-7 through 5-10. It should be noted that piles may experience a settlement of about 1/2 inch before mobilizing full friction resistance, and about 0.5 percent to 2 percent of pile diameter before mobilizing full tip resistance. It is recommended that at least one or two field pile load tests be performed at the site to



Notes: The following underpinning guidelines are for structure foundations in Zones A, B, and C.

Zone A: Foundations within this zone generally require underpinning.

Zone B: Sensitive structure foundations within this zone require underpinning.

Zone C: Underpinning may not be required.

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General Guidelines For Underpinning

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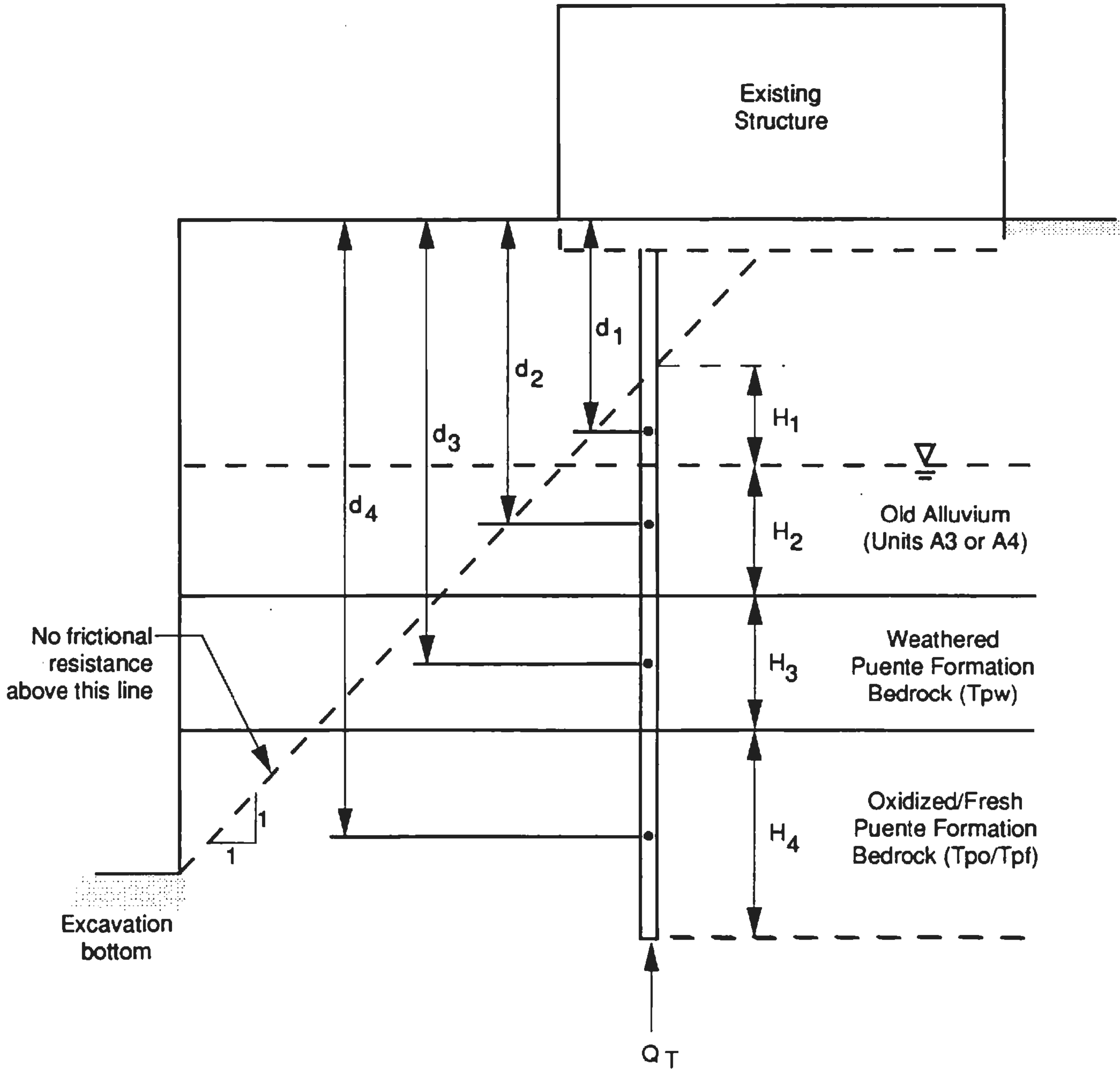
Figure 5-7



Allowable capacity = $Q_T + (H_1 \times Q_{f1}) + (H_2 \times Q_{f2}) + (H_3 \times Q_{f3}) + (H_4 \times Q_{f4})$

Q_T = Allowable tip resistance at tip depth (Figure 5-9)

Q_{f1}, Q_{f2}, Q_{f3}, Q_{f4} = Allowable skin friction at depths d_1, d_2, d_3, and d_4, respectively (Figure 5-10)

Notes: (1) Allowable capacity and Q_T in kips.

(2) Q_{f1}, Q_{f2}, Q_{f3}, and Q_{f4} in kips/feet

(3) d_1, d_2, d_3 and $_4$ are depths to the middle of length segments H_1, H_2, H_3 and H_4, respectively.

(4) H_1, H_2, H_3, H_4, d_1, d_2, d_3, and d_4 in feet.

(5) Drawing is schematic.

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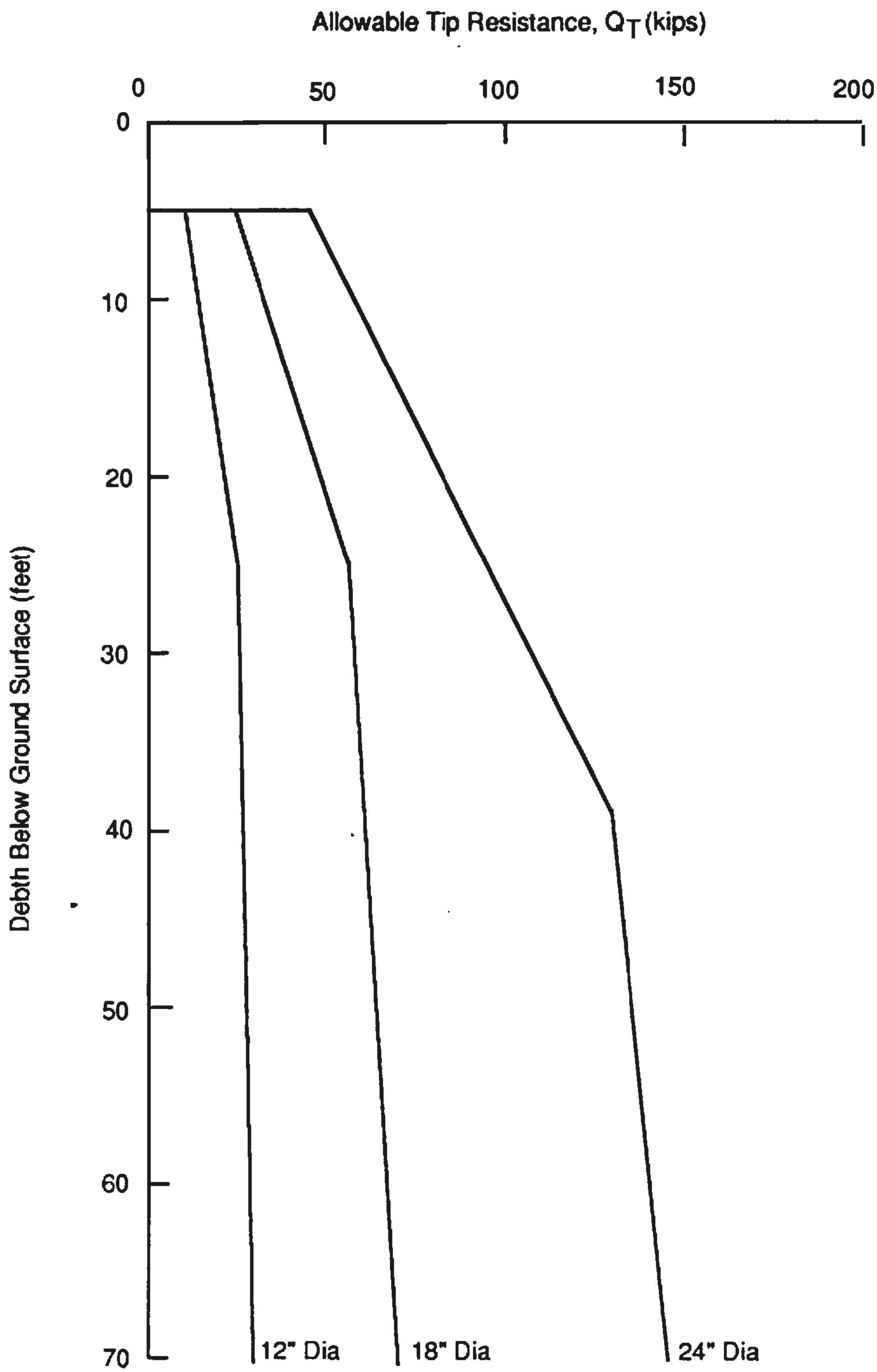
Design Capacity of Straight Shaft Piles for Underpinning Purposes

05-90

Figure 5-8



Note: Factor of safety of 3 is included.

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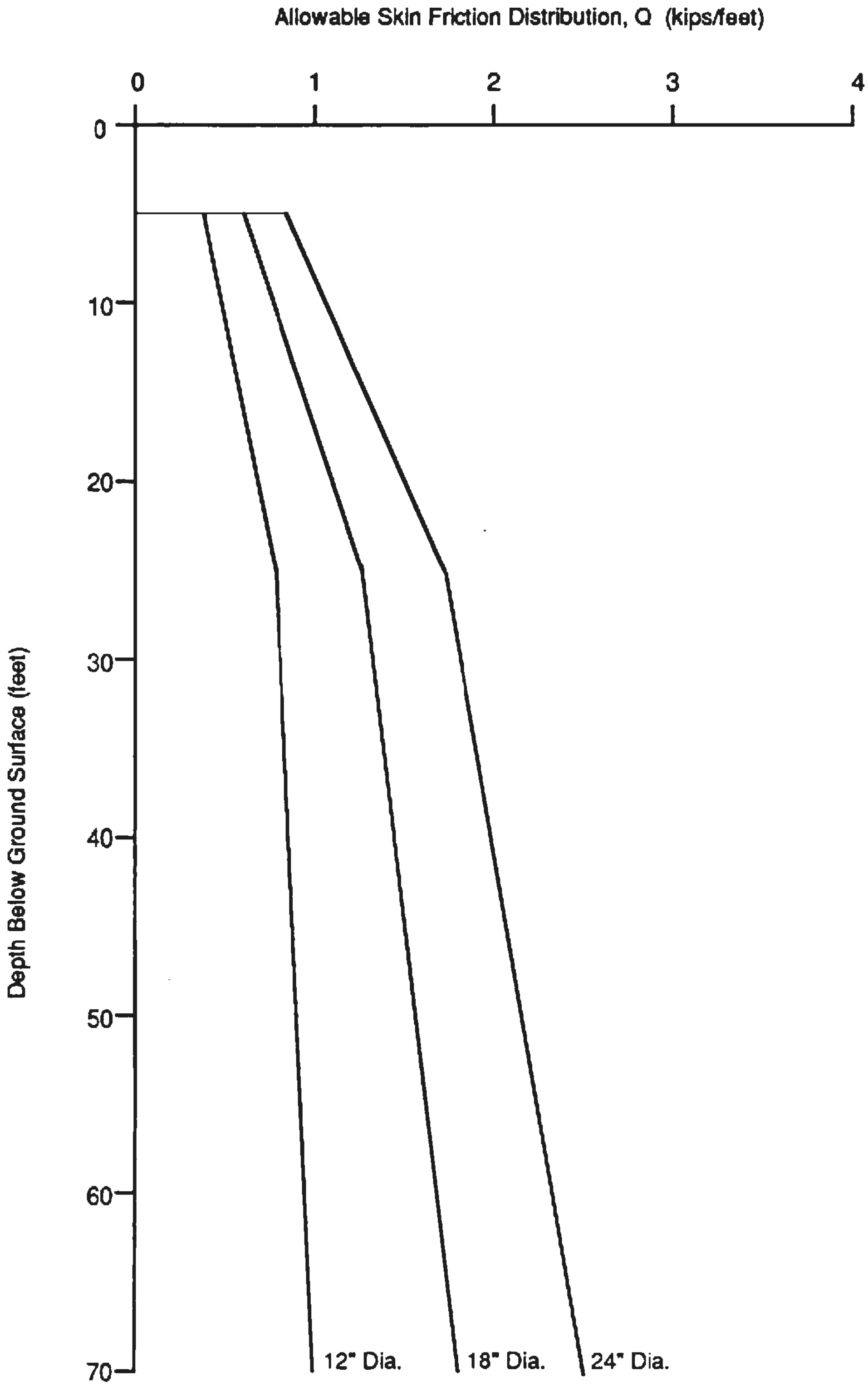
Allowable Tip Resistance For Straight Shaft Piles

05-90

Figure 5-9



Notes: Factor of Safety of 3 is included.

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Allowable Skin Friction Distribution Along Straight Shaft Piles

05-90 Figure 5-10

verify recommended capacities and to ensure that settlement under design load will be acceptable.

The settlements of underpinned buildings should be monitored on a regular basis during construction. If the settlement data indicate potential for excessive settlement beyond allowable limits pre-set by the engineers, the excavation work should be suspended temporarily and immediate remedial measures implemented.

5.1.5 Station Foundation Support and Considerations

The subsurface materials in the station area are Old Alluvium (consisting primarily of dense to very dense granular materials and stiff to very stiff fine-grained materials) over Puente Formation bedrock. These materials will provide adequate foundation support for the planned station structures. However, due to the compressibility of the Puente Formation bedrock, some consolidation settlement may be anticipated and should be carefully considered in the station design.

5.1.5.1 Main Station. We understand that the overall station will be designed and constructed as a relatively rigid box and the main station housing the rail facilities will be supported on wide, thick slabs that will function as relatively rigid mat foundations. These foundations will be supported on Puente Formation bedrock.

Available information indicates that the average bearing pressure on the mat foundations from the station and backfill will be about 5,000 psf, and on the same order of magnitude as the overburden removed by the excavation. This anticipated station load can be safely and adequately supported on the bedrock.

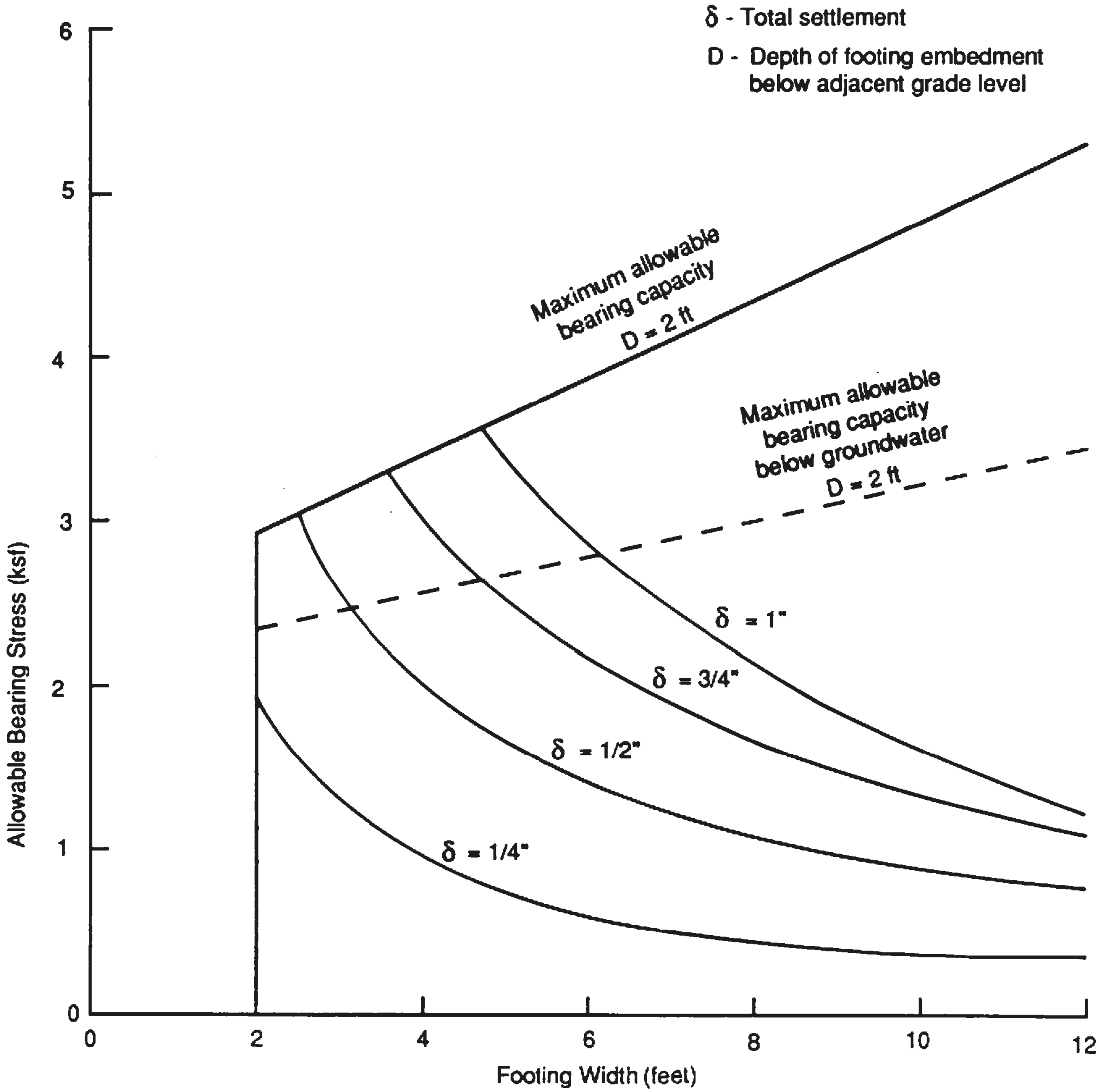
It is estimated that elastic settlement due to the station load of 5,000 psf will be about one inch. This settlement would take place almost immediately during the construction. Analyses also indicate consolidation settlement due to the station load will take place over a period from 6 months to 18 months

and will be on the order of three inches to 4 1/2 inches. However, when the groundwater control scheme is terminated after station construction, the groundwater level around the station will slowly recover to its original elevations at about 40 feet to 60 feet above the station base slab, thus unloading soil layers around and beneath the station. This unloading will result in some ground heave, estimated to be about 2 1/2 inches to 3-3/4 inches. Some tilting of the structure should also be expected due to differential heave induced by different groundwater heights and rates of recovery in Old Alluvium (more pervious) and Puente Formation (less pervious).

5.1.5.2 Other Structures. The entrances and the stairways leading to the mezzanine level will be located above the bedrock. These structures can be supported by conventional spread footings founded on the Old Alluvium, bedrock or properly selected and compacted fill. All spread footings should be a minimum of two feet wide and at least two feet below the lowest adjacent grade. All in situ fill materials should be removed and should not be reused as compacted fill for spread footing support. Allowable bearing capacities and estimated total settlement in terms of footing width and bearing pressures for spread footings on Old Alluvium and bedrock are graphically presented in Figures 5-11, 5-12, and 5-13.

5.1.5.3 Loads on Overall Station Walls and Slabs. The overall station will be constructed as a relatively rigid box. Our recommended permanent earth and water pressure diagrams for the station walls and slabs are shown in Figure 5-14. The following should be noted:

1. To account for potential seasonal variation and potential variations across the station, the groundwater level is set at Elevation 310 feet at the southern end and 318 feet at the northern end for design purposes. Design water level is set at about five feet higher than the observed level in PII-35 to accomodate a relatively steep, uncertain, water level gradient between PII-35 and LPE-7.



Note: (1) Factor of safety of 3 is included.

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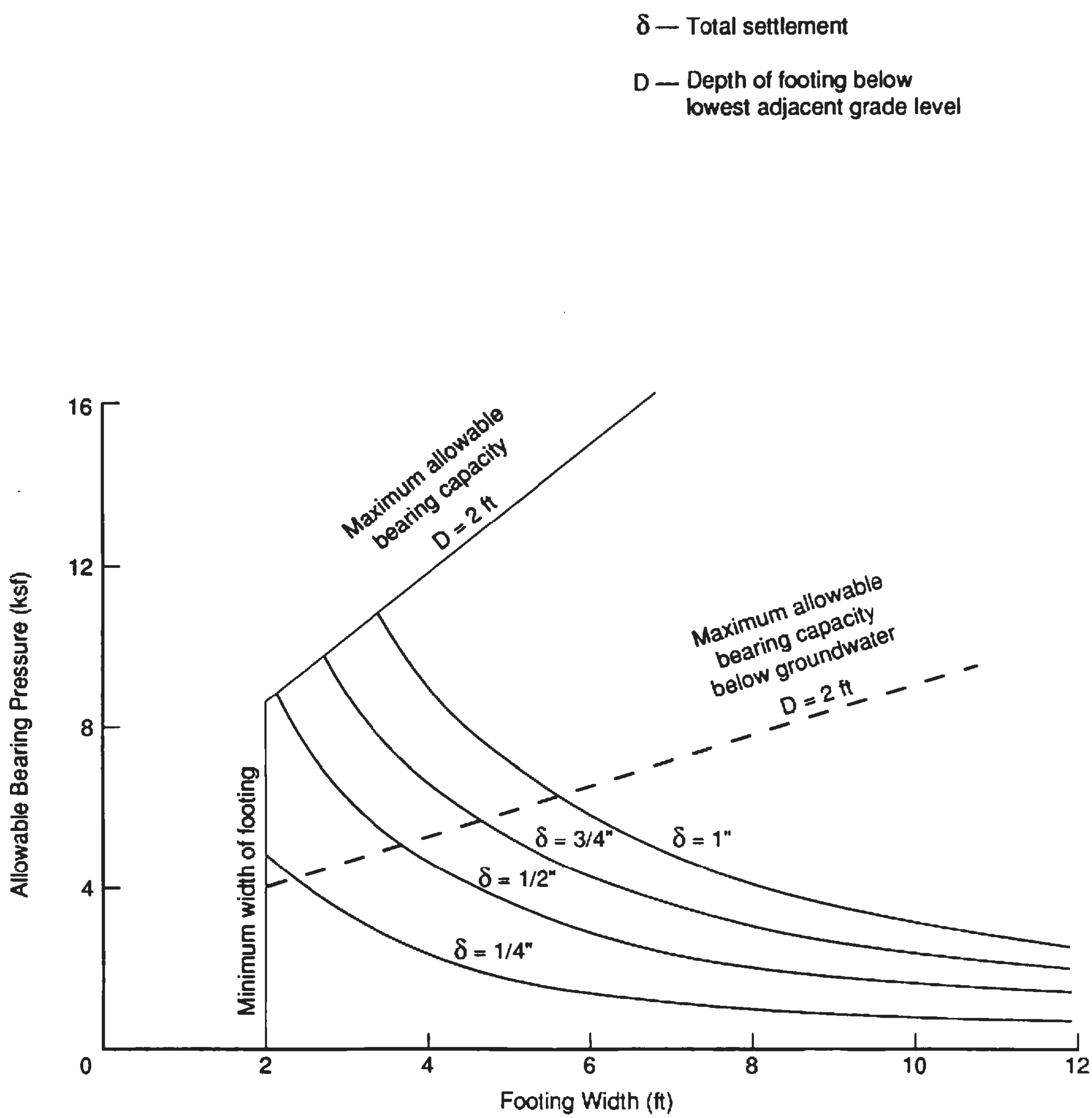
Bearing Capacity for Spread Footings in Fine-Grained Old Alluvium

05-90

Figure 5-11



Note: (1) Factor of safety of 3 is included
(2) Minimum footing embedment depth below lowest adjacent grade level = 2 feet

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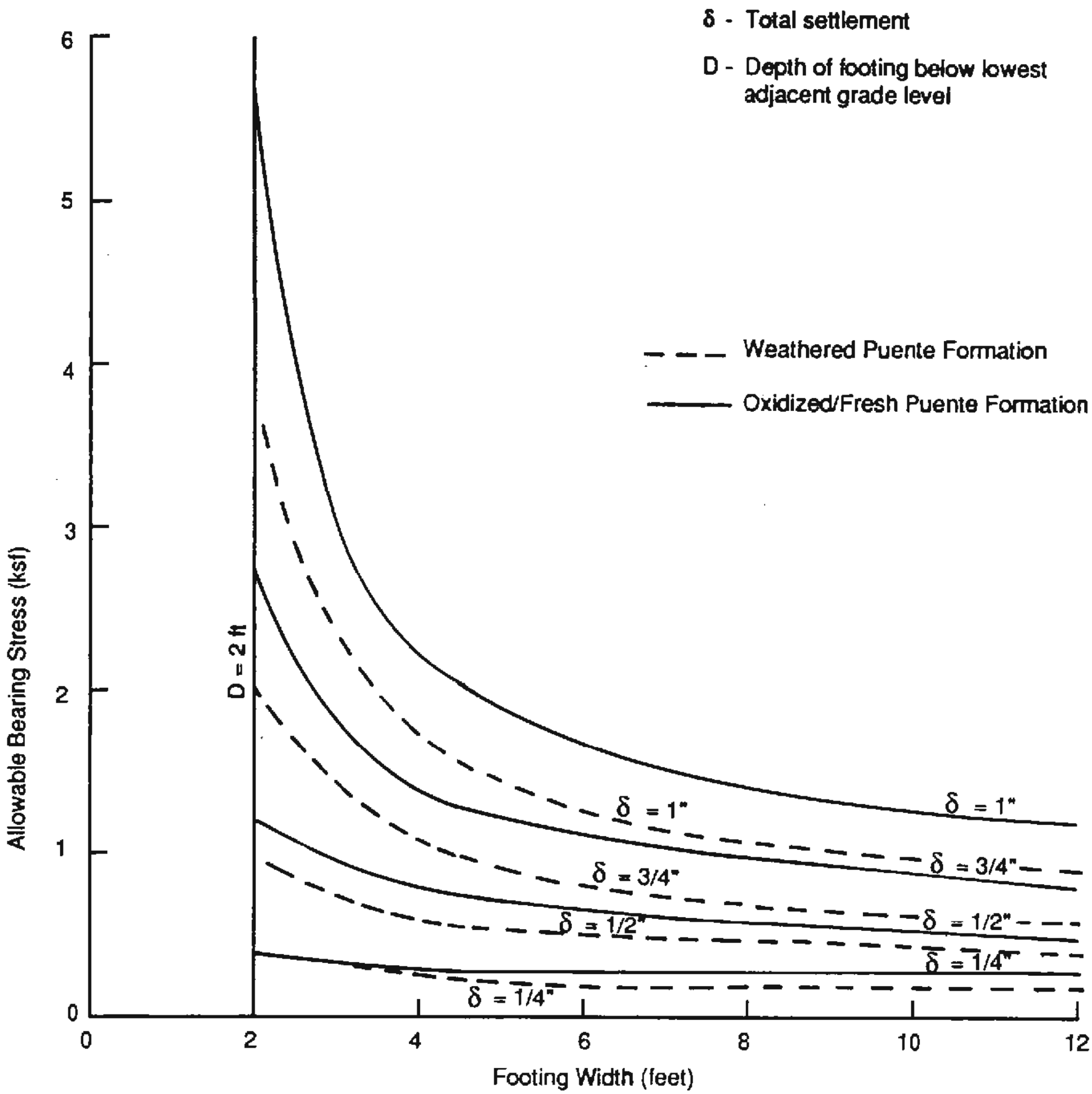
Bearing Capacity for Spread Footings in Granular Alluvium

05-90

Figure 5-12



Note: Factor of safety of 3 is included.

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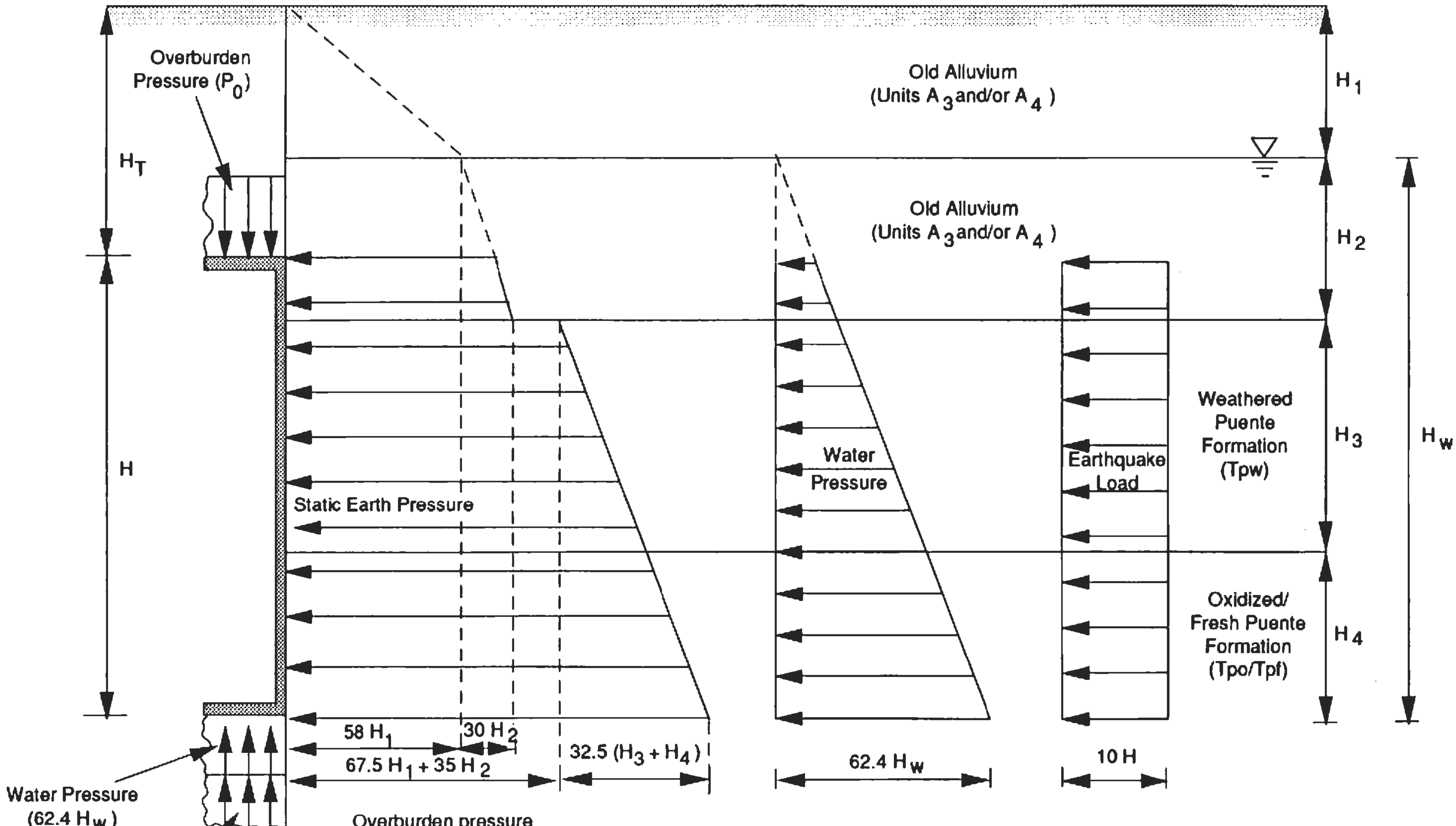
Vermont/Santa Monica Station And Tunnel

Bearing Capacity For Spread Footings In Puente Formation Bedrock

05-90

Figure 5-13



Overburden pressure

$P_0 = \gamma_{bulk} \cdot H_T$, where γ_{bulk} = bulk density in pcf

Notes: (1) All Pressures in psf

(2) Design groundwater elevations, 310 feet at south end and 320 feet at north end of the station . Use interpolated values between two ends.

(3) H, H_1, H_2, H_3, H_4, H_T and H_w are in feet

(4) Use thickness of each layer as in Figure 2-3

(5) Drawing is schematic

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Earth Pressure on Below-Grade Permanent Structures

05-90

Figure 5-14

2. Potential surcharge effects from adjacent existing buildings which are not underpinned should be considered in the wall pressure diagrams (Figure 5-3). Vertical loads from anticipated traffic and other live loads (car parking, etc.) should be determined and added to the roof loadings.

3. In Figure 5-14, a horizontal seismic coefficient, K_h, is used to calculate earthquake-induced lateral earth pressure. We recommend that a K_h value equal to two-thirds of the peak ground acceleration (in terms of gravity -g) be used. For the Metro Rail project, the peak horizontal ground acceleration of the Operating Design Earthquake (ODE) is 0.3g. Thus, a corresponding K_h value of 0.2 is recommended in earthquake-induced earth pressure determination. It should also be noted that the effect of vertical ground acceleration is ignored in earthquake-induced earth pressure consideration to avoid overconservatism.

5.1.5.4 Groundwater Control. Permanent dewatering after completion of the station is expensive and unnecessary. We understand the station is designed to be watertight. Watertight provisions should be carried out at least to Elevation 320 feet at the northern end and 310 feet at the southern end to account for potential seasonal variation and potential in situ variations that were not detected in this investigation.

5.1.6 Earthwork

Earthwork and site preparation activities are expected to consist of excavation for subterranean structures, subgrade preparation for the station floor, foundation preparations for near-surface structures, excavation for utility trenches, subgrade preparation for pavements, and backfill placement for subterranean walls, footings, and utility trenches. Major excavations will need to be provided with temporary shoring according to the recommendations presented in Section 5.1.3.2 of this report. Other minor excavations, subgrade preparations and backfill placement should be done in accordance with the guidelines presented in Appendix D. All work should be in compliance with applicable city (Los Angeles) and federal (Occupational Safety and Health Act) requirements.

Available data indicate that there is some granular Old Alluvium encountered near the northern end of the station. If, during the excavation process,

appreciable amounts of granular alluvium (sand, silty sand, gravelly sand, sandy gravel, and gravel) are encountered, they could be stockpiled to be reused as backfill material. The excavated fine-grained alluvium and bedrock material are not suitable as backfill material. If there is not sufficient material available for backfill, imported granular material could be used for fill, subject to approval of a geotechnical engineer.

5.2 TUNNEL ALIGNMENT

5.2.1 General

Subsurface conditions and potential features that may affect the design and construction of the tunnel segments are described in Section 4. The subsurface conditions along the tunnels are similar to those encountered in the LACFCD's Sacatella Tunnel (LACFCD, 1973 and 1975), the Metro Rail Phase I Contract A171 tunnel (Escandon et al., 1989; Robison, et al., 1989) and Metro Rail Project, Wilshire-Beverly Tunnel segment (Earth Technology 1990b). The experience and performance of these tunnels should be used in the design and construction of Beverly-Santa Monica and Santa Monica-Sunset tunnel segments.

5.2.2 Excavation and Support

5.2.2.1 Tunnel Excavation. As shown in Figures 2-2 and 2-4, the currently planned (MRTC, 1989) Beverly-Santa Monica Tunnel and a major portion of Santa Monica-Sunset Tunnel are located within either the oxidized or fresh Puente Formation bedrock. Highly weathered Puente Formation materials are present within the Santa Monica-Sunset Tunnel elevations in the vicinity of the northern end of the Vermont/Santa Monica Station (Boring PII-39) and between Borings PII-43 and PII-44. In the vicinity of Boring PII-44, the Santa Monica-Sunset Tunnel will also be located within the Old Alluvium. As mentioned in Section 4, except for the very hard sandstone beds and concretionary nodules, the oxidized and fresh Puente Formation materials have the engineering properties similar to those of a hard, dense soil with a high

cohesion strength component. The highly weathered Puente Formation bedrock is soil-like and has engineering properties generally similar to saturated stiff to very stiff silty clay/clayey silt, classified as fine-grained Old Alluvium material, except the local presence of granular weathered Puente Formation bedrock which exhibits properties similar to those of a saturated, medium-dense to dense silty sand.

These subsurface materials are conducive to a shielded mechanical excavation at relatively high advance rates. Similar methods were successsfully employed in the Metro Rail Phase I tunnel excavation and in the construction of the nearby LACFCD Sacatella Tunnel. Several factors that may have significant impacts on excavation equipment and excavation rates are described below.

The presence of very hard sandstone beds of significant thicknesses (one foot thick or more) has not been encountered during the field investigation for this alignment, but their presence in the nearby Wilshire-Beverly Tunnel segment, as well as the presence of thinner very hard sandstone beds (up to one-foot thick) in this alignment, indicate that these conditions should be carefully considered in selecting appropriate excavation equipment and procedures. In the tunnel alignment, the lateral extent of very hard sandstone beds/layers is not certain. However, at the nearby LACFCD Sacatella Tunnel, some of these very hard sandstone interbeds were near horizontal and followed the tunnel face for several hundred feet. Some were at a 45 degree angle to the tunnel alignment and followed the face for several tens of feet. The very hard sandstone beds may have a maximum unconfined compressive strength of about 15,000 psi to 20,000 psi, or more.

In addition, very hard concretionary nodules similar to those encountered in Contract Unit A171 may be encountered in the Puente Formation bedrock. The potential maximum size of these nodules is not known. However, nodules up to 18 inches in diameter were encountered in the A171 Tunnel excavation.

Since Beverly-Santa Monica and Santa Monica Sunset tunnel alignments are outside the known boundaries of the Los Angeles City Oil Field, the potential presence of undocumented cased and uncased abandoned oil wells is not very likely. However, provision should be made for possible reduction of the

tunnel advance rates if this condition is encountered during tunnel excavation. In addition to construction rate delays, each of the cased or uncased abandoned oil wells may contain several hundred gallons of water which can gush into the tunnel within a few seconds alarming the workers. These oil wells may also contain residual accumulation of toxic H_2S, methane, or other explosive gases.

In addition to the very hard sandstone beds, mixed-face conditions between highly weathered Puente Formation or Old Alluvium and oxidized/fresh Puente Formation contacts can be anticipated in the vicinities of Borings PII-39, PII-43, PII-44 and PII-45.

5.2.2.2 Stability and Support. For the Metro Rail project, tunnel support systems consisting of a precast concrete liner as initial support and a cast-in-place concrete liner as permanent support have been successfully used in contract units with subsurface materials and conditions similar to those of this tunnel. Thus, similar support systems should be considered for these tunnel segments.

In general, the subsurface materials at the planned tunnel depth intervals are sufficiently strong so the face should be stable in a shielded mechanical excavation with appropriate and immediate use of the initial support lining following the shield, except in the vicinities of Borings PII-39, PII-43, PII-44, and PII-45 where potential raveling to running sand conditions are possible, due to the presence of saturated silty sand (weathered Puente Formation with little or no cohesion, and granular Old Alluvium) within tunnel elevations. Such a condition can be alleviated by one or a combination of the following provisions:

1. Pre-excavation dewatering from the surface or ahead of the excavation.
2. Chemical grouting from the tunnel face.
3. Compaction grouting.
4. Compressed air.

Stabilization using one or a combination of the above methods should be employed in the areas where raveling to running sand conditions are likely to

occur due to the presence of granular weathered Puente Formation bedrock and granular Old Alluvium in the tunnel elevations.

5.2.3 Groundwater Considerations

As shown in Figures 2-2 and 2-4, the perched groundwater level in this tunnel alignment is generally about 10 feet to 35 feet above the crown of the tunnel. The subsurface materials in the tunnel depths are relatively impervious except in the localized areas adjacent to Borings PII-39, PII-43, PII-44 and PII-45, where somewhat pervious medium-dense to dense silty sand may be encountered within the tunnel elevations. Available local experience (e.g. Metro Rail Phase I tunnel and LACFCD Sacatella Tunnel) and simplified hydrologic analyses indicate the seepage rates for the tunnel alignment except in the localized areas adjacent to above-mentioned borings, are anticipated to vary from too small to measure (i.e., small seeping and dripping) to about 0.1 gallon per minute (gpm) per foot of tunnel. In the areas adjacent to the above-mentioned borings, the initial seepage rates of about 1 gpm to 2 gpm per foot of tunnel are estimated, assuming no stabilization by chemical grouting of the materials from the face is implemented. If such grout stabilization is applied the flow rates are expected to be significantly reduced.

5.2.4 Ground Movement

The amount of tunneling-induced settlement depends on a number of factors including subsurface and groundwater conditions, tunnel configuration and geometry, tunneling equipment and methods, and procedures and cares undertaken by the contractor. It is the contractor's responsibility to alleviate and minimize the settlement by taking prudent procedures and cares to ensure that undue ground loss is minimized by timely erection of the support system and backpacking/grouting of the tail voids, and by employing appropriate measures to counteract any face instability conditions and associated concerns for collapsing of tail voids. Except for the previously described areas in the vicinity of Borings PII-39, PII-43, PII-44 and PII-45, tunnels in this alignment will be excavated primarily through either oxidized (slightly

weathered) or fresh Puente Formation materials which have significant undrained shear strength. Based on local tunneling experience in similar subsurface conditions (i.e., Metro Rail Phase I Project) it is estimated that the maximum ground settlement directly over the centerline of the tunnels is about 1/4 inch to 1/2 inch. In the vicinity of Borings PII-39 and PII-43 through PII-45, tunnel construction will require implementation of provisions to counteract raveling/running sand conditions to minimize ground loss due to tail void collapse and face instability.

The surcharge effects of nearby buildings are minimal since the buildings located within the tunnel's zone of influence are not directly over the tunnel. However, the spread footings of the Vermont Avenue overpass at the 101 Freeway are located directly over the planned tunnel. The planned tunnel may be located within the influence zones of the overpass foundations depending on the size of the spread footings (influence zone of a footing is proportional to the width of the footing). The presence of these foundations must be considered in planning the tunnel excavation.

5.3 LIQUEFACTION POTENTIAL

The liquefaction potential of subsurface materials in the site area is minimal since the subsurface materials below perched groundwater are either very stiff or dense Old Alluvium or Puente Formation bedrock. However, the liquefaction potential of subsurface materials at the vicinity of Boring PII-44 needs further evaluation. Boring log data (Appendix A) indicate the subsurface materials at PII-44 consist of medium-dense silty sand and clayey sand below the perched groundwater with relatively low standard penetration test (SPT) blow counts. Evaluation of liquefaction potential of these alluvial materials using the method recommended by Seed and Idriss (1982) indicates that the liquefaction potential of these soils is marginal under a 7.5 magnitude earthquake, inducing a peak horizontal ground acceleration of 0.3g, which is equivalent to the peak horizontal ground acceleration of the operating design earthquake (ODE) for the Metro Rail project. The potential amount of settlement in the tunnel alignment adjacent to Boring PII-44 induced by an earthquake event equivalent to the ODE was estimated to be on the order of

about 1/2 inch to 3/4 inch, based on the SPT blowcounts encountered at Boring PII-44, and the method recommended by Tokimatsu and Seed (1987). The above liquefaction potential and seismic-induced settlement evaluations for the area adjacent to Boring PII-44 are based solely on the subsurface and SPT blow count data at discrete depth intervals (about five-foot intervals) from a single boring (Boring PII-44) that exhibited significantly different subsurface conditions when compared with those of nearby borings. Thus, further delineation of extent and potential variation of the anomalous conditions exemplified by the data of Boring PII-44 as well as additional continuous SPT data or other measures such as CPT would be needed to increase the confidence level of liquefaction potential and seismic-induced settlement assessment for the area adjacent to Boring PII-44.

5.4 CONSTRUCTION CONTROL AND MONITORING

Provisions for construction control and monitoring are necessary during and after construction. This section provides general recommendations that are considered prudent and reasonable. Detailed requirements and plans should be developed after design of tunnel and station is finalized. In general, these requirements should include, but are not limited to, the followings:

1. Monitoring settlements, surface and subsurface and lateral displacements, across and at various depths above the tunnel crowns by surveying techniques and instrumentations such as borehole extensometers, settlement indicators and inclinometers.

2. Monitoring the performance of shored excavation. This includes monitoring the movements of the excavation in and adjacent to the excavation by surveys, inclinometers and other instrumentation. If internally braced shoring systems are used, selected struts should be instrumented by strain gages to monitor the strut loads so that timely remedial measures can be implemented if struts are overloaded. Similarly, a selected number of tiebacks, if used, should be preloaded and monitored to maintain sufficient locked-off load as specified in Section 5.1.3.2.

3. Before, during and after construction, monitoring of structural integrity (crack survey, photography, etc.), lateral displacements, settlements of the adjacent existing buildings due to tunnel construction, dewatering, excavation, and construction of the station.

4. Continuous monitoring of methane and H_2S during tunnel construction, and during station excavation and construction.

In addition, it is advisable to probe ahead of the tunnel face by drilling probe holes in advance of the tunnel to obtain advanced knowledge of subsurface conditions which may require special procedures and equipment. The probe holes can be used for the following purposes:

1. Monitoring methane and H_2S with a gas sniffer.

2. Performing magnetometer surveys to detect the presence of abandoned oil well casings.

3. Obtaining advanced knowledge of soil conditions.

Advanced knowledge ahead of the tunnel face of the location, extent and distribution of very hard sandstone layers will be extremely desirable. It is recommended that the possibility of economically obtaining such knowledge by geophysical techniques be investigated and implemented. Seismic tomographic techniques which have been successfully used in a number of tunnel projects in locating fracture zones, boulders and specific geologic features (Kjekstad, 1989; Rad et al., 1989) may be one of the feasible techniques.

In addition, the tunnel face should be periodically mapped to keep a record of as-built geologic conditions. In addition to serving as a part of the construction record, the mapping can document and identify geologic conditions that require modifications of excavation methods or tunnel support design. This mapping can also provide a database for interpreting causes of potential concerns (such as excessive ground loss or face instability).

5.5 SUPPLEMENTARY DATA NEEDS

The results of this geotechnical investigation have provided a needed database on the subsurface material and groundwater conditions and engineering parameters for the design of the planned Vermont/Santa Monica Station and adjacent tunnel segments. However, continuous monitoring of the groundwater level, sampling and testing of groundwater, and an environmental audit will be needed to enhance the confidence level. These additional tasks related to groundwater conditions are described below:

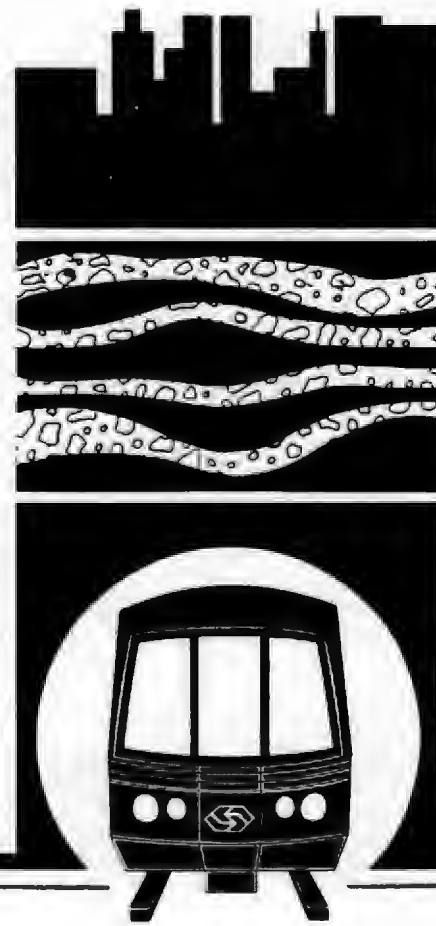
1. Groundwater level in existing piezometers (LPE-7, PII-26, PII-29, PII-35 and PII-43 should be monitored periodically to assess the potential seasonal variation of groundwater levels to establish a realistic design groundwater level.

2. Additional water quality testing should be performed so disposal needs and permit requirements can be met.

3. Closely interact with CRWQCB to determine disposal requirements for the groundwater collected during excavation and construction.

4. An environmental audit is required to identify sources, type and extent of industrial contamination, and their effect on the groundwater.

6.0 Limitations



6.0 LIMITATIONS

The findings, recommendations, specifications, and professional opinions provided in this report are based on design information furnished by MRTC and on the subsurface conditions as disclosed by the field exploration program. Subsurface conditions described in this report were based on discretely located test borings drilled as part of the field exploration and on available geotechnical data. The borings may not reflect variations in subsurface conditions which are likely to exist in the unexplored areas. Thus, subsurface conditions should be monitored and verified in the field during construction. Should significant differences between the described and actual subsurface conditions be revealed during excavation, it may be necessary to re-evaluate the findings, recommendations, and specifications in this report based on onsite observation of the variations, additional field exploration or additional laboratory testing. Similarly, additional evaluation, field exploration or laboratory testing may be necessary if any design information such as location, orientation, site, configuration or nature of the planned facilities has been changed.

The findings, recommendations, specifications, and professional opinions presented in this report were developed within the limits prescribed by MRTC and in general accordance with applicable principles and practices of the geotechnical engineering profession at the time of this report preparation. There is no other warranty, either expressed or implied.

Submitted by:

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7.0 References

7.0 REFERENCES

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Appendix A

Boring Logs and Piezometer Diagrams

APPENDIX A

BORING LOGS, CPT SOUNDINGS LOGS, AND PIEZOMETER DIAGRAMS

This appendix presents the logs and locations of borings, CPT soundings, and piezometer diagrams. This appendix includes the following figures:

	Figure Number		
Boring/ CPT No.	Log	Location	Piezometer Diagram
PII-23	A-1	A-1A	--
PII-25	A-2	A-2A	--
PII-26	A-3	A-3A	A-3B
PII-27	A-4	A-4A	--
PII-28	A-5	A-5A	--
PII-29	A-6	A-6A	A-6B
PII-30	A-7	A-7A	--
PII-31	A-8	A-8A	--
PII-32	A-9	A-9A	--
PII-33	A-10	A-10A	--
PII-34	A-11	A-11A	--
PII-35	A-12	A-12A	A-12B
PII-36	A-13	A-13A	--
PII-36A	A-14	A-14A	--
PII-38	A-15	A-15A	--
PII-39	A-16	A-16A	--
PII-40	A-17	A-17A	--
PII-41	A-18	A-18A	--
PII-42	A-19	A-19A	--
PII-43	A-20	A-20A	A-20B
PII-44	A-21	A-21A	--
PII-45	A-22	A-22A	--
PII-46	A-23	A-23A	--
LPE-6	A-24	A-24A	--
LPE-7	A-25	A-25A	A-25B
CPT-1	A-26	A-26A	--
CPT-2	A-27	A-27A	--

Explanations to the logs of borings are provided in Figures A-I through A-III.

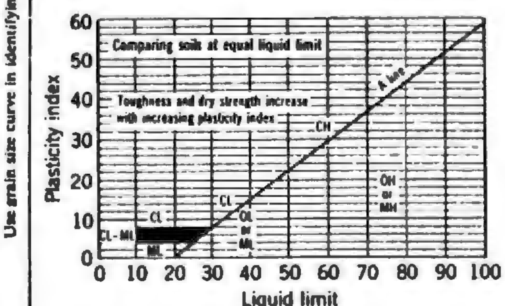
Major divisions		Field Identification Procedures (Excluding particles larger than 3 in. and basing fractions on estimated weights)	Group Symbols[a]	Typical Names	Information Required for Describing Soils	Laboratory Classification Criteria
Coarse-grained soils More than half of material is *larger* than No. 200 sieve size[b] (The No. 200 sieve size is about the smallest particle visible to naked eye) — Gravels: More than half of coarse fraction is larger than No. 4 sieve size (For visual classification, the ¼ in. size may be used as equivalent to the No. 4 sieve size)	Clean gravels (Little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes	*GW*	Well graded gravels, gravel-sand mixtures, little or no fines	Give typical name; indicate approximate percentages of sand and gravel; maximum size; angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbols in parentheses	$C_U = \frac{D_{60}}{D_{10}}$ Greater than 4; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
	Clean gravels (Little or no fines)	Predominantly one size or a range of sizes with some intermediate sizes missing	*GP*	Poorly graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for *GW*
	Gravels with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures see *ML* below)	*GM*	Silty gravels, poorly graded gravel-sand-silt mixtures	For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics	Atterberg limits below "A" line, or *PI* less than 4 — Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols
	Gravels with fines (appreciable amount of fines)	Plastic fines (for identification procedures, see *CL* below)	*GC*	Clayey gravels, poorly graded gravel-sand-clay mixtures		Atterberg limits above "A" line, with *PI* greater than 7
Sands: More than half of coarse fraction is smaller than No. 4 sieve size	Clean sands (little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate particle sizes	*SW*	Well graded sands, gravelly sands, little or no fines	Example: *Silty sand*, gravelly; about 20% hard, angular gravel particles ½-in. maximum size; rounded and subangular sand grains coarse to fine, about 15% non-plastic fines with low dry strength; well compacted and moist in place; alluvial sand; (*SM*)	$C_U = \frac{D_{60}}{D_{10}}$ Greater than 6; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
	Clean sands (little or no fines)	Predominantly one size or a range of sizes with some intermediate sizes missing	*SP*	Poorly graded sands, gravelly sands, little or no fines		Not meeting all gradation requirements for *SW*
	Sands with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures, see *ML* below)	*SM*	Silty sands, poorly graded sand-silt mixtures		Atterberg limits below "A" line or *PI* less than 5 — Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols
	Sands with fines (appreciable amount of fines)	Plastic fines (for identification procedures, see *CL* below)	*SC*	Clayey sands, poorly graded sand-clay mixtures		Atterberg limits below "A" line with *PI* greater than 7

Use grain size curve in identifying the fractions as given under field identification

Determine percentages of gravel and sand from grain size curve. Depending on percentage of fines (fraction smaller than *No.* 200 sieve size) coarse grained soils are classified as follows:
Less than 5% *GW, GP, SW, SP*
More than 12% *GM, GC, SM, SC*
5% to 12% *Borderline* cases requiring use of dual symbols

Identification Procedures on Fraction Smaller than No. 40 Sieve Size

Major divisions		Dry Strength (crushing characteristics)	Dilatancy (reaction to shaking)	Toughness (consistency near plastic limit)	Group Symbols[a]	Typical Names	Information Required for Describing Soils
Fine-grained soils More than half of material is *smaller* than No. 200 sieve size	Silts and clays liquid limit less than 50	None to slight	Quick to slow	None	*ML*	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity	Give typical name; indicate degree and character of plasticity, amount and maximum size of coarse grains; colour in wet condition, odour if any, local or geologic name, and other pertinent descriptive information, and symbol in parentheses
	Silts and clays liquid limit less than 50	Medium to high	None to very slow	Medium	*CL*	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	For undisturbed soils add information on structure, stratification, consistency in undisturbed and remoulded states, moisture and drainage conditions
	Silts and clays liquid limit less than 50	Slight to medium	Slow	Slight	*OL*	Organic silts and organic silt-clays of low plasticity	
	Silts and clays liquid limit greater than 50	Slight to medium	Slow to none	Slight to medium	*MH*	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	Example: *Clayey silt*, brown; slightly plastic; small percentage of fine sand; numerous vertical root holes; firm and dry in place; loess; (*ML*)
	Silts and clays liquid limit greater than 50	High to very high	None	High	*CH*	Inorganic clays of high plasticity, fat clays	
	Silts and clays liquid limit greater than 50	Medium to high	None to very slow	Slight to medium	*OH*	Organic clays of medium to high plasticity	
Highly Organic Soils		Readily identified by colour, odour, spongy feel and frequently by fibrous texture			*Pt*	Peat and other highly organic soils	



Plasticity chart
for laboratory classification of fine grained soils

[a] *Boundary classifications*. Soils possessing characteristics of two groups are designated by combinations of group symbols. For example *GW-GC*, well graded gravel-sand mixture with clay binder.
[b] All sieve sizes on this chart are U.S. standard.

The Earth Technology Corporation

PROJECT NO.: 89-409
Vermont/Santa Monica Station and Tunnel

Unified Soil Classification System

5-90

Figure A-1

ASPHALT

FILL

GRAVEL

SAND

SAND WITH GRAVEL

SAND-SILTY SAND

SAND-SILTY SAND WITH GRAVEL

SILTY SAND

SILTY SAND WITH GRAVEL

CLAYEY SAND

CLAYEY SAND WITH GRAVEL

CLAY

HIGHLY PLASTIC CLAY

SILTY CLAY

SANDY CLAY

SILT

CLAYEY SILT

SANDY SILT

GRAVELLY SILT

SANDSTONE

SILTSTONE

CLAYEY SILTSTONE

SILTSTONE WITH SANDSTONE INTERBEDDED

CLAYEY SILTSTONE WITH SANDSTONE INTERBEDDED

CLAYSTONE

SILTY CLAYSTONE

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PROJECT NO.: 89-409
Vermont/Santa Monica Station and Tunnel

Soil/Rock Symbols for Logs of Borings

5-90

FIGURE A-II

SAMPLE TYPE

S	STANDARD SPLIT SPOON SAMPLE
D	2½" DIA., 12" DRIVE SAMPLE
P	2 7/8" DIA. PITCHER SAMPLE
NR	NO RECOVERY
B	BULK SAMPLE
C	CORE SAMPLE

EXPLANATIONS

PENETRATION RESISTANCE (BLOW COUNT)

–BLOW COUNTS FOR 6" INTERVALS EXCEPT AS NOTED

MOISTURE CONTENT (%)

–LABORATORY DETERMINED MOISTURE CONTENT

PPM –PARTS PER MILLION

PCF –POUNDS PER CUBIC FOOT

OVA–ORGANIC VAPOR ANALYZER

N/A –NOT APPLICABLE

/ –DENOTES ALTERNATING SOIL TYPES IN A LAYER (EXAMPLE: SP/SW i.e. ALTERNATING POORLY AND WELL GRADED SANDS IN A PREDOMINANTLY SANDY LAYER)

DEFINITION OF TERMS

DESCRIPTIVE TERM	PERCENT BY WEIGHT
TRACE	0-10
LITTLE	10-20
SOME	20-35
AND	35-50

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Key for Logs of Boring

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Figure A-3

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FIGURE A-1. LOG OF BORING PII-23

Project Name: METRO RAIL - PHASE II - LOS ANGELES			
Project Number: 89-409	Borehole Number: PII-23		sheet 1 of 4
Borehole location: Vermont Ave., north of Oakwood Ave.	Elevation and Datum(feet): 312		
Health and Safety: Upgraded Level D	Date Started: 5/7/89		Date Finished: 5/7/89
Drilling Equipment: Mayhew 1500	Total Depth(feet): 106.0		Depth to: Bedrock(feet): 2.0
Drilling Method: Rotary Wash	Borehole Diameter: 5-inch		
Drilling Fluid: Bentonite Mud	Piezometer Installation: NO		Depth(feet): --
Hammer Information: SPT Hammer: 140-lb and 30-inch drop. DOWNHOLE Hammer: 266-lb and 18-inch drop.	Logged By: Curtis D. Cushman		Checked By: C. Marshall Payne

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA(ppm)
		6-inch ASPHALT.										
		15-inch BASE COURSE MATERIAL.		FILL								
		TOP OF PUENTE FORMATION.										
5		CLAYEY SILT(STONE); Light olive brown, very stiff, low plasticity, micaceous, oxidized, interbedded with reddish brown layers, bedding parallel to foliation, trace very fine sand. Dip approximately 10 deg.		Tpo	3	S	6 12 17	16"/18"	11			4
10		CLAYEY SILT(STONE); Brownish gray and reddish gray, hard, low plasticity, oxidized, locally interbedded with 3/4 to 1/3-inch thick beds of light gray sandy silt(stone) and very fine sand(stone). Dip approximately 10 to 15 deg.		Tpo	4	D	19 35	6"/12"	51	92	32	4
15		Same as above.		Tpo	5	S	14 25 35	16"/18"	15			4
20		CLAYEY SILT(STONE); Yellowish brown with olive gray, hard, low plasticity, micaceous, oxidized, interbedded with gray, reddish brown and olive colored material, locally 1/4 to 1/2-inch thick beds of very fine silty sand(stone). Dip approximately 10 deg.		Tpo	6	D	35 50/3"	9"/9"	10	87	35	4
25		Same as above.		Tpo	7	S	14 50	12"/12"	18			6
		(Drill chatter between 25 to 30 feet, carbonate composites and very cemented cuttings.)										
30												

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FIGURE A-1. LOG OF BORING PII-23

Project Name: METRO RAIL - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-23 | Sheet 2 of 4

Depth (feet)	Description	USCS Classification	Geologic Unit	Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
	CLAYEY SILT(STONE); Yellowish brown with olive gray, hard, low plasticity, highly oxidized, locally interbedded with thin layers of crystalline material (gypsum?), trace very fine sand(stone). Dip approximately 5 to 10 deg.		Tpo	8	D	50/5"	3"/5"	8	93	30	6
35	Same as above. Very minor sand(stone).		Tpo	9	S	16 32 54	18"/18"	35			6
40	CLAYEY SILT(STONE) - SILTY CLAY(STONE); Brown to yellowish brown, hard, low to medium plasticity, very thinly laminated, micaceous, alternating beds of gray, brown and red. Dip approximately 10 to 15 deg. Brown very fine sandy silt(stone) at tip.		Tpo	10	D	40 50/3"	6"/9"	9	98	26	7
45	CLAYEY SILTSTONE; Dark gray, hard, micaceous, very thinly laminated, some pale gray beds and 1/4 to 1/2-inch thick reddish brown beds, carbonated. Dip approximately 10 deg.		Tpf	11	S	18 50/5"	9"/11"	24			7
50	SILTY CLAYSTONE; Dark gray, hard, brittle, medium to high plasticity, micaceous, thinly laminated, carbonated. Dip approximately 15 deg. (Drill chatter between 52 and 55 feet.)		Tpf	12	D	50/4" 50/3"	1"/7"	26			7
55	Same as above. Dip approximately 10 deg. (Heavy drill chatter between 55 and 60 feet, oil in mud tank.)		Tpf	13	S	50	4"/6"	37			7
60	SILTY CLAYSTONE; Dark gray, hard, thinly laminated, very hard brittle beds upto 1/2-inch thick, micaceous. Dip approximately 15 deg.		Tpf	14	D	50/5"	2"/5"	10			7
65	Same as above.		Tpf	15	S	50/5"	5"/5"	9			7
70											

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FIGURE A-1. LOG OF BORING PII-23

Project Name: METRO RAIL - PHASE II - LOS ANGELES

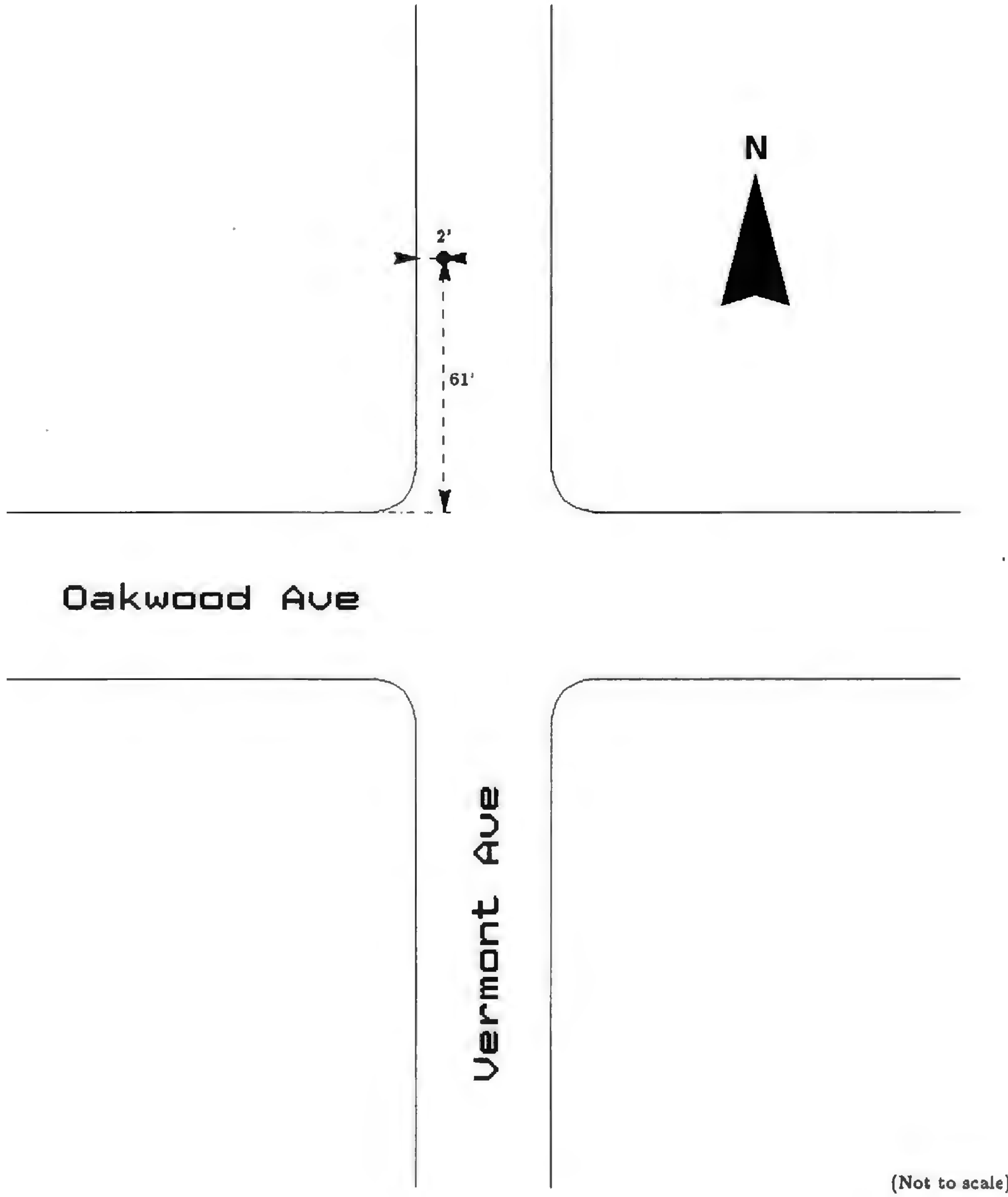
Project Number: 89-409 | Borehole Number: PII-23 | Sheet 3 of 4

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		Same as above.		Tpf	16	D	50/4"	2"/4"	9			7
75		SILTY CLAYSTONE; Dark gray, hard, medium to high plasticity, micaceous, thinly laminated, hydrocarbon odor.		Tpf	17	S	35 50/4"	6"/10"	12			7
80		Same as above. Increasing clay content. Dip approximately 15 deg. (Intermittent drill chatter between 80 and 85 feet.)		Tpf	18	D	50/4"	4"/4"	10			7
85		Same as above. Dip approximately 10 to 15 deg. (Drill chatter between 85 and 87 feet.)		Tpf	19	S	50/2"	1"/2"	10			7
90		Same as above. Dip approximately 10 to 15 deg.		Tpf	20	D	50/4"	3"/4"	11			7
95		Same as above. Slightly lower plasticity. Dip approximately 15 deg.		Tpf	21	S	32/3"	1"/3"	12			7
100		Same as above. Some vertical fractures. Dip approximately 15 deg.		Tpf	22	D	50/3"	0/3"	11			7
105		Same as above.		Tpf	23	S	50/3"	3"/3"	12			7
110		BORING TERMINATED AT 106 FEET. NOTE: This borehole log is based on field classification and visual soil description, and is further modified to include results of laboratory classification tests, where available. This summary applies only at the location of this boring and at the time of drilling. Subsurface										

FIGURE A-1. LOG OF BORING PII-23

Project Name: METRO RAIL - PHASE II - LOS ANGELES		
Project Number: 89-409	Borehole Number: PII-23	Sheet 4 of 4

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA(ppm)
		conditions may differ at other locations and may change at this location with passage of time. The data presented is simplification of actual conditions encountered. The stratification lines represent the approximate boundary between subsurface material types and the transition may be gradual.										
115												
120												
125												
130												
135												
140												
145												
150												



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PROJECT NO.: 89-409

Vermont/Santa Monica Station and Tunnel

Location of Borehole PII-23

5-90

FIGURE A-1A

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FIGURE A-2. LOG OF BORING PII-25

Project Name: METRO RAIL - PHASE II - LOS ANGELES			
Project Number: 89-409	Borehole Number: PII-25		sheet 1 of 3
Borehole location: Rosewood Ave. and Vermont Ave.		Elevation and Datum(feet): 315	
Health and Safety: Upgraded Level D		Date Started: 4/15/89	Date Finished: 4/15/89
Drilling Equipment: Failing 750		Total Depth(feet): 91.0	Depth to: Bedrock(feet): 9.5
Drilling Method: Rotary Wash		Borehole Diameter: 5-inch	
Drilling Fluid: Bentonite Mud		Piezometer Installation: NO	Depth(feet): --
Hammer Information: SPT Hammer: 140-lb and 30-inch drop. DOWNHOLE Hammer: 295-lb and 18-inch drop.		Logged By: Kean Tan	Checked By: C. Marshall Payne

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA(ppm)
		6-inch ASPHALT;										
		CLAYEY SAND; Fine.	SC	FILL								
5		SANDY SILT; Brown, damp, very dense, non-plastic fines, fine sand, micaceous.	ML	A3	1	S	22 50/5"	8"/11"	7			6
		CLAYEY SILT; Yellowish brown, low to medium plasticity, micaceous, with very fine sand.	ML	A4								
10		TOP OF PUENTE FORMATION. SANDY SILT(STONE); Olive brown, damp, dense, thinly bedded, lenses of very fine micaceous sand(stone), moderately weathered, oxidized. Dip approximately 5 deg. Very stiff, medium plasticity, clayey silt(stone) at tip.		Tpo	2	D	12 15	6"/12"	7	91	32	6
		(Cuttings indicate clayey soil at 14 feet.)										
15		CLAYEY SILT(STONE); Yellowish brown, damp, hard, low plasticity, thinly bedded, moderately weathered, oxidized, lenses of sand and plastic clay. Dip approximately 5 deg.		Tpo	3	S	13 29 45	11"/18"	7			7
		(Increasing sand content at 18-1/2 feet.)										
20		CLAYEY SILT(STONE); Olive brown, damp, hard, low to medium plasticity, micaceous, moderately weathered, oxidized, trace very fine sand(stone). Dip approximately 5 deg.		Tpo	4	D	21 50/5"	6"/11"	7	94	28	6
25		SANDY SILT(STONE); Brown, damp, very dense, low plasticity, fresh, fine to very fine sand(stone). Dip approximately 5 deg.		Tpo	5	S	20 22 50/4"		9			8
30												

FIGURE A-2. LOG OF BORING PII-25

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Project Name: METRO RAIL - PHASE II - LOS ANGELES		
Project Number: 89-409	Borehole Number: PII-25	Sheet 2 of 3

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		CLAYEY SILTSTONE; Dark olive gray, damp, hard, medium plasticity, fresh, cemented, interbedded with very dark grayish brown fine sandstone. Dip approximately 5 deg.		Tpf	6	D	40 50/3"	6"/9"	10	99	25	7
		(Oil in mud tank at 33 feet.)										
35		Same as above. Dip approximately 10 deg.		Tpf	7	S	33 50/4"	8"/10"				9
40		CLAYEY SILTSTONE; Dark olive gray with dark olive brown, damp, hard, cemented, micaceous, medium plasticity, fresh, interbedded with dark brown sandstone. Dip approximately 5 deg. Hydrocarbon and slight sulfur odor.		Tpf	8	D	60 40/2"	5"/8"	10			10
45		SILTY CLAYSTONE; Dark olive gray with olive brown, damp, hard, medium to high plasticity. Dip approximately 5 deg.		Tpf	9	S	36 44 20/1"	8"/13"	10			10
50		Same as above.		Tpf	10	D	30 70/4.5"	6"/10"	10	102	22	10
55		SILTY CLAYSTONE; Dark olive gray, damp, hard, slightly cemented, micaceous, medium to high plasticity, fresh, interbedded with fine sandstone, Dip approximately 5 deg. Sulfur odor.		Tpf	11	S	37 50	11"/12"	12			12
60		SILTY CLAYSTONE; Dark olive gray with olive gray, damp, hard, micaceous, interbedded with fine sandstone. Dip approximately 5 deg.		Tpf	12	D	65 35/1"	6"/7"	12			12
		(5-inch thick hard layer at 64 feet.)										
65		Same as at 60 feet.		Tpf	13	P	Push 260 psi	28"/28"	12	108	18	12
70												

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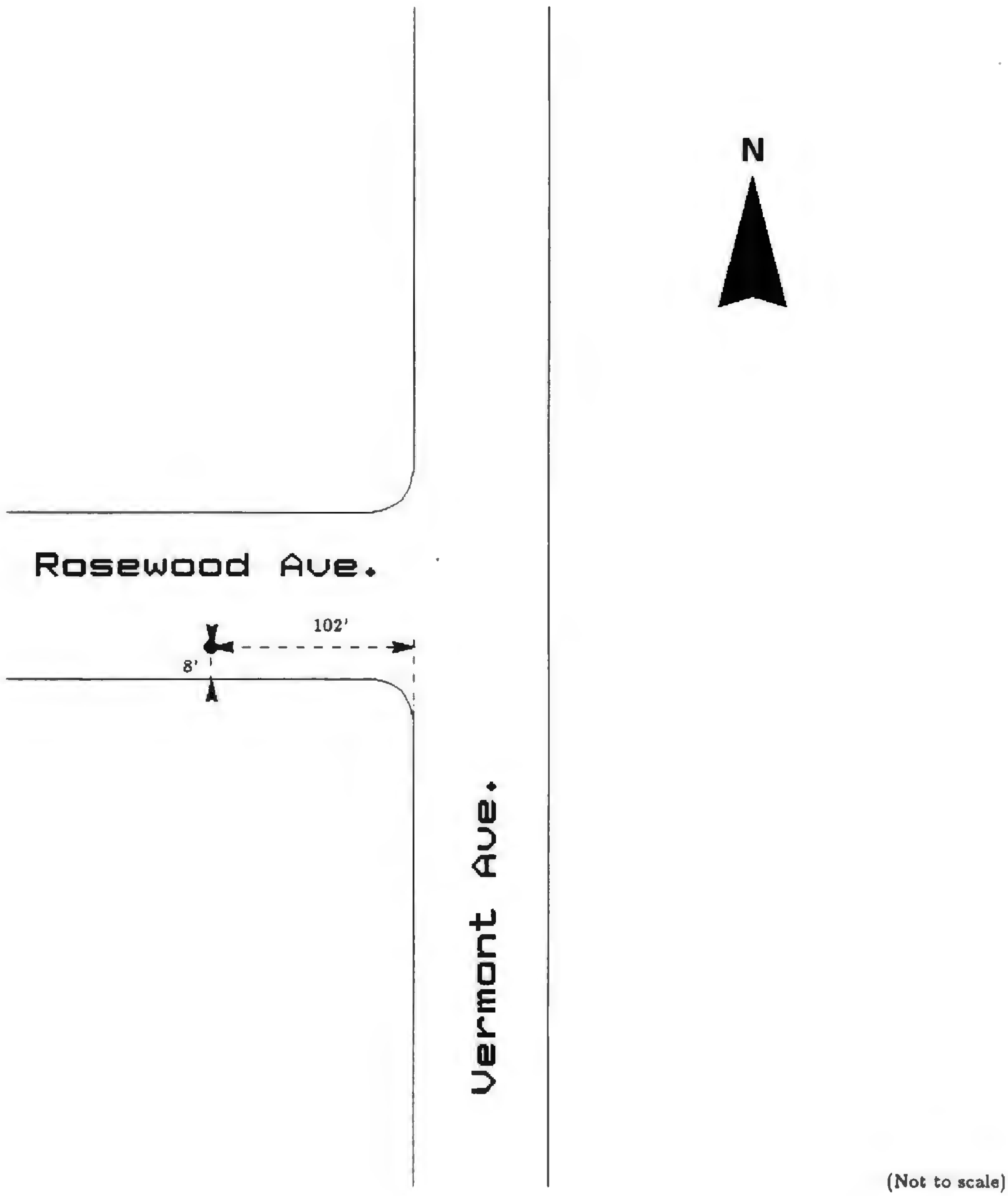
FIGURE A-2. LOG OF BORING PII-25

Project Name: METRO RAIL - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-25 | Sheet 3 of 3

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		Same as above.		Tpf	14	D	45 55/3"	5"/9"	18	102	21	16
75		Same as above.		Tpf	15	S	84 16/0.5"	4"/6.5"	18			16
80		(Drill chatter at 79 feet.) CLAYEY SILTSTONE; Dark olive gray to dark olive brown, damp, hard, low to medium plasticity, micaceous, trace very fine sand. Dip approximately 10 deg.		Tpf	16	D	48 52/3"	6"/9"	18			15
85		CLAYEY SILTSTONE; Dark olive brown, damp, hard, medium plasticity, micaceous, massive, fresh, lenses of gray sandy siltstone with non-plastic fine to very fine sand. Dip approximately 5 deg.		Tpf	17	S	82 18/1"	6"/7"	18			14
90		Same as above. Medium to high plasticity.		Tpf	18	D	41 52/2"	6"/8"	12			12
		BORING TERMINATED AT 90-2/3 FEET. NOTE: This borehole log is based on field classification and visual soil description, and is further modified to include results of laboratory classification tests, where available. This summary applies only at the location of this boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with passage of time. The data presented is simplification of actual conditions encountered. The stratification lines represent the approximate boundary between subsurface material types and the transition may be gradual.										
95												
100												
105												
110												



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PROJECT NO.: 89-409

Vermont/Santa Monica Station and Tunnel

Location of Borehole PII-25

5-90

FIGURE A-2A

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FIGURE A-3. LOG OF BORING PII-26

Project Name: METRO RAIL - PHASE II - LOS ANGELES			
Project Number: 89-409	Borehole Number: PII-26		sheet 1 of 3
Borehole location: BA Storage; Vermont Ave. & 101 Fwy	Elevation and Datum(feet): 293		
Health and Safety: Upgraded Level D	Date Started: 6/30/89		Date Finished: 6/30/89
Drilling Equipment: Mayhew	Total Depth(feet): 101.0		Depth to: Bedrock(feet): 3.5
Drilling Method: Rotary Wash	Borehole Diameter: 5-inch		
Drilling Fluid: Bentonite Mud	Piezometer Installation: YES		Depth(feet): 100
Hammer Information: SPT Hammer: 140-lb and 30-inch drop. DOWNHOLE Hammer: 295-lb and 18-inch drop.	Logged By: Bruce Schell		Checked By: Mahi Galagoda

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA(ppm)
		8-inch ASPHALT pavement.										
		8-inch BASE COURSE.										
		GRAVELLY SILT.	ML	A3	1	B						
		TOP OF PUENTE FORMATION.										
5		SILT(STONE); Light olive brown, damp, very stiff, highly oxidized, low plasticity, trace mica, trace very fine-grained sand(stone), thinly bedded, trace white material on bedding planes. Dip nearly horizontal.		Tpo	2	S	3 4 7	11"/18"	3			3
10		SILT(STONE); Brown mottled with light olive brown and yellowish brown, damp, very stiff, oxidized, low plasticity, trace very fine-grained sand(stone). Dip approximately 5 deg.		Tpo	3	D	11 17	10"/12"	4			3
15		SILTY CLAY(STONE); Dark brown mottled with brown and olive brown, damp, hard, oxidized, low plasticity, micaceous, trace very fine- to fine-grained sand(stone). Dip approximately 5 deg.		Tpo	4	S	10 25 25	12"/18"	4			3
20		SILTSTONE; Dark gray, damp, hard, fresh, low plasticity, micaceous, trace very fine-grained sandstone. Very hard , highly cemented piece in the middle of the sample. Dip approximately 2 deg.		Tpf	5	D	25 40	8"/12"	4			3
25		SILTY CLAYSTONE; Dark gray, damp, hard, fresh, medium to high plasticity, micaceous. Dip approximately 5 deg.		Tpf	6	S	24 50	12"/12"	6			3
30												

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FIGURE A-3. LOG OF BORING PII-26

Project Name: METRO RAIL - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-26 | Sheet 2 of 3

Depth (feet)	Lithology	Description	USCS Classification	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		Same as above.		Tpf	7	D	52	6"/6"	4			3
35		SILTY CLAYSTONE; Dark gray, damp, hard, medium plasticity, trace mica, trace fine- to very fine-grained sandstone. Dip approximately 5 to 10 deg.		Tpf	8	S	50	6"/6"	3			3
40		CLAYEY SILTSTONE; Dark gray, damp, hard, fresh, trace mica, trace very fine- to fine-grained sandstone. Dip approximately 5 to 10 deg.		Tpf	9	D	50	4"/6"	3			3
45		Same as above. Less sand.		Tpf	10	S	37 50	11"/12"	3			3
50		SILTY CLAYSTONE; Dark gray, damp, hard, fresh, medium to high plasticity, trace fine-grained sandstone. Dip approximately 5 deg.		Tpf	11	D	50	5"/6"	4			4
55		Same as above. Medium plasticity, trace very fine sand.		Tpf	12	S	40 50/4"	10"/10"	6			4
60		Same as above. Medium to high plasticity.		Tpf	13	D	50/5"	4"/5"	6			4
65		Same as above.		Tpf	14	S	50/5"	4"/5"	4			4
70												

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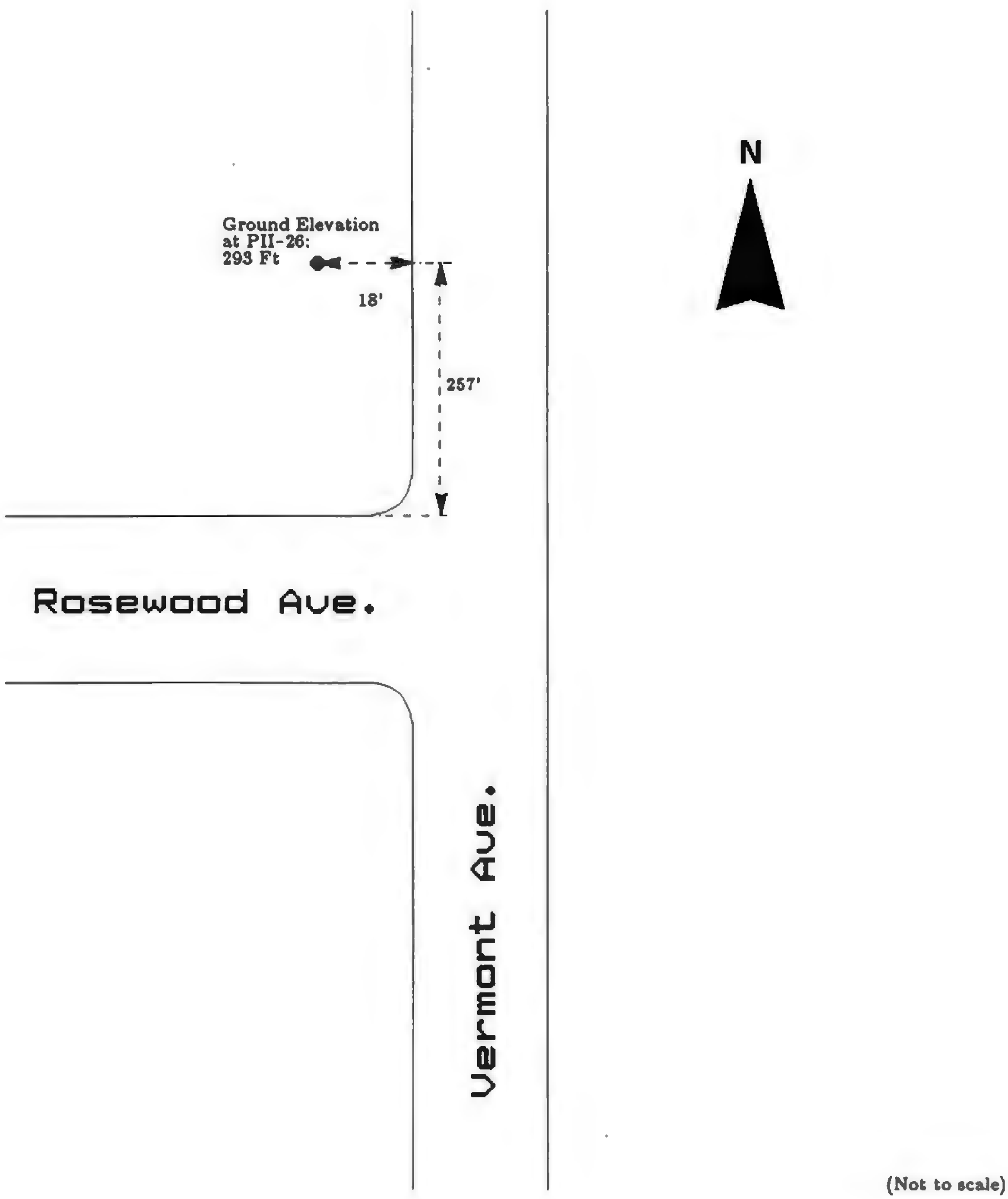
FIGURE A-3. LOG OF BORING PII-26

Project Name: METRO RAIL - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-26 | Sheet 3 of 3

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		CLAYEY SILTSTONE; Dark gray, dry, hard, fresh, medium to high plasticity, cemented and fractured. Dip approximately 10 to 20 deg.		Tpf	15	D	50/5"	4"/5"	6			4
75		CLAYEY SILTSTONE; Dark gray, dry, hard, fresh, medium to high plasticity. Dip approximately 5 deg.		Tpf	16	S	50/5"	4"/5"	6			5
80		CLAYEY SILTSTONE; Dark gray, damp, hard, fresh, medium plasticity, trace mica, lenses of light gray siltstone. Dip approximately 5 to 10 deg.		Tpf	17	D	50	3"/6"	6			5
85		SILTY CLAYSTONE; Dark gray, damp, hard, fresh, medium to high plasticity, micaceous. Dip approximately 5 deg.		Tpf	18	S	50/5"	4"/5"	6			5
90		Same as above. High plasticity. Dip approximately 10 deg.		Tpf	19	D	50/4"	2"/4"	6			6
95		Same as above. Weak cementation.		Tpf	20	S	50/2"	2"/2"				7
100		Same as above, Medium to high plasticity, micaceous. Dip nearly horizontal.		Tpf	21	D	50					
105		BORING TERMINATED AT 101 FEET. NOTE: This borehole log is based on field classification and visual soil description, and is further modified to include results of laboratory classification tests, where available. This summary applies only at the location of this boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with passage of time. The data presented is simplification of actual conditions encountered. The stratification lines represent the approximate boundary between subsurface material types and the transition may be gradual.										
110												



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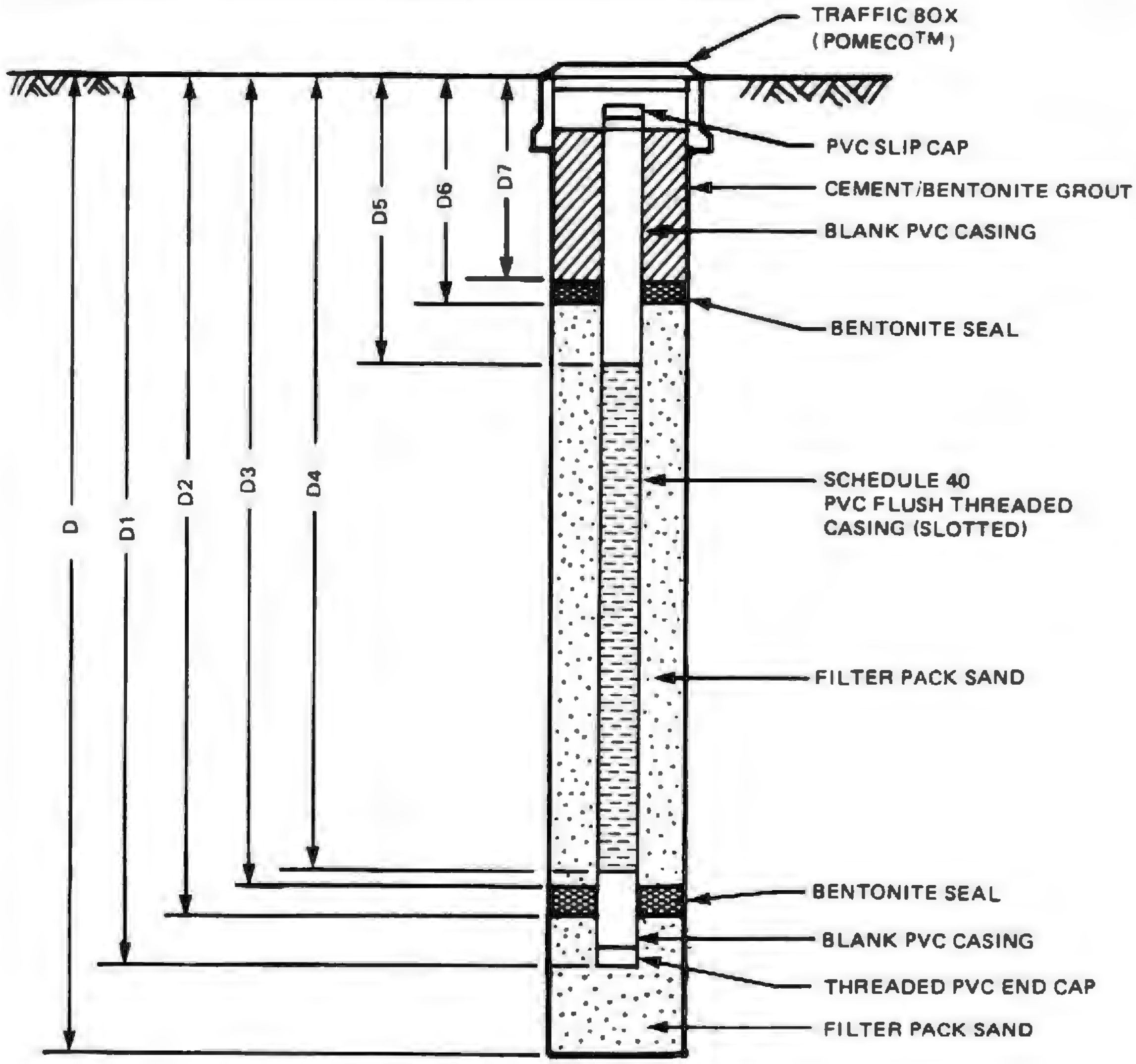
Vermont/Santa Monica Station and Tunnel

Location of Borehole PII-26

5-90

FIGURE A-3A



TOTAL DEPTH (D)	=	102.5	FEET
TOTAL DEPTH OF CASING (D1)	=	100.0	FEET
DEPTH TO BOTTOM OF BOTTOM SEAL (D2)	=	75.2	FEET
DEPTH TO TOP OF BOTTOM SEAL (D3)	=	73.0	FEET
DEPTH TO BOTTOM OF WELL SCREEN (D4)	=	70.0	FEET
DEPTH TO TOP OF WELL SCREEN (D5)	=	45.0	FEET
DEPTH TO BOTTOM OF TOP SEAL (D6)	=	42.5	FEET
DEPTH TO TOP OF TOP SEAL (D7)	=	40.0	FEET
WELL CASING DIAMETER	=	2	INCH
WELL SCREEN SLOT SIZE	=	0.02	INCH
FILTERPACK SAND TYPE	=	NO. 2	MONTEREY
BENTONITE SEAL TYPE	=		HOLE PLUG

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PROJECT NO.: 89-409
Vermont/Santa Monica Station and Tunnel

Diagram of Piezometer PII-26

5-90

FIGURE A-3B

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FIGURE A-4. LOG OF BORING PII-27

Project Name: METRO RAIL - PHASE II - LOS ANGELES			
Project Number: 89-409	Borehole Number: PII-27		sheet 1 of 3
Borehole location: Vermont and 101 North On-Ramp		Elevation and Datum(feet): 310	
Health and Safety: Upgraded Level D		Date Started: 5/7/89	Date Finished: 5/7/89
Drilling Equipment: Failing 750		Total Depth(feet): 96.5	Depth to: Bedrock(feet): 4.5
Drilling Method: Rotary Wash		Borehole Diameter: 5-inch	
Drilling Fluid: Bentonite Mud		Piezometer Installation: NO	Depth(feet): --
Hammer Information: SPT Hammer: 140-lb and 30-inch drop. DOWNHOLE Hammer: 295-lb and 18-inch drop.		Logged By: Pierre Charles	Checked By: C. Marshall Payne

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		4-inch ASPHALT;										
		FILL; Clayey soil, organic.		FILL								
		FILL; Coarse grained, less organic										
		TOP OF PUENTE FORMATION.										
5		CLAYEY SILT(STONE); Yellowish brown, damp, hard, medium plasticity, oxidized, poorly cemented, interbedded with 2-1/8-inch thick well defined sand(stone) beds, carbonated. Horizontal bedding.		Tpo	1	S	8 15 25	18"/18"	5			5
10		CLAYEY SILT(STONE); Yellowish brown, damp, hard, low plasticity, oxidized, interbedded with 1/4-inch thick sand(stone) beds at 1 to 2-inch spacing, well-bedded, lenses of sandy silt(stone) and very fine-grained sand(stone), trace rusty stains. Dip approximately 15 to 20 deg.		Tpo	2	D	15 24	6"/12"	7	93	29	5
15		SILTY CLAY(STONE)-CLAYEY SILT(STONE); Light olive brown mottled with yellowish brown and light olive gray, damp, hard, medium plasticity, oxidized, well-bedded, interbedded with 1/2-inch thick sand(stone) beds. Dip approximately 5 deg.		Tpo	3	S	9 16 23	18"/18"	12			5
20		CLAYEY SILT(STONE); Light brown, damp, hard, low plasticity, micaceous, oxidized, interbedded with sand(stone), black traces in sand(stone). Brown, nonplastic, micaceous, fine- to very fine-grained silty sand(stone) at top. Dip approximately 5 to 10 deg.		Tpo	4	D	36 52	6"/12"	12	89	34	5
25		CLAYEY SILT(STONE); Light brown, damp, hard, low to medium plasticity, oxidized, interbedded with 1/8 inch thick sand(stone) beds. Dip approximately 5 deg.		Tpo	5	S	12 32 30/2"	14"/14"	18			5
		(Dark brown cuttings and harder drilling at 27 feet.)										
30												

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FIGURE A-4. LOG OF BORING PII-27

Project Name: METRO RAIL - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-27 | Sheet 2 of 3

Depth (feet)	Lithology	Description	USCS Classification	Geologic Unit	Samples Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		SILTY CLAYSTONE; Dark gray, damp, hard, micaceous, high plasticity, fresh, thinly bedded, weakly cemented, interbedded with 1/4 inch thick fine-grained sandstone beds at 1-inch spacing. Dip approximately 10 deg. (Softer drilling at 31-3/4 feet.) (Organic stains in mud tank.)		Tpf	6	D	42 58/4"	6"/10"	7	100	24	5
35		SILTY CLAYSTONE; Very dark gray, damp, hard, high plasticity, micaceous, fresh, very weak cementation, interbedded with sandstone. Dip approximately 0 to 5 deg. (Organic stains in cuttings.)		Tpf	7	S	43 57/3"	9"/9"	32			5
40		CLAYEY SILTSTONE; Very dark gray, damp, hard, medium plasticity, micaceous, fresh, interbedded with 1/2-inch thick beds of very fine-grained, poorly graded sandstone, at 2 inch spacing, strong carbonation and cementation. Dip approximately 5 to 15 deg. (Softer drilling at 43 feet.)		Tpf	8	D	39 61/5"	6"/11"	62			5
45		CLAYEY SILTSTONE; Very dark gray, damp, hard, fresh, micaceous, medium plasticity, weakly cemented. Horizontal bedding. (Organic stains in cuttings at 48-1/2 feet.)		Tpf	9	P	Push 275 psi	9"/12"	82	100	23	5
50		SILTY CLAYSTONE; Dark olive gray, damp, hard, fresh, medium to high plasticity, interbedded with very micaceous, fine-grained, 1/4-inch thick, sandstone beds, weak cementation. Dip approximately 0 to 10 deg.		Tpf	10	D	50 50/4"	6"/10"	12	97	25	5
55		Same as above. Horizontal bedding.		Tpf	11	S	78 22/1"	6"/7"	9			5
		(Drill chatter at 57-1/2 feet. Cemented fragments in cuttings.)										
60		CLAYEY SILTSTONE; Very dark gray, damp, hard, fresh, medium plasticity, trace mica, thinly interbedded with very fine-grained sandstone, poorly cemented. (Softer drilling at 63 feet. Cuttings indicate clayey soil.)		Tpf	12	~~D~~	50/5" refusal	3"/5"	10	104	17	5
65		CLAYEY SILTSTONE; Very dark gray, damp, hard, fresh, medium plasticity, micaceous, interbedded with sandstone.		Tpf	13	P	Push 250 psi	30"/30"	160	105	20	5
70												

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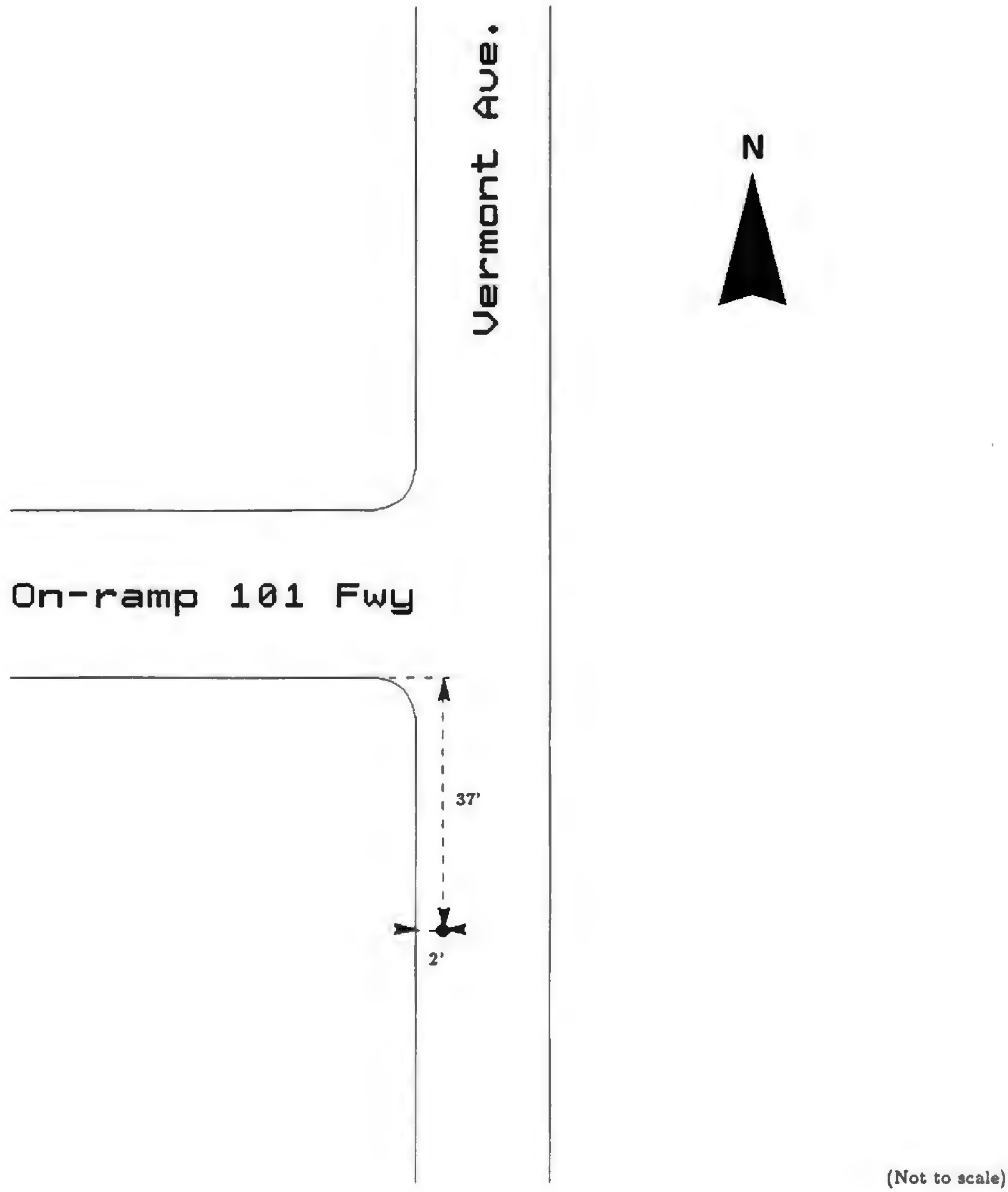
FIGURE A-4. LOG OF BORING PII-27

Project Name: METRO RAIL - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-27 | Sheet 3 of 3

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		CLAYEY SILTSTONE; Very dark gray, damp, hard, fresh, medium plasticity, interbedded with 1/4-inch thick beds of very fine, micaceous sandstone, weakly carbonated, pocket of nonplastic gray sandy siltstone, oil stains and strong hydrocarbon odor.		Tpf	14	D	57 43/1.5"	6"/7.5"	300			5
75		CLAYEY SILTSTONE; Very dark olive gray, hard, fresh, medium plasticity, micaceous, interbedded with thin, micaceous sandstone beds, no cementation, some oil stains, strong hydrocarbon odor.		Tpf	15	S	53 47/2"	8"/8"	500			5
80		CLAYEY SILTSTONE; Very dark grayish brown, damp, hard, micaceous, fresh, medium plastic fines, interbedded with 1/4-1/2 inch thick beds of micaceous, fine- to very fine-grained sandstone, moderately carbonated, strong gasoline odor.		Tpf	16	D	70 30/1"	6"/7"	480	97	27	5
85		CLAYEY SILTSTONE; Very dark gray, damp, very hard, low to medium plasticity, micaceous, fresh, interbedded with 1/2-inch thick beds of very fine- to fine-grained sandstone beds, cemented bedding planes, moderately carbonated, slight gasoline odor.		Tpf	17	S	64 36/1.5"		750			5
90		(Harder cemented fragments in cuttings at 88-1/2 feet.) (Slight drill chatter, hard fragments in cuttings at 90 feet.) SILTSTONE; Very dark gray, damp, very hard, fresh, interbedded with sandstone, one vertical fracture in the sample filled with black tar. Dip approximately 5 to 10 deg. (1/4-foot thick very hard layer at 93 feet.)		Tpf	18	D	88 12/0.2"	5"/6"	700	96	22	5
95		SILTSTONE; Very dark gray, damp, very hard rock fragments in cuttings, moderately carbonated.		Tpf	19	S	100/2.5"	0"/2.5"	95			5
100		BORING TERMINATED AT 95-1/4 FEET. NOTE: This borehole log is based on field classification and visual soil description, and is further modified to include results of laboratory classification tests, where available. This summary applies only at the location of this boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with passage of time. The data presented is simplification of actual conditions encountered. The stratification lines represent the approximate boundary between subsurface material types and the transition may be gradual.										
105												
110												



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PROJECT NO.: 89-409
Vermont/Santa Monica Station and Tunnel

Location of Borehole PII-27

5-90

FIGURE A-4A

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FIGURE A-5. LOG OF BORING PII-28

Project Name: METRO RAIL - PHASE II - LOS ANGELES	
Project Number: 89-409	Borehole Number: PII-28 — sheet 1 of 3
Borehole location: Clinton St. and Vermont Ave.	Elevation and Datum(feet): 294
Health and Safety: Upgraded Level D	Date Started: 3/30/89 — Date Finished: 3/31/89
Drilling Equipment: Failing 750	Total Depth(feet): 67.5 — Depth to: Bedrock(feet): 10.0
Drilling Method: Mud Rotary	Borehole Diameter: 5-inch
Drilling Fluid: Bentonite Mud	Piezometer Installation: NO — Depth(feet): --
Hammer Information: SPT Hammer: 140-lb and 30-inch drop. DOWNHOLE Hammer: 295-lb and 18-inch drop.	Logged By: Kean Tan — Checked By: C. Marshall Payne

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA(ppm)
		SILTY SAND; Dry, fine to medium sand. SILTY SAND; Dry, trace clay.	SM	A3								
5		TOP OF PUENTE FORMATION. SILTY SAND(STONE)/SANDY SILT(STONE); Yellowish brown, damp, very dense, non plastic to slightly plastic fines, fine- to very fine-grained sand(stone), weathered, cemented, trace clayey silt at bottom of sample.		Tpw	1	D	16 50	7"/12"	5			5
10		SILTY CLAY(STONE); Olive brown mottled with yellowish brown, damp, hard, weathered, high plasticity, micaceous, trace very fine-grained sand(stone), thinly bedded, horizontal bedding.		Tpw	2	S	13 24 29	16"/18"	5			5
15		SILTY CLAY(STONE); Olive brown mottled with yellowish brown, damp, hard, oxidized, medium to high plasticity, pocket of sandy silt(stone) at bottom. Dip nearly horizontal.		Tpo	3	D	22 50	7"/12"	5	86	40	5
20		SILTY CLAY(STONE); Yellowish brown to olive brown, damp, hard, low to medium plasticity, oxidized, interbedded with fine cemented sand(stone). Horizontal bedding.		Tpo	4	S	33 20 28	12"/18"	5			5
25		SILT(STONE); Yellowish brown to olive brown, damp, very dense, locally cemented, slightly plastic, interbedded with fine sand(stone), sulfur odor. Horizontal bedding. Clayey silt(stone) at tip of sample; Hard, low to medium plasticity, micaceous.		Tpo	5	D	28 72/5.5"	7"/11.5"	6	97	25	5
30												

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FIGURE A-5. LOG OF BORING PII-28

Project Name: METRO RAIL - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-28 | Sheet 2 of 3

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		CLAYEY SILTSTONE; Dark olive gray, damp, hard, fresh, cemented, medium plasticity, interbedded with fine sandstone. Dip approximately 5 deg.		Tpf	6	S	32 50/5"	10"/11"	6			5
		(Drill chatter at 32-3/4 feet, 2-inch thick hard layer.)										
35		CLAYEY SILTSTONE; Dark olive gray, damp, hard, medium plasticity, cemented, micaceous, interbedded with sandstone. Dip approximately 5 deg.		Tpf	7	D	60/5.5"	2"/5.5"	5			5
40		Same as above. Medium plasticity.		Tpf	8	P	Push 350 psi	24"/30"	5	102	22	5
45		Same as above.		Tpf	9	D	106/5"	2"/5"	10			5
		(Hard drilling at 47 feet.)										
50		Same as above. Medium to high plasticity.		Tpf	10	S	50/4"	4"/4"	120			5
55		Same as above. Medium plasticity, well cemented.		Tpf	11	D	Push 350 psi	24"/30"	60	102	23	5
60		Same as above. Dark olive gray, lenses of light gray sandy siltstone.		Tpf	12	S	50/3.5"	3"/3.5"	80			5
		(Very slow drilling, cuttings indicate very hard material at 62 feet.)										
65		Same as above. Highly cemented.		Tpf	13	P	Push 350 psi	9"/30"	80			5
70		BORING TERMINATED AT 67-1/2 FEET. NOTE: This borehole log is based on field classification and visual soil description, and is further modified to include results of laboratory classification tests, where										

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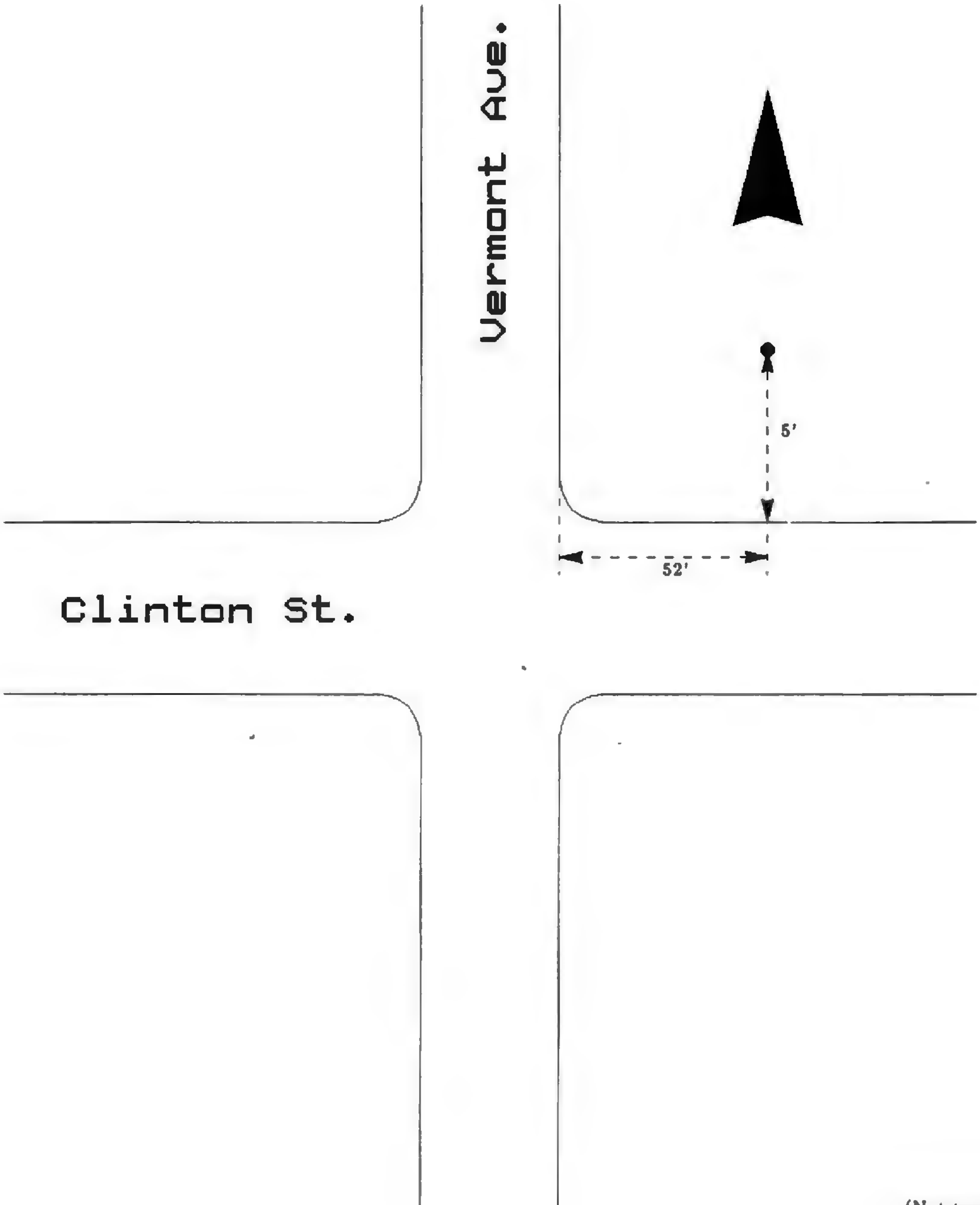
FIGURE A-5. LOG OF BORING PII-28

Project Name: METRO RAIL - PHASE II - LOS ANGELES		
Project Number: 89-409	Borehole Number: PII-28	Sheet 3 of 3

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		available. This summary applies only at the location of this boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with passage of time. The data presented is simplification of actual conditions encountered. The stratification lines represent the approximate boundary between subsurface material types and the transition may be gradual.										
75												
80												
85												
90												
95												
100												
105												
110												



(Not to scale)

The Earth Technology Corporation	PROJECT NO.: 89-409 Vermont/Santa Monica Station and Tunnel

Location of Borehole PII-28

5-90

FIGURE A-5A

FIGURE A-6. LOG OF BORING PII-29

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Project Name: METRO RAIL - PHASE II - LOS ANGELES			
Project Number: 89-409	Borehole Number: PII-29		sheet 1 of 3
Borehole location: Vermont Ave. and Melrose Ave.	Elevation and Datum(feet): 301		
Health and Safety: Upgraded Level D	Date Started: 5/6/89		Date Finished: 5/6/89
Drilling Equipment: Failing 750	Total Depth(feet): 81.0		Depth to: Bedrock(feet): 9.0
Drilling Method: Mud Rotary	Borehole Diameter: 5-inch		
Drilling Fluid: Bentonite Mud	Piezometer Installation: NO		Depth(feet): 80.0
Hammer Information: SPT Hammer: 140-lb and 30-inch drop. DOWNHOLE Hammer: 295-lb and 18-inch drop.	Logged By: Pierre Charles		Checked By: C. Marshall Payne

Depth (feet)	Description	USCS Classification	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
	8-inch ASPHALT.										
	2-inch BASE COURSE.										
	SILTY CLAY; Dark brown, micaceous, trace sand. Fill material.	CL	FILL								
5	CLAYEY SAND; Dark yellowish brown, moist, very dense, fine to medium sand, low to medium plasticity fines.	SC	A4	1	S	15 16 27	18"/18"	6			5
	(Very hard layer at 8.5 feet, sand and gravel in cuttings.)	GP	A3								
10	TOP OF PUENTE FORMATION. SILTY CLAY(STONE); Yellowish brown to light olive brown, moist, very stiff to hard, low to medium plasticity, highly weathered, massive, some cemented nodules, trace organic material. Dip approximately 10 deg.		Tpw	2	D	13 18	6"/12"	7			5
15	Same as above. Hard. Dip approximately 0 to 5 deg.		Tpw	3	S	13 23 30	18"/18"	8			5
20	CLAYEY SILT(STONE); Yellowish brown to light olive brown, damp, hard, oxidized, medium plasticity, interbedded with sand(stone) and sandy silt(stone).		Tpo	4	D	17 23	6"/12"	16	91	32	5
25	Same as above. Disturbed sample. No apparent bedding. Increased clay content.		Tpo	5	S	16 36 38	6"/18"	5			5
30											

FIGURE A-6. LOG OF BORING PII-29

The Earth Technology Corporation

Project Name: METRO RAIL - PHASE II - LOS ANGELES												
Project Number: 89-409		Borehole Number: PII-29						Sheet 2 of 3				

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		CLAYEY SILT(STONE)-SILTY CLAY(STONE) ; Mottled, olive brown to yellowish brown, damp, very stiff, oxidised, medium plasticity, fractured, moderately carbonated, interbedded with sandy siltstone and fine- to very fine-grained sand(stone). Dip approximately 0 to 5 Deg. (Clayey cuttings at 32 feet.)		Tpo	6	D	7 20	6"/12"	5			5
35		CLAYEY SILT(STONE); Olive brown to yellowish brown, damp, stiff, low plasticity, micaceous, oxidized, interbedded with 1/8-inch thick beds of fine- to very fine-grained sand(stone). Horizontal bedding.		Tpo	7	P	Push 185 psi	28"/30"	5	97	26	5
40		CLAYEY SILTSTONE; Dark olive gray to olive brown, damp, hard, fresh, interbedded with very fine-grained sandstone, micaceous, low plasticity. Dip approximately 0 to 5 deg.		Tpf	8	D	33 67/4"	6"/10"	5			5
45		Same as above. Horizontal bedding.		Tpf	9	S	50/4"	4"/4"	9			5
50		CLAYEY SILTSTONE; Very dark gray, damp, hard, fresh, medium plasticity, top 1 inch appears hard and cemented, and mechanically fractured. Dip approximately 5 to 10 deg.		Tpf	10	D	100	3"/6"	6			5
55		SANDY SILTSTONE; Very dark gray, damp, hard, fresh, low plasticity, micaceous, trace fine to very fine sandstone. Dip approximately 0 to 10 deg.		Tpf	11	P	Push 200 psi	30"/30"	8			5
60		CLAYEY SILTSTONE-SILTY CLAYSTONE; Dark gray, damp, hard, fresh, medium plasticity, trace fine sandstone, moderate bedding. Dip approximately 0 to 5 deg. (Organic stains in mud between 60 and 65 feet.)		Tpf	12	D	57 43/3"	6"/9"	9	104	18	5
65		CLAYEY SILTSTONE-SILTY CLAYSTONE; Very dark gray, damp, hard, fresh, low plasticity, micaceous, interbedded with 2-inch thick sandstone beds. Dip approximately 0 to 5 deg. (Drill chatter at 67-1/2 feet. Indication of cemented material.)		Tpf	13	S	71 29/1.5"	7.5"/7.5	6			5
70												

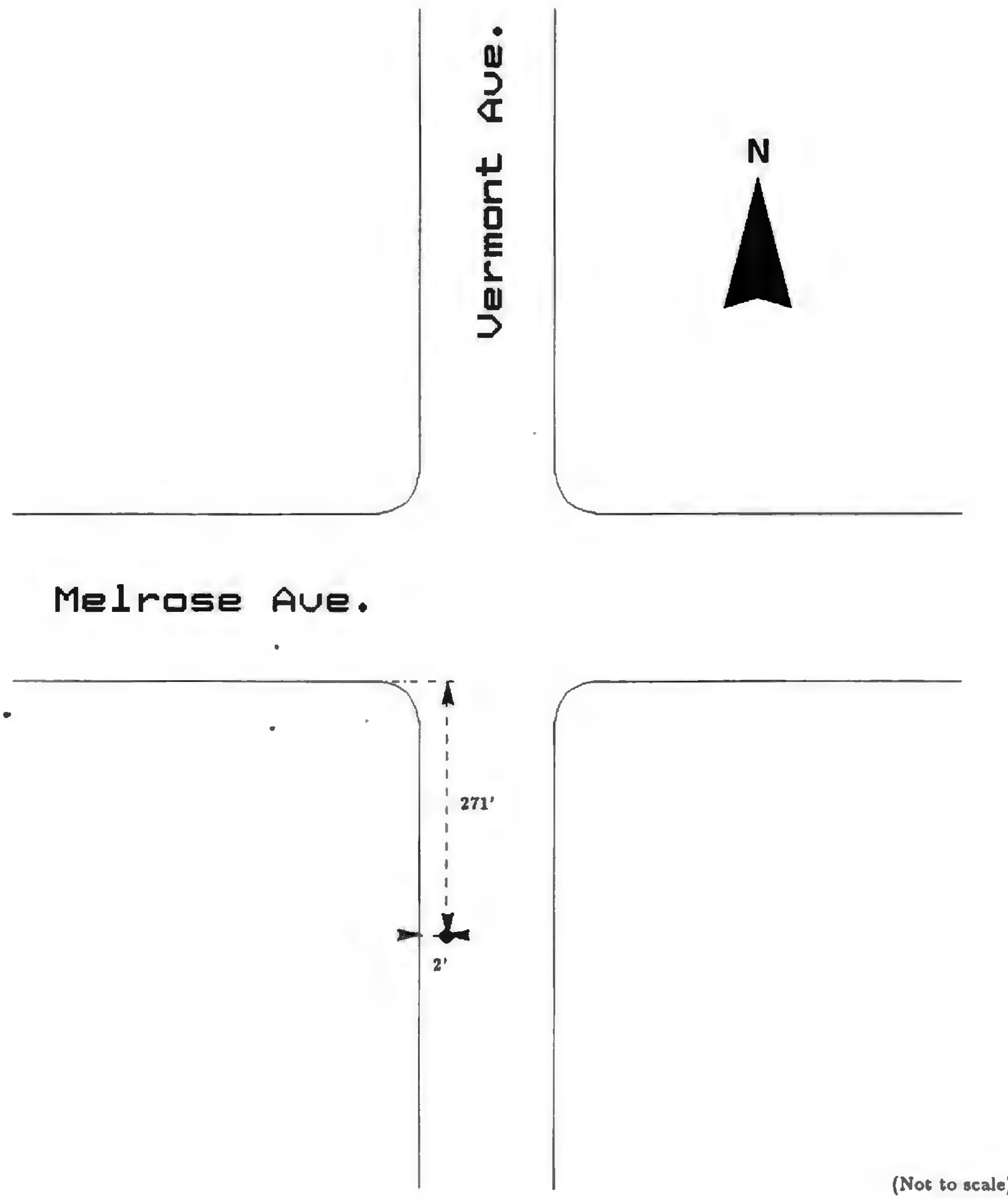
FIGURE A-6. LOG OF BORING PII-29

Project Name: METRO RAIL - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-29 | Sheet 3 of 3

Depth (feet)	Lithology	Description	USCS Classification	Geologic Unit	Samples Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		Same as above. medium plasticity.		Tpf	14	D	60 40/1"	6"/7"	8			5
		(Hard layer between 73 and 74 feet. Cuttings indicate poorly cemented fragments.)										
75		Same as above. 1/8- to 1/4-inch thick sandstone interbeds.		Tpf	15	S	50 50/4"	10"/10"	8			5
80		Same as above. strong gasoline odor.		Tpf	16	D	70 30/1"	6"/7"	6			5
		BORING TERMINATED AT 81 FEET.										
85												
90												
95												
100												
105												
110												

NOTE: This borehole log is based on field classification and visual soil description, and is further modified to include results of laboratory classification tests, where available. This summary applies only at the location of this boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with passage of time. The data presented is simplification of actual conditions encountered. The stratification lines represent the approximate boundary between subsurface material types and the transition may be gradual.



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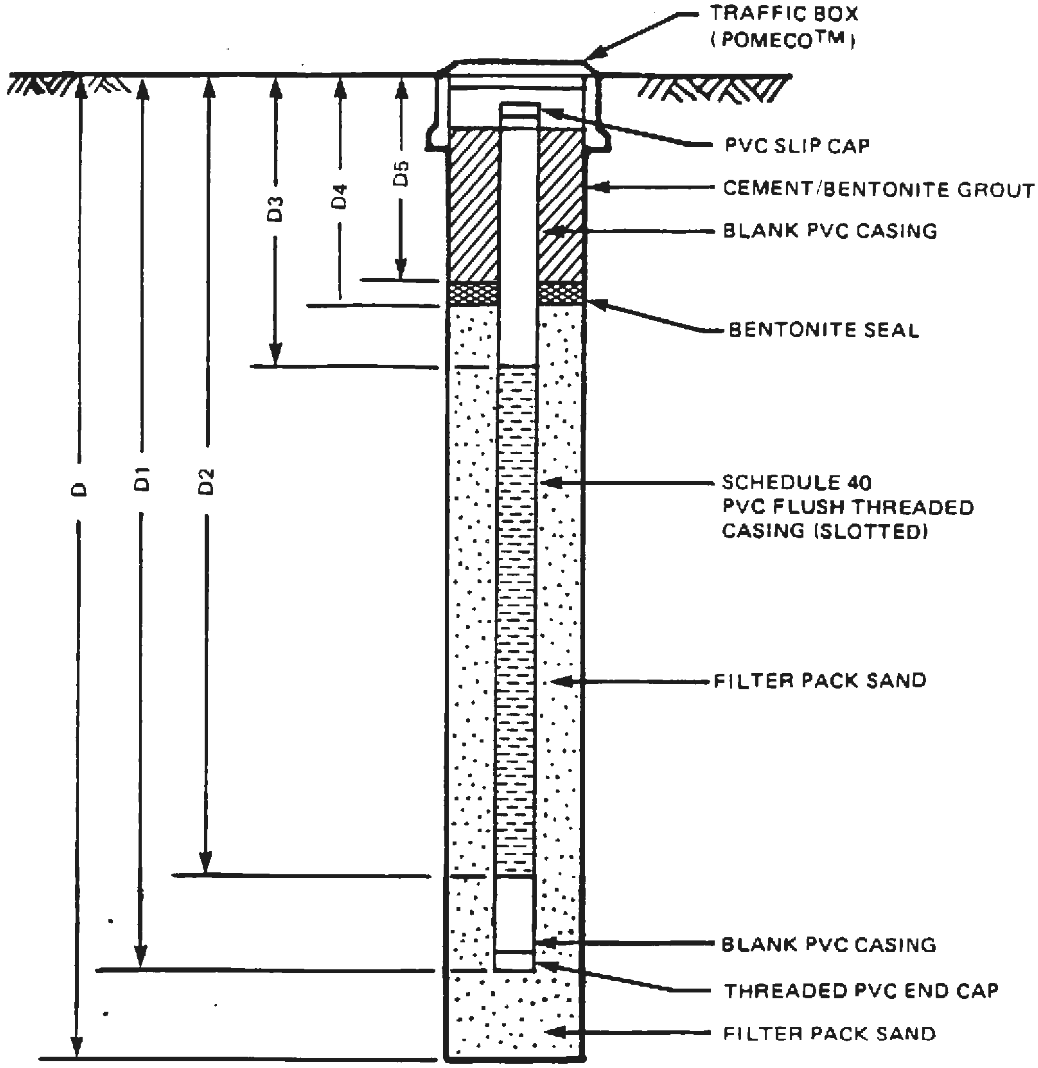
PROJECT NO.: 89-409
Vermont/Santa Monica Station and Tunnel

Location of Borehole PII-29

5-90

FIGURE A-6A



TOTAL DEPTH (D)	=	82.0	FEET
TOTAL DEPTH OF CASING (D1)	=	80.0	FEET
DEPTH TO BOTTOM OF WELL SCREEN (D2)	=	50.0	FEET
DEPTH TO TOP OF WELL SCREEN (D3)	=	20.0	FEET
DEPTH TO BOTTOM OF TOP SEAL (D4)	=	18.0	FEET
DEPTH TO TOP OF TOP SEAL (D5)	=	16.0	FEET
WELL CASING DIAMETER	=	2	INCH
WELL SCREEN SLOT SIZE	=	0.02	INCH
FILTERPACK SAND TYPE	=	NO. 2	MONTEREY
BENTONITE SEAL TYPE	=		1/8" PELLETS

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PROJECT NO.: 89 409
Vermont/Santa Monica Station and Tunnel

Diagram of Piezometer PII-29

5-90

FIGURE A-6B

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FIGURE A-7. LOG OF BORING PII-30

Project Name: METRO RAIL - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-30 | sheet 1 of 2

Borehole location: Melrose Ave. and Vermont Ave. | Elevation and Datum(feet): 298

Health and Safety: Upgraded Level D | Date Started: 4/3/89 | Date Finished: 4/3/89

Drilling Equipment: Failing 750 | Total Depth(feet): 56.0 | Depth to: Bedrock(feet): 10.0

Drilling Method: Mud Rotary | Borehole Diameter: 5-inch

Drilling Fluid: Bentonite Mud | Piezometer Installation: NO | Depth(feet): --

Hammer Information:
SPT Hammer: 140-lb and 30-inch drop.
DOWNHOLE Hammer: 295-lb and 18-inch drop.

Logged By: Kean Tan | Checked By: C. Marshall Payne

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		10-inch ASPHALT.										
		SILTY SAND; Fine sand, trace clay.	SM	A3								
5		TOP OF PUENTE FORMATION. CLAYEY SILT(STONE); Yellowish brown, damp, hard, micaceous, low plasticity, very weathered, trace very fine-grained sand(stone). Sample at tip is oxidised. Dip approximately 5 deg. (Cemented, oxidized cuttings at 7 feet.)		Tpw	1	D	17 26	8"/12"	4			4
10		CLAYEY SILT(STONE); Yellowish brown and light olive gray, damp, hard, oxidized, micaceous, low plasticity, weakly, locally cemented.		Tpo	2	S	10 19 28		4			4
15		CLAYEY SILT(STONE); Yellowish brown to light olive gray, damp, hard, oxidized, low to medium plasticity, trace mica and very fine sand(stone), vertical fractures, black stains on fractures. Dip nearly horizontal.		Tpo	3	D	26 55	8"/12"	4	87	35	4
20		CLAYEY SILT(STONE); Yellowish brown to light olive gray, damp, hard, oxidized, thinly bedded with sand(stone). Horizontal bedding.		Tpo	4	S	12 20 23	18"/18"	4			4
25		CLAYEY SILT(STONE); Yellowish brown to light olive gray, damp, hard, oxidized, low plasticity fines, micaceous, pocket of sandy silt(stone). One vertical fracture. Horizontal bedding.		Tpo	5	D	22 40	7"/12"	4	90	32	4
30												

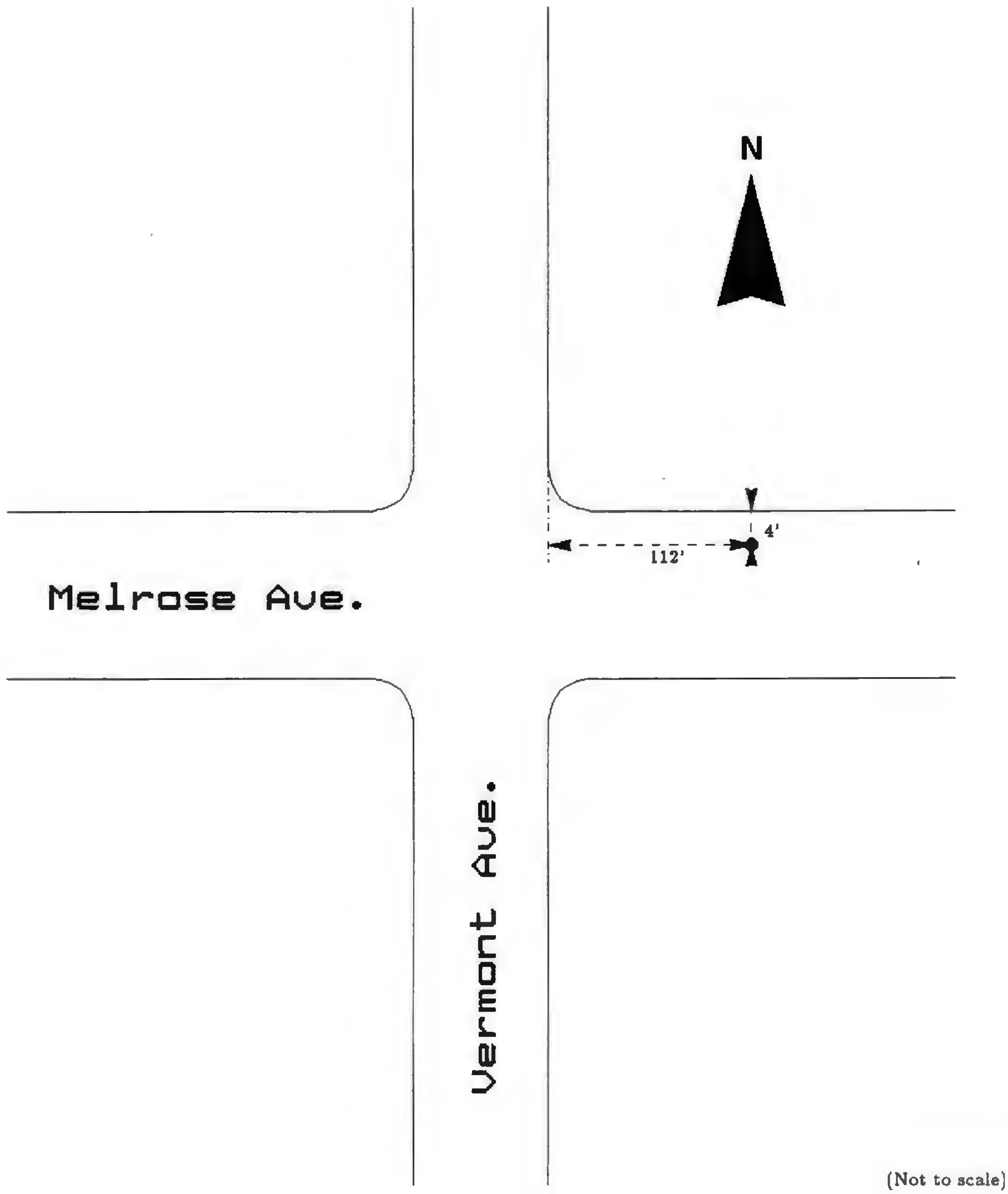
The Earth Technology Corporation

FIGURE A-7. LOG OF BORING PII-30

Project Name: METRO RAIL - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-30 | Sheet 2 of 2

Depth (feet)	Description	USCS Classification	Geologic Unit	Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
	SILTY CLAY(STONE); Light olive brown, damp, very stiff, medium to high plasticity, micaceous, oxidized, trace fine-grained sand(stone). Dip approximately 5 deg.		Tpo	6	P	Push 220 psi	26"/30"	4	97	26	4
35	SILTY CLAY(STONE); Yellowish brown to light olive gray, damp, hard, oxidized, high plasticity, trace fine-grained sand(stone). Clayey silt(stone) at tip of sample. Dip nearly horizontal.		Tpo	7	D	30 70/5.5"	10"/12"	4	90	31	4
40	Same as above.		Tpo	8	S	25 50	12"/12"	4			4
45	SILTY CLAYSTONE; Dark olive gray, damp, very hard, fresh, well-bedded, medium to high plasticity fines. Dip nearly horizontal.		Tpf	9	D	100/5"	2"/5"	4	99	32	4
50	Same as above.		Tpf	10	S	44 50/4"	9"/10"	4			4
55	Same as above.		Tpf	11	D	100/5"	3.5"/5"	4	100	26	4
60	BORING TERMINATED AT 56 FEET. NOTE: This borehole log is based on field classification and visual soil description, and is further modified to include results of laboratory classification tests, where available. This summary applies only at the location of this boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with passage of time. The data presented is simplification of actual conditions encountered. The stratification lines represent the approximate boundary between subsurface material types and the transition may be gradual.										
65											
70											



The Earth Technology Corporation

PROJECT NO.: 89-409
Vermont/Santa Monica Station and Tunnel

Location of Borehole PII-30

5-90

FIGURE A-7A

The Earth Technology Corporation

FIGURE A-8. LOG OF BORING PII-31

Project Name:	METRO RAIL - PHASE II - LOS ANGELES		
Project Number: 89-409	Borehole Number: PII-31		sheet 1 of 3
Borehole location:	Vermont Ave. and Marathon St.	Elevation and Datum(feet): 300	
Health and Safety:	Upgraded Level D	Date Started: 3/30/89	Date Finished: 3/31/89
Drilling Equipment:	Failing 750	Total Depth(feet): 66.0	Depth to: Bedrock(feet): 9.0
Drilling Method:	Mud Rotary	Borehole Diameter: 5-inch	
Drilling Fluid:	Bentonite Mud	Piezometer Installation: NO	Depth(feet): --
Hammer Information: SPT Hammer: 140-lb and 30-inch drop. DOWNHOLE Hammer: 295-lb and 18-inch drop.		Logged By: Pierre Charles	Checked By: C. Marshall Payne

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background (pp
		3-INCH ASPHALT.										
		FILL; Gravelly soil, trace organic materials.		FILL								
5		SANDY SILT.	ML	A3								
		CLAYEY SAND; Light olive brown, damp, very stiff, micaceous, medium plasticity fines, fine to medium sand	SC	A4	1	D	12 16	10"/12"	5			5
10		TOP OF PUENTE FORMATION. CLAYEY SILT(STONE); Yellowish brown to light olive gray, damp, hard, oxidized, low plasticity, interbedded with 1/8-inch thick beds of very fine sand(stone), carbonated. Horizontal bedding.		Tpo	2	S	19 17 23	18"/18"	5			5
15		SILTY CLAY(STONE); Brown mottled with light olive brown and light olive gray, damp, hard, highly oxidized, low to medium plasticity, 1/16-inch thick sand(stone) interbeds. Dip nearly horizontal.		Tpo	3	D	17 29	9"/12"	30	93	31	5
20		CLAYEY SILT(STONE); Olive brown, damp, hard, oxidized, low plasticity, trace mica, fine-grained sand(stone) interbeds. Dip nearly horizontal.		Tpo	4	S	17 21 27	15"/18"	10			5
25		CLAYEY SILT(STONE); Yellowish brown to light olive gray, damp, very stiff to hard, oxidized, low to medium plasticity, trace very fine sand(stone). Dip nearly horizontal.		Tpo	5	D	9 20	9"/12"	40	92	25	5
30												

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FIGURE A-8. LOG OF BORING PII-31

Project Name: METRO RAIL - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-31 | Sheet 2 of 3

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		Same as above. Minor oxidation. Horizontal bedding.		Tpo	6	S	17 30 34	18"/18"	10			5
35		Same as above. Oxidized, fresh puente contact at tip.		Tpo	7	D	22 48	10"/12"	5	95	27	5
		(Harder drilling between 36 and 40 feet.)										
40		CLAYEY SILTSTONE: Very dark gray, damp, hard, medium plasticity, micaceous, fresh, thinly interbedded with cemented sandstone. Dip nearly horizontal.		Tpf	8	S	43 57/5"	8"/11"	5			5
45		(Hard drilling and cemented fragments in cuttings at 44-3/4 feet.) CLAYEY SILTSTONE; Very dark gray to black, damp, very hard, very strongly cemented, massive, strongly carbonated. (Fast drilling at 45-1/4 feet.)		Tpf	9	P	Push 275 psi	2"/12"	5			5
50		SILTY CLAYSTONE; Very dark gray to light olive gray, damp, hard, low plasticity fines, micaceous, interbedded with very fine sandstone. Dip approximately 5 deg.		Tpf	10	P	Push 250 psi	24"/30"	5	107	19	5
55		CLAYEY SILTSTONE; Very dark gray, damp, hard, low plasticity, micaceous, interbedded with very fine grained sandstone. Horizontal bedding.		Tpf	11	D	60 48/3"	9"/9"	100			5
60		CLAYEY SILTSTONE; Very dark gray, damp, hard, low to medium plasticity, micaceous, fresh, interbedded with light gray, very fine sandstone, 1/8 inch in thickness and 2 inch spacing, slight sulfur odor. Horizontal bedding.		Tpf	12	S	64 36/2.5"	7"/8.5"	100			5
65		CLAYEY SILTSTONE; Very dark gray, damp, hard, low to medium plasticity, micaceous, fresh, interbedded with very fine sandstone, carbonated. Horizontal bedding.		Tpf	13	D	70 30/1"	5"/7"	200			5
70		BORING TERMINATED AT 66 FEET. NOTE: This borehole log is based on field classification and visual soil description, and is further modified to include results of laboratory classification tests, where										

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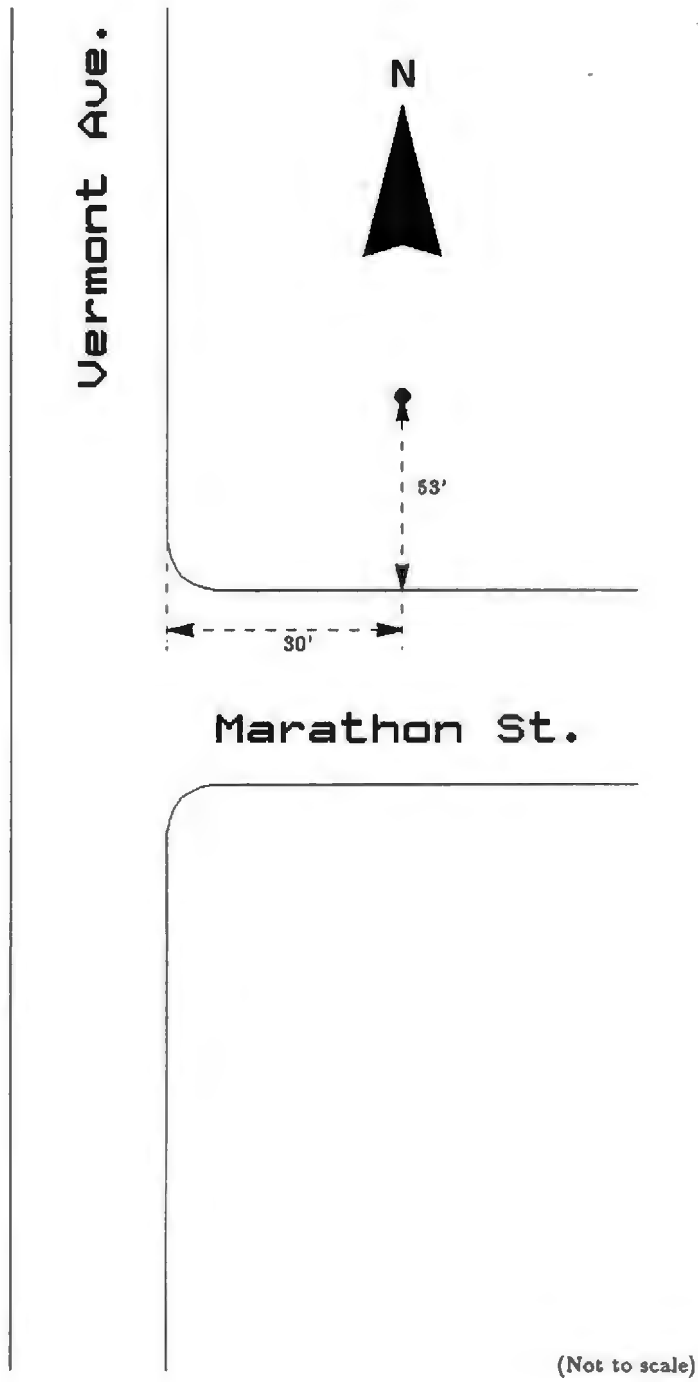
FIGURE A-8. LOG OF BORING PII-31

Project Name: METRO RAIL - PHASE II - LOS ANGELES		
Project Number: 89-409	Borehole Number: PII-31	Sheet 3 of 3

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background ppm
75		available. This summary applies only at the location of this boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with passage of time. The data presented is simplification of actual conditions encountered. The stratification lines represent the approximate boundary between subsurface material types and the transition may be gradual.										
80												
85												
90												
95												
100												
105												
110												



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PROJECT NO.: 89-409
Vermont/Santa Monica Station and Tunnel

Location of Borehole PII-31

5-90

FIGURE A-8A

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FIGURE A-9. LOG OF BORING PII-32

Project Name: METRO RAIL - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-32 | sheet 1 of 3

Borehole location: Vermont Ave. and Monroe Ave. | Elevation and Datum(feet): 300

Health and Safety: Upgraded Level D | Date Started: 4/4/89 | Date Finished: 4/4/89

Drilling Equipment: Failing 750 | Total Depth(feet): 66.5 | Depth to: Bedrock(feet): 2.5

Drilling Method: Rotary Wash | Borehole Diameter: 5-inch

Drilling Fluid: Bentonite Mud | Piezometer Installation: NO | Depth(feet): --

Hammer Information:
SPT Hammer: 140-lb and 30-inch drop.
DOWNHOLE Hammer: 295-lb and 18-inch drop.

Logged By: Pierre Charles | Checked By: C. Marshall Payne

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background (pp
		3-INCH ASPHALT.										
		FILL MATERIAL.		FILL								
		TOP OF PUENTE FORMATION.										
5		CLAYEY SILT(STONE); Yellowish brown to pale brown, dry, hard, medium plasticity, oxidized, few very fine-grained sand(stone) beds, locally cemented. Dip nearly horizontal.		Tpo	1	S	19 39 42	16"/18"	6			6
10		CLAYEY SILT(STONE); Light olive brown, damp, hard, low to medium plasticity, oxidized, well-bedded, black stain. Dip nearly horizontal.		Tpo	2	D	14 28	9"/12"	6	98	27	6
15		CLAYEY SILT(STONE); Light olive brown to yellowish brown, damp, hard, low plasticity, slightly micaceous, oxidized, moderately well-bedded. Dip nearly horizontal.		Tpo	3	S	8 28 28	18"/18"	9			6
20		CLAYEY SILT(STONE); Light olive brown with yellowish red, damp, hard, low to medium plasticity, few sand(stone) interbeds. Dip nearly horizontal.		Tpo	4	D	17 33	8"/12"	9	92	34	6
25		Same as above.		Tpo	5	S	12 22 31	18"/18"	6			6
30												

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FIGURE A-9. LOG OF BORING PII-32

Project Name: METRO RAIL - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-32 | Sheet 2 of 3

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		Same as above. Medium plasticity. Minor oxidation, pocket of clay(stone). Dip nearly horizontal.		Tpo	6	D	19 34	10"/12"	6	98	25	6
35		SILTY CLAYSTONE; Very dark gray, damp, hard, medium to high plasticity, micaceous, fresh, minor interbeds of sandstone. Dip nearly horizontal.		Tpf	7	S	42 68/5"	8"/11"	6			5
		(Harder drilling at 39 feet.)										
40		SILTY CLAYSTONE; Very dark gray, damp, hard, medium to high plasticity, micaceous, locally cemented, fresh, minor interbeds of very fine sandstone. Dip approximately 0 to 5 deg.		Tpf	8	D	30 70/3"	6"/9"	6	98	24	6
45		Same as above.		Tpf	9	S	45 55/4"	7"/12"	6			6
50		SILTY CLAYSTONE-CLAYEY SILTSTONE; Very dark gray, damp, hard, fresh, medium plasticity, interbedded with sandstone, lenses of organic material at middle of sample. Dip approximately 0 to 5 deg.		Tpf	10	D	16 40/2"	6"/8"	25	101	22	6
55		CLAYEY SILTSTONE; Very dark gray, damp, hard, medium plasticity, fresh, micaceous.		Tpf	11	P	Push 250 psi	27"/30"	6	104	20	6
60		Same as above. Cemented.		Tpf	12	D	48 62/2"	6"/8"	6	80	42	6
65		Same as above. Very cemented.		Tpf	13	S	20/2"	2"/2"	6			6
70		BORING TERMINATED AT 66-1/2 FEET. NOTE: This borehole log is based on field classification and visual soil description, and is further modified to include results of laboratory classification tests, where available. This summary applies only at the location of										

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FIGURE A-9. LOG OF BORING PII-32

Project Name: METRO RAIL - PHASE II - LOS ANGELES		
Project Number: 89-409	Borehole Number: PII-32	Sheet 3 of 3

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		this boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with passage of time. The data presented is simplification of actual conditions encountered. The stratification lines represent the approximate boundary between subsurface material types and the transition may be gradual.										
75												
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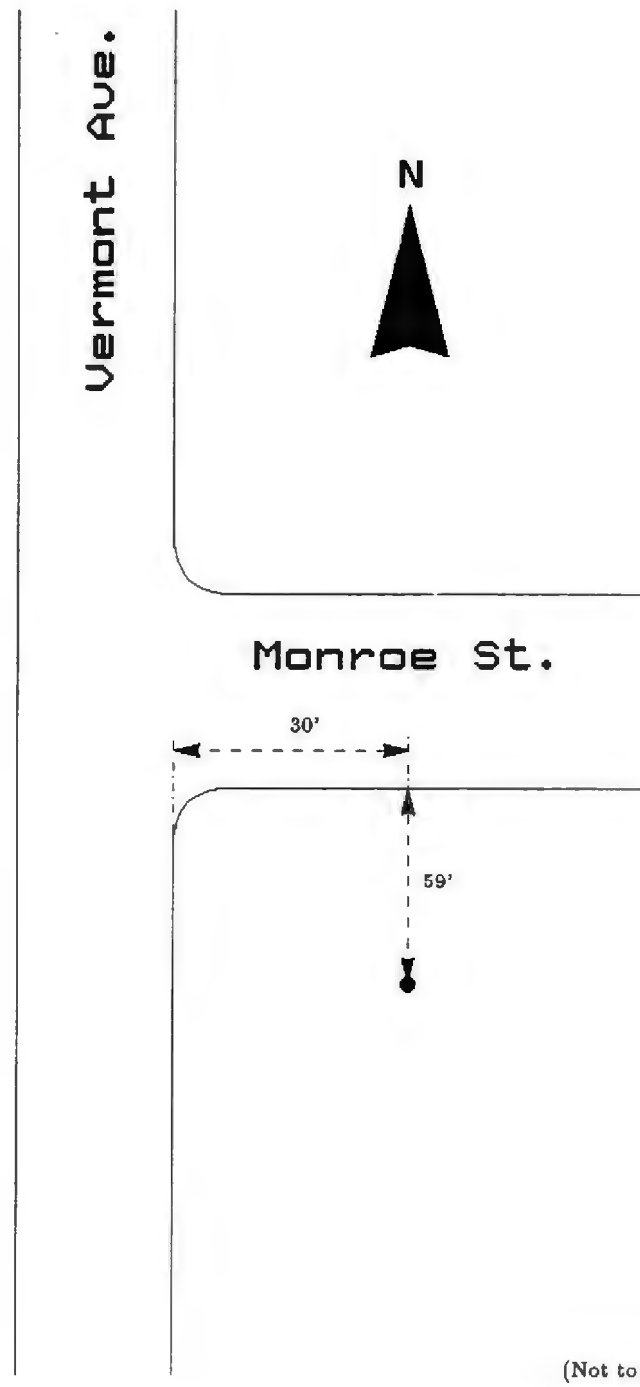
100												
105												
110												



(Not to scale)

The Earth Technology Corporation	PROJECT NO.: 89-409 Vermont/Santa Monica Station and Tunnel

Location of Borehole PII-32

5-90

FIGURE A-9A

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FIGURE A-10. LOG OF BORING PII-33

Project Name: METRO RAIL - PHASE II - LOS ANGELES			
Project Number: 89-409	Borehole Number: PII-33		sheet 1 of 2
Borehole location: Burns Ave. and Vermont Ave.		Elevation and Datum(feet): 304	
Health and Safety: Upgraded Level D		Date Started: 4/4/89	Date Finished: 4/4/89
Drilling Equipment: Failing 750		Total Depth(feet): 61.5	Depth to: Bedrock(feet): 15.0
Drilling Method: Mud Rotary		Borehole Diameter: 5-inch	
Drilling Fluid: Bentonite Mud		Piezometer Installation: NO	Depth(feet): --
Hammer Information: SPT Hammer: 140-lb and 30-inch drop. DOWNHOLE Hammer: 295-lb and 18-inch drop.		Logged By: Kean Tan	Checked By: C. Marshall Payne

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (pp
		8-inch ASPHALT										
		CLAYEY SAND; Fine to medium sand.	SC	A4								
5		SANDY CLAY; Dark olive gray, damp, very stiff, high plasticity, fine to medium sand.	CL	A4	1	D	6 11	4.5"/12"	4			4
10		SILTY CLAY; Yellowish brown, damp, soft, high plasticity, trace sand. (Lost circulation of drilling fluid at 14 feet.)	CH	A4	2	S	5 8 10	12"/18"	4			4
15		TOP OF PUENTE FORMATION. CLAYEY SILT(STONE); Yellowish brown, damp, hard, low plasticity, trace mica, oxidized, interbedded with fine- to very fine-grained sand(stone). Dip nearly horizontal.		Tpo	3	D	14 32	8"/12"	5	93	30	4
20		CLAYEY SILT(STONE); Yellowish brown to light olive brown, damp, hard, medium plasticity, oxidized, interbedded with sand(stone). Horizontal bedding.		Tpo	4	S	15 16 23	16"/18"	4			4
25		SILTY CLAY(STONE); Yellowish brown, damp, very stiff to hard, high plasticity, micaceous, oxidized, interbedded with fine- to very fine-grained sand(stone).		Tpo	5	D	43 57/5"	5"/11"	4	85	43	4
30												

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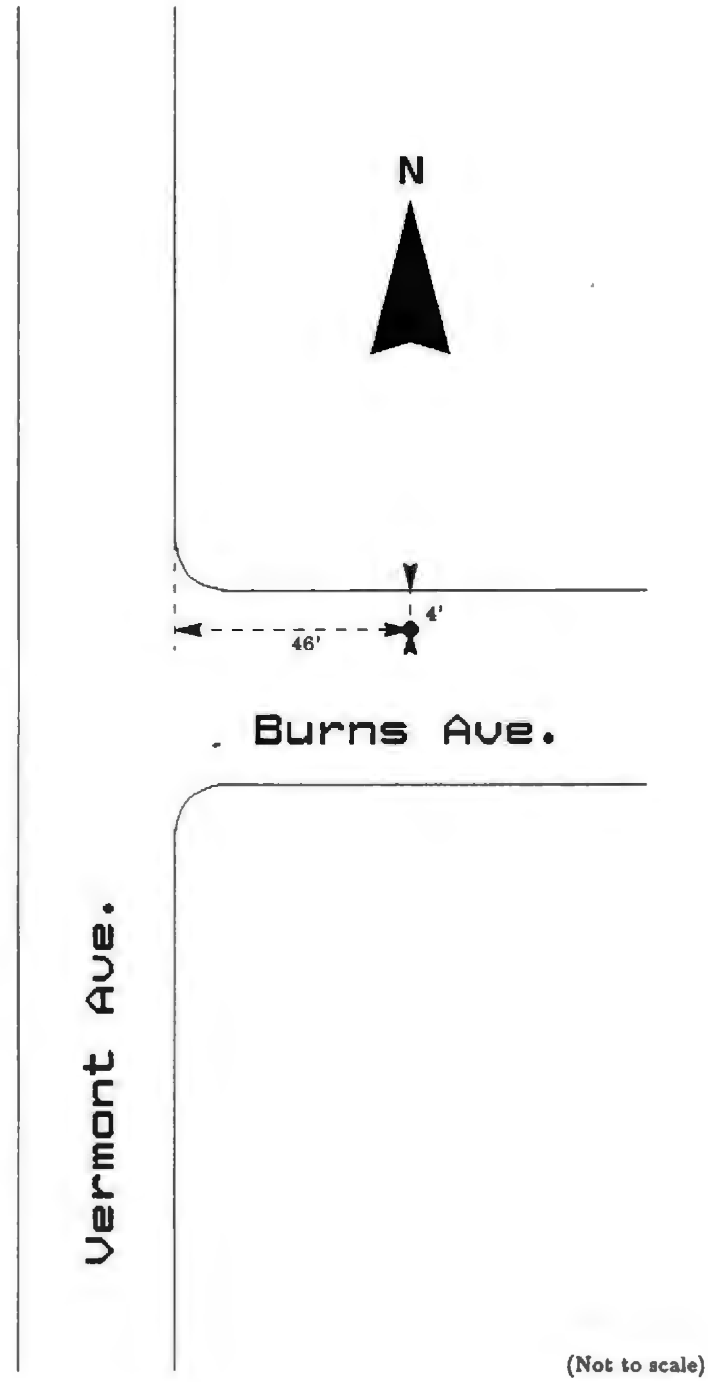
FIGURE A-10. LOG OF BORING PII-33

Project Name: METRO RAIL - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-33 | Sheet 2 of 2

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		CLAYEY SILT(STONE); Light olive brown to yellowish brown, damp, very stiff, oxidized, low plasticity, micaceous, interbedded with fine-grained sand(stone).		Tpo	6	P	Push 350 psi	24"/30"	4	97	25	4
35		CLAYEY SILT(STONE)-SILTY CLAY(STONE); Light olive brown, damp, hard, low plasticity, micaceous, oxidized, interbedded with fine-grained sand(stone). Dip approximately 0 to 5 deg.		Tpo	7	D	35 65/5.5"	6"/11.5"	4	93	27	4
40		CLAYEY SILT(STONE); Dark olive brown to dark olive gray, damp, hard, oxidized, medium plasticity, oxidized, lenses of light gray sand(stone) and silt(stone). Horizontal bedding.		Tpo	8	S	20 37 46	18"/18"	6			4
45		SILTY CLAYSTONE; Dark olive gray, damp, hard, fresh, medium plasticity, micaceous, well bedded, cemented. Dip approximately 10 deg.		Tpf	9	D	100/6"	4"/6"	10	96	26	4
50		Same as above. Dip approximately 5 deg.		Tpf	10	S	50/4.5"	5"/5"	10			4
55		Same as above. Dip approximately 0 to 5 deg.		Tpf	11	D	100/6"	3"/6"	10	97	25	4
60		Same as above.		Tpf	12	S	45 50/4"	8"/10"	100			4
65		BORING TERMINATED AT 61-1/2 FEET. NOTE: This borehole log is based on field classification and visual soil description, and is further modified to include results of laboratory classification tests, where available. This summary applies only at the location of this boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with passage of time. The data presented is simplification of actual conditions encountered. The stratification lines represent the approximate boundary between subsurface material types and the transition may be gradual.										
70												



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PROJECT NO.: 89-409

Vermont/Santa Monica Station and Tunnel

Location of Borehole PII-33

5-90

FIGURE A-10A

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FIGURE A-11. LOG OF BORING PII-34

Project Name: METRO RAIL - PHASE II - LOS ANGELES			
Project Number: 89-409	Borehole Number: PII-34		sheet 1 of 3
Borehole location: Vermont Ave. and Lockwood Ave.		Elevation and Datum(feet): 309	
Health and Safety: Upgraded Level D		Date Started: 4/28/89	Date Finished: 4/28/89
Drilling Equipment: Failing 750		Total Depth(feet): 81.0	Depth to: Bedrock(feet): 9.5
Drilling Method: Rotary Wash		Borehole Diameter: 5-inch	
Drilling Fluid: Bentonite Mud		Piezometer Installation: NO	Depth(feet): --
Hammer Information: SPT Hammer: 140-lb and 30-inch drop. DOWNHOLE Hammer: 295-lb and 18-inch drop.		Logged By: Pierre Charles	Checked By: C. Marshall Payne

Depth (feet)	Description	USCS Classification	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
	11-inch CONCRETE.										
	SILTY SAND; Medium to fine-grained sand, nonpalstic fines.	SM	A3								
5	CLAYEY SAND; Dark grayish brown to olive brown, damp, medium dense, fine to coarse sand, low plasticity fines, micaceous.	SC	A4	1	S	9 18 31	15"/18"	5			2
	SAND-SILTY SAND WITH GRAVEL; Black, moderately plastic, gravel up to 2 inch in size.	SP-SM	A3								
	TOP OF PUENTE FORMATION.										
10	SILTY CLAY(STONE); Grayish brown mottled with olive brown, yellowish brown and olive gray, moist, hard, weathered, medium to high plasticity, micaceous, poorly interbedded with fine- to very fine-grained sand(stone).		Tpw	2	D	11 24	6"/12"	30	93	30	2
15	SILTY CLAY(STONE)/CLAYEY SILT(STONE); Yellowish brown mottled with light gray and white, moist, hard, weathered, low to medium plasticity, micaceous, carbonated, poorly interbedded with very fine-grained sand(stone). Dip approximately 5 deg.		Tpw	3	S	22 26 32	14"/18"	1000			4
20	CLAYEY SILT(STONE); Yellowish brown mottled with light olive gray, moist, hard, oxidized, low to medium plasticity, micaceous, moderately cemented, interbedded with cemented sand(stone). Vertical fractures. Black stains in fractures. Dip approximately 5 deg.		Tpo	4	D	24 46	6"/12"	35	97	25	2
25	Same as above.		Tpo	5	S	18 30 52	18"/18"	50			2
30											

FIGURE A-11. LOG OF BORING PII-34

Project Name: METRO RAIL - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-34 | Sheet 2 of 3

Depth (feet)	Lith-ology	Description	USCS Classification	Geologic Unit	Samples Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		CLAYEY SILT(STONE); Yellowish brown mottled with light olive gray, moist, hard, oxidized, low to medium plasticity, micaceous, interbedded with poorly graded sand(stone). 1/2-inch thick black interbed. Dip approximately 5 deg.		Tpo	6	D	20 65	10"/12"	5			2
35		SILTY CLAY(STONE); Yellowish brown to olive brown, moist, very stiff, oxidized, medium to high plasticity, poorly cemented, interbedded with sand(stone). (Harder drilling at 36-1/2 feet.)		Tpo	7	P	Push 200 psi	30"/30"	6	102	22	4
40		CLAYEY SILT(STONE); Yellowish brown to light olive brown, moist, hard, minor oxidation, medium plasticity, interbedded with nonplastic sandy silt(stone), very fine sand fraction. Dip approximately 5 to 10 deg.		Tpo	8	D	20 46	9"/12"	12			4
45		CLAYEY SILT(STONE); Yellowish brown to olive brown, moist, hard, minor oxidation, low to medium plasticity, micaceous, thinly interbedded with sand(stone). Dip approximately 10 deg.		Tpo	9	S	20 23 48	18"/18"	12			4
50		CLAYEY SILTSTONE/SILTY CLAYSTONE; Yellowish brown to olive brown at top and very dark gray at bottom, moist, hard, fresh, medium to high plasticity at top, medium plasticity at bottom, micaceous. Dip approximately 5 to 10 deg.		Tpf	10	D	36 54	10"/12"	11	100	24	4
55		Same as above with lenses of light gray sandy siltstone.		Tpf	11	S	60 40/3"	8"/9"	25			4
60		(Drill chatter at 58-1/2 feet, siliceous siltstone in cuttings.) SILTSTONE; Very dark gray to black, damp, very hard, fresh, highly cemented, carbonated, fractured. Dip approximately 0 to 5 deg. (Excessive drill chatter at 60-3/4 feet.) (Slow drilling upto 65 feet.)		Tpf	12	P	Push 250 psi	4"/4.5"		138	4	4
65		CLAYEY SILTSTONE; Dark gray, damp, hard, fresh, medium plasticity, micaceous, interbedded with poorly graded sandstone, thinly bedded. Horizontal bedding.		Tpf	13	P	Push 250 psi	24"/24"	25	115	15	5
70												

FIGURE A-11. LOG OF BORING PII-34

The Earth Technology Corporation

Project Name: METRO RAIL - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-34 | Sheet 3 of 3

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		CLAYEY SILTSTONE; Dark gray and dark brown, damp, hard, fresh, well-bedded, micaceous, fractured, cemented, interbedded with sandstone. Dip approximately 10 deg. (Drill chatter at 73-1/2 feet.)		Tpf	14	D	48 52/2"	6"/8"	120	93	31	5
75		CLAYEY SILTSTONE; Very dark gray to black, damp, hard, fresh, medium to high plasticity, micaceous, slightly cemented, interbedded with very fine-grained sandstone. Dip approximately 0 to 10 deg. (Drill chatter at 77-1/2 feet.)		Tpf	15	S	50/4"	3"/4"	20			5
80		CLAYEY SILTSTONE; Very dark gray, damp, hard, medium plasticity, micaceous, interbedded with poorly graded sandstone. Dip approximately 10 deg.		Tpf	16	D	80 20/1"	6"/7"	50	91	32	5
85		BORING WAS TERMINATED AT 81 FEET. NOTE: This borehole log is based on field classification and visual soil description, and is further modified to include results of laboratory classification tests, where available. This summary applies only at the location of this boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with passage of time. The data presented is simplification of actual conditions encountered. The stratification lines represent the approximate boundary between subsurface material types and the transition may be gradual.										
90												
95												
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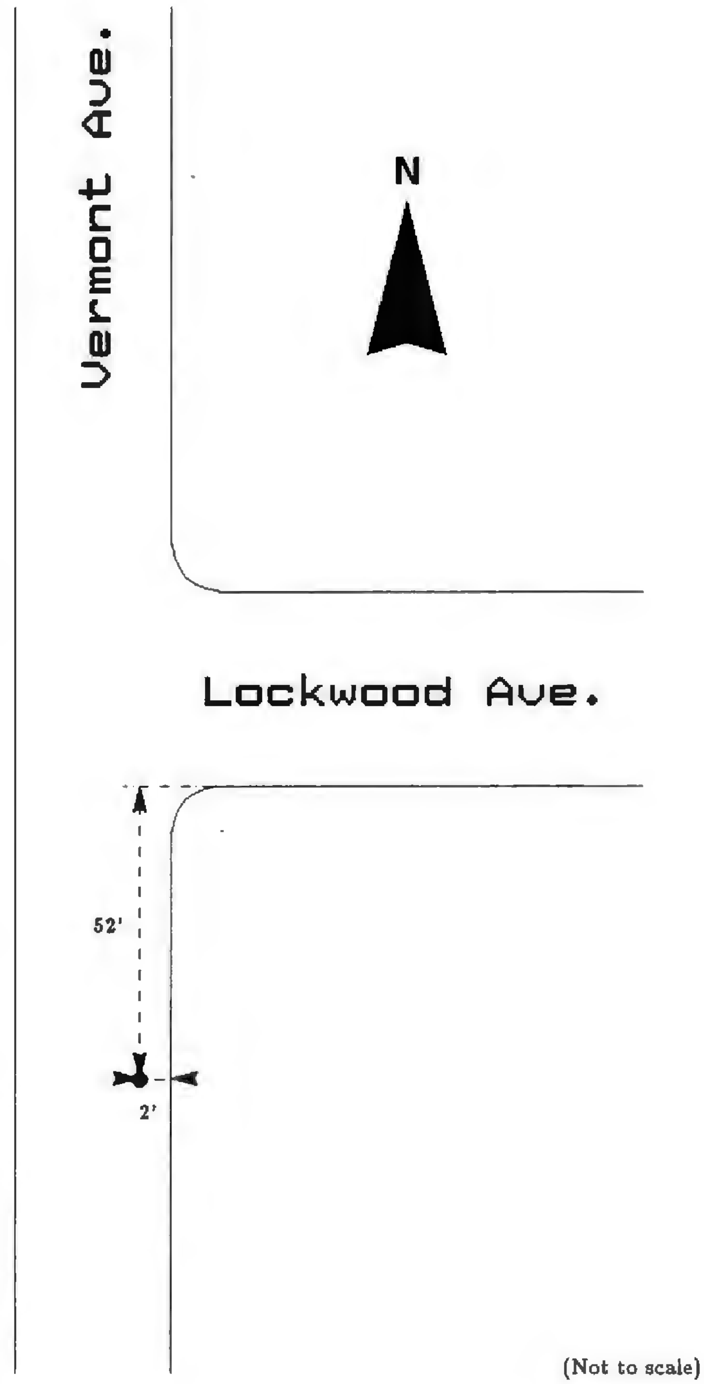

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PROJECT NO.: 89-409
Vermont/Santa Monica Station and Tunnel

Location of Borehole PII-34

5-90

FIGURE A-11A

The Earth Technology Corporation

FIGURE A-12. LOG OF BORING PII-35

Project Name: METRO RAIL - PHASE II - LOS ANGELES			
Project Number: 89-409	Borehole Number: PII-35		sheet 1 of 3
Borehole location: Willow Brook Ave. and Vermont Ave.		Elevation and Datum(feet): 317	
Health and Safety: Upgraded Level D		Date Started: 4/4/89	Date Finished: 4/4/89
Drilling Equipment: Failing 750		Total Depth(feet): 81.5	Depth to: Bedrock(feet): 15.0
Drilling Method: Mud Rotary		Borehole Diameter: 5-inch	
Drilling Fluid: Bentonite Mud		Piezometer Installation: YES	Depth(feet): 80.0
Hammer Information: SPT Hammer: 140-lb and 30-inch drop. DOWNHOLE Hammer: 295-lb and 18-inch drop.		Logged By: Kean Tan	Checked By: C. Marshall Payne

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA(ppm)
		8-inch CONCRETE.										
		SILTY CLAY; Black.										
		SILTY CLAY/CLAYEY SILT; Trace fine sand.	CL	A4								
			CL	A4								
5		SILTY CLAY(STONE); Yellowish brown to olive gray, damp, very stiff, medium plasticity, micaceous, trace very fine sand(stone). Pocket of sandy silt(stone) at bottom, low to medium plasticity, fine to medium sand(stone).		Tpw	1	D	10 15	8"/12"	6	99	22	6
10		SILTY SAND(STONE); Wet, medium dense to dense, poorly graded, weathered, no cementation, no apparent bedding.		Tpw	2	S	9 12 16	18"/18"	6			6
15		SILTY CLAY(STONE); Yellowish brown to light olive brown, damp, very stiff, weathered, medium plasticity, micaceous.		Tpw	3	D	9 15	8"/12"	6	85	39	6
20		SILTY CLAY(STONE); Yellowish brown to light olive gray, damp, very stiff, oxidized, low to medium plasticity, micaceous. Dip approximately 5 deg.		Tpo	4	S	8 11 17	12"/18"	6			6
25		SILTY CLAY(STONE); Yellowish brown to light olive gray, damp, very stiff, oxidized, medium to high plasticity, trace fine sand(stone). Dip approximately 10 to 15 deg.		Tpo	5	D	21 31	6"/12"	6	88	33	6
30												

The Earth Technology Corporation

FIGURE A-12. LOG OF BORING PII-35

Project Name: **METRO RAIL - PHASE II - LOS ANGELES**

Project Number: **89-409** | Borehole Number: **PII-35** | Sheet 2 of 3

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA(ppm)
		Same as above. Medium plasticity, cemented. Dip approximately 10 deg.		Tpo	6	S	12 22 34	14"/18"	6			6
35		Same as above. hard, black stains on bedding planes. Dip approximately 60 deg.		Tpo	7	D	55 45/5.5"	6"/11.5"	5	85	34	5
40		CLAYEY SILT(STONE); Olive brown, damp, hard, oxidized, low plasticity, micaceous, bedding not very apparent. Dip approximately 20 deg.		Tpo	8	S	21 25 31	17"/18"	6			6
45		CLAYEY SILT(STONE); Olive gray with olive brown, damp, hard, minor oxidation, low to medium plasticity, locally cemented, micaceous.		Tpo	9	D	42 58/4.5"	6"/11"	6	90	29	6
50		SILT(STONE); Olive brown, damp, very stiff, oxidized, low plasticity, micaceous, trace very fine sand(stone). Dip approximately 60 deg (not very apparent).,		Tpo	10	P	Push 350 psi	24"/24"	6	90	31	6
55		CLAYEY SILT(STONE)/SILTY CLAY(STONE); Olive gray to olive brown, damp, hard, oxidized, medium plasticity, trace mica. Dip approximately 50 to 60 deg.		Tpo	11	D	38 62/5.5"	6"/12"	6	85	36	6
60		CLAYEY SILTSTONE/SILTY CLAYSTONE; Dark olive brown to olive gray, damp, hard, fresh, medium plasticity, micaceous. Dip approximately 45 deg.		Tpf	12	S	21 29 30/2"	12"/14"	6			6
65		CLAYEY SILTSTONE/SILTY CLAYSTONE; Dark olive gray, damp, hard, fresh, medium to high plasticity, micaceous. Dip approximately 45 deg.		Tpf	13	D	55 45/4"	5"/10"	8	97	23	6
70												

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FIGURE A-12. LOG OF BORING PII-35

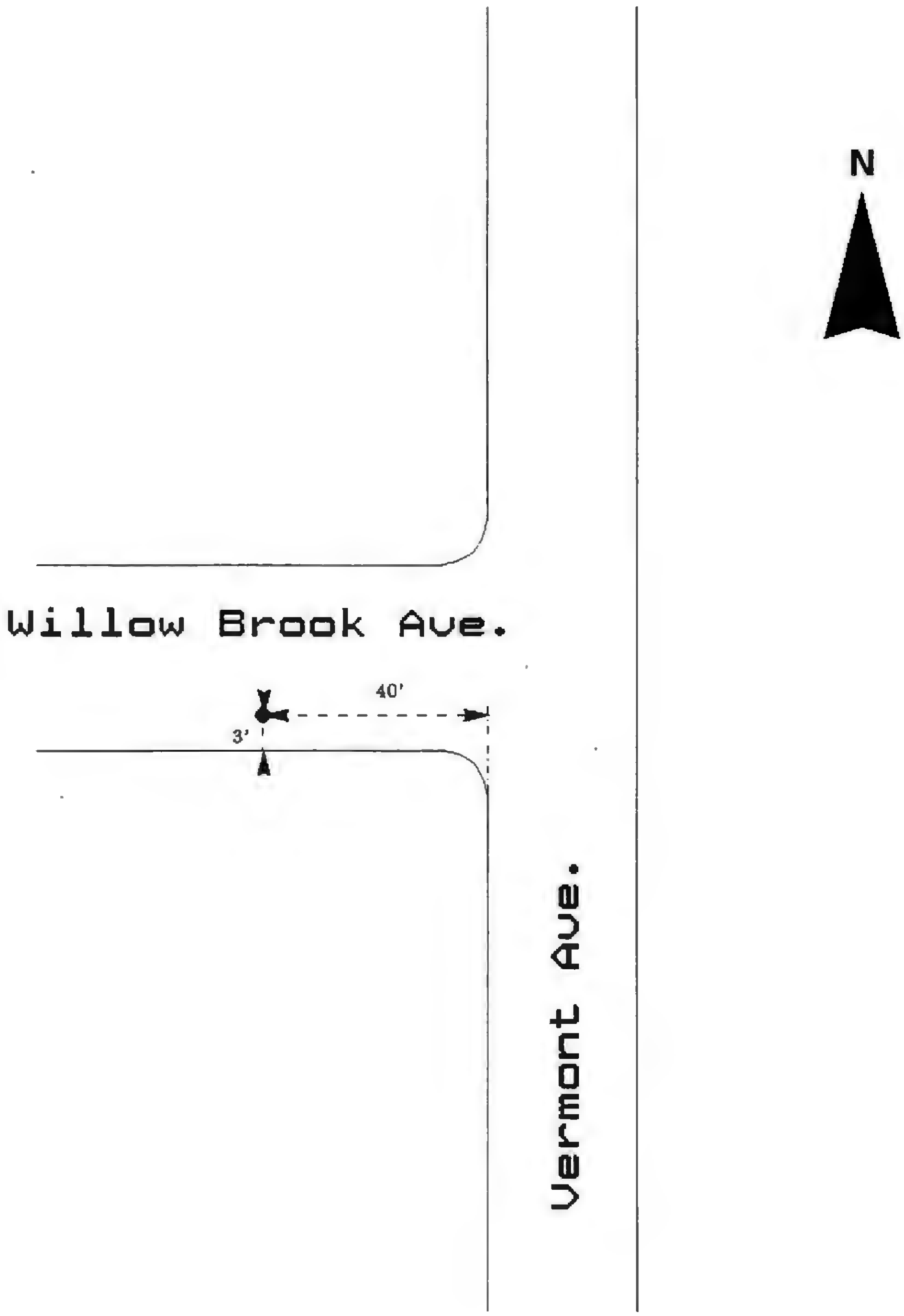
Project Name: METRO RAIL - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-35 | Sheet 3 of 3

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		Same as above.		Tpf	14	S	22 34 35/2"	10"/14"	8			6
75		Same as above. Dip approximately 75 deg.		Tpf	15	D	53 47/3.5"	6"/9.5"	8	97	24	6
80		Same as above. Dip nearly horisontal.		Tpf	16	S	18 37 25/2.5"	10"/15"				6
85												
90												
95												
100												
105												
110												

BORING WAS TERMINATED AT 81-1/2 FEET.
INSTALLED A PIEZOMETER.

NOTE: This borehole log is based on field classification and visual soil description, and is further modified to include results of laboratory classification tests, where available. This summary applies only at the location of this boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with passage of time. The data presented is simplification of actual conditions encountered. The stratification lines represent the approximate boundary between subsurface material types and the transition may be gradual.

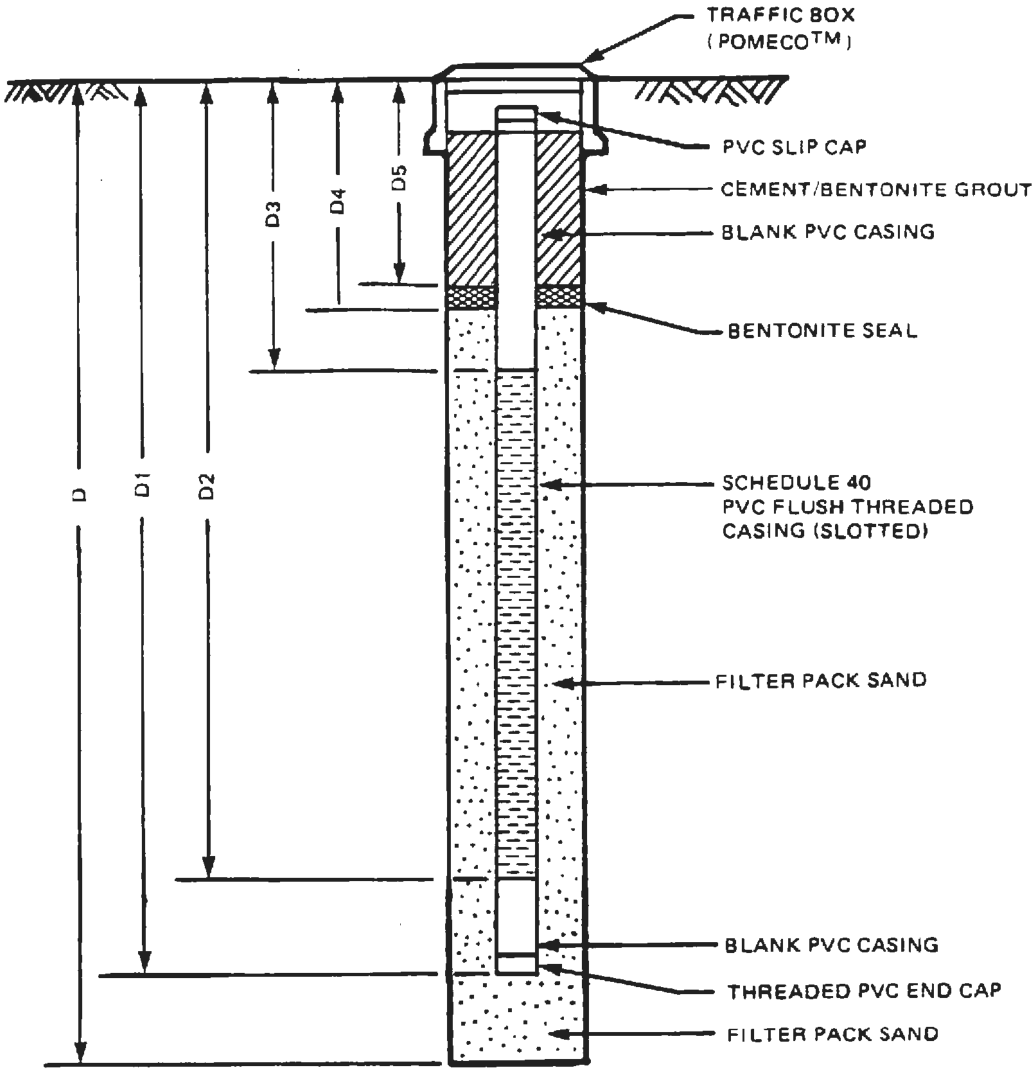


(Not to scale)

The Earth Technology Corporation	PROJECT NO.: 89-409 Metro Rail Phase II

Location of Borehole PII-35

11/89 FIGURE A-12A



TOTAL DEPTH (D)	=	81.5	FEET
TOTAL DEPTH OF CASING (D1)	=	80.0	FEET
DEPTH TO BOTTOM OF WELL SCREEN (D2)	=	35.0	FEET
DEPTH TO TOP OF WELL SCREEN (D3)	=	10.0	FEET
DEPTH TO BOTTOM OF TOP SEAL (D4)	=	5.0	FEET
DEPTH TO TOP OF TOP SEAL (D5)	=	2.0	FEET
WELL CASING DIAMETER	=	2	INCH
WELL SCREEN SLOT SIZE	=	0.02	INCH
FILTERPACK SAND TYPE	=	NO. 2	MONTEREY
BENTONITE SEAL TYPE	=		1/8" PELLETS

The Earth Technology Corporation

PROJECT NO.: 89-409

Metro Rail
Phase II

Diagram of Piezometer PII-35

11/89

FIGURE A-12B

The Earth Technology Corporation

FIGURE A-13. LOG OF BORING PII-36

Project Name: METRO RAIL - PHASE II - LOS ANGELES			
Project Number: 89-409	Borehole Number: PII-36		sheet 1 of 2
Borehole location: Vermont Ave. and Willow Brook Ave.		Elevation and Datum(feet): 317	
Health and Safety: Upgraded Level D		Date Started: 4/7/89	Date Finished: 4/7/89
Drilling Equipment: Mayhew 1500		Total Depth(feet): 45.0	Depth to: Bedrock(feet): 18.0
Drilling Method: Rotary Wash		Borehole Diameter: 5-inch	
Drilling Fluid: Bentonite Mud		Piezometer Installation: NO	Depth(feet): --
Hammer Information: SPT Hammer: 140-lb and 30-inch drop. DOWNHOLE Hammer: 265-lb and 18-inch drop.		Logged By: Curtis D. Cushman	Checked By: C. Marshall Payne

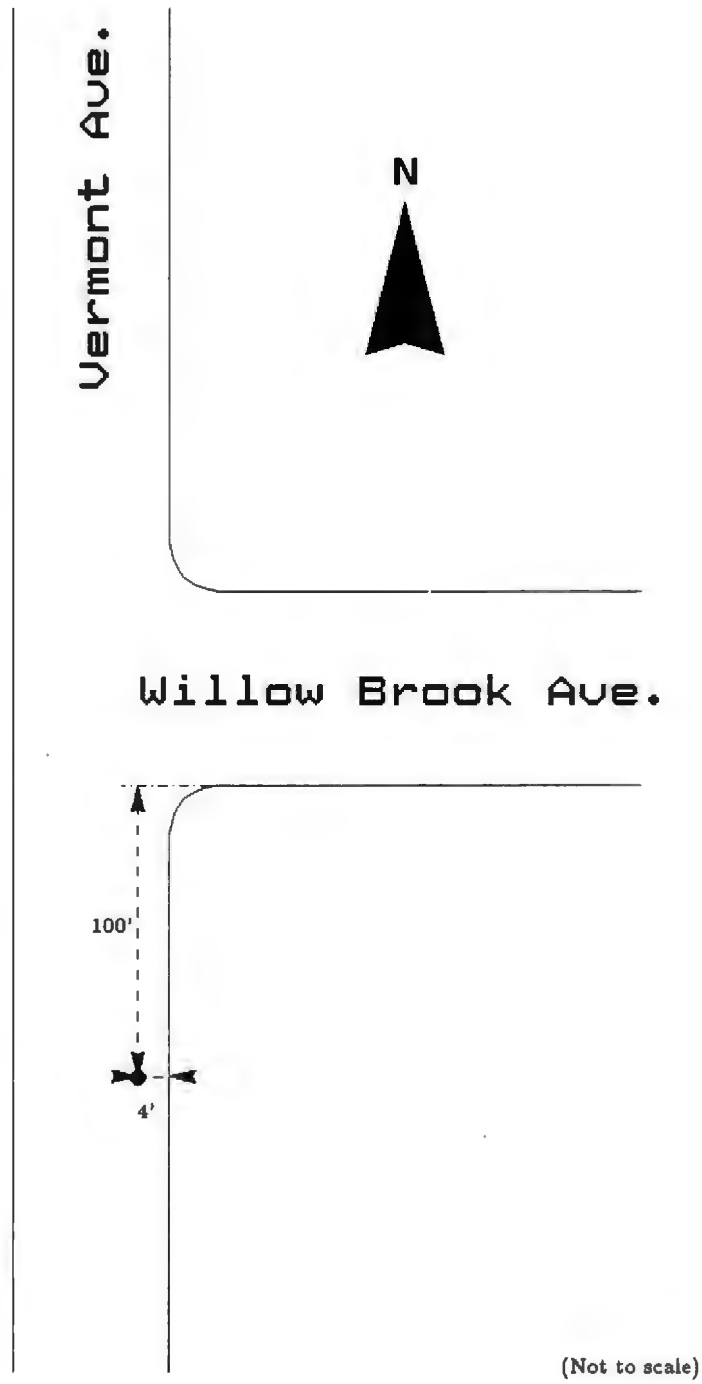
Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA(p
		6-inch ASPHALT CONCRETE.										
		FILL.		FILL								
5		CLAYEY SAND; Pale olive, moist, medium dense, medium plasticity fines, fine to coarse grained sand, trace gravel up to 1/2-inch in diameter, micaceous.	SC	A4	1	S	5 6 6	11"/12"	8			6
10		SILTY SAND; Yellowish brown, moist, dense, fine to medium grained sand.	SM	A3	2	D	6 7	12"/12"	7			6
		(Drill chatter. Gravel at 13 feet.)										
15		SILTY SAND; Reddish yellow, moist, medium dense, non-plastic fines, fine to medium grained sand, .	SM	A3	3	S	11 9 12	18"/18"	8			8
		TOP OF PUENTE FORMATION										
20		SILTY CLAY(STONE); Yellowish brown mottled with light gray, moist, hard, weathered, no bedding massive.		Tpw	4	S	15 30	4"/12"	8			8
25		SILTY CLAY(STONE); Light olive gray with white streaks, moist, hard, weathered, medium to high plasticity fines, fractured, interbedded sand(stone). Dip approximately 5 deg at top and approximately 20 to 45 deg at bottom.		Tpw	5	S	10 23 36	13"/18"	8			8
30												

FIGURE A-13. LOG OF BORING PII-36

Project Name: METRO RAIL - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-36 | Sheet 2 of 2

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		SILTY CLAY(STONE); Gray mottled with reddish brown, moist, hard, highly oxidised, 1/8-inch thick sand(stone) beds at 1-inch spacing. fracture filled with white materials at bottom. (Lost circulation at 31 feet.)		Tpo	6	D	28 42		9			8
35		CLAYEY SILT(STONE); Light olive brown mottled with light olive gray and white streaks, moist, hard, oxidized, medium plasticity, trace very fine sand(stone). Dip approximately 45 deg.		Tpo	7	S	12 16 32	16"/18"	9			8
40		CLAYEY SILT(STONE); Light olive gray mottled light olive brown and white streaks, moist, hard, medium plasticity, silt(stone) is massive, white streaks. Dip approximately 45 deg.		Tpo	8	D	20 35		9	93	31	8
45		(Shelby tube sheared off at coupling. Attempted to pull it out was successful. Boring was terminated.) BORING TERMINATED AT 45 FEET. NOTE: This borehole log is based on field classification and visual soil description, and is further modified to include results of laboratory classification tests, where available. This summary applies only at the location of this boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with passage of time. The data presented is simplification of actual conditions encountered. The stratification lines represent the approximate boundary between subsurface material types and the transition may be gradual.										
50												
55												
60												
65												
70												



The Earth Technology Corporation

PROJECT NO.: 89-409

Vermont/Santa Monica Station and Tunnel

Location of Borehole PII-36

5-90

FIGURE A-13A

FIGURE A-14. LOG OF BORING PII-36A

The Earth Technology Corporation

Project Name: METRO RAIL - PHASE II - LOS ANGELES		
Project Number: 89-409	Borehole Number: PII-36A	sheet 1 of 3
Borehole location: Vermont Ave. and Willow Brook Ave.	Elevation and Datum(feet): 317	
Health and Safety: Upgraded Level D	Date Started: 4/17/89	Date Finished: 4/17/89
Drilling Equipment: Failing 750	Total Depth(feet): 86.5	Depth to: Bedrock(feet):
Drilling Method: Mud Rotary	Borehole Diameter: 5-inch	
Drilling Fluid: Bentonite Mud	Piezometer Installation: NO	Depth(feet): --
Hammer Information: SPT Hammer: 140-lb and 30-inch drop. DOWNHOLE Hammer: 295-lb and 18-inch drop.	Logged By: Kean Tan	Checked By: C. Marshall Payne

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples: Number	Samples: Type	Samples: Blow Count	Samples: Recovery	Samples: OVA (ppm)	Samples: Dry Density (pcf)	Samples: Moisture Content (%)	Background OVA(ppm)
		Boring PII-36A was drilled in the immediate vicinity of Boring PII-36 (within 10 feet), in order to extend the depth of Boring PII-36 below planned station bottom. Hence Boring PII-36 log starts at completion depth of Boring PII-36.										
5												
10												
15												
20												
25												
30												

The Earth Technology Corporation

FIGURE A-14. LOG OF BORING PII-36A

Project Name: METRO RAIL - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-36A | Sheet 2 of 3

Depth (feet)	Lithology	Description	USCS Classification	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background (ppm)
35												
40												
45		SILTY CLAY(STONE); Olive gray, damp, hard, medium plasticity, slightly oxidized, trace very fine sand(stone), fractured, micaceous. Dip approximately 0 to 10 deg.		Tpo	1	S	18 34 41	16"/18"	5			5
50		Same as above. 1-inch size cemented nodules in the middle of sample.		Tpo	2	D	16 18	6"/12"	5			5
55		Same as above. Medium to high plasticity. Dip approximately 45 deg.		Tpo	3	S	17 32 40	18"/18"	5			5
60		CLAYEY SILT(STONE); Dark olive gray, damp, hard, fresh, medium to high plasticity. Dip approximately 60 deg.		Tpf	4	D	48 52/4"	7"/10"	5	92	29	5
65		Same as above.		Tpf	5	P	PUSH 200 PSI	20"/30"	5			5
70												

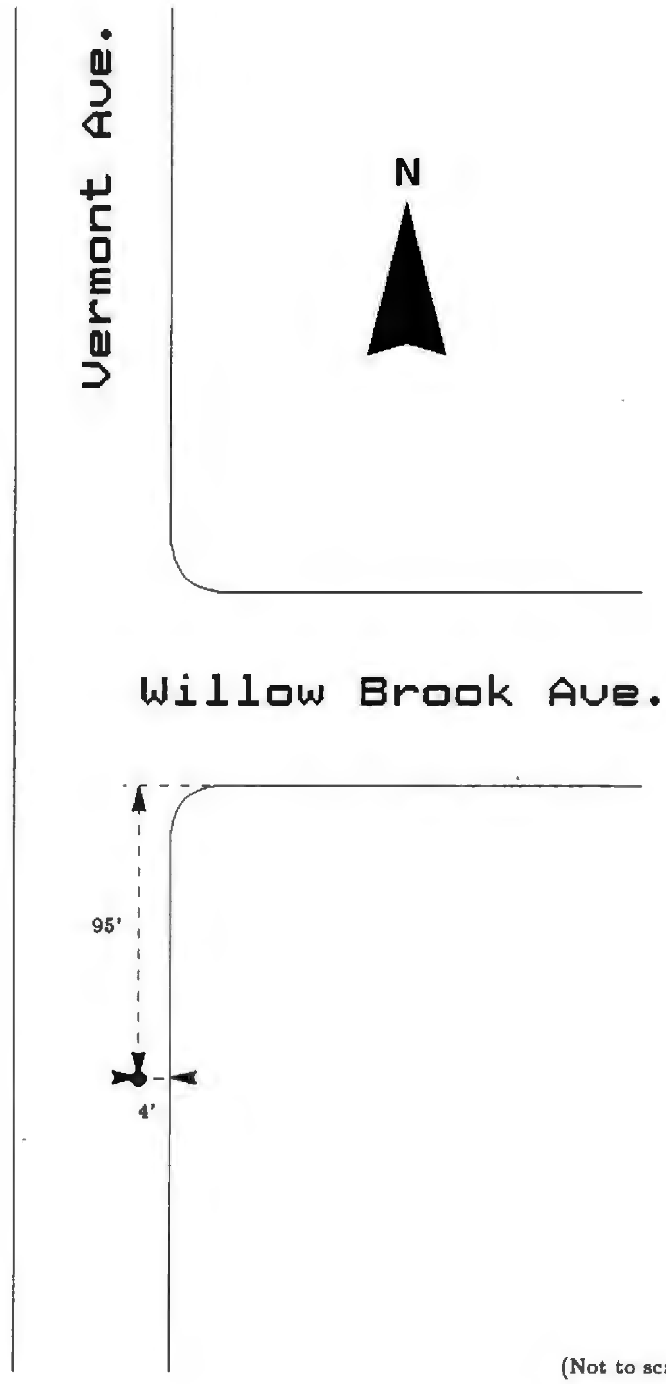
The Earth Technology Corporation

FIGURE A-14. LOG OF BORING PII-36A

Project Name: METRO RAIL - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-36A | Sheet 3 of 3

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		Same as above. Dip approximately 10 to 20 deg.		Tpf	6	D	30 60	8"/12"	5	103	21	5
75		CLAYEY SILTSTONE/SILTY CLAYSTONE; Very dark gray, damp, hard, medium plasticity, fresh, cemented, thin carbonated beds.		Tpf	7	S	25 52 23/1"	12"/13"	5			6
80		Same as above. Highly cemented; nodules, blocky, no bedding.		Tpf	8	D	43 57/4"	6"/12"	6			6
85		Same as above. High plasticity.		Tpf	9	S	19 43 38/4"	14"/18"	8			7
90		BORING TERMINATED AT 86-1/2 FEET. NOTE: This borehole log is based on field classification and visual soil description, and is further modified to include results of laboratory classification tests, where available. This summary applies only at the location of this boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with passage of time. The data presented is simplification of actual conditions encountered. The stratification lines represent the approximate boundary between subsurface material types and the transition may be gradual.										
95												
100												
105												
110												



(Not to scale)

The Earth Technology Corporation	PROJECT NO.: 89-409 Vermont/Santa Monica Station and Tunnel

Location of Borehole PII-36A

5-90

FIGURE A-14A

FIGURE A-15. LOG OF BORING PII-38

The Earth Technology Corporation

Project Name: METRO RAIL - PHASE II - LOS ANGELES			
Project Number: 89-409	Borehole Number: PII-38		sheet 1 of 3
Borehole location: Vermont Ave. and Willowbrook Ave.		Elevation and Datum(feet): 324	
Health and Safety: Upgraded Level D		Date Started: 4/8/89	Date Finished: 4/8/89
Drilling Equipment: Failing 750		Total Depth(feet): 91.5	Depth to: Bedrock(feet): 12.5
Drilling Method: Rotary Wash		Borehole Diameter: 5-inch	
Drilling Fluid: Bentonite Mud		Piezometer Installation: NO	Depth(feet): --
Hammer Information: SPT Hammer: 140-lb and 30-inch drop. DOWNHOLE Hammer: 295-lb and 18-inch drop.		Logged By: Kean Tan	Checked By: C. Marshall Payne

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		8-inch ASPHALT and 6-inch CONCRETE.										
		CLAYEY SAND; Black, fill material.	SC	FILL								
5		SANDY CLAY; Brown, damp, stiff, medium to high plasticity, fine to medium sand.	CL	A4	1	D	8 13	6"/12"	5	109	16	4
10		CLAYEY SILT; Olive brown mottled with olive gray, damp, stiff, medium plasticity, micaceous, trace fine to medium sand.	ML	A4	2	S	4 5 6	16"/18"	5			4
		TOP OF PUENTE FORMATION.										
15		CLAYEY SAND(STONE); Olive brown to pale brown, damp, stiff, fine-to-coarse-grained sand(stone), weathered, interbedded with clayey silt(stone), medium plasticity, few. cemented fragments. No apparent bedding, massive.		Tpw	3	D	11 20	8"/12"	5	112	16	4
		(Harder drilling at 18-1/2 feet.)										
20		CLAYEY SAND(STONE); Olive brown, damp, stiff, weathered, fine to medium sand(stone), micaceous, massive. No apparent bedding.		Tpw	4	S	9 12 19	18"/18"	5			4
25		CLAYEY SAND(STONE); Olive brown, damp, very dense, oxidized, fine to medium sand(stone), micaceous, medium plasticity, nearly horizontal bedding.		Tpo	5	D	24 38	6"/12"	5	114	18	4
30												

The Earth Technology Corporation

FIGURE A-15. LOG OF BORING PII-38

Project Name: METRO RAIL - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-38 | Sheet 2 of 3

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		Same as above.		Tpo	6	S	11 19 29	18"/18"	5			4
35		SANDY CLAY(STONE); Olive brown, damp, hard, oxidized, medium plasticity, fine-grained sand(stone), occasionally medium-grained sand(stone), massive, porous, some cemented fragments.		Tpo	7	D	25 58	8"/12"	5	113	17	4
40		SILTY CLAY(STONE); Olive gray mottled with yellowish brown and olive brown, damp, hard, oxidized, high plasticity, micaceous, nearly horizontal bedding.		Tpo	8	S	12 19 27	18"/18"	7			4
45		CLAYEY SILT(STONE); Olive gray to yellowish brown, damp, hard, oxidized, slightly plastic, micaceous, moderately, locally cemented, thinly bedded with interbeds of fine sand(stone), thin seam of clay(stone). Dip approximately 5 deg.		Tpo	9	D	47 53/5"	6"/11"	7	89	28	4
50		CLAYEY SILT(STONE); Olive brown to yellowish brown, damp, hard, low plasticity, oxidized, moderately cemented, interbedded with very fine sand(stone). Dip approximately 5 deg.		Tpo	10	P	Push 350 psi		8	91	30	4
55		CLAYEY SILT(STONE)/SILTY CLAY(STONE); Olive gray to yellowish brown, damp, hard, low to medium plasticity, micaceous, oxidized, moderately cemented, interbedded with fine sand(stone). Nonplastic, sandy silt(stone) at bottom. Dip approximately 0 to 10 deg.		Tpo	11	D	28 65	6"/12"	8	92	30	4
60		CLAYEY SILT(STONE); Olive gray, damp, hard, low plasticity, micaceous, oxidized, cemented. Dip nearly horizontal.		Tpo	12	S	20 40 36	18"/18"	8			4
65		SILTY CLAY(STONE); Yellowish brown mottled with olive gray and brown, damp, hard, high plasticity, micaceous, oxidized, interbedded with sand(stone), nearly horizontal bedding.		Tpo	13	D	53 47	6"/10"	8	97	26	4
70		(Faster drilling at 68-1/2 feet.)										

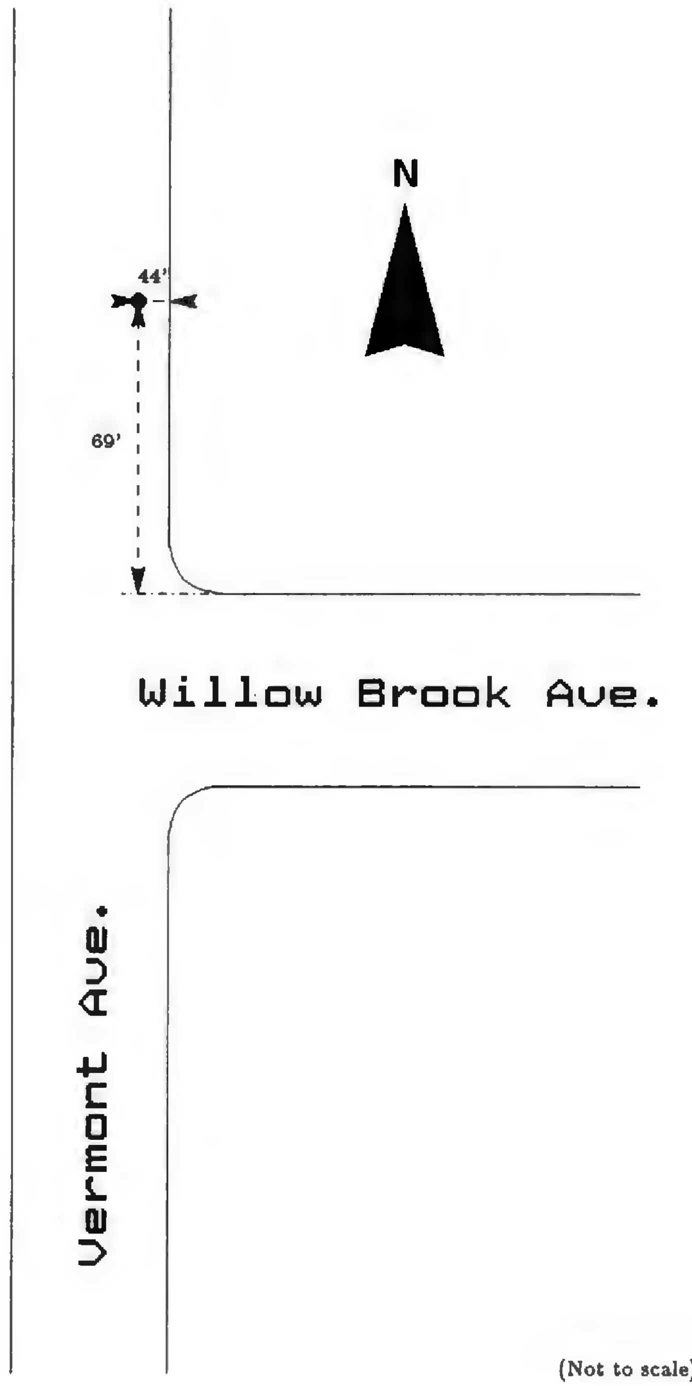
The Earth Technology Corporation

FIGURE A-15. LOG OF BORING PII-38

Project Name: METRO RAIL - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-38 | Sheet 3 of 3

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		CLAYEY SILTSTONE; Dark olive gray to dark olive brown, damp, hard, medium plasticity, micaceous, fresh, interbedded with fine-grained sandstone. Dip approximately 0 to 5 deg.		Tpf	14	S	7 20 26	18"/18"	8			4
		(Hard drilling at 74 feet.)										
75		Same as at 70 feet. Dip approximately 10 deg.		Tpf	15	D	100/5"	1"/5"	8			4
80		Same as above.		Tpf	16	S	50/5"	3"/4"	8			4
85		Same as above. Highly cemented. Dip approximately 5 to 10 deg.		Tpf	17	D	100/4"	1"/4"	10			4
90		Same as above.		Tpf	18	S	50/3"	3"/3"	10			4
		BORING TERMINATED AT 91-1/2 FEET. NOTE: This borehole log is based on field classification and visual soil description, and is further modified to include results of laboratory classification tests, where available. This summary applies only at the location of this boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with passage of time. The data presented is simplification of actual conditions encountered. The stratification lines represent the approximate boundary between subsurface material types and the transition may be gradual.										
95												
100												
105												
110												



The Earth Technology Corporation

PROJECT NO.: 89-409

Vermont/Santa Monica Station and Tunnel

Location of Borehole PII-38

5-90

FIGURE A-15A

The Earth Technology Corporation

FIGURE A-16. LOG OF BORING PII-39

Project Name: METRO RAIL - PHASE II - LOS ANGELES			
Project Number: 89-409	Borehole Number: PII-39		sheet 1 of 3
Borehole location: Vermont Ave. and Sta Monica Blvd.		Elevation and Datum(feet): 329	
Health and Safety: Upgraded Level D		Date Started: 4/2/89	Date Finished: 4/2/89
Drilling Equipment: Failing 750		Total Depth(feet): 91.5	Depth to: Bedrock(feet): 38.0
Drilling Method: Rotary Wash		Borehole Diameter: 5-inch	
Drilling Fluid: Bentonite Mud		Piezometer Installation: NO	Depth(feet): --
Hammer Information: SPT Hammer: 140-lb and 30-inch drop. DOWNHOLE Hammer: 295-lb and 18-inch drop.		Logged By: Kean Tan	Checked By: C. Marshall Payne

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		6-inch ASPHALT and 6-inch CONCRETE.										
		CLAYEY SAND; Fine to medium sand.	SC	A4								
		SAND; Fine to medium sand, slightly micaceous.	SP	A3								
5		SILTY SAND; Olive brown to yellowish brown silty, fine to coarse sand, non plastic fines, moderately cemented. Bottom of the sample clayey silt; olive brown.	SM	A3	1	D	33 67/5"	10"/11"	4	113	13	4
10		CLAYEY SILT; Olive brown, damp, hard, medium plasticity, trace fine-grained sand, micaceous.	ML	A4	2	S	18 28 33	16"/18"	4			4
15		SILTY SAND; Olive brown, damp, dense, fine-to-medium-grained sand with occasionally coarse-grained sand, slightly plastic fines, micaceous.	SM	A3	3	D	13 20	10"/12"	4			4
20		CLAYEY SAND; Olive brown, moist, dense, fine-to-medium-grained sand, low plasticity fines, micaceous.	SC	A4	4	S	9 16 15	14"/18"	5			4
25		CLAYEY SAND/SANDY CLAY; Olive brown, moist, dense, fine-to-medium-grained sand, low plasticity fines, micaceous.	SC/CL	A4	5	D	18 15	12"/12"	6	108	20	4
30												

The Earth Technology Corporation

FIGURE A-16. LOG OF BORING PII-39

Project Name: METRO RAIL - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-39 | Sheet 2 of 3

Depth (feet)	Description	USCS Classification	Geologic Unit	Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
	Same as above.	SC	A4	6	S	8 11 15	18"/18"	7			4
35	SILTY SAND; Dark brown, damp, dense to medium dense, fine to coarse, nonplastic.	SM	A3	7	D	18 33	10"/12"	7	102	25	4
	TOP OF PUENTE FORMATION.										
40	SILTY CLAY(STONE); Olive brown to yellowish brown, damp, very stiff, medium plasticity, weathered, micaceous, trace very fine sand(stone).		Tpw	8	S	8 11 16	18"/18"	7			4
45	SILTY CLAY(STONE); Olive brown to yellowish brown, damp, hard, medium plasticity, weathered, micaceous, oxidized.		Tpw	9	D	34 48	10"/12"	7			4
50	SILTY CLAY(STONE); Olive brown, damp, hard, medium plasticity, weathered, trace fine sand(stone).		Tpw	10	P	Push 350 psi	20"/30"	9	103	23	4
55	SILTY CLAY(STONE), Olive brown to yellowish brown, damp, hard, medium plasticity, weathered, trace fine sand(stone), micaceous.		Tpw	11	D	27 32	11"/12"	9			4
60	SILTY CLAY(STONE); Olive brown, damp, very stiff, low plasticity, oxidized, trace fine sand(stone), micaceous.		Tpo	12	S	8 12 16	18"/18"	9			4
65	Same as above.		Tpo	13	D	15 35		9	112	18	4
70											

The Earth Technology Corporation

FIGURE A-16. LOG OF BORING PII-39

Project Name: METRO RAIL - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-39 | Sheet 3 of 3

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		CLAY(STONE); Olive brown, damp, stiff, low to medium plasticity, oxidized, trace fine to medium sand(stone), micaceous.		Tpo	14	S	27 14 17	2"/18"	9			4
75		CLAYEY SILT(STONE); Olive brown to yellowish brown, damp, hard, medium plasticity, oxidized, micaceous, trace fine sand(stone), very vague bedding. Dip approximately 0 to 5 deg.		Tpo	15	D	20 63	12"/12"	8	78	39	4
80		CLAYEY SILT(STONE); Olive brown mottled with yellowish brown and light gray, damp, hard, oxidized, slightly cemented, thinly bedded. Dip approximately 75 deg (not very apparent).		Tpo	16	S	17 28 34	16"/18"	9			4
		(Drill chatter at 83 feet. Cuttings indicate hard, well cemented silt(stone).)										
85		CLAYEY SILTSTONE; Olive brown mottled with yellowish brown to brown, damp, hard, medium plasticity, fresh, cemented, micaceous. Dip approximately 0 to 10 deg.		Tpf	17	D	45 55/4"	9"/12"	9	91	31	4
90		CLAYEY SILTSTONE; Dark olive gray, damp, hard, medium to high plasticity, trace mica, fresh. Dip nearly horizontal.		Tpf	18	S	50/5"	5"/5"	7			4
95		BORING TERMINATED AT 91-1/2 FEET. NOTE: This borehole log is based on field classification and visual soil description, and is further modified to include results of laboratory classification tests, where available. This summary applies only at the location of this boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with passage of time. The data presented is simplification of actual conditions encountered. The stratification lines represent the approximate boundary between subsurface material types and the transition may be gradual.										
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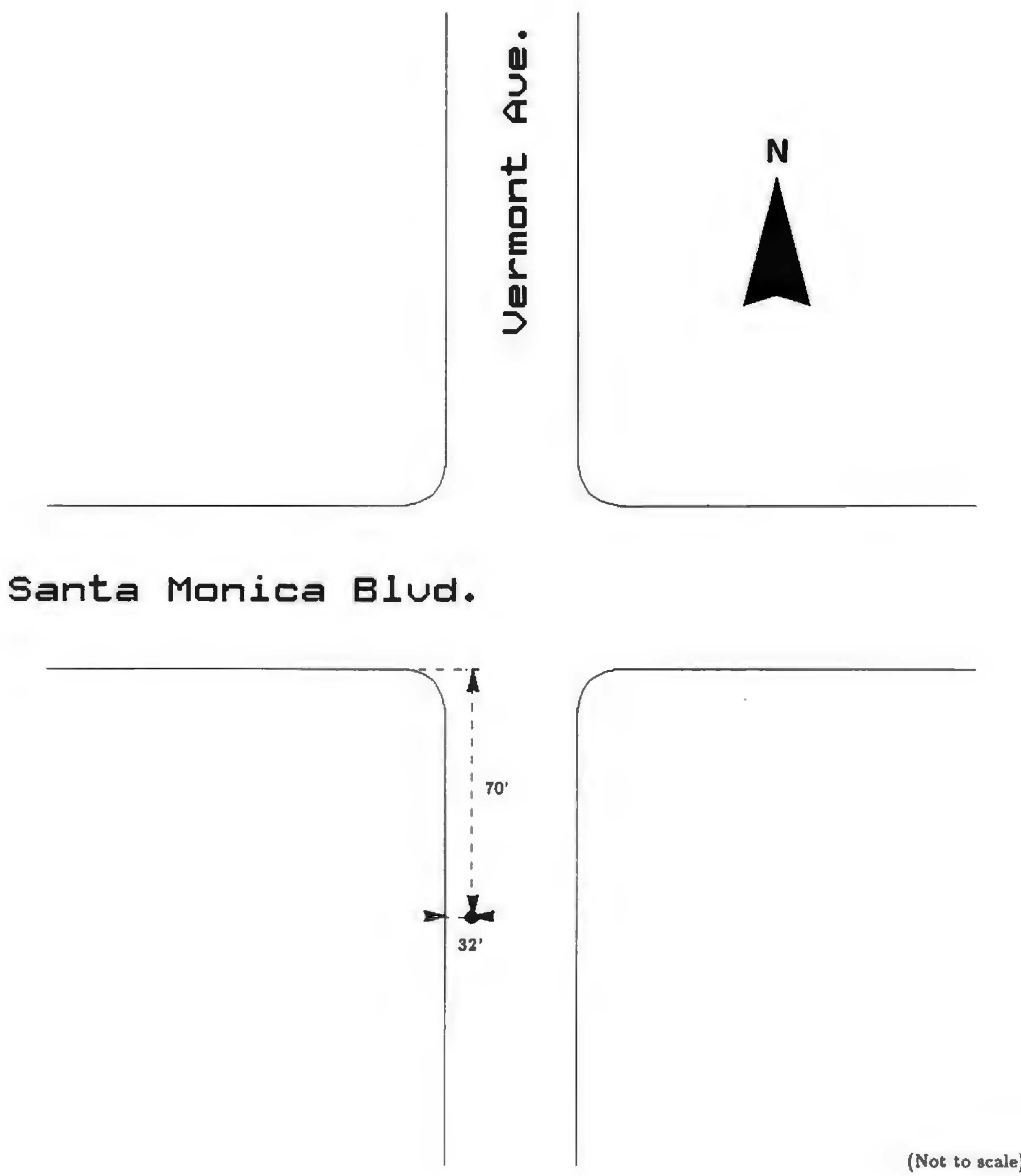
110												



The Earth Technology Corporation

PROJECT NO.: 89-409

Vermont/Santa Monica Station and Tunnel

Location of Borehole PII-39

5-90

FIGURE A-16A

The Earth Technology Corporation

FIGURE A-17. LOG OF BORING PII-40

Project Name: METRO RAIL - PHASE II - LOS ANGELES			
Project Number: 89-409	Borehole Number: PII-40		sheet 1 of 3
Borehole location: Vermont Ave. and Sta Monica Blvd.		Elevation and Datum(feet): 329	
Health and Safety: Upgraded Level D		Date Started: 4/19/89	Date Finished: 4/19/89
Drilling Equipment: Failing 750		Total Depth(feet): 91.0	Depth to: Bedrock(feet): 34.5
Drilling Method: Rotary Wash		Borehole Diameter: 5-inch	
Drilling Fluid: Bentonite Mud		Piezometer Installation: NO	Depth(feet):--
Hammer Information: SPT Hammer: 140-lb and 30-inch drop. DOWNHOLE Hammer: 295-lb and 18-inch drop.		Logged By: Kean Tan	Checked By: C. Marshall Payne

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA(ppm)
		12-inch ASPHALT.										
		SILTY SAND; Dark brown, fine to medium sand, trace silt.	SM	A3								
5		SILTY SAND; Brown, damp, very dense, fine to coarse.	SM	A3	1	S	12 26 35	16"/18"	5			5
10		CLAYEY SAND; Greenish gray to olive brown, damp, dense, medium plasticity fines, fine-to-medium-grained sand, trace silt.	SC	A4	2	D	12 21	6"/12"	4			4
15		(Coarse sand in cuttings at 14-1/2 feet.) CLAYEY SAND; Olive brown, damp, dense to very dense, fine-to-coarse-grained sand, micaceous.	SC	A4	3	S	12 19 26	16"/18"	5			4
20		CLAYEY SAND; Olive brown to reddish brown, damp, medium dense, medium plasticity fines, fine-to-medium-grained sand, micaceous.	SC	A4	4	D	6 9	8"/12"	9			4
25		CLAYEY SAND; Olive brown to reddish brown, moist, dense, medium plasticity fines, fine-to-coarse-grained sand, trace gravel, micaceous.	SC	A4	5	S	9 10 23	16"/18"	5			4
30												

FIGURE A-17. LOG OF BORING PII-40

The Earth Technology Corporation

Project Name: METRO RAIL - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-40 | Sheet 2 of 3

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		Same as above.	SC	A4	6	D	14 21	0"/12"	5			4
35		(Cuttings indicate clayey sand at 34-1/2 feet.)										
		TOP OF PUENTE FORMATION. SILTY CLAY(STONE); Olive brown, damp, hard, medium plasticity, trace fine sand(stone). No apparent bedding.		Tpw	7	S	11 15 24	12"/18"	5			4
40		SILTY CLAY(STONE); Brown, damp, hard, low plasticity, micaceous, trace very fine sand(stone), no apparent bedding.		Tpw	8	D	12 23	8"/12"	7			5
45		(Cuttings indicate cemented clay(stone) at 44 feet.) SILTY CLAY(STONE); Light olive brown, damp, hard, medium plasticity, oxidized, slightly cemented. No apparent bedding.		Tpo	9	S	25 38 42	12"/18"	7			6
50		SILTY CLAY(STONE); Yellowish brown to olive gray, damp, hard, low plasticity, micaceous, oxidized, slightly cemented, minor fractures, few sand(stone) beds.		Tpo	10	D	25 40	8"/12"	7	96	28	7
55		CLAYEY SILT(STONE); Yellowish brown to olive gray, damp, hard, micaceous, oxidized, cemented. No apparent bedding.		Tpo	11	P	Push 250 psi	15"/30"	8	104	22	8
60		Same as above.		Tpo	12	D	28 50	10"/12"	8			8
65		(Heavy drill chatter at 65 feet, cuttings indicate very hard material, strong cementation.)		Tpf	13	B	100/1"	0"/1"				
70												

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FIGURE A-17. LOG OF BORING PII-40

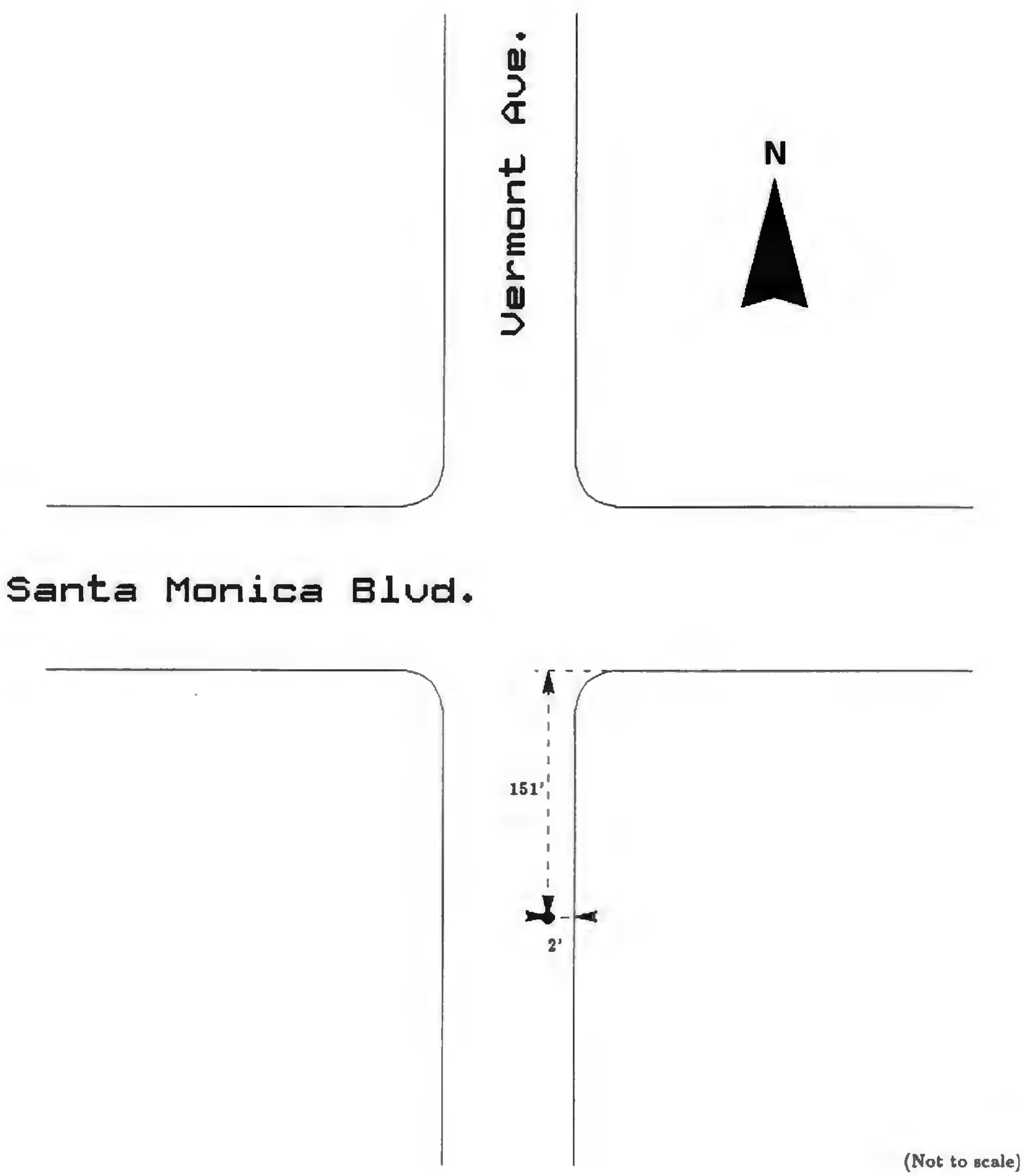
Project Name: METRO RAIL - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-40 | Sheet 3 of 3

Depth (feet)	Description	USCS Classification	Geologic Unit	Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
	CLAYEY SILTSTONE; Yellowish brown, damp, hard, micaceous, minor oxidation traces, few sandstone beds. Dip approximately 0 to 10 deg.		Tpf	14	D	25 50	6"/12"	10			10
75	CLAYEY SILTSTONE; Dark gray, damp, hard, medium plasticity, micaceous, fresh, well cemented, laminated.		Tpf	15	S	60 40/2"	7"/8"	9			10
80	CLAYEY SILTSTONE; Dark gray, damp, hard, low plasticity, micaceous, fresh. Dip approximately 0 to 10 deg.		Tpf	16	D	77 23/1"	6"/7"	9	91	29	9
85	CLAYEY SILTSTONE; Dark gray, damp, hard, high plasticity, micaceous, massive. Dip approximately 5 deg.		Tpf	17	S	50/5"	5"/5"	9			9
90	CLAYEY SILTSTONE; Dark gray, damp, hard, medium plasticity, micaceous, trace organic material, horizontal lenses of siltstone. Dip nearly horizontal.		Tpf	18	D	80 20/1"	5"/8"	9			9
95											
100											
105											
110											

BORING TERMINATED AT 91 FEET.

NOTE: This borehole log is based on field classification and visual soil description, and is further modified to include results of laboratory classification tests, where available. This summary applies only at the location of this boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with passage of time. The data presented is simplification of actual conditions encountered. The stratification lines represent the approximate boundary between subsurface material types and the transition may be gradual.



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PROJECT NO.: 89-409
Vermont/Santa Monica Station and Tunnel

LOCATION OF BOREHOLE PII-40

5-90

FIGURE A-17A

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FIGURE A-18. LOG OF BORING PII-41

Project Name: METRO RAIL - PHASE II - LOS ANGELES			
Project Number: 89-409	Borehole Number: PII-41		sheet 1 of 3
Borehole location: Vermont Ave. and Sta Monica Blvd.		Elevation and Datum(feet): 337	
Health and Safety: Upgraded Level D		Date Started: 4/18/89	Date Finished: 4/18/89
Drilling Equipment: Mayhew 1500		Total Depth(feet): 91.0	Depth to: Bedrock(feet): 23.0
Drilling Method: Rotary Wash		Borehole Diameter: 5-inch	
Drilling Fluid: Bentonite Mud		Piezometer Installation: NO	Depth(feet): --
Hammer Information: SPT Hammer: 140-lb and 30-inch drop. DOWNHOLE Hammer: 265-lb and 18-inch drop.		Logged By: Curtis D. Cushman	Checked By: C. Marshall Payne

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		6-inch ASPHALT.										
		Fill material; gravelly.	SP	FILL								
5		SILTY SAND.	SM	A3								
		SANDY CLAY; Brown, moist, very stiff, medium plasticity, fine-to-medium-grained sand.	CL	A4	3	S	10 12 19	12"/18"	5	.		4
10		SILTY SAND; Brown, dry to moist, very dense, fine-to-coarse-grained sand, micaceous, trace silt.	SM	A3	4	D	50/5"	3"/12"	5	113	11	5
15		SILTY SAND; Brown, moist, very dense, fine-to-coarse-grained, micaceous, trace silt.	SM	A3	5	S	16 19 21	16"/18"	6			5
20			SM	A3	6	D	16 28	5"/12"	8	110	17	5
		TOP OF PUENTE FORMATION.										
25		CLAYEY SILT(STONE); Yellowish brown to olive gray, very stiff, low to medium plasticity, weathered, micaceous, interbedded with 1-inch thick fine sand(stone) beds. Dip approximately 10 deg.		Tpw	7	S	7 14 18	17"/18"	6			5
30												

FIGURE A-18. LOG OF BORING PII-41

Project Name: METRO RAIL - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-41 | Sheet 2 of 3

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		SILTY CLAY(STONE); Olive brown mottled with olive gray and yellowish brown, hard, highly oxidised, medium to high plasticity, micaceous, fractured, vague bedding. Dip approximately 2 deg.		Tpo	8	D	27 50/5"	5"/11"	6	102	23	5
35		SILTY CLAY(STONE); Olive brown mottled with olive gray and dark gray, hard, oxidised, medium plasticity, micaceous. Dip approximately 5 deg.		Tpo	9	S	15 30 50/4"	14"/16"	8			6
40		CLAYEY SILT(STONE); Yellowish brown to olive brown, micaceous, oxidised, cemented, highly carbonated, thinly laminated. Dip approximately 10 deg.		Tpo	10	D	50	4"/6"	6	95	26	6
45		CLAYEY SILT(STONE); Light olive gray, hard, oxidised, low plasticity, micaceous, fractured, thinly laminated. Dip approximately 10 deg. (Hard drilling at 47 feet.)		Tpo	11	S	27 50	12"/12"	9			6
50		SILTY CLAY(STONE)/CLAYEY SILT(STONE); Light olive brown to reddish brown, hard, oxidized, low to medium plasticity, fractured, trace sand(stone). Dip approximately 0 to 10 deg.		Tpo	12	D	42 50/4"	8"/12"	6			6
					12	D	10 50	4"/12"	6			6
55		SILTY CLAY(STONE); Olive gray to olive brown, hard, oxidized, low to medium plasticity, micaceous. No apparent bedding.		Tpo	13	S	12 30 50	17"/18"	8			5
60		SILTY CLAY(STONE)/CLAYEY SILT(STONE); Olive brown to olive gray, hard, minor oxidation, low to medium plasticity, micaceous, interbedded with very fine-grained sand(stone).		Tpo	14	D	50		7	96	25	5
		(Color changes to dark gray.)										
65		CLAYEY SILTSTONE; Dark gray, hard, low to medium plasticity, micaceous, fresh, massive, some 1-inch thick very fine-grained sandstone interbeds.		Tpf	15	S	26 50/4"	8"/11"	7			6
70												

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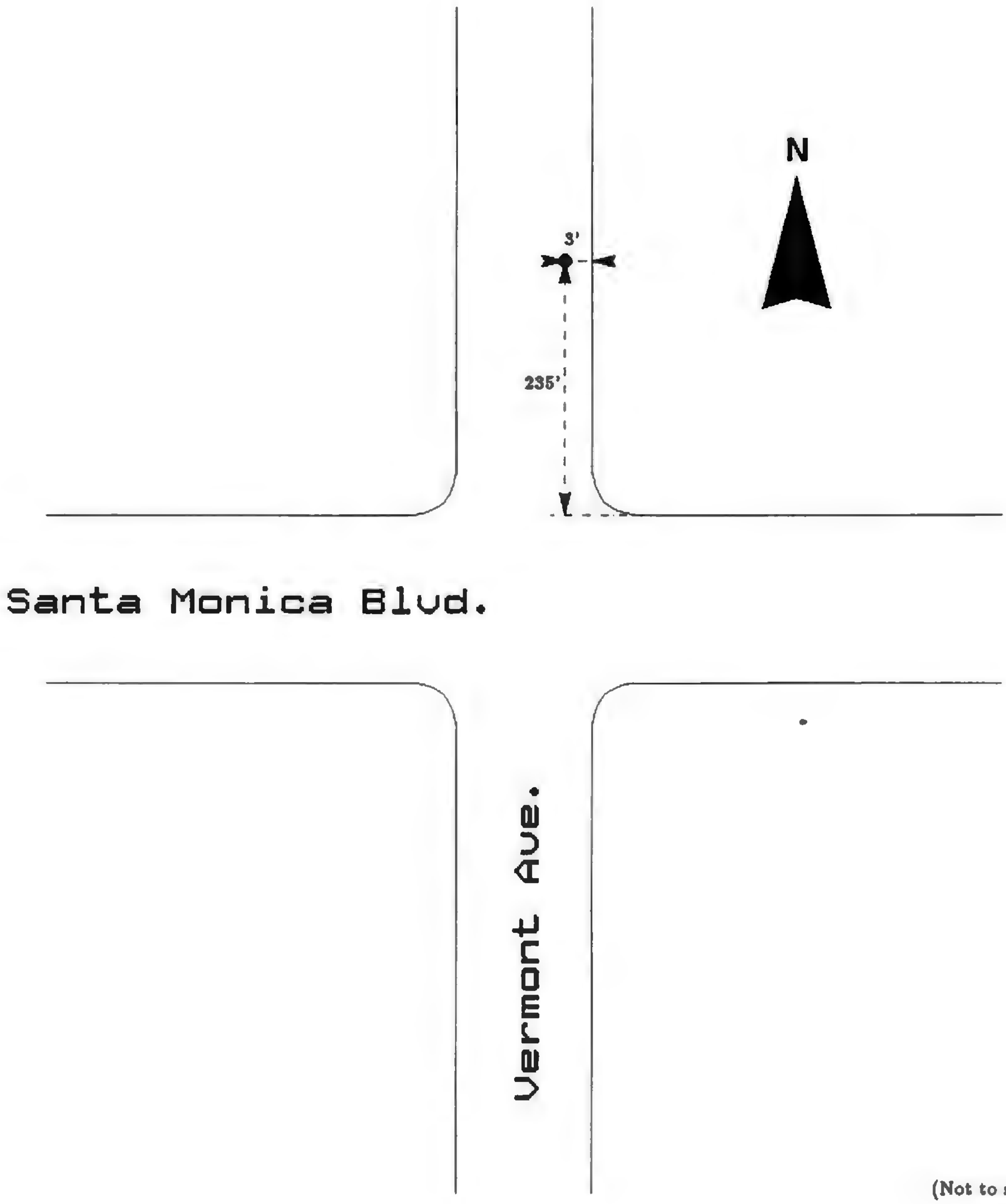
FIGURE A-18. LOG OF BORING PII-41

Project Name: METRO RAIL - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-41 | Sheet 3 of 3

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		CLAYEY SILTSTONE; Dark gray, hard, low to medium plasticity. Dip approximately 10 deg. (Drill chatter between 71 and 72 feet.)		Tpf	16	D	50/5"	3"/5"	12	75	47	5
75		Same as above. No apparent bedding. (Drill chatter between 76 and 78 feet.)		Tpf	17	S	50/3"	2"/3"	14			5
80		CLAYEY SILTSTONE; Dark gray, hard, fresh, laminated, carbonated. Dip approximately 10 to 15 deg. (Hard drilling between 80 and 85 feet.)		Tpf	18	D	50/5"	1"/5"	16			6
85		CLAYEY SILTSTONE; Dark gray, hard, high plasticity, trace mica, fresh.		Tpf	19	S	50/5"	4"/5"	90			6
90		SILTY CLAYSTONE; hard, cemented.		Tpf	20	D	50/4"		180			7
		BORING TERMINATED AT 91 FEET. NOTE: This borehole log is based on field classification and visual soil description, and is further modified to include results of laboratory classification tests, where available. This summary applies only at the location of this boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with passage of time. The data presented is simplification of actual conditions encountered. The stratification lines represent the approximate boundary between subsurface material types and the transition may be gradual.										
95												
100												
105												
110												



(Not to scale)

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PROJECT NO.: 89-409
Vermont/Santa Monica Station and Tunnel

Location of Borehole PII-41

5-90

FIGURE A-18A

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FIGURE A-19. LOG OF BORING PII-42

Project Name: METRO RAIL - PHASE II - LOS ANGELES			
Project Number: 89-409	Borehole Number: PII-42		sheet 1 of 3
Borehole location: Vermont Ave. and Vermont Pl.		Elevation and Datum(feet): 342	
Health and Safety: Upgraded Level D		Date Started: 4/5/89	Date Finished: 4/5/89
Drilling Equipment: Failing 750		Total Depth(feet): 72.5	Depth to: Bedrock(feet): 29.5
Drilling Method: Rotary Wash		Borehole Diameter: 5-inch	
Drilling Fluid: Bentonite Mud		Piezometer Installation: NO	Depth(feet): --
Hammer Information: SPT Hammer: 140-lb and 30-inch drop. DOWNHOLE Hammer: 295-lb and 18-inch drop.		Logged By: Pierce Charles	Checked By: C. Marshall Payne

Depth (feet)	Lithology	Description	USCS Classification	Geologic Unit	Samples Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA(ppm)
		2-inch ASPHALT.										
		Fill.		FILL								
5		SILTY SAND; Yellowish brown, damp, very dense, low plasticity fines, fine-to-coarse-grained sand, micaceous.	SM	A3	1	D	11 24	6"/12"	7			7
10		SAND-SILTY SAND; Yellowish brown, damp, loose to medium dense, nonplastic fines, fine to coarse sand, micaceous.	SP-SM	A3	2	S	7 7 13	9"/18"	7			7
15		SAND-SILTY SAND; Yellowish brown, moist, medium dense to dense, nonplastic fines, fine-to-coarse-grained sand, micaceous. (Becomes more silty, color changes to yellow.)	SP-SM	A3	3	D	15 20	6"/12"	7	109	14	7
20		SILTY SAND; Brown, moist, medium dense to dense, low plasticity fines, trace 1/2-inch thick moderately plastic silty clay, micaceous.	SM	A3	4	S	15 18 18	16"/18"	6			6
25		SILTY SAND; Brown, moist, medium dense, low plasticity fines, fine-to-medium-grained sand, slightly plastic fines, micaceous.	SM	A3	5	D	7 8	6"/12"	6	104	21	6
30												

FIGURE A-19. LOG OF BORING PII-42

The Earth Technology Corporation

Project Name: METRO RAIL - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-42 | Sheet 2 of 3

Depth (feet)	Lithology	Description	USCS Classification	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		TOP OF PUENTE FORMATION. CLAYEY SILT(STONE); Yellowish brown, moist, hard, low to medium plasticity, oxidized, well bedded with 1/4 inch thick sandstone beds. Dip approximately 0 to 10 deg.		Tpo	6	S	11 19 21	16"/18"	6			6
35		CLAYEY SILT(STONE); Light olive gray mottled with brownish yellow, moist, hard, low to medium plasticity, weathered, fractured, moderately cemented, interbedded with lenses of reddish brown sand(stone). Dip approximately 10 deg.		Tpo	7	D	21 40	6"/12"	6	92	27	6
40		SILTY CLAY(STONE); Olive brown mottled with light olive gray and reddish brown, moist, hard, high plasticity, micaceous, oxidized, occasionally fractured, interbedded with sand(stone). Dip approximately 10 deg.		Tpo	8	S	28 31 39	14"/18"	6			6
45		Same as above. Very vague bedding.		Tpo	9	D	20 31	6"/12"	6	89	26	6
50		CLAYEY SILT(STONE); Olive brown mottled with light olive gray and reddish brown, moist, hard, medium plasticity, oxidized, fractured, locally cemented, interbedded with sandy silt(stone). Dip approximately 15 deg.		Tpo	10	S	20 41 39	15"/15"	6			6
55		Same as above, fractured, oxidized.		Tpo	11	D	45 55	6"/12"	6	80	42	6
60		CLAYEY SILT(STONE); Light olive brown mottled with light olive gray and reddish brown, moist, hard, micaceous, oxidized, interbedded with very fine grained sandy silt(stone). Dip approximately 15 deg.		Tpo	12	S	20 28 46	18"/18"	4			4
65		Same as above. Oxidized.		Tpo	13	D	20 41	6"/12"	4	99	24	4
70		(Harder drilling at 69-3/4 feet.)										

The Earth Technology Corporation

FIGURE A-19. LOG OF BORING PII-42

Project Name: METRO RAIL - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-42 | Sheet 3 of 3

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		CLAYEY SILT(STONE); Brown mottled with light olive gray, moist, hard, medium to well cemented, carbonated, interbedded with sandy silt(stone). Dip approximately 10 deg.		Tpf	14	P	Push 280 psi	15"/18"	4	128	11	4
75		BORING TERMINATED AT 72-1/2 FEET. NOTE: This borehole log is based on field classification and visual soil description, and is further modified to include results of laboratory classification tests, where available. This summary applies only at the location of this boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with passage of time. The data presented is simplification of actual conditions encountered. The stratification lines represent the approximate boundary between subsurface material types and the transition may be gradual.										
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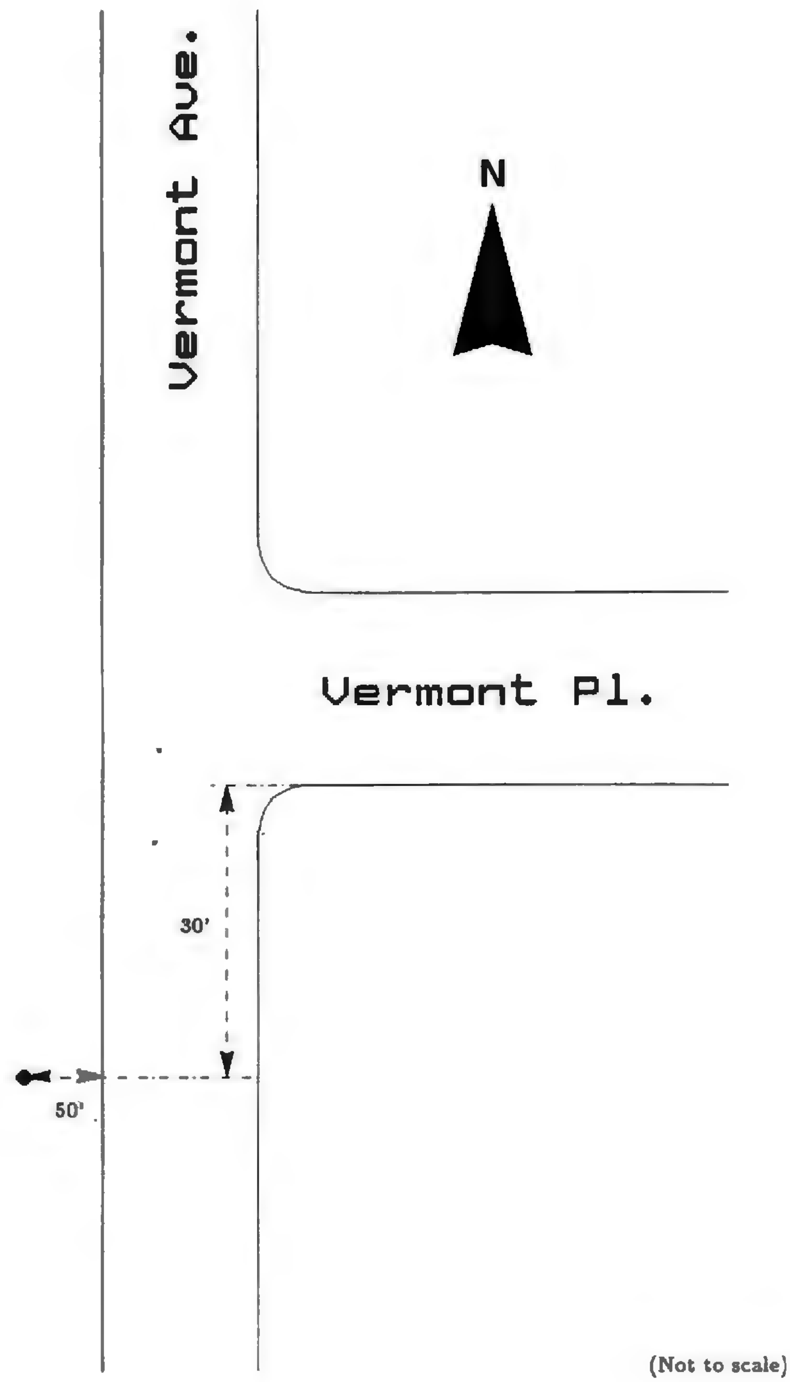

The Earth Technology Corporation

PROJECT NO.: 89-409

Vermont/Santa Monica Station and Tunnel

Location of Borehole PII-42

5-90

FIGURE A-19A

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FIGURE A-20. LOG OF BORING PII-43

Project Name: METRO RAIL - PHASE II - LOS ANGELES			
Project Number: 89-409	Borehole Number: PII-43		sheet 1 of 3
Borehole location: Lexington Ave. and Vermont Ave.		Elevation and Datum(feet): 350	
Health and Safety: Upgraded Level D		Date Started: 4/6/89	Date Finished: 4/6/89
Drilling Equipment: Failing 750		Total Depth(feet): 66.0	Depth to: Bedrock(feet): 5.0
Drilling Method: Rotary Wash		Borehole Diameter: 5-inch	
Drilling Fluid: Bentonite Mud		Piezometer Installation: YES	Depth(feet): 63
Hammer Information: SPT Hammer: 140-lb and 30-inch drop. DOWNHOLE Hammer: 295-lb and 18-inch drop.		Logged By: Kean Tan	Checked By: C. Marshall Payne

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA(ppm)
		6-inch ASPHALT.										
		CLAYEY SAND; Fine to medium sand.	SC	FILL								
		Sand, loose.	SP	A3								
5		SILTY SAND; Fine, trace clay.	SM	A3								
		TOP OF PUENTE FORMATION. CLAY(STONE); Yellowish brown mottled with dark brown, damp, very stiff to hard, medium plasticity, trace mica. (Heavy drill chatter at 7 feet, cuttings indicate 6-inch thick hard cemented bedrock material.)		Tpw	1	D	14 21	6"/12"	4			4
10		SILTY CLAY(STONE)/CLAYEY SILT(STONE); Olive brown, damp, very stiff, low to medium plasticity, cemented, lenses of sandy silt(stone) and nonplastic very fine sand. Dip approximately 5 deg.		Tpw	2	S	8 14 14	14"/18"	5			4
15		SILTY CLAY(STONE)/CLAYEY SILT(STONE); Olive brown, damp, hard, medium plasticity, trace mica, lenses of silt(stone) and very fine sand(stone).		Tpw	3	D	20 27	6"/12"	5	92	28	4
20		Same as above.		Tpw	4	S	19 24 32	18"/18"	5			4
25		SILTY CLAY(STONE)/CLAYEY SILT(STONE); Olive brown mottled with light olive gray, damp, hard, oxidized, low to medium plasticity, fractured, black stains on fractures, vague bedding. Dip approximately 0 to 5 deg.		Tpo	5	D	52 48/5"	6"/11"	6	93	33	4
30												

FIGURE A-20. LOG OF BORING PII-43

The Earth Technology Corporation

Project Name: METRO RAIL - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-43 | Sheet 2 of 3

Depth (feet)	Description	USCS Classification	Geologic Unit	Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
	CLAYEY SILT(STONE); Yellowish brown, damp, hard, oxidized, interbedded with nonplastic silt(stone) and very fine-grained sand(stone).		Tpo	6	S	14 19 27		7			4
35	CLAYEY SILT(STONE); Olive brown to light olive brown, damp, hard, oxidized, low to medium plasticity, trace mica. Dip approximately 5 to 10 deg.		Tpo	7	D	44 56/5"	6"/12"	7	95	27	4
40	CLAYEY SILT(STONE); Olive brown to light reddish brown, damp, hard, oxidized, low plasticity, trace mica, fractured, weakly cemented.		Tpo	8	P	Push 400 psi	24"/30"	7	90	30	4
45	CLAYEY SILT(STONE); Olive brown mottled with yellowish brown, damp, hard, oxidized, low to medium plasticity, locally vertically fractured, interbedded with very fine sand(stone). Dip approximately 5 to 10 deg.		Tpo	9	D	28 50	6"/12"	7	92	28	4
50	CLAYEY SILT(STONE); Olive brown, damp, hard, oxidized, low to medium plasticity, trace mica.		Tpo	10	S	16 25 35	16"/18"	8			4
55	Same as above. Fractured. Dip approximately 5 deg.		Tpo	11	D	75 25/2"	6"/8"	8	92	29	4
60	CLAYEY SILT(STONE); Olive brown, damp, hard, oxidized, low to medium plasticity, trace mica, interbedded with very fine sand(stone).		Tpo	12	S	20 30 40	18"/18"	6			4
65	SILTY CLAY(STONE); Dark olive brown to olive brown and reddish brown, damp, hard, minor oxidation.		Tpo	13	D	60 40/3"	6"/9"	8	99	24	4
70	BORING TERMINATED AT 66 FEET. INSTALLED A PIEZOMETER. NOTE: This borehole log is based on field classification and visual soil description, and is further modified to include results of laboratory classification tests, where										

The Earth Technology Corporation

FIGURE A-20. LOG OF BORING PII-43

Project Name: METRO RAIL - PHASE II - LOS ANGELES		
Project Number: 89-409	Borehole Number: PII-43	Sheet 3 of 3

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA(ppm)
75		available. This summary applies only at the location of this boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with passage of time. The data presented is simplification of actual conditions encountered. The stratification lines represent the approximate boundary between subsurface material types and the transition may be gradual.										
80												
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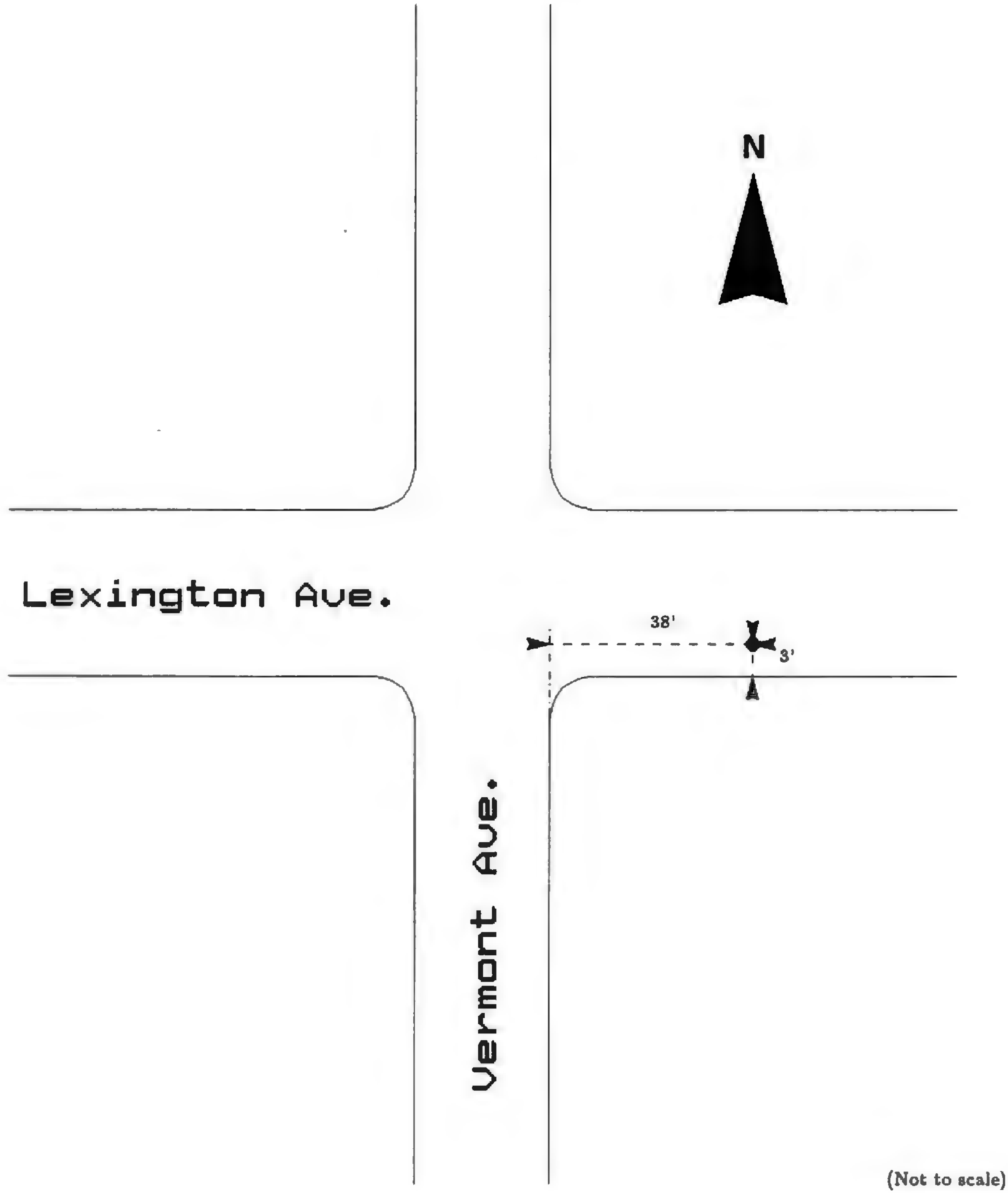
95												
100												
105												
110												

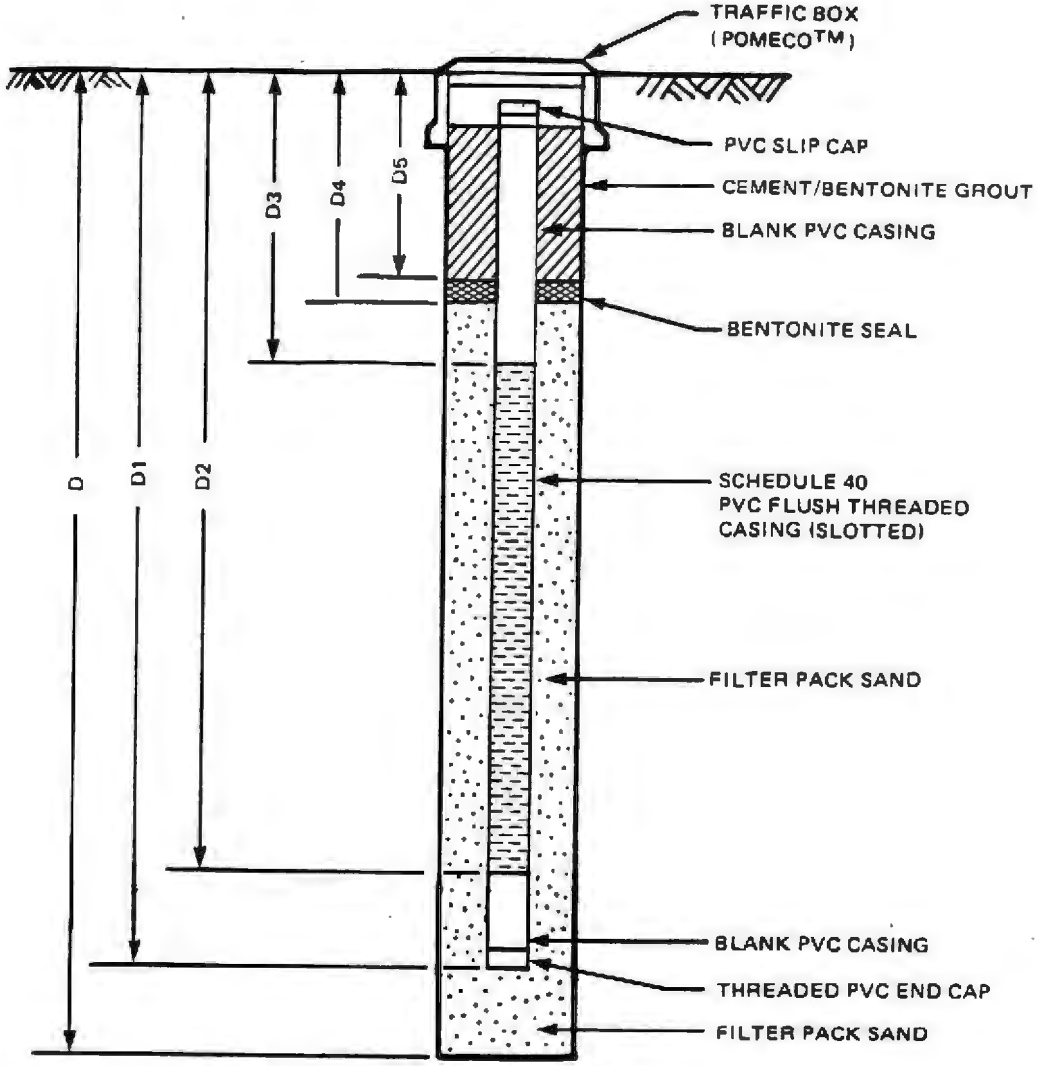


The Earth Technology Corporation	PROJECT NO.: 89-409 Vermont/Santa Monica Station and Tunnel

Location of Borehole PII-43

5-90

FIGURE A-20A



TOTAL DEPTH (D)	=	66.0	FEET
TOTAL DEPTH OF CASING (D1)	=	63.0	FEET
DEPTH TO BOTTOM OF WELL SCREEN (D2)	=	38.0	FEET
DEPTH TO TOP OF WELL SCREEN (D3)	=	8.0	FEET
DEPTH TO BOTTOM OF TOP SEAL (D4)	=	4.5	FEET
DEPTH TO TOP OF TOP SEAL (D5)	=	2.0	FEET
WELL CASING DIAMETER	=	2	INCH
WELL SCREEN SLOT SIZE	=	0.02	INCH
FILTERPACK SAND TYPE	=	NO. 2	MONTEREY
BENTONITE SEAL TYPE	=		1/8" PELLETS

The Earth Technology Corporation

PROJECT NO.: 89-409
Vermont/Santa Monica Station and Tunnel

Diagram of Piezometer PII-43

5-90

FIGURE A-20B

The Earth Technology Corporation

FIGURE A-21. LOG OF BORING PII-44

Project Name: METRO RAIL - PHASE II - LOS ANGELES			
Project Number: 89-409	Borehole Number: PII-44		sheet 1 of 3
Borehole location: La Mirada Ave. and Vermont Ave.	Elevation and Datum(feet):		
Health and Safety: Upgraded Level D	Date Started: 4/18/89		Date Finished: 4/18/89
Drilling Equipment: Failing 750	Total Depth(feet): 81.0		Depth to: Bedrock(feet): 79.0
Drilling Method: Rotary Wash	Borehole Diameter: 6-inch		
Drilling Fluid: Bentonite Mud	Piezometer Installation: NO		Depth(feet): --
Hammer Information: SPT Hammer: 140-lb and 30-inch drop. DOWNHOLE Hammer: 295-lb and 18-inch drop.	Logged By: Kean Tan		Checked By: Marshall Payne

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		6-inch ASPHALT										
		FILL.		FILL								
5		CLAYEY SAND; Dark yellowish brown, damp, dense to very dense, medium plasticity fines, fine-to-coarse-grained sand, micaceous.	SC	A3	1	S	10 15 25	16"/18"	3			3
10		CLAYEY SAND; Dark yellowish brown, damp, dense to very dense, medium plasticity fines, fine-to-coarse-grained sand, micaceous.	SC	A3	2	D	11 22	10"/12"	3	112	19	3
15		CLAYEY SAND; Dark yellowish brown, damp, dense to very dense, low to medium plasticity fines, fine-to-coarse-grained sand, with pockets of sandy clay, medium plasticity, micaceous.	SC	A4	3	S	12 16 17	16"/18"	4			3
20		CLAYEY SAND; Brown, damp, medium dense, low to medium plasticity fines, fine-to-coarse-grained sand, micaceous.	SC	A4	4	D	8 17	10"/12"	4	115	17	4
25		Same as above. More fines, medium plasticity.	SC	A4	5	S	9 16 17	18"/18"	4			4
30												

The Earth Technology Corporation

FIGURE A-21. LOG OF BORING PII-44

Project Name: METRO RAIL - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-44 | Sheet 2 of 3

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		CLAYEY SAND; Brown, damp, medium dense, medium plasticity fines, fine-to-coarse-grained sand, trace gravel up to 3/8-inch in diameter, micaceous.	SC	A4	6	D	8 12	8"/12"	5	111	19	5
35		SANDY SILT/SILTY SAND; Brown mottled with olive gray, damp, medium dense, low plasticity fines, fine-to-medium-grained sand, micaceous.	ML/SM	A4	7	S	9 11 15	16"/18"	5			5
40		SANDY CLAY/CLAYEY SAND; Olive brown, damp, stiff, low to medium plasticity fines, fine-grained sand, micaceous.	CL/SC	A4	8	D	10 14	10"/12"	5	103	24	5
45		SILTY SAND; Light olive brown, damp, medium dense, low plasticity fines, little gravel, micaceous.	SM	A3	9	P	PUSH 250 PSI	24"/30"	7			6
50		SILTY SAND; Light olive brown, wet, medium dense, fine-grained sand, micaceous.	SM	A3	10	D	10 15	6"/12"	8	102	25	8
55		SILTY SAND; Light olive brown, wet, dense, low plasticity fines, fine-to-coarse-grained sand, micaceous.	SM	A3	11	S	18 20 29	16"/18"	8			8
60		SAND-SILTY SAND; Light brown, wet, very dense, medium-to-coarse-grained, micaceous.	SP-SM	A3	12	D	36 46	10"/12"	10			10
65		Same as above. Sandy silt at bottom of the sample.	SP-SM	A3	13	S	14 25 40	12"/18"	10			10
70												

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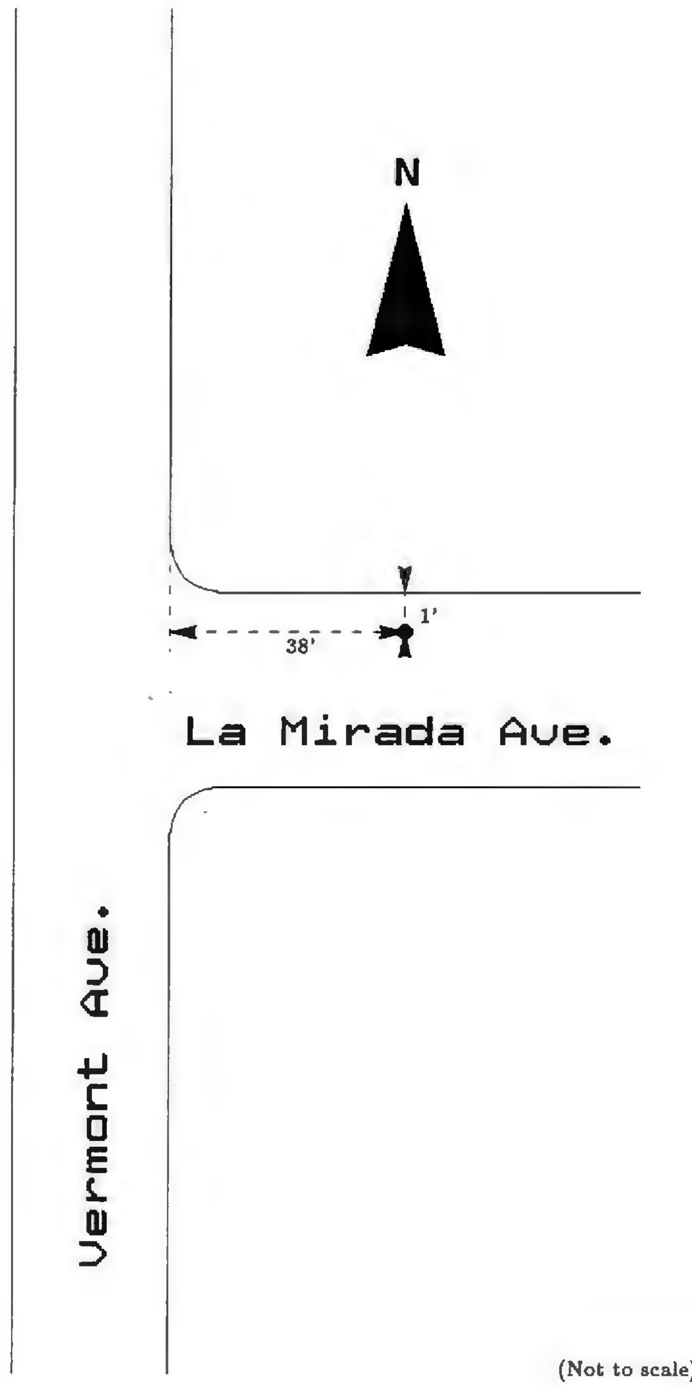
FIGURE A-21. LOG OF BORING PII-44

Project Name: METRO RAIL - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-44 | Sheet 3 of 3

Depth (feet)	Lithology	Description	USCS Classification	Geologic Unit	Samples Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		CLAYEY SILT; Yellowish brown, moist, very stiff, low to medium plasticity, little fine-grained sand, micaceous.	ML	A4	14	D	15 17	8"/12"	10	104	23	10
75		CLAYEY SAND; Brown mottled with gray, moist, medium dense, low to medium plasticity fines, fine-to-coarse-grained sand, micaceous, pockets of olive gray sandy silt.	SC	A4	15	S	13 25 53	14"/18"	10			8
80		TOP OF PUENTE FORMATION. SILT(STONE); Brown mottled with gray and yellow, damp, hard, oxidized, medium plasticity, thinly bedded, cemented, micaceous. Dip approximately 15 deg.		Tpo	16	D	32 68	7"/12"	8	81	45	8
85		CLAYEY SILT(STONE); Light gray mottled with yellowish brown, hard, oxidized, low to medium plasticity, trace very fine sand(stone), weakly cemented, micaceous.		Tpo	17	S	23 44 33/4"	14"/14"	9			9
		BORING TERMINATED AT 86.5 FEET. NOTE: This borehole log is based on field classification and visual soil description, and is further modified to include results of laboratory classification tests, where available. This summary applies only at the location of this boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with passage of time. The data presented is simplification of actual conditions encountered. The stratification lines represent the approximate boundary between subsurface material types and the transition may be gradual.										
90												
95												
100												
105												
110												



The Earth Technology Corporation

PROJECT NO.: 89-409
Vermont/Santa Monica Station and Tunnel

Location of Borehole PII-44

5-90

FIGURE A-21A

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FIGURE A-22. LOG OF BORING PII-45

Project Name: METRO RAIL - PHASE II - LOS ANGELES			
Project Number: 89-409	Borehole Number: PII-45		sheet 1 of 3
Borehole Location: Vermont Ave. and Fountain Ave.		Elevation and Datum(feet): 372	
Health and Safety: Upgraded Level D		Date Started: 5/8/89	Date Finished: 5/8/89
Drilling Equipment: Mayhew 1500		Total Depth(feet): 81.0	Depth to: Bedrock(feet): 21.0
Drilling Method: Rotary Wash		Borehole Diameter: 5-inch	
Drilling Fluid: Bentonite Mud		Piezometer Installation: NO	Depth(feet): --
Hammer Information: SPT Hammer: 140-lb and 30-inch drop. DOWNHOLE Hammer: 265-lb and 18-inch drop.		Logged By: Curtis D. Cushman	Checked By: C. Marshall Payne

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		6-inch ASPHALT.										
		Fill Material.		FILL								
5		CLAYEY SAND; Brown, moist, medium dense, fine-to-medium-grained sand, low to medium plasticity fines, micaceous.	SC	A4	1	S	7 15 17	12"/18"	8			6
10		Same as above. Very dense.	SC	A4	2	D	14 22	6"/12"	6	115	14	6
		(Drill chatter at 14 feet.)										
15		SILTY SAND; Brown, moist, medium dense, trace slightly plastic fines, micaceous.	SM	A3	3	S	12 17 18	12"/18"	7			6
20		CLAYEY SAND; Brown, moist, very dense, fine-to-medium-grained sand, medium plasticity fines, micaceous.	SC	A4	4	D	20 16		6	107	18	6
		TOP OF PUENTE FORMATION.										
25		CLAYEY SILT(STONE); Brown mottled with light olive gray, moist, hard, oxidized, low to medium plasticity, micaceous, massive, trace fine sand(stone).		Tpo	5	S	10 14 26	12"/18"	7			6
30												

The Earth Technology Corporation

FIGURE A-22. LOG OF BORING PII-45

Project Name: METRO RAIL - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-45 | Sheet 2 of 3

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		CLAYEY SILT(STONE); Olive brown mottled with reddish brown, moist, hard, oxidized, low to medium plasticity, trace mica, thinly laminated with very fine-grained sand(stone). Dip approximately 5 deg.		Tpo	6	D	18 42	6"/12"	9	89	33	6
35		SILT(STONE); Olive brown mottled with reddish brown, moist, hard, micaceous, trace slightly plastic fines, fractured, interbedded with fine-grained sand(stone).		Tpo	7	S	11 17 21	16"/18"	7			6
40		SILTY CLAY(STONE); Olive brown mottled with light brown, moist, hard, oxidized, micaceous, trace slightly plastic fines, interbedded with very fine sand(stone), vague bedding. Dip approximately 5 deg.		Tpo	8	D	26 50		6	97	26	6
45		CLAYEY SILT(STONE); Light olive gray mottled with olive brown, moist, hard, oxidized, low plasticity, micaceous, trace nonplastic silt(stone), interbedded with fine-grained sand(stone).		Tpo	9	S	16 30 34	18"/18"	7			7
50		CLAYEY SILT(STONE); Light olive gray mottled with olive brown, moist, hard, oxidized, low plasticity, interbedded with very fine-grained sand(stone). Dip approximately 10 to 20 deg.		Tpo	10	D	34 50/4"	6"/10"	7	99	25	6
55		CLAYEY SILT(STONE); Olive gray, damp, hard, oxidized, medium plasticity, trace mica, interbedded with very fine-grained sand(stone). Dip approximately 10 to 15 deg.		Tpo	11	S	19 36 40	18"/18"	10			6
60		CLAYEY SILT(STONE); Olive gray, moist, hard, oxidized, low plasticity, micaceous, interbedded with very fine-grained sand(stone), locally fractured. Dip approximately 10 deg.		Tpo	12	D	40 50/4"	6"/10"	9	97	26	6
65		CLAYEY SILT(STONE); Gray mottled with brown, moist, hard, oxidized, low plasticity, fractured, lenses of silt(stone). Dip approximately 5 deg.		Tpo	13	S	22 32 39		9			8
70		(Hard drilling at 69 feet.)										

The Earth Technology Corporation

FIGURE A-22. LOG OF BORING PII-45

Project Name: **METRO RAIL - PHASE II - LOS ANGELES**

Project Number: **89-409** Borehole Number: **PII-45** Sheet 3 of 3

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		CLAYEY SILTSTONE; Dark gray, moist, hard, fresh, medium plasticity, micaceous, fractured, cemented. Dip approximately 10 deg.		Tpf	14	D	75 Refusal		12			8
75		Same as above.		Tpf	15	S	36 57 Refusal		9			8
80		CLAYEY SILT(STONE); Dark olive gray, moist, hard, fresh, medium plasticity, micaceous, interbedded with sandstone. Dip approximately 10 deg.		Tpf	16	D	50/3" ~~Refusal~~	2"/3"	10			8
		BORING TERMINATED AT 81 FEET.										
85		NOTE: This borehole log is based on field classification and visual soil description, and is further modified to include results of laboratory classification tests, where available. This summary applies only at the location of this boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with passage of time. The data presented is simplification of actual conditions encountered. The stratification lines represent the approximate boundary between subsurface material types and the transition may be gradual.										
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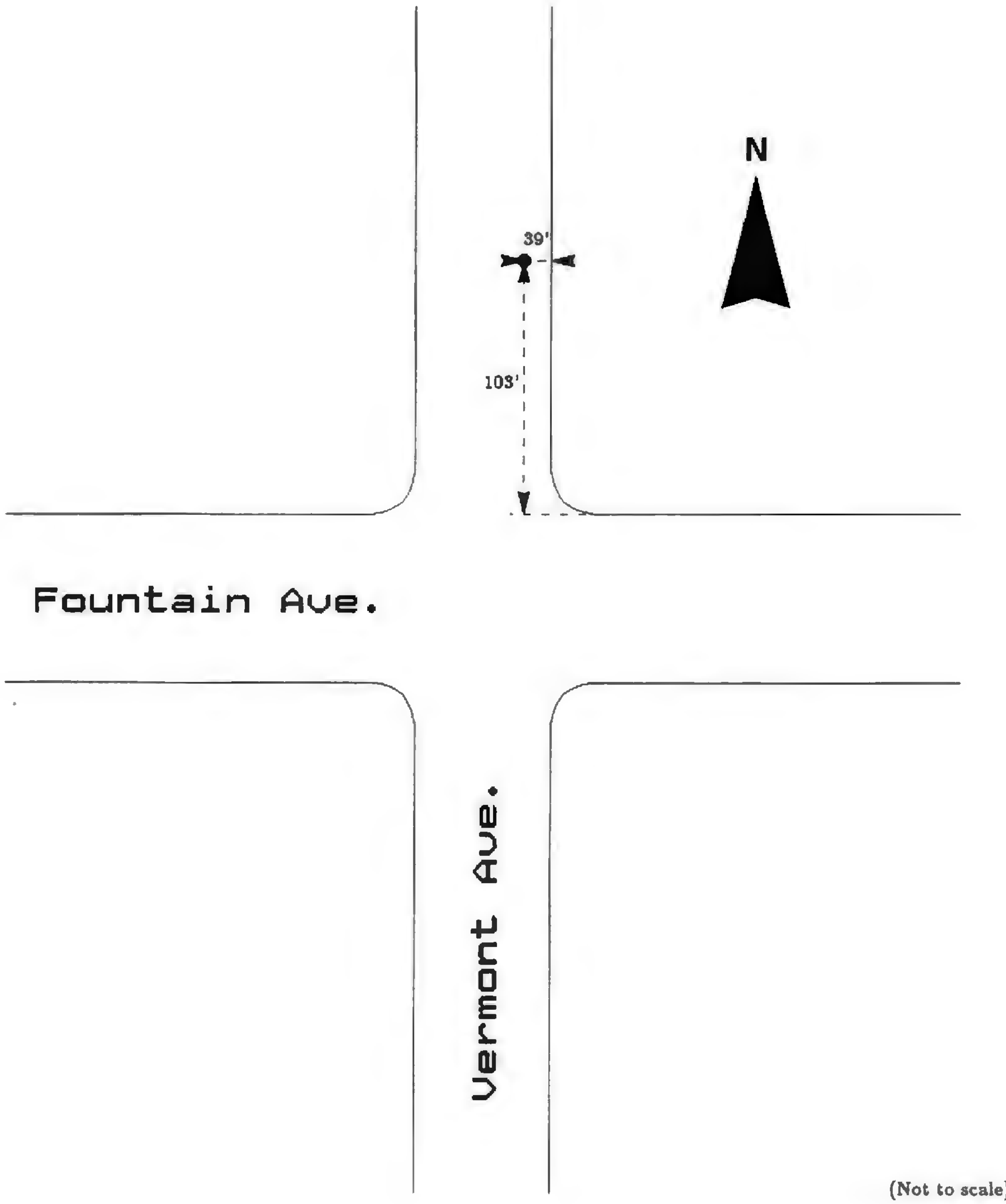

The Earth Technology Corporation	PROJECT NO.: 89-409 Vermont/Santa Monica Station and Tunnel

Location of Borehole PII-45

5-90

FIGURE A-22A

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FIGURE A-23. LOG OF BORING PII-46

Project Name: METRO RAIL - PHASE II - LOS ANGELES			
Project Number: 89-409	Borehole Number: PII-46		sheet 1 of 3
Borehole location: Vermont Ave. and Delongpre Ave.		Elevation and Datum(feet): 379	
Health and Safety: Upgraded Level D		Date Started: 4/21/89	Date Finished: 4/21/89
Drilling Equipment: Failing 750		Total Depth(feet): 81.0	Depth to: Bedrock(feet): 26.0
Drilling Method: Rotary Wash		Borehole Diameter: 5-inch	
Drilling Fluid: Bentonite Mud		Piezometer Installation: YES	Depth(feet): 80
Hammer Information: SPT Hammer: 140-lb and 30-inch drop. DOWNHOLE Hammer: 295-lb and 18-inch drop.		Logged By: Kean Tan	Checked By: C. Marshall Payne

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		10-inch ASPHALT.										
		CLAYEY SAND; Reddish brown, fine sand.		FILL								
5		SANDY CLAY; Brown, damp, hard, medium plasticity fines, fine- to medium-grained sand, micaceous.	CL	A4	1	S	14 23 28	16"/18"	3			3
10		CLAYEY SAND; Brown, damp, very dense, fine- to coarse-grained sand, , medium plasticity fines, micaceous.	SC	A4	2	D	12 21	6"/12"	4	121	14	4
15		Same as above.	SC	A4	3	S	14 17 20	14"/18"	4			4
20		CLAYEY SAND: Brown, damp, very dense, fine- to coarse-grained sand, medium plasticity fines, micaceous.	SC	A4	4	D	15 18	6"/12"	4	118	15	4
25		SILTY CLAY; Brown, damp, very stiff, medium plasticity, micaceous, trace very fine-grained sand.	CL	A4	5	S	10 10 19	16"/18"	4			4
		TOP OF PUENTE FORMATION.										
30												

FIGURE A-23. LOG OF BORING PII-46

The Earth Technology Corporation

Project Name: METRO RAIL - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-46 | Sheet 2 of 3

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		SILTY CLAY(STONE); Brown, damp, very stiff to hard, medium plasticity, micaceous, interbedded with very fine sand(stone), weathered, no bedding.		Tpw	6	D	14 19	8"/12"	4	99	24	4
35		(Drill chatter at 35 feet.) SILTY CLAY(STONE); Light brown, damp, hard, low plasticity, micaceous, interbedded with very fine sand(stone), .		Tpw	7	S	18 26 26	12"/18"	4			4
		(Hard, cemented clay(stone) at 38 feet.)										
40		SILTY CLAY(STONE); Reddish brown, damp, stiff, low plasticity, micaceous, interbedded with very fine-grained sand(stone), almost weathered, clayey silt(stone) at top, cemented nodules.		Tpo	8	D	8 8	8"/12"	4	65	58	4
45		CLAYEY SILT(STONE); Olive gray, damp, hard, medium plasticity, micaceous, thinly interbedded with fine sand(stone). Dip approximately 15 deg.		Tpo	9	S	19 28 46	16"/18"	4			4
50		Same as above, oxidized. Olive gray to olive brown. Dip approximately 5 to 10 deg.		Tpo	10	D	14 26	8"/12"	4	100	25	4
55		Same as above.		Tpo	11	P	PUSH 225 PSI	15"/30"	4	103	23	4
60		CLAYEY SILT(STONE); Olive brown, damp, hard, very low plasticity, micaceous, interbedded with very fine sand(stone), weathered to oxidized. Dip approximately 15 deg. Clayey silt(stone) at top, low to medium plasticity, micaceous, fractured. Dip approximately 15 deg.		Tpo	12	D	23 37	10"/12"	5	97	27	4
65		SILTY CLAY(STONE); Olive brown to olive gray, damp, hard, low to medium plasticity, micaceous, lenses of light gray silt(stone). Dip approximately 15 deg.		Tpo	13	S	21 24 33	16"/18"	5			4
70												

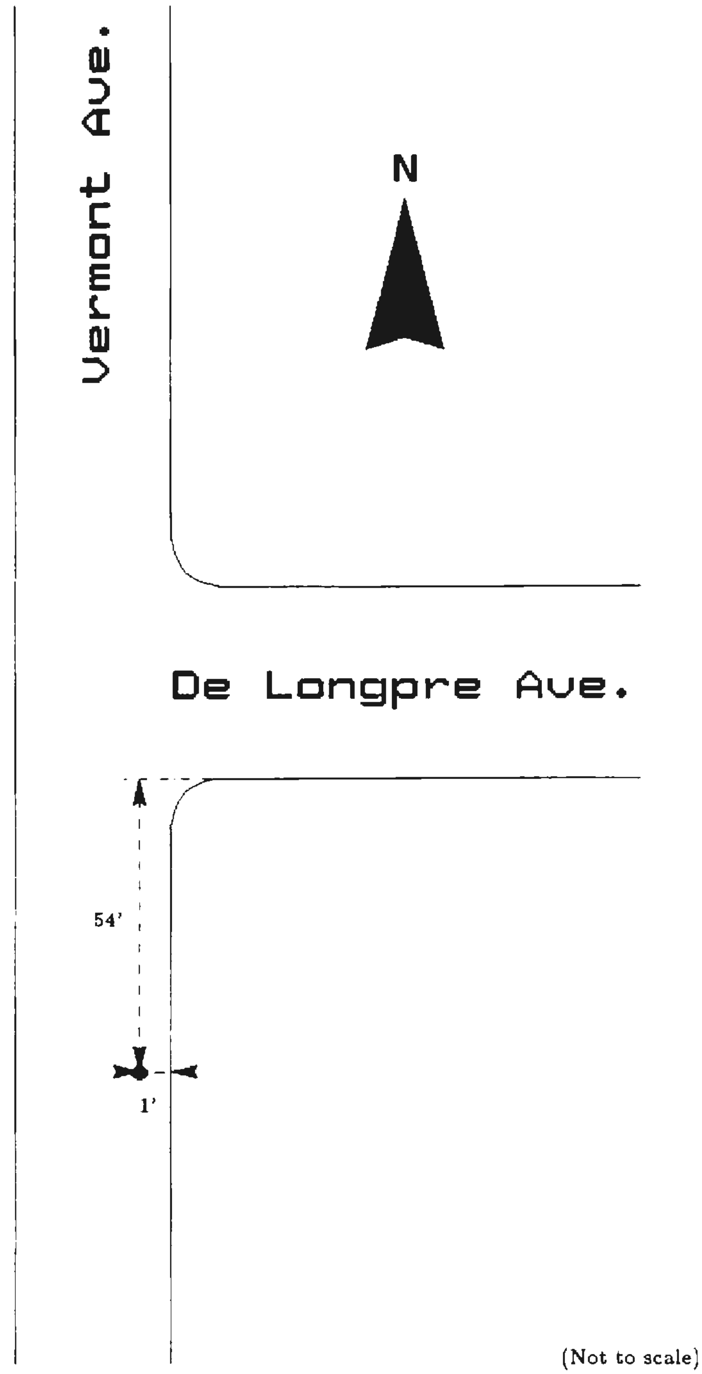
FIGURE A-23. LOG OF BORING PII-46

The Earth Technology Corporation

Project Name: METRO RAIL - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-46 | Sheet 3 of 3

Depth (feet)	Lith-ology	Description	USCS Classi-fication	Geologic Unit	Samples Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		Same as above, clayey at top, siltier at tip, Medium plasticity. Vague bedding (massive), dip 10 to 15 deg.		Tpo	14	D	23 36	9"/12"	5	94	27	5
75		CLAYEY SILTSTONE; Dark gray, damp, hard, medium to high plasticity, micaceous, brittle.		Tpf	15	S	50/5"	5"/5"	6			5
80		SILTY CLAYSTONE at bottom of sample, fresh, siltstone at top. Lenses of light gray, nonplastic sandy siltstone. Dip approximately 10 deg.		Tpf	16	D	28 ~~40~~	10"/12"	7	98	29	7
		BORING TERMINATED AT 81 FEET.										
85		NOTE: This borehole log is based on field classification and visual soil description, and is further modified to include results of laboratory classification tests, where available. This summary applies only at the location of this boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with passage of time. The data presented is simplification of actual conditions encountered. The stratification lines represent the approximate boundary between subsurface material types and the transition may be gradual.										
90												
95												
100												
105												
110												



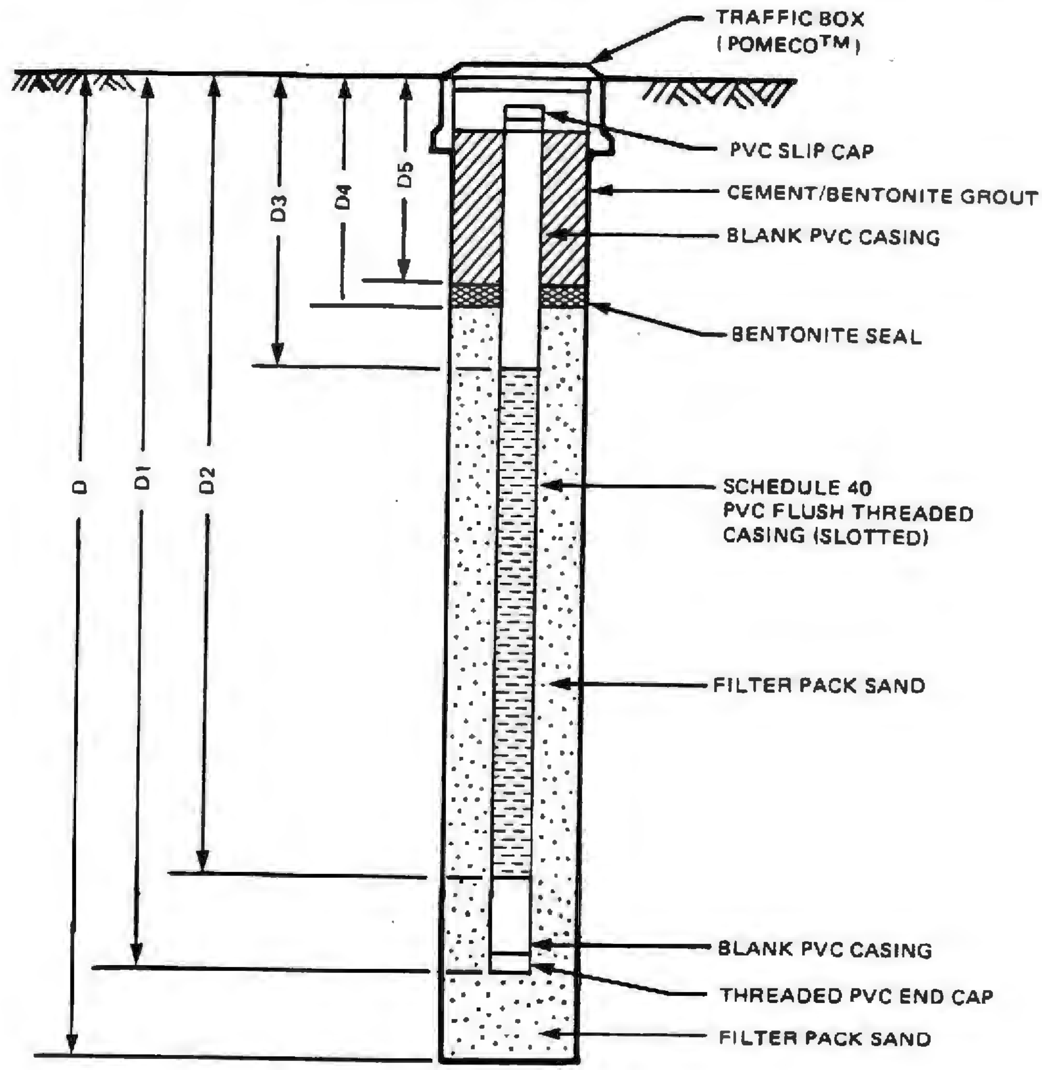
The Earth Technology Corporation

PROJECT NO.: 89-409
Vermont/Santa Monica Station and Tunnel

Location of Borehole PII-46

5-90

FIGURE A-23A



TOTAL DEPTH (D)	=	85.0	FEET
TOTAL DEPTH OF CASING (D1)	=	80.0	FEET
DEPTH TO BOTTOM OF WELL SCREEN (D2)	=	50.0	FEET
DEPTH TO TOP OF WELL SCREEN (D3)	=	20.0	FEET
DEPTH TO BOTTOM OF TOP SEAL (D4)	=	17.0	FEET
DEPTH TO TOP OF TOP SEAL (D5)	=	14.0	FEET
WELL CASING DIAMETER	=	2	INCH
WELL SCREEN SLOT SIZE	=	0.02	INCH
FILTERPACK SAND TYPE	=	NO. 2	MONTEREY
BENTONITE SEAL TYPE	=		1/8" PELLETS

The Earth Technology Corporation

PROJECT NO.: 89-409
Vermont/Santa Monica Station and Tunnel

Diagram of Piezometer PII-46

5-90

FIGURE A-23B

BORINGS FROM EARTH TECHNOLOGY
1988 INVESTIGATION

Note: Oxidized Puente Formation (Tpo) bedrock is categorized as weathered Puente Formation (Tpw) in boring logs LPE-6 and LPE-7

The Earth Technology Corporation

FIGURE A-24. LOG OF BORING LPE-6

Project Name: METRO RAIL MOS-2 ALIGNMENT - LOS ANGELES			
Project Number: 88-429	Borehole Number: LPE-6		Sheet 1 of 2
Borehole Location: Vermont at Normal Av.	Elevation and Datum(feet): 300.0		
Health and Safety: Level D	Date Started: 9/27/88		Date Finished: 9/27/88
Drilling Equipment: Failing 750	Total Depth (feet): 61.0		Depth to Bedrock(feet): 19.0
Drilling Method: Rotary Wash	Borehole Diameter: 5-inch		
Drilling Fluid: Bentonite Mud	Piezometer Installation: No.		Depth(feet): --
Hammer Information: SPT Hammer: 140-lb weight and 30-inch drop. DOWNHOLE Hammer: 350-lb weight and 18-inch drop	Logged By: FJE		Checked By: C. M. Payne

Depth (feet)	Description	USCS Classification	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
	12-inch ASPHALT CONCRETE.										
	CLAYEY SAND/SANDY CLAY . Probably fill material.	SC/CL	FILL	1	S						
5	CLAYEY SAND/SANDY CLAY; Dark grayish brown, moist, stiff, with fine to medium sand.	SC/CL	A4								
10	SILTY SAND; Dark yellowish brown, moist, very dense, fine to medium with olive brown, very stiff clayey silt lense in middle of the sample.	SM	A3	2	S	15 15 18	13"/18"	4.7			4.4
	(Sandier at 12 feet.)										
15	(Disturbed sample.) SILTY SAND; Brown, wet, medium dense, fine to very coarse	SM		3	D	11 12	12"/12"	6.5	106	21.3	4.6
	GRAVEL; well graded, probably old alluvium.	GP	A3								
	SILTY SAND.	SM	A3 A3								
20	TOP OF PUENTE FORMATION. CLAYEY SILTSTONE; Dark yellowish brown mottled with olive brown moist, hard, thinly bedded with dark yellowish brown, moist, very dense very fine to fine Sandstone. Formation is thinly bedded, flat lying and oxidized (moderately weathered).		Tpw	4	S	17 28 50	17"/18"	5.3			5.2
25	Same as above except conglomeratic lense at top of sample.		Tpw	5	D	17 29	9"/12"	3.6	88	32.3	5.4
30											

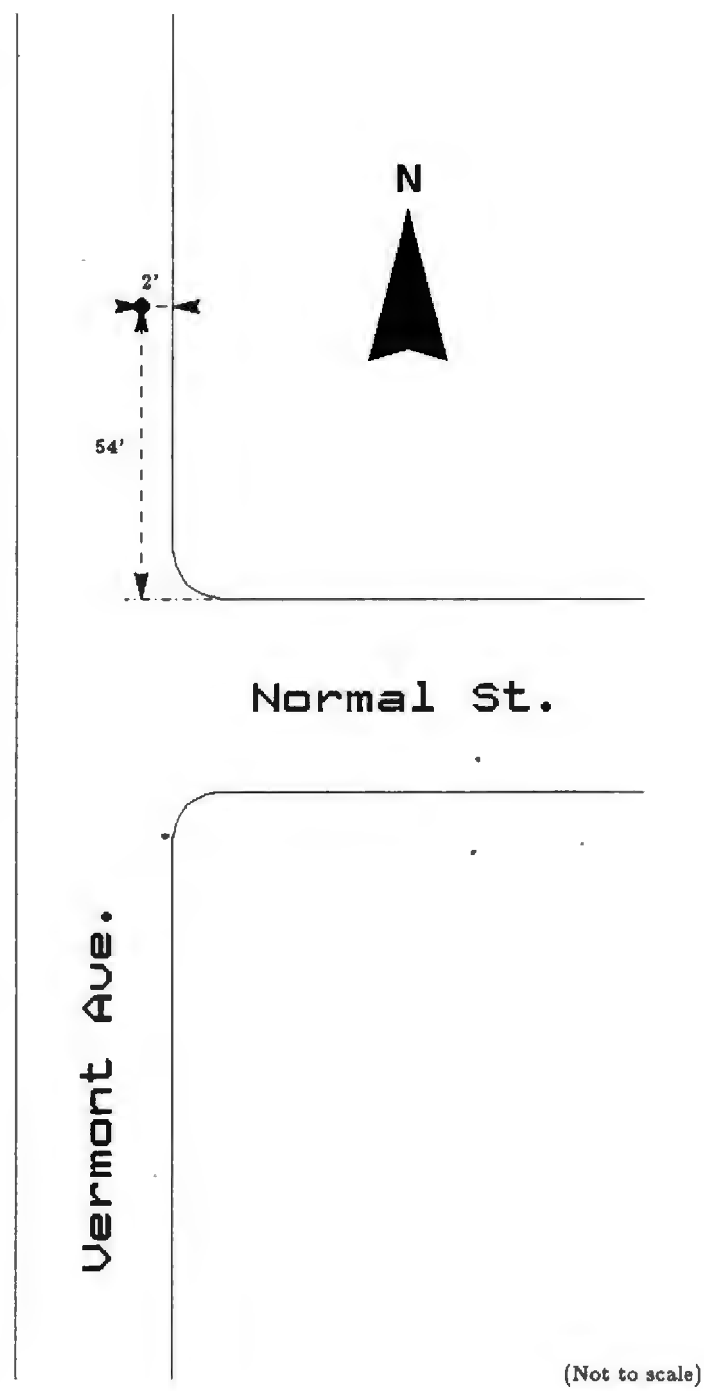
The Earth Technology Corporation

FIGURE A-24. LOG OF BORING LPE-6

Project Name: METRO RAIL MOS-2 ALIGNMENT - LOS ANGELES

Project Number: 88-429 | Borehole Number: LPE-6 | Sheet 2 of 2

Depth (feet)	Description	USCS Classification	Geologic Unit	Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
	Same as above.		Tpw	6	S	32 37 31/3"	18"/18"	5.7			5.6
35	Same as above.			7	D	28 40	11"/12"	6.3			6.1
	(Progressively harder drilling.)										
40	CLAYEY SILTSTONE; Pale brown, dry, hard, laminated, weakly cemented, flat lying, oxidized.		Tpw	8	S	100/3"	3"/3"	5.1			5.5
45	CLAYEY SILTSTONE; Dark olive gray, very stiff, slightly plastic, appears massive, fresh.		Tpf	9	P	Push 400psi	30"/30"	5.2	104	20.4	5.0
50	Same as above. Thinly bedded to laminated. Horizontal bedding planes.		Tpf	10	P	Push 300psi	30"/30"	5.4			5.1
55	Same as above with mica.		Tpf	11	P	Push 420psi	19"/19"	6.5	99	22.7	5.3
	(Easier drilling at 58 feet. Dark gray Shale in cuttings.) CLAYEY SILTSTONE; Gray, hard, thinly bedded, flat lying, fresh with variable hard mica.										
60			Tpf	12	D	55 45/3"	9"/9"	20.0	112	30.3	5.2
65	BORING TERMINATED AT 61 FEET. NOTE: This borehole log is based on field classification and visual soil description, and is further modified to include results of laboratory classification tests, where available. This summary applies only at the location of this boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with passage of time. The data presented is simplification of actual conditions encountered. The stratification lines represent the approximate boundary between subsurface material types and the transition may be gradual.										
70											



The Earth Technology Corporation	PROJECT NO.: 89-409 Vermont/Santa Monica Station and Tunnel

Location of Borehole LPE-6

5-90

FIGURE A-24A

The Earth Technology Corporation

FIGURE A-25. LOG OF BORING LPE-7

Project Name: METRO RAIL MOS-2 ALIGNMENT - LOS ANGELES	
Project Number: 88-429	Borehole Number: LPE-7 — Sheet 1 of 3
Borehole Location: Vermont and Willowbrook	Elevation and Datum(feet): 328.0
Health and Safety: Level D	Date Started: 9/27/88 — Date Finished: 9/28/88
Drilling Equipment: Failing-750	Total Depth (feet): 73.0 — Depth to Bedrock(feet): 11.0
Drilling Method: ROTARY WASH	Borehole Diameter: 5-inch
Drilling Fluid: Bentonite Mud	Piezometer Installation: YES — Depth(feet) 72.5
Hammer Information: SPT Hammer: 140-lb weight and 30-inch drop; DOWN HOLE Hammer: 365-lb weight and 18-inch drop	Logged By: C.M.Payne/C.Duckworth — Checked By: C. Duckworth

Depth (feet)	Description	USCS Classification	Geologic Unit	Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
	14" ASPHALT Concrete.										
	CLAY; Gray, moist.	CL	FILL								
	SILTY SAND; Brown, moist, very fine to very coarse, fill material.	SM	FILL								
5	SILTY SAND; Gray mottled with brown, moist, loose, fine to very fine.	SM	A3	1	D	3 5	12"/12"	5.2	102	19.9	5.2
	(Set casing to 8-1/2 feet. Start rotary wash with drag bit.)										
10				2	S	7 5 6	11"/18"	8.5			6.8
	TOP OF PUENTE FORMATION. CLAYEY SILTSTONE; Gray, moist, stiff, moderately plastic, bedding not apparent, massive oxidized(moderately weathered), poorly cemented.		Tpw								
15	CLAYEY SILTSTONE; Gray mottled with brown, moist, very stiff, very massive, bedding not apparent, oxidized(moderately weathered).		Tpw	3	D	8 11	12"/12"	12.0	110	18.2	8.6
20	CLAYEY SILTSTONE; Pale olive and yellowish brown, moist, hard, moderately plastic, oxidized(moderately weathered), with some fine to coarse sand.		Tpw	4	S	9 14 20	18"/18"	14.0			13.0
25	Same as above. Slightly sandy.		Tpw	5	D	24 35	12"/12"	16.0			13.0
30	(Smooth and fast drilling.)										

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FIGURE A-25. LOG OF BORING LPE-7

Project Name: METRO RAIL MOS-2 ALIGNMENT - LOS ANGELES

Project Number: 88-429 | **Borehole Number:** LPE-7 | Sheet 2 of 3

Depth (feet)	Lith-ology	Description	USCS Classification	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background ppm
		CLAYEY SILT(STONE); Pale yellow, moist, hard, moderately weathered, fine to coarse sand, moderately plastic fines. Bedding is gradational, generally horizontal, indistinct.		Tpw	6	S	11 17 24	18"/18"	20.0			13.0
35		SANDY SILT(STONE); Grayish brown, moist, hard, mottled brown and gray, hard and near vertical bedding in tip, very fine sand to silty clayey sand in top 3 rings, oxidized and weathered, poorly cemented. (Sandier at 38-1/2 feet.) (Clayey at 39-1/2 feet.)		Tpw	7	D	20 37	9"/12"	18.0			13.0
40		SANDY SILT(STONE); Pale olive and yellowish brown, moist, hard, low to medium plasticity, thin seams of very fine silty sand, more soil-like than previous sample.		Tpw	8	S	17 25 33	18"/18"	20.0			13.0
45		SANDY SILT(STONE); Mottled gray and brown, moist, hard, with pockets of brown silty sand, horizontal bedding at top of sample.		Tpw	9	D	32 58	12"/12"	12.0	95	28.5	12.
50		SANDY SILT(STONE); Mottled gray and brown, moist, hard, with seams of silty sand(stone). Dip approximately 10 deg.		Tpw	10	S	28 50/5" ?	18"/18"	7.2			7.0
55		CLAYEY SILT(STONE); Mottled gray and brown, moist, hard, well bedded, moderately weathered. Dip 10 deg.		Tpw	11	D	42 65	12"/12"	7.3	92	31.1	7.0
60		CLAYEY SILT(STONE); Olive gray, moist, hard, massive, indistinctly bedded, micaceous, slightly plastic, fresh with minor brown layers and very fine sand poorly cemented. (Driller reports loosing a lot of fluid from 25 feet level.)		Tpw	12	S	34 50/5.5"	10"/12"	7.4			7.0
65		CLAYEY SILTSTONE; Dark olive, hard, micaceous, slightly plastic, becoming harder, slightly cemented, massive, indistinctly bedded, fresh. (Switched to rock bit at 67 feet.)		Tpf	13	D	68 32/2"	8"/8"	8.2	108	20.1	7.0
70												

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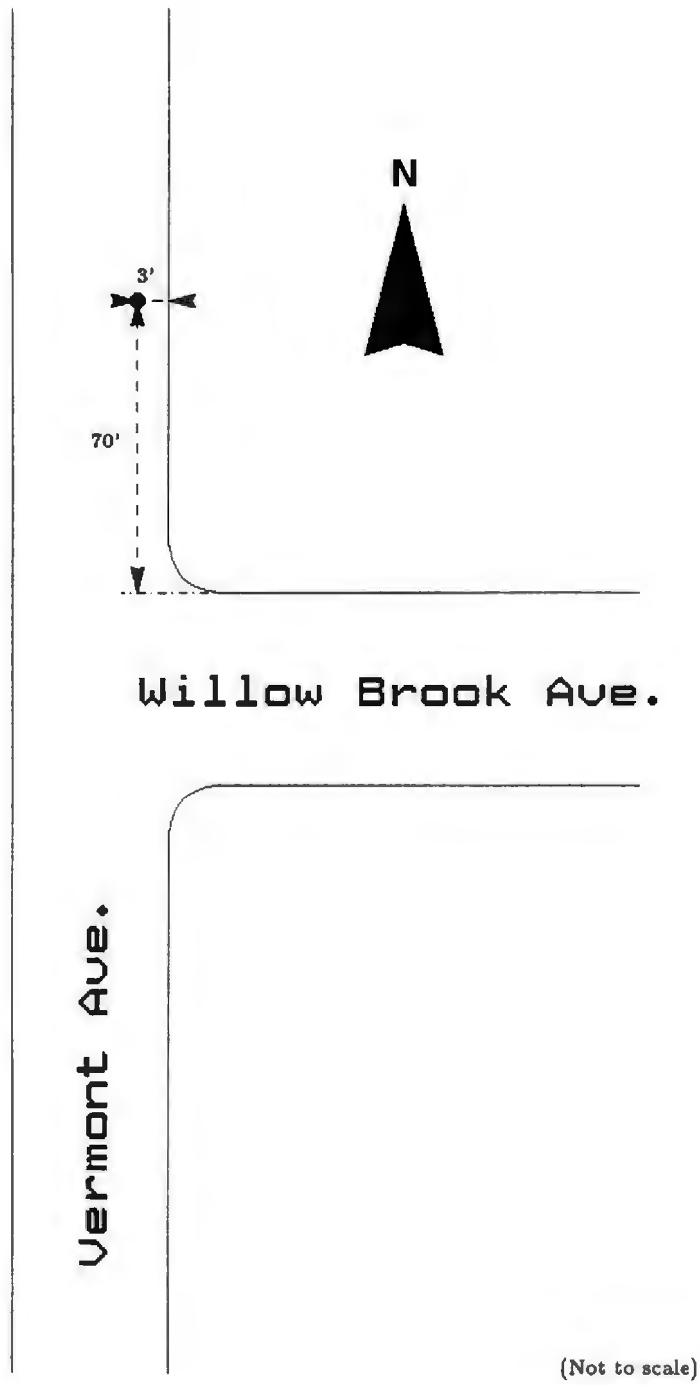
FIGURE A-25. LOG OF BORING LPE-7

Project Name: METRO RAIL MOS-2 ALIGNMENT - LOS ANGELES

Project Number: 88-429 | Borehole Number: LPE-7 | Sheet 3 of 3

Depth (feet)	Lith-ology	Description	USCS Classification	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		CLAYEY SILTSTONE; Dark to medium gray, moist, very stiff, thinly laminated, micaceous, fresh, no fracture, no joints. Dip 5 to 10 deg.		Tpf	14	P	Push 350psi	32"/32"	8.2	106	21.0	7.5
75		BORING TERMINATED AT 72-1/2 FEET. INSTALLED A PIEZOMETER. NOTE: This borehole log is based on field classification and visual soil description, and is further modified to include results of laboratory classification tests, where available. This summary applies only at the location of this boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with passage of time. The data presented is simplification of actual conditions encountered. The stratification lines represent the approximate boundary between subsurface material types and the transition may be gradual.										
80												
85												
90												
95												
100												
105												
110												

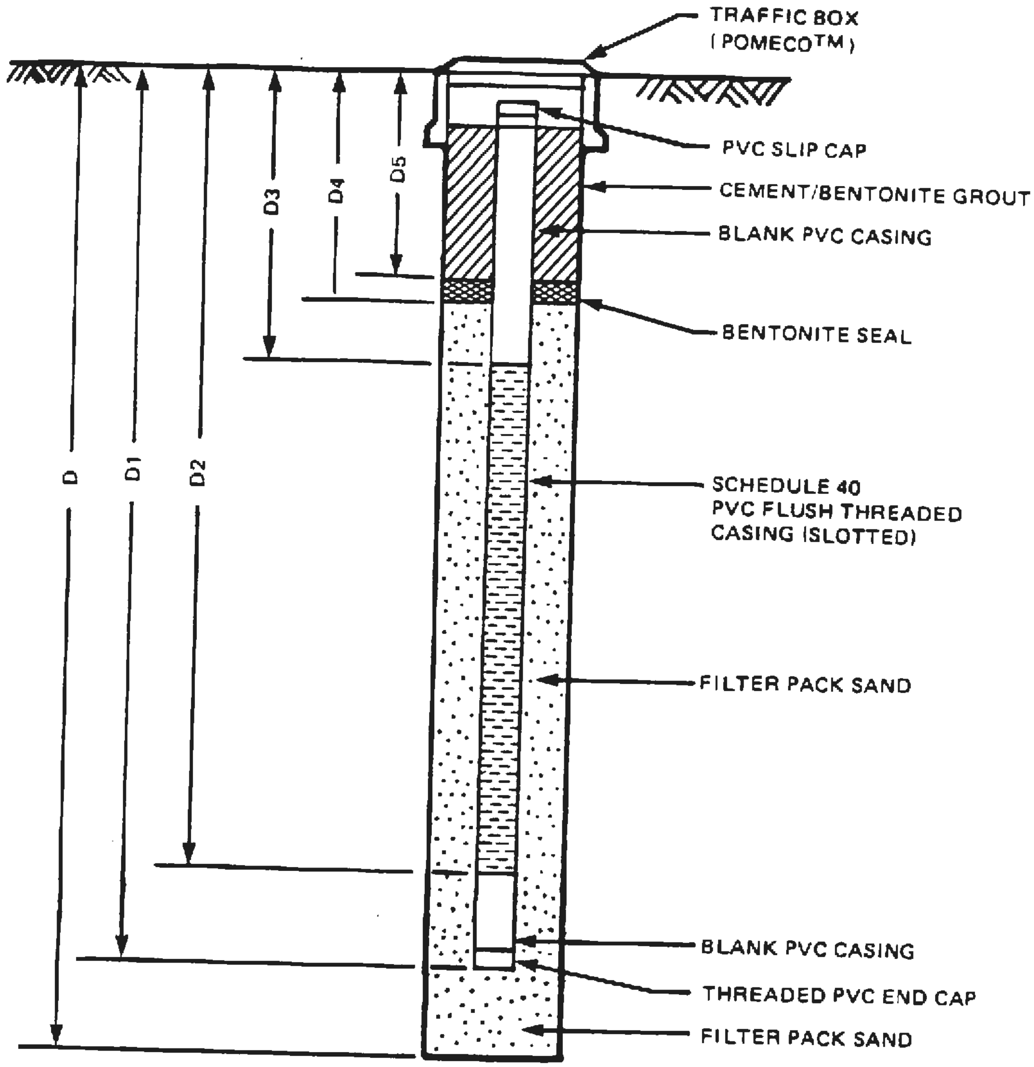


The Earth Technology Corporation	PROJECT NO.: 89-409 Vermont/Santa Monica Station and Tunnel

Location of Borehole LPE-7

5-90

FIGURE A-25A



TOTAL DEPTH (D)	=	72.5	FEET
TOTAL DEPTH OF CASING (D1)	=	70.7	FEET
DEPTH TO BOTTOM OF WELL SCREEN (D2)	=	70.7	FEET
DEPTH TO TOP OF WELL SCREEN (D3)	=	15.7	FEET
DEPTH TO BOTTOM OF TOP SEAL (D4)	=	10.9	FEET
DEPTH TO TOP OF TOP SEAL (D5)	=	12.8	FEET
WELL CASING DIAMETER	=	2	INCH
WELL SCREEN SLOT SIZE	=	0.02	INCH
FILTERPACK SAND TYPE	=	NO. 2	MONTEREY
BENTONITE SEAL TYPE	=		1/8" PELLETS

The Earth Technology Corporation

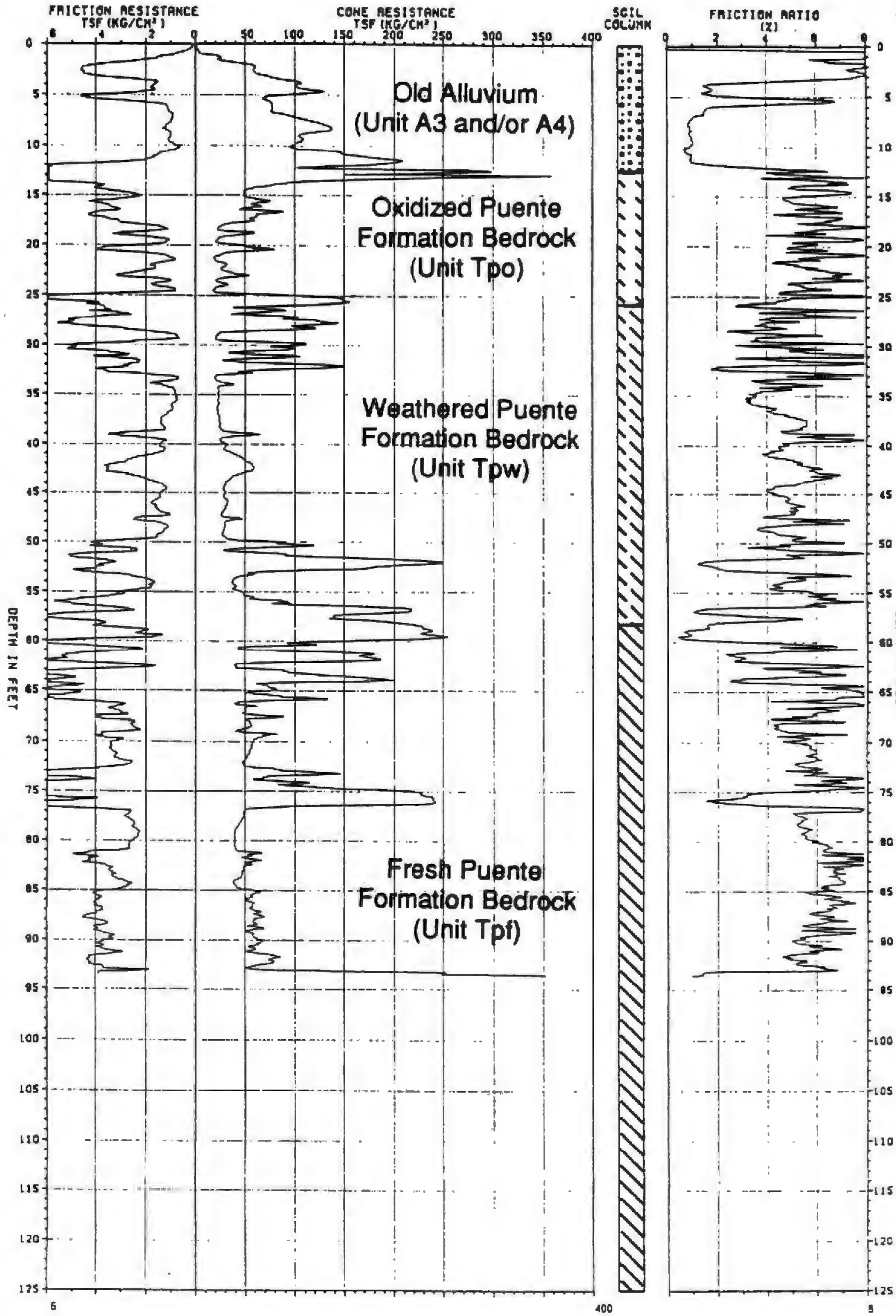
PROJECT NO.: 89-409
Vermont/Santa Monica Station and Tunnel

Diagram of Piezometer LPE-7

5-90

FIGURE A-25B

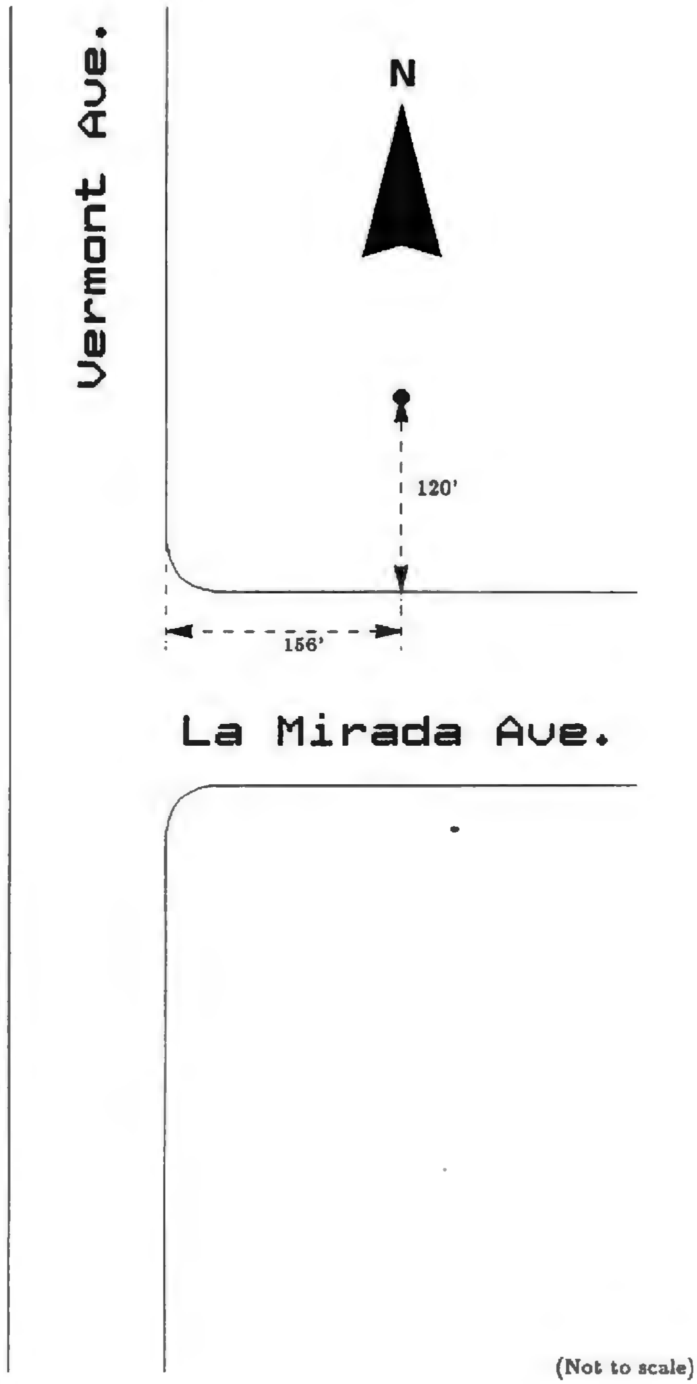
CPT SOUNDINGS FROM EARTH TECHNOLOGY
1989 INVESTIGATION



Project: TETC/Metro Rail LPA
Project No.: 89-230-0101
Instrument Number: F15CKE0BB
Date: 06/20/89

The Earth Technology Corporation

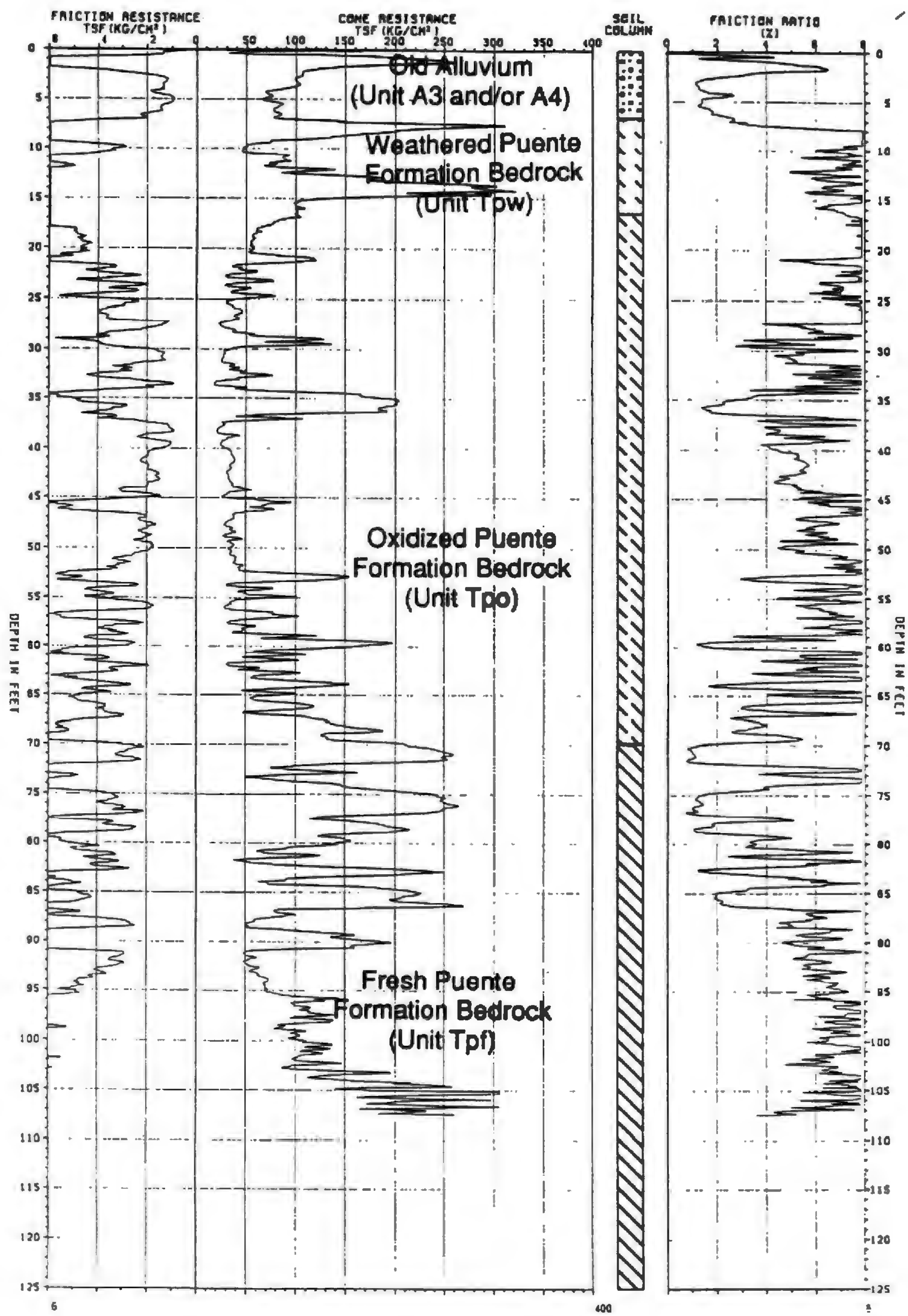
Figure A-26.
Log of Boring CPT-1
Probe: CPT-1



The Earth Technology Corporation	PROJECT NO.: 89-409 Metro Rail Phase II

Location of
Borehole CPT-1

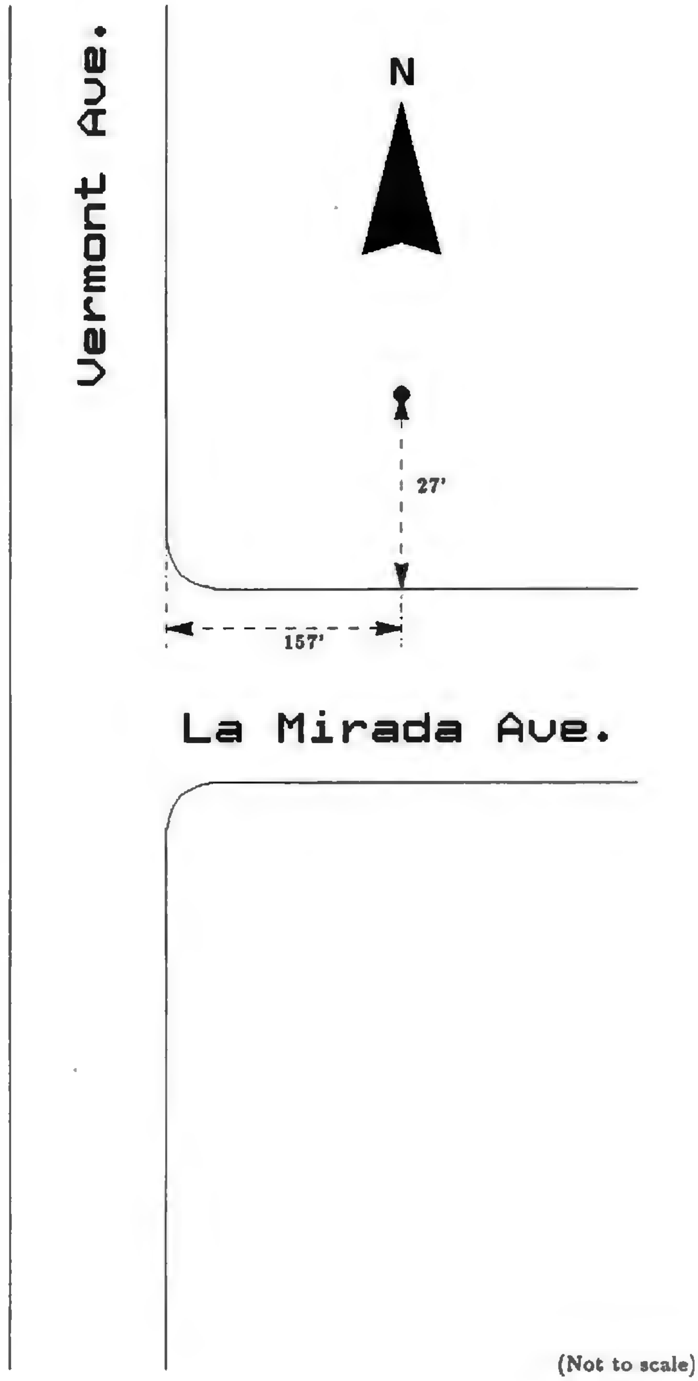
11/89 FIGURE A-26A



Project: TETC/Metro Rail LPA
Project No.: 89-230-0101
Instrument Number: F15CKE0BB
Date: 06/20/89

The Earth Technology Corporation

Figure A-27.
Log of Boring CPT-2
Probe: CPT-2



The Earth Technology Corporation	PROJECT NO.: 89-409 Metro Rail Phase II

Location of Borehole CPT-2

11/89

FIGURE A-27A

Appendix B

Results of Soil Mechanics Laboratory Test Program

APPENDIX B

RESULTS OF SOIL MECHANICS LABORATORY TEST PROGRAM

This appendix presents the results of soil mechanics laboratory tests performed on selected representative soil samples. A description of the soil mechanics laboratory test program and test procedures has been provided in Section 3.2. In this appendix, test results are presented in tables and figures as follows:

Table or Figure	Test Results
Table B-1	Dry Density, Moisture Content and Calculated Void Ratio
Table B-2	Grain Size Analysis
Table B-3	Atterberg Limits
Table B-4	Specific Gravity
Table B-5	Unconfined Compression Tests
Table B-6	Direct Shear Tests
Table B-7	Triaxial Tests
Table B-8	Permeability Determination
Table B-9	Engineering Properties of All Geologic Units - Summary of Laboratory Test Results
Table B-10	Engineering Properties of All Geologic Units - Summary of SPT Correlations
Figures B-1 through B-34	Grain Size Distribution Curves
Figures B-35 through B-55	Unconfined Compression Test Results
Figures B-56 through B-73	Direct Shear Test Results
Figures B-74 through B-76	Triaxial Test Results
Figures B-77 through B-79	Consolidation Test Results

TABLE B-1. SUMMARY OF DRY DENSITY, MOISTURE CONTENT AND CALCULATED VOID RATIO
Page 1 of 3

Boring No.	Sample[(a)] No.	Depth (Feet)	USCS Classi-fication	General Soil Classification	Geologic Unit	Dry Density (PCF)	Moisture Content (%)	Calculated Void Ratio
PII-25	D-2	10-11	-	Sandy Silt(stone)	Tpo	91.4	32.0	0.68
PII-25	D-4	20-21	-	Clayey Silt(stone)	Tpo	94.4	28.0	0.79
PII-25	D-6	30-31	-	Clayey Siltstone	Tpf	98.6	25.0	0.71
PII-25	D-10	50-51	-	Silty Claystone	Tpf	101.5	22.0	0.66
PII-25	P-13	65-67.5	-	Silty Claystone	Tpf	107.9	18.0	0.56
PII-25	D-14	70-71	-	Silty Claystone	Tpf	102.3	21.0	0.58
PII-27	D-2	10-11	-	Clayey Silt(stone)	Tpo	93.2	29.0	0.81
PII-27	D-4	20-21	-	Clayey Silt(stone)	Tpw	88.5	34.0	0.69
PII-27	D-6	30-31	-	Silty Claystone	Tpf	99.9	24.0	0.69
PII-27	P-9	45-47.5	-	Clayey Siltstone	Tpf	100.2	23.0	0.68
PII-27	D-10	50-51	-	Silty Claystone	Tpf	96.9	25.0	0.74
PII-27	D-12	60-61	-	Clayey Siltstone	Tpf	103.7	17.0	0.63
PII-27	P-13	65-67.5	-	Clayey Siltstone	Tpf	104.9	20.0	0.61
PII-27	D-16	80-81	-	Clayey Siltstone	Tpf	96.9	27.0	0.74
PII-27	D-18	90-91	-	Siltstone	Tpf	95.6	22.0	0.76
PII-28	D-3	15-16	-	Silty Clay(stone)	Tpo	85.6	40.0	0.97
PII-28	D-5	25-26	-	Silt(stone)	Tpo	97.4	25.0	0.73
PII-28	P-8	40-42.5	-	Clayey Siltstone	Tpf	101.5	22.0	0.66
PII-28	D-11	55-56	-	Clayey Siltstone	Tpf	101.5	23.0	0.66
PII-29	D-4	20-21	-	Clayey Silt(stone)	Tpo	91.0	32.1	0.85
PII-29	P-7	35-37.5	-	Silty Clay(stone)	Tpo	96.6	25.6	0.75
PII-29	D-12	60-61	-	Silty Claystone/ Clayey Siltstone	Tpf	104.2	17.7	0.62
PII-30	D-3	15-16	-	Clayey Silt(stone)	Tpo	87.3	35.0	0.93
PII-30	D-5	25-26	-	Clayey Silt(stone)	Tpo	90.0	32.0	0.87
PII-30	P-6	30-32.5	-	Silty Clay(stone)	Tpo	96.9	26.0	0.74
PII-30	D-7	35-36	-	Silty Clay(stone)	Tpo	90.0	31.0	0.88
PII-30	D-9	45-46	-	Silty Claystone	Tpf	98.7	32.0	0.71
PII-30	D-11	55-56	-	Silty Claystone	Tpf	99.7	26.0	0.69
PII-31	D-3	15-16	-	Silty Clay(stone)	Tpo	92.8	31.0	0.82
PII-31	D-5	25-26	-	Clayey Silt(stone)	Tpo	92.3	25.0	0.83
PII-31	D-7	35-36	-	Clayey Silt(stone)	Tpo	95.2	27.0	0.77
PII-31	P-10	50-52.5	-	Clayey Siltstone	Tpf	107.2	19.0	0.57
PII-32	D-2	10-11	-	Clayey Silt(stone)	Tpo	97.6	27.0	0.74
PII-32	D-4	20-21	-	Clayey Silt(stone)	Tpo	91.8	34.0	0.84
PII-32	D-6	30-31	-	Clayey Silt(stone)	Tpo	97.8	25.0	0.72
PII-32	D-8	40-41	-	Silty Claystone	Tpf	98.3	24.0	0.71
PII-32	D-10	50-51	-	Silty Claystone/ Clayey Siltstone	Tpf	101.2	22.0	0.67
PII-32	P-11	55-57.5	-	Clayey Siltstone	Tpf	104.4	20.0	0.62
PII-32	D-12	60-61	-	Clayey Siltstone	Tpf	79.9	42.0	1.11
PII-33	D-3	15-16	-	Clayey Silt(stone)	Tpo	93.1	30.0	0.81

Notes: (a) D - Drive Samples
P - Thin Wall Tube (Pitcher) Samples

TABLE B-1. SUMMARY OF DRY DENSITY, MOISTURE CONTENT AND CALCULATED VOID RATIO
Page 2 of 3

Boring No.	Sample[(a)] No.	Depth (Feet)	USCS Classification	General Soil Classification	Geologic Unit	Dry Density (PCF)	Moisture Content (%)	Calculated Void Ratio
PII-33	D-5	25-26	-	Silty Clay(stone)	Tpo	85.0	43.0	0.98
PII-33	P-6	30-32.5	-	Clayey Silt(stone)	Tpo	96.5	25.0	0.75
PII-33	D-7	35-36	-	Clayey Silt(stone)/ Silty Clay(stone)	Tpo	93.3	27.0	0.81
PII-33	D-9	45-46	-	Silty Claystone	Tpf	96.4	26.0	0.71
PII-33	D-11	55-56	-	Silty Claystone	Tpf	96.8	25.0	0.74
PII-34	D-2	10-11	-	Silty Clay(stone)	Tpw	93.2	30.0	0.81
PII-34	D-4	20-21	-	Clayey Silt(stone)	Tpo	96.5	25.0	0.75
PII-34	P-7	35-37.5	-	Silty Clay(stone)	Tpo	101.6	22.0	0.66
PII-34	D-10	50-51	-	Clayey Siltstone/ Silty Claystone	Tpf	99.7	24.0	0.70
PII-34	P-12	60-62.5	-	Siltstone	Tpf	137.9	3.8	0.22
PII-34	P-13	65-67.5	-	Clayey Siltstone	Tpf	114.9	15.0	0.47
PII-34	D-14	70-71	-	Clayey Siltstone	Tpf	92.5	31.0	0.82
PII-34	D-16	80-81	-	Clayey Siltstone	Tpf	91.0	32.0	0.85
PII-35	D-1	5-6	-	Silty Clay(stone)	Tpw	98.6	22.0	0.71
PII-35	D-3	15-16	-	Silty Clay(stone)	Tpw	84.5	39.0	1.00
PII-35	D-5	25-26	-	Silty Clay(stone)	Tpo	87.8	33.0	0.92
PII-35	D-7	35-36	-	Silty Clay(stone)	Tpo	85.3	34.0	0.98
PII-35	D-9	45-46	-	Clayey Silt(stone)	Tpo	89.9	29.0	0.87
PII-35	P-10	50-52.5	-	Silt(stone)	Tpo	89.6	31.0	0.88
PII-35	D-11	55-56	-	Clayey Silt(stone)/ Silty Clay(stone)	Tpo	84.7	36.0	0.99
PII-35	D-13	65-66	-	Clayey Siltstone/ Silty Claystone	Tpf	96.6	23.0	0.75
PII-35	D-15	75-76	-	Clayey Siltstone/ Silty Claystone	Tpf	97.2	24.0	0.74
PII-36	D-8	40-41	-	Clayey Silt(stone)	Tpo	92.8	31.0	0.82
PII-36A	D-4	60-61	-	Clayey Siltstone	Tpf	92.0	29.0	0.83
PII-36A	D-6	70-71	-	Clayey Siltstone	Tpo	103.3	21.0	0.63
PII-38	D-1	5-6	CL	Sandy Clay	A4	109.1	16.0	0.54
PII-38	D-3	15-16	-	Clayey Sand(stone)	Tpw	111.7	16.0	0.51
PII-38	D-5	25-26	-	Clayey Sand(stone)	Tpo	113.8	18.0	0.48
PII-38	D-7	35-36	-	Sandy Clay(stone)	Tpo	112.6	17.0	0.50
PII-38	D-9	45-46	-	Clayey Silt(stone)	Tpo	89.0	28.0	0.89
PII-38	P-10	50-52.5	-	Clayey Silt(stone)	Tpo	90.8	30.0	0.86
PII-38	D-11	55-56	-	Clayey Silt(stone)/ Silty Clay(stone)	Tpo	91.7	30.0	0.46
PII-38	D-13	65-66	-	Silty Clay(stone)	Tpo	96.8	26.0	0.74
PII-39	D-1	5-6	SM	Silty Sand	A3	113.4	13.0	0.49
PII-39	D-5	25-26	SC	Clayey Sand	A4	107.7	20.0	0.57
PII-39	D-7	35-36	SM	Silty Sand	A3	101.9	25.0	0.74
PII-39	P-10	50-52.5	-	Silty Clay(stone)	Tpw	102.9	23.0	0.64
PII-39	D-13	65-66	-	Silty Clay(stone)	Tpo	112.0	18.0	0.51
PII-39	D-15	75-76	-	Clayey Silt(stone)	Tpo	78.0	39.0	0.73

Notes: (a) D - Drive Samples
P - Thin Wall Tube (Pitcher) Samples

TABLE B-1. SUMMARY OF DRY DENSITY, MOISTURE CONTENT AND CALCULATED VOID RATIO
Page 3 of 3

Boring No.	Sample[(a)] No.	Depth (Feet)	USCS Classification	General Soil Classification	Geologic Unit	Dry Density (PCF)	Moisture Content (%)	Calculated Void Ratio
PII-39	D-17	86-87	-	Clayey Silt(stone)	Tpf	90.7	31.0	0.86
PII-40	D-10	50-51	-	Silty Clay(stone)	Tpo	95.6	28.0	0.57
PII-40	P-11	55-57.5	-	Clayey Silt(stone)	Tpo	103.5	22.0	0.63
PII-40	D-16	80-81	-	Clayey Siltstone	Tpf	91.0	29.0	0.86
PII-41	D-4	10-11	SM	Silty Sand	A3	112.6	11.0	0.50
PII-41	D-6	20-21	SM	Silty Sand	A3	109.5	17.0	0.54
PII-41	D-8	30-31	-	Silty Clay(stone)	Tpo	101.9	23.0	0.66
PII-41	D-10	40-41	-	Clayey Silt(stone)	Tpo	95.2	26.0	0.77
PII-41	D-14	60-61	-	Silty Clay(stone)/ Clayey Silt(stone)	Tpo	96.0	25.0	0.75
PII-41	D-16	70-71	-	Clayey Siltstone	Tpf	74.8	47.0	1.26
PII-42	D-3	15-16	SM	Silty Sand	A3	109.3	14.0	0.54
PII-42	D-5	25-26	SM	Silty Sand	A3	104.4	21.0	0.62
PII-42	D-7	35-36	-	Clayey Silt(stone)	Tpo	91.5	27.0	0.84
PII-42	D-9	45-46	-	Silty Clay(stone)	Tpo	89.0	26.0	0.90
PII-42	D-11	55-56	-	Clayey Silt(stone)	Tpo	79.8	42.0	1.11
PII-42	D-13	65-66	-	Clayey Silt(stone)	Tpo	98.7	24.0	0.71
PII-42	P-14	70-72.5	-	Clayey Silt(stone)	Tpf	127.9	11.0	0.32
PII-43	D-3	15-16	-	Silty Clay(stone)/ Clayey Silt(stone)	Tpw	91.5	28.0	0.84
PII-43	D-5	25-26	-	Silty Clay(stone/ Clayey Silt(stone)	Tpo	92.5	33.0	0.82
PII-43	D-7	35-36	-	Clayey Silt(stone)	Tpo	95.2	27.0	0.77
PII-43	P-8	40-42.5	-	Clayey Silt(stone)	Tpo	90.4	30.0	0.86
PII-43	D-9	45-46	-	Clayey Silt(stone)	Tpo	91.6	28.0	0.84
PII-43	D-11	55-56	-	Clayey Silt(stone)	Tpo	91.8	29.0	0.84
PII-43	D-13	65-66	-	Silty Clay(stone)	Tpo	99.0	24.0	0.70
PII-44	D-2	10-11	SC	Clayey Sand	A3	111.8	19.0	0.51
PII-44	D-4	20-21	SC	Clayey Sand	A4	115.2	17.0	0.46
PII-44	D-6	30-31	SC	Clayey Sand	A4	110.9	19.0	0.52
PII-44	D-8	40-41	CL/SC	Sandy Clay/ Clayey Sand	A4	103.0	24.0	0.62
PII-44	D-10	50-51	SM	Silty Sand	A3	102.1	25.0	0.66
PII-44	D-14	70-71	ML	Clayey Silt	A4	104.4	23.0	0.61
PII-44	D-16	80-81	-	Silt(stone)	Tpo	81.3	45.0	1.07
PII-45	D-2	10-11	SC	Clayey Sand	A4	115.1	14.0	0.47
PII-45	D-4	20-21	SC	Clayey Sand	A4	106.7	18.0	0.58
PII-45	D-6	30-31	-	Clayey Silt(stone)	Tpo	89.2	33.0	0.89
PII-45	D-8	40-41	-	Silty Clay(stone)	Tpo	97.1	26.0	0.74
PII-45	D-10	50-51	-	Clayey Silt(stone)	Tpo	99.4	25.0	0.70
PII-45	D-12	60-61	-	Clayey Silt(stone)	Tpo	96.5	26.0	0.75

Notes: (a) D - Drive Samples
P - Thin Wall Tube (Pitcher) Samples

TABLE B-2. SIEVE ANALYSIS RESULTS

Boring No.	Sample No.[a]	Depth (Feet)	USCS Classification	General Soil Classification	Geologic Unit	Percent[b] GR	SA	Fines
PII-25	D-4	20-21	-	Clayey Silt(stone)	Tpo	0	29	71
PII-27	D-4	20-21	-	Silt(stone)	Tpo	0	17	84
PII-28	S-4	20-21.5	-	Silty Clay(stone)	Tpw	1	26	73
PII-28	P-8	40-42.5	-	Clayey Siltstone	Tpf	0	28	72
PII-30	S-2	10-11.5	-	Clayey Silt(stone)	Tpo	0	14	86
PII-31	D-3	15-16	-	Silty Clay(stone)	Tpo	0	8	93
PII-31	D-11	55-56	-	Clayey Siltstone	Tpf	0	12	88
PII-32	D-8	40-41	-	Silty Claystone	Tpf	0	12	88
PII-33	D-5	25-26	-	Silty Clay(stone)	Tpo	0	6	94
PII-35	S-2	10-11.5	-	Silty Sand(stone)	Tpw	0	85	15
PII-35	D-5	25-26	-	Silty Clay(stone)	Tpo	0	4	96
PII-35	P-10	50-52.5	-	Silt(stone)	Tpo	0	8	92
PII-36	D-2	10-11	SM	Silty Sand	A3	0	87	13
PII-36	S-5	25-26	-	Silty Clay(stone)	Tpw	0	14	86
PII-36A	D-2	50-51	-	Silty Clay(stone)	Tpo	24	20	56
PII-36A	S-7	75-76.5	-	Clayey Silt(stone)/ Silty Claystone	Tpf	0	27	74
PII-38	D-5	25-26	-	Clayey Sand(stone)	Tpo	0	54	46
PII-38	P-10	50-52.5	-	Clayey Silt(stone)	Tpo	0	13	88
PII-38	D-11	55-56	-	Clayey Silt(stone)/ Silty Clay(stone)	Tpo	0	18	82
PII-38	D-13	65-66	-	Silty Clay(stone)	Tpo	0	10	90
PII-39	D-1	5-6	SM	Silty Sand	A3	0	67	33
PII-39	S-4	20-21.5	SC	Clayey Sand	A4	0	64	36
PII-39	D-5	25-26	SC/CL	Clayey Sand/ Sandy Clay	A4	0	50	50
PII-39	D-7	35-36	SM	Silty Sand	A3	0	66	34
PII-41	D-4	10-11	SM	Silty Sand	A3	0	76	24
PII-42	D-3	15-16	SP-SM	Sand-Silty Sand	A3	3	86	11
PII-43	D-1	5-6	-	Clay(stone)	Tpw	0	7	93
PII-43	D-11	55-56	-	Clayey Silt(stone)	Tpo	0	7	93
PII-44	D-2	10-11	SC	Clayey Sand	A3	1	69	30
PII-44	D-8	40-41	CL/SC	Sandy Clay/ Clayey Sand	A4	0	42	58
PII-44	D-10	50-51	SM	Silty Sand	A3	0	74	26
PII-44	S-11	55-56.5	SM	Silty Sand	A3	2	67	32
PII-44	D-12	60-61	SP-SM	Sand-Silty Sand	A3	2	91	6
PII-45	D-4	20-21	SC	Clayey Sand	A4	0	75	25

Notes: (a) D - Drive Samples
S - SPT Samples
P - Thin wall tube (pitcher) samples
(b) GR - Gravel
SA - Sand
Fines - Passing 200 sieve

TABLE B-3. ATTERBERG LIMIT TEST RESULTS

Boring No.	Sample No.[(a)]	Depth (Feet)	USCS Class.	General Soil Description	Geologic Unit	Liquid Limit	Plastic Limit	Plasticity Index
PII-25	D-10	50-51	-	Silty Claystone	Tpf	42	20	22
PII-25	P-13	65-67.5	-	Silty Claystone	Tpf	43	18	25
PII-26	S-4	15-16.5	-	Silty Clay(stone)	Tpo	55	27	28
PII-26	S-8	35-36.5	-	Silty Claystone	Tpf	53	20	33
PII-26	D-19	90-91	-	Silty Claystone	Tpf	56	23	33
PII-27	S-3	15-16.5	-	Silty Clay(stone)/ Clayey Silt(stone)	Tpo	47	24	23
PII-28	S-2	10-11.5	-	Silty Clay(stone)	Tpw	57	23	34
PII-29	P-7	35-37.5	-	Silty Clay(stone)	Tpo	57	22	35
PII-30	D-7	35-36	-	Silty Clay(stone)	Tpo	54	20	34
PII-31	P-10	50-52.5	-	Silty Claystone	Tpf	53	20	33
PII-32	D-8	40-41	-	Silty Claystone	Tpf	49	18	31
PII-33	S-2	10-11.5	CH	Silty Clay	A4	65	21	44
PII-33	D-5	25-26	-	Silty Clay(stone)	Tpo	53	21	32
PII-33	D-9	45-46	-	Silty Claystone	Tpf	44	20	24
PII-34	D-2	10-11	-	Silty Clay(stone)	Tpw	57	24	33
PII-34	P-7	35-37.5	-	Silty Clay(stone)	Tpo	54	20	34
PII-35	D-1	5-6	-	Silty Clay(stone)	Tpw	43	17	26
PII-35	D-5	25-26	-	Silty Clay(stone)	Tpo	60	22	38
PII-35	D-11	55-56	-	Clayey Silt(stone)/ Silty Clay(stone)	Tpo	61	26	35
PII-36	S-5	25-26.5	-	Silty Clay(stone)	Tpw	53	21	32
PII-36A	D-2	50-51	-	Silty Clay(stone)	Tpo	66	21	45
PII-36A	S-7	75-76.5	-	Clayey Silt(stone)/ Silty Claystone	Tpf	57	28	29
PII-38	D-5	25-26	-	Clayey Sand(stone)	Tpo	36	13	23
PII-38	S-8	40-41.5	-	Silty Clay(stone)	Tpo	65	25	40
PII-38	D-11	55-56	-	Clayey Silt(stone)/ Silty Clay(stone)	Tpo	57	29	28
PII-38	D-13	65-66	-	Silty Clay(stone)	Tpo	54	22	32
PII-38	S-14	70-71.5	-	Clayey Siltstone	Tpf	63	34	29
PII-39	D-9	45-46	-	Silty Clay(stone)	Tpw	47	17	30
PII-39	S-12	60-61.5	-	Silty Clay(stone)	Tpo	43	17	26
PII-41	D-8	30-31	-	Silty Clay(stone)	Tpo	50	18	32
PII-41	S-13	55-56.5	-	Silty Clay(stone)	Tpo	55	23	32
PII-42	S-8	40-41.5	-	Silty Clay(stone)	Tpo	56	23	33
PII-43	D-1	5-6	-	Clay(stone)	Tpw	70	24	46
PII-43	D-13	65-66	-	Silty Clay(stone)	Tpo	57	22	35
PII-44	D-8	40-41	CL/SC	Sandy Clay/ Clayey Sand	A4	35	15	20
PII-44	S-15	75-76.5	SC	Clayey Sand	A4	38	16	22
PII-45	D-8	40-41	-	Silty Clay(stone)	Tpo	48	20	28

Notes: (a) D-Drive Samples.
P-Thin Wall Tube (Pitcher) Samples.
S-SPT Samples.

TABLE B-4. SPECIFIC GRAVITY TEST RESULTS

Boring No.	Sample No.[a]	Depth (Feet)	General Soil Description	Geologic Unit	Specific Gravity
PII-32	D-10	50-51	Silty Claystone/ Clayey Siltstone	Tpf	2.71
PII-33	D-11	55-56	Silty Claystone	Tpf	2.67

Notes: (a) D - Drive Samples

TABLE B-5. UNCONFINED COMPRESSION TEST RESULTS

Boring No.	Sample No.(a)	Depth (Feet)	General Soil Description	Geologic Unit	Unconfined Compressive Strength (ksf)
PII-27	P-9	45-47.5	Clayey Siltstone	Tpf	18.0
PII-27	P-13	65-67.5	Clayey Siltstone	Tpf	21.3
PII-28	P-8	40-42.5	Clayey Silt(stone)	Tpo	24.9
PII-28	P-11	55-57.5	Clayey Siltstone	Tpf	24.8
PII-29	P-7	35-37.5	Silty Clay(stone)	Tpo	9.34
PII-30	P-6	30-32.5	Silty Clay(stone)	Tpo	9.00
PII-31	P-10	50-52.5	Clayey Siltstone	Tpf	30.5
PII-32	P-11	55-57.5	Clayey Siltstone	Tpf	14.2
PII-33	P-6	30-32.5	Clayey Silt(stone)	Tpo	8.53
PII-34	P-7	35-37.5	Silty Clay(stone)	Tpo	6.00
PII-34	P-13	65-67.5	Clayey Siltstone	Tpf	17.0
PII-35	P-10	50-52.5	Silt(stone)	Tpo	4.00
PII-35	D-15	75-76	Clayey Siltstone/ Silty Claystone	Tpf	2.27
PII-38	P-10	50-52.5	Clayey Silt(stone)	Tpw	7.64
PII-38	D-13	65-66	Silty Clay(stone)	Tpo	3.32
PII-39	P-10	50-52.5	Silty Clay(stone)	Tpw	1.87
PII-40	P-11	55-57.5	Clayey Silt(stone)	Tpo	7.29
PII-42	P-14	70-72.5	Clayey Silt(stone)	Tpf	17.0
PII-43	P-8	40-42.5	Clayey Silt(stone)	Tpo	4.19
PII-43	D-13	65-66	Silty Clay(stone)	Tpo	6.60
PII-45	D-6	30-31	Clayey Silt(stone)	Tpo	4.82

Notes: (a) D-Drive Samples
P-Thin Wall Tube (Pitcher) Samples

TABLE B-6. DIRECT SHEAR TEST RESULTS

Boring No.	Sample No.[a]	Depth (Feet)	General Soil Description	Geologic Unit	Applied Normal Stress (PSF)	Shear Stress (PSF) Peak	Shear Stress (PSF) Residual	Estimated Strength Parameters Cohesion (PSF)	Estimated Strength Parameters Friction Angle (Deg)
PII-27	D-4	20-21	Silt(stone)	Tpo	1,200	1,990	261	265	50
					2,400	2,716	2,118		
					4,800	6,172	4,015		
PII-27	D-10	50-51	Silty Claystone	Tpf	3,000	4,578	2,957	3,148	25
					6,000	6,003	5,816		
					12,000	8,863	7,418		
PII-30	D-7	35-36	Silty Clay(stone)	Tpo	2,100	1,251	1,203	405	30
					4,200	3,342	2,342		
					8,400	5,029	4,928		
PII-32	D-10	50-51	Silty Claystone/ Clayey Siltstone	Tpf	3,000	4,037	3,221	700	45
					6,000	5,165	4,795		
					12,000	14,462	6,795		
PII-33	D-3	15-16	Clayey Silt(stone)	Tpo	900	1,600	1,202	1,170	36
					1,800	2,790	1,820		
					3,600	3,651	3,541		
PII-33	D-9	45-46	Silty Claystone	Tpf	5,500	4,232	3,730	2,690	16
					11,000	5,768	5,157		
PII-34	D-2	10-11	Silty Clay(stone)	Tpw	600	1,395	799	625	54
					1,200	2,382	1,332		
					2,400	3,934	1,991		
PII-35	D-5	25-26	Silty Clay(stone)	Tpo	1,500	1,836	841	980	30
					3,000	2,704	1,437		
					6,000	1,958	1,943		
PII-35	D-13	65-66	Clayey Siltstone/ Silty Claystone	Tpf	4,000	4,993	4,226	2,982	26
					8,000	6,841	6,464		
					16,000	10,864	9,815		
PII-36	D-8	40-41	Clayey Silt(stone)	Tpo	2,500	2,713	1,469	1,300	29
					5,000	3,880	2,390		
					10,000	4,896	3,571		

Notes: (a) D-Drive Samples

TABLE B-6. DIRECT SHEAR TEST RESULTS

Boring No.	Sample No.[(a)]	Depth (Feet)	USCS Classification	General Soil Description	Geologic Unit	Applied Normal Stress (PSF)	Shear Stress (PSF) Peak	Shear Stress (PSF) Residual	Estimated Strength Parameters: Cohesion (PSF)	Estimated Strength Parameters: Friction Angle (Deg)
PII-38	D-5	25-26	---	Clayey Sand(stone)	Tpo	1,500	1,501	1,064	590	35
						3,000	2,847	2,139		
						6,000	4,667	4,305		
PII-38	D-11	55-56	---	Clayey Silt(stone)/ Silty Clay(stone)	Tpo	3,500	3,002	2,017	1,100	29
						7,000	4,902	4,274		
PII-39	D-7	35-36	SM	Silty Sand	A3	2,100	1,607	1,293	490	24
						4,200	2,044	2,044		
						8,400	4,279	4,279		
PII-40	D-16	80-81	---	Clayey Siltstone	Tpf	4,000	6,136	5,016	4,500	23
						8,000	7,858	7,514		
						16,000	9,846	9,064		
PII-41	D-14	60-61	---	Silty Clay(stone)/ Clayey Silt(stone)	Tpo	3,600	5,400	3,647	3,365	24
						7,200	6,042	5,432		
						14,400	10,112	8,954		
PII-43	D-9	45-46	---	Clayey Silt(stone)	Tpo	2,700	2,912	2,662	1,269	33
						5,400	5,009	3,997		
						10,800	8,296	7,670		
PII-44	D-8	40-41	CL/SC	Sandy Clay/ Clayey Sand	A4	2,500	1,570	1,066	1,250	32
						5,000	4,420	4,420		
						10,000	7,620	6,959		
PII-44	D-10	50-51	SM	Silty Sand	A3	3,000	1,320	1,317	0	31
						6,000	2,380	2,194		
						12,000	7,150	7,053		

Notes: (a) D-Drive Samples

TABLE B-7. SUMMARY OF TRIAXIAL COMPRESSION TEST RESULTS

Boring No.	Sample No.[a]	Depth (feet)	General Soil Description	Geologic Unit	Effective Confining Pressure (ksf)	Back Pressure (ksf)	Peak Shear (ksf)	Pore Pressure at Peak Shear (ksf)	Residual Shear (ksf)	Pore Pressure at Residual Shear (ksf)
PII-28	P-8	40-42.5	Clayey Siltstone	Tpf	2.6	9.9	34.2	1.0	16.9	4.45
					4.4	13.0	40.2	3.3	26.1	6.03
PII-34	P-7	35-37.5	Silty Clay(stone)	Tpo	2.6	10.1	16.6	1.0	13.6	5.98
					5.2	10.1	20.5	3.2	13.4	8.77
PII-43	P-8	40-42.5	Clayey Silt(stone)	Tpo	2.2	8.6	13.0	-1.6	12.7	6.81
					4.3	7.2	12.8	1.8	11.2	6.55

Notes: (a) P: Thin Wall Tube (Pitcher) Samples.

TABLE B-8.
LABORATORY PERMEABILITY TEST RESULTS

Boring No.	Sample[a] No.	Depth (feet)	USCS Class.	General Soil Classification	Geologic Unit	Permeability (cm/sec)
PII-38	P-10	50-52.5	-	Clayey Siltstone	Tpw	1.59×10^{-7}
PII-39	D-5	25-26	SC	Clayey Sand	A4	3.80×10^{-7}
PII-41	D-4	20-21	SM	Silty Sand	A3	1.35×10^{-6}

Notes: (a) D: Drive Samples

TABLE B-9. ENGINEERING PROPERTIES OF ALL GEOLOGIC UNITS - SUMMARY OF LABORATORY TEST RESULTS

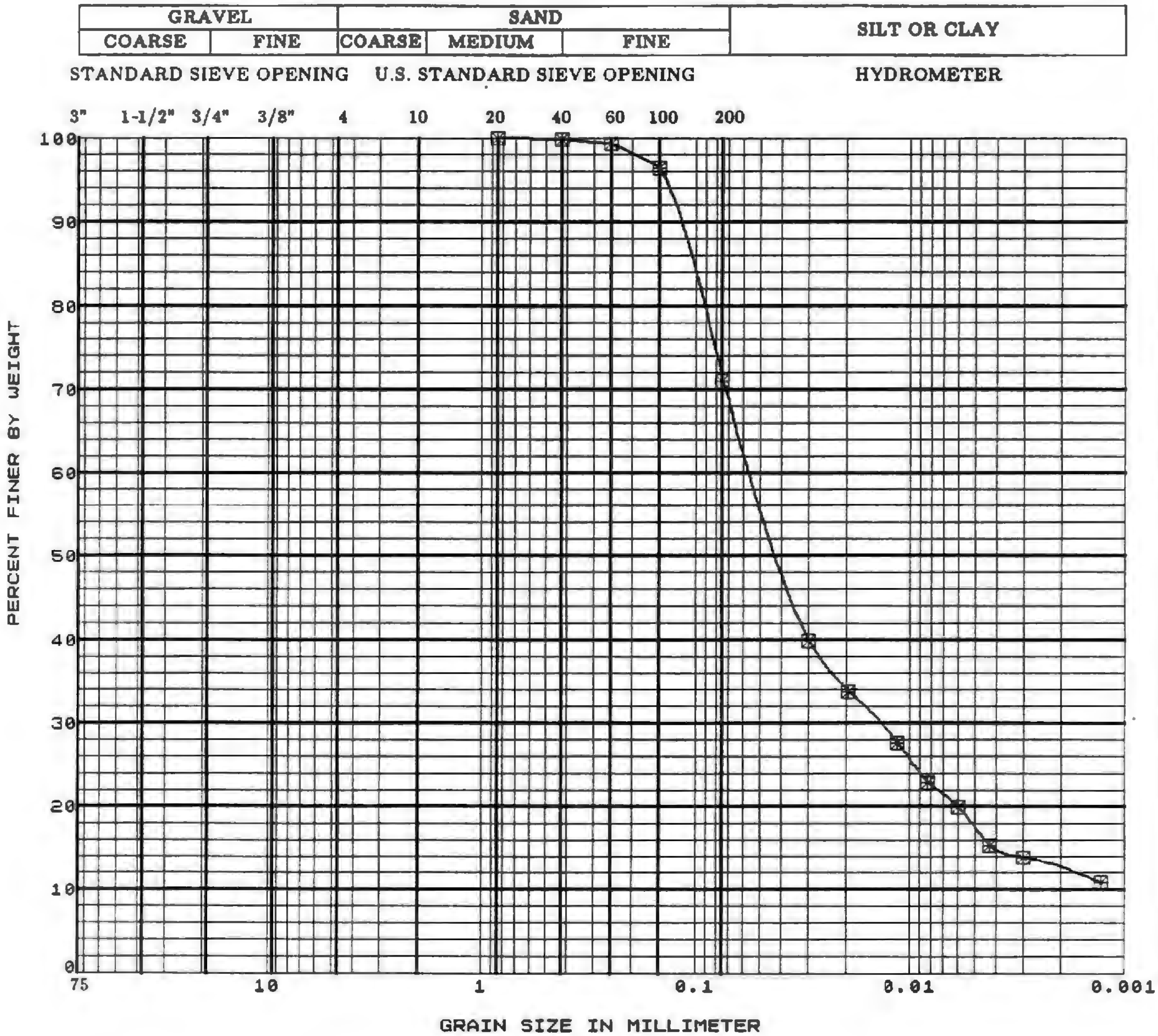
LOGIC ERIAL	GEOLOGIC UNIT	USCS SOIL CLASSIFICATION	SHEAR STRENGTH PARAMETERS: FRICTION ANGLE (degrees) RANGE	MEAN	S.D(a)	SHEAR STRENGTH PARAMETERS: COHESION (ksf) RANGE	MEAN	S.D(a)	UNCONFINED COMPRESSIVE STRENGTH (ksf) RANGE	MEAN	S.D(a)	DRY DENSITY (pcf) RANGE	MEAN	S.D(a)	MOISTURE CONTENT % RANGE	MEAN	S.D(a)	PERMEABILITY (cm/s) RANGE	MEAN	S.D.(a)	CALCULATED VOID RATIO RANGE	MEAN	S.D.(a)	YOUNG'S MODULUS(b) (ksf) RANGE	MEAN	S.D.(a)
UVIUM anular)	A_3	SM, SP-SM, SM/ML, SC	29-31	30 -	1.0 -	0-490	245 -	245 -	- -	- -	- -	101.9-113.4	107.6	4.8	11.0-25.0	18.0	5.7	- -	$1.35x10^{-6}$	- -	0.49-0.74	0.58	0.08	- -	- -	- -
UVIUM ne ined)	A_4	CL, ML, SC, CL-ML, CH	-	32	-	-	1250	-	-	-	-	103.0-115.2	109.1	4.3	14.0-24.0	18.9 -	3.2 -	-	$3.80x10^{-7}$	-	0.46-0.62	0.55	0.06	-	-	-
NTE MATION	Tpw	---	-	-	-	-	-	-	1.87-7.64	4.76	2.89	84.5-111.7	97.1	26.3	16.0-39.0	26.3	7.9	-	$1.59x10^{-7}$	-	0.51-1.00	0.74	0.15	-	-	-
NTE MATION	Tpo, Tpf	---	15.0-47.0	31.7	8.9	0.3-3.9	1.84	1.0	2.27-30.0	12.0	8.3	74.8-137.9	96.0	6.6	11.0-47.0	27.6	6.6	-	-	-	0.64-1.17	0.86	0.13	570-2,230	1,146	642

es: (a) S.D. - Standard Deviation.
(b) Young's Modulus obtained from triaxial test results.

TABLE B-10. OTHER ENGINEERING PARAMETERS OF ALL GEOLOGIC UNITS ESTIMATED USING SPT DATA AND AVAILABLE CORRELATIONS

GEOLOGIC MATERIAL	GEOLOGIC UNIT	USCS SOIL CLASSIFICATION	STANDARD PENETRATION RESISTANCE			SHEAR WAVE VELOCITY (ft/s)			DYNAMIC SHEAR MODULUS(a) (10^5 x psf)			STATIC SHEAR MODULUS(b) (10^5 x psf)			SUBGRADE MODULUS(c) (10^3 x lb/ft^3)		
			RANGE	MEAN	S.D(d)	RANGE	MEAN	S.D(d)	RANGE	MEAN	S.D(d)	RANGE	MEAN	S.D(d)	RANGE	MEAN	S.D(d)
OLD ALLUVIUM (Granular)	A3	SM,SP, SP-SM, GM, SM/ML	11-132	48	30	475-1,226	760	189	8-56	23	12	0.7-7.9	2.9	1.8	48-1,000	600	395
OLD ALLUVIUM (Fine Grained)	A4	CL, SC/CL, ML, SC, CH, OL, ML-CL, ML	11-82	34	16	416-1,222	685	160	6-56	18	9.5	0.7-4.9	2.0	0.9	150-600	480	161
PUENTE FORMATION (Weathered)	Tpw	---	27-96	46	17	521-1,150	746	151	10-49	22	9	1.6-5.8	2.8	1.0	300-600	542	118
PUENTE FORMATION (Oxidized/Fresh)	Tpo/Tpf	---	11-300	115	65	400-1,750	1,160	265	6-113	53	23	0.7-18.0	6.9	3.9	300-600(e)	594	45

Notes: (a) Based on correlations recommended by Ohta and Goto (1978).
(b) Based on correlations recommended by Schmertmann (1970).
(c) Based on correlations recommended by Terzaghi (1955).
(d) S.D. = Standard Deviation.
(e) Estimate based on upper-bound value for hard fine-grained soils, recommended by Terzaghi (1955).



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
⊠	PII-25	D-4	20.0	DRIVE	CLAYEY SILT(STONE)		

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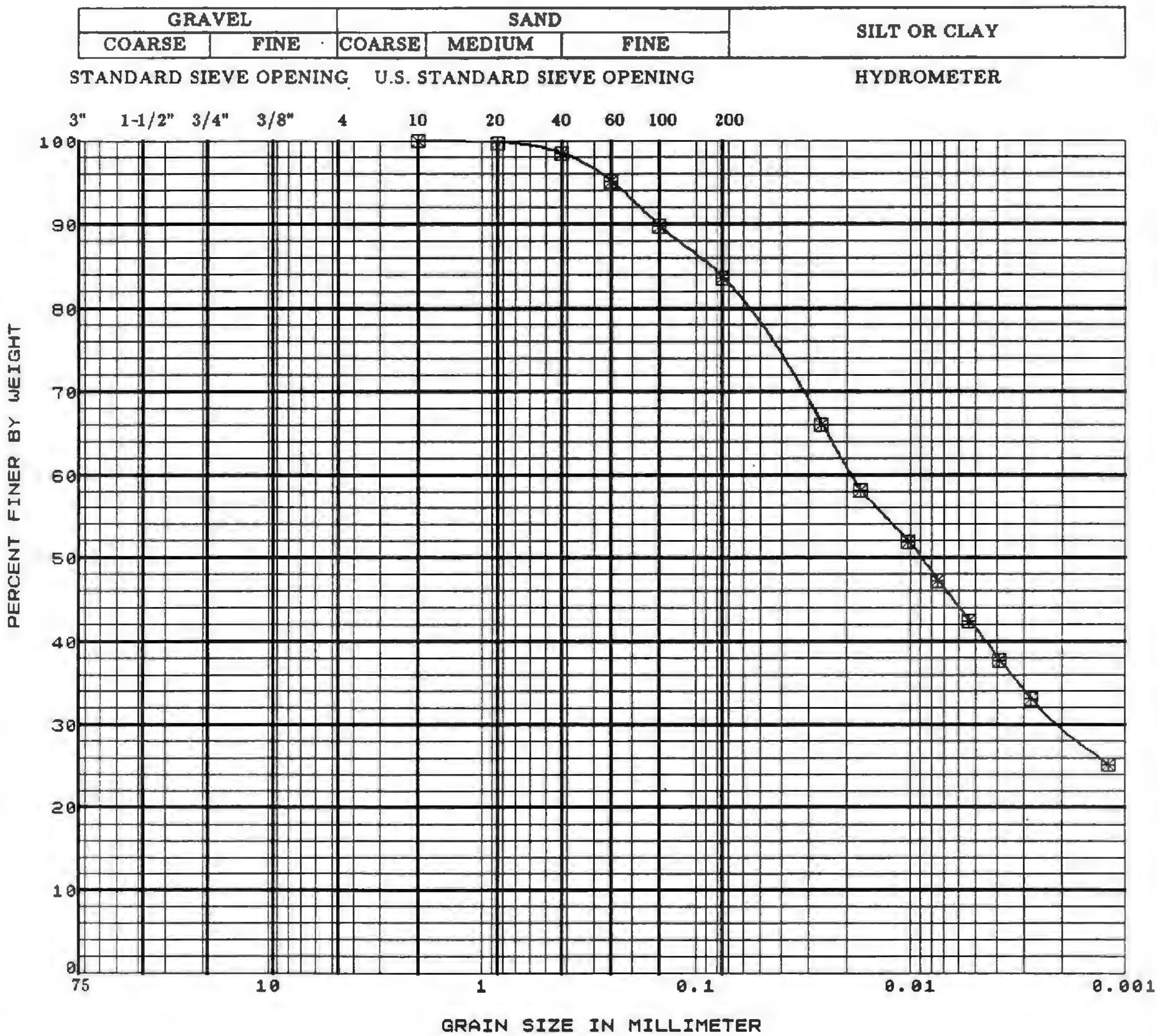
FIGURE B-1



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTI-CITY INDEX
⊠	PII-27	D-4	20.0	DRIVE	CLAYEY SILT(STONE)		

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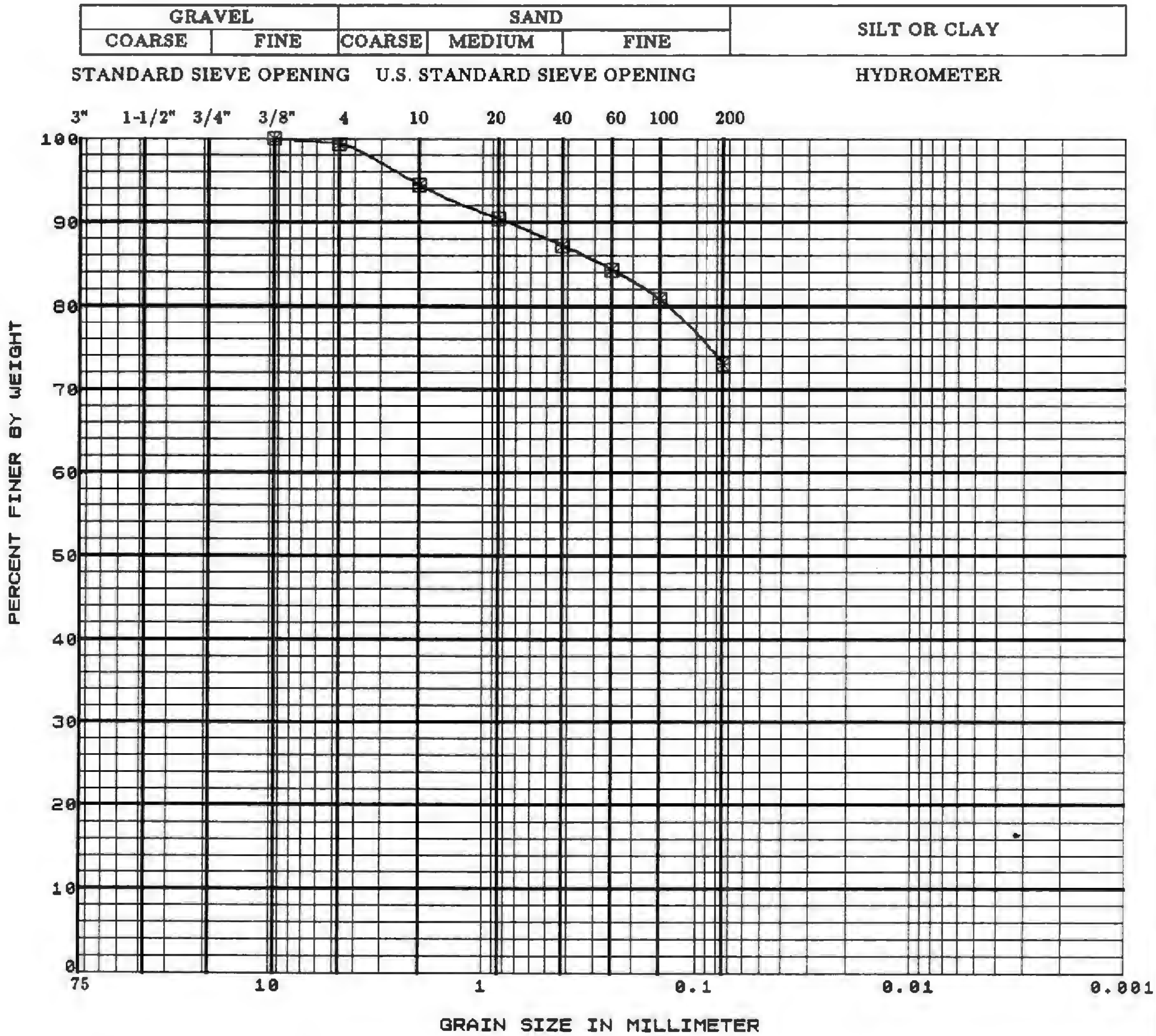
FIGURE B-2



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTI-CITY INDEX
⊠	PII-28	S - 4	20.0	SPT	SILTY CLAY(STONE)		

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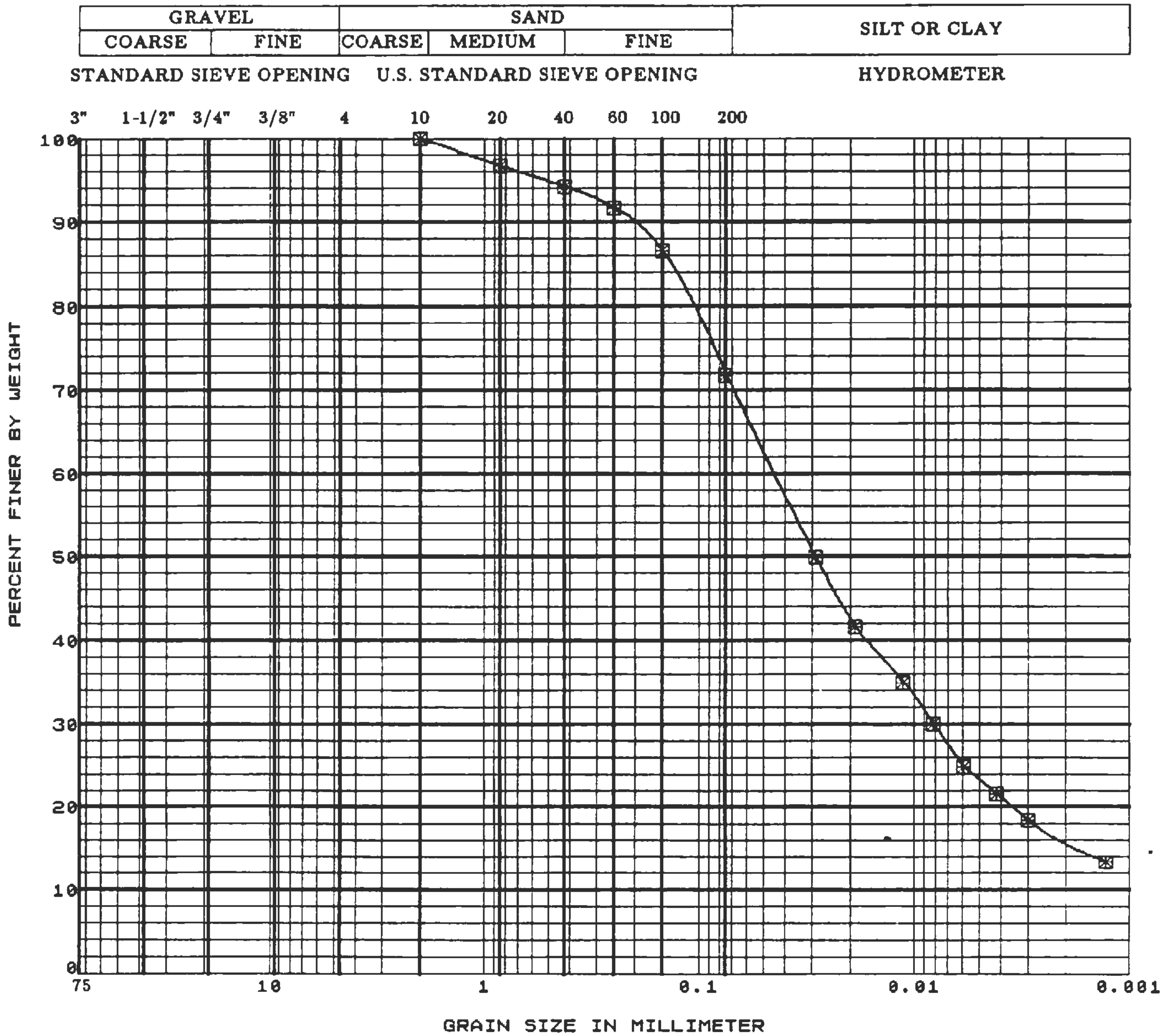
FIGURE B-3



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
⊠	PII-28	P-8	40.0	PITCHER	CLAYEY SILTSTONE		

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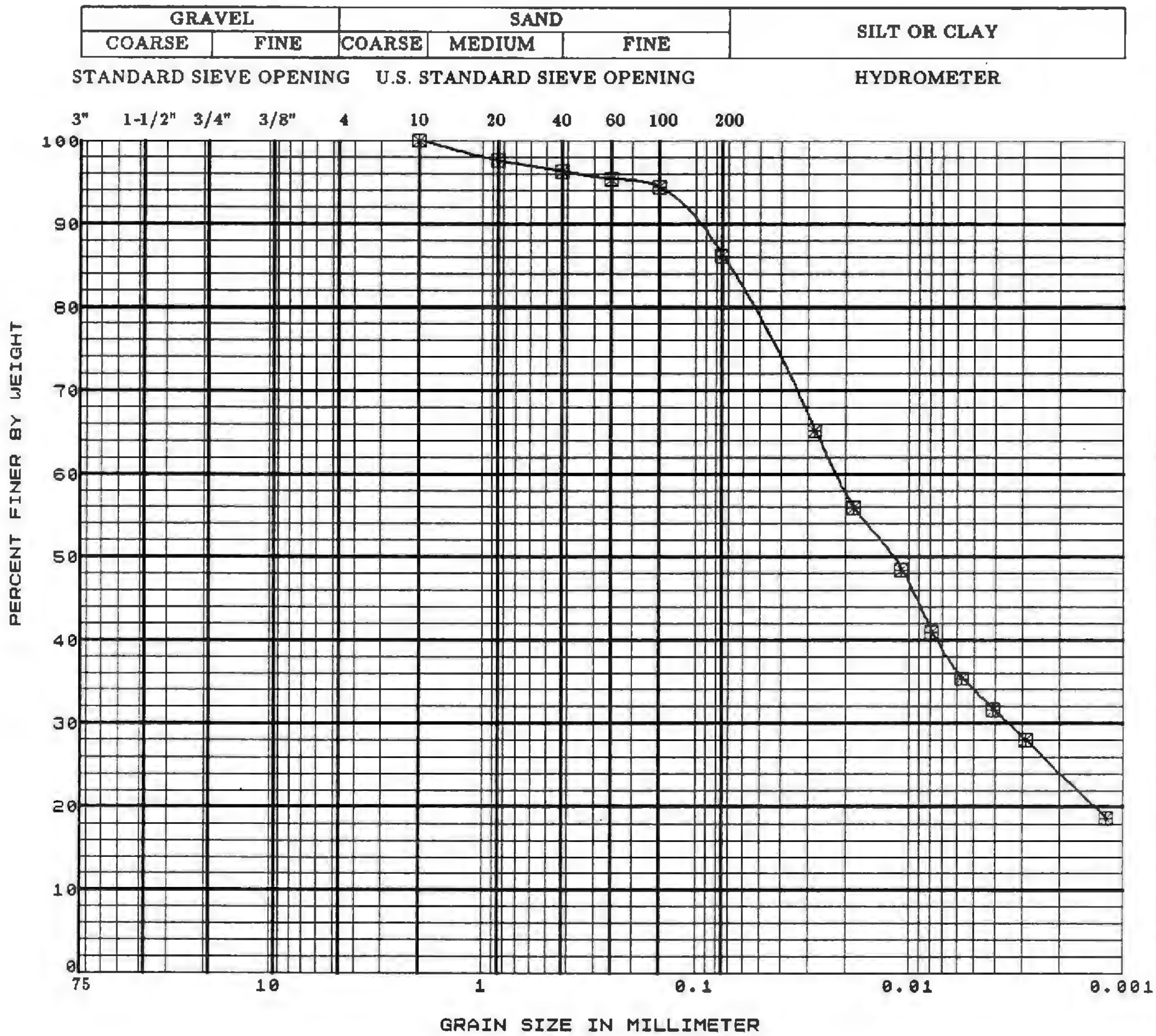
FIGURE B-4



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTI-CITY INDEX
⊠	PII-30	S - 2	10.0	SPT	CLAYEY SILT(STONE)		

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Grain Size Distribution Curve

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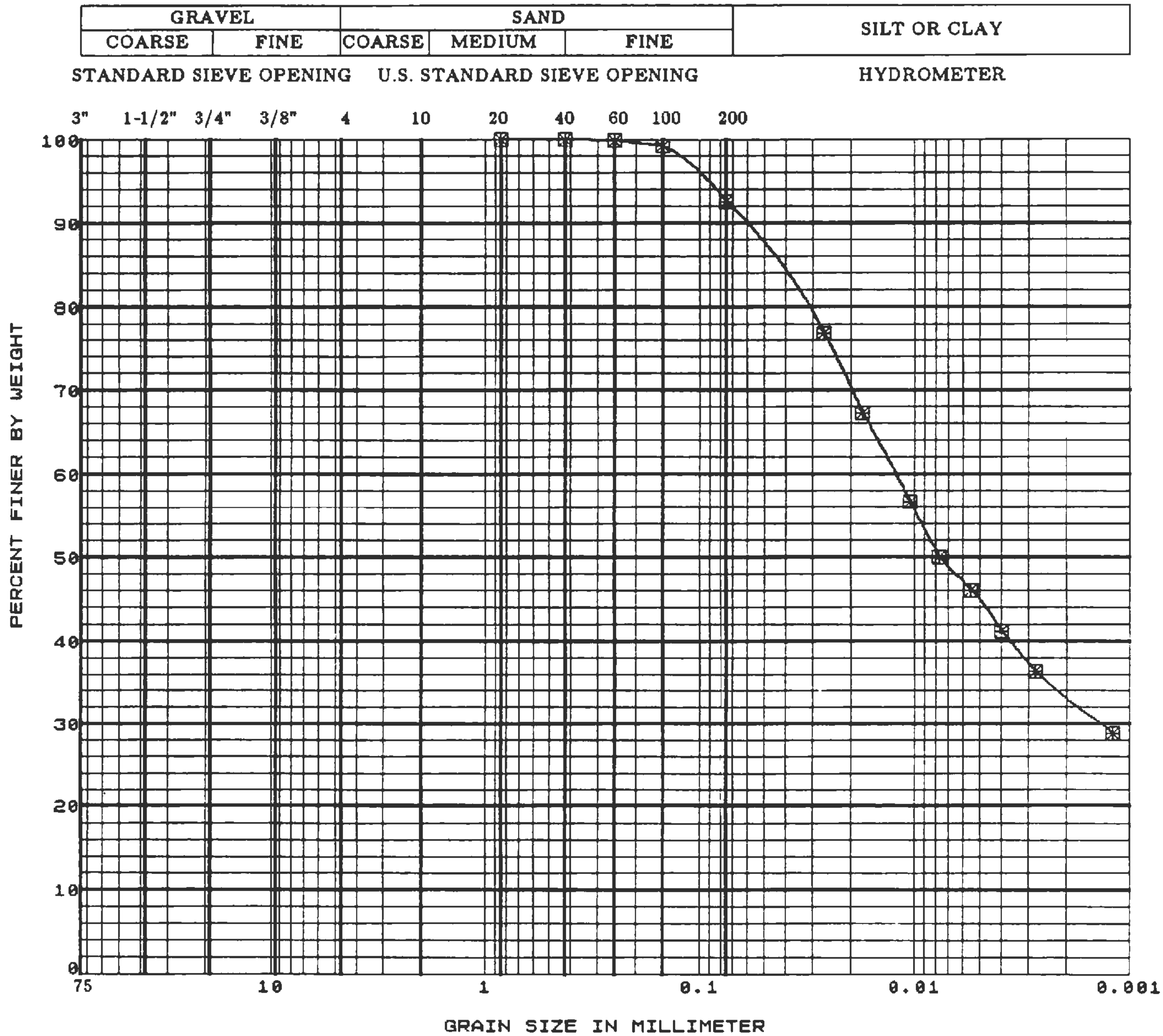
FIGURE B-5



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTI-CITY INDEX
⊠	PII-31	D-3	15.0	DRIVE	SILTY CLAY(STONE)		

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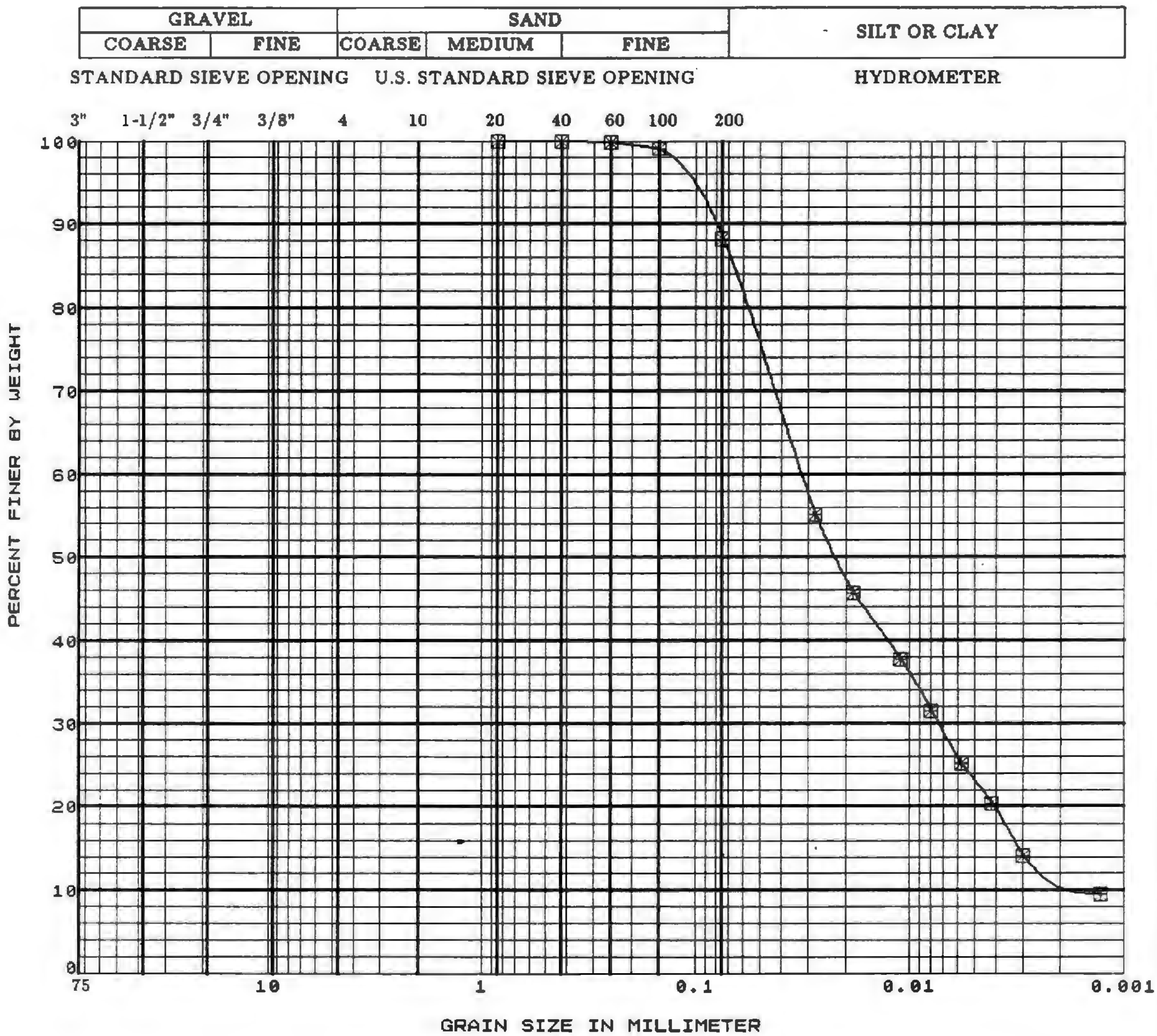
FIGURE B-6



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTI-CITY INDEX
⊠	PII-31	D - 11	55.0	DRIVE	CLAYEY SILTSTONE	53	33

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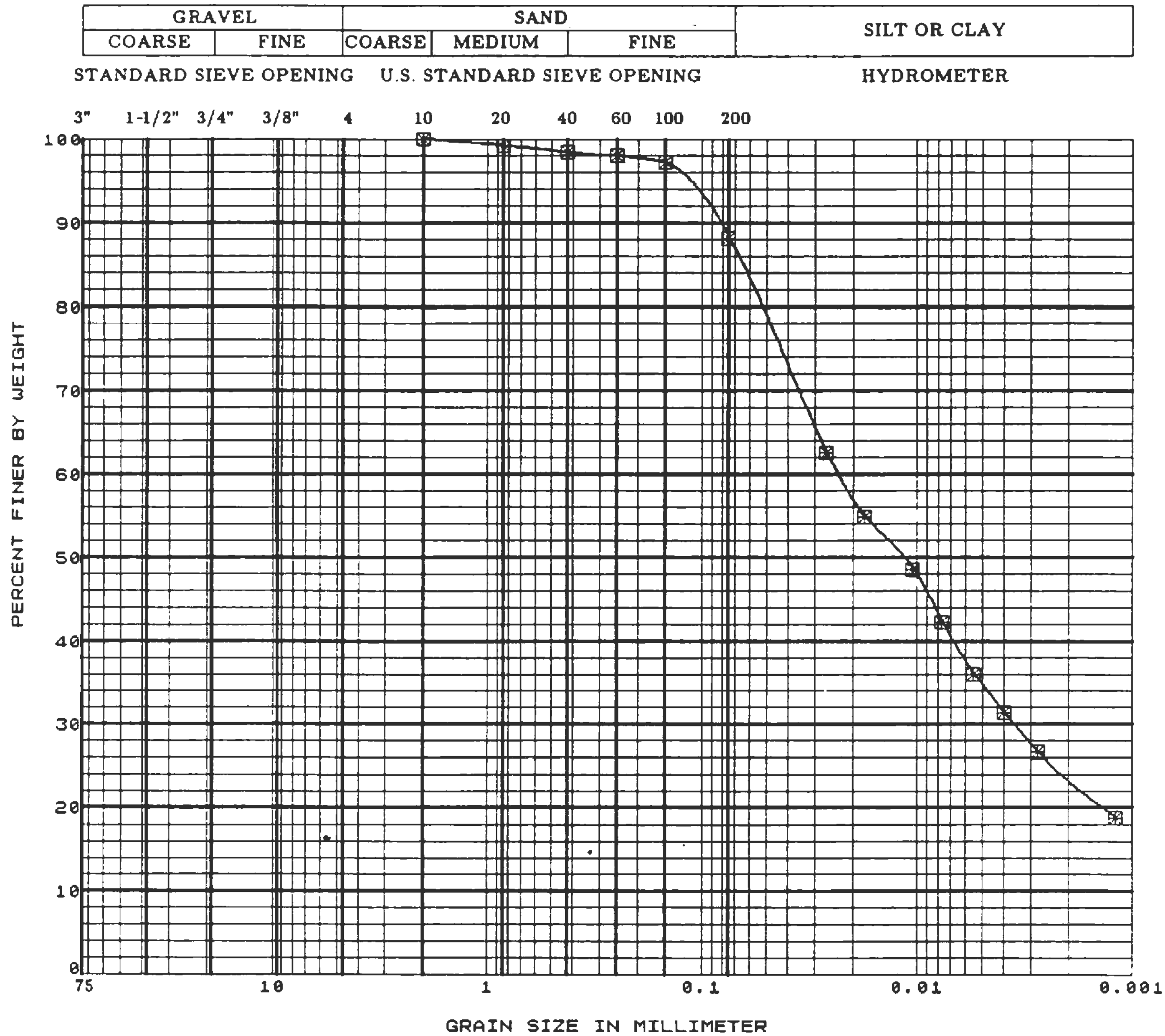
FIGURE B-7



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTI-CITY INDEX
⊠	PII-32	D-8	40.0	DRIVE	SILTY CLAYSTONE	49	31

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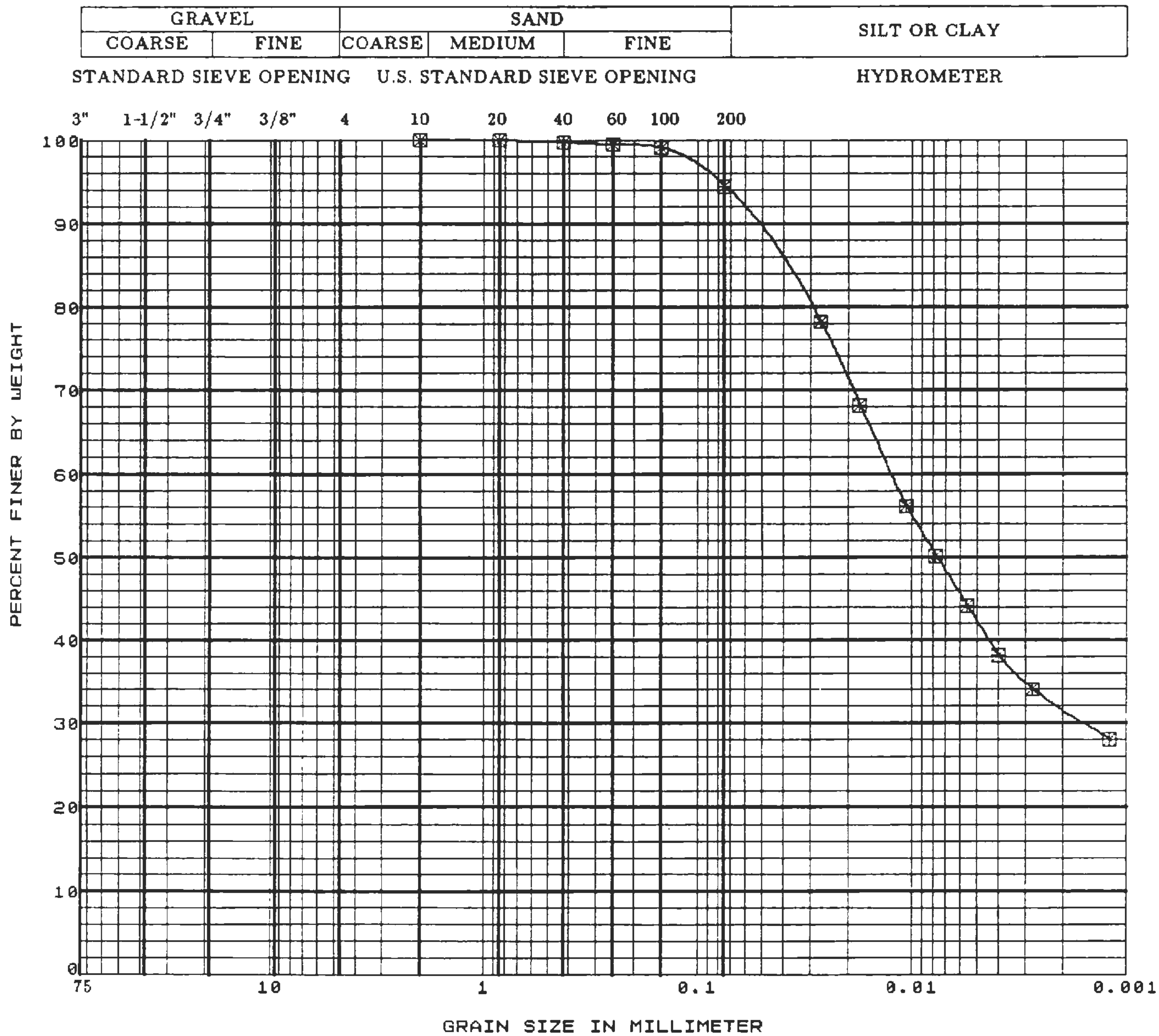
FIGURE B-8



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTI-CITY INDEX
⊠	PII-33	D-5	25.0	DRIVE	SILTY CLAY(STONE)	53	32

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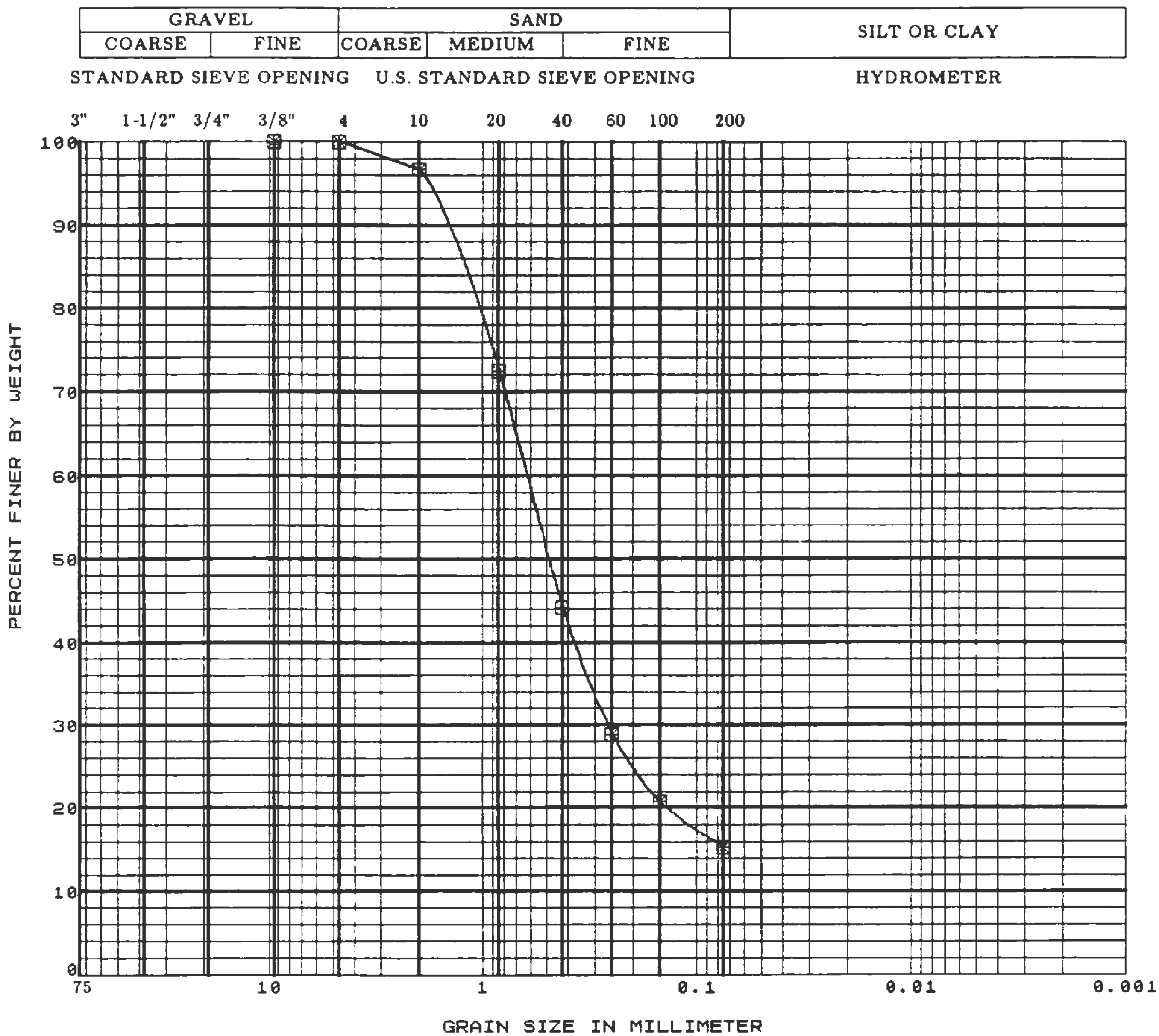
FIGURE B-9



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTI-CITY INDEX
⊠	PH-35	S - 2	10.0	SPT	SILTY SAND(STONE)		

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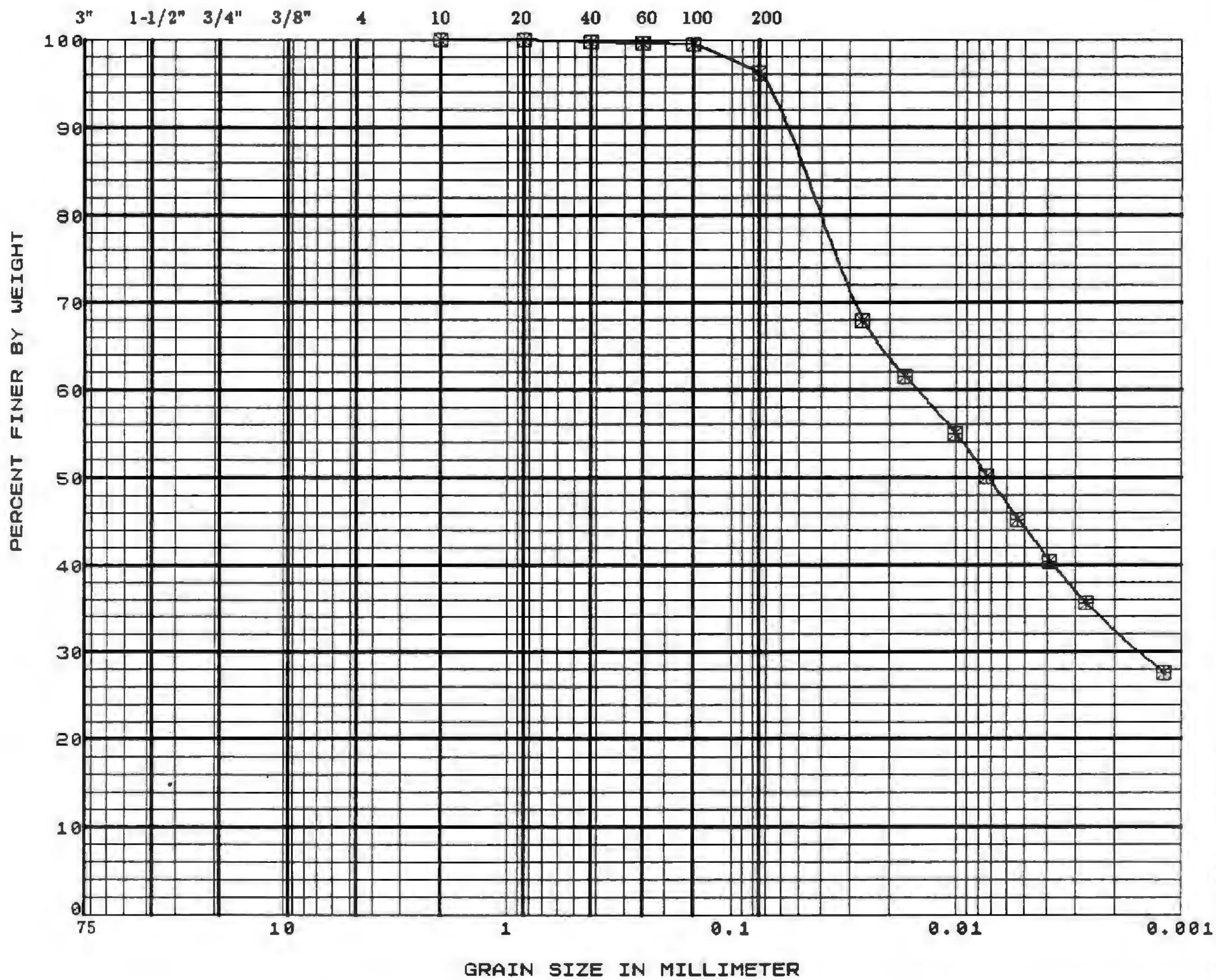
FIGURE B-10

GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	

STANDARD SIEVE OPENING   U.S. STANDARD SIEVE OPENING   HYDROMETER



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTI-CITY INDEX
⊠	PII-35	D-5	25.0	DRIVE	SILTY CLAY(STONE)	60	38

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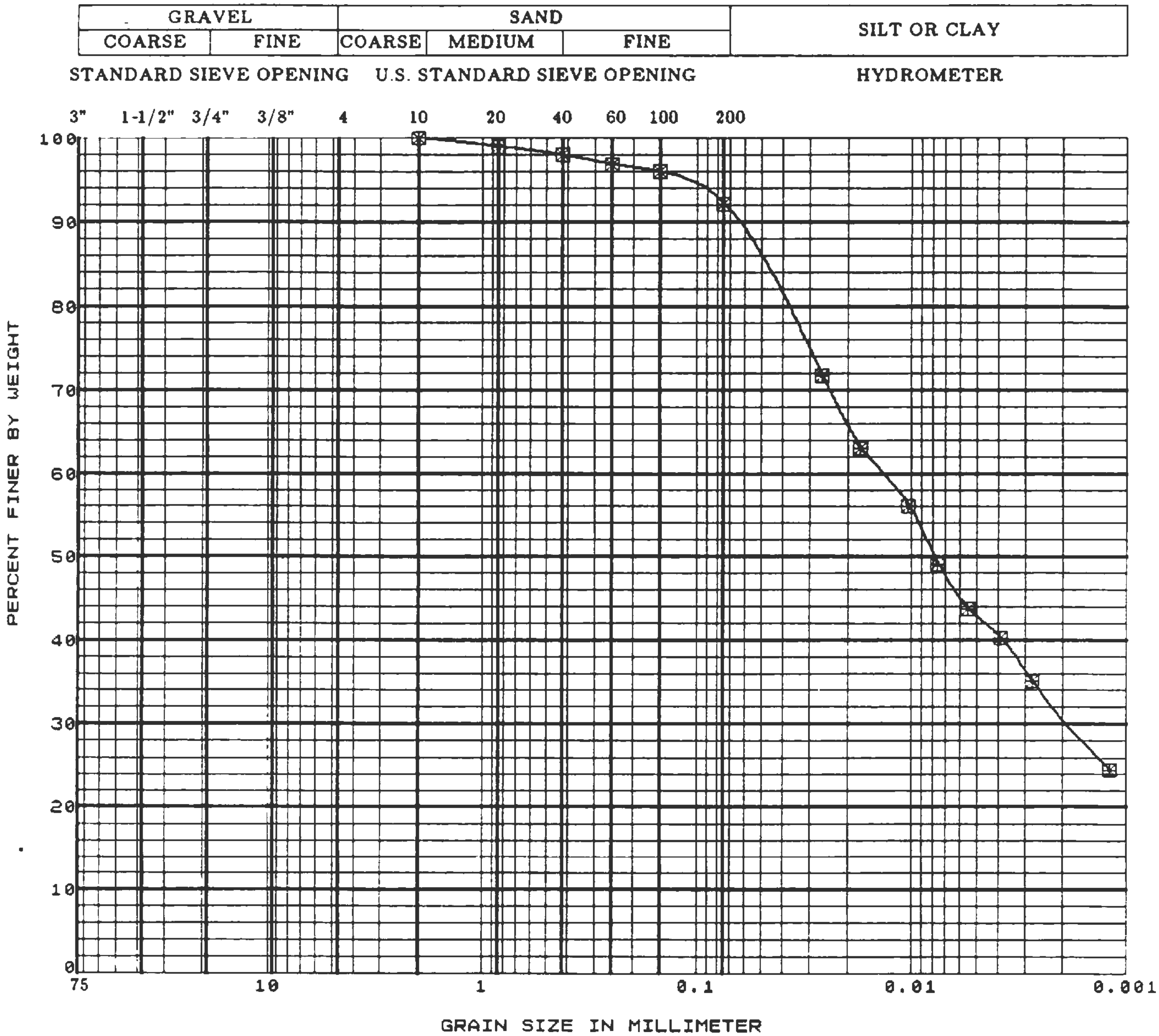

SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
⊠	PII-35	P - 10	50.0	PITCHER	SILT(STONE)		

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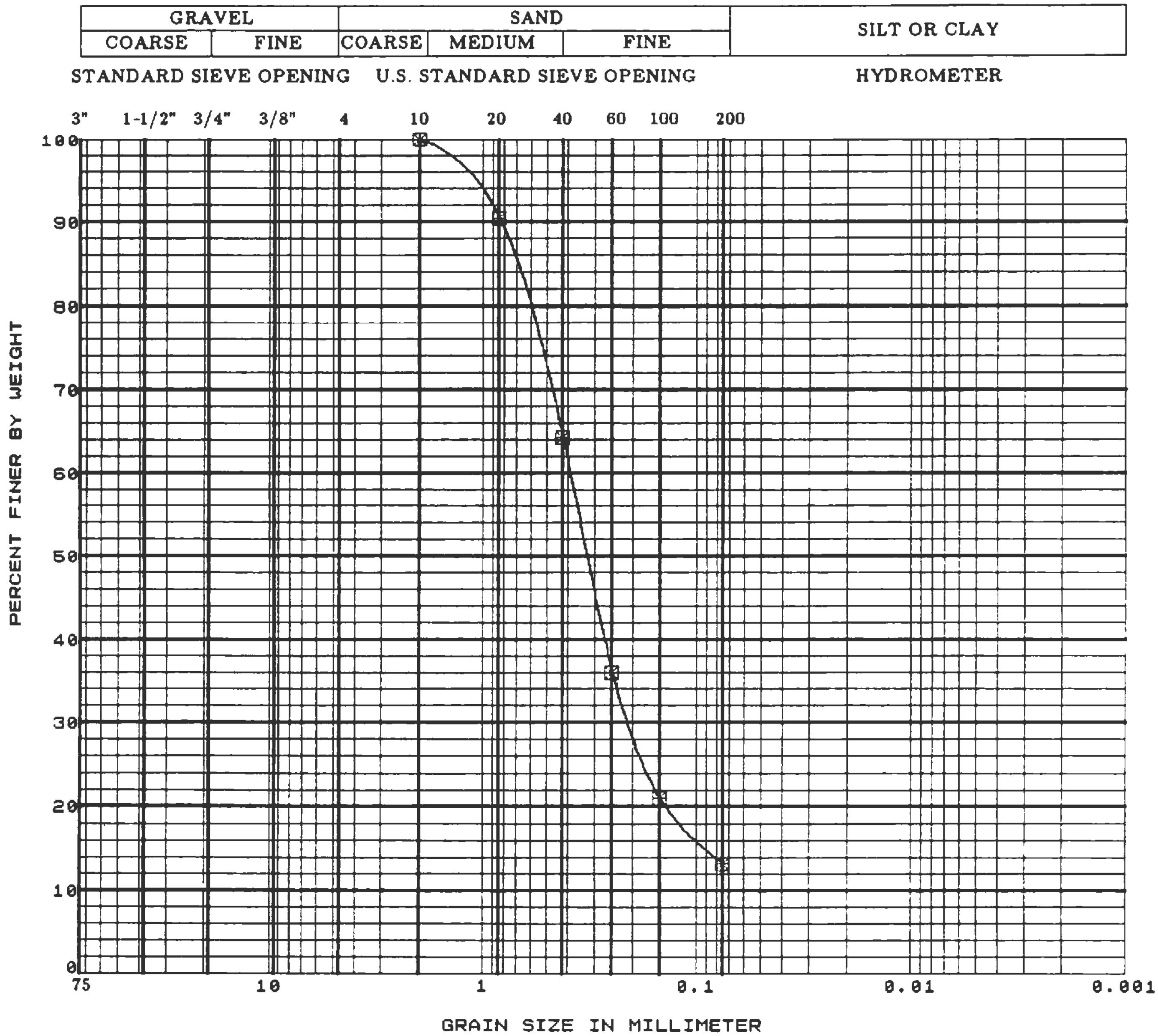
FIGURE B-12



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTI-CITY INDEX
⊠	PII-36	D-2	10.0	DRIVE	SILTY SAND(SM)		

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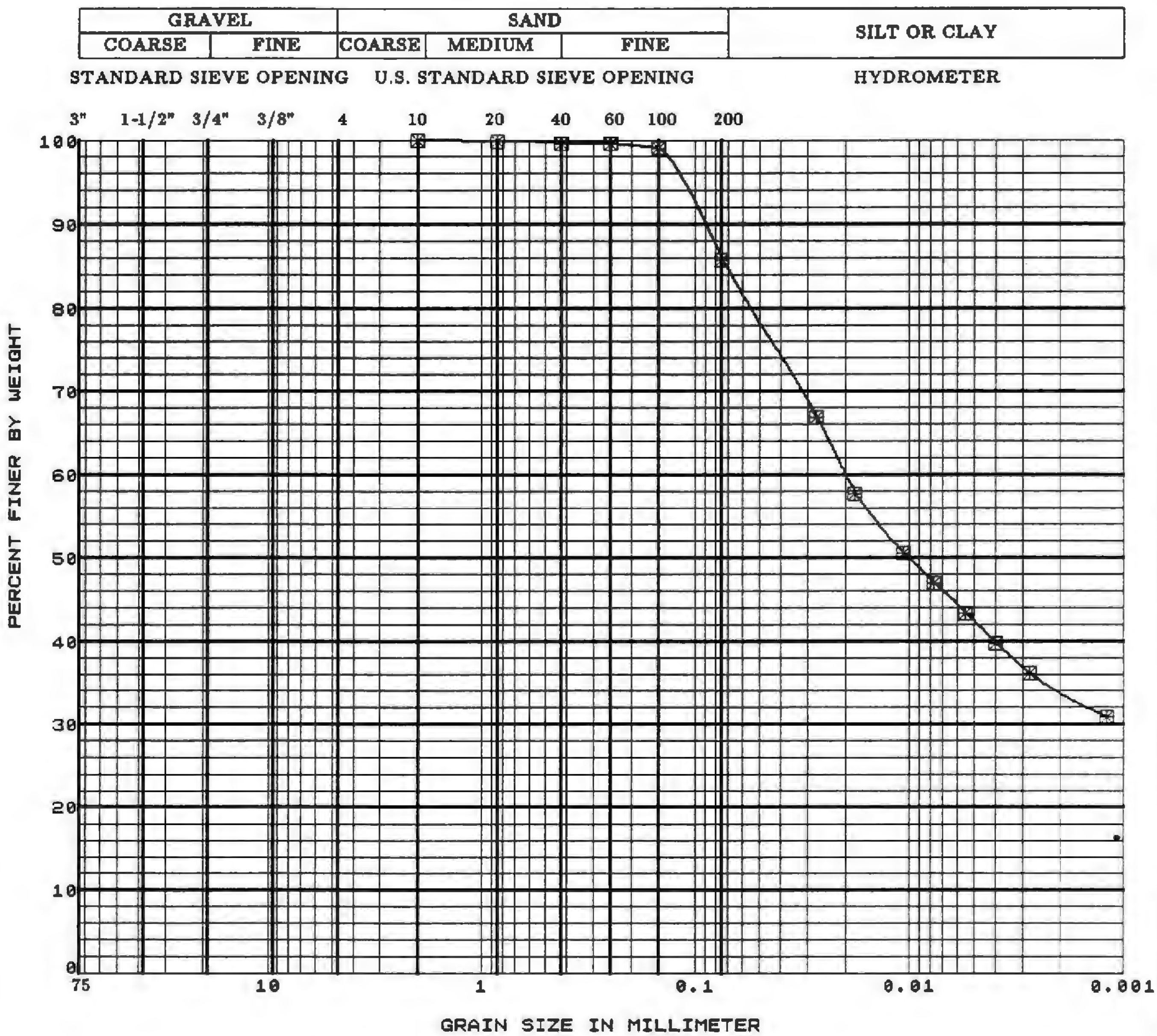
FIGURE B-13



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
⊠	PII-36	S - 5	25.0	SPT	SILTY CLAY(STONE)	53	32

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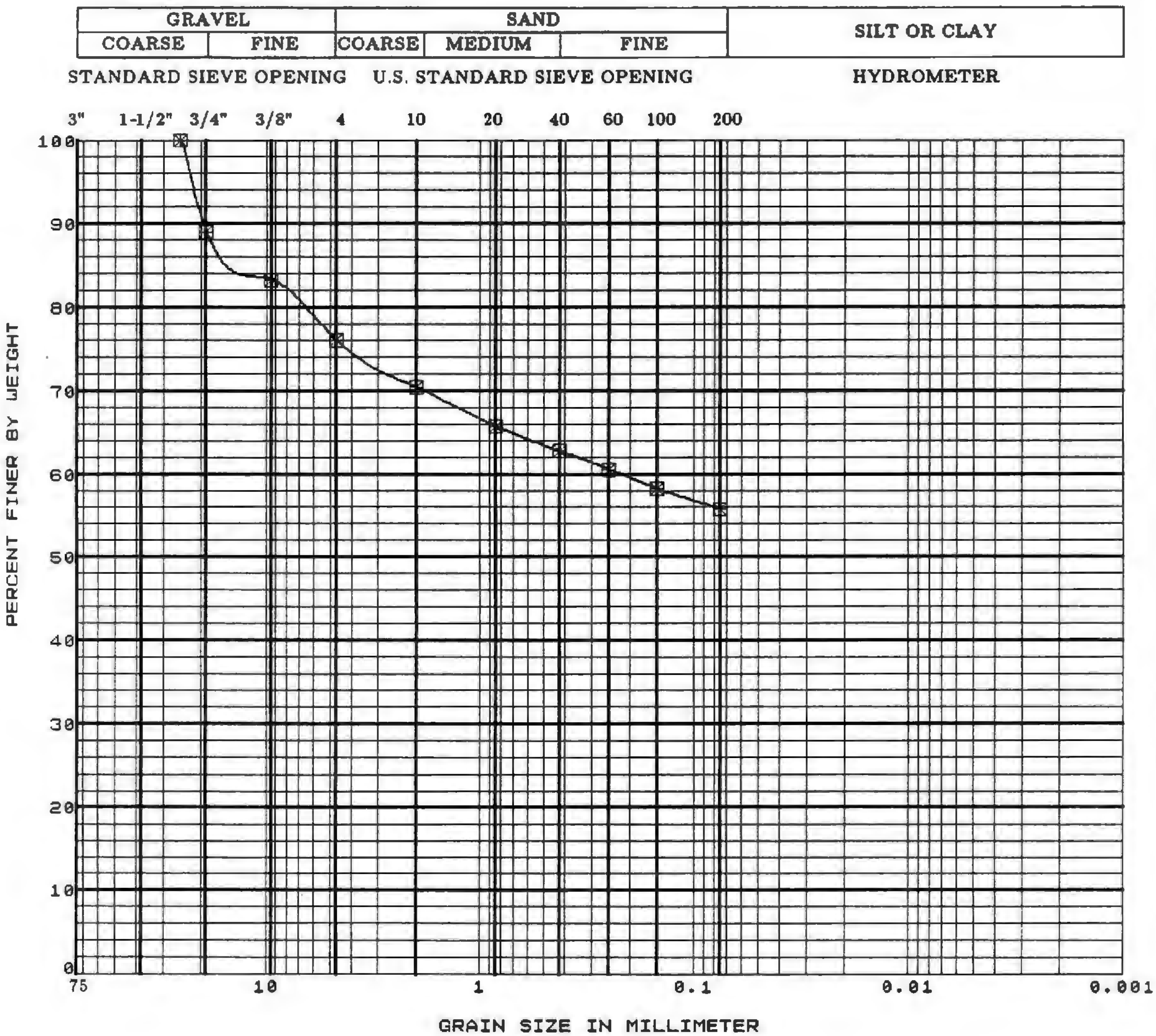
FIGURE B-14



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTI-CITY INDEX
⊠	PII-36A	D- 2	50.0	DRIVE	SILTY CLAY(STONE)	66	45

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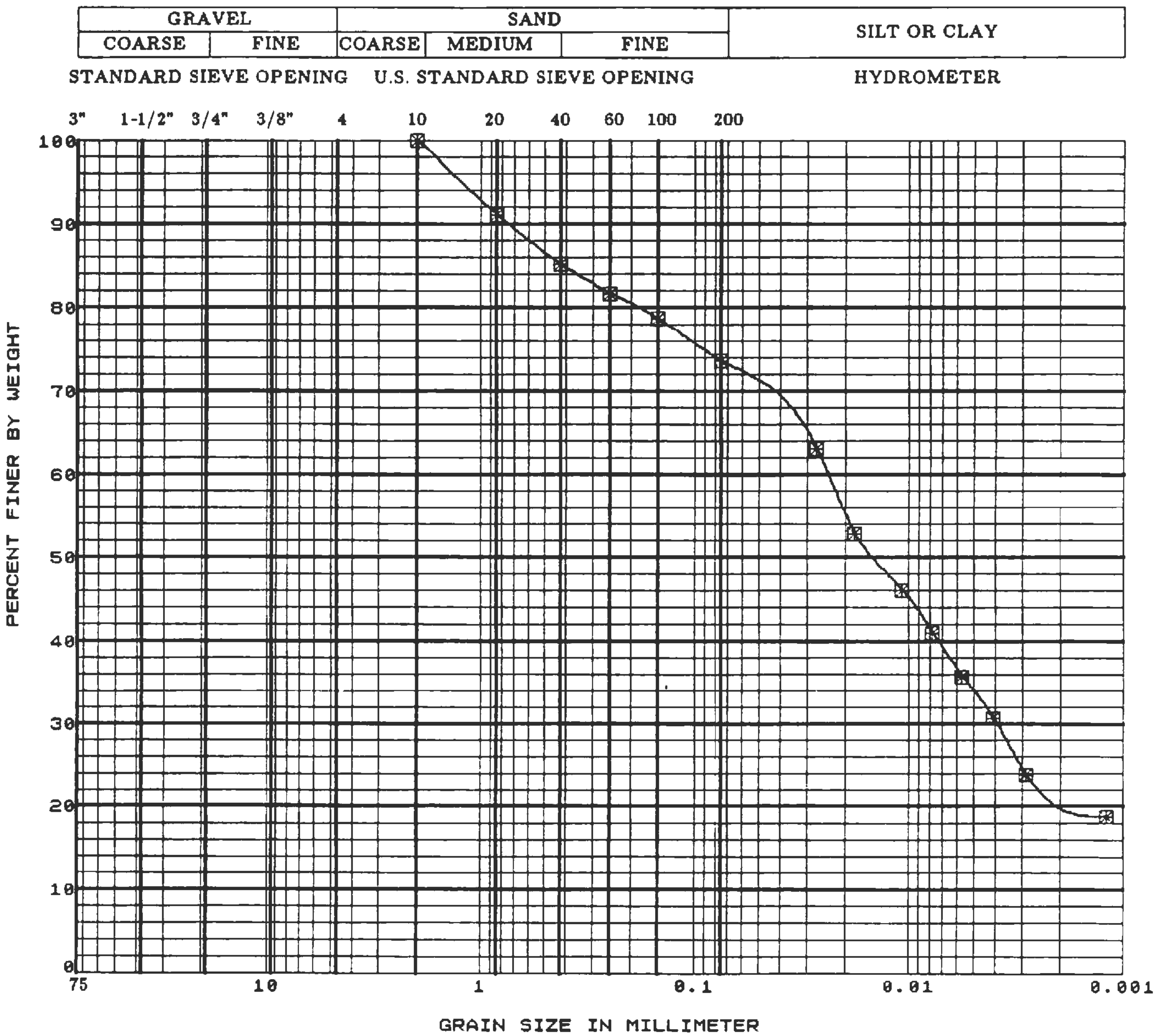
FIGURE B-15



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTI-CITY INDEX
⊠	PII-36A	S - 7	75.0	SPT	CLAYEY SILTSTONE/ SILTY CLAYSTONE	57	29

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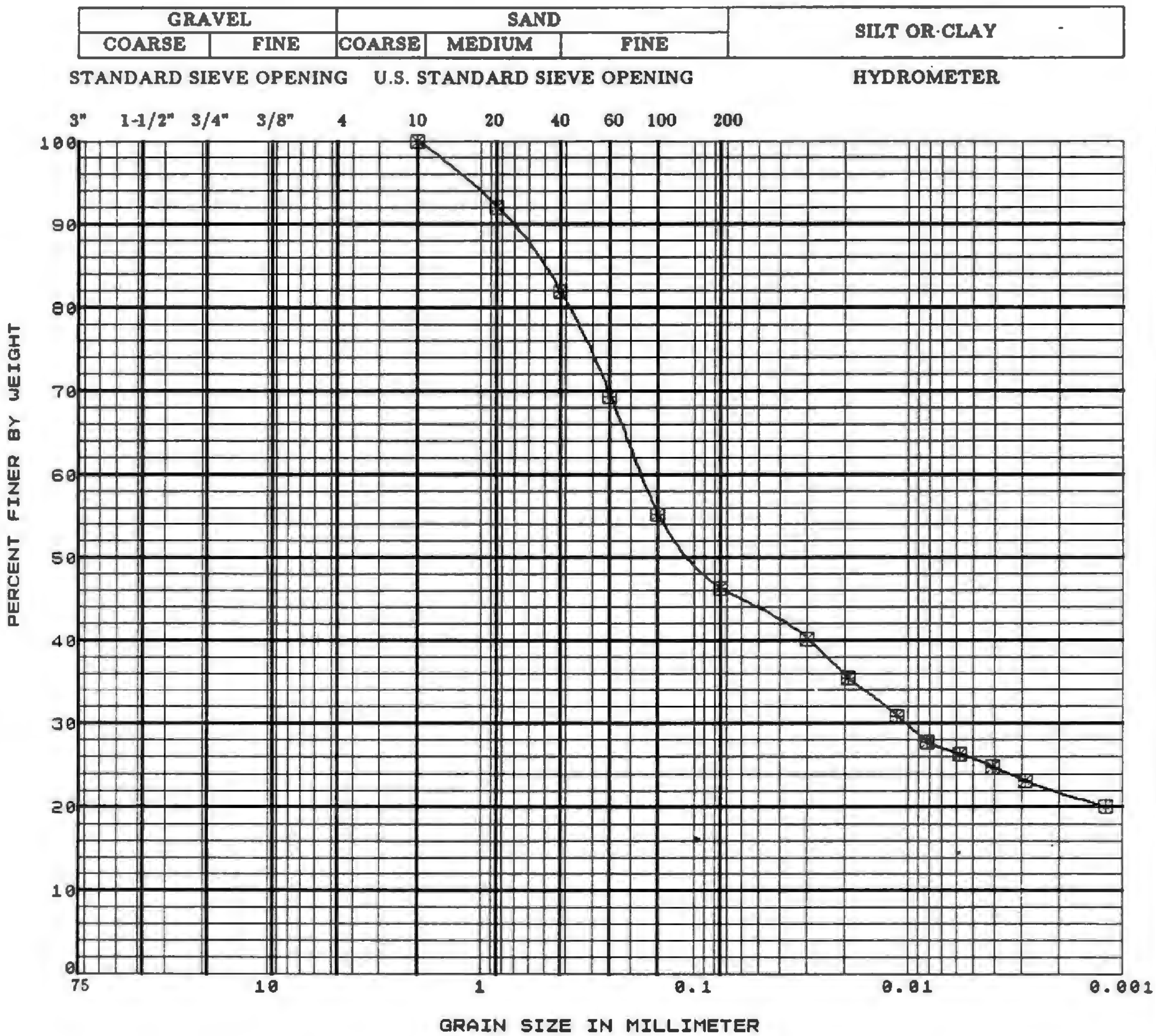
FIGURE B-16



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTI-CITY INDEX
⊠	PII-38	D-5	25.0	DRIVE	CLAYEY SAND(STONE)	36	23

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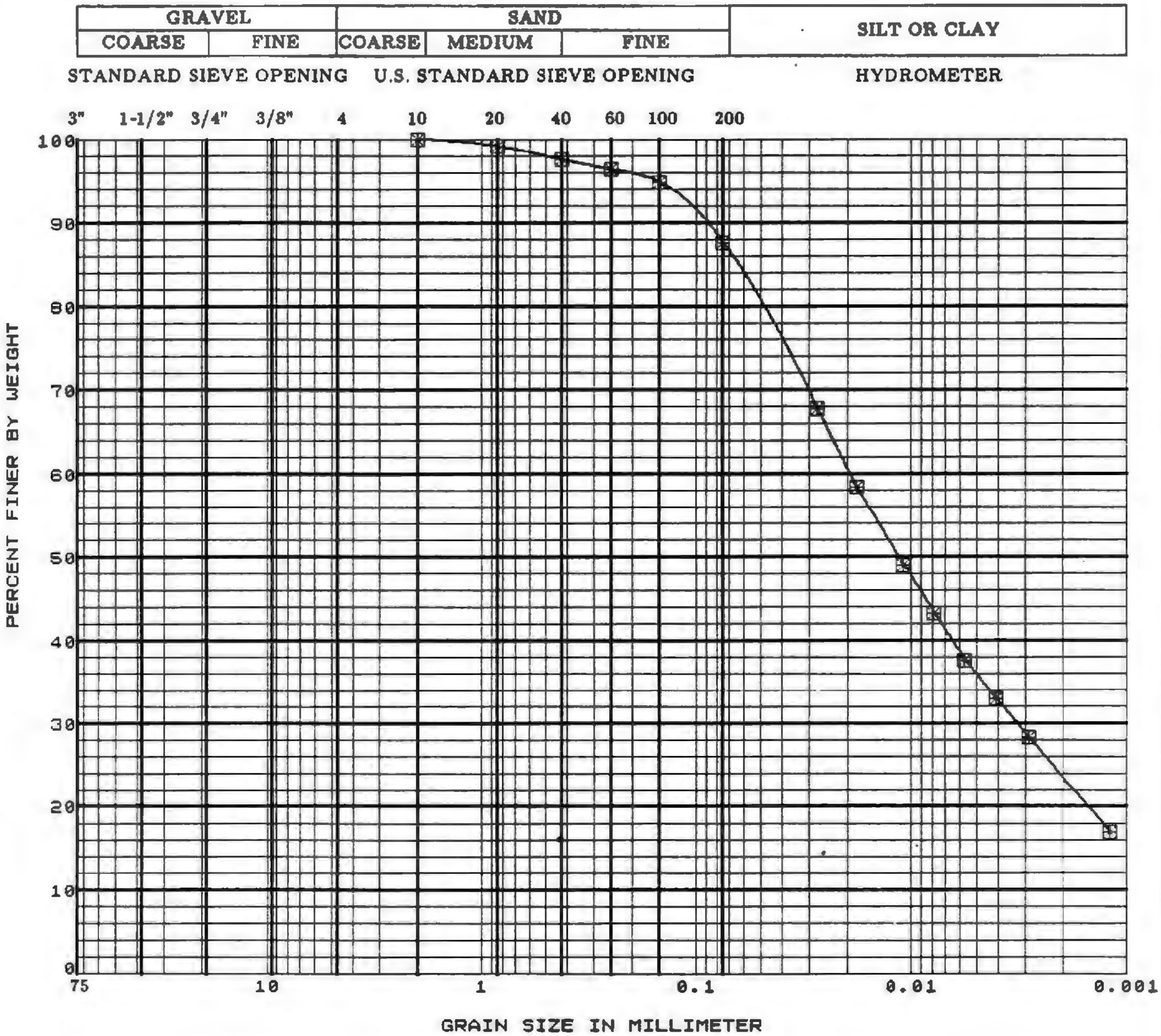
FIGURE B-17



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTI-CITY INDEX
⊠	PII-38	P - 10	50.0	PITCHER	CLAYEY SILT(STONE)		

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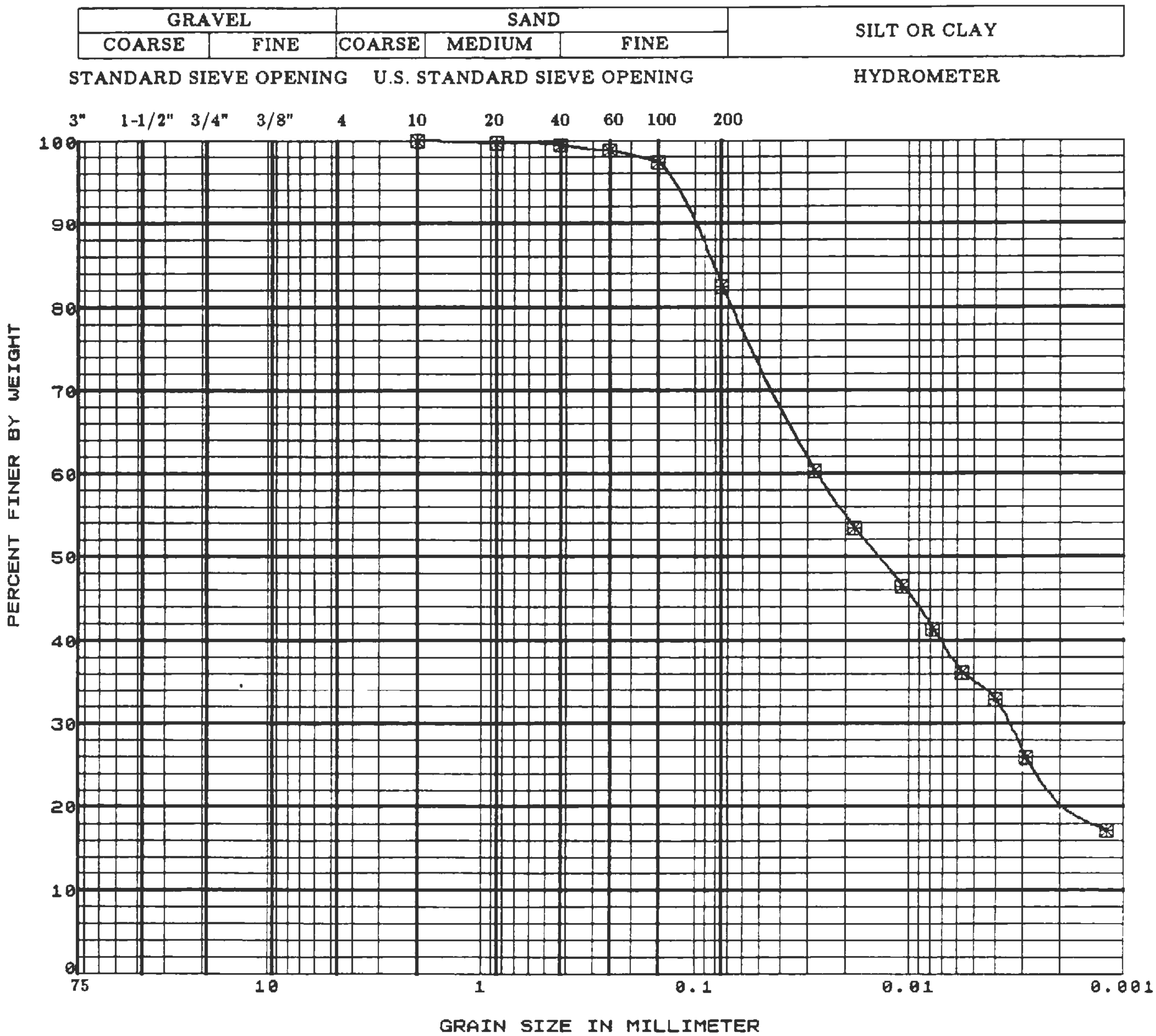
FIGURE B-18



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTI-CITY INDEX
⊠	PII-38	D - 11	55.0	DRIVE	CLAYEY SILTSTONE/ SILTY CLAYSTONE	57	28

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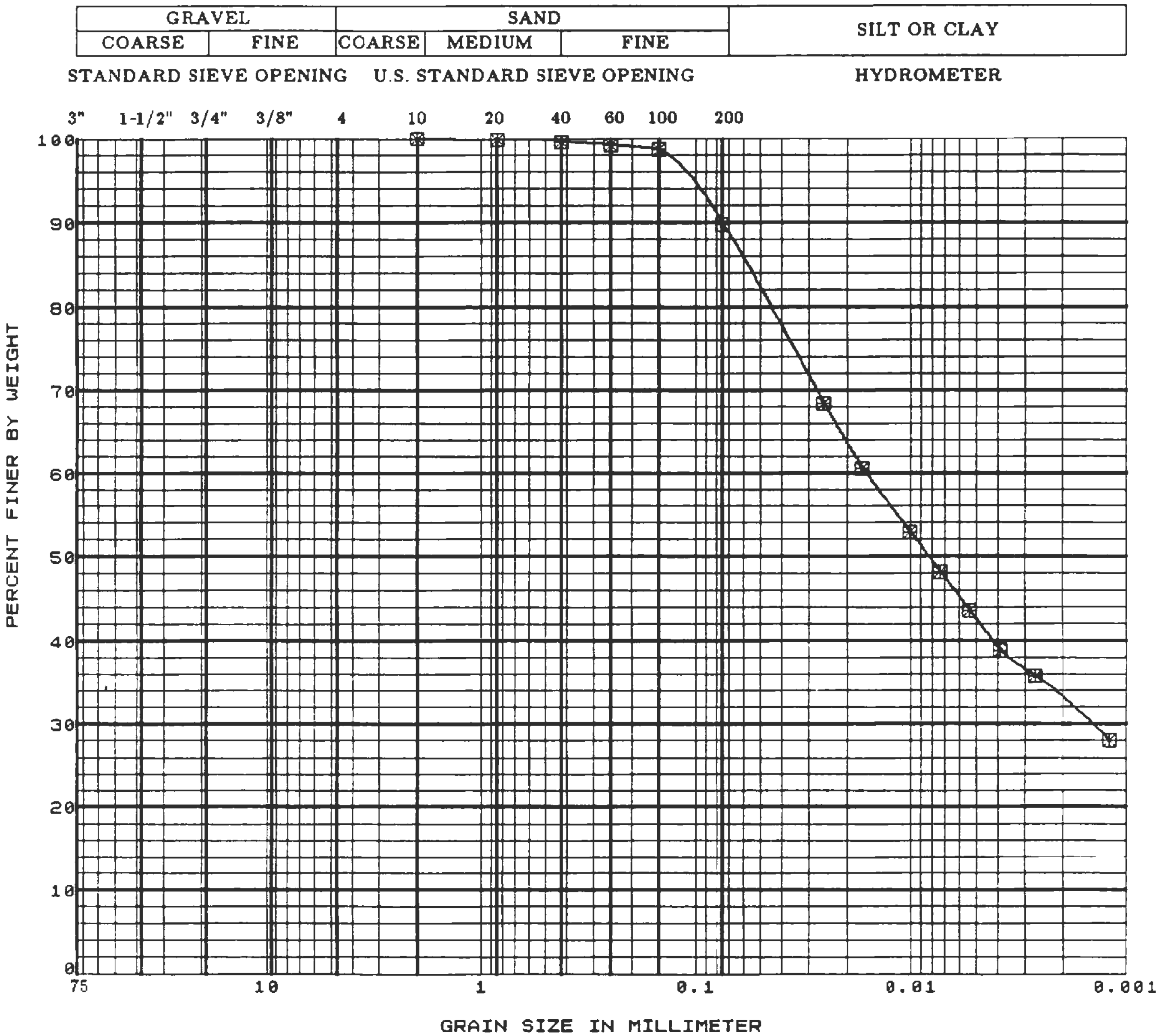
FIGURE B-19



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTI-CITY INDEX
⊠	PII-38	D - 13	65.0	DRIVE	SILTY CLAY(STONE)	54	32

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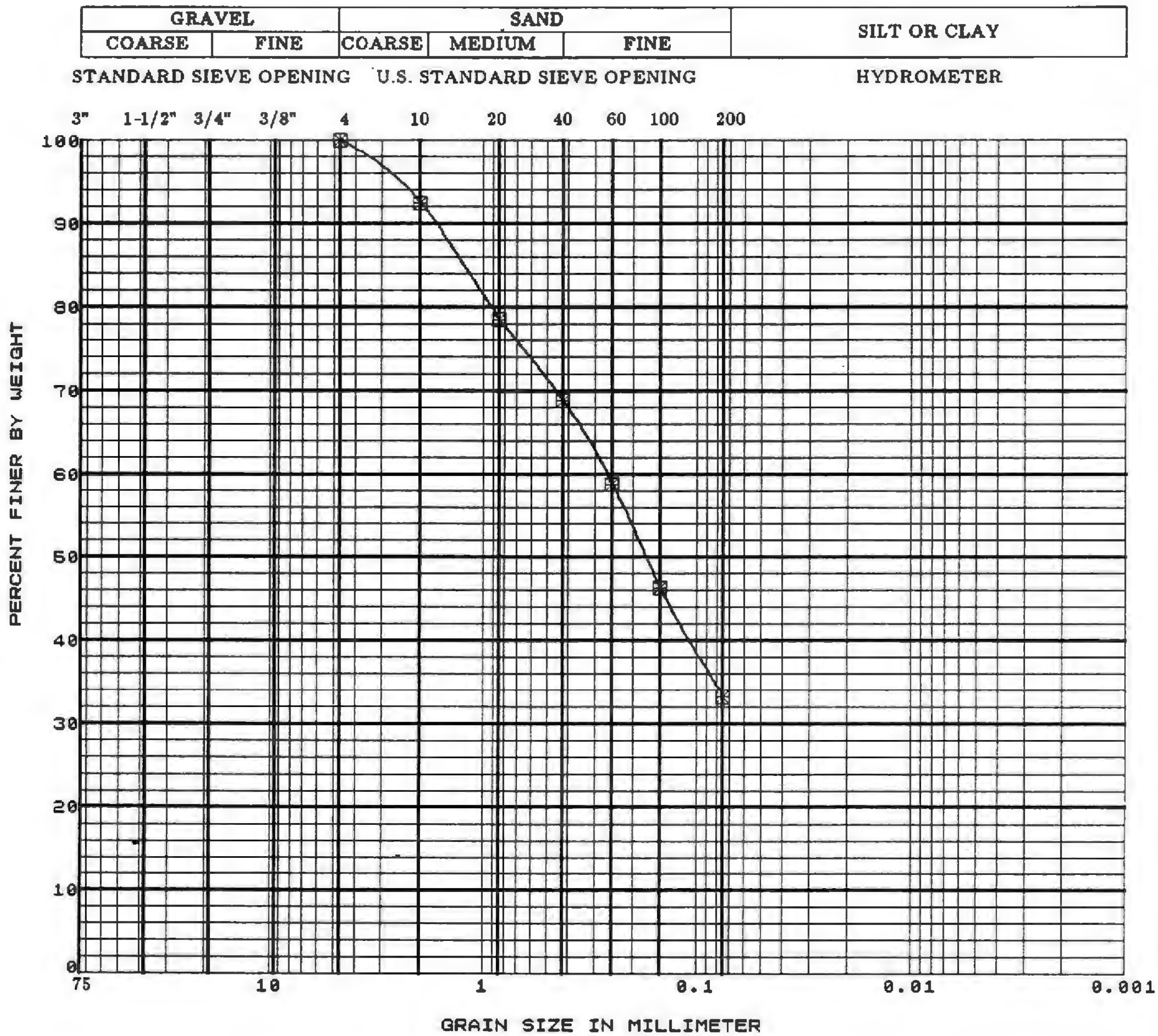
FIGURE B-20



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTI-CITY INDEX
⊠	PII-39	D-1	5.0	DRIVE	SILTY SAND(SM)		

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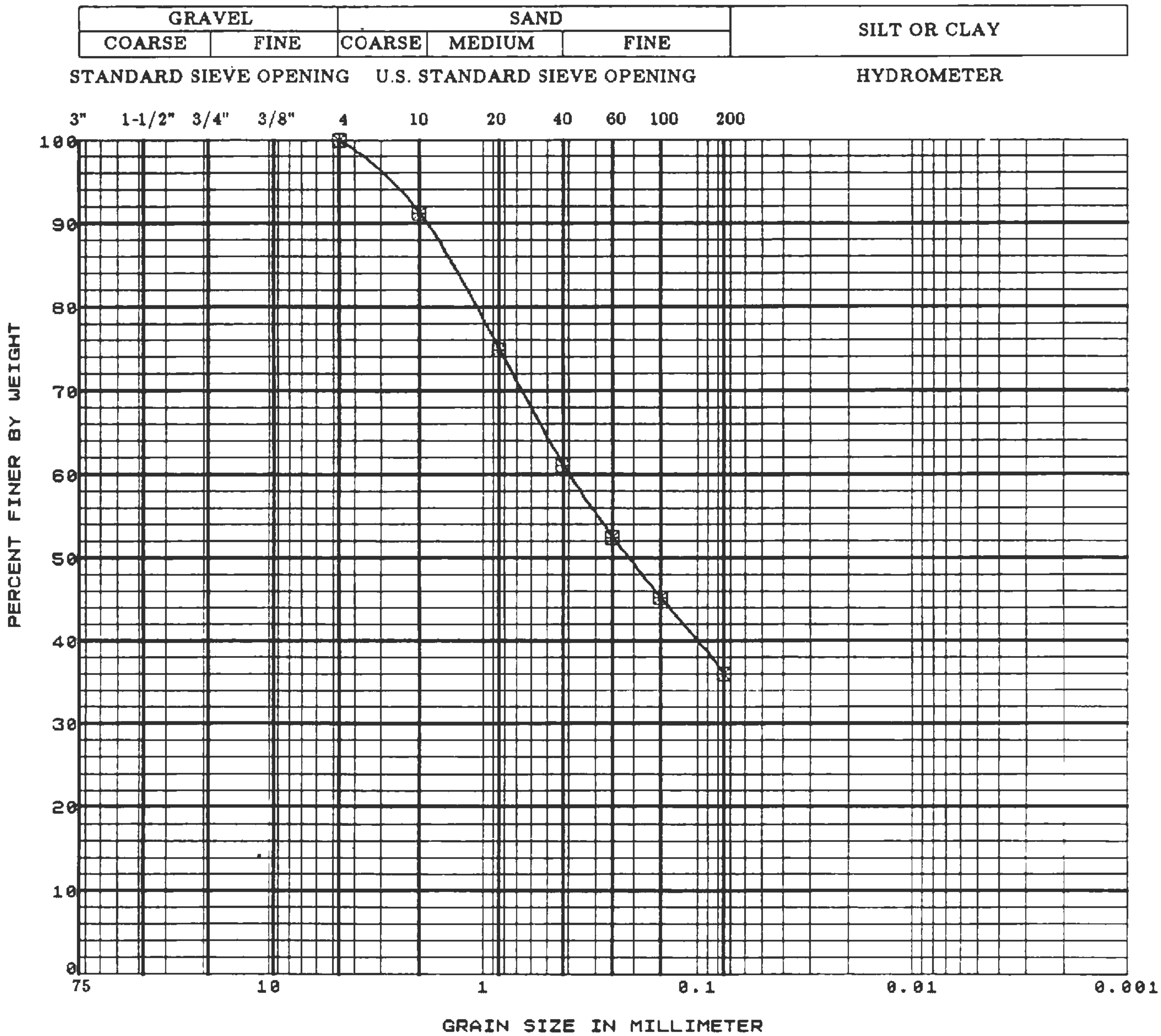
FIGURE B-21



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
⊠	PII-39	S - 4	20.0	SPT	CLAYEY SAND(SC)		

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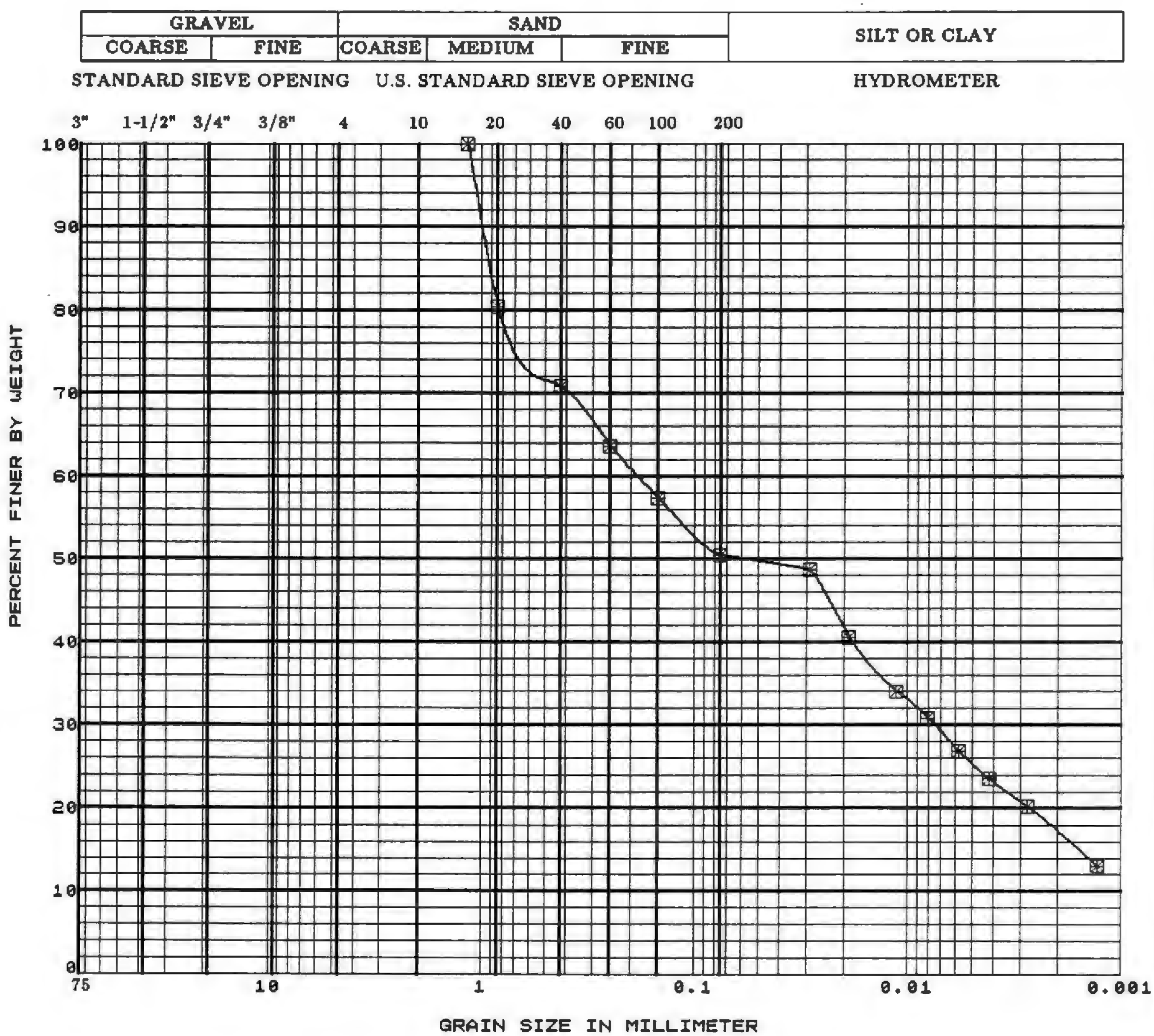
FIGURE B-22



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTI-CITY INDEX
⊠	PII-39	D-5	25.0	DRIVE	CLAYEY SAND(SC)		

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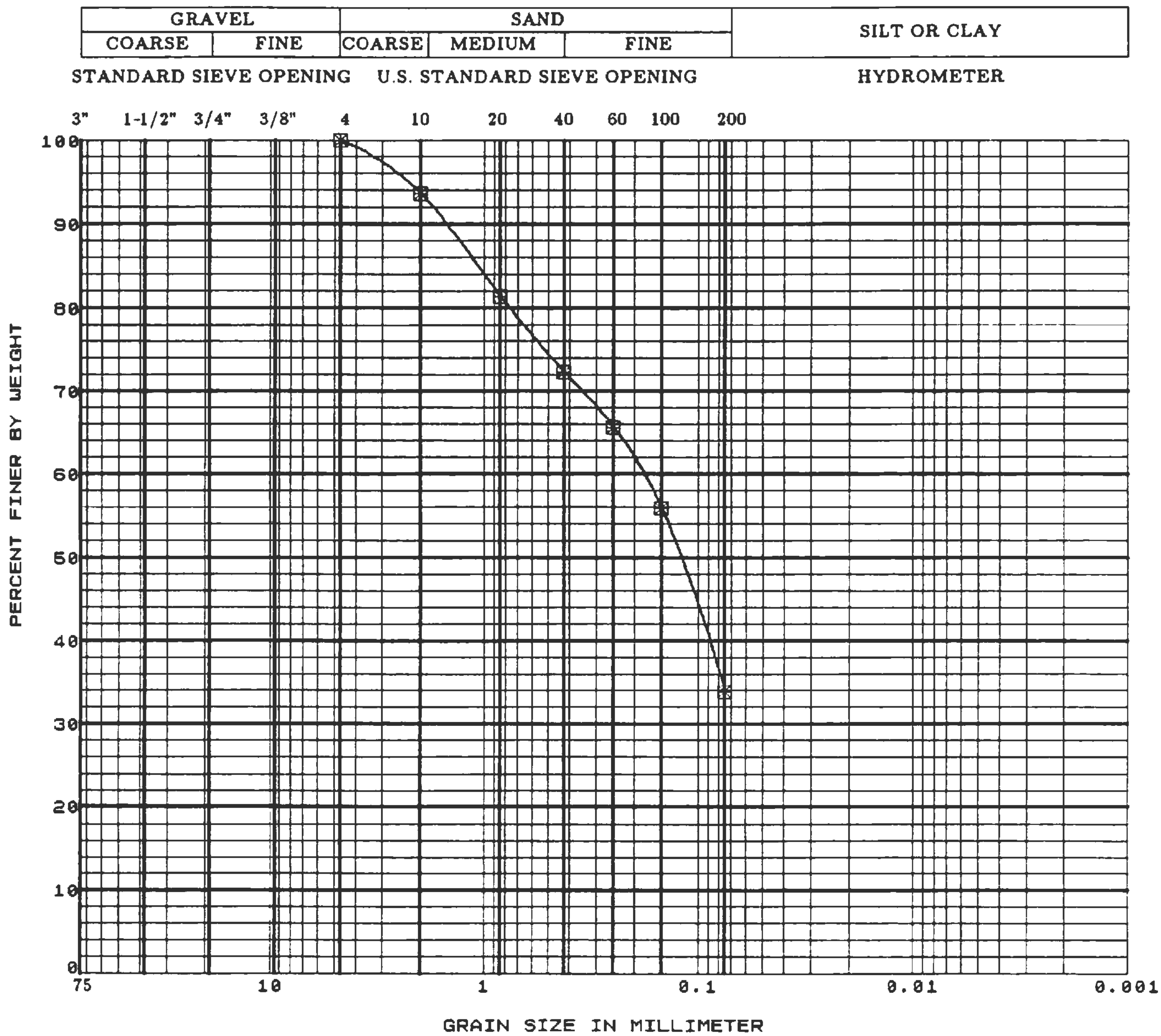
FIGURE B-23



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
⊠	PII-39	D-7	35.0	DRIVE	SILTY SAND(SM)		

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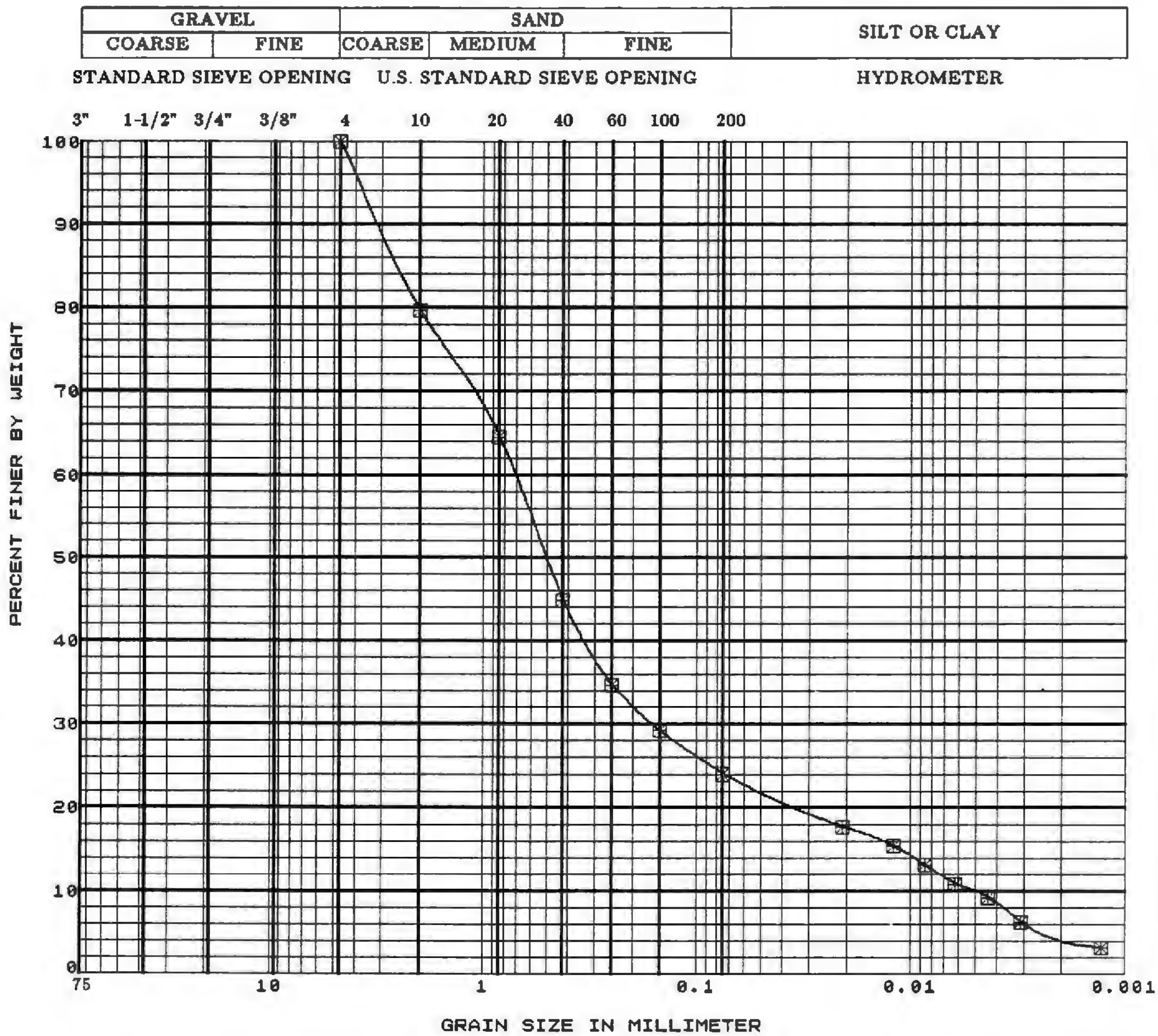
FIGURE B-24



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTI-CITY INDEX
⊠	PII-41	D-4	10.0	DRIVE	SILTY SAND(SM)		

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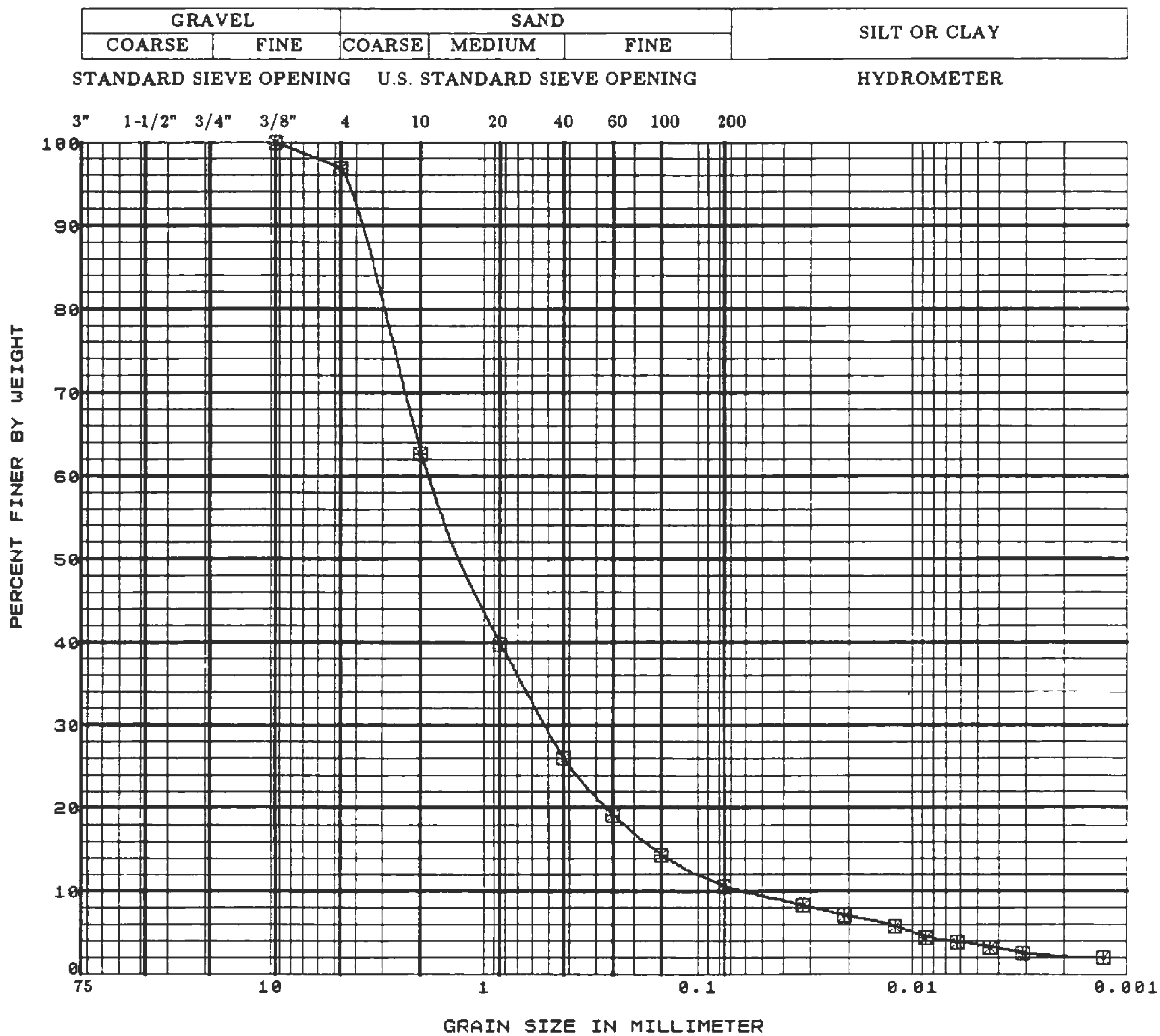
FIGURE B-25



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTI-CITY INDEX
⊠	PII-42	D-3	15.0	DRIVE	SAND-SILTY SAND(SP-SM)		

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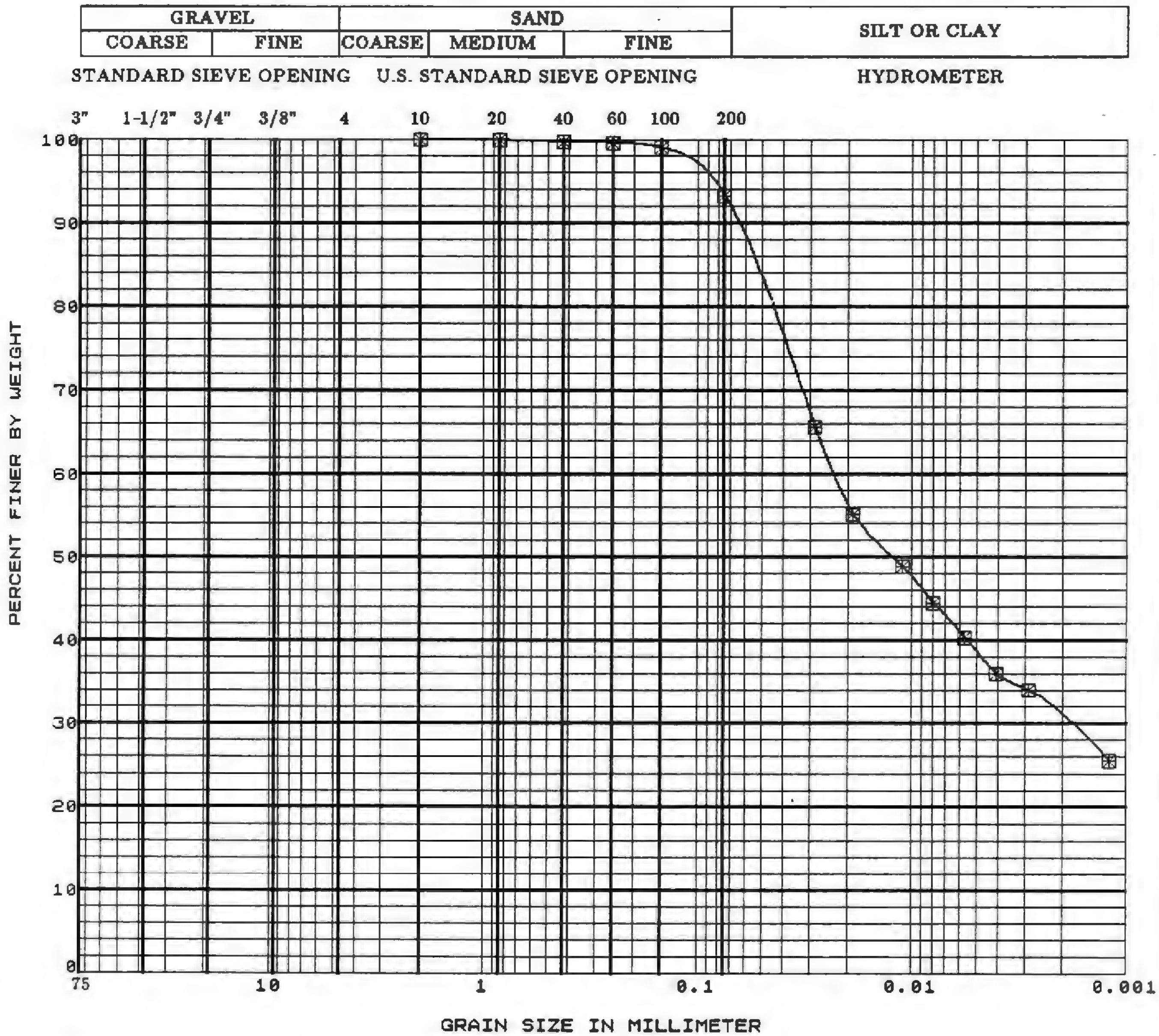
FIGURE B-26



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
⊠	PII-43	D-1	5.0	DRIVE	CLAY(STONE)	70	46

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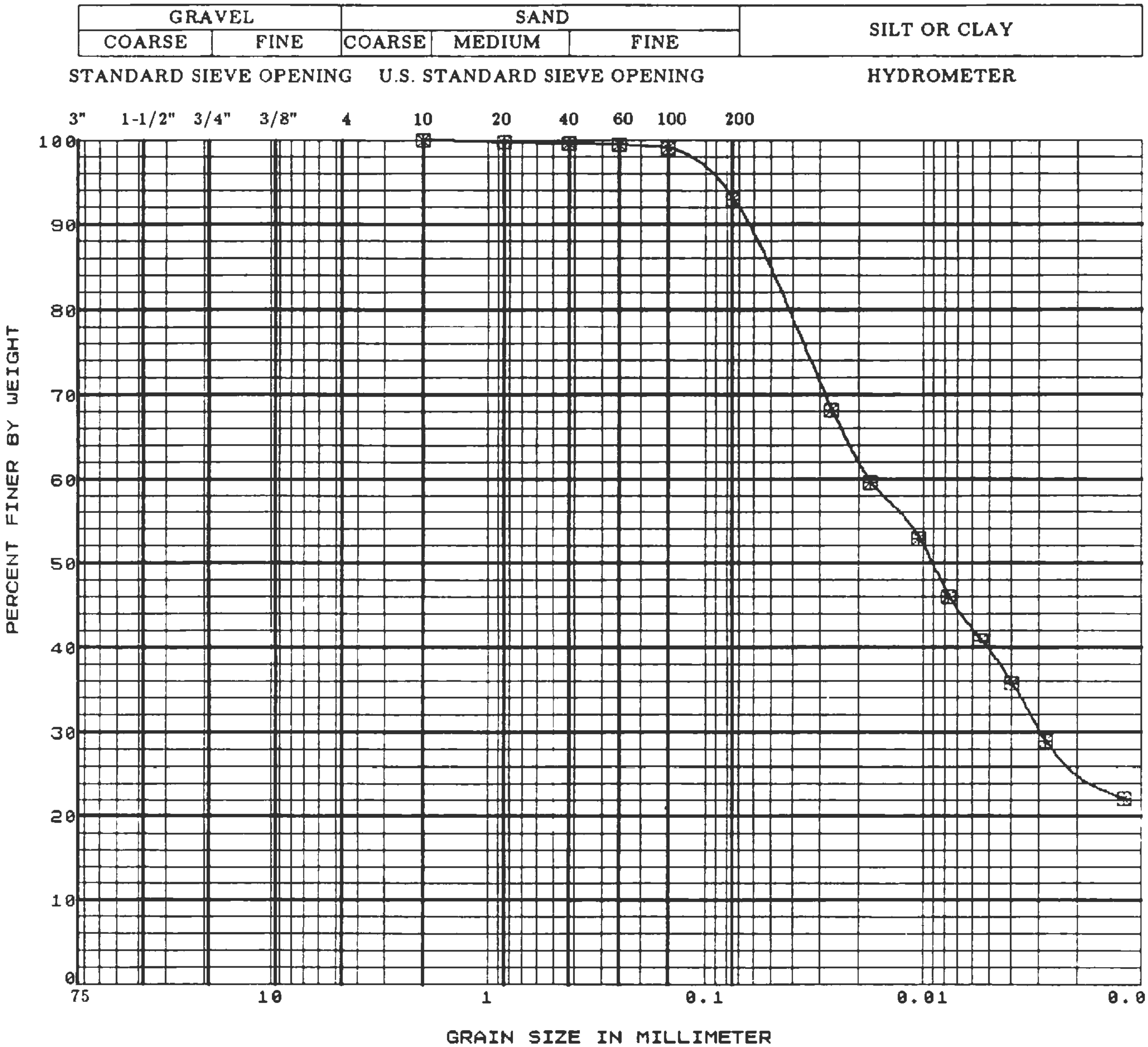
FIGURE B-27



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTI-CITY INDEX
⊠	PII-43	D-11	55.0	DRIVE	CLAYEY SILT(STONE)		

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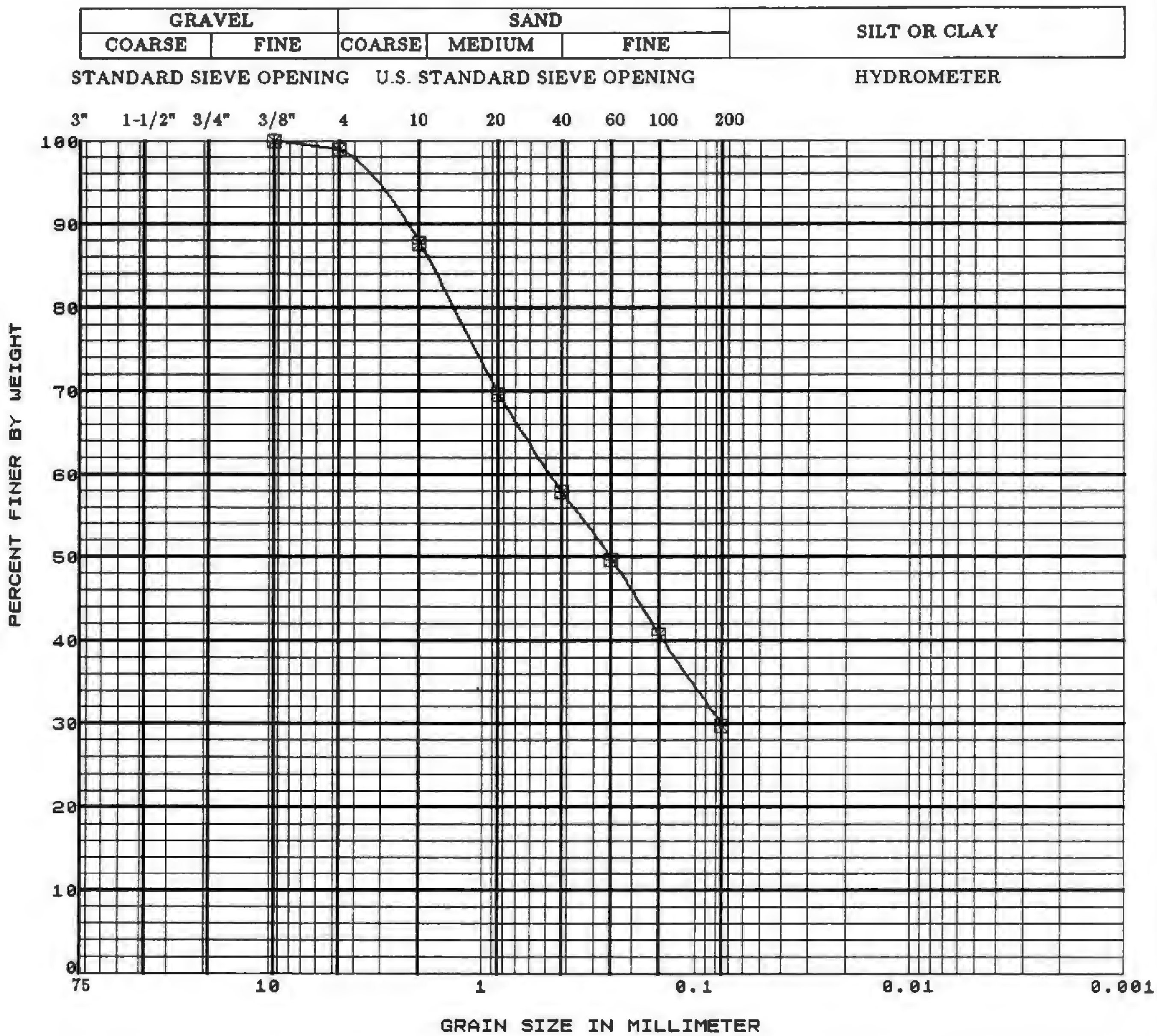
FIGURE B-28



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTI-CITY INDEX
⊠	PH-44	D-2	10.0	DRIVE	CLAYEY SAND(SC)		

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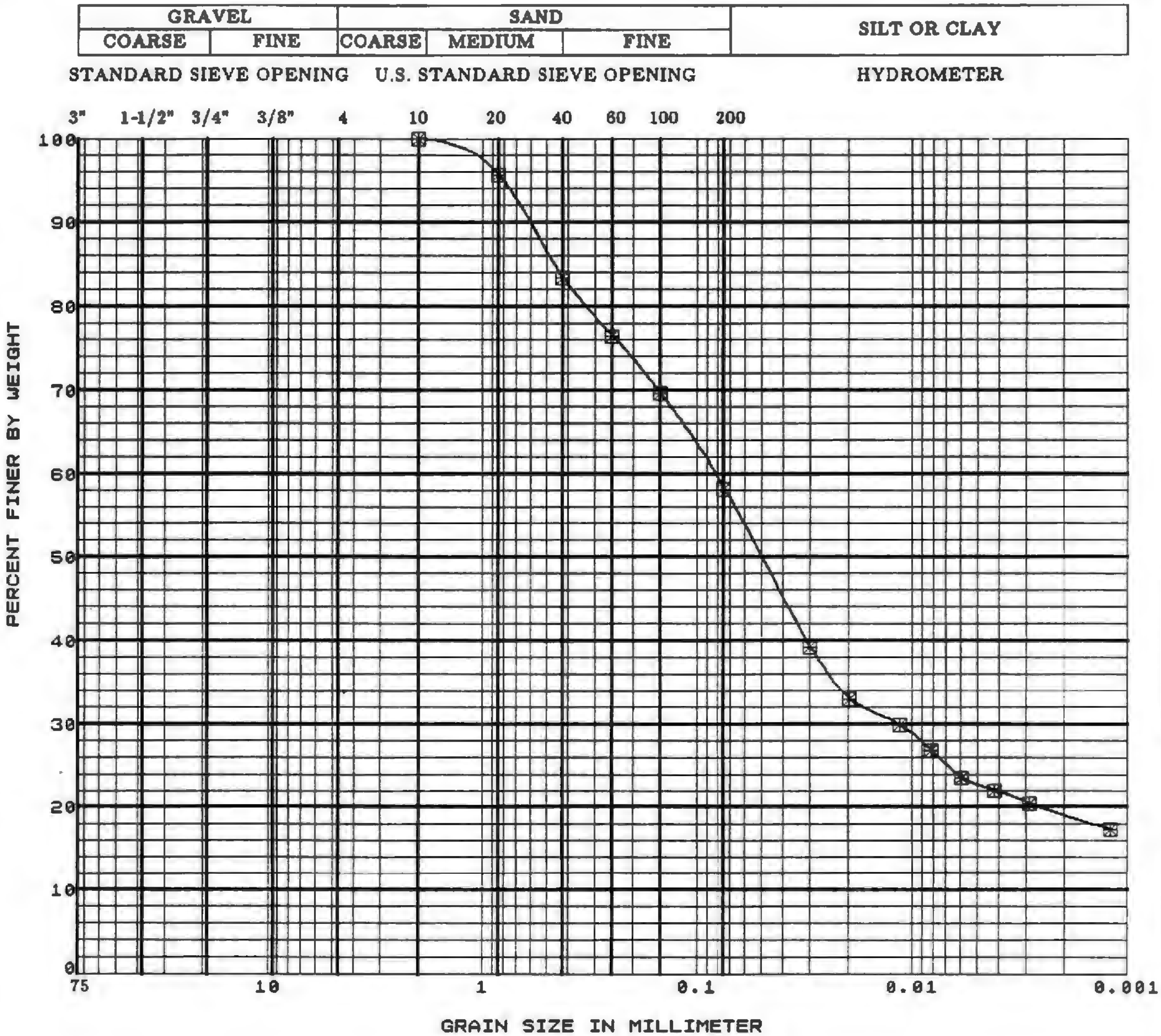
FIGURE B-29



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTI-CITY INDEX
⊠	PII-44	D-8	40.0	DRIVE	SANDY CLAY/ CLAYEY SAND	35	20

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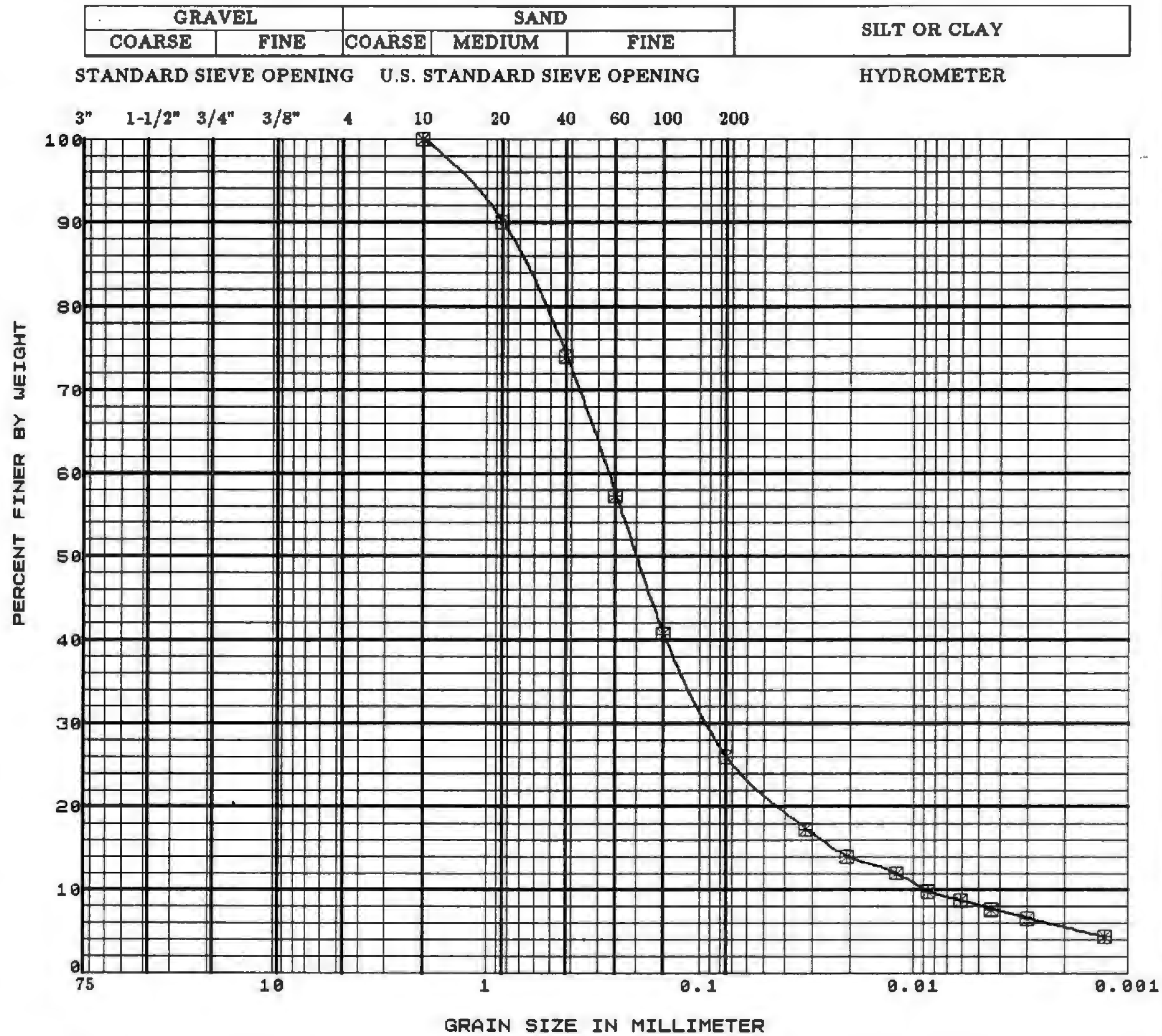
FIGURE B-30



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTI-CITY INDEX
⊠	PII-44	D-10	50.0	DRIVE	SILTY SAND(SM)		

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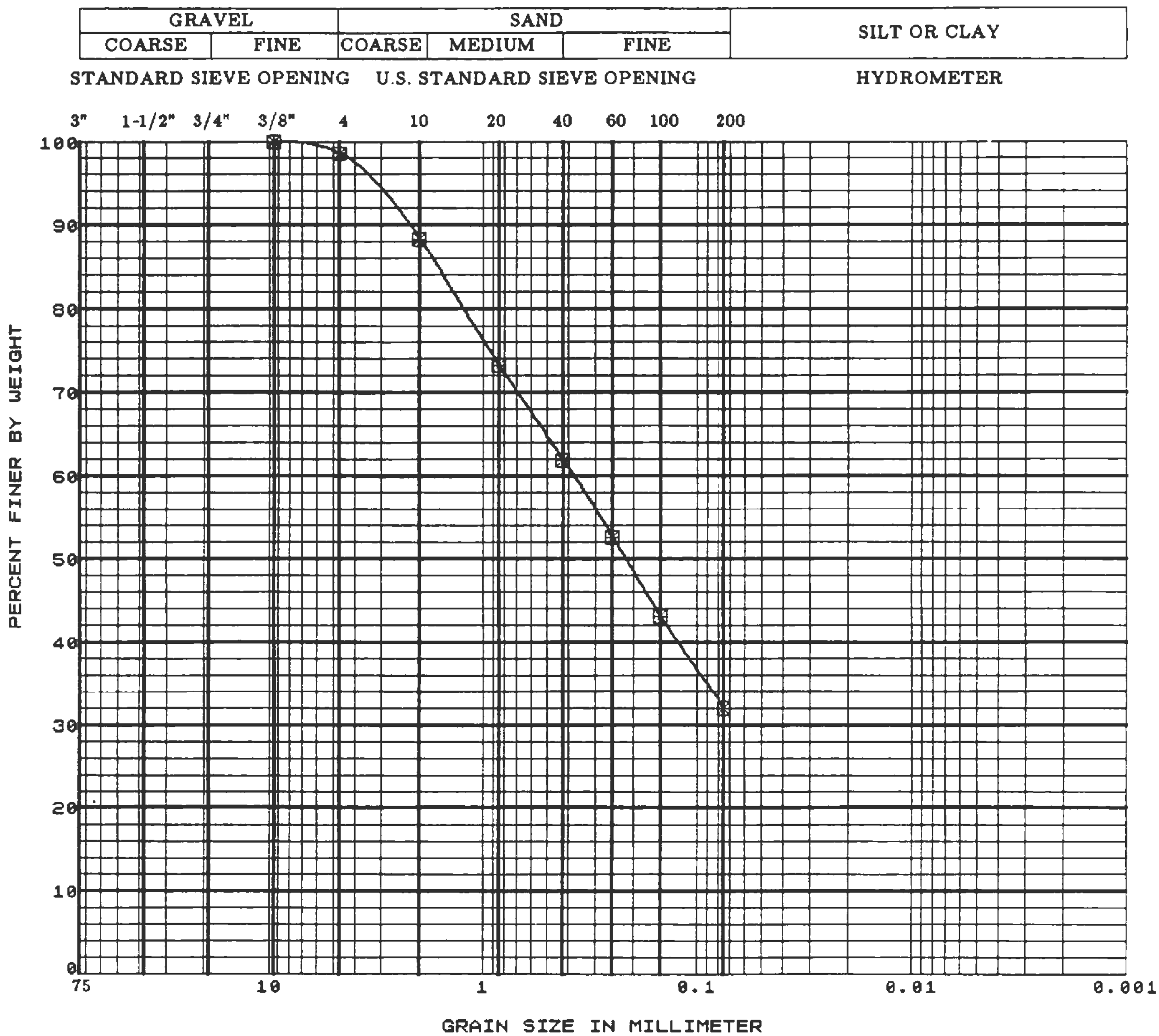
FIGURE B-31



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
⊠	PII-44	S - 11	55.0	SPT	SILTY SAND(SM)		

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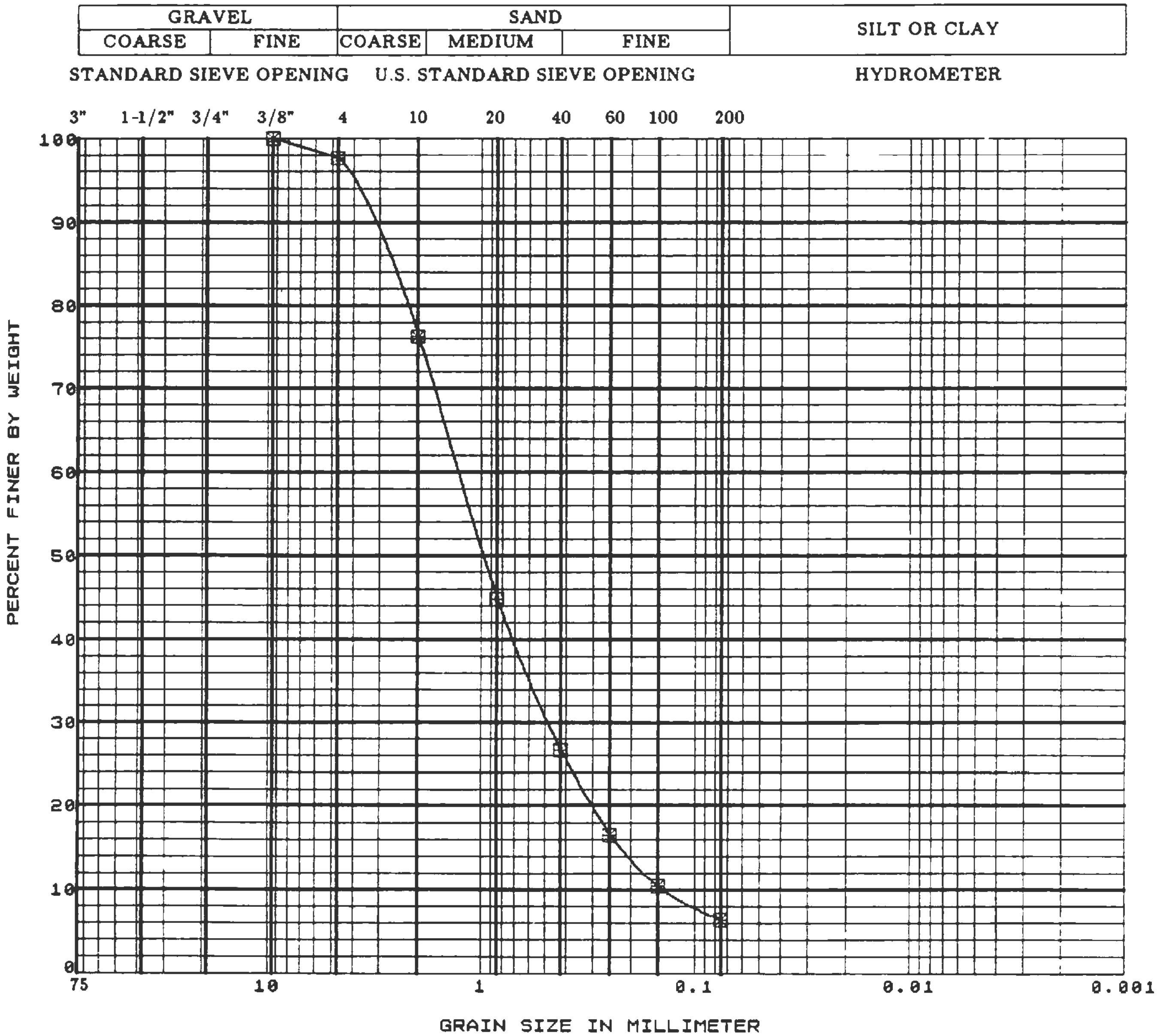
FIGURE B-32



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTI-CITY INDEX
⊠	PII-44	D-12	60.0	DRIVE	SAND-SILTY SAND(SP-SM)		

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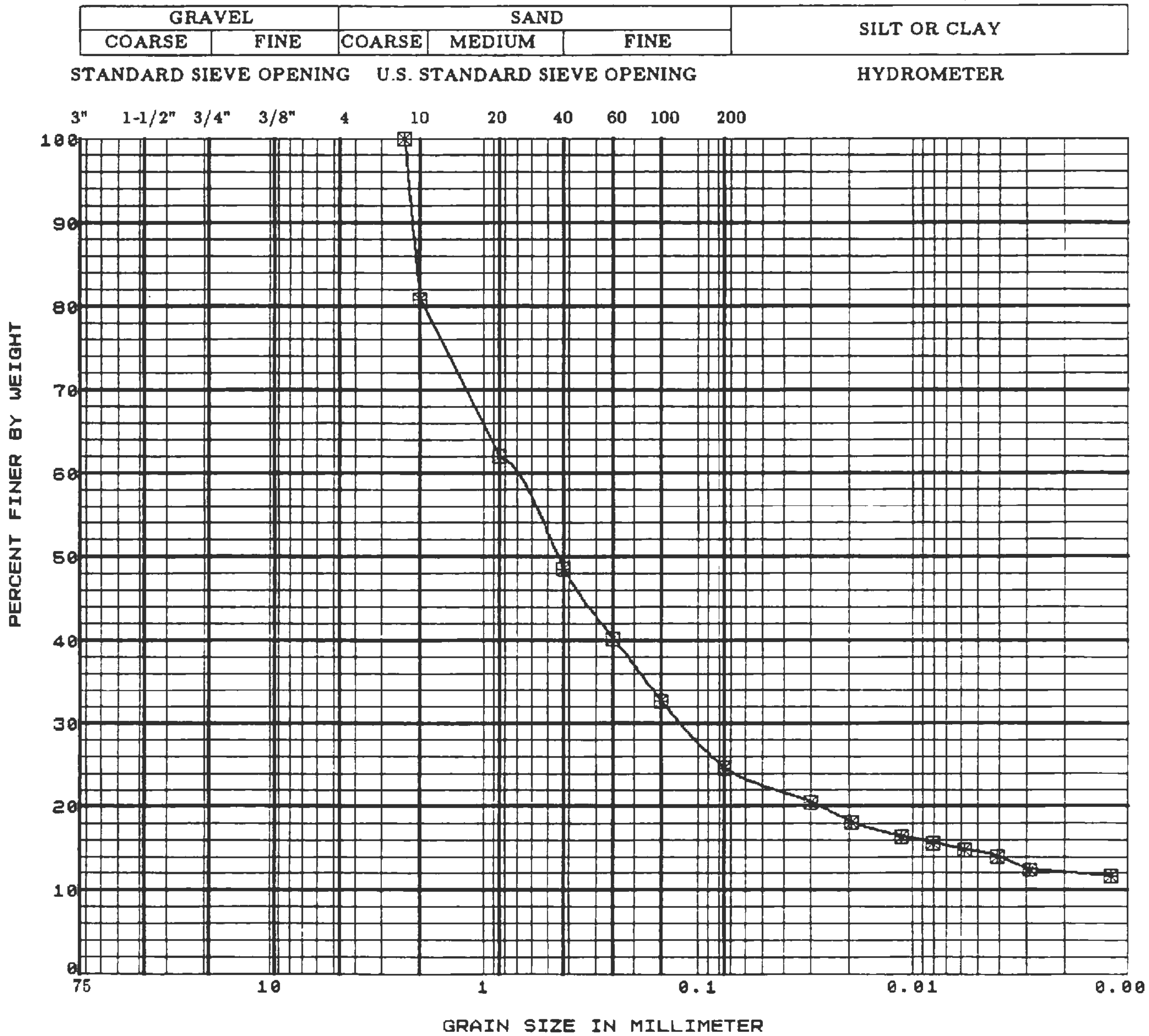
FIGURE B-33



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTI-CITY INDEX
⊠	PII-45	D-4	20.0	DRIVE	CLAYEY SAND(SC)		

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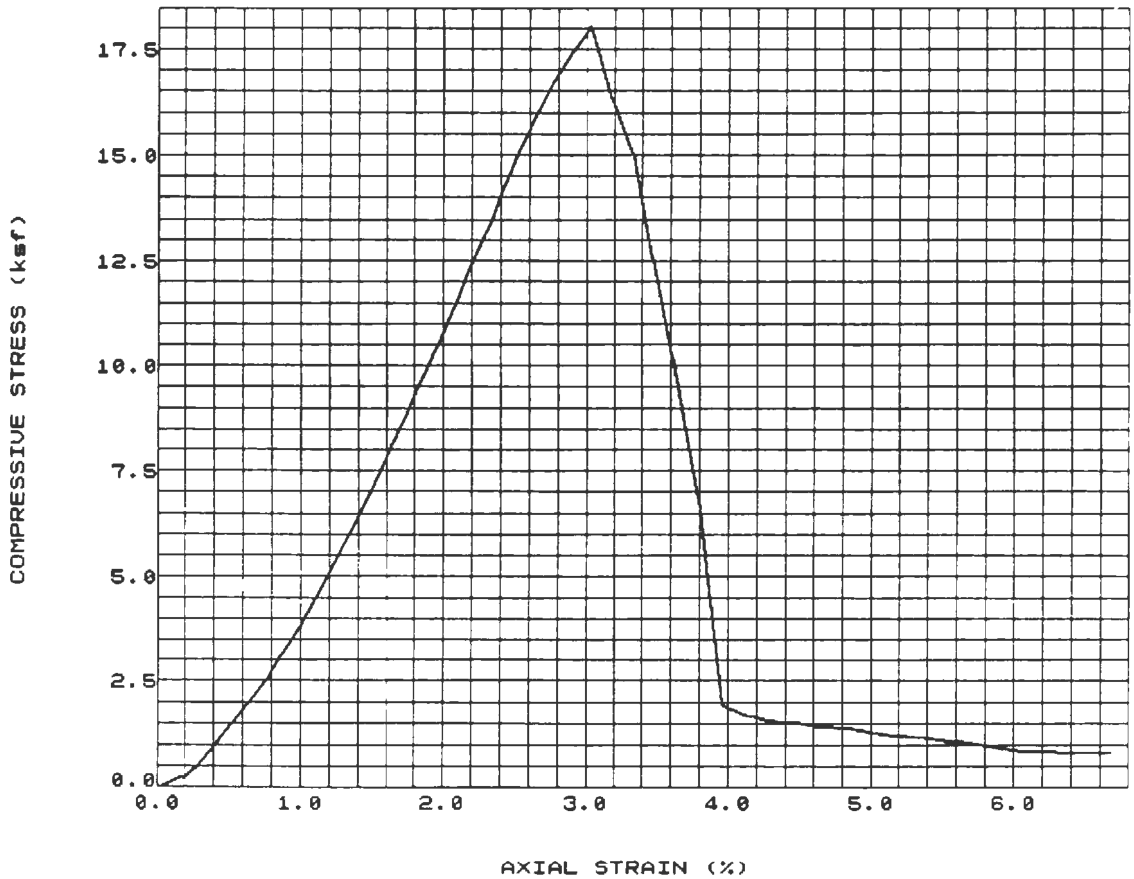
FIGURE B-34



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COMPRESSIVE STRENGTH (ksf)	RESIDUAL STRENGTH (ksf)
	PII-27	P-9	45-47.5	PITCHER	CLAYEY SILTSTONE	18.0	0.81

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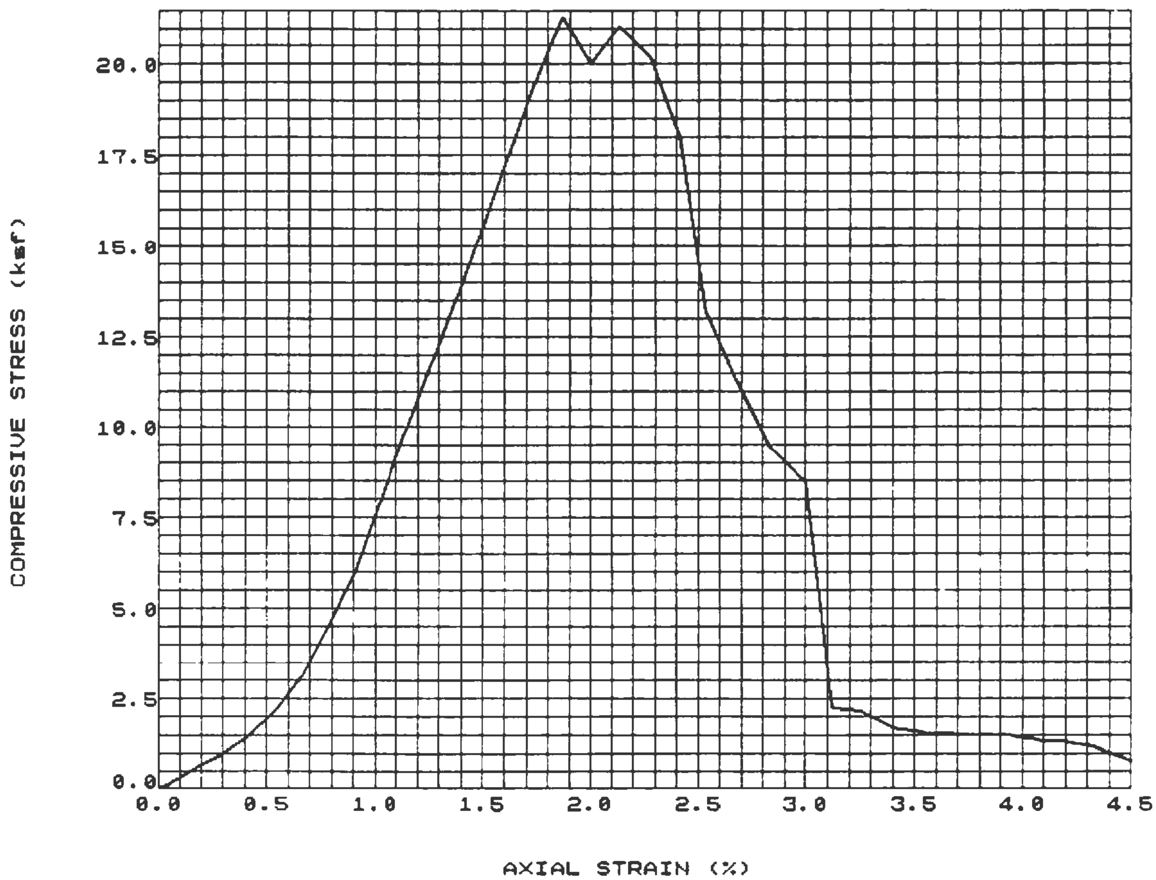
FIGURE B-35



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COMPRESSIVE STRENGTH (ksf)	RESIDUAL STRENGTH (ksf)
	PII-27	P-13	65-67.5	PITCHER	CLAYEY SILTSTONE	21.3	0.76

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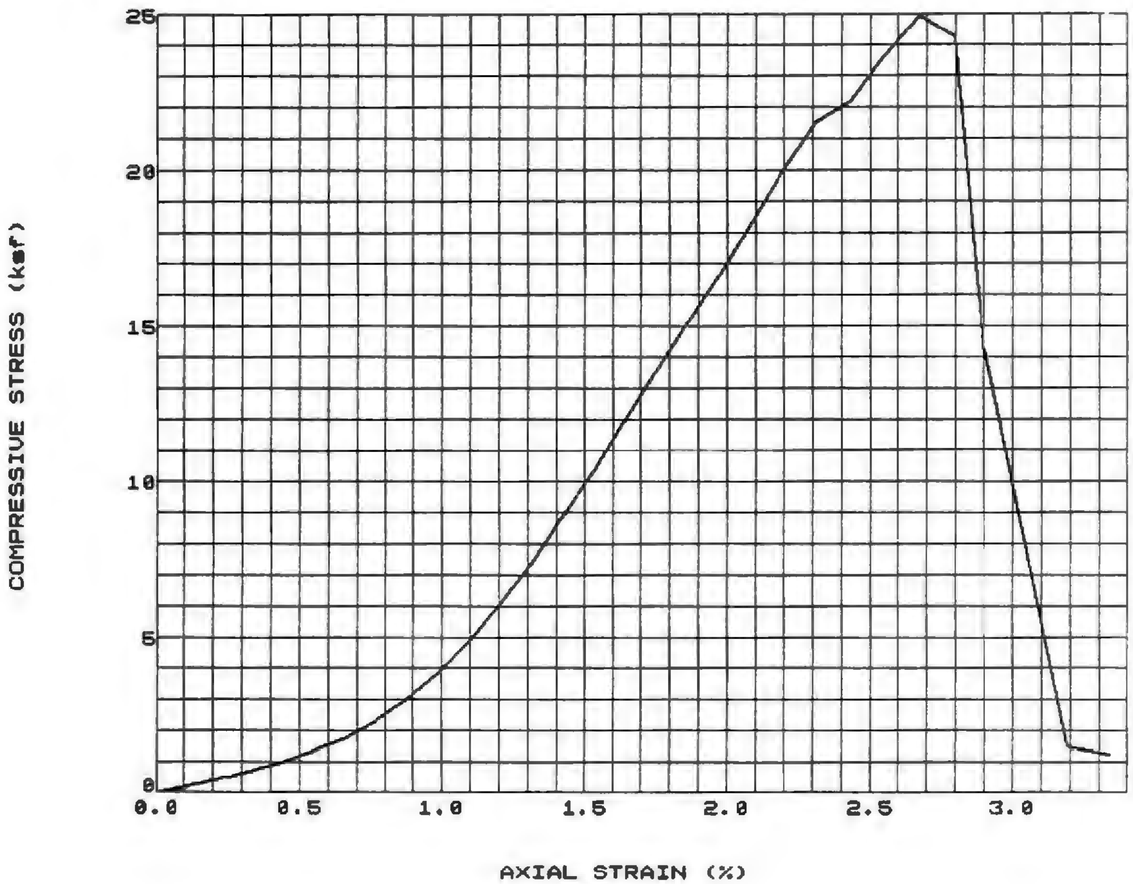
FIGURE B-36



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COMPRESSIVE STRENGTH (ksf)	RESIDUAL STRENGTH (ksf)
	PII-28	P-8	40-42.5	PITCHER	CLAYEY SILT(STONE)	24.9	1.2

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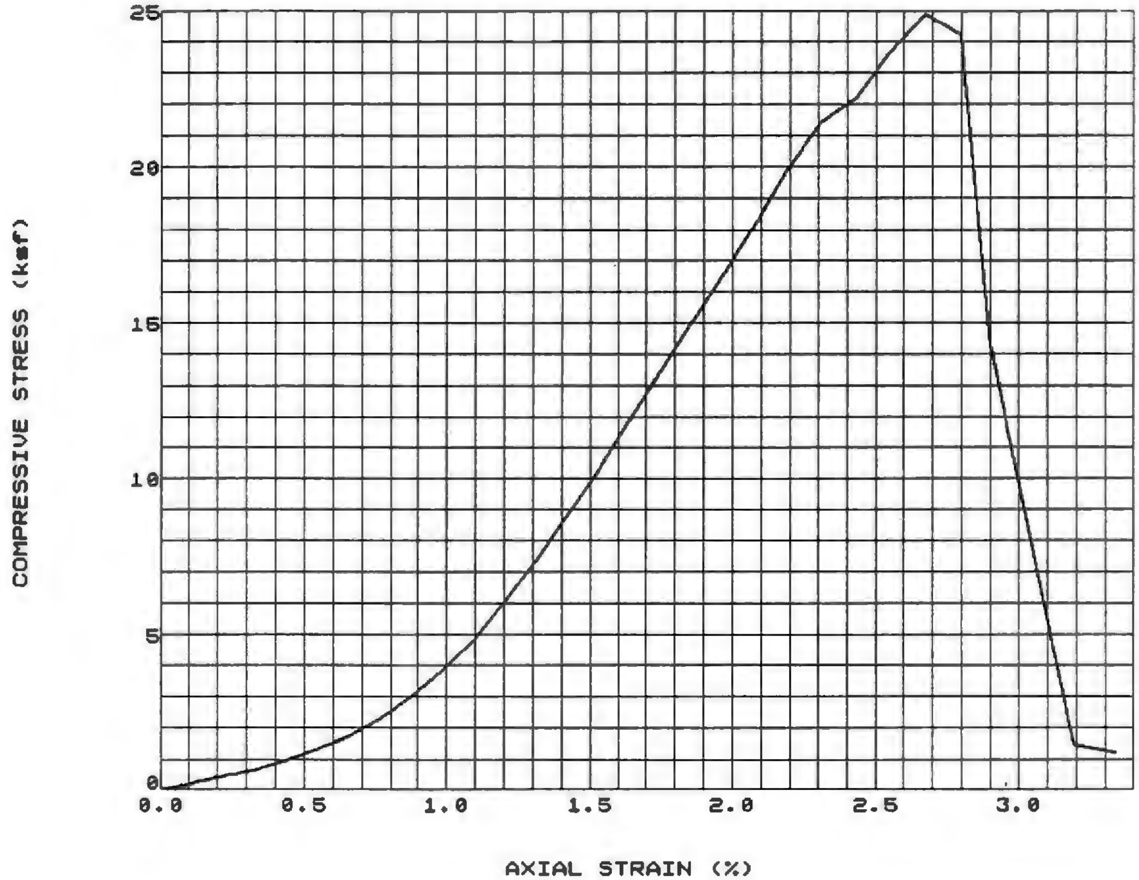
FIGURE B-37



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COMPRESSIVE STRENGTH (ksf)	RESIDUAL STRENGTH (ksf)
	PII-28A	P-11	55-57.5	PITCHER	CLAYEY SILTSTONE	24.8	1.20

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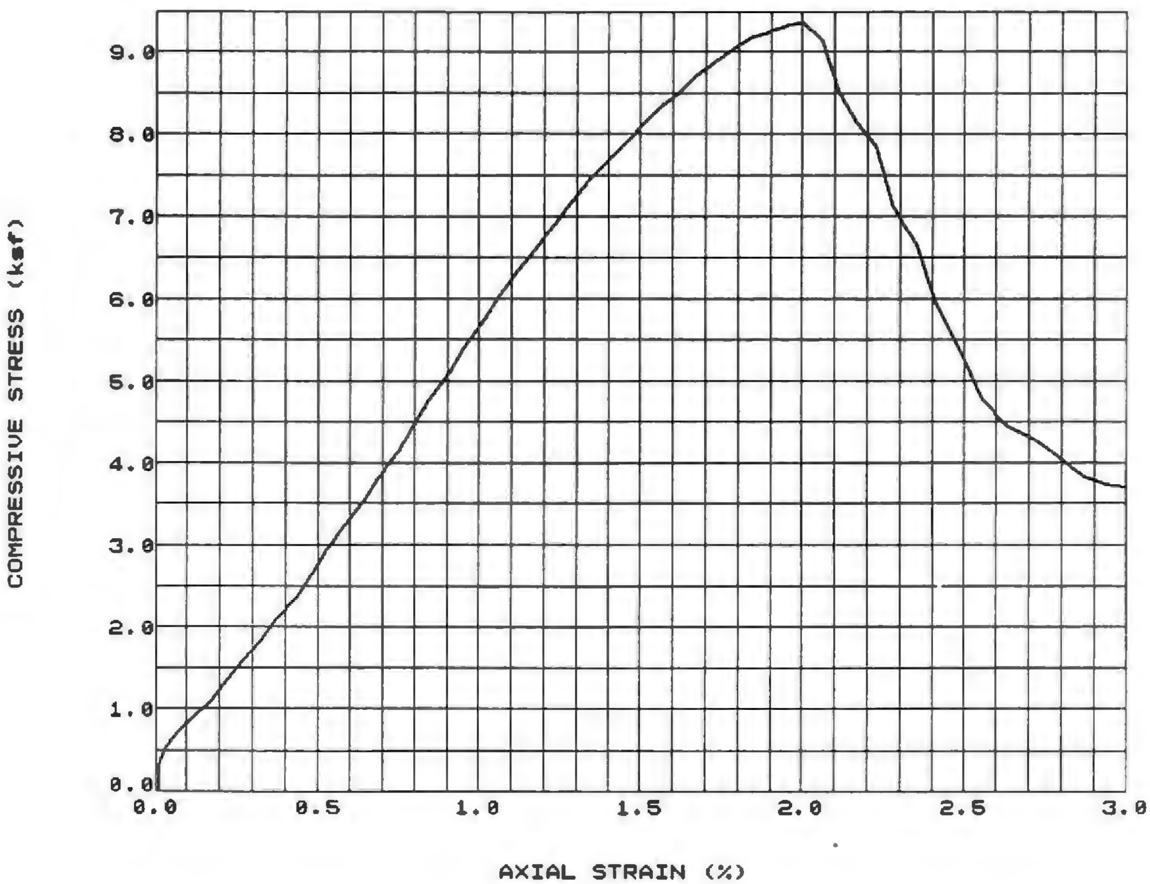
FIGURE B-38



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COMPRESSIVE STRENGTH (ksf)	RESIDUAL STRENGTH (ksf)
	PII-29	P-7	35-37.5	PITCHER	SILTY CLAY(STONE)	9.34	3.69

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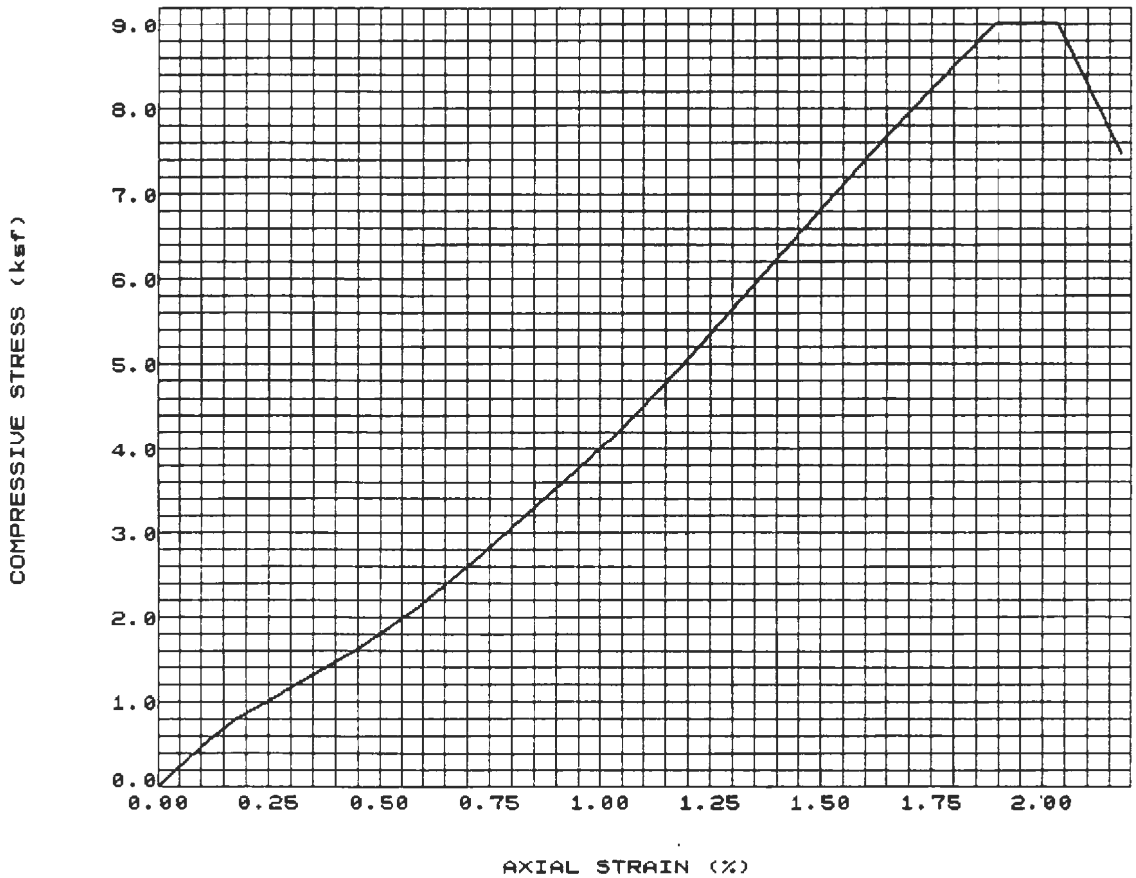
FIGURE B-39



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COMPRESSIVE STRENGTH (ksf)	RESIDUAL STRENGTH (ksf)
	PII-30	P-6	30-32.5	PITCHER	SILTY CLAY(STONE)	9.00	7.46

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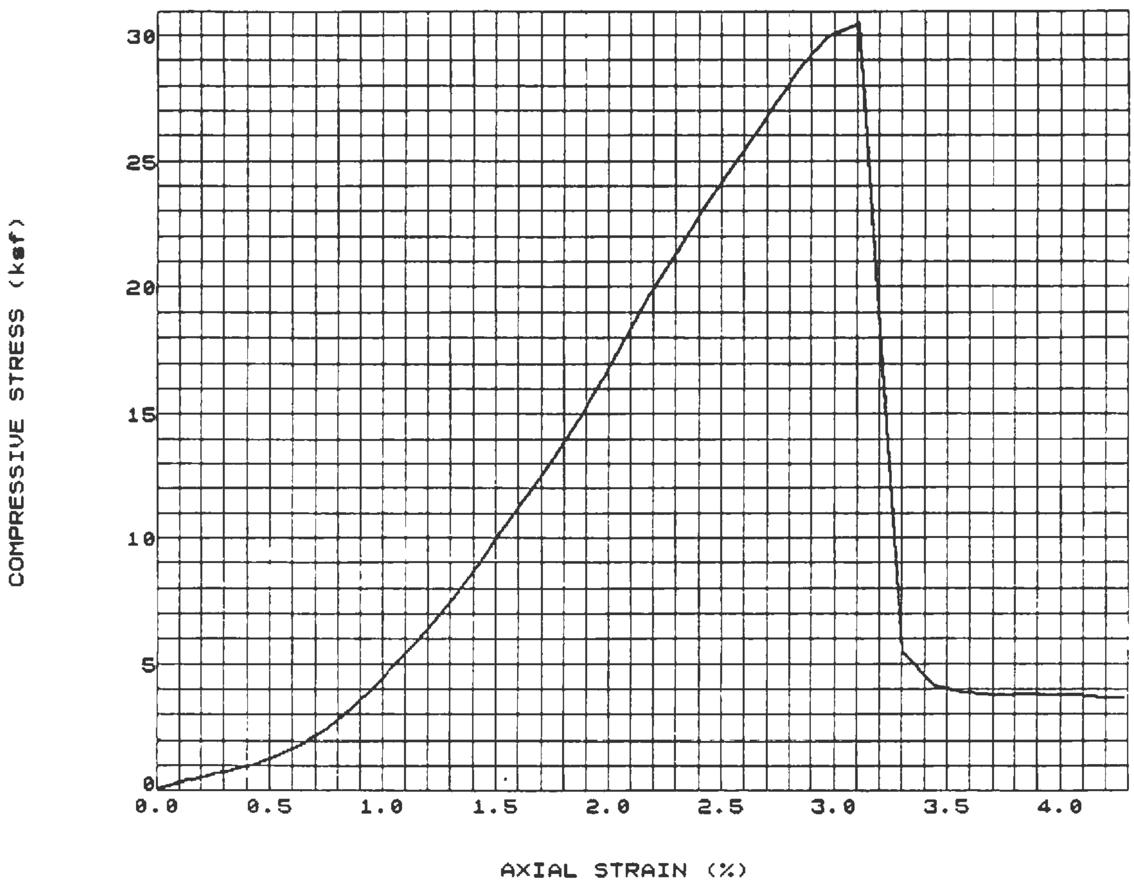
FIGURE B-40



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COMPRESSIVE STRENGTH (ksf)	RESIDUAL STRENGTH (ksf)
	PII-31	P-10	50-52.5	PITCHER	CLAYEY SILTSTONE	30.5	3.63

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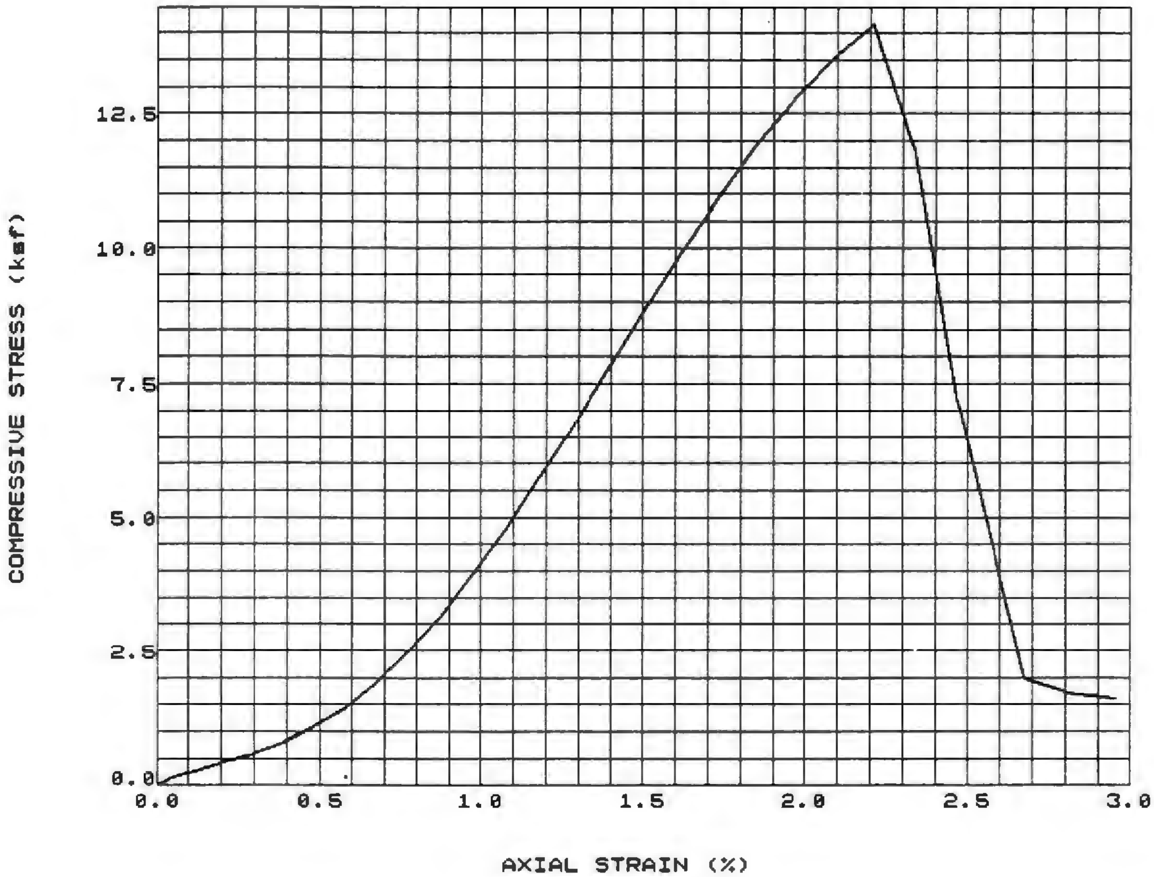
FIGURE B-41



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COMPRESSIVE STRENGTH (ksf)	RESIDUAL STRENGTH (ksf)
	PII-32	P-11	55-57.5	PITCHER	CLAYEY SILTSTONE	14.2	1.61

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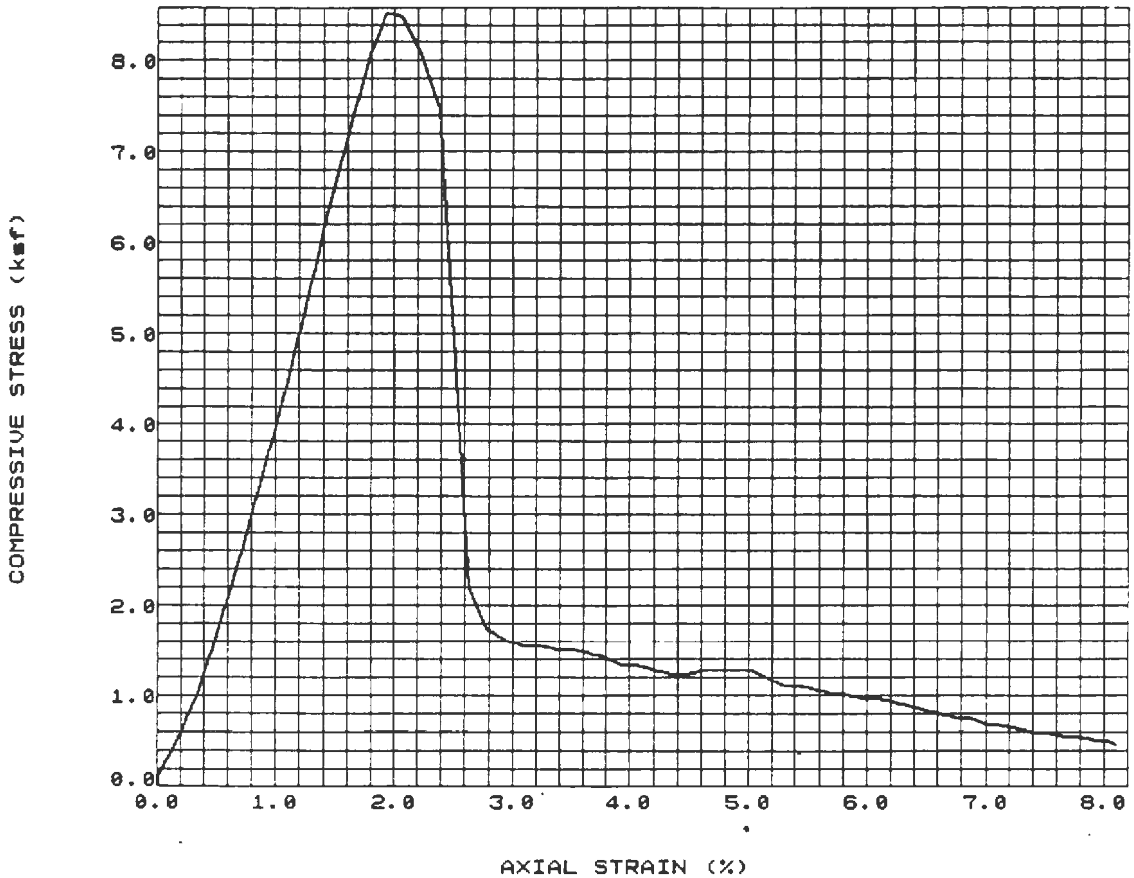
FIGURE B-42



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COMPRESSIVE STRENGTH (ksf)	RESIDUAL STRENGTH (ksf)
	PII-33	P-6	30-32.5	PITCHER	CLAYEY SILT(STONE)	8.53	0.49

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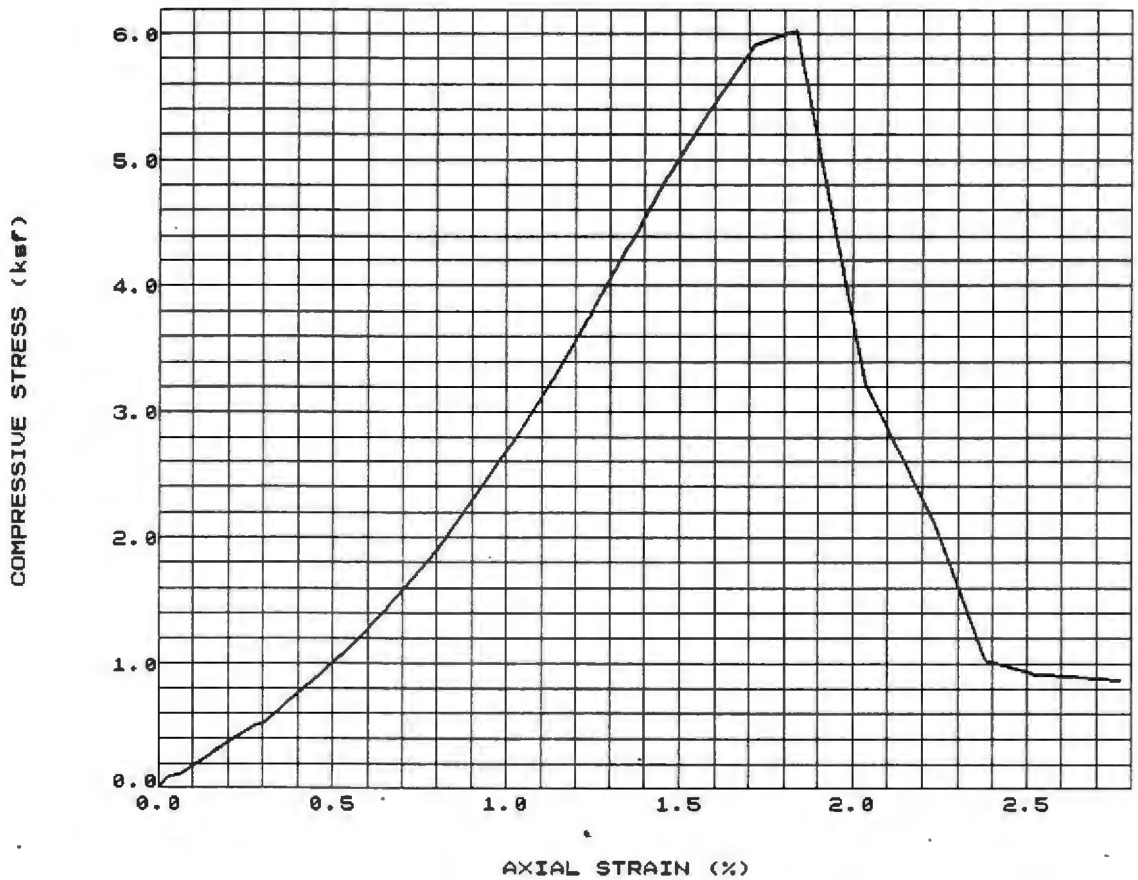
FIGURE B-43



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COMPRESSIVE STRENGTH (ksf)	RESIDUAL STRENGTH (ksf)
	PII-34	P-7	35-37.5	PITCHER	SILTY CLAY(STONE)	6.00	0.86

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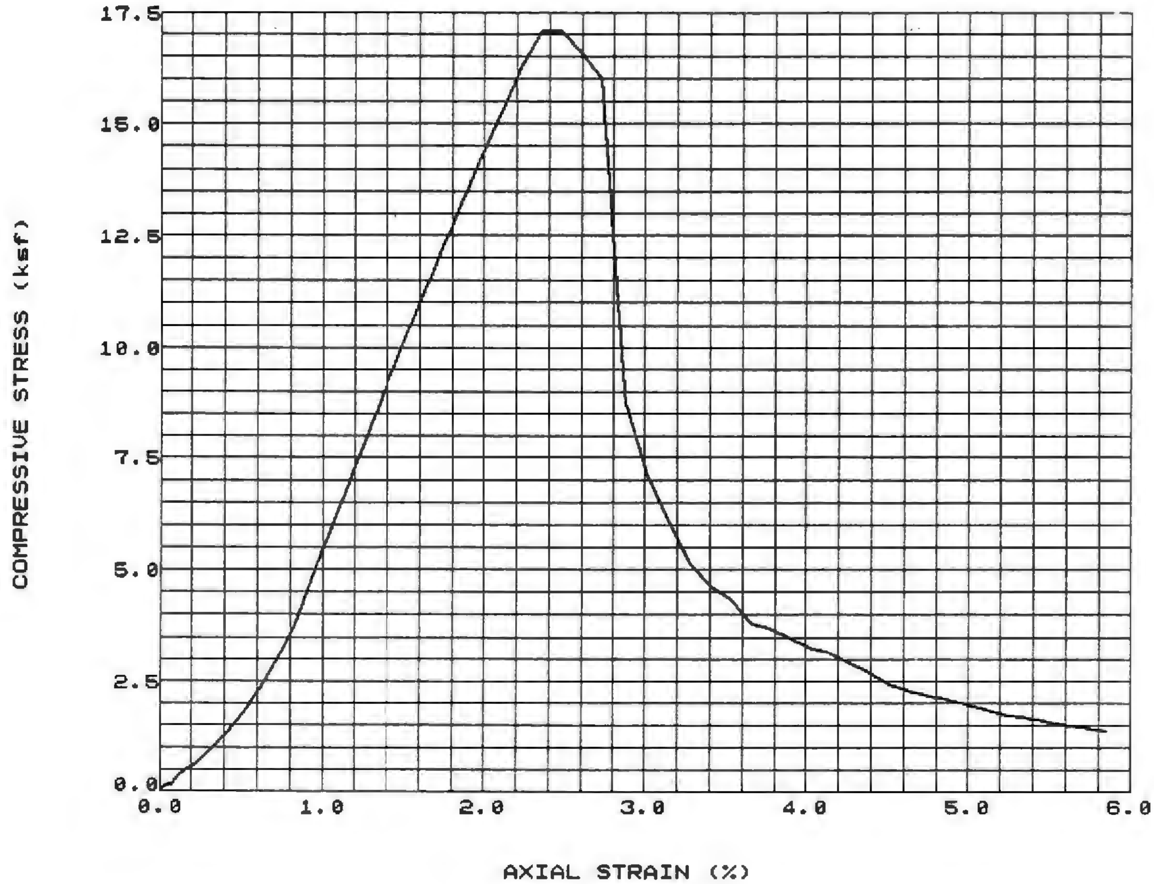
FIGURE B-44



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COMPRESSIVE STRENGTH (ksf)	RESIDUAL STRENGTH (ksf)
	PII-34	P-13	65-67	PITCHER	CLAYEY SILTSTONE	17.0	1.36

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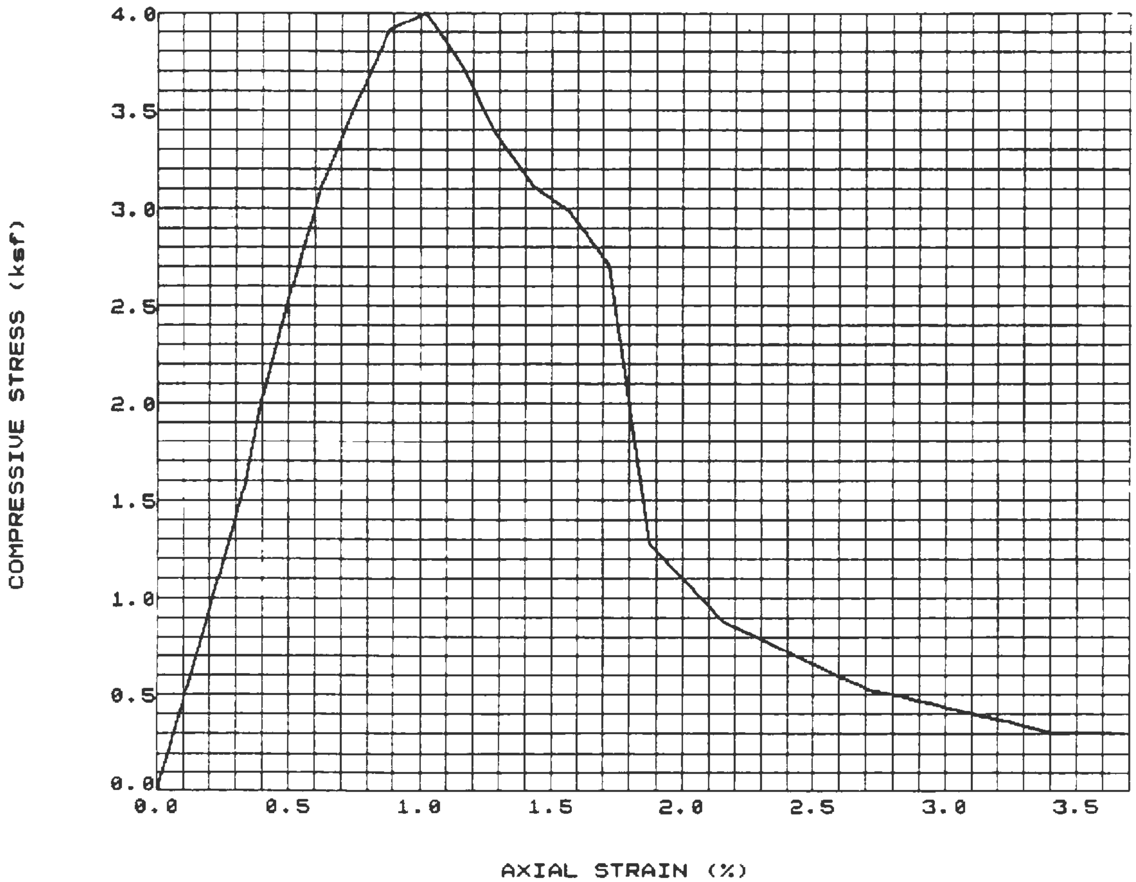
FIGURE B-45



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COMPRESSIVE STRENGTH (ksf)	RESIDUAL STRENGTH (ksf)
	PII-35	P-10	50-52.5	PITCHER	SILT(STONE)	4.00	0.30

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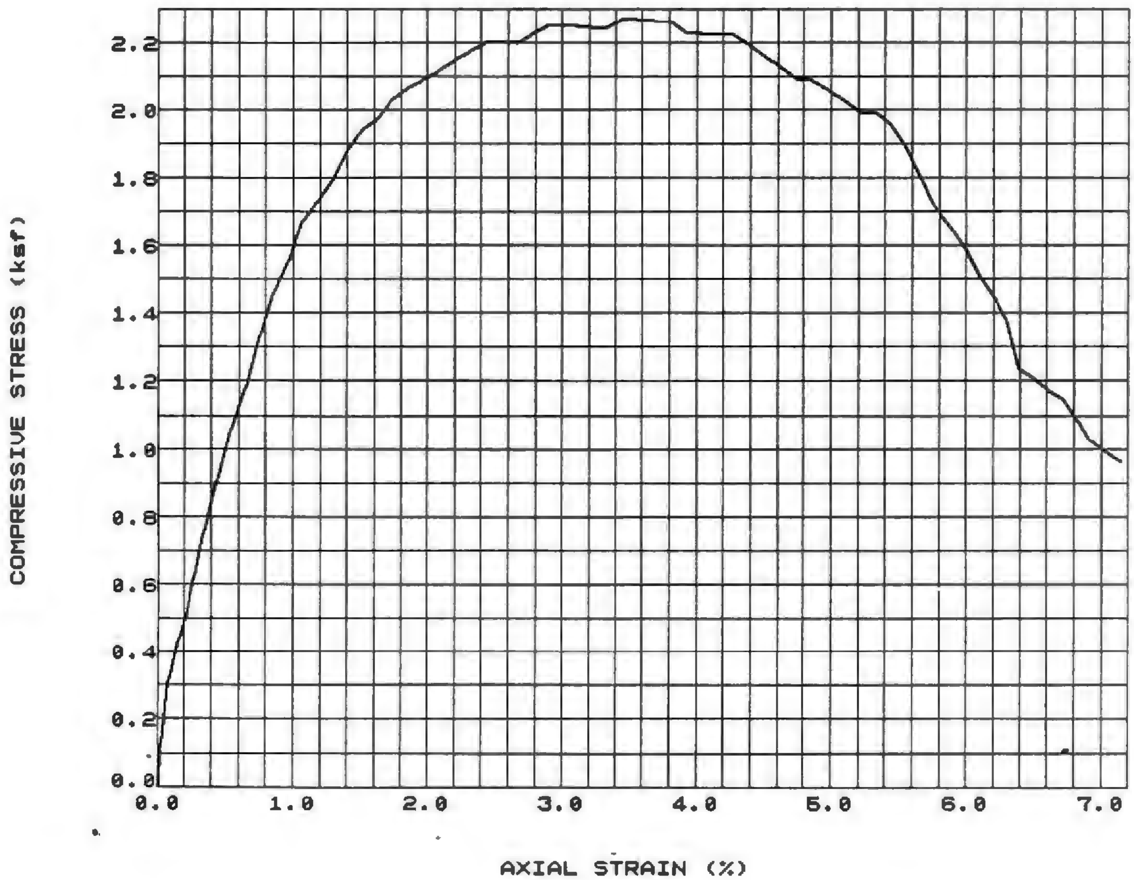
FIGURE B-46



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COMPRESSIVE STRENGTH (ksf)	RESIDUAL STRENGTH (ksf)
	PII-35	D-15	75-76	DRIVE	CLAYEY SILTSTONE	2.27	0.96

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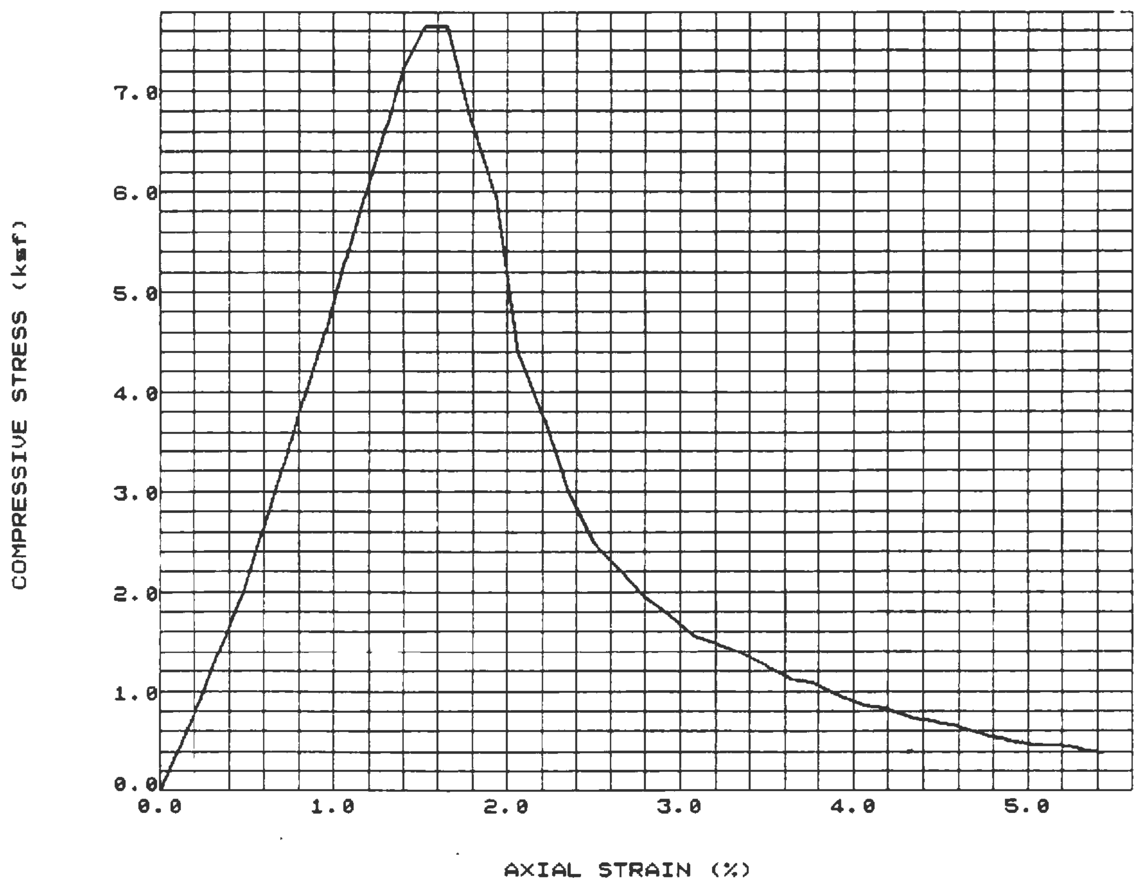
FIGURE B-47



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COMPRESSIVE STRENGTH (ksf)	RESIDUAL STRENGTH (ksf)
	PII-38	P-10	50-52.5	PITCHER	SILTY CLAY(STONE)	7.64	0.38

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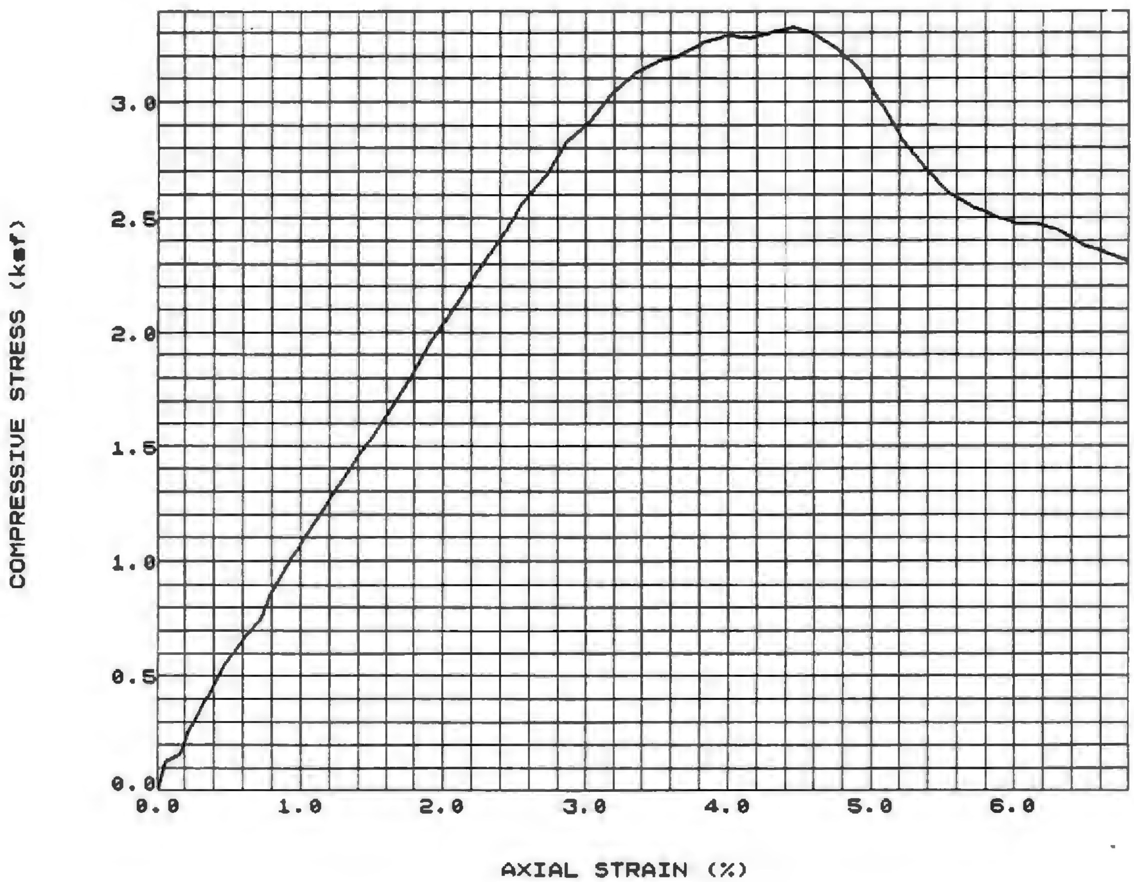
FIGURE B-48



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COMPRESSIVE STRENGTH (ksf)	RESIDUAL STRENGTH (ksf)
	PII-38	D-13	65-66	DRIVE	SILTY CLAY(STONE)	3.32	2.31

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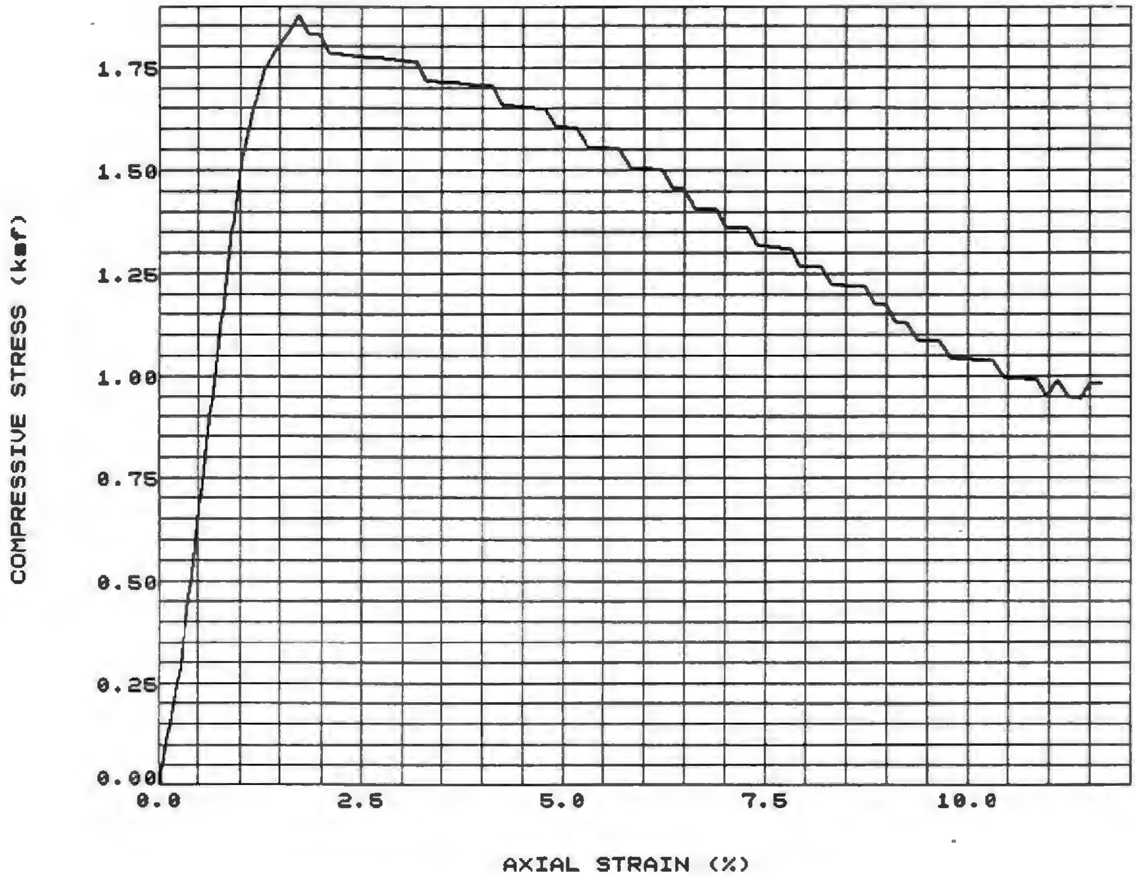
FIGURE B-49



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COMPRESSIVE STRENGTH (ksf)	RESIDUAL STRENGTH (ksf)
	PII-39	P-10	50-52.5	PITCHER	SILTY CLAY(STONE)	1.87	0.98

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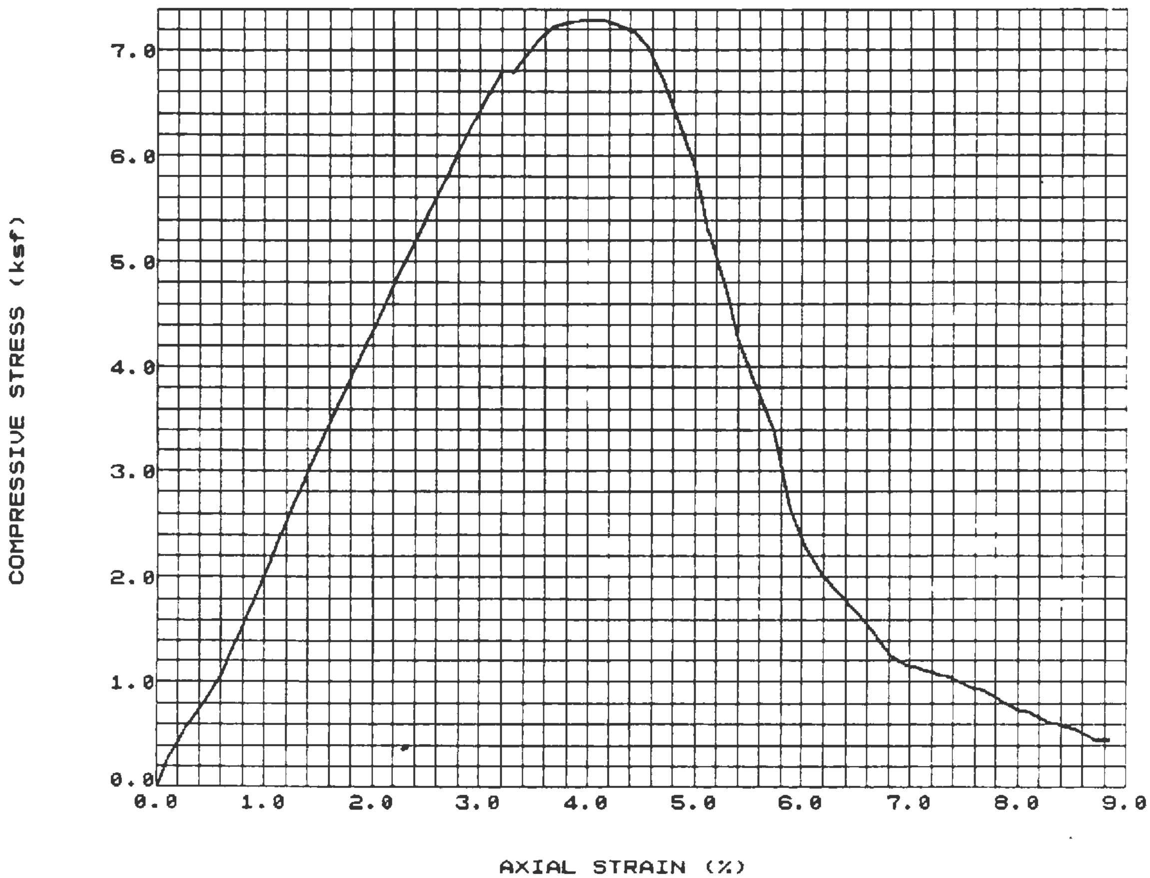
FIGURE B-50



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COMPRESSIVE STRENGTH (ksf)	RESIDUAL STRENGTH (ksf)
	PII-40	P-11	55-57.5	PITCHER	CLAYEY SILTSTONE	7.29	0.44

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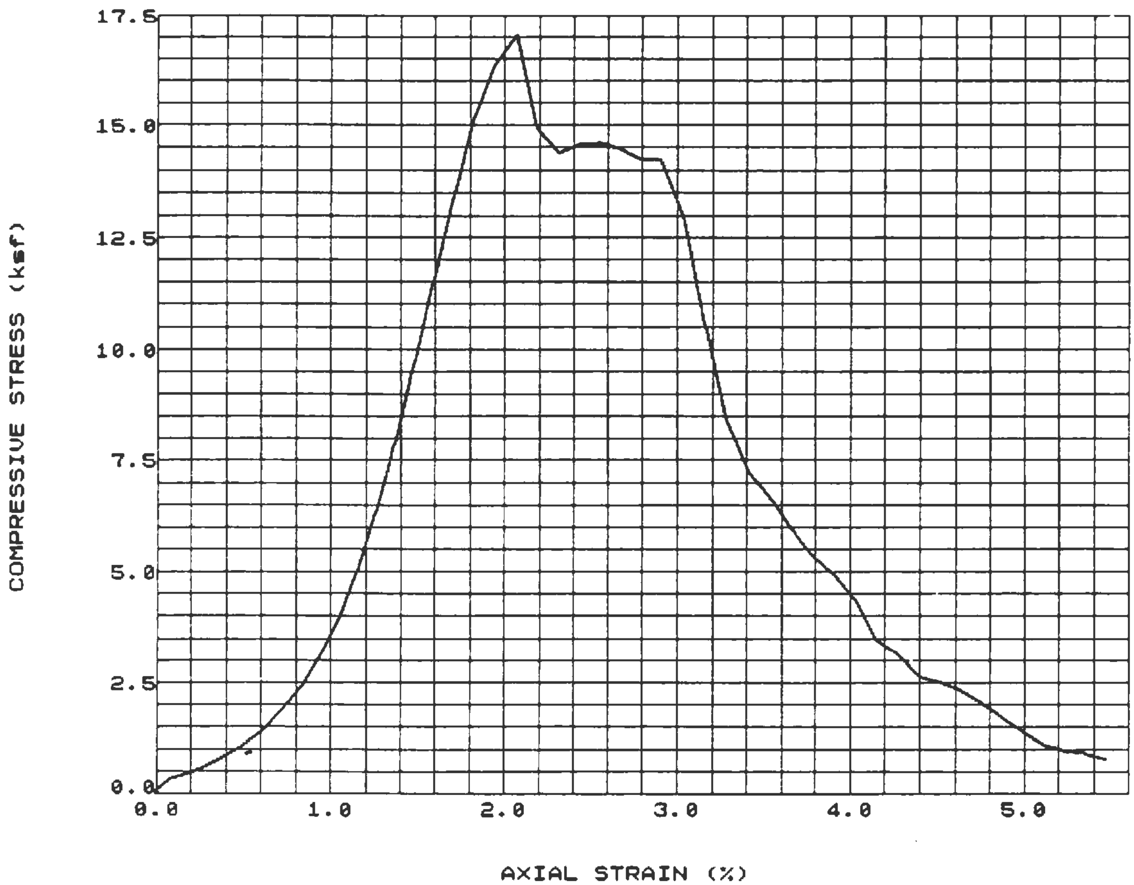
FIGURE B-51



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COMPRESSIVE STRENGTH (ksf)	RESIDUAL STRENGTH (ksf)
	PII-42	P-14	70-72.5	PITCHER	CLAYEY SILT(STONE)	17.0	0.78

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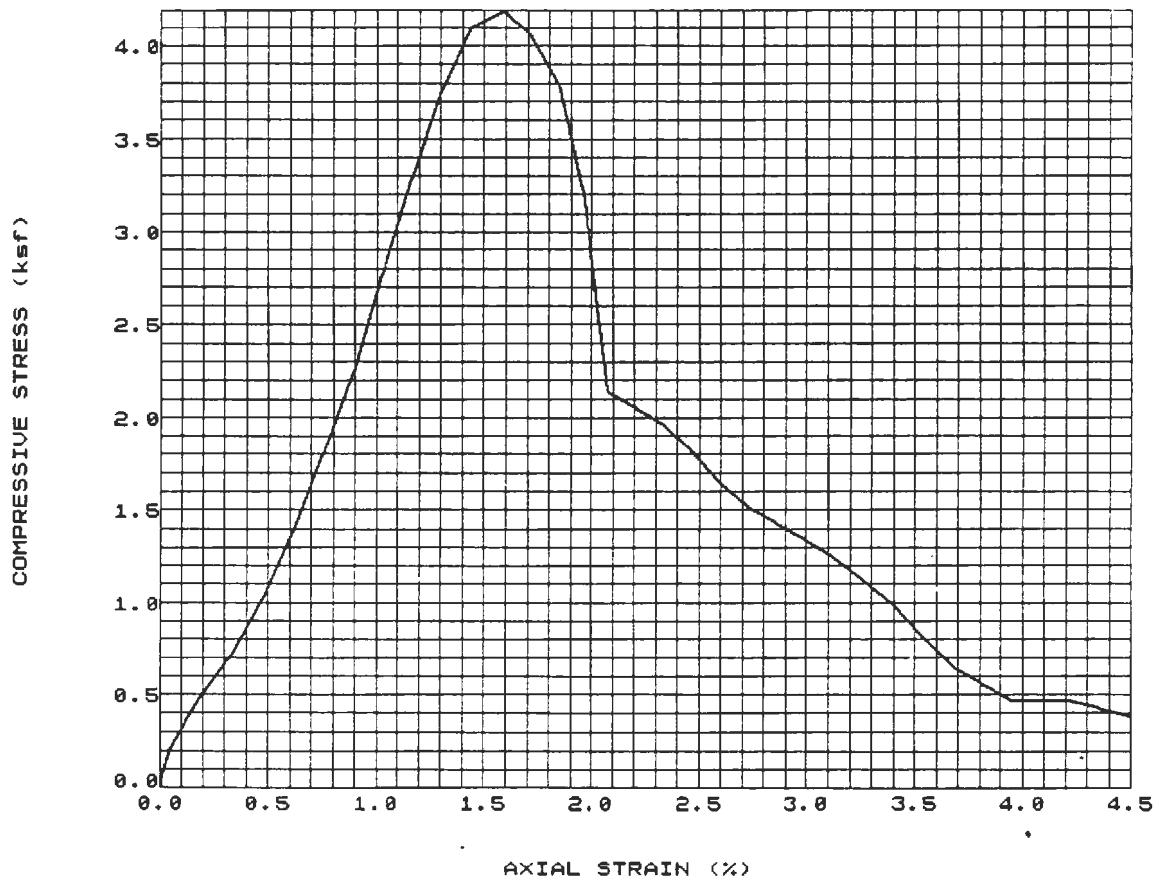
FIGURE B-52



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COMPRESSIVE STRENGTH (ksf)	RESIDUAL STRENGTH (ksf)
	PII-43	P-8	40-42.5	PITCHER	CLAYEY SILT(STONE)	4.19	0.38

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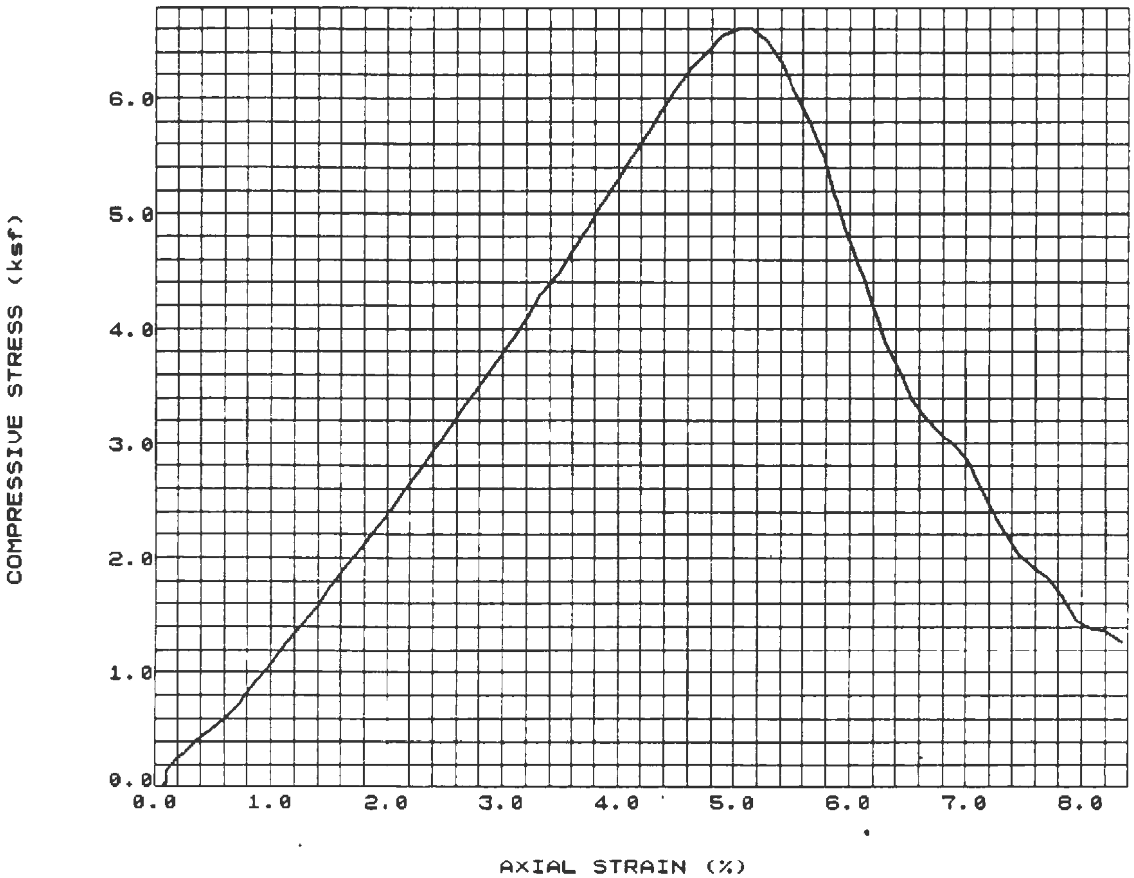
FIGURE B-53



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COMPRESSIVE STRENGTH (ksf)	RESIDUAL STRENGTH (ksf)
	PII-43	D-13	65-66	DRIVE	SILTY CLAY(STONE)	6.60	1.26

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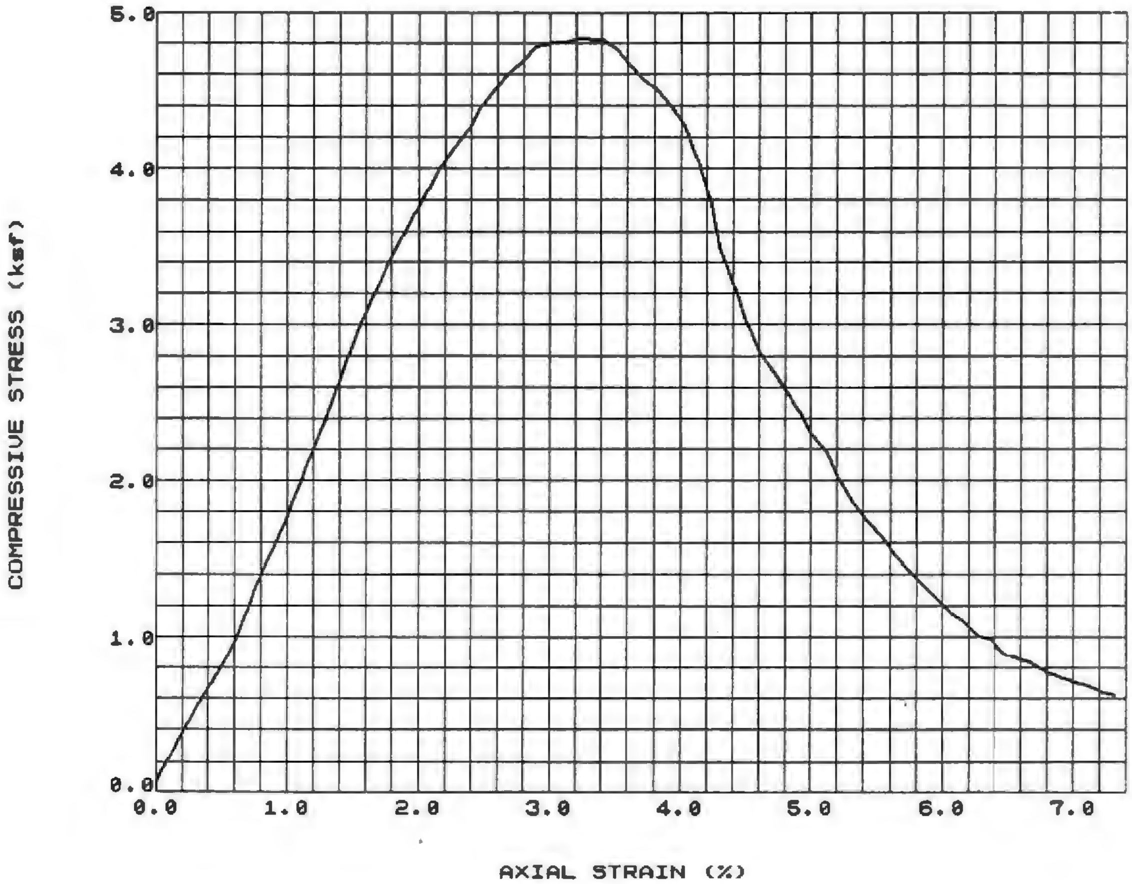
FIGURE B-54



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COMPRESSIVE STRENGTH (ksf)	RESIDUAL STRENGTH (ksf)
	PII-45	D-6	30-31	DRIVE	CLAYEY SILT(STONE)	4.82	0.61

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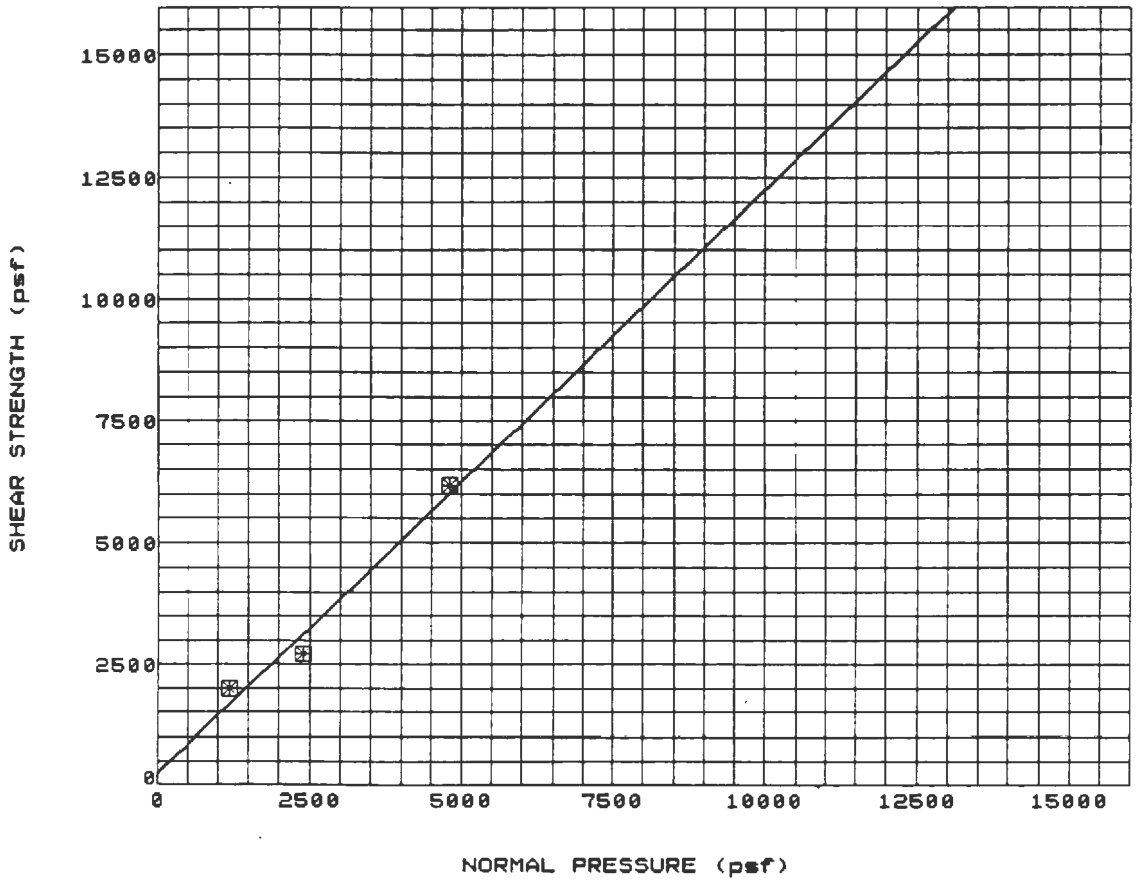
FIGURE B-55



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)
⊠	PII-27	D-4	20.0	DRIVE	CLAYEY SILT(STONE)	265	50

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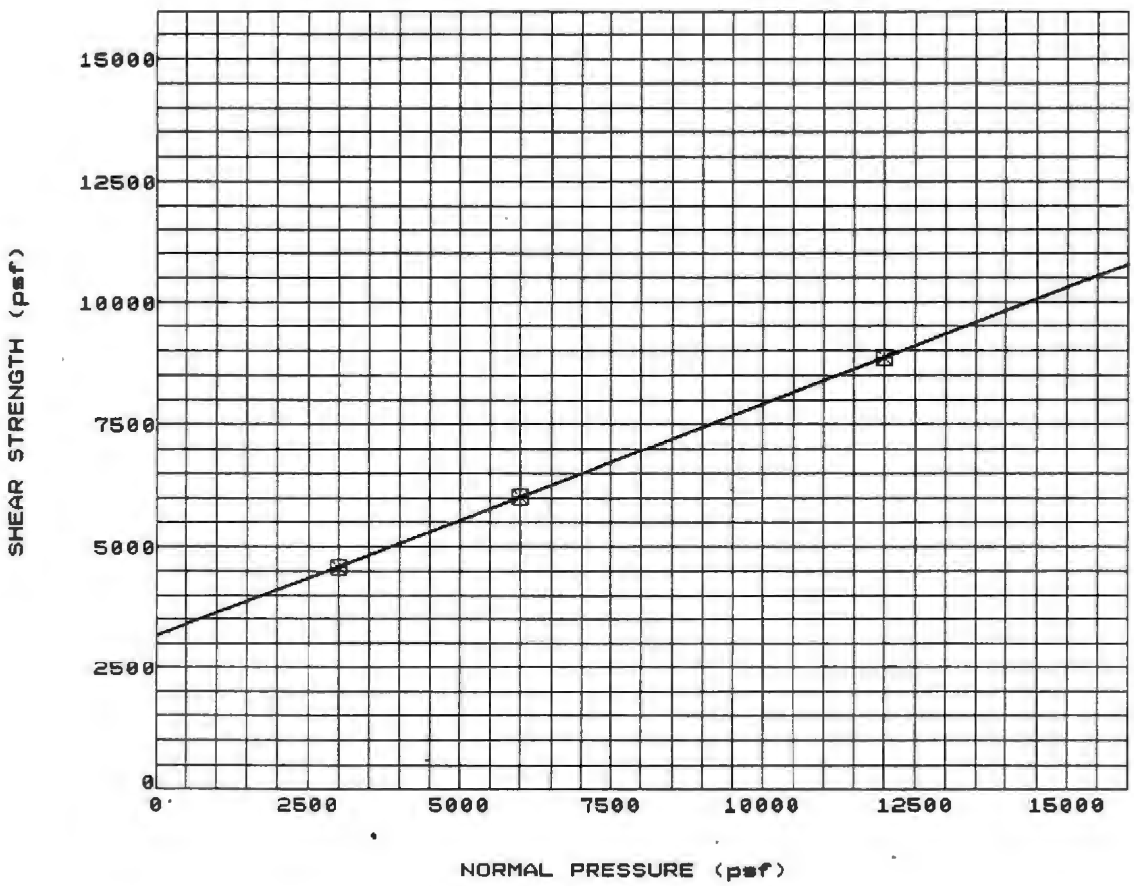
FIGURE B-56



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)
⊠	PII-27	D-10	50.0	DRIVE	SILTY CLAYSTONE	3148	25

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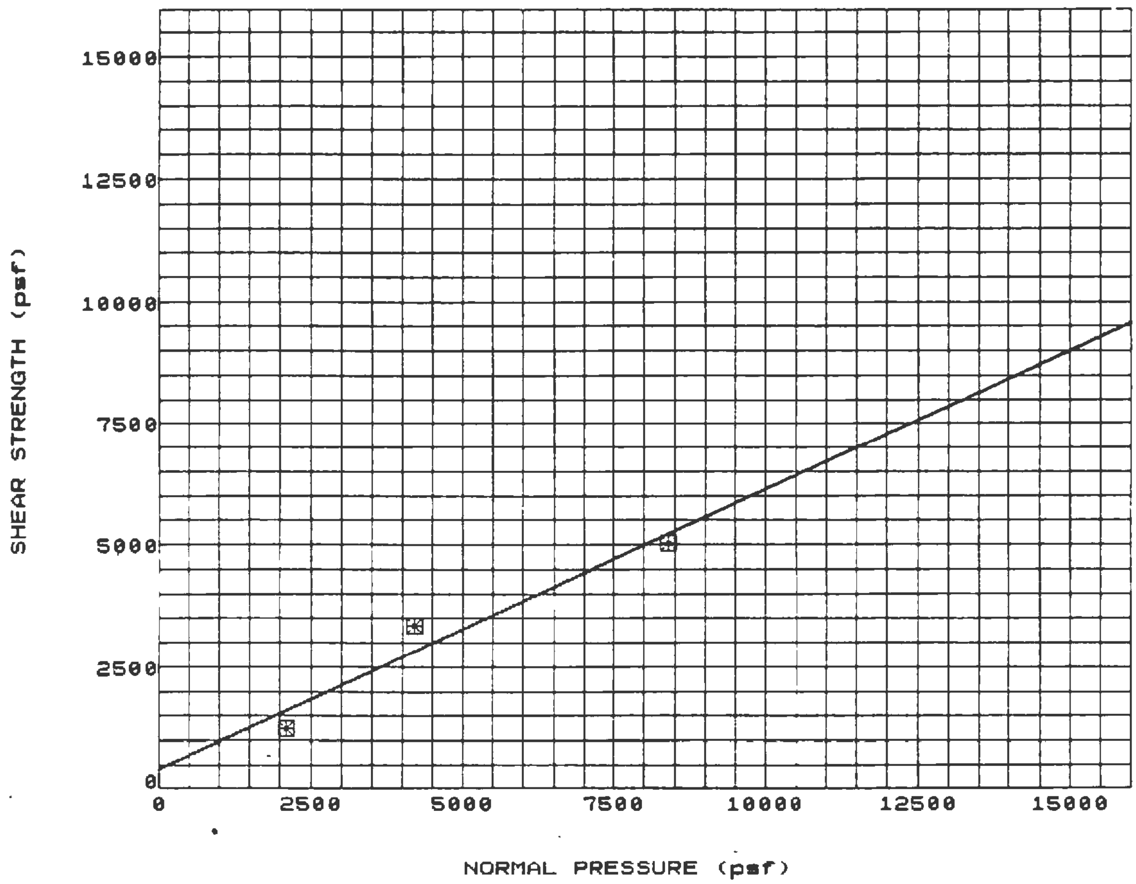
FIGURE B-57



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)
⊠	PII-30	D-7	35.0	DRIVE	SILTY CLAY(STONE)	405	30

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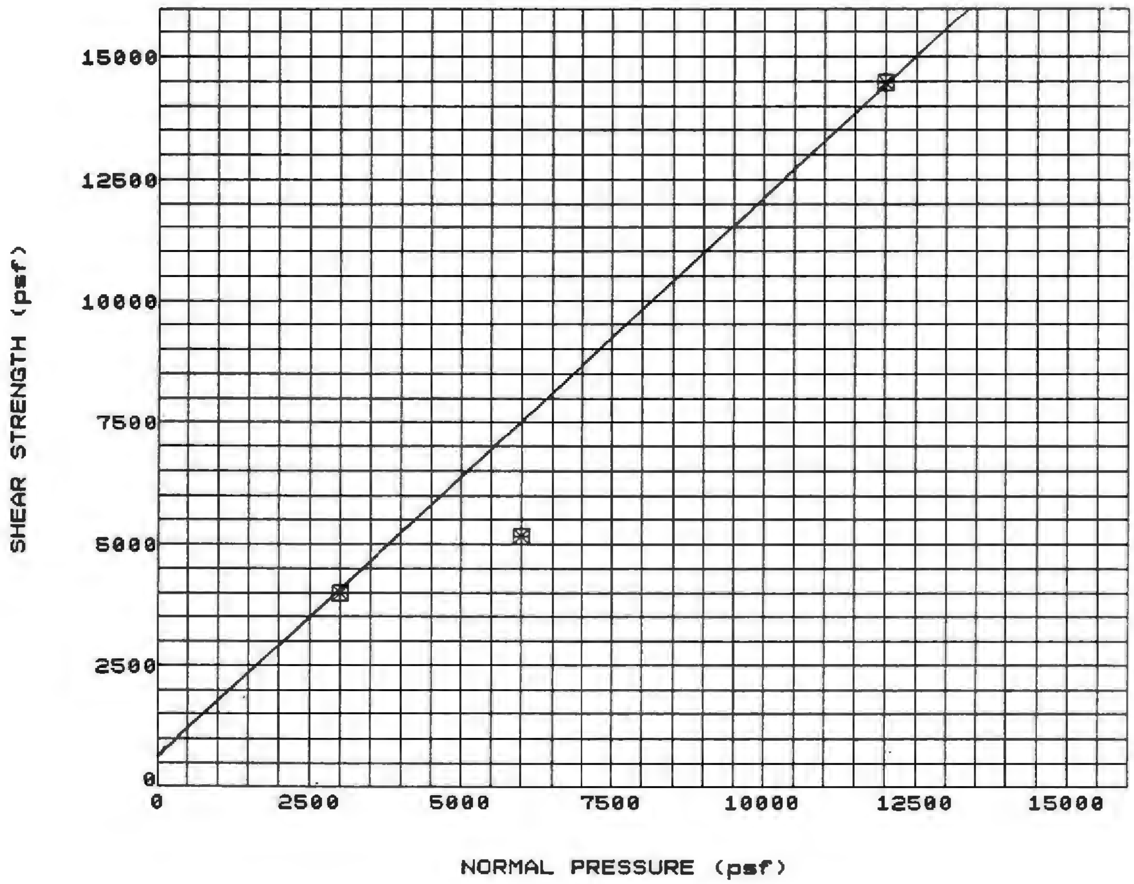
FIGURE B-58



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)
⊠	PII-32	D - 10	50.0	DRIVE	CLAYEY SILTSTONE/ SILTY CLAYSTONE	700	45

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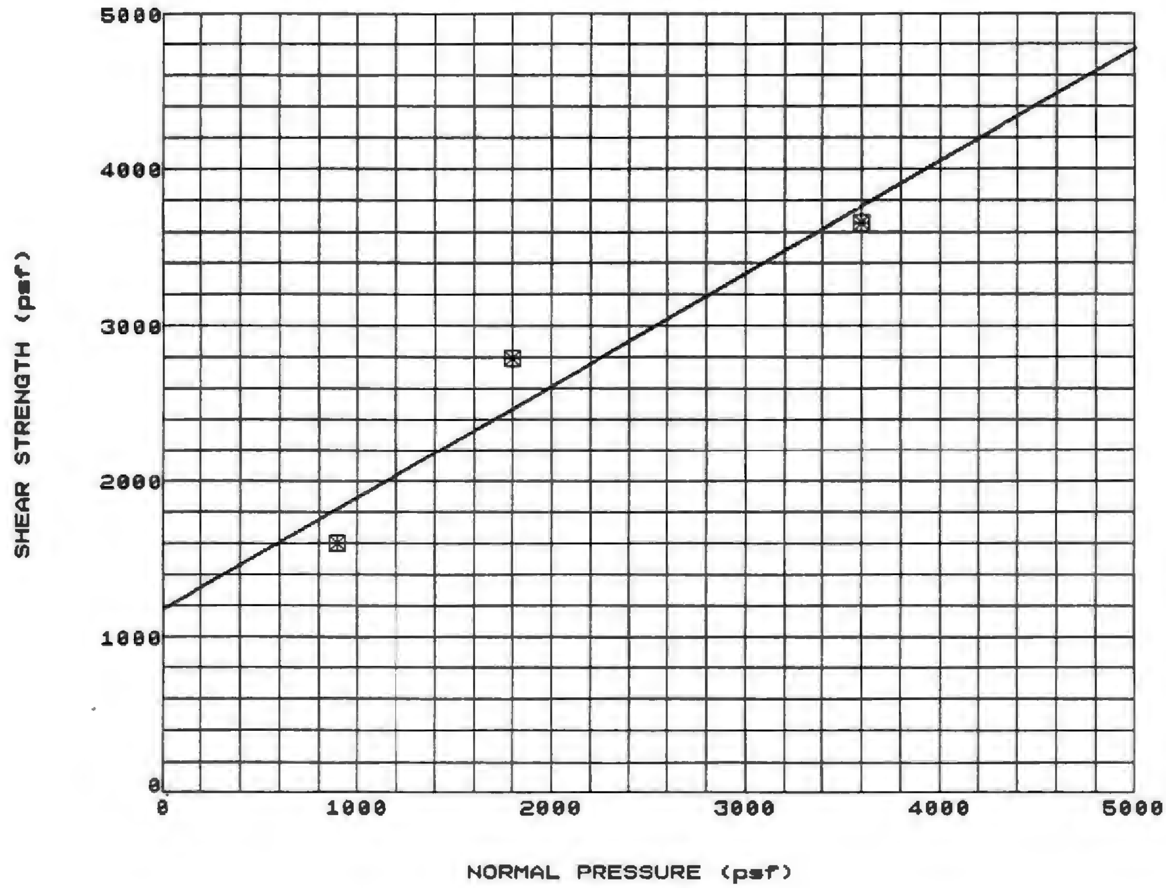

SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)
⊠	PII-33	D-3	15.0	DRIVE	CLAYEY SILT(STONE)	1170	36

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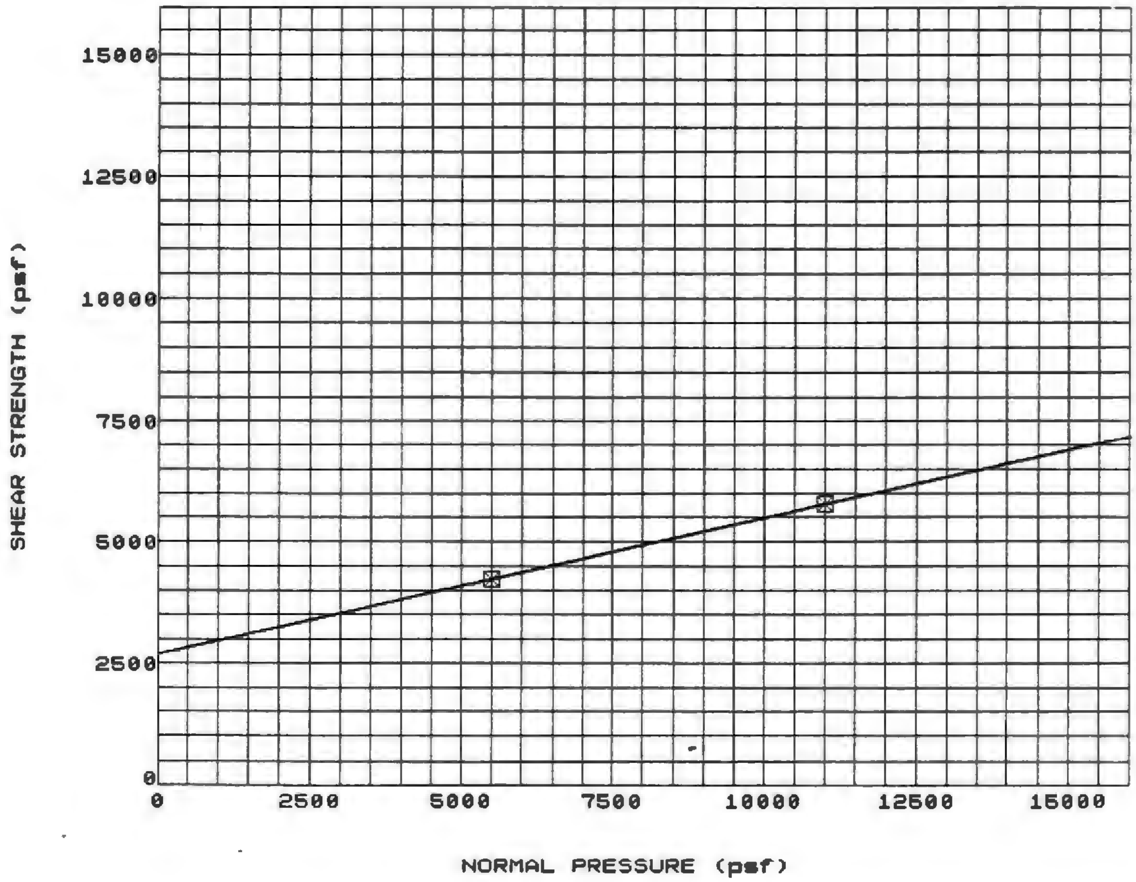
FIGURE B-60



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)
⊠	PII-33	D-9	45.0	DRIVE	SILTY CLAYSTONE	2690	16

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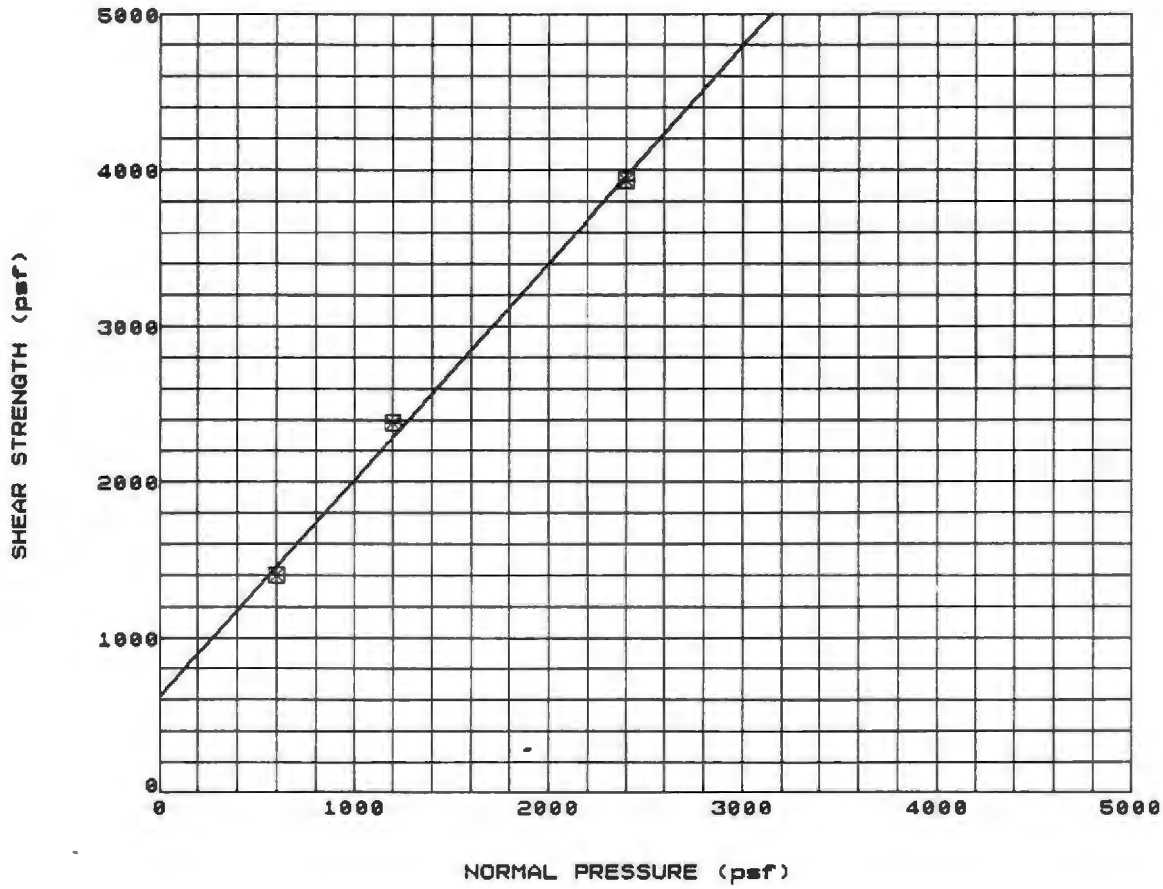
FIGURE B-61



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)
⊠	PII-34	D- 2	10.0	DRIVE	SILTY CLAY(STONE)	625	54

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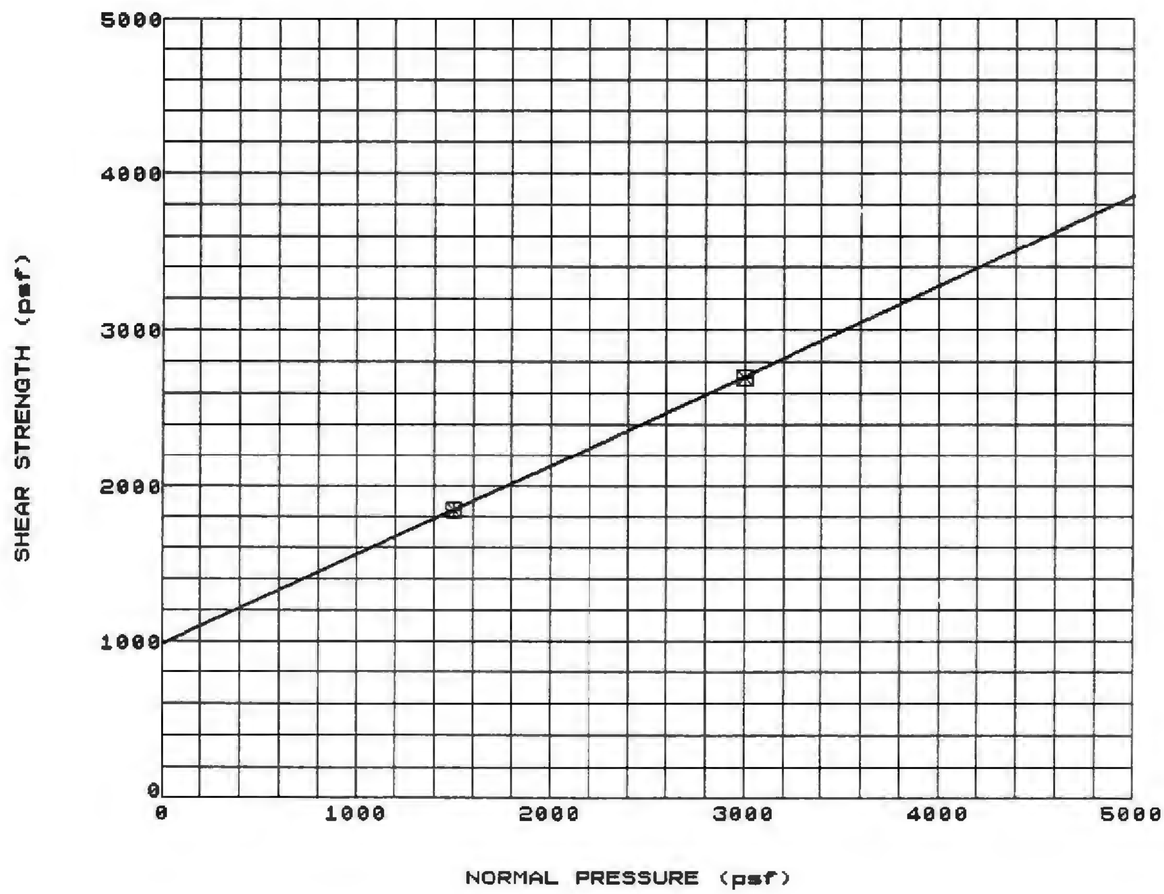
FIGURE B-62



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)
⊠	PII-35	D-5	25.0	DRIVE	SILTY CLAY(STONE)	980	30

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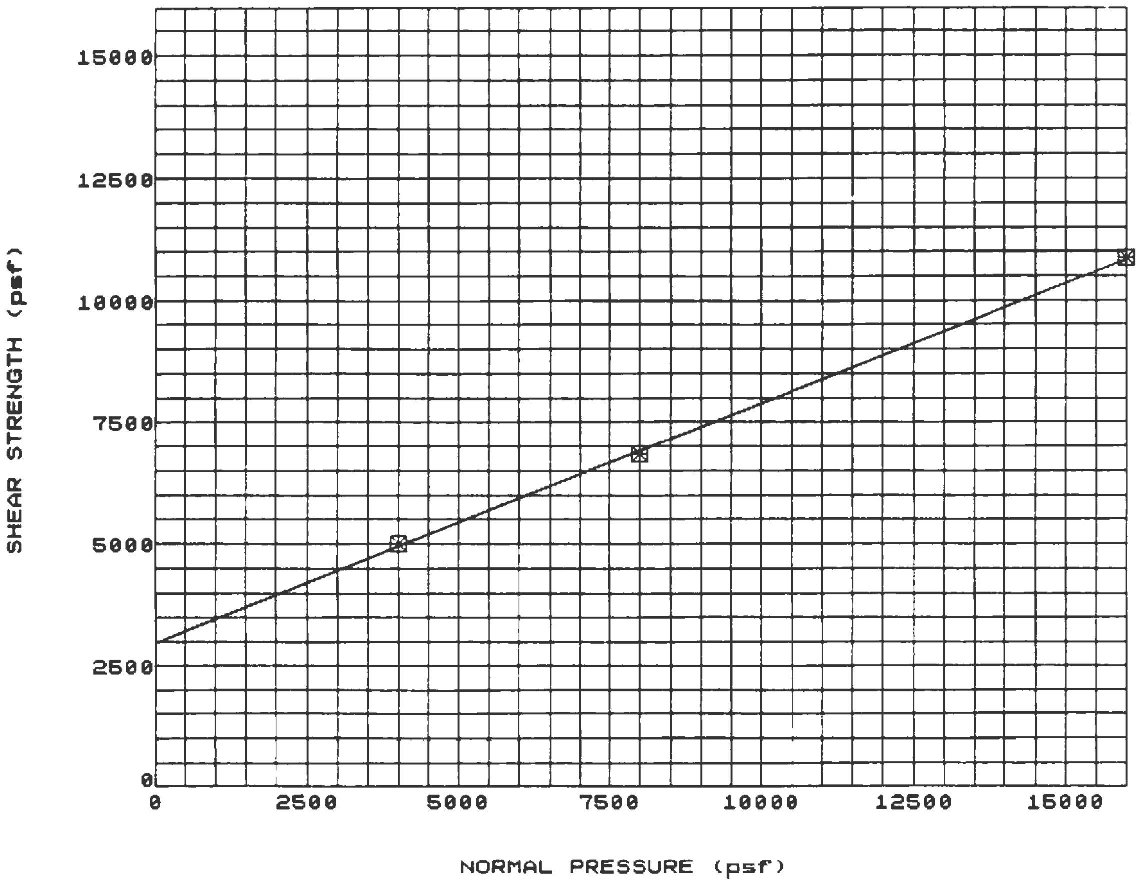
FIGURE B-63



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)
⊠	PII-35	D - 13	65.0	DRIVE	CLAYEY SILTSTONE/ SILTY CLAYSTONE	2982	26

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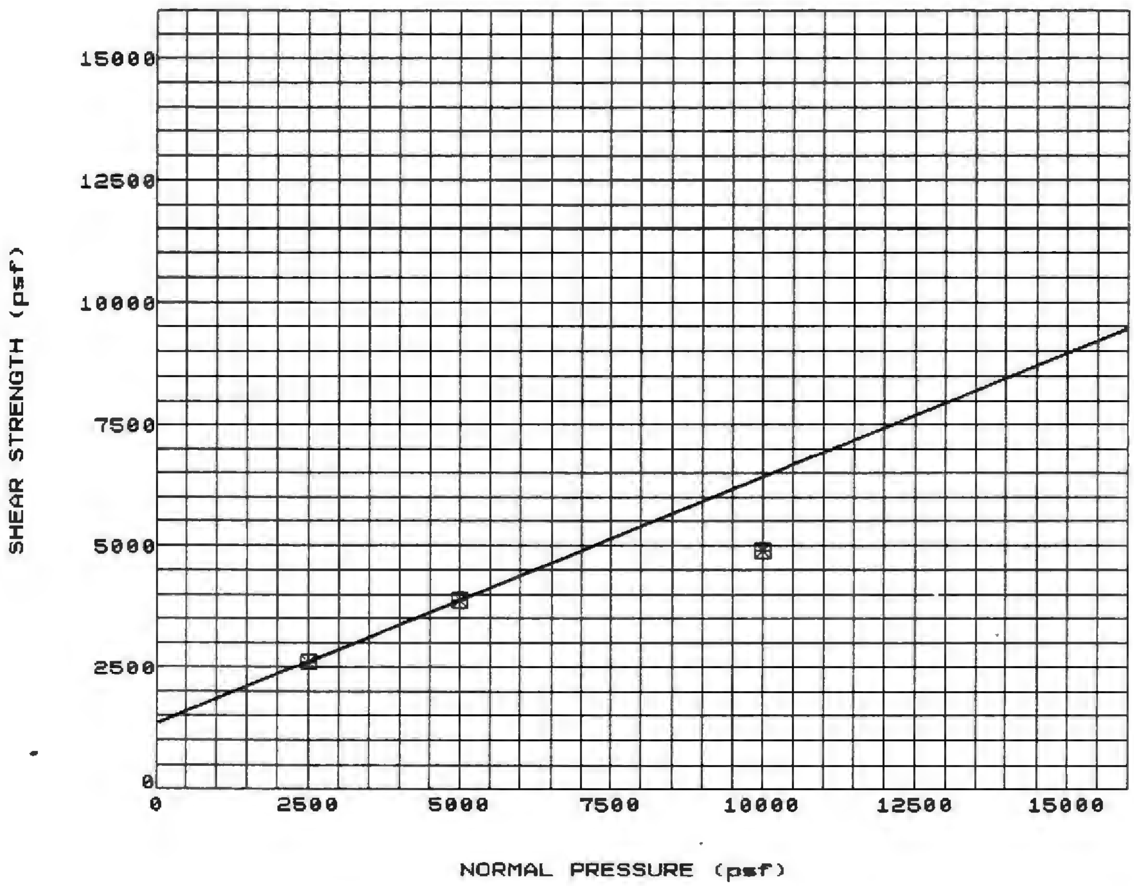
FIGURE B-64



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)
⊠	PII-36	D-8	40.0	DRIVE	SILTY CLAY(STONE)	1300	29

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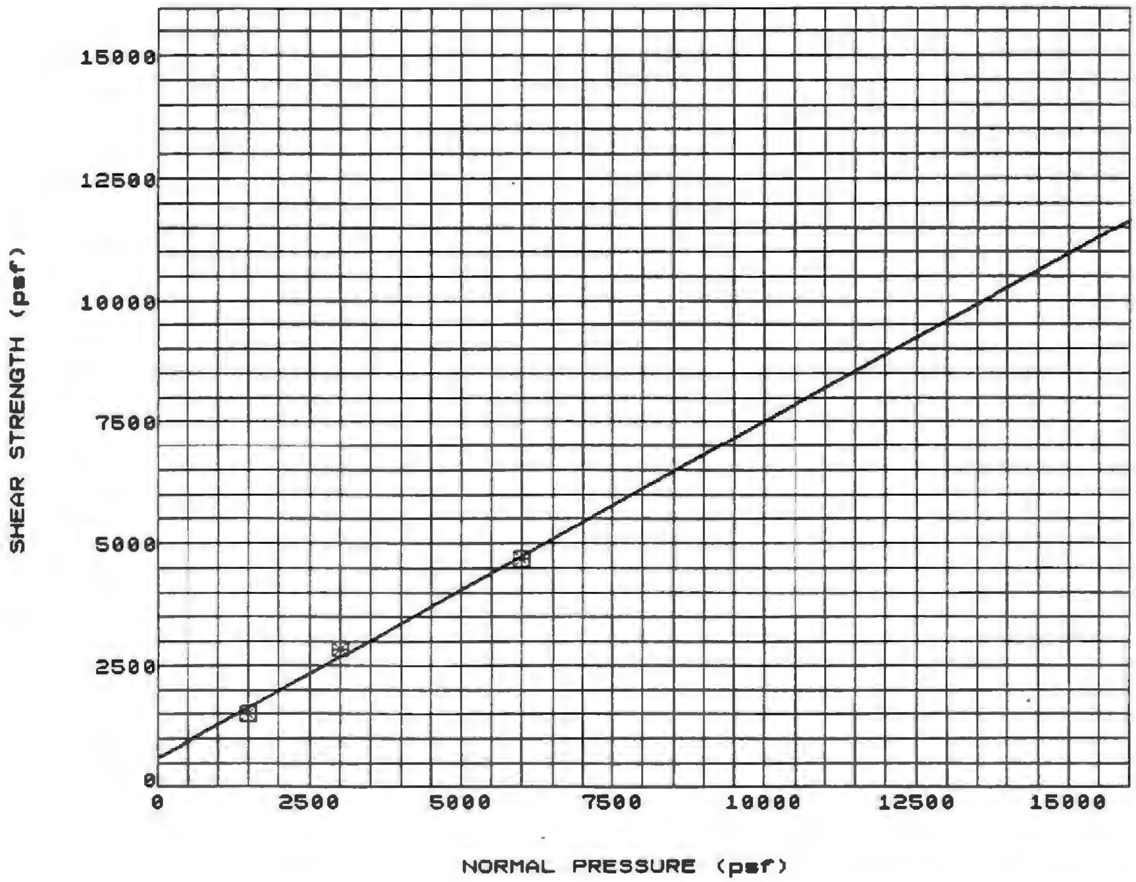
FIGURE B-65



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)
⊠	PII-38	D-5	25.0	DRIVE	CLAYEY SAND(STONE)	590	35

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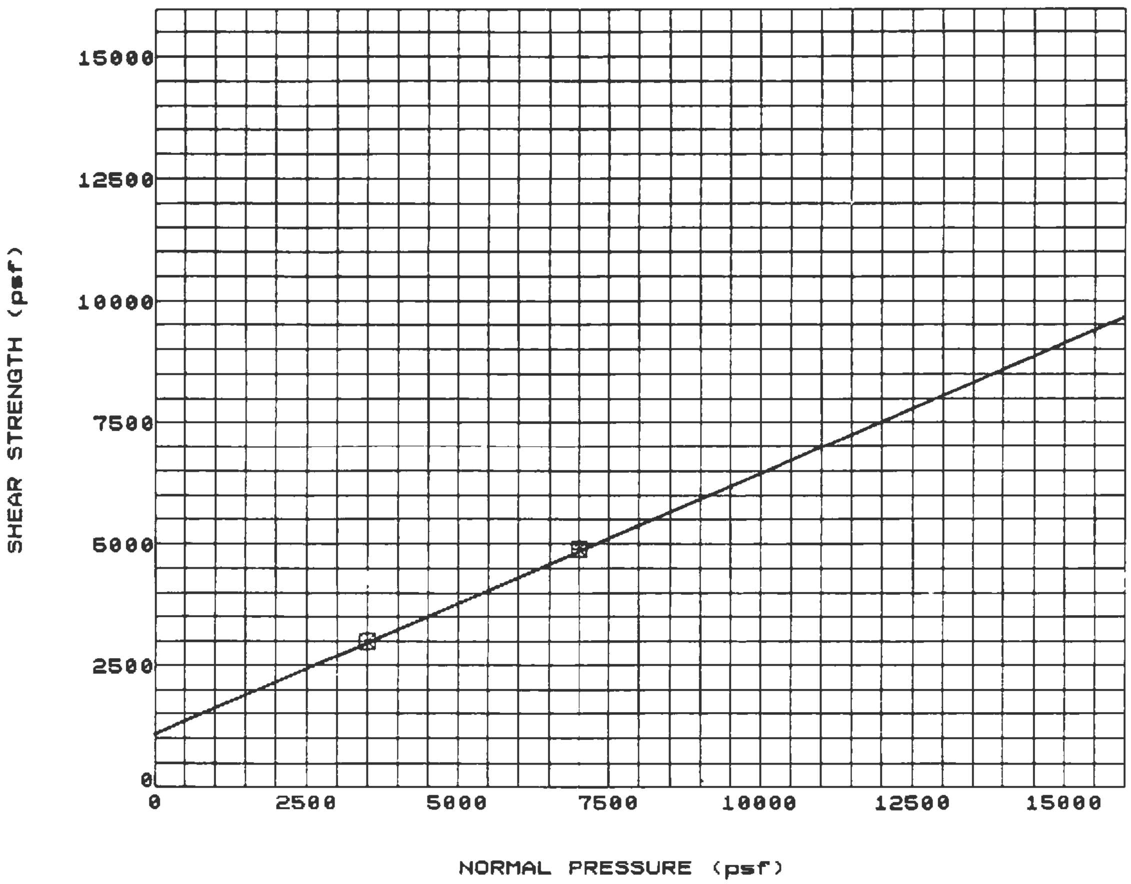
FIGURE B-66



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)
⊠	PII-38	D-11	55.0	DRIVE	CLAYEY SILT(STONE)/ SILTY CLAY(STONE)	1100	29

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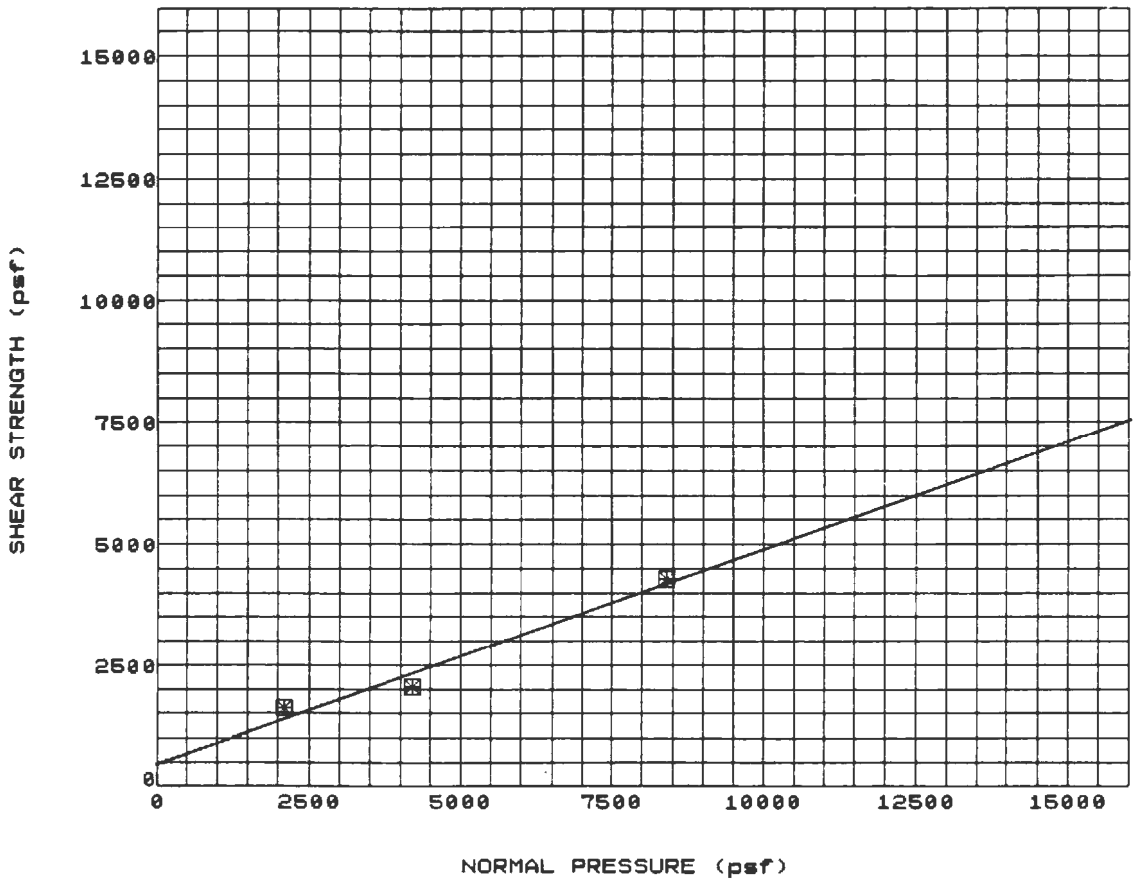
FIGURE B-67



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)
⊠	PII-39	D-7	35.0	DRIVE	SILTY SAND	490	24

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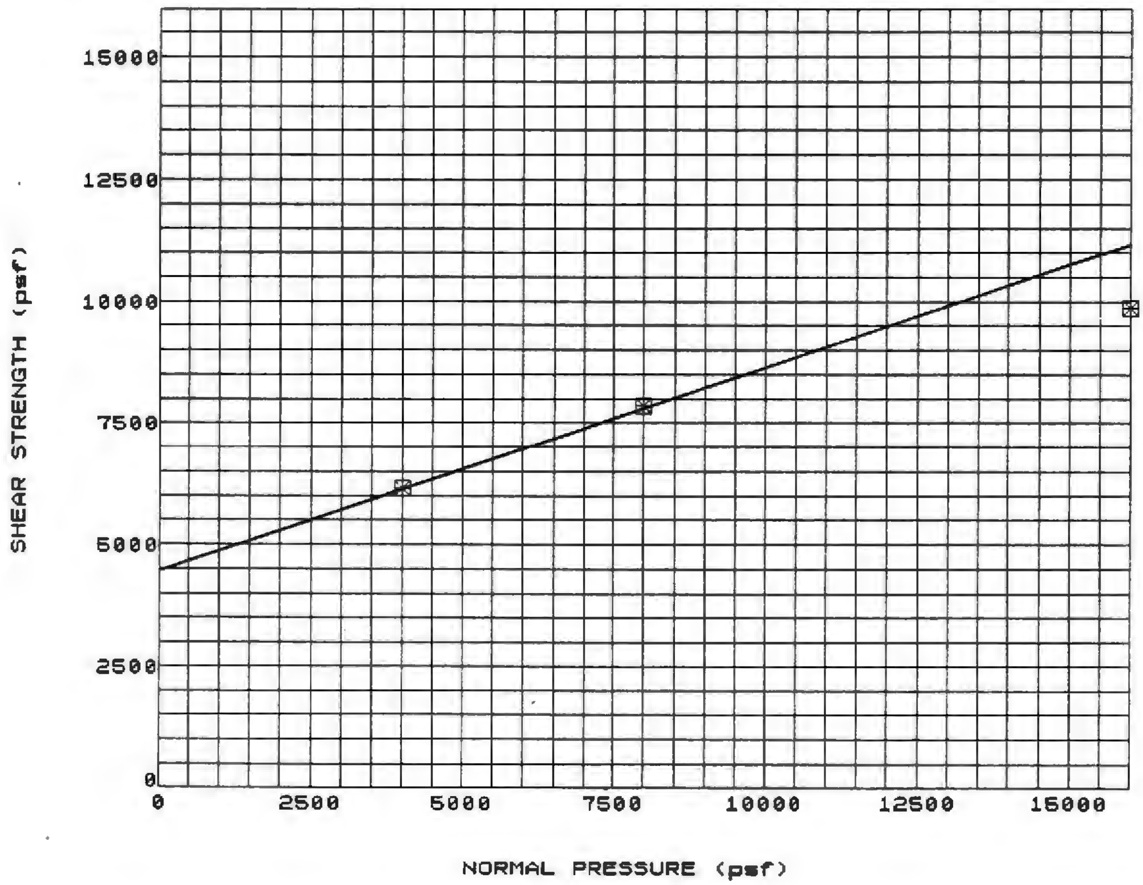
FIGURE B-68



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)
⊠	PII-40	D-16	80.0	DRIVE	CLAYEY SILTSTONE	4500	23

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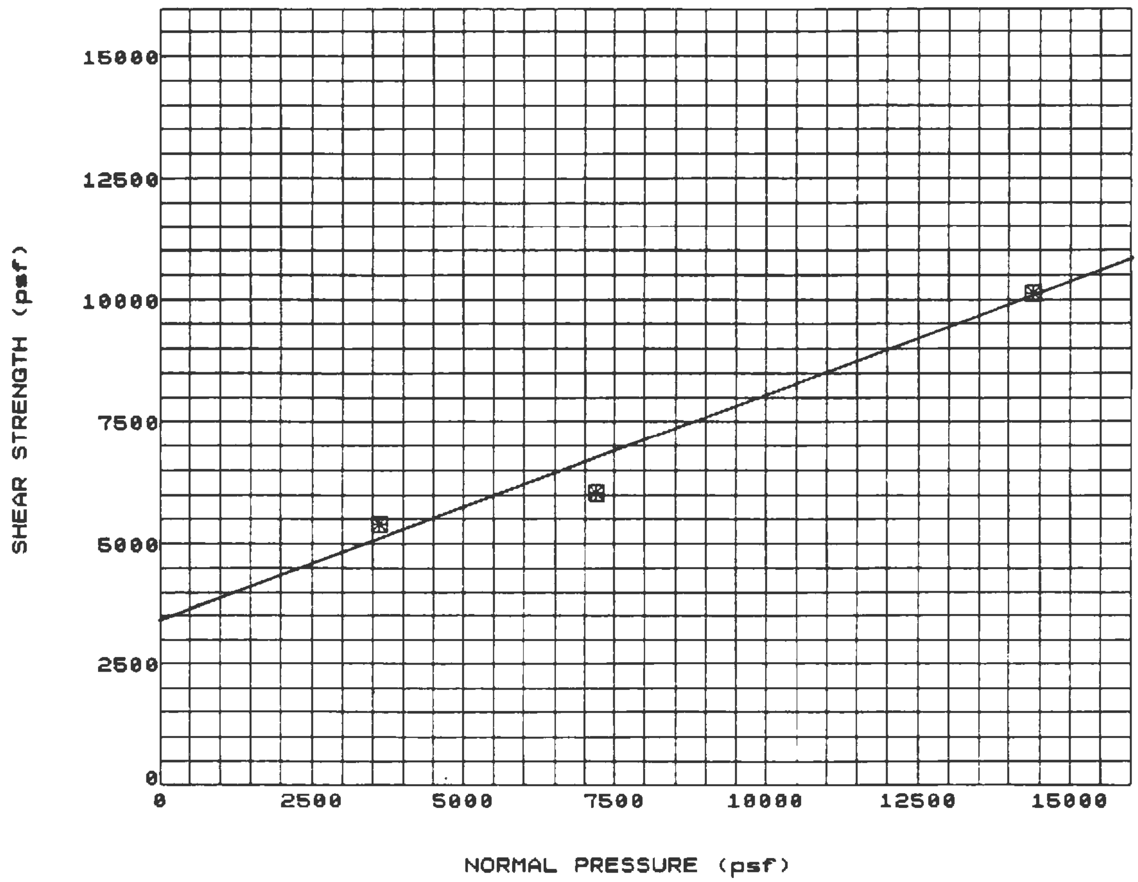
FIGURE B-69



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)
⊠	PII-41	D - 14	60.0	DRIVE	SILTY CLAY(STONE)/ CLAYEY SILT(STONE)	3365	24

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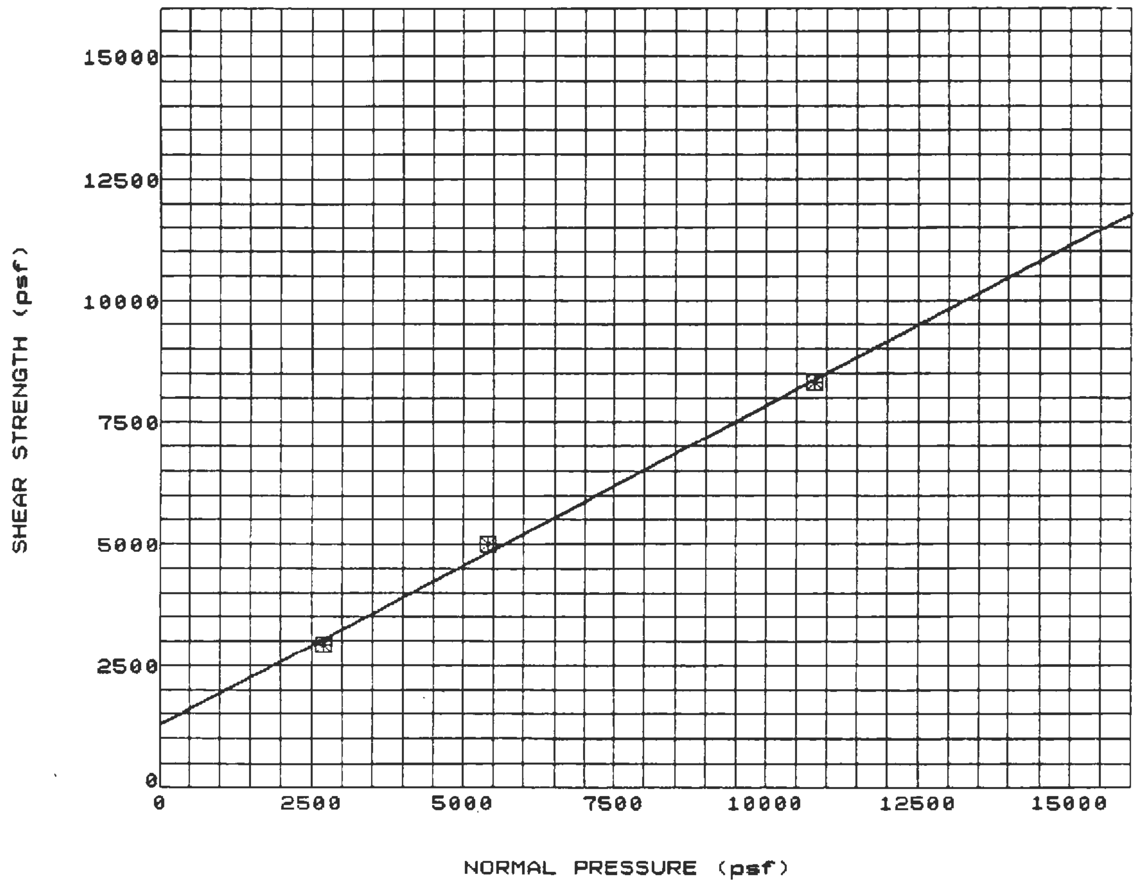
FIGURE B-70



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)
⊠	PII-43	D-9	45.0	DRIVE	CLAYEY SILT(STONE)	1269	33

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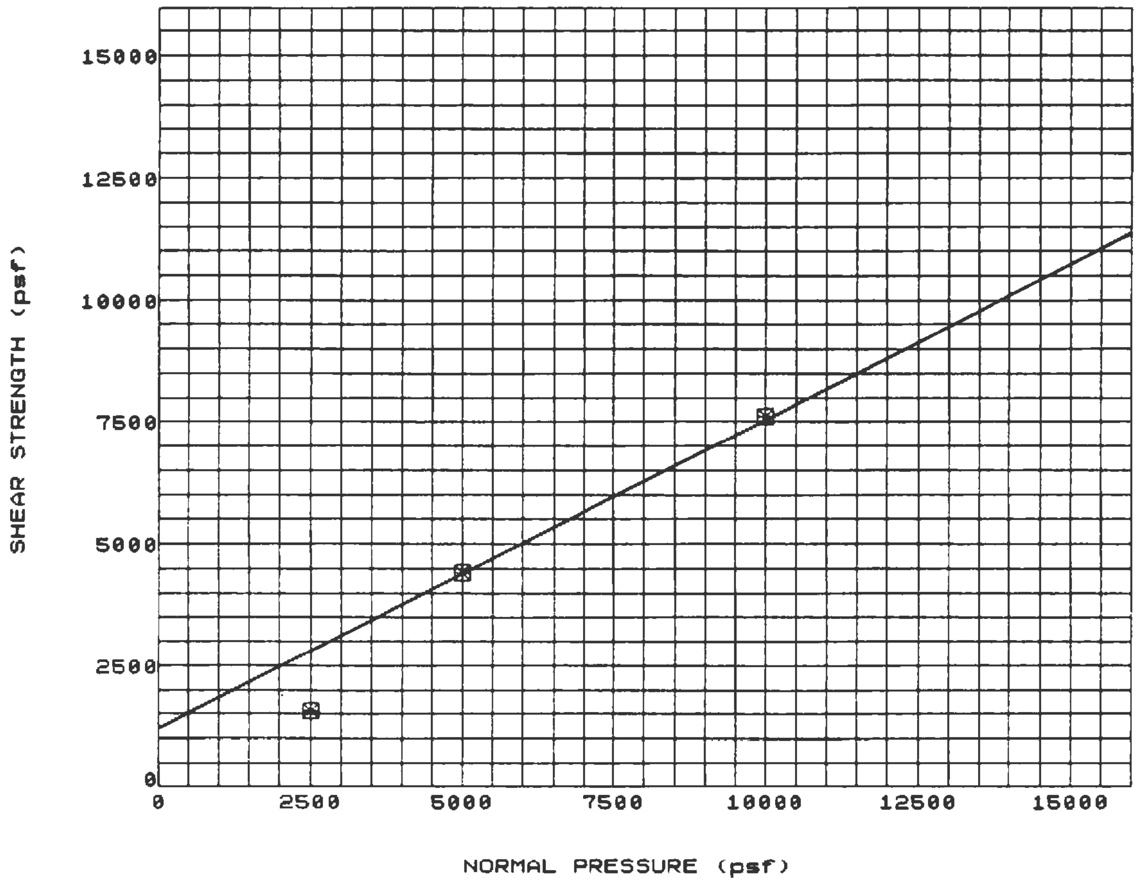
FIGURE B-71



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)
⊠	PII-44	D-8	40.0	DRIVE	SANDY CLAY/ CLAYEY SAND	1250	32

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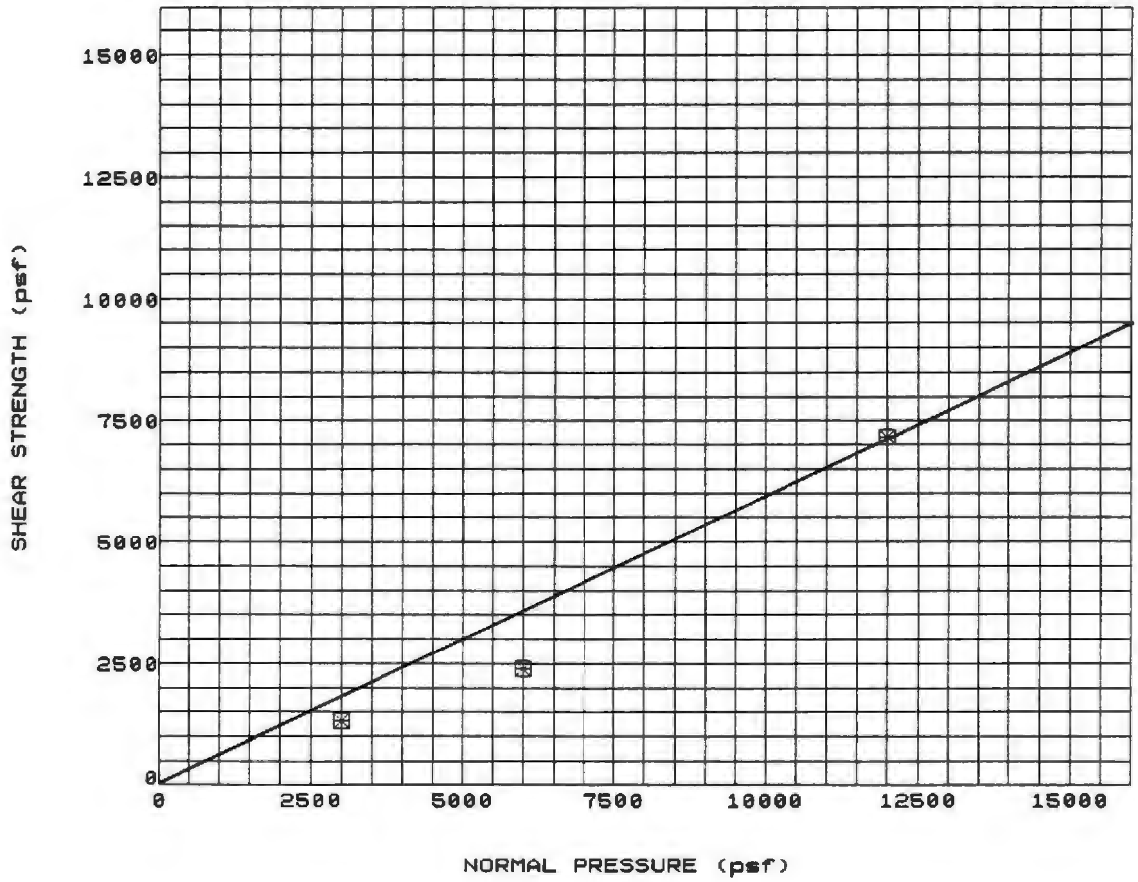
FIGURE B-72



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)
⊠	PII-44	D-10	50.0	DRIVE	SILTY SAND	0	31

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FIGURE B-73

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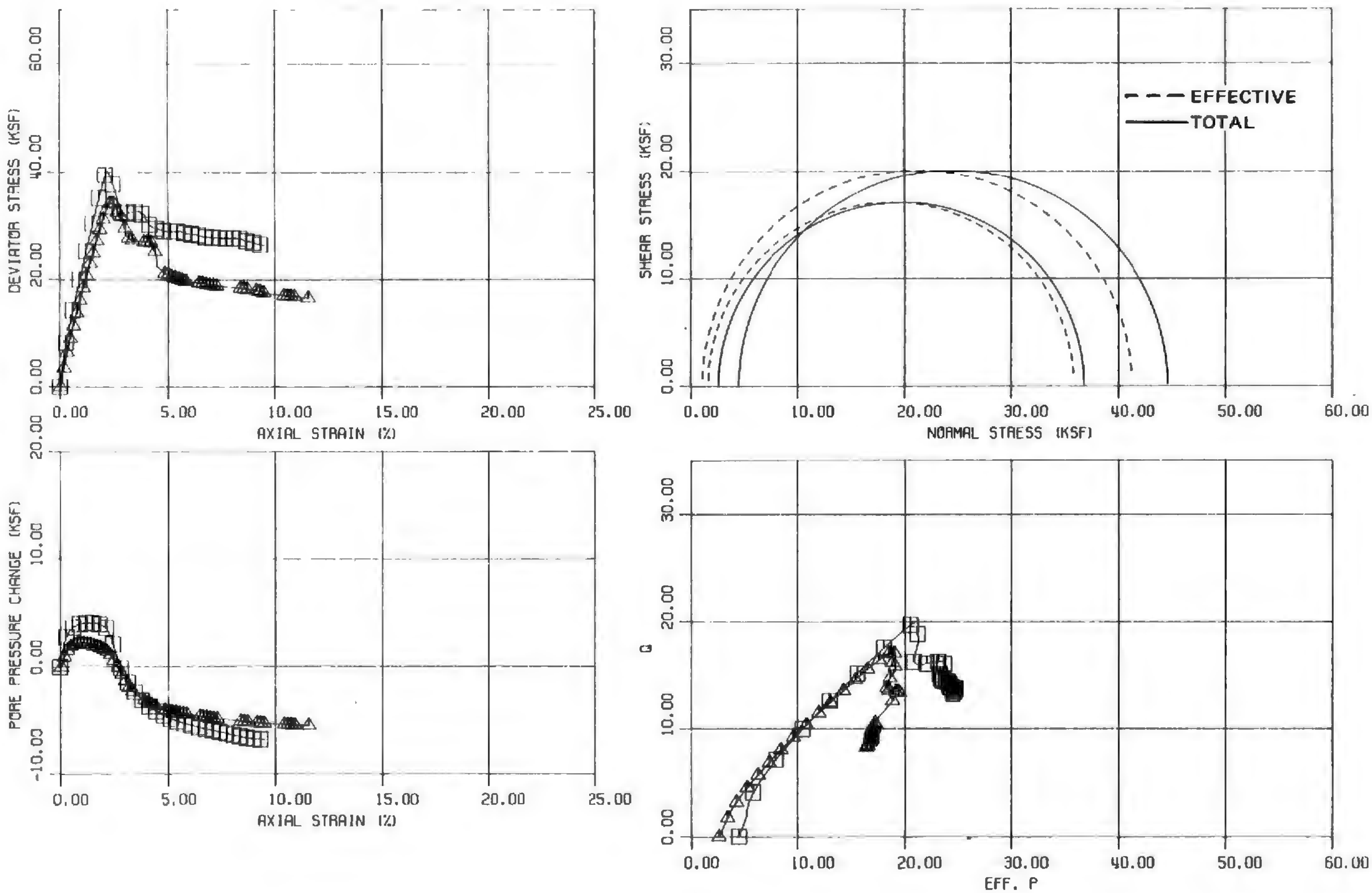
DATE: 5-90

The Earth Technology Corporation

TRIAXIAL TEST RESULTS

TEST TYPE: CIU



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	EFF. CONF. PRESSURE (KSF)	MAX DEV. STRESS (KSF)	STRAIN RATE (%/HR)	BACK PRESSURE (KSF)
⊡	PII-28	P-8	40-42.5	PITCHER	Clayey Siltstone	101.3	23.1	4.4	40.2	6.000	13.0
▵	PII-28	P-8	40-42.5	PITCHER	Clayey Siltstone	99.1	24.4	2.6	34.2	6.000	9.9

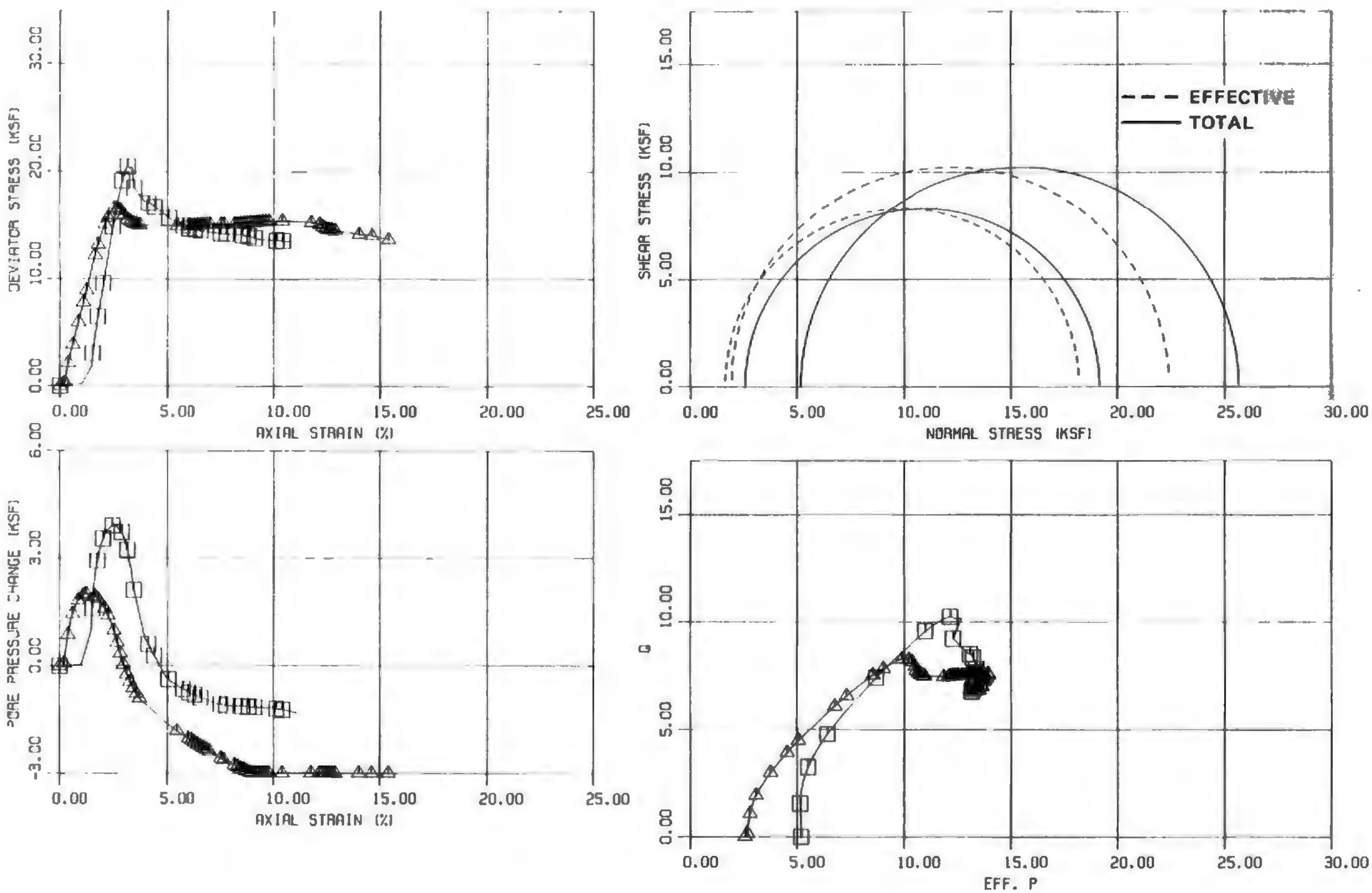
FIGURE B-74

PROJECT: VERMONT/SANTA MONICA STATION AND TUNNEL
PROJECT NO.: 89-409
DATE: 5-90

The Earth Technology Corporation

TRIAXIAL TEST RESULTS

TEST TYPE: $\overline{\text{CIU}}$



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	EFF. CONF. PRESSURE (KSF)	MAX DEV. STRESS (KSF)	STRAIN RATE (%/HR)	BACK PRESSURE (KSF)
⊡	PII-34	P-7	35-37.5	PITCHER	Silty Clay(stone)	100.1	23.9	5.2	20.5	6.000	10.1
▲	PII-34	P-7	35-37.5	PITCHER	Silty Clay(stone)	97.2	26.4	2.6	16.6	6.000	10.1

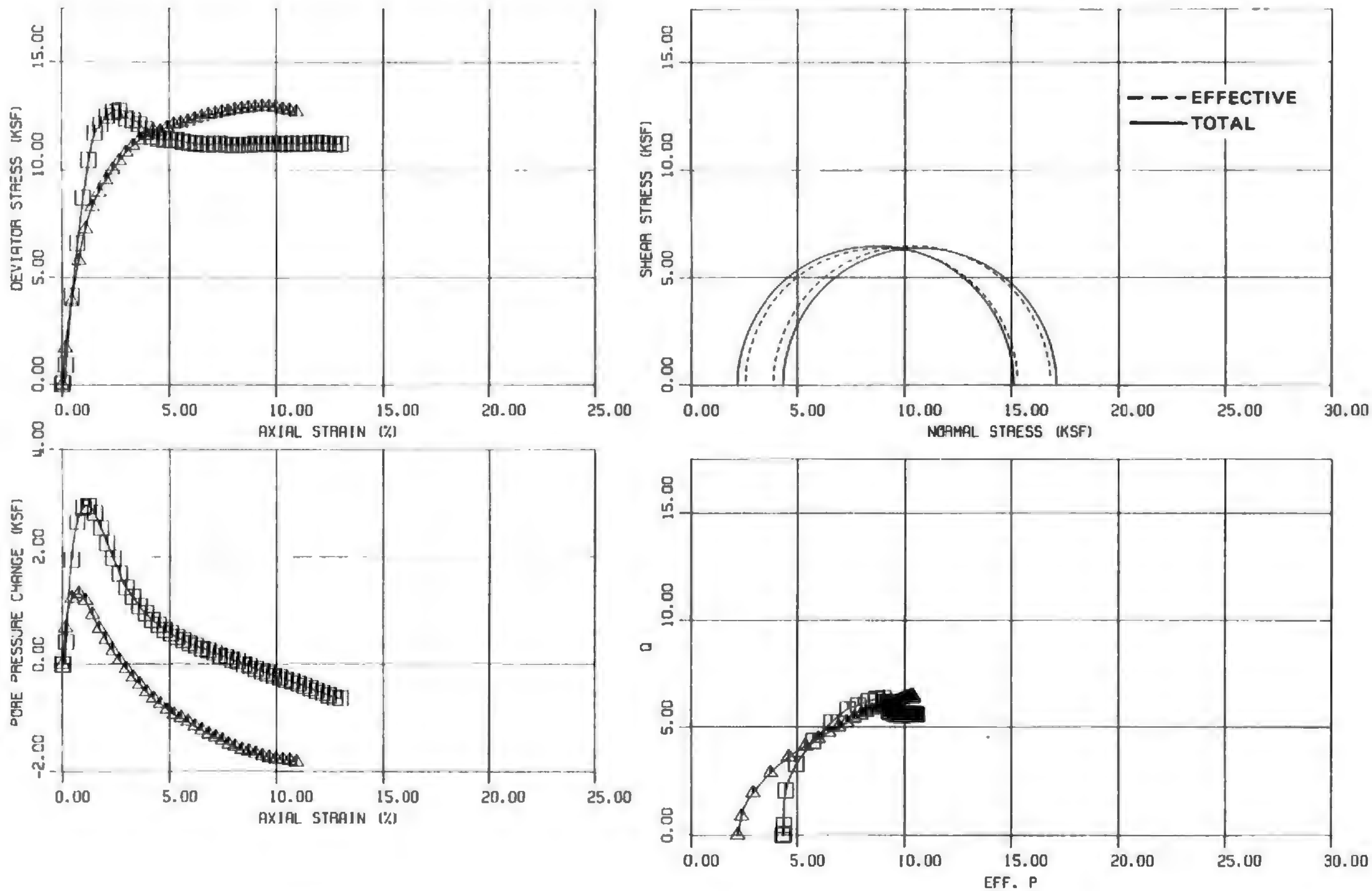
FIGURE B-75

PROJECT: VERMONT/SANTA MONICA STATION AND TUNNEL
PROJECT NO.: 89-409
DATE: 5-90

The Earth Technology Corporation

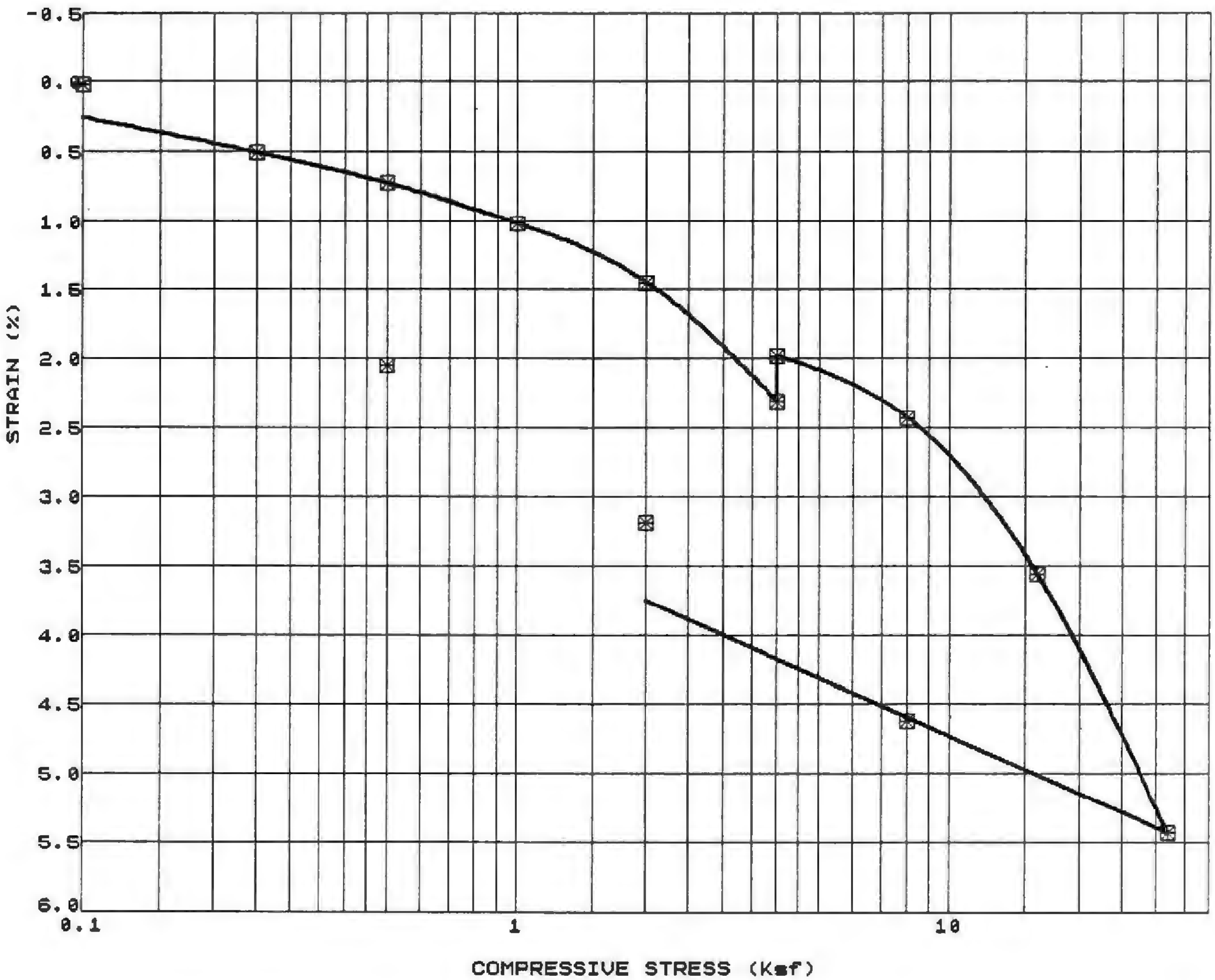
TRIAXIAL TEST RESULTS

TEST TYPE: CIU



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	EFF. CONF. PRESSURE (KSF)	MAX DEV. STRESS (KSF)	STRAIN RATE (%/HR)	BACK PRESSURE (KSF)
□	PII-43	P-8	40-42.5	PITCHER	Clayey Silt(stone)	85.8	33.3	4.3	12.8	6.000	7.2
△	PII-43	P-8	40-42.5	PITCHER	Clayey Silt(stone)	90.0	28.5	2.2	13.0	6.000	8.6

FIGURE B-76



SYMBOL	BORING NO.	SAMPLE NO	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	Cc *	Cr *	REMARKS *
⊠	PII-38	D-7	35.00	DRIVE	Sandy Clay(stone)	5.9	1.5	Coefficients Strain Related

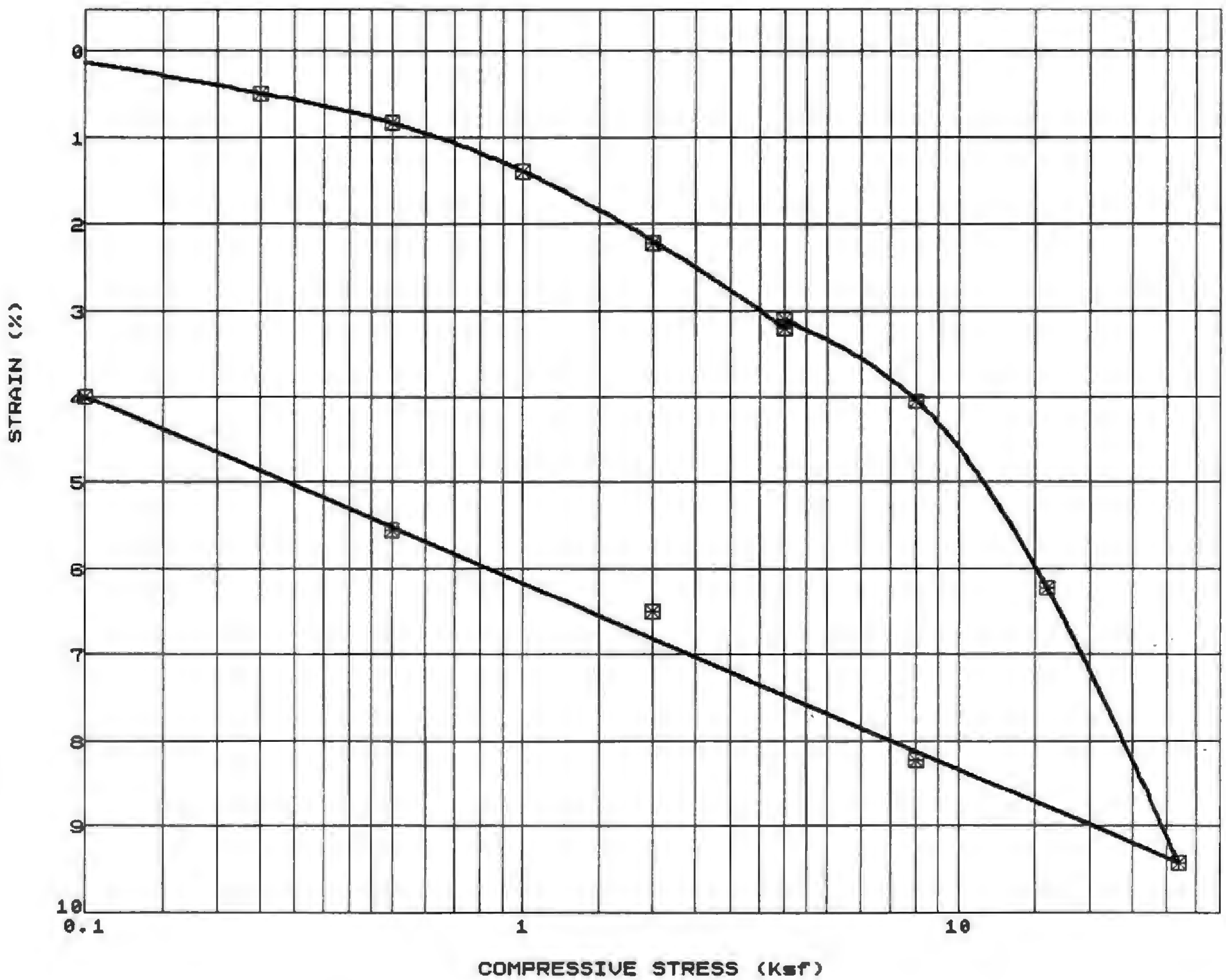
The Earth Technology Corporation

PROJECT NO.: 89-409
Vermont/Santa Monica Station and Tunnel

Consolidation Test Results

5-90

FIGURE B-77



SYMBOL	BORING NO.	SAMPLE NO	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	Cc *	Cr *	REMARKS *
⊠	PII-39	D- 15	75.00	DRIVE	Clayey Silt(stone)	10.6	2.2	Coefficients Strain Related

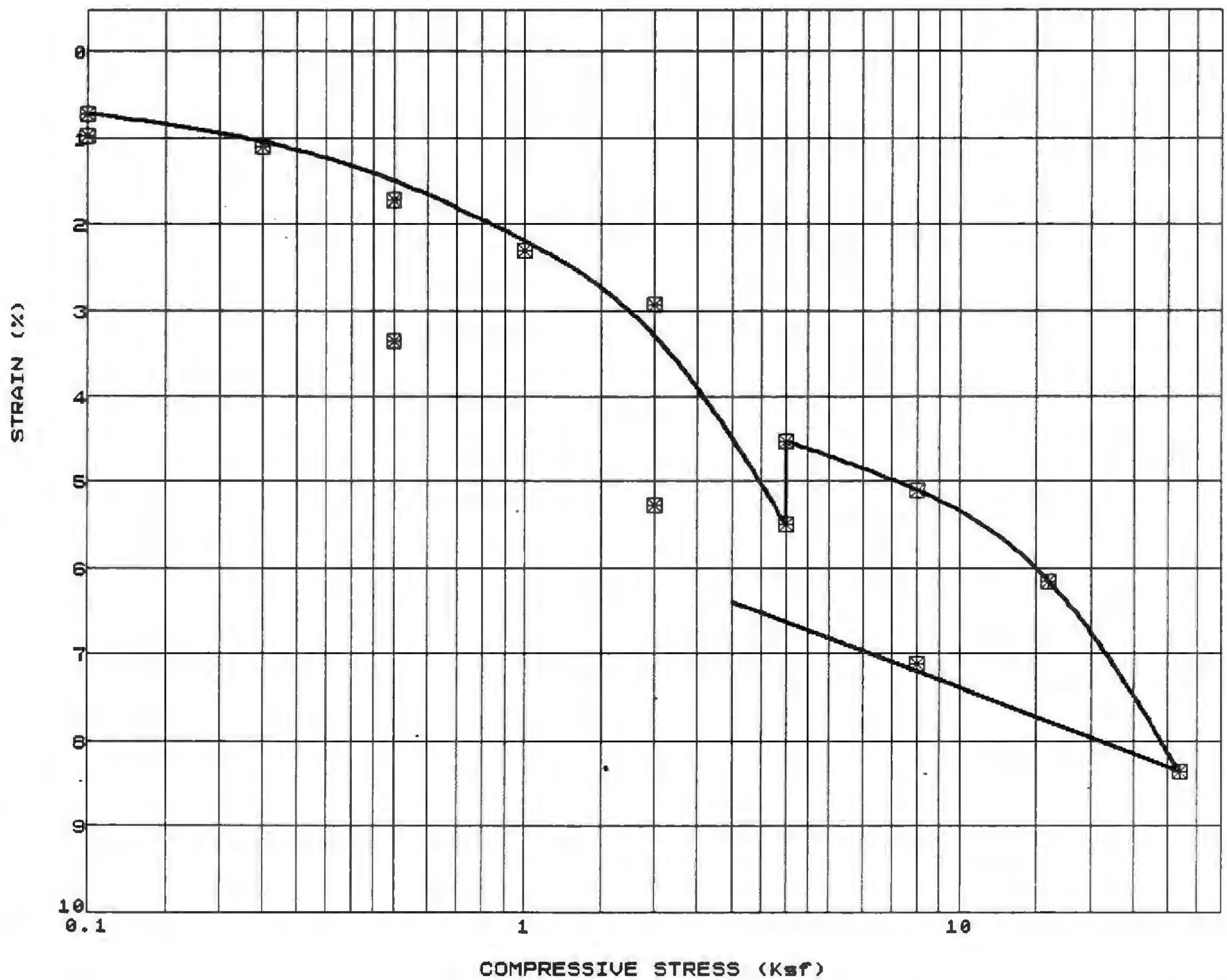
The Earth Technology Corporation

PROJECT NO.: 89-409
Vermont/Santa Monica Station and Tunnel

Consolidation Test Results

5-90

FIGURE B-78



SYMBOL	BORING NO.	SAMPLE NO	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	Cc *	Cr *	REMARKS *
⊠	PII-40	D-10	50.00	DRIVE	Silty Clay(stone)	7.6	2.1	Coefficients Strain Related

The Earth Technology Corporation

PROJECT NO.: 89-409

Vermont/Santa Monica Station and Tunnel

Consolidation Test Results

5-90

FIGURE B-79

Appendix C

Chemical Laboratory Test Results

APPENDIX C

CHEMICAL LABORATORY TEST RESULTS

A total of 22 soil and five water samples were selected and transported to CKY Environmental Services, Inc. of Torrance, California, for a limited characterization of potential chemical contamination. The results presented in their reports are included in this Appendix.

CKY

C K Y incorporated
Environmental Services

Date: 06/06/89
890543

Earth Technology Corporation
3777 Long Beach Blvd.
Long Beach, CA 90807-3309

Attn: Mr. Bill Lu

Subject: Laboratory Report
Project: Metro II/89-409-03

Enclosed is the laboratory report for samples received on 05/18/89. The samples were received in coolers with ice and intact; the chain-of-custody forms were properly filled out. The data reported includes:

Method	No. of Analysis
EPA 418.1 (TRPH)	10 Water
EPA 8020 (BTEX)	11 Water
EPA 9038 (Sulfate)	10 Water
EPA 9030 (Sulfide)	10 Water
EPA 9040 (pH)	10 Water

The results are summarized on six pages.

Please feel free to call if you have any questions concerning these results.

Sincerely,

Kam Pang

Dr. Kam Pang
Laboratory Director

3551 Voyager St., Suite 102, Torrance, Calif. 90503 • Telephone (213) 371-0048

EPA METHOD 418.1
TOTAL RECOVERABLE PETROLEUM HYDROCARBONS

CLIENT:	The Earth Technology	**DATE REC'D:**	05/18/89
PROJECT:	Metro II/89-409-03	**DATE EXTRACTED:**	05/24/89
CONTROL NO:	890543	**DATE ANALYZED:**	05/25/89
MATRIX TYPE:	Water		

SAMPLE ID:	CONTROL NO:	RESULTS (mg/L)	DETECTION LIMIT (mg/L)
PII-13-Bulk	890543-1	110	1
PII-20-Bulk	890543-2	600	1
PII-29A-Bulk	890543-3	34	1
PII-35-Bulk	890543-4	ND	1
PII-43-Bulk	890543-5	ND	1
PII-46B-Bulk	890543-6	ND	1
PII-66-Bulk	890543-7	ND	1
PII-86-Bulk	890543-8	ND	1
PII-95A-Bulk	890543-9	15	1
PII-105-Bulk	890543-10	110	1

EPA METHOD - 8020
BTEX

CLIENT:	The Earth Technology	**DATE REC'D:**	05/18/89
PROJECT:	Metro II/89-409-03	**DATE EXTRACTED:**	05/23/89
CONTROL NO:	890543	**DATE ANALYZED:**	05/23/89
MATRIX TYPE:	Water		

SAMPLE ID:	CONTROL NO:	RESULTS (ppb) Benz	Toluene	Et Benz	Xyls
PII-13-Bore Hole	890543-1	ND	ND	6.9	11
P11-20-Bore Hole	890543-2	350	78	50	2300
PII-29A-Bore Hole	890543-3	ND	ND	ND	2.5
PII-35-Bore Hole	890543-4	ND	ND	21	4.5
PII-43-Bore Hole	890543-5	ND	ND	11	16
PII-46B-Bore Hole	890543-6	ND	ND	ND	ND
PII-66-Bore Hole	890543-7	ND	ND	ND	ND
PII-86-Bore Hole	890543-8	ND	ND	1.7	3.1
PII-95A-Bore Hole	890543-9	ND	ND	ND	ND
PII-105-Bore Hole	890543-10	ND	ND	4.3	21
Trip Blank	890543-11	ND	ND	ND	ND
DETECTION LIMIT		0.5	1	1	1

EPA METHOD 9038
SULFATE

CLIENT:	The Earth Technology	**DATE REC'D:**	05/18/89
PROJECT:	Metro II/89-409-03	**DATE EXTRACTED:**	05/22/89
CONTROL NO:	890543	**DATE ANALYZED:**	05/30/89
MATRIX TYPE:	Water		

SAMPLE ID:	CONTROL NO:	RESULTS (mg/L SO_4)	DETECTION LIMIT (mg/L SO_4)
PII-13-Bulk	890543-01	490	10
PII-20-Bulk	890543-02	690	10
PII-29A-Bulk	890543-03	31	10
PII-35-Bulk	890543-04	100	10
PII-43-Bulk	890543-05	150	10
PII-46B-Bulk	890543-06	470	10
PII-66-Bulk	890543-07	230	10
PII-86-Bulk	890543-08	320	10
PII-95A-Bulk	890543-09	180	10
PII-105-Bulk	890543-10	150	10

EPA METHOD 9030
SULFIDE

CLIENT:	The Earth Technology	**DATE REC'D:**	05/18/89
PROJECT:	Metro II/89-409-03	**DATE EXTRACTED:**	05/24/89
CONTROL NO:	890543	**DATE ANALYZED:**	05/24/89
MATRIX TYPE:	Water		

SAMPLE ID:	CONTROL NO:	RESULTS (ppm)	DETECTION LIMIT (ppm)
PII-13-Bulk	890543-01	40	1
PII-20-Bulk	890543-02	7.5	1
PII-29A-Bulk	890543-03	12	1
PII-35-Bulk	890543-04	2	1
PII-43-Bulk	890543-05	ND	1
PII-46B-Bulk	890543-06	2	1
PII-66-Bulk	890543-07	ND	1
PII-86-Bulk	890543-08	ND	1
PII-95A-Bulk	890543-09	4	1
PII-105-Bulk	890543-10	ND	1

PH - 9040

CLIENT: The Earth Technology — **DATE REC'D:** 05/18/89
PROJECT: Metro II/89-409-03 — **DATE EXTRACTED:** 05/24/89
CONTROL NO: 890543 — **DATE ANALYZED:** 05/24/89
MATRIX TYPE: Water

SAMPLE I.D.	CONTROL NO.	pH
PII-13-Bulk	890543-01	6.8
PII-20-Bulk	890543-02	6.8
PII-29A-Bulk	890543-03	7.0
PII-35-Bulk	890543-04	6.4
PII-43-Bulk	890543-05	6.4
PII-46B-Bulk	890543-06	6.8
PII-66-Bulk	890543-07	6.4
PII-86-Bulk	890543-08	6.4
PII-95A-Bulk	890543-09	6.8
PII-105-Bulk	890543-10	6.4

QUALITY CONTROL DATA

CLIENT: The Earth Technology Corp.
PROJECT: Metro II/89-409-03
CKY I.D.: 890543

METHOD 418.1
MATRIX: Water

SAMPLE ID: 890543-09

COMPOUND	SAMPLE RESULTS (ppm)	AMOUNT SPIKED (ppm)	% REC.	DUP. % REC.	RPD
IR Ref Oil	15	112	97	94	3

METHOD 8020
MATRIX: Water

SAMPLE ID: Water Blank

COMPOUND	SAMPLE RESULTS (ppb)	AMOUNT SPIKED (ppb)	% REC.	DUP. % REC.	RPD
Benzene	ND	20	85	80	6
Toluene	ND	20	95	85	11
Et. Benzene	ND	20	70	80	13
Xylenes	ND	40	103	100	3

C K Y incorporated
Environmental Services

Date: 06/13/89
890554

The Earth Technology Corporation
3777 Long Beach Blvd.,
Long Beach, CA 90807-3309

Attn: Mr. Bill Lu

Subject: Laboratory Report
Project: Metro Rail II/89-409-09

Enclosed is the laboratory report for samples received on 05/23/89. The samples were received in coolers with ice and intact; the chain-of-custody forms were properly filled out. The data reported includes:

Method	No. of Analysis
EPA 418.1 (TRPH)	53 Soils
EPA 8020 (BTEX)	53 Soils
EPA 9038 (Sulfate)	53 Soils

The results are summarized on eleven pages.

Please feel free to call if you have any questions concerning these results.

Sincerely,

Kam Pang

Dr. Kam Pang
Laboratory Director

3551 Voyager St., Suite 102, Torrance, Calif. 90503 • Telephone (213) 371-0048

EPA METHOD 418.1
TOTAL RECOVERABLE PETROLEUM HYDROCARBONS

CLIENT:	Earth Technology Corp.	**DATE REC'D:**	05/23/89
PROJECT:	Metro Rail II/89-409-09	**DATE EXTRACTED:**	05/26/89
CONTROL NO:	890554	**DATE ANALYZED:**	06/06/89
MATRIX TYPE:	Soil		

SAMPLE ID:	**CONTROL NO:**	**RESULTS (mg/kg)**	**DETECTION LIMIT (mg/kg)**
PII-13 D-13	890554-1	35,000	5
PII-25 D-10	890554-2	220	5
PII-25 D-16	890554-3	150	5
PII-32A D-10	890554-4	6.0	5
PII-33 D-9	890554-5	8.0	5
PII-34 D-6	890554-6	ND	5
PII-34 D-10	890554-7	ND	5
PII-35 D-3	890554-8	ND	5
PII-35 D-9	890554-9	ND	5
PII-38 D-3	890554-10	ND	5
PII-38 D-7	890554-11	ND	5
PII-38 D-13	890554-12	6.0	5
PII-40 D-2	890554-13	ND	5
PII-40 D-12	890554-14	ND	5
PII-41B D-12	890554-15	ND	5
PII-41B D-18	890554-16	18	5
PII-42A D-9	890554-17	ND	5
PII-42A D-13	890554-18	ND	5
PII-43 D-11	890554-19	ND	5
PII-44 D-10	890554-20	ND	5
PII-44 D-14	890554-21	ND	5
PII-45 D-12	890554-22	ND	5
PII-46B D-10	890554-23	ND	5
PII-49B D-2	890554-24	ND	5
PII-49D D-4	890554-25	ND	5
PII-49D D-12	890554-26	ND	5
PII-51 D-8	890554-27	600	5
PII-51 D-14	890554-28	ND	5
PII-51 D-18	890554-29	ND	5
PII-52 D-4	890554-30	ND	5
PII-52 D-18	890554-31	ND	5
PII-59B D-8	890554-32	ND	5
PII-59D D-8	890554-33	ND	5
PII-62 D-14	890554-34	ND	5
PII-74 D-2	890554-36	90	5
PII-81 D-13	890554-37	ND	5

EPA METHOD 418.1
TOTAL RECOVERABLE PETROLEUM HYDROCARBONS

CLIENT:	Earth Technology Corp.	**DATE REC'D:**	05/23/89
PROJECT:	Metro Rail II/89-409-09	**DATE EXTRACTED:**	05/26/89
CONTROL NO:	890554	**DATE ANALYZED:**	06/06/89
MATRIX TYPE:	Soil		

SAMPLE ID:	CONTROL NO:	RESULTS (mg/kg)	DETECTION LIMIT (mg/kg)
PII-83 D-13	890554-38	ND	5
PII-82 D-12	890554-39	ND	5
PII-84 D-8	890554-40	ND	5
PII-89 D-6	890554-41	ND	5
PII-92 D-4	890554-42	ND	5
PII-92 D-6	890554-43	ND	5
PII-92 D-12	890554-44	ND	5
PII-95A D-11	890554-45	ND	5
PII-97 D-10	890554-46	ND	5
PII-97 D-16	890554-47	ND	5
PII-98 D-10	890554-48	ND	5
PII-100A D-11	890554-49	ND	5
PII-102A D-11	890554-50	ND	5
PII-104 D-2	890554-51	ND	5
PII-104 D-11	890554-52	ND	5
PII-109 D-9	890554-53	ND	5
PII-110 D-16	890554-54	ND	5

EPA METHOD 8020
BTEX

CLIENT:	Earth Technology Corp.	**DATE REC'D:**	05/23/89
PROJECT:	Metro Rail II/89-409-09	**DATE EXTRACTED:**	05/24/89
CONTROL NO:	890554	**DATE ANALYZED:**	05/24/89
MATRIX TYPE:	Soil		

SAMPLE ID:	CONTROL NO:	Benz	RESULTS Toluene	(ug/kg) Et Benz	Xyls
PII-13 D-13	890554-1	50	330	110	490
PII-25 D-10	890554-2	18	170	44	290
PII-25 D-16	890554-3	54	340	150	570
PII-32A D-10	890554-4	36	320	120	490
PII-33 D-9	890554-5	ND	29	8.2	62
PII-34 D-6	890554-6	37	400	270	740
PII-34 D-10	890554-7	ND	210	54	360
PII-35 D-3	890554-8	ND	25	ND	36
PII-35 D-9	890554-9	ND	17	ND	27
PII-38 D-3	890554-10	ND	28	5.9	44
PII-38 D-7	890554-11	ND	16	ND	29
PII-38 D-13	890554-12	13	180	53	350
PII-40 D-2	890554-13	ND	25	72	57
PII-40 D-12	890554-14	5.4	39	8.6	64
PII-41B D-12	890554-15	5.0	41	8.4	69
PII-41B D-18	890554-16	ND	380	20.0	650
PII-42A D-9	890554-17	ND	33	8.2	67
PII-42A D-13	890554-18	ND	31	7.1	54
PII-43 D-11	890554-19	5.8	40	8.4	65
PII-44 D-10	890554-20	ND	25	5.7	39
PII-44 D-14	890554-21	ND	19	4.0	31
PII-45 D-12	890554-22	ND	18	ND	34
PII-46B D-10	890554-23	ND	28	5.8	49
PII-49B D-2	890554-24	ND	ND	ND	ND
PII-49D D-4	890554-25	ND	26	ND	37
PII-49D D-12	890554-26	ND	33	6.6	55
PII-51 D-8	890554-27	11	53	140	620
PII-51 D-14	890554-28	26	260	72	410
PII-51 D-18	890554-29	73	330	110	480
PII-52 D-4	890554-30	ND	25	17	110
PII-52 D-18	890554-31	14	260	84	430
PII-59B D-8	890554-32	ND	18	ND	34
PII-59D D-8	890554-33	ND	21	ND	33
PII-62 D-14	890554-34	ND	16	16	76
PII-74 D-2	890554-36	ND	20	5.4	63
PII-81 D-13	890554-37	ND	13	ND	23
DETECTION LIMIT		5	5	5	5

EPA METHOD 8020
BTEX

CLIENT:	Earth Technology Corp.	**DATE REC'D:**	05/23/89
PROJECT:	Metro Rail II/89-409-09	**DATE EXTRACTED:**	05/24/89
CONTROL NO:	890554	**DATE ANALYZED:**	05/24/89
MATRIX TYPE:	Soil		

			RESULTS	(ug/kg)	
SAMPLE ID:	CONTROL NO:	Benz	Toluene	Et Benz	Xyls
PII-83 D-13	890554-38	ND	13	ND	32
PII-82 D-12	890554-39	ND	21	ND	41
PII-84 D-8	890554-40	ND	13	ND	22
PII-89 D-6	890554-41	ND	23	5.1	43
PII-92 D-4	890554-42	ND	17	8.7	50
PII-92 D-6	890554-43	ND	22	5.1	44
PII-92 D-12	890554-44	ND	20	ND	39
PII-95A D-11	890554-45	ND	16	5.2	33
PII-97 D-10	890554-46	ND	19	ND	37
PII-97 D-16	890554-47	ND	ND	ND	ND
PII-98 D-10	890554-48	ND	22	6.1	47
PII-100A D-11	890554-49	ND	22	ND	33
PII-102A D-11	890554-50	ND	18	ND	30
PII-104 D-2	890554-51	6.2	48	17	150
PII-104 D-11	890554-52	ND	7	ND	17
PII-109 D-9	890554-53	ND	20	ND	34
PII-110 D-16	890554-54	ND	7.5	ND	23
DETECTION LIMIT		5	5	5	5

EPA METHOD 9038
SULFATE

CLIENT:	Earth Technology Corp.	DATE REC'D:	05/23/89
PROJECT:	Metro Rail II/89-409-09	DATE EXTRACTED:	05/24/89
CONTROL NO:	890554	DATE ANALYZED:	05/30/89
MATRIX TYPE:	Soil		

SAMPLE ID:	CONTROL NO:	RESULTS (mg/Kg SO_4)	DETECTION LIMIT (mg/Kg SO_4)
PII-13 D-13	890554-1	270	10
PII-25 D-10	890554-2	710	10
PII-25 D-16	890554-3	920	10
PII-32A D-10	890554-4	480	10
PII-33 D-9	890554-5	960	10
PII-34 D-6	890554-6	68	10
PII-34 D-10	890554-7	100	10
PII-35 D-3	890554-8	80	10
PII-35 D-9	890554-9	60	10
PII-38 D-3	890554-10	280	10
PII-38 D-7	890554-11	190	10
PII-38 D-13	890554-12	43	10
PII-40 D-2	890554-13	290	10
PII-40 D-12	890554-14	43	10
PII-41B D-13	890554-15	53	10
PII-41B D-18	890554-16	340	10
PII-42A D-9	890554-17	220	10
PII-42A D-13	890554-18	58	10
PII-43 D-11	890554-19	130	10
PII-44 D-10	890554-20	45	10
PII-44 D-14	890554-21	120	10
PII-45 D-12	890554-22	120	10
PII-46B D-10	890554-23	31	10
PII-49B D-2	890554-24	450	10
PII-49D D-4	890554-25	540	10
PII-49D D-12	890554-26	10	10
PII-51 D-8	890554-27	99	10
PII-51 D-14	890554-28	12	10
PII-51 D-18	890554-29	260	10
PII-52 D-4	890554-30	210	10
PII-52 D-18	890554-31	240	10
PII-59B D-8	890554-32	420	10
PII-59D D-8	890554-33	110	10
PII-62 D-14	890554-34	250	10
PII-74 D-2	890554-36	53	10
PII-81 D-13	890554-37	140	10

EPA METHOD 9038
SULFATE

CLIENT:	Earth Technology Corp.	**DATE REC'D:**	05/23/89
PROJECT:	Metro Rail II/89-409-09	**DATE EXTRACTED:**	05/24/89
CONTROL NO:	890554	**DATE ANALYZED:**	05/30/89
MATRIX TYPE:	Soil		

SAMPLE ID:	CONTROL NO:	RESULTS (mg/Kg SO_4)	DETECTION LIMIT (mg/Kg SO_4)
PII-83 D-13	890554-38	35	10
PII-82 D-12	890554-39	39	10
PII-84 D-8	890554-40	180	10
PII-89 D-6	890554-41	130	10
PII-92 D-4	890554-42	47	10
PII-92 D-6	890554-43	82	10
PII-92 D-12	890554-44	ND	10
PII-95A D-11	890554-45	50	10
PII-97 D-10	890554-46	710	10
PII-97 D-16	890554-47	31	10
PII-98 D-10	890554-48	500	10
PII-100A D-11	890554-49	39	10
PII-102A D-11	890554-50	68	10
PII-104 D-2	890554-51	23	10
PII-104 D-11	890554-52	520	10
PII-109 D-9	890554-53	45	10
PII-110 D-16	890554-54	76	10

QUALITY CONTROL DATA

CLIENT: Earth Technology Corporation
PROJECT: Metro Rail II
CKY I.D.: 890554

METHOD 418.1
MATRIX: Soil

SAMPLE ID: 890554-10

COMPOUND	SAMPLE RESULTS (ppm)	AMOUNT SPIKED (ppm)	% REC.	DUP. % REC.	RPD
IR Ref Oil	ND	155	111	109	2

METHOD 418.1
MATRIX: Soil

SAMPLE ID: 890554-11

COMPOUND	SAMPLE RESULTS (ppm)	AMOUNT SPIKED (ppm)	% REC.	DUP. % REC.	RPD
IR Ref Oil	ND	155	109	109	0

METHOD 418.1
MATRIX: Soil

SAMPLE ID: 890554-34

COMPOUND	SAMPLE RESULTS (ppm)	AMOUNT SPIKED (ppm)	% REC.	DUP. % REC.	RPD
IR Ref Oil	ND	200	92	104	12

QUALITY CONTROL DATA

CLIENT: Earth Technology Corporation
PROJECT: Metro Rail II
CKY I.D.: 890554

METHOD 418.1
MATRIX: Soil

SAMPLE ID: 890554-44

COMPOUND	SAMPLE RESULTS (ppm)	AMOUNT SPIKED (ppm)	% REC.	DUP. % REC.	RPD
IR Ref Oil	ND	155	98	120	22

METHOD 418.1
MATRIX: Soil

SAMPLE ID: 890554-51

COMPOUND	SAMPLE RESULTS (ppm)	AMOUNT SPIKED (ppm)	% REC.	DUP. % REC.	RPD
IR Ref Oil	ND	200	110	96	14

METHOD 9038
MATRIX: Soil

SAMPLE ID: 890554-06

COMPOUND	SAMPLE RESULTS (mg/Kg)	AMOUNT SPIKED (mg/Kg)	% REC.	DUP. % REC.	RPD
Sulfate	68	500	87	93	6

QUALITY CONTROL DATA

CLIENT: Earth Technology Corporation
PROJECT: Metro Rail II
CKY I.D.: 890554

METHOD 9038
MATRIX: Soil

SAMPLE ID: 890554-14

COMPOUND	SAMPLE RESULTS (mg/Kg)	AMOUNT SPIKED (mg/Kg)	% REC.	DUP. % REC.	RPD
Sulfate	43	500	95	96	0.2

METHOD 9038
MATRIX: Soil

SAMPLE ID: 890554-38

COMPOUND	SAMPLE RESULTS (mg/Kg)	AMOUNT SPIKED (mg/Kg)	% REC.	DUP. % REC.	RPD
Sulfate	35	500	98	97	1.0

METHOD 9038
MATRIX: Soil

SAMPLE ID: 890554-42

COMPOUND	SAMPLE RESULTS (mg/Kg)	AMOUNT SPIKED (mg/Kg)	% REC.	DUP. % REC.	RPD
Sulfate	47	500	99	93	6

QUALITY CONTROL DATA

CLIENT: Earth Technology Corporation
PROJECT: Metro Rail II
CKY I.D.: 890554

METHOD 8020
MATRIX: Soil

SAMPLE ID: 890554-09

COMPOUND	SAMPLE RESULTS (ppb)	AMOUNT SPIKED (ppb)	% REC.	DUP. % REC.	RPD
Benzene	<5	20	90	90	0
Toluene	17	20	85	110	26
Et. Benzene	<5	20	80	75	6
Xylenes	27	40	85	95	11

METHOD 8020
MATRIX: Soil

SAMPLE ID: 890554-18

COMPOUND	SAMPLE RESULTS (ppb)	AMOUNT SPIKED (ppb)	% REC.	DUP. % REC.	RPD
Benzene	<5	20	105	90	15
Toluene	31	20	120	95	20
Et. Benzene	7.1	20	104	85	20
Xylenes	54	40	112	93	6

METHOD 8020
MATRIX: Soil

SAMPLE ID: 890554-27

COMPOUND	SAMPLE RESULTS (ppb)	AMOUNT SPIKED (ppb)	% REC.	DUP. % REC.	RPD
Benzene	11	20	90	80	12
Toluene	53	20	85	90	6
Et. Benzene	140	20	115	100	14
Xylenes	620	40	110	88	22

QUALITY CONTROL DATA

CLIENT: Earth Technology Corporation
PROJECT: Metro Rail II
CKY I.D.: 890554

METHOD 8020
MATRIX: Soil

SAMPLE ID: 890554-36

COMPOUND	SAMPLE RESULTS (ppb)	AMOUNT SPIKED (ppb)	% REC.	DUP. % REC.	RPD
Benzene	ND	20	85	85	0
Toluene	20	20	120	95	23
Et. Benzene	5.4	20	83	93	11
Xylenes	63	40	92	85	8

METHOD 8020
MATRIX: Soil

SAMPLE ID: 890554-45

COMPOUND	SAMPLE RESULTS (ppb)	AMOUNT SPIKED (ppb)	% REC.	DUP. % REC.	RPD
Benzene	ND	20	90	100	10
Toluene	16	20	110	95	14
Et. Benzene	5.2	20	79	79	0
Xylenes	33	40	118	108	9

METHOD 8020
MATRIX: Soil

SAMPLE ID: 890554-54

COMPOUND	SAMPLE RESULTS (ppb)	AMOUNT SPIKED (ppb)	% REC.	DUP. % REC.	RPD
Benzene	ND	20	95	80	17
Toluene	7.5	20	88	102	15
Et. Benzene	ND	20	80	85	6
Xylenes	23	40	92	85	8

C K Y incorporated
Environmental Services

Date: 07/05/89
890554

The Earth Technology Corporation
3777 Long Beach Blvd.,
Long Beach, CA 90807-3309

Attn: Mr. Bill Lu

Subject: Laboratory Report
Project: Metro Rail II/89-409-09

Enclosed is the additional laboratory report for samples received on 05/23/89. The samples were received in coolers with ice and intact; the chain-of-custody forms were properly filled out. The data reported includes:

Method	No. of Analysis
EPA 9030 (Sulfide)	53 Soils

The results are summarized on four pages.

Please feel free to call if you have any questions concerning these results.

Sincerely,

Kam Pang

Dr. Kam Pang
Laboratory Director

3551 Voyager St., Suite 102, Torrance, Calif. 90503 • Telephone (213) 371-0048

EPA METHOD 9030
SULFIDE

CLIENT:	Earth Technology Corp.	**DATE REC'D:**	05/23/89
PROJECT:	Metro Rail II/89-409-09	**DATE EXTRACTED:**	06/29/89
CONTROL NO:	890554	**DATE ANALYZED:**	06/30/89
MATRIX TYPE:	Soil		

SAMPLE ID:	CONTROL NO:	RESULTS (mg/Kg)	DETECTION LIMIT (mg/Kg)
PII-13 D-13	890554-1	62	1
PII-25 D-10	890554-2	7.2	1
PII-25 D-16	890554-3	12	1
PII-32A D-10	890554-4	3.7	1
PII-33 D-9	890554-5	15	1
PII-34 D-6	890554-6	ND	1
PII-34 D-10	890554-7	9.2	1
PII-35 D-3	890554-8	9.2	1
PII-35 D-9	890554-9	6.8	1
PII-38 D-3	890554-10	14	1
PII-38 D-7	890554-11	4.2	1
PII-38 D-13	890554-12	12	1
PII-40 D-2	890554-13	6.3	1
PII-40 D-12	890554-14	ND	1
PII-41B D-13	890554-15	2.8	1
PII-41B D-18	890554-16	ND	1
PII-42A D-9	890554-17	7.8	1
PII-42A D-13	890554-18	3.3	1
PII-43 D-11	890554-19	6.2	1
PII-44 D-10	890554-20	ND	1
PII-44 D-14	890554-21	13	1
PII-45 D-12	890554-22	8.7	1
PII-46B D-10	890554-23	11.2	1
PII-49B D-2	890554-24	10	1
PII-49D D-4	890554-25	18	1
PII-49D D-12	890554-26	14	1
PII-51 D-8	890554-27	8.2	1
PII-51 D-14	890554-28	6.7	1
PII-51 D-18	890554-29	12	1
PII-52 D-4	890554-30	4.2	1
PII-52 D-18	890554-31	15	1
PII-59B D-8	890554-32	5.2	1
PII-59D D-8	890554-33	ND	1
PII-62 D-14	890554-34	19	1
PII-74 D-2	890554-36	ND	1
PII-81 D-13	890554-37	7.2	1

EPA METHOD 9030
SULFIDE

CLIENT:	Earth Technology Corp.	**DATE REC'D:**	05/23/89
PROJECT:	Metro Rail II/89-409-09	**DATE EXTRACTED:**	06/29/89
CONTROL NO:	890554	**DATE ANALYZED:**	06/30/89
MATRIX TYPE:	Soil		

SAMPLE ID:	CONTROL NO:	RESULTS (mg/Kg)	DETECTION LIMIT (mg/Kg)
PII-83 D-13	890554-38	ND	1
PII-82 D-12	890554-39	24	1
PII-84 D-8	890554-40	23	1
PII-89 D-6	890554-41	2.2	1
PII-92 D-4	890554-42	5.7	1
PII-92 D-6	890554-43	4.2	1
PII-92 D-12	890554-44	1.7	1
PII-95A D-11	890554-45	ND	1
PII-97 D-10	890554-46	1.2	1
PII-97 D-16	890554-47	21	1
PII-98 D-10	890554-48	24	1
PII-100A D-11	890554-49	6.2	1
PII-102A D-11	890554-50	6.2	1
PII-104 D-2	890554-51	8.7	1
PII-104 D-11	890554-52	5.2	1
PII-109 D-9	890554-53	12	1
PII-110 D-16	890554-54	1.7	1

QUALITY CONTROL DATA

CLIENT: Earth Technology Corporation
PROJECT: Metro Rail
CKY I.D.: 890554

METHOD 9030
MATRIX: Soil

SAMPLE ID: BL 1 SP/SP D

COMPOUND	SAMPLE RESULTS (ppm)	AMOUNT SPIKED (ppm)	% REC.	DUP. % REC.	RPD
Sulfide	Blank	1720	104	107	3

METHOD 9030
MATRIX: Soil

SAMPLE ID: BL 2 SP/SP D

COMPOUND	SAMPLE RESULTS (ppm)	AMOUNT SPIKED (ppm)	% REC.	DUP. % REC.	RPD
Sulfide	Blank	1720	93	99	6

METHOD 9030
MATRIX: Soil

SAMPLE ID: BL 3 SP/SP D

COMPOUND	SAMPLE RESULTS (ppm)	AMOUNT SPIKED (ppm)	% REC.	DUP. % REC.	RPD
Sulfide	Blank	1720	102	102	0

QUALITY CONTROL DATA

CLIENT: Earth Technology Corporation
PROJECT: Metro Rail
CKY I.D.: 890554

METHOD 9030
MATRIX: Soil

SAMPLE ID: BL 4 SP/SP D

COMPOUND	SAMPLE RESULTS (ppm)	AMOUNT SPIKED (ppm)	% REC.	DUP. % REC.	RPD
Sulfide	0	1720	93	93	0

METHOD 9030
MATRIX: Soil

SAMPLE ID: BL 5 SP/SP D

COMPOUND	SAMPLE RESULTS (ppm)	AMOUNT SPIKED (ppm)	% REC.	DUP. % REC.	RPD
Sulfide	0	1720	93	93	0

C K Y incorporated
Environmental Services

Date: 07/13/89
890657

Earth Technology Corporation
3777 Long Beach Blvd.
Long Beach, CA 90807-3309

Attn: Mr. Bill Lu

Subject: Laboratory Report
Project: Metro Rail

Enclosed is the laboratory report for samples received on 06/27/89. The samples were received in coolers with ice and intact; the chain-of-custody forms were properly filled out. The data reported includes:

Method	No. of Analysis
EPA 8270	12 Soils
EPA 8240 (VOC by GC/MS)	12 Soils
CAM Metals	12 Soils

The results are summarized on forty pages.

Please feel free to call if you have any questions concerning these results.

Sincerely,

Kam Pang

Dr. Kam Pang
Laboratory Director

3551 Voyager St., Suite 102, Torrance, Calif. 90503 • Telephone (213) 371-0048

EPA METHOD - 8270
SEMIVOLATILE ORGANICS BY GC/MS

CLIENT:	Earth Technology Corp.	**DATE REC'D:**	06/27/89
PROJECT:	Metro Rail	**DATE EXTRACTED:**	07/02/89
SAMPLE ID:	PII-25 D-10	**DATE ANALYZED:**	07/05/89
CONTROL NO:	890657-3	**MATRIX TYPE:**	Soil

PARAMETER	RESULTS (mg/kg)	PARAMETER	RESULTS (mg/kg)
Phenol	ND (2.0)	Acenaphthene	ND (2.0)
bis(2-chloroethyl)ether	ND (2.0)	2,4-Dinitrophenol	ND(10.0)
2-Chlorophenol	ND (2.0)	4-Nitrophenol	ND(10.0)
1,3-Dichlorobenzene	ND (2.0)	Dibenzofuran	ND (2.0)
1,4-Dichlorobenzene	ND (2.0)	2,4-Dinitrotoluene	ND (2.0)
Benzyl Alcohol	ND (4.0)	2,6-Dinitrotoluene	ND (2.0)
1,2-Dichlorobenzene	ND (2.0)	Diethylphthalate	ND (2.0)
2-Methylphenol	ND (2.0)	4-Chlorophenyl-phenylether	ND (2.0)
bis(2-chloroisopropyl)ether	ND (2.0)	Fluorene	ND (2.0)
4-Methylphenol	ND (2.0)	4-Nitroaniline	ND(10.0)
N-Nitroso-Di-n-Propylamine	ND (2.0)	4,6-Dinitro-2-Methylphenol	ND(10.0)
Hexachloroethane	ND (2.0)	N-Nitrosodiphenylamine	ND (2.0)
Nitrobenzene	ND (2.0)	4-Bromophenyl-phenylether	ND (2.0)
Isophorone	ND (2.0)	Hexachlorobenzene	ND (2.0)
2-Nitrophenol	ND (2.0)	Pentachlorophenol	ND(10.0)
2,4-Dimethylphenol	ND (2.0)	Phenanthrene	ND (2.0)
Benzoic Acid	ND(10.0)	Anthracene	ND (2.0)
bis-(2-Chloroethoxy)methane	ND (2.0)	Di-n-Butylphthalate	ND (2.0)
2,4-Dichlorophenol	ND (2.0)	Fluoranthene	ND (2.0)
1,2,4-Trichlorobenzene	ND (2.0)	Pyrene	ND (2.0)
Naphthalene	ND (2.0)	Butylbenzylphthalate	ND (2.0)
4-Chloroaniline	ND (4.0)	3,3'-Dichlorobenzidine	ND (4.0)
Hexachlorobutadiene	ND (2.0)	Benzo(a)Anthracene	ND (2.0)
4-Chloro-3-Methylphenol	ND (4.0)	bis(2-Ethylhexyl)Phthalate	ND (2.0)
2-Methylnaphthalene	ND (2.0)	Chrysene	ND (2.0)
Hexachlorocyclopentadiene	ND (2.0)	Di-n-Octyl Phthalate	ND (2.0)
2,4,6-Trichlorophenol	ND (2.0)	Benzo(b)Fluoranthene	ND (2.0)
2,4,5-Trichlorophenol	ND (2.0)	Benzo(k)Fluoranthene	ND (2.0)
2-Chloronaphthalene	ND (2.0)	Benzo(a)Pyrene	ND (2.0)
2-Nitroaniline	ND(10.0)	Indeno(1,2,3-cd)Pyrene	ND (2.0)
Dimethyl Phthalate	ND (2.0)	Dibenz(a,h)Anthracene	ND (2.0)
Acenaphthylene	ND (2.0)	Benzo(g,h,i)Perylene	ND (2.0)
3-Nitroaniline	ND(10.0)		

ND = Not Detected
( ) = Detection Limit (mg/k

EPA METHOD - 8270
SEMIVOLATILE ORGANICS BY GC/MS

CLIENT:	Earth Technology Corp.	**DATE REC'D:**	06/27/89
PROJECT:	Metro Rail	**DATE EXTRACTED:**	07/02/89
SAMPLE ID:	PII-35 D-9	**DATE ANALYZED:**	07/05/89
CONTROL NO:	890657-4	**MATRIX TYPE:**	Soil

PARAMETER	RESULTS (mg/kg)	PARAMETER	RESULTS (mg/kg)
Phenol	ND (0.1)	Acenaphthene	ND (0.1)
bis(2-chloroethyl)ether	ND (0.1)	2,4-Dinitrophenol	ND (0.5)
2-Chlorophenol	ND (0.1)	4-Nitrophenol	ND (0.5)
1,3-Dichlorobenzene	ND (0.1)	Dibenzofuran	ND (0.1)
1,4-Dichlorobenzene	ND (0.1)	2,4-Dinitrotoluene	ND (0.1)
Benzyl Alcohol	ND (0.2)	2,6-Dinitrotoluene	ND (0.1)
1,2-Dichlorobenzene	ND (0.1)	Diethylphthalate	ND (0.1)
2-Methylphenol	ND (0.1)	4-Chlorophenyl-phenylether	ND (0.1)
bis(2-chloroisopropyl)ether	ND (0.1)	Fluorene	ND (0.1)
4-Methylphenol	ND (0.1)	4-Nitroaniline	ND (0.5)
N-Nitroso-Di-n-Propylamine	ND (0.1)	4,6-Dinitro-2-Methylphenol	ND (0.5)
Hexachloroethane	ND (0.1)	N-Nitrosodiphenylamine	ND (0.1)
Nitrobenzene	ND (0.1)	4-Bromophenyl-phenylether	ND (0.1)
Isophorone	ND (0.1)	Hexachlorobenzene	ND (0.1)
2-Nitrophenol	ND (0.1)	Pentachlorophenol	ND (0.5)
2,4-Dimethylphenol	ND (0.1)	Phenanthrene	ND (0.1)
Benzoic Acid	ND (0.5)	Anthracene	ND (0.1)
bis-(2-Chloroethoxy)methane	ND (0.1)	Di-n-Butylphthalate	ND (0.1)
2,4-Dichlorophenol	ND (0.1)	Fluoranthene	ND (0.1)
1,2,4-Trichlorobenzene	ND (0.1)	Pyrene	ND (0.1)
Naphthalene	ND (0.1)	Butylbenzylphthalate	ND (0.1)
4-Chloroanline	ND (0.2)	3,3'-Dichlorobenzidine	ND (0.2)
Hexachlorobutadiene	ND (0.1)	Benzo(a)Anthracene	ND (0.1)
4-Chloro-3-Methylphenol	ND (0.2)	bis(2-Ethylhexyl)Phthalate	ND (0.1)
2-Methylnaphthalene	ND (0.1)	Chrysene	ND (0.1)
Hexachlorocyclopentadiene	ND (0.1)	Di-n-Octyl Phthalate	ND (0.1)
2,4,6-Trichlorophenol	ND (0.1)	Benzo(b)Fluoranthene	ND (0.1)
2,4,5-Trichlorophenol	ND (0.1)	Benzo(k)Fluoranthene	ND (0.1)
2-Chloronaphthalene	ND (0.1)	Benzo(a)Pyrene	ND (0.1)
2-Nitroaniline	ND (0.5)	Indeno(1,2,3-cd)Pyrene	ND (0.1)
Dimethyl Phthalate	ND (0.1)	Dibenz(a,h)Anthracene	ND (0.1)
Acenaphthylene	ND (0.1)	Benzo(g,h,i)Perylene	ND (0.1)
3-Nitroaniline	ND (0.5)		

<u>% Surrogate Recovery:</u>

2-Fluorophenol	46
Phenol-d_5	63
Nitrobenzene-d_5	58
2-Fluorobiphenyl	76
Terphenyl-d_{14}	112

ND = Not Detected
( ) = Detection Limit (mg/kg)

EPA METHOD - 8270
SEMIVOLATILE ORGANICS BY GC/MS

CLIENT:	Earth Technology Corp.	**DATE REC'D:**	06/27/89
PROJECT:	Metro Rail	**DATE EXTRACTED:**	07/02/89
SAMPLE ID:	PII-42A D-9	**DATE ANALZYED:**	07/05/89
CONTROL NO:	890657-5	**MATRIX TYPE:**	Soil

PARAMETER	RESULTS (mg/kg)	PARAMETER	RESULTS (mg/kg)
Phenol	ND (0.1)	Acenaphthene	ND (0.1)
bis(2-chloroethyl)ether	ND (0.1)	2,4-Dinitrophenol	ND (0.5)
2-Chlorophenol	ND (0.1)	4-Nitrophenol	ND (0.5)
1,3-Dichlorobenzene	ND (0.1)	Dibenzofuran	ND (0.1)
1,4-Dichlorobenzene	ND (0.1)	2,4-Dinitrotoluene	ND (0.1)
Benzyl Alcohol	ND (0.2)	2,6-Dinitrotoluene	ND (0.1)
1,2-Dichlorobenzene	ND (0.1)	Diethylphthalate	ND (0.1)
2-Methylphenol	ND (0.1)	4-Chlorophenyl-phenylether	ND (0.1)
bis(2-chloroisopropyl)ether	ND (0.1)	Fluorene	ND (0.1)
4-Methylphenol	ND (0.1)	4-Nitroaniline	ND (0.5)
N-Nitroso-Di-n-Propylamine	ND (0.1)	4,6-Dinitro-2-Methylphenol	ND (0.5)
Hexachloroethane	ND (0.1)	N-Nitrosodiphenylamine	ND (0.1)
Nitrobenzene	ND (0.1)	4-Bromophenyl-phenylether	ND (0.1)
Isophorone	ND (0.1)	Hexachlorobenzene	ND (0.1)
2-Nitrophenol	ND (0.1)	Pentachlorophenol	ND (0.5)
2,4-Dimethylphenol	ND (0.1)	Phenanthrene	ND (0.1)
Benzoic Acid	ND (0.5)	Anthracene	ND (0.1)
bis-(2-Chloroethoxy)methane	ND (0.1)	Di-n-Butylphthalate	ND (0.1)
2,4-Dichlorophenol	ND (0.1)	Fluoranthene	ND (0.1)
1,2,4-Trichlorobenzene	ND (0.1)	Pyrene	ND (0.1)
Naphthalene	ND (0.1)	Butylbenzylphthalate	ND (0.1)
4-Chloroanline	ND (0.2)	3,3'-Dichlorobenzidine	ND (0.2)
Hexachlorobutadiene	ND (0.1)	Benzo(a)Anthracene	ND (0.1)
4-Chloro-3-Methylphenol	ND (0.2)	bis(2-Ethylhexyl)Phthalate	ND (0.1)
2-Methylnaphthalene	ND (0.1)	Chrysene	ND (0.1)
Hexachlorocyclopentadiene	ND (0.1)	Di-n-Octyl Phthalate	ND (0.1)
2,4,6-Trichlorophenol	ND (0.1)	Benzo(b)Fluoranthene	ND (0.1)
2,4,5-Trichlorophenol	ND (0.1)	Benzo(k)Fluoranthene	ND (0.1)
2-Chloronaphthalene	ND (0.1)	Benzo(a)Pyrene	ND (0.1)
2-Nitroaniline	ND (0.5)	Indeno(1,2,3-cd)Pyrene	ND (0.1)
Dimethyl Phthalate	ND (0.1)	Dibenz(a,h)Anthracene	ND (0.1)
Acenaphthylene	ND (0.1)	Benzo(g,h,i)Perylene	ND (0.1)
3-Nitroaniline	ND (0.5)		

<u>% Surrogate</u> <u>Recovery:</u>

2-Fluorophenol	84
Phenol-d_5	93
Nitrobenzene-d_5	98
2-Fluorobiphenyl	114
Terphenyl-d_{14}	114

ND = Not Detected
( ) = Detection Limit (mg/kg)

EPA METHOD - 8240
VOLATILE ORGANICS BY GC/MS

CLIENT:	Earth Technology Corp.	**DATE REC'D:**	06/27/89
PROJECT:	Metro Rail	**DATE EXTRACTED:**	07/03/89
SAMPLE ID:	PII-25 D-10	**DATE ANALZYED:**	07/03/89
CONTROL NO:	890657-3	**MATRIX TYPE:**	Soil

PARAMETERS (8240)	**RESULTS (ug/kg)**	**DETECTION LIMIT (ug/kg)**
Acetone	ND	200
Benzene	40	10
Bromodichloromethane	ND	10
Bromoform	ND	10
Bromomethane	ND	50
2-Butanone (MEK)	ND	100
Carbon Disulfide	ND	10
Carbon Tetrachloride	ND	10
Chlorobenzene	ND	10
Chlorodibromomethane	ND	10
Chloroethane	ND	50
2-Chloroethyl vinyl ether	ND	10
Chloroform	ND	10
Chloromethane	ND	50
1,1-Dichloroethane	ND	10
1,2-Dichloroethane	ND	10
1,1-Dichloroethene	ND	10
1,2-Dichloroethene (total)	ND	10
1,2-Dichloropropane	ND	10
cis-1,3-Dichloropropene	ND	10
trans-1,3-Dichloropropene	ND	10
Ethylbenzene	ND	10
2-Hexanone	ND	100
Methylene chloride	ND	200
4-Methyl-2-pentanone (MIBK)	ND	50
Styrene	ND	10
1,1,2,2-Tetrachloroethane	ND	10
Tetrachloroethene	ND	10
Toluene	85	10
1,1,1-Trichloroethane	ND	10
1,1,2-Trichloroethane	ND	10
Trichloroethene	ND	10
Trichlorofluoromethane	ND	50
Vinyl Acetate	ND	100
Vinyl Chloride	ND	50
Xylene (total)	100	10

ND = Not Detected

% Surrogate Recovery:	
1,2 Dichloroethane-d_4	92
Toluene-d_8	93
Bromoflurobenzene	64

EPA METHOD - 8240
VOLATILE ORGANICS BY GC/MS

CLIENT:	Earth Technology Corp.	DATE REC'D:	06/27/89
PROJECT:	Metro Rail	DATE EXTRACTED:	07/03/89
SAMPLE ID:	PII-35 D-9	DATE ANALYZED:	07/03/89
CONTROL NO:	890657-4	MATRIX TYPE:	Soil

PARAMETERS (8240)	RESULTS (ug/kg)	DETECTION LIMIT (ug/kg)
Acetone	ND	200
Benzene	ND	10
Bromodichloromethane	ND	10
Bromoform	ND	10
Bromomethane	ND	50
2-Butanone (MEK)	ND	100
Carbon Disulfide	ND	10
Carbon Tetrachloride	ND	10
Chlorobenzene	ND	10
Chlorodibromomethane	ND	10
Chloroethane	ND	50
2-Chloroethyl vinyl ether	ND	10
Chloroform	ND	10
Chloromethane	ND	50
1,1-Dichloroethane	ND	10
1,2-Dichloroethane	ND	10
1,1-Dichloroethene	ND	10
1,2-Dichloroethene (total)	ND	10
1,2-Dichloropropane	ND	10
cis-1,3-Dichloropropene	ND	10
trans-1,3-Dichloropropene	ND	10
Ethylbenzene	ND	10
2-Hexanone	ND	100
Methylene chloride	ND	200
4-Methyl-2-pentanone (MIBK)	ND	50
Styrene	ND	10
1,1,2,2-Tetrachloroethane	ND	10
Tetrachloroethene	ND	10
Toluene	25	10
1,1,1-Trichloroethane	ND	10
1,1,2-Trichloroethane	ND	10
Trichloroethene	ND	10
Trichlorofluoromethane	ND	50
Vinyl Acetate	ND	100
Vinyl Chloride	ND	50
Xylene (total)	ND	10

ND = Not Detected

% Surrogate Recovery:	
1,2 Dichloroethane-d_4	97
Toluene-d_8	105
Bromoflurobenzene	89

EPA METHOD - 8240
VOLATILE ORGANICS BY GC/MS

CLIENT:	Earth Technology Corp.	**DATE REC'D:**	06/27/89
PROJECT:	Metro Rail	**DATE EXTRACTED:**	07/03/89
SAMPLE ID:	PII-42A D-9	**DATE ANALZYED:**	07/03/89
CONTROL NO:	890657-5	**MATRIX TYPE:**	Soil

PARAMETERS (8240)	RESULTS (ug/kg)	DETECTION LIMIT (ug/kg)
Acetone	ND	200
Benzene	ND	10
Bromodichloromethane	ND	10
Bromoform	ND	10
Bromomethane	ND	50
2-Butanone (MEK)	ND	100
Carbon Disulfide	ND	10
Carbon Tetrachloride	ND	10
Chlorobenzene	ND	10
Chlorodibromomethane	ND	10
Chloroethane	ND	50
2-Chloroethyl vinyl ether	ND	10
Chloroform	ND	10
Chloromethane	ND	50
1,1-Dichloroethane	ND	10
1,2-Dichloroethane	ND	10
1,1-Dichloroethene	ND	10
1,2-Dichloroethene (total)	ND	10
1,2-Dichloropropane	ND	10
cis-1,3-Dichloropropene	ND	10
trans-1,3-Dichloropropene	ND	10
Ethylbenzene	ND	10
2-Hexanone	ND	100
Methylene chloride	ND	200
4-Methyl-2-pentanone (MIBK)	ND	50
Styrene	ND	10
1,1;2,2-Tetrachloroethane	ND	10
Tetrachloroethene	ND	10
Toluene	25	10
1,1,1-Trichloroethane	ND	10
1,1,2-Trichloroethane	ND	10
Trichloroethene	ND	10
Trichlorofluoromethane	ND	50
Vinyl Acetate	ND	100
Vinyl Chloride	ND	50
Xylene (total)	ND	10

ND = Not Detected

% Surrogate Recovery:

1,2 Dichloroethane-d_4	90
Toluene-d_8	102
Bromoflurobenzene	86

CAM METALS

CLIENT:	Earth Technology Corp.	**DATE REC'D:**	06/27/89
PROJECT:	Metro Rail	**DATE EXTRACTED:**	06/30/89
SAMPLE ID:	PII-25 D-10	**DATE ANALYZED:**	07/05/89
CONTROL NO:	890657-3	**MATRIX TYPE:**	Soil

PARAMETERS	**RESULTS (mg/kg)**	**DETECTION LIMIT (mg/kg)**
Antimony	ND	5.0
Arsenic	8.9	1.0
Barium	11	5.0
Beryllium	ND	1.0
Cadmium	5.3	1.0
Chromium - Total	14	1.0
Cobalt	9.5	1.0
Copper	51	1.0
Lead	11	1.0
Mercury	ND	0.05
Molybdenum	2.9	1.0
Nickel	21	1.0
Selenium	2.3	1.0
Silver	ND	1.0
Thallium	8.8	1.0
Vanadium	21	5.0
Zinc	70	1.0

CAM METALS

CLIENT:	Earth Technology Corp.	DATE REC'D:	06/27/89
PROJECT:	Metro Rail	DATE EXTRACTED:	06/30/89
SAMPLE ID:	PII-35 D-9	DATE ANALZYED:	07/05/89
CONTROL NO:	890657-4	MATRIX TYPE:	Soil

PARAMETERS	RESULTS (mg/kg)	DETECTION LIMIT (mg/kg)
Antimony	ND	5.0
Arsenic	9.4	1.0
Barium	95	5.0
Beryllium	ND	1.0
Cadmium	5.4	1.0
Chromium - Total	14	1.0
Cobalt	7.3	1.0
Copper	27	1.0
Lead	9.2	1.0
Mercury	ND	0.05
Molybdenum	1.2	1.0
Nickel	25	1.0
Selenium	ND	1.0
Silver	ND	1.0
Thallium	8.1	1.0
Vanadium	21	5.0
Zinc	130	1.0

CAM METALS

CLIENT:	Earth Technology Corp.	**DATE REC'D:**	06/27/89
PROJECT:	Metro Rail	**DATE EXTRACTED:**	06/30/89
SAMPLE ID:	PII-42A D-9	**DATE ANALYZED:**	07/05/89
CONTROL NO:	890657-5	**MATRIX TYPE:**	Soil

PARAMETERS	**RESULTS (mg/kg)**	**DETECTION LIMIT (mg/kg)**
Antimony	ND	5.0
Arsenic	9.6	1.0
Barium	100	5.0
Beryllium	ND	1.0
Cadmium	4.6	1.0
Chromium - Total	17	1.0
Cobalt	4.1	1.0
Copper	27	1.0
Lead	14	1.0
Mercury	ND	0.05
Molybdenum	1.8	1.0
Nickel	17	1.0
Selenium	ND	1.0
Silver	ND	1.0
Thallium	9.8	1.0
Vanadium	30	5.0
Zinc	87	1.0

C K Y incorporated
Environmental Services

Date: 07/21/89
890702

Earth Technology Corporation
3777 Long Beach Blvd.
Long Beach, CA 90807-3309

Attn: Mr. Mahi Galagoda

Subject: Laboratory Report
Project: Metro Rail II

Enclosed is the laboratory report for samples received on 07/05/89. The samples were received in coolers with ice and intact; the chain-of-custody forms were properly filled out. The data reported includes:

Method	No. of Analysis
EPA 418.1 (TRPH)	1 Soil
EPA 8020 (BTEX)	1 Soil
EPA 9038 (Sulfate)	1 Soil
EPA 9030 (Sulfide)	1 Soil

The results are summarized on seven pages.

Please feel free to call if you have any questions concerning these results.

Sincerely,

Kam Pang

Dr. Kam Pang
Laboratory Director

3551 Voyager St., Suite 102, Torrance, Calif. 90503 • Telephone (213) 371-0048

EPA METHOD 418.1
TOTAL RECOVERABLE PETROLEUM HYDROCARBONS

CLIENT:	Earth Technology	**DATE REC'D:**	07/05/89
PROJECT:	Metro Rail II	**DATE EXTRACTED:**	07/07/89
CONTROL NO:	890702	**DATE ANALYZED:**	07/10/89
MATRIX TYPE:	Soil		

SAMPLE ID:	**CONTROL NO:**	**RESULTS (mg/Kg)**	**DETECTION LIMIT (mg/Kg)**
PII-26 D-13	890702-1	30,000	5

EPA METHOD - 8020
BTEX

CLIENT:	Earth Technology	**DATE REC'D:**	07/05/89
PROJECT:	Metro Rail II	**DATE EXTRACTED:**	07/13/89
CONTROL NO:	890702	**DATE ANALYZED:**	07/13/89
MATRIX TYPE:	Soil		

SAMPLE ID:	CONTROL NO:	Benz	RESULTS (ug/kg) Toluene	Et Benz	Xyls
PII-26 D-13	890702-1	ND	33	5.6	48
DETECTION LIMIT		5	5	5	5

EPA METHOD 9038
SULFATE

CLIENT:	Earth Technology	**DATE REC'D:**	07/05/89
PROJECT:	Metro Rail II	**DATE EXTRACTED:**	07/17/89
CONTROL NO:	890702	**DATE ANALYZED:**	07/19/89
MATRIX TYPE:	Soil		

SAMPLE ID:	CONTROL NO:	RESULTS (mg/Kg)	DETECTION LIMIT (mg/Kg)
PII-26 D-13	890702-1	210	10

EPA METHOD 9030
SULFIDE

CLIENT:	Earth Technology	**DATE REC'D:**	07/05/89
PROJECT:	Metro Rail II	**DATE EXTRACTED:**	07/14/89
CONTROL NO:	890702	**DATE ANALYZED:**	07/14/89
MATRIX TYPE:	Soil		

SAMPLE ID:	CONTROL NO:	RESULTS (mg/Kg)	DETECTION LIMIT (mg/Kg)
PII-26 D-13	890702-1	5	1

QUALITY CONTROL DATA

CLIENT: Earth Technology Corporation
PROJECT: Metro Rail
CKY I.D.: 890702

METHOD 418.1
MATRIX: Soil

SAMPLE ID: Blank Spike II

COMPOUND	SAMPLE RESULTS (ppm)	AMOUNT SPIKED (ppm)	% REC.	DUP. % REC.	RPD
IR Ref Oil	ND	134	82	82	0

METHOD 418.1
MATRIX: Soil

SAMPLE ID: 890705-03

COMPOUND	SAMPLE RESULTS (ppm)	AMOUNT SPIKED (ppm)	% REC.	DUP. % REC.	RPD
IR Ref Oil	ND	134	80	78	2

QUALITY CONTROL DATA

CLIENT: Earth Technology Corporation
PROJECT: Metro Rail
CKY I.D.: 890702

METHOD 8020
MATRIX: Soil

SAMPLE ID: 890705-1

COMPOUND	SAMPLE RESULTS (ppb)	AMOUNT SPIKED (ppb)	% REC.	DUP. % REC.	RPD
Benzene	ND	20	90	80	12
Toluene	ND	20	105	100	5
Et. Benzene	ND	20	80	75	6
Xylenes	ND	40	110	100	10

QUALITY CONTROL DATA

CLIENT: Earth Technology Corporation
PROJECT: Metro Rail
CKY I.D.: 890702

METHOD 9030
MATRIX: Soil

SAMPLE ID: 890704-6

COMPOUND	SAMPLE RESULTS (ppm)	AMOUNT SPIKED (ppm)	% REC.	DUP. % REC.	RPD
Sulfide	ND	800	98	96	2

METHOD 9038
MATRIX: Soil

SAMPLE ID: 890554-6

COMPOUND	SAMPLE RESULTS (ppm)	AMOUNT SPIKED (ppm)	% REC.	DUP. % REC.	RPD
Sulfate	68	500	87	93	6

C K Y incorporated
Environmental Services

Date: 07/21/89
890704

Earth Technology Corporation
3777 Long Beach Blvd.
Long Beach, CA 90807-3309

Attn: Mr. Mahi Galagoda

Subject: Laboratory Report
Project: Metro Rail II

Enclosed is the laboratory report for samples received on 07/06/89. The samples were received in coolers with ice and intact; the chain-of-custody forms were properly filled out. The data reported includes:

Method	No. of Analysis
EPA 418.1 (TRPH)	4 Water
EPA 8020 (BTEX)	4 Water
EPA 9038 (Sulfate)	2 Water
EPA 9030 (Sulfide)	2 Water
EPA 9040 (pH)	2 Water

The results are summarized on eight pages.

Please feel free to call if you have any questions concerning these results.

Sincerely,

Dr. Kam Pang
Laboratory Director

3551 Voyager St., Suite 102, Torrance, Calif. 90503 • Telephone (213) 371-0048

EPA METHOD 418.1
TOTAL RECOVERABLE PETROLEUM HYDROCARBONS

CLIENT:	Earth Technology	**DATE REC'D:**	07/06/89
PROJECT:	Metro Rail II	**DATE EXTRACTED:**	07/07/89
CONTROL NO:	890704	**DATE ANALYZED:**	07/10/89
MATRIX TYPE:	Water		

SAMPLE ID:	**CONTROL NO:**	**RESULTS (mg/L)**	**DETECTION LIMIT (mg/L)**
PII-58B Blank	890704-1	ND	1
PII-58B Bulk	890704-3	ND	1
PII-26A Blank	890704-4	ND	1
PII-26A Bulk	890704-6	ND	1

EPA METHOD - 8020
BTEX

CLIENT:	Earth Technology	**DATE REC'D:**	07/06/89
PROJECT:	Metro Rail II	**DATE EXTRACTED:**	07/13/89
CONTROL NO:	890704	**DATE ANALYZED:**	07/13/89
MATRIX TYPE:	Water		

			RESULTS	**(ug/L)**	
SAMPLE ID:	CONTROL NO:	Benz	Toluene	Et Benz	Xyls
PII-58B Blank	890704-1	ND	ND	ND	ND
PII-58B	890704-2	ND	ND	ND	ND
PII-26A Blank	890704-4	ND	ND	ND	ND
PII-26A	890704-5	ND	ND	ND	ND
DETECTION LIMIT		0.5	1	1	1

EPA METHOD 9038
SULFATE

CLIENT:	Earth Technology	**DATE REC'D:**	07/06/89
PROJECT:	Metro Rail II	**DATE EXTRACTED:**	07/18/89
CONTROL NO:	890704	**DATE ANALYZED:**	07/19/89
MATRIX TYPE:	Water		

SAMPLE ID:	**CONTROL NO:**	**RESULTS (mg/l)**	**DETECTION LIMIT (mg/l)**
PII-58B Bulk	890704-3	1,700	10

EPA METHOD 9030
SULFIDE

CLIENT:	Earth Technology	**DATE REC'D:**	07/06/89
PROJECT:	Metro Rail II	**DATE EXTRACTED:**	07/14/89
CONTROL NO:	890704	**DATE ANALYZED:**	07/14/89
MATRIX TYPE:	Water		

SAMPLE ID:	CONTROL NO:	RESULTS (mg/l)	DETECTION LIMIT (mg/l)
PII-58B Bulk	890704-3	1.5	1
PII-26A Bulk	890704-6	ND	1

EPA METHOD - 9040 - pH

CLIENT:	Earth Technology	**DATE REC'D:**	07/06/89
PROJECT:	Metro Rail II	**DATE EXTRACTED:**	07/19/89
CONTROL NO:	890704	**DATE ANALYZED:**	07/20/89
MATRIX TYPE:	Water		

SAMPLE I.D.	CONTROL NO.	pH
PII-58B Bulk	890704-3	7.8
PII-26A Bulk	890704-6	8.5

QUALITY CONTROL DATA

CLIENT: Earth Technology Corporation
PROJECT: Metro Rail
CKY I.D.: 890704

METHOD 418.1
MATRIX: Water

SAMPLE ID: Blank Spike I

COMPOUND	SAMPLE RESULTS (ppm)	AMOUNT SPIKED (ppm)	% REC.	DUP. % REC.	RPD
IR Ref Oil	ND	134	82	82	0

METHOD 418.1
MATRIX: Water

SAMPLE ID: 890704-03

COMPOUND	SAMPLE RESULTS (ppm)	AMOUNT SPIKED (ppm)	% REC.	DUP. % REC.	RPD
IR Ref Oil	ND	256	82	85	2

QUALITY CONTROL DATA

CLIENT: Earth Technology Corporation
PROJECT: Metro Rail
CKY I.D.: 890704

==

METHOD 8020
MATRIX: Water

SAMPLE ID: D.I. Water

COMPOUND	SAMPLE RESULTS (ppb)	AMOUNT SPIKED (ppb)	% REC.	DUP. % REC.	RPD
Benzene	ND	20	95	90	5
Toluene	ND	20	100	100	0
Et. Benzene	ND	20	85	80	6
Xylenes	ND	40	105	100	5

QUALITY CONTROL DATA

CLIENT: Earth Technology Corporation
PROJECT: Metro Rail
CKY I.D.: 890704

METHOD 9030
MATRIX: Water

SAMPLE ID: 890704-6

COMPOUND	SAMPLE RESULTS (ppm)	AMOUNT SPIKED (ppm)	% REC.	DUP. % REC.	RPD
Sulfide	ND	800	98	96	2

METHOD 9038
MATRIX: Water

SAMPLE ID: 890710-6

COMPOUND	SAMPLE RESULTS (ppm)	AMOUNT SPIKED (ppm)	% REC.	DUP. % REC.	RPD
Sulfate	140	40	125	0	30

C K Y incorporated
Environmental Services

Date: 07/25/89
890704

Earth Technology Corporation
3777 Long Beach Blvd.
Long Beach, CA 90807-3309

Attn: Mr. Mahi Galagoda

Subject: Additional Laboratory Report
Project: Metro Rail II

Enclosed is the additional laboratory report for samples received on 07/06/89. The samples were received in coolers with ice and intact; the chain-of-custody forms were properly filled out. The data reported includes:

Method	No. of Analysis
EPA 9038 (Sulfate)	2 Water

The results are summarized on one page.

Please feel free to call if you have any questions concerning these results.

Sincerely,

Dr. Kam Pang
Laboratory Director

3551 Voyager St., Suite 102, Torrance, Calif. 90503 • Telephone (213) 371-0048

EPA METHOD 9038
SULFATE

CLIENT:	Earth Technology	DATE REC'D:	07/06/89
PROJECT:	Metro Rail II	DATE EXTRACTED:	07/18/89
CONTROL NO:	890704	DATE ANALYZED:	07/19/89
MATRIX TYPE:	Water		

SAMPLE ID:	CONTROL NO:	RESULTS (mg/l)	DETECTION LIMIT (mg/l)
PII-58B Bulk	890704-3	1,700	10
PII-26A Bulk	890704-6	10	10

Appendix D
Cone Penetrometer Testing

APPENDIX D

Equipment

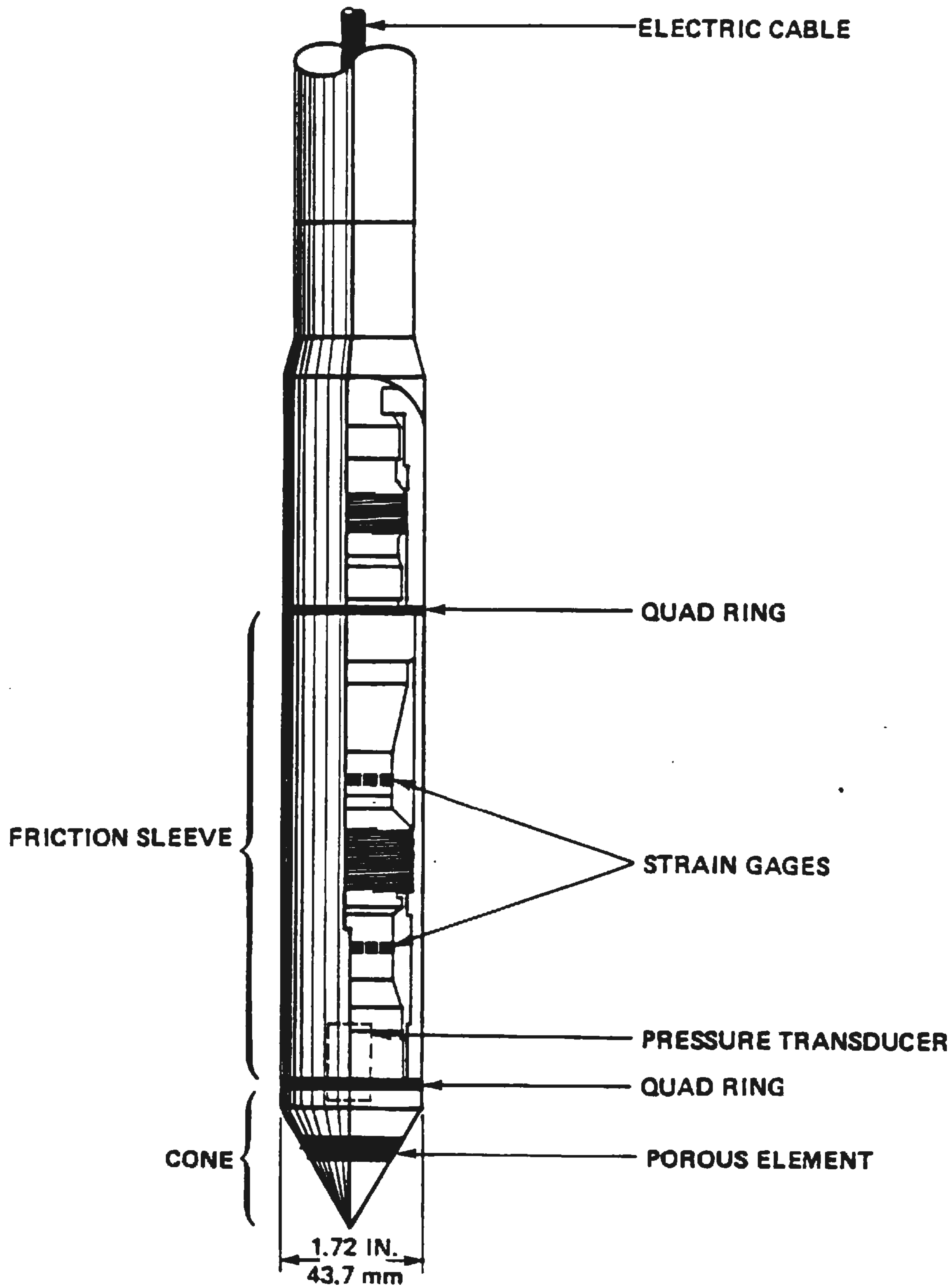
The Cone Penetrometer Test (CPT) equipment consists of a cone assembly mounted at the end of a series of hollow sounding rods. A set of hydraulic rams is used to push the cone and rods into the soil, while a continuous record of cone and friction resistance versus depth is obtained in both analog and digital form. A specially designed all wheel drive truck is used to transport and house the test equipment and to provide a 20 ton reaction to the thrust of the hydraulic rams. Other CPT modular systems are available for limited access areas.

The cone penetrometer assembly (Figure D-1) consists of a conical tip and a cylindrical friction sleeve. The conical tip has a 60° apex angle and a projected cross-sectional area of 15 square centimeters; the cylindrical friction sleeve has a surface area of 200 square centimeters. Both the conical tip and the cylindrical friction sleeve have outer diameters of about 4.37 centimeters.

The interior of the cone penetrometer is instrumented with strain gauges that allow simultaneous measurement of cone tip and friction sleeve resistance during penetration. Continuous electric signals from the strain gauges are transmitted by a cable in the sounding rods to analog and digital data recorders in the CPT truck. The continuous analog recordings of subsurface soil resistance may be evaluated and used in the field if required.

Data Reduction

CPT data reduction involves inputting field data recordings into Earth Technology Western's in-house computer and subsequently computer processing this information. Computer plots of the reduced CPT data are presented in this report. The individual sounding plots include the continuous cone and friction resistance measured in the field and the calculated friction ratio (friction resistance divided by cone resistance in percent) versus depth.



The Earth Technology Corporation	Project No.: 89-409 Vermont/Santa Monica Station and Tunnel

15-Ton Electric Friction Cone Instrument With Tip Sensing Pore Pressure Element

5-90

Figure D-1

CPT-Soil Behavior Types

The calculated friction ratio (CPT friction sleeve resistance divided by cone end bearing) is used as an indicator of soil type. Granular soils typically have low friction ratios (Typically below 2 percent) and high cone resistance, while cohesive or organic soils have high friction ratios (typically more than 4 percent) and low cone resistance. Mixtures of granular and cohesive soils have intermediate combinations of cone resistance and friction ratio. These cone resistance - friction ratio relationships have been used to identify soil types, as described in the following section.

CPT-Soil Behavior Types were evaluated by computer processing of CPT sounding logs. Essentially, the computer program estimates Soil Behavior Types by tracking the continuous cone tip resistance and friction ratio through a classification chart. The CPT data is averaged over a vertical distance of six inches to smooth nonuniformities. The Soil Behavior Type is then evaluated at a series of specified depths.

The Soil Behavior Types tabulations are only representative of the response of the soil to the large shear deformations imposed during cone penetration.

This is not necessarily a prediction of grain size distribution. However, it has been found that Soil Behavior Types agree generally well with soil types defined in accordance with grain size distribution methods such as used in the Unified Soil Classification system.

Appendix E
Earth Work
Recommendations

APPENDIX E

EARTHWORK RECOMMENDATIONS

Earthwork and site preparation activities will encompass clearing and grubbing, subgrade preparation for pavements and structural support, excavation for foundation and utility line relocations and fill placement. The following guidelines are recommended for earthwork associated with the Vermont/Santa Monica Station.

Clearing and Grubbing

Fill material, trash and any vegetation should be removed from the site area to be graded. Existing asphalt pavement may be crushed (if economically justified) for reuse in fills. Subsurface conditions at the site may differ from those observed in the borings and, therefore, a qualified geotechnical engineer should inspect and approve the prepared graded area prior to the placement of fill.

Excavations

Minor excavations at the site will include those for utility lines and near-surface foundations. Major excavations will be for the main station housing the rail facilities. Recommendations for major temporary excavations are presented in Section 5.1.3 of this report. Temporary shallow excavations to a depth of 5 feet can be expected to remain stable with near vertical slopes for short periods. Temporary excavations deeper than 5 feet should be shored or sloped back. Sloped excavations should not be steeper than 1:1 (horizontal to vertical) in fine-grained alluvium and fresh/oxidized Puente Formation bedrock (in areas where bedding planes either parallel or dip away from the side of the excavation opening), and 1½:1 (horizontal to vertical) in granular alluvium and highly weathered Puente Formation bedrock (Unit Tpw). If the bedding planes dip onto the excavation opening, recommended slopes should be modified according to the dip angle observed in the field.

Fill Materials and Placements

Fill materials may consist of excavated onsite granular soils or approved granular soils free from expansive materials, debris, organic contaminants or rock fragments larger than 6 inches. The existing asphalt pavement may be crushed and blended with granular soils for reuse in fills.

The following specifications are recommended for fill placments. All work shall be performed under the overall supervision of an experienced geotechnical engineer.

- All areas that are to receive compacted fill shall be observed by a geotechnical engineer
- Exposed soil surface shall be scarified to a minimum of 6 inches, moisture conditioned as necessary and compacted to a minimum dry density of 90 percent of the maximum dry density as determined by procedure ASTM D1557
- All fill materials shall be placed in layers, compatible with the type of compaction equipment used, but not exceeding 8 inches in loose thickness. Each layer shall be compacted to a minimum of 90 percent of the maximum dry density as determined by ASTM procedure D1557. Granular fill material shall be moisture conditioned to within plus or minus 2 percent of the optimum moisture content, either by drying or wetting, prior to compaction
- A geotechnical engineer or an experienced soils technician shall observe fill placement and compaction and conduct inplace field density tests on the compacted fill to check the adequacy of compaction. If the dry density of the compacted layer is less than 90 percent of the maximum dry density, soils shall be moisture conditioned as necessary and recompacted until 90 percent of the maximum dry density is attained.

In deep fill areas or fill areas for support of sensitive structures, the compaction requirement should be increased from the normal 90 percent to 95 percent or 100 percent of the maximum dry density, as directed by a geotechnical engineer.

Subgrade Preparation

Concrete slabs located at Puente Formation bedrock may be placed directly on undisturbed materials. The subgrade should be proof rolled to detect soft or disturbed areas, and, if detected, such areas should be excavated and replaced with structural fill. If existing fill soils are encountered at near surface subgrade, they should be removed completely to at least 5 feet from the foundation area and replaced with properly compacted fill. In fine-grained alluvium, exposed subgrade should be excavated at least 2 feet below the design grade and replaced with properly compacted fill. In granular alluvium, exposed subgrade should be opproved by a geotechnical engineer, and, if disturbed, should be scarified to a minimum of 6 inches and recompacted. All fill placements and compactions should be performed as recommended in "Fill Materials and Placements."

Site Drainage

Adequate positive drainage should be provided away from the surface structures to prevent water from ponding and to reduce water percolation into subsoils. If there is any granular backfill directly underneath the area of surface drainage, the backfill should be covered or capped with at least 18 inches of relatively impervious clayey soils.