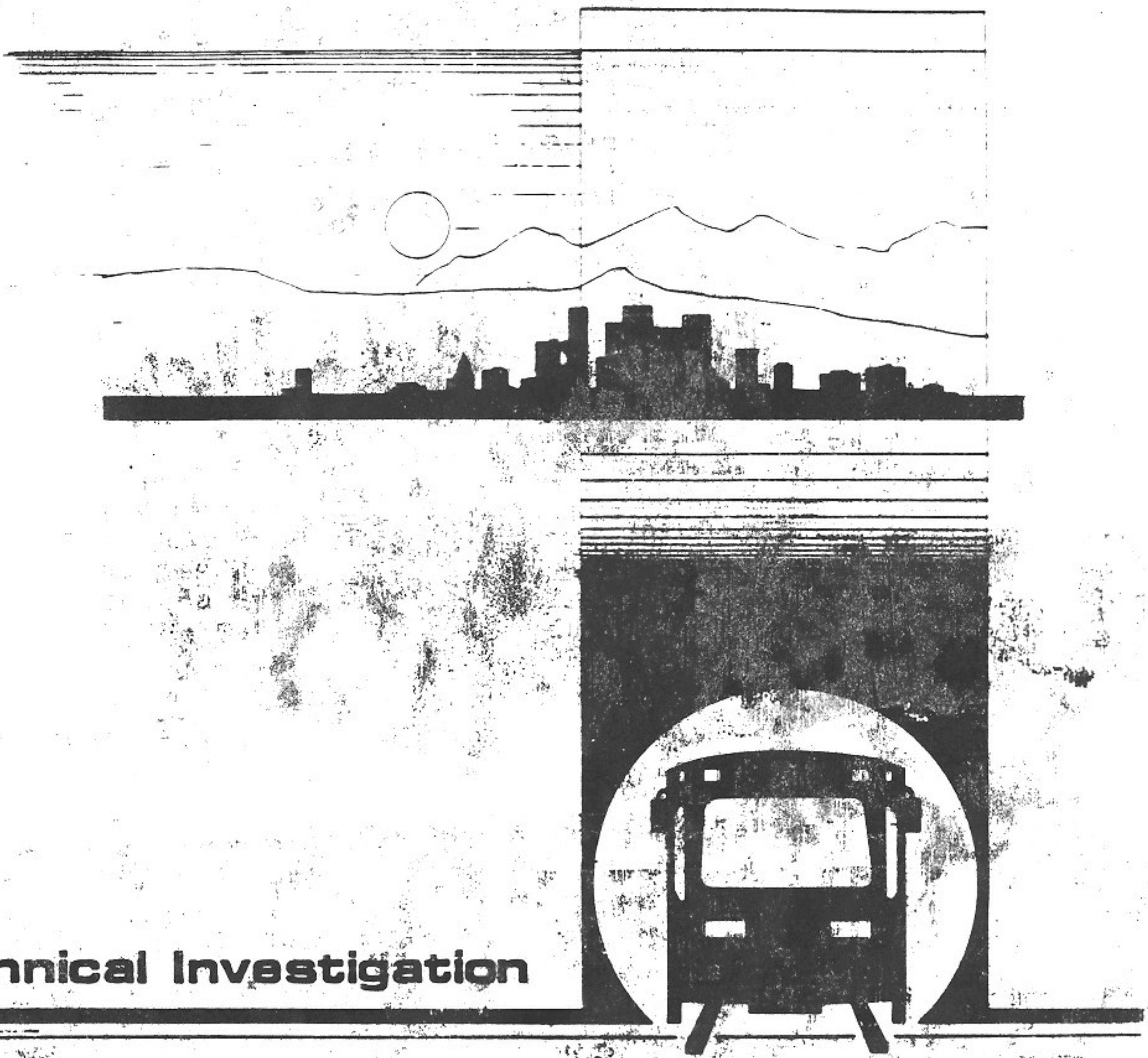

Geotechnical Investigation

Limited Preliminary Engineering Program

MOS-2 Alignment • Metro Rail Project

The Earth Technology Corporation

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December 22, 1988

Metro Rail Transit Consultants
548 South Spring Street, 7th Floor
Los Angeles, California 90013

Attention: Dr. James E. Monsees, Chief Tunnel Engineer

Subject: Geotechnical Investigation
Limited Preliminary Engineering Program
MOS-2 Alignment, Metro Rail Project
Contract No.: 1003
Earth Technology Project No.: 88-429

Gentlemen:

The Earth Technology Corporation is pleased to submit six copies of the subject report. This investigation was conducted under the Metro Rail Transit Consultants (MRTC) Contract No. 1003 and in general accordance with the statement of work included in the contract agreement.

This report presents the findings and conclusions of the investigation. Specific recommendations for the planned future engineering effort are also provided. The successful completion of this project has been a combined effort of MRTC staff and the Earth Technology project team which included Earth Technology, Geofon, Inc., and MAA Engineering Consultants. We appreciate the technical guidance provided by Dr. James Monsees and Mr. Bomi Ghadiali of MRTC and the valuable assistance provided by Mr. Nadeem Tahir of the Southern California Rapid Transit District. We would also like to acknowledge the efforts of the personnel from Geofon and MAA, led by Mr. A. Khan and Mr. Fred Chen, respectively.

It has been a privilege to work with you on this important project and we look forward to further associations of a similar nature. If you have any questions or comments regarding this report, please contact us.

Sincerely,

THE EARTH TECHNOLOGY CORPORATION (Western)

Bill Lu

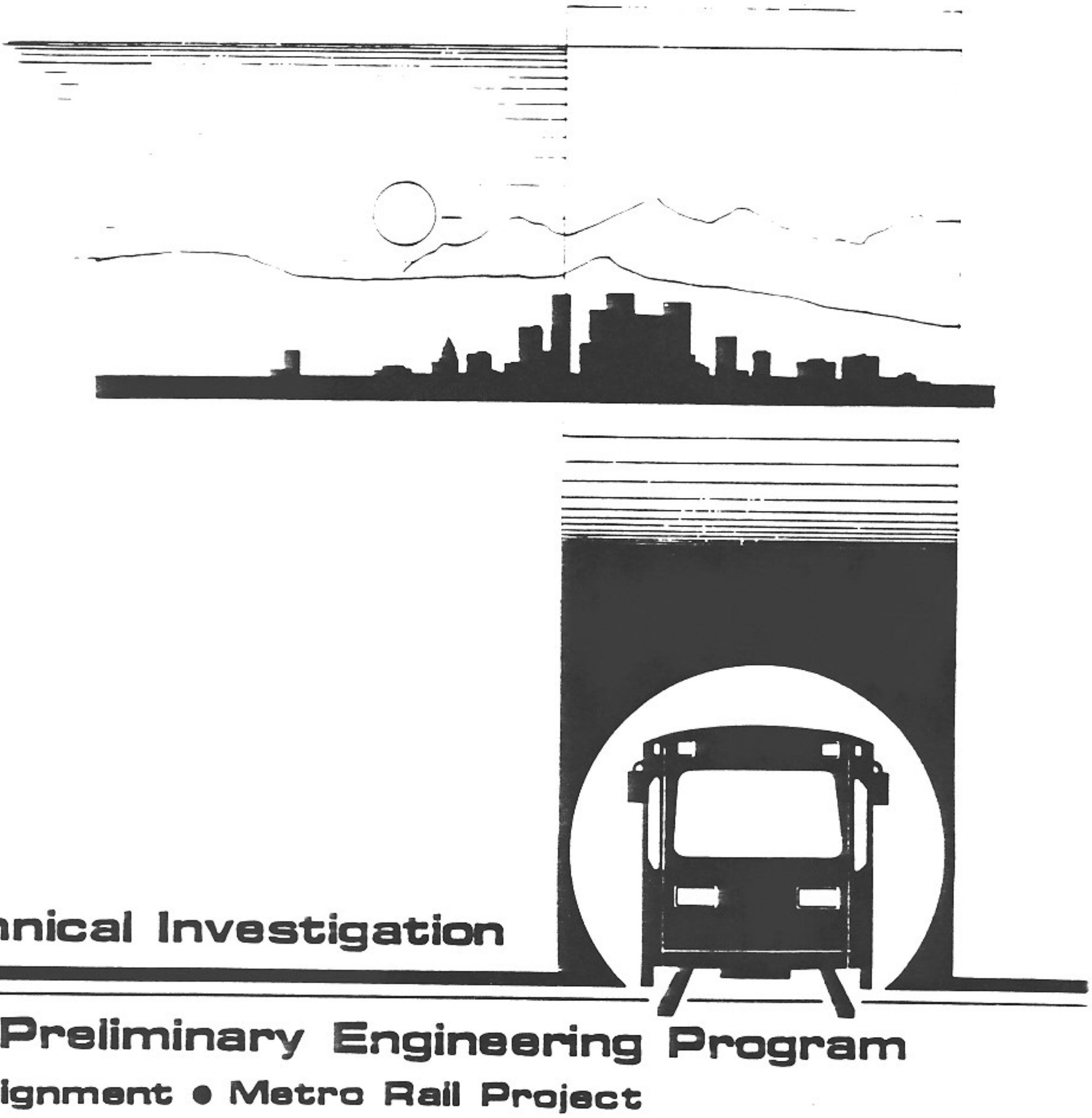
Bill T. D. Lu, Ph.D., P.E.
Project Manager

G. Ramanjaneya

G. Ramanjaneya, Ph.D., P.E.
Project Director

The Earth Technology Corporation

December 1988



Geotechnical Investigation

Limited Preliminary Engineering Program

MOS-2 Alignment • Metro Rail Project

Prepared for
METRO RAIL TRANSIT CONSULTANTS
548 South Spring Street, 7th Floor
Los Angeles CA 90013

Prepared by
THE EARTH TECHNOLOGY CORPORATION
3777 Long Beach Boulevard
Long Beach CA 90807

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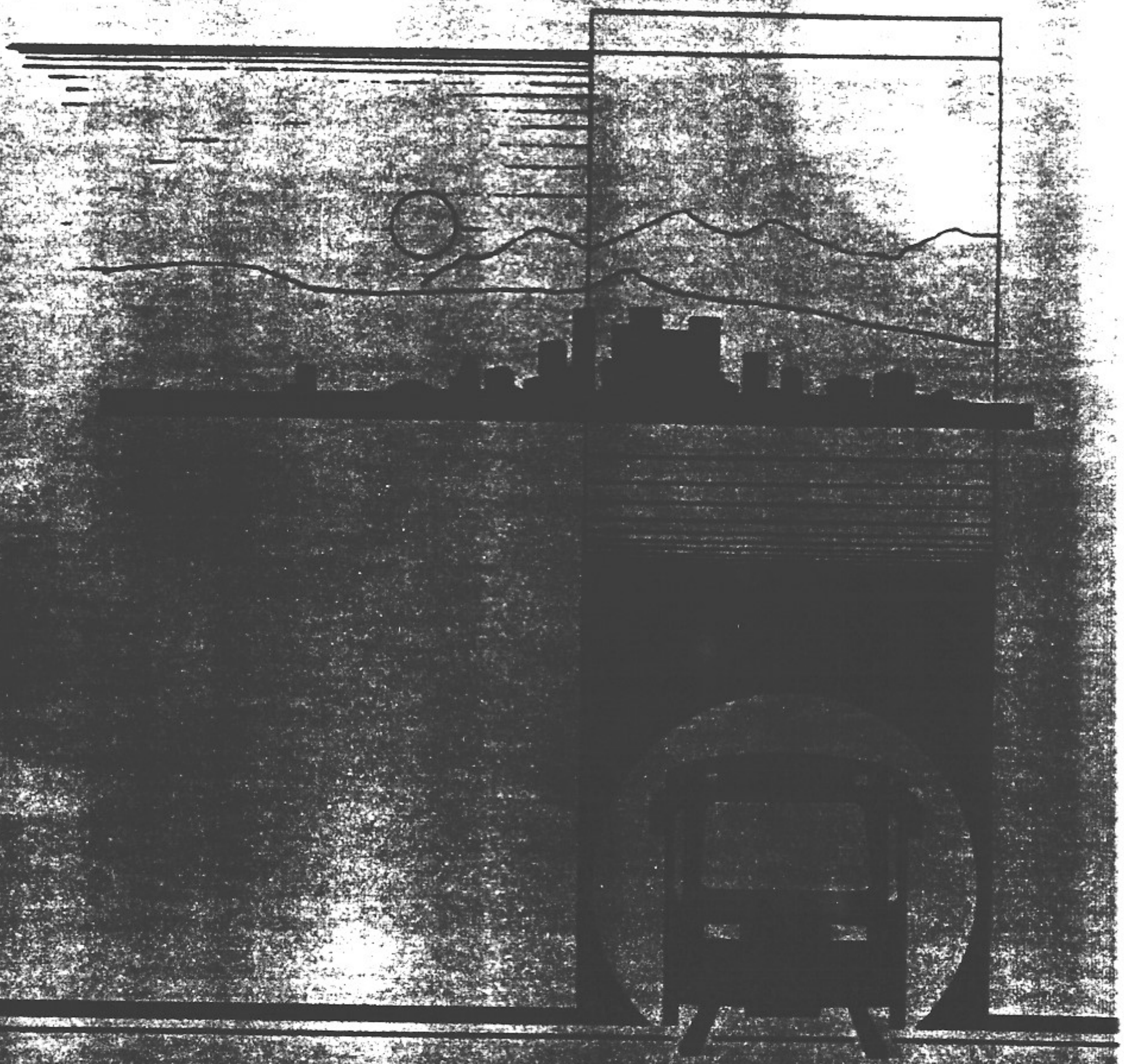


1.0 EXECUTIVE SUMMARY

1.1 GENERAL CONCLUSIONS

In support of the Limited Preliminary Engineering (LPE) effort for the planned Metro Rail Minimum Operable Segment-2 (MOS-2) alignment, being undertaken by the Metro Rail Transit Consultants (MRTC), a limited preliminary geotechnical investigation was performed. This LPE program was designed to gain a general understanding of the geologic and subsurface conditions along the alignment and to provide an initial definition of pertinent subsurface engineering parameters.

The results of this program indicate that, except for the Santa Monica Mountains alignment portion, subsurface conditions along the MOS-2 alignment are anticipated to be favorable for rapid and economical tunnel construction by mechanical excavation methods within a shield similar to those used in the current tunnel construction along the MOS-1 alignment. Tunneling along the Santa Monica Mountains alignment portion will require the use of drill-and-blast methods or hard-rock tunnel boring machines.

The results also indicate that the subsurface conditions along the MOS-2 alignment can provide excellent support for the structures in the planned stations. Cut-and-cover excavation of these stations can be accomplished at a relatively high rate using mechanical excavation methods with readily available equipment.

Potential subsurface concerns which may require further attention in design and construction of the tunnel and stations along the MOS-2 alignment are also identified in this report. All of the identified subsurface concerns can easily be alleviated through proper design and proven construction techniques and provisions.

1.2 MOS-2 ALIGNMENT

The planned MOS-2 alignment extends westward from the MOS-1 alignment currently under construction to the Wilshire/Vermont Station, where it branches into two lines. One line continues west and ends at a temporary terminal at the Wilshire/Western Station. The other line turns north along Vermont Avenue, curves west to and along Hollywood Boulevard, turns northwest at the Hollywood/La Brea intersection through the Santa Monica Mountains to the Universal City Station, continues along Lankershim Boulevard, and terminates at the North Hollywood Station.

Since the MOS-2 alignment is in the LPE stage, details of structural features and project design requirements are not available. According to the current plan, construction of the MOS-2 alignment will include double-line tunnels, cut-and-cover stations, and vent shafts. In general, the planned tunnel and stations will extend from about 30 to about 110 feet below the ground surface, except for the alignment portion through the Santa Monica Mountains, where tunneling will extend up to about 800 feet below the surface of the mountains.

1.3 FIELD EXPLORATION AND TESTING PROGRAM

Subsurface exploration in this program consisted of drilling and sampling 19 borings and installing 8 piezometers at 19 widely-spaced locations along the alignment portion south of the Santa Monica Mountains foothills. Water and gas samples were also obtained for chemical testing. Borings were generally drilled to depths of about 10 feet or more below the planned tunnel invert depths. A limited laboratory test program consisting of soil mechanics and chemical tests was conducted on selected soil, water, and gas samples. The objective of the test program was to enable preliminary assessment of pertinent engineering parameters and concentration levels of selected chemical compounds and heavy metals.

1.4 GEOLOGY AND ENGINEERING GEOLOGY

The planned MOS-2 alignment will traverse a portion of the Los Angeles Basin, the Santa Monica Mountains, and the San Fernando Basin. Within the planned depths of tunnel invert, the subsurface conditions along the alignment in the Los Angeles and San Fernando Basins (excluding the Santa Monica Mountains alignment portion) consist predominantly of Holocene-aged Young Alluvium over Pleistocene-aged Old Alluvium or Old Alluvium underlain by the Miocene-aged Puente Formation (mostly weak rocks with engineering properties similar to hard, dense soils). The Santa Monica Mountains alignment portion will encounter hard rock consisting predominantly of the Cretaceous-aged granodiorites and the Miocene-aged Topanga basalt and Topanga clastics (sandstone, siltstone and conglomerate).

The planned alignment will traverse several major geologic features which are mostly inferred and not well delineated within the alignment vicinity. These include the Los Angeles anticline crossing the Vermont Avenue alignment portion; the Santa Monica fault, Hollywood syncline, and Hollywood fault traversing the Hollywood Boulevard alignment portion; and the Hollywood, Hollywood Bowl, Benedict Canyon and at least two unnamed faults in the Santa Monica Mountains alignment portion. These geologic features may be potential sources of trapped oil and gas, they may represent groundwater barriers, and they may reflect subsurface concerns with respect to tunnel construction methods and stability. Further investigations are necessary to sufficiently delineate and characterize these features for the planned future engineering effort.

1.5 SUBSURFACE CONDITIONS

Based on the results of this LPE geotechnical investigation program and an evaluation of available literature data, a general understanding of the subsurface conditions has been developed. For purposes of illustration, the description of subsurface conditions is divided into the following alignment portions:

- OS-A segment along the Wilshire Boulevard corridor
- Along Vermont Avenue
- Along Hollywood Boulevard to the foothills of the Santa Monica Mountains
- Through the Santa Monica Mountains.

Subsurface conditions in the OS-A segment along the Wilshire Boulevard corridor and the alignment portion along Vermont Avenue are similar; they consist of Old Alluvium overlying the Puente Formation. The Old Alluvium consists predominantly of stiff to hard silty clay, clayey silt, and clayey sand, with scattered pockets of dense to very dense sand and silty sand. The Puente Formation encountered in the LPE borings consists predominantly of clayey siltstone with thinly-bedded sandstone. The Puente Formation materials generally have engineering properties similar to hard, dense soils with a high cohesion strength component. Although not detected in the LPE borings, it is possibile that localized massive, highly cemented, and hard sandstone pockets in the Puente Formation may be present in some areas along these alignment portions. A perched groundwater level above the planned tunnel depths is observed along these alignment portions. Gassy conditions are likely to occur in localized areas, especially in the OS-A segment along the Wilshire Boulevard corridor and the southern half of the Vermont Avenue alignment portion.

These subsurface conditions are, in general, similar to those encountered in the Detail Design Unit A170 of the MOS-1 alignment, and, therefore, the design and construction experience gained from work on Detail Design Unit A170 and Construction Contract Unit A171 is anticipated to be applicable to these alignment portions.

Within the planned tunnel depths, subsurface conditions along the Hollywood Boulevard alignment portion generally consist of very nonhomogeneous Young Alluvium overlying nonhomogeneous Old Alluvium. The Young Alluvium consists of about 70 percent medium-dense to dense silty sand with occasional lenses of gravelly sand and sandy gravel, interspersed with about 30 percent stiff to very stiff silty clay, clayey silt, and clayey sand. The Old Alluvium consists of layers of dense to very dense silty sand with occassional pockets of dense clean sand and sandy gravel, interspersed with stiff to very hard silty clay, clayey silt, and clayey sand. Along this alignment portion, the groundwater level is generally below the planned tunnel depths except in a small area approximately east of the Hollywood Boulevard/Harvard Boulevard intersection. Gassy conditions were not observed in the field work and are not anticipated in this alignment portion.

No field work was performed along the Santa Monica Mountains alignment portion in this program. Based on available project files and literature data, it is anticipated that the planned tunnel and vent shafts along this alignment portion will encounter various hard rocks with a wide range of strength and hardness. The alignment portion will also cross at least five inferred faults, including the Hollywood, Hollywood Bowl, Benedict Canyon, and two unnamed faults. Subsurface conditions along this alignment portion are expected to be similar to those encountered in the construction of the Los Angeles City sewer tunnel and the Metropolitan Water District's (MWD) Hollywood Tunnel. The experience gained from the construction of these two tunnels will be applicable to this alignment portion.

1.6 DESIGN AND CONSTRUCTION CONSIDERATIONS

As described in Section 1.1, it is anticipated that tunneling along the MOS-2 alignment, except in the Santa Monica Mountains portion, can be advanced at a relatively high rate using mechanical excavation methods within a shield, similar to those used in the Construction Contract Unit A171 of the MOS-1 alignment. Tunneling along the Santa Monica Mountains alignment portion can be advanced by either drill-and-blast methods or hard-rock tunnel boring machines.

Several potential subsurface conditions may affect tunnel design and construction. These conditions are likely to exist to a varying extent in some areas along the alignment. They are generally associated with mixed face excavation conditions, the presence of granular alluvium and fault gouge materials that may be susceptible to running conditions and tunnel instability, high groundwater conditions, and gassy conditions. If they are anticipated, these potential concerns can be readily alleviated by proper design, proven construction techniques and procedures, and adequate construction monitoring and provisions.

The subsurface conditions along the MOS-2 alignment are anticipated to provide excellent foundation support for the planned cut-and-cover stations, which will be founded on medium-dense to very dense granular alluvium, or stiff to very hard fine-grained alluvium, or the Puente Formation (weak rocks with engineering properties similar to hard, dense soils). Cut-and-cover excavation in these "soft ground" conditions can be accomplished in a relatively rapid rate using mechanical excavation methods and readily available equipment, similar to those used in the construction of Construction Contract Units A134 through A139 (Union Station) and A147 (Civic Center Station) for the MOS-1 alignment. For station excavation, shoring will generally be required due to proximity to existing buildings and limited construction space.

Shallow groundwater conditions above the planned tunnel depths can be expected in the OS-A segment along the Wilshire Boulevard corridor and the Vermont Avenue alignment portion. Dewatering prior to and during excavation may be required at the Wilshire/Vermont Station where a relatively thick permeable granular layer exists. For excavation of other stations along this alignment portion, some groundwater inflows of lesser extent may be present, but the excavations can probably be dewatered by open pumping. Groundwater levels along the Hollywood Boulevard alignment portion were found to be below the planned depths of station excavation. The potential inflows from moist alluvium are anticipated to be small.

1.7 CHEMICAL CONTAMINATION

The results of a limited chemical testing program indicate that concentration levels of total recoverable petroleum hydrocarbons (TRPH), aromatic organic compounds (BTEX), and heavy metals in the selected soil and water samples are low, and are below cleanup action levels specified in regulatory guidelines by various agenices. Although more detailed data are needed, it is unlikely that the excavated subsurface materials and pumped groundwater would require special hazardous waste material clean up or handling.

Methane or hydrogen sulfide may be present in some areas in the OS-A segment along the Wilshire Boulevard corridor and the southern half of the Vermont Avenue alignment portion. Further investigations will be necessary to adequately estimate the extent and spatial/areal distribution of these gases.

The results of the limited chemical test program also detected moderate to high concentration levels of sulfate compounds in selected soil and water samples. To prevent potential corrosion, Type II cement is likely to be needed for tunnel and station construction along a major portion of the MOS-2 alignment south of the Santa Monica Mountains foothills, except in the vicinity of Boring LPE-4, where Type V cement may be required.

1.8 RECOMMENDATIONS

The field work for this program consisted of 19 borings and 8 piezometers at 19 widely-spaced locations along the MOS-2 alignment portion south of the Santa Monica Mountains foothills. Due to its intended preliminary nature, this geotechnical program did not result in sufficiently detailed information to support the planned future engineering effort for the alignment design. In addition, there is little or no existing site-specific information related to subsurface conditions and engineering parameters along the planned MOS-2 alignment portion through the Santa Monica Mountains to North Hollywood. Therefore, a more detailed investigation program will be needed to appropriately support the planned future engineering effort for this alignment.

Appropriate scoping of the more detailed investigation will require additional planning to ensure that the anticipated results will be commensurate with the future engineering effort and needs. Thus, only qualitative recommendations are provided herein. In general, the investigation program should include a combination of geologic, geophysical, geotechnical, and hydrologic investigation efforts to better define the subsurface conditions and engineering parameters along the entire alignment, and a seismic study to address issues related to seismic design and response of the alignment. In summary, a more detailed investigation consisting of the following elements will be needed to support the planned future engineering effort:

- Performing closely-spaced borings and geophysical surveys to gain a better understanding of subsurface conditions.
- Installing additional peizometers, performing in situ pumping tests, and conducting additional chemical tests on water samples to obtain a more detailed definition of hydrologic conditions and characteristics.
- Installing gas probes to monitor gas pressure and extent, and to determine spatial/areal distribution of harmful gases which may be present in some areas along the alignment.
- Conducting more detailed laboratory tests to determine static and dynamic engineering parameters of the subsurface materials and to characterize extent and spatial/areal distribution of chemical concentrations in soil, water, and gas along the alignment
- Performing a seismic study to define seismic potential, seismic response, and seismic design of the planned tunnel and stations along the alignment.

2.0 INTRODUCTION

2.1 GENERAL

This report presents the results of a limited preliminary geotechnical investigation along the planned MOS-2 alignment. This investigation was designed to support the limited preliminary engineering (LPE) effort being undertaken by MRTC. The investigation was performed to gain a general understanding of the geologic conditions and to provide an initial definition of the subsurface conditions and engineering parameters along the MOS-2 alignment. Results of this LPE geotechnical investigation will be used to develop a more detailed geotechnical investigation program to better define the subsurface conditions and engineering parameters along the alignment in support of the planned future engineering effort to be undertaken by MRTC.

2.2 ALIGNMENT LOCATION AND PLANNED CONSTRUCTION

2.2.1 Alignment Location

Figure 2-1 shows a plot plan of the planned MOS-2 Metro Rail alignment. This alignment includes:

1. The OS-A segment along the Wilshire Boulevard corridor, which extends westward from the end of the MOS-1 alignment at the Wilshire/Alvardo Station to the Wilshire/Western Station, where the future planned segment begins.
2. The Hollywood/Valley segment, which starts at the Wilshire/Vermont Station heading northeast, curves back under Vermont Avenue at Third Street, continues north along Vermont Avenue, curves west to and along Hollywood Boulevard, turns northeast at the Hollywood Boulevard/La Brea Avenue intersection through the Santa Monica Mountains to the Universal City Station, and continues to the North Hollywood Station.

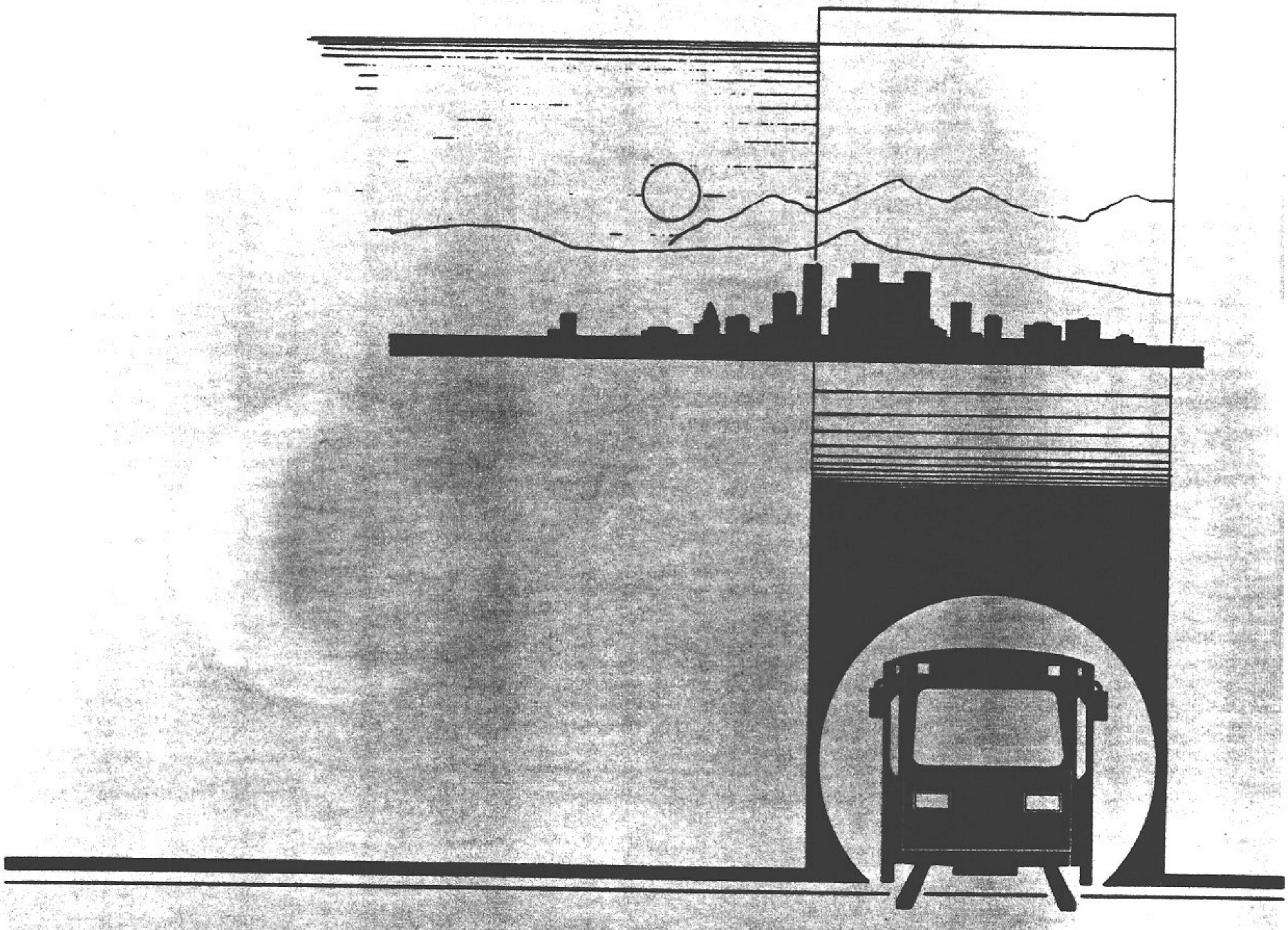
As will be described in Section 3, the the field work for this investigation was limited to the portion of the MOS-2 alignment south of the Santa Monica Mountains.

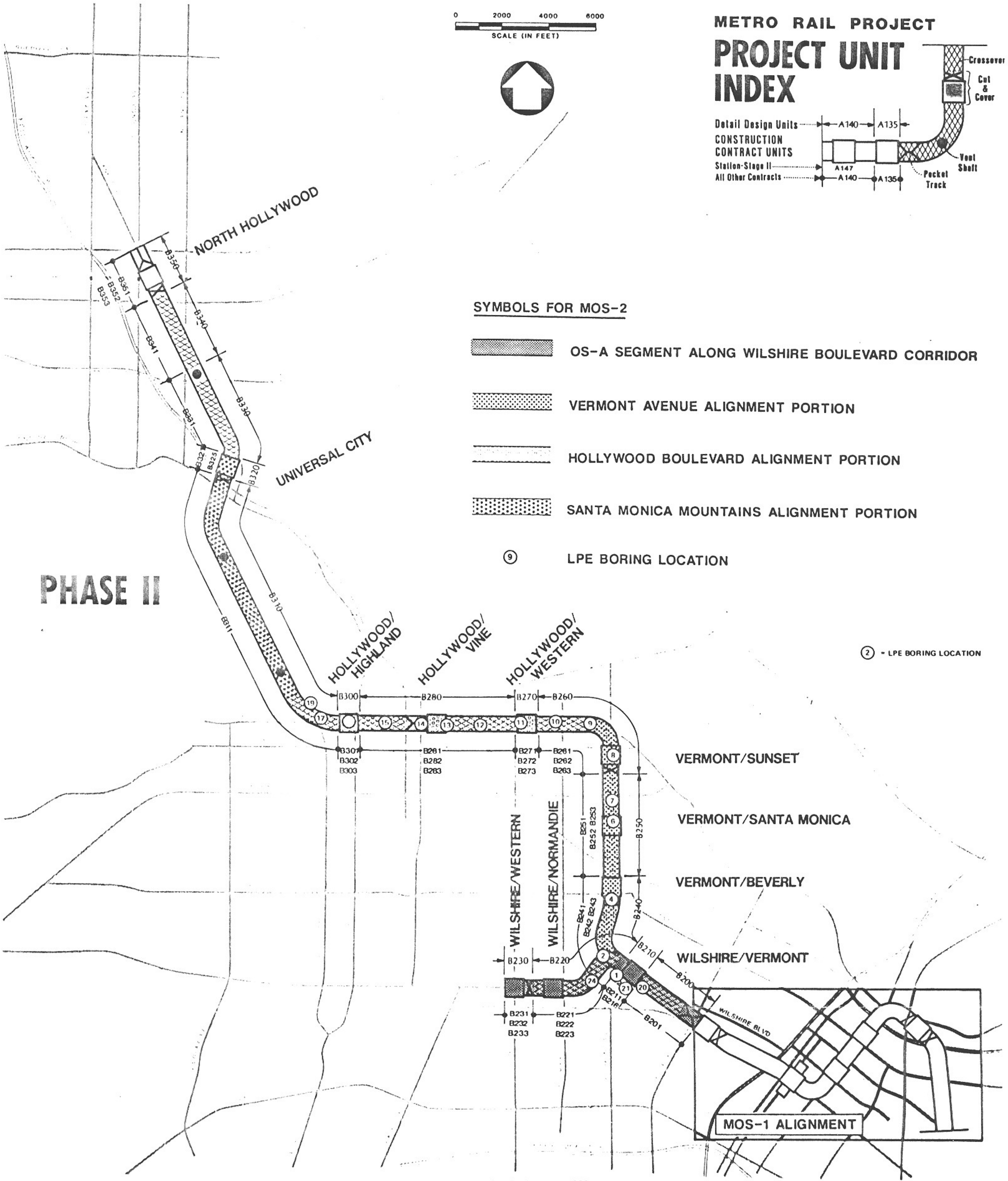
2.2.2 Planned Construction

Since the design of the MOS-2 alignment is in the LPE stage, details of structural features and project design requirements are not available.

According to current plans, construction of the MOS-2 alignment will consist of tunneling, station construction, and installation of vent shafts. The current planned locations of tunnel, stations, and vent shafts are shown in Figure 2-1. This investigation was tailored to the following general concepts:

2.0 INTRODUCTION





NOTE: ADOPTED FROM PROJECT UNIT INDEX MAP PREPARED BY MRTC AND ADOPTED BY SCRTD BOARD, JULY 14, 1988

FIGURE 2-1. MOS-2 ALIGNMENT AND PLOT PLAN OF LPE BORINGS

Structural Feature	Dimension	Construction Method
Tunnel	18-foot diameter finished opening, single-track, double-line configuration	Soft-ground tunneling or hard-rock tunneling
Station	30 to 80 feet deep, about 500 feet long, and 50 to 60 feet wide	Cut-and-cover
Vent Shaft	10-foot diameter	Drill-and-blast or machine excavation methods

2.3 OBJECTIVES AND SCOPE

2.3.1 Objectives

This geotechnical investigation was limited in scope and performed for limited preliminary engineering purposes only. The objectives of this investigation were as follows:

- To gain an initial general understanding of the soils and geologic conditions along portions of the MOS-2 alignment under investigation (Figure 2-1)
- To obtain limited basic soil, geologic, and groundwater data as well as general information on hydrocarbon levels via organic vapor analyzer (OVA) readings, and limited chemical analyses of selected soil, water, and gas samples.
- To identify potential data gaps that require further evaluation.
- To make a preliminary recommendation for a more detailed geotechnical investigation program needed to develop and complete a final design.

2.3.2 Scope

The scope of this investigation consisted of the following:

1. Review of available literature and reports along the MOS-2 alignment.
2. Planning and coordination of field work, including:
    - Development of field procedures and manuals
    - Planning of the field investigation program
    - Procurement of necessary permits and licenses
    - Coordination with government agencies and utility companies prior to, during, and after the field work
    - Development and implementation of a project-specific Health and Safety Plan.

3. Performance of a field exploration program, including:
    - Drilling and sampling of 19 test borings
    - Obtaining OVA readings on soil samples and background environments
    - Installing 8 piezometers at selected boring locations
    - Monitoring groundwater levels and taking water samples for chemical testing
    - Taking gas pressure readings and gas samples at two piezometer locations.
4. Performance of a limited laboratory testing program on selected representative soil, water, and gas samples to preliminarily assess their index and engineering properties and to evaluate general chemical characteristics of the encountered subsurface materials.
5. Preparation of this report documenting the findings, conclusions, and recommendations.

The field investigation was limited to a portion of the MOS-2 alignment south of the Santa Monica Mountains. However, potential subsurface conditions along the portion of the alignment through the Santa Monica Mountains to the Universal City Station were also examined based on available data from previous investigations and other data available in the literature.

2.4 PREVIOUS INVESTIGATIONS AND AVAILABLE DATA

2.4.1 Previous Investigations

The following reports and project data files of previous investigations performed by others along or near the MOS-2 alignment were provided by MRTC and reviewed in this investigation:

1. Geotechnical Investigation Report for the Metro Rail Project, prepared by CWDD/ESA/GRC (1981).
2. Report of Subsurface Gas Investigation - Southern California Rapid Transit District, Metro Rail Project, Wilshire Alignment, prepared by Engineering Science and Associates (1984).
3. Core Study and Subsurface Condition Report - An evaluation of methane gas potential along candidate alignments of the L. A. Metro Rail Project, prepared by Engineering Science and Associates (1986).
4. Draft Geotechnical Report, Sunset Boulevard Vibration Study Borings, Metro Rail Core Study, Hollywood, California, prepared by Converse Consultants, Inc. (1987).
5. Draft Subsequent Environmental Impact Report, Los Angeles Rapid Transit Project, Metro Rail, prepared by Southern California Rapid Transit District (1987).
6. Field exploration data and laboratory data associated with Design Units A170, A195, A350 and A410.

7. Plan and Profile Drawings Core Study, Candidate Alignments, 1, 2, 3, 4, and 5, Prepared by MRTC, dated January 9, 1987.

8. Topographic maps Nos. 101 to 124 and 12A, prepared by MRTC (1988).

2.4.2 Local Tunneling Experience

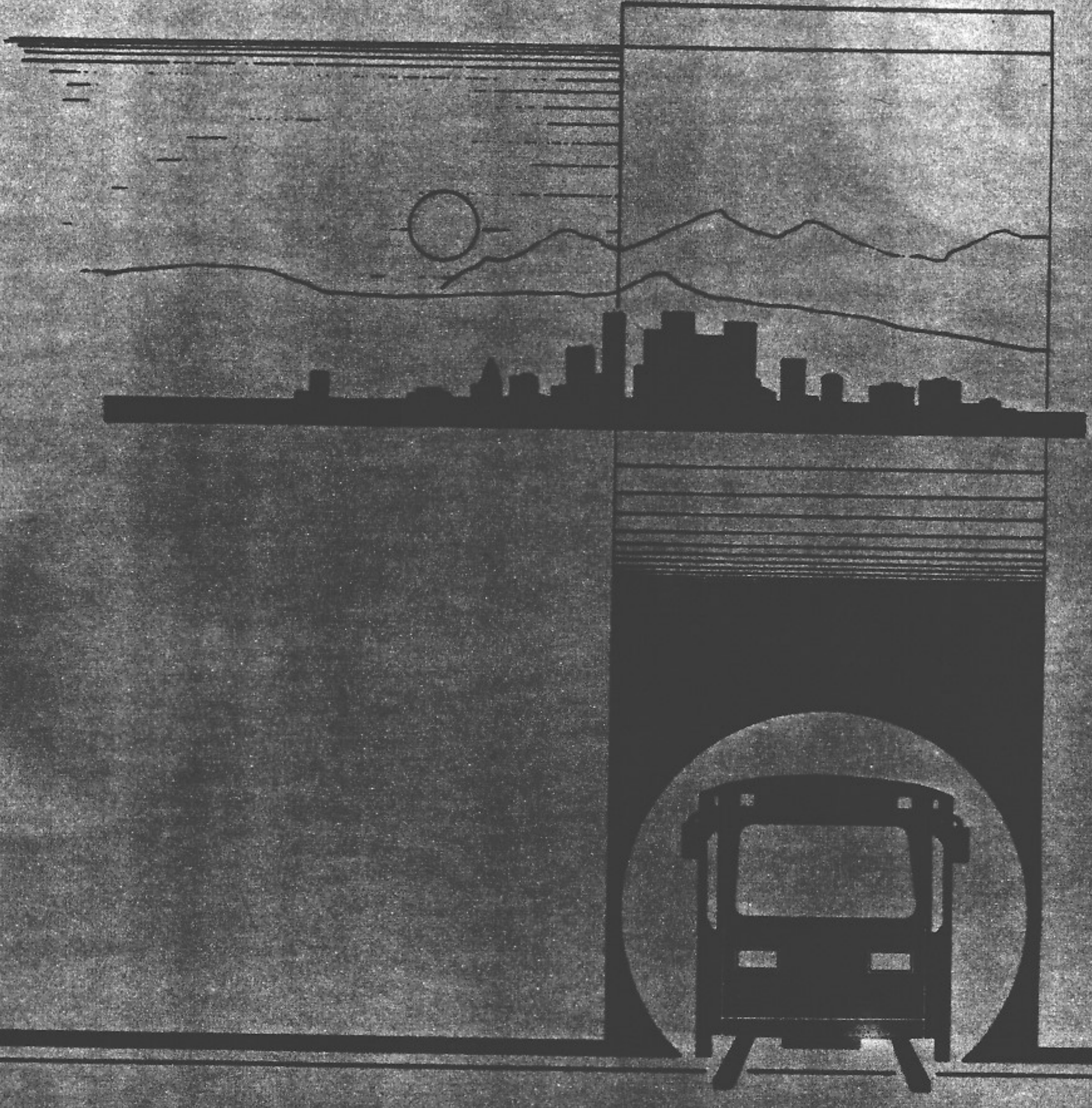
A previous investigation (CWDD/ESA/GRC, 1981) included a detailed review of local tunneling experience in the Los Angeles area with particular attention to case histories that involved subsurface conditions similar to those anticipated along the MOS-2 alignment. Relevant conclusions of the review which would be applicable to the MOS-2 alignment construction include:

- Rapid and economical progress can be made by mechanical excavation methods using soft-ground or hard-rock tunneling techniques on the MOS-2 alignment.
- Some excavation problems including the presence of gas and oil, groundwater-related dewatering needs, caving, and slow progress were encountered. Some of these problems could be anticipated and easily resolved with appropriate provisions for the MOS-2 alignment construction.

Since the above study, project-specific tunneling and station construction experience for the MOS-1 alignment has been gained. Particular experience includes:

- Detail Design Unit A170 and Construction Contract Unit A171, with subsurface conditions (Puente Formation and shallow groundwater) similar to those anticipated in the OS-A segment along Wilshire Boulevard and the alignment portion along Vermont Avenue.
- Detail Design Unit A135 and Construction Contract Units A134 through A139, with subsurface conditions (deep alluvial deposits with relative shallow groundwater table that is generally above the tunnel invert or base of station) similar to conditions expected during station excavation along the Vermont Avenue alignment portion and the Hollywood Boulevard alignment portion.

3.0 FIELD EXPLORATION AND LABORATORY TESTING



3.0 FIELD EXPLORATION AND LABORATORY TESTING

This section provides a description of the subsurface exploration and the laboratory testing work performed in this program. The scope of work was either directed by MRTC or developed and performed by The Earth Technology Corporation project team after receiving approval from MRTC.

3.1 FIELD EXPLORATION

Field exploration consisted of drilling and sampling of 19 widely-spaced borings, installing groundwater monitoring wells (piezometers) in 8 of those borings, groundwater-level monitoring and water sampling, and gas sampling and gas pressure monitoring in two of the boring locations. The borings were drilled between September 20 and November 4, 1988. Twenty-four borings were initially planned, however, five were cancelled due to access or utility clearance difficulties. General boring locations are presented in Figure 2-1. Detailed locations and logs of the borings are presented in Appendix A. Installation and monitoring data for the groundwater wells are presented in Section 3.1.2.

The field work was performed in two stages. In Stage 1, no provisions were made to handle contaminated soil or to work around high-concentration levels of volatile organic gases. Stage 1 included monitoring the drilling work space and soil samples with an organic vapor analyzer (OVA) for indication of potential presence of volatile organic compounds. Action levels were set at safe levels. During the course of drilling, Borings LPE-2, -4, and -4A were terminated short of the planned penetration depths due to high OVA readings which exceeded the action levels. Sulfur odors were also detected from the soil samples. The field work was temporarily suspended and a plan was developed to continue the drilling with safety provisions for handling potentially contaminated samples, including an increased monitoring effort to detect organic vapors, hydrogen sulfide, carbon monoxide, and explosivity.

After the plan was developed, Stage 2 was performed to complete the remaining borings. A total of four borings (LPE-1, -2A, -4B, and -24) and two piezometers (LPE-1 and -4B) were completed during the Stage 2 work.

The Field Procedures Manual and the Health and Safety Plan developed for this program were approved by MRTC and followed during field operation.

3.1.1 Borings

The 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 10 feet or more below the planned tunnel invert. Penetration depths of 19 LPE borings are shown in Table 3-1. Soil samples were obtained at 5-foot depth intervals by alternately using standard split-spoon samplers and California-type drive samplers lined with 1-inch-high brass rings. Two types of California-type drive samplers were used. These included The Earth Technology Corporation (TETC) sampler and the Geomatic sampler. The primary differences are that the TETC sampler has a one-piece barrel with a 2.5-inch inside diameter while the Geomatic has a split-barrel with a 2.4-inch inside diameter. Standard split-spoon soil samples were obtained by driving the

TABLE 3-1

PENETRATION DEPTHS OF LPE BORINGS

Boring No.	Ground Surface Elevation (ft)	Borehole Penetration Depth (ft)	Piezometer Installation in the Borehole
LPE-1**	255	100.0	Yes
LPE-2	243	51.0*	-
LPE-2A**	245	127.5	-
LPE-4	284.5	11.5*	-
LPE-4A	294.5	21.5*	-
LPE-4B**	294.5	65.5	Yes
LPE-6	300	61.0	-
LPE-7	322.5	72.5	Yes
LPE-8	377	71.0	Yes
LPE-9	408.5	61.5	-
LPE-10	394.5	91.0	Yes
LPE-11	395	96.0	-
LPE-12	394.5	96.0	-
LPE-13	376.0	76.0	-
LPE-14	374	76.0	Yes
LPE-15	385	76.0	-
LPE-16	383	81.5	Yes
LPE-17	414	75.5	-
LPE-19	472	77.0	-
LPE-20	245	101.0	-
LPE-21	260	76.0	-
LPE-24**	218	115.5	-

*Terminated before reaching planned penetration depth because of high OVA reading

**Performed in accordance with the procedures specified in the upgraded Level D Health and Safety Plan sampler 18 inches with a 140-pound hammer falling 30 inches. Blow counts were recorded for each 6-inch driving increment. The total blowcount for the last 12 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
- No obvious sampler advance was observed
- Sampler was advanced 18 inches.

Soil samples were obtained with the California-type drive samplers by driving the sampler with a 320-pound downhole hammer falling 18 inches. Blowcounts were recorded for each 6-inch driving increment. A Pitcher-barrel sampler was occassionally used when penetration or soil recovery with the drive samplers was difficult due to hard/dense subsurface conditions or when longer samples were desired.

The borings were continuously logged by an experienced geologist or soils engineer. The boring logs were prepared and/or reviewed by a certified engineering geologist (CEG). Drilling operations and borehole log preparation were performed in accordance with the Field Procedures Manual and Health and Safety Plan.

3.1.2 Piezometer Installation

Piezometers were installed in eight of the borings (LPE-1, -4B, -7, -8, -10, -11, -14, and -16). The purpose of the piezometers is to monitor groundwater levels and to obtain water quality samples. Two-inch-diameter PVC casing with 0.01-inch slotted well screen was primarily used for the piezometer. In two of the piezometers (LPE-7 and -10), 0.02-inch well screen was used due to temporary unavailability of the 0.01-inch screen. The piezometer well-screened depth interval was estimated based on groundwater levels that were extrapolated from the closest existing available water-level records. Observation of groundwater during drilling and 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 2 feet of backfill sand was placed at the bottom of the boring. The PVC casing assembly was inserted into the boring and backfill sand placed to about 2 feet above the slotted portion of the assembly. Backfill sand consisted of No. 2 and No. 3 Monterey sand for the 0.01-inch and 0.02-inch well screens, respectively. After sand backfilling, bentonite pellets were then poured by gravity to form a bentonite plug about 3 feet thick. Cement grout was then pumped into the annulus between the PVC casing and the borehole wall from the top of the bentonite plug to within 12 to 18 inches of the ground surface. At each piezometer location, a circular 12-inch-diameter metal traffic (Pomeco) box was also installed flush with the ground surface. Diagrams of the piezometer installations are presented in Appendix A.

3.1.3 Groundwater Level Monitoring and 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 3-2. Each piezometer was developed by bailing about 10 casing volumes of water. Water quality samples were obtained after bailing.

TABLE 3-2

SUMMARY OF GROUNDWATER LEVEL READINGS

	WATER LEVEL, FEET BELOW GROUND SURFACE							
	Piezometer No.							
Time of Reading	LPE-1	LPE-4B	LPE-7	LPE-8	LPE-10	LPE-11	LPE-14	LPE-16
Before development*	22.6	16.4	9.8	29.3	42.3	66.1	69.2	Dry**
Immediately after development	24.1	--	10.3	66.7	45.0	66.5	72.3	Dry**
November 14, 1988	22.8	16.4	9.9	29.4	44.4	66.2	70.2	Dry**
December 8, 1988	22.5	16.8	10.1	29.5	44.6	66.2	70.0	Dry**

* Before bailing out water in the piezometer (i.e., before a water quality sample can be taken)

** Groundwater level is below bottom of piezometer LPE-16 - 76 feet below ground surface

3.1.4 Gas Pressure Monitoring and Sampling

Two piezometers (LPE-1 and -4B) were selected at the start of the Stage 2 portion of field work to be outfitted with a special cap such that gases accumulating in the casing could be pressure-monitored and sampled. A schematic drawing of the special cap is shown in Appendix A. The cap is a PVC-tee assembly. A pressure gauge (1/16-pound-per-square-inch sensitivity) is attached to the tee-branch. A valve and small-diameter tubing is attached to the pressure gauge which is used for gas sampling. The central portion of the tee is fitted with a threaded PVC cap which is removable in order to monitor and sample the groundwater.

Readings of gas pressure were performed on November 14 and November 28, 1988. Gas pressure was not registered at either piezometer. Gas samples were also taken at the two piezometer locations for further chemical analysis.

3.2 LABORATORY TESTING PROGRAM

A laboratory testing program was developed and performed on selected soil, water, and gas samples obtained in this investigation. The laboratory test program was limited in nature and intended to provide a general preliminary indication of subsurface conditions and associated engineering parameters, as well as potential extent of chemical contamination along the MOS-2 alignment. Thus, the findings will be preliminary and additional work will be necessary. In general, the laboratory test program was developed to:

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

The following sections provide a general description of the test program, which is divided into soil mechanics laboratory testing and analytical laboratory (chemical) analysis.

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 American Society for Testing Materials (ASTM) or procedures acceptable in geotechnical engineering practice. The test program and procedures are summarized as follows:

Test Type	**No. of Tests**	**Test Procedure**
Visual Examination	Every sample	ASTM D 2488-84
Grain Size Distribution	68	ASTM D 422-63 and D 1140-54
Hydrometer Analysis	20	ASTM D 422-63
Unit Weight	140	ASTM D 2937-83
Moisture Content	140	ASTM D 2216-80
Specific Gravity	14	ASTM D 854-83
Atterberg Limit	28	ASTM D 4318-84
Direct Shear Tests	149	ASTM D 3080-72
Permeability	11	ASTM D 2434-68 and EPA 9100
Consolidation Test	1	ASTM D 2435-80
Unconfined Compression	37	ASTM D 2166-85

The results of soil mechanics laboratory tests are presented in Appendix B and in the boring logs found in Appendix A. Results of evaluation of the laboratory test data for the engineering properties of encountered subsurface materials are presented in Section 5.

3.2.2 Analytical Laboratory (Chemical) Analysis

In addition to monitoring the background and headspace OVA readings of every soil sample, triple-meter monitoring was performed on samples from borings LPE-1, -2A, -4B, and -24 for indication of potential presence of hydrogen sulfide (H_2S) concentration, explosivity level, and carbon monoxide concentration during the field work. A very limited analytical laboratory (chemical) analysis program was also performed on 18 selected soil samples, 7 groundwater samples obtained from 7 piezometers, and 2 gas samples obtained from 2 piezometers (LPE-1 and -4B). In summary, the following analytical laboratory analysis program was performed:

Test Type	**Sample Type**	**No. of Tests**	**Test Procedure**
Total Recoverable Petroleum Hydrocarbons (TRPH)	Soil	16	EPA 418.1
Aromatic Organic Compounds (BTEX)	Soil Water	16 7	EPA 8020
Volatile Organic Compounds (VOC)	Soil	2	EPA 8240
Semivolatile Organic Compounds	Soil	2	EPA 8270
CAM Metals	Soil	2	California Metals
Sulfide	Soil Water	16 9	EPA 9030

Test Type	**Sample Type**	**No. of Tests**	**Test Procedure**
Sulfate	Soil Water	16 7	EPA 9035
Volatile Organic Compounds	Gas	2	GC/MS (EPA 624)
Hydrogen Sulfide (H_2S) and Sulfur Compound (H_2S)	Gas	2	GC with flame photometric detection
Other Gases (Methane, CO_2, O_2 and N_2)	Gas	1	Gas chromatography SCAQMD 10.1 EPA Method 3

The results of the analytical laboratory analysis program are presented in Appendix C and summarized in Tables 3-3 through 3-9. A preliminary evaluation of the results and the potential impacts on subsurface conditions and construction are presented in Sections 5 and 6, respectively.

TABLE 3-3

CHEMICAL TEST RESULTS OF TOTAL RECOVERABLE PETROLEUM HYDROCARBONS (TRPH) ON SELECTED SOIL AND WATER SAMPLES

Location/ Sample No.	Sample Type	Concentration (mg/kg)
LPE-1	Water	84
LPE-4	Water	180
LPE-7	Water	96
LPE-8	Water	140
LPE-10	Water	66
LPE-11	Water	110
LPE-14	Water	81
Sample Location		
LPE-1/D-8	Soil	66
LPE-2A/D-10	Soil	140
LPE-4/D-5	Soil	78
LPE-6/D-12	Soil	84
LPE-7/D-7	Soil	120
LPE-8/D-6	Soil	72
LPE-9/D-7	Soil	72
LPE-10/D-14	Soil	78
LPE-11/D-13	Soil	110
LPE-12/D-14	Soil	99
LPE-14/D-5	Soil	84
LPE-16/D-11	Soil	81
LPE-20/D-18	Soil	160
LPE-21/D-14	Soil	180
LPE-24/D-16	Soil	90
LPE-24/D-22	Soil	75

NOTES: (1) Cleanup action level for TRPH concentration is about 1,000 mg/kg according to Leaking Underground Fuel Tank Field Manual.

(2) Action level for air concentration of TRPH that requires respiratory protection is 300 ppm according to OSHA and NIOSH regulations.

TABLE 3-4

CHEMICAL TEST RESULTS OF AROMATIC VOLATILE ORGANICS (BTEX) ON SELECTED WATER AND SOIL SAMPLES

	Concentration (µg/L)			
Location/Sample No.	Benzene	Toluene	Ethylbenzene	Xylene
LPE-1 (water)	8	80	12	123
LPE-4 (water)	ND	ND	ND	ND
LPE-7 (water)	3	3	3	ND
LPE-8 (water)	ND	ND	ND	ND
LPE-10 (water)	ND	ND	ND	ND
LPE-11 (water)	ND	ND	ND	ND
LPE-14 (water)	4	ND	ND	ND
LPE-1/D-8 (soil)	5	44	ND	5
LPE-2A/D-10 (soil)	ND	5	ND	ND
LPE-4/D-5 (soil)	ND	15	ND	5
LPE-6/D-12 (soil)	ND	42	ND	5
LPE-7/D-7 (soil)	ND	ND	ND	ND
LPE-8/D-6 (soil)	ND	ND	ND	ND
LPE-9/D-7 (soil)	ND	ND	ND	ND
LPE-10/D-14 (soil)	ND	ND	ND	ND
LPE-11/D-13 (soil)	ND	ND	ND	ND
LPE-12/D-14 (soil)	ND	ND	ND	ND
LPE-14/S-5 (soil)	5	ND	ND	ND
LPE-16/D-11 (soil)	ND	ND	ND	ND
LPE-20/D-18 (soil)	ND	25	ND	5
LPE-21/D-14 (soil)	ND	33	ND	8
LPE-24/D-16 (soil)	ND	124	ND	8
LPE-24/D-22 (soil)	ND	25	ND	5

NOTES: (1) ND = Not detected; detection limits for BTEX are 1 µg/L and 5 µg/kg for water and soil samples, respectively.

(2) According to the Leaking Underground Fuel Tank (LUFT) Field Manual, cleanup action levels for BTEX concentrations are 300 µg/kg, 300 µg/kg, 1,000 µg/kg and 1,000 µg/kg for benezene, toluene, ethylbenzene and xylene, respectively.

(3) According to OHSA and NIOSH regulations, the action levels for Time-Weighted Average (TWA) air concentrations of BTEX that require respirator protection are 5, 100, 100, and 100 ppm for benzene, toluene, ethylbenzene and xylene, respectively.

TABLE 3-5

RESULTS OF CHEMICAL TESTS OF VOLATILE ORGANICS BY GC/MS (EPA METHOD - 8240) ON TWO SELECTED SOIL SAMPLES

	Concentration (mg/kg)		
	Boring No./Sample No.		
Parameters (8240)	LPE-2A/D-8	LPE-24/D-18	Detection Limit
Acetone	ND	ND	100
Benzene	ND	ND	10
Bromodichloromethane	ND	ND	10
Bromoform	ND	ND	10
Bromomethane	ND	ND	50
2-Butanone (MEK)	ND	ND	100
Carbon Disulfide	ND	ND	10
Carbon Tetrachloride	ND	ND	10
Chlorobenzene	ND	ND	10
Chlorodibromomethane	ND	ND	10
Chloroethane	ND	ND	50
2-Chloroethyl vinyl ether	ND	ND	10
Chloroform	ND	ND	10
Chloromethane	ND	ND	50
1,1-Dichloroethane	ND	ND	10
1,2-Dichloroethane	ND	ND	10
1,1-Dichloroethene	ND	ND	10
1,2-Dichloroethene (total)	ND	ND	10
1,2-Dichloropropane	ND	ND	10
cis-1,3-Dichloropropene	ND	ND	10
trans-1,3-Dichloropropene	ND	ND	10
Ethylbenzene	ND	ND	10
2-Hexanone	ND	ND	100
Methylene chloride	ND	ND	100
4-Methyl-2-pentanone (MIBK)	ND	ND	50
Styrene	ND	ND	10
1,1,2,2-Tetrachloroethane	ND	ND	10
Tetrachloroethene	ND	ND	10
Toluene	228	75	10
1,1,1-Trichloroethane	ND	ND	10
1,1,2-Trichloroethane	ND	ND	10
Trichloroethene	ND	ND	10
Trichlorofluoromethane	ND	ND	50
Vinyl Acetate	ND	ND	100
Vinyl Chloride	ND	ND	50
Xylene (total)	ND	ND	10

NOTES: (1) ND = Not Detected

(2) Refer to Table 3-4 for action levels for toluene concentrations.

TABLE 3-6

CHEMICAL TEST RESULTS OF SEMIVOLATILE ORGANICS BY GC/MS (EPA METHOD-8270) ON SOIL SAMPLE NO. D-8, BORING LPE-2A

Parameter	Concentration (µg/kg)	Parameter	Concentration (µg/kg)
Phenol	ND (0.6)	Acenaphthene	ND (0.6)
bis(2-chloroethyl)ether	ND (0.6)	2,4-Dinitrophenol	ND (3.3)
2-Chlorophenol	ND (0.6)	4-Nitrophenol	ND (3.3)
1,3-Dichlorobenzene	ND (0.6)	Dibenzofuran	ND (0.6)
1,4-Dichlorobenzene	ND (0.6)	2,4-Dinitrotoluene	ND (0.6)
Benzyl Alcohol	ND (1.3)	2,6-Dinitrotoluene	ND (0.6)
1,2-Dichlorobenzene	ND (0.6)	Diethylphthalate	ND (0.6)
2-Methylphenol	ND (0.6)	4-Chlorophenyl-phenylether	ND (0.6)
bis(2-chloroisopropyl)ether	ND (0.6)	Fluorene	ND (0.6)
4-Methylphenol	ND (0.6)	4-Nitroaniline	ND (3.3)
N-Nitroso-Di-n-Propylamine	ND (0.6)	4,6-Diknitro-2-Methylphenol	ND (3.3)
Hexachloroethane	ND (0.6)	N-Nitrosodiphenylamine	ND (0.6)
Nitrobenzene	ND (0.6)	4-Bromophenyl-phenylether	ND (0.6)
Isophorone	ND (0.6)	Hexachlorobenzene	ND (0.6)
2-Nitrophenol	ND (0.6)	Pentachlorophenol	ND (3.3)
2,4-Dimethylphenol	ND (0.6)	Phenanthrene	ND (0.6)
Benzoic Acid	ND (3.3)	Anthracene	ND (0.6)
bis-(2-Chloroethoxy)methane	ND (0.6)	Di-n-Butylphthalate	ND (0.6)
2,4-Dichlorophenol	ND (0.6)	Fluoranthene	ND (0.6)
1,2,4-Trichlorobenzene	ND (0.6)	Pyrene	ND (0.6)
Naphtalene	ND (0.6)	Butylbenzylphthalate	ND (0.6)
4-Chloroanline	ND (1.3)	3,3'-Dichlorobenzidine	ND (1.3)
Hexachlorobutadiene	ND (0.6)	Benzo(a)Anthracene	ND (0.6)
4-Chloro-3-Methylphenol	ND (1.3)	bis(2-Ethylhexyl)Phthalate	ND (0.6)
2-Methylnaphthalene	ND (0.6)	Chrysene	ND (0.6)
Hexachlorocyclopentadiene	ND (0.6)	Di-n-Octyl Phthalate	ND (0.6)
2,4,6-Trichlorophenol	ND (0.6)	Benzo(b)Fluoranthene	ND (0.6)
2,4,5-Trichlorophenol	ND (0.6)	Benzo(k)Fluoranthene	ND (0.6)
2-Chloronaphthalene	ND (0.6)	Benzo(a)Pyrene	ND (0.6)
2-Nitroaniline	ND (3.3)	Indeno(1,2,3-cd)Pyrene	ND (0.6)
Dimethyl Phthalate	ND (0.6)	Dibenz(a,h)Anthracene	ND (0.6)
Acenaphthylene	ND (0.6)	Benzo(g,h,i)Perylene	ND (0.6)
3-Nitroaniline	ND (3.3)		ND (0.6)

NOTES:

ND = Not Detected

( ) = Detection Limit (µg/kg)

TABLE 3-7

CHEMICAL TEST RESULTS OF SEMIVOLATILE ORGANICS BY GC/MS (EPA METHOD-8270) ON SOIL SAMPLE NO. D-18, BORING LPE-24

Parameter	Concentration (μg/kg)	Parameter	Concentration (μg/kg)
Phenol	ND (0.6)	Acenaphthene	ND (0.6)
bis(2-chloroethyl)ether	ND (0.6)	2,4-Dinitrophenol	ND (3.3)
2-Chlorophenol	ND (0.6)	4-Nitrophenol	ND (3.3)
1,3-Dichlorobenzene	ND (0.6)	Dibenzofuran	ND (0.6)
1,4-Dichlorobenzene	ND (0.6)	2,4-Dinitrotoluene	ND (0.6)
Benzyl Alcohol	ND (1.3)	2,6-Dinitrotoluene	ND (0.6)
1,2-Dichlorobenzene	ND (0.6)	Diethylphthalate	ND (0.6)
2-Methylphenol	ND (0.6)	4-Chlorophenyl-phenylether	ND (0.6)
bis(2-chloroisopropyl)ether	ND (0.6)	Fluorene	ND (0.6)
4-Methylphenol	ND (0.6)	4-Nitroaniline	ND (3.3)
N-Nitroso-Di-n-Propylamine	ND (0.6)	4,6-Diknitro-2-Methylphenol	ND (3.3)
Hexachloroethane	ND (0.6)	N-Nitrosodiphenylamine	ND (0.6)
Nitrobenzene	ND (0.6)	4-Bromophenyl-phenylether	ND (0.6)
Isophorone	ND (0.6)	Hexachlorobenzene	ND (0.6)
2-Nitrophenol	ND (0.6)	Pentachlorophenol	ND (3.3)
2,4-Dimethylphenol	ND (0.6)	Phenanthrene	ND (0.6)
Benzoic Acid	ND (3.3)	Anthracene	ND (0.6)
bis-(2-Chloroethoxy)methane	ND (0.6)	Di-n-Butylphthalate	ND (0.6)
2,4-Dichlorophenol	ND (0.6)	Fluoranthene	ND (0.6)
1,2,4-Trichlorobenzene	ND (0.6)	Pyrene	ND (0.6)
Naphtalene	ND (0.6)	Butylbenzylphthalate	ND (0.6)
4-Chloroanline	ND (1.3)	3,3'-Dichlorobenzidine	ND (1.3)
Hexachlorobutadiene	ND (0.6)	Benzo(a)Anthracene	ND (0.6)
4-Chloro-3-Methylphenol	ND (1.3)	bis(2-Ethylhexyl)Phthalate	ND (0.6)
2-Methylnaphthalene	ND (0.6)	Chrysene	ND (0.6)
Hexachlorocyclopentadiene	ND (0.6)	Di-n-Octyl Phthalate	ND (0.6)
2,4,6-Trichlorophenol	ND (0.6)	Benzo(b)Fluoranthene	ND (0.6)
2,4,5-Trichlorophenol	ND (0.6)	Benzo(k)Fluoranthene	ND (0.6)
2-Chloronaphthalene	ND (0.6)	Benzo(a)Pyrene	ND (0.6)
2-Nitroaniline	ND (3.3)	Indeno(1,2,3-cd)Pyrene	ND (0.6)
Dimethyl Phthalate	ND (0.6)	Dibenz(a,h)Anthracene	ND (0.6)
Acenaphthylene	ND (0.6)	Benzo(g,h,i)Perylene	ND (0.6)
3-Nitroaniline	ND (3.3)		ND (0.6)

NOTES:

ND = Not Detected

( ) = Detection Limit (μg/kg)

TABLE 3-8

CHEMICAL TESTS RESULTS OF CAM METALS ON TWO SOIL SAMPLES

(SAMPLE NO. D-8, BORING LPE-2A AND SAMPLE NO. D-18, BORING LPE-24)

	Concentration (mg/kg)			
	Concentration			
Substances	LPE-2A/D-8	LPE-24/D18	Cleanup Action Level (Note 1)	Air Concentration Limit (mg/m3) that Requires Respiratory Protection (Note 2)
Antimony	< 5.0	< 5.0	500	0.5
Arsenic	3.7	12.8	500	0.2
Barium	97.0	51.0	10,000	0.5
Beryllium	< 1.0	< 1.0	75	0.02
Cadmium	1.6	1.3	100	0.05
Chromium - Total	31.8	40.3	500	0.5
Cobalt	13.7	13.2	8,000	0.05
Copper	27.4	34.6	2,500	1
Lead	< 1.0	14.2	1,000	0.15
Mercury	< 0.05	0.50	20	1
Molybdenum	< 1.0	< 1.0	3,500	10
Nickel	25.9	27.4	2,000	1
Selenium	< 1.0	< 1.0	100	0.2
Silver	< 1.0	< 1.0	500	0.1
Thallium	6.7	6.3	700	0.1
Vanadium	49.6	43.7	2,400	0.05
Zinc	67.5	75.3	5,000	10

NOTES: (1) California Department of Health Services, Title 22, Section 66699.

(2) OSHA and NIOSH Regulations.

TABLE 3-9

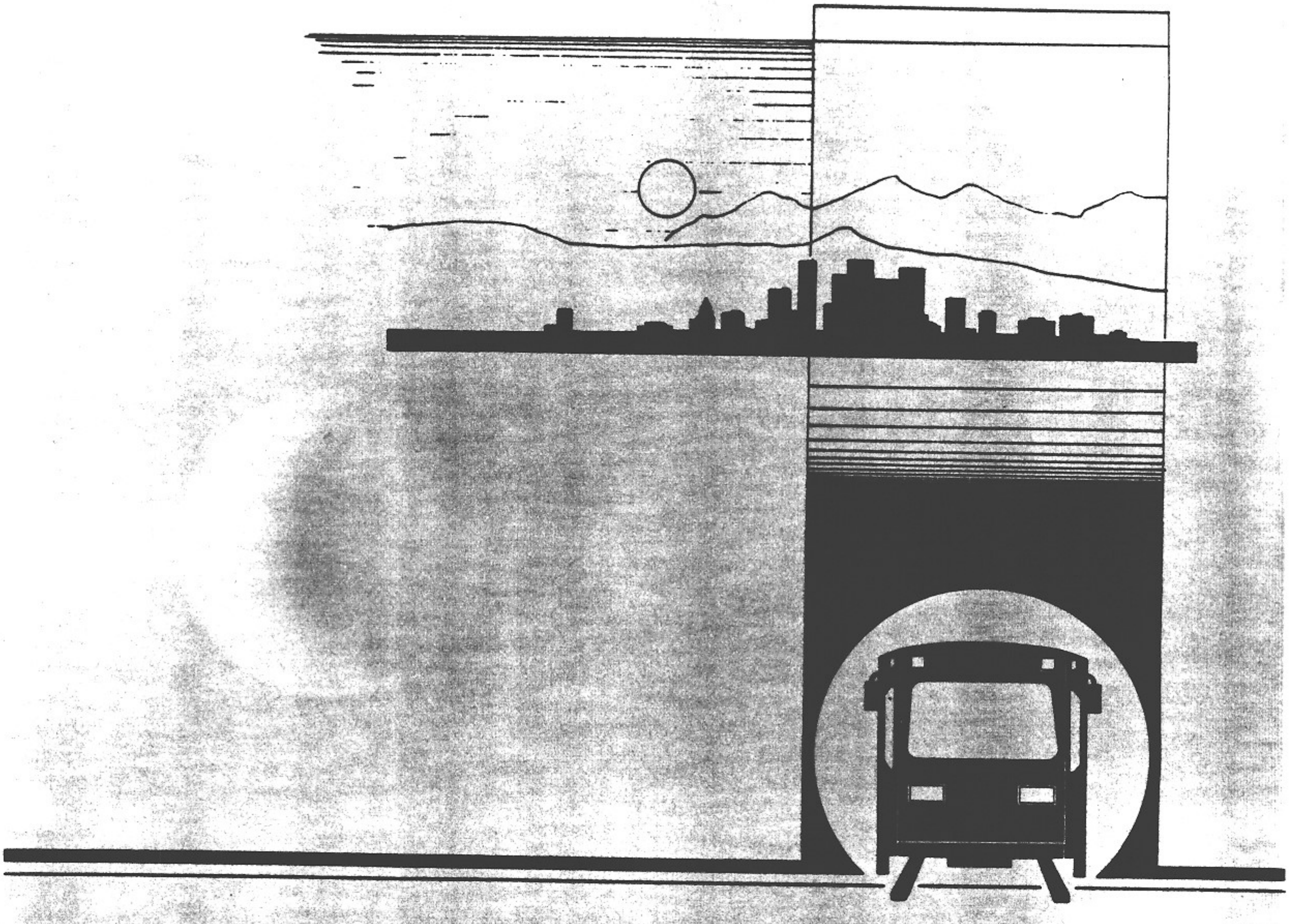
CHEMICAL TEST RESULTS OF SULFIDE AND SULFATE CONCENTRATIONS IN SOIL AND WATER SAMPLES

Location/ Sample No.	Sample Type	Concentration				Potential Cement Type for Construction
		Sulfide		Sulfate		
		(ppm)	(DL)	(ppm)	(DL)	
LPE-1	water	< 1	(1)	680	(50)	II
LPE-4	water	< 1	(1)	1,600	(50)	V
LPE-7	water	< 1	(1)	160	(50)	II
LPE-8	water	< 1	(1)	95	(50)	Regular
LPE-10	water	< 1	(1)	180	(50)	II
LPE-11	water	< 1	(1)	160	(50)	II
LPE-14	water	< 1	(1)	150	(50)	II
LPE-1/D-8	soil	< 3	(3)	900	(50)	Regular
LPE-2A/D-10	soil	< 10	(10)	100	(50)	Regular
LPE-4/D-5	soil	< 3	(3)	210	(50)	Regular
LPE-6/D-12	soil	< 3	(3)	1,100	(50)	II
LPE-7/D-7	soil	< 3	(3)	< 50	(50)	Regular
LPE-8/D-6	soil	< 3	(3)	< 50	(50)	Regular
LPE-9/D-7	soil	< 3	(3)	< 50	(50)	Regular
LPE-10/D-14	soil	< 3	(3)	170	(50)	Regular
LPE-11/D-13	soil	< 3	(3)	< 50	(50)	Regular
LPE-12/D-14	soil	< 3	(3)	< 50	(50)	Regular
LPE-14/D-5	soil	< 3	(3)	< 50	(50)	Regular
LPE-16/D-11	soil	< 3	(3)	< 50	(50)	Regular
LPE-20/D-18	soil	< 3	(3)	1,300	(50)	II
LPE-21/D-14	soil	< 3	(3)	1,100	(50)	II
LPE-24/D-16	soil	36	(10)	640	(50)	Regular
LPE-24/D-22	soil	85	(10)	130	(50)	Regular

NOTES: (1) DL = Detection Limit.

(2) Cement types are based on recommendations specified in Concrete Manual.

4.0 GEOLOGY AND ENGINEERING GEOLOGY



4.0 GEOLOGY AND ENGINEERING GEOLOGY

4.1 REGIONAL GEOLOGY AND GEOMORPHIC FEATURES

The Los Angeles Basin is generally considered to be the alluviated coastal plain bounded on the north by the Santa Monica-San Gabriel Mountains of the Transverse Range Geomorphic Province, on the east and southeast by the Santa Ana Mountains and San Joaquin Hills of the Peninsular Range Geomorphic Province, and on the south and west by the Pacific Ocean. However, this report utilizes the United States Geological Survey's (USGS) definition of the Los Angeles Basin (Yerkes et al., 1965), which is based upon tectonic or structural blocks that include the previously described basin while also including the San Fernando Valley (Figure 4-1). On the basis of fault zones, the Basin can be divided into four structural blocks, known as: the Northwestern Block, the Northeastern Block, the Central Block, and the Southwestern Block.

The Northwestern Block is bounded on the south by the Santa Monica and Raymond Hill fault zones, on the east by the Sierra Madre fault zone, on the north by the Santa Susana-Oak Ridge and San Gabriel fault zones, and on the west by the Pacific Ocean (Figure 4-1). The Northeastern Block is bounded on the north and east by the Raymond Hill and Cucamonga fault zones, and on the west and south by the Whittier-Elsinore fault zone (Figure 4-1). The Central Block is bounded on the north by the Santa Monica fault zone, on the east by the Whittier-Elsinore fault zone, and on the west-southwest by the Newport-Inglewood fault zone (Figure 4-1).

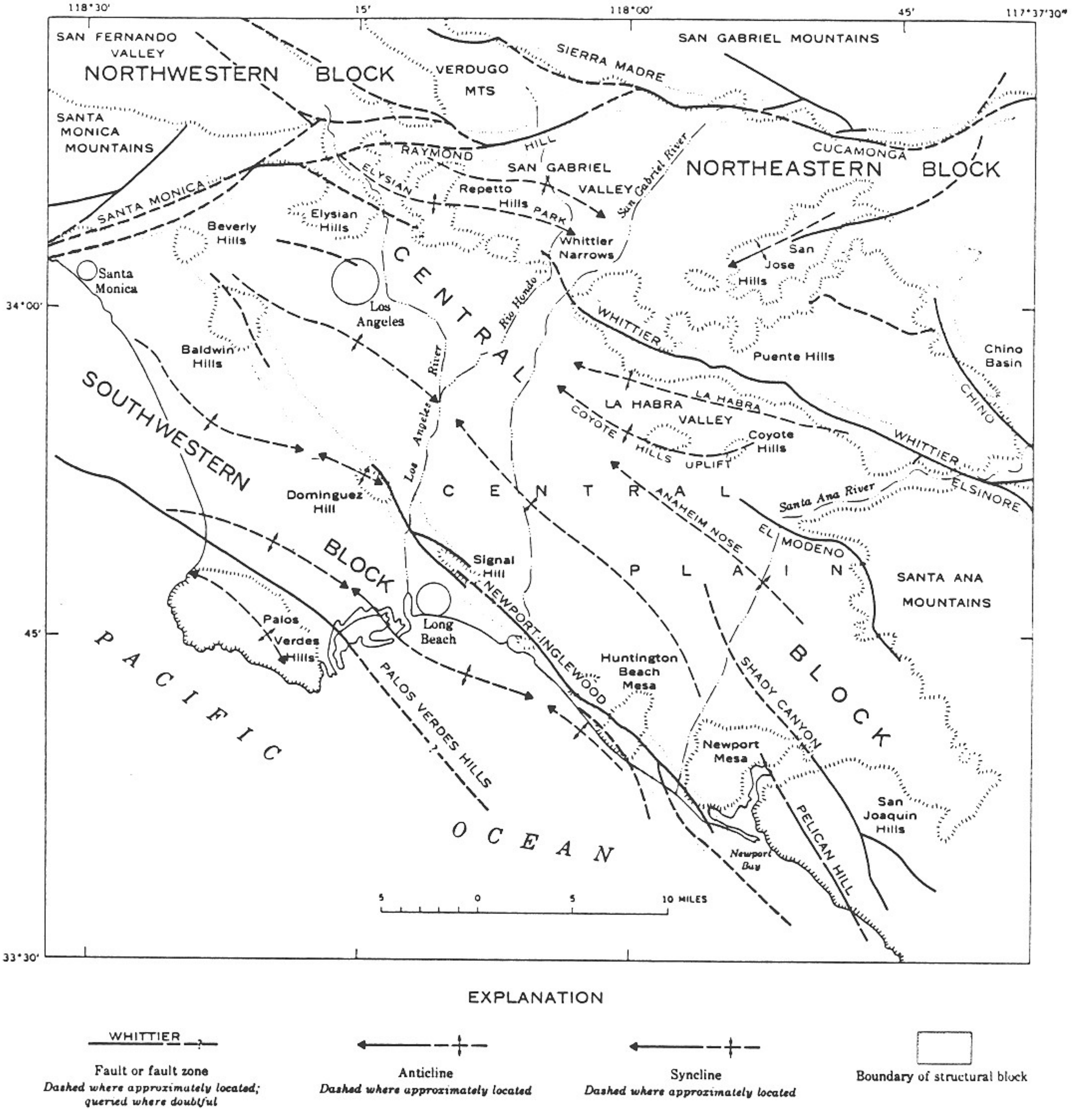
4.2 PROJECT STRATIGRAPHY

The MOS-2 alignment will traverse several known lithologic boundaries or formations and two separate sub-basins, the Los Angeles Basin and the San Fernando Basin, along the proposed route from the MacArthur Park area northward through the Santa Monica Mountains and into the San Fernando Valley. Geologic formations that will be encountered en route range in age from late Cretaceous (approximately 70 million years ago) to Holocene time (within the past 11,000 years). Figure 4-2 depicts the known surface geology along the intended route.

4.2.1 Basement Stratigraphy (Kg)

Basement (herein referred to as pre-Miocene-aged) rock outcrops mostly along the Central Block-Northwestern Block boundary and consists mostly of Cretaceous-aged intrusive granodiorite, with its composition ranging from quartz diorite to quartz monzonite. A granodiorite is defined by the International Union of Geological Sciences as a plutonic rock which consists primarily of quartz and feldspar (alkali and sodium). These rocks are exposed locally north of the Hollywood fault and are identified as "Kg" in Figure 4-2.

As planned, the proposed alignment will traverse a relatively thick section (approximately 8,000+ feet) of granodiorite as the tunnel enters into the Santa Monica Mountains from Hollywood Boulevard near La Brea Avenue (Figure 4-2). The granodiorite consists mostly of quartz and plagioclase feldspar, with minor amounts of orthoclase, microcline, and mafic accessory minerals. Generally, the granodiorite is massive and hard, but is deeply weathered along vertical joints or fractures and, where weathered, can become crumbly to moderately



ADOPTED FROM YERKES, ET AL (1965)

FIGURE 4-1. KEY TO PHYSIOGRAPHIC FEATURES, AND MAJOR STRUCTURAL FEATURES ON THE BASEMENT SURFACE, LOS ANGELES BASIN.

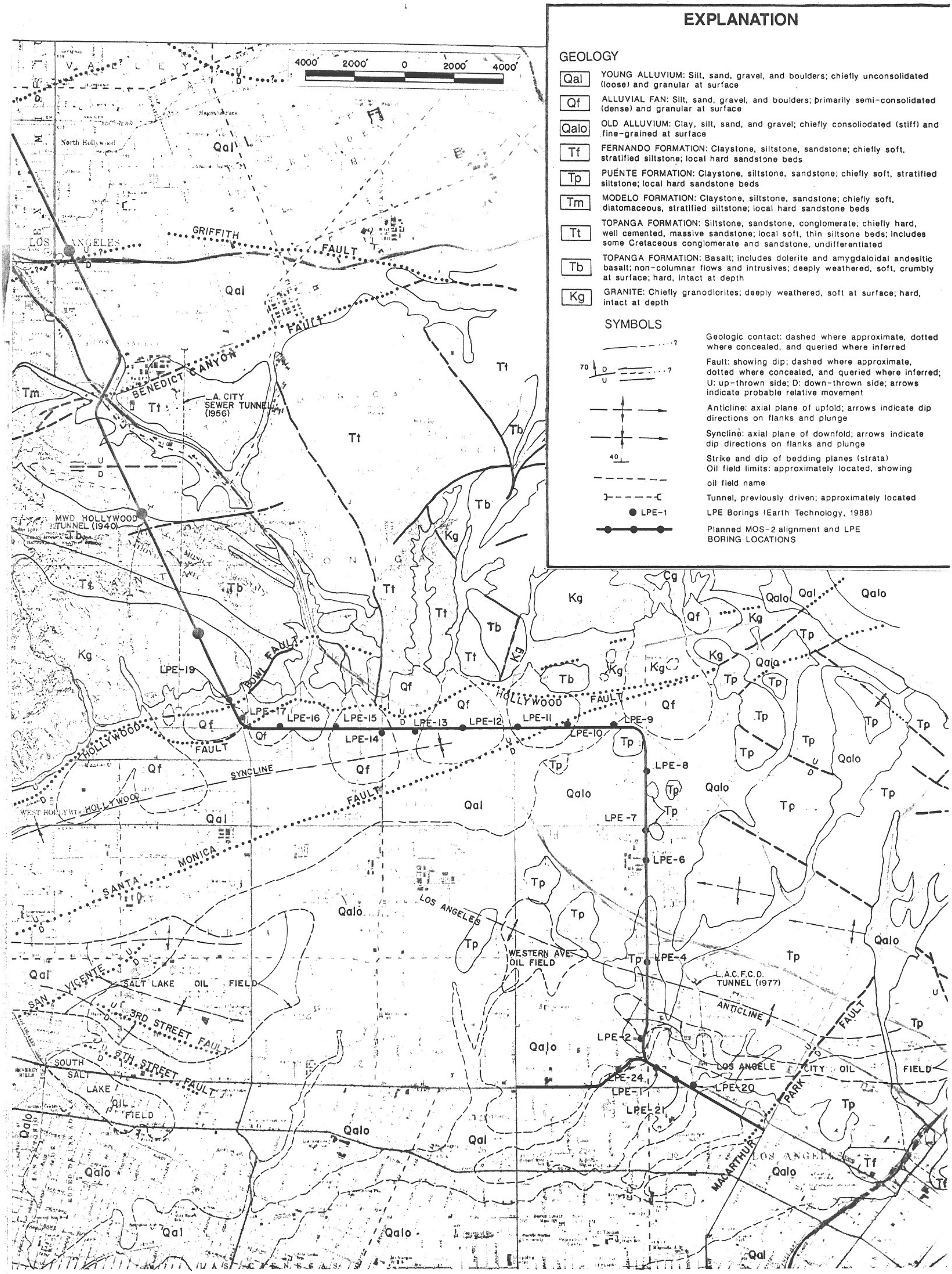


FIGURE 4-2. SURFICIAL GEOLOGIC MAP IN MOS-2 ALIGNMENT VICINITY

hard. Locally, at the surface, the granodiorite is in contact with Recent alluvium along the southern flank of the Santa Monica Mountains, and is in contact with the Topanga Formation along the northwesterly-trending contact near Cahuenga Pass (Figure 4-2). The northern contact is intrusive, whereas the southern contact is controlled by the Hollywood fault zone, as evidenced by the juxtaposition of Cretaceous Formation.

Starting in 1954 and ending in 1956, the City of Los Angeles constructed a 2.8-mile long sewer tunnel through the Santa Monica Mountains near the proposed alignment (Figure 4-2). This tunnel was drilled through a stratigraphy that is similar to that anticipated for the proposed tunnel. Specifically, the Los Angeles City sewer tunnel cut through approximately 4,700 feet of granite, 8,000 feet of Topanga clastics, 1,200 feet of Topanga basalt, and 430 feet of Recent alluvium (Campbell, 1955). The Metro Rail tunnel path will be west of and approximately on-grade with the Los Angeles City sewer tunnel. Thus, the thickness of stratigraphic rock units in the Santa Monica Mountains traverse are estimated to be approximately the same.

During construction of the sewer tunnel, tunneling conditions varied from hard and blocky diorite to soft (muddy)-to-caving sand and silt. The granite and/or diorite encountered was highly faulted, causing variation in rock types. Within the predominantly granodiorite zone, lithology varied from granite, conglomerate, arkosic sandstone, volcanics, and altered diorite (clay gouge associated with fault zones). Some fault or fracture zones were healed over with calcium carbonate, while others were open and water-bearing. Numerous fault planes and fracture zones were encountered throughout the tunnel. Gouge and/or breccia were often associated with seepage zones, with water volumes varying from a trickle to more than 600 gallons per minute (gpm) (Campbell, 1955). Steel ribs were needed in several fault zone areas for additional support.

None of the CEG (CWDD/ESA/GRC, 1981) and LPE (this program) series of borings encountered granodiorites. However, Boring LPE-19 encountered granite-derived laterite (red) soils (granite wash) at about 40 feet below the ground surface. This granite wash consists of plagioclase, quartz, and mafic fragments within a silty/clayey matrix. The sub-angular, sub-rounded fragments indicate limited transport, and the clay content may be altered plagioclase, thus indicating in situ weathering. Therefore, the granite wash may represent an older, possibly Pliocene-aged, alluvium which was shed from the nearby granodiorites.

4.2.2 Miocene Stratigraphy (Tb and Tt)

During the end of Miocene time, the relatively deep submarine depression (approximately 3,000 feet deep) which covered most of the present-day Los Angeles Basin was receiving vast quantities of clastic material derived from the nearby Santa Monica and San Gabriel Mountains. Subsidence and deposition continued (up to 18,000 feet of sediments) in the central part of the Basin into late Pliocene time after attaining a maximum water depth of more than 6,000 feet in early Pliocene time. The rate of deposition gradually overtook the rate of subsidence, and, by the end of Pliocene time, the water depth began to decrease (Yerkes et al., 1965).

Middle to Upper Miocene-aged rocks (approximately 5 to 15 millions years ago) consisting of marine sediments and volcanic basalt unconformably overly basement rocks on the northern end of the Central Block. These Miocene rocks are distributed generally on the eastern end of the Santa Monica Mountains and are subdivided into two formations: the Middle Miocene Topanga Formation (Tb and Tt) and the Upper Miocene Puente Formation (Tp).

4.2.2.1 Topanga Formation (Tb and Tt). The Topanga Formation can be further subdivided into two units, the Topanga basalt (Tb) and the Topanga clastics (Tt). The basalt is spatially located in and around the Cahuenga Pass area and is identified as Tb in Figure 4-2. The basalt is intruded into the conglomerate and sandstone of the Topanga clastics. Locally, along the intrusive contact, low-grade metamorphism has baked the surrounding clastics, resulting in a quartzitic halo. The basalt is predominantly hard and massive, but with vertical joints or fractures. These joints are known to store groundwater that permit temporary inflows into tunnel construction. Previous tunneling through the Topanga basalt, during construction of the Los Angeles City sewer tunnel, encountered temporary inflows in excess of 100 gpm. Mostly, the basalts were highly jointed, fractured, and blocky. Zones of volcanic tuff, sandstone, and breccia were common throughout the basalt zone. Groundwater inflow is common along the many faults and fractures.

Interbeds of conglomerate, sandstone, and siltstone make up the clastic unit of the Topanga Formation. Steeply dipping beds (from about 40 degrees to nearly vertical) of the clastic unit are distributed along the eastern end of the Santa Monica Mountains. These beds are in contact with Cretaceous basement (granite) rocks to the west and east of Cahuenga Pass. These very hard to hard well-cemented sandstone and conglomerate are marine in origin and, depending on basement topography, can be in excess of 10,000 feet thick. As planned, the proposed route through the Santa Monica Mountains may encounter approximately 6,000 + feet of these interbedded clastics. Additionally, the proposed route will cut the Topanga clastics obliquely to the mapped strike, and therefore will remain roughly in the same stratigraphic horizon.

Tunneling conditions through the Topanga clastics along the Los Angeles City sewer tunnel alignment ranged from firm-to-hard, calcium-cemented, massive sandstone to soft, thinly bedded sandstone and shale. Numerous faults and joints were encountered. Deformed bedding in several locations was associated with fault zones. Several fractures and/or fault zones were water-bearing. Steel supports were required across most fault zones for additional support. During construction, extremely wet, muddy ground was encountered near the north portal and under the Los Angeles River. Subsequently, this ground caved in and created an emergency situation. This wet zone was not identified during exploratory borings and necessitated a "change of condition" with the contractor.

4.2.2.2 Puente Formation (Tp). The Upper Miocene marine sediments of the Puente Formation, consisting of predominantly stratified claystone, siltstone, and sandstone, unconformably overly the Topanga Formation. The stratigraphy of the Puente Formation consists mainly of thin to thick bedded sandstone within thinly laminated interbeds of siltstone and claystone. Shallow oil production from the Puente Formation was exploited from stratigraphic traps in the now predominantly abandoned Los Angeles City Oil Field (Figure 4-2). Additionally, the Puente Formation is gently folded into a broad northwesterly-trending anticline known as the Los Angeles anticline. Within the planned tunnel depths, the proposed route will encounter the Puente Formation from the MacArthur Park area northward along Vermont Aveune to Hollywood Boulevard near Barnsdale Park.

4.2.3 Pliocene Stratigraphy

During early Pliocene time, vast quantities of clastic debris, consisting mostly of silt, sand, clay, and gravel, were transported from their northerly source areas and deposited in the central basin. Yerkes et al. (1965) state that "a gradual increase in grain size or percentage of sand from the base to the top of the lower Pliocene sequence in the central part of the basin suggests a gradual increase of the topographic relief in the source areas," thus indicating an upward movement of the Santa Monica Mountains along the Santa Monica fault zone. Shallow water sediments are prevalent in the upper Pliocene along the basin margins, indicating that water depths were approximately 900 feet deep (Yerkes et al., 1965). By the end of the Pliocene time, many marginal areas were above sea level, namely the Palos Verdes Hills, the Puente Hills, the Santa Ana Mountains, the San Gabriel Mountains, the Santa Monica Mountains, and large areas along the Newport-Inglewood fault zone.

Massive, very poorly bedded siltstone and claystone of the Fernando Formation (Tf) conformably overly the Puente Formation. Lamar (1970) noted that the contact is mostly gradational and difficult to locate. However, the contact is sometimes unconformable in structurally complex areas.

The only area with Fernando Formation present at the surface occurs along Wilshire Boulevard, just west from the Harbor Freeway (Figure 4-2). This formation was not encountered in this LPE program.

4.2.4 Pleistocene Stratigraphy

During early Pleistocene time (approximately 1.6 million years ago), the central part of the basin was still below sea level and continued to receive clastic sediments. Large quantities of coarse clastic sediments derived from the San Gabriel and Santa Monica Mountains were deposited in the Central Basin, which subsequently pushed the shoreline westward and southward. The alluvium shed off the nearby Santa Monica Mountains consists of coarse sand and gravel with clay and silt, and was deposited as alluvial fans throughout the project area. This alluvium, which is defined as Old Alluvium for the Metro Rail project, is depicted as Qalo in Figure 4-2. Old Alluvium unconformably overlies the Puente Formation where the Puente Formation is present.

4.2.5 Holocene Stratigraphy

Holocene (within the past 11,000 years) or Recent sediments generally were deposited in a similar manner as late Pleistocene sediments. Deposition of Young Alluvium, mostly silt, sand, and gravel along with alluvial fan sediments, occurred generally along the Santa Monica Mountains front. On the southern flank of the Santa Monica Mountains, the low relief of the Elysian Park Hills prevented the deposition of Young Alluvium there, and generally directed or channeled the deposition of clastic debris toward the west, along the front of the Santa Monica Mountains.

Borings LPE-9 through LPE-17 and LPE-19 indicate the depth of this Young Alluvium to be approximately 15 to 70 feet below the ground surface. However, the contact between Old Alluvium and Young Alluvium is difficult to delineate as the criteria for distinction are complex; generally, the distinction is based on color, density (as determined by blow-counts), and the presence of clays with higher plasticity.

4.3 RELEVANT GEOLOGIC STRUCTURES

4.3.1 Overview

Within the Los Angeles Basin, and specifically within the Central and Northwestern Blocks, several geologic structures are present in the general vicinity of the MOS-2 alignment. Mostly, these tectonic features are covered by Old and/or Young Alluvium, and are inferred to be present where they are not mapped at the surface. The relevant geologic structures known to traverse the alignment are described in the following sections. Other relevant tectonic features are described in Section 4.5.

4.3.2 Los Angeles Anticline

The Los Angeles anticline is a broad gentle fold involving the Puente Formation. It trends northwesterly from just north of the Los Angeles City Oil Field near Alvarado Street towards the Western Avenue Oil Field (Figure 4-2). The limbs of this fold generally dip between 10 and 20 degrees, and appear to gently plunge northwesterly at approximately 10 degrees. Puente Formation samples obtained from borings along Vermont Avenue appeared to agree with these dip values. However, as the boring samples were not oriented, a strike measurement could not be obtained. Nevertheless, dip values agree with mappable outcrops of Puente siltstones located east of Vermont Avenue. The Los Angeles anticline should pose no significant problems to tunneling along Vermont Avenue, except for the possibility of gassy ground associated with hydrocarbon accumulation.

4.3.3 Hollywood Syncline

The Hollywood syncline has been inferred on previous geologic maps to be present, paralleling the Santa Monica Mountains front in a general east-west trend. As the depth to bedrock could not be established along Hollywood Boulevard (Borings LPE-9 through LPE-17 and LPE-19), the location and configuration of this structural feature could not be confirmed.

4.3.4 Santa Monica Fault Zone

The Santa Monica fault zone has been inferred to be present along the Santa Monica Mountains front through the project area in previous investigations by several different methods: gravity gradients, groundwater contours, juxtaposition of basement rocks against the Puente Formation, and extrapolation of mappable segments from Beverly Hills eastward to the Raymond Hill fault zone. The presence of this fault is not disputed; however, the actual surface location of this fault zone is not known. Boring LPE-8 was the nearest boring to encounter Puente Formation bedrock. The lack of penetration into bedrock by the intervening borings cannot be used to accurately locate this fault zone, especially when these borings only penetrate 65 to 96 feet of sediments.

The depth of Holocene and Pleistocene sediments along the Santa Monica Mountains front precludes the precise location of this fault. Recent movement along this fault is unknown, as it has not moved during historic time. However, this fault should be considered capable of movement, because the forces present today are similar to those which are associated with movement along this fault zone during the late Miocene time.

4.3.5 Hollywood Fault

The Hollywood fault is mappable along the base of the Santa Monica Mountains as a scarp-like feature within Old and Young Alluvium (Weber et al., 1980). However, it is inferred because recent urban development has obscured any surface expression of this fault. Geomorphic features (i.e., faceted, steeply inclined spurs) along the mountain front near the fault trace suggest this fault may have had Holocene movement (Weber et al., 1980). This fault may join the Santa Monica fault zone west from the Golden State Freeway near Los Felix Boulevard (Figure 4-2). Additional work, including detailed field-mapping and borings, must be undertaken before an accurate interpretation of this fault and any associated seismicity can be determined.

4.3.6 Hollywood Bowl Fault

Ths Hollywood Bowl fault appears to be a normal fault with right-lateral offset (Weber et al., 1980). The proposed alignment will cross this fault zone as the tunnel enters the Santa Monica Mountains north of the junction of La Brea Avenue and Hollywood Boulevard (Figure 4-2). Numerous faults and/or fractures were mapped in the Los Angeles City sewer tunnel as it crossed this area. Even though the Los Angeles City sewer tunnel was in granite, these numerous fractures were often filled with gouge and/or breccia and were usually conduits for water into the tunnel, which required additional roof support. Further delineation of this fault is needed for the MOS-2 design and construction.

4.3.7 Benedict Canyon Fault

The Benedict Canyon fault was originally mapped by Hoots (1931) in the northern Santa Monica Mountains, near the present day junction of the Hollywood Freeway and Lankershim Boulevard (Figure 4-2). The normal fault, down to the north, also exhibits approximately 1 mile of left-lateral offset between Upper Cretaceous and Paleocene rocks along the fault (Weber et al., 1980). Although stratigraphic evidence, based upon subsurface offset of water-bearing sediments, suggests that this fault was active during Holocene time (Weber et al., 1980), the fault has not been classified as active.

4.3.8 Unnamed Faults

Several unnamed faults are mapped in and around the Cahuenga Pass area. These faults juxtapose Cretaceous granite against Topanga sediments east of Cahuenga Pass, while other faults in the general area put Topanga basalt against the basement rock. Stratigraphic offset or fault throw cannot be determined at the present time, but these faults appear to be minor in their stratigraphic offset and extent.

Several fault zones were also mapped during construction of the Los Angeles City sewer tunnel through the granite and basalt sections. These fault zones were conduits for water inflow and resulted in the need for additional tunnel support.

4.4 ADJACENT OIL AND GAS PRODUCTION

Within the general project area, several known oil fields are present. They are: the Los Angeles City Oil Field, the Western Avenue Oil Field, the Salt Lake Oil Field, and the South Salt Lake Oil Field. Oil and gas production began from these fields around the turn of the century, except for the South Salt Lake Oil Field which was discovered in 1970. The Los Angeles Oil Field is the only oil/gas field that is in proximity to the planned MOS-2 alignment (Figure 4-2).

The Los Angeles City Oil Field is the oldest field. This field was discovered in 1890 via a hand-dug well known as the "Dryden well" (approximately 1,000 feet east from Vermont on Third Street). Since that time, this field has produced more than 21 million barrels of oil with no gas. The faulted anticline acts as the trap for producing horizons within the Puente Formation. Depth to producing zones was approximately 150 feet. For the most part, this oil field has been abandoned, however there are several producing wells near Dodger Stadium on the east end of the field.

The proposed alignment will cross the mapped extent of the Los Angeles City Oil Field along Vermont Avenue between Third Street and approximately First Street (Figure 4-2). Tunneling through this area should not present a problem as the known producing zones are much deeper than the planned tunnel. Nevertheless, dead oil, tar, or methane gas may be trapped and present along bedding planes within the upper Puente Formation.

4.5 REGIONAL SEISMICITY

Seismicity evaluation is not within the scope of this program. The following description is provided for future consideration.

The Metro Rail alignment lies in an area of high seismic potential due to its proximity to several major fault zones. Locations of known surface traces of faults that are generally considered to be "active" and the seismicity of the greater Los Angeles Basin for the years 1930 through 1988 are depicted in Figure 4-3. Several major faults may be considered as sources of critical or controlling ground motions in the Los Angeles Basin area. These faults are the Newport-Inglewood fault, the San Andreas fault, and the Santa Monica fault zone. Additionally, several smaller faults within close proximity to the proposed alignment also need to be considered as potential sources of seismic energy. These are the Benedict Canyon fault, the Hollywood fault, and the Hollywood Bowl fault. However, as evidenced by the October 1987 Whittier Narrows earthquake (Magnitude 5.9) and the December 1988 Pasadena earthquake (Magnitude 5.0) with epicenter in the deeply-buried (8 to 10 miles) Elysian Park fault zone (Figure 4-1), other faults may exist within the Greater Los Angeles Basin and/or project area which are unknown or unmapped, or are deeply-buried, but are capable of producing a Magnitude 6.0 or greater earthquake. Therefore, the referenced faults should not be viewed as the only faults capable of strong motion damage to Metro Rail facilities.

A regional seismicity map showing seismic activities in the general area is presented in Figure 4-3. Seismic potential of various faults traversing the MOS-2 alignment has been described in Section 4.3. The following paragraphs provide a brief description of two major faults and associated seismic potential in the general region.

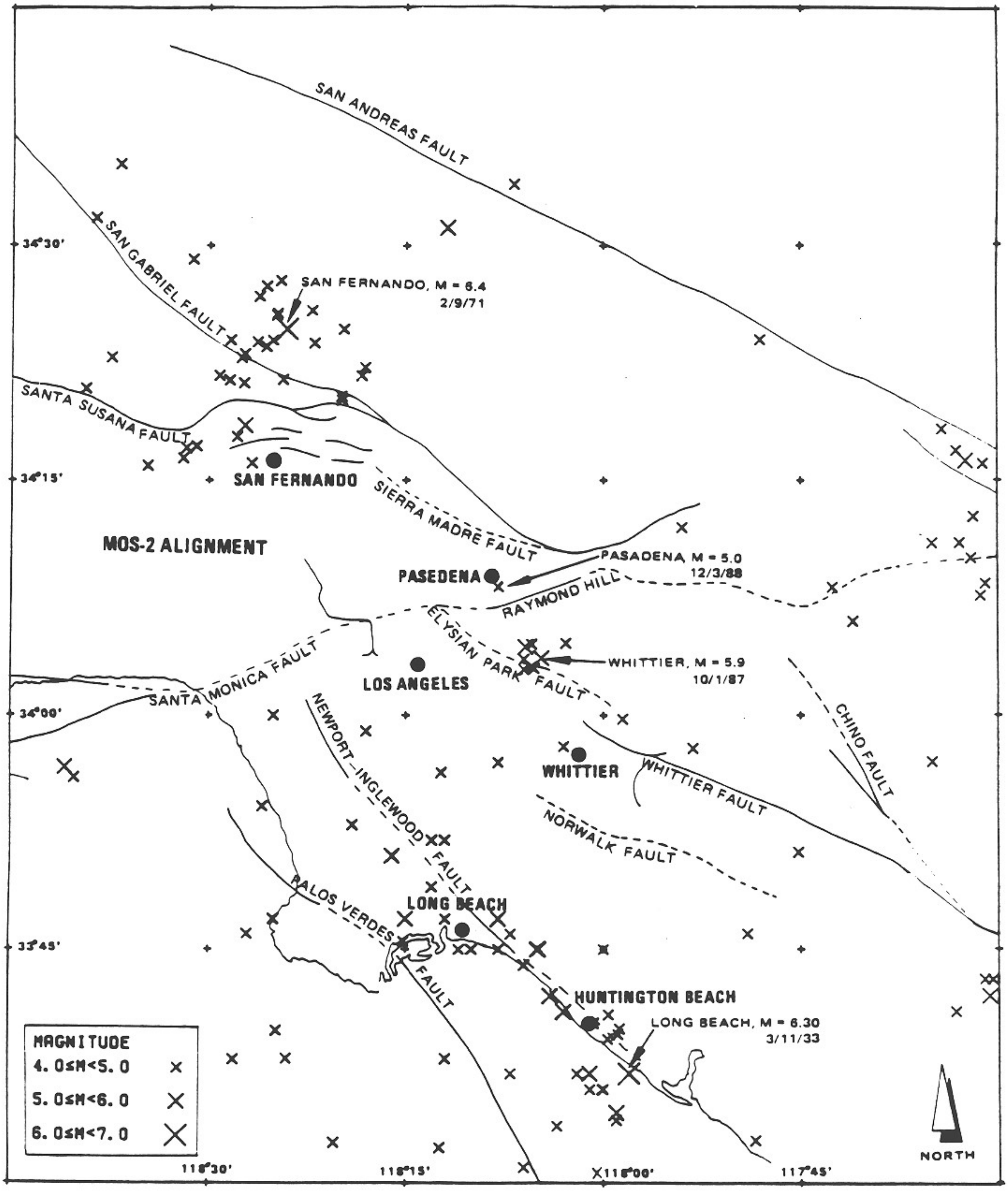


FIGURE 4-3. SEISMICITY IN LOS ANGELES REGION -1932 TO 1988.

4.5.1 Newport-Inglewood Fault

The Newport-Inglewood fault trends northwestward from Newport Beach to the Beverly Hills area, where it terminates at the eastward-trending Santa Monica fault zone (Figure 4-1). The Newport-Inglewood fault marks the eastward boundary of the Southwestern Block within the greater Los Angeles Basin. The Newport-Inglewood fault is characterized as a wrench fault (i.e., with strike-slip movement at depth), which has resulted in the folding of overlying sediments (e.g., Signal Hill, Dominquez Hill, Baldwin Hills). Recency of movement along the Newport-Inglewood fault includes five earthquakes of Magnitude 4.9 or larger since 1920. The Inglewood earthquake of 1920 (Magnitude 4.9) caused moderate damage to the town of Inglewood and was the result of movement on the Newport-Inglewood fault segment just west of Inglewood. The Long Beach earthquake of 1933 (Magnitude 6.3) is the largest recorded earthquake to occur along the Newport-Inglewood fault, and was centered 5.5 km southwest of Newport Beach. Later that year, a large aftershock (Magnitude 5.4) occurred near Signal Hill. In 1941, two earthquakes of Magnitude 5.0 and Magnitude 5.4 caused damage in the Torrance-Gardena area (Richter, 1958). Consequently, the Newport-Inglewood fault is considered to be an active fault and is listed as a specific study zone under the Alquist-Priolo Special Studies Zones Act of 1972.

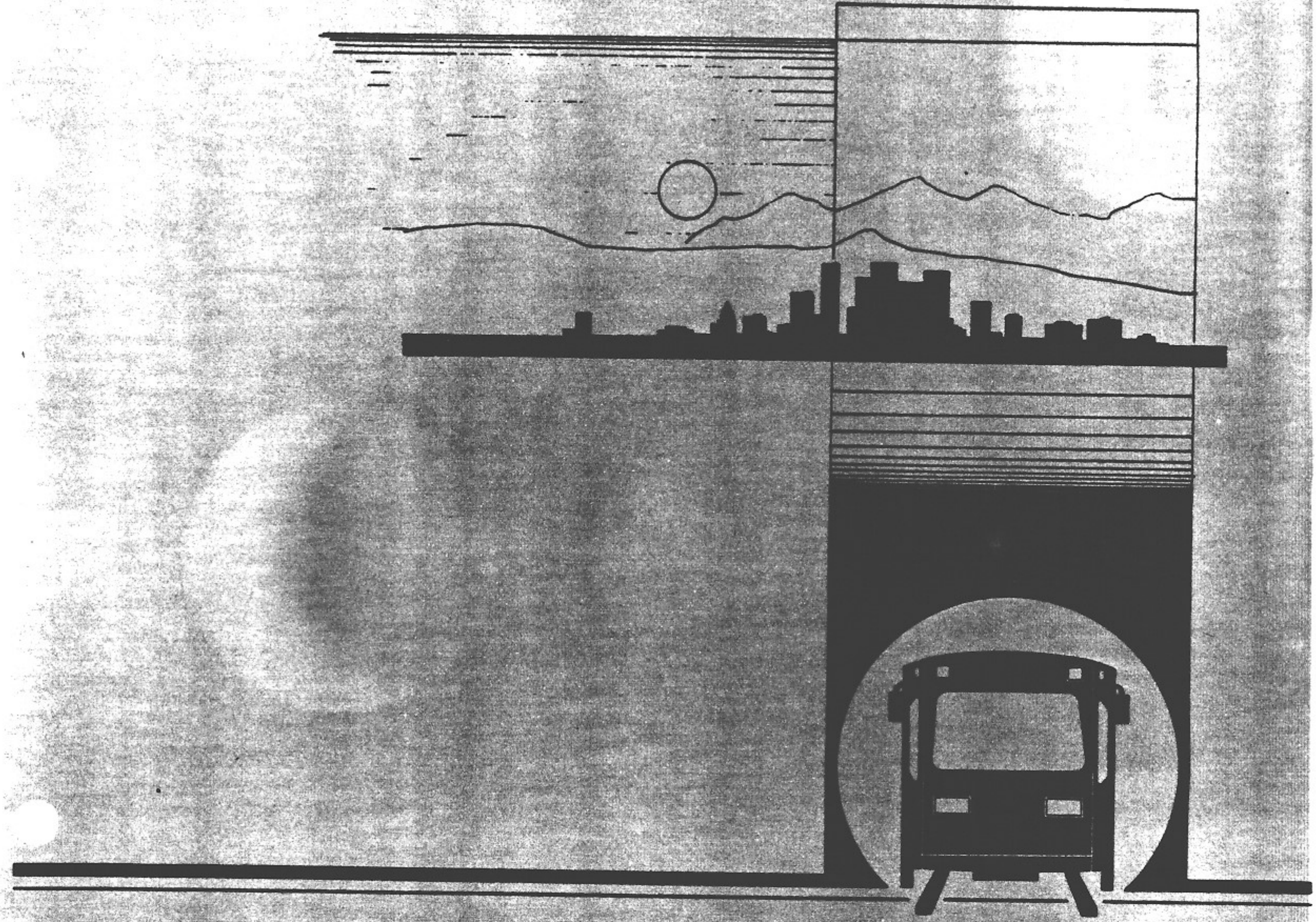
The Newport-Inglewood fault is approximately 6 miles westward from the proposed alignment at its closest approach (Figure 4-1). The close proximity of the Newport-Inglewood fault, combined with its recorded past activity, makes this fault one of the most likely earthquake sources that could affect the Metro Rail tunnel. Hauksson (1987) has estimated a mean recurrence interval for the Newport-Inglewood fault, based on Quaternary slip rates and displacement during the 1933 Long Beach earthquake, on the order of several hundred years. Ziony et al. (1985) suggest a Magnitude 6.5 earthquake could rupture the northern segment of the fault along with secondary ruptures along the Avalon-Compton fault, Potereo fault, and Inglewood fault. Hauksson (1987) suggests that smaller branch faults striking subparallel to the trace of the main fault zone are also active. Generally, Hauksson (1987) identifies the northwest-trending, strike-slip faults of the Los Angeles Basin as contributing significantly to seismic hazards within the basin, as they may accommodate 10 to 15 percent of the relative plate motion between the North American and Pacific plates.

4.5.2 San Andreas Fault

The San Andreas fault represents the major boundary between the North American and Pacific tectonic plates, and trends northwestward from the Salton trough to the San Francisco area before trending offshore and possibly joining the Mendicino fracture zone. The San Andreas fault is considered very active with numerous major earthquakes having occurred along the fault zone. Hauksson (1987) identifies the San Andreas fault as having more potential for damage within the Los Angeles Basin than the Newport-Inglewood fault due to its greater slip rates. Additionally, the United States Geological Survey has issued a seismic alert for the San Andreas fault, as they expect a major earthquake (Magnitude 7+) to occur within the next 20 years. Experts predict a Magnitude 8+ earthquake may occur eventually on this fault.

The San Andreas fault is more than 30 miles from the proposed alignment at its closest approach, yet, this fault is a potentially significant source of damage within the Los Angeles Basin because of the much longer duration of ground motions that would be expected for a Magnitude 8+ earthquake.

5.0 SUBSURFACE CONDITIONS



5.0 SUBSURFACE CONDITONS

5.1 GEOTECHNICAL TERMS AND DEFINITIONS USED IN THIS REPORT

The subsurface materials encountered in the investigation program have been grouped into several "soft ground" and "rock" geologic units consistent with current practice in the Metro Rail project. The materials in each geologic unit share similar geologic history and features, and are expected to exhibit similar engineering properties and behavior in construction. Subsurface materials which require soft-ground tunneling techniques (hand mining or mechanical excavation with or without a shield) for tunnel construction are designated as "soft ground" units. Subsurface materials which require rock tunneling techniques (drill-and-blast or rock tunneling machines) for tunnel construction are designated as "rock" geologic units.

5.1.1 "Soft Ground" Units

Along the portion of MOS-2 alignments investigated in the field program, the "soft ground" materials encountered include Young Alluvium (designated as Qal in Figure 4-2), Old Alluvium (designated as Qalo in Figure 4-2), and the Puente Formation (designated as Tp in Figure 4-2). These "soft ground" materials are divided into the following units:

1. **Unit A1 - Young Alluvium (Granular)**

Granular Young Alluvium (Holocene sediments) was deposited in a relatively "swift" stream environment. This unit consists of loose to dense clean sand, silty sand, gravelly sand, and sandy gravel with potential for the local presence of cobbles and boulders. This geologic unit is present along the Hollywood Boulevard portion (Borings LPE-9 through LPE-17 and LPE-19) of the MOS-2 alignment. However, no cobbles or boulders were detected during the field program.

2. **Unit A2 - Young Alluvium (Fine-grained)**

Fine-grained Young Alluvium (Holocene sediments) was deposited in relatively "quiet" water environments. This unit consists of sandy clay, clayey silt, and clay with local presence of traces of gravel. The unit is predominantly stiff, its consistency ranging from firm to hard. This unit is encountered in the Hollywood Boulevard portion (Borings LPE-9 through LPE-17 and LPE-19) of the MOS-2 alignment.

3. **Unit A3 - Old Alluvium (Granular)**

Granular Old Alluvium (Pleistocene sediments) was deposited in relatively "swift" water environments. This unit consists primarily of medium-dense to very dense clean sand, silty sand, gravelly sand, and sandy gravel. This unit is present along the Wilshire Boulevard corridor and along the Vermont Avenue portion of the MOS-2 alignment as surficial (discounting presence of fill material) sediments overlying the Puente Formation.

Along the Hollywood Boulevard portion of the MOS-2 alignment, this unit is also present and overlain by Young Alluvium (Units A1 and A2).

4. Unit A4 - Old Alluvium (Fine-Grained)

Fine-grained Old Alluvium (Pleistocene sediments) in Unit A4 was deposited in relatively "quiet" water environments and primarily consists of medium-stiff to very hard clay, silty clay, clayey silt, sandy clay, and clayey sand with local presence of traces of gravel. This unit is encountered overlying the Puente Formation in the OS-A segment along the Wilshire Boulevard corridor and the Vermont Avenue portions of the MOS-2 alignment. Along the Hollywood Boulevard portion of the MOS-2 alignment, this unit is underlying the Young Alluvium. In comparison with Unit A2, Unit A4 is generally stiffer and denser, and its fines content is generally more plastic.

5. Unit Tp - Puente Formation

In the Los Angeles Basin area, the Puente Formation consists of thinly to thickly bedded claystone, siltstone, and sandstone. Within the explored depths of this LPE program, this unit primarily consists of clayey siltstone with thinly bedded sandstone. This unit consists of marine sediments of Miocene age. Based on the results of this LPE program, the materials in the unit are generally very low-strength (weak) rocks with local presence of hard sandstone beds ranging from fractions of an inch to as much as 3 feet in thickness. However, there exists the possibility of local presence of high-strength and massive sandstone pockets within the planned tunnel depths along the MOS-2 alignment south of Hollywood Boulevard, similar to those found in MWD's Tonner Tunnel (sandstone and conglomerate with high unconfined compression strength of about 12,000 to 15,000 psi).

For purposes of discussion, this unit is further divided into the following two subunits in terms of weathering and depth.

Subunit Tpw - Oxidized/Weathered Puente Formation

Materials in this subunit are located at the top of the Puente Formation. The materials are oxidized and weathered to a varying extent. The extent of oxidization and weathering decreases with depth. Highly weathered and oxidized materials are soil-like, with little or no cementation and with either undistinguishable or fractured bedding planes. Slightly to moderately oxidized/weathered materials are cemented to some extent and have distinguishable bedding planes that range from intact (slightly oxidized/ weathered) to easily separable (moderately oxidized/weathered).

Subunit Tpf - Fresh (Unweathered and Non-Oxidized) Puente Formation

The materials in this unit are unweathered and generally have well defined bedding planes which are generally intact. The materials are moderately cemented and friable. Except for potential local presence of hard sandstone beds, the subunits Tpw and Tpf can be generally classified as very weak rock with engineering properties similar to hard, dense soils with a significantly high cohesion strength component.

5.1.2 "Rock" Geologic Units

The anticipated "rock" geologic units along the MOS-2 alignment include the Cretaceous-aged intrusive granodiorite (designated as "Kg" unit in Figure 4-2), the Miocene-aged sedimentary rocks of the Topanga Formation (designated as "Tt" unit in Figure 4-2), and the Miocene-aged volcanic basalt of the Topanga Formation (designated as "Tb" in Figure 4-2). The origins, composition, hardness, and extent of weathering/fracturing features are described in Section 4.2 and summarized as follows:

- "Kg" unit - Consisting predominantly of granodiorite (granite); deeply weathered and fractured; soft and weathered at shallow depth and hard and intact at greater depth.
- "Tt" unit (Topanga Formation) - Consisting primarily of sandstone, siltstone and conglomerate with some Cretaceous conglomerate and sandstone; generally hard and well-cemented with local soft thin beds of siltstone and shale.
- "Tb" unit (Topanga Formation) - Consisting of basalt; deeply weathered, hard and massive at depth with vertical joints or fractures; soft and weathered at or near surface.

These rock unit were not encountered in the LPE borings in this program. However, based on available data, they are present along the Santa Monica Mountains portion of the MOS-2 alignment.

5.2 SUBSURFACE CONDITIONS

The description of subsurface conditions presented herein is based on the results of this LPE program and an evaluation of available data in the literature. While the description is appropriate for LPE purposes, further investigations are necessary to provide an adequate database for the planned future engineering stage of the design effort. To facilitate discussion, the description of subsurface conditions along the MOS-2 alignment is divided into the following alignment portions:

1. OS-A segment along Wilshire Boulevard corridor (Borings LPE-1, -20, -21 and -24)
2. Alignment portion along Vermont Avenue (Borings LEP-1, -2, -4, -6, -7 and -8)
3. Alignment portion along Hollywood Boulevard to the foothills of the Santa Monica Mountains (Borings LPE-9 through LPE-17 and LPE-19)
4. Alignment portion through the Santa Monica Mountains to Universal City Station (No borings - based solely on available literature data).

5.2.1 OS-A Segment Along Wilshire Boulevard Corridor

Based on the results of this investigation and available data (CWDD/ESA/GRC, 1981), a general cross-sectional profile along a portion of the OS-A segment is presented in Figure 5-1. The subsurface materials, as revealed at the boring locations, consist generally of Old Alluvium overlying the Puente Formation. The overburden alluvial soils range in thickness from 10 feet (Boring LPE-24) to 110 feet (Boring CEG-15 near the Wilshire/Western Station - refer to CWDD/ESA/GRC, 1981), and primarily consist of stiff silty clay and clayey silt (Unit A4) with zones/pockets of dense to very dense clean sand and silty sand (Unit A3). The Puente Formation (Unit Tp) underlying the overburden soils consists predominantly of clayey siltstone with thin interbeds of sandstone and with dip angles of the beddings ranging from 0 degrees to about 50 degrees. The thickness and top elevations of the Puente subunits with respect to the planned tunnel/station depths encountered in this LPE program are shown in Figure 5-1.

Among the four LPE borings (LPE-1, -20, -21 and -24) performed along this alignment portion, sulfur odors were occasionally noticed during drilling and sampling of Borings LPE-21 and -24. Sulfur odors can be generated from various sulfide or sulfate compounds. Among these compounds, hydrogen sulfide (H_2S) is one of the most toxic. The explosure limit as set by OSHA and the National Institute for Occupational Safety and Health (NIOSH, 1985) is 10 ppm. Triple-meter readings taken during the Boring LPE-4 operation indicated that the H_2S concentrations in the background and the work space/headspace surrounding the obtained soil samples had the same values, and ranged from 0 to 4 ppm, which is less than the specified exposure limit. However, the limited nature of this LPE program cannot completely eliminate the possibility of such an exposure limit being exceeded.

Headspace OVA readings were taken for all recovered samples to evaluate the possible presence and concentration of volatile chemical compounds. In most cases, the OVA reading differences between the background and sample headspace were found to be small. However, zones with headspace OVA readings which were significantly higher than the corresponding background values were encountered. These zones (OVA reading greater than 10 ppm) are indicated in the cross-sectional profile (Figure 5-1). The results of limited chemical tests performed on selected samples with high OVA readings indicate that the concentration levels of total recoverable petroleum hydrocarbon (TRPH) and four selected volatile (aromatic) organic compounds (BTEX, including benzene, toluene, ethylbenzene, and xylene) are low, and all are less than the cleanup action levels (Table 3-4). The low BTEX readings, the proximity to an existing oil field (Los Angeles City Oil Field), and the high headspace OVA readings of soil samples may be postulated to be primarily due to presence of methane gas and dead petroleum. Further validation of this postulation will be necessary.

The measured groundwater level encountered at piezometer LPE-1 is approximately 22 feet below the ground surface and occurs within the Old Alluvium. This appears to be a perched water condition, since available data (CWDD/ESA/GRC, 1981) indicate that the permanent groundwater levels along the OSA segment are about 140 to 180 feet below the ground surface.

NOTES:
1. THIS PROFILE IS BASED ON INTERPRETATION BETWEEN WIDELY-SPACED BORINGS AND LIMITED PIEZOMRTRIC DATA, AND WAS DEVELOPED AS A VISUAL AID TO ESTABLISH A GENERAL UNDERSTANDING OF SUB-SURFACE CONDITIONS AND ENGINEERING CONSIDERATIONS. ACTUAL CONDITIONS ENCOUNTERED DURING SUBSEQUENT INVESTIGATIONS OR CONSTRUCTION MAY BE DIFFERENT.
2. SUBSURFACE DATA PRESENTED HEREIN ARE SIMPLIFIED INTERPRETATIONS OF BOREHOLE DATA INCLUDED IN APPENDIX A.
3. GROUNDWATER LEVEL DATA ARE BASED ON MONITORING OF LIMITED PIEZOMETERS FOR A SHORT TIME PERIOD. SEASONAL VARIATION SHOULD BE EXPECTED.
4. DEPTHS AND LOCATIONS OF TUNNEL AND STATIONS ARE BASED ON AVAILABLE DATA PROVIDED BY MRTC AND ARE ARE SUBJECT TO REFINEMENTS.
5. PLAN AND LOCATION OF THIS ALIGNMENT ARE SHOWN IN FIGURE 2-1.
6. DIMENSIONS AND LOCATIONS OF TUNNEL AND STATIONS ARE BASED ON 'PLAN AND PROFILE' DRAWINGS FOR CANDIDATE ALIGNMENTS 1,2,3,4, AND 5, COR STUDY, PREPARED BY MRTC AND DATED JAN. 9, 1987.
7. DATA FOR BOREHOLES CEG-12 THROUGH CEG-15 ARE BASED ON CWDD/ESA/GRC (1981).

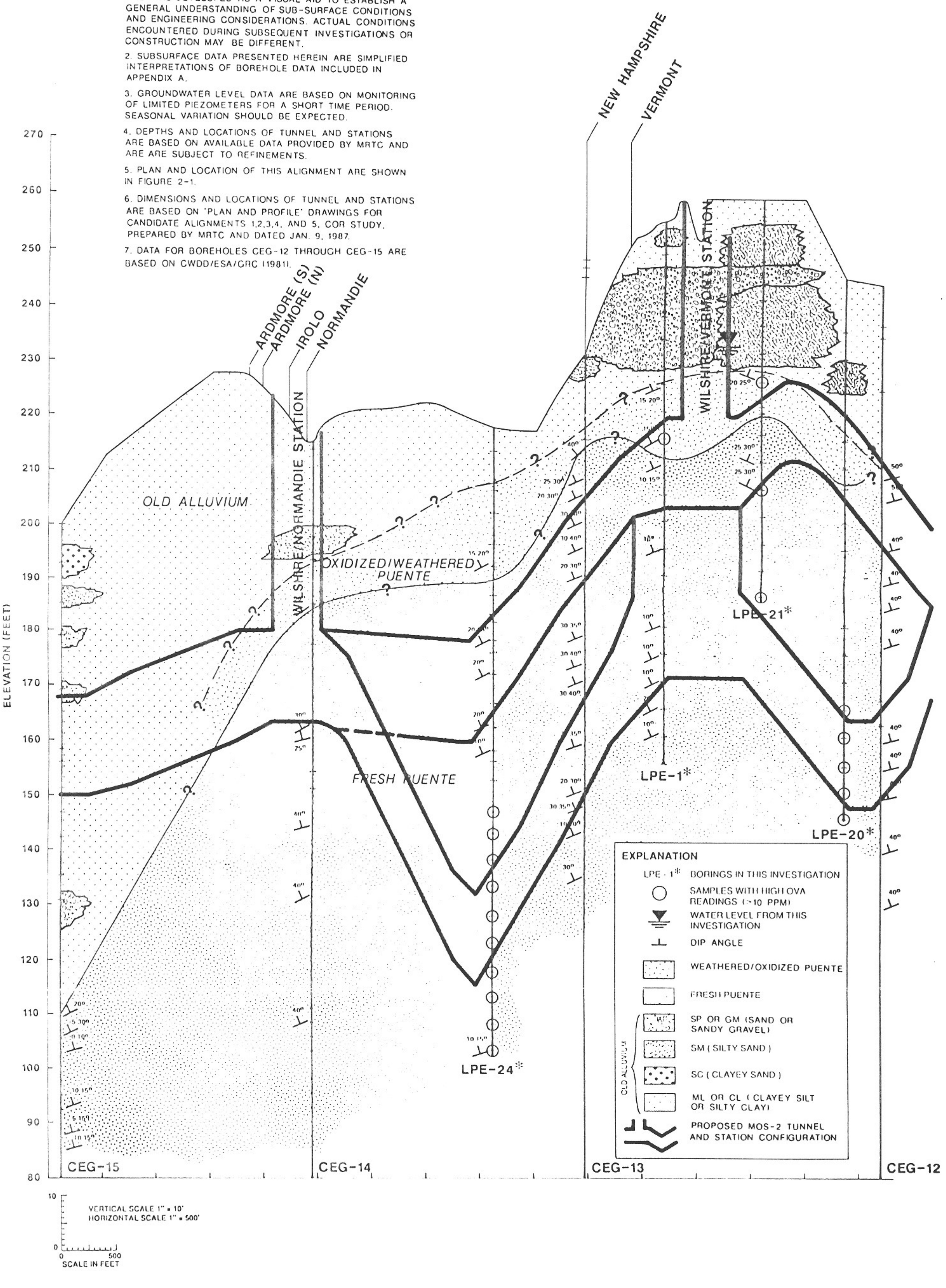


FIGURE 5-1. GENERALIZED SUBSURFACE PROFILE-OS-A SEGMENT ALONG WILSHIRE BOULEVARD CORRIDOR

5.2.2 Vermont Avenue Alignment Portion

Based on the results of the LPE program and available soil data (ESA, 1986), a general cross-sectional profile through the Vermont Avenue portion of the MOS-2 alignment was developed and is shown in Figure 5-2. The origin, composition, and layering of this cross-sectional profile are similar to those found in the OS-A segment along the Wilshire Boulevard corridor (Figure 5-1). The overburden soils are about 5 to 20 feet thick and primarily consist of stiff to very stiff silty clay and clayey sand (Unit A4) with lenses of dense to very dense sand and silty sand (Unit A3). The Puente Formation (Unit T_p) underlying the overburden alluvium consists of predominantly clayey siltstone with thinly bedded standstone. The dip angles of beddings range from 0 degrees to 20 degrees.

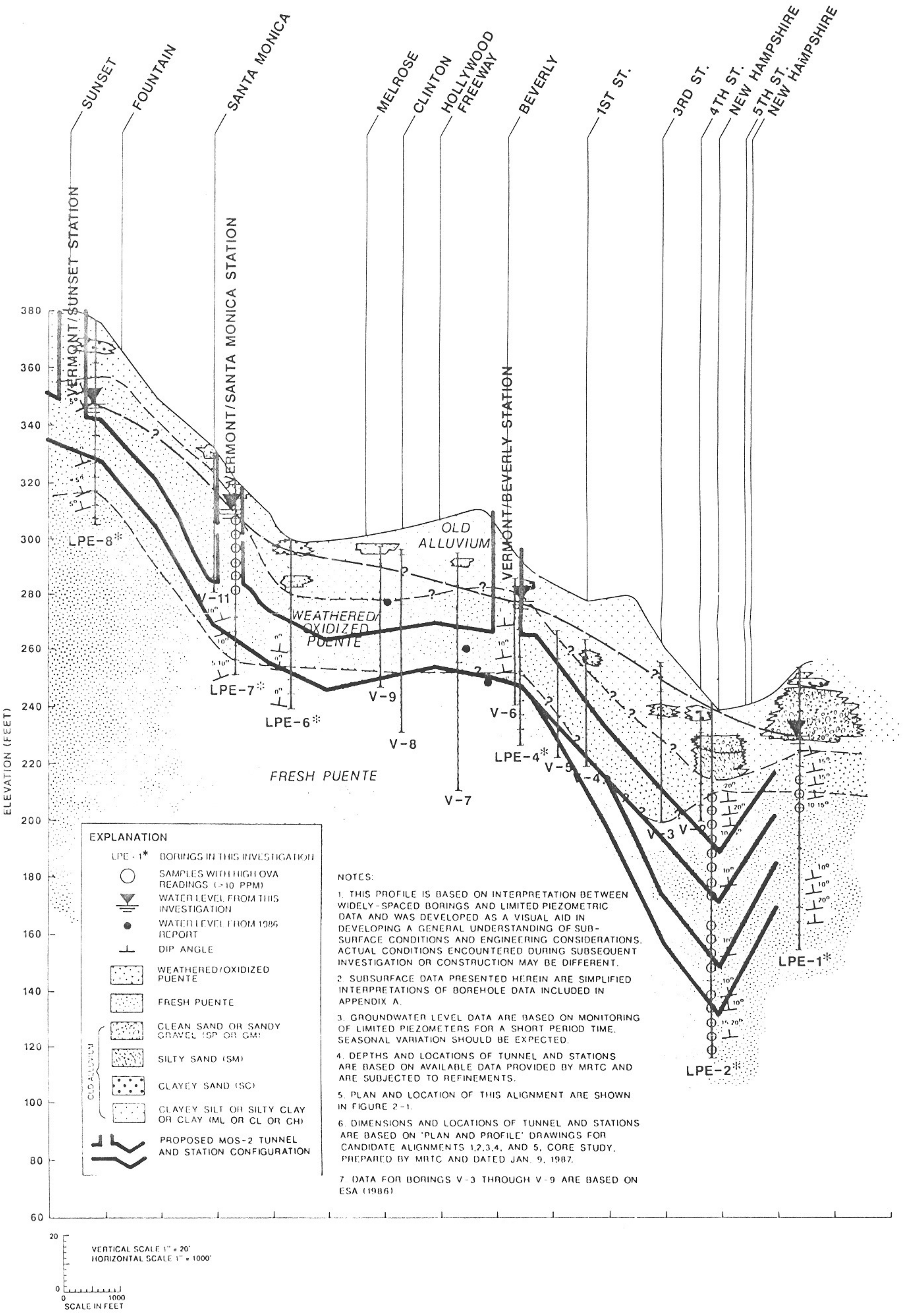
Along this alignment portion, sulfur odors were occasionally noticed at borings LPE-2 and -2A. Monitoring of triple-meter readings during Boring LPE-2A work indicated the same concentration levels of H_2S in the background and in the headspace surrounding the soil samples, with values ranging from 0 to 3 ppm, which are below the allowable exposure limit specified by OSHA and NIOSH.

As shown in Figure 5-3, zones of high OVA readings (exceeding 10 ppm) are present at borings LPE-2, -2A, -4, and -4A. Similar to the OS-A segment along the Wilshire Boulevard corridor, these high OVA readings may be postulated to be due to the presence of methane and dead petroleum (Borings LPE-2, -2A, -4, -4A and -4B are near the Los Angeles City Oil Field - Figure 4-2). The presence of high-OVA-reading zones is more likely in the southern half of the Vermont Avenue alignment portion (i.e., south of Boring LPE-6). The distribution of high-OVA-reading zones is difficult to predict. For example, high-OVA-reading zones were found about 20 feet below the ground surface at Boring LPE-4A, while no high-OVA-reading zones were found at Boring LPE-4B, which is located about 3 feet from Boring LPE-4.

Groundwater levels along this portion of the MOS-2 alignment were monitored in four piezometer locations (LPE-1, -4B, -7 and -8). The results are shown in Figure 5-2. In general, the groundwater levels vary from about 10 to 30 feet below the ground surface and have a gentle gradient toward the south.

5.2.3 Hollywood Boulevard Alignment Portion

The LPE borings performed for this alignment portion include Borings LPE-9 through LPE-17 and LPE-19. A general cross-sectional profile through this alignment portion is shown in Figure 5-3. As shown in this figure, the subsurface soils within the exploration depth of this LPE program are very nonuniform and consist of Young Alluvium (Units A1 and A2) overlying the Old Alluvium (Units A3 and A4). Along this alignment portion, the Young Alluvium appears to be distributed in a valley shape with its thickest deposits of approximately 70 feet at the vicinity of Boring LPE-15, and its thinnest deposit at Borings LPE-9 and -19 (16 to 20 feet thick, respectively). The Young Alluvium consists of about 70 percent medium-dense to dense fine silty sand with occasional lenses of clean sand, gravelly sand and sandy gravel (Unit A1), and about 30 percent stiff to very stiff clayey sand, clayey silt, and silty clay (Unit A2). The soils in both units intersperse with each other and, thus, are very nonuniform. Similarly, the underlying Old Alluvium is also very nonuniform and consists of interspersed layers of dense to very dense silty sand (Unit A3) and stiff to very hard silty clay, clayey silt, and clayey sand (Unit A4).



NOTES:

1. THIS PROFILE IS BASED ON INTERPRETATION BETWEEN WIDELY-SPACED BORINGS AND LIMITED 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 PRESENTED HEREIN ARE SIMPLIFIED INTERPRETATIONS OF BOREHOLE DATA INCLUDED IN APPENDIX A.

3. GROUNDWATER LEVEL DATA ARE BASED ON MONITORING OF LIMITED PIEZOMETERS FOR A SHORT PERIOD TIME. SEASONAL VARIATION SHOULD BE EXPECTED.

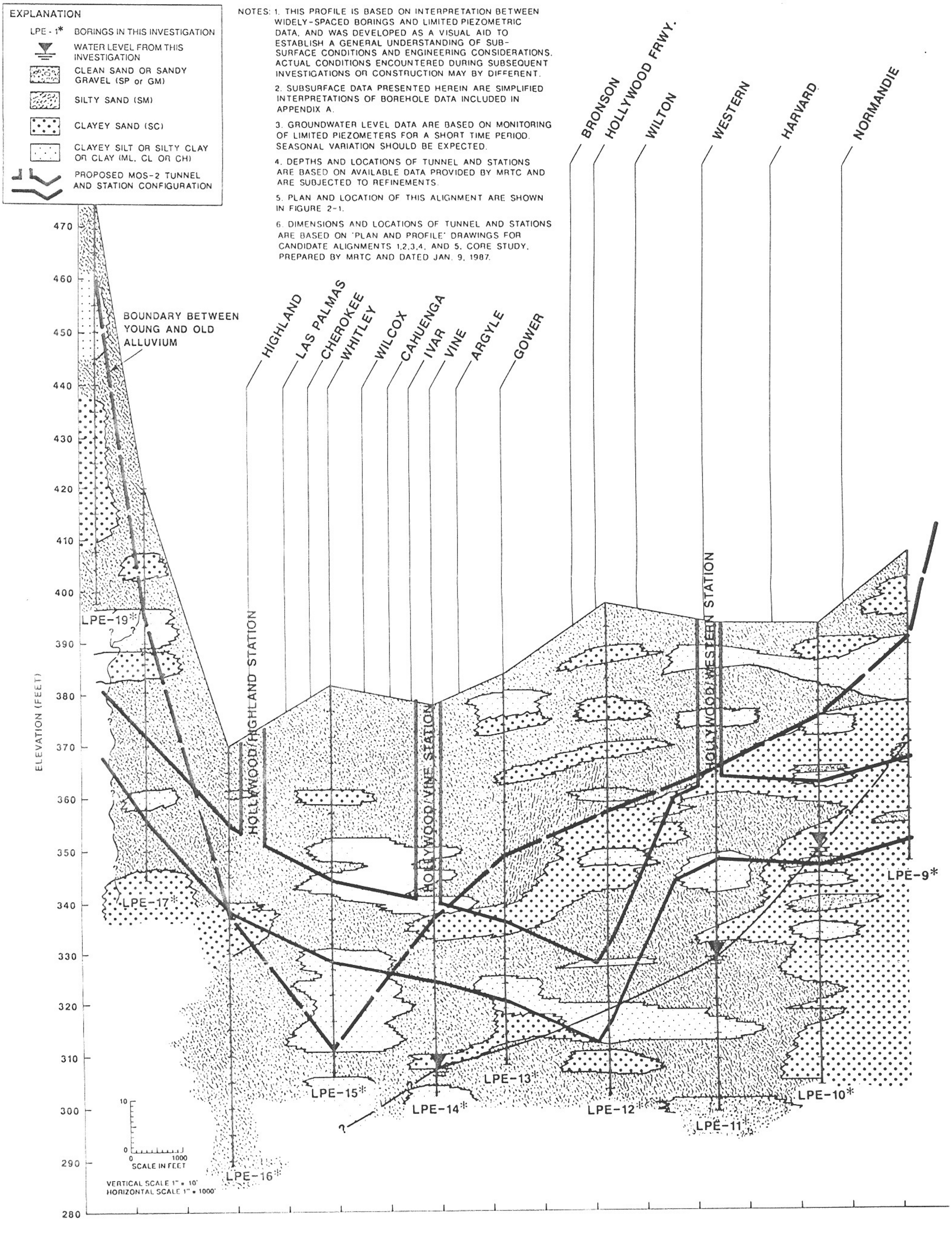
4. DEPTHS AND LOCATIONS OF TUNNEL AND STATIONS ARE BASED ON AVAILABLE DATA PROVIDED BY MRTC AND ARE SUBJECTED TO REFINEMENTS.

5. PLAN AND LOCATION OF THIS ALIGNMENT ARE SHOWN IN FIGURE 2-1.

6. DIMENSIONS AND LOCATIONS OF TUNNEL AND STATIONS ARE BASED ON 'PLAN AND PROFILE' DRAWINGS FOR CANDIDATE ALIGNMENTS 1,2,3,4, AND 5, CORE STUDY, PREPARED BY MRTC AND DATED JAN. 9, 1987.

7. DATA FOR BORINGS V-3 THROUGH V-9 ARE BASED ON ESA (1986)

FIGURE 5-2 GENERALIZED SUBSURFACE PROFILE-VERMONT AVENUE ALIGNMENT PORTION



NOTES: 1. THIS PROFILE IS BASED ON INTERPRETATION BETWEEN WIDELY-SPACED BORINGS AND LIMITED PIEZOMETRIC DATA, AND WAS DEVELOPED AS A VISUAL AID TO ESTABLISH A GENERAL UNDERSTANDING OF SUBSURFACE CONDITIONS AND ENGINEERING CONSIDERATIONS. ACTUAL CONDITIONS ENCOUNTERED DURING SUBSEQUENT INVESTIGATIONS OR CONSTRUCTION MAY BY DIFFERENT.

2. SUBSURFACE DATA PRESENTED HEREIN ARE SIMPLIFIED INTERPRETATIONS OF BOREHOLE DATA INCLUDED IN APPENDIX A.

3. GROUNDWATER LEVEL DATA ARE BASED ON MONITORING OF LIMITED PIEZOMETERS FOR A SHORT TIME PERIOD. SEASONAL VARIATION SHOULD BE EXPECTED.

4. DEPTHS AND LOCATIONS OF TUNNEL AND STATIONS ARE BASED ON AVAILABLE DATA PROVIDED BY MRTC AND ARE SUBJECTED TO REFINEMENTS.

5. PLAN AND LOCATION OF THIS ALIGNMENT ARE SHOWN IN FIGURE 2-1.

6. DIMENSIONS AND LOCATIONS OF TUNNEL AND STATIONS ARE BASED ON 'PLAN AND PROFILE' DRAWINGS FOR CANDIDATE ALIGNMENTS 1,2,3,4, AND 5. CORE STUDY, PREPARED BY MRTC AND DATED JAN. 9, 1987.

FIGURE 5-3. GENERALIZED SUBSURFACE PROFILE-HOLLYWOOD BOULEVARD ALIGNMENT PORTION

The headspace OVA readings of the soil samples along this alignment portion are generally less than 10 ppm; thus, it can be postulated that soil contamination is likely to be minimal. Limited chemical testing on selected soil samples (Section 3.2.2) appears to substantiate this postulation.

Groundwater levels along this alignment portion were monitored in four piezometer locations (LPE-1, -11, -14 and -16). The measured results are shown in Table 3-2 and Figure 5-3. In general, the groundwater surfaces are located within the Old Alluvium. Based on the current results, except for small areas east of Boring LPE-10 and possibly near Boring LPE-12, the groundwater surfaces are generally below the planned tunnel and station elevations along this alignment portion. However, this finding is tentative, since seasonal variation in groundwater levels may somewhat modify the finding.

5.2.4 Alignment Portion Underlying the Santa Monica Mountains

This alignment portion will include a tunnel and two vertical vent shafts as shown in Figure 2-1. No field work was performed during this LPE program for this alignment portion. Available project and literature data (CWDD/ESA/GRC, 1981; AEG, 1982; Campbell, 1955) were used to develop a postulated cross-sectional profile along this alignment portion, which is shown in Figure 5-4. As shown in this figure, this alignment portion will traverse the Santa Monica Mountains through the following hard rock units, from south to north:

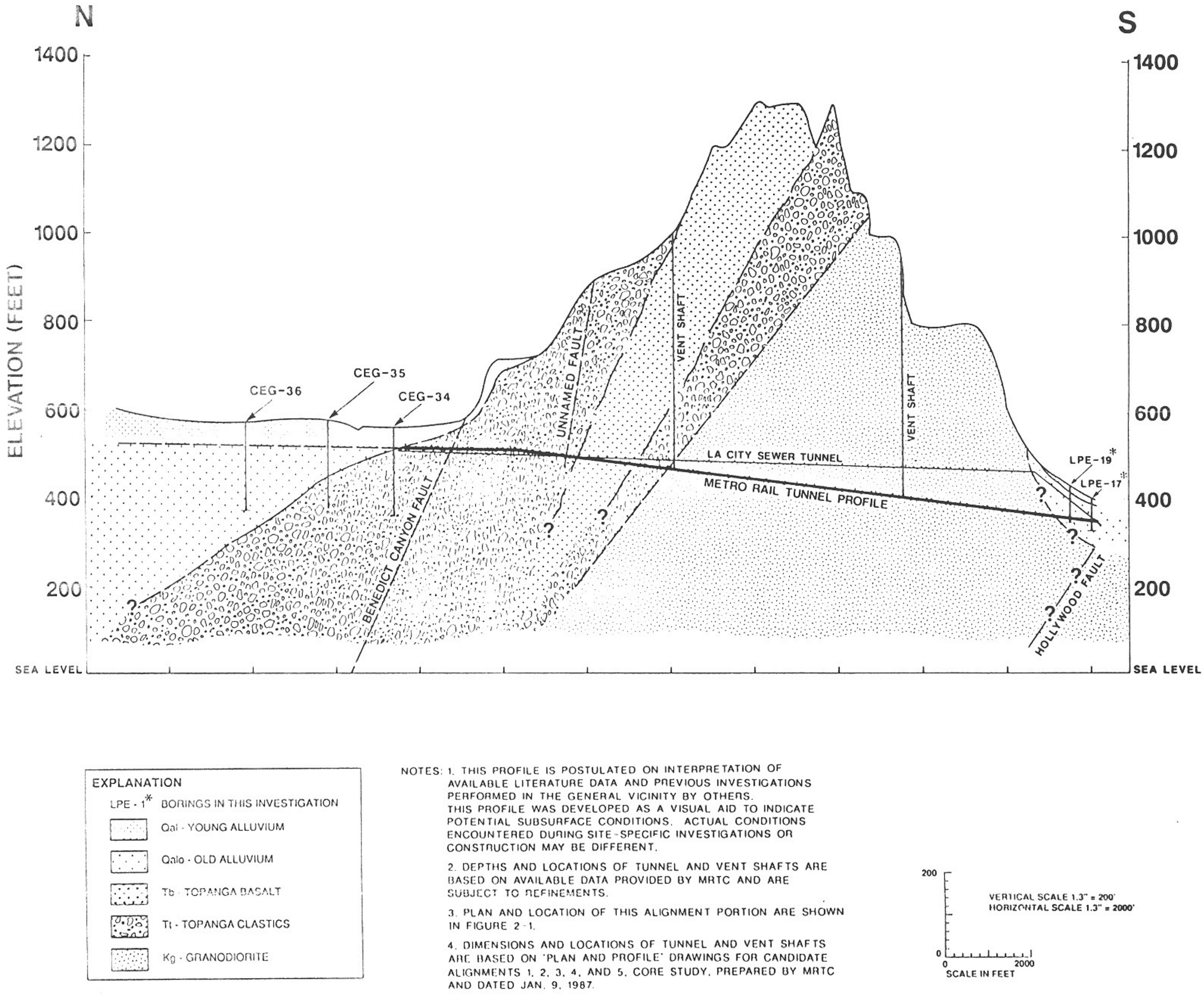
- Granodiorite (granite) - Unit Kg
- Topanga Clastics (sandstone, siltstone, conglomerate) - Unit Tt
- Topanga Basalt - Unit Tb
- Topanga Clastics - Unit Tt

General descriptions of these rock units are provided in Section 5.1.2. Specific potential engineering characteristics and geologic features which may affect tunnel and shaft design and construction in this alignment portion are highlighted as follows:

1. At tunnel depths, the granite rock (Unit Kg) could vary from hard and blocky to highly fractured, and may be nonhomogeneous. Within the granite zone, lithology may vary from granite to conglomerate, sandstone, and altered diorite (gouge material in the fault zones).

2. At tunnel depths, the basalt (Unit Tb) is probably hard and massive to moderately jointed.

3. At tunnel depths, the Topanga clastics (Unit Tt) could vary from hard, well-cemented, and massive sandstone and conglomerate with local soft, thinly-bedded siltstone to relatively soft thinly-bedded siltstone or with local hard sandstone beds. Bedding of this unit most likely dips 40 degrees to nearly vertical.



NOTES: 1. THIS PROFILE IS POSTULATED ON INTERPRETATION OF AVAILABLE LITERATURE DATA AND PREVIOUS INVESTIGATIONS PERFORMED IN THE GENERAL VICINITY BY OTHERS. THIS PROFILE WAS DEVELOPED AS A VISUAL AID TO INDICATE POTENTIAL SUBSURFACE CONDITIONS. ACTUAL CONDITIONS ENCOUNTERED DURING SITE-SPECIFIC INVESTIGATIONS OR CONSTRUCTION MAY BE DIFFERENT.

2. DEPTHS AND LOCATIONS OF TUNNEL AND VENT SHAFTS ARE BASED ON AVAILABLE DATA PROVIDED BY MRTC AND ARE SUBJECT TO REFINEMENTS.

3. PLAN AND LOCATION OF THIS ALIGNMENT PORTION ARE SHOWN IN FIGURE 2-1.

4. DIMENSIONS AND LOCATIONS OF TUNNEL AND VENT SHAFTS ARE BASED ON 'PLAN AND PROFILE' DRAWINGS FOR CANDIDATE ALIGNMENTS 1, 2, 3, 4, AND 5, CORE STUDY, PREPARED BY MRTC AND DATED JAN. 9, 1987.

REFERENCES: CWDD/ESA/CTRC (1981), AEG (1982), AND CAMPBELL (1955).

FIGURE 5-4. POSTULATED SUBSURFACE PROFILE-SANTA MONICA MOUNTAINS ALIGNMENT PORTION

4. There exist at least five known major fault zones, including the Hollywood, Hollywood Bowl, Benedict Canyon, and two unnamed faults along this alignment portion. The exact extent (width) and material composition of each fault zone are not known. The materials in the fault zones could range from crushed rock to soil-like gouge materials. Some fault zones might be healed with calcium carbonate, while the others might be open and water-bearing.

5. Except near the southern foothills of the Santa Monica Mountains, the groundwater level will be well above the planned tunnel elevations (CWDD/ESA/GRC, 1981).

6. Gassy conditions are not anticipated since no gas was detected either in the construction of MWD's Hollywood Tunnel or the Los Angeles City sewer tunnel, or in the general vicinity of the 1981 field investigation (CWDD/ESA/GRC, 1981).

6.0 DESIGN AND CONSTRUCTION CONSIDERATIONS

Based on the results of this LPE program as well as available data in the project files and in the literature, this section provides a general description of anticipated ground behavior, construction methods, and potential subsurface constraints that require consideration in the design and construction of the planned MOS-2 alignment.

The scope of this LPE program is limited. The current alignment is still in the planning stage and various alignment elements require further design. As such, the description provided in this section, by necessity, is general and preliminary in nature and will require further refinement after additional information becomes available.

6.1 ANTICIPATED CONSTRUCTION METHODS

6.1.1 Tunneling

Based on this LPE program as well as on local tunneling experience under similar conditions, the subsurface conditions along the planned MOS-2 alignment are anticipated to be favorable for mechanical excavation with an expected relatively high rate of advance. Along the planned alignment, it is anticipated that soft-ground tunneling methods will be applicable except for the alignment portion underneath the Santa Monica Mountains, where hard-rock tunneling methods are applicable.

6.1.1.1 Soft-Ground Tunneling. Soft-ground conditions for the Metro Rail project include all alluvial materials (Units A1, A2, A3, and A4) and the Puente Formation (Unit Tp with Subunits Tpw and Tpf). These subsurface conditions are encountered along the planned MOS-2 alignment south of the Santa Monica Mountains. Previous tunneling experience in the general vicinity and current tunneling experience along the MOS-1 alignment in similar subsurface conditions indicate that the advance of tunneling under such conditions can be economically and rapidly achieved using mechanical excavation methods within a shield and with initial support consisting of either precast concrete or ribs-and-timbers. In either case, a final lining of cast-in-place concrete would be used. As will be described in Section 6.2, provisions for groundwater control, ventilation and monitoring of toxic or flammable gases, caving-in prevention, mixed-face tunneling, and ground stabilization may be necessary in some areas in conjunction with soft-ground tunneling.

6.1.1.2 Rock Tunneling. As described in Section 5.2.4, the Santa Monica Mountains portion of the MOS-2 alignment will encounter various hard rock units that will require rock tunneling methods to advance the tunnel. Such methods may include the drill-and-blast method or mechanical excavation methods using hard-rock tunnel boring machines within a shield. Rock tunneling through the Santa Monica Mountains alignment portion, especially in and adjacent to the anticipated fault zones, may require provisions for groundwater control and temporary tunnel support systems.

6.1.2 Cut-and-Cover at Stations

All planned stations along the MOS-2 alignment have a maximum excavation depth of less than 80 feet and will be entirely located within soft-ground conditions (Section 6.1.1.1). The results of this LPE program as well as local experience in the general vicinity and in similar subsurface conditions in MOS-1 construction indicate that such stations can be designed and constructed using proven and routinely available practices for cut-and-cover construction. As will be discussed in Section 6.2, the following provisions may be necessary at critical locations along the alignment:

1. Shoring will be required at all station excavations due to subsurface conditions, the proximity of stations to existing buildings, and limited construction space along the alignment.

2. Groundwater control will be required at some of the stations.

6.2 GROUND BEHAVIOR AND DESIGN/CONSTRUCTION CONSIDERATIONS

Anticipated subsurface conditions along the planned MOS-2 alignment are detailed in Section 5. Based on the results of laboratory tests and correlations of SPT blowcounts with literature data, various relevant engineering properties for the "soft-ground" units encountered in this investigation are presented in Tables 6-1 and 6-2. Based on these subsurface conditions and local construction experience in similar subsurface conditions, this section provides a general evaluation of anticipated ground behavior and its effects on construction methods, as well as potential subsurface constraints for preliminary design considerations. Again, this general evaluation will be divided into the following alignment portions:

1. OS-A segment along the Wilshire Boulevard corridor.

2. Alignment portion along Vermont Avenue.

3. Alignment portion along Hollywood Boulevard to foothills of the Santa Monica Mountains.

4. Alignment portion through the Santa Monica Mountains to the Universal City Station.

The subsurface conditions for the first three alignment portions are anticipated to be favorable for mechanical excavation with relatively high rate of advance, while subsurface conditions anticipated in the Santa Monica Mountains portion will require hard-rock tunneling and shaft construction methods.

6.2.1 OS-A Segment Along Wilshire Boulevard Corridor

6.2.1.1 Relevant Subsurface Conditions. The subsurface conditions along this alignment portion are described in Section 5.2.1 and shown in Figure 5-1. These conditions are summarized as follows:

TABLE 6-1. ENGINEERING PROPERTIES OF ALL GEOLOGIC UNITS BASED ON LABORATORY TEST RESULTS

GEOLOGIC MATERIAL	GEOLOGIC UNIT	USCS SOIL CLASSIFICATION	SHEAR STRENGTH PARAMETERS						UNCONFINED COMPRESSIVE STRENGTH (KSF)			DRY DENSITY (PCF)			MOISTURE CONTENT (%)			PERMEABILITY (cm/s)			CALCULATED VOID RATIO		
			FRICTION ANGLE (degrees)			COHESION (KSF)																	
			RANGE	MEAN	S.D.(1)	RANGE	MEAN	S.D.(1)	RANGE	MEAN	S.D.(1)	RANGE	MEAN	S.D.(1)	RANGE	MEAN	S.D.(1)	RANGE	MEAN	S.D.(1)	RANGE	MEAN	S.D.(1)
YOUNG ALLUVIUM (Granular)	A1	SM, SP, SP-SM, GM, SM/ML	25-44	36	5.8	0.5-2.2	1.2	0.6	-	-	-	88.0-117.8	106.3	6.8	6.3-21.2	14.5	2.6	-	2.1x 10^{-4}	-	0.40-0.88	0.56	0.11
YOUNG ALLUVIUM (Fine Grained)	A2	CL, SC/CL, ML, SC, ML-CL, CL	24-38	31	5.6	0.7-4.4	2.2	1.6	4.2-6.8	2.7	0.5	98.3-127.0	113.3	8.9	9.3-24.1	16.3	3.0	-	3.5x 10^{-8}	-	0.31-0.70	0.48	0.12
OLD ALLUVIUM (Granular)	A3	SM, SP-SM, SP, GM, SM/ML	32-48	38	4.8	0.4-3.0	1.2	0.8	1.3	1.3	-	95.4-128.1	110.2	9.1	7.2-29.3	16.4	3.0	3.3x 10^{-7} 8.5x 10^{-5}	9.1x 10^{-5}	7.9x 10^{-5}	0.32-0.77	0.54	0.12
OLD ALLUVIUM (Fine Grained)	A4	CL, SC/CL, ML, SC, ML-CL, ML	17-42	31	7.1	1.0-3.0	1.9	0.5	1.0-6.1	2.6	2.0	84.5-123.6	108.8	10.5	12.4-36.4	19.0	3.2	8.5x 10^{-5} 4.5x 10^{-7}	1.9x 10^{-7}	- -	0.36-0.99	0.56	0.17
PUENTE FORMATION (Weathered/Oxidized)	Tpw	---	25-44	35	5.7	0.3-3.2	1.8	1.1	-	-	-	82.5-109.9	91.3	6.9	18.2-38.9	30.3	2.6	-	-	-	0.52-1.02	0.84	0.13
PUENTE FORMATION (Fresh)	Tpf	---	26-46	35	6.9	0.3-5.5	2.8	1.7	2.7-27.2	7.7	5.8	74.5-111.5	92.8	7.9	20.1-40.2	29.9	2.8	-	1.3x 10^{-8}	-	0.56-1.33	0.88	0.16

NOTE: (1) S.D. = Standard Deviation

6.0 DESIGN AND CONSTRUCTION CONSIDERATIONS

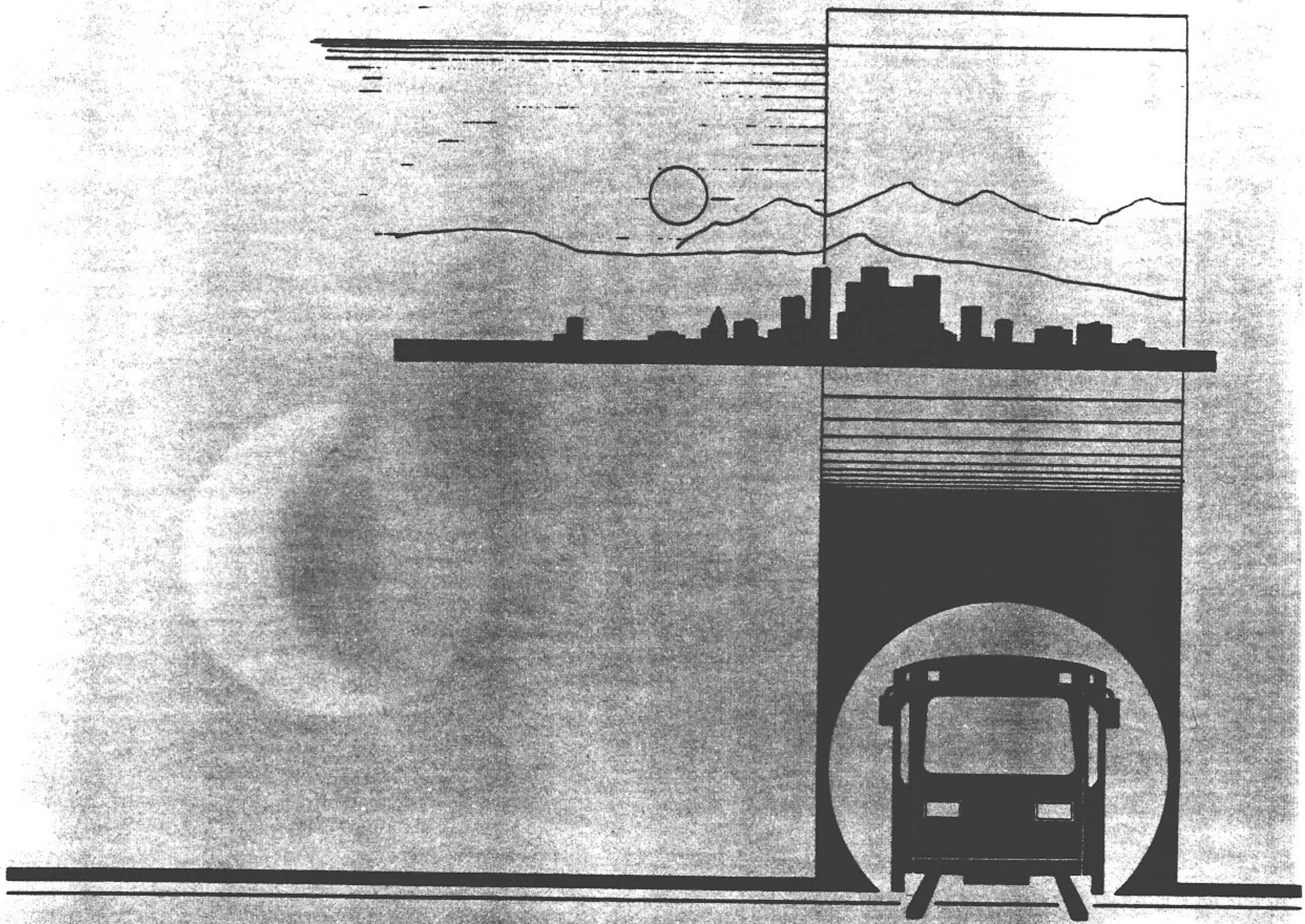


TABLE 6-2. OTHER ENGINEERING PARAMETERS OF ALL GEOLOGIC UNITS ESTIMATED USING SPT DATA AND AVAILABLE CORRELATIONS

GEOLOGIC MATERIAL	GEOLOGIC UNIT	USCS SOIL CLASSIFICATION	STANDARD PENETRATION RESISTANCE			SHEAR WAVE VELOCITY (ft/s)			DYNAMIC SHEAR (1) MODULUS (10^5 x psf)			STATIC SHEAR (2) MODULUS (10^5 x psf)			SUBGRADE (3) MODULUS (103 x lb/ft3)		
			RANGE	MEAN	S.D.(4)	RANGE	MEAN	S.D.(4)	RANGE	MEAN	S.D.(4)	RANGE	MEAN	S.D.(4)	RANGE	MEAN	S.D.(4)
YOUNG ALLUVIUM (Granular)	A1	SM, SP, SP-SM, GM, SM/ML	7-195	30	36	360-1450	690	250	5-80	20	16.1	0.4-12.0	1.8	2.2	260-1000	330	225.0
YOUNG ALLUVIUM (Fine Grained)	A2	CL, SC/CL, ML, SC,CH/CL, ML-CL, CL	7-135	30	26	420-1350	720	223	7-70	21	13.9	0.4-8.0	1.8	1.6	150-600	360	- 198
OLD ALLUVIUM (Granular)	A3	SM, SP, SP-SM, GM, SM/ML	9-200	66	36	400-1300	1000	237	6-60	39	16.5	0.5-12.0	4.0	2.2	260-1000	600	360.0
OLD ALLUVIUM (Fine Grained)	A4	CL, CC/CL, ML,SC, CH, CL, ML-CL, ML	13-166	53	29	500-1350	950	189	9-70	35	13.2	0.8-10.0	3.2	1.75	150-600	560	110
PUENTE FORMATION (Weathered/Oxidized)	Tpw	---	20-129	68	28	550-1300	950	170	11-70	34	11.9	1.2-6.7	4.1	1.7	300-600	550	81
PUENTE FORMATION (Fresh)	Tpf	---	47-234	120	38	900-1730	1300	165	30-110	64	16.5	2.8-14.0	7.1	2.3		600(5)	

NOTE:
(1) Based on correlations recommended by Ohta and Goto (1978).
(2) Based on correlations recommended by Schmertmann (1970).
(3) Based on correlations recommended by Terzaghi (1955).
(4) S.D. = Standard Deviation.
(5) Estimate based on upper-bound value for hard fine-grained soils, recommended by Terzaghi (1955).

Subsurface Condition	**Summary Description**
Subsurface Materials (Figure 5-1)	Old Alluvium (Units A3 and A4) overlying the Puente Formation (Unit Tp with Subunits Subunits Tpw and Tpf).
Groundwater Level	Perched groundwater level at about 15 to 30 feet below ground surface with the permanent groundwater level at about 140 to 180 feet below ground surface.
Groundwater Quality	Moderate limited chemical tests on selected water samples indicate high concentrations of sulfide and sulfate compounds; therefore, Type II cement may be needed for construction.
Soil Contamination	Limited test data indicate that concentrations of volatile organic compounds and hazardous metals (CAM metals) are below action levels. However, the possibility of local soils being contaminated with methane and dead petroleum cannot be eliminated since the Los Angeles City Oil Field is nearby.
Toxic and Flammable Gas	Limited chemical analysis on one gas sample indicates minimal concentrations. However, high OVA readings at Borings LPE-20, -21 and -24, as well as proximity to the Los Angeles City Oil Field, indicate that potential for local presence of methane is likely.

In general, the subsurface conditions along this alignment portion are similar to those encountered along the Detail Design Unit A170 and the Construction Contract Unit A171 in the MOS-1 alignment. Thus, previous MOS-1 tunneling and station construction experience is considered applicable to this alignment portion.

6.2.1.2 Tunnel. As shown in Figure 5-1, the planned tunneling will be within the oxidized Puente Formation (Subunit Tpw) and the fresh Puente Formation (Subunit Tpf) along the alignment portion east of the Wilshire/Normandie Station. Between Wilshire/Western and Wilshire/Normandie Stations, the planned tunneling will be primarily in Old Alluvium (consisting of stiff, silty clay with pockets of dense sand). However, mixed-face conditions (between Old Alluvium and Puente Formation) can be anticipated just west of the Wilshire/Normandie Station.

The planned tunnel in this alignment can be advanced at a relatively high rate using mechanical excavation methods within a shield.

The planned tunnel will be entirely under perched groundwater conditions and within primarily oxidized and fresh Puente Formation or in predominantly fine-grained Old Alluvium, which are relatively impervious. Thus, large inflows of water are not anticipated except in localized zones of previous sand in the Old Alluvium (Unit A3), where provisions for groundwater control may be necessary. Similiarly, running or flowing sand conditions are possible in the localized sand pockets, when encountered. Although the exact areal extent/distribution of these sand pockets was not determined during this LPE program, results from this program and from available project files indicate that the extent of the potentially problematic sand pockets in the tunnel area along this alignment portion will be very limited.

Gassy Conditions

Hydrocarbon gases (especially methane) are expected to be present in some areas along this alignment portion, especially in the vicinity of Borings LPE-20, -21 and -24, where high OVA readings were found in some of the soil samples obtained at scattered depths. Methane is odorless and combustible in air, and can explode when the methane-air mixture is in the range of about 5 to 15 percent by volume. Provisions during construction to monitor the methane concentration level and to have adequate ventilation to keep the mixture below 20 percent of the lower explosivity limit (LEL) will be necessary. To prevent methane combustion and explosion after construction, the tunnel needs to be tightly sealed against hydrocarbon gases. The limited scope of this program precluded an adequate determination of the potential concentration range and areal/spatial distribution of hydrocarbon gases along this alignment portion. Further investigation and monitoring will be necessary.

Stability and Ground Loss

A preliminary evaluation of the stability and potential ground loss of the planned tunnel along this alignment was performed by estimating the simple overload factor, OLF, which is defined as the ratio of overburden pressure less the internal pressure (if compressed air pressure is used) to the undrained shear strength of the surrounding fine-grained alluvium on the Puente Formation. The estimated OLF values and their implications are as follows:

Tunnel	Depth Range (Ft)	Approximate OLF	Implication
Upper tunnel in Puente Formation, east of Wilshire/ Normandie Station	35 to 60	1.5 to 3.0	Minimal ground loss. No rapid squeezing.
Lower tunnel in Puente Formation, east of Wilshire/ Normandie Station	50 to 110	2.2 to 4.5	Some ground loss likely but can be engineered to acceptable level. No rapid squeezing.
Tunnel in fine-grained alluvium (A4), west of Wilshire/ Normandie Station	40 to 60	2.5 to 4.5	Some ground loss likely, but can be engineered to acceptable level. No rapid squeezing.

The above findings are preliminary in nature and require future refinement after more data become available.

6.2.1.3 Cut-and-Cover Stations. As shown in Figure 5-1, three cut-and-cover stations will be located along this alignment portion. These include Wilshire/Vermont, Wilshire/Normandie, and Wilshire/Western Stations with the following relevant features:

Station	**Approximate Cut-and-Cover Excavation Depth (Ft)**	**Foundation Support**
Wilshire/Vermont	50	Fresh Puente
Wilshire/Normandie	60	Fresh Puente
Wilshire/Western	50	Unit A4

The subsurface conditions along this alignment portion (Section 5.2.1) and the planned excavation depth indicate that cut-and-cover excavation can be rapidly and economically achieved using mechanical excavation methods and readily available equipment.

Shoring Requirements

As indicated previously, shoring will be required due to the proximity of the stations to existing buildings and limited construction space along the alignment. Various shoring systems may be applicable. These may include various temporary walls (precast, slurry, sheet pile, soldier pile, etc.) supported by tiebacks, anchors, or internal bracing struts. The most appropriate shoring system depends on subsurface conditions, excavation geometry, the dewatering scheme, construction procedures, characteristics of nearby buildings, and local experience. Since most of the needed data are either preliminary in nature or yet to be defined, further work will be required for final design of appropriate shoring systems.

Dewatering Requirements

The perched groundwater level along this alignment portion is relatively shallow (15 to 30 feet below the ground surface). The planned cut-and-cover excavation along this alignment portion will penetrate either to the Old Alluvium (Wilshire/Western Station) or through the Old Alluvium into the Puente Formation (Wilshire/Vermont and Wilshire/Normandie Stations). At the Wilshire/Vermont Station (Boring LPE-1), there is a thick layer of fine to coarse sand and silty sand which is relatively permeable. Thus, substantial groundwater inflows are likely to occur during the station excavation. Groundwater control provisions (dewatering) prior to and during excavation in this area may be required. Elsewhere, groundwater inflows of lesser extent are also likely due to the presence of local pockets of sand and silty sand. However, the inflows are anticipated to be small and can probably be dewatered by open pumping inside the excavation.

Bottom Stability

The bottoms of planned station excavations will most likely be located in stiff silty clay or on the fresh Puente Formation. The potential instability of excavation bottoms due to heaving ground, hydraulic uplift, or piping is unlikely.

Foundation Support

In general, the foundation materials underlying the planned stations in this alignment portion are either stiff silty clay (Unit A4) or fresh Puente Formation (Subunit Tpf) which will provide adequate foundation support for the planned station structures. In addition, depending on subsurface conditions, appropriate foundation types will also depend on structure-loading characteristics which are not clearly defined at this time. Thus, appropriate foundation design should be performed after further structural and station-specific subsurface information becomes available.

Most of the planned stations along this alignment portion will be very close to existing structures. Most of these structures are generally supported on foundations located above the planned depths of station excavation. Thus, provisions to protect these existing structures from damages due to station construction must be considered in the design and construction of the planned stations.

Gassy Conditions

The potential presence of methane or other hydrocarbon gases at the planned station locations cannot be eliminated. Those provisions for tunnel construction in this alignment portion that were described in Section 6.2.1.1 are also applicable to station construction.

6.2.2 Vermont Avenue Alignment Portion

6.2.2.1 Relevant Subsurface Conditions. The subsurface conditions along this alignment portion are described in Section 5.2.2 and shown in Figure 5-2. In general, the subsurface conditions along this alignment portion are very similar to those encountered in the OS-A segment along the Wilshire Boulevard corridor, described previously. Most of the ground behavior and design and construction considerations for this alignment portion are anticipated to be similar to those described in Section 6.2.1.1. For discussion purposes, the subsurface conditions are summarized as follows:

Subsurface Conditions	**Summary Description**
Subsurface Materials	Old Alluvium overlying the Puente Formation.
Groundwater Level	Limited chemical tests indicate moderate to high concentrations of sulfide and sulfate compounds. Type II cement may generally be required for construction along this alignment, except in the vicinity of Boring LPE-4, where sulfate concentration is severe and may require the use of Type V cement.
Soil Contamination	Samples with high headspace OVA readings are found at various depth intervals (Figure 5-2; Appendix A) at borings LPE-2, -2A, -4 and -4A. Limited chemical tests on selected soil samples indicate that concentrations of total recoverable petroleum hydrocarbons (TRPH), selected volatile organic compounds (BTEX), and hazardous heavy metals are below action levels.

Subsurface Conditions	**Summary Description**
Soil Contamination (continued)	However, the possibility of local soils being contaminated with dead petroleum cannot be eliminated, especially along the alignment portion south of Boring LPE-6.
Toxic and Flammable Gas	Methane or other hydrocarbon gases are potentially present, especially along the alignment portion south of Boring LPE-6.

6.2.2.2 Tunnel. As shown in Figure 5-2, the planned tunnel along this alignment will be entirely within the oxidized or fresh Puente materials (Subunits Tpw and Tpf) and generally below the observed perched groundwater level. Since subsurface conditions of this alignment portion are similar to those found along the OS-A segment along the Wilshire Boulevard corridor, a preliminary assessment of relevant ground behavior and design/construction considerations for tunneling along this alignment portion is presented in the following summary to avoid repetitive descriptions:

- The tunnel construction experience at the Detail Design Unit A170 in the MOS-1 alignment is generally applicable to this alignment portion.
- Tunneling can be advanced at a relatively high rate using mechanical excavation methods within a shield.
- Although some groundwater inflows are expected, large inflows of water are not likely during tunnel construction, and dewatering by open pump may be sufficient.
- Hydrocarbon gases, especially methane, may be present in localized areas along the alignment portion, especially south of Boring LPE-6. Areal and spatial extents of hydrocarbon gas concentrations cannot be adequately determined without further investigation.
- Instability of tunnel walls or excessive ground-loss conditions due to tunnel construction are unlikely.

6.2.2.3 Cut-and-Cover Stations. As shown in Figure 5-2, the planned cut-and-cover stations along this alignment portion will penetrate through the Old Alluvium (predominantly stiff to hard fine-grained soils [Unit A3] with pockets of dense sand and silty sand) to the oxidized or fresh Puente Formation materials. Since subsurface conditions are similar to those encountered in the OS-A segment along the Wilshire Boulevard corridor, a preliminary assessment of the anticipated ground behavior and station construction considerations is summarized as follows to avoid repetitive descriptions:

- Excavation can be economically achieved using mechanical excavation methods and readily available equipment.
- Shoring support will be required due to the proximity of the planned stations to existing buildings and due to limited construction space.
- Some groundwater inflows may occur through scattered and localized sandy pockets in the Old Alluvium and in the contact between the Old Alluvium and the Puente Formation. Quantities of inflow are likely to be relatively small and probably can be dewatered by pumping inside the excavation without the need for dewatering prior to construction.

- Instability of station excavation bottoms due to piping or hydraulic uplift is unlikely.
- The foundation materials underlying the planned stations can provide excellent foundation support.
- Local gassy conditions are likely to be present along this alignment portion, especially south of Boring LPE-6. Provisions to monitor hydrocarbon gases, especially methane, eliminate potential combustion/explosion hazards, and seal stations from harmful accumulation will be needed.
- Scattered zones of subsurface materials contaminated with natural petroleum deposits may be likely along the alignment, south of Boring LPE-6.

6.2.3 Hollywood Boulevard Alignment Portion

6.2.3.1 Relevant Subsurface Conditions. The subsurface conditions along this alignment portion are described in Section 5.2.3 and shown in Figure 5-3. These conditions are summarized as follows:

Subsurface Conditions	Summary Description
Subsurface Materials	Young Alluvium overlying Old Alluvium - very heterogenous and nonuniform. Mixed face conditions are anticipated during tunneling.
Groundwater Level	Located within Old Alluvium with a gentle, westerly gradient, and generally below the planned tunnel and station elevations except in the tunnel area east of Boring LPE-10 and in a small area near Boring LPE-12.
Groundwater Quality	Limited chemical analyses on selected water samples indicate moderate sulfide and sulfate compound concentrations which may require the use of Type II cement in construction.
Soil Contamination	Headspace OVA readings of soil samples are generally less than 10 ppm. Limited chemical tests on selected soil samples indicate that TRPH and selected volatile organic compound (TBEX) concentrations are below action levels. The possibility of soil contamination is minimal.
Toxic and Flammable Gas	No evidence of its presence from results of this field work and limited chemical tests on selected soil and water samples.
Faults	Three inferred faults (Santa Monica, Hollywood, and Hollywood Bowl faults) are present along this alignment portion; however, they were not detected within the penetration depth range (65 to 96 feet below ground surface) of this LPE program. Further work is necessary to delineate the fault zones and their impact on tunnel design and construction.

6.2.3.2 Tunnel. As shown in Figure 5-3, the planned tunneling along this alignment portion will be within the Old and Young Alluvium, which are heterogenous, with interspersed layers of granular and fine-grained soils. In addition to exhibiting the likelihood of mixed face conditions in tunnel construction, this figure also indicates that a significant portion of the tunnel in this alignment may penetrate through granular alluvial soils (Units A5 and A3) which consist primarily of medium-dense (Young Alluvium) and dense to very dense (Old Alluvium) silty sand with some cohesive strength component. This cohesive strength may not be sufficent to prevent running sand, tunnel instability, or excessive ground loss from occurring. Thus, provisions to alleviate those concerns may be necessary.

As described in the subsurface conditions summary, provisions for gassy conditions and soil contamination encountered during construction will probably not be needed for tunneling in this alignment portion. However, moderate sulfate concentration levels detected from limited chemical tests indicate that Type II cement will be needed for tunnel construction.

6.2.3.3 Stations. As shown in Figure 5-3, the planned cut-and-cover stations (Hollywood/Western, Hollywood/Vine and Hollywood/Highland) will be entirely located within alluvial deposits and above the groundwater table. Station excavation can be readily and economically achieved using mechanical excavation methods and readily available construction equipment. Shoring support systems will be needed due to limited construction space and proximity of the planned stations to existing structures. Provisions to protect nearby existing buildings will most likely be needed since most of the foundation support levels for these buildings are likely to be above the planned depths of station excavation.

The alluvial soils underlying the planned stations are either stiff to hard silty clay, clayey silt, or clayey sand (Units A2 and A4), or medium dense to dense silty sand (Units A1 and A3), which should provide excellent foundation support for the planned station construction. Appropriate foundation design should be performed after more detailed station (site)-specific subsurface information and relevant structural loading characteristics become available.

Although the planned stations are above the groundwater table, the possible existence of perched water contained in the fine-grained alluvium at or near the stations cannot be eliminated. However, the potential water inflows are expected to be small and can most likely be controlled by pumping during the excavation.

As described previously, gassy and contaminated soil conditions are unlikely to occur along this alignment portion during station construction. Limited chemical tests on selected soil and water samples indicate moderate concentration levels of sulfide and sulfate compounds; therefore, Type II cement will be needed for station construction.

6.2.4 Alignment Portion Underlying the Santa Monica Mountains

This alignment portion consists of a tunnel and two vent shafts. No field work was performed along this alignment portion in the LPE program. Based on available project and literature data, the postulated subsurface conditions along this alignment portion are described in Section 5.2.4 and shown in Figure 5-4. Potential engineering characteristics of various rock units and geologic features are also described in Section 5.2.4 and will not be repeated here.

6.2.4.1 Tunnel. Tunneling in this alignment portion will penetrate three hard-rock units ("Kg", "Tt", and "Tb" - Sections 5.1.2 and 5.2.4) and at least five fault zones (Hollywood, Hollywood Bowl, Benedict Canyon, and two unnamed faults). The encountered hard-rock units at the planned tunnel depths could range from hard and blocky to highly fractured in the granodiorite (Kg) unit, to massive and moderately jointed in the Topanga basalt (Tb) unit, to hard and stratified to blocky and seamy in the Topanga clastics (Tt) unit. Tunneling in these hard rocks can be achieved either by conventional drill-and-blast methods (successfully used in the Los Angeles City sewer tunnel and MWD's Hollywood Tunnel construction in the general vicinity), or by hard-rock boring machines. If a hard-rock boring machine is used, it should be properly equipped to handle the anticipated wide range of hard-rock characteristics (hardness and strength) and anticipated mixed face conditions. The tunnel, especially in the crown area, may require stabilization with rock bolts or shotcrete in some areas.

The exact extent and configuration of each fault zone along this alignment portion is not known. Based on available information, the materials in the fault zones range from fractured rock to crushed rock to soil-like gouge materials. Some areas of fault zones might be healed while the others might be open and water-bearing. Tunneling from hard rock through the fault zones presents several potential concerns which require consideration in the design and construction stages. These could include the following:

- Mixed face conditions between hard rock and fault zone (below groundwater table).
- Fault zones may be sources of significant groundwater inflows (maximum of 800 and 250 gpm inflows were observed in the Los Angeles City sewer tunnel and MWD's Hollywood Tunnel, respectively); thus, provisions for dewatering will most likely be required
- Stability of the tunnel is of concern in the fault zones. Tunnel lining and support systems may have to be designed to respond to a variety of conditions, ranging from full-face rock conditions, to mixed face, to the soil-like gouge materials (below groundwater table).
- No gas was detected in borings during drilling in the general vicinity in a previous investigation (CWDD/ESA/GRC, 1981), or during the construction of the Los Angeles City sewer tunnel and MWD's Hollywood Tunnel. Therefore, the possibility of gassy conditions present along this alignment portion is unlikely.

6.2.4.2 Vent Shafts. As shown in Figure 5-4, the two planned vent shafts along this alignment portion will most likely penetrate through various hard rock units and some fault zones. The vent shafts can be advanced either by drill-and-blast methods or by readily available shaft drilling machines. The selection of construction methods and the evaluation of shaft stability during excavation depends on the stratigraphy and engineering properties of the hard-rock units, which require further determination.

6.3 OVERALL SUBSURFACE CHEMICAL CONTAMINATION AND CONSTRUCTION CONSIDERATIONS

The results of the limited chemical analysis program on selected soil, water, and gas samples obtained in the LPE program are presented in Tables 3-3 through 3-9 and in Appendix C. The results indicate that the concentration levels of total recoverable petroleum hydrocarbons, aromatic volatile organics in soil and water, and some heavy metals in soil are low and well below cleanup action levels specified by various guidelines and regulatory agencies. These low concentration levels indicate that these chemical compounds and heavy metals are from natural sources and are not due to industrial contamination. Although additional data from a more detailed investigation are needed, it is anticipated that the excavated materials (spoils) from MOS-2 construction can be routinely handled and disposed of without posing any threat to the general public and without the need for special hazardous waste cleanup and disposal.

Dust production during excavation could result in unhealthy levels of TRPH, BTEX, and heavy metals in the air and could pose an inhalation hazard for workers if dust is not controlled. The concentration limits of these compounds and metals in air for workers without respiratory protection (Level B or C protection), as specified by various guidelines and regulatory agencies, are summarized in Tables 3-3, 3-4, and 3-8. It is unlikely that the air concentrations would reach these limits if the dust is properly controlled.

The workspace and breathing-zone hydrogen sulfide (H_2S) readings during the LPE field operation were observed to be minimal, ranging from 0 to 4 ppm, which is less than the action level for 10 ppm specified by OSHA and NIOSH. However, sulfur odors were occasionally noticed during drilling and sampling of borings LPE-2, -2A, -4, -21, and -24, and the results of limited chemical tests show high concentrations of sulfide compounds in selected soil samples from borings LPE-2A and -24, as well as moderate (150 to 1,500 ppm) to severe (more than 1,500 ppm) concentrations of sulfate compounds in most of the listed soil and water samples. Sulfide and sulfate compounds may be potential sources for generating H_2S under a certain chemical environment, and the possibility of breathing-zone H_2S concentration exceeding the 10 ppm action level during MOS-2 construction can not be eliminated, especially in the general vicinity of borings LPE-2, -21 and -24 (in the OS-A segment along the Wilshire Boulevard corridor and along the southern half of the Vermont Avenue monitored alignment portion). It is advisable that breathing-zone H_2S concentrations be monitored during MOS-2 construction, especially in the vicinity of the aforementioned critical areas.

Moderate to severe levels of sulfate concentrations in selected soil and water samples indicate that Type II cement is likely to be required for construction along most of the investigated alignment portions (south of the Santa Monica Mountain foothills), except near Boring LPE-4 (water sample with sulfate concentration of 1,600 ppm), where Type V cement may be needed. It should be noted that this finding may require further refinement after additional data from a more detailed investigation becomes available.

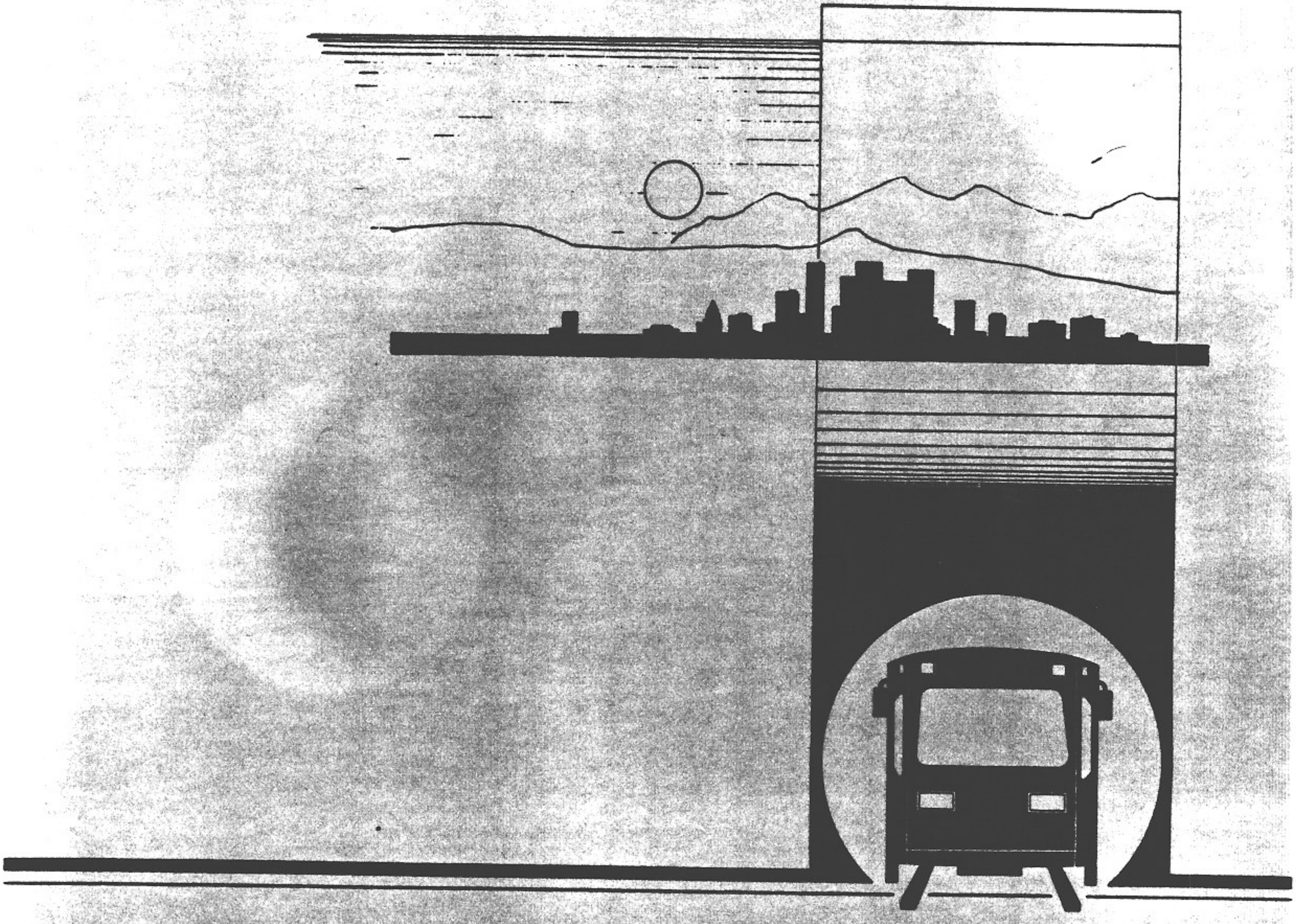
As indicated in Section 5.2, a high methane concentration is likely to exist in some areas in the OS-A segment along the Wilshire Boulevard corridor and south of Boring LPE-6 along the Vermont Avenue alignment portion. The extent and spatial/areal distribution of methane concentrations along these alignment portions can not be determined without further investigation.

Methane is combustible in air and can explode when the air mixture is about 5 to 15 percent by volume. During construction in these alignment portions, provisions to monitor the methane concentration, explosivity level, and oxygen concentration will be necessary. To ensure the safety of workers and to minimize shutdown, adequate ventilation should be maintained during construction to keep methane concentration and explosivity levels in the work area within safety levels. The potential presence of high concentrations of methane also require that the tunnel and stations in these alignment portions be tightly sealed to prevent accumulation of methane and to avoid combustion and explosion hazards.

The results of chemical tests on two gas samples from piezometers LPE-1 and -4B are presented in Appendix C. In addition to being limited in nature, these results are inconclusive as discussed below.

The tests generally detected very low concentration levels (significantly less than action levels recommended by various agencies - e.g., ACGIH, 1988) of various volatile organic gases, including H_2S and methane. The only exception was an abnormally high concentration level of methyl ethyl ketone (78-93-3 MEK). The generally low concentration levels appear to correspond to the low OVA readings observed in soil samples from Borings LPE-1 and -4B where the gas samples were obtained. However, these results may not be representative, since higher OVA readings on soil samples were obtained elsewhere during the field work, especially in Borings LPE-2, -2A, -4, -4A, -20, -21 and -24. The abnormally high MEK concentration levels (about 1,400 and 2,800 ppm for the gas samples from piezometers LPE-1 and -4B, respectively) are believed to be artificially generated from the glue compounds used in installing the piezometer caps for gas sampling and pressure monitoring (Section 3.1.4). Although more data are needed for further confirmation, it is believed that there is minimal potential for the MEK concentration level in the work space during construction to exceed the action level recommended by ACGIH (time-weighted average of 200 ppm or 15-minute weighted average of 300 ppm: ACGIH, 1988).

7.0 CONCLUSIONS AND RECOMMENDATIONS



7.0 CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS

This LPE geotechnical investigation program has been successfully carried out and has resulted in important results to meet intended objectives. Although a more detailed geotechnical investigation program will be needed to better define subsurface engineering conditions and parameters in supporting the planned future engineering effort to be undertaken by MRTC, the results of the program have provided a subsurface engineering database needed for a general understanding of the subsurface conditions and an initial definition of associated engineering parameters and potential subsurface ground behavior along the MOS-2 alignment.

The subsurface conditions in the OS-A segment along the Wilshire Boulevard corridor and the alignment portion along Vermont Avenue generally consist of Old Alluvium overlying the Puente Formation with a shallow perched groundwater level generally above the planned tunnel depths. Although the limited data obtained in this program are not sufficient to adequately determine the spatial distribution and areal extent of gassy conditions, they are likely to occur in localized areas along these two alignment portions, especially in the vicinity of Borings LPE-2, -4, -20, -21 and -24. In general, these subsurface conditions are similar to those encountered in the Detail Design Unit A170 of the MOS-1 alignment. Thus, the design and construction experience from Detail Design Unit A170 and Construction Contract Unit A171 will be applicable to the design and construction of the OS-A segment along the Wilshire Boulevard corridor and the Vermont Avenue alignment portion.

Subsurface conditions along Hollywood Boulevard to the foothills of the Santa Monica Mountains generally consist of very nonhomogeneous Young Alluvium overlying Old Alluvium. The groundwater level is generally below the planned tunnel depths except in a small area east of boring LPE-10. Gassy conditions are not anticipated along this alignment portion.

The tunnel and vent shafts along the Santa Monica Mountains are anticipated to encounter various hard rocks of a wide range of strength and hardness and at least five fault zones. The subsurface conditions in this alignment portion will be similar to those encountered during the construction of the Los Angeles City sewer tunnel and MWD's Hollywood Tunnel in the same general vicinity.

Based on an evaluation of the results of this program and the design and construction experience gained from construction of existing tunnels in the general vicinity and from current MOS-1 alignment construction, it is anticipated that the subsurface conditions along the planned MOS-2 alignment, except in the Santa Monica Mountains alignment portion, are favorable for rapid and economical tunnel construction using mechanical excavation methods within a shield similar to those used in the current tunnel construction along the MOS-1 alignment. Tunneling along the Santa Monica Mountains alignment portion will require the use of drill-and-blast methods or hard-rock tunnel boring machines. The results also indicate that the subsurface conditions along the MOS-2 alignment can provide excellent support for the structures in the planned stations. Cut-and-cover excavation of these stations can be accomplished at a relatively high rate using mechanical excavation methods with readily available equipment.

Subsurface conditions along the MOS-2 alignment and local tunnel/station construction experience in the general vicinity indicate that various subsurface concerns normally associated with tunnel and station construction in the general area are likely to occur to a varying extent in some localized areas along the MOS-2 alignment. These concerns are generally associated with mixed face conditions, the presence of granular alluvium, high perched groundwater conditions, gassy conditions, the presence of fault zones and potential problematic materials in the fault zones, and required protection for nearby existing buildings. All these concerns can be easily alleviated with proper design, proven construction techniques, and appropriate construction provisions and monitoring during construction.

The results of limited chemical tests on selected soil, water, and gas samples indicate low concentration levels of TRPH, BTEX, and heavy metals. These concentration levels are below cleanup action levels specified in various guidelines by various regulatory agencies.

Unhealthy levels of TRPH, BTEX, and heavy metals in the air are unlikely if the dust generated during excavation and handling of subsurface materials is properly controlled.

During MOS-2 construction, especially in the OS-A segment along the Wilshire Boulevard corridor and the Vermont Avenue alignment portion south of boring LPE-6, careful monitoring of H_2S concentrations in the breathing zone and methane, oxygen, and lower exposivity limit in the work area is needed, with appropriate action levels and actions established. Provisions for good ventilation and sealing of structures to prevent accumulation of these toxic and flammable gases to harmful levels will also be needed. Moderate to severe concentrations of sulfate compounds in selected soil and water samples indicate that Type II cement is likely to be needed for tunnel and station construction along a major portion of the MOS-2 alignment south of the Santa Monica Mountains foothills, except in the vicinity of boring LPE-4, where Type V cement may be required.

7.2 RECOMMENDATIONS

The results of the LPE program have provided a general understanding of the geologic and subsurface conditions and an initial definition of pertinent subsurface engineering parameters and potential subsurface concerns for design and construction of the planned MOS-2 alignment. The field work for this program consisted of 19 borings and 8 piezometers at 19 widely-spaced locations along the MOS-2 alignment portion south of the foothills of the Santa Monica Mountains. There remains a lack of detailed information for final design of the alignment portion investigated in this program. In addition, little or no site-specific information related to subsurface engineering conditions and parameters along the planned MOS-2 alignment portion through the Santa Monica Mountains to North Hollywood is available to support the planned design effort. Therefore, a more detailed investigation program will be needed to appropriately support the MRTC's planned design effort.

Appropriate scoping of the more detailed investigation will require further planning to ensure that anticipated results will be commensurate with the planned future engineering effort and its needs. The investigation program should include a combination of geologic, geophysical, geotechnical, and hydrologic investigation efforts to better define the subsurface conditions and engineering parameters along the planned MOS-2 alignment. Emphasis of the investigation should be placed on the following:

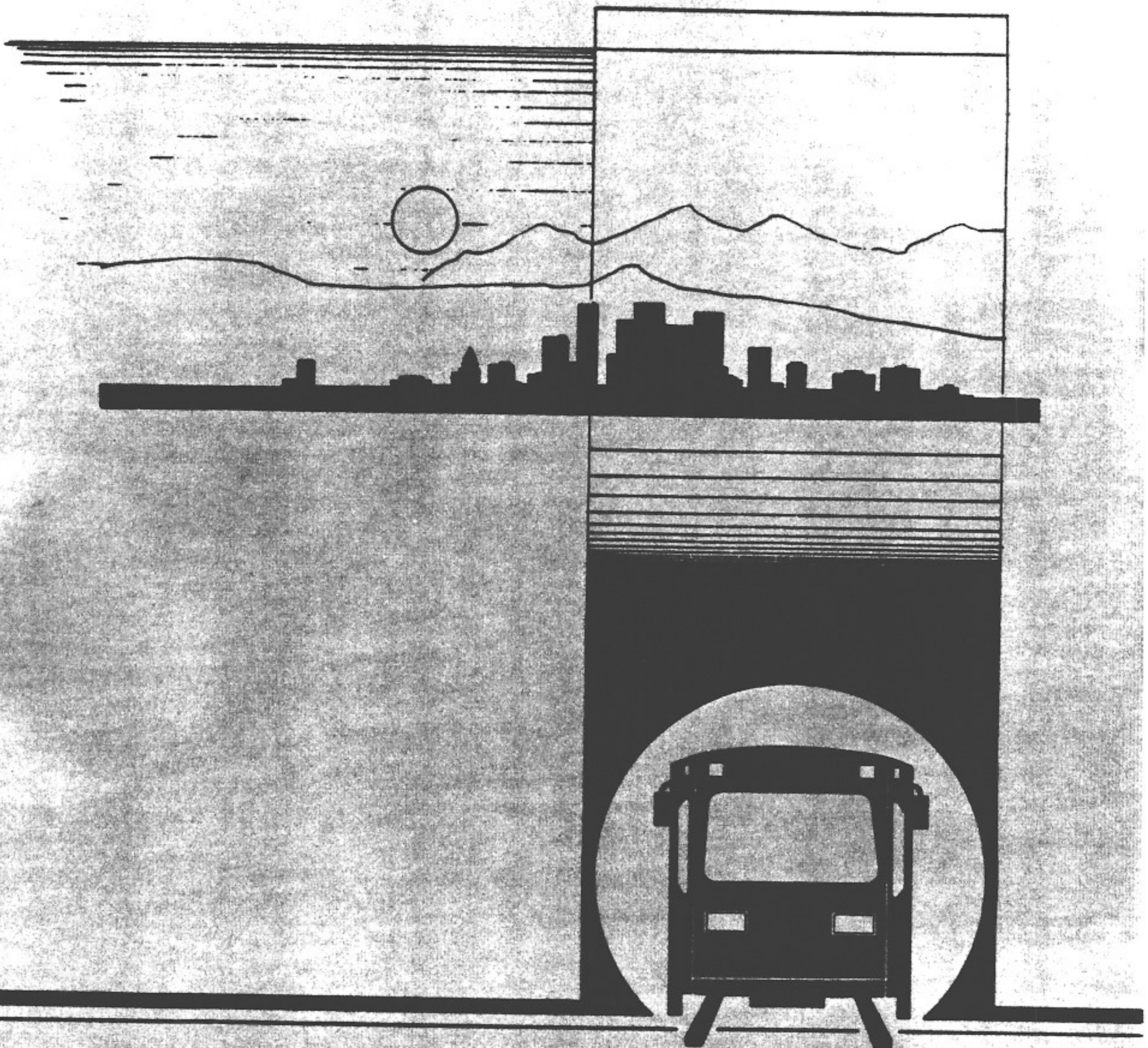
1. Obtain a better understanding of subsurface geologic conditions along the alignment by performing closely-spaced borings with the following features:
    - More closely-spaced borings with deeper penetrations are needed along this alignment portion. The relatively nonhomogeneous nature of the subsurface conditions along the Hollywood Boulevard alignment portion (nonhomogeneous Old Alluvium overlain by nonhomogeneous Young Alluvium), and the need to locate and define the extent and characteristics of the Santa Monica and Hollywood faults, require that borings along this alignment portion be more closely spaced and deeper than the borings needed for the OS-A segment along the Wilshire Boulevard corridor and along the Vermont Avenue alignment portion, which have relatively uniform subsurface conditions (Old Alluvium overlying the Puente Formation).
    - Sufficient borings with deeper penetration are needed to better define the transition zone between Borings LPE-8 (located along the Vermont alignment portion where shallow Puente Formation was found in this LPE program) and Boring LPE-9 (located near the east end of the Hollywood Boulevard alignment portion, where no Puente Formation was found within the penetration depth of Boring LPE-9).
    - Sufficient borings along the Santa Monica Mountains alignment portion are needed to adequately define the hard-rock subsurface conditions and the fault zones and their characteristics within this alignment portion. Drilling in hard-rock conditions is slow and expensive. It is important that a detailed review of additional literature data, a field geologic reconnaissance, and seismic refraction profiling along this alignment be performed prior to determining the number and location of borings along the alignment in order to effectively obtain sufficient subsurface information for the planned future engineering effort.
    - Geophysical investigations, including downhole and crosshole surveys and electric and caliper borehole loggings, should be performed on selected borings to gain sufficient seismic properties and subsurface characterization.
2. Obtain a more detailed definition of hydrologic conditions and characteristics along the alignment, especially in the OS-A segment along the Wilshire Boulevard corridor and the Vermont Avenue alignment portion where perched groundwater conditions exist. This can be accomplished by installing multi-staged piezometers for monitoring groundwater conditions and water quality sampling, and by performing pumping tests to better define hydraulic transmissity characteristics of the subsurface materials.

3. Install multi-staged gas probes to monitor the gas pressure and extent and to determine the spatial/areal distribution of flammable or toxic gases (especially methane and H_2S). For the gas probe installation and monitoring, emphasis should be placed on the OS-A segment along the Wilshire Boulevard corridor and the portion of the Vermont Avenue alignment south of Boring LPE-6.

4. Conduct more detailed laboratory testing to characterize static and dynamic engineering parameters of encountered subsurface soils and rocks. In addition, a detailed chemical test program should be conducted on soil, water, and gas samples to determine extent of chemical concentrations and their effect on design and construction.

5. Perform a seismic study to define seismic potential, seismic responses of subsurface materials, and seismic design of the planned tunnel and stations along the alignment.

8.0 REFERENCES



8.0 REFERENCES

American Conference of Governmental Industrial Hygienists (ACGIH), 1988. Threshold Limit Values and Biological Exposure Indices for 1988-1989, Cincinnati, Ohio.

Association of Engineering Geologists (AEG), 1982. Geologic Maps, Santa Monica Mountains, Los Angeles, California, compiled by the City of Los Angeles, published by AEG, Southern California Section.

Campbell, D. G., 1955. Geologic notes and log of Los Angeles City Sewer tunnel, Los Angeles City.

Converse Consultants, Inc., 1987. Draft Geotechnical Report, Sunset Boulevard Vibration Study Borings, Metro Rail Core Study, Hollywood, Califoria, Report to Metro Rail Transit Consultants.

CWDD/ESA/GRC, 1981. Geotechnical Investigation Report - Metro Rail Project, Report to Southern California Rapid Transit District.

Engineering Science and Associates (ESA), 1984. Report of Subsurface Gas Investigation - Southern California Rapid District, Metro Rail Project, Wilshire Alignment, Report to DMJM/PBQD, A Joint Venture.

Engineering Science and Associates (ESA), 1986. Core Study and Subsurface Conditions Report - An Evaluation of Methane Gas Potential Along Candidate Alignment of the L.A. Metro Rail Project, Report to Metro Rail Transit Consultants.

Hauksson, E., 1987. Seismotectonics of the Newport-Inglewood Fault Zone in the Los Angeles Basin, Southern California, Bulletin of the Seismological Society of America, Vol. 77, No. 2, pp. 539-561.

Lamar, D. L., 1970. Geology of the Elysian Park-Reppto Hill Area, Los Angeles County, California: California Division of Mines and Geology, Special Report 101.

National Institute for Occupational Safety and Health (NIOSH), 1985. Pocket Guide to Chemical Hazards, DHHS (NIOSH) Publication No. 85-114, Washington, D.C.

Ohta, Y. and N. Goto, 1978. Empirical Shear Wave Velocity Equations in Terms of Characteristic Soil Indexes, Earthquake Engineering and Structural Dynamics, Vol. 6, pp. 167-187.

Richter, C. F., 1958. Elementary Seismology, W. H. Freeman and Company, San Francisco, California.

Schmertmann, J. H., 1970. Static Cone to Compute Static Settlement Over Sand, JSMFED, Vol. 96, No. SM3, May, pp. 1011-1043.

Terzaghi, K., 1955. Evaluation of Coefficients of Subgrade Reaction, Geotechnique, Vol. 5, pp. 297-326.

Weber, H. F., J. H. Bennet, R. H. Chapman, G. W. Chase, and R. B. Saul, 1980. Earthquake Hazards Associated with the Verdugo-Eagle Rock and Benedict Canyon Fault Zones, Los Angeles County, California, California Division of Mines and Geology, Open File Report 80-10 LA.

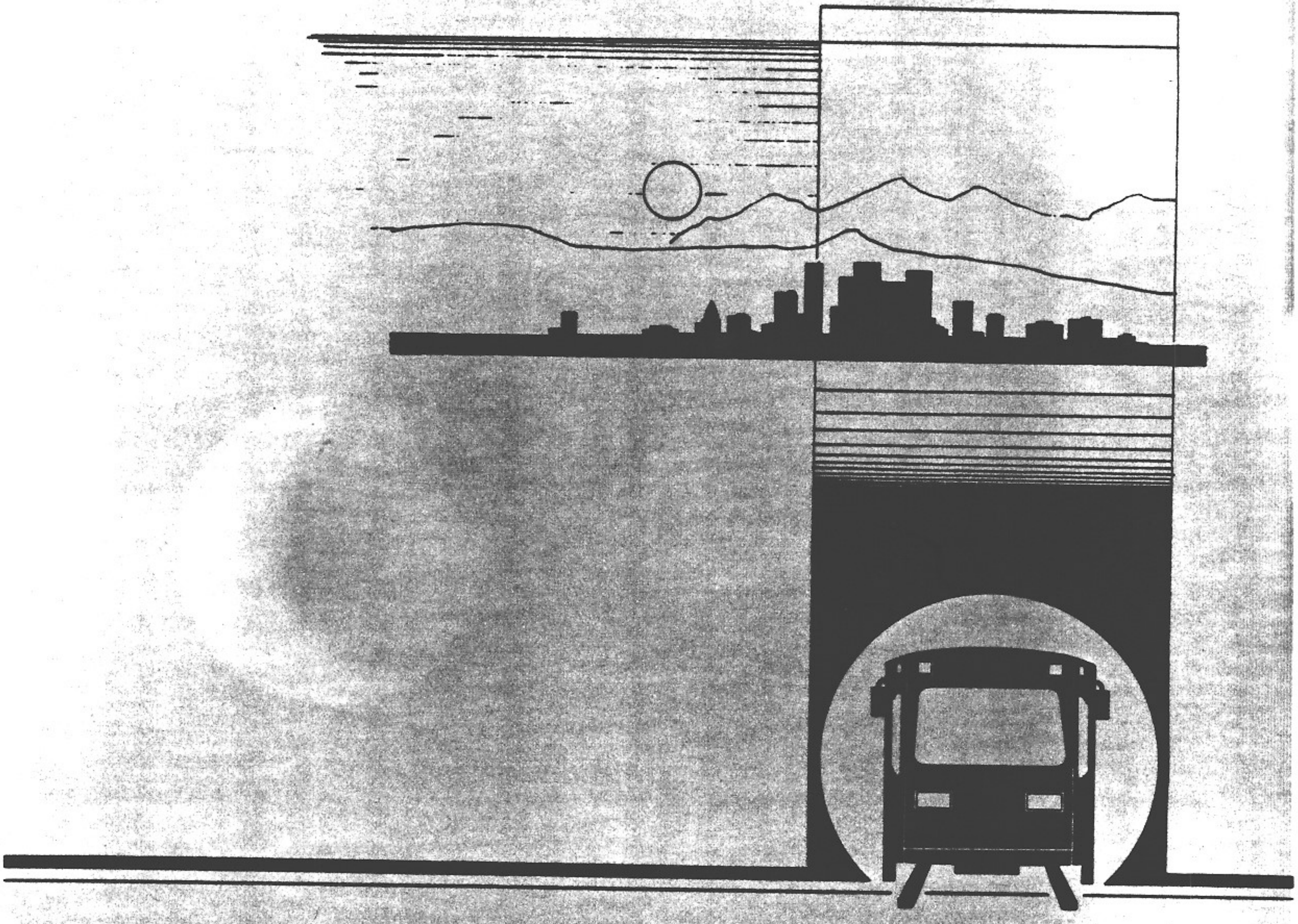
Yerkes, R. F., J. C. Tinsley, and K. M. Williams, 1975. Geologic Aspects of Tunneling in the Los Angeles Area, United States Geological Survey MF-0866.

Yerkes, R. F., T. H. McCulloh, J. E. Schoellhamer, and J. G. Vedder, 1965. Geology of the Los Angeles Basin California - An Introduction, United States Geological Survey Professional Paper 420-A.

Ziony, J. I., J. F. Evernden, T. E. Fumal, E. L. Harp, S. H. Hartzell, W. B. Joyner, D. K. Keefer, J. C. Spudich, J. C. Tinsley, Y. F. Yerkes, and T. L. Youd, 1985. Predicted Geologic and Seismological Effects of a Postulated Magnitude 6.5 Earthquake Along the Northern Part of the Newport-Inglewood Zone, in Evaluating Earthquake Hazards in the Los Angeles Region, Ziony, J. I., Editor, United States Geological Survey Professional Paper 1360, pp. 415-441.

APPENDIX A

BORING LOGS AND PIEZOMETER DIAGRAMS



APPENDIX A

BORING LOGS AND PIEZOMETER DIAGRAMS

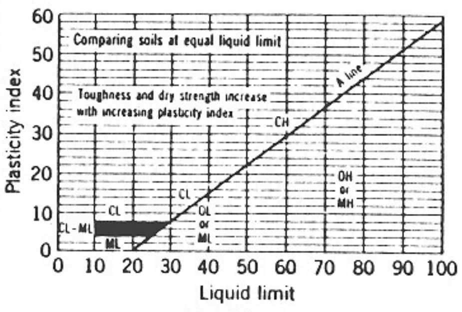
Subsurface exploration consisted of drilling and sampling 19 borings and installing 8 piezometers in 8 of these boring locations. This appendix presents the logs and locations of borings, piezometer diagrams and a schematic of the device installed at two piezometer locations for gas sampling and pressure monitoring purposes. This appendix includes the following figures:

	Figure Number		
Boring No.	Log	Location	Piezometer Diagram
LPE-1	A-1	A-1A	A-1B
LPE-2	A-2	A-2B	--
LPE-2A	A-2A	A-2B	--
LPE-4	A-3	A-3C	--
LPE-4A	A-3A	A-3C	--
LPE-4B	A-3B	A-3C	A-3D
LPE-6	A-4	A-4A	--
LPE-7	A-5	A-5A	A-5B
LPE-8	A-6	A-6A	A-6B
LPE-9	A-7	A-7A	--
LPE-10	A-8	A-8A	A-8B
LPE-11	A-9	A-9A	A-9B
LPE-12	A-10	A-10A	--
LPE-13	A-11	A-11A	--
LPE-14	A-12	A-12A	A-12B
LPE-15	A-13	A-13A	--
LPE-16	A-14	A-14A	A-14B
LPE-17	A-15	A-15A	--
LPE-19	A-16	A-16A	--
LPE-20	A-17	A-17A	--
LPE-21	A-18	A-18A	--
LPE-22	A-19	A-19A	--

Explanations to the logs of borings are provided in Figures A-I through A-III. The schematic drawing of the devices installed for gas sampling and pressure monitoring are shown in Figure A-20.

			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	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 $C_U = \frac{D_{60}}{D_{10}}$ Greater than 4 $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3	
			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		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
			Plastic fines (for identification procedures, see *CL* below)	*GC*	Clayey gravels, poorly graded gravel-sand-clay mixtures	For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics	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	
			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
			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	

		Identification Procedures on Fraction Smaller than No. 40 Sieve Size					
		Dry Strength (crushing characteristics)	Dilatancy (reaction to shaking)	Toughness (consistency near plastic limit)			
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
		Medium to high	None to very slow	Medium	*CL*	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	
		Slight to medium	Slow	Slight	*OL*	Organic silts and organic silt-clays of low plasticity	For undisturbed soils add information on structure, stratification, consistency in undisturbed and remoulded states, moisture and drainage conditions
	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	
		High to very high	None	High	*CH*	Inorganic clays of high plasticity, fat clays	Example: *Clayey silt*, brown; slightly plastic; small percentage of fine sand; numerous vertical root holes; firm and dry in place; loess; (*ML*)
		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.

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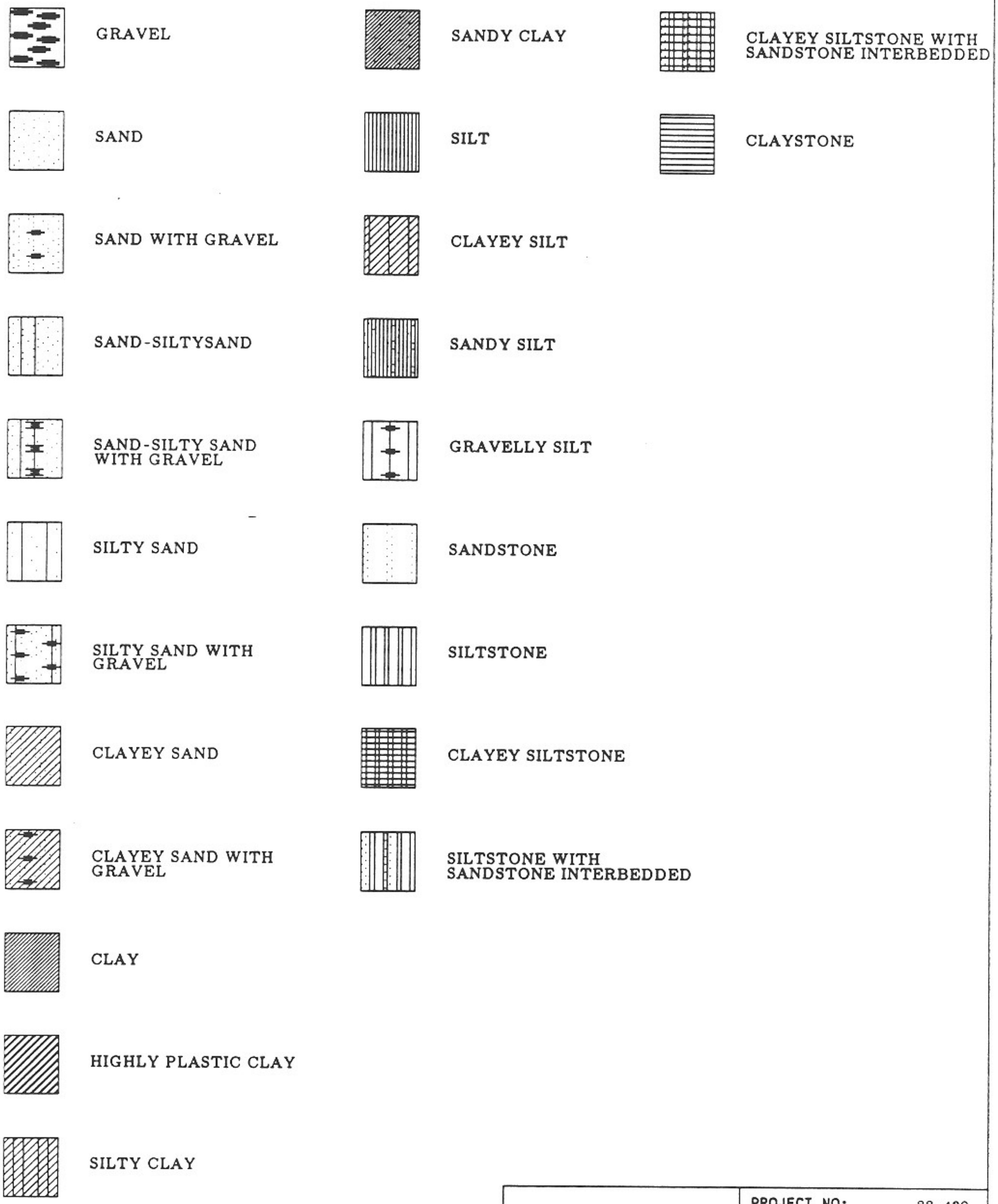
PROJECT NO.: 88-429

METRO RAIL – MOS – 2

UNIFIED SOIL CLASSIFICATION SYSTEM

12 88

FIGURE A 1



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PROJECT NO: 88-429

METRO RAIL MOS-2

SOIL/ROCK SYMBOLS FOR
LOGS OF BORINGS

12/88

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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PROJECT NO.: 88 429

METRO RAIL – MOS – 2

KEY FOR LOGS OF BORINGS

12 88

FIGURE A III

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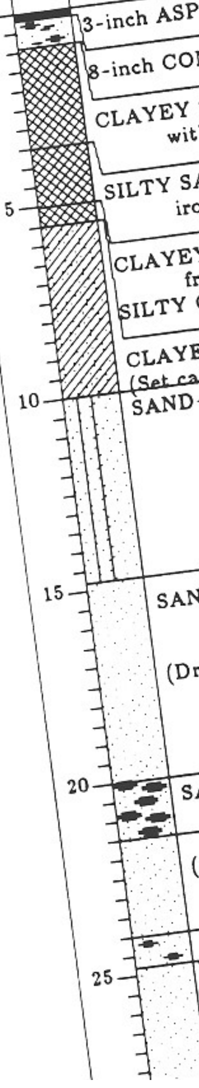
FIGURE A-1. LOG OF BORING LPE-1

Project Name: METRO RAIL MOS-2 ALIGNMENT - LOS ANGELES
Sheet 1 of 3
Borehole Number: LPE-1
Project Number: 88-429
Elevation and Datum(feet): 255.0
Date Started: 10/29/88
Date Finished: 10/29/8
Borehole Location: Vermont and 6th Street.
Total Depth (feet): 100.0
Depth to Bedrock(feet): 30.0
Health and Safety: Upgraded level D
Borehole Diameter: 5-inch
Drilling Equipment: Failing 750
Piezometer Installation: YES.
Depth(feet): 100.0
Drilling Method: Mud Rotary
Checked By: C. Duckworth
Drilling Fluid: Bentonite Mud
Logged By: C.M.Payne
Hammer Information:
SPT Hammer: 140-lb weight and 30-inch drop;
DOWNHOLE Hammer: 365-lb weight and 18-inch drop.



					Samples						
Depth (feet)	Lith-ology	Description	USCS Classification	Geologic Unit	Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content
		3-inch ASPHALT-CONCRETE.	SC	FILL							
		8-inch CONCRETE.									
		CLAYEY SAND; Tan, moist, dense, silty, very fine to fine with rock fragments.	SM	FILL							
5		SILTY SAND; Tan, moist, dense, fine to coarse, with slight iron stains(oxidized).	SC/CL	FILL							
		CLAYEY SAND/SANDY CLAY; Moist, firm, with rock fragments.	SC	A4							
		SILTY CLAY, brown, moist, stiff.									
		CLAYEY SAND; Tan mottled with rust, moist, dense. (Set casing to 7 feet and switched to Rotary Wash.)									
10		SAND-SILTY SAND; Olive, moist, very dense, very fine to fine with trace medium, poorly graded.	SP-SM	A3	1	S	10 18 24	16"/18"	4.0		
15		SAND; Light olive brown, moist, very dense, fine to medium.	SP	A3	2	D	26 36	12"/12"	4.3	9	
		(Drill chatter, gravel fragments in mud.)									
20		SANDY GRAVEL.	GP	A3	3	S	18 27 34	NR 0"/18"			
		(Fine to medium sand in cuttings from 21-1/2 to 24 feet.)	SP	A3							
			SP/GP	A3							
25		(Gravel-Gravelly sand in cuttings from 24 to 25 feet.)	SP-SM	A3	4	D	32 54	12"/12"	3.8		
		SAND-SILTY SAND; Light grey, wet, very dense, very fine to medium, poorly cemented.									
		ttings at 28 feet.)									

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FIGURE A-1. LOG OF BORING LPE-1

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

Project Number: 88-429 Borehole Number: **LPE-1** 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)
		TOP OF PUENTE FORMATION. CLAYEY SILTSTONE; Light olive brown to dark olive brown, moist, hard, slightly plastic, moderately well bedded to laminated, oxidized, micaceous. Dip 15 to 20 deg.		Tpw	5	S	13 15 50	18"/18"	9.5			3.4
35		(Easier drilling, cuttings are dark gray.) CLAYEY SILTSTONE; Light to medium grayish brown, moist, hard, well bedded, oxidized, interbedded with widely spaced 1/4-inch thick clean light gray, fine to medium sand(stone) lens. Dip 15 deg.		Tpw	6	D	20 45	12"/12"	5.8	85	39.0	3.4
		(Medium to very coarse sandstone in cuttings from 38 to 40 feet.)		Tpw								
40		CLAYEY SILTSTONE; Dark olive gray, moist, hard, well bedded, micaceous, interbedded with very fine to fine, clean-loose sandstone beds. Beds are 1/4-inch thick and 2 to 3-inch apart. Dip 15 deg.		Tpw	7	S	22 50	10"/12"	18.0			3.3
45		CLAYEY SILTSTONE; Medium to dark grey, moist, hard, moderately cemented, well bedded, fresh. Dip 10 to 15 deg.		Tpf	8	D	55 45/4"	10"/12"	14.0	75	40.2	3.6
50		CLAYEY SILTSTONE; Dark gray, very stiff, laminated, fresh.		Tpf	9	P	Push 400psi	27"/32"	14.0	84	35.8	3.6
55		CLAYEY SILTSTONE; Dark gray, hard, appears massive, micaceous, fresh.		Tpf	10	D	48 52/4"	10"/10"	5.2	93	30.8	3.8
60		CLAYEY SILTSTONE; Dark olive gray, moist, very stiff, thinly laminated, fresh, poorly cemented, slightly plastic, with few thin 1/8-inch thick medium gray, fine, soft to medium hard sandstone beds. Dip approximatly 10 deg.		Tpf	11	S	17 27 40	14"/18"	5.0			3.8
65		Same as above.		Tpf	12	D	21 79/5"	11"/11"	5.0	90	32.8	3.8
		(Drill chatter at 69 feet 9 inches. Silicaceous shale? Unable to drive SPT, tried pitcher and proceeded only 1 inch, lost sample.)		Tpf								
70												

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FIGURE A-1. LOG OF BORING LPE-1

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

Project Number: 88-429 | Borehole Number: **LPE-1** | 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)
		(Switched to rock bit at 69 feet.)		Tpf	13	P	Push 350psi	1"/1"				
		(Dark gray siliceous siltstone in cuttings.) (Smooth drilling at 69 feet 10 inches.)										
75		CLAYEY SILTSTONE; Medium to dark grey, hard, well bedded to laminated, fresh, moderately to well indurated, interbedded with widely spaced, 1/8 to 1/16-inch thick, loose, fine to medium sandstone beds. Dip 10 deg.		Tpf	14	D	30 70	12"/12"	5.6	94	30.3	2.0
80		CLAYEY SILTSTONE; Dark olive grey to dark olive brown, moist, hard, slightly plastic, micaceous, thinly laminated, fresh, interbedded with widely spaced, 1/8 to 1/16-inch thick, very fine to fine, clean sandstone beds. Dip 10 deg.		Tpf	15	S	23 44 33/3"	15"/15"	9.2			3.7
		(Drill chatter at 84 feet. May be siliceous siltstone.)										
85		Same as above(at 80 feet). Dip approximately 20 deg. More cemented.		Tpf	16	D	45 55/4"	10"/10"	9.5	92	31.9	4.2
		(Drill chatter at 87 feet 9 inches. Very hard chips in cuttings, probably siliceous siltstone.)										
90		Same as above(at 80 feet). Dip 10 deg.		Tpf	17	S	18 44 38/3.5"	13"/15"	5.0			4.2
95		Same as above. Very consistent in lithology-structure, color and consistency.		Tpf	18	D	32 68	12"/12"	4.6	94	31.0	4.3
		Same as above but less interbeds of sandstone.		Tpf	19	S	24 50/5"	11"/11"	5.4			4.3
100		BORING TERMINATED AT 100 FEET. PIEZOMETER INSTALLED. 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 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 surface material types and the transition may be gradual.										
105												
110												

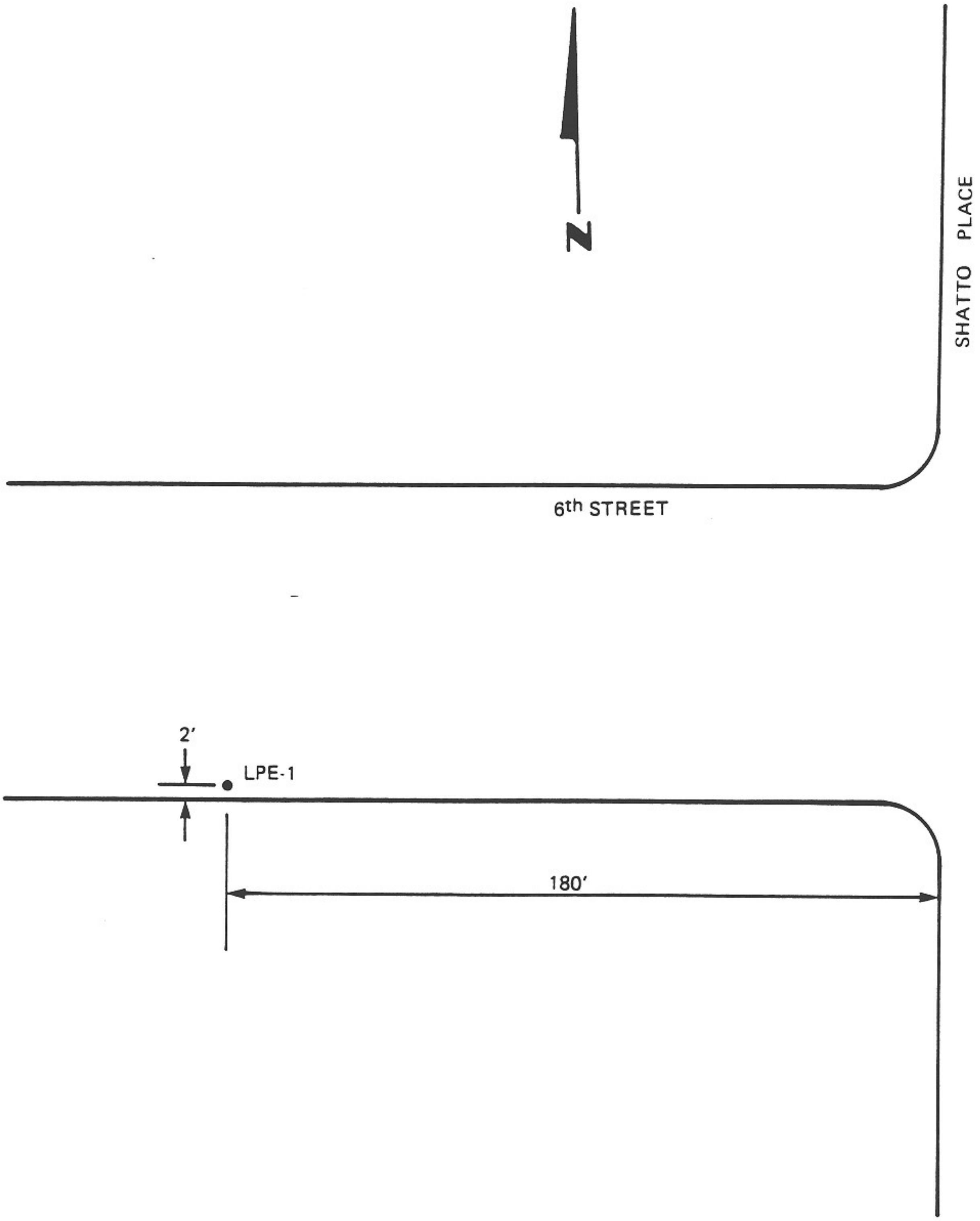

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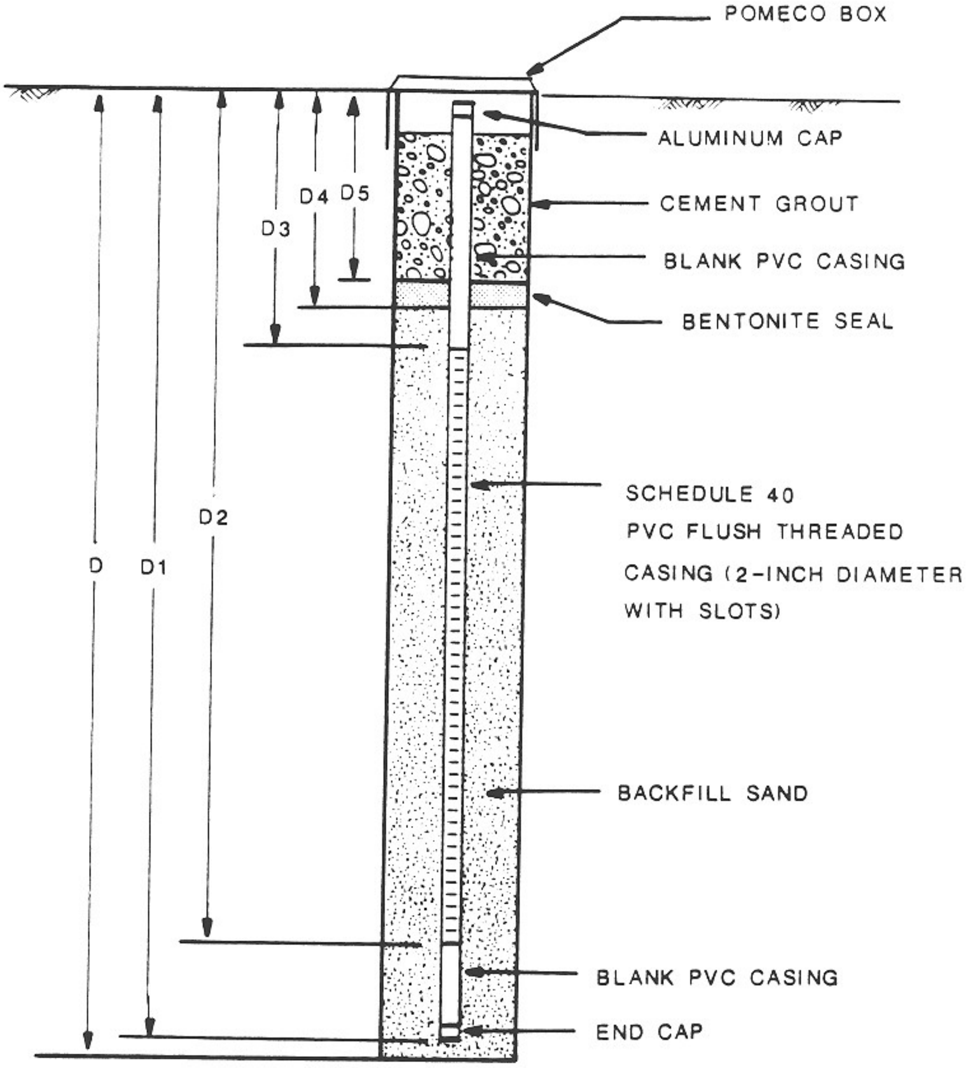
FIGURE A-1A

LOCATION OF BORING LPE-1



TOTAL DEPTH (D)	= 99.9	FEET
DEPTH TO BOTTOM OF CASING (D1)	= 97.0	FEET
DEPTH TO BOTTOM OF WELL SCREEN (D2)	= 87.0	FEET
DEPTH TO TOP OF WELL SCREEN (D3)	= 16.7	FEET
DEPTH TO BOTTOM OF BENTONITE SEAL (D4)	= 14.7	FEET
DEPTH TO TOP OF BENTONITE SEAL (D5)	= 12.7	FEET
WELL SCREEN SLOT SIZE	= 0.01	INCH
BACKFILL SAND TYPE	= NO.2	MONTEREY

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FIGURE A-1B

PIEZOMETER DIAGRAM LPE-1

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FIGURE A-2. LOG OF BORING LPE-2

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

Project Number: 88-429

Borehole Number: LPE-2

Sheet 1 of 2

Borehole Location: New-Hampshire and 4th

Elevation and Datum(feet): 245.0

Health and Safety: Level D

Date Started: 10/4/88

Date Finished: 10/4/88

Drilling Equipment: Failing 750

Total Depth (feet): 51.5

Depth to Bedrock(feet): 28.0

Drilling Method: Rotary Wash

Borehole Diameter: 5-inch

Drilling Fluid: Bentonite Mud

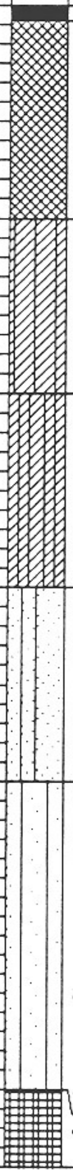
Piezometer Installation: No.

Depth(feet): --

Hammer Information:
SPT Hammer: 140-lb weight and 30-inch drop.
DOWNHOLE Hammer: 365-lb weight and 18-inch drop.

Logged By: C.M.Payne

Checked By: C. Duckworth



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)
		3-inch ASPHALT CONCRETE										
		SILT, SAND, GRAVEL AND CLAY. CLAYEY SAND; brownish gray, silty at 1-1/2 feet. SAND; loose, clean at 2 feet.	SM/ML SC SM	FILL								
5		CLAYEY SILT; gray, moist, very stiff.	ML	A4	1	D	13 25	12"/12"	7.4	99	24.3	5.8
10		SILTY CLAY; Olive and yellowish brown, moist, very hard, iron stained, low to meduium plastic. (Driller reports sandy.)	CL	A4	2	S	11 22 31	18"/18"	7.4			7.4
15		SAND-SILTY SAND; Yellowish brown, moist, fine to medium, clean, medium dense to dense.	SP-SM	A3	3	D	17 30	12"/12"	5.4	105	12.2	7.4
20		SILTY SAND; Yellowish brown, moist, very fine to medium, dense, friable, fairly clean, slightly silty. (Drill chatter at 23-feet, may be coarse gravel.)	SM	A3	4	S	21 35 50/3"	10"/18"	5.0			11.0
25		SILTY SAND; same as above from 20-feet. (Drill chatter at 27-28 feet, Coarse gravel.) (Clay chips in mud at 28-ft.)	SM	A3	5	D	38 62/5"	12"/12"	5.2	104	11.2	11.0
30		TOP OF PUENTE FORMATION.										

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FIGURE A-2. LOG OF BORING LPE-2

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

Project Number: 88-429

Borehole Number: LPE-2

Sheet 2 of 2

Depth (feet)	Lith- ology	Description	USCS Classi fication	Geologic Unit	Samples							Background OVA (ppm)
					Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	
		CLAYEY SILT(STONE); Dark olive, moist, interbedded at 1/4-1/2 inch layers of gray micaceous silty clay(stone) and olive gray organic clay, beds are horizontal. (Sulfur odor.) (Noted oily film on mud tank, very slow and smooth drilling.)		Tpw	6	S	14 21 23	18"/18"	6.2			4.7
35		CLAYEY SILTSTONE; Dark gray, moist, fresh unoxidized thin pronounced bedding, dip 10-15 deg., Sulfur odor.		Tpf	7	D	60 40/3"	9"/9"	34.0	86	32.5	4.7
40		SILICEOUS SHALE; Dark gray, very hard and brittle chips. (Slow and rough drilling, strong chatter, changed to rock bit.)										
		(Smooth and fast drilling with rock bit.) CLAYEY SILTSTONE; Dark gray, moist, very hard, micaceous, horizontal beds of dark gray (probably organic) clay and brownish clayey silt, 1/16 to 2-inch apart, low plastic.		Tpf	8	S	25 38 50/4.5"	16"/16"	520.0			6.4
					9	B						
45		(Tar (stickey black oil) in cuttings at 43-ft.) CLAYEY SILTSTONE, Dark and light gray, moist, thin beds with dip of 5-7 deg.,unoxidized, fresh, slightly cemented. (Very slow drilling. Switched to drag bit.)		Tpf	10	D	65 35/2"	8"/8"	400.0	95	26.6	6.4
50		CLAYEY SILTSTONE; Dark greenish gray and dark gray alternate beds at 1 to 2-inch apart, flat, soft to moderately cemented, dark clay appears to be organic, high OVA reading.		Tpf	11	S	27 34 50/5"	17"/17"	590.0			6.4
55 60 65 70		BOREHOLE TERMINATED AT 51-1/2 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 surface material types and the transition may be gradual.										

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FIGURE A-2A. LOG OF BORING LPE-2A

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

Project Number: **88-429** Borehole Number: **LPE-2A** Sheet **1** of **4**

Borehole Location: **New Hampshire at 4th Street.** Elevation and Datum(feet): **245.0**

Health and Safety: **Upgraded Level D** Date Started: **11/1/88** Date Finished: **11/2/88**

Drilling Equipment: **Failing 750** Total Depth (feet): **127.5** Depth to Bedrock(feet): **27.0**

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. DOWN HOLE Hammer: 365-lb weight and 18-inch drop.

Logged By: **C. M. Payne** Checked By: **C. Duckworth**

Depth (feet)	Lith-ology	Description	USCS Classification	Geologic Unit	Samples							Background OVA(ppm)
					Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	
		3-inch ASPHALT CONCRETE and 3-inch base material.										
		SILTY SAND; yellowish brown,loose,fine to coarse fill material.	SM	FILL								
5		CLAYEY SILT; grayish brown, moist, stiff, appears native material. (Set casing to 7 feet. Start rotary wash drilling.)	ML	A4								
10		CLAYEY SILT; Gray, moist.	ML	A4								
15		SAND-SILTY SAND;Yellowish brown, wet, fine to medium, clean, dense.	SP-SM	A3	1	S	21 33 29	"9/18"	2.0			0.5
20		CLAY;Yellowish brown, firm, highly plastic.	CL	A4								
		SAND;Yellowish brown, wet, loose, fine to medium weathered.	SP	A3								
		(Gravel. Drill chatter between 23 to 24 feet.)	GP	A3								
25		SILTY SAND;Yellowish brown, wet, loose, oxidized, with minor gravel up to 1/4-inch size. (Coarse sand and minor gravel in cuttings at 27 feet.)	SM	A4	2	S	48 52/4.5"	9"/10.5"	3.5			0.5
		(Clayey silt in cuttings;Yellowish brown to medium gray, plastic.	ML	A4								
30												

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FIGURE A-2A. LOG OF BORING LPE-2A

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

Project Number: 88-429 | Borehole Number: **LPE-2A** | Sheet 2 of 4

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)
			ML	A3								
		CLAYEY SILT;Dark gray, fresh.										
		GRAVEL lense. (Drill chatter at 32 feet and 2 inches.)										
35		TOP OF PUENTE FORMATION. (Drill chatter from 34 to 35 feet.) CLAYEY SILTSTONE; Dark gray, firm, siliceous, poorly indurated. Becoming clayey and hard, thickly bedded. Dip approximatly 20 deg. Mild sulfur odor.		Tpw	3	S	20 36 50/4"	16"/16"	250.0			1.0
40		(Hard slow drilling. Silcified Siltstone. Switch to rock bit at 36 feet 4 inches.) (Small pieces of tar in drill cuttings at 38-1/2 feet.) Hard Silsified Siltstone.		Tpf	4	D	84 16/0.5"	6.5/6.5"	700.0	92	30.0	1.0
		CLAYEY SILTSTONE; Brownish dark gray, moist, hard, micaceous, laminated, fresh. Dip approximately 20 deg.										
45		CLAYEY SILTSTONE; Dark gray, moist, hard, micaceous, laminated, fresh. Loosly interbedded with thin light gray, very fine to fine Sandstone beds. Beds are 1/32" - 1/16" thick and 1/8" to 1/2" apart. Dip 10 to 15 deg. (Hard drilling at 49 feet.)		Tpf	5	S	22 33 50	18"/18"	650.0			0.0
50		Same as above; except very hard, siliceous, approximately 2-inch thick, Siltstone piece at middle of the sample.		Tpf	6	D	30 20/3"	9"/9"	230.0	91	34.0	0.0
55		CLAYEY SILTSTONE; Dark to medium gray, moist, hard, micaceous, fresh. Interbedded with Sandstone; Dark brown, moist, loose, very fine to fine, 1/4" - 2" thick, massive Sandstone.		Tpf	7	S	40 60	12"/12"	110.0			0.2
60		(Drill chatter at 59 feet.) Hard, silliceous Siltstone bed. SILTSTONE; Dark gray to dark brown, moist, hard, fresh, laminated, moderately well indurated, interbedded with thin medium gray, very fine to fine, clean Sandstone. SILTSTONE becoming softer. (Fast, smooth drilling.)		Tpf	8	D	30 70	12"/12"	1000.0	98	26.5	0.5
65		SILTSTONE/SANDSTONE; Dark gray to dark brown, moist, thin interbeds of 50% very fine to fine grained sandstone with clayey siltstone (50%), micaceous, laminated, unoxidized, fresh.		Tpf	9	S	20 50 30/3"	15"/15"	800.0			0.2
70												

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FIGURE A-2A. LOG OF BORING LPE-2A

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

Project Number: 88-429 Borehole Number: LPE-2A Sheet 3 of 4

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)
		Same as above.		Tpf	10	S	30 70	12"/12"	1000.0	84	32.0	1.0
		(Drill chatter at 72-1/2 feet.)										
75		Pitcher sample, Pushed with 350 PSI.		Tpf	11	P	Push 350psi	30"/30"	460.0	97	29.5	0.8
		(Moderately hard drilling from 78 to 78-3/4 feet.)										
80		CLAYEY SILTSTONE; Dark gray to dark brown, moist, hard, fresh, laminated, with medium gray, moist, dense, very fine to fine Sandstone.		Tpf	12	D	19 42	12"/12"	1000.0			1.0
85		Same as above except about 40% Sandstone. (Soft drilling.)		Tpf	13	S	50/2.5"	2.5/2.5"	850.0			2.8
90		CLAYEY SILTSTONE; Dark gray to dark brown, moist, hard, clayey, fresh, moderately indurated, with thinly bedded, medium gray, moist, dense Sandstone. Dip at approximately 10 deg.		Tpf	14	D	36 64/5.5	12"/12"	1000.0			2.8
95		Same as above.		Tpf	15	S	44 50/4"	10"/10"	800.0			3.2
100		Same as above.		Tpf	16	D	50 50/2"	5"/8"	1000.0	83	38.5	3.2
105		Same as above.			17	S	60 40/2"	8"/8"	1000.0			4.2
110												

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FIGURE A-2A. LOG OF BORING LPE-2A

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

Project Number: 88-429 Borehole Number: **LPE-2A** Sheet 4 of 4

Depth (feet)	Lith-ology	Description	USCS Classification	Geologic Unit	Samples							Background OVA(ppm)
					Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	
		Same as above.		Tpf	18	D	70 30/1.5"	6"/7.5"	1000.0	81	38.5	3.0
		(Drill chatter at 113-1/2 feet.) Hard silliceous Siltstone from 113-1/2 to 114-1/2 feet.										
115		Same as Above.		Tpf	19	S	43 57/4"	10"/10"	890.0			3.2
120		Same as above. Dip approximately 15 to 20 deg.		Tpf	20	D	50 50/3"	9"/9"	1000.0	90	25.5	3.5
125		Same as above.		Tpf	21	P	Push 350psi	30"/30"	920.0	101	12.2	3.6
		BORING TERMINATED AT 127-1/2 FEET. NOTE: This borehole log is based on filed 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.										
130												
135												
140												
145												
150												

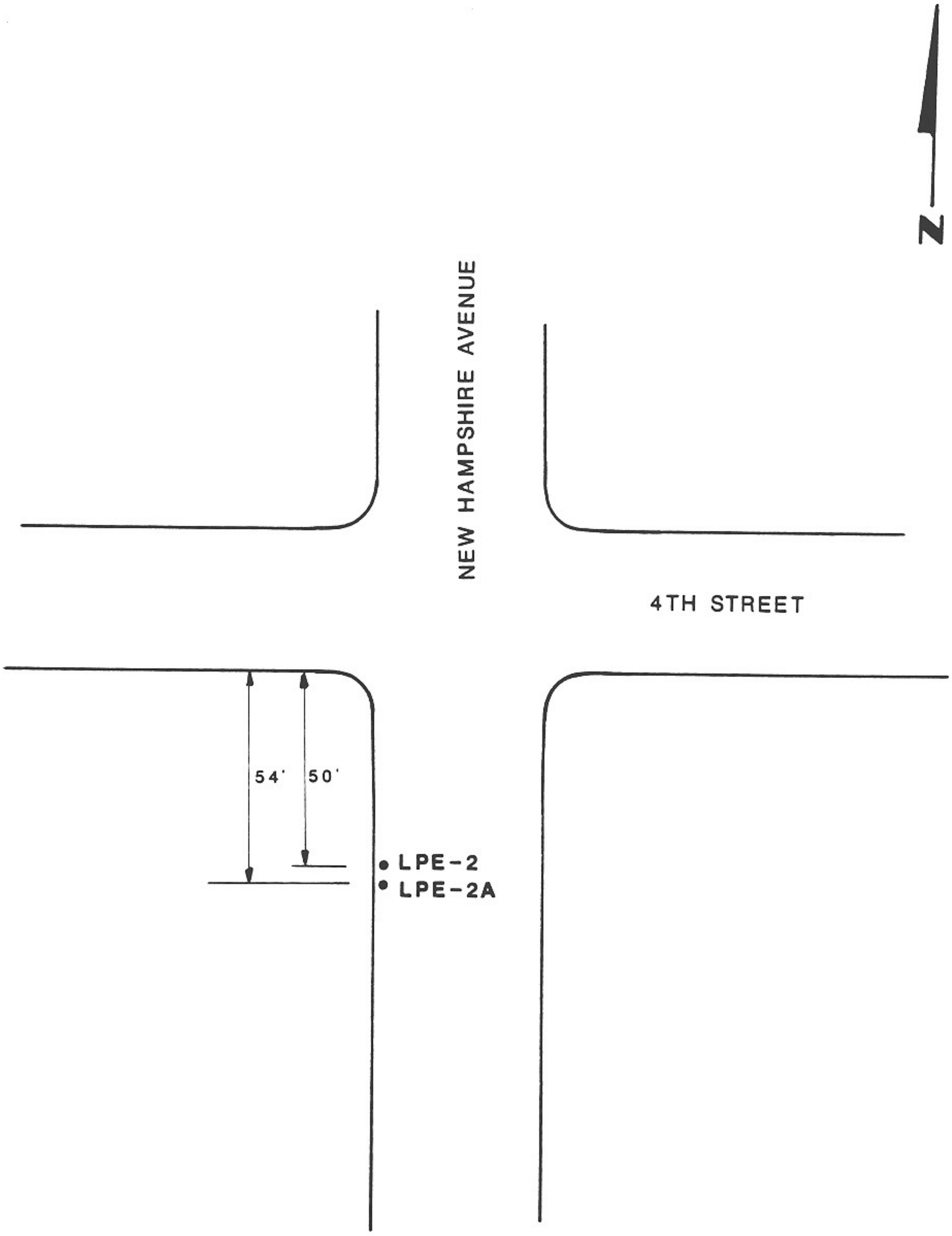

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FIGURE A-2B

LOCATION OF BORINGS LPE-2 AND 2A

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FIGURE A-10. LOG OF BORING LPE-12

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

Project Number: 88-429 Borehole Number: LPE-12 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 SAND; Reddish brown, very moist, stiff, moderately plastic fines, fine to coarse sand, varying clay content. (Easy fast drilling.)	SC	A2	5	S	5 8 8	13"/18"	5.6			4.0
35		SILTY SAND; Brown, very moist, medium dense to dense, slightly clayey. (Easy fast drilling.)	SM	A1	6	D	10 12	12"/12"	5.8	110	18.5	4.0
		(Gravelly lens in cuttings from 37-1/2 to 38-1/2 feet.)	GP	A1								
40		CLAYEY SAND; Brown, very moist, stiff and dense, fine to coarse, with pieces of leaves in sample.	SC	A2	7	S	10 16 22	12"/18"	5.8			4.0
		Harder drilling, most likely changes to old alluvium										
45		CLAYEY SAND; Slightly reddish brown, moist, dense to very dense, very fine to very coarse, silty. (Smooth slower drilling.)	SC	A4	8	D	19 32	12"/12"	5.2	120	14.5	4.0
50		SANDY CLAY; Reddish brown, moist, hard, moderately plastic fines, fine to medium sand.	CL	A4	9	S	8 16 22	14"/18"	6.8			4.0
55		SILTY SAND/SANDY SILT; Reddish brown, moist, dense, slightly clayey, with trace of gravel up to 1/2-inch size. (Smooth drilling from 56 to 58 feet., may be clayey sand.)	SM/ML	A3	10	D	18 19	12"/12"	17.0	120	10.5	3.6
60		SILTY SAND; Reddish brown, moist, dense to very dense, very, fine to coarse, slightly clayey with scattered 1/4 to 3/4-inch weathered gravel.	SM	A3	11	S	7 19 49	10"/18"	10.0			3.6
65		SILTY SAND; Brown, moist, dense, fine to coarse, variable silt content, with sand lens in sample. (Note: due to high organic reading in samples D-10 and S-11, shut rig down for 1 hour. Resume work afterwards.)	SM	A3	12	D	21 30	12"/12"	20.0	117	14.4	10.0
70												

FIGURE A-10. LOG OF BORING LPE-12

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

Project Number: 88-429 | Borehole Number: LPE-12 | 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)
		SILTY SAND; Brown, very moist, very dense, very fine to coarse, trace slightly plastic fines, upper half of sample more silt, lower half fine to coarse sand.	SM	A3	13	S	16 40 55/5"	8"/17"	22.0			10.0
		(Drill chatter from 74 to 75 feet.)										
75		SILTY SAND; Brown, very moist, dense to very dense, fine to coarse, micaceous, trace very fine gravel, upper 3 rings indicate medium to coarse.	SM	A3	14	D	42 43	9"/12"	30.0	110	7.2	14.0
		(Driller notes soft drilling, may be clay just short of 80 feet.										
80		SANDY SILT; Brown to reddish brown, moist, dense, slightly plastic, very fine sand, micaceous. Sand become coarser in lower portion.	ML	A4	15	S S	5 8 12	15"/18"	12.0			12.0
85		CLAYEY SAND/SANDY CLAY; Reddish brown, moist, stiff to hard, moderately plastic, very fine to medium sand with trace of coarse sand, 1-inch size stone at top of sample.	SC/CL	A4	16	D	12 19	12"/12"	12.0			12.0
90		(Driller notes gravel at 89 feet.) CLAYEY SAND; Reddish brown, moist, dense, slightly to moderately plastic fines, fine to coarse sand, micaceous, occasional red colorations, trace very fine gravel.	SC	A4	17	S	15 31 34	13"/18"	5.0			5.0
95		SILTY SAND; Reddish brown, moist, dense, fine to coarse, moderately plastic fines.	SM	A3	18	D	24 47	9"/12"	4.6	124	14.5	4.4
100		BORING TERMINATED AT 96 FEET. NOTE: This borehole log is based on field classifiaction 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 soil types and the transition may be gradual.										
105												
110												

FIGURE A-3. LOG OF BORING LPE-4

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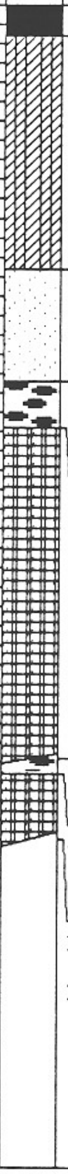
Project Name: METRO RAIL MOS-2 ALIGNMENT - LOS ANGELES	
Project Number: 88-429	Borehole Number: LPE-4 — Sheet 1 of 2
Borehole Location: Vermont and Beverly Blvd.	Elevation and Datum(feet): 284.5
Health and Safety: Level D	Date Started: 9/28/88 — Date Finished: 9/28/88
Drilling Equipment: Failing 750	Total Depth (feet): 21.5 — Depth to Bedrock(feet): 11.0
Drilling Method: Rotary Wash	Borehole Diameter: 5-inch
Drilling Fluid: Bentonie 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: G.R. Allen — Checked By: C. M. Payne



				Samples							
Depth (feet)	Description	USCS Classification	Geologic Unit	Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
	8-inch ASPHALT CONCRETE.										
	SILTY CLAY; Very dark grayish brown, moist, stiff, with fine to coarse sand.	SC	FILL	1	B			6.0			5.3
5	CLAYEY SAND; Dark yellowish brown, moist, medium dense, fine to medium, moderately plastic fines.			2	B			5.3			5.3
	(Material becoming sandier. Probably sand.)										
10	(Gravel in cuttings.)	GP	A3								
	(Attempted sampling at 10 feet. SPT would not penetrate. Attempted drilling. Drill chatter. Switched to rock bit.)		Tpw	3	S	12 16 25	18"/18"	6.3			6.3
	TOP OF PUENTE FORMATION. CLAYEY SILTSTONE; Yellowish brown, moist, very stiff, with very fine Sandstone. Distinct fine bedding, oxidized. Dip approximately 15 deg.										
15	CLAYEY SILTSTONE; Yellowish brown, wet, oxidized, with widely spaced thin beds of very fine fine sandstone. Dip approximately 10 deg.		Tpw	4	D	11 13	12"/12"	100.0			6.6
20	GRAVEL. (Excessive drill chatter.)		Tpw	5	S	15 21 27	18"/18"	6.5			6.3
	CLAYEY SILTSTONE; Dark yellowish brown, moist, dense, finely laminated, oxidized. Interbedded with fine sandstone. Dip approximately 15 deg.										
25	BORING TERMINATED AT 21-1/2 FEET DUE TO HYDROCARBON ODOR. HOLE GROUTED. 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										
30											

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FIGURE A-3. LOG OF BORING LPE-4

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

Project Number: **88-429** Borehole Number: **LPE-4** Sheet 2 of 2

Depth (feet)	Lith-ology	Description	USCS Classification	Geologic Unit	Samples							Background OVA (ppm)
					Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	
		encountered. The stratification lines represent the approximate boundary between subsurface material types and the transition may be gradual.										
35												
40												
45												
50												
55												
60												
65												
70												

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FIGURE A-3A. LOG OF BORING LPE-4A

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

Project Number: 88-429
Borehole Number: **LPE-4A**
Sheet 1 of 1

Borehole Location: Vermont and Beverly Blvd.
Elevation and Datum(feet): 294.5

Health and Safety: Level D
Date Started: 10/9/88
Date Finished: 10/9/88

Drilling Equipment: Failing 750
Total Depth (feet): 11.5
Depth to Bedrock(feet): 10.5

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 24-inch drop.

Logged By: C. M. Payne
Checked By: C. Duckworth

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)
		4-inch ASPHALT CONCRETE and base couse materials.										
		CLAYEY SILT; Dark brown, moist, firm with brick and concrete fragments. Fill material.	ML	FILL								
5		CLAYEY SILT; Browniish gray, moist, plastic, with rock fragments at 4 feet. CLAYEY SILT; Brown, moist, with rock and brick fragments at 5-1/2 feet. CLAYEY SILT; mixed with brick and bedrock fragments, and paint chips at 8 feet. (Drive casing to 8-1/2 feet. Switch to rotary wash with drag bit.)	ML	FILL								
10		SAND; Medium gray, moist to wet, medium dense, fine to medium, slightly silty, weathered. Strong gasoline odor from the sample.	SP	A3	1	S	3 5 13	14"/18"	1000.0			
15		BORING TERMINATED AT 11-1/2 FEET DUE TO HIGH OVA READING. HOLE GROUTED. 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.										
20												
25												
30												

FIGURE A-3B. LOG OF BORING LPE-4B

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

Project Number: 88-429 | Borehole Number: LPE-4B | Sheet 1 of 3

Borehole Location: Vermont and Beverly Blvd. | Elevation and Datum(feet): 294.5

Health and Safety: Upgraded Level D | Date Started: 10/30/88 | Date Finished: 10/30/88

Drilling Equipment: Failing 750 | Total Depth (feet): 65.5 | Depth to Bedrock(feet): 15.0

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

Drilling Fluid: Bentonite Mud | Piezometer Installation: YES | Depth(feet) 65.5

Hammer Information:
SPT Hammer: 140-lb weight and 30-inch drop.
DOWNHOLE Hammer: 350-lb weight and 24-inch drop.

Logged By: C. M. Payne | Checked By: C. Duckworth

Depth (feet)	Lith-ology	Description	USCS Classification	Geologic Unit	Samples								Background OVA (ppm)
					Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	
	■	2-feet thick ASPHALT CONCRETE paving.										
	▩	SILTY CLAY; Dark brown to gray. Appears fill material.	CL	FILL								
	▥	CLAYEY SAND; Medium brown, moist, soft. Appears fill material.	SC	FILL								
5	▥	SILTY SAND; Yellowish brown, very fine to medium grained, slightly clayey.	SM	A3								
	░	SAND; Yellowish brown, fine to medium, slightly silty. (Start Rotary wash at 7-1/2 feet.) (Gravelly, medium to coarse sand in drill cuttings at 9 feet.)	SP	A3								
10	░	SAND-SILTY SAND; Yellowish brown, wet, medium dense, very fine to very coarse, slightly silty.	SP-SM	A3	1	S	11 23 30/.5"	12"/17"	8.5			6.8
		(Very heavy drill chatter from 11 to 11-1/2 feet, Gravel in cuttings.)	GP	A3								
	░	Yellowish brown clayey silt in drill cuttings at 12-1/2 feet. (Yellowish brown, stiff clayey sand/clayey silt in drill cuttings between 13 to 14 feet.)	SP-SM	A3								
15	▦	TOP OF PUENTE FORMATION CLAYEY SILTSTONE; Yellowish brown, wet, hard, plastic, oxidized, with widely spaced beds of gray, very fine to fine Sandstone. Dip approximately 15 deg.		Tpw	2	D	21 28	12"/12"	8.0			8.0
20	▦				3	S	14 20 28	0"/18"				8.0
	▦	CLAYEY SILTSTONE; Yellowish brown to gray, moist, hard, thinly bedded, moderately cemented, oxidized (moderately weathered), interbedded with widely spaced 1/8-inch thick beds of poorly cemented Sandstone. About 3 inches of white, soft chalk(?) at top of the sample.			4	S	12 38 34	12"/18"	8.0			
25	▦	Same as above except slightly weathered.		Tpw	5	D	24 46	12"/12"	8.5	87	33.5	8.0
30	▦	(Drill chatter from 29 to 31 feet.)										

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FIGURE A-3B. LOG OF BORING LPE-4B

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

Project Number: 88-429 | Borehole Number: LPE-4B | 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 SILTSTONE/SANDY SILTSTONE; Yellowish brown to gray, moist, hard, laminated, oxidized (moderately weathered) interbedded with very fine to fine sandstone.		Tpw	6	S	32 50	2"/12"	8.5			7.0
35		CLAYEY SILTSTONE; Grayish brown, moist, hard, laminated, oxidized (moderately weathered), with about 1/16-inch thick layers of very fine to fine sandstone. Dip approximately 10 deg.		Tpw	7	D	20 45	12"/12"	6.5	94	25.9	6.5
40		CLAYEY SILTSTONE; Olive gray, moist, hard, slightly plastic, micaceous, fresh, thinly bedded with very fine to fine sandstone lenses. Dip approximately 10 deg.		Tpf	8	S	14 35 50/4"	15"/16"	6.2			6.2
		(Hard drilling. Drill chatter at 44 feet.)										
45		CLAYEY SILTSTONE; Medium gray and brown, moist, hard, moderately to well cemented, laminated, fresh, interbedded with thin (about 1/16") very fine to fine sandstone beds. Dip approximately 10 deg. (Smooth fast drilling.)		Tpf	9	D	32 50/5"	11"/11"	6.2	102	25.3	5.6
50		Same as above(at 45 feet).		Tpf	10	P	Push 350psi	18"/18"	2.0			1.0
		(Moderately hard drilling, Cuttings indicate slightly indurated material.)										
55		Same as above(at 45 feet) except moderately hard Sandstone at top 3 to 4 inches of the sample.		Tpf	11	D	45 55/3"	9"/9"	2.0			2.0
60		CLAYEY SILTSTONE; Dark gray, moist, very stiff, moderately to well cemented, fresh, interbedded with very stiff Sandstone.		Tpf	12	P	Push 350psi	6"/7"	1.5			1.5
		(Softer, faster drilling.)										
65		Same as above.		Tpf	13	D	75 25/1"	7"/7"	1.5	97	25.7	1.0
70		BORING TERMINATED AT 65-1/2 FEET. INSTALLED A PIEZOMETER. NOTE: This borehole log is based on field classification and visual soil description, and is further modified to include laboratory classification tests, where available. This summary applies only at the location of this										

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FIGURE A-3B. LOG OF BORING LPE-4B

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

Project Number: 88-429 | Borehole Number: **LPE-4B** | Sheet 3 of 3

Depth (feet)	Lith-ology	Description	USCS Classification	Geologic Unit	Samples							Background OVA (ppm)
					Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	
		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												

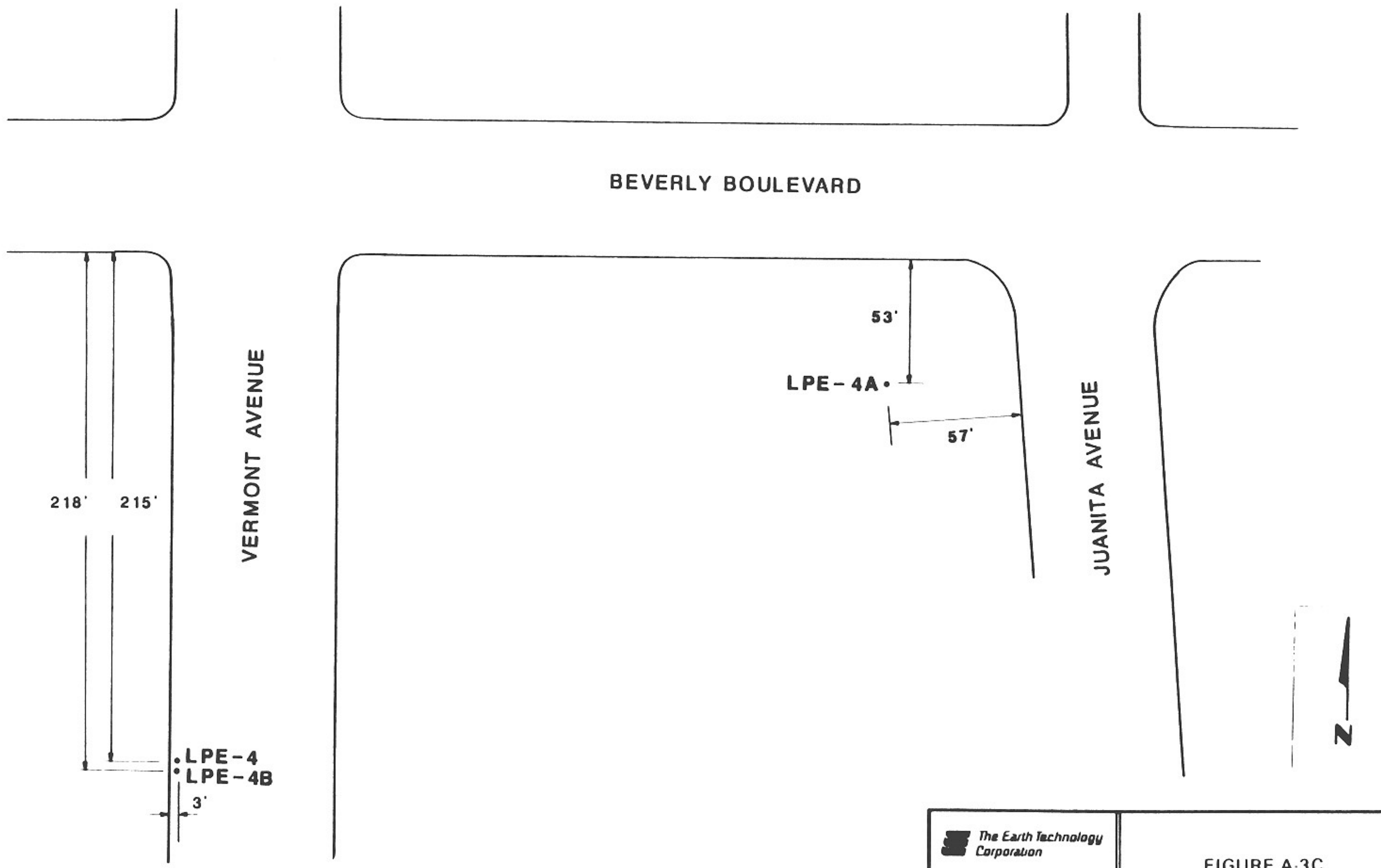

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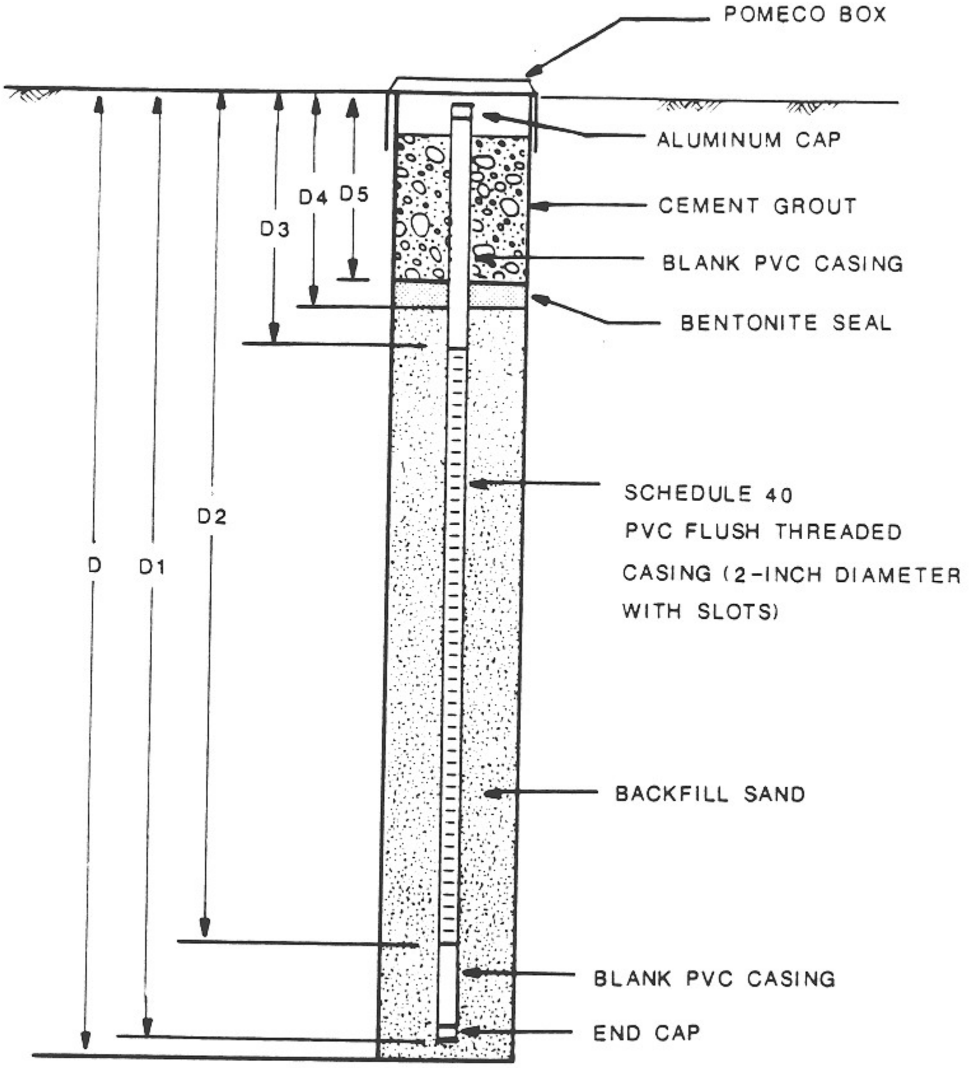
FIGURE A-3C

LOCATIONS OF BORINGS
LPE-4, 4A AND 4B



TOTAL DEPTH (D)	=	FEET
DEPTH TO BOTTOM OF CASING (D1)	=	FEET
DEPTH TO BOTTOM OF WELL SCREEN (D2)	=	FEET
DEPTH TO TOP OF WELL SCREEN (D3)	= 15	FEET
DEPTH TO BOTTOM OF BENTONITE SEAL (D4)	= 10	FEET
DEPTH TO TOP OF BENTONITE SEAL (D5)	= 8	FEET
WELL SCREEN SLOT SIZE	= 0.01	INCH
BACKFILL SAND TYPE	= NO.2	MONTEREY

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FIGURE A-3D

PIEZOMETER DIAGRAM LPE-4B

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FIGURE A-4. 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)	Lith-ology	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. (Sandier at 12 feet.)	SM	A3	2	S	15 15 18	13"/18"	4.7			4.4
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												

FIGURE A-4. LOG OF BORING LPE-6

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

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

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)
		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
		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.										
65												
70												

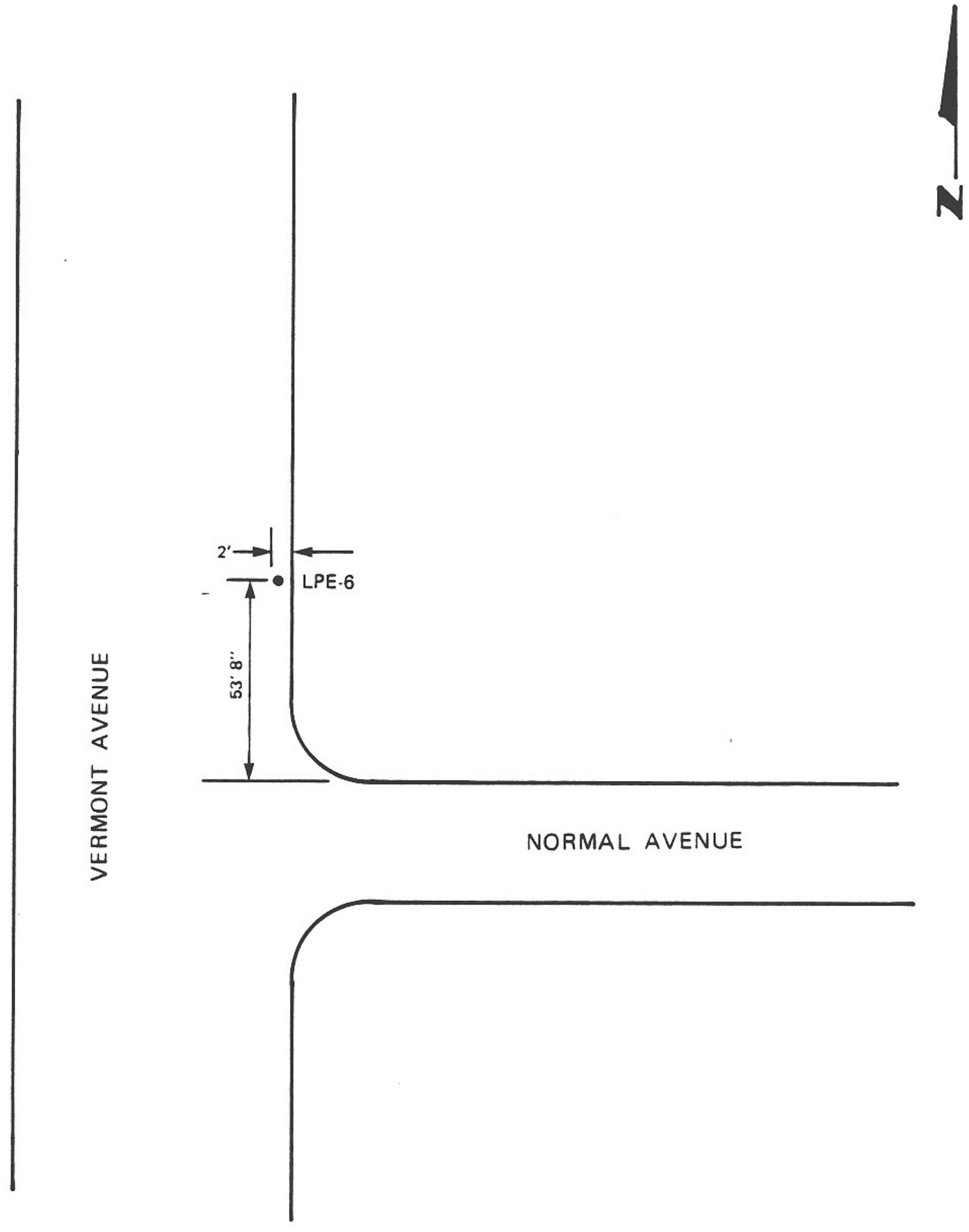

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FIGURE A-4A

LOCATION BORING LPE-6

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FIGURE A-5. 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)	Lith-ology	Description	USCS Classification	Geologic Unit	Samples: 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.)										

FIGURE A-5. 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 OVA (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	12.0
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												

FIGURE A-5. 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 80		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.										
85												
90												
95												
100												
105												
110												

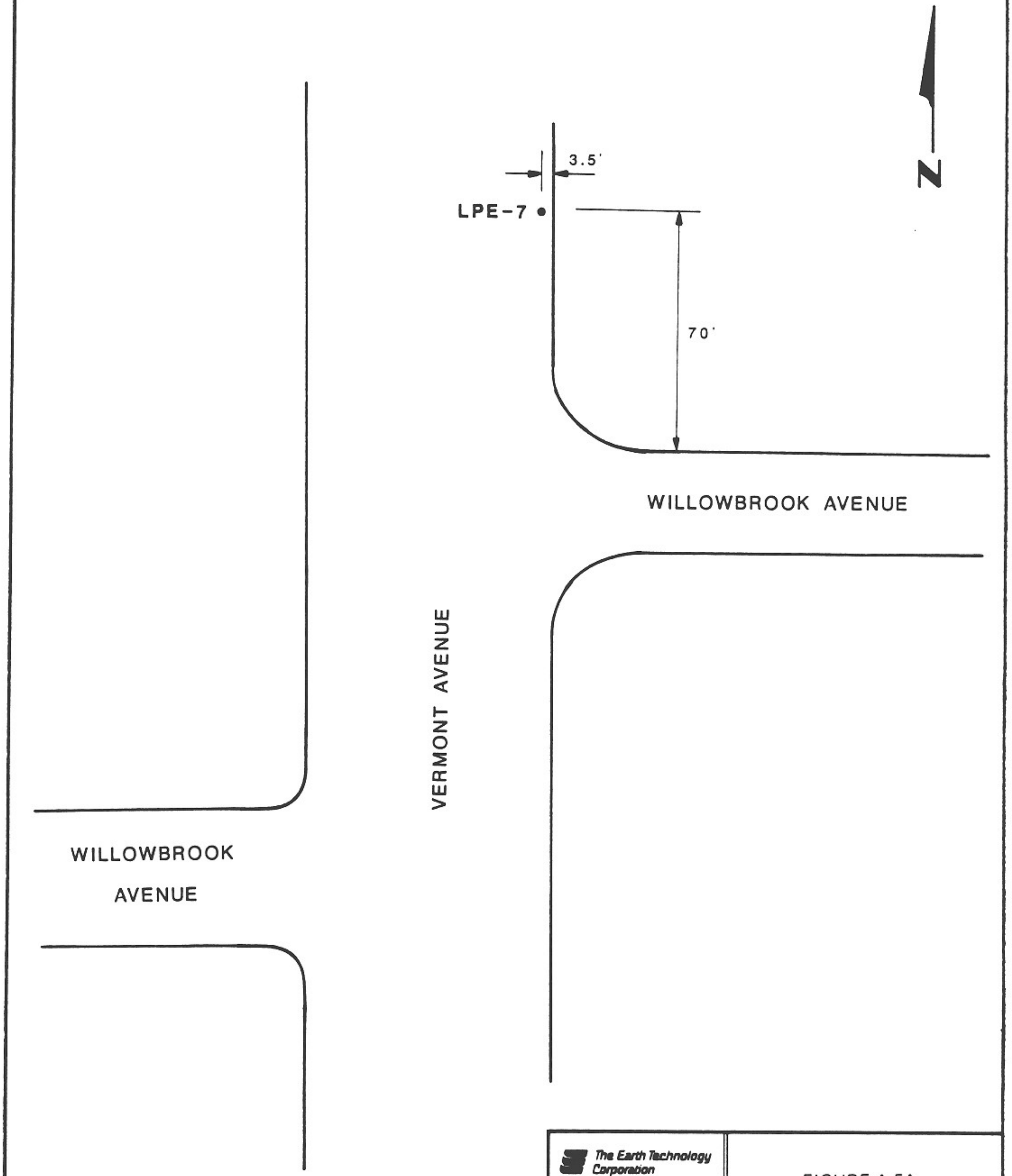

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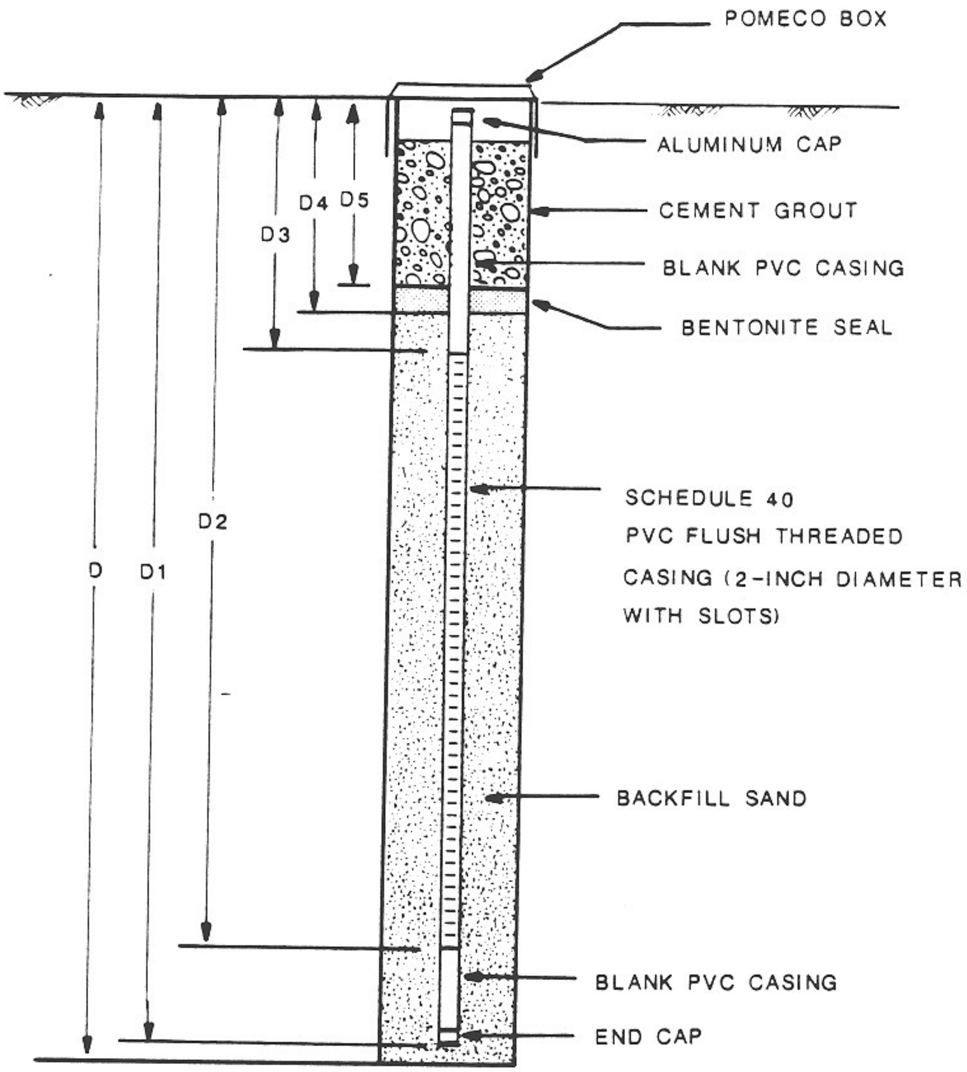
FIGURE A-5A

LOCATION OF BORING LPE-7



TOTAL DEPTH (D) = 72.7 FEET
DEPTH TO BOTTOM OF CASING (D1) = 70.7 FEET
DEPTH TO BOTTOM OF WELL SCREEN (D2) = 70.7 FEET
DEPTH TO TOP OF WELL SCREEN (D3) = 15 FEET
DEPTH TO BOTTOM OF BENTONITE SEAL (D4) = 12.8 FEET
DEPTH TO TOP OF BENTONITE SEAL (D5) = 10.9 FEET
WELL SCREEN SLOT SIZE = 0.02 INCH
BACKFILL SAND TYPE = NO.3 MONTEREY

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FIGURE A-5B

PIEZOMETER DIAGRAM LPE-7

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FIGURE A-6. LOG OF BORING LPE-8

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

Project Number: **88-429** Borehole Number: **LPE-8** Sheet 1 of 3

Borehole Location: **Vermont and Delonpre.** Elevation and Datum(feet): **377.0**

Health and Safety: **Level D** Date Started: **10/7/88** Date Finished: **10/8/88**

Drilling Equipment: **Failing 750** Total Depth (feet): **71.0** Depth to Bedrock(feet): **19.5**

Drilling Method: **Rotary wash** Borehole Diameter: **5-inch**

Drilling Fluid: **Bentonite Mud** Piezometer Installation: **YES** Depth(feet):**71.0**

Hammer Information:
SPT Hammer: 140-lb weight and 30-inch drop.
DOWNHOLE Hammer: 365-lb weight and 18-inch drop.

Logged By: **C. M. Payne** Checked By: **C. Duckworth**

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)
		6 to 7-inch of ASPHALT CONCRETE.										
		SAND-SILT; multi colored, coarse sand with minor clay. Fill material. (Yellowish brown rock fargments; appears layered.)	SP/ SP-SM/ ML	FILL								
5		CLAYEY SAND; Medium brown, moist, very dense and stiff, fine to coarse, very massive. Appears native. (Set casing to 8-1/2 feet. Switch to Rotary wash with drag bit.)										
10		CLAYEY SAND; Reddish brown, moist, dense and stiff, fine to coarse, moderately plastic fines, massive. (Very clayey cuttings at 12 feet.)	SC	A4	1	S	7 11 15	18"/18"	5.0			5.3
15		SILTY CLAY; Yellowish brown, moist, hard, with minor sand and completely weathered, scattered, massive, angular silt(stone) clasts.	CL	A4	2	D	15 20	12"/12"	4.9	102	23.6	5.3
20		TOP OF PUENTE FORMATION. (Driller reported stiffer layer. Probably Siltstone.) CLAYEY SILTSTONE; Mottled yellowish brown and gray, moist, hard, completely weathered, massive, micaceous, no structure. (Slow smooth drilling at 22 feet.)		Tpw	3	S	8 13 23	10"/18"	5.4			5.6
25		CLAYEY SILTSTONE; Yellowish brown and gray, moist, hard, laminated, oxidized, micaceous, fractured (1/2 to 1-inch apart) with minor very fine sand. Dip approximately 5 deg. (Driller reported thin streaks of siliceous siltstone at 27 feet.) (Hard shale chips in cuttings.)		Tpw	4	D	16 30	12"/12"	5.5			5.6
30												

FIGURE A-6. LOG OF BORING LPE-8

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

Project Number: **88-429** Borehole Number: **LPE-8** 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 SILTSTONE; Brownish yellow to olive yellow, moist, hard, slightly plastic, oxidized, fractured(1/4 to 1/2-inch apart), iron stained, interbedded with very fine to fine Sand(stone) beds. Beds are 1-inch thick and 2-inch apart. Dip approximately 5 deg.		Tpw	5	S	16 28 38	18"/18"	5.3			5.6
35		CLAYEY SILTSTONE; Medium gray, moist, hard, laminated, oxidized (moderately weathered), micaceous with iron stains, fractures at about 2-inch apart.		Tpw	6	D	18 36	12"/12"	5.4	85	35.3	5.6
40		CLAYEY SILTSTONE; Pale olive, moist, hard, slightly plastic, oxidized (moderately weathered), micaceous, interbedded with widely spaced siliceous Siltstone. Few widely spaced fractures. Iron stains on hard beds and fractures. (Drill chatter - Thin siliceous bed.)		Tpw	7	S	18 24 29	16"/18"	5.2			5.6
45		CLAYEY SILTSTONE; Medium gray and brown, moist, hard, oxidized (moderately weathered), micaceous, interbedded with 1/2 to 3/4-inch thick, very hard, siliceous Siltstone and Shale. Fractures at 1/2 to 1-inch spacing. Iron stains on fractures(oxidized). (Excessive drill chatter.)		Tpw	8	D	40 55	12"/12"	5.0	83	36.8	6.0
50		CLAYEY SILTSTONE; Pale olive, moist, hard, slightly plastic, thinly bedded to laminated, oxidized (moderately weathered), micaceous, with minor very fine to fine Sandstone and thin silicious Siltstone beds. Iron stains on widely spaced open fractures. Dip approximately 5 deg.		Tpw	9	S	18 34 40	18"/18"	5.2			6.0
55		CLAYEY SILTSTONE; Medium gray and black, moist, hard, laminated, micaceous, fresh, with interbedded thin beds of light gray, very fine to fine Sandstone. Horizontal bedding. (Drill chatter between 56-1/2 and 57-1/2 feet.)		Tpf	10	D	44 56/5"	11"/11"	5.3	99	25.2	6.0
60		CLAYEY SILTSTONE; Dark olive gray and brownish yellow, moist, hard, slightly plastic, laminated, fresh to slightly weathered, micaceous, thinly bedded(4 to 5-inch apart) with about 1-inch thick, iron stained(reddish brown), very fine to fine sandstone beds. Dip less than 5 deg.		Tpf	11	S	22 39 50/5"	17"/17"	5.2			6.0
65		CLAYEY SILTSTONE; Dark to medium gray, moist, hard, slightly plastic, laminated, fresh, micaceous, interbedded with 1/16 to 1/18-inch thick, medium gray, very fine to fine sandstone. No fractures. Dip less than 5 deg.		Tpf	12	D	65 35/3"	9"/9"	5.4	105	22.3	6.0
70							39					

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FIGURE A-6. LOG OF BORING LPE-8

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

Project Number: 88-429 | Borehole Number: LPE-8 | 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	13	S	50/3.5"	9.5/9.5"	6.0			6.0
		BORING TERMINATED AT 70 FEET 9-1/2 INCHES. PIEZOMETER INSTALLED. 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 transition the approximate boundary between subsurface material types and the transition may be gradual.										
75												
80												
85												
90												
95												
100												
105												
110												

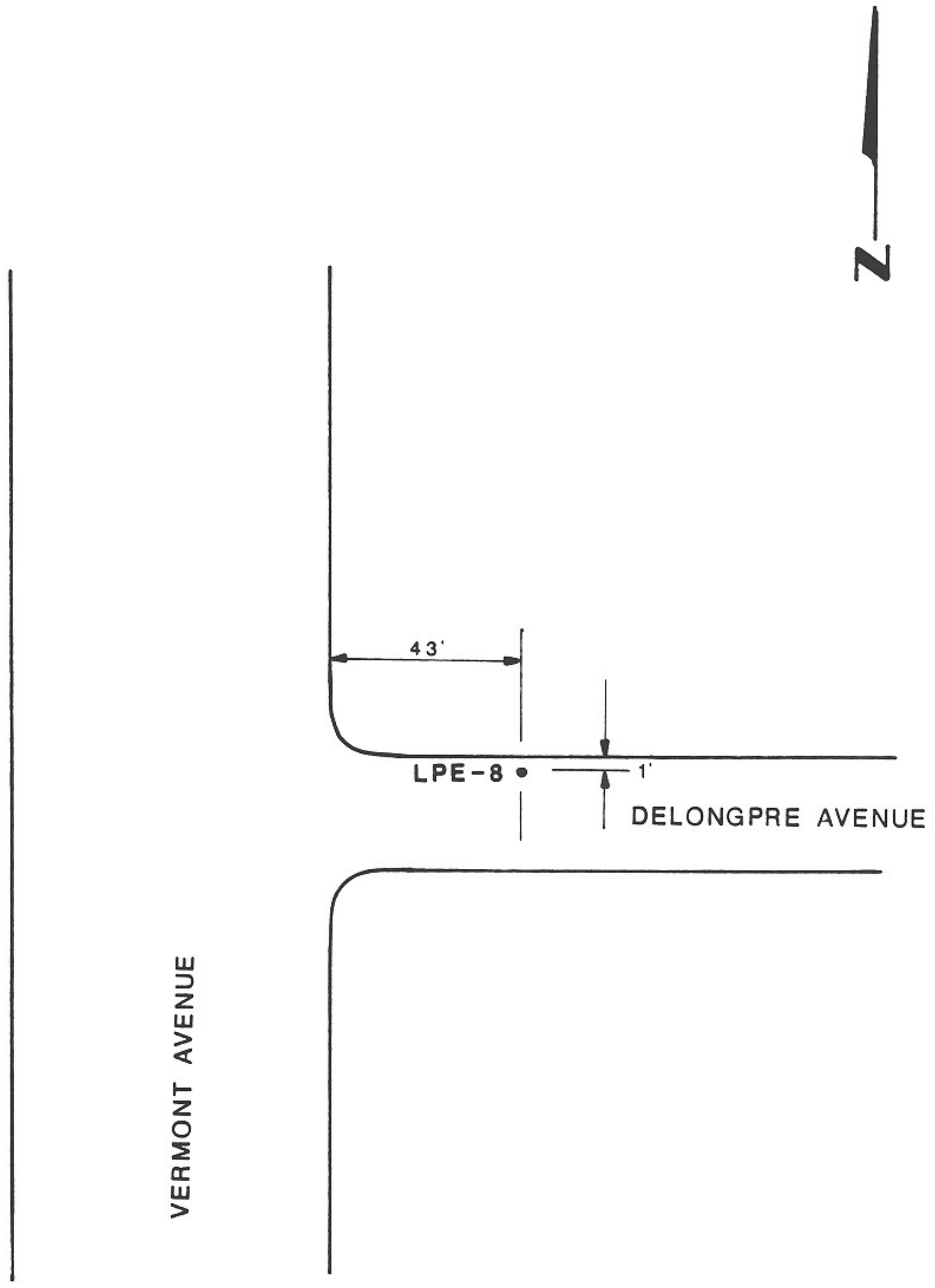

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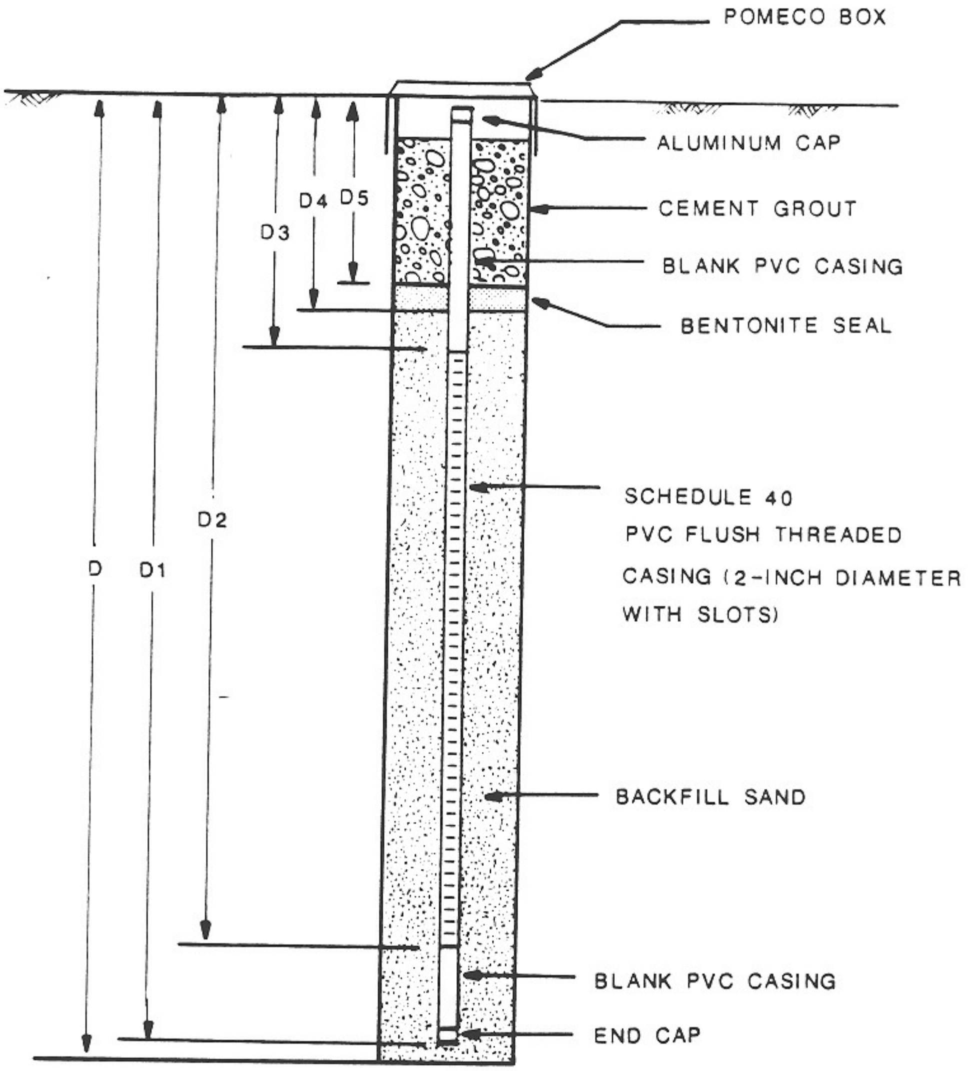
FIGURE A-6A

LOCATION OF BORING LPE-8



TOTAL DEPTH (D)	= 70.8	FEET
DEPTH TO BOTTOM OF CASING (D1)	= 68.8	FEET
DEPTH TO BOTTOM OF WELL SCREEN (D2)	= 68.8	FEET
DEPTH TO TOP OF WELL SCREEN (D3)	= 13	FEET
DEPTH TO BOTTOM OF BENTONITE SEAL (D4)	= 11	FEET
DEPTH TO TOP OF BENTONITE SEAL (D5)	= 9	FEET
WELL SCREEN SLOT SIZE	= 0.01	INCH
BACKFILL SAND TYPE	= NO.2	MONTEREY

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FIGURE A-6B

PIEZOMETER DIAGRAM LPE-8

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FIGURE A-7. LOG OF BORING LPE-9

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

Project Number: 88-429

Borehole Number: LPE-9

Sheet 1 of 2

Borehole Location: Edgemont and Hollywood

Elevation and Datum(feet): 408.5

Health and Safety: Level D

Date Started: 9/24/88

Date Finished: 9/24/88

Drilling Equipment: Failing-750

Total Depth (feet): 61.5

Depth to Bedrock(feet):

Drilling Method: Rotary Wash

Borehole Diameter: 5-inch

Drilling Fluid: Bentonie Mud

Piezometer Installation: NO

Depth(feet): --

Hammer Information:
SPT Hammer: 140-lb weight and 30-inch drop;
DOWNHOLE Hammer: 365-lb weight and 18-inch drop.

Logged By: FJE

Checked By: C. M. Payne

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)
		9-inch ASPHALT CONCRETE.										
		(Clayey sand in cuttings at 2-1/2 feet.)										
5		CLAYEY SAND; Reddish brown, moist, fine to coarse, moderately plastic fines.	SC	A2	1	B						
		(Easy drilling.)										
10		CLAYEY SAND; Reddish brown, moist, dense, fine to coarse, moderately plastic fines, some gravel at top of sample up to 1/4 to 1/2-inch size. Zone from 10.9 to 11.3 feet with less sand and more clay.	SC	A2	2	S	7 10 14	12"/18"	3.9			3.8
15		SANDY CLAY/CLAYEY SAND; Brown, moist, very stiff, fine to coarse sand, moderately plastic fines. More fines at tip.	SC/CL	A2	3	D	7 8 9	12"/18"	12.0	110	19.7	3.8
		(More clay, less sand in cuttings at 18-1/2 feet.)										
20		SANDY CLAY; Brown, moist, very stiff, moderately plastic.	CL	A4	4	S	9 12 19	16"/18"	4.2			3.8
25		Same as above.	CL	A4	5	D	18 24	12"/12"	4.4	124	11.8	3.8
30												

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FIGURE A-7. LOG OF BORING LPE-9

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

Project Number: 88-429 Borehole Number: **LPE-9** Sheet 2 of 2

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 SAND; Reddish brown, moist, dense, fine to coarse, moderately plastic fines with mica and one piece of 1/2-inch gravel at top of sample.	SC	A4	6	S	10 14 23	12"/18"	7.2			3.8
35	▨	(Color change.) CLAYEY SAND; Green-gray, moist, dense, fine to coarse, moderately plastic fines.	SC	A4	7	D	12 23	12"/12"	13.0	122	13.1	3.8
40	░	SILTY SAND; Gray, moist, dense to very dense, fine to coarse, moderately plastic fines.	SM	A3	8	S	15 22 24	15"/18"	25.0			3.8
45	▩	(Color change.) CLAYEY SAND / SANDY CLAY; Brown, moist, medium dense to dense, coarse to fine, moderately plastic fines.	SC/CL	A4	9	D	14 14	12"/12"	4.8	120	15.0	3.8
50	▨	CLAYEY SAND; Reddish brown, moist, dense, fine to coarse, moderately plastic fines with mica.	SC	A4	10	S	25 19 20	16"/18"	4.8			3.8
55	▨	CLAYEY SAND; Grayish brown, moist, dense, fine to coarse, moderately plastic fines, brown at top, grayish brown at lower portion, coarser at top.	SC	A4	11	D	22 28	12"/12"	4.8	123	13.3	3.8
60	▨	(Easier drilling.) CLAYEY SAND; brown, moist, medium dense to dense, fine to coarse, moderately plastic fines with mica, grading down to finer sand and more fines at bottom.	SC	A4	12	S	11 12 21	12"/18"	10.5			10.5
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 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 the subsurface material types and the transition may be gradual.										
70												

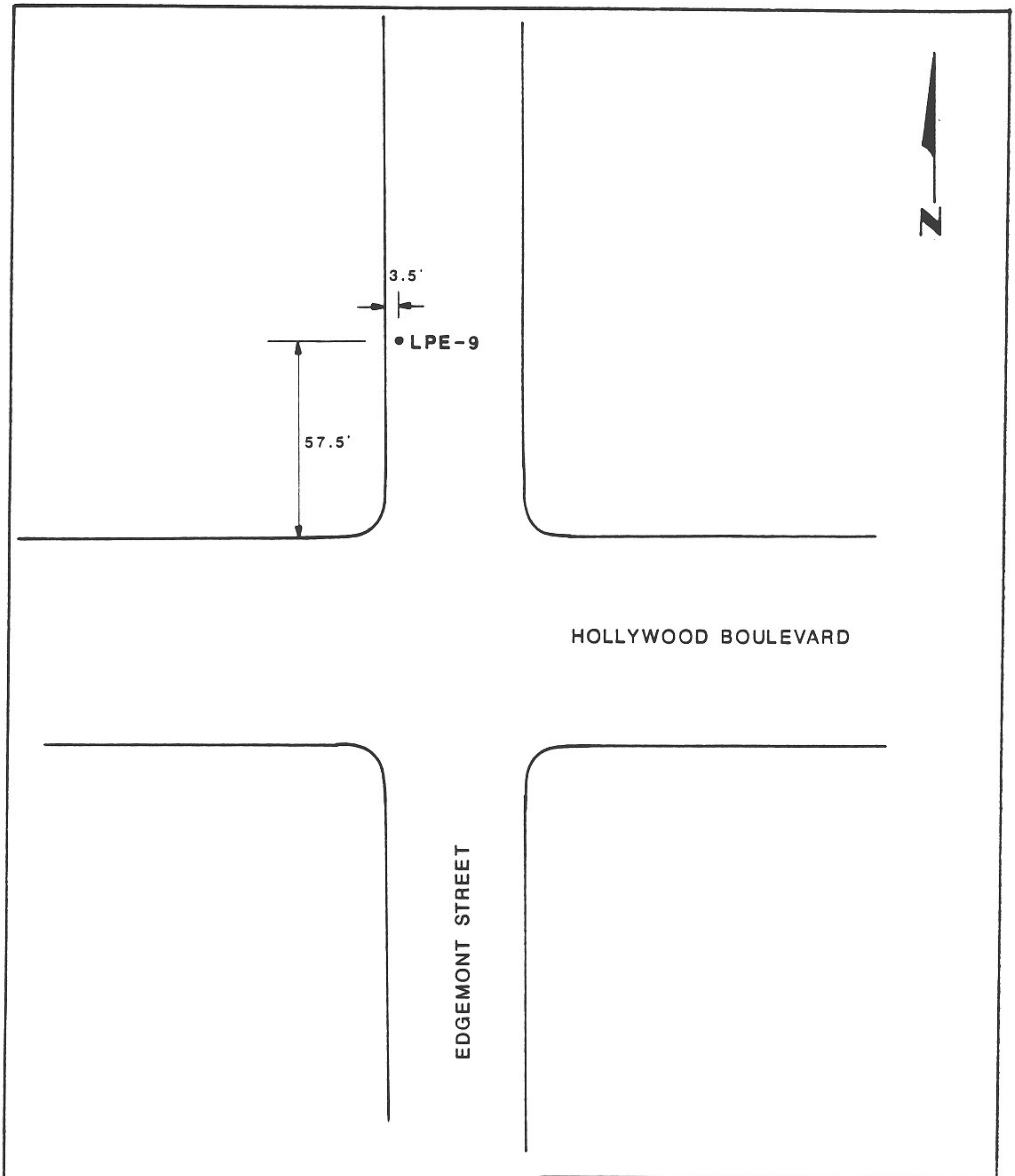

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FIGURE A-7A

LOCATION OF BORING LPE-9

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FIGURE A-8. LOG OF BORING LPE-10

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

Project Number: **88-429**

Borehole Number: **LPE-10**

Sheet 1 of 3

Borehole Location: **Winona and Hollywood**

Elevation and Datum(feet): **394.5**

Health and Safety: **Level D**

Date Started: **9/24/88**

Date Finished: **9/25/88**

Drilling Equipment: **Failing 750**

Total Depth (feet): **91.0**

Depth to Bedrock(feet):

Drilling Method: **Rotary Wash**

Borehole Diameter: **5-inch**

Drilling Fluid: **Bentonie Mud**

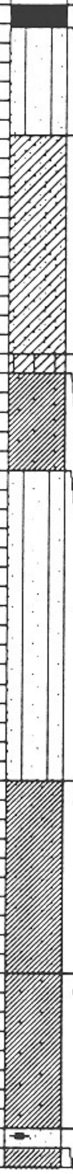
Piezometer Installation: **Yes**

Depth(feet) **91.0**

Hammer Information:
SPT Hammer: 140-lb weight and 30-inch drop,
DOWNHOLE Hammer: 365-lb weight and 18-inch drop.

Logged By: **C.M.Payne**

Checked By: **C. Duckworth**



Depth (feet)	Description	USCS Classification	Geologic Unit	Samples							Background OVA (ppm)
				Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	
	7-inch ASPHALT CONCRETE.										
	SILTY SAND; Dark yellowish brown, moist, loose, fine to medium, micaceous, organic odor. Probably fill material.	SM	FILL	1	B			2.4			2.4
	(Dark brown clayey sand in cuttings. Appears native.)										
5	CLAYEY SAND; dark brown, moist, medium stiff, very fine to fine, non-porous, with silt. (Fast, easy smooth drilling.)	SC	A2	2	D	5 8	12"/12"	3.0	98	24.1	2.5
		ML	A2								
10	(Fast drilling. Clayey silt in cuttings.)										
	(Slightly sandy (very fine to fine grained).) CLAY; brown, moist, medium stiff, moderately plastic fines, very fine sand, silty.	CL	A2	3	S	2 3 4	9"/18"	3.4			3.4
	SILTY SAND.										
15	SILTY SAND; Brown, moist, loose to medium loose, fine to coarse, well sorted. (Easy fast drilling.) (Sandy clay in cuttings at 17 feet.)	SM	A1	4	D	3 3 6	18"/18"	3.5	112	15.8	3.7
		SM	A1								
20	SANDY CLAY; Brown, moist, hard, fine to coarse sand. (Fast drilling using drag bit.)	CL	A4	5	S	12 26 33	6"/18"	3.3			3.3
25	CLAYEY SAND/SANDY CLAY; Dark yellowish brown, moist, hard, very fine to coarse sand.	SC/CL	A4	6	D	12 20	12"/12"	3.4	106	22.8	3.4
		SP	A3								
30	(Driller reports 6-inch gravelly sand lens at 29 feet.)										

FIGURE A-8. LOG OF BORING LPE-10

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

Project Number: 88-429 Borehole Number: LPE-10 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)
		SANDY CLAY; Dark yellowish brown, moist, hard, massive, very fine to fine sand, very weathered equal parts of sand, silt and clay with occasional black stringers.	CL	A4	7	S	18 35 55	14"/18"	4.0			4.0
35		CLAYEY SAND; Brown, moist, hard, fine to coarse sand, appears layered, weathered. Grading to silty sand at tip. (Still drilling with drag bit.)	SC	A4	8	D	19 27	12"/12"	4.4	121	13.9	4.4
40		CLAYEY SAND/SANDY CLAY; Dark yellowish brown, moist, hard/very dense, moderately plastic fines, fine to coarse sand.	SC/CL	A4	9	S	12 16 22	12"/18"	4.9			4.9
45		CLAYEY SAND with SILT; Brown, moist, dense, very fine (slightly plastic) to coarse, appears interlayered, equal parts of clayey sand and silt, contacts gradational sand with some irregular light gray zones (slightly mottled).	SC	A4	10	D	17 20	12"/12"	5.0	118	16.5	5.0
50		SANDY CLAY; Reddish brown, gray, moist, very stiff, massive, with trace very fine angular gravel.	CL	A4	11	S	9 17 24	18"/18"	4.7			4.7
55		(Gravel in drill cuttings from 54 to 55 feet.) SILTY GRAVEL; Brown, moist, dense to very dense, appears angular, compacted dense clasts to 1-1/2 inches, mostly very weathered, consists of sandstone granitices and volcanic rocks. Also sandy and clayey matrix in addition to the silt.	GM	A3	12	D	40 60	12"/12"	5.6	123	15.4	5.2
60		CLAYEY SAND/SANDY CLAY; Brown, moist, hard, fine to coarse well graded sand, appears massive. (Slow, easy, smooth drilling; switched to rock bit.)	SC/CL	A4	13	S	7 21 25	18"/18"	5.6			5.2
65		CLAYEY SAND/SANDY CLAY; Brown, moist, hard, very fine to very coarse sand, weathered.	SC/CL	A4	14	D	17 20	12"/12"	7.9	112	18.2	5.2
70												

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FIGURE A-8. LOG OF BORING LPE-10

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

Project Number: 88-429

Borehole Number: LPE-10

Sheet 3 of 3

Depth (feet)	Lith-ology	Description	USCS Classification	Geologic Unit	Samples: Number	Samples: Type	Samples: Blow Count	Samples: Recovery	Samples: OVA (ppm)	Samples: Dry Density (pcf)	Samples: Moisture Content (%)	Samples: Background OVA (ppm)
		CLAYEY SAND; Dark yellowish brown, very moist, dense to very dense, fine to coarse, micaceous, with some very fine gravel. Consists of a 3-inch silty sand lens in middle of sample. (Slow, smooth drilling.)	SC	A4	15	S	12 38 30	18"/18"	2.9			1.8
75		Same as above, appears interbedded with 2 to 3-inch thick sandy lenses 2 to 3-inch thick interbedded; but is dominantly a clay sand with silt, a few 1/4 to 1/2-inch scattered gravel fragments.	SC	A4	16	D	17 22	12"/12"	3.0	108	21.0	1.8
80		SANDY CLAY; Reddish brown, moist, hard, about equal parts of sand, silt, and clay, massive, very fine to coarse sand. (Slow, smooth drilling.)	CL	A4	17	S	11 16 22	18"/18"	2.2			1.8
85		CLAYEY SAND; Brown, moist, very dense, fine to very, massive, very weathered, with silt. No signs of ground water yet.	SC	A4	18	D	38 50	12"/12"	2.0	109	20.2	1.8
		(Sandy cuttings at 89 feet.)										
90		CLAYEY SAND; Reddish brown, moist, very dense, fine to coarse, moderately plastic fines with silt binder.	SC	A4	19	S	28 50/5"	13"/13"	2.0			1.8
		BORING TERMINATED AT 91 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 boundary between subsurface material types and the transition may be gradual.										
95												
100												
105												
110												

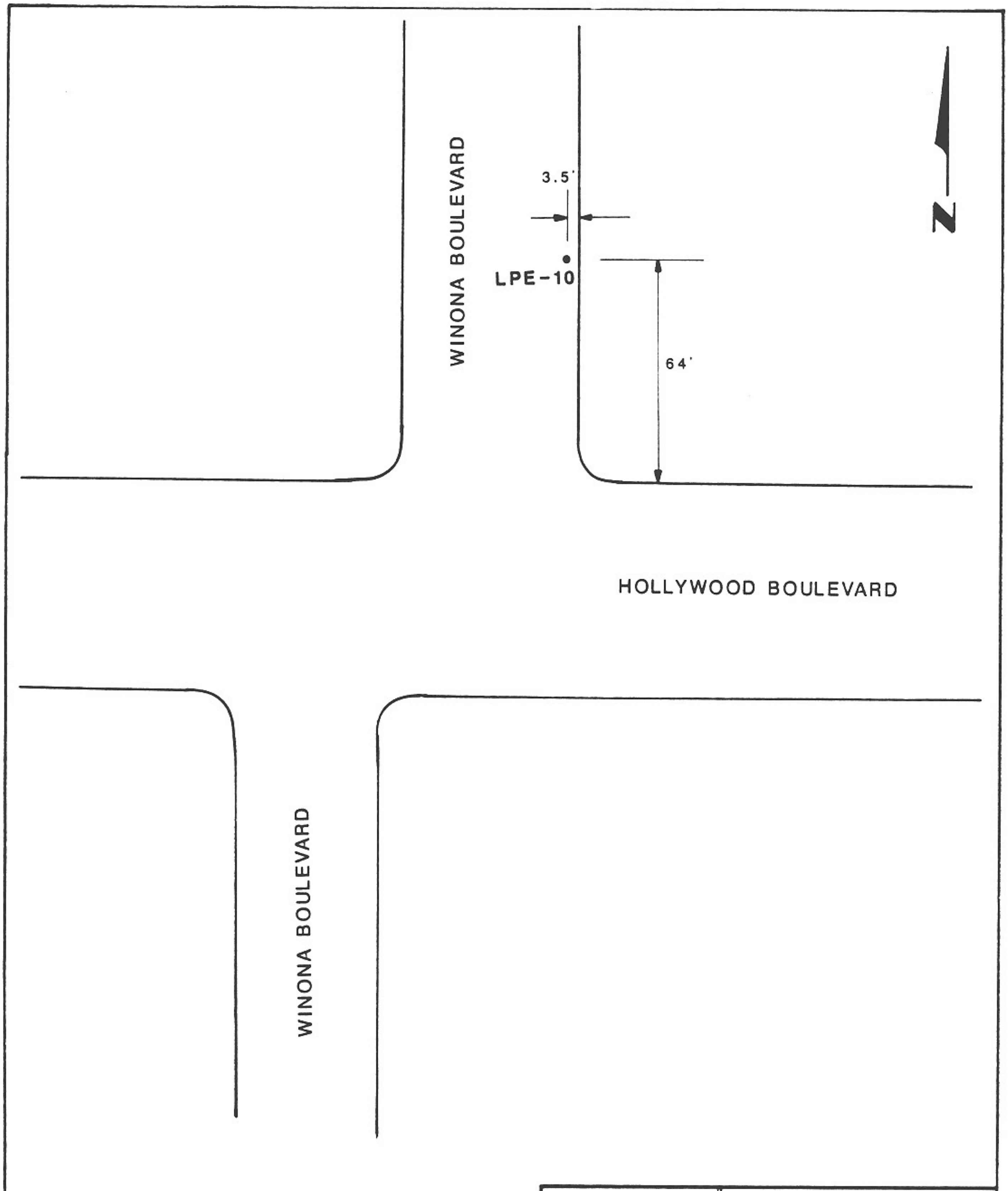

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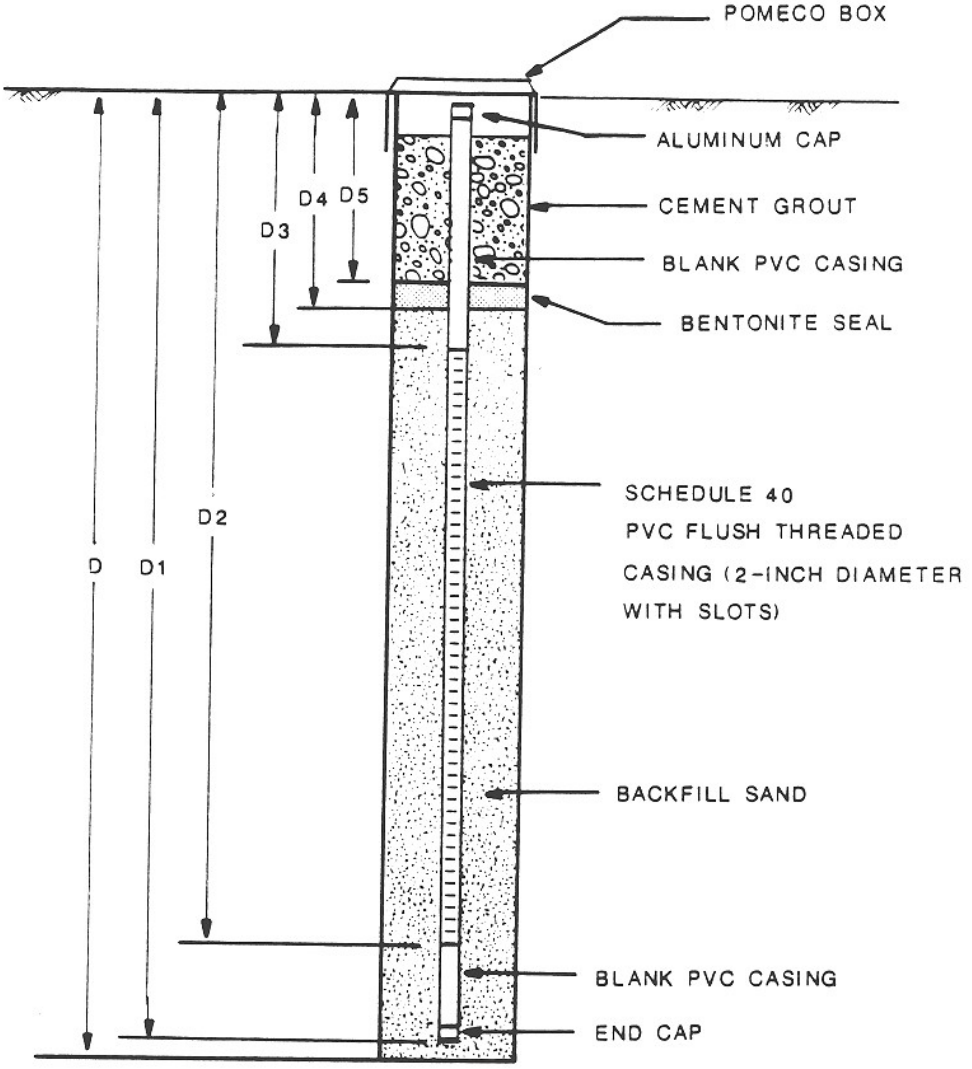
FIGURE A-8A

LOCATION OF BORING LPE-10



TOTAL DEPTH (D)	= 90	FEET
DEPTH TO BOTTOM OF CASING (D1)	= 88	FEET
DEPTH TO BOTTOM OF WELL SCREEN (D2)	= 88	FEET
DEPTH TO TOP OF WELL SCREEN (D3)	= 48	FEET
DEPTH TO BOTTOM OF BENTONITE SEAL (D4)	= 46	FEET
DEPTH TO TOP OF BENTONITE SEAL (D5)	= 44	FEET
WELL SCREEN SLOT SIZE	= 0.02	INCH
BACKFILL SAND TYPE	= NO.3	MONTEREY

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FIGURE A-8B

PIEZOMETER DIAGRAM LPE-10

FIGURE A-9. LOG OF BORING LPE-11

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

Project Number: 88-429 | Borehole Number: **LPE-11** | Sheet 1 of 3

Borehole Location: Hollywood and Western. | Elevation and Datum(feet): 395.0

Health and Safety: Level D | Date Started: 9/24/88 | Date Finished: 9/25/88

Drilling Equipment: Failing 750 | Total Depth (feet): 96.0 | Depth to Bedrock(feet):

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

Drilling Fluid: | Piezometer Installation: YES. | Depth(feet) 96.0

Hammer Information:
SPT Hammer: 140-lb weight and 30-inch drop.
DOWNHOLE Hammer: 365-lb weight and 18-inch drop.

Logged By: FJE | Checked By: C. M. Payne

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)
		8-inch ASPHALT CONCRETE.										
		SANDY SILT; Brown, moist, stiff, some clay.	ML	A1								
5		SANDY CLAY; Brown, moist, stiff, slightly plastic fines, fine to coarse sand.	CL	A2	1	B						
10		SILTY SAND; Brown, moist, loose to medium dense, trace clay and gravel up to 1/4-inch size.	SM	A1	2	S	3 4 5	12"/18"	4.8			5.2
15		SILTY SAND; Brown, moist, medium dense, fine to coarse.	SM	A1	3	D	7 6 5	16"/18"	7.8	106	11.6	4.8
20		SANDY SILT; Dark yellowish brown, moist, medium dense, slightly plastic fines, fine sand with trace medium to coarse sand.	ML	A1	4	S	5 7 8	8.5"/18"	5.8			5.7
		(Becoming sandier.)										
25		SILTY SAND; Brown, moist, medium dense to dense, medium to coarse, trace clay.	SM	A1	5	D	8 12	12"/12"	5.9	115	17.3	5.7
		(Harder drilling.)										
30												

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FIGURE A-9. LOG OF BORING LPE-11

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

Project Number: 88-429 Borehole Number: **LPE-11** 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 SAND; Dark yellowish brown, moist, very dense, fine to coarse, moderately plastic fines, trace gravel at top of the sample.	SC	A4	6	S	13 18 26	14"/18"	6.0			5.7
35	░	SILTY SAND; Brown, moist, medium dense to dense, fine to coarse, with some clay. More fines at tip.	SM	A3	7	D	8 12	12"/12"	6.7	112	14.5	6.2
40	░	SILTY SAND; Dark yellowish brown, moist, dense, fine to coarse, micaceous, slightly plastic fines.	SM	A3	8	S	13 15 19	14"/18"	6.9			6.8
45	▨	CLAYEY SAND/SANDY CLAY; Brown, moist, very stiff, slightly plastic, fine to medium sand.	SC/CL	A4	9	D	11 14	12"/12"	6.5	112	14.8	6.8
50	▨	CLAYEY SAND; Dark yellowish brown, moist, hard, micaceous, moderately plastic fines, fine to coarse sand, trace gravel up to 1/2-inch size at top.	SC	A4	10	S	15 25 14	18"/18"	6.6			6.4
55	░	SILTY SAND; Brown, moist, medium dense to dense, some coarse sand and trace clay.	SM	A3	11	D	11 18	12"/12"	6.4	119	15.2	6.4
60	▨	CLAYEY SAND; Reddish brown, moist, very stiff, fine to coarse, moderately plastic fines. More fines at tip. More fine at tip. (Easier drilling.)	SC	A4	12	S	8 16 12	18"/18"	7.5			7.5
65	░	SILTY SAND; Brown, moist, medium dense, medium to coarse at top and fine to medium at bottom of sample. (Drill chatter -- possibly encounters sand and gravel.)	SM	A3	13	D	13 14	12"/12"	8.3	112	17.0	8.0
70												

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FIGURE A-9. LOG OF BORING LPE-11

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

Project Number: **88-429** Borehole Number: **LPE-11** 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)
		SAND-SILTY SAND WITH GRAVEL; Dark yellowish brown, moist to wet, dense, very fine to coarse, very micaceous, gravel up to 3/4-inch size.	SP-SM	A3	14	S	25 30 40	18"/18"	7.3			8.0
		(Easier drilling.)										
75		SILTY SAND; Brown, moist, dense, fine to medium, trace coarse sand	SM	A3	15	D	15 23	12"/12"	7.2	114	16.4	7.0
80		SANDY CLAY; Reddish brown, moist, very stiff, slightly plastic fines, fine to medium sand.	CL	A4	16	S	13 16 26	18"/18"	5.8			5.8
85		SILTY SAND; Brown, moist, medium dense, medium to coarse on top and fine on bottom of sample, trace clay. (Thin 1-inch layer of silt at tip.)	SM	A3	17	D	9 20	12"/12"	6.0	112	16.6	5.6
90		(No recovery.)			18	S	23 24 27	0"/18"				5.6
		(Drill chatter from 93 to 93-1/2 feet)										
95		SAND-SILTY SAND; Brown, wet, dense, coarse to medium with some fine sand and silt and trace gravel up to 1/2-inch size.	SP-SM	A3	19	D	38 62	12"/12"	6.3			4.8
		BORING TERMINATED AT 96 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. The subsurface conditions may differ at other locations and may change at this alocation 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.										
100												
105												
110												

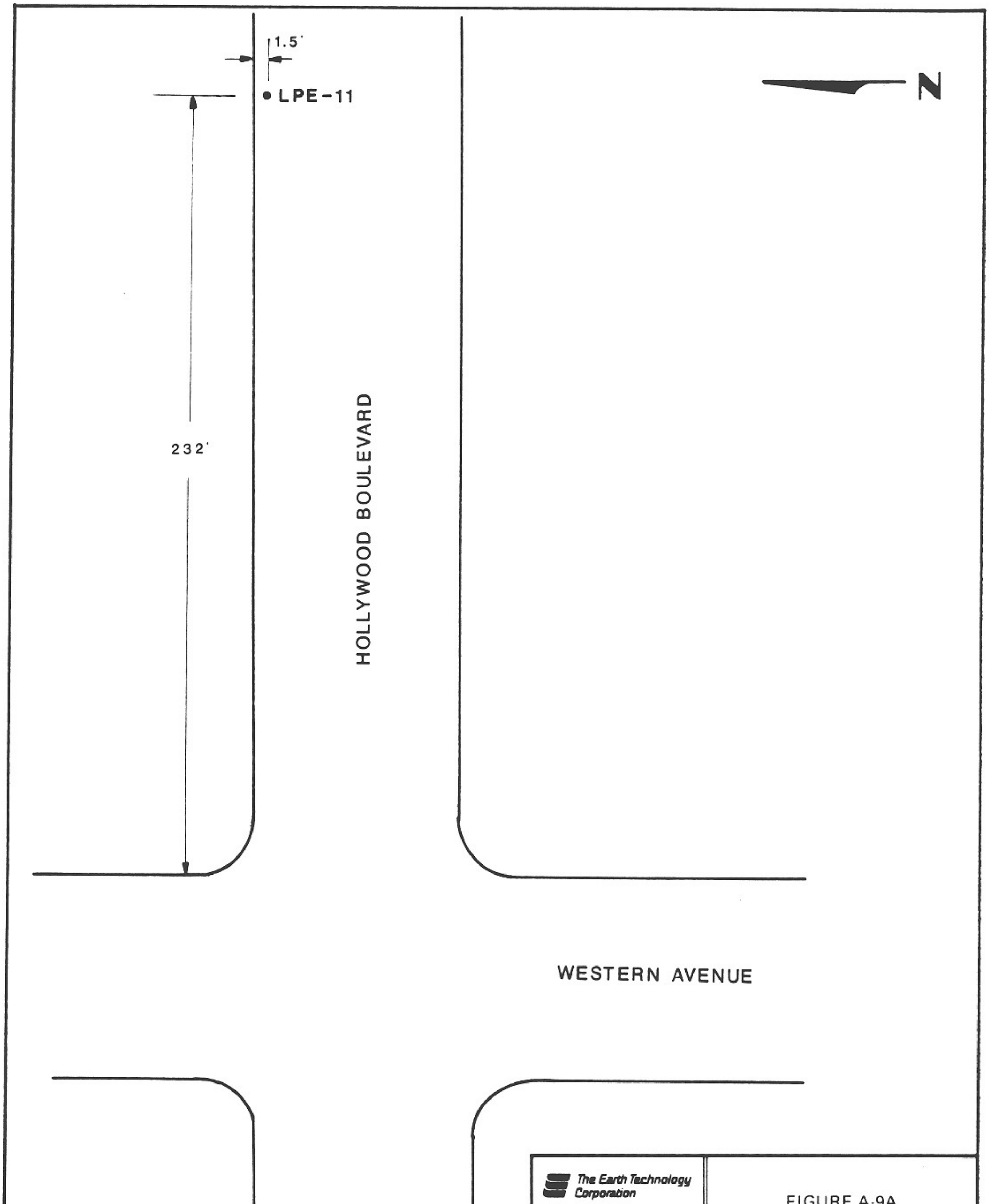

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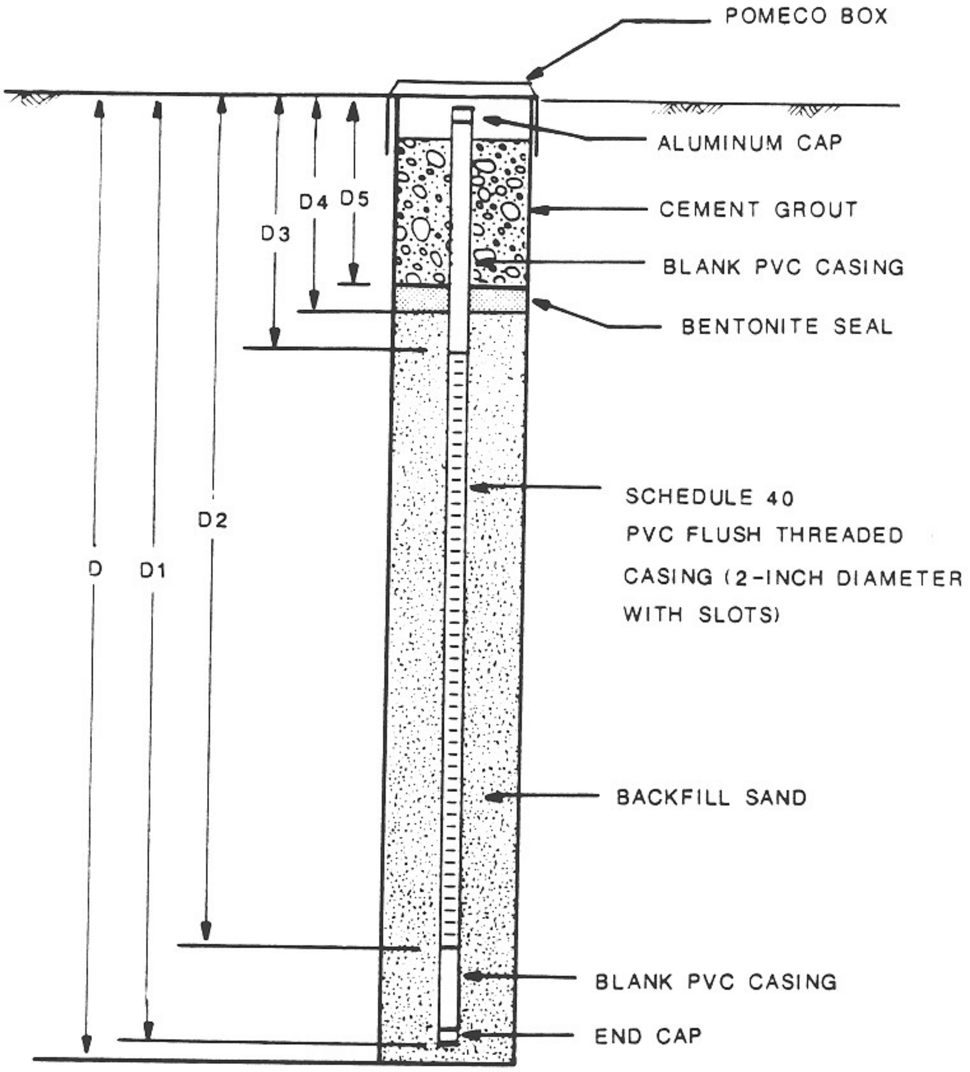
FIGURE A-9A

LOV LOCATION OF BORING LPE-11



TOTAL DEPTH (D)	= 97	FEET
DEPTH TO BOTTOM OF CASING (D1)	= 95	FEET
DEPTH TO BOTTOM OF WELL SCREEN (D2)	= 95	FEET
DEPTH TO TOP OF WELL SCREEN (D3)	= 15	FEET
DEPTH TO BOTTOM OF BENTONITE SEAL (D4)	= 13	FEET
DEPTH TO TOP OF BENTONITE SEAL (D5)	= 11	FEET
WELL SCREEN SLOT SIZE	=	INCH
BACKFILL SAND TYPE	=	MONTEREY

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FIGURE A-9B

PIEZOMETER DIAGRAM LPE-11

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FIGURE A-10. LOG OF BORING LPE-12

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

Project Number: **88-429**

Borehole Number: **LPE-12**

Sheet 1 of 3

Borehole Location: **Van Ness and Hollywood.**

Elevation and Datum(feet): **394.5**

Health and Safety: **Level D**

Date Started: **9/26/88**

Date Finished: **9/27/88**

Drilling Equipment: **Failing 750**

Total Depth (feet): **96.0**

Depth to Bedrock(feet):

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: 365-lb weight and 18-inch drop.

Logged By: **C.M.Payne/C.Duckworth**

Checked By: **Bill Lu**

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)
	▩	GRAVELLY SILT; brown, dry, dense, fill materials with sand and pieces of asphalt concrete.	ML	FILL								
5	░	SILTY SAND; brown , moist, loose, very fine to very coarse, slightly clayey becoming more sandy with depth.	SM	A1	1	D	1 5	12"/12"	4.7	98	9.7	4.0
	░	(Switch from auger to 5-inch mud rotary with drag bit.)										
10	▨	CLAYEY SAND; Brown, moist, loose and medium stiff, silty, moderately plastic fines, fine to medium sand with trace of 1/4 to 1/2-inch size angular gravel.	SC	A2	2	S	3 4 5	7"/18"	5.8			4.0
15	▨	(Large rock fragment 2-1/2 to 3-inch size caught in tip, no recovery.)					9 11	NR 0"/12"				
20	▨	CLAYEY SAND; Brown, wet, medium dense, slightly plastic fines, fine to coarse sand with trace fine gravel.	SC	A2	3	S	6 7 7	10"/18"	5.7			4.0
25	░	SILTY SAND; brown, very moist, medium dense, with scattered angular gravel to 3/8-inch size.	SM	A1	4	D	7 14	12"/12"	5.8			4.0
30	▨											

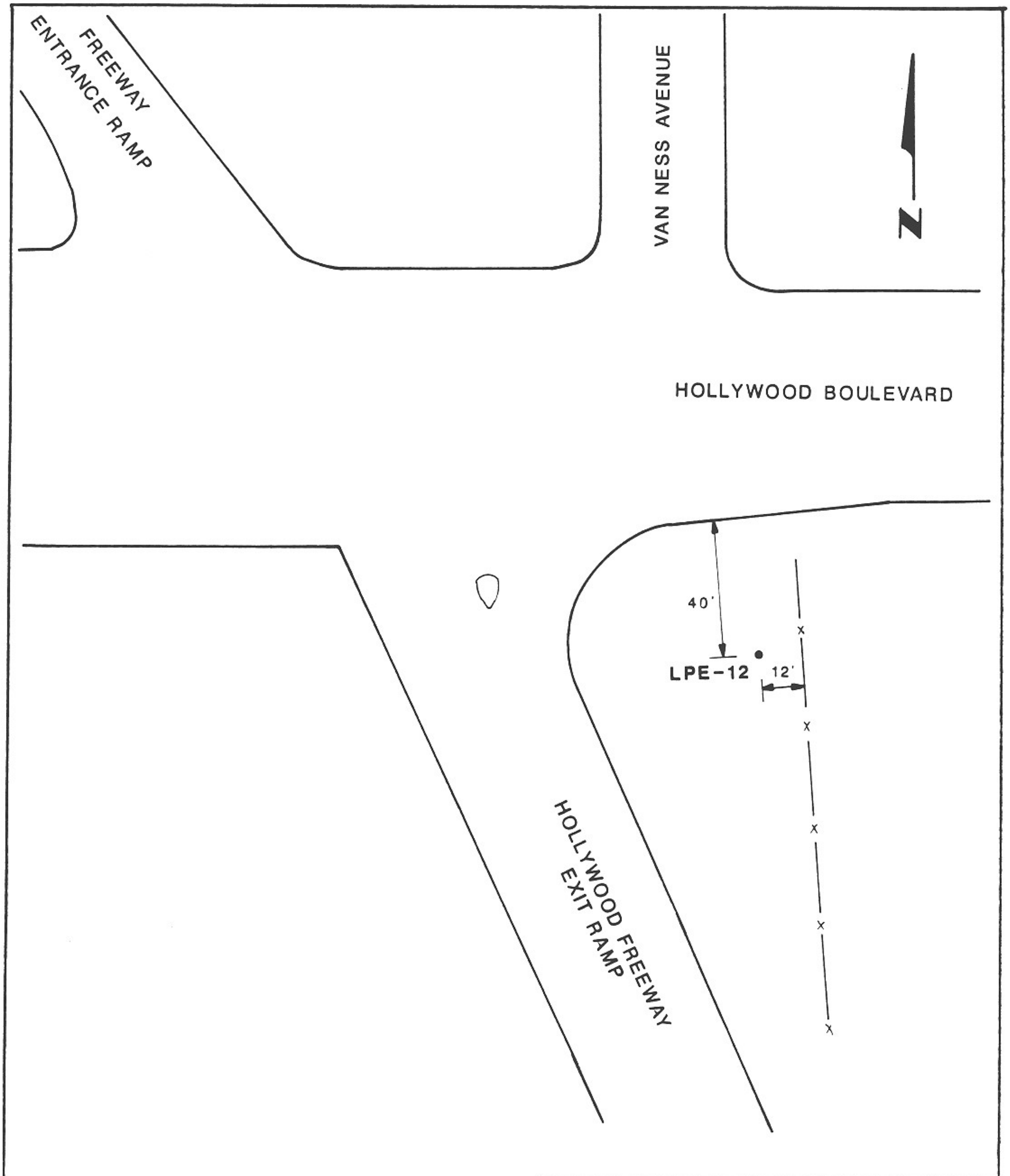

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FIGURE A-10A

LOCATION OF BORING LPE-12

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FIGURE A-11. LOG OF BORING LPE-13

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

Project Number: 88-429

Borehole Number: LPE-13

Sheet 1 of 3

Borehole Location: Hollywood and Gower.

Elevation and Datum(feet): 376.0

Health and Safety: Level D

Date Started: 9/23/88

Date Finished: 9/23/88

Drilling Equipment: Failing 750

Total Depth (feet): 76.0

Depth to Bedrock(feet):

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: 365-lb weight and 24-inch drop.

Logged By: FJE

Checked By: C. M. Payne

Depth (feet)	Lith-ology	Description	USCS Classification	Geologic Unit	Samples							Background OVA(ppm)
					Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	
	■	8-inch CONCRETE										
5	▨	SANDY CLAY; Very dark brown, very moist, very stiff, moderately plastic, fine to medium sand, with mica, organic odor.	CL	A2	1	B						
10	▨	(Clayey sand in cuttings at 8-1/2 feet; Brown, moist, with 20-30% fines.) CLAYEY SAND; Brown, moist, loose to medium dense, medium to coarse, moderately plastic fines with trace gravel to 1/4-inch size.	SC	A2	2	S	2 4 5	12"/18"				
15	░	SILTY SAND; Brown, moist, loose to medium dense, coarse to fine, some gravel to 1/2-inch size and trace clay. More fines at the tip.	SM	A1	3	D	10 6 4	12"/18"	2.2	118	6.3	
	░	(Cuttings from 17 to 18 feet indicate alternating silty sand and gravelly silty sand.)										
20	░	(No recovery.)				S	5 6 7	NR 0"/18"				
	▨	(Brown clayey sand/sandy clay in cuttings.)	SC/CL	A2								
25	░	SILTY SAND; Brown, moist, medium dense, fine to coarse, some gravel up to 1/4-inch size.	SM	A1	4	D	12 16 10	18/18"	2.8	128	9.1	
30												

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FIGURE A-11. LOG OF BORING LPE-13

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

Project Number: 88-429 Borehole Number: LPE-13 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)
		(Driller indicated very dense sand material.) (No recovery. Possibly hit a large clast.)				S	20 21 17	NR 0"/18"				
35		SILTY SAND with GRAVEL; Dark yellowish brown, moist, dense, fine to coarse with gravel up to 1-1/4-inch size.	SM	A3	5	D	13 33	12"/12"		128	9.1	
40		CLAYEY SAND; Dark yellowish brown, moist, dense to very dense, fine to coarse, trace gravel.	SC	A4	6	S	16 22 32	12"/18"	2.4			
45		(Hard drilling, may encountered gravel.) CLAYEY SAND; Dark yellowish brown, moist, dense, fine to coarse, some gravel up to 1-inch size, 2-inch clast at top of the sample; disturbed sample.	SC	A4	7	D	22 50	12"/12"	2.4	118	9.4	
50		SILTY SAND; Dark yellowish brown, moist, dense, fine to coarse, slightly plastic fines, micaceous, some gravel up to 1/2-inch size.	SM	A3	8	S	28 20 22	11"/18"	2.5			
55		(Lost sample. Resample with catcher. Disturbed sample.) SILTY SAND; Brown, moist, medium dense, fine to coarse, some clay. Gravel pieces at top of the sample.	SM	A3	9	D	16 28	12"/12"	5.2			
60		(Fast, easier drilling.) SANDY CLAY/CLAYEY SAND; Brown, moist, very stiff, fine to medium, moderately plastic fines, with trace coarse sand and gravel up to 1/2-inch size. Sandier at the tip.	SC/CL	A4	9	S	7 12 19	12"/18"	6.2			
65		Same as above.	SC/CL	A4	10	D	8 16	12"/12"	8.6	112	18.9	
70		(Drill chatter.)										

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FIGURE A-11. LOG OF BORING LPE-13

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

Project Number: 88-429 Borehole Number: LPE-13 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)
		SILTY CLAYEY SAND; Reddish brown, moist, dense, fine to coarse sand, moderately plastic fines, trace mica, some gravel up to 1/4-inch size. Finer sand and less gravel at the tip. (Easier drilling.)	SC	A4	11	S	28 25 19	9"/18"	2.4			
75		SILTY SAND; Brown, moist, dense, fine to coarse, with some Gravel up to 1/4-inch size.	SM	A3	12	D	36 40	11"/12"	2.3			
		BORING TERMINATED AT 76 FEET. NOTE: This borehole log is based on field classification and visual soil decsription, 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 line represent the approximate boundary between subsurface material types and the transition may be gradual.										
80												
85												
90												
95												
100												
105												
110												

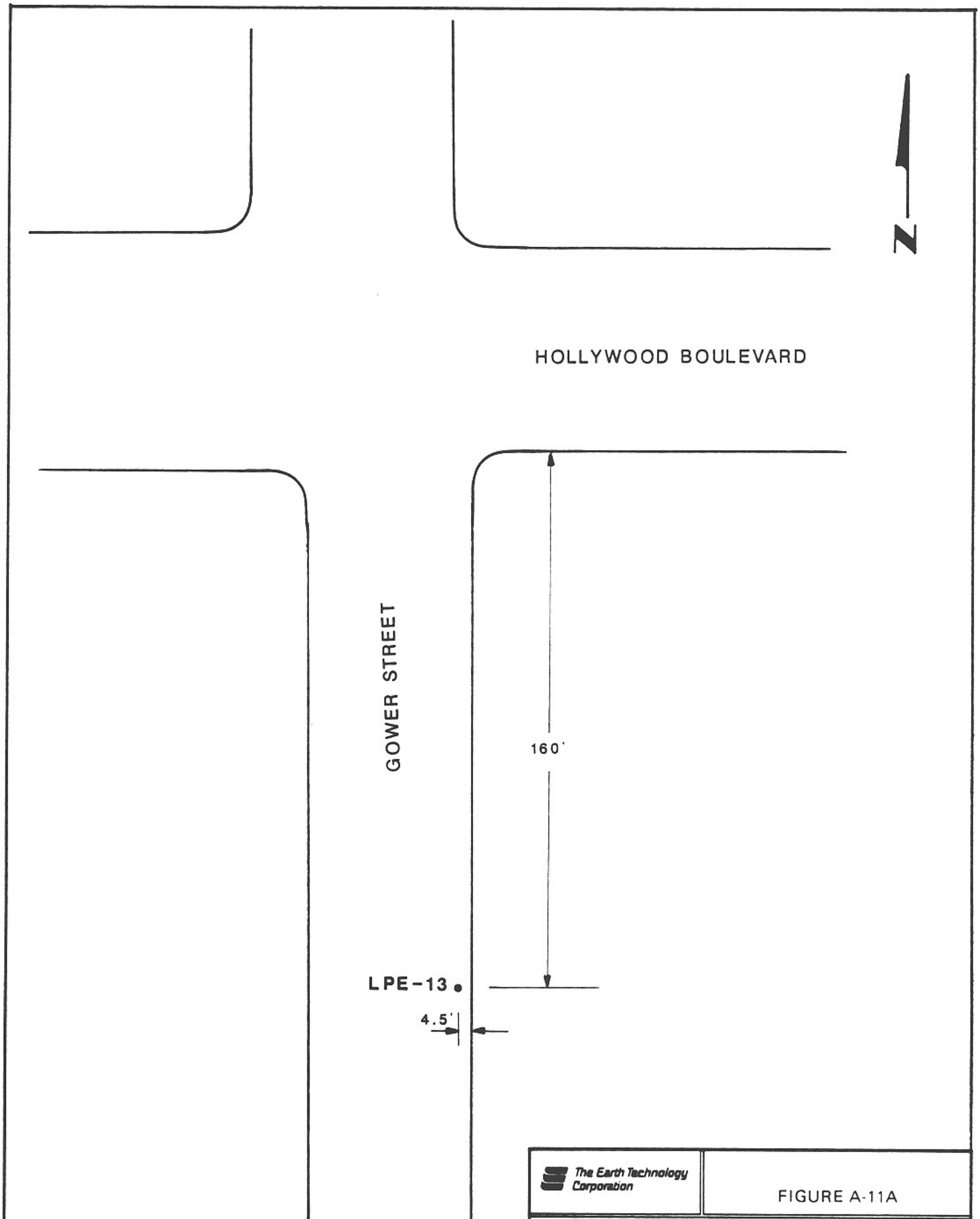

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FIGURE A-11A

LOCATION OF BORING LPE-13

FIGURE A-12. LOG OF BORING LPE-14

Project Name: METRO RAIL MOS-2 ALIGNMENT - LOS ANGELES
Project Number: 88-429
Borehole Number: LPE-14
Sheet 1 of 3
Borehole Location: Vine St. and Holoywood Blvd.
Elevation and Datum(feet): 374.0
Health and Safety: Level D
Date Started: 9/23/88
Date Finished: 9/24/88
Drilling Equipment: Failing 750
Total Depth (feet): 76.0
Depth to Bedrock(feet):
Drilling Method: Rotary Wash
Borehole Diameter: 6-inch
Drilling Fluid: Bentonite Mud
Piezometer Installation: Yes
Depth(feet) 76.0
Hammer Information: SPT Hammer: 140-lb weight and 30" drop; DOWN HOLE Hammer: 365-lb weight and 18" drop.
Logged By: C.M.Payne
Checked By: C. Duckworth

Depth (feet)	Lith-ology	Description	USCS Classification	Geologic Unit	Samples							Background OVA (ppm)
					Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	
		8-inch CONCRETE paving.										
		SANDY CLAY; with scattered gravel to 3/4-inch size. Fill material.	CL	FILL								4.8
		SAND/SILTY SAND/SANDY SILT; Browon, moist and loose. appears native.	SP/SM /ML	A1								
5												
		(Set casing to about 12 feet. Start rotary wash with drag bit.)										
		(Sand in cuttings; Brown, fine to medium, slightly silty.)										
10		(Silty sand in cuttings from 10 to 11 feet; loose, fine to medium.)										
		SILTY SAND; Yellowish brown, moist, loose to medium dense, trace gravel with some angular fragments up to 1-inch size.	SM	A1	1	D	5 6	12"/12"	7.5	103	6.7	6.6
		(Very coarse sand in cuttings at 13 to 14 feet.)	SP	A1								
15		SILTY SAND; Dark yellowish brown, moist, medium dense, fine to medium, massive.	SM	A1	2	S	7 5 8	12"/18"	7.4			
		(Easy drilling.)										
20		SILTY SAND WITH GRAVEL; Brown, moist, loose to medium dense, fine to medium gravel, appears massive.	SM	A1	3	D	7 11	12"/12"	8.4	110	16.5	
		(Easy drilling.)										
25		SILTY SAND WITH GRAVEL; Dark yellowish brown, moist, dense to very dense, with 6-inch thick layer of hard, rounded gravel in the middle.	SM	A1	4	S	10 25 30	4"/18"	8.9			
		(Clay in cuttings from 28 to 28-1/2 feet.)	CL	A2								
30												

FIGURE A-12. LOG OF BORING LPE-14

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

Project Number: **88-429** Borehole Number: **LPE-14** Sheet 2 of 3

Depth (feet)	Lith-ology	Description	USCS Classification	Geologic Unit	Samples							Background OVA (ppm)
					Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	
		SILTY SAND; Brown, moist, medium dense to dense, fine to medium.	SM	A1	5	D	7 15	12"/12"	9.5	110	18.4	
		(About 6-inch thick clay layer at 32 feet.)	CL	A2								
			SM	A1								
35		CLAYEY SAND; Brown, moist, dense, fine to coarse, moderately plastic, with mica and scattered amount of hard, rounded gravel. (Clayey cuttings at 37 feet.)	SC	A2	6	S	7 12 15	13"/18"	9.7			
40		CLAYEY SAND; Brown, moist, dense, fine to coarse.	SC	A2	7	D	11 23	12"/12"	9.2	106	18.7	
45		CLAYEY SAND; Brown, moist, very dense, fine to medium, moderately plastic fines, minor coarse sand and gravel up to 3/4-inch size.	SC	A2	8	S	16 27 40	12"/18"	9.4			
		(Clay layer in cuttings from 47-1/2 to 48-1/2 feet.)	CL	A2								
			SC	A2								
50		GRAVEL; very dense, coarse with some cobbles. (Excessive drill chatter. Cuttings indicate coarse gravel and cobbles. Switched to tricone bit.)	GP	A1	9	D	65 35/1"	0"/12" NR				
		(Sand in cuttings at 52 feet.)										
55		SAND-SILTY SAND; Brown, moist, very dense, fine to coarse, with scattered rounded gravel to 1-inch size. (Slow rough drilling.)	SP-SM	A1	10	D	40 55	12"/12"	7.5	106	9.5	
60		Sand and gravel in cuttings at 60 feet.) (Heavy chatter on rig. Rock fragments are unweathered and hard.) Dense, fine to very coarse SAND from cuttings. Chip of gravel to 1/2-inch size, no recovery. (Driller estimates coarse fraction is up to cobble size.) (Rough slow drilling.)	SP/GP	A1	11 12	S S	50/5.5" 65/3"	0"/5.5" NR 0"/3" NR				7.5
65		CLAYEY SAND; Brown, moist, very dense, medium to coarse with minor rounded gravel. Becoming silty at tip.	SC	A2	13	D	47 53/4.5"	10"/10"	7.4	127	9.3	
		(Smooth drilling.)										
70												

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FIGURE A-12. LOG OF BORING LPE-14

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

Project Number: 88-429 Borehole Number: LPE-14 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 SAND; Dark yellowish brown, moist, very dense and stiff, fine to very coarse.	SC	A2	14	S	17 38 46	14"/18"	4.4			
	▨	(Minor gravel lense (about 1-inch thick) at 72-1/2 feet. Drill chatter.) (Smooth slow drilling.)										
75	▥	SANDY SILT; Reddish brown, moist, dense, moderately plastic, very fine to medium sand, with scattered gravel 1/4 to 1/2-inch size and minor clay.	ML	A2	15	D	13 21	12"/12"	4.4	113	19.0	4.4
		BORING TERMINATED AT 76 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 condtions may differ at other locations and may change at this location with passage of time. The data presented is simplification of actual data 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												

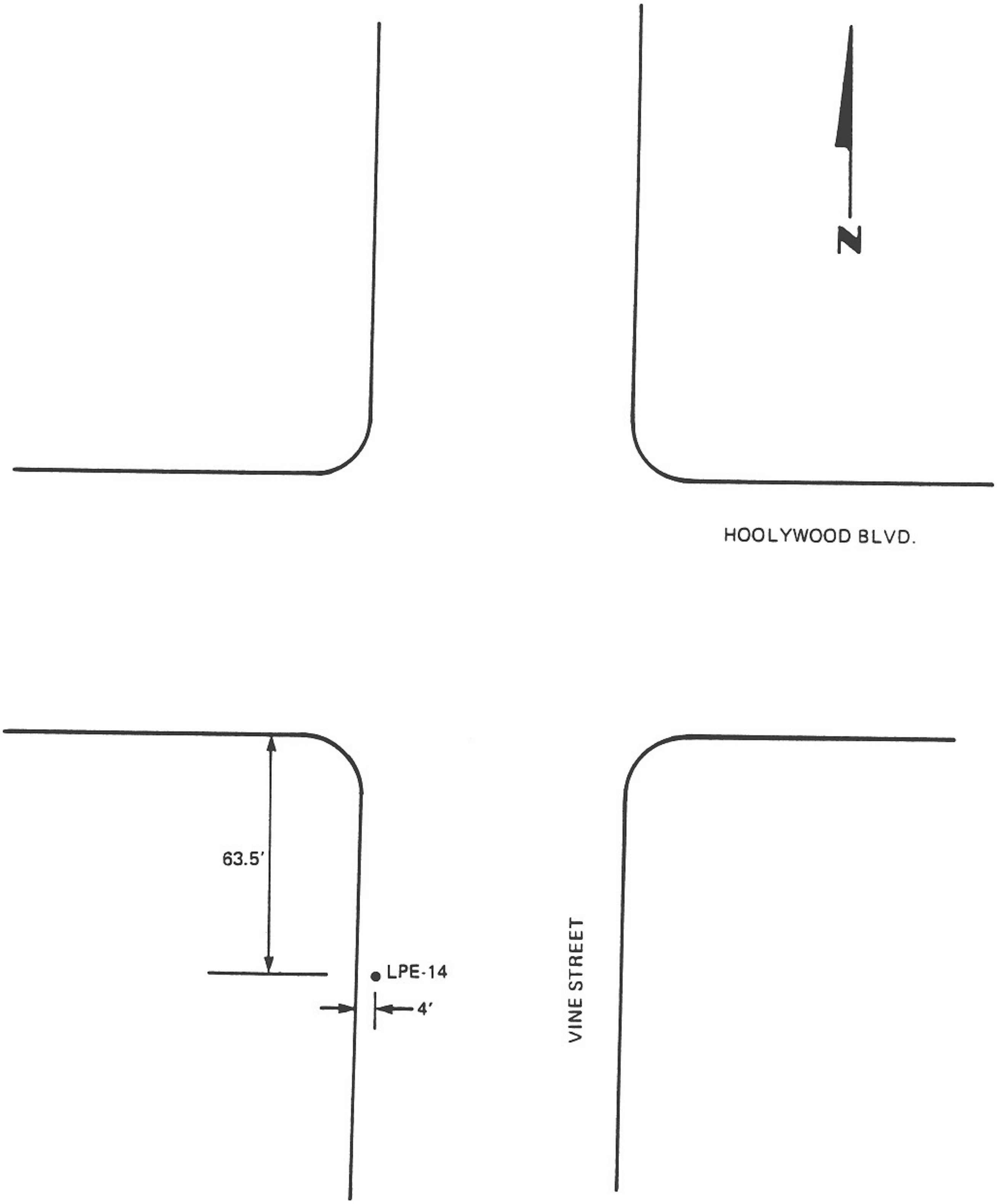

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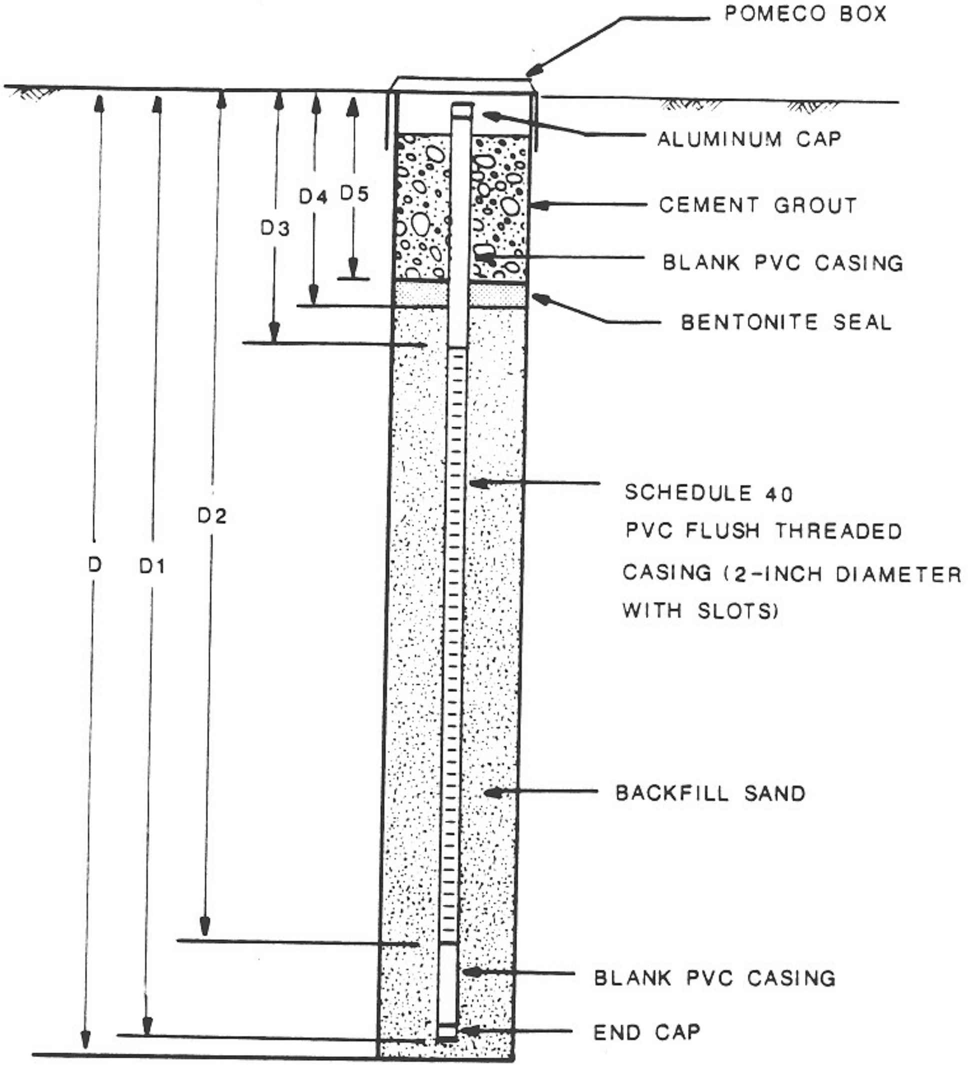
FIGURE A-12A

LOCATION OF BORING LPE-14



TOTAL DEPTH (D)	= 76	FEET
DEPTH TO BOTTOM OF CASING (D1)	= 74	FEET
DEPTH TO BOTTOM OF WELL SCREEN (D2)	= 74	FEET
DEPTH TO TOP OF WELL SCREEN (D3)	= 44	FEET
DEPTH TO BOTTOM OF BENTONITE SEAL (D4)	= 41	FEET
DEPTH TO TOP OF BENTONITE SEAL (D5)	= 39	FEET
WELL SCREEN SLOT SIZE	= 0.01	INCH
BACKFILL SAND TYPE	= NO.2	MONTEREY

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FIGURE A-12B

PIEZOMETER DIAGRAM LPE-14

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FIGURE A-13. LOG OF BORING LPE-15

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

Project Number: **88-429** Borehole Number: **LPE-15** Sheet 1 of 3

Borehole Location: **Hollywood and Whitley** Elevation and Datum(feet): **385.0**

Health and Safety: **Level D** Date Started: **9/26/88** Date Finished: **9/26/88**

Drilling Equipment: **Failing 750** Total Depth (feet): **76.0** Depth to Bedrock(feet):

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

Drilling Fluid: Piezometer Installation: **No.** Depth(feet):--

Hammer Information:
SPT Hammer: 140-lb weight and 30-inch drop;
DOWNHOLE Hammer: 365-lb weight and 18-inch drop.

Logged By: **FJE** Checked By: **C. M. Payne**

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)
		2-inch ASPHALT CONCRETE.										
		SILTY SAND; Brown, damp, possible fill material.	SM	FILL								
5		SILTY SAND; Dark yellowish brown, dry, loose, fine to medium, some coarse sand.	SM	A1	1	B			4.4			4.2
10		SILTY SAND; Brown, moist, loose to medium dense, fine to coarse some gravel up to 3/8-inch size and trace clay.	SM	A1	2	S	5 7 3	7"/18"	4.6			4.3
		(Harder drilling.)										
15		SILTY SAND; Brown, moist, medium dense, fine to medium.	SM	A1	3	D	6 7	12"/12"	4.2	114	10.4	4.2
		(Easier drilling.)										
20		CLAYEY SAND/SANDY CLAY; Brown, moist, medium stiff, moderately plastic fines, grading to sandy silt at tip.	SC/CL	A2	4	S	3 4 5	13"/18"	4.3			4.2
25		SILTY SAND; Brown,moist, medium dense, fine to medium, trace coarse sand and gravel up to 1/2-inch size.	SM	A1	5	D	5 8	12"/12"	4.2	114	11.7	4.2
		(Drill chatter from 27-1/2 to 28 feet. Driller reported sand and gravel.)	GP	A1								
		(Clayey Sand in cuttings at 28.5 feet.)	SM	A1								
30												

FIGURE A-13. LOG OF BORING LPE-15

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

Project Number: **88-429** Borehole Number: **LPE-15** 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)
	▨	SANDY CLAY; Brown, moist, stiff, slightly plastic fines at top of sample and moderately plastic fines at tip, moderately fine to medium sand.	CL	A2	6	S	3 5 6	11"/18"	4.2			4.2
35	░	SILTY SAND; Brown, moist, medium dense, fine to medium, trace coarse sand and gravel up to 1/4-inch size. Brown, moist sandy silt at lower 4 inches of sample.	SM	A1	7	D	8 6	11"/12"	4.4	103	18.5	4.2
40	▨	SILTY CLAY; Dark yellowish brown, moist, stiff, moderately plastic fines, trace fine to coarse sand.	CL	A2	8	S	7 7 8	6"/18"	4.2			4.2
45	░	SILTY SAND; Brown, moist, medium dense to dense, fine to coarse, some gravel up to 1/2-inch size at tip. (Easier drilling.)	SM	A1	9	D	11 14	12"/12"	4.4	114	16.6	4.4
50	▨	SANDY CLAY; Dark yellowish brown, moist, stiff to very stiff, moderately plastic to highly plastic fines with fine sand. Brown, moist, loose, fine silty sand at top 4 inches.	CH	A2	10	S	4 8 10	17"/18"	4.8			4.2
55	▨	SILTY CLAY; Brown, moist, stiff, fine to coarse sand and silt.	CL	A2	11	D	8 14	12"/12"	4.2	103	20.5	4.2
60	▨	SILTY CLAY; Brown, moist, stiff to very stiff, moderately plastic fines, trace fine sand.	CL	A2	12	S	5 7 12	13"/18"	4.4			4.2
65	▨	SANDY CLAY; Dark brown, moist, stiff, moderately plastic fines, fine to medium sand.	CL	A2	13	D	7 9	12"/12"	4.7	107	20.6	3.7
70												

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FIGURE A-13. LOG OF BORING LPE-15

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

Project Number: **88-429** Borehole Number: **LPE-15** Sheet 3 of 3

Depth (feet)	Lith-ology	Description	USCS Classification	Geologic Unit	Samples							Background OVA (ppm)
					Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	
	▨	SANDY CLAY; Reddish brown, moist, very stiff, with very fine sand.	CL	A2	14	S	12	18"/18"	4.0			3.8
	▨	CLAYEY SAND; Reddish brown, moist, very dense, moderately plastic fines, trace fine to medium gravel up to 3/4-inch size. (Drill chatter at 72 feet.)	SC	A2		S	30 33		4.4			3.8
75	░	(Softer drilling.) SILTY SAND; Brown, moist, dense, fine to coarse, trace clay. Sandy clay at tip.	SM	A3	15	D	16 19	12"/12"	3.8	105	21.2	3.8
						B						
80 85		BORING TERMINATED AT 76 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 at 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												

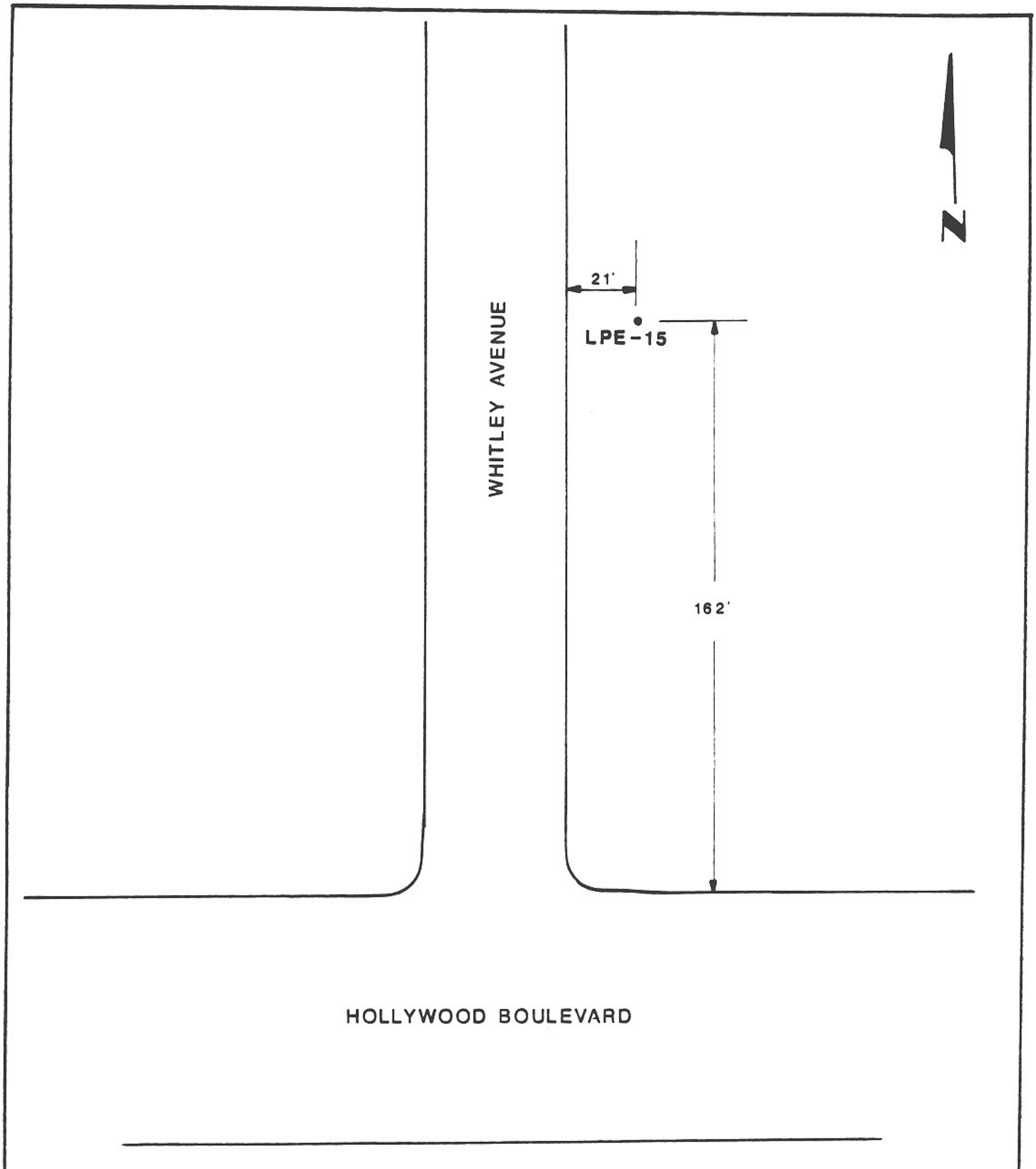

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FIGURE A-13A

LOCATION OF BORING LPE-15

FIGURE A-14. LOG OF BORING LPE-16

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

Project Number: 88-429 | Borehole Number: **LPE-16** | Sheet 1 of 3

Borehole Location: Hollywood and Orchid | Elevation and Datum(feet): 383.0

Health and Safety: Level D | Date Started: 9/20/88 | Date Finished: 9/21/88

Drilling Equipment: Failing 750 | Total Depth (feet): 81.5 | Depth to Bedrock(feet):

Drilling Method: Rotary Wash | Borehole Diameter: 6-inch

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

Hammer Information:
SPT hammer: 140-lb weight and 30-inch drop.
DOWNHOLE hammer: 365-lb weight and 18-inch drop.

Logged By: C.M.Payne

Checked By: C. Duckworth

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)
		10-inch thick concrete pavement.										
		SILTY SAND - base material.	SM	FILL								
		SILTY SAND; Appears native										
5		SILTY SAND; Brown, moist, medium dense, trace gravel to 1/4-inch size.	SM	A1	1	D	4 5 5	18"/18"	3.8	88	17.1	4.5
		(Cuttings indicated scattered gravel up to 2-inch size from 7 to 9 feet.)										
		(Gravel in cuttings from 9 to 10 feet.)	GP	A1								
10		SILTY SAND; Dark yellowish brown, moist, medium dense, fine to medium, with trace coarse sand and fine gravel.	SM	A1	2	S	5 4 6	6"/18"	5.2			4.5
15		Same as above except no gravel.	SM	A1	3	D	4 9 10	18"/18"	5.0	98	21.0	4.5
20		Same as above with 3 to 4-inch thick 2-innch gravel lense.	GP SM	A1 A1	4	S	19 11 12	5"/18"	5.4			4.5
25		Same as above except no gravel.	SM	A1	5	D	6 13 17	18"/18"	5.8	101	11.2	4.5
		(Driller indicated about 6-inch thick gravel lens from 28-1/2 to 29 feet.)	GP	A1								
30												

FIGURE A-14. LOG OF BORING LPE-16

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

Project Number: **88-429**

Borehole Number: **LPE-16**

Sheet 2 of 3

Depth (feet)	Lith- ology	Description	USCS Classi fication	Geologic Unit	Samples							Background OVA (ppm)
					Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	
		SILTY SAND; Dark yellowish brown, moist, very dense, fine to coarse, with fine to medium gravel up to 2-inch size. Clasts are completely weathered. Appears old alluvium.	SM	A3	6	S	21 47 50	8"/18"	6.0			4.5
		CLAYEY SAND; Reddish brown, slightly silty with 1-inch gravel.										
35		CLAYEY SAND; Reddish brown, moist, very dense, highly weathered, slightly silty with 3/4-inch gravel.	SC	A4	7	D	80 57 13/1"	11"/11"	6.2	103	18.2	4.5
40		CLAYEY SAND; Reddish brown, moist, dense to very dense, fine to medium, moderately plastic fines with scattered, gravel up to 1-inch size.	SC	A4	8	S	14 17 30	10"/18"	6.0			4.5
		(Sand and gravel in cuttings at 42 feet.)										
45		SILTY SAND; Brownish gray, moist, very dense, fine to very coarse, fairly clean, trace angular gravel 1/4 to 3/4 - inch size.	SM	A3	9	D	85 50/3.5	8"/8"	5.6	128	13.0	4.5
50		SILTY SAND WITH GRAVEL; Reddish brown, moist, very dense, fine to coarse, some angular gravel clasts up to 1-inch size.	SM	A3	10	S	62 32 33	8"/18"	5.6			4.5
		(Clay in cuttings at 53 feet.)										
55		SILTY SAND; Yellowish brown, moist, very dense, very fine to fine, scattered gravel of 1 to 2-inch size.	SM	A3	11	D	30 40 50/5"	17"/17"	5.6	101	22.7	4.5
60		SILTY SAND; Dark yellowish brown, moist, very dense, fine to medium.	SM	A3	12	S	17 22 18	13"/18"	5.0			4.5
65		SILTY SAND; Reddish brown, moist, very dense, trace gravel 1/4 to 1/2-inch size.	SM	A3	13	D	45 65	12"/12"	4.4	104	17.7	4.5
70												

FIGURE A-14. LOG OF BORING LPE-16

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

Project Number: 88-429 | Borehole Number: **LPE-16** | Sheet 3 of 3

Depth (feet)	Lith-ology	Description	USCS Classification	Geologic Unit	Samples: Number	Samples: Type	Samples: Blow Count	Samples: Recovery	Samples: OVA (ppm)	Samples: Dry Density (pcf)	Samples: Moisture Content (%)	Background OVA (ppm)
		SILTY SAND; Dark yellowish brown, moist, dense, fine to coarse, trace gravel up to 1/4-inch size.	SM	A3	14	S	12 20 28	9"/18"	5.2			3.2
75		SILTY SAND; Brown, moist, dense, trace gravel.	SM	A3	15	D	31 45 50/5"	17"/17"		106	19.3	3.2
		(Harder drilling.)										
80		(No recovery.)	SM	A3	15	S	26 28 50/4.5"	NR 0"/16"	6.5			3.2
		BORING TERMINATED AT 81-1/2 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.										
85												
90												
95												
100												
105												
110												

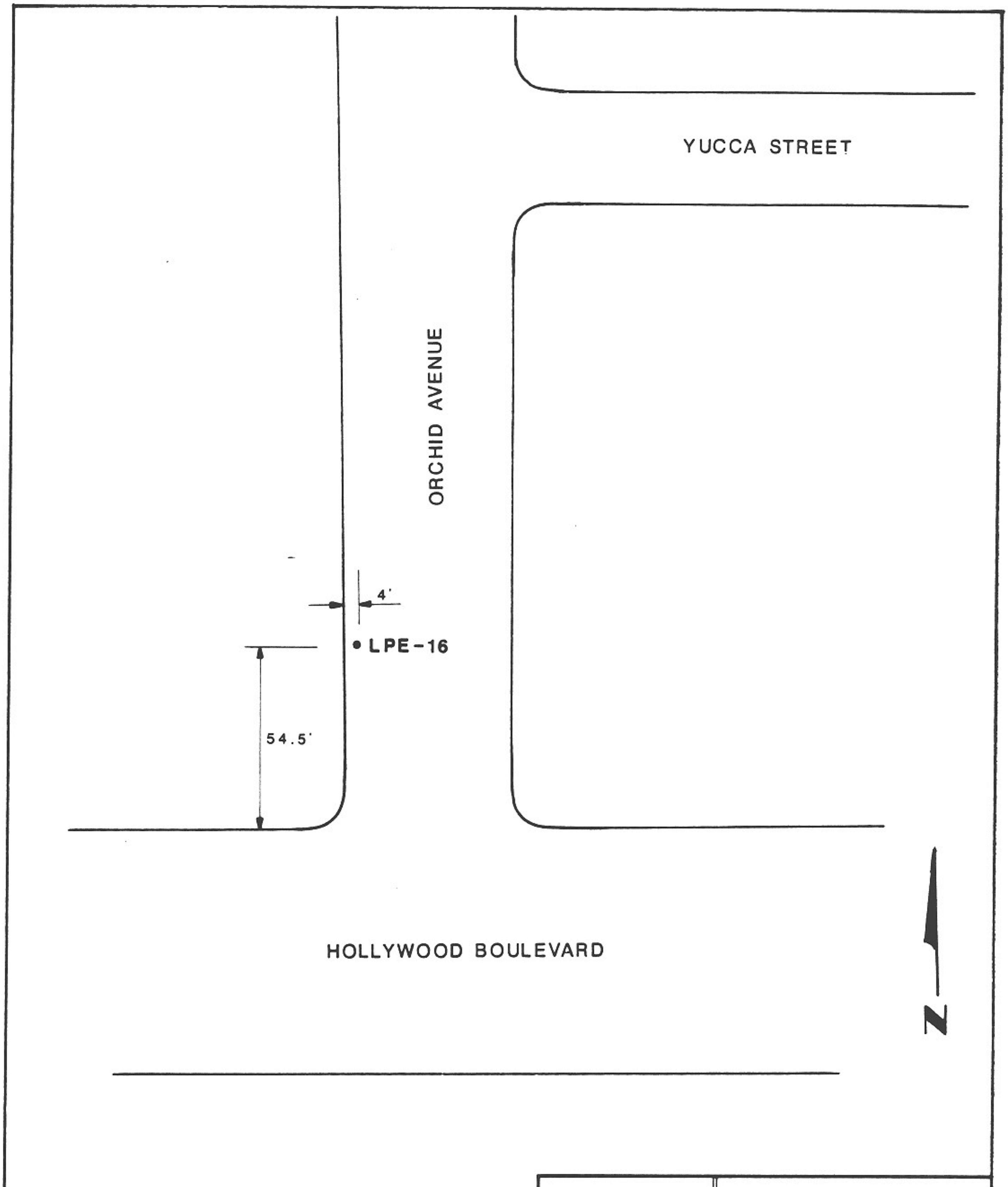

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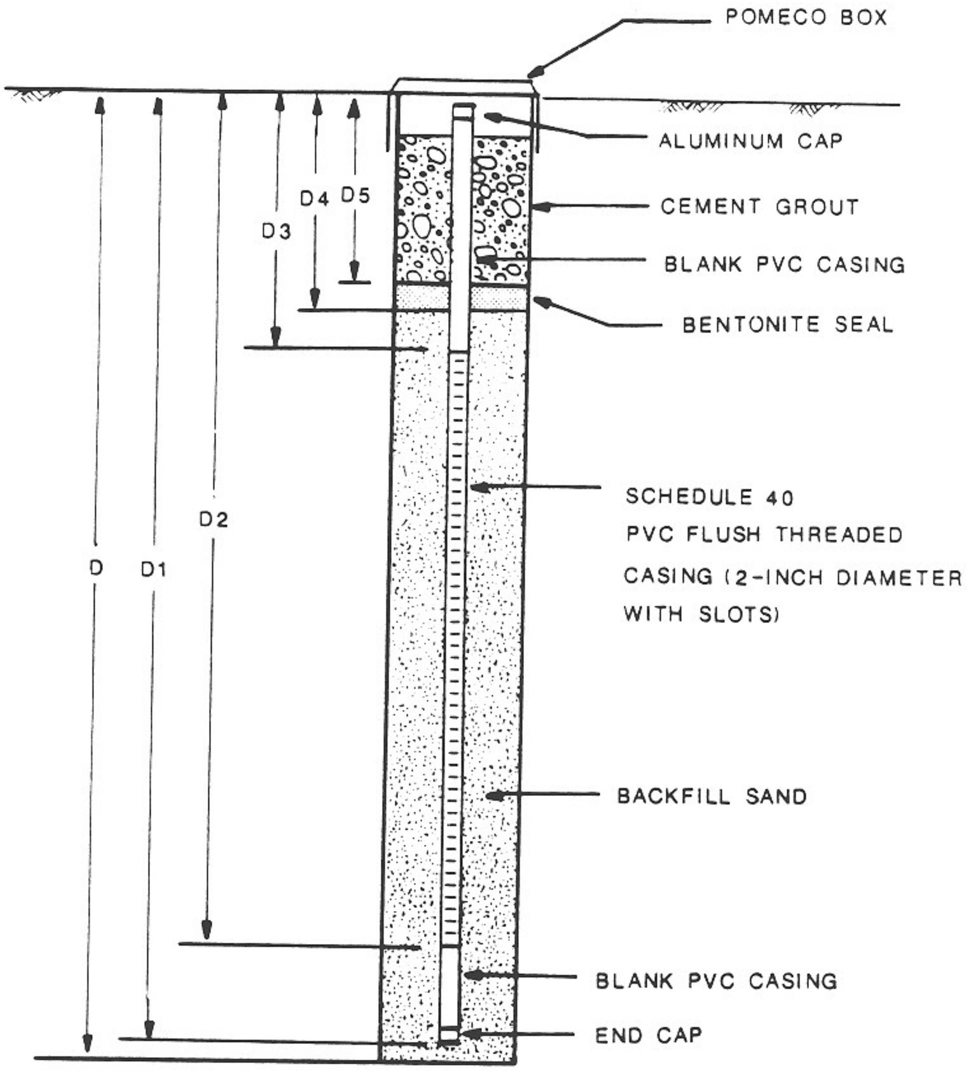
FIGURE A-14A

LOCATION OF BORING LPE-16



TOTAL DEPTH (D)	= 77	FEET
DEPTH TO BOTTOM OF CASING (D1)	= 75	FEET
DEPTH TO BOTTOM OF WELL SCREEN (D2)	= 45	FEET
DEPTH TO TOP OF WELL SCREEN (D3)	= 45	FEET
DEPTH TO BOTTOM OF BENTONITE SEAL (D4)	= 40	FEET
DEPTH TO TOP OF BENTONITE SEAL (D5)	= 36	FEET
WELL SCREEN SLOT SIZE	= 0.01	INCH
BACKFILL SAND TYPE	= NO.2	MONTEREY

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FIGURE A-14B

PIEZOMETER DIAGRAM LPE-16

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FIGURE A-15. LOG OF BORING LPE-17

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

Project Number: **88-429** Borehole Number: **LPE-17** Sheet 1 of 3

Borehole Location: **El Cerrito and Yucca** Elevation and Datum(feet): **414.0**

Health and Safety: **Level D** Date Started: **9/22/88** Date Finished: **9/22/88**

Drilling Equipment: **Failing 750** Total Depth (feet): **76.0** Depth to Bedrock(feet):

Drilling Method: **Rotary Wash** Borehole Diameter: **6-inch**

Drilling Fluid: **Bentonite Mud** Piezometer Installation: **No.** Depth(feet): --

Hammer Information:
SPT Hammer: 140-lb weight and 30-inch drop.
DOWNHOLE Hammer: 365-lb weight and 18-inch drop.

Logged By: **Steve Townsend** Checked By: **C. M. Payne**

Depth (feet)	Lith-ology	Description	USCS Classification	Geologic Unit	Samples							Background OVA (ppm)
					Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	
	■	8-inch ASPHALT pavement										
	▩	SILTY SAND; Dark brown, trace gravel.	SM	FILL								
	░	SILTY SAND; Brown, with coarse sand.										
5	░	SILTY SAND; Dark yellowish brown, moist, loose, some coarse sand, trace angular gravels up to 1/2-inch size.	SM	A1	1	S	6 5 2	12"/18"	5.8			4.0
	░	(Install casing to 8 feet.) (Switch to rotary wash with 6-inch tri cone bit.)										
10	░	SILTY SAND; Brown, moist, loose to medium dense, slightly clayey with some coarse, subangular sand.	SM	A1	2	D	4 6 6	18"/18"	5.8	102	16.4	4.0
15	▨	CLAYEY SAND; Brown, moist, medium dense, fine to coarse, moderately plastic fines, trace gravel up to 1/4-inch size.	SC	A2	3	S	2 5 7	18"/18"	6.0			4.0
	▨	(Harder drilling at 17-1/2 feet.)										
20	▨	CLAYEY SAND; Brown, moist, dense, fine to coarse, moderately plastic fines.	SC	A2	4	D	6 9 11	6"/18"	6.0	110	10.4	4.0
25	▨	SANDY CLAY; Brown, moist, hard, moderately plastic fines, fine to coarse sand and fine silt trace gravel.	CL	A4	5	S	10 20 35	12"/18"	7.5			4.0
	▨	(Slow drilling.)										
30												

FIGURE A-15. LOG OF BORING LPE-17

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

Project Number: 88-429 Borehole Number: **LPE-17** 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)
		SANDY CLAY; Brown, moist, hard, medium to fine sand and some silt.	CL	A4	6	D	57 43/2.5	5"/18"	7.2	105	19.0	4.0
		(Hard drilling.)										
35		SANDY CLAY; Reddish brown, moist, hard, moderately plastic fines, fine to coarse sand, micaceous trace gravel.	CL	A4	7	S	15 18 22	18"/18"	7.4			4.0
40		SILTY SAND; Red, slightly moist, very dense, trace gravel up to 2-inch size.	SM	A3	8	D	100/5.5"	3"/5.5"	7.5	105	18.0	4.0
45		SILTY SAND; Dark yellowish brown, slightly moist, very dense, fine to medium.	SM	A3	9	S	24 50/5.5"	8"/12"	5.2			4.0
		(Drill chatter indicating coarse sand and gravel from 46-1/2 to 50 feet.)	SP	A3								
50		SILTY SAND; Reddish brown, moist, very dense, fine to medium, trace gravel up to 1/4-inch size.	SM	A3	10	D	58 42/3"	6"/9"	5.0	105	18.0	4.0
55		SILTY SAND; Dark yellowish brown, moist, very dense, medium to coarse, slightly clayey, trace gravel up to 1/4-inch size.	SM	A3	11	S	27 47 50/5"	3"/17"	4.0			4.0
60		SILTY CLAY; Reddish brown, slightly moist, hard, some coarse sand, trace gravel up to 1/2-inch size.	CL	A4	12	D	50/5" 50/4"	6"/12"	4.8	102	17.4	4.0
65		SILTY SAND; Red, slightly moist, dense to very dense, slightly plastic fines, fine to coarse sand, trace gravel up to 1/4-inch.	SM	A3	13	S	17 32 37	6"/18"	5.2			4.0
70												

FIGURE A-15. LOG OF BORING LPE-17

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

Project Number: 88-429

Borehole Number: LPE-17

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)
		SILTY SAND; Dark yellowish brown, slightly moist, very dense, medium to coarse, some gravel up to 1-inch size.	SM	A4	14	D	45 55/5"	6"/12"	5.4	107	16.4	4.0
75		CLAYEY SAND WITH GRAVEL; Dark yellowish brown, slightly moist, very dense, fine to coarse, moderately plastic fines, with gravels up to 2-inch. Appears to be decomposed granite.	SC	A3	15	S	27 50/5"	5"/11"	5.2			4.0
80		BORING TERMINATED AT 76 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 boundary between subsurface material types and the transition may be gradual.										
85												
90												
95												
100												
105												
110												

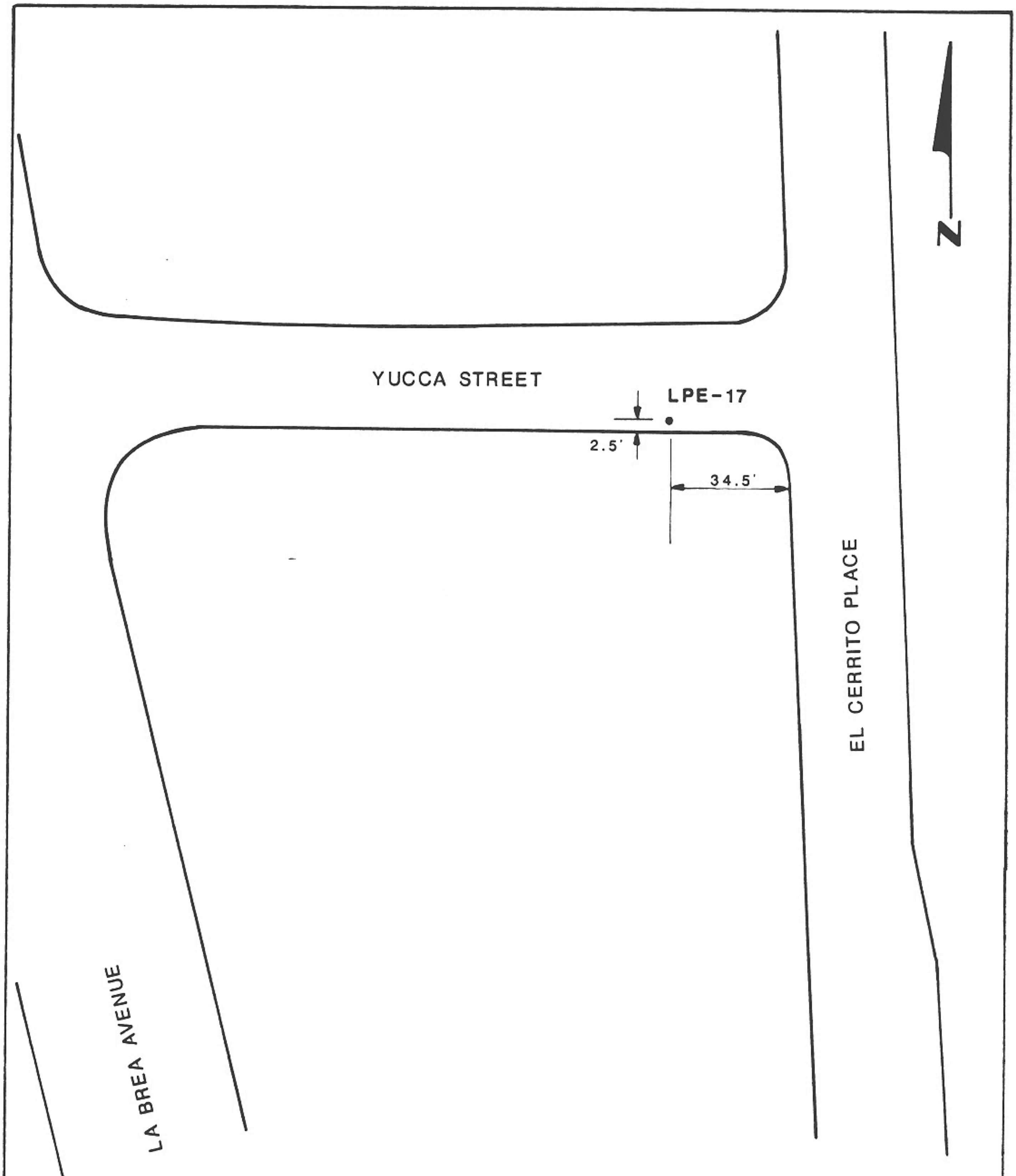

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FIGURE A-15A

LOCATION OF BORING LPE-17

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FIGURE A-16. LOG OF BORING LPE-19

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

Project Number: **88-429**
Borehole Number: **LPE-19**
Sheet 1 of 3

Borehole Location: **Hill Side and La Brea**
Elevation and Datum(feet): **472.0**

Health and Safety: **Level D**
Date Started: **9/21/88**
Date Finished: **9/22/88**

Drilling Equipment: **Failing 750**
Total Depth (feet): **77.0**
Depth to Bedrock(feet):

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: 365-lb weight and 18-inch drop.

Logged By: **Dan Bush**
Checked By: **C. M. Payne**

Depth (feet)	Lith-ology	Description	USCS Classification	Geologic Unit	Samples								Background OVA (ppm)
					Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)		
		5-inch ASPHALT.											
5		SAND-SILTY SAND; Brown, dry, dense to very dense, fine to medium, slightly plastic fines, trace gravel and clay.	SP-SM	A2	1	D	15 25 30	18"/18"	2.8	113	13.4		2.8
		(Hard drilling.)											
10		(Clay-silt in cuttings from 9-1/2 to 10 feet.)	CL/ML	A2									
		SILTY SAND; Dark yellowish brown, dry, very dense, fine to coarse, moderately plastic fines.	SM	A1	2	S	15 30 45	18"/18"	2.8				2.8
15		CLAYEY SAND; Reddish brown, dry, very dense, fine to coarse, moderately plastic fines, with some silt.	SC	A4	3	D	30 70	10"/10"	2.8	113	16.3		2.8
20		SANDY CLAY; Reddish brown, damp, hard, moderately plastic fines, fine to coarse sand.	CL	A4	4	S	32 68	10"/10"	3.0				2.8
25		CLAYEY SAND; Reddish brown, damp, hard, fine to coarse moderately plastic fines.	CL	A4	5	D	50 50	12"/12"	2.2				2.2
30													

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FIGURE A-16. LOG OF BORING LPE-19

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

Project Number: 88-429 Borehole Number: **LPE-19** Sheet 2 of 3

Depth (feet)	Lith-ology	Description	USCS Classification	Geologic Unit	Samples							Background OVA (ppm)
					Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	
		SILTY SAND with granite fragments, no recovery.			6	S	100	0"/6" NR	2.6			2.2
35		SILTY SAND; Reddish brown, moist, very dense, fine to coarse, slightly plastic fines, trace gravel (granite fragments) 1/4 to 1/2 - inch size.	SM	A3	7	D	100	6"/6"				2.2
40		CLAYEY SAND; Reddish brown, moist, very dense, fine to coarse, trace fine gravel(decomposed granite). Weakly cemented at top.	SC	A4	8	P	Push	31"/31"		118	14.1	2.2
45		Same as above.	SC	A4	9	D	41 59/5"	10"/11"	4.4			3.4
50		Same as above.	SC	A4	10	S	44 56/1.2"		3.4			3.4
55		CLAYEY SAND; Reddish brown, moist, dense to very dense, fine to coarse, trace fine gravel (decomposed granite).	SC	A4	11	P	Push	30"/32"		115	12.4	3.4
60		Same as above.	SC	A4	12	S	49 51/5"	12"/12"				3.4
65		CLAYEY SAND; Reddish brown, moist, very dense, fine to coarse with trace fine gravel. Occasionally weakly cemented.	SC	A4	13	P	Push	30"/30"		105	15.4	3.4
		SAND-SILTY SAND; Brown, moist, medium dense, fine to coarse, with trace gravel.	SP-SM									
70												

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FIGURE A-16. LOG OF BORING LPE-19

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

Project Number: 88-429

Borehole Number: LPE-19

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)
		SAND-SILTY SAND; Reddish brown grading to brownish gray and yellowish brown, dense to very dense, fine to coarse, slightly plastic fines, trace fine gravel. (Harder drilling.)	SP-SM	A3	14	S	40 35 25/0.25"	8"/13"				3.4
75		Same as above.	SP-SM	A3	15	P	Push	24"/24"		118	13.4	3.4
		BORING TERMINATED AT 77 FEET. HOLE GROUTED TO SURFACE. 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												

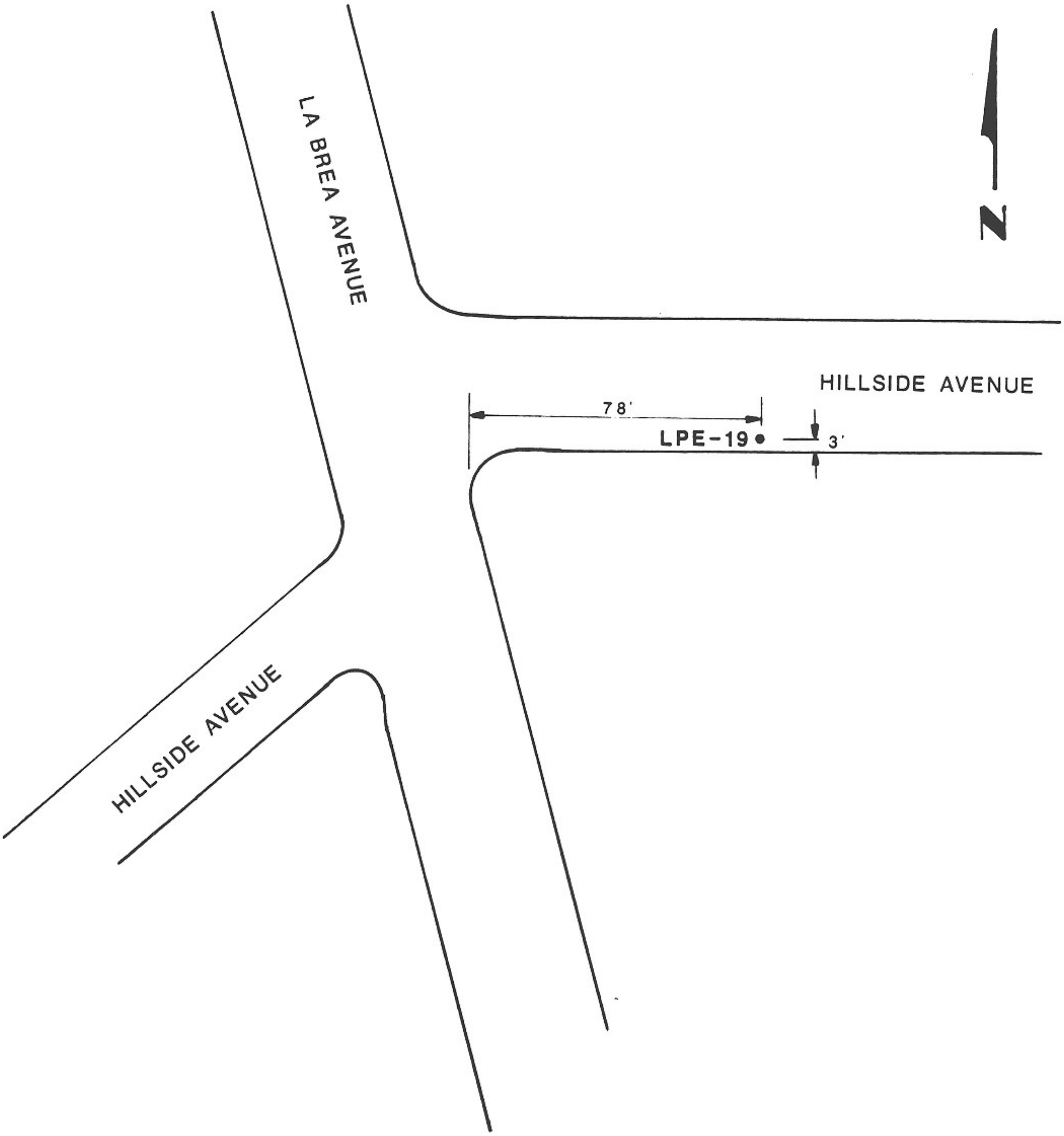

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FIGURE A-16A

LOCATION OF BORING LPE-19

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FIGURE A-17. LOG OF BORING LPE-20

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

Project Number: 88-429

Borehole Number: LPE-20

Sheet 1 of 4

Borehole Location: Wilshire and Commonwealth

Elevation and Datum(feet): 245.0

Health and Safety: Level D

Date Started: 10/6/88

Date Finished: 10/7/88

Drilling Equipment: Failing 750

Total Depth (feet): 104.0

Depth to Bedrock(feet): 29.0

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: 365-lb weight and 18-inch drop.

Logged By: C. M. Payne

Checked By: C. Duckworth

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)
		4-inch ASPHALT CONCRETE										
		4-inch CONCRETE										
5		FILL; medium dark brown, moist, mixed silt-sand-clay, with minor gravel (rock fragments)	SM/ML /CL	FILL								
		(Little firmer-rock fragments in a dark brown clay-silt matrix; wet but not saturated.)										
10		(Set casing to 8-1/2 feet, start rotary wash with drag bit.)										
		(Black clay in cuttings. Appears native material.) SILTY CLAY; Dark gray to black, moist, stiff, slightly sandy, moderately plastic, organic odor.	CL	A4	1	S	3 6 7	18"/18"	4.8			4.0
15		SILTY CLAY; Green-blue-yellow-brown (multi colored), moist, stiff, very fine to fine, highly plastic fines, moderatly weathered, micaceous.	CL/CH	A4	2	D	6 9	12"/12"	4.6	85	36.4	4.0
20		CLAYEY SILT; Olive brown, moist, very stiff, slightly to moderately plastic fines, micaceous.	ML	A4	3	S	7 11 13	18"/18"	5.2			4.6
25		CLAYEY SILT; Olive brown with yellowish brown mottled, moist, very stiff to hard, very fine to fine sand, micaceous, oxidized iron stains .	ML	A4	4	D	11 22	12"/12"	5.1	85	31.5	4.0
30		TOP OF PUENTE FORMATION										

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FIGURE A-17. LOG OF BORING LPE-20

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

Project Number: 88-429 Borehole Number: **LPE-20** Sheet 2 of 4

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 brown, moist, hard, slightly plastic, laminated, oxidized, interbedded with sandstone, very fine to fine, micaceous. Dip approximately 15 deg.		Tpw	5	S	17 39 35	18"/18"	5.6			5.6
35		Same as above.		Tpw	6	D	25 65	12"/12"	6.0	88	32.8	5.6
		(Minor oil film in mud tank.)										
40		SILTY CLAYSTONE; Dark olive gray, moist, hard, slightly plastic, fresh, laminated, micaceous, with oxidized beddings. Dip 15 to 20 deg.		Tpw	7	S	25 50/5.5"	8"/11.5"	8.0			4.0
		(Drag bit - slow smooth drilling.)										
45		CLAYEY SILTSTONE; Dark gray to dark brown, moist, hard, slightly plastic, laminated, fresh, micaceous, interbedded with thin seams of very fine to fine sandstone. Dip 15 to 20 deg.		Tpf	8	D	31 69/5.5"	11/11.5"	5.0	86	37.6	4.0
		(Drag bit - slow smooth drilling.)										
50		CLAYEY SILTSTONE; Olive gray, moist, hard, slightly plastic, laminated, fresh, micaceous with minor very fine to fine sandstone interbeds. Dip 15 to 20 deg.		Tpf	9	S	19 45 50/2"	16"/16"	5.5			4.0
55		CLAYEY SILTSTONE; Dark gray to dark brown, moist, hard, slightly plastic, laminated, fresh, interbedded with thin layers of weakly cemented, very fine to fine sandstone. Dip approximately 20 deg.		Tpf	10	D	25 58	12"/12"	5.1	96	26.5	4.0
60		CLAYEY SILTSTONE; Olive gray, moist, hard, slightly plastic, laminated, fresh, micaceous, with scattered, weakly cemented, very fine to fine sandstone beds. Dip 40 to 45 deg.		Tpf	11	D	30 50/4.5"	10/10.5"	4.5			4.0
65		Same as above except dip approximately 20 deg.		Tpf	12	D	50 50/3"	9"/9"	3.0	89	30.7	3.0
70												

FIGURE A-17. LOG OF BORING LPE-20

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

Project Number: 88-429 Borehole Number: LPE-20 Sheet 3 of 4

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)
		Same as above. (Slow smooth drilling with drag bit.)		Tpf	13	S	28 50/4"	10"/10"	3.4			2.5
75		Same as above.		Tpf	14	D	50 50/4"	10"/10"	6.6			2.5
		(Slow smooth drilling.)										
80		CLAYEY SILTSTONE; Dark gray and dark brown, moist, hard, thinly bedded, fresh, micaceous. Dip approximately 20 deg.		Tpf	15	S	15 34 50/5.5"	14/17.5"	18.0			2.5
85		CLAYEY SILTSTONE; Dark gray, moist, hard, slightly clayey thinly bedded to laminated, fresh, micaceous with occasional beds of very fine to fine sandstone. Dip approximately 25 deg. (Driller reported fast drilling.)		Tpf	16	D	45 53/5"	11"/11"	20.0	94	27.8	2.5
90		CLAYEY SILTSTONE; Olive gray, moist, hard, slightly plastic to non plastic, fresh, micaceous, interbedded with 1/2 to 3/4-inch thick, about 5-inch apart, medium gray, very fine to fine sandstone.		Tpf	17	S	31 50/3"	12"/9"	16.0			2.5
95		CLAYEY SILTSTONE; Dark to medium gray and dark brown, moist, hard, fresh, micaceous, interbedded with 1/16 to 1/8-inch thick, medium gray, very fine to fine sandstone.		Tpf	18	D	45 55/4"	10"/10"	28.0	90	30.9	2.5
100		(Drill chatter.) (Very hard siliceous shale in drill cuttings. Estimated 1 to 2-inch thick layer.) Same as above. Mild sulfur odor coming from the sample.		Tpf	19	S	40 50/3"	9"/9"	1000.0			2.5
105		BORING TERMINATED AT 104 FEET DUE TO HIGH (1000+) OVA READING 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 o f time. The data										
110												

FIGURE A-17. LOG OF BORING LPE-20

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

Project Number: **88-429** Borehole Number: **LPE-20** Sheet 4 of 4

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)
115 120 125 130 135 140 145 150		presented is simplification of actual conditions encountered. The stratification lines represent the approximate boundary between subsurface material types and the transition may be gradual.										

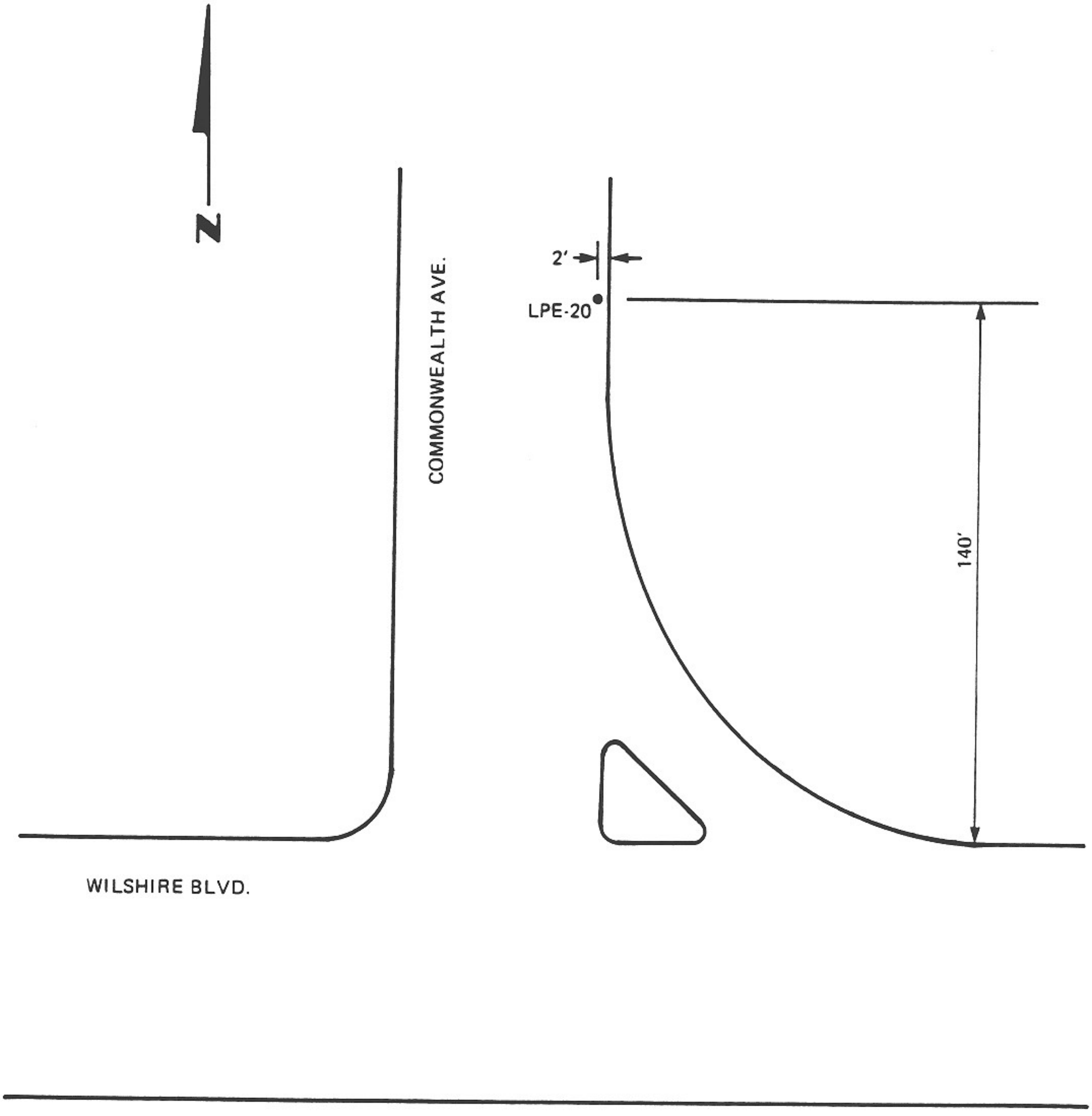

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FIGURE A-17A

LOCATION OF BORING LPE-20

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FIGURE A-18. LOG OF BORING LPE-21

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

Project Number: **88-429**

Borehole Number: **LPE-21**

Sheet 1 of 3

Borehole Location: **Wilshire and Westmoreland**

Elevation and Datum(feet): **260.0**

Health and Safety: **Level D**

Date Started: **10/5/88**

Date Finished: **10/5/88**

Drilling Equipment: **Failing 750**

Total Depth (feet): **76.0**

Depth to Bedrock(feet): **32.5**

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: 365-lb weight and 18-inch drop

Logged By: **C. M. Payne**

Checked By: **C. Duckworth**

Depth (feet)	Lith-ology	Description	USCS Classification	Geologic Unit	Samples								Background OVA (ppm)
					Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)		
	■	5-inch ASPHALT CONCRETE.											
	▩	CLAYEY SAND with shale and rock fragments. Fill material.	SC	FILL									
5	▨	(Clayey sand in cuttings; brown, moist.) CLAYEY SILT; Gray and brown mottled, moist, stiff, moderately plastic fines.	ML	A4	1	D	9 18	12"/12"	6.4				3.7
	▨	(Set casing to 8-1/2 feet. Start rotary wash with drag bit.)											
10	░	SILTY SAND; Pale olive, moist, dense, very fine to fine, slightly plastic fines, slightly cemented, no structure.	SM	A3	2	S	7 11 13	6"/18"	5.1				3.7
15	░	SAND; Yellowish brown, wet, dense to very dense, slightly silty, fine to medium, poorly cemented.	SP	A3	3	D	12 19	12"/12"	5.1	104	11.5		3.7
20	░	SILTY SAND; Pale yellow, wet, very dense, very fine to very coarse, trace gravel (decomposed granite and shale) up to 1/2-inch size. Some iron stains.	SM	A3	4	S	16 22 24	16"/18"	5.6				3.7
25	░	SILTY SAND; Yellowish gray, wet, very dense, very fine to coarse, massive, no apparent bedding.	SM	A3	5	D	22 28	12"/12"	5.3	106	18.7		4.9
30													

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FIGURE A-18. LOG OF BORING LPE-21

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

Project Number: 88-429 | Borehole Number: LPE-21 | 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)
		Same as above. (Driller reported clay at 32 feet.)	SM	A3	6	S	22 31 34	8"/18"	5.4			4.9
		TOP OF PUENTE FORMATION.										
35		CLAYEY SILTSTONE; grayish brown, moist, hard, oxidized, interbedded with poorly cemented, fine sand(stone). Beds are 1/32 to 1/16-inch thick, about 2-inch apart. Dip 20 to 25 deg. Slight Sulfur odor. (Dark gray organic clay in cuttings at 39 feet.)		Tpw	6	D	22 47	12"/12"	20.0	93	27.1	4.9
40		CLAYEY SILTSTONE; Dark olive gray, moist, hard, slightly plastic, laminated, fresh, micaceous. Dip approximately 25 deg. Sulfur odor. (Siliceous, gray, hard shale in cuttings from 42 to 42-1/2 feet.)		Tpf	7	S	22 50/5"	11"/11"	95.0			4.9
45		CLAYEY SILTSTONE; Olive gray, moist, hard, slightly plastic, laminated, fresh. Dip approximately 25 deg. Slight sulfur odor. (Oil trace in mud tank. Oil spots in strainer.)		Tpf	8	D	30 55	12"/12"	9.2	91	30.2	4.9
50		Same as above.		Tpf	9	S	26 50/5"	10"/11"	8.2			4.9
55		Same as above.		Tpf	10	D	37 63/5"	11"/11"	12.0	86	34.7	4.9
60		CLAYEY SILTSTONE; Olive gray grading to gray, moist, hard, slightly to moderately plastic, laminated with alternating olive gray and gray thin beds of very fine silty sandstone, fresh. Dip 25 to 30 deg.		Tpf	11	S	22 47 50/3"	10"/15"	6.2			4.9
65		Same as above.		Tpf	12	D	40 60/4"	9"/10"	8.2	91	30.2	4.9
70												

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FIGURE A-18. LOG OF BORING LPE-21

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

Project Number: 88-429 Borehole Number: LPE-21 Sheet 3 of 3

Depth (feet)	Lith-ology	Description	USCS Classification	Geologic Unit	Samples								Background OVA (ppm)
					Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)		
	▦	CLAYEY SILTSTONE; Olive brown with dark olive gray mottled, moist, hard, slightly plastic, laminated, fresh. Dip 25 to 30 deg. Strong Sulfur odor.		Tpf	13	S	23 50/5"	10"/11"	120.0				4.9
75	▤	SILTY CLAYSTONE; Light brown, moist, hard, laminated, fresh. Dip 25 to 30 deg. Strong Sulfur odor.		Tpf	14	D	40 60/4"	10"/11"	4.4	84	35.7		4.9
		BORING TERMINATED AT 76 FEET DUE TO HIGH OVA READING. 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													
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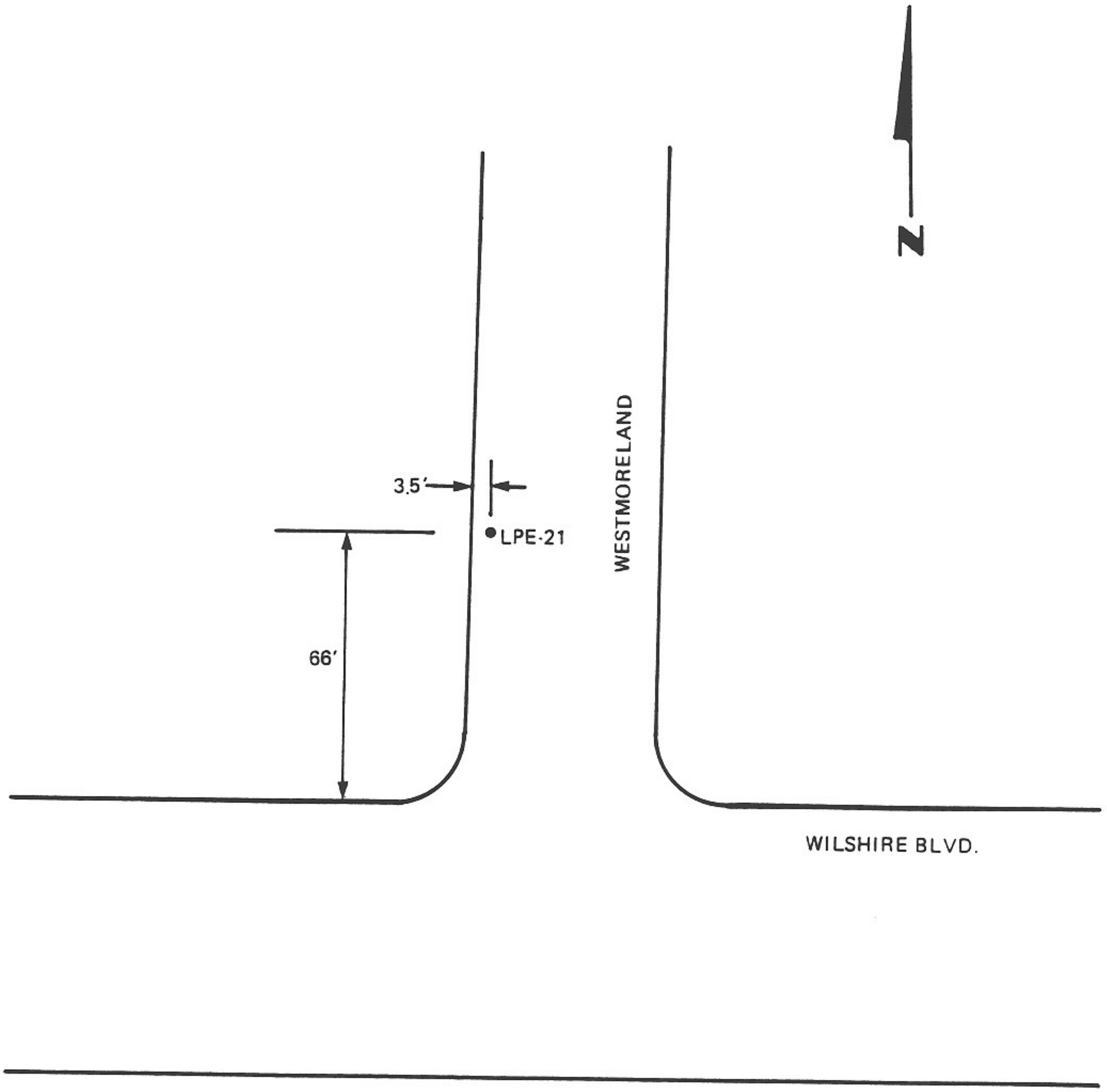

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FIGURE A-18A

LOCATION OF BORING LPE-21

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FIGURE A-19. LOG OF BORING LPE-24

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

Project Number: **88-429**
Borehole Number: **LPE-24**
Sheet 1 of 4

Borehole Location: **Catalina and 6th**
Elevation and Datum(feet): **218.0**

Health and Safety: **Upgraded Level D**
Date Started: **11/2/88**
Date Finished: **11/3/88**

Drilling Equipment: **Failing 750**
Total Depth (feet): **115.5**
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 weight and 30-inch drop.
DOWNHOLE Hammer: 365-lb weight and 18-inch drop.

Logged By: **C. M. Payne**
Checked By: **C. Duckworth**

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 CONCRETE.										
		3-inch CONCRETE.										
		SILTY SAND; Medium brown, wet, loose. (Pea gravel in cuttings at 4 feet.)	SM	A3	1	B						
5		SAND; Moist to wet, loose, fine to coarse, slightly silty, fairly clean. Appears native. (Switch to rotary wash at 6 feet.) (Set casing to 8-1/2 feet.)	SP	A3	2	B						
10		TOP OF PUENTE FORMATION. (Clayey siltstone in cuttings.) CLAYSTONE/SILTSTONE; Tan-medium gray-yellowish brown, moist, very stiff, thinly interbedded, oxidized (moderately weathered), micaceous, well bedded. Dip 10 to 15 deg.		Tpw	3	S	6 9 11	18"/18"				
15		CLAYSTONE/SILTSTONE; Yellowish brown to tan and gray, moist, very stiff, oxidized (moderately weathered), micaceous with iron stained fractures 1-inch apart. Dip approximately 20 deg. (Rock fragments in cuttings at 19 feet.)		Tpw	4	D	8 15	12"/12"				
20		CLAYEY SILTSTONE; Medium to dark grayish brown, moist, hard, slightly weathered and oxidized, thinly bedded, micaceous, with widely spaced, approximately 1/2-inch thick very fine to fine sandstone beds. Dip approximately 20 deg.		Tpw	5	S	14 17 28	18"/18"				
25		CLAYEY SILTSTONE; Medium brown and medium gray, moist, hard, interbedded with very fine to fine sandstone, laminated, moderately weathered and oxidized, friable. Dip 15 to 20 deg.		Tpw	6	D	21 69	12"/12"		88	33.2	
30												

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FIGURE A-19. LOG OF BORING LPE-24

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

Project Number: 88-429 Borehole Number: LPE-24 Sheet 2 of 4

Depth (feet)	Lith-ology	Description	USCS Classification	Geologic Unit	Samples							Background OVA (ppm)
					Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	
		CLAYEY SILTSTONE; Medium dark gray to dark gray, moist, hard, thinly bedded, fresh, micaceous, interbedded with 1/8 to 1/2-inch thick, very fine to fine sandstone beds. Dip approximately 15 to 20 deg.		Tpf	7	S	19 28 40/5"	18"/18"				
		(Moderate drill chatter. Siliceous siltstone in cuttings.)										
35		Same as above.		Tpf	8	D	40 60/5"	11"/11"		79	39.1	
40		CLAYEY SILTSTONE; Dark gray, moist, hard, fresh, micaceous, interbedded with 1/16 to 1/8-inch thick , sandstone beds, friable. Dip 20 to 25 deg.		Tpf	9	S	25 37 38/4"	16"/16"				
45		Same as above except less sandstone beds. Dip approximately 20 deg.		Tpf	10	D	43 57	12"/12"		92	30.8	
		(Softer, faster drilling.)										
50		Same as above.		Tpf	11	S	34 66/6.5"	9"/12.5"				
55		Same as above. Sandstone beds are 1/32 to 1/8-inch thick. Moderately cemented. Dip approximately 10 deg.		Tpf	12	D	48 52/4.5"	9"/10.5"	4.2			4.2
60		Same as above. Dip 5 to 10 deg.		Tpf	13	S	25 38 37/3"	14"/15"	4.4			4.4
		(Faster drilling at 62 feet.)										
65		CLAYEY SILTSTONE; Dark gray, moist, hard, micaceous, massive. Bedding not apparent.		Tpf	14	D	69 39/1"	7"/7"	4.6			4.6
		(Softer drilling from 69 to 70 feet.)										
70												

FIGURE A-19. LOG OF BORING LPE-24

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

Project Number: 88-429 | Borehole Number: LPE-24 | Sheet 3 of 4

Depth (feet)	Lith-ology	Description	USCS Classification	Geologic Unit	Samples								Background OVA(ppm)
					Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)		
		Same as above.		Tpf	15	S	21 40 49/3.5"	15/15.5"	5.4				5.4
75		Same as above.		Tpf	16	D	28 72/5"	11"/11"	4.8	93	30.0		4.8
80		CLAYEY SILTSTONE; Dark brown to dark gray, moist, hard, fresh, micaceous with 1/32 to 1/16-inch thick beds of medium gray, very fine to fine, sandstone, friable.		Tpf	17	P	Push 350psi	30"/30"	3.0	88	34.0		3.0
85		Same as above.		Tpf	18	D	28 50	12"/12"	3.0	92	32.0		3.0
90		Same as above.		Tpf	19	S	23 38 39/3"	15"/15"	4.5				4.5
95		Same as above.		Tpf	20	D	42 58/5"	11"/11"	4.5	97	27.5		4.5
100		Same as above.		Tpf	21	S	21 46 33/1"	13"/13"	4.2				4.2
105		Same as above.		Tpf	22	D	30 70/5.5	11"/11"	3.7	83	34.5		3.7
110													

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FIGURE A-19. LOG OF BORING LPE-24

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

Project Number: **88-429** Borehole Number: **LPE-24** Sheet 4 of 4

					Samples							
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)
		Same as above.		Tpf	23	P	Push 350psi	30"/30"	3.6			3.6
115		Same as above. Dip 10 to 15 deg.		Tpf	24	D	73 27/1"	7"/7"	3.8			3.8
		BORING TERMINATED AT 115-1/2 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.										
120												
125												
130												
135												
140												
145												
150												

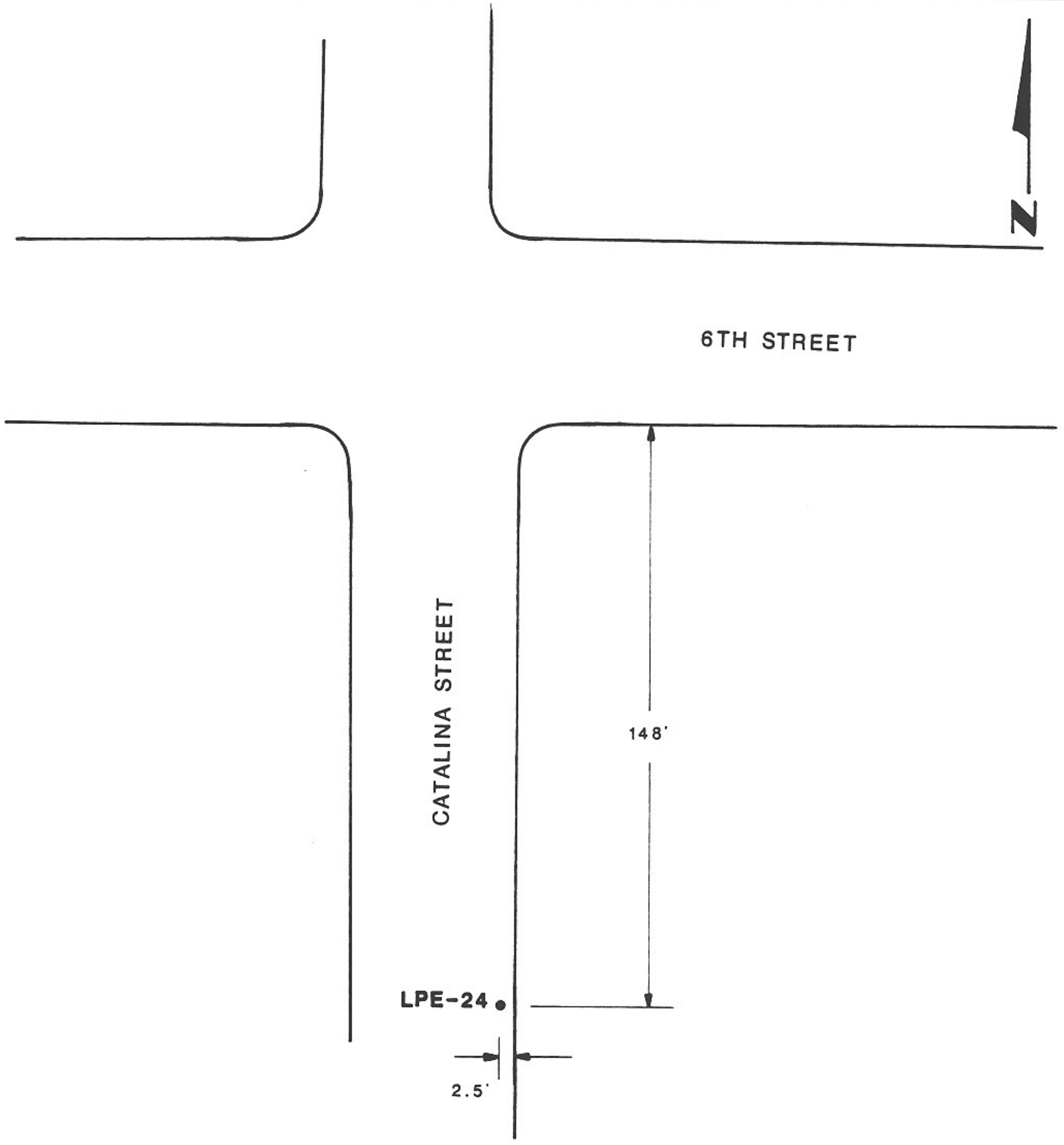

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FIGURE A-19A

LOCATION OF BORING LPE-24

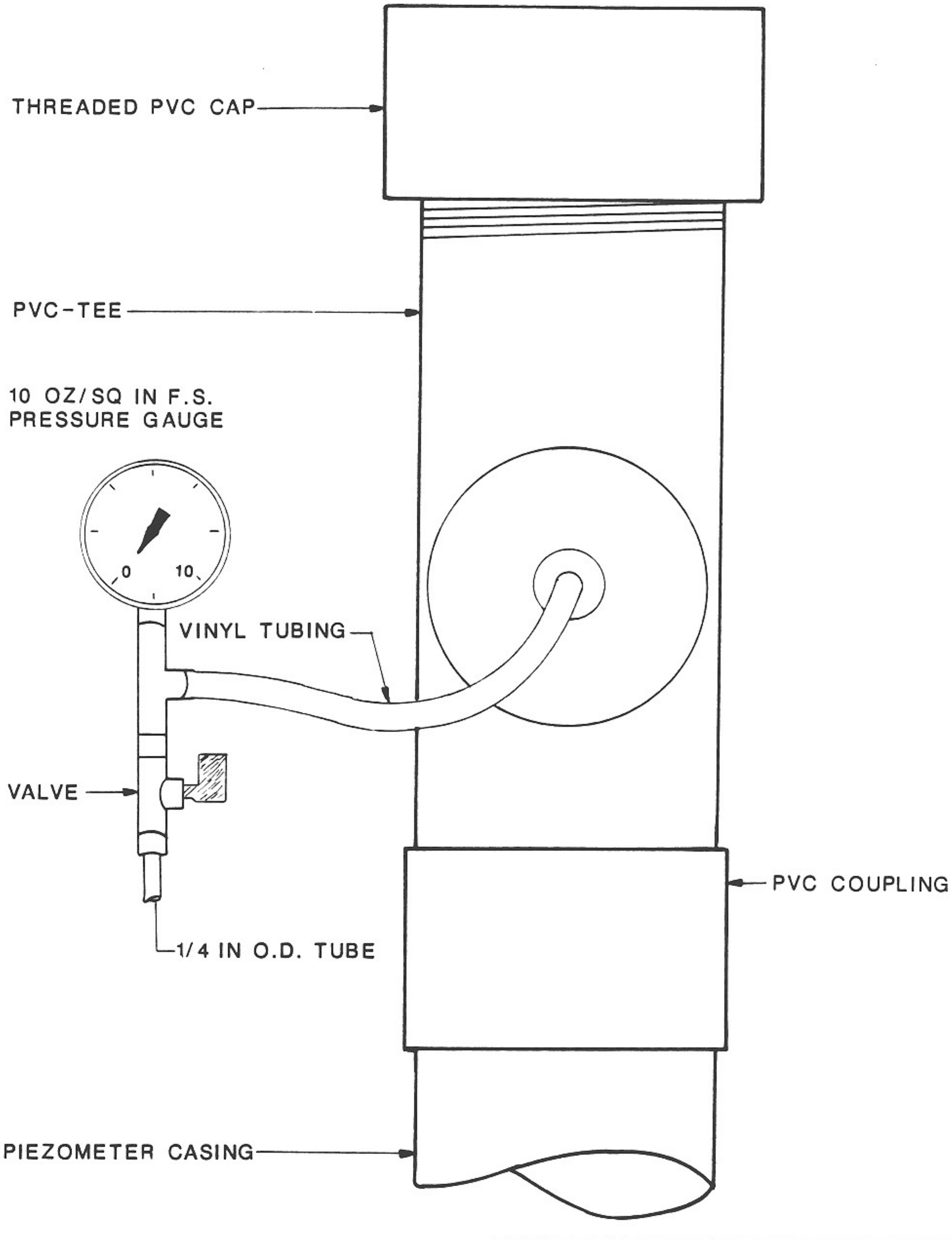

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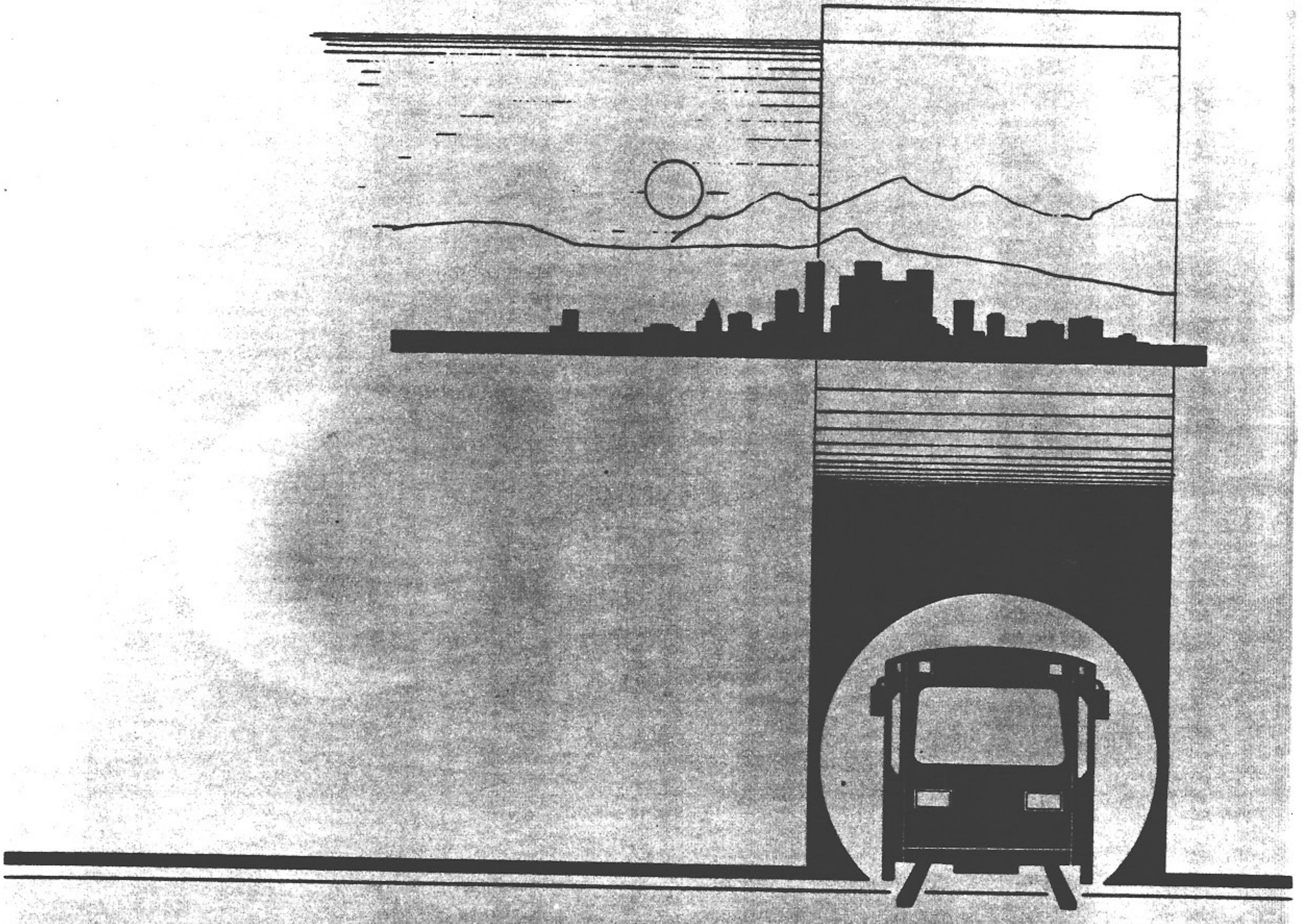
FIGURE A-20

SCHEMATIC DRAWING SHOWING
THE DEVICE USED IN GAS PRESSURE
MONITORING AND SAMPLING

NOT TO SCALE

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. An evaluation of the test results has been summarized in Table 5-1. 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	Permeability Determination
Figures B-1 through B-60	Grain Size Distribution Curves
Figures B-61 through B-111	Direct Shear Test Results
Figures B-112 through B-148	Unconfined Compression Test Results
Figure B-149	Consolidation Test Results

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

(Page 1 of 3)

BORING NO.	SAMPLE NO.	DEPTH (feet)	USCS CLASSIFICATION	GEOLOGIC UNIT	DRY DENSITY (PSF)	MOISTURE CONTENT (%)	CALCULATED* VOID RATIO
LPE-1	D-2	15.0	SP	A3	98.4	14.5	0.71
LPE-1	D-4	25.0	SP-SM	A3	95.4	29.3	0.77
LPE-1	D-6	35.0	-	Tpw	84.6	39.0	0.97
LPE-1	D-8	45.0	-	Tpf	74.5	40.2	1.33
LPE-1	D-10	55.0	-	Tpf	92.7	30.8	0.82
LPE-1	D-12	65.0	-	Tpf	90.4	32.8	0.92
LPE-1	D-14	75.0	-	Tpf	94.2	30.3	0.84
LPE-1	D-16	85.0	-	Tpf	92.1	31.9	0.88
LPE-1	D-18	95.0	-	Tpf	93.6	31.0	0.85
LPE-2	D-1	6.0	ML/CL	A3	99.0	24.3	0.70
LPE-2	D-3	15.0	SP-SM	A3	105.0	12.2	0.61
LPE-2	D-5	25.0	SM	A3	108.5	11.2	0.55
LPE-2	D-7	35.0	-	Tpw	85.6	32.5	0.95
LPE-2	D-10	45.0	-	Tpw	94.8	26.6	0.76
LPE-2A	D-4	40.0	-	Tpf	92.0	30.0	0.89
LPE-2A	D-6	50.0	-	Tpf	91.0	34.0	0.91
LPE-2A	D-8	60.0	-	Tpf	97.5	26.5	0.78
LPE-2A	D-10	70.0	-	Tpf	84.2	32.0	1.06
LPE-2A	P-11	75.0	-	Tpf	97.0	29.5	0.79
LPE-2A	D-16	100.0	-	Tpf	83.0	38.5	1.09
LPE-2A	D-18	110.0	-	Tpf	80.5	38.5	1.16
LPE-2A	D-20	120.0	-	Tpf	89.5	25.5	0.94
LPE-2A	P-21	125.0	-	Tpf	100.5	9.3	0.68
LPE-4B	D-5	25.0	-	Tpw	87.2	33.5	0.91
LPE-4B	D-7	35.0	-	Tpf	94.2	25.9	0.84
LPE-4B	D-9	45.0	-	Tpf	101.7	25.3	0.71
LPE-4B	D-13	65.0	-	Tpf	97.1	25.7	0.79
LPE-6	D-3	15.0	SM	A3	106.0	21.3	0.59
LPE-6	D-5	25.0	-	Tpw	87.8	32.3	0.90
LPE-6	P-9	45.0	-	Tpf	104.0	20.4	0.67
LPE-6	P-11	55.0	-	Tpf	99.3	22.7	0.70
LPE-6	D-12	65.0	-	Tpf	111.5	30.3	0.56
LPE-7	D-1	5.0	SM	A3	101.6	19.9	0.66
LPE-7	D-3	15.0	ML	Tpw	109.9	18.2	0.52
LPE-7	D-9	45.0	-	Tpw	94.9	28.5	0.76
LPE-7	D-11	55.0	-	Tpw	91.7	31.0	0.82
LPE-7	D-13	65.0	-	Tpf	108.2	20.1	0.60
LPE-7	P-14	70.0	-	Tpf	106.0	20.9	0.64
LPE-8	D-2	15.0	-	A4	102.6	23.6	0.64
LPE-8	D-6	35.0	-	Tpw	85.3	35.3	0.95
LPE-8	D-8	45.0	-	Tpw	82.5	36.8	1.02
LPE-8	D-10	55.0	-	Tpw	99.2	25.2	0.68
LPE-8	D-12	65.0	-	Tpf	104.8	22.3	0.66
LPE-9	D-3	15.0	SC/CL	A2	109.9	19.7	0.52
LPE-9	D-5	25.0	CL	A2	123.6	11.8	0.35
LPE-9	D-7	35.0	SC	A2	122.4	13.1	0.36
LPE-9	D-9	45.0	SC/CL	A4	119.8	15.0	0.41
LPE-9	D-11	55.0	SC	A4	123.6	13.3	0.36

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

(Page 2 of 3)

BORING NO.	SAMPLE NO.	DEPTH (feet)	USCS CLASSIFICATION	GEOLOGIC UNIT	DRY DENSITY (PSF)	MOISTURE CONTENT (%)	CALCULATED* VOID RATIO
LPE-10	D-2	5.0	SC	A2	98.3	24.1	0.70
LPE-10	D-4	15.0	SM	A2	112.3	15.8	0.48
LPE-10	D-6	25.0	SC	A4	105.9	22.8	0.59
LPE-10	D-8	35.0	SC	A4	121.4	13.9	0.39
LPE-10	D-10	45.0	SC	A4	117.5	16.5	0.43
LPE-10	D-12	55.0	GM	A3	122.5	15.4	0.38
LPE-10	D-14	65.0	SC	A4	111.9	18.2	0.51
LPE-10	D-16	75.0	SC	A4	108.0	21.0	0.56
LPE-10	D-18	85.0	SC	A4	108.1	20.2	0.56
LPE-11	D-3	15.0	SM	A1	105.7	11.6	0.56
LPE-11	D-5	25.0	SM	A1	111.5	17.3	0.48
LPE-11	D-7	35.0	SM	A3	112.2	14.5	0.50
LPE-11	D-9	45.0	SC/CL	A4	111.9	14.8	0.51
LPE-11	D-11	55.0	SM	A3	118.5	15.2	0.42
LPE-11	D-13	65.0	SM	A3	111.7	17.0	0.51
LPE-11	D-15	75.0	SM	A3	114.1	16.4	0.48
LPE-11	D-17	85.0	SM	A3	112.4	16.6	0.50
LPE-12	D-1	5.0	SM	A1	98.1	9.7	0.69
LPE-12	D-6	35.0	SM	A1	109.8	18.5	0.51
LPE-12	D-8	45.0	SC	A4	120.0	14.5	0.40
LPE-12	D-10	55.0	SM	A3	120.0	10.5	0.40
LPE-12	D-12	65.0	SM	A3	117.0	14.4	0.44
LPE-12	D-14	75.0	SM	A3	110.2	7.2	0.53
LPE-12	D-18	90.0	SC	A4	123.5	14.5	0.36
LPE-13	D-3	15.0	SM	A1	117.8	6.3	0.40
LPE-13	D-5	35.0	SM	A3	127.8	9.1	0.32
LPE-13	D-10	65.0	SC/CL	A4	111.5	18.9	0.51
LPE-14	D-1	11.0	SM	A1	103.2	6.7	0.60
LPE-14	D-3	20.0	SM	A1	110.2	16.5	0.50
LPE-14	D-5	30.0	SM	A1	109.8	18.4	0.51
LPE-14	D-7	40.0	SC	A2	106.1	18.7	0.57
LPE-14	D-10	55.0	SM	A1	106.1	9.4	0.56
LPE-14	D-13	66.0	SC	A2	127.0	9.3	0.31
LPE-14	D-15	75.0	ML	A4	113.0	19.0	0.49
LPE-15	D-3	15.0	SM	A1	113.6	10.4	0.46
LPE-15	D-5	25.0	SM	A1	114.3	11.9	0.45
LPE-15	D-7	35.0	SM	A1	103.3	18.4	0.60
LPE-15	D-9	45.0	SM	A1	114.2	16.6	0.45
LPE-15	D-11	55.0	CL	A2	102.7	20.5	0.61
LPE-15	D-13	65.0	CL	A2	106.7	20.6	0.56
LPE-15	D-15	75.0	CL	A1	105.5	21.2	0.57
LPE-16	D-1	5.0	SM	A1	88.0	17.1	0.88
LPE-16	D-3	15.0	SM	A1	98.3	21.0	0.68
LPE-16	D-5	25.0	SM	A1	101.0	11.2	0.64
LPE-16	D-7	35.0	SC	A4	103.2	18.2	0.63
LPE-16	D-9	45.0	SM	A3	128.1	13.0	0.31

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

(Page 3 of 3)

BOREHOLE	SAMPLE NO.	DEPTH (feet)	USCS CLASSIFICATION	GEOLOGICAL UNIT	DRY DENSITY (PSF)	MOISTURE CONTENT (%)	CALCULATED* VOID RATIO
LPE-16	D-11	55.0	SM	A3	100.9	22.7	0.67
LPE-16	D-13	65.0	SM	A3	103.9	17.7	0.62
LPE-16	D-15	75.0	SM	A3	105.6	19.3	0.60
LPE-17	D-2	10.0	SM	A1	102.4	16.4	0.62
LPE-17	D-4	20.0	SM	A1	109.6	10.4	0.51
LPE-17	D-6	30.0	CL	A4	105.3	19.0	0.60
LPE-17	D-8	40.0	SM	A3	104.7	18.0	0.61
LPE-17	D-10	50.0	SM	A3	104.7	18.0	0.61
LPE-17	D-12	60.0	CL	A4	102.3	17.4	0.65
LPE-17	D-14	70.0	SM	A4	107.0	16.4	0.58
LPE-19	D-1	5.0	SP-SM	A1	113.3	13.4	0.47
LPE-19	D-3	14.8	SC	A4	113.2	16.3	0.49
LPE-19	P-8	40.0	SC	A4	117.7	14.1	0.43
LPE-19	P-11	55.0	SC	A4	115.0	12.4	0.47
LPE-19	P-13	65.0	SC	A4	105.4	15.4	0.69
LPE-19	P-15	75.0	SP-SM	A3	118.3	13.4	0.43
LPE-20	D-2	15.0	ML/CL	A4	84.5	36.4	0.99
LPE-20	D-4	25.0	ML	A4	84.6	31.5	0.99
LPE-20	D-6	35.0	-	Tpw	88.1	32.8	0.89
LPE-20	D-8	45.0	-	Tpf	85.8	37.6	1.02
LPE-20	D-10	55.0	-	Tpf	95.8	26.5	0.81
LPE-20	D-12	65.0	-	Tpf	89.0	30.7	0.95
LPE-20	D-16	85.0	-	Tpf	94.1	27.8	0.84
LPE-20	D-18	95.0	-	Tpf	89.7	30.9	0.93
LPE-21	D-3	15.0	SP	A3	103.6	11.4	0.63
LPE-21	D-5	25.0	SM	A3	105.5	18.6	0.60
LPE-21	D-6	35.0	-	Tpw	92.9	27.0	0.79
LPE-21	D-8	45.0	-	Tpf	90.8	30.2	0.91
LPE-21	D-10	55.0	-	Tpf	85.7	34.0	1.02
LPE-21	D-14	75.0	-	Tpf	84.2	35.7	1.00
LPE-24	D-6	25.0	-	Tpf	87.6	33.2	0.98
LPE-24	D-8	35.0	-	Tpf	78.7	39.1	1.14
LPE-24	D-10	45.0	-	Tpf	91.8	30.8	0.84
LPE-24	D-16	75.0	-	Tpf	92.5	30.0	0.88
LPE-24	P-17	80.0	-	Tpf	87.5	34.0	0.98
LPE-24	D-18	85.0	-	Tpf	91.5	32.0	0.90
LPE-24	D-20	95.0	-	Tpf	96.5	27.5	0.80
LPE-24	D-22	105.0	-	Tpf	82.5	34.5	1.10

*Calculated based on dry density and specific gravity test results.

TABLE B-2. RESULTS OF GRAIN SIZE AND FINES CONTENT ANALYSES
(Page 1 of 3)

BORING NO.	SAMPLE NO.	DEPTH (feet)	USCS CLASSIFICATION	GEOLOGIC UNIT	PERCENT*		
					GR	SA	FINES
LPE-1	S-1	10-10.5	SP-SM	A3			6**
LPE-1	D-4	25.0-26.0	SP-SM	A3			10**
LPE-1	S-5	30.0-31.5	ML	A4	0	4	96
LPE-2	D-3	15-16.0	SP-SM	A3	0	87	13
LPE-2	S-4	20.0-21.2	SM	A3	0	67	33
LPE-2A	S-2	25.0-25.9	SM	A3			16**
LPE-4B	S-1	10.0-11.1	SP-SM	A3			8**
LPE-8	D-2	15.0-16.0	CL	A4	0	11	89
LPE-9	D-3	15.0-16.5	SC/CL	A2	1	51	48
LPE-9	S-8	40.0-41.5	SM	A1	1	81	18
LPE-9	D-9	45.0-46.0	SC/CL	A4	1	49	50
LPE-10	D-8	35.0-36.0	SC	A4	0	63	37
LPE-10	S-9	40.0-41.5	SC/CL	A4	0	50	50
LPE-10	D-10	45.0-46.0	SC	A4	0	57	43
LPE-10	S-15	70.0-71.5	SC	A4	2	70	28
LPE-11	S-2	10.0-11.5	SM	A1	6	52	42
LPE-11	D-3	15.0-16.5	SM	A1	9	69	22
LPE-11	D-5	25.0-26.0	SM	A1	6	64	30
LPE-11	S-8	40.1-41.6	SM	A3	2	73	25
LPE-11	D-9	45.0-46.0	SC/CL	A4	1	49	50
LPE-11	S-10	50.0-51.5	SC	A4	0	65	35
LPE-12	D-1	5.0-6.0	SM	A1	2	60	38
LPE-12	S-2	10.0-11.5	SC	A2	0	55	45
LPE-12	S-9	50.0-51.5	CL	A4	0	40	60

TABLE B-2. RESULTS OF GRAIN SIZE AND FINES CONTENT ANALYSES
(Page 2 of 3)

BORING NO.	SAMPLE NO.	DEPTH (feet)	USCS CLASSIFICATION	GEOLOGIC UNIT	PERCENT*		
					GR	SA	FINES
LPE-12	S-13	70.0-71.4	SM	A3			25
LPE-12	D-14	75.0-76.0	SM	A3	6	77	17
LPE-12	S-15A	80.0-80.7	ML	A4	7	39	54
LPE-12	S-15B	80.7-81.5	ML	A4	3	37	60
LPE-12	D-16A	85.0-85.5	SC/CL	A4	1	48	51
LPE-13	S-8	50.0-51.5	SM	A3	5	58	37
LPE-13	D-9	55.0-56.0	SM	A3	6	70	24
LPE-13	S-9A	60.0-61.5	SC/CL	A4	0	49	51
LPE-13	D-10	64.9-65.9	SC/CL	A4	0	49	51
LPE-14	D-1	11.0-12.0	SM	A1	11	72	17
LPE-14	S-2	15.0-16.5	SM	A1	0	67	33
LPE-14	S-4	25.0-26.5	SM	A1	34	46	20
LPE-14	D-7	40.0-41.0	SC	A2	2	52	46
LPE-14	S-8	45.0-46.5	SC	A2	7	69	24
LPE-14	D-10	55.0-56.0	SP-SM	A1	3	87	10
LPE-14	D-13	65.5-66.3	SC	A2	6	65	29
LPE-14	S-14	70.0-71.5	SC	A4	6	47	47
LPE-15	S-2	10.0-11.5	SM	A1	20	67	13
LPE-15	S-4	20.2-21.7	SC/CL	A2	12	40	48
LPE-15	S-6	30.0-31.5	CL	A2	0	26	74
LPE-15	D-9	45.0-46.0	SM	A1	3	63	34
LPE-15	S-10A	50.2-57.0	CL/CH	A2	0	45	55
LPE-16	S-2	10.0-10.5	SM	A1	10	59	31
LPE-16	D-5	24.9-26.4	SM	A1	6	60	34

TABLE B-2. RESULTS OF GRAIN SIZE AND FINES CONTENT ANALYSES
(Page 3 of 3)

BORING NO.	SAMPLE NO.	DEPTH (feet)	USGS CLASSIFICATION	GEOLOGIC UNIT	PERCENT*		
					GR	SA	FINES
LPE-16	S-6	29.8-31.3	SM	A3	22	53	25
LPE-16	D-9	44.8-45.6	SM	A3	11	69	20
LPE-16	S-10	49.7-51.2	SM	A3			18**
LPE-16	D-11	54.7-56.1	SM	A3			23**
LPE-16	S-12	59.7-61.2	SM	A3	3	58	39
LPE-16	S-14	70.0-71.5	SM	A3	3	51	46
LPE-17	S-1	5.0-6.5	SM	A1	8	59	33
LPE-17	S-3	15.0-16.5	SC	A2	3	52	45
LPE-17	S-5	25.0-26.5	SC/CL	A2	1	47	52
LPE-17	D-8	40.0-40.5	SM	A3	5	68	27
LPE-17	D-10	50.0-50.7	SM	A3	4	73	23
LPE-17	S-11	55.0-56.4	SM	A3	3	59	38
LPE-17	D-12	60.0-60.7	CL	A4	1	41	58
LPE-17	S-13	65.0-66.5	SC	A3			32**
LPE-17	D-14	70.0-70.9	SC	A3	1	52	47
LPE-19	D-5	19.9-20.8	CL	A4	0	46	54
	P-11	55.0-57.1	SM	A3	7	78	15
LPE-19	P-13	65.0-67.5	SM	A3	2	70	28
LPE-19	P-15	75.0-77.0	SP-SM	A3	14	76	10
LPE-21	D-5	25.0-26.0	SM	A3	4	74	22

* GR = Gravel
SA = Sand
FINES = Silt and Clay

** Only fines content was determined

TABLE B-3. ATTERBERG LIMITS TEST RESULTS

POINT IDENTIFICATION	DEPTH (feet)	SAMPLE NUMBER	USCS CLASSSIFICATION	GEOLOGIC UNIT	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
LPE-9	20.0	S-4	CL	A4	33	17	16
LPE-9	40.0	S-8	SM	A3	NP*	NP*	NP*
LPE-10	35.0	D-8	SC	A4	29	13	16
LPE-10	40.0	S-9	SC/CL	A4	38	21	17
LPE-10	45.0	D-10	SC	A4	29	14	15
LPE-10	70.0	S-15	SC	A4	29	18	11
LPE-11	30.0	S-6	SC	A4	34	22	12
LPE-11	34.8	D-7	SM	A3	32	27	5
LPE-11	45.0	D-9	SC/CL	A4	32	21	11
LPE-11	50.0	S-10	SC	A4	31	20	11
LPE-12	10.0	S-2	SC	A2	33	22	11
LPE-12	50.0	S-9	CL	A4	38	22	16
LPE-13	10.0	S-2	SC	A2	23	15	8
LPE-13	40.0	S-6	SC	A4	23	15	8
LPE-13	60.0	S-9	SC/CL	A4	32	11	21
LPE-13	64.9	D-10	SC/CL	A4	28	21	7
LPE-13	70.0	S-11	SC	A4	37	16	21
LPE-14	40.0	D-7	SC	A2	34	17	17
LPE-14	70.0	S-14	SC	A2	37	16	21
LPE-15	50.2	S-10	CH	A2	54	22	32
LPE-15	65.0	D-13	CL	A2	31	17	14
LPE-16	34.7	D-7	SC	A4	36	27	9
LPE-17	25.0	S-5	CL	A4	47	18	29
LPE-17	30.0	D-6	CL	A4	38	21	17
LPE-19	20.0	S-4	CL	A4	39	20	19
LPE-19	25.0	D-5	SM	A4	31	18	13
LPE-20	10.0	S-1	CL	A4	36	16	20
LPE-20	15.0	D-2	CL/CH	A4	53	27	26

* NP = Non-plastic

TABLE B-4. SPECIFIC GRAVITY TEST RESULTS

BORING NO.	SAMPLE No.	DEPTH (feet)	USGS CLASSIFICATION	GEOLOGICAL UNIT	SPECIFIC GRAVITY
LPE-1	S-11	60.0-61.5	-	Tpf	2.67
LPE-4B	D-5	21.5-23.0	-	Tpw	2.62
LPE-8	D-12	65.0-66.0	-	Tpf	2.78
LPE-9	D-3	15-16.5	SC/CL	A2	2.69
LPE-9	S-8	40-41.5	SM	A1	2.69
LPE-11	D-9	45.0-46.0	SC/CL	A4	2.72
LPE-14	D-10	55.0-56.0	SP-SM	A1	2.62
LPE-15	D-11	55.0-56.0	SM/ML	A1	2.64
LPE-15	D-13	65.0-66.0	CL	A2	2.65
LPE-16	D-7	35.0-36.0	SM	A3	2.70
LPE-16	D-9	45.0-46.0	SM	A3	2.62
LPE-17	D-10	50.0-50.5	SM	A3	2.70
LPE-17	D-12	60.0-60.5	CL	A4	2.70
LPE-24	D-4	15.0-16.0	-	Tpw	2.72

TABLE B-5. UNCONFINED COMPRESSION TEST RESULTS

Page 1 of 2

BORING NO.	SAMPLE NO.	DEPTH (feet)	USCS CLASSIFICATION	GEOLOGIC UNIT	UNCONFINED COMPRESSIVE STRENGTH (KSF)	
					PEAK	RESIDUAL
LPE-1	D-6	35.0-36.0	-	Tpf	2.7	0.7
LPE-1	P-9	49.8-52.5	-	Tpf	12.0	3.4
LPE-1	D-10	55.0-55.8	-	Tpf	7.7	0.2
LPE-1	D-12	65.0-65.9	-	Tpf	4.2	0.2
LPE-1	D-14	75.0-76.0	-	Tpf	2.7	1.6
LPE-1	D-16	85.0-85.8	-	Tpf	3.2	0.4
LPE-1	D-18	95.0-96.0	-	Tpf	6.5	1.6
LPE-2A	D-4	40.0-40.5	-	Tpf	5.4	1.0
LPE-2A	D-8	60.0-61.0	-	Tpf	5.5	1.9
LPE-2A	P-11	75.0-77.5	-	Tpf	7.6	0.8
LPE-2A	D-16	100.0-100.7	-	Tpf	5.1	1.5
LPE-2A	D-18	110.0-110.6	-	Tpf	5.9	2.4
LPE-2A	D-20	120.0-120.7	-	Tpf	5.9	1.3
LPE-2A	P-21	125.0-127.5	-	Tpf	9.3	5.5
LPE-4B	D-7	35.0-36.0	-	Tpw	5.8	0.8
LPE-4B	D-9	45.0-45.9	-	Tpf	5.4	0.1
LPE-4B	D-13	65.0-65.6	-	Tpf	4.7	0.9
LPE-6	P-9	45.0-47.5	-	Tpf	9.1	2.0
LPE-6	P-11	55.0-56.6	-	Tpf	9.6	1.4
LPE-7	D-9	45.0-46.0	-	Tpw	7.6	0.3
LPE-7	D-11	55.0-56.0	-	Tpw	5.1	0.5
LPE-7	P-14	70.0-72.7	-	Tpf	25.5	4.5

TABLE B-5. UNCONFINED COMPRESSION TEST RESULTS
Page 2 of 2

BORING NO.	SAMPLE NO.	DEPTH (feet)	USCS CLASSIFICATION	GEOLOGIC UNIT	UNCONFINED COMPRESSIVE STRENGTH (KSF)	
					PEAK	RESIDUAL
LPE-8	D-12	60.0-60.7	-	Tpf	27.1	0.2
LPE-13	D-10	64.9-65.9	SC/CL	A4	6.1	2.6
LPE-15	D-13	65.0-66.0	CL	A2	4.5	3.1
LPE-19	P-8	39.8-42.4	SC	A4	2.3	0.2
LPE-19	P-11	55.0-57.0	SC	A4	1.4	0.5
LPE-19	P-13	65.0-67.5	SC	A4	1.0	0.5
LPE-19	P-15	75.0-77.0	SP-SM	A3	1.3	0.4
LPE-20	D-4	25.0-26.0	ML	A4	2.0	1.8
LPE-21	D-12	65.0-66.0	-	Tpf	2.6	1.2
LPE-21	D-14	75.0-75.8	-	Tpf	5.1	0.8
LPE-24	D-6	25.0-26.0	-	Tpw	3.7	0.2
LPE-24	D-10	45.0-46.0	-	Tpf	4.7	0.9
LPE-24	D-16	75.0-76.0	-	Tpf	11.3	1.6
LPE-24	P-17	80.0-82.5	-	Tpf	4.4	1.2
LPE-24	D-18	85.0-86.0	-	Tpf	8.8	1.9

TABLE B-6. DIRECT SHEAR TEST RESULTS
Page 1 of 6

BORING NO.	SAMPLE NO.	DEPTH (feet)	USCS CLASSIFICATION	GEOLOGIC UNIT	APPLIED NORMAL STRESS (PSF)	SHEAR STRESS (PSF)		ESTIMATED STRENGTH PARAMETERS	
						PEAK	RESIDUAL	COHESION (PSF)	FRICTION ANGLE (DEGREES)
LPE-1	D-2	15.0-16.0	SP-SM	A3	900 1800 3600	968 1572 4161	678 967 3508	320	34
LPE-1	D-4	25.0-26.0	SP-SM	A3	1500 3000 6000	2226 3701 6459	1790 2782 5347	850	43
LPE-1	D-8	45.0-45.8	-	Tpf	2500 5000	2875 5416	2719 5036	330	46
LPE-2	D-1	6.0-7.0	CL-ML	A4	400 800 1600	1586 2746 3571	- 1069 1838	1920	46
LPE-2	D-3	15.0-16.0	SP-SM	A3	900 1800 3600	1942 2407 4122	1340 1860 3395	1100	40
LPE-2	D-7	35.0-35.8	-	Tpf	2000 4000 8000	4782 4981 8160	3129 2966 5408	3200	31
LPE-2	D-10	55.0-55.6	-	Tpf	3500 7000 14000	4793 8271 11415	3009 7223 10322	3200	31
LPE-4B	D-5	26.0-27.0	-	Tpw	1500 3000 6000	2226 3919 5854	2032 2565 4694	1300	38
LPE-6	D-3	15.0-16.0	SM	A3	900 1800 3600	1306 2153 3580	1161 2104 3531	700	40

TABLE B-6. DIRECT SHEAR TEST RESULTS
Page 2 of 6

BORING NO.	SAMPLE NO.	DEPTH (feet)	USCS CLASSIFICATION	GEOLOGIC UNIT	APPLIED NORMAL STRESS (PSF)	SHEAR STRESS (PSF)		ESTIMATED STRENGTH PARAMETERS	
						PEAK	RESIDUAL	COHESION (PSF)	FRICTION ANGLE (DEGREES)
LPE-6	D-5	25.0-26.0	-	Tpw	1500	2492	2250	1500	26
					3000	2613	2589		
					6000	4524	4113		
LPE-7	D-3	15.0-16.0	ML	A4	900	2764	1493	2000	39
					1800	3388	2162		
					3600	4926	3968		
LPE-8	D-2	15.0-16.0	CL	A4	900	2484	725	1830	36
					1800	3139	1567		
					3600	5392	3067		
LPE-8	D-8	45.0-46.0	-	Tpw	3000	3745	3232	2500	24
					6000	5217	4859		
					12000	7735	7646		
LPE-8	D-10	55.0-55.9	-	Tpf	3500	8910	3355	890	25
					7000	4195	2113		
					14000	7502	5864		
LPE-9	D-5	25.0-26.0	CL	A2	1500	3071	2162	2200	33
					3000	4042	3182		
					6000	5973	4568		
LPE-9	D-9	45.0-46.0	SC/CL	A4	2500	3780	2536	1250	42
					5000	5301	4321		
					10000	10410	9208		
LPE-10	D-4	15.0-16.5	SM	A1	900	1427	1271	700	38
					1800	1962	1895		
					3600	3505	3489		
LPE-10	D-6	25.0-26.0	SC	A4	1500	2452	2077	2200	21
					3000	3668	3315		
					6000	4281	4258		

TABLE B-6. DIRECT SHEAR TEST RESULTS

Page 3 of 6

BORING NO.	SAMPLE NO.	DEPTH (feet)	USCS CLASSIFICATION	GEOLOGIC UNIT	APPLIED NORMAL STRESS (PSF)	SHEAR STRESS (PSF)		ESTIMATED STRENGTH PARAMETERS	
						PEAK	RESIDUAL	COHESION (PSF)	FRICTION ANGLE (DEGREES)
LPE-10	D-10	45.0-46.0	SC	A4	2500	3263	2615	1000	33
					5000	5181	4710		
					10000	8225	7890		
LPE-11	D-3	15.0-16.0	SM	A1	900	1393	1036	500	43
					1800	1984	1839		
					3600	3868	3633		
LPE-11	D-5	25.0-26.0	SM	A1	1500	2320	1719	700	44
					3000	3216	2970		
					6000	6530	6459		
LPE-11	D-7	35.0-36.0	SM	A3	2000	2831	2564	1000	36
					4000	3322	3165		
					8000	7023	6933		
LPE-11	D-9	45.0-46.0	SC/CL	A4	3500	5618	4077	4300	27
					7000	8436	6986		
					14000	10930	-		
LPE-11	D-11	55.0-56.0	SM	A3	3500	4682	3077	2500	34
					7000	7469	7224		
					14000	11816	11660		
LPE-12	D-8	45.0-46.0	SC	A4	2500	4214	2698	2500	37
					5000	6577	5440		
					10000	9966	9766		
LPE-12	D-12	65.0-66.0	SM	A3	4000	5305	4300	3000	32
					8000	8455	7405		
					16000	13034	12059		
LPE-13	D-5A	35.0-36.0	SM	A3	2000	3983	2586	2000	33
					4000	5183	4039		
					8000	8916	8191		

TABLE B-6. DIRECT SHEAR TEST RESULTS
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BORING NO.	SAMPLE NO.	DEPTH (feet)	USCS CLASSIFICATION	GEOLOGIC UNIT	APPLIED NORMAL STRESS (PSF)	SHEAR STRESS (PSF)		ESTIMATED STRENGTH PARAMETERS	
						PEAK	RESIDUAL	COHESION (PSF)	FRICTION ANGLE (DEGREES)
LPE-13	D-10	65.0-65.9	SC/CL	A4	4000	4258	3642	2200	29
					8000	6765	6111		
					16000	10933	10836		
LPE-14	D-3	20.0-21.0	SM	A1	1000	1873	1516	1000	38
					2000	2497	2297		
					4000	4214	4192		
LPE-14	D-7	40.0-41.0	SC	A2	2500	2926	2813	1600	31
					5000	4777	4648		
					10000	7463	7444		
LPE-14	D-10	55.0-56.0	SP-SM	A1	3500	4656	3100	2200	39
					7000	7988	6696		
					14000	13080	11772		
LPE-14	D-13	65.5-66.3	SC	A2	4000	6243	4281	4440	24
					8000	11705	8472		
					16000	11660	11482		
LPE-14	D-15	75.0-76.0	ML	A2	4000	3857	3723	1830	27
					8000	5886	-		
					16000	9405	-		
LPE-15	D-7	35.0-36.0	SM	A1	2000	2332	2134	1250	34
					4000	5536	-		
					8000	6530	-		
LPE-15	D-9	45.0-46.0	SM	A1	2500	3601	3488	1790	36
					5000	5412	5053		
LPE-15	D-11	55.0-56.0	SM/ML	A2	3500	3099	3054	1600	25
					7000	5061	4994		
					14000	7959	7937		

TABLE B-6. DIRECT SHEAR TEST RESULTS
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BORING NO.	SAMPLE NO.	DEPTH (feet)	USCS CLASSIFICATION	GEOLOGIC UNIT	APPLIED NORMAL STRESS (PSF)	SHEAR STRESS (PSF)		ESTIMATED STRENGTH PARAMETERS	
						PEAK	RESIDUAL	COHESION (PSF)	FRICTION ANGLE (DEGREES)
LPE-16	D-5	24.9-26.4	SM	A1	1500 3000 6000	1338 3054 4325	1293 - -	750	32
LPE-16	D-7	34.7-35.8	SC	A4	2000 4000 8000	4403 5322 8201	2710 4161 7112	3000	33
LPE-16	D-11	54.7-56.1	SM	A3	3500 7000 14000	3992 5080 11297	3532 4645 11250	950	36
LPE-17	D-10	50.0-50.7	SM	A3	3000 6000	3943 7257	3290 6265	630	48
LPE-17	D-12	60.0-60.7	CL	A4	3600 7200	4403 4814	3822 4500	4000	7
LPE-19	P-11	55.0-57.1	SC	A4	3500 7000 14000	4058 5551 11482	3924 5663 -	1100	36
LPE-19	P-13	65.0-67.5	SC	A4	4000 8000 14000	4385 7068 10903	4204 - -	1800	33
LPE-20	D-2	15.0-16.0	CL/CH	A4	900 1800 3600	2095 2095 2653	1270 2028 2608	1540	17
LPE-20	D-6	35.0-36.0		Tpw	2000 4000 8000	3054 4480 8693	2630 4013 6465	1000	44

TABLE B-6. DIRECT SHEAR TEST RESULTS
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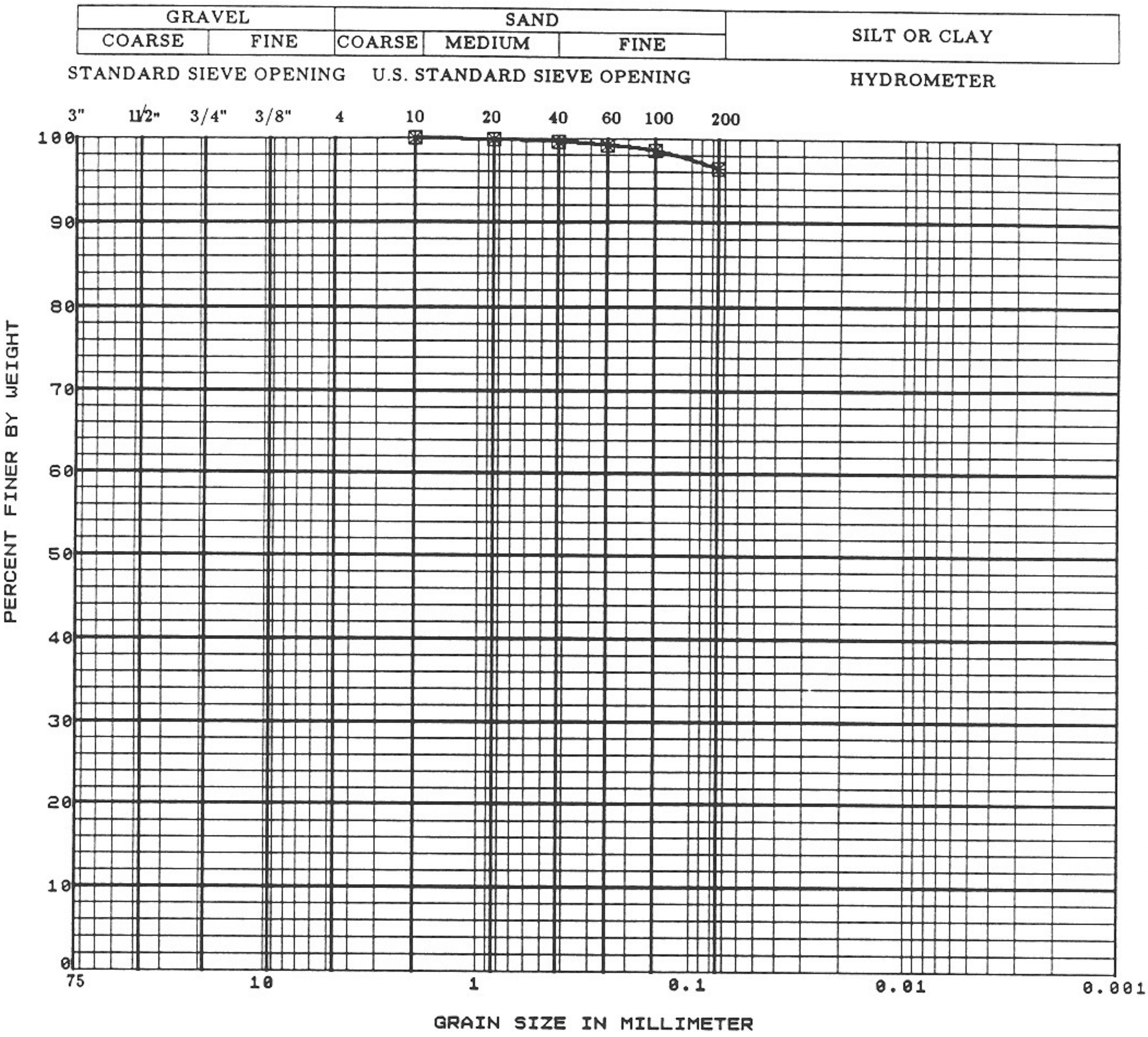
BORING NO.	SAMPLE NO.	DEPTH (feet)	USCS CLASSIFICATION	GEOLOGIC UNIT	APPLIED NORMAL STRESS (PSF)	SHEAR STRESS (PSF)		ESTIMATED STRENGTH PARAMETERS	
						PEAK	RESIDUAL	COHESION (PSF)	FRICTION ANGLE (DEGREES)
LPE-20	D-8	45.0-46.0	-	Tpw	3000 6000 12000	4752 6958 11423	3523 5783 8995	2500	37
LPE-20	D-16	85.0-86.0	-	Tpf	5000 10000 20000	8584 9252 15406	4838 8205 14559	5500	26
LPE-20	D-18	95.0-95.8	-	Tpf	6000 12000 16000	6688 10947 13890	5283 9497 10634	2400	37
LPE-21	D-5	25.0-26.0	SM	A3	1500 3000 6000	1720 3920 5451	1454 2835 4778	1000	38
LPE-21	D-6A	35.0-36.0	-	Tpw	2000 4000 8000	2460 6040 7436	1939 4783 6184	1800	36
LPE-21	D-8	45.0-46.0	-	Tpf	3000 6000 12000	4469 7032 9657	2956 4736 7361	3200	29

TABLE B-7. LABORATORY PERMEABILITY TEST RESULTS

BORING NO.	SAMPLE No.	DEPTH (feet)	USCS CLASSIFICATION	GEOLOGICAL UNIT	PERMEABILITY cm/sec
LPE-1	P-9	49.8-52.5	-	Tpf	1.4×10^{-8}
LPE-9	D-9	45.0-46.0	SC/CL	A4	1.2×10^{-7}
LPE-10	D-8	35.0-36.0	SC	A4	4.5×10^{-7}
LPE-11	D-7	34.8-35.8	SM	A3	3.3×10^{-7}
LPE-12	D-14	75.0-76.0	SM	A3	2.2×10^{-4}
LPE-14	D-10	55.0-56.0	SP-SM	A1	2.1×10^{-4}
LPE-15	D-11	55.0-56.0	CL	A2	3.5×10^{-8}
LPE-15	D-9	45.0-46.0	SM	A1	3.4×10^{-6}
LPE-16	D-9	45.0-46.0	SM	A3	8.6×10^{-5}
LPE-17	D-10	50.0-50.7	SM	A3	6.4×10^{-5}
LPE-17	D-12	60.0-60.7	CL	A4	8.5×10^{-5}*

* Questionable data



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	LPE-1	S-5	30.00	SPT				

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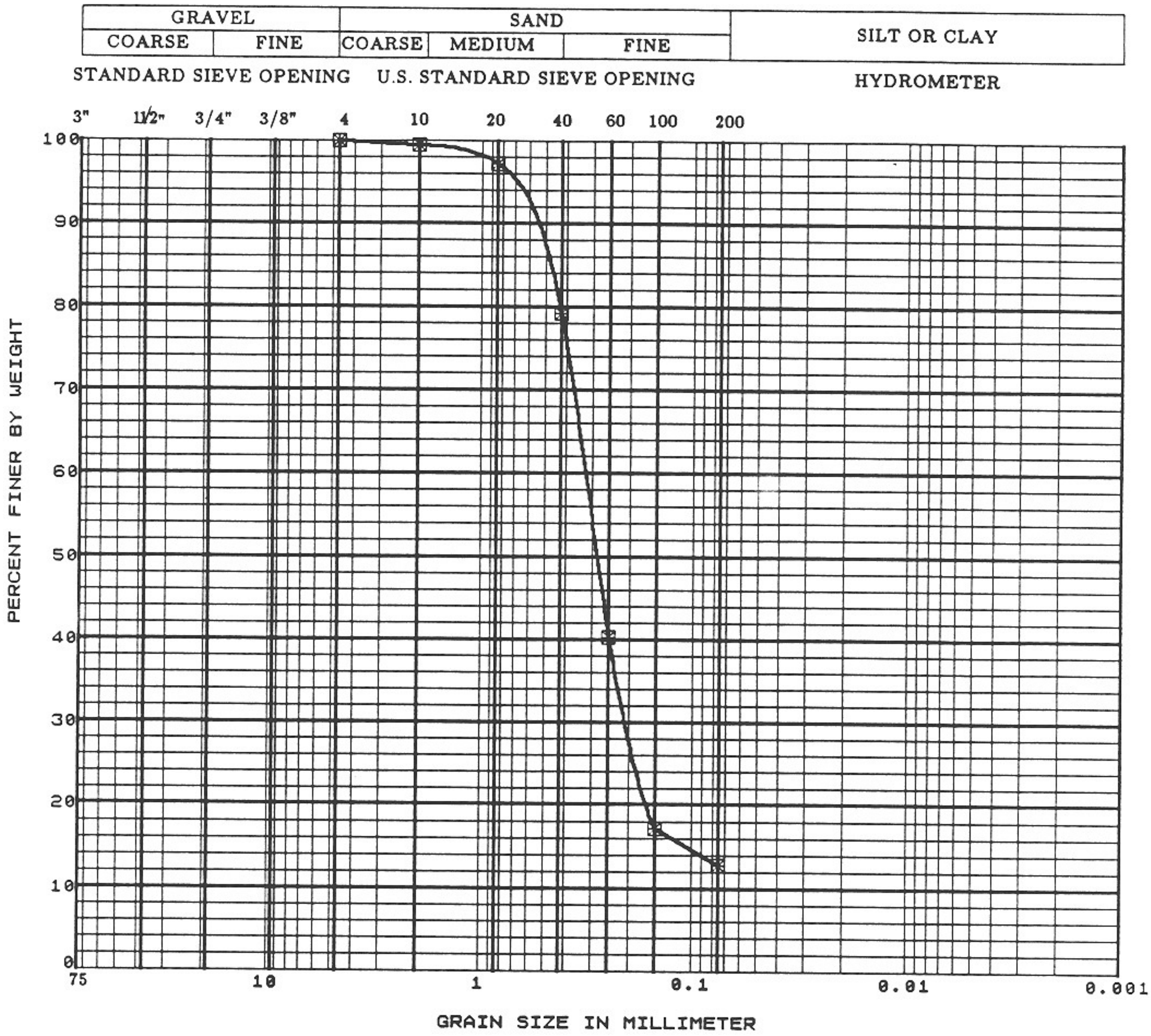
FIGURE B- 1



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	LPE-2	D - 3	15.00	DRIVE	SP-SM			

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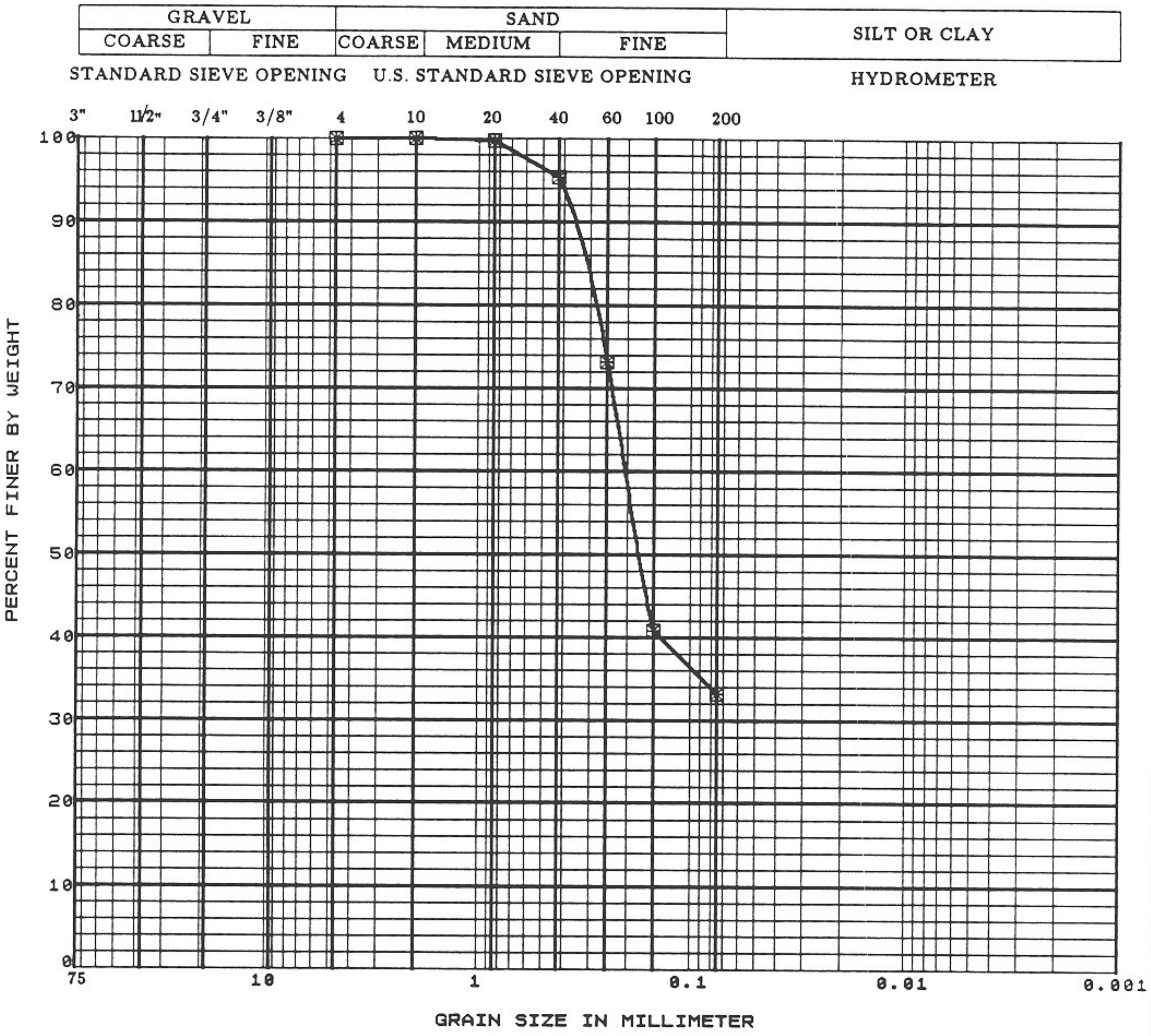
FIGURE B- 2



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
☒	LPE-2	S - 8	41.00	SPT				

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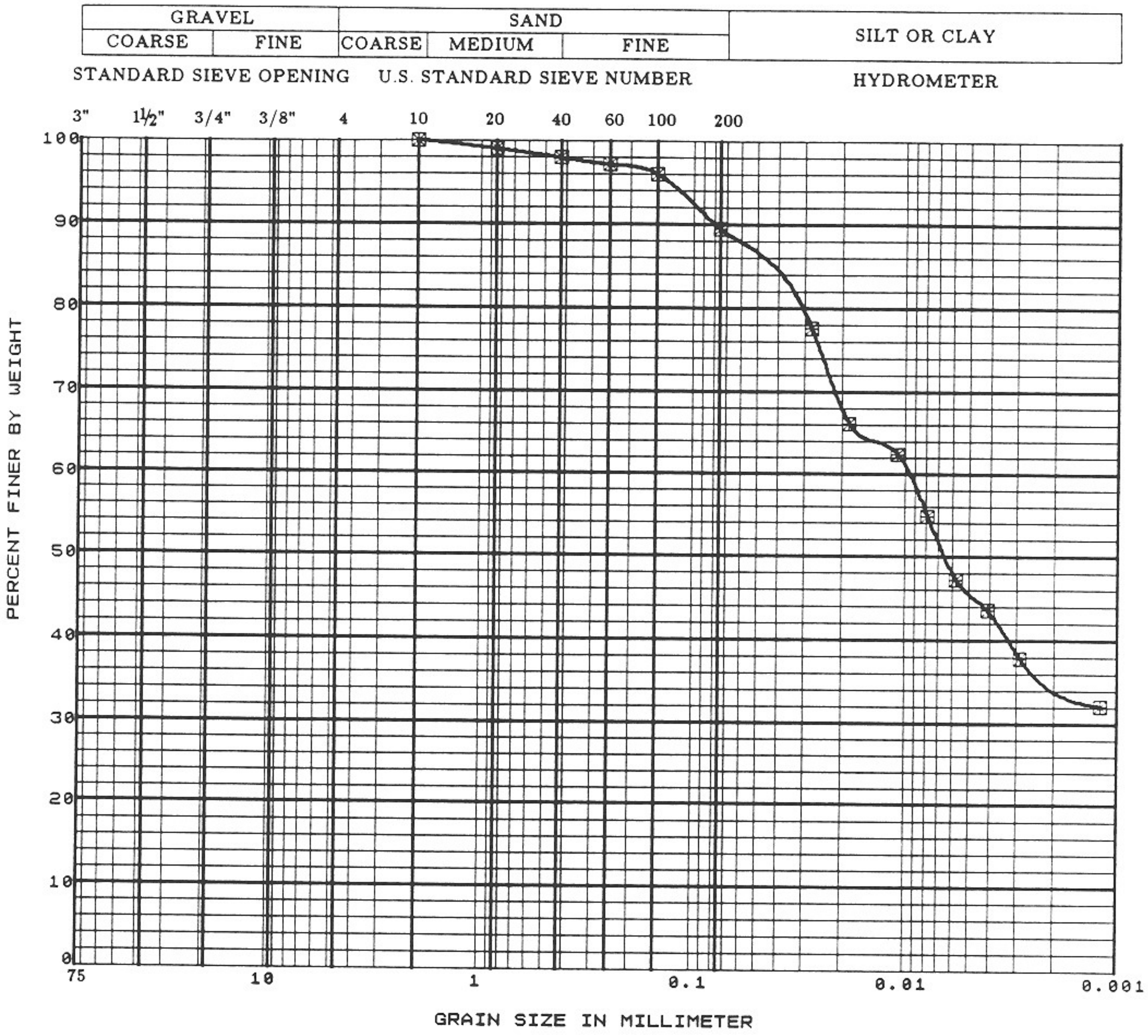
FIGURE B- 3



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
☒	LPE-8	D-2	15.00	DRIVE	CL			

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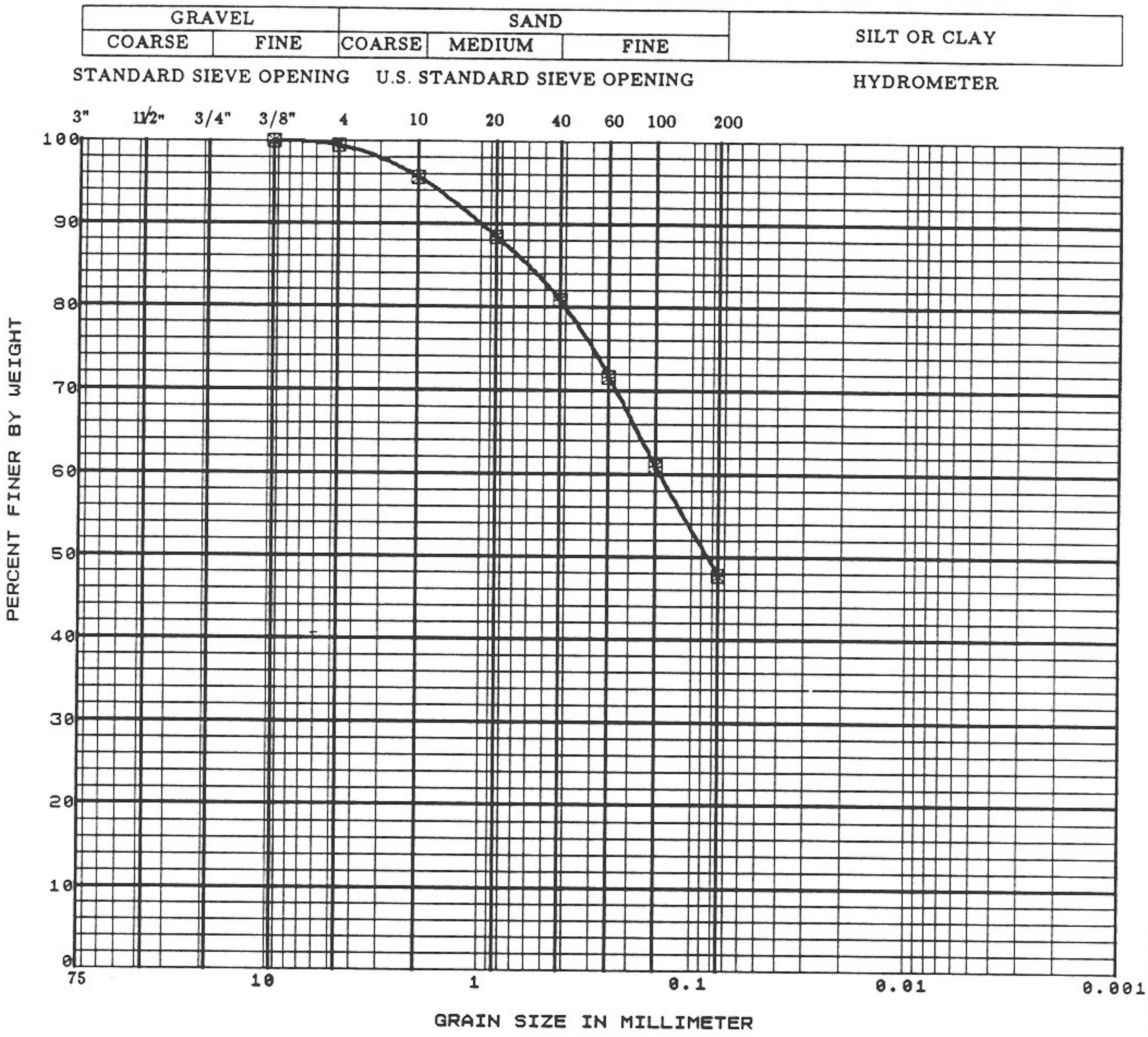
FIGURE B- 4



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	LPE-9	D - 3	15.00	DRIVE	SC/CL			

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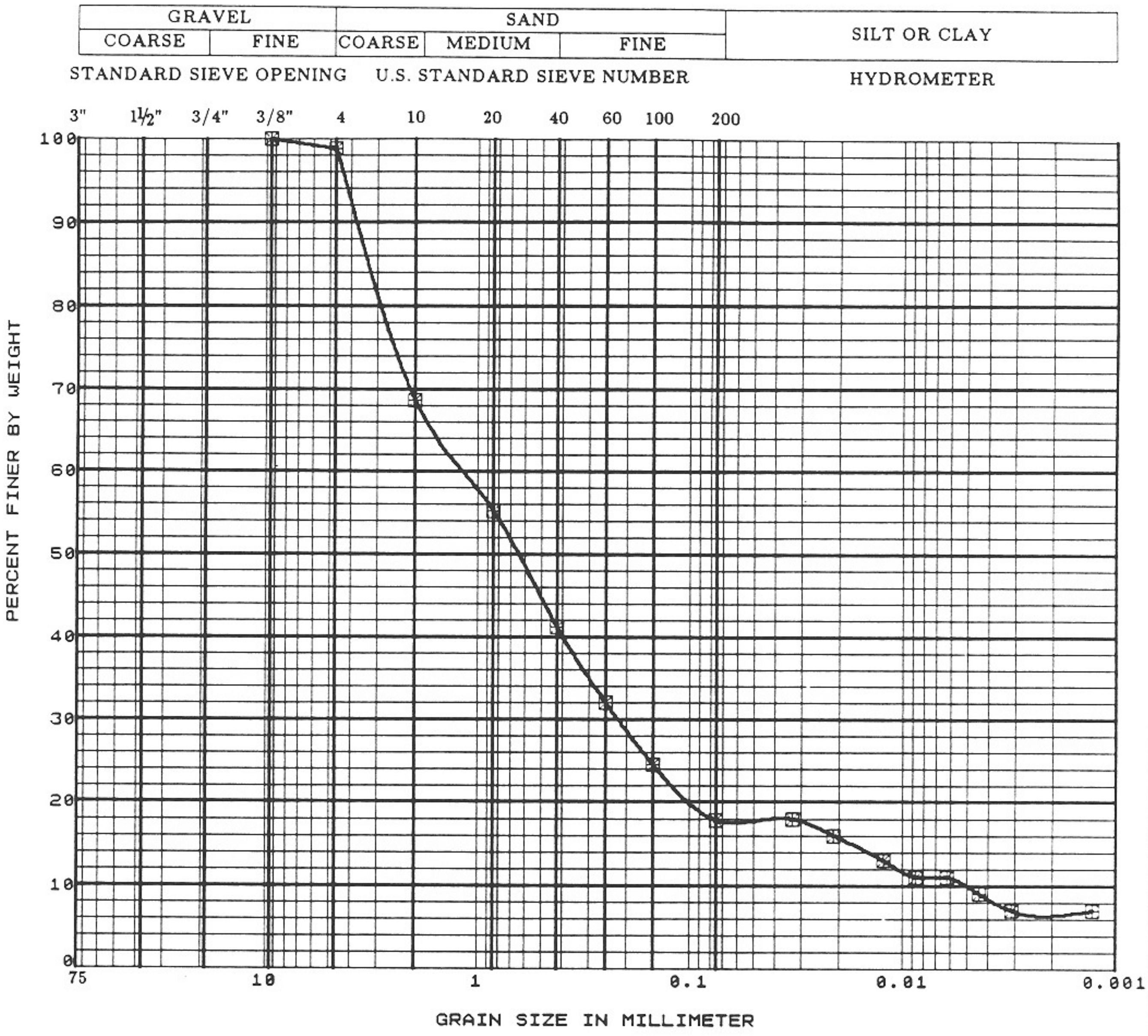
FIGURE B- 5



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
☒	LPE-9	S-8	40.00	SPT	SM	NP	NP	NP

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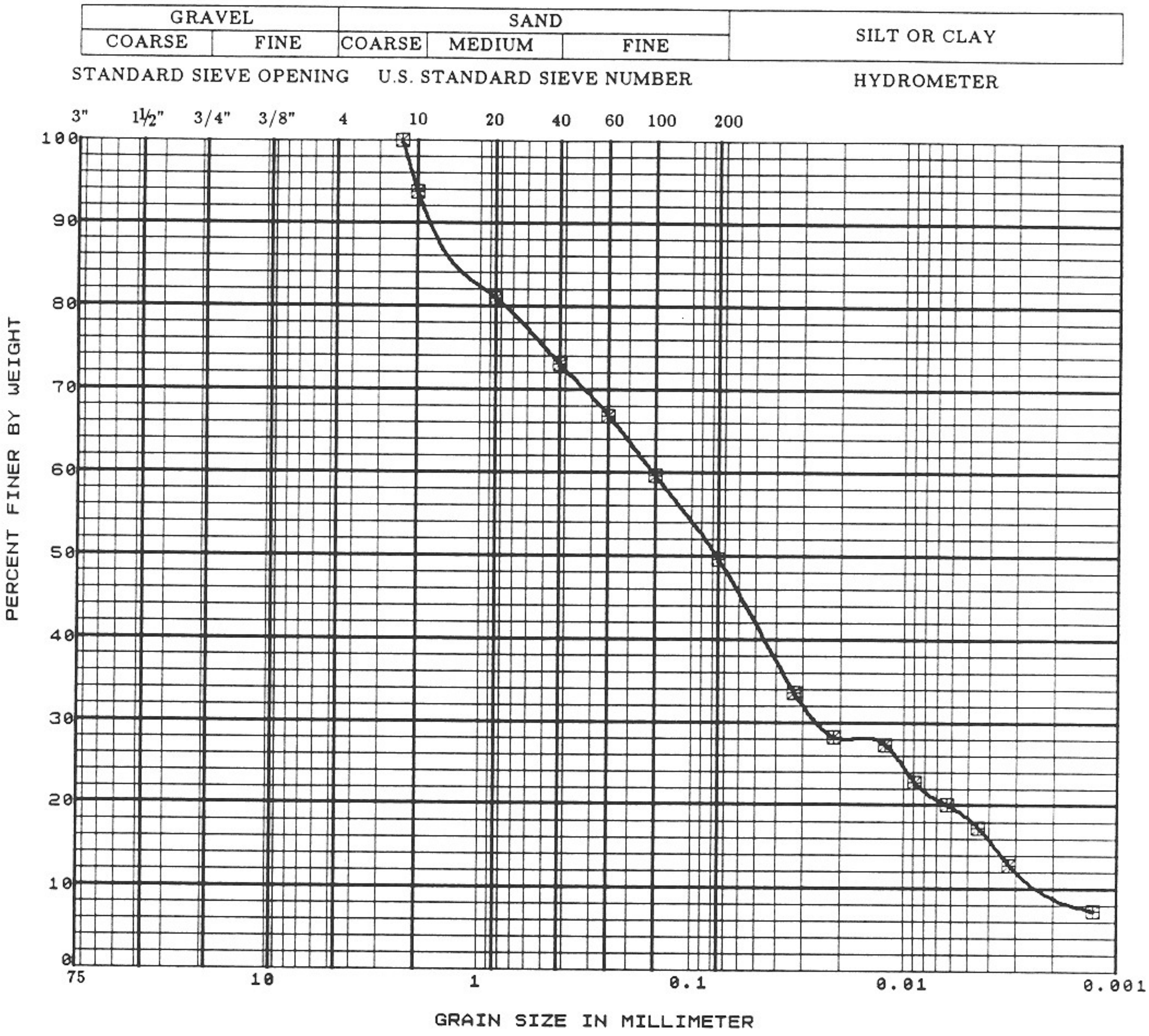
FIGURE B- 6



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
☒	LPE-9	D-9	45.00	DRIVE	SC/CL			

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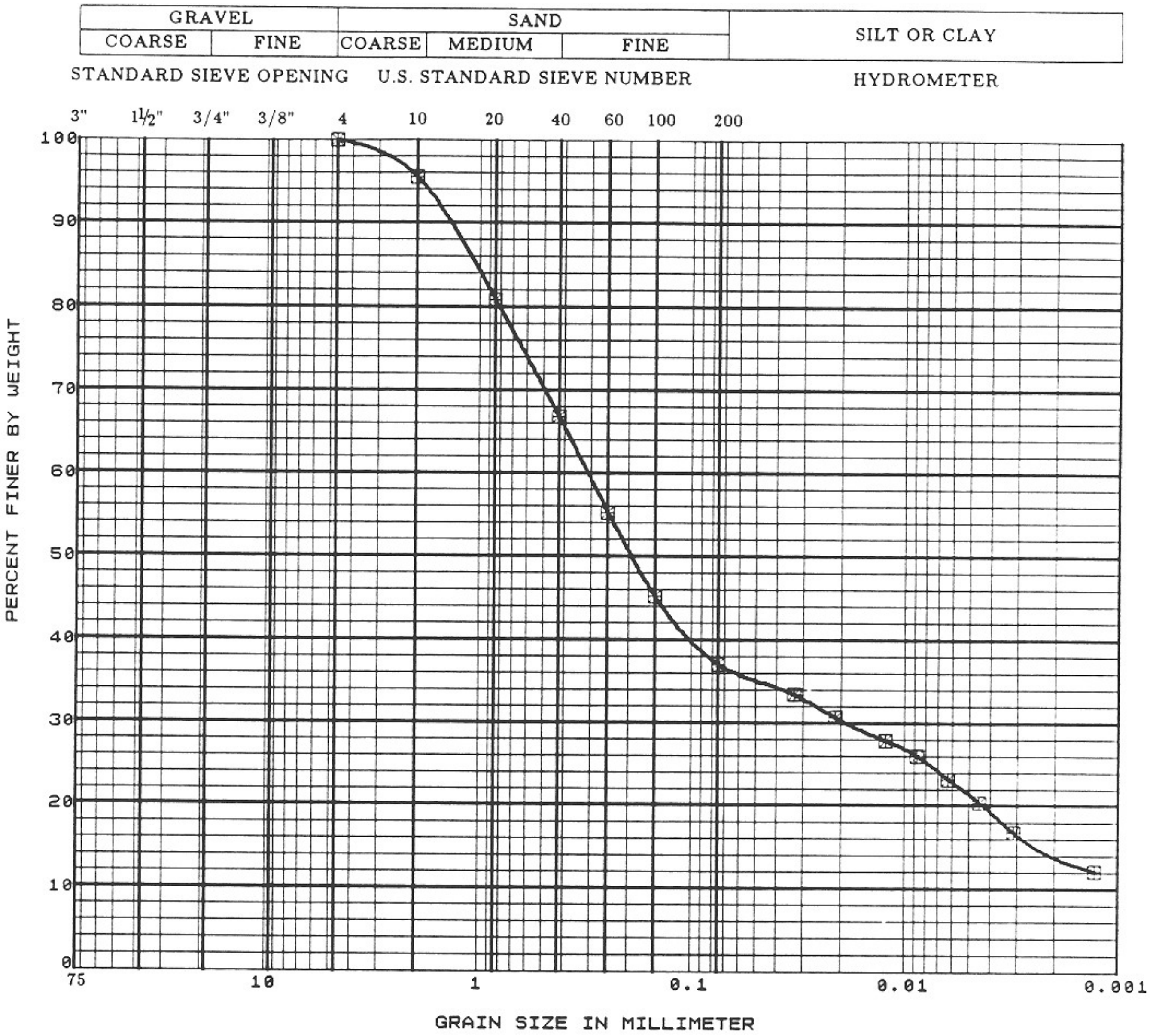
FIGURE B- 7



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	LPE-10	D-8	35.00	DRIVE	SC	29	13	16

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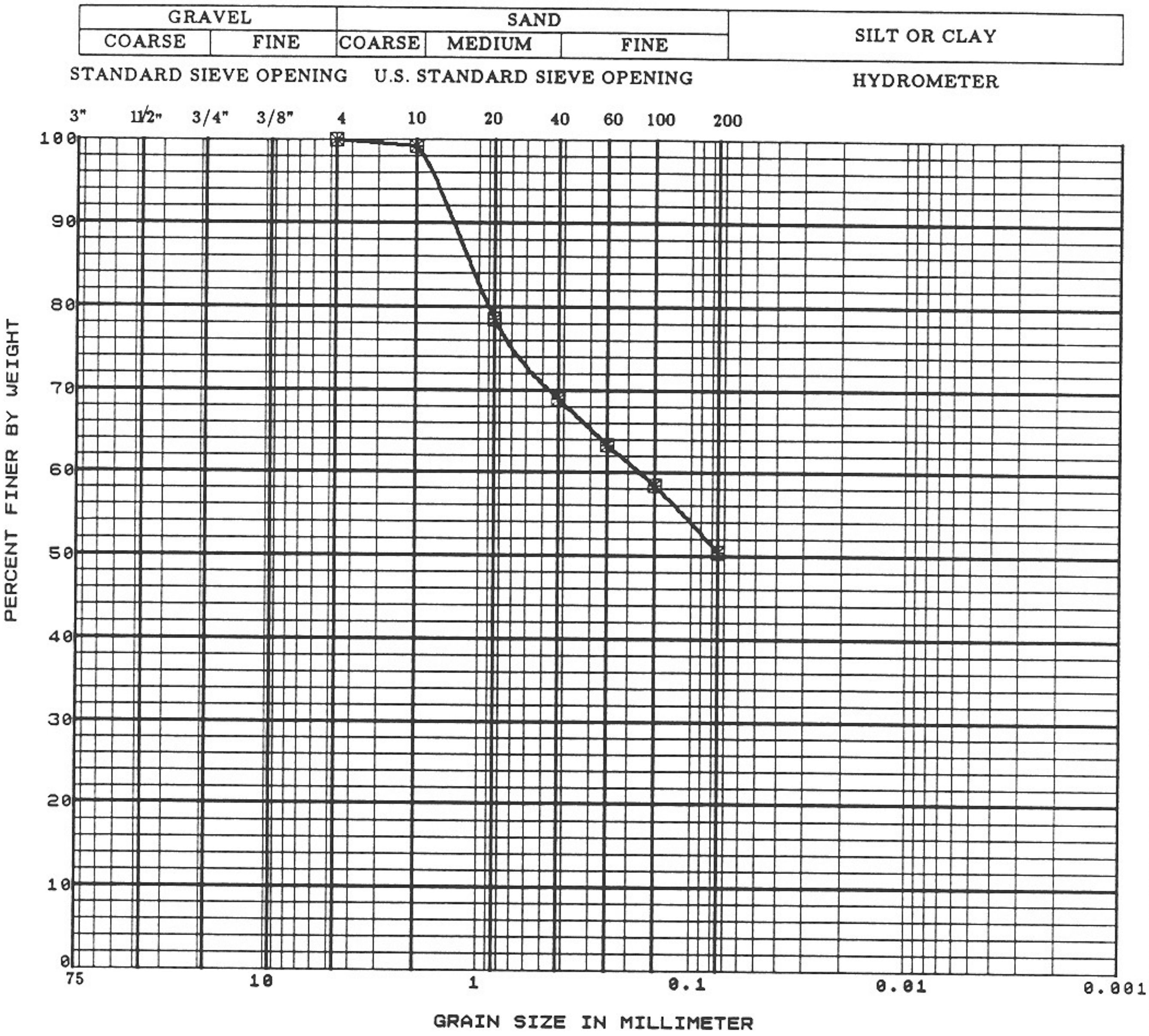
FIGURE B- 8



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
☒	LPE-10	S-9	40.00	SPT	SC/CL	38	21	17

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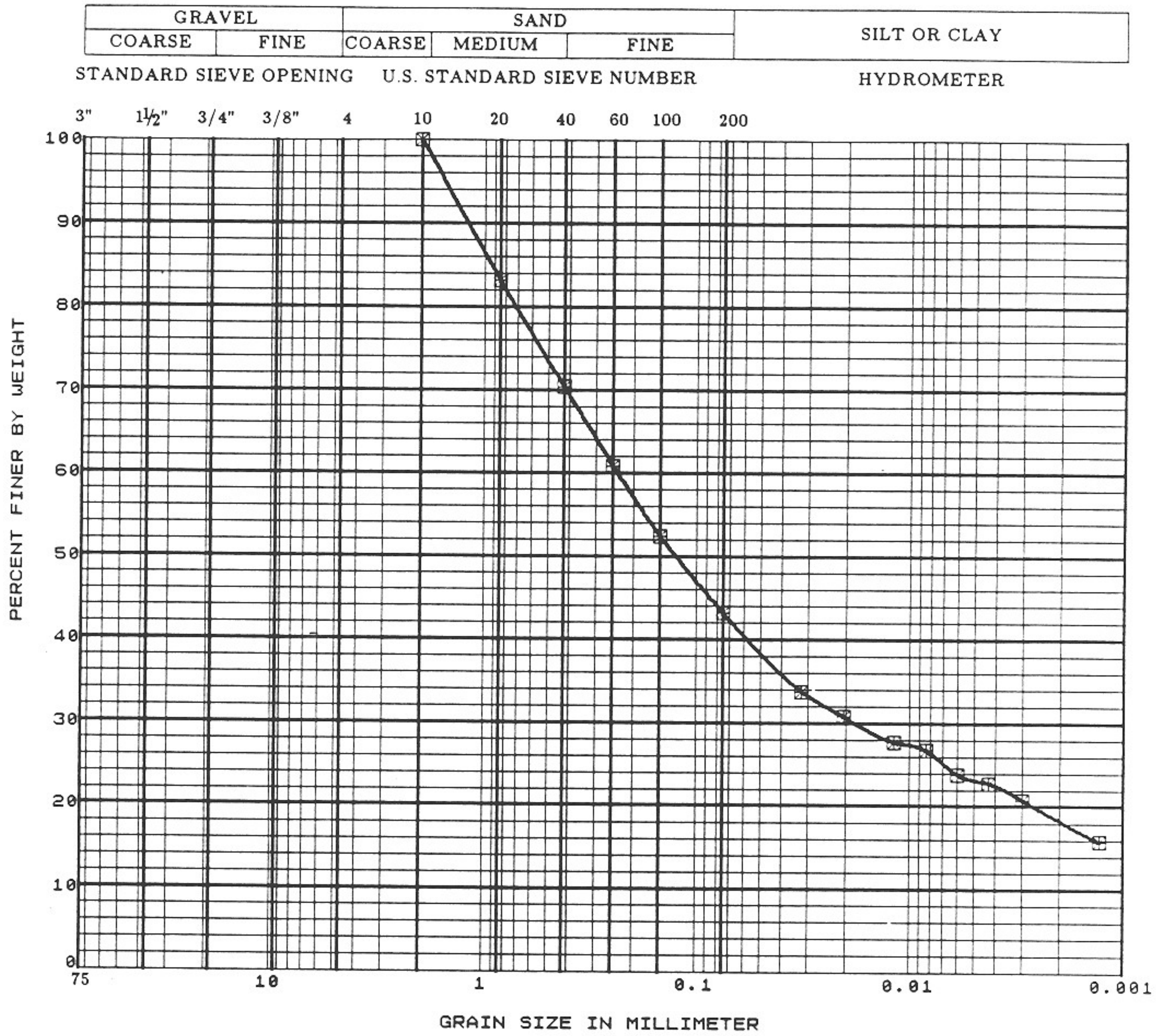
FIGURE B-9



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	LPE-10	D-10	45.00	DRIVE	SC	29	14	15

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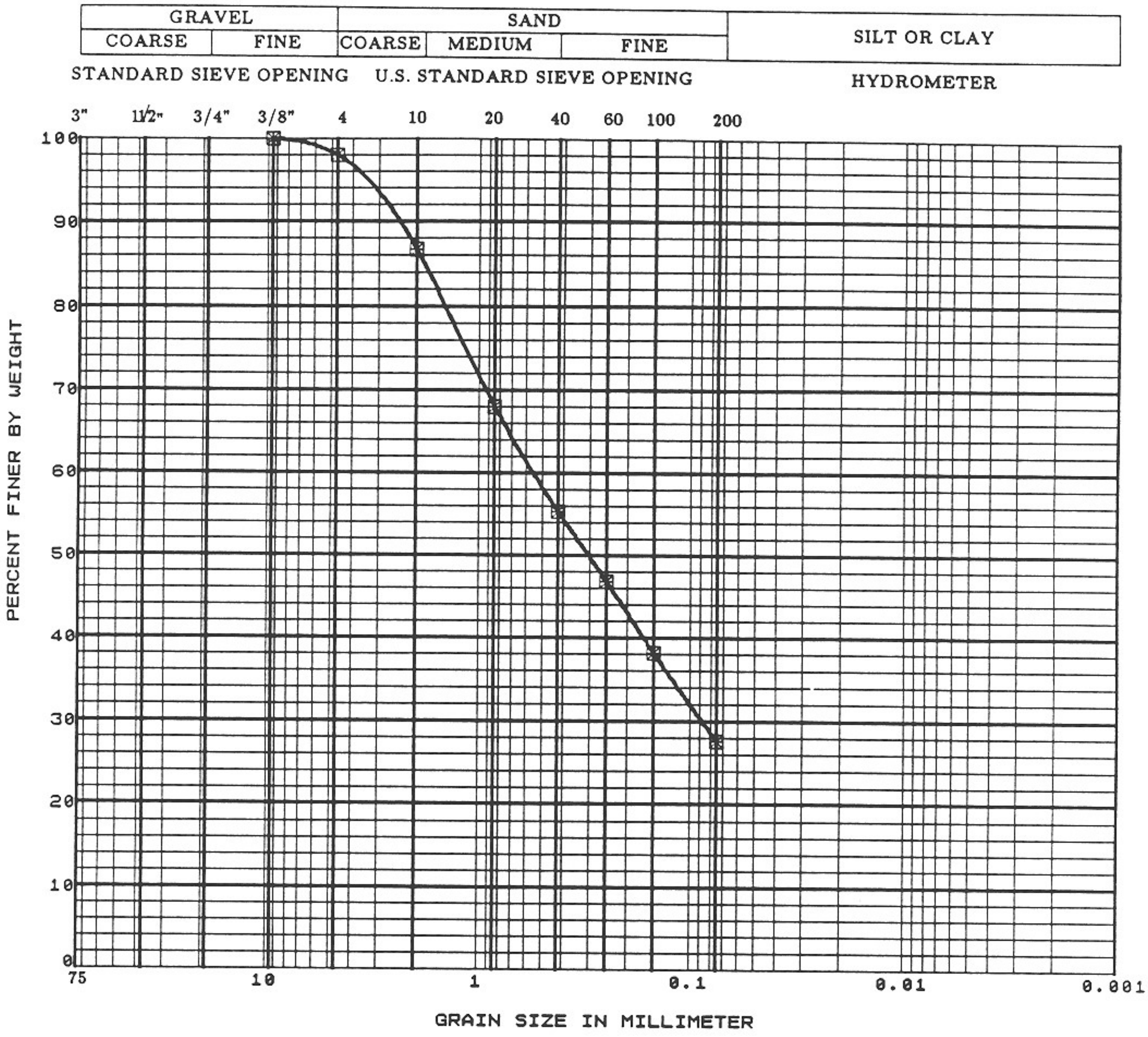
FIGURE B- 10



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	LPE-10	S-15	70.00	SPT	SC	29	18	11

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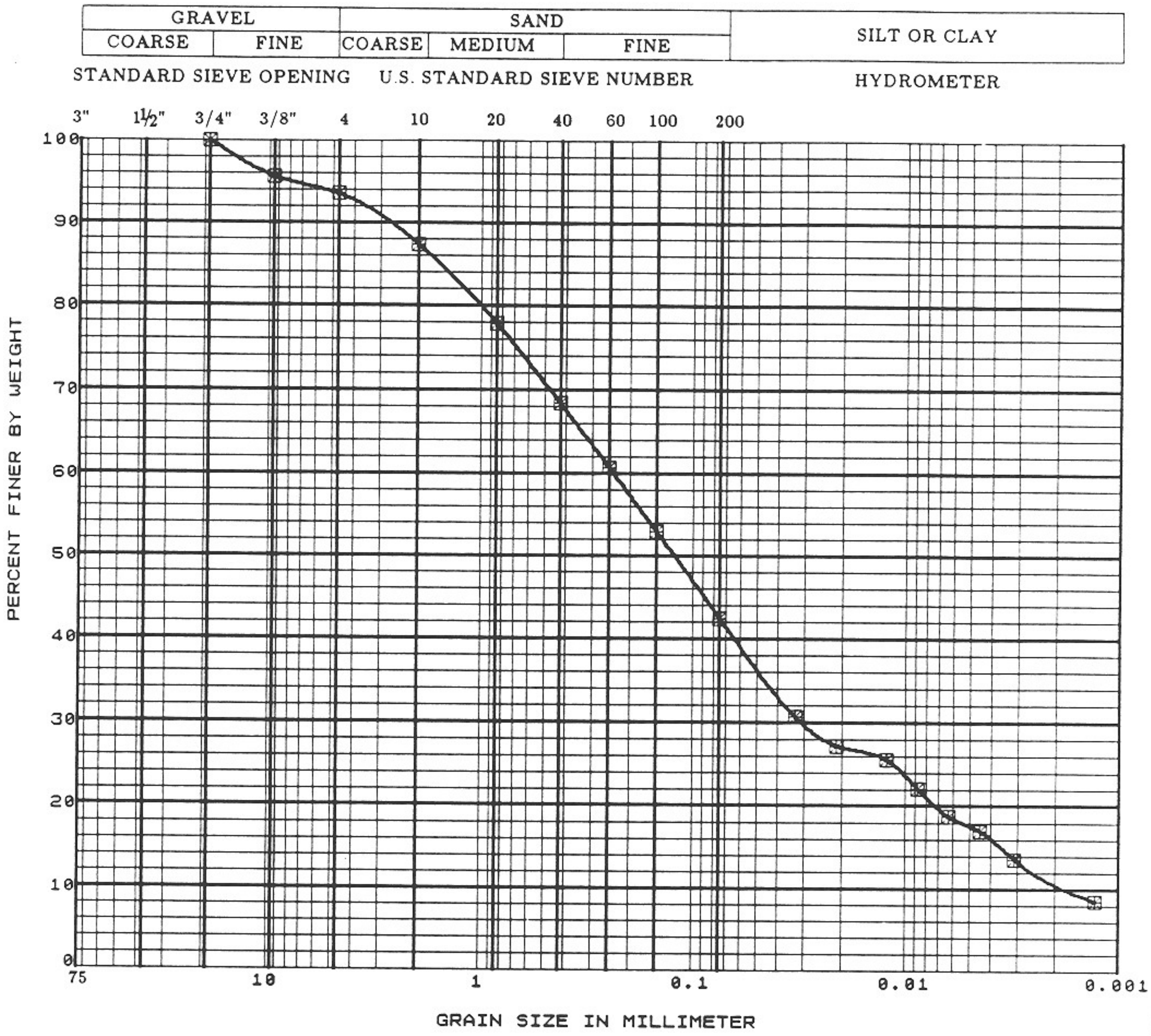
FIGURE B-11



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
☒	LPE-11	D-3	10.00	DRIVE	SM			

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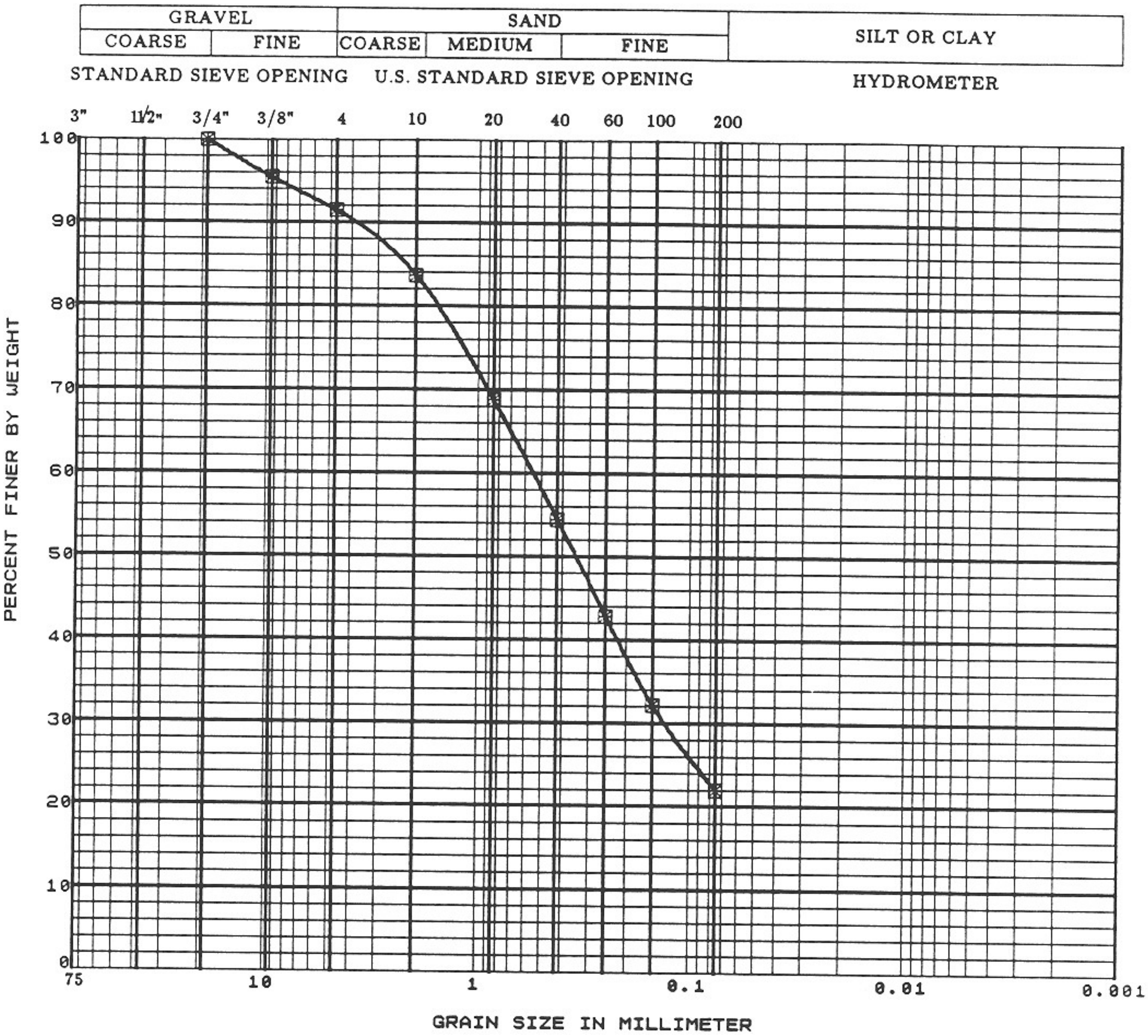
FIGURE B- 12



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
☒	LPE-11	D - 3	15.00	DRIVE	SM			

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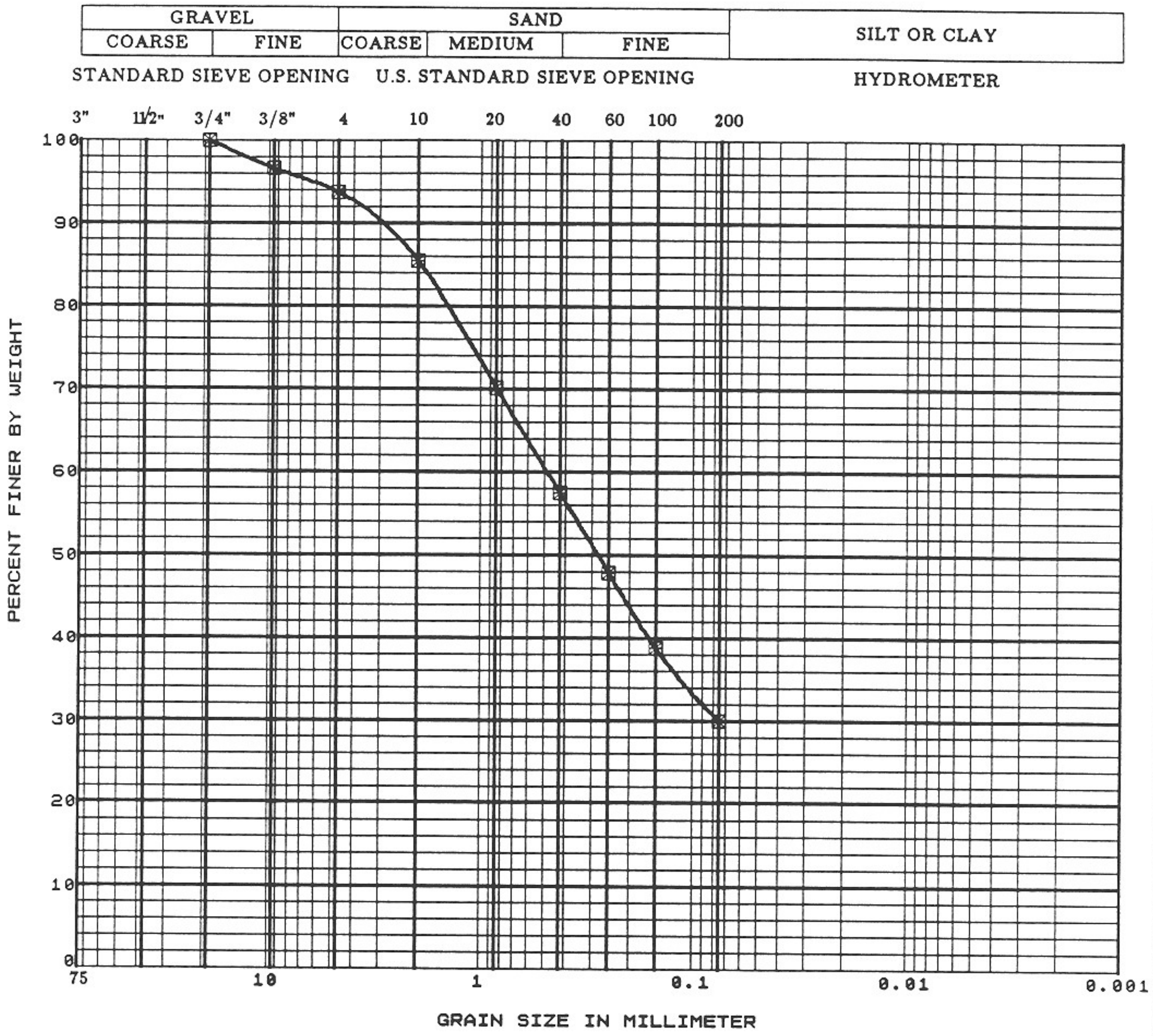
FIGURE B- 13



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
☒	LPE-11	D-5	25.00	DRIVE	SM			

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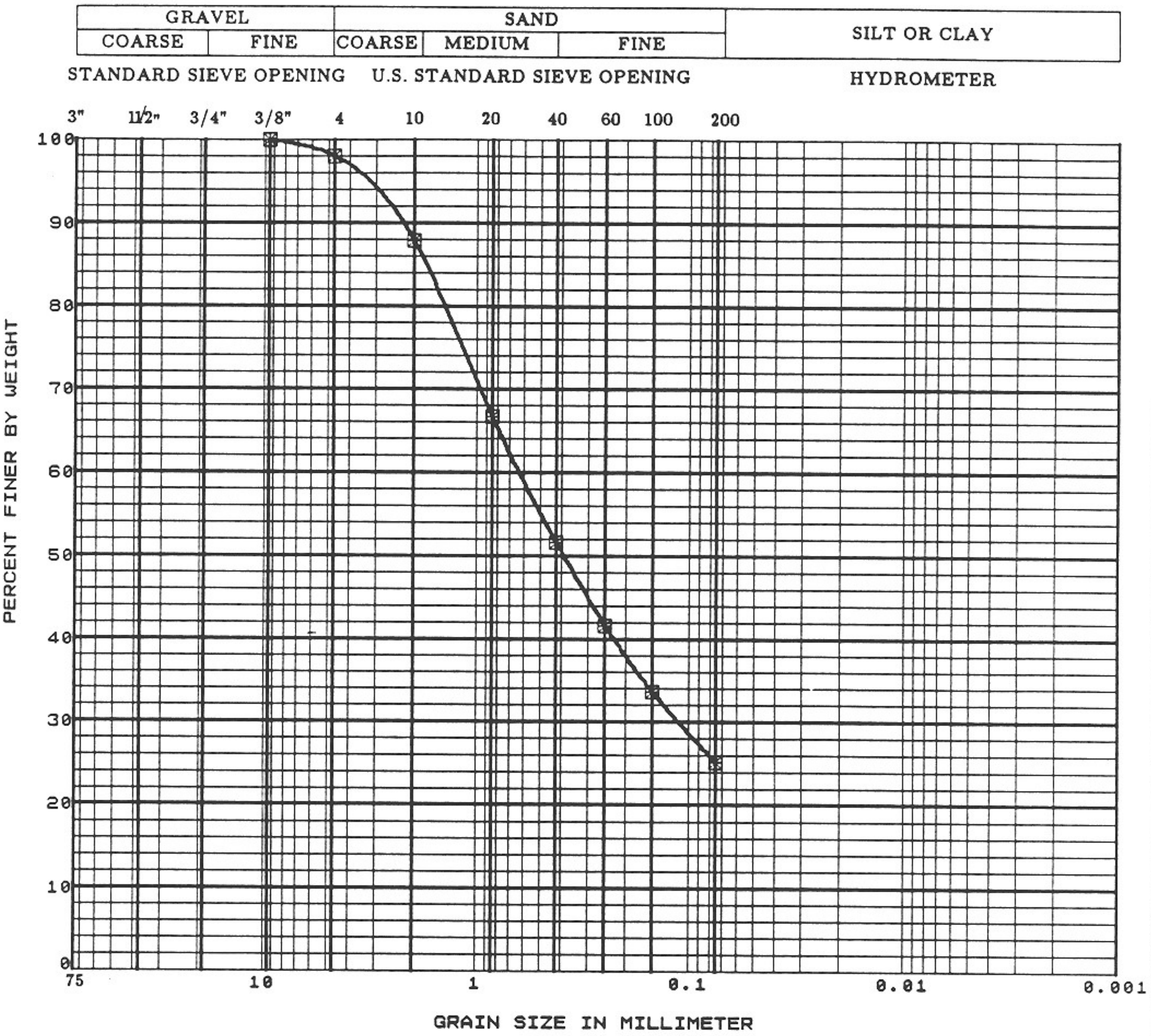
FIGURE B- 14



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	LPE-11	S-8	40.10	SPT	SM			

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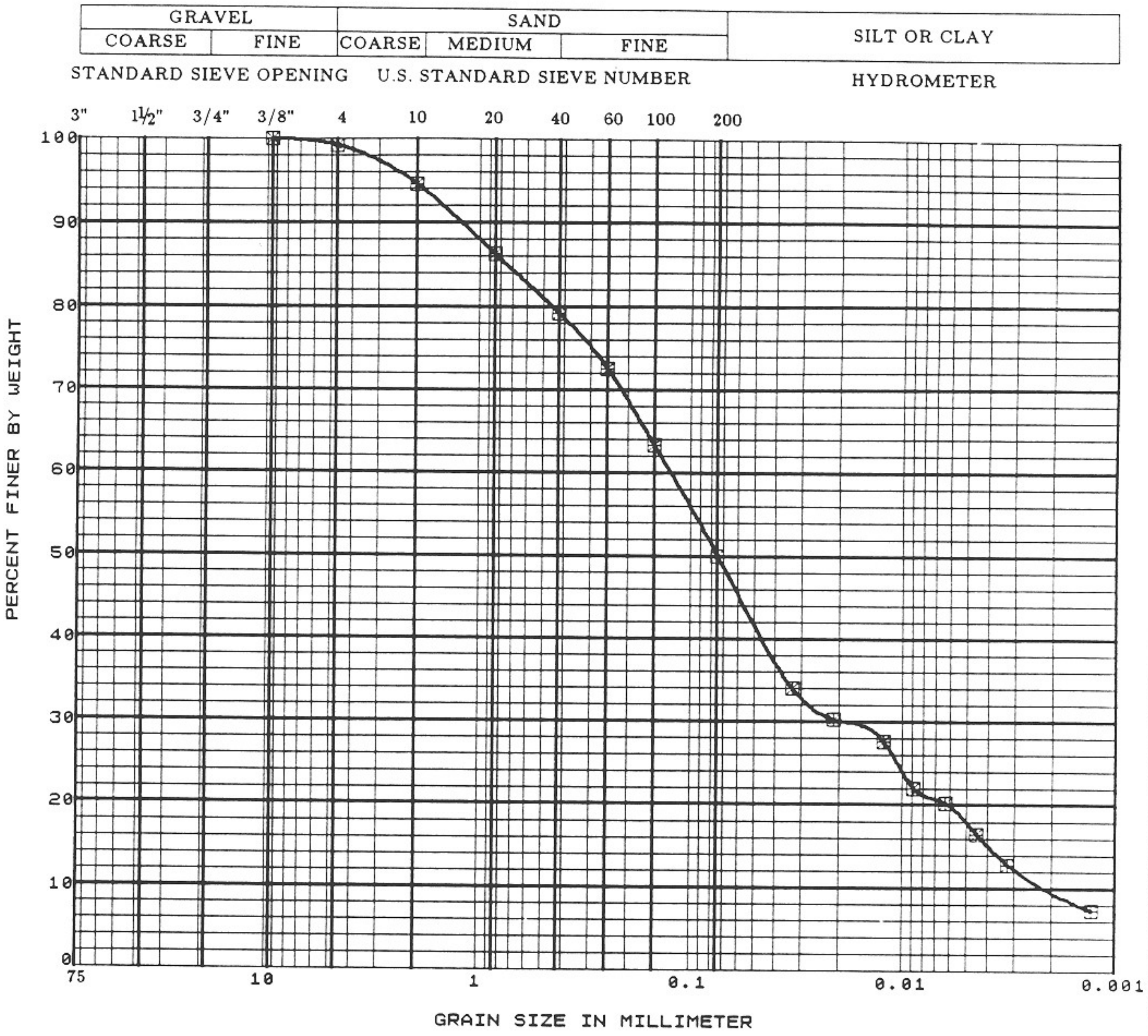
FIGURE B- 15



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	LPE-11	D-9	45.00	DRIVE	SC/CL	32	21	11

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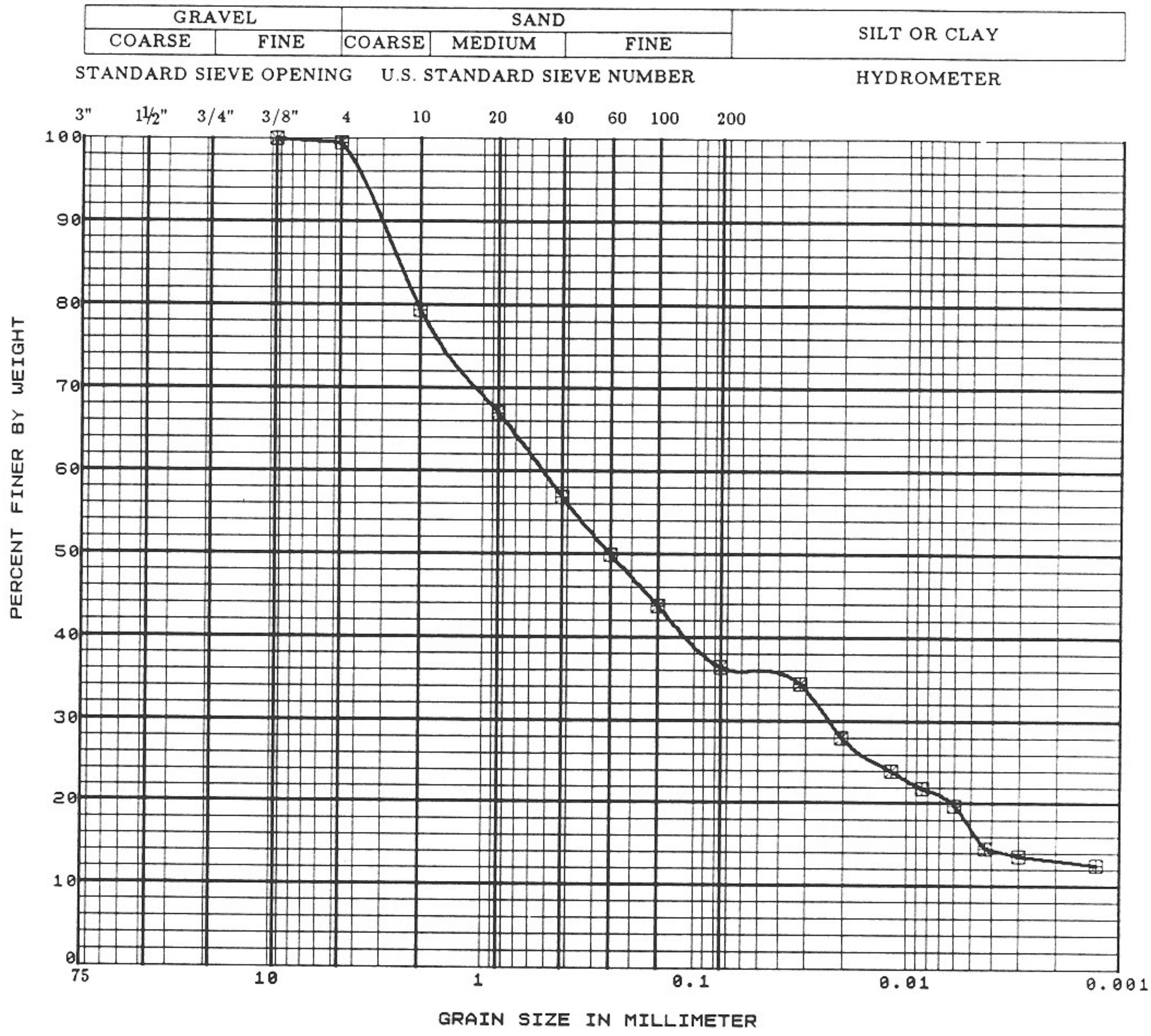
FIGURE B- 16



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	LPE-11	S-10	50.00	SPT	SC	31	20	10

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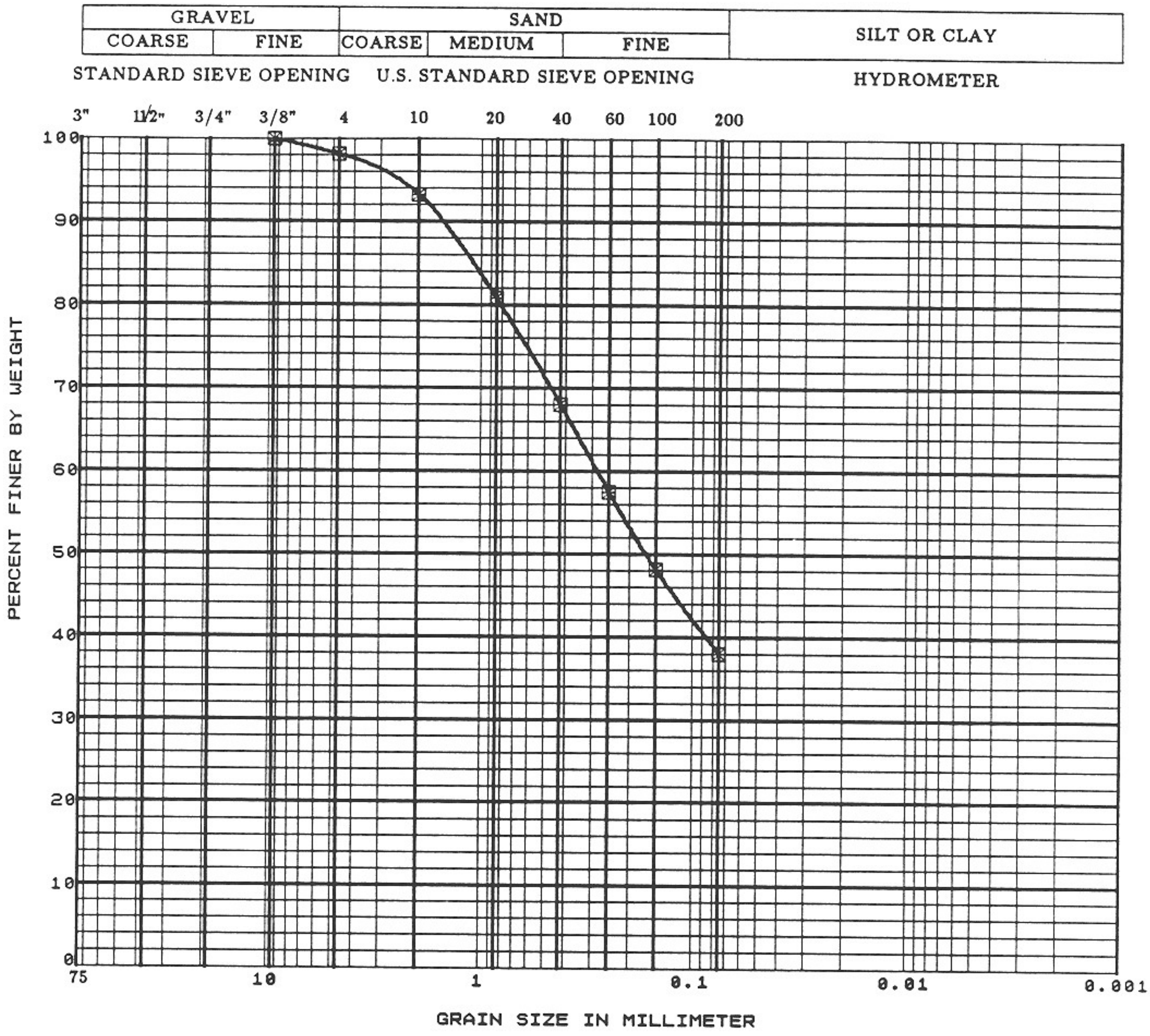
FIGURE B- 17



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	LPE-12	D-1	5.00	DRIVE	SM			

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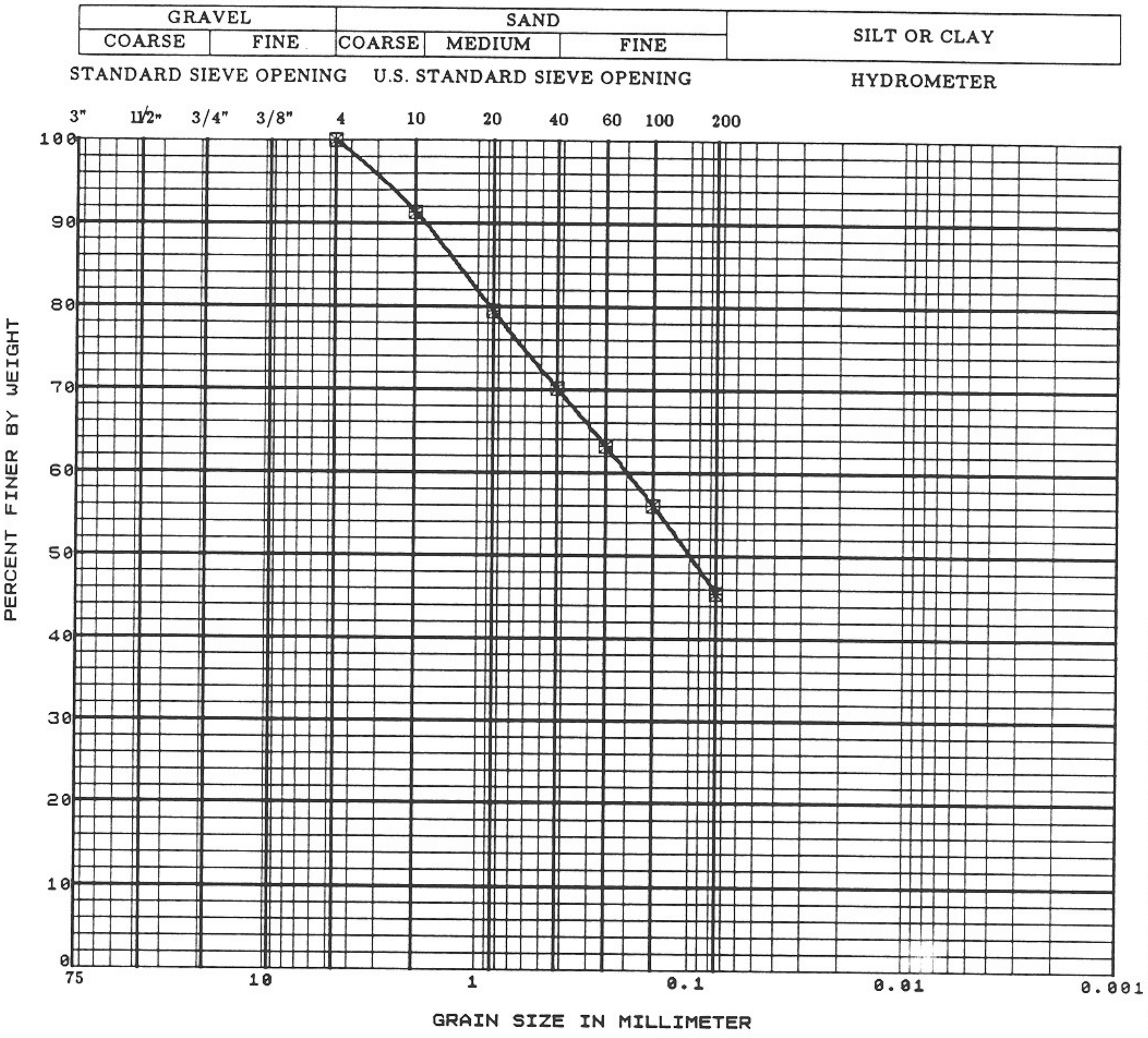
FIGURE B- 18



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
☒	LPE-12	S - 2	10.00	SPT	SC	33	22	11

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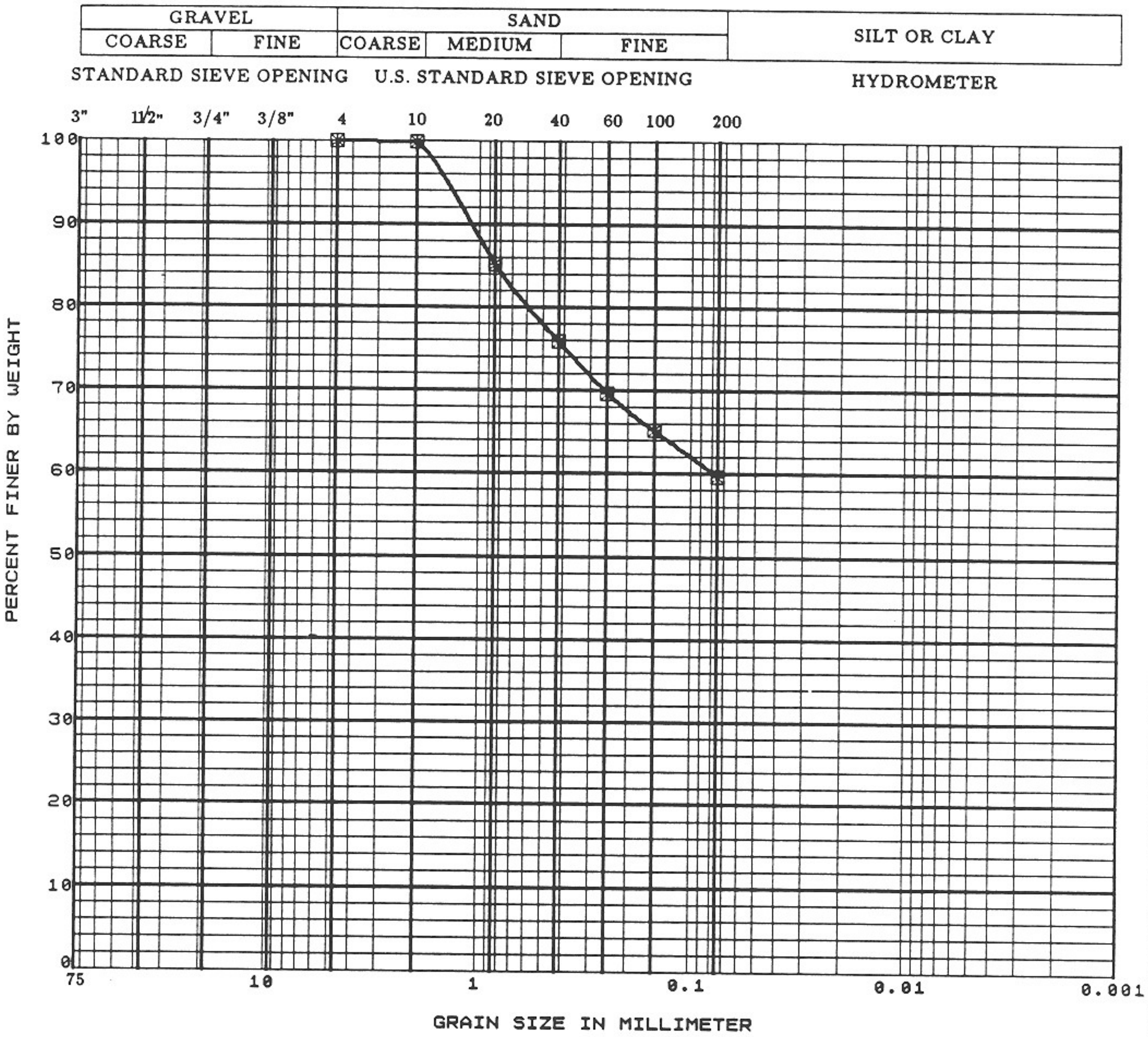
FIGURE B- 19



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	LPE-12	S-9	50.00	SPT	CL	38	22	16

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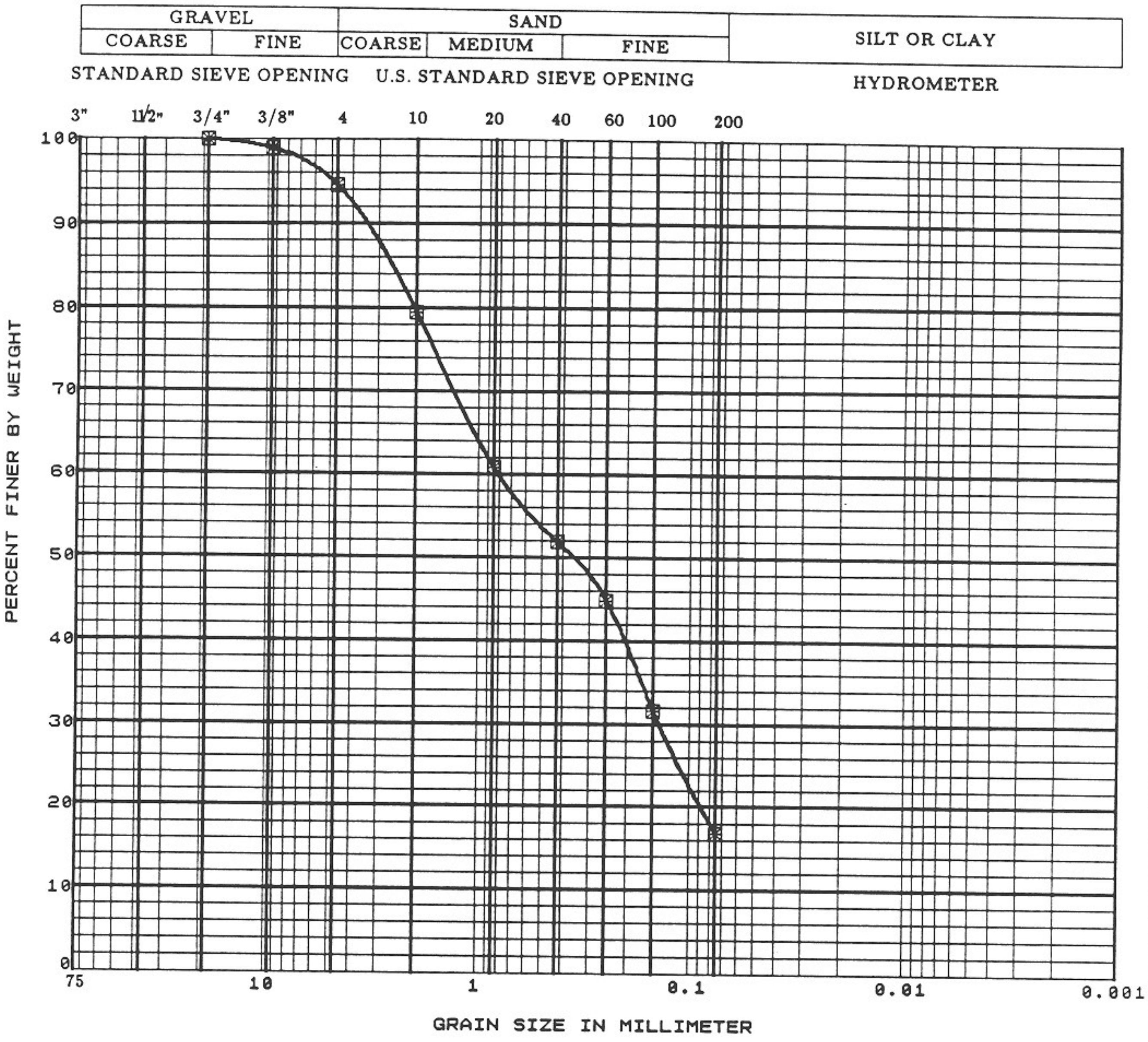
FIGURE B- 20



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	LPE-12	D - 14	75.00	DRIVE	SM			

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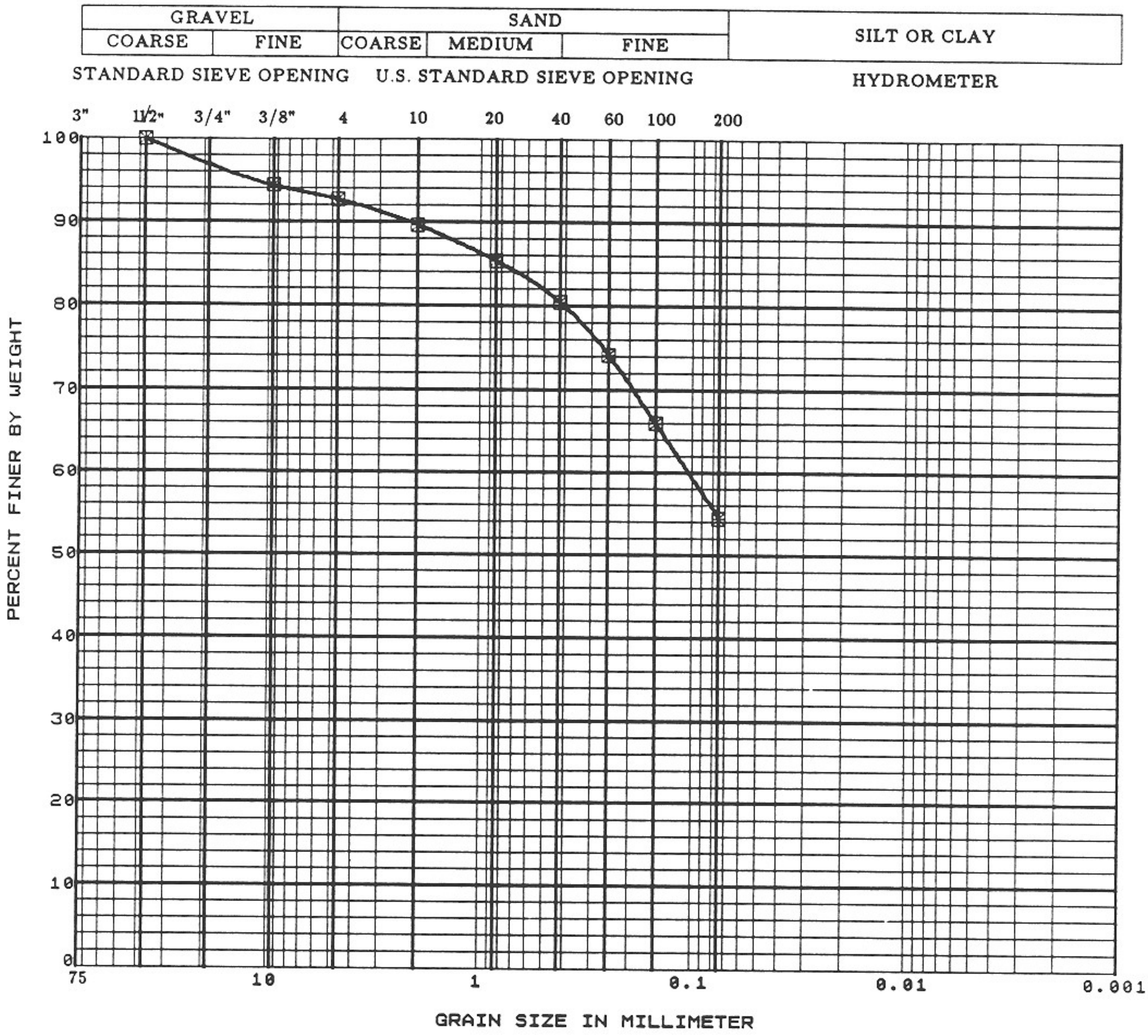
FIGURE B- 21



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	LPE-12	S - 15	80.00	SPT	ML			

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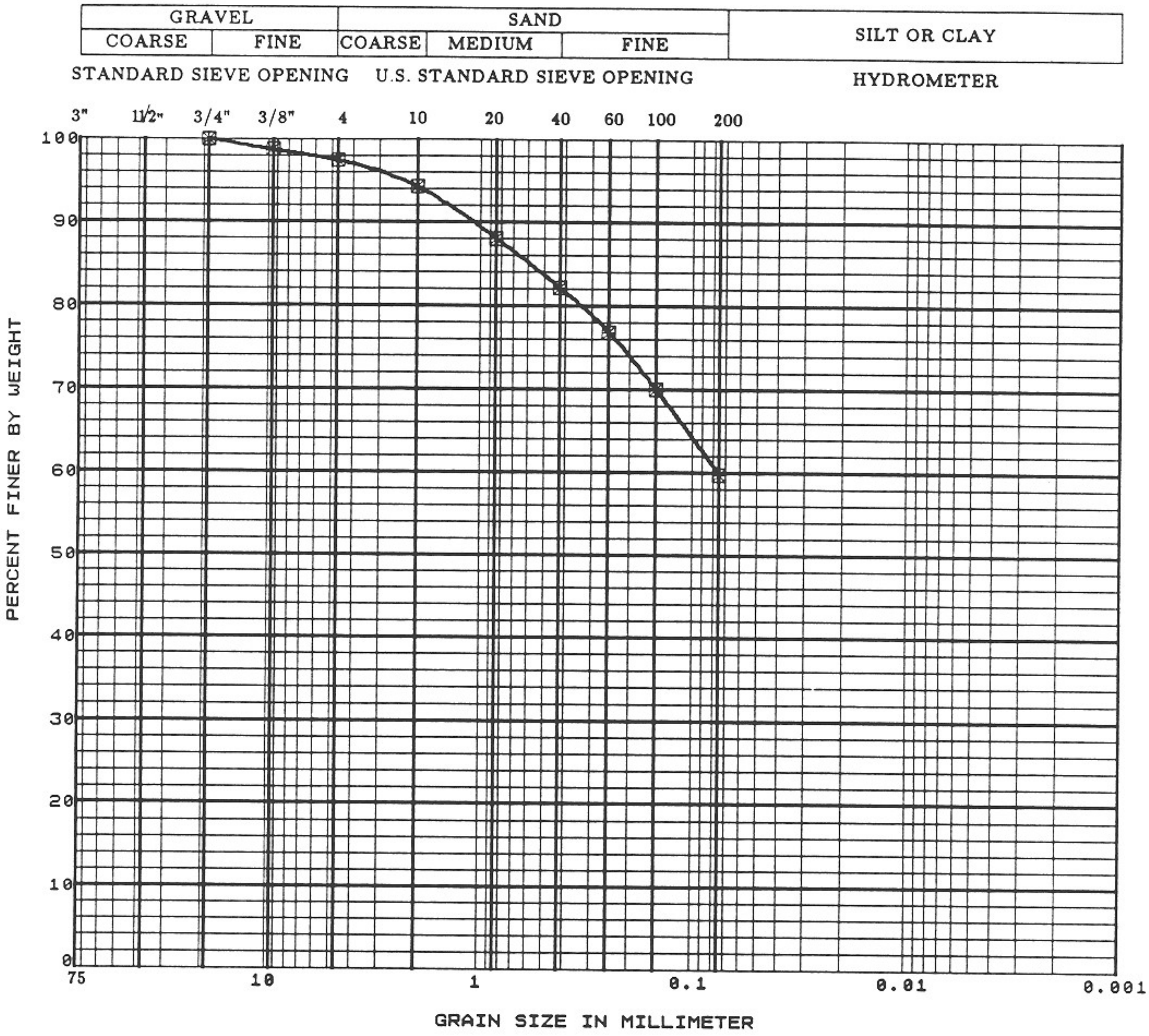
FIGURE B- 22



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	LPE-12	S - 15	80.75	SPT	ML			

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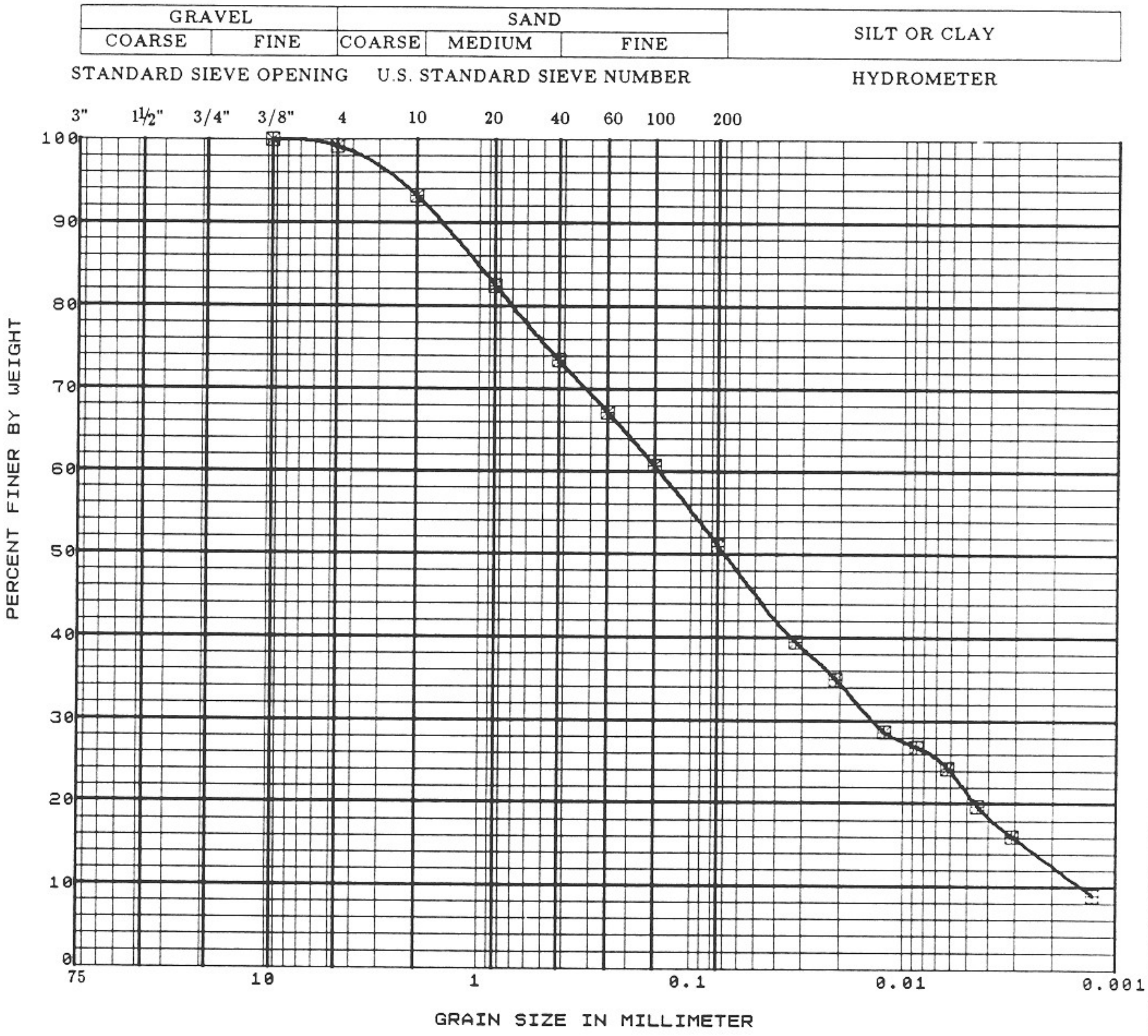
FIGURE B- 23



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	LPE-12	D-16	85.00	DRIVE	SC/CL			

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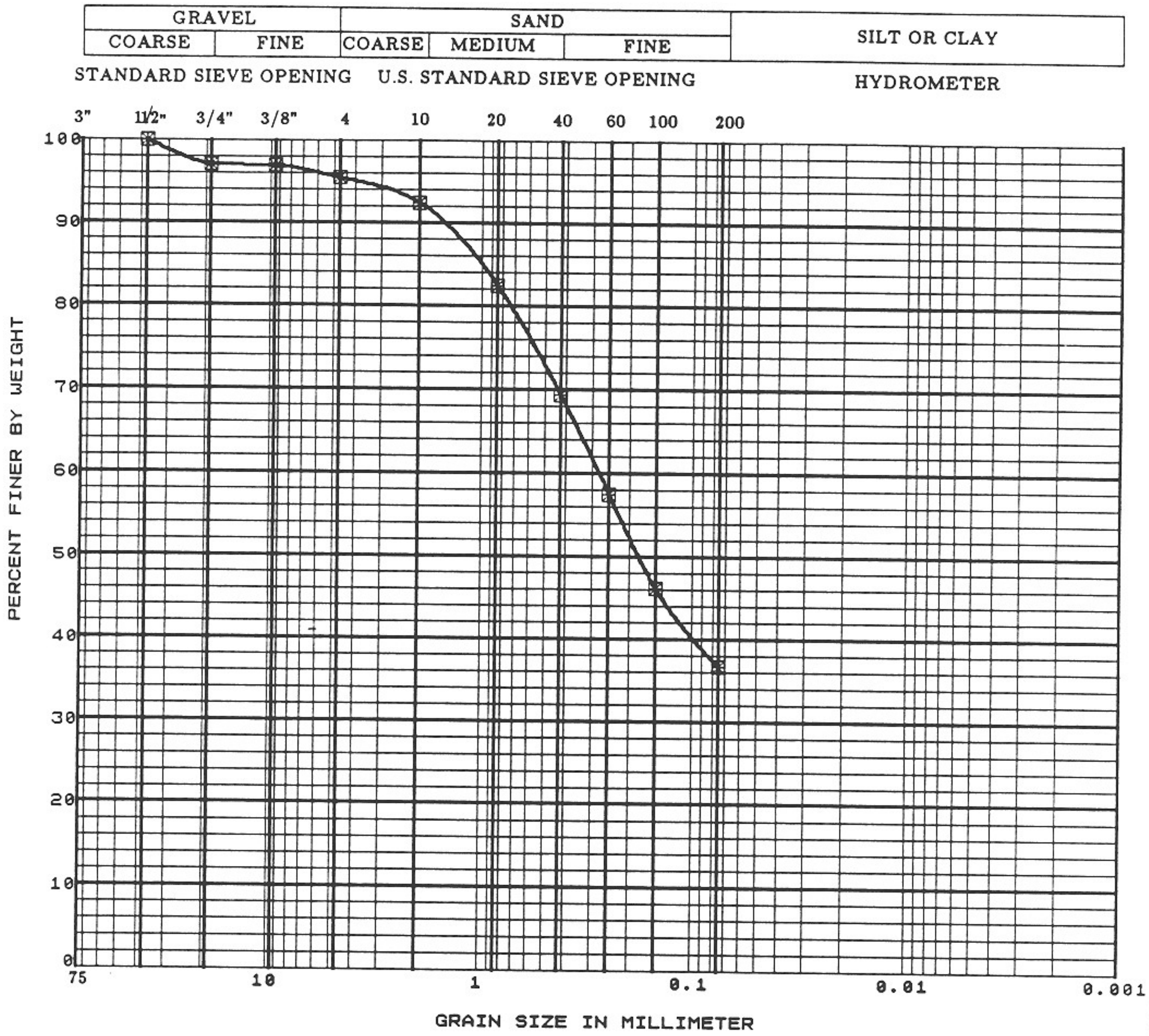
FIGURE B-24



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
☒	LPE-13	S-8	50.00	SPT	SM			

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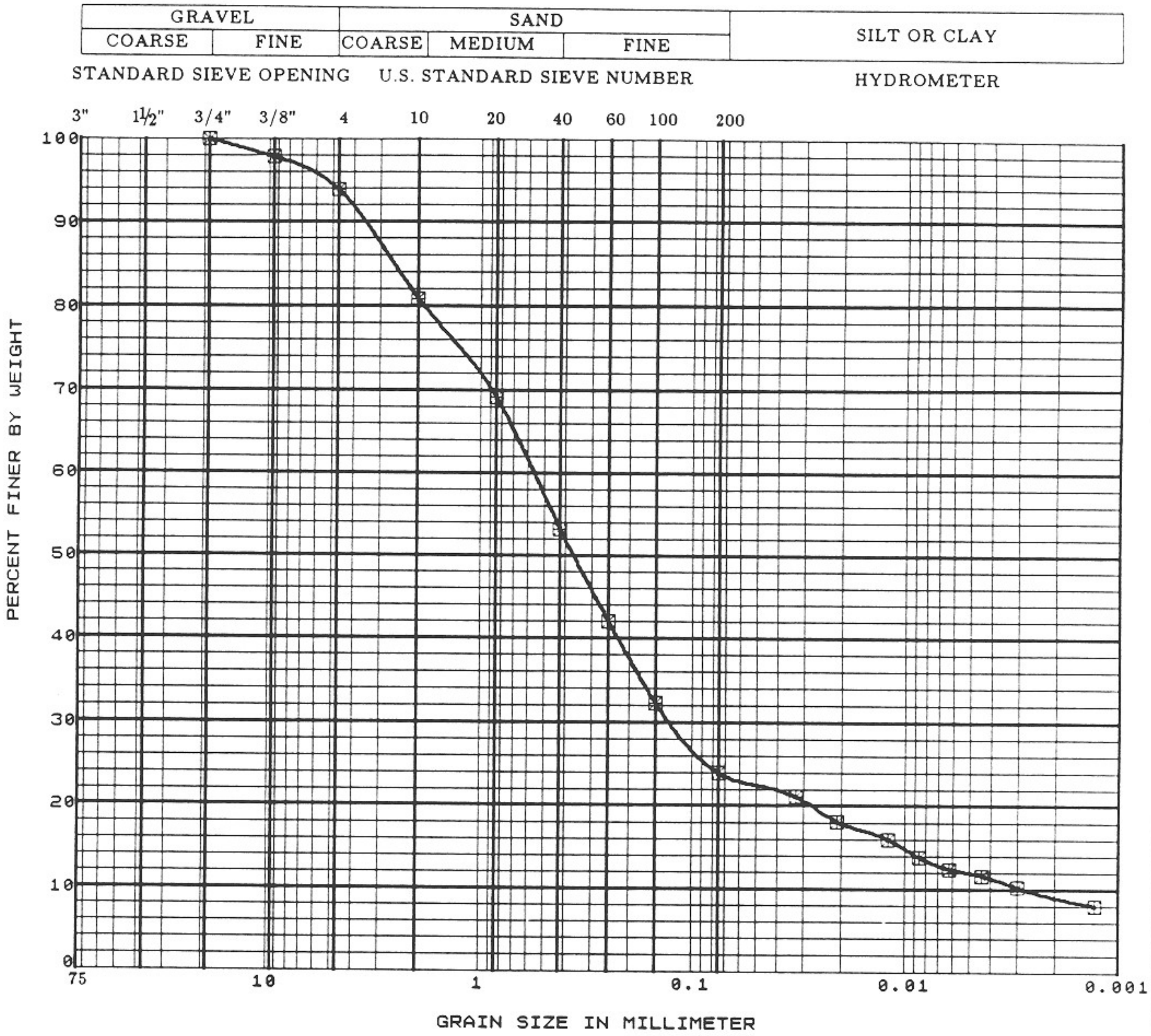
FIGURE B- 25



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	LPE-13	D-9	55.00	DRIVE	SM			

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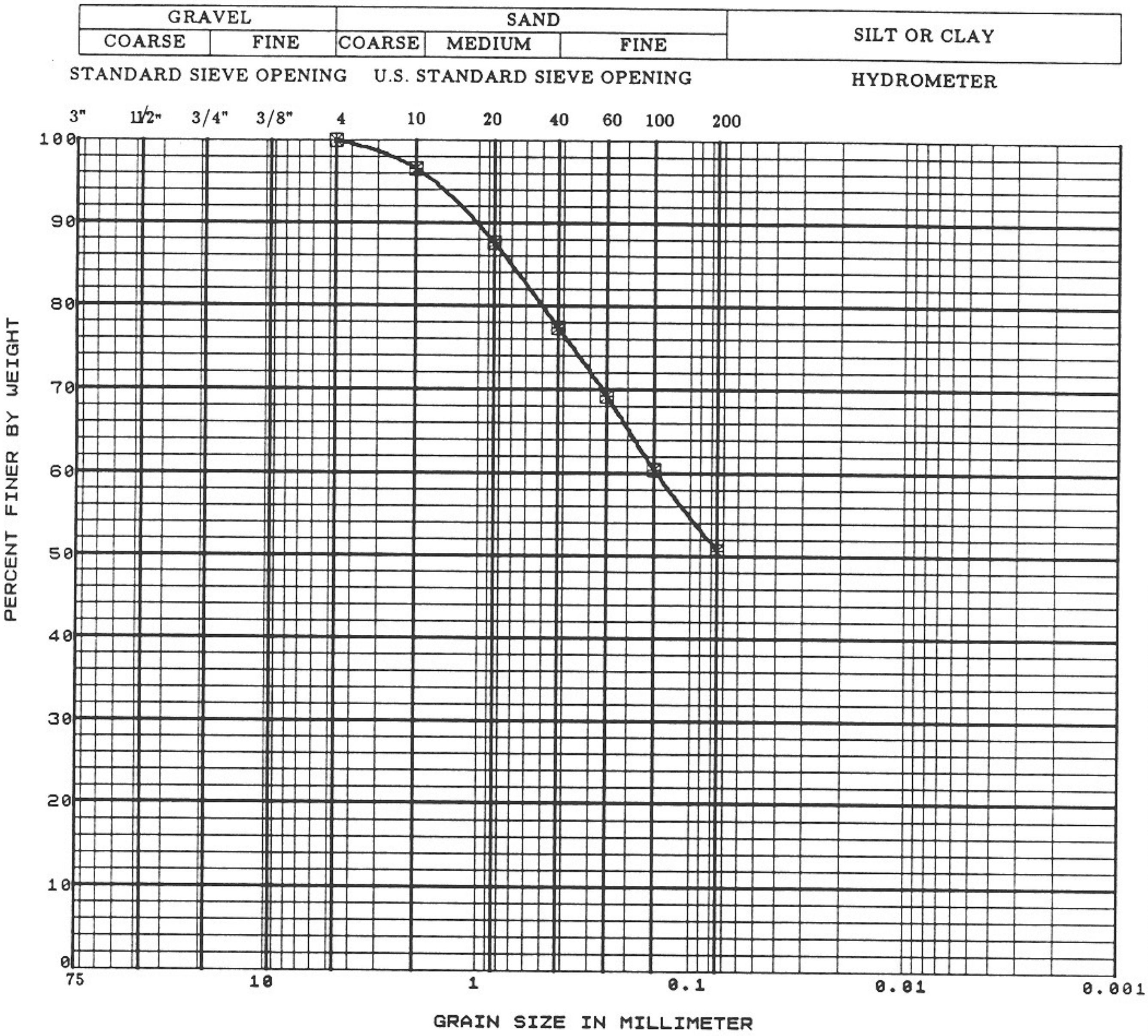
FIGURE B- 26



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
☒	LPE-13	S-9	60.00	SPT	SC/CL	32	11	21

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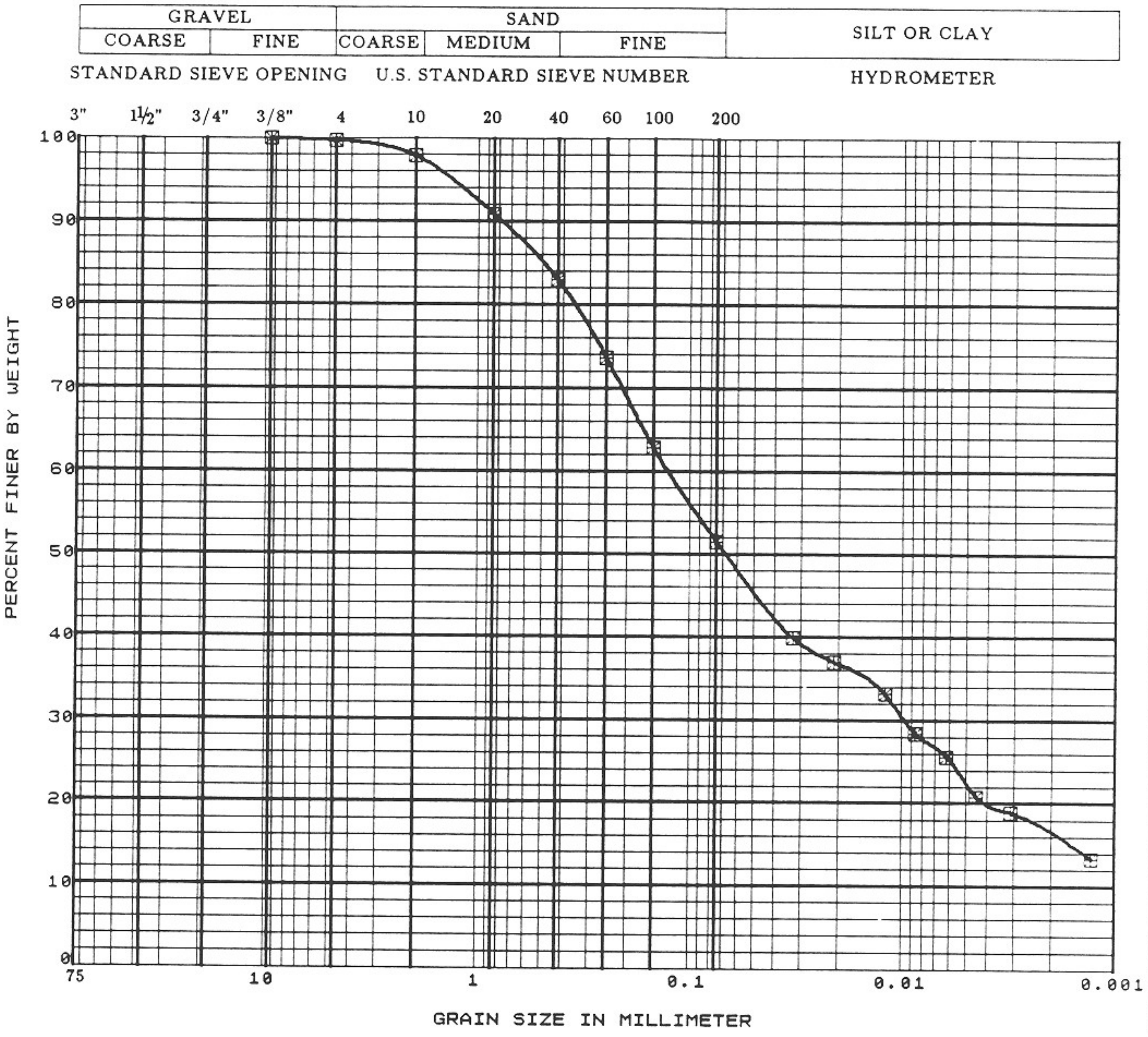
FIGURE B-27



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	LPE-13	D-10	64.90	DRIVE	SC/CL	28	21	7

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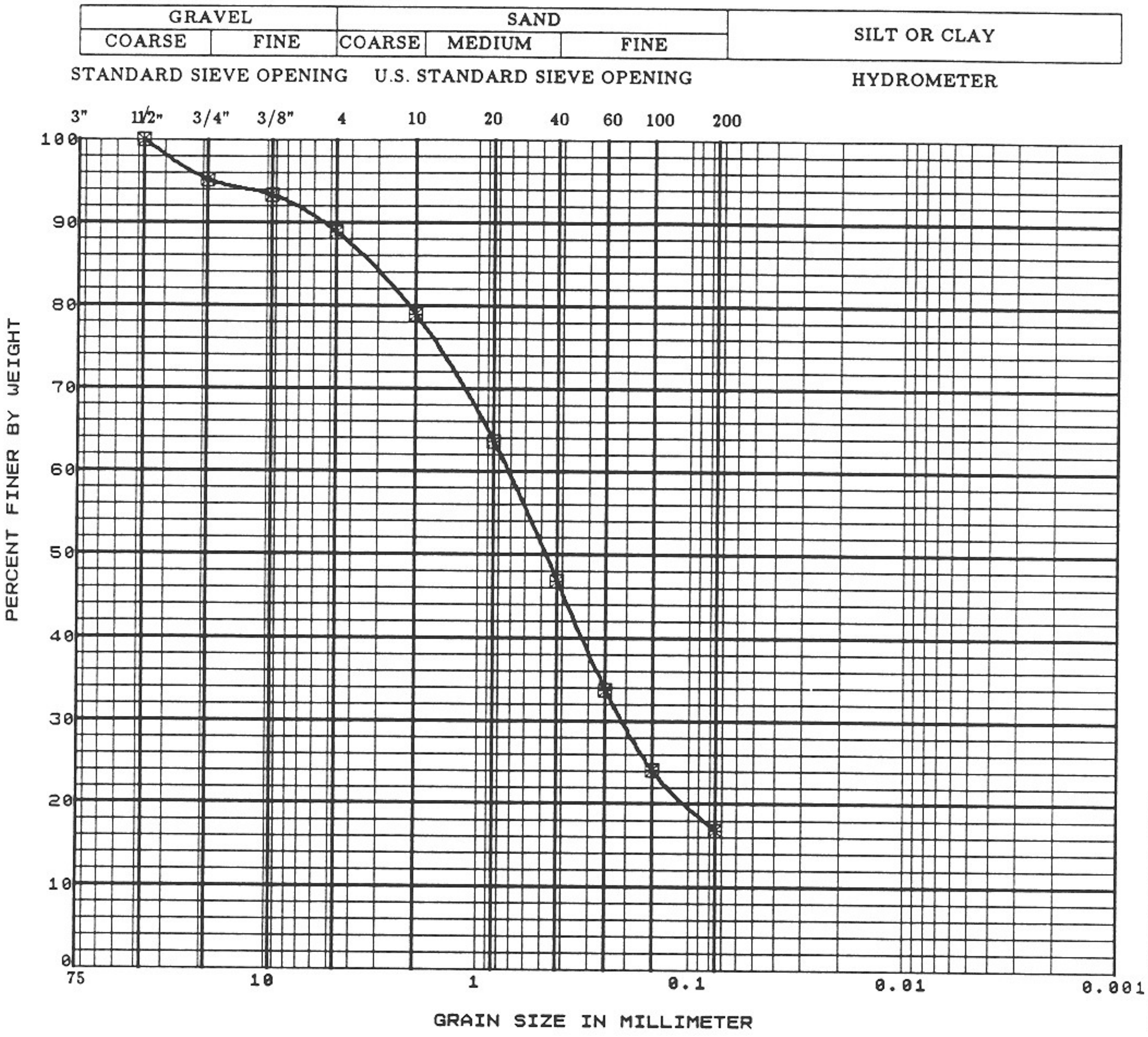
FIGURE B- 28



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	LPE-14	D - 1	11.00	DRIVE	SM			

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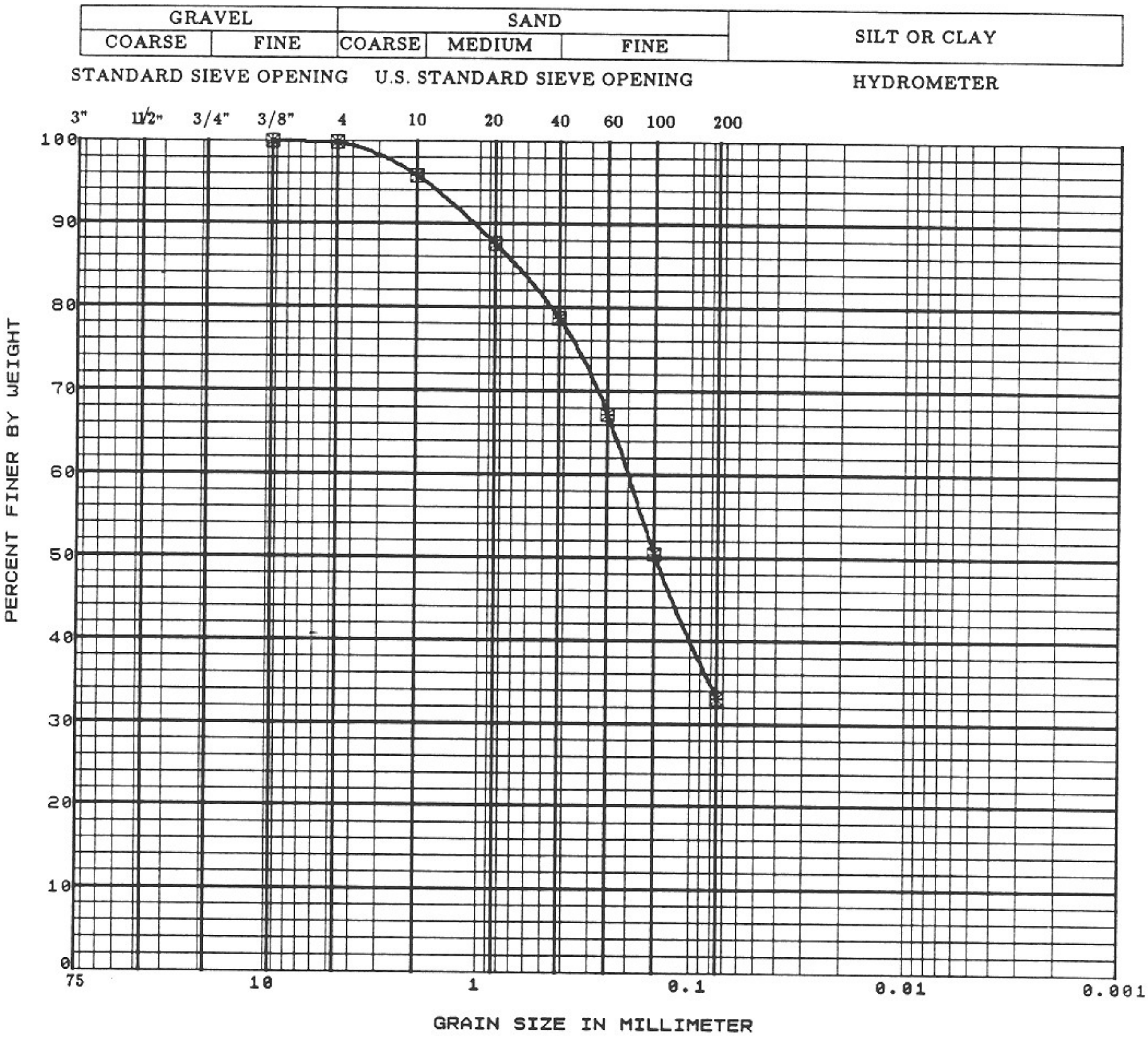
FIGURE B- 29



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
☒	LPE-14	S-2	15.00	SPT	SM			

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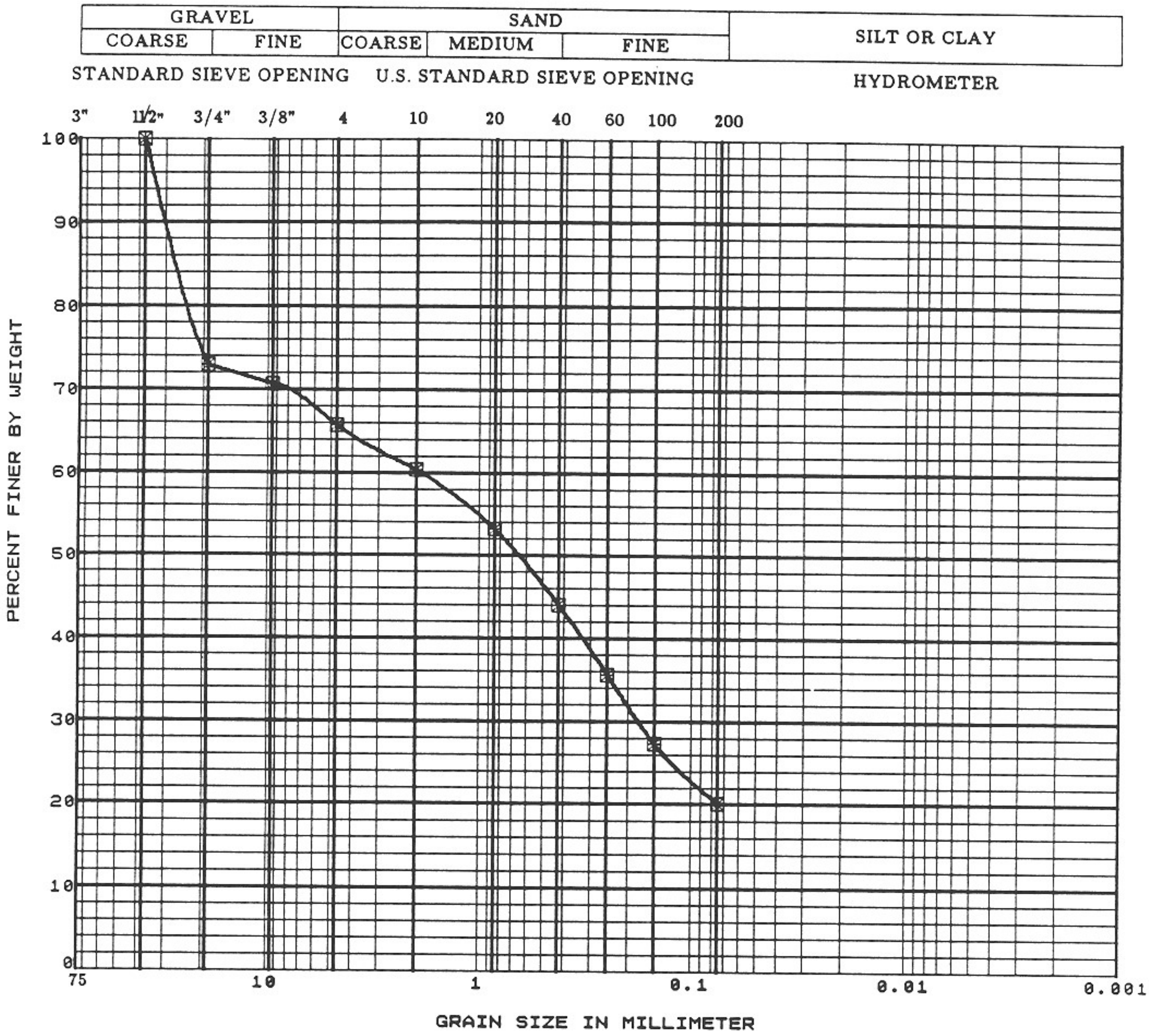
FIGURE B-30



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
☒	LPE-14	S-4	25.00	SPT	SM			

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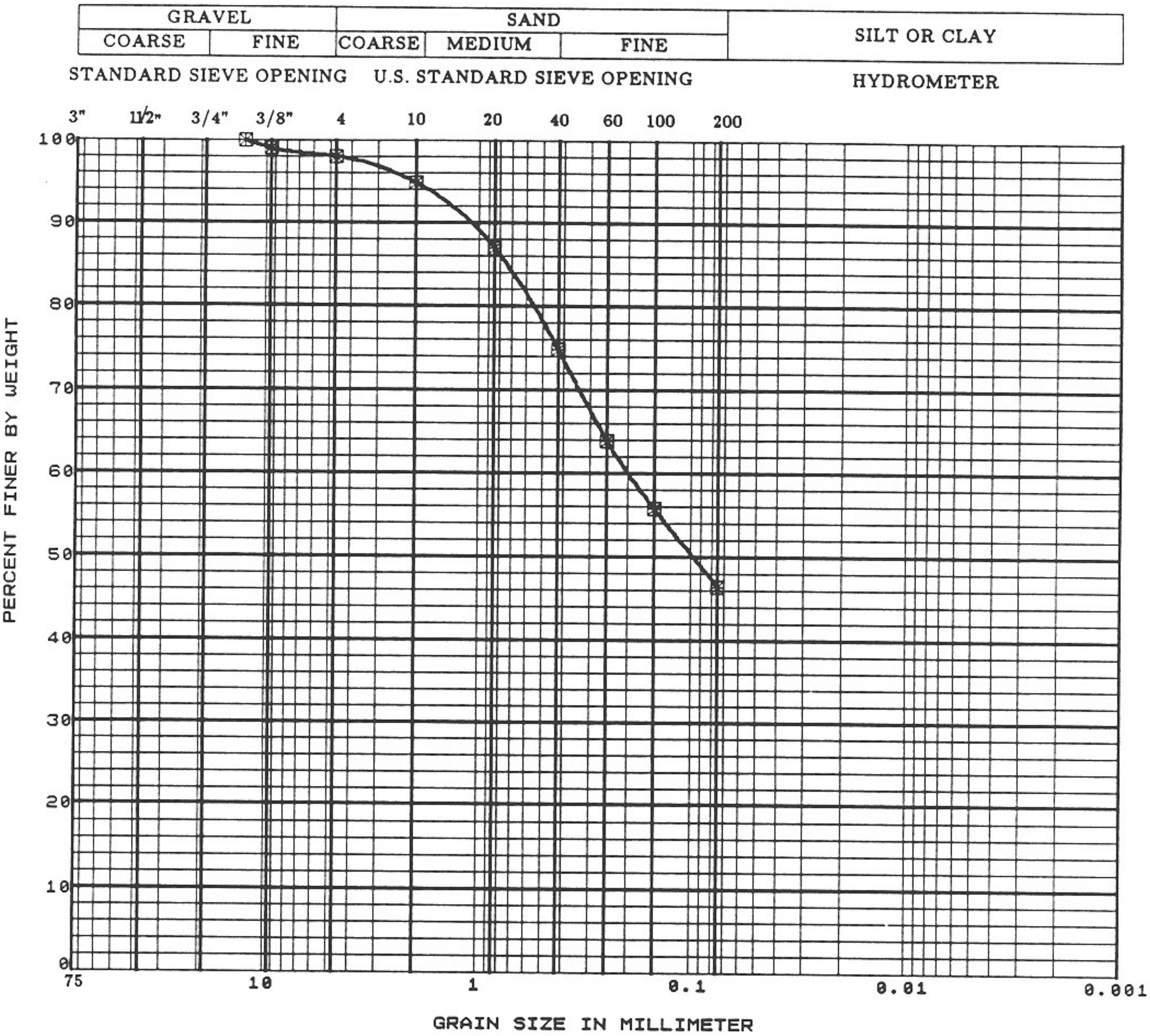
FIGURE B-31



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
☒	LPE-14	D-7	40.00	DRIVE	SC	34	17	17

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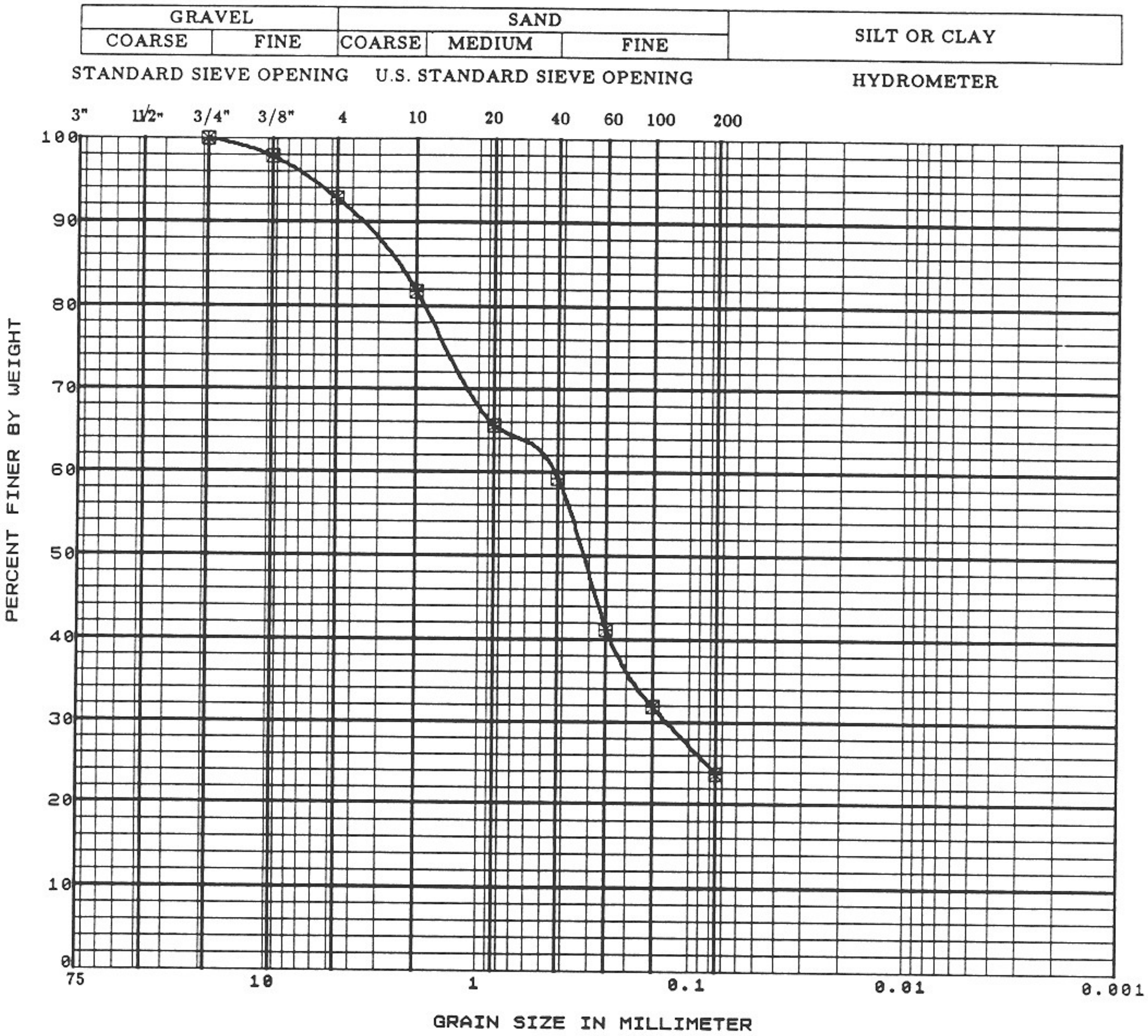
FIGURE B- 32



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
☒	LPE-14	S-8	45.00	SPT	SC			

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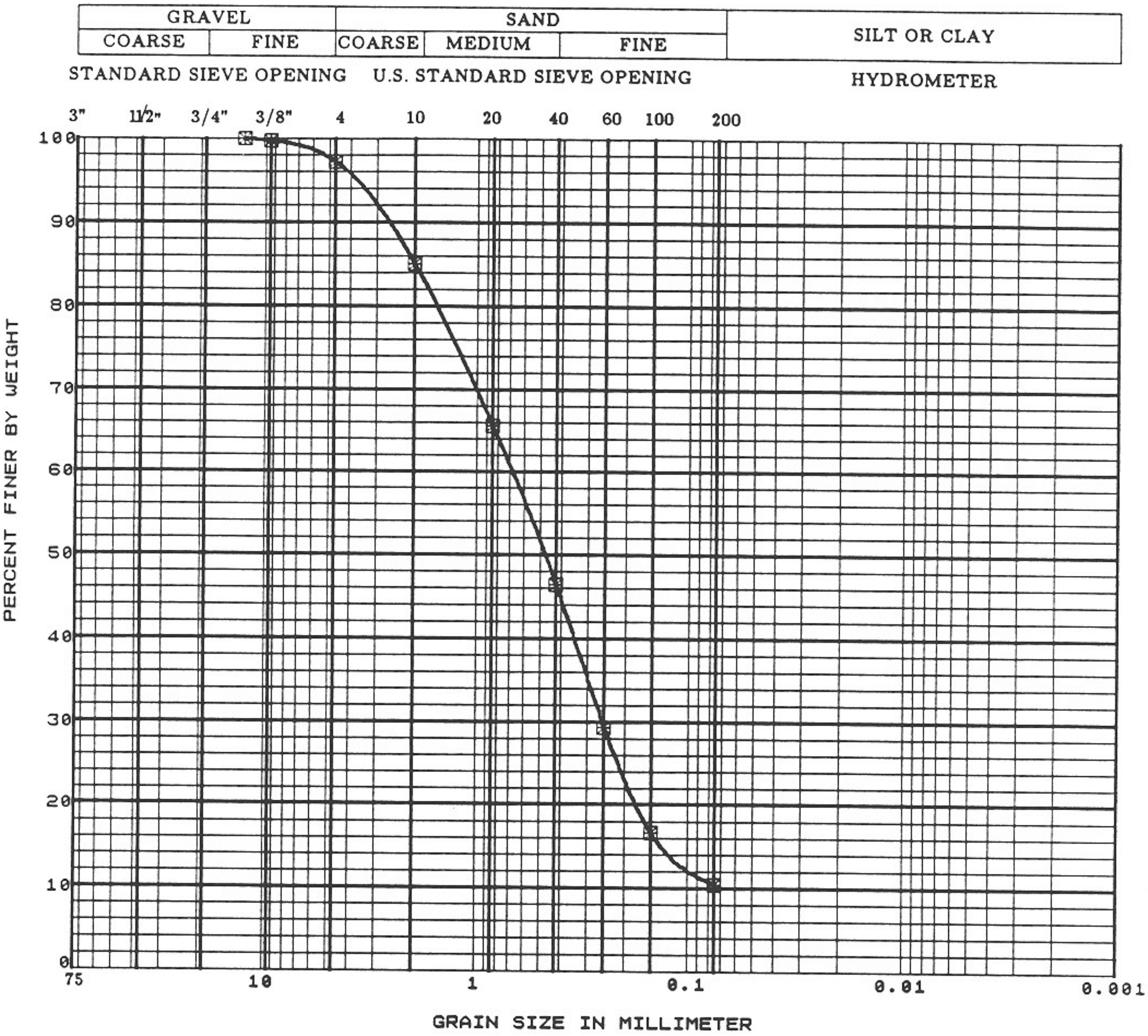
FIGURE B-33



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	LPE-14	D - 10	55.00	DRIVE	SP-SM			

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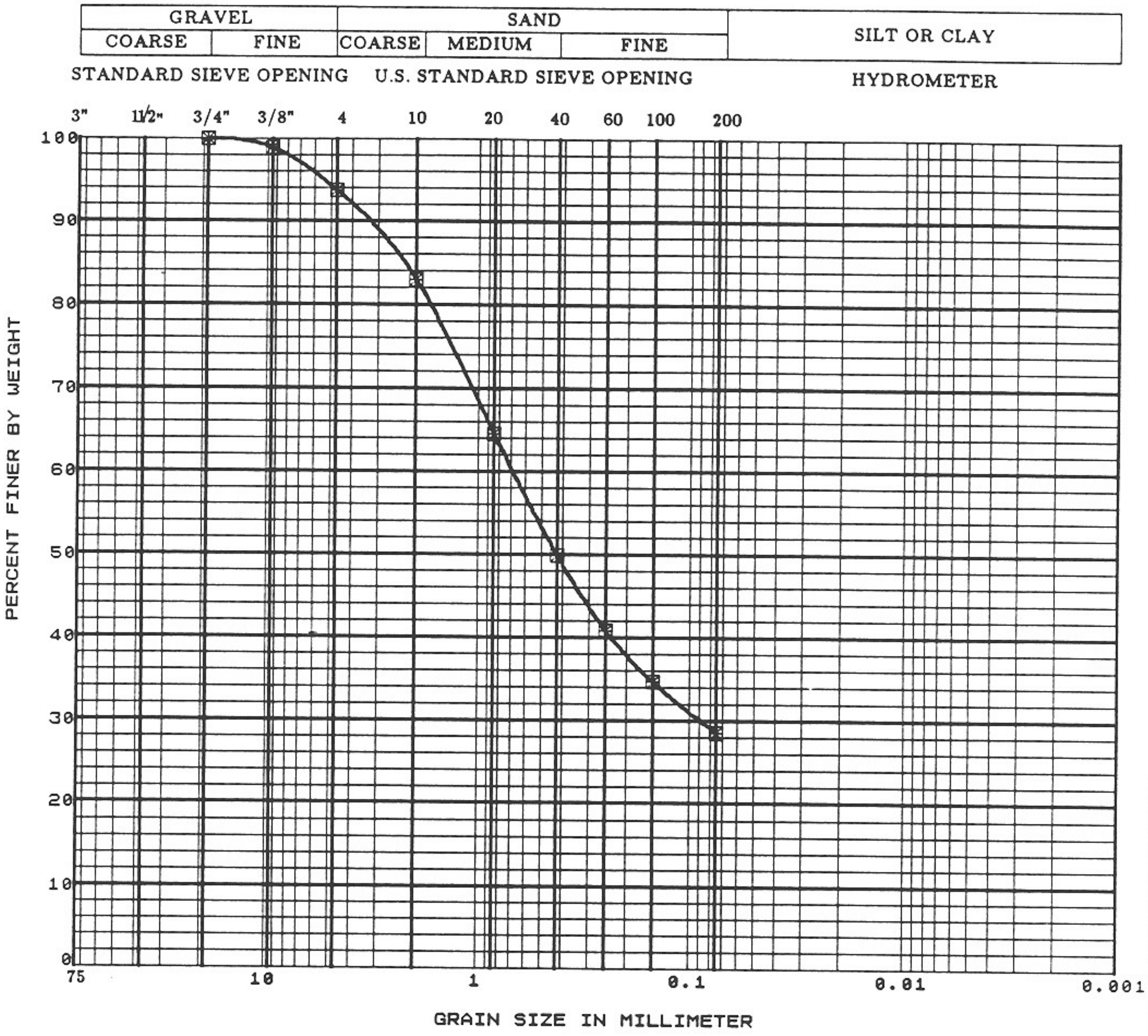
FIGURE B- 34



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC. LIMIT	PLASTICITY INDEX
⊠	LPE-14	D - 13	65.50	DRIVE	SC			

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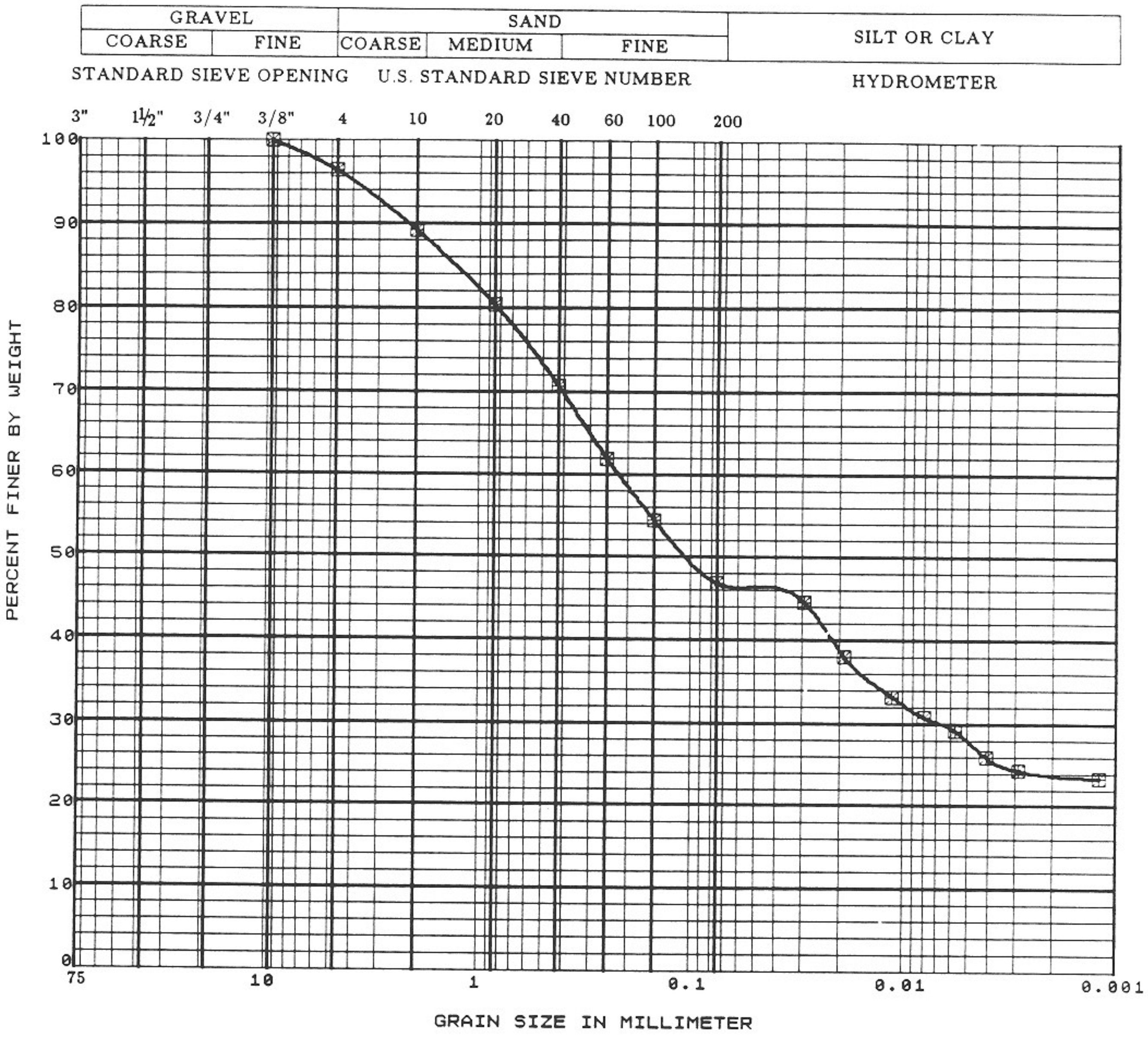
FIGURE B- 35



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	LPE-14	S-14	70.00	SPT	SC	37	16	21

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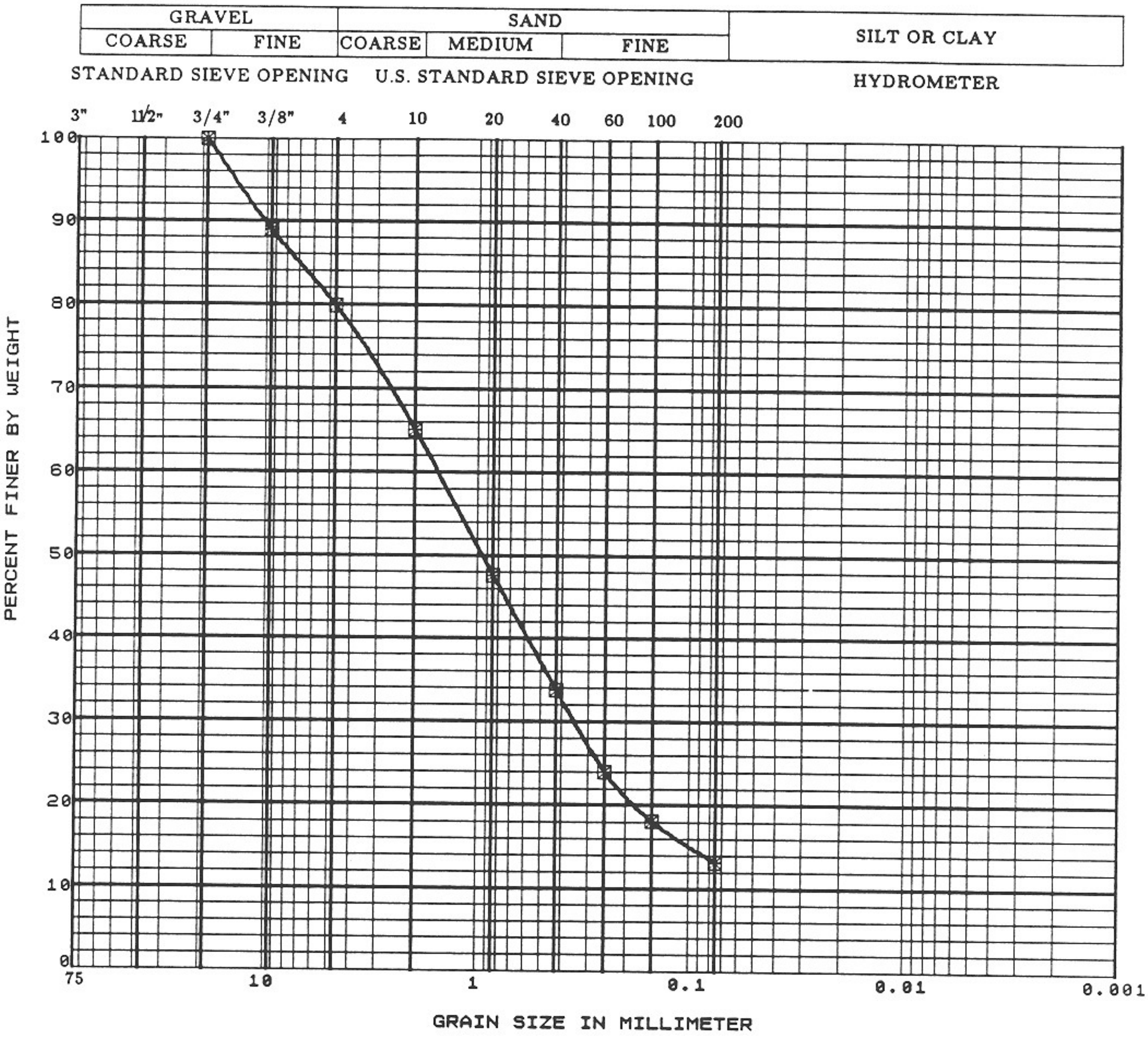
FIGURE B-36



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	LPE-15	S - 2	10.00	SPT	SM			

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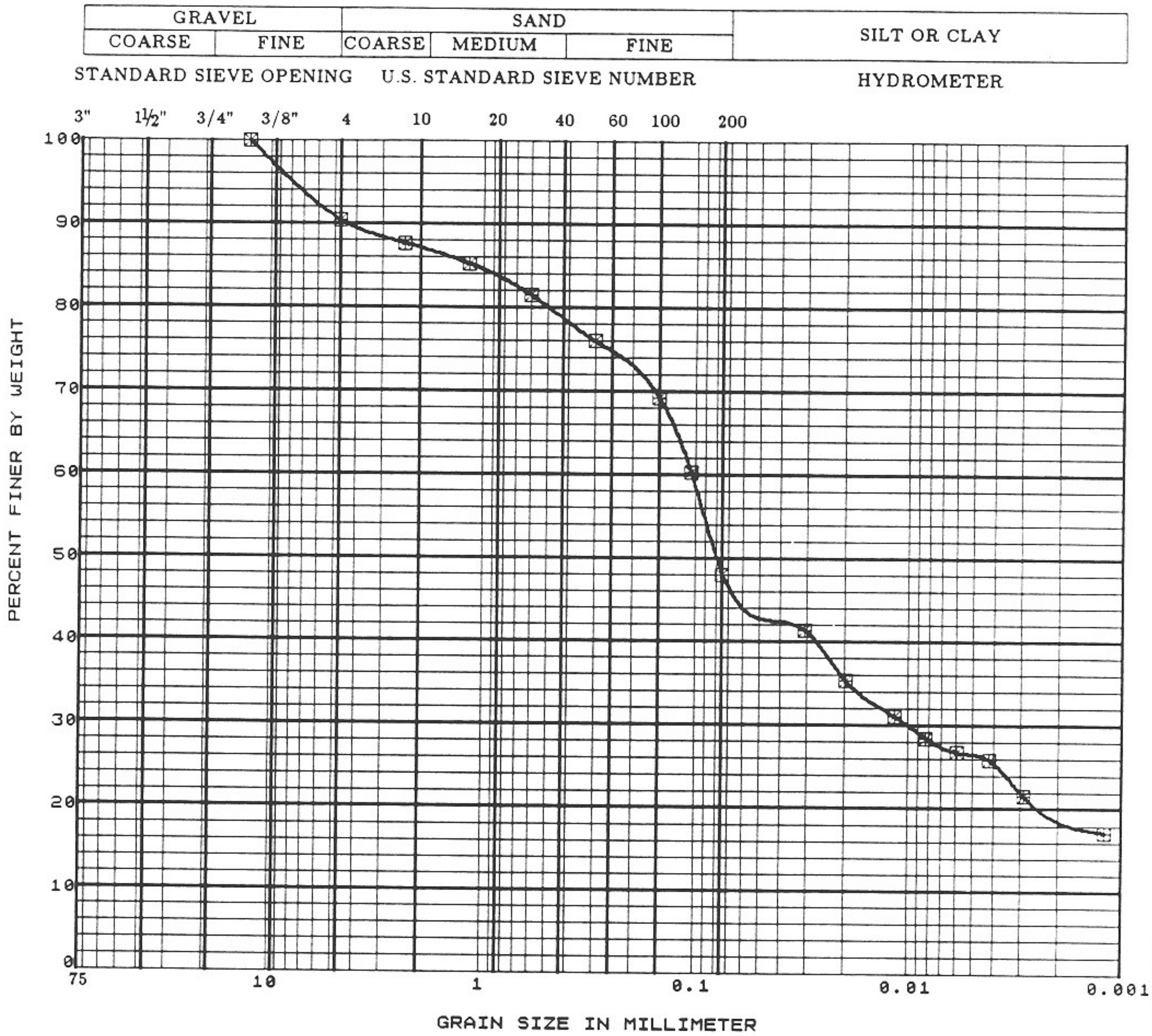
FIGURE B- 37



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	LPE-15	S-4	20.20	SPT	SC/CL			

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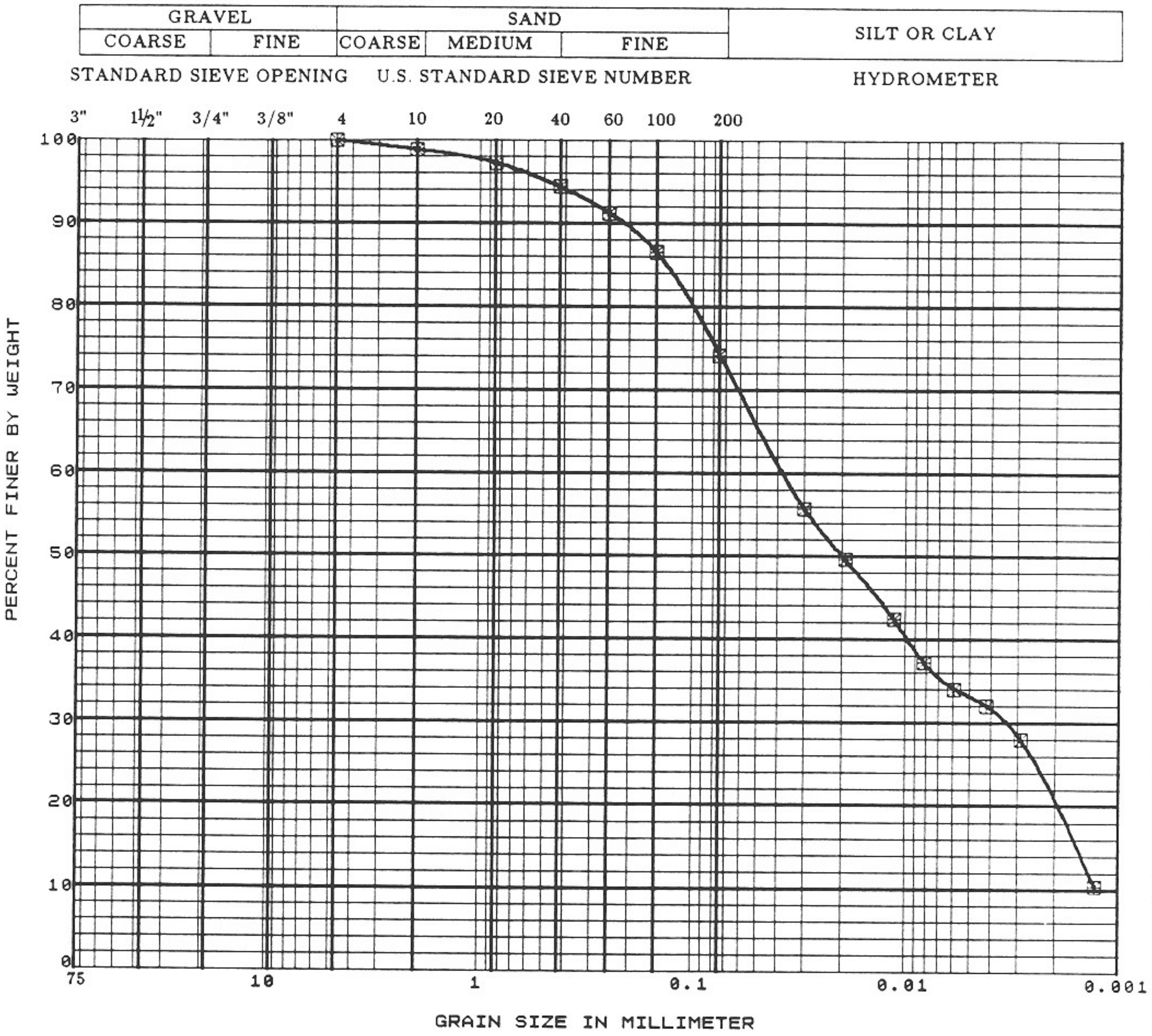
FIGURE B-38



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
☒	LPE-15	S-6	30.00	SPT	CL			

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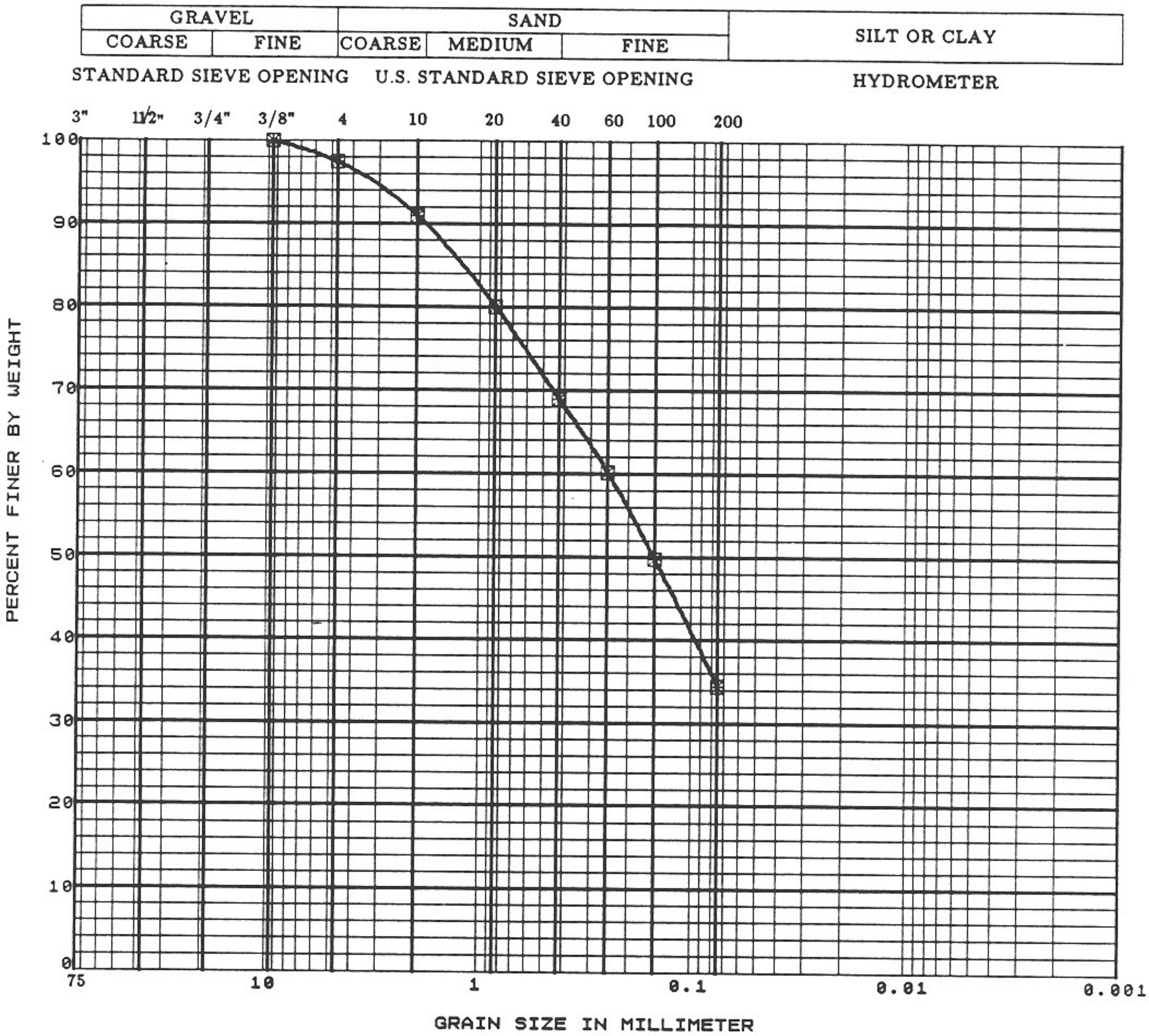
FIGURE B-39



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
☒	LPE-15	D-9	45.00	DRIVE	SM			

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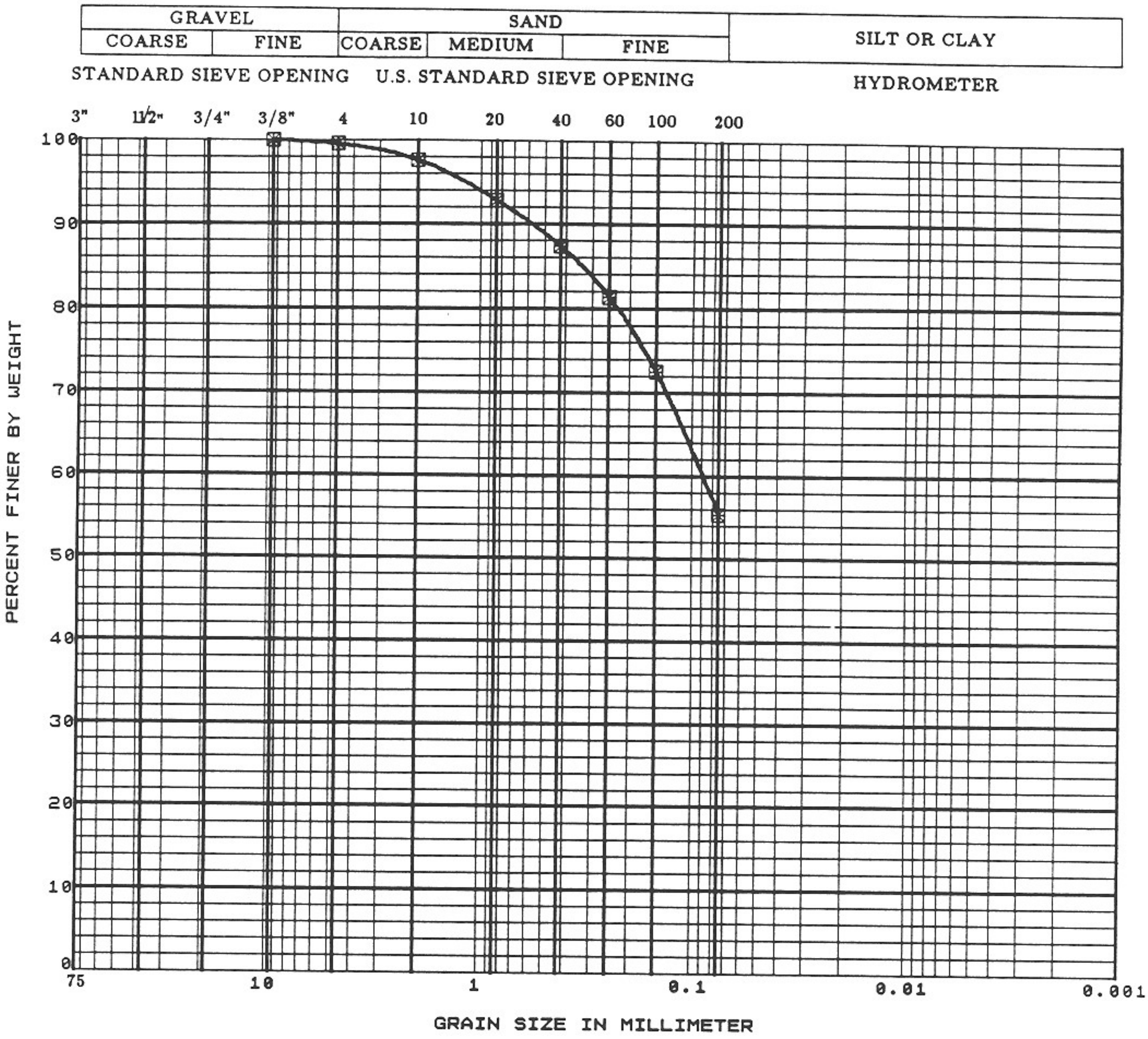
FIGURE B- 40



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
☒	LPE-15	S - 10	50.20	SPT	CH	54	22	32

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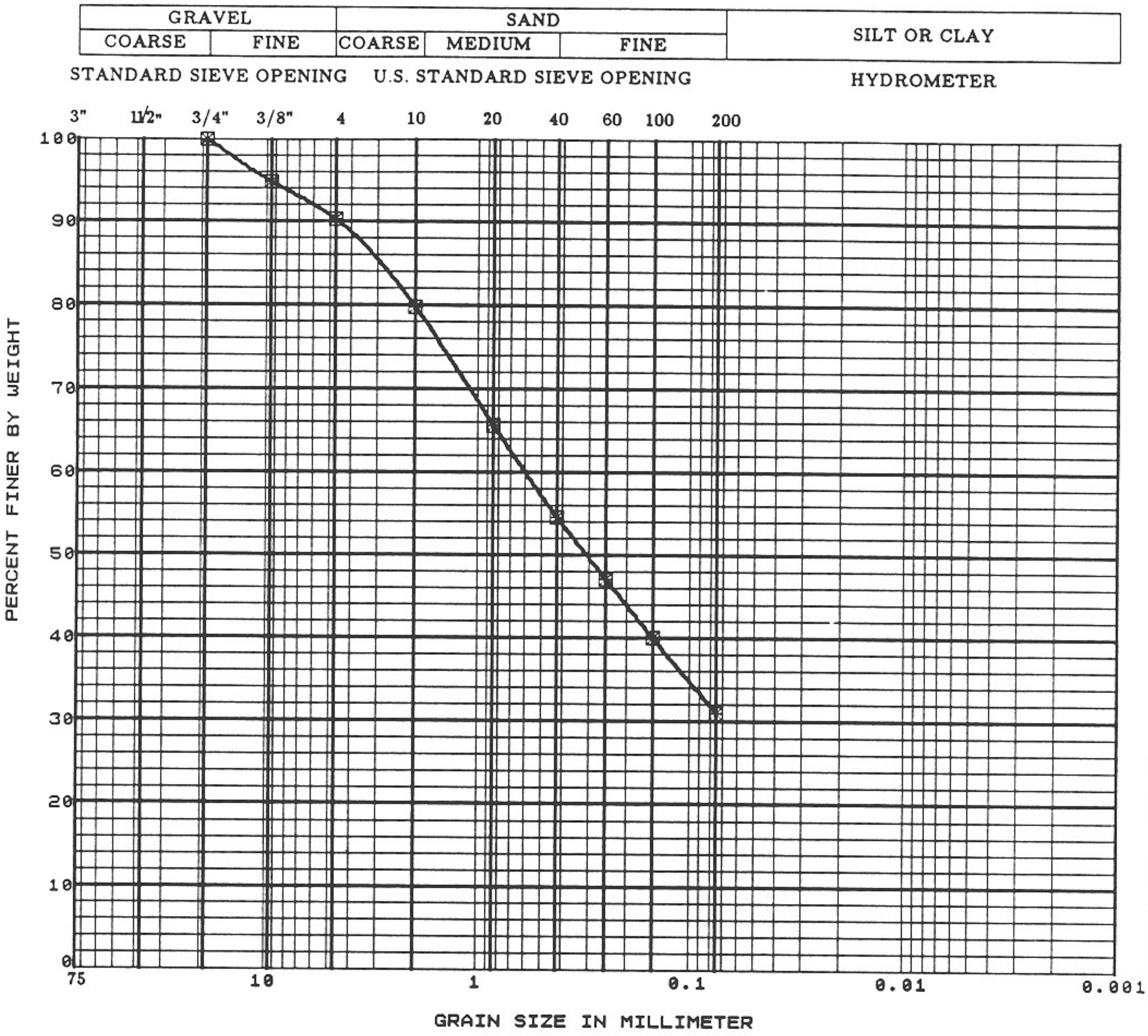
FIGURE B- 41



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
☒	LPE-16	S-2	10.00	SPT	SM			

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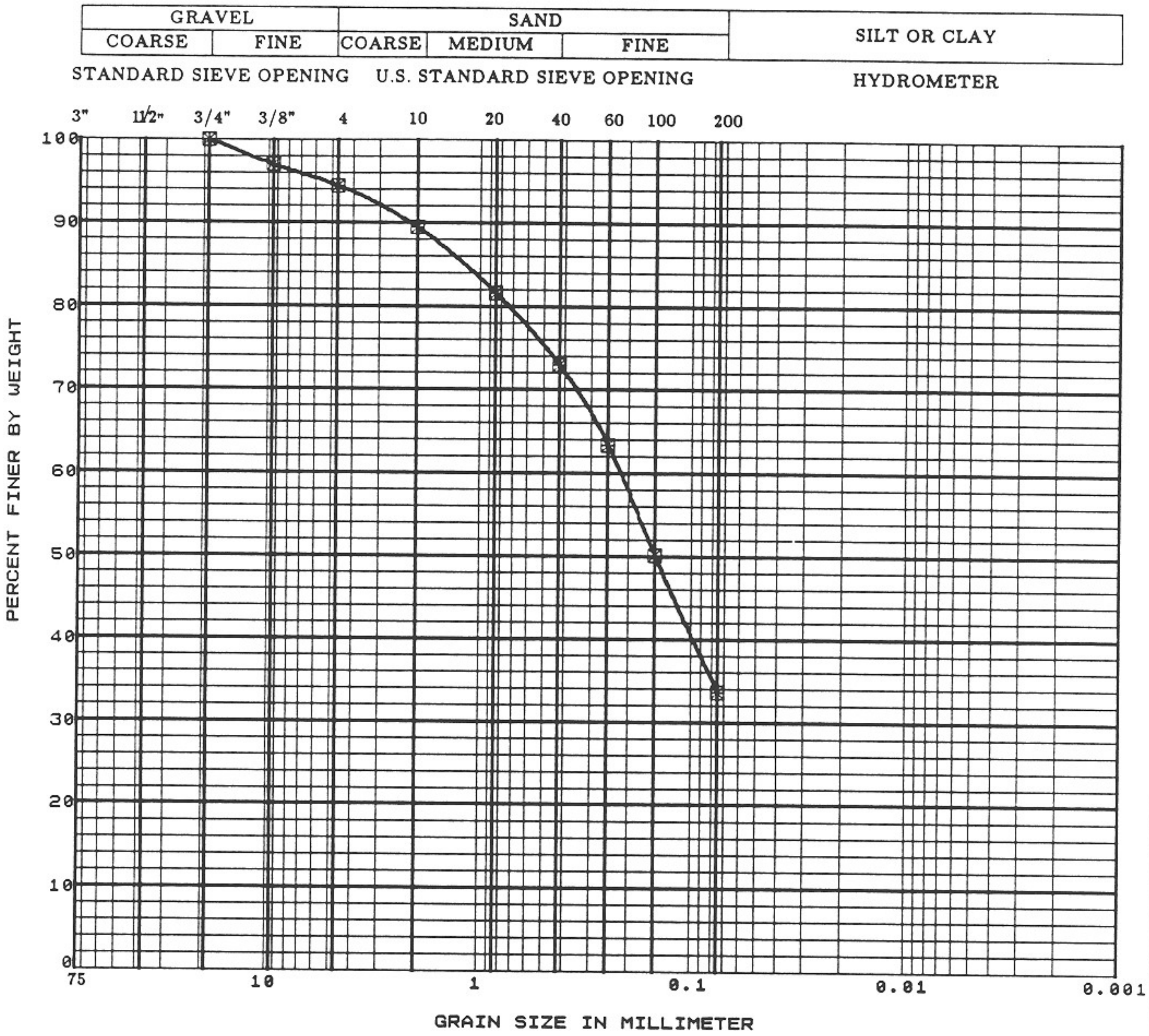
FIGURE B- 42



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
☒	LPE-16	D - 5	24.90	DRIVE	SM			

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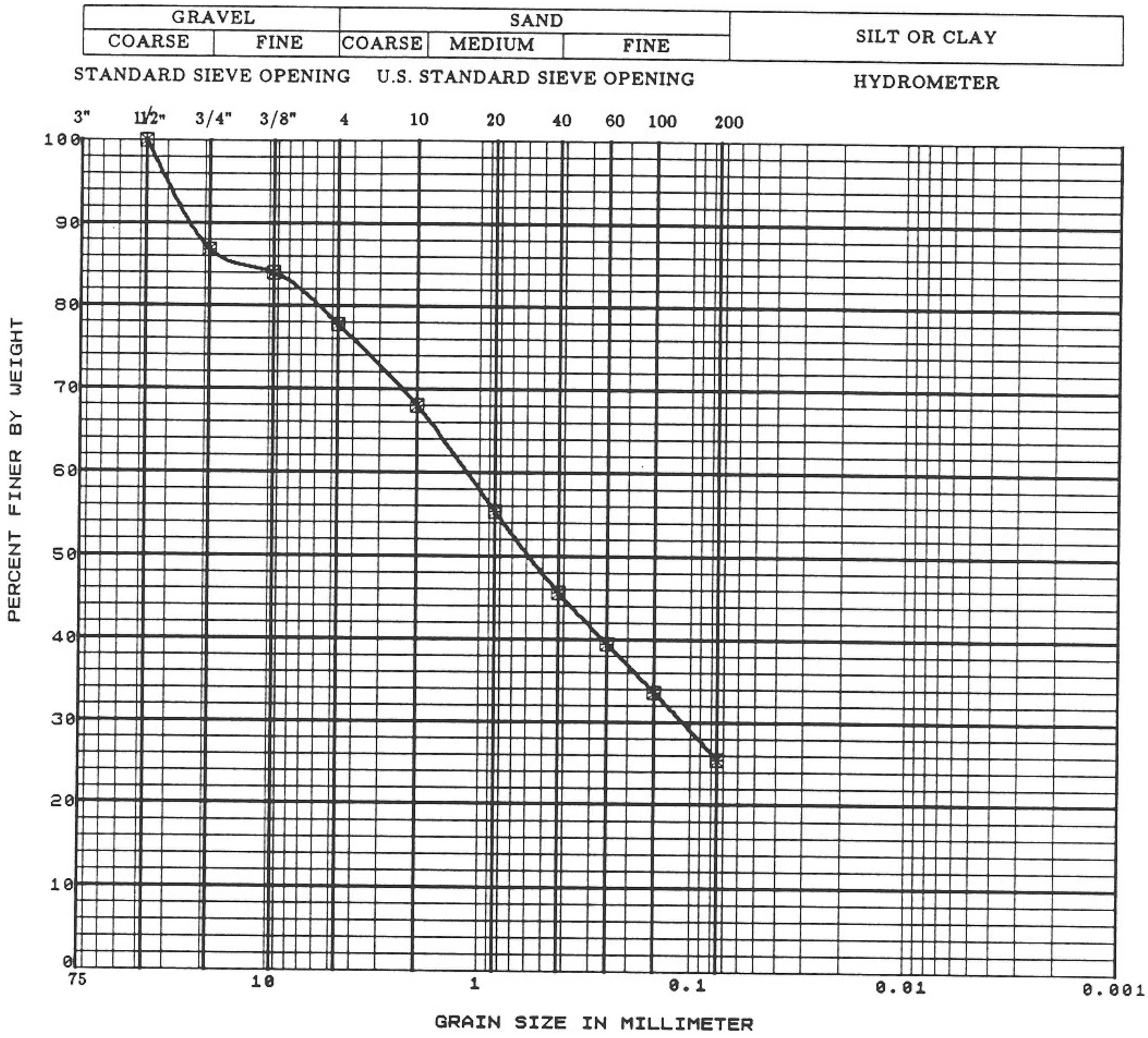
FIGURE B- 43



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
☒	LPE-16	S - 6	29.80	SPT	SM			

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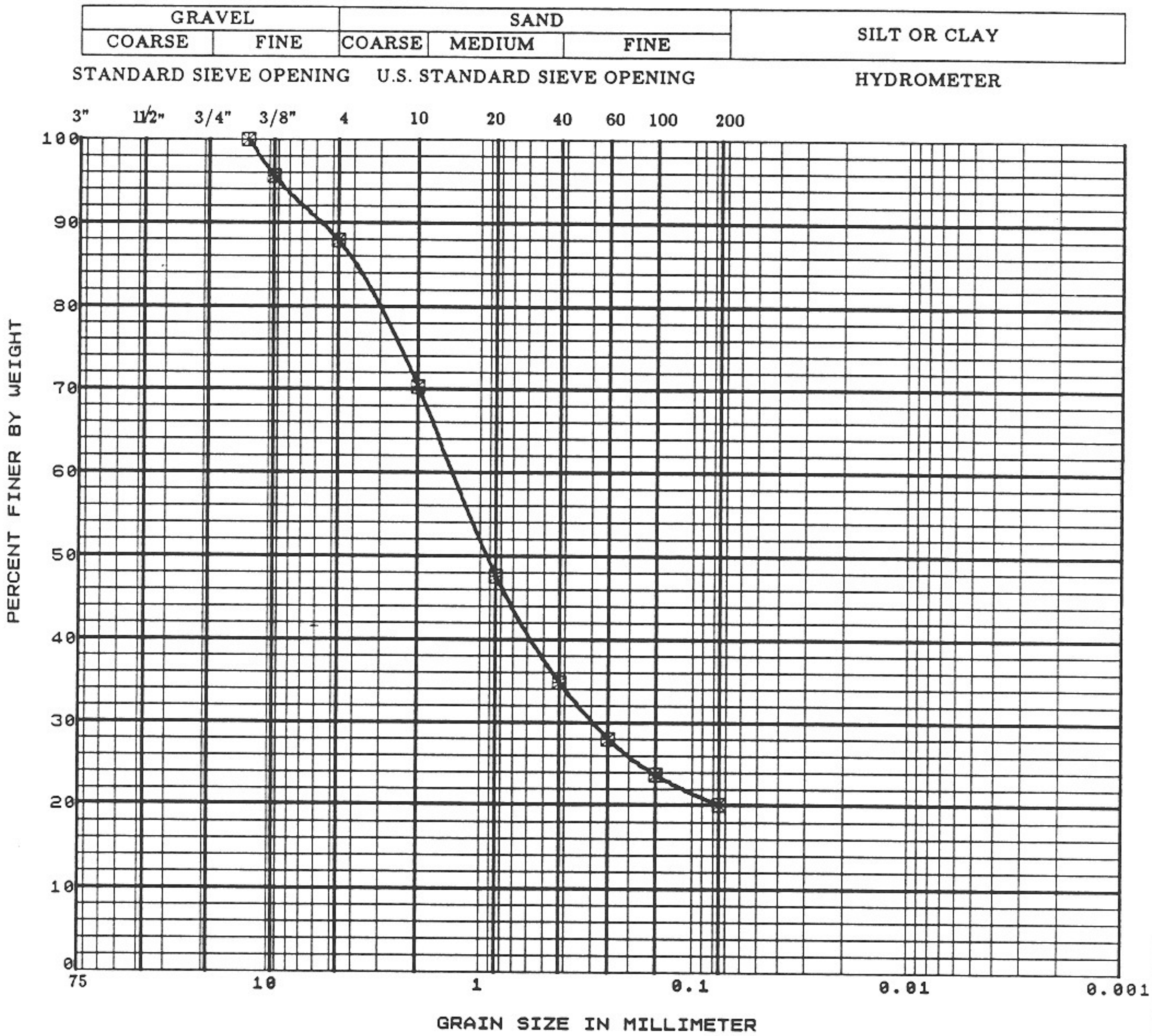
FIGURE B- 44



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	LPE-16	D - 9	44.80	DRIVE	SM			

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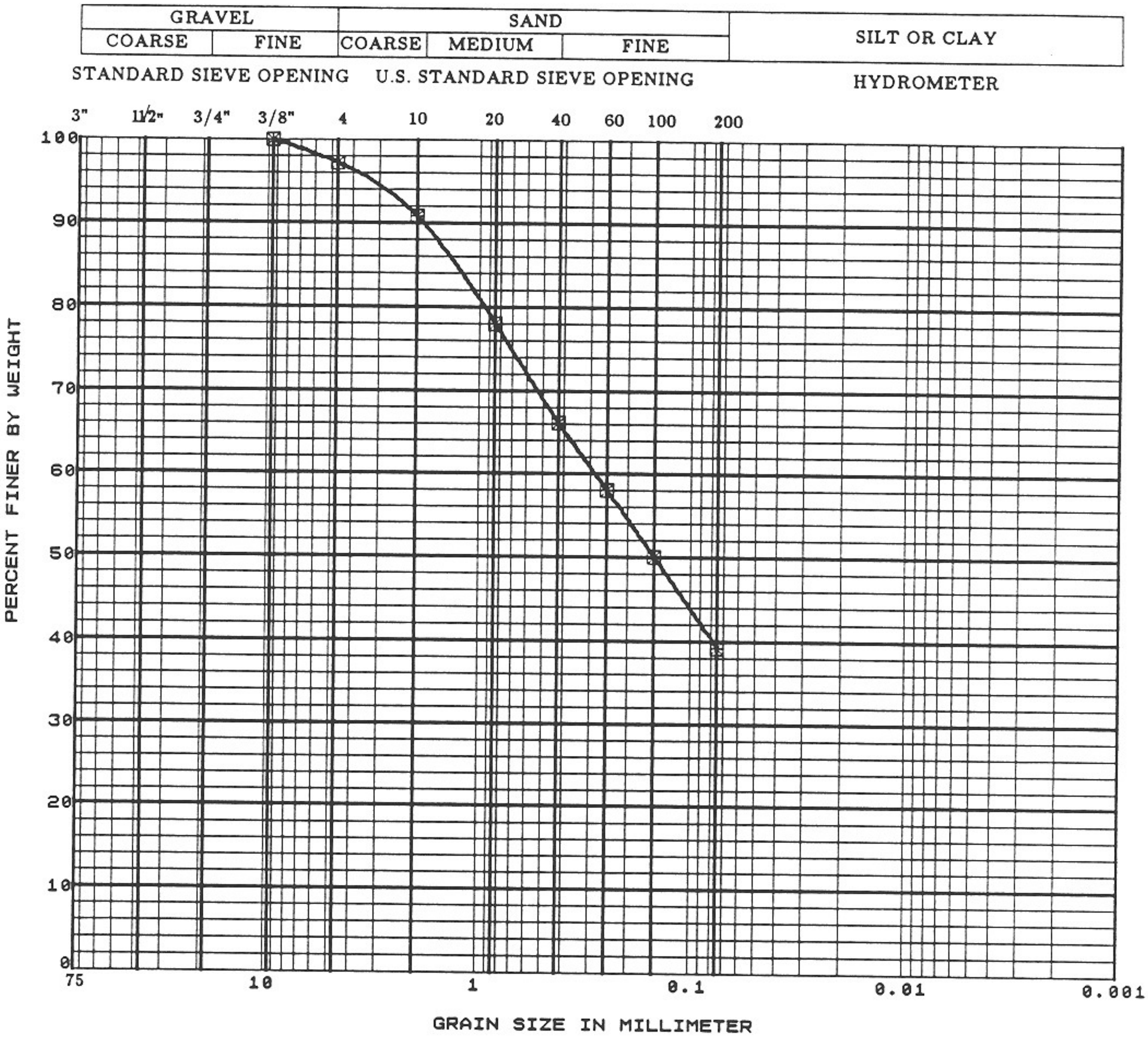
FIGURE B- 45



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
☒	LPE-16	S - 12	59.70	SPT	SM			

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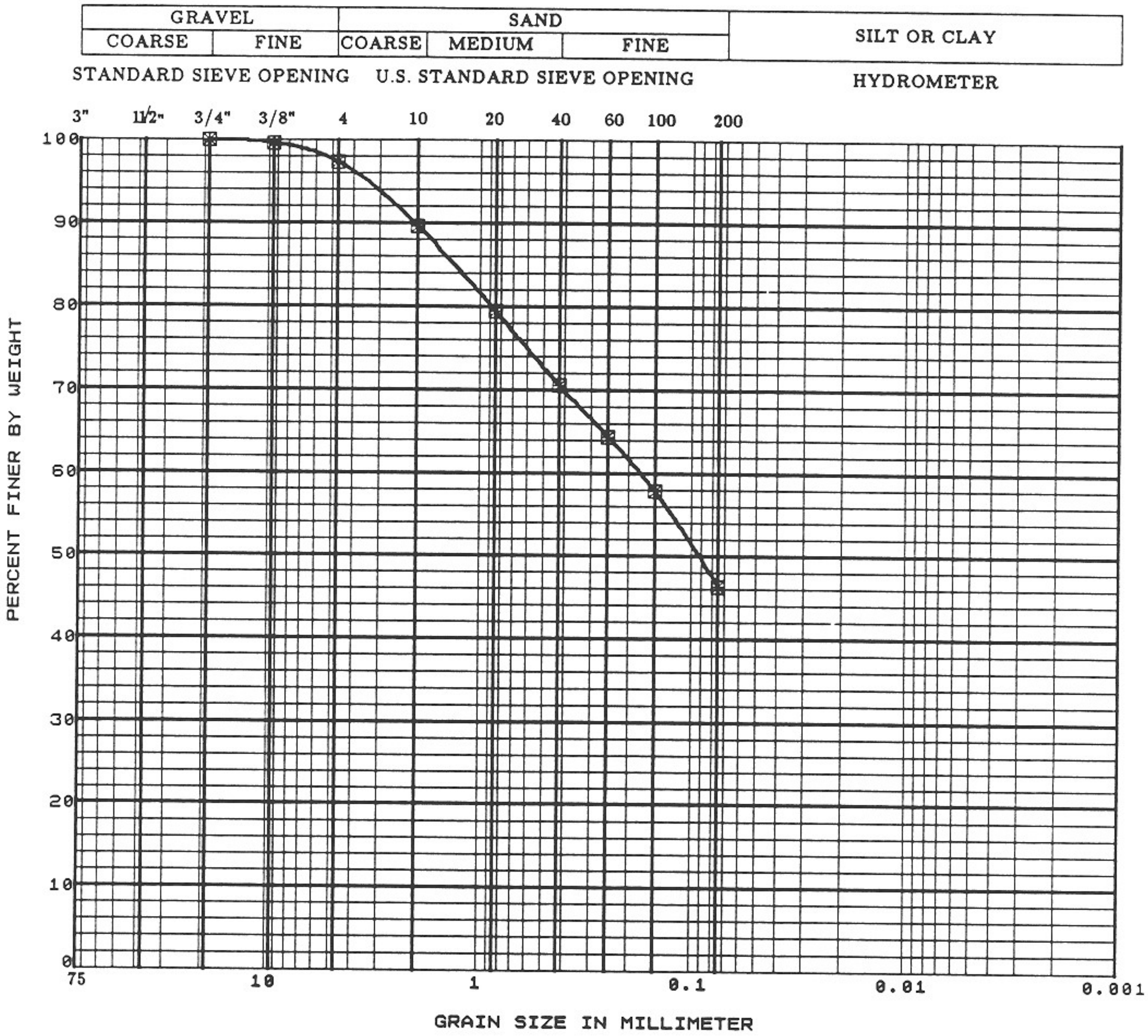
FIGURE B- 46



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
☒	LPE-16	S - 14	70.00	SPT	SM			

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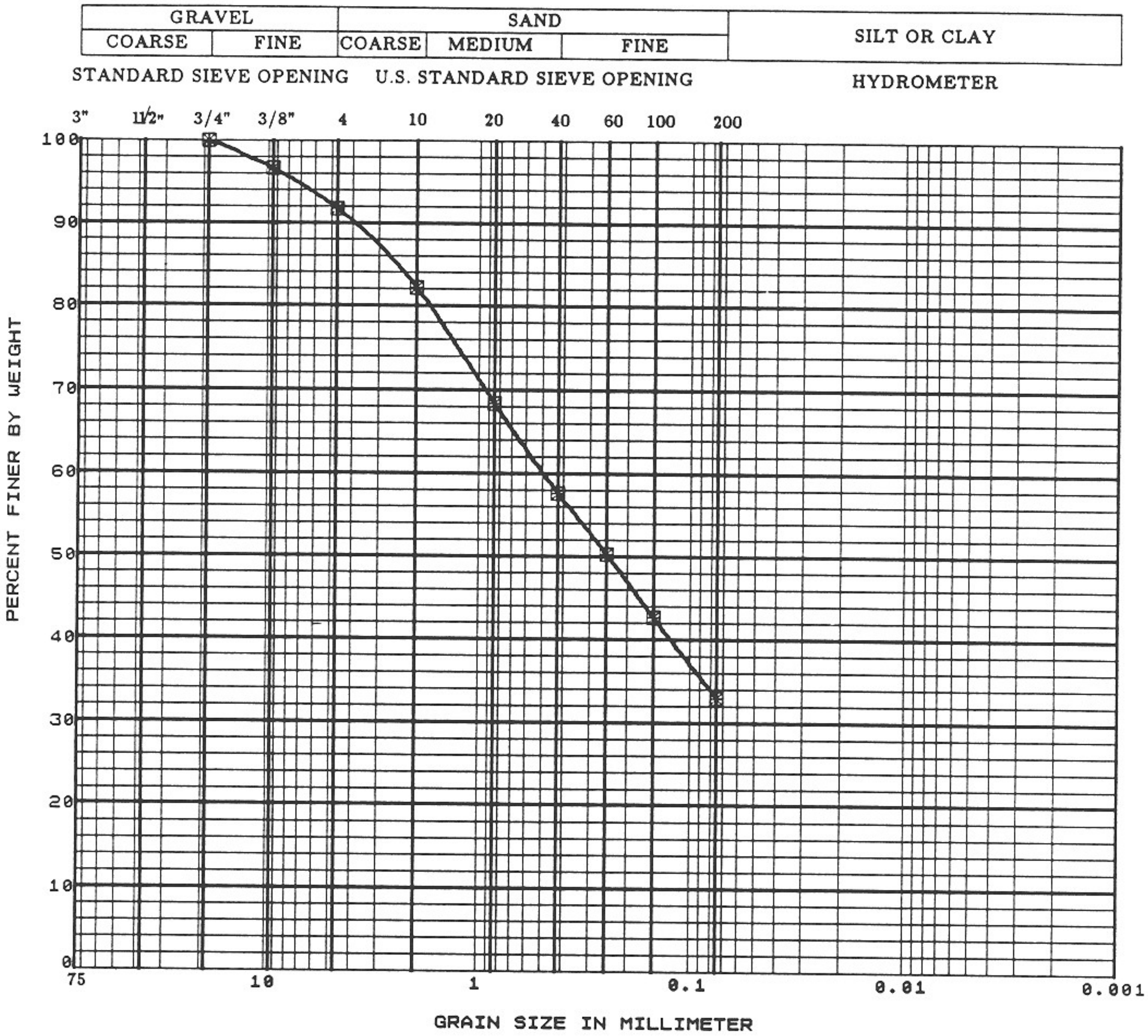
FIGURE B- 47



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
☒	LPE-17	S-1	5.00	SPT	SM			

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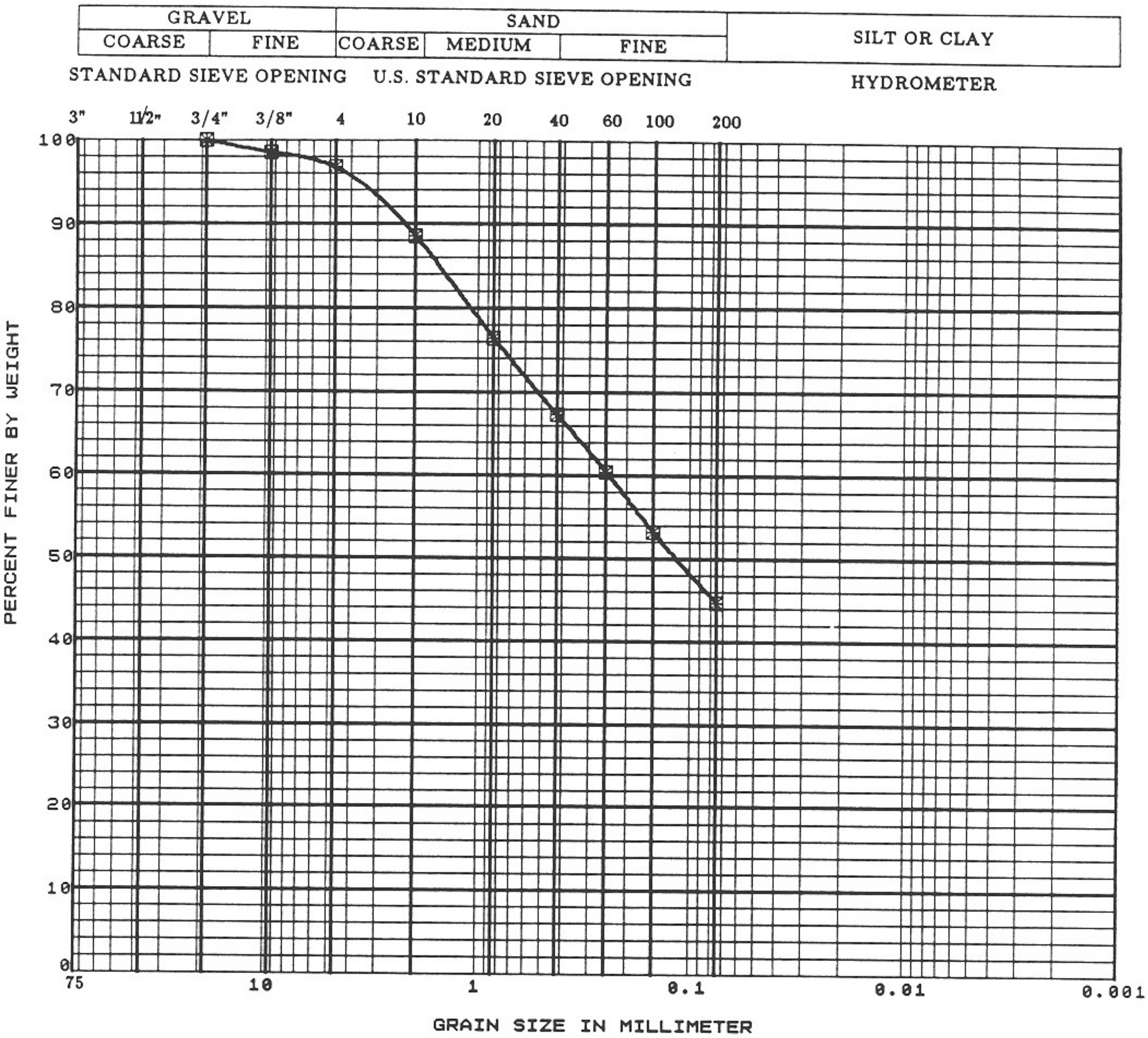
FIGURE B-48



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	LPE-17	S-3	15.00	SPT	SC			

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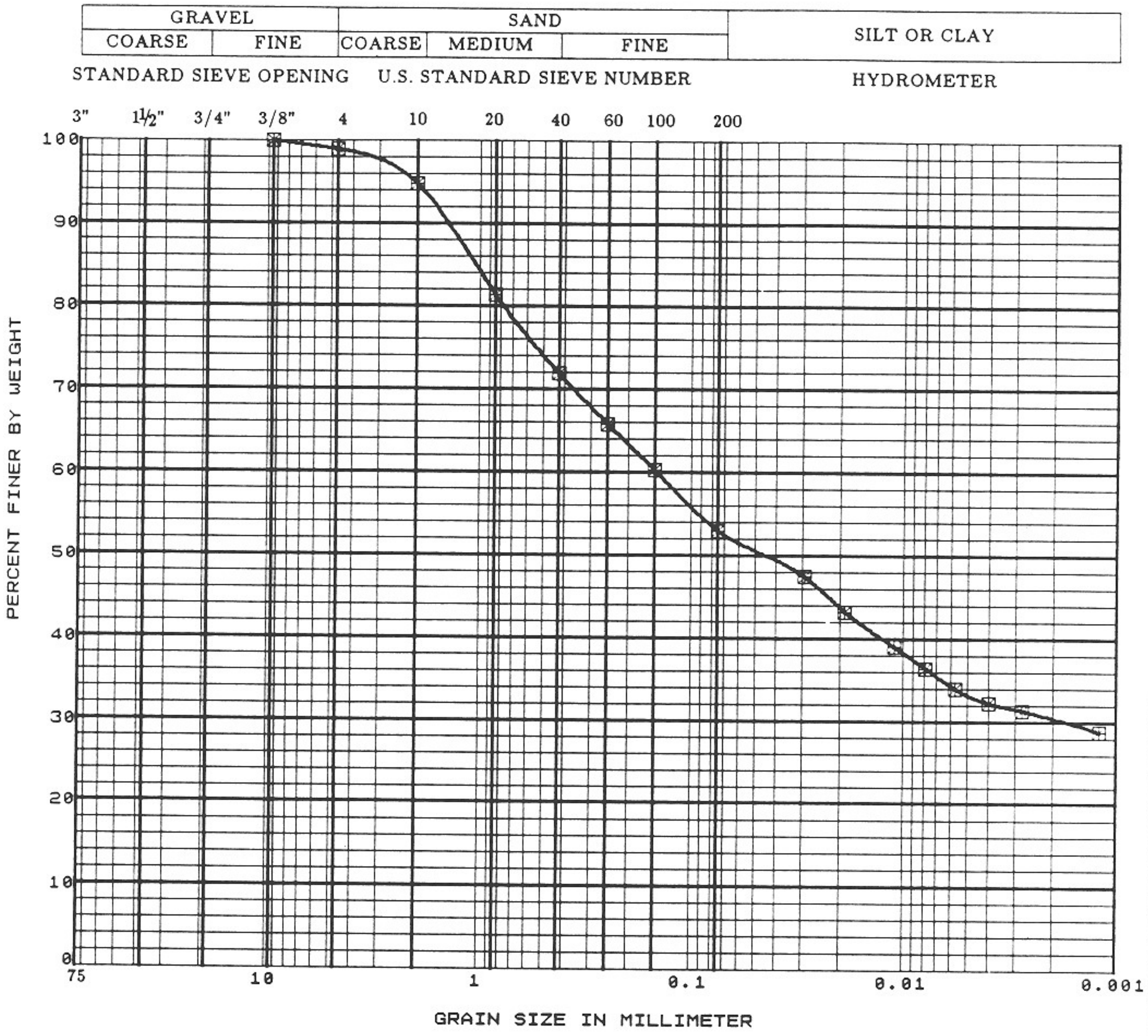
FIGURE B- 49



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
☒	LPE-17	S-5	25.00	SPT	CL	47	18	29

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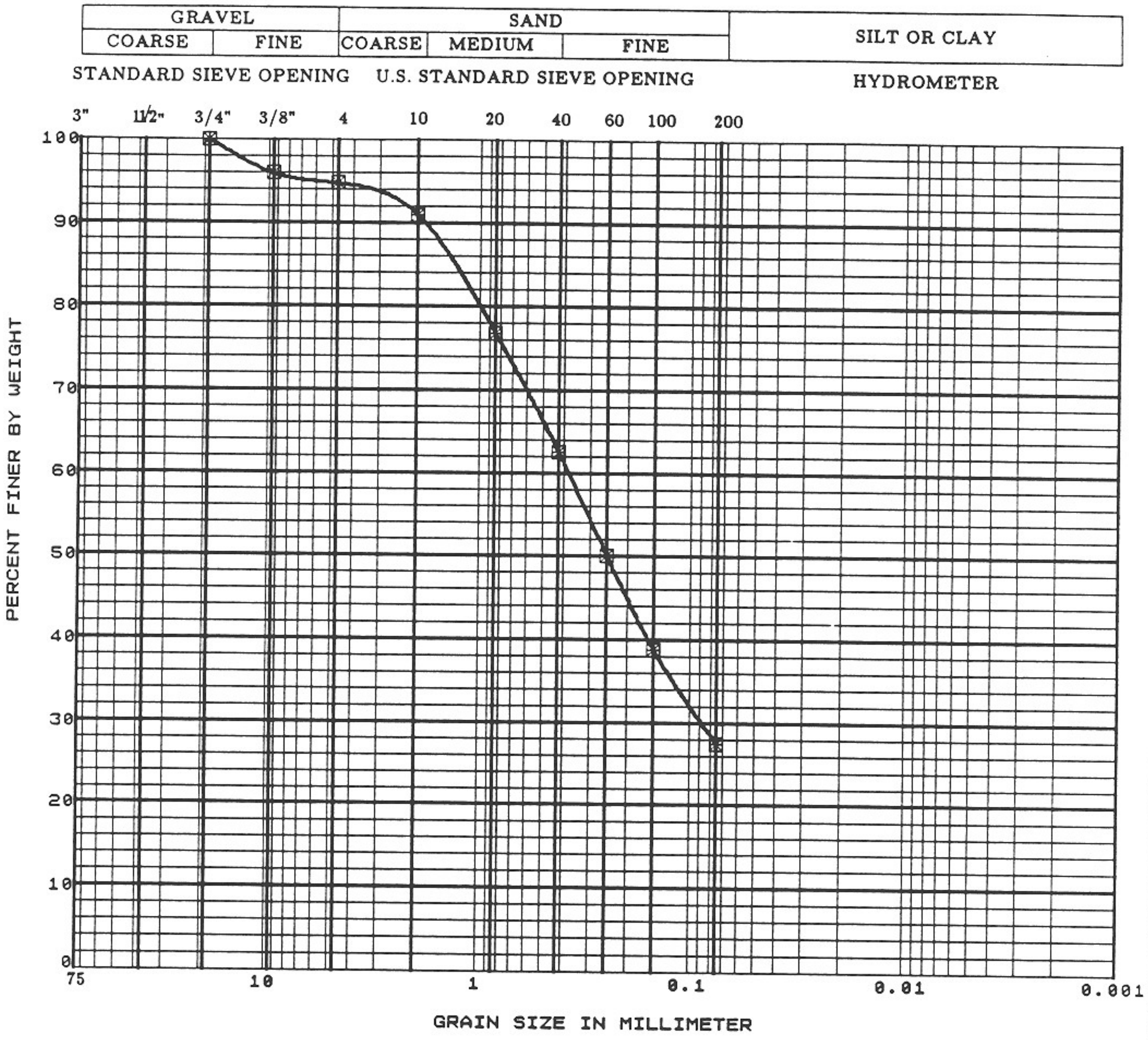
FIGURE B- 50



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	LPE-17	D-8	40.00	DRIVE	SM			

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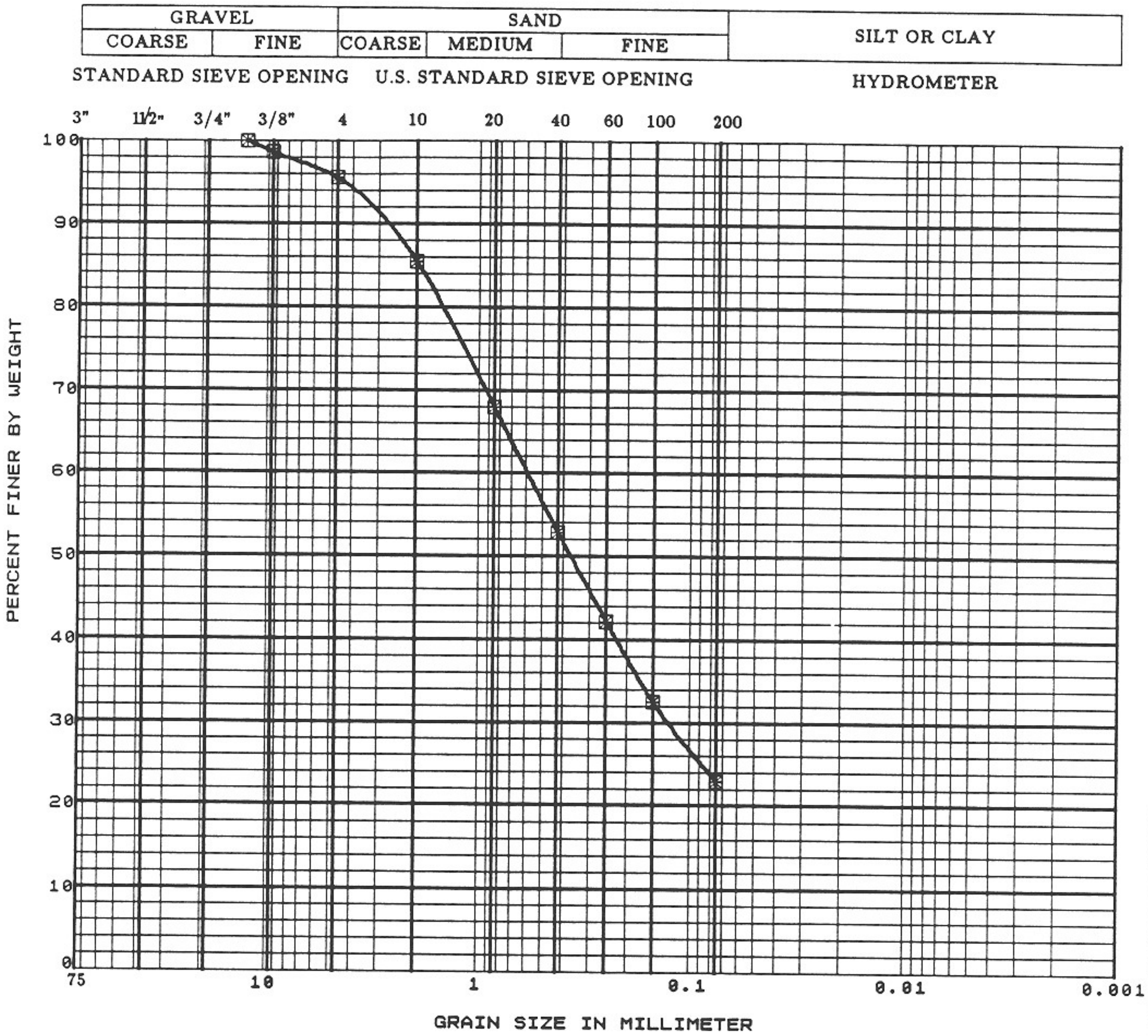
FIGURE B-51



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
☒	LPE-17	D - 10	50.00	DRIVE	SM			

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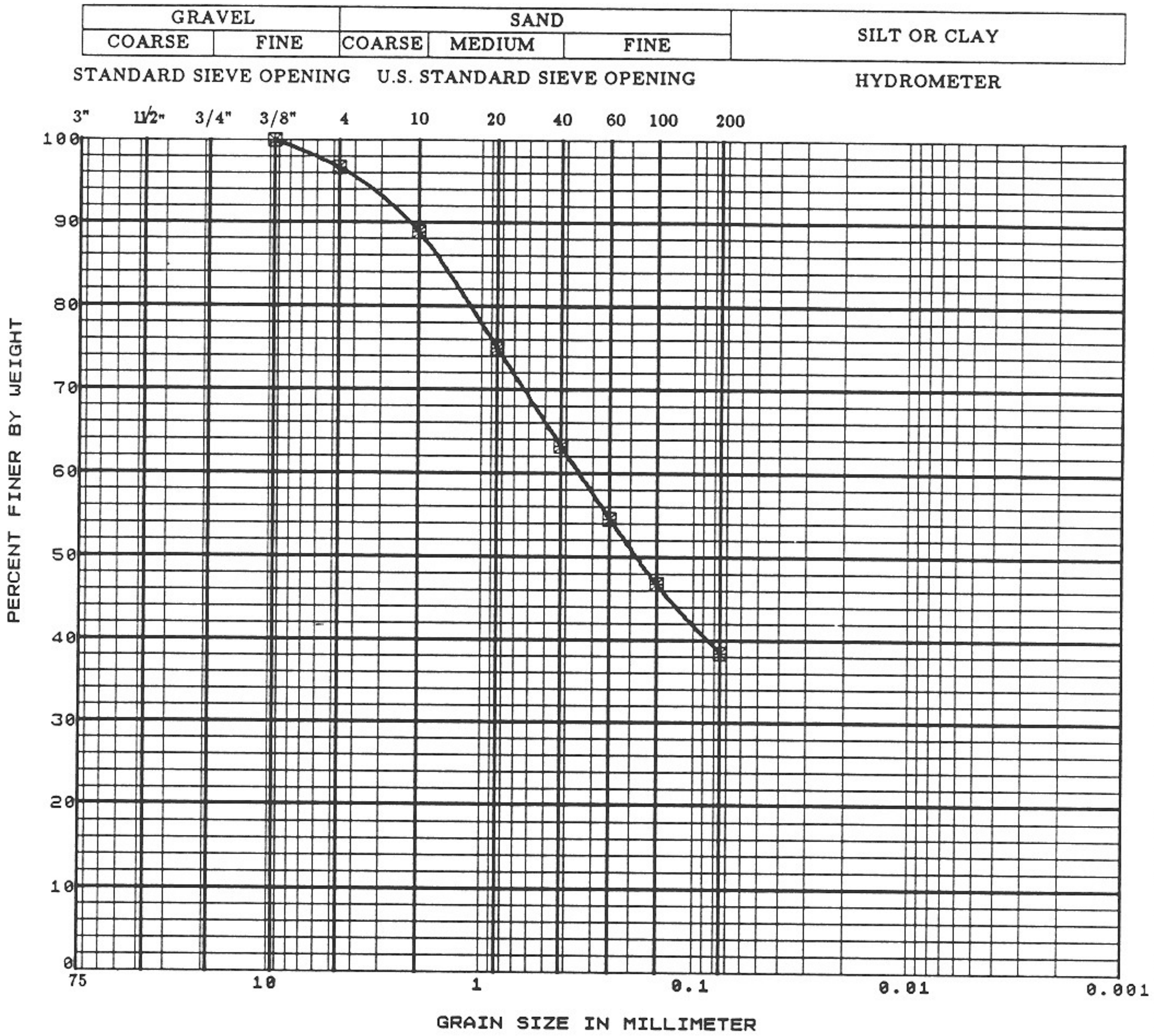
FIGURE B- 52



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	LPE-17	S - 11	55.00	SPT	SM			

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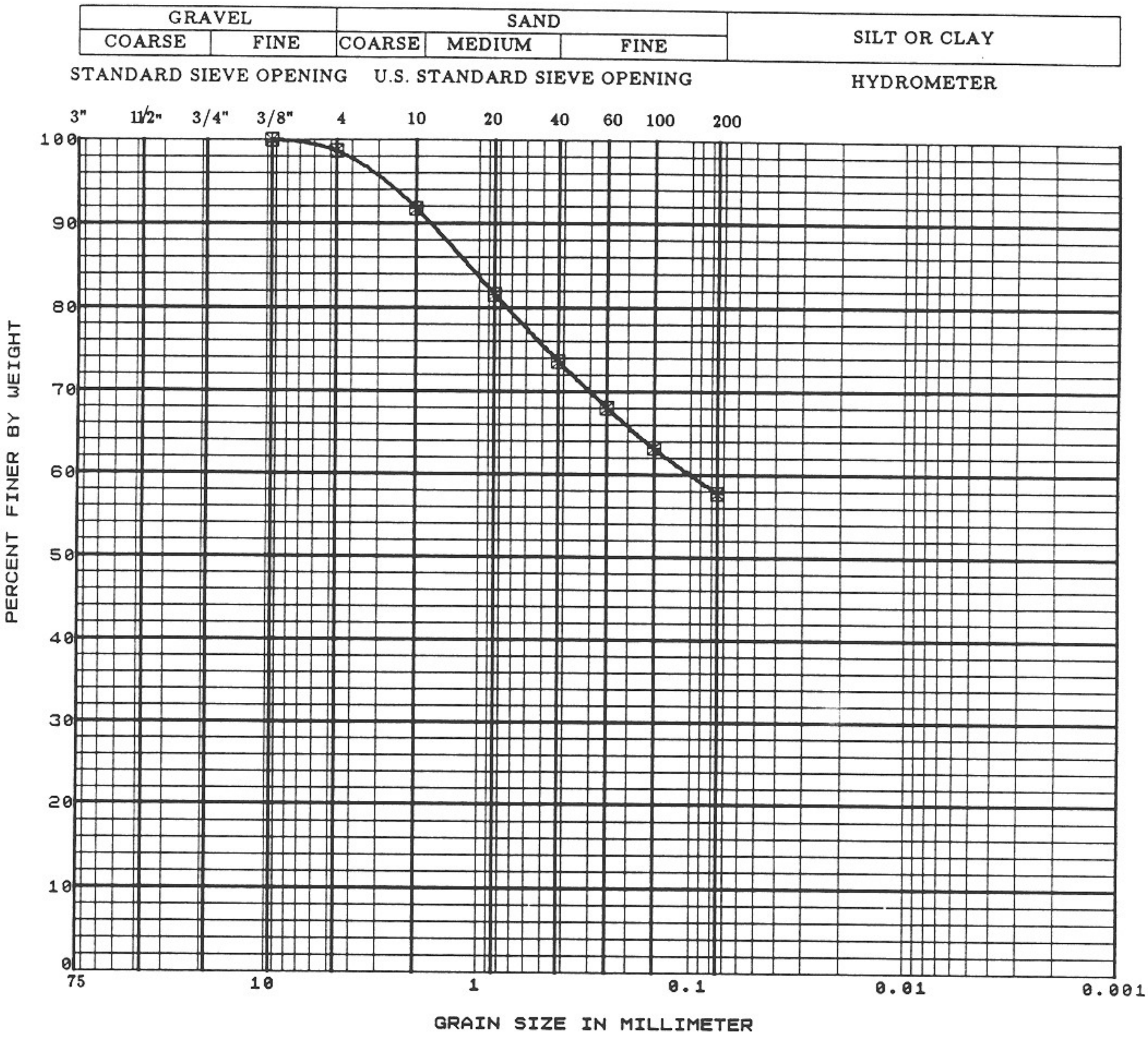
FIGURE B- 53



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
☒	LPE-17	D - 12	60.00	DRIVE	CL			

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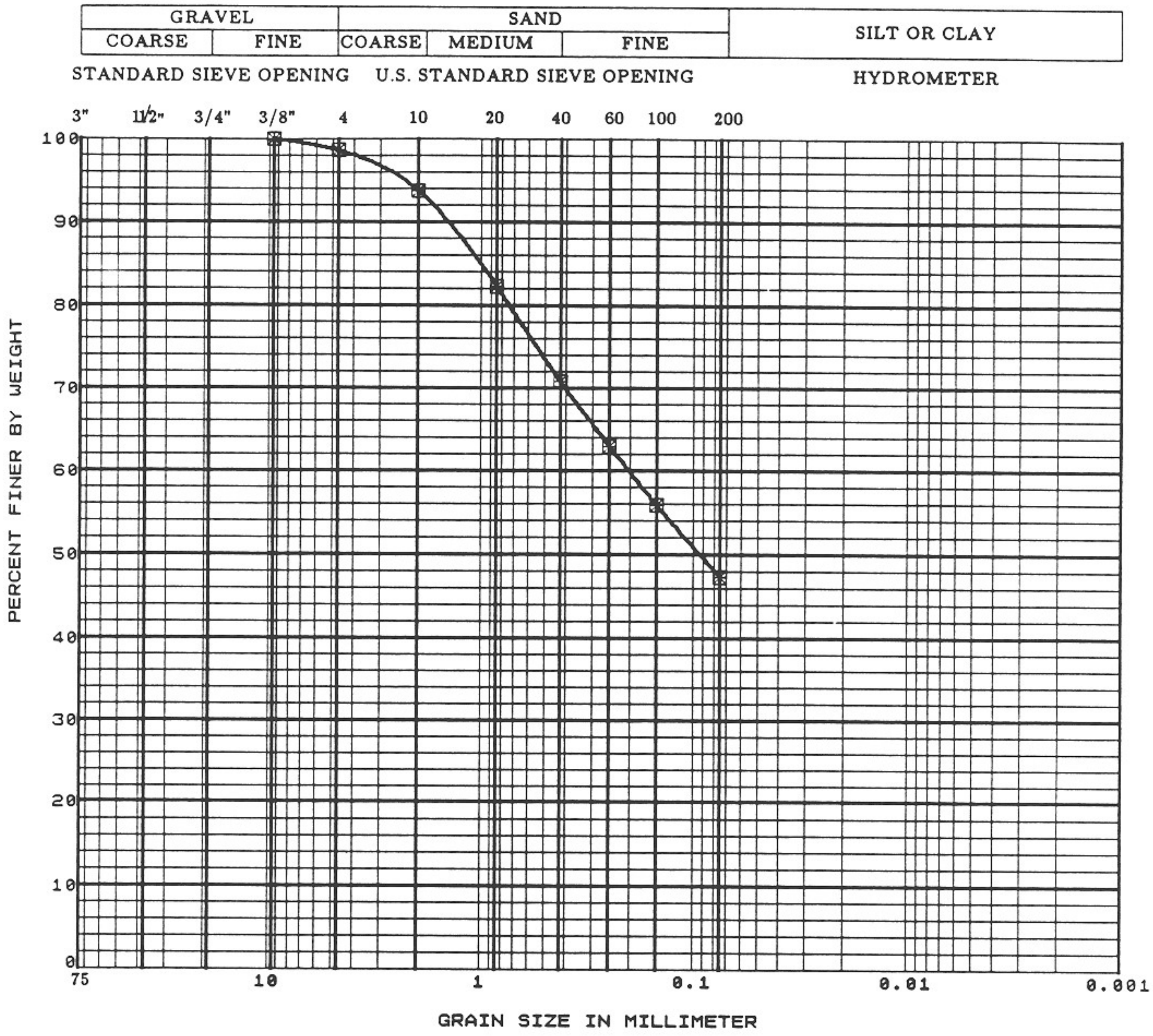
FIGURE B- 54



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
☒	LPE-17	D - 14	70.00	DRIVE	SM			

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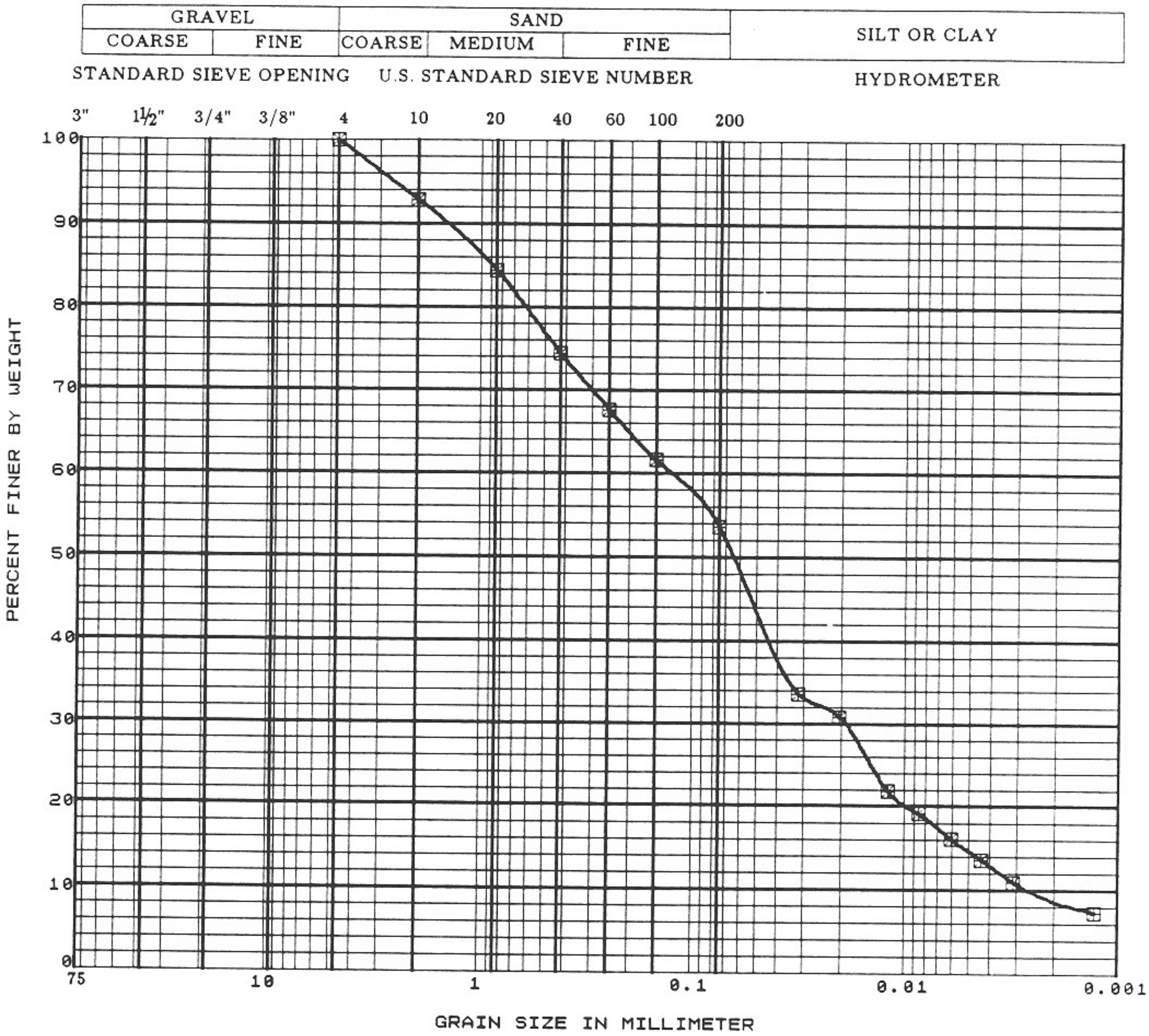
FIGURE B- 55



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⧆	LPE-19	D-5	25.00	DRIVE	CL	31	18	13

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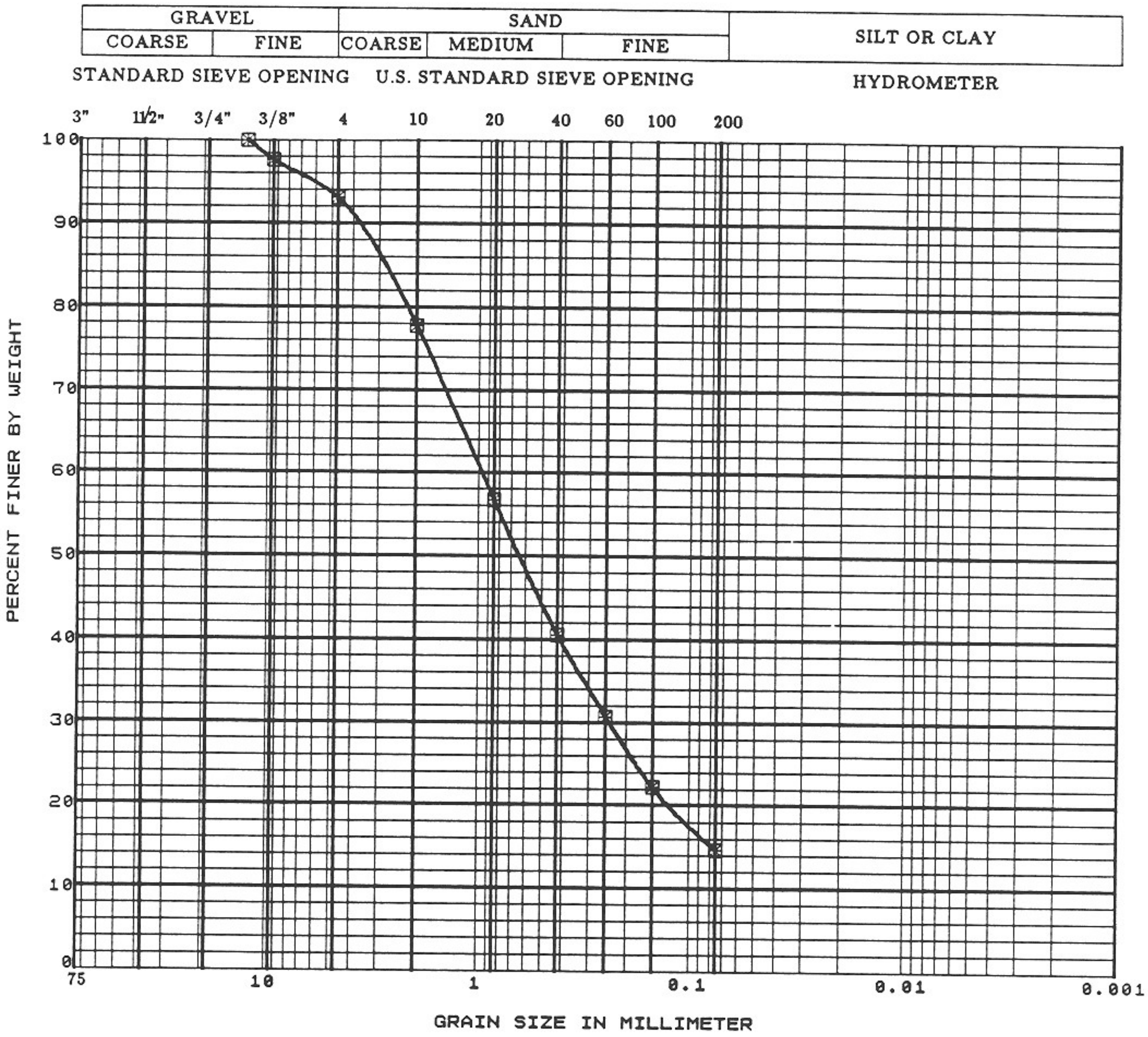
FIGURE B-56



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	LPE-19	P - 11	55.00	PITCHER	SC			

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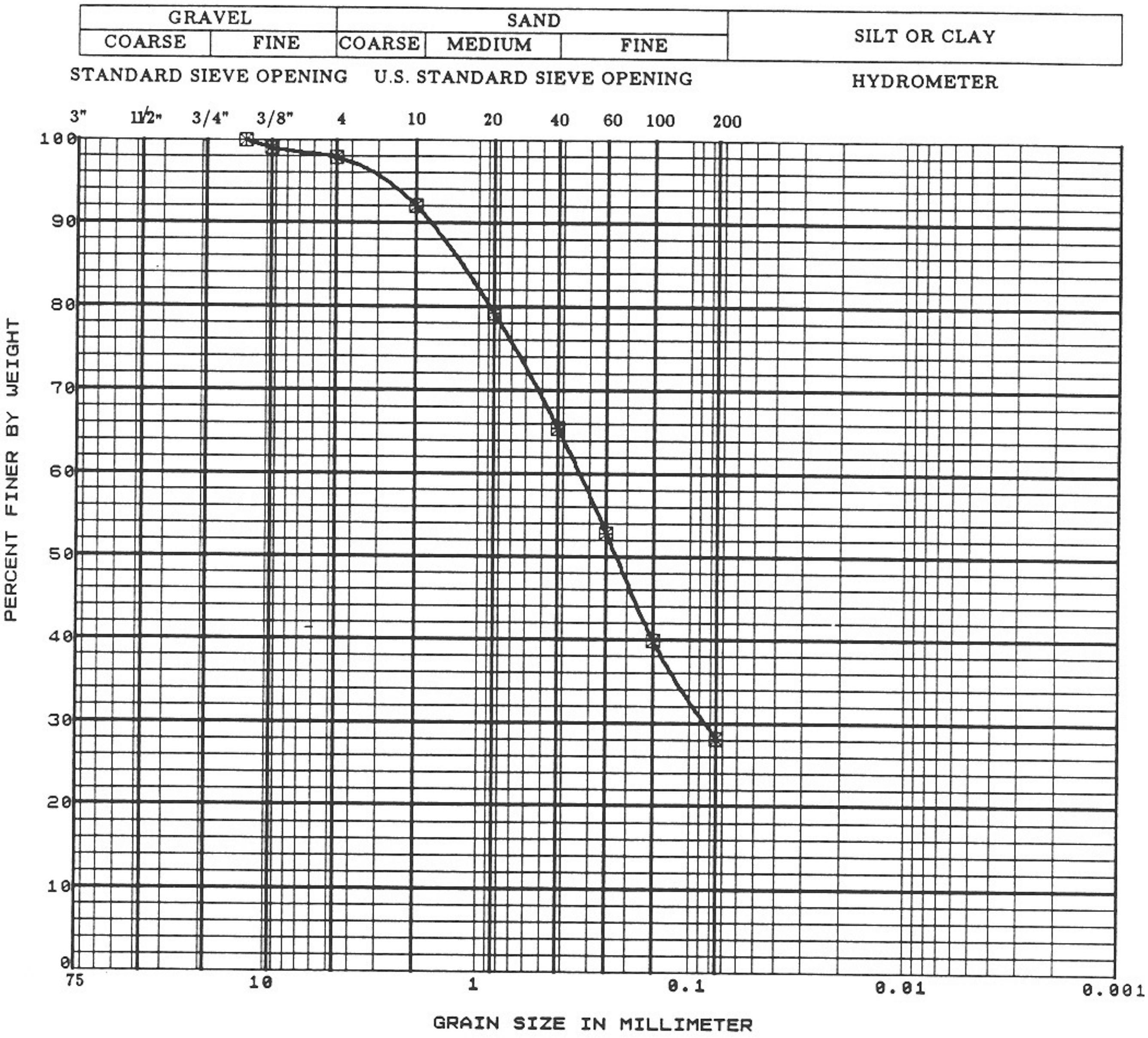
FIGURE B- 57



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	LPE-19	P - 13	65.00	PITCHER	SC			

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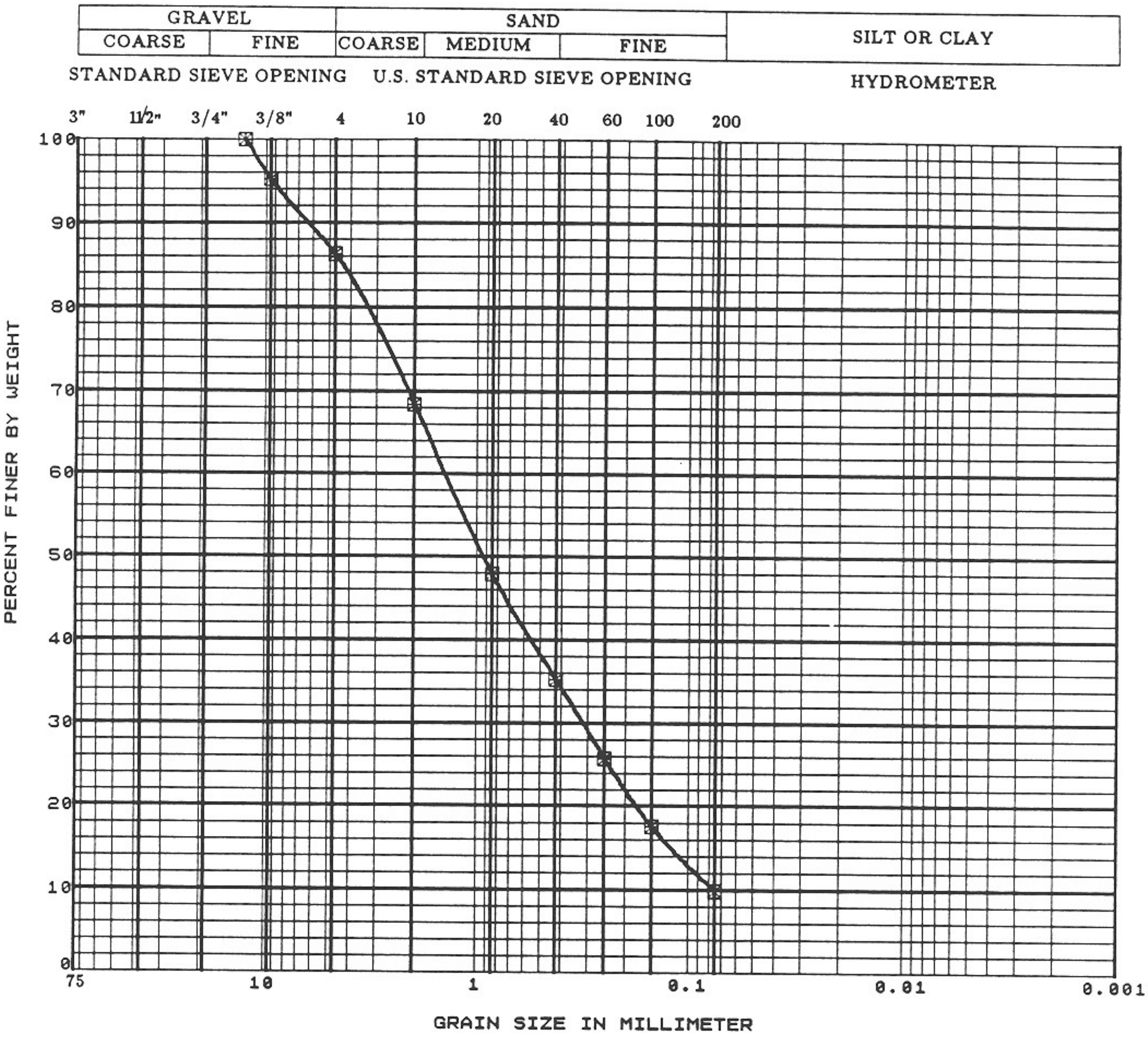
FIGURE B- 58



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	LPE-19	P - 15	75.00	PITCHER	SP-SM			

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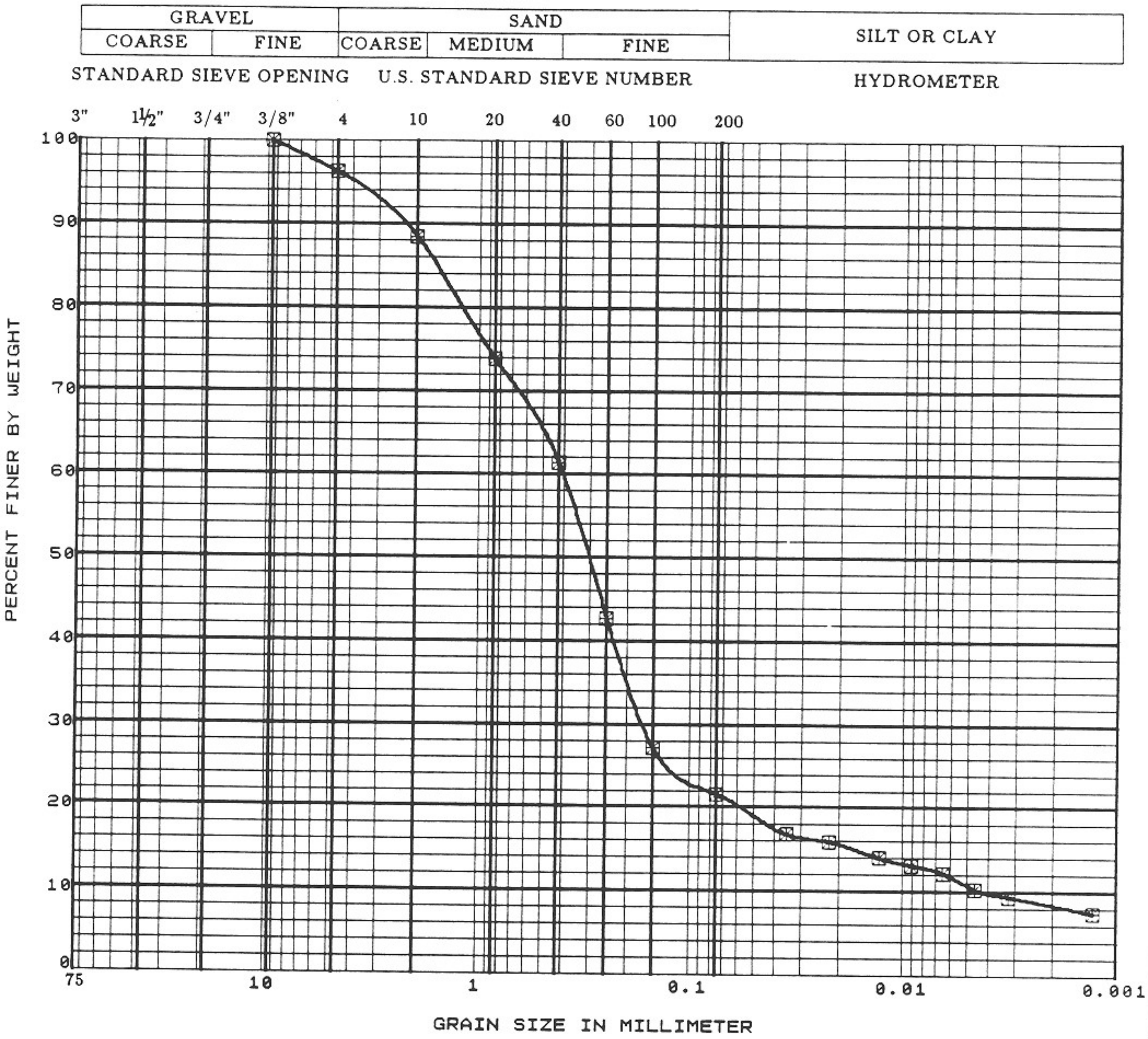
FIGURE B- 59



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
☒	LPE-21	D-5	25.00	DRIVE	SM			

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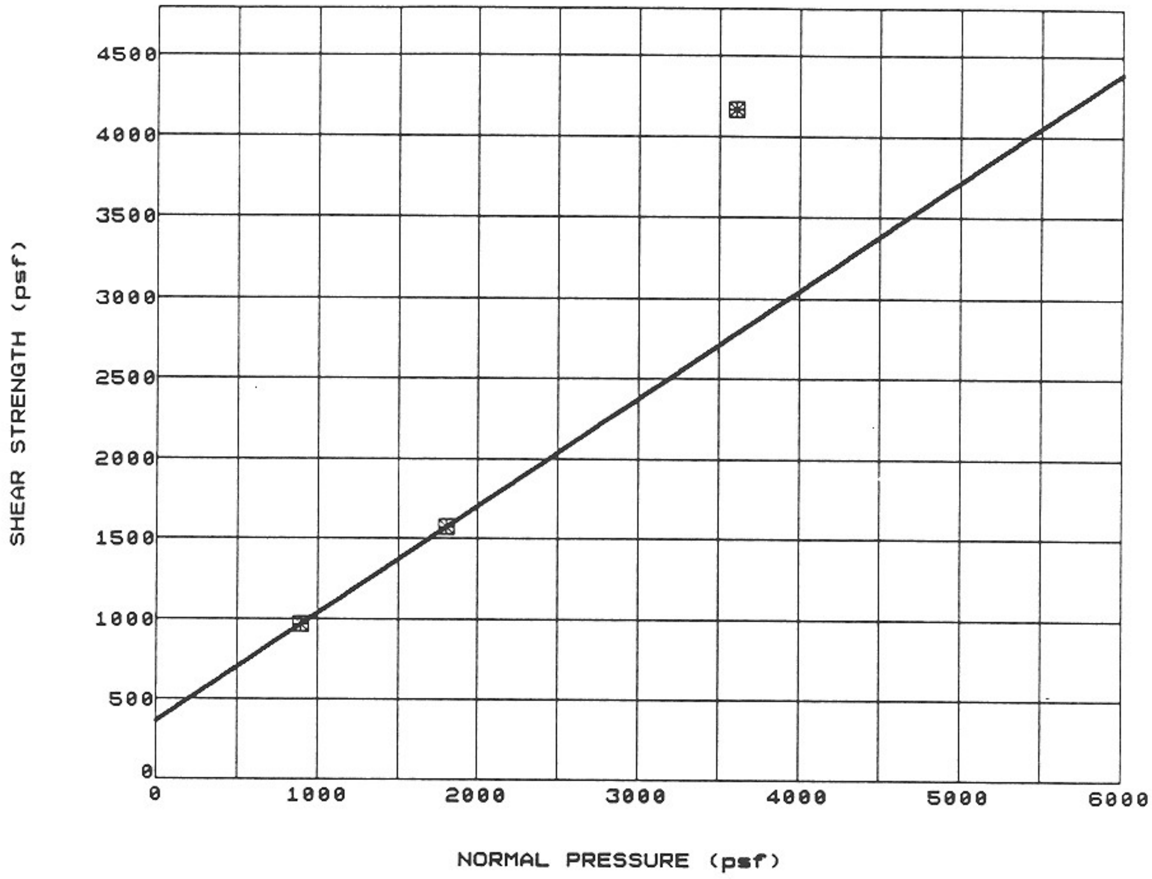
FIGURE B- 60



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
⊠	LPE-1	D - 2	15.00	DRIVE	SP	360	34	

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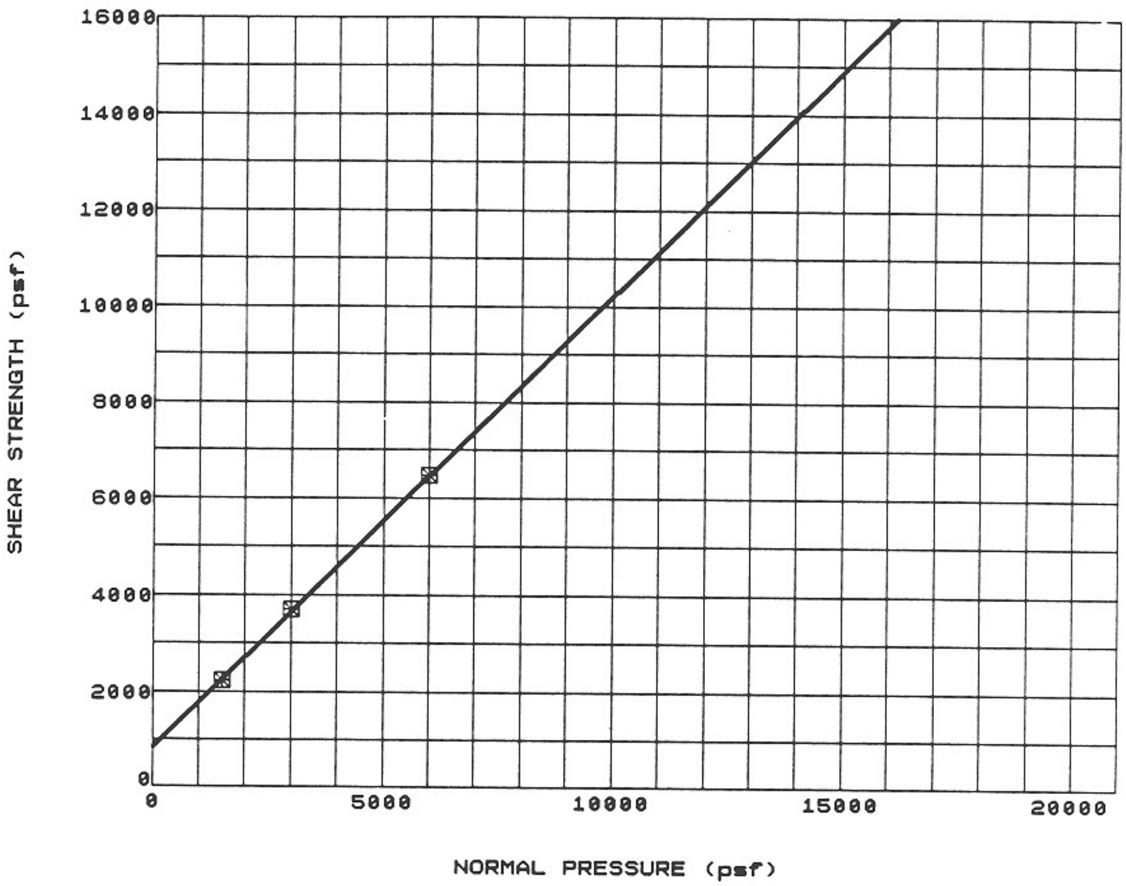
FIGURE B- 61



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
☒	LPE-1	D - 4	25.00	DRIVE	SP-SM	850	43	

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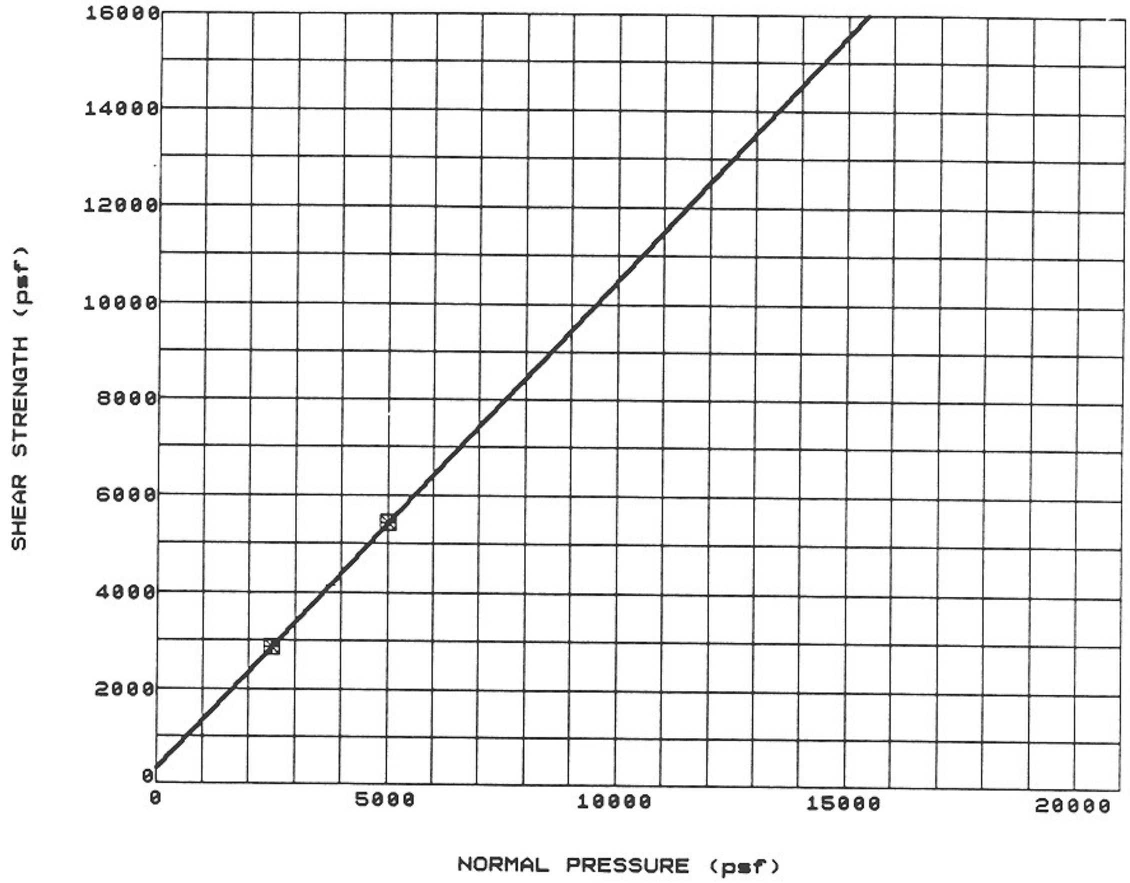
FIGURE B- 62



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
☒	LPE-1	D - 8	45.00	DRIVE		330	46	

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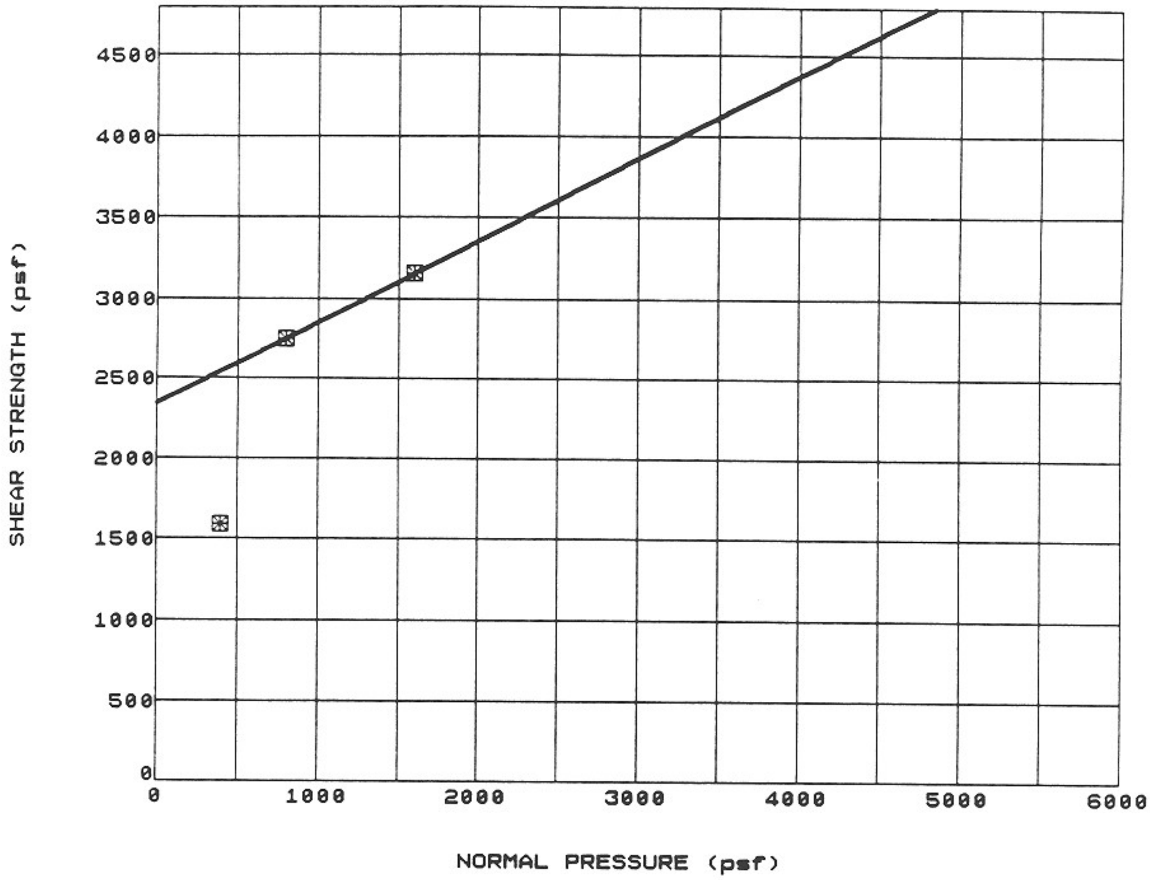
FIGURE B- 63



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
☒	LPE-2	D - 1	6.00	DRIVE	ML	2340	27	

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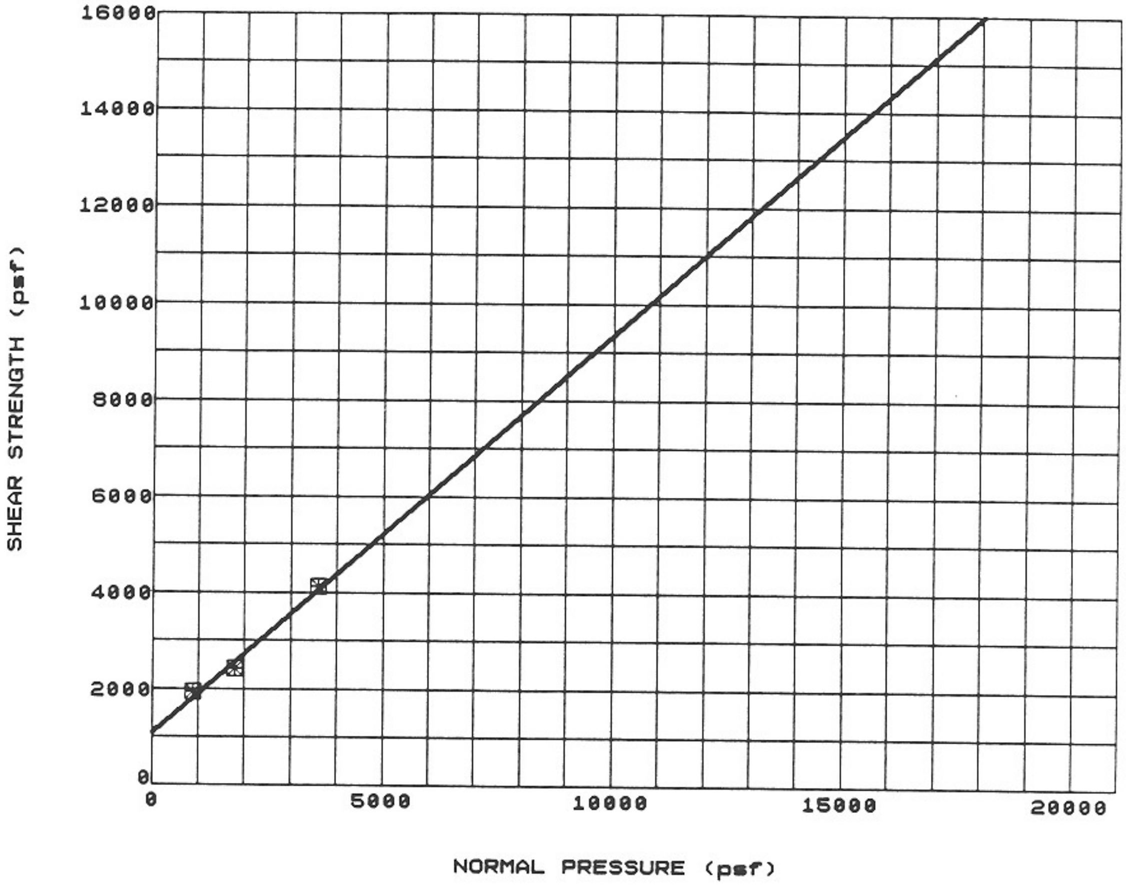
FIGURE B- 64



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
☒	LPE-2	D - 3	15.00	DRIVE	SP-SM	1100	40	

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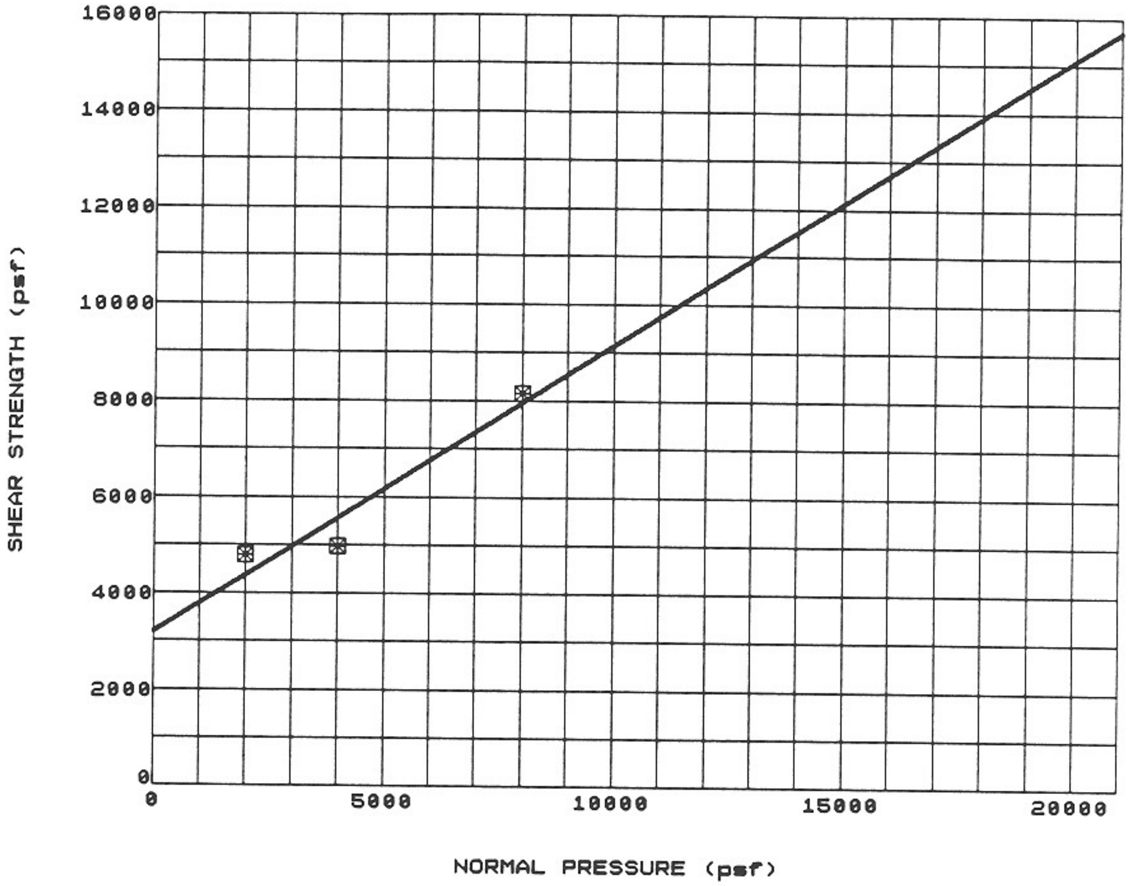
FIGURE B- 65



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
☒	LPE-2	D - 7	35.00	DRIVE		3200	31	

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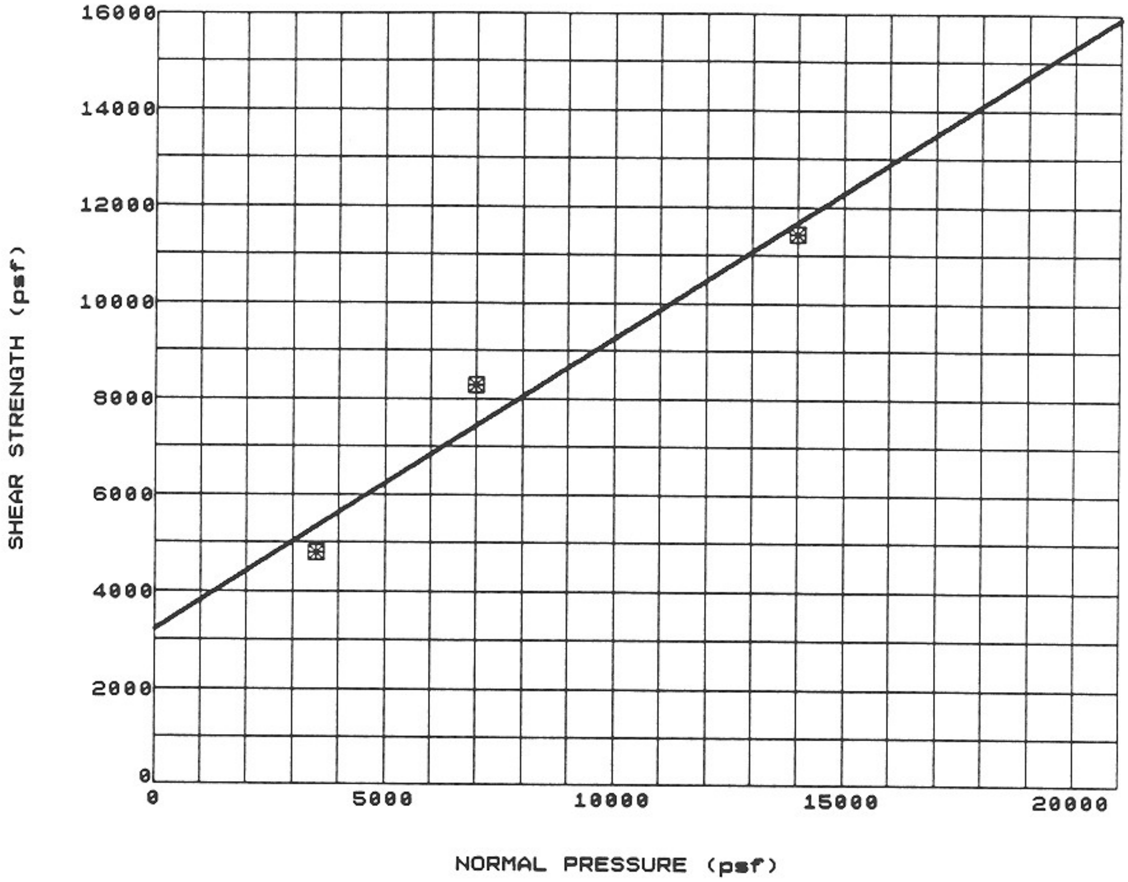
FIGURE B- 66



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
☒	LPE-2	D - 10	45.00	DRIVE		3200	31	

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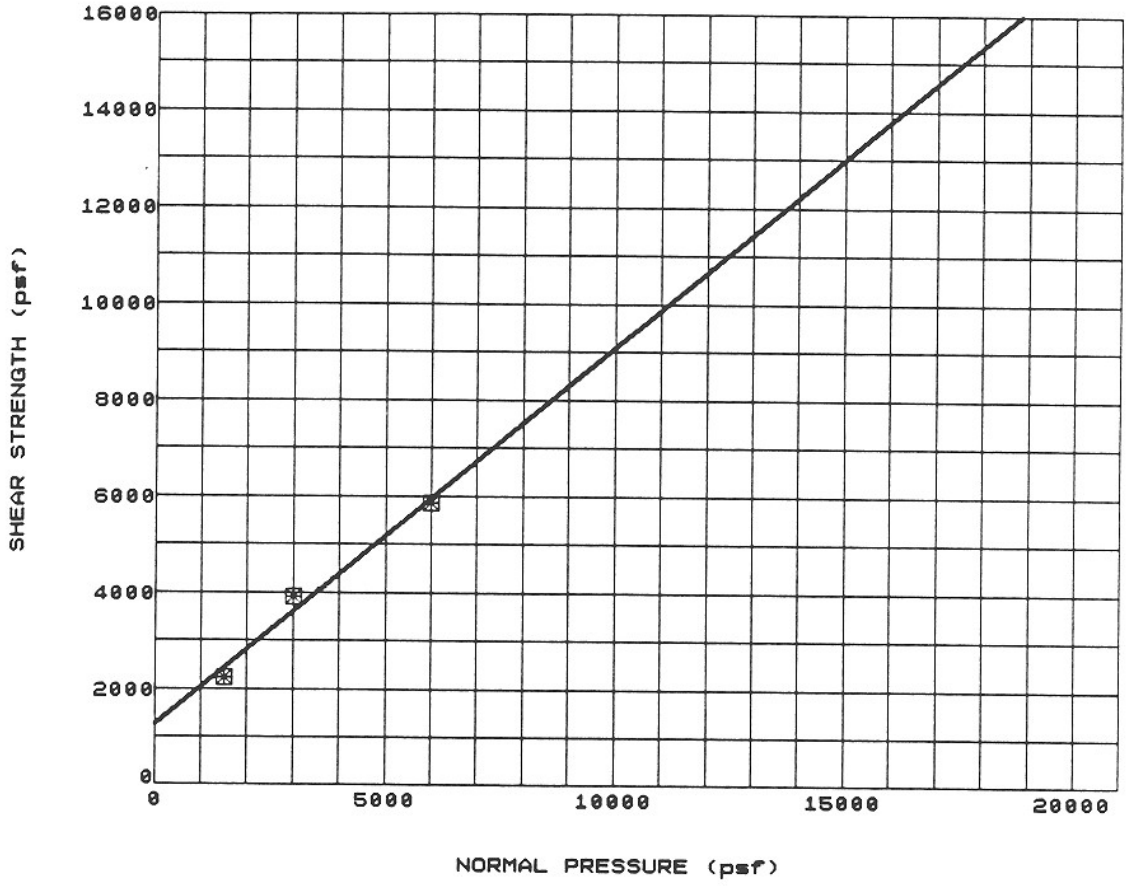
FIGURE B- 67



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
☒	LPE-4B	D - 5	26.00	DRIVE		1300	38	

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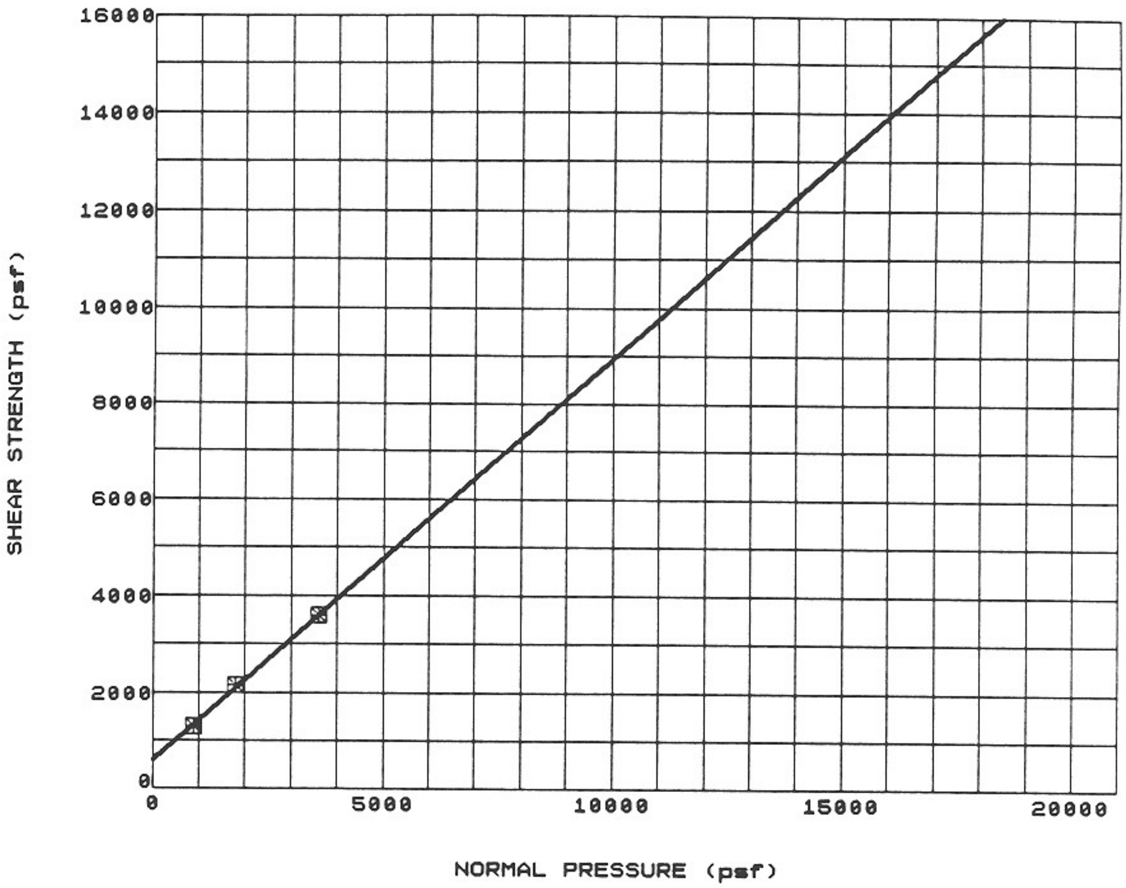
FIGURE B- 68



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
☒	LPE-6	D - 3	15.00	DRIVE	SM	700	40	

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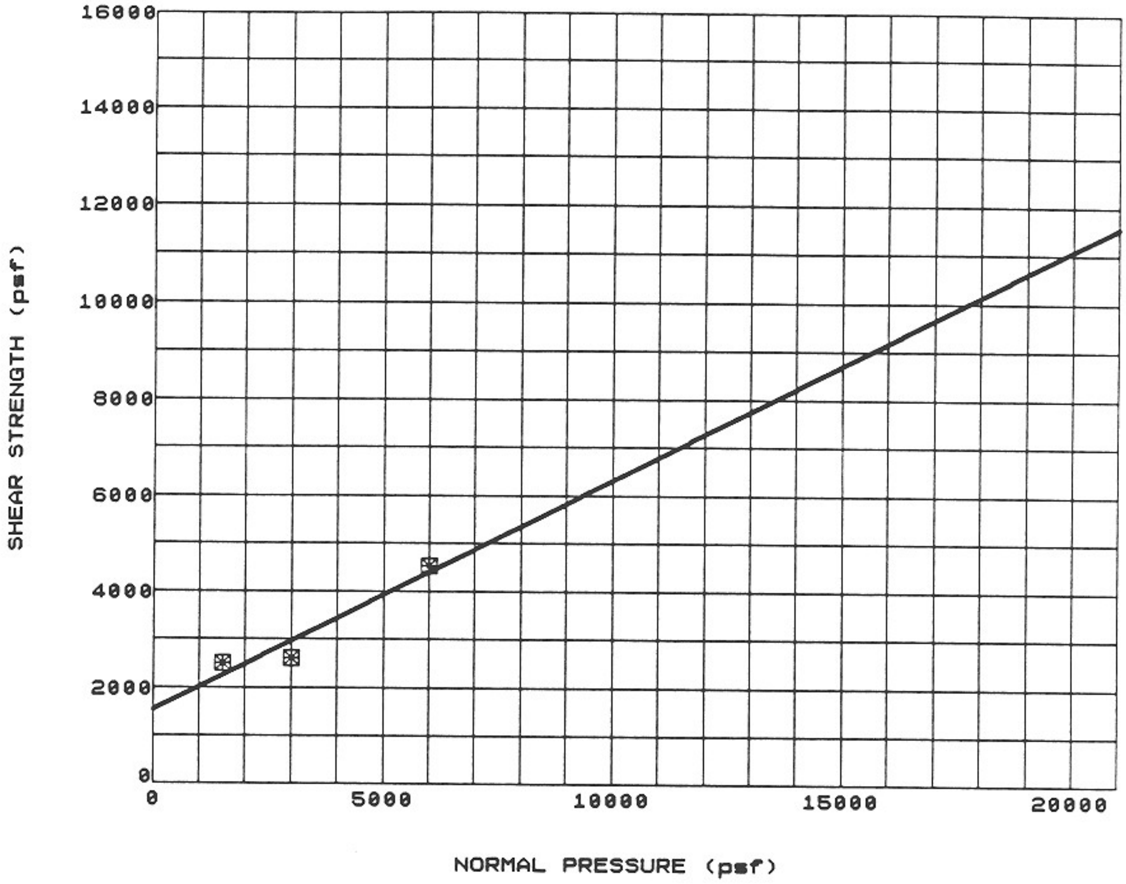
FIGURE B- 69



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
⊠	LPE-6	D - 5	25.00	DRIVE		1500	26	

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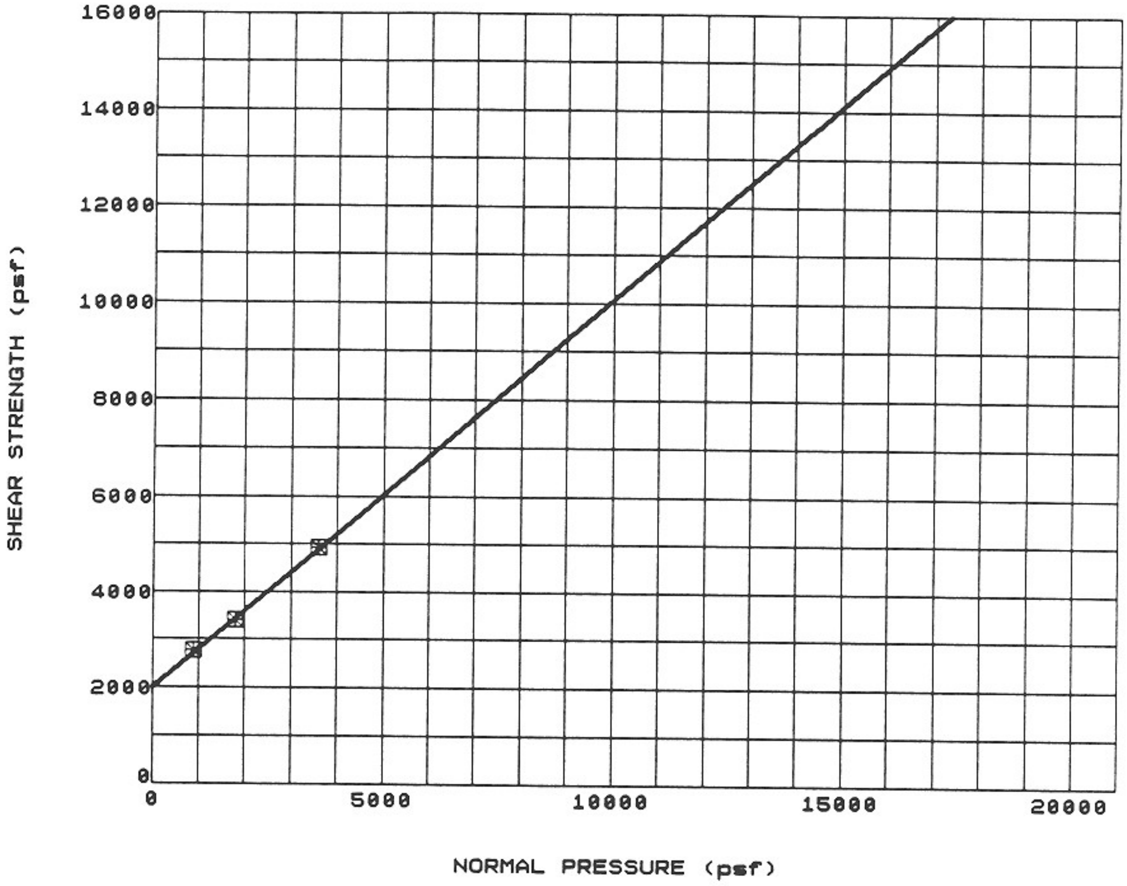
FIGURE B- 70



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
☒	LPE-7	D-3	15.00	DRIVE		2000	39	

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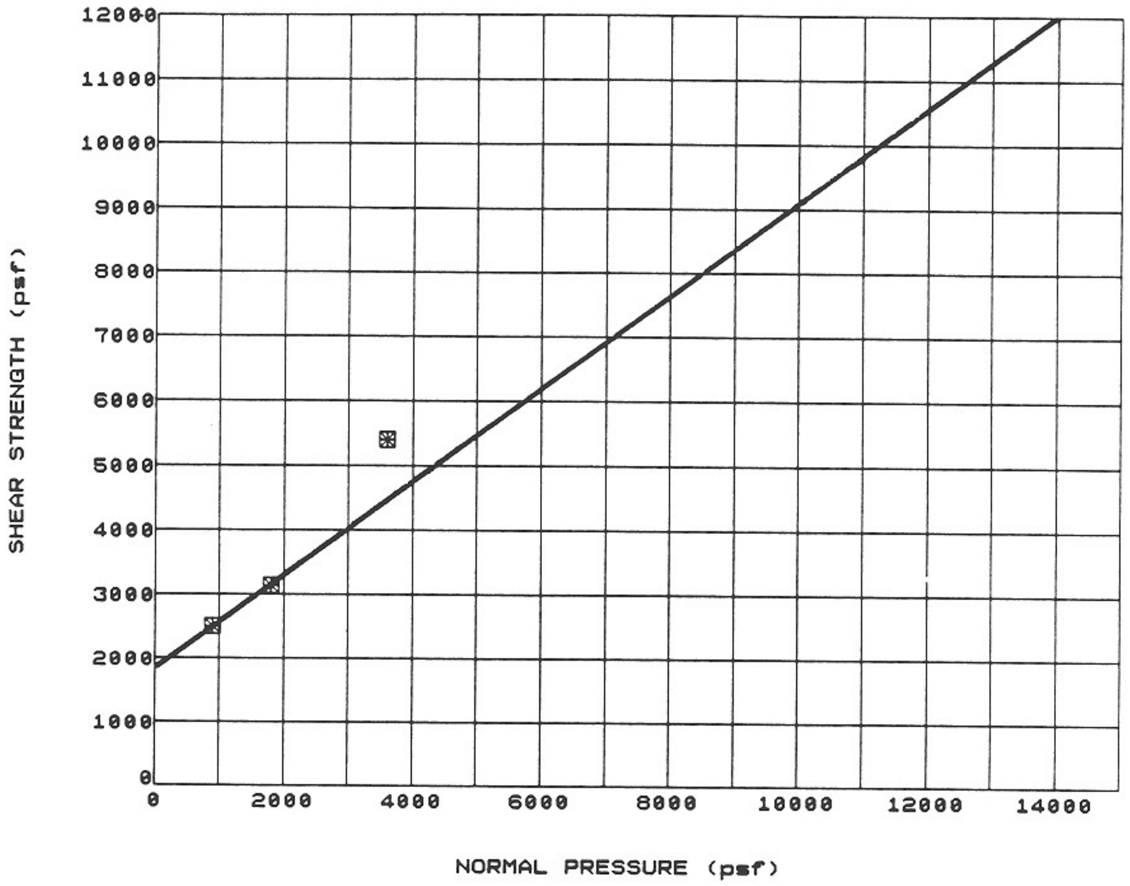
FIGURE B-71



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
☒	LPE-8	D - 2	15.00	DRIVE	CL	1830	36	

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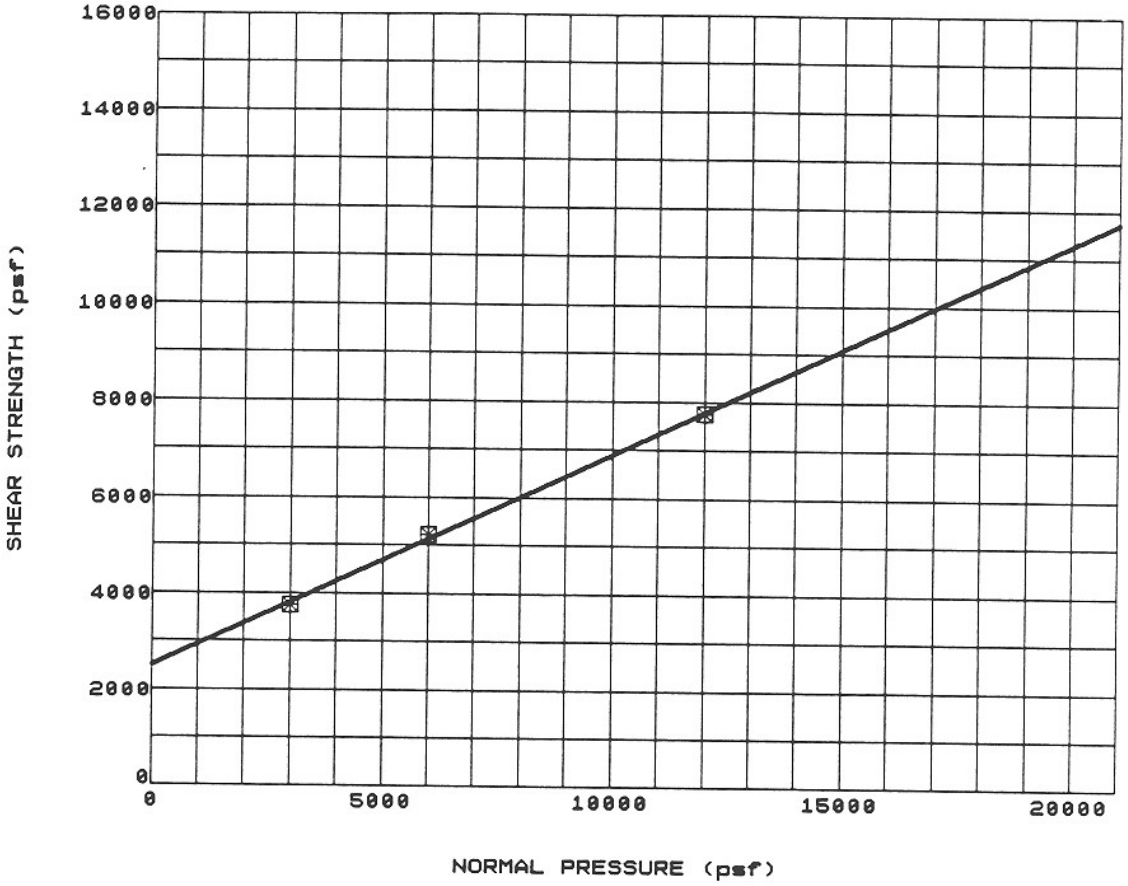
FIGURE B- 72



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
☒	LPE-8	D - 8	45.00	DRIVE		2500	24	

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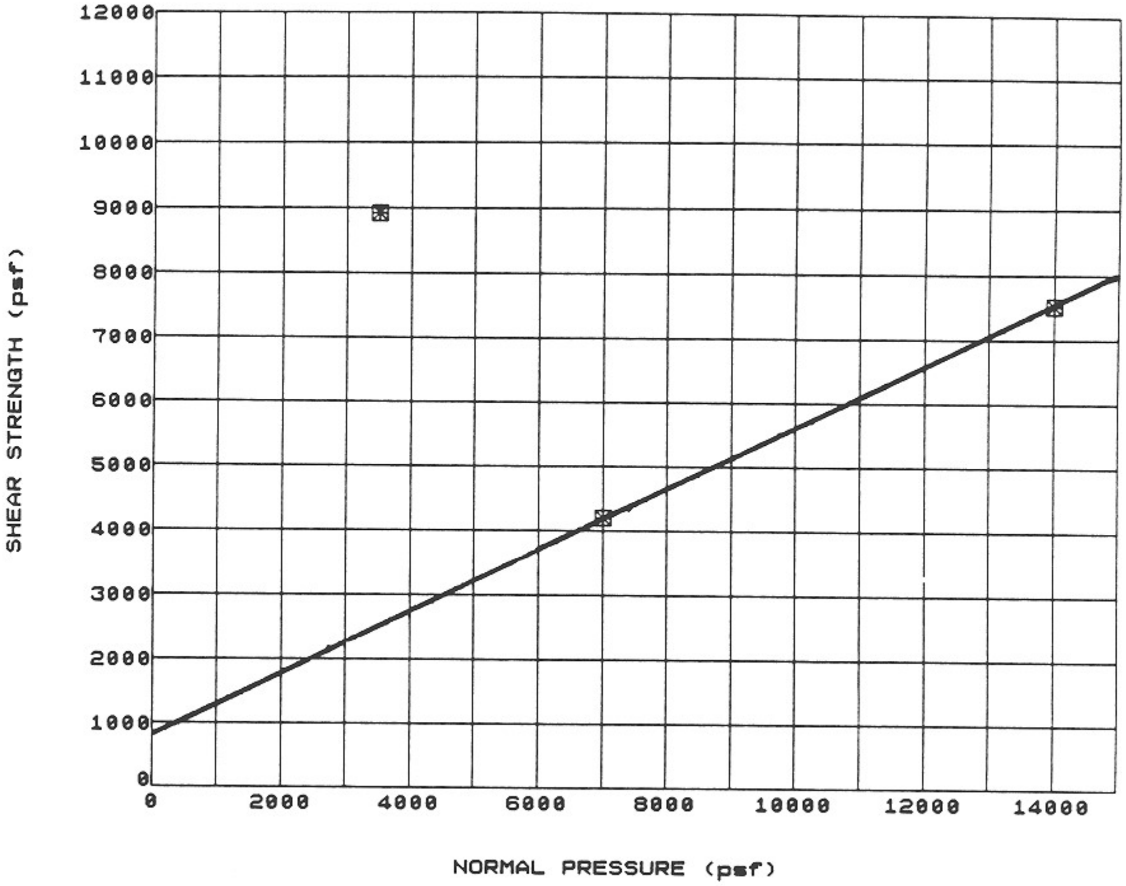

SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
☒	LPE-8	D - 10	55.00	DRIVE		890	25	

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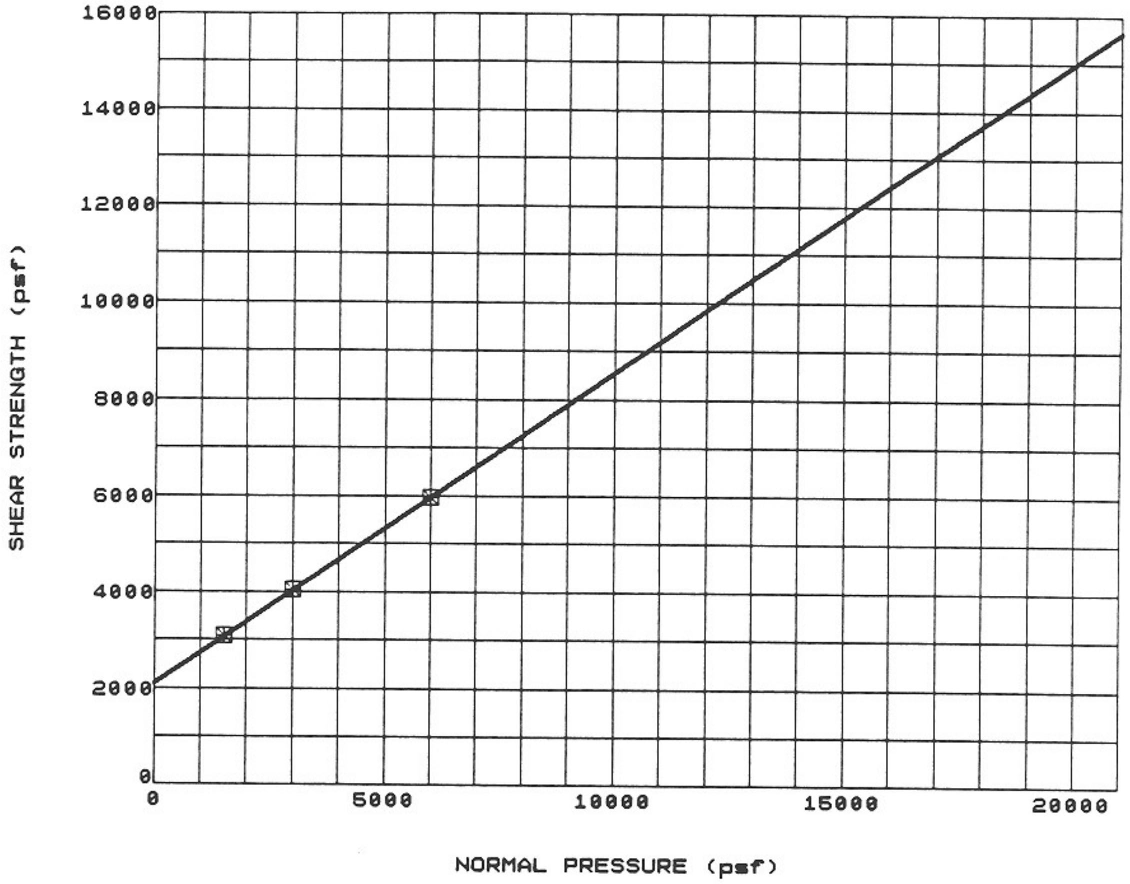
FIGURE B- 74



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
☒	LPE-9	D - 5	25.00	DRIVE	CL	2200	33	

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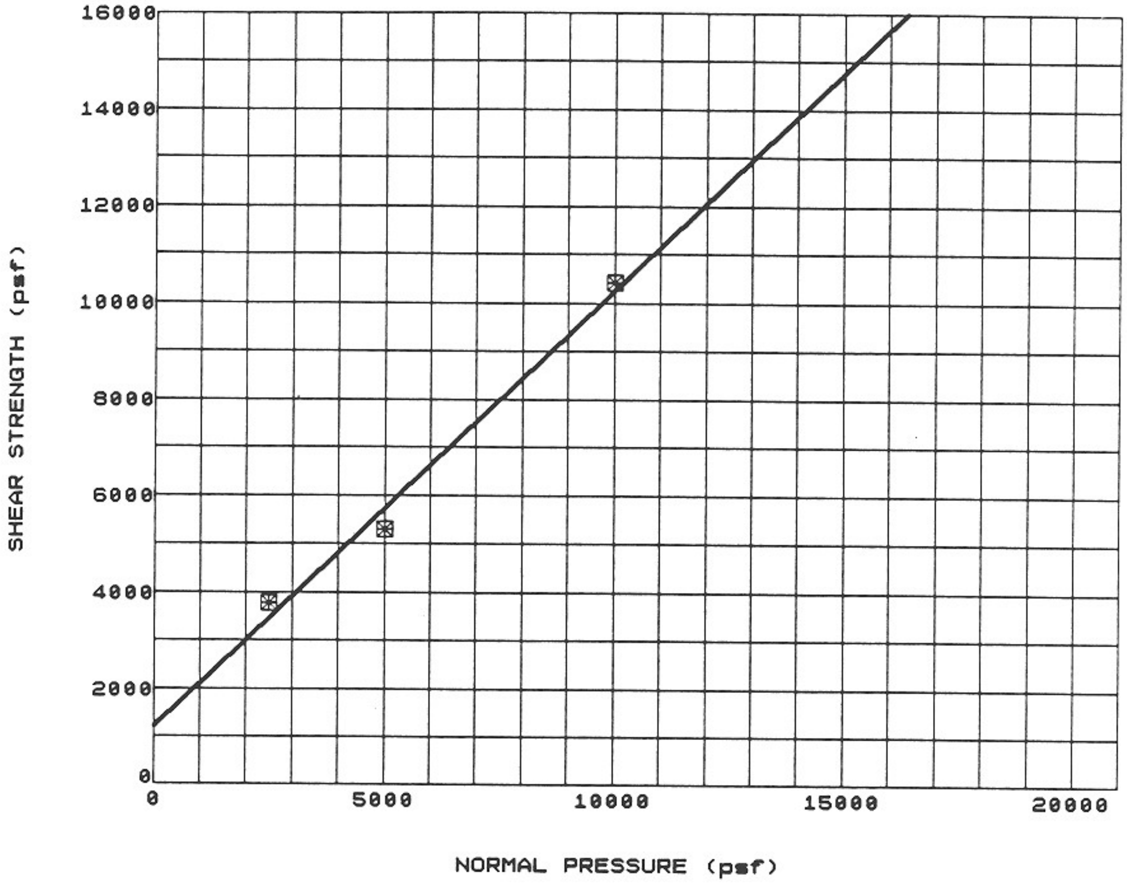
FIGURE B- 75



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
⊠	LPE-9	D - 9	45.00	DRIVE	SC/CL	1250	42	

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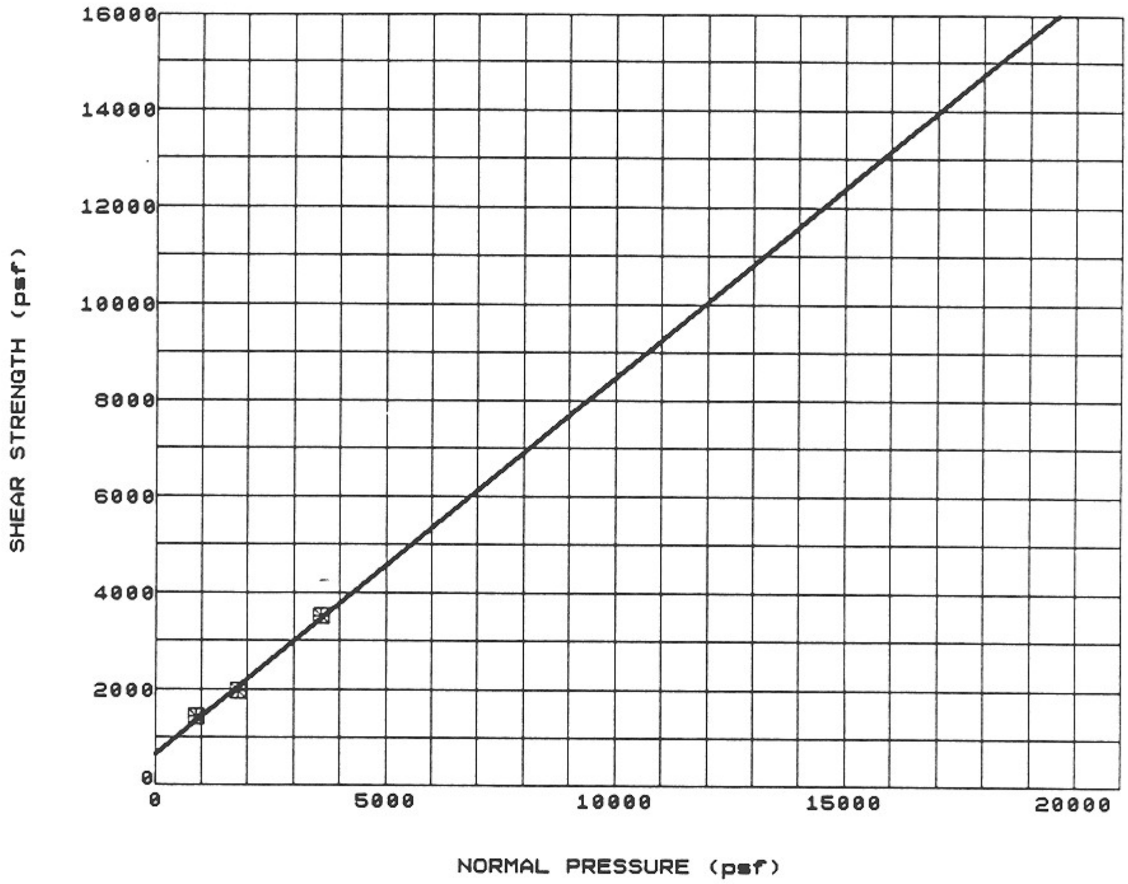
FIGURE B- 76



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
☒	LPE-10	D - 4	15.00	DRIVE	SM	700	38	

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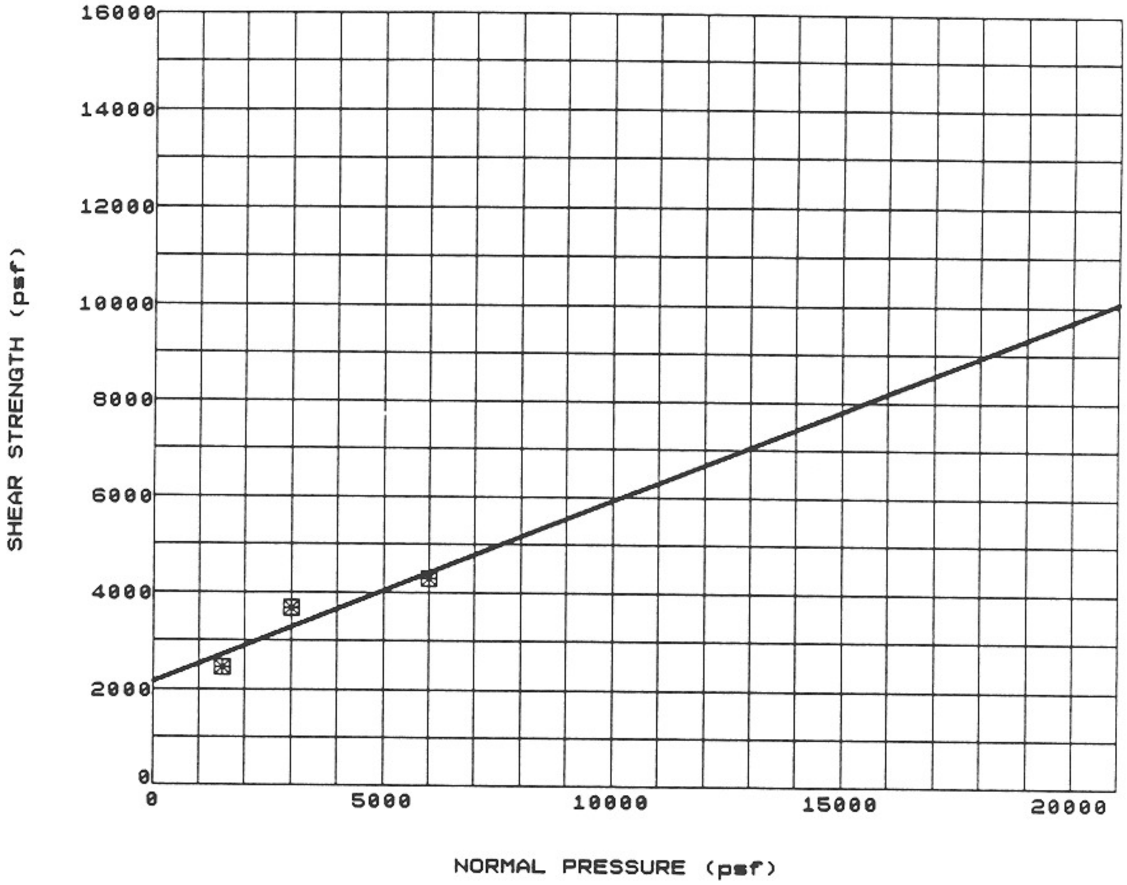
FIGURE B- 77



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
☒	LPE-10	D - 6	25.00	DRIVE	SC/CL	2200	21	

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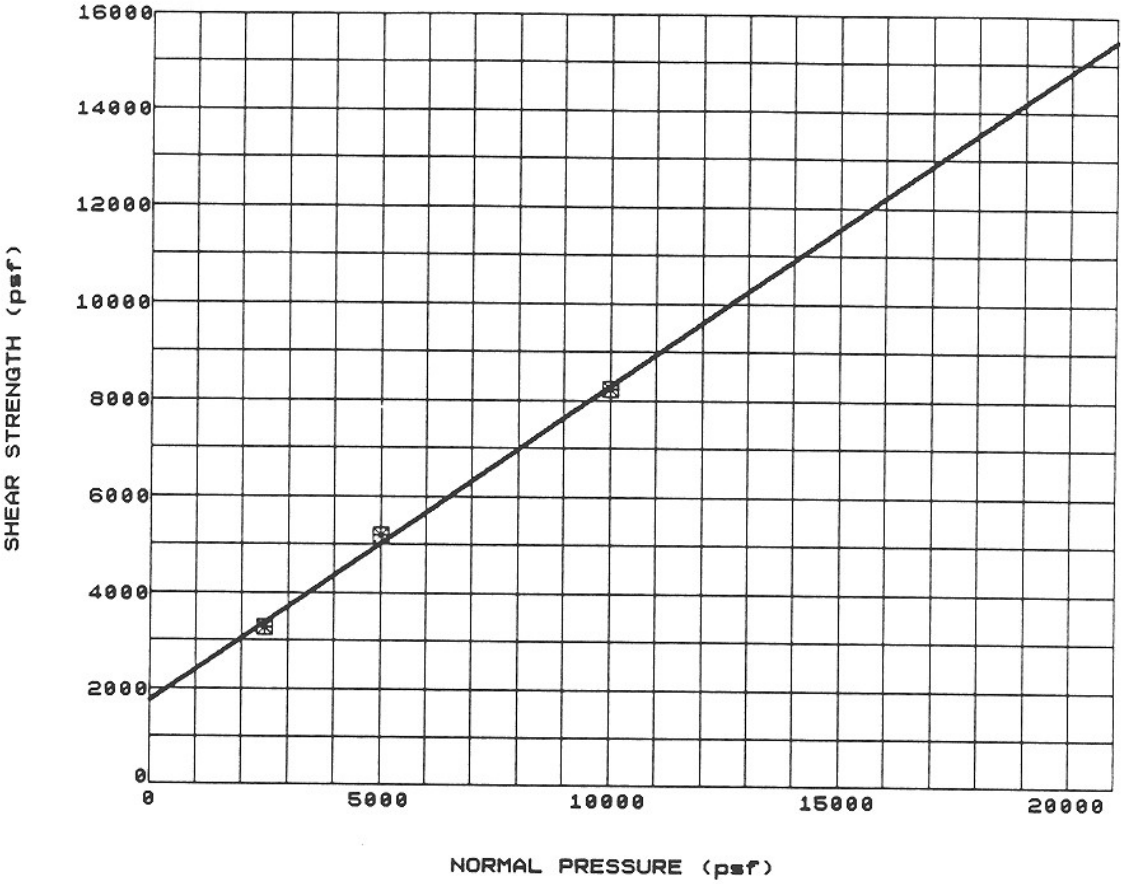
FIGURE B- 78



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
☒	LPE-10	D - 10	45.00	DRIVE	SC	1800	33	

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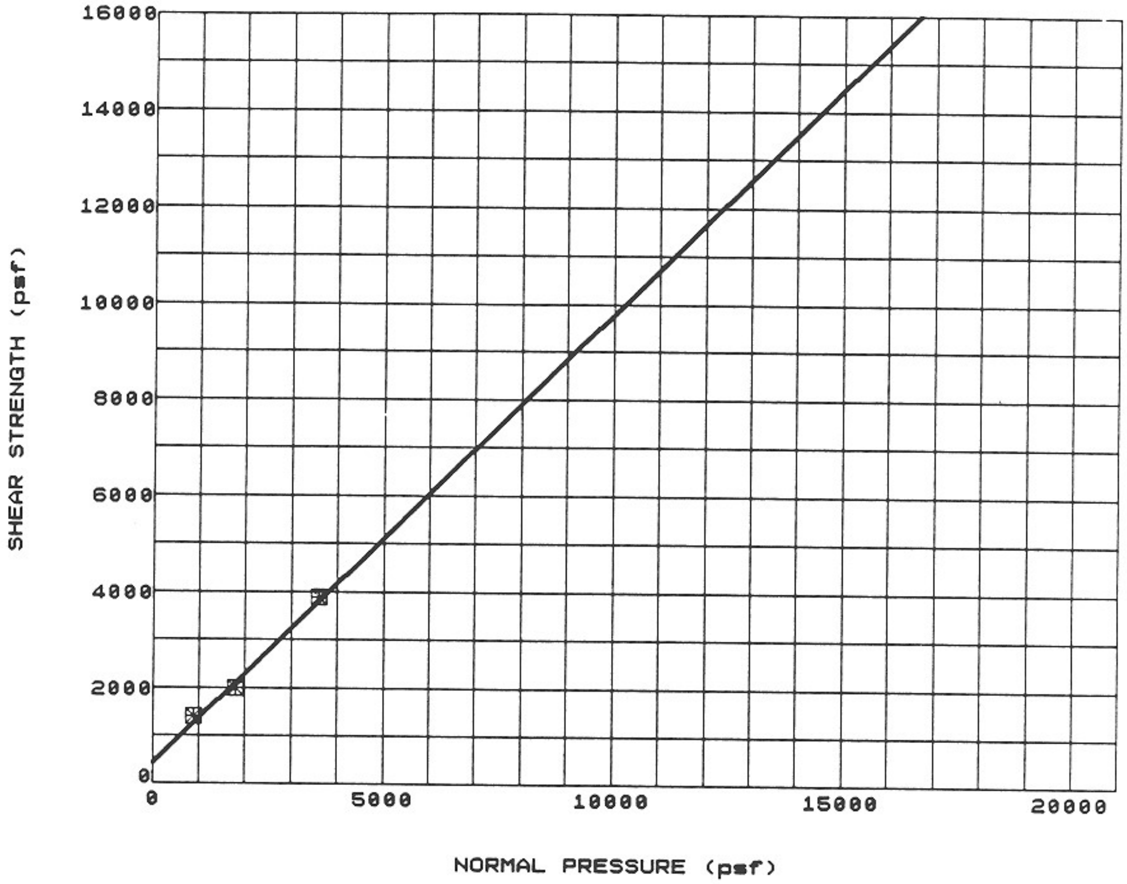
FIGURE B- 79



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
⊠	LPE-11	D - 3	15.00	DRIVE	SM	500	43	

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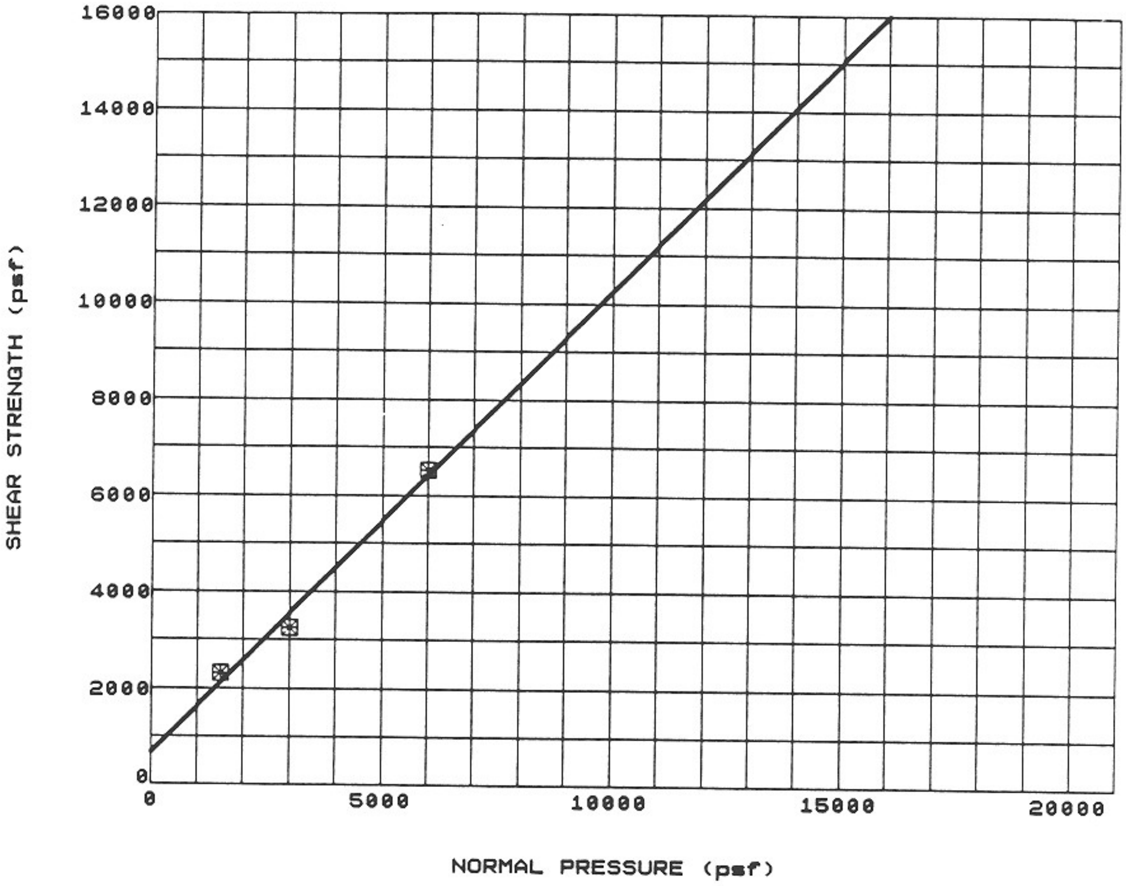
FIGURE B- 80



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
⊠	LPE-11	D - 5	25.00	DRIVE	SM	700	44	

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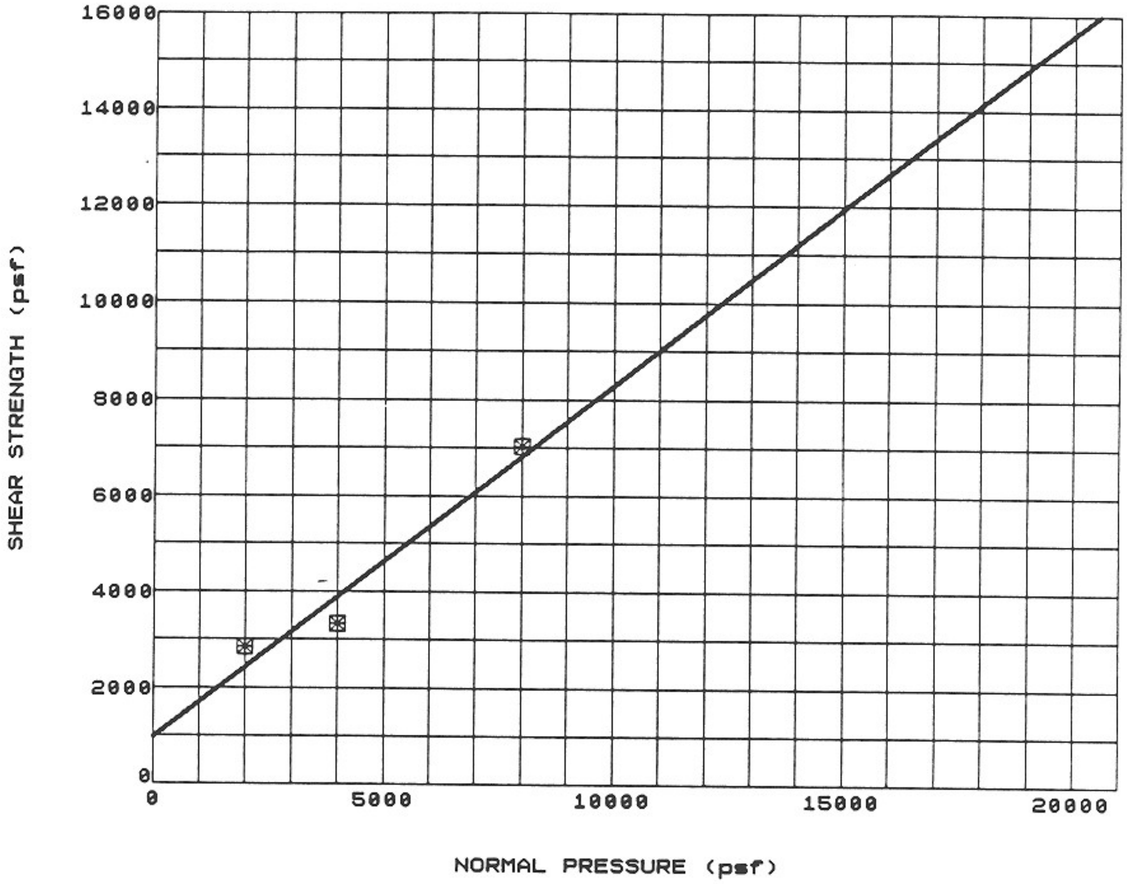
FIGURE B- 81



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
⊠	LPE-11	D - 7	34.80	DRIVE	SM	1000	36	

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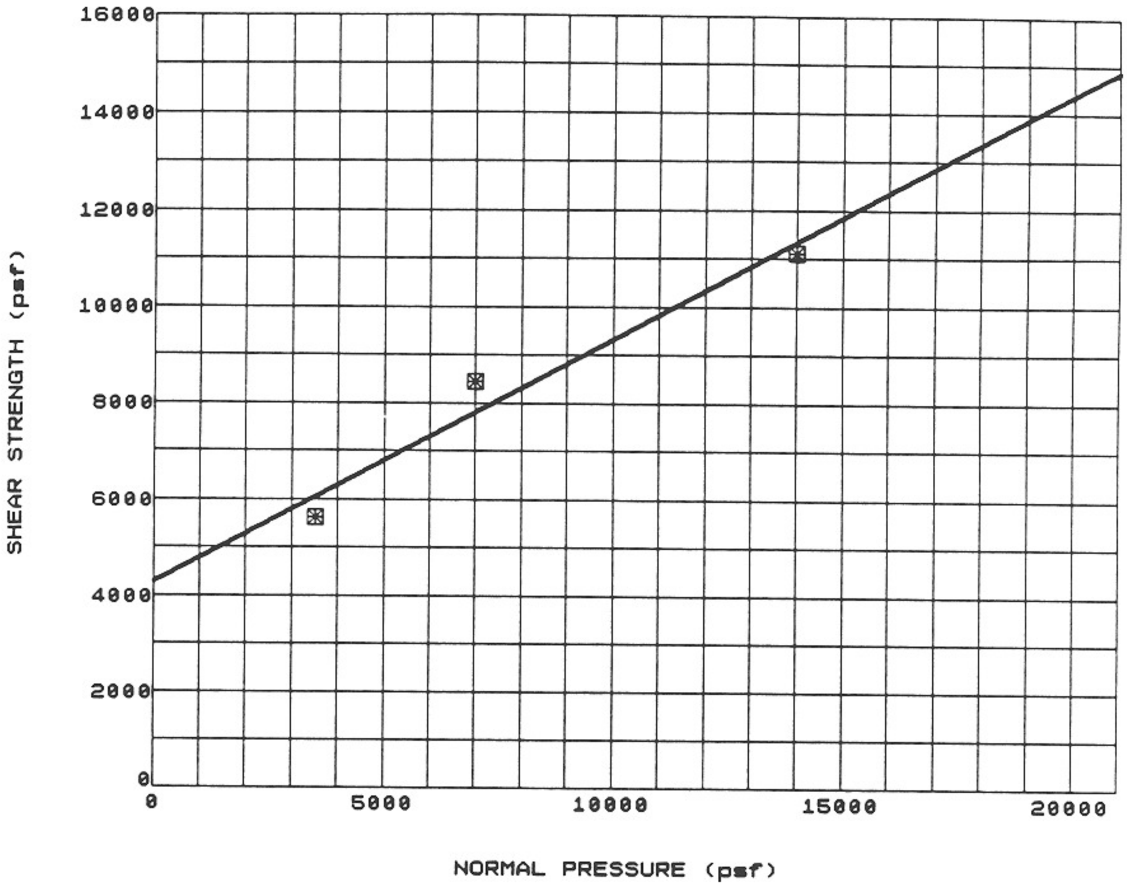
FIGURE B- 82



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
☒	LPE-11	D-9	45.00	DRIVE	SC/CL	4300	27	

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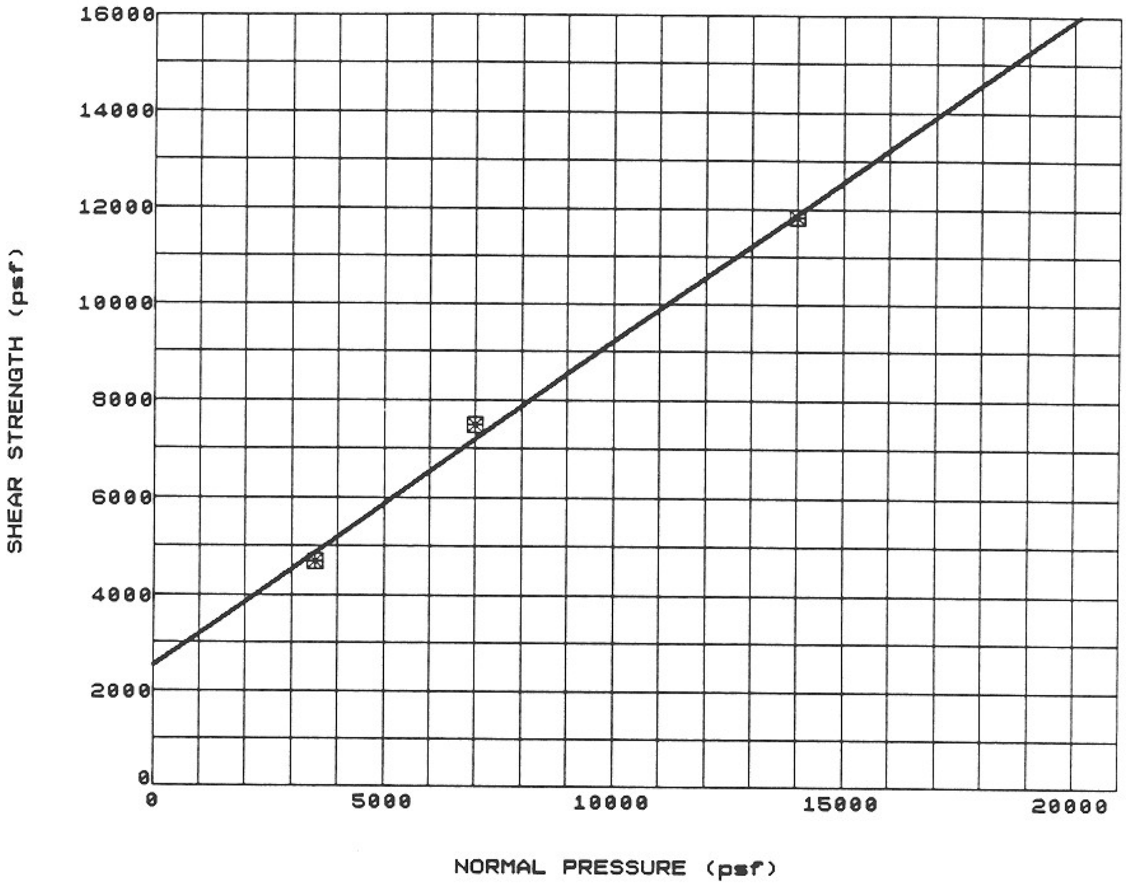
FIGURE B- 83



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
☒	LPE-11	D - 11	55.00	DRIVE	SM	2500	34	

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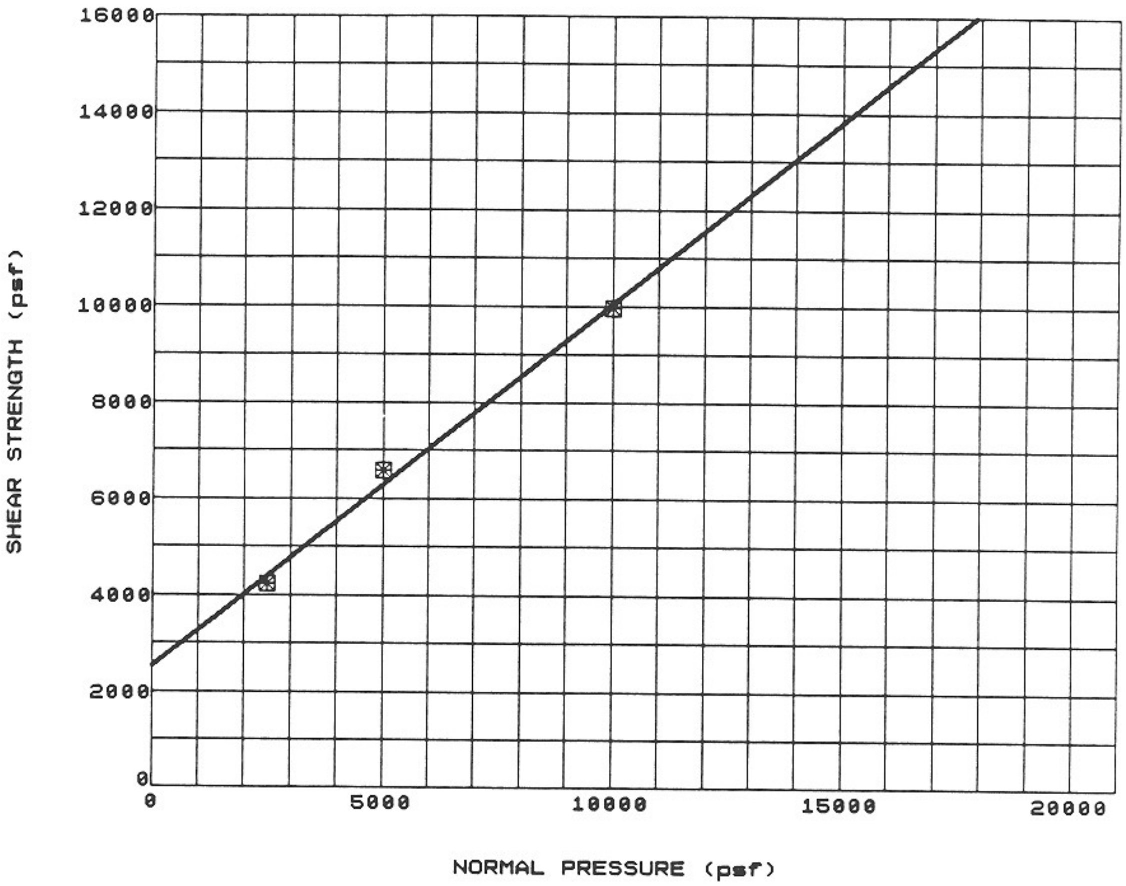
FIGURE B- 84



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
☒	LPE-12	D-8	45.00	DRIVE	SC	2500	37	

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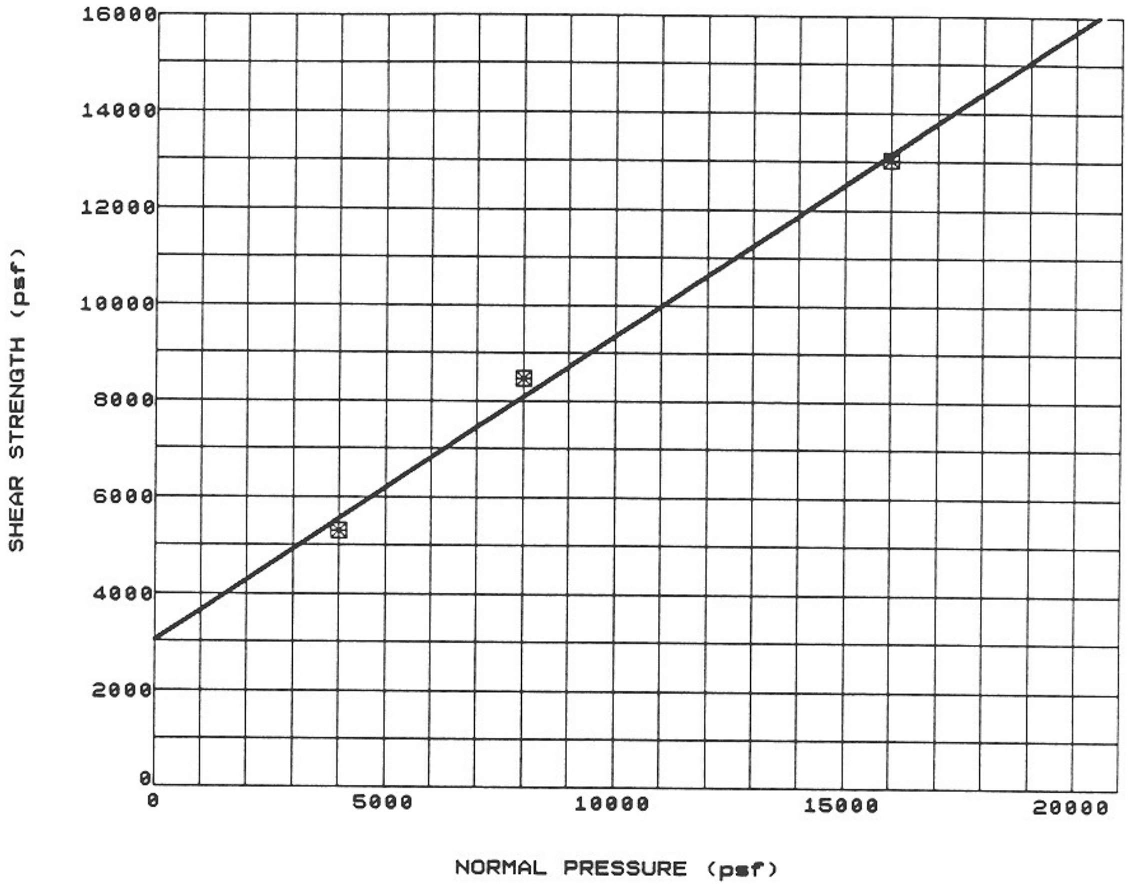
FIGURE B-85



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
☒	LPE-12	D - 12	65.00	DRIVE	SM	3000	32	

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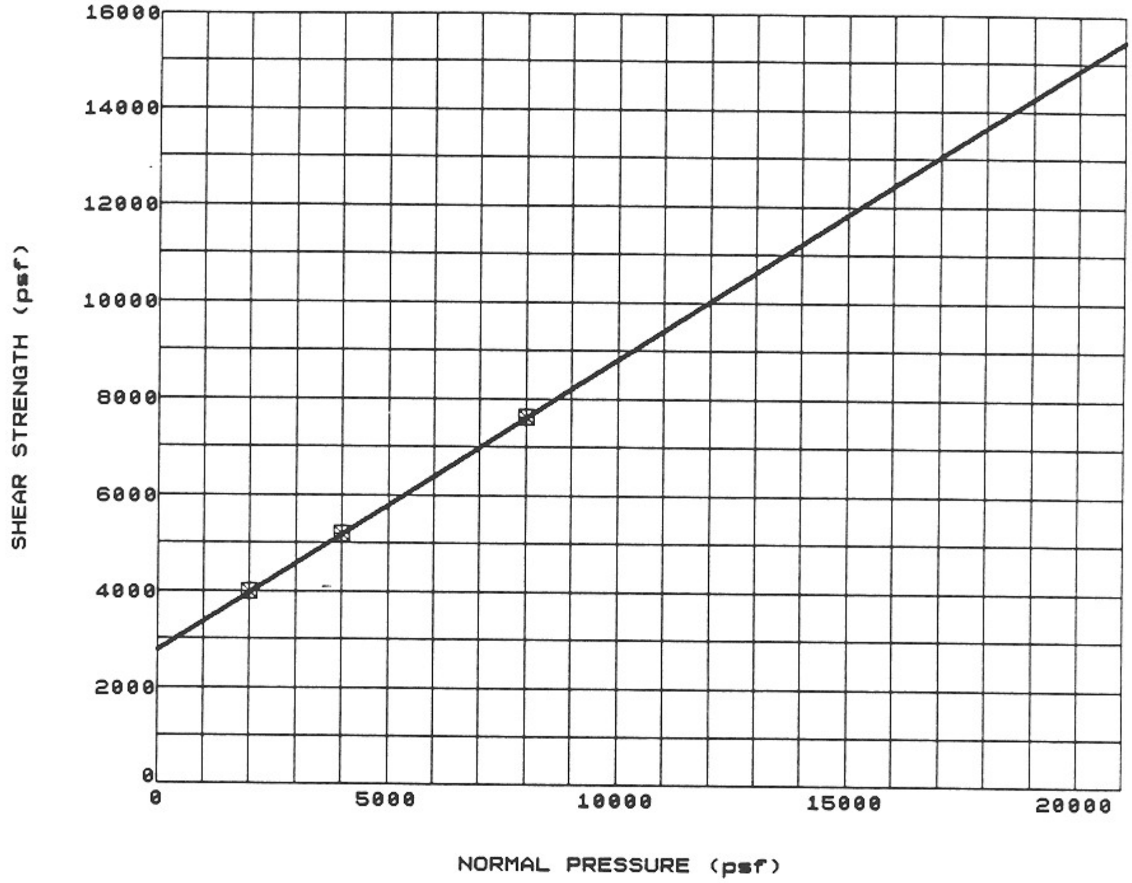
FIGURE B- 86



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
☒	LPE-13	D-5	35.20	DRIVE		2800	33	

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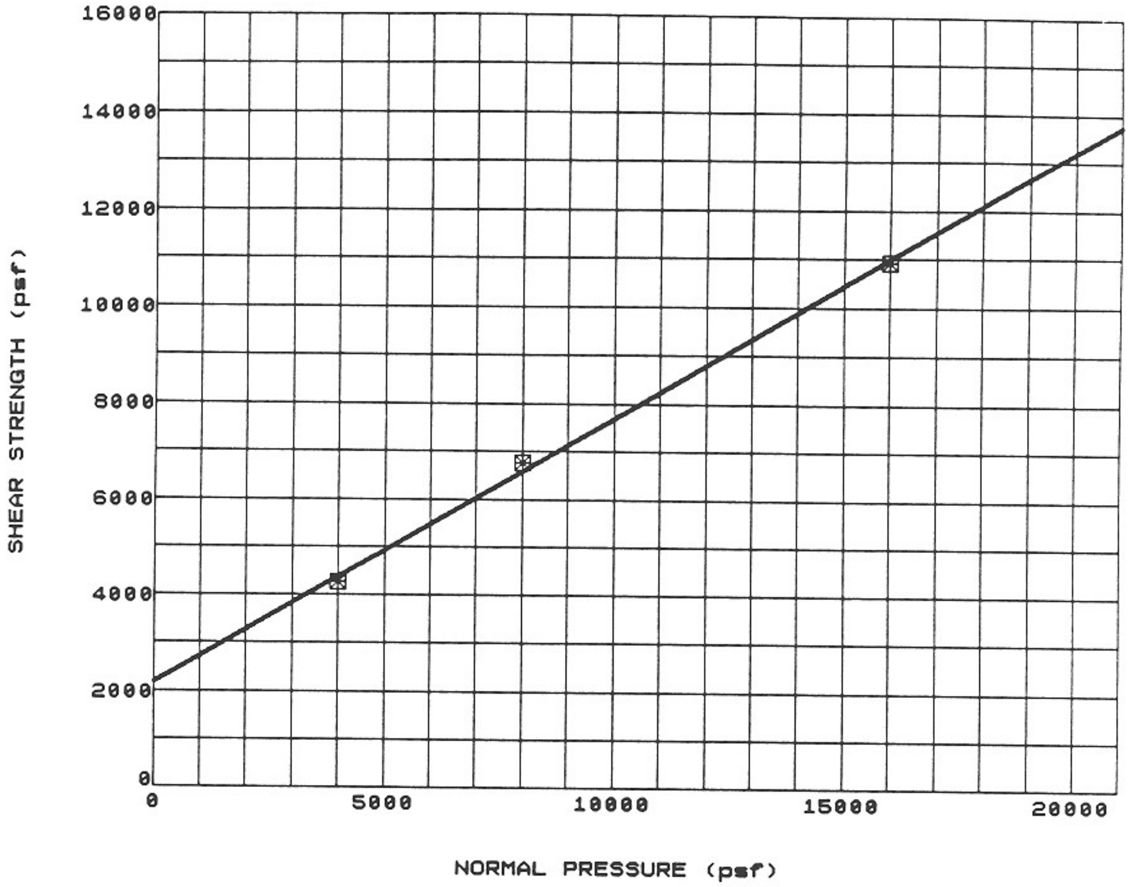
FIGURE B- 87



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
☒	LPE-13	D - 10	64.90	DRIVE	SC/CL	2200	29	

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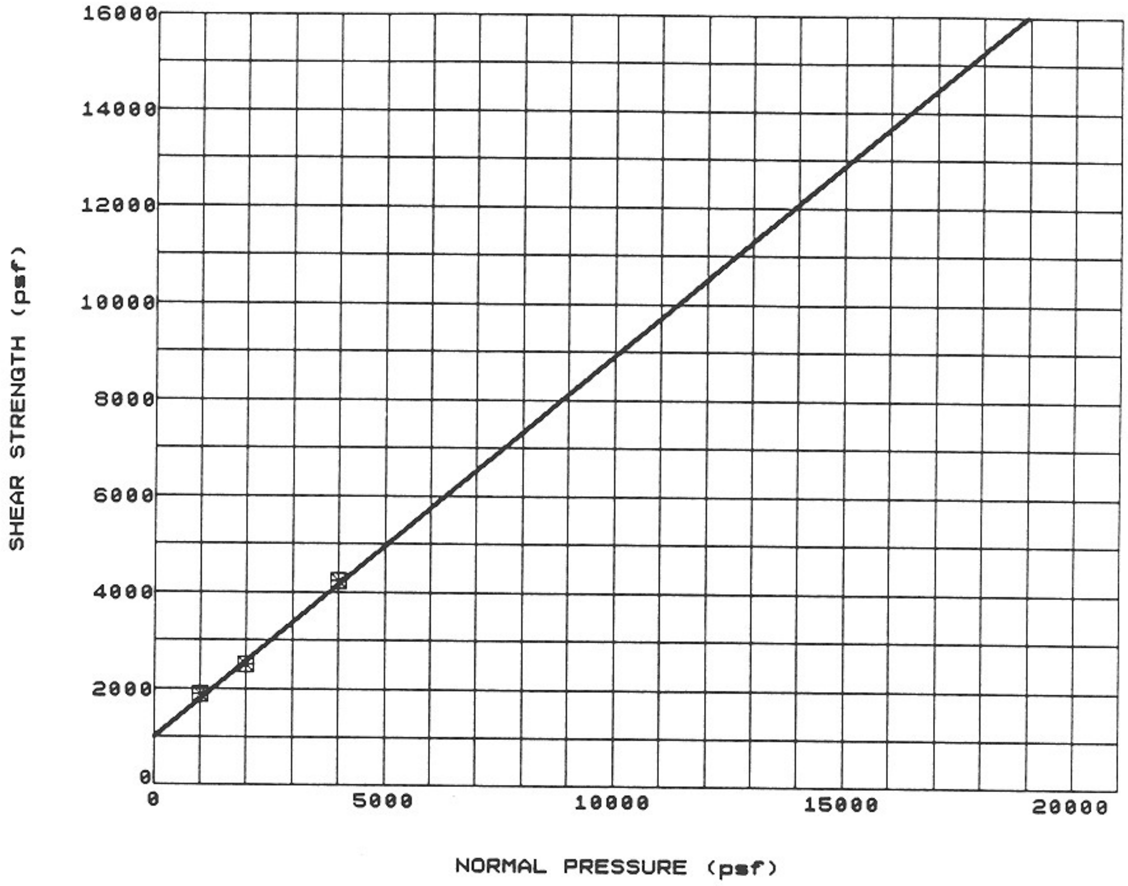
FIGURE B- 88



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
☒	LPE-14	D - 3	20.00	DRIVE	SM	1000	38	

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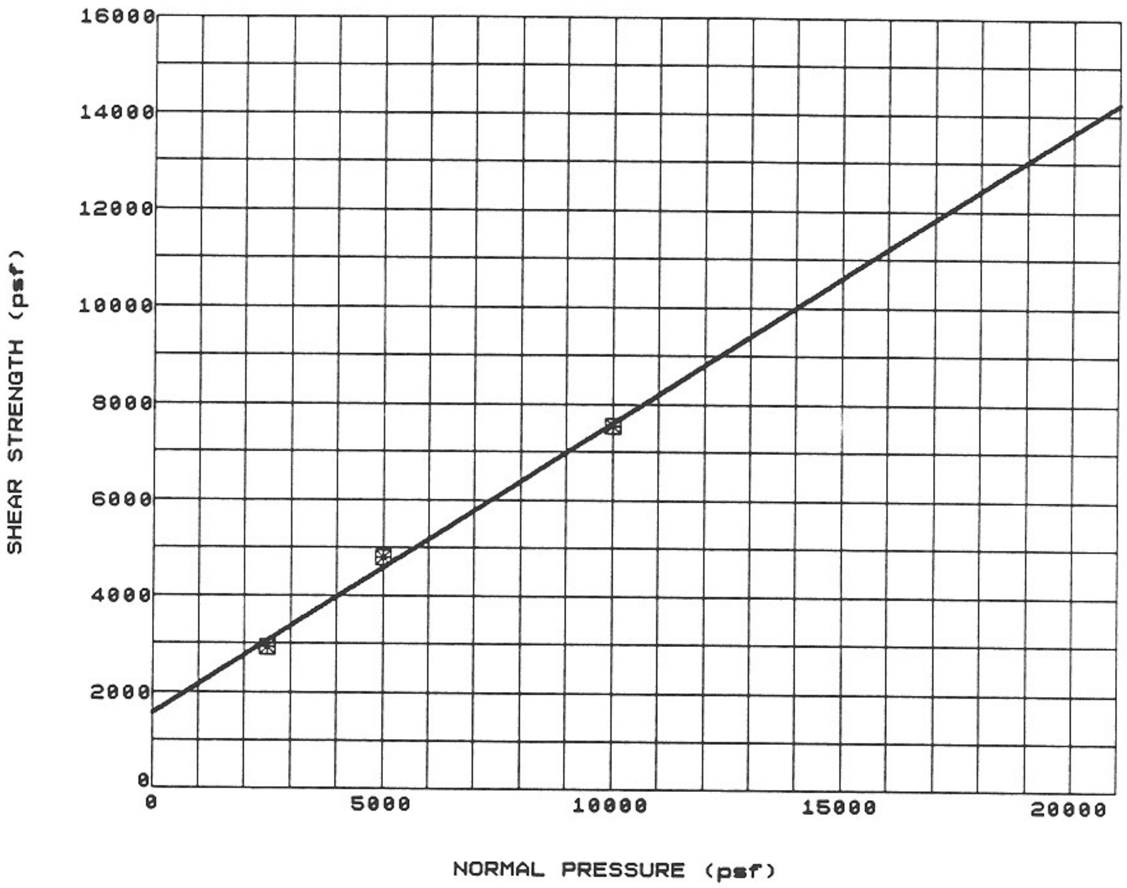
FIGURE B- 89



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
☒	LPE-14	D - 7	40.00	DRIVE	SC	1600	31	

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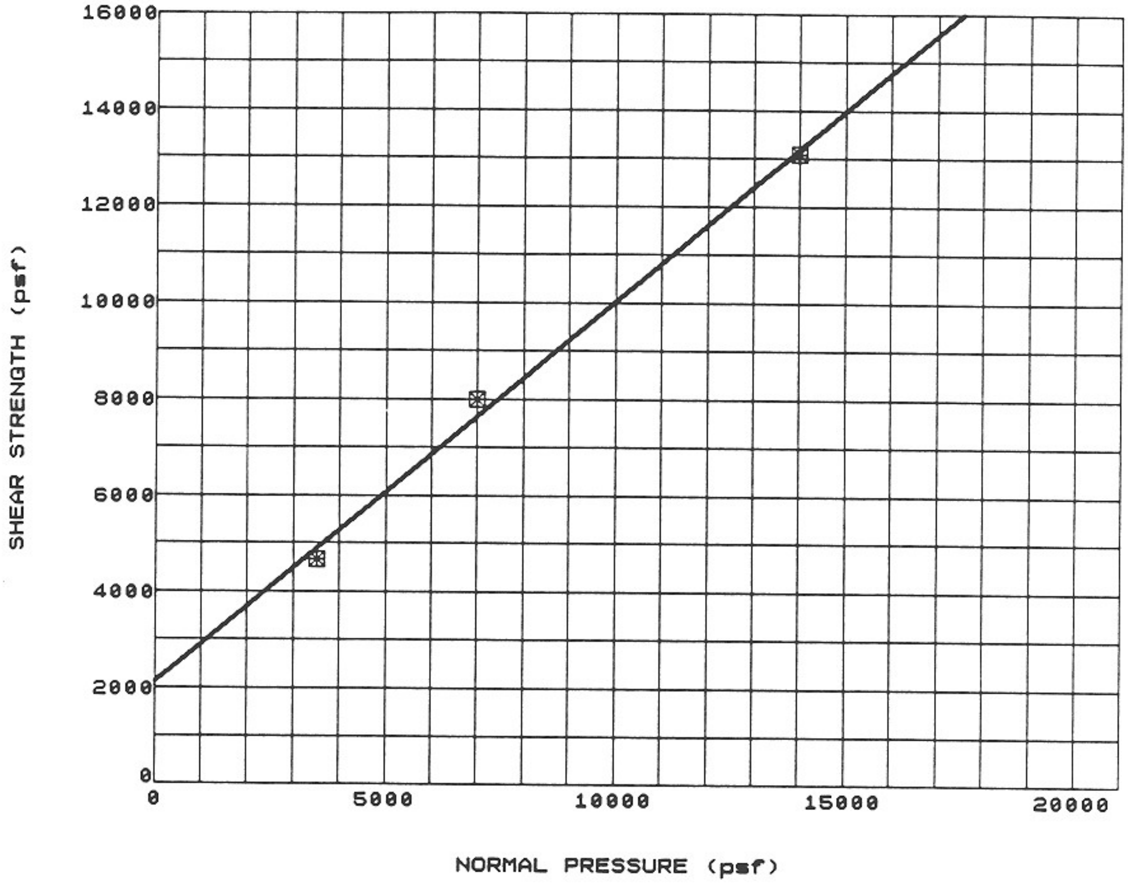
FIGURE B- 90



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
⊠	LPE-14	D - 10	55.00	DRIVE	SP-SM	2200	39	

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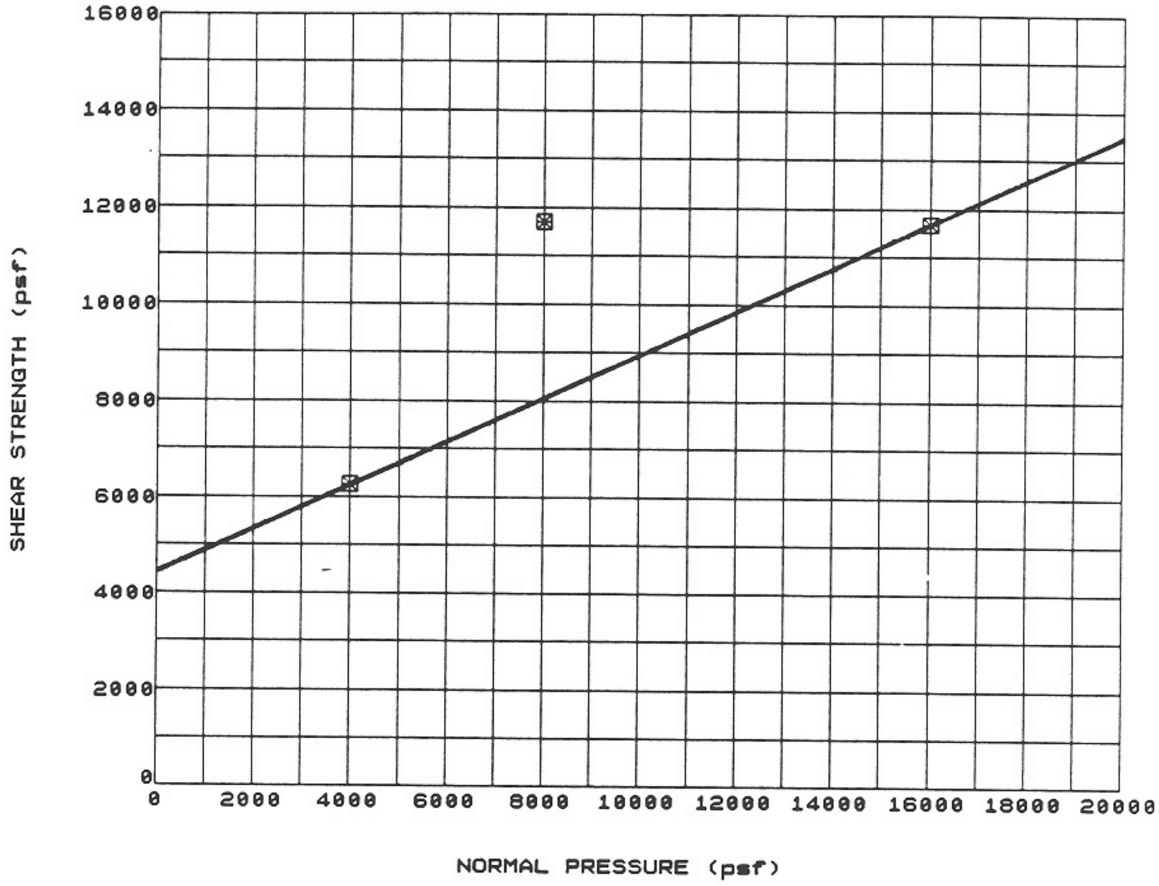
FIGURE B- 91



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
☒	LPE-14	D - 13	65.50	DRIVE	SC	4440	24	

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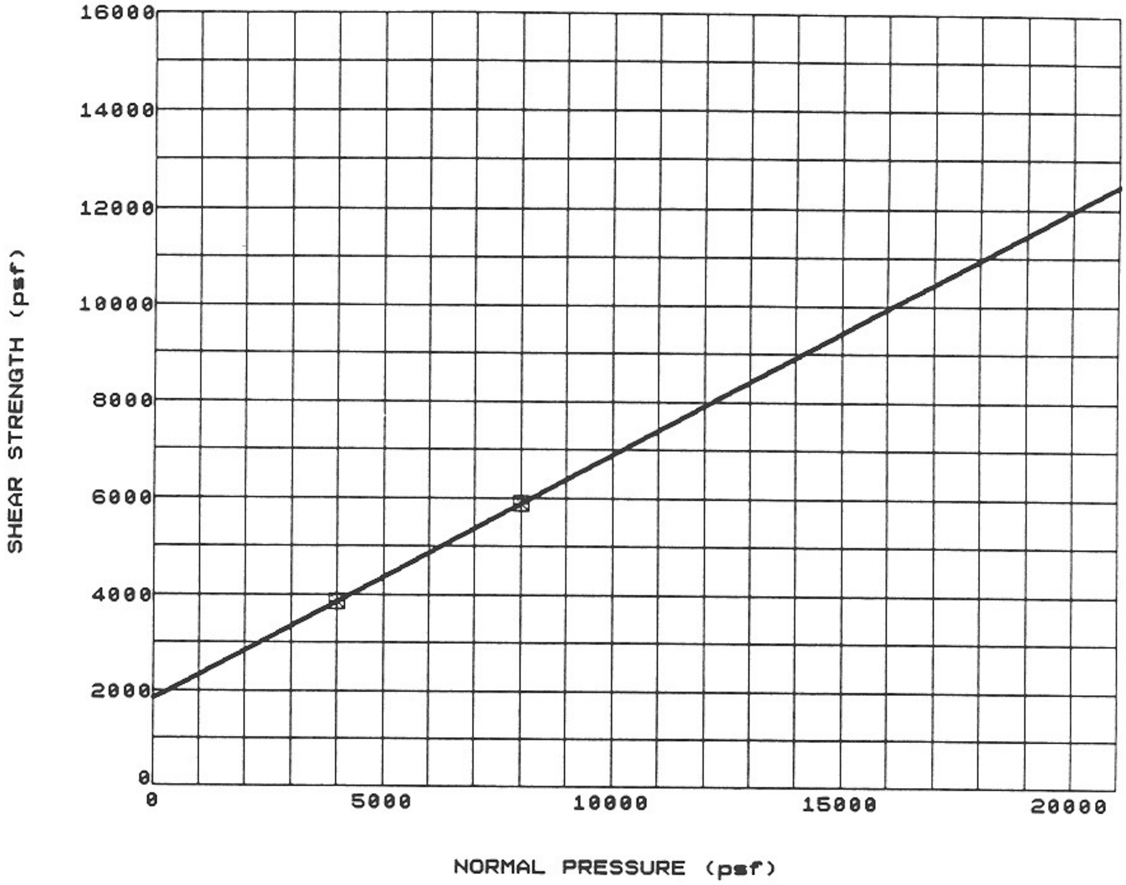
FIGURE B- 92



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
☒	LPE-14	D - 15	75.00	DRIVE	ML	1830	27	

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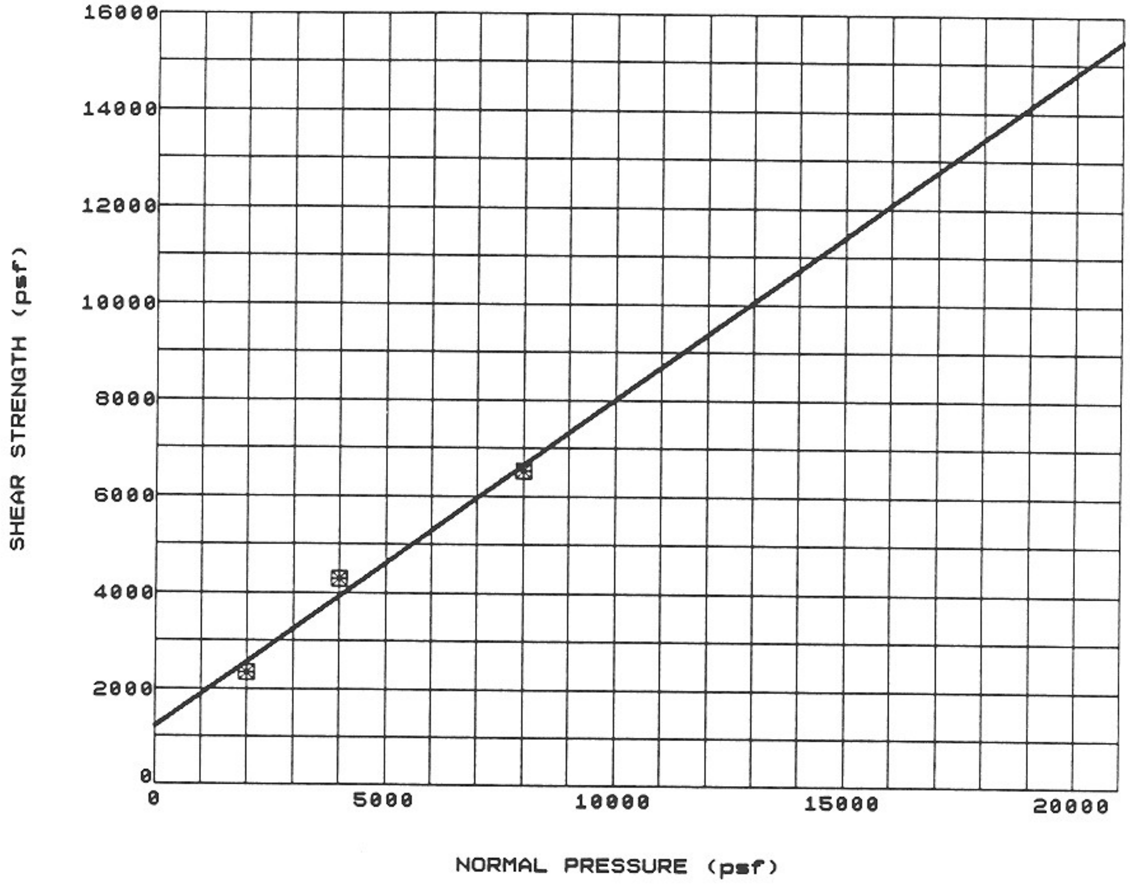
FIGURE B- 93



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
⊠	LPE-15	D - 7	35.00	DRIVE	SM	1250	34	

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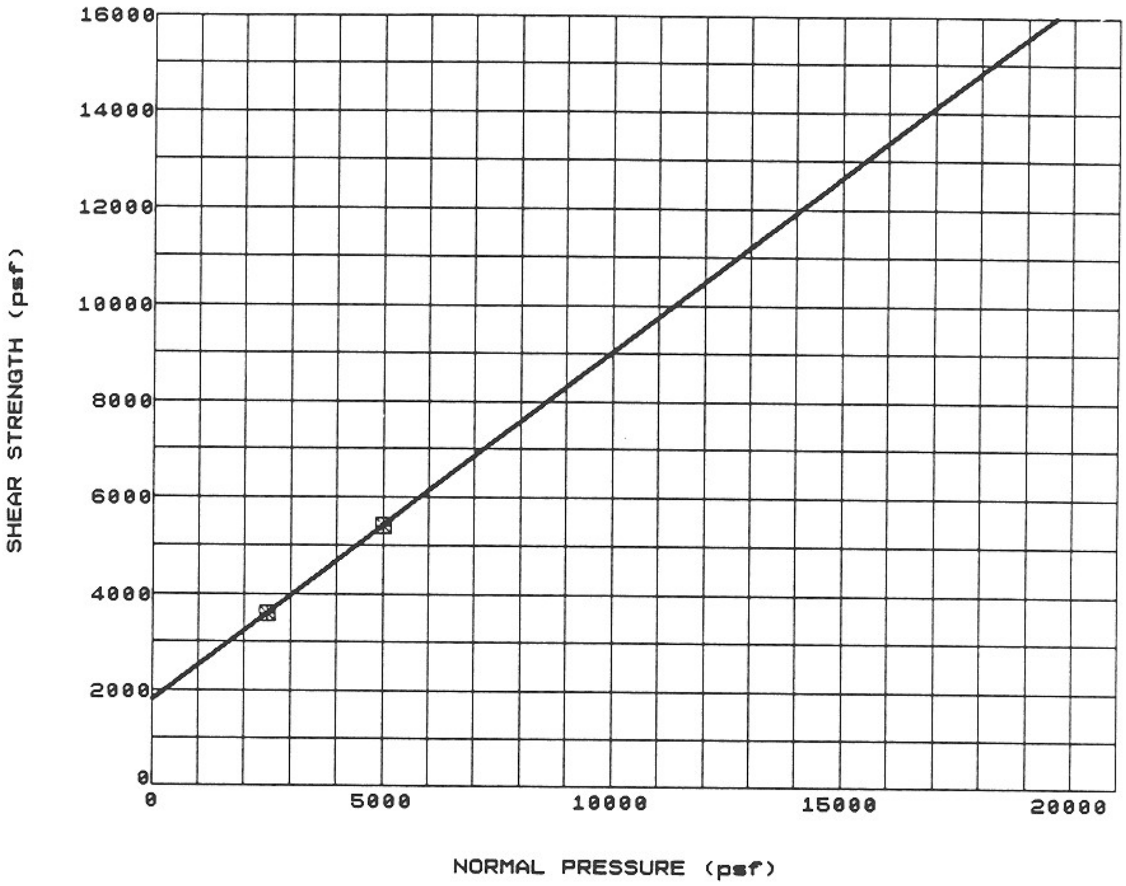
FIGURE B- 94



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
☒	LPE-15	D - 9	45.00	DRIVE	SM	1790	36	

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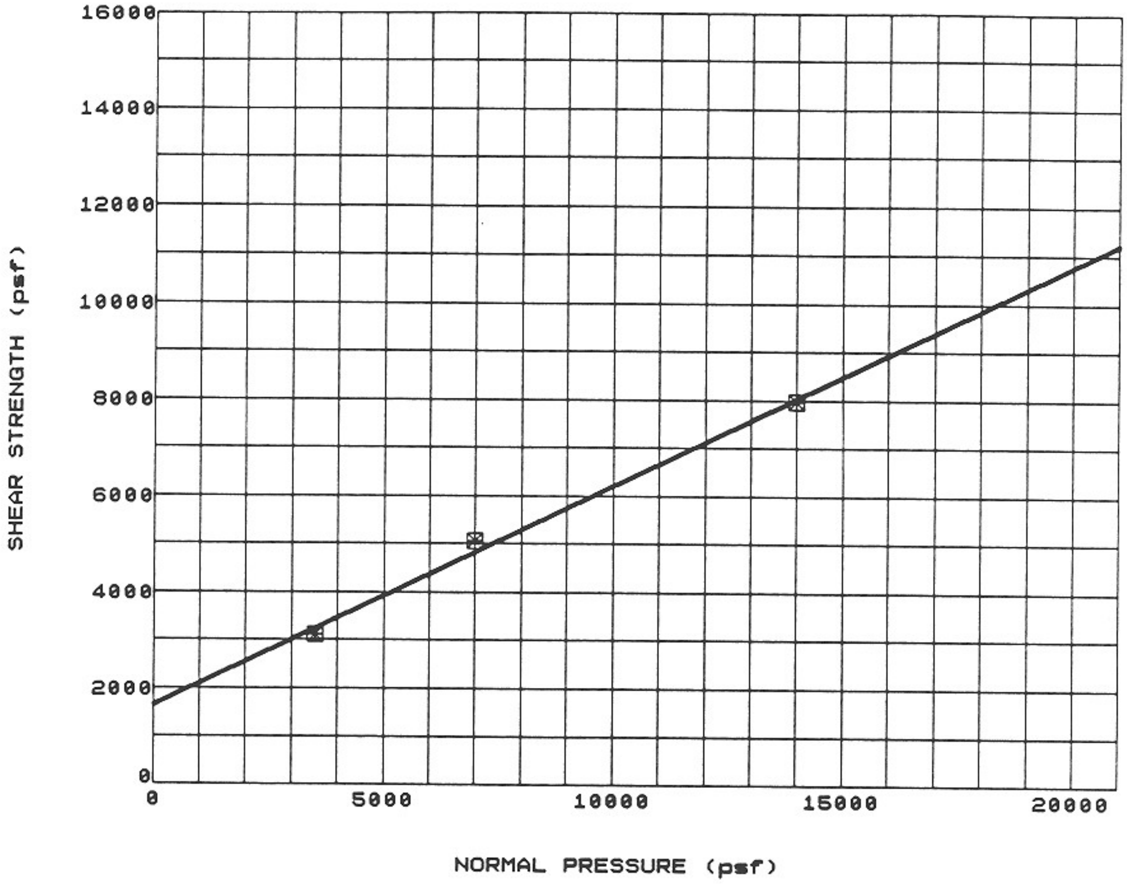
FIGURE B- 95



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
☒	LPE-15	D - 11	55.00	DRIVE	CL	1600	25	

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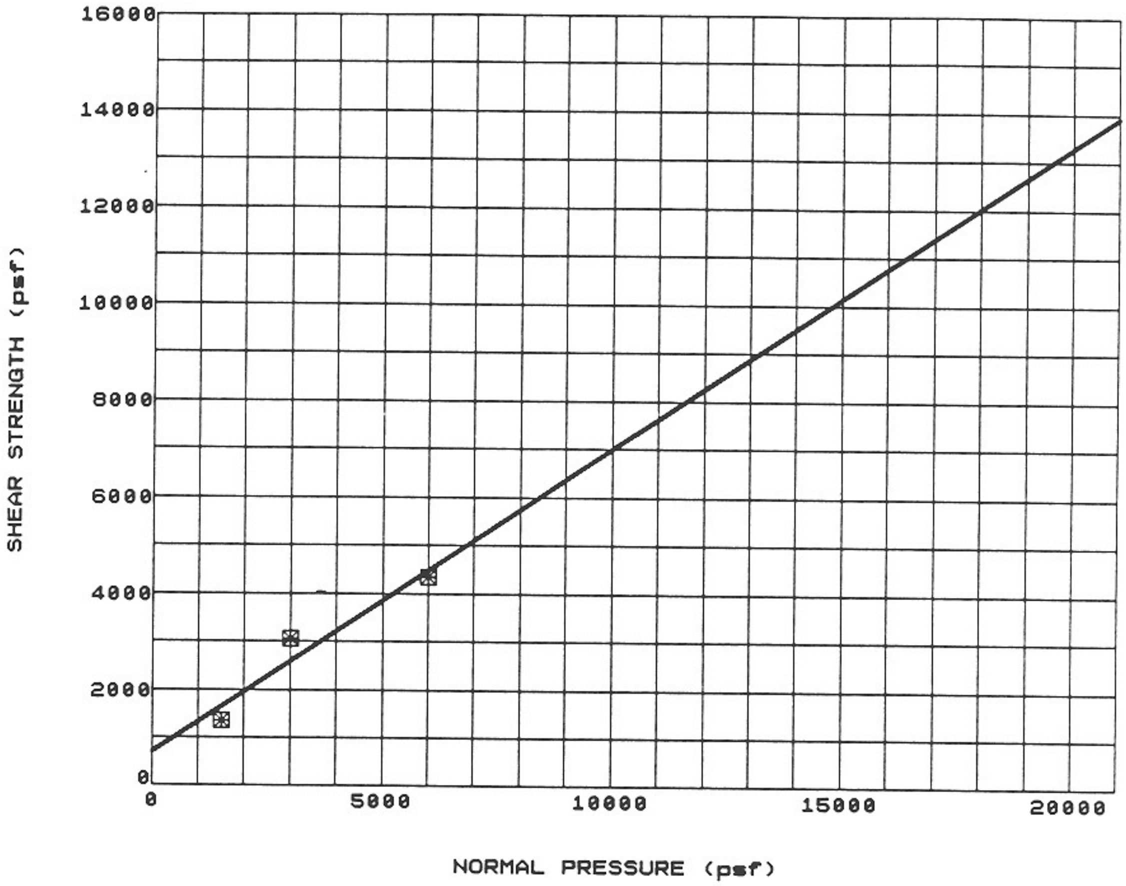
FIGURE B- 96



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
☒	LPE-16	D-5	24.90	DRIVE	SM	750	32	

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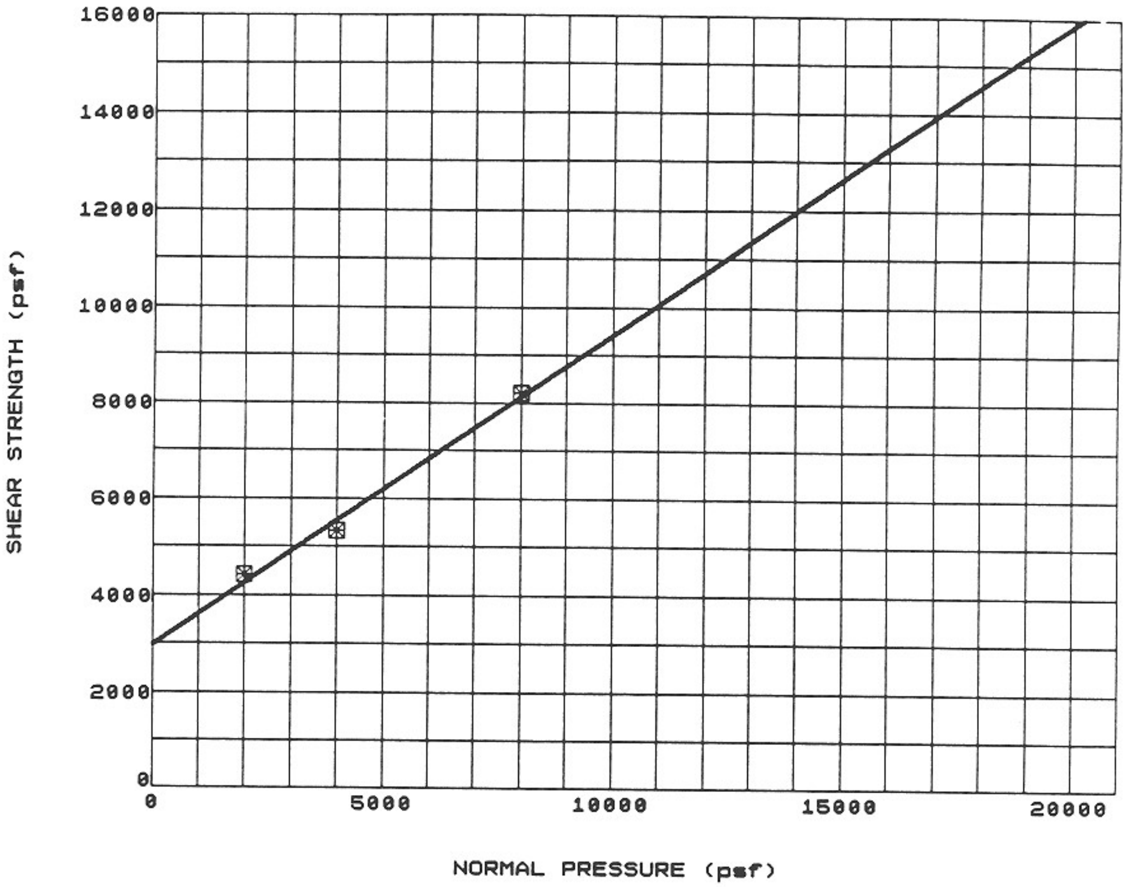
FIGURE B-97



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
☒	LPE-16	D - 7	34.70	DRIVE	SC	3000	33	

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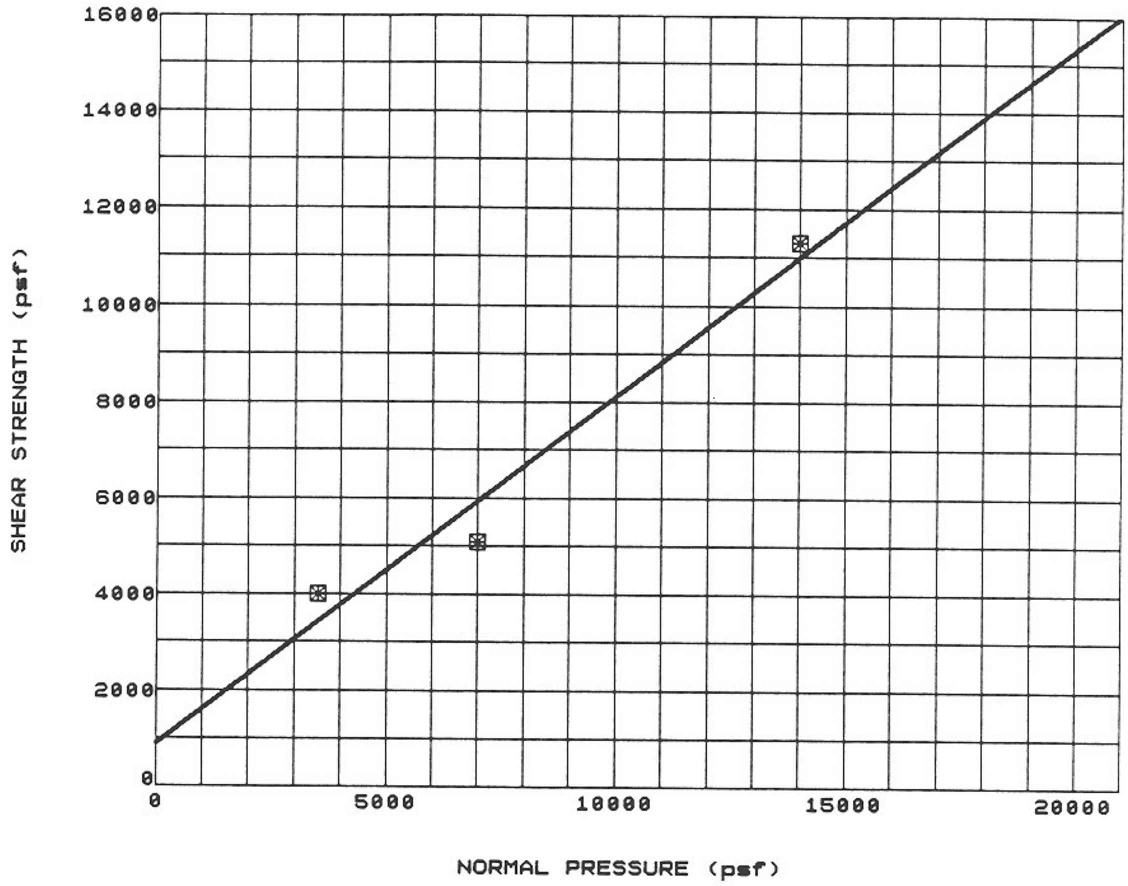
FIGURE B- 98



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
☒	LPE-16	D - 11	54.70	DRIVE	SM	950	36	

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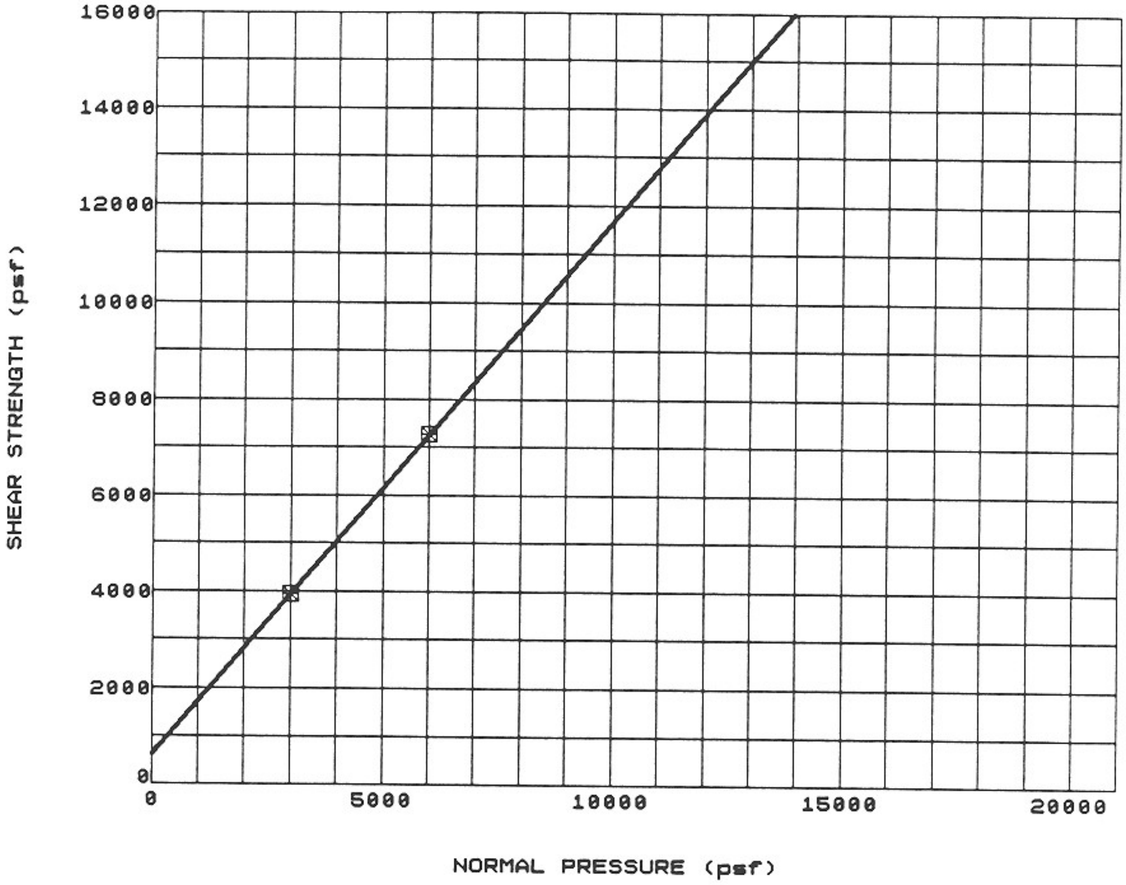
FIGURE B- 99



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
☒	LPE-17	D - 10	50.00	DRIVE	SM	630	48	

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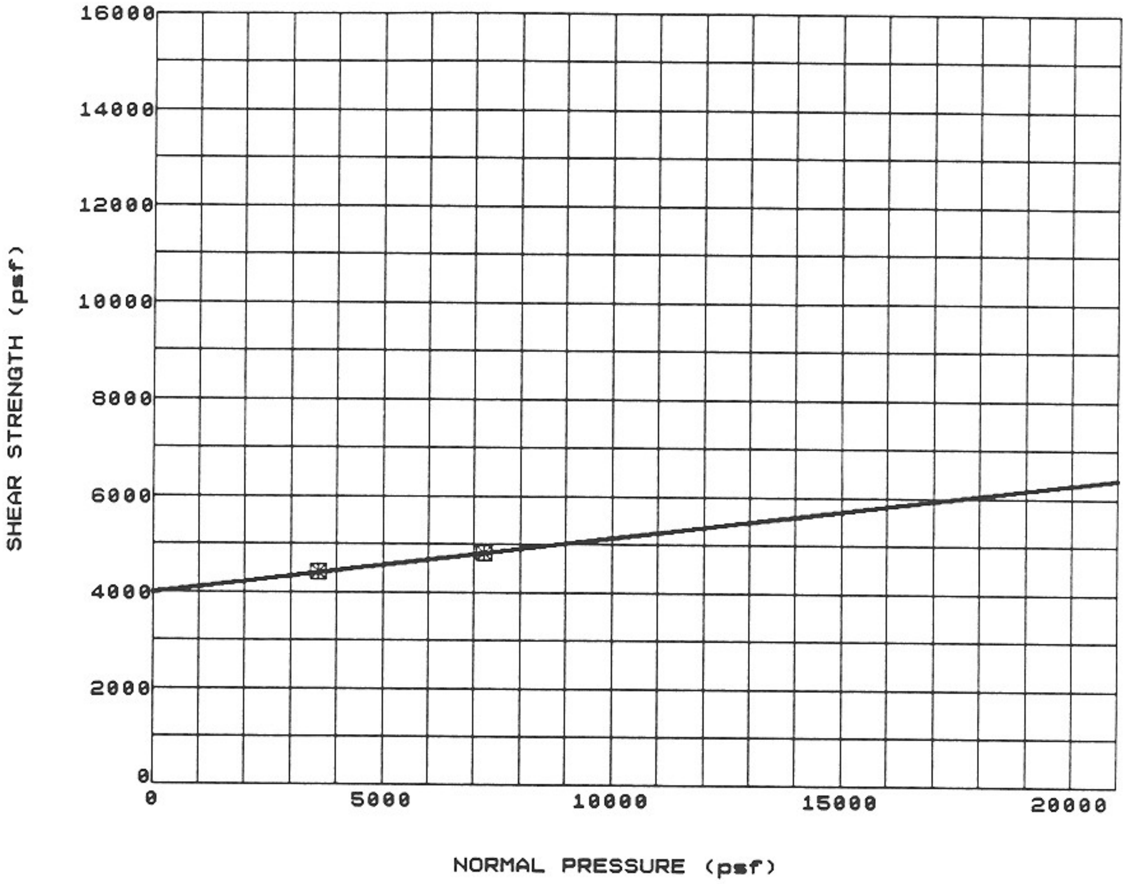
FIGURE B- 100



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
☒	LPE-17	D - 12	60.00	DRIVE	CL	4000	7	

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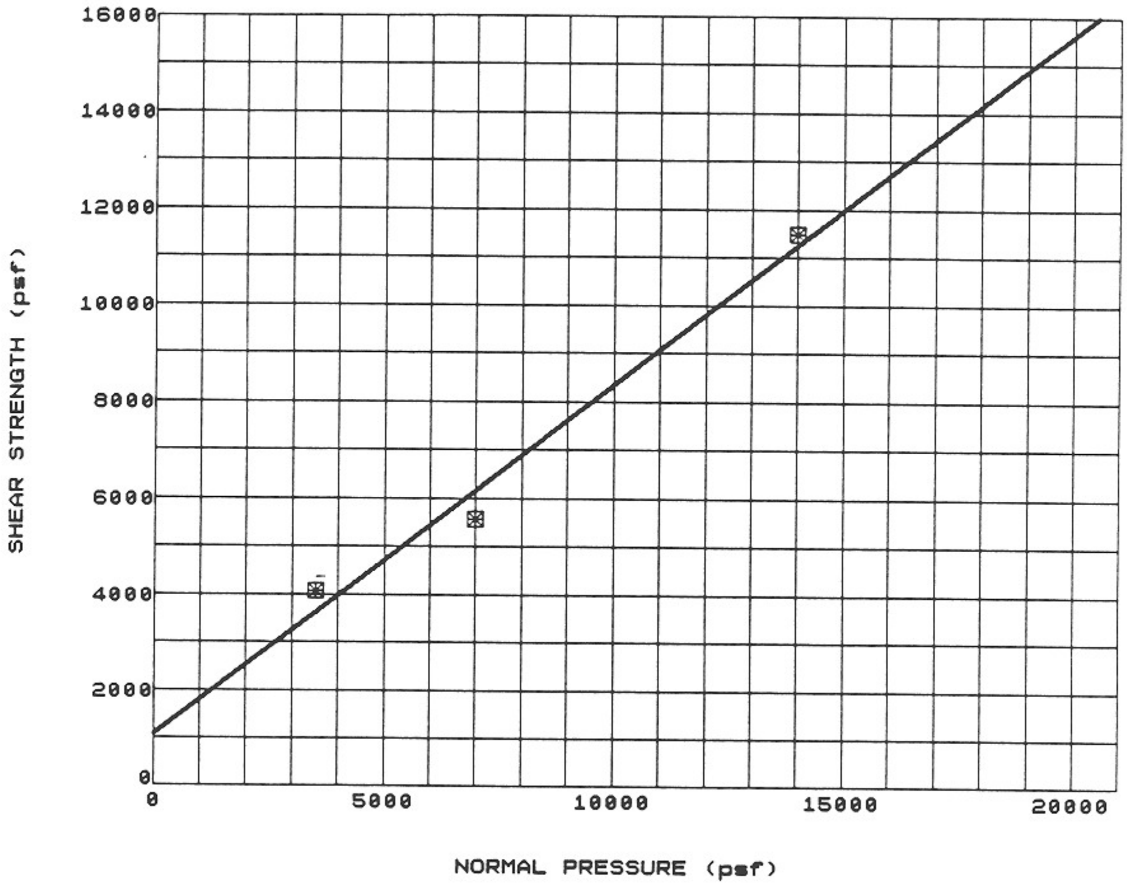
FIGURE B- 101



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
⊠	LPE-19	P - 11	55.00	PITCHER	SC	1100	36	

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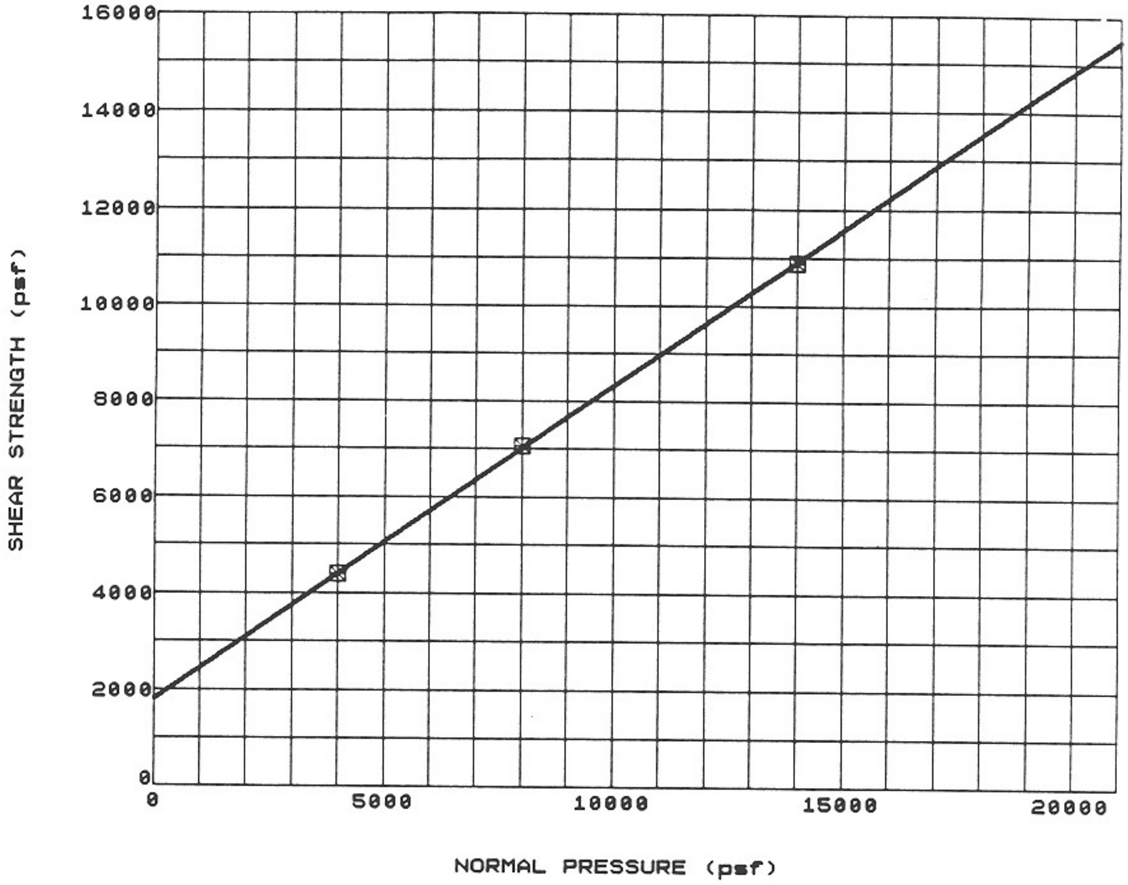
FIGURE B- 102



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
⊠	LPE-19	P - 13	65.00	PITCHER	SC	1800	33	

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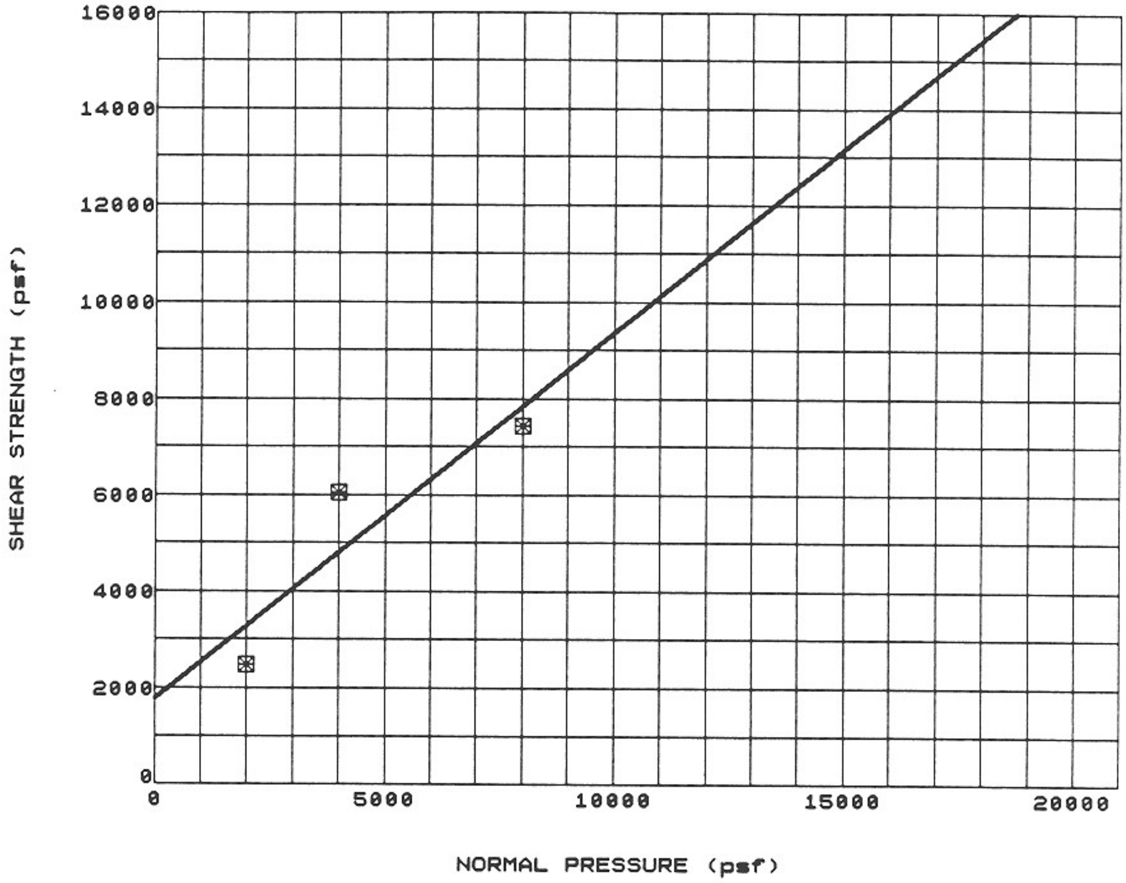
FIGURE B- 103



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
☒	LPE-21	D - 7	35.00	DRIVE		1800	36	

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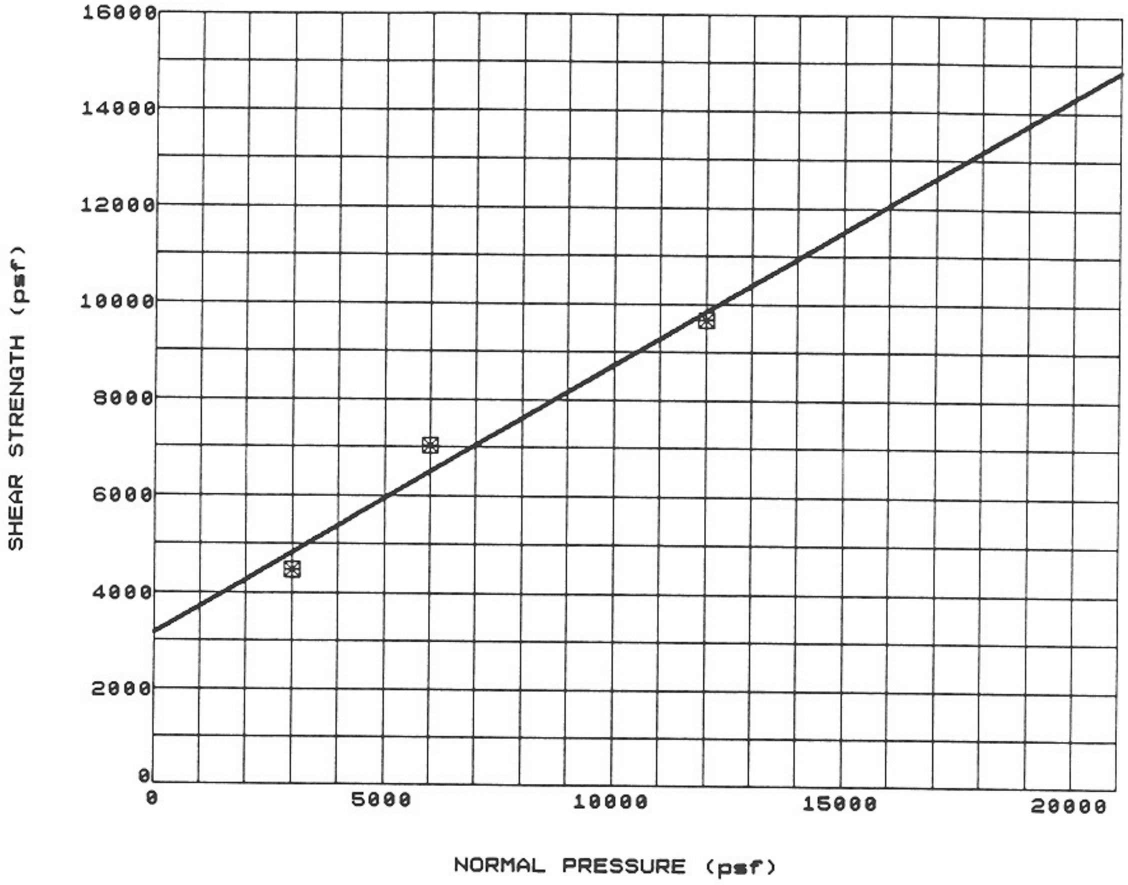
FIGURE B- 110



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
☒	LPE-21	D - 9	45.00	DRIVE		3200	29	

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FIGURE B- 111

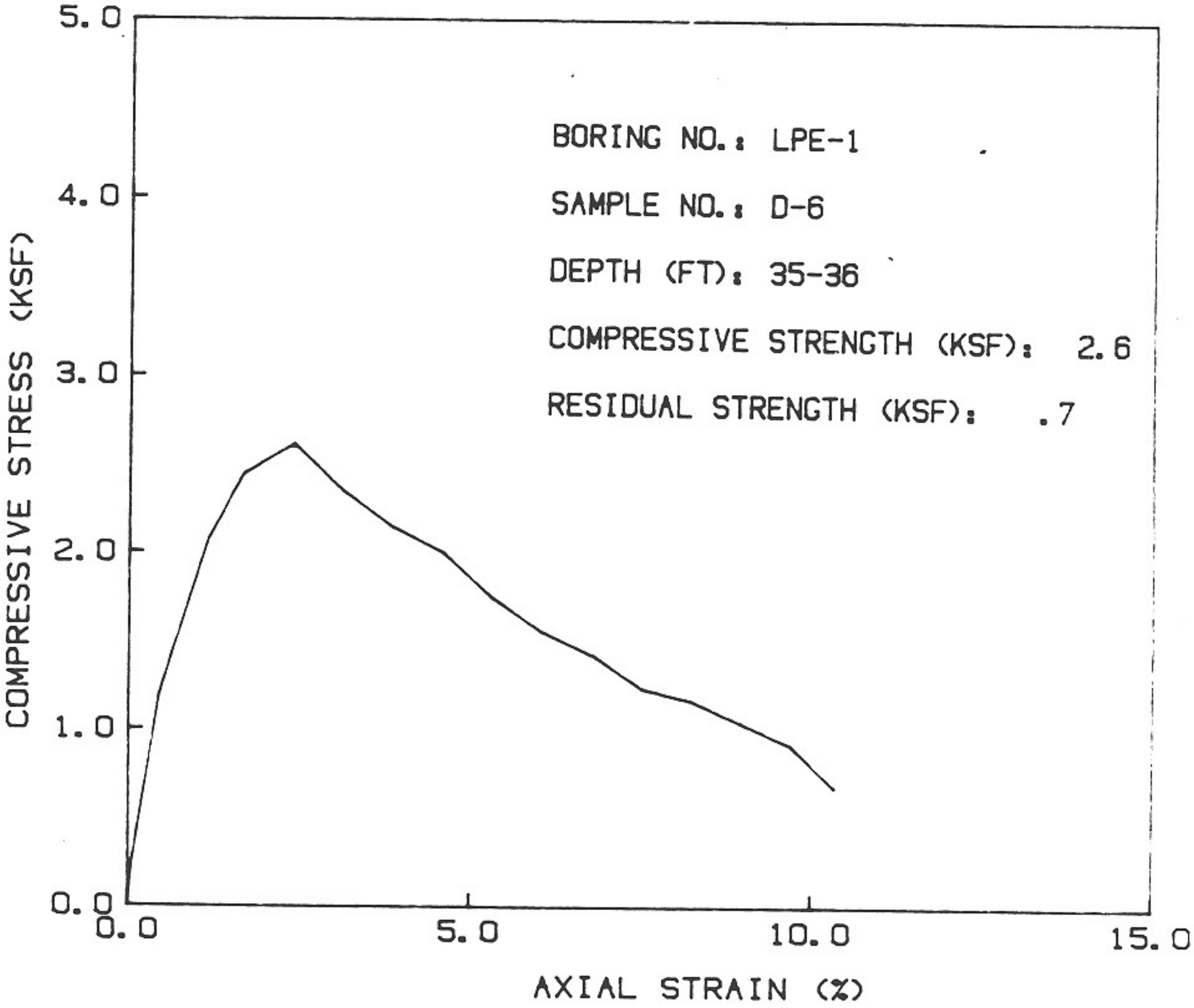

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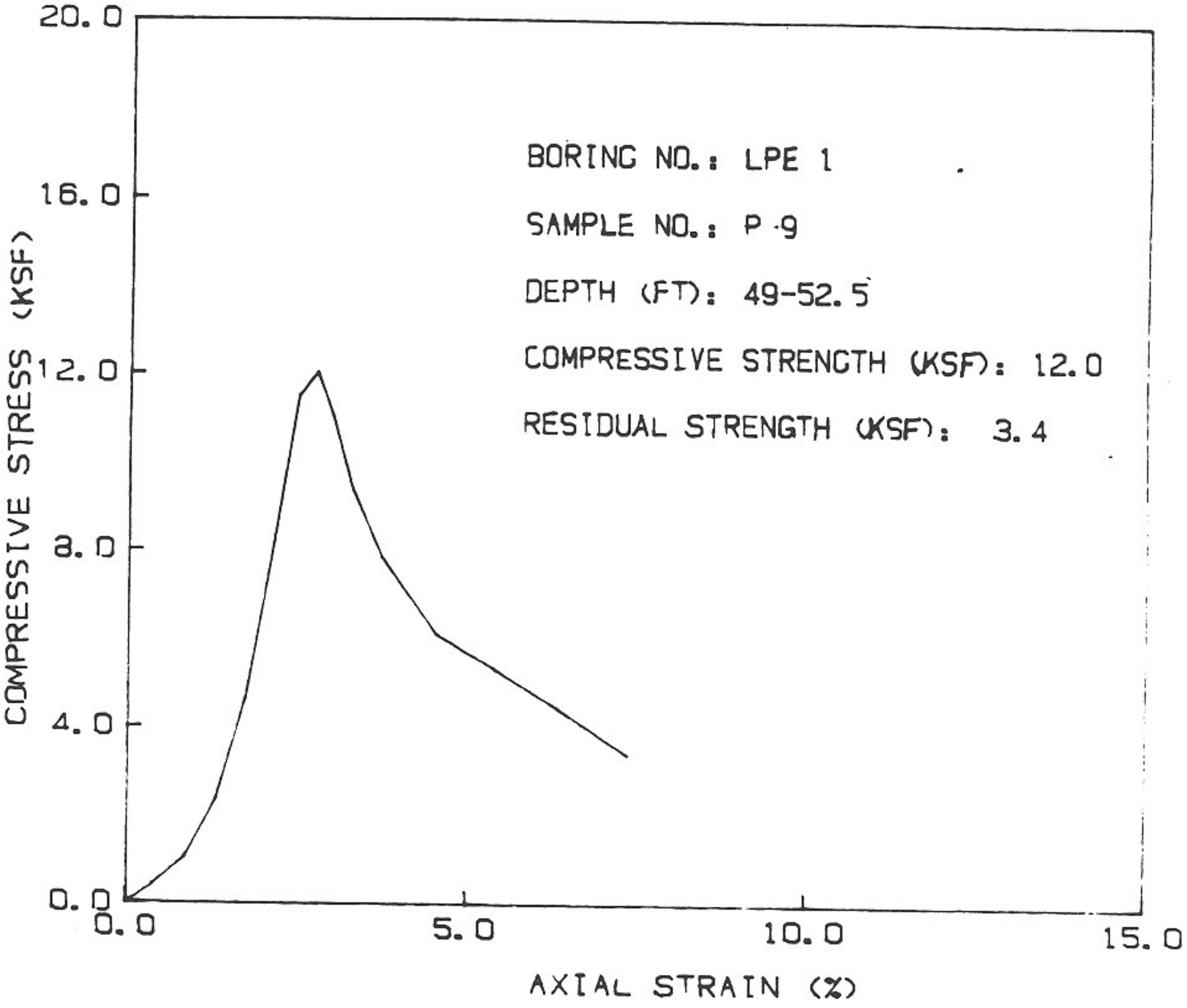
FIGURE B- 112



BORING NO.: LPE 1

SAMPLE NO.: P-9

DEPTH (FT): 49-52.5

COMPRESSIVE STRENGTH (KSF): 12.0

RESIDUAL STRENGTH (KSF): 3.4

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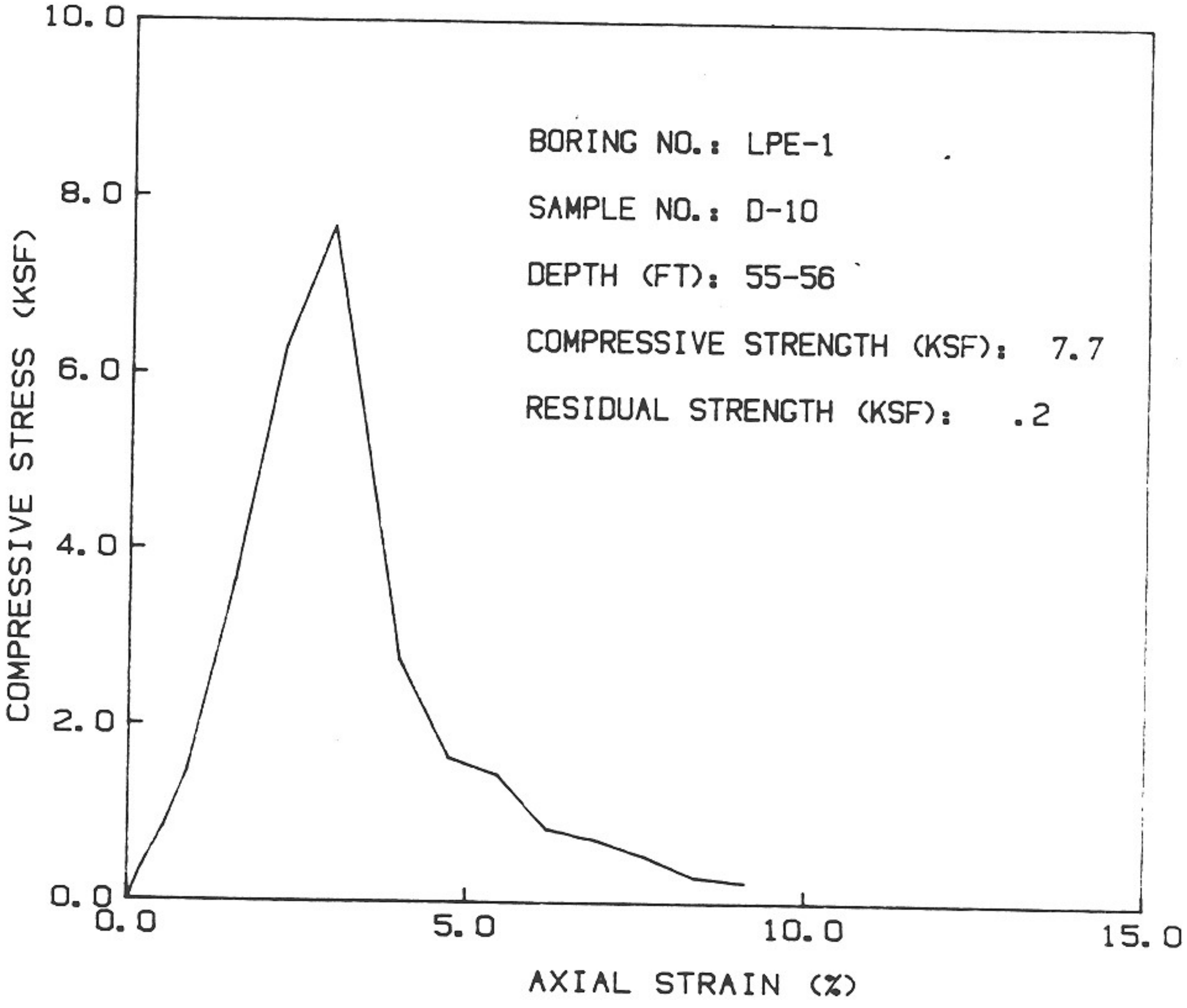
FIGURE B-113



BORING NO.: LPE-1

SAMPLE NO.: D-10

DEPTH (FT): 55-56

COMPRESSIVE STRENGTH (KSF): 7.7

RESIDUAL STRENGTH (KSF): .2

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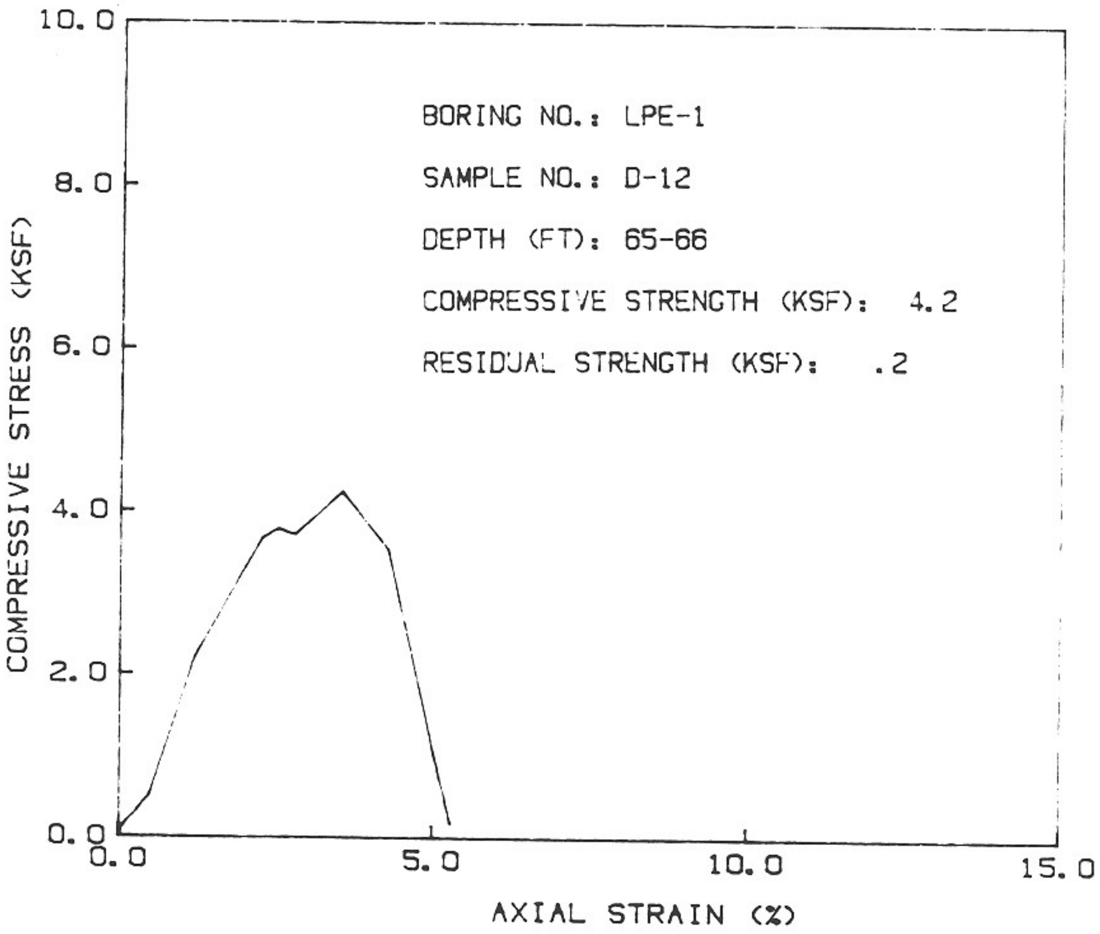
FIGURE B-114



BORING NO.: LPE-1

SAMPLE NO.: D-12

DEPTH (FT): 65-66

COMPRESSIVE STRENGTH (KSF): 4.2

RESIDUAL STRENGTH (KSF): .2

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FIGURE B-115

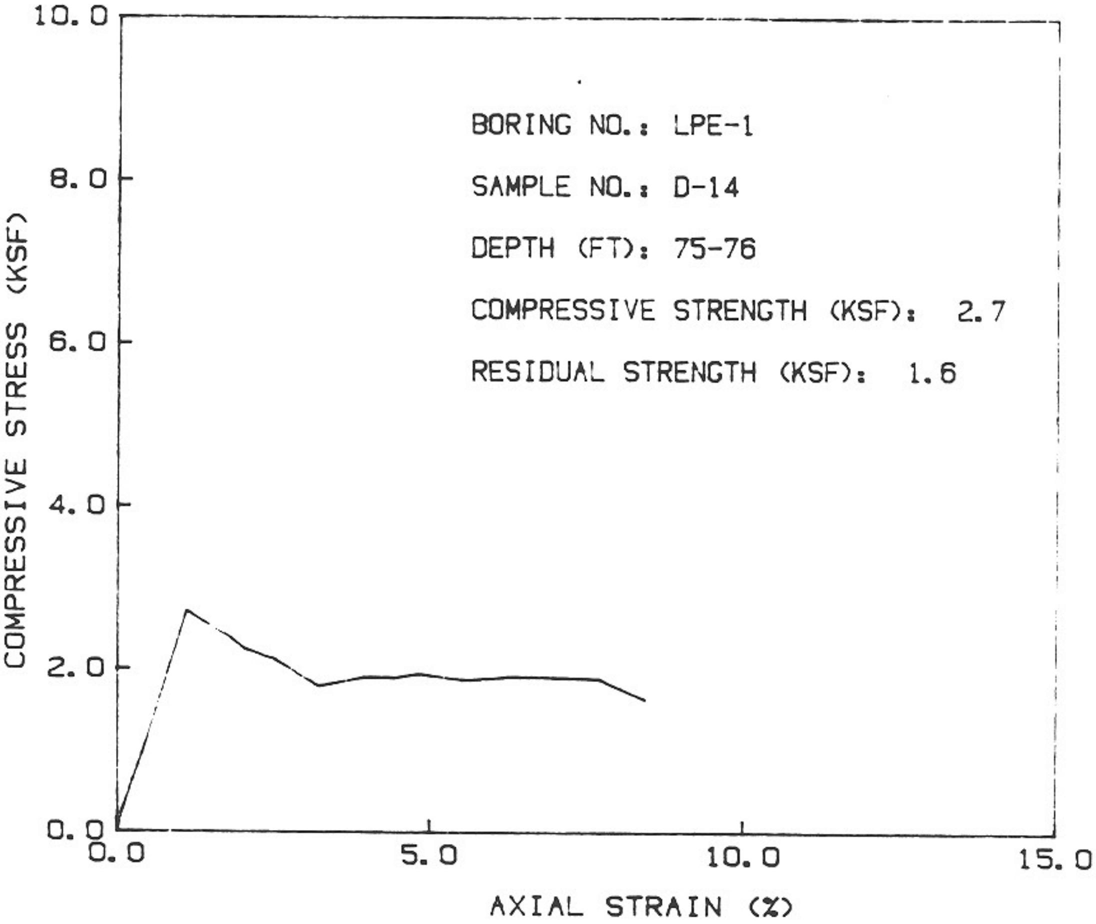

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FIGURE B-116

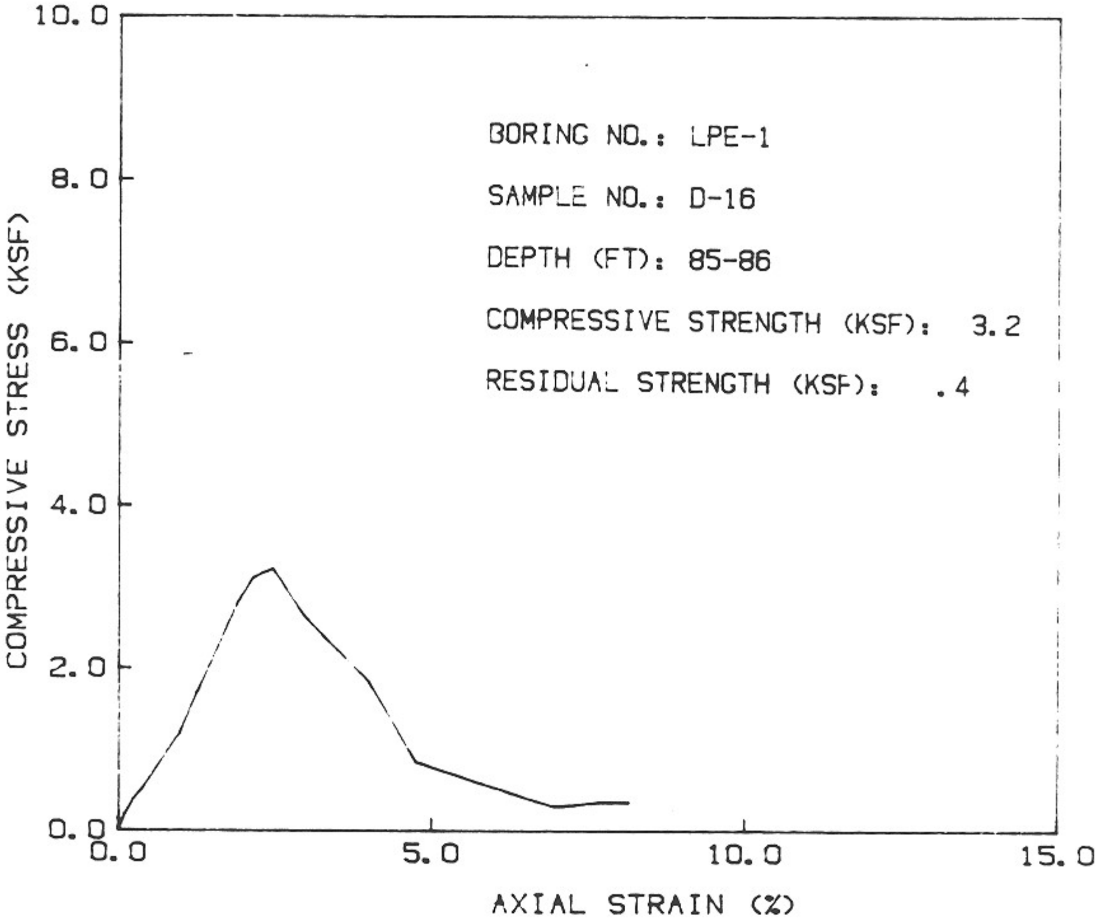

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FIGURE B-117

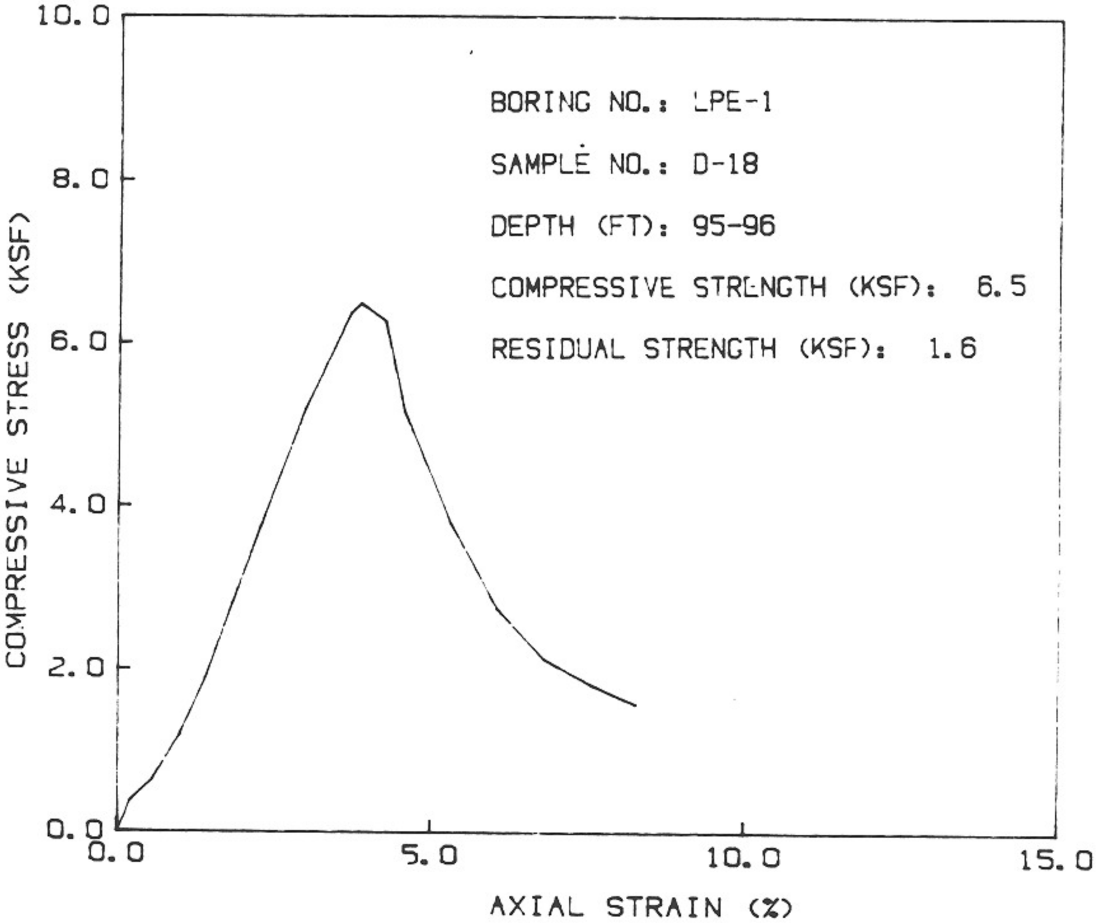

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FIGURE B-118

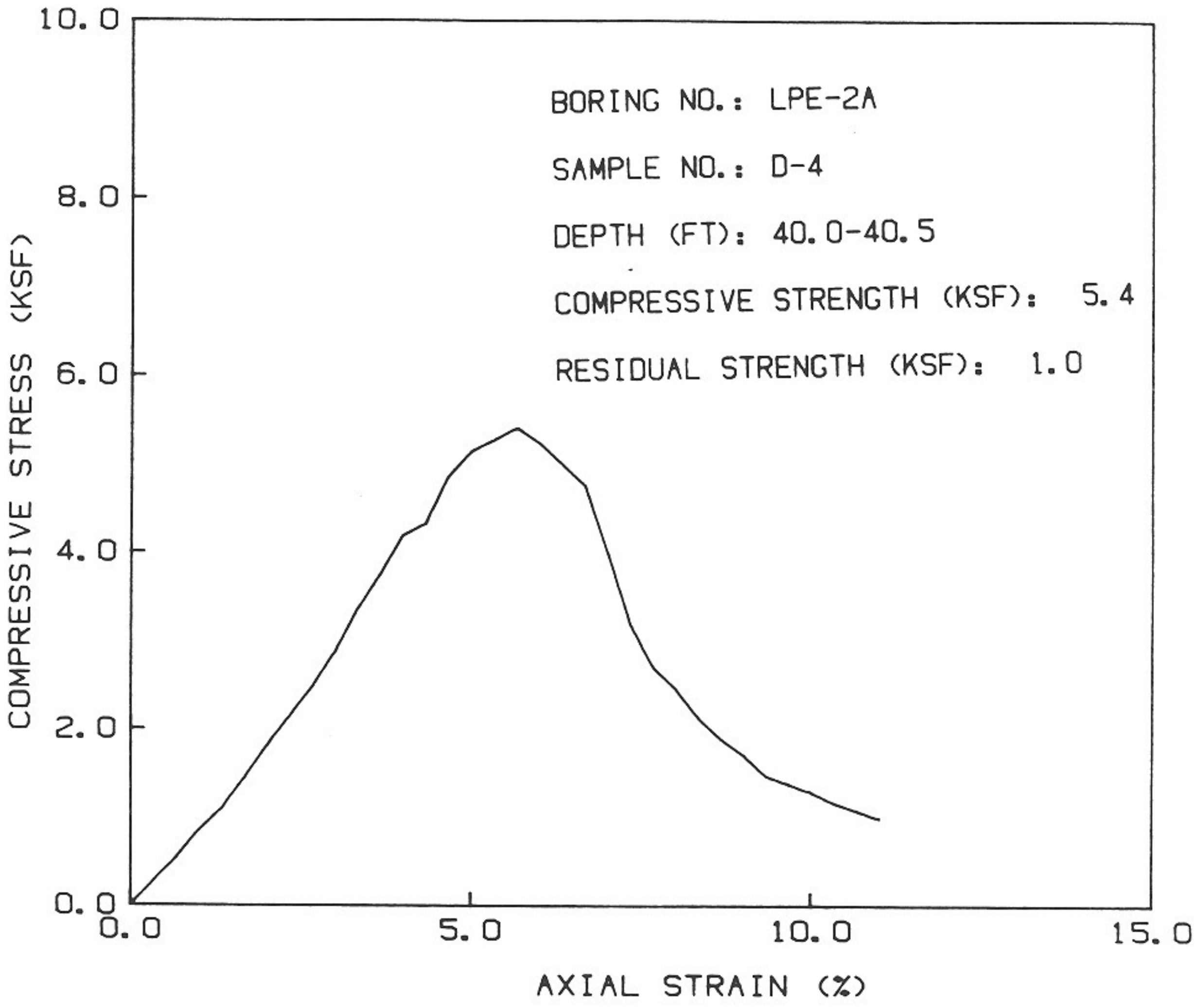

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FIGURE B-119

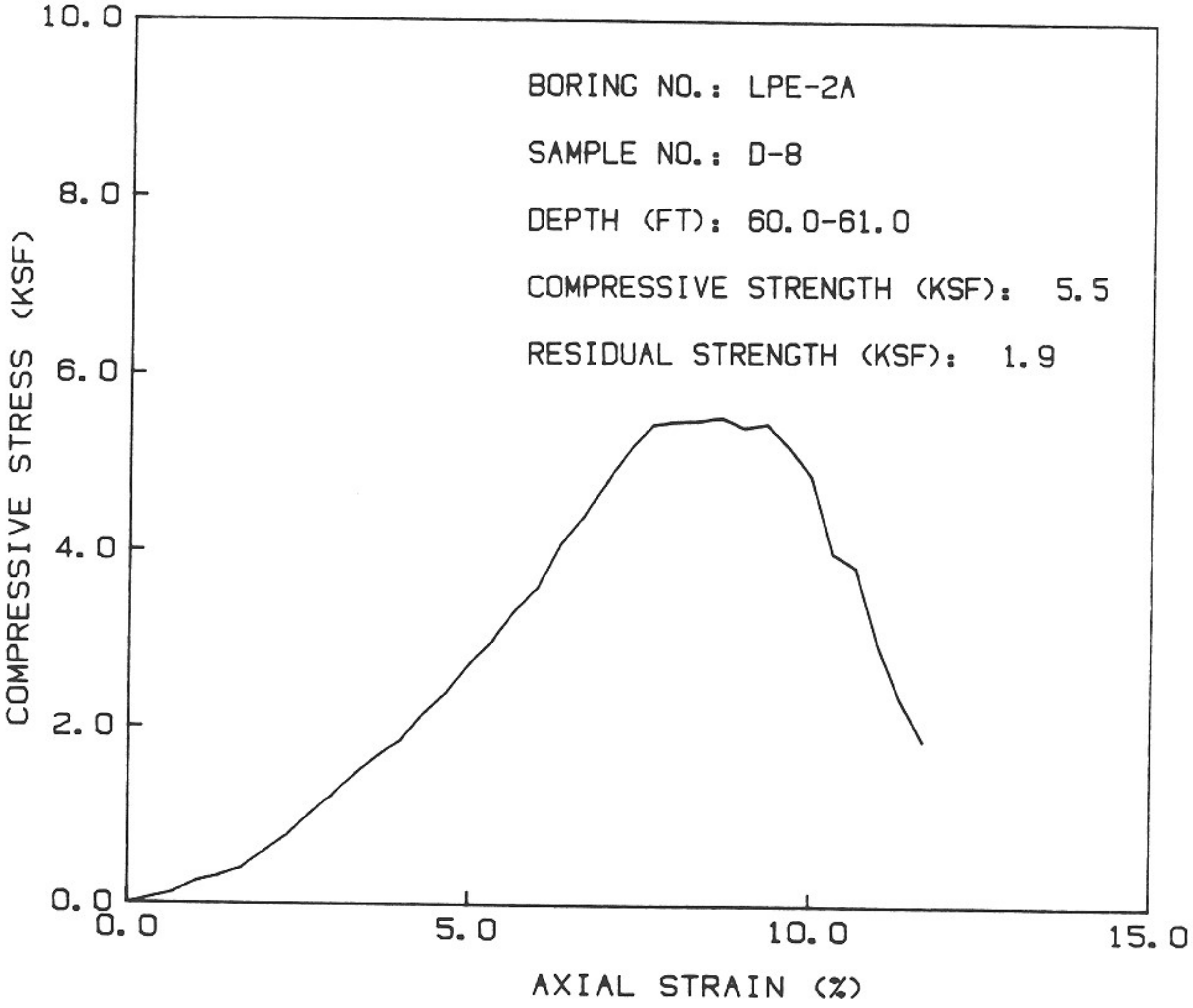

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FIGURE B-120

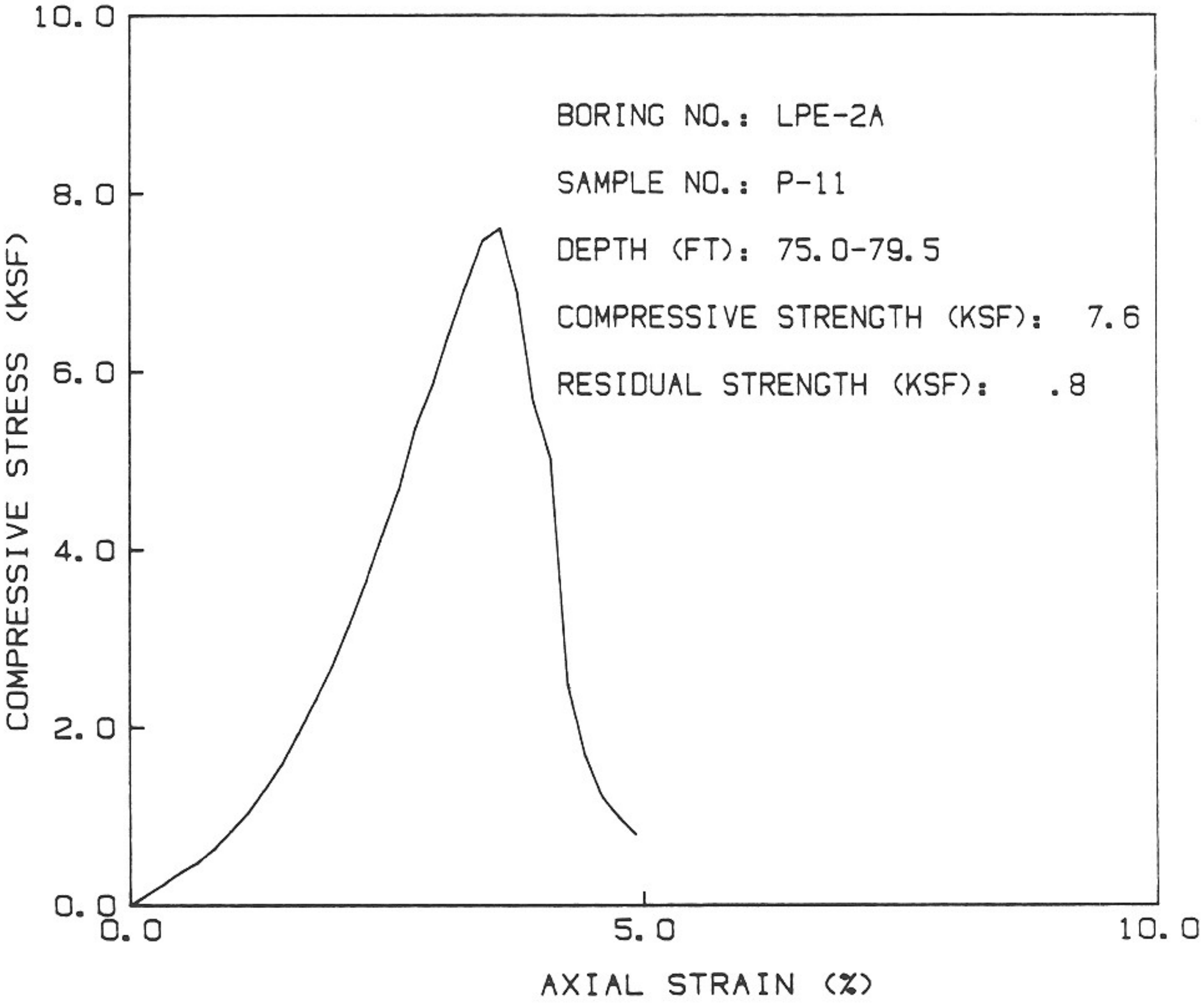

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FIGURE B-121

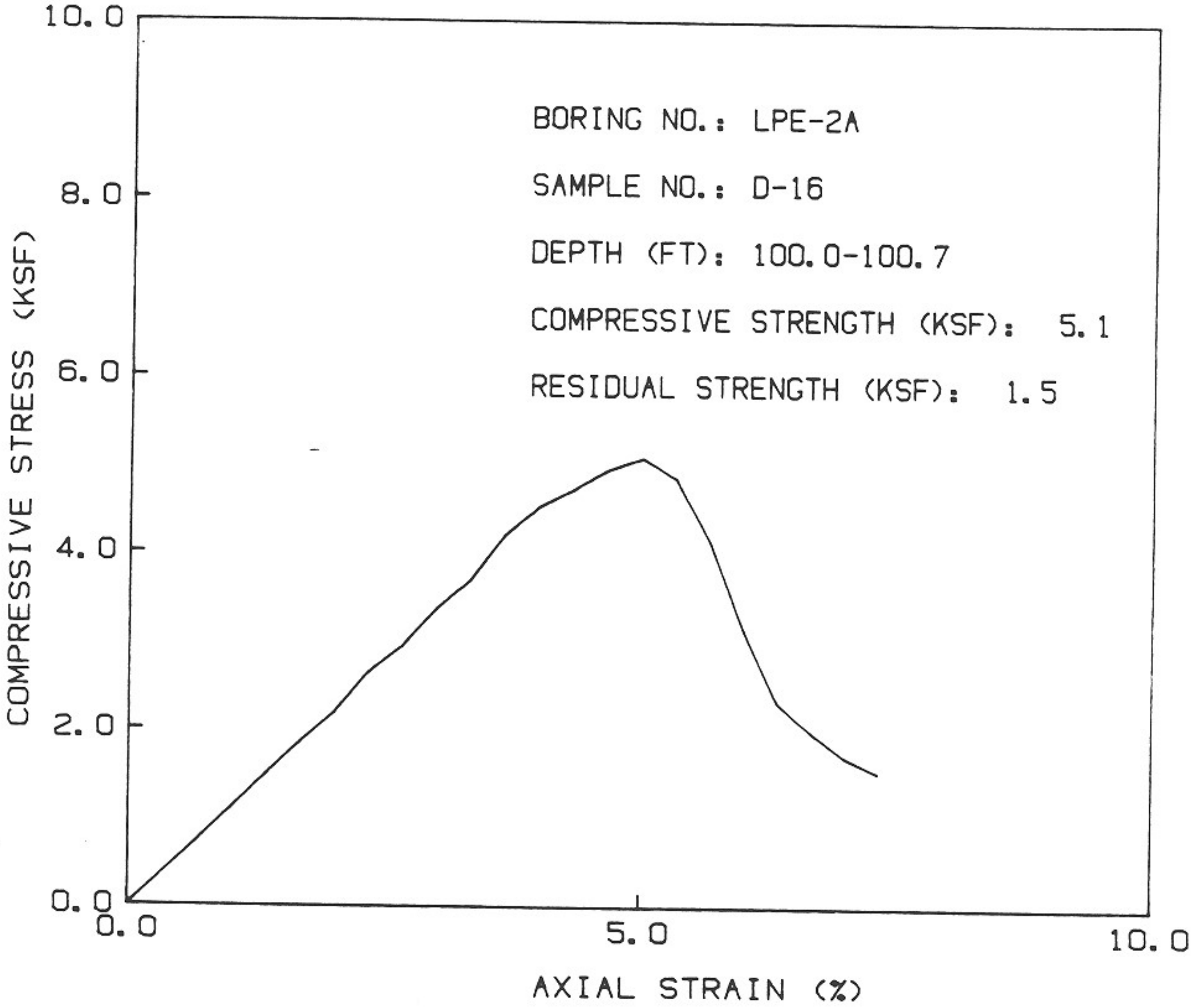

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FIGURE B-122

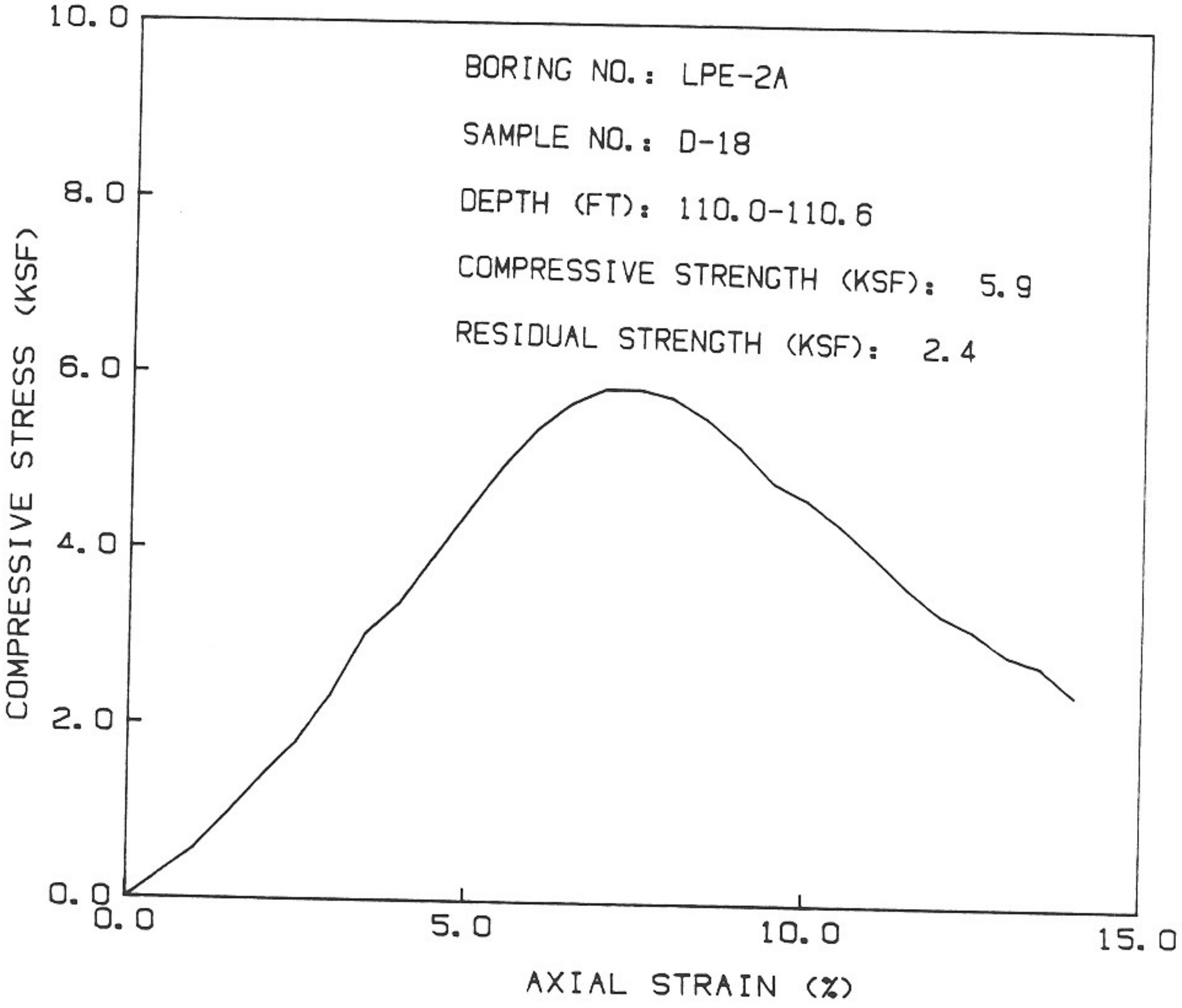

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FIGURE B-123

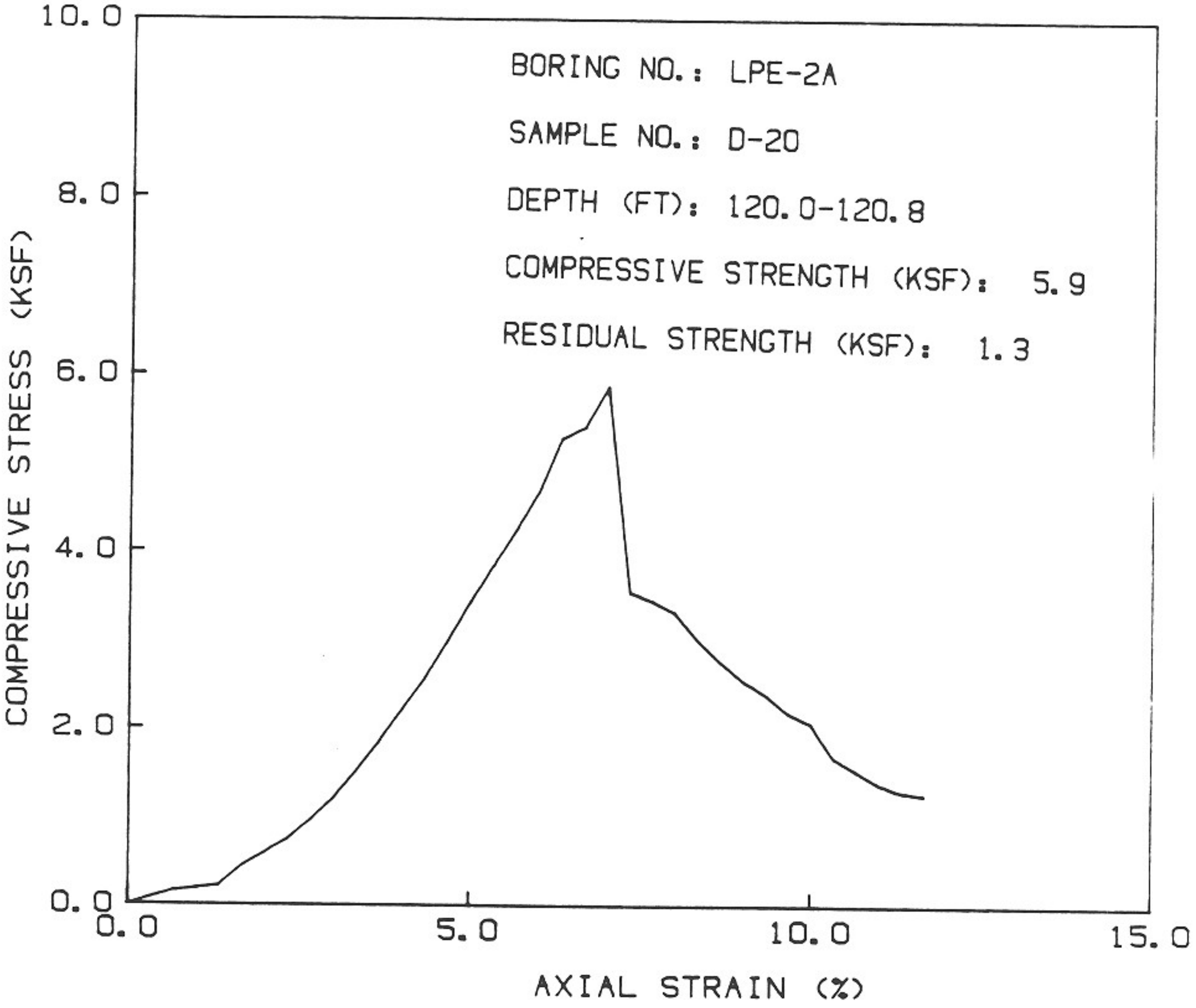

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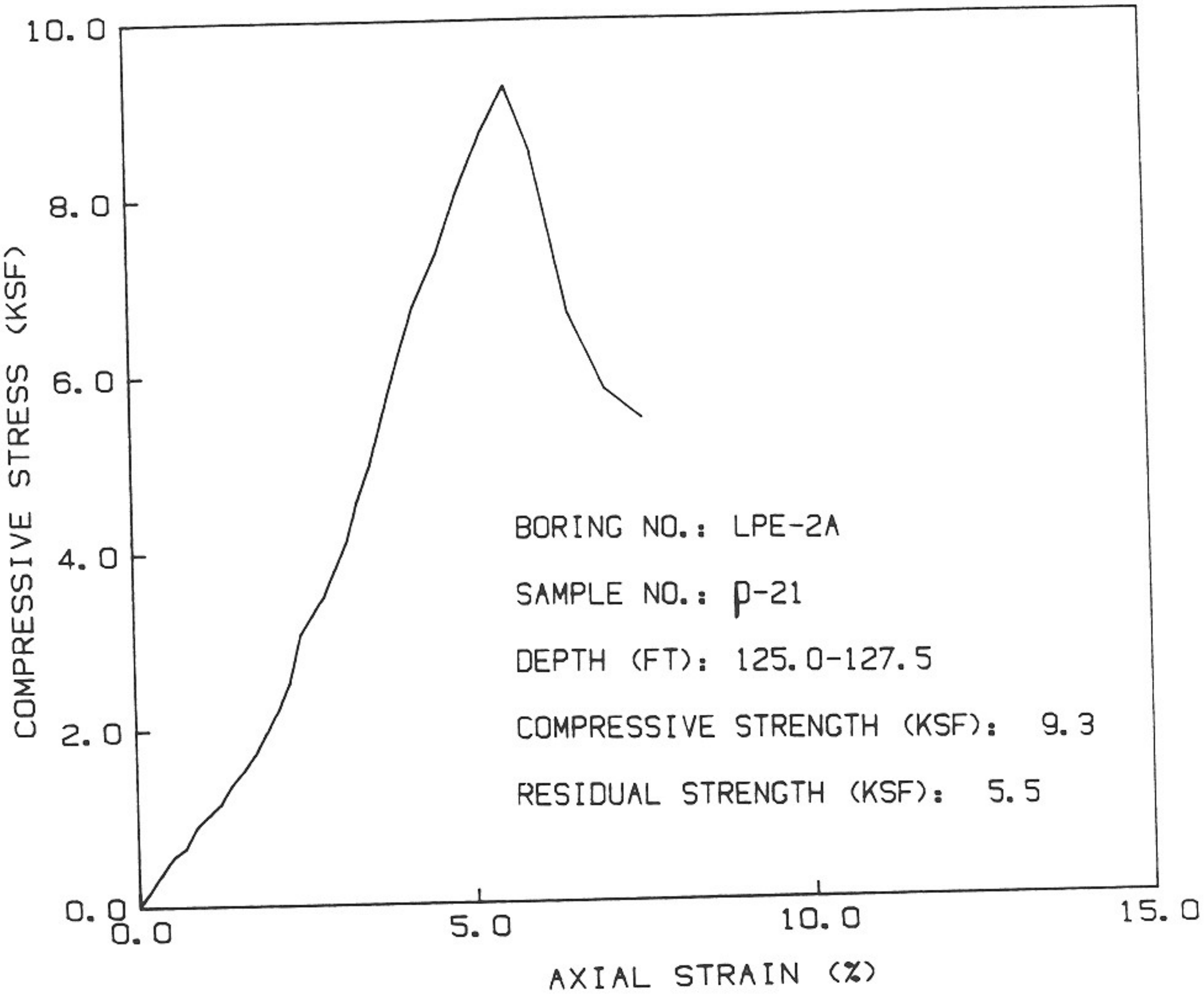
FIGURE B-124



BORING NO.: LPE-2A

SAMPLE NO.: P-21

DEPTH (FT): 125.0-127.5

COMPRESSIVE STRENGTH (KSF): 9.3

RESIDUAL STRENGTH (KSF): 5.5

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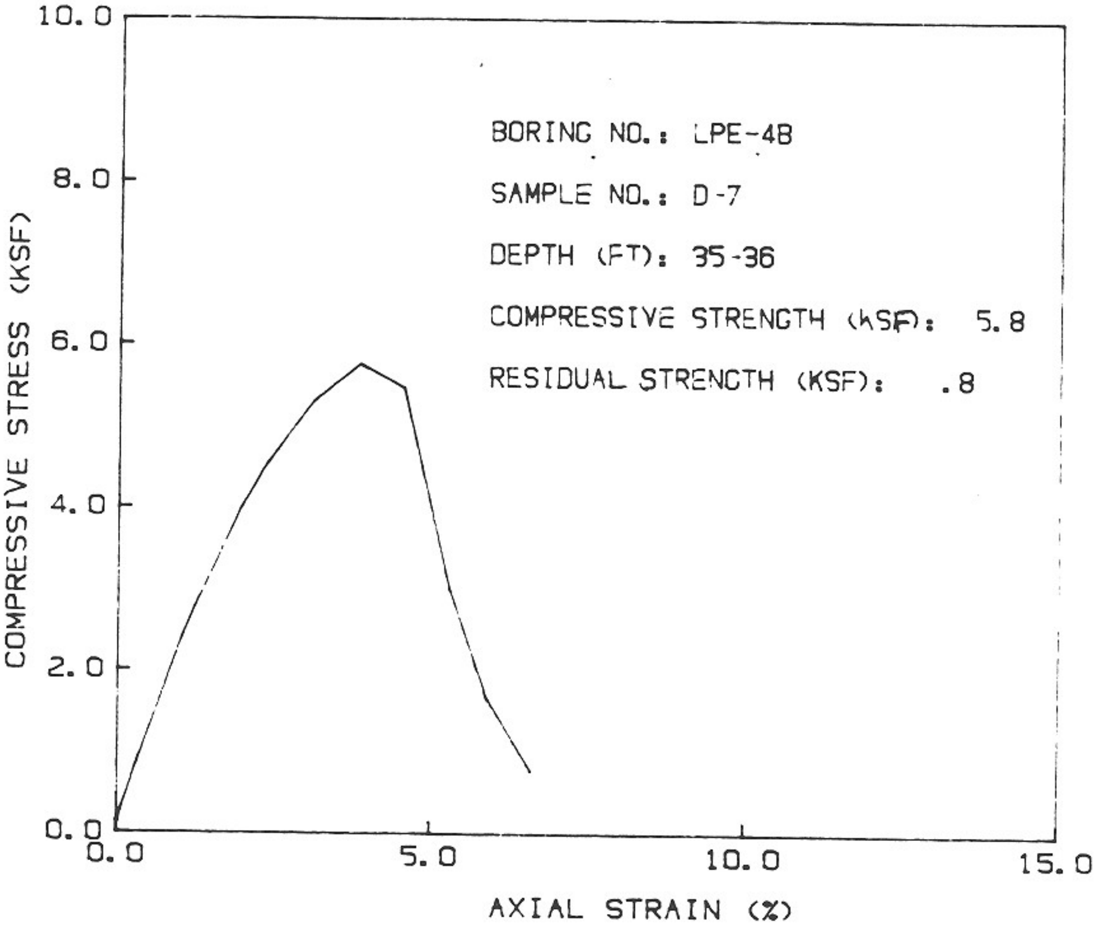
FIGURE B-125



The Earth Technology Corporation

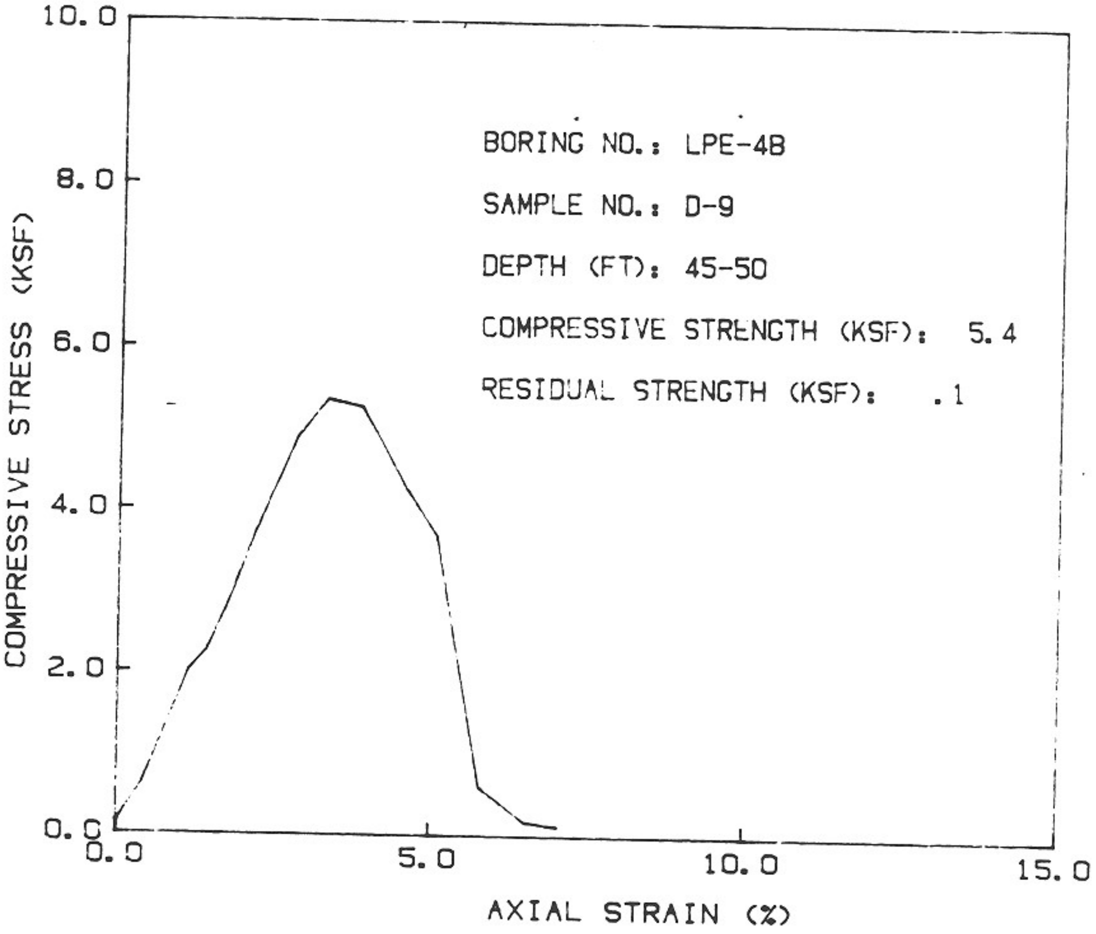
PROJECT NO.: 88-429

METRO RAIL MOS-2

UNCONFINED COMPRESSION TEST RESULTS

12/88

FIGURE B-126

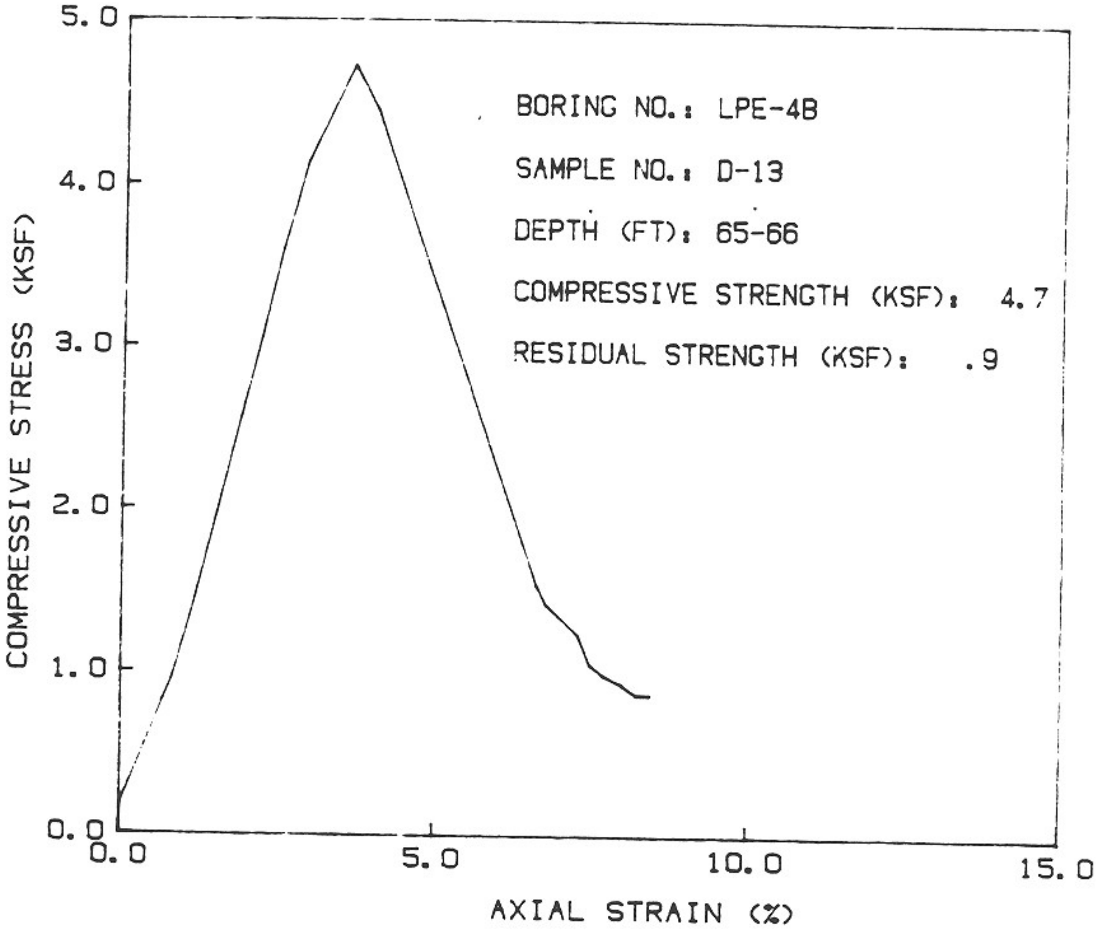


The Earth Technology Corporation	**PROJECT NO.:** 88-429 **METRO RAIL MOS-2**

UNCONFINED COMPRESSION TEST RESULTS

12/88

FIGURE B-127



The Earth Technology Corporation

PROJECT NO.: 88-429

METRO RAIL MOS-2

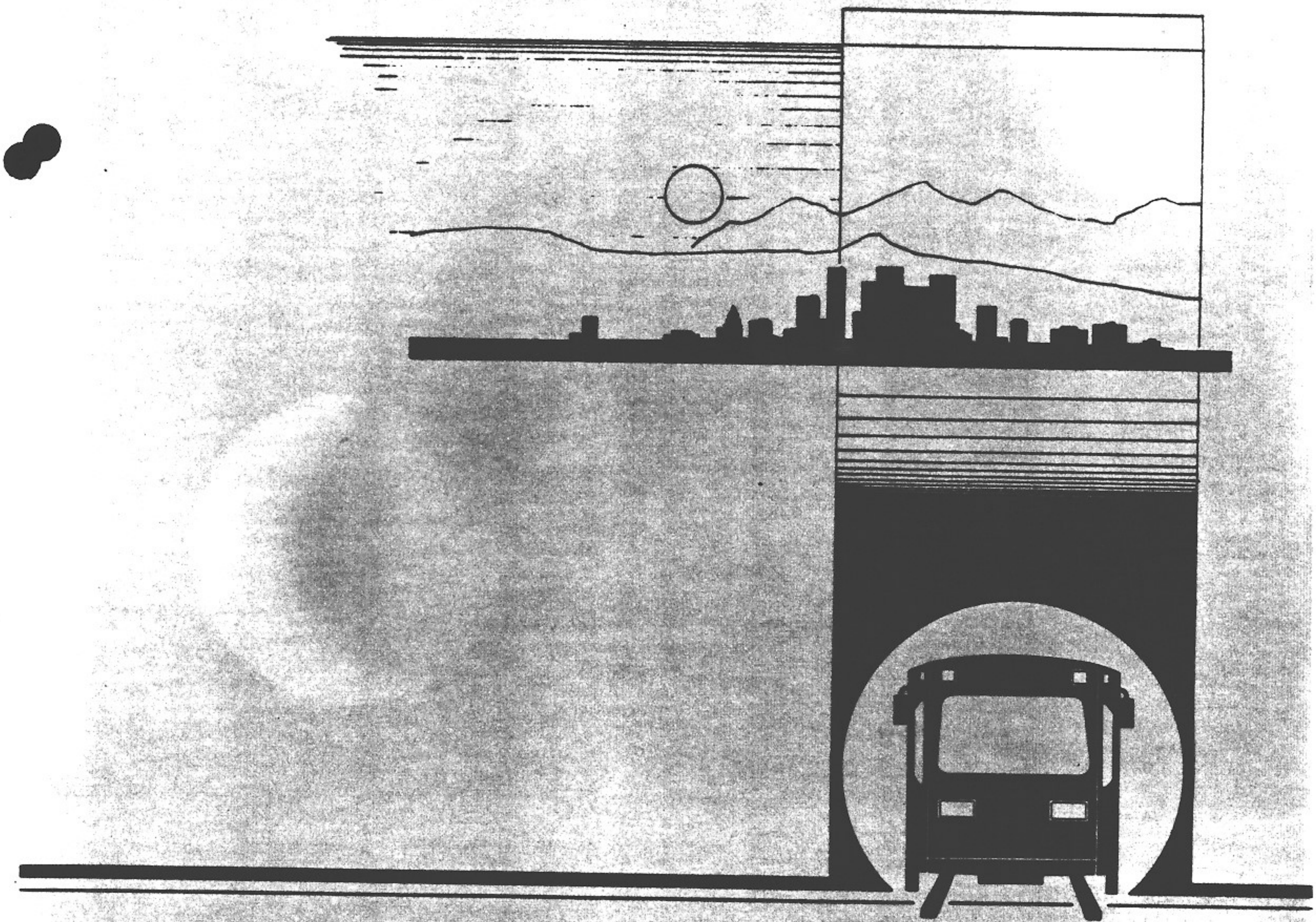
UNCONFINED COMPRESSION TEST RESULTS

12/88

FIGURE B-128

APPENDIX C

CHEMICAL LABORATORY TEST RESULTS



APPENDIX C

CHEMICAL LABORATORY TEST RESULTS

A total of 18 soil, 7 water, and 2 gas samples were selected and transported to CKY Environmental Services, Inc. of Torrance, California, and Truesdail Laboratory, Inc. of Tustin, California, for a limited characterization of potential chemical contamination. The results presented in their reports are included in this Appendix. A summary of the test results and potential effects on the MOS-2 alignment construction are described in Section 3.2 (Tables 3-3 through 3-9) and Section 6.3, respectively.

CKY

C K Y incorporated
Environmental Services

Date: 12/06/88

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

Attn: Mr. Bill Lu

Subject: Laboratory Report
Project: Metro Rail: 88-429-0012

Enclosed is the laboratory report for samples received on 11/18/88. 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)	16 Soils, 7 Water
EPA 8020 (BTEX)	16 Soils, 7 Water
EPA 8240 (VOC by GC/MS)	2 Soils
EPA 8270 (Semivolatile)	2 Soils
CAM Metals	2 Soils
EPA 9030 - Sulfide	16 Soils, 7 Water
EPA 9035 - Sulfate	16 Soils, 7 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

GKY

EPA METHOD 418.1
TOTAL RECOVERABLE PETROLEUM HYDROCARBONS

CLIENT: Earth Technology
PROJECT: Metro Rail: 88-429-0012
CONTROL NO: 881113
DATE REC'D: 11/18/88
DATE ANALYZED: 11/28/88
MATRIX TYPE: WATER

SAMPLE ID:	CONTROL NO:	RESULTS (mg/kg)	DETECTION LIMIT (mg/kg)
LPE-1	881113-1	84	5
LPE-4	881113-2	180	5
LPE-7	881113-3	96	5
LPE-8	881113-4	140	5
LPE-10	881113-5	66	5
LPE-11	881113-6	110	5
LPE-14	881113-7	81	5

CLIENT: Earth Technology
PROJECT: Metro Rail: 88-429-0012
CONTROL NO: 881113
DATE REC'D: 11/18/88
DATE ANALYZED: 11/28/88
MATRIX TYPE: SOIL

SAMPLE ID:	CONTROL NO:	RESULTS (mg/kg)	DETECTION LIMIT (mg/kg)
LPE-1/D-8	881113-8	66	5
LPE-2A/D-10	881113-10	140	5
LPE-4/D-5	881113-11	78	5
LPE-6/D-12	881113-12	84	5
LPE-7/D-7	881113-13	120	5
LPE-8/D-6	881113-14	72	5
LPE-9/D-7	881113-15	72	5
LPE-10/D-14	881113-16	78	5
LPE-11/D-13	881113-17	110	5
LPE-12/D-14	881113-18	99	5
LPE-14/D-5	881113-19	84	5
LPE-16/D-11	881113-20	81	5
LPE-20/D-18	881113-21	160	5
LPE-21/D-14	881113-22	180	5
LPE-24/D-16	881113-24	90	5
LPE-24/D-22	881113-25	75	5

GKY

EPA METHOD 8020
AROMATIC VOLATILE ORGANICS

CLIENT: Earth Technology **DATE REC'D:** 11/18/88
PROJECT: Metro Rail: 88-429-0012 **DATE ANALYZED:** 11/20/88
CONTROL NO: 881113 **MATRIX TYPE:** WATER

RESULTS (ug\L)

SAMPLE ID:	**Benzene**	**Toluene**	**Ethylbenz**	**Xylenes**
LPE-1	8	80	12	123
LPE-4	ND	ND	ND	ND
LPE-7	3	3	3	< 1
LPE-8	ND	ND	ND	ND
LPE-10	ND	ND	ND	ND
LPE-11	ND	ND	ND	ND
LPE-14	4	< 1	ND	< 1

*** DETECTION LIMITS = 1 ug/L**

CLIENT: Earth Technology **DATE REC'D:** 11/18/88
PROJECT: Metro Rail: 88-429-0012 **DATE ANALYZED:** 11/20/88
CONTROL NO: 881113 **MATRIX TYPE:** SOIL

RESULTS (ug\Kg)

SAMPLE ID:	**Benzene**	**Toluene**	**Ethylbenz**	**Xylenes**
LPE-1/D-8	5	44	ND	5
LPE-2A/D-10	ND	5	ND	< 5
LPE-4/D-5	ND	15	ND	5
LPE-6/D-12	< 5	42	ND	5
LPE-7/D-7	ND	ND	ND	ND
LPE-8/D-6	ND	ND	ND	ND
LPE-9/D-7	ND	ND	ND	ND
LPE-10/D-14	ND	ND	ND	ND
LPE-11/D-13	ND	ND	ND	ND
LPE-12/D-14	ND	ND	ND	ND
LPE-14/D-5	5	ND	ND	ND
LPE-16/D-11	< 5	< 5	ND	< 5
LPE-20/D-18	ND	25	ND	5
LPE-21/D-14	ND	33	ND	8
LPE-24/D-16	< 5	124	ND	8
LPE-24/D-22	ND	25	ND	5

*** DETECTION LIMITS = 5 ug/Kg**

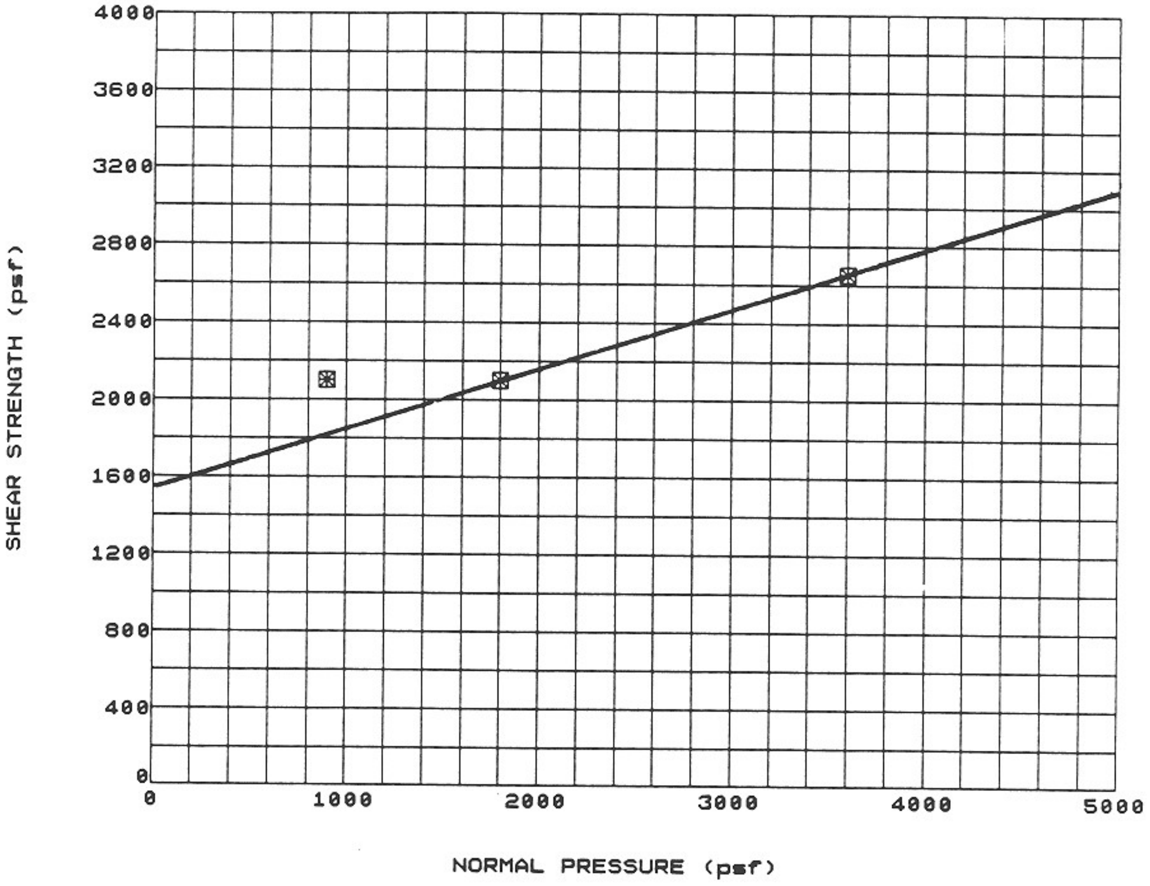
GKY

EPA METHOD - 8240
VOLATILE ORGANICS BY GC/MS

CLIENT: Earth Technology
PROJECT: Metro Rail: 88-429-0012
SAMPLE ID: LPE-2A/D-8
DATE REC'D: 11/18/88
DATE ANALYZED: 11/21/88
MATRIX TYPE: Soil

PARAMETERS (8240)	RESULTS (ug/kg)	DETECTION LIMIT (ug/kg)
Acetone	ND	100
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	100
4-Methyl-2-pentanone (MIBK)	ND	50
Styrene	ND	10
1,1,2,2-Tetrachloroethane	ND	10
Tetrachloroethene	ND	10
Toluene	75	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



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
☒	LPE-20	D - 2	15.00	DRIVE	CL/CH	1540	17	

The Earth Technology Corporation

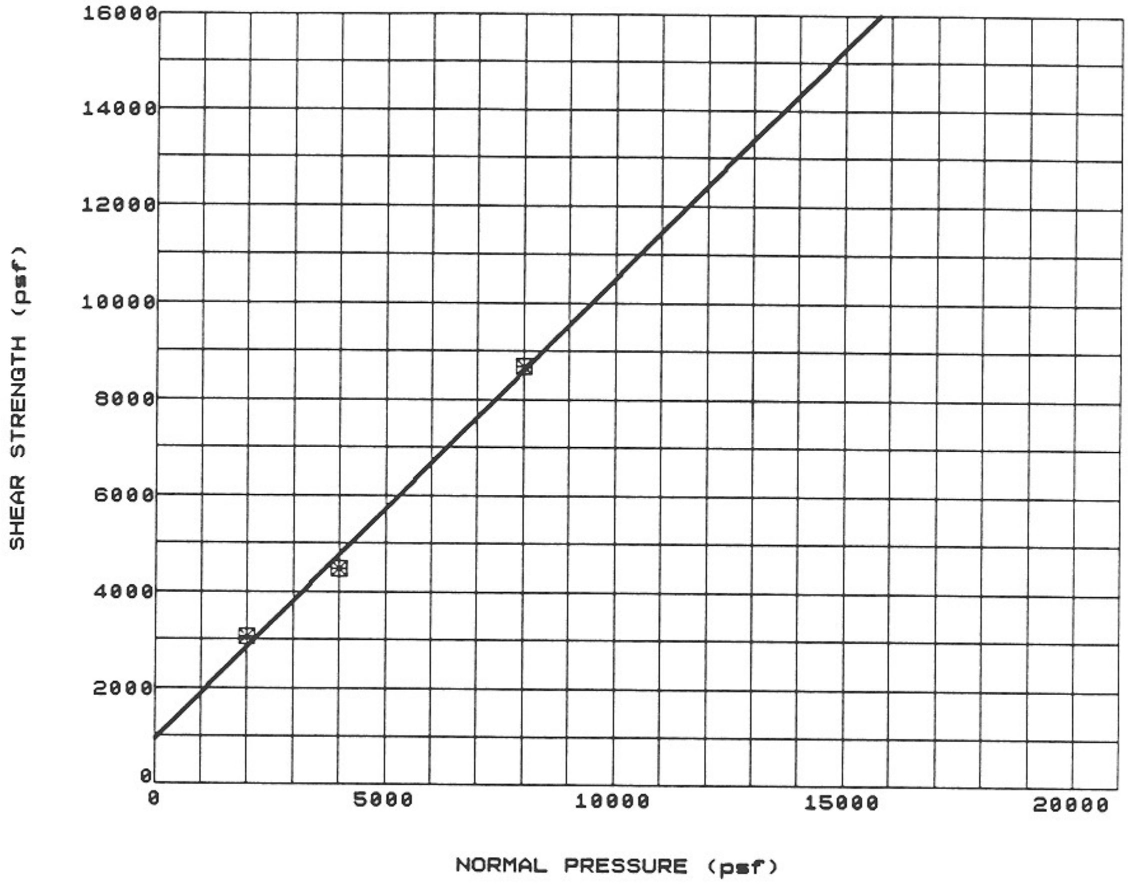
PROJECT NO.: 88-429

METRO RAIL MOS-2

DIRECT SHEAR TEST RESULTS

12/88

FIGURE B- 104



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
☒	LPE-20	D - 6	35.00	DRIVE		1000	44	

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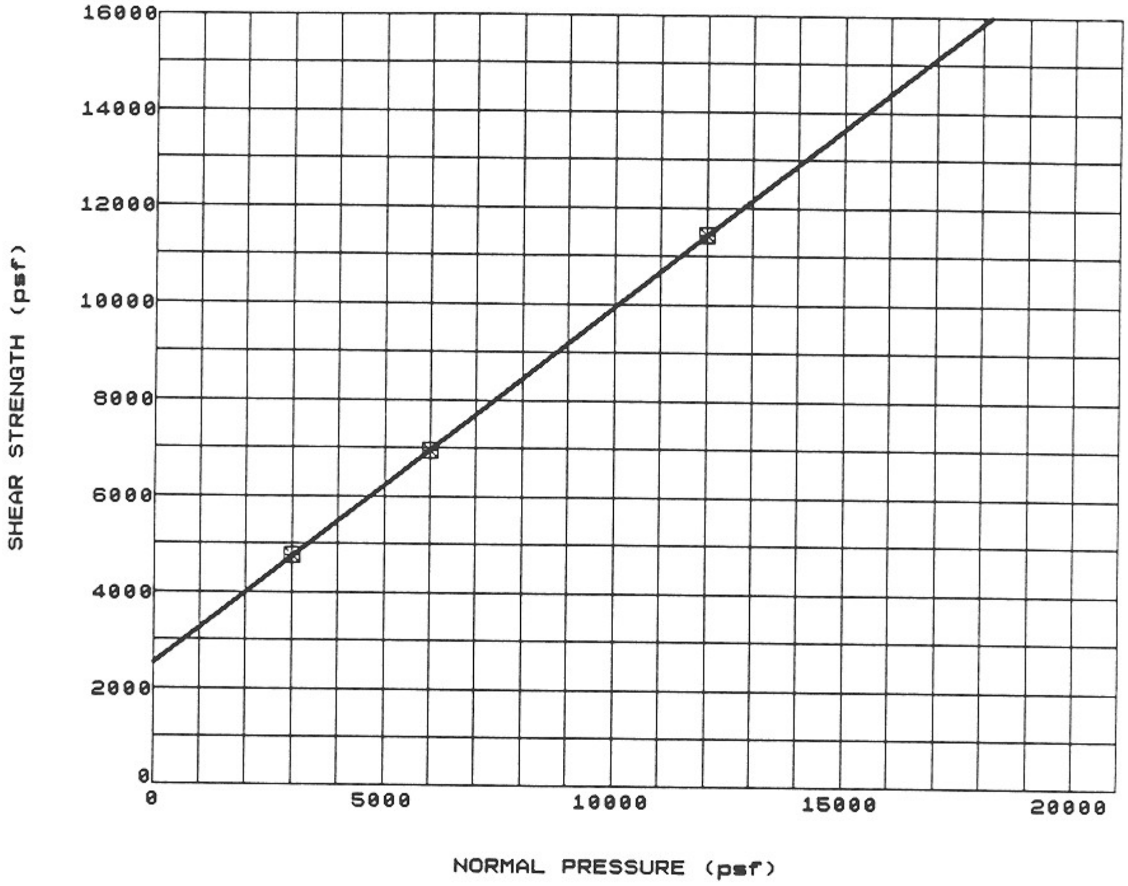
PROJECT NO.: 88-429

METRO RAIL MOS-2

DIRECT SHEAR TEST RESULTS

12/88

FIGURE B- 105



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
⊠	LPE-20	D - 8	45.00	DRIVE		2500	37	

The Earth Technology Corporation

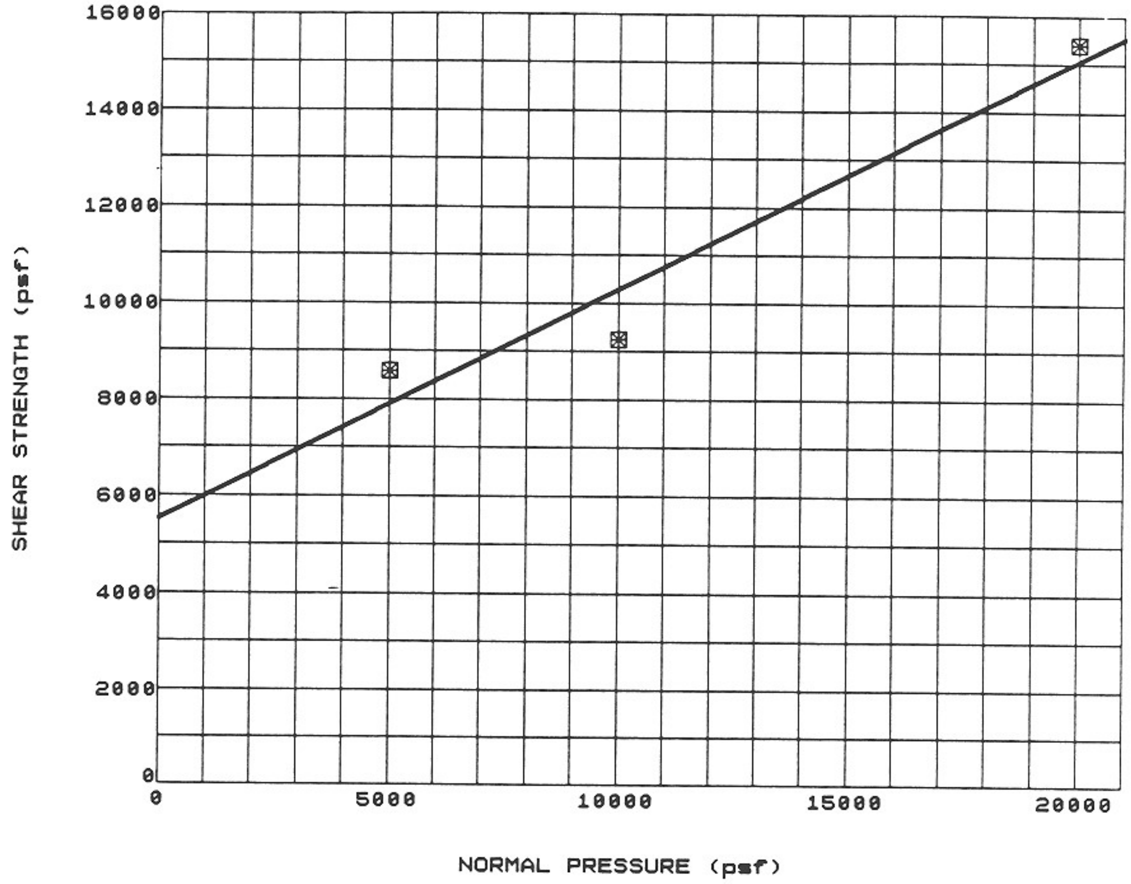
PROJECT NO.: 88-429

METRO RAIL MOS-2

DIRECT SHEAR TEST RESULTS

12/88

FIGURE B- 106



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
⊠	LPE-20	D - 16	85.00	DRIVE		5500	26	

The Earth Technology Corporation

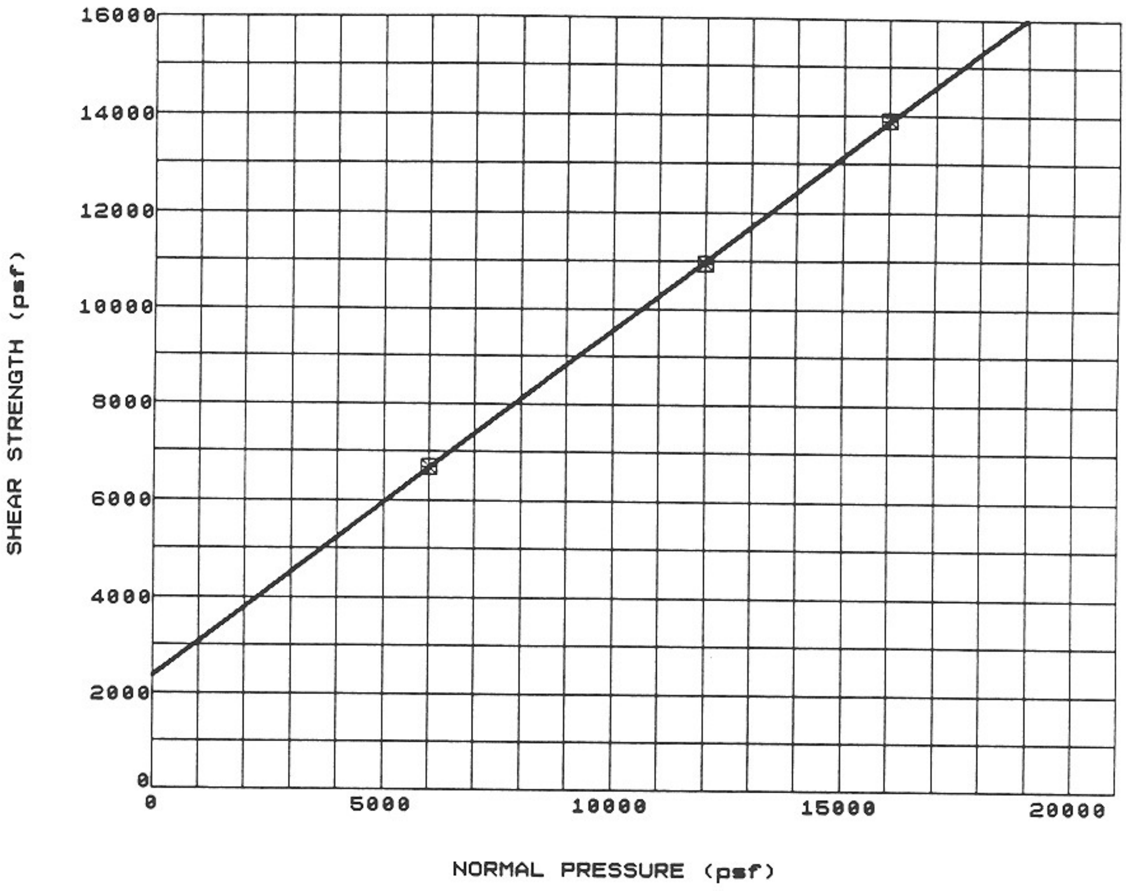
PROJECT NO.: 88-429

METRO RAIL MOS-2

DIRECT SHEAR TEST RESULTS

12/88

FIGURE B- 107



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
☒	LPE-20	D - 18	95.00	DRIVE		2400	37	

The Earth Technology Corporation

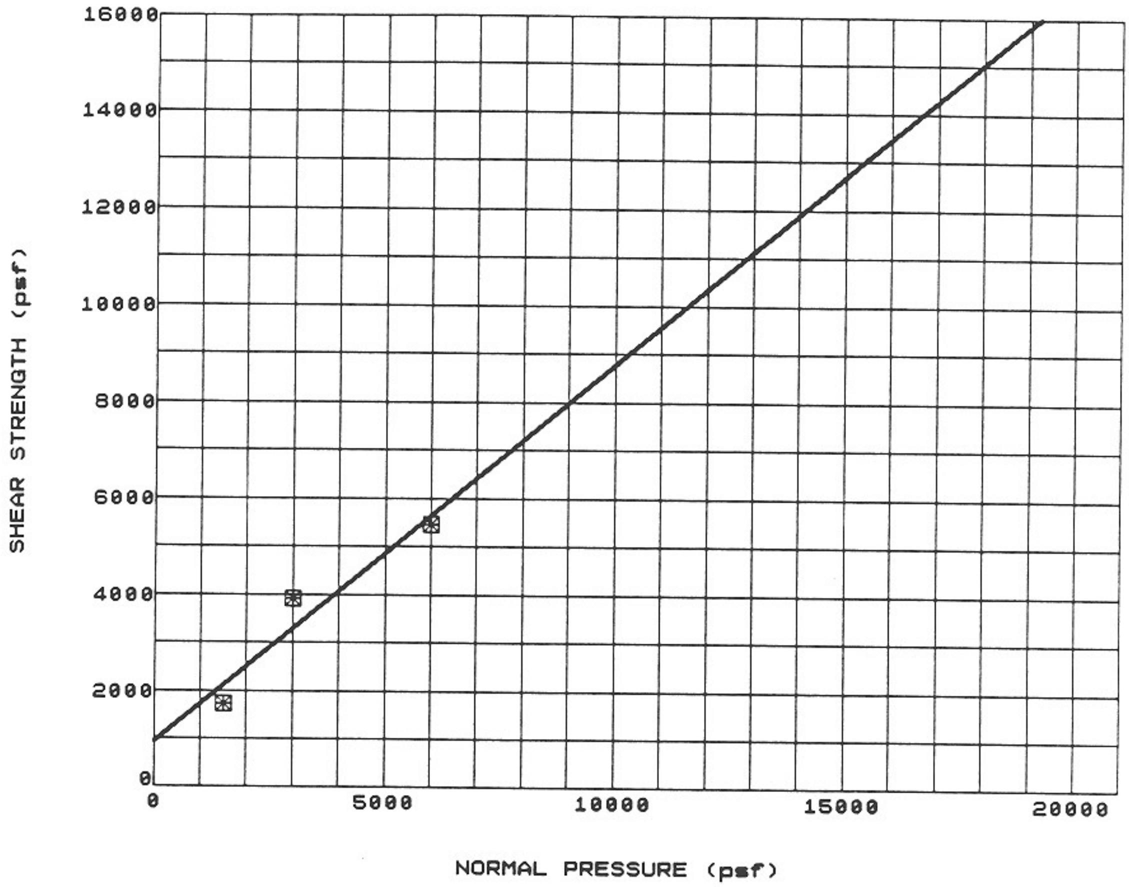
PROJECT NO.: 88-429

METRO RAIL MOS-2

DIRECT SHEAR TEST RESULTS

12/88

FIGURE B- 108



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
⊠	LPE-21	D - 5	25.00	DRIVE	SM	1000	38	

The Earth Technology Corporation

PROJECT NO.: 88-429

METRO RAIL MOS-2

DIRECT SHEAR TEST RESULTS

12/88

FIGURE B- 109

GKY

EPA METHOD - 8240
VOLATILE ORGANICS BY GC/MS

CLIENT: Earth Technology
PROJECT: Metro Rail: 88-429-0012
SAMPLE ID: LPE-24/D-18
DATE REC'D: 11/18/88
DATE ANALYZED: 11/21/88
MATRIX TYPE: Soil

PARAMETERS (8240)	**RESULTS (ug/kg)**	**DETECTION LIMIT (ug/kg)**
Acetone	ND	100
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	100
4-Methyl-2-pentanone (MIBK)	ND	50
Styrene	ND	10
1,1,2,2-Tetrachloroethane	ND	10
Tetrachloroethene	ND	10
Toluene	228	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

GKY

EPA METHOD - 8270
SEMIVOLATILE ORGANICS BY GC/MS

CLIENT: Earth Technology **DATE REC'D:** 11/18/88
PROJECT: Metro Rail: 88-429-0012 **DATE ANALYZED:** 11/21/88
SAMPLE ID: LPE-2A/D-8 **MATRIX TYPE:** Soil

PARAMETER	RESULTS (mg/kg)	PARAMETER	RESULTS (mg/kg)
Phenol	ND (0.6)	Acenaphthene	ND (0.6)
bis(2-chloroethyl)ether	ND (0.6)	2,4-Dinitrophenol	ND (3.3)
2-Chlorophenol	ND (0.6)	4-Nitrophenol	ND (3.3)
1,3-Dichlorobenzene	ND (0.6)	Dibenzofuran	ND (0.6)
1,4-Dichlorobenzene	ND (0.6)	2,4-Dinitrotoluene	ND (0.6)
Benzyl Alcohol	ND (1.3)	2,6-Dinitrotoluene	ND (0.6)
1,2-Dichlorobenzene	ND (0.6)	Diethylphthalate	ND (0.6)
2-Methylphenol	ND (0.6)	4-Chlorophenyl-phenylether	ND (0.6)
bis(2-chloroisopropyl)ether	ND (0.6)	Fluorene	ND (0.6)
4-Methylphenol	ND (0.6)	4-Nitroaniline	ND (3.3)
N-Nitroso-Di-n-Propylamine	ND (0.6)	4,6-Dinitro-2-Methylphenol	ND (3.3)
Hexachloroethane	ND (0.6)	N-Nitrosodiphenylamine	ND (0.6)
Nitrobenzene	ND (0.6)	4-Bromophenyl-phenylether	ND (0.6)
Isophorone	ND (0.6)	Hexachlorobenzene	ND (0.6)
2-Nitrophenol	ND (0.6)	Pentachlorophenol	ND (3.3)
2,4-Dimethylphenol	ND (0.6)	Phenanthrene	ND (0.6)
Benzoic Acid	ND (3.3)	Anthracene	ND (0.6)
bis-(2-Chloroethoxy)methane	ND (0.6)	Di-n-Butylphthalate	ND (0.6)
2,4-Dichlorophenol	ND (0.6)	Fluoranthene	ND (0.6)
1,2,4-Trichlorobenzene	ND (0.6)	Pyrene	ND (0.6)
Naphthalene	ND (0.6)	Butylbenzylphthalate	ND (0.6)
4-Chloroanline	ND (1.3)	3,3'-Dichlorobenzidine	ND (1.3)
Hexachlorobutadiene	ND (0.6)	Benzo(a)Anthracene	ND (0.6)
4-Chloro-3-Methylphenol	ND (1.3)	bis(2-Ethylhexyl)Phthalate	ND (0.6)
2-Methylnaphthalene	ND (0.6)	Chrysene	ND (0.6)
Hexachlorocyclopentadiene	ND (0.6)	Di-n-Octyl Phthalate	ND (0.6)
2,4,6-Trichlorophenol	ND (0.6)	Benzo(b)Fluoranthene	ND (0.6)
2,4,5-Trichlorophenol	ND (0.6)	Benzo(k)Fluoranthene	ND (0.6)
2-Chloronaphthalene	ND (0.6)	Benzo(a)Pyrene	ND (0.6)
2-Nitroaniline	ND (3.3)	Indeno(1,2,3-cd)Pyrene	ND (0.6)
Dimethyl Phthalate	ND (0.6)	Dibenz(a,h)Anthracene	ND (0.6)
Acenaphthylene	ND (0.6)	Benzo(g,h,i)Perylene	ND (0.6)
3-Nitroaniline	ND (3.3)		

ND = Not Detected
( ) = Detection Limit (mg/kg)

EPA METHOD - 8270
SEMIVOLATILE ORGANICS BY GC/MS

CLIENT: Earth Technology
PROJECT: Metro Rail: 88-429-0012
SAMPLE ID: LPE-24/D-18
DATE REC'D: 11/18/88
DATE ANALYZED: 11/21/88
MATRIX TYPE: Soil

PARAMETER	RESULTS (mg/kg)	PARAMETER	RESULTS (mg/kg)
Phenol	ND (0.6)	Acenaphthene	ND (0.6)
bis(2-chloroethyl)ether	ND (0.6)	2,4-Dinitrophenol	ND (3.3)
2-Chlorophenol	ND (0.6)	4-Nitrophenol	ND (3.3)
1,3-Dichlorobenzene	ND (0.6)	Dibenzofuran	ND (0.6)
1,4-Dichlorobenzene	ND (0.6)	2,4-Dinitrotoluene	ND (0.6)
Benzyl Alcohol	ND (1.3)	2,6-Dinitrotoluene	ND (0.6)
1,2-Dichlorobenzene	ND (0.6)	Diethylphthalate	ND (0.6)
2-Methylphenol	ND (0.6)	4-Chlorophenyl-phenylether	ND (0.6)
bis(2-chloroisopropyl)ether	ND (0.6)	Fluorene	ND (0.6)
4-Methylphenol	ND (0.6)	4-Nitroaniline	ND (3.3)
N-Nitroso-Di-n-Propylamine	ND (0.6)	4,6-Dinitro-2-Methylphenol	ND (3.3)
Hexachloroethane	ND (0.6)	N-Nitrosodiphenylamine	ND (0.6)
Nitrobenzene	ND (0.6)	4-Bromophenyl-phenylether	ND (0.6)
Isophorone	ND (0.6)	Hexachlorobenzene	ND (0.6)
2-Nitrophenol	ND (0.6)	Pentachlorophenol	ND (3.3)
2,4-Dimethylphenol	ND (0.6)	Phenanthrene	ND (0.6)
Benzoic Acid	ND (3.3)	Anthracene	ND (0.6)
bis-(2-Chloroethoxy)methane	ND (0.6)	Di-n-Butylphthalate	ND (0.6)
2,4-Dichlorophenol	ND (0.6)	Fluoranthene	ND (0.6)
1,2,4-Trichlorobenzene	ND (0.6)	Pyrene	ND (0.6)
Naphthalene	ND (0.6)	Butylbenzylphthalate	ND (0.6)
4-Chloroanline	ND (1.3)	3,3'-Dichlorobenzidine	ND (1.3)
Hexachlorobutadiene	ND (0.6)	Benzo(a)Anthracene	ND (0.6)
4-Chloro-3-Methylphenol	ND (1.3)	bis(2-Ethylhexyl)Phthalate	ND (0.6)
2-Methylnaphthalene	ND (0.6)	Chrysene	ND (0.6)
Hexachlorocyclopentadiene	ND (0.6)	Di-n-Octyl Phthalate	ND (0.6)
2,4,6-Trichlorophenol	ND (0.6)	Benzo(b)Fluoranthene	ND (0.6)
2,4,5-Trichlorophenol	ND (0.6)	Benzo(k)Fluoranthene	ND (0.6)
2-Chloronaphthalene	ND (0.6)	Benzo(a)Pyrene	ND (0.6)
2-Nitroaniline	ND (3.3)	Indeno(1,2,3-cd)Pyrene	ND (0.6)
Dimethyl Phthalate	ND (0.6)	Dibenz(a,h)Anthracene	ND (0.6)
Acenaphthylene	ND (0.6)	Benzo(g,h,i)Perylene	ND (0.6)
3-Nitroaniline	ND (3.3)		

ND = Not Detected
( ) = Detection Limit (mg/kg)

CAM METALS

CLIENT: Earth Technology
PROJECT: Metro Rail: 88-429-0012
CONTROL NO: 881113
DATE REC'D: 11/18/88
DATE ANALYZED: 11/21/88
MATRIX TYPE: Soil

SAMPLE ID:	**LPE-2A/D-8**	**LPE-24/D18**	**DET. LIMIT**
PARAMETERS	**(mg/kg)**	**(mg/kg)**	**(mg/Kg)**
Antimony	< 5.0	< 5.0	5.0
Arsenic	3.7	12.8	1.0
Barium	97.0	51.0	5.0
Beryllium	< 1.0	< 1.0	1.0
Cadmium	1.6	1.3	1.0
Chromium - Total	31.8	40.3	1.0
Cobalt	13.7	13.2	1.0
Copper	27.4	34.6	1.0
Lead	< 1.0	14.2	1.0
Mercury	< 0.05	0.50	0.05
Molybdenum	< 1.0	< 1.0	1.0
Nickel	25.9	27.4	1.0
Selenium	< 1.0	< 1.0	1.0
Silver	< 1.0	< 1.0	1.0
Thallium	6.7	6.3	1.0
Vanadium	49.6	43.7	5.0
Zinc	67.5	75.3	1.0

EPA METHODS 9030 & 9035
SULFIDE and SULFATE

CLIENT:	Earth Technology	**DATE REC'D:**	11/18/88
PROJECT:	Metro Rail: 88-429-0012	**DATE ANALYZED:**	11/26-12/6
CONTROL NO:	881113	**MATRIX TYPE:**	WATER

SAMPLE ID:	**CONTROL NO:**	**SULFIDE**		**SULFATE**	
		(ppm)	**(DL)**	**(ppm)**	**(DL)**
LPE-1	881113-1	< 1	(1)	680	(50)
LPE-4	881113-2	< 1	(1)	1,600	(50)
LPE-7	881113-3	< 1	(1)	160	(50)
LPE-8	881113-4	< 1	(1)	95	(50)
LPE-10	881113-5	< 1	(1)	180	(50)
LPE-11	881113-6	< 1	(1)	160	(50)
LPE-14	881113-7	< 1	(1)	150	(50)

CLIENT:	Earth Technology	**DATE REC'D:**	11/18/88
PROJECT:	Metro Rail: 88-429-0012	**DATE ANALYZED:**	11/26-12/6
CONTROL NO:	881113	**MATRIX TYPE:**	SOIL

SAMPLE ID:	**CONTROL NO:**	**SULFIDE**		**SULFATE**	
		(ppm)	**(DL)**	**(ppm)**	**(DL)**
LPE-1/D-8	881113-8	< 3	(3)	900	(50)
LPE-2A/D-10	881113-10	< 10	(10)	100	(50)
LPE-4/D-5	881113-11	< 3	(3)	210	(50)
LPE-6/D-12	881113-12	< 3	(3)	1,100	(50)
LPE-7/D-7	881113-13	< 3	(3)	< 50	(50)
LPE-8/D-6	881113-14	< 3	(3)	< 50	(50)
LPE-9/D-7	881113-15	< 3	(3)	< 50	(50)
LPE-10/D-14	881113-16	< 3	(3)	170	(50)
LPE-11/D-13	881113-17	< 3	(3)	< 50	(50)
LPE-12/D-14	881113-18	< 3	(3)	< 50	(50)
LPE-14/D-5	881113-19	< 3	(3)	< 50	(50)
LPE-16/D-11	881113-20	< 3	(3)	< 50	(50)
LPE-20/D-18	881113-21	< 3	(3)	1,300	(50)
LPE-21/D-14	881113-22	< 3	(3)	1,100	(50)
LPE-24/D-16	881113-24	36	(10)	640	(50)
LPE-24/D-22	881113-25	85	(10)	130	(50)

* Note: **DL** = Detection Limit

REPORT

TRUESDAIL LABORATORIES, INC.

CHEMISTS - MICROBIOLOGISTS - ENGINEERS
RESEARCH - DEVELOPMENT - TESTING

14201 FRANKLIN AVENUE
TUSTIN, CALIFORNIA 92680
AREA CODE 714 • 730-6239
AREA CODE 213 • 225-1564
CABLE: TRUELABS

CLIENT
CKY, Inc.
3551 Voyager St. Suite 102
Torrance, CA. 90503
Attention: Dan Hong

DATE December 14, 1988

RECEIVED December 8, 1988

LABORATORY NO. 26148

SAMPLE 2 air samples from Metro Rail project.

INVESTIGATION

H_2S, EPA 624, permanent gases, total nonmethane hydrocarbons, and C_1 to C_6 hydrocarbons.

RESULTS

On December 8, 1988 a representative of Truesdail Laboratories, Inc collected air samples from two locations (LPE-1, LPE-4) of the Metro- Rail project in Los Angeles, California. For each location, a sample of the air was collected with a Teflon sampling line connected to an SKC model 222 diaphragm pump and a 5-liter Tedlar bag.

The bags were analyzed for volatile organics by EPA method 624 utilizing gas chromatography with a Tekmar purge and trap sample concentrator and detection by mass spectrometry.

Hydrogen sulfide (H_2S) and sulfur compounds were determined by gas chromatography with flame photometric detection (CARB method 16) against a 10 ppm H_2S standard.

The total nonmethane hydrocarbons were determine by gas chromatography utilizing Tenax adsorption at 0°C to isolate the nonmethane hydrocarbons, followed by desorption at 100°C, combustion-oxidation of the desorbed hydrocarbons to CO_2, and detection of the CO_2 by nondispersive infrared spectrophotometry (SCAQMD method 25.2).

The permanent gases (nitrogen, oxygen, methane, and carbon monoxide) were determined by gas chromatography with thermal conductivity detection (SCAQMD method 10.1). Carbon dioxide was determined by Orsat (EPA method 3).

The normal hydrocarbon speciation (C_1 to C_6) was determined by gas chromatography with flame ionization detection (EPA method 18).

The results are as follows:

Metro Rail Project
12-8-88

Sample I.D.	LPE-1	LPE-4
Acetone, ppmv	43	52
Methylethylketone, ppmv	1414	2798
Hydrogen Sulfide, ppmv	<0.1	<0.1
Sulfur Compounds ppmv as H_2S	<0.1	<0.1
Nitogen, %v	82.7	*
Oxygen, %v	12.8	*
Methane, %v	<0.1	*
Carbon Dioxide, %v	3.6	*
Nonmethane HC, ppmv C_1	1224	*
C_1 to C_6 HC, ppmv each	<1	*

* Bag flat - no analysis.

Respectfully submitted,

TRUESDAIL LABORATORIES, INC.

S. Hugh Brown

S. Hugh Brown, Supervisor
Air Pollution Testing

TRUESDAIL LABORATORIES, INC.

Earth Technology Corp.

Date: December 14, 1988
Recv'd: December 8, 1988
Lab. No.: 26148

Attn:

Sample: Two(2) Tedlar bags labelled LPE-1 and LPE-4.

P.O. No.:

Investigation: Analyze for volatile organics by modified EPA 624.

RESULTS

The tabulated results for EPA 624 are enclosed.

Both samples had high levels of tetrahydrofuran which was not analyzed quantitatively. The high concentrations of tetrahydrofuran, methylethylketone (2-butanone), and acetone necessitated running the analysis at higher detection limits for the normal EPA 624 constituents.

The major constituents are listed below:

	Microliters per Liter (ppm)	
	LPE-1	LPE-4
Acetone	43.2	51.7
Methylethylketone	1414.0	2798.0
Tetrahydrofuran	NQ	NQ

NQ-Not quantitated.

The compounds found in the bag samples are common in paint and coating products.

TRUESDAIL LABORATORIES, INC.

Client: Earth Technology Corp.
Attention:
Project No:
Lab Number: 26148
Sample ID: LPE-1
Analyst: S.M.

Report Date: 14-Dec-88
Date Recv'd: 8-Dec-88
Date Sampled: 1-Mar-88
Date Analyzed: 9-Dec-88
Instr. No.: GCMS #1
Dil. Factor: 50

INVESTIGATION: Purgeable Organics (Volatiles) by GCMS (EPA 624)

Constituent	Approximate Detection Limit*	Concentration:PPM (Microliters/Liter)**
Acetone	10.0 nl/L	43.2 Detected
Benzene	5.0 nl/L	ND< 0.5
Bromodichloromethane	5.0 nl/L	ND< 0.5
Bromoform	5.0 nl/L	ND< 0.5
Bromomethane	5.0 nl/L	ND< 0.5
Carbon Tetrachloride	5.0 nl/L	ND< 0.5
Chlorobenzene-HALL	5.0 nl/L	ND< 0.5
Chloroethane	5.0 nl/L	ND< 0.5
2-Chloroethylvinyl ether	10.0 nl/L	ND< 1.0
Chloroform	5.0 nl/L	ND< 0.5
Chloromethane	5.0 nl/L	ND< 0.5
Dibromochloromethane	5.0 nl/L	ND< 0.5
1,2-Dichlorobenzene	5.0 nl/L	ND< 0.5
1,3-Dichlorobenzene	5.0 nl/L	ND< 0.5
1,4-Dichlorobenzene	5.0 nl/L	ND< 0.5
Dichlorodifluoromethane	5.0 nl/L	ND< 0.5
1,1-Dichloroethane	5.0 nl/L	ND< 0.5
1,2-Dichloroethane	5.0 nl/L	ND< 0.5
1,1-Dichloroethene	5.0 nl/L	ND< 0.5
trans 1,2-Dichloroethene	5.0 nl/L	ND< 0.5
1,2-Dichloropropane	5.0 nl/L	ND< 0.5
cis 1,3-Dichloropropene	5.0 nl/L	ND< 0.5
trans 1,3-Dichloropropene	5.0 nl/L	ND< 0.5
Ethyl Benzene	5.0 nl/L	ND< 0.5
Methylene Chloride	10.0 nl/L	ND< 1.0
Methyl Ethyl Ketone	10.0 nl/L	1414.0 Detected
1,1,2,2-Tetrachloroethane	5.0 nl/L	ND< 0.5
Tetrachloroethene	9.0 nl/L	ND< 0.9
Toluene	9.0 nl/L	ND< 0.9
1,1,1-Trichloroethane	5.0 nl/L	ND< 0.5
1,1,2-Trichloroethane	5.0 nl/L	ND< 0.5
Trichloroethene	5.0 nl/L	ND< 0.5
Trichlorofluoromethane	5.0 nl/L	ND< 0.5
Vinyl chloride	10.0 nl/L	ND< 1.0
Xylenes	5.0 nl/L	ND< 0.5

* Detection limits may vary with the type of sample and with the concentrations of other species present.

** ND = Not detected; constituent is below the detection limit for this sample.

*** NA = Not analyzed; constiuent was not included in standard.

TRUESDAIL LABORATORIES, INC.

Client: Earth Technology Corp.
Attention:
Project No:
Lab Number: 26148
Sample ID: LPE-4
Analyst: S.M.

Report Date: 14-Dec-88
Date Recv'd: 8-Dec-88
Date Sampled: 1-Mar-88
Date Analyzed: 9-Dec-88
Instr. No.: GCMS #1
Dil. Factor: 50

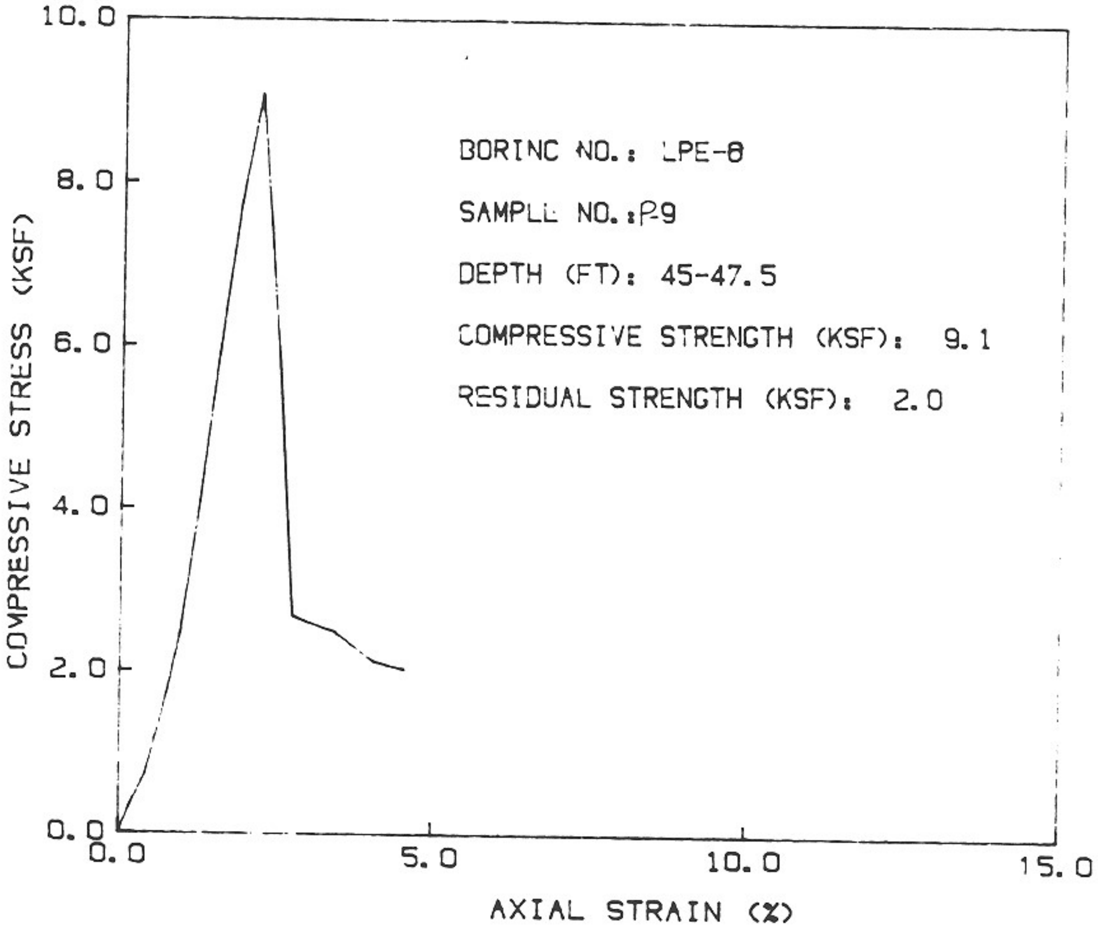
INVESTIGATION: Purgeable Organics (Volatiles) by GCMS (EPA 624)

Constituent	Approximate Detection Limit*	Concentration:PPM (Microliters/Liter)**
Acetone	10.0 nl/L	51.7 Detected
Benzene	5.0 nl/L	ND< 0.5
Bromodichloromethane	5.0 nl/L	ND< 0.5
Bromoform	5.0 nl/L	ND< 0.5
Bromomethane	5.0 nl/L	ND< 0.5
Carbon Tetrachloride	5.0 nl/L	ND< 0.5
Chlorobenzene-HALL	5.0 nl/L	ND< 0.5
Chloroethane	5.0 nl/L	ND< 0.5
2-Chloroethylvinyl ether	10.0 nl/L	ND< 1.0
Chloroform	5.0 nl/L	ND< 0.5
Chloromethane	5.0 nl/L	ND< 0.5
Dibromochloromethane	5.0 nl/L	ND< 0.5
1,2-Dichlorobenzene	5.0 nl/L	ND< 0.5
1,3-Dichlorobenzene	5.0 nl/L	ND< 0.5
1,4-Dichlorobenzene	5.0 nl/L	ND< 0.5
Dichlorodifluoromethane	5.0 nl/L	ND< 0.5
1,1-Dichloroethane	5.0 nl/L	ND< 0.5
1,2-Dichloroethane	5.0 nl/L	ND< 0.5
1,1-Dichloroethene	5.0 nl/L	ND< 0.5
trans 1,2-Dichloroethene	5.0 nl/L	ND< 0.5
1,2-Dichloropropane	5.0 nl/L	ND< 0.5
cis 1,3-Dichloropropene	5.0 nl/L	ND< 0.5
trans 1,3-Dichloropropene	5.0 nl/L	ND< 0.5
Ethyl Benzene	5.0 nl/L	ND< 0.5
Methylene Chloride	10.0 nl/L	ND< 1.0
Methyl Ethyl Ketone	10.0 nl/L	2798.0 Detected
1,1,2,2-Tetrachloroethane	5.0 nl/L	ND< 0.5
Tetrachloroethene	9.0 nl/L	ND< 0.9
Toluene	9.0 nl/L	ND< 0.9
1,1,1-Trichloroethane	5.0 nl/L	ND< 0.5
1,1,2-Trichloroethane	5.0 nl/L	ND< 0.5
Trichloroethene	5.0 nl/L	ND< 0.5
Trichlorofluoromethane	5.0 nl/L	ND< 0.5
Vinyl chloride	10.0 nl/L	ND< 1.0
Xylenes	5.0 nl/L	ND< 0.5

* Detection limits may vary with the type of sample and with the concentrations of other species present.

** ND = Not detected; constituent is below the detection limit for this sample.

*** NA = Not analyzed; constiuent was not included in standard.



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UNCONFINED COMPRESSION TEST RESULTS

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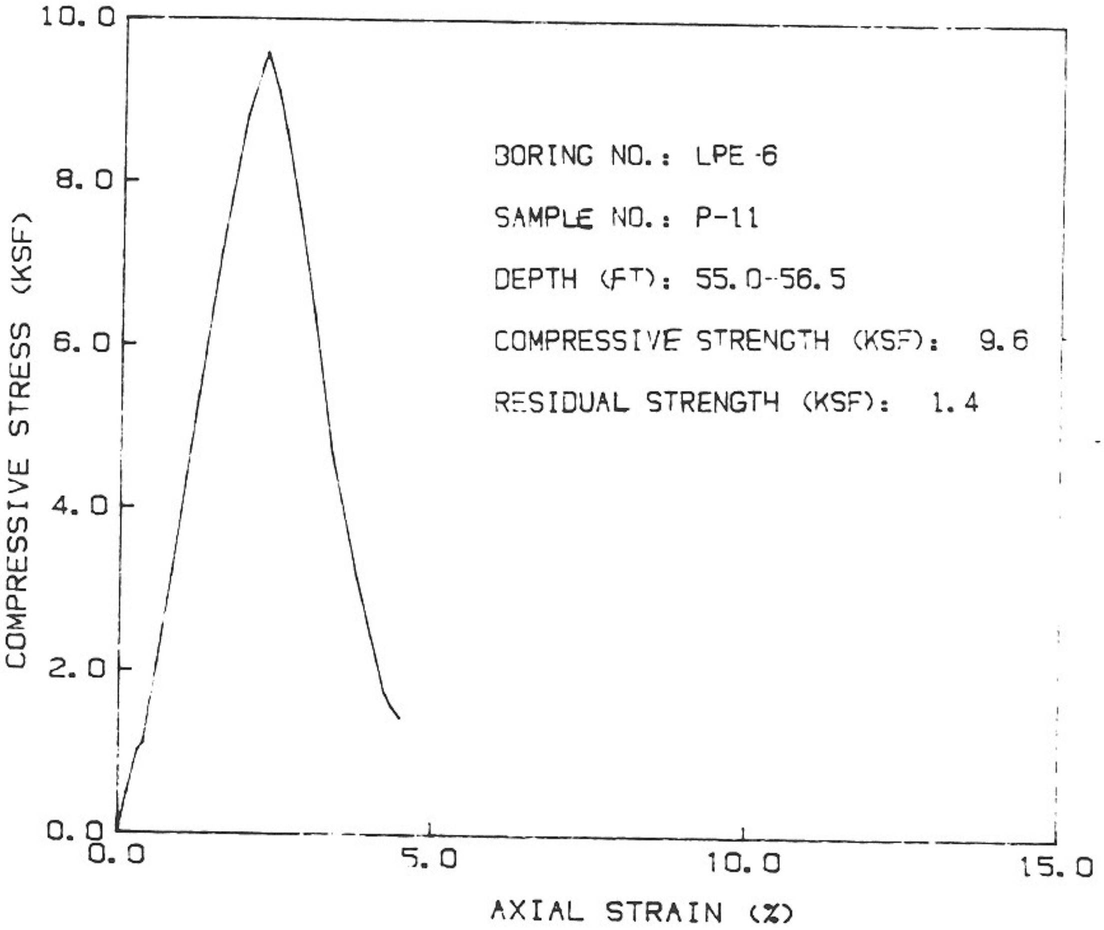
FIGURE B-129



The Earth Technology Corporation	PROJECT NO.: 88-429 METRO RAIL MOS-2

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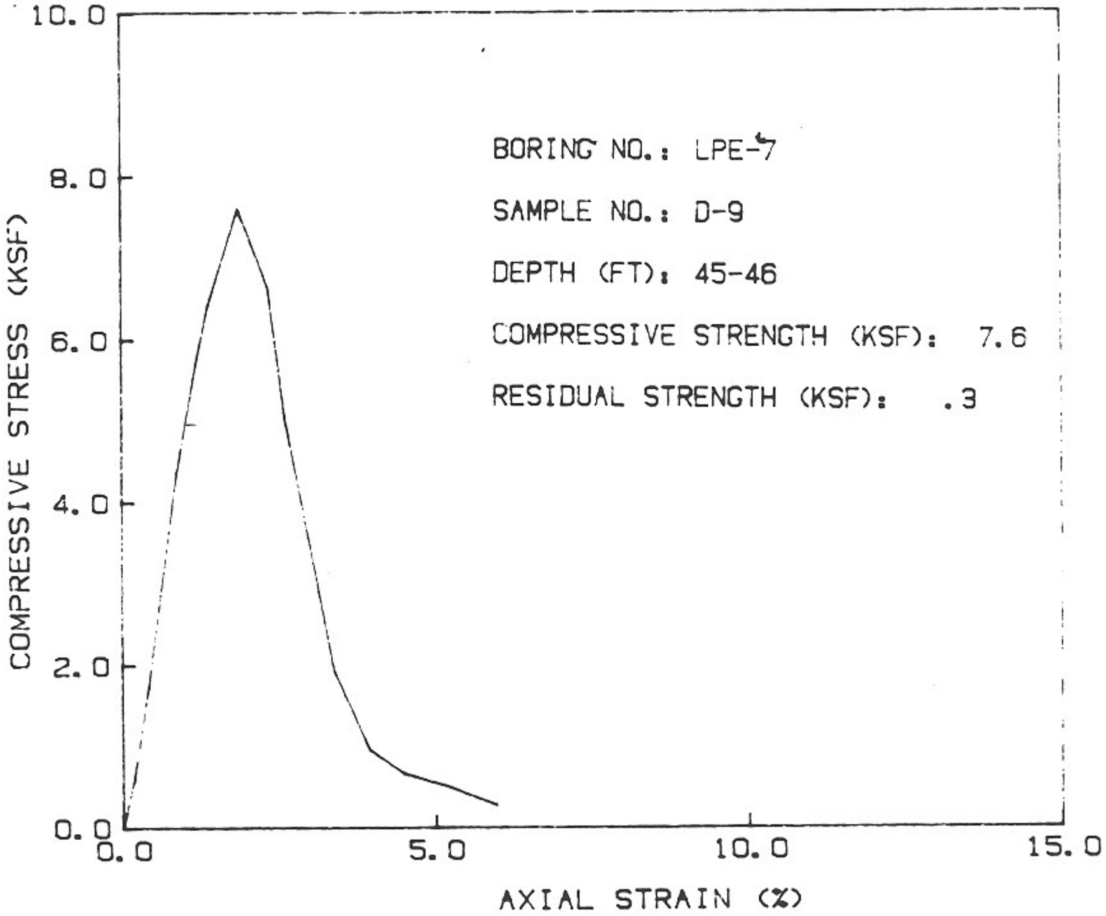
FIGURE B-130



The Earth Technology Corporation

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METRO RAIL MOS-2

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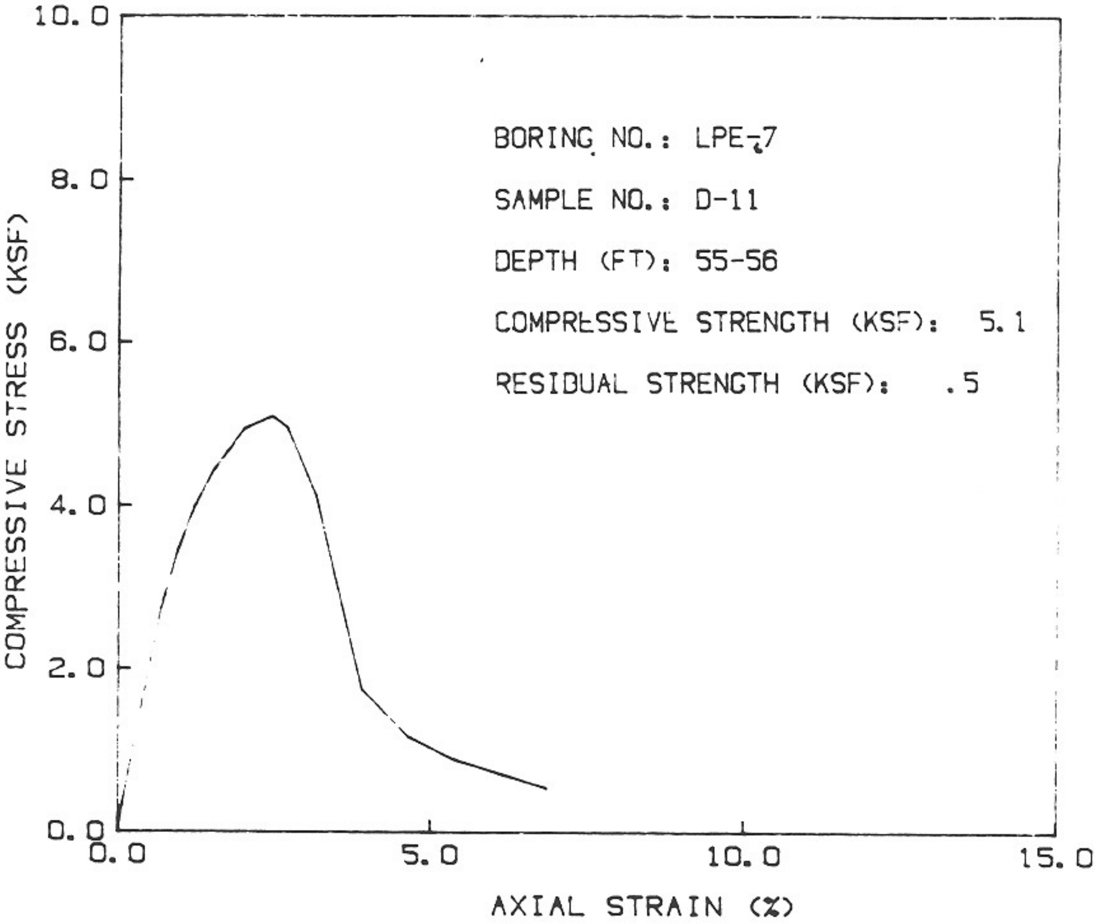
FIGURE B-131



The Earth Technology Corporation

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METRO RAIL MOS-2

UNCONFINED COMPRESSION TEST RESULTS

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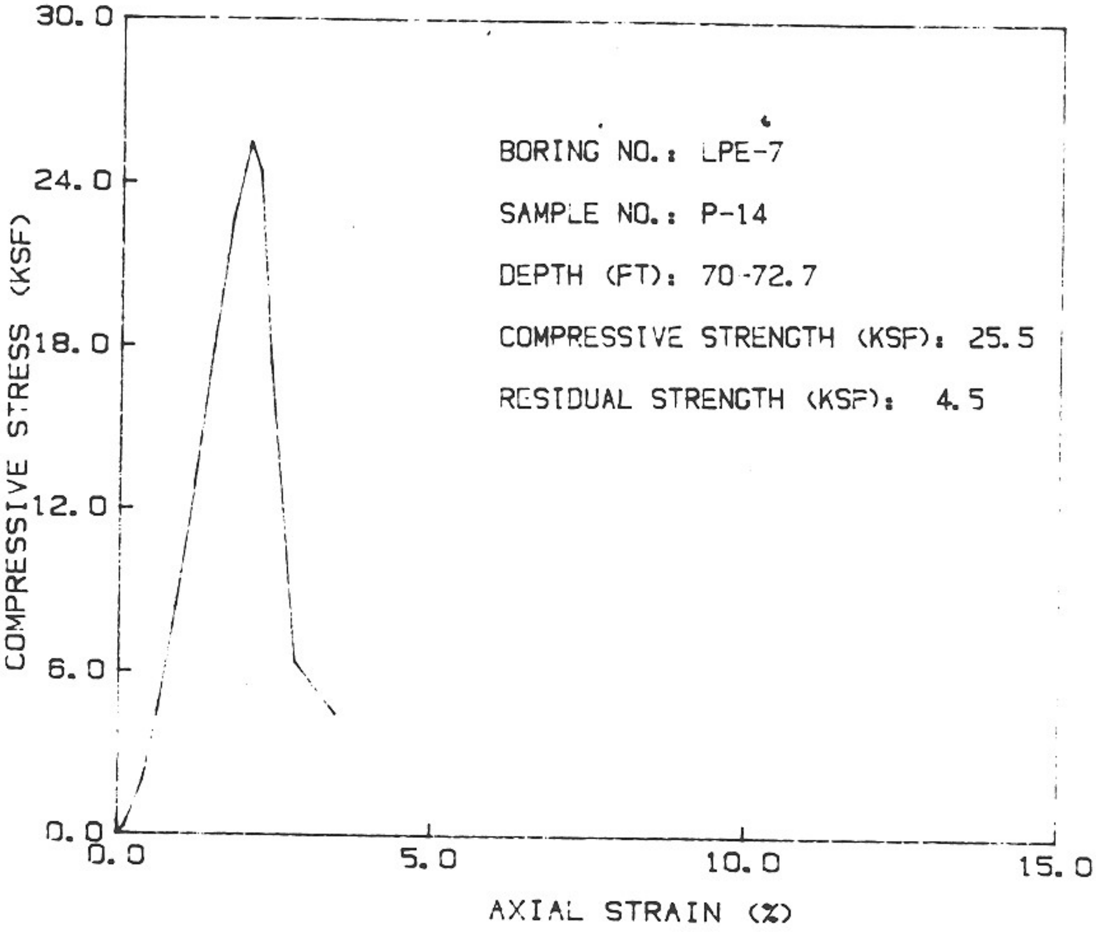
FIGURE B-132



BORING NO.: LPE-7

SAMPLE NO.: P-14

DEPTH (FT): 70-72.7

COMPRESSIVE STRENGTH (KSF): 25.5

RESIDUAL STRENGTH (KSF): 4.5

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METRO RAIL MOS-2

UNCONFINED COMPRESSION TEST RESULTS

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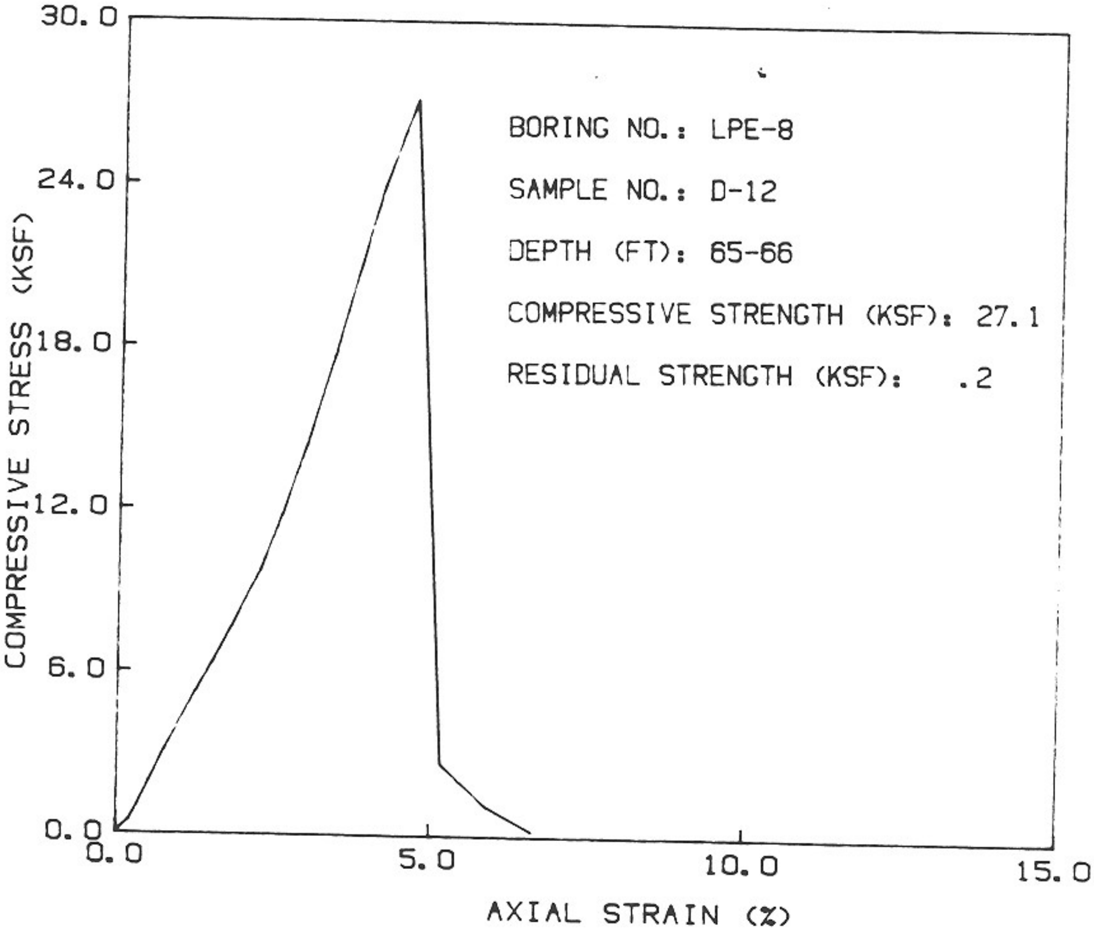
FIGURE B-133



BORING NO.: LPE-8

SAMPLE NO.: D-12

DEPTH (FT): 65-66

COMPRESSIVE STRENGTH (KSF): 27.1

RESIDUAL STRENGTH (KSF): .2

The Earth Technology Corporation	PROJECT NO.: 88-429 METRO RAIL MOS-2

UNCONFINED COMPRESSION TEST RESULTS

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FIGURE B-134

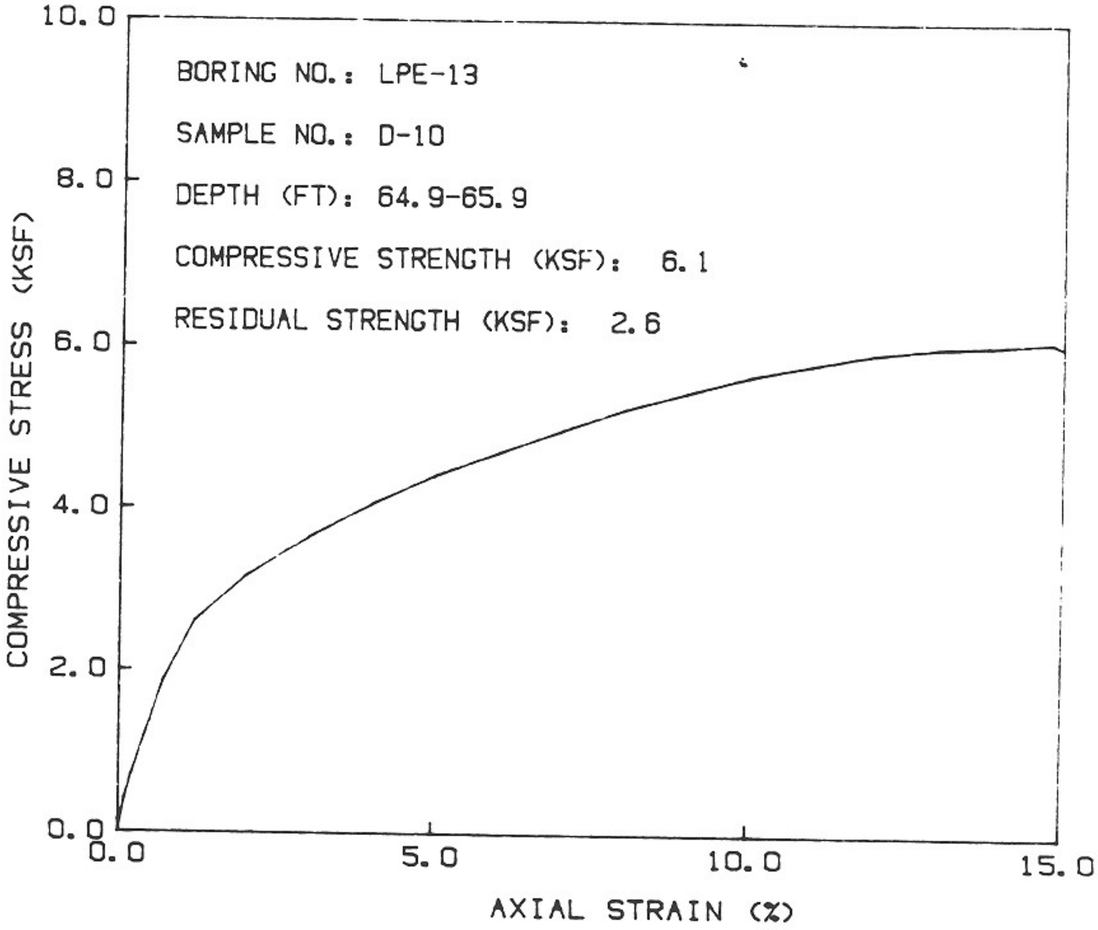

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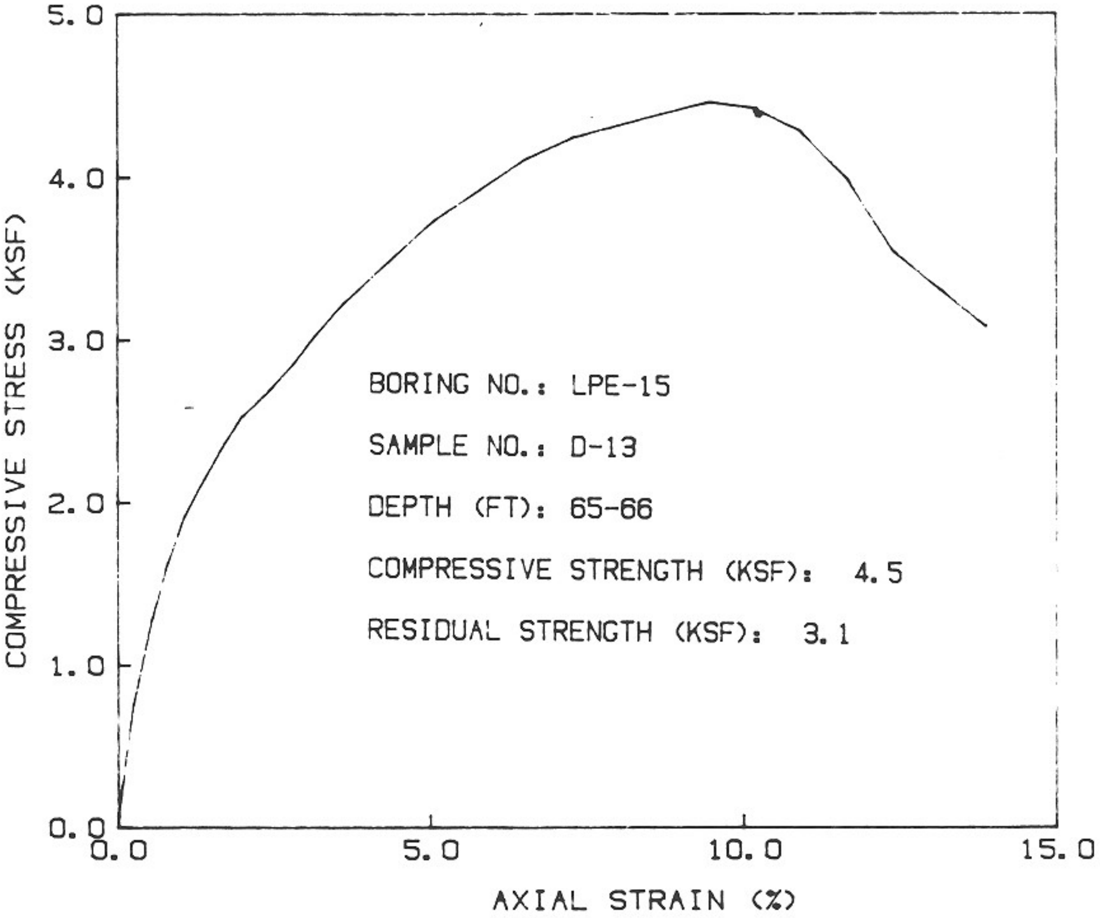
FIGURE B-135



BORING NO.: LPE-15

SAMPLE NO.: D-13

DEPTH (FT): 65-66

COMPRESSIVE STRENGTH (KSF): 4.5

RESIDUAL STRENGTH (KSF): 3.1

The Earth Technology Corporation	**PROJECT NO.:** 88-429 METRO RAIL MOS-2

UNCONFINED COMPRESSION TEST RESULTS

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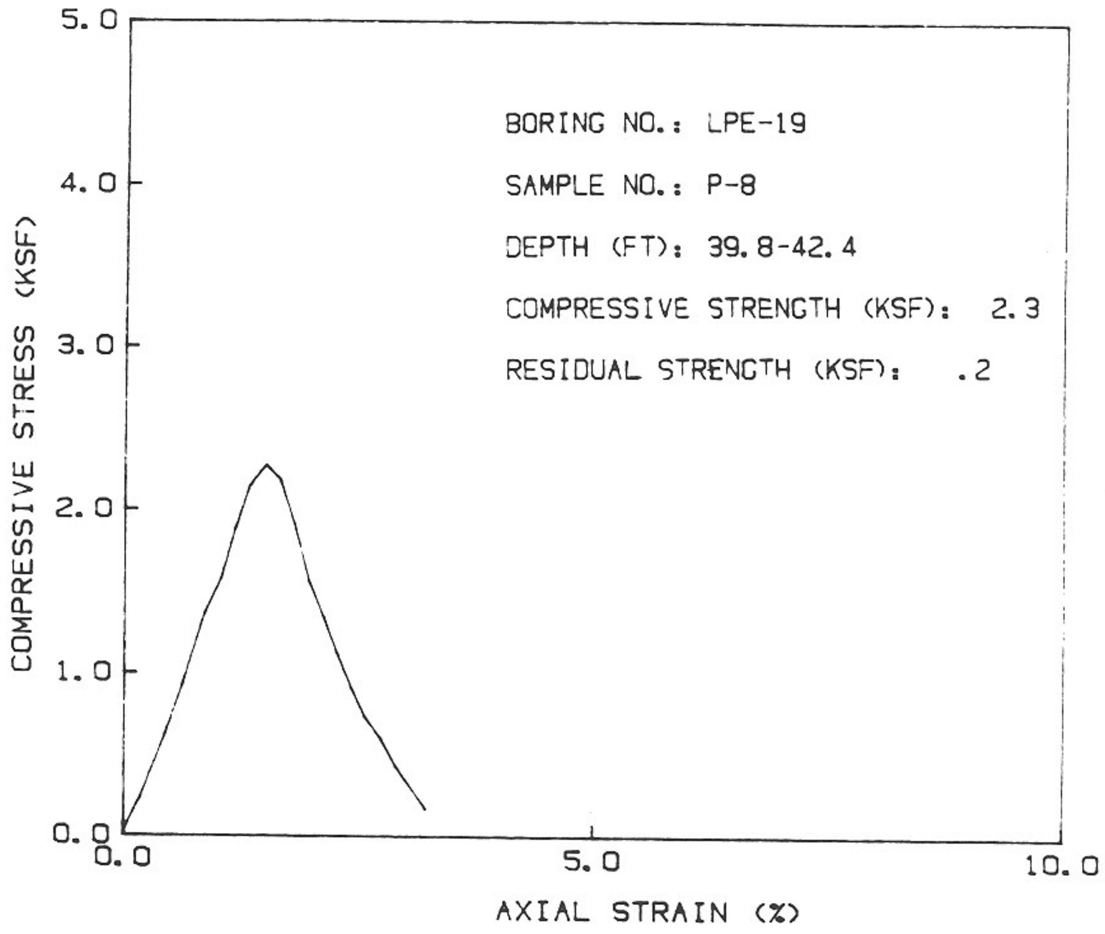
FIGURE B-136



The Earth Technology Corporation

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UNCONFINED COMPRESSION TEST RESULTS

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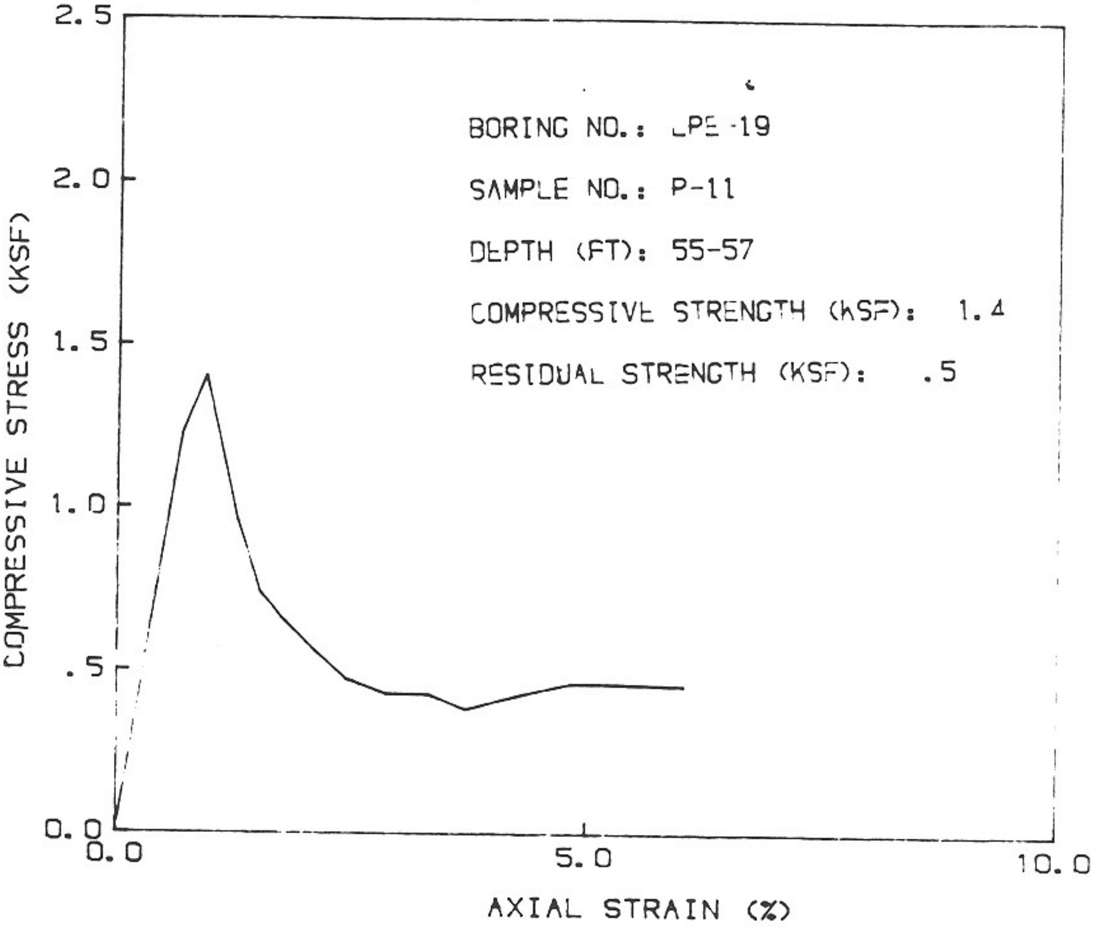
FIGURE B-137



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UNCONFINED COMPRESSION TEST RESULTS

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FIGURE B-138

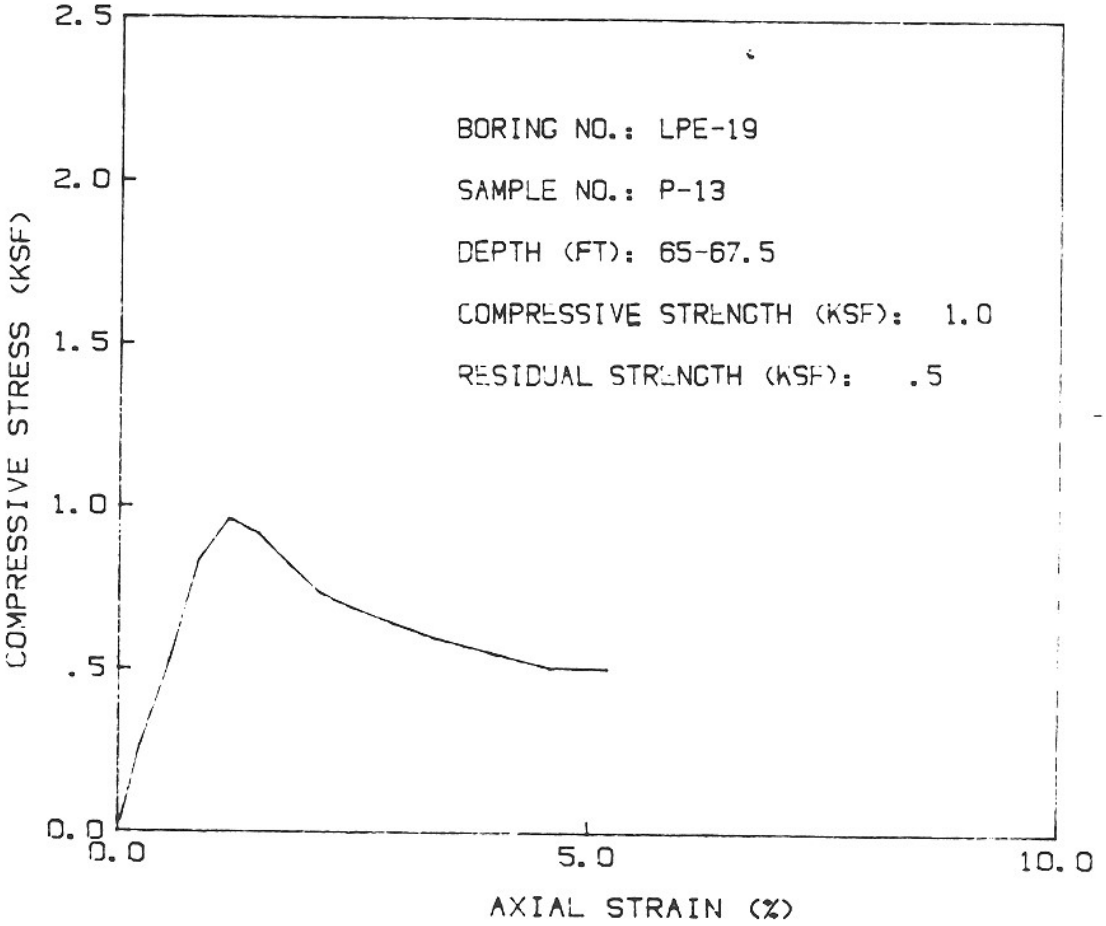

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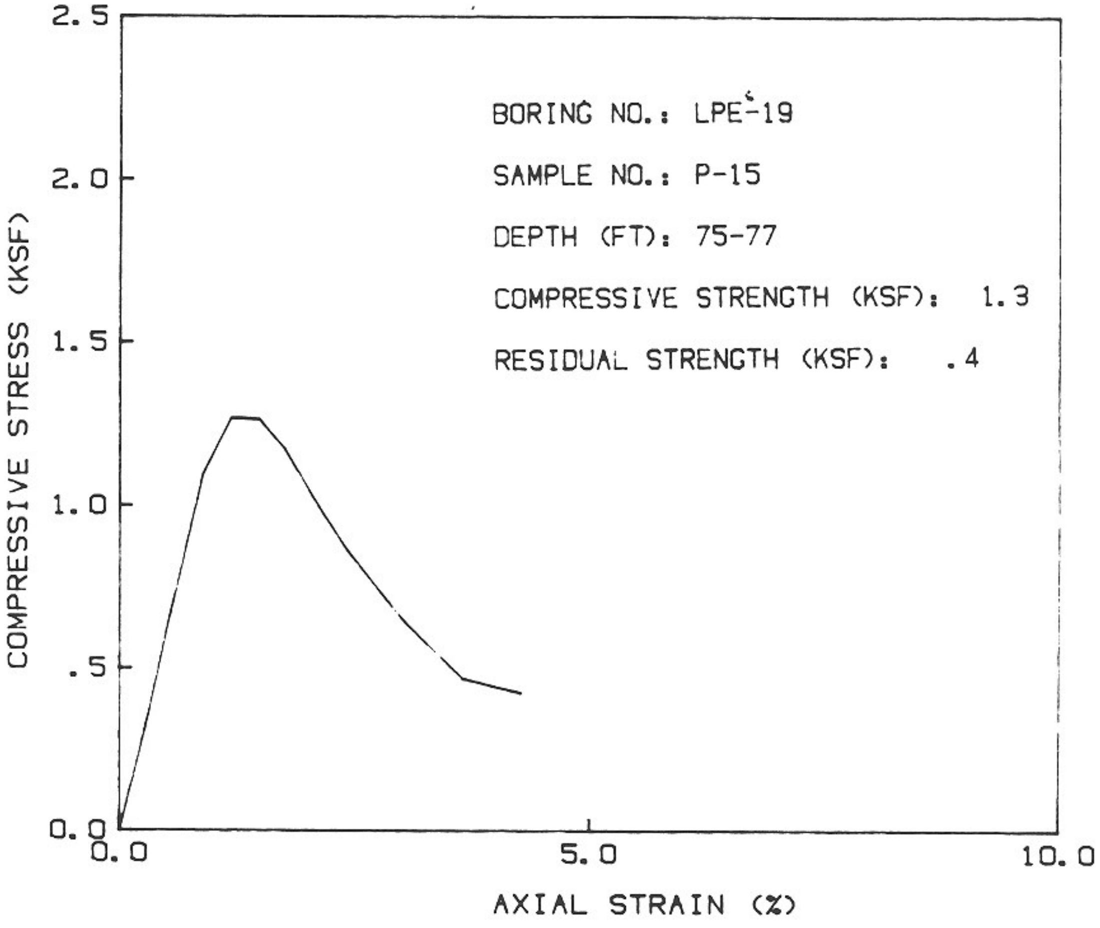
FIGURE B-139



BORING NO.: LPE-19

SAMPLE NO.: P-15

DEPTH (FT): 75-77

COMPRESSIVE STRENGTH (KSF): 1.3

RESIDUAL STRENGTH (KSF): .4

The Earth Technology Corporation

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METRO RAIL MOS-2

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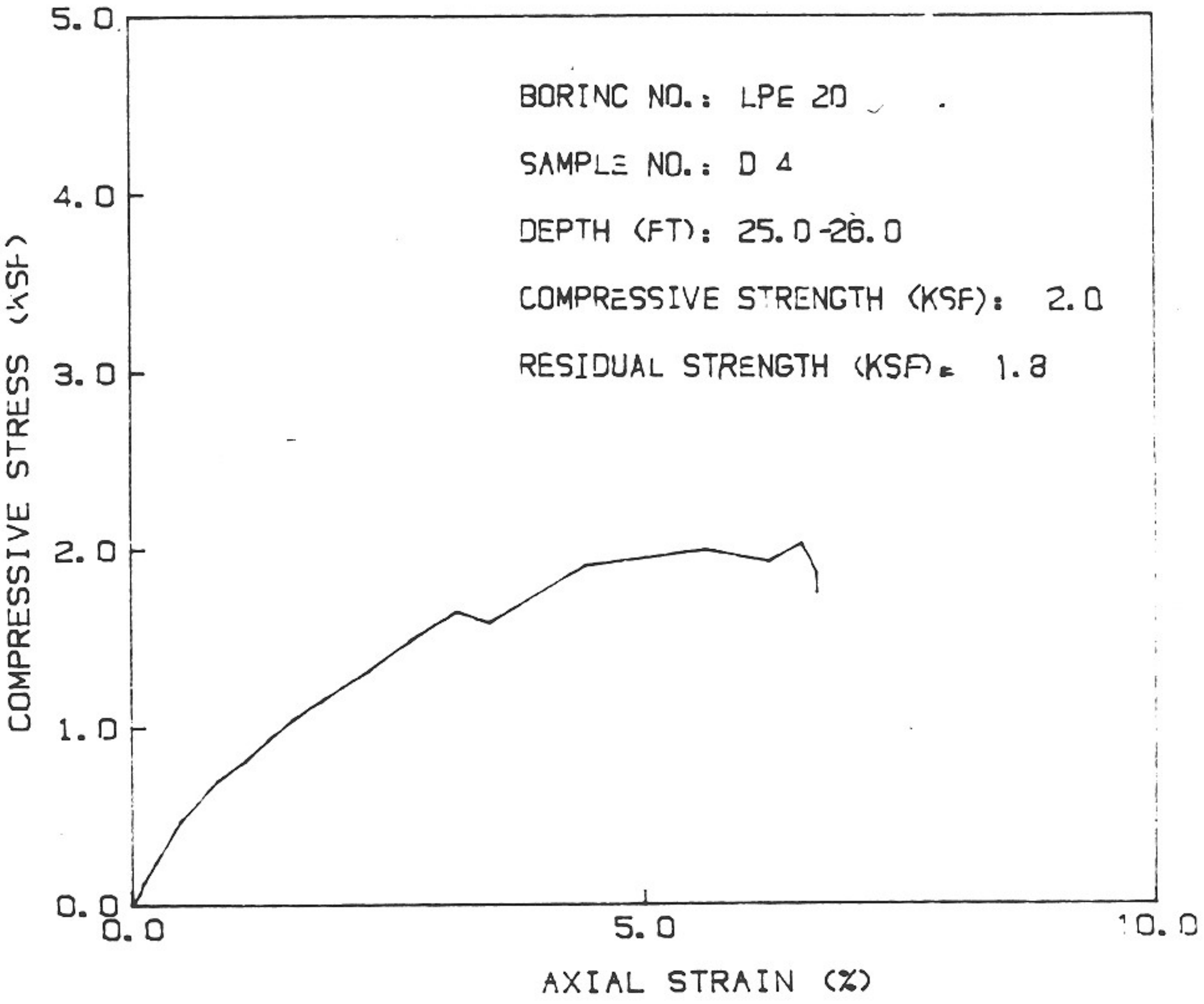
FIGURE B-140



BORINC NO.: LPE 20

SAMPLE NO.: D 4

DEPTH (FT): 25.0-26.0

COMPRESSIVE STRENGTH (KSF): 2.0

RESIDUAL STRENGTH (KSF): 1.8

The Earth Technology Corporation

PROJECT NO.: 88-429

METRO RAIL MOS-2

UNCONFINED COMPRESSION TEST RESULTS

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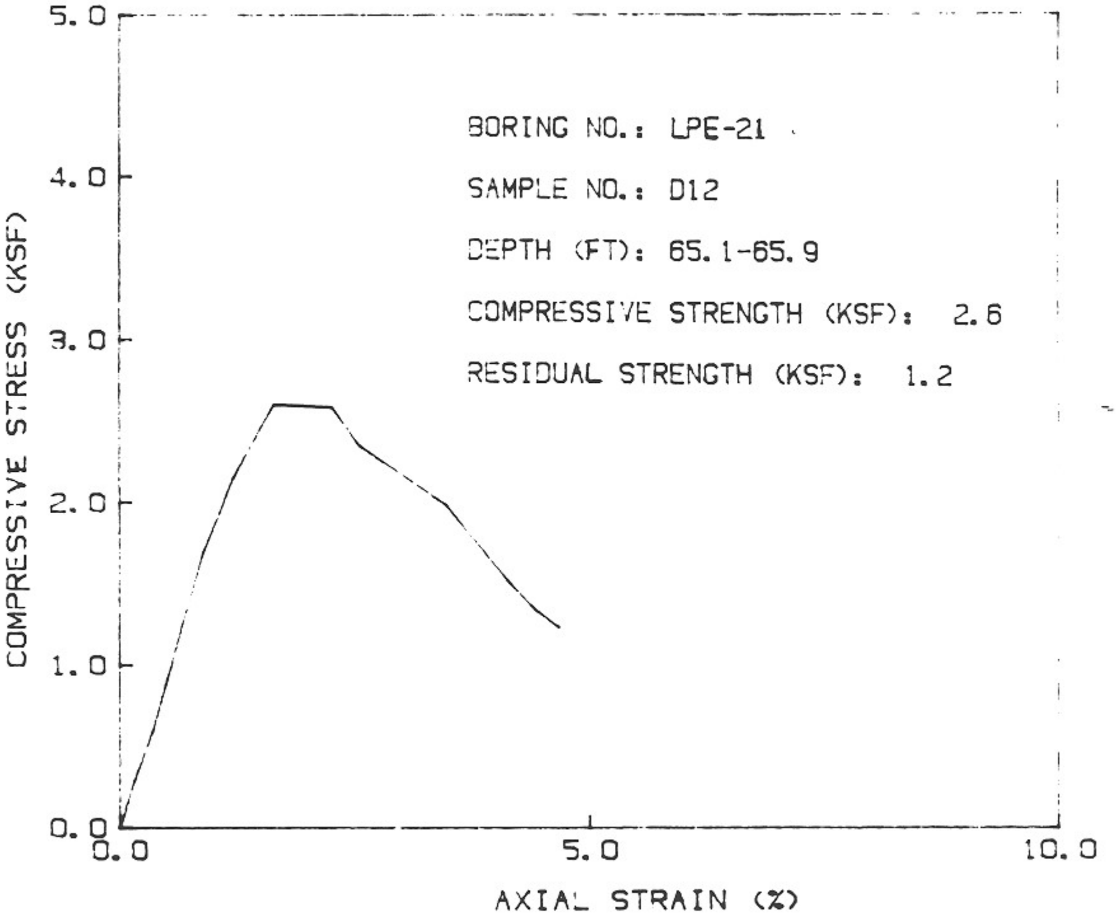
FIGURE B-141



The Earth Technology Corporation	PROJECT NO.: 88-429 METRO RAIL MOS-2

UNCONFINED COMPRESSION TEST RESULTS

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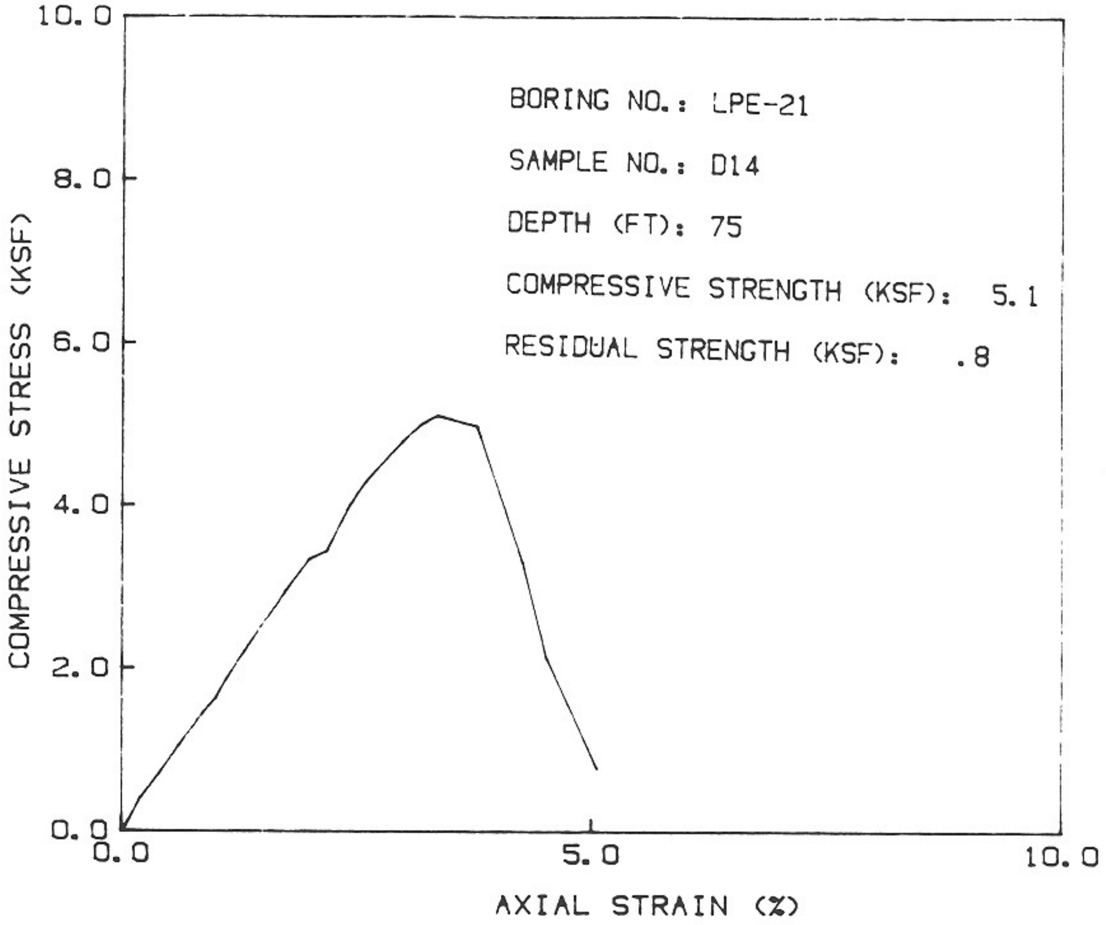
FIGURE B 142



The Earth Technology Corporation	PROJECT NO.: 88-429 METRO RAIL MOS-2

UNCONFINED COMPRESSION TEST RESULTS

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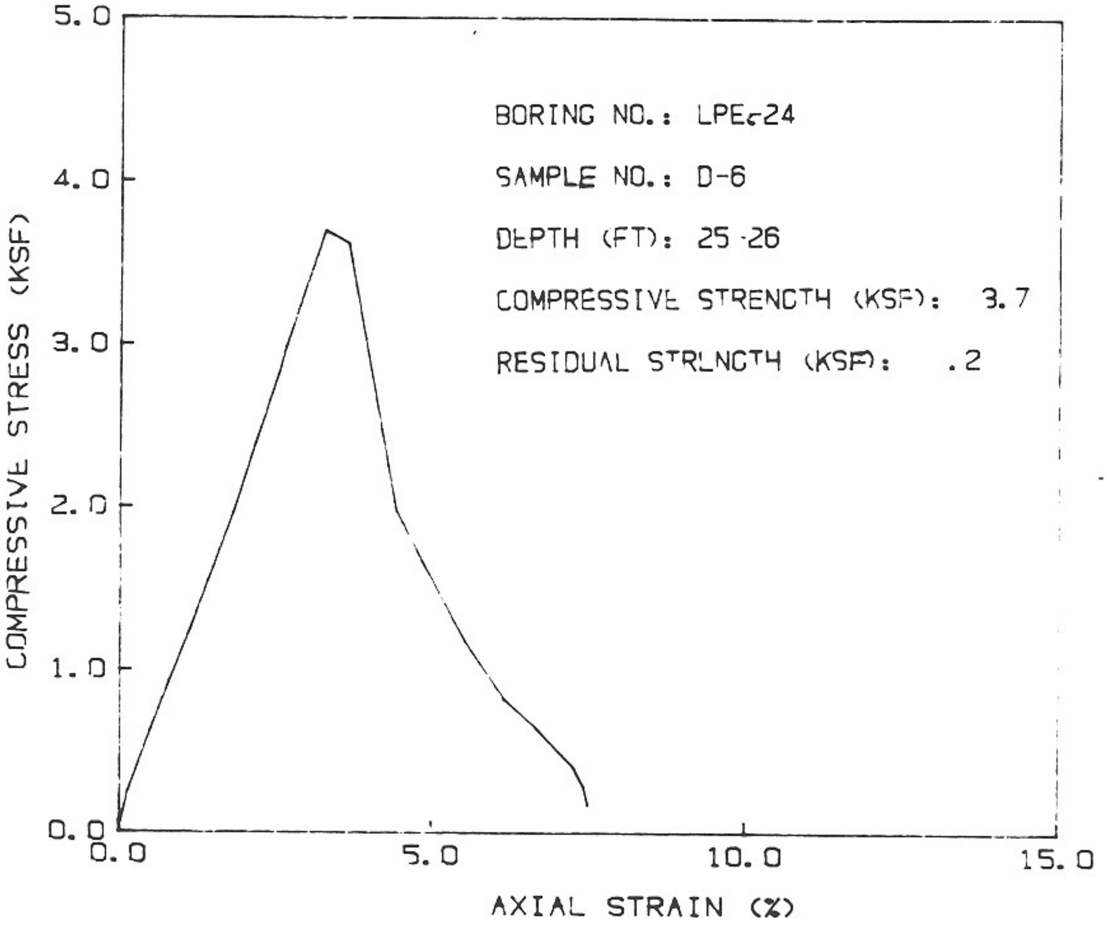
FIGURE B-143



The Earth Technology Corporation

PROJECT NO.: 88-429

METRO RAIL MOS-2

UNCONFINED COMPRESSION TEST RESULTS

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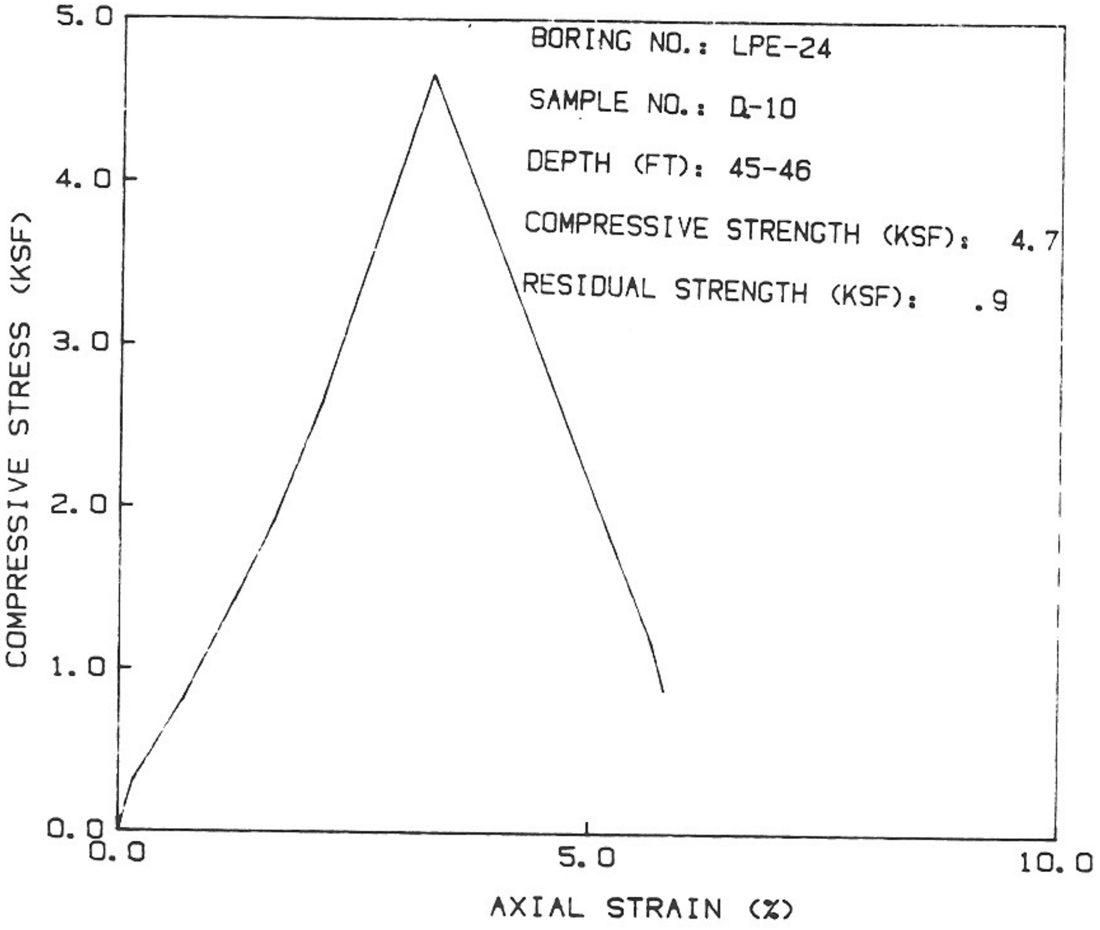
FIGURE B-144



The Earth Technology Corporation

PROJECT NO.: 88-429

METRO RAIL MOS-2

UNCONFINED COMPRESSION TEST RESULTS

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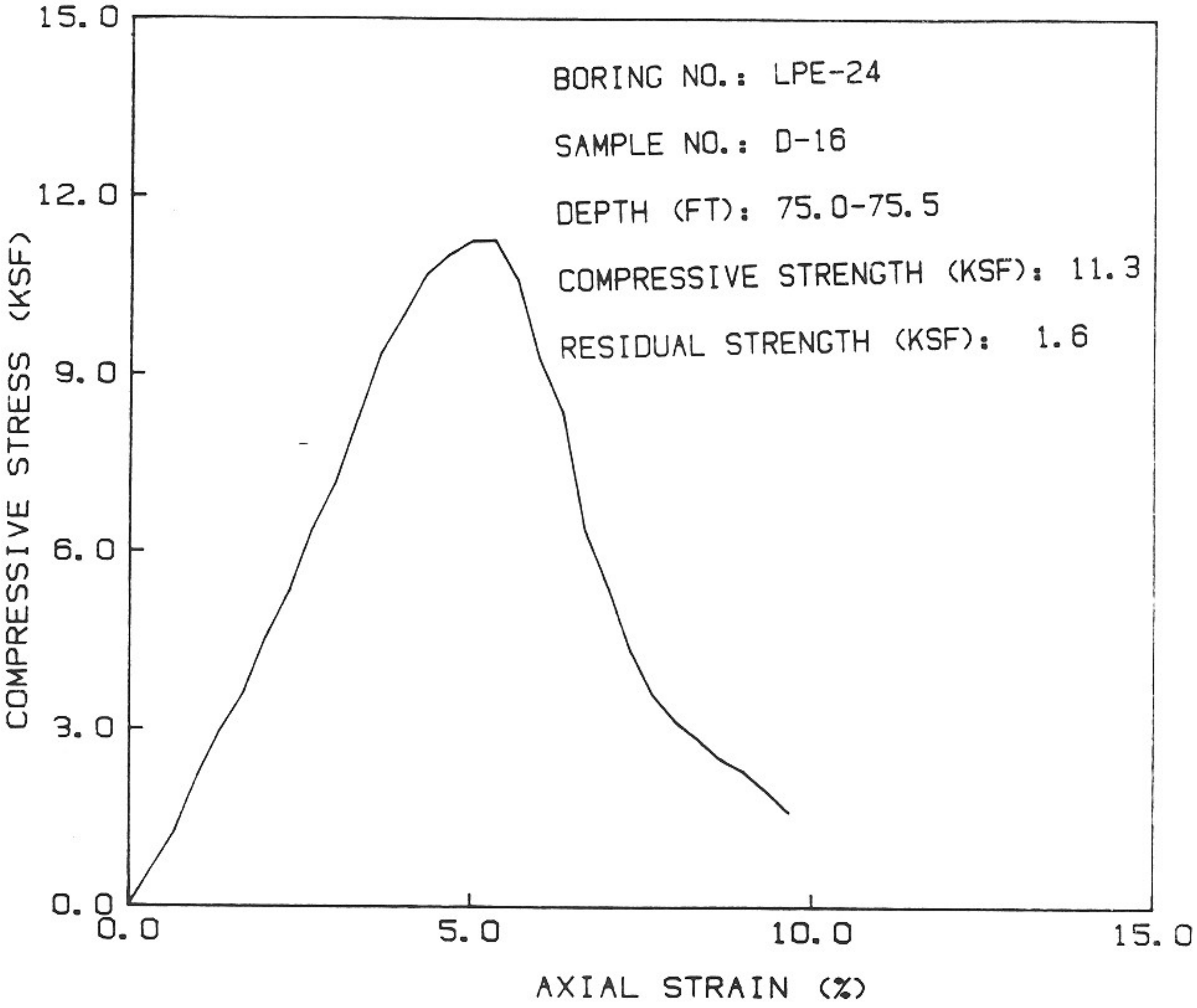
FIGURE B-145



The Earth Technology Corporation

PROJECT NO.:	88-429
METRO RAIL MOS-2	

UNCONFINED COMPRESSION TEST RESULTS

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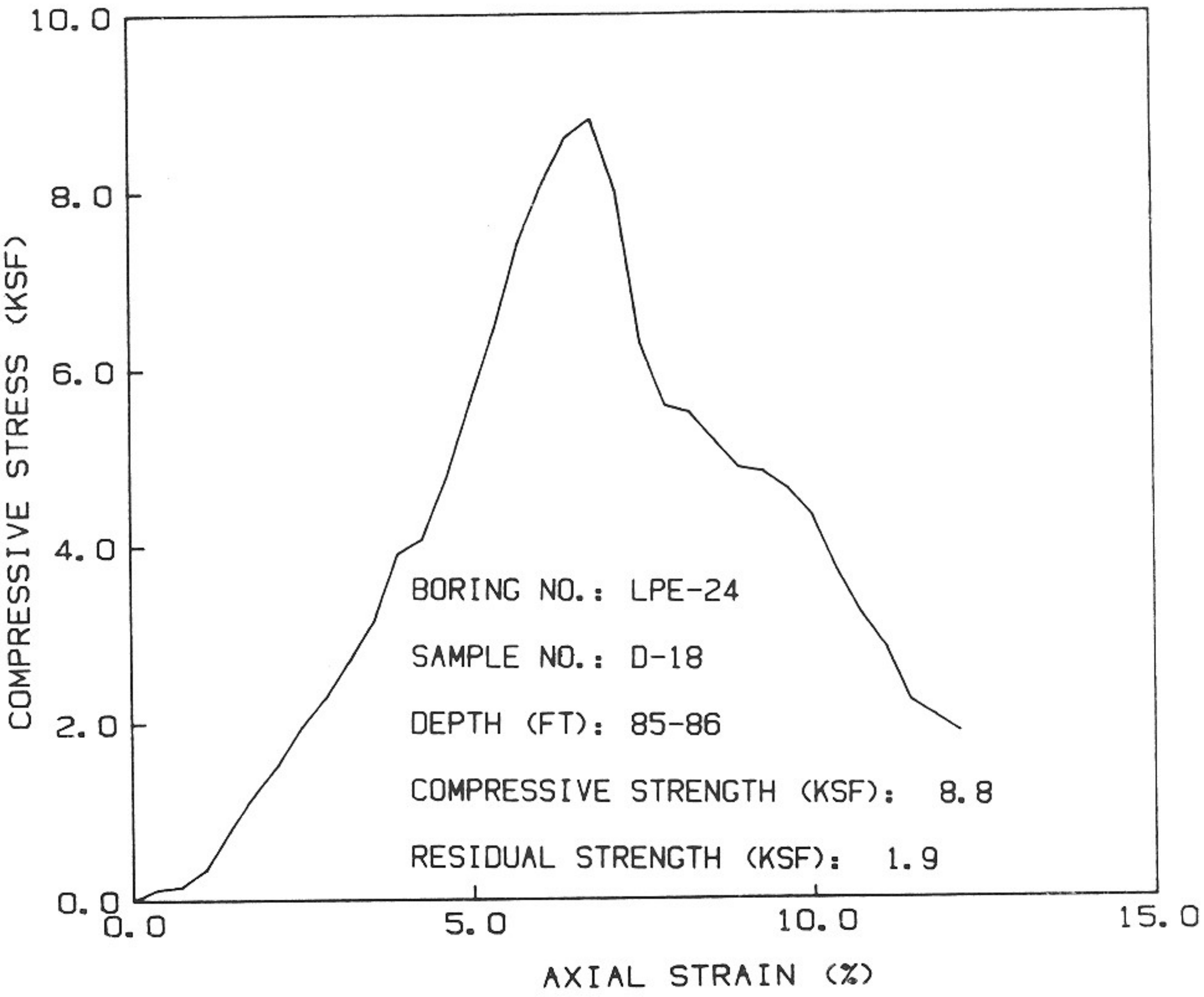
FIGURE B-146



The Earth Technology Corporation

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METRO RAIL MOS-2

UNCONFINED COMPRESSION TEST RESULTS

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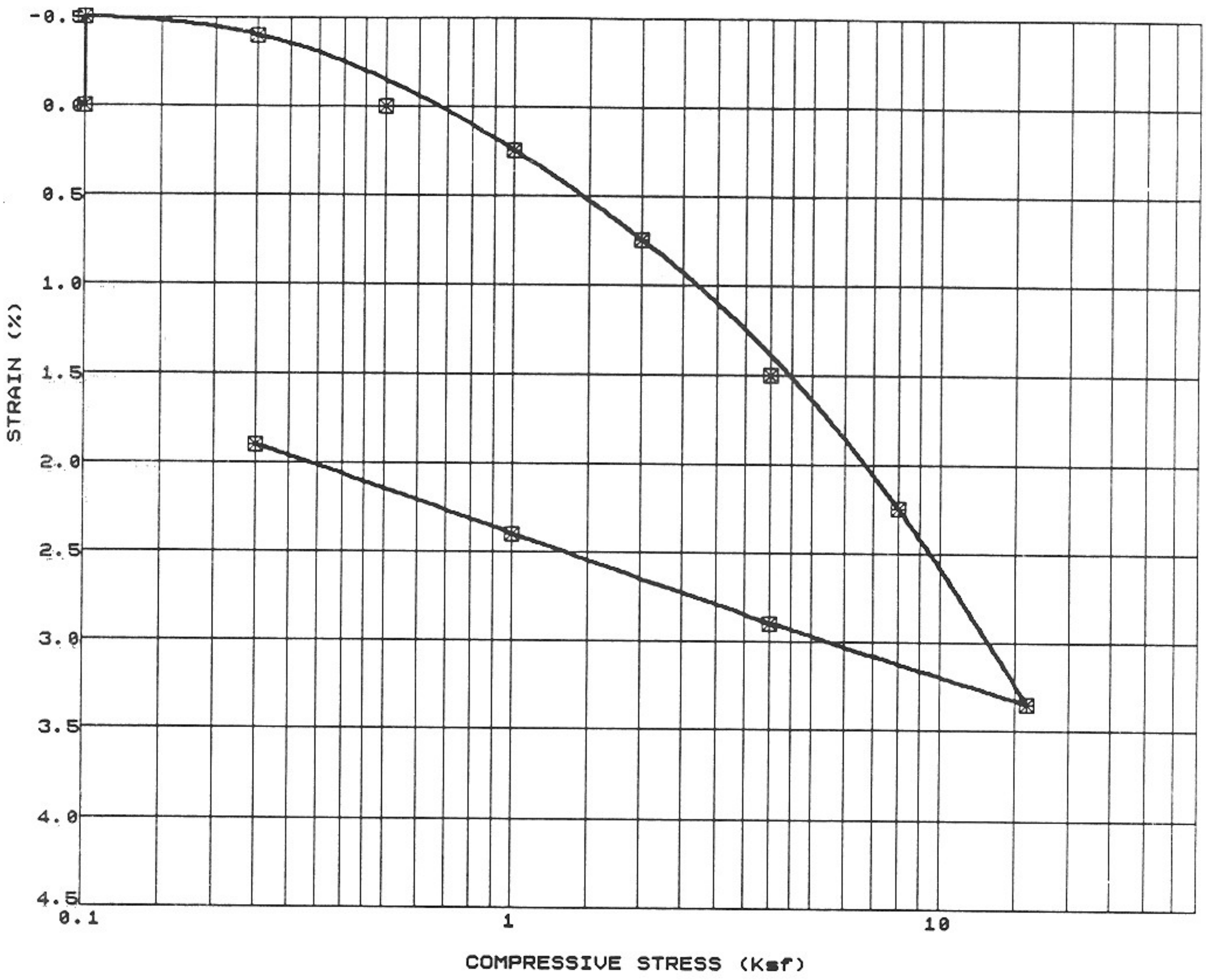
FIGURE B **148**



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	Cc	Cr	Remarks
⊠	LPE-11	D-9	45.00	DRIVE	SC/CL	3.5	0.7	Coefficients Strain Related

The Earth Technology Corporation

PROJECT NO.: 88-429

METRO RAIL MOS-2

CONSOLIDATION TEST RESULTS

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FIGURE B-149