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Corporation*



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SUBSURFACE INVESTIGATION
AT THE
METRO RAIL REALIGNED A-130 CORRIDOR
LOS ANGELES, CALIFORNIA

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1.0 INTRODUCTION

1.1 GENERAL

This report presents the results of a subsurface investigation performed for Metro Rail Transit Consultants (MRTC) by The Earth Technology Corporation (Earth Technology) for the realigned Metro Rail A-130 corridor to be located in Los Angeles, California (Figure 1-1). Briefly, this investigation included reviewing existing data, drilling exploratory borings to various depths, performing field and laboratory tests, conducting geotechnical engineering evaluations, and developing geotechnical engineering recommendations. The scope of work for this study is presented in Section 1.5.

The present investigation was performed in general accordance with the terms of Amendment No. 4 to Subcontract No. AG-001, dated April 20, 1987.

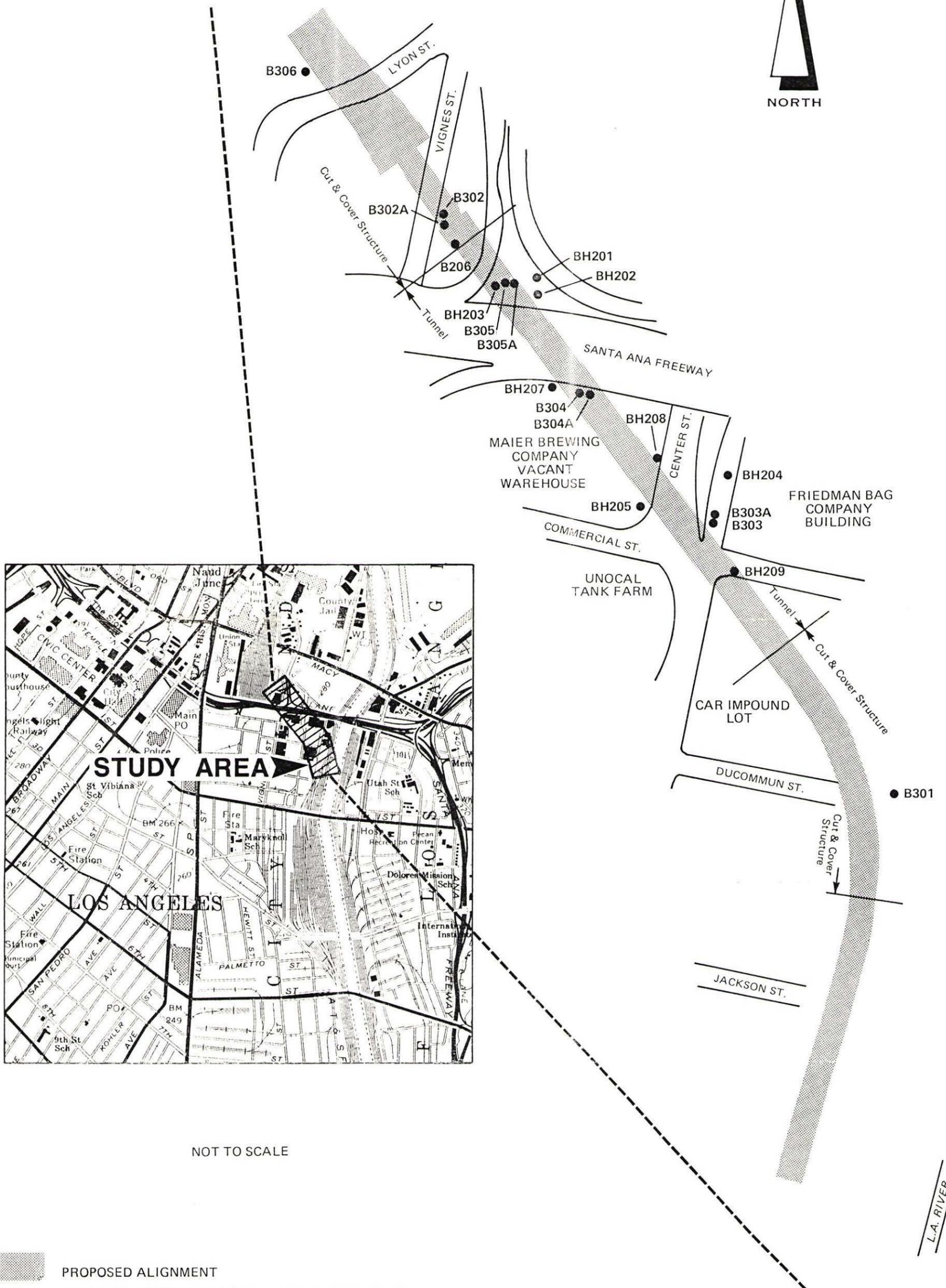
1.2 OBJECTIVES

The primary objective of this study was to provide geotechnical data and recommendations for construction of the Metro Rail System along the realigned Los Angeles Metro Rail A-130 corridor. A secondary objective was to further explore the nature and extent of potential chemical compounds in the subsurface soils and groundwater encountered along the realigned A-130 corridor.

1.3 PROJECT DESCRIPTION

Based on information provided by MRTC, we understand that the realigned A-130 corridor is a portion of the Los Angeles Metro Rail System currently being developed by the Southern California Rapid Transit District (SCRTD). The corridor is approximately 2,160 feet long. The southern terminus of the

UNION STATION



NOT TO SCALE

-  PROPOSED ALIGNMENT
-  APPROXIMATE BOREHOLE LOCATIONS (SEE FIGURE 1-2 FOR PRECISE LOCATIONS)
- B301-B306 BORINGS PERFORMED FOR THIS STUDY
- BH201-BH209 BORINGS PERFORMED FOR JANUARY 1987 INVESTIGATION (EARTH TECHNOLOGY, 1987c)

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A-130 CORRIDOR LOCATION MAP

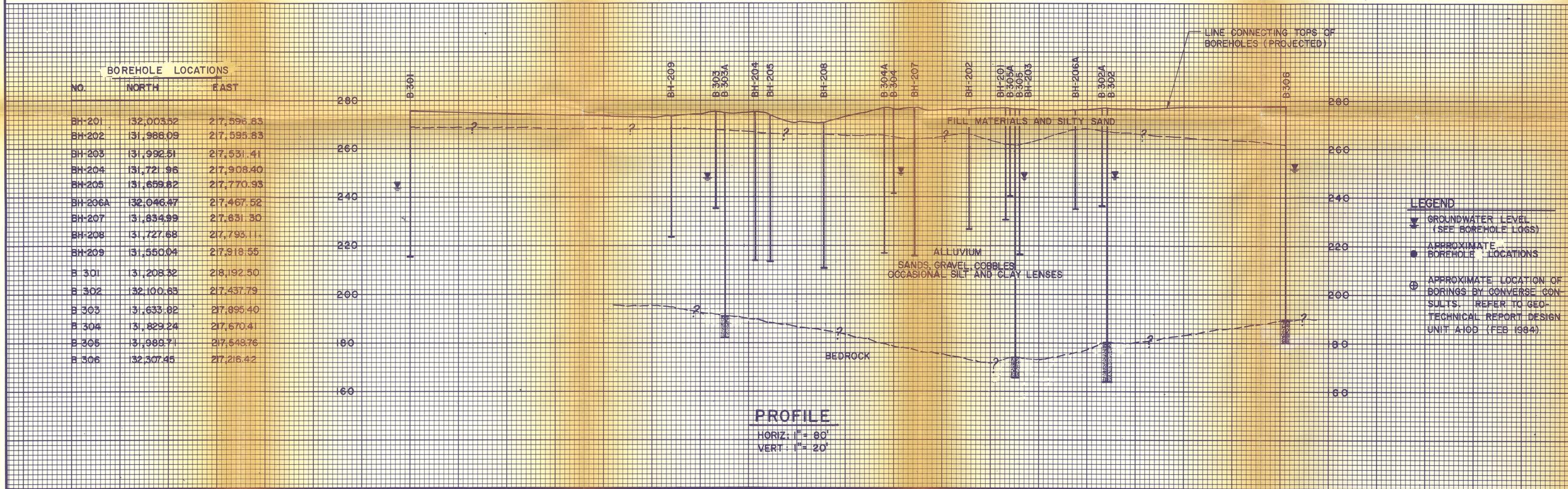
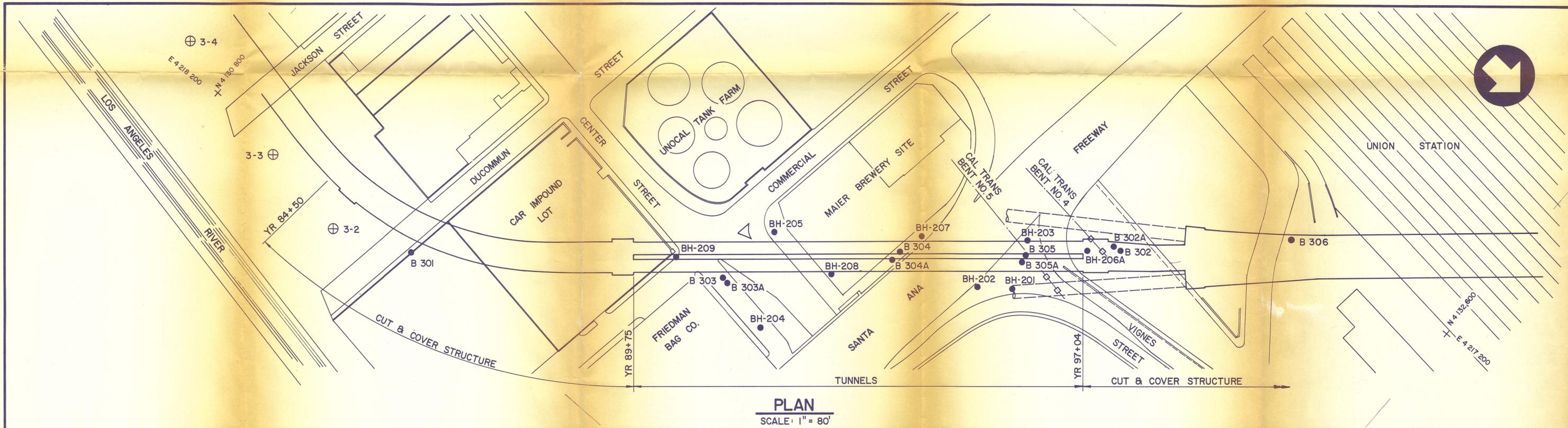
realigned A-130 corridor is located south of Jackson Street (Figure 1-1). From this point, the alignment continues north, approximately parallel to the Los Angeles River, to just past Ducommun Street. Beyond this point, the alignment turns northwest, crossing an existing vehicle impound lot, the intersection of Commercial and Center streets, an existing vacant warehouse, the Santa Ana Freeway (101 Freeway portion), Vignes Street, a vacant lot, and Lyon Street. As shown in Figure 1-1, the realigned A-130 corridor ends just north of Lyon Street.

The realigned corridor consists of two distinct portions: an at-grade portion and an underground portion. According to the current MRTC plan, the at-grade portion of the corridor will be located approximately between Stations 79 + 00 and 84 + 50 and will consist of a gently sloped slab, with finished track elevations of approximately +265.5 feet to +264.5 feet above mean sea level (MSL), and retaining walls on both sides of the slab. The underground portion of the alignment will be located approximately between Stations 84 + 50 and 101 + 50 and will consist of a subway tunnel and a crossover structure. The invert elevation of the underground structure varies between elevations of approximately +264.5 feet and +239.5 feet. Locations of the tunnel and the cut-and-cover structures are shown in Figure 1-2.

A shield-driven tunnel is planned by MRTC for the underground structures approximately between Stations 89 + 00 and 97 + 00. This includes the portion of the alignment that crosses under the Santa Ana Freeway. MRTC also plans to grout most of the zone approximately between Stations 89 + 00 to 97 + 00 prior to the tunneling operation.

Outside of the shield-driven tunnel construction area, cut-and-cover construction is planned by MRTC. The cut-and-cover sections will be located approximately between Stations 84 + 50 and 89 + 00 and Stations 97 + 00 and 101 + 50.

MRTC has also indicated that the cut-and-cover structure will be a rigid, reinforced, concrete-box type, approximately 68 feet wide. The shield-driven tunnel area will have two concrete-lined tunnels, each approximately 20 feet in diameter and separated by an approximately 8-foot wide pillar.

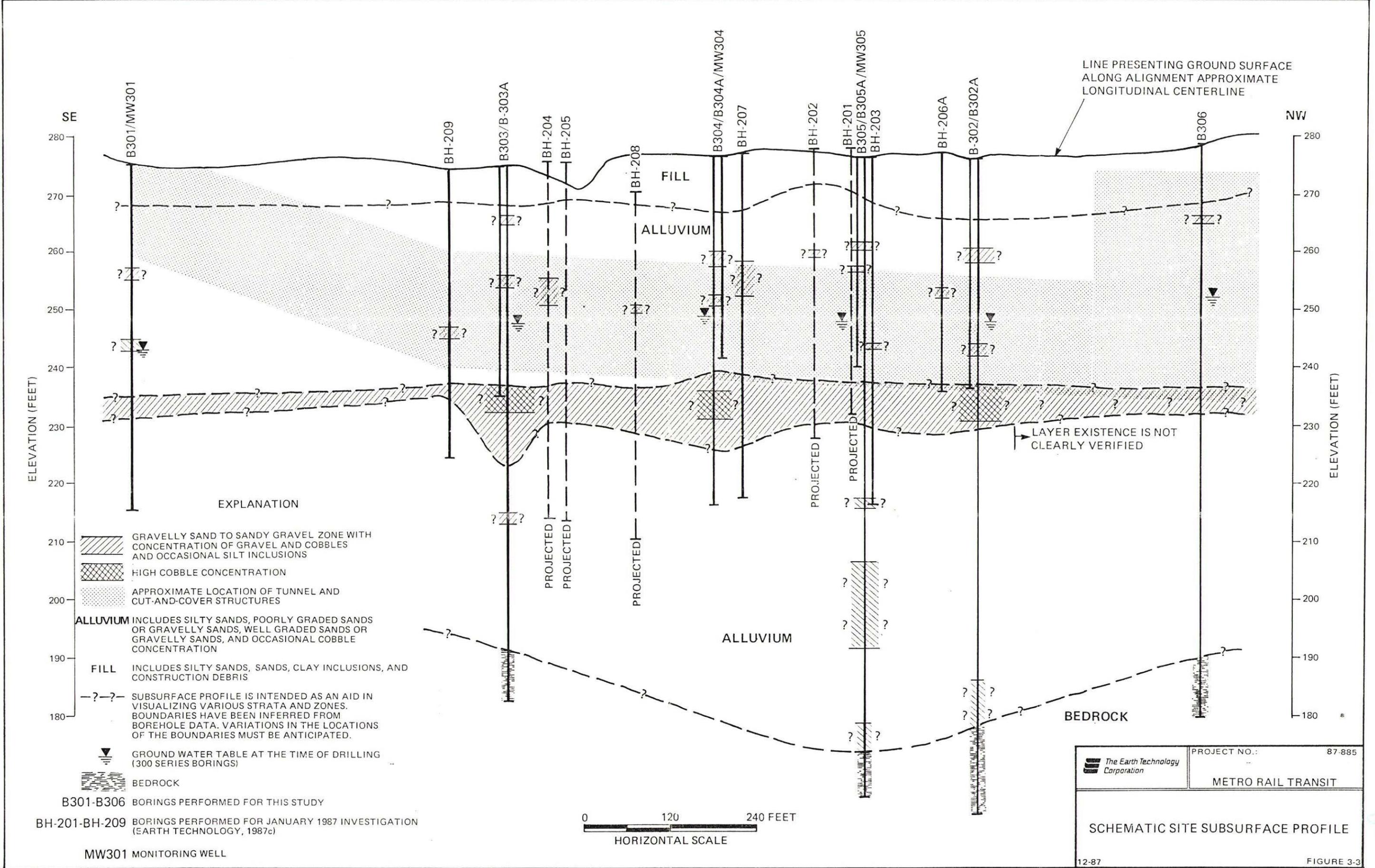


REFERENCE: SHEET NO. 365, DRAWING NO. K-001 REV. 0, CONTRACT NO. A-130
LOCATIONS OF BORINGS AND SOILS PROFILE, MAIN YARD AND
SHOPS YARD LEADS, METRO RAIL PROJECT, SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT

PROJECT NO. 87-885
METRO RAIL TRANSIT

BOREHOLE LOCATIONS
AND
SITE PROFILE

12-87 87-885
FIGURE 1-2



LINE PRESENTING GROUND SURFACE
ALONG ALIGNMENT APPROXIMATE
LONGITUDINAL CENTERLINE

ELEVATION (FEET)

280

270

260

250

240

230

220

210

200

190

180

NW

ELEVATION (FEET)

280

270

260

250

240

230

220

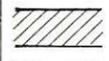
210

200

190

180

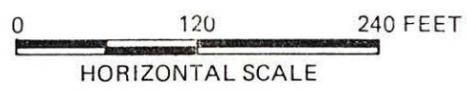
EXPLANATION

-  GRAVELLY SAND TO SANDY GRAVEL ZONE WITH CONCENTRATION OF GRAVEL AND COBBLES AND OCCASIONAL SILT INCLUSIONS
-  HIGH COBBLE CONCENTRATION
-  APPROXIMATE LOCATION OF TUNNEL AND CUT-AND-COVER STRUCTURES
- ALLUVIUM** INCLUDES SILTY SANDS, POORLY GRADED SANDS OR GRAVELLY SANDS, WELL GRADED SANDS OR GRAVELLY SANDS, AND OCCASIONAL COBBLE CONCENTRATION
- FILL** INCLUDES SILTY SANDS, SANDS, CLAY INCLUSIONS, AND CONSTRUCTION DEBRIS
- ?-?-? SUBSURFACE PROFILE IS INTENDED AS AN AID IN VISUALIZING VARIOUS STRATA AND ZONES. BOUNDARIES HAVE BEEN INFERRED FROM BOREHOLE DATA. VARIATIONS IN THE LOCATIONS OF THE BOUNDARIES MUST BE ANTICIPATED.
-  GROUND WATER TABLE AT THE TIME OF DRILLING (300 SERIES BORINGS)
-  BEDROCK

B301-B306 BORINGS PERFORMED FOR THIS STUDY

BH-201-BH-209 BORINGS PERFORMED FOR JANUARY 1987 INVESTIGATION (EARTH TECHNOLOGY, 1987c)

MW301 MONITORING WELL



The Earth Technology Corporation

PROJECT NO.: 87-885

METRO RAIL TRANSIT

SCHEMATIC SITE SUBSURFACE PROFILE

1.4 PROJECT BACKGROUND

The A-130 corridor was originally proposed to be located northeast of the present realigned location discussed in this report. During a 1986 excavation for footings for the El Monte Busway adjacent to the originally proposed A-130 corridor, chemical compounds were encountered in the subsurface soils (Woodward-Clyde Consultants, 1986). Subsequently, Earth Technology was retained by MRTC in 1986 to investigate the nature and concentration of potential chemical compounds in the subsurface soil and groundwater at the site (Earth Technology, 1987a). The study indicated that portions of the original A-130 corridor did contain chemical compounds. Consequently, a remedial action plan was prepared for the site (Earth Technology, 1987b).

One of the alternatives identified in the remedial action plan was the realignment of the A-130 corridor to avoid development in areas containing chemical compounds. Hence, a subsurface investigation was conducted in the proposed realigned A-130 corridor to estimate the nature and extent of potential chemical compounds in the subsurface soils and groundwater (Earth Technology, 1987c, Phase IV report). The current study, reported herein, has been performed to evaluate the geotechnical engineering characteristics of the subsurface materials, and to further evaluate the nature and extent of potential chemical compounds in the subsurface soils and groundwater.

1.5 SCOPE OF WORK

The scope of the present study was outlined by MRTC and consisted of the following:

- o Obtaining necessary permits for drilling activities
- o Preparing and implementing a site-specific Health and Safety Plan
- o Conducting a subsurface soil and groundwater exploration and sampling program
- o Preparing and implementing an onsite decontamination program during drilling activities

- o Conducting an organic vapor analyzer (OVA) program
- o Setting up procedures for storing drums containing soils and waste water on site and for transporting the drums to a disposal site after appropriate treatment
- o Performing a geophysical survey to evaluate the existence of underground man-made structures and objects
- o Assessing subsurface conditions at the proposed project site including characterization of soil strata encountered during the field explorations and evaluation of chemical compounds
- o Performing field hydraulic conductivity tests at selected boring locations
- o Conducting a laboratory testing program to evaluate engineering properties and selected chemical characteristics of the subsurface soils and groundwater
- o Providing soil samples to GKN Hayward Baker, Inc., for evaluation of groutability and grout effectiveness
- o Developing geotechnical engineering recommendations for construction procedures during excavation for cut-and-cover and tunnel sections and for design of temporary and permanent structures
- o Preparing and submitting a report documenting the findings, conclusions, and recommendations resulting from the investigation.

1.6 CONTENTS

This report is organized into five sections and nine appendices as follows:

- Section 1 - Introduction
- Section 2 - Field Explorations and Laboratory Testing Program
- Section 3 - Site Conditions
- Section 4 - Geotechnical Evaluations and Recommendations
- Section 5 - References
- Appendix A - Subsurface Exploration
- Appendix B - Boring Logs of January 1987 Investigation
- Appendix C - Hydrologic Testing
- Appendix D - Geophysical Testing

- Appendix E - Physical and Mechanical Laboratory Testing
- Appendix F - Chemical Laboratory Testing
- Appendix G - Pumping Analyses
- Appendix H - Geotechnical Design Considerations
- Appendix I - Groutability Evaluation.

2.0 FIELD EXPLORATION AND LABORATORY TESTING PROGRAM

2.1 FIELD EXPLORATIONS

The field exploration program consisted of subsurface exploration, hydrologic testing, and geophysical testing. Field work was performed between June and September 1987.

2.1.1 Subsurface Exploration

The subsurface exploration program consisted of drilling and sampling ten boreholes (Table 2-1) along the proposed corridor alignment. The approximate borehole locations were recommended by MRTC. The final locations are shown in Figure 1-2. The boreholes were drilled to depths ranging from 36 to 113 feet. Four of the boreholes, B302A, B303A, B305A, and B306, were extended into the underlying bedrock while the remaining six were terminated in overburden soils. Boreholes B301, B304, and B305A were converted to groundwater monitoring wells MW-301, MW-304, and MW-305, respectively. Logs of borings for this investigation are presented in Appendix A. The boring logs from a previous investigation (Earth Technology, 1987c) are presented in Appendix B for information.

Drilling techniques used to advance the test boreholes included hollow-stem auger, rotary wash, and percussion hammer, depending on subsurface soil conditions and the difficulties encountered during drilling. Based on the subsurface conditions encountered along the alignment during the previous investigation (Earth Technology, 1987c), it was originally planned to use hollow-stem and rotary wash augers to advance the boreholes. However, in Boreholes B302 and B302A, a gravelly sand layer containing concentrations of coarse gravel and cobbles was encountered about 40 feet below ground surface. Considerable difficulty was encountered in penetrating this layer. In Boreholes B303 and B304, this layer could not be penetrated even with powerful drilling equipment such as a CME 75 drilling rig. Therefore, a percussion hammer drilling technique was employed in Boreholes B303A, B304A, B305, and

B306 to extend the boreholes to the desired depths. Without the use of the percussion hammer technique, it would not have been possible to obtain the subsurface information below an approximate depth of 40 feet where the high concentration of coarse gravel and cobbles was encountered. A summary of drilling methods and borehole depths is presented in Table 2-1. Details of drilling operations are presented in Appendix A.

Relatively undisturbed and disturbed soil samples as well as groundwater samples were obtained from the boreholes. The relatively undisturbed soil samples were obtained using a 2.5-inch inside diameter ring sampler (California Drive Sampler) and those of the bedrock were obtained using a 2.4-inch inside diameter, carbide-tipped core barrel. Disturbed samples were obtained using a standard split-spoon sampler and also from the cuttings from the drilling equipment. Details of the sampling operations are presented in Appendix A.

A portion of the soil and water samples were tested in the field for possible chemical compounds. The headspace volatile organic concentration was analyzed as an indication of chemical compounds at the sample depth. Details and results of field testing are presented on the borehole logs in Appendix A. The remaining portion of the samples was examined in the field for lithologic description, sealed, packaged, and delivered to the laboratory for physical and mechanical soil properties determination and chemical content analysis. In addition, three soil samples were sent to GKN Hayward Baker, Inc., for subsurface soils groutability evaluation.

2.1.2 Groundwater Quality Investigation

Groundwater samples were collected from seven boreholes during drilling and from three monitoring wells. They were generally obtained from the upper 5 to 10 feet of the static groundwater table using a Teflon™ bailer. In Borehole B306, a groundwater sample was obtained from a depth of approximately 79 feet due to a strong hydrogen sulfide odor at this depth. The bailer was steam cleaned between sampling events. Samples were properly labeled, iced, and packed for transport to the laboratory. All samples were accompanied by chain-of-custody forms.

TABLE 2-1. SUMMARY OF BOREHOLES

Borehole Number	Drilling Method	Depth (feet)	Remarks
B301	Hollow-stem auger	0 - 60	Converted to monitoring well MW-301
B302	Hollow-stem auger	0 - 40	
B302A	Hollow-stem auger Rotary wash	0 - 40 40 - 113	Bedrock encountered at about 97 feet below ground surface
B303	Hollow-stem auger	0 - 40	
B303A	Hollow-stem auger Rotary wash Percussion hammer	0 - 40 40 - 47 47 - 93	Bedrock encountered at about 84 feet below ground surface
B304	Hollow-stem auger	0 - 45	Converted to monitoring well MW-304. The borehole was deepened from 35 feet to 45 feet depth for well installation. Logging was not performed beyond 35 feet depth
B304A	Percussion hammer	0 - 60	
B305	Percussion hammer	0 - 110	Bedrock encountered at about 102½ feet below ground surface
B305A	Hollow-stem auger	0 - 36	Converted to monitoring well MW-305
B306	Percussion hammer	0 - 99	Bedrock encountered at about 89 feet below ground surface

Water samples were collected from the following boreholes and monitoring wells:

- | | |
|----------|--------------------|
| 1. B301 | 7. B306 at 33 feet |
| 2. B302 | 8. B306 at 79 feet |
| 3. B303 | 9. MW-301 |
| 4. B304 | 10. MW-304 |
| 5. B305 | 11. MW-305 |
| 6. B305A | |

2.1.3 Hydrologic Testing

Three boreholes, B301, B304 and B305A, were converted into groundwater monitoring wells. Details of well construction and development are presented in Appendix C. Falling head tests were performed in monitoring wells MW-304 and MW-305, and rate of recovery was monitored in monitoring well MW-301. The test procedures and results are also presented in Appendix C.

2.1.4 Geophysical Testing

Records indicate that the northwest and southeast corners of the car impound lot located east of Center Street between Commercial and Ducommun streets were formerly occupied by the Ducommun Street Compressor Plant. MRTC was concerned that some 750-ton flywheels and a concrete water tank foundation associated with this plant may have been left in place when the plant was demolished. Hence, a geophysical survey using ground penetrating radar (GPR) was performed along the portion of the realigned A-130 corridor that passes through these areas in an attempt to determine if these objects were present in the subsurface. The survey was confined to available open areas between the impounded cars. A detailed description of the GPR survey is presented in Appendix D.

2.2 LABORATORY TESTING PROGRAM

2.2.1 Physical and Mechanical Testing

A limited laboratory testing program was performed on selected soil samples. The scope of the laboratory tests conducted at Earth Technology's Huntington Beach facility consisted of the following:

- o In situ moisture content and dry density
- o Grain-size distribution
- o Compaction
- o Direct shear
- o Permeability
- o Consolidation.

Testing was carried out in accordance with applicable ASTM standards. The results of laboratory tests for physical and mechanical soil properties are presented in Appendix E and on the borehole logs.

2.2.2 Analytical Laboratory Analysis

As outlined in the scope of work, a total of eight soil samples from the boreholes were selected for analytical laboratory analysis (Table 2-2). Sample selection was based on visual observations, headspace OVA readings, and the soil material encountered. Soil samples were analyzed by West Coast Analytical Services, Inc., for priority pollutants (EPA Methods 8240, 8270, and 8080). The detailed results of these analyses are presented in Appendix F.

Groundwater samples from seven boreholes and three monitoring wells were collected for analytical laboratory analysis. Groundwater samples from the boreholes were analyzed by West Coast Analytical Services, Inc., for sulfides (EPA Method 9030), sulfates (EPA Method 300.6), pentachlorophenol (EPA Method

TABLE 2-2. SOIL SAMPLES SELECTED FOR ANALYTICAL LABORATORY TESTS

Borehole Number	Sample Depth, feet
B301	50
B302	30
B303	30
B303A	88
B304	30
B305	84
B305A	20
B306	33

625), total petroleum hydrocarbons (EPA Method 418.1), and pH. The ground-water samples from the monitoring wells were also analyzed by West Coast Analytical Services, Inc., for priority pollutants (EPA Methods 624, 625, and 608), suspended solids (Standard Method 209C), settleable solids (Standard Method 209E), BOD (Standard Method 507), oil and grease (EPA Method 413.2), sulfides, phenols (Standard Method 510C), and pentachlorophenols (EPA Method 625). The results of these analyses are presented in Appendix F and summarized in Section 3.4.2.

3.0 SITE CONDITIONS

3.1 PHYSIOGRAPHY

The ground surface along the alignment is relatively flat and generally varies between elevations +270 and +280 feet MSL (Figure 1-2). At the time of this investigation, the site was occupied by various structures and pavements. The structures included a vacant warehouse between Stations 83 + 00 and 84 + 00, a vacant lot (former site of the recently demolished Maier Brewing Company warehouse) between Stations 92 + 60 and 94 + 00, the Santa Ana Freeway and its on-ramp between Stations 94 + 00 and 97 + 00, and an elevated busway bent between Stations 97 + 10 and 97 + 30. The conditions of these structures and their foundations were not investigated for the present study.

The streets and the vehicle impound lot are paved. Measurements made at the field exploration sites indicate that the thickness and composition of the pavement vary greatly along the alignment. The vehicle impound lot is currently filled with impounded vehicles.

Railroad tracks cross the alignment at several locations. The majority of these tracks are located at the southern end of the new alignment. The vacant lots near the northern end of the corridor are not paved. Concrete blocks, other construction debris, and currently exposed buried conduits may be observed in these areas.

In addition to structures located directly on the corridor, two major structures are located adjacent to the proposed alignment. These structures are: (1) Friedman Bag Company building and (2) UNOCAL tank farm. The closest distance between these two structures and the alignment occurs near Station 91 + 00. Further, the subway alignment is proposed to cross over a drainage tunnel (the Ducommun Drain) near Station 86 + 20.

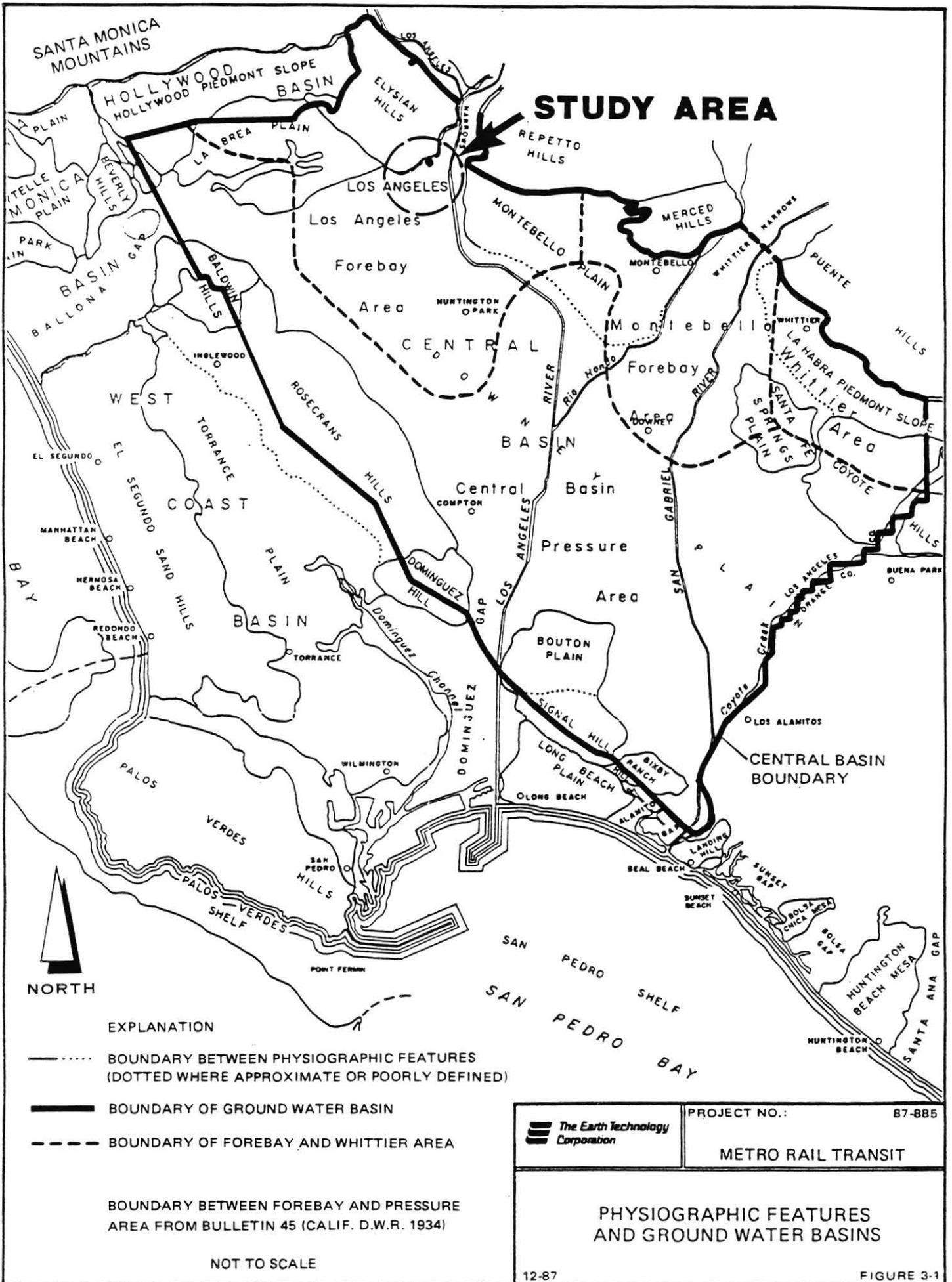
3.2 REGIONAL GEOLOGY

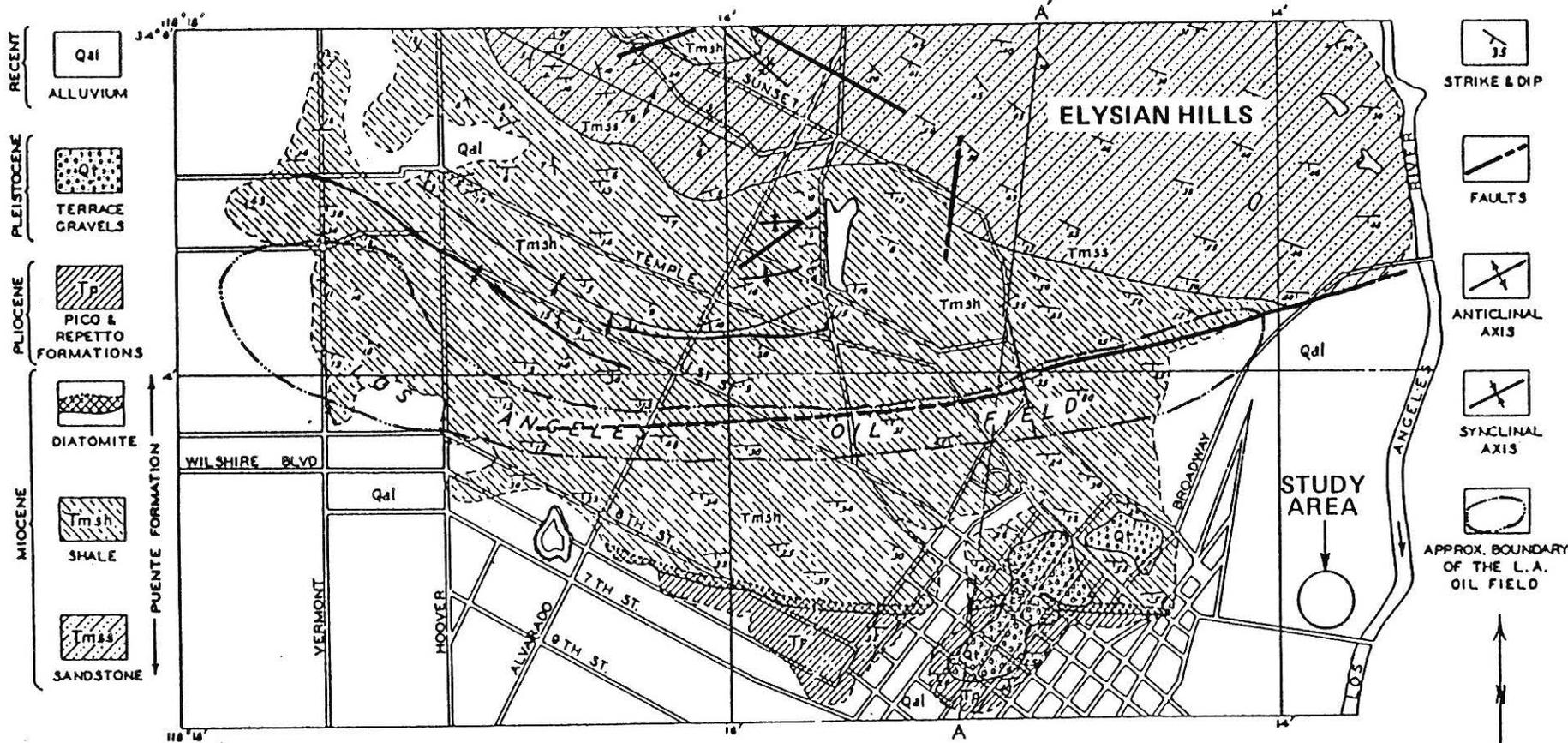
The site area is within the Los Angeles physiographic basin, an alluviated lowland bounded on the north and northeast by the Santa Monica Mountains and the Elysian, Repetto, and Puente Hills (Figure 3-1). The site is located near the northeastern edge of this basin, near the southern edge of the Elysian Park anticline. The physiographic basin is underlain by a structural depression filled with predominantly Tertiary siltstone, sandstone, and shale. These formations are generally covered by Quaternary alluvium and river sand and gravel but are exposed at the surface in many of the hills of the basin.

The northern and eastern margins of the basin are formed by zones of folding and uplift along basin-bounding faults of the Santa Monica-Raymond Hill and Whittier fault zones. Many of these folds are areas of oil production; the Los Angeles oil field in the study area (Figure 3-2) is one of these. The Los Angeles anticline, the N70°W striking fold in the Los Angeles oil field, influences the dip of bedrock strata in the area. Several faults that are inferred to cut older alluvium have been mapped in the area based on data from exploratory borings (Yerkes et al., 1977). Occasionally, such faults create groundwater barriers in the alluvium resulting in differences of water elevations across the faults.

3.3 SITE GEOLOGY

The corridor area is generally underlain by various thicknesses of artificial fill. This fill is relatively thin (typically 5 to 15 feet) and typically consists of silty sand and sand with some silty clay, gravel, and occasional brick fragments. The fill overlies Quaternary alluvium which in turn overlies the bedrock formations. Bedrock exposed in the nearby Elysian Hills consists of sandstone and shale of the Puente Formation (Figure 3-2). Although commonly well indurated where exposed, the bedrock strata are soft and more closely resemble hard, dense soils in the subsurface. At the locations of the boreholes extended to bedrock, the Puente Formation underlies alluvium from 84





NOT TO SCALE

	PROJECT NO.:	87-885
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GEOLOGY IN THE SITE VICINITY

SOURCE: BULLETIN NO. 118, CALIFORNIA DIVISION OF MINES

to 103 feet below the surface. Yerkes et al. (1977) report that bouldery ground consisting of younger and older alluvium exists in the vicinity of Union Station.

The alluvium beneath the site in adjacent corridor segments was deposited by the Los Angeles River and its tributaries, which pass between the Elysian and Repetto Hills (Los Angeles Narrows, Figure 3-1). Prior to channelizing of the Los Angeles River, the Los Angeles Narrows acted to confine the river during flood stages resulting in a higher energy flow environment and movement of coarser sediments such as gravels, cobbles, and boulders in the site vicinity. As the river emerged from the narrows, the coarser sediments were deposited and concentrated in the ancient river channels and tributaries. This mode of sediment transport and deposition results in irregular pockets and lenses of gravel, cobbles, and boulders throughout the alluvium.

The data from exploration borings indicate that the pockets and zones of gravel and cobbles are laterally discontinuous and occur at varying depths. Gravel and cobbles appear to occur most frequently within one poorly defined horizon between elevation +230 and +240 feet MSL. That horizon is schematically illustrated in Figure 3-3. Lenses and zones of cobbles and occasional boulders appear to occur as channel infillings randomly within the horizons.

Two faults that offset alluvium project toward corridor segment A-130 (Yerkes et al., 1977). Those inferred faults may intersect the corridor near Center Street. No information on the recent activity of these faults is available.

3.4 SUBSURFACE MATERIAL

3.4.1 Subsurface Soils

The subsurface soils, as revealed at the borehole locations, are generally coarse grained with varying amounts of fines and cobbles. An upper layer of silty sand and sand fill was encountered in the boreholes drilled during this investigation to depths ranging from about 5 to 15 feet below the ground sur-

face. As indicated by field and laboratory studies, the fill and the silty sand materials are generally loose to medium dense with varying amounts of moisture.

In Borehole BH-201 (Earth Technology, 1987c), concrete debris, 5 inches in diameter, was encountered when the drill auger tip was at a depth of 25 feet. It is uncertain if this material came from this depth or if it came off the side of the borehole at a shallower depth.

Below the fill and silty sand materials, an alluvial unit of sands and gravels was encountered. These alluvial materials appear to be discontinuously interbedded. They are generally moist above the water table, dense to very dense, with varying amounts of fines. Occasional silt and clay lenses were encountered, and cobbles were also encountered intermittently in the alluvium. The layer is generally dense to very dense with zones of loose to medium dense material at shallower depths. The hydraulic conductivity of the layer, as indicated by field and laboratory tests is considerably variable. At the time of the field exploration, the groundwater table was encountered at depths varying between about 27 and 32 feet below the ground surface (approximately between elevations +244 and +251 feet MSL) in the boreholes.

At about 40-foot depth, a gravelly sand to sandy gravel layer containing coarse gravel and cobbles with occasional silty sand inclusions was encountered in several boreholes. This layer will hereinafter be referred to as the sandy gravel layer. This layer may be discontinuous with pockets, lenses, and zones of heavy concentrations of gravel and cobbles. Due to the heavy concentrations of gravel and cobbles, standard hollow-stem auger and rotary wash drilling techniques were not able to advance some of the boreholes. Therefore, as explained in Section 2.1.1, a percussion hammer drill rig was used to penetrate through this zone. The heavy concentration of cobbles in zones or pockets was not observed in the previous boreholes drilled at this site (Earth Technology, 1987c). This indicates that heavy concentrations of cobbles are not uniformly distributed. The presence of gravel and cobbles at Borehole B306 was also not strongly manifested. Below this sandy gravel layer, dense to very dense sandy and gravelly soils similar to the shallow alluvial soils were encountered. The layer is observed to be nonuniform in

composition and may represent a period of time during which the ancient Los Angeles River and its tributaries incised numerous channels that filled with varying amounts of cobbles and gravels.

Several boreholes were drilled in to bedrock which was encountered at depths ranging from 84 to 103 feet below ground surface at the site. An interpreted site subsurface profile along the proposed alignment is presented in Figure 3-3. The profile was developed based on the information obtained from the boreholes and the laboratory test results. The subsurface soil conditions between the boreholes are expected to vary somewhat from the conditions presented herein.

A previous study at a nearby location (Converse Consultants, 1983a) has indicated that boulders up to 2- to 4-foot in diameter may also be encountered in the alluvial layer. Materials of these sizes were not encountered at the borehole locations in this study; however, the possibility of encountering these materials should be considered.

As discussed in Section 2.1.4, a GPR survey was performed in the northwest and southeast corners of the existing car impound lot, located east of Center Street between Commercial and Ducommun streets, in an attempt to determine if some 750-ton flywheels and a concrete water tank foundation from previous site developments may have been left in place. At the survey locations, no such objects were detected with radar signatures similar to those expected for the water tank foundation or the flywheels within 10 to 15 feet below the ground surface. However, such objects may exist under areas which could not be surveyed or at depths greater than those surveyed.

In borehole B303, a bone fragment approximately 6 inches long was brought up to the surface along with the auger cuttings while the auger tip was between 35 to 40 feet below the ground surface. The bone appeared to be somewhat mineralized and saturated, indicating it was below groundwater (approximately 27 feet below the ground surface at Borehole B303). The bone fragment was delivered to the Los Angeles County Coroner's office for evaluation. Earth Technology was later informed that the bone fragment was of animal origin and it was disposed of by the Coroner's office.

3.4.2 Subsurface Chemical Substances

General

Sulfur odors were noticed at various times coming from the boreholes, and there were many indications of hydrocarbon staining on samples and in the drilling fluid. The sulfur odors and/or hydrocarbon staining were noticed below the water table in all boreholes except B302 and B302A. Sulfur odors were noticed more frequently in the northern portion of the site and hydrocarbon staining generally was seen throughout the site.

Soil Samples

Semi-volatile organic compounds were detected in two of the soil samples from Boreholes B303 and B304. Eleven semi-volatile organic compounds were detected in a sample collected at a depth of 30 feet from Borehole B304. The concentrations of these compounds ranged from 110 µg/kg for benzo (a) anthracene to 760 µg/kg for pyrene. Compounds detected at relatively high concentrations were pyrene (760 µg/kg), fluoranthene (510 µg/kg), and phenanthrene (420 µg/kg). Compounds detected at relatively low concentrations were acenaphthene (300 µg/kg), fluorene (270 µg/kg), anthracene (200 µg/kg), acenaphthylene (170 µg/kg), benzo (a) pyrene (130 µg/kg), benzo (b & k) fluoranthenes (120 µg/kg), chrysene (130 µg/kg), and benzo (a) anthracene (110 µg/kg). Two semi-volatile organic compounds, fluoranthene (53 µg/kg) and pyrene (93 µg/kg) were detected in the soil sample obtained from a depth of 30 feet at boring B303. A summary of the results of analytical tests performed on soil samples is presented in Table 3-1.

These detected semi-volatile organic compounds were not on the list of Organic Persistent and Bioaccumulative Toxic Substances in Article 11, Criteria for Identification of Hazardous and Extremely Hazardous Wastes, of Title 22 of the California Administrative Code (CAC). However, anthracene is reported to have potential toxic properties and phenanthrene, anthracene, pyrene, benzo (a) anthracene, chrysene, benzo (b & k), fluoranthene, and benzo (a) pyrene are reported to be carcinogenic compounds.

TABLE 3-1. SUMMARY OF ANALYTICAL LABORATORY ANALYSIS OF SOIL SAMPLES

Constituent ⁽¹⁾	Boring Number: Sample Depth (feet):	B301	B302	B303	B303A	B304	B305	B305A	B306
		50	30	30	88	30	84	20	33
Freon - TF		*	6	*	*	*	*	*	26
Acenaphthylene		*	*	*	*	170	*	*	*
Acenaphthene		*	*	*	*	300	*	*	*
Fluorene		*	*	*	*	270	*	*	*
Phenanthrene		*	*	*	*	420	*	*	*
Anthracene		*	*	*	*	200	*	*	*
Fluoranthene		*	*	53	*	510	*	*	*
Pyrene		*	*	93	*	760	*	*	*
Benzo (a) Anthracene		*	*	*	*	110	*	*	*
Chrysene		*	*	*	*	130	*	*	*
Benzo (b & k) fluoranthenes		*	*	*	*	120	*	*	*
Benzo (a) pyrene		*	*	*	*	130	*	*	*

* Not detected.

(1) Concentrations reported in hg/kg (PPB). Only constituents that were detected are listed.

Groundwater Samples

The results of the analysis of the groundwater sample from Borehole B301 indicated that eight volatile organic compounds were detected with concentrations ranging from 1 µg/l (toluene, trichloroethylene, and freon) to 21 µg/l (dibromochloromethane). However, a groundwater sample collected from Monitoring Well MW-301 (installed in Borehole B301) contained none of the priority pollutant volatile organics. The cause(s) of these differences cannot be readily explained. However, since a groundwater sample from a properly constructed and developed monitoring well is more representative than samples taken during drilling, the analytical results of the sample obtained from Monitoring Well MW-301 are considered to be more representative of the site conditions than the analytical results of the sample obtained during drilling.

Semi-volatile organic compounds, primarily acenaphthylene (18 µg/l to 31 µg/l), acenaphthene (49 µg/l to 76 µg/l), fluorene (18 µg/l to 52 µg/l), phenanthrene (22 µg/l to 26 µg/l), fluoranthene (9 µg/l to 110 µg/l) and pyrene (6 µg/l to 100 µg/l) were detected in boring groundwater samples from Borings B303 and B304. Three semi-volatile compounds, dimethyl phthalate (15 µg/l), diethyl phthalate (51 µg/l), and di-N-butyl phthalate (9 µg/l), were detected in a sample from Borehole B305A. Di-N-butyl phthalate (1 µg/l) and naphthalene (2 µg/l) were detected in Boreholes B301 and B306.

As noted above, analysis of the groundwater samples from the three monitoring wells showed that organic compounds were not detected in Monitoring Well MW-301. In Monitoring Well MW-304, fuel-related compounds (benzene, toluene, xylene, and ethylbenzene) were detected (7 µg/l to 250 µg/l) in addition to tetrahydrofuron (240 µg/l). Analysis of the sample from Monitoring Well MW-304 for semi-volatile organic compounds generally detected the same compounds that had been detected in the Borehole B303 groundwater sample, but generally at lower levels. In the sample from Monitoring Well MW-304, three volatile compounds, benzene (1 µg/l), ethylbenzene (13 µg/l), styrene (4 µg/l) and one semi-volatile compound, pyrene (4 µg/l), were detected. A summary of the results of analytical tests performed on groundwater samples is presented in Table 3-2.

TABLE 3-2. SUMMARY OF ANALYTICAL LABORATORY ANALYSIS OF WATER SAMPLES
(Page 1 of 3)

Constituent	B306(a)	B306(b)	MW-301	B301	B302	B303	B304	MW-304	B305	B305A	MW-305
Total Petroleum Hydrocarbons	NA	ND	NA	ND	ND	52	ND	NA	ND	ND	NA
Total Hydrocarbons	NA	NA	ND	ND	NA	NA	NA	ND	NA	NA	ND
pH	NA	7.0	NA	7.9	6.5	8.0	6.9	NA	8.1	7.1	NA
Total Suspended Solids, mg/L	NA	NA	4,800	10	NA	NA	NA	7,500	NA	NA	1,000
Settleable Solids, mg/L	NA	NA	4,800	9	NA	NA	NA	7,500	NA	NA	1,000
Sulfide, ppm	ND	ND	ND	0.24	0.40	ND	ND	ND	2.3	ND	ND
BOD, ppm	NA	NA	1.5	2.1	NA	NA	NA	1.5	NA	NA	4.4
Total Phenolics, ppm	NA	NA	0.3	NA	NA	NA	NA	0.3	NA	NA	0.3
Phenols, ppm	NA	NA	NA	0.26	NA	NA	NA	NA	NA	NA	NA
Pentachlorophenol, ppm	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sulfate, ppm	106	980	NA	NA	1,300	860	1,400	NA	ND	1,550	NA
Priority Pollutants (EPA Method 608)	NA	NA	ND	ND	NA	NA	NA	ND	NA	NA	ND

(a) Water sample at 79-foot depth.

(b) Water sample at 33-foot depth.

NA - Not analyzed.

ND - Not detected.

TABLE 3-2. SUMMARY OF ANALYTICAL LABORATORY ANALYSIS OF WATER SAMPLES
(Page 2 of 3)

Constituent(a)	Priority Pollutants (EPA Method 624)										
	B306(b)	B306(c)	MW-301	B301	B302	B303	B304	MW-304	B305	B305A	MW-305
Tetrahydrofuran	NA	NA	ND	ND	NA	NA	NA	240	NA	NA	ND
Freon - TF	NA	NA	ND	1	NA	NA	NA	ND	NA	NA	ND
Chloroform	NA	NA	ND	5	NA	NA	NA	ND	NA	NA	ND
1,1,1-Trichloroethane	NA	NA	ND	1	NA	NA	NA	ND	NA	NA	ND
Bromodichloromethane	NA	NA	ND	12	NA	NA	NA	ND	NA	NA	ND
Trichloroethene	NA	NA	ND	1	NA	NA	NA	ND	NA	NA	ND
Dibromochloromethane	NA	NA	ND	21	NA	NA	NA	ND	NA	NA	ND
Benzene	NA	NA	ND	ND	NA	NA	NA	7	NA	NA	1
Bromoform	NA	NA	ND	15	NA	NA	NA	ND	NA	NA	ND
Toluene	NA	NA	ND	1	NA	NA	NA	33	NA	NA	ND
Ethylbenzene	NA	NA	ND	ND	NA	NA	NA	250	NA	NA	13
Styrene	NA	NA	ND	ND	NA	NA	NA	ND	NA	NA	4
Total Xylenes	NA	NA	ND	ND	NA	NA	NA	66	NA	NA	ND

(a) Concentration reported in $\mu\text{g}/\text{kg}$ (PPB). Only constituents that were detected are listed.

(b) Water sample at 79-foot depth.

(c) Water sample at 33-foot depth.

NA - Not analyzed.

ND - Not detected.

TABLE 3-2. SUMMARY OF ANALYTICAL LABORATORY ANALYSIS OF WATER SAMPLES
(Page 3 of 3)

Constituent(a)	Priority Pollutants (EPA Method 624)										
	B306(b)	B306(c)	MW-301	B301	B302	B303	B304	MW-304	B305	B305A	MW-305
Phenol	NA	ND	ND	ND	NA	ND	16	ND	ND	ND	ND
2,4-Dimethylphenol	NA	ND	ND	ND	NA	ND	4	ND	ND	ND	ND
Naphthalene	NA	2	ND	ND	NA	ND	ND	100	ND	ND	ND
Dimethyl Phthalate	NA	ND	ND	ND	NA	ND	ND	ND	ND	15	ND
Acenaphthylene	NA	ND	ND	ND	NA	31	18	23	ND	ND	ND
Acenaphthene	NA	ND	ND	ND	NA	49	76	16	ND	ND	ND
Diethyl Phthalate	NA	ND	ND	ND	NA	ND	ND	ND	ND	51	ND
Fluorene	NA	ND	ND	ND	NA	18	52	20	ND	ND	ND
Phenanthrene	NA	ND	ND	ND	NA	26	22	4	ND	ND	ND
Anthracene	NA	ND	ND	ND	NA	ND	8	5	ND	ND	ND
Di-N-Butyl Phthalate	NA	ND	ND	1	NA	ND	ND	ND	ND	9	ND
Fluoranthene	NA	ND	ND	ND	NA	110	9	3	ND	ND	ND
Pyrene	NA	ND	ND	ND	NA	100	6	4	ND	ND	4

(a) Concentrations reported in $\mu\text{g}/\text{kg}$ (PPB). Only constituents that were detected are listed.

(b) Water sample at 79-foot depth.

(c) Water sample at 33-foot depth.

NA - Not analyzed.

ND - Not detected.

Federal and/or State agencies have developed Maximum Contamination Limits (MCLs), Recommended MCLs (RMCLs), and drinking water action levels for some of the volatile organic compounds. Currently no MCLs or action levels are established for any of the semi-volatile organic compounds that were detected in the groundwater samples. However, in comparison with the state action level for volatile organic compounds, groundwater samples from Monitoring Wells MW-304 and MW-305 were found to contain benzene exceeding the state action level of 0.7 µg/l. Table 3-3 presents a summary of the comparison of detected volatile organic concentration to their MCL's and action levels. The concentrations of the other compounds were below their MCLs and/or action level values.

3.5 SITE HYDROLOGY

The site is located in the Los Angeles Forebay area of the Central Basin Area (Figure 3-1). A semiperched aquifer consisting of coarse sands and gravels is common near the surface in the Forebay area (CDWR, 1961). This semiperched aquifer occurs above the Bellflower aquitard as irregular patches, from 0 to 60 feet thick (CDWR, 1961). The Gaspur, Exposition, and Gage aquifers exist west of and south of the Los Angeles River and in the vicinity of the study area. Based on an interpretation of the maps and cross-sections presented in Bulletin No. 104 of CDWR (1961), only the Gaspur aquifer seems to be present and the Bellflower aquitard is absent in the study area.

The Gaspur aquifer (overlying bedrock) ranges in thickness from 40 to 60 feet in the study area and consists of sand and gravel with clay and silt lenses. The gravel and cobble layer (possibly an extension of the Bellflower aquitard), approximately 5 to 15 feet thick, overlies this aquifer. Overlying this layer is a possibly semiperched aquifer which has a thickness of from 0 to 15 feet.

Three field hydraulic conductivity tests were conducted as part of this study (Appendix C); one in the Gaspur aquifer, one in the possibly semiperched aquifer, and one in the gravel and cobble layer. Based on these tests, the hydraulic conductivities of the hydrogeologic units were calculated and are presented in Appendix C. The overall transmissivity of the subsurface layers ranges from about 200 to 4,000 gallons per day per foot.

TABLE 3-3. COMPARISON OF DETECTED CONCENTRATION OF VOLATILE ORGANICS AND THEIR MCLS AND ACTION LEVELS IN GROUNDWATER

Chemical Compound	<u>Detected Concentration, µg/l</u>				MCLs	Calif. Action Levels	
	B301	MW-301	MW-304	MW-305		Levels	RMCLs
Benzene	ND	ND	7	1	5	0.70	---
Toluene	1	ND	33	ND	---	100	2,000
Ethylbenzene	ND	ND	250	13	---	680	680
Total Xylene	ND	ND	66	ND	---	620	440
Styrene	ND	ND	ND	4	---	---	140
1,1,1-Trichloroethane	1	ND	ND	ND	200	---	---
Trichloroethene	1	ND	ND	ND	5	5	---

MCL - Maximum Contamination Limits.
 RMCL - Recommended Maximum Contamination Limits.
 ND - Not Detected.
 --- - No designated levels.

Previous studies have estimated a groundwater gradient of approximately 0.006 feet per foot (vertical/horizontal) at the site. Groundwater generally flows southeast in the area. Assuming an average porosity of 20 to 25 percent and a hydraulic conductivity of 10×10^{-3} cm/sec for the semiperched aquifer as measured in the field test results, the natural groundwater velocity is calculated to be about 1/2 to 1 foot per day.

We note that the contamination in the groundwater appears to move more slowly than 1/2 to 1 foot per day. This is based on the observation that the contaminant has spread only about 200 feet in about 40 years (Earth Technology, 1987b). Using this observation, a contaminant movement of about 0.01 to 0.02 feet per day is calculated, which is about 1/50 of the velocity calculated on the basis of measured hydraulic conductivity, assumed porosity, and hydraulic gradient alone. Vertical spreading of the contamination probably is the result of water-level fluctuations and some diffusion.

4.0 GEOTECHNICAL EVALUATIONS AND RECOMMENDATIONS

4.1 GENERAL

Construction of the realigned A-130 corridor including shield-driven tunnel and cut-and-cover sections, as planned by MRTC, will involve excavation of generally dense to very dense granular soils partly below the groundwater surface. Based on the results of our field and laboratory investigations, the subsurface soils are variable with respect to the degree of compactness, the amount of fines, and the hydraulic conductivity. Further, noxious gases and odors were encountered in some of the boreholes, and at certain depths, the site soils and the groundwater contain some chemical compounds. Therefore, special construction provisions may be required to provide for personnel safety at the working areas, to transport and dispose of portions of the excavated material, to control the groundwater during excavation, to limit ground movement, and to minimize construction costs and impact to the surrounding areas.

The primary geotechnical considerations at the site are:

- o Groundwater control
- o Subsidence control
- o Support of excavated openings--temporary and permanent
- o Support of existing structures
- o General construction procedures.

4.2 GROUNDWATER CONTROL

4.2.1 Tunneling Section

Groundwater in the tunneling section of realigned A-130 corridor may be controlled by several alternative methods depending on the hydrologic and physical characteristics of the materials at the site. We understand from MRTC that grouting is proposed for the portion of the alignment crossing under the

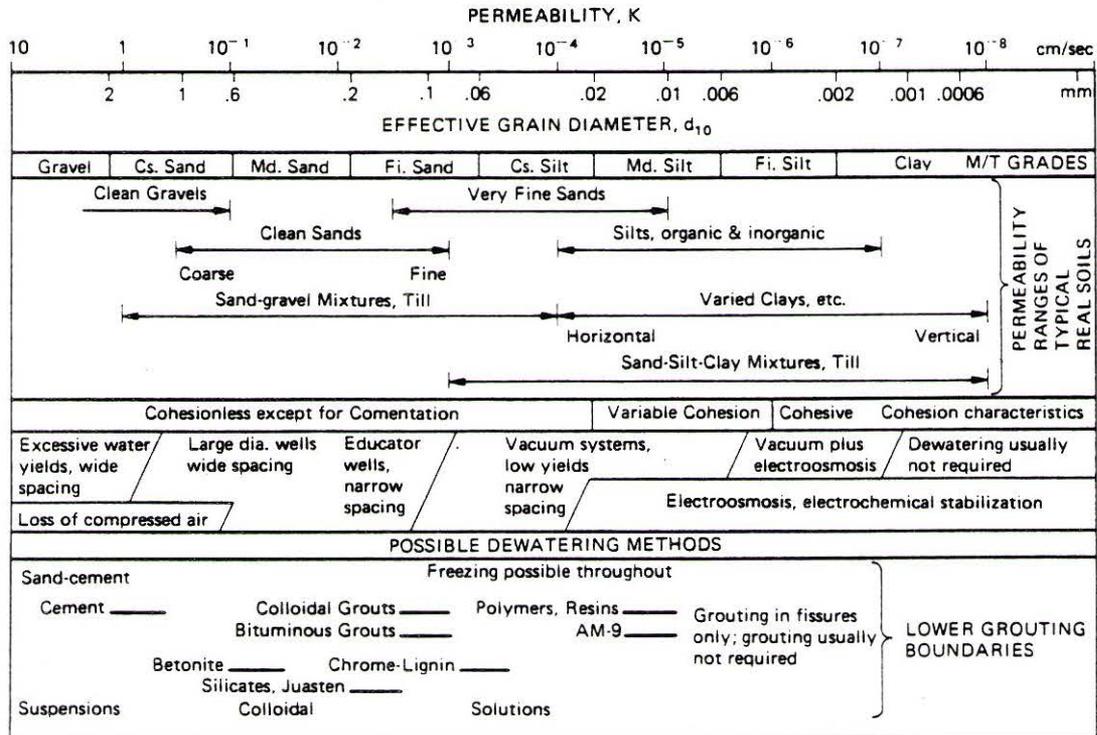
freeway and may be extended throughout the entire tunneling section. This process should also serve as a groundwater control. However, many potential methods may be considered for controlling groundwater during tunneling in the realigned A-130 corridor. Some of these methods are:

- o Compressed air
- o Pressure grouting
- o Dewatering by pumping
- o Slurry wall
- o Freeze wall
- o Slurry-faced shield.

The applicability of certain groundwater control methods including grouting for various soil gradation ranges is presented in Figure 4-1. A general discussion of various methods is given below.

Compressed Air - Compressed air tunneling could be considered for areas to the north and the south of the freeway where pressure grouting is not being considered. Compressed air tunneling is commonly used to stabilize ground in tunnels in soils below the water table where dewatering is impractical. Using the generally accepted rule of 1 pound per square inch (psi) of air pressure for each 2 feet of water pressure, based on the existing groundwater table information, an estimated air pressure of about 5 to 6 psi was estimated for the deepest tunneling portion of the realigned A-130 corridor.

Care must be taken to prevent air loss in gravelly and clean sandy soils because of the over-pressurization of the upper portion of the face and crown. In such areas, it may be possible to limit the exposure of the face to the portion being actively worked and reduce the permeability by covering the face with reworked clay or similar materials. Pre-grouting may also be used for the gravelly and sandy site soils. All soils must be protected from prolonged exposure or rapidly escaping air which causes drying and loss of apparent cohesion or shrinkage, especially in the upper portion of the face. All areas of the face not actively being worked should be supported.



REFERENCE: TUNNEL ENGINEERING HANDBOOK, J.O. BICKEL AND T.R. KUESEL, VON NOSTRAND REINHOLD COMPANY, 1982.

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CORRELATION BETWEEN SOIL GRADATION RANGES AND VARIOUS GROUNDWATER CONTROL SCHEMES

This may mean special care to prevent opening air escape paths to the surface, such as existing wells, sewers, and conduits through the soil caused by over-pressurization.

Pressure Grouting - Pressure grouting is currently being considered by MRTC for tunneling under the freeway and may also serve to control groundwater inflows in the areas adjacent to the Santa Ana Freeway. A study of groutability and the strength of the grouted site soils was performed by GKN Hayward Baker, Inc. The results of this study are presented in Appendix I. This study indicates that the coarse-grained site soils generally demonstrate favorable groutability. However, some difficulties in grouting may be encountered in the areas where the soils contain excessive amount of fines. Therefore, some localized groundwater control measures may still be required during tunnel excavation to handle minor groundwater inflows. It is further indicated by this study that the in situ strength of subsurface soils, using a 60 percent concentration sodium silicate type chemical grout, will be on the order of 100 to 200 pounds per square inch (psi).

Dewatering by Pumping - Groundwater control may also be achieved by dewatering through pumping. Assuming a minimum invert elevation of +241 feet at the northern end of the tunneling operations, a water level drawdown of the order of 10 feet or more may be necessary. Although several techniques are available for dewatering, installation of a deep well system may be suitable to lower the groundwater along the realigned corridor, where the proposed construction is under the current groundwater level.

A number of preliminary simulations were conducted to evaluate the effect of dewatering and well field design (Appendix G). Based on the results of these studies, as many as 40 deep wells, pumping over a period of 6 to 8 weeks (depending on pump capacity), may be required to lower the groundwater table to the desired level. Based on the assumptions used in the simulations, total capacity of approximately 500 to 1,000 gallons per minute for all pumps was estimated. A summary of these simulations is presented in Appendix G.

In performing these simulations, attempts were made to avoid placing a well in a sensitive area such as the freeway and the streets; however, field checks

will be required to provide for proper locations for the well sites. It was assumed that the entire section would be dewatered at the same time, which may not be the case since dewatering efforts could be concentrated on the areas where excavation is in progress and excavations are unlined.

In addition, it was assumed that the water-bearing aquifers were continuous and about 80 feet thick which, as was noted earlier, may not be the case because of the possible existence of a semiconfining layer along the gravel and cobble layer. If this proves to be the case, the upper semiperched aquifer would be about 15 feet thick and the volume of pumpage would be less than that estimated herein. However, the vertical hydraulic conductivity of the gravel and cobble layer could be determined accurately prior to well installation so that adequate pumping rates may be designed to overcome possible vertical leakage from the underlying Gaspur aquifer. This may be accomplished by conducting specially designed pumping tests in the existing or new wells. In the case of the existence of a continuous semiconfining layer (the gravel and cobble layer), the wells need only be drilled to the top of this layer (35 to 45 feet deep).

Some difficulties may be encountered during well installation through the gravel and cobble zone. Wells installed for dewatering should be perforated through the water-bearing zone. The wells should be embedded in properly designed, protective sand filters to prevent washout and ground subsidence due to loss of fines. To avoid washout of the bedrock, the bottom portion of the wells, if extended into the bedrock, should not be perforated. Similar precautionary measures should be taken if the wells are only extended into the gravel and cobble layer. Well efficiency should be checked by performing field tests prior to system installation.

Various levels of chemical compounds were encountered in the material obtained from the boreholes. Previous studies also indicated the presence of some chemical compounds in the vicinity of the alignment. Employing any dewatering scheme will induce a flow of water and chemical compounds toward the dewatering wells. Based on the dewatering simulations and related assumptions presented in Appendix G, it is estimated that chemical compounds may travel at

a rate of over 2 feet per day under pumping conditions. It was estimated that the chemical compounds encountered at the original A-130 corridor might migrate toward the wells and appear in the extracted water after approximately 100 days of continuous pumping. This travel time may be longer because of the immiscible nature of the chemical compounds and the possible retardation properties of the aquifer. The water extracted from the wells should be monitored for chemical compounds and, if required, properly treated.

To limit migration of chemical compounds, consideration was given to the viability of installing injection wells between the dewatering wells and the contaminated area to the northeast. Preliminary analysis indicated that the injection wells may not be effective in retarding the movement of chemical compounds toward the dewatering wells. A slurry wall between the excavation and the contaminated area could also be considered to reduce the possibility of chemical compound movement away from or toward the excavation.

Installation of observation wells in conjunction with discharge wells is recommended. These wells should be properly spaced on the upstream sides of the dewatering system. Water samples should be regularly taken from these wells and tested for chemical compounds. This precautionary measure would serve as a warning system for movement of chemical compounds into the dewatering system.

In addition to liquid chemicals, dewatering may release gases. This may interfere with the pumping process in the form of air-lock at the pump inlet. It is recommended that provisions be made for gas-liquid separation at the inlet.

In general, the dewatering system should satisfy the following criteria:

1. The dewatering system should be installed and in operation in sufficient time before the start of construction to adequately draw down the static groundwater level.
2. The system should maintain the groundwater levels at least 4 feet below the lowest excavation level.

3. The system should be operated continuously. Emergency power and backup pumps should be required to ensure continual excavation dewatering.
4. The wells must be designed and developed to eliminate loss of ground from piping. The well operations should be constantly monitored for evidence of piping.

Slurry Wall - A more effective alternative method of preventing the contaminant from migrating toward dewatering wells may be to construct a slurry or grout curtain on the northeast side of the realigned corridor to separate the areas of heavy concentration of contaminants, as determined from the previous study (Earth Technology, 1987b), from the realigned corridor. Another slurry wall could be constructed on the southwest side to reduce the pumping rates and the number of wells required. The slurry walls or grout curtains may need to be as deep as 50 feet or more below groundwater level to be effective. If the gravel and cobble layer is found to be a continuous semiconfining layer, the depth of the wall may not need to exceed 15 feet below current groundwater levels.

Freeze Wall - A freeze wall could be considered for controlling the inflow of groundwater during tunneling. Sufficient time, depending on coolant type and cooling pipes spacing, must be allotted to complete a freeze wall prior to the start of the tunneling section and utilities, such as sewers, within the zone of influence must be protected from freezing. There also exists a possibility of frost heave in the areas where the subsurface soils contain an appreciable amount of silts. In our opinion, a freeze wall would not be cost-competitive with other groundwater control methods such as compressed air tunneling and grouting.

Slurry-Faced Shield - A slurry-faced shield could be considered for excavation under the groundwater table in soil types found at the site. The economic feasibility of excavation using this method is questionable if used only for a short tunnel section. Therefore, although it may be technically acceptable, this method is not recommended if it is used only in the realigned A-130 corridor.

As stated earlier, gravels and cobbles were encountered in this study. In a previous study (Converse Consultants, 1983a), 2- to 4-foot boulders were encountered in the alluvium soils at nearby locations. Although such a condition was not encountered at the borehole locations in this study, the potential of encountering these materials during tunnel construction cannot be dismissed. Special construction consideration and proper construction tools may be required for removal of these materials, if present.

In summary, various methods exist that can be used for groundwater control in the tunneling section. Of the methods discussed above, pressure grouting appears to be the most feasible from a geotechnical engineering standpoint. Due to the anticipated restraint of maintaining traffic flow, groundwater pumping, slurry walls, and freeze walls may not be practical in the vicinity of the Santa Ana Freeway. Due to the generally coarse-grained nature of the subsurface soils, compressed air methods are expected to be impractical due to excessive air loss. A slurry-faced shield, while technically feasible, may not be cost-effective due to the relatively short length of the proposed tunnel.

4.2.2 Cut-and-Cover Sections

At the time of our field exploration, groundwater was interpreted to be at an elevation above the bottom of the proposed excavation in the cut-and-cover section north of Station 97 + 00. For the cut-and-cover section south of Station 90 + 00 groundwater was recorded below the bottom of the proposed excavation. A groundwater control scheme, therefore, will be required during the construction of the northern cut-and-cover section. Similar measures should be provided for, should groundwater be observed above the bottom of the excavation during the construction of the southern cut-and-cover section. Several potential groundwater control methods are conceivable for the northern section. Some of these methods are:

- o Dewatering by pumping
- o Slurry wall
- o Freeze wall

- o Areal grouting
- o Areal freezing
- o Deep cement mix.

Dewatering by Pumping - The relevant considerations for dewatering for the cut-and-cover section are similar to those presented in the tunneling section. In addition to the recommendations presented in the previous section, the following are also recommended.

- o Wells should be located outside of the excavation area
- o To prevent "quick" conditions, the water level should be lowered to a minimum of 6 to 8 feet below the bottom of the excavation at the walls in order to maintain the water level at least 4 feet below the excavation bottom at the centerline.

To provide for the "dry" condition at the bottom of the excavation, a well point system may also be installed at the excavation level to lower the water level a few feet.

Slurry Wall - As an alternative to dewatering, a deep slurry wall could be installed through the permeable soils and into the underlying Puente Formation bedrock. The deep slurry wall would provide an effective cut-off and minimize groundwater flow into the excavation. This would eliminate the need for an extensive dewatering system although excavation sumps would still be required initially to dispose of water in the soils confined by the slurry walls.

In general, slurry walls are grouped into nonstructural and structural types. Either type may be selected for groundwater control for the construction of the northern cut-and-cover section. Nonstructural slurry walls are constructed by excavating deep, narrow trenches away from the main excavation area, provided that the right-of-way for such construction exists. The trench is filled with the excavated material combined with an impermeable slurry (usually bentonite slurry) and functions as a water barrier. The bentonite slurry provides for trench wall stability during the trench excavation. In the main excavation area stability may be provided for by soldier piles and lagging, with or without ground anchors or cross-lot or raked bracing.

Construction of a structural slurry wall is similar to that of a nonstructural type. However, in this method, after the trench is excavated and filled with slurry, a reinforcement cage or rolled section is lowered in the trench and concrete is tremied into the trench, displacing the slurry. The structural slurry walls may be constructed adjacent to the excavation wall locations. The slurry wall may be supported by internal bracing or ground anchors. If either nonstructural or structural slurry wall methods are selected, detailed structural and construction design studies will be required for the slurry wall. Recommended values for earth pressure on excavation walls and design of internal bracing and ground anchors are presented in Appendix H.

Some difficulties may be encountered during the construction of the slurry walls. Special excavation considerations and digging tools may be necessary for excavation through the gravel and cobble zone or if boulders are encountered. Further, trench wall stability should be maintained by proper control of trenching fluid pressure.

The slurry wall, if properly designed and installed, would provide a technically acceptable alternative to dewatering. The cost-effectiveness of this alternative, however, should be compared to that of other dewatering methods.

Freeze Wall - A deep freeze wall may be substituted for the deep slurry wall. A deep freeze wall installation consists of drilling a row of closely spaced, 4- to 6-inch diameter holes below the water table and to an impermeable layer, and installing cooling pipes in the holes. Freeze walls are formed by circulating a special coolant in the pipes. For rapid wall construction, liquid nitrogen at approximately -196°C is used. Alternatively, low temperature brine or ethylene glycol, with lowest achievable temperature around -55°C , is used at a slower rate of freezing. During the construction of the freeze wall, the stability of the drilled holes (usually cased) and provisions for drilling through the gravel and cobble zones should be considered. The excavation may be supported by ground anchors at the frozen soil areas and by soldier piles and lagging above the frozen ground. Sufficient time, depending on coolant type and cooling pipes spacing, must be allotted to complete the freeze wall prior to the start of excavation. Utilities, such as sewers, within the zone of influence must be protected.

Areal Grouting or Freezing - In lieu of deep slurry or freeze walls extending to the Puente Formation bedrock, the sides and the bottom of the excavation may be stabilized by grouting or freezing. With these alternatives, the stability of the bottom of the excavation against a hydraulic uplift condition should be provided for by properly designing the thickness of the grouted or frozen layer. Depending on the depth as well as other dimensions of the excavated area, it is estimated that a treated layer (grouted or frozen) 5 to 10 feet thick may be required to resist the water pressure at the level encountered in the field. An accurate determination of the excavation bottom stability should be made upon the selection of the technique and, if grouting is selected, the type of the grout.

If either of these groundwater control techniques is selected, the excavation can proceed in a dry condition. However, some localized groundwater control measures may still be required during excavation to handle minor groundwater inflows. The excavation may be supported by ground anchors, internal bracing, or a combination of both.

Deep Cement Mix - Another alternative for groundwater control is the deep cement mix (DCM) technique. In this procedure, the ground is drilled using equipment similar to a rotary drill rig. The rig consists of a single or a group of drill shafts equipped with auger-type mixing fins at the bottom. The soils are drilled with this equipment to a desired depth, above or below groundwater. At the desired depth, the drilling is stopped and the rotation of the shafts is reversed for withdrawal. As the shafts are withdrawn, a cement slurry is fed in through a set of pipes and mixed with the soils by the rotating blades. The result, following a curing period, is a type of soil-cement pile, column, or block.

By careful positioning, the treated columns can be made to form continuous walls, cells, blocks, or various other configurations. Cement mixing may be done over the entire drilled length or over a desired depth interval. Depending on the subsurface soil conditions and the equipment, columns of approximately 7 feet in diameter and blocks of 10 by 6 feet may be constructed by each application.

This technique may be used for the cut-and-cover section. The boundaries of the excavation area, including the sides and the bottom of the excavation, may be treated using DCM technique; and, following the curing period, the excavation may proceed in a dry condition. However, some localized groundwater control measures may be required to handle minor inflows. The excavation walls may be supported by ground anchors, soldier piles and lagging, or a combination of both.

The advantage of employing this procedure is that a dry working pad may be readily prepared even prior to beginning of the excavation. Further, because the procedure is applicable below as well as above the groundwater level, dewatering is no longer necessary.

It is our understanding that the DCM equipment may be readily available in the Los Angeles area. It is anticipated that the DCM technique may be applicable to soils similar to those encountered at the site. The use of this technique through cobbles and boulders, however, should be further evaluated.

In summary, various methods exist that can be used for groundwater control in the northern cut-and-cover section. Of the methods discussed above, dewatering by pumping appears to be the most feasible from a geotechnical engineering standpoint. However, due to the potential for drawing offsite chemical compounds into the area by pumping of the groundwater, methods limiting the amount of groundwater pumped should be considered. Of these methods, areal grouting or the DCM technique may be the most feasible, although both methods might still require some localized groundwater control. Use of a slurry wall may be complicated by difficulties in excavating through cobbles and boulders. Freeze wall methods are expected to be prohibitively expensive at this site.

4.3 SUBSIDENCE CONTROL

4.3.1 Tunneling Section

Subsidence control will be an important consideration throughout the tunneling section of the realigned A-130 corridor since it crosses the Santa Ana Freeway and streets. Case histories summarized in Table 4-1 show typical settlements above tunnels in granular soils with comparable depths of soil overburden. In general, subsidence can be controlled by careful tunneling practices and a well-designed primary lining system. It is understood from MRTC that rib and wood lagging will be used as primary lining for the tunnel. Assuming the tunnel will be driven using a shield, the annular space created by moving the shield tailpiece should be eliminated by expanding the rings with hydraulic jacks, as soon as possible to minimize movement of the surrounding soil.

To minimize ground subsidence in running gravels and sands, continuous support of the face by a method such as breasting boards is recommended. Grouting may decrease the risk of running sands. The use of a grout curtain to provide cohesion to a cohesionless granular soil could substantially increase the standup time and decrease subsidence. However, as previously mentioned for groundwater control, if a window in the grout curtain is exposed, especially below the water table, runs of ground may occur causing substantial subsidence.

If dewatering is used in the construction area, subsidence could occur from two causes: increase in effective stress or loss of ground. Dewatering increases the effective stress and results in some surface settlement. It is estimated that the settlements due to dewatering could be approximately 1/2 to 3/4 inches at the well locations for a groundwater drawdown on the order of 20 feet. It is also estimated that the ground would rebound to nearly its original elevation after dewatering is terminated and the groundwater regains its original level. It is anticipated that the subsidence slope would be very

TABLE 4-1. DEEP EXCAVATIONS AND TUNNELING

Table II Settlements above Tunnels in Granular Soils (Cohesionless except for Capillarity)

No.	Case	Reference	Depth to Center, z, ft	Diameter, 2R, ft	Av. Settlement Volume, %	Largest Settlement δ''_{max} , ft	Normal Settlement δ'_{max} , ft	Method of Tunneling	Soil Conditions
1	San Francisco Mission Line, BART	Pers. files	36	17.5	0.5*	0.07* 0.10* ^a	0.03* 0.04* ^a	Digger shield, air 13 psi	Dense silty fine sand (N=30) with occ. thin lenses of peat. Dewatered by deep wells.
2	Toronto Subway under Parliament	Bartlett et, al, 1965	49	17.0	--	**	--	Hand-mined shield air 15 psi	Crown in dense fine to medium sand, some silt. Groundwater level 15 ft above crown.
3	Toronto Subway	Pers. files	34-44	17.0	1.0	0.33	0.10	Hand-mined shield. No air.	Med. to fine uniform dense sand (N=40 to 60) above water table.
4	Toronto Subway	Matich and Carling (unpubl.)	34	17.0	1.0 2.0 ^b	0.06 0.22 ^b	--	Hand-mined shield. No air.	Dense fine to med. sand (N=36-58). Groundwater 25 ft above crown.

* Settlement due to groundwater lowering not included.

** Settlement less than about 0.01 ft; no cracks in overlying masonry building.

^a Values for two parallel circular tunnels on 33-ft centers.

^b Values for two parallel circular tunnels on 21-ft centers.

N = Standard Penetration Resistance (blows per ft of 140-lb hammer falling 30 inches to drive standard 2-inch O.D. sampling spoon 1 ft into undisturbed material).

Source: Peck (1969).

gentle with differential settlement along any ground distance being considerably less than the total. Settlement could also occur from ground loss. Ground loss could be especially critical near the dewatering wells. The amount of potential subsidence due to ground loss would be dependent on the depth, size, construction methods, and pumping rates of the dewatering wells. Therefore, it is essential that a properly designed protective sand filter be used in constructing the dewatering wells.

As mentioned earlier, it our understanding that the tunneling operation will be accompanied with grouting under the Santa Ana Freeway. The study by GKN Hayward Baker, Inc. (Appendix I) indicates that the ground movement at the Freeway location under careful grouting and tunneling operations is not expected to exceed 3/4 inches. We recommend that, prior to the start of construction, a monitoring system for the adjacent structures and streets be established and maintained throughout the project . Recommendations for observation and testing during construction is presented in Section 5.0.

4.3.2 Cut-and-Cover Sections

Ground subsidence at the vicinity of the cut-and-cover sections may occur from two causes, dewatering and movement of temporary retaining structures. The effects of dewatering on the ground subsidence are presented in the previous section. Some settlement should be expected due to installation of temporary walls around the excavated area. An estimate for ground settlement at the vicinity of the cut-and-cover sections is presented in Section 4.4.2.

Furthermore, the excavation of the cut-and-cover sections may change the state of ground stresses at the bottom and in the vicinity of the excavated areas. It is estimated that the bottom of the excavation may heave approximately 1 to 2 inches during the excavation period. Ground settlement due to the weight of the permanent structures and the backfill is estimated to be about 1/2 to 1-1/2 inches. It is anticipated that ground settlement taking place during the construction and backfill periods will have no adverse effect on the integrity of the structures.

4.4 SUPPORT SYSTEMS

4.4.1 Tunnel Lining

It is understood that MRTC plans to use an initial support system consisting of ribs and wood lagging or precast concrete segments erected within the tailpiece of the shield to support the soil. The secondary lining will consist of cast-in-place concrete. In our opinion, these tunnel linings are feasible for the geotechnical conditions encountered for this corridor.

4.4.2 Cut-and-Cover Wall Support System

The excavation for the cut-and-cover sections will extend to various depths below the ground surface with a maximum of approximately 46 feet at the northern end of the alignment. Further, it is anticipated that the excavations will extend to a maximum of about 20 feet below the current groundwater level at the northern cut-and-cover section. The selection of a temporary retaining system to support the excavation walls depends on the groundwater control technique. The following presents the anticipated procedures that may be utilized at various segments of the cut-and-cover sections to maintain the stability of the excavation walls.

Sloped Excavation - For portions of the corridor, especially in the shallower excavations and above the water table, sloped excavations could be made, provided that easements can be obtained to remove additional material for the excavation slopes. In these areas, temporary construction slopes with an inclination of 1.75:1 (horizontal : vertical) may be suitable for the fill and the silty sands. The slope may be increased to 1.5:1 through the gravelly sands. The impact of such parameters as variations in soil and groundwater conditions, weather, construction procedure, and scheduling on slope stability should also be considered during design.

Anchored/Braced Excavations - Above the groundwater table, where easements for sloped excavation are not available, and below the groundwater table, stability of the excavation walls may be maintained using anchored or cross-lot braced or raked shoring. The selection of any method for this purpose depends on the soil conditions, selected groundwater control method, availability of right-of-way, and the requirement for working area within the site. A shoring system consisting of soldier piles and wooden or concrete lagging may be selected if installation of deep wells and dewatering is considered for groundwater control during construction. The soldier piles may be driven or drilled. Driven soldier piles may encounter difficulty because of the presence of subsurface cobbles and boulders and would probably require strengthening through the use of proper shoes. Driven soldier piles may also be undesirable due to excessive noise and vibration-induced settlement of nearby existing structures. In contrast, drilled piers may be installed in gravelly and cobbly soils with relative ease, provided that the potential for caving of the subsurface soils, particularly below the water table, is mitigated by maintaining a sufficient head of slurry of appropriate weight or by installing temporary casing in the drilled holes. The soldier piles may be constructed of "H" piles and a combination of lean concrete above the excavation limits and structural concrete below the excavation limits. Soldier piles construction should be completed prior to excavation. Lagging should be installed as the excavation progresses. Recommendations regarding design values of earth pressure on temporary walls are presented in Appendix H.

Above the depth of embedment, the soldier piles will have to be supported either by ground anchors, such as tiebacks, cross-lot bracing, or rakers. The advantage of using tiebacks, where right-of-way exists, is that this method produces an unobstructed area for continuation of excavation and construction of the permanent structures. The anchors or internal bracing should be installed as the excavation is progressed to the design depths. Delayed installation accompanied with further excavation may result in undesirable wall yield causing substantial ground settlement and possibly wall failure.

Alternatively, grouting, slurry, or freeze walls may be considered for support of temporary excavations. For these walls, similar support, i.e., anchored or interior braced, may also be needed.

In addition, it may be anticipated, where appropriate, that a combination of the preceding recommendations may be utilized for greater efficiency. For example, in areas where some easements for sloped excavation are provided, this technique may be combined with anchored or interior braced wall supports, greatly reducing the design requirements and ground movements. Further, the soldier pile and lagging system may be combined with slurry or grout walls to expedite the construction schedule.

The ground vertical settlement and wall horizontal movement is controlled by the stiffness of the entire wall system. The ground settlement and wall movement for anchored walls, for example, may exceed 1 percent of the excavation height. However, with proper design and construction control, the ground settlement and wall movement could be potentially reduced to less than 0.2 percent of the excavation depth. Recommended values for excavation support are presented in Appendix H.

4.5 SUPPORT OF EXISTING STRUCTURES

4.5.1 Tunneling Section

The tunneling section of the corridor crosses below two facilities: the Santa Ana Freeway and a vacant lot (former site of the recently demolished Maier Brewing Company warehouse). The potential for ground subsidence during the tunneling operation may require underpinning of the freeway. As indicated by the GKN Hayward Baker, Inc., study (Appendix I), the grouting prior to tunneling, however, should eliminate the need for underpinning the freeway, control the ground movement, and reduce the cave-in potential. During the course of the present study, the Maier Brewing Company warehouse structure was demolished and, currently, only the floor slab may be observed at the warehouse site. It is anticipated that the presence of the slab may have no adverse impact on the tunneling operation at this site.

In addition, the realigned corridor will be located near the UNOCAL tank farm and the Friedman Bag Company building. Based on the survey data (Figure 1-2), the shortest distance between the closest storage tank to the

tunnel wall will be about 90 feet. Based on the soil conditions encountered at the site, it is estimated that the tank foundation is located beyond the zone of influence. However, the Friedman Bag Company building, which is a relatively lightweight masonry structure, will be in the zone of influence of the tunnel. Therefore, it is expected that a portion of the building loads will be partially transferred to the tunnel walls. Depending on the building loads, grouting prior to tunneling may reduce the need for underpinning the footings. A study of the footings and the loads for this building is recommended. Mitigation schemes may be developed based on the results of such study.

4.5.2 Cut-and-Cover Sections

The Caltrans above-ground busway crosses the realigned corridor at the northern cut-and-cover section. Bent number 4 of the busway is located, approximately, between Stations 97 + 10 and 97 + 30 (Figure 1-2). The busway construction is currently underway. Depending on the construction schedule for the busway structure, it may need to be supported during the construction of the cut-and-cover section.

To provide support for the busway, it is recommended that piers be drilled and constructed outside of and on the centerline of the realigned corridor. The piers may be extended above ground and to the busway deck level. At this level, a steel or reinforced concrete beam may be constructed to rest on the extended columns, and to support the busway loads. The load due to the self weight of the bent may be transferred to the drilled piers by another structural beam constructed under the bent by underpinning methods. Design recommendations for piers drilled through the granular alluvium are presented in Appendix H.

The busway bent design loads may require extending the drilled piers to the bedrock. Based on the field observation and a previous study in the adjacent area (Converse Consultants, 1983b), an ultimate pier tip capacity of 80 kips per square foot (ksf) is recommended for the drilled piers supported by the bedrock. For the drilled piers into the underlying bedrock, a minimum depth of embedment equal to 2-pier diameter is also recommended.

The excavation around and under the bent may proceed as planned after the underpinning process is completed. After the cut-and-cover construction and the backfill are completed, the above-ground portion of the support structure may be removed, while the underground portion may remain intact to support portions of the busway loads.

At the vicinity of Station 86 + 20, the alignment will cross over the Ducommun Street drainage tunnel. The structural condition of the drain is not known. Therefore, it is recommended that the subway foundation to be supported on drilled piers to prevent load transfer to the drain. Alternatively, the subway foundation may be strengthened such that the loads are transferred to adjacent areas, away from the drain.

4.6 GENERAL CONSIDERATIONS

The following geotechnical considerations are described in this section:

- o Earthwork
- o Potential for encountering noxious gases during excavation
- o Potential for encountering chemical compounds in soils during excavation
- o Pile installation.

Based on the soil conditions encountered in the boreholes, the excavation for the cut-and-cover section of the realigned A-130 corridor may be accomplished by conventional excavation equipment. For the shield driven tunnel section, the shield may be equipped with a backhoe, especially for excavation in the pressure grouted area. Special considerations may also be required for removal of large cobbles and boulders.

Some fine-grained soils and relatively soft areas may be encountered at the foundation level during the construction of cut-and-cover sections. These soils should be removed and replaced with an approved, clean granular fill material. Generally, it is expected that the site soils will be suitable for use as structural fill material, provided that these soils do not contain construction debris, deleterious material, cobbles and boulders, and unde-

sirable chemical compounds. Prior to placing any new fill or placing foundation concrete, the exposed subgrade should be compacted to a minimum of 95 percent of the maximum dry density as determined by ASTM Procedure D1557.

All fill material should be placed in layers, with each layer compacted to a minimum of 90 percent of the maximum dry density as determined by ASTM Procedure D1557. Fills supporting footings should be compacted to 95 percent of the maximum dry density as determined by ASTM D1557. The maximum permissible loose thickness of each fill layer will depend on the type of material and compaction equipment used. In general, fill material should be placed in layers not exceeding 8 inches of loose thickness. Fill material should be moisture conditioned to within plus or minus 3 percent of the optimum moisture content prior to compaction.

It is our understanding that in the cut-and-cover sections the structures will be supported on wide, thick base slabs that will function as mat foundations. The mat foundations will be supported on the alluvium at the northern cut-and-cover section, and on the alluvium and fill at the southern cut-and-cover section. For design of the mat foundations, the horizontal and vertical coefficients of subgrade reaction on both the undisturbed alluvium and compacted fill may be taken as 75 and 100 kips per cubic foot (kcf), respectively.

Previous investigations in the adjacent corridor (A-135) encountered noxious gases (methane and hydrogen sulfide) during well pumping tests (Converse Consultants, 1983a). The possibility exists that these gases could be encountered during dewatering of the A-130 corridor. Significant volumes of gas released during dewatering could cause problems including impacts on pump operation, offensive odors in the construction area and along the discharge disposal route, and safety hazards. Mitigation methods such as gas separators, well venting, gas removal systems, and the use of construction provisions for gassy formations should be considered.

If present, these gases impose additional hazards on the tunneling and cut-and-cover excavation operations. Tunneling operations may require constant monitoring, additional ventilation, and potentially, the use of equipment designed for use in gassy mining operations. Cut-and-cover operations will also require monitoring and possible use of specialized equipment.

Cuttings and fluids collected during the exploration for the realigned A-130 corridor, except those from Borehole B301, did contain some chemical compounds. Specialized disposal at a qualified facility was required. Excavation spoils for the realigned A-130 corridor are anticipated to locally contain such materials and potentially other chemical compounds not encountered during this investigation which may require specialized disposal. It is recommended that monitoring be performed during construction for the occurrence of materials that may require management as hazardous waste. As a minimum, the contractor should be prepared to handle materials from the areas of Boreholes B303 and B304 and areas where construction monitoring indicates the existence of previously undetected chemical compounds, as hazardous if testing demonstrates that they conform to any criteria for identification of hazardous wastes. The criteria to identify hazardous wastes are toxicity, ignitability, reactivity, and corrosivity as established in Article 11 of Title 22 of the California Administrative Code (CAC). The groundwater samples from Monitoring Wells MW-304 and MW-305 were found to contain benzene exceeding the state action level of 0.7 µg/l (Table 3-3). These samples indicate that removal of benzene from groundwater extracted from these areas is required for storm drain and surface-water discharge as imposed by the National Pollution Discharge Elimination System (NPDES) permit.

Deep foundations may be required for support of temporary excavation and underpinning purposes. It is anticipated that driven piles may be difficult to install because of the occurrence of cobbles and boulders within the sub-surface soil along the realigned corridor. Alternatively, drilled piers have reportedly been constructed in the area with relative ease. Caving of excavations should be anticipated during construction of drilled piers. A slurry method or a temporary casing may be used to provide for excavation stability. Upon completion of drilling, reinforcing cages may be lowered into the borehole and concrete cast by the tremie method, displacing the slurry. If soldier piles consisting of wide flange steel profiles are used for support of temporary excavations, the drilled holes below the bottom of the proposed structure excavation should be filled with structural concrete. Above the excavation bottom, a lean concrete may be used to displace the slurry.

5.0 CONSTRUCTION OBSERVATION AND TESTING

The conclusions and recommendations provided in this report are based on design information furnished by MRTC and on the subsurface conditions as disclosed by our field investigation. They do not reflect variations in subsurface conditions which are likely to exist in unexplored areas. The subsurface conditions described herein were based on ten test boreholes drilled as part of this investigation and on existing geotechnical data. They should be verified in the field during construction. Should significant differences between the described and actual soil conditions be revealed during excavation, it may be necessary to reevaluate our recommendations based on onsite observation of the variations.

As explained earlier, the alignment corridor was occupied previously by several structures. Therefore, it should be noted that the subsurface areas under the previous structures as well as the subsurface areas between boreholes may contain buried objects, utilities or chemical compounds not detected during this investigation.

All foundation and structure excavations, grouting, dewatering, slurry wall construction, underpinning, and installation of temporary construction walls, tiebacks, and drilled piles should be inspected by a qualified registered geotechnical engineer to ensure that proper approved procedures are being followed in the field. During construction, structures adjacent to the alignment, structures above and below the corridor, adjacent pavements, and selected locations around the cut-and-cover excavation should be periodically monitored for horizontal or vertical movements. If any detrimental movement is observed, appropriate action to remedy the situation should be taken. In addition, during dewatering of the corridor area, wells should be installed adjacent to critical structures and at selected locations along the tunnel and open excavations to monitor the drawdown, groundwater level or flow, and chemical compound composition of the groundwater.

Furthermore, a preconstruction survey of existing structures that may be potentially affected by construction should be performed before start of construction to document their existing conditions (cracks in walls, cracks in

floor slabs, differential settlement cracks, etc.). They should also be inspected periodically during construction, and the conditions should be documented. If the periodic inspection indicates that conditions appear to be changing, appropriate remedial action should be taken.

6.0 LIMITATIONS

The conclusions, professional opinions, and recommendations presented in this report were developed by Earth Technology for the MRTC, in accordance with generally accepted geotechnical engineering principles and practices. The data, conclusions, and recommendations contained herein should be considered to relate only to the specific project and location discussed herein.

MRTC may distribute the report or excerpts therefrom to others as it deems appropriate, provided the following statement is prominently displayed thereon:

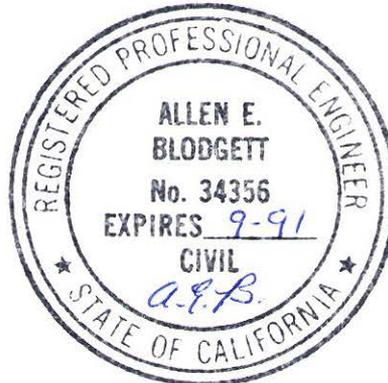
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Respectfully submitted:



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APPENDIX A
SUBSURFACE EXPLORATION

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SUBSURFACE EXPLORATION

This appendix presents a summary of field drilling and sampling operations for the Metro Rail realigned A-130 corridor. The logs of boreholes are also presented in this appendix.

The number and locations of the boreholes were selected by Metro Rail Transit Consultants (MRTC). A total of six locations for exploratory borings, numbered B301 through B306, were selected. Based on the anticipated subsurface conditions as interpreted from the previous investigations and as indicated by others, it was proposed to employ a combination of hollow stem and rotary wash drilling techniques to advance the boreholes to the designated depths.

In general, many difficulties were encountered during the drilling operation. These difficulties included caving of the boreholes, sand heave at the bottom of the boreholes, auger refusal, and casing installation problems. Further, during the course of drilling, a layer containing large cobbles and gravel was encountered. The drilling operations through this layer were much more difficult at several locations than those experienced during our previous subsurface investigations in the area and apparently more difficult than those experienced by previous consultants. In general, drilling through this layer was accompanied by a significant reduction in the anticipated rate of progress and severely strained the type of equipment originally selected. The adverse impacts of drilling through this layer included breakage and loss of a sampler in Borehole B302 at a depth of about 40 feet below the ground surface, breakage and loss of auger in Borehole B303 while drilling at about 40 feet below ground surface, breakage of the rig swivel (twice) because of hard drilling in Borehole B303, and stoppage of auger (freezing) in Borehole B304.

Because of the difficulties experienced in Boreholes B302 through B304 and to enable completion of the program on a timely basis and acquisition of high quality representative samples and subsurface information, it was decided to employ a more effective drilling procedure. Subsequently, these boreholes were abandoned and drilling proceeded using percussion hammer drilling equipment. The drilling was performed in locations adjacent to the original loca-

tions, and the boreholes were numbered B302A through B304A. Further, Borehole B305A was drilled adjacent to Borehole B305 to enable the acquisition of more representative samples and installation of a groundwater monitoring well.

Drilling was performed in June and July, 1987. The boreholes were extended to various depths to a maximum of 113 feet at Borehole B302A. The boreholes were logged using the Unified Soil Classification System (ASTM D2487). In general, the redrilled interval of the adjacent boreholes were not logged. Borehole locations are shown on Figures 1-1, 1-2A, and 1-2B. Borehole Logs are presented in this appendix.

Soil samples were taken in the boreholes during the drilling operations. Generally, samples were taken at approximately 5 foot intervals with more frequent sampling (approximately 2 foot intervals) in the upper 40 feet of boreholes B304 and B305A in the proximity of the Santa Ana Freeway. The majority of the samples were obtained by driving a 2.5-inch inside diameter ring sampler (California Drive Sampler) into the soil using a 140-pound hammer falling 30 inches. The weight of the hammer and the height of the drop was measured in the field.

The sampler consists of a tip, a soil barrel, and a waste barrel. The soil barrel is 12 inches long and is lined with 1-inch long brass rings. Soil samples were taken by driving the sampler 12 inches into the soil at the bottom of the boreholes. However, in Borehole B304A, below 35 feet depth, Borehole B305, between 32 and 100 feet depths, and Borehole B306, between 32 and 90 feet depths, the sampler was driven 18 inches as requested by MRTC's representative. In Borehole B305A, a sampler having an 18-inch long soil barrel was used. In Borehole B303A, between 55 and 88 feet depths, the drilling rod was used to push the sampler into the soils. No attempt was made to measure the weight of the drilling rod. In several occasions, when no recovery was made with the drive sampler, a split spoon sampler was used to obtain disturbed samples. In the boreholes terminating in bedrock, a minimum of 5 feet of bedrock was cored. Sample descriptions, depths, and blow counts were recorded on the borehole logs.

The samples, encased in the sampling rings, were extruded from the sampler after recovery from the borehole. The bottom ring with the enclosed sample

was sealed, labeled, placed in a refrigerated container, and delivered to the laboratory for chemical analyses. All samples were accompanied by chain-of-custody forms (Appendix F). The soil from the second ring was sealed in a clean glass container and allowed to volatilize for a minimum of 25 minutes. The headspace volatile organic concentration was then analyzed and compared to background levels to obtain an indication of contamination at the sample depth. The remaining portion of the sample was examined for lithologic descriptions for the borehole log, sealed, packaged, and delivered to the laboratory for engineering property determinations.

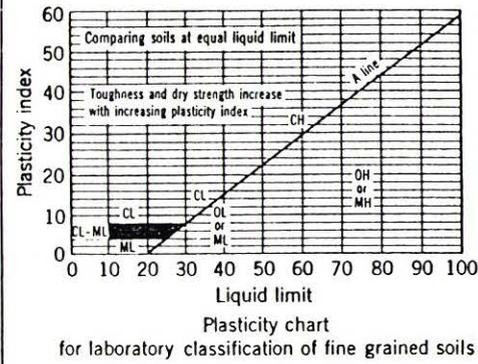
Water samples were also taken from each of the borings. For samples taken during drilling operations, the drilling was stopped and the borehole was bailed. This was done when an indication that the ground water table had been penetrated was noted. A water sample was extracted using the bailer. The samples were sealed in glass containers, labelled, packaged into a refrigerated container and delivered to the laboratory for chemical analysis. Water samples were taken using a similar method after conversion and development into monitoring wells of selected boreholes.

Boreholes B301, B304, and B305A were converted into groundwater monitoring wells. The monitoring wells contain a 2-inch or a 4-inch diameter threaded PVC riser and slotted screens. A sand pack was placed between the soil and PVC casing to a minimum of 1.5 feet above the screened interval. A minimum of a 2-foot thick bentonite seal was installed above the sand pack. The borehole annulus was then sealed to the surface with a cement grout. The monitoring well was then developed and field tests for permeability evaluations were performed. A security cover was grouted in place over the monitoring wells to protect them while still permitting limited access to the wells. All boreholes that were not converted to monitoring wells were sealed with grout to the surface.

A strict washing and cleaning schedule was followed to minimize cross-contamination between borings and samples. Prior to the start of each boring, the drilling equipment was steam-cleaned. Before each soil sample was taken, the sampler was cleaned with an Alconox wash, two tap water rinses, and a distilled water rinse. The water sample bailer and monitoring well casing was

steam-cleaned prior to each use. The drilling cuttings, development water, and drilling fluids were placed in 55-gallon drums and a Baker™ tank for subsequent stabilization and transportation for disposal in a licensed hazardous waste disposal site.

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	Gravels More than half of coarse fraction is larger than No. 4 sieve size (For visual classification, the 1/2 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 For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics Example: <i>Silty sand, gravelly</i> ; about 20% hard, angular gravel particles 1/2-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 4 $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3 Not meeting all gradation requirements for GW Atterberg limits below "A" line, or PI less than 4 Atterberg limits above "A" line, with PI greater than 7 $C_U = \frac{D_{60}}{D_{10}}$ Greater than 6 $C_C = \frac{(D_{20})^2}{D_{10} \times D_{60}}$ Between 1 and 3 Not meeting all gradation requirements for SW Atterberg limits below "A" line or PI less than 5 Atterberg limits below "A" line with PI greater than 7				
			Predominantly one size or a range of sizes with some intermediate sizes missing	GP	Poorly graded gravels, gravel-sand mixtures, little or no fines						
		Gravels with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures see ML below)	GM	Silty gravels, poorly graded gravel-sand-silt mixtures						
			Plastic fines (for identification procedures, see CL below)	GC	Clayey gravels, poorly graded gravel-sand-clay mixtures						
		Sands More than half of coarse fraction is smaller than No. 4 sieve size (For visual classification, the 1/2 in. size may be used as equivalent to the 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			
				Predominantly one size or a range of sizes with some intermediate sizes missing	SP			Poorly graded sands, gravelly sands, little or no fines			
	Sands with fines (appreciable amount of fines)		Nonplastic fines (for identification procedures, see ML below)	SM	Silty sands, poorly graded sand-silt mixtures						
			Plastic fines (for identification procedures, see CL below)	SC	Clayey sands, poorly graded sand-clay mixtures						
	Identification Procedures on Fraction Smaller than No. 40 Sieve Size										
	Fine-grained soils More than half of material is smaller than No. 200 sieve size (The No. 200 sieve size is about the smallest particle visible to naked eye)		Silt and clays liquid limit less than 50	Dry Strength (crushing characteristics)	Dilatancy (reaction to shaking)			Toughness (consistency near plastic limit)		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 For undisturbed soils add information on structure, stratification, consistency in undisturbed and remoulded states, moisture and drainage conditions Example: <i>Clayey silt, brown</i> ; slightly plastic; small percentage of fine sand; numerous vertical root holes; firm and dry in place; loess; (ML)	Use grain size curve in identifying the fractions as given under field identification curve 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 Borderline cases requiring use of dual symbols
		None to slight		Quick to slow	None			ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity		
		Medium to high		None to very slow	Medium			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays		
Silt and clays liquid limit greater than 50		Slight to medium	Slow	Slight	OL	Organic silts and organic silt-clays of low plasticity					
		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					
		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		PI	Peat and other highly organic soils							



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

The Earth Technology Corporation

PROJECT NO.: 87-885

METRO RAIL TRANSIT

UNIFIED SOIL CLASSIFICATION SYSTEM

12-87
FIGURE A-1

SAMPLE TYPE	
S	STANDARD SPLIT SPOON SAMPLE
D	2½" DIA., 12" LONG DRIVE SAMPLE
DL	2½" DIA., 18" LONG DRIVE SAMPLE
NR	NO RECOVERY
B	BULK SAMPLE
C	CORE SAMPLE

EXPLANATIONS
<p>PENETRATION RESISTANCE (BLOW COUNT)</p> <p>–BLOW COUNTS FOR CALIFORNIA DRIVE SAMPLER FOR 6" INTERVALS EXCEPT AS NOTED.</p> <p>MOISTURE CONTENT (%)</p> <p>–LABORATORY DETERMINED MOISTURE CONTENT</p> <p>PPM –PARTS PER MILLION</p> <p>PCF –POUNDS PER CUBIC FOOT</p> <p>OVA –ORGANIC VAPOR ANALYZER</p> <p>BG –BACKGROUND</p> <p>O.D. –OUTSIDE DIAMETER</p> <p>N/A –NOT APPLICABLE</p> <p>/ –DENOTES ALTERNATING SOIL TYPES IN A LAYER (EXAMPLE: SP/SW i.e. ALTERNATING POORLY AND WELL GRADED SANDS IN A PREDOMINANTLY SANDY LAYER)</p>

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

	PROJECT NO.:	87-885
	METRO RAIL TRANSIT	

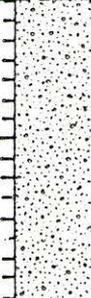
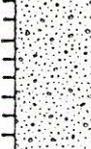
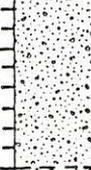
KEY FOR SOIL EXPLORATION LOGS

12-87 FIGURE A-2

BOREHOLE LOG

Project Name: METRO RAIL TRANSIT
 Project Number: 87-885 Field Log of Borehole Number: B 301 Sheet 1 of 2

Borehole Location: <u>A-130 CORRIDOR</u>		Elevation and Datum: <u>275.8 FEET</u>	
Drilling Agency: <u>DATUM EXPLORATION</u>	Driller: <u>DAN STEVE LONNIE ROBERTS</u>	Date Started: <u>06/01/87</u>	Date Finished: <u>06/01/87</u>
Drilling Equipment: <u>CME 55</u>		Completion: <u>60</u> Depth (feet)	Rock Depth: <u>----</u> (feet)
Method of Drilling: <u>HOLLOW STEM AUGER, 6" DIAMETER</u>		Number of Samples: <u>13/14</u>	Dist.: <u>0</u> Undist.: <u>13</u> Core: <u>0</u>
Borehole Size: <u>6" O.D.</u>		Water Depth (ft): <u>32</u>	First: <u> </u> Compl.: <u> </u> 24 hrs.
Type of Perforation Backfill: <u>#3 LONE STAR SAND</u>		Logged By: <u>RAY BASILIO</u> Checked by: <u>ALLISON URBON</u>	
Type of Seal: <u>5% BENTONITE CEMENT GROUT</u>			

Depth (feet)	Description	Graphic Log		Samples			Remarks	
		Lithology	OVA (ppm)	Type	Penetration Resistance (Blowcount)	Moisture Content (%)		Dry Density (PCF)
5	SILTY SAND (SM); moist, loose, dark brown, fine to medium with some clay inclusions; trace of gravel.		3.0	D	5/4	7.5	116	2" asphalt concrete and 6" concrete. Cuttings having fill material composition to 6.5'. Wellhead OVA reading -- 0.6 ppm.
10	GRAVELLY SAND (SP/SW); moist, loose, brown, fine to coarse, with trace to little fine gravel, occasionally grading to Sandy Gravel (GP/GW).		0.8	D	3/4	3.5	107	Wellhead OVA reading at background level.
15	Very loose Sandy Gravel (GW) at 15 feet.			D	2/1	4.5	116	
20	Occasional coarse gravel and cobbles between 18 and 20 feet depth		2.1	D	NR			No recovery at 19 feet. Only OVA sample recovered. Wellhead OVA reading -- 0.2 ppm.
25	Becoming coarser.		3.3	D	3/4	4.0	109	Wellhead OVA reading -- 2.5 ppm.
30	SANDY GRAVEL (GP/GW); moist, very dense, grayish brown, fine.		1.5	D	60/4"	3.5	109	Wellhead OVA reading -- 2.5 ppm.

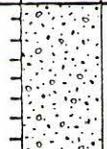
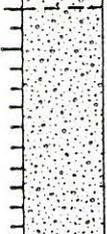
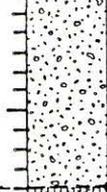
BOREHOLE LOG

Project name: METRO RAIL TRANSIT

Project Number: 87-885

Field Log of Borehole Number: B 301

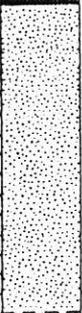
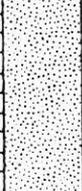
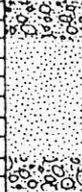
Sheet 2 of 2

Depth (feet)	Description	Graphic Log		Samples				Remarks
		Lithology	OVA (ppm)	Type	Penetration Resistance (Blowcount)	Moisture Content(%)	Dry Density (PCF)	
	Grading to Gravelly Sand (SW/SP) below 30 feet depth, with occasional cobbles.		2.6	D	36/40	5.5	117	Water table at 32'
35	GRAVELLY SAND (SP/SW); wet, dense to very dense, gray, medium to coarse, little to some fine gravel.		3.0	D	40/27	11.0	128	Wellhead OVA -- 0.8 ppm OVA reading at background near hole
40	Some gravel and cobbles below 40 feet.		4.6	D	15/27	13.5	124	Hydrocarbon odor and stain
45			4.6	D	20/50	13.0	118	Wellhead OVA reading at background level
50	SANDY GRAVEL (GP/GW); wet, very dense, gray, fine.		7.3	D	45/50	9.5	126	OVA reading from cuttings at background level
55	SILTY SAND (SM); wet, very dense, gray, fine to medium.		4.6	D	22/27	15.0	119	Wellhead OVA reading -- 60 ppm
60	BORING TERMINATED AT 60 FEET.		4.6	D	27/45	16.0	117	Wellhead OVA reading -- 8 ppm, at background levels near hole
65	THIS BOREHOLE LOG IS BASED ON FIELD CLASSIFICATION AND VISUAL SOIL DESCRIPTION, BUT IS MODIFIED TO INCLUDE RESULTS OF LABORATORY CLASSIFICATION TESTS WHERE AVAILABLE. THIS LOG IS APPLICABLE ONLY AT THIS LOCATION AND TIME. CONDITIONS MAY DIFFER AT OTHER LOCATIONS OR TIME.							Installed a monitoring well. Hydraulic conductivity test between 43 and 58 feet.
70								

BOREHOLE LOG

Project Name: METRO RAIL TRANSIT
 Project Number: 87-885 Field Log of Borehole Number: B 302 Sheet 1 of 2

Borehole Location: <u>A-130 CORRIDOR</u>		Elevation and Datum: <u>276.6'</u>	
Drilling Agency: <u>DATUM EXPLORATION</u>	Driller: <u>DAN STEVE LONNIE ROBERTS</u>	Date Started: <u>06/05/87</u>	Date Finished: <u>06/05/87</u>
Drilling Equipment: <u>CME 55</u>		Completion: <u>41</u>	Rock Depth: <u>----</u>
Method of Drilling: <u>HOLLOW STEM AUGER 6" O.D.</u>		Number of Samples: <u>7/8</u>	Dist.: <u>0</u> Undist.: <u>7</u> Core: <u>0</u>
Borehole Size: <u>6" O.D.</u>		Water Depth (ft): <u>28</u>	First: <u>--</u> Compl.: <u>--</u> 24 hrs. <u>--</u>
Type of Perforation Backfill: <u>N/A</u>		Logged By: <u>RAY BASILIO</u> Checked by: <u>ALLISON URBON</u>	
Type of Seal: <u>5% BENTONITE CEMENT GROUT</u>			

Depth (feet)	Description	Graphic Log		Samples				Remarks
		Lithology	OVA (ppm)	Type	Penetration Resistance (Blowcount)	Moisture Content (%)	Dry Density (PCF)	
0 - 10	SAND (SP); dry to moist, loose, dark brown, fine to medium, grading to silty Sand (SM) with depth. Moist below 5 feet depth. Color changing to grayish brown.		2.7	D	3/3	9.5	88	2" Asphalt concrete. Fill material to 10'. OVA reading from cuttings at background level.
10 - 11	SILTY CLAY (CL); moist, stiff, low plasticity.							
11 - 15	SAND (SP); moist, loose to medium dense, grayish brown, medium to coarse, occasionally grading to Silty Sand (SP-SM/SM). Gravel and cobbles below 15 feet depth.		1.6	D	4/4	12.5	93	Drill cutting OVA reading at background level.
15 - 20	Seam of low plasticity clay (CL). GRAVEL (GW); moist, very dense, grayish brown, fine to coarse, with little coarse-grained sand. Traces of silt and mica.		2.6	D	8/13	5.5	109	Wellhead OVA reading -- 0.8 ppm.
20 - 25	GRAVELLY SAND (SP-SM); moist, very dense, brown, fine to coarse, with some fine to coarse gravel. Color changing to gray; increasing water content.		4.0	D	31/58	2.5	118	Wellhead OVA reading -- 0.3 ppm.
25 - 28				D	37/48			Wellhead OVA reading -- 0.4 ppm.
28 - 30								Water table at 28'.

BOREHOLE LOG

Project name: METRO RAIL TRANSIT

Project Number: 87-885 Field Log of Borehole Number: B 302 Sheet 2 of 2

Depth (feet)	Description	Graphic Log		Samples			Remarks	
		Lithology	OVA (ppm)	Type	Penetration Resistance (Blowcount)	Moisture Content (%)		Dry Density (PCF)
32	SILTY SAND (SM); wet, very dense, gray, coarse, with little fine gravel and silt. Gravel and cobbles at 32 feet.		12.0	D	27/38	8.0	132	Wellhead OVA reading -- 0.2 ppm. No recovery.
35	SAND (SP); wet, very dense, gray, medium to coarse, with occasional gravelly and silty lenses. Cobbles at 38 feet.		2.5	D	40/52	17.0	114	
40	BORING ABANDONED AT 40'. (SAMPLER SHEARED OFF DOWNHOLE, UNABLE TO RECOVER)			D	38/50, NR			
45	THIS BOREHOLE LOG IS BASED ON FIELD CLASSIFICATION AND VISUAL SOIL DESCRIPTION. BUT IS MODIFIED TO INCLUDE RESULTS OF LABORATORY CLASSIFICATION TESTS WHERE AVAILABLE. THIS LOG IS APPLICABLE ONLY AT THIS LOCATION AND TIME. CONDITIONS MAY DIFFER AT OTHER LOCATIONS OR TIME.							
50								
55								
60								
65								
70								

BOREHOLE LOG

Project Name: METRO RAIL TRANSIT

Project Number: 87-885 Field Log of Borehole Number: B 302A Sheet 1 of 3

Borehole Location: A-130 CORRIDOR		Elevation and Datum: 276.6	
Drilling Agency: DATUM EXPLORATION	Driller: DAN STEVE LONNIE ROBERTS	Date Started: 06/08/87	Date Finished: 06/13/87
Drilling Equipment: CME 55/FAILING 1500		Completion: 113.0 Depth (feet)	Rock Depth: 97.0 (feet)
Method of Drilling: 6" O.D. HOLLOW STEM AUGER UP TO 40' ROTARY WASH TO TOTAL DEPTH		Number of Samples: 12/17	Dist.: 6 Undist.: 4 Core: 2
Borehole Size: 6" O.D.		Water Depth (ft):	First: Compl.: 24 hrs.
Type of Perforation Backfill: N/A		Logged By: RAY BASILIO Checked by: BRENDA MEYER	
Type of Seal: 5% BENTONITE CEMENT GROUT			

Depth (feet)	Description	Graphic Log		Samples			Remarks	
		Lithology	OVA (ppm)	Type	Penetration Resistance (Blowcount)	Moisture Content (%)		Dry Density (PCF)
40	SAND (SP); wet, very dense, gray, coarse with little fine gravel and silt.	[Dotted pattern]					See Boring Log B-302 for soil description above 40 feet. OVA reading at background level in work area and drilling mud.	
45	GRAVELLY SAND (SP-SM/SW-SM); wet, dense to very dense, gray, medium to coarse, with some fine gravel and little silt, occasionally grading to Sandy Gravel (GP-GM/GW-GM).		0.5	D	26/19			
50			1.1	D	50/50 5"	20.0	108	OVA reading at background level in work area and drilling mud.
55			3.4	D	100/6"	21.0	108	20% Recovery.
60			D	100/4", NR			No recovery.	
65	SILTY SAND (SM); wet, very dense, gray, fine to medium, traces of mica and gravel.	[Vertical line pattern]					20% recovery. Disturbed sample. OVA reading at background level in work area and drilling mud.	
70				D	90/9"			

BOREHOLE LOG

Project name: METRO RAIL TRANSIT

Project Number: 87-885

Field Log of Borehole Number: B 302A

Sheet 2 of 3

Depth (feet)	Description	Graphic Log		Samples			Remarks
		Lithology	OVA (ppm)	Type	Penetration Resistance (Blowcount)	Moisture Content (%)	
70			85	D	100/8"		10% recovery. Disturbed sample.
75				D	100/10", NR		No recovery.
80	SANDY GRAVEL (GW); wet, very dense, gray.			D	100/4", NR		No recovery.
				S	100/12"		
85	SAND (SP/SW); wet, very dense, gray, medium to coarse, with little fine gravel.		>1000	S	86/76		OVA reading at background level in work area and drilling mud.
90	GRAVEL (GP); wet, very dense, gray.			S	300/6"		5% recovery.
95				C			2-1/2" core barrel was used for sampling. OVA reading at background level in work area and drilling mud.
	CLAYSTONE; olive gray.						Bedrock at 97'.
100	Traces of mica.			D	65/100/3"		Coring started at 101' No recovery 101'-103'. Sample probably washed away due to high water pressure.
				C	NR		Disturbed core samples 103' to 104'.
105				C			
				C	NR		107' to 113' core samples not recovered. Samples probably washed away due to high water pressure.
110							

BOREHOLE LOG

Project name: METRO RAIL TRANSIT

Project Number: 87-885 Field Log of Borehole Number: B302A Sheet 3 of 3

Depth (feet)	Description	Graphic Log		Samples			Remarks
		Lithology	OVA (ppm)	Type	Penetration Resistance (Blowcount)	Moisture Content (%)	
<div style="display: flex; align-items: center;"> <div style="width: 100px; border-right: 1px solid black; margin-right: 5px;"> <div style="text-align: center; font-weight: bold;">15</div> <div style="text-align: center; font-weight: bold;">20</div> <div style="text-align: center; font-weight: bold;">25</div> <div style="text-align: center; font-weight: bold;">30</div> <div style="text-align: center; font-weight: bold;">35</div> <div style="text-align: center; font-weight: bold;">40</div> <div style="text-align: center; font-weight: bold;">45</div> <div style="text-align: center; font-weight: bold;">50</div> <div style="text-align: center; font-weight: bold;">55</div> <div style="text-align: center; font-weight: bold;">60</div> <div style="text-align: center; font-weight: bold;">65</div> <div style="text-align: center; font-weight: bold;">70</div> <div style="text-align: center; font-weight: bold;">75</div> <div style="text-align: center; font-weight: bold;">80</div> <div style="text-align: center; font-weight: bold;">85</div> <div style="text-align: center; font-weight: bold;">90</div> <div style="text-align: center; font-weight: bold;">95</div> <div style="text-align: center; font-weight: bold;">100</div> <div style="text-align: center; font-weight: bold;">105</div> <div style="text-align: center; font-weight: bold;">110</div> <div style="text-align: center; font-weight: bold;">115</div> <div style="text-align: center; font-weight: bold;">120</div> <div style="text-align: center; font-weight: bold;">125</div> <div style="text-align: center; font-weight: bold;">130</div> <div style="text-align: center; font-weight: bold;">135</div> <div style="text-align: center; font-weight: bold;">140</div> <div style="text-align: center; font-weight: bold;">145</div> <div style="text-align: center; font-weight: bold;">150</div> </div> <div style="width: 100%; border-left: 1px solid black; border-right: 1px solid black; padding: 5px;"> <p style="margin-top: 0;">CLAYSTONE; olive, gray.</p> <p style="margin-top: 10px;">BORING TERMINATED AT 113'.</p> <p style="margin-top: 20px; font-size: small;">THIS BOREHOLE LOG IS BASED ON FIELD CLASSIFICATION AND VISUAL SOIL DESCRIPTION, BUT IS MODIFIED TO INCLUDE RESULTS OF LABORATORY CLASSIFICATION TESTS WHERE AVAILABLE. THIS LOG IS APPLICABLE ONLY AT THIS LOCATION AND TIME. CONDITIONS MAY DIFFER AT OTHER LOCATIONS OR TIME.</p> </div> </div>							

BOREHOLE LOG

Project Name: METRO RAIL TRANSIT
 Project Number: 87-885 Field Log of Borehole Number: B 303 Sheet 1 of 2

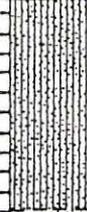
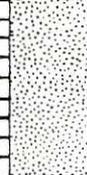
Borehole Location: <u>A-130 CORRIDOR</u>		Elevation and Datum: <u>275.1</u>	
Drilling Agency: <u>DATUM EXPLORATION</u>	Driller: <u>DAN STEVE LONNIE ROBERTS</u>	Date Started: <u>06/15/87</u>	Date Finished: <u>06/16/87</u>
Drilling Equipment: <u>CME 55</u>		Completion: <u>40</u>	Rock Depth: <u>(feet)</u>
Method of Drilling: <u>HOLLOW STEM AUGER, 6" O.D.</u>		Number of Samples: <u>8/8</u>	Dist.: <u>1</u> Undist.: <u>7</u> Core: <u>0</u>
Borehole Size: <u>6" O.D.</u>		Water Depth (ft): <u>27</u>	First: <u></u> Compl.: <u></u> 24 hrs.
Type of Perforation Backfill: <u>N/A</u>		Logged By: <u>RAY BASILIO</u> Checked by: <u>BRENDA MEYER</u>	
Type of Seal: <u>5% BENTONITE CEMENT GROUT</u>			

Depth (feet)	Description	Graphic Log		Samples			Remarks	
		Lithology	OVA (ppm)	Type	Penetration Resistance (Blowcount)	Moisture Content (%)		Dry Density (PCF)
0 - 3	SAND (SP-SM); dry to moist, medium dense, dark brown, fine to coarse, with little silt.						3" asphalt concrete and 5" concrete pavement. Fill material to 6-1/2'.	
3 - 5	Traces of mica, becoming moist.							
5 - 6	Layer of silty clay (CL).		0.5	D	6/8	10	100	
6 - 8.5	SAND (SP); moist, loose to medium dense, gray-brown, fine, seams of silty sand. Some gravel and cobbles at 8.5 feet.							
8.5 - 10			0.5	D	4/7	22	100	Wellhead and drill cuttings OVA reading at background level.
10 - 15	SILTY SAND (SM) grading to SAND (SP) with depth, moist, dense to very dense, brown, medium sand, trace fine gravel.							
15 - 19			0.8	D	20/20	11	109	Drill cuttings OVA reading at background level.
19 - 23	GRAVELLY SAND (SW); moist, dense to very dense, brown, fine to coarse, with some fine gravel.							
23 - 25	Gravel and cobbles below 19 feet.		0.2	D	17/24		117	Wellhead OVA reading -- 0.4 ppm.
25 - 27	Sandy gravel (GP) layer at 23 feet.							Hard drilling below 20 feet.
27 - 30	SILTY SAND (SM); wet, medium dense, gray, fine, with trace fine gravel.		0.3	D	9/10	31	92	Wellhead OVA reading at background level. Water table at 27'.

BOREHOLE LOG

Project name: METRO RAIL TRANSIT

Project Number: 87-885 Field Log of Borehole Number: B 303 Sheet 2 of 2

Depth (feet)	Description	Graphic Log		Samples			Remarks	
		Lithology	OVA (ppm)	Type	Penetration Resistance (Blowcount)	Moisture Content (%)		Dry Density (PCF)
35	SAND (SP-SM); wet, very dense, gray, medium to coarse, with little fine to coarse gravel and trace silt.		2.5	D	53/42	11.5	125	Some blackish discoloration. OVA reading at background level.
40	SAND (SP); grading to SILTY SAND (SM) with depth, wet, very dense, gray, fine, with some fine gravel.		0.8	D	43/38	11.0	118	Minor heaving at 35'. Piece of bone was found between 35' and 40' OVA reading at background level.
40	BORING ABANDONED AT 40'. (Auger sheared off downhole, unable to recover).			B				Bag sample from drill cuttings.
45	THIS BOREHOLE LOG IS BASED ON FIELD CLASSIFICATION AND VISUAL SOIL DESCRIPTION, BUT IS MODIFIED TO INCLUDE RESULTS OF LABORATORY CLASSIFICATION TESTS WHERE AVAILABLE. THIS LOG IS APPLICABLE ONLY AT THIS LOCATION AND TIME. CONDITIONS MAY DIFFER AT OTHER LOCATIONS OR TIME.							
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BOREHOLE LOG

Project Name: METRO RAIL TRANSIT

Project Number: 87-885 Field Log of Borehole Number: B 303A Sheet 1 of 2

Borehole Location: <u>A-130 CORRIDOR</u>		Elevation and Datum: <u>275.1</u>	
Drilling Agency: <u>LAYNE ENVIRONMENTAL</u>	Driller: <u>MIKE MILLS BILL HILL TERRY HIGGINS DAROL WILSON</u>	Date Started: <u>06/19/87</u>	Date Finished: <u>07/08/87</u>
Drilling Equipment: <u>CME 55/FAILING 1500/AP 1000</u>		Completion Depth (feet): <u>93.0</u>	Rock Depth (feet): <u>84.0</u>
Method of Drilling: <u>HOLLOW STEM AUGER, ROTARY WASH, PERCUSSION HAMMER</u>		Number 10/14 of Samples: <u>6</u>	Dist.: <u>6</u> Undist.: <u>3</u> Core: <u>1</u>
Borehole Size: <u>9" O.D.</u>		Water Depth (ft): <u> </u>	First: <u> </u> Compl.: <u> </u> 24 hrs.
Type of Perforation Backfill: <u>N/A</u>		Logged By: <u>RAY BASILIO</u>	
Type of Seal: <u>5% BENTONITE CEMENT GROUT</u>		Checked by: <u>BRENDA MEYER</u>	

Depth (feet)	Description	Graphic Log		Samples				Remarks	
		Lithology	OVA (ppm)	Type	Penetration Resistance (Blowcount)	Moisture Content (%)	Dry Density (PCF)		
40	GRAVELLY SAND (SP); wet, dense to very dense gray, medium to coarse, with some gravel and cobbles, occasionally grading to sandy gravel (GP/GW).							See Boring Log B-303 for soil description above 40 feet.	
45	Gravel and cobbles between 44 and 47 feet.			D	3/3, NR				Bag samples from drill cuttings.
50	Gravel and cobbles between 48 and 52 feet.			B					
55	SAND (SP); wet, dense to very dense, gray, medium to coarse, with some gravel.			D	Pushed NR			Hydrocarbon odor at 50'. Oily substance in drilling fluid. OVA reading at background level near rig.	
				D	Pushed	9.0	112		OVA reading at background level near rig.
				D	Pushed, NR				Refusal, 6" size cobble stuck inside vacuum pump.
60	Gravel and cobbles at 60 feet.			D	Pushed, NR				Hydrocarbon odor. Minor heaving at 60' to 63'.
65				D	Pushed	26.5	98	Hydrocarbon odor.	
70	SANDY SILT (ML) grading to SILTY SAND (SM); wet, medium dense, gray, medium to coarse.								

BOREHOLE LOG

Project name: METRO RAIL TRANSIT

Project Number: 87-885

Field Log of Borehole Number: B 303A

Sheet 2 of 2

Depth (feet)	Description	Graphic Log		Samples				Remarks
		Lithology	OVA (ppm)	Type	Penetration Resistance (Blow count)	Moisture Content (%)	Dry Density (PCF)	
75	SAND (SP); wet, gray, medium to coarse with some coarse gravel.		32	B				Bag sample from drill cuttings. Oily coloration on water. Strong sulfur odor. High OVA reading at wellhead and cyclone (>1000 ppm). OVA readings at 80 ppm in cuttings. Disturbed sample at 78'-79'. Bag samples from drill cuttings.
				D				
				B				
				B				
85	CLAYSTONE; olive.		>1000	D	Pushed			
90				C				
95	BORING TERMINATED AT 93'.							
100	THIS BOREHOLE LOG IS BASED ON FIELD CLASSIFICATION AND VISUAL SOIL DESCRIPTION, BUT IS MODIFIED TO INCLUDE RESULTS OF LABORATORY CLASSIFICATION TESTS WHERE AVAILABLE. THIS LOG IS APPLICABLE ONLY AT THIS LOCATION AND TIME. CONDITIONS MAY DIFFER AT OTHER LOCATIONS OR TIME.							

BOREHOLE LOG

Project Name: METRO RAIL TRANSIT

Project Number: 87-885 Field Log of Borehole Number: B 304 Sheet 1 of 2

Borehole Location: A-130 CORRIDOR		Elevation and Datum: 276.4	
Drilling Agency: DATUM EXPLORATION	Driller: DAN STEVE LONNIE ROBERTS	Date Started: 06/17/87	Date Finished: 06/17/87
Drilling Equipment: D-25	Completion: 35.0	Rock Depth: --	
Method of Drilling: HOLLOW STEM AUGER 6" O.D.	Number 15/15 of Samples:	Dist.: 2	Undist.: 13
Borehole Size: 6" O.D.	Water Depth (ft): 27	First:	Core: 24 hrs.
Type of Perforation Backfill: #3 LONE STAR SAND	Logged By: RAY BASILIO		Checked by: BRENDA MEYER
Type of Seal: 5% BENTONITE CEMENT GROUT			

Depth (feet)	Description	Graphic Log		Samples				Remarks
		Lithology	OVA (ppm)	Type	Penetration Resistance (Blow count)	Moisture Content (%)	Dry Density (PCF)	
0								7" concrete slab.
5	SAND (SP-SM/SM); dry to moist, loose, brown, fine to medium, with occasional gravel and little to some silt. Brick fragments at 3.5 feet. Becoming moist		1.0	D	3/3	21.5	76	Background OVA reading at 1 to 2 ppm. Fill material to 12'.
10	Lens of SANDY SILT (ML) at 8.5 feet.		1.0	D	5/6	35.0	86	
15	SAND (SP); moist, medium to very dense, light brown, medium to coarse.		1.5	D	3/3	13.5	104	
15	GRAVELLY SAND (SP); moist, very dense, brown to gray, medium to coarse, with little fine to coarse gravel, occasionally grading to Silty Sand (SM).		1.2	D	7/14	2.5	100	No recovery. Returned downhole with catcher.
15	Gravel and cobbles at 17 feet.		1.2	D	28/36			Disturbed sample at 14 feet.
20	Traces of mica.		1.2	D	36/23	2.5	118	
25	Cobbles at 24 feet.		1.2	D	20/31			
25			1.8	D	23/26	2.5	111	Background OVA reading at 1.5 to 2 ppm.
25			1.8	D	32/60 4"			
30			1.0	D	29/45	3.5	114	
30			1.2	D	50/60 4"			Hydrocarbon odor. Water table at 27'.
30			1.8	D	25/47	10.5	127	Hydrocarbon odor.

BOREHOLE LOG

Project name: METRO RAIL TRANSIT

Project Number: 87-885 Field Log of Borehole Number: B 304 Sheet 2 of 2

Depth (feet)	Description	Graphic Log		Samples			Remarks	
		Lithology	OVA (ppm)	Type	Penetration Resistance (Blow count)	Moisture Content (%)		Dry Density (PCF)
35	GRAVELLY SAND (SP); moist, very dense, brown to gray, medium to coarse, with little fine to coarse gravel, occasionally grading to Silty Sand (SM).		2.5	D	30/35			Sulfur odor.
			2.0	D	51/52	7.0	132	Minor heaving at 27.5 to 35 feet. Bag sample from drill cuttings.
				B				
35	BORING ABANDONED AT 35' (AUGER COULD NO LONGER PENETRATE).							Installed a monitoring well. Hydraulic conductivity test between 39.5 and 44.5 feet.
40	THIS BOREHOLE LOG IS BASED ON FIELD CLASSIFICATION AND VISUAL SOIL DESCRIPTION, BUT IS MODIFIED TO INCLUDE RESULTS OF LABORATORY CLASSIFICATION TESTS WHERE AVAILABLE. THIS LOG IS APPLICABLE ONLY AT THIS LOCATION AND TIME. CONDITIONS MAY DIFFER AT OTHER LOCATIONS OR TIME.							
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70								

BOREHOLE LOG

Project Name: METRO RAIL TRANSIT

Project Number: 87-885 Field Log of Borehole Number: B 304A Sheet 1 of 1

Borehole Location: <u>A-130 CORRIDOR</u>		Elevation and Datum: <u>276.4'</u>	
Drilling Agency: <u>LAYNE ENVIRONMENTAL</u>	Drillor: <u>MIKE MOTTE W. HILL M. TOLBERT</u>	Date Started: <u>07/18/87</u>	Date Finished: <u>07/18/87</u>
Drilling Equipment: <u>AP 1000</u>	Completion: <u>60</u>	Rock Depth: <u>--</u>	
Method of Drilling: <u>PERCUSSION HAMMER</u>	Number of Samples: <u>5/5</u>	Dist.: <u>0</u>	Undist.: <u>5</u> Core: <u>0</u>
Borehole Size: <u>9" O.D.</u>	Water Depth (ft): <u> </u>	First: <u> </u>	Compl.: <u>24 hrs.</u>
Type of Perforation Backfill: <u>N/A</u>	Logged By: <u>R. JIE</u>		Checked by: <u>BRENDA MEYER</u>
Type of Seal: <u>5% BENTONITE CEMENT GROUT</u>			

Depth (feet)	Description	Graphic Log		Samples				Remarks
		Lithology	OVA (ppm)	Type	Penetration Resistance (Blowcount)	Moisture Content (%)	Dry Density (PCF)	
35	GRAVELLY SAND (SP); moist, very dense, brown to gray, medium to coarse. Pocket of uniform, fine, silty sand (SM).	[Lithology Pattern]						See Boring Log B-304 for soil description above 35 feet.
40	SANDY GRAVEL (GP); wet, dense to very dense, gray, fine to coarse, with some sand and occasional silt pockets and cobbles.	[Lithology Pattern]		D	16/104	9.0	129	OVA reading at background in drill cuttings. Strong sulfur odor.
45		[Lithology Pattern]	Back-ground	D	35/62			OVA reading at background in drill cuttings.
50	GRAVELLY SAND (SW-SM); wet, very dense, gray, fine to coarse, with some fine to coarse gravel and occasional cobbles.	[Lithology Pattern]		D	18/31	10.5	126	Reddish brown hydrocarbon stains. Hydrocarbon odor. OVA reading at background in drill cuttings.
55	SAND (SP); wet, medium dense, gray, fine to medium.	[Lithology Pattern]		D	9/7/ ² / ₃ "	23.5	103	Hydrocarbon stains. OVA reading at background in drill cuttings. Hydrocarbon odor and stains. Hole heaving.
60	SANDY GRAVEL (GP); wet, very dense, gray, fine to coarse, with some fine gravel.	[Lithology Pattern]		D	5/25/ 37		114	Sulfur odor.
65	BORING TERMINATED AT 60'. THIS BOREHOLE LOG IS BASED ON FIELD CLASSIFICATION AND VISUAL SOIL DESCRIPTION, BUT IS MODIFIED TO INCLUDE RESULTS OF LABORATORY CLASSIFICATION TESTS WHERE AVAILABLE. THIS LOG IS APPLICABLE ONLY AT THIS LOCATION AND TIME. CONDITIONS MAY DIFFER AT OTHER LOCATIONS OR TIME.							

BOREHOLE LOG

Project Name: METRO RAIL TRANSIT
 Project Number: 87-885 Field Log of Borehole Number: B 305 Sheet 1 of 3

Borehole Location: A-130 CORRIDOR		Elevation and Datum: 276.2'	
Drilling Agency: LAYNE ENVIRONMENTAL	Driller: MIKE MOTTET MIKE MILLS	Date Started: 07/16/87	Date Finished: 07/17/87
Drilling Equipment: AP 1000	Completion: 110.5 Depth (feet)	Rock Depth: 102.5 (feet)	
Method of Drilling: PERCUSSION HAMMER	Number of Samples: 14/15	Dist.: 0	Undist.: 13 Core: 1
Borehole Size: 9" O.D.	Water Depth (ft):	First:	Compl.: 24 hrs.
Type of Perforation Backfill: N/A	Logged By: REYNOLD JIE		Checked by: BRENDA MEYER
Type of Seal: 5% BENTONITE CEMENT GROUT			

Depth (feet)	Description	Graphic Log		Samples				Remarks	
		Lithology	OVA (ppm)	Type	Penetration Resistance (Blowcount)	Moisture Content (%)	Dry Density (PCF)		
35	SAND (SP/SW); wet, dense to very dense, gray, fine to coarse, with occasional cobbles and pockets of silty sand.							See Boring Log B-305A for soil description above 35 feet.	
40	Occasional Gravel and coabbles between 40 and 45 feet.				D	9/30/33	24.5	113	From 5 feet to 30 feet depth, bag samples were taken at every 5 feet interval.
45									
50					D	11/10/9	14.0	108	Strong sulfur odor.
55					D	2/5/18	25.0	103	
60	GRAVELLY SAND (SP/SW/SP-SM/SW-SM); wet dense to very dense, gray, fine to coarse, with little to some fine to coarse gravel; occasional clay pockets.			D	9/19/36	16.5	108		
65				D	NR			No recovery. Strong sulfur odor.	

BOREHOLE LOG

Project name: METRO RAIL TRANSIT

Project Number: 87-885

Field Log of Borehole Number: B 305

Sheet 2 of 3

Depth (feet)	Description	Graphic Log		Samples			Remarks	
		Lithology	OVA (ppm)	Type	Penetration Resistance (Blowcount)	Moisture Content (%)		Dry Density (PCF)
65				D	6/20/28	8.5	127	
70	SANDY GRAVEL (GP-GM/GP); wet, very dense gravel, fine to coarse, with some sand. Occasionally grading to Silty Gravel (GM).			D	11/48/67	6.0	139	
75				D	65/90/4.5"	6.0		Strong sulfur odor.
80	Pocket of olive-gray silty clay. Some wood chips.			D	27/100/5"			
85				D	32/101	9.5	113	Strong sulfur odor.
90	GRAVELLY SAND (SP); wet, very dense, gray, fine to coarse, with some fine to coarse gravel.			D	11/46/84/5"	6.5	138	Encountered heavy seepage.
95	SILTY SAND (SM); wet, very dense, gray, fine to coarse, with some fine gravel.			D	32/103/3"	20.0	106	
100	SAND (SP-SM); wet, very dense, gray, fine to coarse, with little fine to coarse gravel and trace silt, cobbles.			D	35/63/38/3"	6.5	136	
105	Interbedded: CLAYSTONE; dark olive-gray. SILTSTONE; olive-gray; and SANDSTONE; brown, fine.			D	14/25	21.0	104	Bedrock at 102'6".

BOREHOLE LOG

Project Name: METRO RAIL TRANSIT

Project Number: 87-885 Field Log of Borehole Number: B 305A Sheet 1 of 2

Borehole Location: A-130 CORRIDOR		Elevation and Datum: 276.2'	
Drilling Agency: LAYNE ENVIRONMENTAL	Driller: WAYNE BURGESS DWAYNE REED PAUL WAGNER	Date Started: 07/22/87	Date Finished: 07/23/87
Drilling Equipment: CME 75		Completion: 36 Depth (feet)	Rock Depth: ---- (feet)
Method of Drilling: HOLLOW STEM AUGER 6" O.D.		Number 19/19 of Samples	Dist.: 2 Undist.: 17 Core: --
Borehole Size: 6" O.D.		Water 27.8 Depth (ft):	First: Compl.: 24 hrs.
Type of Perforation Backfill: #3 LONE STAR SAND	Logged By: RAY BASILIO		Checked by: BRENDA MEYER
Type of Seal: 5% BENTONITE CEMENT GROUT			

Depth (feet)	Description	Graphic Log		Samples			Remarks	
		Lithology	OVA (ppm)	Type	Penetration Resistance (Blowcount)	Moisture Content (%)		Dry Density (PCF)
1-15	SILTY SAND (SM); dry to moist, medium dense to dense, brown, fine to medium with occasional brick fragments.	[Vertical Line Pattern]	1.1	DL	17/9/10	8.0	100	Bag sample was taken at 1-15' from drill cuttings.
5	Moist below 5 feet depth.	[Vertical Line Pattern]	0.8	DL	10/9/11	11.5	103	OVA reading at background level in work area.
10	Loose below 10 feet depth.	[Vertical Line Pattern]	0.7	DL	10/17/19			
		[Vertical Line Pattern]	2.0	DL	7/13/14	11.0	110	OVA reading at background level in work area. Black stain.
		[Vertical Line Pattern]	0.3	DL	3/3/3	9.5	92	OVA reading at background level in work area.
		[Vertical Line Pattern]	1.0	DL	2/2/2			
15	Gravel and cobbles at 15 feet.	[Vertical Line Pattern]	2.4	DL	3/3/3	11.5	99	Bag sample was taken at 15-30 feet from drill cuttings
	SAND (SP/SW/SW-SM); dry to wet, tan to gray, medium dense to very dense, fine to coarse with some gravel.	[Dotted Pattern]	2.2	DL	7/10/8	9.0	94	
		[Dotted Pattern]	1.0	DL	10/19/16			OVA reading at 0.4 ppm in work area.
		[Dotted Pattern]	3.7	DL	20/31/39	2.5	116	
	GRAVEL and cobbles at 23 feet.	[Dotted Pattern]	1.4	DL	37/44/39	3.5	112	OVA reading at background level in work area.
25	SILTY SAND (SM), at 25 feet.	[Vertical Line Pattern]	0.2	DL	15/25/50	4.0	114	
		[Vertical Line Pattern]	4.0	DL	20/22/48	16.5	109	Water level at 27'9".
		[Vertical Line Pattern]	2.8	DL	20/21/30			OVA reading at background level in work area.

BOREHOLE LOG

Project name: METRO RAIL TRANSIT

Project Number: 87-885

Field Log of Borehole Number: B 305A

Sheet 2 of 2

Depth (feet)	Description	Graphic Log		Samples			Remarks	
		Lithology	OVA (ppm)	Type	Penetration Resistance (Blow count)	Moisture Content (%)		Dry Density (PCF)
35	LENS OF SILTY SAND (SM); wet, very dense, gray, below 32 feet depth.		2.6	DL	40 / $\frac{60}{3''}$	17.0	106	OVA reading at background level in work area. No OVA sample recovery.
				DL	20 / 29 / 20			
			3.6	DL	30 / $\frac{20}{3''}$	25.5	109	
40	BORING TERMINATED AT 36'.							Installed a monitoring well. Hydraulic conductivity test between 30 and 35 feet.
45	<p>THIS BOREHOLE LOG IS BASED ON FIELD CLASSIFICATION AND VISUAL SOIL DESCRIPTION, BUT IS MODIFIED TO INCLUDE RESULTS OF LABORATORY CLASSIFICATION TESTS WHERE AVAILABLE. THIS LOG IS APPLICABLE ONLY AT THIS LOCATION AND TIME. CONDITIONS MAY DIFFER AT OTHER LOCATIONS OR TIME.</p>							
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BOREHOLE LOG

Project name: METRO RAIL TRANSIT

Project Number: 87-885 Field Log of Borehole Number: B 305 Sheet 3 of 3

Depth (feet)	Description	Graphic Log		Samples			Remarks
		Lithology	OVA (ppm)	Type	Penetration Resistance (Blowcount)	Moisture Content (%)	
105	Interbedded: CLAYSTONE; dark olive-gray. SILTSTONE; olive-gray and SANDSTONE; brown, fine.	[Hatched pattern]		C			Coring bedrock at 105'6".
110	BORING TERMINATED AT 110'6".						
115	<p>THIS BOREHOLE LOG IS BASED ON FIELD CLASSIFICATION AND VISUAL SOIL DESCRIPTION, BUT IS MODIFIED TO INCLUDE RESULTS OF LABORATORY CLASSIFICATION TESTS WHERE AVAILABLE. THIS LOG IS APPLICABLE ONLY AT THIS LOCATION AND TIME. CONDITIONS MAY DIFFER AT OTHER LOCATIONS OR TIME.</p>						
120							
125							
130							
135							
140							
145							

BOREHOLE LOG

Project Name: METRO RAIL TRANSIT
 Project Number: 87-885 Field Log of Borehole Number: B 306 Sheet 1 of 3

Borehole Location: A-130 CORRIDOR		Elevation and Datum: 278.0'	
Drilling Agency: LAYNE-ENVIRONMENTAL	Driller: MIKE MOTTET BILL HILL	Date Started: 07/14/87	Date Finished: 07/15/87
Drilling Equipment: AP 1000	Completion: 98.7 Depth (feet)	Rock Depth: 89 (feet)	
Method of Drilling: PERCUSSION HAMMER	Number 22/22 of Samples:	Dist.: 5	Undist.: 15 Core: 2
Borehole Size: 9"	Water Depth (ft): 26.5	First: --	Compl.: -- 24 hrs. --
Type of Perforation Backfill: N/A	Logged By: RAY BASILIO APICHART		Checked by: BRENDA MEYER
Type of Seal: 5% BENTONITE CEMENT GROUT			

Depth (feet)	Description	Graphic Log		Samples				Remarks
		Lithology	OVA (ppm)	Type	Penetration Resistance (Blowcount)	Moisture Content (%)	Dry Density (PCF)	
0 - 5	SILTY SAND (SM); moist, loose to medium dense, brown, fine, with occasional mica and gravel.							
5 - 10			1.2	D	3/9/11	7.5	111	OVA reading at background level in work area.
10 - 12	GRAVEL and cobbles at 12 feet.			B				Bag sample from drill cuttings.
12 - 15			2.0	D	2/9			Disturbed sample.
15 - 18	Becoming GRAVELLY SAND (SP); moist, loose, brown, medium to coarse, with some fine to coarse gravel.			B				OVA reading at background level in work area. Bag sample from drill cuttings.
18 - 20	GRAVEL (GP); moist, medium dense, brown, coarse to fine, with occasional cobbles.			D	7/15			OVA reading at background level on cuttings.
20 - 25	Cobbles at 20 feet.			D	5/24			Disturbed sample.
25 - 26'6"								Water level at 26' 6".
26'6" - 30	SAND (SP/SP-SM); wet, dense to very dense, dark brown to gray, fine to coarse with trace fine to coarse gravel and silt.		1.3	D	22/32	20.0	112	Wellhead OVA reading at background level.

BOREHOLE LOG

Project name: METRO RAIL TRANSIT

Project Number: 87-885

Field Log of Borehole Number: B 306

Sheet 2 of 3

Depth (feet)	Description	Graphic Log		Samples			Remarks	
		Lithology	OVA (ppm)	Type	Penetration Resistance (Blowcount)	Moisture Content (%)		Dry Density (PCF)
35	SAND (SP/SP-SM); wet, dense to very dense, dark brown to gray, medium to coarse with trace fine to coarse gravel and silt.	[Stippled pattern]		D	8/21/28	6.0	134	
40	GRAVELLY SAND (SP-SM); wet, very dense, gray, fine to medium, with some fine to coarse gravel.			D	7/48/51	10.5	132	
45	SAND (SP); wet, very dense, gray, fine to medium with some gravel and occasional cobbles.	[Stippled pattern]		D	17/35/24	23.5		Disturbed sample.
50	GRAVELLY SAND (SP/SW); wet, very dense, gray, fine to coarse, some fine to coarse sand.			D	8/40/41	12.0	127	
55	Occasional pockets of slightly plastic fines.	[Stippled pattern]		D	25/50/35			Strong sulfur odor.
60	Fine Silty Sand (SM) at 60 feet depth.			D	22/57/85	10.5	129	
65	Medium dense at 65 feet depth	[Stippled pattern]	9.0	D	5/10/17	25.5	98	
70				D	9/42/49			Poor recovery.

APPENDIX B
BOREHOLE LOGS OF JANUARY 1987 INVESTIGATION

APPENDIX B
BOREHOLE LOGS OF JANUARY 1987 INVESTIGATION

This appendix presents the borehole logs prepared for a previous subsurface investigation performed by The Earth Technology Corporation (The Earth Technology Corporation, 1987c) in the vicinity of the Metro Rail realigned A-130 corridor. A total of nine boreholes, numbered BH-201 through BH-209, were drilled to depths ranging between 40 to 60 feet below ground surface. The locations of these boreholes are shown in Figure 1-1 of the main text of the present report. The locations of these boreholes are also shown in Figure 3-3, the cross section of subsurface soil conditions at the site.

UNIFIED SOIL CLASSIFICATION SYSTEM (ASTM D-2487)

PRIMARY DIVISIONS			GROUP SYMBOL	SECONDARY DIVISIONS
COARSE GRAINED SOILS MORE THAN HALF OF MATERIALS IS LARGER THAN #200 SIEVE SIZE	GRAVELS MORE THAN HALF OF COARSE FRACTION IS LARGER THAN #4 SIEVE	CLEAN GRAVELS (LESS THAN 5% FINES)	GW	WELL GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES.
			GP	POORLY GRADED GRAVELS OR GRAVEL-SAND MIXTURES, LITTLE OR NO FINES.
		GRAVEL WITH FINES	GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURE, NON PLASTIC FINES.
			GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES, PLASTIC FINES.
	SANDS MORE THAN HALF OF COARSE FRACTION IS SMALLER THAN #4 SIEVE	CLEAN SANDS (LESS THAN 5% FINES)	SW	WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES.
			SP	POORLY GRADED SANDS OR GRAVELLY SANDS, LITTLE OR NO FINES.
		SANDS WITH FINES	SM	SILTY SANDS, SAND-SILT MIXTURES, NON-PLASTIC FINES.
			SC	CLAYEY SANDS, SAND-CLAY MIXTURES, PLASTIC FINES.
FINE GRAINED SOILS MORE THAN HALF OF MATERIAL IS SMALLER THAN #200 SIEVE SIZE	SILTS AND CLAYS LIQUID LIMIT IS LESS THAN 50	ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY.	
		CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS.	
		OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY.	
	SILTS AND CLAYS LIQUID LIMIT IS GREATER THAN 50	MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS, ELASTIC SILTS.	
		CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS.	
		OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS.	
	HIGHLY ORGANIC SOILS	PT	PEAT AND OTHER HIGHLY ORGANIC SOILS.	

CLASSIFICATION CRITERIA BASED ON LAB TESTS

The chart plots Plasticity Index (0-60) against Liquid Limit (0-100). A diagonal 'A' line separates regions for different soil types. Regions above the line include CH, CL, and OH & MH. Regions below the line include ML & CL, ML, and OH & MH.

GW AND SW— $C_u = \frac{D_{60}}{D_{10}}$ GREATER THAN 4 FOR GW AND 6 FOR SW; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ BETWEEN 1 AND 3

GP AND SP—CLEAN GRAVEL OR SAND NOT MEETING REQUIREMENT FOR GW AND SW

GW AND SM—ATTERBERG LIMIT BELOW "A" LINE OR P.I. LESS THAN 4

GC AND SC—ATTERBERG LIMIT ABOVE "A" LINE P.I. GREATER THAN 7

FINES (SILT OR CLAY)	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	COARSE GRAVEL	COBBLES	BOULDERS
SIEVE SIZES	200	40	10	4	3/4"	3"	10"

CLASSIFICATION OF EARTH MATERIALS IS BASED ON FIELD INSPECTION AND SHOULD NOT BE CONSTRUED TO IMPLY LABORATORY ANALYSIS UNLESS SO STATED.

SAMPLE TYPE	
S	STANDARD SPLIT SPOON SAMPLE
D	2 1/2" DIA., 12" LONG DRIVE SAMPLE
DL	2 1/2" DIA., 18" LONG DRIVE SAMPLE
NR	NO RECOVERY
B	BULK SAMPLE
C	CORE SAMPLE

EXPLANATIONS
PENETRATION RESISTANCE (BLOW COUNT) —BLOW COUNTS FOR CALIFORNIA DRIVE SAMPLER 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
BG —BACKGROUND
O.D.—OUTSIDE DIAMETER
N/A —NOT APPLICABLE

BOREHOLE LOG

METRO RAIL TRANSIT

Project Name: _____
 Project Number: 87-600-0033 Field Log of Borehole Number: BH-201 Sheet 1 of 2

Borehole Location: Traffic Island off 101 Fwy		Elevation and Datum: 277.4 feet	
Drilling Agency: DRILL LINE	Driller: Gregg DeLuca John Hale	Date Started: 1-8-87	Date Finished: 1-8-87
Drilling Equipment: B-53		Completion: 46.5	Rock Depth: (feet)
Method of Drilling: Hollow Stem Auger - 6 Inch Dia.		Number of Samples: 6	Dist.: Undist.: 6 Core:
Borehole Size: 8 Inch		Water Depth (ft): 29	First: Compl.: 24 hrs.
Type of Perforation Backfill: None		Logged By: Sharon Lagas	
Type of Seal: 5% Bentonite Cement Grout		Checked by: Barbara Fontes	

Depth (feet)	Description	Graphic Log		Samples			Remarks	
		Lithology	OVA (ppm)	Number	Type	Blow Count		Drilling Rate/Time
	Dry, dark brown, silty fine to medium size grain sand with some small gravel	SM					9:30	Baseline OVA reading at 2 ppm. Traffic island has been disturbed during freeway construction
5	5-6.5' Same as above with small chips of brick	SM	1	1	Z	12/26/26	10:00	
	7' Hit debris (possibly brick)							OVA Readings at Baseline
10	10-11.5' Dry, dark brown, silty, fine to medium size sand	SM	1	2	Z	18/22/32	10:08	OVA Readings at Baseline
15	15-16.5' Dry, brown to light brown silty sand with gravel	SM	-	3	Z	14/9/7	10:13	OVA Readings at Baseline No recovery for OVA
20	20' No recovery-cobble, gravel		-	-		NOTE	10:20	OVA Readings at Baseline
25	25' No recovery - 5" chunk of concrete		-	-		NOTE	10:30	Possibility of disturbed soil to 25 ft. OVA readings at Baseline
	Groundwater encountered at approximately 29 feet							

BOREHOLE LOG

Project name: METRO RAIL TRANSIT

Project Number: 87-600-0033 Field Log of Borehole Number: BH-201 Sheet 2 of 2

Depth (feet)	Description	Graphic Log		Samples			Remarks
		Lithology	OVA (ppm)	Number	Type	Blow Count	
30-31.5'	Wet, gray, fine to medium size sand	SP	70	4	16/32/37	10:37	OVA Readings at Baseline, sample has oily film and slight oily odor with sheen
35-36.5'	Wet, gray, medium to coarse grained sand	SP	-	5	10/22/50	10:54	OVA Readings at Baseline No recovery for OVA
40'	No recovery - cobble, gravel	-	-	-	50/6"	11:04	
45-46.0'	Wet, dark gray, fine to medium size sand	SP	8	6	5/50	11:18	OVA Readings at Baseline
46.5'	Hit boulder End Hole					11:25	Collected water samples
55'	<p>Note: On this and all logs that follow, there are missing blow counts at some sampling intervals. In those cases, blow counts were not recorded due to other demands on personnel time.</p>						
60'							
65'							
70'							

BOREHOLE LOG

METRO RAIL TRANSIT

Project Name: _____
 Project Number: 87-600-0033 Field Log of Borehole Number: BH-202 Sheet 1 of 2

Borehole Location: Traffic Island off 101 FWY		Elevation and Datum: 277.3 ft	
Drilling Agency: DRILL LINE	Driller: Gregg Deluca John Hale	Date Started: 1/8/87	Date Finished: 1/8/87
Drilling Equipment: B-53		Completion: Depth (feet) 50	Rock Depth: (feet)
Method of Drilling: Hollow Stem Auger - 6 Inch Dia.		Number of Samples: 8	Dist.: Undist.: 8 Core:
Borehole Size: 8 Inch		Water Depth (ft): 29	First: Compl.: 24 hrs.
Type of Perforation Backfill: None		Logged By: _____	
Type of Seal: 5% Bentonite Cement Grout		Checked by: _____	
		Sharon Lagas Barbara Fontes	

Depth (feet)	Description	Graphic Log		Samples			Remarks
		Lithology	OVA (ppm)	Number	Type	Blow Count	
	Dry, dark brown, silty fine to medium size sand with gravel. Hit concrete @ 1'	SM Fill					1:30 Baseline OVA Reading @2 ppm
5	5-6.5' Dry, light brown, fine to medium size sand with some silt	SM	2	1	8/12/13	1:40	OVA Readings at Baseline
10	10-10.5' Dry, brown, silty, fine to medium size sand with clay	SC	1	2	8/4/16	1:45	OVA Reading at Baseline
	10.5-11.5' Dry, light brown, medium to coarse grained sand with gravel	SP					
15	15-16.5' Dry, light brown, medium to coarse sand with gravel	SP	4	3	23/40/25	1:50	OVA Readings at Baseline
	17.5' Hit cobble						
20	20-21.0' Same as above	SP	2	4	28/50	1:58	OVA Readings at Baseline, oily film on sand
	25-25.5' Dry, light brown, medium to coarse sand which grades into a brown-gray silty clay	SP/CL	6	5	14/23	2:06	OVA Readings at Baseline
25	25.5-26.0' Moist, brown-gray, medium to coarse sand Groundwater encountered at approximately 29 feet	SP					
30							

BOREHOLE LOG

METRO RAIL TRANSIT

Project name: _____
 Project Number: 87-600-0033 Field Log of Borehole Number: BH-202 Sheet 2 of 2

Depth (feet)	Description	Graphic Log		Samples			Remarks	
		Lithology	OVA (ppm)	Number	Type	Blow Count		Drilling Rate/Time
30-31.5'	Wet, gray, medium to coarse grained sand	SP	16	6	/	13/35/50	2:15	OVA Readings at Baseline
35'	No Recovery	-	-	-	-	8/16/40	2:20	
40-41.5'	Wet, gray, medium to coarse grained sand	SP	10	7	/	8/16/47	2:28	OVA Readings at Baseline
45'	Hit boulder							
45.5'-46.5'	Wet, dark gray, fine to medium size sand	SP	-	8	/	30/50	2:42	OVA Readings at Baseline No recovery for OVA
50'	Hammer broke, ended hole						3:15	No water sample

BOREHOLE LOG

METRO RAIL TRANSIT

Project Name: _____
 Project Number: 87-600-0033 Field Log of Borehole Number: BH-203 Sheet 1 of 2

Borehole Location: Traffic Island off 101 FWY		Elevation and Datum: 276.5 ft	
Drilling Agency: DRILL LINE	Driller: Gregg Deluca John Hale	Date Started: 1/14/87	Date Finished: 1/14/87
Drilling Equipment: B-53		Completion: Depth (feet): 60	Rock Depth: (feet)
Method of Drilling: Hollow Stem Auger - 6 Inch Dia.		Number of Samples: 5	Dist.: Undist.: 5 Core:
Borehole Size: 8 Inch		Water Depth (ft): 30	First: Compl.: 24 hrs.
Type of Perforation Backfill: None		Logged By: Sharon Lagas	
Type of Seal: 5% Bentonite Cement Grout		Checked by: Barbara Fontes	

Depth (feet)	Description	Graphic Log		Samples			Remarks
		Lithology	OVA (ppm)	Number	Type	Blow Count	
							Slant Drilling Angle = 20°
	Dry, brown, silty fine to medium size sand - at 6" hit old brick and large boulder	SM					10:00 OVA not working
5'	Same as above with gravel and cobble - no sample collected	FILL		-	Note		No sample collected, augers grinding on gravel and cobble
7'	Broke through gravel	---					Black brown color soil
10-11.5'	Dry, black-brown, fine to medium sand and silt with small wood fragments	SM		1		15/19/26	10:51 Soil becomes brown in color and fluffy in texture
15-16.5'	Dry, brown, medium to coarse grained sand with gravel	SP		2		10/10/8	11:00
20'	No recovery			-	Note		Hammer sticking so drilling another 5 feet
25-25.5'	Dry, light brown, medium to coarse grained sand with gravel	SP		3	Note		11:21 Only 6" of sample due to sampler falling at an angle. Sampler hitting against the auger
30'	Groundwater encountered at approx. 30 feet						

BOREHOLE LOG

Project name: METRO RAIL TRANSIT

Project Number: 87-600-0033 Field Log of Borehole Number: BH-203 Sheet 2 of 2

Depth (feet)	Description	Graphic Log		Samples			Remarks	
		Lithology	OVA (ppm)	Number	Type	Blow Count		Drilling Rate/Time
30-30.5'	Wet, brown, coarse grained sand and gravel	SP		4		50/6"	1:30	
32.5'	Small Cobble, large gravel	GP						
35-35.7'	Wet, gray, medium to coarse grained sand	SP		5		39/50 for 2"	1:43	Slight oily odor, only 8-10" of sample, rest was slough
39'	Small Cobble, large gravel (about 2 in.)	GP						
40'	No recovery - Possibly cobble and gravel*			-		Note	12:00	Hammer sticking
45'	No recovery - Possibly cobble and gravel*			-		Note	1:11	Hammer sticking- cannot sample without hammer getting stuck so continuing on to 60 feet
50'	No recovery - Possibly cobble and gravel*			-		Note	12:17	
55'	No recovery			-		Note		Hitting cobbles
60'	Wet, gray, medium to coarse grained sand with slight hydrocarbon odor coming up from augers 60' End hole						12:33	Appears to be predominantly slough Collected water samples
65'								
70'	*Augers bringing up slough from upper portion of borehole.							

BOREHOLE LOG

METRO RAIL TRANSIT

Project Name: _____
 Project Number: 87-600-0033 Field Log of Borehole Number: BH-204 Sheet 1 of 2

Borehole Location: Old Center St. (b/t Aliso & Comm.)		Elevation and Datum: 275.4 ft	
Drilling Agency: DRILL LINE	Driller: Gregg Deluca John Hale	Date Started: 1/12/87	Date Finished: 1/12/87
Drilling Equipment: B-53		Completion: Depth (feet) 61.5	Rock Depth: (feet)
Method of Drilling: Hollow Stem Auger - 6 Inch Dia.		Number of Samples: 6	Dist.: Undist.: 6 Core:
Borehole Size: 8 Inch		Water Depth (ft): 30	First: Compl.: 24 hrs.
Type of Perforation Backfill: None		Logged By: Barbara Fontes	
Type of Seal: 5% Bentonite Cement Grout		Checked by: Sharon Lagas	

Depth (feet)	Description	Graphic Log		Samples			Remarks	
		Lithology	OVA (ppm)	Number	Type	Blow Count		Drilling Rate/Time
	Asphalt, concrete debris						7:30	Baseline OVA Reading at 4 ppm
	Dry, dark brown, silty fine to medium size sand	SM						
5'	Same as above	SM		-				No samples collected
8-9'	Moist clayey sand	SC						
10-11.5'	Dry, brown, silty, fine to medium size sand	SM	2	1	8/15/11	8:00		OVA Readings @ baseline
15-15.5'	Same as above	SM	4	2	18/6"	8:10		Collected only OVA sample. Hit large object-refusal. Sampler is not penetrating
20-21.5'	Dry, brown, medium to coarse grained sand with fragmented gravel and small cobbles	SP	4	3	39/50/49	8:17		OVA readings @ baseline
25-25.5'	Same as above	SP	160	4	25/6"	8:25		Soil has hydrocarbon odor. OVA values recorded at 160 ppm
	Groundwater encountered at approx. 30 feet							

BOREHOLE LOG

METRO RAIL TRANSIT

Project name: _____
 Project Number: 87-600-0033 Field Log of Borehole Number: BH-204 Sheet 2 of 2

Depth (feet)	Description	Graphic Log		Samples			Remarks
		Lithology	OVA (ppm)	Number	Type	Blow Count	
30-31.0'	Wet, gray, coarse grained sand	SP	-	5		20/50	No OVA recovery
35	35-36.5' Same as above	SP		6		Note	
38.5'	Cobble, gravel						
40	40' No recovery - cobble, gravel			-		Note	8:59 OVA reading 2 ppm Hole has slight creosote odor (40 to 60 feet)
45	45' No recovery - cobble, gravel			-		Note	
50	50' No recovery - slough			-		Note	Augers contained approx. 4 feet of slough
55	55' No recovery			-		Note	
60	60' Wet, gray, coarse grained sand End Hole	SP	>1000	-		8/11/ 16	9:44 10:01 Collected water samples, not enough recovery for soil samples
65							
70							

BOREHOLE LOG

METRO RAIL TRANSIT

Project Name: _____
 Project Number: 87-600-0033 Field Log of Borehole Number: BH-205 Sheet 1 of 2

Borehole Location: Commercial and Center St., West		Elevation and Datum: 274.7 ft	
Drilling Agency: DRILL LINE	Driller: Gregg Deluca John Hale	Date Started: 1/13/87	Date Finished: 1/13/87
Drilling Equipment: B-53		Completion Depth (feet): 61.5	Rock Depth (feet):
Method of Drilling: Hollow Stem Auger - 6 Inch Dia.		Number of Samples: 7	Dist.: Undist.: 7 Core:
Borehole Size: 8 Inch		Water Depth (ft): 30	First: Compl.: 24 hrs.
Type of Perforation Backfill: None		Logged By: Barbara Fontes	
Type of Seal: 5% Bentonite Cement Grout		Checked by: Sharon Lagas	

Depth (feet)	Description	Graphic Log		Samples				Remarks
		Lithology	OVA (ppm)	Number	Type	Blow Count	Drilling Rate/Time	
5'	Dry, brown, silty, fine to medium size sand with brick chips, possibly fill material	SM Fill					9:00	Baseline OVA reading @ 2ppm Surface soil contains shells and broken pottery. Soil type not evident in other areas
5'	No sample collected	---		-		Note		
10-11.5'	Dry, light brown, medium to coarse sand with gravel	SP	4	1	26/22	9:05	23	
15-16.0'	Same as above	SP	-	2	48/50	9:10		
20-21.0'	Dry, brown, coarse grained sand and small gravel	SP	-	3	49/50	9:20		
25-26.0'	Same as above	SP	-	4	33/56	9:36		Decomposed granite cobble in auger (cobble > 3 in.)

BOREHOLE LOG

METRO RAIL TRANSIT

Project name: _____
 Project Number: 87-600-0033 Field Log of Borehole Number: BH-205 Sheet 2 of 2

Depth (feet)	Description	Graphic Log		Samples			Remarks	
		Lithology	OVA (ppm)	Number	Type	Blow Count		Drilling Rate/Time
30-31.0'	Wet, grey, medium to coarse grained sand Groundwater encountered at approximately 30 feet	SP	30	5	/	28/50	9:48	OVA and 1 brass recovery
35-36.5'	Same as above	SP	4	6	/	14/37/48	9:54	
40-41.5'	Same as above	SP		7	/	Note	10:00	1 brass recovery, no OVA sample OVA reading @ base-line
43'	Cobble, gravel	GP						
45'	No recovery - cobble, gravel			-		Note	10:27	
50'	Wet, dark gray, fine to medium size sand, oily film and odor	SP	100	-		10/26/50	10:37	Only OVA sample recovery OVA reading @ base-line
55-56.5'	Same as above	SP	100	-		3/13/50	10:48	
60'	No recovery-sampler and "A" rods stuck in augers End Hole			-		Note	10:59	Water samples collected

BOREHOLE LOG

METRO RAIL TRANSIT

Project Name: _____
 Project Number: 87-600-0033 Field Log of Borehole Number: BH-206 Sheet 1 of 1

Borehole Location: Vignes St. (C.C. Meyer's yard)		Elevation and Datum: 276.8 ft	
Drilling Agency: DRILL LINE	Driller: Gregg Deluca John Hale	Date Started: 1-9-87	Date Finished: 1-9-87
Drilling Equipment: B-53	Completion: Depth (feet) N/A	Rock Depth: (feet)	
Method of Drilling: Hollow Stem Auger - 6 Inch Dia.	Number of Samples: 0	Dist.:	Undist.:
Borehole Size: 8 inch	Water Depth (ft):	First:	Core: 24 hrs.
Type of Perforation Backfill: None	Logged By: Sharon Lagas		Checked by: Barbara Fontes
Type of Seal: 5% Bentonite Cement Grout			

Depth (feet)	Description	Graphic Log		Samples				Remarks
		Lithology	OVA (ppm)	Number	Type	Blow Count	Drilling Rate/Time	
0		SM					9:25	Baseline OVA reading @ 2 ppm. Hit concrete at 4 feet and could not get drill straight-abandoned hole.
5	4' concrete Borehole abandoned after two attempts	Fill					9:48	
10								
15								
20								
25								
30								

BOREHOLE LOG

METRO RAIL TRANSIT

Project Name: _____
 Project Number: 87-600-003 Field Log of Borehole Number: BH-206A Sheet 1 of 2

Borehole Location: Vignes St. (C.C. Meyer's yard)		Elevation and Datum: 276.5 ft	
Drilling Agency: DRILL LINE	Driller: Gregg Deluca John Hale	Date Started: 1-9-87	Date Finished: 1-9-87
Drilling Equipment: B-53	Completion: 41.5	Rock Depth: (feet)	
Method of Drilling: Hollow Stem Auger - 6 Inch Dia.	Number of Samples: 6	Dist.:	Undist.: 6 Core:
Borehole Size: 8 Inch	Water Depth (ft): 29.5	First:	Compl.: 24 hrs.
Type of Perforation Backfill: None	Logged By:		Checked by:
Type of Seal: 5% Bentonite Cement Grout	Sharon Lagas		Barbara Fontes

Depth (feet)	Description	Graphic Log		Samples			Remarks
		Lithology	OVA (ppm)	Number	Type	Blow Count	
	Dry, dark brown, sand and gravel with some silt	SP					10:00 Baseline OVA reading @ 2 to 5ppm
5	5-6' Dry, medium to coarse sand with some gravel	SP	3	1	Z	10/10/10:10	OVA reading @ baseline
	6-6.5' Dry, medium grained sand with silt and some clay	SC				10	
10	10' No recovery (probably fill)			-		10/15/10:13	OVA reading @ baseline
						27	
15	15-15.5' Dry, light brown, medium to coarse sand with gravel	SP	14	2	Z	50/6"	10:23 OVA reading @ baseline
20	20' Dry, gravel with coarse grained sand	GP		-		23/6"	10:30 No recovery, cobble stuck in sampler
	23' Gravel and cobble	GP					
25	25-26.5' Moist, medium to coarse grained sand with gravel	SP	12	3	Z	10/43/10:38	OVA reading @ baseline
						50	
30	Groundwater encountered at approx. 29.5 feet						

BOREHOLE LOG

Project name: METRO RAIL TRANSIT

Project Number: 87-600-0033 Field Log of Borehole Number: BH-206A Sheet 2 of 2

Depth (feet)	Description	Graphic Log		Samples			Remarks
		Lithology	OVA (ppm)	Number	Type	Blow Count	
30-31.5'	Wet, gray, medium to coarse grained sand	SP	8	4	3/6/10	11:20	OVA reading @ baseline
35-36.5'	Wet, gray, fine to medium size sand	SP	10	5	6/10/13	11:26	OVA reading @ baseline
40-41.5'	Same as above End Hole	SP	6	6	23/49/48	11:36	OVA reading at baseline, 10 feet of slough in hole Collected water samples

BOREHOLE LOG

METRO RAIL TRANSIT

Project Name: _____
 Project Number: 87-600-0033 Field Log of Borehole Number: BH-207 Sheet 1 of 2

Borehole Location: 101 FWY South from Vignes		Elevation and Datum: 276.9 ft	
Drilling Agency: DRILL LINE	Driller: Gregg Deluca John Hale	Date Started: 1/12/87	Date Finished: 1/12/87
Drilling Equipment: B-53		Completion: Depth (feet) 60	Rock Depth: (feet)
Method of Drilling: Hollow Stem Auger - 6 Inch Dia.		Number of Samples: 4	Dist.: Undist.: 4 Core:
Borehole Size: 8 Inch		Water Depth (ft): 30	First: Compl.: 24 hrs.
Type of Perforation Backfill: None		Logged By: Barbara Fontes	
Type of Seal: 5% Bentonite Cement Grout		Checked by: Sharon Lagas	

Depth (feet)	Description	Graphic Log		Samples			Remarks
		Lithology	OVA (ppm)	Number	Type	Blow Count	
	Dry, dark brown, silty, fine to medium size sand with gravel and rock/garbage debris	Fill					12:10 Baseline OVA reading @ 2 ppm
5	5-6.5' Same as above	Fill			Note		Very little pressure on augers
10	10-11.5' Moist, black-brown, silty sand, medium plasticity clay with oxidation staining	SC	2	1	3/5/8	12:28	
12.5	12.5' Hit debris-augers crunching						
15	15-16.5' Moist to dry, medium to coarse sand	SP	4	2	31/36/33	12:35	OVA reading @ baseline
19	19' Gravel and cobbles	GP					
20	20' Dry, coarse grained sand with gravel and cobbles	SP	6	-	50/6"	12:56	OVA reading @ baseline, cobble stuck in sampler No recovery for lab samples
25	25' Same as above	SP	6	-	50/6"	1:01	No recovery for lab samples
30							

BOREHOLE LOG

Project name: METRO RAIL TRANSIT

Project Number: 87-600-0033

Field Log of Borehole Number: BH-207

Sheet 2 of 2

Depth (feet)	Description	Graphic Log		Samples			Remarks	
		Lithology	OVA (ppm)	Number	Type	Blow Count		Drilling Rate/Time
30-31.5'	Wet, gray, coarse sand with some silt Groundwater encountered at approximately 30 feet	SP	12	3	/	4/4/ 24	1:07	
35	35-36.0' Same as above	SP	4	4	/	20/50	1:14	
38'	Gravel and cobble	GP						Augers vibrating
40'	Wet, gray, medium to coarse grained sand	SP	12	-		50/6"	1:27	No recovery for lab samples
45'	No recovery - Possibly medium to coarse grained sand			-		Note	1:30	Having problem with sand heaves going to 60'-sand locking around drill
50'	No recovery - Possibly medium to coarse grained sand			-		Note		
55'	No recovery - Possibly medium to coarse grained sand			-		Note		
60'	End Hole						2:15	Collected water Samples

BOREHOLE LOG

METRO RAIL TRANSIT

Project Name: _____
 Project Number: 87-600-0033 Field Log of Borehole Number: BH-208 Sheet 1 of 2

Borehole Location: NE of BH-205/Adjacent to Center St.		Elevation and Datum: 270.6 ft	
Drilling Agency: DRILL LINE	Driller: Gregg Deluca John Hale	Date Started: 1/13/87	Date Finished: 1/13/87
Drilling Equipment: B-53		Completion: Depth (feet) 60	Rock Depth: (feet)
Method of Drilling: Hollow Stem Auger - 6 Inch Dia.		Number of Samples: 6	Dist.: Undist.: 6 Core:
Borehole Size: 8 Inch		Water Depth (ft): 25	First: Compl.: 24 hrs.
Type of Perforation Backfill: None		Logged By: Barbara Fontes	
Type of Seal: 5% Bentonite Cement Grout		Checked by: Sharon Lagas	

Depth (feet)	Description	Graphic Log		Samples				Remarks
		Lithology	OVA (ppm)	Number	Type	Blow Count	Drilling Rate/Time	
	Dry, dark brown, silty fine to medium size sand	SM					12:42	Baseline OVA reading @ 2 ppm
5'	No sample collected					Note	12:45	OVA reading @ baseline
10'	10-11.5' Dry, brown, medium to coarse grained sand with gravel	SP	2	1	33/45/45		12:48	OVA reading @ baseline, large cobble in sampler
15'	15-16.0' Dry, brown, fine to medium grained sand	SP	2	2	34/50		12:58	OVA reading @ baseline
20'	20-21.0' Dry, brown, medium to coarse sand with gravel and broken cobble	SP	4	3	40/50		1:05	Bouncing off large cobble
25'	25-26.5' Wet, gray, medium to coarse grained sand with occasional gravel Groundwater encountered at approx. 25 feet	SP	100	4	16/19/15		1:12	Slight oily odor
30'								

BOREHOLE LOG

METRO RAIL TRANSIT

Project name: _____
 Project Number: 87-600-0033 Field Log of Borehole Number: BH-208 Sheet 2 of 2

Depth (feet)	Description	Graphic Log		Samples			Remarks	
		Lithology	OVA (ppm)	Number	Type	Blow Count		Drilling Rate/Time
30-31.5'	Same as above-not as coarse	SP	40	5	/	7/7/13	1:19	Drilling very difficult
34'	Gravel and cobble	GP						
35'	No recovery-gravel and cobble	GP		-		Note	1:28	
40-41.5'	Wet, gray, medium grained sand	SP	2	6	/	7/9/34	1:43	OVA reading @ baseline, slight creosote odor
45'	No recovery - Possibly sand			-		Note		
50'	No recovery-6 feet of slough in augers - Possibly sand			-		Note		
55'	No recovery - Possibly sand			-		Note		
60'	Abandoned hole due to sampler being stuck in augers. Could not advance hole any further						2:44	Upon removal of augers, strong creosote odor. No water samples collected due to sampler being stuck

BOREHOLE LOG

Project Name: METRO RAIL TRANSIT
 Project Number: 87-600-0033 Field Log of Borehole Number: BH-209 Sheet 1 of 2

Borehole Location: <u>East Corner Center & Commercial St.</u>		Elevation and Datum: <u>273.6 ft</u>	
Drilling Agency: <u>DRILL LINE</u>	Driller: <u>Greg Deluca</u> <u>John Hale</u>		Date Started: <u>1/21/87</u> Date Finished: <u>1/21/87</u>
Drilling Equipment: <u>B-53</u>	Completion: <u>50</u>		Rock Depth: (feet)
Method of Drilling: <u>Hollow Stem Auger - 6 Inch Dia.</u>	Number of Samples: <u>8</u>	Dist.: <u>8</u>	Undist.: <u>8</u> Core:
Borehole Size: <u>8 Inch</u>	Water Depth (ft): <u>30</u>	First:	Compl.: <u>24 hrs.</u>
Type of Perforation Backfill: <u>None</u>	Logged By: <u>Sharon Lagas</u>		Checked by: <u>Barbara Fontes</u>
Type of Seal: <u>5% Bentonite Cement Grout</u>			

Depth (feet)	Description	Graphic Log		Samples			Remarks	
		Lithology	OVA (ppm)	Number	Type	Blow Count		Drilling Rate/Time
0-6"	Asphalt						9:18	Baseline OVA reading @ 6 ppm
6"-1.2'	Brick Road							
1.2'-1.6'	Concrete	Fill						
5	Dry, dark brown, silty, fine to medium size sand with some gravel							
5-6.5'	Dry, brown-black, silty, fine to medium size sand with some gravel	SM	6	1	5/4/4	9:54	9:54	OVA reading @ baseline, only OVA sample recovery
10	10.7-11.7' Moist, black-brown, silty, fine to medium size sand with some gravel	SM	6	2	16/17	10:00	10:00	At 10' sampler hit pocket and dropped approx. 8"
15	15-16.5' Dry, brown, fine to medium sand with pea size gravel. Upper 8" stained black. Gravel increasing in size with depth. Entire sample saturated with gasoline	SP	33	3	14/41/37	10:05	10:05	OVA reading @ baseline Large cobble in bottom of sampler Oily film on sampler
20	20-20.5' Dry, brown, silty sand	SM	6	4	20/37/43	10:20	10:20	OVA reading @ baseline Strong oily odor
	20.5-21.5' Moist, gray, medium to coarse sand with pea size gravel	SP						
25	25-26.0' Dry, brown, silty, medium to coarse sand with gravel.	SM	6	5	27/50	10:27	10:27	OVA reading @ baseline Strong oily odor
27.5'	Hit cobble and gravel							
30	Groundwater encountered at approx. 30 feet	GP						

BOREHOLE LOG

Project name: METRO RAIL TRANSIT

Project Number: 87-600-0033

Field Log of Borehole Number: BH-209

Sheet 2 of 2

Depth (feet)	Description	Graphic Log		Samples			Remarks	
		Lithology	OVA (ppm)	Number	Type	Blow Count		Drilling Rate/Time
30-31.0'	Wet, green-gray, medium to coarse sand with some gravel	SP	24	6		36/50	10:35	OVA reading at baseline Hit void Soil has H ₂ S odor Oily film on sampler
35'	35'-35.5' Wet, gray, medium to coarse grained sand	SP	46	7		50/6"	10:44	OVA reading @ baseline
37'	Hit cobble and gravel	GP						Strong H ₂ S odor
39'	Broke through cobble							Slight creosote odor on sampler
40-41.5'	Wet, gray, medium to coarse grained sand with gravel	SP	12	8		6/8/ 16	10:59	OVA reading @ baseline Oily film on sampler
45'	No recovery - 4' slough in augers			-		Note		
50'	End hole - no recovery due to sampler sticking in augers						11:21	Water samples collected OVA reading 14 ppm at top of hole

APPENDIX C
HYDROLOGIC TESTING

APPENDIX C
HYDROLOGIC TESTING

Field hydrologic testing was performed in the monitoring wells in Boreholes B301, B304, and B305A during a period between July 25 and 28, 1987. The purpose of these tests was to estimate the horizontal hydraulic conductivity of the site soils at various depths. The monitoring wells were constructed by installing slotted PVC pipes in the boreholes. The lower 5 feet of the pipes was perforated and screened with 0.02-inch slot size. The bottom of the pipe was capped. A protective filter was formed by placing No. 3 Monterey sand around the well screens. The filter was placed between the bottom of the borehole and approximately 1½ feet above the well screen. A 2-foot thick bentonite seal was placed above the sand filter. The remainder of the borehole was backfilled, with a cement grout containing 5% bentonite, to the ground surface.

Two testing techniques were selected for this study. A pump test was performed in Borehole B301 and two slug tests (falling head) were performed in Boreholes B304 and B305A. The pump test was performed by pumping the groundwater in Borehole B301 and monitoring the rate of recovery. Using a pumping rate of 5 gallons per minute, a maximum drawdown of approximately 23 feet was achieved after 24 minutes of continuous pumping. After this period, pumping was stopped and water was allowed to rise in the well. The water level was monitored in the well for a 20-minute period. The pump test results are presented in Table C-1.

The slug tests (falling head) were performed in Borings B304 and B305A. A measured amount of deionized water was quickly poured into the wells to bring the water level to within one foot of the top of the well casing. Water was allowed to dissipate into the adjacent ground through the well screen, and the time for dissipation of excess head and the water level were monitored as the water level approached the initial static groundwater level. The slug test results are presented in Table C-1.

TABLE C-1. RESULTS OF FIELD HYDRAULIC CONDUCTIVITY TEST

Monitoring Well	Casing Size	Screen Depths (ft)	Hydraulic Conductivity (cm/sec)	Test Type
B301	4-inch	43 - 58	3×10^{-4}	Recovery
B304	2-inch	39.5 - 44.5	6×10^{-5}	Falling Head
B305A	4-inch	30 - 35	10×10^{-3}	Falling Head

APPENDIX D
GEOPHYSICAL TESTING

APPENDIX D GEOPHYSICAL TESTING

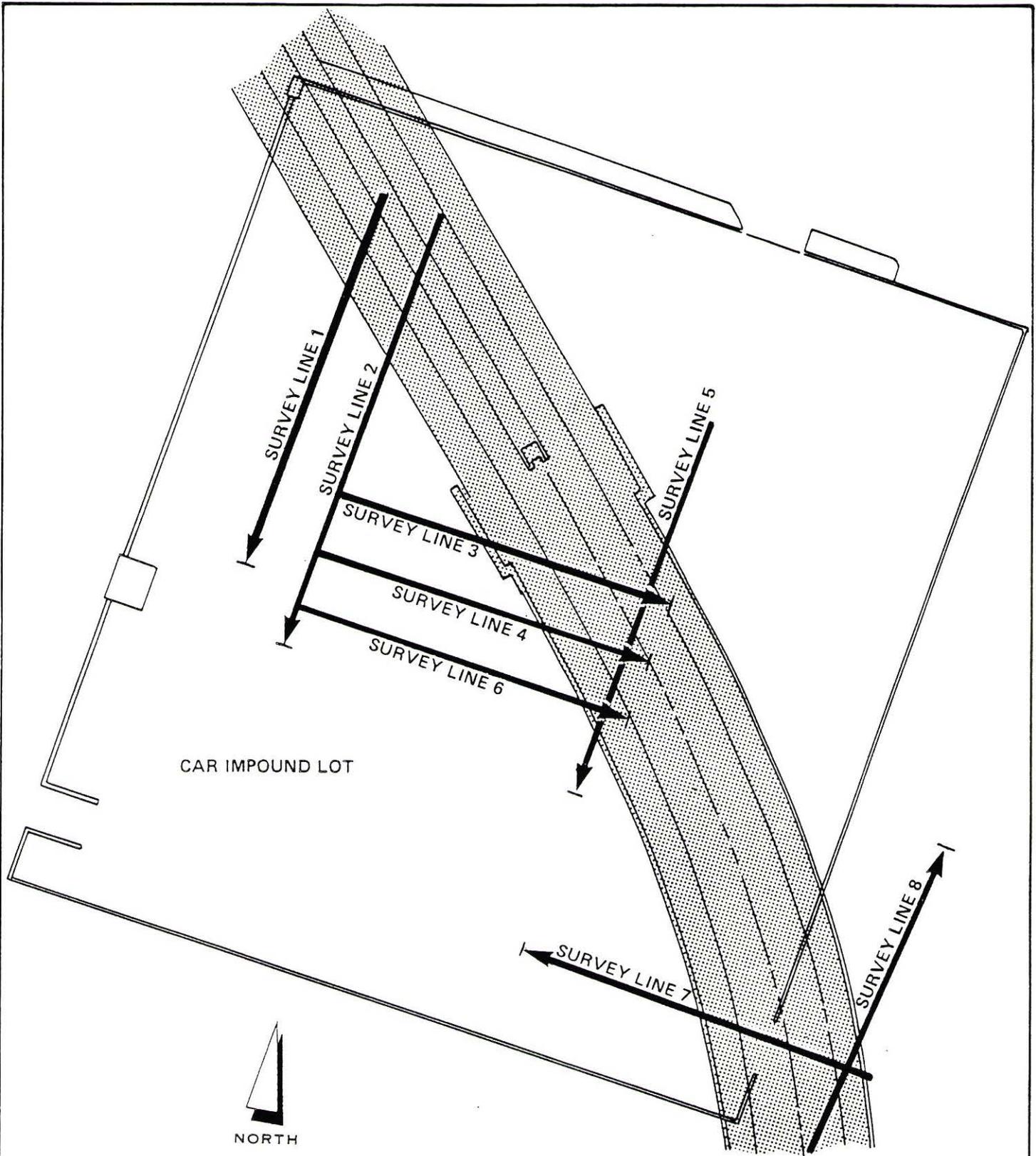
As a part of the subsurface exploration, a geophysical survey was performed in September 1987. A ground penetrating radar (GPR) survey was conducted in an attempt to detect and locate buried targets at the existing car impound lot located east of Center Street between Commercial Street and Ducommun Street. Two prominent targets were suspected to be buried in the northwest and southeast sections of the study area at an approximate depth of 10 to 15 feet. The suspected targets were a concrete pad at the northwest and a very large (750 ton) flywheel at the southeast portion of the study area.

The GPR data were taken with a Geophysical Survey System, Inc. SIR System 3 Ground Penetrating Radar. Impulse radar radiates repetitive, short-time duration electromagnetic pulses into the ground from a broad band-width antenna placed very close to the ground surface. The equipment functions as an echo sounding system using radar pulses at only a few nanoseconds to detect and measure the location and depth of reflecting discontinuities in subsurface soils. Continuous profiles are generated by towing the antenna along the profile and displaying the reflected radar signals on a graphic recorder. The 300 megahertz (MHZ) antenna was used for this survey, which offers less penetration than the 120 MHZ antenna but offers more shielding against adjacent or overhead sources of noise. The prominent sources of noise in the study area were lines of parked automobiles adjacent to survey lines. The effective penetration depth is estimated at 12 to 15 feet.

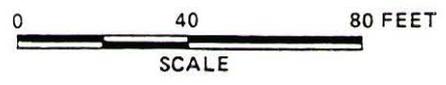
The GPR profiles were recorded along eight survey lines in the study area. The survey lines are shown in Figure D-1. The selection of the location and the number of survey lines was controlled by two considerations. The location of the proposed Metro Rail A-130 corridor with respect to the study area was the primary parameter in the choice of survey lines. The limited open spaces due to lines of parked automobiles, which covered approximately 60 percent of the study area, was the secondary factor (a constraint) in the choice of survey lines.

The GPR records clearly show soil variations and irregularities due to rocks and cobbles. However, anomalies corresponding to any buried features are

absent. Metallic objects which have the most identifiable signature in GPR records are not present in any of the records. The lateral interface between the concrete pad and the surrounding area would have provided a clear evidence of the location of such a buried feature. No such anomaly is present in the records. However, due to the physical movement constraint imposed by the impounded cars, it is possible that all of the survey lines fell within the perimeter of the concrete water tank pad. Hence the survey lines may not have crossed over the edge of the concrete pad. As such we cannot conclusively say that this pad does not exist at the site, although, based on the results of the GPR survey, it is considered unlikely.



CAR IMPOUND LOT



NOTE: SURVEY LINE REFERS TO GROUND PENETRATING RADAR SURVEY

	PROJECT NO.: 87-885 METRO RAIL TRANSIT
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LOCATION OF GROUND PENETRATING RADAR SURVEY

12-87 FIGURE D-1

APPENDIX E
PHYSICAL AND MECHANICAL
LABORATORY TESTING

APPENDIX E
PHYSICAL AND MECHANICAL LABORATORY TESTING

PROCEDURES

This appendix presents descriptions and results of physical and mechanical laboratory tests performed on selected representative undisturbed and bulk soil samples from the project site. The testing program included moisture-density tests, grain size distribution tests, compaction test, direct-shear tests, permeability tests, and consolidation test. A discussion of the test details is presented in the following paragraphs. Test results are presented in tables and figures that follow, as well as on the boring logs included in Appendix A.

Moisture-Density Tests

The moisture content of undisturbed samples was determined in accordance with ASTM D 2216-71. The in situ density was computed in accordance with ASTM D 2937-71. Moisture and density test results are presented on the boring logs in Appendix A.

Grain Size Analyses

Grain size analyses were performed in general accordance with the ASTM D 422-63. Test results are presented graphically in Figures E-1 through E-5.

Compaction Tests

Compaction characteristics of the upper 5 to 10 feet were determined by conducting a compaction test in accordance with ASTM D 1557-70. Test results are presented in Table E-1.

Direct Shear Tests

Shear strength of the site soil was characterized by performing direct shear tests on representative samples obtained from the upper 50 feet. The tests were performed in accordance with the ASTM D-3080. Test results are presented in Figures E-9 and E-10.

High values of internal friction angle were obtained from direct interpretation of the laboratory test results. It is believed that the presence of gravel in the samples caused an increase in the shearing force that, in turn, manifested itself as a high friction angle value. For design purposes, the use of these values are not recommended. Recommended design values are presented in Appendix H of this report.

Permeability Tests

Permeability tests were conducted on two samples from Borehole B304A and Borehole B305A. The tests were performed in accordance with Army Corps of Engineers Test EM 1110-2-1906 (Nov. 30, 1970), and the test results are presented in Table E-2.

Consolidation Tests

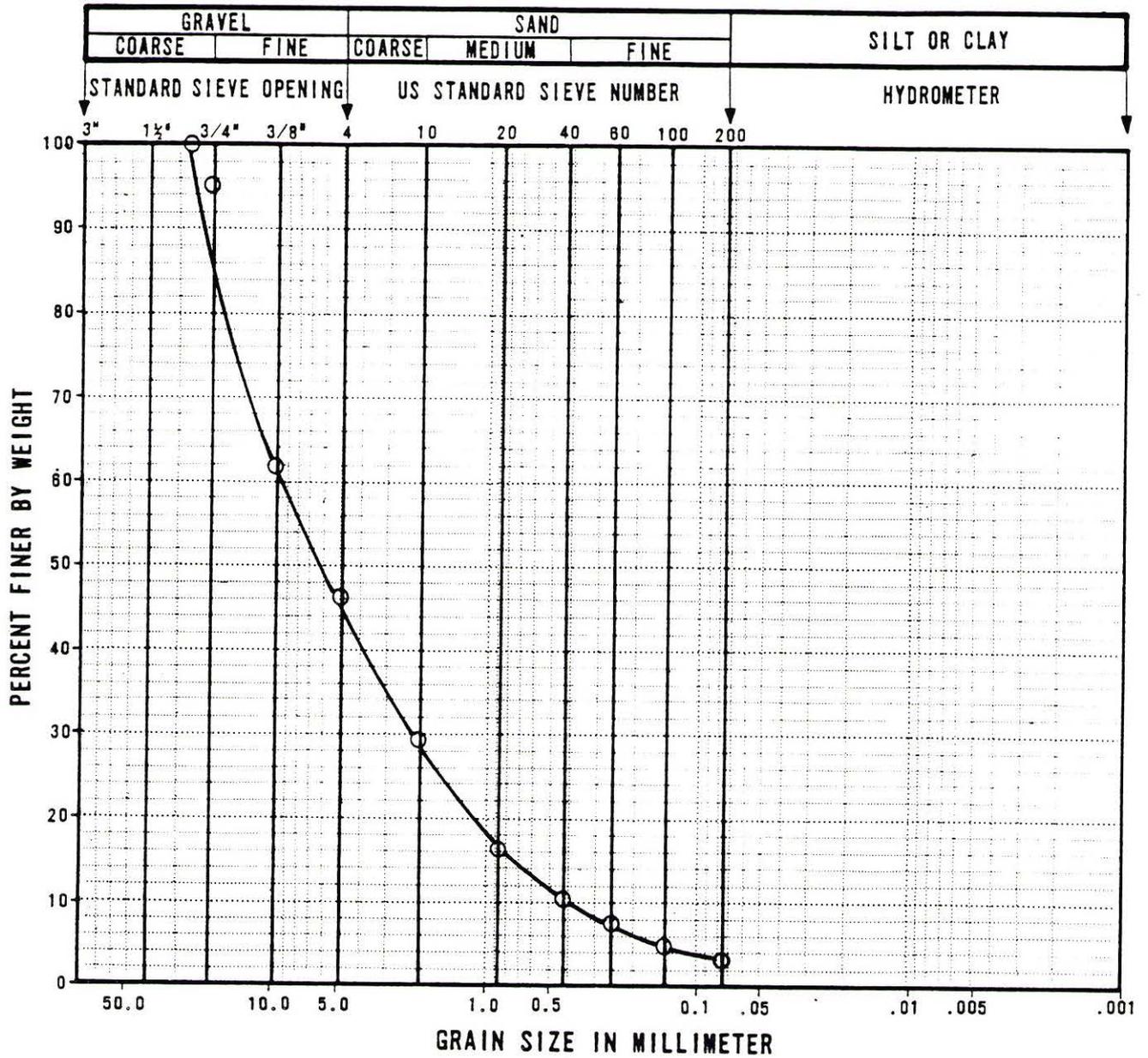
The compressibility of site soil was evaluated by a consolidation test performed in accordance with ASTM D 2435-80 on 1.00-inch thick, 2.50-inch diameter sample. The test involved loading and unloading cycles to properly evaluate the recompression characteristics of the site granular soils. During the initial loading, up to approximately 0.5 kips per square foot (ksf), the sample was tested under in situ (field) moisture conditions. Subsequent load and unload cycles were conducted under saturated conditions. Test results are summarized in Figure E-12.

TABLE E-1. COMPACTION TEST RESULTS

Borehole No.	Sample Depth (ft)	Soil Type	Maximum Dry Density (pcf)	Optimum Moisture Content (%)	ASTM Designation
B305	10	SM	130.5	8.5	D 1557
B306	8-13	SM	120.0	10.5	D 1557

TABLE E-2. SUMMARY OF HYDRAULIC CONDUCTIVITY TEST RESULTS

Borehole No.	Sample Depth (ft)	Soil Type	Hydraulic Conductivity (Permeability) cm/s
B304A	49-50	SW-SM	1.8×10^{-5}
B305A	33-34	SM	4.5×10^{-6}



SYMBOL	BORING NUMBER	SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SOIL TYPE
————	B 301		14-15	GW

-.-.-.-				

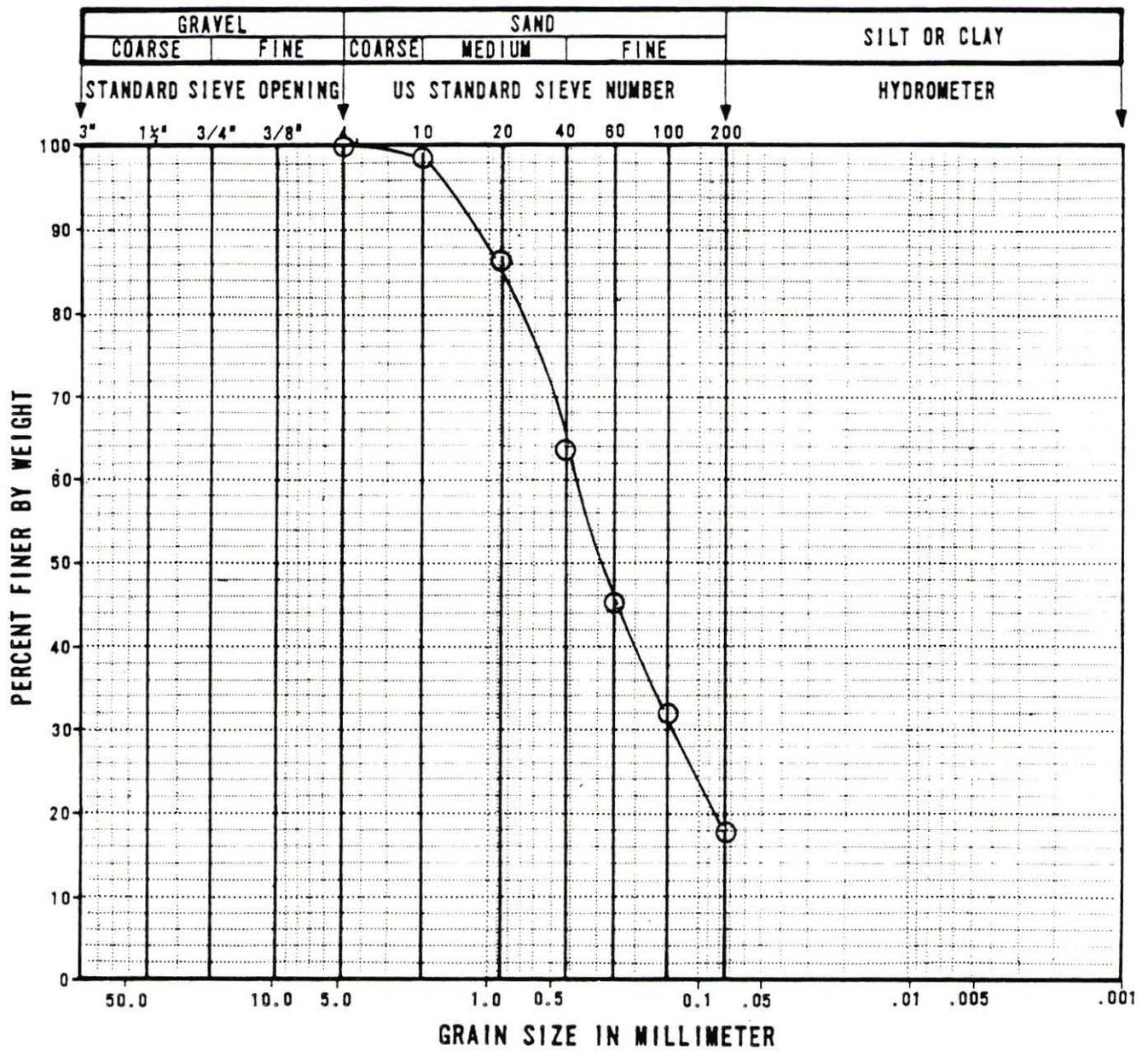
NOTE:
COEFFICIENT OF UNIFORMITY = 25

	PROJECT NO.:	87-885
	METRO RAIL TRANSIT	

GRAIN SIZE DISTRIBUTION CURVE

12-87 FIGURE E-1

Approved by _____
 Checked by _____
 Drawn by _____
 Compiled by _____

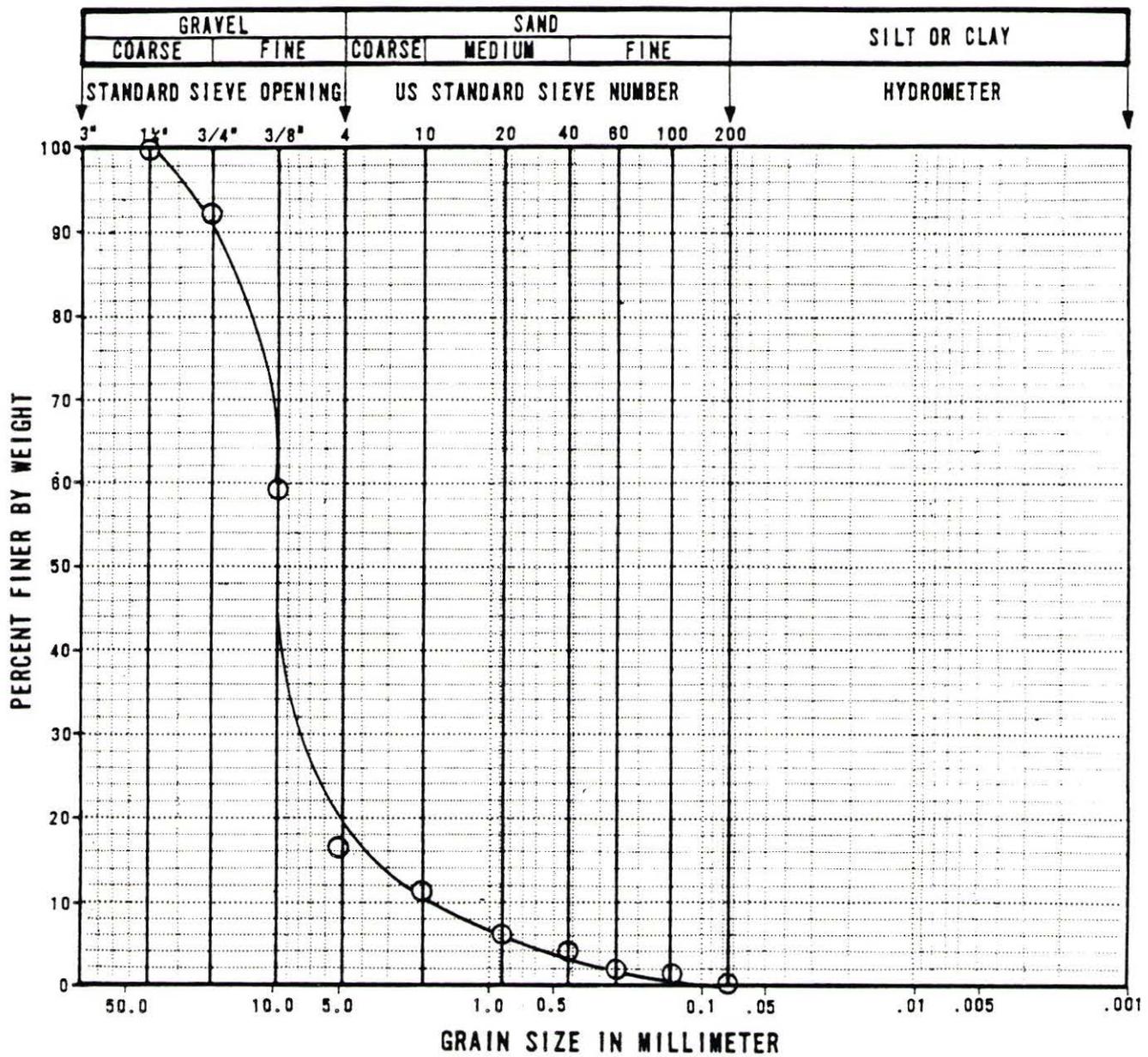


SYMBOL	BORING NUMBER	SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SOIL TYPE
—————	301		54.0–55.0	SM

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	PROJECT NO.:	87-885
	METRO RAIL TRANSIT	

GRAIN SIZE DISTRIBUTION CURVE

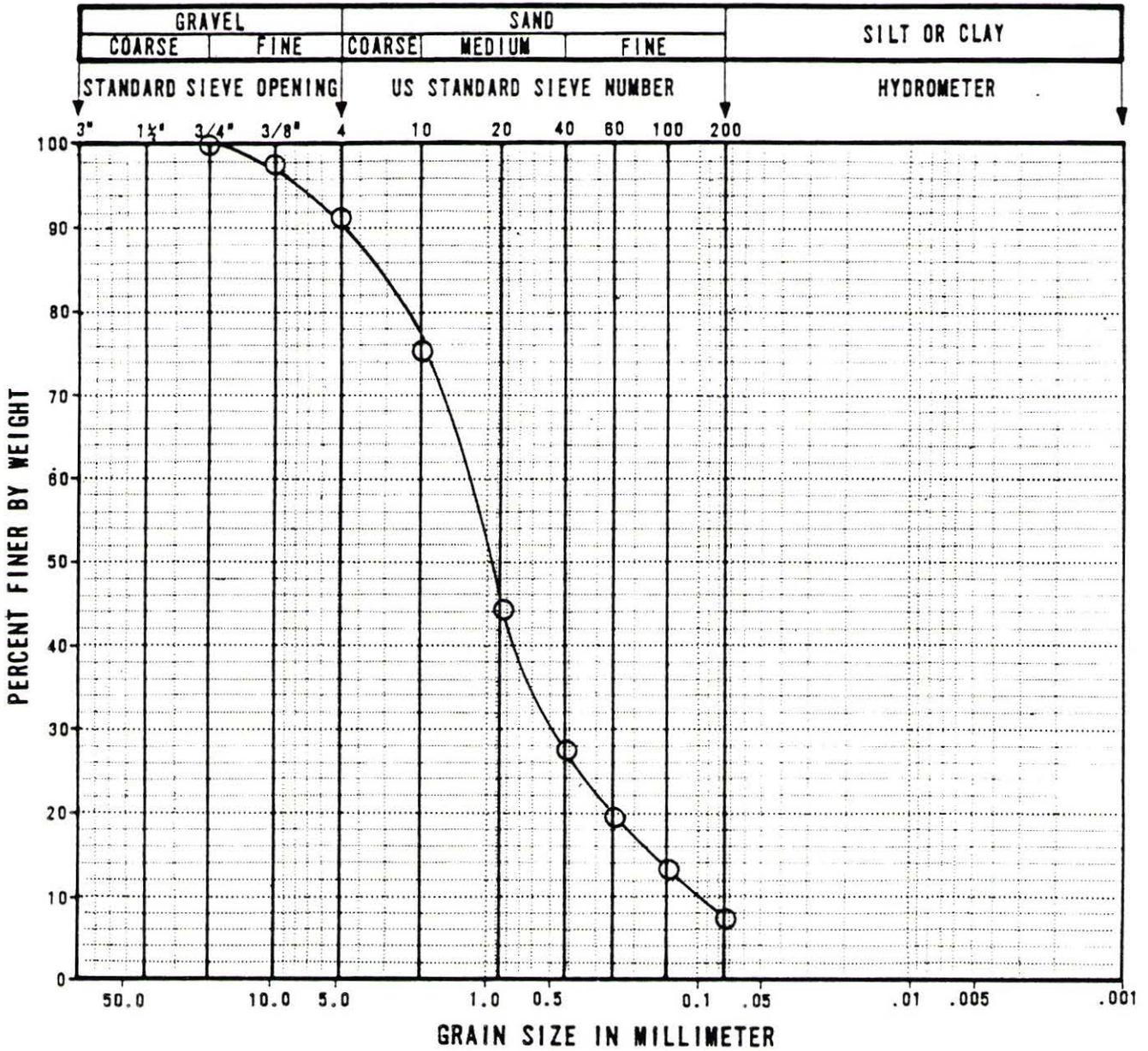


SYMBOL	BORING NUMBER	SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SOIL TYPE
—	302A		45.0-46.0	GW
- - -				
- · - · -				

NOTE:
COEFFICIENT OF UNIFORMITY = 5

	PROJECT NO.:	87-885
	METRO RAIL TRANSIT	

GRAIN SIZE DISTRIBUTION CURVE



SYMBOL	BORING NUMBER	SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SOIL TYPE
—————	302A		50.0-51.0	SW-SM
- - - - -				
- . - . - .				

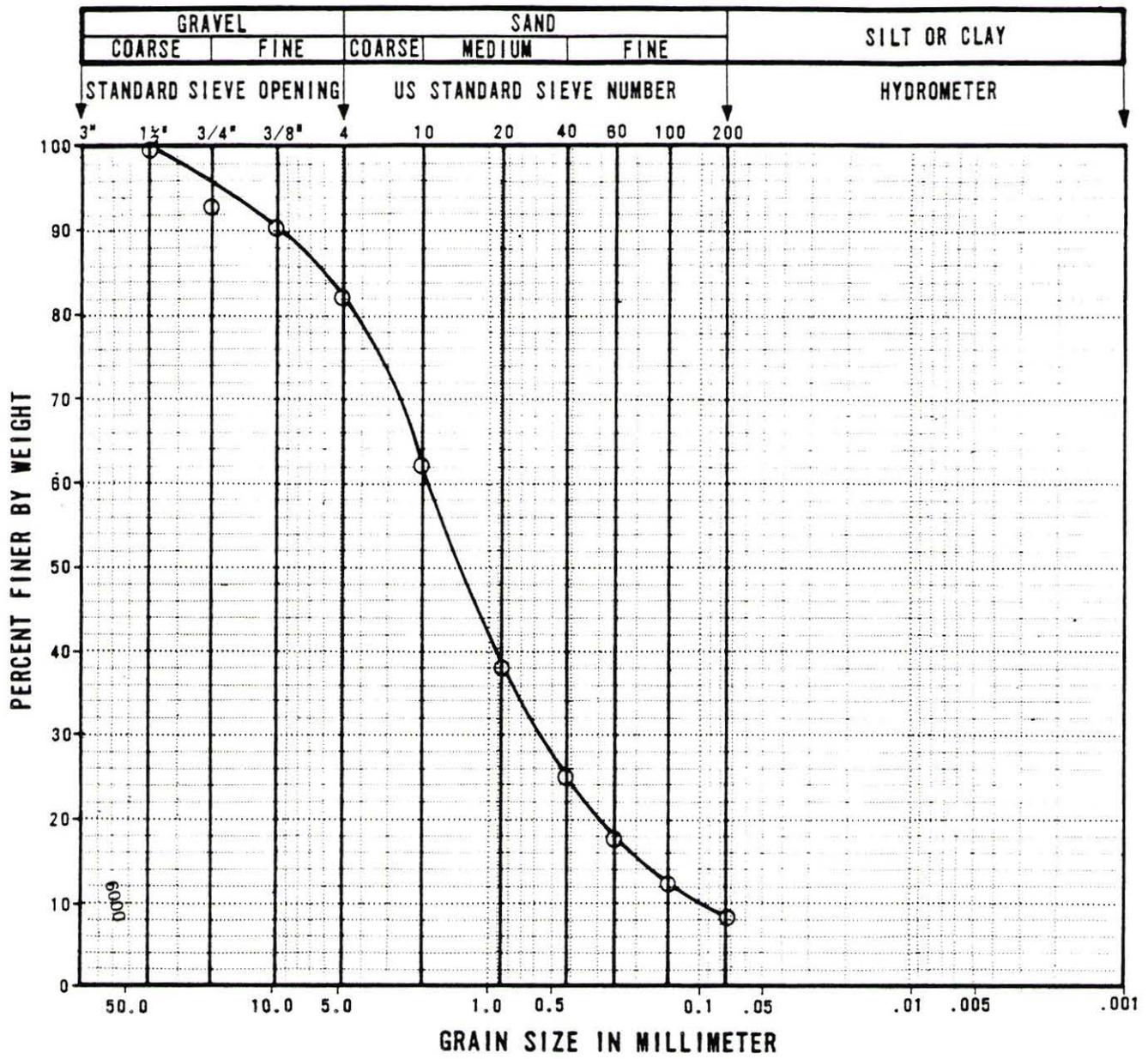
NOTE:
COEFFICIENT OF UNIFORMITY = 13

	PROJECT NO.:	87-885
	METRO RAIL TRANSIT	

GRAIN SIZE DISTRIBUTION CURVE

12-87 FIGURE E-4

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SYMBOL	BORING NUMBER	SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SOIL TYPE
—————	B 304		26-27	SW-SM
- - - - -				
- . - . - .				

NOTE:
COEFFICIENT OF UNIFORMITY = 20

	PROJECT NO.:	87-885
	METRO RAIL TRANSIT	

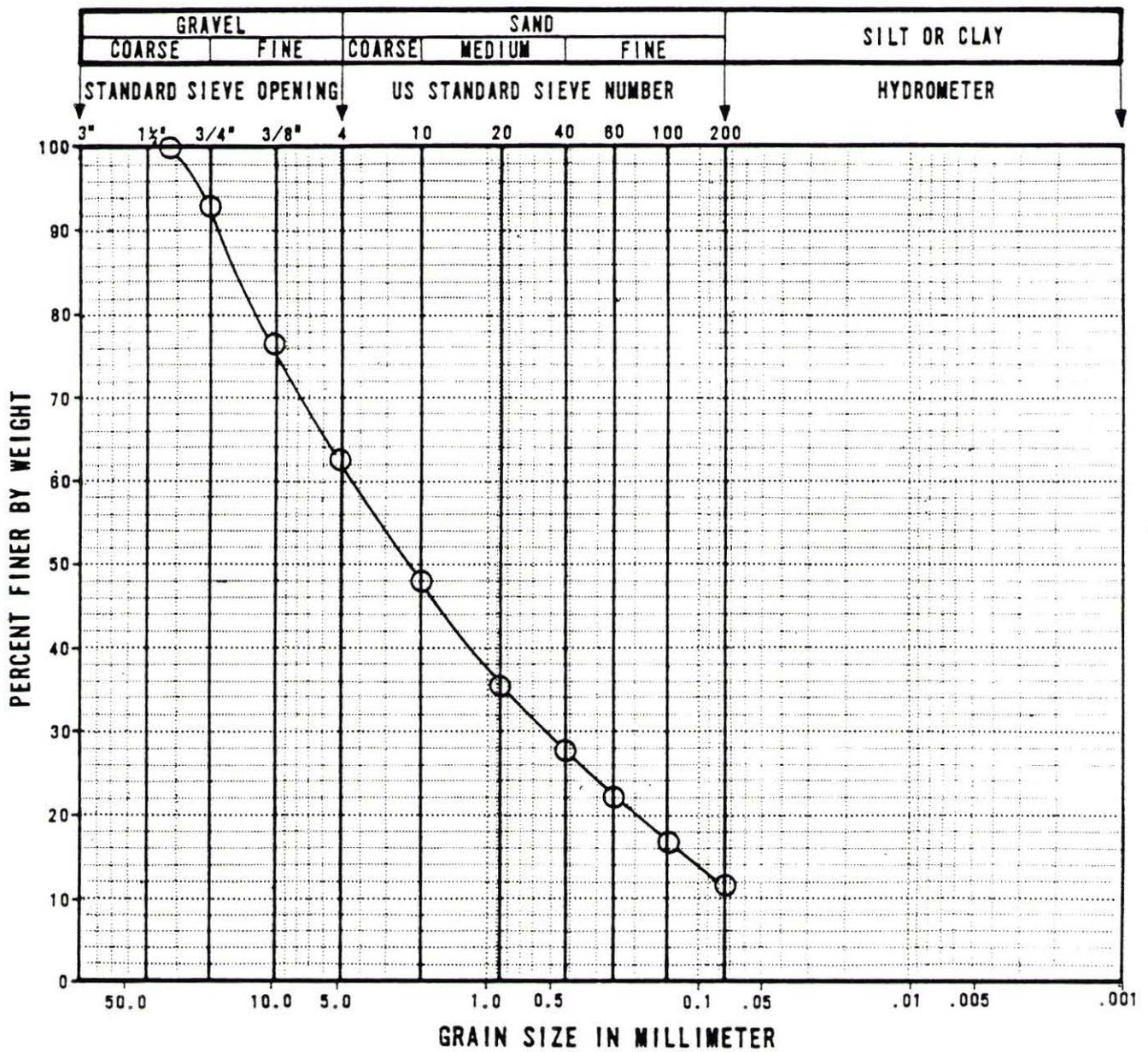
GRAIN SIZE DISTRIBUTION CURVE

Approved by

Checked by

Drawn by

Compiled by



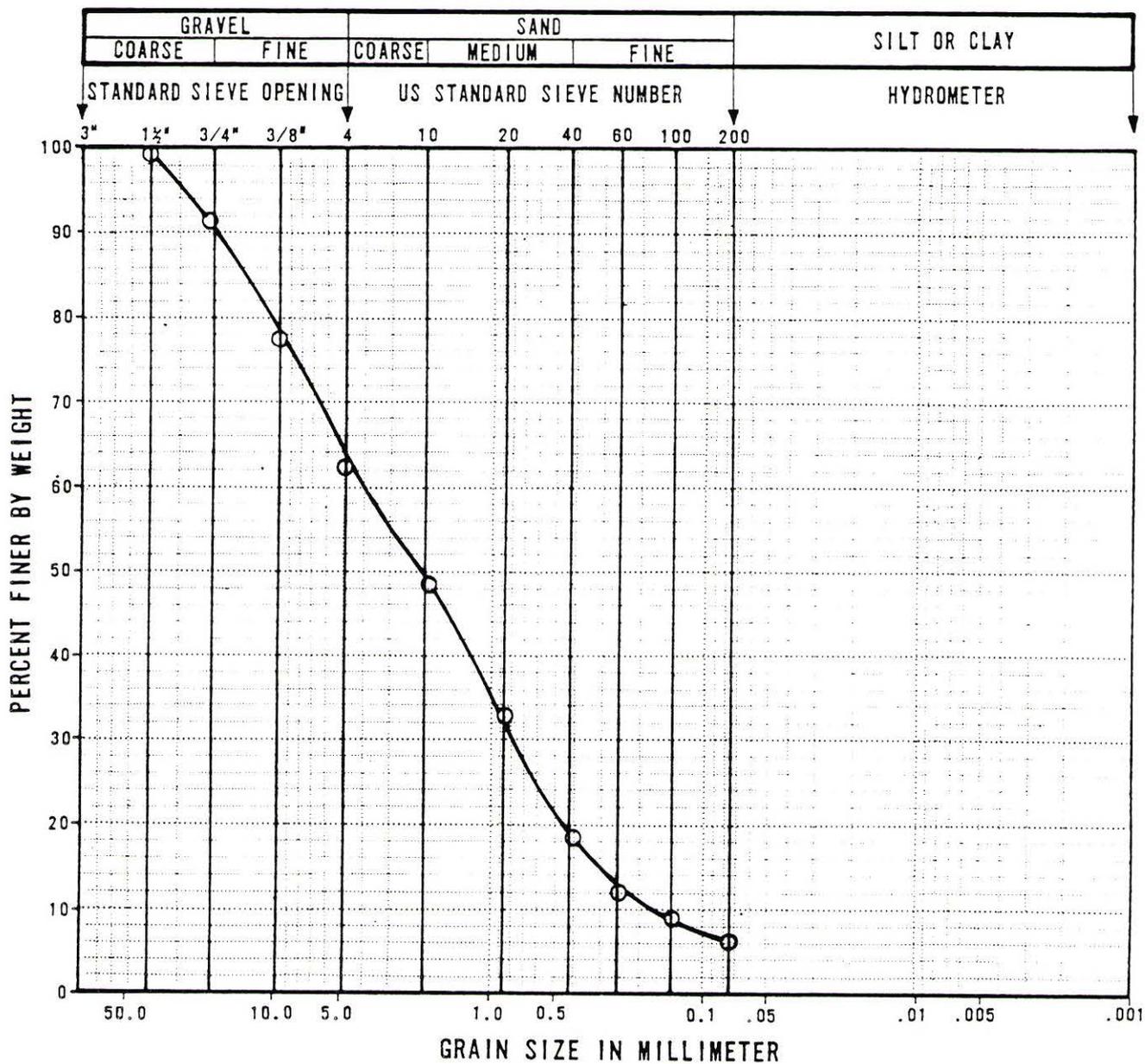
SYMBOL	BORING NUMBER	SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SOIL TYPE
————	304A		49.1—49.7	SW-SM

- . - . -				

NOTE:
COEFFICIENT OF UNIFORMITY = 50

	PROJECT NO.:	87-885
	METRO RAIL TRANSIT	

GRAIN SIZE DISTRIBUTION CURVE



SYMBOL	BORING NUMBER	SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SOIL TYPE
—————	305A		21-22	SW-SM

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NOTE:
COEFFICIENT OF UNIFORMITY = 22



PROJECT NO.: 87-885

METRO RAIL TRANSIT

GRAIN SIZE DISTRIBUTION CURVE

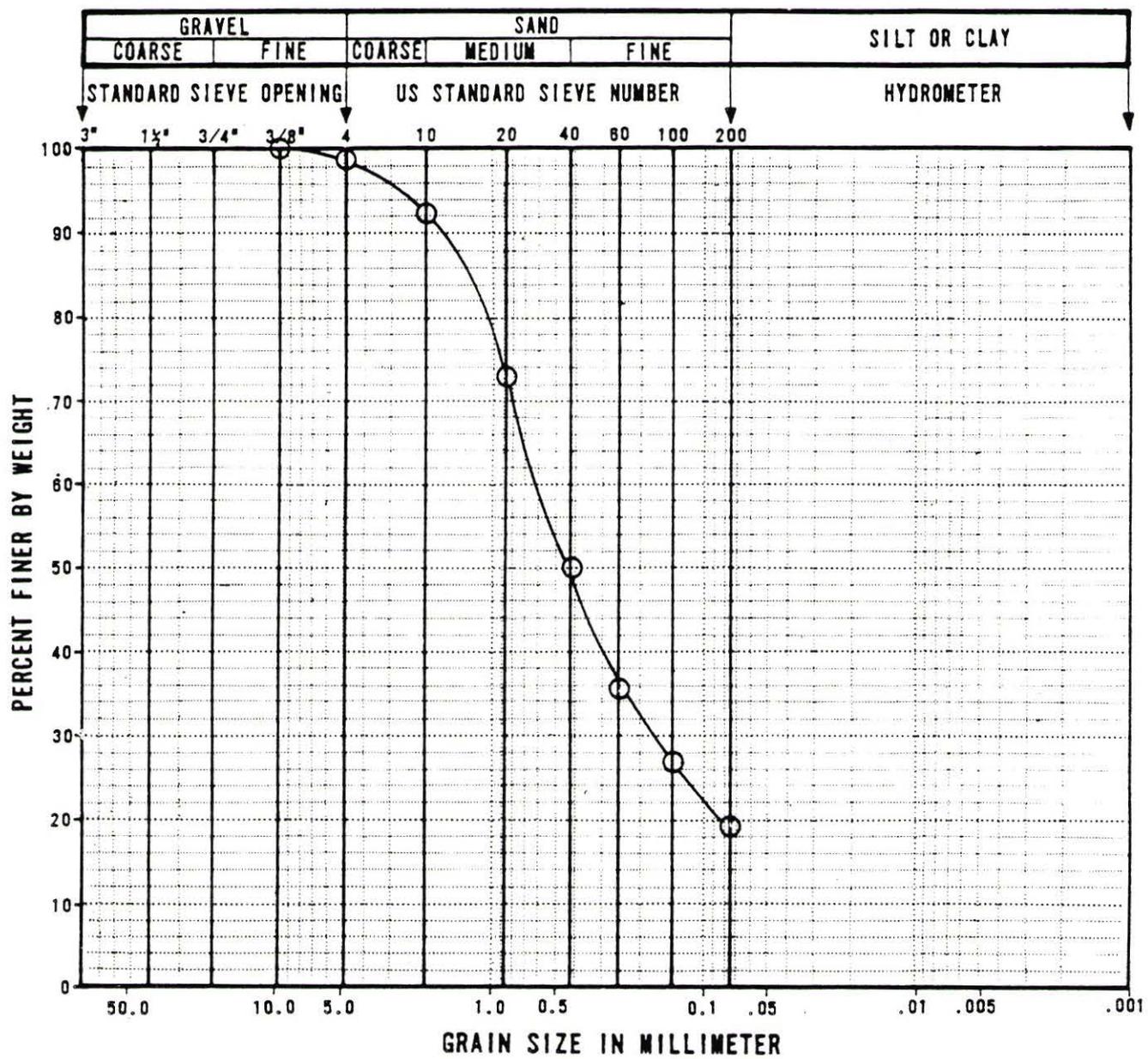
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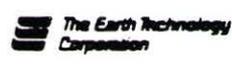
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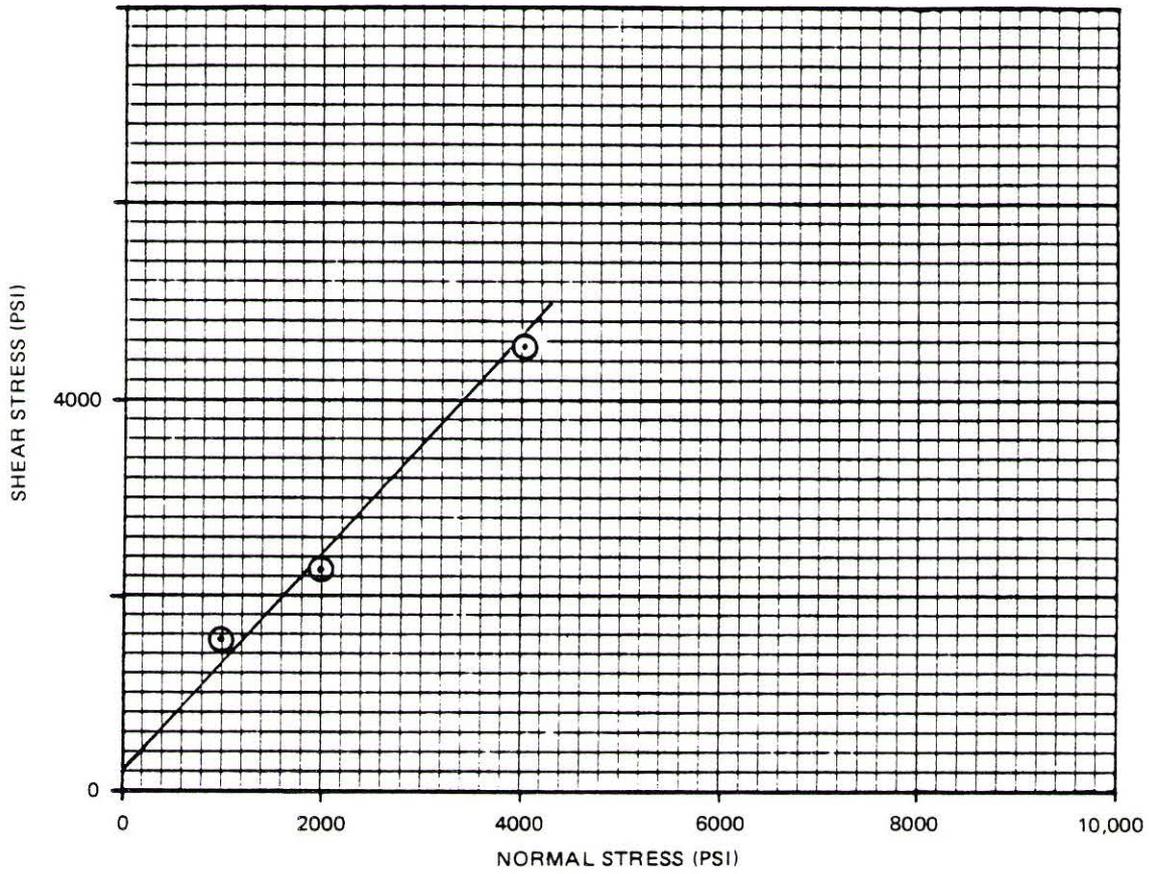
SYMBOL	BORING NUMBER	SAMPLE NUMBER	SAMPLE DEPTH (FEET)	SOIL TYPE
—————	305A		33.0-33.6	SM

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 PROJECT NO.: 87-885
 METRO RAIL TRANSIT

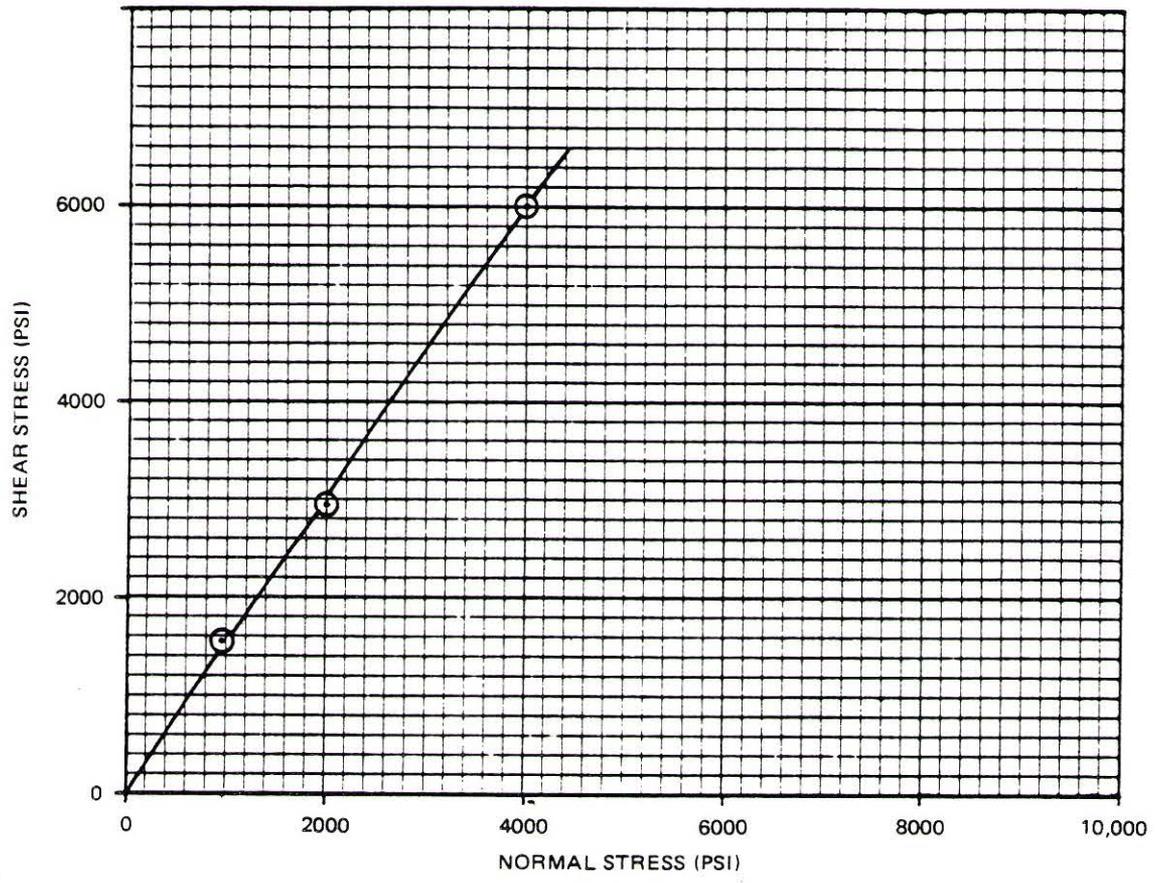
GRAIN SIZE DISTRIBUTION CURVE

Checked by
 Drawn by
 Compiled by



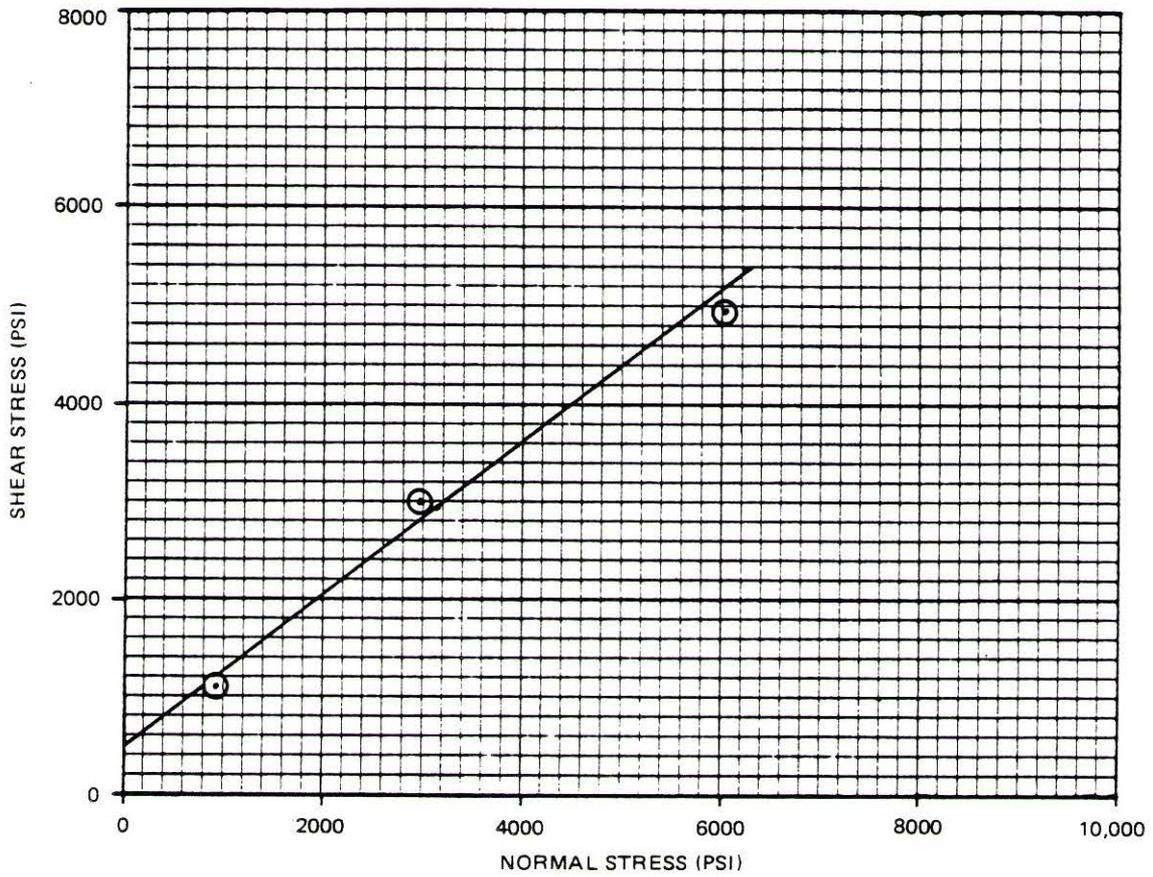
DESCRIPTION	SYMBOL	BORING NUMBER	SAMPLE NUMBER	DEPTH (FEET)	COHESION (PSF)	FRICTION ANGLE	CEMENTATION
SP-SM	⊙	301		14.0-15.0	175	48°	NONE

	PROJECT NO.: 87-885
	METRO RAIL TRANSIT
DIRECT SHEAR TEST RESULTS	
12-87	FIGURE E-9



DESCRIPTION	SYMBOL	BORING NUMBER	SAMPLE NUMBER	DEPTH (FEET)	COHESION (PSF)	FRICTION ANGLE	CEMENTATION
GP	⊕	302		20.0-21.0	0	56°	NONE

	PROJECT NO.:	87-885
	METRO RAIL TRANSIT	
DIRECT SHEAR TEST RESULTS		
12-87	FIGURE E-10	



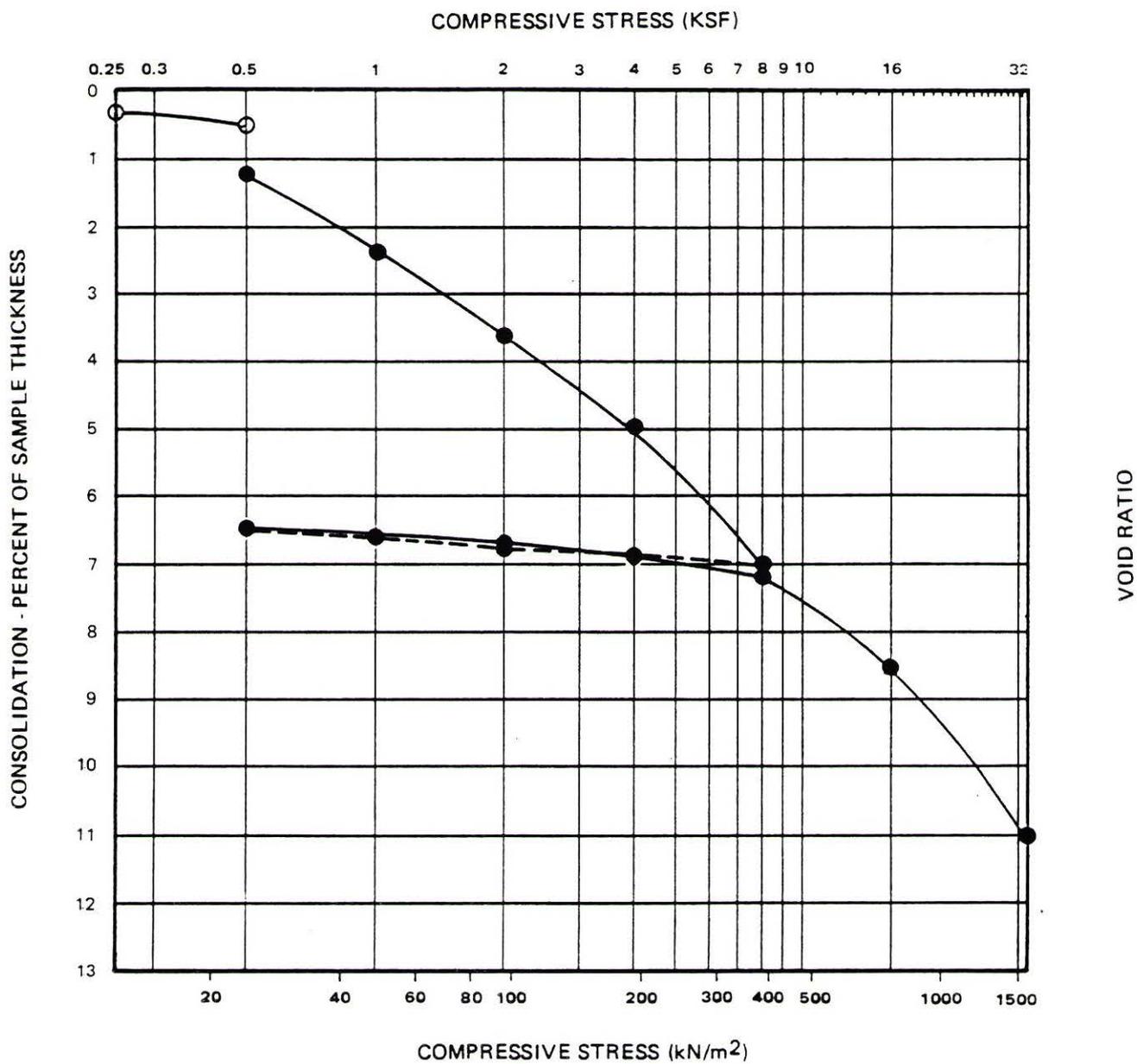
DESCRIPTION	SYMBOL	BORING NUMBER	SAMPLE NUMBER	DEPTH (FEET)	COHESION (PSF)	FRICTION ANGLE	CEMENTATION
SW-SM	⊙	302A		50.0-51.0	500	38°	NONE

	PROJECT NO.:	87-885
	METRO RAIL TRANSIT	

DIRECT SHEAR TEST RESULTS

12-87 FIGURE E-11

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SYMBOL	BORING NUMBER	SAMPLE NUMBER	SAMPLE INTERVAL		SOIL TYPE	INITIAL DRY DENSITY		INITIAL MOISTURE CONTENT (%)	INITIAL VOID RATIO	INITIAL DEGREE OF SATURATION (%)
			FEET	METERS		PCF	KG/M ³			
	B-301		24.0-25.0	-	SP	109.1	-	4.0	-	-

- AT FIELD MOISTURE
- AFTER ADDITION OF WATER
- COMPRESSION
- - - REBOUND



The Earth Technology Corporation

PROJECT NO.: 87-885

METRO RAIL TRANSIT

CONSOLIDATION TEST RESULTS

12-87
FIGURE E-12

APPENDIX F
CHEMICAL LABORATORY TESTING

APPENDIX F
CHEMICAL LABORATORY TESTING

A total of 114 soil samples and 11 water samples were selected and transported to West Coast Analytical Service, Inc. of Santa Fe Springs, California for possible testing for soil and water contaminants. Sample selection was based on visual observations, headspace OVA readings, and the soil material encountered. Details of the sampling process are presented in Appendix A.

Soil and water samples were analyzed for a variety of contaminants including organic priority pollutants, total petroleum hydrocarbons, and other pollutants. In the pages to follow, test results reported by West Coast Analytical Services, Inc., are presented. Soil samples are identified by borehole number, sample sequence number, and sample depth below ground surface (feet). Water samples are identified by borehole number, letter "w," and the depth at which the sample was taken.

Laboratory quality assurance/quality control (QA/QC) included, in addition to reagent blanks and standards, 10 percent duplicates and 10 percent spikes (surrogates). The replicate and recovery data are within the acceptable range of reproductibility and accuracy described by the California Department of Health Services.

TABLE F-1. SUMMARY OF CHEMICAL TEST PROCEDURES

TEST TYPE	REFERENCE PROCEDURE
<u>Water Samples</u>	
Volatile Organics	EPA 624
BNA Extractable	EPA 625
Chlorinated Pesticide & PCB	EPA 608
Total Hydrocarbon	EPA 413.2
Suspended Solids	Std. 209C
Settleable Solids	Std. 209E
Sulfide	EPA 9030
Phenols	Std. 510C
BOD	Std. 507
Semi-Volatile Organics	EPA 8270/625
Sulfate	EPA 300.6/Ion Chromatography
Total Petroleum Hydrocarbons	EPA 418.1
pH	EPA 9040/EPA 150.1
<u>Soil Samples</u>	
Volatile Organics	EPA 8240
Semi-Volatile Organics	EPA 8270/625
Organochlorine Pesticide & PCB	EPA 8080
Priority Pollutant Metals	EPA 6020

CHAIN OF CUSTODY RECORD

PROJECT NAME: Retro Rail
 PROJECT NUMBER: 87-885-0003

Shipment No.: 10
 Page 1 of 1
 Date 7-28-87

Sample Number	Location	Type of Sample		Type of Container	Type of Preservation		Analysis Required*
		Material	Method		Temp.	Chemical	
301W (2 jar)	MW-301	water	bailer	1 liter, glass	4°C	ice	
304W (2)	MW-304						
305W (2)	MW-305						
301W (2)	MW-301	water	bailer	40-oz VOA	4°C	ice	
304W (2)	MW-304						
305W (2)	MW-305						
							Above samples all
							need analysis for:
							priority pollutants
							(624, 625, 608)
							suspended solids
							settleable solids
							BOD
							oil & grease (413.2)
							sulfide (9030)
							phenols (604)
							pentachlorophenol (625)

Total Number of Samples Shipped: 12 | Sampler's Signature _____

Relinquished By: Signature <u>Allison T. Urbon</u> Printed _____ Company <u>The Earth Technology Corp.</u> Reason _____	Received by: Signature _____	Date _____
	Printed _____	Time _____
	Company _____	
	Reason _____	
Relinquished By: Signature _____ Printed _____ Company _____ Reason _____	Received By: Signature _____	Date _____
	Printed _____	Time _____
	Company _____	
	Reason _____	
Relinquished By: Signature _____ Printed _____ Company _____ Reason _____	Received by: Signature _____	Date _____
	Printed _____	Time _____
	Company _____	
	Reason _____	

Special Shipment/Handling/Storage Requirements:
 Four samples were collected from each well: two 1-liter glass jars and two VOAs.
 This shipment is sent under the same job number as previous samples.
 Note: This does not constitute authorization to proceed with analysis

CHAIN OF CUSTODY RECORD

PROJECT NAME: Metro Rail A-130

Shipment No.: 4

Page 1 of 1x 2

PROJECT NUMBER: 87-885-0003

Date 6/18/87

Sample Number	Location	Type of Sample		Type of Container	Type of Preservation		Analysis Required*
		Material	Method		Temp.	Chemical	
304-W-35	MW-304	Water	Bailer	Glass, Liter	4°C	Ice	Sulfide 9030, pentachloropheno 625 TPH(418.1) Sulfates, pH
³⁰⁴⁻¹⁻⁵ 304-5	MW-304	Soil	Drive Sampler	40 ml glass VOA			
304-8	304-2-8				4°C	Ice	Hold - do not analyze at this time
304-10	304-3-10						
304-12	304-4-12						
304- 14 15	304-5-15						
304-16	304-6-16						
304-18	304-7-18						
304-20	Lost this sample - Bill						
304-22	304-9-22						
304-24	304-10-24						
304-26	304-11-26						
304-28	304-12-28						
304-30	304-13-30	— LATER REQUESTED 8240, 8270 AND 8000 09/18 8-28-87					
304-32	304-14-35						
³⁰⁴⁻¹⁻⁵ 304-5	MW-304	Soil	Drive Sampler	4/8oz glass	4°C	Ice	Hold - do not analyze at this time
304-8	304-2-8						
304-10	304-3-10						
304-12	304-4-12						
304- 14 15	304-5-15						
304-16	304-6-16						
304-18	304-7-18						
304-20	Lost this sample - Bill						

Total Number of Samples Shipped: 29 Sampler's Signature _____

Relinquished By: Signature <u>Barbara Fontes</u> Printed <u>Barbara Fontes</u> Company <u>Earth Technology Corp</u> Reason _____	Received by: Signature <u>Glenn Daniels</u> Printed <u>Glenn Daniels</u> Company <u>West Coast Analytical</u> Reason _____	Date <u>6-18-87</u> Time _____
Relinquished By: Signature _____ Printed _____ Company _____ Reason _____	Received By: Signature _____ Printed _____ Company _____ Reason _____	Date _____ Time _____
Relinquished By: Signature _____ Printed _____ Company _____ Reason _____	Received by: Signature _____ Printed _____ Company _____ Reason _____	Date _____ Time _____

Special Shipment/Handling/Storage Requirements:

*Note: This does not constitute authorization to proceed with analysis

CHAIN OF CUSTODY RECORD

PROJECT NAME: Metro Rail A-130
 PROJECT NUMBER: 87-885-0001

Shipment No.: 1
 Page 1 of 1
 Date 6-1-87

Sample Number	Location	Type of Sample		Type of Container	Type of Preservation		Analysis Required*
		Material	Method		Temp.	Chemical	
301-10-50	B-301	soil	drive	glass, 4-oz	4°C	ice	EPA Methods
301-10-50	B-301	soil	sample	glass, 40 ml	4°C	ice	8240, 8270, 8080 (priority pollutants)
301-1-5	B-301	soil	drive	glass, 4-oz	4°C	ice	hold - no analysis at this time
301-2-10			sample				
301-3-15							
301-5-25							
301-6-32							
301-7-35							
301-8-40							
301-9-45							
301-11-55							
301-12-60							
301-1-5	B-301	soil	drive	glass, 40 ml	4°C	ice	hold - no analysis at this time
301-2-10			sample				
301-3-15							
301-7-35							
301-11-55							
301-12-60							

Total Number of Samples Shipped: 18 | Sampler's Signature: Allison T. Urban

Relinquished By: Signature: <u>Allison T. Urban</u> Printed: <u>ALLISON T. URBAN</u> Company: <u>EARTH TECHNOLOGY CORP</u> Reason: _____	Received by: Signature: <u>Margaret Felt #6093</u> Printed: <u>Margaret Felt #6092</u> Company: <u>JULAS</u> Reason: <u>See Inconspicuous</u>	Date: <u>6/2/87</u> Time: <u>1000</u>
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Relinquished By: Signature: _____ Printed: _____ Company: _____ Reason: _____	Received By: Signature: _____ Printed: _____ Company: _____ Reason: _____	Date: _____ Time: _____
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Relinquished By: Signature: _____ Printed: _____ Company: _____ Reason: _____	Received by: Signature: _____ Printed: _____ Company: _____ Reason: _____	Date: _____ Time: _____
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Special Shipment/Handling/Storage Requirements:

*Note: This does not constitute authorization to proceed with analysis

WEST COAST ANALYTICAL SERVICE, INC.

CLIENT: EARTH TECHNOLOGY
SAMPLE: 305W

TENTATIVELY IDENTIFIED COMPOUNDS

COMPOUND NAME	FRACTION	CONCENTRATION UG/L (PPB)
1 C9-C11 ALIPHATIC & ALICYCLIC HYDROCARBONS	VOA	200.

WEST COAST ANALYTICAL SERVICE, INC.

CLIENT: EARTH TECHNOLOGY
 SITE: METRO RAIL
 SAMPLE: 305 W
 ANALYSIS TYPE: EPA METHOD 625 (8270)

ORGANICS ANALYSIS DATA RESULTS

DATE RECEIVED: 07/28/87 GCMS FILENAME: 6645B3
 LEVEL: LOW MATRIX: WATER
 DATE PREPARED: 07/30/87 DATE ANALYZED: 08/01/87
 STANDARD ID: BNAZ174 GCMS TUNING: DFTPP45
 INSTRUMENT ID: 4500
 SAMPLE AMOUNT: 500ML:1ML

CAS #	COMPOUND	CONC: UG/L (PPB)	DETECTION LIMIT
108-95-2	PHENOL	ND	2.
111-44-4	BIS (2-CHLOROETHYL) ETHER	ND	2.
95-57-8	2-CHLOROPHENOL	ND	2.
541-73-1	1,3-DICHLOROBENZENE	ND	2.
106-46-7	1,4-DICHLOROBENZENE	ND	2.
100-51-6	BENZYL ALCOHOL	ND	2.
95-50-1	1,2-DICHLOROBENZENE	ND	2.
95-48-7	2-METHYLPHENOL	ND	2.
39638-32-9	BIS (2-CHLOROISOPROPYL) ETHER	ND	2.
106-44-5	4-METHYLPHENOL	ND	2.
621-64-7	N-NITROSODIPROPYLAMINE	ND	2.
67-72-1	HEXACHLOROETHANE	ND	2.
98-95-3	NITROBENZENE	ND	2.
78-59-1	ISOPHORONE	ND	2.
88-75-5	2-NITROPHENOL	ND	2.
105-67-9	2,4-DIMETHYLPHENOL	ND	2.
65-85-0	BENZOIC ACID	ND	10.
111-91-1	BIS (2-CHLOROETHOXY) METHANE	ND	2.
120-33-2	2,4-DICHLOROPHENOL	ND	2.
120-82-1	1,2,4-TRICHLOROBENZENE	ND	2.
91-20-3	NAPHTHALENE	ND	2.
106-47-8	4-CHLOROANILINE	ND	2.
87-68-3	HEXACHLOROBUTADIENE	ND	2.
59-50-7	4-CHLORO-3-METHYLPHENOL	ND	2.
91-57-6	2-METHYLNAPHTHALENE	ND	2.
77-47-4	HEXACHLOROCYCLOPENTADIENE	ND	2.
88-06-2	2,4,6-TRICHLOROPHENOL	ND	2.
95-95-4	2,4,5-TRICHLOROPHENOL	ND	10.
91-58-7	2-CHLORONAPHTHALENE	ND	2.
88-74-4	2-NITROANILINE	ND	10.
131-11-3	DIMETHYL PHTHALATE	ND	2.
208-96-8	ACENAPHTHYLENE	ND	2.
99-09-2	3-NITROANILINE	ND	10.
83-32-9	ACENAPHTHENE	ND	2.
51-28-5	2,4-DINITROPHENOL	ND	10.
100-02-7	4-NITROPHENOL	ND	10.
132-64-9	DIBENZOFURAN	ND	2.
121-14-2	2,4-DINITROTOLUENE	ND	2.
606-20-2	2,6-DINITROTOLUENE	ND	2.

WEST COAST ANALYTICAL SERVICE, INC.

CLIENT: EARTH TECHNOLOGY
 SAMPLE: 305W
 ANALYSIS TYPE: EPA METHOD 8240 (624)

ORGANICS ANALYSIS DATA RESULTS

DATE RECEIVED: 07/28/87 GCMS FILENAME: 6645V5
 LEVEL: LOW MATRIX: WATER
 DATE PREPARED: 08/04/87 DATE ANALYZED: 08/04/87
 STANDARD ID: VOA533 INSTRUMENT ID: 5100
 SAMPLE AMOUNT: 5.0ML

CAS #	COMPOUND	CONC: UG/L(PPB)	DETECTION LIMIT
74-87-3	CHLOROMETHANE	ND	5.
74-83-9	BROMOMETHANE	ND	5.
75-01-4	VINYL CHLORIDE	ND	5.
75-00-3	CHLOROETHANE	ND	5.
75-09-2	METHYLENE CHLORIDE	ND	10.
67-64-1	ACETONE	ND	10.
107-02-8	ACROLEIN	ND	10.
107-13-1	ACRYLONITRILE	ND	10.
75-15-0	CARBON DISULFIDE	ND	1.
75-35-4	1,1-DICHLOROETHENE	ND	1.
75-34-3	1,1-DICHLOROETHANE	ND	1.
156-60-5	TRANS-1,2-DICHLOROETHENE	ND	1.
109-99-9	TETRAHYDROFURAN	ND	1.
75-69-4	TRICHLOROFLUOROMETHANE	ND	1.
76-13-1	FREON-TF	ND	1.
106-93-4	ETHYLENE DIBROMIDE	ND	1.
123-91-1	1,4-DIOXANE	ND	1.
96-12-8	1,2-DIBROMO-3-CHLOROPROPANE	ND	1.
67-66-3	CHLOROFORM	ND	1.
107-06-2	1,2-DICHLOROETHANE	ND	1.
78-93-3	2-BUTANONE	ND	10.
71-55-6	1,1,1-TRICHLOROETHANE	ND	1.
16-23-5	CARBON TETRACHLORIDE	ND	1.
108-05-4	VINYL ACETATE	ND	5.
75-27-4	BROMODICHLOROMETHANE	ND	1.
79-34-5	1,1,2,2-TETRACHLOROETHANE	ND	1.
78-87-5	1,2-DICHLOROPROPANE	ND	1.
10061-02-6	TRANS-1,3-DICHLOROPROPENE	ND	1.
79-01-6	TRICHLOROETHENE	ND	1.
124-48-1	CHLORODIBROMOMETHANE	ND	1.
79-00-5	1,1,2-TRICHLOROETHANE	ND	1.
71-43-2	BENZENE	1.	1.
10061-01-5	CIS-1,3-DICHLOROPROPENE	ND	1.
110-75-8	2-CHLOROETHYLVINYLEETHER	ND	10.
75-25-2	BROMOFORM	ND	1.
119-78-6	2-HEXANONE	ND	5.
108-10-1	4-METHYL-2-PENTANONE	ND	5.
127-18-4	TETRACHLOROETHENE	ND	1.
108-88-3	TOLUENE	ND	1.

WEST COAST ANALYTICAL SERVICE, INC.

CLIENT: EARTH TECHNOLOGY
 SITE: METRO RAIL
 SAMPLE: 304 W
 ANALYSIS TYPE: EPA METHOD 625 (8270)

ORGANICS ANALYSIS DATA RESULTS

DATE RECEIVED: 07/28/87 GCMS FILENAME: 6645B2
 LEVEL: LOW MATRIX: WATER
 DATE PREPARED: 07/30/87 DATE ANALYZED: 08/01/87
 STANDARD ID: BNAZ174 GCMS TUNING: DFTPP45
 INSTRUMENT ID: 4500
 SAMPLE AMOUNT: 500ML:1ML

CAS #	COMPOUND	CONC: UG/L (PPB)	DETECTION LIMIT
84-66-2	DIETHYL PHTHALATE	ND	2.
7005-72-3	4-CHLOROPHENYL PHENYL ETHER	ND	2.
86-73-7	FLUORENE	20.	2.
100-01-6	4-NITROANILINE	ND	10.
534-52-1	4,6-DINITRO-2-METHYLPHENOL	ND	10.
86-30-6	N-NITROSODIPHENYLAMINE	N	2.
101-55-3	4-BROMOPHENYL PHENYL ETHER	ND	2.
118-74-1	HEXACHLOROBENZENE	ND	2.
87-86-5	PENTACHLOROPHENOL	ND	10.
85-01-8	PHENANTHRENE	4.	2.
120-12-7	ANTHRACENE	5.	2.
84-74-2	DI-N-BUTYL PHTHALATE	ND	2.
206-44-0	FLUORANTHENE	3.	2.
129-00-0	PYRENE	4.	2.
85-68-7	BUTYL BENZYL PHTHALATE	ND	2.
91-94-1	3,3'-DICHLOROBENZIDINE	ND	4.
56-55-3	BENZO(A) ANTHRACENE	ND	2.
117-81-7	BIS(2-ETHYLHEXYL) PHTHALATE	ND	2.
218-01-9	CHRYSENE	ND	2.
117-84-0	DI-N-OCTYL PHTHALATE	ND	2.
205-99-2	BENZO(B & K) FLUORANTHENES	ND	2.
50-32-8	BENZO(A) PYRENE	ND	2.
193-39-5	INDENO(1,2,3-CD) PYRENE	ND	2.
53-70-3	DIBENZO(A,H) ANTHRACENE	ND	2.
191-24-2	BENZO(GHI) PERYLENE	ND	2.

WEST COAST ANALYTICAL SERVICE, INC.

CLIENT: EARTH TECHNOLOGY
SAMPLE: 304W
ANALYSIS TYPE: EPA METHOD 8240 (624)

ORGANICS ANALYSIS DATA RESULTS

DATE RECEIVED: 07/28/87 GCMS FILENAME: 6645V4
LEVEL: LOW MATRIX: WATER
DATE PREPARED: 08/04/87 DATE ANALYZED: 08/04/87
STANDARD ID: VOA533 INSTRUMENT ID: 5100
SAMPLE AMOUNT: 1.0ML

CAS #	COMPOUND	CONC: UG/L (PPB)	DETECTION LIMIT
108-90-7	CHLOROBENZENE	ND	5.
100-41-4	ETHYLBENZENE	250.	5.
100-42-5	STYRENE	ND	5.
95-47-6	TOTAL XYLENES	66.	5.
108-41-8	M-CHLOROTOLUENE	ND	5.
541-73-1	1,3-DICHLOROBENZENE	ND	5.
106-46-7	1,4-DICHLOROBENZENE	ND	5.
95-50-1	1,2-DICHLOROBENZENE	ND	5.

WEST COAST ANALYTICAL SERVICE, INC.

CLIENT: EARTH TECHNOLOGY
SITE: METRO RAIL
SAMPLE: 301 W

TENTATIVELY IDENTIFIED COMPOUNDS

COMPOUND NAME	FRACTION	CONCENTRATION UG/L (PPB)
1 MOLECULAR SULFUR	BNA	2000.
2 UNIDENTIFIED COMPOUNDS	BNA	60.
3 C9-C11 ALIPHATIC & ALICYCLIC HYDROCARBONS	VOA	20.

WEST COAST ANALYTICAL SERVICE, INC.

CLIENT: EARTH TECHNOLOGY
 SITE: METRO RAIL
 SAMPLE: 301 W
 ANALYSIS TYPE: EPA METHOD 625 (8270)

ORGANICS ANALYSIS DATA RESULTS

DATE RECEIVED: 07/28/87 GCMS FILENAME: 6645B1
 LEVEL: LOW MATRIX: WATER
 DATE PREPARED: 07/30/87 DATE ANALYZED: 08/01/87
 STANDARD ID: BNAZ174 GCMS TUNING: DFTPP45
 INSTRUMENT ID: 4500
 SAMPLE AMOUNT: 670ML:1ML

CAS #	COMPOUND	CONC: UG/L (PPB)	DETECTION LIMIT
108-95-2	PHENOL	ND	1.
111-44-4	BIS (2-CHLOROETHYL) ETHER	ND	1.
95-57-8	2-CHLOROPHENOL	ND	1.
541-73-1	1,3-DICHLOROBENZENE	ND	1.
106-46-7	1,4-DICHLOROBENZENE	ND	1.
100-51-6	BENZYL ALCOHOL	ND	1.
95-50-1	1,2-DICHLOROBENZENE	ND	1.
95-48-7	2-METHYLPHENOL	ND	1.
39638-32-9	BIS (2-CHLOROISOPROPYL) ETHER	ND	1.
106-44-5	4-METHYLPHENOL	ND	1.
621-64-7	N-NITROSODIPROPYLAMINE	ND	1.
67-72-1	HEXACHLOROETHANE	ND	1.
98-95-3	NITROBENZENE	ND	1.
78-59-1	ISOPHORONE	ND	1.
88-75-5	2-NITROPHENOL	ND	1.
105-67-9	2,4-DIMETHYLPHENOL	ND	1.
65-85-0	BENZOIC ACID	ND	5.
111-91-1	BIS (2-CHLOROETHOXY) METHANE	ND	1.
120-33-2	2,4-DICHLOROPHENOL	ND	1.
120-82-1	1,2,4-TRICHLOROBENZENE	ND	1.
91-20-3	NAPHTHALENE	ND	1.
106-47-8	4-CHLOROANILINE	ND	1.
87-68-3	HEXACHLOROBUTADIENE	ND	1.
59-50-7	4-CHLORO-3-METHYLPHENOL	ND	1.
91-57-6	2-METHYLNAPHTHALENE	ND	1.
77-47-4	HEXACHLOROCYCLOPENTADIENE	ND	1.
88-06-2	2,4,6-TRICHLOROPHENOL	ND	1.
95-95-4	2,4,5-TRICHLOROPHENOL	ND	5.
91-58-7	2-CHLORONAPHTHALENE	ND	1.
88-74-4	2-NITROANILINE	ND	5.
131-11-3	DIMETHYL PHTHALATE	ND	1.
208-96-8	ACENAPHTHYLENE	ND	1.
99-09-2	3-NITROANILINE	ND	5.
83-32-9	ACENAPHTHENE	ND	1.
51-28-5	2,4-DINITROPHENOL	ND	5.
100-02-7	4-NITROPHENOL	ND	5.
132-64-9	DIBENZOFURAN	ND	1.
121-14-2	2,4-DINITROTOLUENE	ND	1.
606-20-2	2,6-DINITROTOLUENE	ND	1.

WEST COAST ANALYTICAL SERVICE, INC.

CLIENT: EARTH TECHNOLOGY
 SAMPLE: 301W
 ANALYSIS TYPE: EPA METHOD 8240 (624)

ORGANICS ANALYSIS DATA RESULTS

DATE RECEIVED: 07/28/87 GCMS FILENAME: 6645V2
 LEVEL: LOW MATRIX: WATER
 DATE PREPARED: 08/04/87 DATE ANALYZED: 08/04/87
 STANDARD ID: VOA533 INSTRUMENT ID: 5100
 SAMPLE AMOUNT: 5.0ML

CAS #	COMPOUND	CONC: UG/L (PPB)	DETECTION LIMIT
74-87-3	CHLOROMETHANE	ND	5.
74-83-9	BROMOMETHANE	ND	5.
75-01-4	VINYL CHLORIDE	ND	5.
75-00-3	CHLOROETHANE	ND	5.
75-09-2	METHYLENE CHLORIDE	ND	10.
67-64-1	ACETONE	ND	10.
107-02-8	ACROLEIN	ND	10.
107-13-1	ACRYLONITRILE	ND	10.
75-15-0	CARBON DISULFIDE	ND	1.
75-35-4	1,1-DICHLOROETHENE	ND	1.
75-34-3	1,1-DICHLOROETHANE	ND	1.
156-60-5	TRANS-1,2-DICHLOROETHENE	ND	1.
109-99-9	TETRAHYDROFURAN	ND	1.
75-69-4	TRICHLOROFLUOROMETHANE	ND	1.
76-13-1	FREON-TF	ND	1.
106-93-4	ETHYLENE DIBROMIDE	ND	1.
123-91-1	1,4-DIOXANE	ND	1.
96-12-8	1,2-DIBROMO-3-CHLOROPROPANE	ND	1.
67-66-3	CHLOROFORM	ND	1.
107-06-2	1,2-DICHLOROETHANE	ND	1.
78-93-3	2-BUTANONE	ND	10.
71-55-6	1,1,1-TRICHLOROETHANE	ND	1.
16-23-5	CARBON TETRACHLORIDE	ND	1.
108-05-4	VINYL ACETATE	ND	5.
75-27-4	BROMODICHLOROMETHANE	ND	1.
79-34-5	1,1,2,2-TETRACHLOROETHANE	ND	1.
78-87-5	1,2-DICHLOROPROPANE	ND	1.
10061-02-6	TRANS-1,3-DICHLOROPROPENE	ND	1.
79-01-6	TRICHLOROETHENE	ND	1.
124-48-1	CHLORODIBROMOMETHANE	ND	1.
79-00-5	1,1,2-TRICHLOROETHANE	ND	1.
71-43-2	BENZENE	ND	1.
10061-01-5	CIS-1,3-DICHLOROPROPENE	ND	1.
110-75-8	2-CHLOROETHYL VINYLETHER	ND	10.
75-25-2	BROMOFORM	ND	1.
119-78-6	2-HEXANONE	ND	5.
108-10-1	4-METHYL-2-PENTANONE	ND	5.
127-18-4	TETRACHLOROETHENE	ND	1.
108-88-3	TOLUENE	ND	1.

WEST COAST ANALYTICAL SERVICE, INC.

CLIENT: EARTH TECHNOLOGY CORP.
SITE: METRO RAIL
SAMPLE: 303A-12-88
ANALYSIS TYPE: EPA METHOD 8240 (624)

ORGANICS ANALYSIS DATA RESULTS

DATE RECEIVED: 07/09/87 GCMS FILENAME: 6445V1
LEVEL: LOW MATRIX: SOIL
DATE PREPARED: 07/18/87 DATE ANALYZED: 07/18/87
STANDARD ID: VOA361 INSTRUMENT ID: 5101
SAMPLE AMOUNT: 1.00G

CAS #	COMPOUND	CONC: UG/KG (PPB)	DETECTION LIMIT
108-90-7	CHLOROBENZENE	ND	5.
100-41-4	ETHYLBENZENE	ND	5.
100-42-5	STYRENE	ND	5.
95-47-6	TOTAL XYLENES	ND	5.
108-41-8	M-CHLOROTOLUENE	ND	5.
95-50-1	1,2-DICHLOROBENZENE	ND	5.
541-73-1	1,3-DICHLOROBENZENE	ND	5.
106-46-7	1,4-DICHLOROBENZENE	ND	5.

Laboratory WCAS

Sample EARTH TECHNOLOGY
305W

Organics Analysis Data Sheet

Pesticides/PCBs

Concentration	_____	LOW	WATER
Date Extracted/Prepared:	_____	30 JUL 87	
Date Analyzed:	_____	03 AUG 87	
Sample Volume/Weight:	_____	500	mL
Total Extract Volume:	_____	10	mL
% Moisture:	_____	100	
Conc/Dil Factor:	1		

CAS #

ug/L

319-85-6	Alpha-BHC	_____	.1	ND
319-85-7	Beta-BHC	_____	.1	ND
319-86-8	Delta-BHC	_____	.1	ND
58-89-9	Gamma-BHC (Lindane)	_____	.1	ND
76-44-8	Heptachlor	_____	.1	ND
309-00-2	Aldrin	_____	.1	ND
1024-57-3	Heptachlor Epoxide	_____	.1	ND
959-98-8	Endosulfan I	_____	.1	ND
60-57-1	Dieldrin	_____	.2	ND
72-55-9	4,4'-DDE	_____	.2	ND
72-20-8	Endrin	_____	.2	ND
3321-65-9	Endosulfan II	_____	.2	ND
72-54-8	4,4'-DDD	_____	.9	ND
7421-93-4	Endrin Aldehyde	_____	.2	ND
1031-07-8	Endosulfan Sulfate	_____	.2	ND
50-29-3	4,4'-DDT	_____	.2	ND
72-43-5	Methoxychlor	_____	1	ND
53494-70-5	Endrin Ketone	_____	.2	ND
57-74-9	Chlordane	_____	1	ND
8001-35-2	Toxaphene	_____	2	ND
12674-11-2	Arochlor-1016	_____	1	ND
11104-28-2	Arochlor-1221	_____	1	ND
11141-16-5	Arochlor-1232	_____	1	ND
53469-21-9	Arochlor-1242	_____	1	ND
12672-29-6	Arochlor-1248	_____	1	ND
11097-69-1	Arochlor-1254	_____	2	ND
11096-82-5	Arochlor-1260	_____	2	ND

ND - NOT DETECTED
NA - NOT ANALYZED

Laboratory WCAS

Sample EARTH TECHNOLOGY
301W

Organics Analysis Data Sheet

Pesticides/PCBs

Concentration ----- LOW WATER
 Date Extracted/Prepared: ----- 30 JUL 87
 Date Analyzed: ----- 04 AUG 87
 Sample Volume/Weight: ----- 670 mL
 Total Extract Volume: ----- 10 mL
 % Moisture: ----- 100
 Conc/Dil Factor: 10

CAS #		ug/L	
319-85-6	Alpha-BHC -----	.7	ND
319-85-7	Beta-BHC -----	.7	ND
319-86-8	Delta-BHC -----	.7	ND
58-89-9	Gamma-BHC(Lindane) -----	.7	ND
76-44-8	Heptachlor -----	.7	ND
309-00-2	Aldrin -----	.7	ND
1024-57-3	Heptachlor Epoxide -----	.7	ND
959-98-8	Endosulfan I -----	.7	ND
60-57-1	Dieldrin -----	1.5	ND
72-55-9	4,4'-DDE -----	1.6	ND
72-20-8	Endrin -----	1.5	ND
3321-65-9	Endosulfan II -----	1.5	ND
72-54-8	4,4'-DDD -----	6.4	ND
7421-93-4	Endrin Aldehyde -----	1.5	ND
1031-07-8	Endosulfan Sulfate -----	1.5	ND
50-29-3	4,4'-DDT -----	1.5	ND
72-43-5	Methoxychlor -----	7.5	ND
53494-70-5	Endrin Ketone -----	1.5	ND
57-74-9	Chlordane -----	7.5	ND
8001-35-2	Toxaphene -----	15	ND
12674-11-2	Arochlor-1016 -----	7.5	ND
11104-28-2	Arochlor-1221 -----	7.5	ND
11141-16-5	Arochlor-1232 -----	7.5	ND
53469-21-9	Arochlor-1242 -----	7.5	ND
12672-29-6	Arochlor-1248 -----	7.5	ND
11097-69-1	Arochlor-1254 -----	15	ND
11096-82-5	Arochlor-1260 -----	15	ND

ND - NOT DETECTED
 NA - NOT ANALYZED

WEST COAST ANALYTICAL SERVICE, INC.

CLIENT: EARTH TECHNOLOGY
SITE: METRO RAIL
SAMPLE: 305A-10-20

TENTATIVELY IDENTIFIED COMPOUNDS

COMPOUND NAME	FRACTION	CONCENTRATION UG/KG (PPB)
1 NONE FOUND	VOA/BNA	

WEST COAST ANALYTICAL SERVICE, INC.

CLIENT: EARTH TECHNOLOGY
 SITE: METRO RAIL
 SAMPLE: 305A-10-20
 ANALYSIS TYPE: EPA METHOD 625 (8270)

ORGANICS ANALYSIS DATA RESULTS

DATE RECEIVED: 07/23/87 GCMS FILENAME: 6586B3
 LEVEL: LOW MATRIX: SOIL
 DATE PREPARED: 07/28/87 DATE ANALYZED: 08/01/87
 STANDARD ID: BNAZ174 GCMS TUNING: DFTPP45
 INSTRUMENT ID: 4500
 SAMPLE AMOUNT: 30G:1ML

CAS #	COMPOUND	CONC: UG/KG (PPB)	DETECTION LIMIT
108-95-2	PHENOL	ND	30.
111-44-4	BIS (2-CHLOROETHYL) ETHER	ND	30.
95-57-8	2-CHLOROPHENOL	ND	30.
541-73-1	1,3-DICHLOROBENZENE	ND	30.
106-46-7	1,4-DICHLOROBENZENE	ND	30.
100-51-6	BENZYL ALCOHOL	ND	30.
95-50-1	1,2-DICHLOROBENZENE	ND	30.
95-48-7	2-METHYLPHENOL	ND	30.
39638-32-9	BIS (2-CHLOROISOPROPYL) ETHER	ND	30.
106-44-5	4-METHYLPHENOL	ND	30.
621-64-7	N-NITROSODIPROPYLAMINE	ND	30.
67-72-1	HEXACHLOROETHANE	ND	30.
98-95-3	NITROBENZENE	ND	30.
78-59-1	ISOPHORONE	ND	30.
88-75-5	2-NITROPHENOL	ND	30.
105-67-9	2,4-DIMETHYLPHENOL	ND	30.
65-85-0	BENZOIC ACID	ND	200.
111-91-1	BIS (2-CHLOROETHOXY) METHANE	ND	30.
120-33-2	2,4-DICHLOROPHENOL	ND	30.
120-82-1	1,2,4-TRICHLOROBENZENE	ND	30.
91-20-3	NAPHTHALENE	ND	30.
106-47-8	4-CHLOROANILINE	ND	30.
87-68-3	HEXACHLOROBUTADIENE	ND	30.
59-50-7	4-CHLORO-3-METHYLPHENOL	ND	30.
91-57-6	2-METHYLNAPHTHALENE	ND	30.
77-47-4	HEXACHLOROCYCLOPENTADIENE	ND	30.
88-06-2	2,4,6-TRICHLOROPHENOL	ND	30.
95-95-4	2,4,5-TRICHLOROPHENOL	ND	200.
91-58-7	2-CHLORONAPHTHALENE	ND	30.
88-74-4	2-NITROANILINE	ND	200.
131-11-3	DIMETHYL PHTHALATE	ND	30.
208-96-8	ACENAPHTHYLENE	ND	30.
99-09-2	3-NITROANILINE	ND	200.
83-32-9	ACENAPHTHENE	ND	30.
51-28-5	2,4-DINITROPHENOL	ND	200.
100-02-7	4-NITROPHENOL	ND	200.
132-64-9	DIBENZOFURAN	ND	30.
121-14-2	2,4-DINITROTOLUENE	ND	30.
606-20-2	2,6-DINITROTOLUENE	ND	30.

WEST COAST ANALYTICAL SERVICE, INC.

CLIENT: EARTH TECHNOLOGY
 SITE: METRO RAIL
 SAMPLE: 305A-W-32
 ANALYSIS TYPE: EPA METHOD 625 (8270)

ORGANICS ANALYSIS DATA RESULTS

DATE RECEIVED: 07/23/87 GCMS FILENAME: 6586B2
 LEVEL: LOW MATRIX: WATER
 DATE PREPARED: 07/28/87 DATE ANALYZED: 08/01/87
 STANDARD ID: BNAZ174 GCMS TUNING: DFTPP45
 INSTRUMENT ID: 4500
 SAMPLE AMOUNT: 360ML:1ML

CAS #	COMPOUND	CONC: UG/L (PPB)	DETECTION LIMIT
84-66-2	DIETHYL PHTHALATE	51.	3.
7005-72-3	4-CHLOROPHENYL PHENYL ETHER	ND	3.
86-73-7	FLUORENE	ND	3.
100-01-6	4-NITROANILINE	ND	20.
534-52-1	4,6-DINITRO-2-METHYLPHENOL	ND	20.
86-30-6	N-NITROSODIPHENYLAMINE	ND	3.
101-55-3	4-BROMOPHENYL PHENYL ETHER	ND	3.
118-74-1	HEXACHLOROBENZENE	ND	3.
87-86-5	PENTACHLOROPHENOL	ND	20.
85-01-8	PHENANTHRENE	ND	3.
120-12-7	ANTHRACENE	ND	3.
84-74-2	DI-N-BUTYL PHTHALATE	9.	3.
206-44-0	FLUORANTHENE	ND	3.
129-00-0	PYRENE	ND	3.
85-68-7	BUTYL BENZYL PHTHALATE	ND	3.
91-94-1	3,3'-DICHLOROBENZIDINE	ND	6.
56-55-3	BENZO(A) ANTHRACENE	ND	3.
117-81-7	BIS(2-ETHYLHEXYL) PHTHALATE	ND	3.
218-01-9	CHRYSENE	ND	3.
117-84-0	DI-N-OCTYL PHTHALATE	ND	3.
205-99-2	BENZO(B & K) FLUORANTHENES	ND	3.
50-32-8	BENZO(A) PYRENE	ND	3.
193-39-5	INDENO(1,2,3-CD) PYRENE	ND	3.
53-70-3	DIBENZO(A,H) ANTHRACENE	ND	3.
191-24-2	BENZO(GHI) PERYLENE	ND	3.

WEST COAST ANALYTICAL SERVICE, INC.

CLIENT: EARTH TECHNOLOGY CORP.
 SITE: METRO RAIL
 SAMPLE: 305A-10-20
 ANALYSIS TYPE: EPA METHOD 8240 (624)

ORGANICS ANALYSIS DATA RESULTS

DATE RECEIVED: 07/23/87 GCMS FILENAME: 6586V1
 LEVEL: LOW MATRIX: SOIL
 DATE PREPARED: 07/31/87 DATE ANALYZED: 07/31/87
 STANDARD ID: VOA531 INSTRUMENT ID: 5100
 SAMPLE AMOUNT: 1.00G

CAS #	COMPOUND	CONC: UG/KG (PPB)	DETECTION LIMIT
108-90-7	CHLOROBENZENE	ND	5.
100-41-4	ETHYLBENZENE	ND	5.
100-42-5	STYRENE	ND	5.
95-47-6	TOTAL XYLENES	ND	5.
108-41-8	M-CHLOROTOLUENE	ND	5.
541-73-1	1,3-DICHLOROBENZENE	ND	5.
106-46-7	1,4-DICHLOROBENZENE	ND	5.
95-50-1	1,2-DICHLOROBENZENE	ND	5.

Laboratory WCAS

Sample EARTH TECHNOLOGY
305A-10-20

Organics Analysis Data Sheet

Pesticides/PCBs

Concentration ----- LOW SOIL
 Date Extracted/Prepared: ----- 28 JUL 87
 Date Analyzed: ----- 29 JUL 87
 Sample Volume/Weight: ----- 30 g
 Total Extract Volume: ----- 10 mL
 % Moisture: ----- NA
 Conc/Dil Factor: ----- 1

CAS #

ug/Kg

CAS #	Pesticide/PCB	ug/Kg	Result
319-85-6	Alpha-BHC	1.7	ND
319-85-7	Beta-BHC	1.7	ND
319-86-8	Delta-BHC	1.7	ND
58-89-9	Gamma-BHC (Lindane)	1.7	ND
76-44-8	Heptachlor	1.7	ND
309-00-2	Aldrin	1.7	ND
1024-57-3	Heptachlor Epoxide	1.7	ND
959-98-8	Endosulfan I	1.7	ND
60-57-1	Dieldrin	3.3	ND
72-55-9	4,4'-DDE	3.3	ND
72-20-8	Endrin	3.3	ND
3321-65-9	Endosulfan II	3.3	ND
72-54-8	4,4'-DDD	3.3	ND
7421-93-4	Endrin Aldehyde	3.3	ND
1031-07-8	Endosulfan Sulfate	3.3	ND
50-29-3	4,4'-DDT	3.3	ND
72-43-5	Methoxychlor	17	ND
53494-70-5	Endrin Ketone	3.3	ND
57-74-9	Chlordane	17	ND
8001-35-2	Toxaphene	33	ND
12674-11-2	Arochlor-1016	17	ND
11104-28-2	Arochlor-1221	17	ND
11141-16-5	Arochlor-1232	17	ND
53469-21-9	Arochlor-1242	17	ND
12672-29-6	Arochlor-1248	17	ND
11097-69-1	Arochlor-1254	33	ND
11096-82-5	Arochlor-1260	33	ND

ND - NOT DETECTED

NA - NOT ANALYZED

August 4, 1987

THE EARTH TECHNOLOGY CORP.
3777 Long Beach Blvd.
Long Beach, CA 90807

Attn: Allison Urbon

JOB NO. 6586

WCAS
WEST COAST
ANALYTICAL
SERVICE, INC.

LABORATORY REPORT

Samples Received: Twenty-three (23) soil samples and one (1) water sample

Date Received: 7-23-87

Purchase Order No: 87-885-0003/Metro Rail

The samples were analyzed as follows:

<u>Samples Analyzed</u>	<u>Analysis</u>	<u>Results</u>
305A-10-20	Volatile Organics by EPA 8240	Data Sheets
305A-10-20, 305A-W-32	Semi-volatile Organic by EPA 8270/625	Data Sheets
305A-10-20	Organochlorine Pest. & PCB's by EPA 8080	Data Sheets
305A-W-32	Sulfate by EPA 300.6	Table I
305A-W-32	Sulfide by EPA 9030	Table I
305A-W-32	Total Petroleum Hydrocarbons by EPA 418.1	Table I
305A-W-32	pH by EPA 9040	Table I

Page 1 of 2


Michael Shelton
Senior Chemist


D.J. Northington, Ph.D.
Technical Director

WEST COAST ANALYTICAL SERVICE, INC.

CLIENT: EARTH TECHNOLOGY
 SITE: METRO RAIL
 SAMPLE: 306-6-33
 ANALYSIS TYPE: EPA METHOD 625 (8270)

ORGANICS ANALYSIS DATA RESULTS

DATE RECEIVED: 07/16/87 GCMS FILENAME: 6497B4
 LEVEL: LOW MATRIX: SOIL
 DATE PREPARED: 07/21/87 DATE ANALYZED: 07/23/87
 STANDARD ID: BNAZ168 INSTRUMENT ID: 4500
 SAMPLE AMOUNT: 30G:1ML

CAS #	COMPOUND	CONC: UG/KG (PPB)	DETECTION LIMIT
84-66-2	DIETHYL PHTHALATE	ND	30.
7005-72-3	4-CHLOROPHENYL PHENYL ETHER	ND	30.
86-73-7	FLUORENE	ND	30.
100-01-6	4-NITROANILINE	ND	200.
534-52-1	4,6-DINITRO-2-METHYLPHENOL	ND	200.
86-30-6	N-NITROSODIPHENYLAMINE	ND	30.
101-55-3	4-BROMOPHENYL PHENYL ETHER	ND	30.
118-74-1	HEXACHLOROBENZENE	ND	30.
87-86-5	PENTACHLOROPHENOL	ND	200.
85-01-8	PHENANTHRENE	ND	30.
120-12-7	ANTHRACENE	ND	30.
84-74-2	DI-N-BUTYL PHTHALATE	ND	30.
206-44-0	FLUORANTHENE	ND	30.
129-00-0	PYRENE	ND	30.
85-68-7	BUTYL BENZYL PHTHALATE	ND	30.
91-94-1	3,3'-DICHLOROBENZIDINE	ND	70.
56-55-3	BENZO(A) ANTHRACENE	ND	30.
117-81-7	BIS(2-ETHYLHEXYL) PHTHALATE	ND	30.
218-01-9	CHRYSENE	ND	30.
117-84-0	DI-N-OCTYL PHTHALATE	ND	30.
205-99-2	BENZO(B & K) FLUORANTHENES	ND	30.
50-32-8	BENZO(A) PYRENE	ND	30.
193-39-5	INDENO(1,2,3-CD) PYRENE	ND	30.
53-70-3	DIBENZO(A,H) ANTHRACENE	ND	30.
191-24-2	BENZO(GHI) PERYLENE	ND	30.

WEST COAST ANALYTICAL SERVICE, INC.

CLIENT: EARTH TECHNOLOGY
 SITE: METRO RAIL
 SAMPLE: 306-6-33
 ANALYSIS TYPE: EPA METHOD 8240 (624)

ORGANICS ANALYSIS DATA RESULTS

DATE RECEIVED: 07/16/87 GCMS FILENAME: 6497V1
 LEVEL: LOW MATRIX: SOIL
 DATE PREPARED: 07/21/87 DATE ANALYZED: 07/21/87
 STANDARD ID: VOA364 INSTRUMENT ID: 5101
 SAMPLE AMOUNT: 1.00G

CAS #	COMPOUND	CONC: UG/KG (PPB)	DETECTION LIMIT
108-90-7	CHLOROBENZENE	ND	5.
100-41-4	ETHYLBENZENE	ND	5.
100-42-5	STYRENE	ND	5.
95-47-6	TOTAL XYLENES	ND	5.
108-41-8	M-CHLOROTOLUENE	ND	5.
95-50-1	1,2-DICHLOROBENZENE	ND	5.
541-73-1	1,3-DICHLOROBENZENE	ND	5.
106-46-7	1,4-DICHLOROBENZENE	ND	5.

WEST COAST ANALYTICAL SERVICE, INC.

CLIENT: EARTH TECHNOLOGY
SITE: METRO RAIL
SAMPLE: 306-W-33

TENTATIVELY IDENTIFIED COMPOUNDS

COMPOUND NAME	FRACTION	CONCENTRATION UG/L (PPB)
=====	=====	=====
1 NONE FOUND	BNA	

WEST COAST ANALYTICAL SERVICE, INC.

CLIENT: EARTH TECHNOLOGY
 SITE: METRO RAIL
 SAMPLE: 306-W-33
 ANALYSIS TYPE: EPA METHOD 625 (8270)

ORGANICS ANALYSIS DATA RESULTS

DATE RECEIVED: 07/16/87 GCMS FILENAME: 6497B2
 LEVEL: LOW MATRIX: WATER
 DATE PREPARED: 07/21/87 DATE ANALYZED: 07/23/87
 STANDARD ID: BNAZ168 INSTRUMENT ID: 4500
 SAMPLE AMOUNT: 680ML:1ML

CAS #	COMPOUND	CONC: UG/L (PPB)	DETECTION LIMIT
108-95-2	PHENOL	ND	1.
111-44-4	BIS(2-CHLOROETHYL) ETHER	ND	1.
95-57-8	2-CHLOROPHENOL	ND	1.
541-73-1	1,3-DICHLOROBENZENE	ND	1.
106-46-7	1,4-DICHLOROBENZENE	ND	1.
100-51-6	BENZYL ALCOHOL	ND	1.
95-50-1	1,2-DICHLOROBENZENE	ND	1.
95-48-7	2-METHYLPHENOL	ND	1.
39638-32-9	BIS(2-CHLOROISOPROPYL) ETHER	ND	1.
106-44-5	4-METHYLPHENOL	ND	1.
621-64-7	N-NITROSODIPROPYLAMINE	ND	1.
67-72-1	HEXACHLOROETHANE	ND	1.
98-95-3	NITROBENZENE	ND	1.
78-59-1	ISOPHORONE	ND	1.
88-75-5	2-NITROPHENOL	ND	1.
105-67-9	2,4-DIMETHYLPHENOL	ND	1.
65-85-0	BENZOIC ACID	ND	5.
111-91-1	BIS(2-CHLOROETHOXY) METHANE	ND	1.
120-33-2	2,4-DICHLOROPHENOL	ND	1.
120-82-1	1,2,4-TRICHLOROBENZENE	ND	1.
91-20-3	NAPHTHALENE	2.	1.
106-47-8	4-CHLOROANILINE	ND	1.
87-68-3	HEXACHLOROBUTADIENE	ND	1.
59-50-7	4-CHLORO-3-METHYLPHENOL	ND	1.
91-57-6	2-METHYLNAPHTHALENE	ND	1.
77-47-4	HEXACHLOROCYCLOPENTADIENE	ND	1.
88-06-2	2,4,6-TRICHLOROPHENOL	ND	1.
95-95-4	2,4,5-TRICHLOROPHENOL	ND	5.
91-58-7	2-CHLORONAPHTHALENE	ND	1.
88-74-4	2-NITROANILINE	ND	5.
131-11-3	DIMETHYL PHTHALATE	ND	1.
208-96-8	ACENAPHTHYLENE	ND	1.
99-09-2	3-NITROANILINE	ND	5.
83-32-9	ACENAPHTHENE	ND	1.
51-28-5	2,4-DINITROPHENOL	ND	5.
100-02-7	4-NITROPHENOL	ND	5.
132-64-9	DIBENZOFURAN	ND	1.
121-14-2	2,4-DINITROTOLUENE	ND	1.
606-20-2	2,6-DINITROTOLUENE	ND	1.

Laboratory WCAS

Sample EARTH TECHNOLOGY
306-6-33

Organics Analysis Data Sheet

Pesticides/PCBs

Concentration _____ LOW SOIL
 Date Extracted/Prepared: _____ 21 JUL 87
 Date Analyzed: _____ 22 JUL 87
 Sample Volume/Weight: _____ 30 g
 Total Extract Volume: _____ 10 mL
 % Moisture: _____ NA
 Conc/Dil Factor: 1:1

CAS #

ug/Kg

CAS #	Pesticide/PCB Name	ug/Kg	Result
319-85-6	Alpha-BHC	1.7	ND
319-85-7	Beta-BHC	1.7	ND
319-86-8	Delta-BHC	1.7	ND
58-89-9	Gamma-BHC (Lindane)	1.7	ND
76-44-8	Heptachlor	1.7	ND
309-00-2	Aldrin	1.7	ND
1024-57-3	Heptachlor Epoxide	1.7	ND
959-98-8	Endosulfan I	1.7	ND
60-57-1	Dieldrin	3.3	ND
72-55-9	4,4'-DDE	3.3	ND
72-20-8	Endrin	3.3	ND
3321-65-9	Endosulfan II	3.3	ND
72-54-8	4,4'-DDD	3.3	ND
7421-93-4	Endrin Aldehyde	3.3	ND
1031-07-8	Endosulfan Sulfate	3.3	ND
50-29-3	4,4'-DDT	3.3	ND
72-43-5	Methoxychlor	17	ND
53494-70-5	Endrin Ketone	3.3	ND
57-74-9	Chlordane	17	ND
8001-35-2	Toxaphene	33	ND
12674-11-2	Arochlor-1016	17	ND
11104-28-2	Arochlor-1221	17	ND
11141-16-5	Arochlor-1232	17	ND
53469-21-9	Arochlor-1242	17	ND
12672-29-6	Arochlor-1248	17	ND
11097-69-1	Arochlor-1254	33	ND
11096-82-5	Arochlor-1260	33	ND

ND - NOT DETECTED

NA - NOT ANALYZED

July 31, 1987

THE EARTH TECHNOLOGY CORP.
3777 Long Beach Blvd.
Long Beach, CA 90807

Attn: Allison Urbon

JOB NO. 6497

WCAS

**WEST COAST
ANALYTICAL
SERVICE, INC.**

LABORATORY REPORT

Samples Received: Five (5) soil samples & one (1) water sample
Date Received: 7-15-87
Purchase Order No: 87-885-0003/Metro Rail

The samples were analyzed as follows:

<u>Samples Analyzed</u>	<u>Analysis</u>	<u>Results</u>
One soil	Volatile Organics by EPA 8240	Data Sheets
One soil & one water	Semi-volatile Organics by EPA 8270	Data Sheets
One soil	Organochlorine Pest. & PCB's by EPA 8080	Data Sheets
One soil	Priority Pollutant metals by EPA 6020	Quant. Report
One water	Sulfate by EPA 300.6	Table I
One water	Total Petroleum Hydrocarbons by EPA 418.1	Table II
One water	pH by EPA 9040	Table III
One water	Sulfide by EPA 9030	Table IV

Page 1 of 2


Michael Shelton
Senior Chemist


D.J. Northington, Ph.D.
Technical Director

WEST COAST ANALYTICAL SERVICE, INC.

CLIENT: EARTH TECHNOLOGY
SITE: METRO RAIL
SAMPLE: B305-1-W-84

TENTATIVELY IDENTIFIED COMPOUNDS

COMPOUND NAME	FRACTION	CONCENTRATION UG/L (PPB)
1 MOLECULAR SULFUR	BNA	4000.

WEST COAST ANALYTICAL SERVICE, INC.

CLIENT: EARTH TECHNOLOGY
 SITE: METRO RAIL
 SAMPLE: B305-1-W-84
 ANALYSIS TYPE: EPA METHOD 625 (8270)

ORGANICS ANALYSIS DATA RESULTS

DATE RECEIVED: 07/20/87 GCMS FILENAME: 6540B1
 LEVEL: LOW MATRIX: WATER
 DATE PREPARED: 07/21/87 DATE ANALYZED: 07/27/87
 STANDARD ID: BNAZ171 INSTRUMENT ID: 4500
 SAMPLE AMOUNT: 650ML:1ML

CAS #	COMPOUND	CONC: UG/L (PPB)	DETECTION LIMIT
108-95-2	PHENOL	ND	2.
111-44-4	BIS (2-CHLOROETHYL) ETHER	ND	2.
95-57-8	2-CHLOROPHENOL	ND	2.
541-73-1	1,3-DICHLOROBENZENE	ND	2.
106-46-7	1,4-DICHLOROBENZENE	ND	2.
100-51-6	BENZYL ALCOHOL	ND	2.
95-50-1	1,2-DICHLOROBENZENE	ND	2.
95-48-7	2-METHYLPHENOL	ND	2.
39638-32-9	BIS (2-CHLOROISOPROPYL) ETHER	ND	2.
106-44-5	4-METHYLPHENOL	ND	2.
621-64-7	N-NITROSODIPROPYLAMINE	ND	2.
67-72-1	HEXACHLOROETHANE	ND	2.
98-95-3	NITROBENZENE	ND	2.
78-59-1	ISOPHORONE	ND	2.
88-75-5	2-NITROPHENOL	ND	2.
105-67-9	2,4-DIMETHYLPHENOL	ND	2.
65-85-0	BENZOIC ACID	ND	10.
111-91-1	BIS (2-CHLOROETHOXY) METHANE	ND	2.
120-33-2	2,4-DICHLOROPHENOL	ND	2.
120-82-1	1,2,4-TRICHLOROBENZENE	ND	2.
91-20-3	NAPHTHALENE	ND	2.
106-47-8	4-CHLOROANILINE	ND	2.
87-68-3	HEXACHLOROBUTADIENE	ND	2.
59-50-7	4-CHLORO-3-METHYLPHENOL	ND	2.
91-57-6	2-METHYLNAPHTHALENE	ND	2.
77-47-4	HEXACHLOROCYCLOPENTADIENE	ND	2.
88-06-2	2,4,6-TRICHLOROPHENOL	ND	2.
95-95-4	2,4,5-TRICHLOROPHENOL	ND	10.
91-58-7	2-CHLORONAPHTHALENE	ND	2.
88-74-4	2-NITROANILINE	ND	10.
131-11-3	DIMETHYL PHTHALATE	ND	2.
208-96-8	ACENAPHTHYLENE	ND	2.
99-09-2	3-NITROANILINE	ND	10.
83-32-9	ACENAPHTHENE	ND	2.
51-28-5	2,4-DINITROPHENOL	ND	10.
100-02-7	4-NITROPHENOL	ND	10.
132-64-9	DIBENZOFURAN	ND	2.
121-14-2	2,4-DINITROTOLUENE	ND	2.
606-20-2	2,6-DINITROTOLUENE	ND	2.

WEST COAST ANALYTICAL SERVICE, INC.

CLIENT: EARTH TECHNOLOGY
 SITE: METRO RAIL
 SAMPLE: B305-7-84
 ANALYSIS TYPE: EPA METHOD 625 (8270)

ORGANICS ANALYSIS DATA RESULTS

DATE RECEIVED: 07/20/87 GCMS FILENAME: 6540B2
 LEVEL: LOW MATRIX: SOIL
 DATE PREPARED: 07/21/84 DATE ANALYZED: 07/27/87
 STANDARD ID: BNAZ171 INSTRUMENT ID: 4500
 SAMPLE AMOUNT: 30G:1ML

CAS #	COMPOUND	CONC: UG/KG (PPB)	DETECTION LIMIT
84-66-2	DIETHYL PHTHALATE	ND	30.
7005-72-3	4-CHLOROPHENYL PHENYL ETHER	ND	30.
86-73-7	FLUORENE	ND	30.
100-01-6	4-NITROANILINE	ND	200.
534-52-1	4,6-DINITRO-2-METHYLPHENOL	ND	200.
86-30-6	N-NITROSODIPHENYLAMINE	ND	30.
101-55-3	4-BROMOPHENYL PHENYL ETHER	ND	30.
118-74-1	HEXACHLOROBENZENE	ND	30.
87-86-5	PENTACHLOROPHENOL	ND	200.
85-01-8	PHENANTHRENE	ND	30.
120-12-7	ANTHRACENE	ND	30.
84-74-2	DI-N-BUTYL PHTHALATE	ND	30.
206-44-0	FLUORANTHENE	ND	30.
129-00-0	PYRENE	ND	30.
85-68-7	BUTYL BENZYL PHTHALATE	ND	30.
91-94-1	3,3'-DICHLOROBENZIDINE	ND	70.
56-55-3	BENZO(A) ANTHRACENE	ND	30.
117-81-7	BIS(2-ETHYLHEXYL) PHTHALATE	ND	30.
218-01-9	CHRYSENE	ND	30.
117-84-0	DI-N-OCTYL PHTHALATE	ND	30.
205-99-2	BENZO(B & K) FLUORANTHENES	ND	30.
50-32-8	BENZO(A) PYRENE	ND	30.
193-39-5	INDENO(1,2,3-CD) PYRENE	ND	30.
53-70-3	DIBENZO(A,H) ANTHRACENE	ND	30.
191-24-2	BENZO(GHI) PERYLENE	ND	30.

WEST COAST ANALYTICAL SERVICE, INC.

CLIENT: EARTH TECHNOLOGY
 SITE: METRO RAIL
 SAMPLE: B305-7-84
 ANALYSIS TYPE: EPA METHOD 8240 (624)

ORGANICS ANALYSIS DATA RESULTS

DATE RECEIVED: 07/20/87 GCMS FILENAME: 6540V1
 LEVEL: LOW MATRIX: SOIL
 DATE PREPARED: 07/27/87 DATE ANALYZED: 07/27/87
 STANDARD ID: VOA369 INSTRUMENT ID: 5101
 SAMPLE AMOUNT: 1.0G

CAS #	COMPOUND	CONC: UG/KG (PPB)	DETECTION LIMIT
108-90-7	CHLOROBENZENE	ND	5.
100-41-4	ETHYLBENZENE	ND	5.
100-42-5	STYRENE	ND	5.
95-47-6	TOTAL XYLENES	ND	5.
108-41-8	M-CHLOROTOLUENE	ND	5.
95-50-1	1,2-DICHLOROBENZENE	ND	5.
541-73-1	1,3-DICHLOROBENZENE	ND	5.
106-46-7	1,4-DICHLOROBENZENE	ND	5.

Laboratory WCAS

Sample EARTH TECHNOLOGY
B305-7-84

Organics Analysis Data Sheet

Pesticides/PCBs

Concentration ----- LOW SOIL
 Date Extracted/Prepared: ----- 21 JUL 87
 Date Analyzed: ----- 22 JUL 87
 Sample Volume/Weight: ----- 30 g
 Total Extract Volume: ----- 10 mL
 % Moisture: ----- NA
 Conc/Dil Factor: 1:1

CAS #		ug/Kg	
319-85-6	Alpha-BHC -----	1.7	ND
319-85-7	Beta-BHC -----	1.7	ND
319-86-8	Delta-BHC -----	1.7	ND
58-89-9	Gamma-BHC (Lindane) -----	1.7	ND
76-44-8	Heptachlor -----	1.7	ND
309-00-2	Aldrin -----	1.7	ND
1024-57-3	Heptachlor Epoxide -----	1.7	ND
959-98-8	Endosulfan I -----	1.7	ND
60-57-1	Dieldrin -----	3.3	ND
72-55-9	4,4'-DDE -----	3.3	ND
72-20-8	Endrin -----	3.3	ND
3321-65-9	Endosulfan II -----	3.3	ND
72-54-8	4,4'-DDD -----	3.3	ND
7421-93-4	Endrin Aldehyde -----	3.3	ND
1031-07-8	Endosulfan Sulfate -----	3.3	ND
50-29-3	4,4'-DDT -----	3.3	ND
72-43-5	Methoxychlor -----	17	ND
53494-70-5	Endrin Ketone -----	3.3	ND
57-74-9	Chlordane -----	17	ND
8001-35-2	Toxaphene -----	33	ND
12674-11-2	Arochlor-1016 -----	17	ND
11104-28-2	Arochlor-1221 -----	17	ND
11141-16-5	Arochlor-1232 -----	17	ND
53469-21-9	Arochlor-1242 -----	17	ND
12672-29-6	Arochlor-1248 -----	17	ND
11097-69-1	Arochlor-1254 -----	33	ND
11096-82-5	Arochlor-1260 -----	33	ND

ND - NOT DETECTED
 NA - NOT ANALYZED

July 30, 1987

THE EARTH TECHNOLOGY CORP.
3777 Long Beach Blvd.
Long Beach, CA 90807

Attn: Allison Urbon

JOB NO. 6540

WCAS
WEST COAST
ANALYTICAL
SERVICE, INC.

LABORATORY REPORT

Samples Received: Eleven (11) soil samples in duplicate and one
(1) water sample in duplicate

Date Received: 7-20-87

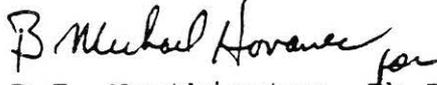
Purchase Order No: 87-885-03/Metro Rail

The samples were analyzed as follows:

<u>Samples Analyzed</u>	<u>Analysis</u>	<u>Results</u>
B305-7-84	Volatile Organics by EPA 8240	Data Sheets
B305-7-84, B305-1-W-84	Semi-Volatile Organics by EPA 625/8270	Data Sheets
B305-7-84	Chlorinated Pest. by EPA 8080	Data Sheet
B305-1-W-84	Sulfate by modified EPA 300.6	Table I
B305-1-W-84	Total Petroleum Hydrocarbons by EPA 418.1	Table II
B305-1-W-84	pH by EPA 150.1	Table III
B305-1-W-84	Sulfide by EPA 9030	Table IV

Page 1 of 2


Mary Stordal
Analytical Chemist


D.J. Northington, Ph.D.
Technical Director

WEST COAST ANALYTICAL SERVICE, INC.

CLIENT: EARTH TECHNOLOGY
 SITE: METRO RAIL
 SAMPLE: 303A-12-88
 ANALYSIS TYPE: EPA METHOD 625 (8270)

ORGANICS ANALYSIS DATA RESULTS

DATE RECEIVED: 07/09/87 GCMS FILENAME: 6445B2
 LEVEL: LOW MATRIX: SOIL
 DATE PREPARED: 07/15/87 DATE ANALYZED: 07/17/87
 STANDARD ID: BNAZ165 GCMS TUNING: DFTPP42
 INSTRUMENT ID: 4500
 SAMPLE AMOUNT: 30G:1ML

CAS #	COMPOUND	CONC: UG/KG (PPB)	DETECTION LIMIT
84-66-2	DIETHYL PHTHALATE	ND	30.
7005-72-3	4-CHLOROPHENYL PHENYL ETHER	ND	30.
86-73-7	FLUORENE	ND	30.
100-01-6	4-NITROANILINE	ND	200.
534-52-1	4,6-DINITRO-2-METHYLPHENOL	ND	200.
86-30-6	N-NITROSODIPHENYLAMINE	ND	30.
101-55-3	4-BROMOPHENYL PHENYL ETHER	ND	30.
118-74-1	HEXACHLOROBENZENE	ND	30.
87-86-5	PENTACHLOROPHENOL	ND	200.
85-01-8	PHENANTHRENE	ND	30.
120-12-7	ANTHRACENE	ND	30.
84-74-2	DI-N-BUTYL PHTHALATE	ND	30.
206-44-0	FLUORANTHENE	ND	30.
129-00-0	PYRENE	ND	30.
85-68-7	BUTYL BENZYL PHTHALATE	ND	30.
91-94-1	3,3'-DICHLOROBENZIDINE	ND	70.
56-55-3	BENZO (A) ANTHRACENE	ND	30.
117-81-7	BIS (2-ETHYLHEXYL) PHTHALATE	ND	30.
218-01-9	CHRYSENE	ND	30.
117-84-0	DI-N-OCTYL PHTHALATE	ND	30.
205-99-2	BENZO (B & K) FLUORANTHENES	ND	30.
50-32-8	BENZO (A) PYRENE	ND	30.
193-39-5	INDENO (1,2,3-CD) PYRENE	ND	30.
53-70-3	DIBENZO (A,H) ANTHRACENE	ND	30.
191-24-2	BENZO (GHI) PERYLENE	ND	30.

Client: Earth Technology Corp.
Job Number: 6445
Date Analyzed: 7-16-87

Quantitative Analysis Report
Inductively Coupled Plasma-Mass Spectrometry

Parts Per Million (mg/Kg)
Soil Sample

	303A-12-88	Detection Limit
Beryllium	0.25	0.1
Chromium	36	0.6
Nickel	34	0.5
Copper	35	0.8
Zinc	81	2
Arsenic	ND	0.2
Selenium	ND	3
Silver	0.22	0.03
Cadmium	1.8	0.07
Antimony	ND	3
Mercury	ND	0.2
Thallium	0.28	0.06
Lead	3.5	0.6

ND-Not Detected. The Limit of Detection is reported above.

July 21, 1987

THE EARTH TECHNOLOGY CORP.
3777 Long Beach Blvd.
Long Beach, CA 90807

Attn: Allison Urbon

JOB NO. 6445

WCAS
WEST COAST
ANALYTICAL
SERVICE, INC.

LABORATORY REPORT

Samples: Three (3) soil samples
Date Received: 7-9-87
Purchase Order No: 87-885-0003/Metro Rail

The samples were analyzed as follows:

<u>Sample</u>	<u>Analysis</u>	<u>Results</u>
303A-12-88	Volatile Organics by EPA 8240	Data Sheets
303A-12-88	Semi-Volatile Organics by EPA 8270	Data Sheets
303A-12-88	Organochlorine Pesticides by EPA 8080	Data Sheets

Page 1 of 1


Michael Shelton
Senior Chemist


D.J. Northington, Ph.D.
Technical Director

WEST COAST ANALYTICAL SERVICE, INC.

CLIENT: EARTH TECHNOLOGY
 SITE: METRO RAIL
 SAMPLE: 304-13-30
 ANALYSIS TYPE: EPA METHOD 625 (8270)

ORGANICS ANALYSIS DATA RESULTS

DATE RECEIVED: 07/01/87 GCMS FILENAME: 6392B1
 LEVEL: LOW MATRIX: SOIL
 DATE PREPARED: 07/08/87 DATE ANALYZED: 07/10/87
 STANDARD ID: BNAZ161 INSTRUMENT ID: 4500
 SAMPLE AMOUNT: 20G:1ML

CAS #	COMPOUND	CONC: UG/KG (PPB)	DETECTION LIMIT
84-66-2	DIETHYL PHTHALATE	ND	50.
7005-72-3	4-CHLOROPHENYL PHENYL ETHER	ND	50.
86-73-7	FLUORENE	270.	50.
100-01-6	4-NITROANILINE	ND	300.
534-52-1	4,6-DINITRO-2-METHYLPHENOL	ND	300.
86-30-6	N-NITROSODIPHENYLAMINE	ND	50.
101-55-3	4-BROMOPHENYL PHENYL ETHER	ND	50.
118-74-1	HEXACHLOROBENZENE	ND	50.
87-86-5	PENTACHLOROPHENOL	ND	300.
85-01-8	PHENANTHRENE	420.	50.
120-12-7	ANTHRACENE	200.	50.
84-74-2	DI-N-BUTYL PHTHALATE	ND	50.
206-44-0	FLUORANTHENE	510.	50.
129-00-0	PYRENE	760.	50.
85-68-7	BUTYL BENZYL PHTHALATE	ND	50.
91-94-1	3,3'-DICHLOROBENZIDINE	ND	100.
56-55-3	BENZO(A) ANTHRACENE	110.	50.
117-81-7	BIS(2-ETHYLHEXYL) PHTHALATE	ND	50.
218-01-9	CHRYSENE	130.	50.
117-84-0	DI-N-OCTYL PHTHALATE	ND	50.
205-99-2	BENZO(B & K) FLUORANTHENES	120.	50.
50-32-8	BENZO(A) PYRENE	130.	50.
193-39-5	INDENO(1,2,3-CD) PYRENE	ND	50.
53-70-3	DIBENZO(A,H) ANTHRACENE	ND	50.
191-24-2	BENZO(GHI) PERYLENE	ND	50.

WEST COAST ANALYTICAL SERVICE, INC.

CLIENT: EARTH TECHNOLOGY CORP.
 SITE: METRO RAIL
 SAMPLE: 304-13
 ANALYSIS TYPE: EPA METHOD 8240 (624)

ORGANICS ANALYSIS DATA RESULTS

DATE RECEIVED: 07/01/87 GCMS FILENAME: 6392V3
 LEVEL: LOW MATRIX: SOIL
 DATE PREPARED: 07/08/87 DATE ANALYZED: 07/08/87
 STANDARD ID: VOA358 INSTRUMENT ID: 5101
 SAMPLE AMOUNT: 1.00G

CAS #	COMPOUND	CONC: UG/KG (PPB)	DETECTION LIMIT
108-90-7	CHLOROBENZENE	ND	5.
100-41-4	ETHYLBENZENE	ND	5.
100-42-5	STYRENE	ND	5.
95-47-6	TOTAL XYLENES	ND	5.
108-41-8	M-CHLOROTOLUENE	ND	5.
95-50-1	1,2-DICHLOROBENZENE	ND	5.
541-73-1	1,3-DICHLOROBENZENE	ND	5.
106-46-7	1,4-DICHLOROBENZENE	ND	5.

Laboratory WCAS

Sample EARTH TECHNOLOGY
304-13

Organics Analysis Data Sheet

Pesticides/PCBs

Concentration	-----	LOW	SOIL
Date Extracted/Prepared:	-----	08 JUL 87	
Date Analyzed:	-----	10 JUL 87	
Sample Volume/Weight:	-----	20	g
Total Extract Volume:	-----	10	mL
% Moisture:	-----	NA	
Conc/Dil Factor:	1:1		

CAS #

ug/Kg

319-85-6	Alpha-BHC	-----	2.5	ND
319-85-7	Beta-BHC	-----	2.5	ND
319-86-8	Delta-BHC	-----	2.5	ND
58-89-9	Gamma-BHC (Lindane)	-----	2.5	ND
76-44-8	Heptachlor	-----	2.5	ND
309-00-2	Aldrin	-----	2.5	ND
1024-57-3	Heptachlor Epoxide	-----	2.5	ND
959-98-8	Endosulfan I	-----	2.5	ND
60-57-1	Dieldrin	-----	5	ND
72-55-9	4,4'-DDE	-----	5	ND
72-20-8	Endrin	-----	5	ND
3321-65-9	Endosulfan II	-----	5	ND
72-54-8	4,4'-DDD	-----	5	ND
7421-93-4	Endrin Aldehyde	-----	5	ND
1031-07-8	Endosulfan Sulfate	-----	5	ND
50-29-3	4,4'-DDT	-----	5	ND
72-43-5	Methoxychlor	-----	25	ND
53494-70-5	Endrin Ketone	-----	5	ND
57-74-9	Chlordane	-----	25	ND
8001-35-2	Toxaphene	-----	50	ND
12674-11-2	Arochlor-1016	-----	25	ND
11104-28-2	Arochlor-1221	-----	25	ND
11141-16-5	Arochlor-1232	-----	25	ND
53469-21-9	Arochlor-1242	-----	25	ND
12672-29-6	Arochlor-1248	-----	25	ND
11097-69-1	Arochlor-1254	-----	50	ND
11096-82-5	Arochlor-1260	-----	50	ND

ND - NOT DETECTED

NA - NOT ANALYZED

WEST COAST ANALYTICAL SERVICE, INC.

CLIENT: EARTH TECHNOLOGY
SITE: METRO RAIL
SAMPLE: 303-6-30

TENTATIVELY IDENTIFIED COMPOUNDS

COMPOUND NAME	FRACTION	CONCENTRATION UG/KG (PPB)
1 NONE FOUND	VOA/BNA	

WEST COAST ANALYTICAL SERVICE, INC.

CLIENT: EARTH TECHNOLOGY
 SITE: METRO RAIL
 SAMPLE: 303-6-30
 ANALYSIS TYPE: EPA METHOD 625 (8270)

ORGANICS ANALYSIS DATA RESULTS

DATE RECEIVED: 06/30/87 GCMS FILENAME: 6385B1
 LEVEL: LOW MATRIX: SOIL
 DATE PREPARED: 07/08/87 DATE ANALYZED: 07/10/87
 STANDARD ID: BNAZ161 INSTRUMENT ID: 4500
 SAMPLE AMOUNT: 30G:1ML

CAS #	COMPOUND	CONC: UG/KG (PPB)	DETECTION LIMIT
108-95-2	PHENOL	ND	30.
111-44-4	BIS (2-CHLOROETHYL) ETHER	ND	30.
95-57-8	2-CHLOROPHENOL	ND	30.
541-73-1	1,3-DICHLOROBENZENE	ND	30.
106-46-7	1,4-DICHLOROBENZENE	ND	30.
100-51-6	BENZYL ALCOHOL	ND	30.
95-50-1	1,2-DICHLOROBENZENE	ND	30.
95-48-7	2-METHYLPHENOL	ND	30.
39638-32-9	BIS (2-CHLOROISOPROPYL) ETHER	ND	30.
106-44-5	4-METHYLPHENOL	ND	30.
621-64-7	N-NITROSODIPROPYLAMINE	ND	30.
67-72-1	HEXACHLOROETHANE	ND	30.
98-95-3	NITROBENZENE	ND	30.
78-59-1	ISOPHORONE	ND	30.
88-75-5	2-NITROPHENOL	ND	30.
105-67-9	2,4-DIMETHYLPHENOL	ND	30.
65-85-0	BENZOIC ACID	ND	200.
111-91-1	BIS (2-CHLOROETHOXY) METHANE	ND	30.
120-33-2	2,4-DICHLOROPHENOL	ND	30.
120-82-1	1,2,4-TRICHLOROBENZENE	ND	30.
91-20-3	NAPHTHALENE	ND	30.
106-47-8	4-CHLOROANILINE	ND	30.
87-68-3	HEXACHLOROBUTADIENE	ND	30.
59-50-7	4-CHLORO-3-METHYLPHENOL	ND	30.
91-57-6	2-METHYLNAPHTHALENE	ND	30.
77-47-4	HEXACHLOROCYCLOPENTADIENE	ND	30.
88-06-2	2,4,6-TRICHLOROPHENOL	ND	30.
95-95-4	2,4,5-TRICHLOROPHENOL	ND	200.
91-58-7	2-CHLORONAPHTHALENE	ND	30.
88-74-4	2-NITROANILINE	ND	200.
131-11-3	DIMETHYL PHTHALATE	ND	30.
208-96-8	ACENAPHTHYLENE	ND	30.
99-09-2	3-NITROANILINE	ND	200.
83-32-9	ACENAPHTHENE	ND	30.
51-28-5	2,4-DINITROPHENOL	ND	200.
100-02-7	4-NITROPHENOL	ND	200.
132-64-9	DIBENZOFURAN	ND	30.
121-14-2	2,4-DINITROTOLUENE	ND	30.
606-20-2	2,6-DINITROTOLUENE	ND	30.

WEST COAST ANALYTICAL SERVICE, INC.

CLIENT: EARTH TECHNOLOGY CORP.
 SITE: METRO RAIL
 SAMPLE: 303-6-30
 ANALYSIS TYPE: EPA METHOD 8240 (624)

ORGANICS ANALYSIS DATA RESULTS

DATE RECEIVED: 06/30/87 GCMS FILENAME: 6385V1
 LEVEL: LOW MATRIX: SOIL
 DATE PREPARED: 07/08/87 DATE ANALYZED: 07/08/87
 STANDARD ID: VOA358 INSTRUMENT ID: 5101
 SAMPLE AMOUNT: 1.00G

CAS #	COMPOUND	CONC: UG/KG (PPB)	DETECTION LIMIT
74-87-3	CHLOROMETHANE	ND	30.
74-83-9	BROMOMETHANE	ND	30.
75-01-4	VINYL CHLORIDE	ND	30.
75-00-3	CHLOROETHANE	ND	30.
75-09-2	METHYLENE CHLORIDE	ND	50.
67-64-1	ACETONE	ND	50.
107-02-8	ACROLEIN	ND	50.
107-13-1	ACRYLONITRILE	ND	50.
75-15-0	CARBON DISULFIDE	ND	5.
75-35-4	1,1-DICHLOROETHENE	ND	5.
75-34-3	1,1-DICHLOROETHANE	ND	5.
156-60-5	TRANS-1,2-DICHLOROETHENE	ND	5.
109-99-9	TETRAHYDROFURAN	ND	5.
75-69-4	TRICHLOROFLUOROMETHANE	ND	5.
76-13-1	FREON-TF	ND	5.
106-93-4	ETHYLENE DIBROMIDE	ND	5.
123-91-1	1,4-DIOXANE	ND	5.
96-12-8	1,2-DIBROMO-3-CHLOROPROPANE	ND	5.
67-66-3	CHLOROFORM	ND	5.
107-06-2	1,2-DICHLOROETHANE	ND	5.
78-93-3	2-BUTANONE	ND	50.
71-55-6	1,1,1-TRICHLOROETHANE	ND	5.
16-23-5	CARBON TETRACHLORIDE	ND	5.
108-05-4	VINYL ACETATE	ND	30.
75-27-4	BROMODICHLOROMETHANE	ND	5.
79-34-5	1,1,2,2-TETRACHLOROETHANE	ND	5.
78-87-5	1,2-DICHLOROPROPANE	ND	5.
10061-02-6	TRANS-1,3-DICHLOROPROPENE	ND	5.
79-01-6	TRICHLOROETHENE	ND	5.
124-48-1	DIBROMOCHLOROMETHANE	ND	5.
79-00-5	1,1,2-TRICHLOROETHANE	ND	5.
71-43-2	BENZENE	ND	5.
10061-01-5	CIS-1,3-DICHLOROPROPENE	ND	5.
110-75-8	2-CHLOROETHYL VINYL ETHER	ND	50.
75-25-2	BROMOFORM	ND	5.
119-78-6	2-HEXANONE	ND	30.
108-10-1	4-METHYL-2-PENTANONE	ND	30.
127-18-4	TETRACHLOROETHENE	ND	5.
108-88-3	TOLUENE	ND	5.

July 14, 1987

THE EARTH TECHNOLOGY CORP.
3777 Long Beach Blvd.
Long Beach, CA 90807

Attn: Allison Urbon

JOB NO. 6385

WCAS
WEST COAST
ANALYTICAL
SERVICE, INC.

LABORATORY REPORT

Samples: One (1) soil sample from previous WCAS job # 6240
Date Received: 6-30-87
Purchase Order No: 87-885-0003

The sample was analyzed as follows:

<u>Sample</u>	<u>Analysis</u>	<u>Results</u>
303-6-30	Volatile organics by EPA 8240	Data Sheets
303-6-30	Semi-volatile organics by EPA 8270	Data Sheets
303-6-30	Organochlorine pesticides and PCB's by EPA 8080	Data Sheets

Page 1 of 1


Michael Shelton
Senior Chemist


D.J. Northington, Ph.D.
Technical Director

WEST COAST ANALYTICAL SERVICE, INC.

CLIENT: EARTH TECHNOLOGY
 SITE: METRO RAIL
 SAMPLE: 303-W-35
 ANALYSIS TYPE: EPA METHOD 625 (8270)

ORGANICS ANALYSIS DATA RESULTS

DATE RECEIVED: 06/16/87 GCMS FILENAME: 6240B2
 LEVEL: LOW MATRIX: WATER
 DATE PREPARED: 06/18/87 DATE ANALYZED: 07/01/87
 STANDARD ID: BNAZ151 INSTRUMENT ID: 4500
 SAMPLE AMOUNT: 500ML:10ML

CAS #	COMPOUND	CONC: UG/L (PPB)	DETECTION LIMIT
84-66-2	DIETHYL PHTHALATE	ND	20.
7005-72-3	4-CHLOROPHENYL PHENYL ETHER	ND	20.
86-73-7	FLUORENE	18. TR	20.
100-01-6	4-NITROANILINE	ND	100.
534-52-1	4,6-DINITRO-2-METHYLPHENOL	ND	100.
86-30-6	N-NITROSODIPHENYLAMINE	ND	20.
101-55-3	4-BROMOPHENYL PHENYL ETHER	ND	20.
118-74-1	HEXACHLOROBENZENE	ND	20.
87-86-5	PENTACHLOROPHENOL	ND	100.
85-01-8	PHENANTHRENE	26.	20.
120-12-7	ANTHRACENE	ND	20.
84-74-2	DI-N-BUTYL PHTHALATE	ND	20.
206-44-0	FLUORANTHENE	110.	20.
129-00-0	PYRENE	100.	20.
85-68-7	BUTYL BENZYL PHTHALATE	ND	20.
91-94-1	3,3'-DICHLOROBENZIDINE	ND	40.
56-55-3	BENZO(A) ANTHRACENE	ND	20.
117-81-7	BIS(2-ETHYLHEXYL) PHTHALATE	ND	20.
218-01-9	CHRYSENE	ND	20.
117-84-0	DI-N-OCTYL PHTHALATE	ND	20.
205-99-2	BENZO(B & K) FLUORANTHENES	ND	20.
50-32-8	BENZO(A) PYRENE	ND	20.
193-39-5	INDENO(1,2,3-CD) PYRENE	ND	20.
53-70-3	DIBENZO(A,H) ANTHRACENE	ND	20.
191-24-2	BENZO(GHI) PERYLENE	ND	20.

July 3, 1987

WCAS
WEST COAST
ANALYTICAL
SERVICE, INC.

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

Attn: Ms. Allison Urbon

JOB NO. 6240

LABORATORY REPORT

Samples: One (1) Water Sample, Fifteen (15) Soil Samples
Date Received: June 16, 1987
Purchase Order No: 87-885-0003/ Metro Rail

The one (1) water sample was analyzed for semi-volatile organic compounds using GCMS according to EPA Method 625. Results of this analysis are given on the enclosed Organic Analysis Data Results Sheets.

The sample was also analyzed for Total Petroleum Hydrocarbons according to EPA Method 418.1, for sulfide according to EPA method 9030, for sulfate using ion chromatography, and for pH using an Altex 70 pH meter. These results are reported below.

	<u>303-W-35</u>	<u>Detection</u> <u>Limit</u>	<u>Date</u> <u>Analyzed</u>
Total Petroleum Hydrocarbon, ppm	52	10	6/18/87
Sulfide, ppm	ND	0.02	6/19/87
Sulfate, ppm	860	10	6/24/87
pH	8.0	-	6/18/87

ND - Not Detected
ppm - parts per million

Page 1 of 1

Mary C. Stadel
for Michael Shelton
Senior Chemist

D.J. Northington
D.J. Northington, Ph.D.
Technical Director

WEST COAST ANALYTICAL SERVICE, INC.

CLIENT: EARTH TECHNOLOGY
 SITE: METRO RAIL
 SAMPLE: 304-W-35
 ANALYSIS TYPE: EPA METHOD 625 (8270)

ORGANICS ANALYSIS DATA RESULTS

DATE RECEIVED: 06/18/87 GCMS FILENAME: 6268B2
 LEVEL: LOW MATRIX: WATER
 DATE PREPARED: 06/25/87 DATE ANALYZED: 07/01/87
 STANDARD ID: BNAZ151 INSTRUMENT ID: 4500
 SAMPLE AMOUNT: 500ML:1ML

CAS #	COMPOUND	CONC: UG/L (PPB)	DETECTION LIMIT
84-66-2	DIETHYL PHTHALATE	0. TR	2.
7005-72-3	4-CHLOROPHENYL PHENYL ETHER	ND	2.
86-73-7	FLUORENE	52.	2.
100-01-6	4-NITROANILINE	ND	10.
534-52-1	4,6-DINITRO-2-METHYLPHENOL	ND	10.
86-30-6	N-NITROSODIPHENYLAMINE	ND	2.
101-55-3	4-BROMOPHENYL PHENYL ETHER	ND	2.
118-74-1	HEXACHLOROBENZENE	ND	2.
87-86-5	PENTACHLOROPHENOL	ND	10.
85-01-8	PHENANTHRENE	22.	2.
120-12-7	ANTHRACENE	8.	2.
84-74-2	DI-N-BUTYL PHTHALATE	ND	2.
206-44-0	FLUORANTHENE	9.	2.
129-00-0	PYRENE	6.	2.
85-68-7	BUTYL BENZYL PHTHALATE	ND	2.
91-94-1	3,3'-DICHLOROBENZIDINE	ND	4.
56-55-3	BENZO(A) ANTHRACENE	ND	2.
117-81-7	BIS(2-ETHYLHEXYL) PHTHALATE	ND	2.
218-01-9	CHRYSENE	ND	2.
117-84-0	DI-N-OCTYL PHTHALATE	ND	2.
205-99-2	BENZO(B & K) FLUORANTHENES	ND	2.
50-32-8	BENZO(A) PYRENE	ND	2.
193-39-5	INDENO(1,2,3-CD) PYRENE	ND	2.
53-70-3	DIBENZO(A,H) ANTHRACENE	ND	2.
191-24-2	BENZO(GHI) PERYLENE	ND	2.

July 3, 1987

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

Attn: Ms. Allison Uron

JOB NO. 6268

WCAS

**WEST COAST
ANALYTICAL
SERVICE, INC.**

LABORATORY REPORT

Samples: One (1) Water Sample, Twenty-Eight (28) Soil Samples
Date Received: June 18, 1987
Purchase Order No: 87-858-0003/Metro Rail

The water sample was analyzed for semi-volatile organic compounds using GCMS according to EPA Method 625. Results of this analysis are given on the enclosed Organic Analysis Data Results Sheets.

The sample was also analyzed for Total Petroleum Hydrocarbons according to EPA Method 418.1, for sulfide according to EPA Method 9030, for sulfate using ion chromatography and for pH using an Altex 70 pH meter. These results are given below.

	<u>304-W-35</u>	<u>Detection Limit</u>	<u>Date Analyzed</u>
Total Petroleum Hydrocarbons, ppm	ND	5	6/30/87
Sulfide, ppm	ND	0.1	6/25/87
Sulfate, ppm	1400	100	6/25/87
pH	6.9	-	6/25/87

ND - Not Detected
ppm - parts per million

Page 1 of 1

May C. Stadel
for Michael Shelton
Senior Chemist

D.J. Northington
D.J. Northington, Ph.D.
Technical Director

WEST COAST ANALYTICAL SERVICE, INC.

CLIENT: EARTH TECHNOLOGY CORP.
 SITE: METRO RAIL
 SAMPLE: INW
 ANALYSIS TYPE: EPA METHOD 625 (8270)

ORGANICS ANALYSIS DATA RESULTS

DATE RECEIVED: 06/08/87 GCMS FILENAME: 6153B4
 LEVEL: LOW MATRIX: WATER
 DATE PREPARED: 06/16/87 DATE ANALYZED: 06/17/87
 STANDARD ID: BNAZ137 INSTRUMENT ID: 4500
 SAMPLE AMOUNT: 1L:1ML

CAS #	COMPOUND	CONC: UG/L (PPB)	DETECTION LIMIT
84-66-2	DIETHYL PHTHALATE	ND	1.
7005-72-3	4-CHLOROPHENYL PHENYL ETHER	ND	1.
86-73-7	FLUORENE	ND	1.
100-01-6	4-NITROANILINE	ND	5.
534-52-1	4,6-DINITRO-2-METHYLPHENOL	ND	5.
86-30-6	N-NITROSODIPHENYLAMINE	ND	1.
101-55-3	4-BROMOPHENYL PHENYL ETHER	ND	1.
118-74-1	HEXACHLOROBENZENE	ND	1.
87-86-5	PENTACHLOROPHENOL	ND	5.
85-01-8	PHENANTHRENE	ND	1.
120-12-7	ANTHRACENE	ND	1.
84-74-2	DI-N-BUTYL PHTHALATE	1.	1.
206-44-0	FLUORANTHENE	ND	1.
129-00-0	PYRENE	ND	1.
85-68-7	BUTYL BENZYL PHTHALATE	ND	1.
91-94-1	3,3'-DICHLOROBENZIDINE	ND	2.
56-55-3	BENZO(A) ANTHRACENE	ND	1.
117-81-7	BIS(2-ETHYLHEXYL) PHTHALATE	ND	1.
218-01-9	CHRYSENE	ND	1.
117-84-0	DI-N-OCTYL PHTHALATE	ND	1.
205-99-2	BENZO(B & K) FLUORANTHENES	ND	1.
50-32-8	BENZO(A) PYRENE	ND	1.
193-39-5	INDENO(1,2,3-CD) PYRENE	ND	1.
53-70-3	DIBENZO(A,H) ANTHRACENE	ND	1.
191-24-2	BENZO(GHI) PERYLENE	ND	1.

WEST COAST ANALYTICAL SERVICE, INC.

CLIENT: EARTH TECHNOLOGY CORP.
SITE: METRO RAIL
SAMPLE: 302-6-30

TENTATIVELY IDENTIFIED COMPOUNDS

COMPOUND NAME	FRACTION	CONCENTRATION UG/KG (PPB)
1 NONE FOUND	VOA/BNA	

WEST COAST ANALYTICAL SERVICE, INC.

CLIENT: EARTH TECHNOLOGY CORP.
 SITE: METRO RAIL
 SAMPLE: 302-6-30
 ANALYSIS TYPE: EPA METHOD 625 (8270)

ORGANICS ANALYSIS DATA RESULTS

DATE RECEIVED: 06/08/87 GCMS FILENAME: 6153B2
 LEVEL: LOW MATRIX: SOIL
 DATE PREPARED: 06/16/87 DATE ANALYZED: 06/17/87
 STANDARD ID: BNAZ136 INSTRUMENT ID: 4500
 SAMPLE AMOUNT: 30G:1ML

CAS #	COMPOUND	CONC: UG/KG (PPB)	DETECTION LIMIT
108-95-2	PHENOL	ND	30.
111-44-4	BIS(2-CHLOROETHYL) ETHER	ND	30.
95-57-8	2-CHLOROPHENOL	ND	30.
541-73-1	1,3-DICHLOROBENZENE	ND	30.
106-46-7	1,4-DICHLOROBENZENE	ND	30.
100-51-6	BENZYL ALCOHOL	ND	30.
95-50-1	1,2-DICHLOROBENZENE	ND	30.
95-48-7	2-METHYLPHENOL	ND	30.
39638-32-9	BIS(2-CHLOROISOPROPYL) ETHER	ND	30.
106-44-5	4-METHYLPHENOL	ND	30.
621-64-7	N-NITROSODIPROPYLAMINE	ND	30.
67-72-1	HEXACHLOROETHANE	ND	30.
98-95-3	NITROBENZENE	ND	30.
78-59-1	ISOPHORONE	ND	30.
88-75-5	2-NITROPHENOL	ND	30.
105-67-9	2,4-DIMETHYLPHENOL	ND	30.
65-85-0	BENZOIC ACID	ND	200.
111-91-1	BIS(2-CHLOROETHOXY) METHANE	ND	30.
120-33-2	2,4-DICHLOROPHENOL	ND	30.
120-82-1	1,2,4-TRICHLOROBENZENE	ND	30.
91-20-3	NAPHTHALENE	ND	30.
106-47-8	4-CHLOROANILINE	ND	30.
87-68-3	HEXACHLOROBUTADIENE	ND	30.
59-50-7	4-CHLORO-3-METHYLPHENOL	ND	30.
91-57-6	2-METHYLNAPHTHALENE	ND	30.
77-47-4	HEXACHLOROCYCLOPENTADIENE	ND	30.
88-06-2	2,4,6-TRICHLOROPHENOL	ND	30.
95-95-4	2,4,5-TRICHLOROPHENOL	ND	200.
91-58-7	2-CHLORONAPHTHALENE	ND	30.
88-74-4	2-NITROANILINE	ND	200.
131-11-3	DIMETHYL PHTHALATE	ND	30.
208-96-8	ACENAPHTHYLENE	ND	30.
99-09-2	3-NITROANILINE	ND	200.
83-32-9	ACENAPHTHENE	ND	30.
51-28-5	2,4-DINITROPHENOL	ND	200.
100-02-7	4-NITROPHENOL	ND	200.
132-64-9	DIBENZOFURAN	ND	30.
121-14-2	2,4-DINITROTOLUENE	ND	30.
606-20-2	2,6-DINITROTOLUENE	ND	30.

WEST COAST ANALYTICAL SERVICE, INC.

CLIENT: EARTH TECHNOLOGY CORP.
 SAMPLE: 302-6-30
 ANALYSIS TYPE: EPA METHOD 8240 (624)

ORGANICS ANALYSIS DATA RESULTS

DATE RECEIVED: 06/08/87 GCMS FILENAME: 6153V2
 LEVEL: LOW MATRIX: SOIL
 DATE PREPARED: 06/15/87 DATE ANALYZED: 06/15/87
 STANDARD ID: VOA341 INSTRUMENT ID: 5101
 SAMPLE AMOUNT: 1.00G

CAS #	COMPOUND	CONC: UG/KG (PPB)	DETECTION LIMIT
74-87-3	CHLOROMETHANE	ND	30.
74-83-9	BROMOMETHANE	ND	30.
75-01-4	VINYL CHLORIDE	ND	30.
75-00-3	CHLOROETHANE	ND	30.
75-09-2	METHYLENE CHLORIDE	ND	50.
67-64-1	ACETONE	ND	50.
107-02-8	ACROLEIN	ND	50.
107-13-1	ACRYLONITRILE	ND	50.
75-15-0	CARBON DISULFIDE	ND	5.
75-35-4	1,1-DICHLOROETHENE	ND	5.
75-34-3	1,1-DICHLOROETHANE	ND	5.
156-60-5	TRANS-1,2-DICHLOROETHENE	ND	5.
109-99-9	TETRAHYDROFURAN	ND	5.
75-69-4	TRICHLOROFLUOROMETHANE	ND	5.
76-13-1	FREON-TF	6.	5.
106-93-4	ETHYLENE DIBROMIDE	ND	5.
123-91-1	1,4-DIOXANE	ND	5.
96-12-8	1,2-DIBROMO-3-CHLOROPROPANE	ND	5.
67-66-3	CHLOROFORM	ND	5.
107-06-2	1,2-DICHLOROETHANE	ND	5.
78-93-3	2-BUTANONE	ND	50.
71-55-6	1,1,1-TRICHLOROETHANE	ND	5.
16-23-5	CARBON TETRACHLORIDE	ND	5.
108-05-4	VINYL ACETATE	ND	30.
75-27-4	BROMODICHLOROMETHANE	ND	5.
79-34-5	1,1,2,2-TETRACHLOROETHANE	ND	5.
78-87-5	1,2-DICHLOROPROPANE	ND	5.
10061-02-6	TRANS-1,3-DICHLOROPROPENE	ND	5.
79-01-6	TRICHLOROETHENE	ND	5.
124-48-1	DIBROMOCHLOROMETHANE	ND	5.
79-00-5	1,1,2-TRICHLOROETHANE	ND	5.
71-43-2	BENZENE	ND	5.
10061-01-5	CIS-1,3-DICHLOROPROPENE	ND	5.
110-75-8	2-CHLOROETHYL VINYL ETHER	ND	50.
75-25-2	BROMOFORM	ND	5.
119-78-6	2-HEXANONE	ND	30.
108-10-1	4-METHYL-2-PENTANONE	ND	30.
127-18-4	TETRACHLOROETHENE	ND	5.
108-88-3	TOLUENE	ND	5.

WEST COAST ANALYTICAL SERVICE, INC.

CLIENT: EARTH TECHNOLOGY CORP.
 SAMPLE: INW
 ANALYSIS TYPE: EPA METHOD 8240 (624)

ORGANICS ANALYSIS DATA RESULTS

DATE RECEIVED: 06/08/87 GCMS FILENAME: 6153V1
 LEVEL: LOW MATRIX: WATER
 DATE PREPARED: 06/15/87 DATE ANALYZED: 06/15/87
 STANDARD ID: VOA341 INSTRUMENT ID: 5101
 SAMPLE AMOUNT: 5ML

CAS #	COMPOUND	CONC: UG/L (PPB)	DETECTION LIMIT
74-87-3	CHLOROMETHANE	ND	5.
74-83-9	BROMOMETHANE	ND	5.
75-01-4	VINYL CHLORIDE	ND	5.
75-00-3	CHLOROETHANE	ND	5.
75-09-2	METHYLENE CHLORIDE	ND	10.
67-64-1	ACETONE	ND	10.
107-02-8	ACROLEIN	ND	10.
107-13-1	ACRYLONITRILE	ND	10.
75-15-0	CARBON DISULFIDE	ND	1.
75-35-4	1,1-DICHLOROETHENE	ND	1.
75-34-3	1,1-DICHLOROETHANE	ND	1.
156-60-5	TRANS-1,2-DICHLOROETHENE	ND	1.
109-99-9	TETRAHYDROFURAN	ND	1.
75-69-4	TRICHLOROFLUOROMETHANE	ND	1.
76-13-1	FREON-TF	1.	1.
106-93-4	ETHYLENE DIBROMIDE	ND	1.
123-91-1	1,4-DIOXANE	ND	1.
96-12-8	1,2-DIBROMO-3-CHLOROPROPANE	ND	1.
67-66-3	CHLOROFORM	5.	1.
107-06-2	1,2-DICHLOROETHANE	ND	1.
78-93-3	2-BUTANONE	ND	10.
71-55-6	1,1,1-TRICHLOROETHANE	1.	1.
16-23-5	CARBON TETRACHLORIDE	ND	1.
108-05-4	VINYL ACETATE	ND	5.
75-27-4	BROMODICHLOROMETHANE	12.	1.
79-34-5	1,1,2,2-TETRACHLOROETHANE	ND	1.
78-87-5	1,2-DICHLOROPROPANE	ND	1.
10061-02-6	TRANS-1,3-DICHLOROPROPENE	ND	1.
79-01-6	TRICHLOROETHENE	1.	1.
124-48-1	DIBROMOCHLOROMETHANE	21.	1.
79-00-5	1,1,2-TRICHLOROETHANE	ND	1.
71-43-2	BENZENE	ND	1.
10061-01-5	CIS-1,3-DICHLOROPROPENE	ND	1.
110-75-8	2-CHLOROETHYL VINYL ETHER	ND	10.
75-25-2	BROMOFORM	15.	1.
119-78-6	2-HEXANONE	ND	5.
108-10-1	4-METHYL-2-PENTANONE	ND	5.
127-18-4	TETRACHLOROETHENE	ND	1.
108-88-3	TOLUENE	1.	1.

Laboratory WCAS

Sample EARTH TECHNOLOGY
302-6-30

Organics Analysis Data Sheet

Pesticides/PCBs

Concentration	-----	LOW	SOIL
Date Extracted/Prepared:	-----	16 JUN 87	
Date Analyzed:	-----	18 JUN 87	
Sample Volume/Weight:	-----	30	g
Total Extract Volume:	-----	10	mL
% Moisture:	-----	NA	
Conc/Dil Factor:	1:1		

CAS #

ug/Kg

319-85-6	Alpha-BHC	-----	1.7	ND
319-85-7	Beta-BHC	-----	1.7	ND
319-86-8	Delta-BHC	-----	1.7	ND
58-89-9	Gamma-BHC (Lindane)	-----	1.7	ND
76-44-8	Heptachlor	-----	1.7	ND
309-00-2	Aldrin	-----	1.7	ND
1024-57-3	Heptachlor Epoxide	-----	1.7	ND
959-98-8	Endosulfan I	-----	1.7	ND
60-57-1	Dieldrin	-----	3.3	ND
72-55-9	4,4'-DDE	-----	3.3	ND
72-20-8	Endrin	-----	3.3	ND
3321-65-9	Endosulfan II	-----	3.3	ND
72-54-8	4,4'-DDD	-----	3.3	ND
7421-93-4	Endrin Aldehyde	-----	3.3	ND
1031-07-8	Endosulfan Sulfate	-----	3.3	ND
50-29-3	4,4'-DDT	-----	3.3	ND
72-43-5	Methoxychlor	-----	17	ND
53494-70-5	Endrin Ketone	-----	3.3	ND
57-74-9	Chlordane	-----	17	ND
8001-35-2	Toxaphene	-----	33	ND
12674-11-2	Arochlor-1016	-----	17	ND
11104-28-2	Arochlor-1221	-----	17	ND
11141-16-5	Arochlor-1232	-----	17	ND
53469-21-9	Arochlor-1242	-----	17	ND
12672-29-6	Arochlor-1248	-----	17	ND
11097-69-1	Arochlor-1254	-----	33	ND
11096-82-5	Arochlor-1260	-----	33	ND

ND - NOT DETECTED
NA - NOT ANALYZED

June 26, 1987

THE EARTH TECHNOLOGY CORP.
3777 Long Beach Blvd.
Long Beach, CA 90807

Attn: Allison Urbon

JOB NO. 6153

WCAS
WEST COAST
ANALYTICAL
SERVICE, INC.

LABORATORY REPORT

Samples: Two (2) water sample (INW and 302-W-35) and seven (7) soil samples

Date Received: 6-8-87

Purchase Order No: 87-885-0003/Metro Rail A-130

The samples were analyzed as follows:

<u>Samples</u>	<u>Method</u>	<u>Results</u>
INW, 302-6-30	Volatile Organics/EPA 624	Data Sheets
INW, 302-6-30	BNA's/EPA 625	Data Sheets
INW, 302-6-30	Pesticides/EPA 608	Data Sheets
INW, 302-W-35	Total Petroleum Hydrocarbons EPA 418.1	Table I
INW	Total Hydrocarbons/EPA 413.2	Table I
INW, 302-W-35	pH	Table I
INW	Total Suspended Solids	Table I
INW	Settleable Solids	Table I
IMW, 302-W-35	Sulfide/EPA 9030	Table I
INW	BOD/Probe Method	Table I
INW	Phenols	Table I
302-W-35	Pentachlorophenol	Table I
302-W-35	Sulfate	Table I

Page 1 of 2


Michael Shelton
Senior Chemist


D.J. Northington, Ph.D.
Technical Director

WEST COAST ANALYTICAL SERVICE, INC.

CLIENT: EARTH TECHNOLOGY
 SITE: METRO RAIL
 SAMPLE: 301-10-50
 ANALYSIS TYPE: EPA METHOD 625 (8270)

ORGANICS ANALYSIS DATA RESULTS

DATE RECEIVED: 06/02/87 GCMS FILENAME: 6093B2
 LEVEL: LOW MATRIX: SOIL
 DATE PREPARED: 06/08/87 DATE ANALYZED: 06/11/87
 STANDARD ID: BNAZ135 INSTRUMENT ID: 4500
 SAMPLE AMOUNT: 30G:1ML

CAS #	COMPOUND	CONC: UG/KG (PPB)	DETECTION LIMIT
84-66-2	DIETHYL PHTHALATE	ND	30.
7005-72-3	4-CHLOROPHENYL PHENYL ETHER	ND	30.
86-73-7	FLUORENE	ND	30.
100-01-6	4-NITROANILINE	ND	200.
534-52-1	4,6-DINITRO-2-METHYLPHENOL	ND	200.
86-30-6	N-NITROSODIPHENYLAMINE	ND	30.
101-55-3	4-BROMOPHENYL PHENYL ETHER	ND	30.
118-74-1	HEXACHLOROBENZENE	ND	30.
87-86-5	PENTACHLOROPHENOL	ND	200.
85-01-8	PHENANTHRENE	ND	30.
120-12-7	ANTHRACENE	ND	30.
84-74-2	DI-N-BUTYL PHTHALATE	ND	30.
206-44-0	FLUORANTHENE	ND	30.
129-00-0	PYRENE	ND	30.
85-68-7	BUTYL BENZYL PHTHALATE	ND	30.
91-94-1	3,3'-DICHLOROBENZIDINE	ND	70.
56-55-3	BENZO(A) ANTHRACENE	ND	30.
117-81-7	BIS(2-ETHYLHEXYL) PHTHALATE	ND	30.
218-01-9	CHRYSENE	ND	30.
117-84-0	DI-N-OCTYL PHTHALATE	ND	30.
205-99-2	BENZO(B & K) FLUORANTHENES	ND	30.
50-32-8	BENZO(A) PYRENE	ND	30.
193-39-5	INDENO(1,2,3-CD) PYRENE	ND	30.
53-70-3	DIBENZO(A,H) ANTHRACENE	ND	30.
191-24-2	BENZO(GHI) PERYLENE	ND	30.

WEST COAST ANALYTICAL SERVICE, INC.

CLIENT: EARTH TECHNOLOGY CORP.
SITE: METRO RAIL
SAMPLE: 301-10-50
ANALYSIS TYPE: EPA METHOD 8240 (624)

ORGANICS ANALYSIS DATA RESULTS

DATE RECEIVED: 06/02/87 GCMS FILENAME: 6093V1
LEVEL: LOW MATRIX: SOIL
DATE PREPARED: 06/12/87 DATE ANALYZED: 06/12/87
STANDARD ID: VOA502 INSTRUMENT ID: 5100
SAMPLE AMOUNT: 1.00G

CAS #	COMPOUND	CONC: UG/KG (PPB)	DETECTION LIMIT
108-90-7	CHLOROBENZENE	ND	5.
100-41-4	ETHYLBENZENE	ND	5.
100-42-5	STYRENE	ND	5.
95-47-6	TOTAL XYLENES	ND	5.
108-41-8	M-CHLOROTOLUENE	ND	5.
541-73-1	1,3-DICHLOROBENZENE	ND	5.
106-46-7	1,4-DICHLOROBENZENE	ND	5.
95-50-1	1,2-DICHLOROBENZENE	ND	5.

Laboratory WCAS

Sample EARTH TECHNOLOGY
301-10-50

Organics Analysis Data Sheet

Pesticides/PCBs

Concentration _____ LOW SOIL
Date Extracted/Prepared: _____ 09 JUN 87
Date Analyzed: _____ 12 JUN 87
Sample Volume/Weight: _____ 30 g
Total Extract Volume: _____ 10 mL
% Moisture: _____ NA
Conc/Dil Factor: 1:1

CAS #		ug/Kg	
319-85-6	Alpha-BHC _____	1.7	ND
319-85-7	Beta-BHC _____	1.7	ND
319-86-8	Delta-BHC _____	1.7	ND
58-89-9	Gamma-BHC (Lindane) _____	1.7	ND
76-44-8	Heptachlor _____	1.7	ND
309-00-2	Aldrin _____	1.7	ND
1024-57-3	Heptachlor Epoxide _____	1.7	ND
959-98-8	Endosulfan I _____	1.7	ND
60-57-1	Dieldrin _____	3.3	ND
72-55-9	4,4'-DDE _____	3.3	ND
72-20-8	Endrin _____	3.3	ND
3321-65-9	Endosulfan II _____	3.3	ND
72-54-8	4,4'-DDD _____	3.3	ND
7421-93-4	Endrin Aldehyde _____	3.3	ND
1031-07-8	Endosulfan Sulfate _____	3.3	ND
50-29-3	4,4'-DDT _____	3.3	ND
72-43-5	Methoxychlor _____	17	ND
53494-70-5	Endrin Ketone _____	3.3	ND
57-74-9	Chlordane _____	17	ND
8001-35-2	Toxaphene _____	33	ND
12674-11-2	Arochlor-1016 _____	17	ND
11104-28-2	Arochlor-1221 _____	17	ND
11141-16-5	Arochlor-1232 _____	17	ND
53469-21-9	Arochlor-1242 _____	17	ND
12672-29-6	Arochlor-1248 _____	17	ND
11097-69-1	Arochlor-1254 _____	33	ND
11096-82-5	Arochlor-1260 _____	33	ND

ND - NOT DETECTED
NA - NOT ANALYZED

APPENDIX G
PUMPING ANALYSES

APPENDIX G PUMPING ANALYSES

This appendix provides more detailed description of the simulation of the well-field dewatering system presented in Section 4.2 of this report. Seven cases were simulated to evaluate potential optimum arrangements of the well spacing and pumping rates. The objectives in the design of this dewatering system were:

- o To lower the water table along the proposed excavation and tunneling corridor
- o To minimize pumping rates
- o To minimize potential for migration of the contaminants toward dewatering wells.

Because this portion of the study was primarily for evaluation of the feasibility of a well-field dewatering system, only a trial-and-error method of analysis of the problem was used. For actual design of the dewatering well-field, it is recommended to use optimization routines to obtain the best results.

For this analysis, it was assumed that the aquifer is confined, infinite in lateral extent, and uniform in both thickness and hydraulic conductivity. The hydraulic conductivity values obtained from the field tests were used in the analysis to calculate layer transmissivity. The transmissivity (hydraulic conductivity x thickness) was calculated by adding the transmissivity of the possible semiperched aquitard, the gravel and cobbles layer, and the Gaspar Aquifer (5.5×10^{-4} , 1×10^{-5} , and 3.43×10^{-3} ft²/s respectively or an overall transmissivity of 3.99×10^{-3} ft²/s, 2,585 gpd/ft). A storage coefficient of 0.15 was assumed which is equivalent to the average porosity of the three layers. It was also assumed that the wells were acting as a line sink (or source in the case of injection wells) in the aquifer.

Seven cases were simulated which are summarized in Table G-1. The results of the dewatering cases listed in this table are shown in Figures G-1 through G-7. In all cases, there are two rows of pumping wells; 12 wells along the southwest side of the alignment and 13 along the northeast side. The injection wells for cases 3 to 7 are located midway between the northeast row and

TABLE G-1. SUMMARY OF THE VARIOUS SIMULATED DEWATERING SCHEMES

Case No.	Number of Wells @ discharge rates (in GPM)	Total Pumping rates (GPM)	Total Injection rates (GPM)	Net flow rates	Purpose of Simulation/Comment
1	25 @ 10GPM	250	---	250	To dewater the excavation area by more than 11 ft
2	23 @ 10GPM 2 @ 50GPM	330	---	330	To increase drawdown at the ends of the corridor
3	23 @ 10GPM 2 @ 50GPM 4 @ - 5GPM	330	-20	310	To prevent contaminant from migrating toward the excavation area
4	23 @ 10GPM 2 @ 50GPM 4 @ -10GPM	330	-40	290	To prevent contaminant from migrating toward the excavation area
5	23 @ 10GPM 2 @ 50GPM 7 @ -10GPM	330	-70	260	To prevent contaminant from migrating toward the excavation area
6	12 @ 30GPM 13 @ 10GPM 7 @ -10GPM	490	-70	420	To maintain the 11 ft of drawdown by increasing the pumpage at the southwest array of wells
7	12 @ 20GPM 13 @ 10GPM 7 @ -10GPM	370	-70	300	To maintain the 11 ft of drawdown by increasing the pumpage at the southwest array of wells. The most optimum case.

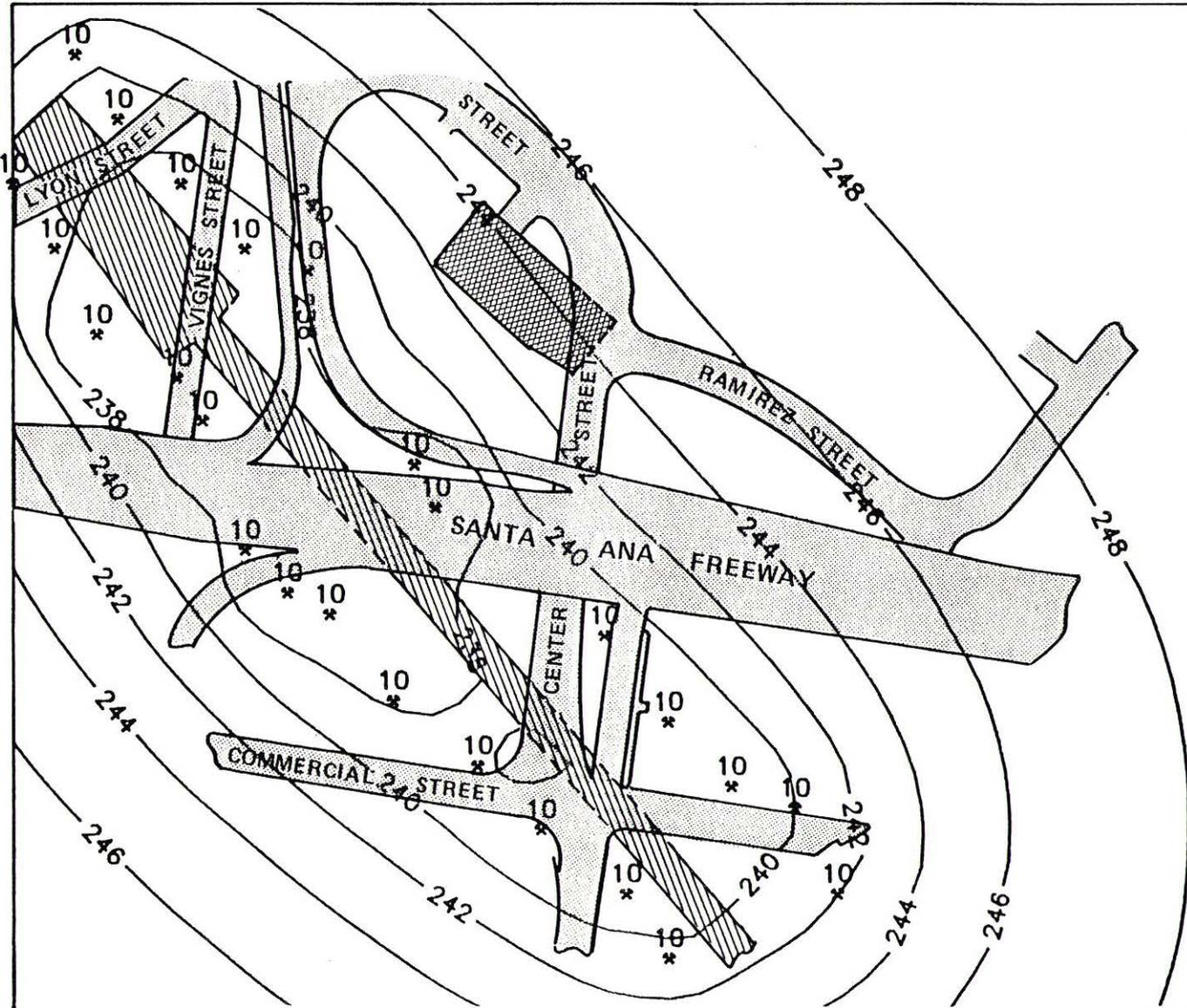
NOTES: 1) Duration of pumping was 40 days for all cases
2) Negative numbers indicate injection rates

the contaminated-water boundary. The first two cases were tried to determine the amount of pumpage required to lower the water table to the desired elevation. These cases are presented to facilitate future designs in case this method of dewatering is selected. The main concern in these two schemes was the potential migration of the contaminated water into the pumping wells. The second pumping scheme creates a gradient of 0.02 (2 feet per 100 feet) toward the dewatered area. This would increase the pore water velocity by a factor of 3 ($0.02/0.006$, induced/natural gradient). In other words, the contaminant would travel at an approximate velocity of 2.22 feet per day and would break through the closest well after about 100 days of pumping.

However, it may be possible that the travel time is longer because of the immiscible nature of the contaminant and the possible retardation properties of the aquifer.

Figures G-3 through G-7 show the cases where a series of injection wells are installed between the pumping wells and the contaminated area to reduce the possibility of contaminant migration toward the pumping wells. The first case with injection wells (Figure G-3) has about the same gradient (0.02 ft/ft) toward the pumping wells so injection rates were increased for the next case to 10 gpm (Figure G-4). In this case, the fastest travel time to the nearest well is estimated to be 54 days (shorter than without injection wells). In the next run (Figure G-5), the number of injection wells were increased to seven. In this case, the travel time to the nearest well is still 100 days. In Figures G-6 and G-7, the pumping rates were adjusted to improve the travel time; however, the fastest travel time to the closest well could not be increased to more than 100 days. This is mainly because of the proximity of the contaminated water to the dewatering wells. Further increase of the injection rates would move the contaminated water away from the dewatering wells. This effect is assumed not desirable because of potential spread of the contaminant to the northeast direction. It is possible to increase the length of the travel path of the contaminant by installing more injection wells along the line between the dewatering wells and the contaminated area. However, increase in number of injection wells would increase the pumpage required in the dewatering wells which could increase the cost of pumping and well installation substantially. A groundwater barrier, such as a slurry

wall, could be installed to prevent migration of the contaminants toward the dewatering wells and reduce or eliminate the need for injection wells. Such a barrier also would reduce the number of pumping wells and the pumpage required to dewater the corridor, especially if an additional barrier is installed along the southwest side of the corridor. A cost-benefit analysis will need to be conducted to evaluate the most optimum combination of pumping-injection wells and slurry wall.



NORTH

NOT TO SCALE

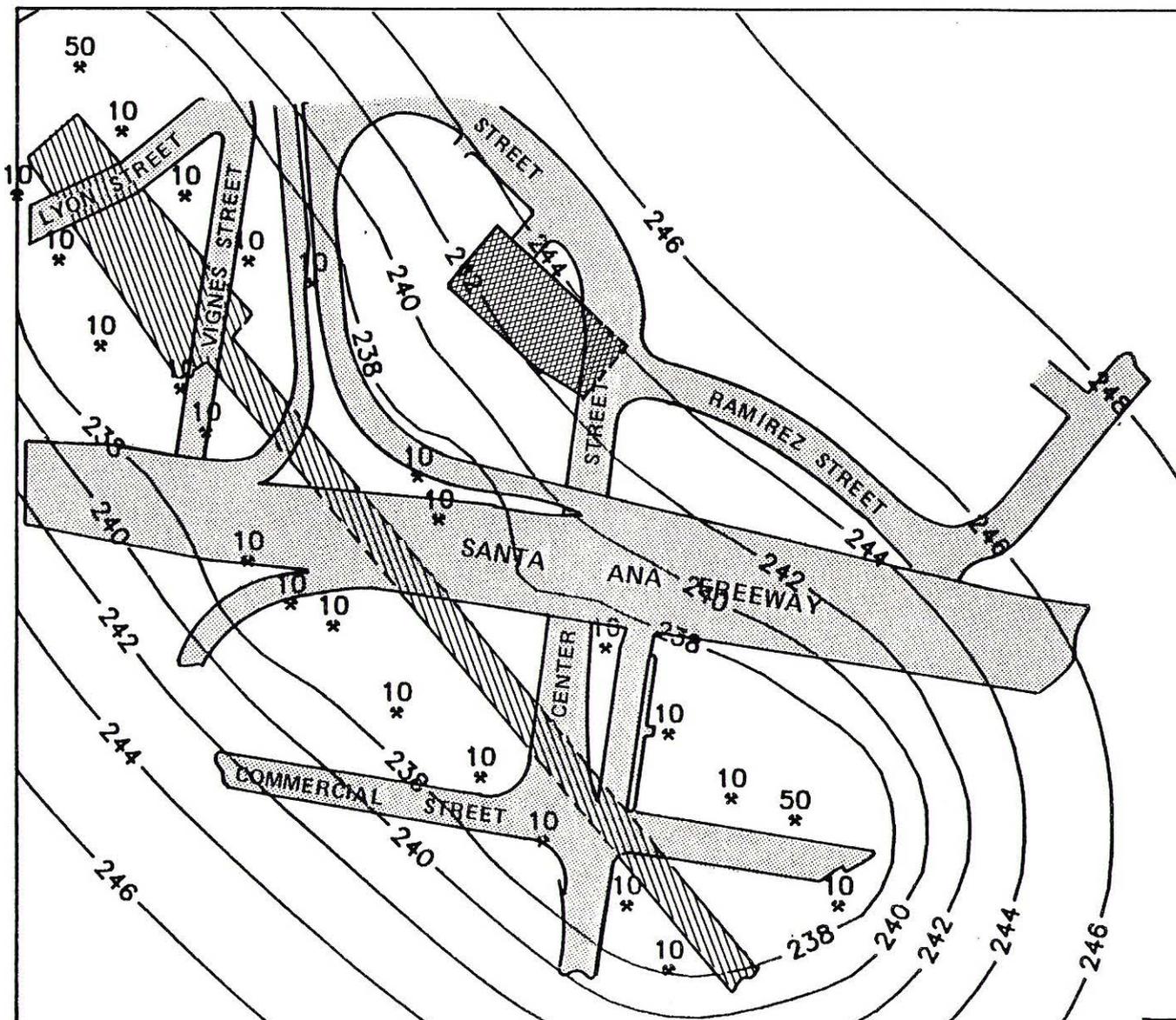
LEGEND :

-  ASSUMED BOUNDARY OF HIGHLY CONTAMINATED AREA (EARTH TECHNOLOGY, 1987b)
-  PORTION OF REALIGNED A-130 CORRIDOR
- 248- GROUNDWATER LEVEL ELEVATION, FEET
- 10 X LOCATION OF DEWATERING WELLS AND QUANTITY OF DISCHARGE IN GALLONS PER MINUTE

	PROJECT NO: 87 885
	METRO RAIL

DEWATERING CASE NUMBER 1

597



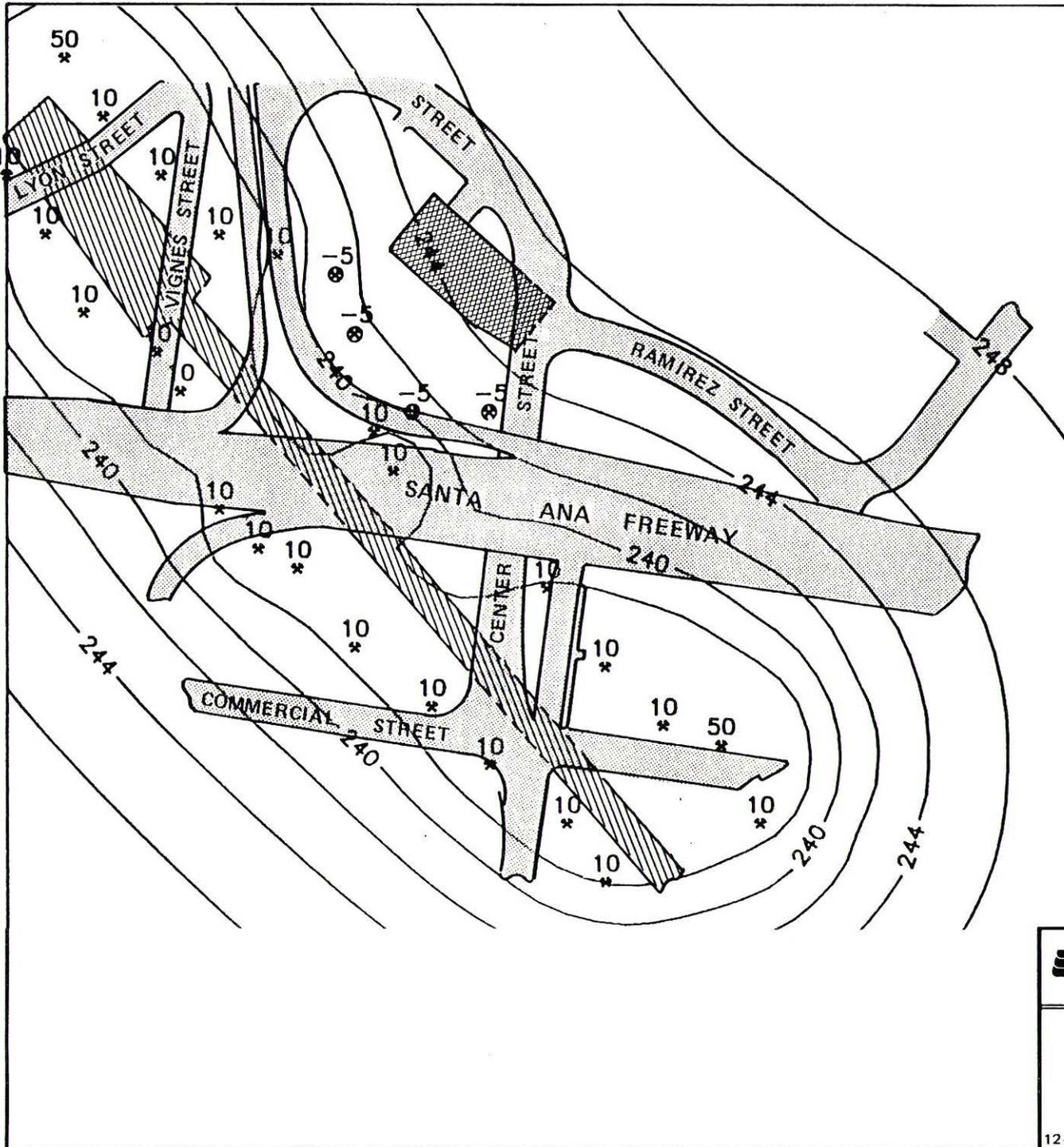
NORTH
NOT TO SCALE

LEGEND :

-  ASSUMED BOUNDARY OF HIGHLY CONTAMINATED AREA (EARTH TECHNOLOGY, 1987b)
-  PORTION OF REALIGNED A-130 CORRIDOR
- 248- GROUNDWATER LEVEL ELEVATION, FEET
- 10 X LOCATION OF DEWATERING WELLS AND QUANTITY OF DISCHARGE IN GALLONS PER MINUTE

	PROJECT NO: 87-885 METRO RAIL
DEWATERING CASE NUMBER 2	
12-87	FIGURE G-2

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NORTH
NOT TO SCALE

LEGEND :

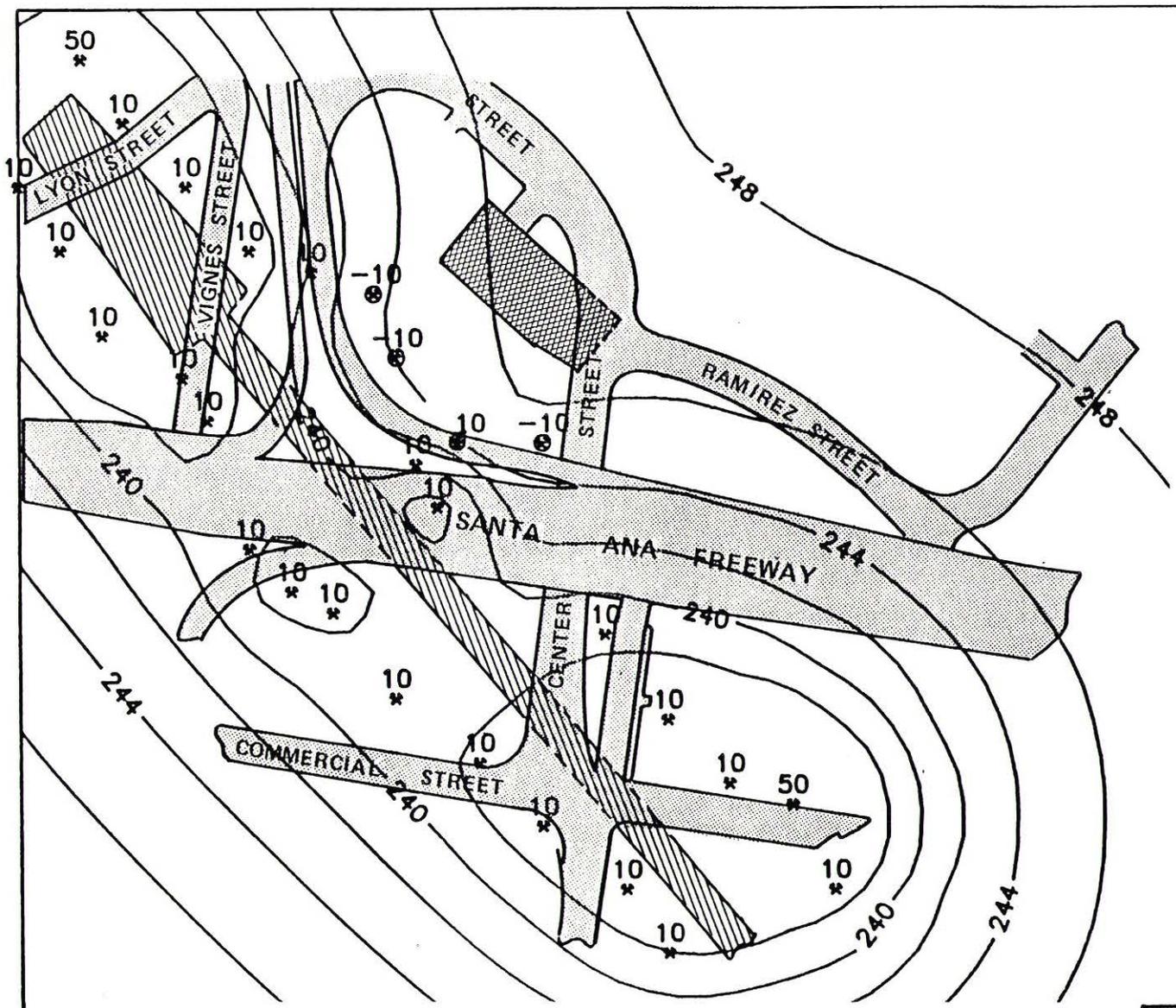
-  ASSUMED BOUNDARY OF HIGHLY CONTAMINATED AREA (EARTH TECHNOLOGY, 1987b)
-  PORTION OF REALIGNED A-130 CORRIDOR
- 248- GROUNDWATER LEVEL ELEVATION, FEET
- 10 X LOCATION OF DEWATERING WELLS AND QUANTITY OF DISCHARGE IN GALLONS PER MINUTE
- 5  LOCATION OF INJECTION WELLS AND QUANTITY OF RECHARGE IN GALLONS PER MINUTE



PROJECT NO: 87 885
METRO RAIL

DEWATERING CASE NUMBER 3

172




 NORTH
 NOT TO SCALE

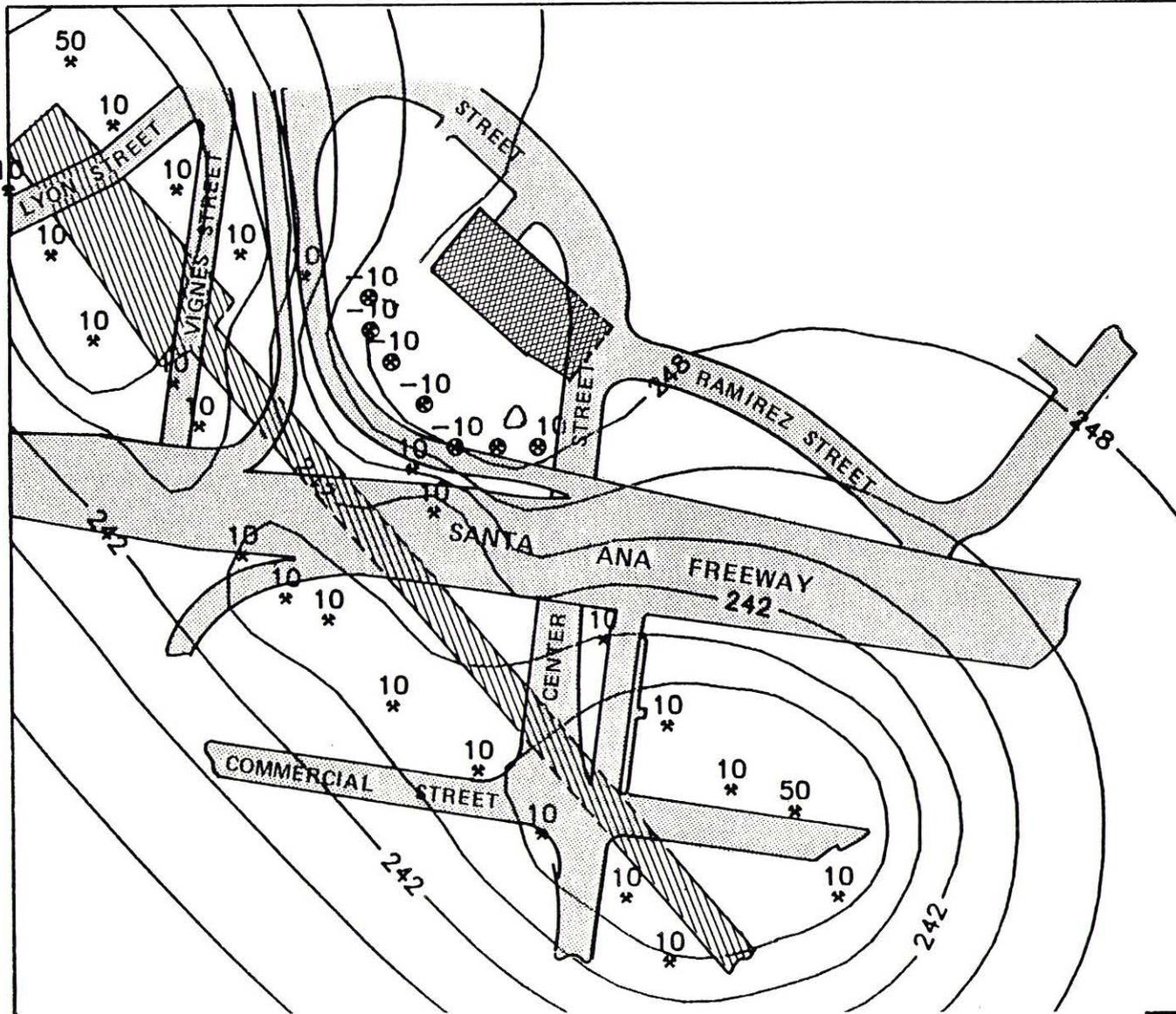
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-  ASSUMED BOUNDARY OF HIGHLY CONTAMINATED AREA (EARTH TECHNOLOGY, 1987b)
-  PORTION OF REALIGNED A-130 CORRIDOR
- 248- GROUNDWATER LEVEL ELEVATION, FEET
- 10 X LOCATION OF DEWATERING WELLS AND QUANTITY OF DISCHARGE IN GALLONS PER MINUTE
- 10 ⊗ LOCATION OF INJECTION WELLS AND QUANTITY OF RECHARGE IN GALLONS PER MINUTE

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PROJECT NO: 87 885
 METRO RAIL

DEWATERING CASE NUMBER 4



NORTH
NOT TO SCALE

LEGEND :

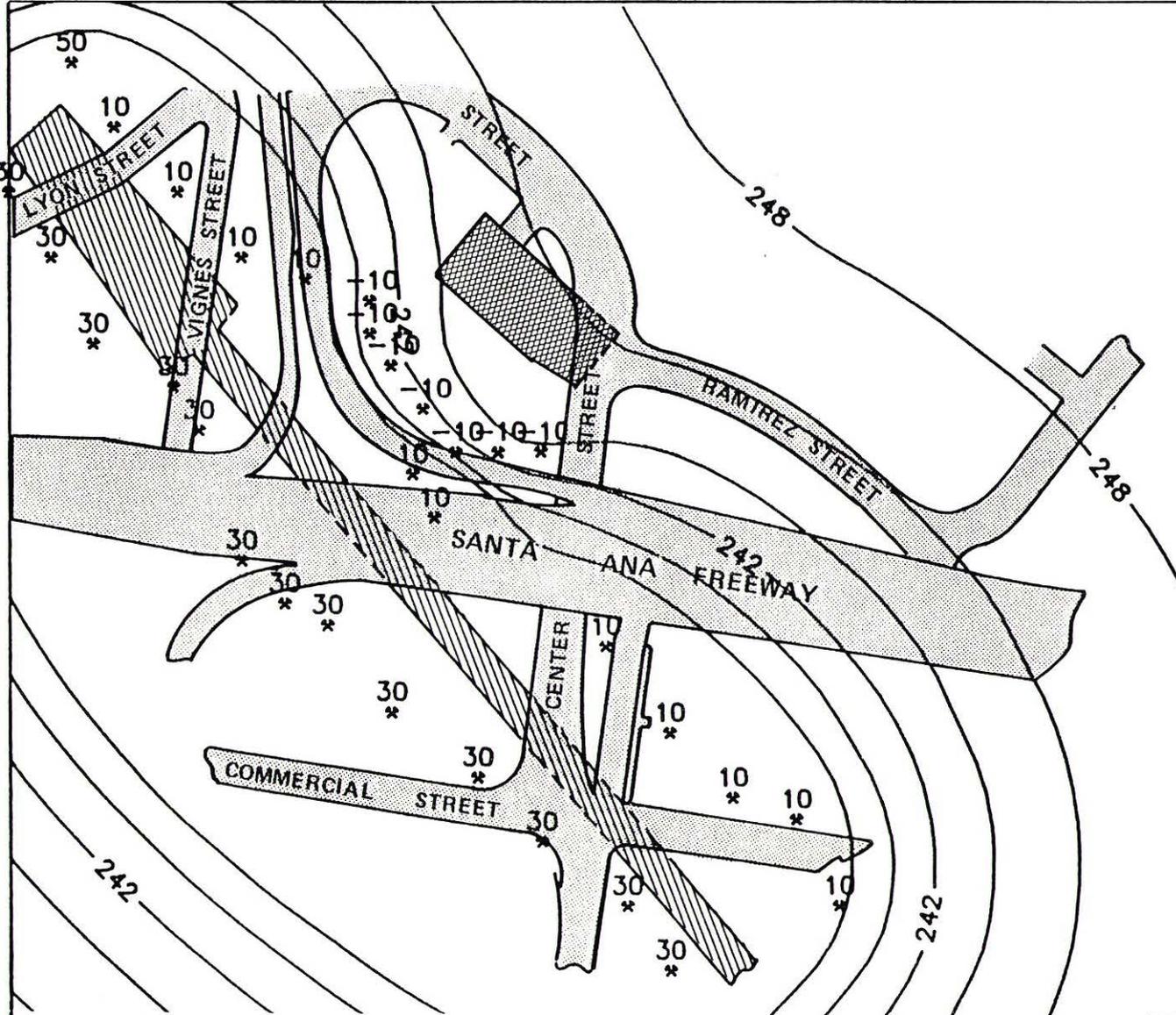
-  ASSUMED BOUNDARY OF HIGHLY CONTAMINATED AREA (EARTH TECHNOLOGY, 1987b)
-  PORTION OF REALIGNED A-130 CORRIDOR
- 248- GROUNDWATER LEVEL ELEVATION, FEET
- 10 X LOCATION OF DEWATERING WELLS AND QUANTITY OF DISCHARGE IN GALLONS PER MINUTE
- 10 ⊗ LOCATION OF INJECTION WELLS AND QUANTITY OF RECHARGE IN GALLONS PER MINUTE



PROJECT NO: 87-885
METRO RAIL

DEWATERING CASE NUMBER 5

672



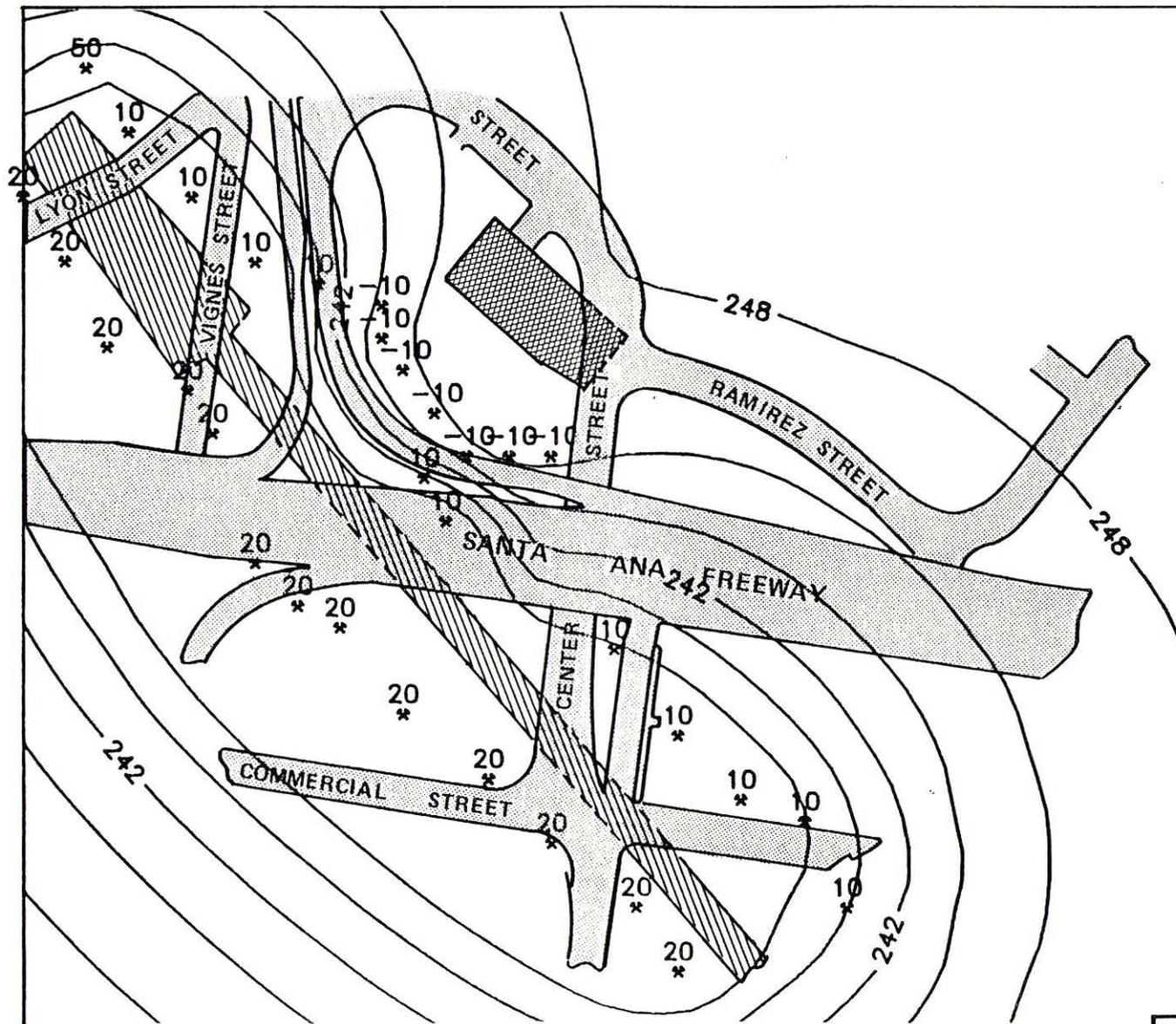
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-  ASSUMED BOUNDARY OF HIGHLY CONTAMINATED AREA (EARTH TECHNOLOGY, 1987b)
-  PORTION OF REALIGNED A-130 CORRIDOR
- 248- GROUNDWATER LEVEL ELEVATION, FEET
- 10 X LOCATION OF DEWATERING WELLS AND QUANTITY OF DISCHARGE IN GALLONS PER MINUTE
- 10 X LOCATION OF INJECTION WELLS AND QUANTITY OF RECHARGE IN GALLONS PER MINUTE



PROJECT NO: 87 885
METRO RAIL

DEWATERING CASE NUMBER 6




 NORTH
 NOT TO SCALE

LEGEND :

-  ASSUMED BOUNDARY OF HIGHLY CONTAMINATED AREA (EARTH TECHNOLOGY, 1987b)
-  PORTION OF REALIGNED A-130 CORRIDOR
- 248- GROUNDWATER LEVEL ELEVATION, FEET
- 10 X LOCATION OF DEWATERING WELLS AND QUANTITY OF DISCHARGE IN GALLONS PER MINUTE
- 10 X LOCATION OF INJECTION WELLS AND QUANTITY OF RECHARGE IN GALLONS PER MINUTE

	PROJECT NO: 87 885
METRO RAIL	
DEWATERING CASE NUMBER 7	
12-87	FIGURE G-7

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APPENDIX H
GEOTECHNICAL DESIGN CONSIDERATIONS

APPENDIX H
GEOTECHNICAL DESIGN CONSIDERATIONS

This appendix presents site soils engineering properties and values that may be required for the design of temporary and permanent structures.

Soil Properties: Table H-1 presents soil parameters used for the analyses in this study. These parameters were obtained from field and laboratory test results as well as published data and engineering judgement and interpretations. It should be noted that the site soils show a great degree of variability. Therefore, this fact should be considered when the values given in Table H-1 are used in analysis and design.

Design wall pressure: Estimated ground pressures for design of temporary excavation walls are presented in Figures H-1 and H-2. The design pressures are presented for dewatering as well as partial or no dewatering cases. Recommended ground pressure distribution for design of soldier piles is presented in Figure H-3. Recommended ground pressure distribution on permanent underground structures is presented in Figure H-4.

Drilled Pier Capacity - It is anticipated that piles will be required for support of temporary and permanent structures. Because of the subsurface soil conditions, installation of driven piles may be accompanied with some difficulties. In contrast, drilled piers are installed in Los Angeles area with relative ease. The ultimate unit capacities for shaft and tip resistance are presented in Figures H-5 and H-6, respectively, for drilled piers with embedment starting at the ground surface. For the drilled piers with embedments starting at elevations below the ground surface, i.e., bottom of the excavation, the ultimate unit capacities for shaft and tip resistance should be calculated. These values may be obtained by calculating the overburden pressure at points below the excavation bottom multiplied by appropriate coefficients (capacity = coefficient x overburden pressure). The values of these coefficients are presented in the following table.

Layer	<u>Ultimate Unit Capacity Coefficient, No Units</u>	
	Shaft Friction	Tip Resistance
Fill	0.27	8
Alluvium (Shallow)	0.35	25
Gravel and Cobble Zone	0.35	25
Alluvium (Deep)	0.38	43

The soil overburden pressure for pier capacity may be calculated using the values of soil density presented in Table H-1.

The ultimate lateral load capacity of drilled piers depends on the location of the loads and the resulting overturning moments, values which are not available at this time. When this information is determined, the ultimate lateral load capacity of the drilled piers can be calculated using the following equation:

$$P_U = \frac{A d_s L^3}{H + L}$$

- where
- P_U = the ultimate lateral load capacity in tons
 - A = a coefficient equal to 0.10 for embedment length above ground-water and equal to 0.06 for submerged piers; for intermediate groundwater levels use interpolation.
 - d_s = the diameter of the pier shaft in feet
 - L = the embedded length of the pier in feet
 - H = the distance of the resultant lateral load above the ground surface in feet

Tieback Anchors: As a preliminary estimate, the capacity of pressure-grouted straight shaft anchors for the site soils may be computed based on the following equation:

P = BDLH

where

P = ultimate anchor design load in tons

B = a coefficient equal to 0.005 for grout length fully above groundwater and equal to 0.004 for grout length fully submerged; for intermediate groundwater levels use interpolations

D = average shaft diameter in inches

L = average length of grout in feet

H = average depth of grout length L in feet

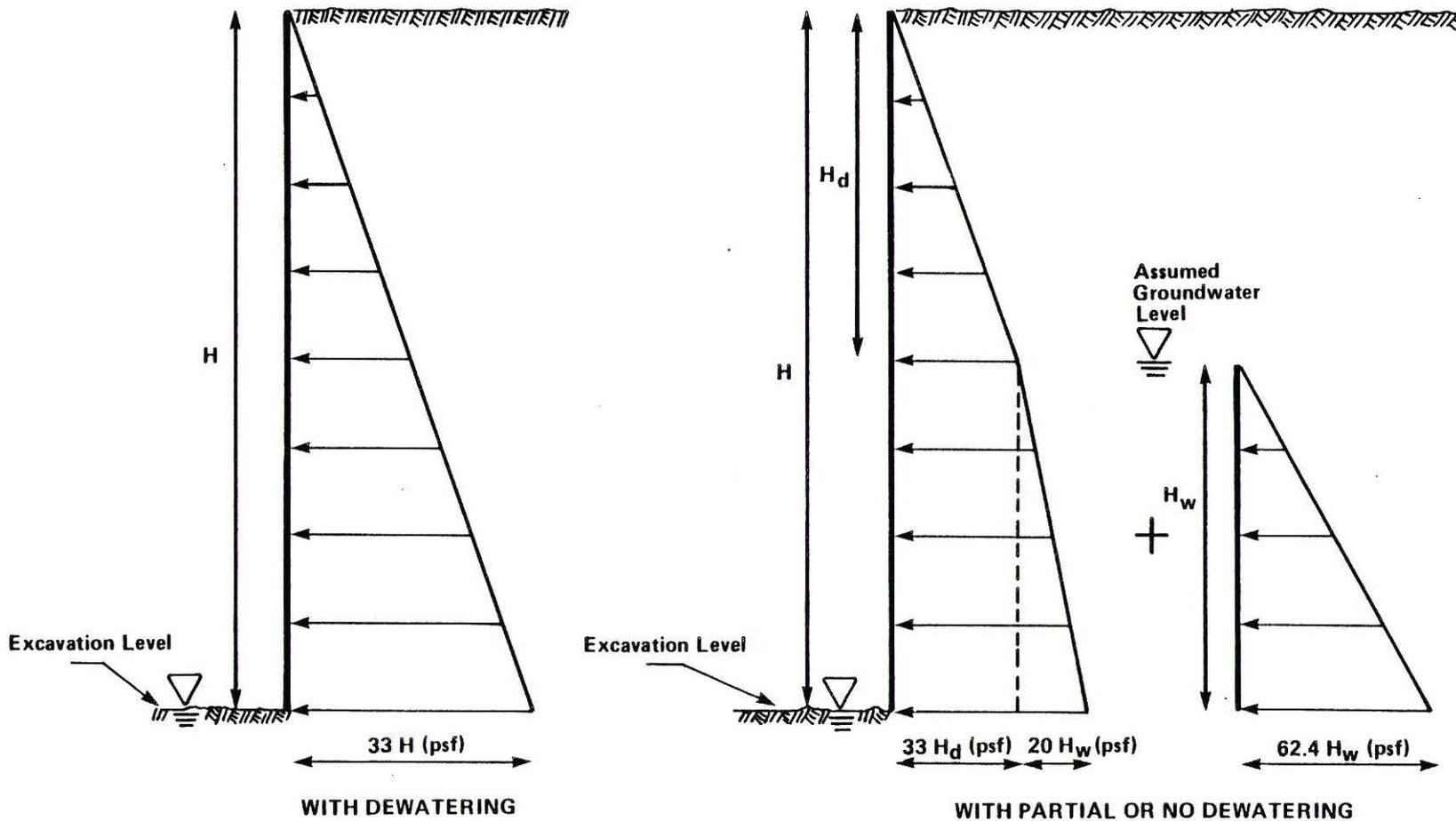
Anchors may be installed at angles ranging between 20 to 50 degrees below the horizontal. The effective grout length should be considered beyond a zone bounded by the shoring and a line drawn with a slope of 2:3 (horizontal: vertical) from the bottom of the excavation. Allowable tieback anchor capacity should be determined in the field based on anchor load tests. No frictional resistance should be assumed for the fill soils.

TABLE H-1. SITE SOILS ENGINEERING PROPERTIES

Properties	Fill	Alluvium (Shallow)	Gravel and Cobble Zone	Alluvium (Deep)
Average Dry Unit Weight (pcf)	105	115	120	120
Average Moisture Content (%)	9	7(13)	13	13
Effective Internal Friction Angle	28	35	35	38
Hydraulic Conductivity (cm/sec)	--	10×10^{-3}	6×10^{-5}	3×10^{-4}

Note: Number in parenthesis indicates average moisture content below ground water table for shallow alluvium.

The subsurface soils engineering properties were found to be highly variable across the site. Typical values are presented in the table above. Hydraulic conductivity values presented above are those obtained from the field testing. Layers, zones, and pockets having higher or lower values of hydraulic conductivity should be considered to exist. In general, variability of soils engineering properties should be considered in the design of temporary and permanent structures.



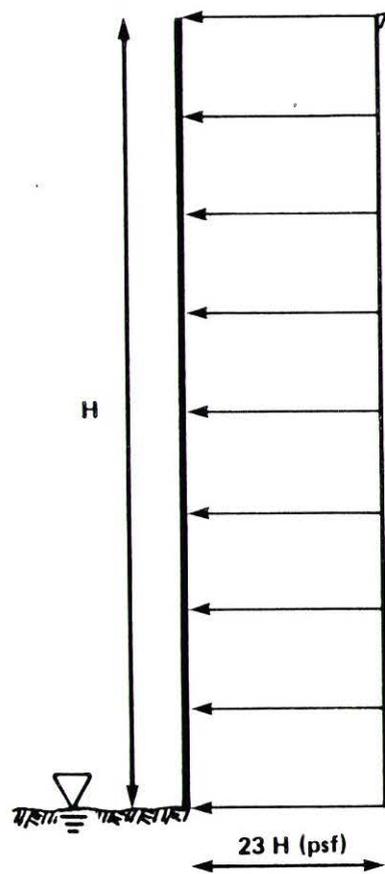
NOTES:

- 1.) FOR WALLS WITH $H \leq 50$ FEET
- 2.) WALL AND GROUNDWATER HEIGHTS IN FEET
- 3.) PROPER FACTOR OF SAFETY SHOULD BE CONSIDERED FOR STRUCTURAL DESIGN OF WALLS

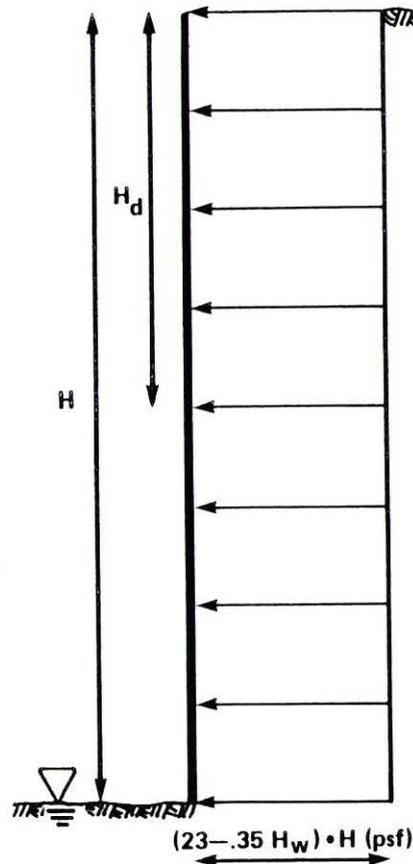
REFERENCE: DEPARTMENT OF THE NAVY, NAVFAC DM 7.2

	PROJECT NO: 87-885
	METRO RAIL
LOADS ON FLEXIBLE TEMPORARY SHORING FOR CANTILEVER AND RAKING BRACED WALLS	
12-87	FIGURE H-1

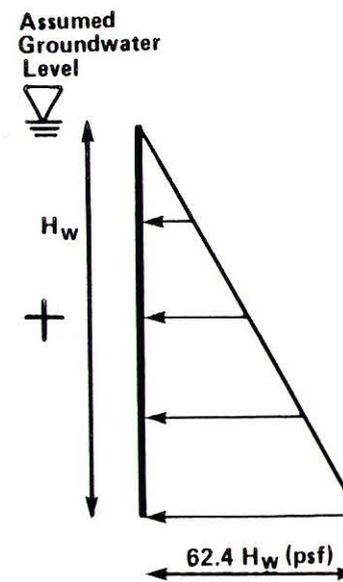
277



WITH DEWATERING



WITH PARTIAL OR NO DEWATERING



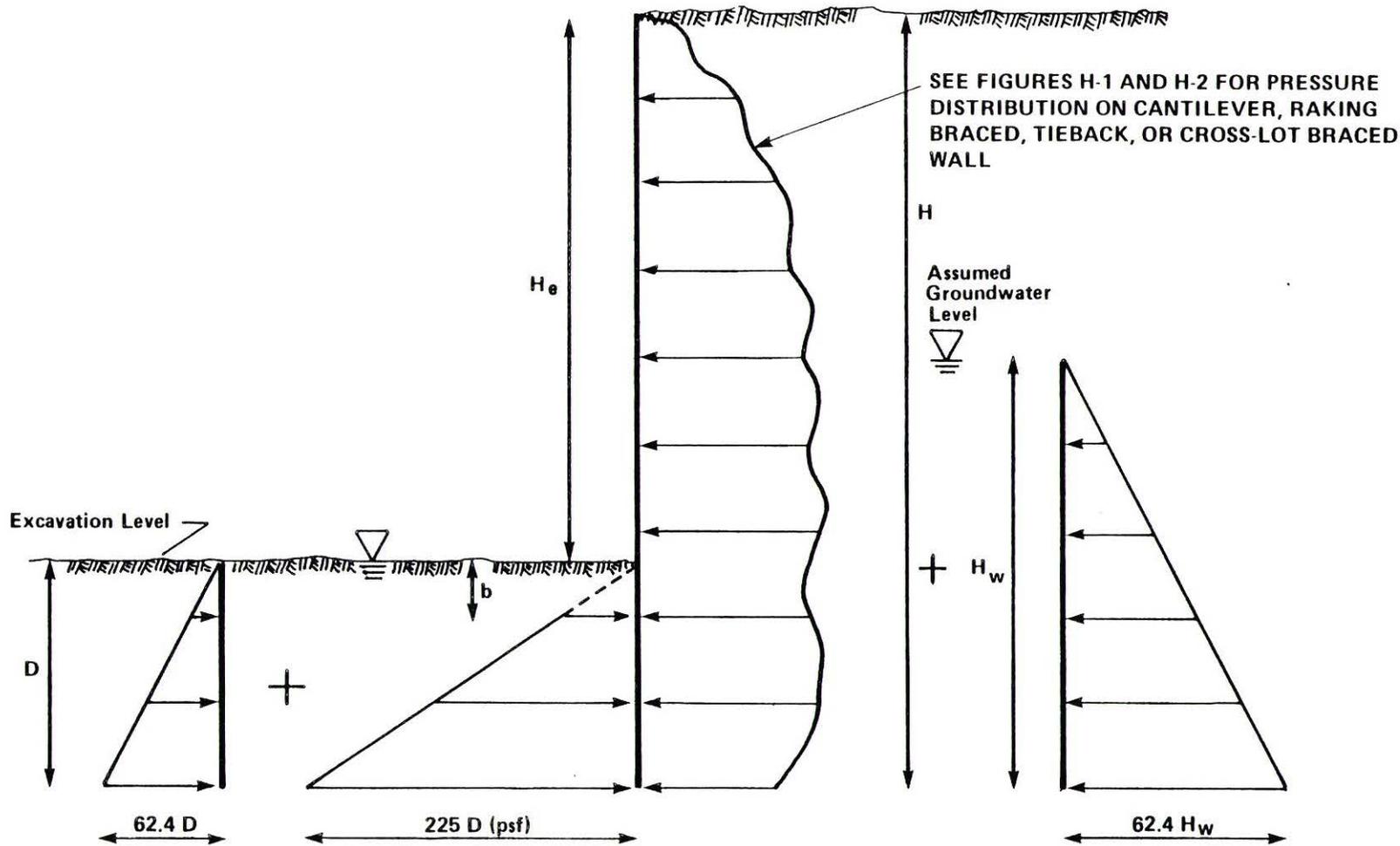
NOTES:

- 1.) FOR WALLS WITH $H \leq 50$ AND $H_w \leq 35$ FEET
- 2.) WALL AND GROUNDWATER HEIGHTS IN FEET
- 3.) PROPER FACTOR OF SAFETY SHOULD BE CONSIDERED FOR STRUCTURAL DESIGN OF WALLS

REFERENCE: DEPARTMENT OF THE NAVY, NAVFAC DM 7.2

	PROJECT NO: 87-885
	METRO RAIL
LOADS ON FLEXIBLE TEMPORARY SHORING FOR ANCHORED TIEBACK AND CROSS-LOT BRACED WALLS	
12-87	FIGURE H-2

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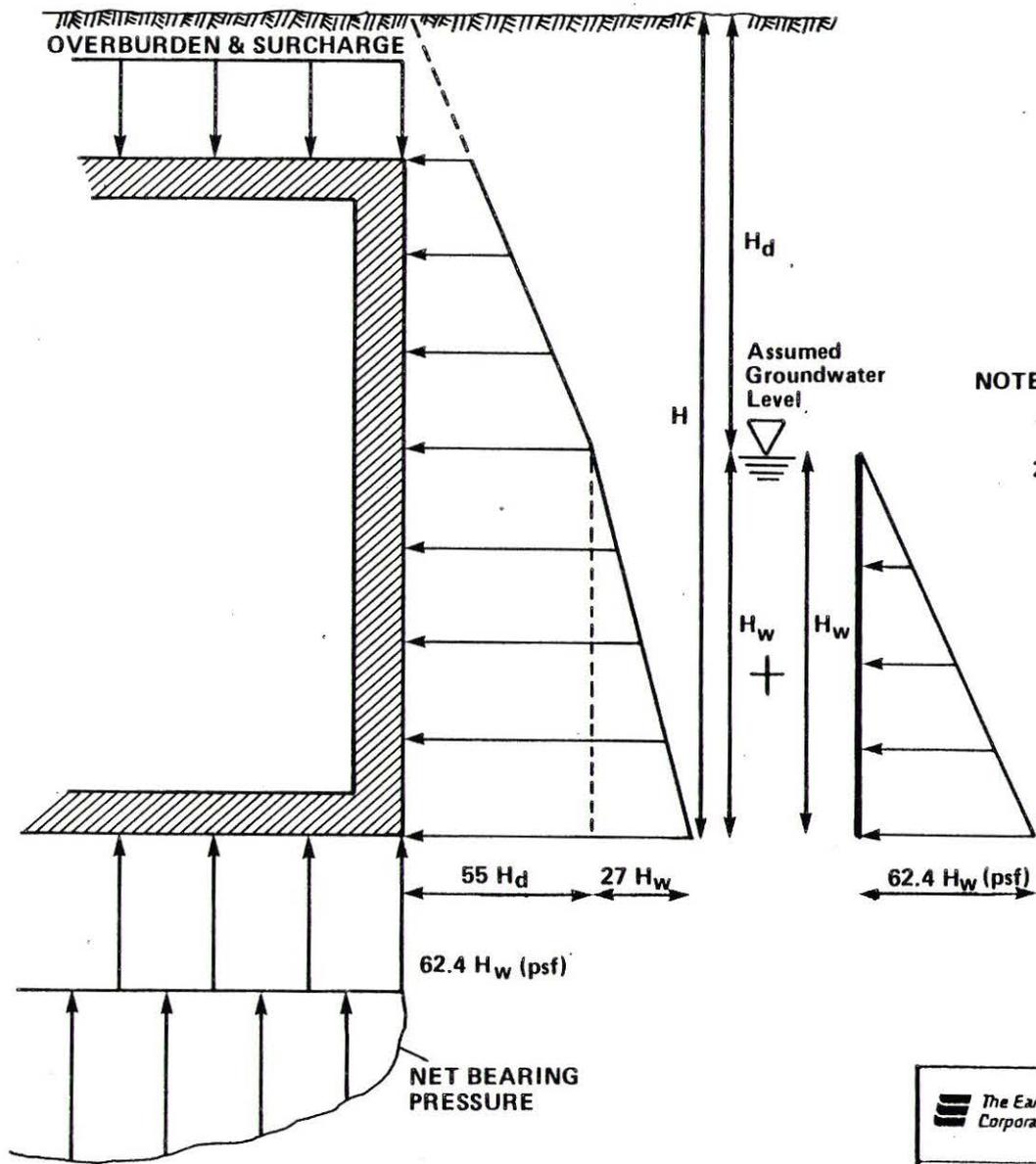


NOTES:

- 1.) FOR WALLS WITH $H_e \leq 50$ FEET
- 2.) LOADS ARE PRESENTED FOR ONE FOOT OF SOLDIER PILE
- 3.) USE 3 PILE DIAMETERS OR PILE TO PILE SPACING, WHICHEVER IS LESS, FOR PASSIVE RESISTANCE OF SOLDIER PILES
- 4.) b INDICATES PILE DIAMETER
- 5.) PROPER FACTOR OF SAFETY SHOULD BE CONSIDERED FOR PILE DESIGN

	PROJECT NO: 87-885
	METRO RAIL
LOADS ON SOLDIER PILES	
12-87	FIGURE H-3

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NOTES:

- 1.) FOR STRUCTURES WITH $H \leq 50$ FEET
- 2.) PROPER FACTOR OF SAFETY SHOULD BE CONSIDERED FOR STRUCTURAL DESIGN

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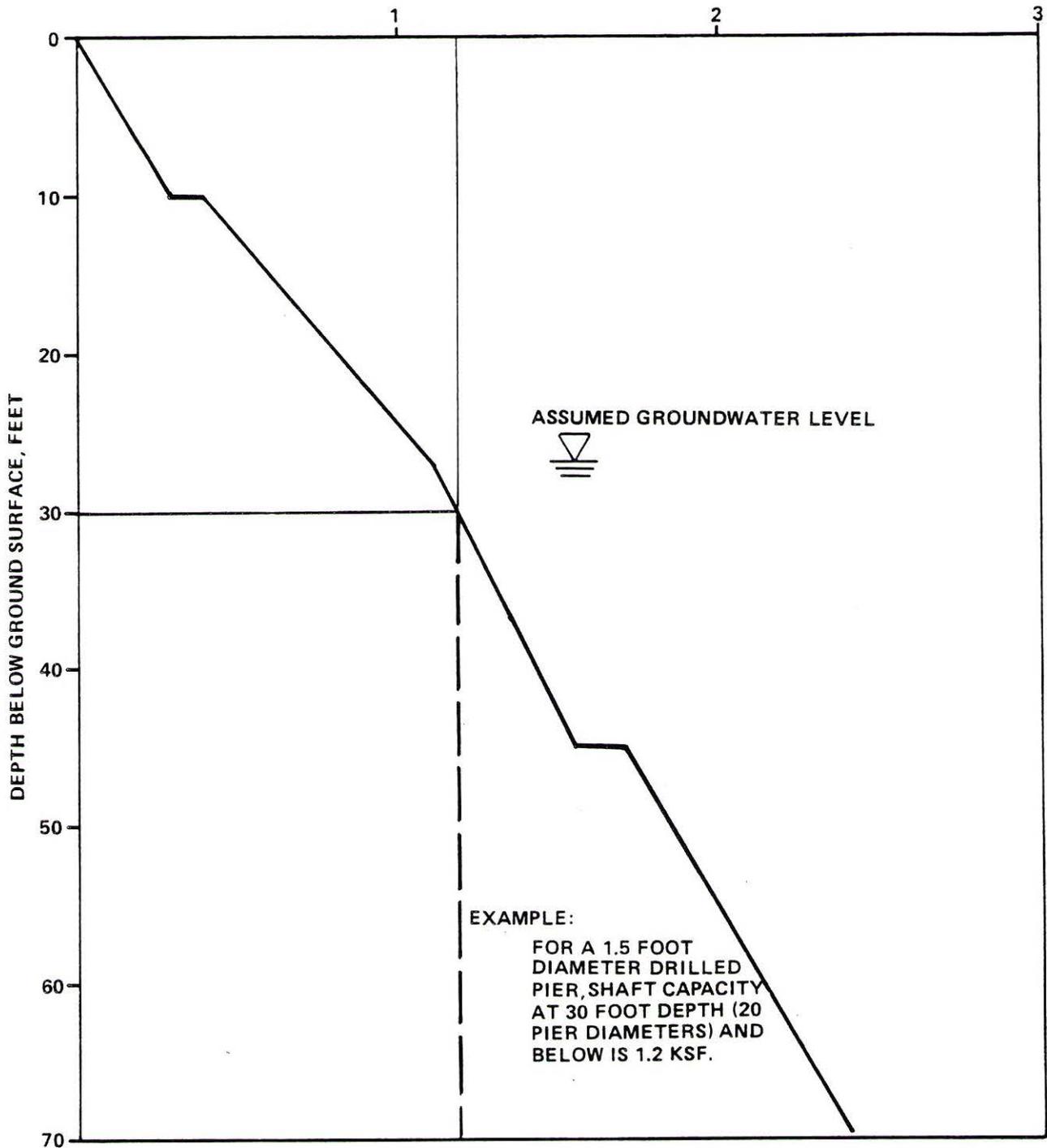
PROJECT NO: 87-885

METRO RAIL

LOADS ON PERMANENT STRUCTURES

280

ESTIMATED ULTIMATE UNIT SHAFT FRICTION CAPACITY FOR DRILLED PIERS, KSF



NOTES:

- 1) VALUES OF FACTOR OF SAFETY OF 2.5 AND 3 SHOULD BE CONSIDERED FOR DESIGN OF TEMPORARY AND PERMANENT DRILLED PIERS, RESPECTIVELY
- 2) BELOW AN EMBEDMENT DEPTH OF 20 PIER DIAMETER UNIT SHAFT CAPACITY IS EQUAL TO UNIT SHAFT CAPACITY AT 20 PIER DIAMETER (SEE EXAMPLE ABOVE)

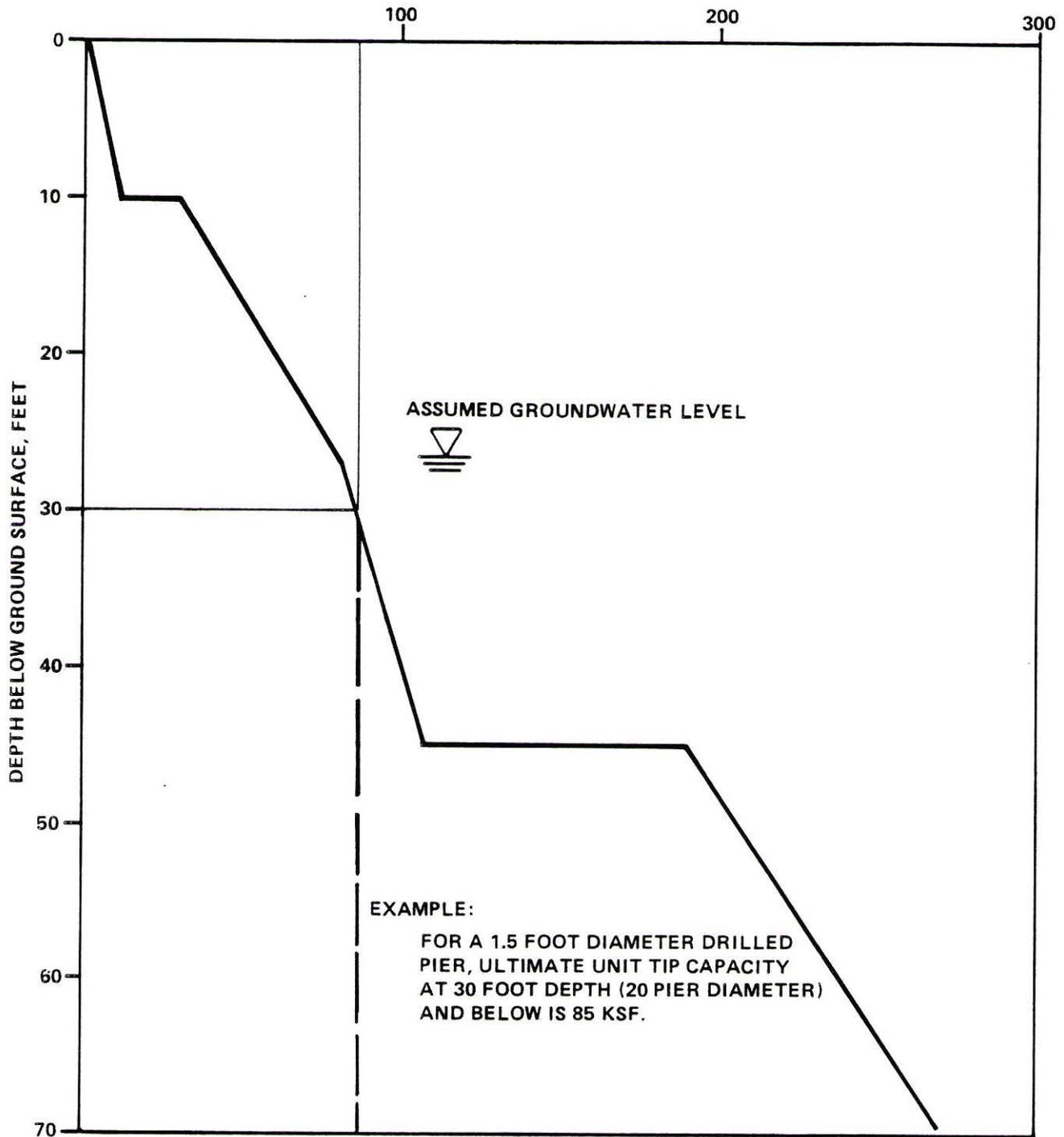
 The Earth Technology Corporation

PROJECT NO: 87-885

METRO RAIL TRANSIT

DRILLED PIER UNIT SHAFT FRICTION CAPACITY (FOR PIERS WITH EMBEDMENT STARTING AT GROUND SURFACE)

ESTIMATED ULTIMATE UNIT TIP BEARING CAPACITY FOR DRILLED PIERS, KSF



NOTES:

- 1) VALUES OF FACTOR OF SAFETY OF 2.5 AND 3 SHOULD BE CONSIDERED FOR DESIGN OF TEMPORARY AND PERMANENT DRILLED PIERS, RESPECTIVELY
- 2) BELOW AN EMBEDMENT DEPTH OF 20 PIER DIAMETER TIP CAPACITY IS EQUAL TO TIP CAPACITY AT 20 PIER DIAMETER (SEE EXAMPLE ABOVE)



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APPENDIX I
GROUTABILITY EVALUATION

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Three soil samples from Boreholes B304 and B305A were submitted to GKN Hayward Baker, Inc., of Ventura, California, for grout study. The purpose of this study was to evaluate grout-injectibility of the site soils, and the unconfined compression strength that can be developed on grouted samples. Test results and conclusions regarding this evaluation are presented in this appendix.

October 15, 1987
Rev. Nov 30, 1987
C1311

The Earth Technology Corporation
3777 Long Beach Boulevard
Long Beach, California 90807

Attention: Messrs: Allen E. Blodgett and Siamak Jafroudi

Subject: Chemical Grout Stabilization
Los Angeles Metro Rail Section A-130
Los Angeles, California

It is our understanding chemical grout stabilization is being considered to aid tunneling between stations 89+75 and 97+08 of the Los Angeles Metro Rail Section A-130, which is below the Santa Ana Freeway and the intersection of Commercial and Center Streets. To investigate the groutability the, approximate strength that can be developed from the site soils, remolded laboratory samples were made up, injected, cured and unconfined compression tested. In addition, sieve analyses were performed on the samples tested. The strength data, injectability, sieve analyses and suggested specifications for this potential work are attached.

Based on the results of the laboratory testing the higher 60 percent sodium silicate concentration Geloc 4 chemical grout is required to produce the desired 250+ psi (pounds per square inch) unconfined compressive strength in laboratory prepared ideal Ottawa sand samples. Strength testing results of the field samples with 60% Geloc 4 chemical grout indicate in-situ strengths varying from 100 to 200 psi for samples prepared at approximately field density.

The grout injectability of the boring 304-1 sample is excellent, which is confirmed by its ideal gradation curve and low amount of fines passing the number 100 and 200 sieves. The material from boring 305A was not as clean; therefore, it will require either a longer grouting time or a higher pressure for permeation. This is apparently due to the non-uniform gradation, specifically less of the coarser particles and a larger quantity of material passing the number 100 sieve.

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Page 2

Upon reviewing the field boring logs and sieve analyses transmitted to us on November 24, 1987, along with the results of this study and past experience, it is our opinion that the application of chemical grout will effectively permeate the intended zone, providing the desired support during tunneling excavation. The sieve tests indicate that the fines content vary throughout the depth investigated; therefore, the groutability and strength will also vary. It is possible there will be isolated zones where full permeation will not occur; however, based on past experience, zones of semi-grouted and/or impermeable soils between grouted soils are effectively stabilized.

The sample preparation, grouting and testing was performed by a graduate student under the direction of Dr. Roy Borden, associate professor at North Carolina State University. Please let us know if we can be of further service.

Respectfully Yours

GKN HAYWARD BAKER INC.
WESTERN REGION



Francis B. Gularte, P.E.
Vice President

cc: Dr. James Monsees, Chief Tunnel Engineer
MRTC

A 130 METRO GROUT STUDY

A. INTRODUCTION

This laboratory study investigates both the chemical groutability and the grouted strength of Ottawa sand and the project field soil samples. The following soil samples were used in the investigation: a) Ottawa 20-30 sand for control purposes, b) Field sample B-304-1 (18 to 30 ft) and B-304-2 (33.5 to 35 ft), c) Field sample from B-305A (20 to 30 ft). Grain size distribution curves for the Ottawa sand and field samples are shown in Figures 1, 2, and 3.

The chemical grout consisted of sodium silicate, reactant and water, and is referred to as Geloc 4 as used by GKN Hayward Baker Inc. Several chemical grout combinations of reactant and sodium silicate content were tried on both the Ottawa sand and the field soil samples.

B. SAMPLE PREPARATION

1. General Information:

- a) Samples were prepared in cylindrical plastic mold 3 inches in diameter and 6 inches in height.
- b) A half inch layer of coarse sand, passing the #4 sieve and retained on the #10 sieve, was put in the bottom of the mold as a filter.
- c) To simulate the field situation, samples were saturated before grouting, except for those field samples taken from above the ground water table. Samples were saturated by using 6 psi pressure to inject water until the water flowed from the sample top.
- d) After grouting, all of the samples were left at room temperature 23°C for 24 hours before the molds were removed. After the molds were removed the samples were wrapped with plastic and placed in 100% humidity curing room until tested. The temperature of the curing room was maintained at 15°C.
- e) The samples were capped with sulfur compound prior to compressive strength testing. The compression tests were conducted using a load cell and a digital strain indicator that was calibrated to display stress in psi.

2. Ottawa Sand Sample Preparation:

Ottawa 20-30 sand samples were prepared in three layers, the outside of the mold was tapped 25 times for each layer. Prior to the initiation of grouting, 15 samples were made to determine the density of the sand sample. The average dry density was 107.9 pcf. All Ottawa sand samples were saturated before grouting.

3. Field Sample B-304 Preparation:

The molds were filled in three equal layers, each layer was compacted with 6 blows from a standard proctor hammer falling 4 inches. Prior testing had shown this procedure to produce a sample moist density of approximately 120 pcf. Sample 1 was left unsaturated because it was located above ground water table, whereas, sample 2 was saturated before grouting. An additional 0.5" coarse sand filter was placed on top of the sample to assure uniform permeation at top of the samples.

4. Field Sample B-305A Preparation:

Samples were prepared in three layers, the outside of the mold was tapped 10 times for each layer. Prior testing had shown this procedure to produce a moist sample density of approximately 92 pcf.

5. Grouting Of The Samples:

Enough grout (1000 ml) was prepared to inject two samples at one time. Each sample was permeated with 2 void volumes of grout to enhance complete filling of voids. Ottawa sand samples were injected by using 6 psi, while field samples were injected using 10 psi pressure.

6. Preparation And Injection Of The Chemical Grout:

The water and reactant components were mixed in a 1500 ml capacity blender for approximately 20 seconds. Then, the sodium silicate was added to the water/reactant mixture and blended an additional 20 seconds. Finally the samples were injected according to the method recommended by Paul M. Blakita of GKN Hayward Baker in "Injection Procedure for Laboratory Grouted Soil Samples".

C. GEL TIME STUDIES

Gel time studies were conducted to ensure the samples could be grouted before the mix would gel. Gel time studies were made for 50% and 60% sodium silicate mix for a various reactant contents. The results are shown in Figure 4.

D. COMPRESSIVE STRENGTH RESULTS

Figure 5 shows a summary of strengths at given times for Ottawa sand samples with 50% Geloc 4 and varying reactant contents. Strength data are also shown in Table 1.

Figures 6 and 7 present the stress-strain plots at 14 and 28 days for Ottawa sand grouted with 50% Geloc 4 at various reactant contents.

Figure 8 and Table 2 show a summary of unconfined compressive strengths for Ottawa sand samples with 60% / 8% reactant Geloc 4 with respect to time. A stress-strain plot, for a 28 day old sample is shown in Figure 9.

Figures 10 and 11 show results of unconfined compressive tests of field samples B-304-1 and B-304-2 grouted with 60%/8% Geloc 4, respectively. Figure 12 shows the results for sample B-305A prepared at the lower density. The number data is presented in Table 3.

Figure 13 shows a comparison of the strength change with time for Ottawa sand and field samples with 60%/8% Geloc 4 chemical grout.

E. PROBLEMS ENCOUNTERED

The material from B-304-1 (depth 18-30 ft.) appears to show a generally stronger response than from B-304-2 (depth 33.5 to 35 ft.), as shown in Figures 10 and 11.

At the start of the study, a proving ring was used in the compression tests for determining the 7 day strength of Ottawa sand samples. The individual results of these tests are not presented because of inconsistent strain measurements.

Initially, the B-305A samples were prepared using the same procedure as B-304 samples and produced a sample density of approximately 112 pcf. However, after 5 minutes injection time at 10 psi injection pressure, the samples were not fully grouted. It appears that the high density of the sample and the fine material content (Figure 3) caused this problem. As previously mentioned in section B.4., lower density samples were prepared.

After grouted B-305A samples were removed from the molds a pure grout layer formed between the filter layer and the soil. The neat grout at the base of the sample was removed and the samples capped. The results from compressive strength tests has shown relatively low strength.

F. PERMEABILITY

Permeability tests were performed on the samples using both water and Geloc 4 grout. The results are shown in Table 4.

G. OBSERVATIONS

Variability between batches and a pair of samples injected with one volume of grout, have occurred inadvertently. Initially no record of which samples were prepared together or from one volume of grout was kept, which has resulted in some nonuniformity of results.

Later this practice was undertaken and allowed the specific strength gain with time for two samples injected with the same batch of grout to be evaluated. For example, as noted in Table 1, the strength of 50% sodium silicate with 8% reactant grouted samples increased from 140 psi at 7 days to 168 psi at 28 days. However, one of the 28 day strengths was measured to be 74 psi. This sample might be from the same batch as the one which had a 62 psi compressive strength tested in 7 days. With this observation, it appears that the variability between batches prepared in the laboratory can affect the strength significantly.

H. SYNERESIS OF NEAT SILICATE GROUT

Syneresis of 60%/8% Geloc 4 grout was observed. The results indicates a syneresis of 1.5% and 2.9% for two prepared samples after 28 days.

TABLE 1. A summary of unconfined compressive strengths for Ottawa 20-30 sand with 50% Geloc 4 with respect to time and varying reactant contents.

time	reactant contents			
	4%	6%	8%	10%
7 days	59 psi	*74 psi 114 psi	**140 psi 62 psi	127 psi
14 days	59 psi 76 psi	71 psi 50 psi	91 psi 149 psi	172 psi 138 psi
28 days	86 psi	*86 psi 117 psi	**168 psi 136 psi 74 psi	191 psi 170 psi
60 days	79 psi	105 psi	149 psi	167 psi

* injected with grout from same batch
 ** injected with grout from same batch

TABLE 2. A summary of unconfined compressive strengths with respect to time for Ottawa 20-30 sand samples with 60% / 8% Geloc 4.

Time	* Ottawa Sand
7 days	210 psi
14 days	291 psi 267 psi
28 days	242 psi
60 days	290 psi

* Average dry density 108 pcf.

TABLE 3. A summary of unconfined compressive strengths of field samples 304-1, 304-2, and 305A grouted with 60% / 8% Geloc 4.

SAMPLES			
Time	304-1*	304-2*	305A**
7 days	152 psi	76 psi	45 psi
14 days	174 psi	76 psi	50 psi
	141 psi	77 psi	52 psi
28 days	191 psi	95 psi	57 psi
			55 psi
60 days	186 psi	122 psi	Dec. 13

* Average dry density of 112 pcf.

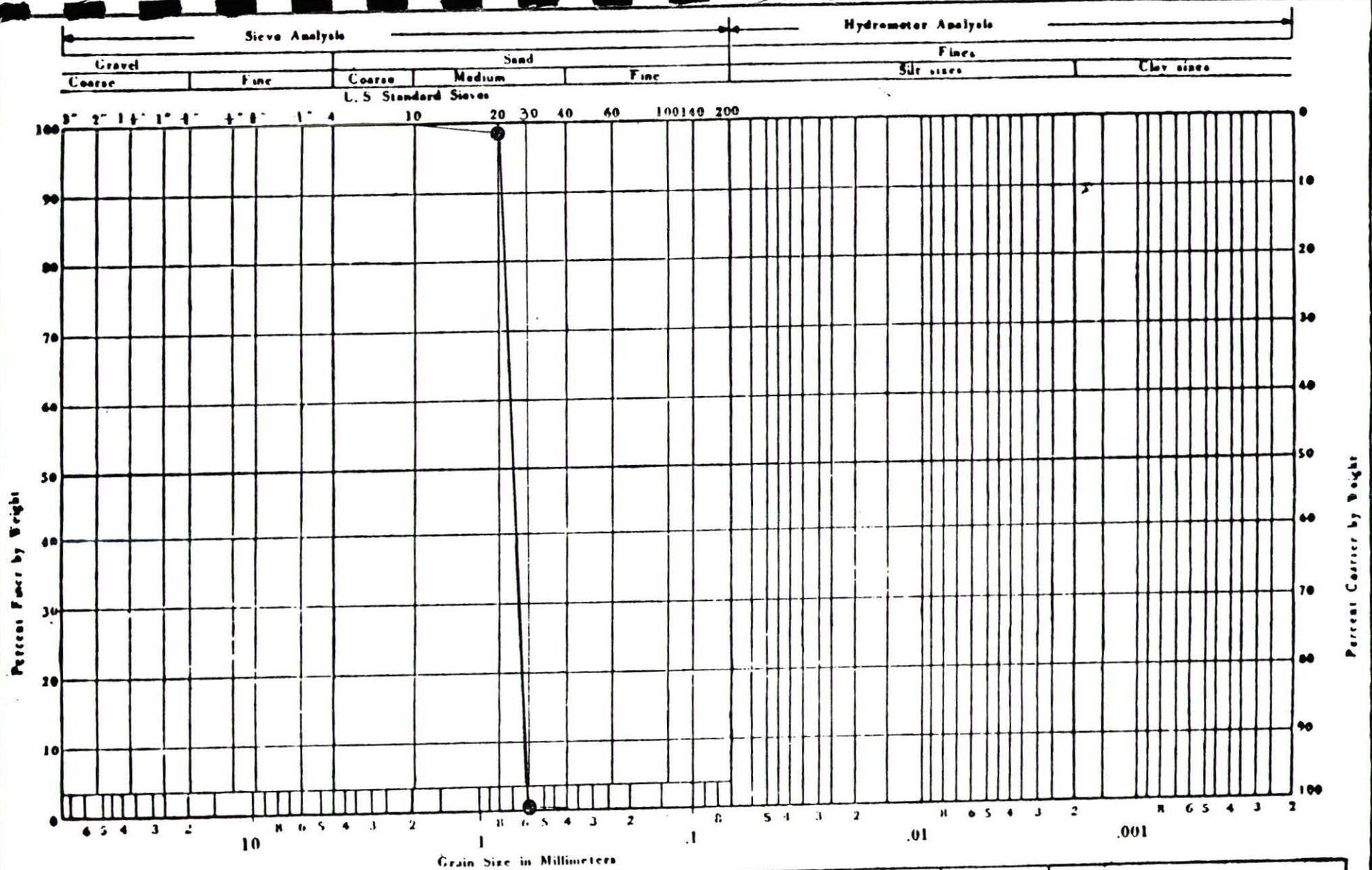
** Average dry density of 92 pcf.

TABLE 4: Permeability of Ottawa sand and project samples.

Sample	Permeant	Volume (ml)	Time (sec)	Pressure (psi)	K (cm/sec)
Ottawa 20-30 Sand	water	500	14.5	6	1.9×10^{-1}
	50% / 8% Geloc 4	250	10.5	6	1.3×10^{-1}
Field Sample 304-1	water	250	36	10	2×10^{-2}
	60% / 8% Geloc 4	no data			
Field Sample 304-2	water	500	22	8	3×10^{-2}
	60% / 8% Geloc 4	500	65	8	3×10^{-2}
Field* Sample 305 A	water	no data			
	60% / 8% Geloc 4	no data			
Field** Sample 305A	water	210	70	6	1.2×10^{-2}
	60% / 8% Geloc 4	500	105	12	1×10^{-2}

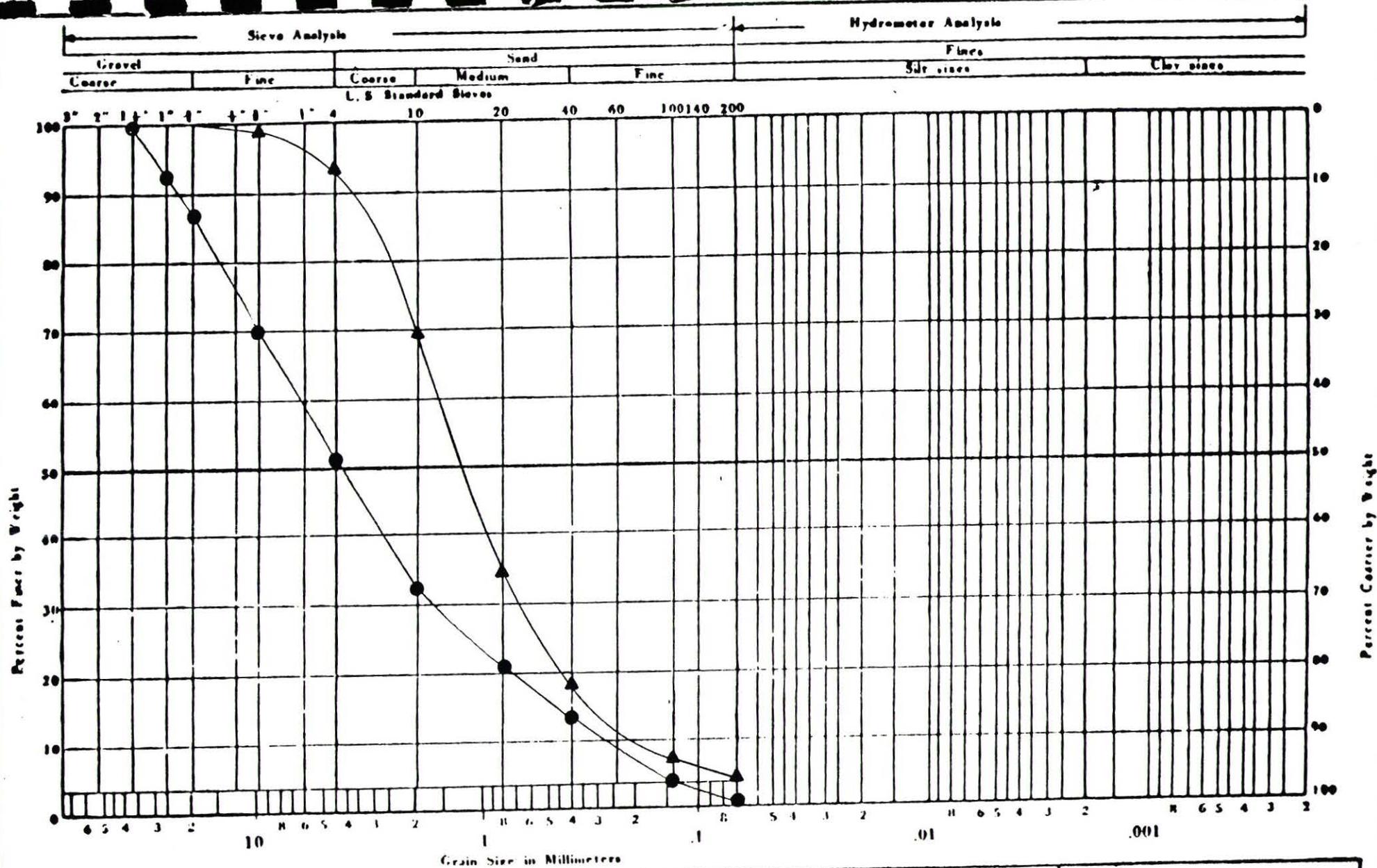
* Samples were prepared using standard proctor hammer, an average density 112 pcf was obtained.

** Samples were prepared in loose status, the average density of the samples was 91 pcf.



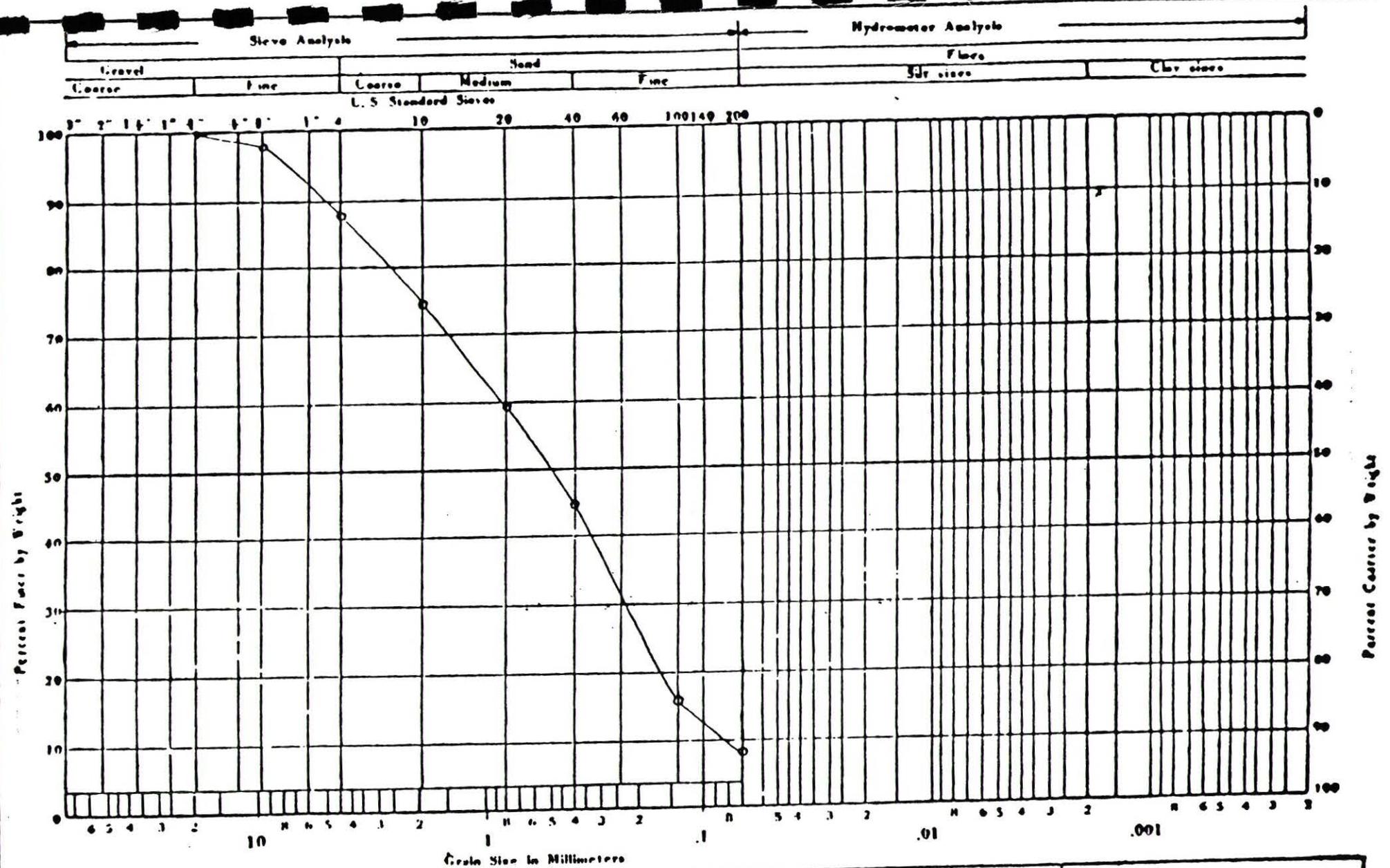
HOLE NO.	SYM.	DEPTH(M)	D ₁₀ (m.m.)	D ₆₀ (m.m.)	Cu	L.L.	P.L.	CLASSIFICATION
N/A	⊙	N/A	0.605	0.72	1.2			

FIGURE 1: GRAIN SIZE DISTRIBUTION FOR OTTAWA 20-30 SAND.



HOLE No.	SYM.	DEPTH(M)	D_{10} (mm)	D_{60} (mm)	Cu	L. L.	P. I.	CLASSIFICATION
B304-1	●	18'-30'	0.27	6.1	23			
B304-2	▲	33.5-35'	0.21	1.06	5			

FIGURE 2: GRAIN SIZE DISTRIBUTION FOR B304-1 AND B304-2 SAMPLES.



HOLE NO.	SYM.	DEPTH(M)	D ₁₀ (mm)	D ₆₀ (mm)	C _u	L.L.	P.I.	CLASSIFICATION
B305A	0	20' - 30'	0.085	0.81	10			

FIGURE 3: GRAIN SIZE DISTRIBUTION CURVE OF B305A SAMPLE.

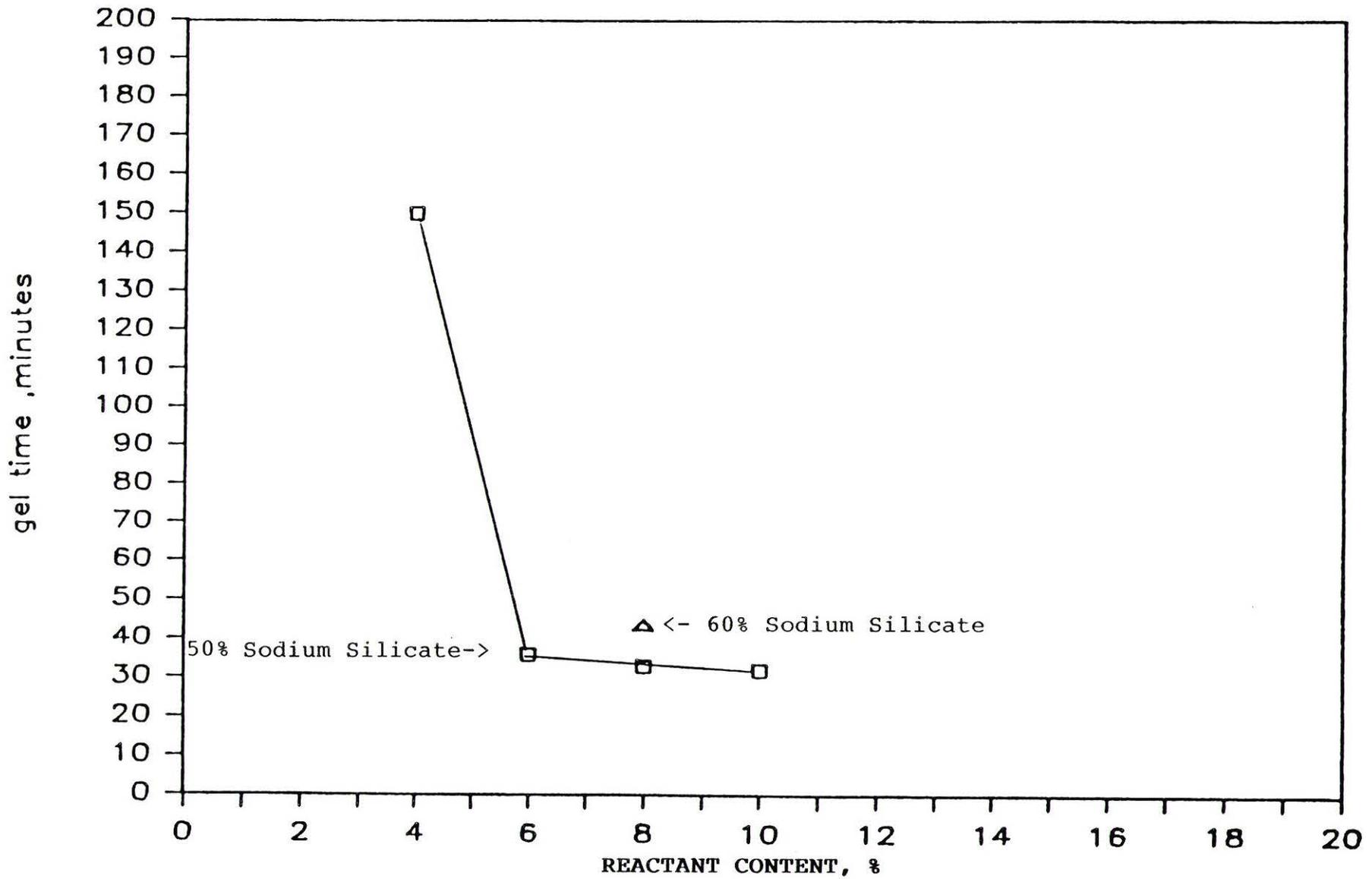


FIGURE 4: GELTIME VS REACTANT CONCENTRATION FOR 50% AND 60% GELOC 4 CHEMICAL GROUT.

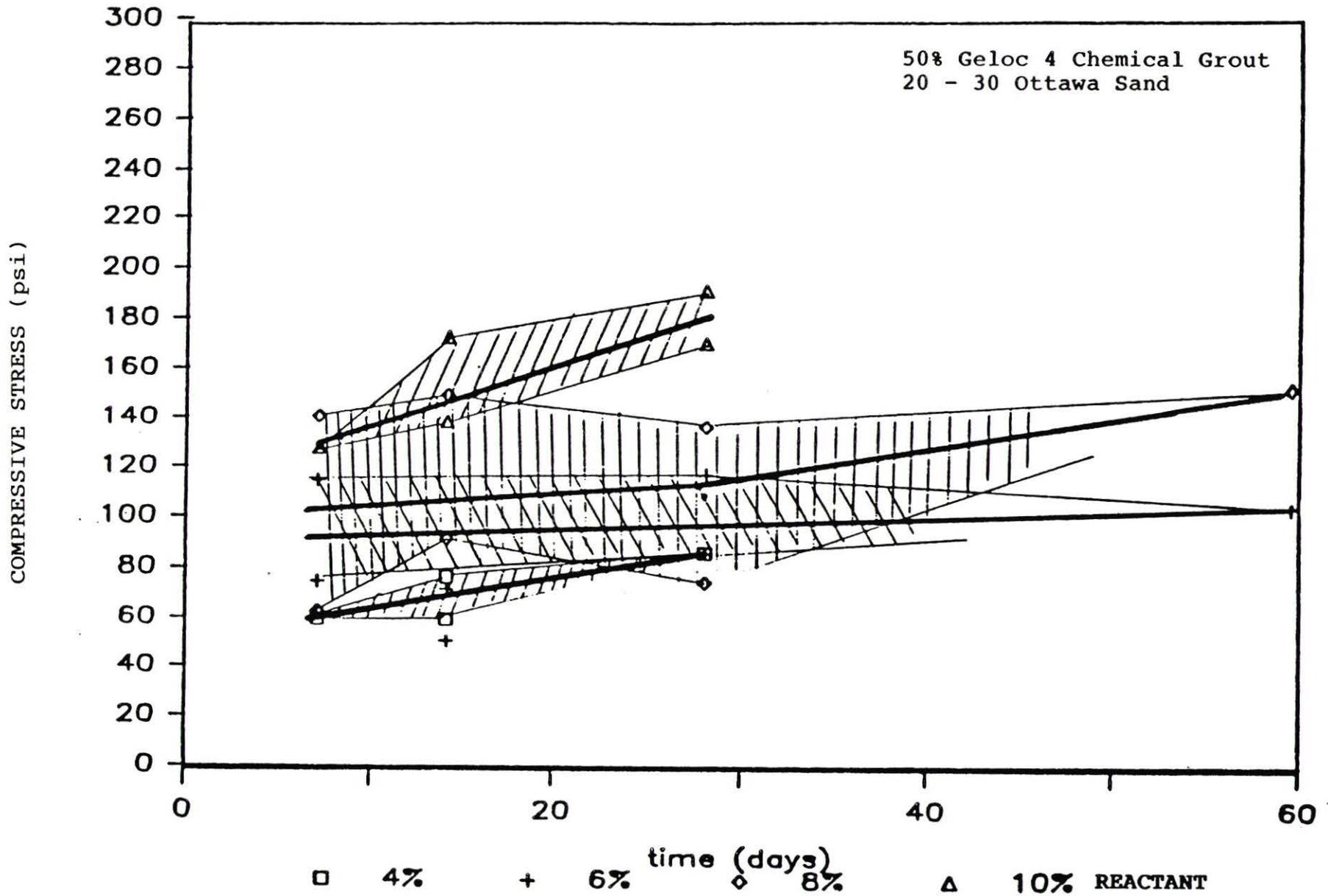


FIGURE 5: SUMMARY OF UNCONFINED COMPRESSIVE STRESS VS TIME FOR 50% GELOC 4 AT VARYING REACTANT CONTENTS.

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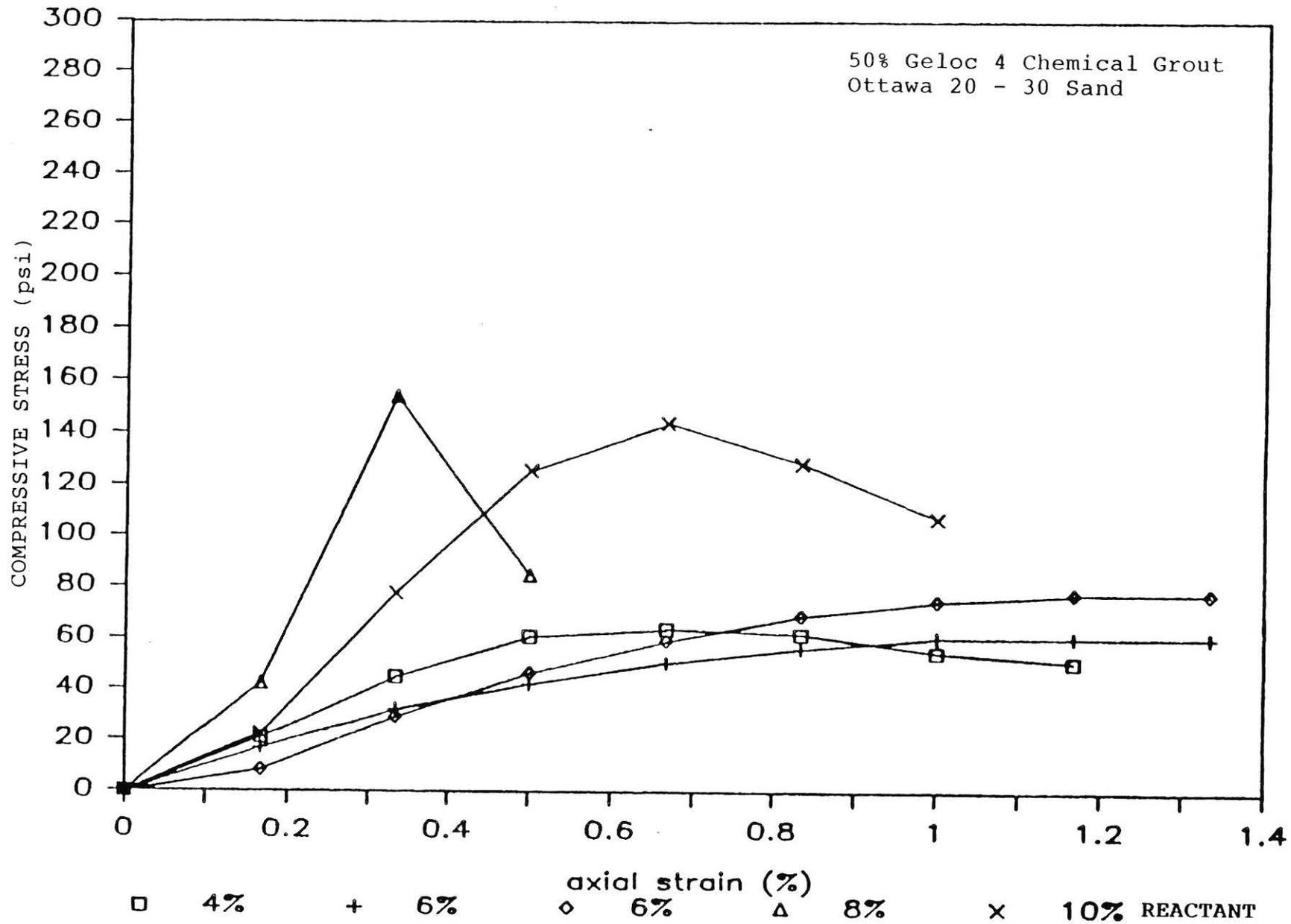


FIGURE 6 : 14 DAY COMPRESSIVE STRESS VS AXIAL STRAIN AT VARYING REACTANT CONTENTS

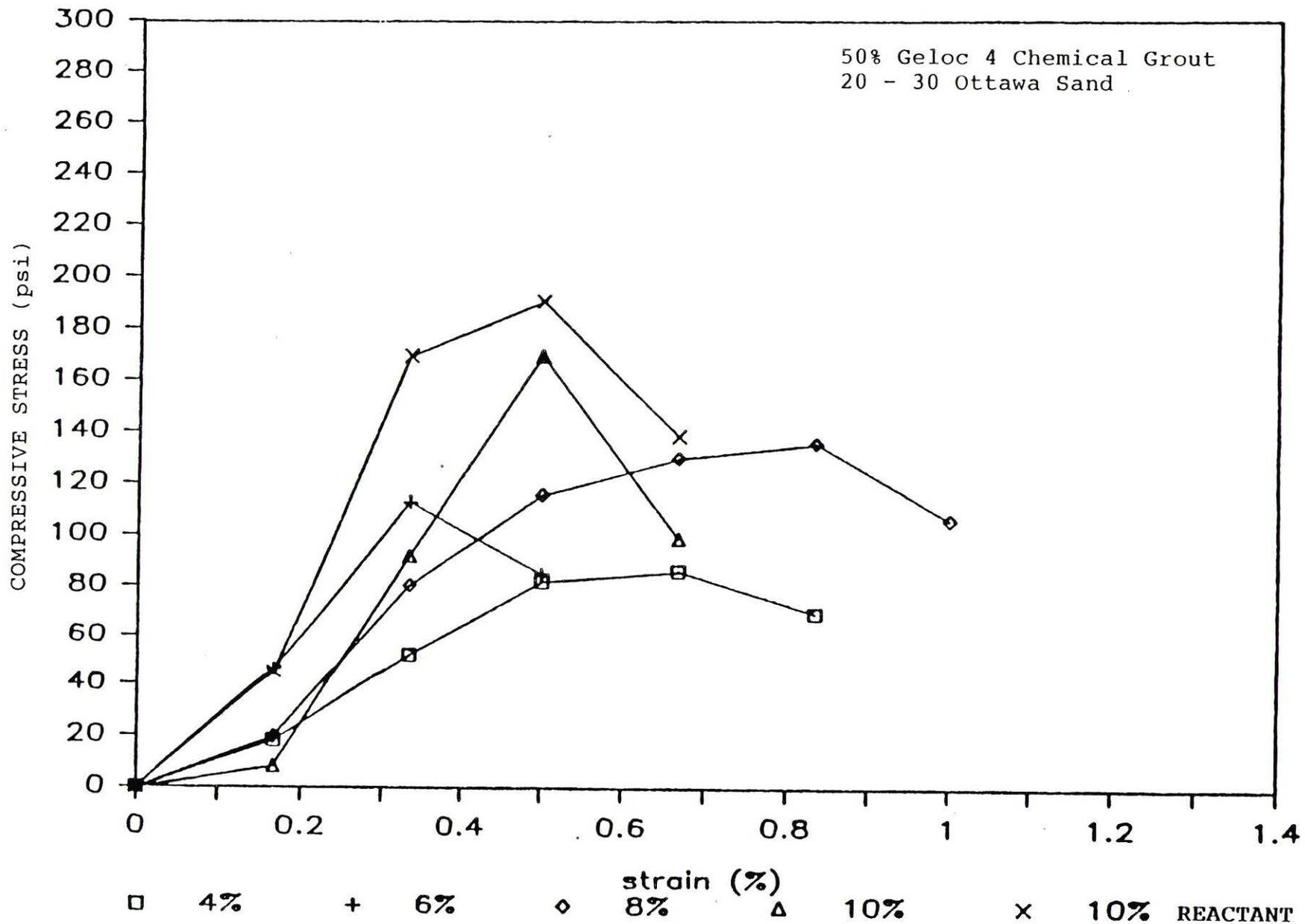


FIGURE 7: 28 DAY COMPRESSIVE STRESS VS AXIAL STRAIN AT VARYING REACTANT CONTENTS

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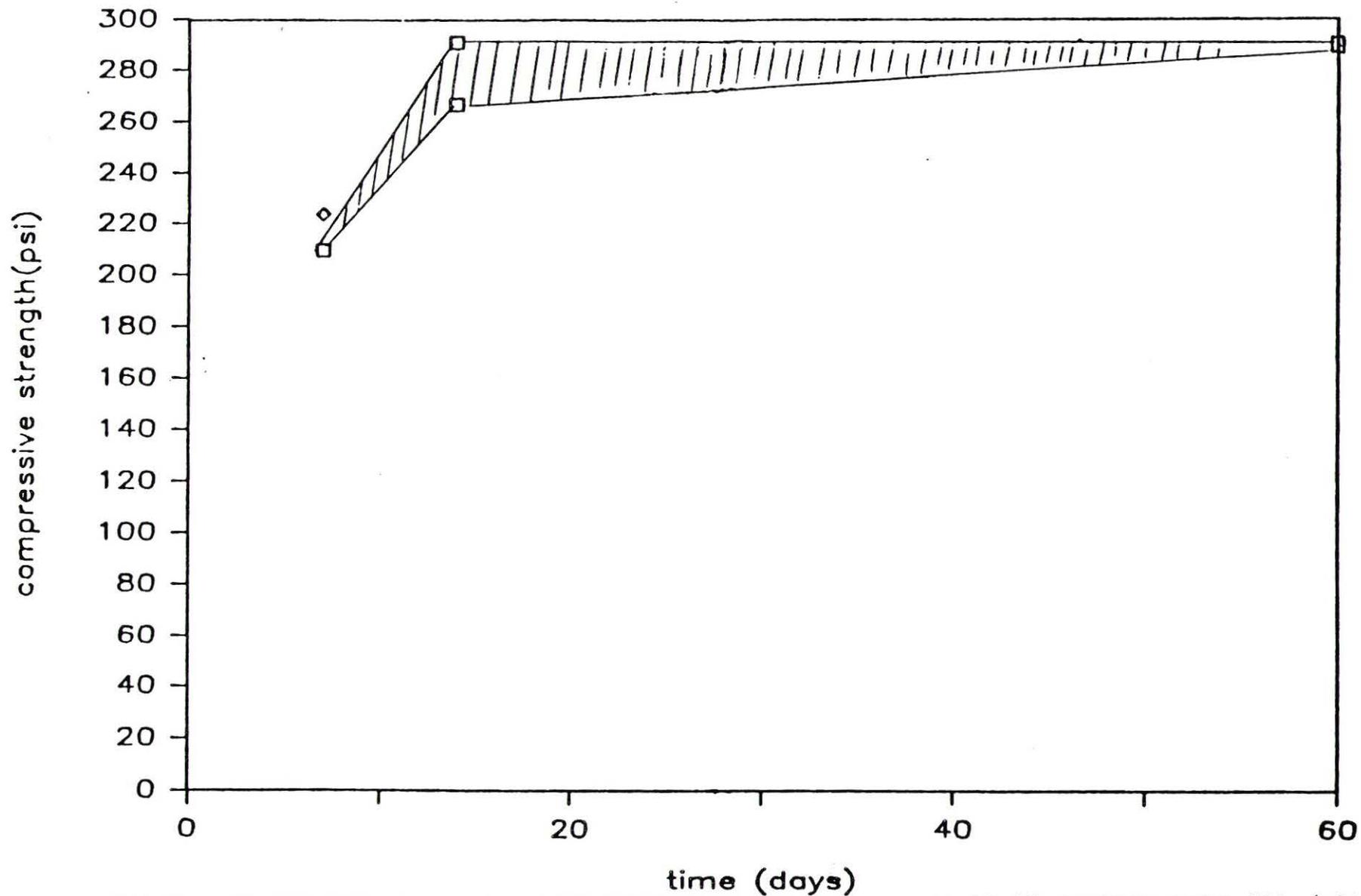


FIGURE 8: UNCONFINED COMPRESSIVE STRENGTH VS TIME FOR OTTAWA 20-30 GROUTED WITH 60% / 8% GELOC 4 CHEMICAL GROUT.

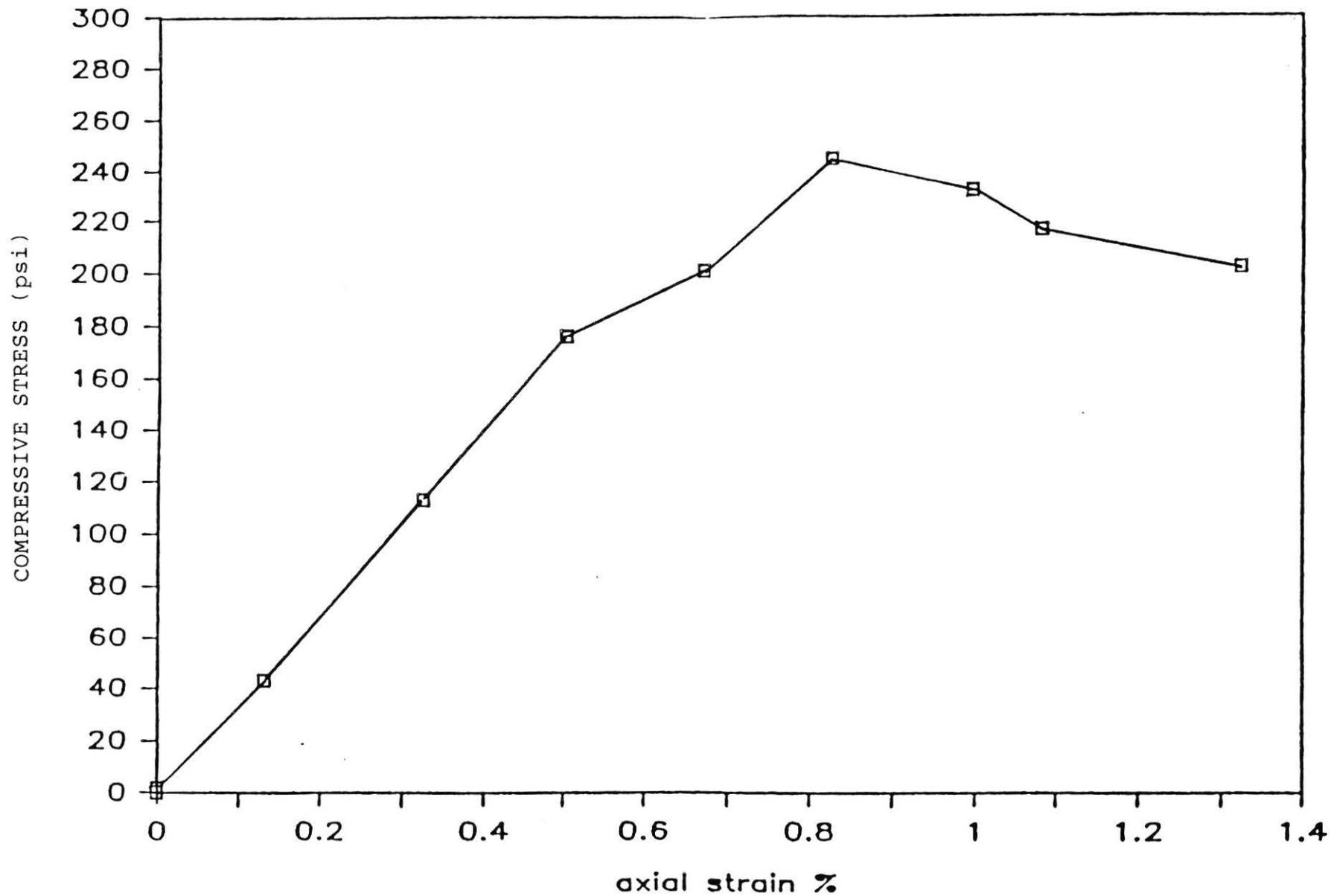


FIGURE 9: 28 DAY COMPRESSIVE STRESS VS AXIAL STRAIN FOR OTTAWA 20-30 SAND GROUTED WITH 60% / 8% GELOC 4 CHEMICAL GROUT

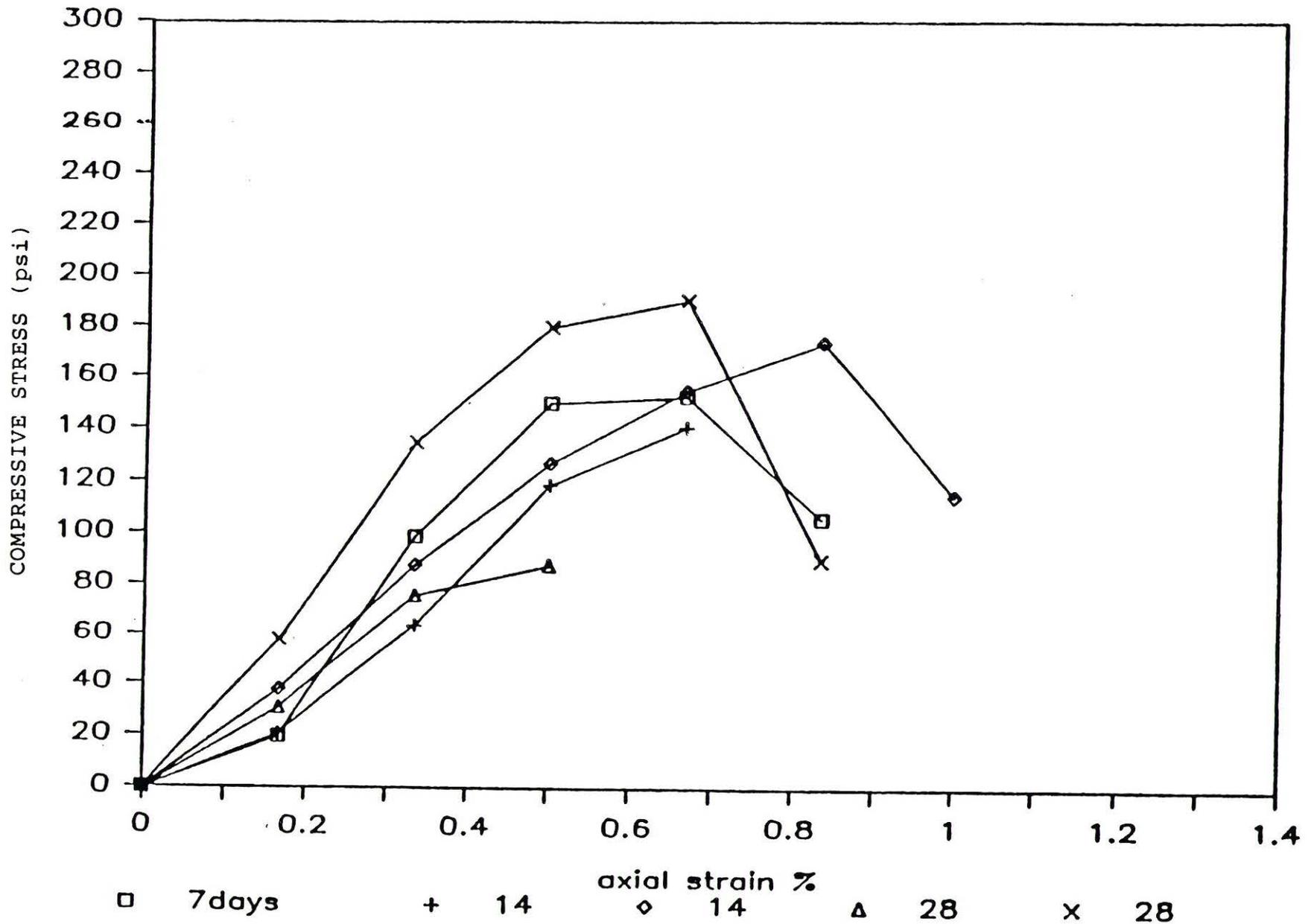


FIGURE 10: COMPRESSIVE STRESS VS AXIAL STRAIN FOR B304-1 SAND GROUTED WITH 60% / 8% GELOC 4 GROUT.

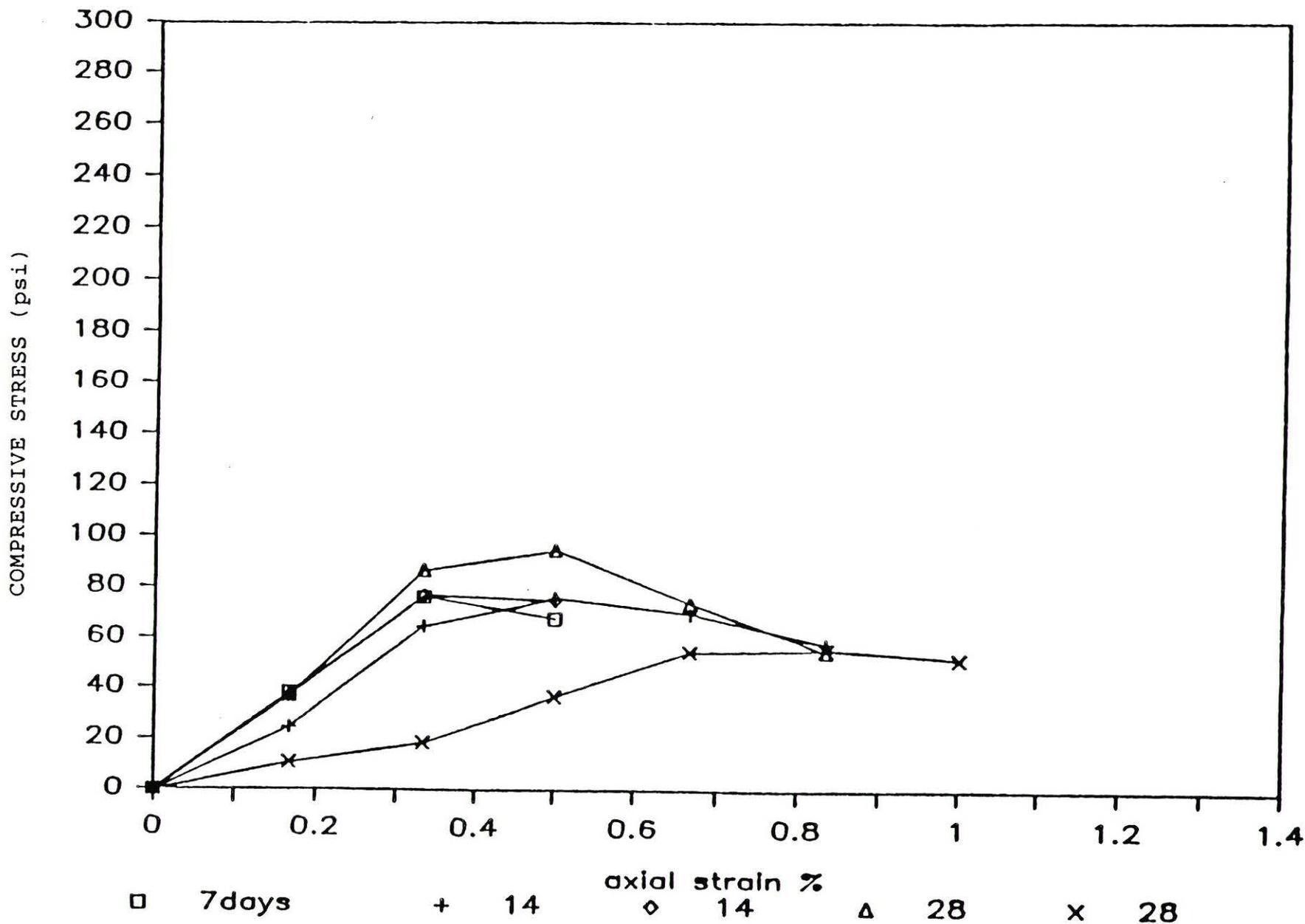


FIGURE 11: COMPRESSIVE STRESS VS AXIAL STRAIN FOR B304-2 SAND GROUTED WITH 60% / 8% GELOC 4 GROUT.

202

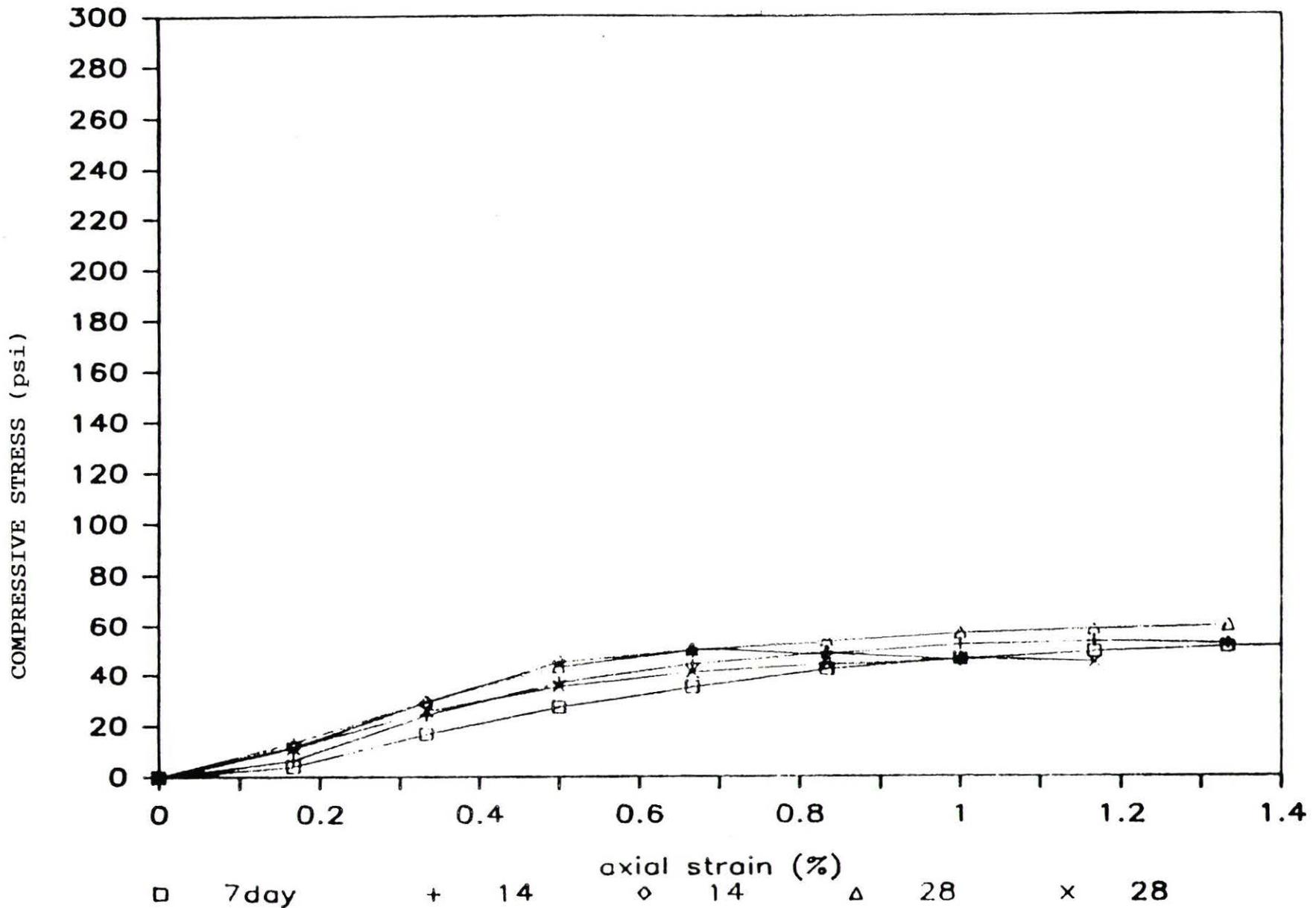


FIGURE 12: COMPRESSIVE STRESS VS AXIAL STRAIN FOR B305A SAMPLES GROUTED WITH 60% / 8% GELOC 4 GROUT.

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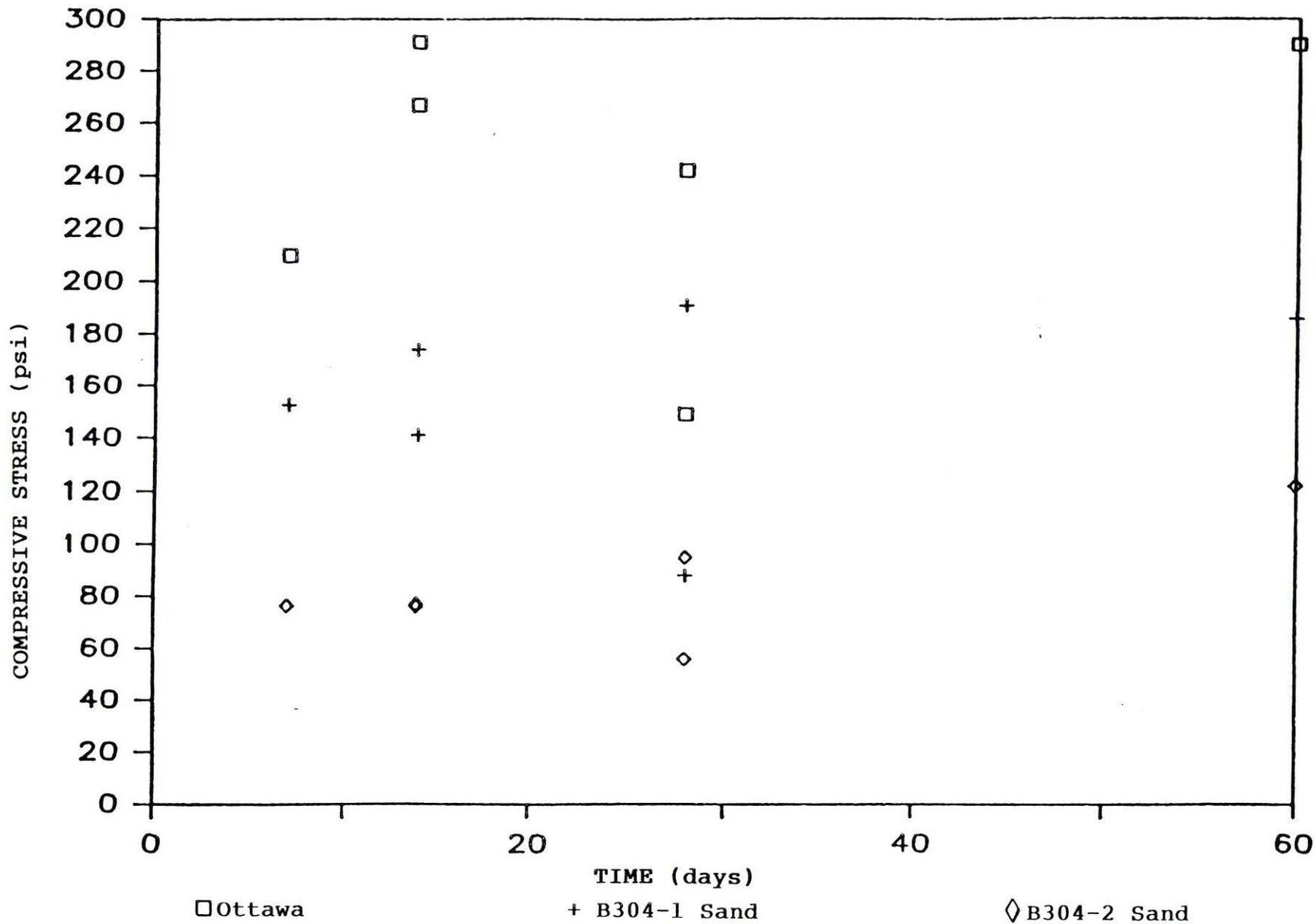


FIGURE 13: COMPARISON OF UNCONFINED COMPRESSIVE STRESS VS TIME FOR 60% / 8% GELOC 4 GROUTED SAMPLES.

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CHEMICAL GROUTING STABILIZATION BELOW THE SANTA ANA
FREEWAY AND INTERSECTION OF COMMERCIAL & CENTER STREETS

PART 1 - GENERAL

1.1 DESCRIPTION

A. The work performed in this section consists of the chemical grout stabilization of granular soils present along the alignment under the Santa Ana Freeway and intersection of Commercial & Center Streets, as shown on the construction drawings. It should be understood the specified zone shown on the drawings is to be completely grouted which will require some grouting outside the designated zone.

B. The intent of the Work is to protect the roadways from excessive settlements and cave-ins given the granular soil conditions and the close proximity of the tunnel alignments to each other and the shallow depth of cover. When properly executed in combination with careful tunneling excavation work, surface roadway movements, settlement or heave, shall be held to less than 3/4 inch.

C. The chemical grout stabilization work below the Santa Ana Freeway is to be performed from horizontally installed sleeve port grout pipes (tube-a-manchette) placed below the roadway from access shafts adjacent to the roadway, no work is to be performed from the freeway surface. The chemical grout stabilization work for protection of the intersection of Commercial & Center Streets can be performed from the roadway surface by means of angled and/or vertical sleeve port grout pipes. No ground dewatering is planned in the Work areas. This work shall be performed prior to the start of tunneling in this area.

D. The Work includes, but is not limited to, the following:

1. The drilling of horizontal, inclined and vertical cased holes, the installation of regroutable sleeve port grout pipes, the supplying of the chemical grout materials, the pump injection of chemical grout, and the cement sealing of grout pipes after completion of tunneling.

2. Mobilization and demobilization of all men, equipment and material required to complete the work in this section.

3. Provide verifiable references for the above, to substantiate the satisfactory performance of the referenced operations.

4. Provide a Civil or Geotechnical Engineer, registered in the State of California, who has at least three years of actual on-the-job experience in supervising similar grouting applications.

5. The supervising engineer shall be assisted by an experienced chemical grouting foreman on each grouting shift. The foreman shall have a minimum of five years of similar chemical grout soil stabilization type work.

B. Records for drilling and grouting

1. Keep accurate, timely and legible records.

2. Submit records to the District or its designer on a daily basis while performing the Work.

3. Records shall include, but not limited to, grout mix proportions, gel time, date, and time of day, shift and foreman.

4. At a given sleeve port grout pipe injection location the pressure, flowrate, volume and time shall be recorded.

5. The data shall be displayed in an acceptable chart-type format, and shall be updated daily.

C. The Specialty Subcontractor shall demonstrate to the District or its designer that the specified grout zones have been thoroughly impregnated and stabilized with chemical grout, prior to the start of tunneling operations. Soil sampling methods and/or geophysical methods such as acoustic velocity measurements satisfactory to the District or its designer will be employed.

1.3 SUBMITTALS

A. Refer to Section 01300, Submittals, and Section 01342, Working Drawings, for submittal procedures.

B. Descriptions of drilling, grouting, and monitoring work procedures. Descriptions of the materials and equipment required.

C. Cooperation with the freeway and roadway owners

1. Before starting Work, obtain necessary permits from the owners or their authorized representative, and coordinate the sequence of operations, including:

- a. Means of access to the area
- b. Permitted areas of operation
- c. Permitted work hours for performing the Work
- d. Maintenance of traffic

2. Prepare a Worksite Traffic Control Plan, for submittal to the District or its designer.

3. Give at least three days' notice to the District or its designer of intended meetings with the owners, so that the District or its designer may attend the meetings.

4. Meet with the freeway and roadway owners or their authorized representative, and with the District or its designer, to determine the scope of any restoration Work required.

5. Submit to the District or its designer copies of agreements with the freeway owner.

D. Freeway Access and Facilities

1. Maintain vehicular and pedestrian access at the site, according to the Worksite Traffic Plan.

2. Locate, protect, support and maintain without interruption, utility facilities, equipment and services. Restore such facilities to the condition existing before the start of the Work under this Contract.

1.5 MEASUREMENT

The Work of this Section will be measured as a unit, acceptably performed.

1.6 PAYMENT

Payment will be made under item no. 02154.01 - Chemical Grout Stabilization of the Santa Ana Freeway and Commercial and Center Street Intersection - per lump sum.

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2.2 EQUIPMENT

A. Drilling equipment shall be capable of installing the sleeve port grout pipe given the site conditions and required grouting. Equipment shall be capable of installing a suitably sized drill casing to the required depths and with the required accuracy. Either rotary drive and/or percussion drilling methods utilizing air, foam or water flushing may be employed. It should be noted no dewatering will be performed in the work area and any drilling method causing loss or loosening of ground will not be permitted.

B. Chemical grouting equipment shall have the capacity and mechanical capability to do the specified Work. The equipment shall be maintained in operating condition at all times. Grout holes that are lost or damaged due to mechanical failure of the equipment, inadequacy of grout supply, or improper injection procedure shall be properly filled and replaced by other holes, at no additional cost to the District.

C. The chemical grout plant shall be of the continuous mixing type, and shall be capable of supplying, proportioning, mixing and pumping the grout with a gel time of ten to thirty minutes. Main pumps shall be equipped with recording, positive displacement meters constructed of materials that are noncorrodible for the intended products and operating independently of the viscosity of the products. The pumping unit shall be capable of varying the rate of pumping while maintaining the component ratios constant. Batch-type systems will not be permitted.

D. The pumping unit shall be equipped with piping and/or hoses of adequate capacity to carry the base grout and reactant solutions separately to the point of mixing. The hoses shall unite in a "Y" fitting containing check valves to prevent backflow. The "Y" fitting shall be followed by a baffled mixing chamber. A sampling valve shall be placed beyond the point of mixing chamber, and shall be easily accessible for sampling mixed grout. Distribution of proportioned grout, under pressure, to the grouting locations shall be monitored by separate, automatic real time display, flow rate indicators and gauges.

E. Store chemicals in tanks of made of suitable material and adequately protected from accidental or unauthorized discharge. Storage tank capacity shall be sufficient to supply at least two day's worth of grouting materials so as not to interrupt the Work if chemical delivery delays occur.

3.2 GROUTING PROCEDURES

A. Mixing - Chemical grouting shall be performed by the continuous mixing method, with the proper amounts of sodium silicate, water, reactant, and admixtures automatically proportioned and continuously supplied at proper flow rates and pressures. The sodium silicate and water, reactant, and accelerator shall pass through separate hoses to a baffled mixing chamber prior to injection. The batch type method of mixing grout will not be permitted.

A sampling cock, to allow frequent gel time checks, shall be placed after the mixing chamber. Check valves shall be placed in the grout lines to prevent backflow into the individual component supply hoses.

The grout flow rate, pressure and volume shall be electronically monitored and recorded. Records as previously noted shall be maintained and turned in daily.

B. Injection

1. Using double packers, chemical grout shall be injected into the specified design zones through ports in the sleeve port grout pipes. The grouting pressure for a given sleeve port shall be less than one psi per foot depth, given an allowance for grout flow resistance thru hose, fittings, packer rods, packer and sleeve port. Pressures greater than one psi can be used if acoustic monitoring is to be performed in adjacent boreholes to detect hydraulic fracturing, in which case pressures may be increased up to two psi per foot of depth. Detection of excessive hydraulic fracturing, as determined by using acoustic monitoring equipment placed in adjacent grout pipes, shall require reduction of injection pressure.

2. Roadway elevation monitoring shall be carried out continuously during grouting. Injection procedures shall be adjusted as required to prevent excessive surface heave. Temporary, very high injection pressures will be permitted to crack open sleeve-ports, but these pressures will not be allowed for longer than one minute. The rate of injection into any port shall not exceed eight gallons per minute.

C. Gel Times - Grout shall have a gel time of five to forty minutes, with most grout having gel times of ten to thirty minutes. Samples shall be obtained for gel time checks at least once every half hour of pumping or for every 500 gallons of grout, whichever is more frequent. Gel samples shall be properly containerized, labeled, and stored until completion of the tunneling thru the grouted zone.

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+2