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Converse Consultants
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GEOTECHNICAL REPORT

METRO RAIL PROJECT
DESIGN UNIT A410

BY

CONVERSE CONSULTANTS, INC.
EARTH SCIENCES ASSOCIATES
GEO/RESOURCE CONSULTANTS

JUNE 1984

Funding for this Project is provided by grants to the Southern California Rapid Transit District from the United States Department of Transportation, the State of California and the Los Angeles County Transportation Commission.

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June 29, 1984

Metro Rail Transit Consultants
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Attention: Mr. B.I. Maduke, Senior Geotechnical Engineer

Gentlemen:

This letter transmits our final geotechnical investigation report for Design Unit A410 prepared in accordance with our Contract No. 503 agreement dated September 30, 1983 between Converse Consultants, Inc. and Metro Rail Transit Consultants (MRTC). This report provides geotechnical information and recommendations to be used by design firms in preparing designs for Design Unit A410.

Our study team appreciate the assistance provided by the MRTC staff, especially Mr. B.I. Maduke. We also want to acknowledge the efforts of each member of the Converse team, in particular Howard A. Spellman, Jr.

Respectfully submitted,

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PROFESSIONAL CERTIFICATION

This report has been prepared by CCI/ESA/GRC under the professional supervision of the principal soils engineer and engineering geologist whose seals and signatures appear hereon.

The findings, recommendations, specifications or professional opinions are presented, within the limits prescribed by the client, after being prepared in accordance with generally accepted professional engineering and geologic principles and practice. There is no other warranty, either express or implied.

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Section 1.0

Executive Summary

1.0 EXECUTIVE SUMMARY

1.1 GENERAL

This report presents the results of our geotechnical investigation for Design Unit A410, the Santa Monica Mountain tunnel. The purpose of the investigation is to provide geotechnical information to be used by design firms in preparing designs for the project. Although this report may be used for construction purposes, it is not intended to provide all of the information that may be required to construct the project. Construction methods and type(s) of excavation equipment for the tunnel, cross-passages, and vent shafts are being prepared by the design engineer.

The construction features about 3 miles of twin bore tunnels, between station locations, having an outside diameter of approximately 19 feet.

1.2 GROUND COVER

The minimum ground cover above the crown is 15 feet, and the maximum 500 feet. Caltrans piles for the Hollywood Freeway near Station 792± may intersect the tunnel. At Station 867+00, the Metro Rail Tunnel passes above the Los Angles City Sewer tunnel with about 10 feet of cover.

1.3 MIXED-FACE CONDITIONS

Mixed-face alluvial-bedrock tunnelling conditions will be encountered near the Hollywood/Cahuenga Station, Highland Avenue, Hollywood Bowl Station and Universal City Station before entering fully bedrock tunnelling conditions. Except for the Hollywood Bowl Station, dewatering of alluvium should be anticipated because ground water inflows are believed to be large.

1.4 BEDROCK UNITS

The majority of the tunnel alignment will pass through the following Topanga Formation bedrock units:

1. Topanga Formation (Tt) - "low hardness", interbedded siltstone, claystone and sandstone
2. Topanga Formation (Tt scgl) - "hard", sandstone and conglomerate
3. Topanga Formation (Tb)- "hard", basalt.

There are considerable variations in hardness and unconfined compressive strengths within each bedrock unit; i.e.,

UNIT	RANGE (psi)	"AVERAGE" (psi)
Tt	7 to 28,700	1000
Tb	980 to 35,600	4000
Tt scgl	350 to 33,600	2000

1.5 GROUND WATER

Ground water levels lie above the tunnel the entire length. Bedrock units are judged to be tight, and ground water inflows, in the main, should be nuisance dripping that can be handled with invert drains and sump pumps. Local 100 to 200 gpm inflows of short duration should be expected from bedrocks, based on records from the Los Angeles Sewer Tunnel excavated in 1955. Mineral analyses of water from our borings indicate total dissolved solids range from 511 ppm to 5,996 ppm.

1.6 FAULTS

The tunnel line will cross the projected traces of several known faults which could influence the physical properties of the rock and ground water conditions at tunnel grade. None of the faults crossing design Unit A410 are known to be active. The nearest fault judged to be active is the Hollywood fault, located about 300 feet south of Design Unit A410.

1.7 GAS AND OIL

The entire tunnel line segment in Design Unit A410 is judged to be non-gassy and devoid of oil according to boring records along this segment.

1.8 DESIGN FOR EARTHQUAKES

Design procedures and criteria for underground structures under earthquake loading conditions are defined in the Southern California Rapid Transit District (SCRTD) report entitled "Guidelines for Design of Underground Structures", dated 1984. Evaluations of the seismologic conditions which may impact the project and the probable and maximum credible earthquakes, which may be anticipated in the Los Angeles area, are described in Converse's report to SCRTD entitled "Seismological Investigation & Design Criteria", dated May, 1983. The 1984 report complements and supplements the 1983 report.

1.9 LIQUEFACTION POTENTIAL

The potential for liquefaction of alluvial materials at Design Units A350 (low to moderate), A415 (unlikely) and A425 (high) are discussed in the respective reports for these design units.

Section 2.0

Introduction

2.0 INTRODUCTION

This report presents the results of a geotechnical investigation for Design Unit A410. The subject design unit includes the proposed Santa Monica Mountain tunnel. This 3-mile tunnel will be part of the proposed 18-mile long Metro Rail Project (see Drawing 1, Vicinity Map). The purpose of the investigation is to provide geotechnical information to be used by design firms in preparing designs for the project. Although this report may be used for construction purposes, it is not intended to provide all the geotechnical information that may be required to construct the project. The work performed for this study included literature research, field reconnaissance, drilling and logging of exploratory borings, geologic interpretation, field and laboratory testing, engineering analyses, and the development of recommendations.

Additional geotechnical information on the Metro Rail Project is included in the following reports, some of which may pertain to Design Unit A410.

- "Geotechnical Investigation Report, Metro Rail Project", Volume I - Report, and Volume II - Appendices, prepared by Converse Ward Davis Dixon, Earth Sciences Associates and Geo/Resource Consultants, submitted to SCRTD in November 1981: This report presents general geologic and geotechnical data for the entire project. The report also comments on tunneling and shoring experiences and practices in the Los Angeles area.

- "Geotechnical Report, Metro Rail Project, Design Unit A430," prepared by Converse Consultants, Inc., Earth Sciences Associates, and Geo/Resource Consultants, submitted to SCRTD in May 1984. This report presents the results of our findings for about two miles of subsurface track line proceeding south to north from the north end of the Universal City Station to the south end of the North Hollywood Station.

- "Seismological Investigation & Design Criteria Metro Rail Project", prepared by Converse Consultants, Lindvall Richter & Associates, Earth Sciences Associates and Geo/Resource Consultants, submitted to SCRTD in May 1983: This report presents the results of a seismological investigation.

- "Geologic Notes and Log of Los Angeles City Sewer Tunnel", by David G. Campbell 1955; provides excellent description of geologic conditions encountered from drill and blast excavation along the alignment.

- "Rapid Transit System Backbone Route", Volume IV, Book 1, 2 and 3, prepared by Kaiser Engineers, June, 1962 for the Los Angeles Metropolitan Transit Authority. This report presents the results of a Test Boring Program for the Wilshire Corridor and logs of borings.

- "Report of Supplementary Alignment Rotary Borings, Metro Rail Project, Contract No. 2256-2," prepared by Converse Consultants, Inc., submitted to SCRTD in September 1983. This report presents the soil, rock, and ground water conditions encountered in 10 supplementary rotary wash borings drilled along the Metro Rail Project alignment. Results of laboratory tests performed on selected soil and rock samples are also summarized in the report.

- "Report of Man-Size Auger Boring, Metro Rail Project, Contract No. 2256-2," prepared by Converse Consultants, Inc., submitted to SCRTD in August 1983. This report presents the soil, rock, oil/gas, ground water and other subsurface conditions encountered in 10 large-diameter or man-sized auger holes drilled at various locations along the Metro Rail Project alignment. Results of water quality analyses are also presented.

Pertinent data from the above reports have been incorporated in this report.

The design concepts discussed in this report are based on the following plans for the respective design units:

A350 - "Final Report for the Development of Milestone 10: Fixed Facilities" dated September 1983; CBD to North Hollywood Line Plans, dated September 1983; and Preliminary Site Plans, and Structure Plans and Sections for Hollywood/Cahuenga Station and Pocket Track, dated March, June and July 1983.

A410 - "Milestone 10, Definitive Fixed Facilities Plans, Alignment Plan and Profile", Sheets 15, 16, 17, 18 and 19 of 21, dated March, 1983.

"Final Report for the Development of Milestone 10: Fixed Facilities", dated September 1983.

A415 - "Final Report for the Development of Milestone 10, CBD to North Hollywood Line Plans, Sheets 7 and 8, dated July 1983; and Preliminary Site Plans, Plans and Sections for Hollywood Bowl Station, dated August, 1983.

A425 - "General Plans, CBD to North Hollywood, Contract No. A425, Universal City Station," Sheets 1 to 14 of 20, dated July 1983, and "Final Report for the Development of Milestone 10: Fixed Facilities," dated September 1983 and revised plans A-63 through A-66. These documents were prepared by SCRTD.

If the line and grade of the proposed tunnel, and related stations, are changed from that shown, this report will not be completely applicable to the changed conditions.

Section 3.0

Site and Project Description

3.0 SITE AND PROJECT DESCRIPTION

3.1 SITE DESCRIPTION

The proposed Santa Monica Mountain tunnel line starts at the north end of Hollywood/Cahuenga Station's Pocket Track at about Elevation 340 feet (Drawing 2). The line curves westward, beneath the Hollywood Freeway, rising at a steep grade to about Elevation 460 feet at the south end of the Hollywood Bowl Station (Drawing 3). The line continues through the Santa Monica Mountains, from the north end of the Hollywood Bowl Station, rising at a gentle grade to about Elevation 520 feet near tunnel Station 890+00 (Drawings 3, 4 and 5). From here, the line descends at a gentle grade to about Elevation 500 feet as it enters the south end of the Universal City Station (Drawings 5 and 6).

Ground cover above the tunnel crown ranges from a minimum of about 15 feet beneath Highland Avenue (Drawing 3) to a maximum of about 500 feet of ground cover in the core of the Santa Monica Mountains in the vicinity of Station 866+00 (Drawing 4). The ground surface above portions of the tunnel line is moderately to well developed.

3.2 PROPOSED TUNNEL

The construction features about 3 miles of twin bore tunnels, between Station locations, having an outside diameter of about 19 feet. Numerous cross passages are planned at locations shown on Drawings 2 through 6, inclusive. Two vent structures are located at about Stations 820+00 (Drawing 3) and 874+00 (Drawing 4). Possible alternate vent structure locations are also shown on Drawings 3 and 4.

Section 4.0

Field Exploration and Laboratory Testing

4.0 FIELD EXPLORATION AND LABORATORY TESTING

4.1 GENERAL

The information presented in this report is based primarily upon field and laboratory investigations carried out in 1981 and 1983. This information was derived from field reconnaissance, borings, geologic reports and maps, ground water measurements, field geophysical surveys, ground water quality tests, and laboratory tests on soil and rock samples.

4.2 BORINGS

A total of 31 exploratory boreholes have been drilled at or in relatively close proximity to the proposed tunnel of Design Unit A410. These are:

Nine rotary wash type borings:

28-8, 29A, 29B, 29C, 30A, 31-6, 31-7, 34A, and 34-1

19 NX diamond core borings:

CEG-29, 29-1, 29-2, 29-3, CEG-30, CEG-31, 31-1, 31-2, 31-3, 31-4, 31-5, 32-1, CEG-32, 32-2, CEG-32A, 33-1, 33-2, CEG-33 and CEG-34

Two 36-inch diameter man-sized auger borings:

30B and 34C

One pump test boring (near Universal City Station).

Locations of all the borings used in the interpretation of the subsurface conditions present along the proposed tunnel are shown in Drawings 2 through 6. A detailed description of the field procedures employed in logging the boreholes as well as the edited field logs of all the borings are included in Appendix A. Some water pressure test results are also in Appendix A.

Ground water observation wells (piezometers) were installed in several of the borings drilled at or near the tunnel. Free water was also observed in the man-size auger borings. A summary of the ground water levels measured in the borings is presented in Section 5.7.

4.3 GEOPHYSICAL MEASUREMENTS

Downhole and crosshole compression and shear wave velocity surveys were made in Boreholes CEG-31 and CEG-34 during the 1981 geotechnical investigation.

The downhole survey was conducted down to a depth of about 200 feet, and the crosshole survey was performed in a borehole array down to a depth of about 100 feet. The results of the downhole and crosshole surveys are summarized in Appendix B in addition to a discussion of the procedures employed in the field to perform these surveys.

4.4 OIL AND GAS ANALYSES

Strong natural gas odors and oil were not detected during the drilling and logging of the borings located at or near the tunnel. Occasional oil films appeared in the drilling fluid during drilling of a few borings.

Some organic type odors were detected in man-size auger boring 34C and several of the rotary-wash borings. However, these odors have been attributed to the decay of roots and wood fragments in the Alluvial soils.

4.5 GEOTECHNICAL LABORATORY TESTING

A laboratory testing program was performed on representative soil and rock samples. These consisted of classification tests, consolidation tests, triaxial compression tests, unconfined compression tests, point load tests, direct shear tests, and permeability tests.

About 70% of the unconfined compressive tests failed along bedding planes.

Appendix C summarizes the testing procedures and presents detailed results of the testing program performed as part of the Design Unit A410 investigation. Appendix C also presents some results of laboratory testing programs for Design Units A350, A415, A425 as well as A410.

4.6 WATER QUALITY ANALYSES

Mineral analyses have been performed on water samples obtained from Borings 29, 29-1, 29-2, 29-3, 30, 30B, 31, 32, 32A, 33, 33-1 and 33-2. The results of these tests are presented in Appendix D.

4.7 PETROGRAPHIC ANALYSES

The results of the petrographic analyses performed on selected rock samples obtained from Santa Monica Mountain cores in Borings CEG-30, 31, 32 and 32-A are presented in Appendix I, "Petrology".

Section 5.0

Subsurface Conditions

5.0 SUBSURFACE CONDITIONS

5.1 GENERAL DESCRIPTION

For purposes of our engineering geology evaluation, the subsurface materials were grouped into the following units:

1. Alluvium (A_1/A_2)
2. Topanga Formation (Tt) - "low hardness", interbedded siltstone, claystone and sandstone
3. Topanga Formation (Tt scgl) - "hard", sandstone and conglomerate
4. Topanga Formation (Tb)- "hard", basalt.

We want to emphasize at the outset that bedrocks of the Topanga Formation vary in hardness within each unit. For example, the bedrock unit classified as "low hardness" contains "hard" strata and "hard" cobbles. Also, bedrock classified as "hard" contains weak intervals of "low hardness".

> "Low hardness" is defined in this report as bedrock that can be gouged deeply, or carved, with a pocket knife. Unconfined compressive strengths "average" less than 1000 psi but range from 7 to 4700 psi with one granite cobble up to 28,700 psi. The bulk of the interbedded siltstone, claystone and sandstone unit (designated Tt on Drawings 2 through 6, inclusive) fits this classification. However, we want to emphasize that there are some "hard" interbeds within the Tt unit; for example, near tunnel grade in Boring 29-2 at 95 feet, Boring 29-3 at 98 feet, and Boring 33-1 between 253 to 270 feet.

> "Hard" is defined in this report as basalt and sandstone/conglomerate bedrock that can be scratched with difficulty; that is, the scratch produces only a little powder, and the scratch is often faintly visible. Unconfined compressive strengths average 2000 to 4000 but range from 340 to 9700 psi. The bulk of the sandstone/conglomerate unit (designated Tt scgl on Drawings 4 and 5), as well as the basalt unit (designated Tb on Drawings 3 and 4) fits this classification. However, we again want to emphasize there are "low hardness" intervals within the basalt and sandstone/conglomerate units near tunnel grade; for example, basalt in Boring 31-5 at 104 feet, and sandstone/conglomerate in Boring CEG 32A between 260 to 295 feet.

The range of hardness is best illustrated in the summary plots on Figures C-1, C-2, C-3 and C-4 (Appendix C).

About 95% of the recorded core breaks are due to natural fractures; the balance are mechanical breaks. Borings recorded wide variations in Rock Quality Designations (RQD) (Deere, 1966).

> RQD, as defined in this report, is the percentage of core 4 inches or longer obtained from a coring run.

For example: RQD is poor to fair at the south end of the Hollywood Bowl Station and good to excellent near the north end of the Station. We believe the RQD is better at the north end of the station because this end is farther from the Hollywood Bowl fault zone. Mountain building (uplift) forces that created the Santa Monica Mountains contributed to discontinuities (fractures) in all borings along the tunnel line.

The following paragraphs present engineering descriptions of each of these subsurface materials. Engineering parameters assigned to these alluvial units are in Table 5-1 (Alluvial Material). The laboratory testing program and laboratory test results are presented in Appendix C.

Laboratory testing of the bedrock for this study has generally been limited to unconfined compression tests and point load tests performed during this investigation (Table C-2, Appendix C).

5.2 ALLUVIUM

During the field program for this investigation and neighboring design units, the contact between Young and Old Alluvium has been difficult to identify since the soils in these two deposits are generally very similar. However, considering the close proximity of the site to the Santa Monica Mountains, it is concluded that the alluvial deposits at the north and south ends of the tunnel line are relatively young (geologically speaking). Therefore, for purposes of this report, all references to alluvial deposits should be assumed to mean Young Alluvium.

Alluvial material properties for Design Units A350, A410, A415 and A425 are summarized on Table 5-1 and are described in the following sections.

5.2.1 Hollywood/Cahuenga Station Alluvium (A350)

The alluvial soils encountered at the boring locations generally consisted of a mixture of coarse- and fine-grained soils to depths of 50 to 65 feet underlain by predominately coarse-grained soils. Near surface alluvium was predominately granular, medium dense to dense, consisting of sands, clayey sands and gravelly sands to depths up to 15 feet. The underlying soils were mixtures of clay and sand and were generally classified medium dense to dense clayey sand with some firm to stiff sandy clay. Coarse-grained alluvial soils encountered below depths of 50 to 65 feet included dense to very dense sands, gravelly sands and sandy gravel materials. This material may also contain zones of cobbles and boulders although none were encountered.

5.2.2 Highland Avenue Alluvium (A410)

The alluvium encountered at this site consisted primarily of silty, fine to medium sand with a trace of clay and fine gravel. However, at Boring 31-3, the material graded to a sandy silt with clay. The gravel content of the alluvium tends to increase within about 10 feet of the bedrock surface. Standard Penetration Test (SPT) results ranged from 5 to 77 in this soil unit but averaged approximately 33. Laboratory density tests carried out on samples from this unit generally indicated dry densities ranging between 95 and 105 pcf. Triaxial test results indicated effective stress friction angles

TABLE 5-1

ALLUVIUM MATERIAL PROPERTIES SELECTED FOR STATIC DESIGN

MATERIAL PROPERTY	A350		A410	A415	A425	
	FINE-GRAINED ALLUVIUM	GRANULAR ALLUVIUM	HIGHLAND AVENUE ALLUVIUM	ALLUVIUM	FINE-GRAINED ALLUVIUM	GRANULAR ALLUVIUM
Moist Density Above Ground Water (pcf)	125	125	120	120	125	125
Saturated Density (pcf)	130	130	125	125	130	130
Effective Stress Strength						
ø' (degrees)	30	35	30	33	33	38
c' (psf)	0	0	0	200	0	0
Total Stress Strength[a]						
ø (degrees)	15	-	20	25	20	-
c (psf)	500	-	0	500	0	-
Permeability (cm/sec)	10^{-3} to 10^{-6}	10^{-1} to 10^{-4}	10^{-3} to 10^{-6}	10^{-2} to 10^{-4}	10^{-4} to 10^{-7}	10^{-3} to 10^{-5}
Vertical Compression Modulus[b] (psf)	$150 \cdot \sigma_{v'}$[c]	$450 \cdot \sigma_{v'}$[c]	$150 \cdot \sigma_{v'}$[c]	$260 \cdot \sigma_{v'}$[c]	$300 \cdot \sigma_{v'}$[c]	$500 \cdot \sigma_{v'}$[c]
Poisson's Ratio (non-saturated)	0.40	0.35	0.40	0.35	0.40	0.35

[a] The total stress parameters should be used to determine the increase in undrained strength with depth for use in undrained strength analyses.

[b] Modulus values are secant modulus at 1/2% strain.

[c] $\sigma_{v'}$ is the effective overburden pressure (psf) equal to effective density times overburden depth. Moist density should be used to determine $\sigma_{v'}$ above the water table and submerged density (saturated density minus water density) should be used for the effective density of soils below the water table.

of 32° to 33° and total stress friction angles of 24° to 25°. Direct shear test results were generally higher, with friction angles ranging from 29° to 45°. The strength values of Table 5-1 are somewhat lower than may be expected for "granular" alluvium due to the high silt content of the soils at this site. Undrained modulus values from triaxial tests exhibited a moderate increase with consolidation pressure. Permeability tests performed on silty sand specimens from this unit indicated permeabilities on the order of 10^{-3} to 10^{-4} cm/sec; however, the permeability of the more gravelly soils generally present at the base of the unit is considered to be 10^{-2} to 10^{-3} cm/sec.

Man-size Boring 30B was drilled at the intersection of Highland Avenue and Odin Street (Drawing 3). The purpose was to observe alluvial channel deposits and ground water conditions.

- Facts and Figures - Boring 30B ground Elevation 467 feet; drilled to a total depth of 32 feet.

- Material Types -

  0- to 9-foot interval encountered artificial fill

  9- to 15-foot interval encountered alluvial deposits consisting of sandy clay and boulders up to 1 foot in diameter, dense, moist, stiff to very stiff

  27.5- to 32-foot interval encountered the Topanga bedrock formation consisting of moderately hard sandstone with beds dipping 72° northerly.

- Caving - the boring stood well for its full depth, and no caving was observed.

- Ground Water - At a depth of 27.5 feet which is at the contact of the alluvial and bedrock material, a seep on the order of 1 gpm entered the north side of the boring,and another seep on the order of 1/2 gpm entered the east side of the boring. This suggests that ground water flowing on top of the alluvial bedrock contact is likely to occur along this segment of the tunnel route. The static water level in Boring 30B was 21.7 feet, 20 hours after completing the boring. This depth is about 6 feet above the bedrock contact, suggesting there is a slight head on the water, typical of alluvial channel tributaries.

- Water Quality - The total TDS were 1290 ppm, and the pH was 7.6. This water might be classified as a calcium sulfate water. A general mineral analysis is presented in Appendix D.

- Gas - No gas was detected by meter or odor in this boring.

5.2.3 Universal City Station Alluvium (A425)

The fine-grained alluvium at the site consists of alternating layers and lenses of sandy and silty clays, clayey and sandy silts, and clayey sands. SPT blow count measurements taken in these soils situated near or below the level of the ground water at the site range from 1 to 27 blows per foot and are typically between 10 and 20 blows per foot. These measurements and results of laboratory tests indicate that these soils range from very soft to stiff and very loose to medium dense below the ground water level but are generally firm to stiff and medium dense. Above the water table, these soils have SPT blow counts between 9 and 43 blows per foot with average values in the range of 20 to 25 blows per foot. These SPT data indicate that these shallower soils are stiff to very stiff and medium dense to dense.

Within this generally coarse-grained unit, the materials were predominantly silty fine to coarse sands and gravelly sands. Some of these deposits contain cobbles reported to be up to 6 inches in size. Borings drilled in close proximity to the station site also encountered sandy gravels. These materials generally overlie the bedrock; however, relatively thin, discontinuous layers of silty and poorly graded sand were also found to be present within the fine-grained alluvium. Results of Standard Penetration Tests (SPT) in these soils range from 11 to over 100 blows per foot with typical values between 20 to 50 blows per foot. These measurements indicate that these soils are generally medium dense to dense.

During the drilling of the rotary wash borings at the station site, some difficulty was experienced in the sampling of some of the fine-grained alluvium. As noted in the description of this material type, the SPT blow counts measured in some of the soils situated below the water table were exceptionally low and, in a few cases, the SPT sampler was advanced in the hole by the weight of the drill rod and/or the weight of the hammer. Sample recovery of these soils was also sometimes poor since the soil samples tended to "pull out" of the sampler.

Some difficulty was also experienced during the drilling of Boring 34-5. Caving of this hole was noted by the geologist at a depth of about 38 feet. During installation of the piezometer in this hole, the geologist indicated that the pea gravel placed around the PVC piezometer pipe either bridged in the hole or the hole caved in.

The behavior described above, as well as the results of laboratory tests, indicate that very soft and/or loose layers, lenses, and/or pockets of clayey and sandy materials are present within the fine-grained alluvium close to or below the ground water table.

One large-diameter borehole (Boring 34C) was drilled near this station site. This boring was drilled in Weddington Park on Valleyheart Drive, about 140 feet from the intersection of Bluffside Drive and Valleyheart Drive (see Drawing 6 for location of Boring 34C). This boring is located about 700 feet from the northern end of the Universal City Station structure. The ground surface at the location of Boring 34C is at approximately Elevation 552, which is about 21 feet lower than the ground surface elevation at the north end of the station site. The purpose of this boring was to determine water levels and depths of alluvium above bedrock.

Artificial fill was encountered in Boring 34C from the ground surface to a depth of 10.5 feet and consisted of loose to medium dense silty sand and sandy silt that contained a significant amount of concrete and asphalt rubble. The artificial fill was subject to caving and ravelling.

Between the depths of 10.5 and 26 feet in Boring 34C, alluvium consisting of sand and silty sand with 15% to 25% round cobbles was encountered. It began to cave excessively at a depth of 21 feet, where ground water was encountered. Upon reaching a depth of 26 feet, the hole caved back to 21 feet. Bedrock was not encountered during the drilling of this hole.

5.3 TOPANGA FORMATION (Middle Miocene)

Topanga bedrock material properties for Design Units A350, A410, A415 and A425 are summarized in Table 5-2.

The best general description of the Topanga bedrock formation in the vicinity of Cahuenga Pass is by Hoots (1930). Some excerpts we believe pertinent to the Santa Monica Mountain Tunnel are noted below:

> The formation consists essentially of a thick, steeply dipping series of sandstone, conglomerate, and shale, together with a large amount of intrusive and extrusive basalt ....
>
> The Topanga formation in this area is divisible into three rather distinct members - a lower one that consists essentially of soft coarse gray conglomerate and loose granitic sandstone; a middle one composed of massive, more indurated beds of brown conglomerate and fossiliferous sandstone associated with minor amounts of gray shale and a thick body of basalt of both intrusive and extrusive origin; and an upper, less resistant member that consists essentially of soft thin-bedded shale and sandstone but contains a few massive ledges of brown conglomerate sandstone.
>
> Lower conglomerate member. - The lower member, of coarse detrital character, was derived in part from the granitic and metamorphic core of the range and was deposited upon its irregular surface. Largely because of the preexisting irregularities of this old surface this conglomerate member varies considerably in thickness ... this member is fairly uniform throughout and consists of a mass of soft light-colored granitic and arkosic sandstone with abundant embedded cobbles and boulders as much as 1 foot in diameter. These cobbles and boulders are commonly very well rounded and have a strikingly smooth and highly polished surface. For the most part they are very hard and consist of about equal proportions of granite and gneissic granite, hard dense porphyritic basalt and andesite, and clear varicolored quartzite of fine uniform texture ....
>
> Middle conglomeratic sandstone and basalt member. - [Author's Note: designated Tt scgl and Tb on Drawings 3, 4 and 5) ... the middle member of massive sedimentary and basic igneous rocks ... is massive brown conglomeratic sandstone with a minor amount of thin-bedded sandstone and shale ... the base of this member is overlain by a prominent elongate body of basalt which is far from uniform in thickness ... the basalt is overlain by massive coarse sandstone and conglomerate, together with a subordinate amount of thin-bedded sandstone and shale. The upper part of this largely massive unit grades into finer and thinner bedded shale and sandstone, so that the contact between this middle member and the overlying less massive upper member ... is difficult to draw ....
>
> One of the most significant features of the conglomeratic portion of this middle member is the striking difference between the boulders present in beds below the basalt and those characteristic of much of the 500 to 700 feet of beds which directly overlie the

TABLE 5-2

TOPANGA BEDROCK MATERIAL PROPERTIES

MATERIAL PROPERTY	A350 UNIT	A410 UNIT			A415	A425
	Tt "Low Hardness"	Tt "Low Hardness"	Tb "Hard"	Tt scgl "Hard"	Tb "Hard"	Tt "Low Hardness"
Moist Density Above Ground Water (pcf)	-	-	155	130	155	130
Saturated Density (pcf)	130	130	155	135	155	130
Effective Stress Strength						
ø' (degrees)	28	28	-	-	-	28
c' (psf)	0	0	-	-	-	0
Total Stress Strength[a]						
ø (degrees)	15	12	-	-	-	12
c (psf)	2000	1500	-	-	-	1200
Unconfined Compressive Strength (psi)						
Average	14	1000	4000	2000	1500	30
Range	7 to 200	7 to 4700	980 to 9700	350 to 4100	340 to 2500	7 to 120
Point Load Tests[b] (psi)						
Average	50	2000	10,000	6000	2000	-
Range	20 to 300	80 to 28,700	1550 to 35,600	1800 to 33,600	400 to 11,100	-
Permeability (cm/sec)	10^{-3} to 10^{-7}	10^{-3} to 10^{-7}	-	-	-	10^{-6} to 10^{-7}
Poisson's Ratio (non-saturated)	0.35	0.35	0.25	0.30	0.35	0.40
Vertical Compression Modulus[c] (psi)	1.4×10^4	1.4×10^4	5×10^4	4×10^4	4×10^4	1.4×10^4

[a] The total stress parameters should be used to determine the increase in undrained strength with depth for use in undrained strength analyses.

[b] Estimated strength based on 25 times the Point Load Diametral Strength Index (Bieniawski, 1975).

[c] Modulus values are secant modulus at 1/2% strain.

basalt. In the lower beds the cobbles and boulders are generally [Author's Note: very hard] well rounded and, like those of the underlying conglomerate, consist essentially of granite, granodiorite, dense andesite and basalt porphyry, and quartzites of various color. In the beds above the basalt, the most striking feature is the abundance of [Author's Note: friable) deeply weathered subangular boulders of basalt as large as 4 feet across ... in outcrops where only 10 feet of a bed is exposed it is not uncommon to find six or eight basalt boulders that average 1 foot in diameter ....

Upper thin-bedded shale and sandstone member. - [Author's Note: designated Tt on Drawings 2, 3, 5 and 6] ... an upper member ... is well exposed in street cuts southwest and northeast of Cahuenga Avenue and is composed, to a large extent, of soft thin-bedded brown and bluish-gray shale and fine-grained sandstone, although massive beds of soft brown and gray sandstone and conglomeratic sandstone also occur in the middle and upper parts, northeast of Cahuenga Avenue .... [Author's Note: The contact between the upper and middle member is gradational.]

5.4 TOPANGA FORMATION (Tt)
"Low Hardness" interbedded siltstone, claystone and sandstone

The areal distribution of these rocks is shown on Drawings 2 through 6, inclusive. These rocks occupy the southern and northern portions of the tunnel line. The Hollywood Bowl fault (Drawing 3) rather sharply defines the contact between "low hardness" rocks (Tt) and "hard" basalt (Tb) at the southern end of the line.

The contact between "low hardness" rock and "hard" sandstone/conglomerate (Tt scgl) at the southern end of the line is not sharply defined (shown on Drawing 5 as a queried contact). This contact is not sharp because the contact is gradational in a northward direction; i.e., the deposits gradually grade from coarse-grained (gravelly conglomerates) to finer-grained (sandstone and siltstone) materials near the Universal City Station. This means there are likely to be some "hard" interbeds of conglomerate dispersed in the "low hardness" rocks north of the contact, as evidenced in Borings 33-1 and CEG-33.

Borings drilled into the "low hardness" interbedded siltstone, claystone and sandstone bedrocks were:

Southern end tunnel line -
28-8, CEG-29, 29-A, 29-B, 29-1, 29-C, 29-2, 29-3, 30-B, CEG-30

Northern end tunnel line -
33-1, 33-2, CEG-33 (1100 feet east of tunnel line), CEG-34 (1200 feet west of tunnel line), 34-A, 34-1.

Bedrocks encountered in these borings are of friable to low hardness, with "average" unconfined compressive strengths on the order of 30 psi but ranging from 7 to 4700 (Table 5-2). Occasional (not pervasive) "hard" interbeds were recorded with unconfined compressive strengths of 4700 psi (Boring 29-2), 1400 psi (Boring 29-3) and 2700 psi (Boring 33-1).

Point load tests were performed on some cores during the drilling operation. From the standpoint of strength, the results were considerably higher than our laboratory's unconfined compression strengths. The point load test diametral strength index was multiplied by 25 as a conversion factor to compare with unconfined compression tests (see Table C-2, Appendix C). A few exceptionally high point load test strengths were recorded in the "low hardness" Tt unit in Borings CEG-33 and 33-1; i.e.,

BORING No.	DEPTH (ft)	POINT LOAD TEST (psi)	REMARKS
CEG-33	84	28,100	Quartzite
	102	16,300	Conglomerate interbed
	112	14,600	Quartzite
33-1	260	28,700	Granite cobble
	287	18,000	Granite cobble

The above illustrates there is a wide range of rock strengths within the "low hardness" unit at the northern end of the tunnel line.

The "low hardness" interbedded siltstone, claystone and sandstones are generally intensely to little fractured, thinly bedded, friable to low hardness, moderately strong, deep to moderately weathered as defined in Table A-3, "Bedrock Description Terms" (Appendix A).

Boring 34 (see Drawing 5), located about 1200 feet west of the tunnel line, recorded an average shear wave velocity of 1400 fps and average compressional wave velocities of 6200 fps (Appendix B).

5.5 TOPANGA FORMATION (Tt scgl)
"Hard" sandstone and conglomerate

Borings 32-2 and CEG-32A were drilled in the "hard" sandstone and conglomerate bedrocks.

Bedrocks encountered in these borings are moderately hard to hard, with unconfined compressive strengths ranging from 350 to 2965 psi (Boring 32-2) and 472 to 4100 psi (Boring CEG-32A). The "average" unconfined compression strength is believed to be 2000 psi (see Table 5-2).

The "hard" sandstone and conglomerate are intensely fractured (spaced 0.05 feet to 0.1 feet apart) to little fractured (spaced 1.0 foot to 3.0 feet apart), averaging moderately fractured (spaced 0.5 feet to 1.0 foot apart); other physical properties are moderately hard to hard, weak to strong and deep to little weathered, as defined in Table A-3 (Appendix A).

Generally, this unit is strongly cemented. However, Boring 32-2 encountered a sheared, weakly cemented siltstone matrix at tunnel grade. Very hard, gravel, cobbles and boulders of chert, quartzite and granite were embedded in this matrix which resulted in almost 0% recovery and very difficult diamond core drilling because the cobbles wobbled around in the hole (see Sections 6.2.5 and 6.3.3 for further discussion). Point load tests in Boring 32-2 indicate some individual granite cobbles in the conglomerate go as high as 33,000 psi (Table C-2, Appendix C), but these were located well above tunnel grade.

5.6 TOPANGA FORMATION (Tb)
"Hard" basalt

Borings 31-1, CEG-31, 31-5, 31-6, 32-1 and CEG-32 were drilled into "hard" basalt. The basalt, in general, is hard, strong and little weathered, as defined in Table A-3 (Appendix A).

Bedrocks encountered in these borings are moderately hard to hard, with unconfined compressive strengths ranging from 980 to 9700 psi and "averaging" 4000 psi (see Table 5-2).

A few very high point load test strengths were recorded in the "hard" Tb unit in Borings 31-3, 32-1 and CEG-32; i.e.,

BORING No.	DEPTH (ft)	POINT LOAD TEST (psi)	REMARKS
31-1	69	11,100	Unfractured
32-1	393	10,900	-
	401	13,800	-
	406	26,100	Unfractured
	424	35,600	Unfractured
CEG-32	280	10,700	Unfractured
	307	11,200	Unfractured

The "hard" basalt bedrocks are intensely to little fractured, averaging moderately fractured (spaced 0.5 to 1.0 feet apart). Basalt in Boring 32-1, although hard, is intensely fractured (spaced 0.05 ft. to 0.1 ft. apart) at tunnel grade. There was considerable evidence in Boring 32-1 at tunnel grade of "spun" basalt core suggesting mechanical breaks. However, after careful examination and discussion with the geologist who logged the hole, we conclude the cores in Boring 32-1 were in the main "spun" along natural fracture breaks. "Spun" in this case means core rotating in the core barrel.

Boring CEG-31 downhole geophysical tests in basalt recorded average shear wave velocities of 4800 fps and average compressional wave velocities of 8800 fps (Appendix B).

Basalt in Borings 31-2 through 31-4 is intensely fractured (spaced 0.05 foot to 0.1 foot apart) to moderately fractured (spaced 0.5 foot to 1.0 foot apart). Basalt in Boring 31-5 is moderately fractured to little fractured (spaced 1.0 foot to 3.0 feet apart). Fractures nearer the Hollywood Bowl fault zone are weakly cemented with soft, secondary minerals, chlorite and talc. Thus, cores break more easily, and the RQD is generally poor to fair. Fractures in Boring 31-5, farthest from the Hollywood Bowl fault zone, are more strongly cemented, predominantly with quartz. Thus cores do not break readily, and the RQD is generally good. Table 5-3 shows RQD variations in basalt at various depths near the Hollywood Bowl.

TABLE 5-3

RQD VARIATIONS - BASALT

BORING No.	RQD (%)	APPROXIMATE DEPTH INTERVAL (ft)
31-2	96	35 - 37
	41	37 - 42
	79	42 - 47
	0	47 - 51
Station Grade →	38	51 - 56
	28	56 - 59
	32	59 - 63
	77	63 - 70
	43	70 - 76
	75	76 - 82
	34	82 - 85
	19	85 - 90

BORING No.	RQD (%)	APPROXIMATE DEPTH INTERVAL (ft)
31-3	17	46 - 51
	68	51 - 56
	63	56 - 59
	68	59 - 64
	100	64 - 69
Station Grade →	83	69 - 74
	60	74 - 79
	92	79 - 84
	45	84 - 89
	65	89 - 90
	84	90 - 95
	96	95 - 100

BORING No.	RQD (%)	APPROXIMATE DEPTH INTERVAL (ft)
31-4	76	21 - 26
	84	26 - 32
	67	32 - 36
	58	36 - 41
	27	41 - 46
	33	46 - 51
	61	51 - 56
	60	56 - 61
	60	61 - 66
	69	66 - 71
	84	71 - 76
	54	76 - 81
	57	81 - 86
	75	86 - 91
Station Grade →	90	91 - 100

BORING No.	RQD (%)	APPROXIMATE DEPTH INTERVAL (ft)
31-5	96	13 - 17
	100	17 - 27
	100	27 - 37
	98	37 - 45
	95	45 - 55
	79	55 - 65
	100	65 - 75
	95	75 - 80
	62	80 - 84
	82	84 - 88
	65	88 - 96
	93	96 - 105
	80	105 - 113
Tunnel →	98	113 - 121
	87	121 - 131
	97	131 - 150

RQD AS RELATED TO ROCK-MASS PROPERTIES:

RQD (%)	DESCRIPTION	APPROXIMATE EQUIVALENT FRACTURE SPACING
0- 25	Very poor	Intensely
25- 30	Poor	Closely
30- 75	Fair	Moderately
75- 90	Good	Little
90-100	Excellent	Massive

If compared to rock tunnelling conditions, we believe the following Terzaghi Rock Condition Numbers (Drawing 7) would apply to the basalt (Terzaghi, 1946).

Borings 31-2, 31-3, 31-4 and 32-1: Terzaghi No. 4 (moderately blocky and seamy)
Terzaghi No. 5 (very blocky and seamy)

Borings 31-5 and CEG-32: Terzaghi No. 3 (massive, moderately jointed)
Terzaghi No. 4 (moderately blocky and seamy)

5.7 GROUND WATER

Ground water levels along the tunnel line were measured in borings. Table 5-4 presents ground water levels measured in these borings. Drawings 2, 3, 4, 5 and 6 show the known current water levels. Table 5-4 indicates ground water levels measured in piezometers have remained relatively constant for the period 1981 to 1984.

Mineral analyses of water obtained from Borings CEG-29, 29-1, 29-2, 29-3, CEG-30, 30-B, CEG-31, CEG-32, CEG-32A, CEG-33, 33-1 and 33-2 are presented in Appendix D. The total dissolved solids (TDS) in these borings ranges from a minimum of 511 ppm in Boring CEG-31 to a maximum of 5,996 ppm in Boring CEG-29.

We did not study the effects of corrosion. For details on corrosion, refer to the "Corrosion Control Final Report", dated June 20, 1983, for SCRTD by Professional Services Group, Waters Consultants Division, San Diego, California.

5.8 PUMP TEST

A pump test was performed about 750 feet west of the Universal City Station site in April 1983 (see Drawing 6, Pump Test Well PT-2). The materials that were selected for aquifer testing consisted of a bed of clean sand and gravel and fine sand. It is our judgment that these soils have hydraulic characteristics which are similar to those of the sands and gravels which directly overlie the bedrock at the tunnel and Universal City Station site. However, the aquifer thickness at the tunnel is likely considerably greater than the aquifer tested 750 feet west of the tunnel. The general hydraulic characteristics determined on the basis of the pump test results are as follows:

- Transmissivity: About 19,000 gpd/ft (average).
- Storage Coefficient: Computed values vary between 0.008 to 0.059 because of the short duration of the test. It should be noted that, as these deposits are dewatered, a specific yield value that is considerably greater than the computed value of storativity will apply.
- Boundaries: A boundary was observed during one of the two pump tests conducted at the location of PT-2. The distance to the observed boundary could have been computed; however, it would not be applicable to the Universal City Station excavation.
- Average Formation Permeability: Computed to be about 9.0×10^{-2} cm/sec (average). However, individual layers may have widely varying permeabilities.

A description of the general procedures and the results of the pump test are presented in Appendix E.

TABLE 5-4

GROUND WATER OBSERVATION WELL DATA

	GROUND WATER ELEVATION*									
	Initial		1981	1982	1983			1984		
BORING	Reading	Date	06/17	04/28	03/02	10/24	12/20	02/13	03/14	05/08
28-8	396	02/24/84							376	
CEG-29	344	03/23/81		374						
29-A	379	02/15/83			dry		dry		dry	
29-B	391	02/14/83			390				383	
29-1	---	--------								420
29-C	438	02/10/83			441		434		432	
29-2	---	--------								452
29-3**	---	--------								469
30-B**	442	02/23/83								
CEG-30	454	03/03/81	456	453						455
31-1	453	10/06/83				453	453	453		454
CEG-31	453	02/24/81		456				457		458
31-6**	---	--------								dry
31-2**	486	10/24/83				486				
31-3**	470	10/09/83								
31-4**	516	11/03/83								
31-7	dry	03/14/84								dry
30-A**	dry	02/22/83								
31-5	530	10/19/83				531	531	533		531
32-1**	808	01/23/84								
32	713	03/20/81	714	720						
32-2**	---	--------							893	
32-A	761	03/17/81		755						
33-1	754	05/17/84								
33	597	03/17/81		599						
33-2	---	--------								590
CEG-34	555	04/02/81								
34-A	566	02/14/83					569		566	

*Rounded to the nearest foot.

**No piezometer casing.

Section 6.0

Geotechnical Evaluation – Tunnels

6.0 GEOTECHNICAL EVALUATION - TUNNELS

6.1 GENERAL

The major soil and bedrock units which will be encountered along the proposed tunnel line are shown on Drawings 2, 3, 4, 5 and 6 and described in Sections 5.1 through 5.6, inclusive. These units are:

Alluvium (A_1/A_2):

loose to medium dense sand and firm to stiff silts and clays with occasional gravel and cobbles

Topanga Formation (Tt):

"low hardness" interbedded siltstone/claystone and sandstone

Topanga Formation (Tt scgl):

"hard" sandstone and conglomerate

Topanga Formation (Tb):

"hard" basalt.

Water pressure tests were performed in Borings 29-1, 29-2, 29-3, 32-1 and 32-2. The results are appended to Appendix A, and summarized below.

BORING	COMMENT
29-1	no take, "low hardness" rock
29-2	0.6 gpm take, "low hardness" rock
29-3	no take, "low hardness" rock
32-1	no take, "hard" basalt
32-2	1.2 gpm take (some due to rod leakage), "hard" conglomerate
33-1	hole too large to seat packer, "low hardness" rock
33-2	hole too large to seat packer, "low hardness" rock

Based on the results, both "low hardness" and "hard" bedrock units are tight. However, minor flows from a labyrinth of interconnected fractures should be anticipated. Most of these flows we believe can be handled with normal gravity invert drains and sump pumps.

Geologic mapping along and adjoining the ground surface of the tunnel alignment was not part of this contract. Therefore, oriented geologic contacts of various key bedrock units, faults, bedding planes, fracture attitudes are sparse to non-existent, and rosettes of discontinuities were not prepared. The areal distribution of geologic units shown on the drawings is from one or a combination of the following sources:

° Los Angeles City's "Preliminary Geologic Map of the Santa Monica Mountains" (1970)

° Weber (1980) "Earthquake Hazards Associated with the Verdugo-Eagle Rock and Benedict Canyon Fault Zones, Los Angeles County, California" (CDMG Open File Report 80-10LA)

- Hoots (1930) "Geology of the Eastern Part of the Santa Monica Mountains, Los Angeles County, California", USGS Professional Paper 165-C.

- Converse Consultants, Inc. file data.

Projecting unoriented surface geologic features hundreds of feet into tunnel grade is risky and very judgemental, especially when considering the strata are tilted 30° to 70° from the horizontal. Therefore, the locations of faults and geologic contacts at tunnel grade (Drawings 2, 3, 4, 5 and 6) may be ten to hundreds of feet from where shown or may be non-existent at tunnel grade.

6.2 FAULTS

Faults shown on the drawings are discussed below:

6.2.1 Hollywood Fault Zone - Stations 758± to 764±

The trace of the Hollywood fault zone is located between Stations 758± to 764± at Pocket Track grade (Drawing 2). The northernmost part of the Hollywood fault zone is believed to be 250 feet south of the tunnel contract for Design Unit A410, and should not affect tunnelling conditions.

However, this fault is judged to be active; i.e., there is evidence of displacement at or near the ground surface at least once within the past 10,000 years (Holocene time). This opinion is based on:

a) Interpretation of Bouger Gravity and Density Model Profile 5 showing a vertical bedrock offset of about 400 feet along a thrust feature dipping about 50° to the north (Converse, et al, "Geotechnical Investigation Report, Volume II, Appendices", November 1981, p. II-714, and Figure No. D-5, p. II-721, prepared for SCRTD).

b) Alignment of 2- to 3-meter high scarp-like features in the Hollywood, Los Feliz, Atwater area of Los Angeles; i.e., have offset very late Quaternary (including Holocene) alluvial sediments (Weber, et al, "Earthquake Hazards Associated with the Verdugo-Eagle Rock and Benedict Canyon Fault Zones, Los Angeles County, California", 1980, OFR 80-10LA, p. A-3, B-104, B-105 and B-106.

c) Interpretation of Borings 28-B, 28-C, 28-2, CEG-28-A, 28-1 and 28-8 drilled by Converse for SCRTD and MRTC in 1981, 1983 and 1984.

A 1983 study to establish the date of the last movement on the Hollywood fault was inconclusive because the fault, where observed in granite bedrock, was not overlain by datable alluvium (Crook, R., Proctor, R.J. and Lindvall, C.E., "Seismicity of the Santa Monica and Hollywood Faults Determined by Trenching", February 1983, U.S. Geological Survey Contract No. 14-08-0001-20523).

The approximate 600-foot width of the fault zone is based on interpretation of alluvium and bedrock contacts from our 1981, 1983 and 1984 borings.

The seismic characteristics of the Hollywood fault are discussed in the "Seismological Investigation & Design Criteria" report of May, 1983 prepared by Converse et al for SCRTD. This report assigns a maximum design earthquake (Richter magnitude) of 6.5M to the Hollywood Fault. Although there is a low probability of this event (and attendant displacement) on the Hollywood fault, during the estimated 100-year life of the facility, such a potential event requires consideration in tunnel design.

6.2.2 Hollywood Bowl Fault

The Hollywood Bowl fault was encountered in Borings CEG 30 and 31 and is interpreted to be present in Gravity Profile 6 and Seismic Line S-51 (see Converse et al, 1981, Vol. II, p. 695 and 722). This fault does not appear to have offset alluvial deposits and is steeply dipping (±80°), with the north side reported to be displaced upward relative to the south side (see Drawing 3). The amount of displacement and the age of last displacement is unknown. However, the fault is not known to be an active or potentially active fault. The fault is judged not to be present in bedrock at the planned final grade, and should have little, if any, impact on tunnelling conditions.

6.2.3 Los Angeles City Faults - Stations 844+00, 847+00 and 851+00

These faults are shown on Los Angeles City's "Preliminary Geologic Map of the Santa Monica Mountains" (1970) and were projected vertically into the tunnel section (Drawing 4). We do not know the attitude, vertical depth, nor the physical condition, and have not confirmed the existence of these faults in the field. They are not known to be active faults.

6.2.4 Unnamed Fault No. 1 - Station 866+00

This fault is believed to occur at the contact of Topanga sandstone/conglomerate and Topanga basalt (Drawing 4) as mapped by Hoots (1930), and may be nearly vertical, but there is no subsurface data to confirm that attitude. The north side is reported to be down relative to the south side. The fault is judged inactive as it is not designated active or potentially active on any State or City seismic hazard maps. The fault line crosses the tunnel line at an oblique angle and may follow the excavation for several tens of feet.

Metropolitan Water District's 1940 Hollywood Tunnel (Appendix F) was reported to have encountered a blocky and seamy area about 80 feet wide and a two-day inflow of 600 gpm from this fault.

However, the Los Angeles City Sewer Tunnel (Station 429+00±) also crosses the Metro Rail Tunnel (Station 866+00±) at this fault. Other than a 100-gpm inflow for a few hours from one joint, no unusual ground water inflows, nor unusually poor tunnelling conditions were reported. According to geologic notes (by David Campbell, 1955) taken during excavation, there were a few small 1/2 inch wide faults trending N72°-81°E, dipping 73°-87°SE that required only light support. These discrete breaks, as logged by Campbell, apparently extend for distances of 400 feet on each side of Unnamed Fault No. 1, but did not impede tunnel progress nor require extra supports.

6.2.5 Boring 32-2 Shear Zone - Station 873+50

A zone of shearing which could impact tunnelling and vent shaft conditions, has been interpreted for the depth interval 417 to 470 feet in Boring 32-2 (Drawing 4). Only 4 feet of core (fragments) were recovered in this 53-foot interval.

In the depth interval 417-470 feet a few greenish-colored friable, brecciated siltstone/claystone fragments were recovered. These fragments exhibit soft, shiny, curved slickensided surfaces, probably due to shearing. Therefore, if we assume this feature is steeply dipping, and the green-colored material makes up the bulk of the matrix from 417 to 470 feet, we would interpret this as a 53-foot wide shear zone at tunnel and vent shaft grade (Drawing 4).

6.2.6 Unnamed Fault No. 2 - Station 894+50

This fault is believed to occur near the contact between the Topanga sandstone/conglomerate (Tt scgl) and Topanga siltstone, shale and sandstone (Tt) (Drawing 5), and may be nearly vertical as mapped by Weber (1980). The north side is reported to be down relative to the south side. The fault is believed to be inactive as it is not designated active or potentially active on any State or City seismic hazard maps. The fault line crosses the tunnel line at an oblique angle and may follow the excavation several tens of feet.

The physical conditions of the fault may be comparable to the fault zones encountered between Los Angeles City Sewer Tunnel Stations 444+34 to 446+24 and again between Stations 451+22 to 452+72, if projected into the Metro Rail tunnel. According to geologic notes (by David Campbell, 1955) taken during excavation of the Sewer Tunnel, these zones required moderate to heavy support for brecciated sandstone and shale bedrock. Seepage was noted in these fault zones, but no unusual quantities of inflow were reported. Bedding plane attitudes ranged from N50 to 70°W, dipping 34° to 72°NE with local slippage (faulting) along bedding planes.

6.2.7 Boring 33-1 Fault - Station 901+50

The bottom 19 feet (depth interval 351 to 370 feet) is judged to be faulted siltstone and sandstone that could influence tunnelling conditions if projected upward into the tunnel line (Drawing 5). The rocks are intensely fractured to crushed and slickensided, containing plastic clay (gouge). Fractures are filled with clay, and locally the clay surfaces are striated and polished. RQD was about 17% for 14 feet of the 19-foot interval.

6.2.8 Benedict Canyon Fault - Station 921+50 and 922+50

Approximately 1.5 miles of left-lateral offset has occurred along the Benedict Canyon fault based on the apparent separation of a stratigraphic contact between 10 to 15-million year old Miocene-age Topanga Formation (Hoots, 1930, Weber and others, 1980). Also, normal dip-slip offset has occurred along the fault, with the north side down relative to the south side (Weber, 1980). The youngest formation offset along the known segment of the fault is the late (5 to 10 million years old) Miocene-age Modelo Formation (Weber and others, 1980, and Woodward Clyde Consultants, 1982). Thus, the most recent documented movement of the fault is about 5 million years before present. Based on the above, and the fact that the fault is not designated active or potentially active on any State or City seismic hazard map, it is our opinion the Benedict Canyon fault is not active or potentially active.

The Benedict Canyon fault is shown on Drawings 5 and 6. The location is based on a compilation of work by others; i.e., Los Angeles City Geologic Map Sheet No. 94 (1970); Hill (1979); Weber (1980); Woodward Clyde Consultants (1982) and in part on Converse et al (1981) interpretation of seismic refraction survey data from Seismic Lines S-28 and S-33 (see Converse et al, 1981, Vol. II, p. 676, 677 and 697).

The physical condition of bedrock at tunnel grade is not known. However, the physical condition may be similar to two faults observed at the Universal Sheraton Hotel site (Clements, 1966) and one observed at the Getty Plaza site (Woodward Clyde Consultants, 1982). If these faults continue through the tunnel alignment, the following descriptions may be applicable to tunnelling conditions (they are shown on Drawings 5 and 6 as faults 1, 2 and 3):

1) Trend N65° to 70°E, dip vertical, 15- to 25-foot wide zone of crushed, broken and sheared bedrock with considerable gouge material and seepage from sandstone beds adjacent to and on the south side of the faults.

2) Trend N65° to 70°W, dip vertical, 1.5-foot wide zone of crushed, broken and sheared bedrock with gouge material and seepage from sandstone beds adjacent to and on the south side of the fault.

3) Trend N50° to 55°E, dip unknown, 10-foot wide zone of sheared and contorted bedrock material with fault gouge.

We point out that Boring 33-2, located a few feet south of the Benedict Canyon fault (Drawing 5), did not encounter sheared or faulted bedrock.

6.3 STRATIGRAPHIC, GROUND WATER AND TUNNELLING CONDITIONS

6.3.1 Station 766+50 and 800+50 (3,400, Drawings 2 and 3)

The twin bore tunnels emerge from the north end of the Hollywood/Cahuenga Station in primarily "low hardness" interbedded siltstone and claystone bedrock of the Topanga Formation (Tt). Variations in the bedrock surface may result in mixed faced conditions near the crown with alluvium above and Topanga Formation below between Stations 766+50 and 770+00; 5 to 10 feet of bedrock covers the crown in this segment. Hollywood/Cahuenga Station alluvium is described in Section 5.2.1. Dewatering will likely be required; dewatering systems are discussed in Section 6.4.1 The siltstone and claystone interbeds are likely to air-slake, but no treatment is believed necessary provided advance rates are reasonable. The bedrock should stand up well; the alluvium will likely cave. Squeezing ground is not likely.

Boring 29-1 encountered crushed, sheared, clay-filled fractures at the bottom of the hole (depth 110 to 120 feet). We interpret this as a fault zone as shown on Drawing 2.

The tunnel emerges out of the Topanga Formation at about Station 792+50, passing through a mixed faced condition entirely into the saturated Highland Avenue alluvium. This alluvium terminates some 200 feet south of the Hollywood Bowl Station. The Highland Avenue alluvium is described in Section 5.2.2. Dewatering will probably be required as discussed in Section 6.4.2.

The tunnel passes over a buried channel with ground water near the crown between Stations 792+50 and 797+50. The tunnel invert on each side of the channel is supported on bedrock, and some differential settlement may result in this length of line due to vibrations from subway trains and/or seismic ground shaking. We base this opinion on low SPT blow count recorded in Boring 31-1; i.e., 8 to 10 blow counts above and slightly below tunnel grade, increasing to 33 blow counts at a depth of 50 feet, suggesting the Highland Avenue alluvium could densify.

The Hollywood Bowl fault zone is believed to be located beneath the Highland Avenue alluvial channel, but we do not believe the channel deposits are disrupted by the fault (Drawing 3). The Hollywood Bowl fault is discussed in Section 6.2.2.

Between Stations 797+50 to 800+50, the tunnels will pass through moderately hard to hard basalt (Tb), except the crown may encounter mixed faced conditions of alluvium above and basalt bedrock below just as it enters the south end of the Hollywood Bowl Station.

Figures 6-1, 6-2, 6-3, 6-4 and 6-5 show transverse sections relating the variable ground water levels, soil stratigraphy and unconfined compressive strengths of bedrock with the vertical tunnel alignment. Near tunnel grade, sedimentary bedrocks are considered primarily friable to low hardness and the basalt moderately hard to hard. The range of unconfined compressive strengths, as shown on these figures, are:

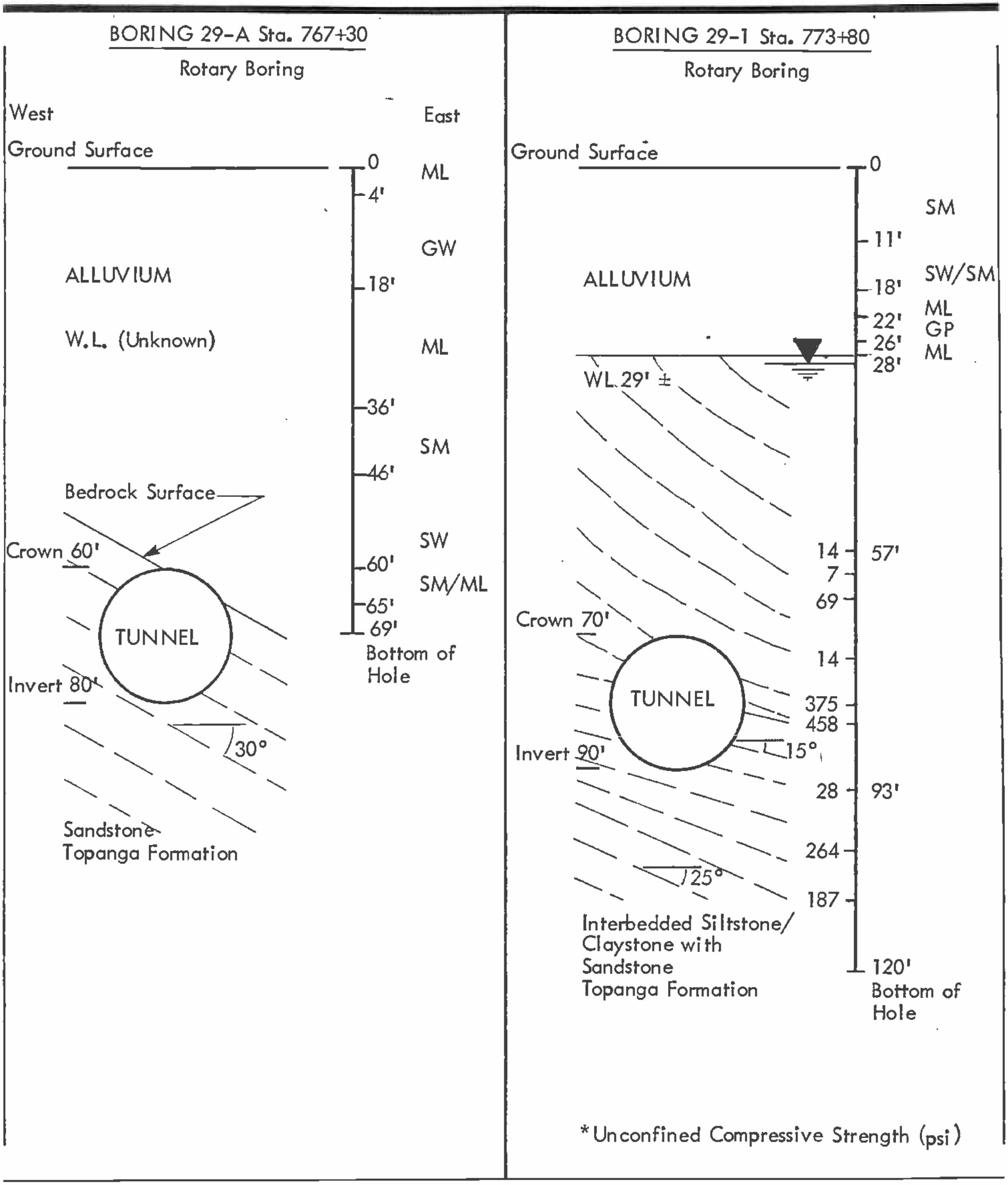
BORING	DESCRIPTION	psi
29-1	Siltstone, claystone and sandstone	7 to 458
29-2	Siltstone, claystone and sandstone	7 to 4700
29-3	Siltstone, claystone and sandstone	64 to 1440
31-5	Basalt	896 to 4000

As noted in Sections 5.1 and 5.4, variable hardness bedrock should be anticipated in both Tt and Tb units.

6.3.2 Station 806+00 and 866+00 (6,000 feet, Drawings 3 and 4)

The primary tunneling media between the north end of the Hollywood Bowl Station and Station 866+00 will be moderately hard to hard basalt of the Topanga Formation (Tb). The basalt should stand up well and require nominal support.

Vertical projection of surface geology to tunnel grade suggests some steeply dipping bands of sedimentary rock could be encountered between Stations 835+00 and 840+00 as well as Stations 844+00 to 847+00. These bands of sedimentary rock could well be altered by basalt intrusions. Bands of sedimentary rock



EXAMPLES OF STRATIGRAPHIC VARIATIONS

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Southern California Rapid Transit District
METRO RAIL PROJECT

Project No. 83-1140

Figure No. 6-1

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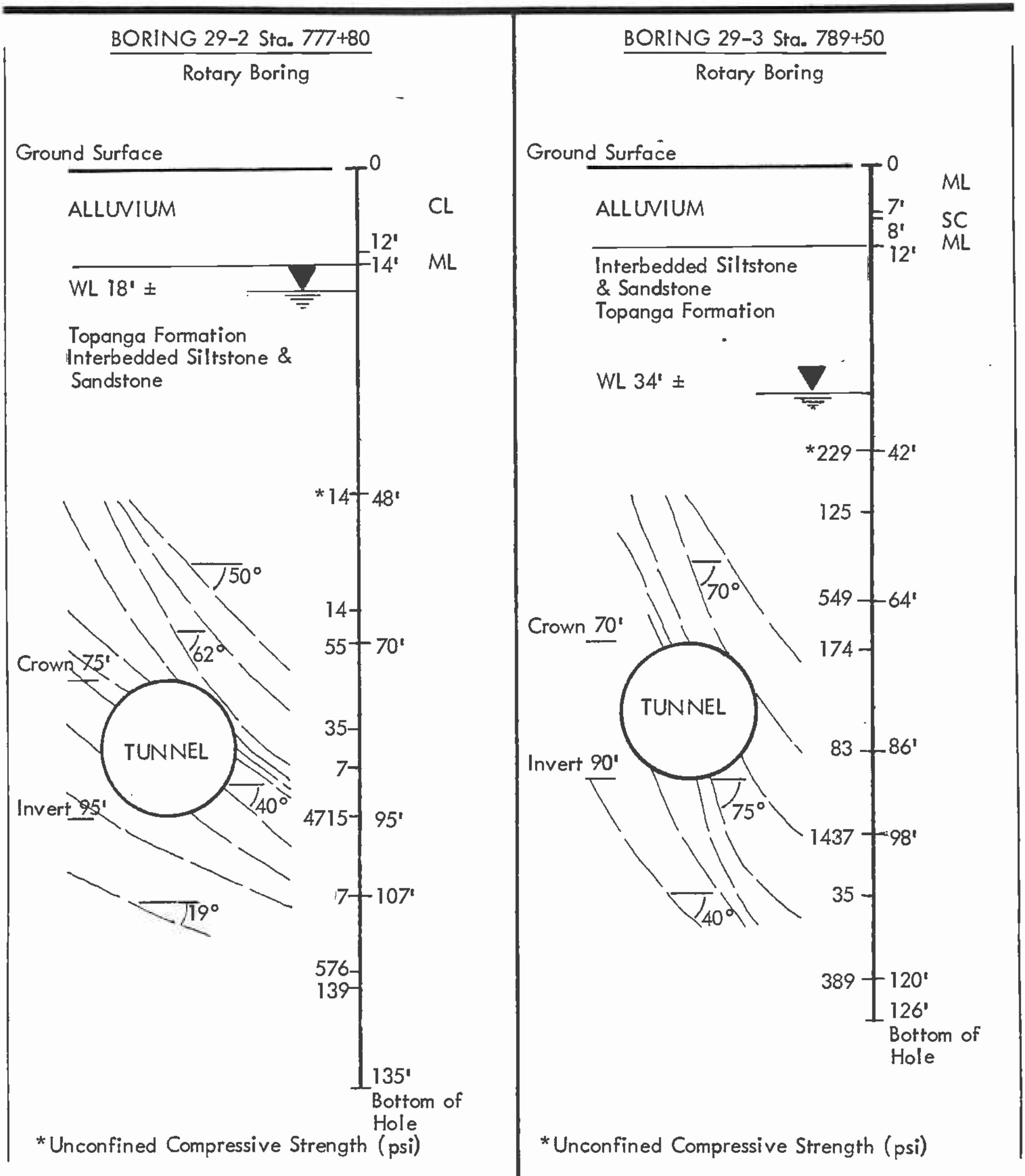

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Figure No. 6-2

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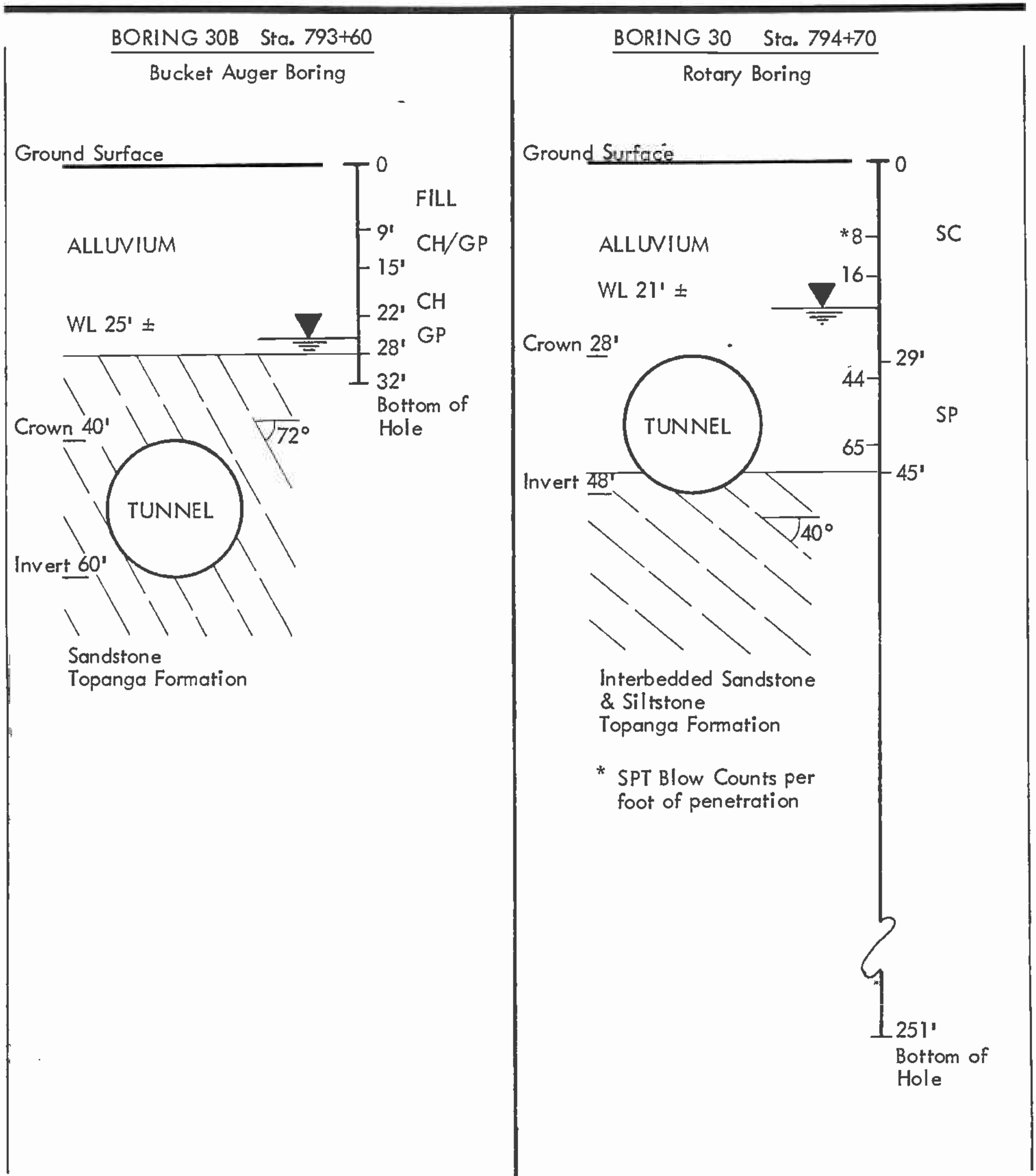

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Figure No. 6-3

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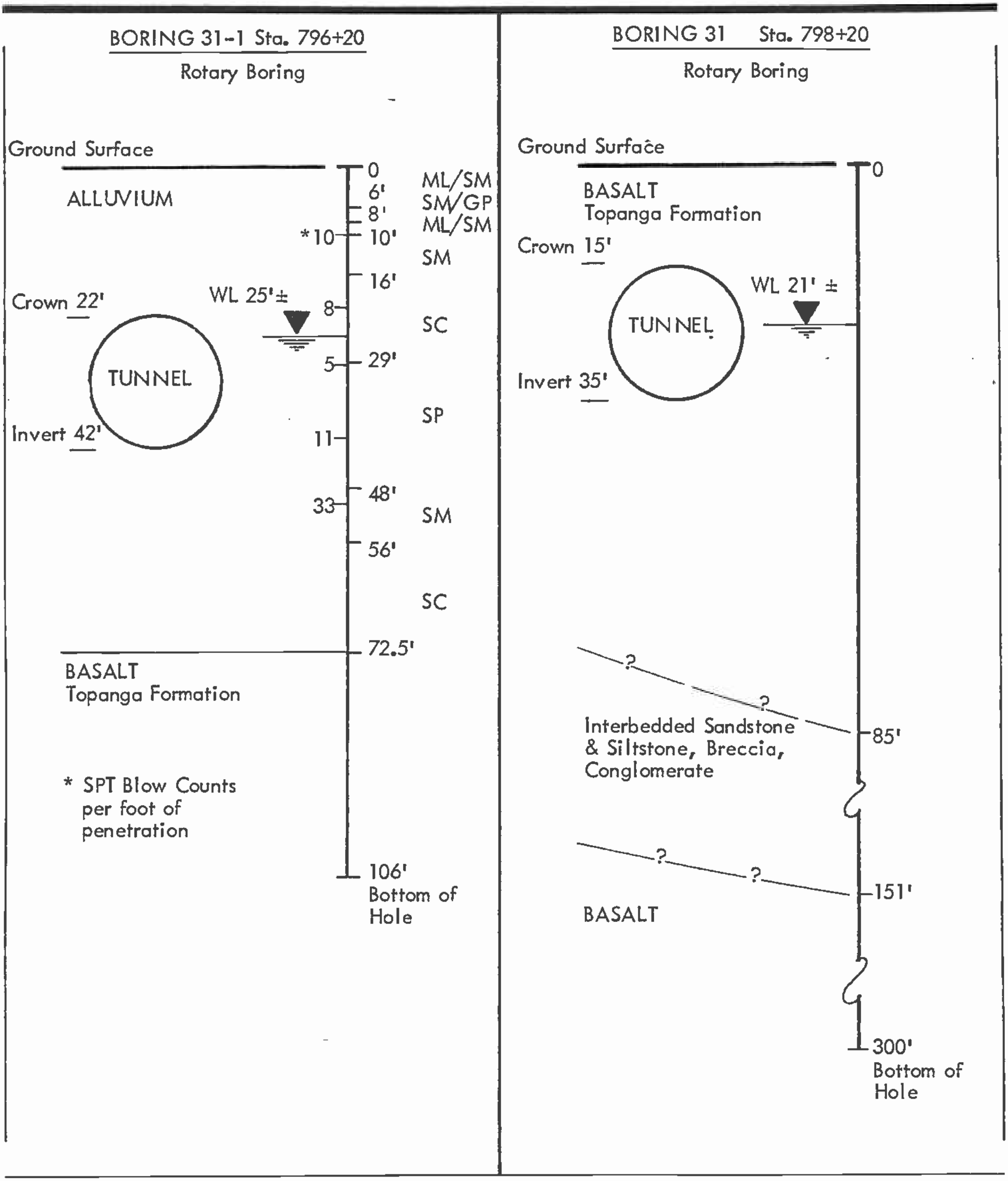

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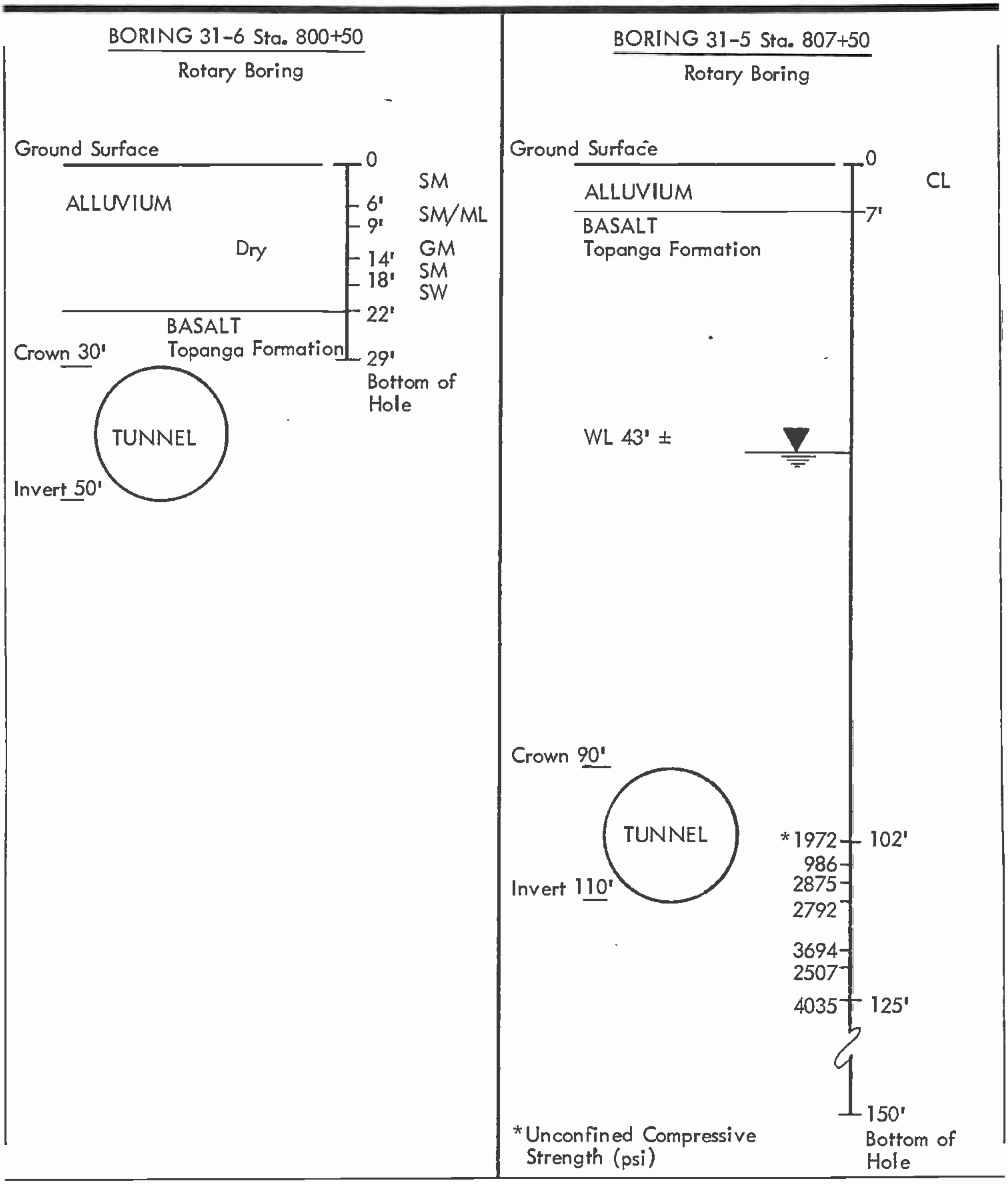
Figure No. 6-4



EXAMPLES OF STRATIGRAPHIC VARIATIONS

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Figure No. 6-5

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Approved for publication 6/2/8? by [illegible] could conceivably be encountered at tunnel grade locations other than these. Vertical projection of three unconfirmed faults mapped by City of Los Angeles geologists would intersect the tunnel at about Stations 844+00, 847+00 and 851+00, as discussed in Section 6.2.3. Unnamed Fault No. 1 intersects the tunnel near Station 866+00 (see Section 6.2.4).

Boring 31-5: basalt encountered near tunnel grade was moderately hard to hard and little fractured. Fractures were strongly cemented; unconfined compressive strengths range from 986 to 4000 psi.

Boring 32-1 (south vent shaft): basalt encountered near tunnel grade was intensely to closely fractured. These fractures were strongly cemented, and the basalt was judged to be hard. Unconfined compressive strengths ranged from 3700 to 9700 psi, with one test registering 37,000 psi.

Boring CEG-32: although this boring was located about 900 feet east of the alignment, basalt was also encountered at about tunnel grade with unconfined compressive strengths ranging from 2900 to 9500 psi. This basalt was intensely to closely fractured, brecciated and slickensided, yet strongly cemented, therefore is classified as hard.

Ground cover above the tunnel ranges from a minimum of 65 feet at the north end of the Hollywood Bowl Station, rising steadily to a maximum of 470 feet near Station 866+00.

Ground water elevations in this segment are unknown; except one, at Elevation 808 feet in Boring 32-1 (Station 818+50), which represented 328 feet of head above the crown. We believe, in the main, there will be little more than nuisance dripping at tunnel grade from ground water stored in fractures for most of this segment. Exceptions to this general condition may be encountered. Experience from the nearby Los Angeles City Sewer Tunnel suggests there could be local inflows of 100 gpm (gallons per minute) for a short duration (Appendix F).

The Metro Rail Tunnel will pass above the Los Angeles City Sewer Tunnel near Station 866+00 with something on the order of 10 feet of cover between them. The vertical alignment of both tunnels should be carefully checked, and blasting (if this is the selected construction method) should be carefully controlled to avoid possible damage to the sewer tunnel.

Figures 6-5 and 6-6 show transverse sections relating the variable unconfined compressive strengths of basalt bedrock with the vertical tunnel alignment. The basalt bedrock is judged to be moderately hard to hard based on unconfined compressive strengths shown on these figures as well as on Table C-2 (Appendix C).

6.3.3 Station 866+00 and 893+00 (2,700 feet , Drawings 4 and 5)

The primary tunnelling media will be moderately hard to hard sandstone and conglomerate of the Topanga Formation (Tt scgl). The average unconfined compressive strength is believed to be 6000 psi, but individual granite cobbles (33,600 psi) and chert (19,900 psi) could be interspersed throughout the formation (Table C-2, Appendix C). The sandstone and conglomerate should stand up well and require nominal support. Squeezing ground is not likely.

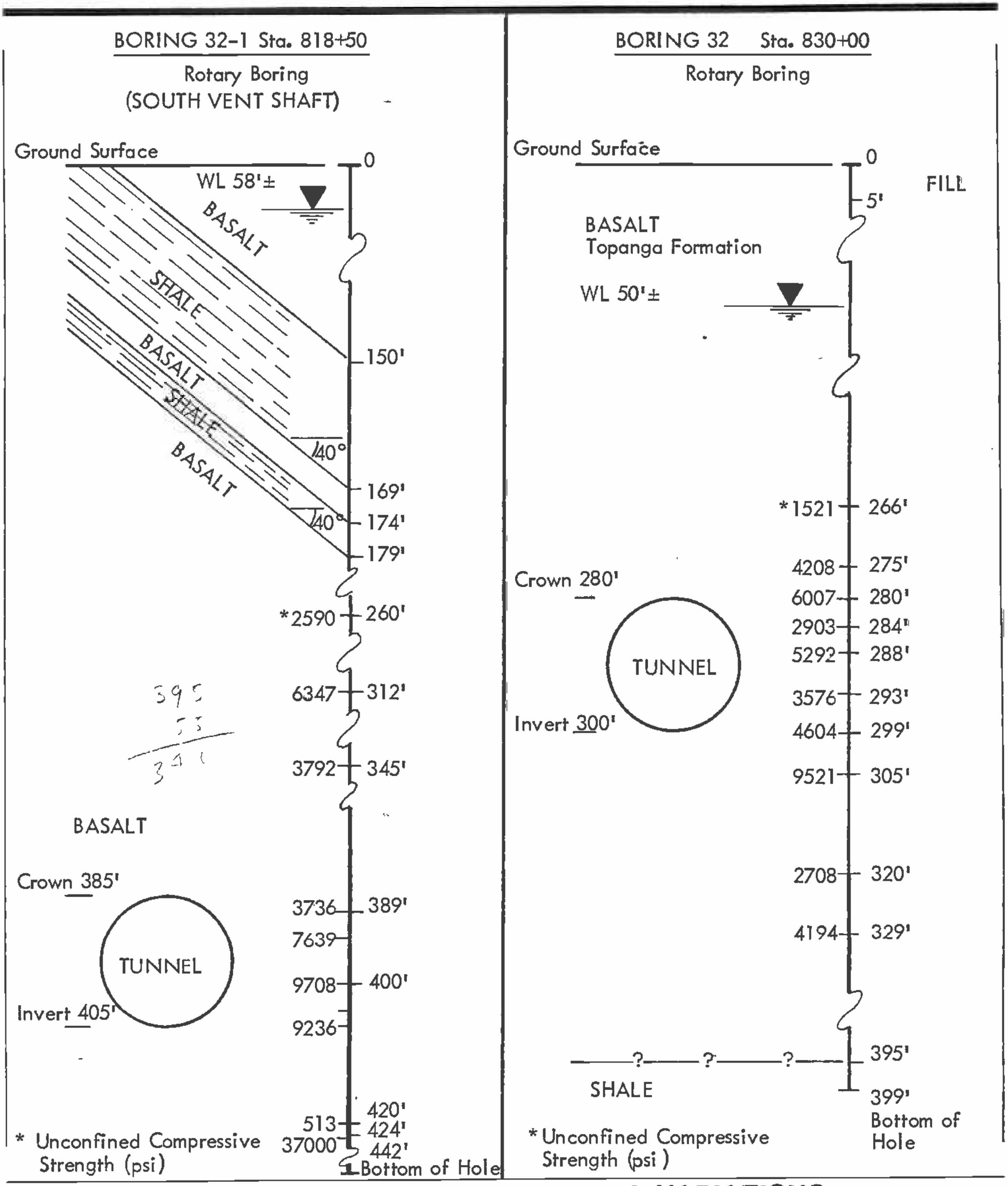

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Figure No. 6-6

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Borings 32-2 (Station 873+50), and CEG-32A were drilled in the sandstone and conglomerate unit.

Boring 32-2 (north vent shaft): near tunnel grade, at depths between 417 to 470 feet, encountered very hard chert, quartzite and granitic cobbles and boulders embedded in apparently a weakly cemented sandstone and claystone shear zone (see Section 6.2.5). There was only one foot of core recovery at the tunnel grade interval because the drill fluids washed much of the matrix away. Drilling was difficult because very hard cobbles wobbled around in the hole, wearing out 4 diamond drill bits. A hard 5-foot thick basalt dike was encountered above tunnel grade at Elevation 580 with an unconfined compressive strength of 2965 psi. Sandstone and conglomerate above the basalt dike has unconfined compressive strength ranging from 354 to 1257 psi. Some point load tests on individual granite cobbles registered up to 33,600 psi.

Boring CEG-32A: drilled in 1981 and located 400 feet east of the tunnel line, encountered little fractured to massive, moderately hard to hard sandstone and conglomerate in the vicinity of tunnel grade (if projected into the tunnel line). Cobble-size makes up 10% of the material. Locally (depth interval 340-370 feet) the formation contains 20-40% cobbles and 10% boulders. Core recovery was 95% to 100%. A 3-foot wide shear zone containing gravel was encountered at depth interval 268 to 271 feet. Unconfined compression strengths range from 472 psi (near the invert) to 4100 psi near the crown (Table C-2, Appendix C).

Mixed face conditions of hard sandstone/conglomerate and "low hardness" interbedded sandstone, siltstone and claystone may occur in the vicinity of the North Vent Shaft, as well as other locations.

Figure 6-7 shows transverse sections relating the variable bedrock stratigraphy within the vertical tunnel alignment, including some unconfined compressive strengths.

6.3.4 Station 893+00 and 930+00 (3,700 feet, Drawings 5 and 6)

The primary tunnelling media will be "low hardness" siltstone, claystone and sandstone of the Topanga Formation. The "average" unconfined compressive strength is judged to be 1000 psi. Some interbedded conglomerate in Boring CEG-33 recorded 16,300 psi, and quartzite 14,600 psi.

Borings 33-1 (Station 901+50), CEG-33 (located 1000 feet east of the alignment), 33-2 (Station 921+00), 34-A (Station 926+00) and 34-1 (Station 930+00) were drilled in this segment.

A mixed face condition of alluvium above and siltstone/sandstone bedrock below are anticipated between Station 925+00 and 930+00 (south end of the Universal City Station). The ground water level is believed to be 50 to 65 feet above the crown in the alluvium.

Boring 33-1: in the vicinity of tunnel grade, encountered alternating beds of siltstone, sandstone with some conglomerate interbeds with unconfined compressive strengths ranging from 778 to 2750 psi. Some granite cobbles registered 28,700 psi. The formation is closely fractured above the springline (RQD 38%) and moderately to little fractured below the springline (RQD 79%). Fractures are moderately to strongly cemented.

Boring CEG 33: located about 1,000 feet east of the alignment. If projected into the tunnel line grade, it would encounter interbedded sandstone, conglomerate, claystone and quartzite beds. A 1-foot wide, clay-filled shear zone, inclined 75° from the horizontal occurs at Elevation 528 feet. Vertical, hairline width slickensides were recorded at Elevations 517 and 522 feet. The conglomerate and quartzite interbeds are hard (unconfined compressive strengths up to 28,100 psi), and these interbeds alternate with claystone and sandstone of low hardness (unconfined compressive strength 71 to 212 psi).

Boring 34-A: encountered nearly horizontally layered, low hardness siltstone and sandstone near tunnel grade. At this location, there is about 7 feet of bedrock cover over the crown. No unconfined compression tests were performed in Boring 34-A.

Boring 33-2: near tunnel grade, is intensely to closely fractured, low hardness interbedded sandstone and siltstone. RQD ranged from 0% to 22%, improving at the invert to 50%. Steeply dipping, 68° to 75° bedding planes cross the line. Unconfined compression strengths from a few cores ranged from 49 to 132 psi near tunnel grade.

Figures 6-7, 6-8 and 6-9 show transverse sections relating the variable soil, stratigraphy, ground water levels, and variable unconfined compressive strengths of bedrock with the vertical tunnel alignment.

6.4 TUNNEL DEWATERING

In our opinion, ground water flow within the bedrock along the A410 tunnel alignment is generally expected to be minor. A system of internal sumps and/or gravity drains is believed adequate to control ground water inflows.

Ground water flow from alluvium at Hollywood/Cahuenga Station, Highland Avenue, and Universal City Station are judged to be large. The following subsections present discussions of the dewatering requirements at these three locations.

6.4.1 Hollywood/Cahuenga Station Alluvium

Current ground water levels are about 20 feet above the bedrock surface and 40 to 75 feet above the proposed tunnel invert north of the Hollywood/Cahuenga Station pocket track section (see Drawing 2).

In the area immediately north of the A350 pocket track, bedrock cover will be very thin, and/or mixed face conditions may be encountered. Therefore, dewatering of the alluvium will likely be required. We recommend that the tunnel dewatering system be coordinated with Design Unit A350's system. We expect that the tunnel dewatering system will not be able to draw water levels down significantly below the bedrock surface. Therefore, some water may flow

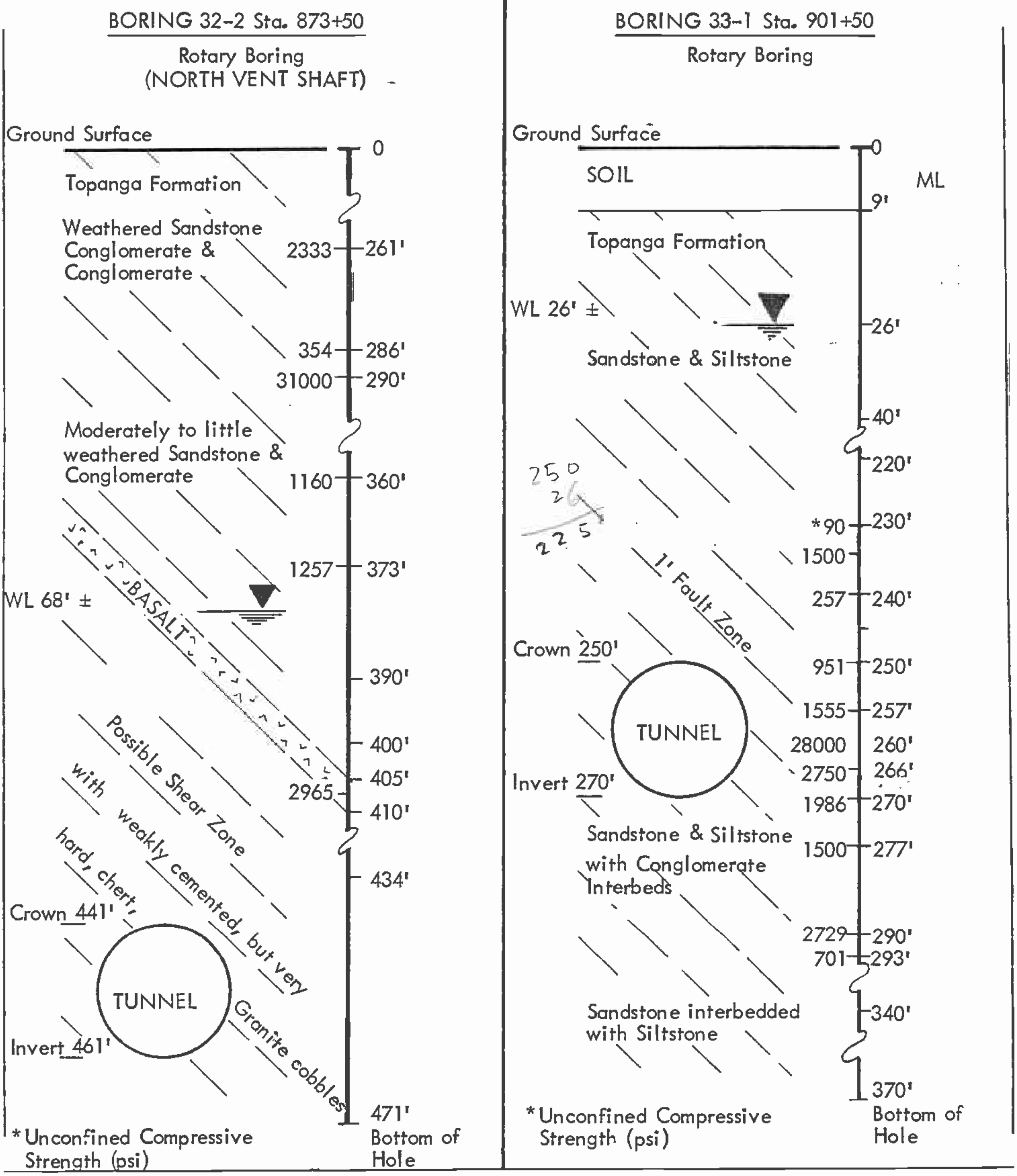

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Figure No. 6-7

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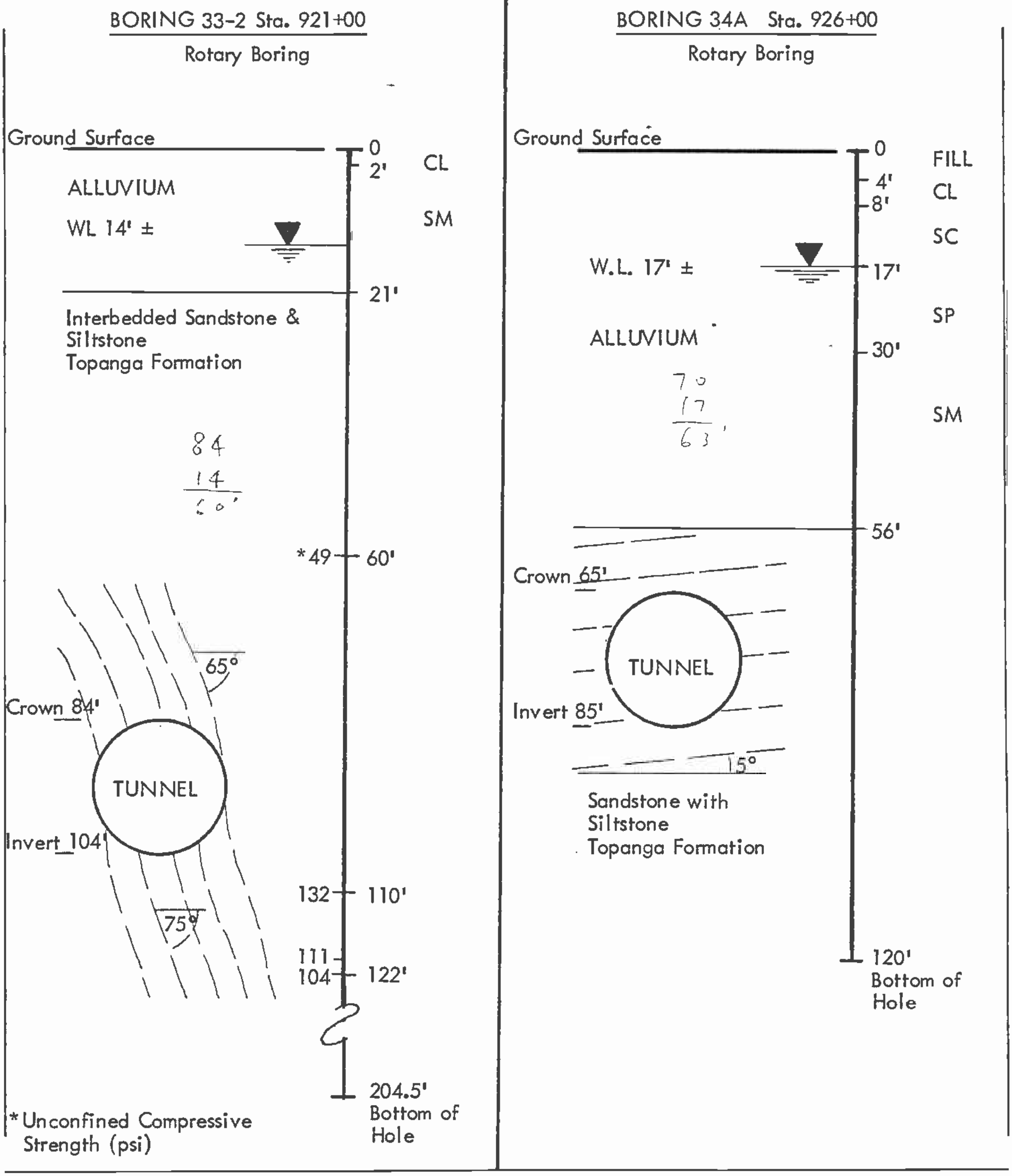

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Figure No. 6-8

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BORING 34-1 Sta. 930+00 ±

Rotary Boring

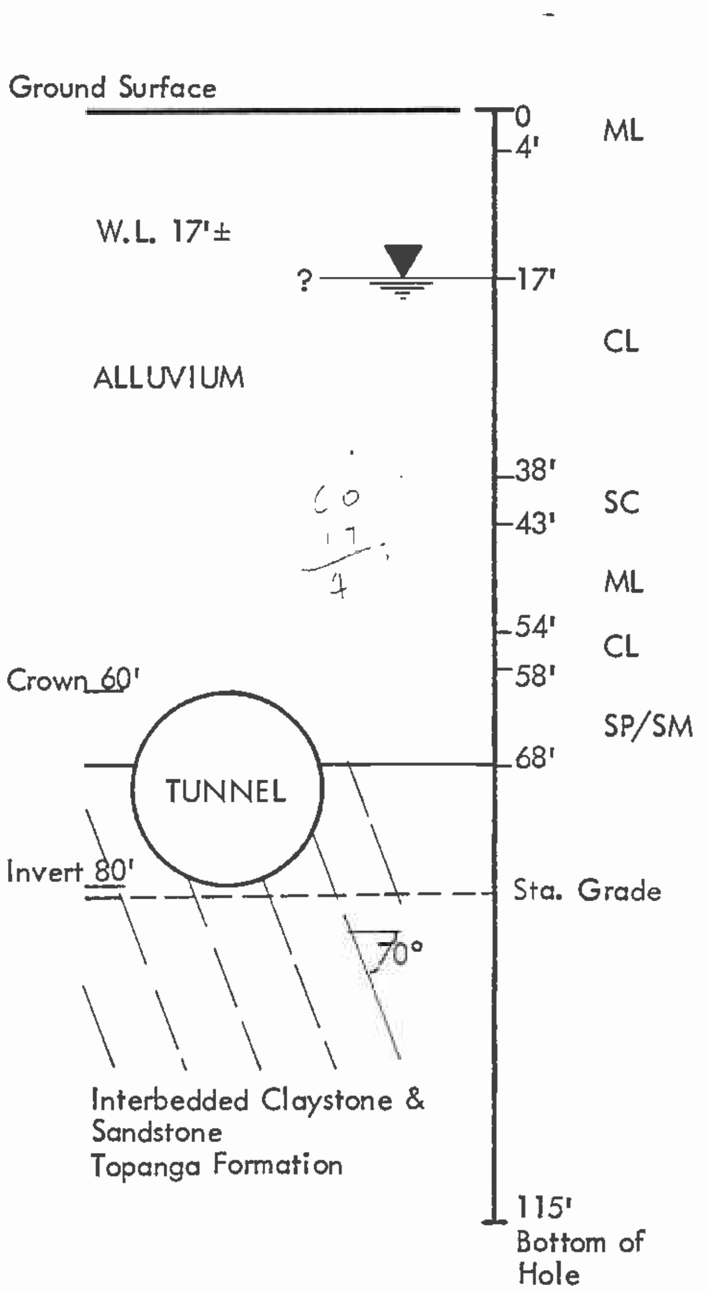

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Figure No. 6-9

into the tunnel face at the bedrock contact. A possible dewatering system might consist of the following:

- deep wells and/or ejector wells placed along the alignment. The wells should penetrate to the bedrock surface.

- supplementary systems within the tunnel to control flow into the tunnel along the bedrock surface.

About 1 inch of refined gasoline was observed floating on top of the water table in Boring 28-C (Drawing 2). Even though this boring is located some 700 feet south of Design Unit A410's starting point, the source of gasoline could possibly be upgradient. If this is the case, the gasoline may pose a hazard to tunnelling and may require special permits for disposal of the water.

Submerged alluvial deposits varying in thickness up to a maximum of about 20 feet are expected to be dewatered during construction. Potential settlements due to dewatering were calculated based on the assumption that the materials below the water table were granular and similar to those encountered in the borings. In addition, it was assumed that the dewatered soils overlie Topanga bedrock. These calculations indicate that total surface settlement would be less than 1/4 inch for up to 20 feet of drawdown. Differential settlements across the length of adjacent structures should be less than 1/8 inch.

6.4.2 Highland Avenue Alluvial Channel

Current ground water levels in the Highland Avenue alluvial channel (south of Design Unit A415, Hollywood Bowl Station) are about 10 to 15 feet above the proposed tunnel invert grade (see Drawing 3). Preconstruction dewatering will probably be required in this area to prevent flowing ground at the tunnel face. Dewatering could possibly be provided by a deep well system extending below the tunnel invert. Considering the relatively minor amount of drawdown required, dewatering related subsidence is not expected to be significant.

In the vicinity of the Hollywood Bowl Station, ground water levels are within the basalt bedrock below the alluvial soils (see Drawing 3). Therefore, preconstruction dewatering of this alluvium is not anticipated. Some gravity seepage from the bedrock is expected as the tunnel proceeds, but flow quantities should generally be low.

6.4.3 Universal City Station Alluvium

Thin bedrock cover and/or mixed face tunnel conditions are expected within a few hundred feet of Design Unit A425, Universal City Station (see Drawing 6). Ground water levels currently are about 60 to 65 feet above the proposed tunnel invert and, therefore, preconstruction dewatering is expected to be required in this area. We recommend that dewatering for the tunnel be coordinated with dewatering for Design Unit A425. Water levels cannot practically be drawn down below the bedrock surface and, therefore, some flow would enter the tunnel face along the bedrock surface where mixed face conditions exist. A possible dewatering system might consist of the following:

- Deep wells and/or ejector wells placed along the alignment penetrating to the bedrock surface;

- supplementary systems within the tunnel to control flow into the tunnel along the bedrock surface.

Subsidence due to ground water drawdown may be significant here. Calculations for Design Unit A425 indicate that total surface settlement would be about 3 inches for up to 50 feet of drawdown and 1 inch for up to 20 feet of drawdown. Settlement of this magnitude could damage nearby structures but total subsidence would require several weeks to months to occur due to the low permeability of the fine-grained alluvium. Local dewatering contractors indicate that significant dewatering subsidence does not occur during construction; but, unless this can be verified by documented case histories, it should be assumed that significant settlement could occur.

6.4.4 Criteria for Dewatering System

It is understood that the contractor will be responsible for designing, installing, and operating a suitable construction dewatering system subject to review and acceptance by the Metro Rail Construction Manager. The system should satisfy the following criteria:

- The preconstruction dewatering system should be installed and in operation for a sufficient period prior to the excavation reaching the level of static ground water level to adequately draw down the ground water table. This period is a function of the maximum pumping capacity installed.

- A dewatering well system should maintain the ground water levels low enough to prevent flowing ground at the tunnel face. Inflow quantities should be reduced to levels which can be handled by a drain sump system and allow construction to proceed.

- Wells must be designed and developed to eliminate loss of ground from piping of soils from around the wells. The well operation should be constantly monitored for evidence of piping.

- The well system should be operated continuously. Emergency power and backup pumps should be required to ensure continual excavation dewatering.

- Internal sump systems should have the capability of quickly increasing pumping capacity to handle zones of high flow.

- Internal sump systems should operate continuously.

- Internal sump systems should include emergency power and backup pumps in case of power or equipment failure.

- Disposal of pumped water must be in accordance with all local ordinances.

6.5 GAS AND OIL

The entire tunnel line segment in Design Unit A410 is judged to be non-gassy. For details on gas, refer to studies performed for SCRTD by Engineering Science, Arcadia, California.

The entire tunnel line is considered devoid of oil according to boring records along this segment. Oil slicks on the drilling mud tanks were noted at Borings 28-8 (72 feet), 29-3 (50 feet), CEG-30 (72 feet), CEG-31 (87, 192, 214, 232, 240 feet), 33-1 (90, 124, 258, 274, 316 feet) and 34-A (15 feet). This suggests some interbeds contain very minor amounts of petroliferous material.

6.6 SPECIAL TUNNELLING PROBLEM AREAS

Due to a high ground water table, relatively shallow cover over the tunnel crown and discontinuities (fractures, faults), problems may occur at the following stations:

- Station 766+50 - possibly refined gasoline is floating on top of the water table.
- Station 766+50 to 770+00 - launching the excavation with 0 to 10 feet of cover.
- Station 792± - depth of Caltran's Hollywood Freeway piles could intercept tunnel.
- Station 793 to 798± - mixed face condition passing over a buried channel.
- Station 800± - about 7 feet of cover at the south end of the Hollywood Bowl Station.
- Station 924 - 930± - Shallow ground cover, ground water, and mixed face at the south end of Universal City Station.
- Possible broken rock conditions at fault crossings noted on Drawings 3, 4, 5 and 6.

Excavating equipment should anticipate dealing with at least three ground conditions: wet running alluvial deposits, "low hardness" bedrocks, and "hard" bedrocks (all three containing abrasive, hard, cobbly materials).

6.7 DESIGN FOR EARTHQUAKES

Design procedures and criteria for underground structures under earthquake loading conditions are defined in the Southern California Rapid Transit District (SCRTD) report entitled "Guidelines for Design of Underground Structures", dated 1984. Evaluations of the seismologic conditions which may impact the project and the probable and maximum credible earthquakes, which may be anticipated in the Los Angeles area, are described in Converse's report to SCRTD entitled "Seismological Investigation & Design Criteria", dated May, 1983. The 1984 report complements and supplements the 1983 report.

6.8 LIQUEFACTION POTENTIAL

The potential for liquefaction of alluvial materials at Design Units A350 (low to moderate), A415 (unlikely) and A425 (high) are discussed in the respective reports for these design units.

6.9 SUPPLEMENTARY GEOTECHNICAL SERVICES

Based on the available data and the current tunnel line and grade, the following supplementary geotechnical services may be warranted:

o <u>Geologic Mapping</u>: We recommend geologic mapping along, and closely adjoining, the alignment to provide designers and bidders with a clearer picture of:

- ° rock type distribution/percentages
- ° orientation/frequency patterns of discontinuities (joint rosettes)
- ° faults/condition of adjoining rocks.

Mapping, in our opinion, would reduce bidder contingencies by providing a better handle on costs for supports, excavation, advance rates. Results of mapping, tied to boring data, may influence the selection of construction method(s).

o We recommend photographing the exterior and interior of structures along and adjoining the alignment before construction.

o We recommend the following borings to help reduce contingency costs:

BORING No.	APPROXIMATE STATION	DEPTH (ft)	PURPOSE
1	811+50	430	Rock and ground water conditions at alternate south vent shaft
2	843+00	600	Drill 45° angle hole northward to intersect "L.A. City Faults" for rock conditions
3	853+00	400	Altered sedimentary rock conditions from the basalt intrusion
4	879+00	360	Rock and ground water conditions at alternate north vent shaft
5	911+50	150	Determine depth of alluvium in "Regal Place" canyon and better define lateral limit of "low hardness" rocks (Boring 33-1 had some very hard cobbly conglomerate beds)

o <u>Pump Test</u>: It is recommended that pumping tests be performed at: (1) the Highland Avenue alluvial channel and (2) the Universal City Station portal to evaluate the pumping and dewatering characteristics. The pump test well(s) should ideally approximate characteristics of the dewatering wells. The number and locations of observation wells should be based on the known subsurface conditions and locations of areas in which settlement could be critical.

o <u>Observation Well Monitoring</u>: The ground water observation wells should be read several times a year until project construction, and more frequently during construction if possible. They will provide valuable data to the contractor in determining his construction schedule and procedures.

- Review Final Design Plans and Specifications: A qualified geotechnical engineer should be consulted during the development of the final tunnel design and construction concepts and should complete a review of the geotechnical aspects of the construction/excavation methods, plans and specifications.

- Dewatering Design Review: Assuming that the dewatering systems are designed by the contractor, a qualified geotechnical engineer should review the proposed systems in detail including review of engineering computations. This review would not be a certification of the contractor's plan but rather an independent review made with respect to the owner's interests.

- Construction Observations: An "as-built" geologic log of tunnel conditions (Proctor, 1971) should be prepared by an experienced engineering geologist as the tunnel is being excavated (prior to lining). Geologic notes should include ground water flows, seeps, support spacing, "heavy ground", bedrock structure, overbreak, faults, advance rates, and problem areas. The geologic log is invaluable for future tunnelling, and for assessing problems that develop after construction.

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Drawings

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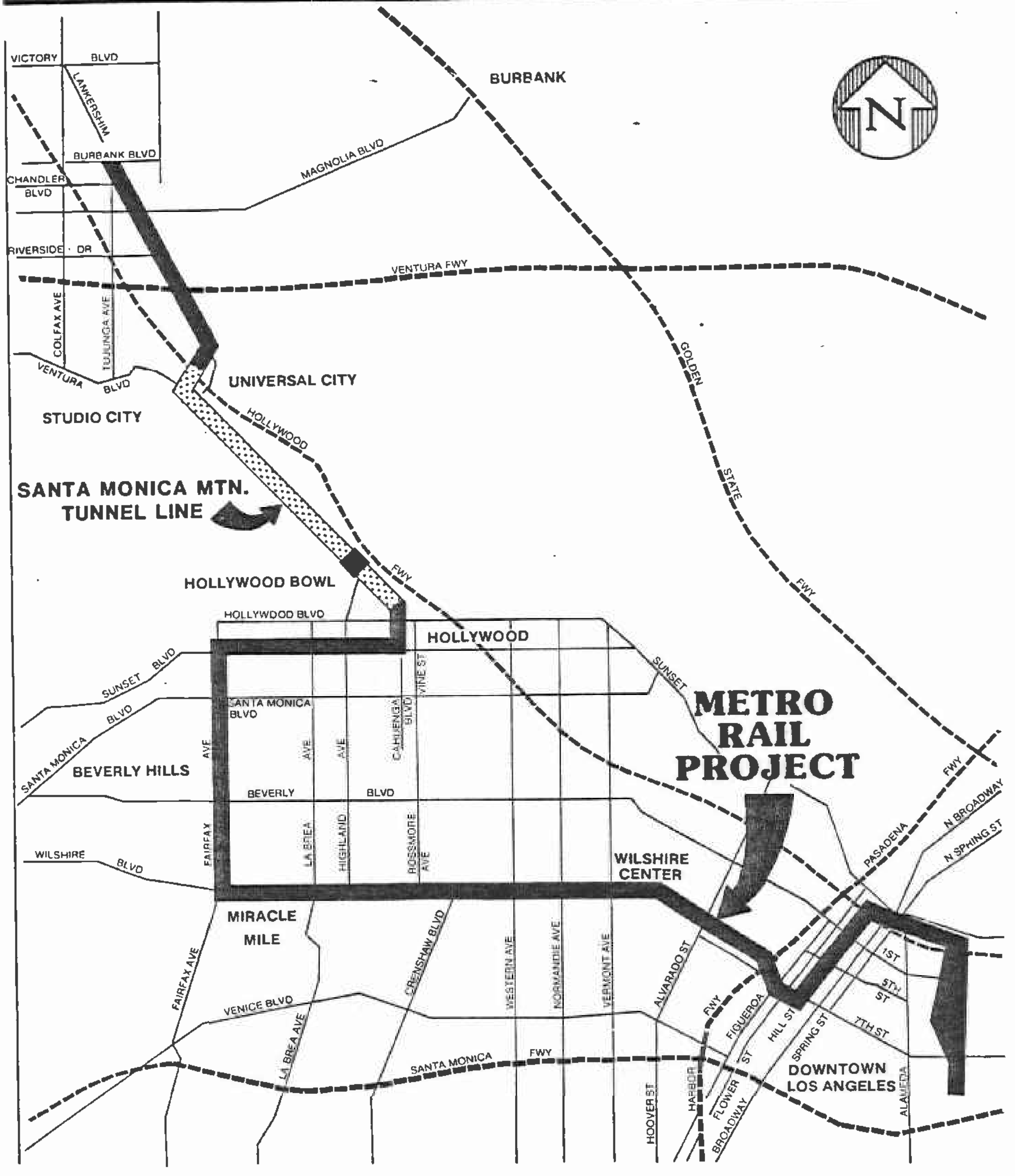


VICINITY MAP

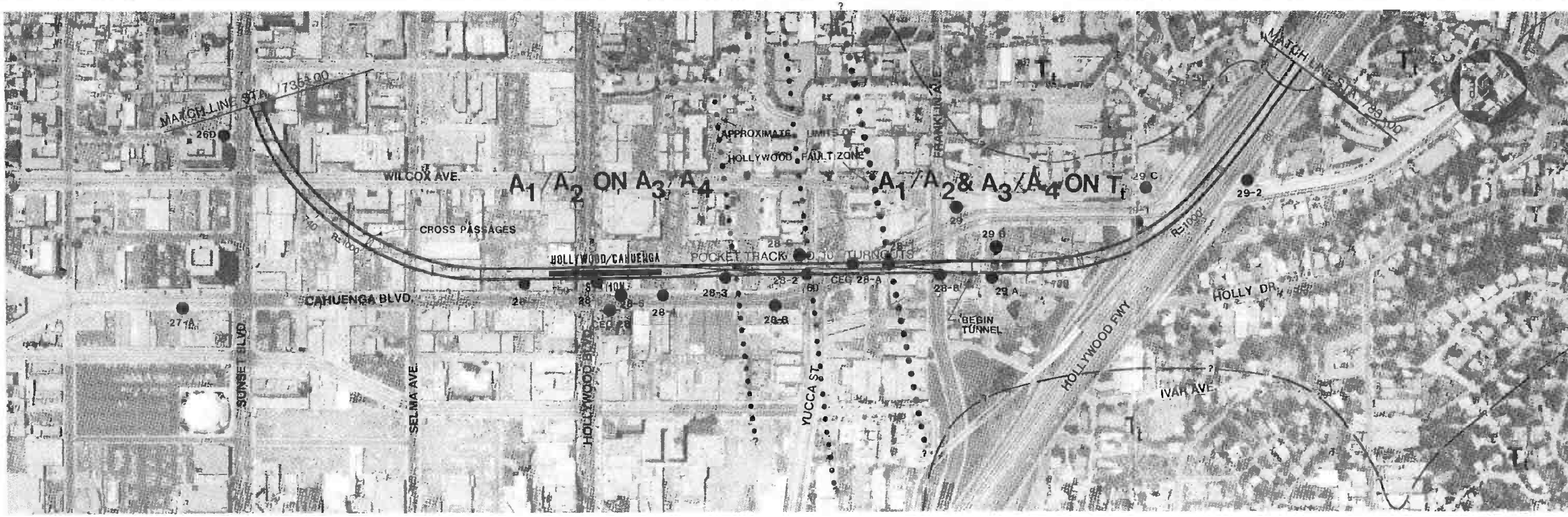
DESIGN UNIT A410
Southern California Rapid Transit District
METRO RAIL PROJECT

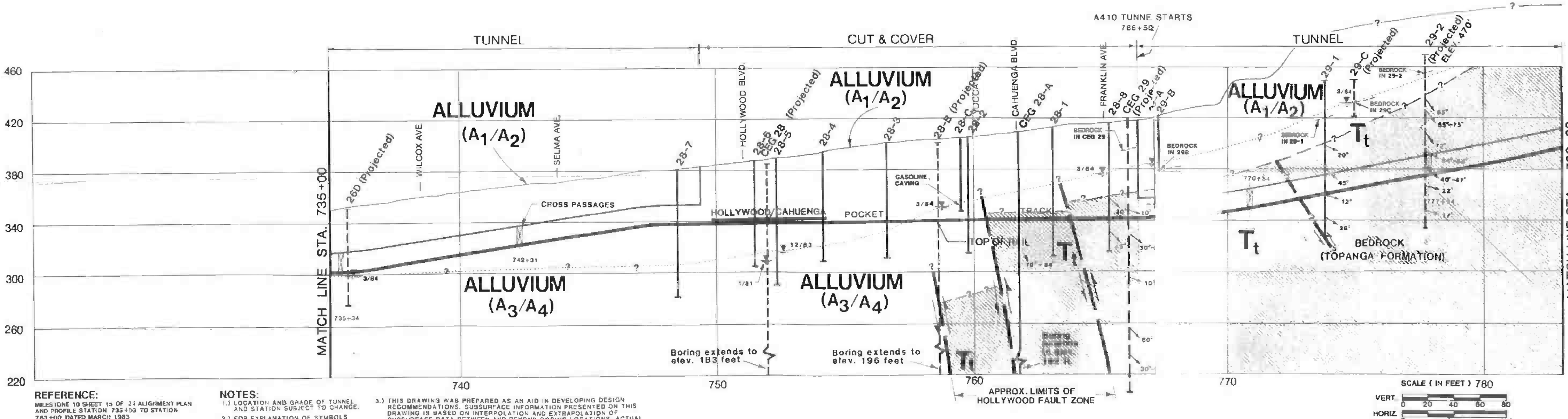
Project No.
83-1140

Drawing No.
1

Converse Consultants
Geotechnical Engineering and Applied Sciences

D-10-10/81 Approved for publication ______ by ______





REFERENCE:
MILESTONE 10 SHEET 15 OF 21 ALIGNMENT PLAN AND PROFILE STATION 735+00 TO STATION 783+00 DATED MARCH 1983

NOTES:
1.) LOCATION AND GRADE OF TUNNEL AND STATION SUBJECT TO CHANGE.
2.) FOR EXPLANATION OF SYMBOLS SEE DRAWING NO 7
3.) THIS DRAWING WAS PREPARED AS AN AID IN DEVELOPING DESIGN RECOMMENDATIONS. SUBSURFACE INFORMATION PRESENTED ON THIS DRAWING IS BASED ON INTERPOLATION AND EXTRAPOLATION OF SUBSURFACE DATA BETWEEN AND BEYOND BORING LOCATIONS. ACTUAL CONDITIONS ENCOUNTERED DURING CONSTRUCTION MAY BE DIFFERENT.

REV.	DATE	BY	SUB.	APP.	DESCRIPTION

THE PREPARATION OF THIS DRAWING HAS BEEN FINANCED IN PART THROUGH A GRANT FROM THE U. S. DEPARTMENT OF TRANSPORTATION, URBAN MASS TRANSPORTATION ADMINISTRATION, UNDER THE URBAN MASS TRANSPORTATION ACT OF 1964, AS AMENDED, AND IN PART BY THE TAXES OF THE CITIZENS OF LOS ANGELES COUNTY AND OF THE STATE OF CALIFORNIA

REV.	DATE	BY	SUB.	APP.	DESCRIPTION

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SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT
METRO RAIL PROJECT

CCI/ESA/GRC
General Geotechnical Consultants
Submitted K.M. Price Date Jan 1984

DMJM/PBQD/KE/HWA
A JOINT VENTURE
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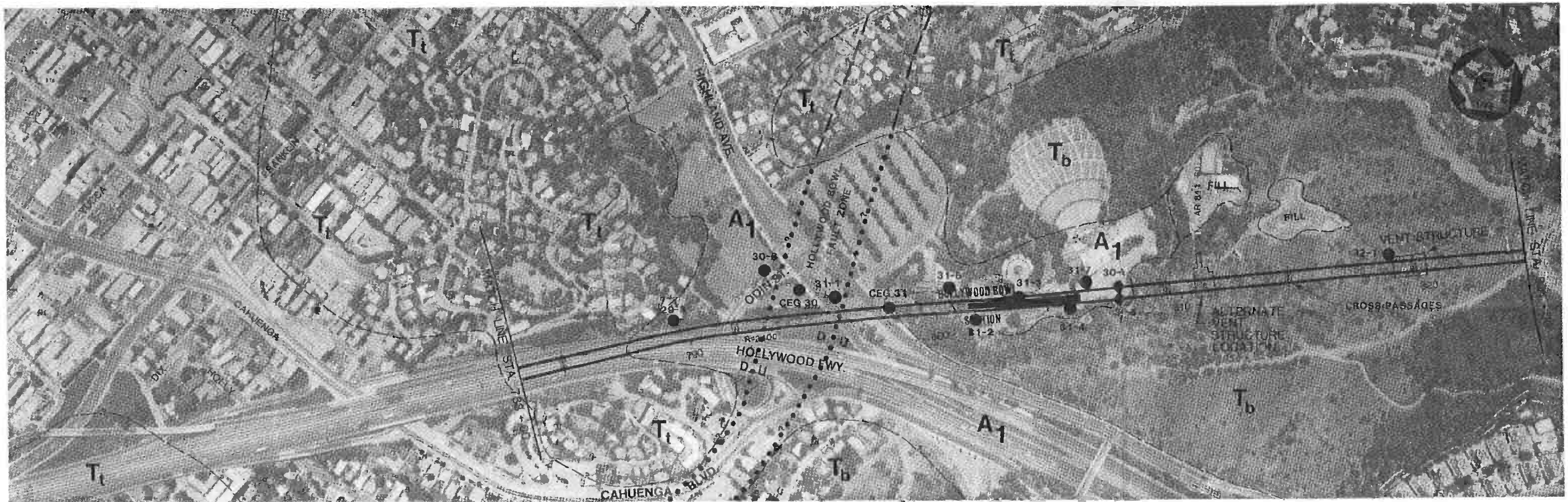
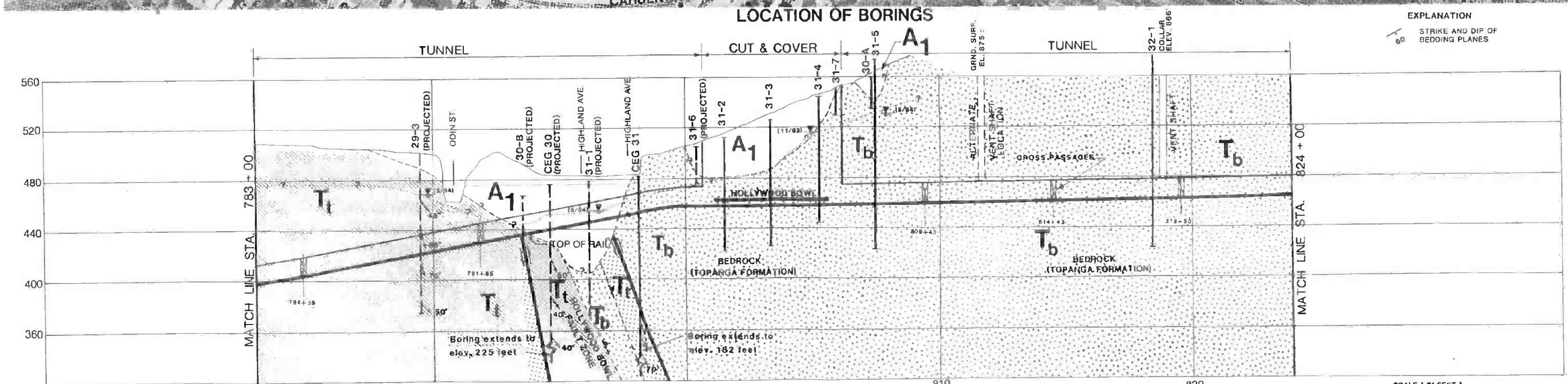
DESIGN UNIT A410
LOCATION OF BORINGS AND GEOLOGIC SECTION

PROJECT NO. 83-1140
DRAWING NO. 2
REV.
SCALE AS SHOWN
SHEET NO

LOCATION OF BORINGS



GEOLOGIC SECTION



SCALE (IN FEET)

VERT. 0 20 40 60 80

HORIZ. 0 200 400

REFERENCE:

MILESTONE 10 SHEET 16 OF 21 ALIGNMENT PLAN & PROFILE STATION 783+00 TO STATION 824+00 DATED MARCH 1983.

NOTES:

1.) LOCATION AND GRADE OF TUNNEL AND STATION SUBJECT TO CHANGE.

2.) FOR EXPLANATION OF GEOLOGIC SYMBOLS SEE DRAWING NO. 7

3.) THIS DRAWING WAS PREPARED AS AN AID IN DEVELOPING DESIGN RECOMMENDATIONS. SUBSURFACE INFORMATION PRESENTED ON THIS DRAWING IS BASED ON INTERPOLATION AND EXTRAPOLATION OF SUBSURFACE DATA BETWEEN AND BEYOND BORING LOCATIONS. ACTUAL CONDITIONS ENCOUNTERED DURING CONSTRUCTION MAY BE DIFFERENT.

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REV.	DATE	BY	SUB.	APP.	DESCRIPTION

REV.	DATE	BY	SUB.	APP.	DESCRIPTION

DESIGNED BY

DRAWN BY

CHECKED BY

IN CHARGE

DATE

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT
METRO RAIL PROJECT

RTD

CCI/ESA/GRC
General Geotechnical Consultants
Submitted R.M. Price Date Jun 1984

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DESIGN UNIT A410
LOCATION OF BORINGS AND GEOLOGIC SECTION

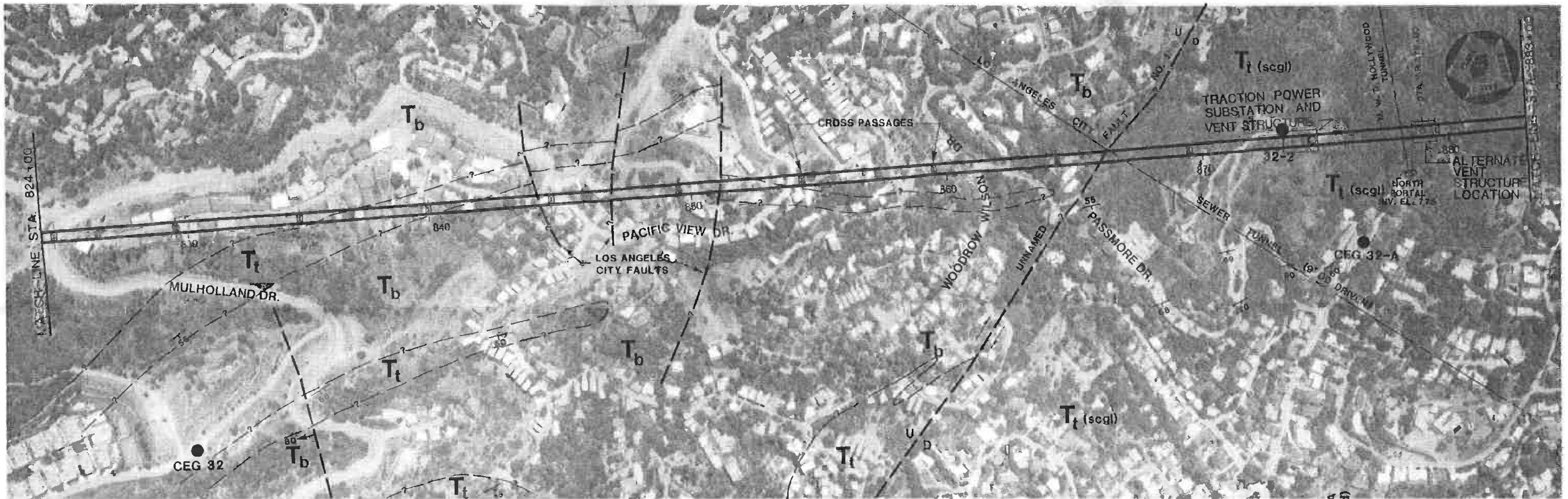
PROJECT NO. 83-1140

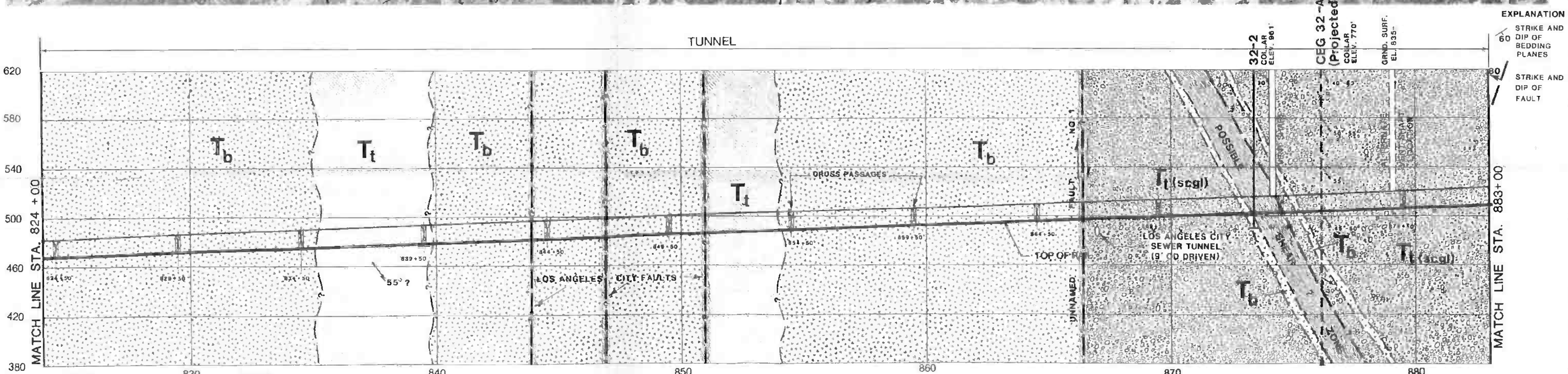
DRAWING NO. 3

REV.

SCALE AS SHOWN

SHEET NO.





REFERENCE:
MILESTONE 10, SHEET 17 OF 21 ALIGNMENT PLAN AND PROFILE STATION 824+00 TO STATION 883+00, DATED MARCH 1983.

NOTES:
1.) LOCATION OF AND GRADE OF TUNNEL AND STATION SUBJECT TO CHANGE
2.) FOR EXPLANATION OF GEOLOGIC SYMBOLS SEE DRAWING NO. 7.
3.) THIS DRAWING WAS PREPARED AS AN AID IN DEVELOPING DESIGN RECOMMENDATIONS. SUBSURFACE INFORMATION PRESENTED ON THIS DRAWING IS BASED ON INTERPOLATION AND EXTRAPOLATION OF SUBSURFACE DATA BETWEEN AND BEYOND BORING LOCATIONS. ACTUAL CONDITIONS ENCOUNTERED DURING CONSTRUCTION MAY BE DIFFERENT.

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REV	DATE	BY	SUB.	APP.	DESCRIPTION

DESIGNED BY
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SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT
METRO RAIL PROJECT
RTD

CCI/ESA/GRC
General Geotechnical Consultants
Submitted R.M. Pride Date Jun 1984

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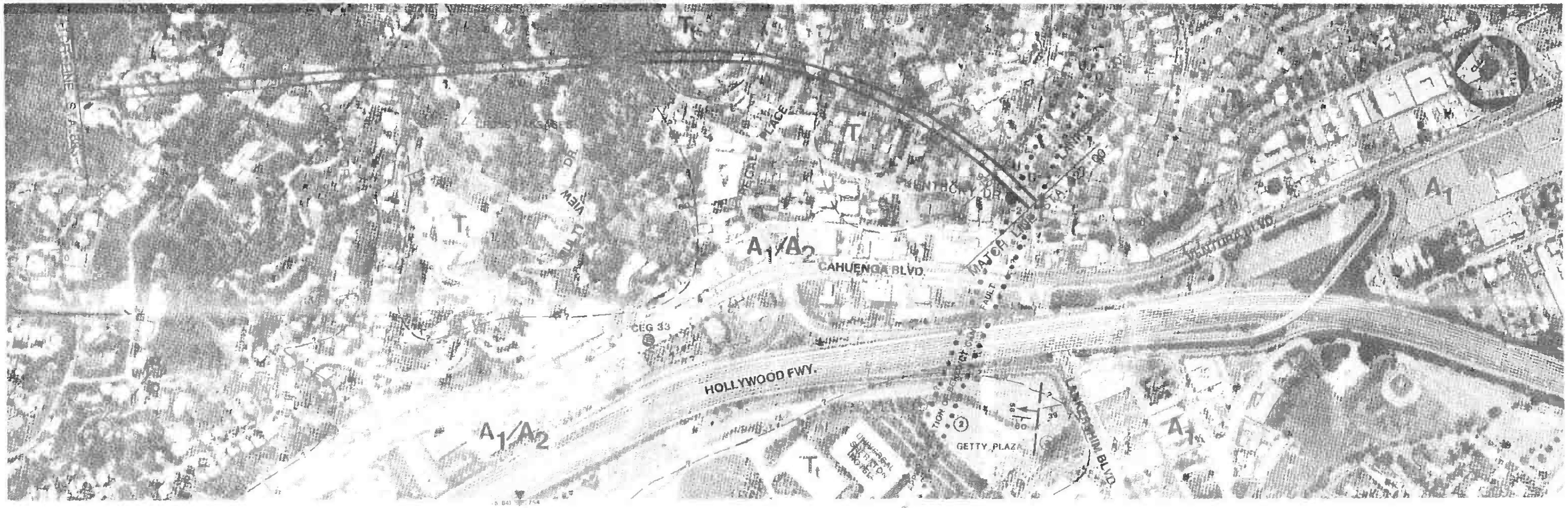
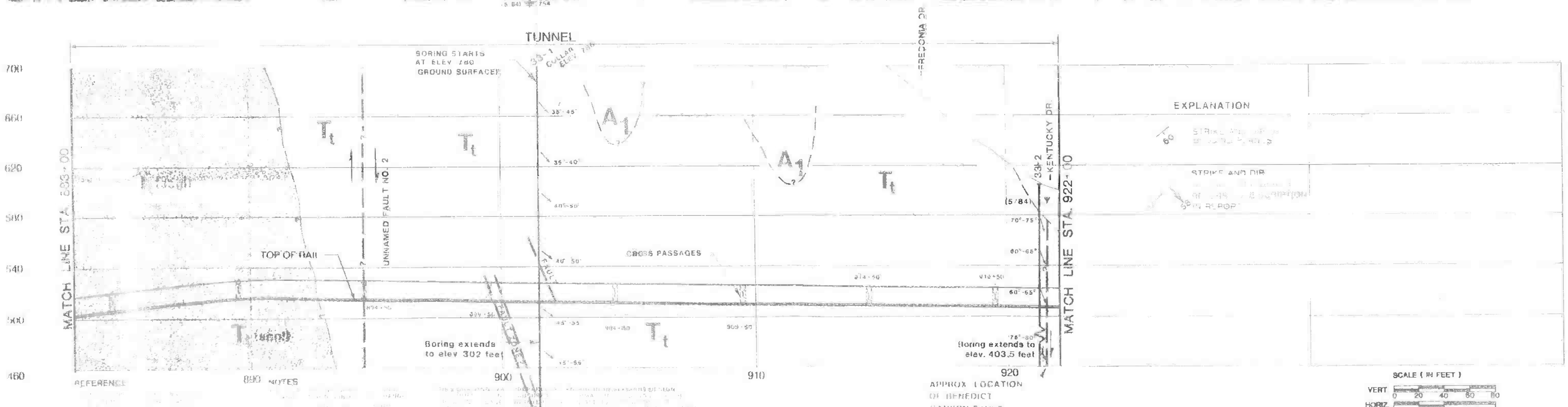
DESIGN UNIT A410 LOCATION OF BORINGS AND GEOLOGIC SECTION

PROJECT NO. 83-1140
DRAWING NO. 4
REV.
SCALE AS SHOWN
SHEET NO.





THE PREPARATION OF THIS DRAWING HAS BEEN FINANCED IN PART THROUGH A GRANT FROM THE U.S. DEPARTMENT OF TRANSPORTATION, URBAN MASS TRANSPORTATION ADMINISTRATION, UNDER THE URBAN MASS TRANSPORTATION ACT OF 1964, AS AMENDED AND IN PART BY THE TAXES OF THE CITIZENS OF LOS ANGELES COUNTY AND OF THE STATE OF CALIFORNIA

REV	DATE	BY	SUB	APP	DESCRIPTION

DESIGNED BY
DRAWN BY
CHECKED BY
IN CHARGE
DATE

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT
METRO RAIL PROJECT

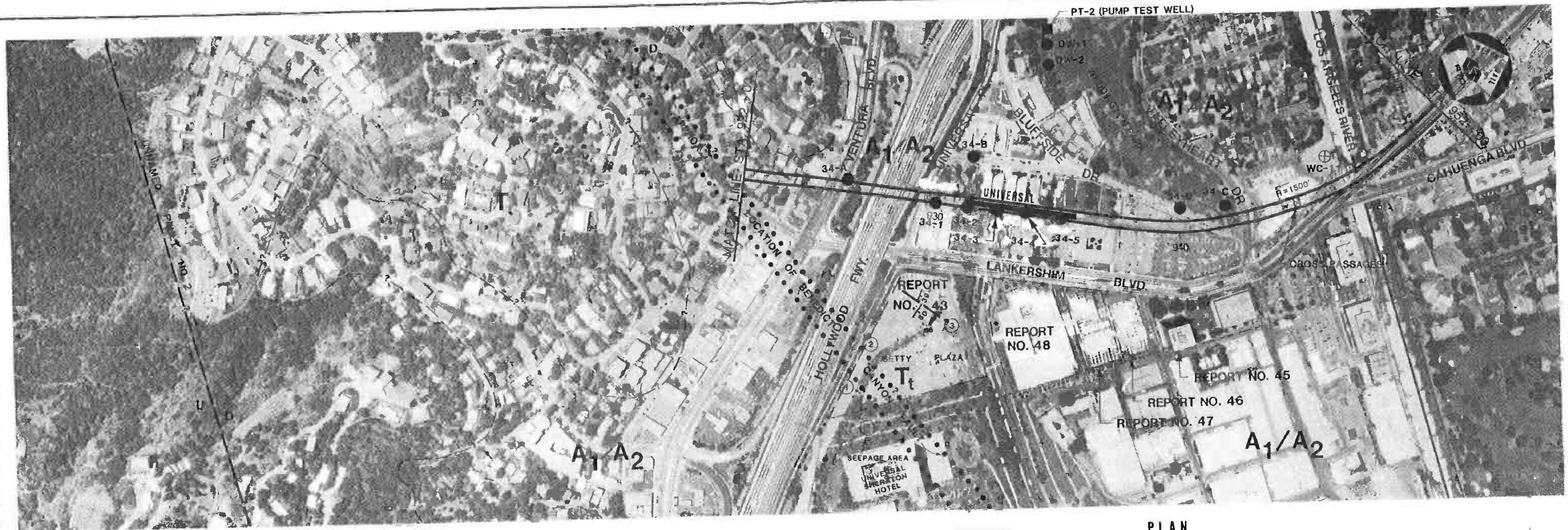
RTD

CCI/ESA/GRC
General Geotechnical Consultants
Submitted

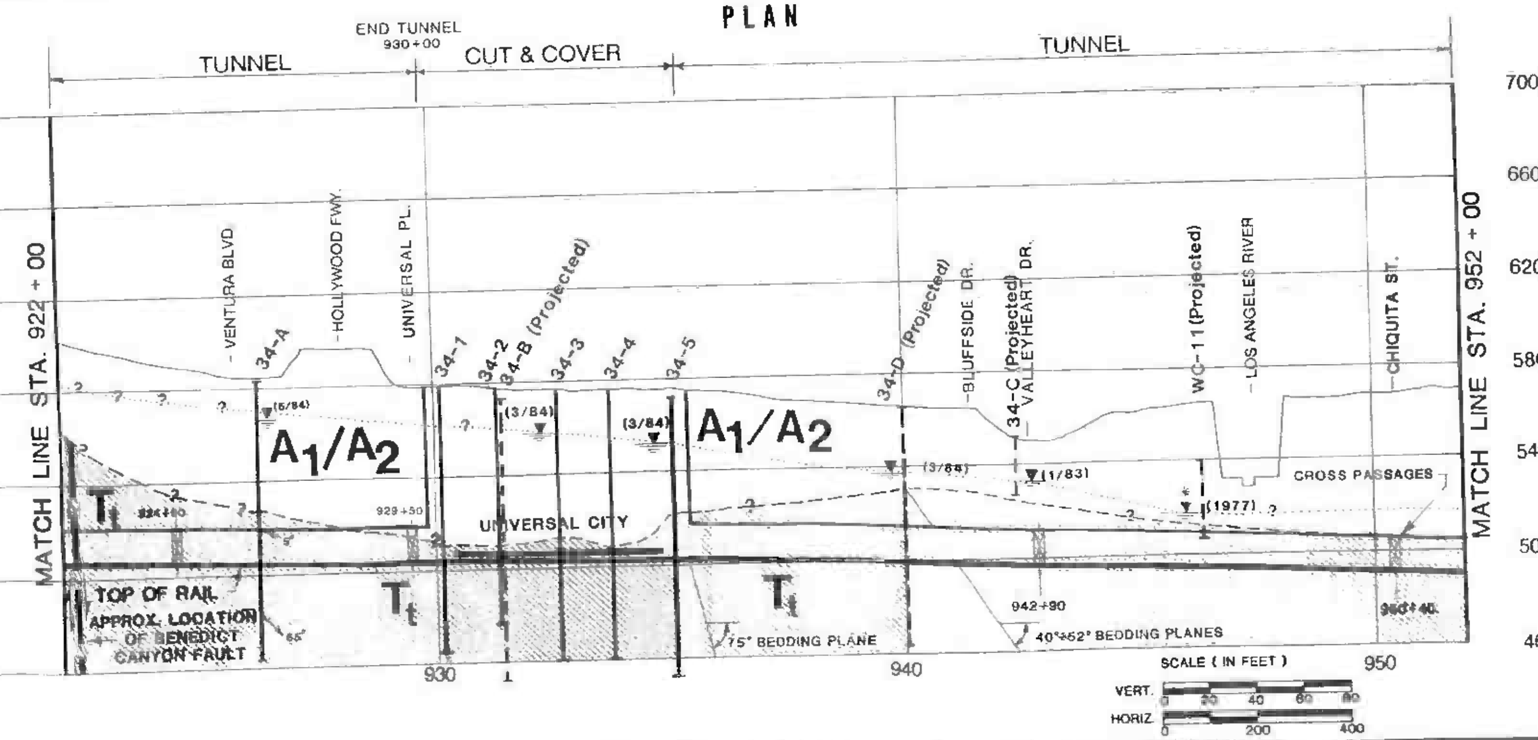
DMJM PBQD KE HWA
GENERAL CONSULTANTS
APPROVED

DESIGN UNIT A410
LOCATION OF BORINGS AND GEOLOGIC SECTION

83-1140
DRAWING NO. 5
REV
SCALE AS SHOWN
SHEET NO.



PLAN



EXPLANATION

- STRIKE AND DIP OF BEDDING PLANES (60)
- STRIKE AND DIP OF FAULT; NUMBER (3) REFERS TO DESCRIPTION IN REPORT (58)
- W.L. IN 1983-84 COULD NOT BE MEASURED

REFERENCE:
MILESTONE 10, SHEET 19 OF 21 ALIGNMENT PLAN AND PROFILE STATION 922+00 TO STATION 952+00 DATED MARCH 1983.

NOTES:
1.) LOCATION AND GRADE OF TUNNEL AND STATION SUBJECT TO CHANGE.
2.) FOR EXPLANATION OF GEOLOGIC SYMBOLS SEE DRAWING NO 7
3.) THIS DRAWING WAS PREPARED AS AN AID IN DEVELOPING DESIGN RECOMMENDATIONS. SUBSURFACE INFORMATION PRESENTED ON THIS DRAWING IS BASED ON INTERPOLATION AND EXTRAPOLATION OF SUBSURFACE DATA BETWEEN AND BEYOND BORING LOCATIONS. ACTUAL CONDITIONS ENCOUNTERED DURING CONSTRUCTION MAY BE DIFFERENT.

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REV.	DATE	BY	SUB.	APP.	DESCRIPTION

DESIGNED BY
DRAWN BY
CHECKED BY
IN CHARGE
DATE

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT
METRO RAIL PROJECT
RTD

CCI/ESA/GRC
General Geotechnical Consultants
Submitted D.M. Price Date Jun 1984

DMJM/PBQD/KE/HWA
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DESIGN UNIT A410 LOCATION OF BORINGS AND GEOLOGIC SECTION

PROJECT NO. 83-1140
DRAWING NO. 6
REV
SCALE As Shown
SHEET NO.

GEOLOGIC UNITS

SOFT GROUND TUNNELLING

QUATERNARY — HOLOCENE

- **A_1** YOUNG ALLUVIUM (Granular): Includes clean sands, silty sands, gravelly sands, sandy gravels, and locally contains cobbles and boulders. Primarily dense, but ranges from loose to very dense.
- **A_2** YOUNG ALLUVIUM (Fine-grained): Includes clays, clayey silts, sandy silts, sandy clays, clayey sands. Primarily stiff, but ranges from firm to hard.

QUATERNARY — PLEISTOCENE

- **A_3** OLD ALLUVIUM (Granular): Includes clean sands, silty sands, gravelly sands, and sandy gravels. Primarily dense, but ranges from medium dense to very dense.
- **A_4** OLD ALLUVIUM (Fine-grained): Includes clays, clayey silts, sandy silts, sandy clays, and clayey sands. Primarily stiff, but ranges from firm to hard.
- **SP** SAN PEDRO FORMATION: Predominantly clean, cohesionless, fine to medium-grained sands, but includes layers of silts, silty sands, and fine gravels. Primarily dense, but ranges from medium dense to very dense. Locally impregnated with oil or tar.

TERTIARY — PLIOCENE

- **C** FERNANDO AND PUENTE FORMATIONS: Claystone, siltstone, and sandstone; thinly to thickly bedded. Primarily low hardness, weak to moderately strong. Locally contains very hard, thin cemented beds and cemented nodules.

ROCK TUNNELLING
(Terzaghi Rock Condition Numbers apply)*

- 3 ← Terzaghi Rock Condition Number
- ← Approximate boundary between Terzaghi numbers

TERTIARY — MIOCENE

- **2-5** TOPANGA FORMATION: Conglomerate, sandstone, and siltstone; thickly bedded; primarily hard and strong (Geologic symbol Tt).
- **1-5** TOPANGA FORMATION: Basalt; intrusive, primarily hard and strong (Geologic symbol Tb).

TERZAGHI ROCK CONDITION NUMBERS:*

1 Hard and intact

2 Hard and stratified or schistose

3 Massive, moderately jointed

4 Moderately blocky and seamy

5 Very blocky and seamy (closely jointed)

6 Crushed but chemically intact rock or unconsolidated sand; may be running or flowing ground

7 Squeezing rock, moderate depth

8 Squeezing rock, great depth

9 Swelling rock

*In practice, there are not sharp boundaries between these categories, and a range of several Terzaghi Numbers may best describe some rock.

SYMBOLS

- ------? Geologic contact: approximately located; queried where inferred
- U ●●●●●? D Fault (view in plan): dotted where concealed; queried where inferred; (U) upthrown side, (D) downthrown side
- Fault (view in geologic section): approximately located; queried where inferred; arrows indicate probable movement; attitude in profile is an apparent dip and is not corrected for scale distortion
- 40 Dip of bedding: from unoriented core samples; bedding attitudes may not be correctly oriented to the plane of the profile, but represent dips to illustrate regional geologic trends; number gives true dip in degrees, as encountered in boring
- ▼? Ground water level: approximately located; queried where inferred
- Boring — CEG (1981)
- Boring — CCI/ESA/GRC (1983)
- Boring — Nuclear Regulatory Commission (1980)
- Boring — Woodward-Clyde (1977)
- Boring — Kaiser Engineers (1962)
- Boring — Other (USGS 1977 and various foundation studies)

NOTES:

1) The geologic sections are based on interpolation between borings and were prepared as an aid in developing design recommendations. Actual conditions encountered during construction may be different.

2) Borings projected more than 100' to the profile line were considered in some of the interpretation of subsurface conditions. However, final interpretation is based on numerous factors and may not reflect the boring logs as presented in Appendix A.

3) Displacements shown along faults are graphic representations. Actual vertical offsets are unknown.

SILT
CLAY
SANDY SILT
SANDY CLAY
CLAYEY SILT
SILTY CLAY
SILTY SAND
CLAYEY SAND
SAND
GRAVELLY SAND
SANDY GRAVEL
GRAVEL
GRAVELLY CLAY
TAR SILT & CLAY
TAR SAND
FILL
SILTSTONE
CLAYSTONE
INTERBEDDED SANDSTONE WITH SILTSTONE OR CLAYSTONE
SANDSTONE
SANDSTONE, CONGLOMERATE
CEMENTED ZONE
META—SANDSTONE
BASALT
BRECCIA
SHEAR ZONE

GEOLOGIC EXPLANATION

DESIGN UNIT A410
Southern California Rapid Transit District
METRO RAIL PROJECT

Converse Consultants — Geotechnical Engineering and Applied Sciences

Scale	N/A
Date	JUN., 1984
Prepared by	RG
Checked by	JAD
Approved By	HAS
Project No	83-1140
Drawing No	7

Appendix A

Field Exploration

APPENDIX A FIELD EXPLORATION

A.1 GENERAL

Field exploration data presented in this report for Design Unit A410 includes logs of borings drilled for the 1981 Geotechnical Investigation Report, and 1983 borings drilled for this investigation. The specific boring logs included are numbered 28-8, CEG-29, 29-A, 29-B, 29-C, 29-1, 29-2, 29-3, 30-A, 30-B, CEG-30, CEG-31, 31-1 through 31-7, CEG-32, 32-1, 32-2, CEG-32A, CEG-33, 33-1, 33-2, CEG-34, 34-1, 34-A.

Locations of the borings are shown on Drawings 2 and 6, inclusive. Ground water observation wells (piezometers) were installed in borings listed in Section 5.4 (Table 5-2). Geophysical downhole and crosshole surveys were made for the 1981 investigation at Boring CEG-34 (see Appendix B). A downhole survey was conducted at CEG-31

The borings were drilled to depths ranging from 20 to 471 feet, and penetrated through the alluvium into the underlying bedrock. All borings were sampled at regular intervals using the Converse ring sampler, pitcher barrel sampler and the standard split spoon sampler. Continuous rock core samples were obtained in all of the borings except 28-8, 29-B, 29-C, 30-A, 30-B, 31-C, 31-7, 34, 34-1. Sample recovery was generally good in both the siltstone and claystone bedrock and the alluvium.

The following subsections describe the field exploration procedures and provide explanations of symbols and notation used in preparing the field boring logs. Copies of the field boring logs are presented following the text of this appendix.

A.2 FIELD STAFF AND EQUIPMENT

A.2.1 Technical Staff

Members of the three firms (CCI/ESA/GRC) participated in the drilling exploration program. The field geologist continuously supervised each boring during the drilling and sampling operation. The geologist was also responsible for preparing detailed lithologic log and for sample/core identification, labelling and storage of all samples, and installation of piezometer pipe, gravel pack and bentonite seals.

A.2.2 Drilling Contractor and Equipment

The rotary wash drilling was performed by Pitcher Drilling Company of East Palo Alto, California, with Failings 750 and 1500 rotary wash rigs, each operated by a two-man crew. A Mayhew 1000 rotary wash and man-sized bucket auger equipments of A&W Drilling Company of Brea, California, were also used.

A.3 SAMPLING AND LOGGING PROCEDURES

Logging and sampling were performed in the field by the project geologists. The following describes sampling equipment and procedures and notations used on the lithologic logs to indicate drilling and sampling modes.

A.3.1 Sampling

In the overburden at about 10-foot intervals, the Converse ring sampler was driven using either a down-hole 450-pound or a 340-pound slip-jar hammer. The Converse sampler was followed with the standard split spoon sample (SPT) driven with a 140-pound hammer with a 30-inch stroke. Where the soft bedrock was encountered, the borings were sampled using a Pitcher Barrel and Converse ring sampler at 20-foot intervals.

At locations where the bedrock was too hard for Pitcher Barrels or Converse rings, continuous rock core samples were obtained. The rock cores were cut with a diamond impregnated bit and removed in 5- and 10-foot runs.

The most common cause for loss of samples or altering the sample interval was when gravel was encountered at the desired sampling depth. Standard penetration blow count information can often be misleading in this type of formation, and it is difficult to recover an undisturbed sample. Therefore, at some locations, borings were advanced until drill response and cutting suggested a change in formation.

The following symbols were used on the logs to indicate the type of sample and the drilling mode:

Log Symbol	Sample Type	Type of Sampler
B	Bag	-
J	Jar	Split Spoon
C	Can	Converse Ring
S	Shelby Tube	Pitcher Barrel
Box	Box	Pitcher Barrel, Core Barrel

Log Symbol	Drilling Mode
AD	Auger Drill
RD	Rotary Drill
PB	Pitcher Barrel Sampling
SS	Split Spoon
DR	Converse Drive Sample
C	Coring

A.3.2 Field Classification of Soils

All soil types were classified in the field by the field geologist using the "Unified Soil Classification System". Based on the characteristics of the soil, this system indicates the behavior of the soil as an engineering construction material.* Although particle size distribution estimates were based on volume rather than weight, the field estimates should fall within an acceptable range of accuracy. A description of the Unified Soil Classification Symbols used on boring logs is presented in Table A-1.

TABLE A-1
UNIFIED SOIL CLASSIFICATION SYMBOLS

GRANULAR SOILS

SYMBOL	DESCRIPTION
GW	Well-graded gravels, gravel-sand mixtures, little or no fines
GP	Poorly graded gravels, gravel-sand mixtures, little or no fines
GM	Silty gravels, gravel-sand-silt mixtures
GC	Clayey gravels, gravel-sand-clay mixtures
SW	Well-graded sands, gravelly sands, little or no fines
SP	Poorly graded sands, gravelly sands, little or no fines
SM	Silty sands, sand-silt mixtures
SC	Clayey sands, sand-clay mixtures

FINE-GRAINED SOILS

SYMBOL	DESCRIPTION
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
MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
CH	Inorganic clays of high plasticity, fat clays
OH	Organic clays or medium to high plasticity, organic silts
Pt	Peat and other highly organic soils

Table A-2 shows the correlation of standard penetration information and the physical description of the consistency of clays (hand-specimen) and the compactness of sands used by the field geologists for describing the materials encountered.

TABLE A-2 Correlation of N-Values and Consistency/Compactness of Soil Obtained in the Field

N-Values (blows/foot)	Hand-Specimen (clay only)	Consistency (clay or silt)	Compactness (sand only)	N-Values (blows/foot)
0 - 2	Will squeeze between fingers when hand is closed	Very soft	Very loose	0 - 4
2 - 4	Easily molded by fingers	Soft	Loose	4 - 10
4 - 8	Molded by strong pressure of fingers	Firm	---	---
8 - 16	Dented by strong pressure of fingers.	Stiff	Medium dense	10 - 30
16 - 32	Dented only slightly by finger pressure	Very stiff	Dense	30 - 50
32+	Dented only slightly by pencil point	Hard	Very dense	50+

* For a more complete discussion of the Unified Soil Classification System, refer to Corps of Engineers, Technical Memorandum No. 3-357, March 1953, or Department of the Interior, Bureau of Reclamation, Earth Manual, 1963.

A.3.3 Field Description of the Formations

The description of the formations is subdivided in two parts: lithology and physical condition. The lithologic description consists of:

- rock name;
- color of wet core (from GSA rock color chart);
- mineralogy, textural and structural features; and
- any other distinctive features which aid in correlating or interpreting the geology.

The physical condition describes the physical characteristics of the rock believed important for engineering design consideration. The form for the description is as follows:

Physical condition: ______________ fractured, minimum ______, maximum ________, mostly __________; __________ hardness; __________ strength; __________ weathered.

Bedrock description terms used on the boring logs are given on Table A-3.

A.4 PIEZOMETER INSTALLATION

Piezometers were installed in borings 28-8, CEG-29, 29-B, 29-C, 29-1, 29-2, 29-3, CEG-30, CEG-31, 31-1, 31-5, 31-7, CEG-32, CEG-32A, CEG-33, 33-1, 33-2 and CEG-34. Procedures for piezometer installation were as follows:

A 2-inch diameter plastic ABS pipe was installed in the boring. At least the lower 20 feet of the ABS pipe was perforated, and the annulus of the boring around the perforated portion of the pipe was backfilled with a coarse sand/pea gravel aggregate. Concrete/bentonite slurry was used to backfill around the non-perforated portion of the pipe to prevent surface water from artificially recharging the gravel-packed hole or contaminating local ground water. After the piezometer was installed, the boring was flushed using air lift provided by a trailer-mounted air compressor. The piezometer was covered with a standard 7-inch diameter steel water meter cap held at surface grade by a grouted in-place 3- to 4-foot long, 5-inch diameter plastic sleeve. Ground water data obtained from the piezometers are presented in Section 5.4 of the text.

TABLE A-3 Bedrock Description Terms

PHYSICAL CONDITION*	SIZE RANGE	REMARKS
Crushed	-5 microns to 0.1 ft	Contains clay
Intensely Fractured	0.05 ft to 0.1 ft	Contains no clay
Closely Fractured	0.1 ft to 0.5 ft	
Moderately Fractured	0.5 ft to 1.0 ft	
Little Fractured	1.0 ft to 3.0 ft	
Massive	4.0 ft and larger	

HARDNESS**	
Soft	- Reserved for plastic material
Friable	- Easily crumbled or reduced to powder by fingers
Low Hardness	- Can be gouged deeply or carved with pocket knife
Moderately Hard	- Can be readily scratched by a knife blade; scratch leaves heavy trace of dust
Hard	- Can be scratched with difficulty; scratch produces little powder & is often faintly visible
Very Hard	- Cannot be scratched with knife blade

STRENGTH	
Plastic	- Easily deformed by finger pressure
Friable	- Crumbles when rubbed with fingers
Weak	- Unfractured outcrop would crumble under light hammer blows
Moderately Strong	- Outcrop would withstand a few firm hammer blows before breaking
Strong	- Outcrop would withstand a few heavy ringing hammer blows but would yield, with difficulty, only dust & small fragments
Very Strong	- Outcrops would resist heavy ringing hammer blows & will yield with difficulty, only dust & small fragments

WEATHERING	DECOMPOSITION	DISCOLORATION	FRACTURE CONDITION
Deep	- Moderate to complete alteration of minerals, feldspars altered to clay, etc.	Deep & thorough	All fractures extensively coated with oxides, carbonates, or clay
Moderate	- Slight alteration of minerals, cleavage surfaces lusterless & stained	Moderate or localized & intense	Thin coatings or stains
Little	- No megascopic alteration in minerals	Slight & intermittent & localized	Few stains on fracture surfaces
Fresh	- Unaltered, cleavage surface glistening	None	

*Joints and fractures are considered the same for physical description, and both are referred to as "fractures"; however, mechanical breaks caused by drilling operation were not included.

**Scale for rock hardness differs from scale for soil hardness.

THIS BORING 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.

Converse Consultants, Inc.
Earth Sciences Associates
Geo/Resource Consultants

BORING LOG 28-8

Proj: DESIGN UNIT A350 Date Drilled 2-21-84 Ground Elev. 436'

Drill Rig FAILING 1500 Logged By M. Schluter Total Depth 100.0'

Hole Diameter 4 7/8" Hammer Weight & Fall SS: 325 lbs. @ 18", 140 lbs @ 30"

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
0		0.0-0.2 A.C.PAVEMENT			C	
	SM	0.2-2.4 SILTY SAND - FILL: moderate yellowish brown; trace of gravel; loose; moist			A	
2			C-1	12 42	DR	
		2.4-3.0 CONCRETE SLURRY			A	
4		4.0-9.0 SILTY SAND: moderate yellowish brown; very loose to loose; moist; trace of gravel; concrete & brick fragments				
6			J-1	2 3 4	SS 140	1.3/1.5 recovery Rotary wash
					RD	
8		ALLUVIUM				
		9.0-15.0 SAND: moderate yellowish brown; trace of fines; loose to medium dense; moist;				
10			C-2	8 10	DR 325	0.0-/2.5 recovery
12						
		gravel lenses				
14					PB	no recovery
	SM/SW	15.0-21.0 SILTY SAND/SAND moderate brown; moist; trace to little gravel				
16			C-3	9 10	DR 325	
					RD	
18						slight rig chatter
			J-2	9 8 9	SS 140	1.0.1.5 recovery
20						

Project DESIGN UNIT A350 Date Drilled 2-21-84 Hole No. 28-8

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
20	SM/SW	15.0-21.0 SILTY SAND/SAND: (continued)			RD	
	SW	21.0-28.0 SAND/GRAVELLY SAND: dark yellowish brown; medium dense to dense; moist				
22				24	DR	
			C-4	27	325	
					RD	
24			PB-1		PB	1-7-2.3 recovery
26		fine to coarse gravel				
				30	DR	
			C-5	36	325	
					RD	
28	SM/SP	28.0-33.0 SILTY SAND/GRAVELLY SAND: dark yellowish brown; medium dense to dense				
				14	SS	
				14	140	
30			J-3	18		0.9/1.5 recovery
					RD	
32				16	DR	
			C-6	17	325	
	SW	33.0-35.0 SAND: dark yellowish brown; trace of fines & gravel; medium dense			RD	
34			PB-2		PB	
		35.0-36.5 SILTY SAND: medium dense				1.9-2.5 recovery
	SM			14	DR	
36		36.5-44.0 SAND: moderate yellowish brown trace to little gravel; medium dense	C-7	16	325	
	SW/SP				RD	
38						rig chatter
				11	SS	
				16	140	
			J-4	24		
40					RD	
	SW	gravel lenses				rig chatter
42				20	DR	no recovery
				12	325	rig chatter
					RD	
44						

Project DESIGN UNIT A 350 **Date Drilled** 2-21/22-84 **Hole No.** 28-8

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
44	SW/ GW	44.0-51.0 SAND/SANDY GRAVEL: moderate yellowish brown; medium dense to dense	PB-3		PB	2.2/2.5 recovery
46				26	DR 325	
			C-8	27		
					RD	
48				15	SS	
				12		1.0/1.5 recovery
50			J-5	15		
					RD	
		51.0-56.5 CLAYEY SILT: moderate yellowish brown; moist; stiff; trace gravel;				
52	ML			14	DR	
			C-9	15	325	
					RD	2.5/1.5 recovery
54			PB-4		PB	
56		BEDROCK 56.5-100.0 SANDSTONE/SILTSTONE: pale yellowish brown and light brown; soft to moderately hard; very thinly laminated; slightly moist to moist		47	DR	
			C-10	73	325	
58					RD	
	30-40					
60				29	DR	refusal at 11"
			C-11	75	325	
					RD	
62						
64			PB-5		PB	2.4/2.5 recovery
66					RD	
68						

Sheet 3 of 5

Project DESIGN UNIT A350 Date Drilled 2-22-84 Hole No. 28-8

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
68		56.5-100.0 SANDSTONE/SILTSTONE: (continued) with interbedded claystone; medium grey sandstone; dark grey;siltstone; trace of petroleum			RD	
70			C-12	47 79	DR 325	
72					RD	slight oil film developing on drilling fluid tub -petroleum slight rig chatter at 74'
74						
75			PB-6		PB	
76						
77					RD	
78						
80			C-13	80 50	DR 325	refusal @ 9"
82					RD	
84	40-45°	moderately hard	PB-7		PB	2.2/2.2 recovery
86					RD	rig chatter
88						
90		cemented	C-14	35 108	DR 325	
91					RD	
92						

Sheet 4 of 5

Project DESIGN UNIT A350 Date Drilled 2-22-84 Hole No. 28-8

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
92					RD	0.3/0.3 recovery
94		94.0-96.0 hard; well cemented sandstone; medium light grey; fractured; thinly bedded; little weathered	PB-8		F3	rig chatter (94'-96')
96						
98						variable rig chatter
			C-15	150	DR 325	refusal @ 4" disturbed sample
100	B.H.	100.0' Terminated Hole				2-22-84 installed 100' piezometer, perforated from 80-100'; backfilled with pea gravel 2-24-84, water level 40.2' below street level, installed casing and cover
102						
104						
106						
108						
110						
112						
114						
116						

Sheet 5 of 5

THIS BORING 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.

Converse Consultants, Inc.
Earth Sciences Associates
Geo/Resource Consultants

BORING LOG 29

Proj: DESIGN UNIT A-350 Date Drilled 1/19-23/81 Ground Elev. 417'

Drill Rig Mobile B-40 Logged By D. Gillette Total Depth 209.8'

Hole Diameter 3", 6" Hammer Weight & Fall 140 lbs @ 15-18"

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
0		FILL 0.0-0.4 CONCRETE			AD	
	SM	ALLUVIUM 0.4-16.5 SILTY SAND: moderate brown; trace of gravel; occasional thin silty clay lenses; moist; medium dense.			RD	
10			J-1	6 10 10	SS	1.0/1.5 recovery
12					RD	
14		14.5-15.0 gravel				rig chatter
16	GP	16.5-20.5 SANDY GRAVEL and COBBLES: light brown and brownish gray; trace of fines; moist; dense				rig chatter
20					PB	

Sheet 1 of 9

Project DESIGN UNIT A-350 Date Drilled 1/19-23/81 Hole No. 29

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
20	GP	16.5-20.5 SANDY GRAVEL and COBBLES: (cont)			PB	no recovery
		WEATHERED TOPANGA FORMATION 20.5-36.0 SANDY CLAYSTONE: mottled gray inclusions and streaks; moist; firm to very stiff				
22			J-2	5 8 10	SS	0.9/1.5 recovery
		Physical Condition: massive or little fractured; soft to friable hardness; friable strength; deep weathered				
24					RD	
26						
28		29.0-29.6 cobbles or boulders				
30					PB	cobble pushed through clay no recovery
32			J-3	7 10 13	SS	1.2/1.5 recovery
34					RD	
36		36.0-42.0 SANDY CLAYSTONE/SILTSTONE: moderate yellow brown and medium gray; thin sandy claystone beds with siltstone interbeds				
38		38.2-39.8 fracture zone Physical Condition: closely to moderately fractured; friable to low hardness; weak to moderate strength; deep to moderate weathering				
40	10° 55°		Box 1		PB	2.0/2.0 recovery
42	35°	42.0-45.0 SILTY CLAYSTONE: light brown Physical Condition: massive or little fractured; soft; plastic; moderate weathered	J-4	11 30 45	SS	1.5/1.5 recovery pocket penetrometer 3.5 tsf (broke apart) 2/
44			Box 1		PB	

Project DESIGN UNIT A-350 Date Drilled 1/19-23/81 Hole No. 29

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
44		42.0-45.0 <u>SILTY CLAYSTONE</u>: (continued)	Box 1		PB	2.1/2.1 recovery 1/19/81 1/20/81
		45.0-209.8 <u>SANDSTONE</u>: moderate yellowish brown and medium light gray; moderate yellowish brown beds with very thin medium light gray clayey siltstone interbeds; contains dark brown organic inclusions; lightly cemented;				
46					RD	
48	80°		Box 2		C	1.1/1.1 recovery
50	60°	Physical Conditions: moderate fractured; low hardness; weak strength; moderate to little weathered				
52		50.0-209.8 sandstone is medium light gray and grayish black; occurs as thin sandstone beds with very thin grayish black siltstone and claystone interbeds				4.9/4.9 recovery
54						
56						
58						2.8/5.0 recovery
			Box 3			
60	15°	60.0-68.0 claystone beds				2.4/3.0 recovery
62	10°					
64						
		65.0-65.2 well cemented sandstone; medium light gray; very dense				
66		66.0 cemented				4.2/5.0 recovery 4.0/5.0 recovery
68	10°					

Project DESIGN UNIT A-350 Date Drilled 1/19-23/81 Hole No. 29

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
68	10°	45.0-209.8 SANDSTONE: (continued)	Box 3		C	
70	65°	70.2-70.5 cemented (as at 65')				
			Box 4			4.0/5.0 recovery
72	10°					
74						
						4.5/4.5 recovery
76						
78	10°					
80						5.0/5.0 recovery
			Box 5			
82						
84	50°					
						4.9/5.0 recovery
86						
88	36°					
90						4.8/5.0 recovery
			Box 6			
92						

Sheet 4 of 9

Project DESIGN UNIT A-350 **Date Drilled** 1/19-23/81 **Hole No.** 29

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
92	40° 30°	45.0-209.8 SANDSTONE: (continued) 92.0-92.5 cemented sandstone	Box 6		C	
94	60°					5.0/5.0 recovery
96	40° 39°	Physical Condition: as previously described				
98	40°	99.0' cemented sandstone (as at 65.0')				
100	45°		Box 7			5.0/5.0 recovery 1/20/81 1/21/81
102	70° 65°					
104	80° 45°					3.5/3.5 recovery
106	55° 55° 45°					
108			Box 8			5.0/5.0 recovery
110	50° 65° 70°					gas test: O_2 - 21% combustibles - 0%
112	82°	113.0-118.0' brecciated sandstone				4.8/4.8 recovery
114						
116						

Sheet 5 of 9

Project DESIGN UNIT A-350 Date Drilled 1/19-23/81 Hole No. 29

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
116		45.0-209.8 SANDSTONE: (continued)	Box 8		C	
			Box 9			
118	50°					5.0/5.0 recovery
		119.0-119.2 cemented sandstone (as at 65.0')				
120	30°	120.0-123.5 slate: very hard; claystone interbed				
122	10°					2.6/3.2 recovery
		123.5-132.2 medium light gray with thin slate interbeds				
124						2.0/2.0 recovery
126						
			Box 10			
128	70°	Physical Condition: closely to intensely fractured; moderate hard to hard; moderate strong; little weathered				4.5/4.5 recovery
130						3.0/3.0 recovery
132		132.2-209.8' sandstone as at 50.0'				
134	70°					
	75°					
136						4.5/5.0 recovery
	45°		Box 11			
138	45°					5.0/5.0 recovery
	30°					
140	85°					

Project DESIGN UNIT A-350 Date Drilled 1/19-23/81 Hole No. 29

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
140	45°	45.0-209.8 <u>SANDSTONE</u>: (continued)	Box 11		C	5.0/5.0 recovery
	30°					
142						
144						4.0/4.0 recovery
146	20°		Box 12			
	50°					
148	50°	Physical Condition: 146-151' intensely fractured; friable; weak; little weathered				
150						4.7/5.0 recovery
152						
154	55°					
	45°		Box 13			3.5/3.5 recovery 1/21/81 1/22/81
156						
	55°					
	60°					
158	50°					5.0/5.0 recovery
160	60°					
162	50°					5.0/5.0 recovery
164	65°					

Project DESIGN UNIT A-350 Date Drilled 1/19-23/81 Hole No. 29

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
164	60°	45.0-209.8 SANDSTONE: (continued)	Box 14		C	
	80°	Physical Condition: 165-175' intensely fractured; low to moderate hardness; moderate to weak strength; little to fresh weathering				
166	70°					
	85°					
	30°					
168						5.0/5.0 recovery
170						
172						
						5.0/5.0 recovery
174	45°		Box 15			
176	45°					
178						4.3/4.3 recovery
	15°					1.5/1.5 recovery
180	30°					
182		182.0-209.8' brecciated shear zone				
	65°		Box 16			
	50°					
184	52°					
	50°					5.0/5.0 recovery
186	60°					
	80°					
188						

Project DESIGN UNIT A-350 Date Drilled 1/19-23/81 Hole No. 29

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
188		45.0-209.8 SANDSTONE: (continued)	Box 16		C	5.0/5.0 recovery
	50°	182-209.8 brecciated shear zone continued				
190	40°					
	40° 55°	Physical Condition: 182-209.8' closely to intensely fractured; low hardness; moderate strong; little to fresh weathering				
192	85°		Box 17			
	40°					
194	60°					5.0/5.0 recovery
	60°					
196	85° 70°					
	50° 75°					
198	65°					5.0/5.0 recovery
200	50° 85°					
202	15°		Box 18			
204						5.0/5.0 recovery
206						
208		208.0 cemented sandstone				
						5.0/5.0 recovery
210		B.H. 209.8' Terminated hole				
		water sampled 2/25/81				
212						

Sheet 9 of 9

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BORING LOG 29A

Proj: DESIGN UNIT A-350 Date Drilled 2/11-14/83 Ground Elev. 418'
Drill Rig Maynew 1000 Logged By G. Halbert Total Depth 69'
Hole Diameter 4 7/8" Hammer Weight & Fall 140 lb @ 30", 340 lb @ 24"

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
0		0.0-0.5 A.C. PAVEMENT			C	
	ML	FILL 0.5-4.0 CLAYEY SILT: contains sand			RD	
4	GW	ALLUVIUM 4.0-18.0 SAND:				
6		6.0-7.0' gravelly sand layer				moderate chatter
10		fine gravelly sand				moderate to heavy chatter continuous light to moderate chatter
12		occasional siltysand lens				
14						drill rate: 1'/min.
18	ML	18.0-36.0 SANDY SILT: moderate yellowish brown; very stiff; very moist				
20						

Project DESIGN UNIT A-350 Date Drilled 2/11-14/83 Hole No. 29A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
20	ML	18.0-36.0 SANDY SILT: (continued) with gravelly sand lenses; moderate yellowish brown; very moist; very stiff to hard			RD	
22						drill rate 0.8'/min.
24						
	(SP)	25.0-25.8' sand lens				moderate chatter
26						
28	(SP)	28.0-28.8' gravelley sand lens				moderate chatter
30						
32						
34						
		gravelly lens				
36	SM	36.0-46.0 SILTY SAND: moderate yellowish brown; dense				drill rate 2'/min
38						
40						
42						
44						

Project DESIGN UNIT A-350 Date Drilled 2/11-14/83 Hole No. 29A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
44	SM	36.0-46.0 <u>SILTY SAND</u>: (continued)			RD	
46	SW	46.0-60.0 <u>SAND</u>: contains fine gravel; trace of fines				
48						
50						drill rate 3'/min.
52						
54	(SP)	fine gravelly sand lens				
	(SM)	silty sand with gravel				
56	(GW)	gravel lens				heavy chatter
58						
60	SM/ML	60.0-65.0 <u>SILTY SAND/SILT</u>: moderate yellowish orange with dusky yellowish brown silt				
62						drill rate 0.4'/min
64						
66		TOPANGA FORMATION - BEDROCK 66.0-69.0 <u>SANDSTONE</u>: medium gray; fine with very thin darker gray silt layers; also dark yellowish orange weathering stains; jointed, otherwise massive;				
68			C-1	18/20	DR	

Project DESIGN UNIT A-350 Date Drilled 2/11-14/83 Hole No. 29A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
68		66.0-69.0 SANDSTONE: (continued) friable strength; friable to low hardness 66.0-67.0' very hard with possible basalt intrusion	J-1	25 45	SS	
70						installed 2" pvc perforated from 39' to 69'
		B.H. 69.0' Terminated hole				
72						
74						
76						
78						
80						
82						
84						
86						
88						
90						
92						

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BORING LOG 29B

Proj: DESIGN UNIT A350 | Date Drilled 2/10-11/83 | Ground Elev. 421'

Drill Rig Mayhew 1000 | Logged By G. Halbert | Total Depth 47'

Hole Diameter 4 7/8" | Hammer Weight & Fall SPT 140lb, 30", C 340lb, 20"

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
0		0.0-0.5 A.C. PAVEMENT			C	
	CL	FILL 0.5-3.0 CLAYEY SILT: dark yellowish brown; very stiff; low plasticity			RD	
4	SW	ALLUVIUM 3.0-22.6 SAND: mixed white, black, red, brown, dense				
7		occasional silty sand lenses				
9						light chatter
12	SP	fine gravel				moderate chatter
16	GP	15.5-16.6 gravel layer				moderate chatter
17						moderate to heavy chatter
20						

Project DESIGN UNIT A350 Date Drilled 2/10-11/83 Hole No. 29B

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
20	SW	3.0-22.6 SAND: (continued)			RD	
						drill rate: 0.5 min.
22						
	SM	22.6-26.5 SILTY SAND: moderate yellow brown; dense to very dense; very moist				
24						
26						
	SW/GP	26.5-36.0 SAND & GRAVEL: mixed black, red brown, pale green, little fines; dense to very dense				light chatter
28						
30						
32						
34	SM	34.0-35.0 silty sand lens				
		gravel				drill rate 0.5'/min.
36		BEDROCK				
	35°	36.0-46.5 SANDSTONE: interbedded siltstone mottled dark yellow orange & medium grey; moist; weathered; moderately fractured; friable; weak strength, low hardness	C-1	7 11	DR	1.0/1.0 recovery
38						penetrometer 4.0 tsf
40						
42						drill rate 0.3'/min.
44						

Project DESIGN UNIT A350 Date Drilled 2/10-11/83 Hole No. 29B

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
44		36.0-46.5 SANDSTONE: massive			RD	
			J-1	21	SS	1.5/1.5 recovery
46	45°			34		
				46		
		B.H. 46.5 Terminated Hole				installed P.V.C. 2" diameter 0-46' perforated from 26' to 46'
48						
50						
52						
54						
56						
58						
60						
62						
64						
66						
68						

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BORING LOG 29C

Proj: DESIGN UNIT A350 Date Drilled 2-10-83 Ground Elev. 451'

Drill Rig Mayhew 1000 Logged By G. Halbert Total Depth 28'

Hole Diameter 4 7/8 " Hammer Weight & Fall SPT 140 lb., 30", C 340lb., 24"

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
0		6" CONCRETE PAVEMENT			RD	
	ML	FILL 0.5-5.0 SANDY SILT: moderate yellowish brown; stiff; moist				
5	ML	ALLUVIUM 5.0-7.0 SANDY SILT & GRAVEL:				
	GW	gravel and cobbles				
7	ML	7.0-15.2 SANDY SILT				
		greyish orange; very stiff to hard				
15				12	SS	1.5/1.5 recovery
	30° faint	TOPANGA FORMATION 15.2-28 BEDROCK SILTSTONE with interbedded SANDSTONE: mottled pale yellow orange; dark yellow; orange & medium grey; moist; moderately weathered; friable strength	J-1	23 30		
19		19.0-19.4 cemented zone				moderate chatter @19'
20						

Sheet 1 of 2

Project DESIGN UNIT A350 Date Drilled 2-10-83 Hole No. 29C

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
20	5	15.2-28.0 SILTSTONE interbedded with SANDSTONE: (continued)	J-2	18 39 50	SS	1.3/1.3 recovery refusal @ 15" penetrometer 4.0 tsf (broke apart)
22		little weathered			RD	
27	19°		C-1	14 25	DR	penetrometer(no penetration)
28		B.H. 28' Terminate Hole				28' P.V.C. casing installed

Depth scale: 20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40, 42, 44

Sheet 2 of 2

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Converse Consultants, Inc.
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BORING LOG 29-1

Proj: DESIGN UNIT A-410 **Date Drilled** 4-10/13-84 **Ground Elev.** 449'

Drill Rig FAILING 1500 **Logged By** MARK SCHLUTER **Total Depth** 120.0'

Hole Diameter 4 7/8"/3" **Hammer Weight & Fall** 325#@ 18"

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
0		0.0-0.65 CONCRETE STREET SURFACE			C	started drilling @ 0820
	SM	0.65-11.0 SILTY SAND: moderate brown; moist, loose, trace clay binder			A	
2						
			C-1		DR 325	
4					A	
6						
		interbedded sand layers;medium dense				
8						
	SM		C-2		DR 325	
10					RD	rotary wash tri cone bit
	SW/SM	11.0-18.0 SAND/SILTY SAND: moderate brown; moist, medium dense; occasional trace clay binder; trace gravel				
12						
			C-3		DR 325	
14					RD	
16		weakly to moderately cemented sand layers	C-4		DR 325	
18					RD	slight to moderate rig chatter
	ML	18.0-22.0 CLAYEY SILT: moderate yellowish brown to light olive gray				
			C-5		DR 325	
20						

Sheet 1 **of** 6

Project DESIGN UNIT A-410 Date Drilled 4-10/11-84 Hole No. 29-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
20	ML	18.0-22.0 CLAYEY SILT (continued) moist, firm			RD	
22	GC	22.0-26.0 CLAYEY SANDY GRAVEL moderate brown; medium dense; moist, clay binder	C-6		DR 325	
24					RD	
26	ML	26.0-28.0 CLAYEY SILT: light olive gray; moderate yellowish brown; moist firm --GRADATIONAL CONTACT--	C-7		DR 325	
28		28.0-120.0 TOPANGA FORMATION SILTSTONE/ CLAYSTONE: moderate brown and light olive gray to medium light gray	C-8		RD DR 325	
30			BOX #1	RUN #1	PD C	recovery: 0.4'/3.0' RQD: 0%
32		slightly moist; very intensely to intensely laminated; predominantly siltstone with interbedded claystone				
34				RUN #2		recovery: o'/3.5' RQD: 0%
36		PHYSICAL CONDITION: closely to moderately fractured; friable hardness; plastic to friable strength; moderate to little weathering; breaks along bedding				
38				RUN #3		recovery: 2.5'/3.5' RQD: 60%
40				RUN #4	C	recovery: 3.4/3.5 RQD: 85%
42		dark gray; medium gray; siltstone interbeds oxidized to a moderate yellowish brown				
44				RUN #5		

Project DESIGN UNIT A-410 Date Drilled 4-10/11-84 Hole No. 29-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
44		<u>TOPANGA FORMATION SILTSTONE/ CLAYSTONE</u> (continued)	BOX #1	RUN #5		
46		46.0-59.0-siltstone/claystone with interbedded sandstone; dark gray to gray ; trace petroliferous along fractures; intensely to very intensely laminated; damp,friable hardness &strength; moderately fractured; moderate weathering			C	recovery; 1.6/3.5 RQD: 17%
48				RUN #6		recovery: 3.0/3.5 RQD: 57%
50			BOX #2			
52		52.2' 2"-2.5" offset of siltstone and sandstone units @ 75°-85°, offset fracture clean, very narrow, slight deformation of lamina, fracture zone		RUN #7		recovery: 4.4/4,5 RQD: 80%
54						
56				RUN #8	C	recovery: 3.5/4.1 RQD: 80%
58						
60		59.0-64.0 <u>PHYSICAL CONDITION</u>: moderately to little fractured; friable to low hardness; weak; little weathering; breaks along bedding plains	BOX #3	RUN #9		recovery: 4.5/4.9 RQD: 85%
62						
64		64.0-68.0 increasing interbedded sandstone sandstone interbeds intensely laminated; siltstone units very intensely laminated		RUN #10	C	recovery: 3.0/3.0 RQD: 93%
66			BOX #4			
68				RUN #11		

Sheet 3 of 6

Project DESIGN UNIT A-410 Date Drilled 4-11/12-84 Hole No. 29-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
68		TOPANGA FORMATION SILTSTONE/ CLAYSTONE WITH INTERBEDDED SANDSTONE	BOX #4	RUN #11		recovery 0.3/2.3 RQD: 0% (41%)
				RUN #12		recovery: 1.5/0.5 RQD: 41%
70 72		70.0-75.0-fracture zone-deformation and folding of sandstone/ siltstone lamina, minor offsets, dark gray medium gray closely fractured, friable to low hardness, weak to moderately strong, little weathering to fresh		RUN #13	C	recovery: 2.9/3.0 RQD: 91% 4-11-84
74 76		75.0-87.0-INTERBEDDED SILTSTONE AND SANDSTONE medium gray dark gray		RUN #14		4-12-84 recovery: 4.5"/4.5" RQD: 93%
78 80		-sandstone: thinly to very thinly bedded, moderate to little fractured, low to moderately hard, weak to moderately strong, little weathering to fresh -siltstone: very thinly bedded to very intensely laminated, moderate to little fractured, friable to low hardness, friable to weak strength, little weathering to fresh	BOX #5	RUN #15	C	recovery: 3.2"/4.5" RQD: 68%
82 84				RUN #16		recovery: 3.8/3.5 RQD: 95%
86 88		moderately fractured 87.0-SILTSTONE WITH CLAYSTONE: decreasing sandstone interbeds, predominantly siltstone thinly to intensely laminated	BOX #6	RUN #17		recovery: 4.9/4.1 RQD: 95%
90 92		90.0-94.0- --FRACTURE ZONE-- deformation and folding with offsets to 2" offsets @75°-85°, closely fractured, fracture moderately clean & narrow		RUN #18	C	recovery: 4.7/4.9 RQD: 93%

Project DESIGN UNIT A-410 Date Drilled 4-12/13-84 Hole No. 29.1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
92		TOPANGA FORMATION SILTSTONE/ CLAYSTONE WITH INTERBEDDED SANDSTONE	BOX #6	RUN #18	C	
94						
96		dark gray medium gray	BOX #7	RUN #19		recovery: 4.7/4.3 RQD: 98%
		very thinly bedded to intensely laminated; little fractured, low hardness, weak to moderately strong, fresh				
98		96.0-INTERBEDDED SILTSTONE AND SANDSTONE dark gray medium gray		RUN #20		recovery: 2.3/2.3 RQD: 100%
100		predominantly siltstone with thinly interbedded sandstone, very thinly bedded to intensely laminated siltstone				
102		little fractured, low to moderate hardness and strength		RUN #21	C	recovery: 4.7/4.7 RQD: 80%
104			BOX #8			
106				RUN #22		recovery: 4.9/5.0 RQD: 94%
108						
110		110.0-120.0 --FRACTURE ZONE-- intense to closely fractured, micro offsets to 1" offsets, narrow to wide fractures, clean to clay filled fractures, some crushed zones, deformation and folding, friable to low hardness and strength				4-12-84 4-13-84
112			BOX #9	RUN #23	C	recovery:4.9/5.0 RQD: 20%
114						
116				RUN #24		

Sheet 5 of 6

Project DESIGN UNIT A-410 Date Drilled 4-13-84 Hole No. 29-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
116–120		TOPANGA FORMATION SILTSTONE/SANDSTONE --FRACTURED ZONE CONTINUED-- intensely fractured, deformation and folding of bedding lamina, clay filled fractures, offsets to 1"	BOX #9	RUN #24	C	recovery: 4.5/4.5 RQD: 0%
120–140		End of Boring 120.0'				Installed 120' piezometer 0-20' 0'-20' non perforated 20'-40' perforated 40'-80' non perforated 80'-120' perforated

Depth scale: 116, 118, 120, 122, 124, 126, 128, 130, 132, 134, 136, 138, 140

THIS BORING 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.

Converse Consultants, Inc.
Earth Sciences Associates
Geo/Resource Consultants

BORING LOG 29-2

Proj: DESIGN UNIT A410 | Date Drilled 4/14-17/84 | Ground Elev. 470'

Drill Rig Failing 1500 | Logged By Mark Schluter | Total Depth 135.0'

Hole Diameter 4 7/8" 3" | Hammer Weight & Fall 325 lb. @ 18"

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
0		0.0-0.6 CONCRETE STREET SURFACE			RD	
0.6	CL	0.6-6.5 SANDY CLAY (Fill): moderate brown to dark yellowish brown; moist to very moist; soft; mottled;			A	
			C-1		DR 325	
					A	
6.5	CL	6.5-12.0 SILTY CLAY: moderate brown; moist; firm; trace organics (rootlets)				
			C-2		DR 325	
					A	
12.0	ML	12.0-14.0 CLAYEY SILT: light brown, yellowish gray; moist to slightly moist; firm to stiff; oxidized light brown				
			C-3		DR 325	
14.0		BEDROCK-TOPANGA FORMATION 14.0-135.0 SILTSTONE: light gray and light olive gray to light brown; slightly moist; dense; intensely leminated; oxidized			RD	
					DR 325	
					RD	Rotary wash tri-cone bit
18			Box #1	1	C	
20						

Sheet 1 of 6

Project DESIGN UNIT A410 Date Drilled 4/14/84 Hole No. 29-2

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
20		14.0-135.0 SILTSTONE: continued Physical Condition: closely fractured; soft to friable hardness; plastic to friable strength; deep to moderate weathering;		1	C	3.5/4.8 recovery RQD =45%
22		23.0-dark gray to medium gray	Box #1			
24	78			2		1.9/2.3 recovery RQD = 34%
26		26.0-101.0 SILTSTONE/CLAYSTONE: with interbedded sandstone; dark gray to medium gray; sandstone: thinly bedded; moderately fractured; low to moderately hard; moderately strong; little weathering. siltstone/claystone: thinly to intensely bedded; friable hardness and strength; moderate to little weathering; closely fractured		3	C	1.4/4.7 recovery RQD = 18%
28						
30						3.0/3.0 recovery RQD = 56%
32	68			4		
34	65			5		3.4/3.5 recovery RQD = 71%
36			Box #2			
38				6		0 recovery RQD = 0
40	75			7	C	
42		40.5-42.0- fractured zone; micro offset; deformation and folding of bedding lamina; intensely fractured		8		2.0/3.5 recovery RQD = 57%
44				9		

Project DESIGN UNIT A410 Date Drilled 4/14-15/84 Hole No. 29-2

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
44	65	14.0-135.0 SILTSTONE: continued with interbedded sandstone slightly petroliferous		9		1.9/2.5 recovery RQD = 52% 4/14/84 4/15/84
46						
48		47.5-fractured zone, 0.5" offset along 60° fracture, clean and narrow	Box #3	10		2.3/3.0 recovery RQD = 43%
50				11	C	0 recovery RQD = 0
52		52.0-56.0-fractured zone, intensely fractured to crushed; deformation; offsets to 1"		12		2.5/2.2 recovery RQD = 50%
54		intense to very intensely laminated siltstone interbedded with thinly bedded sandstone				
56				13	C	4.7/4.9 recovery RQD = 25%
58						
60		59.0-63.0-fractured zone, intensely fractured to crushed; offsets to 0.75"	Box #4			
62				14		4.0/5.0 recovery RQD = 20%
64		dark gray to medium gray; closely to moderately fractured; friable to moderately hard, weak to moderately strong, little weathered to fresh			C	
66		64.0-68.5-fractured zone; intensely fractured to crushed; deformation of bedding lamina		15		4.5/5.0 recovery
68			Box #5			

Project DESIGN UNIT A410 Date Drilled 4/15-16/84 Hole No. 29.2

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
68		14.0-135.0 SILTSTONE: with interbedded sandstone; continued				
70		71.0-74.0-fractured zone; crushed to intensely fractured; bedding indistinct; friable to plastic	Box #5	16	C	4.4/4.0 recovery RQD = 47%
72						
74		75.5-77.5-fractured zone crushed to intensely fractured; bedding indistinct;		17		4.0/4.0 recovery RQD = 15%
76						4-15-84
						4-16-84
78		78.0-80.0-fractured zone intensely fractured to crushed; offsets to 0.75"	Box #6	18	C	2.7/3.1 recovery RQD = 35%
80		predominantly siltstone with interbedded sandstone; moderately to closely fractured; low hardness to moderately hard; fresh; dark gray to medium gray				
82		82.5-88.0-fractured zone; intensely fractured to closely fractured		19		4.1-4.7 recovery RQD = 27%
84						
86			Box #7	20	C	3.0/3.5 recovery
88		88.5-92.5-fractured zone; crushed to intensely fractured; bedding indistinct				
90				21		4.7/5.2 recovery RQD = 9%
92						

Project DESIGN UNIT A410 Date Drilled 4/16-17/84 Hole No. 29-2

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
92		14.0-135.0 SILTSTONE: with interbedded sandstone; (continued)	Box #7	21	C	
		slightly petroliferous				
94						
		95.5-101.0-fractured zone; crushed to intensely fractured; bedding indistinct; offsets to 1"				
96				22		4.3/6.7 recovery RQD = 17%
98			Box #8			
100						
		101.0-130.0-siltstone with interbedded sandstone; dark gray; thinly bedded to very intensely laminated; siltstone: moderately fractured; low hardness; weak to moderately strong; fresh. sandstone: moderately to little fractured; moderately hard to hard, moderately strong to strong; fresh.				
102				23	C	3.4/3.3 recovery RQD = 57%
104				24		
106						5.4/6.3 recovery RQD = 40%
108						
			Box #9			4-16-84
110						4-17-84
112				25		
						6.5/6.7 recovery RQD = 56%
114						
116			Box #10			

Sheet 5 of 6

Project DESIGN UNIT A410 Date Drilled 4/17-84 Hole No. 29-2

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
116		14.0-135.0 SILTSTONE with interbedded sandstone, continued		25		
118		little fractured to massive	Box #10	26	C	4.8/5.0 recovery RQD = 96%
120		121.0-127.5-fractured zone; closely fractured; fractures clean and narrow				
122				27		1.2/1.0 recovery RQD = 70%
124						
126			Box #11	28	C	8.3/8.5 recovery RQD = 80%
128						
130		130.0-135.0-fractured zone crushed to intensely fractured; clay filled fractures; folding of lamina; bedding indistinct				
132				29	C	3.5/4.0 recovery
134			Box #12			
136		End of boring 135.0' installed piezometer: 0-20' non perforated 20-80' perforated 80-135' caved material				
138						
140						

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Converse Consultants, Inc.
Earth Sciences Associates
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BORING LOG 29-3

Proj: DESIGN UNIT A415 | Date Drilled 3-12-14-84 | Ground Elev. 503'

Drill Rig Failing 1500 | Logged By M. Schulter | Total Depth 126.0

Hole Diameter 4 7/8" | Hammer Weight & Fall 325# @ 18"/140# @ 18"

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
0		0.0-0.5 ASPHALT			C	
	ML	ALLUVIUM 0.5-6.5 <u>CLAYEY SILT</u>: moderate yellowish brown, with sand; stiff to very stiff; slightly moist to moist			A	
2						
4						
		gravelly zone, moderate brown	C-1		DR	
6						
	SC	6.5-8.0 <u>CLAYEY SAND</u>: dusky yellowish brown; medium dense to dense; slightly moist to moist; trace of gravel			A	
8	SM	8.0-11.5 <u>SILTY SAND</u>: moderate yellowish brown; very dense; slightly moist				
10			J-1		SS	
					RD	
12	55°	BEDROCK 11.5-126.0 <u>SILTSTONE/SANDSTONE</u>: light brown and medium gray; slightly moist; dense; thinly laminated; cemented layers				
					C	
14		<u>Physical Condition</u>: closely fractured; friable; deep to moderate weathering	Box 1	1		3.2/3.5 recovery RQD = 0%
16						
				2		1.9/5.0 recovery
18		18.0-30.0 INTERBEDDED CLAYSTONE & SILT-STONE: intensely fractured; soft to friable deep weathering; plastic to friable				
20						

Project DESIGN UNIT A415 Date Drilled 3-12-13-84 Hole No. 29-3

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
20		11.5-126.0 <u>SILTSTONE</u>: continued			C	RQD = 20%
22		intensely fractured; soft; siltstone with interbedded claystone	Box 1	3		1.5/3.0 recovery RQD = 50%
24				4		1.6/2.0 recovery RQD = 80%
26						
28		intense to closely fractured		5		1.5/5.0 recovery RQD = 30%
30		30.0-34.0 SANDSTONE/SILTSTONE: moderate yellowish brown; dense; moist Physical Condition: moderately fractured; friable; deeply weathered	Box 2			
32				6		1.7/2.5 recovery RQD = 68%
34		34.0-38.0 SILTSTONE: with interbedded sandstone, moderate yellowish brown; stiff; moist Condition: moderately fractured; friable; deep to moderate weathering		7		1.2/1.5 recovery RQD = 48%
36				8		1.7/2.5 recovery RQD = 48%
38		38.0-41.5 CLAYSTONE/SILTSTONE: dark gray; moist, very stiff Physical Condition: moderately fractured, friable, moderately weathered		9		2.5/4.0 recovery RQD = 63%
40						
42		41.5-56.0 SANDSTONE/SILTSTONE: medium gray with moderate yellowish brown weathering and dark gray (siltstone) sandstone; thinly bedded; moderately fractured, low hardness; weak, mod. weathered	Box 3	10		3/12/84
44						

Project DESIGN UNIT A415 Date Drilled 3-13-84 Hole No. 29-3

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
44		SILTSTONE: thinly bedded, moderate to closely fractured, fragile; moderate weathering		10	C	3.0/3.5 recovery RQD = 26%
46		SANDSTONE/SILTSTONE (interbedded) grayish black to medium light gray, thinly bedded Sandstone: moderately to little fractured, low to moderately hard, moderaterly strong, little weathering Siltstone: moderately to little fractured, low hardness, weak to moderately strong, little weathering	Box 3			
48				11		4.1/4.5 recovery RQD = 75%
50	62°					
52						slightly petroliferous
54		53.6 fractured zone in sandstone, little weathering		12		5.0/5.0 recovery RQD = 84%
56		56.0-63.5 SILTSTONE WITH SANDSTONE Physical Condition: little fractured, low (siltstone) to moderately hard (sandstone), moderately strong, little to fresh weathering, very thinly bedded	Box 4			
58				13		5.0/5.0 recovery RQD = 72%
60						
62						
64		63.5-74.5 SANDSTONE: medium light gray, moderately hard to hard, medium to thickly bedded, little fractured to massive, moderately strong, fresh	Box 5	14		5.0/5.0 recovery RQD = 86%
66				15		
68						

Project DESIGN UNIT A415 Date Drilled 3-13-14-84 Hole No. 29-3

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
68		63.5-74.5 SANDSTONE: continued	Box 5	15		4.6/5.0 recovery RQD = 66%
70						
		little fractured, low-moderately hard, weak to moderately strong, little weathering				
72			Box 6	16		4.0/5.0 recovery RQD = 60%
74		74.5-78.7 SILTSTONE/SANDSTONE: dark gray, thinly laminated, little to closely fractured, moderately hard, moderately strong, little weathering to fresh, moist				
76				17		5.0/5.0 recovery RQD = 84%
78		78.7-84.5 SANDSTONE: medium gray, medium bedding, little fractured, moderately hard, moderately strong to strong, fresh, trace gravel, moist				
80	50°					
82			Box 7	18		4.75/5.0 recovery RQD = 94%
84		84.5-86.5 SILTSTONE/SANDSTONE: dark gray, thinly to very thinly laminated, little fractured, moderately hard, strong, fresh, moist				
86		86.5-88.5 SANDSTONE: medium gray, medium bedding, massive, fresh		19		3.5/3.5 recovery RQD = 97%
88		88.5-96.5 SILTSTONE/SANDSTONE: medium gray to dark gray, thinly laminated, closely to little fractured, low to moderately hard, moderately strong				3-13-84 / 3-14-84
90			Box	20		
92						

Sheet 4 of 6

Project DESIGN UNIT A415 Date Drilled 3-14-84 Hole No. 29-3

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
92		88.5-96.5 SILTSTONE/SANDSTONE: continued thinly bedded, little fractured	Box 8	20	C	4.5/4.9 recovery RQD: 67%
94						
96		96.6-98.6 SANDSTONE: medium light gray, little fractured, moderately hard, moderately strong, fresh		21		5.0/5.0 recovery RQD = 70%
98		98.6-106.5 SILTSTONE/SANDSTONE: medium gray to dary gray, thinly laminated, moderately fractured, moderately hard, strong, fresh, moist				
100			Box 9	22		5.0/5.0 recovery RQD = 52%
102						
104						
106		106.5-108.5 soft to low hardness		23		4.7/5.0 recovery RQD = 80%
108						
110	39°		Box 10			
112		111.5-115.5 closely fractured, moderately hard to soft		24		4.9/5.0 recovery RQD = 78%
114						
116				25		

Sheet 5 of 6

Project DESIGN UNIT A415 Date Drilled 3-14-84 Hole No. 29-3

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
116		117.0-118.5 SILTSTONE/SANDSTONE: continued intense to closely fractured, friable to soft, deep to moderate weathering		25		4.0/5.0 recovery RQD = 72%
118			Box 11			
120				26		4.4/5.0 recovery RQD = 60%
122		122.0-124.5 intensely fractured, friable to soft				
124				27		1.4/1.4 recovery RQD = 100%
126		End of Boring 126.0' Flushed hole 3-15-84 Flushed hole. Performed single packer pressure test @ 50' and 86'. Installed 1" PVC piezometer 0-46' non perforated 46-66' perforated (saw cut) 66-86' non perforated 86-126' perforated (saw cut) Backfilled with pea gravel.				
128						
130						
132						
134						
136						
138						
140						

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Converse Consultants, Inc.
Earth Sciences Associates
Geo/Resource Consultants

BORING LOG CEG 30

Proj: DESIGN UNIT A415 | Date Drilled 2/26/81-3/3/81 | Ground Elev. 476'

Drill Rig B-40 | Logged By Stephen M. Testa | Total Depth 251.0'

Hole Diameter NX | Hammer Weight & Fall 140 lb., 30"

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
0		0.0-0.2 CONCRETE:				
	SC	0.2-16.0 CLAYEY SAND: Alluvium grayish brown; moist			RD	clear day
10		continued; moist; loose	J-1		SS	1.0/1.5 recovery
					RD	

Sheet 1 of 11

Project DESIGN UNIT A415 Date Drilled 2/26/81-2/27/81 Hole No. 30

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
20	SC	16.0-29.0 CLAYEY SAND: dark yellowish brown with gravel; moist; medium dense	J-2		SS	1.2/1.5 recovery
					RD	
22						
24						
26						
		27.0-29.0 gravelly layer				minor rod chatter 27.0-29.0'
28		WEATHERED BEDROCK				
		29.0-45.0' SAND, SILTY SAND AND SANDY CLAY: stratified; very thin to thin lamina of dark yellowish orange and dusky yellowish brown fine sand and silty sand; and pale yellowish brown sandy clay; mottled; moist; dense			SS	
30	15-20° SP (SM) (CL)		J-3			1.5/1.5 recovery
					RD	2/27/81
32						
34						
		35.0-40.0 gravelly zone				minor rod chatter from 35.0-40.0
36						
38						
40		moist; very dense			SS	
			J-4			1.5/1.5 recovery
					RD	
42						
44						

Sheet 2 of 11

Project DESIGN UNIT A415 Date Drilled 2/27/81 Hole No. 30

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
44		29.0-45.9 SAND, SILTY SAND AND SANDY CLAY (continued)			RD	
46						
48						
		45.0-155.8 INTERBEDDED SANDSTONE AND SILTSTONE: wavy, parallel, alternating very thin to medium lamina of light olive gray siltstone and dark yellowish orange fine sandstone; moist;			C	
50				1		3.0/3.0 recovery
52		Physical Condition: massive; friable to low hardness; friable to weak strength; moderately weathered	Box #1			
54				2		3.5/4.9 recovery
56						
58	30°	alternating very thin to medium lamina of brownish black siltstone and yellowish gray fine moderately weathered sandstone grading to fresh medium light gray sandstone		3		3.9/3.9 recovery
60						
62						
		primarily sandstone to 62.8 then primarily siltstone to 70.3'		4		1.8/2.4 recovery
64			Box #2			
66				5		3.5/3.5 recovery
68				6		

Project DESIGN UNIT A415 Date Drilled 2/27/81 Hole No. 30

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
68		45.0-155.8 INTERBEDDED SANDSTONE AND SILTSTONE (continued): wavy parallel alternating very thin to medium lamina of light olive gray siltstone and fine to coarse medium light gray sandstone	Box #2	6	C	3.4/3.4 recovery
70		Physical Condition: little fractured, moderately hard to hard; low to moderate strength; fresh		7		oil film in drilling water 1.5/1.9 recovery
72		70.3-71.1 well cemented fine to medium sandstone; hard				
74			Box #3	8		4.5/4.5 recovery
76						
78				9		1.8/1.8 recovery
80				10		3.7/3.7 recovery
82						
84			Box #4	11		pocket penetrometer > 4.5 tsf
86		87.7-89.7 fine to medium sandstone also at 90.3 to 90.9, from 90.9 alternating sandstone and siltstone				4.7/4.7 recovery
88	40° ↘					
90				12		4.7/6.7 recovery
92						

Project DESIGN UNIT A415 Date Drilled 2/27/81-2/28/81 Hole No. 30

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
92		45.0-155.8 INTERBEDDED SANDSTONE AND SILT-STONE (continued):	Box #4	12	C	
		92.4-93.8 fine to medium sand-stone; alternating sandstone and siltstone from 93.8				
94				13		4.8/4.8 recovery
96			Box #5			
		Physical Condition: little fractured; moderately hard to hard; low to moderate strength; fresh; tends to fracture along bedding planes				
98				14		3.8/3.8 recovery
100						2-28-81
102				15		heavy continuous rain 2.0/2.0 recovery
104			Box #6			
106				16		5.0/5.0 recovery
108						
110		110.3-118.0 primarily greenish gray fine to medium grained well cemented sandstone with silt-stone		17		5.0/5.0 recovery
112			Box #7			
				18		1.0/1.0 recovery
114		114.5-115.3 coarse sandstone; well cemented; moderately hard		19		1.0/1.0 recovery
116				20		

Project DESIGN UNIT A415 Date Drilled 2/28/81 Hole No. 30

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
116	40°	45.0-155.8 INTERBEDDED SANDSTONE AND SILTSTONE (continued):	Box #7	20	C	3.0/3.0 recovery
118		from 118.9 wavy parallel alternating very thin to medium lamina of greenish gray sandstone and siltstone				
120			Box #8	21		4.0/5.0 recovery
122		Physical Condition: little fractured; moderately hard to hard; low to moderate strength; fresh		22		0.5/2.5 recovery
124						
126				23		2.5/2.5 recovery
128				24		pocket penetrometer >4.5 tsf
130		131.5 to 132 coarse well cemented greenish gray sandstone		25		2.5/2.5 recovery 2.0/2.5 recovery
132		closely fractured				
134			Box #9	26		1.5/2.0 recovery
136				27		3.0/3.0 recovery
138		137.0-137.5 primarily sandstone; little fractured		28		
140						

Project DESIGN UNIT A415 Date Drilled 2/28/81-3/2/81 Hole No. 30

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
140		45.0-159.8 INTERBEDDED SANDSTONE AND SILT-STONE (continued): wavy, parallel, alternating very thin to medium lamina of greenish gray fine to coarse sandstone and brownish black siltstone			C	
142			Box #9	28		5.0/5.0 recovery
144		Physical Condition: moderately to closely fractured; moderate to low hardness; moderately strong; fresh				
146			Box #10	29		5.0/5.0 recovery
148		148.5-152.8 fine to medium sandstone				3-2-81 heavy rain until 11:00 a.m.
150	40°			30		4.8/4.8 recovery
152		low hardness from 151.0'; closely fractured				
154		155.8 to 156.4 clay shear zone	Box #11	31		4.5/4.5 recovery
156						
158		157.2 to 157.9 fine to medium well cemented sandstone; moderately hard		32		2.5/2.5 recovery
		159.7-162.6 CLAY GOUGE: dark greenish gray				
160				33		3.2/3.2 recovery
162		162.6-171.3 VOLCANIC BRECCIA: dark greenish gray; fine grained basalt fragments in a clay matrix	Box #12	34		
164						

Project DESIGN UNIT A415 Date Drilled 3/2/81 Hole No. 30

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
164		162.6-171.3 VOLCANIC BRECCIA (continued):		34	C	3.0/3.0 recovery
166				35		2.0/2.0 recovery
168		168.5 to 170.0 closely to intensely fractured; slicken-sided surfaces	Box #12	36		3.3/3.3 recovery
170						
172		171.3-173.0 SANDSTONE: greenish black, medium to coarse; hard		37		1.7/1.7 recovery
174		173.0-174.9 VOLCANIC BRECCIA: dark greenish gray; fine grained basalt in a clay matrix; intensely to closely fractured		38		1.7/1.9 recovery
176		174.9-183.5 SANDSTONE: light gray fine to to coarse grained; hard; closely to intensely fractured	Box #13	39		3.1/3.1 recovery
178						
180				40		4.6/4.6 recovery
182						
184		183.5-251.0 BASALT: greenish black; many slickensided surfaces		41		3.5/3.5 recovery
186		Physical Condition: crushed to closely fractured; moderately hard; weak to moderately strong; moderately weathered		42		1.9/1.9 recovery
188						

Project DESIGN UNIT A415 Date Drilled 3/3/81 Hole No. 30

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
188		183.5-251.0 BASALT: greenish black; numerous slickensided fractures	Box #14	43	C	3/3/81 3.3/3.3 recovery
190		190.0-191.0 Physical Condition: little fractured; moderately hard to hard; moderately strong; fresh 191.6 6" shear zone		44		1.7/1.7 recovery
192			Box #15	45		4.7/4.7 recovery
196				46		4.1/4.1 recovery
202				47		1.2/1.2 recovery
203		203.0-215.0 intensely to closely fractured, numerous slickensides	Box #16	48		2.4/2.4 recovery
205				49		1.2/2.6 recovery
208		208.5-212.0 crushed to intensely fractured		50		1.5/1.9 recovery
210				51		2.2/2.7 recovery
212						

Project DESIGN UNIT A415 Date Drilled 3/3/81 Hole No. 30

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
212.0		183.5-251.0 <u>BASALT (continued):</u>	Box #16	51		
				52		
214.0			Box #17			2.4/3.0 recovery
		215.0-226.0 closely to moderately fractured with fault gouge and intensely fractured zones				
216.0				53		2.2/2.4 recovery
		217.8 thin fault gouge zone				
218.0				54		2.2/2.5 recovery
		219.0 and 214.5 fault gouge				
220.0				55		1.9/2.5 recovery
222.0		222.0-223.0 fault gouge				
				56		
224.0		224.0-225.0 gouge; intensely fractured				2.0/2.0 recovery
			Box #18	57		
226.0		226.0 very thin gouge zone 226.0-232.0 <u>Physical Condition:</u> moderately fractured; hard; strong; fresh				2.9/3.0 recovery
228.0				58		
						3.0/3.0 recovery
230.0						
				59		
						2.0/2.0 recovery
232.0						
				60		3.8/3.8 recovery
234.0						
			Box #19			
236.0						

Project DESIGN UNIT A415 Date Drilled 3/3/81 Hole No. 30

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
236.0		Basalt (continued):	Box #19	60		
		Physical Condition: moderately fractured; hard; sttong; fresh		61		1.1/1.2 recovery
238.0				62		2.6/2.6 recovery
		239.8-240.6 intensely fractured				
240.0				63		
242.0						2.4/2.4 recovery
				64		
244.0			Box #20			4.7/4.7 recovery
246.0						
248.0		most fracture sets rehealed with silica		65		2.5/3.2 recovery
250.0		End of Boring 251.0'				
252.0		3/3/81; 3/4/81 E-log 3/4/81 water pressure test				hole cleaned out 2 times before complet-ing E logs
254.0						
256.0						
258.0						
260.0						

Sheet 11 of 11

THIS BORING 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.

Converse Consultants, Inc.
Earth Sciences Associates
Geo/Resource Consultants

BORING LOG 30-A

Proj: DESIGN UNIT A415 Date Drilled 2/22/83 Ground Elev. 560'

Drill Rig Mayhew 1000 Logged By G. Halbert Total Depth 25'

Hole Diameter 4 7/8" Hammer Weight & Fall SPT 140 lb, 30" C-340 lb, 24"

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
0		0.0-0.3 AC PAVEMENT 0.3-7.5 GRAVELLY SAND: coarse sand with fine gravel (slopewash)			RD	
4		grading finer				
6		with silty sand				
8	SM	ALLUVIUM 7.5-15.0 SILTY SAND: dark yellowish brown and black, medium dense, moist				
10			J-1		SS	1.2/1.5 recovery
15	SW	15.0-20.0 GRAVELLY SAND: dense, moist, with fines				light chatter
20						

Sheet 1 of 2

Project DESIGN UNIT A415 Date Drilled 2-22-83 Hole No. 30A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
20		BEDROCK 20.0-25.0 BASALT: olive black, intensely fractured, moderately weathered, friable to weak strength	C-1 J-2			0.7/0.7 recovery refusal at 7"
22						
24						
26		End of Boring 25.0'				No water entered hole while open. Backfilled with pea gravel & plugged with 6" concrete.
28						
30						
32						
34						
36						
38						
40						
42						
44						

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Converse Consultants, Inc.
Earth Sciences Associates
Geo/Resource Consultants

BORING LOG 30-B

Proj: DESIGN UNIT A415 Date Drilled 2-23-83 Ground Elev. 467'

Drill Rig B. Auger Logged By D. Gilette Total Depth 32.0'

Hole Diameter 36" Hammer Weight & Fall N/A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
0		0.0-0.2 ASPHALT				2" asphalt
		FILL 0.2-9.0 SANDY CLAY: various shades of brown, contains bottles, pipe, wood, very stiff, moist	OBSERVATION HOLE - NO SAMPLES REQUIRED			0.0-11.0 slight ravelling
2						11-32 hole stands well
4						
6						GROUND WATER DATA - location and eatimated amount of seepae: ±1.0 gpm from north ±0.5 gpm from south
		7.0 - roots and wood				
8						
10	CL/GP	9.0-15.0 SANDY CLAY AND BOULDERS: dark yellowish orange and light brown, 8-12" boulders (sandstone & basalt), very stiff, moist				
12						
14						
16	CL	15.0-22.0 CLAY AND BOULDERS: medium light gray and light brown with fine sand and 10" boulders (basalt), stiff to very stiff, moist				
18						
20						

Project DESIGN UNIT A415 Date Drilled 2-23-83 Hole No. 30B

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
20	CL	15.0-22.0 CLAY: (continued)				W.L. 21.7 after 20 hours
22	GP	22.0-27.5 SANDY GRAVEL: dark reddish brown, contains cobbles&boulders, dense, wet				ground water seeps in at bedrock contact
28	72° ↘	BEDROCK 27.5-32.0 SANDSTONE: dark yellowish orange, slightly weathered, moderately hard				hard drilling bedding dips 72° northerly not able to drill deeper, too hard
32		END OF BORING 30'				2-24-83 hole backfilled with native material

Depth scale: 20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40, 42, 44

Sheet 2 of 2

THIS BORING 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.

Converse Consultants, Inc.
Earth Sciences Associates
Geo/Resource Consultants

BORING LOG CEG 31

Proj: DESIGN UNIT A415 | Date Drilled 2-12-24-81 | Ground Elev. 482.0'

Drill Rig Mobile B-40 | Logged By Schoeberlein/Testa | Total Depth 300.0'

Hole Diameter 3" | Hammer Weight & Fall 140 lb, 30"

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
0		0.0-0.2 CONCRETE			RD	
		0.2-0.6 SAND BASE				
		BEDROCK				
		0.6-85.4 BASALT: moderate yellowish brown to light olive brown				
2						
		Physical Condition: crushed, friable hardness, friable strength, deeply weathered				
4						
			J-1		SS	0.3/0.3 recovery
6					RD	
8						
						rig chatter
10				1	C	0.0/1.0 recovery
		moderate olive brown, fine grained vesicular, vesicules commonly filled with chlorite and zeolites	Box 1	2		1.6/2.0 recovery
12		Physical Condition: intensely to closely fractured, moderately hard, moderately strong, deep to moderate weathering, fracture planes commonly coated with iron oxides, clay (up to 3 mm) and occasional calcite		3		0.0/1.0 recovery
14					RD	
16						
						rig drilling smoother
18						
20						

Project DESIGN A415 Date Drilled 2-12-13-81 Hole No. 31

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
20		0.6-85.4 BASALT: continued moderate olive brown, fine grained, vesicular Physical Condition: intensely to closely fractured, moderately hard, moderately strong, deeply weathered	Box 1		C	
22					RD	
24						0.1/0.4 recovery
			J-2		SS	
26		26.5-26.8 hard lens			RD	
28						
		29.0-29.5 hard				
30			J-3		SS	0.1/0.1 recovery
					RD	2-12-81 2-13-81
32						5-8 min/ft drilling rate
34		olive gray and light olive brown to brownish black				
36			Box 1	6	C	2.5/3.0 recovery
38						
40		40.4-45.0 dark yellowish brown, fresh volcanic glass fragments in altered olive gray ground mass, 41.5-42.0 intensely fractured, clay binder		7		4.3/4.3 recovery
42						
44			Box 2	8		

Project DESIGN UNIT A415 Date Drilled 2-12-13-81 Hole No. 31

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
44		0.6-84.5 BASALT: continued	Box 2	8	C	4.7/4.7 recovery
		45.0-46.0 fracture set, green basalt inclusions increasing in frequency, greyish blue green, rock becoming more competent, most freactures healed				
48				9		1.9/2.2. recovery
		Physical Condition: closely to moderately fractured, moderately hard to hard, strong, little weathered		10		3.0/3.0 recovery
52			Box	11		1.7/1.7 recovery
54				12		2.9/3.3 recovery
56		56.0-84.5 greyish blue green Physical Condition: closely to moderately fractured, moderately hard to hard, strong, moderately weathered		?		
58				13		5.0/5.0 recovery
62			Box 4	14		2.7/2.7 recovery
64		64.0-65.0 extremely weathered zone, crushed to intensely fractured				
		65.0-85.4 breccia, well recemented				
66				15		2.3/2.3 recovery
68				16		

Project DESIGN UNIT A415 Date Drilled 2-12-24-81 Hole No. 31

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
68		56.0-85.4 BASALT: continued fined grained vesicular basalt with numerous hairline fractures	Box 4	16	C	4.6/4.6 recovery
70						
72			Box 5	17		4.8/4.8 recovery
74		74.0-75.0 intensely to closely fractured zone				
76		calcite filled fractures				
				18		4.1/4.8 recovery
78						
80						
		81.0-82.5 intensely to closely fractured zone				
82				19		0.3/0.5 recovery
				20		
			Box 6			
84		conformable contact				drilling slower 4.9/4.9 recovery
86		85.4-91.0 SILTSTONE: greyish black, thin sandstone inclusions, well cemented, fractures all rehealed with calcite filling, alternating wavy parallel very thin to medium fine grained siltstone and sandstone Physical Condition: little fractured to massive, hard, strong, fresh				oil in return water petroleum sample 87-89
88	30°			21		drill rate increasing 4.7/4.7 recovery
90		conformable contact				
92		91.0-102.7 SANDSTONE BRECCIA:				

Project DESIGN UNIT A415 Date Drilled 2-12-24-81 Hole No. 31

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
92		91.0-102.7 SANDSTONE BRECCIA: continued olive grey to medium dark grey in a greyish black fine grained matrix, thin inclusions of sandstone and fine grained porphyry slightly metamorphased	Box 6	22	C	4.5/4.5 recovery
94		Physical Condition: moderately to little fractured, hard, strong, fresh	Box 7			
96				23		1.0/1.0 recovery
98				24		4.9/4.9 recovery
100		slickensides present, infilling of fracture surface				
102						
		102.7-109.0 CONGLOMERATE: medium gray, matrix of quartz sand, feldspar sand, siltstone, sandstone and igneous gravels well cemented, volcanic and granitic grains up to 1.5" in diameter	Box	25		4.9/4.9 recovery
104						
106		Physical Condition: closely to little fractured, hard, strong, fresh				
108		conformable contact		26		4.7/4.7 recovery minor rig chatter
		109.0-114.5 SANDSTONE BRECCIA: olive grey, medium gray in greenish black fine grained matrix, thin inclusions of sandstone and fine grained porphyry slightly metamorphased				
110						
112			Box 9	27		2.4/2.4 recovery
		113.7-114.7 deeply weathered shear zone				
114						
		114.5-121.4 INTERBEDDED SANDSTONE AND SILTSTONE: dark gray to greyish				
116						

Project DESIGN UNIT A415 Date Drilled 2-12-24-81 Hole No. 31

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
116	60°	114.5-121.4 <u>INTERBEDDED SANDSTONE AND SILTSTONE</u> : continued black, well cemented, bedding dips 60°, fracturing has 3 sets 70°, 20° and 90°, 20° clay filled, 70° fracture open and clay coated, 90° fractures calcite filled	Box 9	28	C	2.9/2.9 recovery
118				29		1.0/1.0 recovery
				30		2.8/2.8 recovery
120		<u>Physical Condition</u>: moderately fractured, very hard, strong, fresh				
		120.8-121.4 shear zone crushed				
		121.4-141.6 <u>METASANDSTONE</u>: medium gray, coarse sand ~ 50% quartz, quartz cement in fractures				
122		<u>Physical Condition</u>: closely to moderately fractured, very hard, strong, fresh	Box 10	31		1.2/1.2 recovery
				32		4.9/4.9 recovery
124						
126						
				33		1.8/1.8 recovery
128	70°	128.5 4" coarse grained zone				
130				34		2.9/2.9 recovery
		131.5 6" metaconglomerate, wavy lineated weakly schistose due to larger grain size up to 4" in diameter	Box 11			
132				35		4.6/4.6 recovery
134						
		135.0 grain size decreases				
136	70°					
				36		
138						
		139.0-141.0 brecciated, closely fractured				
140						

Sheet 6 of 13

Project DESIGN UNIT A415 Date Drilled 2-15-16-81 Hole No. 31

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
140		121.4-141.6 METASANDSTONE: continued	Box11	36	C	4.4/4.4 recovery
142		141.6-151.2 INTERBEDDED SANDSTONE & SILTSTONE: medium gray to grayish black fine sand, fractures open and calcite filled. Physical Condition: intensely to moderately fractured, hard to very hard. strong, fresh, from 144 intensely fractured, many open fractures		37		1.0/1.0 recovery
144			Box 12	38		4.8/4.8 recovery
146	70°					
148						
		149.0-150.7 little fractured, finer grained		39		3.8/3.8 recovery
150		slickensides				
		151.2-190.8 BASALT: olive black, fine to medium grained, closely to intensely fractured, primarily chlorite along fracture planes, commonly showing slickenside surfaces and minor calcite		40		0.2/1.4 recovery
152			Box 13	41		2-16-81 1.8/2.2 recovery
154						
156				42		2.4/2.8 recovery
158		Physical Condition: closely to intensely fractured, moderately hard, moderately strong, fresh		43		1.8/1.8 recovery
160				44		0.4/0.5 recovery
				45		1.2/2.0 recovery
162		60° fracture planes most prominant	Box 14	46		0.7/0.7 recovery
164				47		1.5/1.9 recovery

Project DESIGN UNIT A415 Date Drilled 2-16-17-81 Hole No. 31

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
164		151.7-190.8 BASALT: continued		47	C	
		fracture planes straight to irregular, numerous hairline fractures		48		0.7/1.0 recovery
166				49		0.5/1.0 recovery
		Physical Condition: closely to intensely fractured, moderately hard, moderately strong, fresh		50		0.8/1.2 recovery
168			Box 14	51		2.0/2.5 recovery
170				52		0.8/1.0 recovery
172				53		0.0/1.4 recovery
				54		1.7/3.0 recovery
174			Box 15			
176				55		2-17-81 0.7/1.0 recovery
				56		1.0/1.0 recovery
178				57		1.8/2.4 recovery
180				58		0.7/1.0 recovery
182				59		1.4/1.6 recovery
				60		1.8/2.2 recovery
184						
			Box 16	61		2.5/2.8 recovery
186						
188				62		

Project DESIGN UNIT A415 Date Drilled 2-11-23-81 Hole No. 31

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
188		151.2-190.8 BASALT: continued			C	
				62		4.8/4.8 recovery
190						
		190.8-260.7 SILTSTONE AND SANDSTONE INTERBEDS: primarily olive black, very thin to medium parallel lamina siltstone with subordinate fine well cemented bluish gray sandstone, hairline fractures apparent				
192				63		oil film in drilling water 1.5/2.0 recovery
194				64		pocket penetrometer >4.5 tsf 2.0/2.0 recovery
196				65		0.7/1.2 recovery
198		primarily brownish black siltstone and fine light bluish gray sandstone		66		4.5/4.8 recovery
200						
202		very thin to medium wavy lamina				2-18-81
204		Physical Condition: moderately fractured, moderate hard, weak to moderately strong, fresh, tends to fracture along bedding planes and healed fractures		67		4.2/4.2 recovery
206			Box 18			
				68		0.9/1.0 recovery
208				69		4.7/4.7 recovery
210						
212						

Project DESIGN UNIT A415 Date Drilled 2-12-23-81 Hole No. 31

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
212		190.8-260.7 SILTSTONE AND SANDSTONE INTER-BEDS: continued		69		
			Box 18	70		0.5/0.5 recovery
214		wavy alternating very thin to medium lamina of primarily brownish black siltstone and subordinate light bluish gray fine sandstone, numerous silica filled and hairline fractures		71		oil film in drilling water 4.1/4.8 recovery
216			Box 19			
218		Physical Condition: moderately fractured, moderately hard, weak to moderately strong, fresh, tends to fracture along bedding planes and healed fractures		72		pocket penetrometer >4.5 tsf 4.7/4.7 recovery
220						
222						
224			Box 20	73		4.3/4.8 recovery
226						
		continued, fossiliferous silt-stone		74		2-23-81 0.5/0.5 recovery
228				75		4.9/4.9 recovery
230						
232						oil film in drilling water
234			Box 21	76		5.0/5.0 recovery
236						

Project DESIGN UNIT A415 Date Drilled 2-23-24-81 Hole No. 31

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
236		190.8-260.7 SILTSTONE AND SANDSTONE INTERBEDS: continued	Box 21	76	C	5.0/5.0 recovery
238		Physical Condition: moderately fractured, moderately hard, weak to moderately strong, fresh, tends to fracture along bedding planes and healed fractures continued, fossiliferous, moderate yellowish brown siltstone inclusion at 239.5		77		3.5/3.5 recovery oil film in drilling water
240						
242			Box 22	78		1.5/1.6 recovery
244				79		3.2/4.8 recovery
246						pocket penetrometer >4.5 tsf
248				80		2.8/2.8 recovery
250						
252			Box 23	81		2.4/2.4 recovery
254				82		4.7/4.7 recovery
256		grades sandier from 256.9				
258				83		2-24-84 4.8/4.8 recovery
260			Box 24			

Project DESIGN UNIT A415 Date Drilled 2-24-81 Hole No. 31

DEPTH	USCS	MATERIAL CLASSIFICATION		SAMPLE	RUN NO.	DRILL MODE	REMARKS
260		190.8-260.7	SILTSTONE AND SANDSTONE INTERBEDS: continued			C	
		260.7-262.1	SANDSTONE: medium gray, fine to coarse, well cemented, quartz rich, lower contact 50°		83		4.8/4.8 recovery
262		262.1-265.1	CONGLOMERATE: greenish gray, coarse (up to 10 mm max. dia.), intensely fractured (clay filled), clasts include quartz, numerous volcanics, grades to coarse sandstone with depth	Box 24	84		0.5/1.0 recovery
264					85		4.5/4.5 recovery
		265.1-300.0	BASALT: dark greenish gray, fine grained, vesicular, moderately to closely fractured, fracture planes commonly filled with chlorite, slickenside surfaces at 20° to core axis, numerous hairline fractures apparent				loss of circulation water
268					86		4.8/4.8 recovery
272			at 272.4 olive black, fine to medium grained, vesicules	Box 25			pocket penetrometer 4.5 tsf
274					87		4.8/4.8 recovery
276							gas detector 0.0% LEL, no gas encountered
280				Box 26	88		4.8/4.8 recovery
282					89		4.7/4.7 recovery
284							

Project DESIGN UNIT A415 Date Drilled 2-24-81 Hole No. 31

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
284		265.1-300.0 BASALT: continued olive black, fine to medium grained, moderately to closely fractured, numerous hairline fractured apparent	Box 26	89	C	4.7/4.7 recovery
				90		0.9/0.9 recovery
288				91		2.1/2.1 recovery
290				92		1.0/1.0 recovery
			Box 27	93		1.9/1.9 recovery
292				94		1.5/3.4 recovery
						no recovery, mislatch of sample tube
296				95		0.0/4.0 recovery
300						2-24-81

End of Boring 300.0'

2-25-81: Water pressure test conducted at intervals 51.0' to 138.0', and 138.0' to 300.0' at 20, 40 and 60 psi

2-27-81: Performed downhole geophysics

2-28-81: Piezometer installation, installed 180.0' to 2" PVC perforated PVC at the following intervals: 80.0' to 100.0' and 155.0' to 175.0', backfilled hole with pea gravel

3-2-81: water sampled

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Converse Consultants, Inc.
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BORING LOG 31-1

Proj: DESIGN UNIT A415 — Date Drilled 10/3/83-10/6/83 — Ground Elev. 479

Drill Rig Failing 750 — Logged By DG/MD/SS — Total Depth 106.0

Hole Diameter 3" — Hammer Weight & Fall 140 lbs., 30"

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
0		0.0-0.2 ASPHALT			GB	
	AF	0.2-0.5 BASE ROCK			AD	
	ML/SM	ALLUVIUM 0.5-10.0 SANDY SILT/SILTY SAND: dusky yellowish brown with gravel; moist; stiff; medium dense				
2						
4						
6	SM/GP	6.0-8.0 gravelly layer				6.0-8.0 rig chatter
8	ML/SM				RD	
10	SM	10.0-16.0 SILTY SAND: light brown with gravel; moist; medium dense			SS	
					RD	
12						
14						
16	CL	16.0-29.0 SANDY CLAY: dusky yellowish brown with gravel; moist; firm				
18						
20						

Project DESIGN UNIT A415 Date Drilled 10/3/83-10/6/83 Hole No. 31-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
20	CL	16.0-29.0 SANDY CLAY (continues as above):			SS	
21					RD	
29	SM	29.0-48.0 SILTY SAND: dusky brown; moist; loose; with gravel				
30					SS	
31					RD	
40					SS	
40.5		becoming medium dense				
41					RD	

Depth scale: 20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40, 42, 44

Sheet 2 of 5

Project DESIGN UNIT A415 Date Drilled 10/3/83-10/6/83 Hole No. 31-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
44	SM	29.0-48.0 SILTY SAND (continued): 44.0-46.0 gravelly layer			RD	44.0-46.0 rig chatter
46						
48	SM	48.0-56.0 SILTY SAND: moderate brown and dark gray with gravel; moist; dense; trace organics and slight organic odor				
50					SS	
52					RD	
54						
56	SC	56.0-72.5 CLAYEY SAND: greenish black; wet; very dense	PB-1	1	PB	2.0/2.5 recovery
58					RD	
60						
62						
64		64.0-65.0 gravelly layer	PB-2	2	PB	1.5/2.5 recovery
66			PB-3	3		2.0/2.5 recovery
68						

Project DESIGN UNIT A415 Date Drilled 10/3/83-10/6/83 Hole No. 31-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
68	SC	56.0-72.5 CLAYEY SAND (continued):	PB-3	3	PB	
					RD	
70						
72		BEDROCK				
		72.5-106.0 BASALT: medium light gray; fine grained		4	PB	
74		Physical Condition: intensely fractured; low hardness; weak strength; deeply to moderately weathered	PB-4			1.5/2.5 recovery
76		dark gray, slightly clay, wet, firm to very stiff	PB-5	5		1.2/2.5 recovery
78			PB-6	6		0.9/2.5 recovery
80					RD	
82						
84						
86						
		87.0-90.1 shear zone: gravelly clay; moist to wet; stiff; color change to olive gray		1	C	1.8/2.0 recovery
88						
90		Physical Condition: crushed, soft to low hardness; plastic to weak strength; deep weathering; some fractures filled with dark gray clay-moist; firm to very stiff	Box #1	2		2.0/2.0 recovery
92				3		

Project DESIGN UNIT A415 Date Drilled 10/3/83-10/6/83 Hole No. 31-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
92		72.5-106.0 BASALT (continued): color becoming mottled-dark greenish gray, greenish black, and grayish black	Box #1	3	C	3.5/3.7 recovery
94		Physical Condition: intensely fractured; moderate to low hardness; weak to moderate strength; moderate weathering		4		4.4/4.4 recovery
96–98						drill rate = 20 min/ft
98–100				5		0.0/1.2 recovery drill rate = 8 min/ft
100			Box #2	6		1.0/2.3 recovery drill rate = 22 min/ft
102		thin clay-filled fractures at 104', 105'				5 October 1983
		103.0-103.1 clay-filled shear zone		7		6 October 1983 3.4/3.4 recovery
104		Physical Condition: intensely to closely fractured; moderately hard; weak to moderately strong; deeply to moderately weathered				
106		end of boring = 106.0'				flushed hole; set 2" ABS piezometer from 0.0-106.0, perforated from 86.0-106.0. Pulled casing and backfilled with pea gravel. Sealed top (0.5-4.0) with concrete. Cleaned site; covered hole with steel cap
108						
110						
112						
114						
116						

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BORING LOG 31-2

Proj: DESIGN UNIT A415 **Date Drilled** 10/22/83-10/24/83 **Ground Elev.**

Drill Rig Failing 750 **Logged By** Steve Slaff **Total Depth** 90.1

Hole Diameter NX **Hammer Weight & Fall** 140 lb @ 30" SS; 320 lb @ 18" DR

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
0		0.0-0.3 ASPHALT			GB	
		ALLUVIUM			AD	
		0.3-6.0 SANDY SILT: moderate yellowish brown; trace gravel; dry; with organics (rootlets); becoming moist, firm				
2	ML		C-1		DR	1.0/1.0 recovery
					AD	
4			J-1		SS	1.5/1.5 recovery
					AD	
6	SM/ ML	6.0-18.6 SILTY SAND/SANDY SILT: dark yellowish brown with gravel; moist, medium dense/very stiff			RD	
					DR	
8	GC	7.8-8.8 clayey gravel lens with color change to moderate yellowish brown	C-2			1.0/1.0 recovery
					RD	
	SM/ ML		J-2		SS	0.9/1.5 recovery
10					RD	
12					DR	
			C-3			1.0/1.0 recovery
					RD	
14			J-3		SS	0.9/1.5 recovery
					RD	
16						
			C-4		DR	1.0/1.0 recovery
18					RD	
	SM/ ML	18.6-24.6 SILTY SAND/SANDY SILT: dark yellowish brown with gravel;	J-4		SS	0.75/0.75 recovery refusal at 9"
20					RD	

Project DESIGN UNIT A415 Date Drilled 10/22/83-10/24/83 Hole No. 31-2

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
20	SM/ ML	18.6-24.6 SILTY SAND/SANDY SILT (continued): moist; very dense/hard 19.1-19.2 lense of fine quartz sand			RD	
22			C-5		DR	0.9-0.9 recovery refusal @ 11"
					RD	
24			J-5		SS	0.6/0.6 recovery refusal @ 7"
	GC	24.6-30.0 CLAYEY GRAVEL: moderate yellowish brown; moist; very dense			RD	rig chatter
26						
28			PB-1	1	PB	1.5/2.5 recovery
30	CL	30.0-32.3 SILTY CLAY: moderate yellowish brown; moist; hard with sand and gravel	PB-2	2		0.5/2.5 recovery Pitcher tube end damaged
32		BEDROCK 32.3-90.1 BASALT: mottled-dusky green and medium dark gray; porphyritic; much of basic glass devitrified; phenocrysts fine grained pyroxene and plagioclase feldspar. Clasts of fresher basalt are set in matrix of more highly altered basalt characterized by secondary minerals. Slickensides fairly common. Secondary minerals include quartz, chlorite and epidote.	PB-3	3		1.9/2.5 recovery
34-36			PB-4	4		1.2/1.2 recovery
38		Physical Condition: intensely to closely fractured; moderately hard; moderately strong; moderately weathered; thin calcite coatings on some fracture surfaces, most fractures closed and healed.		1	C	RQD = 96% 2.3/2.3 recovery
				2		0.3/0.3 recovery
40			Box #1	3		RQD = 41% 2.8/2.8 recovery
42						10/22/83
44				4		10/23/83

Sheet 2 of 4

Project DESIGN UNIT A415 Date Drilled 10/22/83-10/24/83 Hole No. 31-2

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
44		32.3-90.1 BASALT (continued): quartz, chlorite are most abundant vessicle, cavity, and fracture filling minerals. Some zones exhibit slickensides at various orientations including horizontal. Predominantly greenish black; minor brown orange and yellow iron oxide on fracture surfaces.	Box #1	4	C	RQD = 79% 4.8/4.8 recovery
46		46.7-47.2 core is fractured				
48		47.2-49.9 core completely disaggregated into fragments	Box #2	5		RQD = 0% 3.6/3.6 recovery
50		49.9-50.5 disaggregated basalt and alteration product: clay-dusky green to greenish black; moist; stiff (shear zone) fine grained calcite on fracture surfaces				
52		51.1-53.1 core disaggregated into fragments		6		RQD = 38% 5.6/5.6 recovery
54		core gradually changes color from green to dark gray after removal from the hole				
56		decreasing slickensides				
58		basalt nearly completely altered	Box #3	7		RQD = 28% 2.9/2.9 recovery
60				8		RQD = 32% 4.1/4.1 recovery
62		61.6-62.4 disaggregated basalt-fragments				
64			Box #4	9		RQD = 77% 6.9/6.9 recovery
66		calcite common on fracture surfaces				
68						

Project DESIGN UNIT A415 Date Drilled 10/22/83-10/24/83 Hole No. 31-2

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
68		32.3-90.1 BASALT (continued):			C	
		some surfaces have a glossy sheen due to microcrystaline micaceous chlorite	Box #4	9		
70						23 October 1983
						24 October 1983
72		72.3-75.1 disaggregated zone with fragments		10		RQD = 43% 6.0/6.0 recovery
74		core does not break cleanly, but makes hackly, uneven surface or disaggregates when struck with hammer				
76		thin layers (0.05") of calcite ubiquitous on fracture surfaces	Box #5			
		disaggregated core may indicate fracture, shear, or fault zone				
78				11		RQD = 75% 6.0/6.0 recovery
80						
82		slickensides common; within 20° of horizontal				
84				12		RQD = 34% 2.9/2.9 recovery
			Box #6			
86				13		RQD = 19% 4.2/4.2 recovery
88						
90		end of boring 90.1'	Box #7	14		1.0/1.0 recovery RQD = 100%
92			tremmied in 2 sack cement grout; cleaned site; topped hole with concrete 10/24/83.			

Sheet 4 of 4

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BORING LOG 31-3

Proj: DESIGN UNIT A415 Date Drilled 10-6-9-83 Ground Elev. 526.0

Drill Rig Failing 750 Logged By S. Slaff Total Depth 100.1

Hole Diameter NX Hammer Weight & Fall 140 lbs, 30"

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
0		0.0-0.4 ASPHALT			GB	
		ALLUVIUM 0.4-4.7 GRAVELLY CLAY: moderate yellowish brown to moderate brown; with sand; moist; firm			AD	
2						
4		becoming less gravelly				
	ML	4.7-24.2 SANDY SILT: dark yellowish brown with gravel; moist; stiff				
6					RD	
8			J-1		SS	1.0/1.5 recovery
					RD	
10						
12						
14			PB-1		PB	1.5/2.5 recovery
		becoming very stiff				
16	SM (ML)	becoming sandier	J-2		SS	1.0/1.5 recovery
					RD	
18						
	GC	19.5-19.8 gravel lens				rig chatter at 19.5'
20	ML					

Sheet 1 of 5

Project DESIGN UNIT A415 Date Drilled 10-6-9-83 Hole No. 31-3

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
20	ML	4.7-24.2 SANDY SILT: continued			RD	
			lost		PB	0.0/2.5 recovery
22						
24	ML	24.2-27.0 SANDY SILT: dark yellowish brown; moist; stiff	PB-2			2.5/2.5 recovery
26			J-3		SS	0.75/1.5 recovery
	CL	27.0-29.4 SILTY CLAY: dark yellowish brown; moist; stiff			RD	10-6-83 10-7-83
28						
30	CL	29.4-35.6 SANDY CLAY: moderate brown; moist; with gravel; very stiff	PB-3		PB	2.5/2.5 recovery
32			J-4		SS	1.0/1.5 recovery
	(SM)	becoming sandier				
34					RD	
36	GC	35.6-30.0 CLAYEY GRAVEL: moderate brown; moist; with sand; very dense				slight rig chatter
38			PB-4		PB	sporadic rig chatter 2.5/2.5 recovery
		BEDROCK 39.0-100.1 BASALT: dusky yellowish green; aphanitic to fine grained; some quartz-filled fractures Physical Condition: intensely fractured, fractures closed by secondary minerals (calcite, zeolite, quartz); moderately hard, moderately strong, moderately weathered	J-5		SS RD	0.3/0.3 recovery refusal at 4"
40						
42						
44						

Project DESIGN UNIT A415 Date Drilled 10-6-9-83 Hole No. 31-3

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
44		39.0-100.1 BASALT: continued basalt is medium gray on fresh surfaces; porphyritic with fine grained plagioclase feldspar, pyroxene in aphanitic groundmass.	PB-5		PB	2.0/2.0 recovery disturbed
46–50		Physical Condition: fractures to 1.0" wide commonly filled with secondary minerals including chlorite. Some zones crushed, with clay filling fractures; some zones hard, strong, little weathered. Predominantly medium dark gray with highly altered zones dusky yellowish green.	Box 1	1	C	RQD of core was higher but it disaggregates upon removal from barrel RQD = 17% 4.8/4.8 recovery
50–54		Gray basalt clasts are hard, moderately strong in matrix of dark green alteration products that are low hardness, weak, feel soapy, display slickensides		2		RQD = 68% 5.0/5.0 recovery
54–58			Box 2	3		RQD = 63% 3.2/3.2 recovery
58–62		Hairline fractures common. Basalt clasts are 0.05"-3.0" long; clasts compose 60-90% of the rock; very little calcite in this zone.		4		10-7-83 10-8-83 RQD = 68% 55' 7:00 10-8-83
62–64		This zone has ~40% matrix of secondary minerals, ~60% primary basalt clasts. Slickensides common on fracture surfaces. More calcite filled fractures, matrix becoming strong. Clasts more completely altered.				
64–68			Box 3	5		RQD = 100% 5.2/5.2 recovery

Project "DESIGN UNIT A415 Date Drilled 10-6-9-83 Hole No. 31-3

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
68		39.0-100.1 BASALT: continued	Box 3	5	C	
70				6		RQD = 83% 4.8/5.0 recovery
72		72.1-72.9 open fractures to 1/2" wide, lines with quartz crystals up to 0.2" across; rock sheared, clay in shear zone				
74			Box 4			
76				7		RQD = 60% 4.9/4.9 recovery
78						
80		white to light green calcite coating fractures; clasts have reaction rims and are more highly altered; slickensides; core breaks into jagged, hackly fragments when struck with hammer		8		RQD = 92% 5.0/5.0 recovery
82						
84		grayish black, clay on fractured surfaces, breccia decreasing rock becoming basalt with secondary mineral filled fractures	Box 5			
86				9		RQD = 45% 4.6/4.6 recovery
88						10-8-83
				10		10-9-83 56' 7:10 10/9/83 RQD = 65% 1.7/1.7 recovery
90		basalt is serpentinized; slickensides are common	Box 6	11		
92						

Sheet 4 of 5

Project DESIGN UNIT A415 Date Drilled 10-6-9-83 Hole No. 31-3

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
92		39.0-100.1 BASALT: continued brecciated zone 92.0-93.0	Box 6	11	C	RQD = 84% 5.0/5.0 recovery
94		white quartz and calcite filling some fractures. Green secondary minerals can be scratched with finnger nail				
96		considerable mottling of secondary minerals, especially quartz, calcite		12		RQD = 96% 4.9/4.9 recovery
98		slickensides rare	Box 7			
						10-9-83
100		End of Boring 100.1'				Tremmied in two sacks cement to grout hole. Removed casing, backfilled with concrete to ground surface. Cleanded site.
102						
104						
106						
108						
110						
112						
114						
116						

Sheet 5 of 5

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BORING LOG 31-4

Proj: DESIGN UNIT A415 **Date Drilled** 10-25/11-1-83 **Ground Elev.**

Drill Rig Failing 750 **Logged By** S. Slaff **Total Depth** 100.3'

Hole Diameter NX **Hammer Weight & Fall** 320 lbs,18" DR/140 lbs, 30" SS

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
0		0.0-0.4 ASPHALT			GB	
	ML	ALLUVIUM 0.4-3.2 CLAYEY SILT: moderate yellowish brown; trace gravel and sand; dry; stiff			AD	
2	(SM)	2.0 - becoming moist; increasing sand content	C-1		DR	1.0/1.0 recovery
	ML	3.2-10.8 SANDY SILT: moderate yellowish brown; moist; stiff; with gravel			AD	
4			J-1		SS	1.5/1.5 recovery
6					RD	
			C-2		DR	1.0/1.0 recovery
8					RD	
		becoming very stiff and gravelly	J-2		SS	1.2/1.5 recovery
10					RD	rig chatter
	GM	10.8-12.6 SILTY GRAVEL: mottled - moderate yellowish brown and grayish with sand, orange; moist; very dense;				
12	(ML)	becoming more silty	C-3		DR	1.0/1.0 recovery
	ML	12.6-21.3 SANDY SILT: moderate yellowish brown; with gravel; moist; hard			RD	
14			J-3		SS	1.0/1.5 recovery
16		becoming wet; color change to shade between moderate brown and moderate yellowish brown; gravel content increasing			RD	
			C-4		DR	1.0/1.0 recovery
18					RD	rig chatter
		becoming hard	J-4		SS	
20						

Project DESIGN UNIT A415 Date Drilled 10-25/11-1-83 Hole No. 31-4

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
20	ML	12.6-21.3 <u>SANDY SILT</u>: continued	J-4		SS RD	1.1/1.4 recovery refusal at 17"
		BEDROCK 21.3-100.3 <u>BASALT</u>: mottled - greenish black and dark gray; porphyritic with aphanitic to hemihyaline ground mass, fine grained phenorysts of plagioclase feld-spar and pyroxeme. Secondary minerals include quartz filling vessicles and veinlets, chlorite, epidote with calcite coating fracture surfaces and less commly in vessicles, iron oxide coating fracture surfaces.				
22			C-5		DR C	0.25/0.25 recovery refusal at 3"
24			Box 1	1		RQD = 76% 4.2/4.2 recovery
26		<u>Physical Condition</u>: intensely to closely fractured; hard to moderately weathered. Rock con-sists of relatively fresh dark gray basalt clasts in a greenish black matrix of altered basalt. Clasts are 0.1-4.0" long, average 1.5" long. 22.3-22.8 core is disaggregated. Relatively fresh clasts comprise 30-40% of the formation. 36.5-41.4 relatively fresh clasts comprise 50-60% of formation.				
28				2		RQD = 84% 5.0/5.0 recovery
30						
32				3		RQD = 67% 5.0/5.0 recovery
34			Box 2			
36						10-25-83 10-26-83 ▼ 7.7'
38		<u>Physical Condition</u>: chlorite-filled fractures are 0.05-0.25 wide, average 0.1" wide		4		RQD = 58% 4.9/4.9 recovery
40		41.3-42.8 zone with softer matrix				4.6/4.6 recovery
42			Box 3	5		RQD = 27% recovered 0.3' of core from run 4
44		43.1-46.0 zone composed of 90% fresher basalt, 10% matrix				

Sheet 2 of 5

Project DESIGN UNIT A415 Date Drilled 10-25/11-1-83 Hole No. 31-4

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
44		21.3-100.3 <u>BASALT</u>: continued	Box 3	5	C	
		45.1-46.0 disaggregated zone				
46		medium dark gray pyrolucite (manganese dioxide) on some fracture surfaces				
48		rare slickensides		6		RQD = 33% 5.0/5.0 recovery
		~80% relatively fresh basalt clasts, ~20% altered matrix				drilling fluid is greenish gray
50		49.1-49.8, 51.4-55.8 zones of less resistant matrix, core darkens and loses much of its green cast after several hours of exposure to air.				
52			Box 4	7		RQD = 61% 4.8/4.8 recovery
54		rock breaks along hackly, uneven surfaces when struck with hammer				
56						10-26-83 / 10-31-83 ▽ 27.5
58		~90% relatively fresh basalt clasts, ~10% altered matrix		8		RQD = 72% 5.0/5.0 recovery
60			Box 5			
62		brown iron oxide on some fracture surfaces ~95% relatively fresh basalt, ~5% secondary minerals (mostly filling fractures). small fault, about of offset undeterminable, surfaces have slickensides in secondary minerals 75% relatiively fresh basalt, ~25% altered matrix		9		RQD = 60% 5.0/5.0 recovery
64						
66				10		RQD = 69% 4.9/4.9 recovery
68			Box 6			

Sheet 3 of 5

Project DESIGN UNIT A415 Date Drilled 10-25/11-1-83 Hole No. 31-4

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
68		21.3-100.3 BASALT: continued			C	
			Box 6	10		
70		slickensides on some fracture surfaces - oriented close to horizontal. relatively fresh basalt clasts are angular to subrounded, mostly subangular; size range is 0.1"-6.0", average 0.6"				
72						
				11		RQD = 84% 5.1/5.1 recovery
74						
76		greenish gray, microcrystalline calcite coating many fracture surfaces in layers 0.01-0.1" thick	Box 7			
78				12		RQD = 54% 4.8/4.8 recovery
80		anahedral, white, quartz filling cavities and veinlets 0.1-0.5" thick, average 0.1" thick				10-31-83 11-1-83 ▽ 28'
82		slickensides continue		13		RQD = 57% 4.9/4.9 recovery
		calcite and chlorite present on most fracture surfaces				
84						
86		60% relatively fresh clasts, 40% altered matrix	Box 8			
88		minor very fine grained, euhedral pyrite grains on some fracture surfaces		14		RQD = 75% 4.8/4.8 recovery
90		alteration products coating fracture surfaces feel slippery	Box 9			
				15		
92						

Project DESIGN UNIT A415 Date Drilled 10-25/11-1-83 Hole No. 31-4

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
92		21.3-100.3 BASALT: continued			C	
		70% relatively fresh clasts, 30% altered matrix	Box 9	15		RQD = 90% 4.9/4.9 recovery
96		core tends to fracture around relatively fresh clasts when broken with hammer. pyrolucite coating some fracture surfaces		16		RQD = 88% 5.1/5.1 recovery
98			Box 10			11-1-83
100		END OF BORING 100.3'				Tremmied in 2 sack cement grout. Removed casing. Cleaned site. Covered hole with steel street cover. 11-6-83 removed street cover, capped with concrete.
102–116						

Sheet 5 of 5

THIS BORING 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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BORING LOG 31-5

Proj: DESIGN UNIT A415 **Date Drilled** 10/9/83-10/19/83 **Ground Elev.** 574

Drill Rig Failing 750 **Logged By** Steve Slaff **Total Depth** 150.0

Hole Diameter NX **Hammer Weight & Fall** 140 lbs @ 30" SS; 320 lbs @ 18" DR

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
0		0.0-0.25 ASPHALT			GB	
		0.25-0.5 BASE ROCK			AD	
		ALLUVIUM 0.5-3.5 SANDY CLAY: grayish brown with gravel; dry, firm; minor organics; color change to moderate yellowish brown at 1.0				
2			C-1		DR	1.0/1.0 recovery
4	CL	3.5-7.0 GRAVELLY CLAY: moderate yellowish brown; moist, hard, with sand, minor organics			AD	
6			J-1		SS	1.5/1.5 recovery
		BEDROCK 7.0-150.0 BASALT: brownish black, fine grained			RD	
8		Physical Condition: intensely fractured (some fractures closed by secondary minerals), hardness-friable, strength-friable, deeply weathered, contains some clay.				
10			C-2		DR	refusal at 5"
		becoming harder, stronger			RD	0.3/0.3 recovery 9 October 1983 10 October 1983
12		Basalt: medium dark gray where little altered, greenish black where altered			C	
14		fine grained, includes plagioclase feldspar, pyroxene, chlorite, epidote, quartz. Minor unfilled vessicles. Altered zones with a waxy to dull luster.		1		RQD = 96% 4.2/4.5 recovery
16			Box #1			
18		Physical Condition: Basalt: intensely fractured, moderately hard to hard, moderately stront , moderately weathered. Altered Basalt: intensely fractured, low to friable hardness, weak strength, little to moderately weathered.		2		RQD = 100% 9.7/9.7 recovery
20						

Project DESIGN UNIT A415 Date Drilled 10/9/83-10/19/83 Hole No. 31-5

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
20		7.0-150.0 <u>BASALT (continued)</u>: fractures straight to uneven, rarely curved. Some fractures filled with quartz, chlorite, epidote, from hairline width to 0.2". Most fractures closed. Rock tends to break along hackly, uneven surfaces and along fractures.	Box #1		C	
22				2		9.7/9.7 recovery
24						
26		predominant fractures dip 50°-60° from horizontal	Box #2			
28		grayish yellow green, very fine grained calcite coats some fracture surfaces				RQD = 100%
30		rock is hard and strong where less altered				
				3		10.2/10.2 recovery
32		harder zone - higher proportion of fresh basalt to altered basalt				
34		quartz, chlorite, epidote	Box #3			
36						10 October 1983 11 October 1983
38		rock is ~90% altered basalt, 10% fresh basalt				
40		clasts of fresh basalt within altered basalt are 0.1"-8.0", have angular to rounded shape		4		RQD = 98% 8.3/8.3 recovery
42			Box #4			
44						

Sheet 2 of 7

Project DESIGN UNIT A415 Date Drilled 10/9/83-10/19/83 Hole No. 31-5

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
44		7.0-150.0 BASALT (continued): most fractures closed or very narrow	Box #4	4	C	
46						RQD = 95%
48						
50				5		10.0/10.0 recovery
52		pyroxene and plagioclase feldspar in a very fine grained groundmass				
54		thin calcite coating fracture surfaces	Box #5			
56		quartz filled vessicles and fractures up to 1.0" wide				RQD = 79%
58				6		10.1/10.1 recovery
60						
62		predominant color: dark gray	Box #6			
64		Physical Condition: intensely to closely fractured, moderately hard to hard, moderately strong to strong, moderately weathered. Nearly all fractures closed, filled with secondary minerals. 2" wide quartz-filled cavity 67.5				11 October 1983 12 October 1983
66						
68			Box #7	7		

Sheet 3 of 7

Project DESIGN UNIT A415 Date Drilled 10/9/83-10/19/83 Hole No. 31-5

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
68		7.0-150.0 BASALT (continued):			C	RQD = 100%
70						
72			Box #7	7		10.0/10.0 recovery
74		slickensides in chlorite show relative movement from horizontal plane to various orientations up to 60° from horizontal				
76		chlorite and other alteration products coating fracture surfaces can be scratched with fingernail; have waxy luster and feel		8		RQD = 95% 4.2/4.5 recovery
78						
80						
82		abundant chlorite-filled veinlets up to 0.15" wide	Box #8	9		RQD = 62% 3.9/3.9 recovery
84		some vessicles only partially filled with secondary minerals; color change to dark greenish gray; very fine grained pyrite in matrix; pyrite more concentrated on fracture surfaces				
86		86.3-87.3 clay filled shear or fracture zone; abundant very fine to fine grained pyrite, dark greenish gray clay, horizontal slickensides		10		RQD = 82% 4.6/4.6 recovery
88						
90		calcite coating fracture surfaces in layers up to 0.1" thick	Box #9	11		RQD = 65% 7.3/7.3 recovery
92						

Project DESIGN UNIT A415 Date Drilled 10/9/83 to 10/19/83 Hole No. 31-5

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
92		7.0-150.0 BASALT (continues as above): 92.0-93.6 shear zone with brecciated rock, sand, silt, clay in fractures	Box #9	11	C	
96		pyrite decreasing	Box #10	12		RQD = 93% 9.5/9.5 recovery
104		tale on some fracture surfaces can be scratched with fingernail; quartz-filled cavities up to 0.4" wide	Box #11	13		RQD = 80% 8.3/8.3 recovery
114		Physical Condition: intensely to closely fractured, moderately hard to hard, strong to moderately strong, moderately weathered	Box #12	14		7.6/7.6 recovery
116						

Project DESIGN UNIT A415 Date Drilled 10/9/83 to 10/19/83 Hole No. 31-5

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
116		7.0 to 150.0 BASALT (continued):			C	RQD = 98%
		Physical Condition (cont'd): nearly all fractures are filled with secondary miner-als and closed				
118			Box #12	14		
120						
122						RQD = 87%
124			Box #13			
				15		10.2/10.2 recovery
126						
128						
130						
132		calcareous clay on some frac-ture surfaces, also calcite				RQD = 97%
134			Box #14			
		quartz-filled fractures		16		9.6/9.6 recovery
136						
138			Box #15			
140						

Sheet 6 of 7

Project DESIGN UNIT A415 Date Drilled 10/9/83 - 10/19/83 Hole No. 31-5

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
140		7.0-150.0 BASALT (continued):		16	C	
142		142.0 - 1" thick quartz-filled fracture				RQD = 96%
144		quartz-filled fractures up to 0.3" thick	Box #15	17		
146		open fractures coated with secondary minerals				8.7/8.7 recovery
148			Box #16			
150				18		0.5/0.5 recovery
		END OF BORING 150.0'				terminated hole at 150.0; set 2" diameter ABS piezometer from surface to 150.0; back-filled annulus with pea gravel; piezometer perforated from 110-150; set 5" PVC sleeve from ground surface to 2.0; covered with steel street cap; cleaned site
152						
154						
156						
158						
160						
162						
164						

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BORING LOG 31-6

Proj: DESIGN UNIT A415 **Date Drilled** 2/24/84 **Ground Elev.** ______

Drill Rig Failing 1500 **Logged By** Mark Schluter **Total Depth** 29.0'

Hole Diameter 4 7/8" **Hammer Weight & Fall** 325 lb @ 18", 140 lb @ 30"

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
0		0.0-0.3 A.C. PAVEMENT			C	
	SM	FILL 0.3-6.0 SILTY SAND: moderate brown; loose; slightly moist to moist; trace gravel; trace of brick; asphalt and rootlets			A	
2						
			C-1		DR 325	
4					RD	
6	SM/ML	ALLUVIUM 6.0-8.5 SILTY SAND/SANDY SILT: moderate brown to dark yellowish brown; medium dense/stiff; moist to slightly moist; trace gravel	J-1		SS 140	0.5/1.5 recovery
8	GM	8.5-13.5 SANDY GRAVEL/SILTY GRAVEL: dusky yellowish brown; medium dense; moist	C-2		DR 325	
10					RD	variable rig chatter
12						
	SM	13.5-18.0 SILTY SAND: moderate brown; medium brown; medium dense; moist with gravel	C-3		DR 325	
14					RD	
16			J-2		SS 140	0.6/1.5 recovery
18	SW	18.0-22.5 SAND: moderate brown to dusky yellowish brown; trace fines and gravel; medium dense; increasing gravel content			RD	
			C-4		DR 325	
20						

Project DESIGN UNIT A415 Date Drilled 2/24/84 Hole No. 31-6

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
20	SW	18.0-22.5 SAND (continued):			RD	
22		BEDROCK 22.5-29.0 BASALT: dusky brown and grayish black; aphanitic to fine grain	C-5		DR 325	drill rig chatter refusal @ 11"
24		Physical Condition: intensely fractured; moderately to deeply weathered; soft	C-6		RD DR 325	refusal @ 6"
26		25.0-28.0 moderately weathered; intensely fractured; moderately hard, narrow to very narrow fracture walls with clay filling			RD	significant drilling fluid loss in basalt formation
28		moderately to deeply weathered; intensely fractured	C-7		DR 325	
		END OF BORING 29.0'				
30		Passive Percolation Test: hole depth 29.0', 5" I.D. casing 13" above ground surface				
32		water level fell 2.6' inside steel casing during 1 minute				
34		water level fell 10.8' below top of casing after 10 minutes				
		2-25-84 water level 26.5' below ground surface				
36						
38						
40						
42						
44						

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BORING LOG 31-7

Proj: DESIGN UNIT A415 **Date Drilled** 2-25-84 **Ground Elev.** ______

Drill Rig Failing 1500 **Logged By** M. Schluter **Total Depth** 20.0'

Hole Diameter 4 7/8" **Hammer Weight & Fall** 325# @ 18"/140# @ 30"

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
0		0.0-0.5 A.C. PAVEMENT: multiple layers			C	started drilling @ 0730
	SM	0.5-3.0 SILTY SAND: moderate brown; loose-medium dense; moist; clay binder			A	
2						
		BEDROCK				
4		3.0-20.0 BASALT: brownish black to dusky brown Physical Condition: intensely fractured, closed-very narrow fractured walls, stained, medium-weathered, moderately hard	C-1		DR	
					A	
6			C-2		DR	
		5.0-10.0 very soft to soft, (soil like), highly weathered, clay infilling 1-10 mm. infilling dark yellowish brown			A	
			C-3		DR	
8					RD	drill rig chatter
10		10.0-15.0 degree of weathering variable, highly weathered - medium weathered, medium - highly fractured, random, clay infill-ings 1-8 mm	C-4		DR	
12					RD	varible drill rig chatter
14						
		15.0-20.0 medium weathered, fresh, hard to very hard rock, highly fractured jagged edges, secondary mineral infilling - chloriate, epidote	C-5		DR	
16						caving and sluffing into hole, added additional bentonite variable drill rig chatter
18						heavy drill rig chatter
		END OF BORING 20.0', finished @ 1100	C-6			
20						

Sheet 1 of 1

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BORING LOG 32

Proj: DESIGN UNIT A410 **Date Drilled** 1/23-29/81 2/2-10/84 **Ground Elev.** 770

Drill Rig Mobile B-40 **Logged By** D. Gillette **Total Depth** 398.6'

Hole Diameter 3" **Hammer Weight & Fall**

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
0		0.0-0.4 ASPHALT			C	
		0.4-4.5 ARTIFICIAL FILL SILTY SAND: moderate yellow brown; medium dense			RD	
2						
4		4.5-398.6 TOPANGA FORMATION 4.5-7.0 very weathered basalt; dusky yellowish brown				
6						
		7.0-18.0 basalt: dusky brown and brownish black; vesicular; slightly weathered; extensive Fe oxide staining; clay deposits in fractures; 6" layers of clay				
8						
		7.0-18.0 Physical Condition: closely to intensely fractured;soft to friable strength; moderate to deep weathered	Box #1	RUN #1	C	
10						
						3.0/3.5 recovery
12				RUN #2		1.5/2.5 recovery
14						
		15.0-18.0 clay; very soft		RUN #3		
16						2.3/2.5 recovery
				RUN #4		0.0/1.0 recovery
18		18.0-38.0 very weathered basalt	BOX #2	RUN #5	PB	1.8/2.0 recovery
20						

Sheet 1 of 17

Project DESIGN UNIT A410 Date Drilled 1/24-29/81 2/2-10-81 Hole No. 32

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
20		4.5-398.6 BASALT: (continued)	Box #2 (cont.)	RUN #6	PB	
22						2.5/3.0 recovery
24				RUN #6A		3.0/3.0 recovery
26		26.0-28.0 BASALT FLOW: olive black vesicular			RD	
28						
30		Physical Condition: (18'-38') closely to moderately fractured; friable to low hardness; weak strength; deep to moderately weathered	Box #2A	RUN #6B	PB	1.0/1.0 recovery
31					RD	
32		Physical Condition (26-28') moderately fractured, hard to very hard; strong to very strong; fresh				
34						
36						
38		38.0-400.0 BASALT: dark greenish grey; vesicular; Fe oxide stains on fractures				
40			Box # 1	RUN # 7	C	3.0/3.0 recovery
42			Box # 3	RUN #8		
44						

Project DESIGN UNIT A410 Date Drilled 1/24-29/81 2/2-10/81 Hole No. 32

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
44		4.5-398.6 BASALT: (continued) vesicular basalt occurs massive and brecciated	Box 3 (cont)	RUN # 8	C	
46						4.7/4.7 recovery
48				RUN # 9		2.0/2.0 recovery
50		49.7-50.2 shear zone; horizontal slicksides	Box 4	RUN # 10		extensive water loss 2.5/3.3 recovery
52						
54				RUN # 11		5.0/5.0 recovery
56						
58		Physical Condition: (38'-68') moderately fractured; low hardness moderate strength; little weathered		RUN # 12		
60		60.0-64.0 fractures 2-4" apart	Box 5			4.0/4.0 recovery
62				RUN #13		5.0/1.0 recovery
64				RUN # 14		
66						5.0/5.0 recovery
68						

Project DESIGN UNIT A410 Date Drilled 1/24-29/81 2/2-10/81 Hole No. 32

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
68		4.5-398.6 BASALT: (continued) 68.0-68.5 offset - 1/16 69'-71' intense fracturing	Box 5 (cont)		C	
70			Box 6	RUN # 15		
72						5.0/5.0 recovery
74		74.5-80.5 CHLORITE VEINS: moderate yellow brown; altered basalt inclusions ranging in size from 1/8" to 3/4"		RUN # 16		
76						5.0/5.0 recovery
78						
80			Box 7	RUN # 17		79.0' - extensive water loss
82		Physical Condition: moderately fractured; moderately hard to hard; moderately strong to strong; little weathered				5.0/5.0 recovery
84		80.5-103.8 BRECCIATED BASALT: broken into ½ to 1" angular blocks separated by 1/16 infillings		RUN # 18		2.8/3.0 recovery
86						
88			Box 8	RUN # 19		3.1/3.2 recovery
90		90.0 - Shear zone - slickensides show two directions of movement		RUN # 20		4.9/5.0 recovery
92						

Project DESIGN UNIT A410 Date Drilled 1/24-29/81 2/2-10/81 Hole No. 32

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
92		4.5-398.6 <u>BASALT:</u> (continued)	Box 8 (cont)	RUN # 20	C	
94						4.9/5.0 recovery
96				RUN # 21		5.0/5.0 recovery
98		97.5-98.5 shear zone; intensely fractured horizontal slicksides	Box 9			
100–104				RUN # 22		5.0/5.0 recovery
106–108			Box 10	RUN # 23		5.0/5.0 recovery
110–112				RUN # 24		5.0/5.0 recovery
114–116		114.4-124.0 Brecciated Basalt		RUN # 25		

Project DESIGN UNIT A 410 Date Drilled 1/24-29/81 2/2-10-81 Hole No. 32

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
116		4.5-398.6 BASALT: (continued)	Box 11	RUN # 25	C	
118						5.0/5.0 recovery
120						
122		Physical Condition: Moderately to closely fractured; moderately hard; moderate strength; little weathering to fresh BASALT- olive grey		RUN # 26		3.8/4.8 recovery
124						
126				RUN # 27		2.8/2.8 recovery
128			Box 12	RUN # 28		lost 1 tank H_2O
130						5.0/5.0 recovery
132		132'- offset -3/8" wide; filled with greyish green mineral				
134				RUN # 29		3.5/3.5 recovery
136		137.8-138.4 intensely fracture zone; intensely fractured	Box 13	RUN # 30		3.1/3.1 recovery
138				RUN # 31		2.9/2.9 recovery
140						

Project DESIGN UNIT A 410 Date Drilled 1/24-29/81 2/2-10/81 Hole No. 32

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
140		4.5-398.6 BASALT: (continued)	Box 13 (cont)	RUN # 32	C	2.3/2.3 recovery
142		fracture zone - crushed 4" wide				
144			Box 14	RUN # 33		
146						5.0/5.0 recovery
148		148-149' Offset - horizontal slickensides on joint plane		RUN # 34		
150						
152						5.0/5.0 recovery
154			Box 15	RUN # 35		
156						4.9/5.0 recovery
158		shear zone - 1" wide; white non-plastic gauge		RUN # 36		
160						
162						5.0/5.0 recovery
164		163-163.4 intense fracturing	Box	RUN #37		

Project DESIGN UNIT A410 Date Drilled 1/24-29/81 2/2-10/81 Hole No.

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
164		4.5-398.6 BASALT: (continued)	Box 16 (cont)		C	
166				RUN # 37		4.8/5.0 recovery
168		shear zone - 1" wide; filled with grey green mineral				
170				RUN # 38		
172						5.0/5.0 recovery
174			Box 17	RUN # 39		
176						5.0/5.0 recovery
178				RUN # 40		
180						
182						4.8/4.8 recovery
184			Box 18	RUN # 41		lost ½ tank H_2O
						3.6/3.6 recovery
186						
188				RUN # 42		

Project DESIGN UNIT A 410 Date Drilled 1/24-19/81 2/2-10/81 Hole No. 32

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
188		4.5-398.6 BASALT: (continued)	Box 18 (cont.)	RUN # 42	C	
190		190.0 fault - ½" wide, filled with greyish mineral				4.0/4.0 recovery
192		Physical Condition: little fractured; hard; very strong; fresh	Box 19	RUN # 43		4.0/4.0 recovery
194						
196				RUN # 44		
198						4.5/4.5 recovery
200		200.0 - offset - slickensildes	Box 20	RUN # 45		
202						4.7/4.7 recovery
204				RUN # 46		
206						4.7/4.7 recovery
208			Box 21	RUN # 47		
210						4.9/4.9 recovery
212						

Project DESIGN UNIT A410 Date Drilled 1/24-29/81 2/2-10/81 Hole No. 32

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
212		4.5-398.6 BASALT: (continued)	Box 21 (cont)	RUN #47	C	
214				RUN # 48		
216						4.8/4.8 recovery
218			Box 22			
220				RUN # 49		4.9/4.9 recovery
222						
224				RUN # 50		
226						4.9/4.9 recovery
228			Box 23			
230				RUN # 51		
232						5.0/5.0 recovery
234				RUN # 52		
236						4.8/4.8 recovery

Project DESIGN UNIT A410 Date Drilled 1/24-29-81 2/2-10/81 Hole No. 32

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
236		4.5-398.6 BASALT: (continued)	Box 24	RUN #52	C	
238						
240				RUN # 53		4.6/4.6 recovery
242				RUN #54		
244		offset-1/8"; filled with greyish green mineral; healed				
246		Physical Condition: little fractured; hard; strong; fresh	Box 25	RUN # 55		4.9/4.9 recovery
248						
		249.5-251.0 shear zone				
250				RUN # 56		4.0/4.0 recovery
252				RUN #57		0.9/1.0 recovery
		253.0-25.6 offset magnitude unknown				
254			Box 26	RUN # 58		lost 1 tank H_2O
256						4.9/4.9 recovery
258						
260				RUN # 59		

Sheet 11 of 17

Project DESIGN UNIT A410 Date Drilled 1/24-29-81 2/2-10/81 Hole No. 32

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
		4.5-398.6 BASALT: (continued)	Box # 24		C	
						4.6/4.6 recovery
		~~offset~~-1/8" filled with greyish green mineral; healed				
		Physical Condition: little fractured; hard; strong; fresh	Box # 25			4.9/4.9 recovery
		249.5-251.0 ~~shear zone~~				
						4.0/4.0 recovery
		253.0-25.6 ~~offset~~ magnitude unknown				
			Box # 26			lost 1 tank H_2O
						4.9/4.9 recovery

Sheet 11 of 17

Project DESIGN UNIT A410 Date Drilled 1/24-29/81 2/2-10/81 Hole No. 32

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
260		4.5-398.6 <u>BASALT</u>: (continued)	Box 26 (cont)	RUN # 59	C	4.7/4.9 recovery
262						
264			Box 27	RUN # 60		4.8/4.9 recovery
266						
268				RUN # 61		
270		271.0-271.4 offset				4.8/4.8 recovery
272						
274		274.0 offset	Box 28	RUN # 62		4.9/4.9 recovery
276						
278				RUN # 63		5.1/5.1 recovery
280						
282			Box 29	RUN # 64		
284						

Project DESIGN UNIT A 410 Date Drilled 1/24-29/81 2/2-10/81 Hole No. 32

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
284		4.5-398.6 BASALT: (continued)	Box 29 (cont)	RUN # 64	C	4.2/4.2 recovery
		285.6-286.2 offset				
286						
288				RUN # 65		
290			Box 31			4.8/4.8 recovery
292				RUN # 66		2.4/2.4 recovery
294						
296				RUN # 67		4.8/4.8 recovery
298						
300		Physical Condition: little fracturing to massive; hard; moderately strong; fresh	Box 31	RUN # 68		
302						5.0/5.0 recovery
304				RUN # 69		
306						4.8/4.8 recovery
308						

Project DESIGN UNIT A410 Date Drilled 1/24-29/81 2/2-10/81 Hole No. 32

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
308		4.5-398.6 BASALT: (continued)	Box 31 (Cont.)		C	
310			Box 32	RUN # 70		
312						4.9/4.9 recovery
314		314.5-318.8 Brecciated Basalt		RUN # 71		
316						4.4/4.9 recovery
318				RUN # 72		
320			Box 33			
322		322.2-324.6 shear zone				4.8/4.8 recovery
324				RUN # 73		1.3/1.3 recovery
326				RUN # 74		
328						4.9/4.9 recovery
330			Box 34	RUN # 75		
332						

Project DESIGN UNIT A410 Date Drilled 1/24-29/81 2/2-10/81 Hole No. 32

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
332		4.5-398.6 BASALT: (continued)	Box 34 (cont)	RUN #75	C	4.8/4.8 recovery
		333.5 ault; slickenslides				
334						
		335.7 - well developed slicksides		RUN # 76		
336		336.0-340.0 shear zone				
						4.6/4.9 recovery
338						
		339.0 offset				
340			Box 35	RUN # 77		
342						4.9/5.0 recovery
344						
				RUN # 78		
346						
						4.9/4.9 recovery
348						
			Box 36			
350				RUN # 79		
352						4.4/4.8 recovery
				RUN #80		
354						1.8/1.8 recovery
		355'-357' Brecciated Basalt		RUN #81		
356						

Project DESIGN UNIT A410 Date Drilled 1/24-29/81 2/2-10/81 Hole No. 32

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
356		4.5-398.6 BASALT: (continued)	Box 36 (cont)	RUN # 81	C	
358			Box 37			4.6/4.8 recovery
360				RUN # 82		
362		362.0-364.0 Brecciated Basalt				
364						4.9/5.0 recovery
366		366.0-368.0 shear zone; well developed slickensides		RUN # 83		
368			Box 38			4.8/4.9 recovery
370		Physical Condition: moderately fractured: moderately hard; strong; little weathering to fresh		RUN # 84		
372						
374						4.9/4.9 recovery
376		376.0-380.0 Fracture zone; closely to intensely fractured		RUN # 85		
378			Box 39			
380				RUN #86		4.6/4.9 recovery

Project DESIGN UNIT A 410 Date Drilled 1/24-29/81 2/2-10/81 Hole No. 32

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
380		4.5-398.6 BASALT: (continued)	Box 39 (cont)	RUN #86	C	3.5/3.5 recovery
382		383.0-385.0 shear zone; well developed slickensides		RUN #87		2.3/2.3 recovery
384				RUN # 88		
386			Box 40			4.8/4.8 recovery
388		389.0-390.0 fracture zone				
390				RUN # 89		
392						4.7/4.9 recovery
394		395.0-398.6 SHALE: olive black; very hard; low grade metamorphism		RUN # 90		
396		Physical Condition: little fractured; hard to very hard; very strong; fresh	Box 41			
398						4.9/4.9 recovery
		B.H. 398.6 Terminated Hole				water sampled 2-24-81 Set 397' ABS 2" casing 1' bentonite seal at surface - placed water meter cap over hole
400						
402						
404						

THIS BORING 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.

Converse Consultants, Inc.
Earth Sciences Associates
Geo/Resource Consultants

BORING LOG 32-1

Proj: DESIGN UNIT A415 | Date Drilled 1-24/2-24-84 | Ground Elev. 865.5'

Drill Rig Failing 250 | Logged By D. Gillette | Total Depth 442.0'

Hole Diameter NX | Hammer Weight & Fall N/A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
0		BEDROCK 0.0-37.0 WEATHERED BASALT: dusky brown to brownish black with dusky yellowish brown streaks (iron oxide stains) contains clay deposits in fractures and exhibits feldspars weathering to clay			A	
3					RD	
4			PB-1		PB	
6.5					RD	1.5/2.5 recovery
7		Physical Condition: closely to intensely fractured, soft to friable hardness, friable strength, moderate to deeply weathered	Box 1	1	C	4.8/5.0 recovery
12				2		3.0/5.0 recovery
14.5		14.5-17.0 intensely fractured				
17				3		5.0/7.0 recovery
20						

Project DESIGN UNIT A415 Date Drilled 1-24/2-24-84 Hole No. 32-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
20		0.0-37.0 WEATHERED BASALT: continued as previously described	Box 2	3	C	5.0/7.0 recovery
22						
24						
26				4		
28						
30					RD	1-24-84 / 1-25-84
32					C	
34				5		3.6/8.0 recovery
36						
38		37.0-155.0 BASALT: brownish black, greenish black and dark greenish gray, vesicular				
40		40.0-60.0 minor iron oxide stains along fractures and joint (healed)	Box 3	6		4.9/5.0 recovery
42						
44						

Project DESIGN UNIT A415 Date Drilled 1-24/2-24-84 Hole No. 32-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
44		37.0-155.0 BASALT: continued Physical Condition: moderate to little fractured; moderately hard to hard; moderately strong to strong, little weathered to fresh	Box	6	C	
		47.0-48.0 shear zone				
48				7		7.0/8.0 recovery
50		vesicule basalt fragments set in a green ground massl quartz stringers present; fractures show $CaCO_3$ infilling	Box 4			
56				8		8.0/8.0 recovery
60		40.0-60.0 minor iron stains along fractures and joints (healed)	Box 5			
61						61.2 shear zone
62				9		5.0/5.0 recovery
66				10		6.0/6.0 recovery
68						

Sheet 3 of 19

Project DESIGN UNIT A415 Date Drilled 1-24/2-24-84 Hole No. 32-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
68		37.0-155.0 BASALT: continued as previously described	Box 5 Box 6	10	C	6.0/6.0 recovery
70		70.0-71.0 fracture zone				
72						
74				11		5.0/5.0 recovery 1-27-84 1-28-84
		75.0 healed joint, $CaCO_3$				
76						
78		78.0-83.0 shear zone, iron oxide staining contains fault gauge	Box 7			
80				12		7.5/9.0 recovery
82						
84						
86		86.0-88.0 fracture zone		13		very hard drilling
88						
90				14		
92			Box 8			

Project DESIGN UNIT A415 Date Drilled 1-24/2-24-84 Hole No. 32-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
92		37.0- 155.0 BASALT: continued	Box 8	14	C	7.0/7.0 recovery
		93.0-102.0 zone of vertical fractures - 1/8" - $CaCO_3$ healed				1-28-84
94						1-29-84
96				15		4.0/4.0 recovery
98				16		4.0/4.0 recovery
100			Box 9			
102						
		103.0 slickensided surface				
104						
106		106.0-107.0 randomly oriented fractures and joints		17		9.9/10.0 recovery
108			Box 10			
110						
		111.0-112.0 shear zone				
112						
114				18		
116						

Project DESIGN UNIT A415 Date Drilled 1-24/2-24-84 Hole No. 32-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
116		37.0-155.0 BASALT: continued	Box 10		C	
118		118.0-119.0 slickensides	Box 11	19		9.9/10.0 recovery
120		120.0-121.- vertical fractures				
122						1-29-84 / 1-30-84
123		123.0-124.0 shear zone with $CaCO_3$ fault gouge				
126			Box 12	20		10.0/10.0 recovery
136				21		10.0/10.0 recovery
137			Box 13			
138		138.0-140.0 fracture zone, hackly surfaces, healed $CaCO_3$				
140						

Project DESIGN UNIT A415 Date Drilled 1-24/2-24-84 Hole No. 32-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
140		37.0-155.0 BASALT: continued 140.0-141.0 shear zone	Box 13	21	C	
142						
144		145.0-146.0 fracture zone	Box 14			
146				22		10.0/10.0 recovery
148		148.0-149.0 fracture zone, random orientation, $CaCO_3$				
150						
152						
154			Box 15	23		7.0/7.0 recovery
156	40°	155.0-169.0 SHALE: medium gray and dark gray Physical Condition: (155-169) moderately fractured, low hardness, moderate strength, little weathered				
158		Physical Appearance: well indudrated with massive bedding				1-30-84 1-31-84
160						
162						
164						

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Project DESIGN UNIT A415 Date Drilled 1-24/2-24-84 Hole No. 32-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
164		155.0-169.0 SHALE: continued	Box 16	24	C	8.5/10.0 recovery
166						
168						
		169.0-173.4 BASALT: brownish black, greenish black and dark greenish gray, vesicular				
170						
		171.0-179.0 fracture zone, randomly oriented fractures and joints, intensely fractured, well healed		25		9.0/10.0 recovery
172						
		173.4-179.0 SHALE: medium gray and dark gray	Box 17			
174						
		175.0 slickensides				
176						
178						
		179.0-442.0 BASALT: brownish black, greenish black and dark greenish gray, vesicular Physical Condition: closely to moderately fractured, well healed (closed), moderately hard to hard, moderately strong to strong, little weathered to fresh				
180				26		6.9/7.0 recovery
182						
184			Box 18			
						1-31-84
186						2-1-84
		187.0-188.0 fractured zone		27		
188						

Project DESIGN UNIT A415 Date Drilled 1-24/2-24-84 Hole No. 32-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
188		179.0-442.0 BASALT: continued	Box 18		C	
190		190.0-193.0 fracture zone, $CaCO_3$ infilling, hackly surface		27		10.0/10.0 recovery
194			Box 19			
		195.0 slickensides				
200				28		9.5/10.0 recovery
204		203.5-204.5 fracture zone, intensely fractured	Box 20			
208				29		9.0/10.0 recovery
211		211.0-212.0 fracture zone, intensely fractured				

Project DESIGN UNIT A415 Date Drilled 1-24/2-24-84 Hole No. 32-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
212		179.0-442.0 BASALT: continued			C	
			Box 21			
214				29		9.0/10.0 recovery
216		216.0-217.0 fractured zone, slickensides				2-1-84 / 2-7-84
218						
220				30		5.5/8.0 recovery
		221.0-224.0 fractured zone, closely fractured, well healed (closed)				
222						
224			Box 22			
226						
228				31		5.1/8.0 recovery
230						
232						
		233.0-234.0 fracture zone, slickensides				
234				32		
236						

Project DESIGN UNIT A415 Date Drilled 1-24/2-24-84 Hole No. 32-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
236		179.0-442.0 BASALT: continued	Box 22	32	C	5.2/7.0 recovery
238			Box 23			2-7-84
						2-8-84
240						
242						
		243.0-244.0 fracture zone		33		9.0/10.0 recovery
244						
246			Box 24			
248						
250						
		251.5-252.5 fracture zone, slickensides, closely fractured, well healed (closed)				
252				34		9.3/10.0 recovery
254						
256			Box 25			
258						2-8-84
260				35		2-9-84

Project DESIGN UNIT A415 Date Drilled 1-24/2-24-84 Hole No. 32-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
260		179.0-442.0 BASALT: continued	Box 25		C	
263				35		9.0/10.0 recovery
264.5		264.5-265.0 fracture zone	Box 26			
268						268-269 very hard drilling
273.5			Box 27	36		10.0/10.0 recovery
279		279.0 slickensides				
281				37		4.0/4.0 recovery
282		282.0 $CaCO_3$ on fracture surfaces				
283						2-9-84
284			Box 28	38		2-10-84

Project DESIGN UNIT A415 Date Drilled 1-24/2-24-84 Hole No. 32-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
284		179.0-442.0 BASALT: continued	Box 28		C	
		285.5-289.0 shear zone, trace clay, slickensides, intensely fractured				
286				38		8.5/10.0 recovery
288						
290						
292			Box 29			
294				39		10.0/10.0 recovery
296		296.0 hackly surface				
298						
		299.5-300.5 fracture zone, closely fractured, healed				
300		Physical Condition (300'-360'): moderately fractured, well healed (closed)				
302			Box 30			2-10-84
				40		2-11-84
304						
306		306.0-308.0 fracture zone, intensely fractured				
308						

Project DESIGN UNIT A415 Date Drilled 1-24/2-24-84 Hole No. 32-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
308		179.0-442.0 BASALT: continued	Box 30		C	
310				40		9.0/10.0 recovery
		311.0-312.0 fracture zone				
312			Box 31			
314		314.0-315.0 fracture zone				
316				41		10.0/10.0 recovery
318						
320						
322			Box 32			2-11-84 / 2-12-84
324						
326				42		7.8/8.0 recovery
328						
330						
332				43		

Project DESIGN UNIT A415 Date Drilled 1-24/2-24-84 Hole No. 32-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
332		179.0-442.0 BASALT: continued	Box 33		C	
		331.5-333.0 fracture zone				
334						
336				43		10.0/10.0 recovery
338						
340						2-12-84 / 2-13-84
342						
344						
			Box 34	44		10.0/10.0 recovery
346						
348						
350						
352						
354			Box 35	45		
356						

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Project DESIGN UNIT A415 Date Drilled 1-24/2-24-84 Hole No. 32-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
356		179.0-442.0 BASALT: continued	Box 35		C	
358				45		9.9/10.0 recovery
		359.0-371.0 fracture zone Physical Condition (359-370): intensely fractured, well healed (closed)				
360						2-13-84
						2-14-84
362						
364			Box 36			
366				46		9.3/10.0 recovery
368		Physical Condition (370-424): closely fractured, well healed (closed)				
370						
372						
374			Box 37			
		375.0 slickensides		47		7.0/8.0 recovery
376		378.0-378.5 facture zone, closely fractured				
378						2-14-84
				48		2-15-84
380						

Project DESIGN UNIT A415 Date Drilled 1-24/2-24-84 Hole No. 32-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
380		179.0-442.0 BASALT: continued	Box 37		C	
		381.0-382.5 fracture zone, intensely fractured, well healed (closed)				
382				48		9.0/10.0 recovery
384			Box 38			
386		386.0 slickensides or hackly surface				
388						
390						
392			Box 39	49		9.0/10.0 recovery
394						
396						
398						2-15-84
						2-16-84
400				50		
402						
404			Box 40			

Sheet 17 of 19

Project DESIGN UNIT A415 Date Drilled 1-24/2-24-84 Hole No. 32-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
404		179.0-442.0 BASALT: continued 404.5-416.6 fracture zone	Box 40		C	
406				50		9.1/10.0 recovery
408						2-16-84 2-21-84
410						
412			Box 41	51		9.5/10.0 recovery
414		415.0 slickensides				
416						
418		418.0-419.0 fracture zone				
420		420.0-424.0 facture zone				
422			Box 42	52		9.0/10.0 recovery
424		Physical Condition (424'-442'): intensely fractured, well healed (closed)				
426		426.0-429.0 fracture zone				
428						

Project DESIGN UNIT A415 Date Drilled 1-24/2-24-84 Hole No. 32-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
428		179.0-442.0 BASALT: continued	Box 42	52	C	2-21-84 / 2-22-84
430						
432			Box 43	53		7.5/8.0 recovery
434						
436		436.5-437.1 fracture zone				
438				54		4.6/5.0 recovery
450		440.0-442.0 fracture zone				
			44			
440		END OF BORING 442.0'				
442						
444						
446						
448						
452						

THIS BORING 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.

Converse Consultants, Inc.
Earth Sciences Associates
Geo/Resource Consultants

BORING LOG 32-2

Proj: DESIGN UNIT A410 | Date Drilled 2/28-3/30/84 | Ground Elev. 960.9'

Drill Rig Failing 250 | Logged By DRG/LS/JRS | Total Depth 471.0'

Hole Diameter NX | Hammer Weight & Fall N/A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
0	60	0.0-36.0 WEATHERED SANDSTONE: light brown and moderate yellowish brown			A	
2		Physical Condition: intensely to closely fractured; soft to friable hardness; plastic to friable strength; deeply weathered (0-15'); moderately weathered (15-36')			RD	
5					C	
8				1		drilling flow is rusty brown in color no recovery
12				2		No recovery
15					RD	
20						

Sheet 1 of 20

Project DESIGN UNIT A410 Date Drilled 2/28-3/30/84 Hole No. 32-2

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
20		0.0-36.0 <u>WEATHERED SANDSTONE:</u> continued			RD	
22						rusty colored drilling fluid no water loss
~23			Box #1		C	
24						
~25				3		
26						3.7/5.0 recovery
28						
30						2-28-84
~31		31.0-33.0-crushed zone				2-29-84
32						
34				4		
36	40	36.0-405.5 <u>SANDSTONE CONGLOMERATE AND INTERBEDDED SANDSTONE:</u> greenish gray and medium gray; sandstone beds (1-4') consist of medium and coarse sand	Box #2			36.0 drilling fluid becomes gray 9.0/9.5 recovery
38						
~39		39.0-40.0-basalt flow				
40					RD	
42			Box #2	5	C	
44						

Project DESIGN UNIT A410 Date Drilled 2/28-3/30/84 Hole No. 32-2

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
44		36.0-405.5 SANDSTONE CONGLOMERATE AND INTERBEDDED SANDSTONE: continued Physical Condition: moderately to little fractured; moderately hard to hard; moderately strong; moderately weathered	Box #2	5	C	
48						8.0/10.0 recovery
50			Box #3			
53		53.0-54.0-fractured zone		6		
56		56.0-slickensides				
58			Box #4			
60						10.0/10.0 recovery
62						2/29/84 3/1/84
66				7		
67			Box #5			
68						

Project DESIGN UNIT A410 Date Drilled 2/28-3/30/84 Hole No. 32-2

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
68		36.0-405.5 SANDSTONE CONGLOMERATE AND INTERBEDDED SANDSTONE: continued	Box #5		C	
70				7		10.0/10.0 recovery
72						
74						
76				8		
			Box #6			
78						
80						10.0/10.0 recovery
82		82.0-82.5-laminated claystone beds				
84						
86		86.5-88.5-shear zone	Box #7	9		
88						6.5/8.0 recovery
90						
92				10		

Sheet 4 of 20

Project DESIGN UNIT A410 Date Drilled 2/28-3/30/84 Hole No. 32-2

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
92		36.0-405.5 <u>SANDSTONE CONGLOMERATE AND INTERBEDDED SANDSTONE</u>: continued	Box #7		C	
94				10		
96			Box #8			
98						10.0/10.0 recovery
						3-1-84
100						100.0 drilling fluid becomes light gray 3-2-84
102						
104				11		
106			Box #9			
108						10.0/10.0 recovery
110						
112				12		
114						
116			Box #10			

Project DESIGN UNIT A410 Date Drilled 2/28-3/30/84 Hole No. 32-2

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
116		36.0-405.5 SANDSTONE CONGLOMERATE AND INTERBEDDED SANDSTONE: continued	Box #10		C	
118				12		10.0/10.0 recovery
120						
122						
			Box #11			
124				13		
126						
128		128.0-130.0-fractured zone				10.0/10.0 recovery
130						
132			Box #12			
134						
				14		
136						
138						137.5-138.5 lost circulation, mixed revert, regained circulation 10.0-10.0 recovery
140						

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Project DESIGN UNIT A410 Date Drilled 2/28-3/30/84 Hole No. 32-2

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
140		36.0-405.5 <u>SANDSTONE CONGLOMERATE AND INTERBEDDED SANDSTONE</u>: continued 141.0-142.0-basalt	Box #12 Box #13		C	
144				15		
148						10.0/10.0 recovery
150			Box #14			3-3-84 3-4-84
154				16		
158						9.5/10.0 recovery
161			Box #15			
163		increase in conglomerate content, angular fragments		17		
164						

Project DESIGN UNIT A410 Date Drilled 2/28-3/30/84 Hole No. 32-2

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
164		36.0-405.5 <u>SANDSTONE CONGLOMERATE AND INTERBEDDED SANDSTONE</u>: continued	Box #15			
166				17		RQD = 60%
168		becoming finer grained				9.5/10.0 recovery
170		numerous slickensided fractures indicated horizontal movement				3-4-84
						3-5-84
172		170-180' intensely to closely fractured	Box #16			
174				18		RQD = 0 5.0/10.0 recovery
176						
178						
180		becoming weakly cemented sandstone, intensely fractured; low hardness to friable; weak to friable				
182				19		
184						RQD = 0 5.5/9.0 recovery
186						
188		187.0-becoming weakly cemented sandstone as above 179'; no regular fracture pattern				

Project DESIGN UNIT A410 Date Drilled 2/28-3/30/84 Hole No. 32-2

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
188		36.0-405.5 SANDSTONE CONGLOMERATE AND INTERBEDDED SANDSTONE: continued	Box #16	19	C	
		Physical Condition: closely to little fractured; moderately hard to hard; strong; fresh				
190			Box #17			
192		fine grained sandstone, fractures filled or coated with calcite				lost circulation rig chatter mixed revert
194						minor circulation return
		increased fracturing		20		lost circulation mixed revert
196						9.7/10.0 recovery
198						
200			Box #18			
		some slickensides 201.0-6" conglomeritic zone				
202				21		RQD = 52% 9.8/10.0 recovery
204		fracture or joint set dipping 45° to 55°, open fractures				
206						
		207.0-shale lense 1" thick				
208						3/5/84
			Box #19			3/6/84
210						
212				22		

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Project DESIGN UNIT A410 Date Drilled 2/28-3/30/84 Hole No. 32-2

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
212		36.0-405.5 <u>SANDSTONE CONGLOMERATE AND INTERBEDDED SANDSTONE</u>: continued	Box #19		C	
214				22		
		2-8" fracture spacing				
216						10.0/10.0 recovery
		217.0-fine grained sandstone; occasional healed fractures				most breaks horizontal and ground slightly probably mechanical
218						
			Box #20			
220						
		220.5-becomes conglomeritic; ¼"-6" grain size with sand matrix; calcite in healed fractures				
222						
				23		9.8/10.0 recovery
224						
226						
228						all breaks mechanical with ground surfaces
			Box #21			
230						
		231.-becomes fine grained sandstone with occasional coarse sand lenses; hard; strong; fresh				
232				24		
		233.0-becomes conglomeritic; coarse grains ¼"-4"; calcite in healed fractures; hard; strong; fresh				
234						
236						

Project DESIGN UNIT A410 Date Drilled 2/28-3/30/84 Hole No. 32-2

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
236		36.0-405.5 SANDSTONE CONGLOMERATE AND INTERBEDDED SANDSTONE: continued	Box #21	24	C	9.8/10.0 recovery most breaks mechanical
238		238.5-becomes fine to medium grained sandstone; hard; strong; fresh				3/6/84
240			Box #22	25		3/7/84
242						
244		245.0-becomes conglomeratic; hard; strong; fresh				mixed liquid mud circulation loss
246						most fractures mechanical and ground RQD = 85% 9.5/9.5 recovery
248			Box #23	26		
250						
252						
254		254.5-medium grained sandstone; well cemented; occasional gravel sized grains 256.5-becomes conglomeratic			C	9.6/10.0 recovery RQD = 85%
256						
258						
260			Box #24	27		

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Project DESIGN UNIT A410 Date Drilled 2/28-3/30/84 Hole No. 32-2

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
260		36.0-405.5 SANDSTONE CONGLOMERATE AND INTERBEDDED SANDSTONE: continued 260.0-becomes medium sandstone	Box #24			
262				27		
		263.5-becomes conglomeratic				
264						9.5/10.0 recovery
266		266.0-becomes closely fractured				3/7/84 3/8/84
268						
270		270.0-becomes conglomeratic	Box #25			
272				28		
274				29		3.0/3.0 recovery
276						3-8-84 3-15-84
278				30		
		6" sandstone lense				
280		becoming mostly 0.2' fracture spacing or mechanical breaks in weaker zones	Box #26			7.5/8.0 recovery
282						
284						

Project DESIGN UNIT A410 Date Drilled 2/28-3/30/84 Hole No. 32-2

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
284		36.0-405.5 SANDSTONE CONGLOMERATE AND INTERBEDDED SANDSTONE: continued	Box #26	30	C	
286		286.0-290.2-sandstone lense with only occasional conglomeratic zones				
288						7.5/10.0 recovery RQD = 80%
290			Box #27	31		
292						
294						
296		297.0-closely fractured				
298				32		6.0/8.0 recovery RQD = 50%
300		intensely fractured to crushed; moderately to deeply weathered				
302		petroleum odor				3/15/84
						3/16/84
304			Box #28	33		
306						
308						

Project DESIGN UNIT A410 Date Drilled 2/28-3/30/84 Hole No. 32-2

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
308		36.0-405.5 SANDSTONE CONGLOMERATE AND INTERBEDDED SANDSTONE: continued 308.0-½" shale bed	Box #28	33		9.0/10.0 recovery
310						
312		311.5-zone with decreased cementation; increased fractures 313.0-316.0-sandstone				
314			Box #29	34		4.8/4.0 recovery
316						3/16/84 3/17/84
318						
320				35		6.7/10.0 recovery
322		approximately vertical fracture, open with thin calcite coating on surfaces				
324		323.0-328.0-intensely to closely fractured; matrix washed away; decreased cementation				
326						
328						
330		several healed vertical fractures, one open vertical fracture 3' long	Box #30	36		
332						

Project DESIGN UNIT A410 Date Drilled 2/28-3/30/84 Hole No. 32-2

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
332		36.0-405.5 SANDSTONE CONGLOMERATE AND INTERBEDDED SANDSTONE: continued 332.0-some graded bedding observed over conglomerate	Box #30	36	C	8.7/10.0 recovery
334						
336						
338		337.5-347.5-crushed to closely fractured, weakly to uncemented; occasional hard zones in friable to low hard matrix, weak to strong, little weathered		37		
340						most of run washed out
342						
344						
346						3/17/84
348				38		3/18/84 0.0/5.0 recovery
350						
352		55° dipping slickensides on fracture surface 352.0-357.0-sandstone				3/18/84
354		35° dipping slickensides on fracture surface	Box #31	39		3/27/84
356						

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Project DESIGN UNIT A410 Date Drilled 2/28-3/30/84 Hole No. 32-2

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
356		36.0-405.5 SANDSTONE CONGLOMERATE AND INTERBEDDED SANDSTONE: continued	Box #31	39	C	10.0/10.0 recovery RQD = 81%
358		352.5-362.0-moderately fractured to massive; hard; strong 356.5- slickensides on fracture dip 70°				
360						
362		362.0-crushed to closely fractured; friable strength and hardness; irregular surfaced fractures; open, clean				3-27-84 3-28-84
364		fracture set; irregular surface, open, clean 364.0-366.0-sandstone; massive bedding; long vertical fracture, open, clean, smooth surface	Box #32			
366		366.0-372.5-conglomeratic; many horizontal fractures; irregular surfaces; intensely to moderately fractured				8.0/10.0 recovery RQD = 20%
368				40		
370						
372		372.5-374.5-medium to coarse sandstone				
374		374.5-385.0-conglomeratic with weakly cemented matrix, closely fractured; low to moderately hard; weak to moderately strong		41		
376						
378			Box #33			6.5/10.0 recovery RQD = 10%
380						

Project DESIGN UNIT A410 Date Drilled 2/28-3/30/84 Hole No. 32-2

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
380		36.0-405.5 SANDSTONE CONGLOMERATE AND INTERBEDDED SANDSTONE: continued	Box #33	41	C	
		380.0-intensely fractured zone 3"				
382		382.0-45° healed fracture				
384		385.0-392.0-sandstone with occasional coarse sand and gravel lenses; closely to moderately fractured; hard; moderately strong fractures tend to dip 30-40° one set and 70-80° a second set, some are healed, some are open		42		
386						
388						6.0/10.0 recovery RQD = 18%
390						
392		392.0-conglomeratic; with weakly cemented sandstone matrix; crushed to closely fractured; matrix friable to low hardness; weak; no regular fracture pattern apparent	Box #34		C	
394						
396				43		3.0/10.0 recovery
398						
400						
402						
404				44		

Project DESIGN UNIT A410 Date Drilled 2/28-3/30/84 Hole No. 32-2

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
404		36.0-405.5 SANDSTONE CONGLOMERATE AND INTERBEDDED SANDSTONE: continued	Box #34		C	3.0/3.0 recovery RQD = 10%
406		405.5-409.5 BASALT FLOW: light greenish black; fine grained; fractures healed with calcite Physical Condition: closely to moderately fractured; hard; strong; fresh		44		
408						
410		409.5-470.0 INTERBEDDED SANDSTONE AND SANDY CONGLOMERATE: medium gray to light gray; conglomerate: weakly to moderately cemented Physical Condition: closely to moderately fractured; friable to moderately hard; weak to moderately strong; little weathered to fresh				5.0/10.0 recovery RQD = 25%
412			Box #35	45		
414						
416						
418						
420						1.2/10.0 recovery
422				46		
424						
426						3-29-84
						3-30-84
428				47		

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Project DESIGN UNIT A410 Date Drilled 2/28-3/30/84 Hole No. 32-2

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
428		409.5-434.0 INTERBEDDED SANDSTONE AND SANDY CONGLOMERATE: continued	Box #35		C	
430						0.0/6.5 recovery
432				47		
434		434.0-470.0 CONGLOMERATE: lt. greenish gray very hard material; cherty in appearance in cuttings sandstone matrix has low hardness with moderately hard to hard interbeds (5-6"); rock is fresh to little weathered; very hard chert and quartzite clasts; matrix is weak to moderately with strong to very strong interbeds (≤ 6")			RD	
436						
438						
				48	C	
440					RD	
442						
				49	C	
					RD	
444						0.0/0.2 recovery
446				50	C	0.2/0.2 recovery
					RD	
448						
450						
452						

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Project DESIGN UNIT A410 Date Drilled 2/28-3/30/84 Hole No. 32-2

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
452		434.0-470.0 <u>CONGLOMERATE</u>: continued		51	C	0.7/3.0 recovery
454						
456				52		0.0/1.6 recovery
					RD	
458						
				53	C	1.5/3.0 recovery
460						Tunnel invert
462				54		0.3/4.5 recovery
464						
466						
468				55		1.0/5.0 recovery
470		470.0-471.0 <u>BASALT</u>: greenish black; fine grained; hard; strong				452-471' recovered core is mechanically broken and eroded
		End of boring 471.0'				
472						
474						
476						

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THIS BORING 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.

Converse Consultants, Inc.
Earth Sciences Associates
Geo/Resource Consultants

BORING LOG 32-A

Proj: DESIGN UNIT A410 — Date Drilled 3/9-17/81 — Ground Elev. 770'

Drill Rig Mobile B-40 — Logged By Dan Gillette — Total Depth 391.7'

Hole Diameter NX — Hammer Weight & Fall N/A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
0		0.0-0.8 CONCRETE			C	
	Af	0.8-1.2 BASE: sand and gravel				
	CL	1.2-14.0 SANDY CLAY: light brown; slightly moist; medium dense			RD	
14	SC	14.0-17.0 CLAYEY SAND: moderately brown and moderately yellow brown; 40% plastic fines; medium to coarse sand; slightly moist; medium dense 16.0-17.0-sand and gravel				
17		17.0-24.0 WEATHERED SANDSTONE: brownish gray and light brown				

Depth scale: 0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20

Sheet 1 of 17

Project DESIGN UNIT A410 Date Drilled 3/9-17/81 Hole No. 32-A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
20		17.0-24.0 WEATHERED SANDSTONE: continued Physical Condition: closely fractured; soft to friable; friable strength; moderate to deep weathered				
24		24.0-235.0 SANDSTONE: medium to dark gray Physical Condition: massive; soft to friable; friable; little weathered				
30			Box #1		C	
31				1		2.7/2.7 recovery
35				2		4.8/4.8 recovery
39	65°		Box #2	3		4.9/4.9 recovery
43				4		

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Project DESIGN UNIT A410 Date Drilled 3/9-17/81 Hole No. 32-A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
44		24.0-235.0 SANDSTONE: continued			C	
46		46.0-46.2-shear zone gray gauge, slickensides			4	46.0 slight water 4.8/5.1 recovery
	60°					
48			Box #3			
50				5		
						4.8-4.9 recovery
52						
				6		1.8/2.0 recovery
54						
				7		2.2/2.3 recovery
56		Physical Condition: closely fractured; low hardness; weak strength; little weathered				
			Box #4			
58				8		
						4.7/4.7 recovery
60						
62						
64				9		
						4.8/4.8 recovery
66						
			Box #5	10		
68						

Project DESIGN UNIT A410 Date Drilled 3/9-17/81 Hole No. 32-A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
68		24.0-235.0 SANDSTONE: continued	Box #5		C	
70		70.0-77.0-fractured zone		10		5.0/5.0 recovery
73		73.0-shear zone		11		change drill water
75	60°					5.0/5.0 recovery
76		76.0-shear zone , 1/8" offsets	Box #6			
79				12		
81						4.7/5.0 recovery
84				13		
85		Physical Condition: closely fractured; low to moderate hardness; weak to moderate strength; little weathered				4.8/5.0 recovery
86			Box #7			
88				14		
89						89' oil blebs
90						4.9/5.0 recovery
92				15		

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Project DESIGN UNIT A410 Date Drilled 3/9-17/81 Hole No. 32-A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
92		24.0-235.0 <u>SANDSTONE</u>: continued	Box #7		C	
94		94.0-95.0-laminated siltstone <u>Physical Condition</u>: sandstone: moderately fractured; moderately hard; strong to very strong; fresh	Box #8	15		4.9/5.0 recovery
96		conglomerate: moderately to little fractured; moderately hard; strong; little weathering siltstone: closely to moderately fractured; low hardness; weak strength; little weathering				
98				16		
100		101.0-104.0 - fracture zone				4.8/5.0 recovery
102						
103.5		103.5-slickensides on joint				
104			Box #9	17		
106						4.9/5.0 recovery
108				18		
109	55°					4.7/5.0 recovery
110						
111		111.0-113.0-fracture zone				
112						
113			Box #10	19		
114						4.9/5.0 recovery
116		115.8-hackly surface $CaCO_3$ ¼"				

Project DESIGN UNIT A410 Date Drilled 3/9-17/81 Hole No. 32-A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
116		24.0-235.0 SANDSTONE: continued	Box #10		C	
118				20		2.7/3.5 recovery
120				21		1.5/2.5 recovery
122	58°					
124				22		
126			Box #11			4.9/5.1 recovery
128		129.0-133.0-fractured zone offsets 1/4-1/8"		23		
130						3.0/5.1 recovery
132		132.0-134.0 multiple shear planes				
134			Box #12	24		
136						4.9/5.1 recovery
138				25		
140						

Project DESIGN UNIT A410 Date Drilled 3/9-17/81 Hole No. 32-A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
140		24.0-235.0 SANDSTONE: continued	Box #12	25	C	
		141.0-143.0-sandstone conglomerate				
142						4.9/5.0 recovery
144			Box #13	26		
146	40°					5.0/5.0 recovery
148						
150		150.0-155.0 Physical Appearance: light gray and medium gray; fine grained sandstone; moderate to well cemented Physical Condition: massive to moderately fractured; hard; strong; fresh		27		4.9/5.0 recovery
152						
154			Box #14	28		4.8/4.8 recovery
156						
158						
160				29		4.6/4.6 recovery
162				30		1.0/1.0 recovery
164			Box #15	31		

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Project DESIGN UNIT A410 Date Drilled 3/9-17/81 Hole No. 32-A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
164		24.0-235.0 SANDSTONE: continued	Box #15		C	
	60°			31		
166		166.5-slickensides on joint surfaces				4.8/4.8 recovery
168		Physical Condition: massive; moderately hard; very strong; fresh				
170				32		
172						4.8/4.9 recovery
			Box #16			
174				33		
		173.0-179.0-fractured zone offsets in sandstone beds				
176						4.8/4.9 recovery
178						
180				34		
			Box #17			
182						4.7/4.9 recovery
184				35		
186						4.4/4.4 recovery
				36		0.9/0.9 recovery
188				37		

Project DESIGN UNIT A410 Date Drilled 3/9-17/81 Hole No. 32-A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
188		24.0-235.0 SANDSTONE: continued	Box #17	37	C	3.0/3.0 recovery
190	55		Box #18	38		2.0/2.0 recovery
192		193.0-196.0-fractured zone		39		3.2/3.2 recovery
194						
196				40		5.0/5.0 recovery
198			Box #19			
200		Physical Condition: little fractured; moderately hard; strong; little weathered		41		1.8/1.8 recovery
202				42		4.9/5.0 recovery
204						
206			Box #20			
208	55			43		4/8/4.8 recovery
210						
212						

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Project DESIGN UNIT A410 Date Drilled 3/9-17/81 Hole No. 32

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARK
212		24.0-235.0 SANDSTONE: continued	Box #20	43	C	
214				44		
216		216.0-221.0-fractured zone				4.9/4.9 recove y
			Box #21			
218				45		2.1/2.1 recove y
220						
	45°			46		
222						3.0/3.0 recove y
224		Physical Condition: little fractured; low to moderate strength; strong; fresh		47		2.8/2.8 recove y
			Box #22			
226				48		2.2/2.2 recove y
228				49		
230		230.0-233.0-fractured zone				4.9/4.9 recove y
232						
234			Box #23	50		3.3/3.3 recov y
236		235.0-259.5 SANDSTONE CONGLOMERATE WITH INTERBEDDED SANDSTONES:		51		

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Project DESIGN UNIT A410 Date Drilled 3/9-17/81 Hole No. 32-A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
236		235.0-259.0 SANDSTONE CONGLOMERATE WITH INTERBEDDED SANDSTONES:	Box #23		C	
238				51		
		light gray sandstone and sandstone conglomerate				
240						4.8/4.9 recovery
		Physical Condition: massive; moderately hard; strong; little weathered to fresh				
242				52		1.9/1.9 recovery
			Box #24			
244				53		
246						4.9/4.9 recovery
248	40°					
		249.0-258.0-fractured zone				
250				54		
252						4.6/4.9 recovery
			Box #25			
254				55		
256						4.0/4.0 recovery
				56		1.1/1.1 recovery
258						
		259.0-slicks on joints		57		3.9/4.0 recovery
260		259.5-261.0-laminated clay-stone and sandstone				

Project DESIGN UNIT A410 Date Drilled 3/9-17/81 Hole No. 32-A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
260		261.0-292.0 SANDSTONE:	Box #25	57	C	
		261.5-263.0-fractured zone				
262			Box #26	58		1.0/1.0 recovery
264						
				59		
266		266.0-268.0-fractured zone				4.6/4.9 recovery
268		268.0-271.0-shear zone intensely fractured				
				60		
270						1.9/3.1 recovery
				61		
272			Box #27			1.9/2.0 recovery
				62		
274						2.8/2.8 recovery
276				63		
						1.9/2.2 recovery
278						
				64		
280		Physical Condition: closely fractured; low to moderate hardness; weak to moderate strength; little weathered				4.5/4.9 recovery
282			Box #28			
				65		
284						

Project DESIGN UNIT A410 Date Drilled 3/9-17/81 Hole No. 32-A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
284		261.0-292.0 SANDSTONE: continued	Box #28	65	C	
286		gray; fine to medium grained sandstone with conglomerate				1.2/3.6 recovery
288				66		
290						1.7/4.3 recovery
				67		
292		292.0-377.0 SANDSTONE CONGLOMERATE: light gray; moderate to heavy cementation				2.2/2.2 recovery
294				68		
296			Box #29			
298						5.0/5.0 recovery
300		Physical Condition: little fractured; moderately hard; moderately strong; little weathered		69		
302	60					5.0/5.0 recovery
304						
306			Box #30	70		4.9/4.9 recovery
308				71		

Sheet 13 of 17

Project DESIGN UNIT A410 Date Drilled 3/9-17/81 Hole No. 32-A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
308		292.0-377.0 SANDSTONE CONGLOMERATE: continued	Box #30	71	C	
310						4.0/4.1 recovery
312				72		0.8/1.0 recovery
314			Box #31			
316				73		4.8/4.9 recovery
318	30					
320				74		
322						4.8/4.9 recovery
324			Box #32			
326				75		4.2/4.9 recovery
328		Physical Condition: little fractured to massive; moderately hard; moderately strong; little weathering to fresh		76		1.6/1.6 recovery
330				77		2.5/2.5 recovery
332	70			78		

Sheet 14 of 17

Project DESIGN UNIT A410 Date Drilled 3/9-17/81 Hole No. 32-A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
332		292.0-377.0 SANDSTONE CONGLOMERATE: continued	Box #32	78	C	1.0/1.0 recovery
			Box #33			
334						
				79		
336						
						4.9/4.9 recovery
		light gray and dusky green and dark greenish gray				
338						
				80		
340						
342	40					5.0/5.0 recovery
			Box #34			
344						
				81		
346						
						4.5/4.5 recovery
				82		0.6/0.6 recovery
348						
				83		
350						
			Box #35			
352						5.0/5.0 recovery
				84		
354						4.9/4.9 recovery
356						

Project DESIGN UNIT A410 Date Drilled 3/9-17/81 Hole No. 32-A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
356		292.0-377.0 SANDSTONE CONGLOMERATE: continued	Box #35	84	C	
358				85		
360			Box #36			
362						4.9/4.9 recovery
364				86		
366		Physical Condition: little fractured to massive; moderately hard; weak to moderately strong; little weathered to fresh				4.2/4.2 recovery
				87		1.0/1.0 recovery
368			Box #37	88		
370						
372						4.9/4.9 recovery
374				89		
376	55	376.0-horizontal slicks on joints				4.4/4.9 recovery
		377.0-380.0 CLAYSTONE AND SANDSTONE: medium gray and black		90		
378						
380			Box #38			

Project DESIGN UNIT A410 Date Drilled 3/9-17/81 Hole No. 32-A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
380		380.0-391.7 SANDSTONE:	Box #38	90	C	4.9/4.9 recovery
382						
384				91		
386						4.8/4.9 recovery
	66					
388			Box #39			
390				92		4.6/4.6 recovery
392		end of boring 391.7'				includes remarks
394						
396						
398						
400						
402						
404						

THIS BORING 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.

Converse Consultants, Inc.
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BORING LOG 33

Proj: DESIGN UNIT A410 | Date Drilled 1/6-12/81 | Ground Elev. 620'

Drill Rig MOBILE B-40 | Logged By D. Gillette | Total Depth 220'

Hole Diameter 5" | Hammer Weight & Fall 140lbs, 12-15"

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
0		0.0-0.4 CONCRETE			RD	
	CL	0.4-4.8 SANDY CLAY: dark yellow brown; slightly porous; moist; soft				
2						
4						
	SM	4.8-17.0 SILTY SAND: medium brown; 15-20% non-plastic fines; 80-85% f. sand; slightly porous; slightly moist; medium dense				
6						
8						
10			J-1	3	SS	
				5		
				5		
12					RD	
14						
16						
	CL	17.0-38.0 SANDY CLAY: light brown; moist; firm				
18						
20						

Project DESIGN UNIT A410 **Date Drilled** 1/6,7,8,9,10,12/81 **Hole No.** 33

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
20	CL	17.0-38.0 SANDY CLAY (cont.)			PB	
			S-1			2.5/3.0 recovery
22						
			J-2	1 1 2	SS	
24						
					RD	
26						
28						
30				1/2 1/2 1	SS	
32					RD	
34						
36						
	CL					
38		38.0-50.0 TOPANGA FORMATION SANDSTONE: dark yellow orange; slightly moist				
40			S-2		PB	1.0/1.2 recovery
		PHYSICAL CONDITION: 38 to 50'			RD	
42		massive; friable to low strength; deep weathering; friable to low hardness				
44						

Sheet 2 **of** 10

Project DESIGN UNIT A-410 Date Drilled 1/6,7,8,9,10,12/81 Hole No. 33

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
44		38.0-50.0 SANDSTONE: (cont.)			RD	
46		47.0-48.0 CLAYSTONE: DARK GRAY				
48						
50		50.0-55.0 SANDSTONE CONGLOMERATE medium light gray	S-3	3	PB	1.5/1.5 recovery
52		PHYSICAL CONDITION little fractured; low hardness; mod. strong; mod. weathered	BOX 1	4	C	1.7/2.5 recovery
54						
55		55.0-57.0 CLAYSTONE: med. light gray				
56				5		
57		57.0-77.0 SANDSTONE CONGLOMERATE as at 55.0; cemented; clay-stone, siltstone and sand-stone in a sandstone matrix				
58						1.6/5.0 recovery
60			±	6		
62						1.8/3.5 recovery
64				7		
66						0.4/5.0 recovery
68				8		

Project DESIGN UNIT A-410 Date Drilled 1/6,7,8,9,10,12/81 Hole No. 33

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
68		57.0-77.0 <u>SANDSTONE CONGLOMERATE</u>:	BOX 1		C	
				8		
70						
						2.0/5.0 recovery
72						
				9		
						2.3/2.5 recovery
74		<u>PHYSICAL CONDITION</u> closely to mod. fractured; low to friable hardness; friable to weak strength; mod. to little weathered	BOX 2			
76				10		
		77.0-84.0 <u>SANDY CLAYSTONE</u>:				
						2.7/4.0 recovery
78						
						1.4/2.0 recovery
				11		
80						
				12		
82						
						2.3/3.0 recovery
84		84.0-89.0 <u>QUARTZITE</u>: med. light gray; hard				
	50°					
86				13		
88						3.1/5.0 recovery
		89.0-90.0 <u>SANDSTONE</u>: light gray	BOX 3	14		
90		90.0-93.0 <u>QUARTZITE</u>				2.0/2.5 recovery
92				15		

Project DESIGN UNIT A-410 Date Drilled 1/6,7,8,9,10,12/81 Hole No. 33

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
92		TOPANGA FORMATION	BOX 3	15	C	
	75°	92.0-93.0 shear zone, clay filled		16		2.2/2.5 recovery 0.7/0.7 recovery
94		93.0-95.0 SANDSTONE CONGLOMERATE:				
		95.0-98.0 CLAYSTONE: grayish black; massive				
96				17		
		97.0 vertical slickensides				
						4.3/4.3 recovery
98		98.0-100.0 SANDSTONE: light gray; friable; little weathered	BOX 4			
				18		
100		100.0-103.0 CLAYSTONE: grayish black				1.8/2.5 recovery
				19		
102						
		103.0-104.5 SANDSTONE CONGLOMERATE:				0.8/2.5 recovery
				20		1.9/2.5 recovery
104		104.5-106.5 CLAYSTONE				
				21		0.5/1.0 recovery
106		106.5-110.0 SANDSTONE CONGLOMERATE:				
				22		
						1.0/1.5 recovery
108						
				23		
110		110.0-112.0 CLAYSTONE				
						2.0/3.0 recovery
112		112.0-113.5 QUARTZITE: hard; little weathered				
				24		
		113.5-121.0 CLAYSTONE				3.4/4.0 recovery
114			BOX 5			
116				25	C	

Project DESIGN UNIT A-410 Date Drilled 1/6,7,8,9,10,12/81 Hole No. 33

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
116		TOPANGA FORMATION			C	
		113.5-121.0 CLAYSTONE:(cont.) 117.0-118.0 Basalt: brownish black; hard;	BOX 5	25		2.8/3.0 recovery
118		119.0-120.9-Basalt				
120				26		
		121.0-128.5 SANDSTONE CONGLOMERATE:				
122						4.0/5.0 recovery
124		124.5-125.0 BASALT				
				27		2.7/3.0 recovery
126			BOX 6			
				28		
128		128.5-220.8 SANDSTONE: predominately medium gray sandstone laminated with thin grayish black clay-stone and siltstone interbeds				2.8/3.0 recovery
130		PHYSICAL CONDITION moderately fractured; mod hard to hard; weak strength little weathering to fresh		29		
132						2.6/3.0 recovery
	70°					
134				30		
136						4.0/5.0 recovery
			BOX 7			
138						4.0/4.0 recovery
140			C	31		

Project DESIGN UNIT A-410 Date Drilled 1/6,7,8,9,10,12/81 Hole No. 33

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
140	86°	TOPANGA FORMATION: 128.5-220.8 SANDSTONE: (cont.)	BOX 7	31	C	4.0/4.0 recovery
142				32		
144		144.0-148.0 shear zone	BOX 8			3.0/3.0 recovery
146				33		
						3.5/3.5 recovery
148		148.0 clay in shear zone-approx 1/8" wide				
150				34		
		151-151.8 shear zone				
152						4.8/5.0 recovery
154			BOX 9	35		
156						3.3/3.3 recovery
		158.5-shear zone				
158				36		
160						5.0/5.0 recovery
162			BOX 10	37		
164						4.7/5.0 recovery

Project DESIGN UNIT A-410 Date Drilled 1/6,7,8,9,10,12/81 Hole No. 33

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
164		TOPANGA FORMATION 128.5-220.8 SANDSTONE:	BOX 10		C	4.7/5.0 recovery
166						
168		168-168.5 QUARTZITE:		38		
170	50°		BOX 11			5.0/5.0 recovery
172						
		173.5 CLAYSTONE:		39		
174						
						4.6/5.0 recovery
176						
178				40		
		179.0-180.0 1/4" offset	BOX 12			
180						4.9/5.0 recovery
	85					
182						
				41		
184						
						4.9/5.0 recovery
186						5.0/5.0 recovery
188				42		

Sheet 8 of 10

Project DESIGN UNIT A-410 Date Drilled 1/6,7,8,9,10,12/81 Hole No. 33

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
188		128.5-220.8 SANDSTONE:	BOX 12	42	C	
		189.5-190.5 shear zone beds offset 1"				
190			BOX 13			5.0/5.0 recovery
192				43		
194		194.0-195.0 CLAYSTONE:				4.8/5.0 recovery
196			BOX 14	44		
198						
200	55°					4.9/5.0 recovery
202		PHYSICAL CONDITION mod. fract.; hard to mod. hard; weak strength; weathering little to fresh		45		
204						5.0/5.0 recovery
206			BOX 15			
208				46		
210						5.0/5.0 recovery
212				47		

Project DESIGN UNIT A-410 Date Drilled 1/6,7,8,9,10,12/81 Hole No. 33

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
212	55°	128.5-220.8 TOPANGA FORMATION SANDSTONE: (continued)	BOX 15	47	C	
214			BOX 16			5.0/5.0 recovery
216				48		1.8/1.8 recovery
218				49		3.2/3.2 recovery
220						
222	B.H.	Total Depth 220.8 Water at 50.0'				set 2" ABS casing to 160' set 1" PVC casing to 40' install bentonite seal at: 0.0 -2.0' 40.0 -44.0' place pea gravel 2.0 - 40.0' cap hole 1-13-81
224						
226						
228						
230						
232						
234						
236						

Sheet 10 of 10

THIS BORING 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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BORING LOG 33-1

Proj: DESIGN UNIT A-410 Date Drilled 4-19/5-3-84 Ground Elev. 780'

Drill Rig FAILING 1500 Logged By MARK SCHLUTER Total Depth 370.0'

Hole Diameter 4 7/8" Hammer Weight & Fall 325# @18"

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
0	ML	0.0-5.5 CLAYEY SANDY SILT: grayish orange; dry to slightly moist; soft to firm, roots, sandstone and siltstone fragments			A	
5.5	ML	5.5-9.0 SANDY CLAYEY SILT: dark yellowish brown; moist; firm; rootlets; fragments of highly weathered sandstone and siltstone	C-1		DR 325	
7–9					RD	
9.0		9.0-370.0 TOPANGA FORMATION SANDSTONE WITH INTERBEDDED CLAYSTONE AND SANDSTONE light olive gray light brown medium light gray				
11		siltstone: moist/very thinly bedded to intensely laminated; very soft	C-2		DR 325	
12		sandstone: moist; thinly-very thinly bedded claystone; moist; intensely laminated		RUN #1	C	recovery 3.0/3.0 RQD: 90%
14		predominantly siltstone with sandstone with occasional claystone interbeds; highly weathered	BOX #1			
16	48	9.0-25.0 PHYSICAL CONDITION: moderately-closely fractured; friable to soft hardness; friable-plastic strength; deep-moderate weathering		RUN #2		recovery: 5.0/5.0 RQD: 90%
20			BOX#2	RUN #3	C	

Sheet 1 of 16

Project DESIGN UNIT A-410 Date Drilled 4-19-84 Hole No. 33-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
20–22.7		TOPANGA FORMATION -INTERBEDDED SILTSTONE AND SANDSTONE (continued) 20.5-22.0-fractured zone; closely to intensely fractured; plastic; friable; very soft; fractures narrow-wide, filled with clay and $CaCO_3$	BOX #2	RUN #3	C	recovery: 3.5/3.5 RQD: 75%
22.7–26.2				RUN #4		recovery: 4.2/5.0 RQD: 76%
26.2–31.5	48	27.0-32.0 --FRACTURED ZONE-- closely fractured; fractures narrow to wide with gypsum crystallization infilling;micro offsets of bedding lamina		RUN #5		recovery: 4.0/4.0 RQD: 67%
31.5–36.5		32.0-47.5-SILTSTONE-SANDSTONE medium gray-dark gray; moderately to little fractured; friable hardness and strength; little weathering	BOX #3	RUN #6	C	recovery: 4.9/5.0 RQD: 92%
36.5–41.2			BOX #4	RUN #7		recovery; 4.9/5.0 RQD: 80%
41.2–44				RUN #8	C	recovery; 4.9/5.0 RQD: 90%

Sheet 2 of 16

Project DESIGN UNIT A-210 Date Drilled 4-19/4-24-84 Hole No. 33-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
44		TOPANGA FORMATION--INTERBEDDED SILTSTONE AND SANDSTONE (continued)	BOX #4	RUN #8		
46						
		47.5-51.0-moderately-closely fractured; fractures clean and narrow		RUN #9	C	recovery 0.2/1.0 RQD: Ø
48				RUN #10		recovery: 3.5/4.5 RQD: 26%
50						
52			BOX #5			4-19-84 4-24-84
54		54.0-94.0-SILTSTONE/SANDSTONE dark gray-medium gray; intensely laminated to very thinly bedded; little fractured to massive; low to moderately hard, weak to moderately strong; little weathering to fresh		RUN #11	C	recovery: 3.9/4.0 RQD: 20%
56						recovery: 4.5/5.0 RQD: 85%
58				RUN #12		
60	41					
		61.5-63.0-moderately-closely fractured zone	BOX #6		C	
62				RUN #13		recovery 3.3/5.0 RQD: 36%
64		--TRACE PETROLIFEROUS--				slight oil film developing on drilling tub
66				RUN #14		
68						

Project DESIGN UNIT A-410 Date Drilled 3-24/25-84 Hole No. 33-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
68		TOPANGA FORMATION-INTERBEDDED SILTSTONE AND SANDSTONE (continued)		RUN #14		recovery: 4.9/5.0 RQD: 65%
70					C	
72			BOX #7	RUN #15		recovery: 4.1/5.0 RQD: 48%
74	39					
76		77.0-80.0-moderately to closely fractured; minor offsets				
78				RUN #16	C	recovery:5.0/4.1 RQD: 55%
80						
82			BOX #8	RUN #17		recovery: 4.9/5.0 RQD: 95%
84						
86						recovery: 4.5/4.5 RQD: 55%
88		trace petroliferous-continued trace tar-bubbles along silt-stone lamina	BOX #9	RUN #18	C	4-24-84
90				RUN #19		4-25-84
92						

Sheet 4 of 16

Project DESIGN UNIT A-410 Date Drilled 4-25-84 Hole No. 33-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
92		TOPANGA FORMATION-INTERBEDDED SILTSTONE AND SANDSTONE (continued)	BOX #9	RUN #19	C	recovery: 4.9/5.0 RQD: 65%
94		trace petroliferous 94.0-100.5 PREDOMINANTLY SANDSTONE WITH INTERBEDDED SILTSTONE light gray to dark gray				
96 98		SANDSTONE: very thinly to medium bedding; little fractured; moderately hard to hard; moderately strong SILTSTONE: very intensely to intensely laminated; little fractured; low hardness; weak; fresh	BOX #10	RUN #20		recovery: 4.5/5.0 RQD: 60%
100 102 104		100.5-105 SILTSTONE WITH INTERBEDDED SANDSTONE very intensely to intensely laminated; moderately to closely fractured; low hardness; weak; fresh		RUN #21	C	recovery: 3.8/4.5 RQD: 42%
106 108		105-155 INTERBEDDED SILTSTONE AND SANDSTONE light gray to dark gray; very intensely laminated to thinly bedded; little to moderately fractured; low hardness to hard; weak to moderately strong; fresh		RUN #22		recovery: 4.8/5.0 RQD: 70%
110 112 114	44		BOX #11	RUN #23	C	recovery: 4.6/5.0 RQD: 84%
116			BOX #12	RUN #24		

Project DESIGN UNIT A-410 Date Drilled 4-25-84 Hole No. 33-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
116		TOPANGA FORMATION-INTERBEDDED SILTSTONE AND SANDSTONE (continued)	BOX #12	RUN #24		recovery: 4.8/5.0 RQD: 70%
118					C	
120						
122				RUN #25		recovery: 4.9/5.0 RQD: 76%
	38	123.0-124.5 closely fractured; fractures clean and narrow; minor offsets				
124		trace petroliferous-continued-oil accumulation on drilling fluid tub, trace inclusions in siltstone				
126			BOX #13	RUN #26		recovery: 4.2/5.0 RQD: 70%
128					C	
130				RUN #27		
132						recovery: 4.8/5.0 RQD: 84%
134		little to moderately fractured; low hardness to hard; weak to moderately strong; fresh				
136			BOX #14	RUN #28		recovery : 4.8/5.0 RQD: 68%
138					C	
140				RUN#29		

Project DESIGN UNIT A-410 Date Drilled 4-25/26-84 Hole No. 33-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
140		TOPANGA FORMATION-INTERBEDDED SILTSTONE AND SANDSTONE (continued)	BOX #14	RUN #29	C	recovery: 0.2/2.0 RQD: Ø
142				RUN #30		recovery: 1.8/3.5 RQD: 28%
144						4-25-84 4-26-84
146		--CONTINUED--		RUN #31		recovery: 4.5/3.8 RQD: 70%
148			BOX #15			
150				RUN #32		recovery: 2.7/3.7 RQD: 56%
152		-trace petroliferous- trace petroleum along fracture and bedding plane surfaces			C	
154	37			RUN #33		recovery: 4.9/4.3 RQD: 56%
156		155.5-162.6-SANDSTONE medium gray-medium light gray medium to thickly bedded; little to moderately fractured; moderately hard; moderately strong to strong; fresh	BOX #16			
158				RUN #34		recovery: 4.6/5.0 RQD: 82%
160					C	
162		162.6'-164.4' -fractured zone- crushed to intensely fractured; friable to plastic		RUN #35		
164						

Sheet 7 of 16

Project DESIGN UNIT A-410 Date Drilled 4-26/27-84 Hole No. 33-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
164		<u>TOPANGA FORMATION-INTERBEDDED SILTSTONE AND SANDSTONE</u> (continued) 162.4-164.4/165.5-167' -fractured zone- crushed to intensely fractured; friable to plastic; 1/2" off-sets; clay infilling of frac-tures; bedding indistinct		RUN #35		recovery: 4.6/4.7 RQD: 32%
166						
168		166.5-<u>SANDSTONE</u> with occasional siltstone interbedded	BOX #17	RUN #36	C	recovery: 4.5/4.7 RQD: 70%
170						
172		little fracturing to massive; moderately hard; moderately strong to strong; fresh				
174				RUN #37		recovery: 4.2/4.8 RQD: 68%
176			BOX #18		C	
178				RUN #38		recovery: 4.7/4.5 RQD: 86%
180						
182						
184			BOX #19	RUN #39		recovery: 4.4/4.5 RQD: 57% 4-26-84 4-27-84
186	42			RUN #40	C	
188						

Sheet 8 of 16

Project DESIGN UNIT A-410 Date Drilled 4-27-84 Hole No. 33-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
188		TOPANGA FORMATION-INTERBEDDED SILTSTONE AND SANDSTONE (continued)				
190		189'-191.5 -Fractured zone-	BOX #19	RUN #40		recovery: 7.2/7.5 RQD: 56%
		intensely to closely fractured; portions crushed; friable; 0.3" offsets; fractures narrow and clean to wide with clay infillings			C	
192						
194	42					
			BOX #20	RUN #41		
196						recovery: 9.9/10 RQD: 81%
198						
200		199.2-200.7 -Fractured zone- closely to intensely fractured; fractures clean and narrow; some wide with clay infilling			C	
202						
204		SANDSTONE medium light gray-light gray; medium-thickly bedded; little fractured to massive; moderately hard; moderately strong to strong; fresh				
206		206.5-209.0 -Fractured zone- closely to intensely fractured; 0.5" offsets; fractures narrow to clay filled	BOX #21	RUN #42		recovery: 9.7/10 RQD: 75%
208						
210			BOX #22			
212						

Sheet 9 of 16

Project DESIGN UNIT A-410 Date Drilled 4-27/28-84 Hole No. 33-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
212		TOPANGA FORMATION-SANDSTONE WITH INTERBEDDED SILTSTONE (continued)			C	
214				RUN #43		
215–218		medium light gray; medium to thickly bedded sandstone; intensely laminated siltstone; little fractured to massive; moderately hard to hard; moderately strong to strong; fresh	BOX #22			recovery: 9.2/10 RQD: 95%
222						4-27-84 4-28-84
223			BOX #23	RUN #44		
224–225						recovery: 4.3/3.5 RQD: 74%
225–227		225-226.0 -Fractured zone- closely to intensely fractured; clay infilling; plastic to friable; sulfurous odor				
230				RUN #45		recovery: 10'/10' RQD: 95%
232			BOX #24			
233					C	
236						

Project DESIGN UNIT A-410 Date Drilled 4-28 Hole No. 33-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
236		TOPANGA FORMATION-SANDSTONE WITH INTER-BEDDED SILTSTONE (continued)	BOX #24		C	
238				RUN #46		
240		239.5-242.5 -FAULTED ZONE- closely to intensely fractured; offsets up to 10"; slicken-slides (apparent rake of 55°-65°); fractures wide to narrow with clay infilling in fractures; sheared fractures with clay coatings	BOX #25			recovery: 8.2/10.0 RQD: 50%
242						
	45					
244						
246		246.5-251.5 -Fractured zone- closely fractured; fractures narrow to wide; little to no clay infilling; offsets to 1-2"				
248						recovery: 9.8/10 RQD: 65%
250				RUN #47		
252			BOX #26			
254		254.0-257.0 -Fractured zone- crushed to closely fractured; offsets of siltstone lamina; wide fractures with clay in-filling				4-28-84
256						4-29-84
258		Trace petroliferous		RUN #48	C	recovery: 4.9/6.0 RQD: 38% oil film developing on drilling fluid tub
260			BOX #27			

Project DESIGN UNIT A-410 Date Drilled 4-29-84 Hole No. 33-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
260		TOPANGA FORMATION -continued SANDSTONE 257.0-268.0' SANDSTONE CONGLOMERATE greenish gray; sandstone with small gravel; medium to thickly bedded; little to moderately fractured; fractures narrow to wide; moderately hard-hard and strong; fresh to little weathering	BOX #27	RUN #48	C	
262				RUN #49		
264						
266						recovery: 9.8'/10.0' RQD: 79%
268		268.0'-276.0' SANDSTONE WITH INTERBEDDED SILTSTONE light gray to medium light gray; medium bedding to intensely laminated; little fractured to moderately fractured; moderately hard to hard; moderately strong to strong, fresh			C	
270						
272	47					
274		TRACE PETROLIFEROUS	BOX #28			oil film on drilling fluid tub and trace inclusions in rock core
276		276.0'-285.5' predominantly sandstone; thickly bedded; massive to little fractured; moderately hard to hard; moderately strong; fresh		RUN #50	C	recovery: 9.7'/10.0' RQD: 96%
278						
280			BOX #29			
282						
284				RUN #51		

Project DESIGN UNIT A-410 Date Drilled 4-29/30-84 Hole No. 33-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
284		TOPANGA FORMATION-continued				
286		285.5-292.8 SANDSTONE CONGLOMERATE medium light to light gray; medium to thickly bedded; little fractured to massive; hard to moderately hard; strong; fresh	BOX #29	RUN #51	C	recovery: 10'/10' RQD: 97%
288						
290						
292	55	292.8-340.0 SANDSTONE WITH INTERBEDDED SILTSTONE light gray to medium dark gray sandstone: medium to thinly bedded siltstone: intensely to very intensely laminated little to moderately fractured; hard to moderately hard; moderately strong to strong; fresh; minor offsets on fractures	BOX #30			4-29-84 4-30-84
294						
296				RUN #52	C	recovery:9.7'/10.0' RQD: 84%
298						
300						
302		301.5-303.0 -Fractured zone- moderately fractured; fractures narrow to wide with calcite infilling	BOX #31			
304				RUN #53	C	
306		306.0-307.5 -Fractured zone- closely fractured; fractures narrow and clean				recovery: 9.9/9.6 RQD: 85%
308			BOX #32			

Project DESIGN UNIT A-410 Date Drilled 4-30/5-1-84 Hole No. 33-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
308		TOPANGA FORMATION SANDSTONE WITH INTERBEDDED SILTSTONE				
				RUN #53		
310		-continued-				
			BOX #32		C	
312						
	52	light gray to medium gray; greenish gray; predominantly sandstone; massive to little fractured; hard to moderately hard; strong; fresh				
314				RUN #54		recovery: 9.4'/10.0' RQD: 91%
316		TRACE PETROLIFEROUS continued				(oil film devel- oping on drilling fluid tub)
318					C	
320			BOX #33			
						4-30-84 5-1-84
322						
324		-CONTINUED-				
326				RUN #55	C	recovery: 9.4/10.0 RQD: 92%
328			BOX #34			
330						
332				RUN#56		

Project DESIGN UNIT A-410 Date Drilled 5-1/2-84 Hole No. 33-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
332		TOPANGA FORMATION SANDSTONE WITH INTERBEDDED SILTSTONE	BOX #34			
334				RUN #56	C	
336		-CONTINUED-				recovery: 9.0/9.0 RQD: 94%
338						
340		340.0-345.0 INTERBEDDED SANDSTONE AND SILTSTONE light gray-medium dark gray; thinly bedded to intensely laminated; moderately fractured; moderately hard to hard, moderately strong to strong; fresh; trace petroliferous	BOX #35			
342	51			RUN #57	C	recovery: 1.7/2.0 RQD: 65% 5-1-84 5-2-84
344						
346		345.0 -Fractured zone- closely to moderately fractured; fractures narrow to wide; low hardness; friable; moderately strong - friable; fresh		RUN #58		recovery:7.3/8.0 RQD: 62%
348						
350			BOX #36			
352		351.0-352.0 intensely fractured zone; fractures narrow-wide, wide fractures with clay infilling		RUN #59	C	recovery: 4.4'/5.0' RQD: 16%
354		354.0-354.5 intensely fractured to crushed zone; fractures wide to narrow with clay infilling				
356				RUN #60		

Project DESIGN UNIT A-410 Date Drilled 5-2/3-84 Hole No. 33-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
356		TOPANGA FORMATION				
357–359	40	357'-359 -Fractured zone- intensely fractured to crushed zone; fractures wide to narrow with clay infilling; crushed zones	BOX #37	RUN #60	C	recovery: 6.5/6.5 RQD: 46%
362						5-2-84 5-3-84
364–365		364.0-365.0 -Fractured zone- intensely fractured; fractures wide with clay; friable; off-sets to 1"	BOX #38	RUN #61	C	recovery: 5.6/7.5 RQD: 18%
370		B. H. 370.0 Terminated Hole			C	Installed 1" PVC piezometer to 360'; 0-20'; non perforated 20-40' perforated 40-360' 20' perforated with 40' non perforated pea-gravel backfill

Depth scale: 356, 358, 360, 362, 364, 366, 368, 370, 372, 374, 376, 378, 380

Sheet 16 of 16

THIS BORING 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.

Converse Consultants, Inc.
Earth Sciences Associates
Geo/Resource Consultants

BORING LOG 33-2

Proj: DESIGN UNIT A410 Date Drilled 4/16-27/84 Ground Elev. 604'

Drill Rig FAILING 1500 Logged By L. Schoeberlein Total Depth 204.5'

Hole Diameter 4 7/8" Hammer Weight & Fall 140 lb. @ 30"

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
0	AC	0.0-0.3 ASHPALT				
	CL	0.3-2.0 SILTY CLAY: dusky yellow to light olive grey; mottled; stiff; moist;			GB	
2	SM	2.0-21.0 SILTY SAND: greenish grey; dry to moist; some clayey lenses			AD	
4						
6						
8					RD	
10						
12						
14						
16						
						slight chatter
18						
20						

Sheet 1 of 9

Project DESIGN UNIT A410 Date Drilled 4-16-84 Hole No. 33-2

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
20	SM	2.0-21.0 SILTY SAND: (continued) 21.0-204.5 TOPANGA FORMATION INTERBEDDED SANDSTONE AND SILTSTONE: medium grey to medium dark grey; fine sandstone, interbedded siltstone			RD	
22						
24						
26						
28		Physical Condition: moderately to little fractured; friable hardness and strength; little weathered				
30	70°		SPT1	50-55	SS	
32						
34						
36			Box 1	RUN # 1	C	
38						80% RQD 5.5/5.5 recovery
40				Run # 2		oil in drill fluid
42						60% RQD 5.0/5.0 recovery
44						

Project DESIGN UNIT A410 Date Drilled 2/16-17/84 Hole No. 33-2

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
44		21.0-204.5 INTERBEDDED SANDSTONE & SILTSTONE: (continued)	Box1	Run # 2	C	4-16-84
			Box 2	RUN # 3		4-17-84
46						
48						92% RQD 4.0/4.0 recovery
50				RUN # 4		
52						80% RQD 5.0/5.0 recovery
54		53.5-54.2 sandstone lense, weakly cemented; increased fracturing		RUN # 5		
			Box 3			
56						78% RQD 4.8/5.0 recovery
58	60°					
60				RUN # 6		
62						72% RQD 4.5/5.0 recovery
64				RUN # 7		
		becoming thinly interbedded	Box 4			
66						45% RQD 3.5/5.0 recovery
68						

Sheet 3 of 9

Project DESIGN UNIT A410 Date Drilled 4/17-18/84 Hole No. 33-2

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
68		21.0-204.5 <u>INTERBEDDED SANDSTONE & SILT STONE</u>: (continued)	Box 4	RUN # 7	C	
				RUN # 8		
70						4-17-84
						4-18-84
		1' well cemented; hard sandstone		RUN # 9		
72						
		73' becomes interbedded with siltstone				
74						
76						
78						10% RQD 3.2/10.0 recovery
80						
				RUN # 10		
82						
		intensely to closely fractured				36% RQD 4.2/5.0 recovery
84						
86			Box 5	RUN # 11		
88	/65°					rig chatter
						3.5/6.0 recovery
90		interbedded siltstone; intensely fractured zone				
92				RUN 12		

Project DESIGN UNIT A410 Date Drilled 4/18-19/84 Hole No. 33-2

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
92		21.0-204.5 INTERBEDDED SANDSTONE & SILTSTONE: (continued)	Box 5	RUN # 12	C	
94	65°	intensely fractured				22% RQD 4.5/5.8 recovery
96						
98				RUN # 13		Ø RQD 2.9/4.2 recovery
100						
102		becomes moderately to little fractured	Box 6	RUN # 14		
104		bedding irregular				50% RQD 3.8/5.0 recovery
106						4-18-84
				RUN # 15		4-19-84
108						60% RQD 5.0/5.0 recovery
110						
		closely fractured zone				
112			Box 7	RUN # 16		
114		rock weak breaking easily in numerous directions				5% RQD 5.0/6.9 recovery
116		fracturing along bedding				

Project DESIGN UNIT A-410 Date Drilled 4/19-20/84 Hole No. 33-2

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
116		INTERBEDDED SANDSTONE & SILTSTONE (cont.)	BOX 7	RUN # 16	C	
118						
		continued steeply dipping siltstone and sandstone		RUN # 17		
120						
122	75°					
		122.5'-8" closely fractured zone				
124						
			BOX 8			64% RQD 8.1/8.1 recovery
126		126.5-6" closely fractured zone				
				RUN # 18		
128						50% RQD 7.0/7.0 recovery
130						
132						
				RUN # 19		2.0/2.0 recovery
134		134-136.5 Physical Condition: closely to moderately fractured; hard to very hard; strong to very strong; fresh	BOX 9			4/19/84
				RUN #20		4/20/84 0.6/0.6 recovery
136		136.5-gradual decreased cementation and increased interbeds of siltstone		RUN # 21		
138		138.5-139.5 sandstone lense				
140						

Project DESIGN UNIT A-410 Date Drilled 4/20-4/24/84 Hole No. 33-2

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
140		INTERBEDDED SANDSTONE & SILTSTONE (cont.)	BOX 9	RUN # 21	C	
142		fracturing along bedding often re-healed w/ clay				95% RQD 7.6/9.4 recovery
144		144.5-147-95% sandstone; hard; strong; well cemented	BOX 10	RUN # 22		4/20/84 4/24/84
146		moderately hard to hard; moderately strong				
148	65°					5.5/6.0 recovery
150				RUN # 23		
152						
154						70% RQD 7.5/8.5 recovery
156			BOX 11			
158		siltstone increase to 60%				
160				RUN # 24		
162						85% RQD 7.5/8.0 recovery
164						

Sheet 7 of 9

Project DESIGN UNIT A-410 Date Drilled 4/24-26/84 Hole No. 33-2

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
164		INTERBEDDED SANDSTONE & SILTSTONE (cont.)	BOX 11	RUN # 24	C	
166			BOX 12			4/24/84
						4/25/84
168	65°			RUN # 25		2.5/2.5 recovery
170		170-173 mostly sandstone; uncemented; friable strength and hardness		RUN # 26		
172						
		173-176.5 sandstone lense; fine grained; well cemented; very hard and very strong				
174						88% RQD 7.8/9.5 recovery
176			BOX 13			
178						
180						
		occasional thicker sand lenses to 1"				
182				RUN # 27		7.0/7.0 recovery
184						
		185- hard, well cemented sandstone lens 1' thick				
186						4/25/84
				RUN # 28		4/26/84
188			BOX 14			

Project DESIGN UNIT A-410 Date Drilled 4/26/84 Hole No. 33-2

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
188		INTERBEDDED SANDSTONE & SILTSTONE (cont.)	BOX 14		C	
190		becomes less fractured; mostly 6-10" sand lenses w/ 1/16"-1/2" silt lenses intermittent		RUN # 28		100% RQD 10.0/10.0 recovery
192						
194						
196						oil on tub increasing
198	75°	fracturing along bedding planes primarily; some horizontalfrac-turing w/ irregular surfaces some arcuate	Box 15	RUN # 29		95% RQD 8.5/8.5 recovery
200						
202						
204						
206		B.H. 204.5 Terminated hole 4/27/84; flushed hole: installed piezometer to bottom, backfilled w/ pea gravel				
208						
210						
212						

THIS BORING 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.

Converse Consultants, Inc.
Earth Sciences Associates
Geo/Resource Consultants

BORING LOG CEG 34

Proj: DESIGN UNIT A425 | Date Drilled 12/2-8/80 | Ground Elev. 574'

Drill Rig Failing 1500 | Logged By S. Testa | Total Depth 200.5'

Hole Diameter 4 7/8" | Hammer Weight & Fall DR: 240 lb @ 18", SS· 140 lb @ 30"

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
0		0.0-0.5 CONCRETE			RD	12/2/80 clear day hole drilled with water
1	ML	ALLUVIUM 0.5-34.0 SANDY SILT: dark yellowish brown; fine sand; moist				
10		yellow brown; stiff; moist				
11			J-1		SS	1.0/1.5 recovery
12					RD	
15						pocket penetrometer 2.0 tsf 2/9/81
16		becomes very stiff; moist; trace gravel	J-2		SS	1.2/1.5 recovery
17					RD	
20						

Sheet 1 of 9

Project DESIGN UNIT A425 Date Drilled 12/2-8/80 Hole No. CEG 34

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
20	ML	0.5-34.0 SANDY SILT: (continued)	C-1		DR	1.5/1.5 recovery
22			J-3		SS	1.5/1.5 recovery
24					RD	12/4/80 moderate to heavy rain hole drilled with bentonite drilling fluid
26		color change to dusky brown; trace fine gravel; stiff; fine roots	J-4		SS	1.5/1.5 recovery
28					RD	
30		color change to dark yellow brown; gravel to 1.5"; fine roots	C-2		DR	1.5/1.5 recovery
32		stiff	J-5		SS	1.5/1.5 recovery
34					RD	
	SM	34.0-38.5 SILTY SAND: dark yellowish brown; fine grained; dense				
36			J-6		SS	1.3/1.5 recovery
					RD	
38	SM	38.5-44.0 GRAVELLY SAND: pale yellow brown; medium to coarse sand; dense to very dense				minor rod chatter, from 38.5 to 40.0'
40			J-7		SS	1.0/1.5 recovery
42					RD	
44						rod chatter at 44.0'

Sheet 2 of 9

Project DESIGN UNIT A425 Date Drilled 12/2-8/80 Hole No. CEG 34

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
44	GP	44.0-50.5 <u>GRAVEL</u>: subangular to subrounded to 1.5"; poorly graded			RD	
			J-8		SS	.25/1.0 recovery refusal at 11.5"
46					RD	
48						considerable rod chatter from 48.0-50.0'; hard drilling resistance at 49.0'
50			C-3		DR	0.3/1.0 recovery refusal at 12"
		TOPANGA FORMATION - BEDROCK 50.5-200.5 <u>INTERBEDDED SHALE AND SANDSTONE</u>: medium to very thin laminae of primarily olive gray sandy clay and subordinate dark greenish gray; fine to medium sand with lesser very thin laminae of siltstone; trace organics; thin sand lenses				
52			J-9		SS	1.5/1.5 recovery
54						
		55.0' color change-olive black				
56		Physical Conditions: little fractured; low hardness; friable to weak strength; fresh	J-10		SS	1.5/1.5 recovery pocket penetrometer >4.5 tsf 2/9/81
					RD	
58						
60		color change to dark greenish gray				
	10-15°		J-11		SS	pocket penetrometer 4.0 tsf (broke apart) 2/9/81
62					RD	
64						
		color change to olive gray; trace organics; becoming sandier with depth	J-12		SS	pocket penetrometer >4.5 tsf 2/9/81 refusal at 15"
66					RD	
68						

Project DESIGN UNIT A425 Date Drilled 12/2-8/80 Hole No. CEG 34

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
68		50.5-200.5' INTERBEDDED SHALE AND SAND-STONE: (continued)			RD	
70	0-15°		PB-1	1	PB	pocket penetrometer >4.5 tsf 2/9/81 2.3/2.5 recovery rod chatter from 72.0 to 75.0'
72		olive gray; fine to medium sand; trace fines			RD	
74		color change to dusky brown; sandy claystone with very thin to thin laminae of dark greenish gray sand	J-13		SS	1.3/1.3 recovery
76					RD	
78						
80		color change to dusky yellowish brown	J-14		SS	0.7/1.0 recovery
82	60°					
84						rod chatter from 84.0 to 85.0'
			J-15		SS	0.9/1.0 recovery
86	15-20°	non-parallel medium to very thin laminae; dark greenish gray fine sand from 85.0-85.3; dusky brown sandy claystone from 85.3 to 85.8; dark greenish gray sand from 85.8 to 85.9'; hard			RD	
88						
90			PB-2	2	PB	2.1/2.5 recovery pocket penetrometer >4.5 tsf 2/9/81
92						

Project DESIGN UNIT A425 Date Drilled 12/2-8/80 Hole No. CEG 34

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
92		50.5-200.5 <u>INTERBEDDED SHALE AND SANDSTONE:</u> (continued)	PB-2	2	PB	
					RD	
94		Physical Conditions: (continued) little fractured; friable to low hardness; friable to weak strength; fresh				0.4/0.4 recovery
			J-16		SS	pocket penetrometer >4.5 tsf 2/9/81
96		color change to olive black; 95.2' very thin sandy claystone lens			RD	12-5-80
98						
100						
		101.0-101.4 well cemented sandstone	PB-3	3	PB	pocket penetrometer >4.5 tsf 2/9/81 1.4/2.5 recovery
102						
104					RD	
		non-parallel medium to very thin laminae of olive black sandy claystone and greenish gray friable fine to medium sandstone	J-17A J-17B		SS	pocket penetrometer >4.5 tsf 2/9/81 1.3/1.4 recovery ~~refusal at~~ 16.5"
106					RD	
108						
110	45°		PB-4	4	PB	pocket penetrometer >4.5 tsf 2/9/81 2.5/2.5 recovery
112						
	80°	dusky yellowish brown sandy claystone	PB-5	5	PB	2.0/2.5 recovery
114						
	45°		PB-6	6	PB	2.5/2.5 recovery
116						

Project DESIGN UNIT A425 Date Drilled 12/2-8/80 Hole No. CEG 34

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
116		50.5-200.5 INTERBEDDED SHALE AND SANDSTONE: (continued)	PB-6	6	PB	pocket penetrometer >4.5 tsf 2/9/81 2.5/2.5 recovery
118		117.5-118.4 thin to very thin alternating shale and sandstone laminae; from 119.0 olive black shale	PB-7	7	PB	1.8/2.5 recovery
120		121.4-122.4 moderate to well cemented sandstone	PB-8	8	PB	2.5/2.5 recovery
122-124		Physical Conditions: (continued) little fractured primarily along bedding planes; low hardness; friable to weak strength; fresh	PB-9	9	PB	2.2/2.5 recovery
126	10-15°		PB-10	10	PB	1.5/1.5 recovery
					RD	variable resistance from 126-126.5'; refusal at 126.5'
128		medium to very thin laminae of alternating shale and subordinate sandstone	PB-11	11	PB	2.0/2.5 recovery pocket penetrometer >4.5 tsf 2/9/81
130-132			PB-12	12	PB	2.5/2.5 recovery
		well cemented sandstone from 131.0-132.0, 133.2 to 133.5	PB-13	13	PB	12-6-80 0.5/0.5 recovery
134	10-15°				RD	133.0-133.5' rod chatter
136			PB-14	14	PB	2.5/2.5 recovery
		shale from 137.0 to 137.5'	PB-15	15	PB	0.2/0.2 recovery
138-140			PB-16	16	PB	2.1/2.1 recovery

Project DESIGN UNIT A425 Date Drilled 12/2-8/80 Hole No. CEG 34

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
140		50.5-200.5 INTERBEDDED SHALE AND SANDSTONE: (continued) alternating medium to very thin laminae of shale and subordinate sandstone	PB-17	17	PB	2.5/2.5 recovery
142		shale from 143.0 to 145.0'	PB-18	18	PB	2.5/2.5 recovery minor rod chatter from 143.5 to 145.0'
144						
146			PB-19	19	PB	pocket penetrometer >4.5 tsf 2/9/81 1.5/1.5 recovery
			PB-20	20	PB	0.1/0.1 recovery
					RD	
		friable sandstone from 147.7 to 148.1'				moderate rod chatter; resumed pitcher sampling at 147.5-150.0'
148	10-15°		PB-21	21	PB	2.5/2.5 recovery
150		sandstone from 150.5 to 150.8'; 152.0 to 152.5'	PB-22	22	PB	0.8/0.8 recovery
					RD	moderate rod chatter 150.8 to 151.8'
152			PB-23	23	PB	pocket penetrometer >4.5 tsf 2/9/81 2.5/2.5 recovery
154		154.5' well cemented sandstone			RD	
156		Physical Condition: (continued) little fractured; low hardness; friable to weak strength; fresh	PB-24	24	PB	2.5/2.5 recovery
158		shale from 158.2 to 158.8', 159.2 to 160.6'	PB-25	25	PB	moderate rod chatter 2.5/2.5 recovery
160	50°		PB-26	26	PB	2.5/2.5 recovery
162						2.0/2.5 recovery
164			PB-27	27	PB	

Project DESIGN UNIT A425 Date Drilled 12/2-8/80 Hole No. CEG 34

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
164		50.5-200.5 INTERBEDDED SHALE AND SANDSTONE: (continued) alternating medium to very thin laminae of shale and subordinate sandstone with lesser very thin siltstone laminae.	PB-27	27	PB	
166		sandstone from 167.0 to 168.0', 169.5 to 170.0'	PB-28	28	PB	2.5/2.5 recovery moderate rod chatter from 167.0-168.0' pocket penetrometer >4.5 tsf 2/9/81
168	10-20°	Physical Condition: little fractured along bedding planes; friable to low hardness; friable to weak strength; fresh	PB-29	29	PB	2.5/2.5 recovery
170						considerable rod chatter
					RD	
172			PB-30	30	PB	0.2/0.2 recovery
					RD	
174		174.0-174.4' medium to coarse sandstone	PB-31	31	PB	12-7-80 0.8/1.0 recovery moderate rod chatter
			PB-32	32	PB	0.9/1.0 recovery
176		shale from 175.6 to 177.0'	PB-33	33	PB	1.5/1.5 recovery
						considerable rod chatter
					RD	
178	10-20°		PB-34	34	PB	2.5/2.5 recovery
180		180.6 to 181.2' well cemented sandstone	PB-35	35	PB	0.6/0.6 recovery
					RD	
182		well cemented sandstone 181.5 to 182.4', 183.0 to 183.2'	PB-36	36	PB	0.4/0.4 recovery
					RD	
184	46°, 40°	184.0 to 200.0' alternating shale, sandstone and subordinate siltstone; siltstone - moderate brown, sandstone - olive gray very thin to thick parallel laminae, shale - dusky yellowish brown to olive black very thin to medium parallel laminae	PB-37	37	PB	
186	80°, 80°		Box #1	1	C	
188						

Project DESIGN UNIT A425 Date Drilled 12/2-8/80 Hole No. CEG 34

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	RUN NO.	DRILL MODE	REMARKS
188	15-20°	150.5-200.5 INTERBEDDED SHALE AND SANDSTONE: (continued) very thin shale laminae from 188.0 to 188.7'	Box #2	1	C	4.8/5.0 recovery
190	45°	Physical Condition: little fractured; friable to low hardness; friable to weak strength; fresh		2		4.2/4.2 recovery
192	15-20°	189.0-190.8' dusky brown very thin shale laminae				
194		194.6 to 197.6 dark greenish gray; fine to coarse sandstone	Box #3	3		5.0/5.0 recovery
196	55°					
198	75°	very thin shale laminae from 198.0 to 198.5' ; very thin fine sandstone from 198.5 to 199.7'		4		12-8-80 1.5/1.5 recovery
200		B.H. 200.5' Terminated hole				Installed 100.0' of 4" PVC and grouted; pushed 3.0' of 6" ID PVC ½ below sidewalk surface, steel water cover was then set flush with concrete surface.
202						
204						
206						
208						
210						
212						

THIS BORING 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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BORING LOG 34-1

Proj: DESIGN UNIT A 425 | Date Drilled 11/5-6/83 | Ground Elev. 580'

Drill Rig FAILING 1500 | Logged By L. Schoeberlein | Total Depth 114.5'

Hole Diameter 4 7/8" | Hammer Weight & Fall 140 lb. @ 30"

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
0	AC	0.0-0.3 ASPHALT			RD	start drilling 4:15
	RD	0.3-0.5 BASEROCK				
	ML	ALLUVIUM				
		0.5-4.0 CLAYEY SILT:dusky brown; low to moderately plastic fines; trace fine sand; firm; moist				
2						
4	CL	4.0-37.6 SANDY CLAY: moderate brown, moderate plastic fines, trace fine sand; very stiff; moist increased sand content at 5'	J-1	5 11 14	SS	Recovery 1.2/1.5
6					RD	set up tub and cased to ~ 5' mixed mud
			C-1	9 13	DR	Recovery 1.0/1.0
8					RD	
		hard	J-2	10 18 25	SS	Recovery 1.0/1.5 5:30 11-5-83
10					RD	7:00 11-6-83
12						
		some medium to coarse sand	PB-1		PB	Recovery 1.8/2.5 pocket pen: 3.25 tsf
14	(SC)	14.5' clayey sand				
			J-3	7 11 15	SS	Recovery 1.4/1.5
16					RD	
		increased content of fine sand	C-2	6 9	DR	Recovery 1.0/1.0
18					RD	
		stiff		5 6	SS	Recovery 0.0/1.5
20						

Sheet 1 of 5

Project DESIGN UNIT A 425 Date Drilled 11/5-6/83 Hole No. 34-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS /6"	DRILL MODE	REMARKS
20	CL	4.0-37.6 SANDY CLAY: (continued)		9	SS	
					RD	
22		sand content decreases with depth				
			PB-2		PB	Recovery 2.4/2.5
24						
			J-6	2 5 5	SS	Recovery 1.5/1.5
26					RD	
				5	DR	Recovery 1.0/1.0
28			C-3	7		
					RD	
				0 2 8	SS	1st 10"-weight of hammer Recovery 0.0/1.5
30		becomes soft to firm				
					RD	
32						
			PB-3		PB	Recovery 2.5/2.5
34	(SM)	34.0-34.3 silty sand lens				
			J-6	6 9 18	SS	Recovery 1.0/1.5
		35.0-silty clay lens; very stiff				
36					RD	
				7	DR	Recovery 1.0/1.0
38	SC	37.6-43.0 CLAYEY SAND: dark yellowish brown; fine to coarse sand; occasional gravel; medium; dense; moist to wet	C-4	17		
					RD	
			J-7	6 5 8	SS	Recovery 0.3/1.5
40						
					RD	
42	(SM)	silty sand lens				
			PB-4		PB	
44	ML	43.0-54.0 CLAYEY SILT: dusky yellowish brown (see next page)				

Sheet 2 of 5

Project DESIGN UNIT A 425 Date Drilled 11/5-6/83 Hole No. 34-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
44	ML	43.0-54.0 CLAYEY SILT: (continued) low plastic fines; trace fine sand medium dense; moist			PB	
			J-8	2 6 10	SS	Recovery 1.5/1.5
46					RD	
48		becomes loose				
50				0 1 8	SS	weight of hammer for 11" Recovery 0.0/1.5 sample pulled out
					RD	
52	(ML) (SM)	52.0-53.0 sandy silt/silty sand lens increased clay content with depth	C-5	11 17	DR	Recovery 1.0/1.0
					RD	
54	CL	54.0-57.5 SANDY CLAY: olive grey; moderate plastic; fines; fine sand; very stiff; moist	J-9	2 5 16	SS	Recovery 0.6/1.5
56	(SC)	grades to clayey sand with depth contains some gravel			RD	
58	SP/ SM	57.5-68.0 SAND/SILTY SAND: salt and pepper; fine sand; occasional gravelly sand lenses; very dense; wet some bedding apparent	J-10	18 34 38	SS	Recovery 1.0/1.5
60					RD	
62			PB-5		PB	Recovery 0.9/1.8
	(CL)	63.8- sandy clay/silty sand in tip of sample				
64	(SC)	63.8-65.3-clayey sand; sand; gravel	J-11	45 31 18	SS	Recovery 0.5/1.5
66		6" cobble			RD	
68						

Sheet 3 of 5

Project DESIGN UNIT A 425 Date Drilled 11/5-6-/83 Hole No. 34-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
68		TOPANGA FORMATION 68.0-114.5 INTERBEDDED CLAYSTONE & SANDSTONE: brownish black; fe stained mottled; contains sand lenses of varying thickness; occasional cemented zones; steeply dipping ~ 70°			RD	
			J-12	35 33 33	SS	Recovery 0.7/1.5
70					RD	
72		physical condition: little fractured; friable to low hardness; friable to weak strength; little weathered	C-6	55 90-5	DR "	Recovery 0.7/0.9
					RD	
74						
76						
78		thinly bedded 1/8"- 1/4"				
			J-13	54	SS	Recovery 0.5/0.5
80					RD	
82		becomes massive	PB-6		PB	Recovery 1.1/2.5
84					RD	
86						
88		interbedded; weakly to moderately cemented	C-7	78 80-2.5"	DR	Recovery 0.6/0.7
					RD	
90						
92						

Project DESIGN UNIT A425 Date Drilled 11/5-6/83 Hole No. 34-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
92		68.0-114.5 INTERBEDDED CLAYSTONE & SAND-STONE: (continued)	PB-7		PB	Recovery 1.8/2.5
94					RD	
96						
98			C-8	66 100-4.5"		Recovery 0.8/0.9
					RD	occasional chatter
100						
102						
104			B-1		PB	tube smashed; cut thin sample ~ 1½" d x 7" long
		interbedded: slicken sides on some fracture surfaces in massive claystone			RD	
106						occasional chatter
108						
110						
112			PB-8		PB	Recovery 2.1/2.5
114						
	BH	114.5 Terminated Hole				complete drilling 3:30 tremied grout to surface
116						

Sheet 5 of 5

THIS BORING 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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BORING LOG 34A

Proj: DESIGN UNIT A425 Date Drilled 2/8-9/83 Ground Elev. 586'

Drill Rig Mayhew 1000 Logged By G. Halbert Total Depth 120'

Hole Diameter 4 7/8" Hammer Weight & Fall SS: 140 lb @ 30", DR: 340 lb @ 24"

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
0	AC	0.0-0.4 A.C. PAVEMENT			RD	
	GW	FILL 0.4-2.5 SANDY GRAVEL: angular; very dense				4 7/8" rotary wash tri-cone
2						
		2.5-4.0 CONCRETE				
4	CL	4.0-8.0 SANDY CLAY: olive gray; very stiff to hard; moist to wet				
6						
		color change				
8	SC	ALLUVIUM 8.0-17.0 CLAYEY SAND: moderate to dark yellowish brown; moderately plastic fines; medium dense; moist				
10	(CL)	10.0-11.0' sandy clay	C-1	3 4	DR	1.0/1.0 recovery
			J-1	4 7 10	SS	1.25/1.5 recovery pocket penetrometer 3.0-4.0 tsf
12					RD	
14						
16						
	SP	17.0-30.0 SAND: moderate yellow brown; fine to medium sand; medium dense; wet; basalt rock fragments				
18						
20						

Project DESIGN UNIT A425 Date Drilled 2/8-9/83 Hole No. 34A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
20	SP	17.0-30.0 SAND: (continued)	J-2	5 / 5 / 6	SS	1.25/1.5 recovery
		occasional gravel to ½"; gravel is angular basalt, shale, sandstone fragments				
22					RD	
24						
	(GP GM)	gravel layer				
26						
		fines increase with depth				
28	(GM)	gravel layer				
		transitional change				
30	SM SC	30.0-50.0 SILTY SAND/CLAYEY SAND: moderate yellowish brown; with clay binder; medium dense; wet	C-2	4 / 4	DR	1.0/1.0 recovery
			J-3	4 / 5 / 10	SS	1.1/1.5 recovery
32					RD	1" basalt fragment in top of sample barrel (cuttings)
34						
36		grading finer				
38						
40		color change to dark yellowish brown; fine sand; slightly plastic	J-4	5 / 5 / 8	SS	1.5/1.5 recovery
42					RD	heavy chatter
44		basalt fragments - cobble size				

Project DESIGN UNIT A425 Date Drilled 2/8-9/83 Hole No. 34A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
44	SM/SC	30.0-50.0 SILTY SAND/CLAYEY SAND: (cont)			RD	
46						
		basalt fragments				heavy chatter 6"
48						
50		WEATHERED BEDROCK 50.0-56.0 SILTY SANDSTONE: mottled light and moderate yellow brown; cemented, dark stained joints; moist; uneven horizontal parting	C-3	18 25	DR	0.7/1.0 recovery
			J-5	20 40/2"	SS	0.7/0.7 recovery 1" piece of basalt in sample
52					RD	
54						pieces of basalt in cuttings; frequent moderate rig chatter, harder drilling
		color change				
56		TOPANGA FORMATION 56.0-120.3 SANDSTONE: medium dark gray; massive; moist; well cemented; slightly calcareous; trace fine; fine to medium sand;				
58		Physical Condition: friable; weak strength; poorly to moderately indurated				rig chatter, slower, harder drilling, hard dark gray, well cemented sandstone fragments in cuttings
60			C-4	80/3"	DR	no recovery too hard for SPT relatively hard, slow drilling
62						
64						continued rig chatter, hard drilling
		65.0-66.0 sandy siltstone; light brown				easier drilling 1'
66						
68						

Project DESIGN UNIT A425 Date Drilled 2/8-9/83 Hole No. 34A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
68		56.0-120.3 SANDSTONE: (continued) color change to medium gray; massive; well-graded sand; dominately sub angular quartz; well cemented; slightly calcareous.			RD	continued moderate chatter
	<5°					too hard for SPT
70		Physical Condition: friable; poorly to moderately indurated; weak strength; low to moderate hardness; near horizontal bedding; occasional clayey silt laminae	PB-1		PB	0.9/2.5 recovery sample disturbed by rotation cutting of sample barrel (spinning at silty layers), bottom of tube ripped,
72					RD	relatively hard drilling; nearly continuous moderate right chatter, occasionally heavy
74		75.0-76.0 siltstone layer, olive gray				no chatter for 1'
76						
78						occasional light brown silty cuttings
80						difficult to sample
			C-5	80/4"	DR	0.3/0.3 recovery
			J-6	100/2"	SS	no recovery
		81.5-82.5 silty zone			RD	no chatter for about 1'
82						continuous moderate chatter, heavy at times
84		sand dominantly quartz with minor gray granite and micaceous grains				2-8-83
86		86.0-87.6 clayey siltstone layer, olive gray, plastic, softer				2-9-83 no chatter for 1.5'
88		color change to medium dark gray, fine to medium grained poorly graded sand with trace fines				
90			PB-2		PB	1.25/2.0 recovery too hard for SPT
92						

Project DESIGN UNIT A425 Date Drilled 2/8-9/83 Hole No. 34A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
92		56.0-120.3 SANDSTONE: (continued)			RD	moderate chatter, heavy at times, fairly difficult drilling, occasional brown silty sand cuttings (weathered fractures)
94		94.0-96.0 clayey siltstone layer with sand, dark gray, plastic				occasional light chatter, slightly easier drilling for 2'
96		color change to medium gray; well graded sand; subangular quartz (trace biolite grains); trace fines				
98						
100			C-6	100/3"	DR	0.25/0.25 recovery
					RD	
102		102.0-102.4 very hard zone				heavy chatter; brown silty sand cuttings mixed with gray sandstone.
104						light to moderate rig chatter, fairly consistent
106		becomes silty sandstone, color changes to moderate brown; some sand sized angular volcanic fragments (red brown and black); sand mostly quartz				
108		color changes back to medium gray; sand is sub-rounded quartz, calcareous				
110	65°	moderately hard to hard; moderately strong to strong; contact dip angle 65° from fabric change	PB-3		PB	heavy chatter, slow advance with Pitcher Barrel, refusal after 17" advance
112		111.6-113.0 hard white rock (intrusion), light gray; hard; moderately strong			RD	1.4/1.4 recovery good hand specimen at bottom of barrel, saved sample of cuttings, 112'.
114		color change to medium dark gray, poorly graded fine quartz sand				heavy rig chatter, 3/4" fragments in cuttings. moderate chatter
116						

Project DESIGN UNIT A425 Date Drilled 2/8-9/83 Hole No. 34A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
116		56.0-120.3 SANDSTONE: (continued) fine to medium quartz sand; weak to moderately strong; friable to low hardness; slightly petroliferous			RD	115' - oil in mud light to moderate rig chatter
118						oil in mud
120			C-7	80/3"	DR	too hard for SPT 0.0/0.25 recovery
		B.H. 120.3' Terminated hole				no sample retained in rings
122						complete drilling 2/9
124						
126						
128						
130						
132						
134						
136						
138						
140						

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BORING LOG 34C

Proj: DESIGN UNIT A 425 | Date Drilled 1-25-83 | Ground Elev. 552'

Drill Rig ______ | Logged By D. Gillette | Total Depth 76.0'

Hole Diameter 36" | Hammer Weight & Fall N/A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
0	FILL	ARTIFICIAL FILL 0.0-10.5 SILTY SAND/SANDY SILT: contains pieces and chunks of asphalt and concrete; dusky brown; loose to medium dense; moist to wet (as observed on walls)			AD	Observation hole no samples required.
2–10						Difficult for auger drilling due to large chunks of concrete (curb and sidewalks asphalt) Note: bore hole subject to caving and raveling from 0-10.5'
10.5	SP/SM	ALLUVIUM 10.5-23.0 SAND/SILTY SAND: consists of sand with silty sand and clayey sand streaks; medium to dark grey; moist to very moist; loose to medium dense; readily caves and ravels; contains cobbles (well rounded to 5½") contain micaceous sand				Easier auger drilling
16		minor content of roots				
20						

Sheet 1 of 2

Project DESIGN UNIT A 425 Date Drilled 1-25-83 Hole No. 34C

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
20	SP/ SM	1.05-23.0 SAND/SILTY SAND: (continued) contains coarse sand layers organic odor			AD	H_2O at 21.0'; flows in from all sides at approximately 20-25 gpm. Note: Bore hole subject to excessive caving at & below water table
22	(CL)	23.0-24.5 sandy clay layer				
24						Drilled to 26.0';hole caved back to 21.0' before placing casing
26	BH	26.0 Terminated				finished drilling at 10am; 1-25-83. Placed 30" CMP casing backfilled hole with native material
28						
30						
32						
34						
36						
38						
40						
42						
44						

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Field Water Pressure Test
Boring No. 29-1

Job No. 83-1140-56 Date FRIDAY APRIL 13, 1984

Job METRO RAIL PROJECT Location CAHUENGA BLVD., 25' N OF HOLLYWOOD FWY ONRAMP

Water Table Elevation ______ Elev. of Pressure Gauge ______

Driller PITCHER DRILLING CO. Tested by MARK SCHLUTER Depth of Hole 120.0'

Type of Packer MECHANICALLY COMPRESSED NX PACKER

Remarks GROUND ELEVATION: 449'

FLOW TEST

Section Tested		Pressure (psi)	Water Meter Readings			Duration of Test (min.)	Flow (gpm)	REMARKS
Depth Top	Depth Bottom		Start	End	Total Gals. Water Used			
52	120	22±1	11:05:30 4312.5	11:15:30 4313.2	0.7	10	0.07	PACKER IN CASING SWIVEL HEIGHT: +12.5'
52	120	35±3	11:18:00 4314.2	11:28:00 4319.9	5.7	10	0.57	" "
52	120	48±5	11:31:00 4326.5	11:41:00	PACKER LEAKAGE, MOVED & RESEATED			
63	120				PACKER LEAKAGE			
69	120				PACKER LEAKAGE –			PACKER PEELED OFF REPLACED
74	120				PACKER LEAKAGE			
79	120				PACKER LEAKAGE – PACKER RUBBER DAMAGED REPLACED			
92	120	52±3	2:46:00 4604.4	2:56:00 4604.4	0	10	NO TAKE	SWIVEL HEIGHT: 12.3
92	120	80±10	3:18:30 4605.2	3:28:30 4605.6	0.4	10	NO TAKE	" " "
	± INDICATES PRESSURE FLUCUATION							

HOLDING TEST

Section Tested		Gauge Pressure at Test Intervals, (psi)					REMARKS
Depth Top	Depth Bottom	Start	15 secs.	30 secs.	45 secs.	60 secs.	
92	120	60	59	58	58	58	53.5@5 min./50@10 min./47@15 min
92	120	80	75	73	71	70	62.5@5 min./57.5@10 min./54@15 min

SHEET 1 OF 1

ConverseWardDavisDixon
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Field Water Pressure Test
Boring No. 29-2

Job No. 83-1140-56 Date WEDNESDAY APRIL 18, 1984

Job METRO RAIL PROJECT Location CAHUENGA BLVD., 26' N/HOLLYWOOD FWY

Water Table Elevation ______ Elev. of Pressure Gauge 475'

Driller PITCHER DRILLING CO. Tested by MARK SCHLUTER Depth of Hole 135.0'

Type of Packer MECHANICALLY COMPRESSED NX PACKER

Remarks GROUND ELEVATION: 470', DRILL STEMS WICKED, CASING TO 59.2' BELOW SURFACE

FLOW TEST

Section Tested		Pressure (psi)	Water Meter Readings			Duration of Test (min.)	Flow (gpm)	REMARKS
Depth Top	Depth Bottom		Start	End	Total Gals. Water Used			
56	135'	28	7:51:00 4796.5	8:01:00 4797.0	0.5	10	0.05	PACKER IN CASING, SWIVEL HEIGHT 13.7
* WITH PACKER SEATED, BORING TOOK APPROX. 30 GALLONS @ 20 P.S.I. TO STABILIZE @ 28 P.S.I TEST. NO LEAKAGE OBSERVED OUT INNER OR OUTER CASINGS								
56	135'	40±2	8:13:00 4798.5	8:23:00 4799.6	1.1	10	0.11	" " "
56	135'	54±3	8:25:00 4800.6	8:35:00 4806.5	5.9	10	0.59	" " "

SIGNIFICANT CAVING OCCURRED AT COMPLETION OF FIRST SERIES OF TESTS. ATTEMPTED TO REDRILL HOLE CLEAN OF CAVED MATERIAL SEVERAL TIMES WITH NO SUCCESS, HOLE WOULD RECAVE AS SOON AS DRILL RODS WERE REMOVED. CAVING OCCURRED BTW 60'-100' BELOW SURFACE, CAVED AREAS WERE AT VARIABLE DEPTHS, AT TIMES SPOTTY. THE WORST CAVING AREAS BTW 60'-75' BELOW SURFACE, MIXED REVERT INTO DRILLING FLUID TO ATTEMPT HOLE CLEAN OUT FOR PIEZOMETER INSTALLATION.

HOLDING TEST

Section Tested		Gauge Pressure at Test Intervals, (psi)					REMARKS
Depth Top	Depth Bottom	Start	15 secs.	30 secs.	45 secs.	60 secs.	
56	135	51.5	49.0	47.5	46.5	46.0	40.5 @ 5 min./36 @ 10 min./33 @ 15 min.
56	135	41	38	37	36.5	36	32 @ 5 min./30 @ 10 min./28 @ 15 min.
	HOLE CAVED	BELOW	60' AS	DRILL	RODS		WERE REMOVED

SHEET ____ OF ____

ConverseWardDavisDixon
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Field Water Pressure Test
Boring No. 29-3

Job No. 83-1140-56 Date THURSDAY 3-15-84

Job METRO RAIL PROJECT Location FAIRFIELD AVENUE, ADJACENT TO S/W SIDE OF HOLLYWOOD FWY

Water Table Elevation ______ Elev. of Pressure Gauge ______

Driller PITCHER DRILLING CO. Tested by MARK SCHLUTER Depth of Hole 126.0'

Type of Packer MECHANICAL NX PACKER

Remarks GROUND ELEV. : 502', SWIVEL HEIGHT 11.0' ABOVE GROUND @ 50' TEST, 13' @ 86' (REFER TO PRESSURE TEST SETUP FIGURE)

FLOW TEST

Section Tested		Pressure (psi)	Water Meter Readings			Duration of Test (min.)	Flow (gpm)	REMARKS
Depth Top	Depth Bottom		Start	End	Total Gals. Water Used			
50'	126	20	10:02:30 3990	10:12:30 3990	0	10	0	SWIVEL HEIGHT : 11' "NO TAKE"
50'	126'	32±1	10:18:20 3991	10:28:20 4001.1	10.1	10	1	SWIVEL HEIGHT 11' EQUIVILANT INTAKE EACH MINUTE
50	126'	50±1	10:35:10 4018	10:45:10 4031.1	13.1	10	1.31	SWIVEL HEIGHT 11' EQUIVILANT INTAKE EACH MINUTE
		±: INDICATES AVERAGE READING,						
		PRESSURE FLUCUATIONS						
86'	126	44±3	13:08:00 4128.5	13:18:00 4128.75	.25-.08 (.17)	10	(0) 0.017	SWIVEL HEIGHT +13' DOUBLE PACKER SEAL @ 86'
							NO TAKE	SLIGHT LEAKAGE - 1.3 CUPS 0.08 gal.
86'	126'	67±3	13:28:00 4129.91	13:38:00 4129.99	.08-0.8 (0)	10	(0)	SWIVEL HEIGHT 13' 1.3 cups SLIGHT LEAKAGE .08 gal
							NO TAKE	
86'	126'	85±3	13:42:00 4131.0	13:52:00 4137.0	6.0-0.18 5.82	10	0.58	SWIVEL HEIGHT 13' SLIGHT LEAKAGE 3 CUPS

HOLDING TEST

Section Tested		Gauge Pressure at Test Intervals, (psi)					REMARKS
Depth Top	Depth Bottom	Start	15 secs.	30 secs.	45 secs.	60 secs.	
50'	126'	50±	49	47	46	45	38 @ 5 MIN., 33.8 @ 10 MIN., 31 @ 15 MIN.
50'	126'	40±	39.5	39	38.5	38	32 @ 5 MIN., 29 @ 10 MIN., 27.5 @ 15 MIN.
50'	126'	22	22	22	22	22	22 @ 5 MIN., 21 @ 10 MIN., 20 @ 15 MIN.

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Field Water Pressure Test

Boring No. 32-1

Job No. 83-1140-56 Date Feb 23 1984

Job [illegible] Location Southern Vent Structure

Water Table Elevation 808.5 (?) Elev. of Pressure Gauge 865

Driller [illegible] Tested by [illegible] Depth of Hole 442

Type of Packer Mechanical

Remarks Hole 32-1 "very Tight — no Take"; [illegible] Hole [illegible] [illegible] [illegible] water [illegible] went into Formation however the pressure [illegible] increase

FLOW TEST

Section Tested		Pressure (psi)	Water Meter Readings			Duration of Test (min.)	Flow (gpm)	REMARKS
Depth Top	Depth Bottom		Start	End	Total Gals. Water Used			
270	442	55	98.2	99.1	0.9	10.0	<0.1	Took [illegible]
								0.9 gal H_2O
								in 10 min;
								[illegible] increase
								[illegible] gallons
								pump into hole
								Hole very Tight
								no Take — [illegible]
								[illegible]
								[illegible]
								[illegible]
270	442	55	98.8	98.7	-0.1	15 min	0	"no Take"
270	442	80	98.7	98.7	0.0	15	0	"no Take"

HOLDING TEST

Section Tested		Gauge Pressure at Test Intervals, (psi)						REMARKS
Depth Top	Depth Bottom	Start	15 secs.	30 secs.	45 secs.	60 secs.	15 min	
270	442	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
270	442	[illegible]	50	47	45	40	25	
270	442	80	78	67	59	52	21	

SHEET 1 OF 1

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Field Water Pressure Test

Boring No. 32-2

Job No. ?? 1140-56 | Date 4-5-84

Job ?? | Location BORING 32-2

Water Table Elevation 373' | Elev. of Pressure Gauge 765'

Driller ?? | Tested by JRS | Depth of Hole 471.0

Type of Packer MECHANICAL

Remarks

FLOW TEST

Section Tested		Pressure (psi)	Water Meter Readings			Duration of Test (min.)	Flow (gpm)	REMARKS
Depth Top	Depth Bottom		Start	End	Total Gals. Water Used			
100	471	20	51	57	6	5 min	1.2 gpm	
		40	00	55	55	4 min	13.75 gpm	max. pressure
260	471	60	61	75	14	5 min	2.8 gpm	
400	471	80	77	83	6	5 min	1.2 gpm	probably rod leakage

HOLDING TEST

Section Tested		Gauge Pressure at Test Intervals, (psi)					REMARKS
Depth Top	Depth Bottom	Start	15 secs.	30 secs.	45 secs.	60 secs.	
400	471	80	50	44	40	37	PRESSURE DROP DUE TO ROD LEAKAGE

SHEET ____ OF ____

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Field Water Pressure Test

Boring No. 33-1

Job No. 83-1140-56 Date May 8/9, 1984

Job Metro Rail Project Location 3641 Multview Drive

Water Table Elevation ______ Elev. of Pressure Gauge ______

Driller Pitcher Drilling Co. Tested by Mark Schluter Depth of Hole 370.0'

Type of Packer Mechanical NY Packer

Remarks Revert additive used to drill out boring, hole repeatedly caved. Repeated difficulties installing packer(s). Added ½ gallon of bleach to break down revert. Flushed hole prior to testing.

FLOW TEST

Section Tested		Pressure (psi)	Water Meter Readings			Duration of Test (min.)	Flow (gpm)	REMARKS
Depth Top	Depth Bottom		Start	End	Total Gals. Water Used			
210	361.5	25	09:58:00 4905.0	10:08:00 4905.2	0.2	10	0.02	"NO TAKE"*
210	361.5	57± 3	10:17:00 4907.1	10:27:00 4910.1	3	10	0.3	
210	361.5	100±10	10:50:00 4917.2	11:00:00 4943.0	25.8	10	2.58	

HOLDING TEST

Section Tested		Gauge Pressure at Test Intervals, (psi)					REMARKS
Depth Top	Depth Bottom	Start	15 secs.	30 secs.	45 secs.	60 secs.	
210	361.5	24	24	23	22	21.5	18.5 @ 5 min.
210	361.5	57	53	50	48.5	46	36 @ 5 min. / 31 @ 10 min. / 27 @ 15 min.
210	361.5	100	96	93	89.5	87.5	69 @ 5 min. / 58 @ 10 min. / 50.5 @ 15 min.

SHEET ____ OF ____

Appendix B

Geophysical Exploration

APPENDIX B GEOPHYSICAL EXPLORATION

B.1 DOWNHOLE SURVEY

B.1.1 Summary

Downhole shear wave velocity surveys were performed in Borings CEG-31 and CEG-34 for Design Unit A410. Measurements were made at 5-foot intervals from the ground surface to depths of 195 feet. A description of the technique and a summary of the results are attached.

B.1.2 Field Procedure

Shearing energy was generated by using a sledge hammer source on the ends of a 4-by-6-inch timber positioned under the tires of a station wagon, tangential to the borehole. A 12-channel signal enhancement seismograph (Geometrics Model ES1210) allowed the summing of several blows in one direction when necessary to increase the signal-to-noise ratio. Shear waves were identified by recording wave arrivals with opposite first motions on adjacent channels of the seismograph.

B.1.3 Data Analysis

For the purpose of illustration, typical wave arrival records from a downhole geophysical survey are reproduced in Figure B-1. The timing line shows a 20 millisecond (MS) break at the end of the record, indicating that each vertical line is 10 MS. The time of the first arrivals of compressional shear energy is indicated by P and S, respectively. Wave arrival records similar to Figure B-1 were analyzed to estimate wave travel times and velocities for CEG-31 and CEG-34.

B.1.4 Discussion of Results

Downhole velocities are summarized in Table B-1.

The error analysis performed for these surveys involved a least squares fit of these data by estimating the mean of the slope ($\bar{V}$) in Table B-1 and the standard deviation of this estimate of the slope. This estimate of the standard deviation was combined with an estimate of the overall accuracy to produce the best estimated velocity (V^*). V_p^* are the values to be used for studies of the response of these sites. N is the number of data points used for the straight line fit for each velocity estimate.

For CEG-31, the near-surface shear wave velocity was found to be approximately 1300 feet per second. To depths of about 115 feet, shear wave velocity estimates generally increased to 5000 feet per second.

CEG-34 had a near-surface shear wave velocity of about 800 feet per second. At a depth of 195 feet, the shear wave velocity was approximately 1400 feet per second.

B.2 CROSSHOLE SURVEY

B.2.1 Summary

Crosshole measurements for the determination of seismic wave velocities were performed in Boring CEG-34 The crosshole technique for determining shear wave velocities of in-situ materials was utilized in a three-borehole array. The array consisted of boring CEG-34 and two additional holes (34-A and 34-B) drilled approximately 15 and 30 feet away. All boreholes were drilled to a depth of 100 feet. Compressional wave and shear wave velocities are presented in Table B-2.

B.2.2 Field Procedure

The shear wave hammer is placed in an end hole of the array, and vertical geophones are placed in the remaining two boreholes. The shear wave generating hammer and the two geophones are lowered to the same depth in all boreholes. The hammer is coupled to the wall of the hole by means of hydraulic jacks, and the geophones are coupled by means of expanding heavy rubber balloons which protrude from one side of the geophone housings. The hammer is then used to create vertically polarized shear waves with either an up or down first motion. A 12-channel signal enhancement seismograph with oscilloscope and electrostatic paper camera is used as a signal storage device. Seismic wave velocity determinations were made at 5-foot intervals from 10 feet below ground surface to a depth of 100 feet.

B.2.3 Data Analysis

For the data analysis actual crosshole distances were determined to within ±0.01 feet. These distances were computed between each of the three boreholes at the elevations of shear measurements. From the crosshole records (seismograms), the travel times for both compressional and shear wave arrivals at each borehole and at each depth were measured. Shear wave arrivals were identified by the reversed first motion on the seismograms. Compression and shear wave estimates were based on the wave arrival records.

B.2.4 Discussion of Results

The shear wave velocity (V_s) is equal to the difference in travel path distance from the shear source to each geophone divided by the difference in shear wave arrival times. The results of the compressional and shear wave velocity analyses are shown in Table B-2. It should be noted that compression wave velocities below the ground water table may be masked by the compression wave response of the water (V_c = 5000 fps) particularly in highly porous materials.

TABLE B-1
DOWNHOLE VELOCITIES

BORING No.	DEPTH (ft)	COMPRESSIONAL WAVE					SHEAR WAVE				
		$\bar{V}p$	σp	Ep	Np	Vp*	$\bar{V}s$	σs	Es	Ns	Vs*
31	15- 30	3922	1253	196	5	3922±1450	1273	333	64	4	1270±400
	30-115	8788	1195	439	17	8790±1630	4842	190	240	18	4840±215
34	10- 35	1100	24	55	6	1100±80	807	31	40	5	810±70
	35-195	6243	541	312	31	6240±760	1412	142	71	24	1410±210

$\bar{V}p$ = mean estimate of compressional wave velocity.

$\bar{V}s$ = mean estimate of shear wave velocity.

σp = standard deviation of estimated compressional wave velocity.

σs = standard deviation of estimated shear wave velocity.

Ep = estimated accuracy of compressional survey.

Es = estimated accuracy of shear survey.

Np = number of points used for straight line fit of compressional wave.

Vp* = overall accuracy of compressional wave velocity estimate.

Vs* = overall accuracy of shear wave velocity estimate.

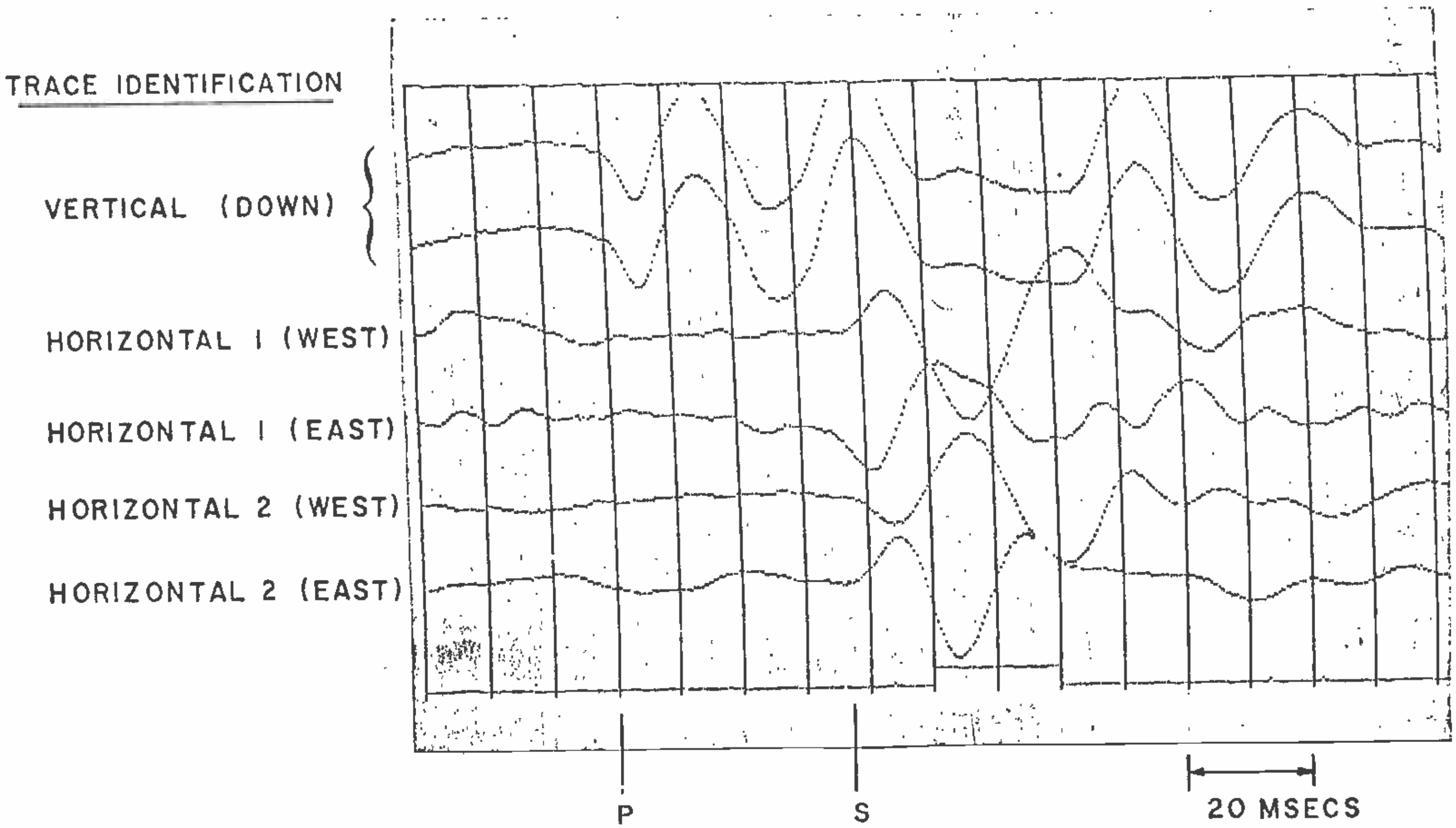
Ns = number of points used for straight line fit of shear wave velocity data.

TABLE B-2
CROSSHOLE VELOCITIES

BORING No.	DEPTH (ft)	COMPRESSIONAL WAVE					SHEAR WAVE				
		$\bar{V}p$	σp	Ep	Np	Vp*	$\bar{V}s$	σs	Es	Ns	Vs*
34	10	1120	51	56	14	1120±110	830	14	41	16	830±60
	15	1240		120		1240±120	744	4	37	6	740±40
	20						634	5	32	6	630±40
	25	1252	8	63	4	1250±70	673	14	34	8	670±50
	30	2900		290		2900±290	793	10	40	19	790±50
	35	2322	132	116	3	2320±250	799	5	40	9	800±50
	40	3570	81	179	8	3570±260	810	2	41	24	810±40
	45	3630	158	161	3	3630±340	841	28	42	9	840±70
	50	5096	165	255	14	5100±420	1033	11	52	12	1030±60
	55	6048	0	301	4	6050±300	1140	15	57	3	1140±70
	60	5818	137	291	16	5820±430	1164	15	58	10	1160±70
	65						1109	14	55	4	1110±70
	70	6291	260	315	6	6290±570	1147	9	57	11	1150±70
	75	5446	310	272	4	5450±580	1260		126	2	1260±130
	80	5930	160	207	8	5930±460	1237	13	62	18	1240±80
	85	5100		510	1	5100±510	1536	161	77	4	1540±240
	90	6156	1061	308	6	6160±1370	1245	49	62	12	1250±110
	97	5757	138	288	9	5760±430	1333	37	67	18	1330±100

$\bar{V}p$ = mean estimate of compressional wave velocity.
$\bar{V}s$ = mean estimate of shear wave velocity.
σp = standard deviation of estimated compressional wave velocity.
σs = standard deviation of estimated shear wave velocity.
Ep = estimated accuracy of compressional survey.
Es = estimated accuracy of shear survey.
Np = number of points used for straight line fit of compressional wave.
Vp* = overall accuracy of compressional wave velocity estimate.
Vs* = overall accuracy of shear wave velocity estimate.
Ns = number of points used for straight line fit of shear wave velocity data.

Approved for publication 4/84 by JHD



BOREHOLE: 13

DEPTH: 70 FT

Converse Consultants
Geotechnical Engineering and Applied Sciences

DOWNHOLE SAMPLE RECORD

DESIGN UNIT A410
Southern California Rapid Transit District
METRO RAIL PROJECT

Project No. 83-1140

Figure No. B-1

Appendix C

Geotechnical Laboratory Testing

APPENDIX C GEOTECHNICAL LABORATORY TESTING

C.1 INTRODUCTION

This appendix presents laboratory geotechnical tests performed on selected soil and bedrock samples obtained from the borings drilled within the A410 alignment.

The soil tests performed may be classified into two broad categories:

- Index or identification tests which included visual classification, grain-size distribution, moisture content, and unit weight testing;
- Engineering properties testing which included unconfined compression, direct shear, and permeability.

The following subsections provide general descriptions of the laboratory testing procedures. Laboratory test data are presented in the form of summary tables, summary plot figures, and individual test plot figures which follow the text.

C.2 INDEX AND IDENTIFICATION

C.2.1 Visual Classification

Field classification was verified in the laboratory by visual examination in accordance with the unified Soil Classification System and ASTM D-2488-69 test method. When necessary to substantiate visual classifications, tests were conducted in accordance with the ASTM D-2478-69 test method.

C.2.2 Grain-Size Distribution

Grain-size distribution tests were performed on representative samples of the geologic units to assist in the soils classification and to correlate test data between various samples. Sieve analyses were performed on that portion of the sample retained on the No. 200 sieve in accordance with ASTM D-422-63 test method. Combined sieve and hydrometer analyses were performed on selected samples which had a significant percentage of soil particles passing the No. 200 sieve. Results of these analyses are presented in the form of grain-size distribution or gradation curves on Figures C-5 through C-9.

It should be noted that the grain-size distribution tests were performed on samples secured with 2.42- and 2.87-inch ID samplers. Thus, material larger than those dimensions may be present in the natural deposits although not indicated on the gradation curves.

C.2.3 Moisture Content

Moisture content determinations were performed on selected soil samples to assist in their classification and to evaluate ground water location. The testing procedure was the ASTM D-2261 test method. Test results are presented on Table C-1.

C.2.4 Unit Weight

Unit weight determinations were performed on selected undisturbed soil samples to assist in their classification and in the selection of samples for engineering properties testing. Samples were generally the same as those selected for moisture content determinations.

The test procedure entailed measuring specimen dimensions with a precision ruler or micrometer. Weights of the sample were than determined at natural moisture content. Total unit weight was computed directly from data obtained from the two previous steps. Dry density was calculated from the moisture content found in Section C.2.4 and the total unit weight. Results of the unit weight tests are presented as dry densities on Table C-1.

C.3 ENGINEERING PROPERTIES: STATIC

C.3.1 Direct Shear

Direct shear tests were performed on selected undisturbed soil samples using a constant strain rate direct shear machine.

Each test specimen was trimmed, soaked and placed in the shear machine, a specified normal load was applied, and the specimen was sheared until a maximum shear strength was developed. Fine-grained samples were allowed to consolidate prior to shearing. The maximum developed shear strengths are presented on Table C-1

Progressive direct shear tests were performed on selected undisturbed samples of coarse-grained material. After the soil specimen had developed maximum shear resistance under the first normal load, the normal load was removed and the specimen was pushed back to its original undeformed configuration. A new normal load was then applied, and the specimen was sheared a second time. This process was repeated for several different normal loads.

C.3.2 Unconfined Compression

Unconfined compression tests were performed on selected samples of sandstone/conglomerate, siltstone and basalt bedrock from the test borings for the purpose of evaluating the unconfined strength. Results of the unconfined compression tests are presented on Table C-2 and on the summary plots of Figures C-1, C-2 and C-3.

C.3.3 Permeability

Permeability tests were performed on undisturbed specimens. Permeability was measured by applying a differential pressure to the ends of the sample and measuring the resulting flow. Results of the tests are tabulated on Table C-1.

C.3.4 Point Load Strength Tests

Point load strength tests were performed on selected NX-size (2± inches in diameter) cores obtained from borings at the following time frames:

- During drilling operations -

  Borings 32-1 (partial) and 32-2 (partial)

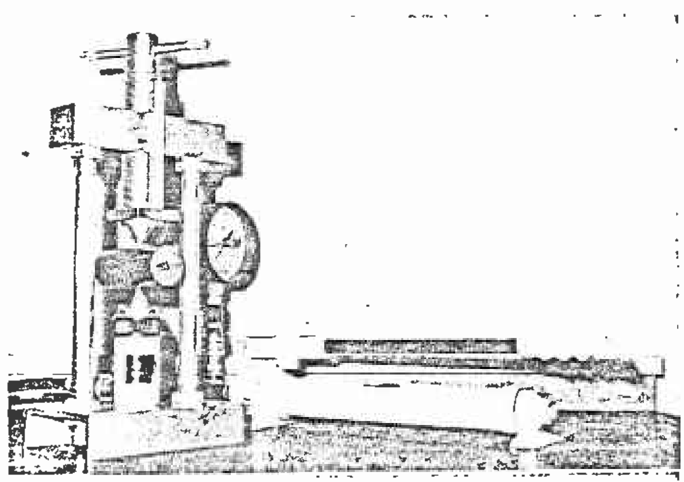
- Few days to one month after drilling -

  Borings 29-1, 29-2, 29-3, 31-2, 31-3, 31-4, 31-5, 32-1 (partial, 32-2 (partial), 33-1 and 33-2

- Two years after drilling -

  Borings CEG-32, CEG-32A and CEG-33.

Point load tests were performed with Soil Test, Inc., "Rock Point Load Tester", Model RM-730. The 10,000-pound capacity apparatus is a hydraulic ram with 2 1/8-inch stroke and hand pump mounted in a rigid frame (see example below).



Rock Point Load Tester

Function

Portable unit to determine Strength Index Log of unprepared rock cores.

Specifications

Ram.	5 ton: hydraulic.
Pump.	Manual: hydraulic.
Sample Size.	4" diam. maximum.
Gauge	Calibrated in lbs. force and kg force. 10,000 lb. and 5000 kg capacity

Models

RM-730.

Weights

Net 56 lbs. (25.4 kg), Shpg. 70 lbs. (31.8 kg).

Our 2-inch diameter NX cores were loaded horizontally (all tests were diametral point load tests) between pointed platens, with provisions for measuring the load P and distance D between the two platen contacts. The distance D used in calculating the strength index, defined as the distance between platen points at the moment of failure, equals the distance at the start of the test only if the specimen is hard and platens do not penetrate into the specimen. For hard rocks, an initial reading of D is sufficiently accurate. For softer rocks where contact penetration occurred before failure of the specimen, the correct distance D was measured between penetration points after failure.

The diametral strength index ($Id = P/D^2$) was obtained. The diametrical strength index (DSI) was converted to unconfined compressive strengths by multiplying by a factor of 25 (Bieniawski, 1975). The results of point load tests are presented on Table C-2 and on the summary plot of Figure C-4.

A few selected point load tests were performed on "very hard" rock fragments and cobbles that were embedded in a "friable" to "low hardness" matrix; i.e., irregular-shaped basalt fragments, cobbles and irregular-shaped quartzite fragments. Although the occurrence of "very hard" rocks is not believed to be pervasive, the results indicate a wide range of strengths within the Topanga formation.

TABLE C-1 LABORATORY TEST DATA FOR ALLUVIUM AND LOW HARDNESS ROCK*

BORING No.	SAMPLE No.	DEPTH (ft)	VISUAL CLASSIFICATION	GEOLOGIC UNIT	DRY DENSITY (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS LL	ATTERBERG LIMITS PI	Kv, COEFFICIENT OF PERMEABILITY (cm/sec) (Confining Pressure, psi)	DIRECT SHEAR STRENGTH ENVELOPE ϕ, deg	DIRECT SHEAR STRENGTH ENVELOPE c, ksf	ONE-DIMENSIONAL SWELL (%) (Normal Load, ksf)	SWELL PRESSURE (ksf)	SIEVE ANALYSIS	HYDROMETER ANALYSIS	OEDOMETER	TRIAXIAL COMPRESSION
29-1	1	3	Silty Sand	A_1	107	13				30.0	0.50						
	2	9	Sand	A_1	117	10				33.5	0.55						
	3	13	Gravelly Sand	A_1	118	10				38.5	0.15						
	5	19	Silty Clay	A_2	105	20											
	7	26	Sandy Clay	A_2	104	20											
	NX	43	Clayey Siltstone	Tt	115	17											
	NX	57	Sandy Claystone	Tt	-	-								X	X		
	NX	76	Sandy Claystone	Tt	-	-								X	X		
	NX	80	Sandstone	Tt	141	6								X	X		
	NX	83	Sandstone	Tt	-	-								X	X		
	NX	88	Clayey Sandstone	Tt	-	-								X	X		
29-2	1	3	Silty Clay	A_2	97	22				18.5	0.75						
	2	8	Silty CLay	A_2	103	20											
	3	13	Silty Clay	A_2	110	6											
	NX	63	Sandy Claystone	Tt	133	10											
	NX	67	Silty Claystone	Tt	-	-								X	X		
	NX	76	Silty Claystone	Tt	124	11								X	X		
	NX	88	Clayey Siltstone	Tt	126	9								X	X		
	NX	92	Sandy Claystone	Tt	-	-								X	X		

*For unconfined compression test results in the "low hardness" and "hard" rock, see Table C-2.

TABLE C-1 LABORATORY TEST DATA FOR ALLUVIUM AND LOW HARDNESS ROCK*

BORING No.	SAMPLE No.	DEPTH (ft)	VISUAL CLASSIFICATION	GEOLOGIC UNIT	DRY DENSITY (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS		Kv, COEFFICIENT OF PERMEABILITY (cm/sec) (Confining Pressure, psi)	DIRECT SHEAR STRENGTH ENVELOPE		ONE-DIMENSIONAL SWELL (%) (Normal Load, ksf)	SWELL PRESSURE (ksf)	SIEVE ANALYSIS	HYDROMETER ANALYSIS	OEDOMETER	TRIAXIAL COMPRESSION
							LL	PI		ø, deg	c, ksf						
29-3	1	5	Sandy Clay	A_2	110	15											
	NX	53	Silty Sandstone	Tt	123	12											
	NX	70	Silty Sandstone	Tt	-	-								X	X		
	NX	82	Sandstone	Tt	131	5											
	NX	86	Sandstone	Tt	-									X	X		
	NX	107	Sandy Claystone	Tt	-	-								X	X		
33-1	PB1	57	Clayey Sand	A_1	96	28			$3x10^{-7}$					X	X		
	PB2	65	Silty Sand	A_1	96	29											
	PB3	67	Organic Silt	A_2	84	39			$3.3x10^{-6}$					X	X		
	1	5	Sandy Clay	A_2	104	10											
	2	10	Silty Clay	A_2	103	20											
	NX	256	Silty Claystone	Tt										X	X		
33-2	NX	60	Silty Claystone	Tt	-	-									X		
	NX	110	Silty Claystone	Tt	120	12											
	NX	120	Sandy Claystone	Tt	-	-								X	X		

*For unconfined compression test results in the "low hardness" and "hard" rock, see Table C-2.

TABLE C-2 - UNCONFINED COMPRESSION & POINT LOAD TESTS ON NX CORES

	BASIC BEDROCK TYPE	BORING No.	DEPTH (ft)	UNCONFINED COMPRESSIVE STRENGTH (psi)	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH FROM POINT LOAD TESTS* (psi)
	Siltstone/Claystone	29-1	19	21	
			26	7	
			48	7	
			53	7	
			57	14	
			60	7	
			64	69	
			70	7	
			72		20
			73	14	
			76	28	
			80	375	
TUNNEL GRADE ±	+ + + + + + + + + + + + + + + + + + +				
	Siltstone/Claystone		83	458	
			85	299	
			86		170
			88	118	
			90		210
			93	28	
			95	7	
			102	264	
			104	14	
			109	187	
			115	62	
			117	21	

*Estimated strength based on 25 times the Point Load Diametral Strength Index (Bieniawski, 1975)

TABLE C-2 - UNCONFINED COMPRESSION & POINT LOAD TESTS ON NX CORES

	BASIC BEDROCK TYPE	BORING No.	DEPTH (ft)	UNCONFINED COMPRESSIVE STRENGTH (psi)	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH FROM POINT LOAD TESTS* (psi)
	Siltstone/Claystone	29-2	8	35	
			13	42	
			48	14	
			63	28	
			65	14	
			67	14	
			70	55	
			72	42	
	Siltstone/Claystone		83	35	
TUNNEL GRADE ±	→ → → → → → → → → → → → → → → → → → →		85		60
			88	7	
			90		20
	Siltstone/Claystone		92	42	
			95	4715	
			107	7	
			113	14	
			118	576	
			120	139	

*Estimated strength based on 25 times the Point Load Diametral Strength Index (Bieniawski, 1975)

TABLE C-2 - UNCONFINED COMPRESSION & POINT LOAD TESTS ON NX CORES

	BASIC BEDROCK TYPE	BORING No.	DEPTH (ft)	UNCONFINED COMPRESSIVE STRENGTH (psi)	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH FROM POINT LOAD TESTS* (psi)
	Siltstone/Claystone	29-3	5	125	
			42	229	
			51	125	
			53	257	
			59		625
			64	549	
			66		2800
			68	264	
			70		2800
			71	174	
TUNNEL GRADE ±	→ → → → → → → → → → → → → → → → → → →		78		750
	Siltstone/Claystone		82	97	
			85		675
			86	83	
			97		7800
			98	1437	
			100		675
			107	35	
			109		675
			117	21	
			120	389	

*Estimated strength based on 25 times the Point Load Diametral Strength Index (Bieniawski, 1975)

TABLE C-2 - UNCONFINED COMPRESSION & POINT LOAD TESTS ON NX CORES

	BASIC BEDROCK TYPE	BORING No.	DEPTH (ft)	UNCONFINED COMPRESSIVE STRENGTH (psi)	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH FROM POINT LOAD TESTS* (psi)
	Basalt	31-2	43	1465	
			54	792	
			55		1900
HOLLYWOOD BOWL STATION	→ → → → → → → → → → → → → → →		65	1778	
			66		3200
			68	1667	
			71	1694	
			74		4800
	Basalt	31-3	56	479	
			61	847	
			62		1400
			65	2222	
			67	1861	
			69		11,100 (unfractured)
HOLLYWOOD BOWL STATION	→ → → → → → → → → → → → → → →				
			70	1694	
			73	986	
			74	1861	
			75		400
			76	340	
			77		8200
			79	2535	

*Estimated strength based on 25 times the Point Load Diametral Strength Index (Bieniawski, 1975)

TABLE C-2 - UNCONFINED COMPRESSION & POINT LOAD TESTS ON NX CORES

	BASIC BEDROCK TYPE	BORING No.	DEPTH (ft)	UNCONFINED COMPRESSIVE STRENGTH (psi)	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH FROM POINT LOAD TESTS* (psi)
	Basalt	31-4	68	1243	
			69	903	
			74	514	
			76	527	
			78		1100
			80	451	
HOLLYWOOD BOWL STATION → → → → → → → → → → → → → → →			84	424	
			85		1700
			87	1014	
			89	1972	
			90		500
			93	736	
			96	1778	
	Basalt	31-5	101		800
			102	1972	
			104	986	
			105		1400
			107	2875	
TUNNEL CRADE ± → → → → → → → → → → → → → → → → → → →			110	2792	
			111		2800
			117	3694	
			120	2507	
			122		5200
			125	4035	

*Estimated strength based on 25 times the Point Load Diametral Strength Index (Bieniawski, 1975)

TABLE C-2 - UNCONFINED COMPRESSION & POINT LOAD TESTS ON NX CORES

	BASIC BEDROCK TYPE	BORING No.	DEPTH (ft)	UNCONFINED COMPRESSIVE STRENGTH (psi)	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH FROM POINT LOAD TESTS* (psi)
	Basalt	32-1	260	2590	
			271		1880
			280		4600
			311	6347	
			344	3792	
			360	3701	
			368		1550
			389	3736	
			393	7639	10,900
TUNNEL GRADE ±	→ → → → → → → → → → → → → → → → → → →		400	9708	
			401		13,800
			404	9361	
			405	9236	
			406		26,100 (unfractured)
			407		12,500
			419		9,400
			420	3532	
			423		625
			424		35,600 (unfractured)
			430		950

*Estimated strength based on 25 times the Point Load Diametral Strength Index (Bieniawski, 1975)

TABLE C-2 - UNCONFINED COMPRESSION & POINT LOAD TESTS ON NX CORES

	BASIC BEDROCK TYPE	BORING No.	DEPTH (ft)	UNCONFINED COMPRESSIVE STRENGTH (psi)	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH FROM POINT LOAD TESTS* (psi)
	Basalt	CEG-32	255	3268	
			258	1285	
			266	1521	
			272	1222	
			273		3400
			275	4208	
			280	6007	10,700 (unfractured)
	Basalt		284	2903	
			288	5292	
TUNNEL GRADE ±	→ → → → → → → → → → → → → → → → → → →		293	3576	
			295		6100
			299	4604	
			305	9521	
			307		11,200 (unfractured)
			308	2625	
			312	1639	
			320	2708	
			329	4194	

*Estimated strength based on 25 times the Point Load Diametral Strength Index (Bieniawski, 1975)

TABLE C-2 - UNCONFINED COMPRESSION & POINT LOAD TESTS ON NX CORES

	BASIC BEDROCK TYPE	BORING No.	DEPTH (ft)	UNCONFINED COMPRESSIVE STRENGTH (psi)	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH FROM POINT LOAD TESTS* (psi)
	Sandstone/Conglomerate	32-2	261	2333	
			270		1900
			280		3800
			282		2400
			283		2200
			282		2400
			286	354	
			288		5300
			289		6500
			290		33,600 (granite cobble)
ALL ABOVE TUNNEL GRADE	→ → → → → → → → → → → → → → →		291		3350
			296		4800
			299		2500
			304		1800
			316		21,100 (granite cobble)
			353	549	
			360	1160	
			362		1400
			373	1257	
			394		19,900 (chert cobble)
	Basalt Dike		407	2965	

*Estimated strength based on 25 times the Point Load Diametral Strength Index (Bieniawski, 1975)

TABLE C-2 - UNCONFINED COMPRESSION & POINT LOAD TESTS ON NX CORES

	BASIC BEDROCK TYPE	BORING No.	DEPTH (ft)	UNCDNFINED COMPRESSIVE STRENGTH (psi)	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH FROM POINT LOAD TESTS* (psi)
	Sandstone/Conglomerate	CEG-32A	217	2951	
			238	1090	
			245	4111	
			247	1819	
			254	1847	
TUNNEL GRADE ±			260	653	
			295	472	
	Siltstone/Claystone/ Sandstone with Conglomerate interbeds	CEG-33	82	110	
			84		28,100 (quartzite)
			86	212	
			96	63	
TUNNEL GRADE ±			97		118
			102		16,300 (conglomerate)
			110	71	
			112		14,600 (quartzite)

*Estimated strength based on 25 times the Point Load Diametral Strength Index (Bieniawski, 1975)

TABLE C-2 - UNCONFINED COMPRESSION & POINT LOAD TESTS ON NX CORES

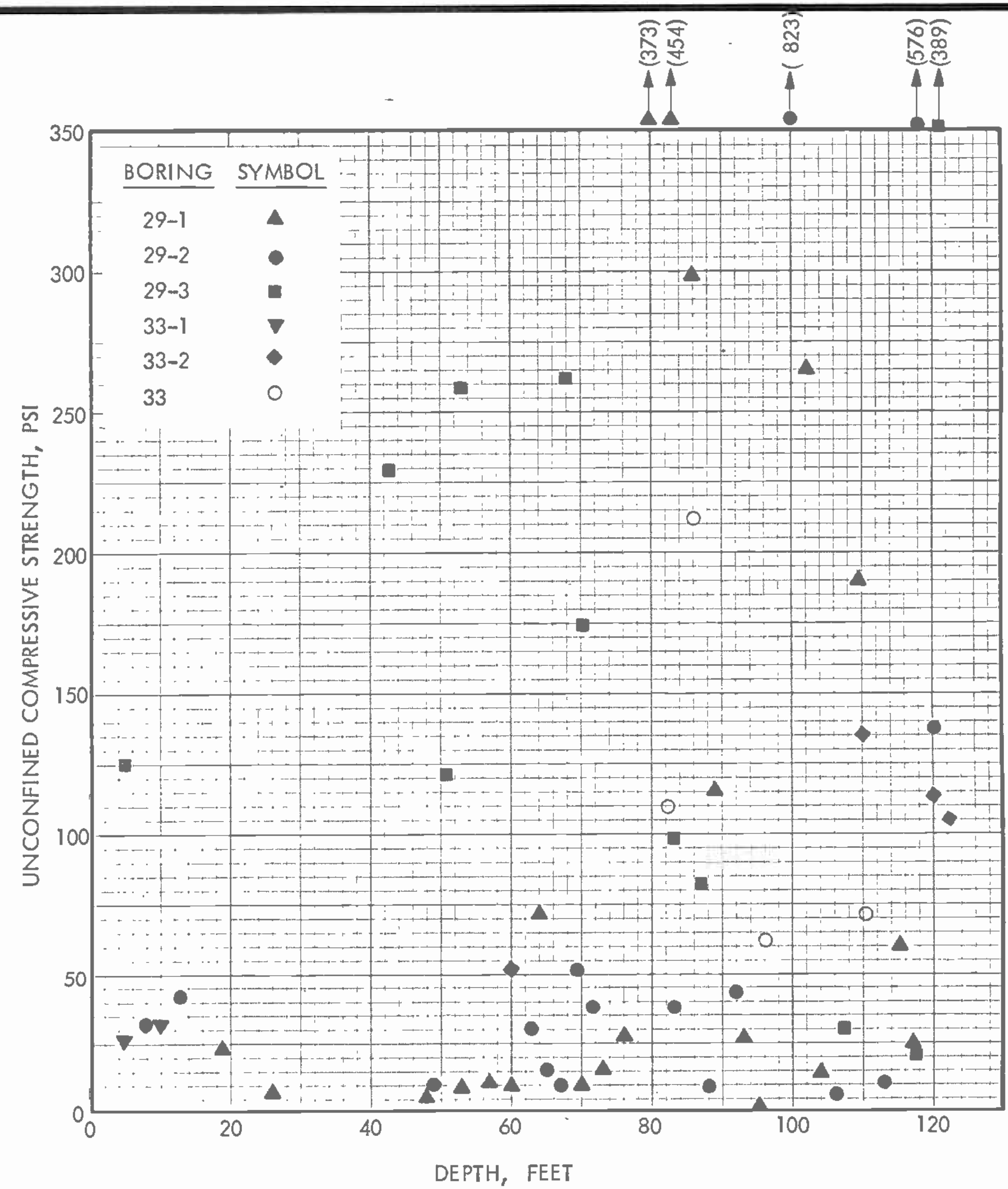
	BASIC BEDROCK TYPE	BORING No.	DEPTH (ft)	UNCONFINED COMPRESSIVE STRENGTH (psi)	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH FROM POINT LOAD TESTS* (psi)
	Sandstone/Siltstone	33-1	5	28	
			10	35	
			230	90	1800
			234	1500	
			235		2400
			240	257	
			244		2450
			245	799	
			250	951	
			253	1486	
			257		2100
			258	1555	
TUNNEL GRADE ± → → → → → → → → → → → → → → → → → → →			260		28,700 (granite cobble)
			263	2604	
			265		8200
	Sandstone/Siltstone with Conglomerate Interbeds		266	2750	
			268		8300
			270	1986	
			273	778	7800
			277	1500	
			280		2500
			281	1063	
			283		5500
			287		18,000 (granite cobble)
			289		3100
			291	2729	
			293	701	
			295		2200
			300	1806	
			306	1194	

*Estimated strength based on 25 times the Point Load Diametral Strength Index (Bieniawski, 1975)

TABLE C-2 - UNCONFINED COMPRESSION & POINT LOAD TESTS ON NX CORES

	BASIC BEDROCK TYPE	BORING No.	DEPTH (ft)	UNCONFINED COMPRESSIVE STRENGTH (psi)	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH FROM POINT LOAD TESTS* (psi)
	Sandstone/Siltstone	33-2	52		90
			60	49	
TUNNEL GRADE ± → → → → → → → → → → → → → → → → → → →			91		250
			110	132	
			114		80
			120	111	
			122	104	

*Estimated strength based on 25 times the Point Load Diametral Strength Index (Bieniawski, 1975)



UNCONFINED COMPRESSION TEST SUMMARY - LOW HARDNESS ROCK

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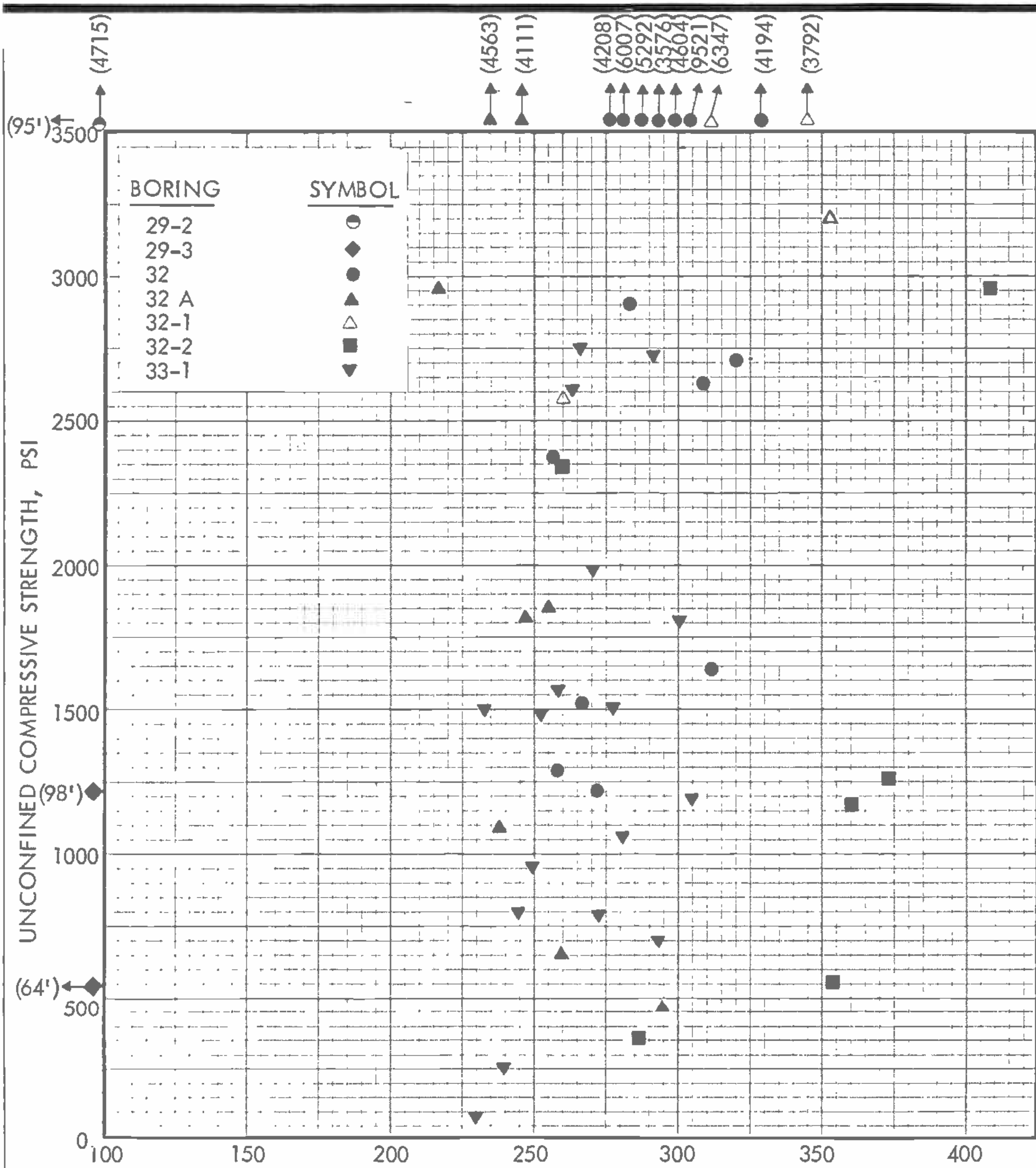
METRO RAIL PROJECT

Project No. 83-1140

Figure No. C-1

Converse Consultants Geotechnical Engineering and Applied Sciences

Approved for publication 5/29/61 by [signature]



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UNCONFINED COMPRESSION TEST SUMMARY - HARD ROCK

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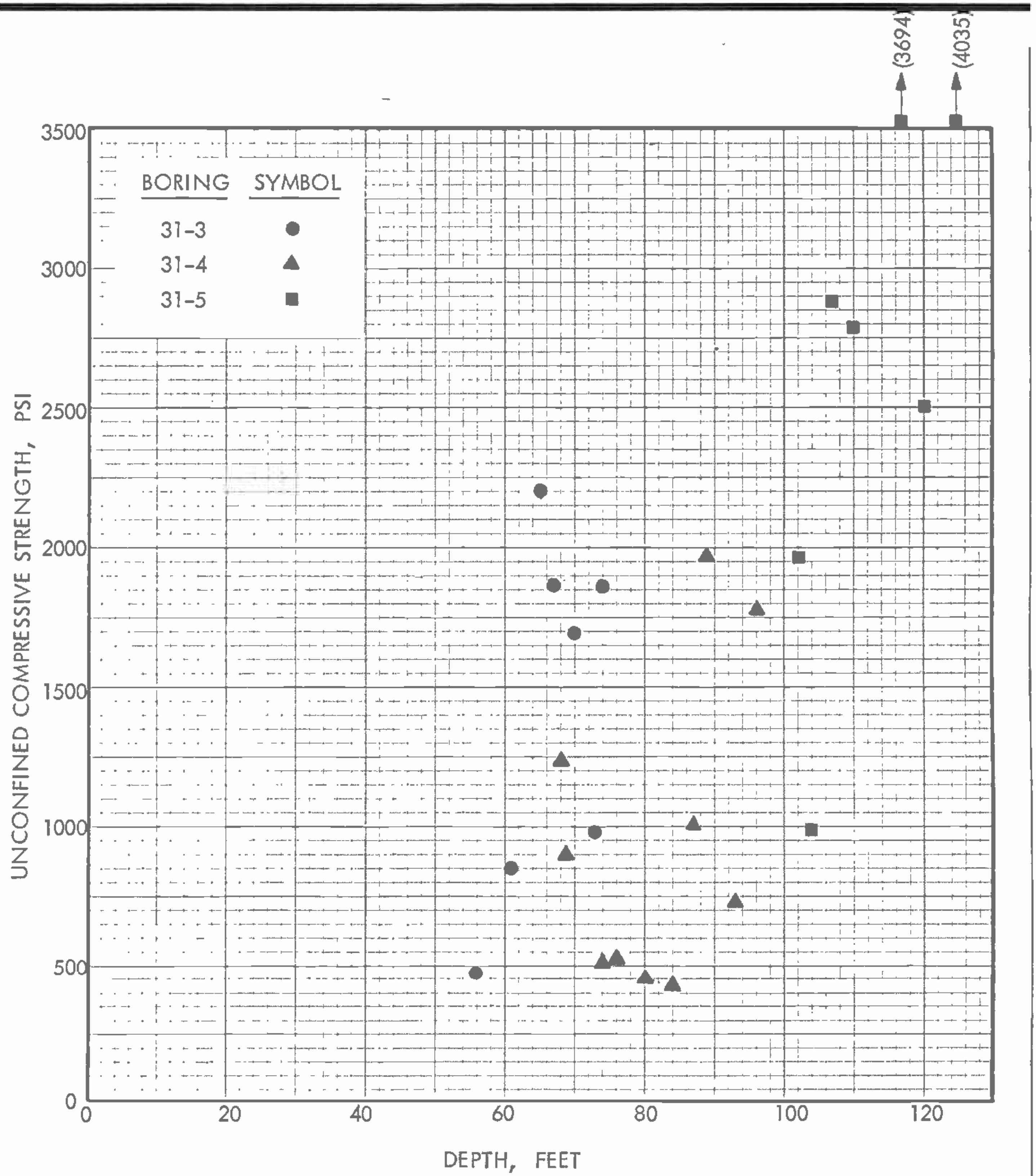
METRO RAIL PROJECT

Project No. 83-1140

Converse Consultants — Geotechnical Engineering and Applied Sciences

Figure No. C-2



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UNCONFINED COMPRESSION TEST SUMMARY - HARD ROCK

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METRO RAIL PROJECT

Project No. 83-1140

Figure No. C-3

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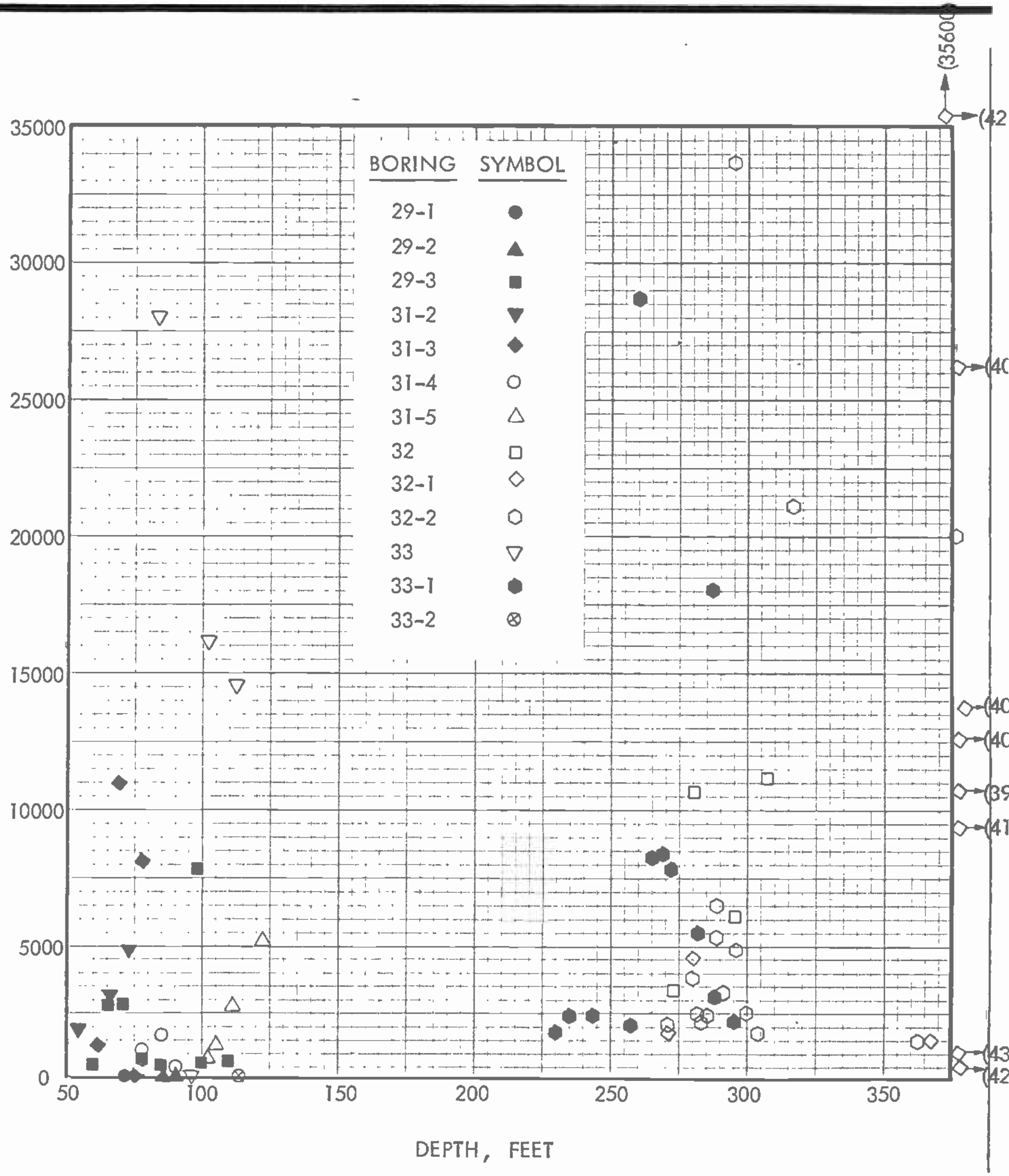

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ESTIMATED UNCONFINED COMPRESSIVE STRENGTH - POINT LOAD TESTS

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Figure No. C-4

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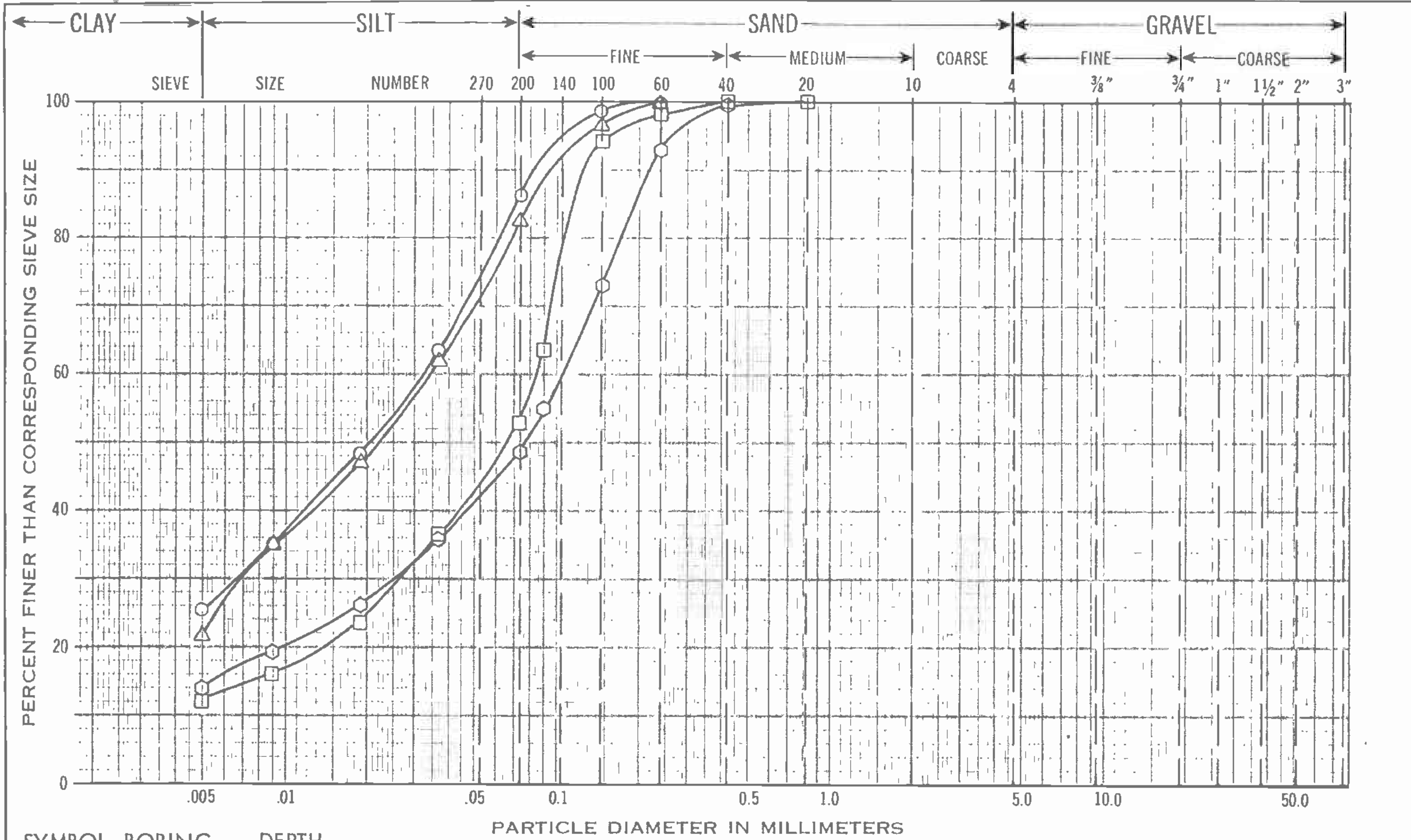
FORM NO. D-3- Approved for publication 6/24/84 by JAD



SYMBOL	BORING	DEPTH
–△–	29-1	56.8' - 57.2'
–○–	29-1	75.6' - 76.0'
–⬡–	29-1	83.2' - 83.4'
–□–	29-1	88.4' - 88.8'

GRAIN-SIZE DISTRIBUTION CHART

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Figure No. C-5

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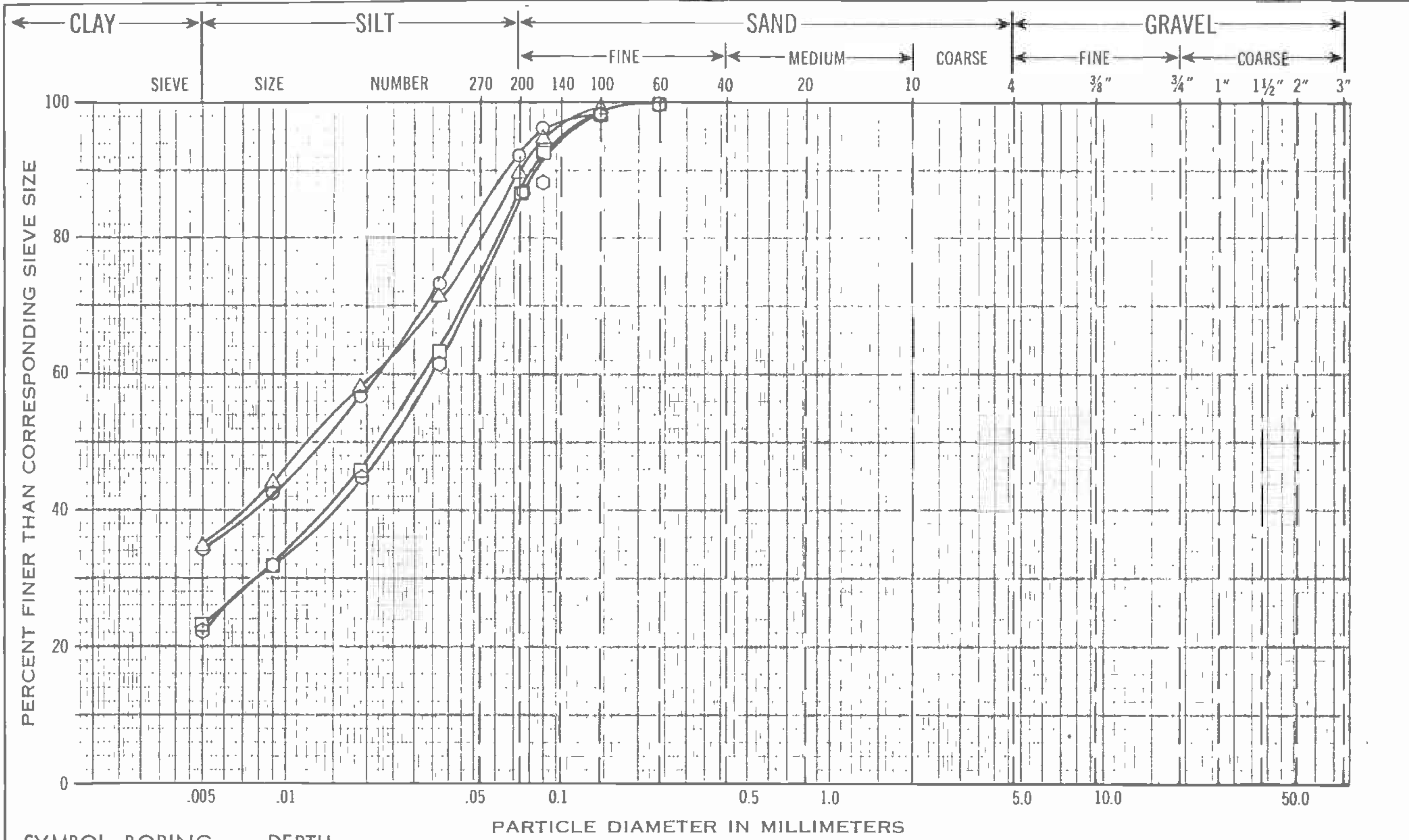

SYMBOL	BORING	DEPTH
—○—	29-2	66.6' - 67.0'
—⬡—	29-2	75.7' - 76.0'
—□—	29-2	87.7' - 88.0'
—△—	29-2	92.3' - 92.6'

GRAIN-SIZE DISTRIBUTION CHART

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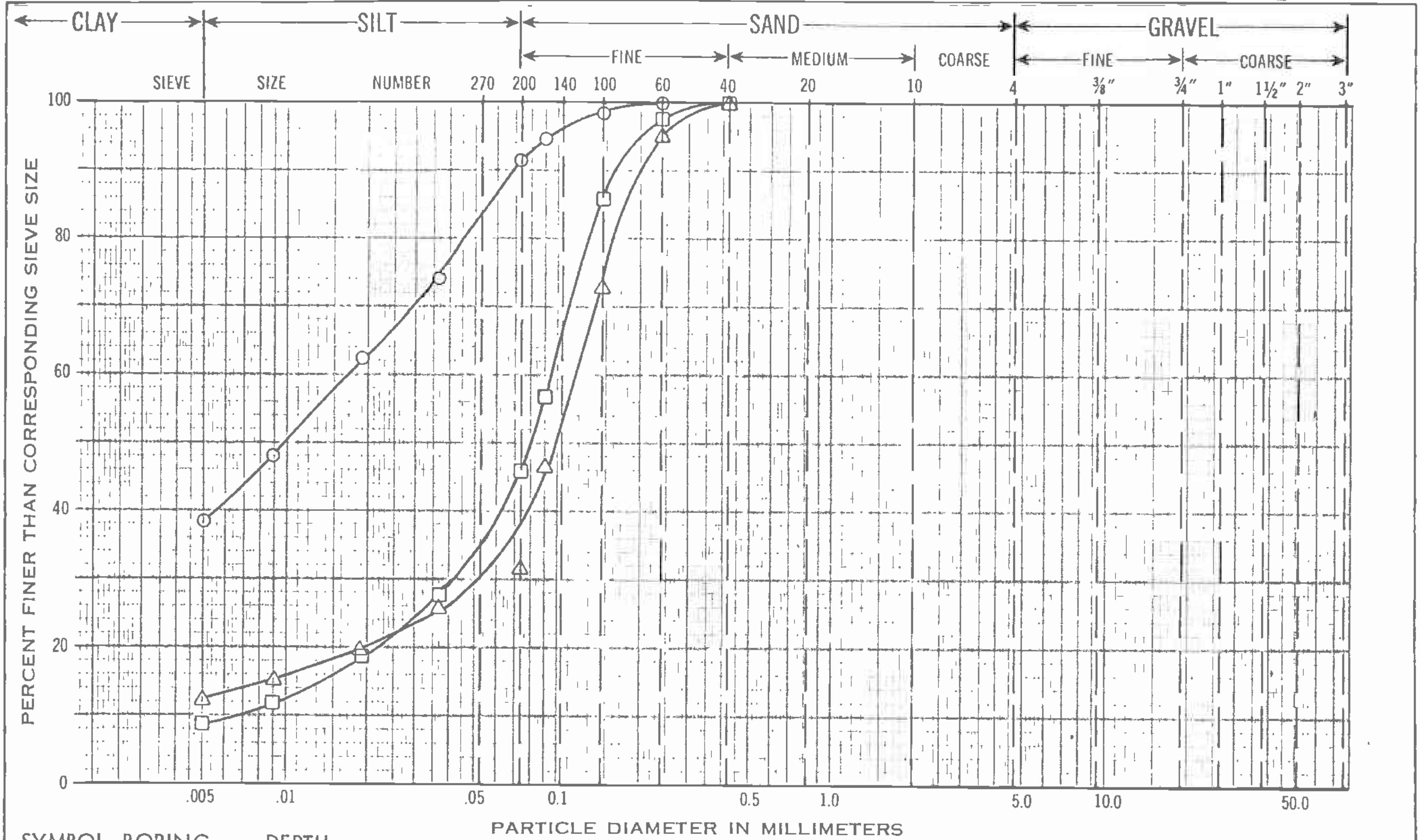
Figure No C-6

FORM NO. D-3-1 Approved for publication 6/29/84 by



SYMBOL	BORING	DEPTH
—△—	29-3	70.4' - 70.8'
—□—	29-3	86.0' - 86.3'
—○—	29-3	107.0' - 107.3'

GRAIN-SIZE DISTRIBUTION CHART

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83-1140

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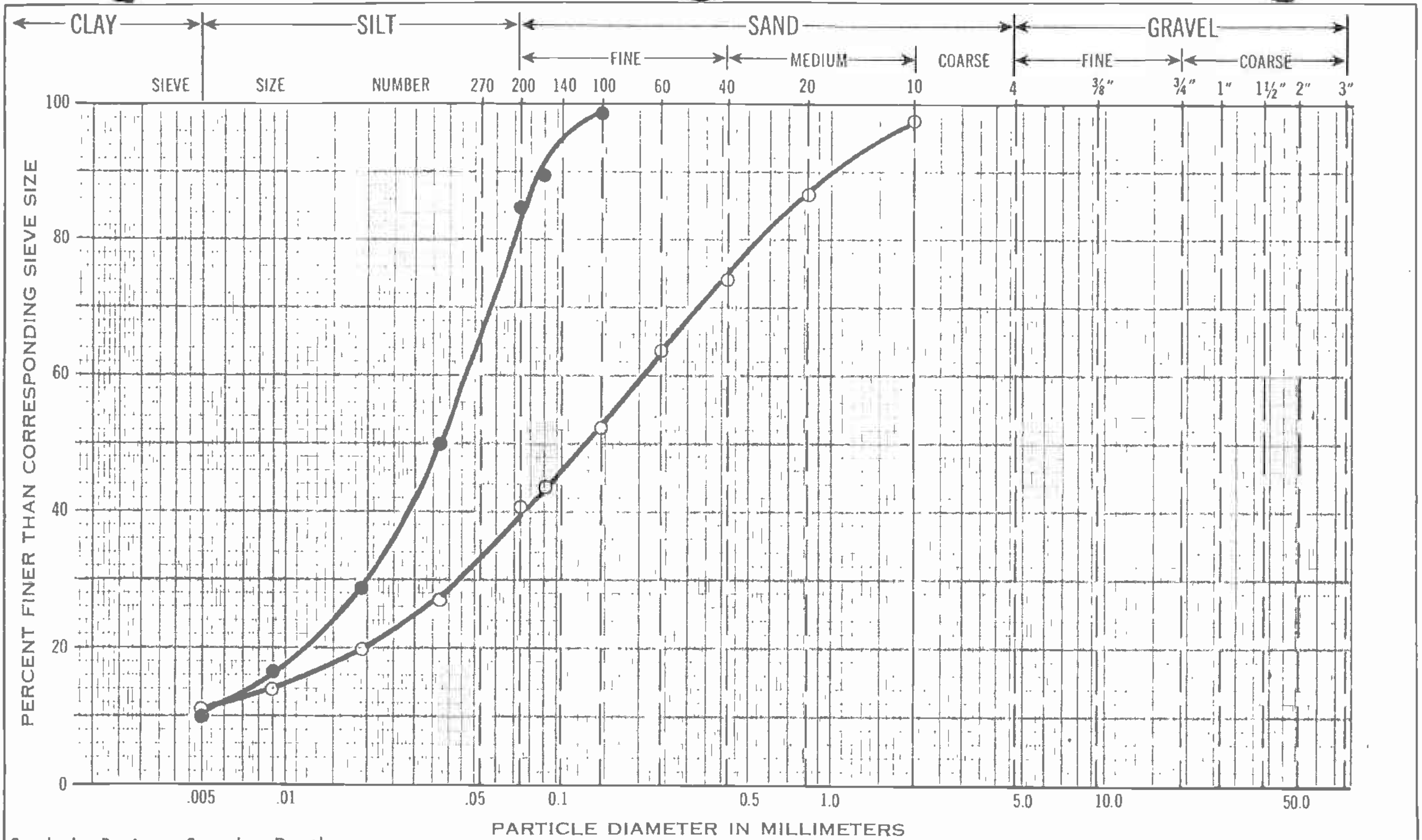
Figure No
C-7

FORM NO. D-3- Approved for publication ________ by ________



Symbol	Boring	Sample	Depth
○	31-1	PB/1	58'-0"
●	31-1	PB/3	68'-2"

GRAIN-SIZE DISTRIBUTION CHART

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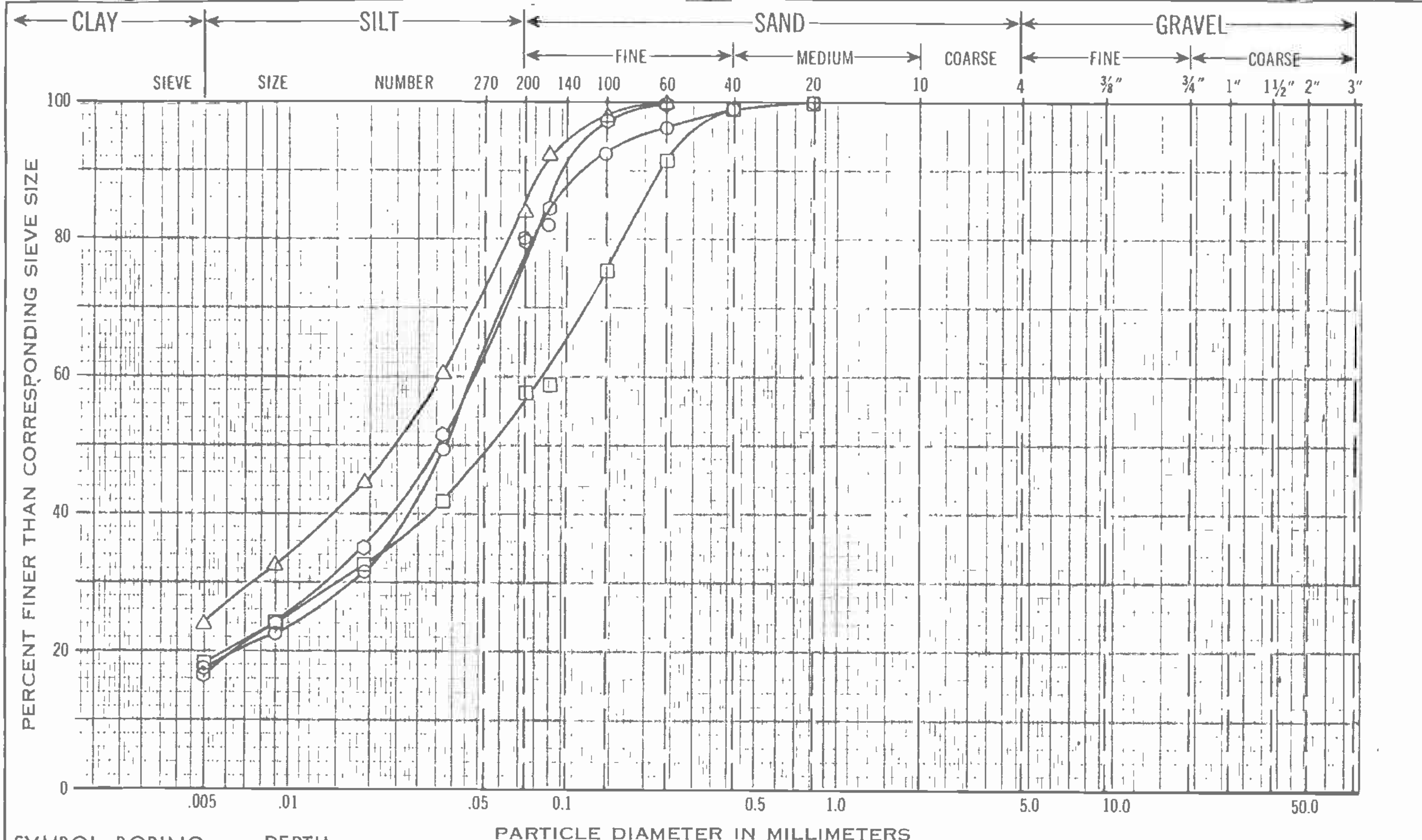
Figure No. C-8

FORM NO. D-3-1 Approved for publication 6/29/14 by JHD



SYMBOL	BORING	DEPTH
—○—	33-1	254.2' - 254.6'
—△—	33-2	60.0' - 60.4'
—○—	33-2	110.1' - 110.3'
—□—	33-2	120.0' - 120.4'

GRAIN-SIZE DISTRIBUTION CHART

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83-1140

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Figure No.
C-9

Appendix D

Water Quality Analysis

APPENDIX D WATER QUALITY ANALYSIS

D.1 RESULTS

Water samples were taken from Borings CEG-29, CEG-30, CEG-31, CEG-32, CEG-32A and CEG-33 during the 1981 investigation and Borings 29-1, 29-2, 29-3, 30B, 33-1 and 33-2 during the 1984 investigation. The purpose was to evaluate water chemicals that could have significant influence on design requirements and to identify chemical constituents for compliance with EPA requirements for future tunneling activities. The chemical constituents tested are attached.

D.2 FIELD PROGRAM

The boreholes were flushed and established as piezometers. At a later date (often several weeks) the established piezometer holes were again flushed and cleaned out. Upon achieving a clean hole, water samples were collected with an air-lifting procedure from various depths within the borehole. The water samples were collected in sterilized one-quart glass containers which were properly identified and marked in the field. The water samples were delivered to both Jacobs Laboratories and Brown and Caldwell Consulting Engineers for testing.

Converse Ward Davis Dixon

Lab No. P81-03-017-6

No. Samples : 7
Sampled By : Client
Brought By : Client
Date Received: 3-3-81

Sample labeled: HOLE 29

Conductivity: 8,220 μ mhos/cm

Turbidity: NTU

pH 8.0 @ 25°C
pHs @ 60°F (15.6°C)
pHs @ 140°F (60°C)

	Milligrams per liter (ppm)	Milli-equivalents per liter
Cations determined:		
Calcium, Ca	43	2.16
Magnesium, Mg	20	1.65
Sodium, Na	2,025	88.09
Potassium, K	14	0.36
		Total 92.26
Anions determined:		
Bicarbonate, as HCO_3	385	6.31
Chloride, Cl	1,066	30.06
Sulfate, SO_4	2,600	54.16
Fluoride, F	0.8	0.04
Nitrate, as N	0.2	0.01
		Total 90.58
Carbon dioxide, CO_2, Calc.	6	
Hardness, as $CaCO_3$	190	
Silica, SiO_2	31	
Iron, Fe	< 0.01	
Manganese, Mn	0.08	
Boron, B	2.6	
Total Dissolved Minerals (by addition: $HCO_3 \rightarrow CO_3$)	5,996	

Lab No. P81-03-152-1

-ANALYSIS OF WATER SAMPLES FROM CONVERSE WARD DAVIS DIXON

Sample labeled: Hole 30

No. Samples : 4
Sampled By : Client
Brought By : Client
Date Received: 3-19-81

Conductivity: 880 μ mhos/cm

Turbidity: NTU

pH 7.9 @ 25°C
pHs @ 60°F (15.6°C)
pHs @ 140°F (60°C)

	Milligrams per liter (ppm)		Milli-equivalents per liter
Cations determined:			
Calcium, Ca	41		2.05
Magnesium, Mg	17.5		1.44
Sodium, Na	142		6.18
Potassium, K	2.1		0.05
		Total	9.72
Anions determined:			
Bicarbonate, as HCO_3	283		4.64
Chloride, Cl	29		0.82
Sulfate, SO_4	202		4.21
Fluoride, F	0.96		0.05
Nitrate, as N	2.5		0.04
		Total	9.76
Carbon dioxide, CO_2, Calc.	5.2		
Hardness, as $CaCO_3$	187		
Silica, SiO_2	32		
Iron, Fe	0.42		
Manganese, Mn	< 0.05		
Boron, B	1.14		
Total Dissolved Minerals, (by addition: $HCO_3 \rightarrow CO_3$)	620		

GENERAL MINERAL ANALYSIS*

BROWN AND CALDWELL
CONSULTING ENGINEERS
ANALYTICAL SERVICES DIVISION
373 SOUTH FAIR OAKS AVE.
PASADENA, CA 91105
PHONE (213) 795-7553

Log No. P83-02-162-3

Date Sampled 2/23/83
Date Received
Date Reported

Reported To: Converse Consultants
126 West Del Mar Avenue
Pasadena, CA 91105

Attn: Al Minas

cc.

Laboratory Director

Sample Description 83-1101-21 BH 30-B -24.5'

Anions	Miligrams per liter	Milliequiv. per liter
Nitrate Nitrogen (as NO_3)	71	1.14
Chloride	103	2.91
Sulfate (as SO_4)	440	9.23
Bicarbonate (as HCO_3)	560	9.23
Carbonate (as CO_3)	4.9	0.16
Total Milliequivalents per Liter		22.67
Cations	**Milligrams per liter**	**Milliequiv. per liter**
Sodium	140	6.18
Potassium	1.4	0.04
Calcium	190	9.28
Magnesium	87	7.16
Total Milliequivalents per Liter		22.66

Determination	Milligrams per liter	Determination	Milligr per li
Hydroxide Alkalinity (as $CaCO_3$)	0.0		
Carbonate Alkalinity (as $CaCO_3$)	8.0		
Bicarbonate Alkalinity (as $CaCO_3$)	462		
Calcium Hardness (as $CaCO_3$)	460		
Magnesium Hardness (as $CaCO_3$)	360		
Total Hardness (as $CaCO_3$)	820		
Iron			
Manganese			
Copper			
Zinc			
Foaming Agents (MBAS)			
Dissolved Residue, Evaporated @ 180°C	1290		
Specific Conductance, micromhos @ 25°C	1730	pH 7.6	

*Conforms to Title 22, California Administrative Code (California Domestic Water Quality and Monitoring Regulations)

Converse Ward Davis Dixon

Lab No. P81-03-017-1

No. Samples : 7
Sampled By : Client
Brought By : Client
Date Received: 3-3-81

Sample labeled: HOLE 31

Conductivity: 811 µ mhos/cm

Turbidity: NTU

pH 8.6 @ 25°C
pHs @ 60°F (15.6°C)
pHs @ 140°F (60°C)

	Milligrams per liter (ppm)	Milli-equivalents per liter
Cations determined:		
Calcium, Ca	15	0.75
Magnesium, Mg	1.8	0.15
Sodium, Na	157	6.83
Potassium, K	3.0	0.08
	Total	7.81
Anions determined:		
Bicarbonate, as HCO_3	167	2.74
Chloride, Cl	50	1.41
Sulfate, SO_4	161	3.35
Fluoride, F	0.9	0.05
Nitrate, as N	2.4	0.17
	Total	7.72
Carbon dioxide, CO_2, Calc.	< 1	
Hardness, as $CaCO_3$	45	
Silica, SiO_2	25	
Iron, Fe	2.12	
Manganese, Mn	< 0.01	
Boron, B	0.58	
Total Dissolved Minerals, (by addition: HCO_3 -> CO_3)	511	

Converse Ward Davis Dixon

Lab No. P81-03-017-2

No. Samples : 7
Sampled By : Client
Brought By : Client
Date Received: 3-3-81

Sample labeled: HOLE 32

Conductivity: 666 μ mhos/cm

Turbidity: NTU

pH 9.8 @ 25°C
pHs @ 60°F (15.6°C)
pHs @ 140°F (60°C)

	Milligrams per liter (ppm)	Milli-equivalents per liter
Cations determined:		
Calcium, Ca	3.3	0.16
Magnesium, Mg	1.8	0.15
Sodium, Na	135	5.87
Potassium, K	3.0	0.77
		Total 6.95
Anions determined:		
Carbonate, CO_3	55	1.83
Bicarbonate, as HCO_3	163	1.16
Chloride, Cl	37	1.04
Sulfate, SO_4	121	2.52
Fluoride, F	1.3	0.07
Nitrate, as N	1.5	0.11
		Total 6.73
Carbon dioxide, CO_2, Calc.	< 1	
Hardness, as $CaCO_3$	16	
Silica, SiO_2	30	
Iron, Fe	110	
Manganese, Mn	0.74	
Boron, B	1.14	
Total Dissolved Minerals, (by addition: HCO_3 -> CO_3)	587	

Converse Ward Davis Dixon

Lab No. P81-03-152-4

Sample labeled: Hole 32A Oakshire

No. Samples : 4
Sampled By : Client
Brought By : Client
Date Received: 3-19-81

Conductivity: 1,200 μ mhos/cm

Turbidity: NTU

pH 8.0 @ 25°C
pHs @ 60°F (15.6°C)
pHs @ 140°F (60°C)

	Milligrams per liter (ppm)	Milli-equivalents per liter
Cations determined:		
Calcium, Ca	91	4.53
Magnesium, Mg	46	3.78
Sodium, Na	152	6.61
Potassium, K	5.7	0.15
		Total 15.07
Anions determined:		
Bicarbonate, as HCO_3	260	4.26
Chloride, Cl	62	1.74
Sulfate, SO_4	434	9.04
Fluoride, F	0.59	0.04
Nitrate, as N	0.5	0.01
		Total 15.09
Carbon dioxide, CO_2, Calc.	3.7	
Hardness, as $CaCO_3$	417	
Silica, SiO_2	12	
Iron, Fe	0.10	
Manganese, Mn	< 0.05	
Boron, B	0.32	
Total Dissolved Minerals, (by addition: $HCO_3 \rightarrow CO_3$)	940	

Converse Ward Davis Dixon

Lab No. P81-03-017-3

No. Samples : 7
Sampled By : Client
Brought By : Client
Date Received: 3-3-81

Sample labeled: HOLE 33

Conductivity: 2,130 µ mhos/cm

Turbidity: NTU

pH 7.2@25°C
pHs @60°F (15.6°C)
pHs @ 140°F (60°C)

	Milligrams per liter (ppm)	Milli-equivalents per liter
Cations determined:		
Calcium, Ca	198	9.88
Magnesium, Mg	98	8.06
Sodium, Na	145	6.31
Potassium, K	5.8	0.15
		Total 24.40
Anions determined:		
Bicarbonate, as HCO_3	474	7.77
Chloride, Cl	94	2.66
Sulfate, SO_4	693	14.44
Fluoride, F	0.6	0.03
Nitrate, as N	0.3	0.00
		Total 24.90
Carbon dioxide, CO_2, Calc.	43	
Hardness, as $CaCO_3$	898	
Silica, SiO_2	31	
Iron, Fe	< 0.01	
Manganese, Mn	< 0.01	
Boron, B	0.66	
Total Dissolved Minerals, (by addition: $HCO_3 \rightarrow CO_3$)	1,504	

Converse Ward Davis Dixon

Lab No. P81-02-123-5

No. Samples : 6
Sampled By : Client
Brought By : Client
Date Received: 2-12-81

Sample labeled: HOLE 33

Conductivity: 1,710 μ mhos/cm

Turbidity: NTU

pH 7.5 @ 25°C
pHs @ 60°F (15.6°C)
pHs @ 140°F (60°C)

	Milligrams per liter (ppm)	Milli-equivalents per liter
Cations determined:		
Calcium, Ca	94	4.69
Magnesium, Mg	68	5.59
Sodium, Na	186	8.09
Potassium, K	5.3	0.14
Total		18.51
Anions determined:		
Bicarbonate, as HCO_3	329	5.39
Chloride, Cl	60	1.70
Sulfate, SO_4	538	11.21
Fluoride, F	0.7	0.04
Nitrate, as N	2.7	0.19
Total		18.53
Carbon dioxide, CO_2, Calc.	15	
Hardness, as $CaCO_3$	515	
Silica, SiO_2	27	
Iron, Fe	< 0.01	
Manganese, Mn	< 0.01	
Boron, B	0.38	
Total Dissolved Minerals, (by addition: $HCO_3 \rightarrow CO_3$)	1,154	

BROWN AND CALDWELL
CONSULTING ENGINEERS
ANALYTICAL SERVICES DIVISION
373 SOUTH FAIR OAKS AVE.
PASADENA, CA 91105
PHONE (818) 795-7553
(213) 681-4655

Log No. P84-05-132

Date Sampled 05-14-84
Date Received 05-14-84
Date Reported 06-11-84

P.O. No. 83-1140-56
Invoice No. 2631, separate cover

Reported To:
Converse Consultants
126 West Del Mar Boulevard
Pasadena, California 91105

Attention: John Campbell

Edward Wilson
Laboratory Director

cc.

Log No.	Sample Description
05-132-1	Boring 29-1
05-132-2	Boring 29-2
05-132-3	Boring 29-3
05-132-4	Boring 33-1
05-132-5	Boring 33-2

RECEIVED
JUN 1 1 1984
CONVERSE CONSULTANTS

Concentration: mg/L (unless otherwise indicated)

	29-1 05-132-1	29-2 05-132-2	29-3 05-132-3	33-1 05-132-4	33-2 05-132-5
pH (units)	7.6	6.4	7.3	7.4	8.2
Total Dissovled Solids	2400	1200	2400	1400	680
Sulfate	1000	300	1300	460	10
Boron	2.4	1.4	1.3	0.62	0.85
Aluminum	< 0.16	< 0.16	< 0.16	< 0.16	< 0.16
Barium	0.07	< 0.07	0.07	< 0.07	< 0.07

lab

Appendix E

Pump Test Results

APPENDIX E PUMP TEST RESULTS

E.1 INTRODUCTION AND SUMMARY

A pump test was performed about 750 feet west of the proposed location of the Universal City Station to provide data for construction dewatering. Two pump tests were run at the same well to determine aquifer properties and boundary conditions and to confirm test results. The location of the pumping well is shown on Drawing 6 (Pump Test Well PT-2).

The methodology used for the test consisted of constant discharge tests with time-drawdown measurements in the observation wells. These measurements were plotted on log-log paper as drawdown versus t/r^2 where t = time in days and r = the radial distance of the observation well from the pumped well in feet. The data plots for the test were matched to a family of type curves by Newman (1975) for wells fully penetrating an unconfined aquifer. Under these conditions the typical log of drawdown versus the log of time response is an S-shaped curve with delayed drainage causing a flattening of the curve between early and late responses. Data plots are presented at the end of this appendix for each test along with matching curves, formulas used, and computations. Aquifer test data sheets for each test and observation well are also included in this appendix.

E.2 SITE CONDITIONS

The location of the multiple well pump test for Universal City Station is north of the end of Bluffside Drive as shown on Drawing 2. The test well was located in the southeast corner of a parking lot and two observation wells were located to the east in Weddington Park. Bedrock penetrated in the wells consists of sandstone of the Topanga Formation. The sandstone was encountered at depths ranging from 63 feet (at PT-2) to 48 feet (at OW-2) and was penetrated only a few feet.

The sandstone is overlain by alluvium of an old Los Angeles River channel that ranges in composition from sandy clay to clean sand and gravel. These deposits appear to be irregular in thickness and are probably lenticular. A clean sand and gravel bed that appears to be continuous between the test well and the two observation wells to the east was selected for aquifer testing. At test well PT-2, the sand and gravel is 12.5 feet thick, overlain by 2.5 feet of fine sand for a total aquifer thickness of 15 feet. Above the fine sand is 18 feet of unsaturated silt and clay. Underlying the sand and gravel aquifer is 30 feet of sandy clay which has a relatively low permeability.

At Observation Well OW-1, which is 66 feet east of PT-2, the aquifer is 12 feet thick. At Observation Well OW-2, the aquifer is 13 feet thick. OW-2 is 166 feet east of PT-2. The aquifer occurs at depths between 18 and 35 feet where penetrated by the three wells.

The static water level is close to the top of the aquifer at PT-2 and a few feet above the top of the aquifer in the two observation wells. The aquifer is under slight artesian pressure. The areal extent of the aquifer is unknown, but geologic boundaries are expected to be close because of the narrow sinuous nature of the stream channel deposits.

E.3 WELL CONSTRUCTION AND DEVELOPMENT

Well PT-2 was drilled by the cable tool method to a depth of 63 feet. The driven 12-inch casing was perforated from 20 to 33 feet with 12 punched slots per foot. The slots are 1-1/4 inches by 5/32 inch and are in staggered rows. The two observation wells were drilled by the rotary wash method. PVC casing 4 inches in diameter was installed in the 6-inch boring with a pea gravel filter and surface seal installed in the annulus. Originally, these wells were completed to bedrock with perforated casing. Later, they were backfilled and sealed with cement grout to a depth of approximately 35 feet.

All of the wells were developed to flush mud and cuttings and to provide hydraulic communication with the aquifer. The 12-inch well was surged with a bailor and then developed for two days with the test pump. The limited available drawdown (<15 feet) made well development difficult. Drawdown measurements for the test well are not available and the hydraulic efficiency of this well is unknown.

E.4 PUMP TESTING PROCEDURE

Because of the expected boundary effects, two relatively short duration, constant discharge tests were conducted. The first test was run on April 14, 1983 for approximately 695 minutes at an average discharge rate of 30 gpm. The discharge, however, fluctuated between 25 and 45 gpm. The second test was performed on April 16, 1983, also at an average discharge of 30 gpm, for approximately 470 minutes as a check for the first test. Also, there was a broken water line near OW-2 during the first test that could have caused some recharge in the area of this well.

The test well was pumped with a lineshaft turbine pump and discharges were measured with an orifice plate and a bucket. Water was discharged into a storm drain.

Drawdowns were measured in the two observation wells with Stevens Recorders. Times were recorded manually on the chart paper at intervals to provide suitable logarithmic distributions.

Recovery measurements were made after the first test but the results were not useful. There was a very long time lag in water level responses partially because of the relatively long distance to observation wells and the relatively low pumping rate. A much higher test well yield was expected and utility lines were encountered at the intended location of OW-2 forcing it to be placed further from the test well. Also, there appeared to be a delayed response especially in OW-1, due to incomplete well development. The far well (OW-2) responded quicker than the near well (OW-1). This trend should have been reversed.

E.5 TEST INTERPRETATIONS

Time-drawdown data were plotted on log-log graphs as shown on the interpretation charges. Figure E-1 shows the plots for the first test for both observation wells. The log of drawdown(s) is plotted against t/r^2 where t is in days and r is the radial distance from the pumped well to the observation well in feet. These data plots were matched to the artesian type curve and appropriate match points were selected to determine values of s and t/r^2 for corresponding values of $W(\mu)$ and $1/\mu$. Calculations for transmissivity (T) and storativity (S) are shown. Figure E-2 shows data plots, match points, and calculations for the second test for both observation wells.

During the first test, both data plots have good initial matches with the artesian type curve (see Figure E-1). Also, both wells show responses to a barrier boundary in the latter part of the test. Water level responses indicate an increased rate of drawdown as the boundary is encountered as shown by the upward deflection on the data plot. Relatively poor matches were obtained during the second test, especially for OW-1 (see Figure E-2). The boundary effect was not well defined during the second test, in part due to the shorter duration of the test. Also, there was poor consistency in the shape of the responses that should have been identical. At least part of this inconsistency was probably due to the difficulty in maintaining a constant discharge during both tests. Both plots indicate delayed responses which was especially severe for OW-1. The delayed response merged with the boundary effect which makes data from OW-1 unreliable.

A check interpretation is shown on Figure E-3 which shows distance drawdown plots for both tests. The first test was influenced by boundary effects resulting in a relatively low transmissivity. The second test is probably high in terms of transmissivity. However, the average of these two interpretations is probably reasonable. Table E-1 summarizes the more reliable test results.

TABLE E-1

RESULTS OF PUMP TEST PT-2

TEST	OBSERVATION WELL	CURVE MATCH	TRANSMISSIVITY (gpd/ft)	AVERAGE HYDRAULIC CONDUCTIVITY (gdp/ft^2)	STORATIVITY
1st	OW-1	Artesian T.C.	22,920	1,910	0.059
1st	OW-2	Artesian T.C.	24,557	1,889	0.014
2nd	OW-1		POOR MATCH -	NOT VALID	
2nd	OW-2	Artesian T.C.	28,650	2,203	0.008
1st & 2nd	OW-1, OW-2	Dist. d.d. (two tests)	19,293 (average)	1,543 (average)	0.008

The mean transmissivity from Table E-1 is approximately 24,000 gpd/ft and the mean hydraulic conductivity is about 1,900 gpd/ft^2 ($\cong 9.0 \times 10^{-2}$ cm/sec). Storativities are relatively high for initial responses suggesting unconfined conditions. As these deposits are dewatered, a specific yield value will apply that is considerably higher than the computed values of storativity. Specific yields of 0.20 to 0.25 are probably reasonable.

E.6 COMMENTS ON TEST RESULTS

Distance to the observed barrier boundary were not computed. This can be done, but it would not apply at the Universal City Station excavation. Barrier boundaries will have a beneficial influence on construction dewatering. Boundary effects may reduce the effective transmissivity by a factor of 3 to 4 depending on distances involved from the dewatering system to the boundaries.

The transmissivity data and average hydraulic conductivities appear quite reasonable in spite of delayed responses of OW-1 and the less than planned stress on the aquifer. Prior to well development, the anticipated pumping rates were several hundred gallons per minute and observation well spacings were determined on that basis. In retrospect, spacings of about 50 and 25 feet would have been better for the 30 gpm pumping rate and the thinner than expected aquifer.

Aquifer thickness is somewhat different at the construction site. However, the computed average hydraulic conductivity of 1,900 gpd/ft^2 is probably reasonable for the sands and gravels encountered at the Station site. Transmissivity can be estimated by multiplying the hydraulic conductivity times the aquifer thickness (clean sands and gravels). The silts and clays will of course have much lower hydraulic conductivities (by several orders of magnitude).

It is beyond the scope of this report to recommend specific dewatering systems. However, the limited aquifer thickness (i.e., up to 16 feet of sands and gravels overlying the Topanga Formation bedrock) at the Station site, suggests that well points would appear applicable. If wells are used, regardless of type, the limited available drawdown will require development of efficient wells. This requires well screens with adequate open areas along with good well development techniques.

[illegible] DATA SHEET

Observation Well No. OW-1

Test Well No. Universal City Station

Static Water Level 17.95

Radius from Pumped Well 62.1

Project No. E167

Date of Test 04/14/83

Observed By TDH

Average Discharge 30 gpm

Time	t min.	t days	t/r^2	Water Level feet	Drawdown, s feet	Remarks
7:40 a	0	--	--	17.950	0.0	
	2.5	1.74×10^{-3}	4.51×10^{-7}	17.955	0.005	
	10	6.94×10^{-3}	1.80×10^{-6}	17.960	0.010	
8:00	20	1.39×10^{-2}	3.60×10^{-6}	17.970	0.020	
8:04	24	1.67×10^{-2}	4.33×10^{-6}	17.975	0.025	
8:07	27	1.88×10^{-2}	4.88×10^{-6}	17.980	0.030	
8:10	30	2.08×10^{-2}	5.39×10^{-6}	17.990	0.040	
8:13	33	2.29×10^{-2}	5.94×10^{-6}	17.990	0.040	
8:16	36	2.50×10^{-2}	6.48×10^{-6}	18.005	0.055	
8:20	40	2.78×10^{-2}	7.21×10^{-6}	18.010	0.060	
8:24	44	3.06×10^{-2}	7.93×10^{-6}	18.010	0.060	
8:28	48	3.33×10^{-2}	8.63×10^{-6}	18.020	0.070	
8:32	52	3.61×10^{-2}	9.36×10^{-6}	18.030	0.080	
8:36	56	3.89×10^{-2}	1.01×10^{-5}	18.035	0.085	
8:40	60	4.17×10^{-2}	1.08×10^{-5}	18.050	0.100	
8:46	66	4.58×10^{-2}	1.19×10^{-5}	18.060	0.110	
8:52	72	5.00×10^{-2}	1.30×10^{-5}	18.070	0.120	
8:58	78	5.42×10^{-2}	1.41×10^{-5}	18.080	0.130	
9:04	84	5.83×10^{-2}	1.51×10^{-5}	18.090	0.140	
9:11	91	6.32×10^{-2}	1.64×10^{-5}	18.100	0.150	
9:20	100	6.94×10^{-2}	1.80×10^{-5}	18.125	0.176	
9:33	113	7.85×10^{-2}	2.04×10^{-5}	18.150	0.200	

Time	t min.	t days	t/r^2	Water level feet	Drawdown, feet	Remarks
9:10	120	8.33×10^{-2}	2.16×10^{-5}	18.170	0.220	
9:50	130	9.03×10^{-2}	2.34×10^{-5}	18.190	0.240	
10:00	140	9.72×10^{-2}	2.52×10^{-5}	18.220	0.270	
10:20	160	1.11×10^{-1}	2.88×10^{-5}	18.250	0.300	
10:40	180	1.25×10^{-1}	3.24×10^{-5}	18.290	0.340	
11:00	200	1.39×10^{-1}	3.60×10^{-5}	18.330	0.380	
11:20	220	1.53×10^{-1}	3.97×10^{-5}	18.370	0.420	
11:43	243	1.69×10^{-1}	4.38×10^{-5}	18.410	0.460	
12:00	260	1.81×10^{-1}	4.69×10^{-5}	18.450	0.500	
12:30	290	2.01×10^{-1}	5.21×10^{-5}	18.490	0.540	
1:00	320	2.22×10^{-1}	5.76×10^{-5}	18.550	0.600	
1:30	350	2.43×10^{-1}	6.30×10^{-5}	18.610	0.660	
2:00	380	2.64×10^{-1}	6.85×10^{-5}	18.650	0.700	
2:30	410	2.85×10^{-1}	7.39×10^{-5}	18.690	0.740	
3:00	440	3.06×10^{-1}	7.93×10^{-5}	18.740	0.790	
4:00	500	3.47×10^{-1}	9.00×10^{-5}	18.830	0.880	
4:30	530	3.68×10^{-1}	9.54×10^{-5}	18.860	0.910	
5:15	575	3.99×10^{-1}	1.03×10^{-4}	18.920	0.970	
6:00	620	4.31×10^{-1}	1.12×10^{-4}	18.980	1.030	
7:00	680	4.72×10^{-1}	1.22×10^{-4}	19.060	1.110	
7:15	695	4.83×10^{-1}	1.25×10^{-4}	19.080	1.130	

AQUIFER TEST DATA SHEET

Observation Well No. OW-2

Project No. E167

Test Well No. Universal City Station

Date of Test 04/14/83

Static Water Level 15.61

Observed By TDH

Radius from Pumped Well 161.9

Average Discharge 30 gpm

Time	t min.	t days	t/r^2	Water Level feet	Drawdown, s feet	Remarks
7:40	0	--	--	15.610	0.0	
10:49	9	6.25×10^{-3}	2.38×10^{-7}	15.615	0.005	
10:51	11	7.63×10^{-3}	2.91×10^{-7}	15.627	0.017	
8:00	20	1.39×10^{-2}	5.30×10^{-7}	15.629	0.019	
8:10	30	2.08×10^{-2}	7.95×10^{-7}	15.632	0.022	
8:20	40	2.78×10^{-2}	1.06×10^{-6}	15.640	0.030	
8:30	50	3.47×10^{-2}	1.32×10^{-6}	15.652	0.042	
8:35	55	3.81×10^{-2}	1.45×10^{-6}	15.660	0.050	
8:40	60	4.17×10^{-2}	1.59×10^{-6}	15.664	0.054	
8:50	70	4.86×10^{-2}	1.85×10^{-6}	15.680	0.070	
8:55	75	5.20×10^{-2}	1.98×10^{-6}	15.685	0.075	
9:00	80	5.55×10^{-2}	2.12×10^{-6}	15.693	0.083	
9:10	90	6.25×10^{-2}	2.38×10^{-6}	15.705	0.095	
9:20	100	6.94×10^{-2}	2.65×10^{-6}	15.711	0.101	
9:30	110	7.63×10^{-2}	2.91×10^{-6}	15.719	0.109	
9:40	120	8.33×10^{-2}	3.18×10^{-6}	15.725	0.115	
9:50	130	9.03×10^{-2}	3.45×10^{-6}	15.733	0.123	
10:00	140	9.72×10^{-2}	3.71×10^{-6}	15.743	0.133	
10:20	160	1.11×10^{-1}	4.23×10^{-6}	15.759	0.149	
10:40	180	1.25×10^{-1}	4.77×10^{-6}	15.771	0.161	
11:00	200	1.39×10^{-1}	5.30×10^{-6}	15.789	0.179	
11:22	222	1.54×10^{-1}	5.88×10^{-6}	15.809	0.199	

Time	t min.	t days	t/r^2	Water level feet	Drawdown, s feet	Remarks
11:45	245	1.70×10^{-1}	6.49×10^{-6}	15.829	0.219	
12:00	260	1.81×10^{-1}	6.91×10^{-6}	15.836	0.226	
12:30	290	2.01×10^{-1}	7.67×10^{-6}	15.860	0.250	
1:00	320	2.22×10^{-1}	8.47×10^{-6}	15.868	0.258	
1:30	350	2.43×10^{-1}	9.27×10^{-6}	15.871	0.261	
2:00	380	2.64×10^{-1}	1.01×10^{-5}	15.871	0.261	
2:30	410	2.85×10^{-1}	1.09×10^{-5}	15.889	0.279	
3:00	440	3.06×10^{-1}	1.17×10^{-5}	15.911	0.301	
4:00	500	3.47×10^{-1}	1.32×10^{-5}	15.956	0.346	
4:30	530	3.68×10^{-1}	1.40×10^{-5}	16.010	0.400	
5:15	575	3.99×10^{-1}	1.52×10^{-5}	16.070	0.460	
6:00	620	4.31×10^{-1}	1.64×10^{-5}	16.120	0.510	
7:00	680	4.72×10^{-1}	1.80×10^{-5}	16.190	0.580	
7.15	695	4.83×10^{-1}	1.84×10^{-5}	16.210	0.600	

AQUIFER TEST DATA SHEET

Observation Well No. OW-1

Project No. E167

Test Well No. Universal City Station

Date of Test 04/16/83

Static Water Level 18.04

Observed By TDH

Radius from Pumped Well 62.1

Average Discharge 30 gpm

Time	t min.	t days	t/r^2	Water Level feet	Drawdown, s feet.	Remarks
8:40 a	0			18.040	0.0	
8:51	11	7.64×10^{-3}	1.98×10^{-6}	18.050	0.010	
8:59	19	1.32×10^{-2}	3.42×10^{-6}	18.060	0.020	
9:06	26	1.81×10^{-2}	4.69×10^{-6}	18.065	0.025	
9:13	33	2.29×10^{-2}	5.94×10^{-6}	18.070	0.030	
9:17	37	2.57×10^{-2}	6.66×10^{-6}	18.075	0.035	
9:21	41	2.85×10^{-2}	7.39×10^{-6}	18.080	0.040	
9:28	48	3.33×10^{-2}	8.63×10^{-6}	18.085	0.045	
9:39	59	4.10×10^{-2}	1.06×10^{-5}	18.090	0.050	
9:51	71	4.93×10^{-2}	1.28×10^{-5}	18.100	0.060	
9:59	79	5.49×10^{-2}	1.42×10^{-5}	18.110	0.070	
10:04	84	5.83×10^{-2}	1.51×10^{-5}	18.120	0.080	
10:10	90	6.25×10^{-2}	1.62×10^{-5}	18.130	0.090	
10:15	95	6.60×10^{-2}	1.71×10^{-5}	18.135	0.095	
10:20	100	6.94×10^{-2}	1.80×10^{-5}	18.145	0.105	
10:30	110	7.64×10^{-2}	1.98×10^{-5}	18.160	0.120	
10:45	125	8.68×10^{-2}	2.25×10^{-5}	18.180	0.140	
11:00	140	9.72×10^{-2}	2.52×10^{-5}	18.190	0.150	
11:20	160	1.11×10^{-1}	2.88×10^{-5}	18.210	0.170	
11:40	180	1.25×10^{-1}	3.24×10^{-5}	18.235	0.195	
12:00	200	1.39×10^{-1}	3.60×10^{-5}	18.260	0.220	
12:30	230	1.60×10^{-1}	4.15×10^{-5}	18.290	0.250	

[illegible]	t min.	t days	t/r^2	Water level feet	Drawdown, s feet	Remarks
1:00	260	1.81×10^{-1}	4.69×10^{-5}	18.540	0.300	
1:30	290	2.01×10^{-1}	5.21×10^{-5}	18.370	0.330	
2:00	320	2.22×10^{-1}	5.76×10^{-5}	18.400	0.360	
2:35	355	2.47×10^{-1}	6.40×10^{-5}	18.450	0.410	
3:00	380	2.64×10^{-1}	6.85×10^{-5}	18.490	0.450	
4:05	445	3.09×10^{-1}	8.01×10^{-5}	18.560	0.520	
4:30	470	3.26×10^{-1}	8.45×10^{-5}	18.580	0.540	

AQUIFER TEST DATA SHEET

Observation Well No. OW-2

Project No. E167

Test Well No. Universal City Station

Date of Test 04/16/83

Static Water Level 15.52

Observed By TDH

Radius from Pumped Well 161.9

Average Discharge 30 gpm

Time	t min.	t days	t/r^2	Water Level feet	Drawdown, s feet.	Remarks
8:40	0			15.520		
8:41	1	6.94×10^{-4}	2.65×10^{-8}	15.525	0.005	
8:44	4	2.78×10^{-3}	1.06×10^{-7}	15.530	0.010	
8:46	6	4.17×10^{-3}	1.59×10^{-7}	15.535	0.015	
8:49	9	6.25×10^{-3}	2.38×10^{-7}	15.540	0.020	
8:52	12	8.33×10^{-3}	3.18×10^{-7}	15.547	0.027	
8:55	15	1.04×10^{-2}	3.97×10^{-7}	15.556	0.036	
8:57	17	1.18×10^{-2}	4.50×10^{-7}	15.559	0.039	
9:00	20	1.39×10^{-2}	5.30×10^{-7}	15.564	0.044	
9:04	24	1.67×10^{-2}	6.37×10^{-7}	15.568	0.048	
9:07	27	1.88×10^{-2}	7.17×10^{-7}	15.575	0.055	
9:12	32	2.22×10^{-2}	8.47×10^{-7}	15.583	0.063	
9:17	37	2.57×10^{-2}	9.80×10^{-7}	15.591	0.071	
9:22	42	2.92×10^{-2}	1.11×10^{-6}	15.600	0.080	
9:27	47	3.26×10^{-2}	1.24×10^{-6}	15.610	0.090	
9:30	50	3.47×10^{-2}	1.32×10^{-6}	15.612	0.092	
9:35	55	3.82×10^{-2}	1.46×10^{-6}	15.615	0.095	
9:40	60	4.17×10^{-2}	1.59×10^{-6}	15.621	0.101	
9:50	70	4.86×10^{-2}	1.84×10^{-6}	15.629	0.109	
10:00	80	5.56×10^{-2}	2.12×10^{-6}	15.640	0.120	
10:10	90	6.25×10^{-2}	2.38×10^{-6}	15.645	0.125	
10:20	100	6.94×10^{-2}	2.65×10^{-6}	15.655	0.135	

Time	t min.	t days	t/r^2	Water level feet	Drawdown, s feet	Remarks
10:30	110	7.64×10^{-2}	2.91×10^{-6}	15.665	0.145	
10:45	125	8.68×10^{-2}	3.31×10^{-6}	15.685	0.165	
11:00	140	9.72×10^{-2}	3.71×10^{-6}	15.695	0.175	
11:20	160	1.11×10^{-1}	4.23×10^{-6}	15.710	0.190	
11:40	180	1.25×10^{-1}	4.77×10^{-6}	15.720	0.200	
12:00	200	1.39×10^{-1}	5.30×10^{-6}	15.735	0.215	
12:30	230	1.60×10^{-1}	6.10×10^{-6}	15.750	0.230	
1:00	260	1.81×10^{-1}	6.91×10^{-6}	15.760	0.240	
1:30	290	2.01×10^{-1}	7.67×10^{-6}	15.775	0.255	
2:00	320	2.22×10^{-1}	8.47×10^{-6}	15.785	0.265	
2:35	355	2.47×10^{-1}	9.42×10^{-6}	15.800	0.280	
3:00	380	2.64×10^{-1}	1.01×10^{-5}	15.810	0.290	
4:05	445	3.09×10^{-1}	1.18×10^{-5}	15.835	0.315	
4:30	470	3.26×10^{-1}	1.24×10^{-5}	15.840	0.320	

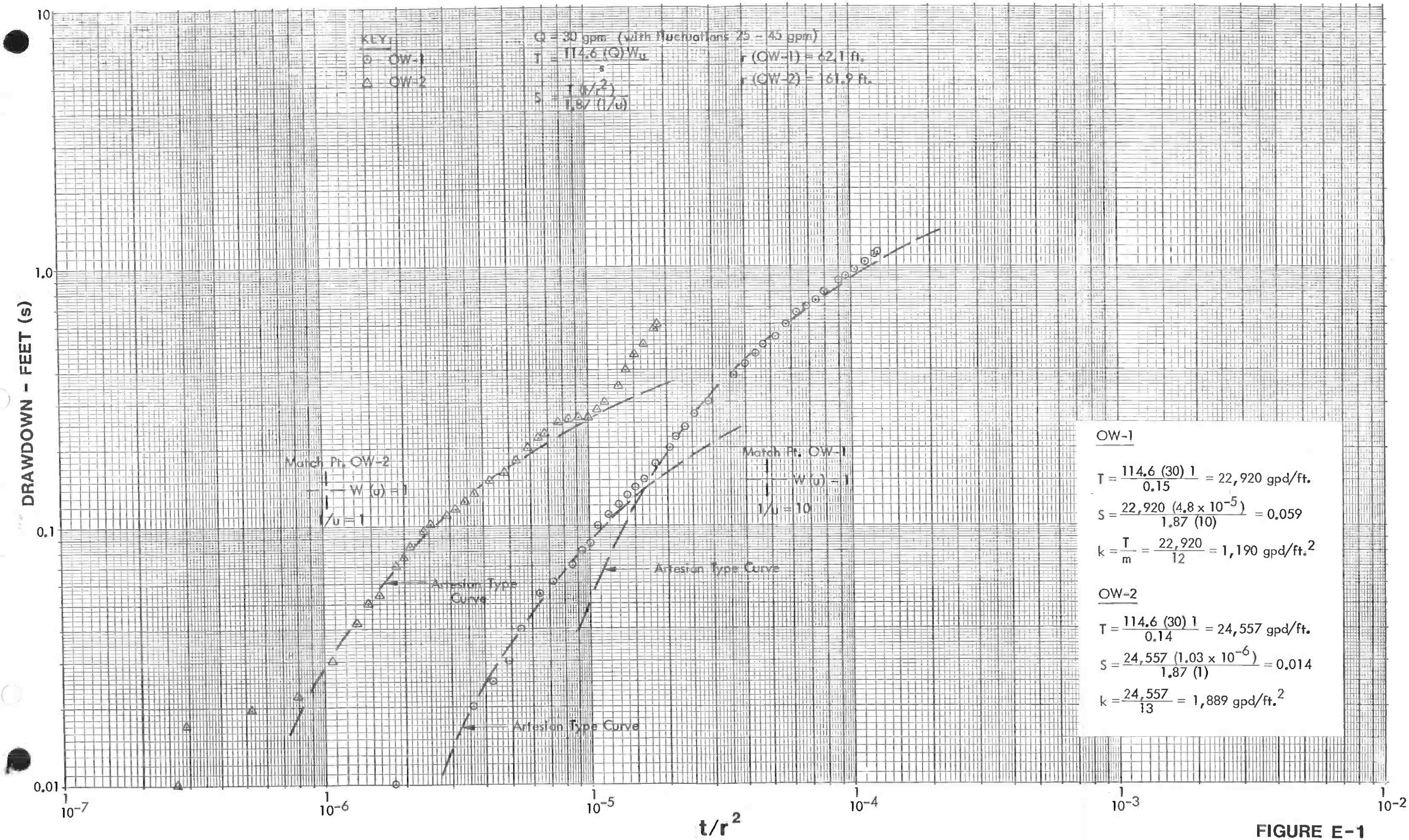
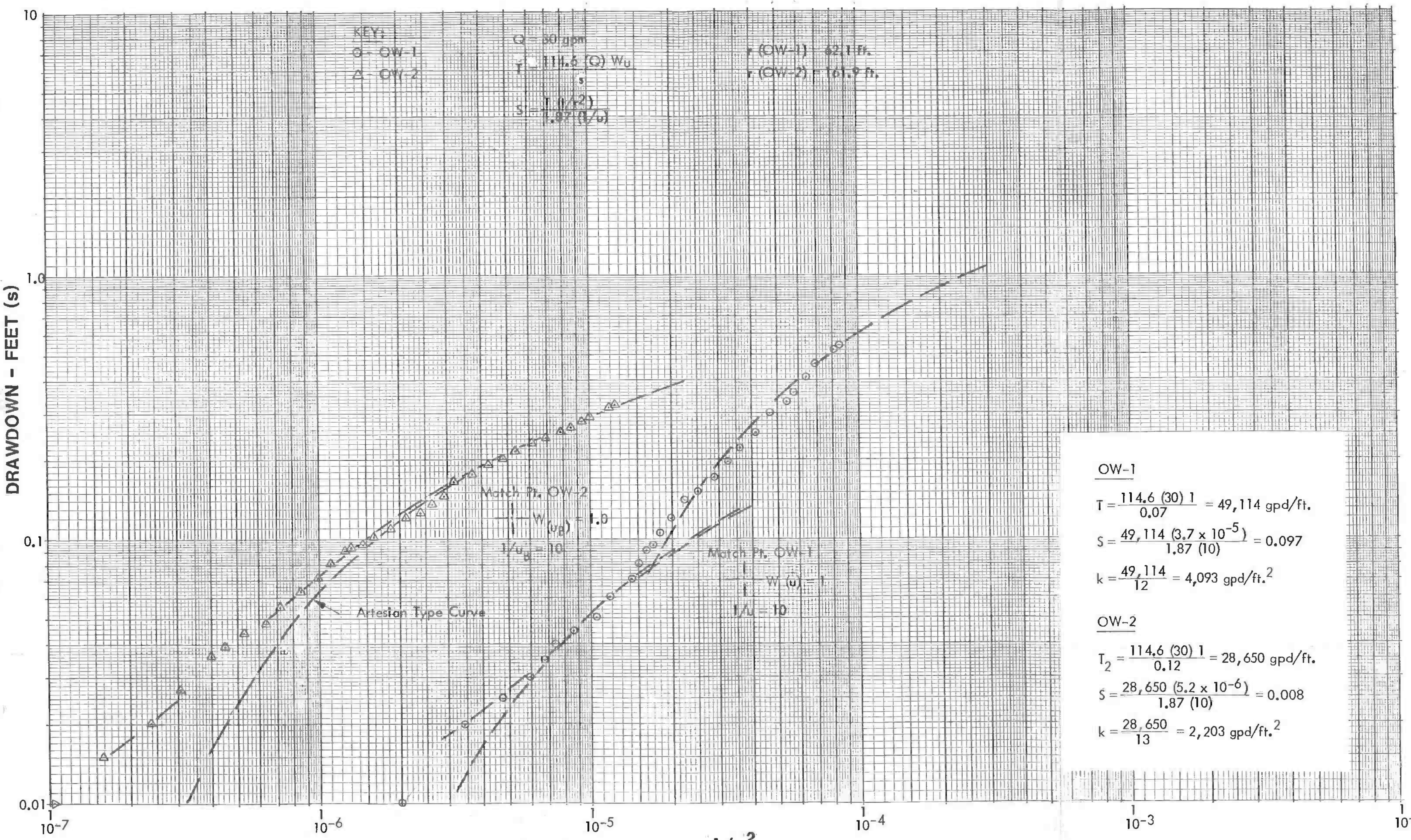

KEY:
⊙ - OW-1
△ - OW-2
Q = 30 gpm (with fluctuations 25 - 45 gpm)
T = 114.6 (Q) Wu / s
S = T (t/r²) / 1.87 (1/u)
r (OW-1) = 62.1 ft.
r (OW-2) = 161.9 ft.
Match Pt. OW-2
W (u) = 1
1/u = 1
Match Pt. OW-1
W (u) = 1
1/u = 10
Artesian Type Curve
Artesian Type Curve
Artesian Type Curve
DRAWDOWN - FEET (s)
t/r²
OW-1
T = 114.6 (30) 1 / 0.15 = 22,920 gpd/ft.
S = 22,920 (4.8 x 10⁻⁵) / 1.87 (10) = 0.059
k = T/m = 22,920 / 12 = 1,190 gpd/ft.²
OW-2
T = 114.6 (30) 1 / 0.14 = 24,557 gpd/ft.
S = 24,557 (1.03 x 10⁻⁶) / 1.87 (1) = 0.014
k = 24,557 / 13 = 1,889 gpd/ft.²

FIGURE E-1



OW-1

$$T = \frac{114.6\ (30)\ 1}{0.07} = 49,114 \text{ gpd/ft.}$$

$$S = \frac{49,114\ (3.7 \times 10^{-5})}{1.87\ (10)} = 0.097$$

$$k = \frac{49,114}{12} = 4,093 \text{ gpd/ft.}^2$$

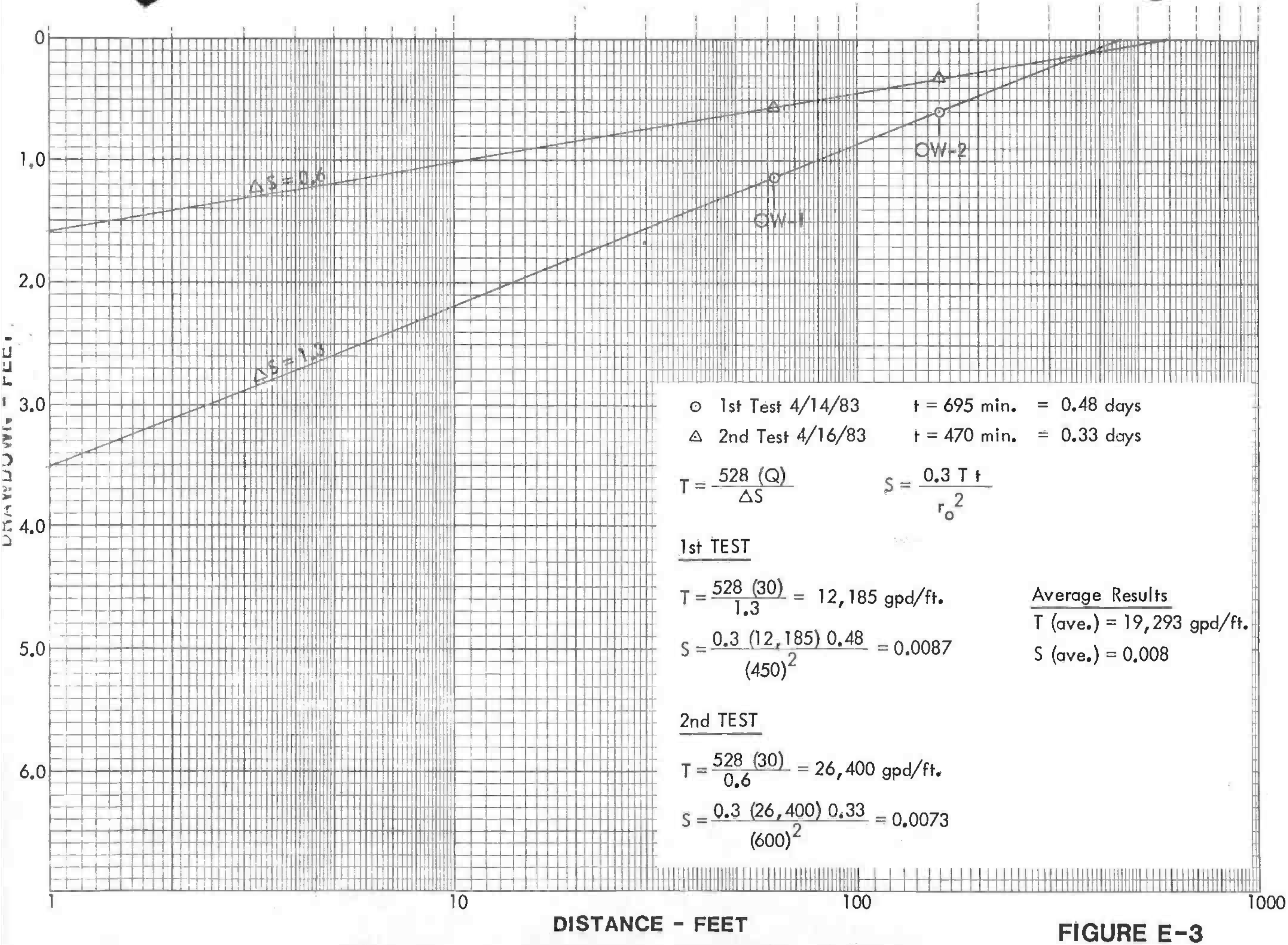
OW-2

$$T_2 = \frac{114.6\ (30)\ 1}{0.12} = 28,650 \text{ gpd/ft.}$$

$$S = \frac{28,650\ (5.2 \times 10^{-6})}{1.87\ (10)} = 0.008$$

$$k = \frac{28,650}{13} = 2,203 \text{ gpd/ft.}^2$$

FIGURE E-2



0
1.0
2.0
3.0
4.0
5.0
6.0
1
10
100
1000
DISTANCE - FEET
ΔS = 0.6
ΔS = 1.3
OW-1
OW-2
⊙ 1st Test 4/14/83 t = 695 min. = 0.48 days
△ 2nd Test 4/16/83 t = 470 min. = 0.33 days
$T = \frac{528 (Q)}{\Delta S}$ $S = \frac{0.3\ T\ t}{r_o^2}$
1st TEST
$T = \frac{528 (30)}{1.3} = 12,185$ gpd/ft.
$S = \frac{0.3 (12,185)\ 0.48}{(450)^2} = 0.0087$
2nd TEST
$T = \frac{528 (30)}{0.6} = 26,400$ gpd/ft.
$S = \frac{0.3 (26,400)\ 0.33}{(600)^2} = 0.0073$
Average Results
T (ave.) = 19,293 gpd/ft.
S (ave.) = 0.008

FIGURE E-3

Appendix F

Previous Tunnelling Experience

Section 6.0: Previous Tunneling Experience in Area

Los Angeles is one of the world's largest cities in area, and with a metropolitan population of over seven million people. More than 60 tunnels, with total length greater than 50 miles, have been bored within the city limits (Proctor, 1973). This history of local tunneling experience was reviewed, with particular attention to case histories that involved geologic formations or settings similar to those anticipated along the Metro Rail alignment. The tunnels selected for detailed study and presented herein are:

- Metropolitan Water District of Southern California (MWD) San Fernando Tunnel
- MWD Newhall Tunnel (LAC)
- City of Los Angeles Sewer Tunnel
- MWD Hollywood Tunnel
- Los Angeles County Flood Control District (LACFCD) Sacatella Tunnel
- MWD Tonner Tunnel

The use of case histories can provide general information on the response of the materials to excavation, methods of excavation and support, construction problems, rates of advance and costs. However, overall success or failure of each tunnel project was dependent on the site-specific geology, methods of excavation and support employed, and organization of the contractor.

6.1 MWD SAN FERNANDO TUNNEL

6.1.1 Facts and Figures

Tunnel Length	29,100 ft (5.5 miles)
Tunnel Diameter	22 ft O.D. excavated; 18 ft I.D. concrete lined
Initial Support	Precast concrete segmented ring 4 segments/ring; segments 8 in. thick & 4 ft wide
Excavation Method	Digger-type Robbins excavator mounted in a shield (the last 1,000 ft were conventional drill & blast)
Geology	Soft sandstone & siltstone (Pico Formation) & Old Alluvium
Eventual Use	MWD water supply tunnel
Contractor	Lockheed Shipbuilding & Construction Company Seattle, Washington
Bid Price	$19,346,800 on February 20, 1969
Estimated Bid Completion Time	1,360 working days
Tunneling Period	January 1970 to November 1975; gas explosion stopped work for 27 months

6.1.2 Major Progress, Prior to Ground Water Problem

During the latter period of the first 17,000 feet of tunneling, record advances were made using a Robbins-built shield, swinging and sliding boom with a rotatable digging head:

104 feet in one 8-hour shift
277 feet in one 3-shift day
1,077 feet for a 5-day week
3,500 feet for one month.

A special tunnel-liner erector installed 4-foot-long concrete segments at a rate of 12 per hour over an 80-hour week to support the shield's 144-hour weekly operation (Construction Methods and Equipment, January 1971, p. 1).

Excavated material consisted of dry and water-bearing Old Alluvium sand, with minor gravel and cobbles, lightly cemented to the extent that slight ripping was required.

6.1.3 Ground Water in Old Alluvium

Just west of the North Olive View fault (see Figure 6-1) substantial amounts

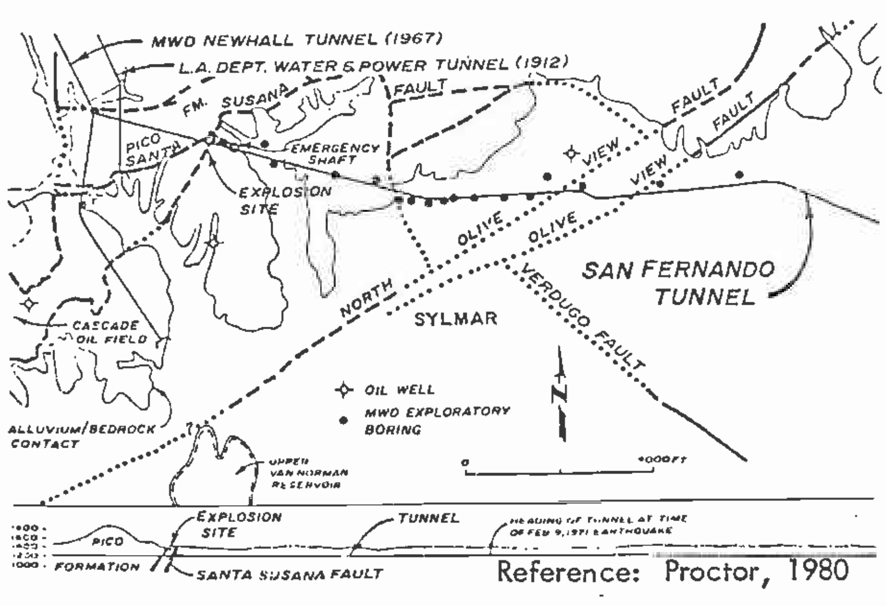


Fig.6-1 *Map and section along part of the San Fernando Tunnel.*

of water (1,400 gpm peak inflow) were forecast and encountered in the Old Alluvium. In this area, tunnel cover was about 140 feet. Prior to encountering this water, rate of advance was 150 to 200 feet per 3-shift day; in the water zone, the advance rate was still a respectable 60 feet per 8-hour shift; the other two shifts drilled horizontal dewatering holes ahead of the shield.

The following are excerpts from California Builder and Engineer, March 26, 1971:

- In late 1970, the excavation encountered perched ground water that sprayed the miners with water under slight pressure.
- Water pressure was relieved by three-inch borings drilled horizontally ahead of the excavator 150 to 250 feet.
- Two-inch perforated plastic pipe was inserted to drain ahead of the heading. This reduced the digging to a single shift per day and slowed progress considerably.

6.1.4 Solution to Ground Water Problem

(The following are excerpts from B.P. Boisen of A.A. Mathews, Inc., Memorandum, March 22, 1971, p. 5).

There are several perched water tables in the tunnel area, and test holes by the owner had pinpointed them before Lockheed Shipbuilding & Construction Co. (LSCC) started work. The solution was horizontal dewatering because an impervious stratum just beneath the tunnel grade would have made dewatering by wells ineffective. Drilling ahead of the shield brought the water around it and into the tunnel where it could be pumped out.

- Horizontal holes were drilled from 150 to 250 ft ahead of the shield, i.e., starting about 30 ft back of the face, running as close to the tunnel edge as possible. The drill stem cut a 4-in-diameter hole and 10-ft-long, 1.5-in-diameter hollow slotted plastic pipe sections were driven inside the drill stem.

- Water drained into the pipe slots and into the tunnel. There, a pair of pumps discharged the water into a surface flood control channel and through holes drilled down from a street above.

6.1.5 Effects of San Fernando Earthquake

On February 9, 1971, a 6.4 Richter Magnitude earthquake occurred, with an epicenter only a few miles from the San Fernando Tunnel. The following was noted from excerpts of Engineering News Record, June 24, 1971, p. 25:

- The tunnel did not suffer any major damage, however, the shield was squeezed laterally and tightly bound in place. It took two weeks to free the shield by jetting along the skin at three o'clock and nine o'clock.
- Tunnel work continued, with all workmen on hand, after a three-day shutdown to assess damage.
- When level coordinates were shot from undisturbed benchmarks, it showed that the east portal elevation was 7.2 ft higher than its original position. The gate structure shaft, about midway through the tunnel, was 2.5 ft higher. And the west portal, where the bore ties into Magazine Canyon shaft and Newhall Tunnel, was up 1.25 ft.

- There were no visible changes in the tunnel, largely due to the articulated precast tunnel supports. The segments are independent of each other, and there was opportunity for movement.
- Nearly 3.5 miles of tunnel were finished when the quake struck and the 7-ft uplift can be absorbed in moving individual segments such a slight amount that it would not be detected by the naked eye.

6.1.6 Caving Problems

(The following are excerpts from B.P. Boisen of A.A. Mathews, Inc., Memorandum, March 22, 1971, p. 4).

In the Old Alluvium west of the North Olive View fault, where the ground water was encountered, the contractor was plagued with problems. Approximately nine times there were runs at the face of several thousand gallons of water, sand and gravel. A number of times a cave would develop up to 40 feet above the shield. When the shield had advanced beyond these runs, the contractor would drill a hole from the surface and drop sand into the void. Grout was then pumped into the sand. On one occasion, a 10-ft-diameter cave worked its way to the surface of Foothill Boulevard. The contractor poured sand into the void and added a surcharge of sand about 8 feet above the street. The next day the sand had settled to around 12 feet below the street.

The shield was equipped with six breast doors that were used to support the upper half of the face. Generally the contractor advanced the shield through these troublesome zones with the breast doors closed and the apron full of muck. This then imposed a greater thrust on the precast segments during shoves. This was when the contractor started using 10 inch-thick segments (instead of original 8 inch-thick segments) to develop the thrust necessary to shove the shield.

6.1.7 Fatal Gas Explosion

(The following are excerpts from R.J. Proctor, 1980, "San Fernando Tunnel Explosion", Underground Space, v. 4, no. 4, p. 217-219).

At 12:30 a.m. on the morning of June 24, 1971, a fatal gas explosion occurred in a Los Angeles area tunnel. Of the heading crew, 17 workers died and one survived. The explosion halted work for 2 1/2 years due to settlement discussions and new contractual agreements. Only 2,500 feet remained to "hole-through" the 5.5-mile tunnel. The explosion occurred near the Santa Susana fault (see Figure 6-1). Several events occurred that provided evidence of a possible gas hazard. The MWD geologic report, given with the specifications to all bidders, warned of the possibility of encountering oil and/or gas in the western part of the tunnel route. This warning was based on:

- producing oil fields in the region, one within 1.7 miles
- oil and tar seeps in the area
- the presence of Pico Formation sandstone, a known producer of oil in the western part of the tunnel route

- the presence of oil and gas in two nearby tunnels - The L.A. Dept. of Water and Power's Newhall Tunnel in 1912, and the MWD's Balboa Tunnel in 1967
- the location of the Santa Susana fault, which acts as an oil trap for the nearby Cascade oil field
- several months prior to the explosion, the contractor posted a notice that stated "expect explosive gas ahead"
- one day before the explosion, a core with "kerosene or diesel smell" was extracted from the face
- one day before the incident, a minor gas explosion occurred that sent four miners to the hospital.

Work resumed 27 months after the disaster, and was completed in November 1975. Most of the interval was spent working out an agreement between the owner and the contractor on procedures and costs, but without the admission of liability by either side.

To complete the tunnel, a board of tunnel consultants (J. Barry Cooke, Lyman D. Wilbur and J. Donavan Jacobs) was convened. Their recommendations, all of which were complied with, included:

- increasing the ventilation system from the rated 35,000 cfm to 70,000 cfm [This can move air down the tunnel at the rate of 200 ft per min.]
- building a remote hydraulic system to power the repaired boring machine
- installing a multiple-head constant monitoring system for gas, plus two full-time sniffer men
- drilling at all times during tunnel excavation at a minumum of 20 ft into the face [Contractor elected to drill 80-ft holes and use up 60 ft before redrilling.] Four holes should be drilled into the face while in the Santa Susana fault zone. [Clay in the fault planes may accumulate gas behind them.]
- limiting daily advances to 20 ft [After this restriction and the TBM were removed, maximum progress was no more than 25 ft daily.]
- drilling a ventilation shaft 150 ft deep, and incorporating a rescue chamber and emergency ladder 600 ft back of the heading.

The following are excerpts from B.P. Boisen of A.A. Mathews, Inc., Memorandum, March 27, 1974, p. 2-3:

After the explosion, and upon resumption of tunneling, with increased ventilation gas monitors did not detect concentrations greater than 7 percent LEL, and gas was not encountered when the heading was beyond the Santa Susana fault zone and into the siltstones, sandstones and conglomerates of the Pico Formation.

In the opinion of B.P. Boisen of A.A. Mathews, successful tunneling in gassy conditions is possible and can be attributed to:

Adequate Ventilation	90%
Constant Testing and Monitoring	9%
Use of Permissible Equipment	1%

The 1% of success due to using permissible equipment is the major cost factor and is looked upon with the most dislike.

6.2 MWD NEWHALL TUNNEL

6.2.1 Facts and Figures

Tunnel Length	3.5 miles (Magazine Canyon to City of Newhall)
Tunnel Diameter	26 ft O.D. excavated; 20.5 ft I.D.
Initial Support	Steel ring beams & wood lagging; also precast concrete lining 3 segments/ring, 12 in. thick & 4 ft wide
Excavation Method	By Kiewit: a Calweld oscillating cutter head TBM (8000 ft) By Dixon: a Calweld rotary cutter head TBM (10,000 ft)
Geology	Hard to soft sandstone (Pico Formation) & gravelly, cobbly sandstone (Saugus Formation) with oil seeps
Eventual Use	MWD water supply tunnel
Contractor	L.E. Dixon Co., Arundel Corp., MacDonald & Kruse, Inc., & Peter Kiewit Sons' Co. (joint venture)
Bid Price	$35,000,000 awarded June 1966
Tunneling Period	1966-1970

6.2.2 Excavation Progress

(The following are excerpts from Maynard M. Anderson, Civil Engineering, Sept 1970, p. 69).

- After rotary boring 10,000 feet, the contractor chose to abandon the "mole", since the weakly consolidated sedimentary rock would frequently slough ahead and above the cutting wheel, stalling the machine and necessitating extensive hand-cribbing of the overbreak. Despite this set-back, the average driving rate was probably better than what it would have been with conventional tunneling. Through ideal ground for the "mole" [CWDD note: in dry, moderately consolidated siltstone and sandstone], it bored over 100 ft in a single 3-shift day.
- Later [September 1969] the contractor started a second heading using a Calweld oscillating mining machine. This machine is mounted in a 26-ft O.D. full-circle shield that thrusts against a tunnel support system almost identical to the Tabor (MEMCO) tunnel lining. Excellent progress was made ... about 100 ft per working day ... through soft but well-standing sedimentary rock.

(The following are excerpts from LeVitt, R.R. of A.A. Mathews, Inc., Memorandum, June 2, 1970, p. 3-4).

- Some sandstone at the face was so hard that it was broken down only by the shearing action of the drag cutters on the [oscillating] cutter head ... lenses of cobbles were noted in the face and these were being sheared off or dislodged with some difficulty ... the contractor has not experienced any severe ground water conditions ... the ground generally has been a fine-grained dense sandstone with a very low percolation rate.
- Pushing the Calweld rotary shield through the earth required a very heavy thrust [nearly 4,000 tons] against a firm base. The contactor felt the walls of the bore were too soft to serve as such a base, therefore, it was decided to axially thrust against the tunnel support system. This necessitated moving the wooden lagging from outside to between the circular steel ribs, where the "tight" lagging would provide support for the forward thrust of the shield.

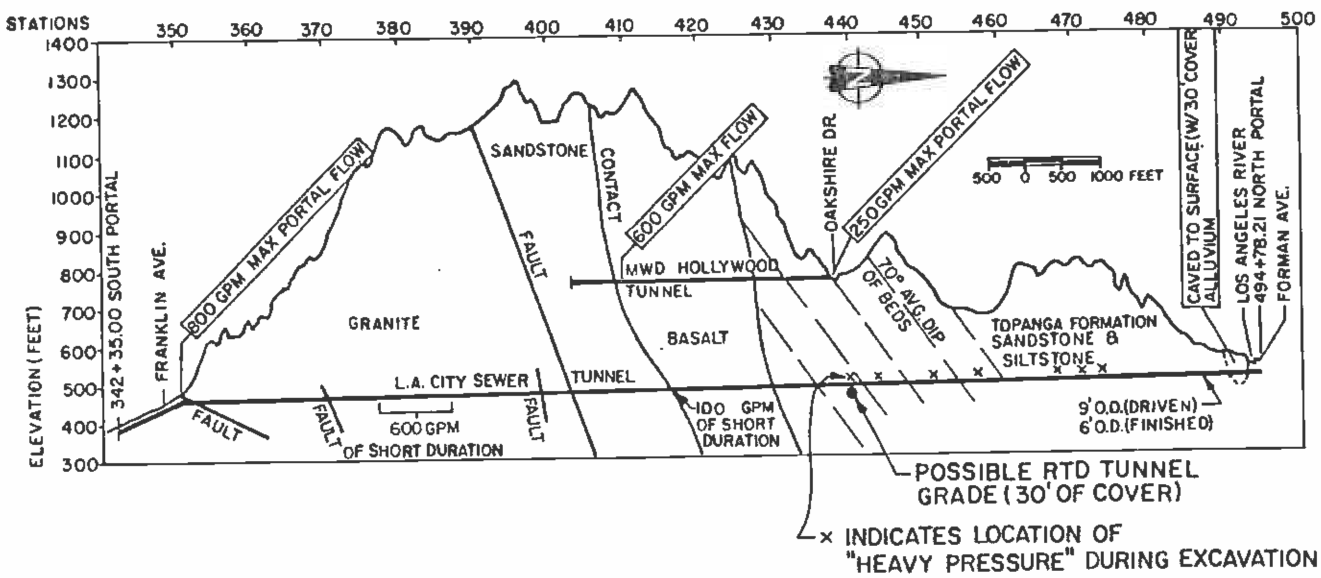
6.3 LAC (LA CIENEGA - SAN FERNANDO VALLEY) SEWER TUNNEL

6.3.1 Facts and Figures

Tunnel Length	2.8 miles
Tunnel Diameter	9.0 ft O.D. excavated
Initial Support	4 in. steel ribs & wood lagging; when soft ground encountered, steel liner plates
Excavation Method	Conventional jumbo drill & blast
Geology	Conglomerate, Sandstone, Shale (Topanga formation) . . . . 8,000 ft Granite . . . . 4,700 ft Basalt . . . . 1,200 ft Young Alluvium . . . . 430 ft 14,330 ft
Eventual Use	Sewer tunnel, City of Los Angeles
Contractor	L.E. Dixon Co.; lining, Kemper Construction Co.
Bid Price	$3,200,000
Tunneling Period	1954-56

6.3.2 Relation to Metro Rail Alignment

Except for the granite, Reach 7 of the Metro Rail alignment will pass through geologic formations similar to those encountered in this tunnel. Reach 7 is also very close to the Los Angeles City Sewer Tunnel (see Drawing 1 for location and Drawings 2 and 11 for subsurface relationships). Some recorded ground water inflows and geologic formations are presented in the profile on Figure 6-2.



NOTE: See Drawing No. 1, "Geologic Map" for location of City Sewer Tunnel

REFERENCE:
1. L.A. City "Key Plan & Profile", La Cienega & San Fernando Valley Relief Sewer, Drawing No. D-10565 Sheet 2 of 17 8-12-53
2. Campbell, D.G., 1955, Geologic Notes and Log of Los Angeles Sewer Tunnel

LOS ANGELES CITY SEWER TUNNEL PROFILE

Southern California Rapid Transit District
METRO RAIL PROJECT

CWDD/ESA/GRC Geotechnical Consultants

Scale —	Project No. 80-1280
Date NOV., 1981	
Prepared by J.A.C.	Figure No.
Checked by H.A.S.	6-2
Approved by H.A.S.	

This sewer tunnel encountered inflows greater than 100 gpm for a few hours to one day at seven locations along its 2.8-mile length. Maximum water flow from the down gradient south Portal was reported to be 1,200,000 gallons per day (gpd), or 800 gpm, but averaged 400,000 gpd (see Figure 6-2). Based on the final selected tunnel grade, the Metro Rail alignment will probably pass under the existing Los Angeles City Sewer tunnel. "Heavy ground pressures" were reported in the shaley parts of the Topanga Formation and in the sheared granite.

6.3.3 Problems in "Muddy" Young Alluvium - North End

The contractor installed steel ribs and lagging progessing southerly to Station 491+33 near the Los Angeles River at North Hollywood. At this point, under shallow cover, a wet, muddy Young Alluvium channel was encountered which had not been indicated in the geologists' report. The formation was chiefly mud, and the loads imposed on the steel ribs caused some sets to fail. This created an emergency condition, causing caving to the surface (see Figure 6-2) and the contractor installed heavy timber sets. This proved successful.

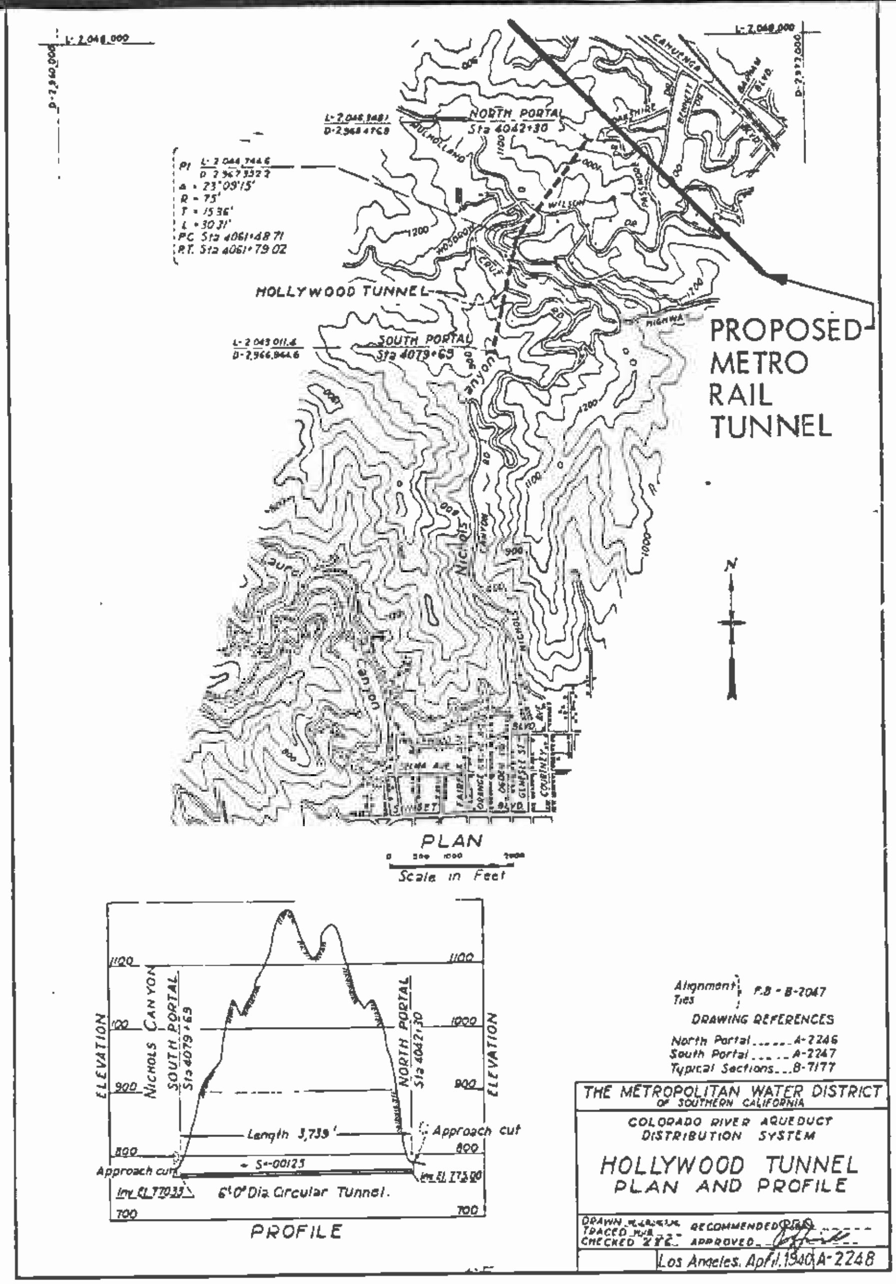
6.4 MWD HOLLYWOOD TUNNEL

6.4.1 Facts and Figures

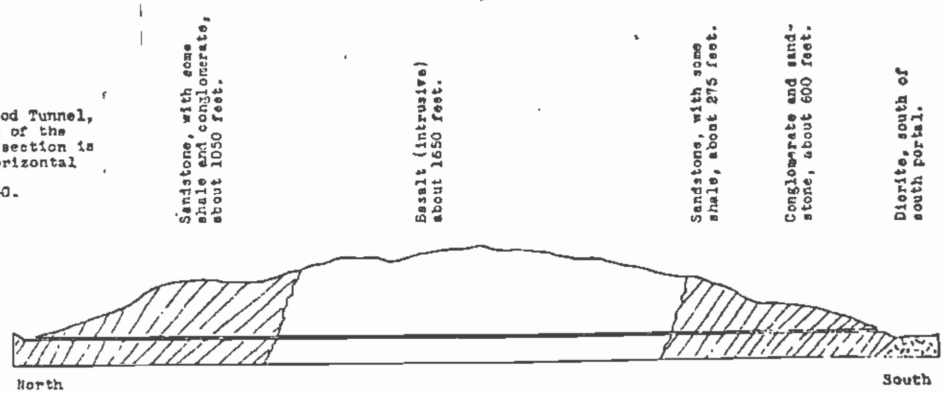
Tunnel Length	0.7 miles
Tunnel Diameter	8.0 ft
Initial Support	Steel ribs & wood lagging
Excavation Method	Drill & blast
Geology	Conglomerate, Sandstone, Shale (Topanga formation) . . . . 1,600 ft Basalt . . . . 2,100 ft 3,700 ft.
Eventual Use	MWD water supply tunnel
Contractor	J.F. Shea Co., Inc.
Bid Price	$190,000
Tunneling Period	June 1940 - May 1941

6.4.2 Relation to Metro Rail Alignment

The Hollywood Tunnel is located approximately 400 feet above the proposed Metro Rail alignment (see Drawing 1 for location). The basalt unit was mostly hard and dense and was described as good blasting rock (but contains soft ash and volcanic breccia layers, as revealed in logs of the tunnel). Water seeps were common, and on one occasion a maximum temporary inflow of about 600 gpm was recorded at the sandstone/basalt fault contact at the north end. No major



Geologic Cross Section of Proposed Hollywood Tunnel, showing rocks to be traversed and attitude of the sedimentary strata. Elevation of base of section is 700 feet above sea level. Vertical and horizontal scale: 400 feet equals 1 inch.
Geology by John P. Buwalda. April 16, 1940.



MWD HOLLYWOOD TUNNEL - GEOLOGIC PLAN AND PROFILE

Southern California Rapid Transit District
METRO RAIL PROJECT

Project No. 80-1280

Figure No. 6-3

CWDD/ESA/GRC Geotechnical Consultants

Approved for publication ________ by ________ faults were encountered and no squeezing ground was encountered. A geologic profile and plan view are presented on Figure 6-3.

6.5 LACFCD SACATELLA TUNNEL

6.5.1 Facts and Figures

The following tunneling data were received in an oral communication in June 1981 with the contractor, Donald Glanville of Glanville Construction Company, and John E. Witte, Tunnel Consultant, as well as LACFCD Pre-construction "Geologic Report", dated December 26, 1973; and Victor L. Wright's "Pre-Bid Geologic Appraisal" report, dated July 1975.

Tunnel Length	0.6 miles
Tunnel Diameter	18 ft O.D. excavated; 14.5 ft I.D.
Initial Support	Precast concrete liner (3 segments/ring)
Excavation Method	Digger Gradall & shield
Advance Rate	Maximum 32 ft/8-hr shift; average 15 ft
Geology	Claystone, siltstone & occasional interbeds of very hard "calcareous" cemented sandstone
Eventual Use	Storm drain, LACFCD
Contractor	Glanville Construction Co.
Bid Price	±$4,000,000
Extras Awarded	±$500,000
Tunneling Period	1975-77

6.5.2 Relation to Metro Rail Alignment

The Los Angeles County Flood Control District's (LACFCD) Sacatella Tunnel is in litigation for "changed (geologic) conditions" in the tunnel (settled) and at both portals (unsettled). For this reason, the LACFCD was reluctant to release information.

Geologic conditions and tunneling methods in this tunnel are very important to the Metro Rail alignment because:

- Tunnel was excavated in a "gassy" reach under Hoover Street, north of Wilshire Boulevard, in claystone, siltstone and sandstone of the Puente Formation (Unit C), at the location shown on Drawing 1.

Appendix G

Earthwork Recommendations

APPENDIX G EARTHWORK RECOMMENDATIONS

The following guidelines are recommended for earthwork associated with site development. Recommendations for dewatering and major temporary excavations are presented in the text.

- Site Preparation (surface structures): Existing vegetation, debris, and soft or loose soils should be stripped from the areas that are to be graded. Soils containing more than 1% by weight of organics may be re-used in planter areas, but should not be used for fill beneath building and paved areas. Organic debris, trash, and rubble should be removed from the site. Subsoil conditions on the site may vary from those encountered in the borings. Therefore, the soils engineer should observe the prepared graded area prior to the placement of fill.

- Minor Construction Excavations: Temporary dry excavations for foundations or utilities may be made vertically to depths up to 5 feet. For deeper dry excavations in existing fill or natural materials up to 15 feet, excavations should be sloped no steeper than 1:1 (horizontal to vertical).

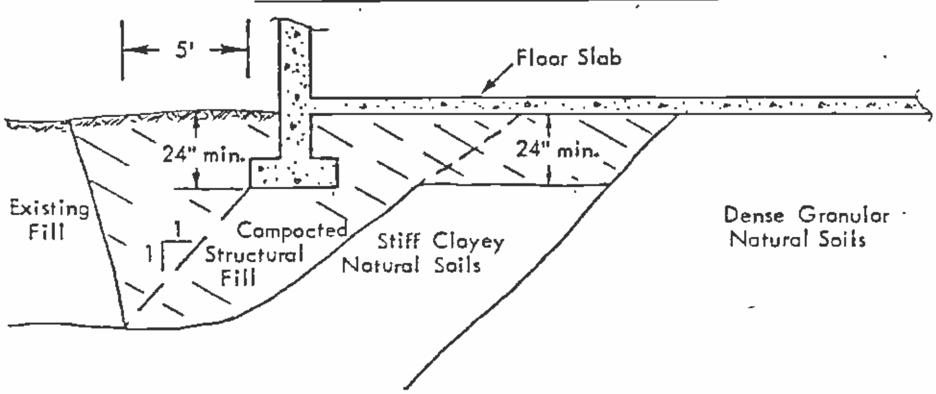
- Structural Fill and Backfill: Where required for support of near surface foundations or where subterranean walls and/or footings require backfilling, excavated onsite granular soils or imported granular soils are suitable for use as structural fill. Loose soil, formwork and debris should be removed prior to backfilling the walls. Onsite soils or imported granular soils should be placed and compacted in accordance with "Recommended Specifications for Fill Compaction". In deep fill areas or fill areas for support of settlement-sensitive structures, compaction requirements should be increased from the normal 90% to 95% or 100% of the maximum dry density to reduce fill settlement.

  Where space limitations do not allow for conventional backfill compaction operations, special backfill materials and procedures may be required. Sand-cement slurry, pea gravel or other selected backfill can be used in limited space areas. Sand-cement slurry should contain at least 1-1/2 sacks cement per cubic yard. Pea gravel should be placed in a moist condition or should be wetted at the time of placement. Densification should be accomplished by vibratory equipment; e.g., hand-operated mechanical compactor, backhoe mounted hydraulic compactor, or concrete vibrator. Lift thickness should be consistent with the type of compactor used. However, lifts should never exceed 5 feet. A soils engineer experienced in the placement of pea gravel should observe the placement and densification procedures to render an opinion as to the adequate densification of the pea gravel.

  If granular backfill or pea gravel is placed in an area of surface drainage, the backfill should be capped with at least 18 inches of relatively impervious type soil; i.e., silt-clay soils.

- Foundation Preparation: Where foundations for near surface appurtenant structures are underlain by existing fill soils, the existing fill should be excavated and replaced with a zone of properly compacted structural fill. The zone of structural fill should extend to undisturbed dense or stiff natural soils. Horizontal limits of the structural fill zone should extend out from the footing edge a distance equal to 5 feet or 1/2 the depth of the zone beneath the footing (a 1:1 ratio), whichever is larger. The structural fill should be placed and compacted as recommended under "Structural Fill and Backfill".

FOUNDATION/SUBGRADE PREPARATION



- Subgrade Preparation: Concrete slabs-on-grade for near-surface structures within the alluvium may be supported directly on undisturbed stiff or dense materials. The subgrade should be proof rolled to detect soft or disturbed areas, and such areas should be excavated and replaced with structural fill. If existing fill soils are encountered in near surface subgrade areas, these materials should be excavated and replaced with properly compacted granular fill. Where clayey natural soils (near existing grade) are exposed in the subgrade, these soils should be excavated to a depth of 24 inches below the subgrade level and replaced with properly compacted granular fill. Where dense natural granular soils are exposed at slab subgrade, the slab may be supported directly on these soils. All structural fill for support of slabs or mats should be placed and compacted as recommended under "Structural Fill and Backfill".

- Site Drainage: Adequate positive drainage should be provided away from the surface structures to prevent water from ponding and to reduce percolation of water into the subsoils. A desirable slope for surface drainage is 2% in landscaped areas and 1% in paved areas. Planters and landscaped areas adjacent to the surface structures should be designed to minimize water infiltration into the subsoils.

- Utility Trenches: Buried utility conduits should be bedded and backfilled around the conduit in accordance with the project specifications. Where conduit underlies concrete slabs-on-grade and pavement, the remaining trench backfill above the pipe should be placed and compacted in accordance with "Structural Fill and Backfill".

- Recommended Specifications for Fill Compaction: The following specifications are recommended to provide a basis for quality control during the placement of compacted fill.

  1. All areas that are to receive compacted fill shall be observed by the soils engineer prior to the placement of fill.

  2. Soil surfaces that will receive compacted fill shall be scarified to a depth of at least 6 inches. The scarified soil shall be moisture-conditioned to obtain soil moisture near optimum moisture content. The scarified soil shall be compacted to a minimum relative compaction of 90%. Relative compaction is defined as the ratio of the inplace soil density to the maximum dry density as determined by the ASTM D1557-70 compaction test method.

  3. Fill shall be placed in controlled layers the thickness of which is compatible with the type of compaction equipment used. The thickness of the compacted fill layer shall not exceed the maximum allowable thickness of 8 inches. Each layer shall be compacted to a minimum relative compaction of 90%. The field density of the compacted soil shall be determined by the ASTM D1556-64 test method or equivalent.

  4. Fill soils shall consist of excavated onsite granular soils essentially cleaned of organic and deleterious material or imported soils approved by the soils engineer. All imported soil shall be granular and non-expansive or of low expansion potential (plasticity index less than 15%). The soils engineer shall evaluate and/or test the import material for its conformance with the specifications prior to its delivery to the site. The contractor shall notify the soils engineer 72 hours prior to importing the fill to the site. Rocks larger than 6 inches in diameter shall not be used unless they are broken down.

  5. The soils engineer shall observe the placement of compacted fill and conduct inplace field density tests on the compacted fill to check for adequate moisture content and the required relative compaction. Where less than 90% relative compaction is indicated, additional compactive effort shall be applied and the soil moisture-conditioned as necessary until 90% relative compaction is attained. The contractor shall provide level testing pads for the soils engineer to conduct the field density tests on.

Appendix H

Geotechnical Report References

APPENDIX H GEOTECHNICAL REPORTS REFERENCES

REPORT No.	REPORT DATE	LOCATION	CONSULTANT
43	05/82	Southwest corner Lankershim & Hollywood Freeway	Woodward/Clyde
45	09/29/61	Universal Studios	L.T. Evans
46	10/27/65	Universal Studios	L.T. Evans
47	08/06/74	Universal Studios	L.T. Evans
48	06/03/76	Universal Studios	L.T. Evans

Appendix I

Petrology

Appendix J: Petrology

J.1 INTRODUCTION

This appendix presents the results of the petrographic analyses performed by CWDD on selected rock samples obtained from Santa Monica Mountain cores in Borings CEG 30, 31, 32 and 32A. Petrographic descriptions of the thin sections examined are appended as pages 1068 through 1093.

The specific objectives of the petrograhpic analyses were to:

- Verify and supplement field identification of lithologies and rock affinities;
- Provide additional data on the mineralogical and micro-structural characteristics of selected rock samples recovered from cores;
- Compare and correlate lithologic characteristics of subsurface samples;
- Provide data to aid in interpretation of geologic relationships in the general vicinity of Borings CEG 30, 31, 32 and 32A.

J.2 PETROGRAPHIC PROCEDURE

Twenty-six rock samples obtained from Borings CEG 30, 31, 32 and 32A were selected for petrographic analyses. Thin sections were prepared by Von Hueue's Petrographic Thin Section Laboratory, Pasadena, California. Each rock sample was slabbed and trimmed, and the resulting rock chip was mounted on standard 27 and 46 mm glass slide(s). The mounted rock chip was then ground to a uniform thickness of 0.03 mm, polished and covered with a thin cover glass. If the rock sample was poorly consolidated, highly fractured or porous, it was impregnated with resin prior to preparation. The thin sections were routinely stained with sodium cobaltinitrate to aid in the identification of potash feldspars.

A petrographic polarizing microscope was used to examine the petrographic sections. The petrographic microscope is essentially a common-compound microscope modified for observation of the optical properties of non-opaque anisotropic minerals. It includes a rotating stage, an upper polarizer (commonly known as the analyzer) and a lower polarizer. Other accessories include an Amici-Bertrand lens, a condenser, and several varieties of compensating plates used in making optical determinations.

J.3 PETROGRAPHIC ANALYSES AND RESULTS

Systematic petrographic descriptions presented include rock name, approximate percentages of mineral constituents (visually estimated), texture, grain-size, structural features, and a brief description or characterization of the rock. The results of the petrographic analysis are presented on pages 1068 through 1093. Specialized petrographic nomenclature is used to describe various features useful in distinguishing rock types. Detailed treatment of this subject may be obtained from numerous reference texts; e.g., Williams, et al (1954). Sedimentary rocks were classified according to Folk (1974).

J.4 CONCLUSIONS

Based on the results of the petrographic analyses the basic rock names distinguished in each boring sampled are:

Boring CEG No.	Rock Name
30 (Odin at Cahuenga Blvd.)	Primarily fine sandstone (arkose), alternating with dolerite, amygdaloidal andesitic basalt
31 (Hollywood Bowl Area)	Primarily sandstone (arkose) alternating with dolerite and fault-related mylonite at 138.7 ft
32	Chiefly basalt and amygdaloidal vitrophyric basalt with sandstone interbed at 397.0 ft
32A	Fine to pebbly sandstone; no basalt

In summary, the predominant volcanic rock type analyzed is basalt, with minor (quantitatively less than 5%) dolerite and amygdaloidal andesitic basalt.

J.5 REFERENCES

Folk, R.L., 1974, Petrology of sedimentary rocks: Austin, Texas, Hemphill Publishing Company, 182 p.

Williams, F.J., Turner, F.S., and Gilbert, C.M., 1954, Petrography: W.H. Freeman and Company, Inc., 406 p.

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Petrographic Report

Boring No. 30

SHT. 1 Of 26

Project Name: SCRTD - METRO RAIL PROJECT	**Job No.** 80-1280
Date Sampled: ----	**Analysis By:** Stephen M. Testa **Date:** 04-13-81
Sample No. 30-69.0	**Source:** Depth 69.0 feet
Location: Cahuenga Blvd. north of Odin St.	
Megascopic Classification: FINE SANDSTONE	

PETROGRAPHIC ANALYSIS:

ROCK NAME: FINE SANDSTONE: SUBMATURE ARKOSE

MINERAL CONSTITUENTS:

Quartz	30	Organics	m
Feldspars		Sericite	m
Plagioclase	30	Amphibole	tr
Potassium Feldspar	20	Biotite	tr
Microcline	tr	Carbonate	tr
Lithic Fragments		Chlorite	tr
Sedimentary	-	Clay	tr
Volcanic	-	Clinopyroxene	tr
Metamorphic	-	Epidote	tr
Opaque Minerals	m	Garnet	tr
		Muscovite	tr

DESCRIPTION:

Submature, angular to subangular, poorly sorted, fine-grained sandstone with silica-filled hairline fractures apparent. Stratification is accented by coaly seams of deep reddish-brown to black organic matter, probably derived from terrestrial, woody sources. Compaction deformation is mininal.

Quartz is characterized by slight to strong undulose extinction ranging from single grains to polycrystalline quartz of metamorphic origin. Polycrystalline quartz, included in the estimated modal quartz percentage, is distinguished by its crenulated interphase boundaries and strong undulose extinction. Boehm lamellar, indicative of intense strain deformation, is evident in some quartz grains. Potassium feldspar occasionally contains muscovite inclusions. Alteration products include partial sericitization of the feldspars and partial chloritization of biotite.

Note:
m = minor constituents less than 5.0% in total volume.
tr = trace constituents less than 1.0% in total volume.

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Boring No. 30

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Project Name: SCRTD - METRO RAIL PROJECT			**Job No.** 80-1280
Date Sampled: ----	**Analysis By:** Stephen M. Testa		**Date:** 04-13-81
Sample No. 30-114.5	**Source:** Depth 114.5 feet		
Location: Cahuenga Blvd. north of Odin St.			
Megascopic Classification: FINE SANDSTONE			

PETROGRAPHIC ANALYSIS:

ROCK NAME: FINE SANDSTONE: SUBMATURE LITHIC ARKOSE

MINERAL CONSTITUENTS:

Quartz	30	Biotite	tr
Feldspars		Carbonate	tr
Plagioclase	25	Chlorite	tr
Potassium Feldspar	15	Clay	tr
Microcline	tr	Epidote	tr
Lithic Fragments		Garnet	tr
Sedimentary	-	Muscovite	tr
Volcanic	20		
Metamorphic	m		
Opaque Minerals	m		

DESCRIPTION:

Submature, angular to subangular, poorly sorted, fine-grained sandstone. No structural features apparent. Compaction deformation is mininal.

Quartz is characterized by slight to strong undulose extinction ranging from single grains to polycrystalline quartz of metamorphic origin. Numerous epidote inclusions are present in some potassium feldspar grains. Lithic constituents consist primarily of volcanic basalt fragments and subordinate schist fragments of metamorphic origin. The basalt rock fragments consist primarily of fine-grained hololycrystalline textures; plagioclase in some fragments is seen as randomly oriented laths with their interstices occupied by micro- to crypto-crystalline material, while others exhibit trachytic texture as a result of flow during emplacement. Albite quartz muscovite and quartz muscovite schists comprise the metamorphic rock fragments along with polycrystalline quartz previously mentioned. The metamorphic rock fragments are moderately foliated and totally recrystallized.

Note:
m = minor constituents less than 5.0% in total volume.
tr = trace constituents less than 1.0% in total volume.

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Boring No. 30

Project Name: SCRTD - METRO RAIL PROJECT	Job No. 80-1280
Date Sampled: ----	Analysis By: Stephen M. Testa — Date: 04-13-81
Sample No. 30-149.0	Source: Depth 149.0 feet
Location: Cahuenga Blvd. north of Odin St.	
Megascopic Classification: FINE SANDSTONE	

PETROGRAPHIC ANALYSIS:

ROCK NAME: FINE SANDSTONE: CALCITIC SUBMATURE LITHIC ARKOSE

MINERAL CONSTITUENTS:

Quartz	25	Amphibole	tr
Feldspars		Biotite	tr
Plagioclase	25	Chlorite	tr
Potassium Feldspar	10	Clay	tr
Microcline	tr	Epidote	tr
Lithic Fragments		Garnet	tr
Sedimentary	-	Muscovite	tr
Volcanic	10	Organics	tr
Metamorphic	5		
Calcite	25		
Opaque Minerals			
Pyrite	tr		
Others	m		

DESCRIPTION:

Submature, angular to subangular, poorly sorted, fine-grained sandstone. Poikilotropic calcite occurs as the cementing agent as well as irregular hairline fracture filling material. Compaction deformation is minimal.

Mineralogically, this rock sample is similar to sample number 30-114.5 with the exception to the preponderance of calcite. Polycrystalline quartz exhibiting strong undulose extinction is ubiquitous. Potassium feldspar grains occasionally contain inclusions of muscovite or epidote. Rock fragments of similar volcanic and metamorphic origin are also apparent.

Note:
m = minor constituents less than 5.0% in total volume.
tr = trace constituents less than 1.0% in total volume.

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Boring No. 30

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Project Name: SCRTD - METRO RAIL PROJECT	Job No. 80-1280
Date Sampled: ----	Analysis By: Stephen M. Testa Date: 04-13-81
Sample No. 30-168.0	Source: Depth 168.0 feet
Location: Cahuenga Blvd. north of Odin St.	
Megascopic Classification: DOLORITE	

PETROGRAPHIC ANALYSIS:

ROCK NAME: DOLERITE

MINERAL CONSTITUENTS:

Plagioclase (labradorite)	50
Augite	35
Chlorite	10
Opaque Minerals	m

DESCRIPTION:

Massive, medium-grained basalt characterized by holocrystalline subophitic texture; however, intergranular texture is also present. Plagioclase occurs as randomly oriented laths commonly exhibiting combined Albite-Carlsbad twinning with an anorthite content of An_{60}, that falling within the range of labradorite. Augite occurs as euhedral to subhedral crystals ranging in color from colorless to pinkish violet, suggesting the incorporation of Ti within its crystal structure during crystallization. Greenish brown chlorite occurs as a pseudomorph after olivine which has since been totally altered, and as an alteration product of augite. Randomly distributed equant grains and skeletal rods which penetrate nearby crystals characterize the opaque minerals. Based on mineralogy and texture, this basalt is classified as dolerite.

Note:
m = minor constituents less than 5.0% in total volume.

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Boring No. 30

Project Name: SCRTD - METRO RAIL PROJECT	**Job No.** 80-1280
Date Sampled: ----	**Analysis By:** Stephen M. Testa **Date:** 04-13-81
Sample No. 30-178.2	**Source:** Depth 178.2 feet
Location: Cahuenga Blvd. north of Odin St.	
Megascopic Classification: FINE SANDSTONE	

PETROGRAPHIC ANALYSIS:

ROCK NAME: VERY FINE TO FINE SANDSTONE: SUBMATURE LITHIC ARKOSE

MINERAL CONSTITUENTS:

Quartz	20	Biotite	tr
Feldspars		Clay	tr
Plagioclase	35	Clinopyroxene	tr
Potassium Feldspar	15	Epidote	tr
Lithic Fragments		Muscovite	tr
Sedimentary	-	Sphene	tr
Volcanic	25		tr
Metamorphic	tr		tr
Calcite	25		
Opaque Minerals	m		

DESCRIPTION:

Submature, angular to subrounded, poorly sorted, very fine- to fine-grained sandstone. No structural features readily apparent. Compaction deformation is minimal.

Mineralogically, this rock sample is similar to sample numbers 30-114.5 and 30-149.0, with the exception to the lower modal of volcanic rock fragments.

Note:
m = minor constituents less than 5.0% in total volume.
tr = trace constituents less than 1.0% in total volume.

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Boring No. 30

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Project Name: SCRTD - METRO RAIL PROJECT	**Job No.** 80-1280
Date Sampled: ----	**Analysis By:** Stephen M. Testa **Date:** 04-13-81
Sample No. 30-190.0	**Source:** Depth 190.0 feet
Location: Cahuenga Blvd. north of Odin St.	
Megascopic Classification: DOLERITE	

PETROGRAPHIC ANALYSIS:

ROCK NAME: DOLERITE

MINERAL CONSTITUENTS:

Plagioclase (labradorite)	45
Augite	20
Chlorite	35
Opaque Minerals	
Iron Oxides	tr
Others	tr

DESCRIPTION:

Massive, medium-grained basalt characterized by holocrystalline subophitic to ophitic texture. Plagioclase occurs as randomly oriented laths commonly exhibiting combined Albite-Carlsbad twinning with an anorthite content of An_{58}, that falling within the range of labradorite. Subhedral augite ranges in color from colorless to pinkish violet, suggesting the incorporation of Ti within its crystal structure during crystallization. The opaque minerals occur as randomly distributed equant grains occasionally showing skeletal growth. Brownish green chlorite exists as pseudomorphs after pre-existing olivine and in part as an alteration product of augite. In addition a fibrous form of green chlorite occuring in clusters and intermixed with the brownish green variety, is ubiquitous and probably resulted from continued hydrothermal alteration.

Based on mineralogy and texture, this sample is classified as dolerite. With the exception to being slightly coarser grained, it is similar both mineralogically and in part texturally to sample number 30-168.0

Note:
tr = minor constituents less than 1.0% in total volume.

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Boring No. 30

Project Name: SCRTD - METRO RAIL PROJECT	**Job No.** 80-1280
Date Sampled: ----	**Analysis By:** Stephen M. Testa **Date:** 04-13-81
Sample No. 30-206.0	**Source:** Depth 206.0 feet
Location: Cahuenga Blvd. north of Odin St.	
Megascopic Classification: BASALT	

PETROGRAPHIC ANALYSIS:

ROCK NAME: AMYGDALOIDAL ANDESITIC BASALT

MINERAL CONSTITUENTS:

Plagioclase	30
Clinopyroxene	15
Chlorite	30
Calcite	m
Zeolites	15
Opaque Minerals	
Iron Oxides	m
Others	m

DESCRIPTION:

Massive, fine-grained vesicular basalt consisting of randomly oriented, partially chloritized lath-like plagioclase and partially to totally chloritized clinopyroxene. Crystals suspected of being olivine have been totally altered to chlorite. Interstices are filled with chlorite and/or a dark mesotasis comprised of dark brown glass and minute opaque granules. Irregular shaped amygdules up to 10mm in maximum dimension are commonly rimmed by a dark brown to black cryptocrystalline material, probably glass; filling material is a combination of chlorite, calcite and/or various zeolites including analcite. Due to the high degree of chloritization, probably the result of hydrothermal alteration, anorthite content of the plagioclase was underterminable. Thus, this rock sample is classified as basaltic andesite due to its textural similarities to the basalts and fine-grained andesites.

Note:
m = minor constituents less than 5.0% in total volume.

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Boring No. 31

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Project Name: SCRTD - METRO RAIL PROJECT	Job No. 80-1280
Date Sampled: ----	Analysis By: Stephen M. Testa — Date: 04-09-81
Sample No. 31-84.0	Source: Depth 84.0 feet
Location: Cahuenga Blvd. in front of Hollywood Bowl	
Megascopic Classification: PEBBLY SANDSTONE	

PETROGRAPHIC ANALYSIS:

ROCK NAME: PEBBLY SANDSTONE: FOSSILIFEROUS IMMATURE VOLCANIC ARENITE

MINERAL CONSTITUENTS:

Lithic Fragments	60%
Matrix	40%

Lithic Fragments		Matrix	
Plagioclase	40	Cryptocrystalline material	65
Chlorite	25	Carbonate (microfossils)	15
Unknown	15	Plagioclase	10
Cryptocrystalline material	10	Quartz	m
Opaque minerals	m	Chlorite	tr
Zeolites	m	Muscovite	tr
		Opaque minerals	tr

DESCRIPTION:

Immature, angular to subangular, moderately sorted, fossiliferous, pebbly sandstone. Compaction deformation is minimal.

Lithic fragments are entirely volcanic in origin consisting of fine-grained amygdaloidal basalt rock fragments. Holocrystalline intersertal texture predominates evident by randomly oriented plagioclase laths in a groundmass of green chlorite, dark greenish brown cryptocrystalline material, and an optically undeterminable mineral specie, possibly of the zeolite variety. Zeolites, notably analcite, and radial fibrous chlorite also occur as secondary mineralization within the amygdules. The volcanic rock fragments are commonly zoned due to relatively less groundmass alteration along their respective rims.

The matrix consist primarily of micro- to cryptocrystalline material in part clay combined with organic matter. Microfossils are abundant and consist of foraminifera (uniserial and biserial varieties), in addition to mollusk and brachiopod fragments, and others.

Note:
m = minor constituents less than 5.0% in total volume.

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Boring No. 31

Project Name: SCRTD - METRO RAIL PROJECT	**Job No.** 80-1280
Date Sampled: ----	**Analysis By:** Stephen M. Testa **Date:** 04-09-81
Sample No. 31-126.0	**Source:** Depth 126.0 feet
Location: Cahuenga Blvd. in front of Hollywood Bowl	
Megascopic Classification: MEDIUM SANDSTONE	

PETROGRAPHIC ANALYSIS:

ROCK NAME: MEDIUM SANDSTONE: SCHISTOSE SUBMATURE LITHIC ARKOSE

MINERAL CONSTITUENTS:

Quartz	15	Amphibole	tr
Feldspars		Biotite	tr
Plagioclase	30	Clay	tr
Potassium Feldspar	m	Clinopyroxene	tr
Lithic Fragments		Epidote	tr
Sedimentary	-	Opaque minerals	tr
Metamorphic	-		
Volcanic	15		
Cryptocrystalline material	m		
Sericite	10		
Chlorite	20		

DESCRIPTION:

Submature, angular to subrounded, poorly sorted, medium-grained sandstone. Mineralogically, this sample is similar to sample numbers 30-114.5 and 30-178-.2. Structurally, this sample is moderately schistose with irregularly spaced comminuted layers. These layers consist primarily of chlorite or sericite enclosing grains of quartz and plagioclase laths that have been rotated and aligned, respectively, parallel to the gliding surfaces.

Lithic fragments are entirely volcanic in origin, exhibiting typical volcanic textures. Polocrystalline quartz is abundant and indicative of a metamorphic origin but is included in the modal quartz percentage.

Note:
m = minor constituents less than 5.0% in total volume.
tr = trace constituents less than 1.0% in total volume.

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Petrographic Report

Boring No. 31

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Project Name: SCRTD - METRO RAIL PROJECT	**Job No.** 80-1280
Date Sampled: ----	**Analysis By:** Stephen M. Testa **Date:** 04-09-81
Sample No. 31-133.6	**Source:** Depth 133.6 feet
Location: Cahuenga Blvd. in front of Hollywood Bowl	
Megascopic Classification: SANDSTONE CONGLOMERATE	

PETROGRAPHIC ANALYSIS:

ROCK NAME: MEDIUM TO PEBBLY SANDSTONE: SEMI-SCHISTOSE SUBMATURE LITHIC ARKOSE

MINERAL CONSTITUENTS:

Quartz	20
Feldspars	
Plagioclase	25
Potassium Feldspar	tr
Lithic Fragments	
Sedimentary	-
Volcanic	30
Metamorphic	tr
Chlorite	10
Cryptocrystalline material	m
Opaque minerals	m
Carbonate	m
Biotite	tr
Clinopyroxene	tr
Epidote	tr

DESCRIPTION:

Submature, angular to subrounded, poorly sorted, medium to granular sandstone. Mineralogically, this sample is similar to previously described submature lithic arkoses. Structurally, this sample differs in respect to a predominate semi-schistose cataclastic texture consisting of irregular gliding planes of finely comminuted layers.

Note:
m = minor constituents less than 5.0% in total volume.
tr = trace constituents less than 1.0% in total volume.

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Petrographic Report

Boring No. 31

Project Name: SCRTD - METRO RAIL PROJECT	**Job No.** 80-1280
Date Sampled: ----	**Analysis By:** Stephen M. Testa **Date:** 04-09-81
Sample No. 31-138.7	**Source:** Depth 138.7 feet
Location: Cahuenga Blvd. in front of Hollywood Bowl	
Megascopic Classification: METASANDSTONE	

PETROGRAPHIC ANALYSIS:

ROCK NAME: MYLONITE

MINERAL CONSTITUENTS:

Cryptocrystalline material	65
Plagioclase	20
Quartz	10
Opaque minerals	tr
Lithic fragments	tr
Potassium feldspar	tr
Biotite	tr
Clinopyroxene	tr
Epidote	tr
Hypersthene	tr

DESCRIPTION:

Cataclastic, schistose, intensely sheared, fine-grained rock characterized by fluxion structure. Wavy comminuted layers of varying thicknesses enclose porphyroclasts comprising about 40% in total volume. Cryptocrystalline material, consisting of a felty groundmass exhibits a preferred orientation parallel to the gliding surfaces. Grain fragments are enclosed and occasionally aligned parallel to the schistosity. Quartz grains are angular and exhibit microfracturing along with moderately altered plagioclase laths leaving trails of crushed particles.

Note:
tr = trace constituents less than 1.0% in total volume.

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Boring No. 31

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Project Name: SCRTD - METRO RAIL PROJECT	**Job No.** 80-1280
Date Sampled: ----	**Analysis By:** Stephen M. Testa **Date:** 04-09-81
Sample No. 31-142.6	**Source:** Depth 142.6 feet
Location: Cahuenga Blvd. in front of Hollywood Bowl	
Megascopic Classification: VERY FINE SANDSTONE	

PETROGRAPHIC ANALYSIS:

ROCK NAME: SILTY VERY FINE SANDSTONE: FOSSILIFEROUS SUBMATURE ARKOSE

MINERAL CONSTITUENTS:

Quartz	25	Amphibole	tr
Feldspars		Biotite	tr
Plagioclase	35	Chlorite	tr
Potassium Feldspar	10	Clay	tr
Muscovite	15	Epidote	tr
Organics	10	Opaque minerals	tr
Calcite	m	Sericite	tr

DESCRIPTION:

Stratified, submature, angular to subangular, fossiliferous, silty very fine-grained sandstone. Discordant irregular hairline veinlets are commonly filled with calcite. Stratification is accented by a preferred orientation of elongate minerals, notably muscovite, and by the ubiquitous occurence of discontinuous organic seams. Compactional deformation is minimal.

Quartz is commonly polycrystalline in nature. The feldspars show partial alteration to sericite and epidote. Foraminifers occur in trace amounts.

Note:
m = minor constituents less than 5.0% in total volume.
tr = minor constituents less than 1.0% in total volume.

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Boring No. 31

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Project Name: SCRTD - METRO RAIL PROJECT	**Job No.** 80-1280
Date Sampled: -----	**Analysis By:** Stephen M. Testa **Date:** 04-09-81
Sample No. 31-149.9	**Source:** Depth 149.9 feet
Location: Cahuenga Blvd. in front of Hollywood Bowl	
Megascopic Classification: VERY FINE SANDSTONE	

PETROGRAPHIC ANALYSIS:

ROCK NAME: SILTY VERY FINE SANDSTONE: FOSSILIFEROUS SUBMATURE ARKOSE

MINERAL CONSTITUENTS:

Quartz	20	Muscovite	m
Feldspars		Amphibole	tr
Plagioclase	35	Chlorite	tr
Potassium Feldspar	10	Epidote	tr
Carbonate	15		
Organics	15		

DESCRIPTION:

Stratified, submature, angular to subangular, poorly sorted, fossiliferous, silty very fine-grained sandstone. Discordant irregular hairline veinlets are filled primarily with calcite in combination with subordinate zeolites and plagioclase. Stratification is accented by a preferred orientation of elongate minerals, notably muscovite, and by the ubiquitous occurence of discontinuous organic seams. Compaction deformation is moderate.

Mineralogically, similar to sample number 31-142.6, with the exception to a higher preponderance of foraminifera (10% to 13% in total volume) and organic matter. Randomly distributed foraminifers, including uniserial and biserial species, show microtized wall structures and typical chamber shapes. Other microfossils are also present.

Note:
m = minor constituents less than 5.0% in total volume.
tr = minor constituents less than 1.0% in total volume.

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Boring No. 31

Project Name: SCRTD - METRO RAIL PROJECT		Job No. 80-1280
Date Sampled: ----	Analysis By: Stephen M. Testa	Date: 04-10-81
Sample No. 31-168.6	Source: Depth 168.6 feet	
Location: Cahuenga Blvd. in front of Hollywood Bowl		
Megascopic Classification: DOLERITE		

PETROGRAPHIC ANALYSIS:

ROCK NAME: DOLERITE

MINERAL CONSTITUENTS:

Plagioclase (labradorite)	65
Augite	30
Chlorite	m
Opaque Minerals	tr
Sericite	tr

DESCRIPTION:

Massive, fine-grained basalt consisting of randomly oriented lath-like plagioclase in an intergranular and occasional subophitic relationship with augite. Plagioclase phenecrysts are rare but, when present, show partial sericitization. Anorthite content of plagioclase is An_{64}, that falling within the range of labradorite. Randomly distributed subhedral augite crystals are slightly pleochroic, ranging in color from colorless to pinkish violet, suggesting incorporation of Ti within its crystal structure during crystallization. Augite occasionally occurs in radial clusters. Greenish brown chlorite occurs as an alteration product of augite and olivine. Crystals suspected of being olivine have been totally altered to chlorite. Chlorite also occurs as a coating along joint planes and in thin irregular veinlets, probably as a result of hydrothermal alteration.

Note:
m = minor constituents less than 5.0% in total volume.
tr = minor constituents less than 1.0% in total volume.

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Boring No. 32

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Project Name: SCRTD - METRO RAIL PROJECT	**Job No.** 80-1280
Date Sampled: ----	**Analysis By:** Stephen M. Testa **Date:** 04-10-81
Sample No. 32-77.6	**Source:** Depth 77.6 feet
Location: Cul de sac; west end of Hillpark Drive	
Megascopic Classification: BASALT	

PETROGRAPHIC ANALYSIS:

ROCK NAME: AMYGDALOIDAL VITROPHYRIC BASALT

MINERAL CONSTITUENTS:

Palagonite	
fresh	25
altered	40
Plagioclase (labradorite)	10
Olivine	m
Clinopyroxene	m
Chlorite	10
Zeolites	m
Iddingsite	tr
Opaque Minerals	tr
Pumpellyite?	tr

DESCRIPTION:

Massive, moderately fractured, fine-grained amygdaloidal basalt. Vitrophyric texture predominates consisting of randomly distributed blebs of pale yellow palagonite (fresh glass) enclosed by olive buff to reddish brown palagonite (altered glass) with ubiquitous perlitic cracks. Phenocrysts consist of euhedral to subhedral olivine, clinopyroxene and lath-like plagioclase microlites with an anorthite content of AN_{54}, that falling within the range of labradorite. Amygdules up to 2mm in maximum dimensionare darkly rimmed and characterized by a concentric radial fibrous texture. Filling material consists of chlorite and/or zeolites including analcite and stilbite. Fibrous chlorite also occurs in thin irregular veinlets possibly intermixed with pumpellyite (?).

Note:
m = minor constituents less than 5.0% in total volume.
tr = minor constituents less than 1.0% in total volume.

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Boring No. 32

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Project Name: SCRTD - METRO RAIL PROJECT	**Job No.** 80-1280
Date Sampled: ----	**Analysis By:** Stephen M. Testa **Date:** 04-10-81
Sample No. 32-131.0	**Source:** Depth 131.0 feet
Location: Cul de sac; west end of Hillpark Drive	
Megascopic Classification: BASALT	

PETROGRAPHIC ANALYSIS:

ROCK NAME: AMYGDALOIDAL VITROPHYRIC BASALT

MINERAL CONSTITUENTS:

Palagonite	
fresh	45
altered	25
Plagioclase (labradorite)	10
Olivine	m
Clinopyroxene	m
Chlorite	10
Zeolites	m
Iddingsite	tr
Opaque Minerals	tr

DESCRIPTION:

Massive, moderately fractured, fine-grained amygdaloidal basalt. Very similar to sample number 32-77.6, with the exception to a greater abundance of modal fresh unaltered palagonite.

Note:
m = minor constituents less than 5.0% in total volume.
tr = minor constituents less than 1.0% in total volume.

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Boring No. 32

Project Name: SCRTD - METRO RAIL PROJECT		**Job No.** 80-1280
Date Sampled: ----	**Analysis By:** Stephen M. Testa	**Date:** 04-10-81
Sample No. 32-152.0	**Source:** Depth 152.0 feet	
Location: Cul de sac; west end of Hillpark Drive		
Megascopic Classification: BASALT		

PETROGRAPHIC ANALYSIS:

ROCK NAME: AMYGDALOIDAL HYALOPILITIC BASALT

MINERAL CONSTITUENTS:

Cryptocrystalline material	35
Plagioclase (labradorite)	35
Chlorite	15
Zeolites	10
Sideromelane (basic glass)	m
Opaque Minerals	tr

DESCRIPTION:

Massive, moderately fractured, fine-grained amygdaloidal basalt. Hyalopilitic intersertal texture predominates consisting of randomly oriented lath-like plagioclase microlites with interstices filled with a mesostatis of micro- to cryptocrystalline dark brown to black glass, chlorite and opaque crystallites. Plagioclase has an anorthite content of An_{55}, that falling within the range of labradorite. These laths are characterized by acute fibrous terminations. Concentric to irregular-shaped amygdules up to 2mm in maximum dimension are commonly filled with radial fibrous chlorite and/or zeolites including stilbite and analcite. Healed irregular veinlets are also filled primarily with zeolites with some chlorite which commonly enclose fragments of the matrix material.

Note:
m = minor constituents less than 5.0% in total volume.
tr = minor constituents less than 1.0% in total volume.

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Boring No. 32

Project Name: SCRTD - METRO RAIL PROJECT	Job No. 80-1280
Date Sampled: ----	Analysis By: Stephen M. Testa Date: 04-10-81
Sample No. 32-175.0	Source: Depth 175.0 feet
Location: Cul de sac; west end of Hillpark Drive	
Megascopic Classification: BASALT	

PETROGRAPHIC ANALYSIS:

ROCK NAME: AMYGDALOIDAL VITROPHYRIC BASALT

MINERAL CONSTITUENTS:

Palagonite	
fresh	25
altered	55
Plagioclase (labradorite)	10
Chlorite	m
Clinopyroxene	m
Olivine	m
Zeolites	m
Iddingsite	tr
Opaque Minerals	tr

DESCRIPTION:

Massive, moderately fractured, fine-grained amygdaloidal basalt. Very similar to sample numbers 32-77.6 and 32-131.0 with a lesser abundance of modal fresh unaltered palagonite in comparison to sample number 32-131.0

Note:
m = minor constituents less than 5.0% in total volume.
tr = minor constituents less than 1.0% in total volume.

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Boring No. 32

Project Name: SCRTD - METRO RAIL PROJECT		Job No. 80-1280
Date Sampled: ----	Analysis By: Stephen M. Testa	Date: 04-10-81
Sample No. 32-248.0	Source: Depth 248.0 feet	
Location: Cul de sac; west end of Hillpark Drive		
Megascopic Classification: BASALT		

PETROGRAPHIC ANALYSIS:

ROCK NAME: AMYGDALOIDAL HYALOPILITIC BASALT

MINERAL CONSTITUENTS:

Cryptocrystalline material	30
Plagioclase (labradorite)	35
Chlorite	15
Zeolites	20
Sideromelane (basic glass)	m
Opaque Minerals	tr

DESCRIPTION:

Massive, moderately fractured, fine-grained amygdaloidal basalt. Mineralogically and texturally similar to sample number 32-152.0.

Note:
m = minor constituents less than 5.0% in total volume.
tr = minor constituents less than 1.0% in total volume.

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Boring No. 32

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Project Name: SCRTD - METRO RAIL PROJECT	Job No. 80-1280
Date Sampled: ---- / Analysis By: Stephen M. Testa	Date: 04-09-81
Sample No. 32-397.0 / Source: Depth 397.0 feet	
Location: Cul de sac; west end of Hillpark Drive	
Megascopic Classification: VERY FINE SILTY SANDSTONE	

PETROGRAPHIC ANALYSIS:

ROCK NAME: SILTY VERY FINE SANDSTONE: FOSSILIFEROUS SUBMATURE ARKOSE

MINERAL CONSTITUENTS:

Quartz	20	Chlorite	tr
Feldspars		Clay	tr
Plagioclase	35	Epidote	tr
Potassium Feldspar	m	Muscovite	tr
Carbonate	15	Oganics	tr
Opaque minerals	m		
Sericite	m		

DESCRIPTION:

Submature, subangular to subrounded, poorly sorted, fossiliferous, silty very fine-grained sandstone. Compositional banding indicative of primary depositional features apparent. Moderately fractured with micro-offsets along discordant hairline fractures and incipient shear planes; fractures commonly filled with calcite. Compositional deformation is minimal. Fossiliferous material consists of numerous randomly distributed foraminifers including uniserial and biserial species showing microtized wall structures and typical chamber shapes. Other microfossils are also present.

Note:
m = minor constituents less than 5.0% in total volume.
tr = minor constituents less than 1.0% in total volume.

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Boring No. 32A

Project Name: SCRTD - METRO RAIL PROJECT	Job No. 80-1280
Date Sampled: ----	Analysis By: Stephen M. Testa Date: 04-10-81
Sample No. 32A-117.5	Source: Depth 117.5 feet
Location: Oakshire Dr., 155' east of Passmore Dr. intersection	
Megascopic Classification: FINE SANDSTONE	

PETROGRAPHIC ANALYSIS:

ROCK NAME: FINE SANDSTONE: CALCITIC SUBMATURE LITHIC ARKOSE

MINERAL CONSTITUENTS:

Quartz	30	Chlorite	tr
Feldspars		Clay	tr
Plagioclase	30	Epidote	tr
Potassium Feldspar	15	Muscovite	tr
Microcline	tr	Opaque minerals	tr
Lithic Fragments			
Sedimentary	-		
Volcanic	10		
Metamorphic	tr		
Calcite	10		

DESCRIPTION:

Submature, angular to subangular, poorly sorted, fine-grained sandstone. Numerous voids are apparent, comprising about 40% of the total surface area of the slide. Compaction deformation appears mininal. Mineralogically similar to previously described submature lithic arkoses.

Quartz is characterized by slight to strong undulose extinction and ranges from single grains to polycrystalline in nature, indicative of metamorphic origin. The feldspars contain numerous inclusions of muscovite and epidote. Lithic fragments, primarily of volcanic origin, are characterized by holocrystalline fine-grained textures. Remnant pore space has been filled with later sparry calcite cement.

Note:
tr = trace constituents less than 1.0% in total volume.

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Boring No. 32A

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Project Name: SCRTD - METRO RAIL PROJECT	**Job No.** 80-1280
Date Sampled: ----	**Analysis By:** Stephen M. Testa **Date:** 04-10-81
Sample No. 32A-252.4	**Source:** Depth 252.4 feet
Location: Oakshire Dr., 155' east of Passmore Dr. intersection	
Megascopic Classification: MEDIUM SANDSTONE	

PETROGRAPHIC ANALYSIS:

ROCK NAME: FINE TO MEDIUM SANDSTONE: SUBMATURE LITHIC ARKOSE

MINERAL CONSTITUENTS:

Quartz	20	Amphibole	tr
Feldspars		Biotite	tr
Plagioclase	35	Calcite	tr
Potassium Feldspar	10	Chlorite	tr
Lithic Fragments		Epidote	tr
Sedimentary	-	Garnet	tr
Volcanic	25	Muscovite	tr
Metamorphic	m	Pumpellyite?	tr
Opaque Minerals		Sphene	tr
Pyrite	tr		
Others	m		

DESCRIPTION:

Submature, angular to subangular, poorly sorted, fine-grained sandstone. Compaction deformation is mininal. Mineralogically, this sample is similar to previously described submature lithic arkoses.

Note:
m = minor constituents less than 5.0% in total volume.
tr = trace constituents less than 1.0% in total volume.

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Boring No. 32A

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Project Name: SCRTD - METRO RAIL PROJECT	**Job No.** 80-1280
Date Sampled: ----	**Analysis By:** Stephen M. Testa **Date:** 04-10-81
Sample No. 32A-271.0	**Source:** Depth 271.0 feet
Location: Oakshire Dr., 155' east of Passmore Dr. intersection	
Megascopic Classification: SANDSTONE CONGLOMERATE	

PETROGRAPHIC ANALYSIS:

ROCK NAME: FINE TO PEBBLY SANDSTONE: SUBMATURE LITHIC ARKOSE

MINERAL CONSTITUENTS:

Quartz	15	Amphibole	tr
Feldspars		Biotite	tr
Plagioclase	30	Epidote	tr
Potassium Feldspar	10	Opaque minerals	tr
Lithic Fragments			
Sedimentary	-		
Volcanic	20		
Metamorphic	15		
Sericite	10		
Calcite	m		
Chlorite	m		

DESCRIPTION:

Submature, angular to subangular, moderately sorted, fine to pebbly sandstone. Compaction deformation is minimal. Lithic constituents consist primarily of volcanic rock fragments in association with subordinate metamorphic rock fragments. Mineralogically similar to previously described submature lithic arkoses. However, texturally, this sample is coarser grained.

Note:
m = minor constituents less than 5.0% in total volume.
tr = trace constituents less than 1.0% in total volume.

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Boring No. 32A

Project Name: SCRTD - METRO RAIL PROJECT	Job No. 80-1280
Date Sampled: ----	Analysis By: Stephen M. Testa — Date: 04-10-81
Sample No. 32A-320.5	Source: Depth 320.5 feet
Location: Oakshire Dr., 155' east of Passmore Dr. intersection	
Megascopic Classification: SANDSTONE CONGLOMERATE	

PETROGRAPHIC ANALYSIS:

ROCK NAME: FINE TO GRANULE SANDSTONE: SUBMATURE PHYLLARENITE

MINERAL CONSTITUENTS:

Quartz	20	Biotite	tr
Feldspars		Chlorite	tr
Plagioclase	15	Epidote	tr
Potassium Feldspar	10	Garnet	tr
Lithic Fragments		Opaque minerals	tr
Sedimentary	-		
Volcanic	10		
Metamorphic	35		
Calcite	m		
Sericite	m		

DESCRIPTION:

Submature, angular to subrounded, moderately sorted, fine to pebbly sandstone. Quartz is typically polycrystalline. Lithic constituents consist primarily of totally recrystallized metamorphic rock fragments in association with subordinate volcanic fragments. A variety of textures is exhibited among the metamorphic rock fragments and includes a preferred orientation of elongate minerals, preferred crystal alignment, foliation, and fluxion structure; mineral assemblages include quartz-albite-garnet-biotite-chlorite-sericite and quartz-albite-muscovite. Calcite occurs as a remnant pore space filling cement.

Note:
m = minor constituents less than 5.0% in total volume.
tr = trace constituents less than 1.0% in total volume.

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Boring No. 32A

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Project Name: SCRTD - METRO RAIL PROJECT		**Job No.** 80-1280
Date Sampled: ----	**Analysis By:** Stephen M. Testa	**Date:** 04-10-81
Sample No. 32A-346.2	**Source:** Depth 346.2 feet	
Location: Oakshire Dr., 155' east of Passmore Dr. intersection		
Megascopic Classification: SANDSTONE CONGLOMERATE		

PETROGRAPHIC ANALYSIS:

ROCK NAME: FINE TO PEBBLY SANDSTONE: SUBMATURE LITHIC ARKOSE

MINERAL CONSTITUENTS:

Quartz	25	Biotite	tr
Feldspars		Carbonate	tr
Plagioclase	10	Muscovite	tr
Potassium Feldspar	25	Opaque minerals	tr
Microcline	m	Sphene	tr
Lithic Fragments			
Sedimentary	-		
Volcanic	-		
Metamorphic	20		
Sericite	10		
Chlorite	m		

DESCRIPTION:

Submature, angular to subangular, moderately sorted, fine to pebbly sandstone. Microbrecciation of lithic clasts and microfracturing of mineral grains is suggestive of some cataclasis. Compaction deformation is mininal.

Quartz is characterized by angular grains that exhibit undulose extinction and commonly have been totally recrystallized. In addition to polycrystalline quartz, lithic rock fragments are entirely metamorphic and have undergone total recrystallization, exhibiting typical metamorphic textures.

Note:
m = minor constituents less than 5.0% in total volume.
tr = trace constituents less than 1.0% in total volume.

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Boring No. 32A

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Project Name: SCRTD - METRO RAIL PROJECT	**Job No.** 80-1280
Date Sampled: ----	**Analysis By:** Stephen M. Testa **Date:** 04-10-81
Sample No. 32A-386.5	**Source:** Depth 386.5 feet
Location: Oakshire Dr., 155' east of Passmore Dr. intersection	
Megascopic Classification: SANDSTONE CONGLOMERATE	

PETROGRAPHIC ANALYSIS:

ROCK NAME: MEDIUM TO PEBBLY SANDSTONE: SUBMATURE LITHIC ARENITE

MINERAL CONSTITUENTS:

Quartz	15	Biotite	tr
Feldspars		Calcite	tr
Plagioclase	20	Chlorite	tr
Potassium Feldspar	10	Sphene	tr
Lithic Fragments			
Sedimentary	-		
Volcanic	45		
Metamorphic	-		
Opaque Minerals	m		

DESCRIPTION:

Submature, angular to subrounded, poorly sorted, medium to pebbly sandstone. Compaction deformation is minimal. This sample is characterized by abundant volcanic lithic rock fragments of varying textures. Sharp irregular depositional contact between the submature volcanic arenite and a silt very fine sandstone with abundant organics is apparent in the corner of the slide.

Note:
m = minor constituents less than 5.0% in total volume.
tr = trace constituents less than 1.0% in total volume.