REPORT OF GEOTECHNICAL SURVEY
LIGO PROJECT
HANFORD, WASHINGTON
PURCHASE ORDER NO. PP066327

For

CALIFORNIA INSTITUTE OF TECHNOLOGY
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DAMES & MOORE

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TABLE OF CONTENTS

FIGURES

LIST OF APPENDICES

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1.0 INTRODUCTION

This report presents the results of the geotechnical survey for the proposed Laser Interferometer Gravitational Observation (LIGO) Project to be constructed near the Wye Barricade on the Hanford site near Richland, Washington. The location of the project with respect to the Hanford Reservation is shown on the Area Map, Plate 1. The purpose of this survey was to investigate subsurface conditions at the site and provide recommendations regarding the design and construction of foundations for the LIGO facility.

2.0 DESCRIPTION OF PROJECT

Information regarding the nature of the facilities to be constructed was obtained from discussions with Caltech and from the Caltech publication "Summary of the Concepts and Reference Design For a Laser Interferometer Gravitational Wave Observatory" dated February 1992. The facility will include an L-shaped structure with 4 Km (13,000-foot) long arms which enclose a 4-foot diameter steel tube for the laser beam. The beam tube will be supported on steel frames spaced at 40 to 60 feet on centers and attached to a 20-foot wide reinforced concrete foundation slab. The beam tube will also be enclosed in a 16-foot diameter reinforced concrete (sprayed-on shotcrete) arch enclosure which exerts a load of 2 kips per lineal foot on each side of the arch. The corner station will consist of an 80,000 square foot steel frame structure roughly 35 to 55 feet high. Foundations will consist of a continuous mat or a combination of shallow footings with mats supporting selected equipment. Column loads of approximately 40 to 100 kips are anticipated. The building will house a variety of overhead cranes.

The end and mid-stations along each leg of the L-shaped structure will have an area dimension of approximately 8000 square feet, and will be supported on a mat with foundation pressures possibly reaching 3000 pounds per square foot (psf).

The finished floor throughout the facility will be Elevation 528.

3.0 SCOPE OF SERVICES

The original scope of work for this project as requested by Caltech in the May 14, 1992 "Statement of Work For a Geotechnical Survey" is presented in Appendix G. Because of technical difficulties anticipated by Dames & Moore with the portion of work relating to geophysical testing, we prepared an alternative scope of services that was accepted by Caltech. Details of the revised scope are presented below:

1. Information Review

We will conduct a reconnaissance of the site to evaluate surface features and conditions that could be important to the development of the site. We will review geologic, geohydrologic and seismic information that currently exists for the Hanford site, including documents found in the files of Hanford site contractors and Dames & Moore. Information from the Fast Flux Test Facility, the Central Landfill, the Skagit Hanford Power Plant (never constructed) and the Basalt Waste Isolation Project will be especially important.

2. Drilling Program

We will obtain a subcontractor to drill the 41 borings shown on the May 14, 1992 Proposed Boring Layout by California Institute of Technology. The deepest boring will be approximately 60 feet deep and the shallowest will be 30 feet deep. The total drilling footage will be approximately 1860 feet. We will drill the borings using the hollow stem auger technique in order to minimize the cost of the drilling program. The drill rig will be capable of drilling by the mud rotary technique with minimal switch-over time in the event that especially difficult conditions are occasionally encountered. Soil samples and penetration resistance values will be obtained at 5-foot intervals in these holes. Soil samples will be collected for laboratory testing. Approximately one half of the samples will be collected using the Dames & Moore sampler, which provides a relatively undisturbed sample suitable for laboratory testing.

In addition to the above primary borings, we will drill 32 secondary borings to an average depth of about 20 feet each to investigate the nature of the near-surface soil most critical to the performance of the structure. Twenty eight (28) of these borings will be located midway between the primary borings, thereby reducing the overall spacing of borings to about 470 feet. The final 4 borings are discretionary, to be used to better define soil conditions at possible problem locations.

As part of the drilling (or field exploration) program, we will conduct in situ plate loading tests at a minimum of 2 locations along the beam tube alignment to measure the deformation modulus of the foundation material. The tests will be conducted in the near-surface dune sands at a depth of about 2 feet. The drill rig will be used as the reaction for the tests. If boring information for these sands indicates that they are obviously too loose for direct use as foundation support, we will delete the in situ plate loading tests and substitute laboratory triaxial shear tests on recompacted samples in order to measure the deformation modulus. As a further part of the drilling (field exploration) program, we will conduct percolation tests using U.S. Department of Health, Education and Welfare recommended methods for use in leach field design. Tests will be conducted at two locations.

3. Geophysical Survey

We propose to obtain shear wave velocity data by conducting downhole seismic tests in a minimum of 3 boreholes at key locations along the beam tube alignment. One hole (60-foot depth to Elevation 470) will be located at the corner station, and two others will be located at the end stations. This test also provides both shear and compressional wave velocity measurements over the entire depth of the hole. The data will be used to estimate dynamic characteristics of the subsoils. The downhole seismic tests will be conducted by our subcontractor Geo Recon International.

4. Laboratory Testing

We will measure physical, engineering, corrosion potential and thermal resistivity of soils at the site. Tests will be conducted for moisture content, density, and grain size distribution. Because of the windblown nature of near-surface soils, we will conduct collapse potential tests. We may also conduct triaxial compression tests to measure the deformation modulus of soils that will be important to the settlement performance of the structure. Because of the need for compacted fill over portions of the site below Elevation 528, we will perform compaction tests using soils that will be excavated and available for borrow.

We will conduct tests for pH, redox potential, electrical resistivity, and for sulfate, sulfide and chloride content of selected soils for estimation of corrosion potential. The full suite of these tests will be conducted on three soil samples from distributed locations along the beam tube alignment.

We will conduct thermal resistivity tests on at least two samples.

5. Foundation Recommendations - Static and Dynamic

We will provide recommendations for allowable bearing pressures for footings and mats, estimated settlements, lateral earth pressures, soil strength and frictional characteristics for resisting lateral load, and parameters for use in designing vibrating foundations. For the case of vibrating foundations we will recommend values of shear modulus and damping ratio, and will evaluate the potential for settlements induced by vibratory densification of foundation sands.

6. Seismic Recommendations

We will evaluate seismic conditions at the site and provide recommendations on static and, where appropriate, dynamic values of density, Poisson's Ratio, modulus of elasticity, shear modulus, coefficient of subgrade reaction and permeability. We will also provide guidance on selection of damping ratios for the soils encountered. We will evaluate the potential for surface faulting, liquefaction, settlements induced by seismic shaking, and will recommend an appropriate value of "site coefficient" as identified in the 1991 Uniform Building Code.

7. Corrosion Evaluation

We will evaluate the corrosion potential of the soils, including their possible impact on subsurface metallic and concrete structures, and recommend appropriate methods of mitigating any adverse impacts from corrosive conditions.

8. Site Preparation and Construction Measures

We will evaluate measures required to prepare the site and construct the facilities, and accordingly provide recommendations on cut and fill slope stability, excavation support, compacted fill placement, subgrade support and preparation for footings, floor slabs, mats, pavements and surface and subsurface drainage facilities.

The deliverable product for this project will be 20 copies of our geotechnical report delivered within 90 days following your written authorization to proceed.

4.0 SITE CHARACTERIZATION

4.1 GEOLOGIC SETTING

The site of the proposed structure lies in the Central Plains Section of the Columbia Intermontane physiographic province, and is more specifically situated within the Pasco Basin topographic depression created by the Columbia River. The terrain is relatively flat with features created by glacial-related floods and subsequently by alluvial and aeolain (wind blown) deposition.

The bedrock at the site is a very thick sequence of Columbia River basalts which occur at a depth of approximately 750 feet below the ground surface, or roughly Elevation -220. Overlying the basalts are Pliocene age lacustrine and fluvial deposits of the Ringold Formation. This formation consists of cemented soils ranging in gradation from coarse sands and gravels to some interlaminations of fine sand, silt, and clays. Overlying the Ringold Formation is a Pleistocene age glaciofluvial deposit called the Hanford Formation. It may consist of coarse sand and gravels (Pasco Gravel) in areas where flows were highest or a finer gradation (Touchet Beds) in slackwater areas. More recent deposits of loess, dune sand, alluvium and colluvium are found near the surface throughout the Hanford area.

The LIGO site is currently unoccupied, with a slightly undulating ground surface supporting a moderately thick cover of sage brush, cheatgrass and other deciduous plants of the area. Ground surface elevations range from approximately Elevation 510 to 550.

4.2 SITE SPECIFIC SUBSURFACE CONDITIONS

Subsurface conditions were investigated by drilling a total of 73 borings ranging in depth from 8 to 64 feet at locations shown on the Site Plan, Plate 2. The deepest borings extended to Elevation 466. Geophysical testing was performed in three of the borings (DM-1-92, DM-20-92 and DM-41-92), plate bearing tests were conducted at two locations and percolation tests were conducted in shallow hand-augered holes. Locations of the plate bearing and percolation tests are shown on Plate 2. Details of the field investigation program are presented in Appendix A, which also contains logs of the borings. A further description of field testing is presented in Section 4.3 and in Appendix B. A separate report of the geophysical tests is contained in Appendix D.

Additional information regarding subsurface conditions at the site was obtained from the Final Safety Analysis Report for the Skagit Hanford Nuclear Project (1984) and from logs of borings previously drilled in the vicinity by U.S. Department of Energy (DOE) contractors. The report for the Skagit Hanford Nuclear Project contains the results of borings, test pits, field tests, geotechnical analysis and foundation recommendations for the canceled nuclear power plant. Locations of these other borings are also shown on Plate 2. Selected boring logs from the previous studies are presented in Appendix E.

The field exploration information indicates that subsurface conditions at depths of importance to the LIGO project consist of a surficial layer of loose to medium dense light brown silty fine sand overlying a medium dense to dense deposit of gray sand. An estimated profile of soil conditions along the entire length of the LIGO structure is presented on Plates 3 through 6. A further discussion of each soil layer encountered, from the surface downward, is presented below:

Brown Silty Fine Sand

The surficial silty sand is typically 2 to 22 feet thick, light brown in color and medium dense in character, as measured by sampler penetration resistance ("N") values measured during drilling. The average thickness of this layer was approximately 7 feet for all borings drilled during this investigation. Although the range of N-values from this layer extends from 4 to 58 blows per foot, the average value is approximately 14 blows per foot. This would suggest a relative density for the surficial silty sand of roughly 70 percent. The loose zones within this layer were typically encountered in the upper 6 feet, but could extend deeper at some locations. A few zones within the lower portion of this layer were found to be in a dense condition, for example in boring DM-68-92 below 8 feet deep. Laboratory tests have indicated that the deposit is poorly graded and contains approximately 5 to 25 percent fines, which are primarily in the silt size range. Moisture contents were generally less than 4 or 5 percent except for the upper 6 feet or so, the soil can be characterized as having moderate strength and compressibility, with a low to moderate potential for collapse upon wetting. In its undisturbed condition, the silty sand should also be considered slightly to moderately susceptible to settlement during shaking from earthquakes or vibrating equipment. Plate bearing tests conducted in the upper portion of this layer indicate an elastic modulus (E) value of 290 KSF to 370 KSF for the virgin loading curves.

Gray Fine to Medium Sand

The underlying gray sand layer is typically a moderately well graded fine to medium soil with small proportions of coarse sand, gravel and silt. However, in some areas this layer grades more narrowly, and is classified as a primarily fine sand (for example, see Boring DM-14-92) with up to 10 percent silt. At such locations, the gradation characteristics of the gray sand is essentially the same as for the overlying brown sand. Occasionally a thin layer of silt or gravel was encountered, as well as zones of light cementation. The range of N values measured in this deposit extends from 8 to greater than 100 blows per foot, with an average value of over 35 blows per foot. An occasional loose zone was encountered, for example at a depth of 12 feet in Boring DM-26-92. The soil can be considered to possess high strength and low compressibility characteristics. All borings drilled during our investigation were terminated in this layer. Information from deeper borings that were previously drilled in the vicinity indicate that this soil layer extends to about Elevation 450, where somewhat coarser sands and gravels were encountered.

Basalt bedrock was encountered during previous investigations at a depth of about 740 feet, i.e. approximately Elevation -210. A generalized soil profile from the ground surface to the top of bedrock is presented on Plate 7. The actual profile may vary over the length of the proposed structure.

No groundwater was encountered in the borings drilled for this investigation. Previous investigations indicate that groundwater is encountered at approximately Elevation 400 in the vicinity of the LIGO project.

4.3 FIELD TESTING

4.3.1 Plate Bearing Tests

Plate bearing tests were conducted to measure the in situ elastic modulus and coefficient of subgrade reaction of the near-surface brown silty fine sand at two locations. The first test was located near Boring DM-25-92 on the Southwest leg, and was conducted at approximately Elevation 530. The second test was located near Boring DM-8-92 on the Northwest leg, and was conducted at approximately Elevation 525. Both tests were conducted at locations where the soil within the depth of influence of the 2-foot diameter plate consisted of the brown silty fine sand in a medium dense condition. Test results were as follows:

		Elastic Modulus (ksf)		**Subgrade Reaction Modulus (pci)**	
Test No.	**Station**	**Virgin Cycle**	**Reload Cycle**	**Virgin Cycle**	**Reload Cycle**
1	SW 20+00	370	1900	150	780
2	NW 84+50	290	880	120	400

Details of the tests and plots of the results are presented in Appendix B.

Results of plate bearing tests conducted by Golder Associates for the Skagit Hanford Nuclear Project indicated elastic modulus values in the range from about 1300 to 2800 ksf for the undisturbed gray fine to medium sand. These values were for the virgin loading curves. Apparently no plate bearing tests were conducted in the surficial brown silty fine sand layer during that investigation.

4.3.2 Percolation Tests

Percolation rates were measured in shallow hand-dug holes at two locations in the vicinity of the corner station in order to provide information for design of leach fields and seepage pits. Details of the tests are presented in Appendix B, and a discussion of the use of results is found in Section 5.8 Leach Fields.

4.3.3 Geophysical Testing

Compressional and shear wave velocity measurements were made by the downhole method in one boring at the corner station (DM-20-92) and in one boring at each of the end stations (DM-1-92 and DM-41-92). Measurements were made to depths up to 60 feet in each hole. Details of the test method and results are presented in Appendix D. The results indicate a 2-layer soil profile consisting of a lower velocity surficial material from 13 to 20 feet thick, underlain by a higher velocity layer which extends to the bottom of the holes. This concept is generally consistent with visual identification and N-value information obtained during drilling. However, the thickness of the surficial layer as interpreted from the seismic velocities is greater than indicated in the boring logs at each geophysical test location. Test results for two of the holes (DM-1 and DM-20) are similar, indicating average compressional and shear wave velocities of about 1960 fps and 890 fps respectively for the upper layer and 5080 fps and 1390 fps respectively for the lower layer (i.e. gray fine to medium sand). Tests in the third hole (DM-41-92) showed velocities that were roughly 20 percent lower than those for the other two holes. There is no immediately obvious explanation for the difference in velocity values, as soil descriptions and N-values were similar for all three borings.

During the Skagit Hanford Nuclear Project investigation, in situ velocity measurements were made using downhole, crosshole and surface refraction techniques. In the range from Elevation 450 to 510, which corresponds to depths occupied by the gray fine to medium sand, the shear wave velocities were similar to those measured by Dames & Moore. However, in that same depth range the compressional velocities were substantially lower than those measured by Dames & Moore.

A typical profile of soil conditions and geophysical parameters, including measured wave velocities and calculated shear modulus values, is presented on Plate 7. The data presented is a synthesis of data obtained from the LIGO investigation and from previous investigations at the Hanford site, particularly for the Skagit Hanford Nuclear Project.

4.4 LABORATORY TESTING

Selected samples were tested in the laboratory to obtain pertinent physical, engineering, chemical/electrochemical and thermal characteristics of the soils at the LIGO site. Details of the tests and tabular and graphical representations of the results are found in Appendix C. Results of tests for moisture content, density and percent fines are shown directly on the boring logs at the appropriate sample locations.

Collapse tests were conducted on samples of the brown silty fine sand in its undisturbed loose to medium dense condition and in a recompacted condition. A percentage of collapse (or "collapse potential") of 2 percent was measured for this soil in the "undisturbed" condition, suggesting "moderate trouble" for foundation design as defined by Jennings and Knight (1975) and the U.S. Navy (1982). This collapse percentage may be somewhat of an overestimate because of some sample disturbance that could be anticipated during test preparation for this type of soil. A percentage of collapse of about 0.1 percent was measured for the sample that was recompacted to 92 percent of the maximum dry density. No collapse problem is anticipated for this recompacted material.

Drained triaxial compression tests were conducted on a sample of the brown silty fine sand recompacted to 95 percent of its maximum dry density. The results indicated a surprisingly high elastic modulus value of 2600 ksf. A similar test conducted on a sample of the gray fine sand from Boring DM-38-92 in its natural condition indicated an elastic modulus value of about 1900 ksf. This value no doubt reflects some sample disturbance that is inevitable for samples of this type.

Results of compaction tests and sieve and hydrometer analyses are presented in Appendix C. The brown silty fine sand tends to be poorly graded with a Coefficient of Uniformity of 3 to 6. The gray fine to medium sand is typically more well graded with a CU of 10 or more. However, this lower layer also contains zones where the silt content may increase to 15 to 20 percent, and the gradations narrow to where CU values are also in the 3 to 6 range. Compaction tests were conducted for the brown silty fine sand, the gray fine to medium sand and for a mixture of the two that would create a well graded "select" fill material. Maximum dry densities all fall in the range from 110 to 120 pcf, with optimum moisture contents from 10 to 14 percent.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 GENERAL

All structures and equipment associated with the LIGO facility may be supported on shallow spread footings or mat foundations that are placed on either compacted on-site fill soil, or the surficial brown silty sand that has first been densified in the upper 8 feet (minimum), or on the gray fine to medium sand in its undisturbed condition. The variation in surface elevations is such that all three of the above-mentioned foundation support conditions will occur along the beam tube alignment. We do not recommend use of the surficial brown silty sand for foundation support without measures to densify the upper portion of this loose to medium dense stratum. Details of our recommendations are presented in the following sections.

5.2 FOUNDATIONS

5.2.1 Beam Tube

We recommend that foundation support for the beam tube consist of shallow footings placed on compacted fill or on the undisturbed sand deposits, depending on the original ground surface elevations. The ground surface at various locations along the beam tube alignment is as much as 18 feet below and 26 feet above the proposed finished floor grade (Elevation 528). Soils at the foundation level will therefore range from relatively deep fill to either the surficial brown silty fine sand layer or the gray fine to medium sand layer. Because of the loose character of portions of the brown silty fine sand, we recommend that foundations be supported on this material only after soil improvements efforts have been adopted in the upper 8 feet (minimum) to reduce the compressibility of this soil and minimize the potential for settlements from either saturation or vibratory ground motion. The brown silty fine sand layer should likewise be improved where it will underlie compacted fill used for foundation support.

An allowable bearing pressure of 2000 psf may be used for design of the beam tube foundation pad for any of the subgrade soil conditions described above. This value may be increased by one-third for transient loads from wind or seismic sources. Compacted fill should consist of either of the natural sand deposits encountered during this investigation, or a "select" mixture of the two. Proctor compaction tests results (see Plates C-5 and C-6) indicate that the maximum density of these two soils are not significantly different. The mixed "select" fill should contain no less than about 40 percent and not more than about 60 percent of either of the two natural sand deposits.

Soil improvement methods applied to the brown silty sand may consist of a combination of removal and recompaction together with in-place densification by vibratory rolling. We recommend that improvement methods be used where footings will be placed either on compacted fill or directly on the silty fine sand itself. As a minimum, the upper 8 feet of the silty fine sand layer should be removed and the exposed subgrade rolled with a heavy vibratory roller. If after removal of the upper 8 feet, the exposed soil still appears to be in a loose condition, additional soil should be excavated until a satisfactory subgrade condition is encountered. We expect that such additional excavation may be needed on an infrequent basis. At least three passes should be made using a roller having a minimum overall weight of 15,000 pounds and a minimum operating frequency of 1750 vibrations per minute (Dynapac CA 15A or equivalent). Proof-rolling of the subgrade is not necessary when the gray sand is encountered unless requested by the soils engineer. The excavated soil should replaced by compacting in 8 to 10 inch thick lifts to at least 95 percent of the maximum dry density as measured using ASTM D-1557. Additional fill required to achieve the finished floor level should be placed using the same compaction criteria.

We estimate that actual applied pressures beneath an approximately 18 to 20-foot wide concrete pad with 5-foot wide thickened strip footing on each side will be roughly 1000 psf. Total settlement at any location along the beam tube will be approximately 0.2 inches. Differential settlement may occur between sections of the beam tube that are supported on the dense undisturbed gray sand and nearby sections on the improved silty fine sand due to the fact that the latter material will likely have a lower elastic modulus. The magnitude of differential settlement is estimated at less than 0.2 inches over a distance of roughly 100 to 200 feet. The settlements will occur essentially simultaneous with the application of load. No long-term post construction settlements are expected. Settlements were estimated using the method of Schmertman (1970 and 1978). Values of elastic modulus for the various soil layers were estimated using the results of laboratory triaxial compression tests, in situ plate bearing tests and published correlations between N-values and modulus (e.g. Bowles, 1988).

Footings should be placed at a depth of at least 2 feet for protection against frost heave. Improvement to the brown silty fine sand should extend laterally a distance of at least 5 feet beyond the outer edges of the footings.

5.2.2 Corner, Mid and End Stations

We recommend that foundations for the corner station, mid stations and end stations consist of shallow spread footings or mats placed on compacted fill or on either of the two natural sand deposits, depending on the ground surface elevation. The midstation on the Northwest leg and most of the corner station must be supported on compacted fill because current ground surface elevations are at least several feet below finished floor grade. The other stations will be supported on one of the natural sand deposits. Because of the loose character of portions of the undisturbed brown silty fine sand, we recommend that foundations be supported on this material only after soil improvements efforts have been adopted in the upper 8 feet (minimum) to reduce the compressibility of this soil and minimize the potential for settlements from either saturation or vibratory ground motion. Improvement efforts should also be adopted for the brown silty fine sand prior to placement of compacted fill on this layer.

An allowable bearing pressure of 2000 psf may be used for the improved brown silty fine sand or for compacted fill soils when footing or mat widths are less than 20 feet. For larger mats an allowable bearing pressure of 3000 psf may be used in those soil conditions. When footings or mats are placed directly on the undisturbed gray sand layer, allowable bearing pressures of 3000 psf and 4000 psf may be used for footing/mat widths less than and greater than 20 feet, respectively. These allowable bearing values may be increased by one-third for transient loads from wind or seismic sources, but not for continuous vibratory loads from vibrating machinery.

Recommendations for improving the brown silty sand and for selecting and compacting fill soils are the same as those presented for the Beam Tube in Section 5.2.1 above.

Settlement estimates for the corner station were made assuming first that the entire structure, except for the Office/Shop Area, is supported on a single 4-foot thick mat with an applied bearing pressure of 3000 psf. Most of the mat would be supported on the densified or recompacted surficial silty fine sand fill. A total settlement of approximately 0.4 inches was estimated for the center of the mat, with settlements around the edge ranging from about 0.1 to 0.3 inches. A maximum differential settlement of approximately 0.3 inches could therefore occur over a distance of about 200 to 300 feet at some locations. This amount of differential settlement would not be expected to be detrimental to a typical commercial or industrial structure. If a portion of the corner station is supported on spread footings instead of the single mat, settlement of an individual column with 100 kip loading is estimated at approximately 0.4 inches where the foundation soil consists of the densified or recompacted brown silty fine sand. Settlement of footings on the undisturbed gray fine to medium sand is estimated at less than 0.3 inches. Settlement of mat foundations covering only a portion of the corner station would be less than the values given above for the single mat.

The mid-stations were assumed to consist of a roughly 40 foot by 100 foot mat along the beam tube alignment. An applied pressure of 3000 psf was assumed for the mat. Associated office/shop areas are expected to be supported on spread footings. Settlement estimates for the mid-stations are significantly affected by the existing surface grades at those locations. Along the Southwest Leg, excavations of about 18 feet are required at the mid-station to reach the finished floor grade. Because of this net "unloading" situation, we estimate that settlement of the mat and footings will be negligible. Along the Northwest Leg the mid-station mat will be supported on the densified or recompacted silty fine sand, and a total settlement of approximately 0.3 inches is estimated for the center of the mat. Settlement at the corner of the mat is estimated at about 0.2 inches, making the differential settlement about 0.1 inches.

The end stations were also assumed to consist of a 40 foot by 100 foot mat along the tube alignment, with associated shop/office areas supported on spread footings. An applied pressure of 3000 psf was assumed for the mat. Total settlement for the mat at the Southwest end is estimated to be less than 0.1 inch, with negligible differential settlement. Total settlement for the mat at the Northwest end is estimated at less than 0.3 inches, with differential settlement between the center and corner of the mat of about 0.1 inches.

5.3 COEFFICIENT OF SUBGRADE REACTION

A commonly employed method of representing a soil subgrade for purposes of soil structure interaction analysis is the "Winkler" foundation, in which the subgrade is modeled as a series of vertical or horizontal springs with a spring constant termed the "modulus of subgrade reaction" K_s. For sand subgrades loaded vertically, K_s should be determined for the actual footing or mat size using the expressions by Terzaghi (1955):

SQUARE FOOTINGS:

$$K_s = K_1 \left(\frac{B+1}{2B}\right)^2$$

RECTANGULAR FOOTINGS:

Same as K_s for square footing, except K_1 should be modified as follows:

$$K_1 = K_1 \cdot \frac{(m+0.5)}{1.5m}$$

Where K_s = the value of vertical modulus of subgrade reaction for a footing or mat of width B.

K_1 = the value of modulus of subgrade reaction for a 1-foot wide square plate.

m = length of rectangular footing divided by width (L/B).

We recommend the following values of K_1 for vertical loading:

	Static K_1 (pci)	Dynamic K_1 (pci)
Brown Silty Fine Sand (Improved or Recompacted)	150	1500
Gray F-M Sand	220	2200

These values were selected based upon the results of field plate bearing tests, laboratory triaxial and grain size distribution tests, penetration resistance values during drilling, and experience obtained by others as reported in the literature. The values apply to a rigid, square plate of one foot width with loading applied at the ground surface.

5.4 LATERAL EARTH PRESSURES

Information about lateral earth pressures will be required to design subsurface walls or retaining walls and to estimate the resistance of structures to lateral forces induced by seismic or wind sources. Permanent retaining walls and subsurface walls that are free to translate or rotate away from the retained soil by an amount equal to approximately 0.1 percent of the height of the wall should be designed for active earth pressures. If the walls are rigid and unable to translate or rotate, at-rest earth pressures should be used. Our recommendations for active and at-rest earth pressures for both the static and dynamic cases are shown graphically on Plate 8. Recommended earth pressure coefficients are as listed below.

RECOMMENDED LATERAL EARTH PRESSURE COEFFICIENTS

	ACTIVE		AT-REST		PASSIVE	
	Static K_A	Dynamic K_{DA}	Static K_o	Dynamic K_{DO}	Static K_p	Dynamic K_{DP}
Silty Fine Sand (Improved or Recompacted)	0.27	0.27	0.43	0.15	2.5	2.0
Gray F-M Sand	0.22	0.24	0.36	0.13	3.0	2.5

Notes:

1. K_{DA} and K_{DO} values are used in equations on Plate 8 to estimate active and at-rest pressures.
2. K_{DP} value is multiplied by total unit weight of soil to get equivalent fluid unit weight for use in estimating passive earth pressure.
3. K_p and K_{DP} values include safety factor of 1.5.

The dynamic lateral earth pressures for the active and passive case were estimated according to the method described by Seed and Whitman (1970) and corrected by Davies et al (1986). These methods are based on the Mononabe-Okabe equations. The dynamic lateral earth pressure for the at-rest case was estimated using the findings of Sherif et al (1982). A horizontal ground acceleration of 0.35 g was used to estimate dynamic earth pressure values. This acceleration value was used in the design of the Skagit Hanford Nuclear Project. It is based on a postulated Richter Magnitude 6.5 earthquake with a recurrence interval of at least 10,000 years.

Lateral forces may also be resisted by friction between the soil and the bottom of footings and mats. We recommend a friction coefficient of 0.4 for the silty fine sand that is either improved in-place or used as compacted fill. A friction coefficient of 0.45 may be used for the gray fine to medium sand in either its undisturbed state or as compacted fill. These values may be assumed constant for both static and dynamic conditions.

5.5 SEISMIC DESIGN CONSIDERATIONS

During this project, direct measurements of unit weights, compressional wave velocities and shear wave velocities were made in the elevation range from 466 to 534. All other seismic design parameters for soils from the ground surface to the top of rock were calculated from these measured parameters, or were estimated from in situ tests performed by others and from laboratory and in situ values published in the literature for similar soil conditions. A graphical summary of some of the key parameters as a function of depth is shown on Plate 7.

The shear modulus (G) values presented in Plate 7 are applicable only to the low amplitudes of shear strains which are created by the seismic shear waves during the downhole or crosshole test, i.e., typically in the range from 10^{-3} to 10^{-5} percent. The modulus values are therefore considered "maximum" values, and must be modified to be applicable to the case of earthquake waves that produce much higher shear strains, i.e., on the order of 10^{-1} to 10^{-3} percent. The modifications for sands can be made using the relationship plotted in Plate 9. Also shown on Plate 9 is the relationship by which the damping values for sands may be estimated for the expected level of shear strain.

In order to estimate the wave velocities and seismic design parameters shown on Plate 7, we examined reports of seismic testing done by Dames & Moore and others at the Hanford site. Results of deep crosshole and downhole testing performed at the N-Reactor site (United Nuclear Industries, Inc. 1978), crosshole tests performed at the Fast Flux Test Facility (Hanford Engineering Development Laboratory 1975), downhole tests performed at the future grout vaults site (Dames & Moore 1988) and downhole, crosshole and refraction seismic test performed for the Skagit Hanford Nuclear Project (1984) were reviewed. A review was also made of estimates of the dynamic shear modulus reported by URS/John A. Blume & Associates (1977) for the 241-AN and 241-AP tank sites in the 200 East area. The data were not entirely consistent for the lower 150 to 200 feet of soil immediately overlying bedrock. Some information indicated increasing then decreasing velocity values, while other information indicated a constant or uniformly increasing velocity profile with depth. We believe that the data presented in Plate 7 represent a reasonable interpretation of the collected data, and are sufficiently accurate for design purposes.

Some methods of soil-structure interaction employ elastic modulus values to estimate the performance of structures during seismic shaking. For such an analysis, we recommend the following values:

	Elastic Modulus (E) in ksf	
	Static	Dynamic
Brown Silty Fine Sand (Improved or Recompacted)	1,500	15,000
Gray F-M Sand	1,800	18,000

Static and dynamic values for coefficient of subgrade reaction have been recommended in Section 5.3.

The substantial depth to the water table at this site and the dense nature of soils at that depth means that liquefaction is extremely unlikely.

Ground shaking during an earthquake is known to cause settlement of dry granular soils that are in a relatively loose condition. We have estimated that as much as 1.5 inches of settlement could occur for portions of the structure that may be supported on the surficial brown silty fine sand layer that has not been improved (i.e. densified in place by rolling or other methods) or recompacted. This estimate was made using the method of Tokimatsu and Seed (1987) assuming a ground acceleration of 0.35g. If the brown silty fine sand is densified and/or recompacted as recommended in this report, the estimated settlement from seismic shaking decreases to approximately 0.3 inches for the design earthquake. This settlement is in addition to the settlement estimates for static loads as presented in Sections 5.2.1 and 5.2.2.

We recommend the use of a Site Coefficient (S-Factor) of 1.2 for seismic analysis of the LIGO facilities. The Site Coefficient is as defined and described in Section 2333 of the 1991 Uniform Building Code (UBC). If a simple representation of ground motion is required, we recommend that the normalized response spectra shape corresponding to a "Soil Type 2" be selected from Figure No. 23-3 of the UBC, page 195.

5.6 VIBRATORY FOUNDATION LOADS

Foundations for vibratory equipment such as compressors should be designed to prevent excessive deformation in the primary directions of motion of the machine, and to prevent settlement of the foundation soils due to long term vibration-induced consolidation.

Foundations for vibratory equipment may be placed on the natural gray fine to medium sand or on a "select" compacted fill consisting of either the gray fine to medium sand or a mixture of that soil with the brown silty fine sand. We do not recommend the use of the silty fine sand alone, either improved in-place or recompacted, unless it is overlain by a layer of select compacted fill of thickness equal to 1.5 times the width of footing/mat for the equipment.

Because of the narrow gradation of the brown silty fine sand, some risk of long term settlement from vibratory loading exists, even if this material is recompacted. We are therefore recommending the restrictions described above. The mixture should contain no less than about 40 percent and not more than about 60 percent of either of the two natural sand deposits.

Allowable bearing pressure values are the same as those recommended in Section 5.2.3. Compacted fill should be placed in accordance with the recommendations given in Section 5.2.1.

We recommend the following parameters for the design of foundations for vibrating equipment:

SOIL PARAMETERS FOR USE IN DESIGN OF FOUNDATIONS FOR VIBRATING EQUIPMENT

	Total Unit Weight (pcf)	Shear Modulus (ksf)	Poisson's Ratio
Select Fill	110	2400	.25
Brown Silty Sand (Improved or Recompacted)	105	2000	.30
Gray F-M Sand	105	3500	.25

The shear modulus values shown in the table above have been reduced from the "maximum" values obtained from geophysical testing in order to correspond to the 10^{-2} shear strain amplitude that probably better approximates the levels that will be induced by vibrating machinery.

5.7 CORROSION AND CHEMICAL DETERIORATION

Deterioration of metallic and/or concrete structures below the ground surface may occur where chemical and electrochemical conditions within the soil and ground water are unfavorable. A series of laboratory tests were conducted during this investigation to evaluate such conditions. A suite of corrosion potential tests were conducted on one sample each from Borings DM-1-92, DM-20-92 and DM-39-92. DM-20-92 is located at the corner station while the other two borings are located at the end stations. The soil sample from Boring DM-39-92 consisted of the gray fine to medium sand, while the other two samples consisted of the brown silty fine sand. The suite of tests included pH, resistivity, redox (i.e. oxidation-reduction) potential, sulfide content, sulfate content and chloride content. A summary of the test results is presented in Appendix C.

The test results do not identify any property of the soils that gives rise to concerns about corrosion or other deterioration of metallic and concrete structures at this site. All resistivity values are high, ranging from 68,000 to 370,000 ohm-cm, while the pH is neutral to slightly basic. These results suggest non-aggressive environments from the standpoint of corrosion. The redox potential values ranging from 287 to 323 mv indicate well aerated soil and suggest the absence of sulfate-reducing bacteria that are typically associated with corrosion. The absence of sulfate-reducing bacteria is also confirmed by the negative results measured for the sulfide screening tests.

This analysis does not consider stray currents which may occur at the site nor does it evaluate the possibility of the interconnection of dissimilar metals. The above analysis is based only on the corrosion behavior of a single material by itself without outside influences.

From this analysis it may be concluded that special corrosion mitigating features need not be included in the design of underground utilities. Standard quality controlled designs including proper bedding materials should result in structures that will experience little or no corrosion over their design life. However any buried structure viewed as "critical" should be reviewed in detail in the design phase for possible outside influences such as the interconnection of dissimilar metals or the possibility of being under the influence of stray currents.

Based on the above analysis, we recommend the following:

1. Standard construction materials and practices may be employed for the installation of sanitary sewer and water utilities.

2. Standard construction materials and practices may be employed for the installation of potable and fire water utilities.

3. Standard construction materials and practices may be employed for the installation of tanks bottoms, underground tanks or buried concrete structures.

4. Standard construction materials and practices may be employed for the installation of the site groundgrid system.

5. The interface connections between existing utilities and utilities to be constructed should be completed in a manner that will minimize or eliminate any galvanic couples and also to avoid the introduction of stray current onto the piping.

6. The sulfate content is such that specialty sulfate resistant portland cements are not required for concrete tanks and utilities for corrosion control. This does not exclude selection of those materials for other than corrosion control reasons.

7. The soil conditions in general (based on the available data) would not require the use of specialty coatings, inert membranes, nor cathodic protection. This does not exclude selection of those materials for other than corrosion control reasons.

8. The groundgrid design should take into consideration the high soil resistivities at this site.

5.8 PAVING

The variation in subgrade soils for paved surfaces will likely be similar to that for footing subgrades, ranging from the dense gray fine to medium sand to compacted fill. If excavations are required to reach the subgrade level, the exposed subgrade should be thoroughly proofrolled using a vibratory roller, especially where the subgrade soil consists of the brown silty fine sand. At least the upper 1-foot of subgrade soil should be at 95 percent of the maximum dry density, as measured using ASTM D-1557. The following are recommended values of California Bearing Ratio (CBR) for use in design of flexible pavement.

RECOMMENDED CBR VALUES FOR PAVEMENT DESIGN

Soil	CBR
Compacted Fill (Silty Fine Sand)	20
Brown Silty Fine Sand (Proofrolled)	15
Gray F-M Sand (Proofrolled)	25

If rigid pavements are desired, the values of vertical subgrade reaction coefficient presented in Section 5.3 may be used for design.

The pavement section should consist of the asphalt (or concrete) surface course underlain by a base course of crushed stone aggregate. The thickness of the base and surface courses should be established following an evaluation of the anticipated traffic weight and volume to be supported by the pavement.

5.9 LEACH FIELD

We understand that leach fields and seepage pits will be used for sewage disposal. Percolation tests were therefore conducted at two locations in the vicinity of the corner station. Test results, presented in Appendix B, indicate a range of percolation rates from about 0.4 to 2.0 minutes per inch. The test conducted at the location of Boring DM-21-92 where the ground surface was at Elevation 522 indicated the lowest percolation rates (2 minutes per inch). The higher percolation rates measured at Boring DM-22-92 (ground surface at Elevation 533) probably reflects the fact that the upper 11 feet of soil consisted of the silty fine sand in a loose to medium dense condition. It would be prudent to design all facilities using a percolation rate of at least 2 minutes per inch.

5.10 EARTHWORK AND SITE PREPARATION

Soil in the upper 6 to 12 inches across the site may contain an undesirable amount of vegetation, and should therefore be stripped from any area to be occupied by structures or pavements. This material can be used for general site grading. Both naturally occurring strata, i.e. the brown silty fine sand and the gray fine to medium sand, are suitable for use as structural compacted fill. An exception to the use of the silty fine sand for compacted fill directly beneath vibrating equipment is discussed in Section 5.6. Laboratory compaction characteristics of each of the two natural soil types and of a mixture of the two soil types are presented in Appendix C. The results for the brown silty fine sand are somewhat variable, showing a maximum dry density between 110 and 120 pcf, depending on the silt content. Further testing should be performed prior to construction to better evaluate the nature of this variation. Fills for general site grading may be placed in 10 to 12 inch lifts and compacted to 90 percent of the maximum dry density. Compaction recommendations for footing/mat and pavement subgrades have been addressed elsewhere. Close attention should be paid to moisture control during hot-weather construction.

During the site grading process, if the soil at the foundation subgrade level is the gray sand, no further excavation would be necessary. If the soil at the subgrade level is the brown silty sand, a minimum of 8 feet should be excavated and recompacted as recommended in Section 5.2.1. If during excavation of the brown sand, the gray sand is encountered at less than 8 feet below the subgrade level, no further excavation is required. Excavations extending to 8 feet depth that continue to reveal the brown silty sand in a loose condition should be further extended until a medium dense condition is encountered or the gray sand is revealed. Information obtained during drilling and sampling for this project suggests that wherever the brown silty sand layer is greater than 10 feet thick, the lower portion of the layer is in a medium dense to dense condition. We therefore expect that excavations to depths greater than 8 feet below the finished floor level will be required only sporadically across the site. We recommend frequent monitoring of subgrade conditions by a representative from Dames & Moore in order to identify locations where subgrade conditions are unacceptable.

Disturbance of the foundation subgrade from foot traffic or other activities during slab and mat preparation should be kept to a minimum. Keeping the surface moistened should aid in this task. However, some additional measures may be required during the hot summer months. Alternative measures for minimizing subgrade disturbance include placement of an upper 4 inch layer of well graded sand and gravel or a 2 to 3-inch thickness of lean concrete immediately after final grading.

Temporary excavations in the surficial layer of brown silty fine sand will likely experience some sloughing if slopes are steeper than about 1.8 Horizontal on 1.0 Vertical (1.8H:1.0V). Furthermore, this soil is considered highly erodible by water and wind, and may be adversely affected during heavy rainfalls or windstorms. Temporary protection from erosion can be provided by covering the slopes with visqueen or similar plastic membranes during construction. Permanent slopes in this layer should not be steeper than about 2H:1V. Erosion protection can be provided by vegetation or a 6 to 8-inch thick layer of gravel and/or crushed stone.

Temporary excavations in the gray fine to medium sand may experience some local sloughing if slopes are steeper than about 1.5H:1V. Where this layer exhibits some natural cementation, slopes stand at 1.25H:1V with only minor sloughing. Permanent slopes should be inclined at 2H:1V. The more narrowly graded zones within this layer (i.e. less medium to coarse sand) will be relatively prone to erosion, and may be protected as indicated in the paragraph above.

5.11 UNDERGROUND UTILITIES

Excavations for underground utilities in the surficial silty fine sand will readily cave into any excavation that is sloped steeper than about 1.8 on 1.0 (horizontal to vertical). The addition of moisture before and during the excavation process may assist in reducing the amount of caving.

The excavated soil will be suitable for both bedding and backfill. Backfill soil should be placed in lifts not exceeding 6 inches in thickness and compacted to 90 percent maximum dry density as determined by ASTM D-1557.

Two bulk samples of the brown silty fine sand were tested for thermal resistivity to assist in determining ampacity derating factors for power cables. Test results indicated thermal resistivity values in the range from 400 to 530 degrees centigrade-centimeter per watt (°C-cm/watt).

Laboratory electrical resistivity tests were conducted on selected samples to assist with calculation of resistance-to-soil for equipment grounding and for assessing the potential for corrosion. The results, presented in Appendix C, indicate that all resistance values are high, typically exceeding 60,000 ohm-centimeters. The potential for corrosion is more fully discussed in Section 5.7.

6.0 LIMITATIONS

The recommendations and descriptions presented in this report are based on soil conditions disclosed by the borings drilled during this and previous investigations at the site. The existing subsurface information referred to herein does not constitute a direct or implied warranty that the soil conditions between boring locations can be directly interpolated or extrapolated, or that subsurface conditions and soil variations different from those disclosed by the borings will not be revealed. If, during construction, subsurface conditions different from those described herein are observed, such conditions should be reviewed and the recommendations given herein revised as necessary. Dames & Moore regards the monitoring of soil conditions at the subgrade during construction as a key element in the successful completion of this project.

Sincerely,

DAMES & MOORE, INC.

Harbans L. Chabra, PE
Principal

W. M. McCabe

W. Martin McCabe, PhD, PE
Senior Engineer

W. MARTIN McCABE
STATE OF WASHINGTON
23499
REGISTERED PROFESSIONAL ENGINEER
W. M. McCabe 2/10/93
EXPIRES: 2-28-94

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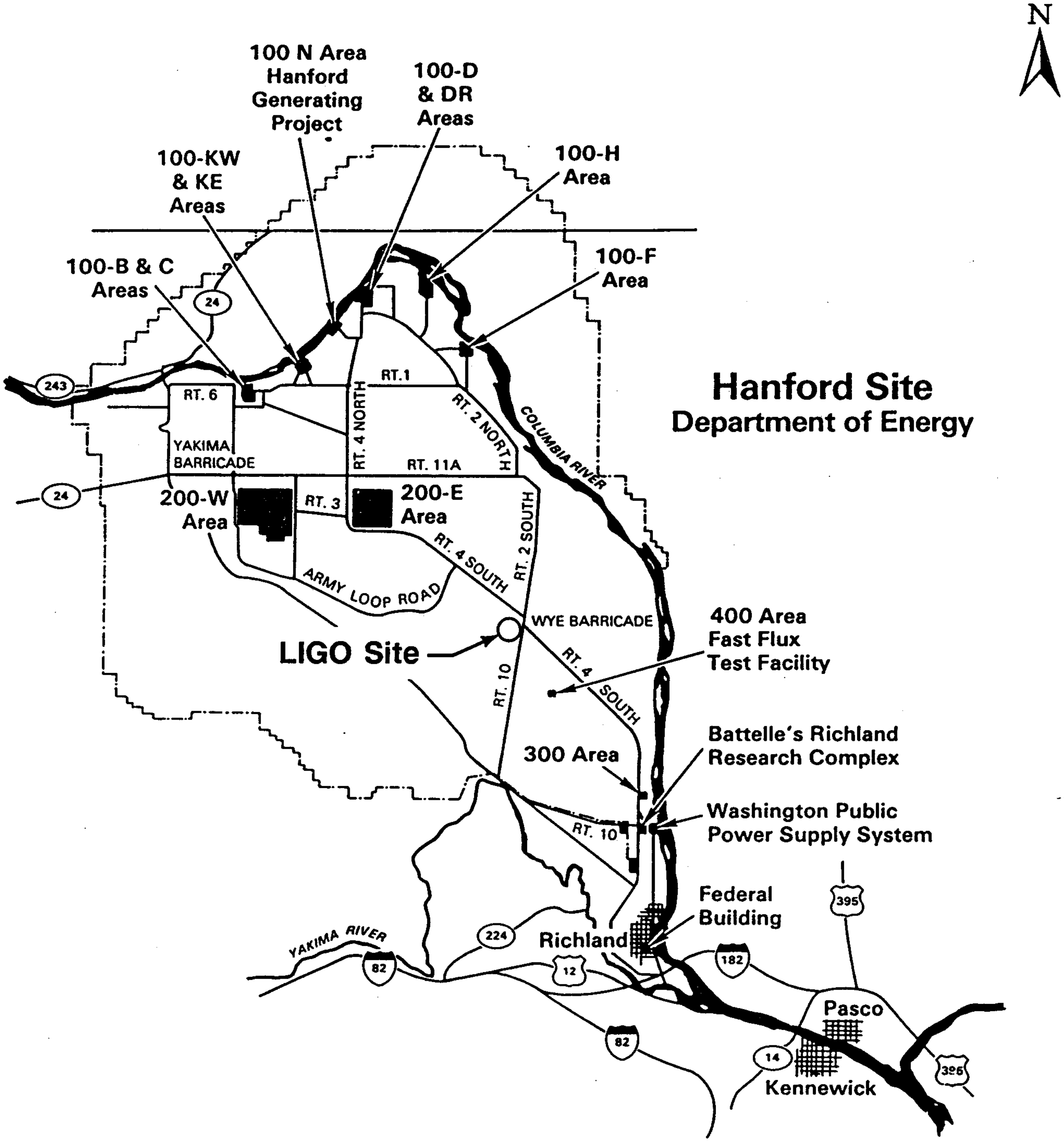

SOURCE: *Department of Energy*

AREA MAP

Job No. 00177-004-016

DAMES & MOORE

LIGO Project
Hanford, Washington
PLATE 1

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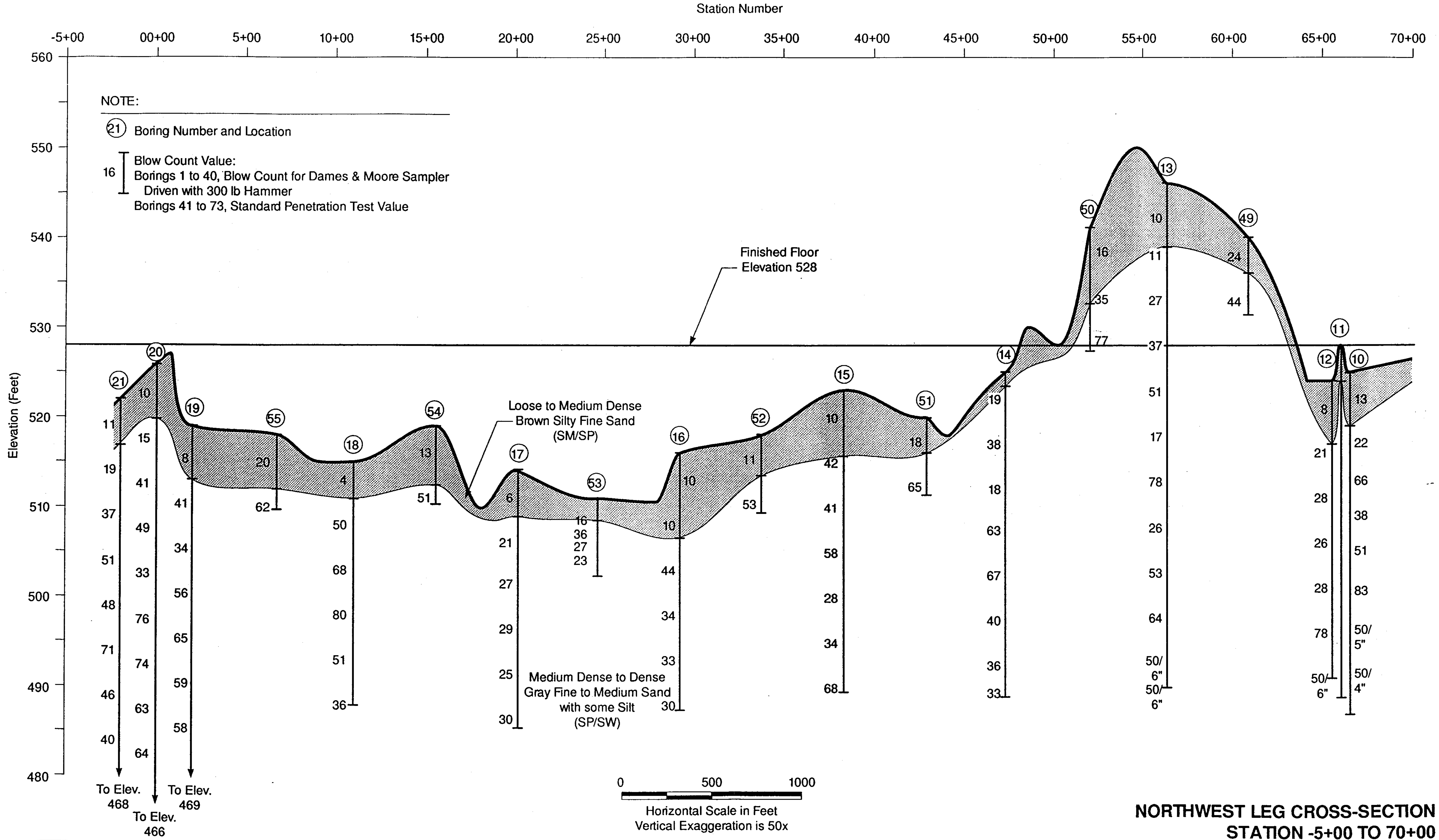
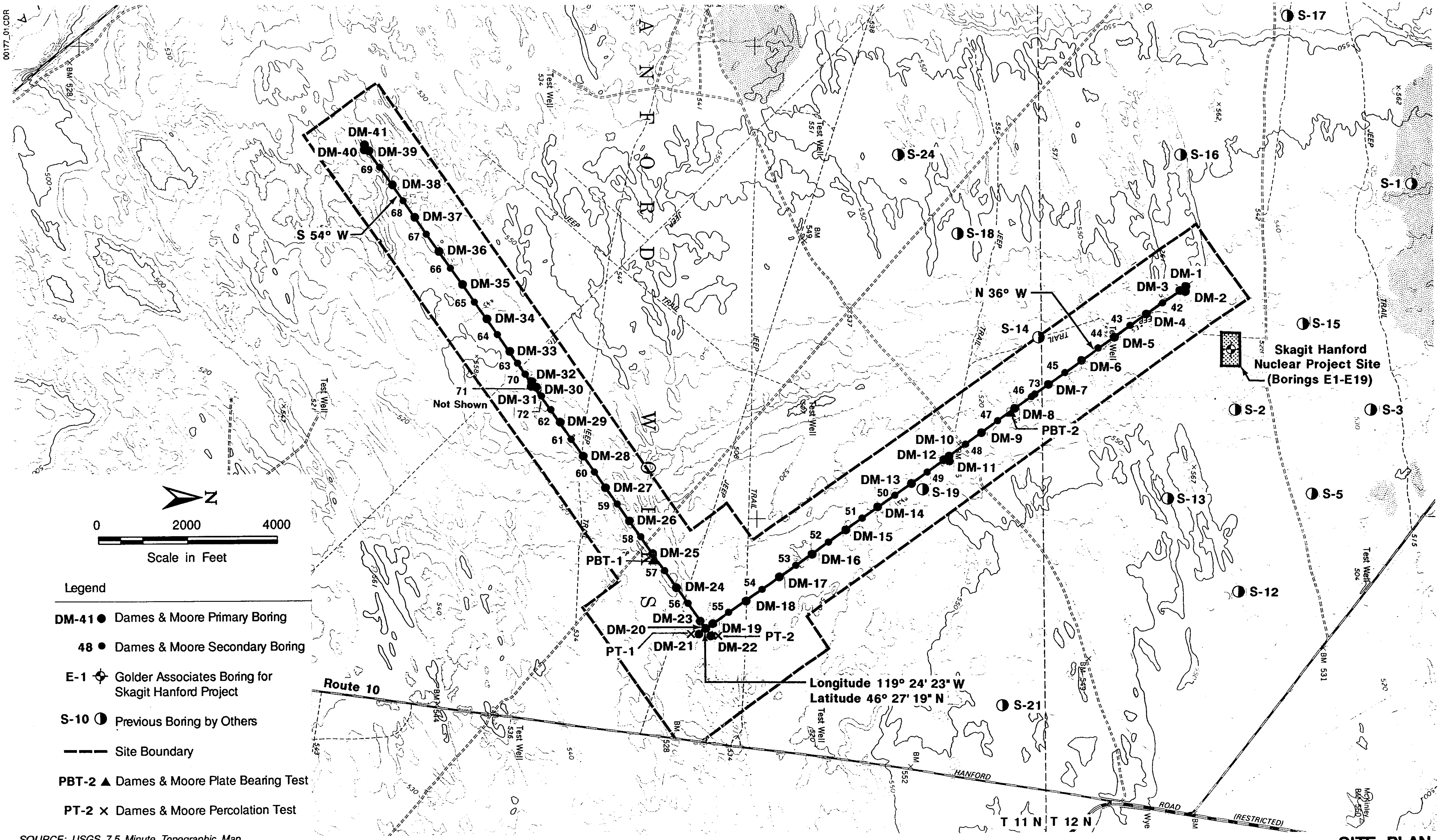


NORTHWEST LEG CROSS-SECTION
STATION -5+00 TO 70+00

LIGO Project
Hanford, Washington
PLATE 3

Job No. 00177-004-016
DAMES & MOORE



Legend

DM-41 ● Dames & Moore Primary Boring

48 ● Dames & Moore Secondary Boring

E-1 ⌖ Golder Associates Boring for Skagit Hanford Project

S-10 ◐ Previous Boring by Others

— — — Site Boundary

PBT-2 ▲ Dames & Moore Plate Bearing Test

PT-2 × Dames & Moore Percolation Test

SOURCE: USGS 7.5 Minute Topographic Map, Horn Rapids Dam, Washington, 1977.

Job No. 00177-004-016

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SITE PLAN

LIGO Project
Hanford, Washington
PLATE 2

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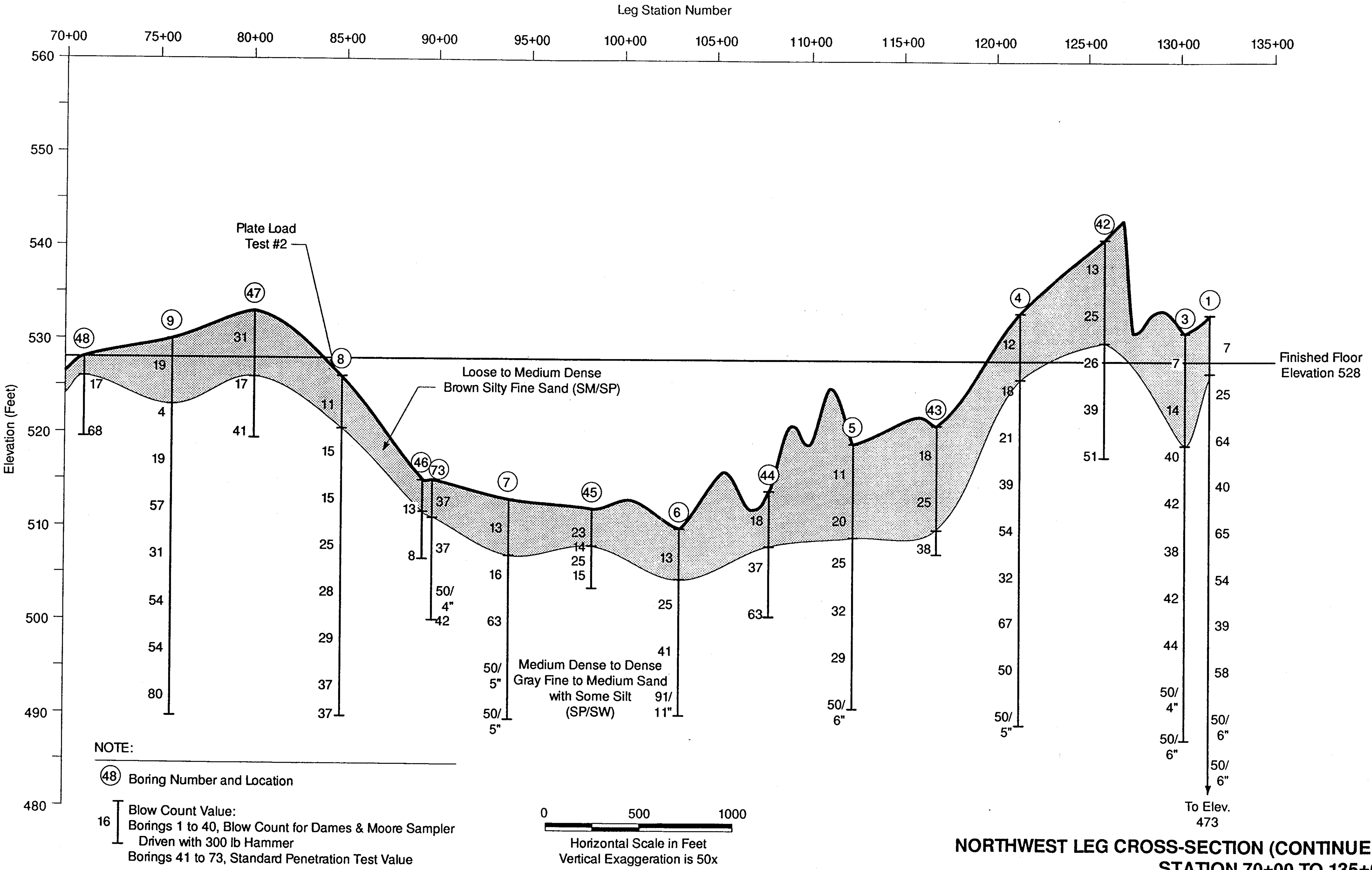

NORTHWEST LEG CROSS-SECTION (CONTINUED)
STATION 70+00 TO 135+00

Job No. 00177-004-016

DAMES & MOORE

LIGO Project
Hanford, Washington
PLATE 4

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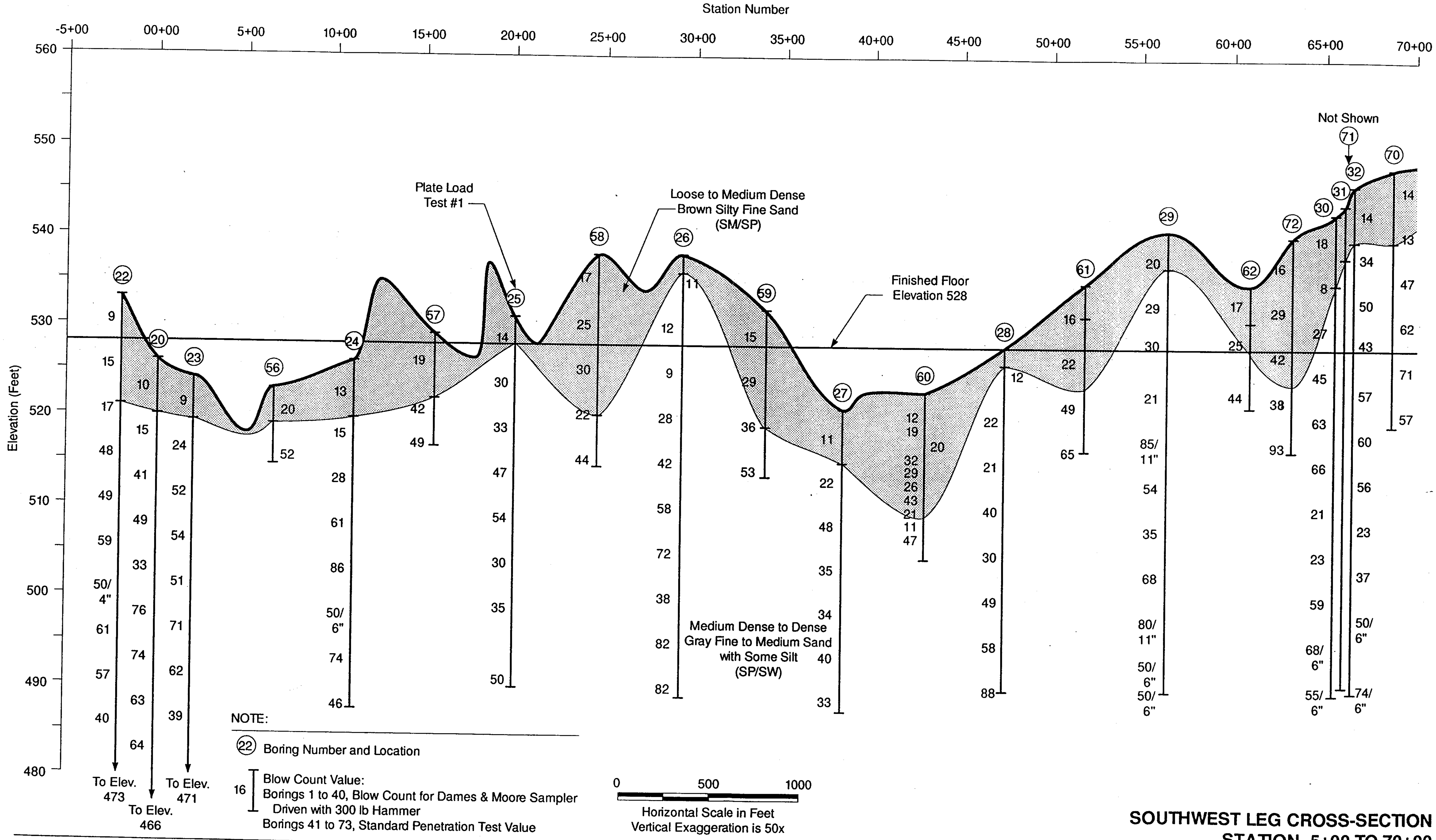
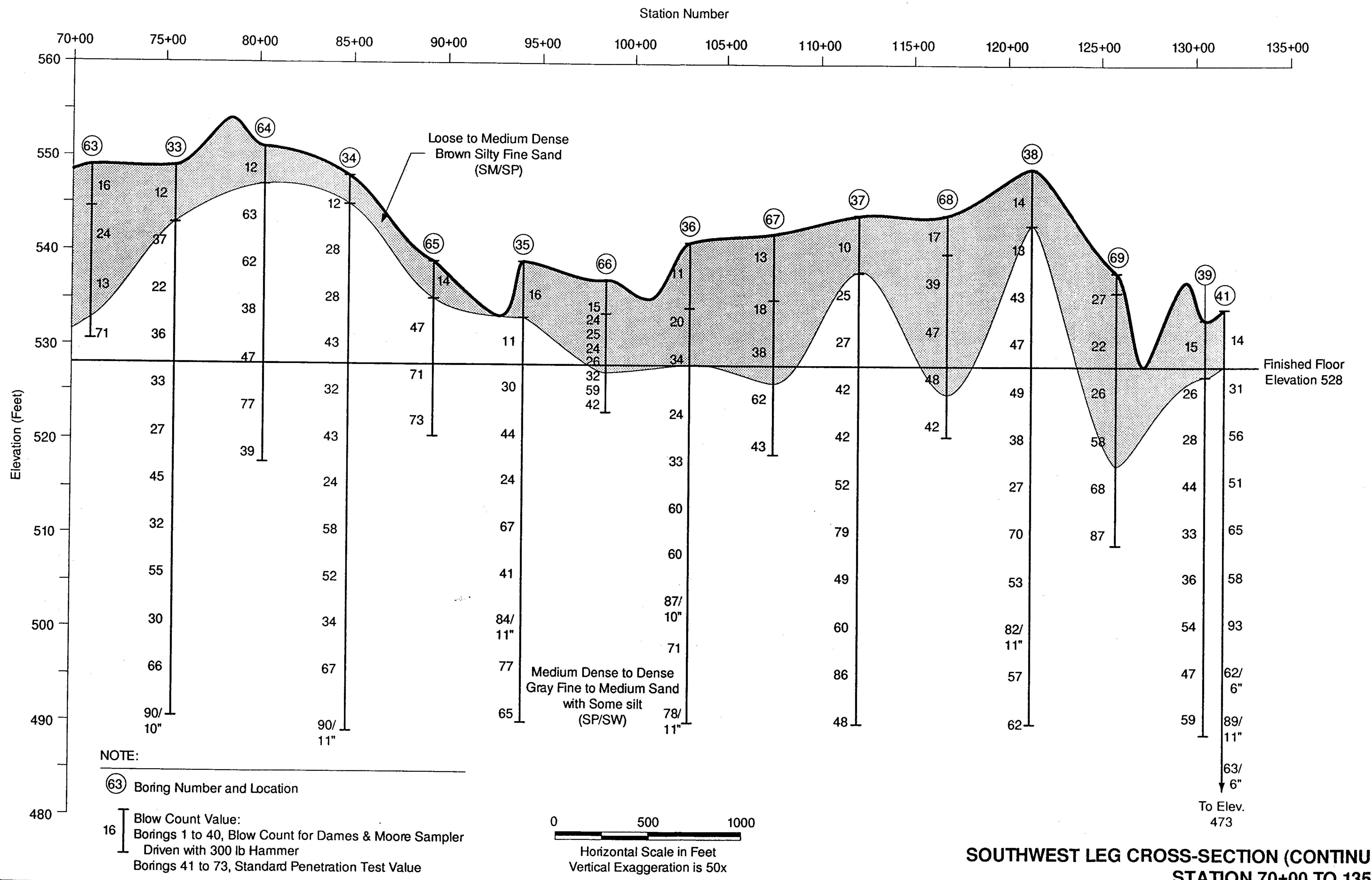


SOUTHWEST LEG CROSS-SECTION
STATION -5+00 TO 70+00

Job No. 00177-004-016

DAMES & MOORE

LIGO Project
Hanford, Washington
PLATE 5



SOUTHWEST LEG CROSS-SECTION (CONTINUED)
STATION 70+00 TO 135+00

Job No. 00177-004-016

DAMES & MOORE

LIGO Project
Hanford, Washington
PLATE 6

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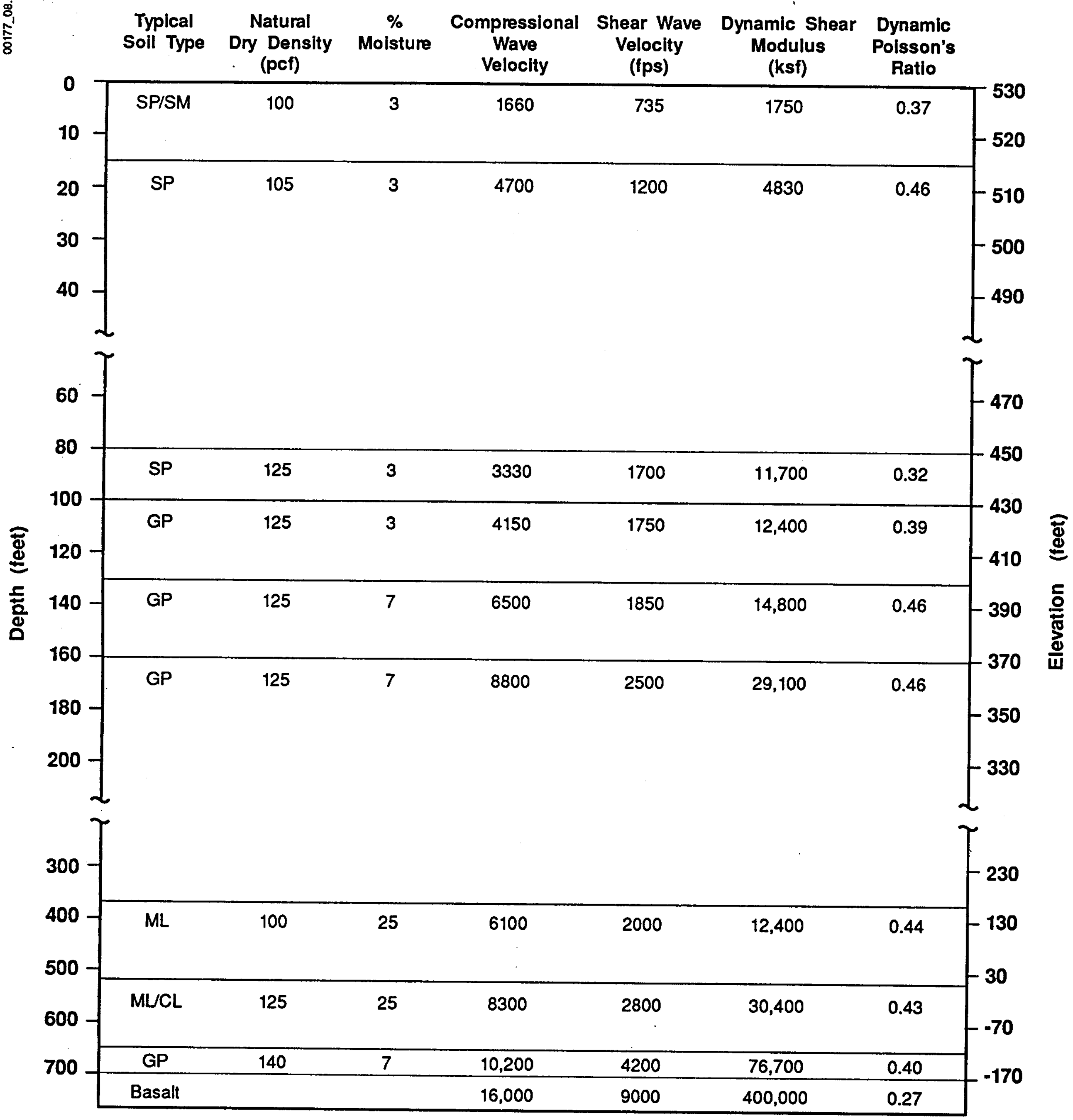

Typical Soil Type	Natural Dry Density (pcf)	% Moisture	Compressional Wave Velocity	Shear Wave Velocity (fps)	Dynamic Shear Modulus (ksf)	Dynamic Poisson's Ratio
SP/SM	100	3	1660	735	1750	0.37
SP	105	3	4700	1200	4830	0.46
SP	125	3	3330	1700	11,700	0.32
GP	125	3	4150	1750	12,400	0.39
GP	125	7	6500	1850	14,800	0.46
GP	125	7	8800	2500	29,100	0.46
ML	100	25	6100	2000	12,400	0.44
ML/CL	125	25	8300	2800	30,400	0.43
GP	140	7	10,200	4200	76,700	0.40
Basalt			16,000	9000	400,000	0.27

Soil parameters below Elevation 466 estimated using data from previous investigations.

SEISMIC DESIGN DATA
TYPICAL SOIL PROFILE

Job No. 00177-004-016

DAMES & MOORE

LIGO Project
Hanford, Washington
PLATE 7

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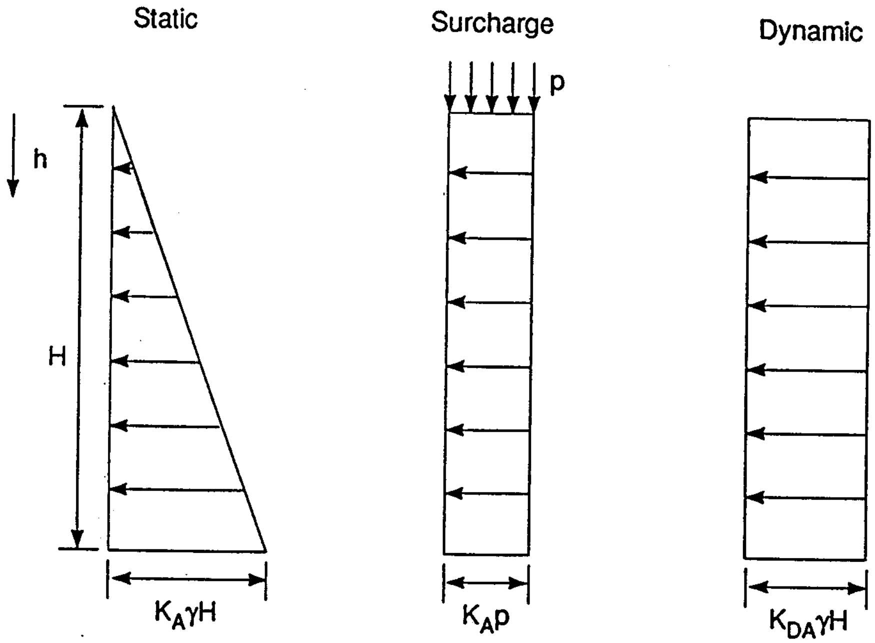
Yielding Walls

Static Pressure =
$K_A\gamma h + K_A p$

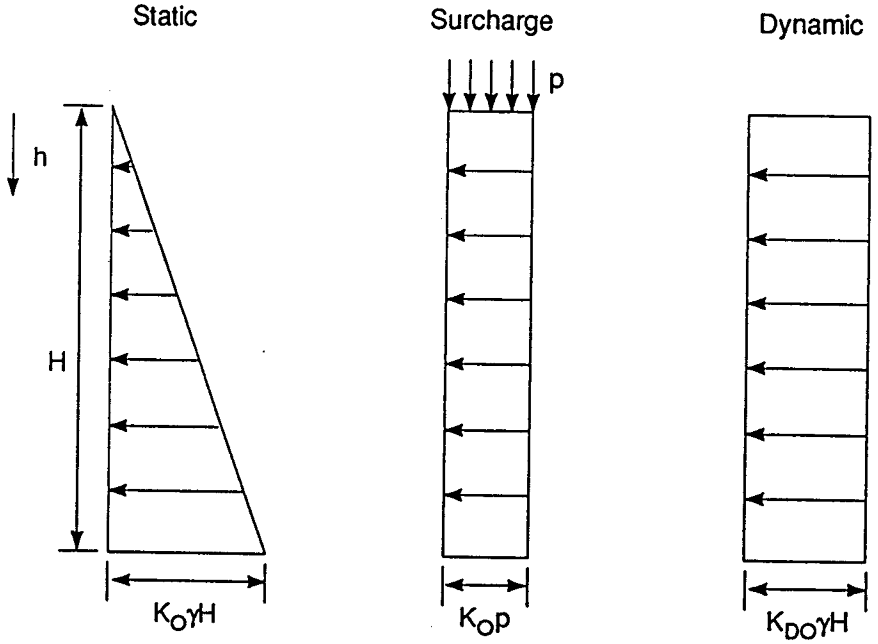
Dynamic Pressure =
$K_A\gamma h + K_A p + K_{DA}\gamma H$



Unyielding Walls

Static Pressure =
$K_O\gamma h + K_O p$

Dynamic Pressure =
$K_O\gamma h + K_O p + K_{DO}\gamma H$



Legend

h	Depth Below Grade
H	Height of Wall Below Grade
γ	Backfill Specific Weight (115 pcf)
p	Surcharge
K_{DA}	Dynamic Earth Pressure Coefficient (see report Section 5.4 for values)
K_A	Active Earth Pressure Coefficient (see report Section 5.4 for values)
K_{DO}	Dynamic At-Rest Earth Pressure Coefficient (see report Section 5.4 for values)
K_O	At-Rest Earth Pressure Coefficient (see report Section 5.4 for values)

LATERAL EARTH PRESSURES

Job No. 00177-004-016

DAMES & MOORE

LIGO Project
Hanford, Washington

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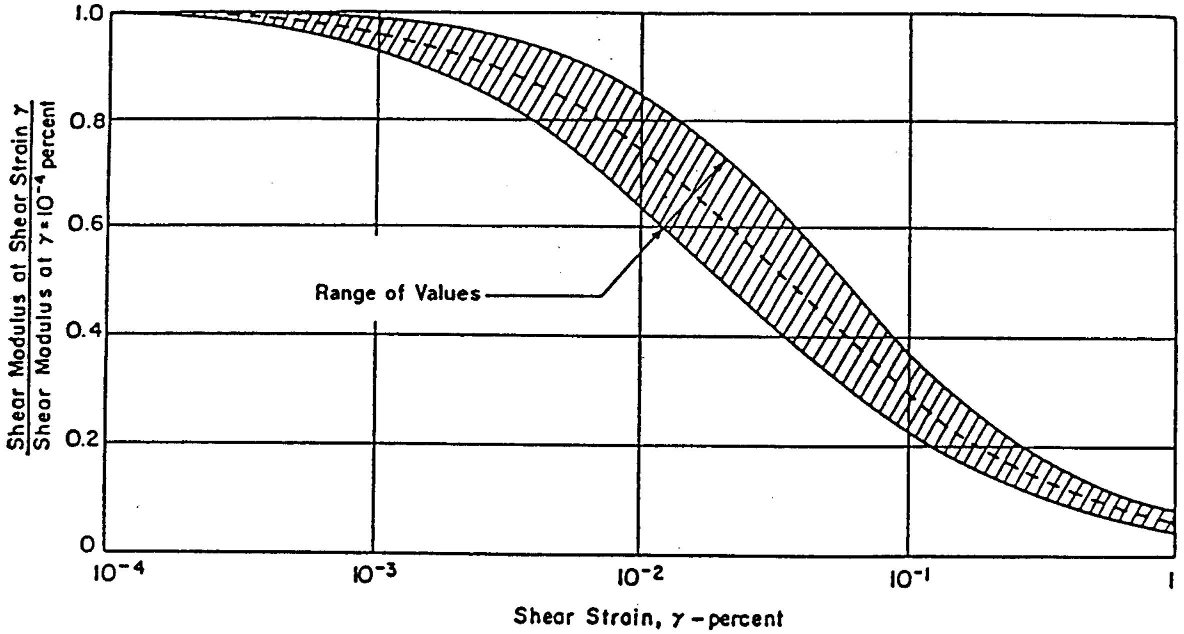
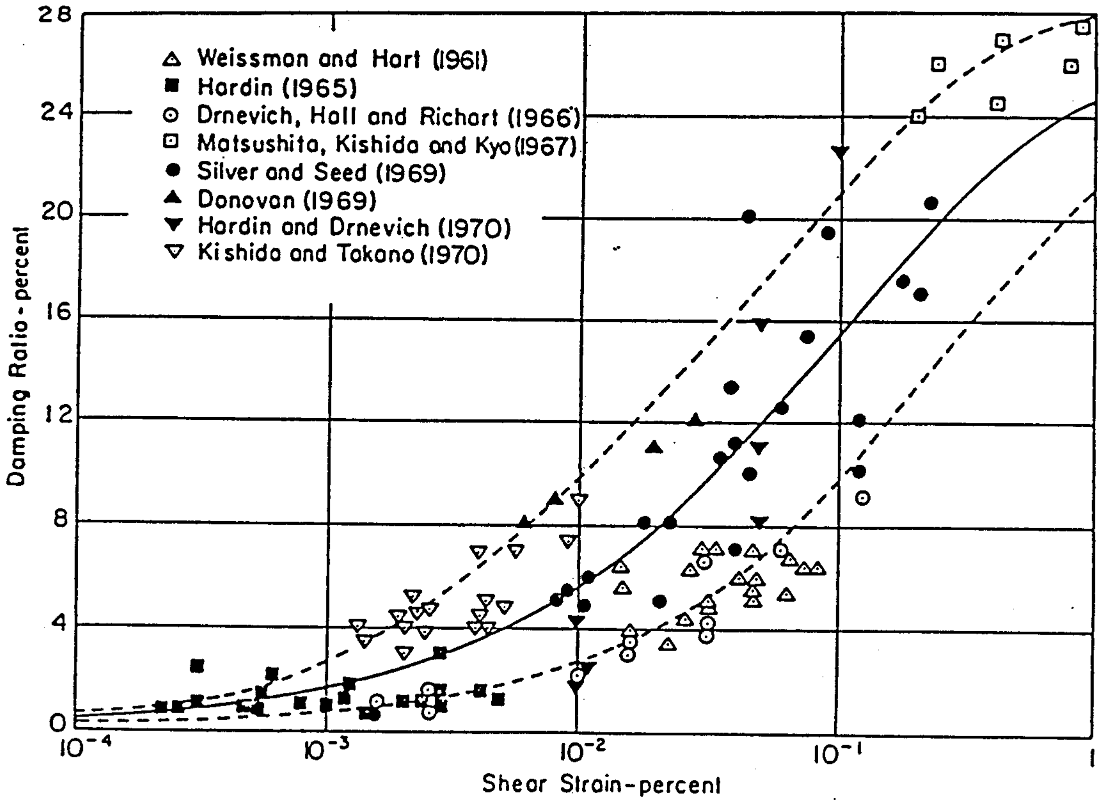


VARIATION OF SHEAR MODULUS WITH SHEAR STRAIN FOR SANDS
(After Seed & Idriss, 1970)



DAMPING RATIOS FOR SANDS
(After Seed & Idriss, 1970)

SHEAR MODULUS AND DAMPING VALUES FOR SAND

Job No. 00177-004-016

DAMES & MOORE

LIGO Project

PLATE 9

APPENDIX A
FIELD INVESTIGATION

Subsurface and ground-water conditions at the site were investigated by drilling 41 primary borings and 32 secondary borings at the locations shown on Plate 2. The borings were drilled utilizing two truck-mounted hollow stem auger drill rigs, a Mobile Drill B-61 and an Acker CME Soil Max. The borings ranged in depth from about 8 to 63 feet below the existing ground surface. After reaching the final depth the borings were backfilled with bentonite mud. The spoils from the borings were spread out over the ground surface surrounding the boring.

Borings DM-1-92, DM-20-92, and DM-41-92 were used in the geophysical survey and had a 2-inch diameter SCH 40 PVC pipe casing installed. The casing was grouted into place using a mixture of bentonite and cement. After the geophysical survey was conducted the borings were backfilled with bentonite mud.

The drilling program was coordinated by a Dames and Moore staff engineer and a field technician who monitored the drilling activities, obtained samples of the soils encountered, classified the soils by visual and textural examination and maintained continuous logs of the subsurface conditions. Logs of the borings are presented on Plates A-1 through A-73.

Relatively undisturbed samples of the soils encountered were obtained at about 5-foot intervals. In the primary borings a Dames & Moore U-Type sampler, as shown on Page A-2, was used to collect soil samples. Soil samples from the secondary borings were obtained using the standard penetration test. The U-Type sampler was driven with a 300-pound safety hammer falling 30 inches. The number of blows required to drive either sampler one foot or less into undisturbed soils is shown adjacent to the appropriate sample notations on the boring logs, Plates A-1 through A-73. A key to the notations used on the logs is presented on Plate A-74. The soils were classified in accordance with the Unified Soil Classification System which is described on Plate A-75.

Based on energy ratios between the two different hammers and samplers used during the field investigation the blow count for a sample obtained using the Dames & Moore U-Type sampler should be equal to or slightly greater than the SPT value for similar sampling depth and soil conditions. However, comparing the U-Type sampler blow count values to the SPT blow count values for similar depth and soil conditions we find that on the average the blow count for samples obtained using the U-Type sampler are actually less than the SPT blow count. This may be due to using two different drill rigs that had different mechanical components used to raise the hammer. It is our opinion that the SPT blow count values may be slightly elevated due to details of the rig, and that the Dames & Moore sampler blow counts more accurately reflect the condition of the soils.

BORING DM-1-92

Surface Elevation: 533±

REMARKS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	BLOWS PER FOOT	SAMPLE TYPE	DEPTH (FT) WATER LEVEL		
					0	SP	Brown fine sand with trace silt (dry) (loose)
3.4% fines	2.3	93	7	■			
	2.5	98	25	■		SP/SW	Gray fine to medium sand (dry) (medium dense-dense)
					10		
			64	■			
	2.6	104	40	■			
					20		
			65	■			grades with occasional gravel
	2.1	104	54	■			
					30		
			39	■			
			58	■			grades damp
					40		
			50/6"	□			
			50/6"	□			grades dry
					50		
	2.4	99	89/11"	■			
			92	■			
					60		Boring DM-1-92 completed at depth of 60 feet on 11-13-92. No groundwater observed during drilling. 2-inch PVC casing installed for geophysical testing.
					70		

NOTE:
Northwest Leg Station 131+50

Logged by TSP 01-15-1993 SUperLOG V 2.0, 3-1991

LOG OF BORING

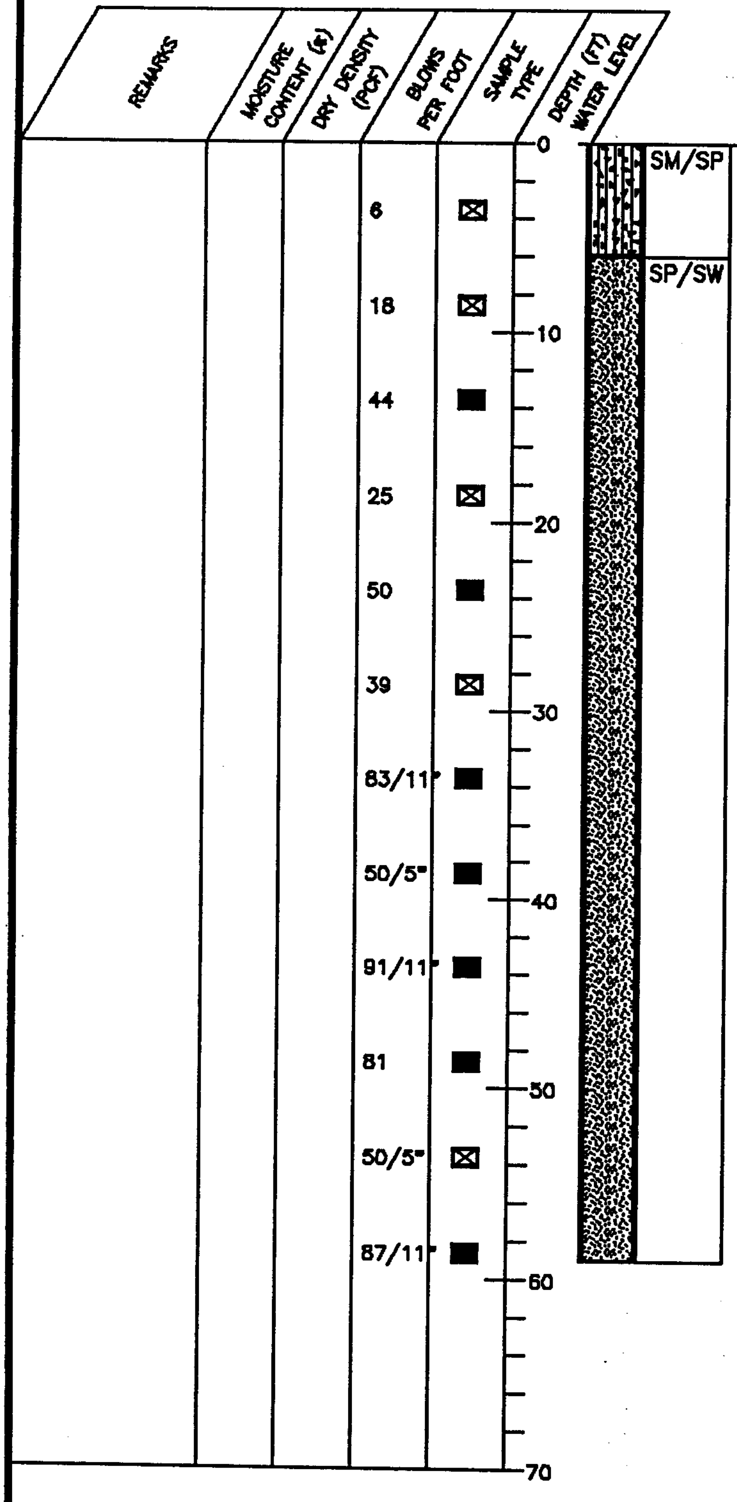
Dames & Moore

Job No. 00177-004-016

PLATE A-1

BORING DM-2-92

Surface Elevation: 532±



REMARKS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	BLOWS PER FOOT	SAMPLE TYPE
			6	☒
			18	☒
			44	■
			25	☒
			50	■
			39	☒
			83/11"	■
			50/5"	■
			91/11"	■
			81	■
			50/5"	☒
			87/11"	■

SM/SP Light brown silty very fine to coarse sand (dry) (loose)

SP/SW Gray fine to coarse sand (dry) (medium dense–dense)

grades to medium sand

grades finer

grades to gray fine to medium sand, some fine gravel

grades to fine sand

Boring DM-2-92 completed at depth of 59 feet on 11-13-92. No groundwater observed during drilling.

NOTE:
Northwest Leg Station 131+00
(offset 50 feet to the northeast)

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

LOG OF BORING

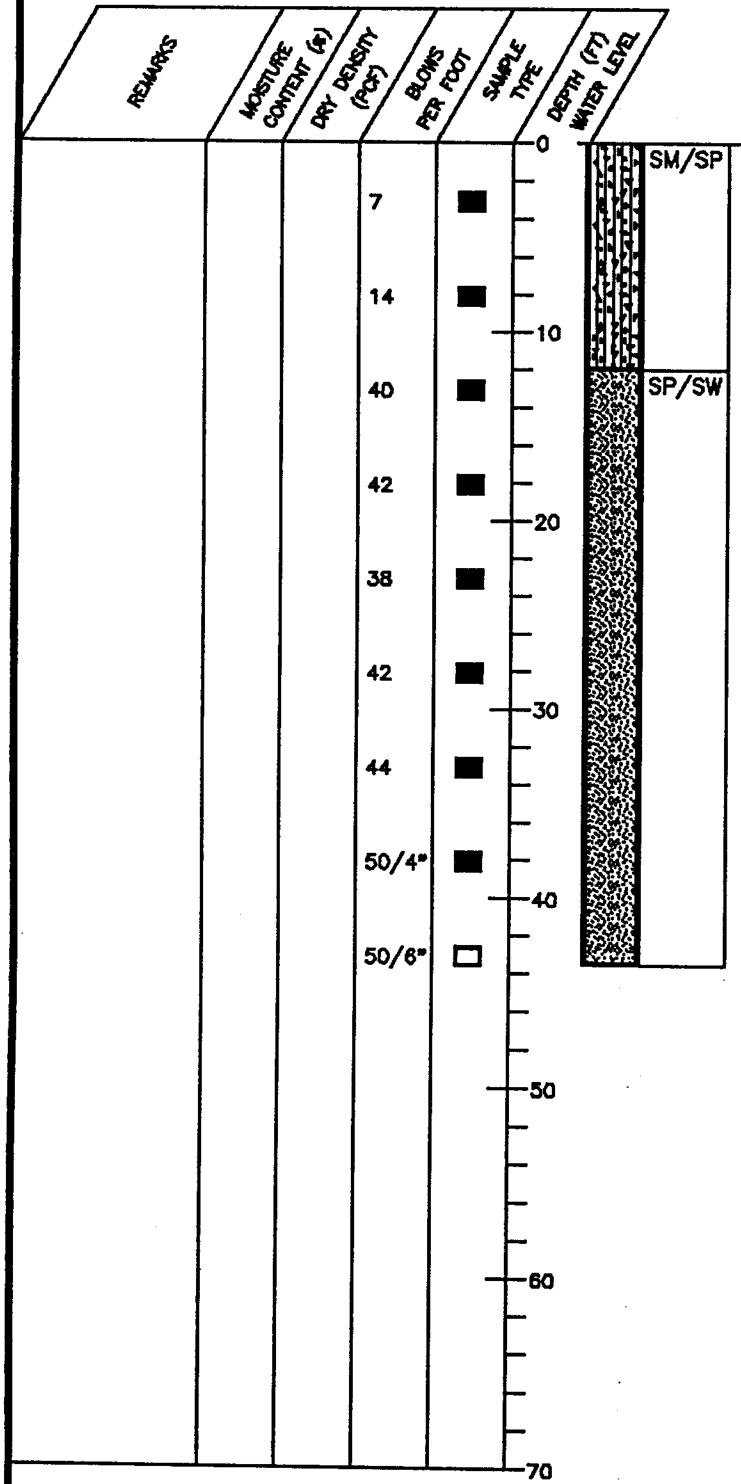
Dames & Moore

Job No. 00177-004-016

PLATE A-2

BORING DM-3-92

Surface Elevation: 531±



Brown fine sand, some silt (dry) (loose)

Gray fine to medium sand (dry) (medium dense–dense)

grades with occasional gravel

grades to light gray and damp

cobble at 35 feet

grades to brown fine sand with silt layer

Boring DM-3-92 completed at depth of 43.5 feet on 11-13-92. No groundwater observed during drilling.

NOTE:
Northwest Leg Station 130+50

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

LOG OF BORING

Dames & Moore

Job No. 00177-004-016

PLATE A-3

BORING DM-4-92

Surface Elevation: 533±

REMARKS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	BLOWS PER FOOT	SAMPLE TYPE	DEPTH (FT) WATER LEVEL		
					0	SP	Brown very fine sand with trace silt and occasional root matter (dry) (loose)
1.5% fines	1.8	104	12	■			
6.7% fines	3.8	102	18	■		SP/SM	Brownish gray to gray fine to medium sand with trace to some silt (damp) (medium dense to dense)
					10		
			21	■			
	5.4	106	39	■			grades to fine sand
					20		
			54	■			grades to fine to medium sand
			32	☒			grades to medium sand, occasional fine gravel
					30		
	3.4	108	67	■			
			50	■			
					40		
			50/5"	■			
							Boring DM-4-92 completed at depth of 44 feet on 11-13-92. No groundwater observed during drilling.
					50		
					60		
					70		

NOTE:
Northwest Leg Station 121+34

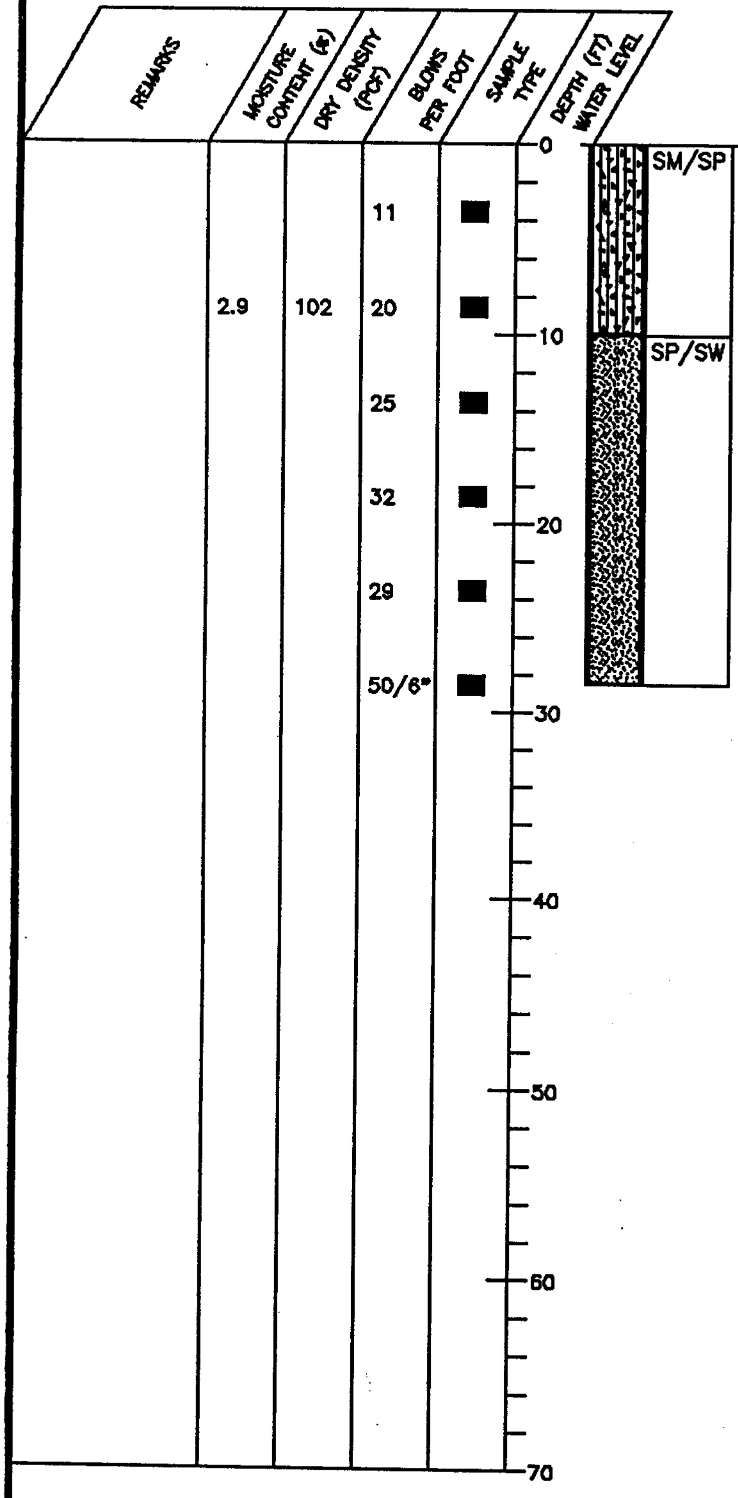
Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

LOG OF BORING

Dames & Moore

BORING DM-5-92

Surface Elevation: 519±



Brown silty very fine to fine sand (dry) (loose)

Gray fine to medium sand, occasional fine gravel (medium dense-dense)

grades to black medium sand, occasional fine gravel

gravel layer from to 25 to 26 feet

Boring DM-5-92 completed at depth of 28.5 feet on 11-14-92. No groundwater observed during drilling.

NOTE:
Northwest Leg Station 112+20

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

LOG OF BORING

Dames & Moore

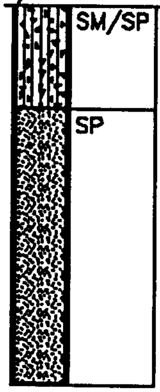
Job No. 00177-004-016

PLATE A-5

BORING DM-6-92

Surface Elevation: 510±

REMARKS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	BLOWS PER FOOT	SAMPLE TYPE	DEPTH (FT) WATER LEVEL
5.4% fines	2.5	102	13	■	
2.9% fines	3.0		25	☒	
2.3% fines	3.0	109	41	■	
			91/11"	■	



Brown very fine to fine sand with some silt (dry) (loose)

Gray fine to medium sand with occasional fine gravel and trace silt (dry) (medium dense to dense)

grades to medium to coarse sand

grades to brown fine sand

Boring DM-6-92 completed at depth of 20 feet on 11-14-92. No groundwater observed during drilling.

NOTE:
Northwest Leg Station 103+06

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

LOG OF BORING

Dames & Moore

Job No. 00177-004-016

BORING DM-7-92

Surface Elevation: 513±

REMARKS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	BLOWS PER FOOT	SAMPLE TYPE	DEPTH (FT) WATER LEVEL		
					0	SM/SP	Brown fine sand, some silt, occasional fine gravel (dry) (loose)
			13	■			
						SP	Gray fine to medium sand, occasional fine gravel (dry) (medium dense–dense)
3.0% fines			16	☒			
					10		
			63	■			grades to fine sand
			50/5"	■			
					20		
			50/5"	■			
							Boring DM-7-92 completed at depth of 23.5 feet on 11-14-92. No groundwater observed during drilling.
					30		
					40		
					50		
					60		
					70		

NOTE:
Northwest Leg Station 93+92

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

LOG OF BORING

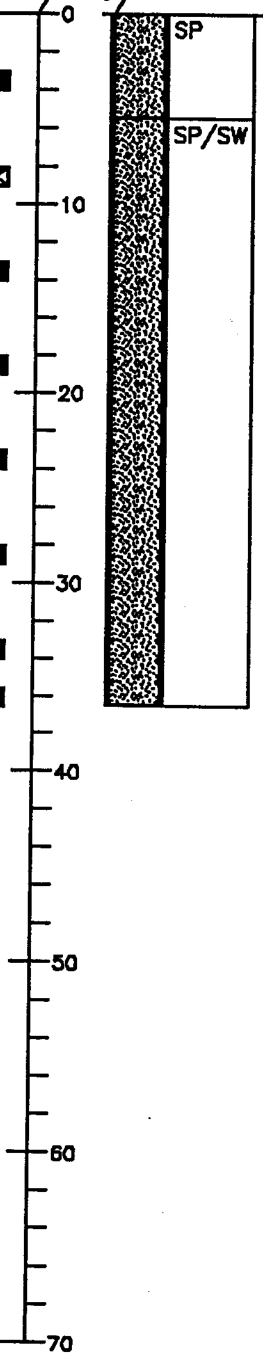
Dames & Moore

Job No. 00177-004-016

BORING DM-8-92

Surface Elevation: 526±

REMARKS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	BLOWS PER FOOT	SAMPLE TYPE
1.0% fines			11	■
			15	☒
	3.7	103	15	■
			25	■
	5.4	100	28	■
			29	■
			37	■
			37	■



SP — Brown fine sand with some silt (dry) (loose)

SP/SW — Gray fine to medium sand, occasional gravel (dry) (medium dense-dense)

grades to brown fine sand, occasional fine gravel

grades to moist

Boring DM-8-92 completed at depth of 36.5 feet on 11-14-92. No groundwater observed during drilling.

NOTE:
Northwest Leg Station 84+78

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

LOG OF BORING

Dames & Moore

Job No. 00177-004-016

PLATE A-8

BORING DM-9-92

Surface Elevation: 530±

REMARKS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	BLOWS PER FOOT	SAMPLE TYPE	DEPTH (FT) WATER LEVEL		
					0	SM/SP	Brown fine sand with some silt and root matter (dry) (medium dense)
			19	☒			
						SP/SW	Gray fine to medium sand, occasional fine gravel (dry) (loose)
	5.1	102	4	■			
					10		grades to medium dense
	3.8	101	19	■			
	4.4	105	57	■			grades to brown fine sand (dense)
					20		
			31	■			grades to gray fine to medium sand
			54	■			occasional fine to coarse gravel
					30		
			54	■			grades to moist brown fine sand
			80	■			
					40		Boring DM-9-92 completed at depth of 40.0 feet on 11-14-92. No groundwater observed during drilling.
					50		
					60		
					70		

NOTE:
Northwest Leg Station 75+64

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

LOG OF BORING

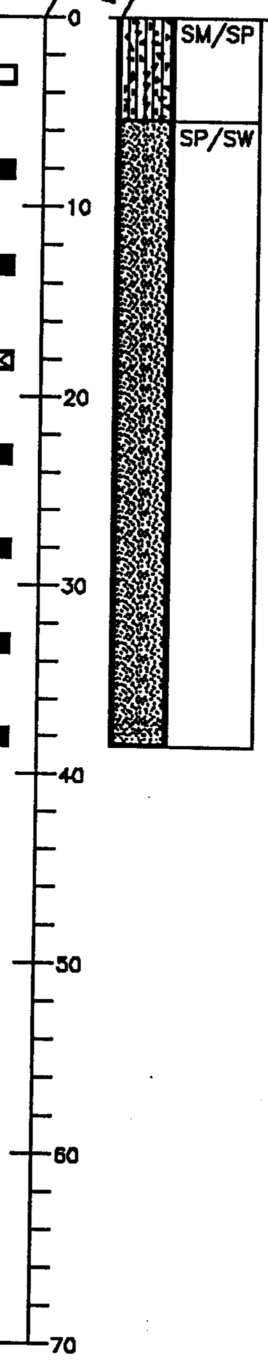
Dames & Moore

Job No. 00177-004-016

BORING DM-10-92

Surface Elevation: 525±

REMARKS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	BLOWS PER FOOT	SAMPLE TYPE
			13	☐
	2.8	110	22	■
			66	■
			38	☒
			51	■
			83	■
			50/5"	■
			50/4"	■



Brown fine sand with some silt (dry) (loose)

Gray fine to coarse sand, occasional gravel (dry) (medium dense–dense)

grades to damp fine to medium sand

Boring DM-10-92 completed at depth of 38.5 feet on 11-14-92. No groundwater observed during drilling.

NOTE:
Northwest Leg Station 66+50

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

LOG OF BORING

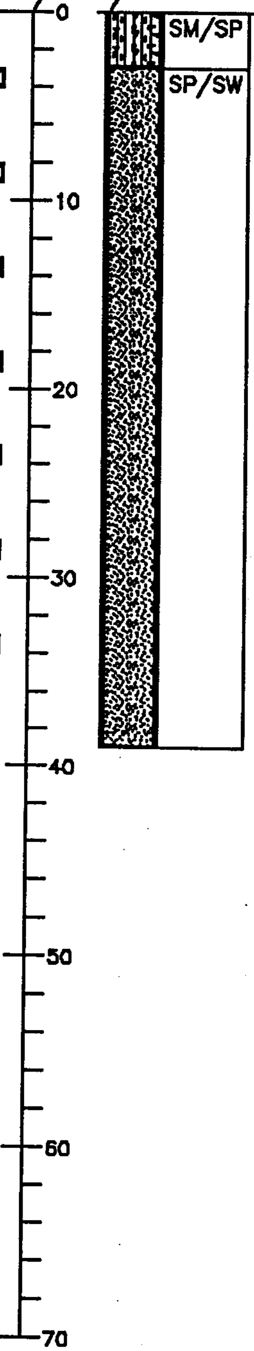
Dames & Moore

BORING DM-11-92

Surface Elevation: 528±

REMARKS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	BLOWS PER FOOT	SAMPLE TYPE
13.3% fines			8	☒
			17	☒
	5.0	103	58	■
			24	☒
			26	■
			23	■
			50/5"	■
			87/10"	■

DEPTH (FT) WATER LEVEL



SM/SP Brown very fine sand with some silt (dry) (loose)

SP/SW Black fine to medium sand (dry) (loose)

grades moist

grades to brown fine sand

Boring DM-11-92 completed at depth of 39 feet on 11-14-92. No groundwater observed during drilling.

NOTE:
Northwest Leg Station 66+00
(offset 50 feet to the northeast)

Logged by JCH 01-15-1993   SUperLOG V 2.0, 3-1991

LOG OF BORING

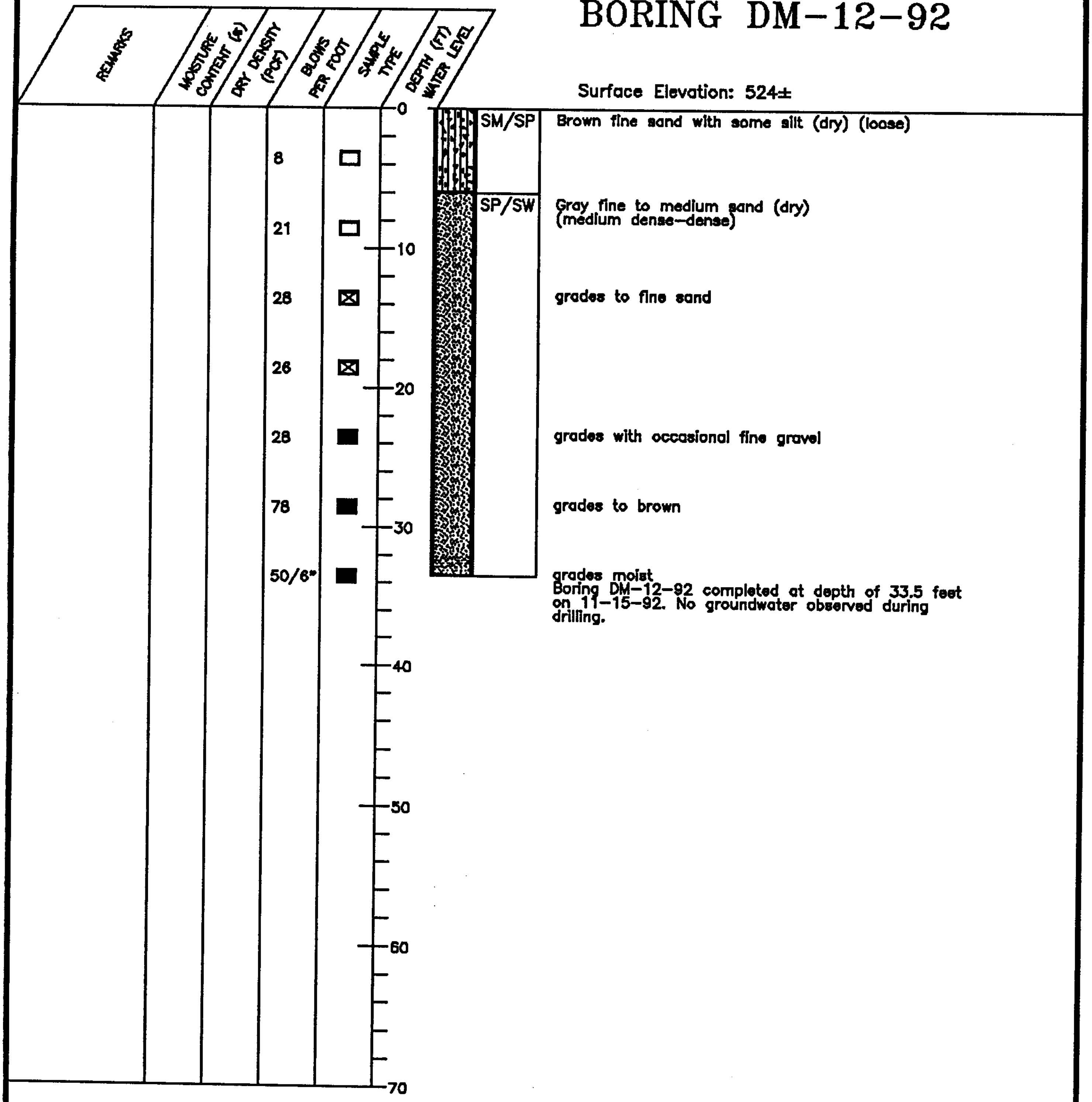
Dames & Moore

Job No. 00177-004-016

PLATE A-11

BORING DM-12-92

Surface Elevation: 524±



Brown fine sand with some silt (dry) (loose)

Gray fine to medium sand (dry) (medium dense—dense)

grades to fine sand

grades with occasional fine gravel

grades to brown

grades moist

Boring DM-12-92 completed at depth of 33.5 feet on 11-15-92. No groundwater observed during drilling.

NOTE:
Northwest Leg Station 65+50

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

LOG OF BORING

Dames & Moore

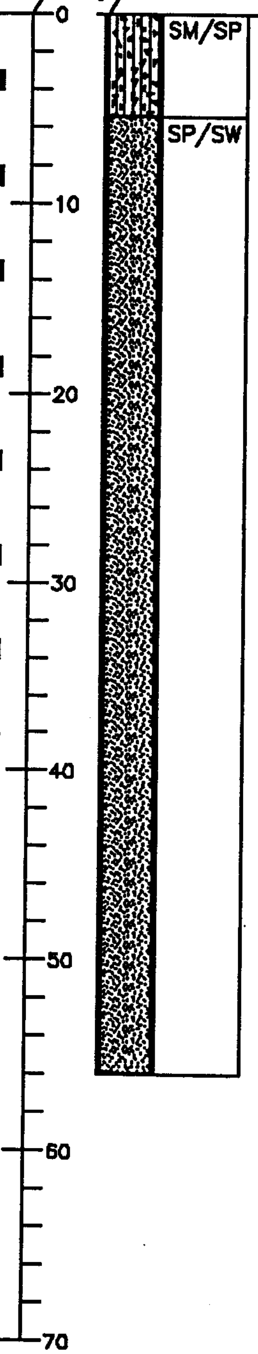
Job No. 00177-004-016

PLATE A-12

BORING DM-13-92

Surface Elevation: 546±

REMARKS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	BLOWS PER FOOT	SAMPLE TYPE
			10	■
3.8% fines			11	■
			27	■
	3.5	103	37	■
	2.7	120	51	■
			17	☒
			78	■
			26	■
			53	■
			64	■
			50/6"	■
			50/6"	■



SM/SP Brown fine sand with some silt (dry) (loose)

SP/SW Gray fine sand (dry) (loose)

grades from medium dense to dense

grades with light cementation

grades with no cementation

Boring DM-13-92 completed at depth of 56 feet on 11-15-92. No groundwater observed during drilling.

NOTE:
Northwest Leg Station 56+42

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

LOG OF BORING

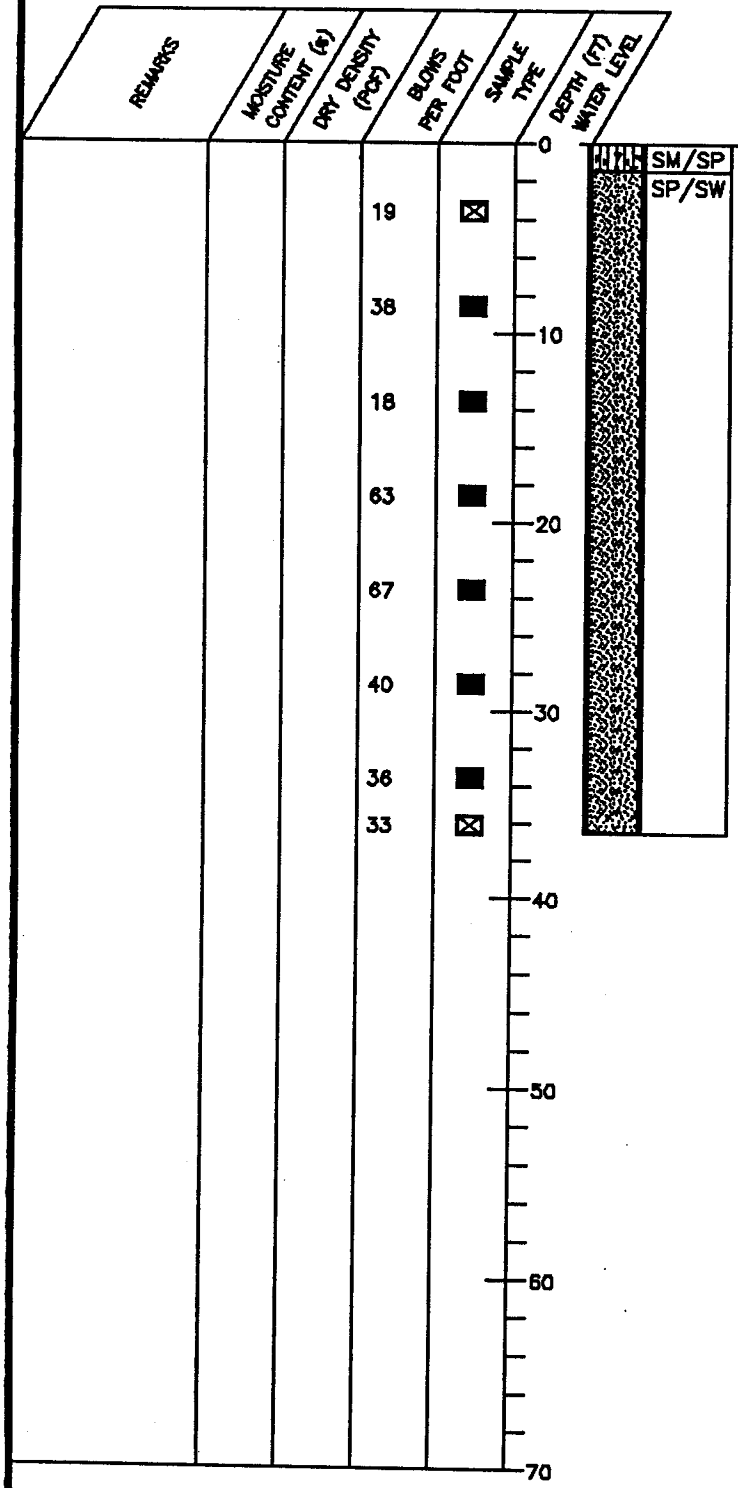
Dames & Moore

Job No. 00177-004-016

PLATE A-13

BORING DM-14-92

Surface Elevation: 525±



Brown fine sand, some silt (dry) (loose)

Gray fine sand (dry) (medium dense–dense)

grades with occasional fine gravel

Boring DM-14-92 completed at depth of 36.5 feet on 11-15-92. No groundwater observed during drilling.

NOTE:
Northwest Leg Station 47+35

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

LOG OF BORING

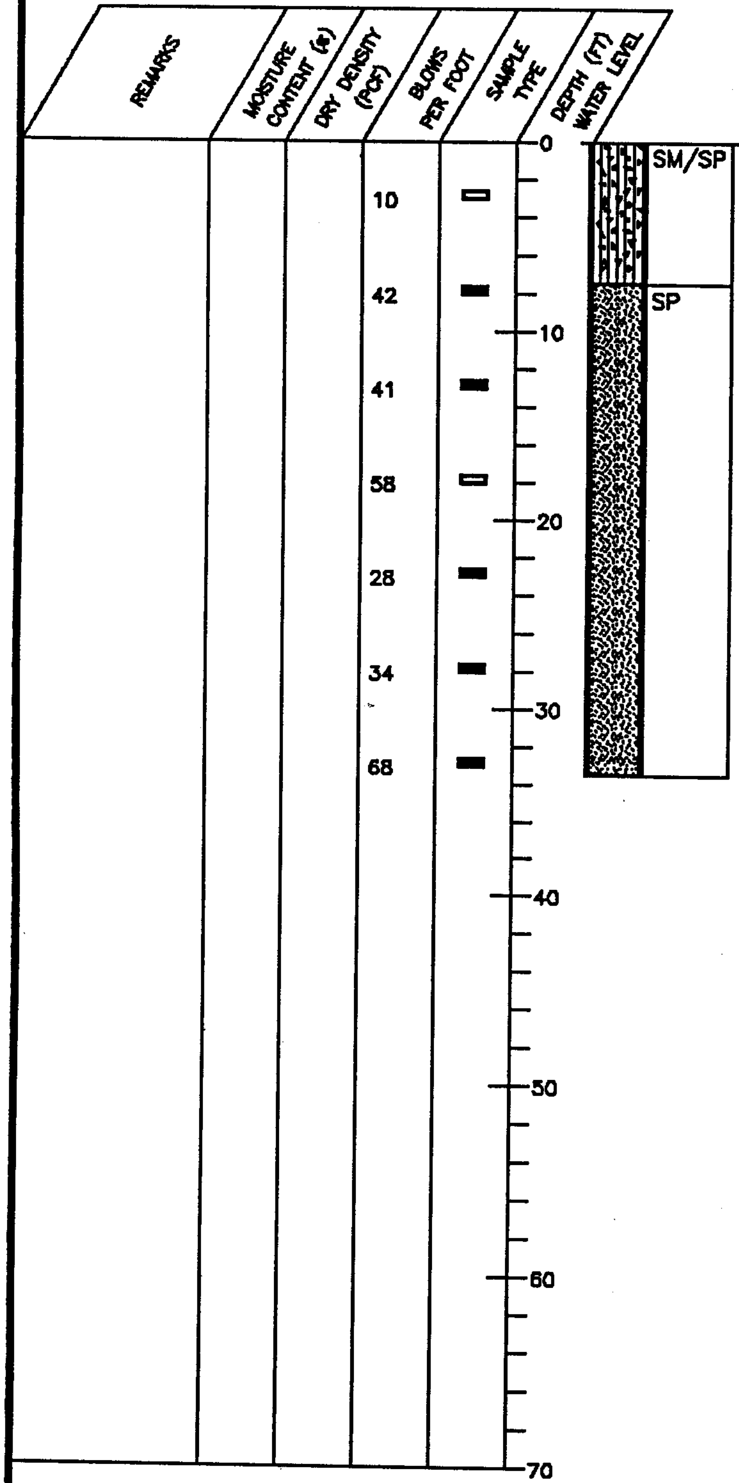
Dames & Moore

Job No. 00177-004-016

PLATE A-14

BORING DM-15-92

Surface Elevation: 523±



REMARKS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	BLOWS PER FOOT	SAMPLE TYPE
			10	▭
			42	▬
			41	▬
			58	▭
			28	▬
			34	▬
			68	▬

SM/SP Brown fine to medium sand with some silt (dry) (loose)

SP Gray fine to medium sand (damp) (dense)

Grades to very dense with occasional gravel

Grades to medium dense

Grades to very dense

Boring DM-15-92 completed at depth of 33.5 feet on 11-12-92. No groundwater encountered during drilling.

NOTE:
Northwest Leg Station 38+28

Logged by JCH 01-15-1993   SUperLOG V 2.0, 3-1991

LOG OF BORING

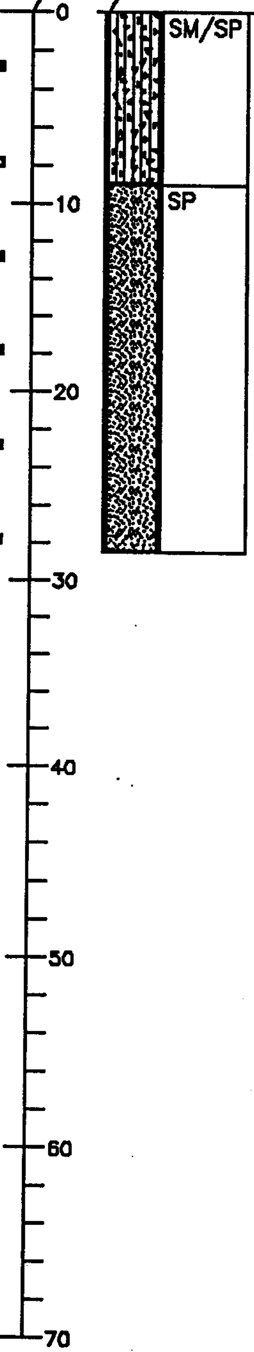
Dames & Moore

Job No. 00177-004-016

BORING DM-16-92

Surface Elevation: 516±

REMARKS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	BLOWS PER FOOT	SAMPLE TYPE
9.6% fines			10	▬
			10	▭
			44	▬
			34	▬
			33	▬
			30	▬



Brown fine to medium sand with some silt (dry) (loose)

Gray fine to medium sand (damp) (dense)

Grades to medium dense

Boring DM-16-92 completed at depth of 28.5 feet on 11-12-92. No groundwater encountered during drilling.

NOTE:
Northwest Leg Station 29+21

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

LOG OF BORING

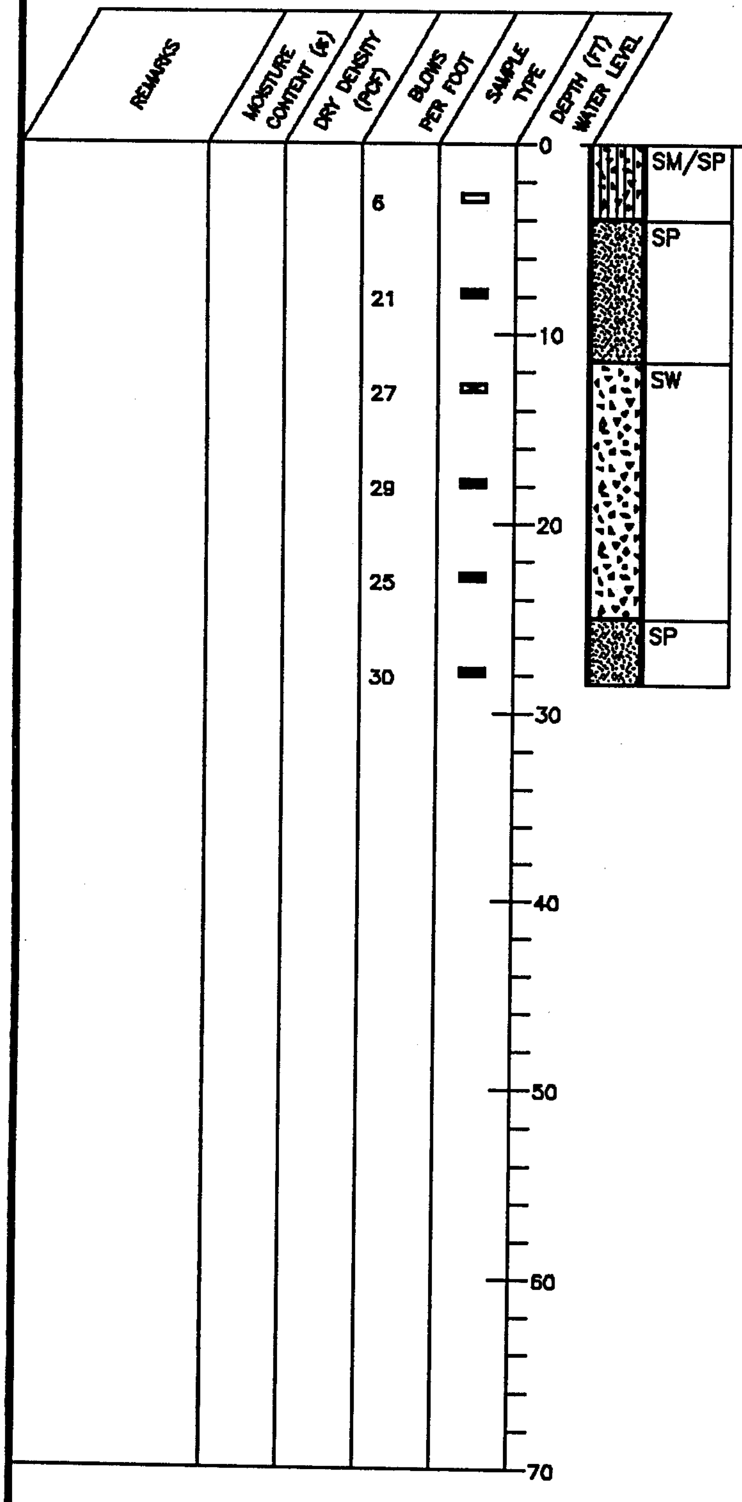
Dames & Moore

Job No. 00177-004-016

PLATE A-16

BORING DM-17-92

Surface Elevation: 514



BLOWS PER FOOT	SAMPLE TYPE
6	▭
21	▬
27	▭
29	▬
25	▬
30	▬

SM/SP Brown fine to medium sand with some silt (dry) (loose)

SP Gray fine to medium sand (damp) (medium dense)

SW Gray fine to coarse sand with trace fine gravel (damp) (medium dense)

SP Gray fine to medium sand (damp) (medium dense)

Boring DM-17-92 completed at depth of 28.5 feet on 11-12-92. No groundwater encountered during drilling.

NOTE:
Northwest Leg Station 20+14

Logged by JCH 01-15-1993   SUperLOG V 2.0, 3-1991

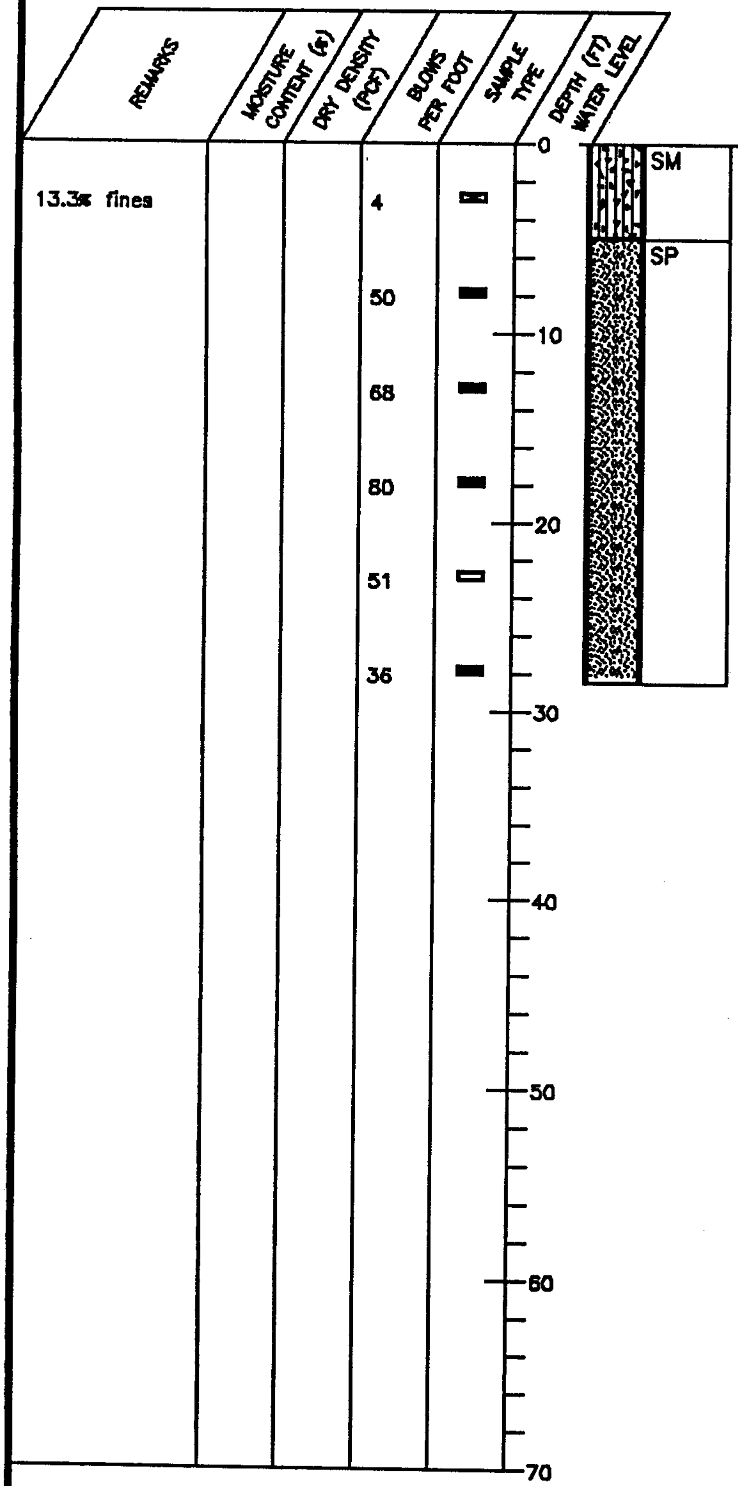
LOG OF BORING

Dames & Moore

Job No. 00177-004-016

BORING DM-18-92

Surface Elevation: 516±



Brown fine to medium sand with some silt (dry) (loose)

Gray fine to medium sand (damp) (dense)

Grades to very dense

Grades to dense

Grades to medium dense

Boring DM-18-92 completed at depth of 28.5 feet on 11-12-92. No groundwater encountered during drilling.

NOTE:
Northwest Leg Station 11+07

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

LOG OF BORING

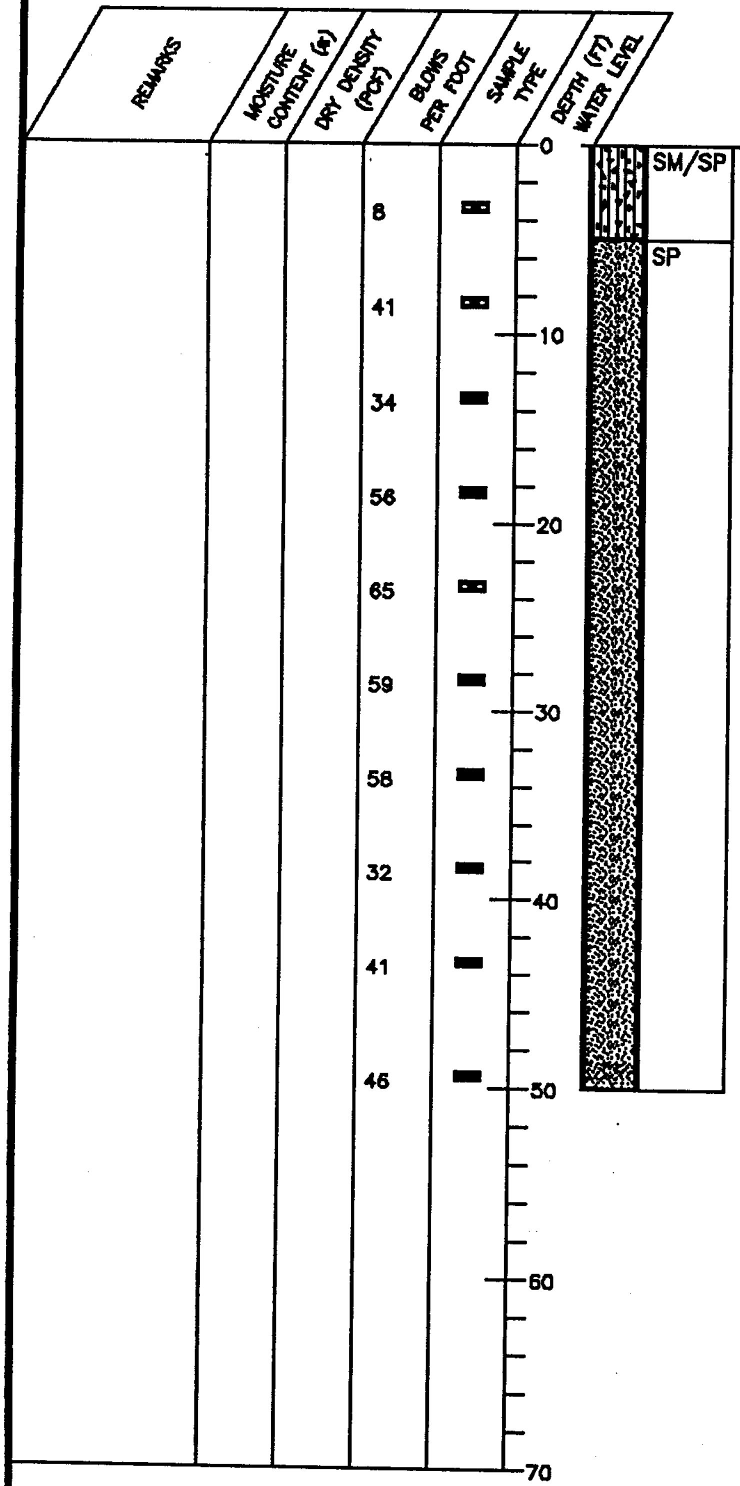
Dames & Moore

Job No. 00177-004-016

PLATE A-18

BORING DM-19-92

Surface Elevation: 519±



Brown fine sand with some silt (dry) (loose)

Gray fine sand (dry) (medium dense)

Grades to dense

Grades to medium dense

Grades to dense

Boring DM-19-92 completed at depth of 50 feet on 11-11-92. No groundwater encountered during drilling.

NOTE:
Northwest Leg Station 2+00

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

LOG OF BORING

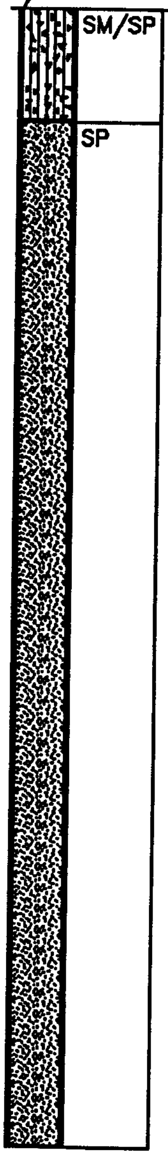
Dames & Moore

BORING DM-20-92

Surface Elevation: 526±

REMARKS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	BLOWS PER FOOT	SAMPLE TYPE
11.6% fines			10	⊟
			15	⊟
			41	▬
			49	▬
			33	▬
			76	▬
			74	⊟
			63	▬
			64	▬
			32	▬
			46	▬
			85/6"	▭

DEPTH (FT) / WATER LEVEL: 0, 10, 20, 30, 40, 50, 60, 70



SM/SP Brown fine sand with some silt (dry) (loose)

SP Brown fine to medium sand (dry) (medium dense)

Grades to gray and dense

Grades to medium dense

Grades to dense

Grades to very dense

Boring DM-20-92 completed at depth of 60 feet on 11-12-92. No groundwater encountered during drilling.

2-inch PVC casing installed for geophysical testing.

NOTE:
Vertex Station 0+00

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

LOG OF BORING

Dames & Moore

Job No. 00177-004-016

PLATE A-20

BORING DM-21-92

Surface Elevation: 522

REMARKS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	BLOWS PER FOOT	SAMPLE TYPE
			11	▬
			19	▬
	2.0	104	37	▬
			51	▬
			48	▬
	3.5	102	71	▬
			46	▭
			40	▬
			26	▬
			25	▬
	3.8	102	50/6"	▬

DEPTH (FT) WATER LEVEL: 0, 10, 20, 30, 40, 50, 60, 70

SM/SP	Brown fine to medium sand with some silt (dry) (loose)
SP	Gray fine to medium sand (dry) (medium dense)
	Grades to dense
	Grades to very dense
	Grades to dense
	Grades to medium dense
	Grades to very dense

Boring DM-21-92 completed at depth of 53.5 feet on 11-11-92. No groundwater encountered during drilling.

NOTE:
Northwest Leg Station -2+00

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

LOG OF BORING

Dames & Moore

Job No. 00177-004-016

PLATE A-21

BORING DM-22-92

Surface Elevation: 533±

REMARKS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	BLOWS PER FOOT	SAMPLE TYPE	DEPTH (FT) WATER LEVEL		
					0	SM/SP	Light brown fine sand with some silt (dry) (loose)
			9	▭			
	4.5	103	15	▬			Grades to medium dense
					10		
			17	▬		SP	Gray fine to medium sand (dry) (medium dense)
	7.5	107	48	▬			Grades to dense
					20		
			49	▬			
			59	▬			grades with occasional gravel
					30		
			50/4"	▬			
			61	▬			
					40		
	3.4	99	57	▬			
			40	▬			
					50		
	4.6	97	35	▬			Grades to medium dense
			50/6"	▭			Grades to very dense
					60		
			54/6"	▬			
					70		

Boring DM-22-92 completed at depth of 63.5 feet on 11-11-92. No groundwater encountered during drilling.

NOTE:
Southwest Leg Station -2+00

Logged by TSP 01-15-1993   SUperLOG V 2.0, 3-1991

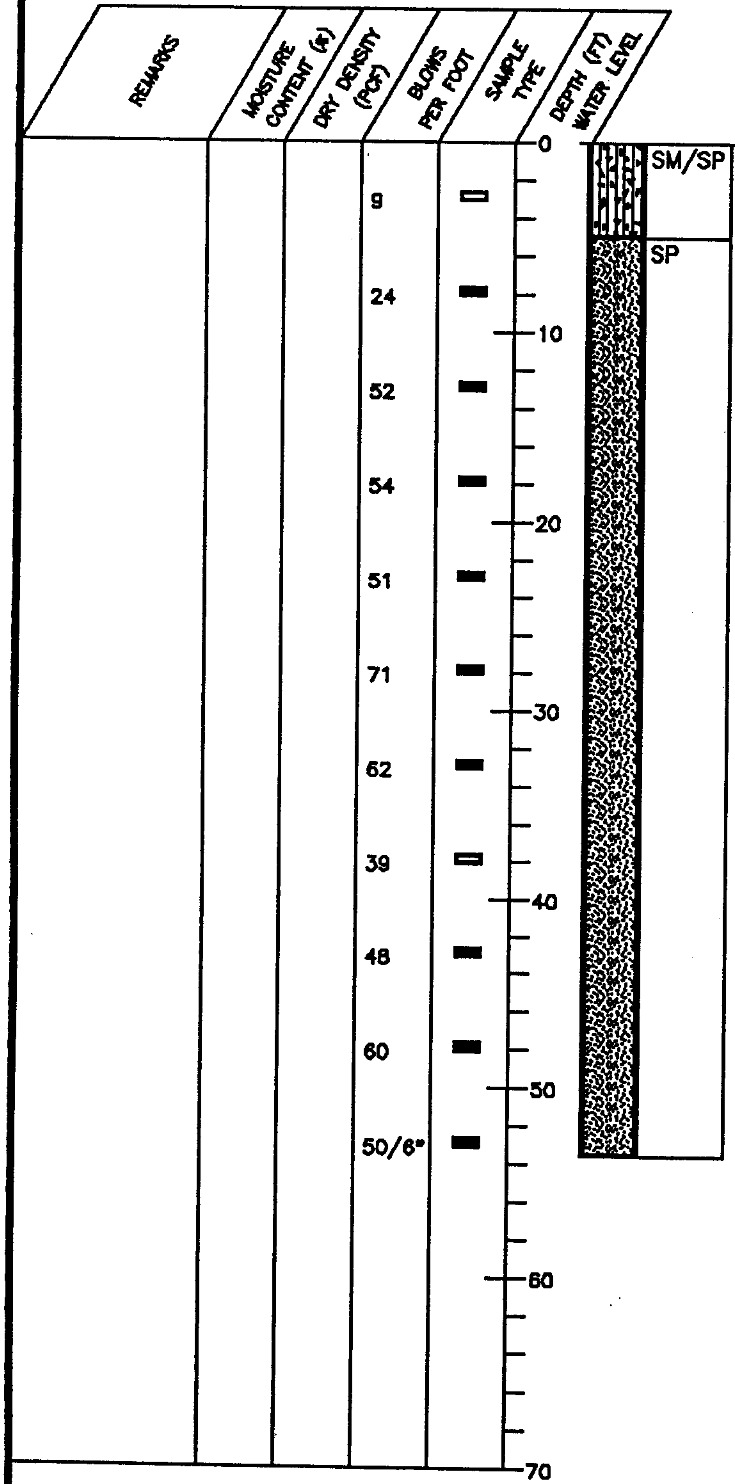
LOG OF BORING

Dames & Moore

Job No. 00177-004-016

BORING DM-23-92

Surface Elevation: 524±



Brown fine sand with some silt (dry) (loose)

Gray fine to medium sand (dry) (medium dense)

Grades to damp and dense

Grades to very dense

Grades to dense

Grades with occasional gravel

Grades to very dense
Boring DM-23-92 completed at depth of 53.5 feet on 11-11-92. No groundwater encountered during drilling.

NOTE:
Southwest Leg Station 2+00

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

LOG OF BORING

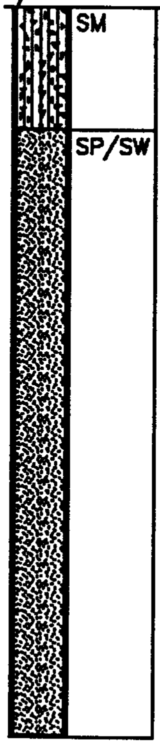
Dames & Moore

Job No. 00177-004-016

BORING DM-24-92

Surface Elevation: 526±

REMARKS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	BLOWS PER FOOT	SAMPLE TYPE	DEPTH (FT) WATER LEVEL
					0
12.7% fines	3.0	96	13	■	
	2.4	87	15	■	
					10
			28	■	
			61	■	
					20
			86	■	
			50/6"	■	
					30
			74	■	
			46	■	
					40
					50
					60
					70



SM — Brown fine sand with some silt (dry) (loose)

SP/SW — Gray fine to medium sand (dry) (medium dense-very dense)

grades to fine sand

grades damp

Boring DM-24-92 completed at depth of 38.5 feet on 11-15-92. No groundwater observed during drilling.

NOTE:
Southwest Leg Station 11+07

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

LOG OF BORING

Dames & Moore

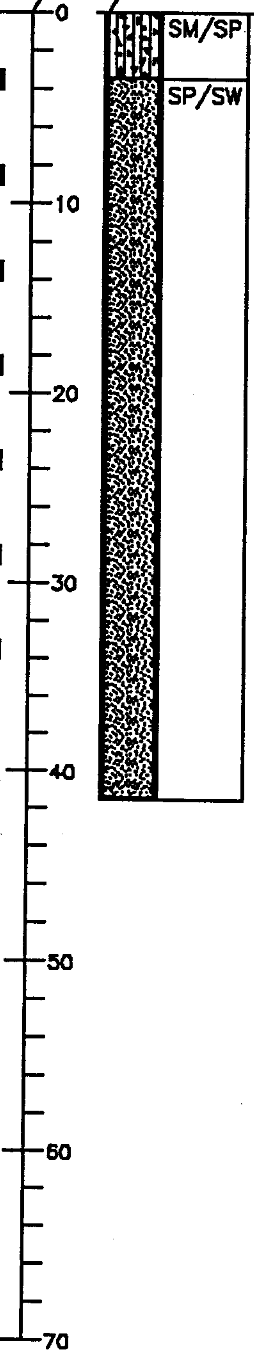
Job No. 00177-004-016

PLATE A-24

BORING DM-25-92

Surface Elevation: 531±

REMARKS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	BLOWS PER FOOT	SAMPLE TYPE
10.7% fines	2.8	108	14	■
	3.5	102	30	■
			33	■
	3.1	105	47	■
			54	■
			30	■
			35	■
			50	■



SM/SP Brown fine sand with some silt (dry) (loose)

SP/SW Gray fine sand (dry) (medium dense-dense)

grades with occasional lenses of light brown silt

grades damp

grades brown

Boring DM-25-92 completed at depth of 41.5 feet on 11-15-92. No groundwater observed during drilling.

NOTE:
Southwest Leg Station 20+14

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

LOG OF BORING

Dames & Moore

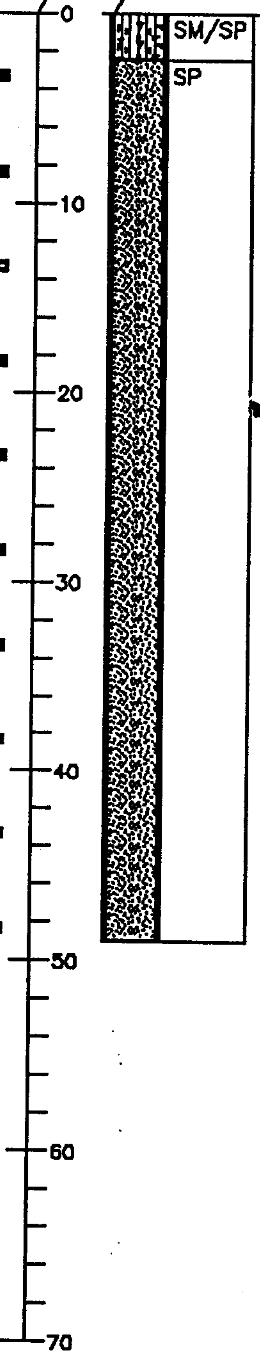
Job No. 00177-004-016

PLATE A-25

BORING DM-26-92

Surface Elevation: 538±

REMARKS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	BLOWS PER FOOT	SAMPLE TYPE		
					SM/SP	Brown fine sand with some silt (dry) (loose)
5.7% fines	1.8	107	11	▬	SP	Gray fine sand (dry) (loose)
			12	▬		
			9	▭		
	3.5	100	28	▬		Grades to medium dense
			42	▬		Grades to dense
			58	▬		
	2.4	108	72	▬		Grades to very dense
			38	▬		Grades to dense
			82	▬		Grades to very dense
			82	▬		



Boring DM-26-92 completed at depth of 49 feet on 11-18-92. No groundwater encountered during drilling.

NOTE:
Southwest Leg Station 29+21

Logged by JCH 01-15-1993   SUperLOG V 2.0, 3-1991

LOG OF BORING

Dames & Moore

Job No. 00177-004-016

BORING DM-27-92

Surface Elevation: 521±

REMARKS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	BLOWS PER FOOT	SAMPLE TYPE	DEPTH (FT) WATER LEVEL
			11	▬	
			22	▬	
			48	▭	
			35	▬	
			34	▬	
			40	▬	
			33	▬	

Depth scale: 0, 10, 20, 30, 40, 50, 60, 70

SM/SP Brown fine sand with some silt (dry) (loose)

SP Gray fine to medium sand (dry) (medium dense)

Grades to dense

Grades to medium dense

Boring DM-27-92 completed at depth of 33.5 feet on 11-18-92. No groundwater encountered during drilling.

NOTE:
Southwest Leg Station 38+28

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

LOG OF BORING

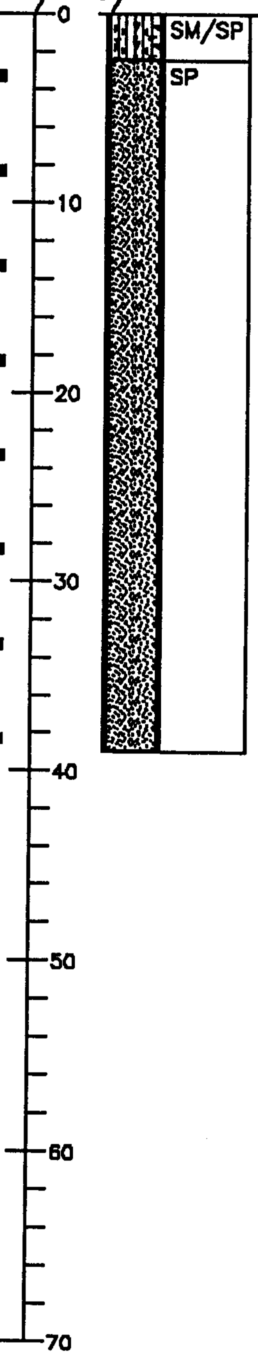
Dames & Moore

Job No. 00177-004-016

BORING DM-28-92

Surface Elevation: 528±

REMARKS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	BLOWS PER FOOT	SAMPLE TYPE	DEPTH (FT) WATER LEVEL
	2.0	108	12	▬	
	4.1	115	22	▬	
	5.7	98	21	▬	
			40	▬	
			30	▬	
			49	▬	
			58	▬	
			88	▬	



SM/SP Brown fine sand with some silt (damp) (loose)

SP Gray fine to medium sand (dry) (loose)

Grades to medium dense with lenses of silty fine sand

Grades to dense

Grades to very dense and moist

Boring DM-28-92 completed at depth of 39 feet on 11-18-92. No groundwater encountered during drilling.

NOTE:
Southwest Leg Station 47+35

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

LOG OF BORING

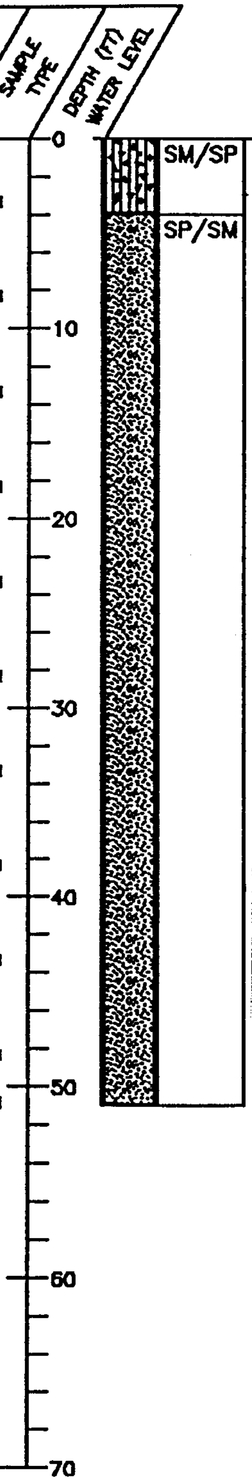
Dames & Moore

Job No. 00177-004-016

BORING DM-29-92

Surface Elevation: 541

REMARKS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	BLOWS PER FOOT	SAMPLE TYPE
			20	▬
10.2% fines	3.6	93	29	▬
			30	▬
			21	▬
			85/11"	▬
			54	▬
			35	▬
			68	▬
			80/11"	▬
			50/6"	▬
			50/6"	▬



Brown fine sand with some silt (damp) (medium dense)

Brownish gray to gray fine sand with some silt (damp) (medium dense to very dense)

Increasing medium sand

Boring DM-29-92 completed at depth of 51 feet on 11-18-92. No groundwater encountered during drilling.

NOTE:
Southwest Leg Station 56+42

Logged by JCH 01-15-1993 SUPERLOG V 2.0, 3-1991

LOG OF BORING

Dames & Moore

BORING DM-30-92

Surface Elevation: 543±

REMARKS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	BLOWS PER FOOT	SAMPLE TYPE	DEPTH (FT) WATER LEVEL		
					0	SM	Brown silty very fine sand (dry) (medium dense)
18.8% fines	2.4	99	18	▬			
			8	▬		SP	Gray fine sand with occasional lenses of silty sand (dry) (loose)
					10		
3.8% fines	2.9	95	27	▬			Grades to medium dense
	4.9	119	45	▬			Grades to dense
					20		
			63	▬			Grades with trace silt
			66	▬			
					30		
			21	▬			Grades to medium dense
			23	▬			
					40		
	2.1	114	59	▬			Grades to dense
							grades to brown and very dense
			68/6"	▬			
					50		
			55/6"	▭			
					60		
					70		

Boring DM-30-92 completed at depth of 53.5 feet on 11-18-92. No groundwater encountered during drilling.

NOTE:
Southwest Leg Station 65+50

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

LOG OF BORING

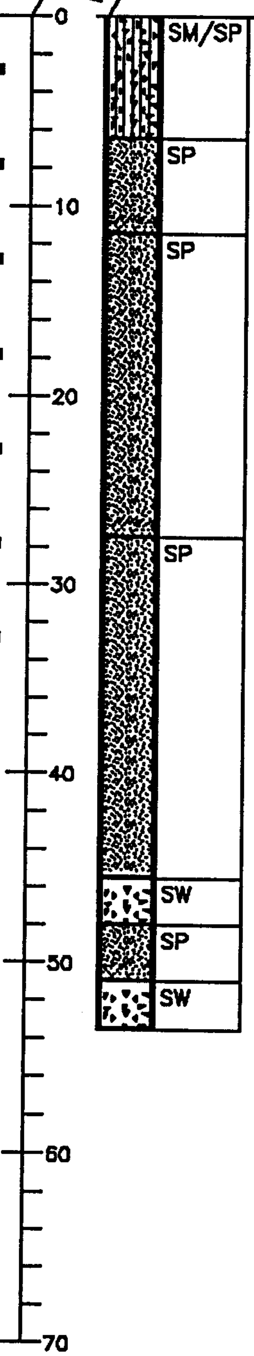
Dames & Moore

Job No. 00177-004-016

BORING DM-31-92

Surface Elevation: 544±

REMARKS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	BLOWS PER FOOT	SAMPLE TYPE
			10	▬
			33	▬
			32	▬
			44	▬
			33	▬
			77	▬
			23	▬
			47	▬
			68	▬
			50/5"	▬
			50/5"	▬



Brown fine sand with some silt (dry) (loose)

Gray fine sand (dry) (medium dense)

Red brown fine sand (damp) (medium dense)

Grades to dense

Grades to gray and medium dense

Gray fine to medium sand (dry) (dense to very dense)

Grades to very dense with occasional gravel

Gray fine to coarse sand with trace gravel (dry) (very dense)

Brown fine sand (dry) (very dense)

Brown fine to coarse sand (dry) (very dense)

Boring DM-31-92 completed at depth of 53.5 feet on 11-18-92. No groundwater encountered during drilling.

NOTE:
Southwest Leg Station 66+00
(offset 50 feet to the southeast)

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

LOG OF BORING

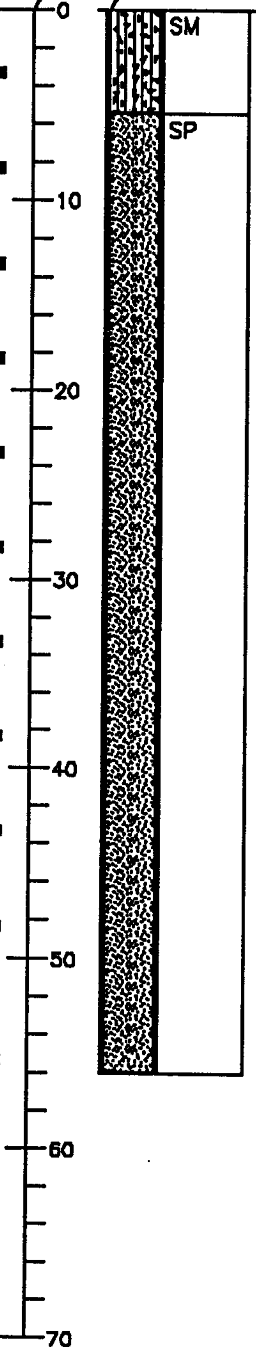
Dames & Moore

Job No. 00177-004-016

BORING DM-32-92

Surface Elevation: 546

REMARKS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	BLOWS PER FOOT	SAMPLE TYPE
19.7% fines	2.5	100	14	▬
2.6% fines	2.8	100	34	▬
4.8% fines	3.6	96	50	▬
	3.2	98	43	▬
			57	▬
			60	▬
			56	▬
	1.8	103	23	▬
			37	▭
			50/6"	▬
			74/6"	▬



Brown fine sand with some silt (dry) (medium dense)

Gray fine sand with trace silt (dry) (medium dense)

Grades to dense with some silt

Grades to very dense with occasional gravel and cobbles

Boring DM-32-92 completed at depth of 56 feet on 11-19-92. No groundwater encountered during drilling.

NOTE:
Southwest Leg Station 66+50

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

LOG OF BORING

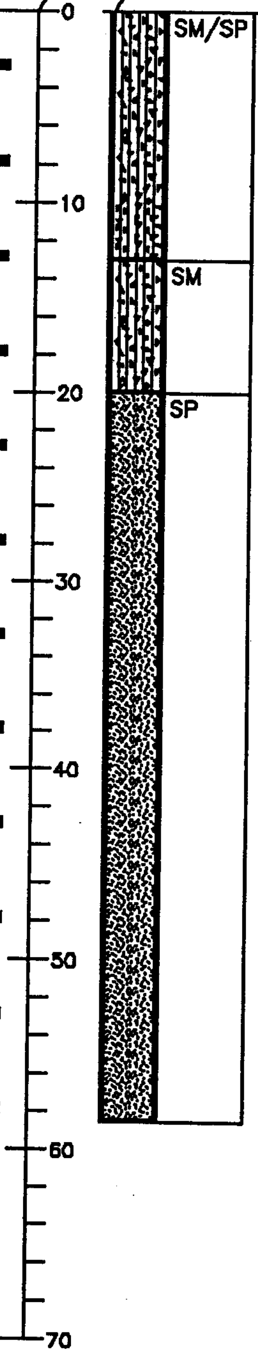
Dames & Moore

Job No. 00177-004-016

BORING DM-33-92

Surface Elevation: 549

REMARKS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	BLOWS PER FOOT	SAMPLE TYPE
7.5% fines	2.2		12	▬
			37	▬
19.0% fines	9.8	86	22	▬
			36	▬
	3.0	104	33	▬
			27	▬
			45	▬
	4.8	97	32	▬
			55	▬
			30	▬
			66	▬
	3.2	109	90/10"	▬



SM/SP Brown fine sand with some silt (dry) (loose)

Grades to gray brown and medium dense

SM Brown silty fine sand (medium dense)

Grades with silt seam about 1/4 inch thick

SP Gray fine to medium sand (dry) (medium dense to dense)

Grades to very dense

Boring DM-33-92 completed at depth of 58.5 feet on 11-19-92. No groundwater encountered during drilling.

NOTE:
Southwest Leg Station 75+64

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

LOG OF BORING

Dames & Moore

Job No. 00177-004-016

BORING DM-34-92

Surface Elevation: 548

REMARKS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	BLOWS PER FOOT	SAMPLE TYPE	DEPTH (FT) WATER LEVEL
					0
			12	▬	
			28	▬	
					10
			28	▬	
15.9% fines	6.3	100	43	▬	
					20
			32	▬	
			43	▬	
					30
			24	▬	
			58	▬	
					40
			52	▬	
			34	▬	
					50
			67	▬	
			90/11"	▭	
					60
					70

SM/SP	Brown fine sand with some silt and occasional roots (dry) (loose)
SP	Gray fine sand (dry) (medium dense)
	Grades to gray brown with lense of brown silt
SM	Brown silty fine sand (dense)
SP	Gray fine sand with trace silt (medium dense to dense)
	Grades to dense
	Grades to medium dense
	Grades to very dense

Boring DM-34-92 completed at depth of 59 feet on 11-19-92. No groundwater encountered during drilling.

NOTE:
Southwest Leg Station 84+78

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

LOG OF BORING

Dames & Moore

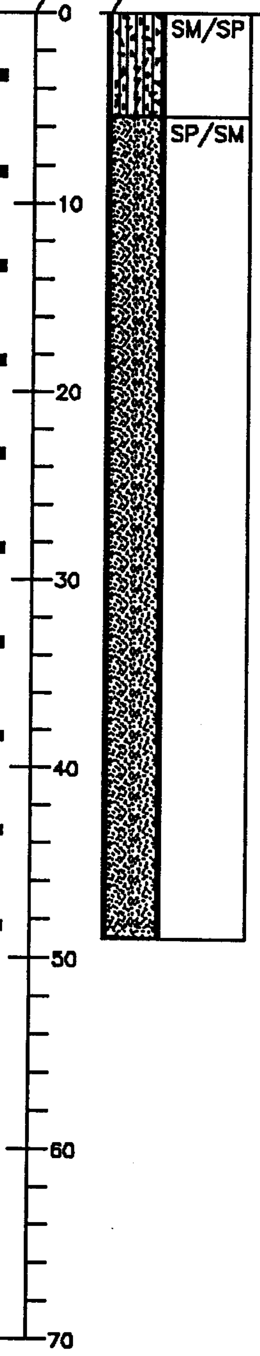
Job No. 00177-004-016

PLATE A-34

BORING DM-35-92

Surface Elevation: 539±

REMARKS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	BLOWS PER FOOT	SAMPLE TYPE
			16	▬
8.4% fines	5.1	95	11	▬
			30	▬
			44	▬
			24	▬
			67	▬
			41	▬
			84/11"	▬
			77	▬
			65	▬



SM/SP Brown fine sand with some silt (dry) (medium dense)

SP/SM Gray fine sand with some silt (dry) (loose)

Grades to medium dense with trace silt (damp) (medium dense)

Grades to very dense

Grades to dense

Grades to very dense

Boring DM-35-92 completed at depth of 49 feet on 11-19-92. No groundwater encountered during drilling.

NOTE:
Southwest Leg Station 93+92

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

LOG OF BORING

Dames & Moore

BORING DM-36-92

Surface Elevation: 541±

REMARKS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	BLOWS PER FOOT	SAMPLE TYPE	DEPTH (FT) WATER LEVEL		
					0	SP	Brown fine sand with trace silt (dry) (loose)
4.8% fines	2.8	98	11	▬			
13.7% fines	4.6	99	20	▬		SM	Brown silty fine sand (medium dense)
					10		
	2.4	104	34	▬		SP	Black fine sand with trace silt (dry) (medium dense)
	3.5	96	24	▬			
					20		
			33	▬			
			60	▬			Grades to dense
					30		
			60	▬			
			87/10"	▬			Grades to very dense
					40		
			71	▬			Grades with occasional fine gravel
					50		
			78/11"	▬			Boring DM-36-92 completed at depth of 51.5 feet on 11-19-92. No groundwater encountered during drilling.
					60		
					70		

NOTE:
Southwest Leg Station 103+06

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

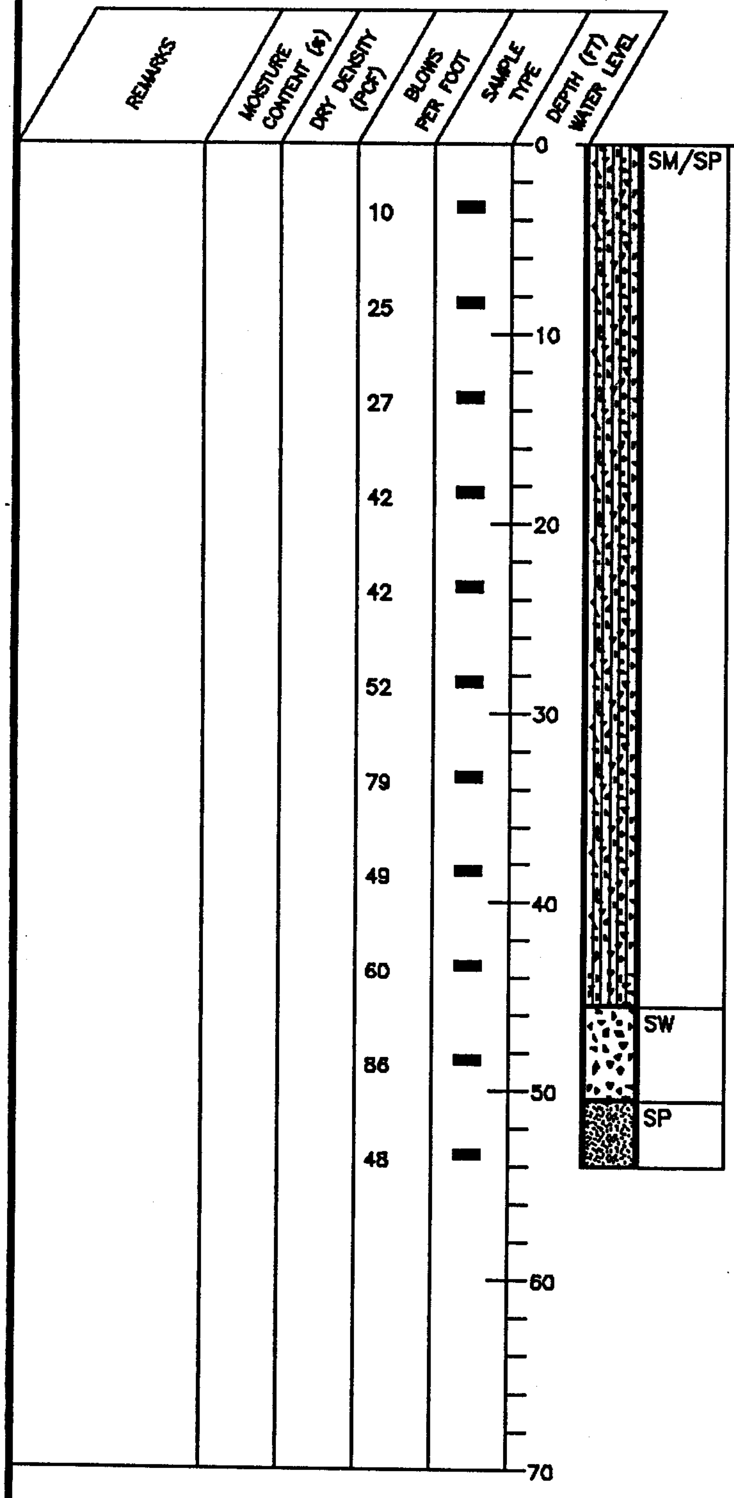
LOG OF BORING

Dames & Moore

Job No. 00177-004-016

BORING DM-37-92

Surface Elevation: 544±



Gray fine sand with some silt (dry) (loose)

Grades to medium dense

Grades to dense

Grades to very dense

Gray fine to coarse sand with occasional fine gravel (dry) (very dense)

Gray fine sand (dry) (dense)

Boring DM-37-92 completed at depth of 54 feet on 11-20-92. No groundwater encountered during drilling.

NOTE:
Southwest Leg Station 112+20

Logged by JCH 01-15-1993   SUperLOG V 2.0, 3-1991

LOG OF BORING

Dames & Moore

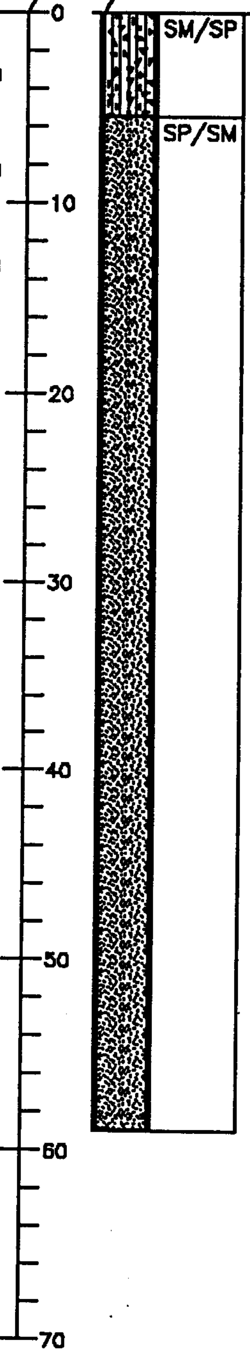
Job No. 00177-004-016

PLATE A-37

BORING DM-38-92

Surface Elevation: 549±

REMARKS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	BLOWS PER FOOT	SAMPLE TYPE
8.9% fines	2.8	103	14	▬
			13	▬
8.6% fines			43	▬
			47	▬
			49	▬
			38	▬
			27	▬
			70	▬
			53	▬
			82/11"	▬
			57	▬
			62	▬



SM/SP Brown fine sand with some silt and occasional roots (dry) (loose)

SP/SM Gray fine sand with some silt (dry) (loose)

Grades with less silt and dense

Grades to medium dense

Grades to very dense

Grades with occasional fine gravel

Boring DM-38-92 completed at depth of 59 feet on 11-20-92. No groundwater encountered during drilling.

NOTE:
Southwest Leg Station 121+34

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

LOG OF BORING

Dames & Moore

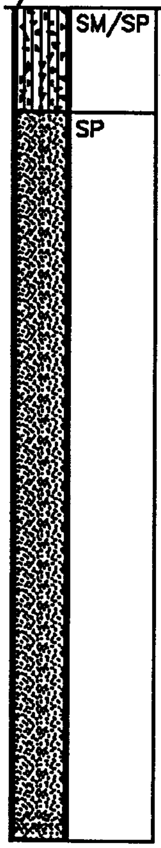
Job No. 00177-004-016

PLATE A-38

BORING DM-39-92

Surface Elevation: 533±

REMARKS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	BLOWS PER FOOT	SAMPLE TYPE	DEPTH (FT)	WATER LEVEL
					0	
			15	▬		
			26	▬		
					10	
			38	▬		
			44	▬		
					20	
			33	▬		
			36	▬		
					30	
			54	▬		
			47	▬		
					40	
			59	▬		
					50	
					60	
					70	



Brown fine sand with some silt (dry) (medium dense)

Gray fine to medium sand with trace silt (dry) (medium dense)

Grades to dense

Boring DM-39-92 completed at depth of 44 feet on 11-20-92. No groundwater encountered during drilling.

NOTE:
Southwest Leg Station 130+50

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

LOG OF BORING

Dames & Moore

Job No. 00177-004-016

PLATE A-39

BORING DM-40-92

Surface Elevation: 529±

REMARKS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	BLOWS PER FOOT	SAMPLE TYPE	DEPTH (FT) WATER LEVEL
	2.7	102	9	▬	
			29	▬	
			29	▬	
	2.3	102	29	▬	
			40	▬	
			40	▬	
			46	▬	
	3.2	108	58	▬	

SM/SP	Brown fine sand with some silt (dry) (loose)
SP	Gray fine sand with occasional silt lenses (dry) (medium dense)
	Grades to dense

Boring DM-40-92 completed at depth of 39 feet on 11-20-92. No groundwater encountered during drilling.

NOTE:

Southwest Leg Station 131+00 (offset 50 feet to the southeast)

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

LOG OF BORING

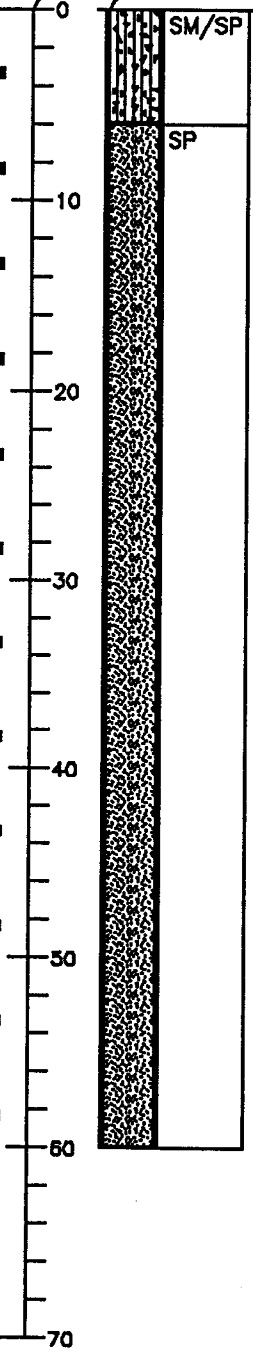
Dames & Moore

Job No. 00177-004-016

BORING DM-41-92

Surface Elevation: 534±

REMARKS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	BLOWS PER FOOT	SAMPLE TYPE	DEPTH (FT)	WATER LEVEL
			14	▬		
			31	▬		
			56	▬		
			51	▬		
			65	▬		
			58	▬		
			93	▬		
			62/6"	▬		
			89/11"	▬		
			63/6"	▬		
			65	▬		
			50/6"	▬		



Brown fine sand with some silt (dry) (medium dense)

Gray fine to medium sand (dry) (dense to very dense)

Boring DM-41-92 completed at depth of 60 feet on 11-12-92. No groundwater encountered during drilling.

2-inch PVC casing installed for geophysical testing.

NOTE:
Southwest Leg Station 131+50

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

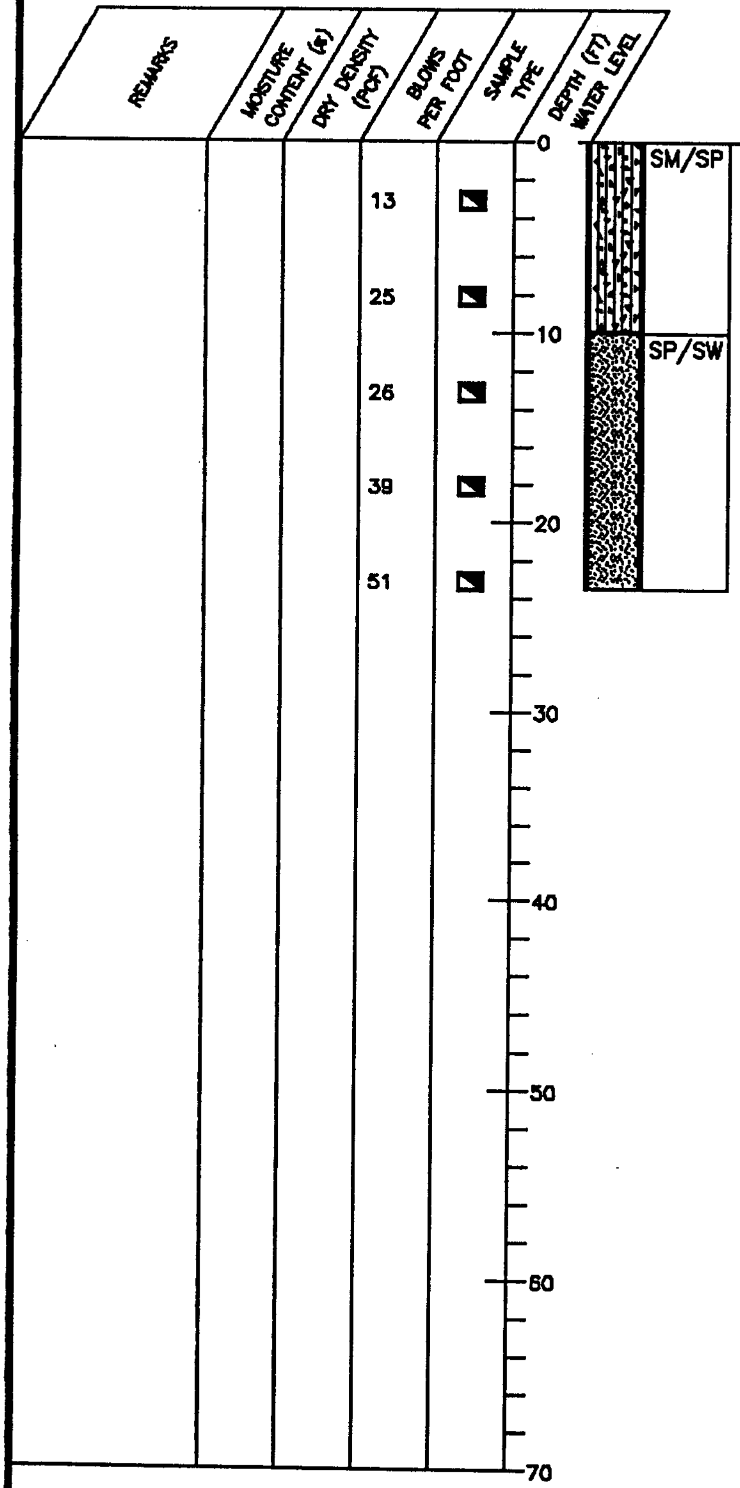
LOG OF BORING

Dames & Moore

Job No. 00177-004-016

BORING DM-42-92

Surface Elevation: 541±



Brown fine sand with some silt (dry) (medium dense)

Gray fine sand (dry) (medium dense-dense)

2 inch silt layer at 12.5 feet

Boring DM-42-92 completed at depth of 23.5 feet on 11-13-92. No groundwater observed during drilling.

NOTE:
Northwest Leg Station 125+91

Logged by TSP 01-15-1993 SUperLOG V 2.0, 3-1991

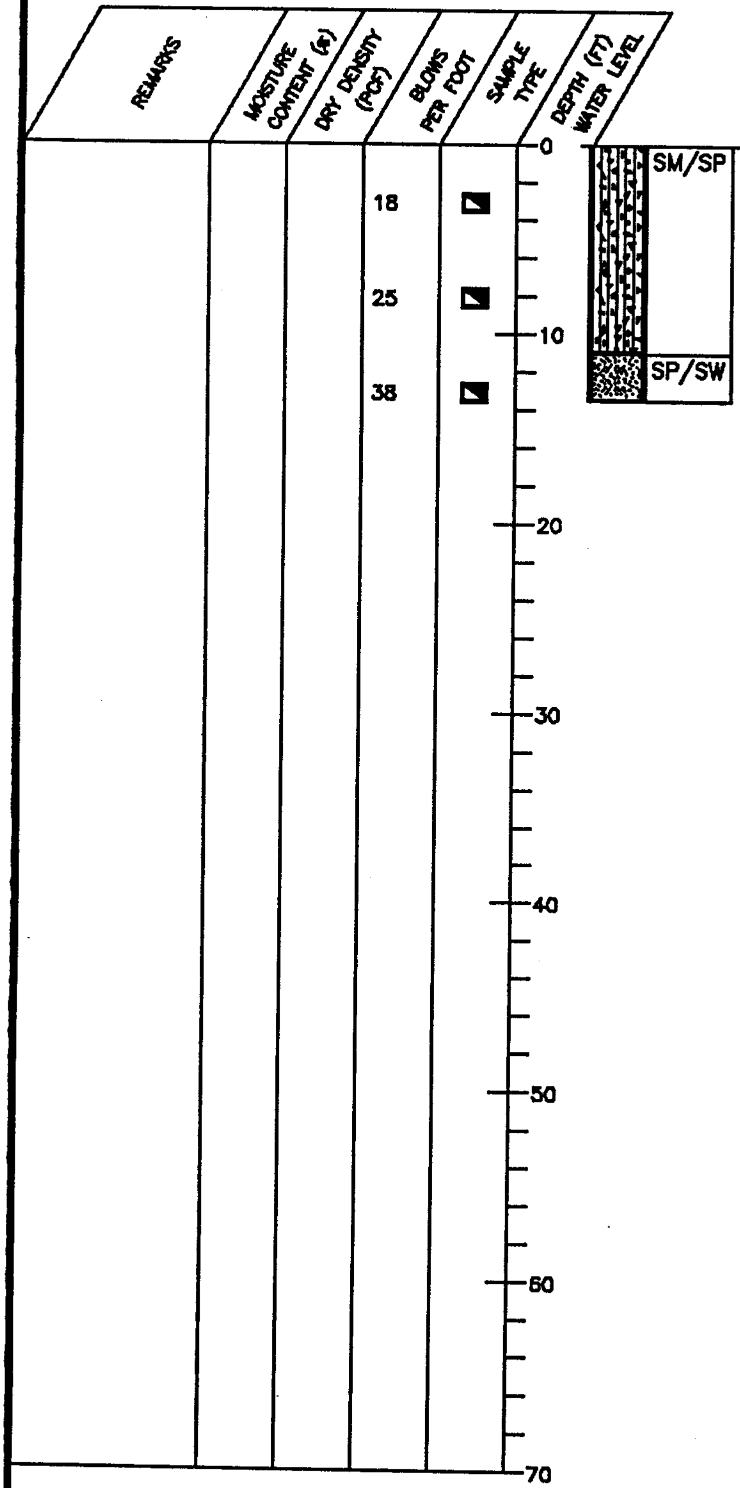
LOG OF BORING

Dames & Moore

Job No. 00177-004-016

BORING DM-43-92

Surface Elevation: 521±



Brown fine sand with some silt (dry) (medium dense)

Gray fine to medium sand (dry) (dense)

Boring DM-43-92 completed at depth of 13.5 feet on 11-14-92. No groundwater observed during drilling.

NOTE:
Northwest Leg Station 116+77

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

LOG OF BORING

Dames & Moore

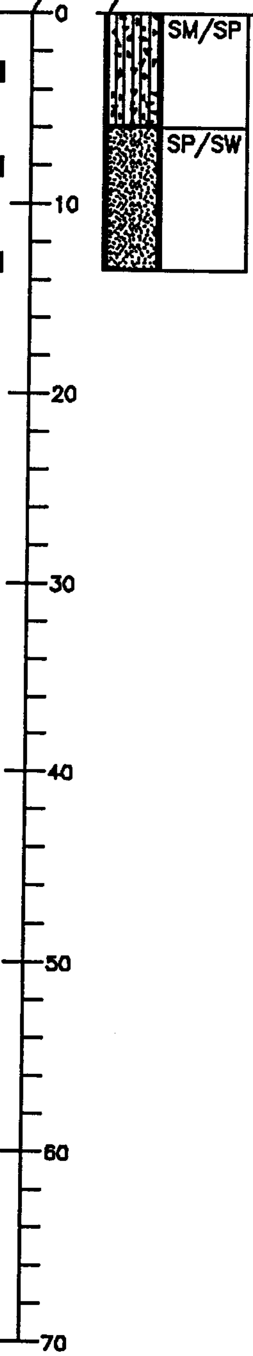
Job No. 00177-004-016

PLATE A-43

BORING DM-44-92

Surface Elevation: 514±

REMARKS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	BLOWS PER FOOT	SAMPLE TYPE	DEPTH (FT) WATER LEVEL
			18	◩	
			37	◩	
			63	◩	



Brown fine sand with some silt (dry) (medium dense)

Gray fine to medium sand, occasional gravel (dry) (dense-very dense)

Boring DM-44-92 completed at depth of 13.5 feet on 11-14-92. No groundwater observed during drilling.

NOTE:
Northwest Leg Station 107+63

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

LOG OF BORING

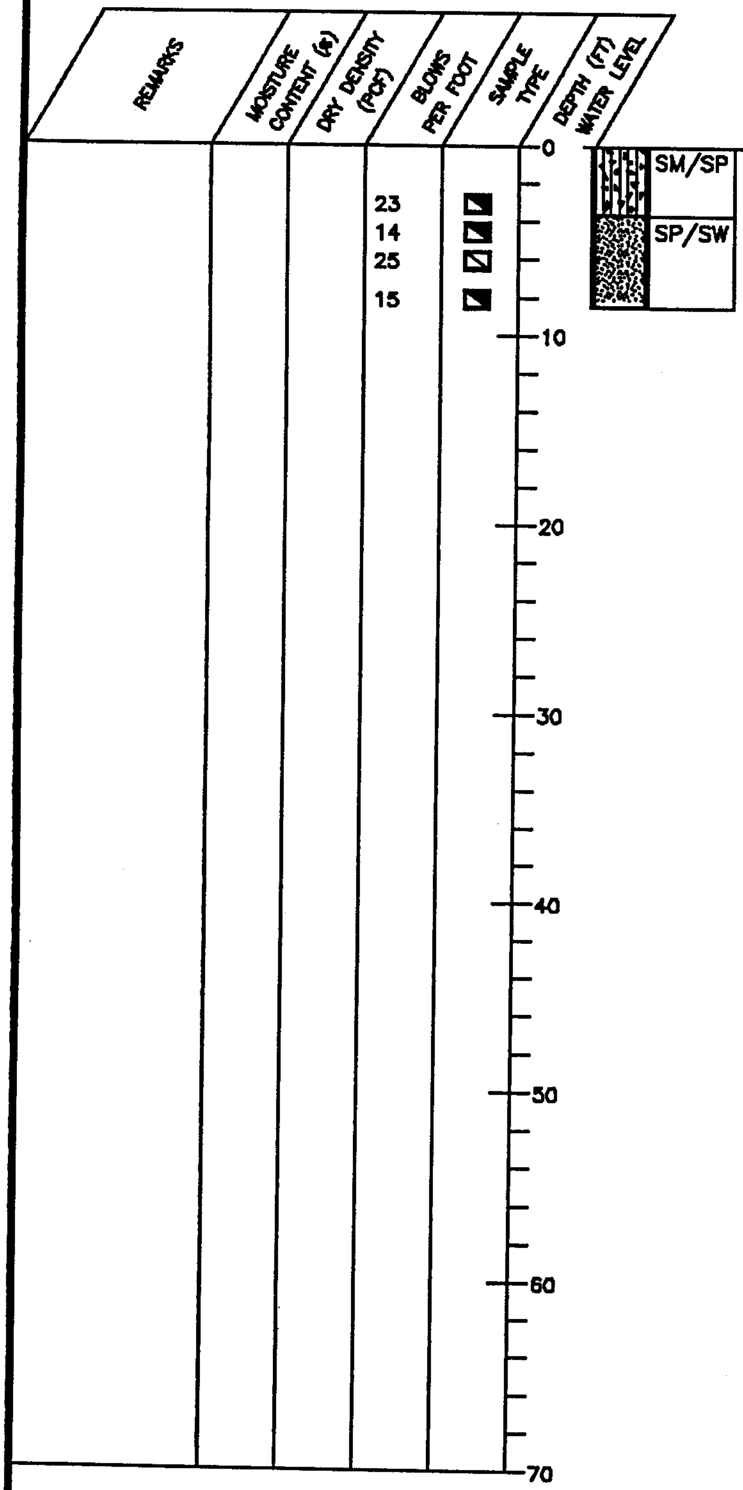
Dames & Moore

Job No. 00177-004-016

PLATE A-44

BORING DM-45-92

Surface Elevation: 512±



Brown fine sand with some silt (dry) (medium dense)

Gray fine to medium sand (dry) (medium dense)

Boring DM-45-92 completed at depth of 8.5 feet on 11-14-92. No groundwater observed during drilling.

NOTE:
Northwest Leg Station 98+49

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

LOG OF BORING

Dames & Moore

Job No. 00177-004-016

PLATE A-45

BORING DM-46-92

Surface Elevation: 515±

REMARKS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	BLOWS PER FOOT	SAMPLE TYPE	DEPTH (FT) WATER LEVEL		
					0	SM/SP	Brown fine sand with some silt (dry) (medium dense)
			13	◪			
						SP/SW	Gray fine to medium sand (dry) (loose)
			8	◪			grades damp

Boring DM-46-92 completed at depth of 8.5 feet on 11-14-92. No groundwater observed during drilling.

NOTE:
Northwest Leg Station 89+35

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

LOG OF BORING

Dames & Moore

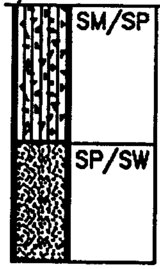
Job No. 00177-004-016

PLATE A-46

BORING DM-47-92

Surface Elevation: 533±

REMARKS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	BLOWS PER FOOT	SAMPLE TYPE	DEPTH (FT) WATER LEVEL
					0
			25	◩	
			17	◩	
					10
			41	◩	
					20
					30
					40
					50
					60
					70



SM/SP Brown fine sand with some silt (dry) (medium dense)

SP/SW Gray fine to medium sand (damp) (medium dense–dense)

Boring DM-47-92 completed at depth of 13.5 feet on 11-14-92. No groundwater observed during drilling.

NOTE:
Northwest Leg Station 80+21

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

LOG OF BORING

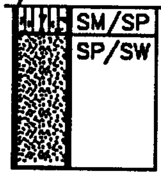
Dames & Moore

Job No. 00177-004-016

BORING DM-48-92

Surface Elevation: 528±

REMARKS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	BLOWS PER FOOT	SAMPLE TYPE	DEPTH (FT) WATER LEVEL
			17	◩	
			68	◩	



SM/SP	Brown fine sand with some silt (dry) (loose)
SP/SW	Gray fine to medium sand (dry) (medium dense-very dense)

Boring DM-48-92 completed at depth of 8.5 feet on 11-14-92. No groundwater observed during drilling.

NOTE:
Northwest Leg Station 71+07

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

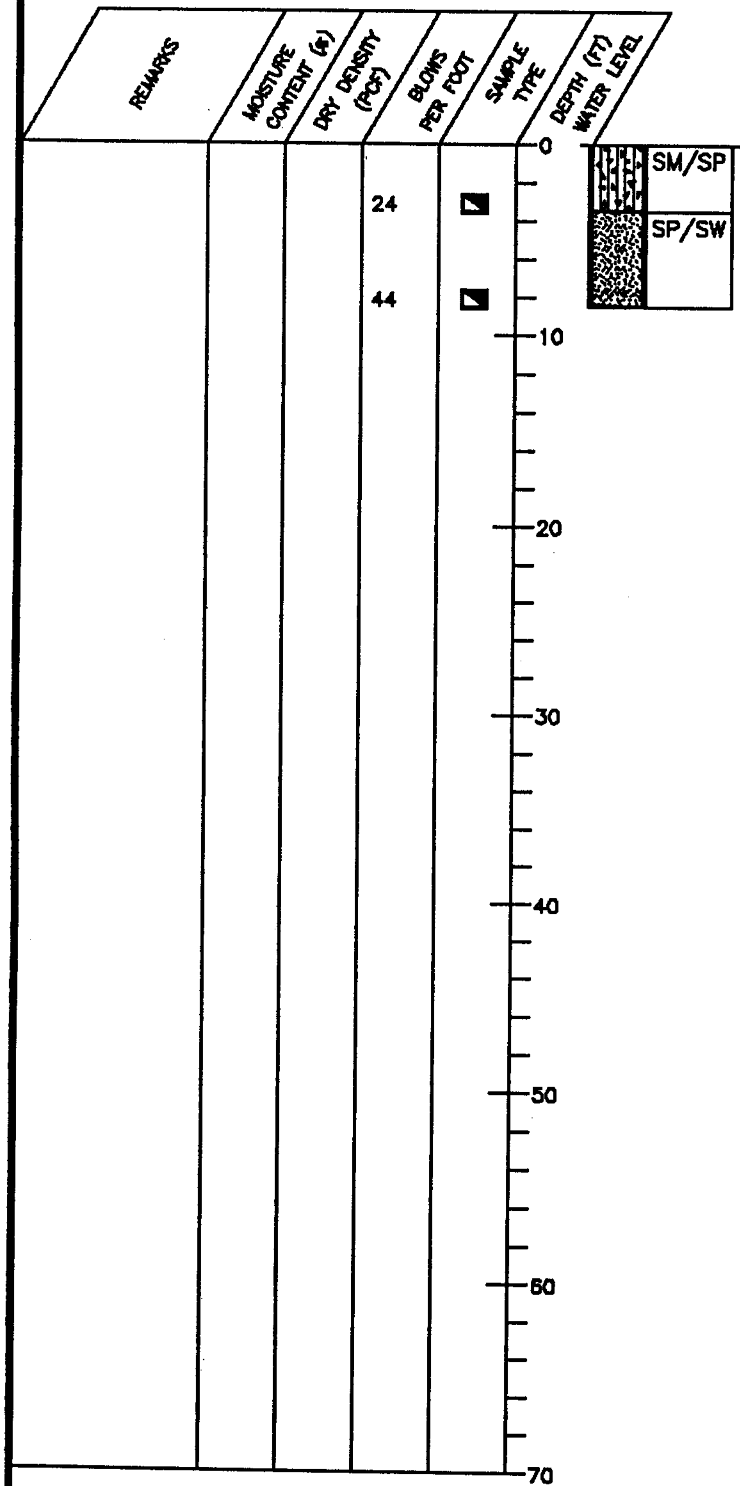
LOG OF BORING

Dames & Moore

Job No. 00177-004-016

BORING DM-49-92

Surface Elevation: 540±



SM/SP Brown fine sand with some silt (dry) (medium dense)

SP/SW Gray fine to medium sand (dry) (dense)

Boring DM-49-92 completed at depth of 8.5 feet on 11-14-92. No groundwater observed during drilling.

NOTE:
Northwest Leg Station 60+96

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

LOG OF BORING

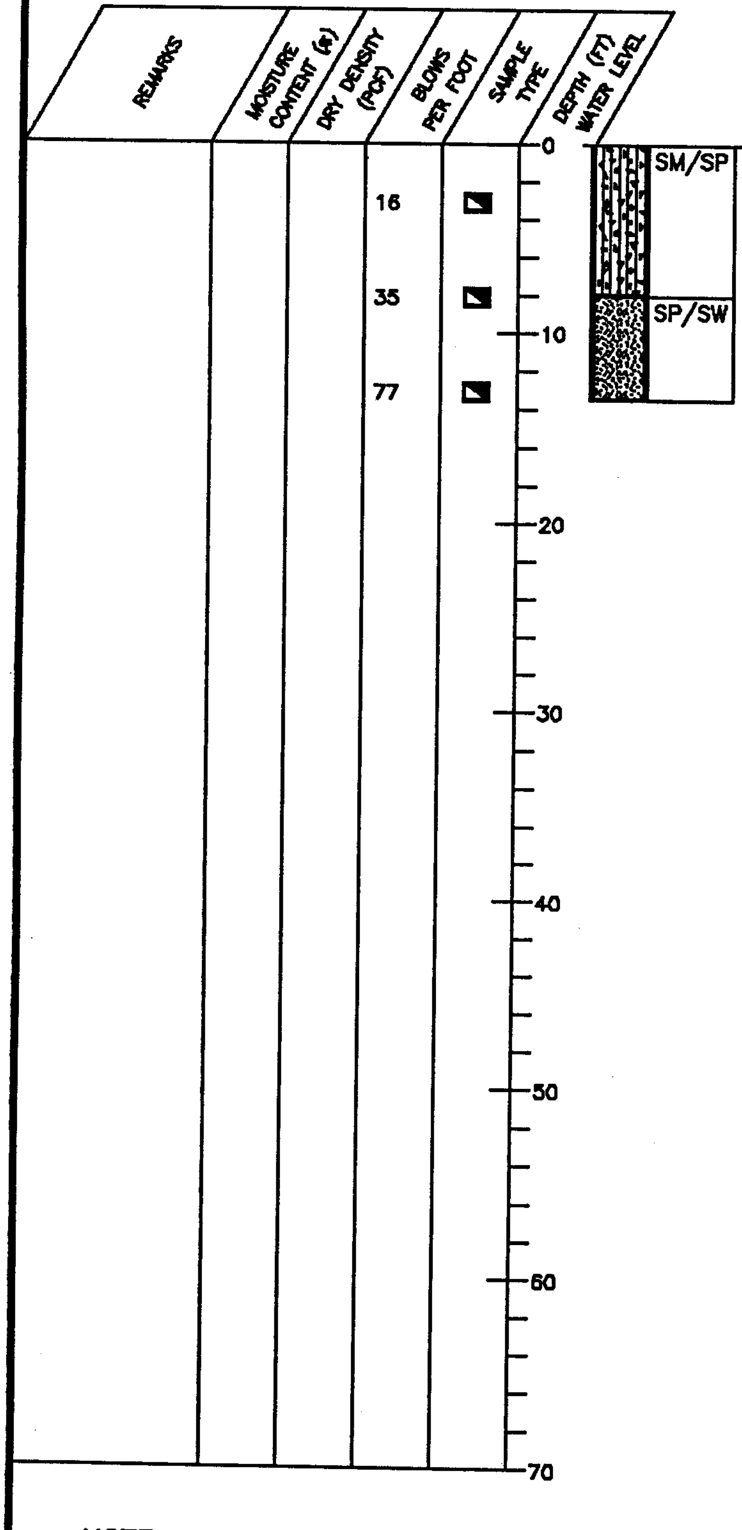
Dames & Moore

Job No. 00177-004-016

PLATE A-49

BORING DM-50-92

Surface Elevation: 541±



Brown fine sand with some silt (dry) (medium dense)

Gray fine sand (dry) (dense–very dense)

Boring DM-50-92 completed at depth of 13.5 feet on 11-15-92. No groundwater observed during drilling.

NOTE:
Northwest Leg Station 51+89

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

LOG OF BORING

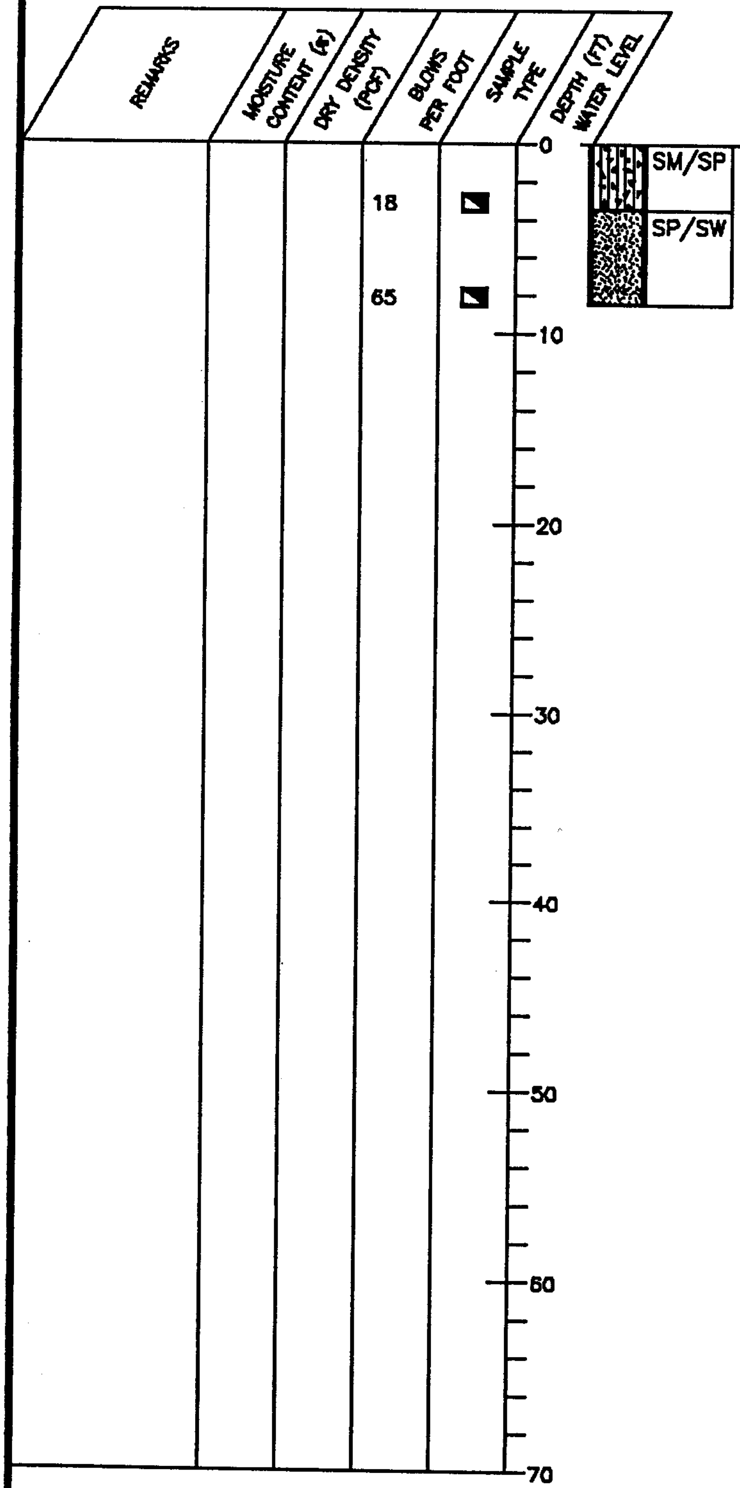
Dames & Moore

Job No. 00177-004-016

PLATE A-50

BORING DM-51-92

Surface Elevation: 520±



Brown fine sand with some silt (dry) (medium dense)

Gray fine to medium sand, occasional gravel (dry) (medium dense–very dense)

Boring DM–51–92 completed at depth of 8.5 feet on 11–15–92. No groundwater observed during drilling.

NOTE:
Northwest Leg Station 42+82

Logged by JCH 01–15–1993 SUperLOG V 2.0, 3–1991

LOG OF BORING

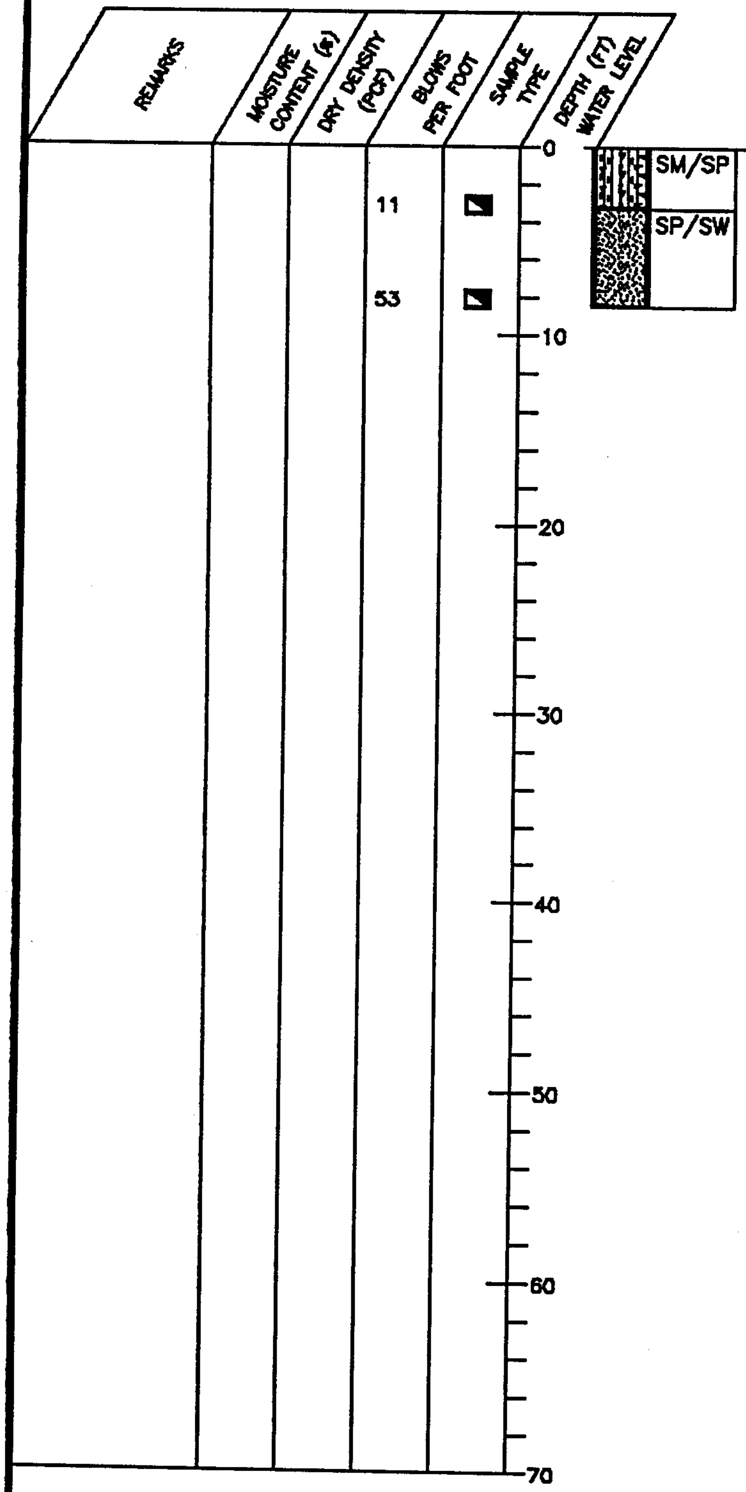
Dames & Moore

Job No. 00177–004–016

PLATE A–51

BORING DM-52-92

Surface Elevation: 518±



SM/SP Brown fine sand with some silt (dry) (loose to medium dense)

SP/SW Gray fine to medium sand (dry) (medium dense–very dense)

Boring DM–52–92 completed at depth of 8.5 feet on 11–15–92. No groundwater observed during drilling.

NOTE:
Northwest Leg Station 33+75

Logged by JCH 01–15–1993   SUperLOG V 2.0, 3–1991

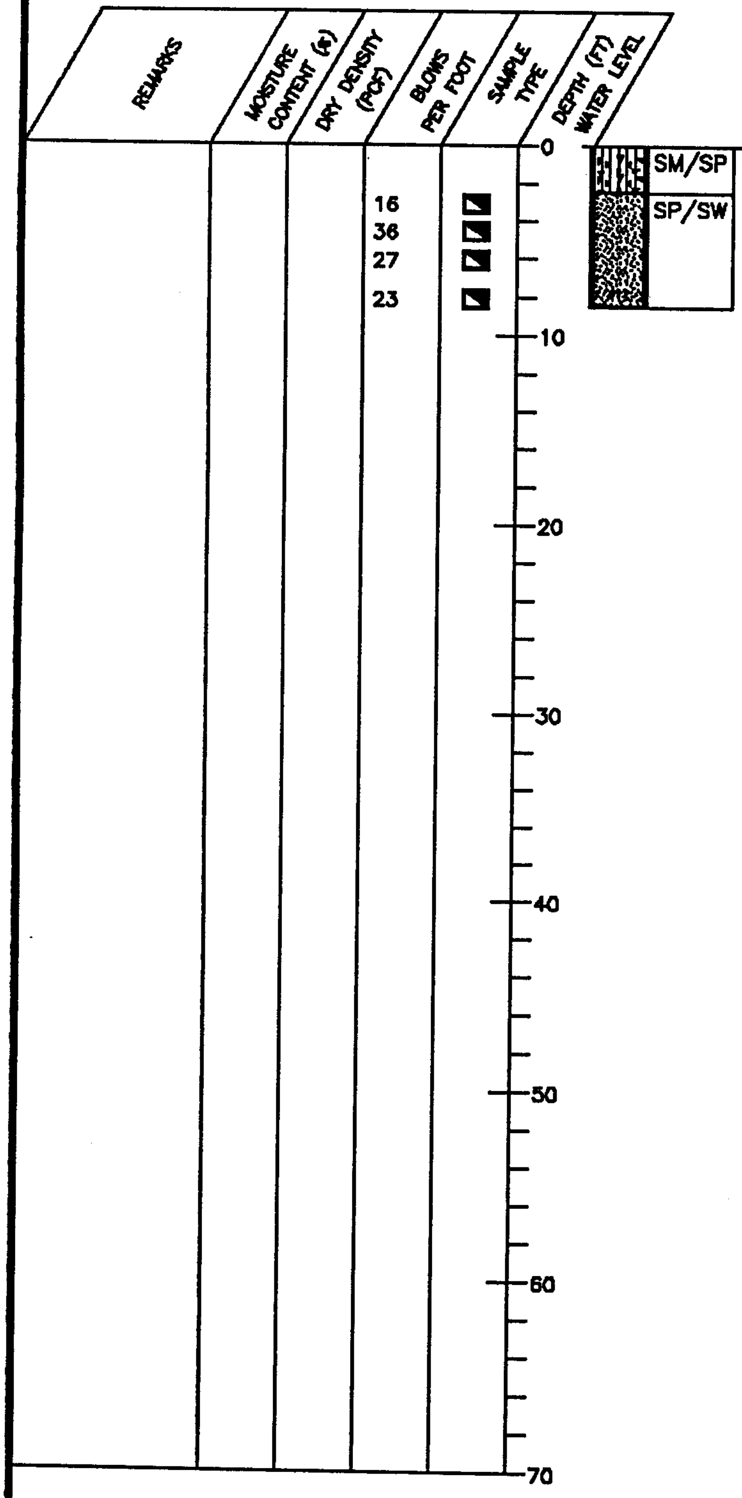
LOG OF BORING

Dames & Moore

Job No. 00177–004–016

BORING DM-53-92

Surface Elevation: 511±



BLOWS PER FOOT	SAMPLE TYPE
16	◪
36	◪
27	◪
23	◪

SM/SP	Brown fine sand with some silt (dry) (medium dense)
SP/SW	Gray fine to medium sand (dry) (medium dense–dense)

Boring DM–53–92 completed at depth of 8.5 feet on 11–15–92. No groundwater observed during drilling.

NOTE:
Northwest Leg Station 24+68

Logged by JCH 01–15–1993 SUperLOG V 2.0, 3–1991

LOG OF BORING

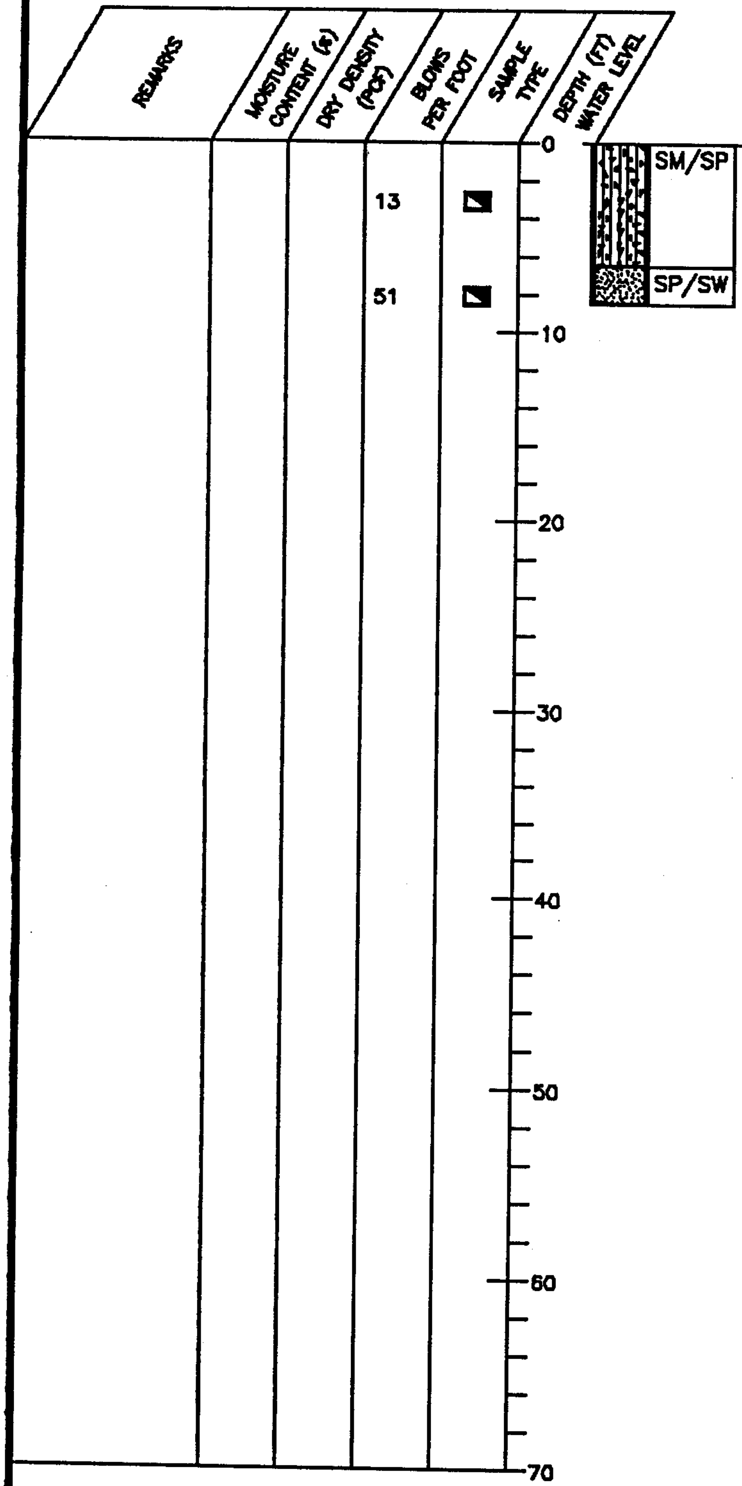
Dames & Moore

Job No. 00177–004–016

PLATE A–53

BORING DM−54−92

Surface Elevation: 519±



Brown fine sand with some silt (dry) (medium dense)

Gray fine to medium sand (dry) (dense−very dense)

Boring DM−15−92 completed at depth of 8.5 feet on 11−15−92. No groundwater observed during drilling.

NOTE:
Northwest Leg Station 15+61

Logged by JCH 01−15−1993   SUperLOG V 2.0, 3−1991

LOG OF BORING

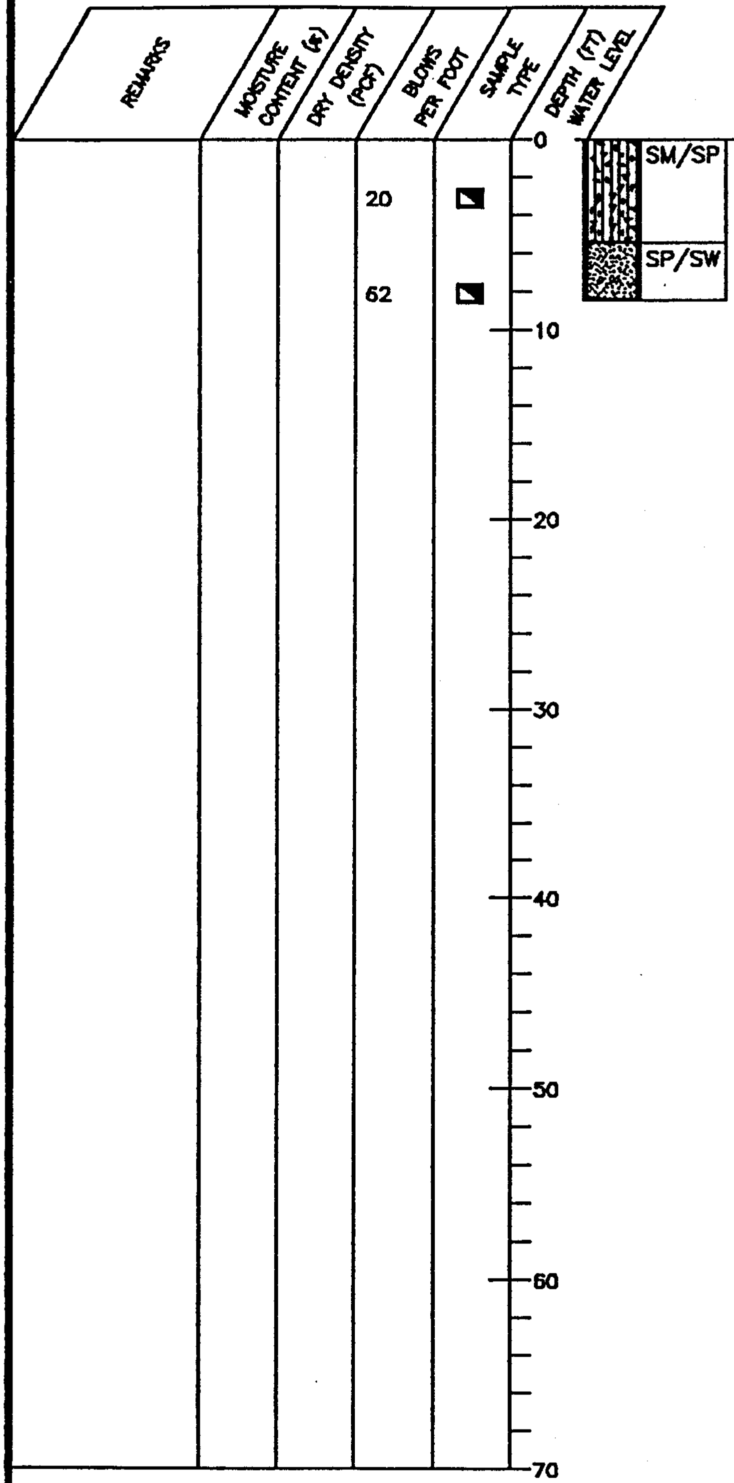
Dames & Moore

Job No. 00177−004−016

PLATE A−54

BORING DM-55-92

Surface Elevation: 518±



Brown fine sand with some silt (dry) (medium dense)

Gray fine to medium sand (damp) (very dense)

Boring DM-55-92 completed at depth of 8.5 feet on 11-15-92. No groundwater observed during drilling.

NOTE:
Northwest Leg Station 6 + 54

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

LOG OF BORING

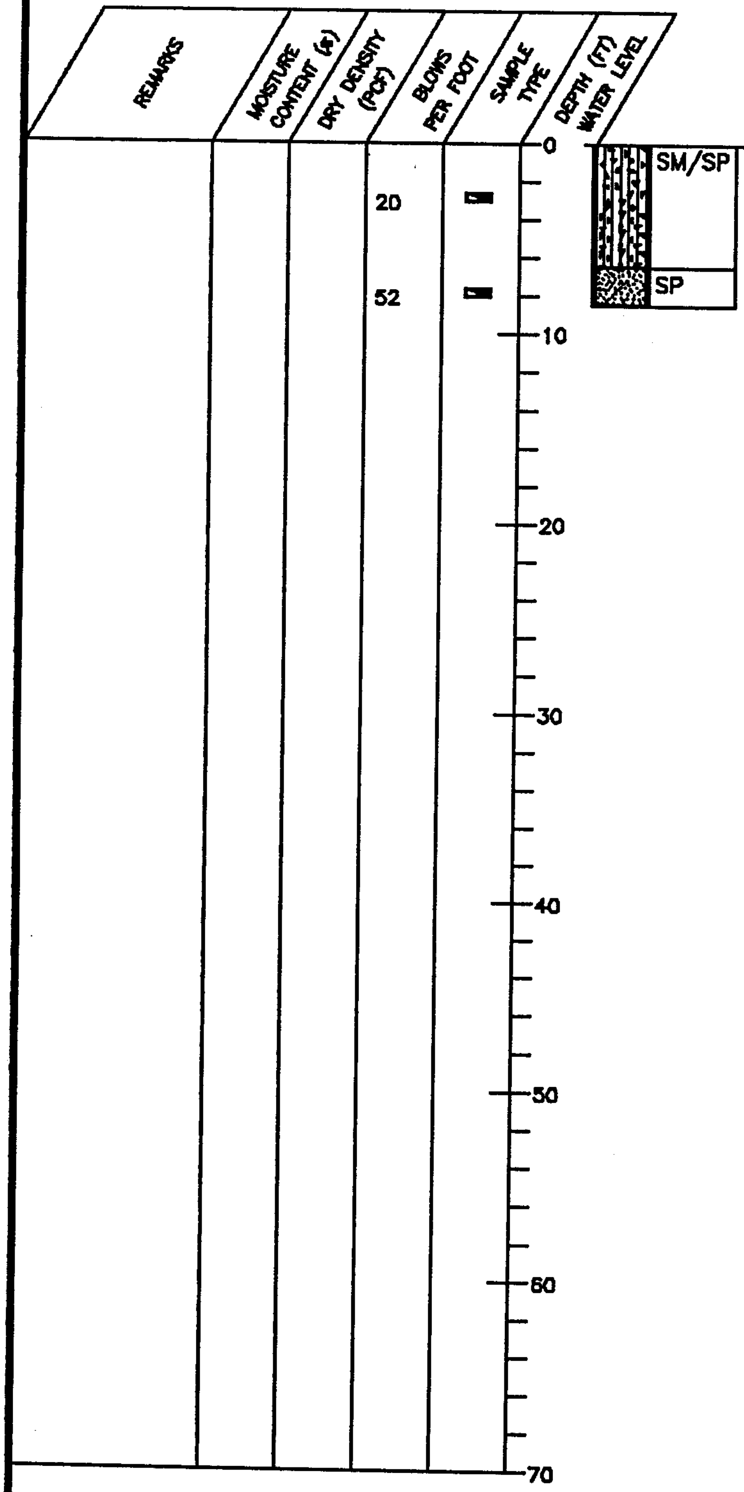
Dames & Moore

Job No. 00177-004-016

PLATE A-55

BORING DM-56-92

Surface Elevation: 523±



Brown fine sand with some silt (dry) (medium dense)

Gray fine sand (dry) (very dense)

Boring DM-56-92 completed at depth of 8.5 feet on 11-15-92. No groundwater encountered during drilling.

NOTE:
Southwest Leg Station 6+54

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

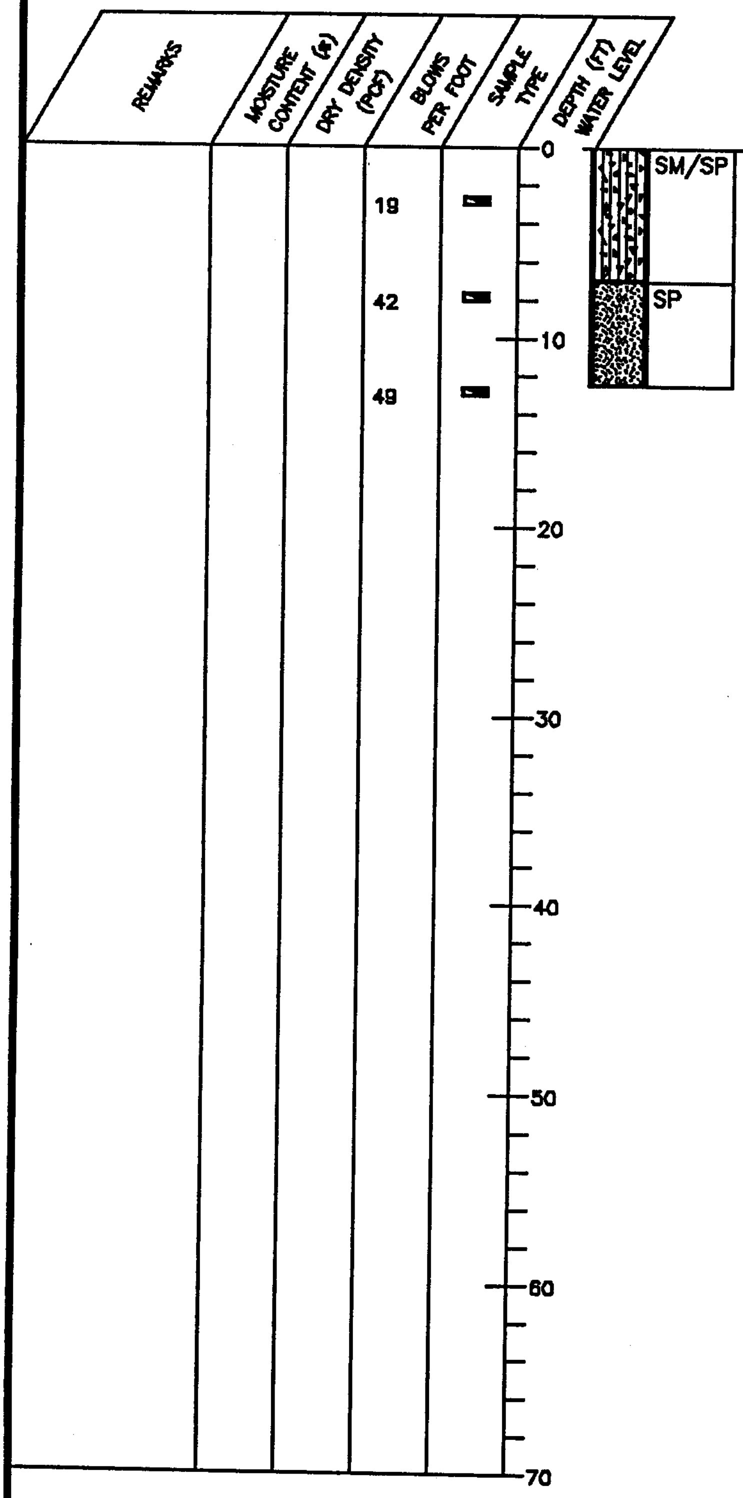
LOG OF BORING

Dames & Moore

Job No. 00177-004-016

BORING DM-57-92

Surface Elevation: 529±



Brown fine sand with some silt (dry) (medium dense)

Gray fine sand (dry) (dense)

Boring DM-57-92 completed at depth of 12.5 feet on 11-15-92. No groundwater encountered during drilling.

NOTE:
Southwest Leg Station 15+61

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

LOG OF BORING

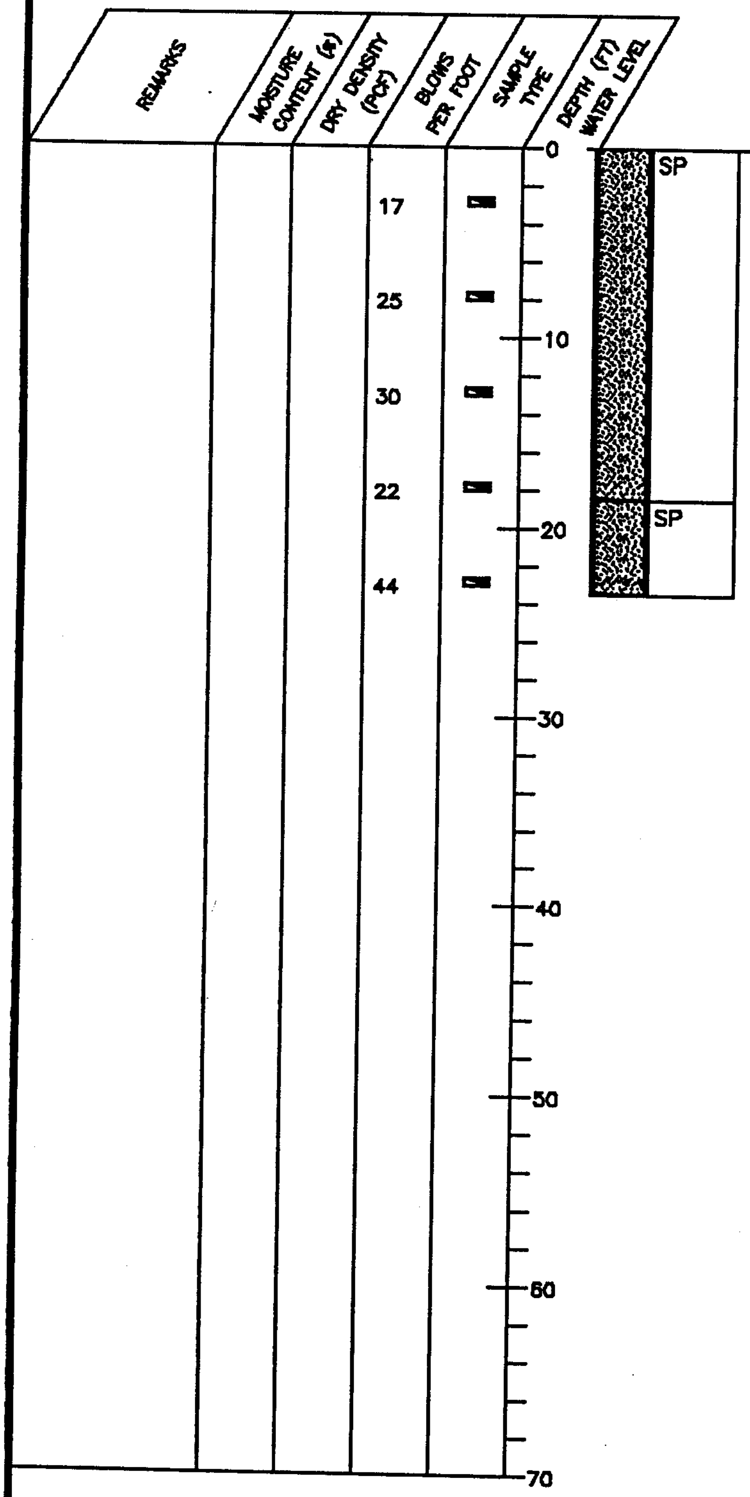
Dames & Moore

Job No. 00177-004-016

PLATE A-57

BORING DM-58-92

Surface Elevation: 538



Brown fine sand with trace silt (damp) (medium dense)

Gray fine sand (damp) (dense)

Boring DM-58-92 completed at depth of 23.5 feet on 11-15-92. No groundwater encountered during drilling.

NOTE:
Southwest Leg Station 24+68

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

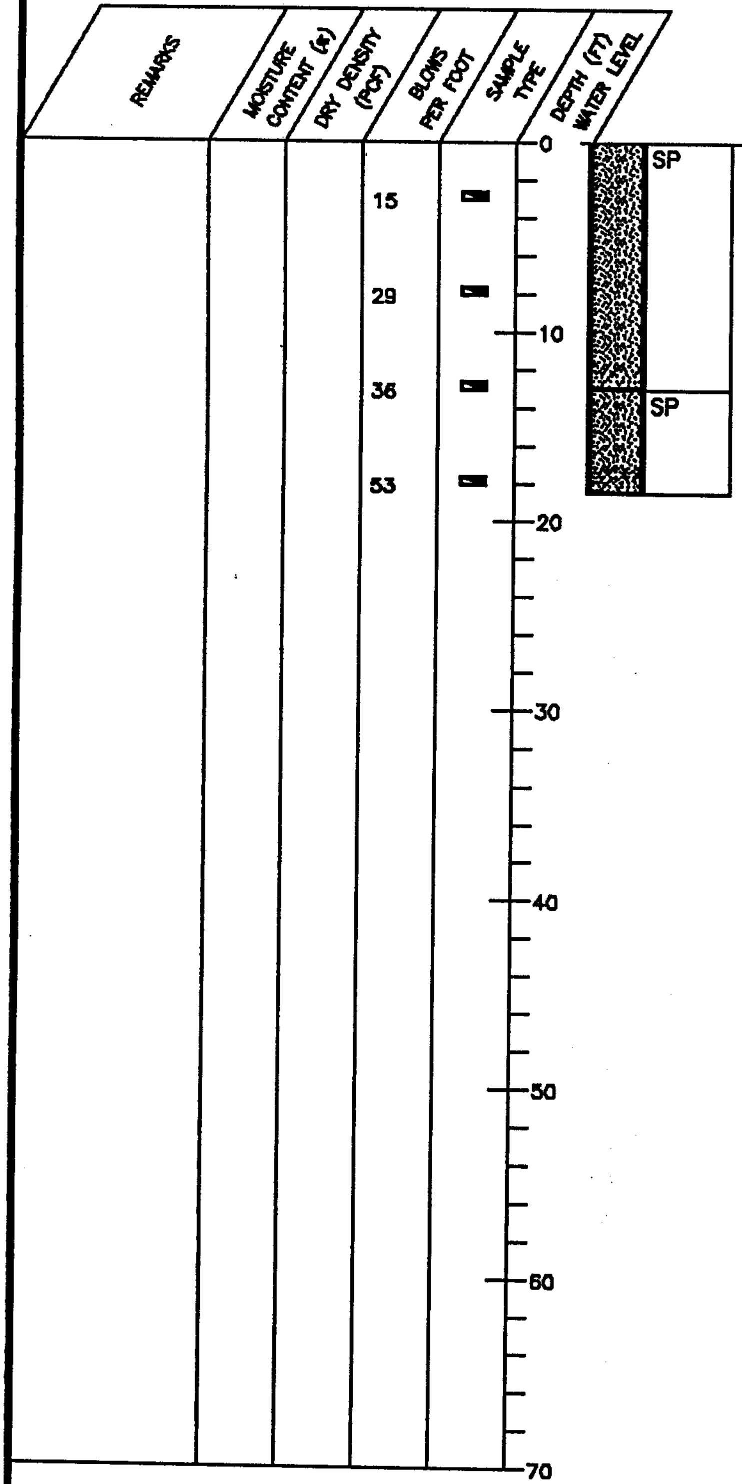
LOG OF BORING

Dames & Moore

Job No. 00177-004-016

BORING DM-59-92

Surface Elevation: 532±



Brown fine sand with trace silt (dry) (medium dense)

Gray fine to medium sand (damp) (dense)

Grades to very dense

Boring DM-59-92 completed at depth of 18.5 feet on 11-18-92. No groundwater encountered during drilling.

NOTE:
Southwest Leg Station 33+75

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

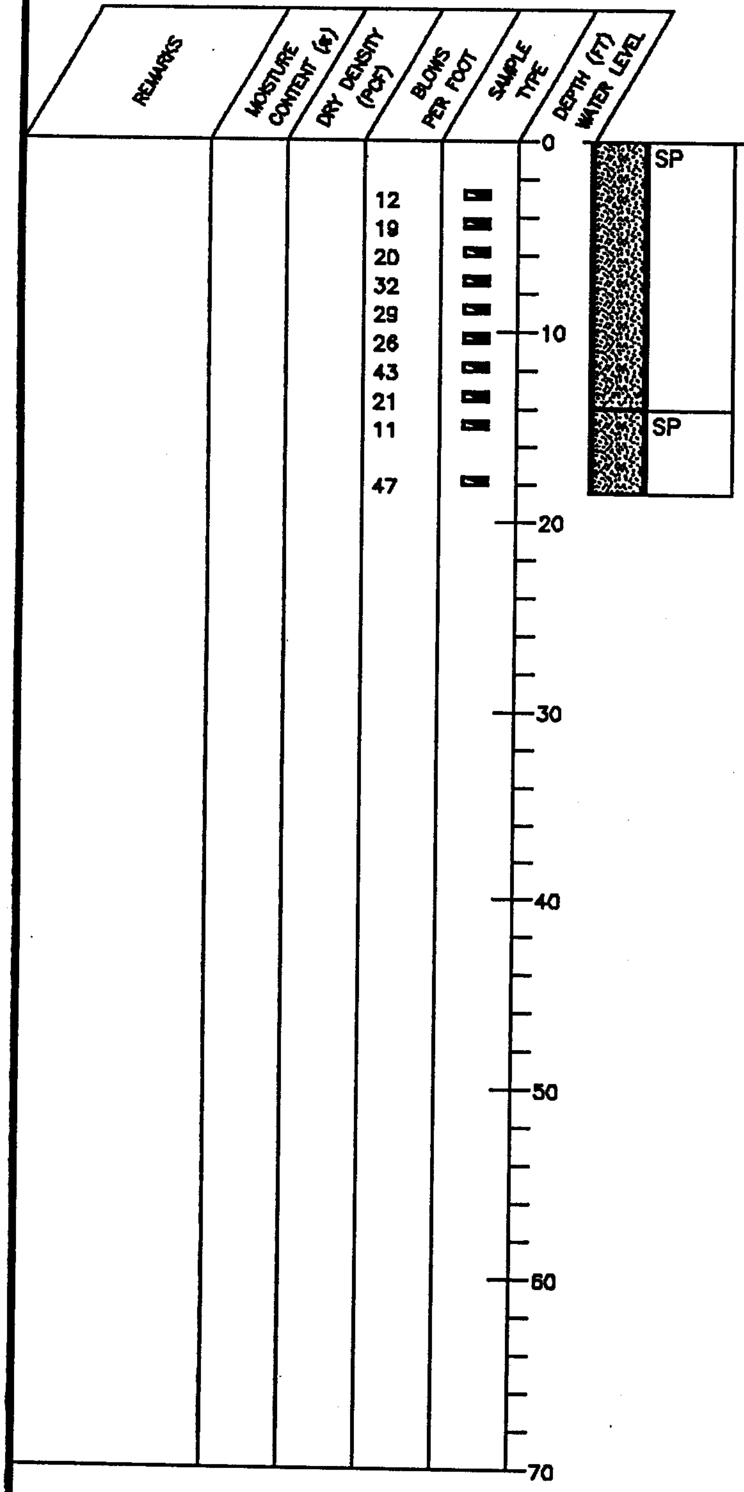
LOG OF BORING

Dames & Moore

Job No. 00177-004-016

BORING DM-60-92

Surface Elevation: 523±



Brown fine sand with trace silt (damp) (medium dense to dense)

Gray fine to medium sand (dry) (medium dense)

Grades to dense

Boring DM-60-92 completed at depth of 18.5 feet on 11-18-92. No groundwater encountered during drilling.

NOTE:
Southwest Leg Station 42+82

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

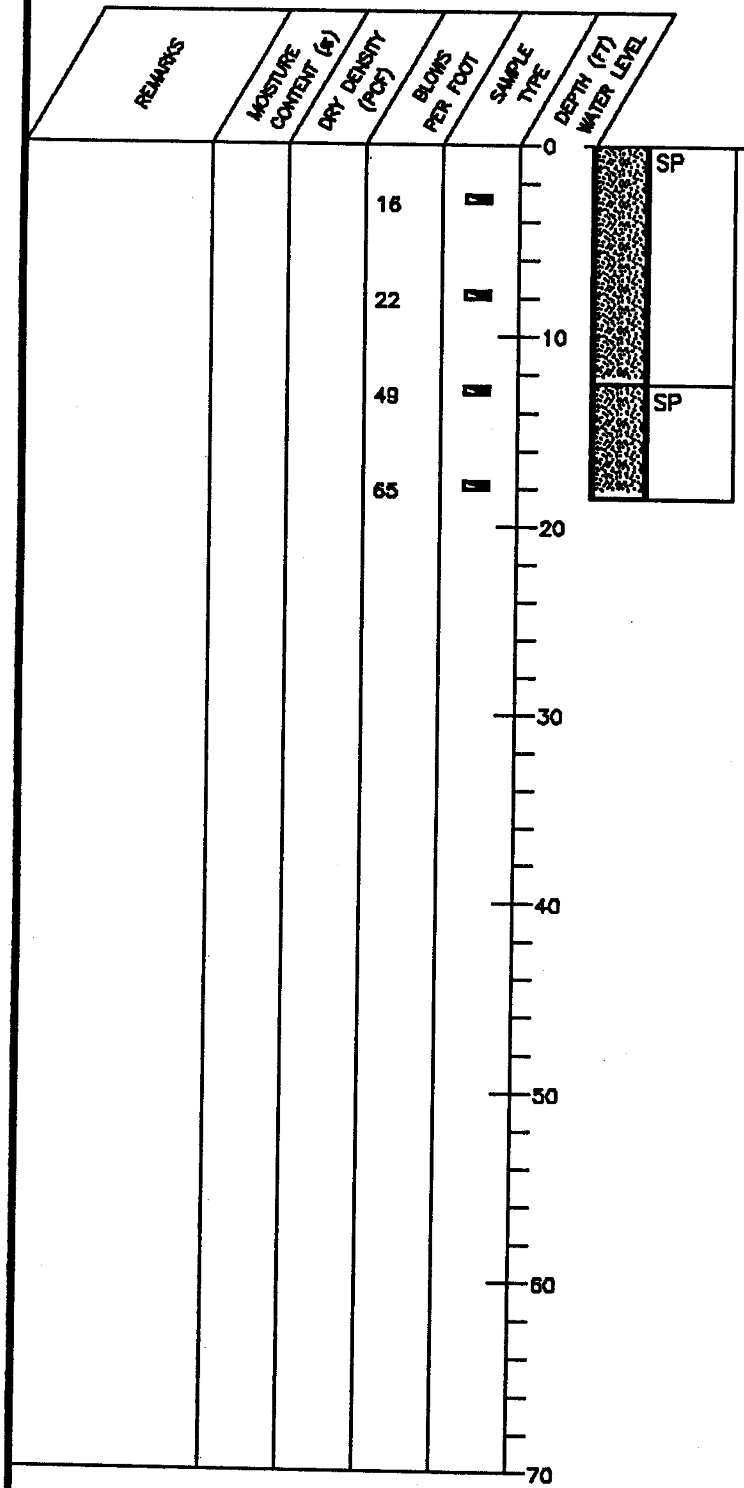
LOG OF BORING

Dames & Moore

Job No. 00177-004-016

BORING DM-61-92

Surface Elevation: 535±



Brown fine sand with trace silt (dry) (medium dense)

Gray fine to medium sand (dry) (dense)

Grades to very dense

Boring DM-61-92 completed at depth of 18.5 feet on 11-18-92. No groundwater encountered during drilling.

NOTE:
Southwest Leg Station 51+89

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

LOG OF BORING

Dames & Moore

Job No. 00177-004-016

PLATE A-61

BORING DM-62-92

Surface Elevation: 535±

REMARKS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	BLOWS PER FOOT	SAMPLE TYPE	DEPTH (FT) WATER LEVEL		
					0	SP	Brown fine sand with trace silt (dry) (medium dense)
			17	▬			
						SP	Gray fine to medium sand (dry) (medium dense)
			25	▬			
					10		
			44	▬			Grades to dense
							Boring DM-62-92 completed at depth of 13.5 feet on 11-18-92. No groundwater encountered during drilling.
					20		
					30		
					40		
					50		
					60		
					70		

NOTE:
Southwest Leg Station 60+96

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

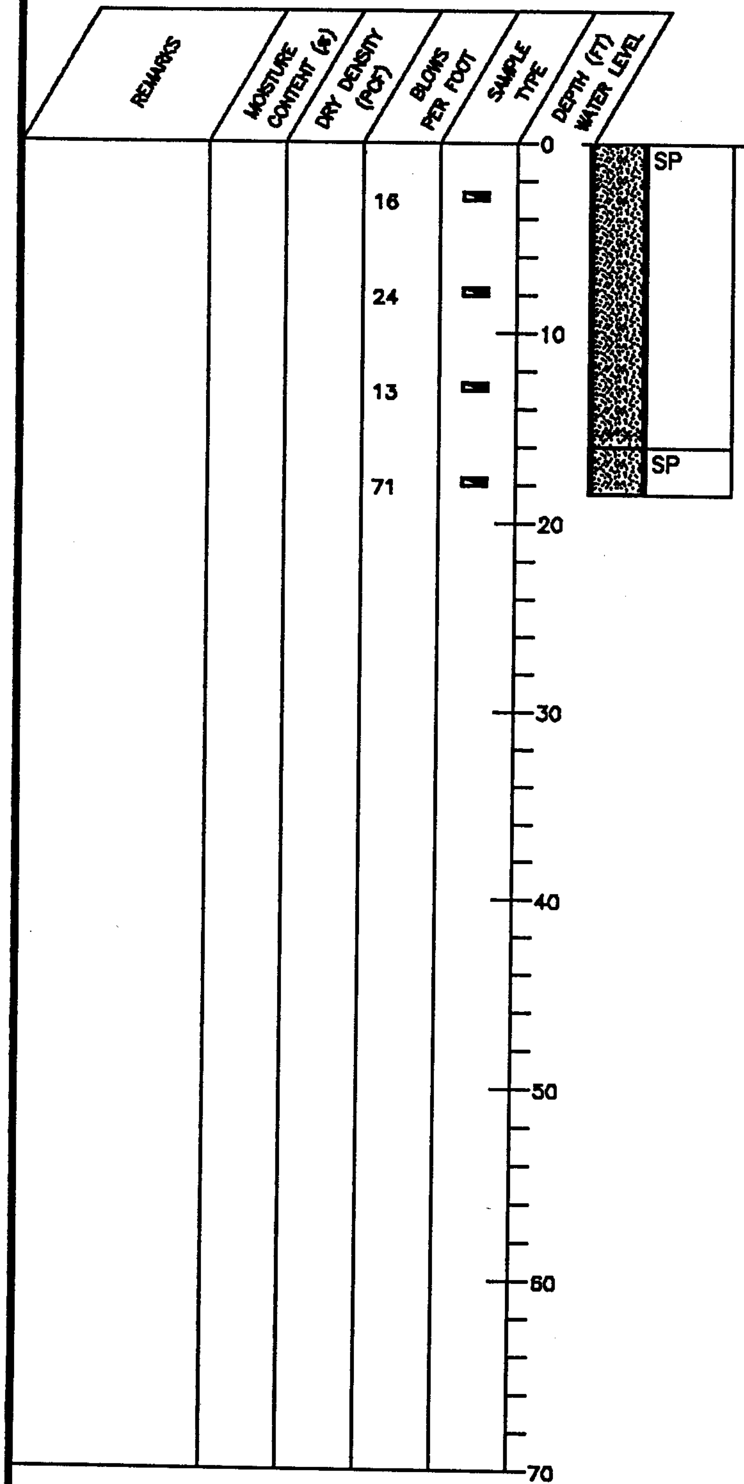
LOG OF BORING

Dames & Moore

Job No. 00177-004-016

BORING DM-63-92

Surface Elevation: 549±



Brown fine sand with trace silt (damp) (medium dense)

Grades to dry

Gray fine to medium sand with occasional layer of brown fine sand with trace silt (dry) (very dense)

Boring DM-63-92 completed at depth of 18.5 feet on 11-19-92. No groundwater encountered during drilling.

NOTE:
Southwest Leg Station 71+07

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

LOG OF BORING

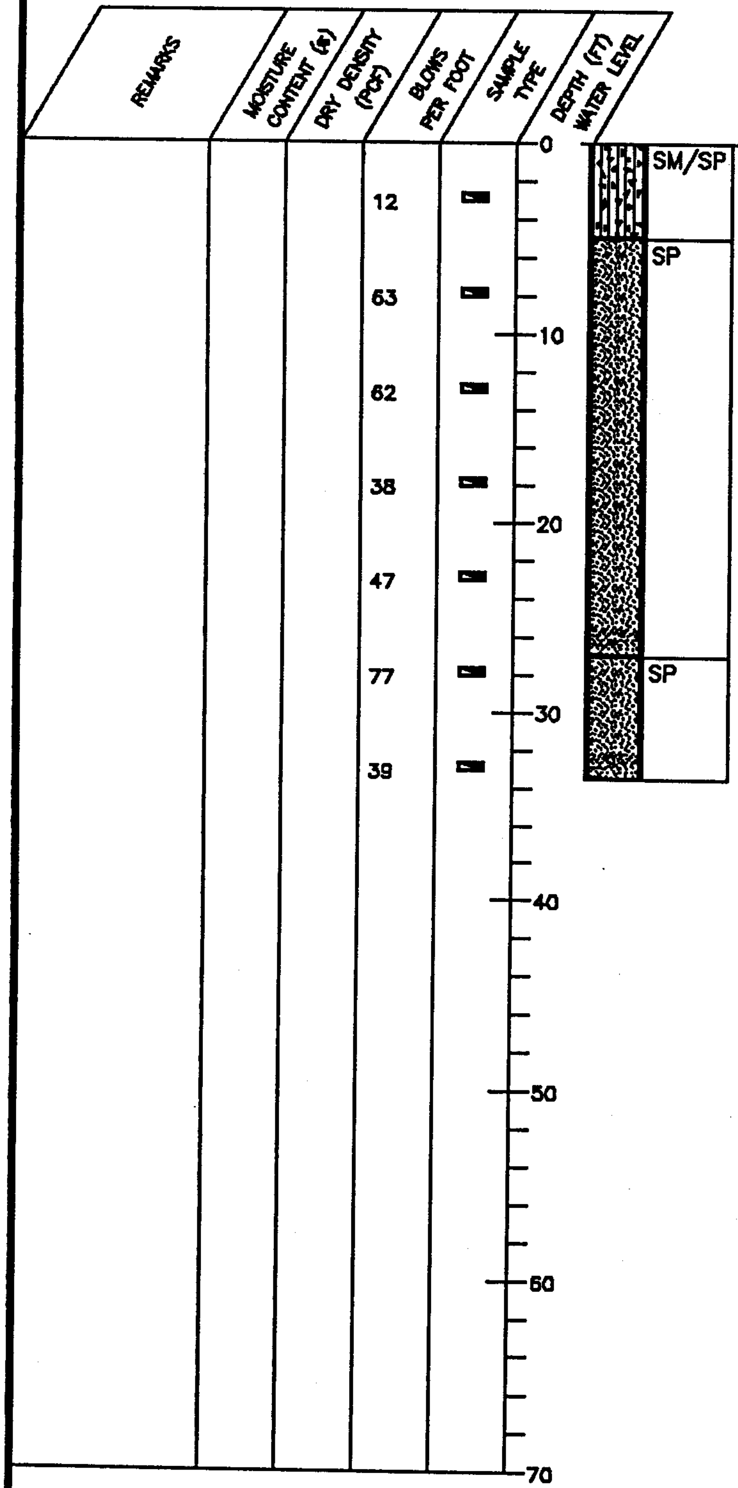
Dames & Moore

Job No. 00177-004-016

PLATE A-63

BORING DM-64-92

Surface Elevation: 551±



SM/SP Brown fine sand with some silt (dry) (medium dense)

SP Brown fine sand (very dense)

Grades to dense

SP Gray fine to medium sand (dry) (very dense)

Grades to dense

Boring DM-64-92 completed at depth of 33.5 feet on 11-19-92. No groundwater encountered during drilling.

NOTE:
Southwest Leg Station 80+21

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

LOG OF BORING

Dames & Moore

Job No. 00177-004-016

BORING DM-65-92

Surface Elevation: 539±

REMARKS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	BLOWS PER FOOT	SAMPLE TYPE	DEPTH (FT) WATER LEVEL			
					0	▨	SP	Gray fine sand (dry) (medium dense)
			14	▬		▨		
			47	▬		▨		Grades to dense and damp
					10	▨		
			71	▬		▨	SP	Gray fine to medium sand (dry) (very dense)
			73	▬		▨		Grades with occasional silt lenses
					20			Boring DM-65-92 completed at depth of 18.5 feet on 11-19-92. No groundwater encountered during drilling.
					30			
					40			
					50			
					60			
					70			

NOTE:
Southwest Leg Station 89+35

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

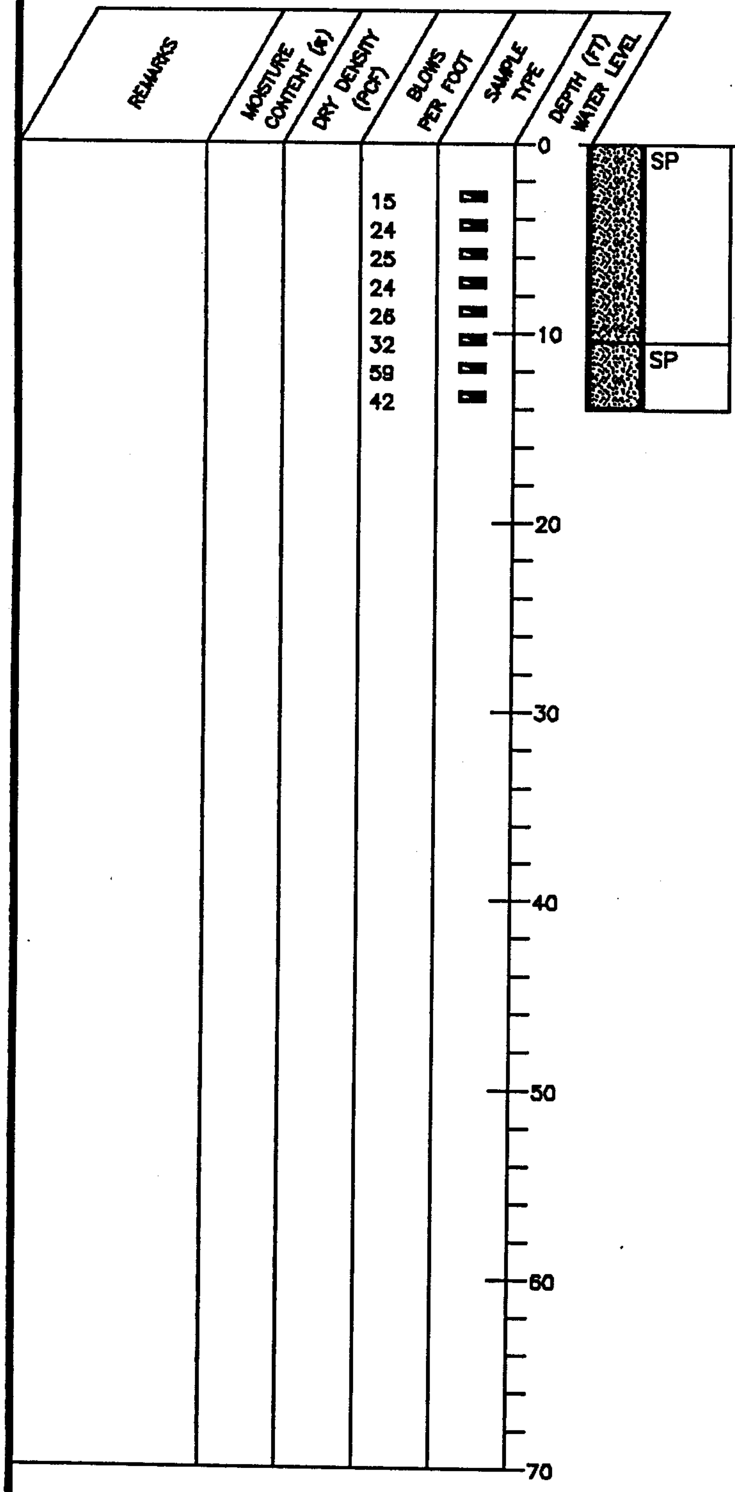
LOG OF BORING

Dames & Moore

Job No. 00177-004-016

BORING DM-66-92

Surface Elevation: 537±



Brown fine sand with trace silt (dry) (medium dense)

Grades to damp

Gray fine to medium sand (dry) (dense to very dense)

Boring DM-66-92 completed at depth of 14 feet on 11-19-92. No groundwater enountered during drilling.

NOTE:
Southwest Leg Station 98+49

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

LOG OF BORING

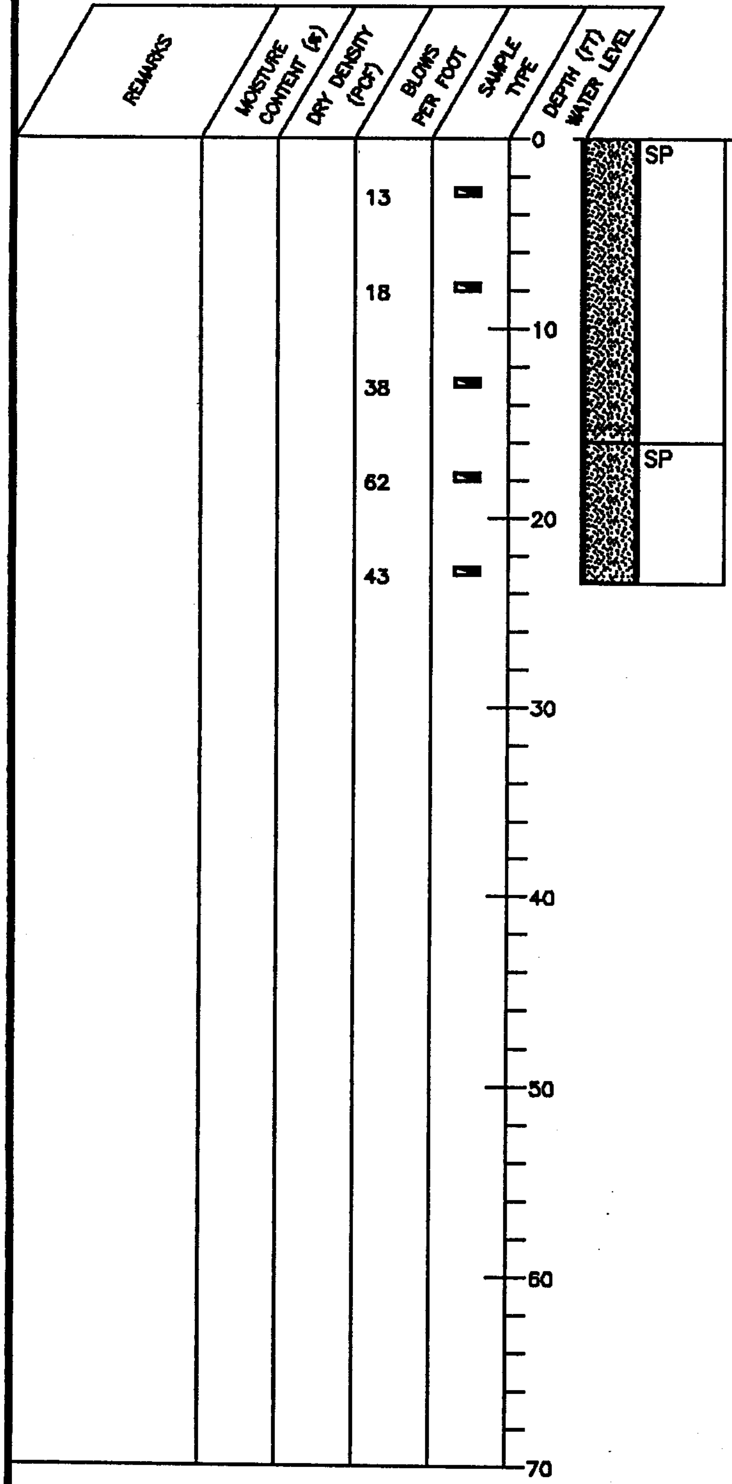
Dames & Moore

Job No. 00177-004-016

PLATE A-66

BORING DM-67-92

Surface Elevation: 542±



Brown fine sand with trace silt (damp) (medium dense)

Grades to dense

Gray fine to medium sand (dry) (dense to very dense)

Boring DM-67-92 completed at depth of 23.5 feet on 11-19-92. No groundwater encountered during drilling.

NOTE:
Southwest Leg Station 107+63

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

LOG OF BORING

Dames & Moore

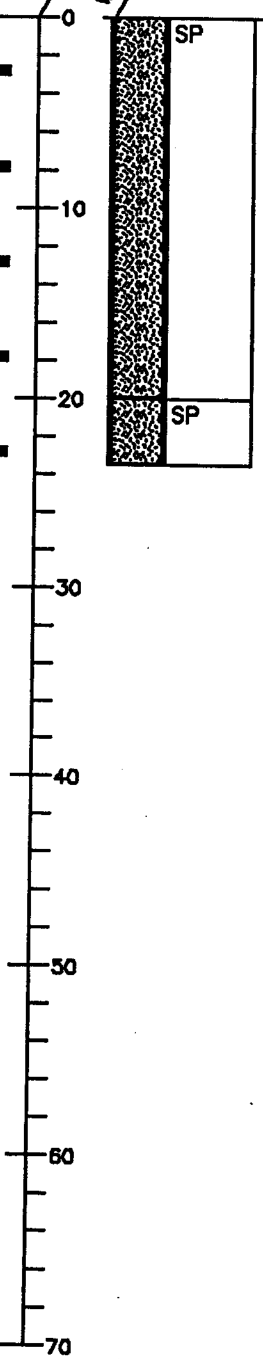
Job No. 00177-004-016

PLATE A-67

BORING DM-68-92

Surface Elevation: 544±

REMARKS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	BLOWS PER FOOT	SAMPLE TYPE
			17	▬
			39	▬
			47	▬
			48	▬
			42	▬



Brown fine sand with trace silt (dry) (medium dense)

Grades to dense and damp

Gray fine to medium sand (dry) (dense)

Boring DM-68-92 completed at depth of 23.5 feet on 11-19-92. No groundwater encountered during drilling.

NOTE:
Southwest Leg Station 116+77

Logged by JCH 01-15-1993   SUperLOG V 2.0, 3-1991

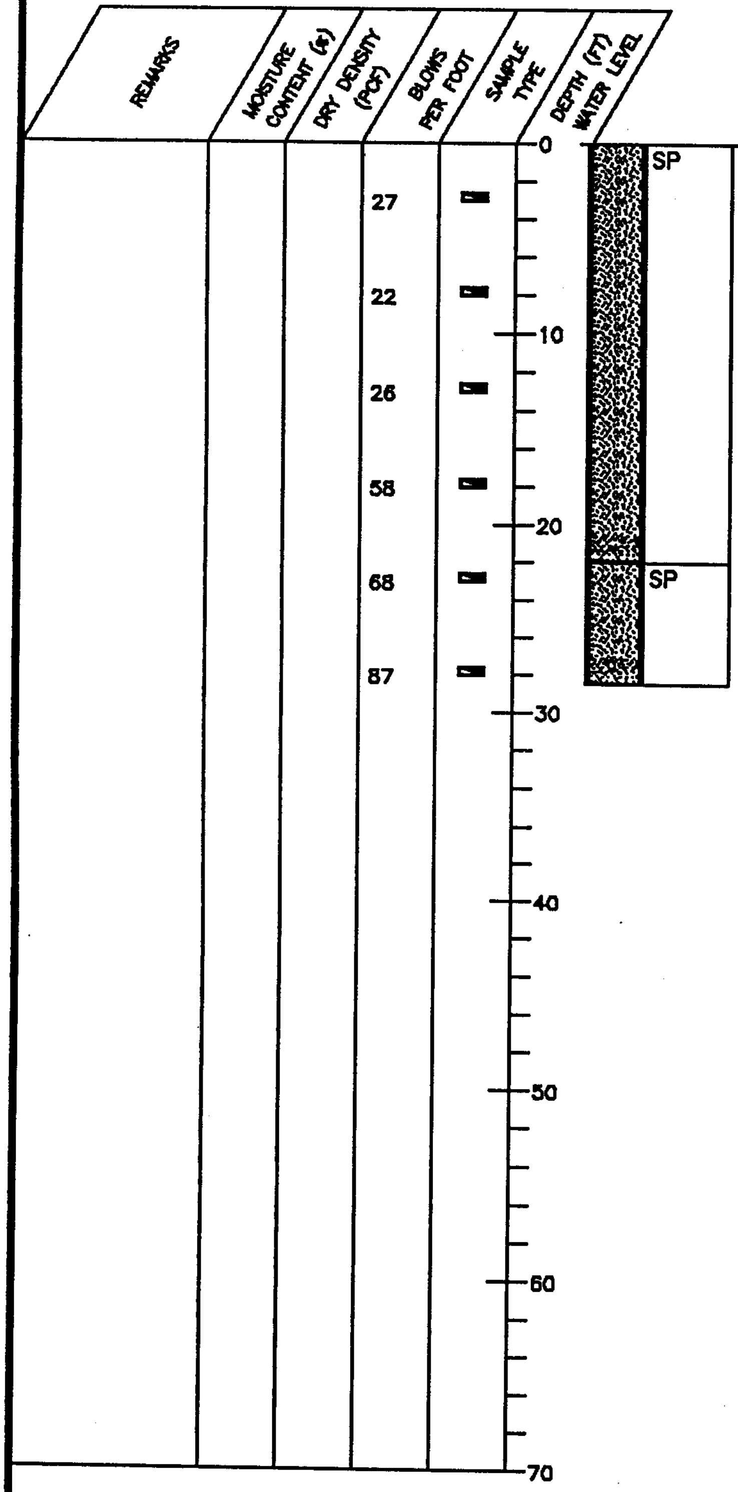
LOG OF BORING

Dames & Moore

Job No. 00177-004-016

BORING DM-69-92

Surface Elevation: 538±



REMARKS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	BLOWS PER FOOT	SAMPLE TYPE	DEPTH (FT) WATER LEVEL
			27	▬	
			22	▬	
			26	▬	
			58	▬	
			68	▬	
			87	▬	

SP Brown fine sand with trace silt (damp) (medium dense)

Grades to very dense

SP Gray fine to medium sand (damp) (very dense)

Boring DM-69-92 completed at depth of 28.5 feet on 11-20-92. No groundwater encountered during drilling.

NOTE:
Southwest Leg Station 125+91

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

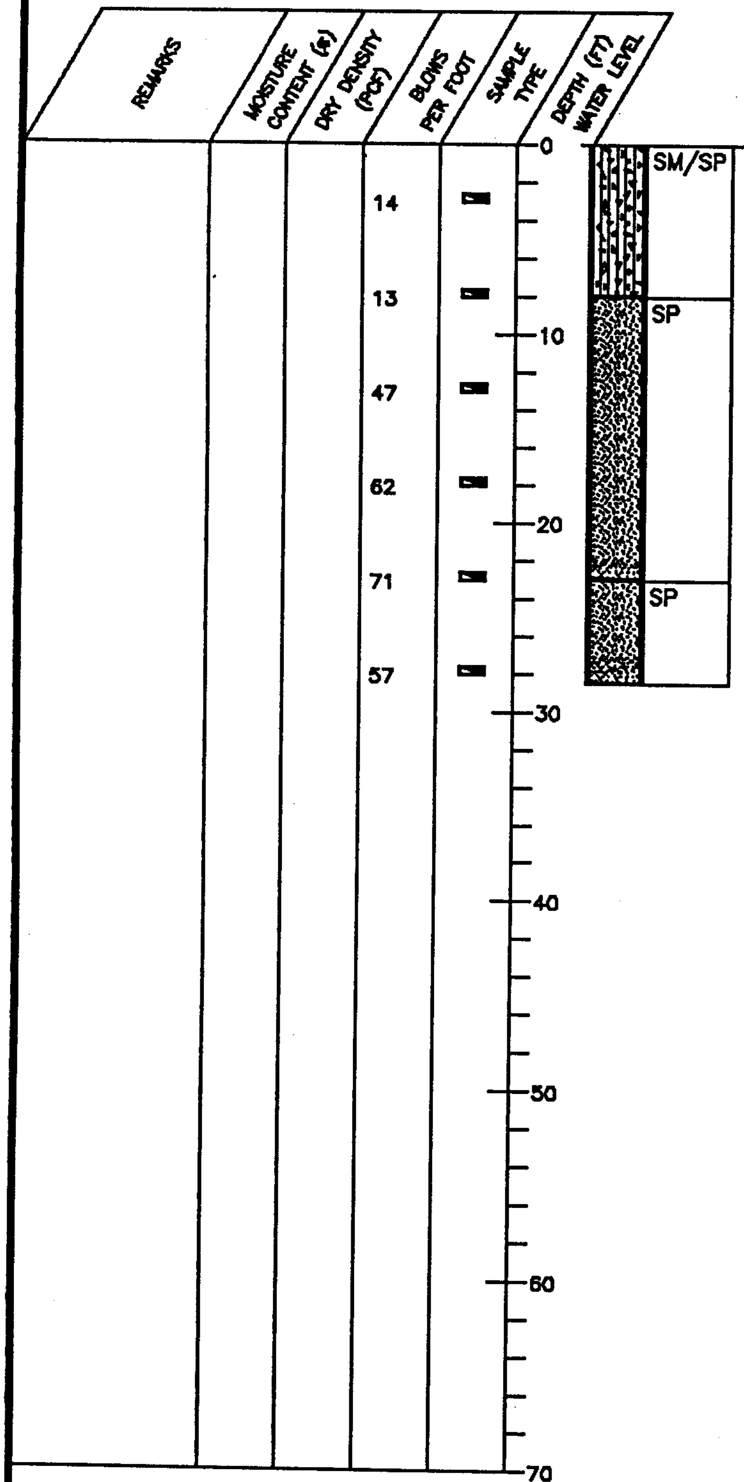
LOG OF BORING

Dames & Moore

Job No. 00177-004-016

BORING DM-70-92

Surface Elevation: 548±



Brown fine sand with some silt (dry) (medium dense)

Gray fine sand (dry) (medium dense)

Grades to dense

Grades to very dense

Gray fine to medium sand (dry) (very dense)

Boring DM-70-92 completed at depth of 28.5 feet on 11-20-92. No groundwater encountered during drilling.

NOTE:
Southwest Leg Station 68+75

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

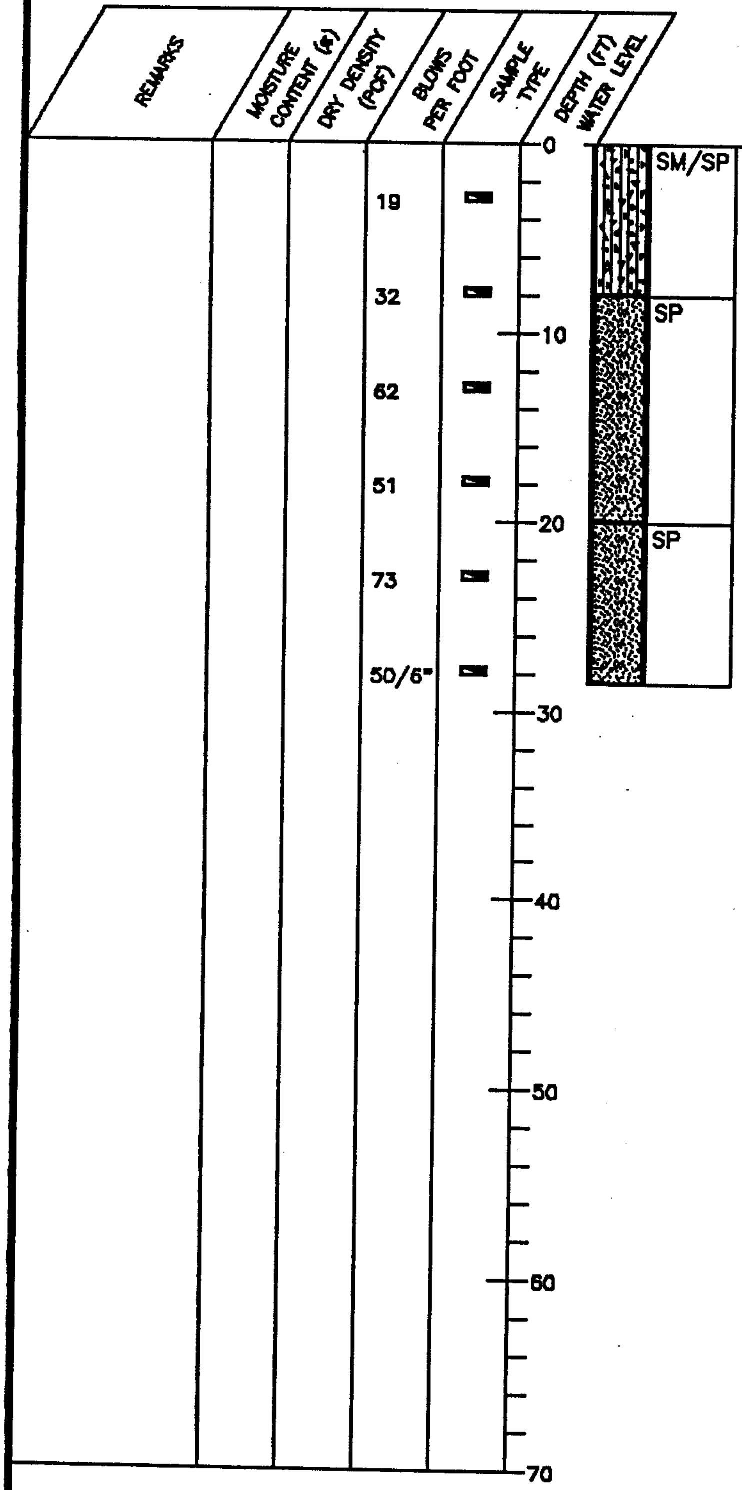
LOG OF BORING

Dames & Moore

Job No. 00177-004-016

BORING DM-71-92

Surface Elevation: 544±



Brown fine sand with some silt (dry) (medium dense)

Gray brown fine sand (dry) (dense)

Grades to very dense

Grades to damp

Gray fine sand (dry) (very dense)

Boring DM-71-92 completed at depth of 28.5 feet on 11-20-92. No groundwater encountered during drilling.

NOTE:
Southwest Leg Station 66+00
Offset 25 feet to the southeast

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

LOG OF BORING

Dames & Moore

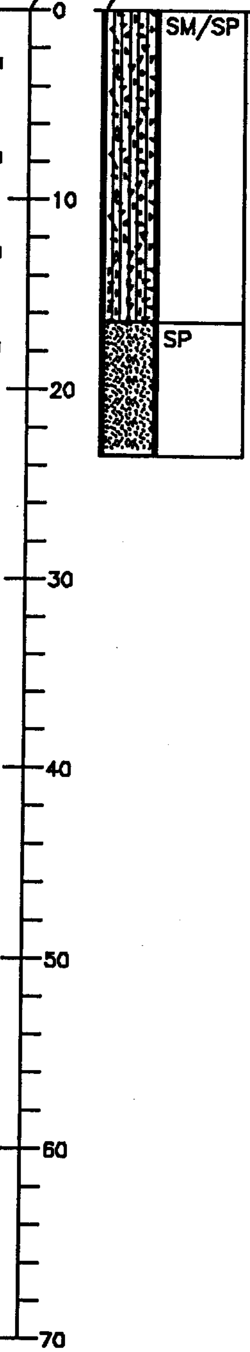
Job No. 00177-004-016

PLATE A-71

BORING DM-72-92

Surface Elevation: 540±

REMARKS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	BLOWS PER FOOT	SAMPLE TYPE	DEPTH (FT) WATER LEVEL
			16	▬	
			29	▬	
			42	▬	
			38	▬	
			93	▬	



Brown fine sand with some silt (dry) (medium dense)

Grades to dense

Gray fine to medium sand (dry) (dense)

Grades to very dense

Boring DM-72-92 completed at depth of 23.5 feet on 11-20-92. No groundwater encountered during drilling.

NOTE:
Southwest Leg Station 63+25

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

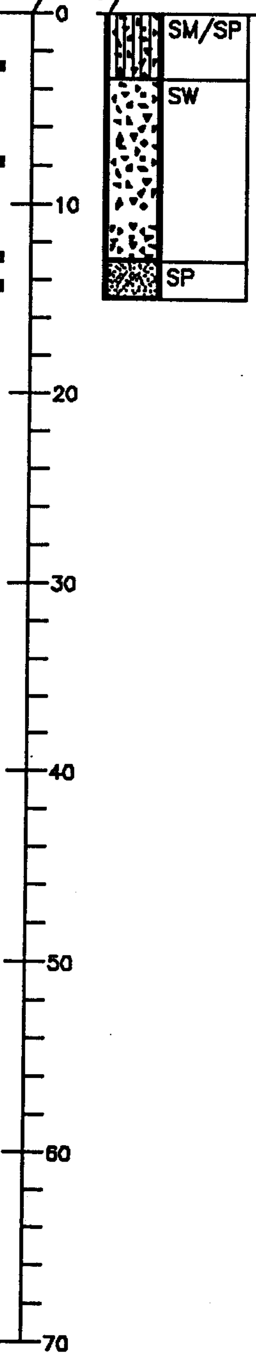
LOG OF BORING

Dames & Moore

BORING DM-73-92

Surface Elevation: 515±

REMARKS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	BLOWS PER FOOT	SAMPLE TYPE
			17	▬
			34	▬
			50/4"	▬
			42	▬



SM/SP	Brown fine sand with some silt (dry) (medium dense)
SW	Gray fine to coarse sand with trace gravel (dry) (dense)
	Grades to very dense
SP	Gray fine to medium sand (dry) (dense)

Boring DM-73-92 completed at depth of 15 feet on 11-20-92. No groundwater encountered during drilling.

NOTE:
Northwest Leg Station 89+80

Logged by JCH 01-15-1993 SUperLOG V 2.0, 3-1991

LOG OF BORING

Dames & Moore

Job No. 00177-004-016

PLATE A-73

KEY:

■	Indicates Depth of Relatively Undisturbed Sample.
☒	Indicates Depth of Disturbed Sample.
☐	Indicates Depth of Sampling Attempt with no Recovery.
⬔	Indicates Depth of Standard Penetration Test.
⧅	Indicates Depth of Standard Penetration Test with no Recovery.

NOTE:

Blows required to drive Dames & Moore sampler one foot or less with 300 pound hammer from 30–inch drop or split spoon sampler with 140 pound hammer from 30–inch drop.

The discussion in this report is necessary for a proper understanding of the nature of the subsurface materials.

KEY

Dames & Moore

Job No. 00177–004–016

Major Divisions			Graphic Symbol	Letter Symbol	Typical Descriptions
Coarse Grained Soils More than 50% of Material is Larger than No. 200 Sieve Size	Gravel and Gravelly Soils More than 50% of Coarse Fraction Retained on No. 4 Sieve	Clean Gravels (little or no fines)	░	GW	Well-Graded Gravels, Gravel-Sand Mixtures, Little or no Fines
			○	GP	Poorly-Graded Gravels, Gravel-Sand Mixtures, Little or no Fines
		Gravels with Fines (appreciable amount of fines)	▥	GM	Silty Gravels, Gravel-Sand-Silt Mixtures
			▨	GC	Clayey Gravels, Gravel-Sand-Clay Mixtures
	Sand and Sandy Soils More than 50% of Coarse Fraction Passing through No. 4 Sieve	Clean Sand (little or no fines)	△	SW	Well-Graded Sands, Gravelly Sands, Little or no Fines
			░	SP	Poorly-Graded Sands, Gravelly Sands, Little or no Fines
		Sands with Fines (appreciable amount of fines)	▥	SM	Silty Sands, Sand-Silt Mixtures
			▨	SC	Clayey Sands, Sand-Clay Mixtures
Fine Grained Soils More than 50% of Material is Smaller than No. 200 Sieve Size	Silts and Clays	Liquid Limit Less than 50	▥	ML	Inorganic Silts and Very Fine Sands, Rock Flour, Silty or Clayey Fine Sands or Clayey Silts with Slight Plasticity
			▨	CL	Inorganic Clays of Low to Medium Plasticity, Gravelly Clays, Sandy Clays, Silty Clays, Lean Clays
			┆	OL	Organic Silts and Organic Silty Clays of Low Plasticity
	Silts and Clays	Liquid Limit Greater than 50	▥	MH	Inorganic Silts, Micaceous or Diatomaceous Fine Sand or Silty Soils
			▨	CH	Inorganic Clays of High Plasticity, Fat Clays
			▨	OH	Organic Clays of Medium to High Plasticity, Organic Silts
Highly Organic Soil			▤	PT	Peat, Humus, Swamp Soils with High Organic Contents

Note: Dual symbols are used to indicate borderline soil classifications.

Job No. 00177-004-016

Unified Soil Classification System

Dames & Moore

PLATE A-75

app 3

APPENDIX B

IN-SITU TESTING

APPENDIX B
IN-SITU TESTING

PLATE LOAD TESTS

Two repetitive static plate load tests were conducted during the field investigation. Test Number 1 was located along the Southwest Leg at Station 20+00. Test Number 2 was located along the Northwest Leg at Station 84+50. Both tests were performed at a depth of approximately 2 feet on the surficial silty fine sand.

The tests were performed in accordance with ASTM D 1195-64. A 2-foot diameter (1-inch thick) loading plate was used in the tests. Stiffening plates of progressively increasing diameter were placed between the hydraulic jack and the loading plate. Applied loads were measured with a 5000 psi gauge calibrated for the 60 ton jack used in the test. Three dial gauges (accuracy 0.001 inch) attached to reference beams were used to measure the plate deflections as each load was applied. The reference beams were supported on wood blocks approximately 6 feet away from the test location.

The loads applied to the plate were developed using the hollow stem auger drill rig as the reaction vehicle. Each load was maintained until the settlement of the plate stabilized, approximately 3 minutes. Three load increments were completed for each test.

The results of the plate load tests are presented on Plates B-1 and B-2. The modulus of subgrade reaction and the elasticity modulus was obtained for the three loads cycled in each test. These values have been reported in the text of the report.

PERCOLATION TESTS

Two percolation tests were performed to aid in the design of the leach field associated with the corner station. Test 1 was conducted next to boring DM-21-92 at Northwest Station -2+00. Test 2 was performed next to boring DM-22-92 at Southwest Station -2+00. The tests were performed in general accordance with procedures outlined in the Manual of Septic-Tank Practice, U.S. Department of Health, Education, and Welfare. At each test location a hole approximately 1 foot deep and 6 inches in diameter was excavated in the surficial material. The hole was then filled with water. The water level was maintained at the top of the hole by using a hose attached to the water tank on the drill rig. After one hour the hose was shut off and the rate of water level drop was recorded by the Dames & Moore representative. The change in water level was monitored for 5 to 10 minutes depending on how long it took the hole to drain. The percolation rate was then calculated by dividing the change in water level by the observed time increment. The test procedure was then repeated 4 times over the next 4 hours at each test location. The results of the tests are presented on Plate B-3.

00177_16.CDR

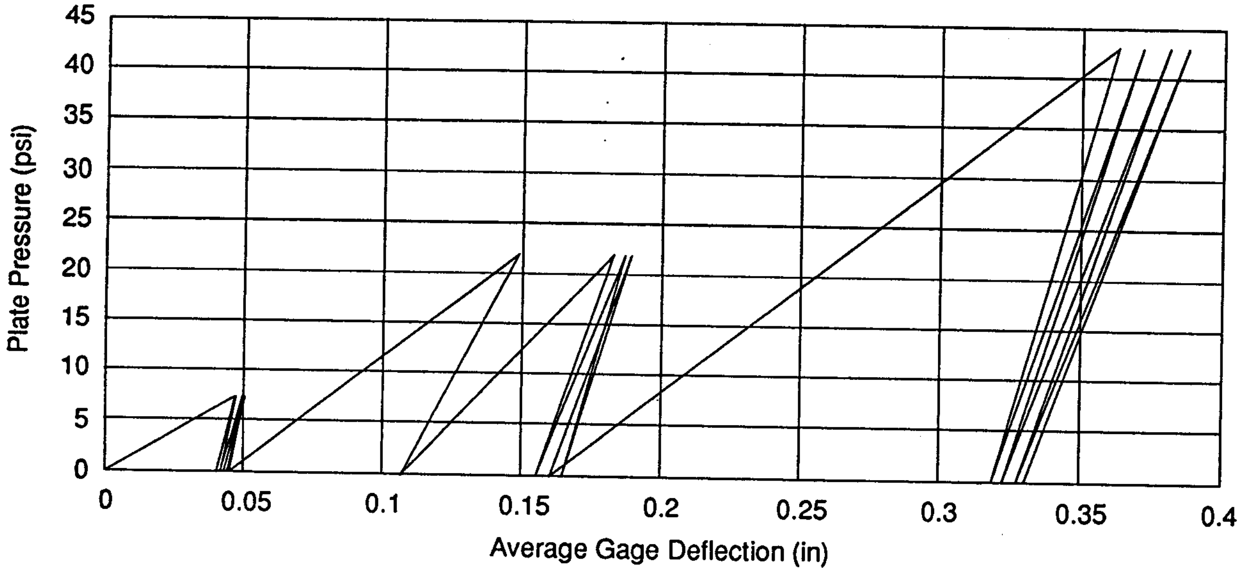


PLATE LOAD TEST DATA - TEST NO. 1 (SW LEG STA 20+00)

Job No. 00177-004-016

DAMES & MOORE

LIGO Project
Hanford, Washington
PLATE B-1

00177_16.CDR

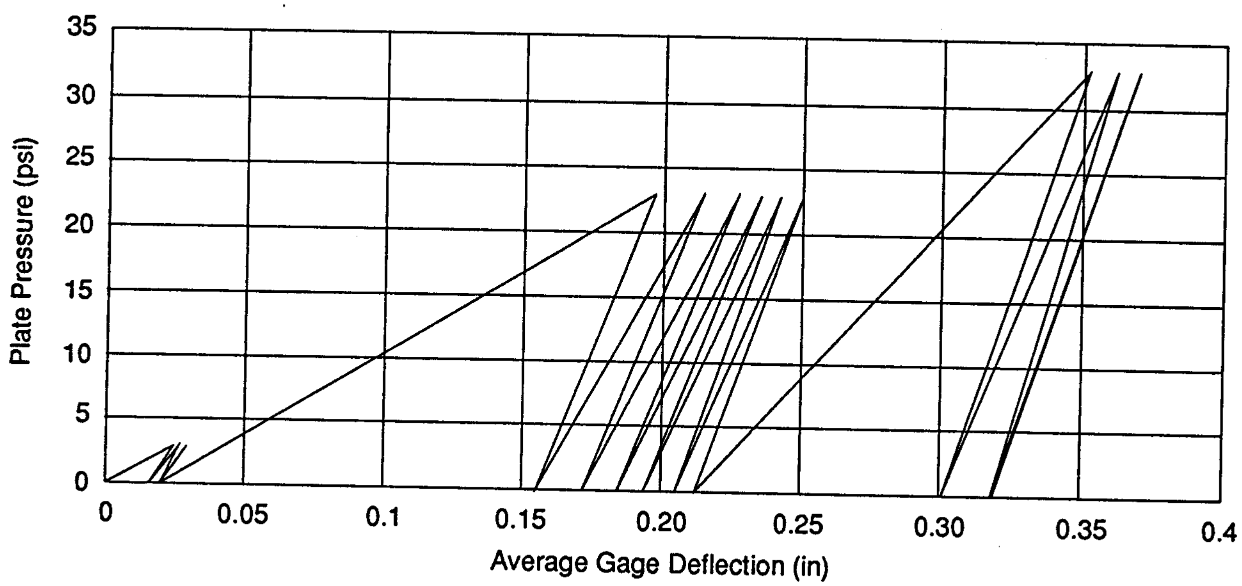


PLATE LOAD TEST DATA - TEST NO. 2 (NW LEG STA 84+50)

Job No. 00177-004-016

DAMES & MOORE

LIGO Project
Hanford, Washington
PLATE B-2

00177_11.CDR

Adjacent Boring	Station	Time	Percolation Rate (in/min)	Percolation Rate (min/in)
DM-21-92	NW Leg -2+00	10:10	2.10	0.48
		11:10	0.50	2.00
		12:10	0.70	1.43
		1:10	0.60	1.67
		2:10	0.50	2.00
DM-22-92	SW Leg -2+00	10:25	3.60	0.28
		11:25	2.50	0.40
		12:25	2.00	0.50
		1:25	2.40	0.42
		2:25	2.00	0.50

Percolation Test Results

Job No. 00177-004-016

DAMES & MOORE

LIGO Project
Hanford, Washington
PLATE B-3

APPENDIX C

LABORATORY TESTING

APPENDIX C
LABORATORY TESTING

LABORATORY TESTS

The physical, corrosive, and thermal characteristics of the soils encountered were evaluated by conducting laboratory tests on selected soil samples. The physical testing program consisted of triaxial compression tests, collapse tests, particle size analyses, compaction tests, and moisture-density determinations. The corrosion potential of the site soil was evaluated through tests for pH, sulfates, chlorides, sulfides, resistivity, and redox potential. The thermal characteristics of the site soils was evaluated through a test in which the thermal conductivity and thermal resistance of the soil could be measured.

Two triaxial compression tests were conducted to determine the strength characteristics and deformation modulus of the soil. One test was performed on a sample of the surficial silty fine sand soil recompacted to 95 percent of the maximum dry density as determined by ASTM D 1557. A second test was performed on a relatively undisturbed sample of the lower fine to medium sand. The results of these tests are presented on Plates C-1 and C-2.

Two collapse tests were performed to evaluate the collapse potential of the silty very fine to fine sand that mantles the surface of the site. One test was conducted on a sample recompacted to 92 percent of the maximum dry density as determined by ASTM D 1557 and the second test was performed on a relatively undisturbed sample. The collapse test procedure was the modified Jennings and Knight method as described by Houston et. al, 1986. Each sample was incrementally loaded to the anticipated stress that will exist below foundation elements, approximately 2000 pounds per square inch. After allowing the soil settlement to stabilize the samples were then saturated and the settlement was measured. The amount of settlement that occurred after the soil was saturated divided by the height of the sample before saturation is the strain due to collapse. The collapse potential value is the strain due to collapse expressed as a percent. The results of the tests are presented on Plates C-3 and C-4.

Compaction characteristics of the site soils were examined by conducting modified Proctor compaction tests, ASTM D 1557. Five compaction tests were performed on samples of the site soils to provide a basis for compacted fill recommendations and to provide data used in other laboratory tests. The curve describing the dry density - moisture relationship for the soil sample from DM-7-92 at 8 feet terminates at the optimum dry density. Due to the free draining nature of the sample conditions wetter than the optimum moisture could not be evaluated. The results of the compaction tests are presented on Plates C-5 through C-7.

Particle size (sieve) analyses were conducted on samples in order to assist in classifying the soils and to provide a basis for estimating engineering performance such as strength, deformability, collapse potential, erodibility, and permeability. Curves describing the particle size gradation of tested samples are presented on Plates C-8 through C-11. The fines content of the tested samples are summarized on Plate C-12.

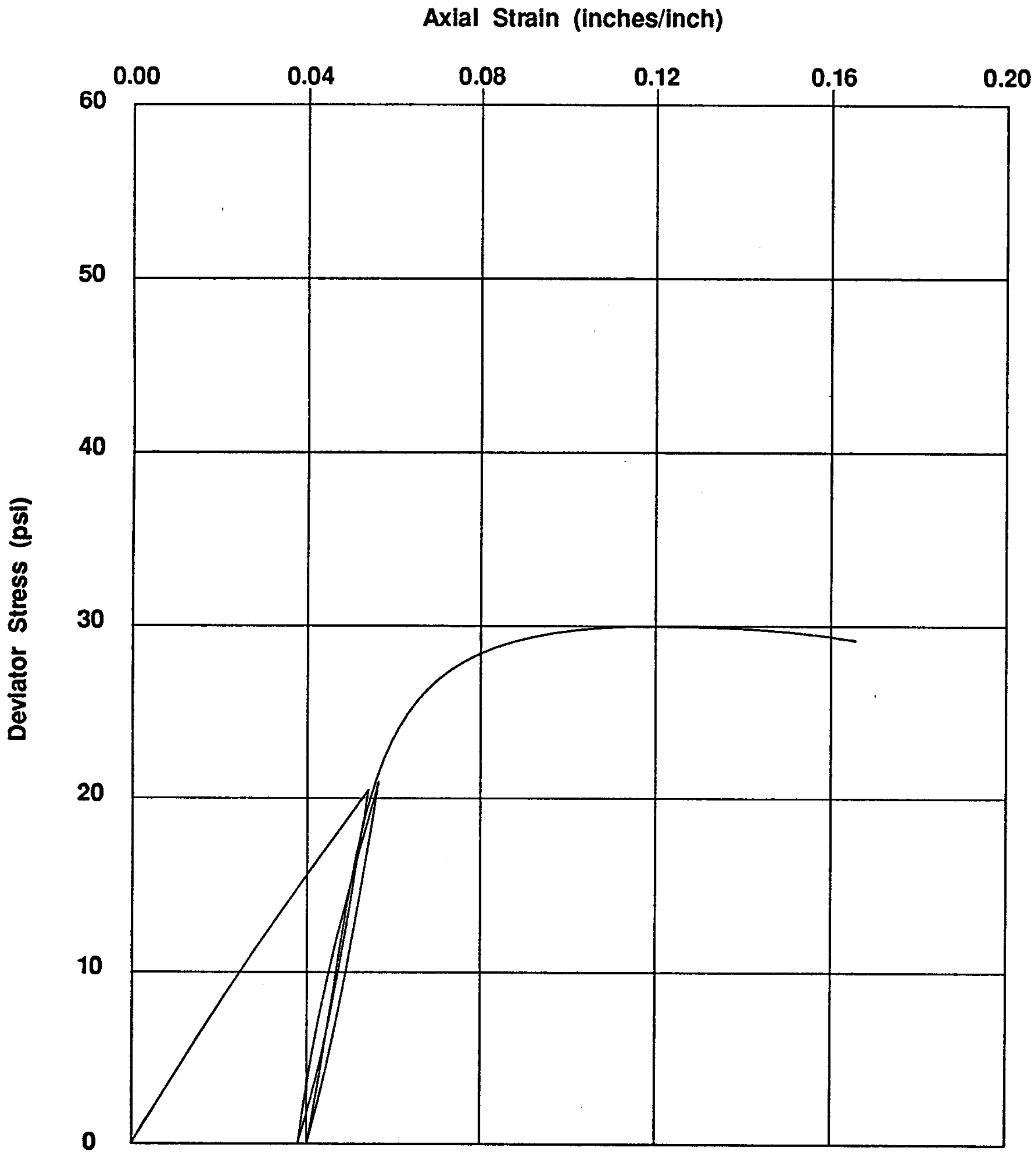
Moisture content and density determinations were performed on selected soil samples for correlation with soil parameters. The test results are indicated adjacent to the appropriate sample notations on the boring logs on Plates A-1 to A-73.

Tests for pH, resistivity, redox potential, and for sulfate, sulfide, and chloride content were conducted on three soil samples for estimation of corrosion potential. Sample location determined which samples were submitted for analysis. The results of the tests are presented on Plate C-13.

The thermal characteristics of the site soils were evaluated through a test in which the thermal conductivity and thermal resistance of the soil could be measured. The thermal resistivity of the soil was then calculated as the inverse of the thermal conductivity. Two soil samples were tested. The tests were performed in accordance with ASTM C 518. The results of the tests are presented on Plate C-14.

REFERENCE

Houston, S.L., Houston W.N., and Spadola, D.J. (1986). "Prediction of Field Collapse of Soils Due to Wetting."J. Geotechnical Engineering, ASCE, Vol. 114, No. 1, 40-58



Summary of Sample Data
Moisture Content: 5.6%
Wet Density: 115.4 pcf
Dry Density: 109.9 pcf
Initial Height: 5.97"
Final Height: 5.8"

Description
Boring: DM-20-92
Sample: Bag #1
Depth: 3'

Summary of Test Data
Confining Pressure: 2,000 psf
Peak Deviator Stress: 8,940 psf
Tangent Modulus: 18,653 psi
Number of Cycles: 3

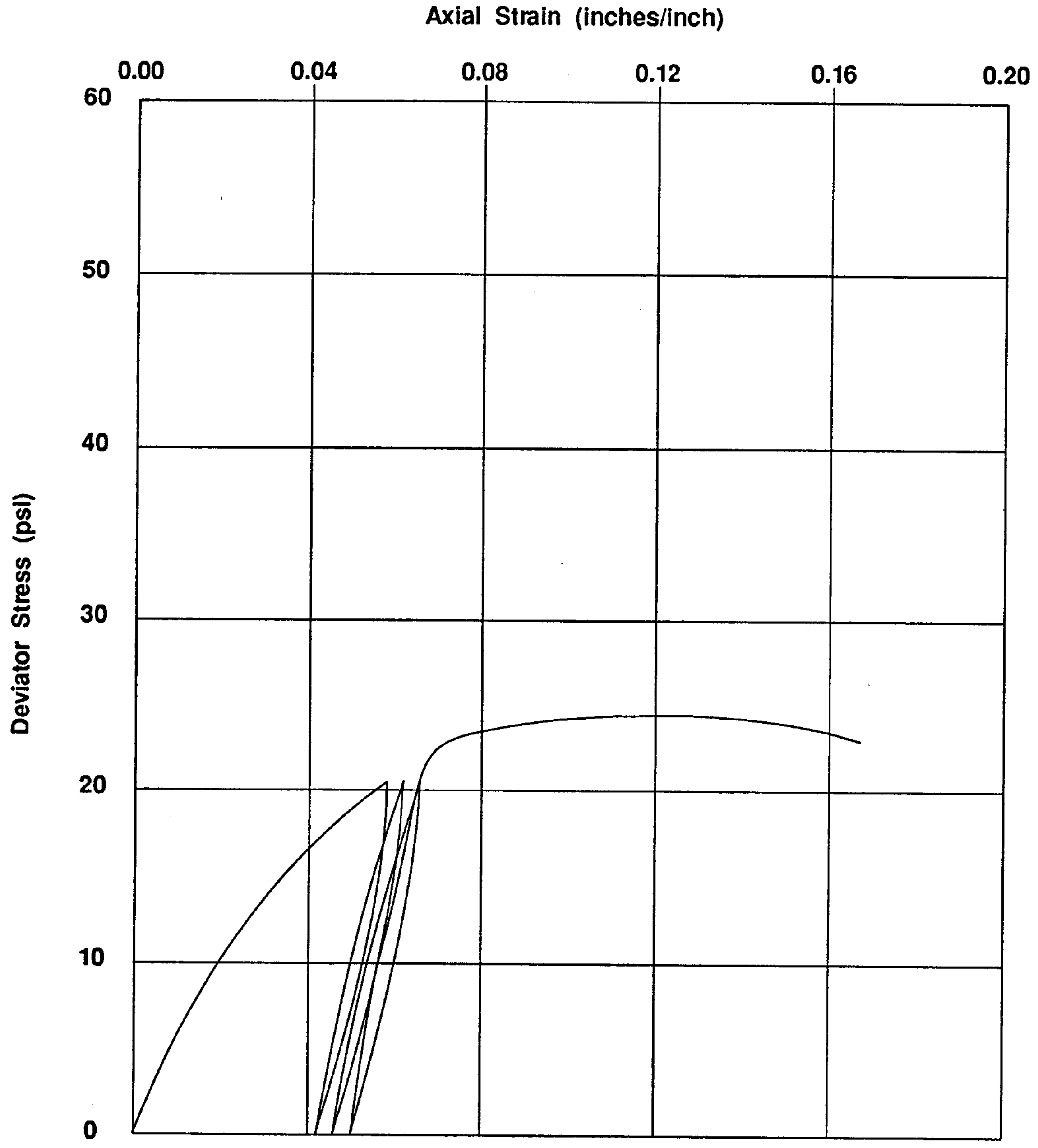
Soil
Brown fine to medium sand with some silt
(recompacted to 95% maximum dry density)

CONSOLIDATED-DRAINED TRIAXIAL TEST DATA

Job No. 00177-004-016

DAMES & MOORE

LIGO Project
Hanford, Washington
PLATE C-1



Summary of Sample Data
Moisture Content: 7.1%
Wet Density: 106.7 pcf
Dry Density: 100.3 pcf
Initial Height: 6.156"
Final Height: 6.046"

Summary of Test Data
Confining Pressure: 2,000 psf
Peak Deviator Stress: 7,350 psf
Tangent Modulus: 13,039 psi
Number of Cycles: 3

Description
Boring: DM-38-92
Sample: Bag #3
Depth: 13'

Soil
Gray fine sand with trace of silt

CONSOLIDATED-DRAINED TRIAXIAL TEST DATA

Job No. 00177-004-016

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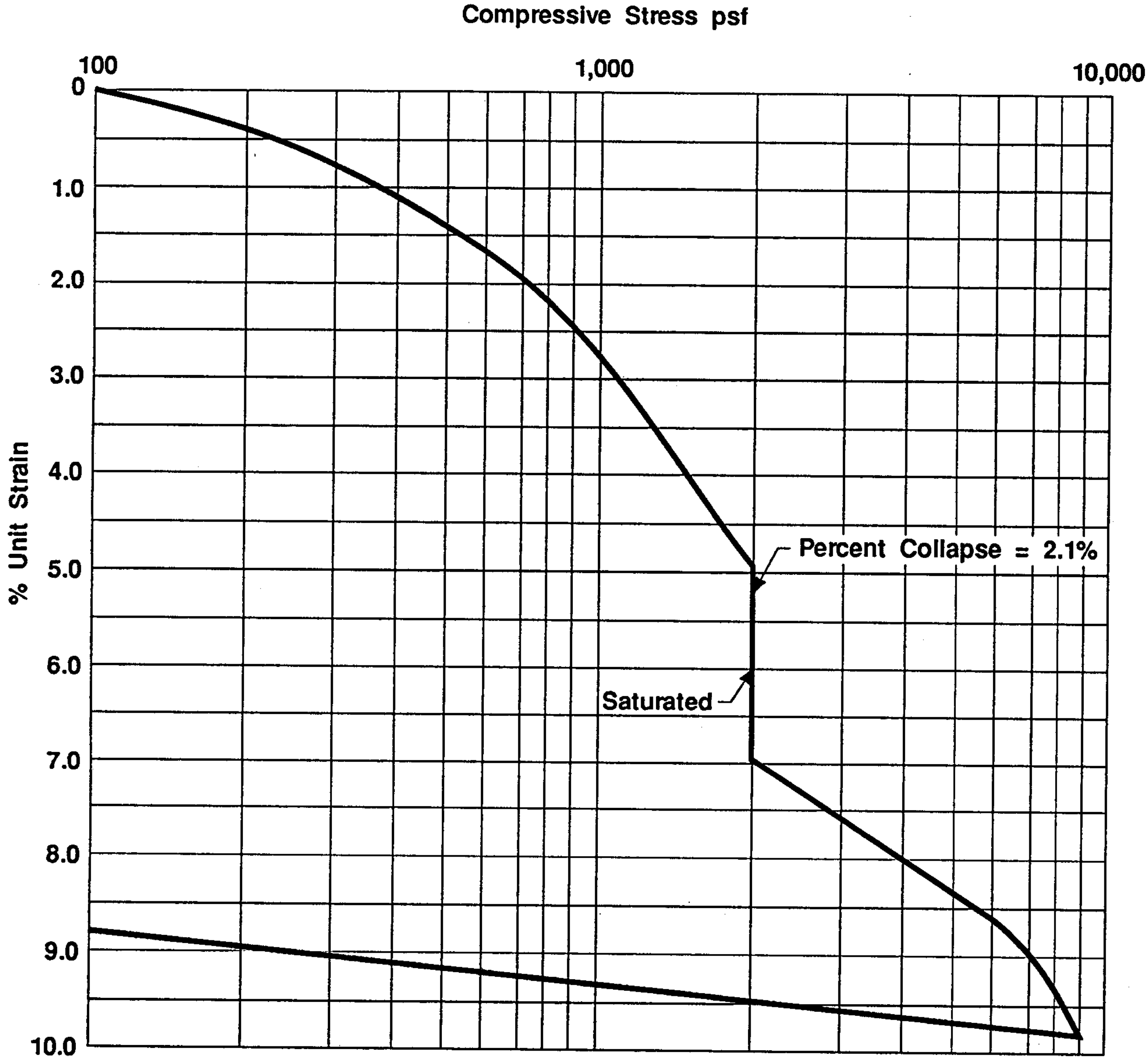
LIGO Project
Hanford, Washington
PLATE C-2

00177_14.CDR



Sample Number: DM-20-92
Depth (FT): 3
Description: brown fine to medium sand with some silt

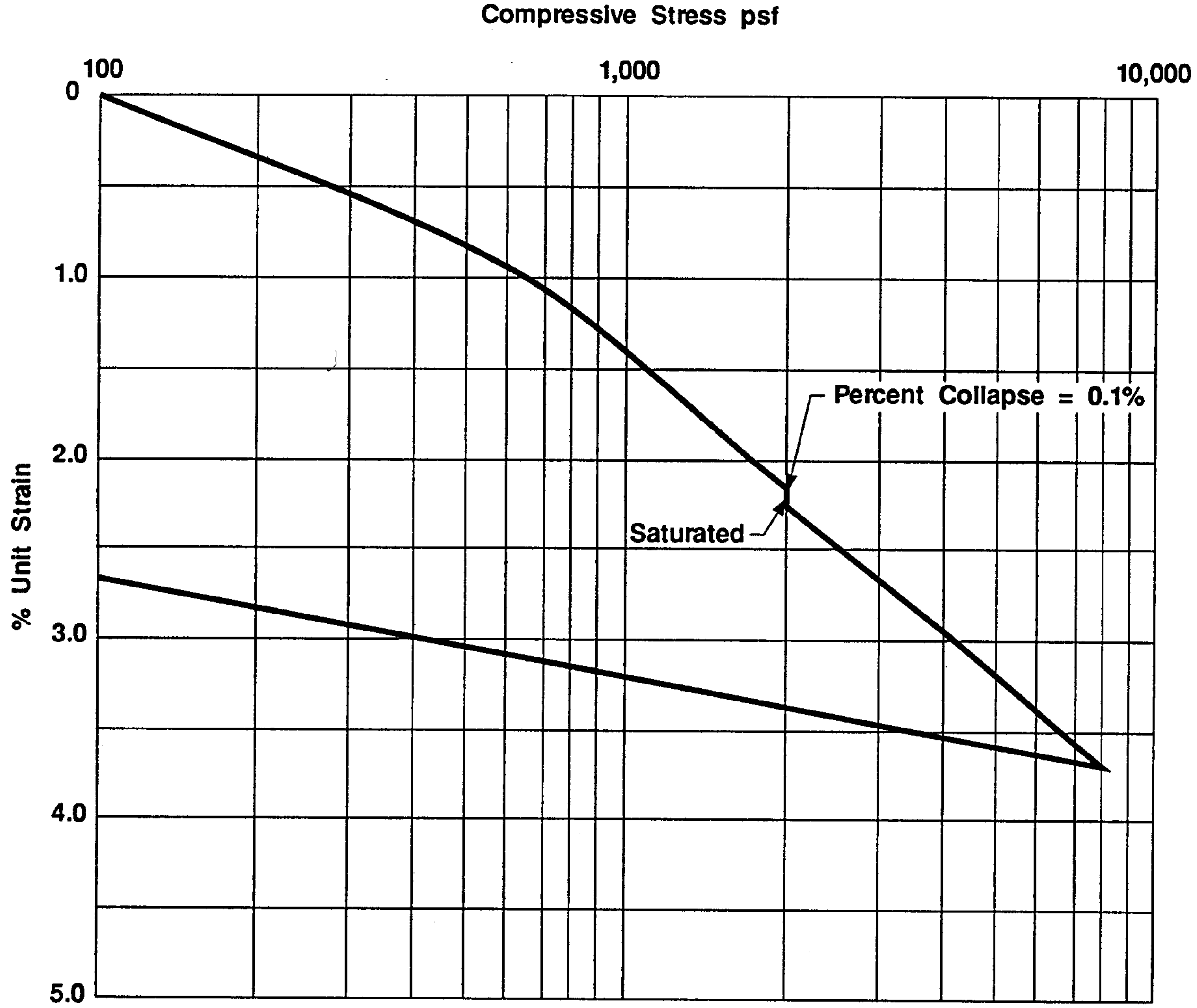
	Moisture Content (%)	Dry Density (pcf)
Initial:	7.1	112
Final	16.6	116

COLLAPSE TEST DATA

Job No. 00177-004-016
DAMES & MOORE

LIGO Project
Hanford, Washington
PLATE C-3

00177_13.CDR



Sample Number: DM-20-92
Depth (FT): 3
Description: brown fine to medium sand with some silt recompacted to 92% maximum dry density

	Moisture Content (%)	Dry Density (pcf)
Initial:	3.9	96
Final	21.8	107

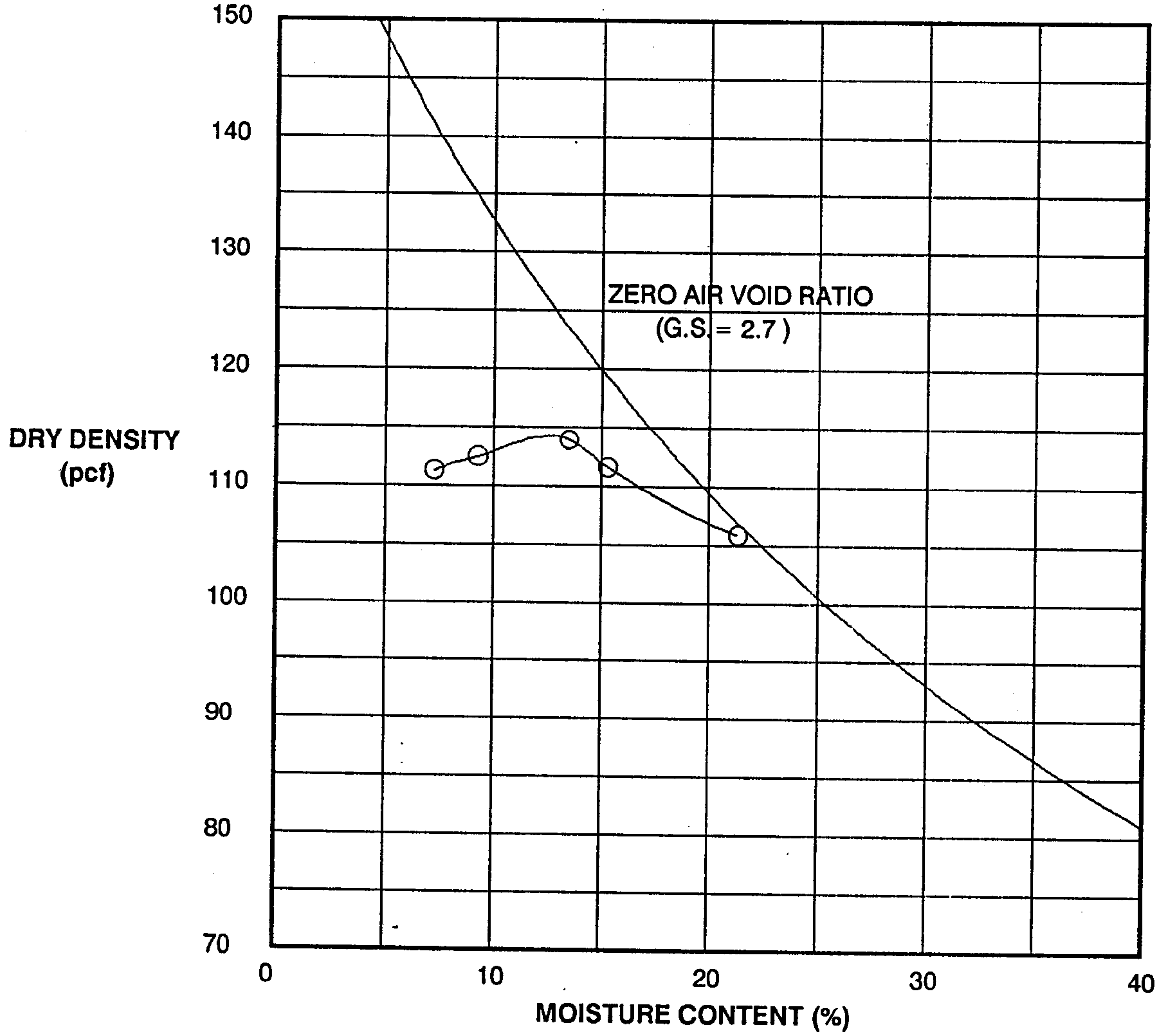
COLLAPSE TEST DATA

Job No. 00177-004-016

DAMES & MOORE

LIGO Project
Hanford, Washington
PLATE C-4

COMPACTION TEST



SYMBOL	SAMPLE LOCATION	DEPTH (ft)	DESCRIPTION	TEST METHOD	OPTIMUM MOISTURE(%)	MAX. DRY DENSITY(pcf)
○	Mixture	-	60% SP + 40% SM	ASTM D1557-A	12.5	114

REMARKS: 60% from DM-38-92 at 13': Gray fine sand, trace silt (SP).

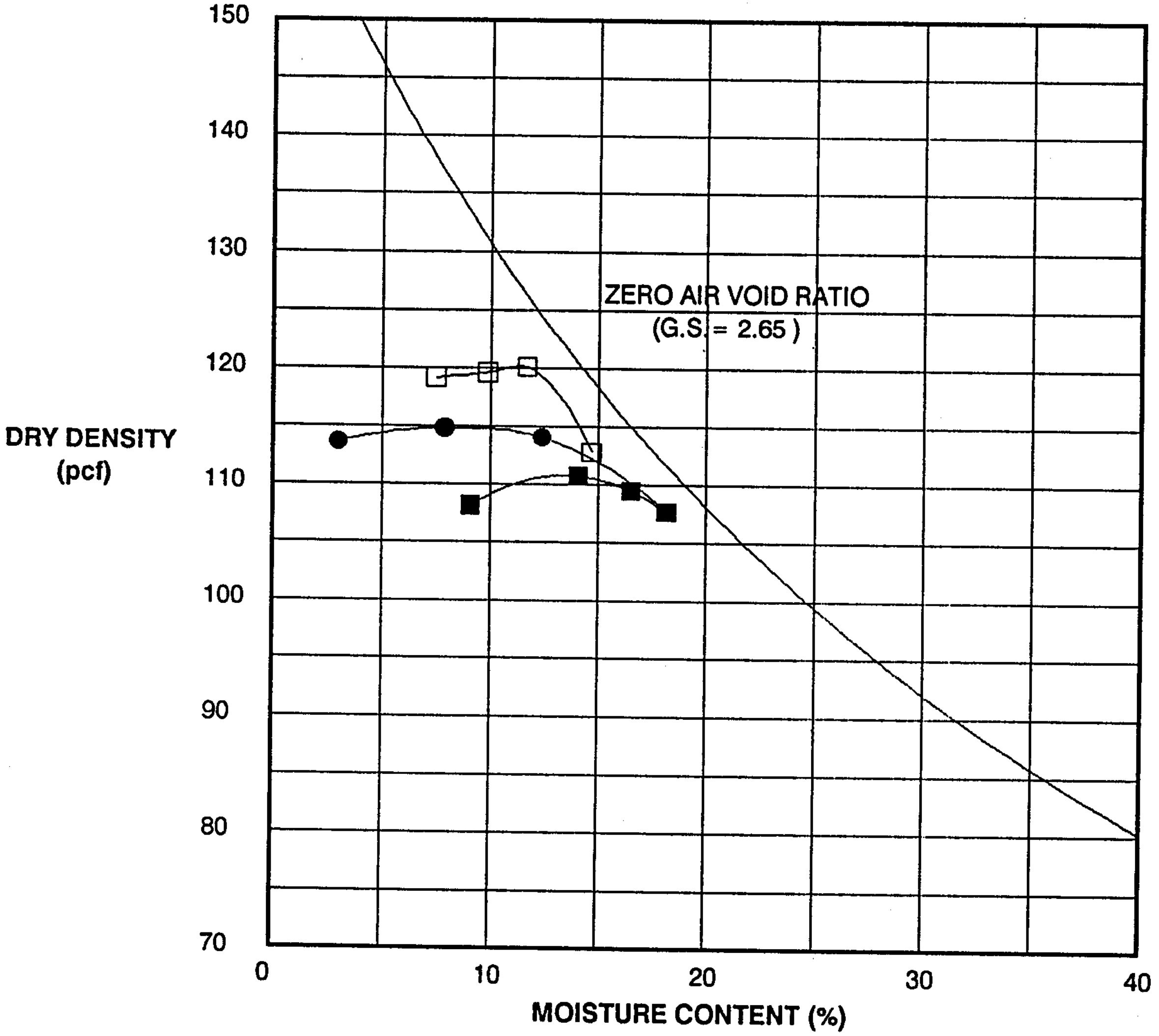
40% from DM-32-92 at 3': Brown silty fine sand (SM).

02-09-1993 LIGO **DAMES & MOORE**

JOB NO. 00177-004-016

Plate **C-5**

COMPACTION TEST



SYMBOL	SAMPLE LOCATION	DEPTH (ft)	DESCRIPTION	TEST METHOD	OPTIMUM MOISTURE(%)	MAX. DRY DENSITY(pcf)
●	DM-20-92	3	Brown fine to med. sand, some silt (SP/SM)	ASTM D1557-A	8.7	115
☐	DM-32-92	3	Brown silty fine sand (SM)	ASTM D1557-A	11.3	120
■	DM-38-92	13	Gray fine sand, trace silt (SM)	ASTM D1557-A	13.9	111

REMARKS:

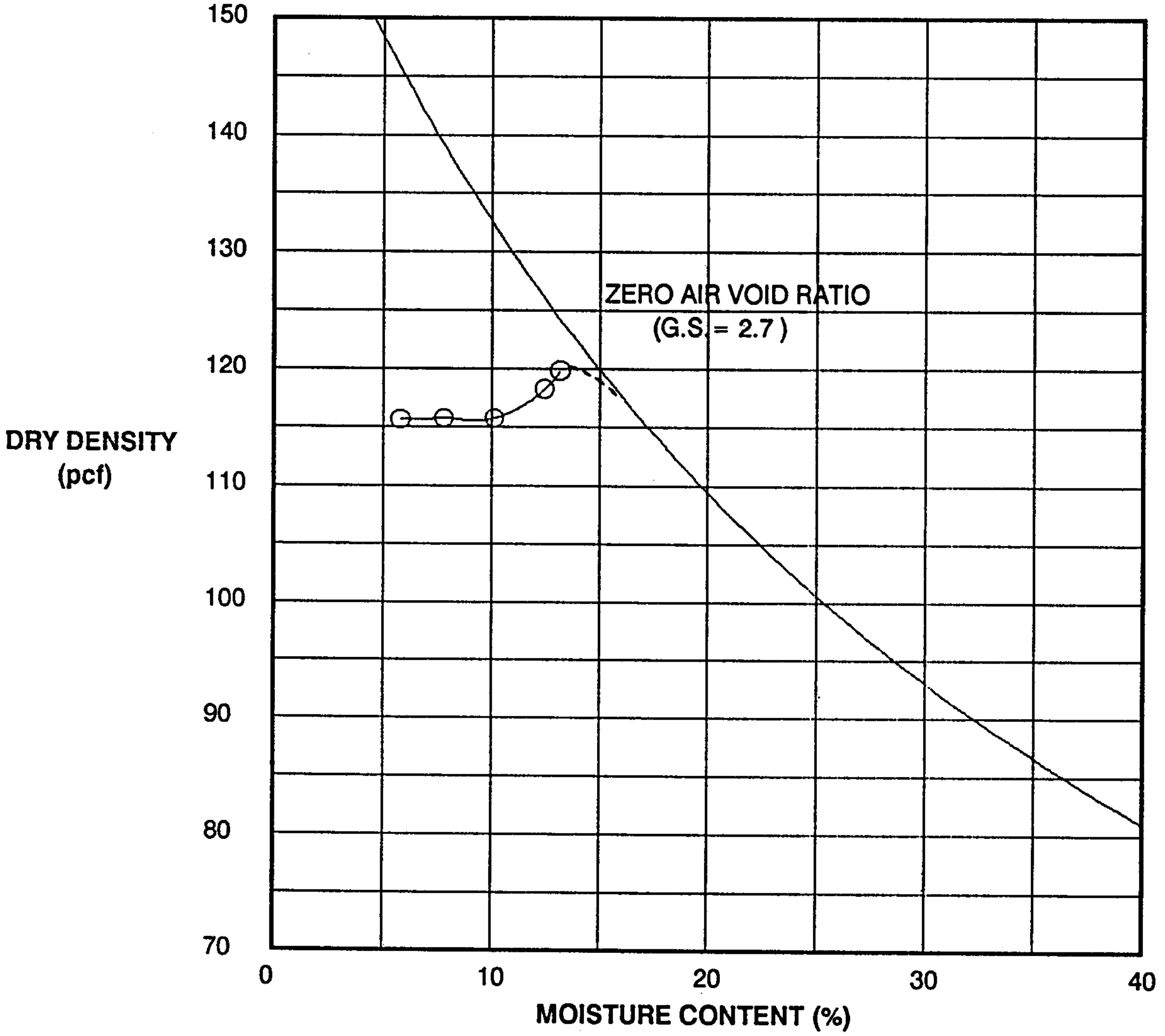
02-09-1993

LIGO

DAMES & MOORE

JOB NO. 00177-004-016

COMPACTION TEST



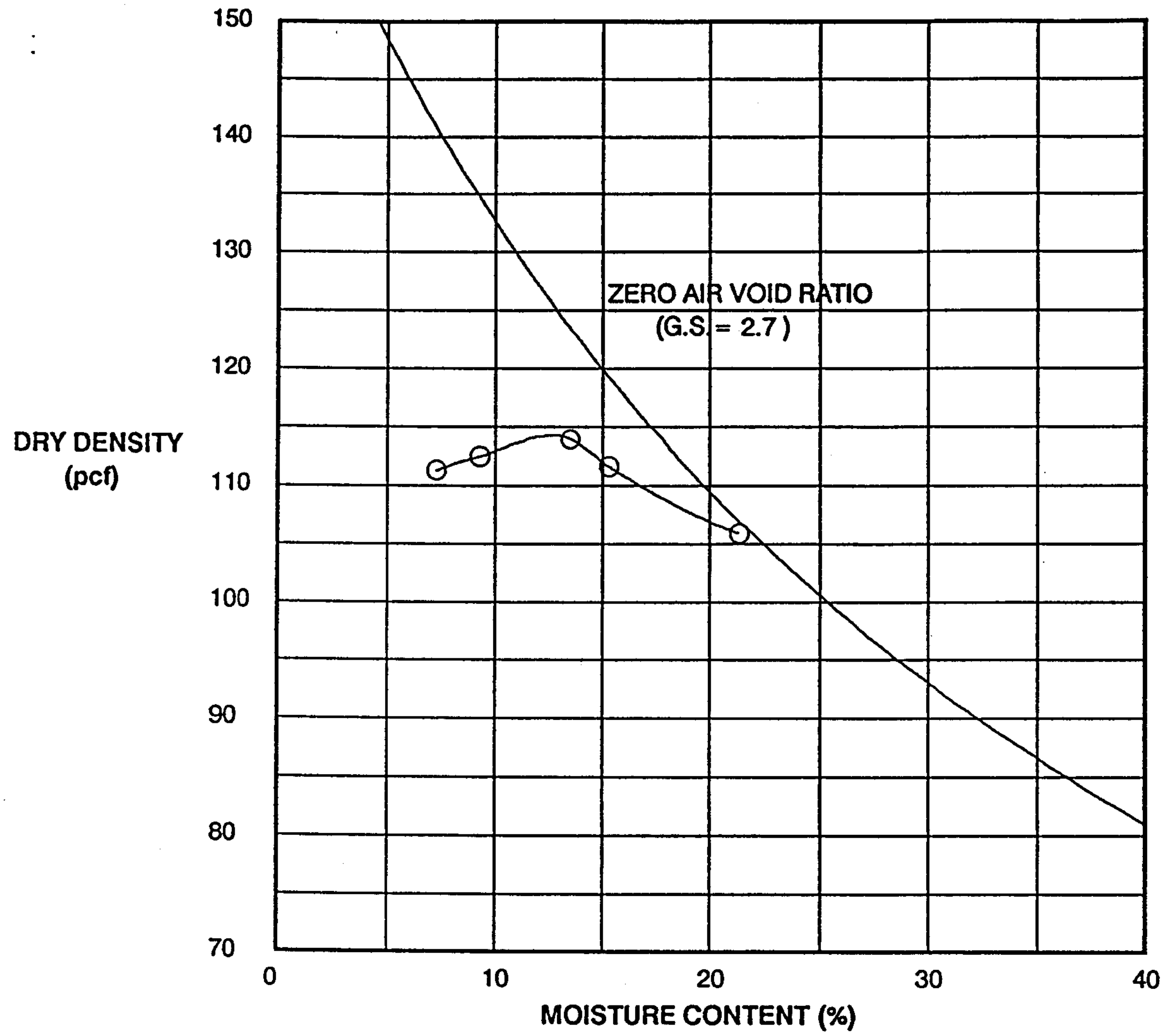
SYMBOL	SAMPLE LOCATION	DEPTH (ft)	DESCRIPTION	TEST METHOD	OPTIMUM MOISTURE(%)	MAX. DRY DENSITY(pcf)
○	DM-7-92	8	Gray medium - coarse sand (SP)	ASTM D1557-A	12.8	119

REMARKS: WET OF OPTIMUM CONDITIONS COULD NOT BE TESTED DUE TO THE FREE DRAINING NATURE OF THE SAMPLE.

02-09-1993 LIGO **DAMES & MOORE**

JOB NO. 00177-004-016

COMPACTION TEST



SYMBOL	SAMPLE LOCATION	DEPTH (ft)	DESCRIPTION	TEST METHOD	OPTIMUM MOISTURE(%)	MAX. DRY DENSITY(pcf)
○	Mixture	-	60% SP + 40% SM	ASTM D1557-A	12.5	114

REMARKS: 60% from DM-38-92 at 13': Gray fine to medium sand.

40% from DM-32-92 at 3': Brown fine silty sand.

01-15-1993

UGO

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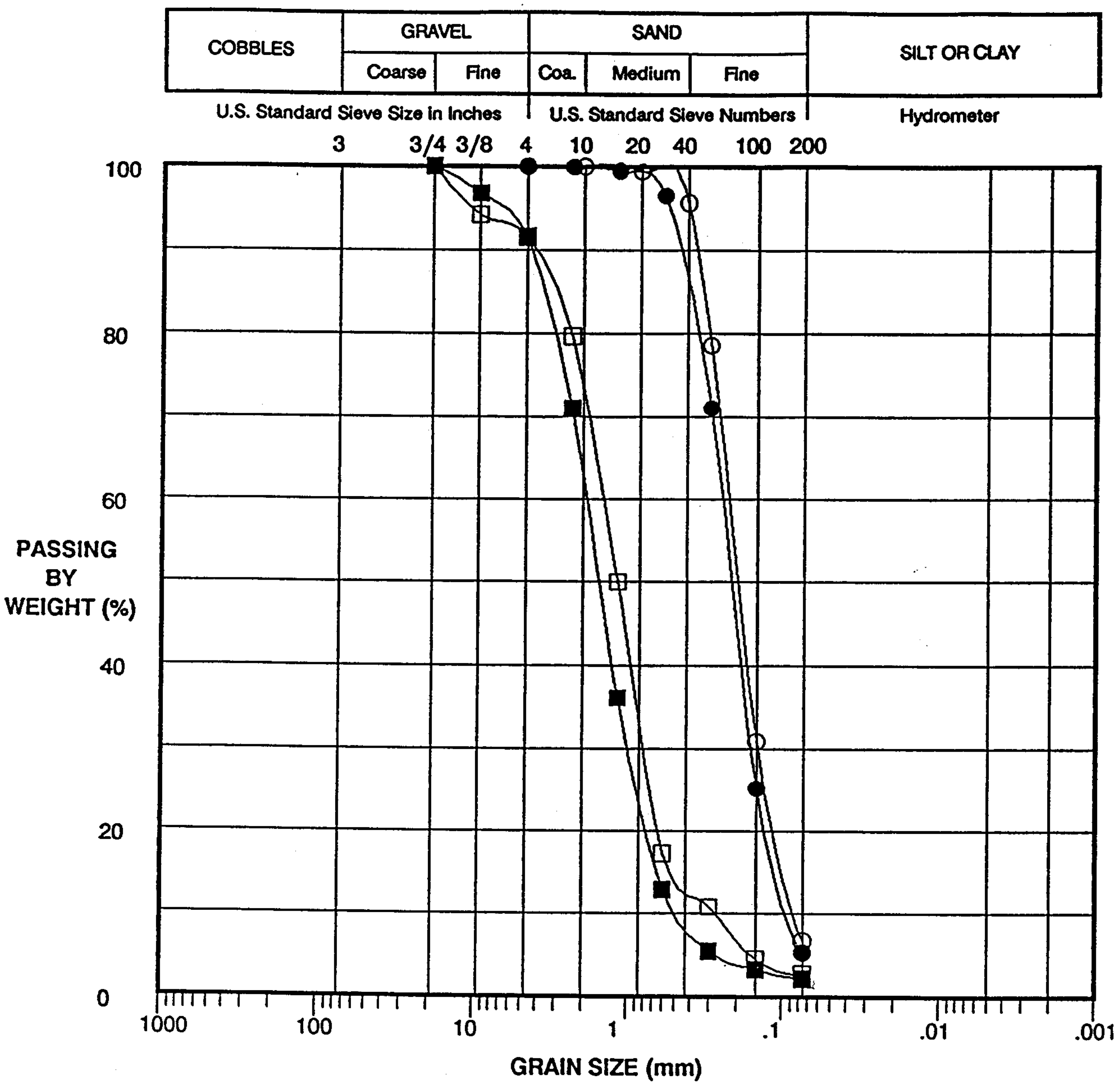
JOB NO. 00177-004-016

PLATE C-7



GRAIN SIZE DISTRIBUTION

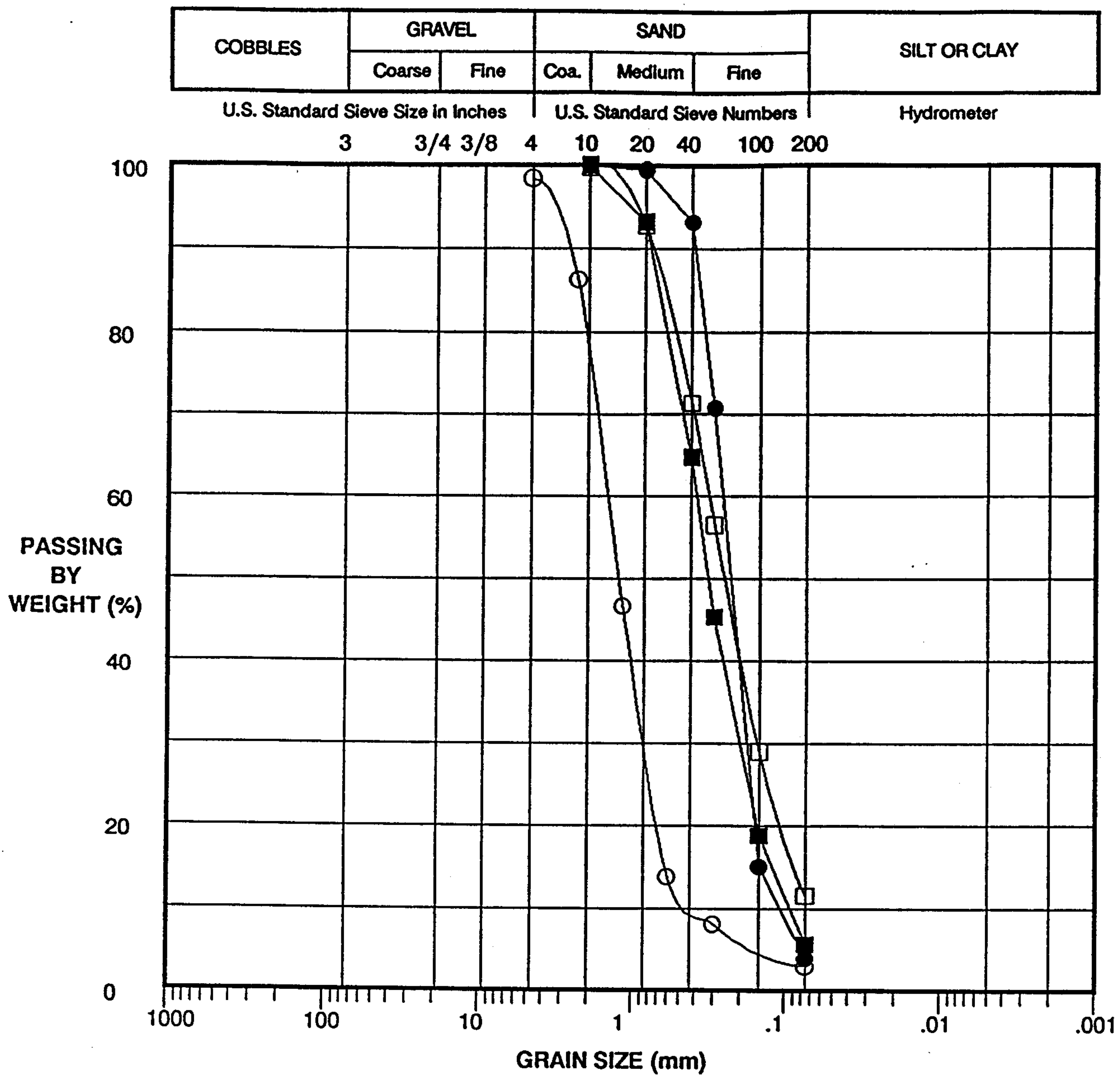
SYMBOL	BORING NO.	DEPTH (ft)	DESCRIPTION	% GRAVEL	% SAND	% FINES
○	DM-4-92	8	Fine sand, trace silt (SP)	0.0	93.3	6.7
●	DM-6-92	3	Fine sand, trace silt (SP)	0.0	94.6	5.4
□	DM-6-92	8	Medium to coarse sand, trace gravel (SP)	8.3	88.9	2.9
■	DM-6-92	13	Medium to coarse sand, trace gravel (SP)	8.4	89.4	2.3

REMARKS:

01-15-1993 LIGO

DAMES & MOORE

JOB NO.00177-004-016



GRAIN SIZE DISTRIBUTION

SYMBOL	BORING NO.	DEPTH (ft)	DESCRIPTION	% GRAVEL	% SAND	% FINES
○	DM-7-92	8	Medium to coarse sand, trace silt (SP)	0.0	97.0	3.0
●	DM-13-92	13	Fine sand with trace silt (SP)	0.0	96.1	3.9
□	DM-20-92	3	Fine to medium sand, some silt (SP/SM)	0.0	88.4	11.6
■	DM-26-92	3	Fine to medium sand, trace silt (SP)	0.0	94.3	5.7

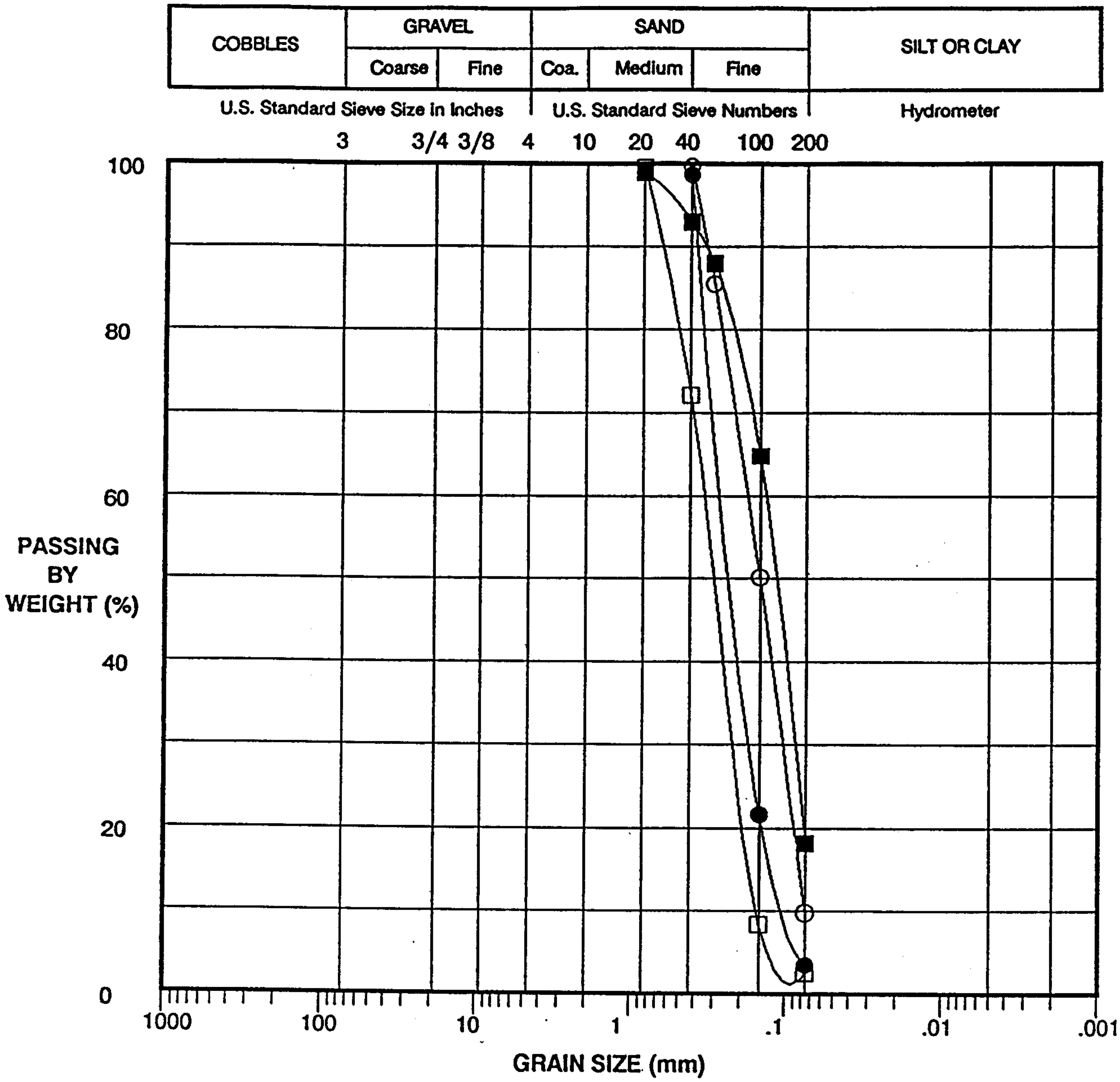
REMARKS:

01-15-1993

LIGO

DAMES & MOORE

JOB NO.00177-004-016



GRAIN SIZE DISTRIBUTION

SYMBOL	BORING NO.	DEPTH (ft)	DESCRIPTION	% GRAVEL	% SAND	% FINES
○	DM-29-92	8	Fine sand, some silt (SP/SM)	0.0	89.8	10.2
●	DM-30-92	13	Fine sand, trace silt (SP)	0.0	96.4	3.6
□	DM-32-92	8	Fine to medium sand (SP)	0.0	97.4	2.6
■	DM-33-92	12.5	Fine sand with some silt (SM)	0.0	81.0	19.0

REMARKS:

01-15-1993

LIGO

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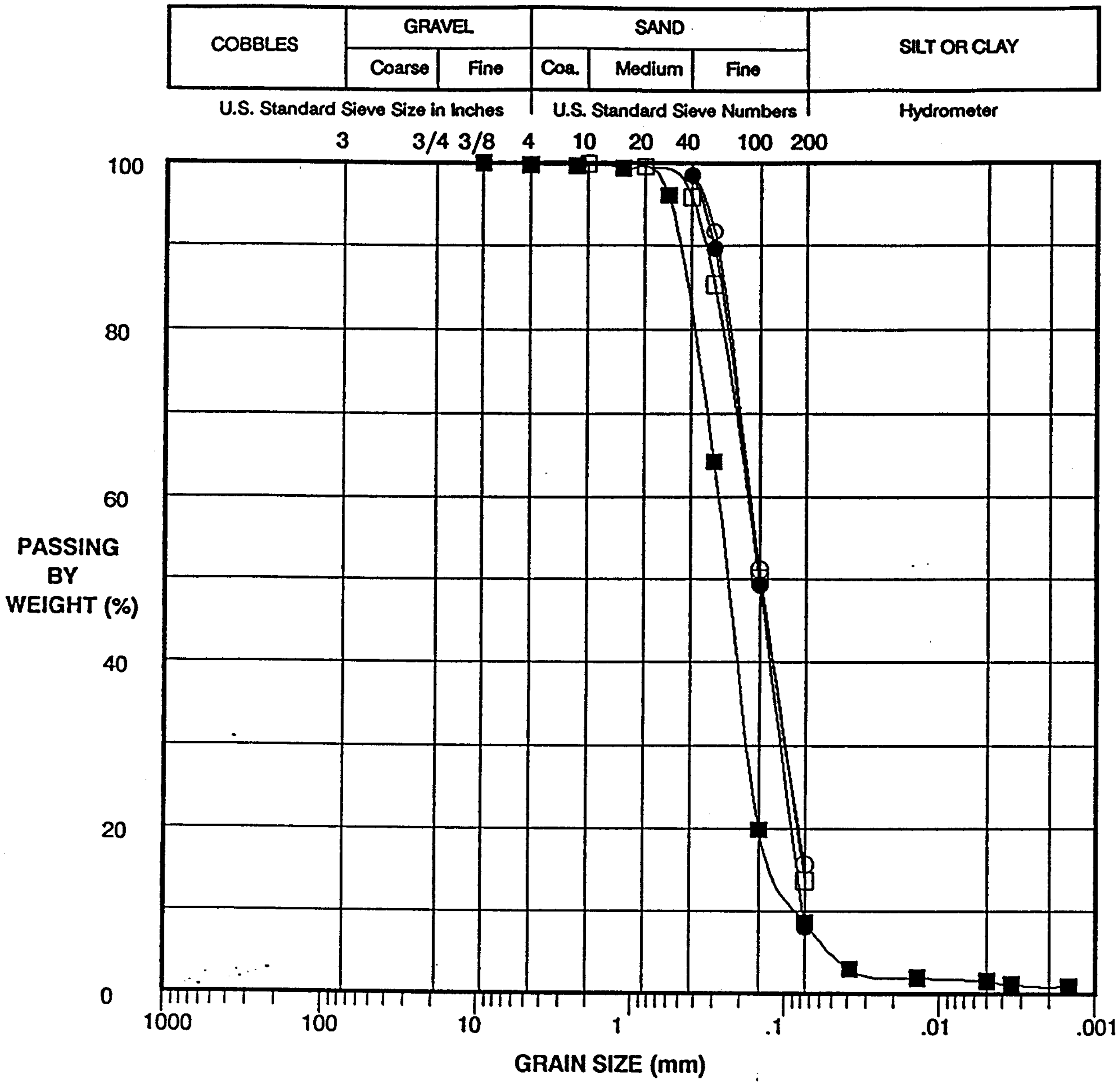
JOB NO.00177-004-016

Plate C-10



GRAIN SIZE DISTRIBUTION

SYMBOL	BORING NO.	DEPTH (ft)	DESCRIPTION	% GRAVEL	% SAND	% FINES
○	DM-34-92	18	Fine sand, some silt (SM)	0.0	84.1	15.9
●	DM-35-92	8	Fine sand, trace silt (SP/SM)	0.0	91.6	8.4
□	DM-36-92	8	Fine sand, some silt (SM)	0.0	86.3	13.7
■	DM-38-92	13	Fine sand, trace silt (SP/SM)	0.3	91.1	8.6

REMARKS:

01-15-1993 LIGO **DAMES & MOORE**

JOB NO.00177-004-016

00177_18.CDR

Boring	Depth (ft)	Moisture Content (%)	Dry Density (pcf)	Fines Content (%)
DM-1-92	2.5	2.3	92	3.4
DM-4-92	3	1.8	104	1.5
DM-4-92	8	3.8	102	6.9
DM-6-92	3	2.5	102	5.4
DM-6-92	8	2.5	---	3.3
DM-6-92	13	3.0	109	2.4
DM-7-92	8	2.9	---	3.0
DM-8-92	3	1.6	---	1.0
DM-11-92	3	4.9	---	13.3
DM-13-92	8	6.9	103	3.8
DM-16-92	2.5	1.8	---	9.6
DM-18-92	2.5	2.5	---	13.3
DM-20-92	3	2.4	---	11.6
DM-24-92	2.5	2.8	---	12.7
DM-25-92	3	2.8	108	10.7
DM-26-92	3	1.8	106	6
DM-29-92	8	3.6	93	10.1
DM-30-92	3	2.4	99	18.6
DM-30-92	13	2.9	95	3.8
DM-32-92	3	2.5	99	12.5
DM-32-92	8	2.8	100	3.2
DM-32-92	13	3.6	95	4.8
DM-33-92	2.5	2.2	---	7.5
DM-33-92	13	9.8	86	18.0
DM-34-92	18	6.3	100	15.8
DM-35-92	8	5.1	95	8.6
DM-36-92	3	2.8	97	4.8
DM-36-92	8	4.6	99	14.3
DM-38-92	3	2.8	103	8.9
DM-38-92	13	3.2	---	8.7

FINES CONTENT ANALYSIS

Job No. 00177-004-016
DAMES & MOORE

LIGO Project
Hanford, Washington
PLATE C-12

00177_18.CDR

Boring	Depth (ft)	Soil Type	Redox Potential (mv)	Moisture (%)	Sulfides (ppm)	Sulfates (ppm)	Chlorides (ppm)	pH	Resistivity (ohm-cm)
DM-1-92	2.5	Brown fine sand with trace silt (SP)	323	2.0	0	6.3	12	7.9	370,000
DM-20-92	3	Brown fine sand with some silt (SM/SP)	316	2.0	0	6.1	11	8.2	170,000
DM-39-92	13	Gray fine to medium sand, trace silt (SP)	287	3.0	0	6.0	11	8.7	68,000

SOILS CORROSIVITY TEST RESULTS

Job No. 00177-004-016

DAMES & MOORE

LIGO Project
Hanford, Washington
PLATE C-13

00177_18.CDR

Boring	Soil Type	Depth (ft)	Test Thickness (inches)	Test Density (pcf)	Mean Temp. (°C)	Apparent Thermal Conductivity (W/m°C)	Calculated Thermal Resistivity (m°C/W)	Thermal Resistance (m^2C/W)
DM-7-92	Gray fine to medium sand, trace gravel (SP)	8	1.04	112	28	0.221	4.525	0.12
DM-20-92	Brown fine sand with some silt (SM/SP)	3	0.97	102	29	0.234	4.273	0.11

THERMAL CONDUCTIVITY TEST RESULTS

LIGO Project
Hanford, Washington
PLATE C-14

GEO RECON INTERNATIONAL
applied geophysics

January 10, 1993
J92-558

Martin McCabe

Dames & Moore
500 Market Place Tower
2025 First Avenue
Seattle, WA 98121

Re: Compressional and Shear Wave Velocity Measurements
Boring DM-1; Boring DM-20 & Boring DM-41
LIGO Project
Hanford, Washington

Gentlemen:

This report presents the results of Compressional and Shear Wave Velocity measurements completed in Boring DM-1; Boring DM-20 and Boring DM-41 at the proposed LIGO site Hanford, Washington. The field measurements were made on December 14 and December 15 , 1992.

The borings were drilled to a depth of approximately 60 feet and cased with a 2 inch Schedule 40 PVC pipe; the 2 inch casing was grouted in the borehole with a weak cement grout. The casing was cut off even with the ground surface. The velocity measurements were made to a depth of 30 feet from ground surface. The inside bottom of the casing was approximately 60 feet from ground surface.

The measured compressional and shear wave velocities are presented on Table 1 respectively, which show the measured time arrivals, interval velocity calculations and the averaged layer velocities computed from the interval layer velocities. The measured slant-angle arrival times have been converted to vertical downhole arrival times to avoid slant range computations. Figure 1 through 3 are the time-depth plots of the corrected downhole times.

The compressional (P) wave energy was a vertical hammer blow on a padded metal plate, offset 10 feet from the boring. The zero time of the hammer blow was determined from a motion sensitive switch on the hammer handle. The receiver was a piezo-electric crystal transducer placed in the borehole casing, which was filled with water. The measurements were made at 5 foot intervals, measured from the top of the casing.

The shear (S) wave energy source as a horizontal hammer blow on the ends of a 6x6 inch plank, offset from the borehole. The plank was placed tangent to a circle with a radius of 10 feet, centered on the borehole. The plank was weighted by placing the front wheels of a vehicle on it. The zero time of the hammer blow was determined by impact to the motion sensitive switch on the hammer. The generated S wave energy was detected by two sets of transducers, separated by 10 feet, placed in the borehole. Each transducer contained 4 horizontal geophones placed on axis of 45 degrees. The measurements were made at two foot intervals measured from the top of the casing.

Two shear wave recordings were made for each measurement interval. The two separate recordings were made with reversed (polarized) energy inputs utilizing the two ends of the 6x6 inch plank (blow 1 and blow 2). The arrival of the shear wave energy was determined by comparing the times and particle motion direction of the energy arrivals from the two records. The particle motion of shear wave energy is polarized, and is dependent on the direction of the energy input. Thus on blow 1, the particle direction of the motion should be reversed from that produced by blow 2. The polarization of the energy, the corresponding wave form and time arrivals recorded, allows the interpreter to separate P wave arrivals, P to S wave conversions, tube wave arrivals and other energy arrivals (eg. casing waves) from the generated shear wave arrival.

The averaged compressional and shear wave velocities with the corresponding, calculated Poisson's ratios are shown below:

Depth	P Velocity	S Velocity	Poisson's Ratio
<u>Boring DM-1</u>			
1 to 18	1744	898	0.3196
18 to 60	5123	1431	0.4577
<u>Boring DM-20</u>			
1 to 20	2181	878	0.4033
20 to 60	5033	1344	0.4612
<u>Boring DM-41</u>			
1 to 12.5	1583	593	0.4184
12.5 to 60	4377	1075	0.4679

The formula for Poisson's ratio is

$$u=\frac{(Vp/Vs)^{2}-2}{2*((Vp/Vs)^{2}-1)}$$

where:
u = Poisson's Ratio
Vp = Compressional Wave Velocity
Vs = Shear Wave Velocity

The time arrivals were picked using proprietary computerized picking routines. The arrival times were then converted to downhole times rather than plotting the arrival time vs the slant distance (a result of the source-borehole offset). The formula for conversion of the record time (slant distance) to the downhole time is:

$$DHTime=RecordTime*(\cos(\arctan(offset/detectordepth))$$

where the DH Time is the resolved vertical travel time down the borehole.

The recording equipment used in the survey was a Geometrics digital recording 1225 seismograph, a signal enhancement recording seismograph. The shear wave records were collected at a 100 ms sweep length and the compressional wave records were collected at a 25 ms sweep length, for a sample rate of 0.1 ms and 0.025 ms (1000 samples per record) respectively. The data were field recorded on a laptop computer for later analysis. The P wave records were collected first. The P wave data was then plotted to determine optimum spacings for recording the S wave data.

We trust that the above is sufficient for your requirements. Please let us know if you have any questions or if we may be of further assistance.

For: Geo-Recon International Ltd.

Clyde A. Ringstad
Principal Geophysicist

Downhole Compressional and Shear Wave Velocity Measurements

Borehole: DM-1

Offset = 10
Stickup= 0.3

Compressional Wave Data - Interval Velocity Computations

Depth Below Top of Casing	Recorded Time	Depth of Data	Corrected Time	Interval Time	Interval Velocity	Average Velocity
0	4.6					
5	7.4	4.7	3.1477	3.1477	1493	
10	8.6	9.7	5.9878	2.8401	1760	
15	10.3	14.7	8.5163	2.5284	1977	1744
VELOCITY BREAK AT 18.0 FEET						
20	12	19.7	10.7003	2.1841	2289	
25	12.8	24.7	11.8645	1.1642	4295	
30	13.8	29.7	13.0786	1.2140	4118	
35	14.7	34.7	14.1251	1.0466	4777	
40	15.6	39.7	15.1275	1.0023	4988	
45	16.4	44.7	16.0044	0.8769	5702	
50	17.2	49.7	16.8621	0.8577	5830	
55	18	54.7	17.7065	0.8445	5921	
60	18.9	59.7	18.6403	0.9338	5355	5123

Downhole Compressional and Shear Wave Velocity Measurements

Borehole: DM-1

Offset = 10
Stickup= 0.3

Shear Wave Data - Interval Velocity Computations

Depth Below Top of Casing	Recorded Time	Depth of Data	Corrected Time	Interval Time	Interval Velocity	Average Velocity
0	4					
5	12.3	4.7	5.2319	5.2319	898	
10	15.6	9.7	10.8616	5.6297	888	
15	19.8	14.7	16.3711	5.5094	908	898
VELOCITY BREAK AT 18.0 FEET						
20	23.4	19.7	20.8657	4.4946	1112	
25	26.3	24.7	24.3779	3.5122	1424	
30	29.4	29.7	27.8630	3.4851	1435	
35	32.7	34.7	31.4212	3.5582	1405	
40	36	39.7	34.9096	3.4883	1433	
45	39.3	44.7	38.3520	3.4424	1452	
50	42.7	49.7	41.8610	3.5090	1425	
55	46.1	54.7	45.3484	3.4874	1434	
60	49.5	59.7	48.8199	3.4714	1440	1431

Downhole Compressional and Shear Wave Velocity Measurements

Borehole: DM-20

Offset = 10
Stickup= 0

Compressional Wave Data - Interval Velocity Computations

Depth Below Top of Casing	Recorded Time	Depth of Data	Corrected Time	Interval Time	Interval Velocity	Average Velocity
0	1.9					
5	6.2	5	2.7727	2.7727	1803	
10	7.2	10	5.0912	2.3184	2157	
15	9.1	15	7.5717	2.4805	2016	
20	10.5	20	9.3915	1.8198	2748	2181
VELOCITY BREAK AT 20 FEET						
25	11.1	25	10.3061	0.9146	5467	
30	11.9	30	11.2893	0.9832	5085	
35	12.8	35	12.3075	1.0182	4911	
40	13.7	40	13.2910	0.9834	5084	
45	14.65	45	14.3011	1.0102	4950	
50	15.6	50	15.2971	0.9959	5020	
55	16.55	55	16.2830	0.9860	5071	
60	17.5	60	17.2619	0.9788	5108	5033

Downhole Compressional and Shear Wave Velocity Measurements

Borehole: DM-20

Offset = 10
Stickup= 0

Shear Wave Data - Interval Velocity Computations

Depth Below Top of Casing	Recorded Time	Depth of Data	Corrected Time	Interval Time	Interval Velocity	Average Velocity
0	4.5					
5	10.4	5	4.6510	4.6510	1075	
10	14.6	10	10.3238	5.6727	881	
15	19.2	15	15.9754	5.6516	885	
20	24.3	20	21.7346	5.7592	868	878
VELOCITY BREAK AT 20 FEET						
25	27.5	25	25.5331	3.7985	1316	
30	30.8	30	29.2194	3.6863	1356	
35	34.3	35	32.9803	3.7608	1329	
40	37.8	40	36.6714	3.6911	1355	
45	41.3	45	40.3165	3.6451	1372	
50	44.9	50	44.0281	3.7115	1347	
55	48.6	55	47.8161	3.7880	1320	
60	52.3	60	51.5884	3.7723	1325	1344

Downhole Compressional and Shear Wave Velocity Measurements

Borehole: DM-41

Offset = 10
Stickup= 0.3

Compressional Wave Data - Interval Velocity Computations

Depth Below Top of Casing	Recorded Time	Depth of Data	Corrected Time	Interval Time	Interval Velocity	Average Velocity
0	3.9					
5	6.4	4.7	2.7223	2.7223	1726	
10	8.9	9.7	6.1967	3.4744	1439	1583
VELOCITY BREAK AT 12.5 FEET						
15	10.9	14.7	9.0124	2.8157	1776	
20	11.2	19.7	9.9870	0.9746	5130	
25	12.4	24.7	11.4938	1.5068	3318	
30	13.3	29.7	12.6047	1.1109	4501	
35	14.1	34.7	13.5486	0.9439	5297	
40	15	39.7	14.5456	0.9970	5015	
45	15.9	44.7	15.5165	0.9708	5150	
50	17	49.7	16.6660	1.1495	4350	
55	18.1	54.7	17.8049	1.1389	4390	
60	19.1	59.7	18.8376	1.0326	4842	4377

Downhole Compressional and Shear Wave Velocity Measurements

Borehole: DM-41

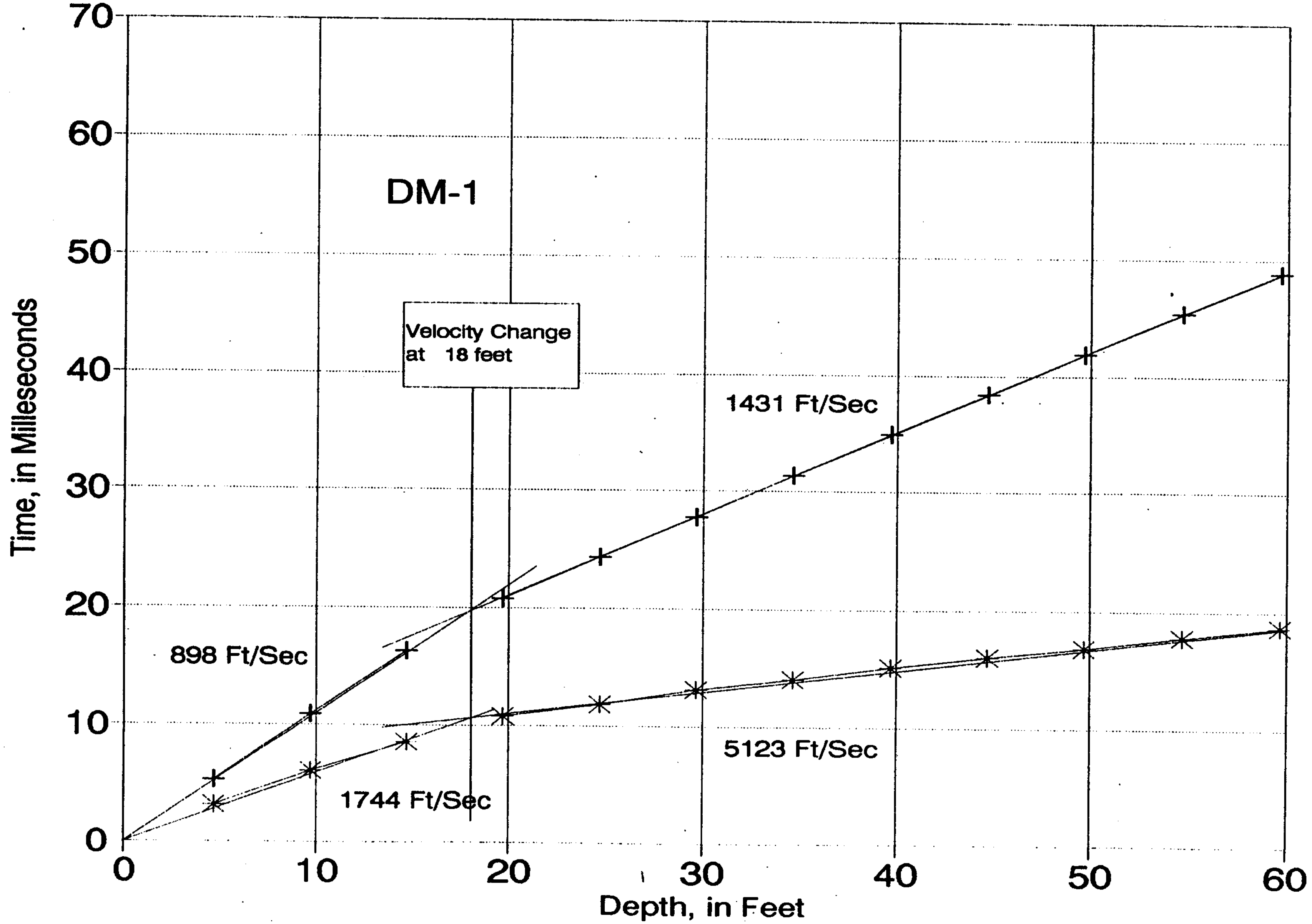
Offset = 10
Stickup= 0.3

Shear Wave Data - Interval Velocity Computations

Depth Below Top of Casing	Recorded Time	Depth of Data	Corrected Time	Interval Time	Interval Velocity	Average Velocity
0	4.5					
5	18.9	4.7	8.0393	8.0393	585	
10	23.5	9.7	16.3621	8.3227	601	593
VELOCITY BREAK AT 12.5 FEET						
15	26	14.7	21.4974	5.1353	974	
20	29.7	19.7	26.4833	4.9860	1003	
25	33.8	24.7	31.3298	4.8464	1032	
30	38.1	29.7	36.1082	4.7784	1046	
35	42.4	34.7	40.7419	4.6337	1079	
40	46.7	39.7	45.2855	4.5435	1100	
45	50.9	44.7	49.6722	4.3867	1140	
50	55.2	49.7	54.1155	4.4433	1125	
55	59.6	54.7	58.6283	4.5129	1108	
60	63.9	59.7	63.0220	4.3937	1138	1075

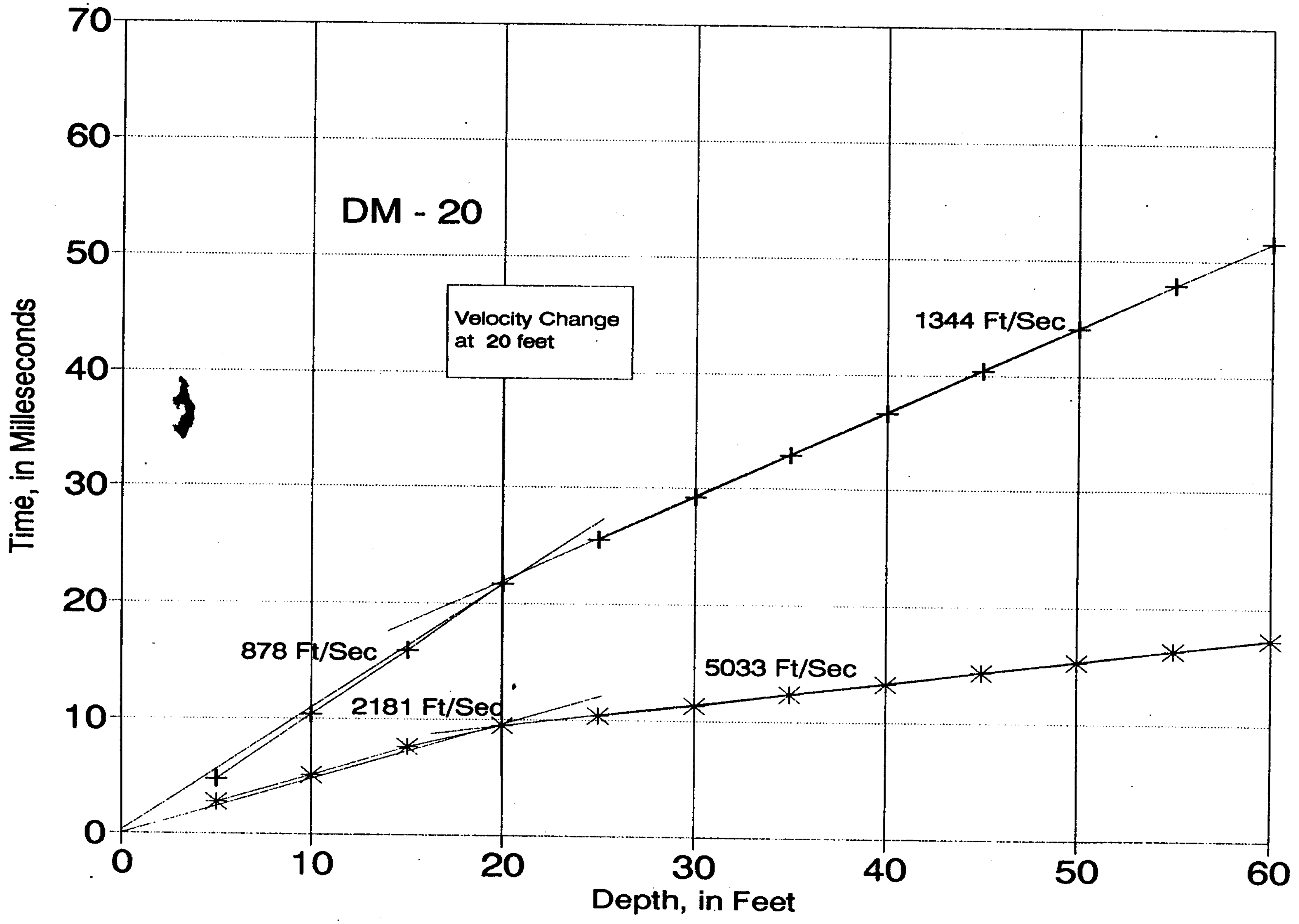
Dames & Moore, LIGO Project Hanford, WA.

Comp. & Shear Wave Time Distance Graph



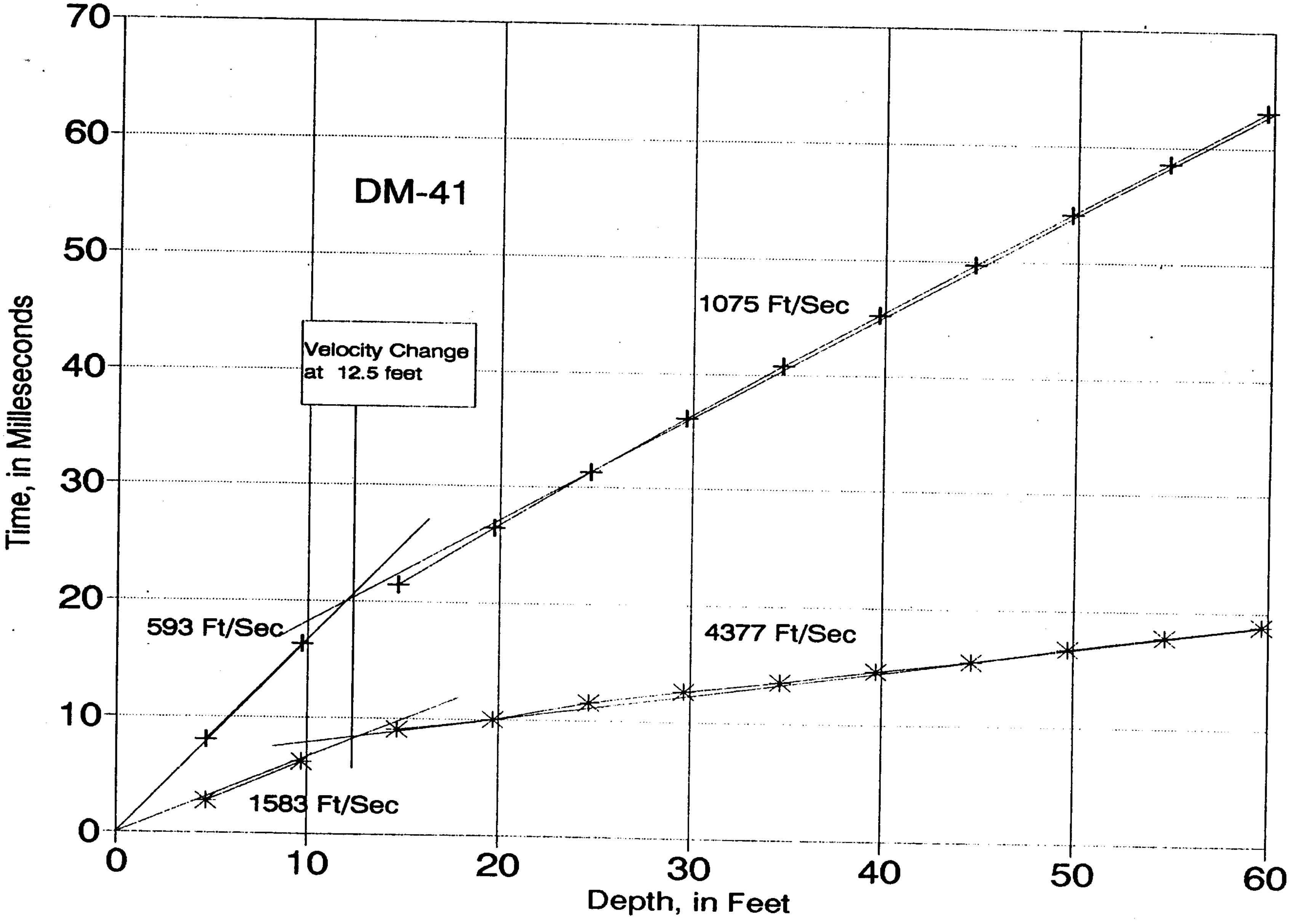
Dames & Moore, LIGO Project Hanford, WA.

Comp. & Shear Wave Time Distance Graph



Dames & Moore, LIGO Project Hanford, WA.

Comp. & Shear Wave Time Distance Graph



DRILL HOLE E-1

Page 1 of 4

Project No : 803-1701H
Elevation : 518.3 ft.
Total Depth : 465.3 ft.
Coordinates : N422,718.18; E269,289.09
Date Completed : 5/15/81

SAMPLE TYPE

▨ Cuttings
95 ■ Core, Number Indicates % Core Recovery
C 2015 ⊡ XRF, With Sample Number Chemical Results Listed in Table 2R-1
☒ Drive Open Sample

Unit Column Refers to General Stratigraphic Divisions Identified Within the Site Area:

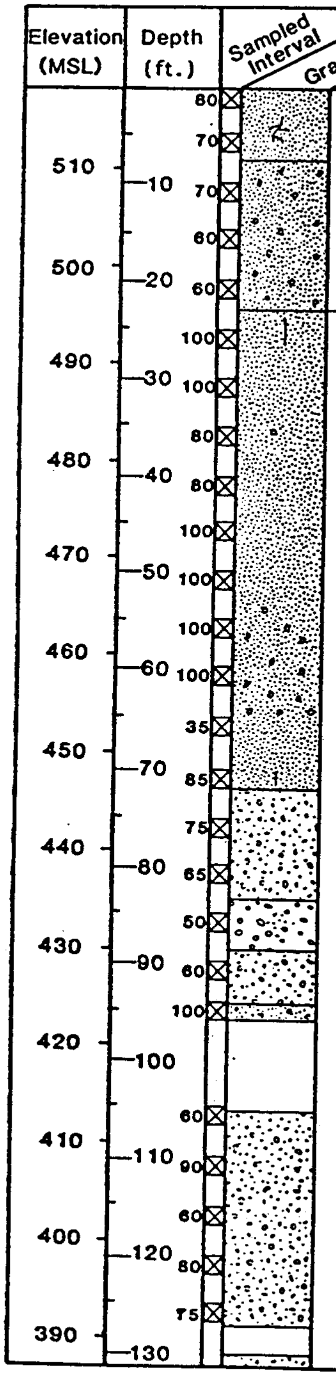
M – Missoula
PM – Pre-Missoula

IV – Ringold, Unit IV
III – Ringold, Unit III
II – Ringold, Unit II
I-u – Ringold, Unit I-upper
I-b – Ringold, Unit I-basal

Columbia River Basalt Group
Tem – Elephant Mountain Member
Ter – Rattlesnake Ridge Interbed
Tp – Pomona Member
B – Basalt, Undifferentiated

NOTE: Lithologies from 0 to 130 ft. from driller's log.

Elevation (MSL)	Depth (ft.)	Sampled Interval	Graphic Log	Lithologic Description	Unit



SAND. Dark-yellowish-brown. Fine- to medium-grained. Trace organic matter.

Gravelly SAND. Dusky-yellowish-brown. Coarse-grained.

M

SAND. Dark-yellowish-brown. Fine- to coarse-grained. Trace silt at 25.7 ft. and 70.7 ft. Trace gravel at 35.7 ft. and 50.7-56 ft. Gravelly from 56 to 65 ft.

Sandy GRAVEL. Sand dark-yellowish-brown; fine- to coarse-grained.

GRAVEL. Trace sand.

Sandy GRAVEL. Sand fine- to coarse-grained.

Gravelly SAND. Dark-yellowish-brown. Fine- to coarse-grained.

No recovery.

Sandy GRAVEL. Sand varicolored; fine- to coarse-grained.

No recovery.

PM

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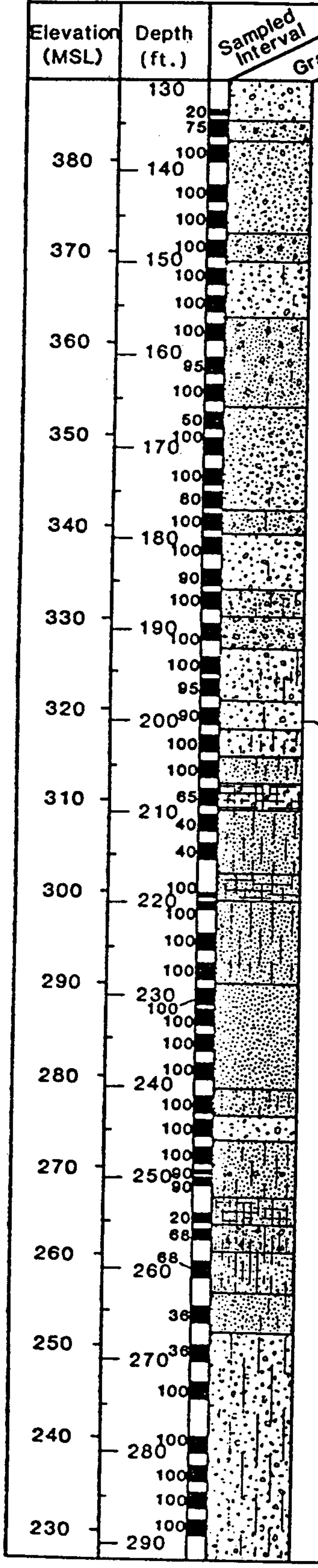
LOG OF DRILL HOLE E-1

FIGURE 2R-A-86

DRILL HOLE E-1 Page 2 of 4



Lithologic Description | Unit

Sandy GRAVEL. Weak calcareous cement on sand.

Gravelly SAND. Medium-grained. 5% mafics. Weak calcareous cement.

Sandy GRAVEL to gravelly SAND. Sand medium-grained, some fine-grained; 5% mafics. Weak calcareous cement at 142 ft. Granite and basalt clasts.

Gravelly SAND. Medium-grained. Weak calcareous cement. No rinds.

Silty sandy GRAVEL. Sand medium-grained; angular to subangular; 5-7% mafics. Weak calcareous cement; no cement rinds.

Gravelly silty SAND to silty sandy GRAVEL. Yellowish-gray. Medium-grained. Angular to subangular. 5% mafics. Weak calcareous cement and micaceous at 160.8 ft.

PM

Sandy GRAVEL to gravelly SAND. Sand medium-grained, some fine-grained; angular to subangular; 5-7% mafics. Weak calcareous cement; no cement rinds. Trace silt at 177.8 ft.

Gravelly SAND. Medium-grained. Weak calcareous cement. Trace silt.

Sandy GRAVEL. Trace silt. Clasts to cobble size. No cement rinds.

Silty sandy GRAVEL to gravelly silty SAND. Sand as in 165.3 to 176.6 ft

Gravelly SAND to sandy GRAVEL. Thin weathering rinds on basalt clasts

Silty sandy GRAVEL. Sand fine- to medium-grained. Very weak calcareous cement and increasing silt at 196 ft.

Sandy GRAVEL. Trace silt. No cement rinds.

Silty sandy GRAVEL. Weak calcareous cement; no rinds. Ferruginous stain.

Silty SAND. Yellowish-gray. Fine- to medium-grained. Silt adheres to sand.

Gravelly silty CLAY to gravelly clayey SILT. Yellowish-gray. Possible ash horizon at 208 ft.

Silty SAND. Yellowish-gray. Very-fine-grained, some fine-grained, fining downward. Micaceous at 214 ft.

Silty clayey SAND. Dusky-yellow. Very-fine-grained, some fine.

Silty SAND. Yellowish-gray. Fine-grained, some very-fine-grained. Angular to subangular. Micaceous. 3-5% mafics.

SAND. Yellowish-gray. Medium-grained, some very-fine- to fine-grained. Angular to subangular. 5-7% mafics, with bluish cast. Slight calcareous rind.

Silty SAND. Yellowish-gray. Medium-grained. 3-5% mafics.

Sandy GRAVEL. Blue cast to mafics. Ferruginous stain.

Silty SAND. Yellowish-gray to dusky-yellow. Medium-grained. Gravelly at 249 ft. Much ferruginous stain at 250 ft.

Sandy clayey SILT. Yellowish-gray. Micaceous. Root casts?

IV

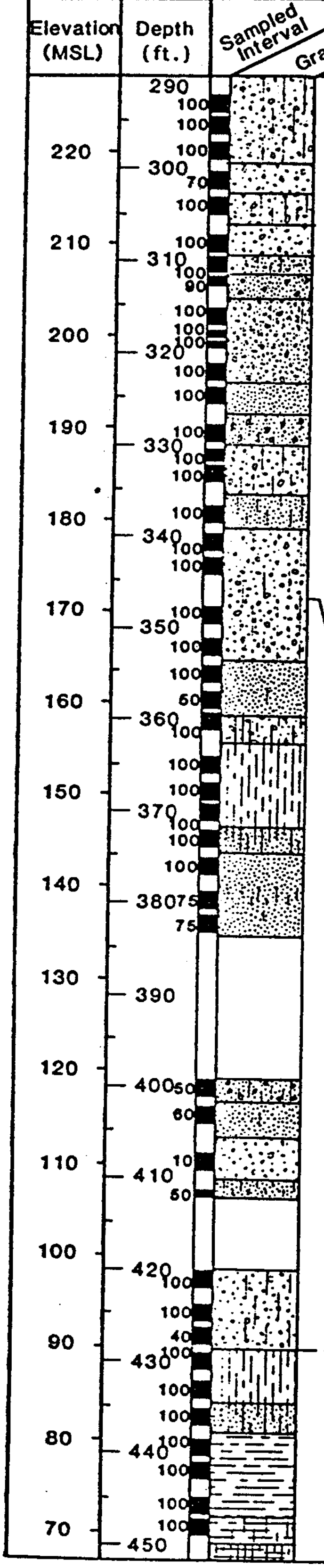
Gravelly sandy SILT to gravelly silty SAND. Yellowish-gray.

Sandy SILT. Yellowish-gray. Mica flakes to fine-sand size.

Silty SAND. Yellowish-gray. Medium-grained. Micaceous. 3% mafics.

Silty sandy GRAVEL. Matrix yellowish-gray to dusky-yellow. Sand medium-grained, some very-fine- to fine-grained; angular to sub-angular 2-5% mafics. Calcareous cement from 267 to 276 ft. and 284 to 294 ft. Sandy rinds on gravel clasts. Some ferruginous stain at 279 ft., 282 ft., and 288 ft. Blue cast to mafics at 273 ft.

DRILL HOLE E-1 Page 3 of 4



Lithologic Description	Unit
Silty sandy GRAVEL. Matrix yellowish-gray. Sand medium-grained; angular to subangular; 5-7% mafics. Calcareous cement at 293 ft. Blue cast to mafics at 295 ft. and 297.8 ft.	IV
Sandy GRAVEL. Sand yellowish-gray. Calcareous cement.	
Silty sandy GRAVEL. Sand as above. Calcareous cement.	
Sandy GRAVEL. Sand yellowish-gray; medium-grained, some fine-grained.	
Silty sandy GRAVEL to silty gravelly SAND. Calcareous cement.	
Gravelly SAND. Yellowish-gray. Micaceous. 7-10% mafics; blue-cast.	
Silty sandy GRAVEL to silty gravelly SAND. Matrix yellowish-gray to dusky-yellow. Sand medium-grained, some fine-grained. Sand cemented to gravel. Sand decreases at 317 ft. and 319 ft.	
SAND. Yellowish-gray. Medium-grained. 7-10% mafics.	
Silty gravelly SAND. Medium-grained, some fine-grained. 10% mafics.	
Silty sandy GRAVEL. Matrix yellowish-gray to dusky-yellow. Sand cemented to pebbles. Blue cast to mafics at 333 ft.	
Silty SAND. Light-olive-gray. Medium-grained. 15% mafics. Micaceous.	
Silty sandy GRAVEL. Matrix light-olive-gray. Sand medium-grained, some fine-grained; angular to subangular; 15% mafics. Matrix increases and mafics with blue cast at 352 ft.	
SAND. Dusky-yellow to yellowish-gray. Medium-grained. Angular to subangular. 15-20% mafics. Trace silt at 358.5 ft.	III
Gravelly SILT to silty GRAVEL, with floating sand grains. Very-light-olive-gray.	
SILT. Yellowish-gray to very-light-olive-gray. Mica to very-fine-sand size.	
Sandy SILT to silty SAND. Very-light-olive-gray. Micaceous.	
SAND. Very-light-olive-gray to light-gray to yellowish-gray. Very-fine- to medium-grained, mostly medium-grained, coarsening downward. Angular to subangular. 10-25% mafics, decreasing with depth. Silty at 379.4 ft. Micaceous and trace silt at 382 ft.	
No recovery.	
Gravelly silty SAND. Sand as at 382 ft.	
SAND. 7-10% mafics, with bluish cast. Trace silt. Medium-grained.	
Sandy GRAVEL. Sand as above; weakly cemented to gravel.	
Silty SAND. Light-gray. Fine- to medium-grained, some very-fine-grained. Angular to subangular. 15-20% mafics. Micaceous.	
No recovery.	
Silty sandy GRAVEL. Matrix light-olive-brown. Sand very-fine- to medium-grained; angular to subangular; 15% mafics. Sandy calcareous rinds on gravel at 421 ft.	
SILT. Very-light-olive-gray to yellowish-gray.	II
Silty SAND to sandy SILT. Light-olive-gray. Very-fine-grained.	
CLAY. Pale-olive to yellowish-gray. Waxy luster in part. Angular fragments, some subrounded fragments at 439.3 ft.	
Silty CLAY. Yellowish-gray. Mica very-fine-sand size.	

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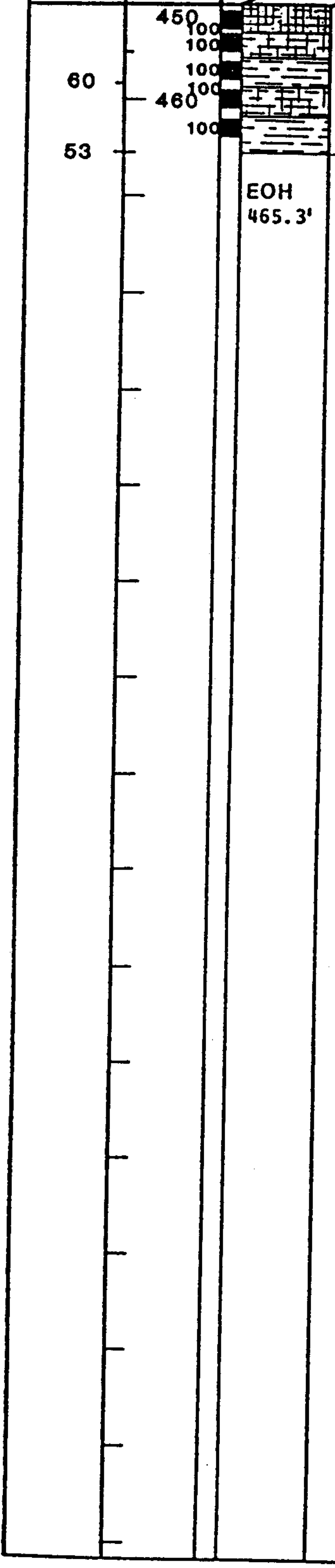
LOG OF DRILL HOLE E-1

FIGURE 2R-A-86

DRILL HOLE E-1

Page 4 **of** 4

Elevation (MSL)	Depth (ft.)	Sampled Interval	Graphic Log	Lithologic Description	Unit



Clayey SILT to silty CLAY, with floating sand grains. Yellowish-gray.
Silty CLAY. Yellowish-gray. Waxy luster in part.
CLAY. Yellowish-gray. Waxy luster. Nodular blocky fragments.
Silty CLAY. Yellowish-gray.
CLAY. Yellowish-gray. Waxy luster.

II

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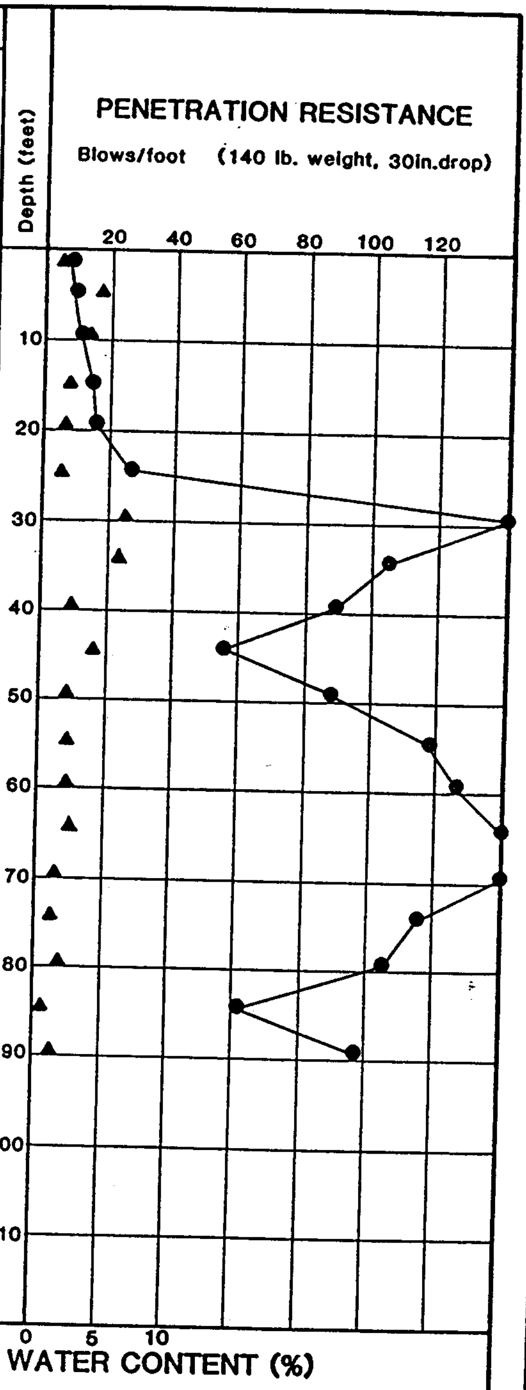
LOG OF DRILL HOLE E-1

FIGURE
2R-A-86

SOIL PROFILE

Elev	Depth	DESCRIPTION	SAMPLES Number	Type	Recovery
524.1	0	Loose dark yellowish brown silty fine SAND	1	I	15/18
			2	I	17/18
515.6	8.5	Medium dense varicolored to olive black slightly silty fine to coarse SAND with scattered gravel	3	I	10/18
			4	I	11/18
			5	I	9/18
			6	I	10/18
496.1	28	Very dense varicolored to olive black silty fine to medium SAND	7	I	13/18
			8	I	17/18
486.1	38	Very dense varicolored to olive black slightly silty fine to medium SAND with scattered gravel	9	I	18/18
			10	I	18/18
			11	I	16/18
			12	I	17/18
			13	I	18/18
			14	I	17/18
			15	I	17/18
		Very dense olive gray silty fine SAND	16	I	17/18
			17	I	18/18
441.1	83	Very dense varicolored to olive black slightly silty sandy fine to coarse GRAVEL	18	I	8/18
			19	I	11/18
434.1	90	End of Hole			



Boring Method: Hollow Stem Auger

Sample Type: I - 2" (O.D.) Drive Open
II - 4 1/2" (O.D.) Drive Open
III - 3" Thin Walled, Push Open

Drill Hole Coordinates N 422800 E 2269160

Standard Penetration Resistance ●
Water Content ▲
Pressuremeter Test →

NOTE: E-2 sampled to 20.1'. E-2A sampled from 23.8' to 40.1' E-2B sampled from 43.6' to 89.9'

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LOG OF DRILL HOLE E-2, E-2A, E-2B

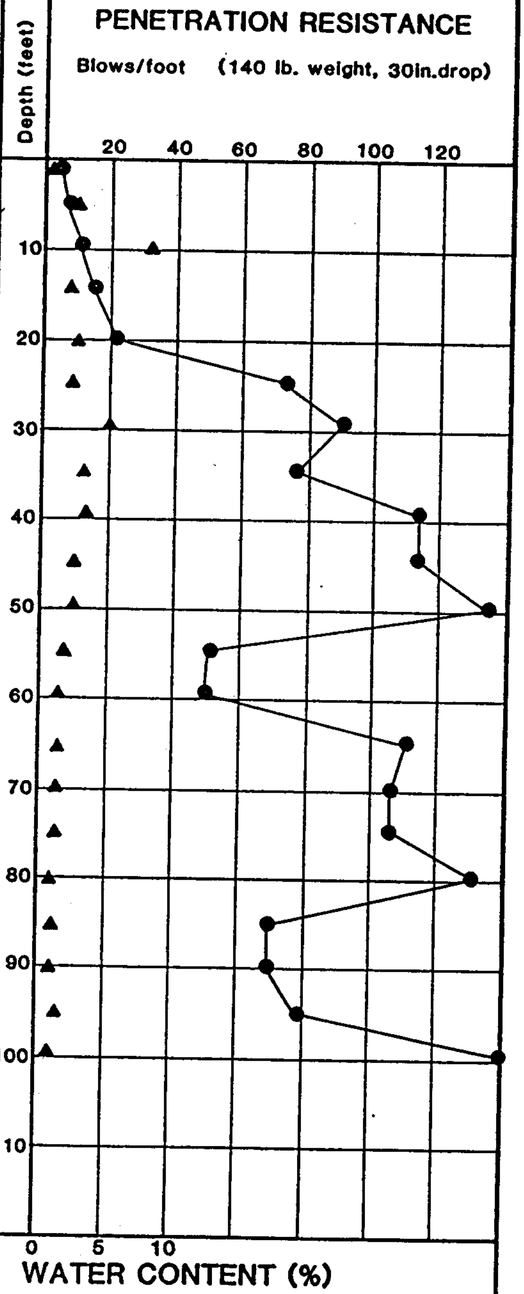
FIGURE 2Q A-21

SOIL PROFILE

Elev Depth	DESCRIPTION	Number	Type	Recovery
521.4 0	Very loose to loose dark yellowish brown slightly silty fine SAND	1	I	14/18
513.4		2	I	16/18
8	Medium dense varicolored to olive black slightly silty fine to coarse SAND with scattered gravel	3	I	15/18
		4	I	10/18
		5	I	12/18
492.4		6	I	11/18
29 487.4	Very dense dark yellowish brown to olive black silty fine to medium SAND	7	I	15/18
34	Very dense varicolored to olive black slightly silty fine to medium SAND with scattered gravel	8	I	18/18
		9	I	18/18
		10	I	16/18
		11	I	17/18
		12	I	14/18
		13	I	8/18
		14	I	16/18
	Very dense olive gray slightly silty fine SAND	15	I	18/18
442.4		16	I	15/18
79	Very dense varicolored to olive black slightly silty gravelly fine to coarse SAND	17	I	12/18
		18	I	13/18
		19	I	15/18
421.2		20	I	13/18
100.2	End of Hole	21	I	12/18

PENETRATION RESISTANCE

Blows/foot (140 lb. weight, 30in.drop)



Boring Method: Hollow Stem Auger

Sample Type: I - 2" (O.D.) Drive Open
II - 4 1/2" (O.D.) Drive Open
III - 3" Thin Walled, Push Open

Drill Hole Coordinates N 422870 E 2269400

Standard Penetration Resistance ●

Water Content ▲

Pressuremeter Test →

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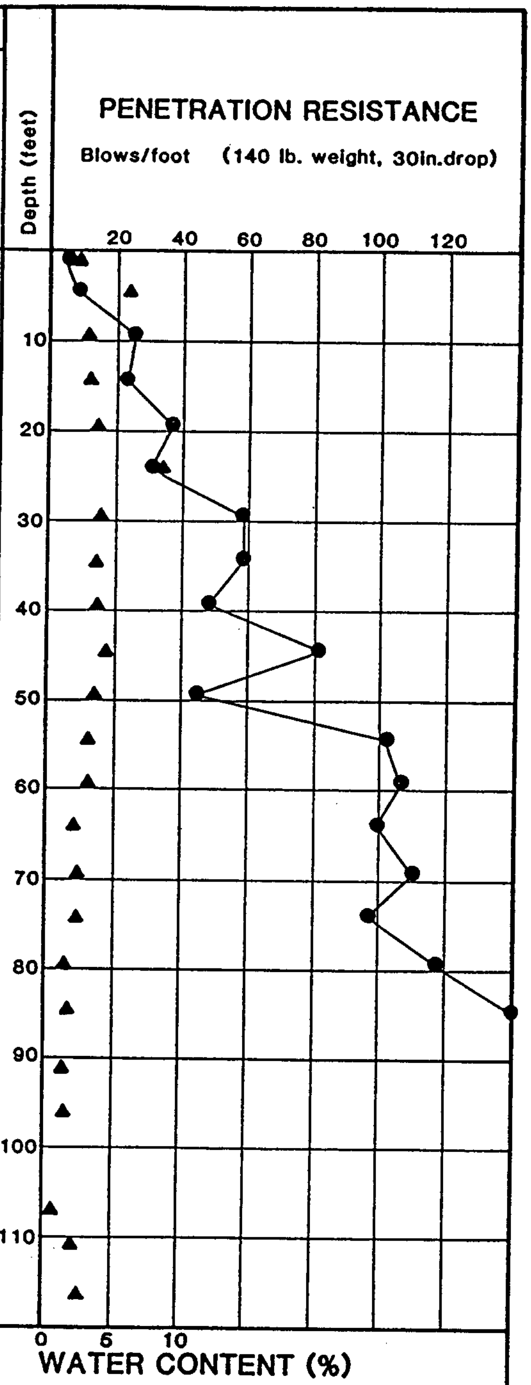
LOG OF DRILL HOLE E-3

FIGURE
2Q A-22

SOIL PROFILE

Elev Depth	DESCRIPTION	SAMPLES Number	Type	Recovery
516.9 0	Loose dark yellowish brown to olive gray slightly silty fine to medium SAND	1	I	14/18
		2	I	16/18
508.9 8	Medium dense to dense varicolored to olive black clean fine to medium SAND	3	I	16/18
		4	I	16/18
		5	I	18/18
		6	I	16/18
488.9 28	Very dense varicolored to olive black clean fine to medium SAND	7	I	17/18
		8	I	16/18
		9	I	18/18
		10	I	18/18
		11	I	18/18
		12	I	18/18
		13	I	18/18
		14	I	18/18
		15	I	17/18
		16	I	18/18
438.9 78	Very dense varicolored to olive black clean gravelly fine to coarse SAND	17	I	17/18
		18	I	17/18
426.9 90	Very dense varicolored to olive black clean sandy fine to coarse GRAVEL	19	II	18/18
		20	II	18/18
		21	II	14/14
		22	II	9/18
		23	II	12/18
		24	II	13/18



Boring Method: Hollow Stem Auger
Top Drive Rotary

Sample Type: I - 2" (O.D.) Drive Open
II - 4 1/2" (O.D.) Drive Open
III - 3" Thin Walled, Push Open

Standard Penetration Resistance ●
Water Content ▲
Pressuremeter Test →

Drill Hole Coordinates N 422680 E 2269680

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LOG OF DRILL HOLE E-4

FIGURE 2Q A-23

SOIL PROFILE			SAMPLES			
Elev Depth	DESCRIPTION	Stratigraphic Plot	Number	Type	Recovery	Depth (feet)
396.9 120	Very dense varicolored to olive black clean sandy fine to coarse GRAVEL	▨	25	II	14/18	120
		▨	26	II	14/18	
390.4 126.5	End of Hole					
						130

PENETRATION RESISTANCE

Blows/foot (140 lb. weight, 30in.drop)

20 40 60 80 100 120

0 5 10

WATER CONTENT (%)

Boring Method: Hollow Stem Auger
Top Drive Rotary

Sample Type: I - 2" (O.D.) Drive Open
II - 4 1/2" (O.D.) Drive Open
III - 3" Thin Walled, Push Open

Drill Hole Coordinates N 422680 E 2269680

Standard Penetration Resistance ●
Water Content ▲
Pressuremeter Test →

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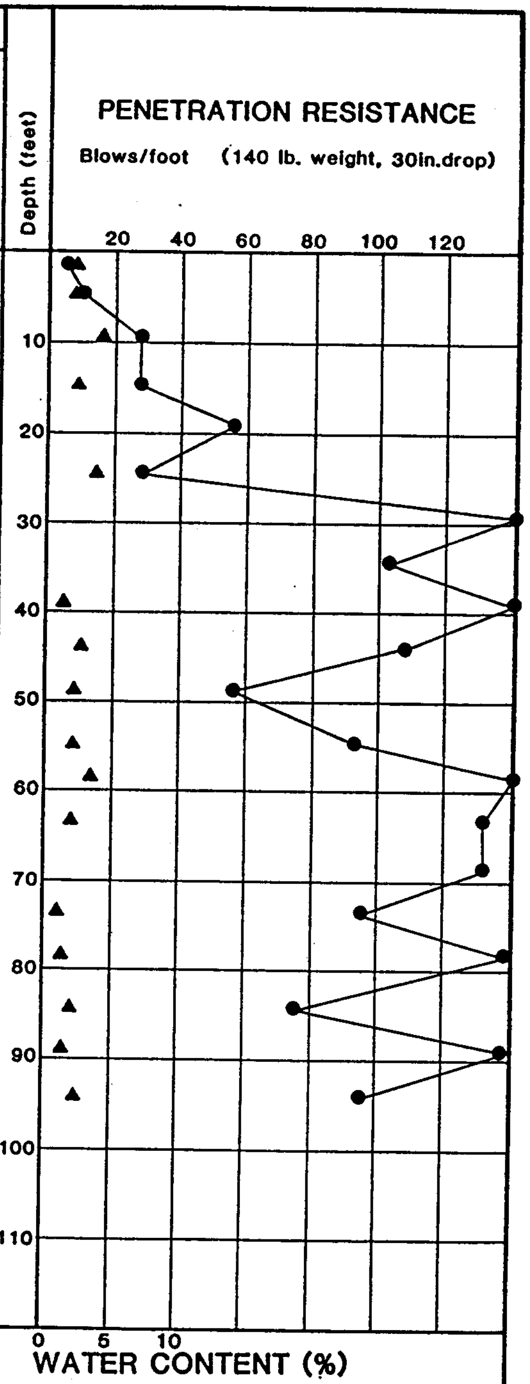
LOG OF DRILL HOLE E-4

FIGURE 2Q A-23

SOIL PROFILE

Elev Depth 520.1	DESCRIPTION	Number	Type	Recovery
0	Loose dark yellowish brown to olive gray slightly silty fine to medium SAND	1	I	13/18
513.1		2	I	13/18
7	Medium dense varicolored to olive black slightly silty fine to medium SAND and olive gray silty fine SAND	3	I	14/18
		4	I	8/18
		5	I	14/18
492.1		6	I	14/18
28	Very dense varicolored to olive gray silty fine SAND	7	I	18/18
480.1		8	I	18/18
40	Very dense varicolored to olive black slightly silty fine to medium SAND	9	I	18/18
		10	I	14/18
		11	I	14/18
	Very dense varicolored to olive black clean gravelly fine to coarse SAND	12	I	9/18
		13	I	17/18
		14	I	15/18
	Very dense varicolored to olive gray slightly silty fine SAND	15	I	18/18
445.1		16	I	18/18
75	Very dense varicolored to olive black clean gravelly fine to coarse SAND	17	I	10/18
		18	I	12/18
		19	I	14/18
425.4		20	I	12/18
94.7	End of Hole			



Boring Method: Hollow Stem Auger

Sample Type: I- 2" (O.D.) Drive Open
II- 4 1/2" (O.D.) Drive Open
III- 3" Thin Walled, Push Open

Drill Hole Coordinates N 422300 E 2269120

Standard Penetration Resistance ●
Water Content ▲
Pressuremeter Test →

NOTE: E-5 sampled to 40.0'.
E-5A sampled from 40.0' to 94.7'

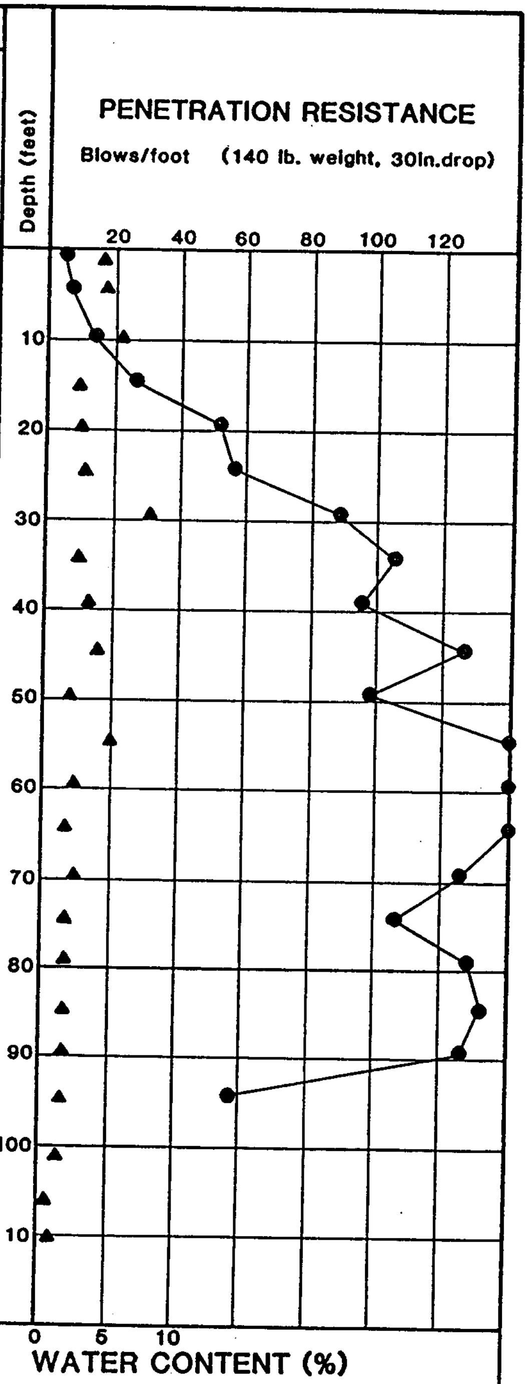
PUGET SOUND POWER & LIGHT COMPANY
SKAGIT / HANFORD NUCLEAR PROJECT

LOG OF DRILL HOLE E-5

FIGURE 2Q A-24

SOIL PROFILE

Elev Depth	DESCRIPTION	Stratigraphic Plot	SAMPLES Number	Type	Recovery
519.1 0	Loose dark yellowish brown slightly silty fine SAND		1	I	16/18
511.1			2	I	18/18
8 506.1	Medium dense varicolored to olive gray silty fine to medium SAND		3	I	12/18
13	Medium dense to very dense varicolored to olive black clean fine to coarse SAND with scattered gravel		4	I	8/18
			5	I	16/18
491.1			6	I	15/18
28	Very dense varicolored to olive black slightly silty fine to medium SAND		7	I	18/18
			8	I	18/18
			9	I	18/18
			10	I	18/18
	Very dense varicolored to olive black clean fine to medium SAND with scattered gravel		11	I	18/18
			12	I	16/16
			13	I	18/18
			14	I	18/18
446.1			15	I	18/18
73	Very dense varicolored to olive black clean gravelly fine to coarse SAND		16	I	16/18
			17	I	17/18
			18	I	19/18
426.1			19	I	14/18
93	Very dense varicolored to olive black clean sandy fine to coarse GRAVEL		20	I	11/18
			21	II	16/18
			22	II	12/18
			23	II	8/9
			24	II	0/3



Boring Method: Hollow Stem Auger
Top Drive Rotary

Sample Type: I - 2" (O.D.) Drive Open
II - 4 1/2" (O.D.) Drive Open
III - 3" Thin Walled, Push Open

Drill Hole Coordinates N 422340 E 2269560

Standard Penetration Resistance	●
Water Content	▲
Pressuremeter Test	→

PUGET SOUND POWER & LIGHT COMPANY
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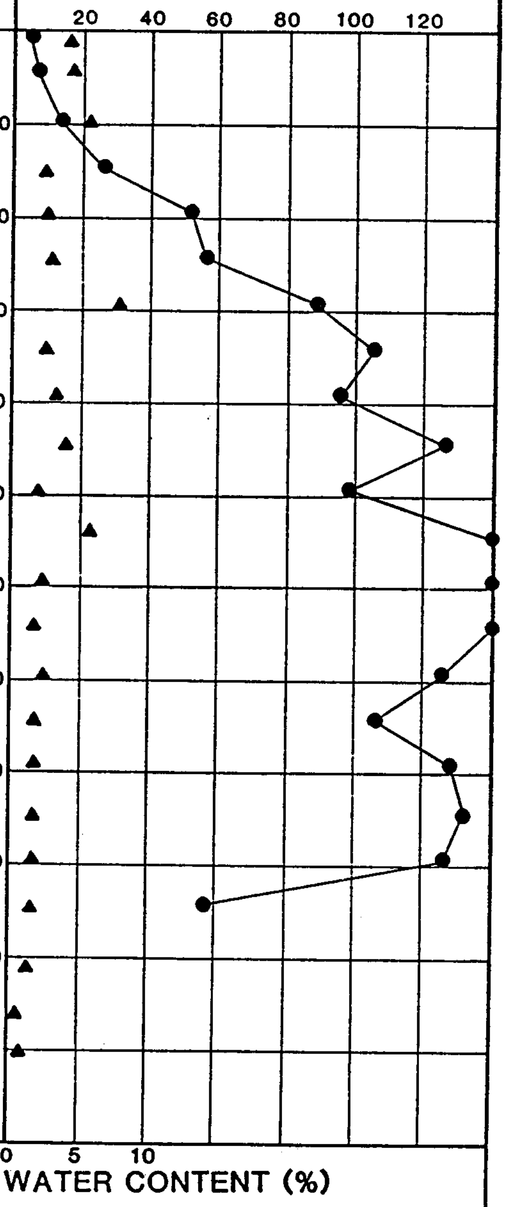
LOG OF DRILL HOLE E-6

FIGURE
2Q A-25

Elev Depth 519.1	SOIL PROFILE DESCRIPTION	Stratigraphic Plot	SAMPLES Number	Type	Recovery	Depth (feet)
0	Loose dark yellowish brown slightly silty fine SAND		1	I	16/18	
511.1			2	I	18/18	
8 506.1	Medium dense varicolored to olive gray silty fine to medium SAND		3	I	12/18	10
13	Medium dense to very dense varicolored to olive black clean fine to coarse SAND with scattered gravel		4	I	8/18	
			5	I	16/18	20
491.1			6	I	15/18	
28	Very dense varicolored to olive black slightly silty fine to medium SAND		7	I	18/18	30
			8	I	18/18	
			9	I	18/18	40
			10	I	18/18	
			11	I	18/18	50
	Very dense varicolored to olive black clean fine to medium SAND with scattered gravel		12	I	16/16	
			13	I	18/18	60
			14	I	18/18	
446.1			15	I	18/18	70
73	Very dense varicolored to olive black clean gravelly fine to coarse SAND		16	I	16/18	
			17	I	17/18	80
			18	I	19/18	
426.1			19	I	14/18	90
93	Very dense varicolored to olive black clean sandy fine to coarse GRAVEL		20	I	11/18	
			21	II	16/18	100
			22	II	12/18	
			23	II	8/9	110
			24	II	0/3	

PENETRATION RESISTANCE

Blows/foot (140 lb. weight, 30in.drop)



Boring Method: Hollow Stem Auger
Top Drive Rotary

Sample Type: I - 2" (O.D.) Drive Open
II - 4 1/2" (O.D.) Drive Open
III - 3" Thin Walled, Push Open

Standard Penetration Resistance ●
Water Content ▲
Pressuremeter Test →

Drill Hole Coordinates N 422340 E 2269560

PUGET SOUND POWER & LIGHT COMPANY
SKAGIT / HANFORD NUCLEAR PROJECT

LOG OF DRILL HOLE E-6

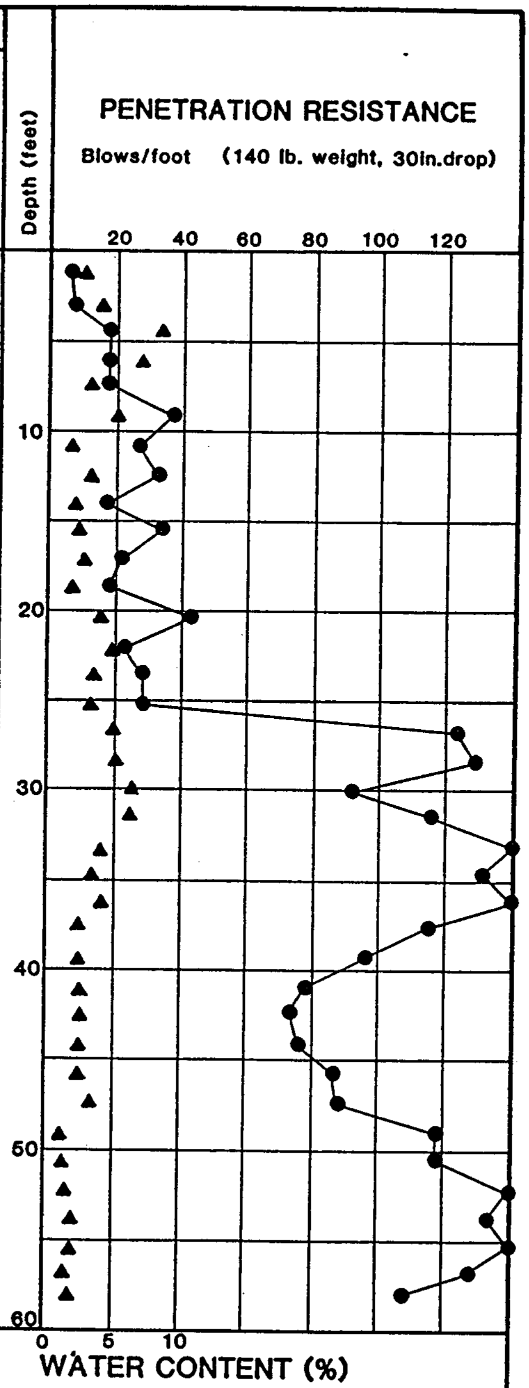
FIGURE 2Q A-25

SOIL PROFILE

Elev Depth 518.1	DESCRIPTION
0 514.9	Loose dark yellowish brown to olive gray silty fine SAND
3.2 505.6	Medium dense varicolored to olive black slightly silty fine to coarse SAND and varicolored to olive gray silty fine to medium SAND with scattered gravel
12.5 492.6	Medium dense to dense varicolored to olive black slightly silty fine to coarse SAND with scattered gravel and silty layers
25.5 481.6	Very dense to olive black silty fine to medium SAND
36.5	Very dense varicolored to olive black slightly silty fine to medium SAND — — — Very dense varicolored to olive black slightly silty fine to coarse SAND with scattered gravel

SAMPLES

Number	Type	Recovery
1	I	15/18
2	I	13/18
3	I	11/18
4	I	10/18
5	I	3/18
6	I	8/18
7	I	8/18
8	I	13/18
9	I	9/18
10	I	14/18
11	I	6/18
12	I	13/18
13	I →	17/18
14	I	18/18
15	I	16/18
16	I	14/18
17	I	18/18
18	I	18/18
19	I	18/18
20	I →	18/18
21	I	18/18
22	I	18/18
23	I	18/18
24	I	18/18
25	I	17/18
26	I →	16/18
27	I	16/18
28	I	17/18
29	I	18/18
30	I	18/18
31	I	15/18
32	I →	17/18
33	I	16/18
34	I	18/18
35	I	18/18
36	I	15/18
37	I	18/18



Boring Method: Hollow Stem Auger
Mud Rotary for Pressuremeter Testing E-7

Sample Type: I - 2" (O.D.) Drive Open
II - 4 1/2" (O.D.) Drive Open
III - 3" Thin Walled, Push Open

Standard Penetration Resistance ●
Water Content ▲
Pressuremeter Test →

Drill Hole Coordinates N 422700 E 2269160

NOTE: Pressuremeter tests performed in E-7. Standard penetration testing performed in E-7A

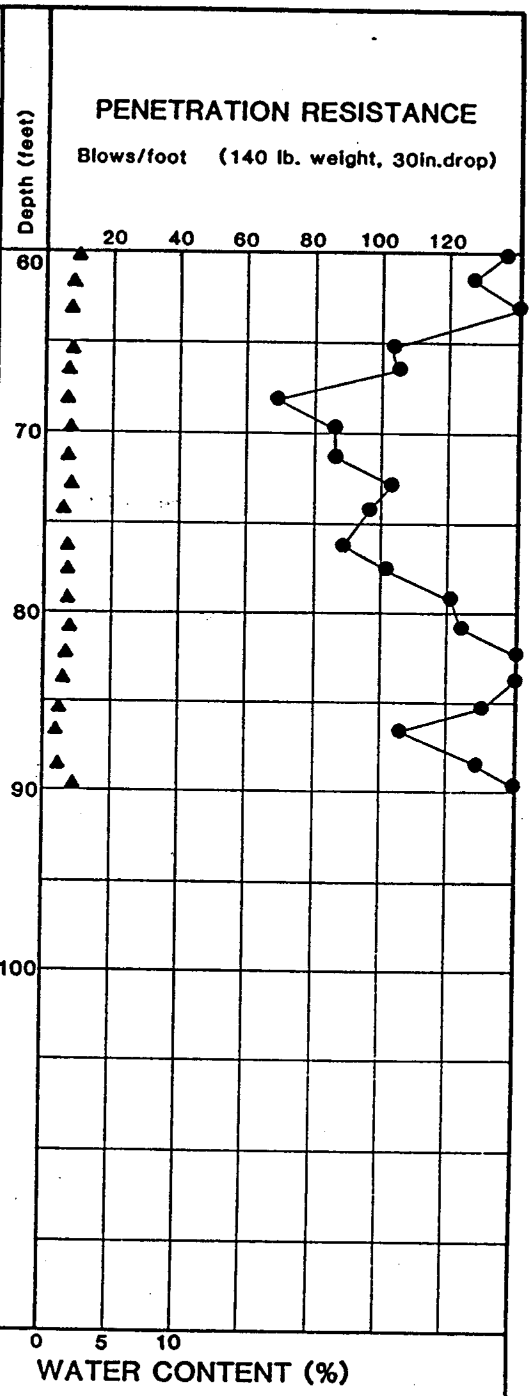
PUGET SOUND POWER & LIGHT COMPANY
SKAGIT / HANFORD NUCLEAR PROJECT

LOG OF DRILL HOLE E-7

FIGURE 2Q A-26

SOIL PROFILE

Elev Depth	DESCRIPTION	Number	Type	Recovery
458.1		38	I	15/18
60	Very dense varicolored to olive black slightly silty fine to coarse SAND with scattered gravel	39	I	18/18
		40	I	18/18
		41	I	18/18
		42	I →	18/18
		43	I	18/18
	Very dense varicolored to olive gray slightly silty fine SAND	44	I	18/18
		45	I	18/18
		46	I	18/18
		47	I	18/18
441.6		48	I →	18/18
76.5	Very dense varicolored to olive black slightly silty gravelly fine to coarse SAND	49	I	14/18
		50	I	13/18
		51	I	15/18
		52	I	14/18
		53	I	15/18
		54	I	13/18
		55	I	9/18
428.1		56	I	12/18
		57	I	9/16
90	End of Hole			



Boring Method: Hollow Stem Auger

Sample Type: I - 2" (O.D.) Drive Open
II - 4 1/2" (O.D.) Drive Open
III - 3" Thin Walled, Push Open

Drill Hole Coordinates N 422700 E 2269160

Standard Penetration Resistance ●
Water Content ▲
Pressuremeter Test →

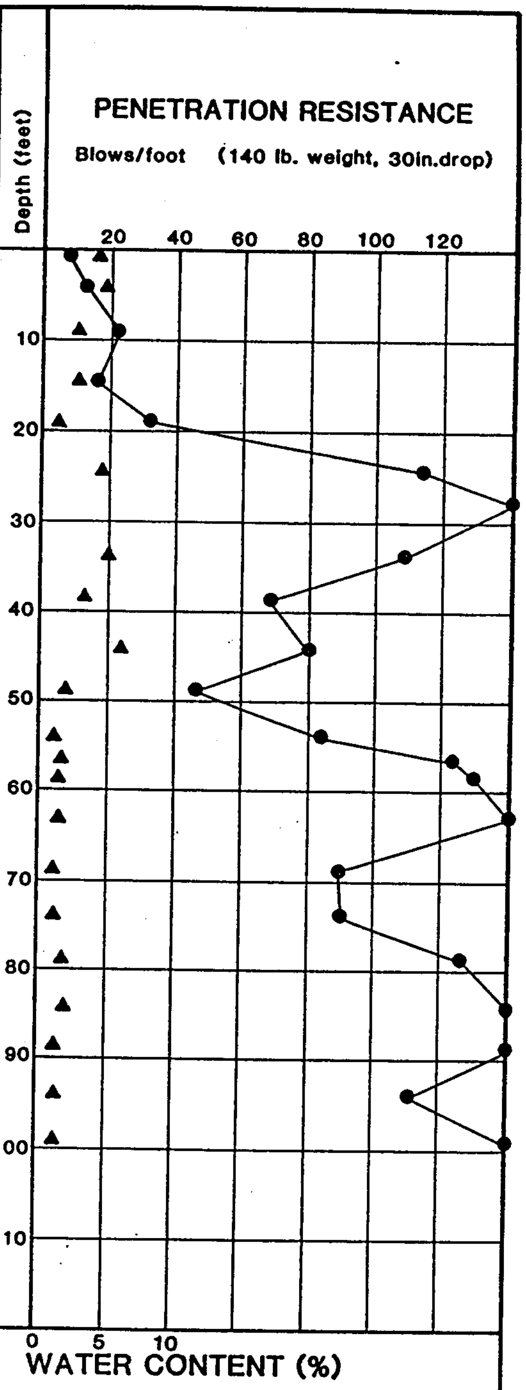
PUGET SOUND POWER & LIGHT COMPANY
SKAGIT / HANFORD NUCLEAR PROJECT

LOG OF DRILL HOLE E-7

FIGURE
2Q A-26

SOIL PROFILE / SAMPLES

Elev	Depth	DESCRIPTION	Number	Type	Recovery
521.5	0	Loose to medium dense dark yellowish brown slightly silty fine SAND	1	I	14/18
			2	I	18/18
513.5	8	Medium dense varicolored to olive black medium to coarse SAND with scattered silty layers and gravel	3	I	14/18
			4	I	9/18
			5	I	18/18
497.5	24	Very dense varicolored to olive gray silty fine to medium SAND	6	I	12/18
			7	I	0/4
			8	I	18/18
483.5	38	Very dense varicolored to olive black clean fine to medium SAND with scattered silty layers	9	I	16/18
			9A	III	10/10
			10	I	10/10
			11	I	13/18
			12	I	15/18
			13	I	0/18
			14	I	15/18
			15	I	17/18
		Very dense varicolored to olive gray slightly silty fine to medium SAND	16	I	9/10
			16A	III	6/6
			17	I	18/18
			18	I	6/6
438.5	83	Very dense varicolored to olive black fine to coarse GRAVEL and gravelly fine to coarse SAND	19	I	7/18
			20	I	18/18
			21	I	12/18
423.5	98	Very dense varicolored to olive black clean sandy fine to coarse GRAVEL	22	I	13/18
421.4	100.1	End of Hole			



Boring Method: Hollow Stem Auger

Sample Type: I - 2" (O.D.) Drive Open
II - 4 1/2" (O.D.) Drive Open
III - 3" Thin Walled, Push Open

Drill Hole Coordinates N 422900 E 2269240

Standard Penetration Resistance ●
Water Content ▲
Pressuremeter Test →

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LOG OF DRILL HOLE E-8

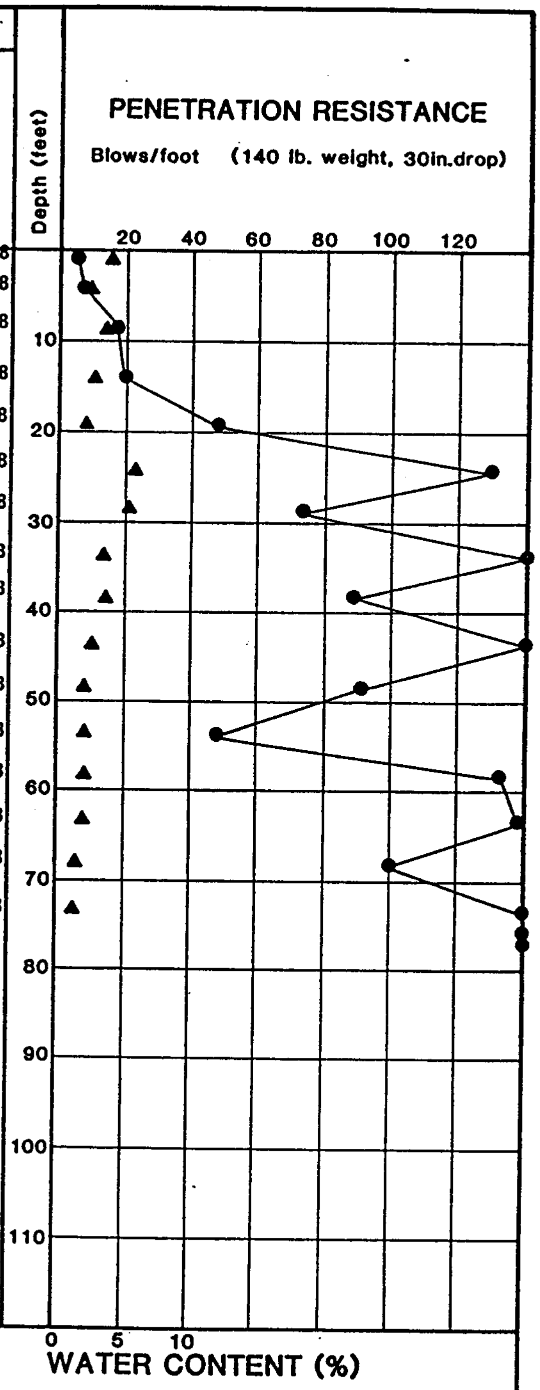
FIGURE 2Q A-27

SOIL PROFILE

Elev Depth	DESCRIPTION
520.6 0	Loose dark yellowish brown silty fine SAND
512.6 8	Medium dense varicolored to olive black fine to coarse SAND with scattered silty layers
497.6 23	Very dense varicolored to olive black silty fine to medium SAND with scattered gravel
482.6 38	Very dense varicolored to olive black clean fine to medium SAND
448.6 72	Very dense varicolored to olive gray slightly silty gravelly fine to medium SAND
442.6 78	End of Hole

SAMPLES

Number	Type	Recovery
1	I	13/18
2	I	14/18
3	I	10/18
4	I	13/18
5	I	10/18
6	I	10/18
7	I	18/18
8	I	18/18
9	I	17/18
10	I	18/18
11	I	13/18
12	I	13/18
13	I	18/18
14	I	18/18
15	I	17/18
16	I	15/18
17	I	0/2
18	I	0/2



Boring Method: Hollow Stem Auger
Mud Rotary for Pressuremeter Testing E-9A

Sample Type: I - 2" (O.D.) Drive Open
II - 4 1/2" (O.D.) Drive Open
III - 3" Thin Walled, Push Open

Drill Hole Coordinates N 422800 E 2269300

Standard Penetration Resistance ●
Water Content ▲
Pressuremeter Test →

NOTE: Pressuremeter test performed in E-9A at 25.9'. Pressuremeter tests performed in E-9B at 36.1, 55.7 and 65.6'.

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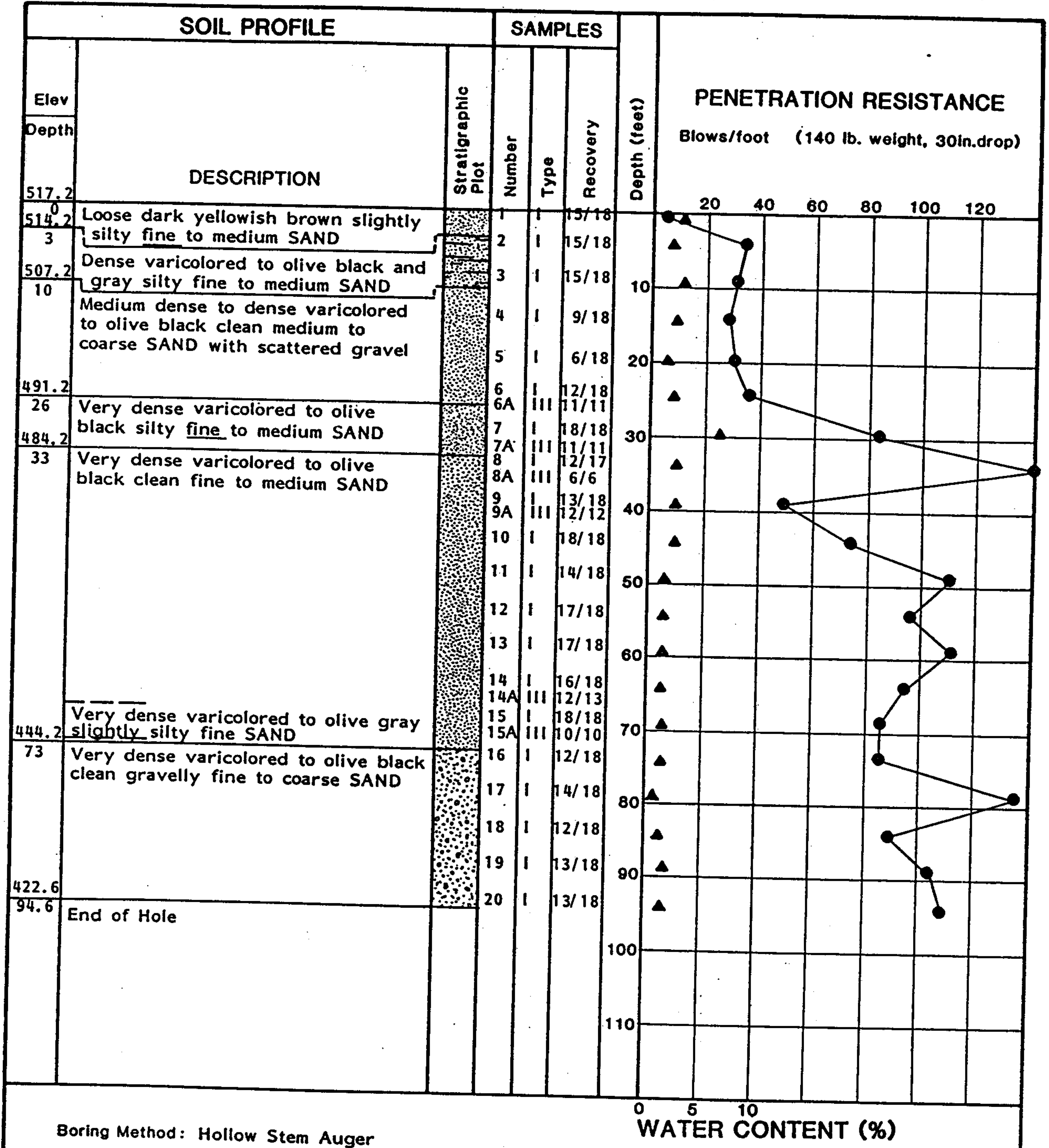
LOG OF DRILL HOLE E-9, E-9A, E-9B

FIGURE 2Q A-28



SOIL PROFILE

Elev	Depth	DESCRIPTION
517.2	0	Loose dark yellowish brown slightly silty fine to medium SAND
514.2	3	Dense varicolored to olive black and gray silty fine to medium SAND
507.2	10	Medium dense to dense varicolored to olive black clean medium to coarse SAND with scattered gravel
491.2	26	Very dense varicolored to olive black silty fine to medium SAND
484.2	33	Very dense varicolored to olive black clean fine to medium SAND Very dense varicolored to olive gray slightly silty fine SAND
444.2	73	Very dense varicolored to olive black clean gravelly fine to coarse SAND
422.6	94.6	End of Hole

SAMPLES

Number	Type	Recovery
1	I	15/18
2	I	15/18
3	I	15/18
4	I	9/18
5	I	6/18
6	I	12/18
6A	III	11/11
7	I	18/18
7A	III	11/11
8	I	12/17
8A	III	6/6
9	I	13/18
9A	III	12/12
10	I	18/18
11	I	14/18
12	I	17/18
13	I	17/18
14	I	16/18
14A	III	12/13
15	I	18/18
15A	III	10/10
16	I	12/18
17	I	14/18
18	I	12/18
19	I	13/18
20	I	13/18

Boring Method: Hollow Stem Auger

Sample Type: I - 2" (O.D.) Drive Open
II - 4 1/2" (O.D.) Drive Open
III - 3" Thin Walled, Push Open

Drill Hole Coordinates N 422620 E 2269300

Standard Penetration Resistance ●
Water Content ▲
Pressuremeter Test →

PUGET SOUND POWER & LIGHT COMPANY
SKAGIT / HANFORD NUCLEAR PROJECT

LOG OF DRILL HOLE E-10

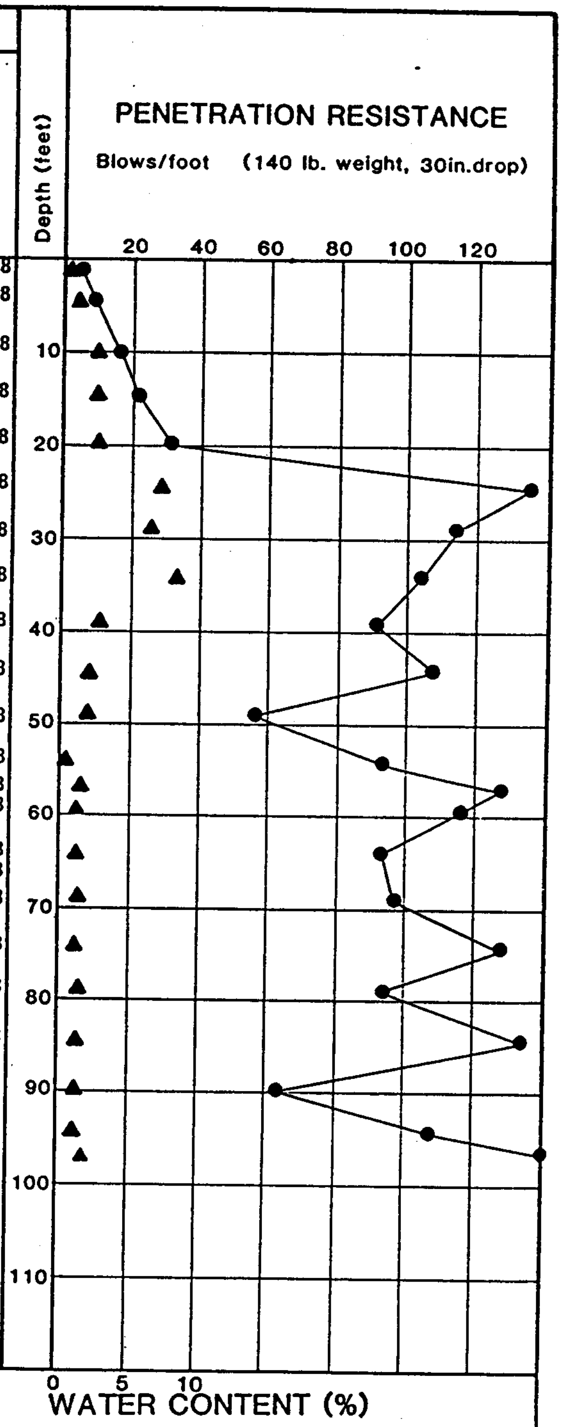
FIGURE 2Q A-29

SOIL PROFILE

Elev Depth	DESCRIPTION
518.4 0	Loose dark yellowish brown and olive gray silty fine SAND
510.4 8	Medium dense to dense clean medium to coarse SAND with scattered gravel
495.4 23	Very dense varicolored to olive black silty fine to medium SAND
480.4 38	Very dense varicolored to olive black clean fine to medium SAND Very dense varicolored to olive gray slightly silty fine to medium SAND
446.4 72	Very dense varicolored to olive black clean gravelly fine to coarse SAND
421.3 97.1	End of Hole

SAMPLES

Number	Type	Recovery
1	I	9/18
2	I	16/18
3	I	12/18
4	I	12/18
5	I	8/18
6	I	18/18
7	I	18/18
8	I	17/18
9	I	16/18
10	I	18/18
11	I	15/18
12	I	0/18
13	I	13/18
14	I	15/18
14A	III	7/7
15	I	12/18
15A	III	13/13
16	I	17/18
17	I	13/18
18	I	13/18
19	I	15/18
20	I	13/18
21	I	14/18
22	I	4/4



Boring Method: Hollow Stem Auger

Sample Type: I - 2" (O.D.) Drive Open

II - 4 1/2" (O.D.) Drive Open

III - 3" Thin Walled, Push Open

Drill Hole Coordinates N 422740 E 2269400

Standard Penetration Resistance	●
Water Content	▲
Pressuremeter Test	→

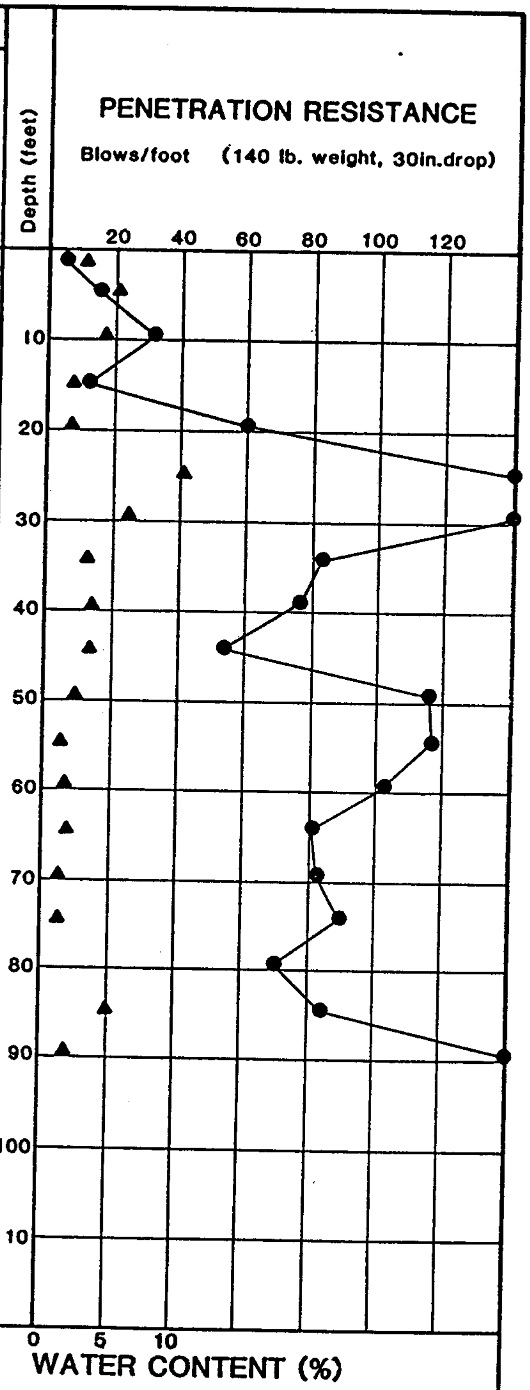
PUGET SOUND POWER & LIGHT COMPANY
SKAGIT / HANFORD NUCLEAR PROJECT

LOG OF DRILL HOLE E-11

FIGURE 2Q A-30

SOIL PROFILE

Elev Depth	DESCRIPTION	Number	Type	Recovery
516.6 0 513.1	Loose dark yellowish brown silty fine to medium SAND	1	I	13/18
3.5 505.6	Medium dense varicolored to olive gray silty fine to medium SAND and clean fine to coarse SAND	2	I	14/18
		3	I	16/18
11 493.6	Medium dense to very dense varicolored to olive black clean fine to coarse SAND with scattered gravel	4	I	12/18
		5	I	12/18
23 483.6	Very dense varicolored to olive gray silty fine to medium SAND	6	I	18/18
		7	I	18/18
33	Very dense varicolored to olive black clean fine to medium SAND	8	I	18/18
		9	I	18/18
		10	I	18/18
		11	I	17/18
		12	I	12/18
		13	I	6/18
	Very dense varicolored to olive gray slightly silty fine to medium SAND	14	I	16/18
443.6		15	I	18/18
73 426.6	Very dense varicolored to olive black clean gravelly fine to coarse SAND and sandy fine to coarse GRAVEL	16	I	15/18
		17	I	13/18
		18	I	15/18
		19	I	14/18
90	End of Hole			



Boring Method: Hollow Stem Auger E-12B
Mud Rotary for Pressuremeter Testing E-12
E-12A

Sample Type: I - 2" (O.D.) Drive Open
II - 4 1/2" (O.D.) Drive Open
III - 3" Thin Walled, Push Open

Standard Penetration Resistance ●
Water Content ▲
Pressuremeter Test →

Drill Hole Coordinates N 422620 E 2269400

NOTE: Pressuremeter Tests at 26.8', 36.5', 46.7' and 56.3' performed in E-12. Pressuremeter Test at 66.7' performed in E-12A. Standard penetration testing performed in E-12B.

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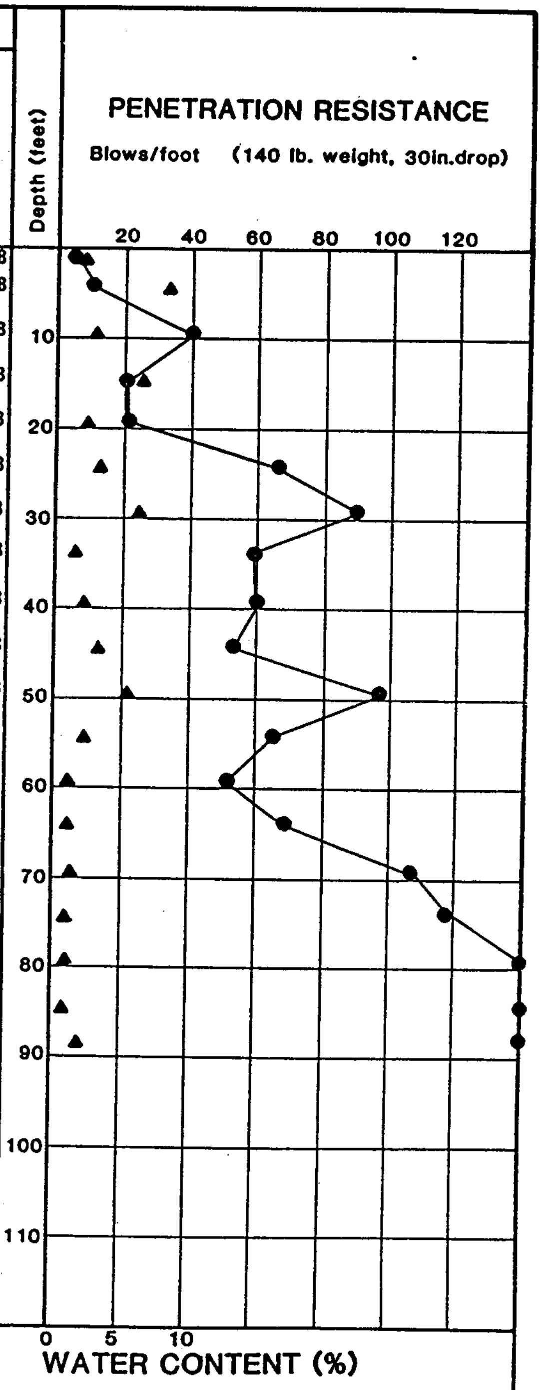
LOG OF DRILL HOLE E-12

FIGURE 2Q A-31

SOIL PROFILE			SAMPLES		
Elev Depth	DESCRIPTION	Stratigraphic Plot	Number	Type	Recovery
517.3 0 513.8	Loose dark yellowish brown slightly silty fine SAND		1	I	15/18
3.5 503.3	Medium dense to dense varicolored to olive gray silty fine to medium SAND and clean fine to coarse SAND		2	I	18/18
			3	I	18/18
			4	I	15/18
14 493.3	Medium dense varicolored to olive black slightly silty fine to medium SAND		5	I	12/18
24 484.3	Very dense varicolored to olive black slightly silty fine to medium SAND		6	I	18/18
			7	:	18/18
33 444.3	Very dense varicolored to olive black clean fine to medium SAND with scattered gravel		8	I	16/18
			9	I	18/18
			10	I	17/18
			11	I	18/18
			12	I	17/18
			13	I	12/18
			14	I	12/18
			15	I	17/18
73 434.3	Very dense varicolored to olive black clean gravelly fine to medium SAND		16	I	15/18
			17	I	15/18
83 428.3	Very dense varicolored to olive black clean sandy fine to coarse GRAVEL		18	I	14/18
			19	I	4/4
89	End of Hole				



Boring Method: Hollow Stem Auger

Sample Type: I - 2" (O.D.) Drive Open
II - 4 1/2" (O.D.) Drive Open
III - 3" Thin Walled, Push Open

Drill Hole Coordinates N 422780 E 2269510

Standard Penetration Resistance ●
Water Content ▲
Pressuremeter Test ⟶

PUGET SOUND POWER & LIGHT COMPANY
SKAGIT / HANFORD NUCLEAR PROJECT

LOG OF DRILL HOLE E-13

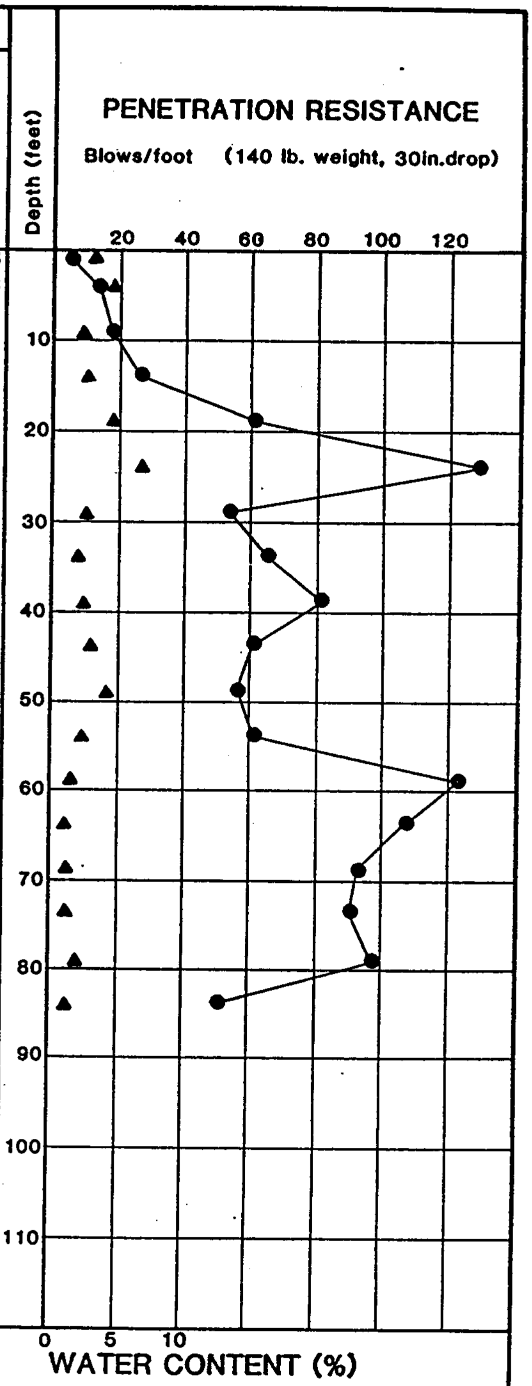
FIGURE 2Q A-32

SOIL PROFILE

Elev Depth	DESCRIPTION
516.4 0	Loose dark yellowish brown silty fine to medium SAND
512.9 3.5	Medium dense to very dense varicolored to olive black clean fine to medium SAND
493.4 23	Very dense varicolored to olive gray silty fine SAND
488.4 28	Very dense varicolored to olive black clean fine to medium SAND
	Very dense varicolored to olive gray slighty silty fine to medium SAND
448.4 68	Very dense varicolored to olive gray clean gravelly fine to medium SAND
433.4 83	Very dense varicolored to olive black clean sandy fine to coarse GRAVEL
431.4 85	End of Hole

SAMPLES

Number	Type	Recovery
1	I	12/18
2	I	12/18
3	I	12/18
4	I	15/18
5	I	18/18
5A	III	10/10
6	I	18/18
7	I	13/18
8	I	18/18
8A	III	9/9
9	I	18/18
10	I	18/18
10A	III	9/9
11	I	18/18
11A	III	18/18
12	I	18/18
12A	III	12/12
13	I	18/18
14	I	16/18
14A	III	6/6
15	I	14/18
16	I	15/18
17	I	15/18
18	I	10/18



Boring Method: Hollow Stem Auger

Sample Type: I - 2" (O.D.) Drive Open
II - 4 1/2" (O.D.) Drive Open
III - 3" Thin Walled, Push Open

Standard Penetration Resistance ●
Water Content ▲
Pressuremeter Test →

Drill Hole Coordinates N 422680 E 2269510

NOTE: E-14 sampled to 25.0'
E-14A sampled from 28.0 - 85.0'

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LOG OF DRILL HOLE E-14

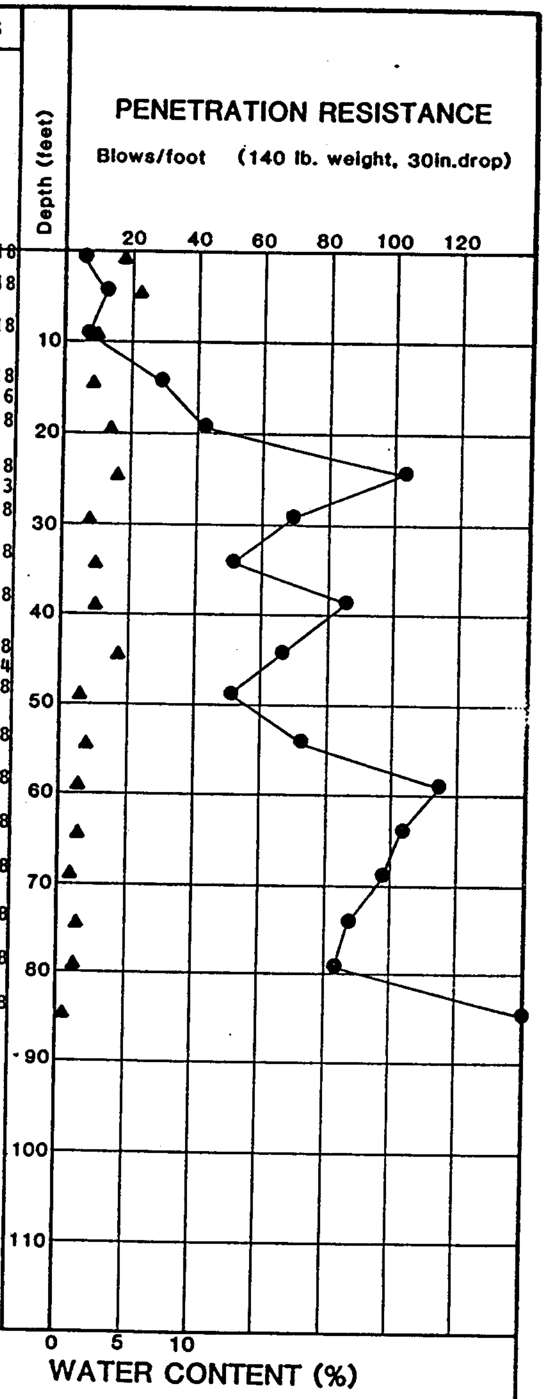
FIGURE 2Q A-33

SOIL PROFILE

Elev Depth	DESCRIPTION
517.5 0	Loose to medium dense dark yellowish brown silty fine to medium SAND
509.5 8	Loose to dense varicolored to olive black clean fine to coarse SAND
494.5 23	Very dense varicolored to olive gray silty fine to medium SAND
489.5 28	Very dense varicolored to olive black and gray clean fine to medium SAND
439.5 78	Very dense varicolored to olive gray clean gravelly fine to medium SAND
434.5 83	
430.5 87	Very dense varicolored to olive black clean sandy fine to coarse GRAVEL
	End of Hole

SAMPLES

Number	Type	Recovery
1	I	12/18
2	I	12/18
3	I	8/18
4	I	9/18
4A	III	16/16
5	I	15/18
6	I	17/18
6A	III	13/13
7	I	14/18
8	I	16/18
9	I	16/18
10	I	16/18
10A	III	14/14
11	I	15/18
12	I	15/18
13	I	14/18
14	I	14/18
15	I	6/18
16	I	14/18
17	I	15/18
18	I	14/18



Boring Method: Hollow Stem Auger

Sample Type: I – 2" (O.D.) Drive Open
II – 4 1/2" (O.D.) Drive Open
III – 3" Thin Walled, Push Open

Standard Penetration Resistance ●
Water Content ▲
Pressuremeter Test →

Drill Hole Coordinates N 422780 E 2269680

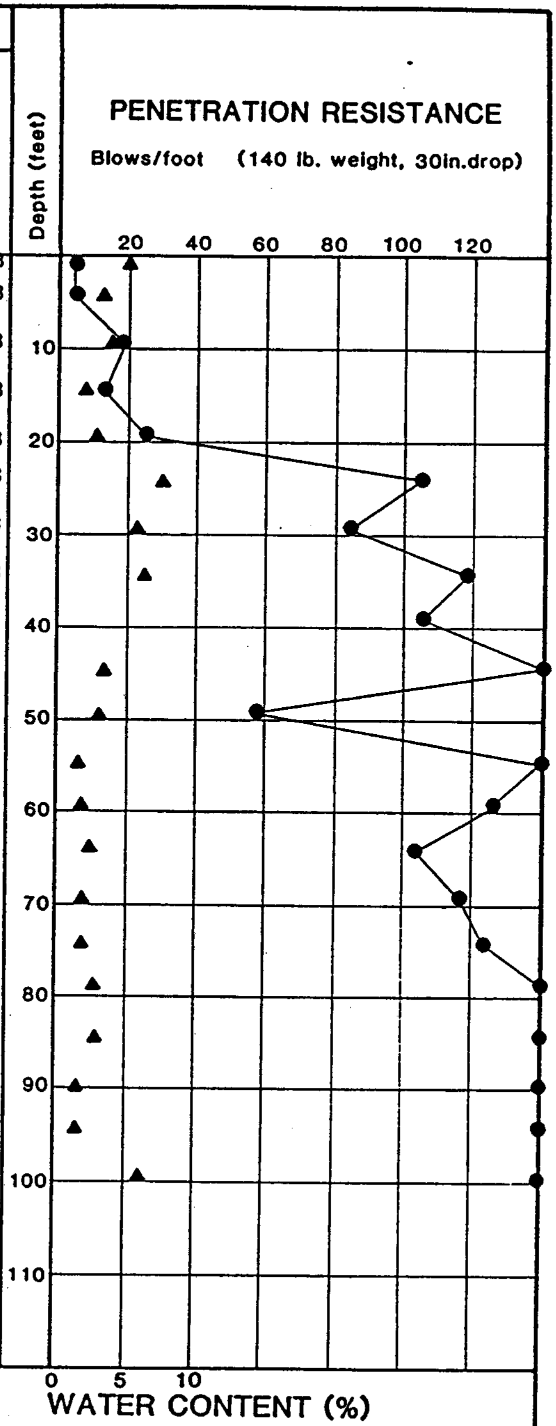
PUGET SOUND POWER & LIGHT COMPANY
SKAGIT / HANFORD NUCLEAR PROJECT

LOG OF DRILL HOLE E-15

FIGURE 2Q A-34

SOIL PROFILE

Elev Depth	DESCRIPTION	Stratigraphic Plot	SAMPLES Number	Type	Recovery
519.8 0	Loose dark yellowish brown clean fine SAND		1	I	14/18
			2	I	14/18
510.8 9	Medium dense varicolored to olive black clean fine to coarse SAND		3	I	16/18
			4	I	5/18
			5	I	13/18
495.8 24	Very dense varicolored to olive gray silty fine to medium SAND		6	I	15/18
			7	I	18/18
			8	I	17/18
			9	I	1/18
479.8 40	Very dense varicolored to olive black clean fine to medium SAND		10	I	16/18
			11	I	16/18
	Very dense varicolored to olive black clean gravelly fine to coarse SAND		12	I	18/18
			13	I	16/18
			14	I	6/18
	Very dense varicolored to olive gray slightly silty fine SAND		15	I	18/18
			16	I	18/18
443.8 76	Very dense varicolored to olive black clean gravelly fine to coarse SAND with silty layers		17	I	8/8
			18	I	15/18
			19	I	15/18
			20	I	14/18
			21	I	13/18
419.6 100.2	End of Hole				



Boring Method: Hollow Stem Auger

Sample Type: I - 2" (O.D.) Drive Open
II - 4 1/2" (O.D.) Drive Open
III - 3" Thin Walled, Push Open

Drill Hole Coordinates N 422440 E 2269120

Standard Penetration Resistance ●
Water Content ▲
Pressuremeter Test →

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LOG OF DRILL HOLE E-16

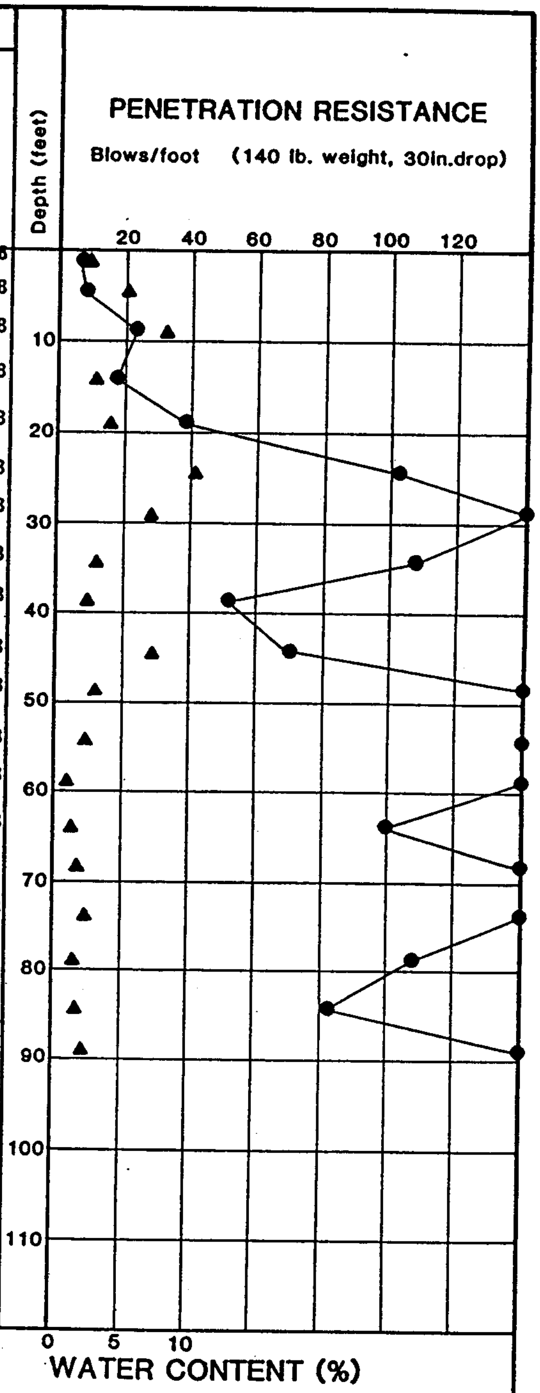
FIGURE 2Q A-35

SOIL PROFILE

Elev Depth	DESCRIPTION
515.6 0	Loose dark yellowish brown slightly silty fine to medium SAND
510.6 5	Medium dense varicolored to olive gray silty fine SAND
505.6 10	Medium dense to dense varicolored to olive black clean fine to coarse SAND with scattered gravel
492.6 23	Very dense varicolored to olive gray slightly silty fine SAND
482.6 33	Very dense varicolored to olive gray clean fine to medium SAND with scattered gravel Very dense varicolored to olive gray slightly silty fine SAND
447.6 68	Very dense varicolored to olive black clean gravelly fine to coarse SAND
423.6 92	End of Hole

SAMPLES

Number	Type	Recovery
1	I	6/18
2	I	13/18
3	I	18/18
4	I	14/18
5	I	13/18
6	I	17/18
7	I	18/18
8	I	10/18
9	I	17/18
10	I	17/18
11	I	18/18
12	I	18/18
13	I	18/18
14	I	18/18
15	I	4/9
16	I	14/18
17	I	12/18
18	I	13/18
19	I	17/18



Boring Method: Hollow Stem Auger

Sample Type: I - 2" (O.D.) Drive Open
II - 4 1/2" (O.D.) Drive Open
III - 3" Thin Walled, Push Open

Drill Hole Coordinates N 422300 E 2269240

Standard Penetration Resistance ●
Water Content ▲
Pressuremeter Test →

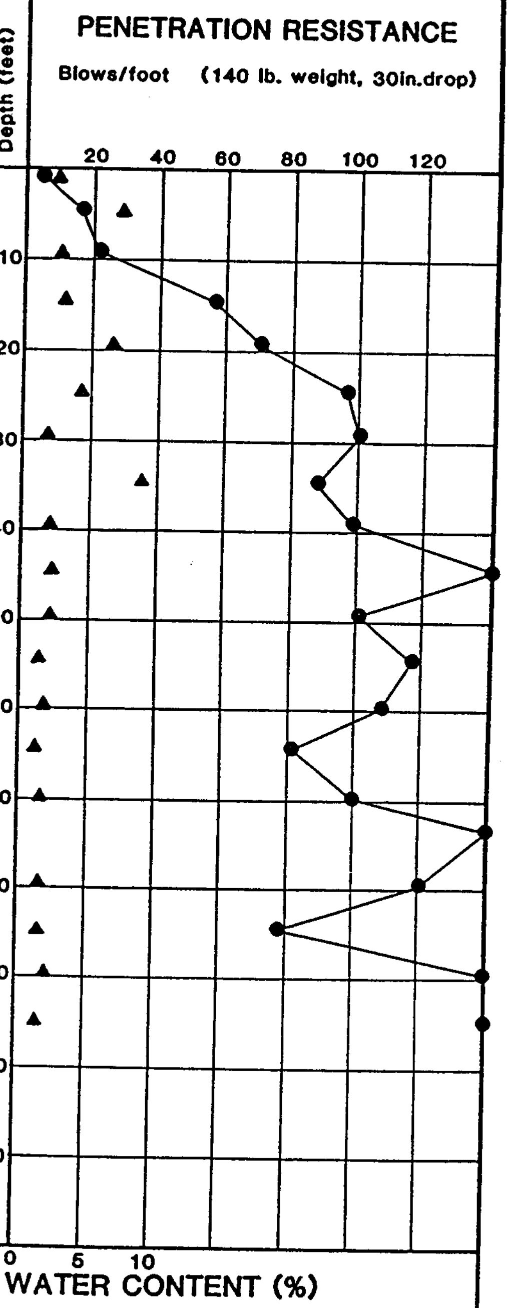
PUGET SOUND POWER & LIGHT COMPANY
SKAGIT / HANFORD NUCLEAR PROJECT

LOG OF DRILL HOLE E-17

FIGURE 2Q A-36

SOIL PROFILE

Elev Depth	DESCRIPTION	Stratigraphic Plot	SAMPLES Number	Type	Recovery	Depth (feet)
516.5 0	Loose to medium dense dark yellowish brown to olive black silty fine to medium SAND		1	I	15/18	
508.5			2	I	12/18	
8	Medium dense to very dense clean fine to medium SAND		3	I	12/18	10
497.5			4	I	14/18	
19	Very dense varicolored to olive black slightly silty <u>fine</u> to medium SAND		5	I	18/18	20
490.5			5A	III	14/14	
26	Very dense varicolored to olive black clean fine to medium SAND with scattered silty layers		6	I	16/18	
			7	I	18/18	30
			8	I	17/18	
			9	I	18/18	40
			10	I	18/18	
			11	I	14/18	50
			12	I	16/18	
			13	I	15/18	60
			14	I	18/18	
			15	I	14/18	70
438.5			16	I	1/5	
78	Very dense varicolored to olive black clean gravelly fine to coarse SAND		17	I	16/18	80
			18	I	12/18	
			19	I	14/18	90
419.5			20	I	15/18	
97	End of Hole					100
						110



Boring Method: Hollow Stem Auger

Sample Type: I- 2" (O.D.) Drive Open
II- 4 1/2" (O.D.) Drive Open
III- 3" Thin Walled, Push Open

Drill Hole Coordinates N 422460 E 2269560

Standard Penetration Resistance ●
Water Content ▲
Pressuremeter Test →

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SKAGIT / HANFORD NUCLEAR PROJECT

LOG OF DRILL HOLE E-18

FIGURE
2Q A-37

DRILL HOLE E-19

Project No : 803-1701H
Elevation : 519.3 ft.
Total Depth : 773 ft.
Coordinates : N422,711.45; E269,239.60
Date Completed : 7/11/81

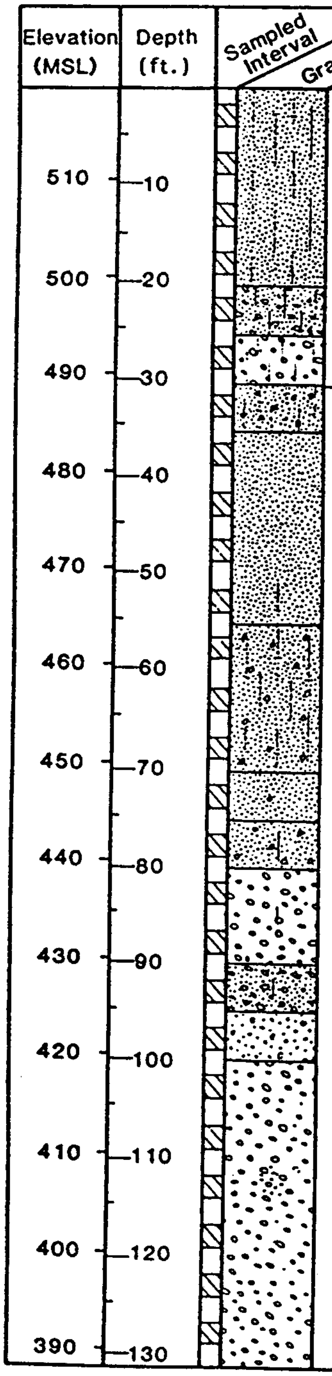
SAMPLE TYPE
▨ Cuttings
95 ■ Core, Number Indicates % Core Recovery
C2015 ⊡ XRF, With Sample Number
Chemical Results Listed in Table 2R-1

Page 1 of 6

Unit Column Refers to General Stratigraphic Divisions Identified Within the Site Area:

M - Missoula	IV - Ringold, Unit IV	Columbia River Basalt Group
PM - Pre-Missoula	III - Ringold, Unit III	Tem - Elephant Mountain Member
	II - Ringold, Unit II	Ter - Rattlesnake Ridge Interbed
	I-u - Ringold, Unit I-upper	Tp - Pomona Member
	I-b - Ringold, Unit I-basal	B - Basalt, Undifferentiated

NOTE: Lithology from 753 to 773 feet taken from driller's log.



Lithologic Description — **Unit**

Silty SAND. 60-70% basalt grains. Very-coarse-grained. Angular to subrounded.

Gravelly silty SAND to silty sandy GRAVEL. Basaltic. Sand very-fine- and coarse- to very-coarse-grained.

Silty GRAVEL. 55% basalt clasts.

M

Gravelly silty SAND. Very-fine-grained, some coarse- to very-coarse-grained. Angular to subangular. 30% mafics. 40% basalt clasts.

SAND. Coarse- to very-coarse-grained, some medium-grained. Angular to subangular. 25-30% mafics. Trace silt at 50-55 ft.

Gravelly silty SAND. Coarse- to very-coarse-grained, some medium-grained. Angular to subrounded. 20% mafics.

SAND. Very-fine- to very-coarse-grained, mostly fine- to medium-grained. Angular to subangular. 7-10% mafics. Trace gravel.

Gravelly SAND. Very-fine- to coarse-grained, mostly fine-grained. Angular to subangular. 10% mafics. Trace silt.

GRAVEL. Trace silt. 55-60% basalt clasts.

Gravelly SAND to sandy GRAVEL. Sand very-fine- to coarse-grained; 15% mafics. Gravel 50% basalt clasts. Trace silt.

Sandy GRAVEL. 40% basalt clasts. Sand very-fine- to coarse-grained, mostly coarse-grained.

GRAVEL. 10-25% basalt clasts. No matrix from 100 to 110 ft. and 115 to 130 ft. Trace sand at 110-115 ft. No cement rinds.

PM

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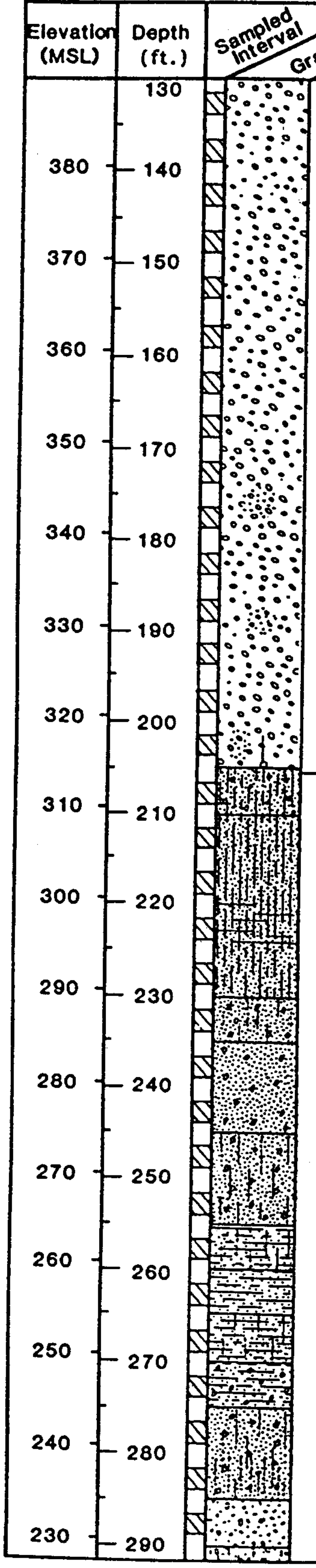
LOG OF DRILL HOLE E-19

FIGURE 2R-A-87

DRILL HOLE E-19

Page 2 **of** 6

Elevation (MSL) | Depth (ft.) | Sampled Interval | Graphic Log | Lithologic Description | Unit



Unit PM

GRAVEL. No matrix to 170 ft. Trace sand below 170 ft. Trace silt at 200-205 ft. No cement rinds.

Unit IV

Gravelly silty SAND to gravelly sandy SILT. Light-olive-gray. Sand very-fine-grained, some fine-grained.

Sandy SILT to silty SAND. Light-olive-gray to yellowish-gray. Sand very-fine- to fine-grained. Micaceous at 210-215 ft. Clayey at 220-225 ft.

Gravelly silty SAND. Yellowish-gray. Fine-grained, some very-fine-grained. Angular to subangular. 3% mafics.
Gravelly SAND. Yellowish-gray. Fine-grained, some very-fine-grained. Angular to subrounded. 3% mafics.

Gravelly silty SAND. Yellowish-gray to dusky-yellow. Very-fine- to medium-grained, mostly fine-grained. Angular to subrounded. Ferruginous stain at 245-250 ft.

Sandy silty CLAY. Yellowish-gray. Sand very-fine-grained.

Sandy CLAY. Yellowish-gray.

Sandy silty CLAY. Yellowish-gray. Sand very-fine- to medium-grained.
Gravelly sandy CLAY. Yellowish-gray. Sand very-fine- to medium-grained.

Gravelly silty SAND. Yellowish-gray. Very-fine- to medium-grained. Angular to subangular. 5% mafics. Silt increases at 280-285 ft. Yellow sandy cement rinds at 275-280 ft.

Sandy GRAVEL. Sand yellowish-gray; very-fine- to medium-grained. Yellow sandy cement rinds.

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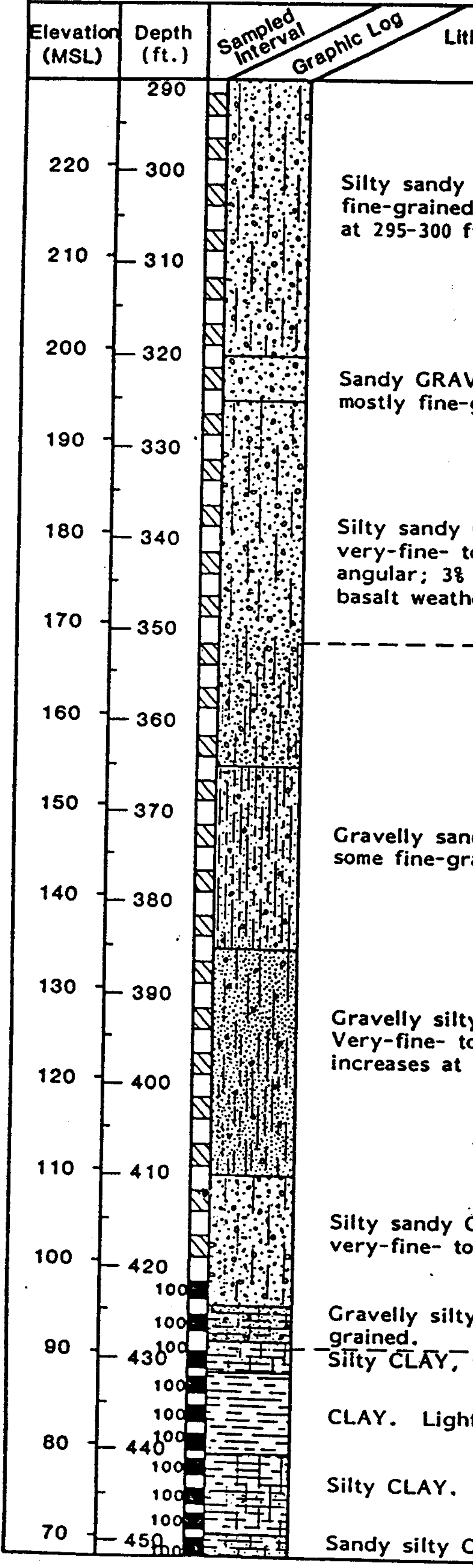
LOG OF DRILL HOLE E-19

FIGURE
2R-A-87

DRILL HOLE E-19

Page 3 of 6



Lithologic Description | Unit

Silty sandy GRAVEL. Sand very-fine- to medium-grained, mostly fine-grained. Yellow sandy cement rinds to 315 ft.; rinds calcareous at 295-300 ft.

Sandy GRAVEL. Sand yellowish-gray; very-fine- to medium-grained, mostly fine-grained; angular to subangular; 3% mafics.

IV

Silty sandy GRAVEL. Matrix yellowish-gray to light-olive-gray. Sand very-fine- to medium-grained, mostly fine-grained; angular to subangular; 3% mafics. Matrix increases from 350 to 365 ft. Thick basalt weathering rind at 325-330 ft.

Gravelly sandy SILT. Yellowish-gray. Sand very-fine-grained, some fine-grained.

Gravelly silty SAND. Off-white grading downward to yellowish-gray. Very-fine- to fine-grained; angular to subrounded; 3-5% mafics. Silt increases at 395-400 ft.

III

Silty sandy GRAVEL. Matrix yellowish-gray to dusky-yellow. Sand very-fine- to medium-grained, coarsening downward.

Gravelly silty CLAY and SAND. Dusky-yellow. Very-fine- to fine-grained.

Silty CLAY, with floating sand grains. Light-olive-gray.

CLAY. Light-olive-gray. Waxy luster.

II

Silty CLAY. Light-olive-gray. Floating sand grains at 445 ft.

Sandy silty CLAY. Light-olive-gray.

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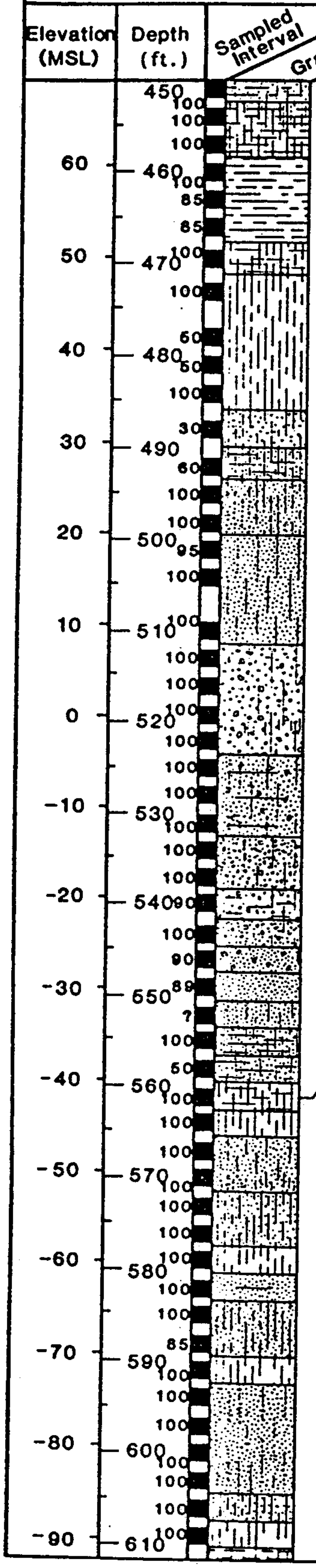
LOG OF DRILL HOLE E-19

FIGURE 2R-A-87

DRILL HOLE E-19

Page 4 of 6



Lithologic Description	Unit
Sandy silty CLAY. Light-olive-gray.	II
Silty CLAY to clayey SILT. Yellowish-gray. Silt decreases with depth.	
CLAY. Light-olive-gray. Waxy luster.	
Clayey SILT. Yellowish-gray.	
SILT. Yellowish-gray. Ferruginous stain at 473 ft. and 478 ft. Vuggy porosity: root casts.	
Sandy SILT. Yellowish-gray. Sand very-fine- to fine-grained.	
Sandy clayey SILT. Yellowish-gray.	
Silty SAND to sandy SILT. Yellowish-gray. Sand very-fine-grained, some fine-grained.	
Silty SAND. Very-light-olive-gray. Fine- to medium-grained. Angular to subangular. 10-15% mafics.	
Silty sandy GRAVEL. Matrix yellowish-gray to light-olive-gray. Sand very-fine- to medium-grained. Matrix increases at 522 ft.	
Gravelly silty SAND, with clay. Light-olive-gray. Very-fine- to medium-grained, mostly medium-grained. Angular to subangular. 7-10% mafics.	
Silty sandy GRAVEL to gravelly silty SAND. Light-olive-gray. Yellow sandy cement rinds on gravel at 534 ft.	
Silty sandy GRAVEL, with olive-gray clay fragments.	
Silty sandy GRAVEL to gravelly silty SAND. Ferruginous stain.	
Gravelly SAND. Medium-gray. Medium-grained. 10-15% mafics.	
SAND. Medium-gray. Fine- to medium-grained. Micaceous.	
Silty SAND. Light-olive-gray. Fine-grained. Micaceous. 10-15% mafics	
Sandy clayey SILT. Yellowish-gray. Sand very-fine-grained.	
Clayey silty SAND. Very-light-olive-gray. Very-fine- to fine-grained.	
Clayey SILT. Pale-olive. Some ferruginous stain. Possible ash at 561 ft	I-u
SILT. Light-olive-gray to olive-gray.	
Silty SAND. Light-olive-gray. Very-fine- to fine-grained. Angular to subangular. 15-20% mafics. Micaceous. Silt increases at 570 ft.	
Sandy SILT. Light-olive-gray. Sand very-fine-grained.	
SILT. Light-olive-gray.	
SAND, with pyritized clay stringer. Medium-gray. Micaceous.	
Silty SAND to sandy SILT. Light-olive-gray. Very-fine- to fine-grained. 20-25% mafics. Micaceous. Silt decreases at 588 ft.	
SILT. Light-olive-gray.	
Silty SAND. Light-olive-gray to medium-gray. Very-fine-grained, some fine-grained. Angular to subangular. 15-20% mafics. Micaceous from 496 to 604 ft.	
Sandy SILT. Light-olive-gray. Sand very-fine-grained.	
SILT. Light-olive-gray.	

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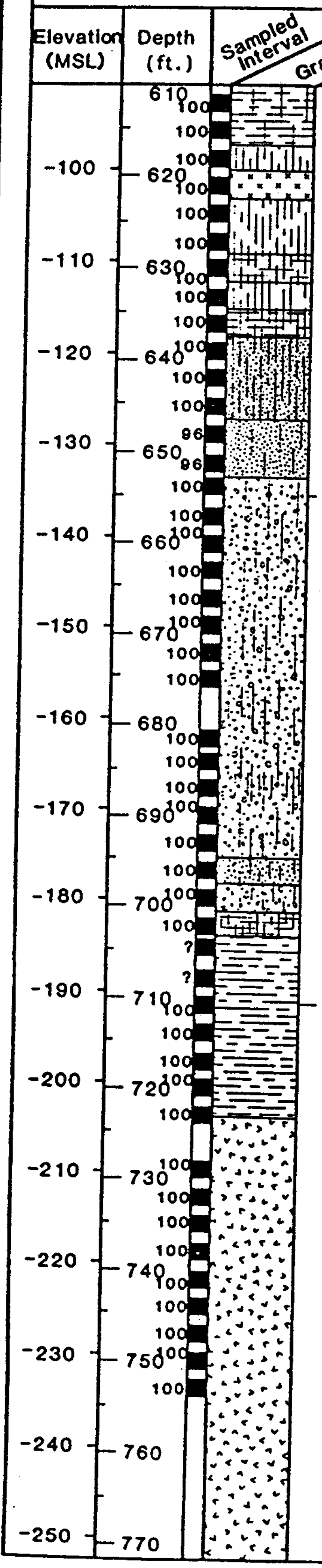
LOG OF DRILL HOLE E-19

FIGURE
2R-A-87

DRILL HOLE E-19

Page 5 of 6



Lithologic Description	Unit
Silty CLAY. Light-olive-gray.	I-u
SILT. Light-olive-gray.	
ASH. White.	
SILT. Light-olive-gray. Organic matter.	
Clayey SILT. Light-olive-gray.	
SILT. Light-olive-gray.	
Clayey SILT to silty CLAY. Light-olive-gray, with white laminations. Two ash horizons separated by a 2-inch layer of silt and clay at 638 ft.	
Sandy SILT to silty SAND. Light-olive-gray. Sand very-fine-grained. Organic matter at 639 ft.	
Silty SAND. Light-olive-gray. Very-fine- to fine-grained. Angular to subangular. 15-20% mafics.	
Silty sandy GRAVEL. Matrix light-olive-gray. Sand medium- to coarse-grained, some very-fine-grained; angular to subangular; 25% mafics at 681.5 ft. Mafics with blue cast from 655.4 ft. to 682.7 ft. Yellowish-brown cast to quartz grains at 657.1 ft. Well cemented (noncalcareous) from 655.4 ft. to 685.5 ft. Matrix increases at 687 ft.	I-b
Silty SAND. Bluish cast to mafics. Weakly cemented.	
Silty sandy GRAVEL. Matrix off-white. Medium-grained. 7% mafics.	
Clayey SILT. Pale-olive.	
CLAY. Medium-gray to pale-olive to light-olive-gray. Waxy luster from 712.5 ft. to 718.6 ft. Clay is weathered basalt.	B
BASALT. Strongly weathered to 742 ft. Moderately weathered to 753 ft. Vesicular at 729 ft. and 738 ft. Clay at 732 ft. and 735 ft. Ferruginous stain at 750 ft. Bluish coating at 753 ft.	

DRILL HOLE E-19

Page 6 of 6

Elevation (MSL)	Depth (ft.)	Sampled Interval	Graphic Log	Lithologic Description	Unit
-253.7	770			BASALT.	B
			EOH 773'		

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LOG OF DRILL HOLE E-19

FIGURE
2R-A-87

DRILL HOLE S-2

Project No : 803-1701H
Elevation : 521.3 ft.
Total Depth : 785 ft.
Coordinates : N422,758.39; E270,388.15
Date Completed : 3/27/81

SAMPLE TYPE
▨ Cuttings
95 ■ Core, Number Indicates % Core Recovery
C2015 ⊡ XRF, With Sample Number
Chemical Results Listed in Table 2R-1

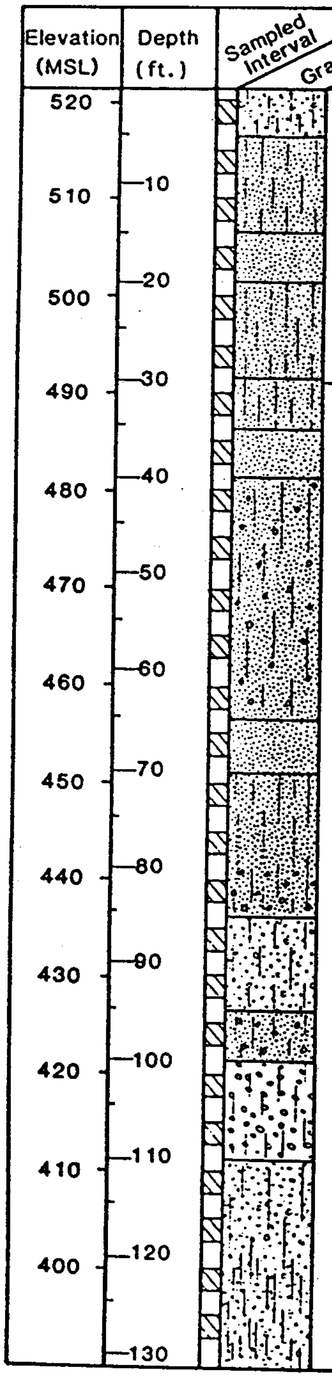
Page 1 of 6

Unit Column Refers to General Stratigraphic Divisions Identified Within the Site Area:

M - Missoula
PM - Pre-Missoula

IV - Ringold, Unit IV
III - Ringold, Unit III
II - Ringold, Unit II
I-u - Ringold, Unit I-upper
I-b - Ringold, Unit I-basal

Columbia River Basalt Group
Tem - Elephant Mountain Member
Ter - Rattlesnake Ridge Interbed
Tp - Pomona Member
B - Basalt, Undifferentiated



Lithologic Description	Unit
Silty sandy GRAVEL. Basalt clasts. Sand very-fine- and very-coarse-grained; subrounded.	M
Silty SAND. Basalt grains. Very-fine- and coarse- to very-coarse-grained. Subangular to subrounded.	
SAND. Basalt grains. Medium- to very-coarse-grained, mostly coarse-grained.	
Silty SAND. Basalt grains. Light-olive-brown. Medium- to very-coarse-grained.	
Silty SAND. Light-olive-brown. Very-fine- to medium-grained, mostly fine-grained. 50% mafics.	PM
SAND. Coarse- to very-coarse-grained. Angular to subrounded. 50% mafics.	
Silty gravelly SAND. Very-fine- to very-coarse-grained, mostly coarse- to very-coarse-grained. 30-50% mafics, decreasing with depth.	
SAND. Very-fine- to coarse-grained, mostly coarse-grained. Angular to subangular. 25% mafics.	
Silty SAND. Coarse- to very-coarse-grained, mostly coarse-grained. 30% mafics. Gravelly at 80-85 ft.	
Silty sandy GRAVEL. <50% basalt clasts. Sand coarse- to very-coarse-grained.	
Gravelly silty SAND. Very-fine- to very-coarse-grained, mostly fine- to medium-grained.	
Silty GRAVEL.	
Silty sandy GRAVEL. Matrix yellowish-gray. Sand very-fine- to medium-grained; angular to subrounded. Matrix increases from 120 to 130 ft. Silt adheres to gravel clasts from 120 to 130 ft.	

PUGET SOUND POWER & LIGHT COMPANY
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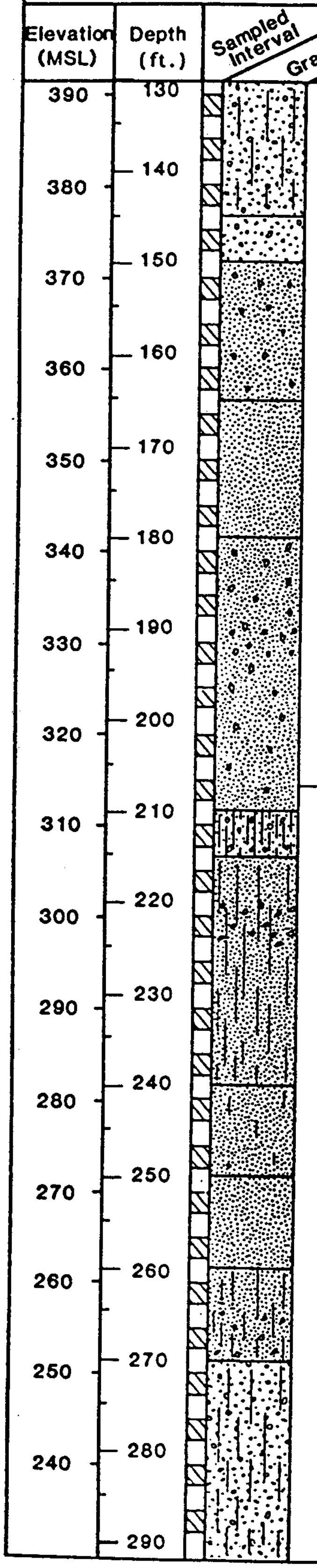
LOG OF DRILL HOLE S-2

FIGURE
2R-A-89

DRILL HOLE S-2

Page 2 of 6



Lithologic Description | **Unit**

Silty sandy GRAVEL. Sand medium-grained; angular to subangular; 5% mafics. Silty sand adheres to clasts.

Sandy GRAVEL. Sand fine- to medium-grained, mostly medium-grained. Calcareous cement.

Gravelly SAND. Fine- to coarse-grained. Angular to subangular. 5-10% mafics. Weak calcareous cement at 150-155 ft. and 160-165 ft. Ferruginous stain at 155-160 ft.

SAND. Fine- to medium-grained, mostly medium-grained. Ferruginous stain. 7% mafics.

Gravelly SAND. Fine- to coarse-grained, mostly medium-grained. Angular. 5-10% mafics. Gravel increases at 190-195 ft. Golden mica at 180-185 ft.

PM

- - - - - - - - - - - - - - - - - - - -

Gravelly sandy SILT. Yellowish-gray. Sand medium-grained.

Silty SAND, with silt fragments. Yellowish-gray to dusky-yellow. Very-fine- to medium-grained, mostly medium-grained. 3-5% mafics. Gravelly at 220-225 ft.

SAND, with minor silt fragments. Yellowish-gray. Medium- to coarse-grained. Angular to subangular. 3-5% mafics. Very clean.

SAND. Medium-grained. Angular to subangular. 3% mafics. Clean. Micaceous at 250-255 ft.

Silty SAND. Light-olive-brown. Very-fine- to medium-grained. 15% mafics. Gravelly at 265-270 ft.

Silty sandy GRAVEL. Matrix light-olive-gray. Sand fine- to medium-grained. Yellow calcareous rinds on some clasts, increasing downward.

IV

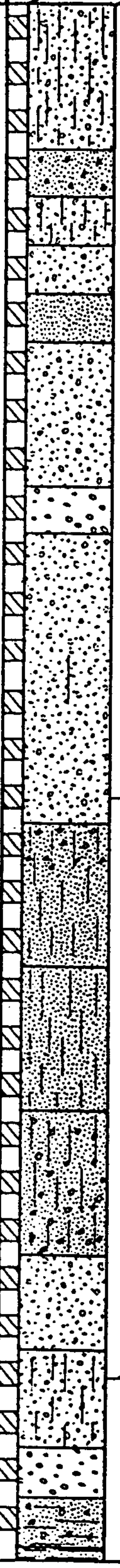
PUGET SOUND POWER & LIGHT COMPANY
SKAGIT / HANFORD NUCLEAR PROJECT

LOG OF DRILL HOLE S-2

FIGURE
2R-A-89

DRILL HOLE S-2 Page 3 of 6

Elevation (MSL)	Depth (ft.)
230	290
220	300
210	310
200	320
190	330
180	340
170	350
160	360
150	370
140	380
130	390
120	400
110	410
100	420
90	430
80	440
	450



Lithologic Description	Unit
Silty sandy GRAVEL, as above.	IV
Gravelly SAND. Light-olive-gray. Fine- to medium-grained. 3-5% mafics.	
Silty sandy GRAVEL.	
Sandy GRAVEL.	
SAND. Very-light-olive-gray. Very-fine- to medium-grained, mostly fine- to medium-grained. 10% mafics. Some mica mats.	
Sandy GRAVEL. Basalt clasts predominate.	
GRAVEL. Basalt clasts. No matrix.	
Sandy GRAVEL. Basalt clasts. Sand light-olive-gray; very-fine- to medium-grained, mostly fine-grained; 25-30% mafics. Trace silt and yellow calcareous rind at 355-360 ft. No matrix.	
Silty SAND. Very-light-olive-gray. Very-fine- to fine-grained. 3% mafics. Gravelly at 375-380 ft. Micaceous at 380-385 ft.	III
Silty SAND, with silt fragments. Light-olive-gray. Very-fine- to fine-grained. Angular to subangular. 7-10% mafics. Ferruginous stain at 400-405 ft.	
Gravelly silty SAND. Light-olive-gray. Very-fine- to medium-grained. Gravel increases at 415-420 ft.	
Sandy GRAVEL. Sand fine-grained.	
Silty sandy GRAVEL. Sand very-fine- to fine-grained. Ferruginous stain at 435-440 ft.	II
GRAVEL. No matrix. Ferruginous stain.	
Gravelly clayey SAND. Sand light-olive-gray. Clay green. Very-fine- to fine-grained, mostly fine-grained. Ferruginous stain.	

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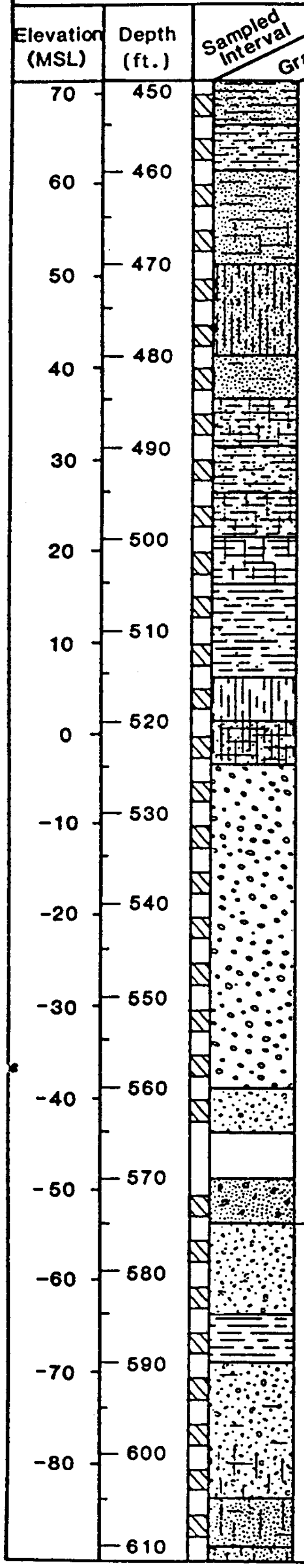
SKAGIT / HANFORD NUCLEAR PROJECT

LOG OF DRILL HOLE S-2

FIGURE 2R-A-89

DRILL HOLE S-2

Page 4 of 6



Lithologic Description	Unit
SAND, with gray CLAY. Light-olive-gray. Fine- to medium-grained. Angular to subangular. Ferruginous stain.	II
Sandy CLAY. Very-light-olive-gray. Ferruginous stain.	
Clayey SAND. Light-olive-gray. Very-fine- to medium-grained. Silt at 465-470 ft. Ferruginous stain.	
Sandy SILT to silty SAND. Yellowish-gray to very-light-olive-gray. Sand increases from 475 to 480 ft. Ferruginous stain.	
SAND, with clay fragments. Light-olive-gray. Very-fine- to fine-grained.	
Sandy silty CLAY. Light-olive-gray. Ferruginous stain.	
Sandy CLAY. Light-olive-gray.	
Sandy silty CLAY. Yellowish-gray. Ferruginous stain.	
Silty CLAY. Light-olive-gray.	
CLAY, with floating sand grains. Light-olive-gray. Ferruginous stain.	
SILT. Light-olive-gray.	
Sandy clayey SILT. Light-olive-gray. Ferruginous stain.	
GRAVEL. No matrix.	
Sandy GRAVEL. Sand fine- to medium-grained. Ferruginous stain.	
No sample.	
Gravelly SAND. Very-fine- to fine-grained. Angular to subangular. 10-15% mafics.	
Sandy GRAVEL.	I-u
CLAY. Greenish-gray. Waxy luster.	
Sandy GRAVEL, with green waxy clay fragments. Silty at 600-605 ft.	
Silty SAND, with clay fragments. Light-olive-gray. Very-fine- to fine-grained, mostly very-fine-grained. 25-30% mafics.	

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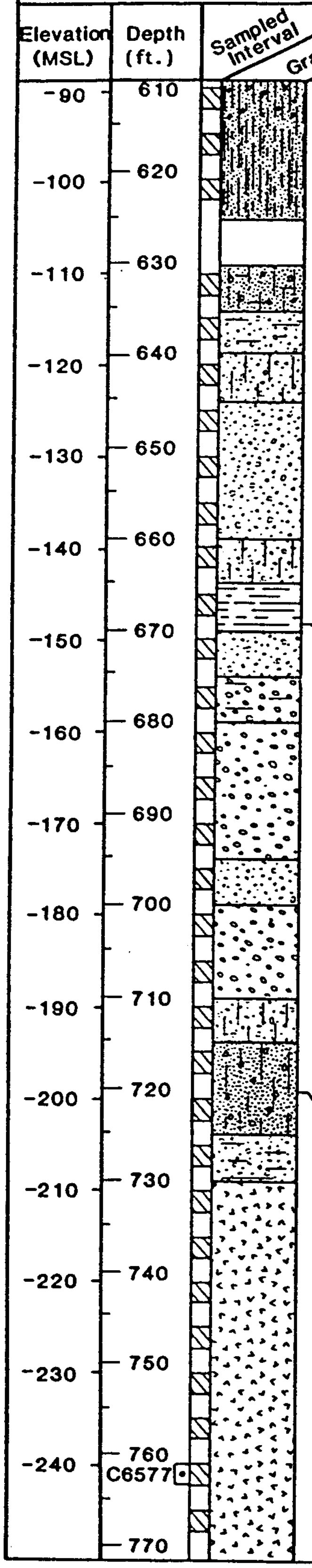
LOG OF DRILL HOLE S-2

FIGURE
2R-A-89

DRILL HOLE S-2 Page 5 of 6



Lithologic Description | **Unit**

Silty SAND to sandy SILT. Light-olive-gray. Very-fine- to fine-grained, mostly very-fine-grained. Gravelly at 610-615 ft. Silt increases from 615-625 ft.

No sample.

Silty gravelly SAND, with minor clay fragments. Light-olive-gray. Very-fine-grained. Ferruginous stain.

Sandy GRAVEL, with clay fragments.

Silty sandy GRAVEL. Sand very-fine- to medium-grained, mostly fine-grained.

Sandy GRAVEL.

Silty sandy GRAVEL.

CLAY. Grayish-olive. Waxy luster.

I-u

Sandy GRAVEL.

GRAVEL, with green clay fragments.

GRAVEL. No matrix. 50% basalt clasts.

Sandy GRAVEL. Ferruginous stain. Sand fine-grained.

GRAVEL. No matrix. Ferruginous stain. 45-50% basalt clasts.

Silty sandy GRAVEL. Basaltic. Sand very-fine- to medium-grained; mostly medium-grained. 55% mafics.

Gravelly silty SAND, with silt fragments. Light-olive-gray. Very-fine- to medium-grained.

I-b

Clayey sandy GRAVEL. Ferruginous stain.

BASALT. Weathered. Ferruginous stain from 730-735 ft.

Tem

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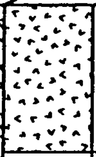
LOG OF DRILL HOLE S-2

FIGURE 2R-A-89

DRILL HOLE S-2 Page 6 of 6

Elevation (MSL)	Depth (ft.)	Sampled Interval	Graphic Log	Lithologic Description	Unit
-250 -260	770 780	▨ ▨ ▨		BASALT. Weathered.	Tem
-263.7			EOH 785'		

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LOG OF DRILL HOLE S-2

FIGURE
2R-A-89

DRILL HOLE S-13

Project No : 803-1701H
Elevation : 554.4 ft.
Total Depth : 790 ft.
Coordinates : N421,219.75; E272,413.07
Date Completed : 2/23/81

SAMPLE TYPE

▨ Cuttings
95 ■ Core, Number Indicates % Core Recovery
C2015 ⊡ XRF, With Sample Number Chemical Results Listed in Table 2R-1

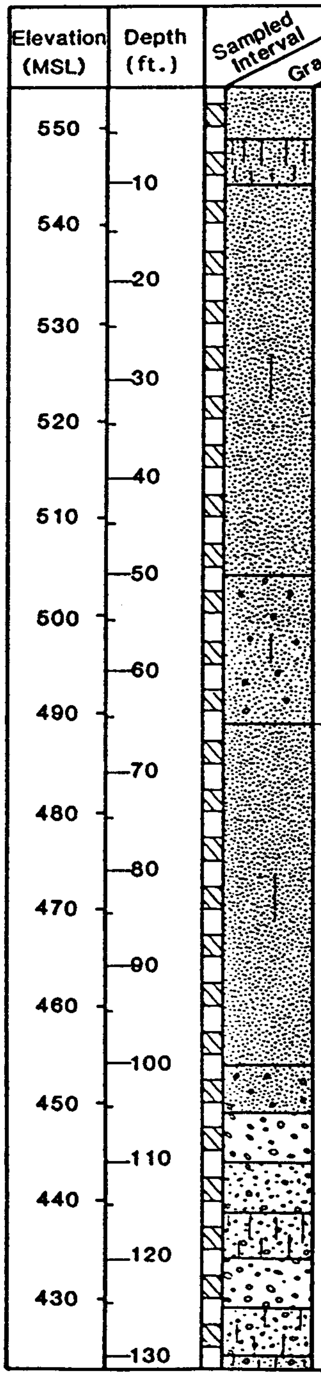
Page 1 of 6

Unit Column Refers to General Stratigraphic Divisions Identified Within the Site Area:

M - Missoula
PM - Pre-Missoula

IV - Ringold, Unit IV
III - Ringold, Unit III
II - Ringold, Unit II
I-u - Ringold, Unit I-upper
I-b - Ringold, Unit I-basal

Columbia River Basalt Group
Tem - Elephant Mountain Member
Ter - Rattlesnake Ridge Interbed
Tp - Pomona Member
B - Basalt, Undifferentiated



Lithologic Description	Unit
SAND. Fine- to coarse-grained, mostly coarse-grained. Subangular to subrounded. 40% mafics.	M
Silty SAND. Light-olive-gray. Very-fine- to medium-grained, mostly medium-grained. 40% mafics.	
SAND. 80% basalt grains. Coarse- to very-coarse-grained, coarsening downward. Trace silt.	
Gravelly SAND. Basalt grains predominate. Coarse- to very-coarse-grained, mostly very-coarse-grained. Trace silt.	
SAND. Nonbasaltic. Coarse- to very-coarse-grained. Subangular. 25% mafics. Trace silt.	PM
Gravelly SAND. Very-fine- to coarse-grained. Angular to subangular.	
GRAVEL. No matrix.	
Sandy GRAVEL. Sand coarse- to very-coarse-grained.	
Silty sandy GRAVEL. Sand medium- to very-coarse-grained.	
GRAVEL. No matrix.	
Silty sandy GRAVEL. Sand very-coarse-grained.	

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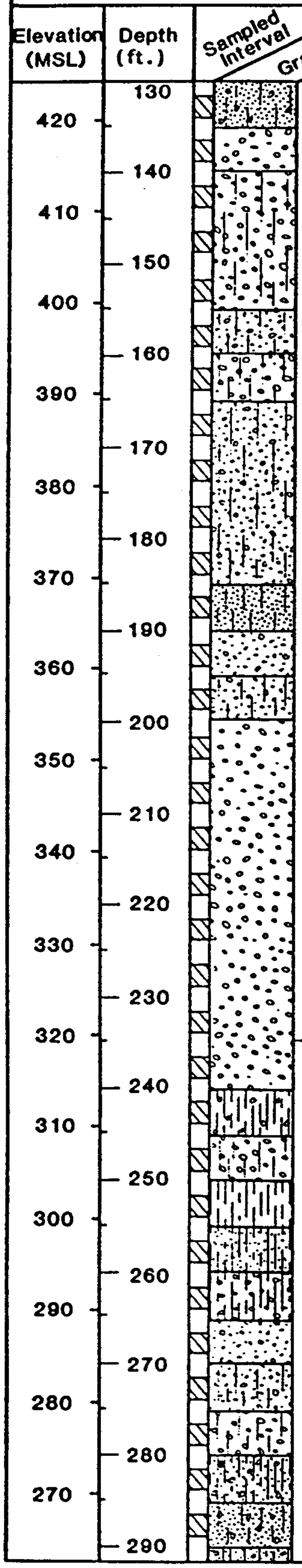
LOG OF DRILL HOLE S-13

FIGURE 2R-A-100

DRILL HOLE S-13 Page 2 of 6



Lithologic Description | **Unit**

Gravelly silty SAND. Coarse- to very-coarse-grained, mostly coarse-grained. 25% mafics.

GRAVEL. No matrix.

Silty GRAVEL. Silt adheres to gravel.

Silty sandy GRAVEL. Sand very-fine- to fine-grained. Silty sand adheres to gravel.

Silty GRAVEL. Silt adheres to gravel.

Silty sandy GRAVEL. Sand medium-grained; angular to subangular. Silt or silty sand adheres to gravel.

Silty SAND. Light-olive-brown. Medium-grained.

Sandy GRAVEL. Sand fine- to medium-grained; angular; 5-7% mafics.

Silty sandy GRAVEL. Sand fine- to medium-grained. Silty sand adheres to gravel.

GRAVEL. No matrix. Thin weathering rinds on some basalt clasts. No cement.

PM

Gravelly SILT. Yellowish-gray.

Silty GRAVEL. Silt yellowish-gray.

SILT. Yellowish-gray.

Sandy SILT. Yellowish-gray. Sand very-fine- to fine-grained.

Gravelly SILT to silty GRAVEL. Yellowish-gray.

Sandy GRAVEL. Sand very-fine- to fine-grained.

Silty sandy GRAVEL. Sand very-fine- to medium-grained. Yellow sandy calcareous rinds on gravel.

Silty GRAVEL. Yellow sandy calcareous rinds on gravel.

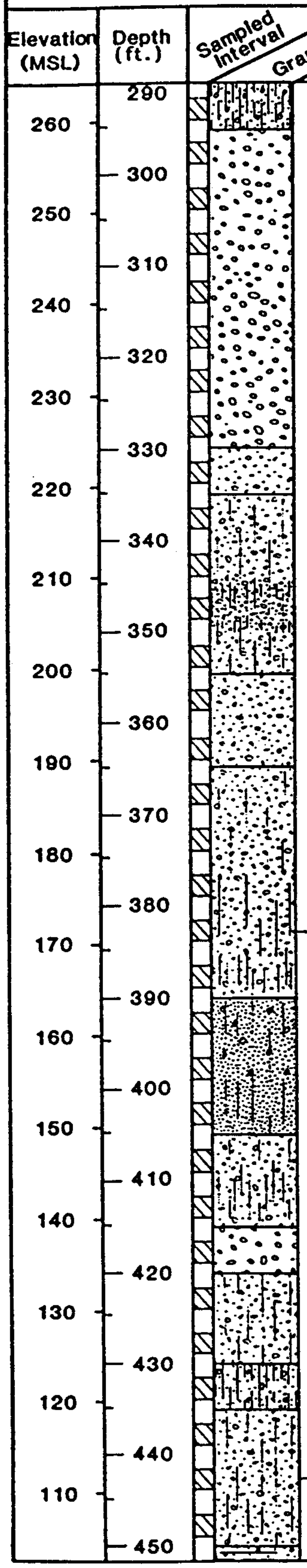
Gravelly sandy SILT. Yellowish-gray. Sand fine-grained.

Gravelly silty SAND. Yellowish-gray. Very-fine- to fine-grained. Angular to subangular. 2-3% mafics.

IV

DRILL HOLE S-13

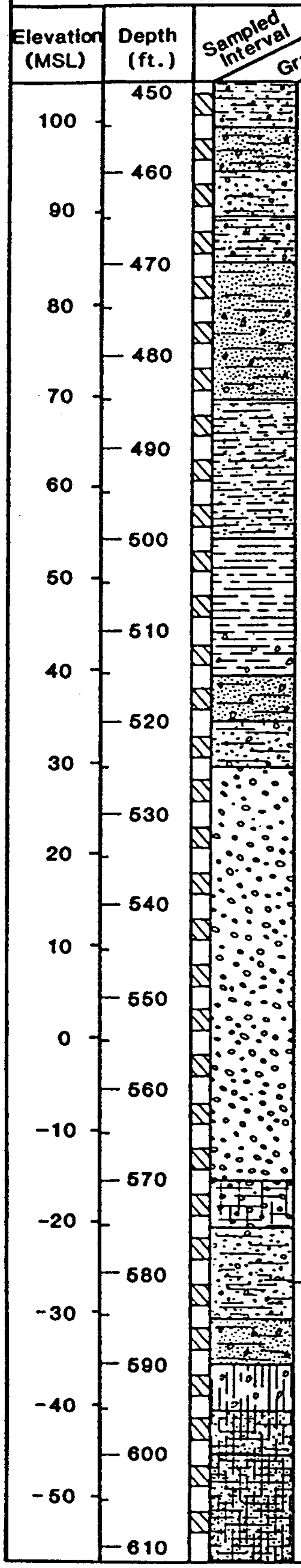
Page 3 of 6



Lithologic Description	Unit
Gravelly sandy SILT. Yellowish-gray.	IV
GRAVEL. Yellow sandy calcareous rinds.	
Sandy GRAVEL.	
Silty sandy GRAVEL. Sand very-fine- to medium-grained, mostly fine-grained. Silty sand increases at 345-350 ft. Yellow sandy calcareous rinds.	
Sandy GRAVEL. Yellow sandy calcareous rinds at 360-365 ft.	
Silty sandy GRAVEL. Matrix light-gray. Sand fine- to medium-grained; angular to subangular; 3-5% mafics. Silty sand increases at 385-390 ft.	
Silty SAND. Light-gray. Fine- to medium-grained. Angular to subangular. 5-7% mafics. Gravelly from 390 to 400 ft.	III
Silty sandy GRAVEL. Sand medium- to coarse-grained, mostly medium-grained. Silt increases at 410-415 ft.	
GRAVEL. No matrix.	
Silty sandy GRAVEL. Yellow sandy calcareous rinds at 420-425 ft.	
Gravelly sandy SILT. Light-olive-gray.	
Silty sandy GRAVEL. Matrix light-olive-gray. Sand very-fine- to medium-grained; angular to subangular; 20-25% mafics.	
	II

DRILL HOLE S-13

Page 4 of 6



Lithologic Description	Unit
Gravelly sandy CLAY. Light-olive-gray.	II
Gravelly clayey SAND. Light-olive-gray.	
Clayey sandy GRAVEL. Matrix light-olive-gray.	
Gravelly sandy CLAY. Light-olive-gray. Clay fragments rounded.	
Clayey SAND. Light-olive-gray. Very-fine- to medium-grained. Angular to subangular. 20-25% mafics. Gravelly from 475 to 485 ft.	
Sandy CLAY. Light-olive-gray. Sand fine- to medium-grained; 15-20% mafics. Rounded clay fragments. Ferruginous stain.	
CLAY. Light-olive-gray. Gravelly at 510-515 ft. Rounded fragments.	
Gravelly clayey SAND. Very-fine- to medium-grained. Ferruginous stain.	
Clayey sandy GRAVEL. Sand very-fine- to medium-grained.	
GRAVEL. Yellow sandy calcareous rinds. Ferruginous stain at 560-565 ft.	
Silty clayey GRAVEL. Matrix light-olive-gray.	
Sandy clayey GRAVEL. Matrix olive-gray. Sandy clay increases at 580-585 ft.	I-u
Gravelly clayey SAND. Olive-gray. Fine- to medium-grained.	
Gravelly SILT. Olive-gray.	
Sandy clayey SILT. Olive-gray.	
Sandy silty CLAY to sandy clayey SILT. Olive-gray.	

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LOG OF DRILL HOLE S-13

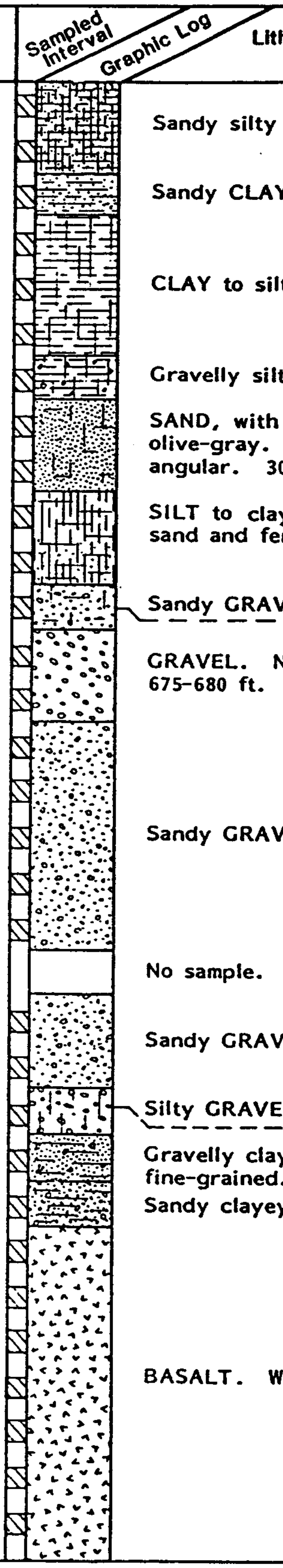
FIGURE 2R-A-100

DRILL HOLE S-13 Page 5 of 6

Elevation (MSL): -60, -70, -80, -90, -100, -110, -120, -130, -140, -150, -160, -170, -180, -190, -200, -210

Depth (ft.): 610, 620, 630, 640, 650, 660, 670, 680, 690, 700, 710, 720, 730, 740, 750, 760, 770

Sampled Interval / Graphic Log



Lithologic Description	Unit
Sandy silty CLAY to clayey SILT. Olive-gray.	I-u
Sandy CLAY, with white ash fragments. Olive-gray.	
CLAY to silty clay, with white ash fragments. Olive-gray.	
Gravelly silty CLAY. Olive-gray.	
SAND, with rounded clay and silt fragments. Olive-gray to light-olive-gray. Very-fine- to medium-grained. Angular to subangular. 30-40% mafics.	
SILT to clayey silt. Light-olive-gray. Rounded fragments. Some sand and ferruginous stain at 660-665 ft.	
Sandy GRAVEL, with silt and clay fragments.	
GRAVEL. No matrix. Some yellow sandy calcareous rinds at 675-680 ft.	I-b
Sandy GRAVEL. Yellow sandy calcareous rinds on some clasts.	
No sample.	
Sandy GRAVEL, as above.	
Silty GRAVEL. Yellow sandy calcareous rinds.	
Gravelly clayey SAND. Very-fine- to very-coarse-grained, mostly fine-grained.	Tem
Sandy clayey GRAVEL to gravelly clayey SAND. Olive-gray.	
BASALT. Weathered.	

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LOG OF DRILL HOLE S-13

FIGURE 2R-A-100

DRILL HOLE S-13

Page 6 of 6

Elevation (MSL)	Depth (ft.)	Sampled Interval	Graphic Log	Lithologic Description	Unit
	770	▨			
-220		▨			
	780			BASALT.	Tem
	C6591	▨			
-230		▨			
-235.6	790		EOH 790'		

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LOG OF DRILL HOLE S-13

FIGURE
2R-A-100

DRILL HOLE S-15

Page 1 of 6

Project No : 803-1701H
Elevation : 526.2 ft.
Total Depth : 780 ft.
Coordinates : N424,192.91; E268,496.96
Date Completed : 3/21/81

SAMPLE TYPE

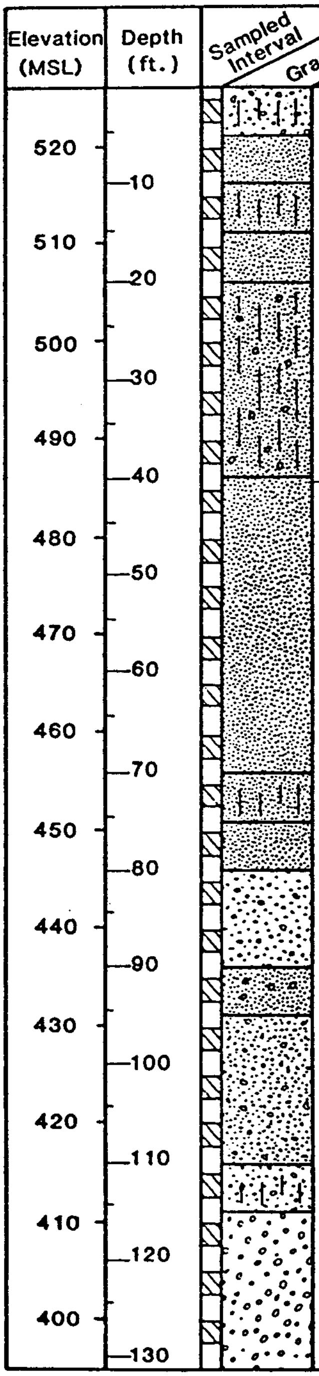
- ▨ Cuttings
- 95 ■ Core, Number Indicates % Core Recovery
- C2015 ⊡ XRF, With Sample Number Chemical Results Listed in Table 2R-1

Unit Column Refers to General Stratigraphic Divisions Identified Within the Site Area:

M - Missoula
PM - Pre-Missoula

IV - Ringold, Unit IV
III - Ringold, Unit III
II - Ringold, Unit II
I-u - Ringold, Unit I-upper
I-b - Ringold, Unit I-basal

Columbia River Basalt Group
Tem - Elephant Mountain Member
Ter - Rattlesnake Ridge Interbed
Tp - Pomona Member
B - Basalt, Undifferentiated



Lithologic Description

Silty sandy GRAVEL. Basalt clasts. Sand very-fine- to medium-grained, mostly very-fine-grained; angular to subangular; 35% mafics.

SAND. Basaltic. Medium- to very-coarse-grained, mostly very-coarse-grained. Angular to subrounded.

Silty SAND. Yellowish-gray. Very-fine- and coarse-grained, mostly very-fine-grained.

SAND. Basaltic. Fine- to very-coarse-grained, mostly very-coarse-grained. Angular to subrounded.

Gravelly silty SAND. Basaltic. Very-fine- to very-coarse-grained, mostly coarse-grained, fining downward. Angular to subrounded. Basalt grains decrease with depth.

Unit: M

SAND. Nonbasaltic. Very-fine- to very-coarse-grained, mostly coarse-grained. Angular to subangular. 25-50% mafics, decreasing with depth.

Silty SAND. Very-fine- to very-coarse-grained. Angular to subangular. 25% mafics.

SAND. Very-fine- to coarse-grained. 25-30% mafics.

Sandy GRAVEL. Sand coarse- to very-coarse-grained.

Gravelly SAND. Very-fine- to very-coarse-grained, mostly coarse-grained. Angular to subangular. 40% mafics.

Sandy GRAVEL to gravelly SAND. Sand fine- to coarse-grained; angular to subangular; 25-30% mafics. Sand decreases at 100-105 ft.

Silty sandy GRAVEL. Sand very-fine- to fine- and coarse-grained.

GRAVEL. No matrix. No cement.

Unit: PM

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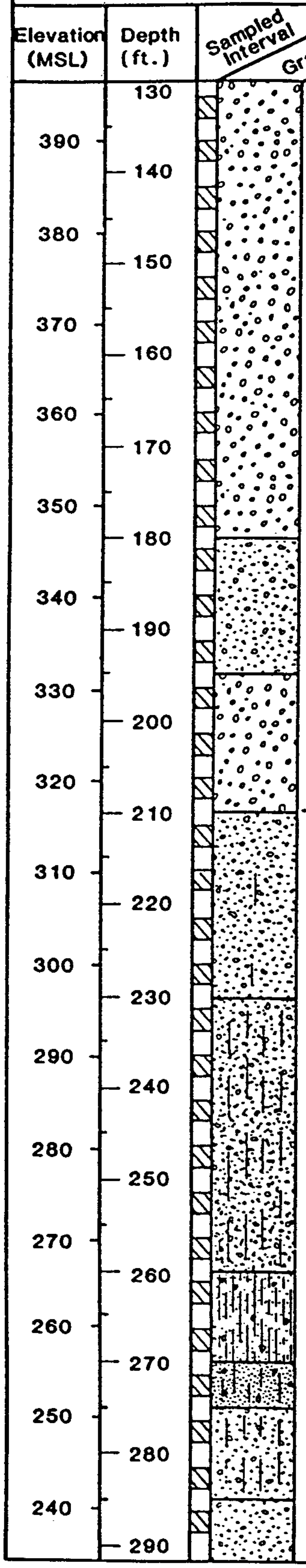
LOG OF DRILL HOLE S-15

FIGURE 2R-A-102

DRILL HOLE S-15 **Page** 2 **of** 6



Lithologic Description	Unit
GRAVEL. No matrix. No cement.	PM
Sandy GRAVEL. Sand fine- to medium-grained; angular to subangular; 3-5% mafics.	
GRAVEL. No matrix. No cement. Thin weathering rinds on basalt at 195-200 ft.	
Sandy GRAVEL. Sand fine- to medium-grained; angular to subangular; 2-3% mafics. Trace silt at 215-220 ft. and 225-230 ft.	IV
Silty sandy GRAVEL to gravelly silty SAND. Matrix light-olive-brown to yellowish-gray. Sand very-fine- to fine-grained; angular to subangular; 3% mafics. Sand increases at 230-235 ft. and 245-250 ft.	
Gravelly sandy SILT. Yellowish-gray.	
Gravelly silty SAND. Yellowish-gray. Very-fine- to fine-grained, mostly fine-grained. Angular to subangular. 3-5% mafics.	
Silty sandy GRAVEL.	
Sandy GRAVEL.	

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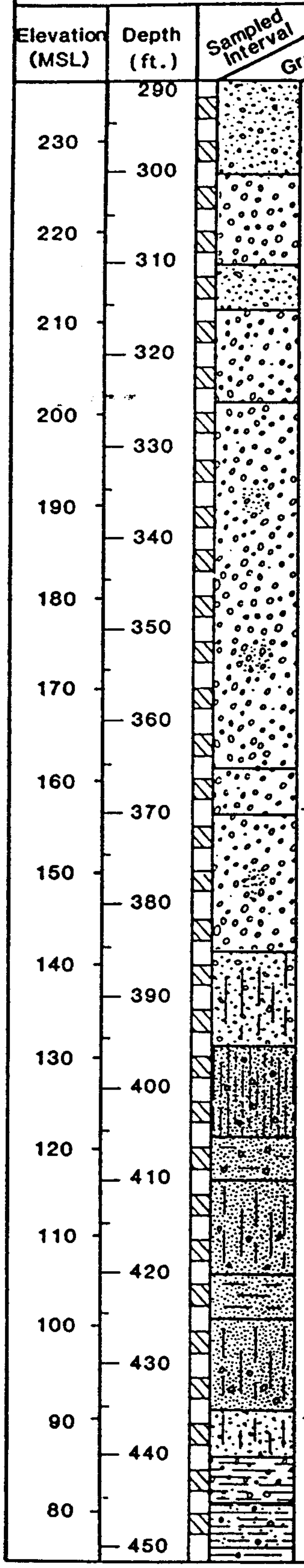
SKAGIT / HANFORD NUCLEAR PROJECT

LOG OF DRILL HOLE S-15

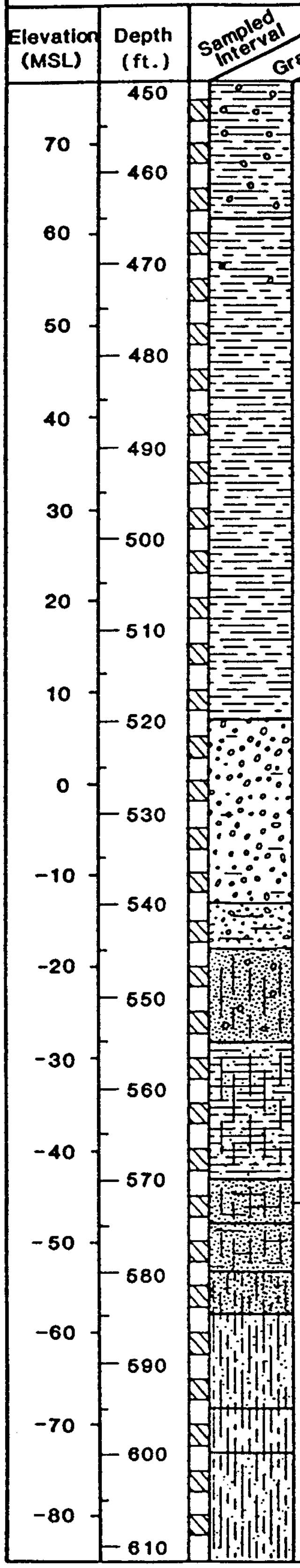
FIGURE 2R-A-102

DRILL HOLE S-15 Page 3 of 6



Lithologic Description	Unit
Sandy GRAVEL. Yellow sandy calcareous rinds at 290-295 ft.	IV
GRAVEL. No matrix.	
Sandy GRAVEL. Yellow sandy calcareous rinds.	
GRAVEL. No matrix.	
GRAVEL. Trace sand.	
GRAVEL. No matrix.	
GRAVEL. Trace sand.	III
Silty sandy GRAVEL.	
Gravelly silty SAND to gravelly sandy SILT. Yellowish-gray. Sand very-fine- to fine-grained, mostly very-fine-grained.	
Gravelly SAND, with clay fragments. Light-olive-gray. Very-fine- to medium-grained, mostly fine-grained.	
Silty SAND. Light-tan. Very-fine- to fine-grained, mostly very-fine-grained. Angular to subangular. 5% mafics. Gravelly at 415-420 ft.	
Clayey SAND. Light-olive-gray. Very-fine- to fine-grained.	
Silty SAND. Light-gray to light-olive-gray. Very-fine- to fine-grained, mostly fine-grained. Angular to subangular. 7-10% mafics. Gravelly at 430-435 ft.	
Silty sandy GRAVEL. Sand very-fine- to medium-grained, mostly fine-grained.	II
Clayey GRAVEL to gravelly CLAY. Light-olive-gray.	
Gravelly sandy CLAY. Very-light-olive-gray.	

DRILL HOLE S-15 Page 4 of 6



Lithologic Description — **Unit**

Gravelly CLAY. Very-light-olive-gray. Clay with waxy luster at 450-455 ft. Pale-olive clay at 455-460 ft. Ferruginous stain at 460-465 ft.

CLAY. Mixed olive-gray, grayish-olive, and moderate-olive-brown fragments. Waxy luster. Minor gravel at 475-480 ft.

II

GRAVEL, with clay fragments. Pyrite at 530-535 ft.

Sandy clayey GRAVEL. Sand fine- to medium-grained. Ferruginous stain.

Gravelly silty SAND. Light-olive-gray to yellowish-gray. Very-fine- to fine-grained. Angular to subangular. 3-5% mafics. Ferruginous stain at 550-555 ft.

Sandy silty CLAY. Light-olive-gray.

Silty clayey SAND. Light-olive-gray. Very-fine- to fine-grained, mostly fine-grained.

Silty SAND, with rounded clay fragments. Light-olive-gray. Very-fine- to fine-grained, mostly very-fine-grained.

Sandy SILT to silty SAND. Olive-gray.

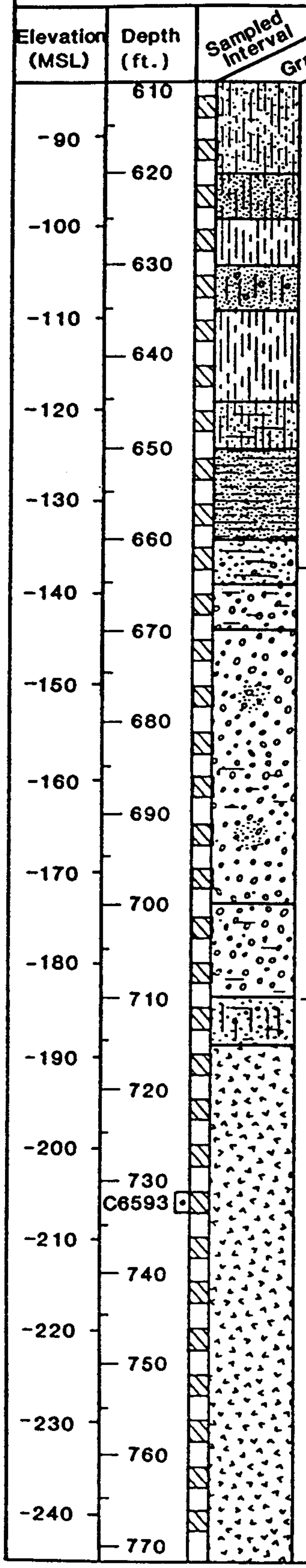
Sandy SILT. Olive-gray.

I-u

SILT. Olive-gray.

SILT to sandy silt. Light-olive-gray. Ferruginous stain at 600-605 ft.

DRILL HOLE S-15 Page 5 of 6



Lithologic Description

SILT to sandy silt. Light-olive-gray. Micaceous at 615-620 ft.

Sandy SILT to silty SAND. Light-olive-gray. Ferruginous stain.

SILT. Light-olive-gray.

Gravelly silty SAND. Light-olive-gray. Very-fine- to fine-grained. Ferruginous stain.

SILT. Light-olive-gray. White ash fragments at 640-645 ft.

Sandy silty CLAY. Light-olive-brown. Ferruginous stain.

Sandy CLAY to clayey SAND. Light-olive-gray. Ferruginous stain at 655-660 ft.

Clayey sandy GRAVEL.

GRAVEL. Minor clay fragments.

GRAVEL. Trace sand. Green clay fragments with waxy luster at 685-690 ft. Pyrite at 695-700 ft.

GRAVEL, with clay fragments.

Silty sandy GRAVEL, with clay fragments. 40% basalt clasts.

BASALT. Weathered.

Unit

I-u

I-b

Tem

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SKAGIT / HANFORD NUCLEAR PROJECT

LOG OF DRILL HOLE S-15

FIGURE
2R-A-102

DRILL HOLE S-15

Page 6 of 6

Elevation (MSL)	Depth (ft.)	Sampled Interval	Graphic Log	Lithologic Description	Unit
	770	▨		BASALT. Vesicular at 770-775 ft.	Tem
-250		▨			
-253.8	780		EOH 780'		

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LOG OF DRILL HOLE S-15

FIGURE 2R-A-102

DRILL HOLE S-18

Page 1 of 6

Project No : 803-1701H
Elevation : 544.9 ft.
Total Depth : 821 ft.
Coordinates : N416,509.05; E266,549.37
Date Completed : 2/26/81

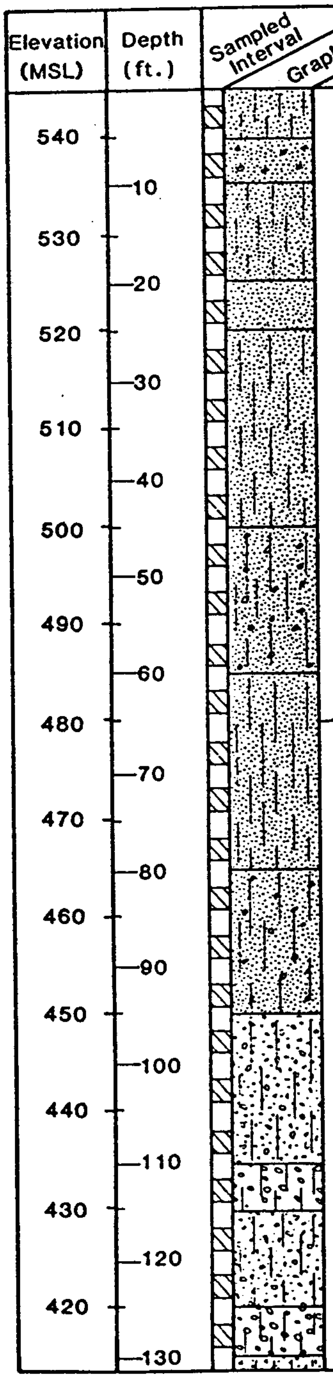
SAMPLE TYPE
▨ Cuttings
95 ■ Core, Number Indicates % Core Recovery
C2015 ⊡ XRF, With Sample Number
Chemical Results Listed in Table 2R-1

Unit Column Refers to General Stratigraphic Divisions Identified Within the Site Area:

M - Missoula
PM - Pre-Missoula

IV - Ringold, Unit IV
III - Ringold, Unit III
II - Ringold, Unit II
I-u - Ringold, Unit I-upper
I-b - Ringold, Unit I-basal

Columbia River Basalt Group
Tem - Elephant Mountain Member
Ter - Rattlesnake Ridge Interbed
Tp - Pomona Member
B - Basalt, Undifferentiated



Lithologic Description	Unit
Silty SAND. Basaltic. Very-fine- to very-coarse-grained, mostly medium-grained. Angular to subrounded.	M
Gravelly SAND. Basaltic. Mostly very-coarse-grained, some coarse-grained. Angular to subrounded. 85% mafics.	
Silty SAND. Basaltic. Mostly coarse- to very-coarse-grained, some very-fine- and medium-grained. Silty sand adheres to larger sand grains.	
SAND. Basaltic. Medium- to very-coarse-grained, mostly coarse-grained.	
Silty SAND. Very-fine- to very-coarse-grained, mostly coarse-grained. Angular to subrounded. Basaltic at 25-30 ft. and 40-45 ft. 45% mafics at 30-40 ft.	
Gravelly silty SAND. Very-fine- to very-coarse-grained, mostly medium- to very-coarse-grained. Angular to subangular. 30-60% mafics.	
Silty SAND. Very-fine- to very-coarse-grained, mostly medium- to coarse-grained. Angular to subangular. 60% mafics at 60-65 ft., decreasing downward to 30-40%.	PM
Gravelly silty SAND. Very-fine- to very-coarse-grained, mostly very-coarse-grained. Angular to subrounded. 45-50% mafics. Silt adheres to gravel clasts at 90-95 ft.	
Silty sandy GRAVEL. Basalt clasts. Sand coarse- to very-coarse-grained, mostly very-coarse-grained. Silt adheres to clasts at 105-110 ft.	
Silty GRAVEL. Silt adheres to gravel clasts.	
Silty sandy GRAVEL. Sand very-fine-grained to fine-grained, mostly very-fine-grained; 10-15% mafics.	
Silty GRAVEL.	

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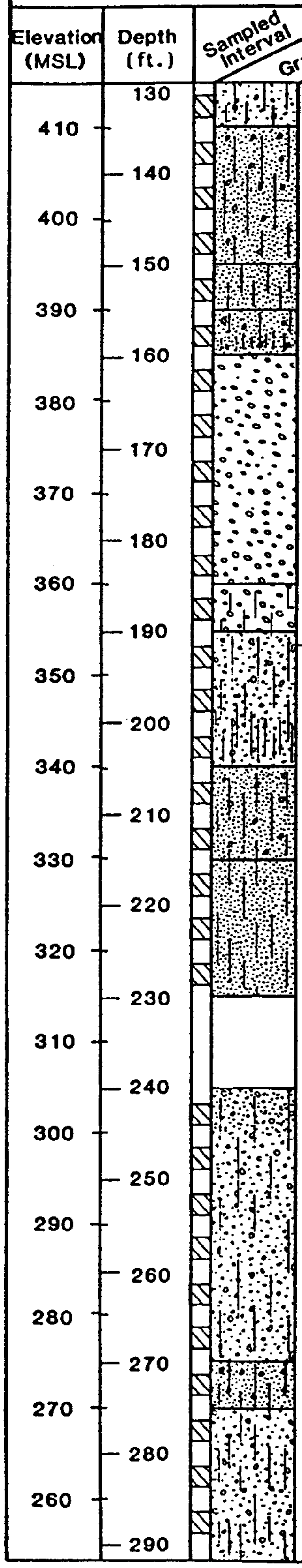
LOG OF DRILL HOLE S-18

FIGURE
2R-A-105

DRILL HOLE S-18

Page 2 of 6



Lithologic Description

Silty sandy GRAVEL. Sand fine- to coarse-grained, mostly medium- to coarse-grained; angular to subrounded; 20-25% mafics.

Gravelly silty SAND. Very-fine- to very-coarse-grained, mostly fine- to medium-grained. Angular to subangular. 7-20% mafics. Silty sand adheres to clasts at 145-150 ft.

Silty SAND. Fine- to coarse-grained, mostly medium- to coarse-grained. 7-10% mafics. Silt adheres to sand grains.

Gravelly silty SAND. Very-fine- to very-coarse-grained, mostly medium- to coarse-grained. 10-15% mafics. Increasing silt.

GRAVEL. No matrix. No cement.

Silty GRAVEL. No cement.

Unit PM

Silty sandy GRAVEL. Sand very-fine- to medium-grained; angular to subangular. Silt increases with depth. No cement.

Gravelly silty SAND. Yellowish-gray. Very-fine- to medium-grained, mostly very-fine- to fine-grained, coarsening with depth. 2-3% mafics.

Silty SAND. Yellowish-gray. Very-fine- to medium-grained, mostly fine- to medium-grained. Angular to subangular. 5-7% mafics.

No sample.

Silty sandy GRAVEL. Sand very-fine- to coarse-grained, mostly medium-grained; angular to subangular; 25-30% mafics. Greater sand at 240-245 ft. Yellow sandy calcareous rinds at 255-260 ft.

Gravelly silty SAND. Very-fine- to medium-grained, mostly fine-grained. 10-15% mafics.

Silty sandy GRAVEL. Sand very-fine- to medium-grained, mostly fine- to medium-grained. Angular to subangular. 30-35% mafics. Sand increases at 285-290 ft.

Unit IV

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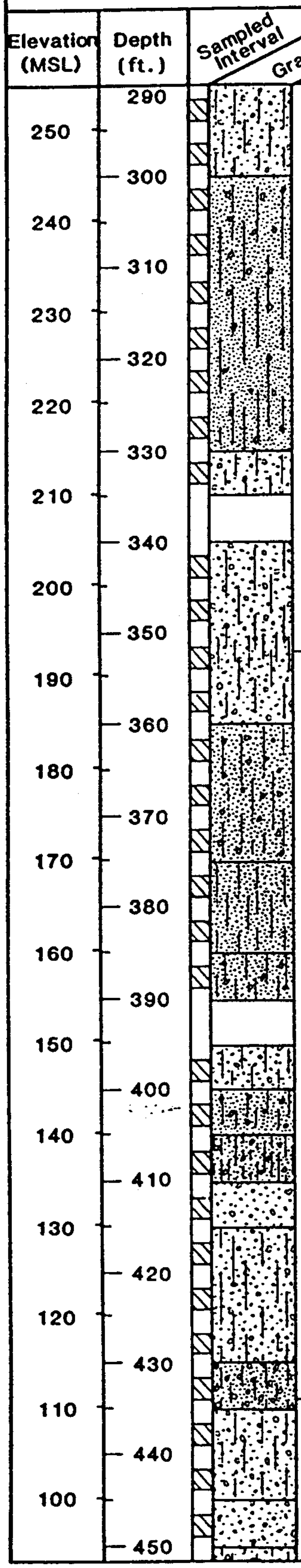
LOG OF DRILL HOLE S-18

FIGURE
2R-A-105

DRILL HOLE S-18

Page 3 of 6



Lithologic Description	Unit
Silty sandy GRAVEL, as above. Yellow sandy calcareous rinds at 290-295 ft.	IV
Gravelly silty SAND. Light-olive-gray. Very-fine- to medium-grained, mostly medium-grained. Angular to subrounded. 10-20% mafics. Ferruginous stain at 325-330 ft.	
Silty sandy GRAVEL. Sand fine- to medium-grained, mostly medium-grained. 15-20% mafics.	
No sample.	
Silty sandy GRAVEL. Matrix yellowish-gray to light-olive-gray. Sand very-fine- to medium-grained; 15-20% mafics. Silt increases at 350-355 ft.	
Gravelly silty SAND. Yellowish-gray. Very-fine- to fine-grained. mostly fine-grained. Angular to subangular. 5-10% mafics.	III
Silty SAND. Yellowish-gray. Very-fine- to fine-grained, mostly very-fine-grained. 25-30% mafics.	
Gravelly silty SAND. Light-olive-gray. Very-fine- to fine-grained.	
No sample.	
Silty sandy GRAVEL. Sand fine- to medium-grained, mostly fine-grained; angular to subangular; 20-25% mafics.	
Gravelly silty SAND. Sand as above.	
Gravelly sandy SILT to gravelly silty SAND. Light-olive-gray.	
Sandy GRAVEL. Sand very-fine- to medium-grained, mostly fine-grained; 25-30% mafics.	
Silty sandy GRAVEL. Sand fine- to medium-grained, mostly medium-grained; angular to subangular; 15-30% mafics. Silt decreases with depth.	
Gravelly silty SAND to silty sandy GRAVEL. Light-olive-gray. Very-fine- to medium-grained.	II
Silty sandy GRAVEL. Matrix light-olive-gray. Sand fine- to medium-grained; angular to subangular; 25-30% mafics.	
Sandy GRAVEL.	

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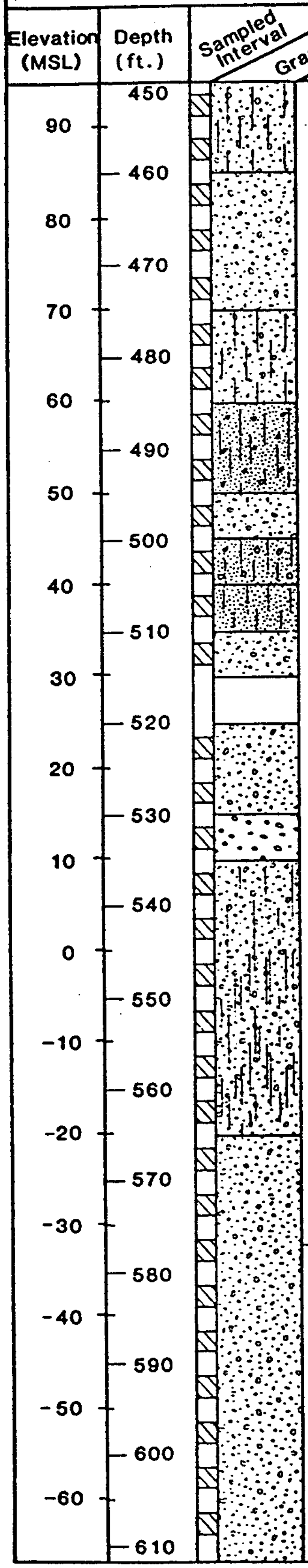
LOG OF DRILL HOLE S-18

FIGURE 2R-A-105

DRILL HOLE S-18

Page 4 of 6



Lithologic Description

Unit

Silty sandy GRAVEL, with rounded silt fragments. Sand fine- to medium-grained, mostly medium-grained; angular to subangular; 7-10% mafics.

Sandy GRAVEL. Sand fine- to medium-grained, mostly medium-grained; angular to subangular; 3-5% mafics.

Silty sandy GRAVEL. Matrix light-olive-gray. Sand very-fine- to medium-grained, mostly fine-grained; 15-20% mafics.

Gravelly silty SAND, with rounded silt fragments. Olive-gray to light-olive-gray. Very-fine- to medium-grained, mostly fine-grained. 25-30% mafics.

II

Sandy GRAVEL. Sand very-fine- to medium-grained, mostly fine-grained; angular to subangular. Ferruginous stain.

Gravelly silty SAND. Light-olive-gray.

Silty SAND, with rounded silt fragments. Sand very-fine- to fine-grained, mostly fine-grained. 15-20% mafics.

Sandy GRAVEL. Sand fine- to medium-grained; 10-15% mafics.

No sample.

Sandy GRAVEL. Sand fine- to medium-grained, mostly medium-grained. Ferruginous stain at 525-530 ft.

GRAVEL. No matrix.

Silty sandy GRAVEL. Matrix light-olive-gray. Sand very-fine- to medium-grained, mostly medium-grained; angular to subangular; 30-40% mafics. Silty sand increases from 545-565 ft. Ferruginous stain from 535 to 545 ft.

Sandy GRAVEL. Sand very-fine- to medium-grained, mostly medium-grained; angular to subangular; 5-30% mafics, increasing with depth. Ferruginous stain at 575-580 ft.

-u ?

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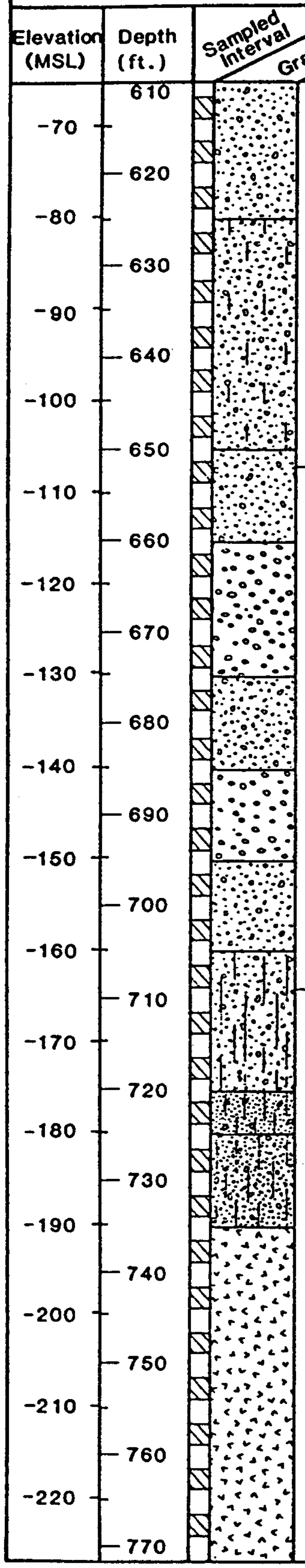
LOG OF DRILL HOLE S-18

FIGURE
2R-A-105

DRILL HOLE S-18 Page 5 of 6



Lithologic Description	Unit
Sandy GRAVEL, as above.	I-u ?
Sandy GRAVEL, with silt fragments. Sand fine- to medium-grained, mostly medium-grained; angular to subangular; 7-10% mafics.	
Sandy GRAVEL. Ferruginous stain at 650-655 ft. 60% basalt clasts.	I-b
GRAVEL. No matrix. Yellow sandy calcareous rinds on some clasts. 40-60% basalt.	
Sandy GRAVEL.	
GRAVEL. No matrix.	
Sandy GRAVEL.	
Silty sandy GRAVEL. Matrix light-gray. Sand fine- to medium-grained, fining with depth; angular to subangular; 2-20% mafics. Yellow sandy calcareous rinds. 60% basalt clasts.	Tem
Gravelly silty SAND. Very-fine- to fine-grained. 10-15% mafics. 80% basalt clasts.	
Silty sandy GRAVEL to gravelly silty SAND. Matrix light-olive-gray. 70% basalt clasts. Sand very-fine- to medium-grained, mostly fine-grained; angular to subangular; 20-25% mafics.	
BASALT. Weathered at 735-740 ft. Moderately fresh from 740 ft. downward.	

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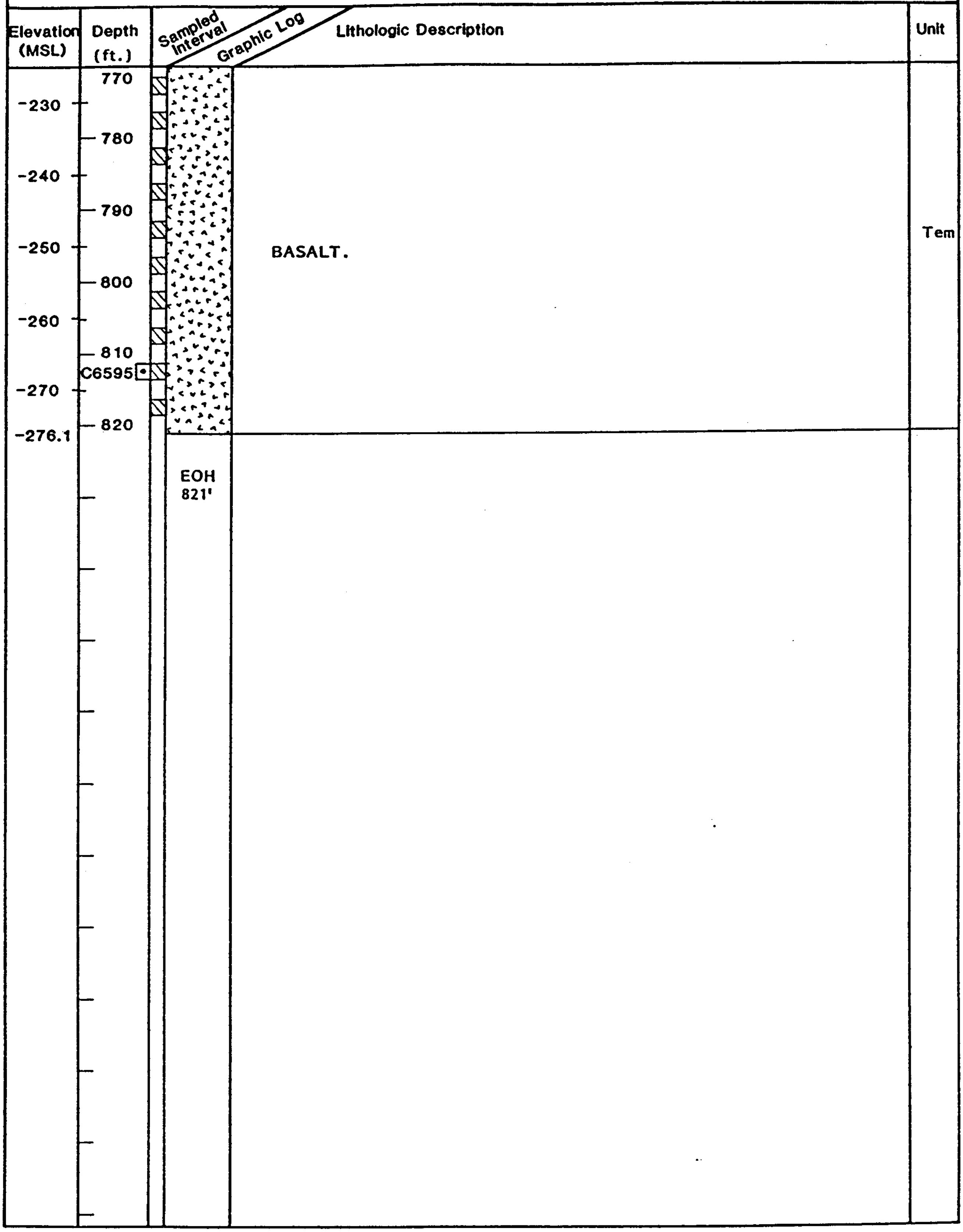
LOG OF DRILL HOLE S-18

FIGURE 2R-A-105

DRILL HOLE S-18

Page 6 of 6



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LOG OF DRILL HOLE S-18

FIGURE
2R-A-105

DRILL HOLE S-19

Page 1 of 5

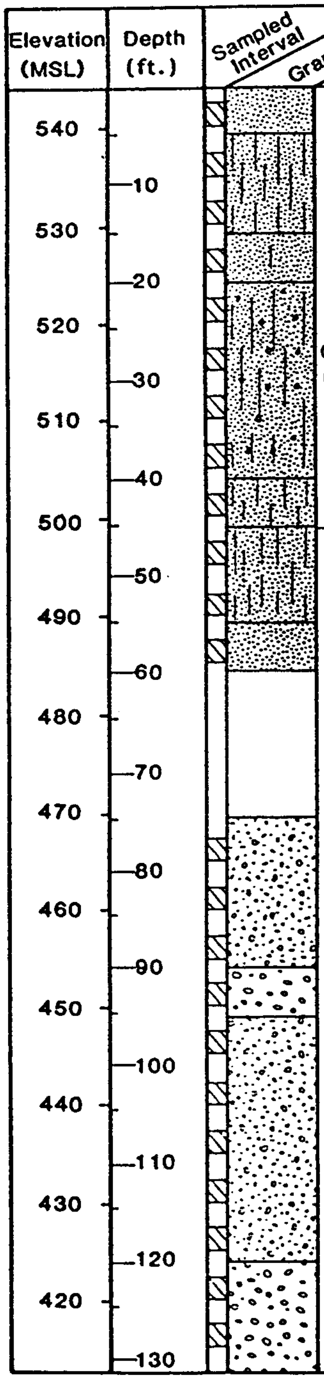
Project No : 803-1701H
Elevation : 544.8 ft.
Total Depth : 755 ft.
Coordinates : N415,760.59; E272,250.08
Date Completed : 5/3/81

SAMPLE TYPE

▨ Cuttings
95 ■ Core, Number Indicates % Core Recovery
C2015 ⊡ XRF, With Sample Number
Chemical Results Listed in Table 2R-1

Unit Column Refers to General Stratigraphic Divisions Identified Within the Site Area:

M - Missoula	IV - Ringold, Unit IV	Columbia River Basalt Group
PM - Pre-Missoula	III - Ringold, Unit III	Tem - Elephant Mountain Member
	II - Ringold, Unit II	Ter - Rattlesnake Ridge Interbed
	I-u - Ringold, Unit I-upper	Tp - Pomona Member
	I-b - Ringold, Unit I-basal	B - Basalt, Undifferentiated



Lithologic Description	Unit
SAND. Basaltic. Medium- to coarse-grained. Angular to subangular.	M
Silty SAND. Basaltic. Medium- to very-coarse-grained, mostly coarse-grained. Angular to subrounded.	
SAND. Medium- to very-coarse-grained, mostly coarse-grained. Trace silt. Basaltic.	
Gravelly silty SAND. Basaltic. Very-fine- to very-coarse-grained, mostly coarse- to very-coarse-grained. Angular to subrounded.	
Silty SAND. Very-fine- and medium- to very-coarse-grained, mostly very-fine- and very-coarse-grained. 55% mafics.	
Silty SAND. Light-olive-gray. Very-fine- to medium-grained. Angular to subangular. 40-45% mafics.	PM
SAND. Very-fine- to fine- and coarse- to very-coarse-grained. Angular to subangular. 50% mafics.	
No sample.	
Sandy GRAVEL. Sand very-fine- to fine- and coarse- to very-coarse-grained.	
GRAVEL. No matrix.	
Sandy GRAVEL. Basalt clasts. Sand very-coarse-grained; angular to subangular; 10-15% mafics.	
GRAVEL. No matrix. Thin weathering rind on basalt clasts at 120-125 ft.	

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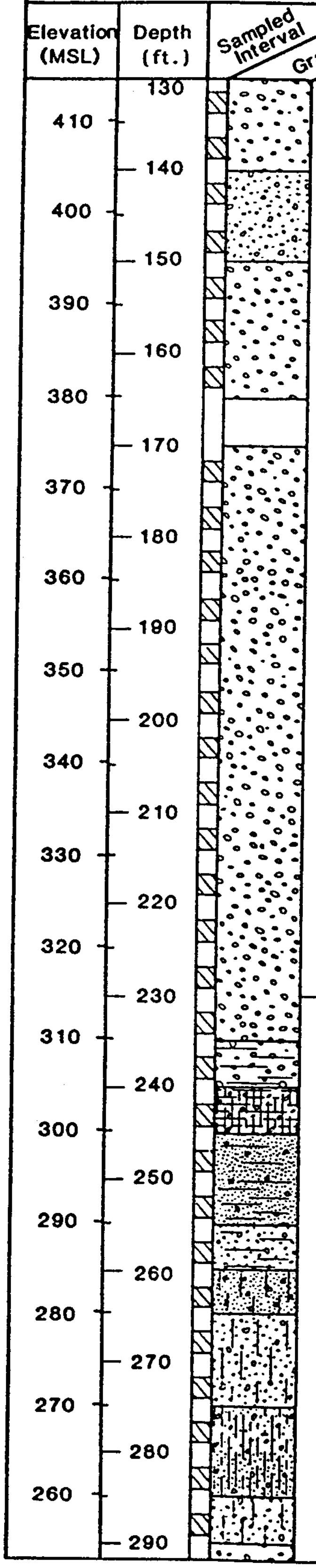
LOG OF DRILL HOLE S-19

FIGURE 2R-A-106

DRILL HOLE S-19

Page 2 of 5



Lithologic Description

GRAVEL. No matrix.

Sandy GRAVEL. Sand coarse- to very-coarse-grained.

GRAVEL. No matrix. No cement.

No sample.

GRAVEL. No matrix. No cement to 210 ft. Yellow sandy calcareous rinds on some clasts from 210 to 235 ft.

Unit: PM

Clayey GRAVEL. Matrix yellowish-gray.

Gravelly silty CLAY to gravelly clayey SILT. Yellowish-gray.

Gravelly clayey SAND. Yellowish-gray. Fine- to medium-grained. Angular to subangular. 1-2% mafics. Clay increases at 250-255 ft.

Clayey sandy GRAVEL. Sand fine-grained; angular to subangular; 3-5% mafics.

Gravelly silty SAND. Yellowish-gray. Medium-grained.

Silty sandy GRAVEL. Matrix yellowish-gray. Sand fine-grained.

Gravelly sandy SILT. Yellowish-gray. Sand fine-grained. Sand increases at 280-285 ft.

Silty sandy GRAVEL.

Unit: IV

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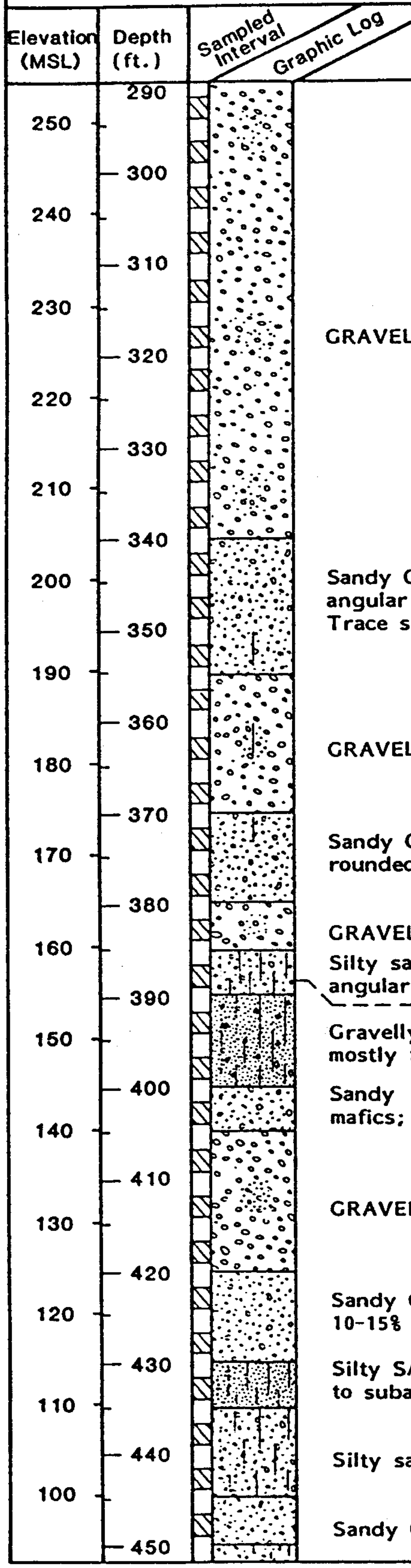
LOG OF DRILL HOLE S-19

FIGURE 2R-A-106

DRILL HOLE S-19

Page 3 of 5



Lithologic Description	Unit
GRAVEL. Trace sand. Yellow sandy calcareous rinds on some clasts.	IV
Sandy GRAVEL. Sand very-fine- to fine-grained, mostly fine-grained; angular to subrounded; 5-7% mafics. Yellow sandy calcareous rinds. Trace silt at 350-355 ft.	
GRAVEL. Trace sand. Trace silt at 365-370 ft.	
Sandy GRAVEL. Sand very-fine- to fine-grained; angular to subrounded; 5-7% mafics. Trace silt at 370-375 ft.	
GRAVEL. Trace sand.	
Silty sandy GRAVEL. Matrix medium-light-gray. Sand fine-grained; angular to subangular; 5-7% mafics.	
Gravelly silty SAND. Medium-light-gray. Very-fine- to fine-grained, mostly fine-grained. Angular to subangular. 5-7% mafics.	III
Sandy GRAVEL. Sand fine-grained; angular to subangular; 5-7% mafics; clean.	
GRAVEL. Trace sand. Yellow sandy calcareous rinds.	
Sandy GRAVEL. Sand very-fine- to fine-grained, fining downward; 10-15% mafics.	
Silty SAND. Light-olive-gray. Very-fine- to fine-grained. Angular to subangular. 20-25% mafics.	
Silty sandy GRAVEL. Silty sand as above.	
Sandy GRAVEL. Sand very-fine- to fine-grained.	

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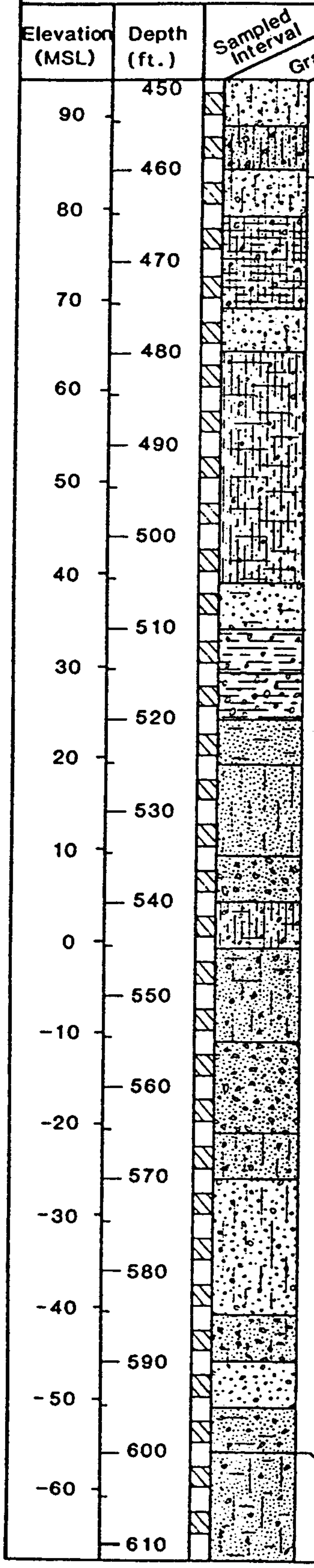
LOG OF DRILL HOLE S-19

FIGURE 2R-A-106

DRILL HOLE S-19

Page 4 of 5



Lithologic Description	Unit
Silty sandy GRAVEL. Sand very-fine- to fine-grained; angular to subangular; 20% mafics. Much pyrite.	III
Gravelly sandy SILT to gravelly silty SAND. Medium-light-gray. Sand very-fine- to fine-grained.	
Silty sandy GRAVEL.	II
Gravelly silty CLAY to gravelly clayey SILT. Medium-light-gray to light-olive-gray. Minor sand.	
Silty sandy GRAVEL. Pyrite.	
Gravelly sandy clayey SILT. Light-olive-gray. Clay fragments at 500-505 ft.	
Sandy GRAVEL, with clay fragments. Pyrite.	
Gravelly CLAY. Light-olive-gray.	
Sandy clayey GRAVEL to gravelly sandy CLAY.	
SAND, with tan and green clay fragments. Sand very-fine- to fine-grained; angular to subangular; 7-10% mafics.	
Silty SAND. Yellowish-gray. Very-fine- to fine-grained. Angular to subangular. 10-15% mafics.	
Gravelly SAND to sandy GRAVEL. Sand very-fine- to fine-grained; angular to subangular; 20-25% mafics.	
Gravelly sandy SILT, with clay fragments. Light-olive-gray.	
Gravelly silty SAND. Light-olive-gray. Very-fine- to fine-grained. Angular to subangular. 20-25% mafics. Clay fragments at 545-550 ft.	
Gravelly SAND to sandy GRAVEL. Sand very-fine- to medium-grained; angular to subangular; 30% mafics.	
Gravelly silty SAND. Very-fine- to medium-grained, mostly very-fine- to fine-grained; angular to subangular; 30% mafics.	
Silty sandy GRAVEL. Matrix increases with depth.	
Gravelly silty SAND to silty sandy GRAVEL. Sand very-fine- to medium-grained, mostly very-fine- to fine-grained; 25-30% mafics.	
Sandy GRAVEL.	
Gravelly SAND, with green clay fragments. Very-fine- to fine-grained. Angular to subangular. 5-7% mafics.	
Gravelly silty SAND, with clay fragments. Light-olive-gray. Very-fine- to medium-grained, mostly fine-grained. Angular to subangular. Clay slightly waxy and increases with depth.	I-u

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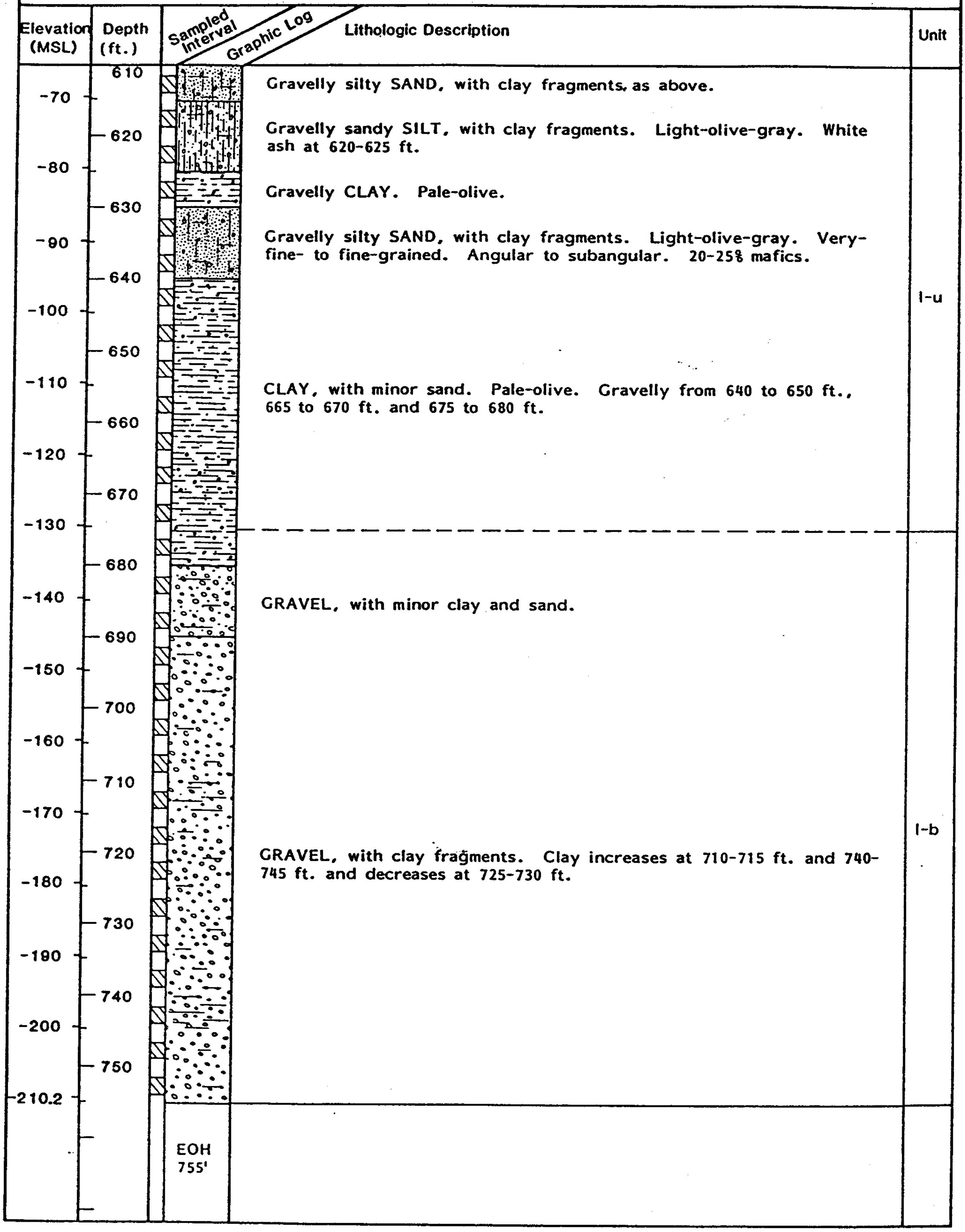
LOG OF DRILL HOLE S-19

FIGURE
2R-A-106

DRILL HOLE S-19

Page 5 **of** 5



Gravelly silty SAND, with clay fragments, as above.

Gravelly sandy SILT, with clay fragments. Light-olive-gray. White ash at 620-625 ft.

Gravelly CLAY. Pale-olive.

Gravelly silty SAND, with clay fragments. Light-olive-gray. Very-fine- to fine-grained. Angular to subangular. 20-25% mafics.

CLAY, with minor sand. Pale-olive. Gravelly from 640 to 650 ft., 665 to 670 ft. and 675 to 680 ft.

GRAVEL, with minor clay and sand.

GRAVEL, with clay fragments. Clay increases at 710-715 ft. and 740-745 ft. and decreases at 725-730 ft.

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LOG OF DRILL HOLE S-19

FIGURE
2R-A-106