81-176

Soils and Foundation Exploration:
Capitol Lake Restoration Project

Rittenhouse-Zeman & Associates

Geotechnical Engineering

SOILS AND FOUNDATION EXPLORATION
CAPITOL LAKE RESTORATION PROJECT

Prepared For

JONGEJAN GERRARD McNEAL, INC.
Bellevue, Washington
Project No. 299

And

STATE OF WASHINGTON
Department of General Administration
Division of Engineering and Architecture
Olympia, Washington
Agreement No. 81-176A

Prepared By

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Project No. W-3718

January 19, 1982

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19 January 1982 W-3718

Jongejan Gerrard McNeal, Inc., P.S.
23 - 103rd Avenue N.E.
Bellevue, Washington 98004

Attention: David McNeal, ASLA

Subject: Soils and Foundation Exploration
Capitol Lake Restoration Project
Olympia, Washington

Gentlemen:

In accordance with your request, Rittenhouse Zeman & Associates, Inc. is pleased to present the results of our soils and foundation exploration program at the above mentioned site. It is our understanding that current plans call for the utilization of this area as an in-basin disposal site for future dredging spoils from Capitol Lake, and as an eventual public recreation site.

We have enjoyed working with you and the entire Design Team on this project. The spirit of cooperation and interest throughout this project has made our design task considerably easier. This report summarizes the findings of our field investigation and engineering analysis of the site as well as our geotechnical recommendations concerning foundation support systems and earthworks design for the proposed development.

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RITTENHOUSE-ZEMAN & ASSOCIATES, INC.
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CAPITOL LAKE RESTORATION PROJECT
SOILS AND FOUNDATION EXPLORATION

I. EXPLORATION AND GEOLOGY

1.0 INTRODUCTION

1.1 Objectives and Scope of Work - This project concerns itself with the disposal site for hydraulic dredge spoils generated by periodic cleaning of sedimentation basins in the Upper and Middle Basins. Furthermore, current plans call for the disposal area, commonly known as the Middle Basin Restoration Site, to be reclaimed for use as a public recreation site.

The purpose of this study was to provide the geotechnical assessments and recommendations necessary for the development and design of the site. At the time our exploration was started, our design tasks included the boat launch and dock, north wier, habitat island, foot bridge, south wier, primary and secondary berms, existing dike, heavy equipment access road, and fishing dock. Filling, preload design, pile design, settlement and stability analyses for the restroom and interpretative center were later added.

Geotechnical recommendations and assessment of the proposed structures include allowable bearing capacities, settlement estimates, preload design, and pile recommendations. Considerations of the proposed earthworks include base and slope stability analyses, allowable slope angles, compaction requirements and expected settlements beneath the berms.

In order to facilitate the study, the work was divided into a multi-phased program.

1. Geology - An investigation was undertaken in order to develop an overview of the geology and recent history of the area. In addition, an extensive subsurface exploration program was undertaken in order to ascertain site-specific soil conditions relative to the engineering analysis of this project.

2. Engineering Analyses - Detailed testing was performed, on select representative samples, in order to classify the materials encountered as well as to determine specific engineering parameters. Concurrent with the testing program, engineering analyses were performed in order to evaluate various geotechnical aspects of the project.

The above mentioned phases will be discussed in-depth within the text of this report.

1.2 Background - The proposed project, known as the Capitol Lake Restoration Project, is situated in the southerly portion of Capitol Lake and is located within the cities of Olympia and Tumwater, Washington. Figure 1 illustrates the approximate present extent of the lake from 5th Avenue south to Interstate 5. The lake, formerly the Deschutes River basin, was formed in 1951 by the construction of the 5th Avenue Bridge/dam which now separates the lake from Budd Inlet to the north.

Other shoreline changes are evident by a comparison of the present lakeshore to the former lakeshore (circa 1873) shown on Figure 2. In addition to the bridge at 5th Avenue, and filling for the Interstate 5 bridge, other notable changes include the enclosure of Percival Core formed by the construction of the Deschutes Parkway and the extention of Percival Point just north of the Cove.

The current shoreline configuration effectively divides Capitol Lake into three adjoining basins: the Lower Basin which encompasses the area from the 5th Avenue Bridge south to the Percival Park railroad bridge; the Middle Basin which includes the area from the railroad bridge south to the Interstate 5 bridge; and the Upper Basin which continues from this point south to Tumwater City Park.

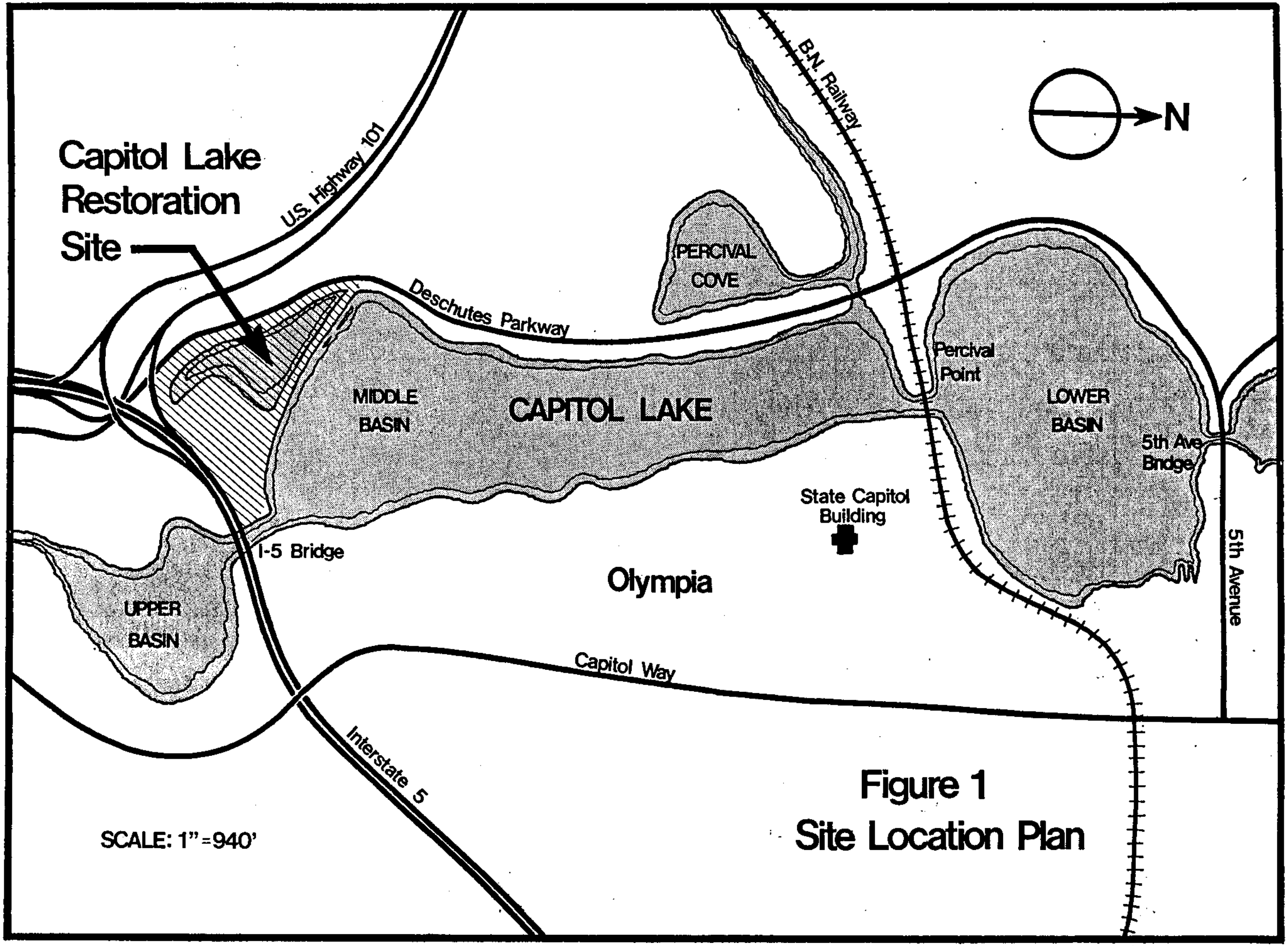


Figure 1
Site Location Plan

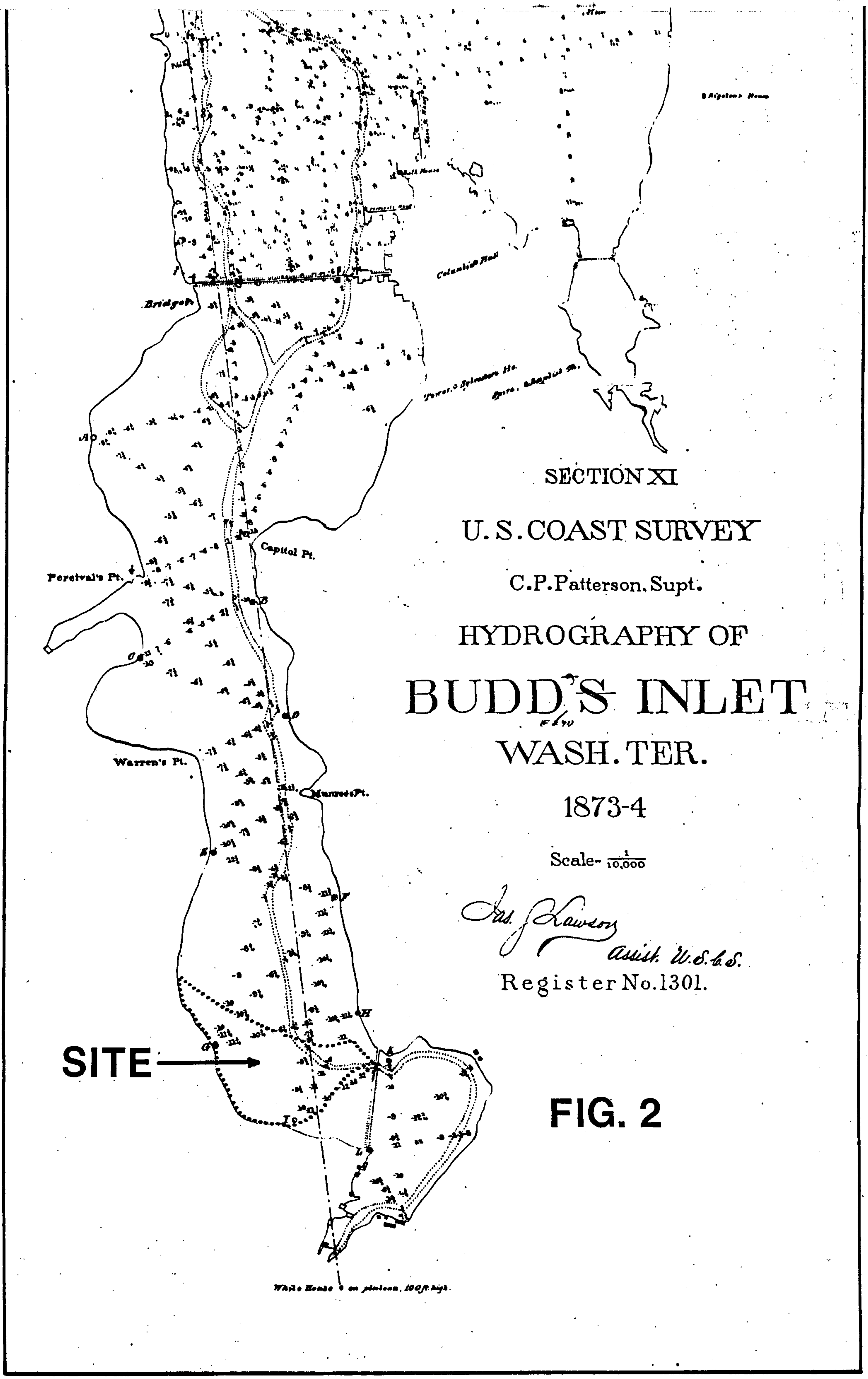
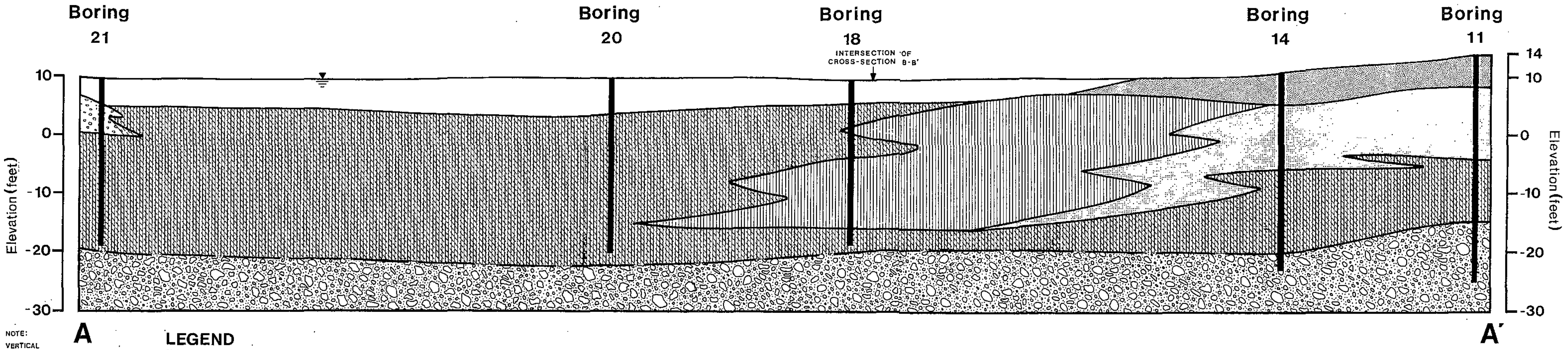
SECTION XI
U.S. COAST SURVEY
C.P. Patterson, Supt.
HYDROGRAPHY OF
BUDD'S INLET
WASH. TER.
1873-4
Scale- $\frac{1}{10,000}$
Jas. J. Lawson
Assist. U.S.C.S.
Register No. 1301.
Bigelow's House
Columbia Hall
Tower's Sylvester Ho.
Bridge
Capitol Pt.
Percival's Pt.
Warren's Pt.
Munroe's Pt.
SITE
White House on plateau, 100 ft. high

FIG. 2

GEOLOGIC CROSS~SECTION A-A′
CAPITOL LAKE RESTORATION PROJECT



NOTE:
VERTICAL
SCALE
EXAGGERATED

LEGEND

- ▒ FILL. MEDIUM DENSE, MOIST, BROWN SAND WITH SOME GRAVEL AND TRACE SHELL FRAGMENTS
- ☐ HYDRAULIC FILL. SILTY, DARK GREY SAND.
- ▥ HYDRAULIC FILL INTRUDING INTO NATURAL MATERIAL. MEDIUM DENSE, SATURATED, GREY SILT
- ⁘ ROAD FILL. LOOSE, SATURATED, GREY, FINE TO COARSE SAND WITH GRAVEL.
- ▧ MEDIUM DENSE, SATURATED, GREY, SILT TO CLAYEY SILT. SOME SHELL FRAGMENTS, ORGANICS, AND INTERBEDS OF SILTY SAND.
- ⁙ MEDIUM DENSE, SATURATED, GREY, COARSE SAND GRADING TO GRAVEL.
- ▼ WATER LEVEL AT TIME OF EXPLORATION PROGRAM.

FIG. 3

0 50 100
HORIZONTAL SCALE IN FEET

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DATE DEC 1981
BY RL
SCALE AS NOTED

This report addresses the geotechnical considerations for that portion of the lake known as the Middle Basin. This area is bounded to the east and south by Interstate 5 and to the west by the Deschutes Parkway. A northwest to southeast trending dike, constructed to contain spoils from the 1978 dredging program, separates the site from the remainder of the Middle Basin.

2.0 EXPLORATION PROGRAM

2.1 Subsurface Exploration - Borehole exploration of the proposed site was performed between 7 October and 17 October 1981 under the full-time inspection of our Field Engineers. A total of 22 borings were drilled using truck- and barge-mounted, hollow-stem augers. The approximate locations of these borings, relative to the Middle Basin Restoration Site, are shown on Figure A-1 included in the Appendix at the end of this report. Representative samples were collected during the exploration at selected intervals and at principal strata changes. Jar samples of disturbed materials from a "split spoon" sampler, as well as Shelby tubes of "undisturbed" materials were recovered from the boreholes.

In conjunction with split spoon sampling Standard Penetration Tests (SPT) were performed and recorded during the drilling program. This test consists of recording the number of blows required to drive the 2-inch diameter split spoon sampler 12 inches using a 140-pound hammer, falling 30 inches. The data gathered is utilized in determining the relative density and/or consistency of the material sampled.

Vane shear tests were performed in 9 of the boreholes in order to determine the in situ shear strength of the silts present in critical areas of the site. The test device consists, essentially, of a 6-inch long, 4-blade vane affixed to the drill rod. After being advanced to a selected depth, the vane is rotated until failure of the soil occurs; i.e., negligible resistance to further rotation. The maximum torque resistance recorded is then correlated to undrained, in situ, shear strength.

Boring logs, with detailed descriptions of the materials encountered, are included at the end of this report. In addition to indicating sample or vane shear test locations, a profile of SPT results with depth are plotted on the right side of the boring log.

2.2 Laboratory Investigation - Representative jar samples of the materials encountered during the exploration program were taken to our laboratory for reinspection and classification testing. Select "undisturbed" Shelby tube samples of the soft silts encountered during the field exploration were subjected to a more intensive testing program in order to determine index and classification characteristics as well as specific geotechnical parameters pertinent to our engineering analysis. It is our opinion that the engineering properties of the "fine-grained" materials encountered during the exploration will be most critical to the design and construction of the proposed project.

2.2.1 Index and Classification Testing - Index and classification testing of the "fine-grained" silts and clays include unit weight, natural water content and void ratio determinations as well as Atterberg Limits tests. The void ratio is defined as the ratio of void volume to solid volume in a soil mass and is related to water content, degree of saturation and specific gravity of the material. The Atterberg Limits are the water contents which define the boundaries between the "liquid" and "plastic" states and between the "plastic" and "semi-solid" states. The Limits are utilized to classify fine-grained soils and can be correlated with other engineering properties.

2.2.2 Additional Testing - Representative samples of the silts were subjected to further testing in order to determine specific consolidation properties. Consolidation characteristics of the silts, determined using a fixed-ring consolidometer, are utilized in estimating the magnitude of settlements as well as the time required for consolidation to occur.

The shear strength of the silts was determined in a multi-phased program which utilized direct shear, unconfined compression and triaxial compression tests. Each type of test was selected to model specific modes of failure. The direct shear test imposes on a soil an idealized condition; that is, the failure plane is forced to occur along a predetermined horizontal plane. The unconfined compression test imposes an axially applied load on a cylindrical specimen and is utilized in estimating the in situ shear strength of the material. More sophisticated, the triaxial compression test provides the option to apply a confining (and consolidation) pressure to the sample as well as to monitor the pore pressures generated during failure.

3.0 GEOLOGY AND SUBSURFACE CONDITIONS

3.1 Regional Geologic Overview - The Deschutes River, which enters Capitol Lake to the south, presently drains approximately 162 square miles of surrounding countryside. With the exception of recently placed fills, such as the dike and interstate highway embankment, the majority of the near-surface materials at the site consist primarily of accumulated sediments borne by the Deschutes River. Coarse, granular sediments are deposited initially as the river enters the wide Upper Basin area due to a significant decrease in stream velocity. Lighter, fine-grained sediment and organic material remain in suspension longer to be deposited in the Middle and Lower Basins. Additional sediments are eroded from the banks of the lake by wave action and storm runoff.

Much of the sediment load carried by the river is derived from reworked alluvial flood plains consisting of detritus, peat, silts, sands and gravels. However, much of the reworked sediments originate from the glacial deposits of the Vashon Stade of the Fraser Glaciation, which was the last glacier extending into the southern Puget Sound lowland. The glacier probably began, early in Wisconsin Time (late Pleistocene), advancing from its area of accumulation in British Columbia. The advancement of the glacier blocked northward flowing rivers, causing a large lake and related flood plains to form in the central part of the lowland that drained southward into Gray's Harbor through the lower Chehalis Valley. Sediments carried into this lake and flood plain, consisted of large quantities of silt, sand and clay, forming what is currently termed the Kitsap Formation. As the glacier advanced southward, meltwater from the icesheet and ice-marginal streams deposited thick accumulations of medium to coarse grained sand, forming the current Colvus Sand Formation, (Nobel and Wallace, 1966).

As the Vashon Glacier advanced further southward, it eroded large portions of the proglacial sediment, redepositing much of it further south as advance outwash. Sediments which were not eroded and carried were over-ridden and greatly consolidated by the weight of the icesheet. Sediments that had been transported by the progressive ice sheet were deposited as a non-sorted, non-stratified unit over the proglacial sediments. This material, termed Vashon Till, is very compact due to the high consolidation effect of thousands of feet of ice. The till can be found mantleing the hillsides and occasionally the sides of valleys throughout the Puget Sound today (Leish and others, 1963; Nobel and Wallace, 1966).

At the time of this maximum extent (approximately 15,000 years ago) the Vashon Glacier consisted of two distinct ice lobes, termed the Olympia (western), and Yelm (eastern). The terminus (farthest reach) of these lobes is presently not in agreement, however, the general area appears to be the southern end of Thurston County. With further recession of the glacier to beyond Johnson Point, a large single lake termed Glacial Lake Russell (Bretz, 1913), was formed. This lake drained through the Black River outlet from Budd and probably Eld Inlets. The lake was fed by the ice to the north and by the Deschutes and Nisqually River to the south (Nobel and Wallace, 1966). Increased recession of the Vashon Glacier allowed Lake Russell to drain through the Strait of Juan De Fuca. Lowering of Lake Russell also allowed continued canyon-cutting by the Deschutes River through easily removed recessional sediments. The continued drainage of Lake Russell also allowed marine water to enter the gorge cut by the Deschutes River, forming the Budd Inlet and creating an estuary in the Capitol Lake Basin area. With the completion of the Fifth Avenue Bridge/dam across the estuary in 1951, the present-day Capitol Lake environment was established.

3.2 Site Specific Subsurface Conditions

3.2.1 Pre-filling Site Conditions - Prior to construction of the existing dike the site consisted primarily of deposited sediment load from the outflow of the Deschutes River. These materials included interlying finer sediments consisting of silty clays, clayey and sandy silts, and silty sands underlain by coarser silty to slightly silty sands and gravels. Organic materials were also present in varying quantities. The locations and stratigraphy of these deposits were predominantly dependent upon the flow patterns and energy environments existing within the lake at the time of deposition.

3.2.2 Existing Site Conditions - At the present time the dry land southeast of the existing dike is relatively flat and slopes gently towards the west into a shallow pond which covers most of the remainder of the site. The highest point of the site in the easternmost portion of the area is approximately level with the top of the dike. Currently, the site is covered with various grasses and brush as well as some conifer and deciduous trees. Water depths within the pond, at the time of the exploration program, ranged from 2.5 to 6.5 feet.

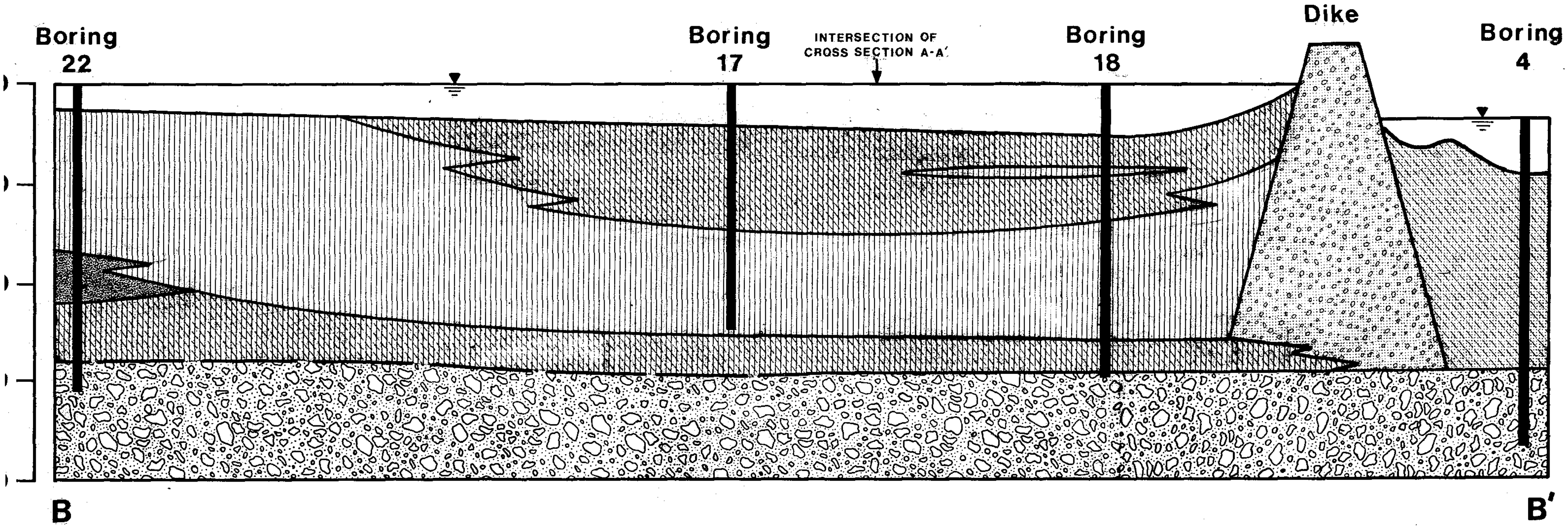
It is our understanding that the dike was constructed as part of the 1978 dredging program and that the silty sand and gravel fills were end-dumped and placed by dozer "in-the-wet" without further compaction. Our exploration indicates that these coarser, more dense materials apparently mixed with and displaced a majority of the underlying soft fine-grained sediments. It is believed that at most locations within the dike, fill materials extend to the underlying sands and gravels trapping discontinuous pockets of the softer surficial materials. As a result of the dike construction, "mud waves" currently exist along the northwest portion of the dike. These features are surface expressions of the displaced silts and indicate that the soft underlying materials failed locally under the weight of the dike fills. Larger scale failures are apt to involve greater volumes of the soft foundation silts.

The construction of the dike separated the present-day site from the Middle Basin of Capitol Lake and essentially contains dredge spoils removed from the main body of the lake. It is our understanding that the dredge spoils were hydraulically discharged into the eastern portion of the site. Based on the results of the exploration program it appears that, with the exception of isolated pockets, most of the coarse-grained fraction of the hydraulic dredge slurry, i.e., the sand and gravel, settled out in the immediate vicinity of the outflow. The finer silts and clays settled out last, in order of density and particle size, further west and southwest of the discharge point. As mentioned previously, these suspended materials, similar in appearance to the natural materials, apparently intruded into and intermixed with the pre-fill sediments creating the present-day conditions. Generally, the fine-grained silts and clays encountered within the area contained by the dike are soft to very soft in consistency. Specific geotechnical characteristics are discussed in greater detail in Section 3.3.

Organic matter and/or shell fragments were encountered throughout the pond area. With the exception of isolated pockets, the organic content appears to decrease with depth. Figures 3 and 4, geologic cross-sections through the site, present conceptually, the result of the sequence of events discussed above and illustrate an interpretation of the existing site conditions. Detailed descriptions of the materials encountered during the drilling are presented in the boring logs, included in the Appendix at the end of this report.

In the eastern portion of the site the soft silts are overlain by about 5 to 25 feet of silty, gravelly sands as shown in Figure 3. It is our understanding that these materials were end-dumped over the hydraulic fills. As indicated in the cross-sections, the soft, fine-grained sediments and hydraulic fills are underlain by medium dense to very dense sands and gravels, encountered in the borings at depths ranging from 20 to 30 feet below the present mudline.

GEOLOGIC CROSS-SECTION B-B'
CAPITOL LAKE RESTORATION PROJECT



LEGEND

- ▥ HYDRAULIC FILL INTRUDING INTO NATURAL MATERIAL. MEDIUM DENSE, SATURATED, GREY SILT
- ░ DIKE FILL. VERY LOOSE TO MEDIUM DENSE, SATURATED, TAN, FINE TO COARSE GRAVELLY SAND
- ▒ VERY LOOSE, SATURATED, GREY, SILTY SAND WITH SILT INTERBEDS.
- ■ LOOSE, SATURATED, GREY, SILTY SAND WITH ORGANICS
- ▨ MEDIUM DENSE, SATURATED, GREY, SILT TO CLAYEY SILT. SOME SHELL FRAGMENTS, ORGANICS, AND INTERBEDS OF SILTY SAND.
- ▩ DENSE, SATURATED GREY, COARSE SAND GRADING TO GRAVEL.
- ▼ WATER LEVEL AT TIME OF EXPLORATION PROGRAM.

FIG. 4

0 50 100
HORIZONTAL SCALE IN FEET

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BY RL SCALE AS NOTED

As illustrated by Figure 4, (and mentioned previously), it is believed that the dike fill materials extend, in most locations, to the deeper underlying sands and gravels trapping discontinuous pockets of the soft sediments. North of the dike, within the Middle Basin, the surficial materials encountered consisted of varying thicknesses of interlying soft to very soft silts, sandy and clayey silts and very loose silty sands underlain by medium dense to very dense sands and gravels encountered at about 20 to 30 feet below the present mudline. The sand content of the surficial sediments in this area appeared to be greatest at the center of the dike, in the location of Boring 4, whereas, the silt and clay content increases laterally east and west along the dike.

3.2.3 Hydraulic Conditions - Lake level of the Middle Basin was at about Elevation 6 at the time of the investigation; from 3.5 feet above mudline along the westerly portion of the dike deepening to 8 feet along the easterly portion of the dike. It is our understanding that the lake level is periodically lowered through the control gates at the 5th Avenue dam. Water level within the pond, at Elevation 10, was from 2.5 to 6.5 above mudline. The difference in water levels indicates that the dike fill materials contain a sufficient quantity of "fines" to inhibit a free flow of water across the dike. At the time of the investigation the easterly portion of the site was from 2 to 4 above the pond level, based on the latest topographic survey.

During the drilling program artesian water conditions were encountered at Borings 4 and 5 in the Middle Basin in the vicinity of the center of the dike. Artesian conditions indicate that the water-bearing stratum (which is capped by an impermeable layer) drains an area which is at a higher elevation than the lake. These conditions produced a differential pressure head of approximately 6 feet above the existing lake level.

3.3 Material Parameters

3.3.1 Classification and Index Properties - In general, the fine-grained, near-surface, sediments encountered during the exploration were found to be silty sands to sandy clayey silts with some silty clays.

Atterberg Limits summarized on Figure A-2 indicate that of the silts and silty sands encountered north of the existing dike, the finer materials were predominantly slightly plastic to plastic sandy, clayey silts. (Note: figure and table designations beginning with "A-" can be found in the Appendix). The Limits, when correlated to the Unified Soil Classification System, indicate that these soils can be designated as ML to MH. Table A-1 following Figure A-2, provides "typical" qualitative descriptions for soils corresponding to the Atterberg Limits designations. Figure A-3 summarizes the results of a hydrometer analyses performed on these silts and indicates that these soils have an average clay content on the order of 20%.

Of the soils encountered within the pond south of the dike, the fine-grained materials were examined and classified as primarily sandy, clayey silts with some silty clays containing varying percentages of organic matter. The Atterberg Limits of these materials, summarized on Figure A-2, indicate that they are somewhat more plastic with Unified Classification System designations ranging from MH and OH to CH.

In addition to soil classification, the results of other geotechnical testing are presented in Table 1, contained within the text. It was found that the saturated unit weight of the fine-grained sediments ranged from 86.4 to 101.6 pounds per cubic foot. The void ratio, i.e., the ratio of void volume to solid volume, varied from 1.60 to 2.30. The materials examined were found to have an average degree of saturation of 100% with natural water contents ranging from a low of 62.6% for some of the silts to as high as 112.2% for the silty clays. In addition, the natural water contents were found to consistently exceed the liquid limit results by 8 to 33 percent.

Table 1.
Laboratory Testing Summary

Boring No.	Sample No.	Depth Below MudLine (ft)	Soil Classification	Sat. Unit Weight (pcf)	Void Ratio	Water Content (%)	Atterberg Limits		Consolidation Chracteristics		Strength Parameters
							PI	LL	C_{ce}	C_v (cm^2/sec)	
B-3A	S-2	11.5 to 13.5	Gray, clayey, sandy SILT with sand lenses, trace organics (MH)	99.8	1.60 (Approx)	62.6 to 64.1	22	56			
B-3A	S-3	13.5 to 15.5	Gray, clayey, slightly sandy to sandy SILT (ML)	101.6	1.91	71.4 to 75.0	17	47			C = 175 psf (UU,DS)
B-3A	S-4	15.5 to 17.5	Gray, clayey, sandy SILT, trace organics (MH)	97.0	1.83 to 2.17	72.1 to 79.8	27.5	65.5		1.59×10^{-4} to 7.70×10^{-4}	$\phi = 18^0$, C = 85 psf (CU,DS)
B-4	S-3	15.5 to 17.5	15.5 to 16.7 Gray, clayey SILT with sand lenses, trace organics 16.7-17.5 Gray medium SAND	103.4 (overall)	1.51 (overall)	61.7					C = 100 psf (UNCON) @ 16.0 - 16.5
B-17	S-3	16.5 to 19.0	Gray, clayey, slightly sandy SILT, trace organics (MH)	96.3	1.79 to 1.99	69.3 to 77.0	26.5	64	0.075	9.7×10^{-4} to 2.34×10^{-3}	C = 240 psf (UNCON) $\phi_T = 19^0$, $\phi' = 23.5^0$, C = 0 ($\overline{\text{CU}}$,TRX)
B-18	S-3	13.0 to 15.5	Gray, clayey SILT with organics (MH to OH)	95.4	1.94	70.0 to 75.0	21	54	0.075	8.47×10^{-4} to 1.26×10^{-3}	C = 190 psf (UNCON)
B-20	S-2	7.0 to 9.5	Gray, slightly sandy silty CLAY, trace organics (CH)	86.4	2.74	98.0 to 112.2	36	83.5			$\phi = 23^0$, C = 55 psf (UU,DS)
B-20	S-3	9.5 to 12.0	Gray, clayey, slightly sandy SILT, trace organics (MH)	92.0	2.1 to 2.3	75.3 to 91.3	28	58			C = 95 psf (UCON) @ 10.5 - 11.0 C = 110 psf (UCON) @ 11.5 - 12.0

LEGEND:

Consolidation Testing

C_{ce} : Modified Compression Index
C_v : Coefficient of Consolidation

Shear Strength Testing

UU: Unconsolidated, Undrained, CU: Consolidated, Undrained
$\overline{\text{CU}}$: Consolidated, Undrained With Pore Pressure Measurements
DS: Direct Shear Test, UNCON: Unconfined Compression Test, TRX: Triaxial Compression test

ϕ : Angle of Internal Friction (ϕ' : Effective Stress, ϕ_T : Total Stress)
C : Cohesion

3.3.2 Consolidation Characteristics - Additional testing was performed on the sediments encountered in the middle of the pond in order to estimate settlements which will be generated within the underlying silts by construction of the primary landscape berm. The results of these tests, performed on select samples from Borings 17 and 18, are presented on Figures A-4 and A-5 respectively.

The Modified Compression Index (C_{ce}) of these silts was found to be on the order of 0.075 as shown in Table 1. This parameter is utilized in estimating the magnitude of consolidation settlements.

The rate at which consolidation can be expected to occur is related to the coefficient of consolidation (C_v). Consolidation test results indicate that the silts in the vicinity of the primary berm, have an average coefficient of consolidation on the order of 1.06×10^{-3} centimeters squared per second (cm^2/sec). Test values ranged from 1.59×10^{-4} to 2.34×10^{-3} cm^2/sec as summarized in Table 1.

3.3.3 Shear Strength Parameters - Undrained direct shear tests were performed on the silts encountered both north and south of the existing dike in order to determine the shearing resistance of these materials along a horizontal plane. The results of both consolidated and unconsolidated tests are shown on Figures A-6 through A-8 and are also summarized in Table 1.

The unconfined compression tests on the soft silts encountered in critical areas indicate cohesion values ranging from 95 psf in the vicinity of the proposed habitat island to 240 psf at the location of the proposed primary berm. Stress-strain relationships for these tests are illustrated on Figure A-9. In addition, the cohesion values, numerically equal to one-half the applied axial stress, are summarized in Table 1.

At the time of our subsurface exploration, field vane shear tests were performed in order to estimate in situ, undrained, shear strengths. Figure A-10 presents a comparison between the results of the unconfined tests and the vane shear tests. This figure indicates that the unconfined shear strengths determined in the laboratory are in good agreement with the lower bound of these strengths obtained from the field vane shear tests.

A triaxial compression test was performed in order to model the in situ conditions which will be generated beneath the primary landscape berm. Pore pressures generated during shear were monitored in order to determine effective and total stress strength parameters. The results of a consolidated undrained triaxial test are summarized on Figure A-11 and indicate that the silts encountered in the center of the pond possess no cohesion and have an effective angle of internal friction of 23.5^{0} and a total friction angle of 19^{0}. As with the other test results, these strength parameters are summarized in Table 1.

II. DESIGN CONSIDERATIONS

4.0 GENERAL

It is our understanding that the site will be utilized as a combination park and dredge spoils area. Two settlement ponds will be constructed and will serve to collect soils hydraulically dredged from sediment traps in the Upper and Middle Basins of Capitol Lake. The primary pond will be constructed so that a bottom elevation of 6.0 feet can be maintained. Because this elevation is above that of the Middle Basin, total drainage of the dredge spoils is theoretically possible. Earthmoving equipment will then be employed to remove the accumulated material. Finally, the remainder of the site will be used as a recreation area for various land and water sports.

5.0 RESTROOM AREA

5.1 General - Support for the restroom and adjacent interpretative center may be obtained by either of two methods. The area may be "preloaded" and support obtained by the use of spread footings, or all the structures may be supported by piling. Piling may be somewhat more expensive but does have the advantage of providing building support with very little settlement. Installation time for piling is also very short compared to the 4-month preloading period anticipated.

5.2 Site Preparation - Site preparation in the restroom area should consist of stripping all organic topsoil and larger masses of organic debris. In all locations where vehicular traffic is permitted or non-pile supported structures are to be built, the upper 3 feet of soil must consist of compacted structural fill. In areas where more than 3 feet of fill must be placed, this is not a problem; however, for areas which are at or within 3 feet of desired grade, overexcavation will be necessary. Since the existing fill and dike are not at recommended compaction, overexcavation and recompaction are essential in these areas as well.

After overexcavation has been performed to the satisfaction of the Soils Engineer, structural fill may be placed to attain desired grades. Fill must be placed in 8-inch lifts and compacted to 90% of the laboratory maximum density using ASTM:D-1557 as the standard. Compacted fill pads under structures must extend a minimum of 10 feet beyond the perimeter of the structure. Onsite soils which do not contain organics or debris may be used in compacted fills, however, if they contain sufficient quantities of silt and clay, compaction will be difficult or impossible if they are more than a few percent above their "optimum moisture content". If fill is to be placed during wet weather or where moisture can be drawn up from below, a select material should be used. Of the material passing the Number 4 sieve, not more than 5% by weight should be finer than Number 200 sieve.

Due to the soft nature of the underlying silts, any fill which is placed to attain grades will cause settlements. We anticipate that 12 to 18 inches of total settlement will occur during the first 2 years under fills on the order of 10 to 12 feet in thickness. Additional fill should be placed so that initial grades are above finish grades to accommodate consolidation of the soft silts. Additional long-term settlements are not expected to exceed 2 to 4 inches. It should be noted that preloading will greatly reduce the time required for these settlements to occur. This would permit construction to proceed much sooner after filling.

If fill is to be placed on slopes steeper than 5H:1V, proper keying and benching must be used. In addition, all fill should be placed under the observation of the Soils Engineer or his representative who is qualified to make engineering decisions in the field.

5.3 Preloading - If piling is not chosen for support of the restroom, we recommend that preloading be used to reduce the amount of anticipated post-construction total and differential settlement. Generally, except in the case of lightly loaded structures with heavy preloads, it does not eliminate all long-term settlement but places it within a more acceptable range. Since a portion of the soils beneath the site consist of silts and clays, settlements will occur over a long priod of time.

With any preloading program, the amount of post-construction settlement to be expected depends on several factors including the following: 1)height of preload; 2)time of preloading; 3)subsurface soil characteristics; 4)anticipated building and site loads. Ideally, a preload should be considerably heavier than any anticipated long-term site load and left in place for an extended time period. Within limits, the greater the preload intensity, the less time is required.

Considering the proposed construction schedule, as well as the volume of material to be moved on the site, we recommend that at least 3 to 4 months be specified for preloading. Soil used for preload and structural fills should be comprised of the same material so that as settlement occurs, the top of the fill will remain suitable for building support. Initially, the top of the preload portion of the fill should be at least 4 feet above the final floor grade for the restrooms.

With the above surcharge, the anticipated long-term (10 years) settlements should be less than 2 inches. We anticipate that much of the settlement will occur as a gentle site warping rather than sharp differential movement.

5.4 Spread Footing Alternative - Shallow spread footings may be used for building support when founded on preloaded, compacted structural fill. An allowable bearing pressure of 1500 psf may be utilized for design purposes. Perimeter footings should extend at least 18 inches into the surrounding soil for frost protection. Interior footings need only extend 12 inches below grade. All footing should have a minimum width of 12 inches. Since the site will still be subject to some long-term settlements, it is suggested that all foundations be heavily reinforced.

Anticipated settlement of footings was discussed above in Section 5.3. In addition to these, disturbed soil not removed from footing excavations prior to pouring concrete, could result in increased settlements. All footing excavations should be inspected by the Soils Engineer prior to pouring concrete to determine if adequate bearing has been achieved.

5.5 Pile Support Alternative - Steel pipe piles are suitable for support of the restroom and adjoining patio/information center. When seated in the underlying dense gravelly sands at 35 to 40 feet below existing ground surface, piles should be capable of supporting loads on the order of 35 tons per pile. This value includes a substantial allowance of "downdrag" forces on the pile shaft due to long-term site settlements. If non-displacement piles (such as H-piles) are used for support, the length required to obtain the stated capacity may be longer than the range given above because of the lower penetration resistance of this type of pile. As such, we recommend that the piling contractor be prepared to drive longer piles if necessary. This will likely require that the piling contract be set up on a unit price basis so that length adjustments can be made as necessary during installation. The capacities given here are based on HP-8x8 H-piles or 10-inch diameter pipe piles.

Driving should be performed with an air, stream, or diesel hammer developing a minimum of 19,000 foot-pounds per blow. Because of the downdrag on the piles due to the soft silts, piles will have to be driven to a total capacity of 50 tons. All piling should be driven under the full-time supervision of the Soils Engineer or his representative who is able to determine in the field when adequate penetration and resistance has been achieved. It should be understood that the lengths given above are only approximate; actual lengths will be determined during installation as mentioned above.

5.6 Floors - A slab-on-grade floor may be used over preloaded, structural fill. The floor should be cast atop a minimum of 4 inches of clean, free-draining sand or pea gravel. It should also be protected from dampness by an impervious moisture barrier. If the building is pile supported, a structural floor must be used, as the underlying soils and fill will settle as discussed in Section 5.2. In addition, a flexible entrance ramp would be in order, to accommodate the handicapped.

5.7 Utilities - For pile supported structures, care must be taken in the design of utility lines. Since lines will tend to settle with the surrounding soil, they should not run through pile supported foundations. It would be appropriate to use some form of flexible connection where utilities connect to the structure.

5.8 Ground and Surface Water Management - Ground water is not expected to cause problems in the restroom area. As such, footing drains are not necessary.

However, exterior grades adjacent to walls should be sloped away from the building to achieve surface drainage and roof runoff should be directed away as well.

6.0 EXISTING DIKE AREA

6.1 Site Preparation - We understand that the paved path along the dike will be used by grounds maintenance vehicles as well as foot traffic. For this reason, its base must be designed to support these heavier loads. As the existing compaction of the dike is less than the recommended 90% of ASTM:D-1557, it must be overexcavated and recompacted. We recommend that a minimum of 12 inches be overexcavated and recompacted to the 90% specification. The overexcavation, and recompaction (in 6-inch lifts) should be supervised by the Soils Engineer or his field representative. The final paving course must be underlain by 2 inches of crushed rock to form a free-draining subbase.

6.2 Stability of Existing Dike - Slope failures along a dike can occur in almost every conceivable manner, slowly or suddenly, and with or without any apparent provocation. Failures can be caused by insufficient compaction and/or an increase in the pore water pressure on adjacent sides. The existing dike on the project site, is in an uncompacted state. Numerous failures have occurred and are presently occuring along the sides and top of the dike. This is evidenced by the cracks and displaced soil visually apparent on the dike. Extensive settlement is also apparent on the surface of the dike. In a telephone conversation with the contractor who constructed the dike, it was learned that the top surface of the dike was flat at its completion. Over the time period since construction of the dike and the present, we anticipate that much of the settlement due to existing loading conditions, has probably occurred. If the loading conditions are not changed, additional settlement should be minimal by comparison. However, if the dike is widened or raised, consolidation of the underlying silts will initiate new settlements.

The amount of settlement which might be expected due to changes in the present dike configuration depends on the load increase, lateral extent of loading, and ground water conditions. Since the ground water conditions will not be substantially different from those presently existing, we do not feel that this will be a factor. The development recommendation for the dike calls for little if any, increase in the height of the dike. However, the lateral extent of the dike will be increased in the area of the primary berm between the two settlement ponds. This lateral increase in loading will cause settlement in the area of the primary berm, however, it is not expected that settlements along the existing dike will occur.

7.0 FOUNDATIONS FOR FISHING DOCKS AND WEIR

Driven steel H-piles or pipe piles are suitable for support of these structures. H-piles will facilitate weir construction by permitting lagging timbers to be placed between flanges on the piles. The only drawback is that driven piles sometimes rotate during placement and the flanges might not be aligned after driving. Theoretically, piling driven into dense, gravelly, sands, at a minimum penetration of 30 to 35 feet below mudline, should be capable of carrying loads on the order of 22 tons per pile. However, if non-displacement piles (such as H-piles) are used for support, the length required to obtain the stated capacity may be longer than the range given above (as discussed under Section 5.5). As with the Restroom Area, we again recommend that the piling contractor be prepared to drive longer piles if necessary. The capacities given here are also based on HP-8x8 H-piles or 10-inch diameter pipe piles.

Driving should be performed with an air, steam, or diesel hammer, developing a minimum of 19,000 foot-pounds per blow. Because of the downdrag on the piles due to soft silts, piles will have to be driven to a total capacity of at least 50 tons. All piling should be driven under the full-time observation of the Soils Engineer or his representative who is able to determine in the field when adequate penetration and resistance has been achieved. As previously discussed, it should be understood that the lengths presented above are only approximate; actual lengths will be determined during installation.

Spread footings may be used for support of access ramps which are hinged from pile-supported docks. Since the fill under such footings is in an uncompacted state, overexcavation and recompaction will be necessary. The fill for a distance of 4 feet from any side of the footing should be overexcavated to a depth of 2 feet below the base of footing. The excavation should then be brought back to footing grade with fill compacted to the specifications outlined under Section 5.2. The footing may then be placed directly onto the compacted fill. Allowable bearing pressures of 1000 psf may be utilized for design purposes. All footings should extend at least 18 inches into the surrounding soils for frost protection. In addition, all footings should have a minimum width of 12 inches.

8.0 SEISMICITY

The Puget Lowland is an area of moderately high seismic activity (see Fig. 5). Most of the earthquakes in the region have occurred at comparatively shallow depths of less than 15 miles. The larger events, however, have occurred in a deeper zone at depths of more than 25 miles. The primary cause of this seismicity is believed to be the motion differential that is occuring between the North American and Pacific lithospheric plates. None of the historic earthquakes in the region have been associated directly with any known or postulated faults.

Of the 13 significant historic earthquakes (those of magnitude 4.0 or greater) that have occurred in the Olympia region, 4 have been of magnitude 5.7 or greater. The largest of these was the event of 13 April 1949. This large shock had a magnitude of 7.1 and occurred approximately 10 miles east of Olympia, causing considerable damage in the region. This event produced a peak horizontal acceleration of 0.32g. Another significant earthquake occurred on 29 April 1965; this shock had a magnitude of 6.5 and produced peak accelerations of 0.20g. These two earthquakes represent the largest historic events in the Puget Sound

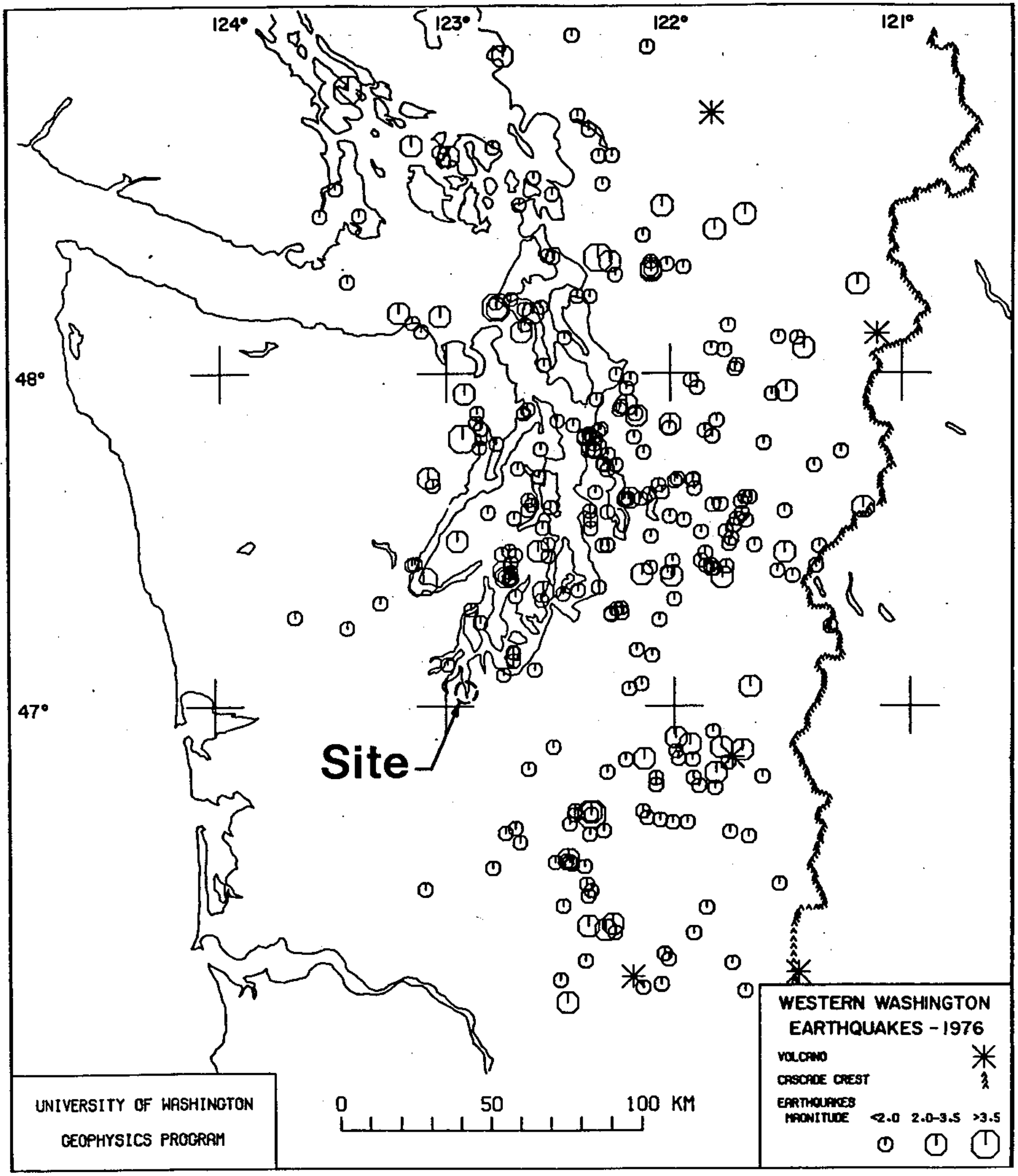

Fig. 5 SEISMICITY OF WESTERN WASHINGTON

region, and presently define the peak acceleration for the Maximum Probable Earthquake. These values must be considered when analyzing the long-term slope stability of the project site.

9.0 PRIMARY AND SECONDARY BERMS

9.1 General - The design recommendation calls for a large, primary berm to be constructed between the two settlement ponds and the smaller, secondary berm to be built near the east end of the site. While both would be approximately the same height, the berm between the ponds would cover considerably more area and thus has been termed "primary". The primary berm is currently planned to have a final top elevation of 37.0 feet and will be constructed of the sands dredged from the sediment traps of the Upper and Lower Basins. The silts obtained from the sediment traps would not be suitable for the construction of the berms because of their slow-drainage characteristcs and low stability.

9.2 Slope Stability of Berms - The stability of the berm slopes was analyzed on a computer using the Bishop - Modified Method of Slices. The cases of rapid drawdown with and without seismic accelerations were analyzed and seepage pore water forces were considered. The results from the analysis indicate that the critical failure circle had a factor of safety of 1.40 without seismic loading with the berm at elevation 37.0. The soil strength values used in the analysis assumed that the berm was built using staged construction as discussed under Section 9.3.1. As discussed under "Seismicity" (Section 8.0) the maximum recorded earthquake produced an acceleration of 0.32g. Proposed and new slopes were reanalyzed, subjecting the berms to various accelerations up to 0.32g. The factors of safety for various accelerations and berm top elevations are presented below:

Berm Elevation	Seismic Acceleration	Factor of Safety
25.0	0.0	2.88
25.0	0.20	1.09
25.0	0.32	0.80
35.0	0.0	1.65
37.0	0.20	0.59
37.0	0.32	0.44

Factors of safety of 1.50 for static conditions and 1.20 for seismic conditions are generally accepted as minimums for "safe" slopes. A factor of safety of less than 1.0 implies that failure will occur. In our opinion, the final height of the berm should not exceed an elevation of 35 feet. This condition would provide minimal risk of failure under static conditions, however, failure would probably occur in a major seismic event. If it is desirable to have a berm with a high probability of surviving an earthquake producing accelerations greater than 0.20g, its top elevation should be less than 25 feet. In any case, the side slopes should not be steeper than 3H:1V.

Figure 6 depicts the critical failure circle and shows where it would fall on a cross-section of the site. Notice that the AA ' cross-section shown in Figure 3, was drawn along the line of critical stability to show the subsurface conditions present in this area.

9.3 Primary Berm

9.3.1 Filling - The silts underlying the primary berm area are quite soft. If fill is placed too rapidly or in a concentrated area, a bearing capacity failure could occur with the silts being displaced in the form of a mud wave. This would be undesireable from two standpoints; 1)it would take considerable more fill material than originally planned to replace the silt that would be displaced and 2)the mud wave created could reduce the volume of the settlement pond to a point where it could not function properly, necessitating the removal of the silt from the pond.

CAPITOL LAKE

RESTORATION PROJECT
PRIMARY BERM STABILITY

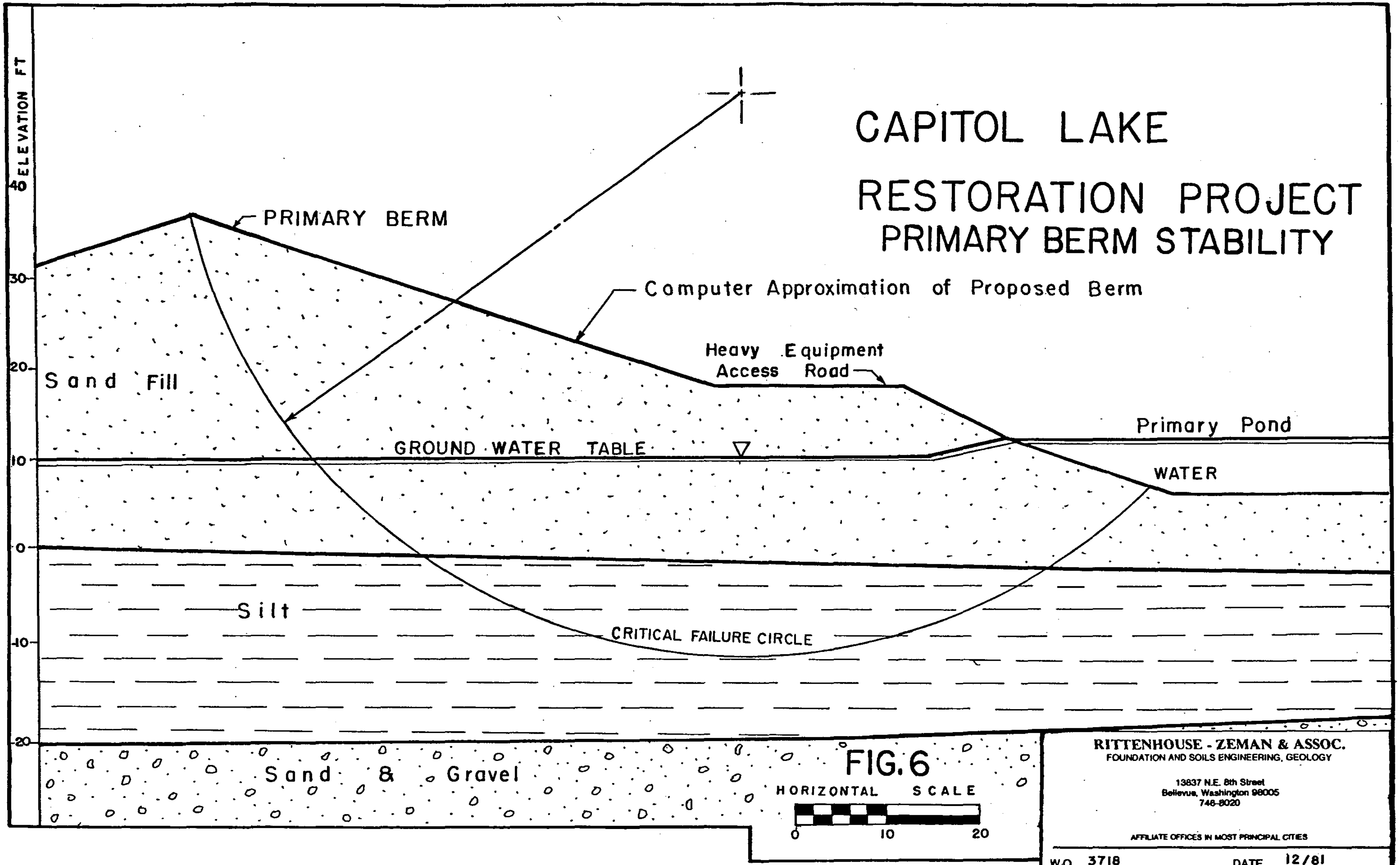

FIG. 6

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FOUNDATION AND SOILS ENGINEERING, GEOLOGY

13837 N.E. 8th Street
Bellevue, Washington 98005
746-8020

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W.O. 3718 DATE 12/81
BY CCL SCALE 1" = 10

Consequently, construction of the primary berm has to be carefully planned and monitored. In order to keep the silts from displacing, initial construction of the berm must start with the building of a containment dike along the western perimeter of the berm area. This dike would form natural safe/side slopes, becoming wider at its base and remaining stable against the increasing lateral pressure of silts with depth. Due to the soft subgrade, some silt will be displaced during the construction of the dike; however, with proper sequencing, the amount of silt should not reduce the pond volume to where it would become a problem.

The containment dike should be constructed by end-dumping fill materials and pushing these down with a large dozer (such as a D-8 or larger). Forcing the fill down into the silt would displace the silts resulting in the least amount of compressible materials under the dike. The overall stability of the dike would be increased, especially if the fill can be pushed all the way through the silts to the gravels below. This was accomplished with the presently existing dike; one of our borings through this dike shows only 2-1/2 feet of silt remaining under the pushed fill. It is possible that the side slopes of the dike in the silts can be constructed at 3H:1V by the contractor. These slopes (and thus the volume of fill required) will be directly dependent on the contractor's skill in pushing the fill into the silts. It should be noted that the volume may be greatly increased if a conscientious effort is not made by the contractor to keep the side slopes as steep as possible.

Once the silts are contained, filling of the central portion of the dike can proceed. This area should be filled as broadly as possible, to cause the greatest area to undergo the slowest load increase. In other words, if the area can be broadly loaded and the underlying soft silts have time to compress, they should remain in place. Even with this, construction of the berm will have to be staged to prevent a bearing capacity failure.

The base tability analysis indicated that the primary berm could be constructed to a maximum elevation of 20 during the first stage of construction. This material would then be allowed to consolidate the underlying silts prior to increasing the height of the berm. It should be understood that the underlying silts are extremely soft because they have been deposited underwater. It is difficult to predict exactly how the silts will react to the filling process; consequently, filling should be monitored on a full-time basis to determine if the silts are being displaced and to what extent. If the Soils Engineer ascertains that a failure may occur, he must be allowed to slow or stop the filling process and make appropriate recommendations.

Consolidation of the silts by the first stage of the berm could take from 2 to 3 years. Additional material may then be added to the berm at maximum side slopes of 3H:1V when the Soils Engineer determines that it is safe to do so. All fill which is placed above the water table should be compacted as outlined under Section 5.2. Fill placed below water cannot be compacted. Fill materials should consist of coarse-grained sands with little or no fines. Silts would not be suitable for fill material.

9.3.2 Settlements - Current plans for the primary berm call for fills on the order of 25 feet. Total settlements of the soft silts at the center of the berm are expected to be on the order of 3 to 3-1/2 feet. If failures occur, greater settlements should be anticipated. These time-dependent settlements should occur as indicated below.

Percent of Total Settlement	Time Required in Months
40 to 50	8 to 9
80 to 85	32 to 36

9.4 Secondary Berm

9.4.1 Filling - Sands underlying the secondary berm area are in a very loose to loose condition. Even so, filling is not considered to pose unique bearing capacity or stability problems. Fill should be placed and compacted as discussed under Section 5.2. The side slopes of the berm should not exceed 3H:1V. All filling should be supervised by the Soils Engineer or his field representative.

9.4.2 Settlements - It is our understanding that current plans call for fills of from 9 to 10 feet. The placement of these fills will generate settlements in the underlying very loose to loose sands. Short-term settlements of approximately 10 to 12 inches should occur quickly as the embankment is constructed. Long-term, post-construction settlements on the order of 4 to 5 inches are anticipated.

10.0 STABILITY OF DREDGE SPOIL SLOPES

Based on our computer slope stability analyses, and information obtained from dredging contractors, we estimate that underwater slopes for hydraulicly placed spoil materials may be on the order of 10H:1V. Once this material drains, or can be brought up from underwater with earthmoving equipment and drained, stable side slopes on the order of 3H:1V are possible. Such slope angles, however, will probably have to be obtained by working the material into steeper slopes as drainage progresses. It should also be noted that drainage of large volumes of soil which are above the watertable will probably take several months. Materials which contain silt will take considerably longer to drain and will thus require more gradual reworking to obtain the steeper slopes.

11.0 HABITAT ISLAND

11.1 Filling - The silts underlying the habitat island area are very soft. Data from our test borings and laboratory analyses indicate that these silts possess less strength than any of the silts found on the site. As was the case with the primary berm, if fill is placed too rapidly during construction of the island, a bearing capacity failure could occur and the lower silts could be displaced. Construction of habitat island should proceed after the containment dike for the primary berm has been completed. By constructing the containment dike first, fill materials placed for the island should be stabilized against failure to the east.

The possibility of bearing capacity failures to the west will still exist, however, and construction of the island will have to be carefully planned and monitored. Since it is impossible to compact fill placed underwater, the side slopes on the island will probably obtain slopes on the order of 10H:1V. Since the western side of the island fill will not be contained, staged construction will be necessary to prevent failure. During the first stage of construction, the top elevation of the habitat island should be limited to 3 feet above the water level in the secondary pond at the time of construction. Consolidation of the lower silts would then be allowed to occur prior to increasing the height of the island. Here again, it is difficult to predict the reaction of the silts to the filling process, thus, all filling should be monitored on a full-time basis to determine if the silts are being displaced. The Soils Engineer should have the authority to slow or stop the filling process at his discretion.

Consolidation of the silts for the first stage of the island will be on the order of 18 to 30 months. Additional material may then be placed in a compacted state with maximum dry side slopes of 3H:1V when the Soils Engineer determines that it is safe to do so. All fill which is placed above the water table, should be compacted as outlined in Section 5.2. Fill materials should consist of coarse-grained sands with little or no fines. Silts would not be suitable for fill material.

11.2 Settlements - Current plans for the habitat island call for a top elevation on the order of 15 feet. Total settlements of the soft silts underlying the island are expected to be on the order of 1 to 2 feet and should occur over a period of 2 to 3 years.

12.0 HEAVY EQUIPMENT ACCESS ROAD

12.1 Site Preparation - Site preparation for the heavy equipment access road should begin by stripping of all organic topsoil and other organic debris. The existing soil is in an uncompacted state and overexcavation and recompaction will be necessary to obtain a firm subbase for the road. As with the dike area, all earthwork must be supervised by the Soils Engineer or his field representative who can assess site conditions as work progresses. The onsite soils which do not contain organics or debris may be used in the compacted fill, although some site soils contain sufficient quantities of silt so that compaction would be difficult or impossible when they are more than a few percent above their "optimum moisture content". Thus, earthwork should be scheduled for the dry summer months if possible. If fill is to be placed on slopes steeper than 5H:1V, proper keying and benching must be employed. If seepage of ground water becomes a problem, the contractor should be prepared to install subdrains as necessary to complete construction in a competent manner. Since no borings were possible on the steeply sloping portion of the site adjacent to the Dechutes Parkway, the ground water conditions in this area are unknown.

12.2 Subbase Design - The heavy equipment access road will require a minimum subbase of 40 inches. The subbase should consist of fill materials as described under Section 12.1 and compacted to at least 90% of the laboratory maximum density using ASTM:D-1557 as the standard. The bearing surface for the access road may consist of concrete paving blocks set directly onto the compacted subbase. These blocks may be spaced as much as 1 inch apart and the area between the blocks filled with topsoil and planted.

13.0 CONSTRUCTION MONITORING

All filling should be closely monitored during placement to minimize any potential for failure. Survey control should be provided so that the rate of fill placement is known at all times. Secondly, settlement readings should be taken so that the rate of consolidation can be monitored. Thirdly, a series of survey "toe stakes" should be extended outward from fill embankments so that both vertical and horizontal movements can be measured. All data should be collected and reviewed at least once per week.

14.0 CLOSURE

The conclusions and recommendations presented in this report are based on the 22 test borings accomplished for this study, as well as the judgement and expertise of the Geotechnical Consultant. The number, location, and depth of the test borings were carefully planned to yield the comprehensive information necessary to formulate design recommendations. Because of the nature of exploratory work below ground, extrapolation between test borings is necessary, and differing subsurface conditions may be present due to the filling operations which have taken place mainly underwater on the site. The nature and extent of any variations between the borings may not become fully evident until construction. If variations are observed at that time, it would be necessary to re-evaluate specific recommendations in this report and make appropriate changes.

We recommend that Rittenhouse-Zeman & Associates, Inc. be provided the opportunity for a general review of the final design plans and specifications prior to the beginning of construction, in order that our earthwork and foundation recommendations may be properly interpreted and implemented in the design and specifications. We would be pleased to provide geotechnical engineering services during construction as well. The integrity of this site and the proposed structures, depends on proper site preparation and construction procedures. Extensive construction monitoring will be essential. Because the site soils are generally soft, competent engineering decisions will have to be made in the field if specific problems become apparent.

We appreciate this opportunity to be of service and submit this report for your approval. If you should have any questions or require additional recommendations or inspections during design or construction phases, please do not hesitate to call.

Respectfully submitted,

RITTENHOUSE-ZEMAN & ASSOCIATES, INC.

Walter W Burke

Walter W. Burke, Geotechnical Engineer

Gary T. Lobdell

Gary T. Lobdell, Project Engineer

Alvin R. Zeman, P.E.

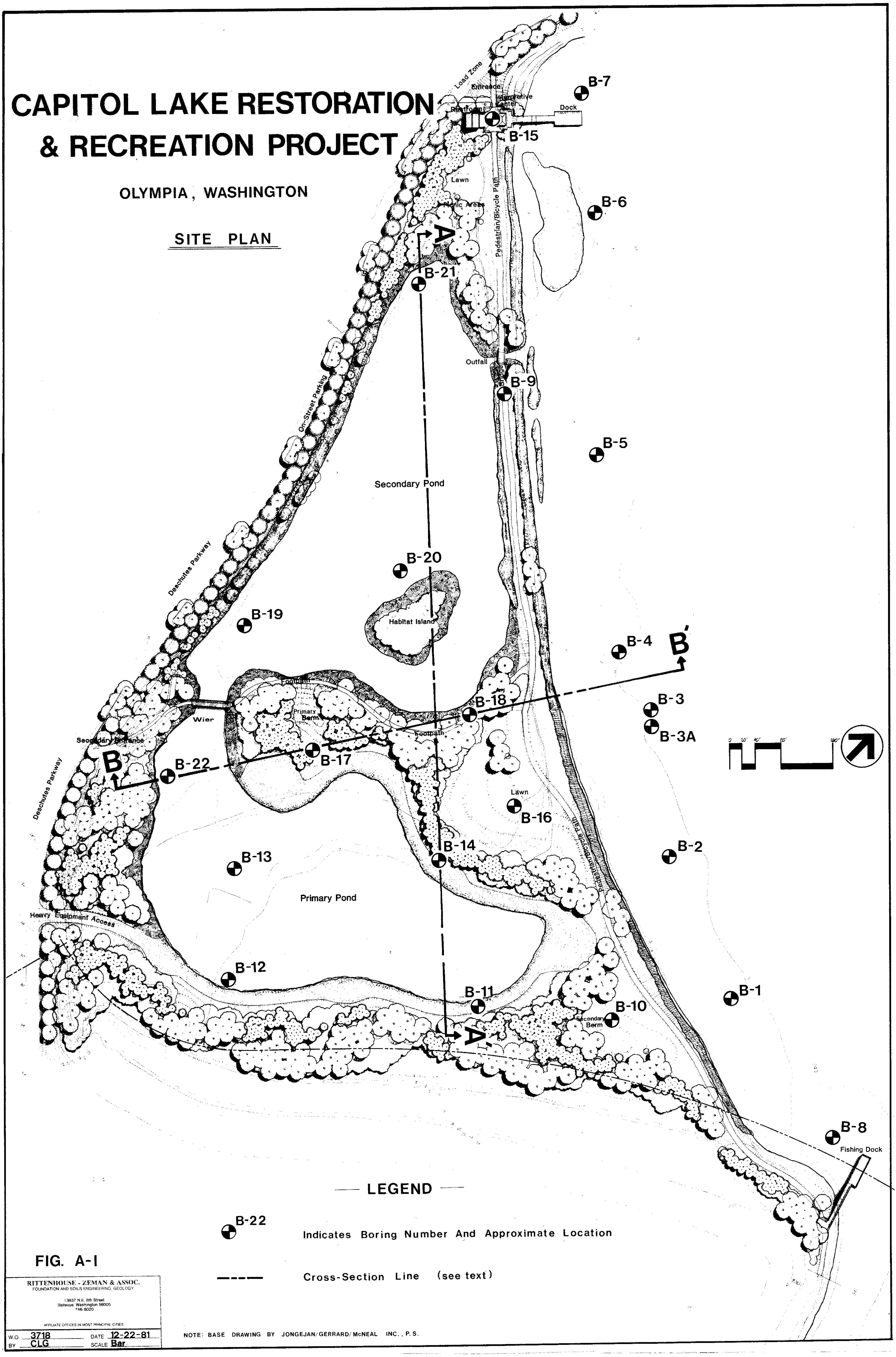
ALVIN R. ZEMAN
STATE OF WASHINGTON
REGISTERED
PROFESSIONAL ENGINEER

APPENDIX

CAPITOL LAKE RESTORATION & RECREATION PROJECT

OLYMPIA, WASHINGTON

SITE PLAN



— LEGEND —

B-22 Indicates Boring Number And Approximate Location

- - - - Cross-Section Line (see text)

FIG. A-I

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13837 N.E. 8th Street
Bellevue, Washington 98005
746-8020

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W.O. 3718 DATE 12-22-81
BY CLG SCALE Bar

NOTE: BASE DRAWING BY JONGEJAN/GERRARD/McNEAL INC., P.S.

SOIL DESCRIPTION

Surface Elevation: Lake Level

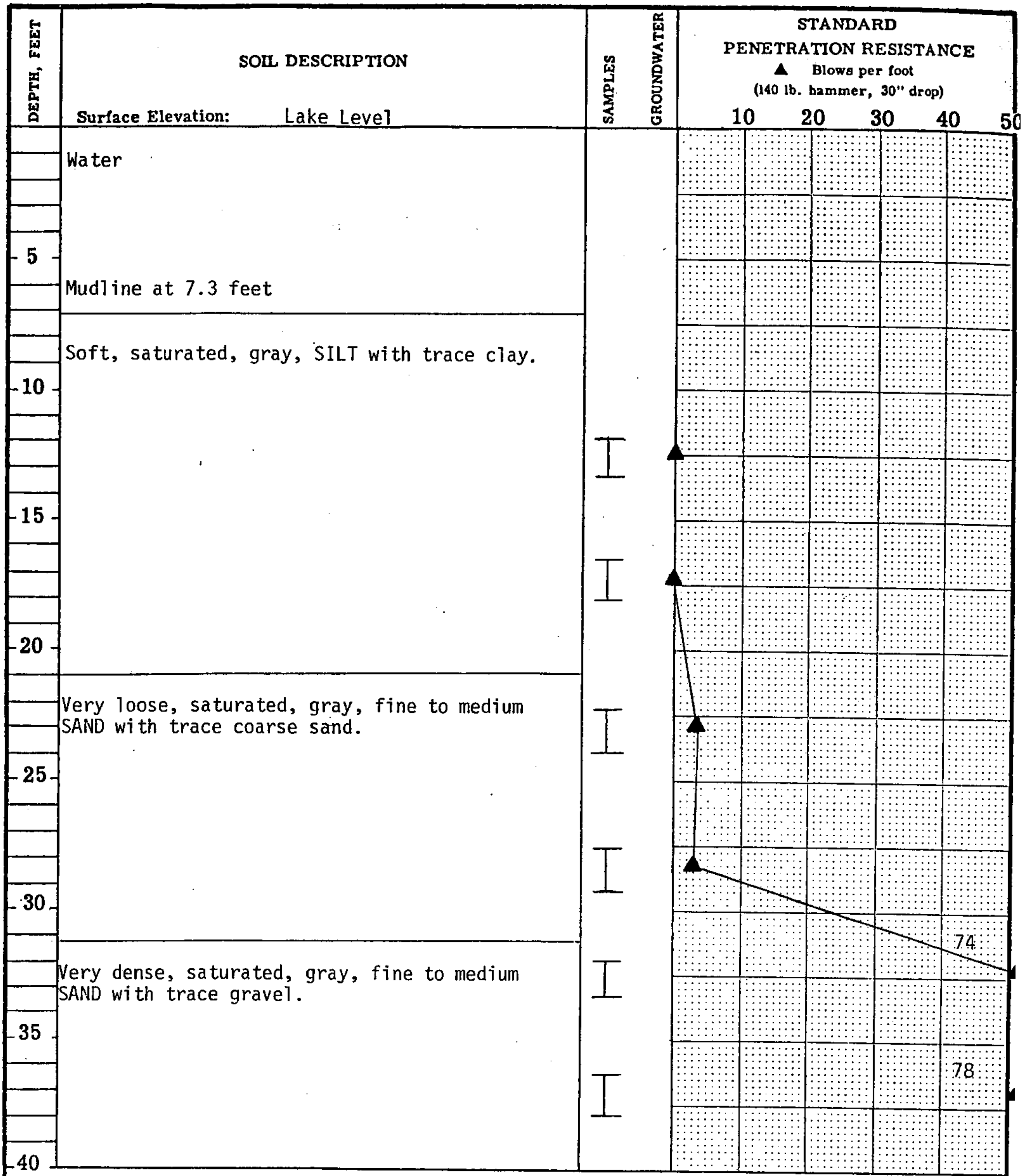
Water

Mudline at 7.3 feet

Soft, saturated, gray, SILT with trace clay.

Very loose, saturated, gray, fine to medium SAND with trace coarse sand.

Very dense, saturated, gray, fine to medium SAND with trace gravel.



7 October 1981

LEGEND

- I 2.0" O.D. split spoon sampler
- II 3.0" O.D. undisturbed sampler
- P Sampler pushed
- * Sample not recovered
- Piezometer tip
- ∇ Water level
- Atterberg limits: ├─●─┤ ← Liquid limit, Natural water content, Plastic Limit

● % Water Content

Capitol Lake
W-3718

LOG OF BORING NO. B-1

RITTENHOUSE-ZEMAN & ASSOC.
SOILS ENGINEERING AND GEOLOGY

DEPTH, FEET

SOIL DESCRIPTION

Surface Elevation: Lake Level

Water.

Mudline at 6.5 feet.

Loose, saturated, gray, slightly silty fine to medium SAND with occasional silt interlayers.

Very loose, saturated, gray, slightly silty, fine to medium SAND with trace gravel.

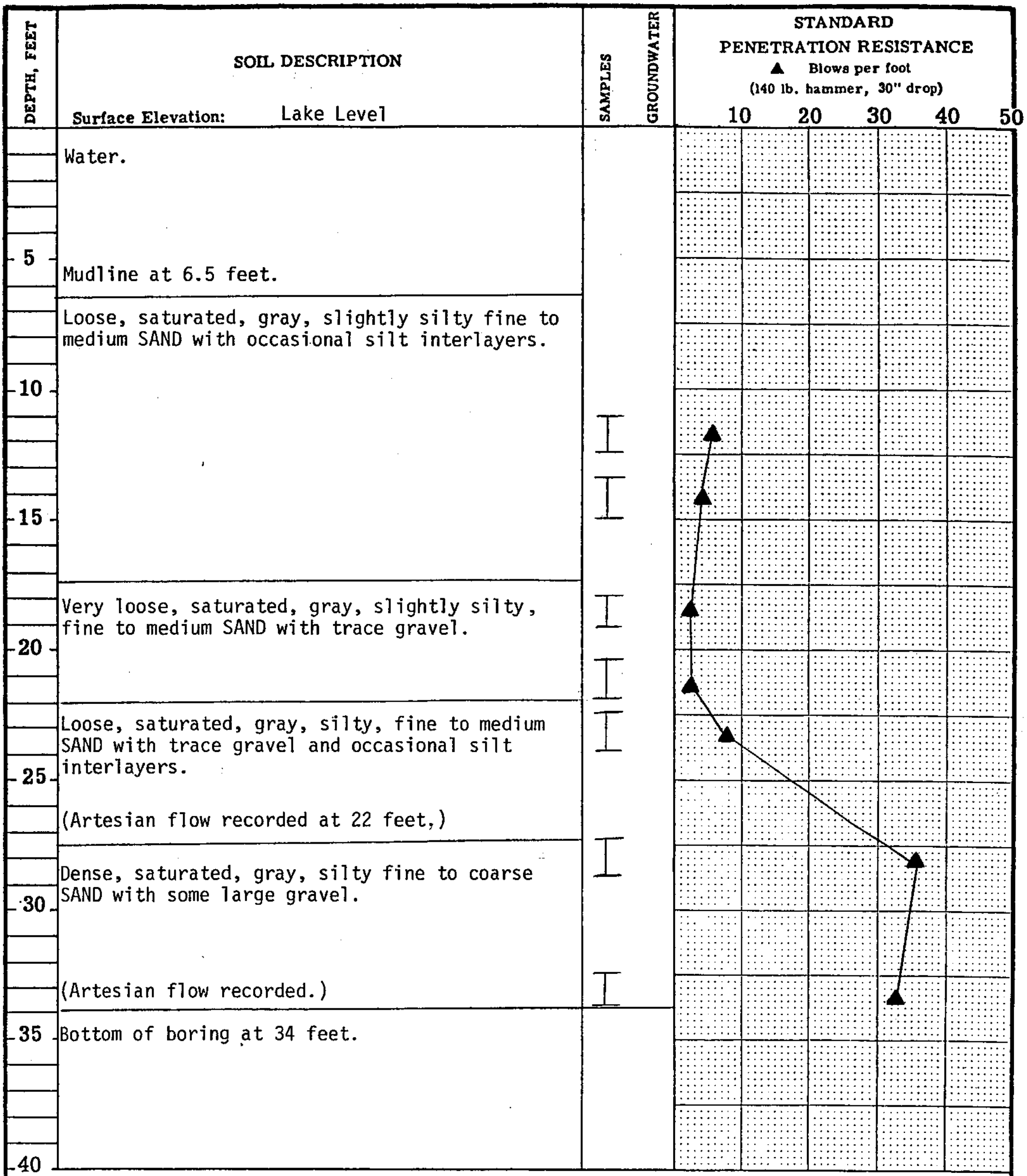
Loose, saturated, gray, silty, fine to medium SAND with trace gravel and occasional silt interlayers.

(Artesian flow recorded at 22 feet,)

Dense, saturated, gray, silty fine to coarse SAND with some large gravel.

(Artesian flow recorded.)

Bottom of boring at 34 feet.



7 October 1981

LEGEND

- I 2.0" O.D. split spoon sampler
- II 3.0" O.D. undisturbed sampler
- P Sampler pushed
- * Sample not recovered
- Piezometer tip
- ∇ Water level
- Atterberg limits: Liquid limit, Natural water content, Plastic Limit
- ● % Water Content

Capitol Lake
W-3718

LOG OF BORING NO. B-2

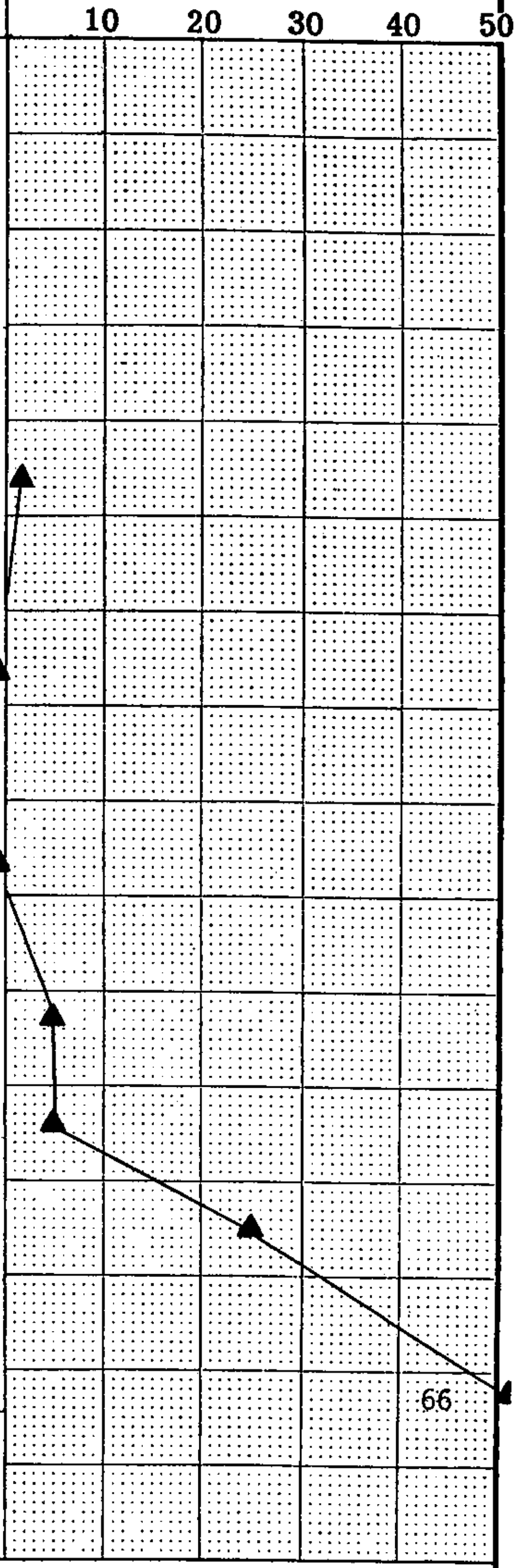
RITTENHOUSE-ZEMAN & ASSOC.
SOILS ENGINEERING AND GEOLOGY

DEPTH, FEET	SOIL DESCRIPTION Surface Elevation: Lake Level	SAMPLES	GROUNDWATER
	Water		
5	Mudline at 6.5 feet.		
	Very loose, saturated, gray, slightly silty fine to medium SAND.	I	
10			
15	Soft, saturated, gray, fine sandy SILT.	I I	
20			
25	Loose, saturated, gray, slightly silty fine SAND with trace medium and coarse sand.	I I	
30	Medium dense, saturated, gray, slightly silty fine to medium SAND with trace gravel.	I	
35	Very dense, saturated, gray, fine coarse SAND with trace gravel.	I	
	Bottom of boring at 36.5 feet.		
40			

STANDARD PENETRATION RESISTANCE

▲ Blows per foot

(140 lb. hammer, 30" drop)



7 October 1981

LEGEND

I 2.0" O.D. split spoon sampler

II 3.0" O.D. undisturbed sampler

P Sampler pushed

* Sample not recovered

Piezometer tip

∇ Water level

Atterberg limits: ← Liquid limit ← Natural water content ← Plastic Limit

● % Water Content

Capitol Lake
W-3718

LOG OF BORING NO. B-3

RITTENHOUSE-ZEMAN & ASSOC.
SOILS ENGINEERING AND GEOLOGY

DEPTH, FEET	SOIL DESCRIPTION Surface Elevation: Lake Level	SAMPLES	GROUNDWATER	STANDARD PENETRATION RESISTANCE ▲ Blows per foot (140 lb. hammer, 30" drop) 10 20 30 40 5
	As before.	I		50/4"
	Bottom of boring at 42.8 feet.			
45				
50				
55				
60				
70				
75				
80				
85				

7 October 1981

LEGEND

I 2.0" O.D. split spoon sampler

II 3.0" O.D. undisturbed sampler

P Sampler pushed

* Sample not recovered

Piezometer tip

∇ Water level

Atterberg limits: ├─●─┤ ← Liquid limit; ← Natural water content; ← Plastic Limit

● % Water Content

Capitol Lake

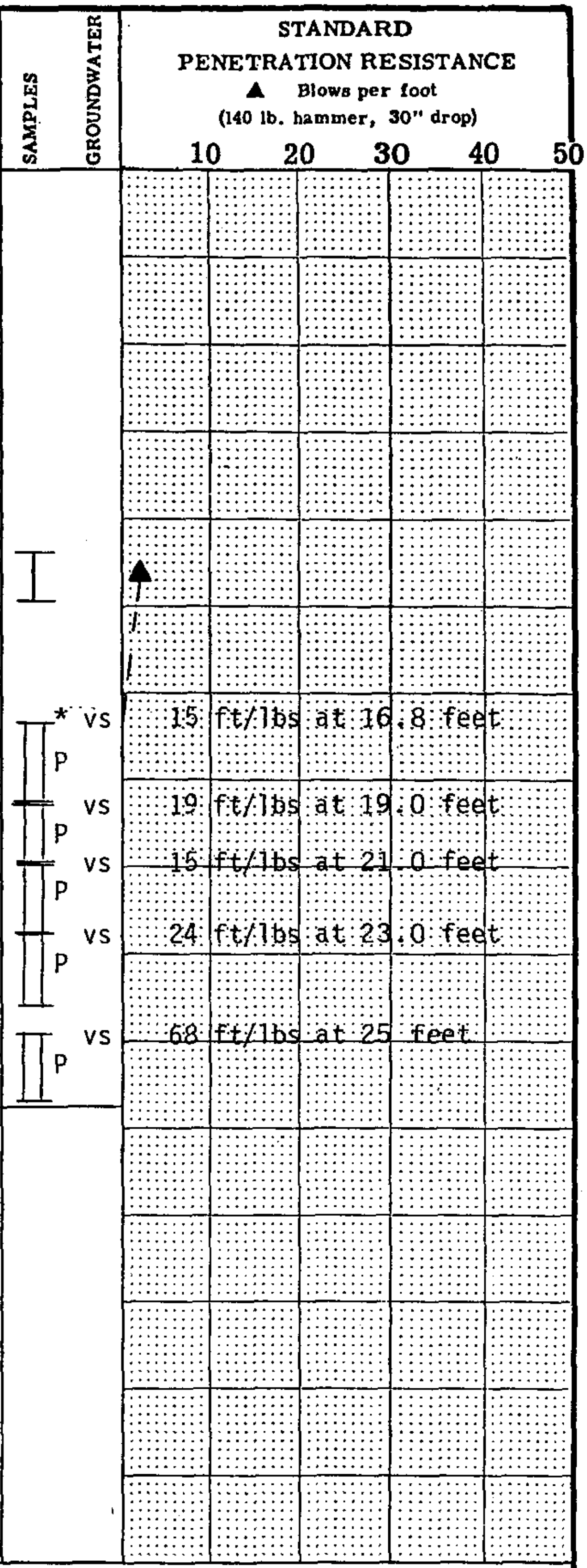
W-3718

LOG OF BORING NO. B-1 (cont.)

RITTENHOUSE-ZEMAN & ASSOC.

SOILS ENGINEERING AND GEOLOGY

DEPTH, FEET	SOIL DESCRIPTION Surface Elevation: Lake Level
0 – 6.5	Water Mudline at 6.5 feet.
6.5 – 15	Very loose, saturated, gray slightly silty fine to medium SAND.
15 – 25.5	Soft, saturated, gray, fine sandy, SILT, trace sand, clayey with depth.
25.5 – 27	Loose, saturated, gray, slightly silty fine SAND.
27	Bottom of boring at 27 feet.



vs 15 ft/lbs at 16.8 feet

vs 19 ft/lbs at 19.0 feet

vs 15 ft/lbs at 21.0 feet

vs 24 ft/lbs at 23.0 feet

vs 68 ft/lbs at 25 feet

8 October 1981

LEGEND

I 2.0" O.D. split spoon sampler
II 3.0" O.D. undisturbed sampler
P Sampler pushed
Atterberg limits: ├─●─┤ ← Liquid limit; Natural water content; Plastic Limit

* Sample not recovered
Piezometer tip
▽ Water level

vs Vane Shear

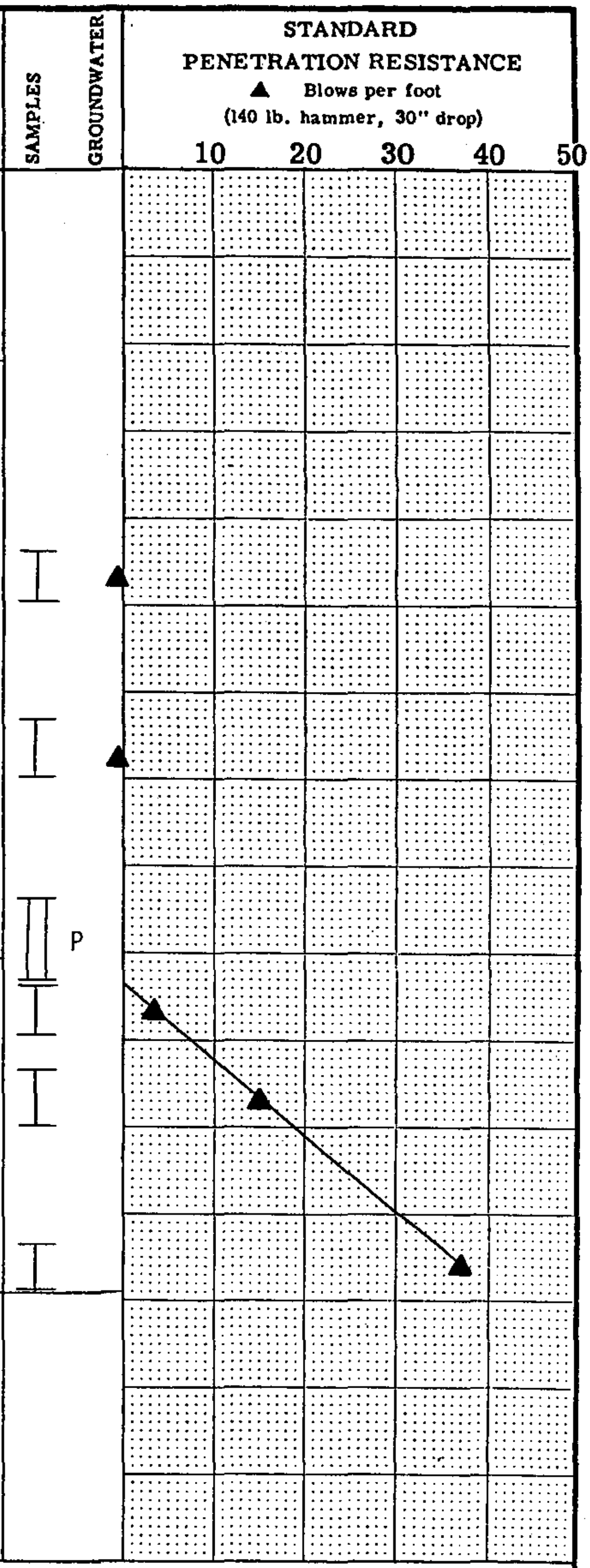
● % Water Content

Capitol Lake
W-3718

LOG OF BORING NO. B-3A

RITTENHOUSE-ZEMAN & ASSOC.
SOILS ENGINEERING AND GEOLOGY

DEPTH, FEET	SOIL DESCRIPTION Surface Elevation: Lake Level
	Water
5	Mudline at 5.5 feet.
	Very loose, saturated, gray, very silty fine SAND with occasional silt interlayers.
10	
15	
20	
	Medium dense, saturated, gray, silty, fine to coarse SAND.
25	
30	Dense, saturated, gray, silty fine to coarse SAND with fine to large gravel. (Artesian pressure recorded at 31 feet.)
	Bottom of boring at 32.5 feet.
35	
40	



10 October 1981

LEGEND

I 2.0" O.D. split spoon sampler
II 3.0" O.D. undisturbed sampler
P Sampler pushed
• Sample not recovered
Piezometer tip
∇ Water level
Atterberg limits: ├─●─┤ ← Liquid limit
Natural water content
Plastic Limit
● % Water Content

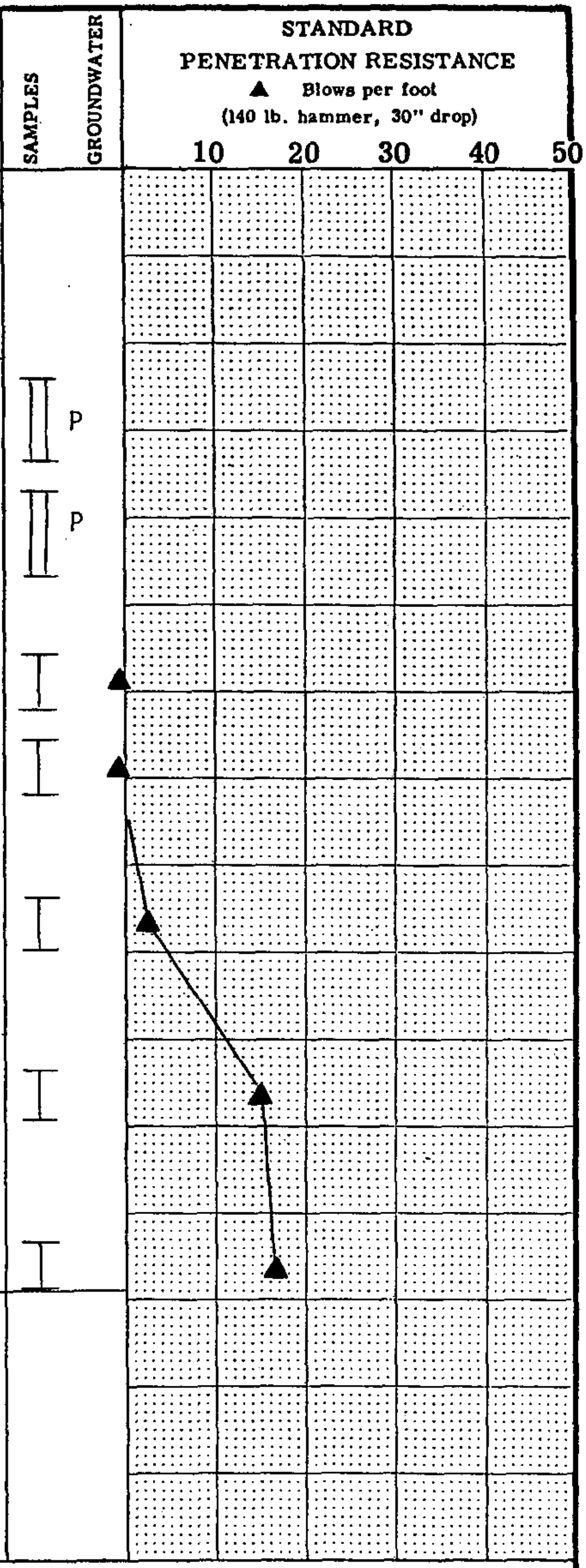
Capitol Lake
W-3718

LOG OF BORING NO. B-4

RITTENHOUSE-ZEMAN & ASSOC.
SOILS ENGINEERING AND GEOLOGY

Surface Elevation: Lake Level

DEPTH, FEET	SOIL DESCRIPTION
	Water
5	Mudline at 5.5 feet.
	Soft, saturated, gray, clayey silt with trace fine SAND.
10	
15	
20	Loose, saturated, gray, silty fine SAND.
25	
	Medium dense, saturated, gray, silty fine to coarse SAND with gravel.
30	
	(Artesian pressure recorded at 25 feet.)
	Bottom of boring at 32.5 feet.
35	
40	



10 October 1981

LEGEND

- I 2.0" O.D. split spoon sampler
- II 3.0" O.D. undisturbed sampler
- P Sampler pushed
- * Sample not recovered
- Piezometer tip
- ∇ Water level
- ● % Water Content

Atterberg limits: ├─●─┤ ← Liquid limit; Natural water content; Plastic Limit

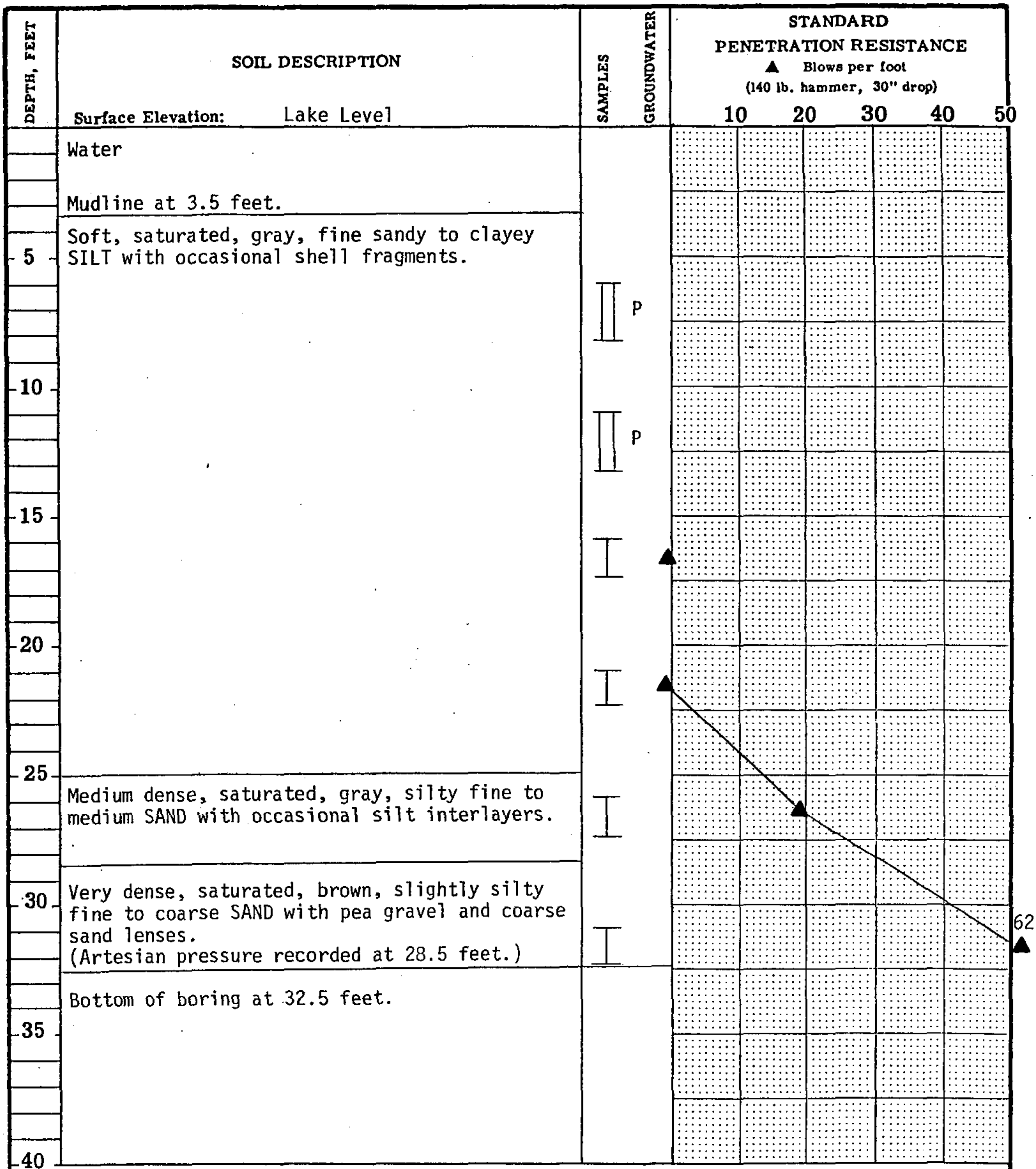
Capitol Lake
W-3718

LOG OF BORING NO. B-5

RITTENHOUSE-ZEMAN & ASSOC.
SOILS ENGINEERING AND GEOLOGY

SOIL DESCRIPTION

Surface Elevation: Lake Level



Water

Mudline at 3.5 feet.

Soft, saturated, gray, fine sandy to clayey SILT with occasional shell fragments.

Medium dense, saturated, gray, silty fine to medium SAND with occasional silt interlayers.

Very dense, saturated, brown, slightly silty fine to coarse SAND with pea gravel and coarse sand lenses.
(Artesian pressure recorded at 28.5 feet.)

Bottom of boring at 32.5 feet.

11 October 1981

LEGEND

I 2.0" O.D. split spoon sampler
II 3.0" O.D. undisturbed sampler
P Sampler pushed
Atterberg limits: ├─●─┤ ← Liquid limit
Natural water content
Plastic Limit

• Sample not recovered
▮ Piezometer tip
▽ Water level

● % Water Content

Capitol Lake

W-3718

LOG OF BORING NO. B-6

RITTENHOUSE-ZEMAN & ASSOC.
SOILS ENGINEERING AND GEOLOGY

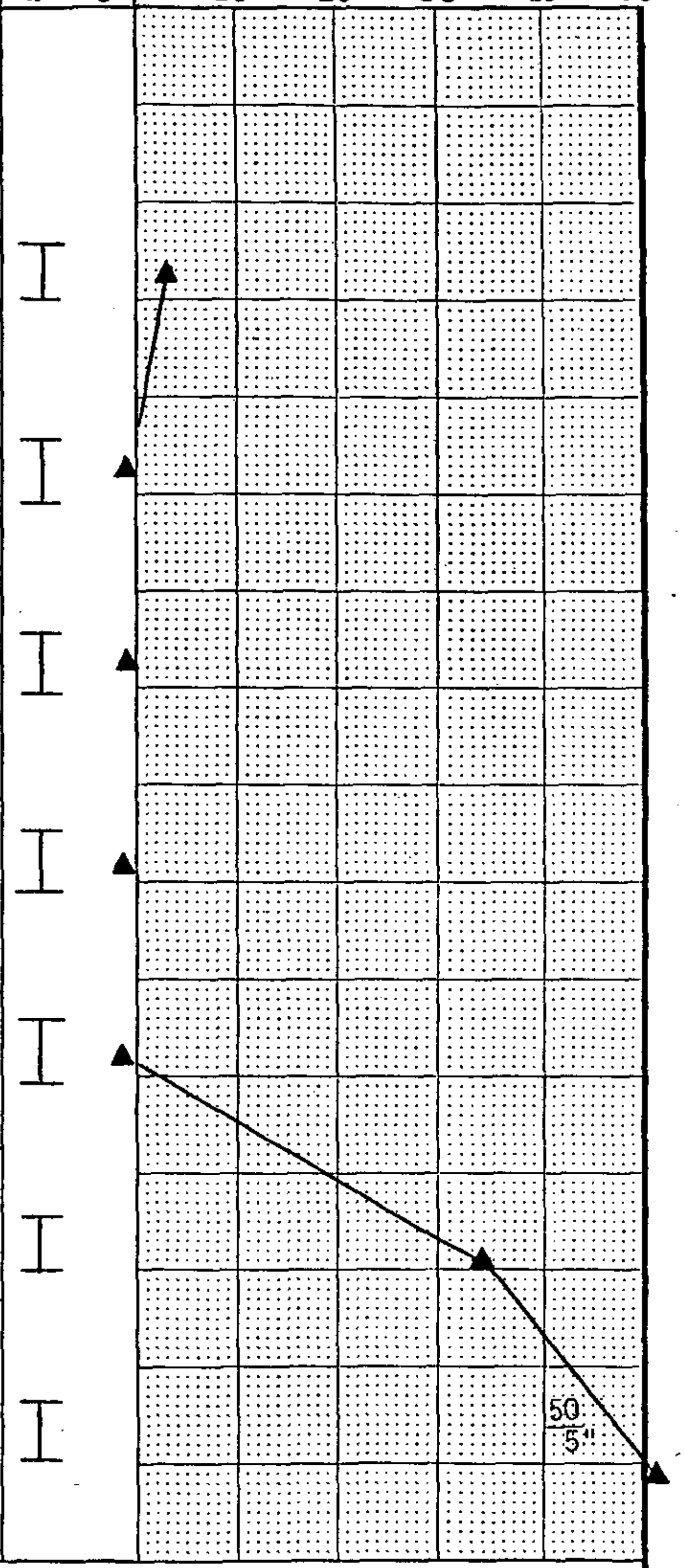
Surface Elevation: Lake Level

DEPTH, FEET	SOIL DESCRIPTION
	Water
	Mudline at 4.5 feet.
5	Soft, saturated, gray to black, fine sandy, clayey SILT.
10	
15	NOTE: Samples obtained by weight of rod alone.
20	
25	Very loose, saturated, gray, silty fine to medium SAND with interlayers of silt.
30	Dense, saturated, gray to brown, silty fine to coarse SAND and pea gravel.
35	Very dense, saturated, gray to brown, silty fine to coarse sand with some pea gravel.
40	

SAMPLES

GROUNDWATER

STANDARD PENETRATION RESISTANCE
▲ Blows per foot
(140 lb. hammer, 30" drop)



11 October 1981

LEGEND

I	2.0" O.D. split spoon sampler	•	Sample not recovered
II	3.0" O.D. undisturbed sampler	▮	Piezometer tip
P	Sampler pushed	∇	Water level

Atterberg limits: ├─●─┤ ← Liquid limit
Natural water content
Plastic Limit

● % Water Content

Capitol Lake
W-3718
LOG OF BORING NO. B-7

RITTENHOUSE-ZEMAN & ASSOC.
SOILS ENGINEERING AND GEOLOGY

DEPTH, FEET

SOIL DESCRIPTION

Surface Elevation: Lake Level

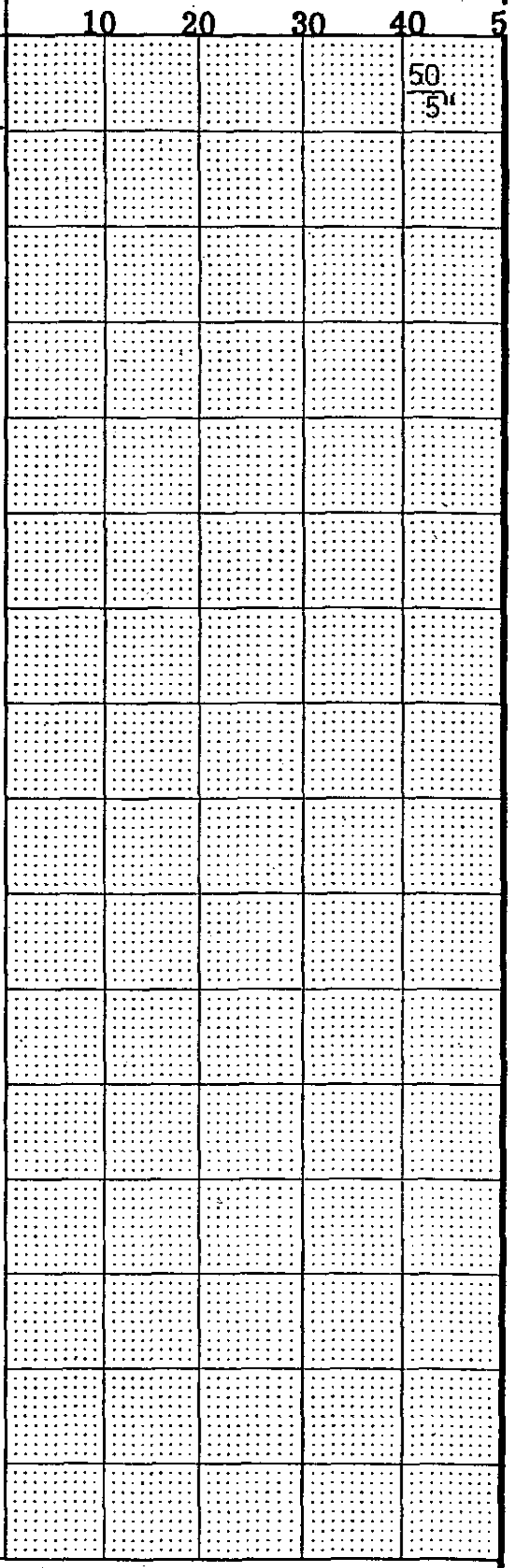
SAMPLES **GROUNDWATER**

STANDARD PENETRATION RESISTANCE
▲ Blows per foot
(140 lb. hammer, 30" drop)

Same as before.

Bottom of boring at 42.5 feet.

45
50
55
60
65
70
75
80



11 October 1981

LEGEND

I 2.0" O.D. split spoon sampler
II 3.0" O.D. undisturbed sampler
P Sampler pushed
* Sample not recovered
Piezometer tip
∇ Water level
Atterberg limits: ├─●─┤ ← Liquid limit
← Natural water content
← Plastic Limit

● % Water Content

Capitol Lake
W-3718
LOG OF BORING NO. B-7 (cont.)

RITTENHOUSE-ZEMAN & ASSOC.
SOILS ENGINEERING AND GEOLOGY

DEPTH, FEET

SOIL DESCRIPTION

Surface Elevation: Lake Level

Water

Mudline at 8.0 feet.

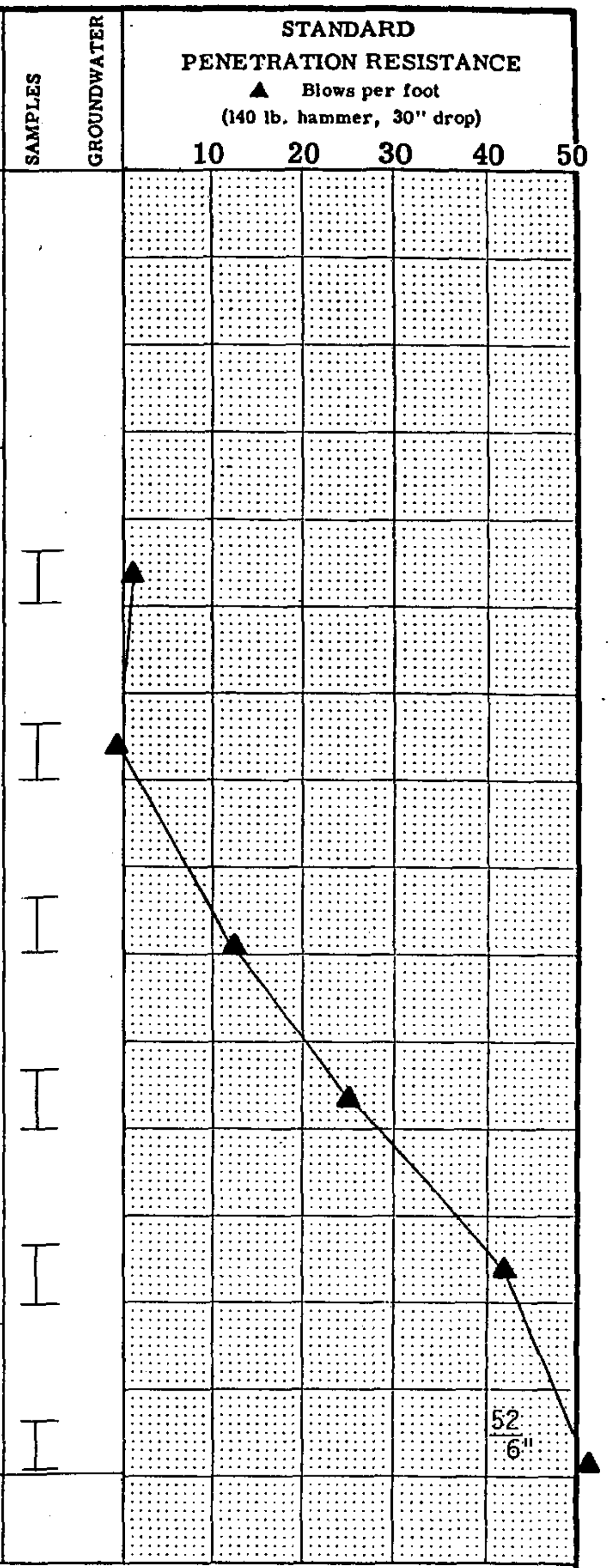
Soft, saturated, gray, clayey SILT with trace fine sand and shell fragments.

Medium dense, saturated, gray, silty fine to coarse SAND with medium gravel and silt interlayers up to 1 foot thick.

Dense, saturated, gray, silty fine to coarse SAND with fine to large gravels and silt interlayers.

Very dense, saturated, gray, silty fine to coarse SAND with fine to large gravel.

Bottom of boring at 37.5 feet.



5
10
15
20
25
30
35
40

11 October 1981

LEGEND

I 2.0" O.D. split spoon sampler
II 3.0" O.D. undisturbed sampler
P Sampler pushed
Atterberg limits: ├─●─┤ ← Liquid limit; Natural water content; Plastic Limit

* Sample not recovered
Piezometer tip
▽ Water level

● % Water Content

Capitol Lake
W-3718

LOG OF BORING NO. B-8

RITTENHOUSE-ZEMAN & ASSOC.
SOILS ENGINEERING AND GEOLOGY

DEPTH, FEET

SOIL DESCRIPTION

Surface Elevation:

Loose, moist, tan-gray, silty, fine to coarse SAND with fine to medium gravel.

5

Very loose to medium dense, saturated, tan, silty, fine to coarse GRAVEL with fine to coarse sand.

10

15

20

25

Medium stiff, saturated, dark gray, slightly sandy SILT.

30

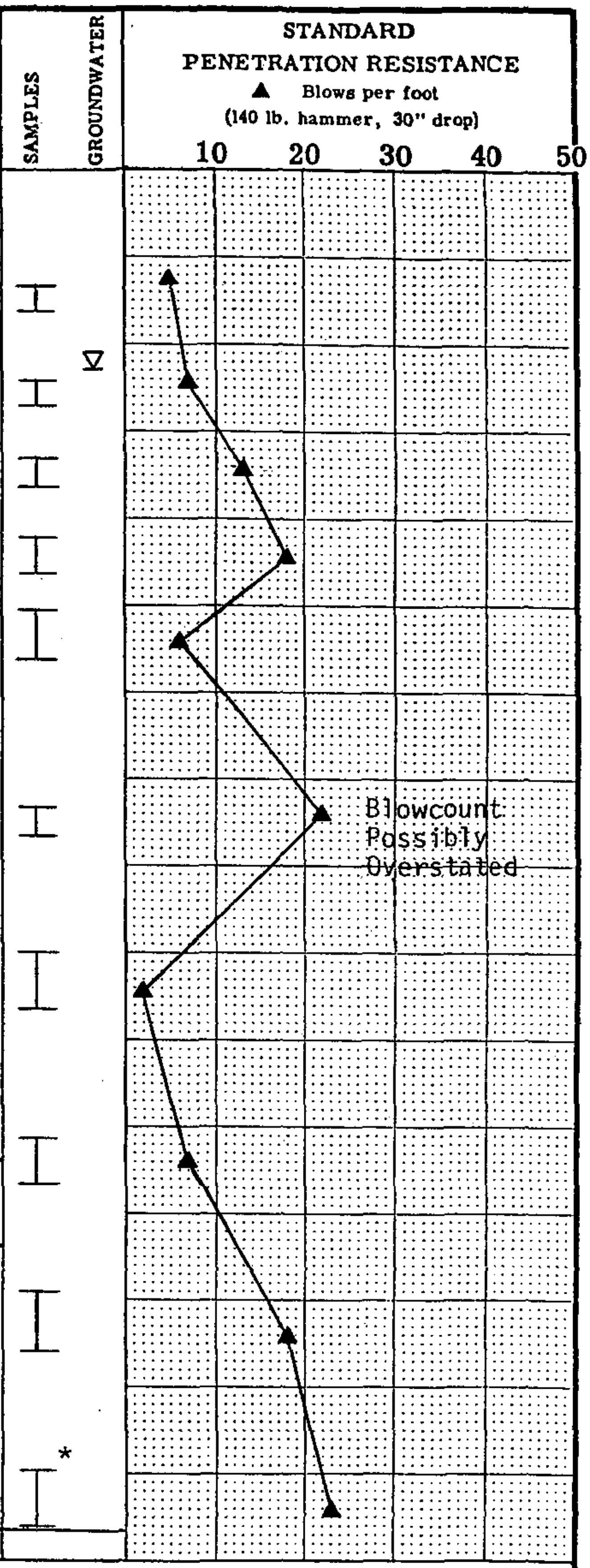
Medium dense, saturated, gray-tan, slightly silty, slightly gravelly, fine to coarse SAND, interbedded sandy, fine to coarse gravel.

35

Bottom of boring at 39 feet

40

17 October 1981



LEGEND

I	2.0" O.D. split spoon sampler	*	Sample not recovered
II	3.0" O.D. undisturbed sampler	ǀ	Piezometer tip
P	Sampler pushed	∇	Water level

Atterberg limits: ├─●─┤ ← Liquid limit

← Natural water content

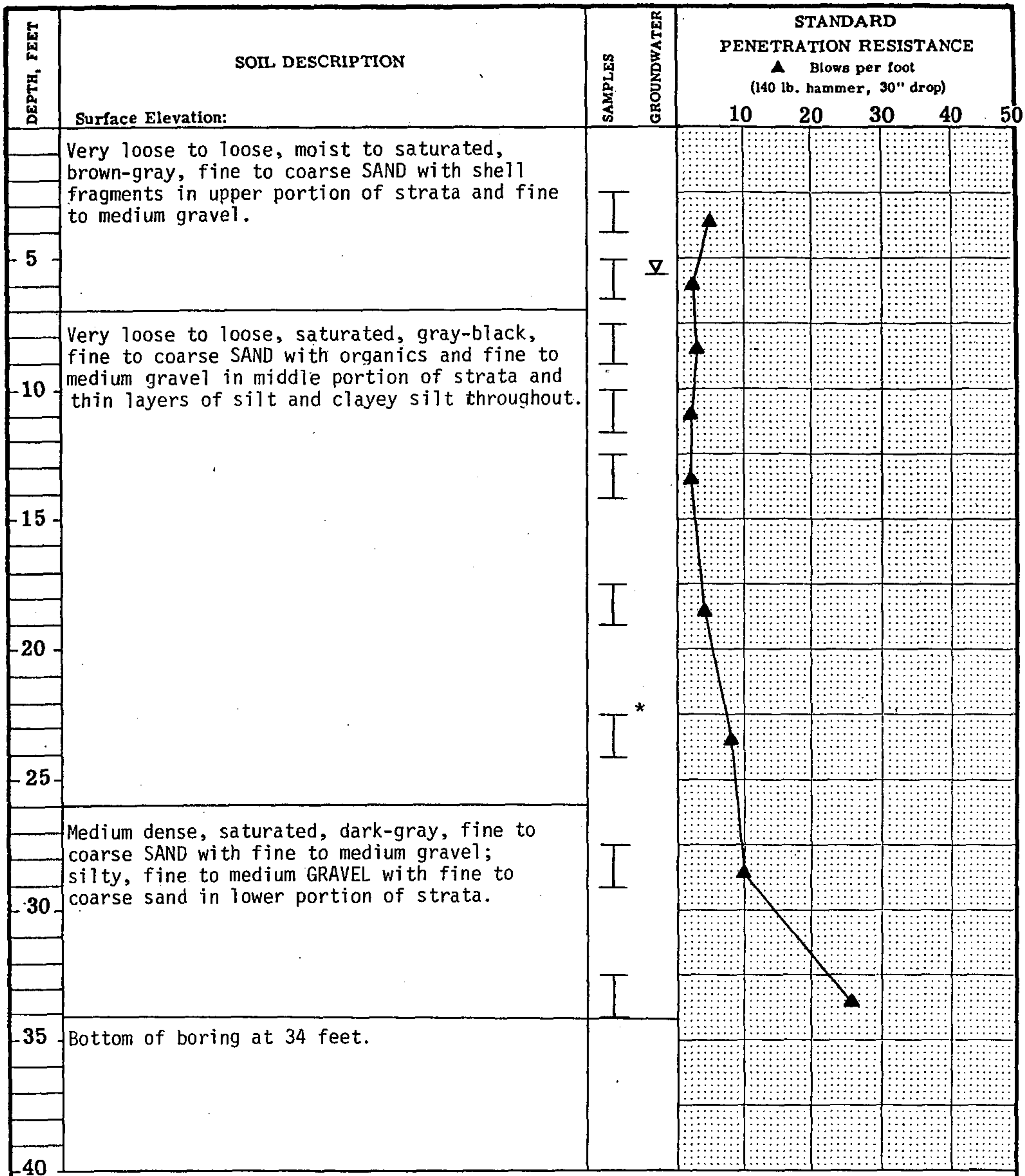
← Plastic Limit

● % Water Content

Capitol Lake
W-3718

LOG OF BORING NO. B-9

RITTENHOUSE-ZEMAN & ASSOC.
SOILS ENGINEERING AND GEOLOGY



Surface Elevation:

Very loose to loose, moist to saturated, brown-gray, fine to coarse SAND with shell fragments in upper portion of strata and fine to medium gravel.

Very loose to loose, saturated, gray-black, fine to coarse SAND with organics and fine to medium gravel in middle portion of strata and thin layers of silt and clayey silt throughout.

Medium dense, saturated, dark-gray, fine to coarse SAND with fine to medium gravel; silty, fine to medium GRAVEL with fine to coarse sand in lower portion of strata.

Bottom of boring at 34 feet.

12 October 1981

LEGEND

I 2.0" O.D. split spoon sampler
II 3.0" O.D. undisturbed sampler
P Sampler pushed
* Sample not recovered
▮ Piezometer tip
∇ Water level
Atterberg limits: ├●┤ ← Liquid limit
← Natural water content
← Plastic Limit

● % Water Content

Capitol Lake
W-3718
LOG OF BORING NO. B-10

RITTENHOUSE-ZEMAN & ASSOC.
SOILS ENGINEERING AND GEOLOGY

DEPTH, FEET

SOIL DESCRIPTION

Surface Elevation:

Loose to medium dense, moist to wet, brown, slightly silty to silty, fine to coarse SAND with fine to medium gravel, trace shell fragments.

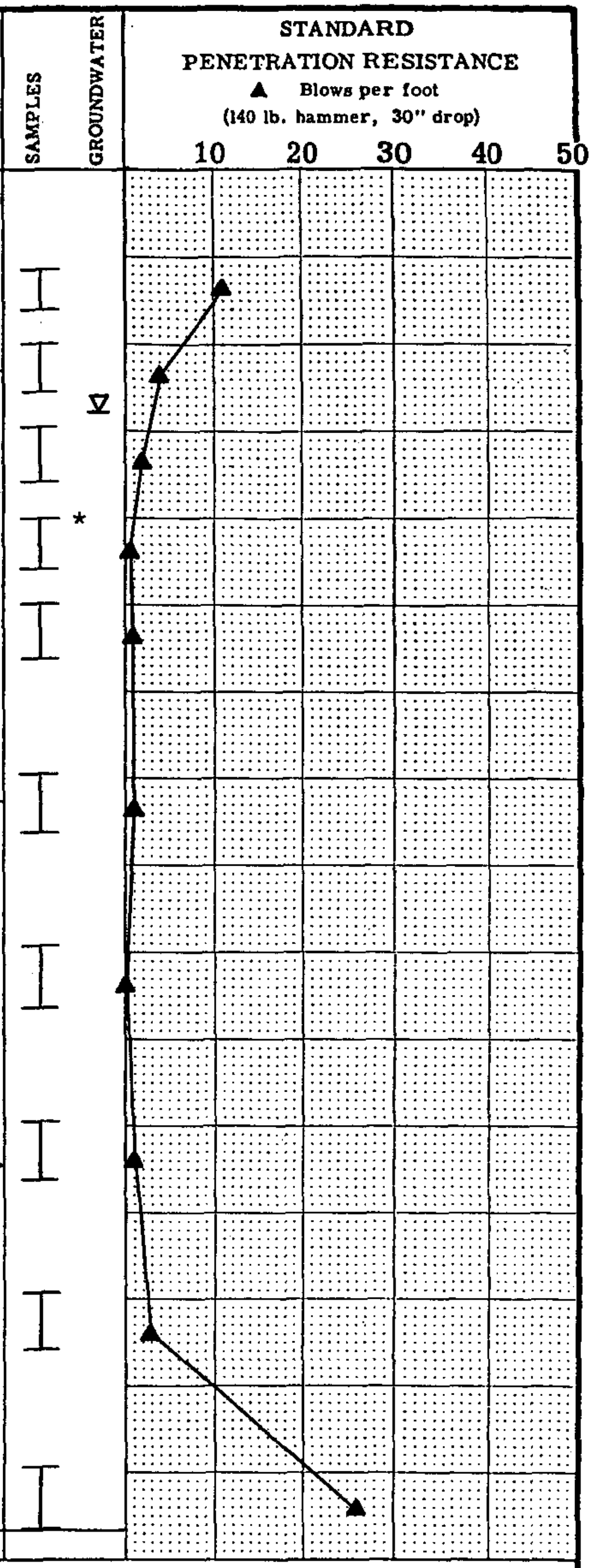
Very loose to loose, wet to saturated, silty, dark-gray, fine to coarse SAND, interlayered sandy silt, trace organics.

Very soft, saturated, dark gray, clayey SILT with fine SAND, trace shell fragments; grading to sandy SILT.

Very loose to medium dense, saturated, dark gray, fine to coarse SAND; grading to fine to medium GRAVEL with fine to coarse sand in lower portion of strata.

Bottom of boring at 39 feet

5
10
15
20
25
30
35
40



12 October 1981

LEGEND

I 2.0" O.D. split spoon sampler
II 3.0" O.D. undisturbed sampler
P Sampler pushed
* Sample not recovered
Piezometer tip
∇ Water level

Atterberg limits: ⊢●⊣ ← Liquid limit
Natural water content
Plastic Limit

● % Water Content

Capitol Lake
W-3718
LOG OF BORING NO. B-11

RITTENHOUSE-ZEMAN & ASSOC.
SOILS ENGINEERING AND GEOLOGY

DEPTH, FEET

5

10

15

20

25

30

35

40

SOIL DESCRIPTION

Surface Elevation:

Very loose, saturated, brown-gray, slightly silty to silty, fine to coarse SAND with organics and trace fine to medium gravel.

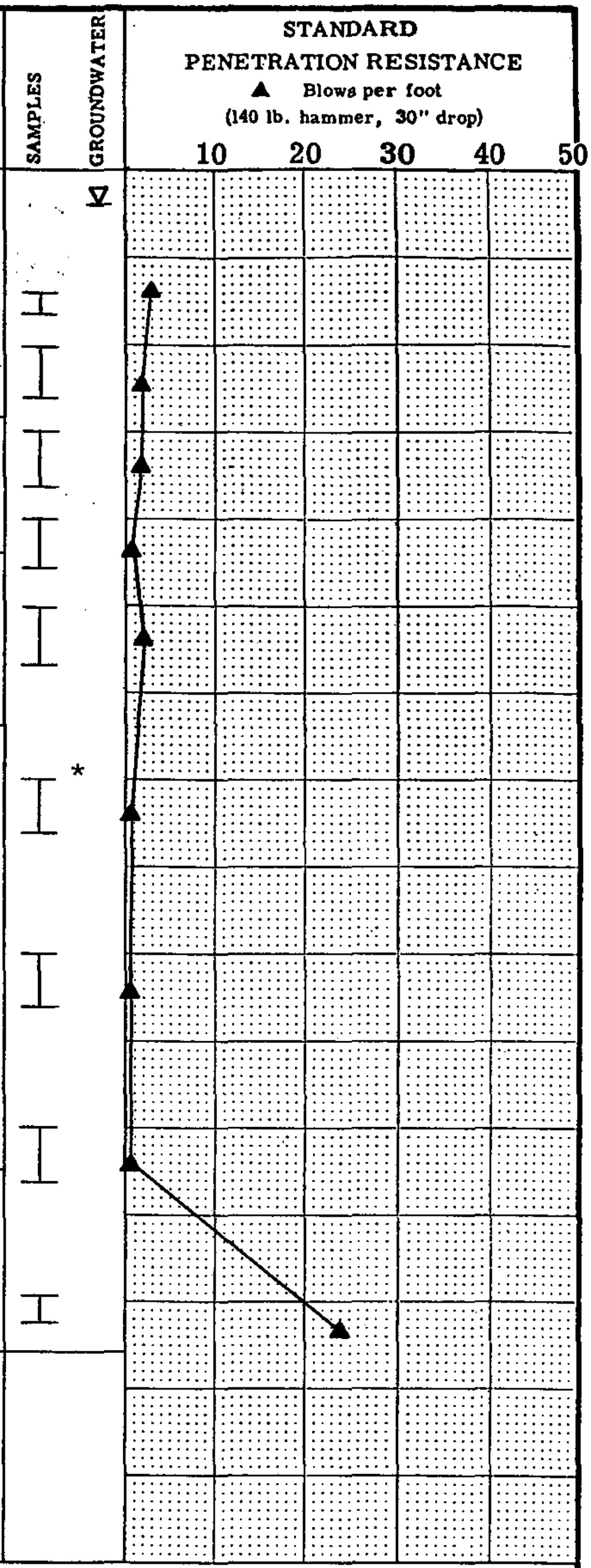
Very loose, saturated, gray, fine to coarse SAND, trace organics; grading to sandy SILT.

Very soft to soft, saturated, gray, sandy SILT, interlayered fine to coarse SAND.

Very soft, saturated, gray, clayey SILT grading to very loose, silty, fine to coarse SAND, fine to medium gravel in lower portion of strata.

Medium dense, saturated, gray, fine to coarse SAND with fine gravel.

Bottom of boring at 34 feet



13 October 1981

LEGEND

I 2.0" O.D. split spoon sampler

II 3.0" O.D. undisturbed sampler

P Sampler pushed

* Sample not recovered

▮ Piezometer tip

∇ Water level

Atterberg limits: ├─●─┤ ← Liquid limit

← Natural water content

← Plastic Limit

● % Water Content

Capitol Lake

W-3718

LOG OF BORING NO. B-12

RITTENHOUSE-ZEMAN & ASSOC.

SOILS ENGINEERING AND GEOLOGY

DEPTH, FEET

SOIL DESCRIPTION

Surface Elevation:

Very loose, moist to saturated, brown, coarse SAND with fine to medium gravel and organics.

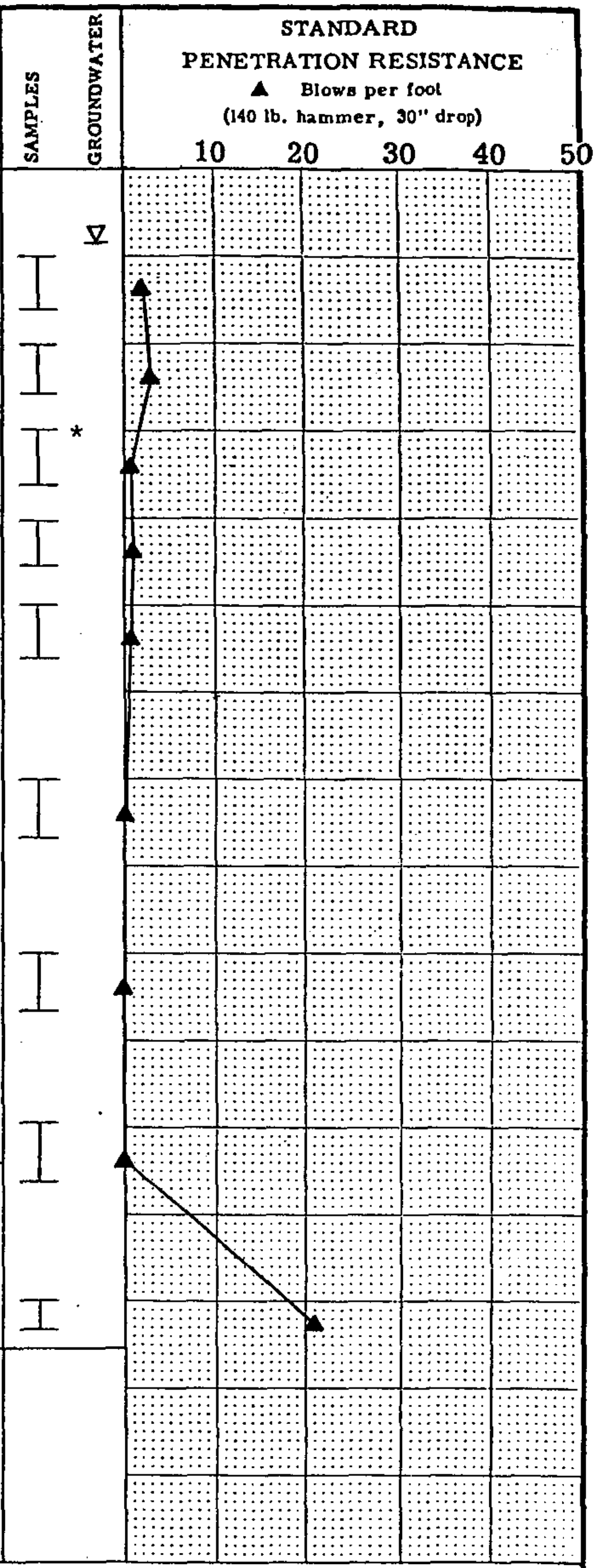
Very loose, saturated, gray, slightly silty, fine to coarse SAND, trace organics and shell fragments in upper portion of strata; grading to very soft, sandy SILT with organics in lower portion of strata.

Very soft, saturated, gray, clayey SILT, trace organics and shell fragments; grading to very loose, fine to medium SAND with fine to medium gravel in lower portion of strata.

Medium dense, saturated, gray, fine to coarse SAND with fine to coarse gravel.

Bottom of boring at 34 feet

5
10
15
20
25
30
35
40



13 October 1981

LEGEND

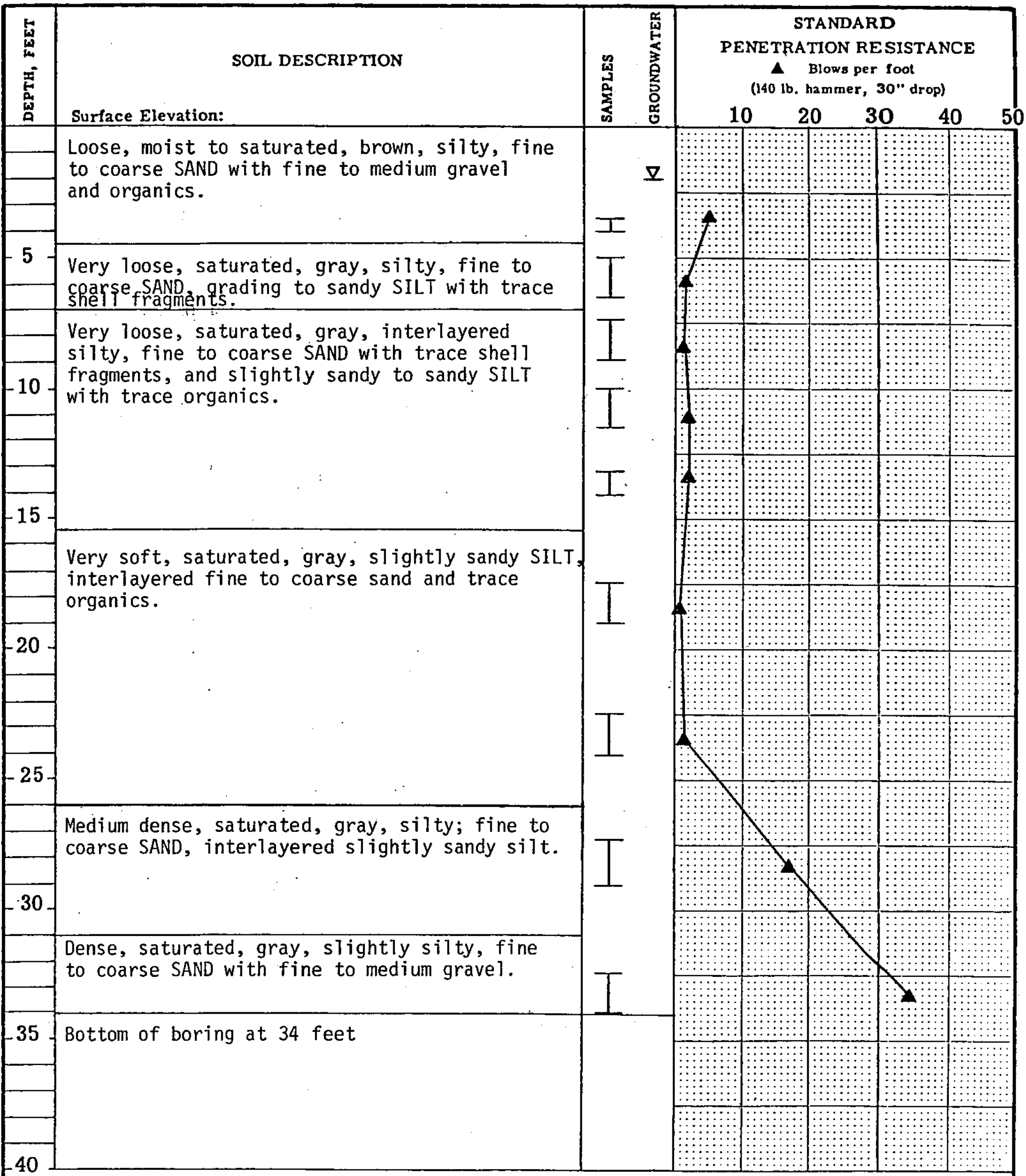
I 2.0" O.D. split spoon sampler
II 3.0" O.D. undisturbed sampler
P Sampler pushed
• Sample not recovered
Piezometer tip
∇ Water level
Atterberg limits: ├─●─┤ ← Liquid limit
Natural water content
Plastic Limit

● % Water Content

Capitol Lake
W-3718

LOG OF BORING NO. B-13

RITTENHOUSE-ZEMAN & ASSOC.
SOILS ENGINEERING AND GEOLOGY



SOIL DESCRIPTION

Surface Elevation:

Loose, moist to saturated, brown, silty, fine to coarse SAND with fine to medium gravel and organics.

Very loose, saturated, gray, silty, fine to coarse SAND, grading to sandy SILT with trace shell fragments.

Very loose, saturated, gray, interlayered silty, fine to coarse SAND with trace shell fragments, and slightly sandy to sandy SILT with trace organics.

Very soft, saturated, gray, slightly sandy SILT, interlayered fine to coarse sand and trace organics.

Medium dense, saturated, gray, silty; fine to coarse SAND, interlayered slightly sandy silt.

Dense, saturated, gray, slightly silty, fine to coarse SAND with fine to medium gravel.

Bottom of boring at 34 feet

17 October 1981

LEGEND

I 2.0" O.D. split spoon sampler
II 3.0" O.D. undisturbed sampler
P Sampler pushed
* Sample not recovered
Piezometer tip
∇ Water level

Atterberg limits: ├─○─┤ ← Liquid limit
Natural water content
Plastic Limit

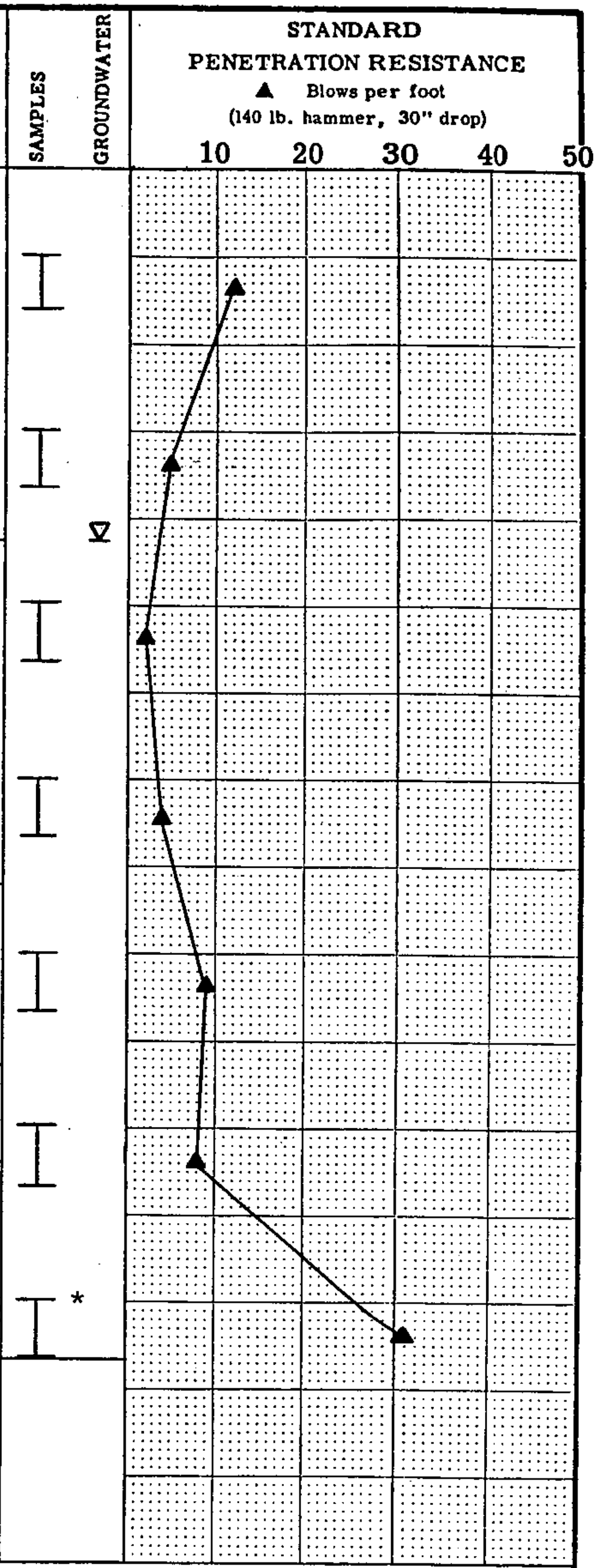
● % Water Content

Capitol Lake
W-3718

LOG OF BORING NO. B-14

RITTENHOUSE-ZEMAN & ASSOC.
SOILS ENGINEERING AND GEOLOGY

DEPTH, FEET	SOIL DESCRIPTION Surface Elevation:
	Medium dense, moist, tan, fine to coarse SAND, trace fine to medium gravel and organics, becomes loose with depth.
5	
10	
	Very soft to soft, saturated, gray, slightly sandy to sandy SILT, trace organics, interlayered silty fine to coarse sand and fine to coarse gravel.
15	
20	
	Loose, saturated, gray, silty, fine to coarse SAND, grading to mottled, gray and brown, fine to coarse SAND with trace organics.
25	
	Loose to dense, saturated, gray, silty, fine to coarse SAND with fine to coarse gravel.
30	
35	Bottom of boring at 34 feet
40	



17 October 1981

LEGEND

I 2.0" O.D. split spoon sampler
II 3.0" O.D. undisturbed sampler
P Sampler pushed
* Sample not recovered
Piezometer tip
∇ Water level
Atterberg limits: ├──●──┤ ← Liquid limit
Natural water content
Plastic Limit

● % Water Content

Capitol Lake
W-3718

LOG OF BORING NO. B-15

RITTENHOUSE-ZEMAN & ASSOC.
SOILS ENGINEERING AND GEOLOGY

DEPTH, FEET

SOIL DESCRIPTION

Surface Elevation:

WATER

Mudline at 4.0 feet

5

Very soft, saturated, gray, SILT with fine to coarse sand, trace organics.

10

Very loose, saturated, gray, silty, fine to coarse SAND, trace organics.

15

Very soft to medium stiff, saturated, gray, SILT, trace organics, interbedded fine to medium sand at 22.5 feet.

20

25

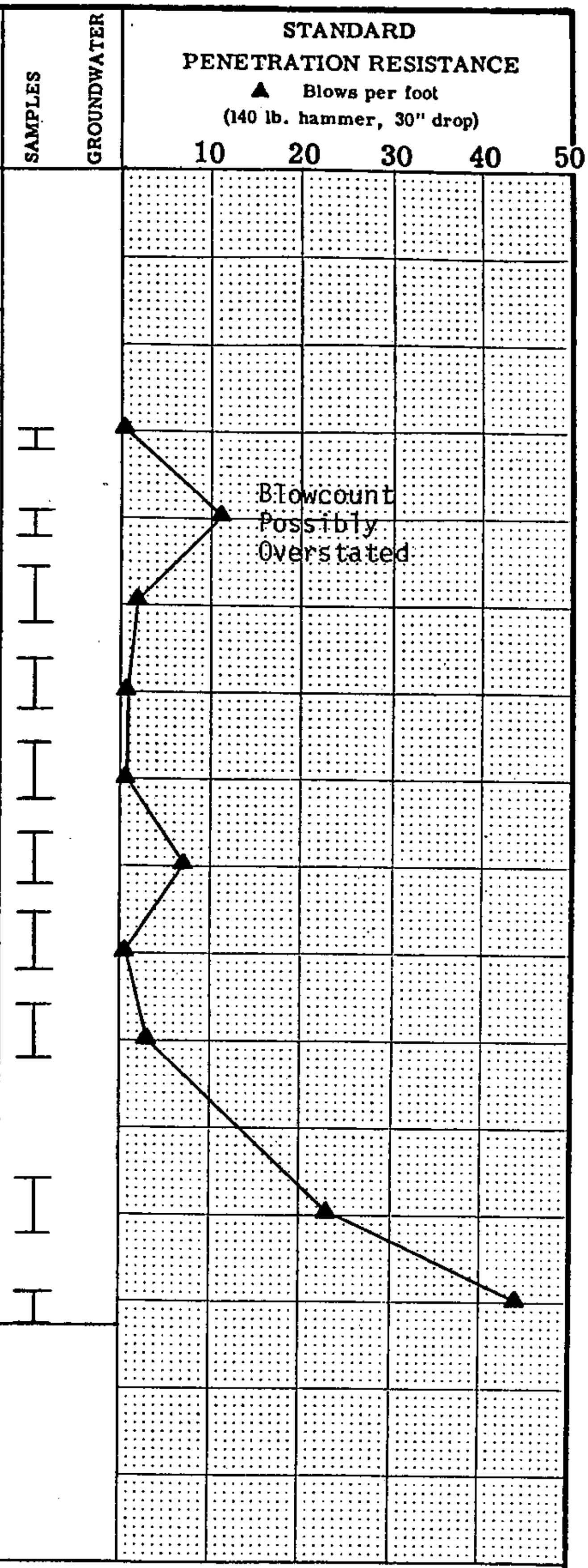
Medium dense to dense, saturated, gray, silty, fine to coarse SAND with fine to medium gravel, trace organics.

30

Bottom of boring at 33 feet

35

40



14 October 1981

LEGEND

I 2.0" O.D. split spoon sampler
II 3.0" O.D. undisturbed sampler
P Sampler pushed
• Sample not recovered
▮ Piezometer tip
▽ Water level
Atterberg limits: ├─●─┤ ← Liquid limit
Natural water content
Plastic Limit

● % Water Content

Capitol Lake
W-3718

LOG OF BORING NO. B-16

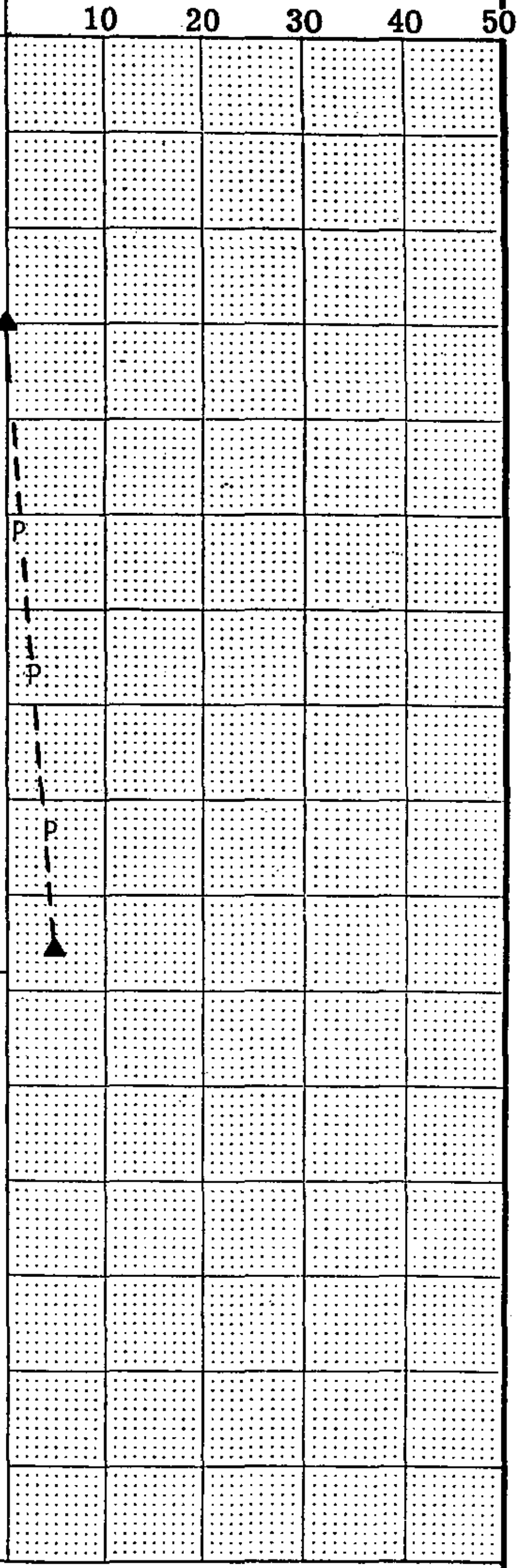
RITTENHOUSE-ZEMAN & ASSOC.
SOILS ENGINEERING AND GEOLOGY

DEPTH, FEET	SOIL DESCRIPTION Surface Elevation:	SAMPLES	GROUNDWATER
	WATER		
	Mudline at 4.0 feet		
5	Very soft to medium dense, saturated, gray, SILT to clayey SILT, trace organics, interbedded fine to coarse sand.		
		I	
10		II	
		VS	
15	NOTE: Resistance to shearing of material with vane shear generally increased with depth.	VS	
		VS	
		VS	
20		II	
		I	
25	Bottom of boring at 24.5 feet		
30			
35			
40			

STANDARD PENETRATION RESISTANCE

▲ Blows per foot

(140 lb. hammer, 30" drop)



15 October 1981

LEGEND

I	2.0" O.D. split spoon sampler	•	Sample not recovered
II	3.0" O.D. undisturbed sampler	╿	Piezometer tip
P	Sampler pushed	▽	Water level

Atterberg limits: ├─●─┤ ← Liquid limit; ← Natural water content; ← Plastic Limit

VS Vane Shear

● % Water Content

Capitol Lake

W-3718

LOG OF BORING NO. B-17

RITTENHOUSE-ZEMAN & ASSOC.

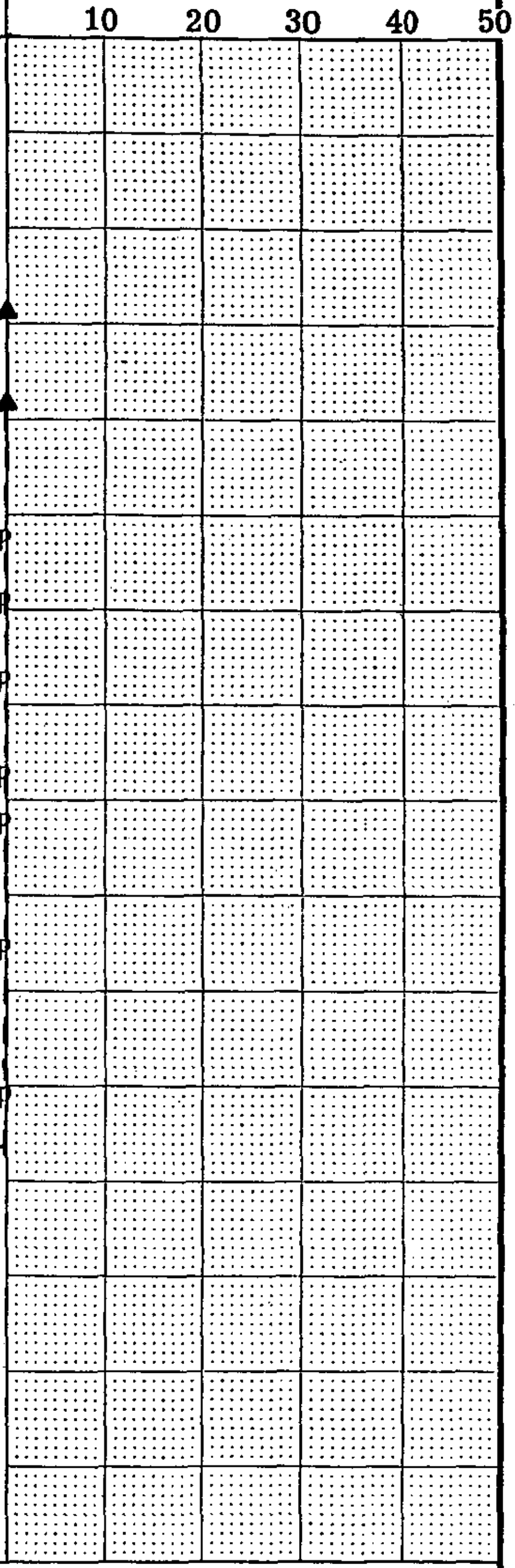
SOILS ENGINEERING AND GEOLOGY

DEPTH, FEET	SOIL DESCRIPTION Surface Elevation:	SAMPLES	GROUNDWATER
	WATER		
5	Mudline at 5.5 feet		
	Very soft, saturated, gray SILT to clayey SILT, trace organics, interbedded fine to coarse sand.	I	
10		I	
		VS	P
		VS	P
15	NOTE: Resistance to shearing of material with vane shear generally increased with depth.		
		VS	P
		II	P
20			P
		VS	
		VS	P
25			
		VS	
		VS	P
		VS	
30	Bottom of boring at 29 feet		
35			
40			

STANDARD PENETRATION RESISTANCE

▲ Blows per foot

(140 lb. hammer, 30" drop)



14 October 1981

LEGEND

I 2.0" O.D. split spoon sampler

II 3.0" O.D. undisturbed sampler

P Sampler pushed

* Sample not recovered

Piezometer tip

∇ Water level

Atterberg limits: ├──●──┤ ← Liquid limit

Natural water content

Plastic Limit

VS Vane Shear

● % Water Content

Capitol Lake

W-3718

LOG OF BORING NO. B-18

RITTENHOUSE-ZEMAN & ASSOC.

SOILS ENGINEERING AND GEOLOGY

DEPTH, FEET

SOIL DESCRIPTION

Surface Elevation:

WATER

Mudline at 5.0 feet

5

Very soft to soft, saturated, gray SILT with fine sand and organics, grading to slightly sandy silt, interbedded fine to coarse sand and organics.

10

15

20

25

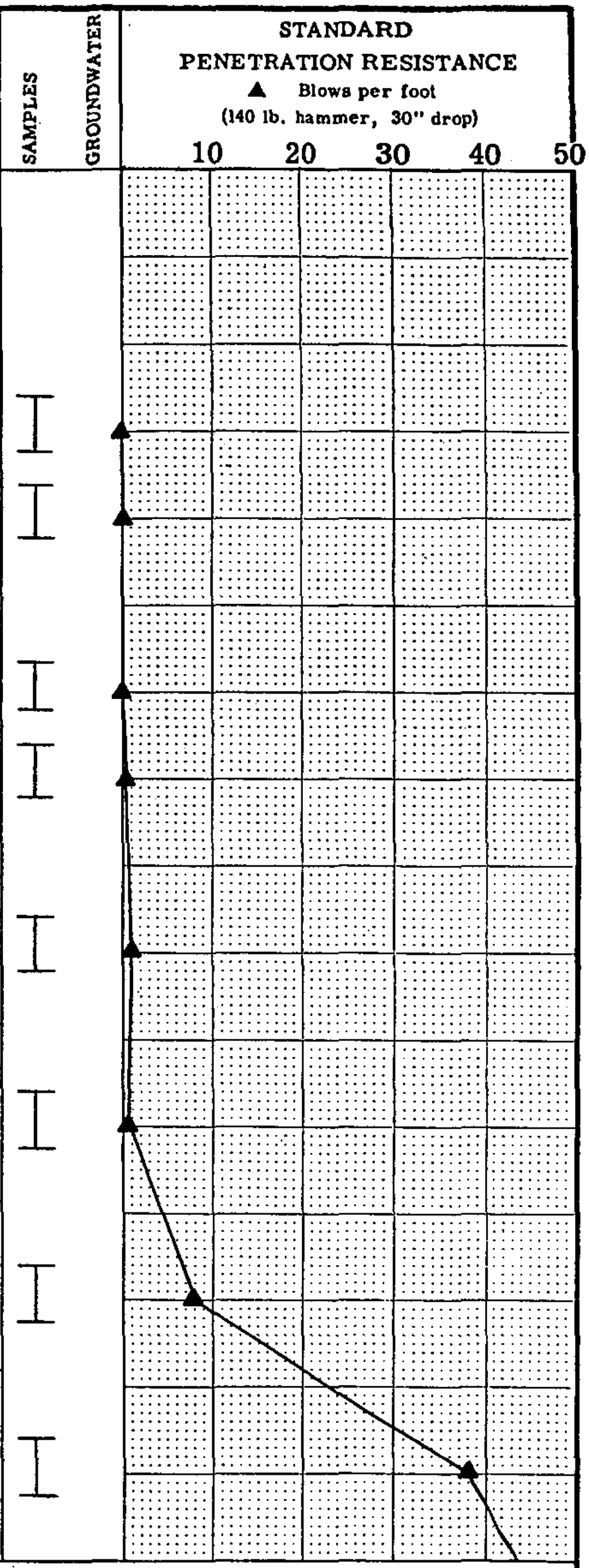
30

Loose, saturated, gray-brown, slightly silty, fine to coarse SAND, trace organics.

35

Dense, saturated, gray to brown, slightly silty to silty, fine to coarse SAND with fine to medium gravel.

40



15 October 1981

LEGEND

Ⅰ 2.0" O.D. split spoon sampler
Ⅱ 3.0" O.D. undisturbed sampler
P Sampler pushed
Atterberg limits: ├─●─┤ ← Liquid limit
Natural water content
Plastic Limit

• Sample not recovered
Piezometer tip
∇ Water level

● % Water Content

Capitol Lake
W-3718
LOG OF BORING NO. B-19

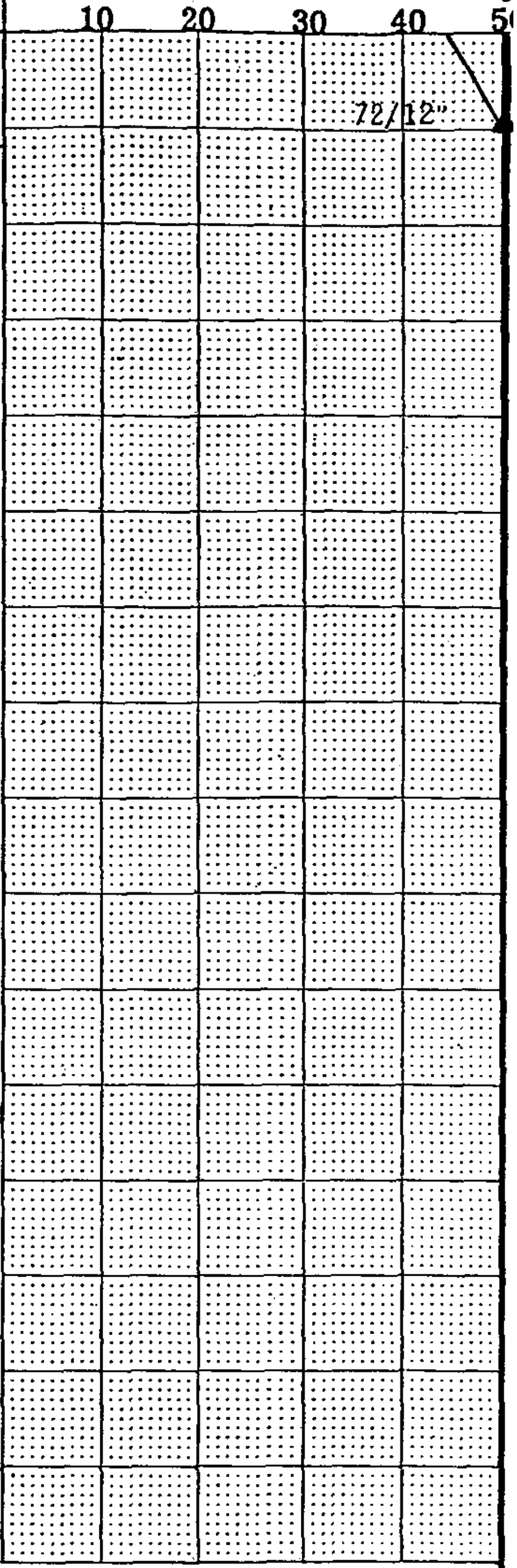
RITTENHOUSE-ZEMAN & ASSOC.
SOILS ENGINEERING AND GEOLOGY

DEPTH, FEET	SOIL DESCRIPTION Surface Elevation:	SAMPLES	GROUNDWATER
	Dense, saturated, gray to brown, slightly silty to silty, fine to coarse SAND with fine to medium gravel.	I	
	Bottom of boring at 43 feet		
45			
50			
55			
60			
65			
70			
75			
80			

STANDARD PENETRATION RESISTANCE

▲ Blows per foot

(140 lb. hammer, 30" drop)



15 October 1981

LEGEND

I 2.0" O.D. split spoon sampler

II 3.0" O.D. undisturbed sampler

P Sampler pushed

* Sample not recovered

Piezometer tip

∇ Water level

Atterberg limits: Liquid limit, Natural water content, Plastic Limit

● % Water Content

Capitol Lake

W-3718

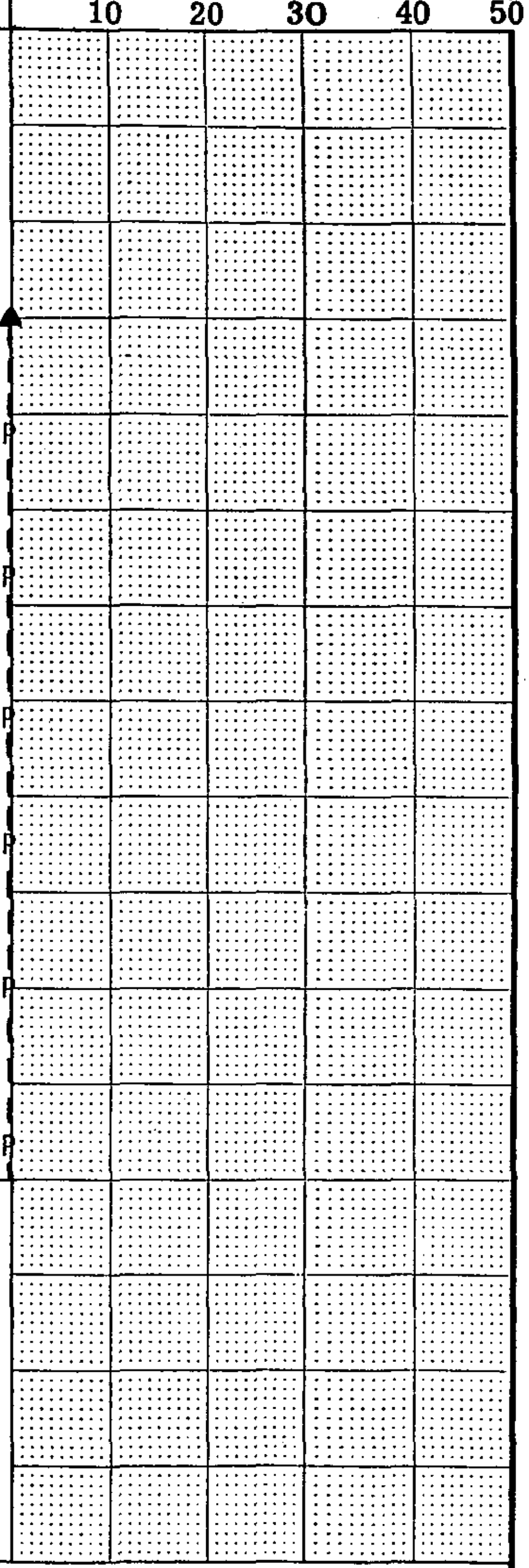
LOG OF BORING NO. B-19(cont.)

RITTENHOUSE-ZEMAN & ASSOC.

SOILS ENGINEERING AND GEOLOGY

DEPTH, FEET	SOIL DESCRIPTION Surface Elevation:	SAMPLES	GROUNDWATER
	WATER		
5	Mudline at 6.5 feet		
	Very soft, saturated, dark gray, SILT to clayey SILT, trace organics, interbedded fine to coarse sand.	I	
10		VS	P
		VS	
		II	P
15	NOTE: Resistance to shearing of material by vane shear generally increased with depth.		
			P
20		VS	
		VS	P
25		VS	P
		VS	
		VS	P
30		VS	
	Bottom of boring at 30 feet		
35			
40			

STANDARD PENETRATION RESISTANCE
▲ Blows per foot
(140 lb. hammer, 30" drop)



15 October 1981

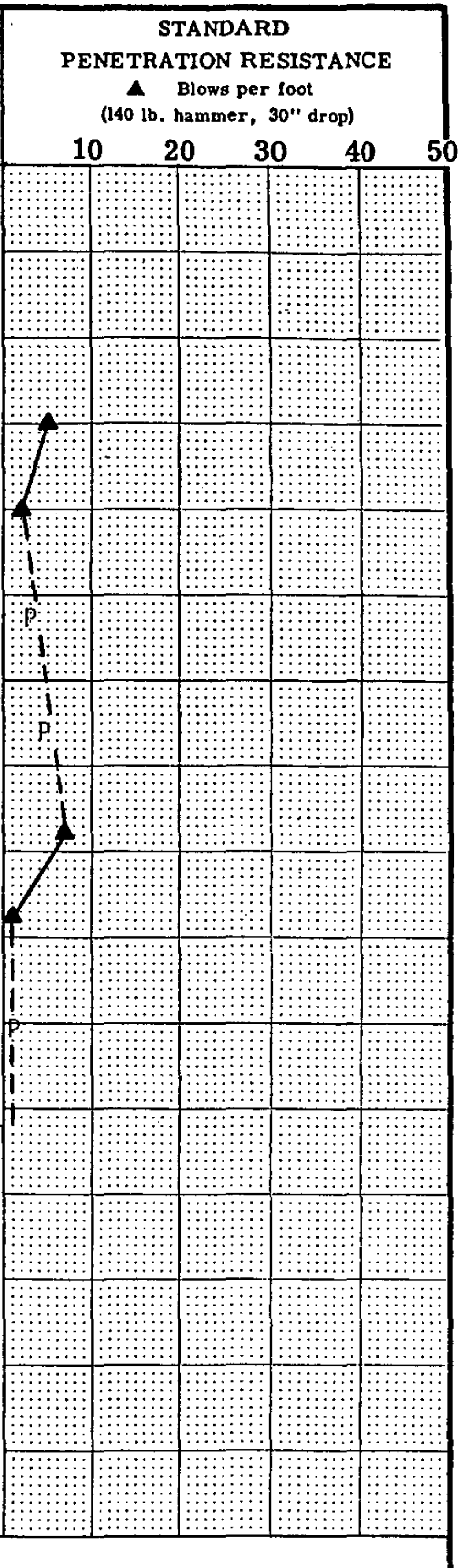
LEGEND

I 2.0" O.D. split spoon sampler
II 3.0" O.D. undisturbed sampler
P Sampler pushed
* Sample not recovered
Piezometer tip
∇ Water level
Atterberg limits: ├─●─┤ ← Liquid limit, Natural water content, Plastic Limit
VS Vane Shear
● % Water Content

Capitol Lake
W-3718
LOG OF BORING NO. B-20

RITTENHOUSE-ZEMAN & ASSOC.
SOILS ENGINEERING AND GEOLOGY

DEPTH, FEET	SOIL DESCRIPTION	SAMPLES	GROUNDWATER
	Surface Elevation:		
	WATER		
	Mudline at 4.5 feet		
5	Very loose to loose, saturated, gray, fine to coarse SAND with fine to medium gravel.		
		I	
10		I	
	Soft to medium dense, saturated, gray, SILT, trace organics and shell fragments, interbedded silty fine to coarse sand.	VS	
		VS	
15			
		VS	
		VS	
		I	
20	NOTE: Resistance to shearing of material with vane shear generally increased with depth.		
		I	
		VS	
25			
		VS	
		VS	
	Bottom of boring at 28 feet		
30			
35			
40			



15 October 1981

LEGEND

I 2.0" O.D. split spoon sampler
II 3.0" O.D. undisturbed sampler
P Sampler pushed
Atterberg limits: ├─●─┤ ← Liquid limit; Natural water content; Plastic Limit
* Sample not recovered
Piezometer tip
∇ Water level
VS Vane Shear

● % Water Content

Capitol Lake
W-3718
LOG OF BORING NO. B-21

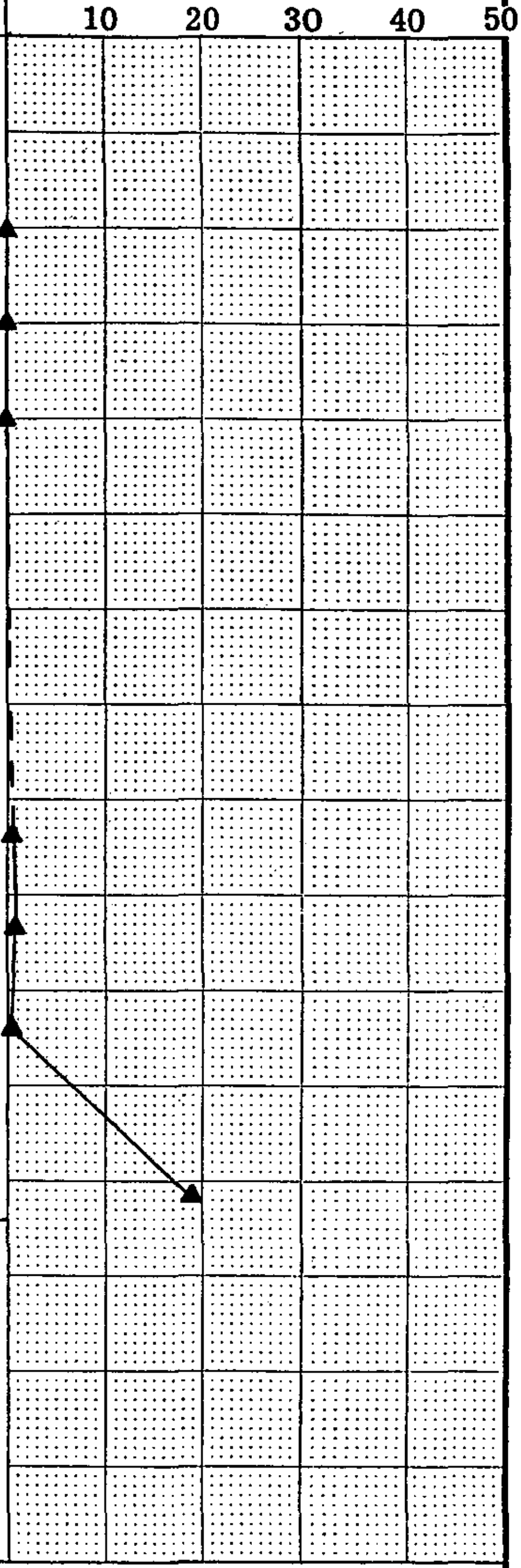
RITTENHOUSE-ZEMAN & ASSOC.
SOILS ENGINEERING AND GEOLOGY

DEPTH, FEET	SOIL DESCRIPTION Surface Elevation:	SAMPLES	GROUNDWATER
	WATER Mudline at 2.5 feet		
5	Very soft, saturated, gray, slightly sandy SILT, trace organics, grading to SILT, trace organics.	I	
		I	
10	NOTE: Resistance to shearing of material with vane shear generally increased with depth.	I VS	P
		VS	P
15		VS VS	P
	Very loose, saturated, gray, silty, fine to coarse SAND with organics.	VS	
20		I	
	Very soft, saturated, gray SILT, interbedded fine to coarse sand and organics, grading to slightly sandy silt, grading to medium dense, brown, silty, fine to coarse SAND with fine to medium gravel.	I	
25		I	
30		I	
35			
40			

STANDARD PENETRATION RESISTANCE

▲ Blows per foot

(140 lb. hammer, 30" drop)



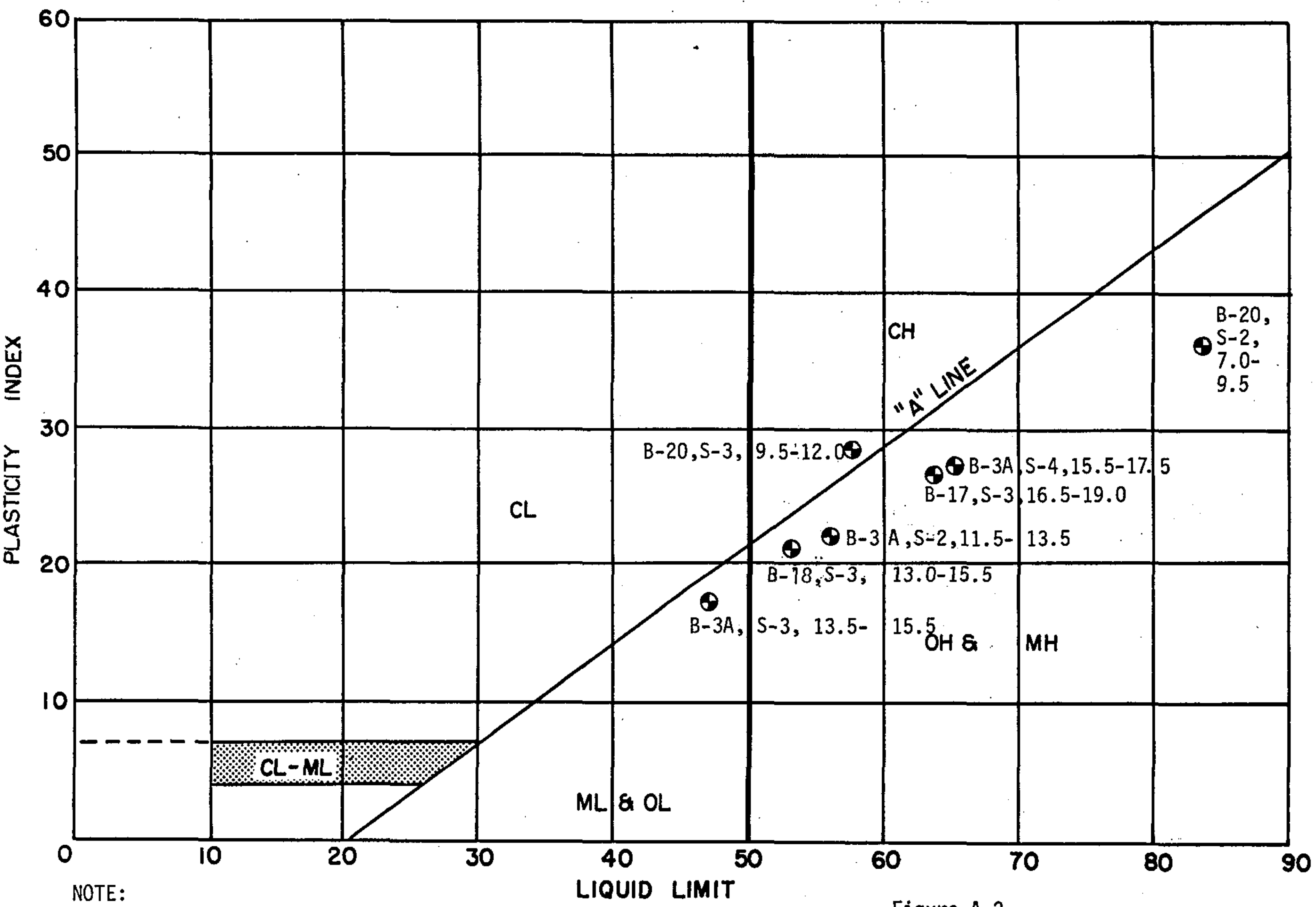
16 October 1981

LEGEND

I 2.0" O.D. split spoon sampler
II 3.0" O.D. undisturbed sampler
P Sampler pushed
* Sample not recovered
Piezometer tip
∇ Water level
Atterberg limits: ├──●──┤ ← Liquid limit, Natural water content, Plastic Limit
VS Vane Shear
● % Water Content

Capitol Lake
W-3718
LOG OF BORING NO. B-22

RITTENHOUSE-ZEMAN & ASSOC.
SOILS ENGINEERING AND GEOLOGY



NOTE:

● Boring,Sample,Depth Below Mudline (ft.)

Wo. W-3718 Capitol Lake

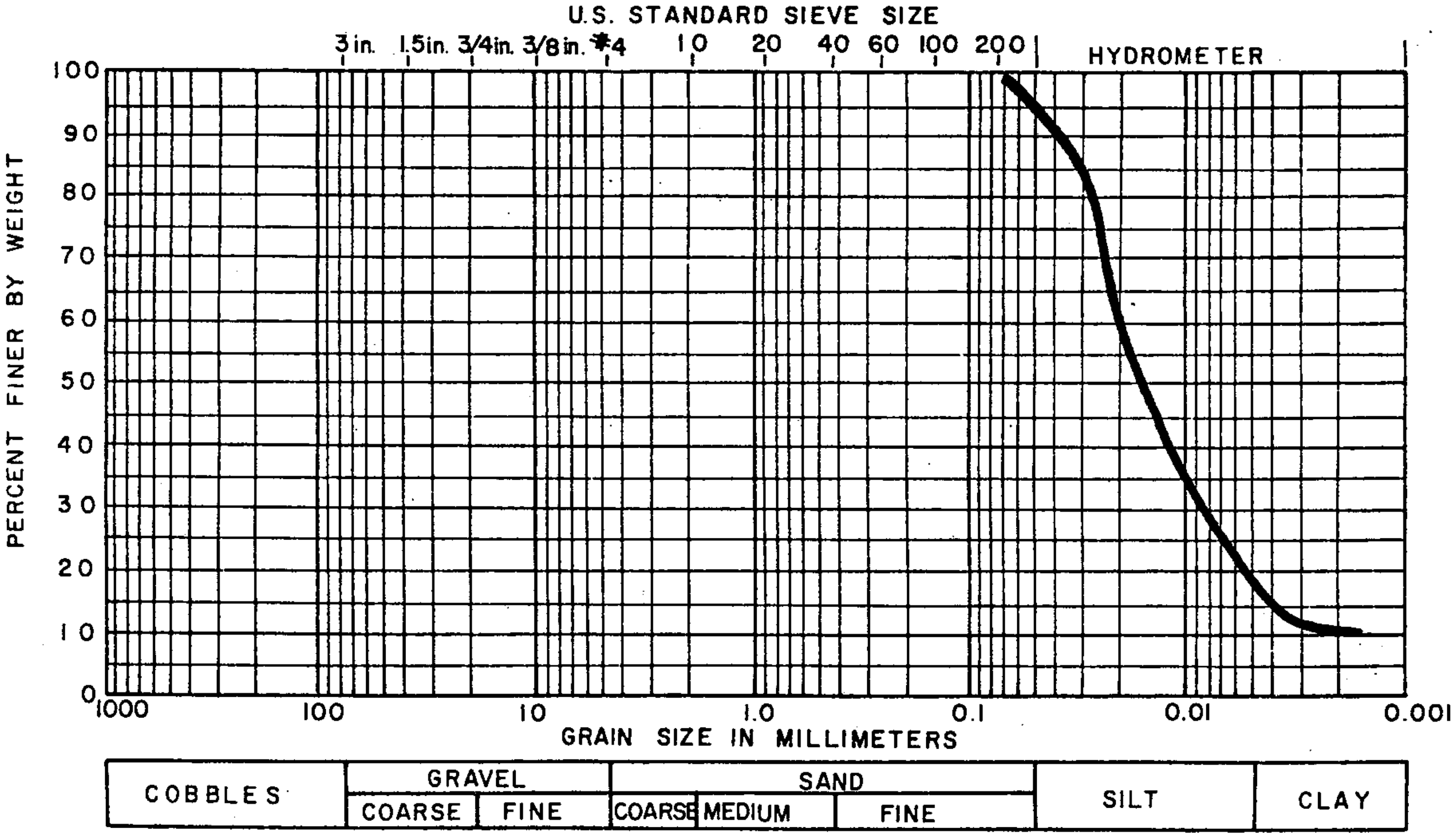
Figure A-2

PLASTICITY CHART

RITTENHOUSE-ZEMAN & ASSOC.

Table A-1. ATTERBERG LIMITS SOIL CLASSIFICATION CHART

GROUP DIVISIONS		GROUP SYMBOLS	GROUP NAMES AND LABORATORY CLASSIFICATION CRITERIA	EXAMPLES OF TYPICAL SOIL DESCRIPTIONS
FINE GRAINED SOILS More than half of the material passes the No. 200 sieve.	SILTS and CLAYS with the liquid limit less than 50%	ML	Inorganic, non-plastic and slightly plastic SILTS and sandy SILTS, medium plastic, clayey SILTS. Plots below the "A" line.	Non-plastic, fine sandy SILT. Slightly plastic, clayey SILT.
		CL	Inorganic, slightly plastic to medium plastic CLAYS, silty CLAYS, sandy CLAYS. Plots above the "A" line.	Medium plastic, silty CLAY, trace fine sand. Plastic, sandy, CLAY.
		OL	Organic, non-plastic to medium plastic SILTS and clayey SILTS. Plots below the "A" line.	Slightly plastic, organic, clayey SILT. Medium plastic, sandy, organic SILT.
	SILTS and CLAYS with the liquid limit greater than 50%	MH	Inorganic, micaceous or diatomaceous, slightly plastic SILTS and medium to very plastic SILTS. Plots below the "A" line.	Plastic, clayey SILT. Medium plastic, sandy, clayey SILT.
		CH	Inorganic, plastic to very plastic CLAYS. Plots above the "A" line.	Plastic to very plastic CLAY. Very plastic CLAY, some silt.
		OH	Organic, medium plastic to very plastic CLAYS, silty CLAYS and highly plastic organic SILTS. Plots below the "A" line.	Plastic to very plastic, organic, clayey SILT. Medium plastic, organic CLAY.
HIGHLY ORGANIC SOILS		PT	PEAT, organic soils with a distinct organic texture and containing particles of fibrous and non-fibrous vegetable matter.	Silty, clayey PEAT. Fibrous PEAT with organic SILT.



PROJECT Capitol Lake

WORK ORDER W-3718

Boring B-3A **Sample** S-4 **Depth** 15.5-17.5
(Below Mud Line)

% Passing 200 95.5%

GRAIN SIZE DISTRIBUTION

Figure A-3
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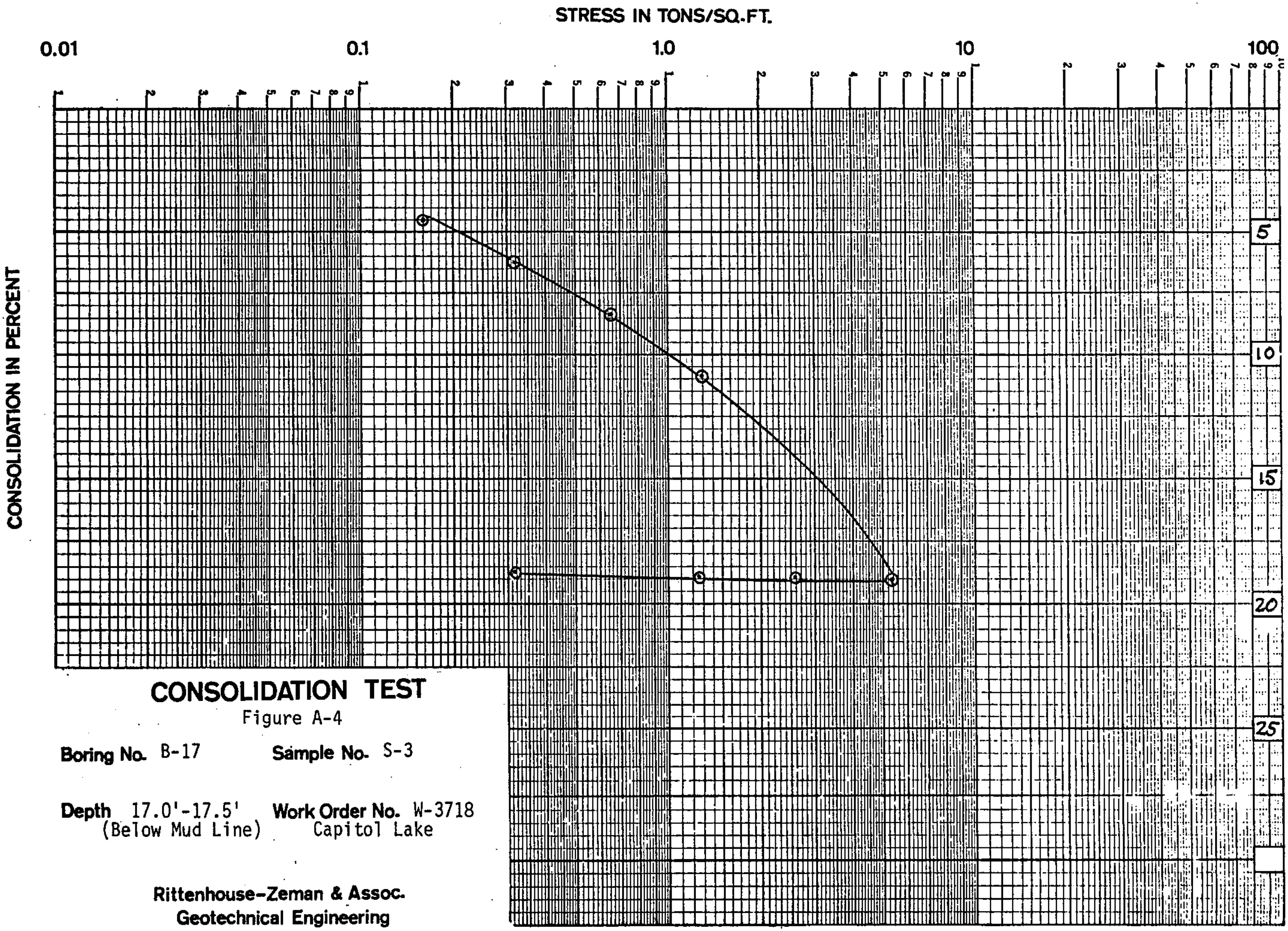

CONSOLIDATION TEST

Figure A-4

Boring No. B-17 **Sample No.** S-3

Depth 17.0'-17.5' **Work Order No.** W-3718
(Below Mud Line) Capitol Lake

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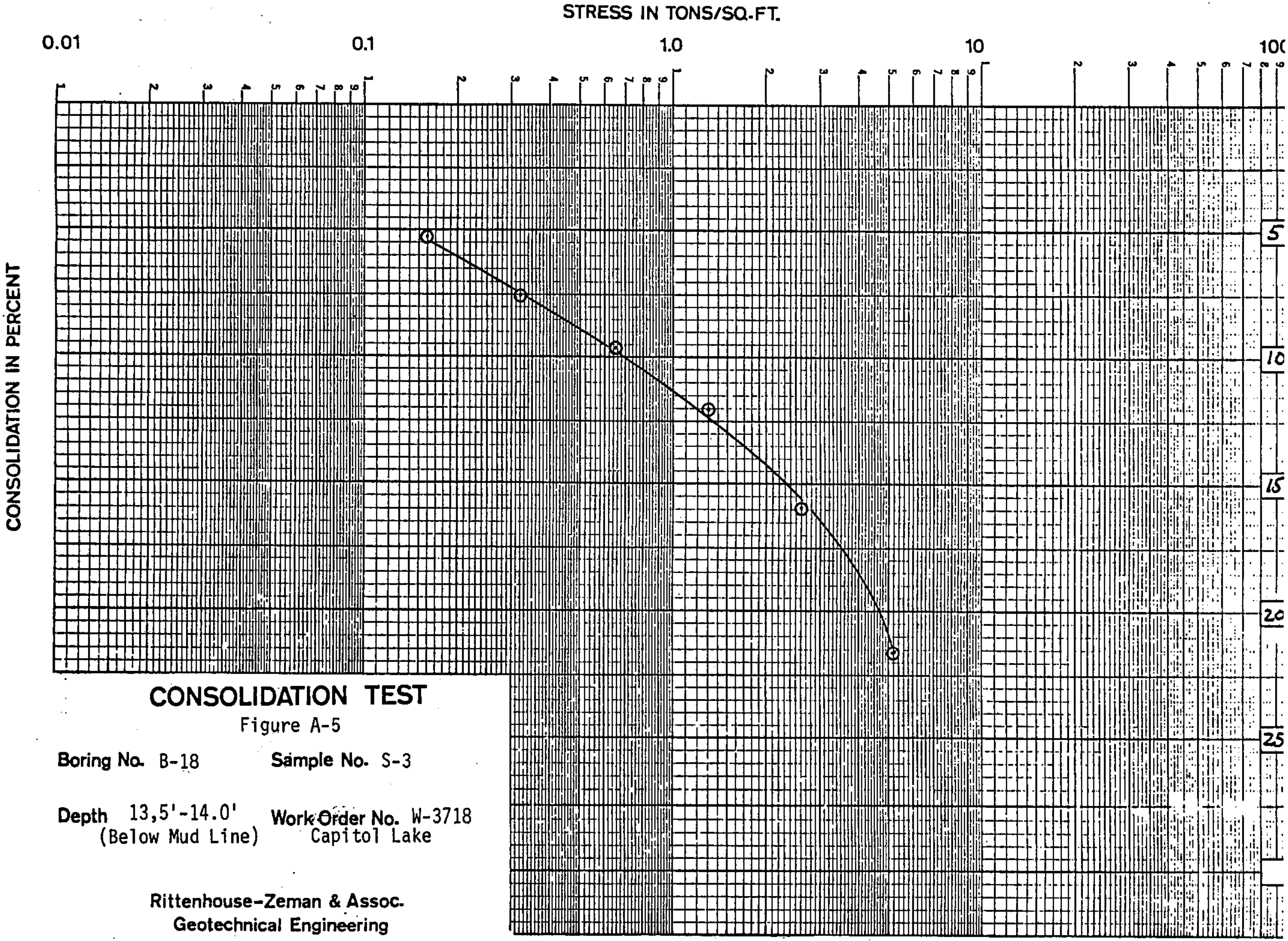
Geotechnical Engineering



CONSOLIDATION TEST

Figure A-5

Boring No. B-18 **Sample No.** S-3

Depth 13,5'-14.0'
(Below Mud Line)

Work Order No. W-3718
Capitol Lake

Rittenhouse-Zeman & Assoc.
Geotechnical Engineering

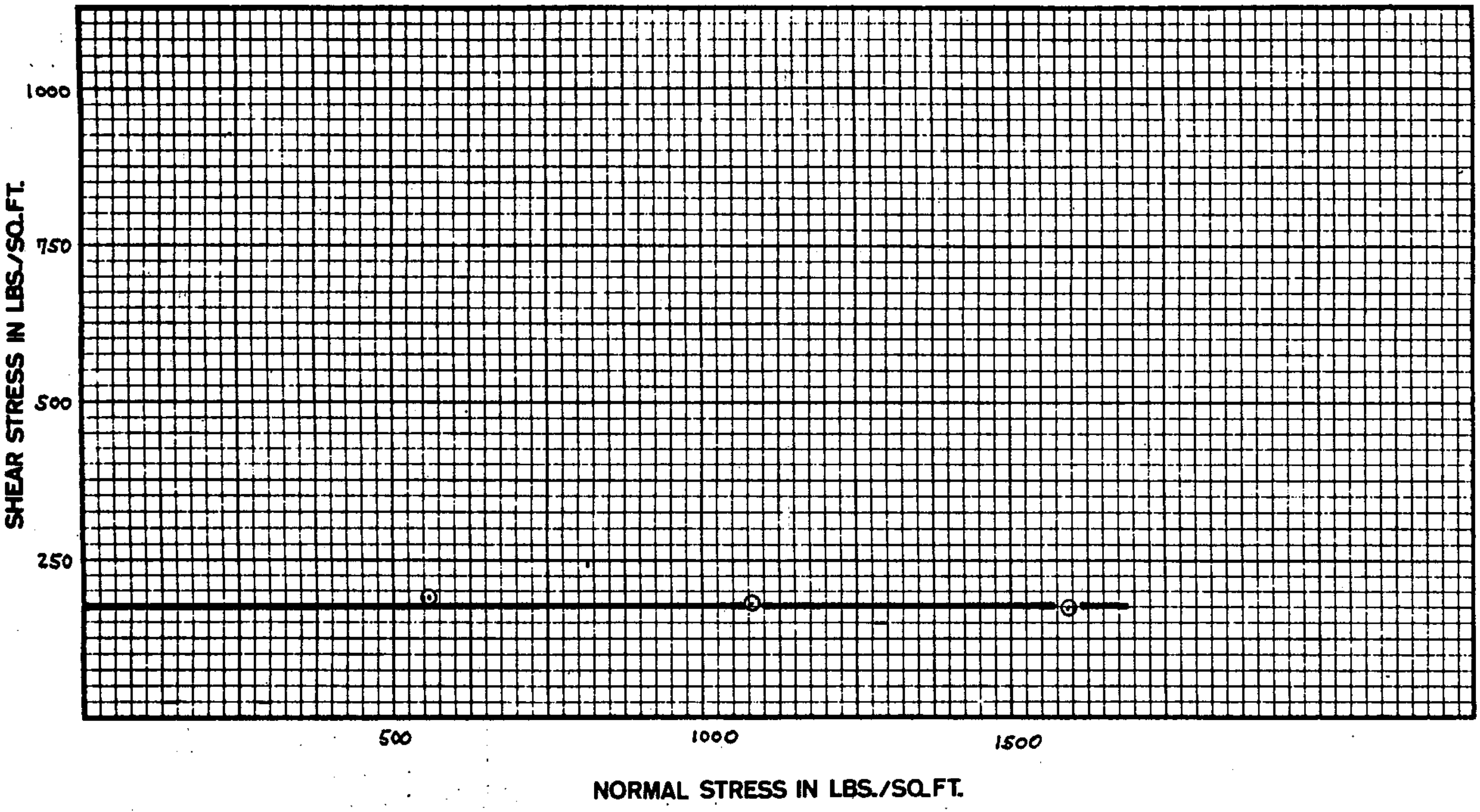


Figure A-6

DIRECT SHEAR TEST

Boring No. B-3A

Sample No. S-3

Depth 13.5 - 15.5 (Below Mud Line)

Work Order No. W-3718

Objective: Unconsolidated, Undrained
Direct Shear

Angle of Internal Friction (ϕ) 0 **degrees**

Cohesion (C) 175 **lbs./sq.ft.**

Soil Type Gray, clayey, slightly sandy to sandy SILT.

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Geotechnical Engineering

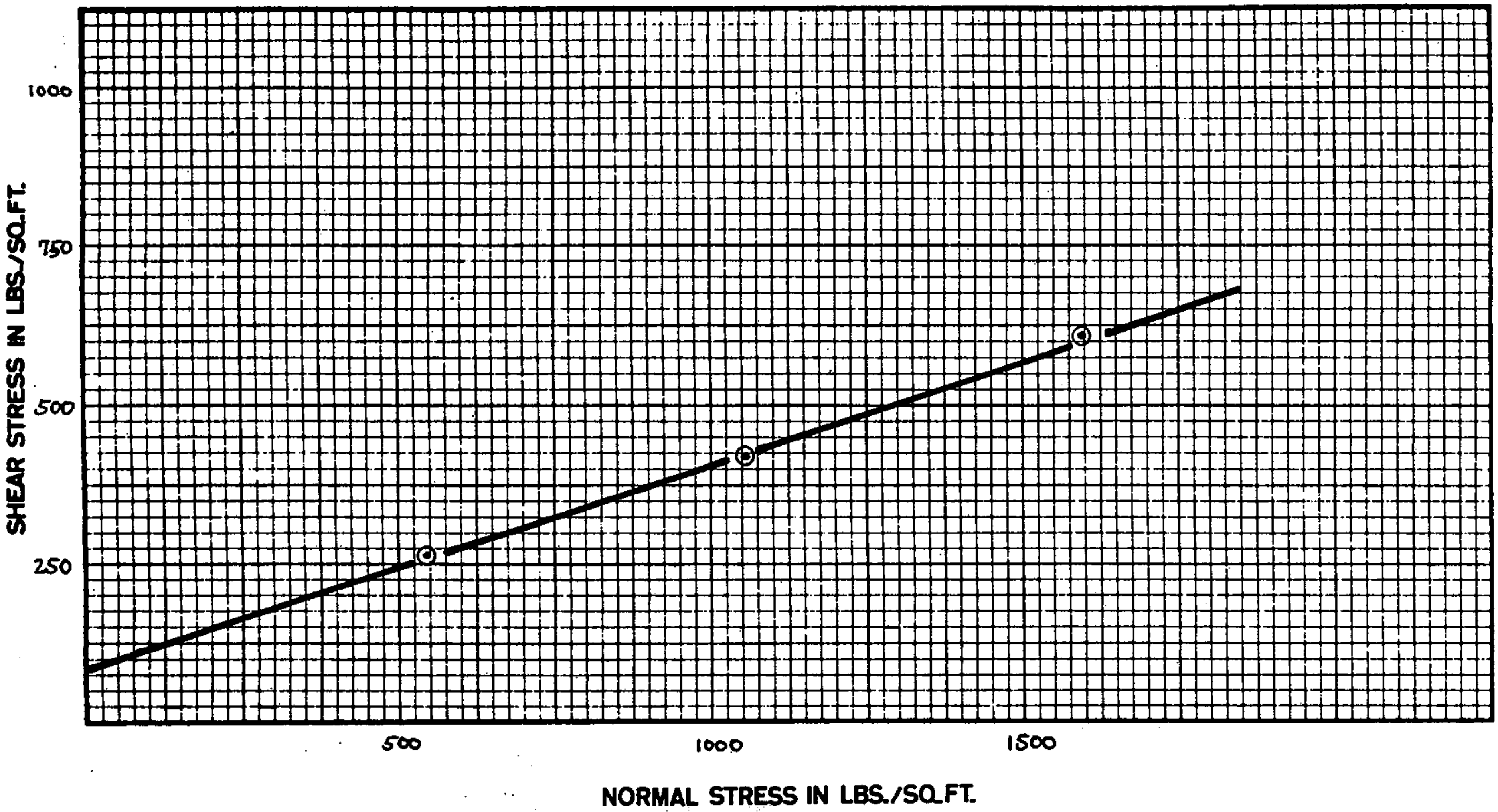

Figure A-7

DIRECT SHEAR TEST

Boring No. B-37

Sample No. S-4

Depth 15.5 - 17.5 (Below Mud Line)

Work Order No. W-3718

Objective: Consolidated, Undrained
Direct Shear

Angle of Internal Friction (φ) 18 **degrees**

Cohesion (C) 85 **lbs./sq.ft.**

Soil Type Gray, clayey, Sandy SILT,
trace organics

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Geotechnical Engineering

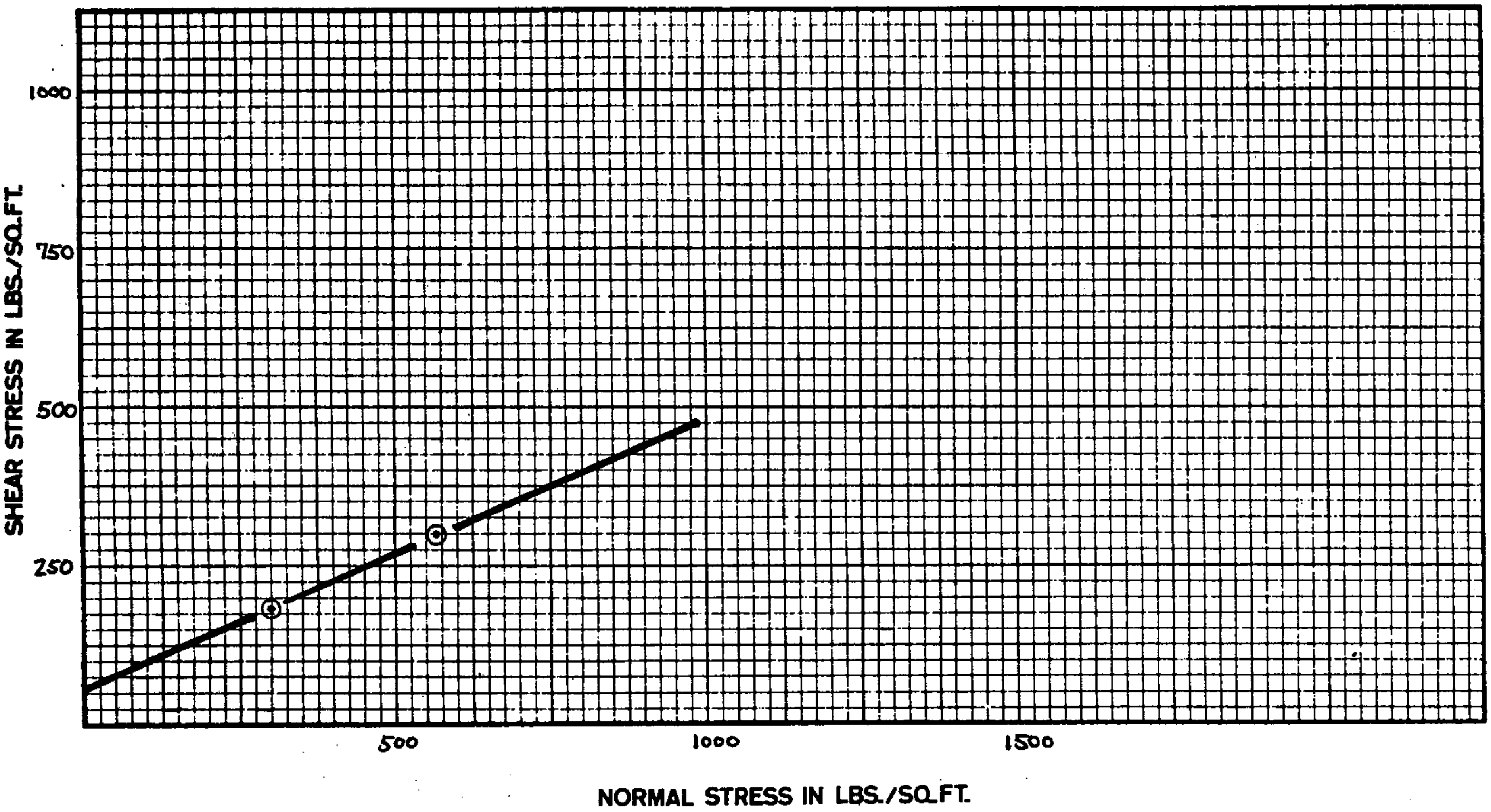

Figure A-8

DIRECT SHEAR TEST

Boring No. B-20

Sample No. S-2

Depth 7.0 - 9.5 (Below Mudline)

Work Order No. W-3718

Objective: Unconsolidated, Undrained Direct Shear

Angle of Internal Friction (φ) 23 **degrees**

Cohesion (C) 55 **lbs./sq.ft.**

Soil Type Gray, slightly Sandy Silty Clay, Trace Organics

Rittenhouse-Zeman & Assoc.
Geotechnical Engineering

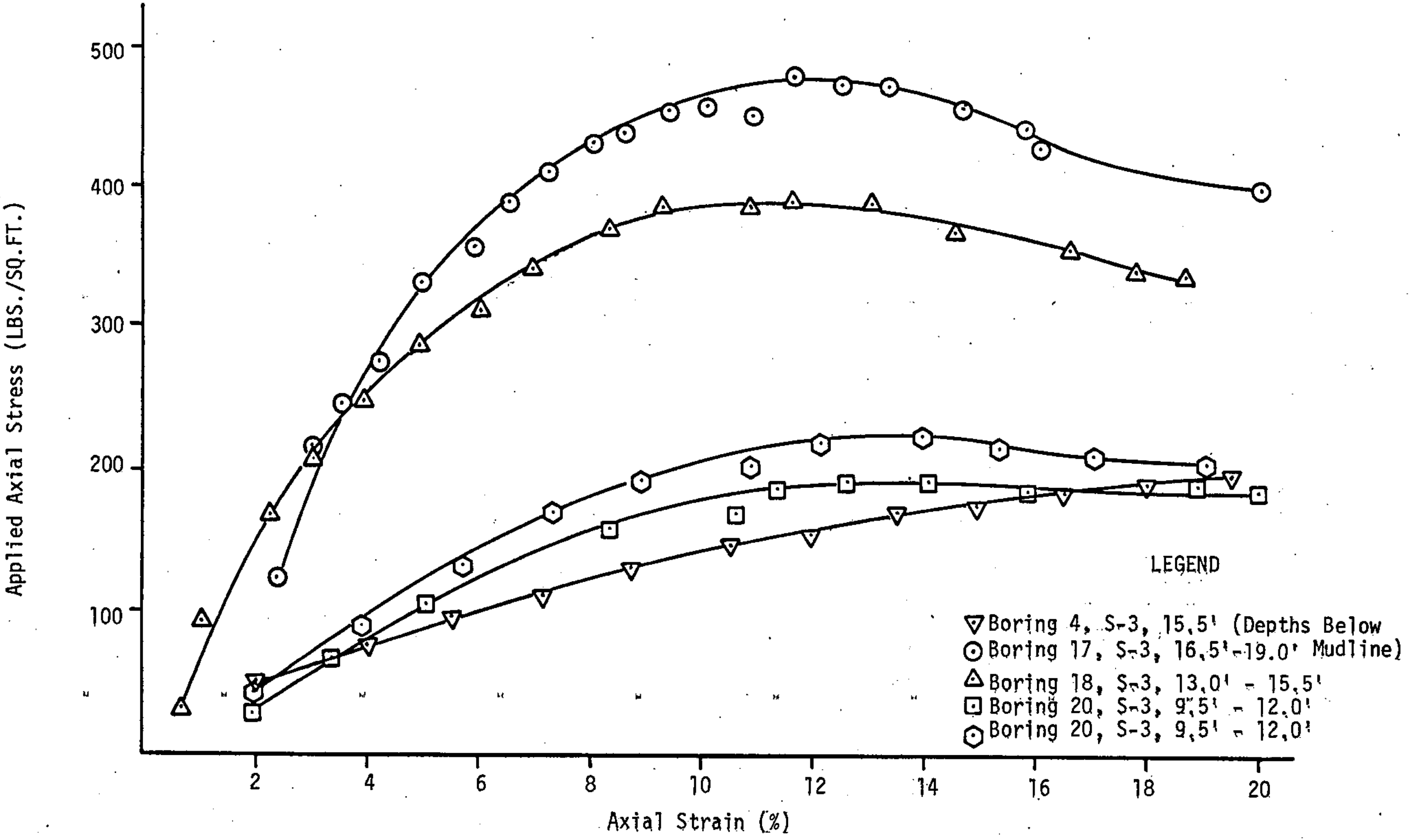

Figure A-9

Unconfined Compression Tests
Stress-Strain Relationships

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AFFILIATE OFFICES IN MOST PRINCIPAL CITIES

W.O. W-3718
BY W.W.B.
DATE 12/8/81
SCALE As Shown

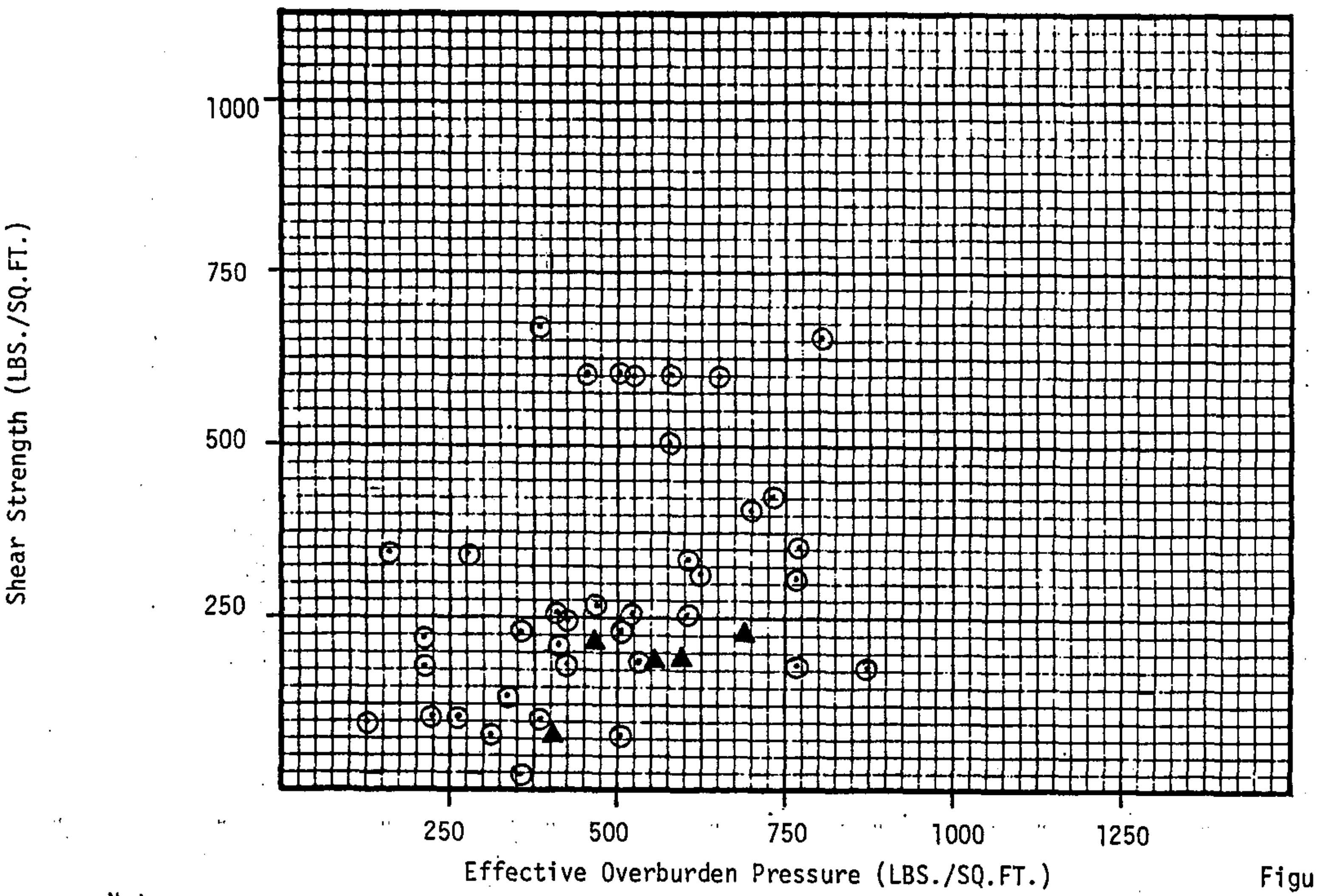

Figure A-10

Undrained Shear Strength Versus
Effective Overburden Pressure

Notes:

1. ⊙ Field Vane Shear Tests
   ▲ Laboratory Unconfined Compression Tests

2. Effective overburden pressure calculated using depth of vane test or sample below mudline and an effective unit weight of 37.6 psf.

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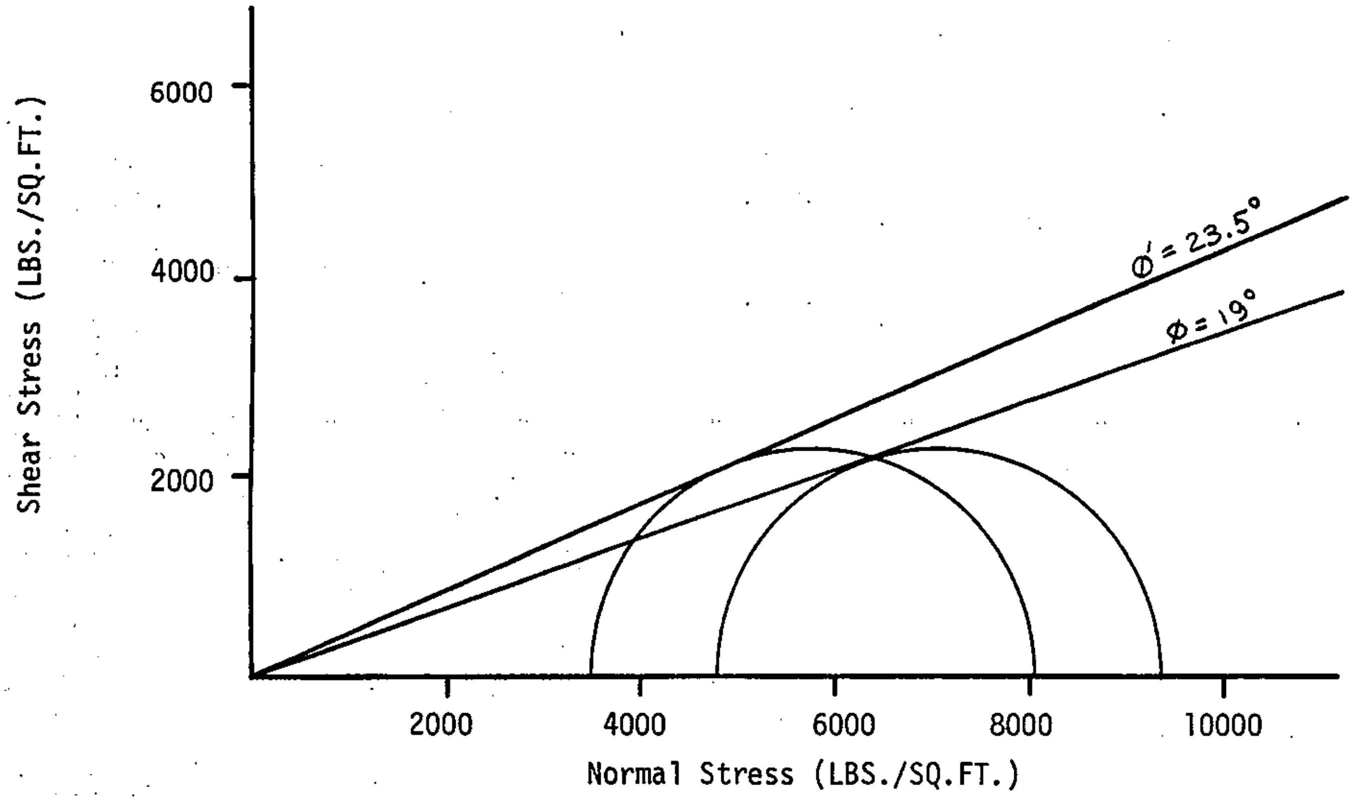

Figure A-11

Consolidated, Undrained
Triaxial Compression test

Notes:

1. Boring B-17, Sample S-3
   16.5' - 19.0' Below Mudline

2. Initial Conditions:

   Water Content= 74.9%
   Void Ratio = 1.79
   Saturated Unit Weight = 96.3 pcf
   Atterberg Limits: LL=64 PI=26.5
   Gray, clayey, slightly sandy SILT, trace organics (MH)

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BY W.W.B. SCALE As Shown

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Liesch, B. A., Price, C.E. and Walters, K. L., 1963 Geology and ground water resources of north western King County, Washington: Washington Division of Water Resources, Water Supply Bulletin, No. 20 (text and map)

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